# Emerging Technology for Deep Foundation Quality Control


JAMES SCHMIDT, P.E., P.ENG, D.GE.

Terracon

# Who is TERRACON?

- **DOTs Projects in 41 states**
- **Current On-Call Geotechnical Contracts in 19 states**
- **Transportation Design-Build projects completed in 21 US states and Canada**
- **Hundreds of county and municipality road and bridge projects**


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# CSL

**West Tower Drilled Shaft Foundations**
Arthur Ravenel Jr. Bridge, Charleston SC

## PROVIDES:

- **Integrity Evaluation**
  - Along entire Shaft length
  - Size & location of anomalies

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# CSL

- Proven Technology
- Concrete Evaluation
- Repair Evaluation


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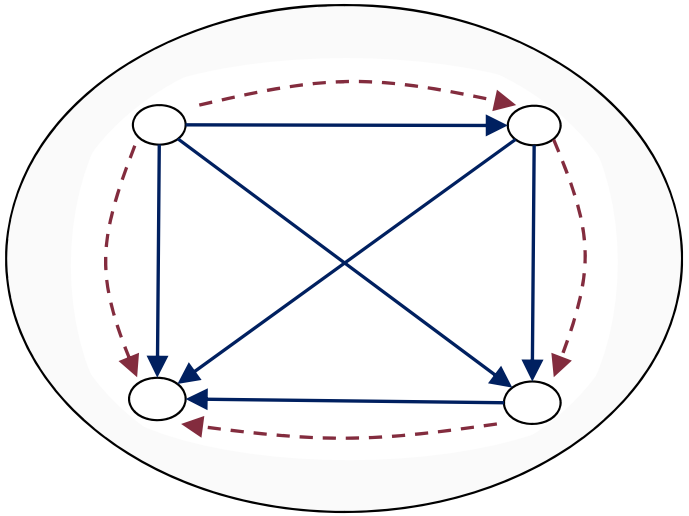
# CSL

- Time Delay (Typ. 3-7 Days)
- Requires Access Tubes
- Testing within cage

  25%-75% of area[1]
- False Positives/*Debonding*



[1] *Dr. Gray Mullins*

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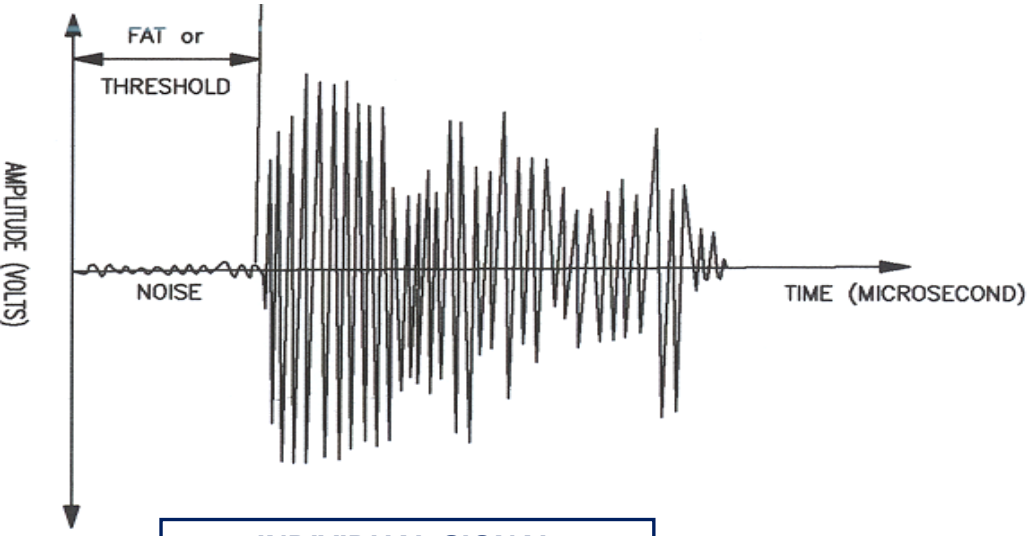
# CSL
## ANALYSIS

**FAT = First Arrival Time**




**INDIVIDUAL SIGNAL**

### WHAT AFFECTS SIGNAL?

- Low density concrete
- Voids
- Soil Intrusions

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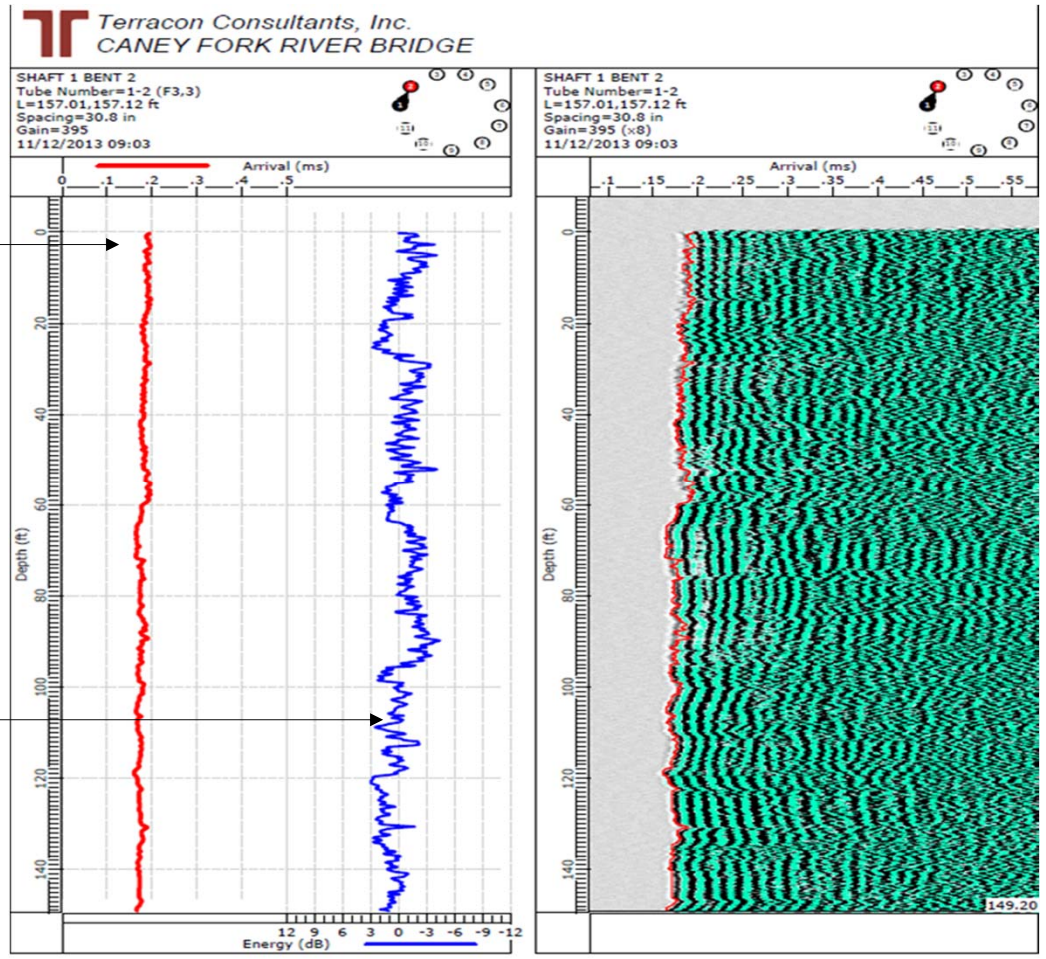
# CSL

Arrival Time

Energy




Waterfall

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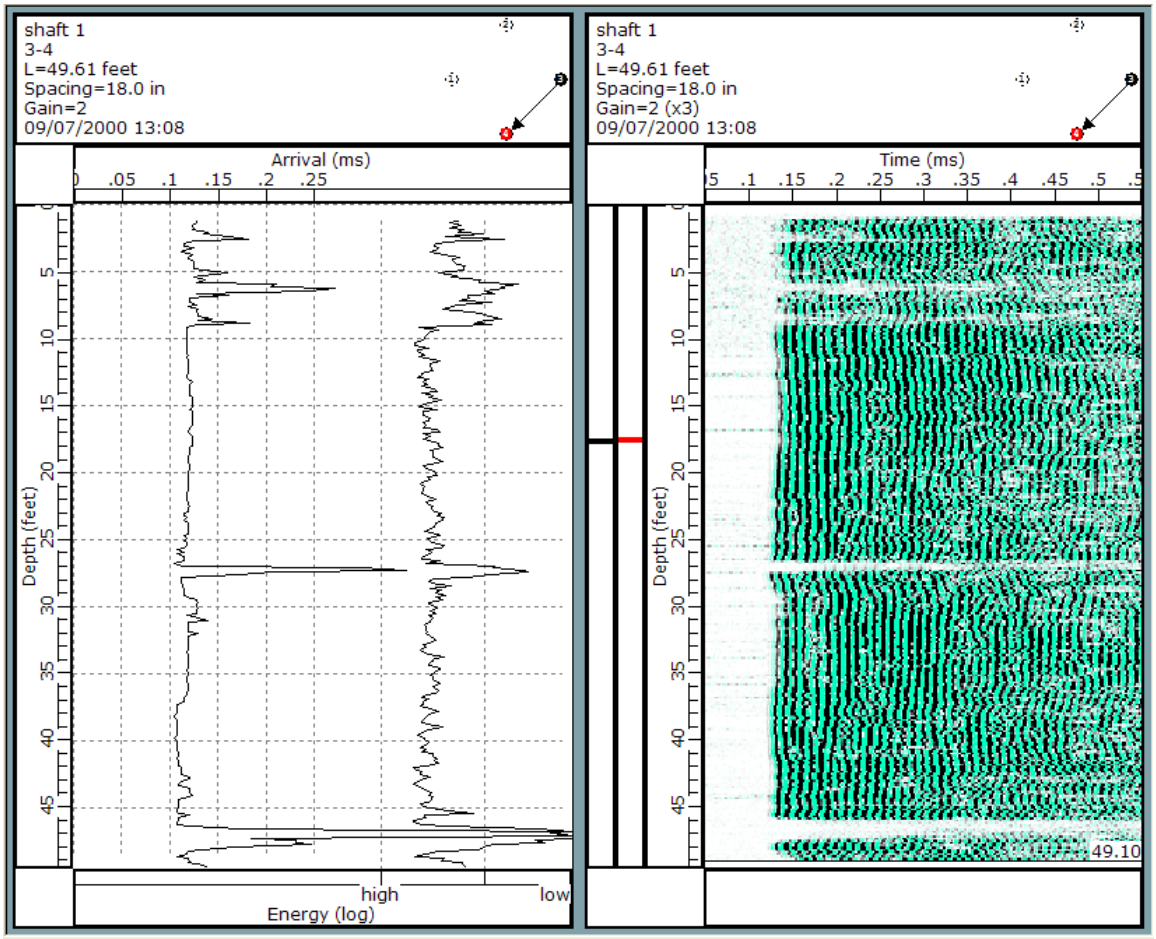
# CSL

## ANALYSIS

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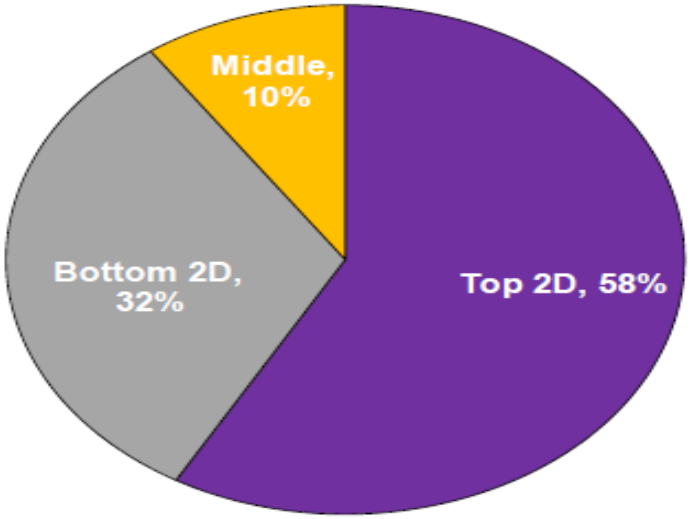
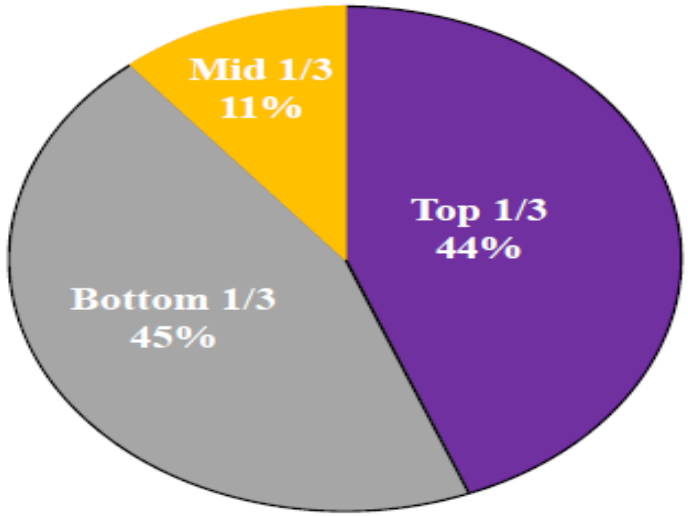
# CSL

## ANOMALIES

37%




Bill Camp, S&ME Inc
"CSL of SC Drilled Shafts: A Ten Year Summary"
ADSC Expo 2012,
San Antonio, March 2012




38%

Jones & Wu, Geotechnology, Inc
"Experiences with CSL and Concrete Coring for Verification of Drilled Shaft Integrity"
ADSC GEO3
Construction QA/QC Technical Conference,
Dallas November 2005

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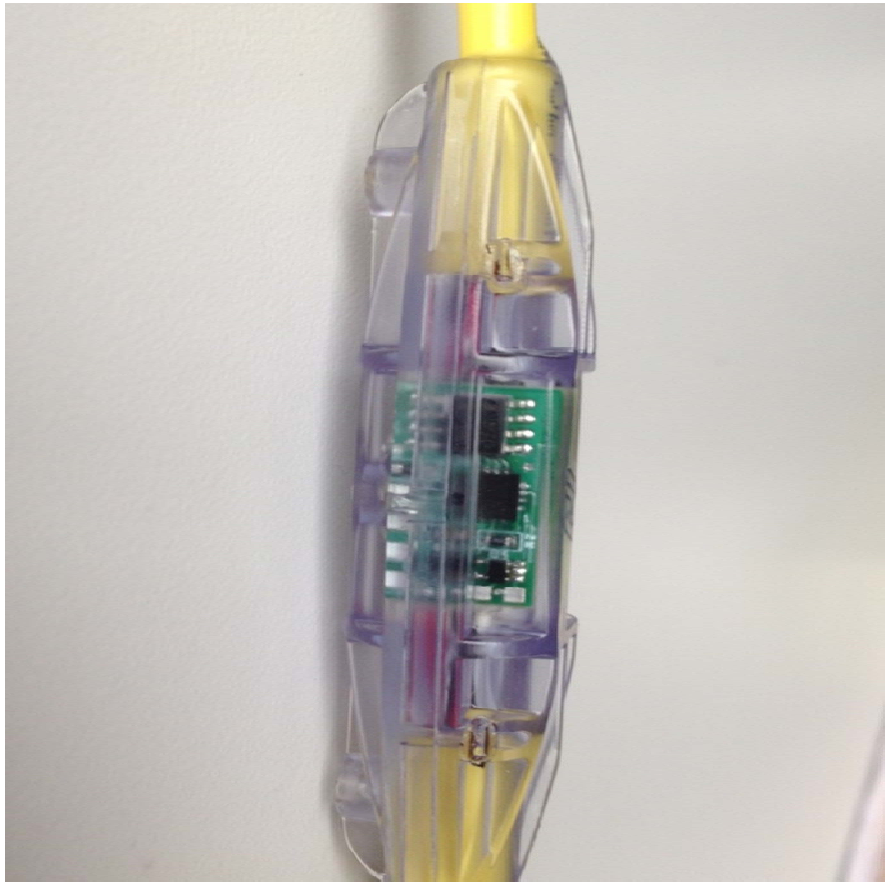
# THERMAL INTEGRITY PROFILING



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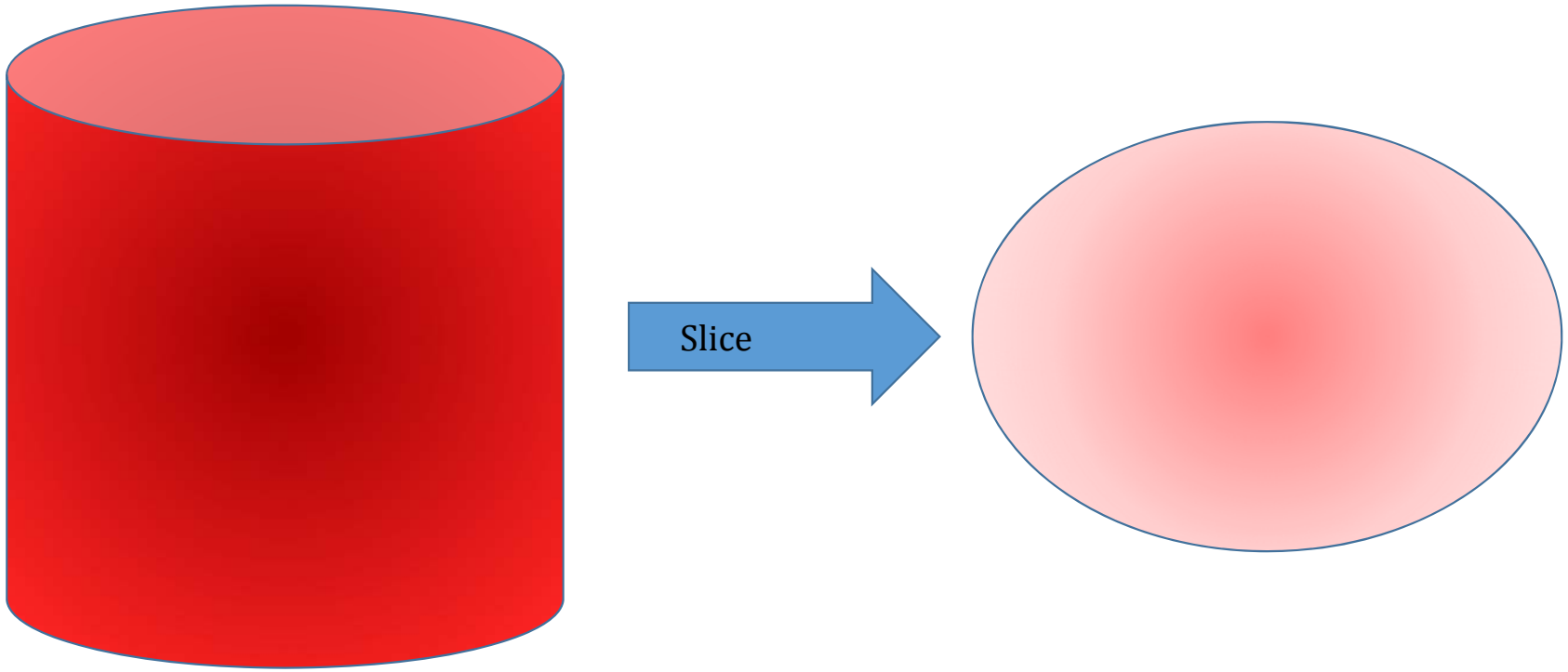
# THERMAL INTEGRITY PROFILING

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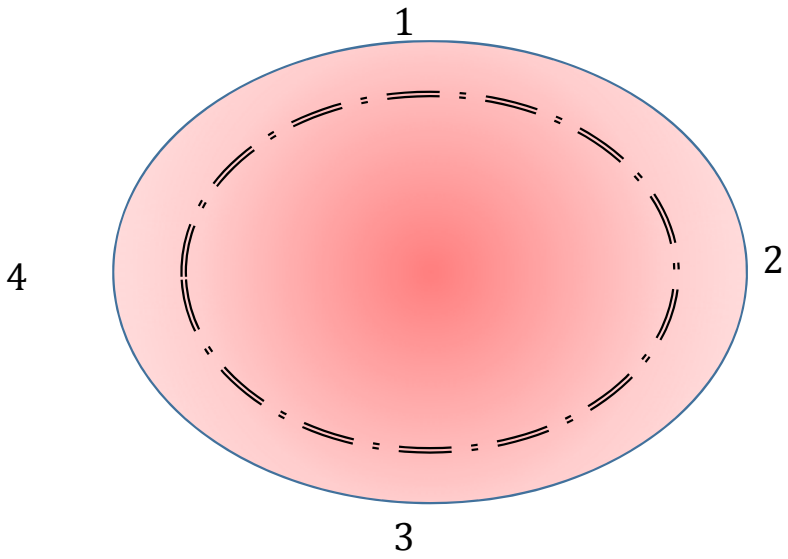
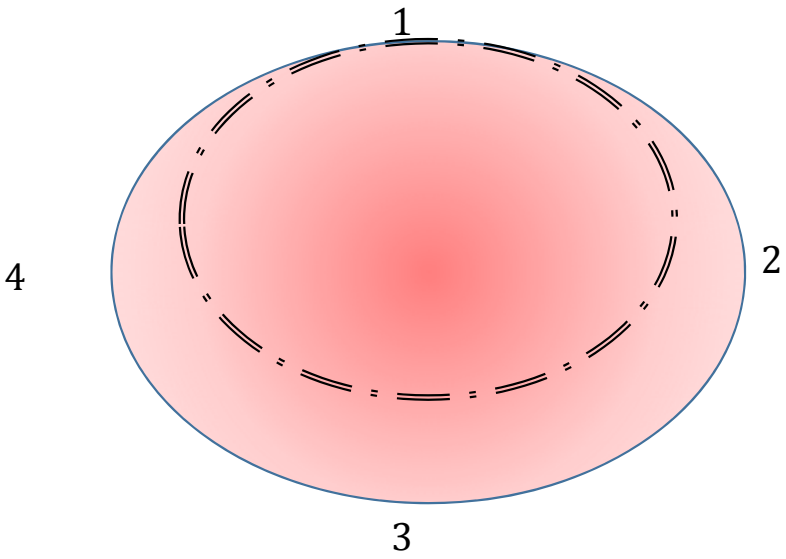
# Thermal Integrity Profiling

## Cage Shift

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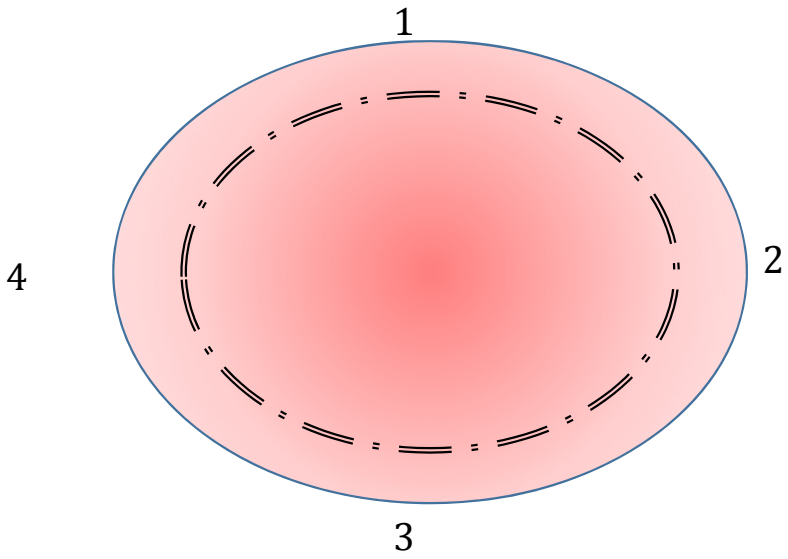
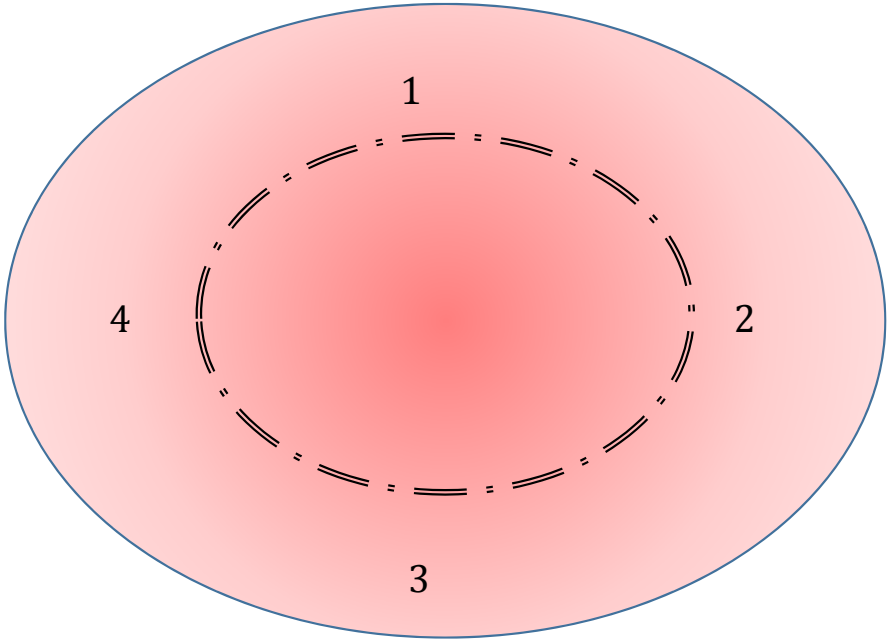
# Thermal Integrity Profiling

## Anomaly

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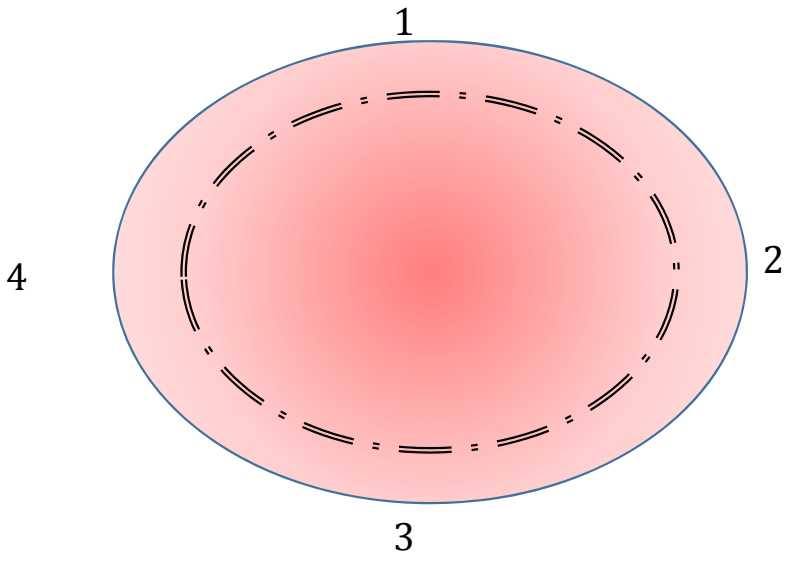
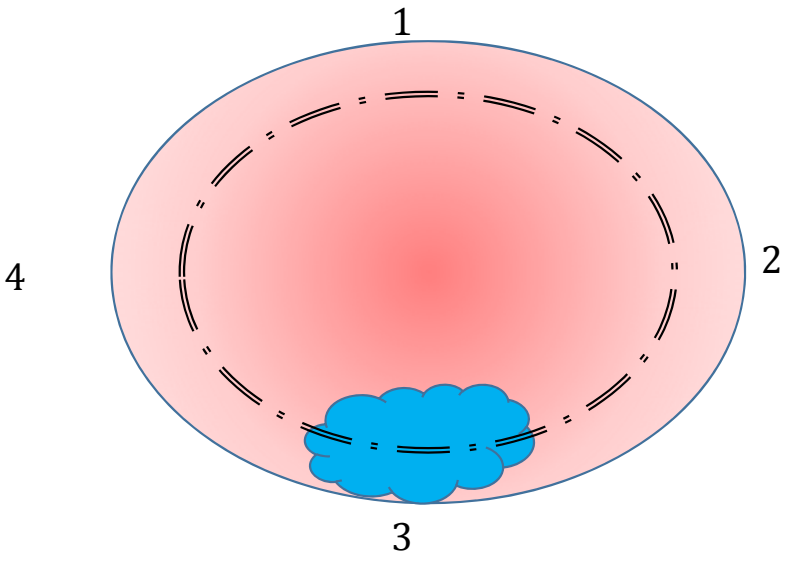
# Thermal Integrity Profiling

## Anomaly

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# Thermal Wire

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# Thermal Wire

I-35E Dallas Texas

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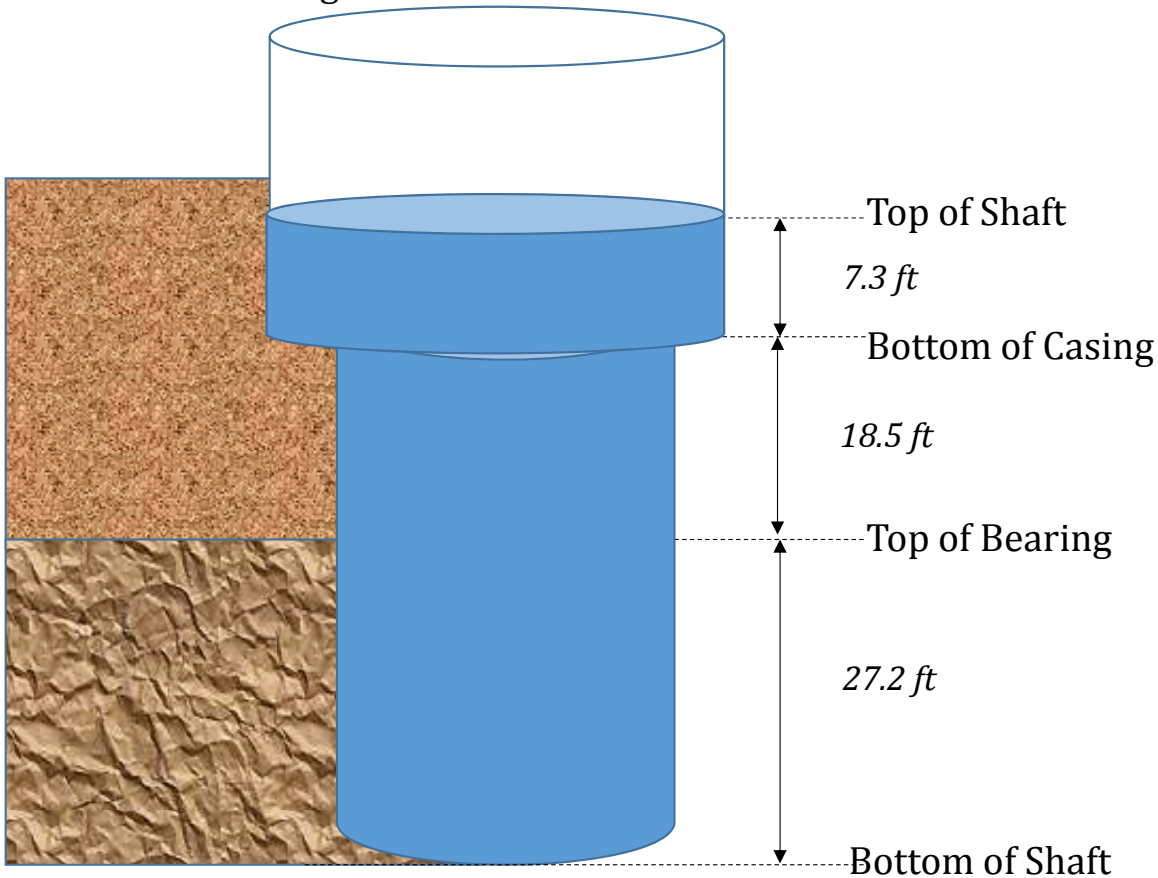
# SHAFT DETAILS

Casing outer diameter 79”




**Sands & Clays**

**Shale**

Shaft diameter 76”

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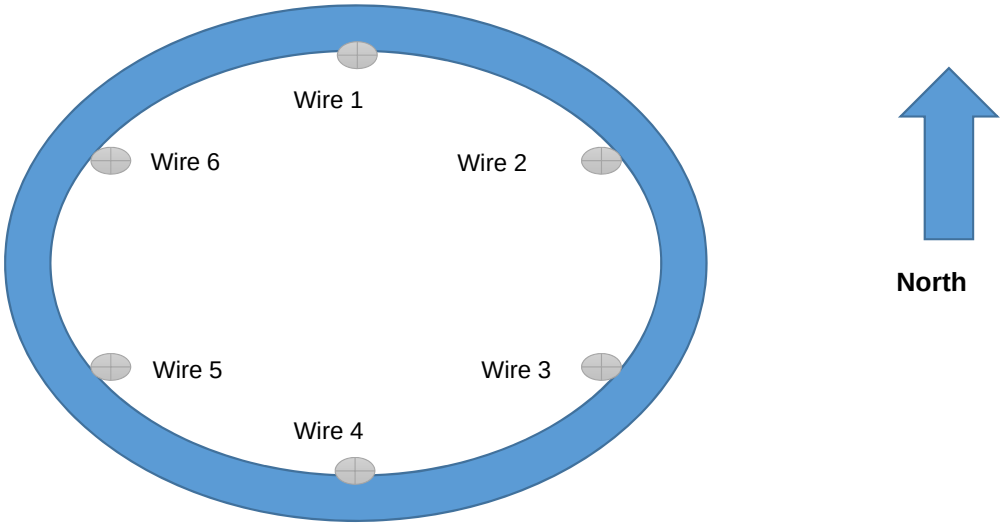
# Thermal Wire Setup

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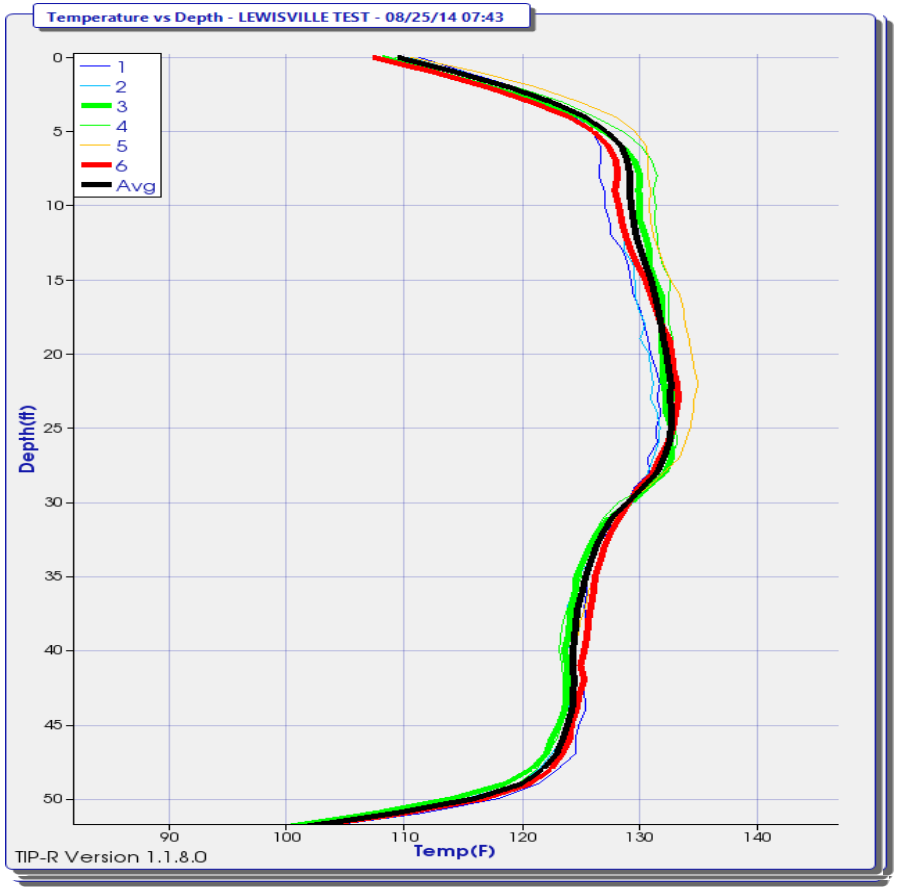
# TEMPERATURE VS TIME




30 min
1 hr
2½ hrs
5 hrs
9 hrs
12 hrs
1 day
1 day 15 hrs
2 days
2 days 12 hrs

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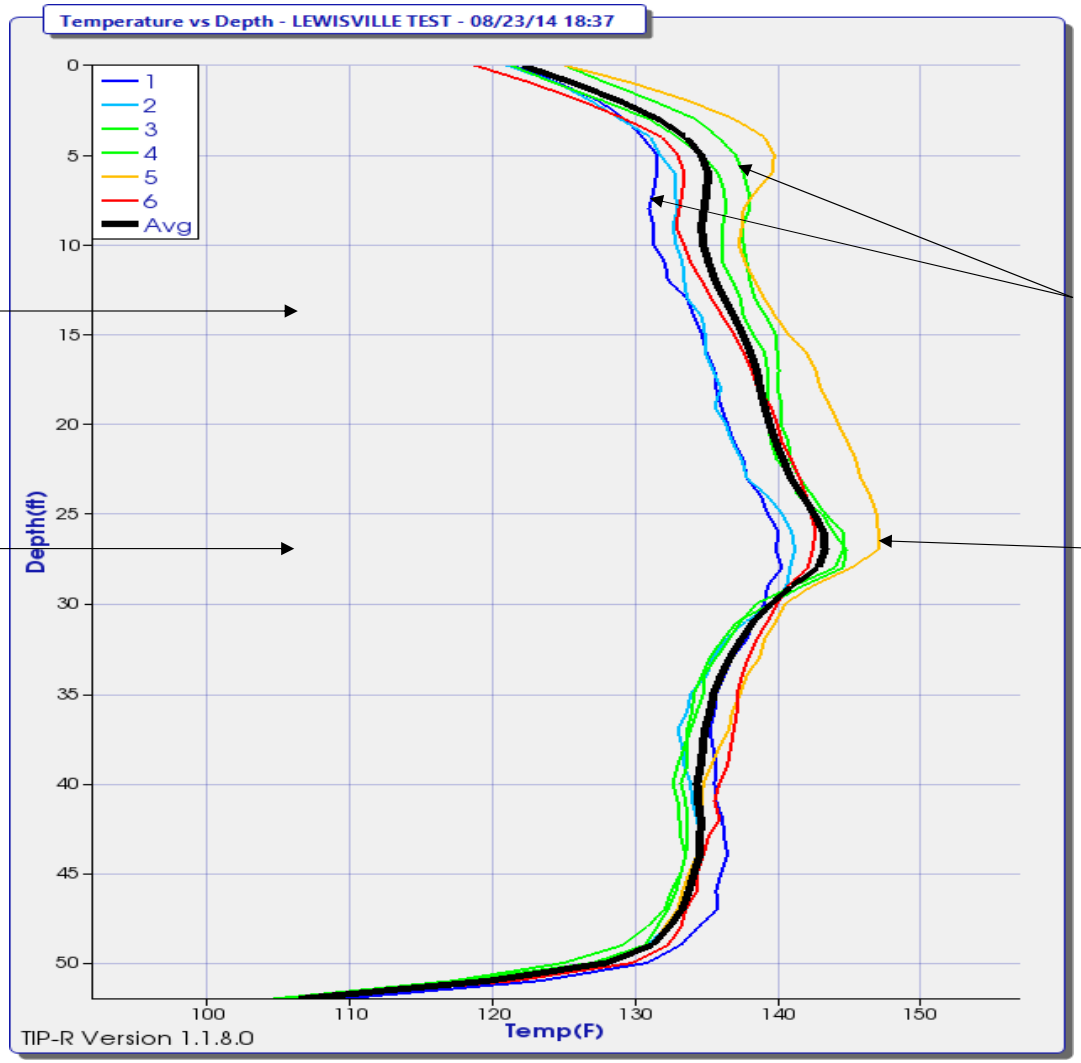
# THERMAL ANALYSIS




23hrs 20 min

Top of water

Rock socket

**Cage Shift**

**Bulge**

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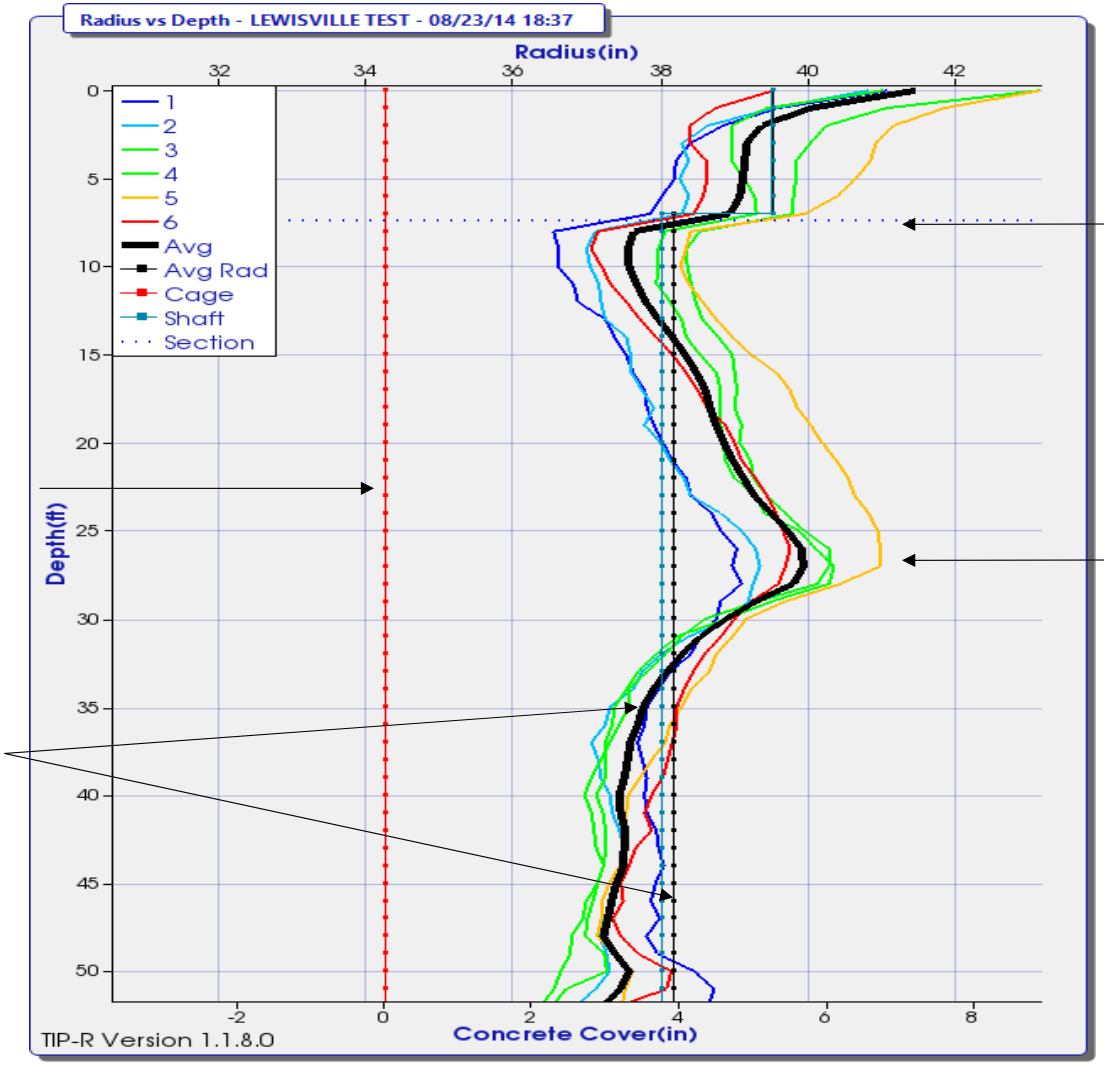
# THERMAL ANALYSIS

**Radius vs Depth**




*Rebar cage*

*Avg radius*

Bottom of casing

Top of bearing

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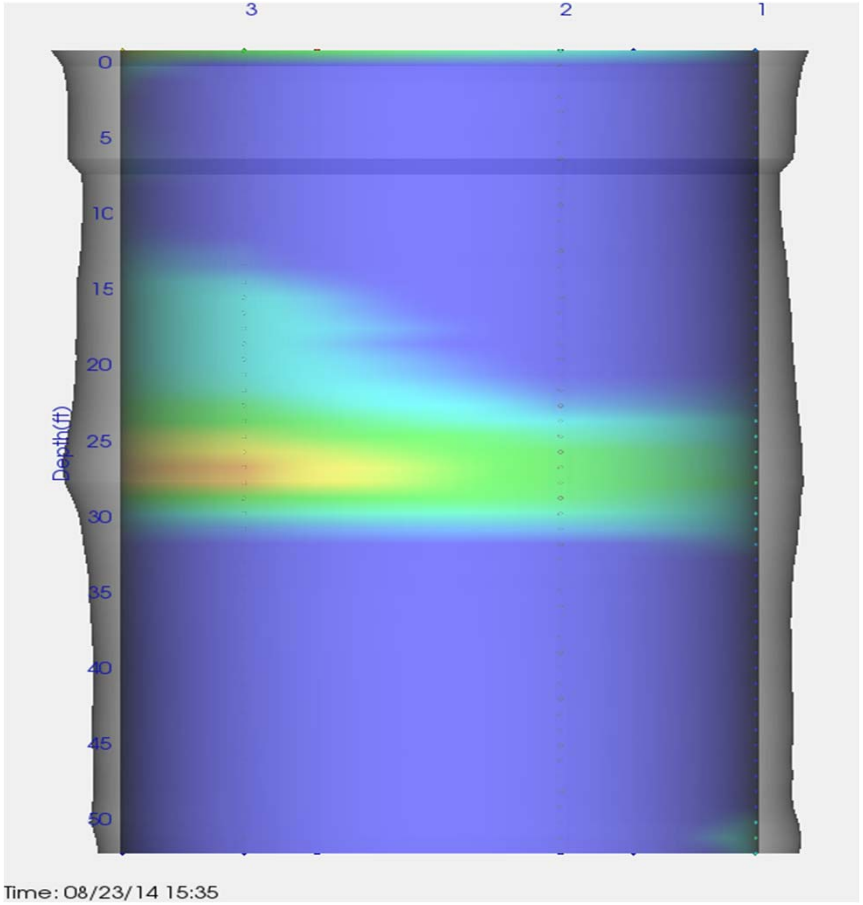
# THERMAL IMAGING




Temp casing

Top of bearing

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# EXAMPLE

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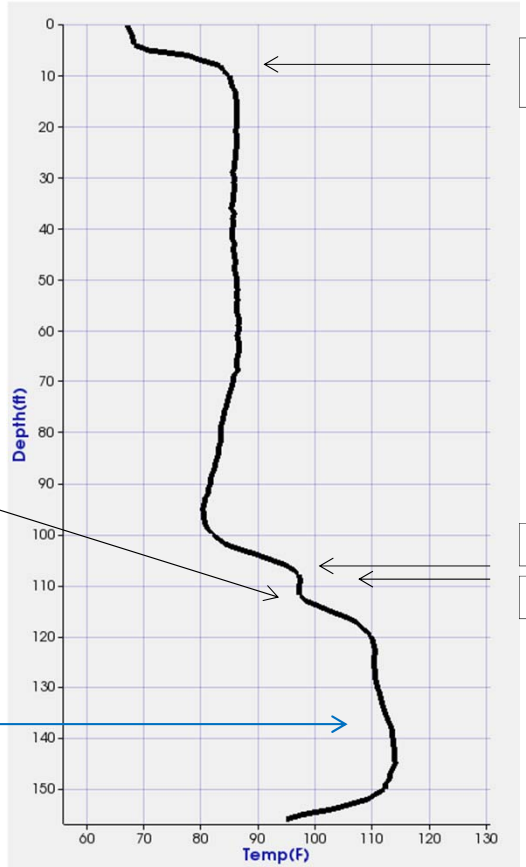
# Temperature vs Depth

Tube 1




Top of river &
Top of shaft

Bottom of casing

Bottom of river

Shaley Limestone

132 cy
theoretical

Bulge

198 cy actual

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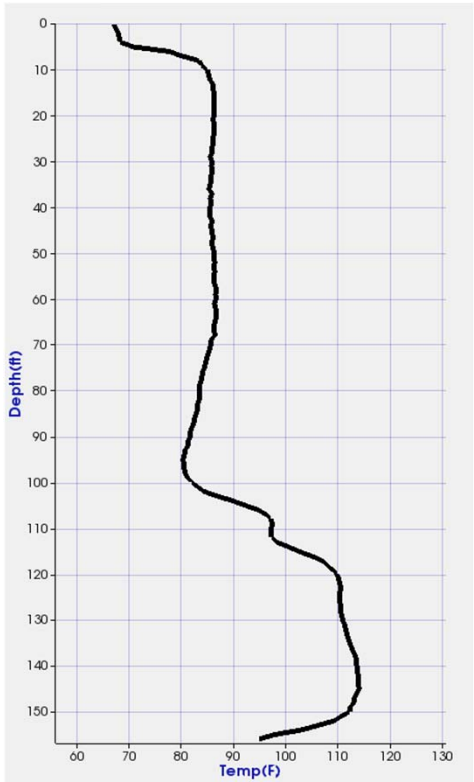
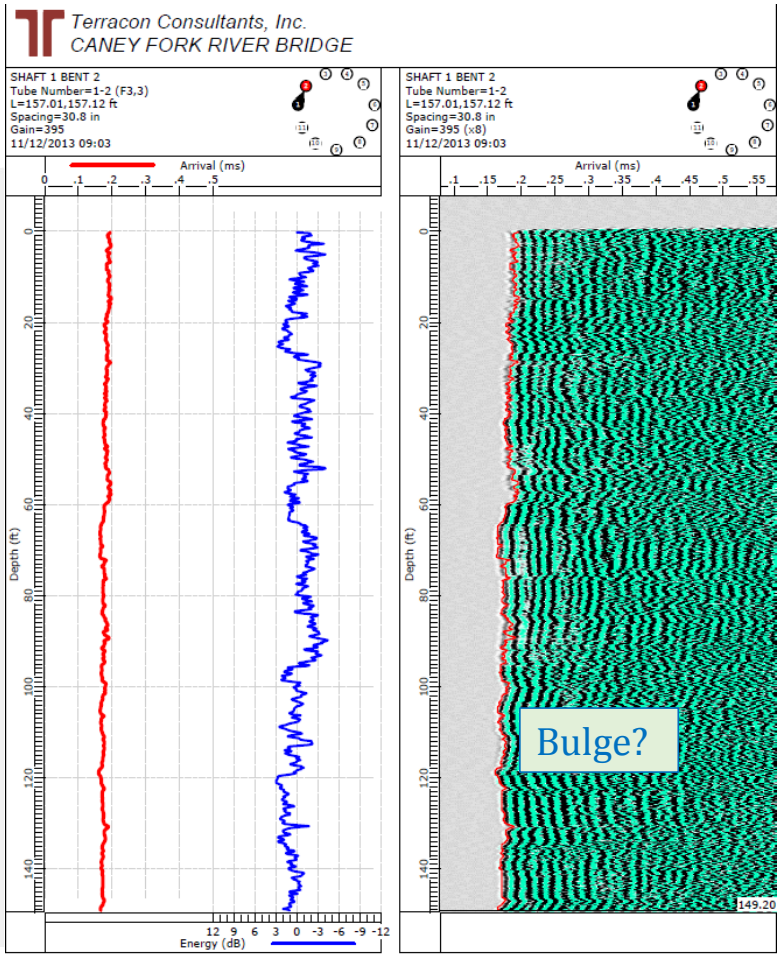
# CSL Vs Thermal

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# EXAMPLE

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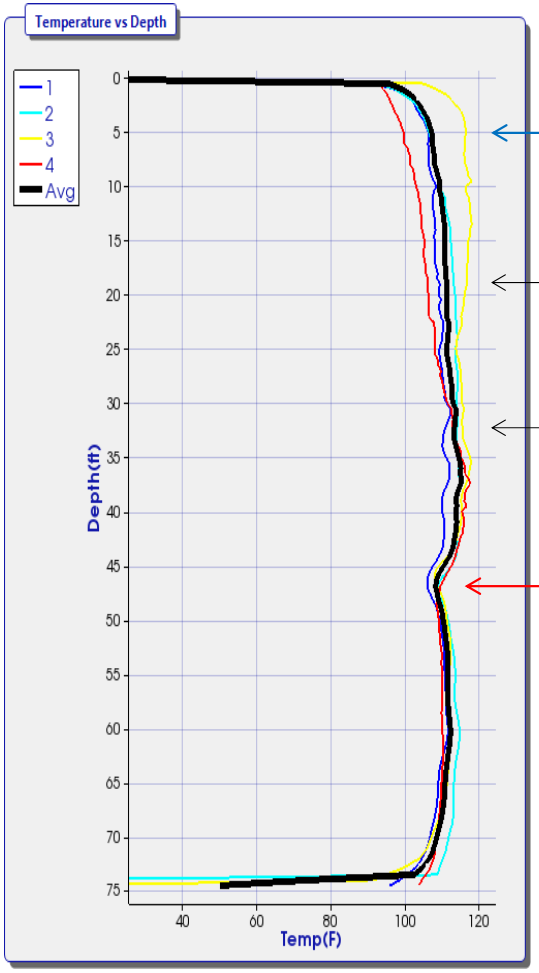
# THERMAL RESULTS




**Cage Shift**

Bottom of Casing

Weathered Limestone

**Anomaly**

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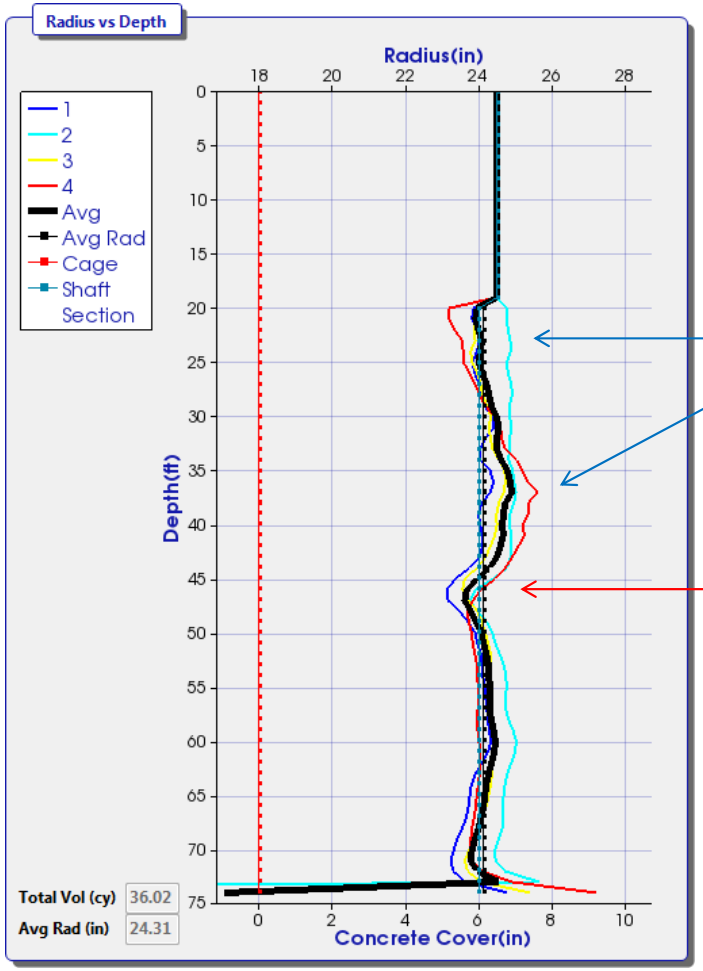
# THERMAL RESULTS




**Cage Shift tubes 2&4**

**Anomaly**

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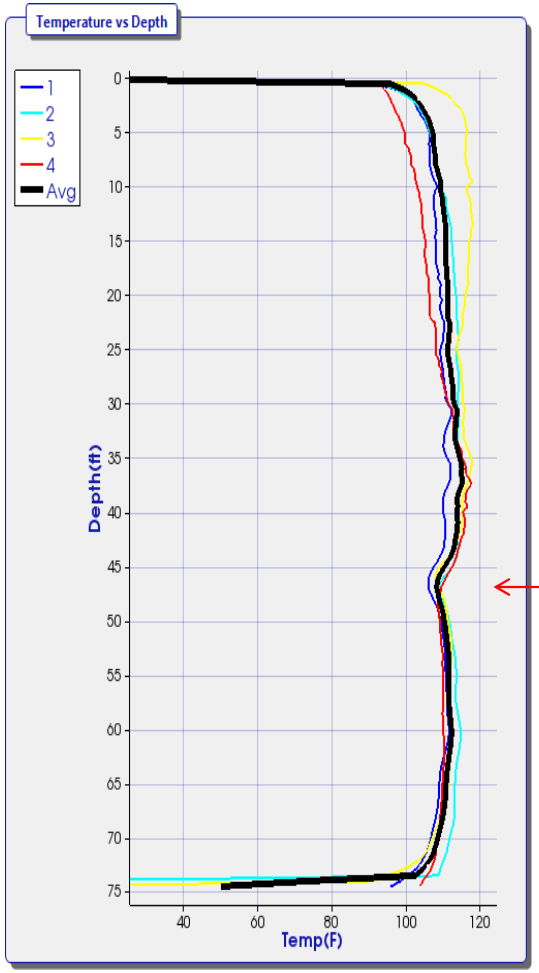
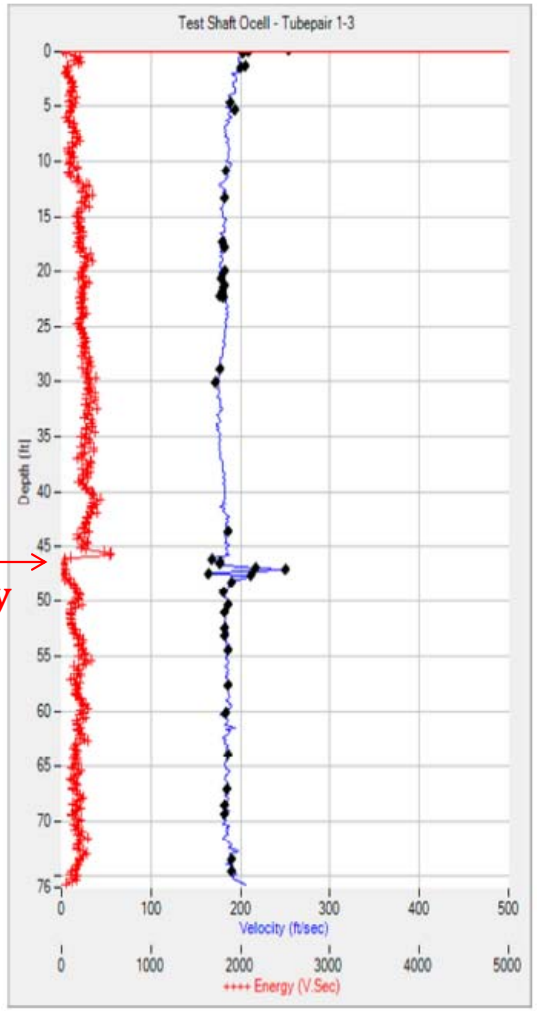
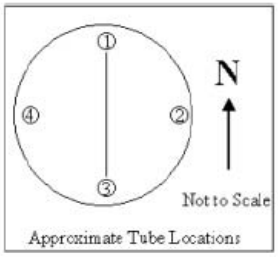
# CSL vs Thermal




Anomaly




Shaft Name - Test Shaft Ocell
Test Date - 1/13/2013
Tube Spacing - 30
Tubepair Depth - 75.71 ft
Gain - 500

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# THERMAL RESULTS

← Anomaly

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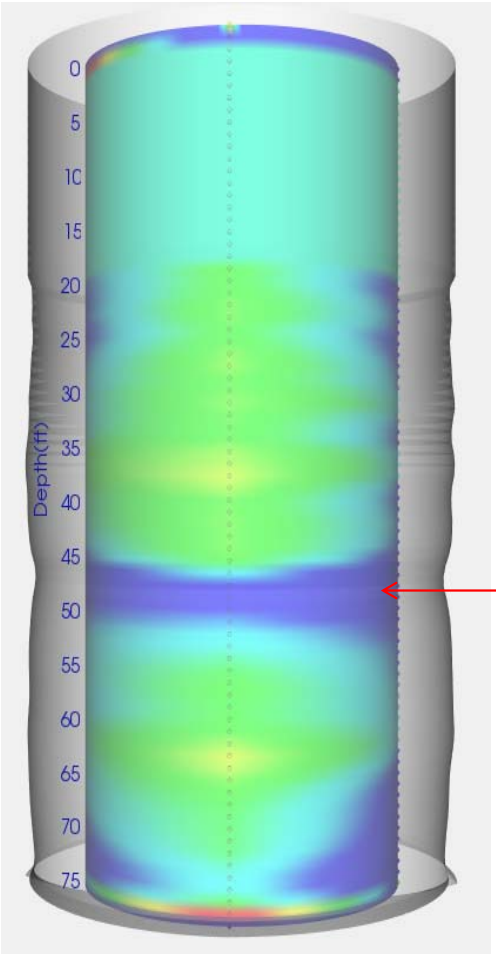
# THERMAL MODEL OF SHAFT




Osterberg Cell

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# THERMAL WIRE

NY/NJ area

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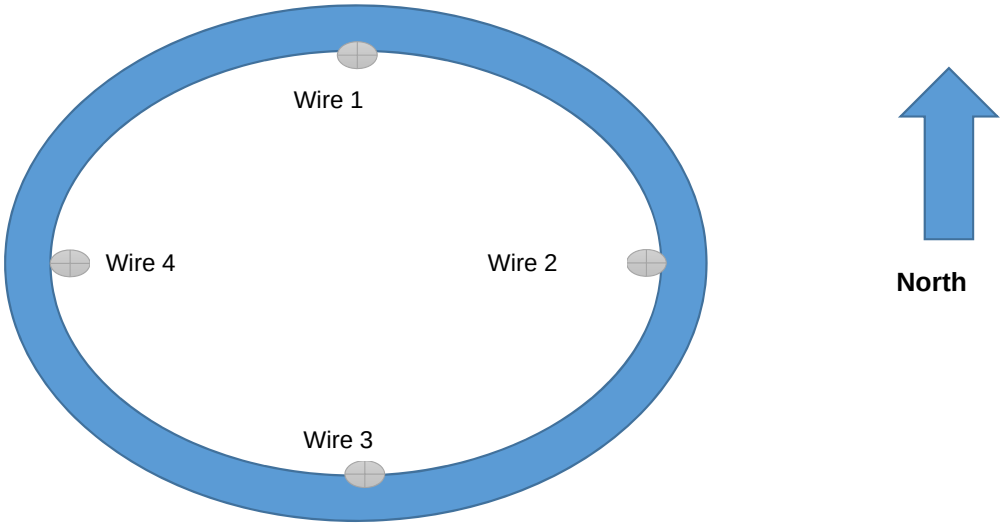
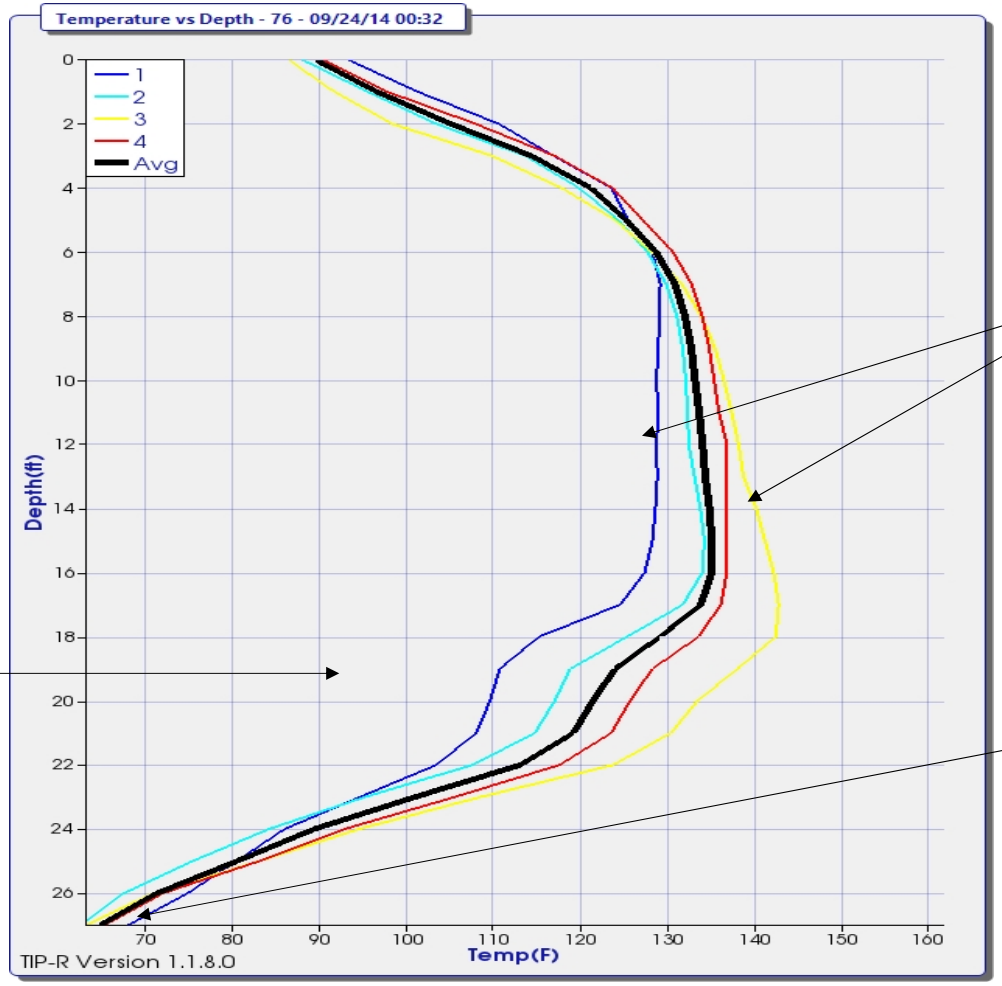
# Thermal Wire Setup



# THERMAL ANALYSIS




Cage Shift

Rock socket

Soft Bottom

NY/NJ Pier 76

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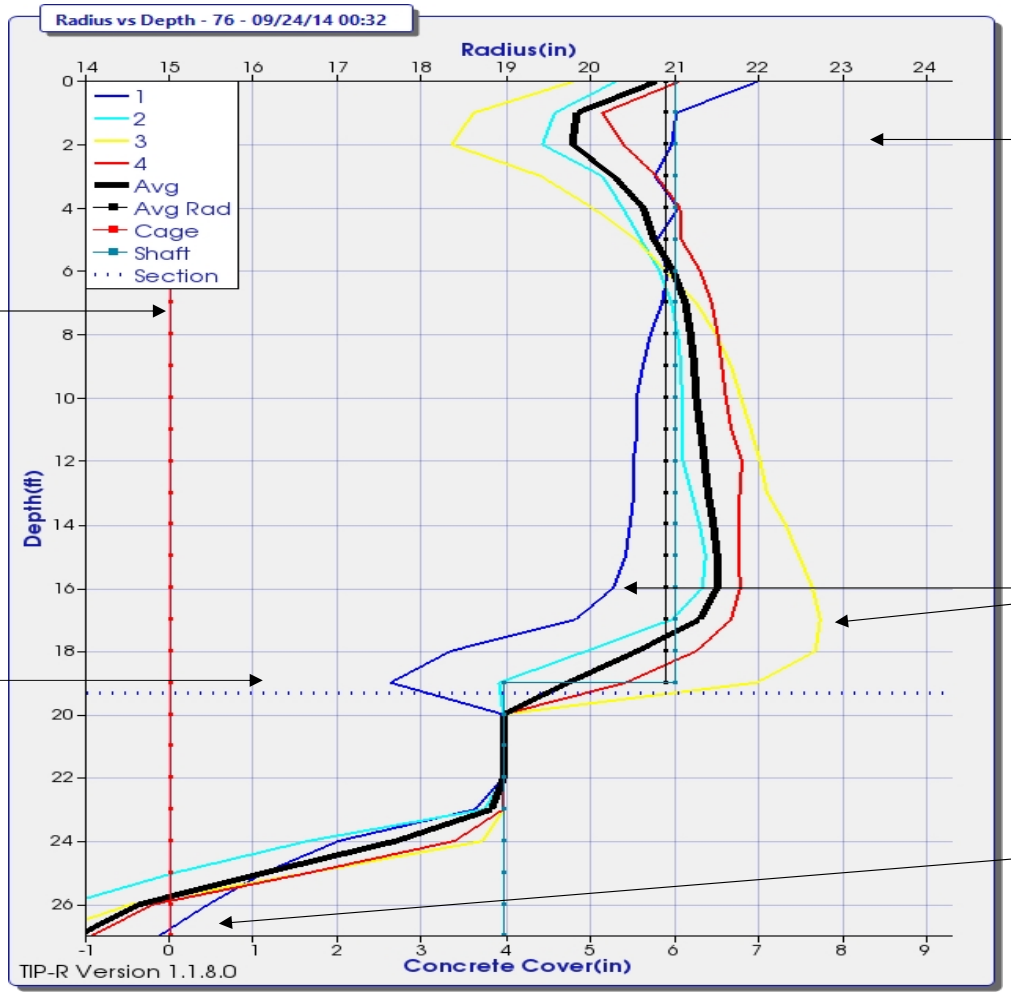
# THERMAL ANALYSIS




Neck

Cage

Cage Shift

Rock socket

Soft Bottom

NY/NJ Pier 76

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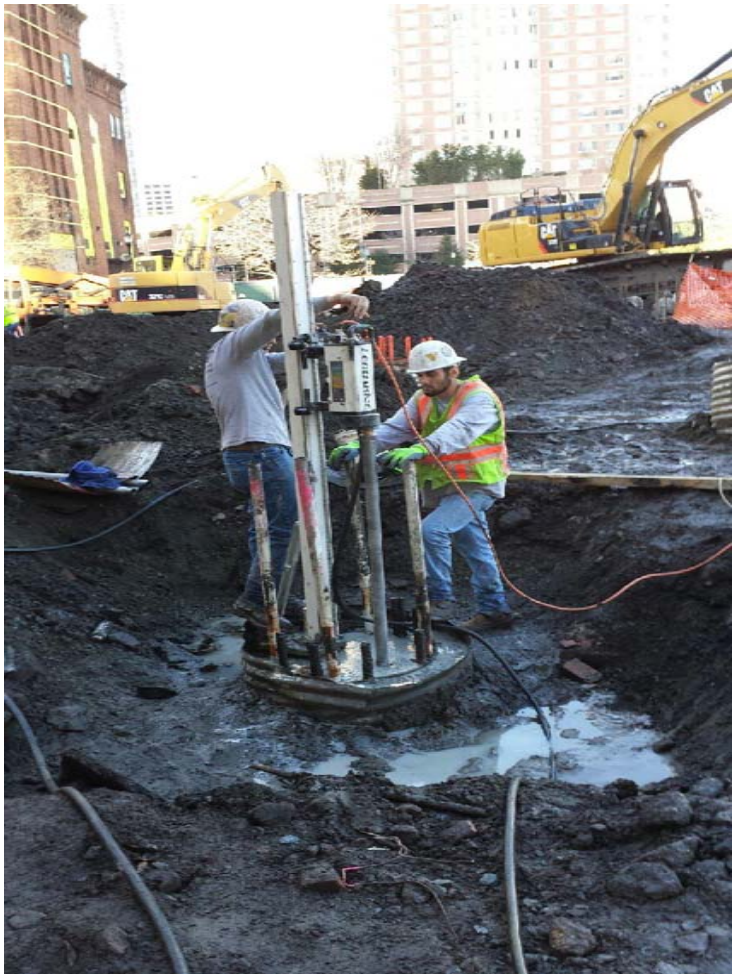
# THERMAL ANALYSIS



NY/NJ Pier 76

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# THERMAL ANALYSIS

NY/NJ Pier 76

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# THERMAL ANALYSIS

96 inch diameter
43 ft long
48º ambient soil temperature

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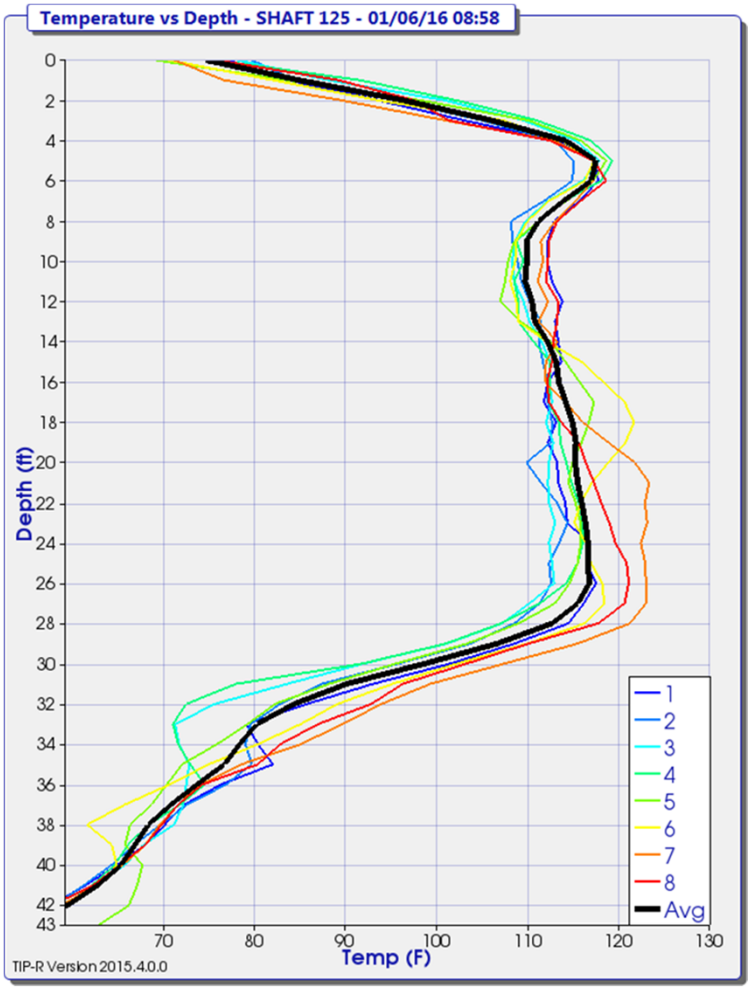
# THERMAL ANALYSIS

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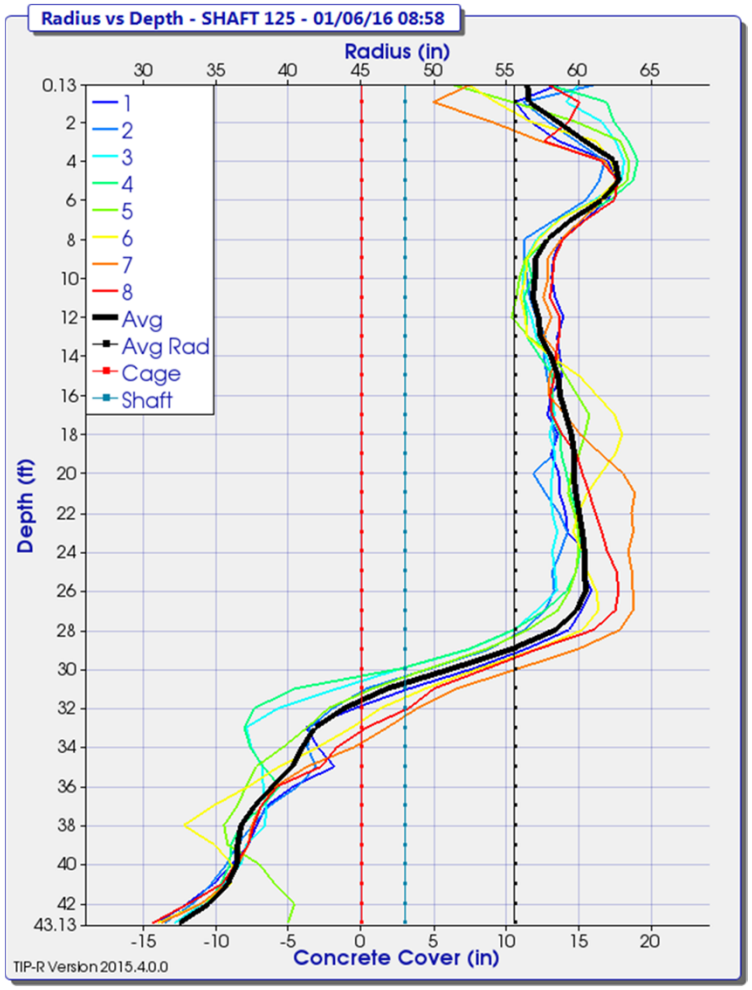
# THERMAL ANALYSIS

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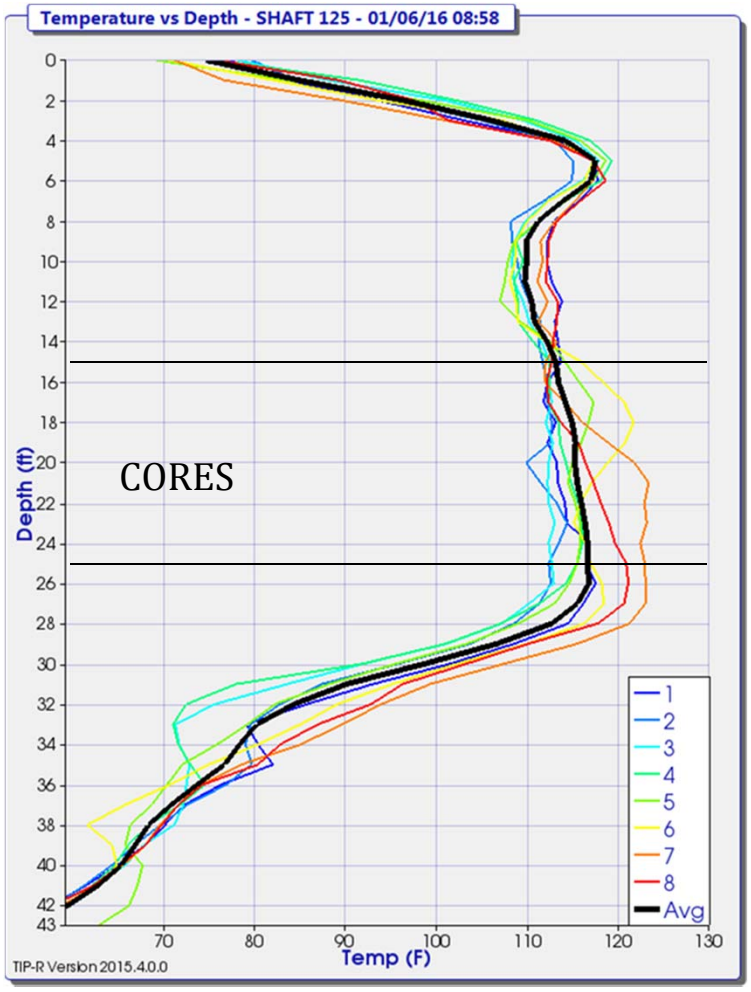
# THERMAL ANALYSIS


Structure 125 – Southwest Core. Concrete cores from 15 to 25 feet.

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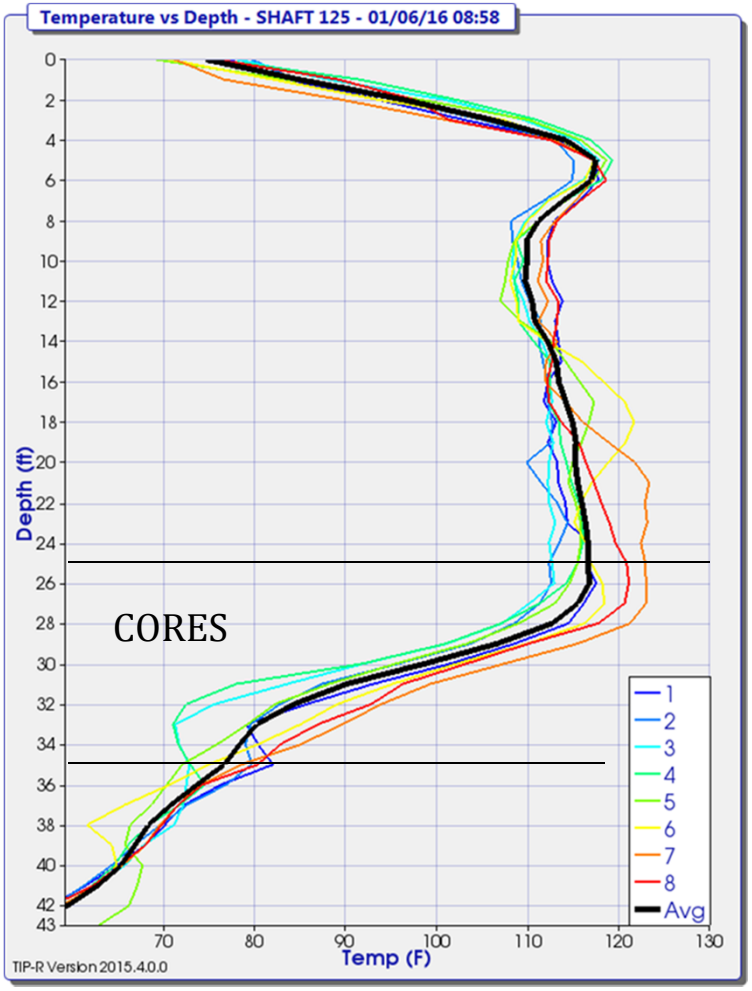
# THERMAL ANALYSIS


Structure 125 – Southwest Core. Concrete cores from 25 to 35 feet.

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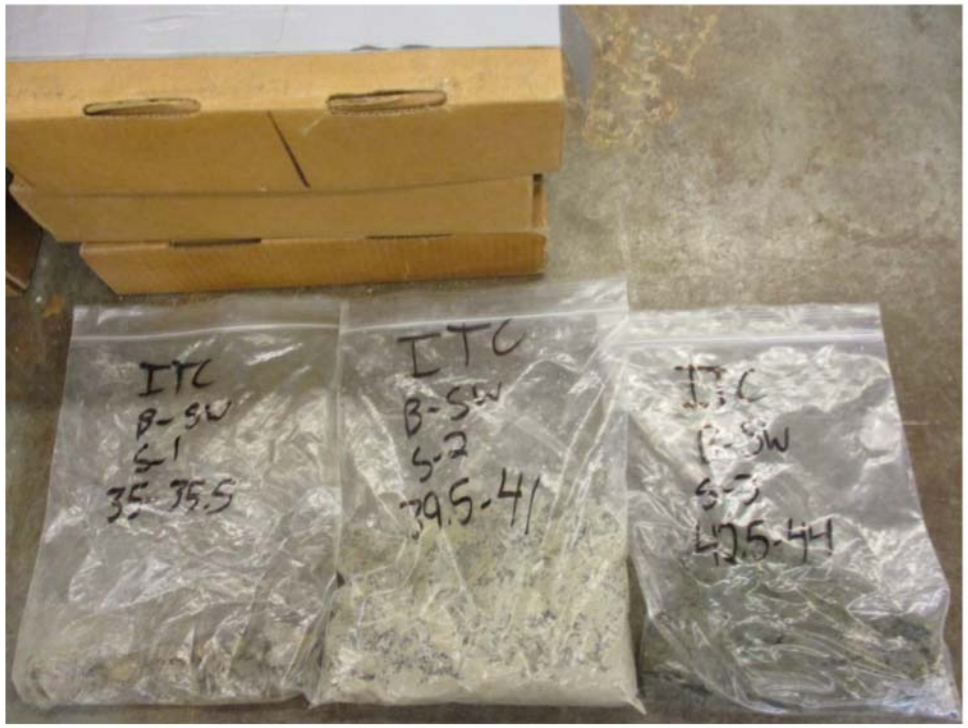
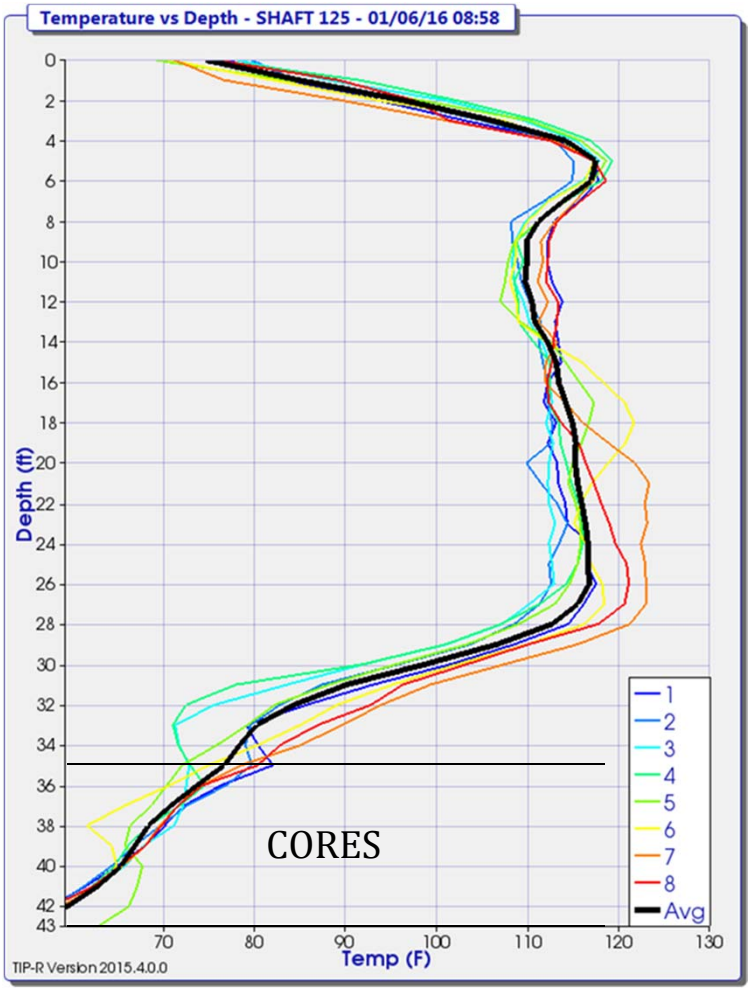
# THERMAL ANALYSIS




Structure 125 – Southwest Core. Concrete cores from 35 to 44 feet.

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# SUMMARY

Diagnostic Tool for

- Integrity
- Anomalies
- Cage Alignment
- Concrete Cover

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# BENEFITS

- No False Anomalies from Tube de-bonding
- Speed
- Correct Construction Techniques
- Easy Coring if Necessary
- Evaluate Additional Capacity

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# Questions

# AUGER CAST PILE

16 in diameter ACIP piles

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# AUGER CAST PILE

## AUGER CAST PILE OBSERVATION REPORT

Terracon
2201 Rowland Ave.
Savannah, GA 31404
912-629-4000

**Report Number:** ES131134.0207
**Service Date:** 03/27/14
**Report Date:** 03/31/14
**Task:**

**Client**
Omega Construction Inc.
Attn: Kevin Hennings
P.O. Box 250
Pilot Mountain, NC 27041

**Project**
Caesarstone
Caesarstone
Richmond Hill, GA

**Project Number:** ES131134

| Pile Number | 324 | 321 | 320 | 317 | 316 | 313 | 312 | 309 | 308 | 305 | 251 | 370 | 248 | 245 | 244 | 304 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start Auger Time | 8:16 | 8:30 | 8:48 | 9:10 | 9:24 | 9:48 | 10:48 | 11:03 | 11:23 | 11:40 | 12:1[illegible] | 12:35 | 12:55 | 13:14 | 13:36 | 13:55 |
| Complete Auger Time | 8:21 | 8:35 | 8:56 | 9:13 | 9:29 | 9:56 | 10:53 | 11:09 | 11:30 | 11:47 | 12:23 | 12:41 | 13:07 | 13:19 | 13:44 | 14:05 |
| Start Grout Time | 8:21 | 8:35 | 8:56 | 9:13 | 9:29 | 9:56 | 10:53 | 11:09 | 11:30 | 11:47 | 12:23 | 12:41 | 13:07 | 13:19 | 13:44 | 14:05 |
| Complete Grout Time | 8:25 | 8:42 | 9:01 | 9:19 | 9:35 | 10:00 | 10:58 | 11:15 | 11:35 | 11:52 | 12:28 | 12:43 | 13:10 | 13:22 | 13:50 | 14:07 |
| Compression/Tension | | | | | | | | | | | | | | | | |
| Pile Top Elevation (ft) | | | | | | | | | | | | | | | | |
| Ground Elevation (ft) | | | | | | | | | | | | | | | | |
| Pile Tip Elevation | | | | | | | | | | | | | | | | |
| Pile Length (ft) | 63 | 63 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 68 | 76 | 68 | 68 | 68 | 76 |
| Theor. Pile Vol. (ft³) | 88.0 | 88.0 | 106.1 | 106.1 | 106.1 | 106.1 | 106.1 | 106.1 | 106.1 | 106.1 | 94.9 | 106.1 | 9[illegible] | | | |
| Reinforcing Steel | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Steel Cage | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Total Grout Volume | 120.1 | 120.1 | 142.7 | 140.9 | 139.2 | 140.1 | 140.9 | 140.1 | 140.1 | 140.1 | 138.3 | 139.2 | 1[illegible] | | | |
| Effect to Adjacent Piles | | | | | | | | | | | | | | | | |
| Total Strokes | 138 | 138 | 164 | 162 | 160 | 161 | 162 | 161 | 161 | 161 | 159 | 160 | 148 | 149 | 149 | 162 |
| Overall Grout Factor | 1.36 | 1.36 | 1.34 | 1.33 | 1.31 | 1.32 | 1.33 | 1.32 | 1.32 | 1.32 | 1.46 | 1.31 | 1.36 | 1.37 | 1.37 | 1.33 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Concrete Truck # | | 7109 | | | | | | | | | | | | | | |
| Ticket # | | 9455 | | | | | | | | | | | | | | |
| Batch Time | | 7:30 | | | | | | | | | | | | | | |
| Cubes Molded | | 1set | | | | | | | | | | | | | | |

| Pile Length (ft) | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Theoretic Vol | 83.8 | 85.2 | 86.6 | 88.0 | 89.4 | 90.8 | 92.2 | 93.5 | 94.9 | 96.3 | 97.7 | 99.1 | 100.5 | 101.9 | 103.3 | 104.7 |
| Min. Number of Strokes* | 126 | 128 | 130 | 132 | 134 | 136 | 138 | 140 | 142 | 144 | 147 | 149 | 151 | 153 | 155 | 157 |

*For 16" diameter piles with pump factor of 0.87 ft³/stroke (1.396 ft³/ft)

Pump Factor 0.87
Min. Grout Factor 1.3
Auger Diameter (in) 16

Comments:

**Services:**
**Terracon Rep:** Anderson, Michael
**Reported To:** Omega and Berkel
**Contractor:** Berkel

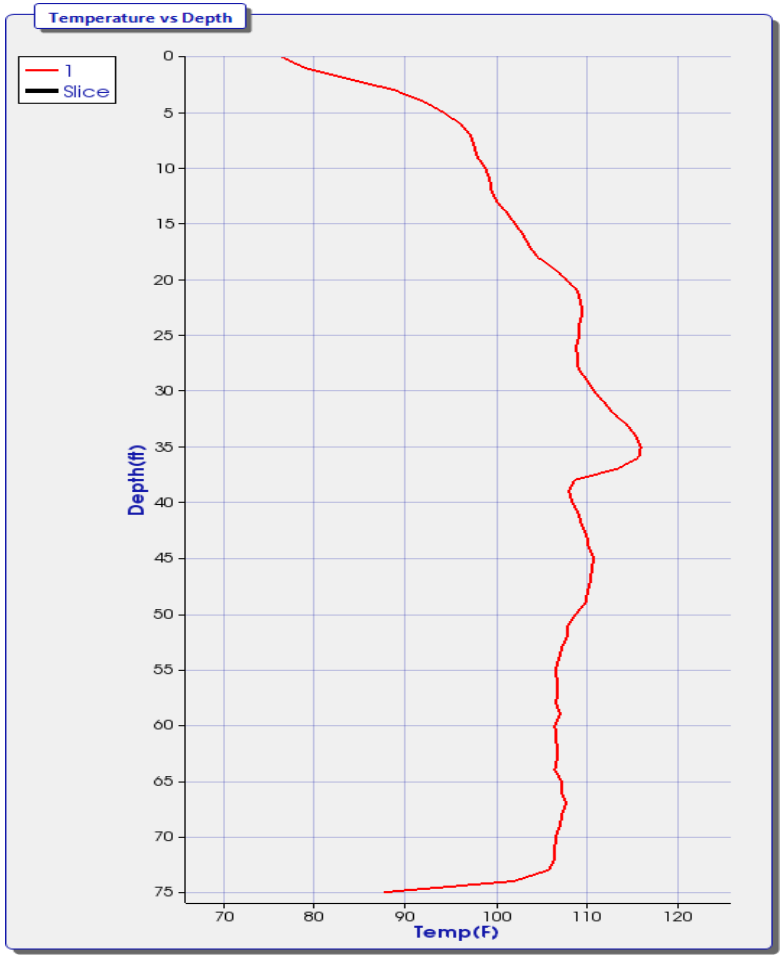
**Report Distribution**
(1) Omega Construction Inc., Kevin Hennings
(1) Berkel & Co Contractors Inc, William Cochran
(1) City of Richmond Hill, Randy Dykes, CFM
(1) Omega Construction Inc., Kirk Matthews
(1) Berkel & Co Contractors Inc, Treagon Messer
(1) City of Richmond Hill, Kim Cobb
(1) Omega Construction Inc., Guy McMillian
(1) Omega Construction Inc., Mac McMillian

**Reviewed By:** Mark Knussmann
Senior Project Manager



106.1 ft$^3$ Theoretical
139.2 ft$^3$ Actual

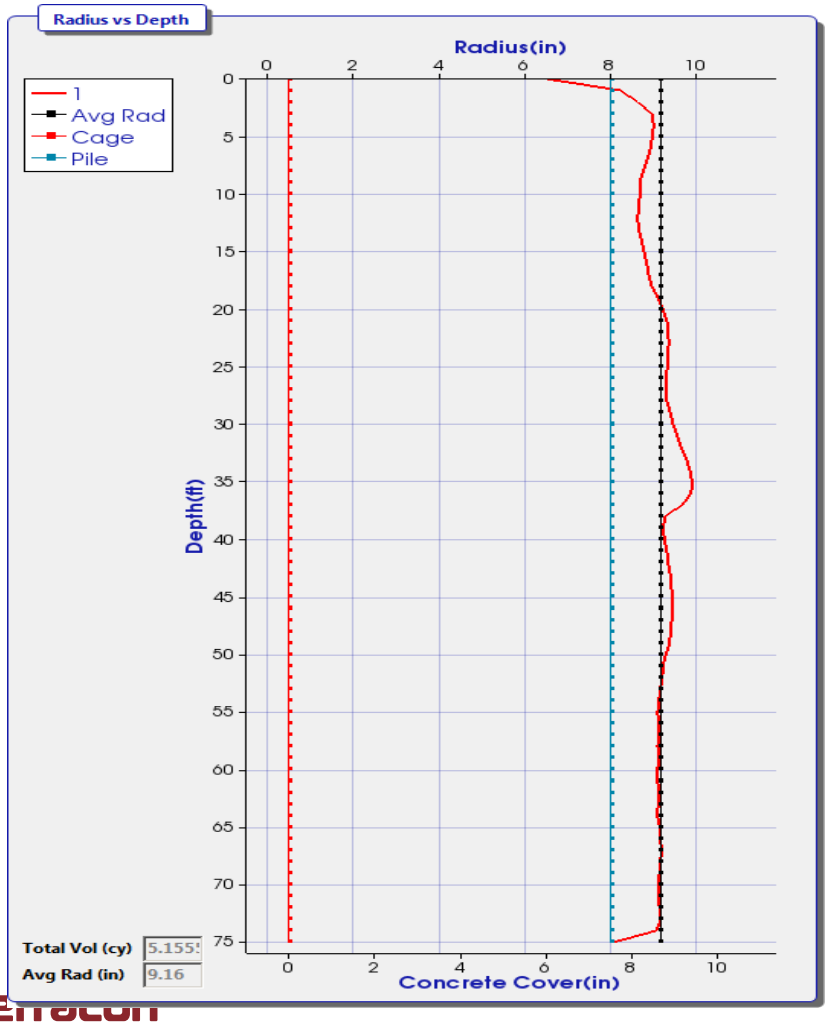
# AUGER CAST PILE




Temperature profile after 12 hours

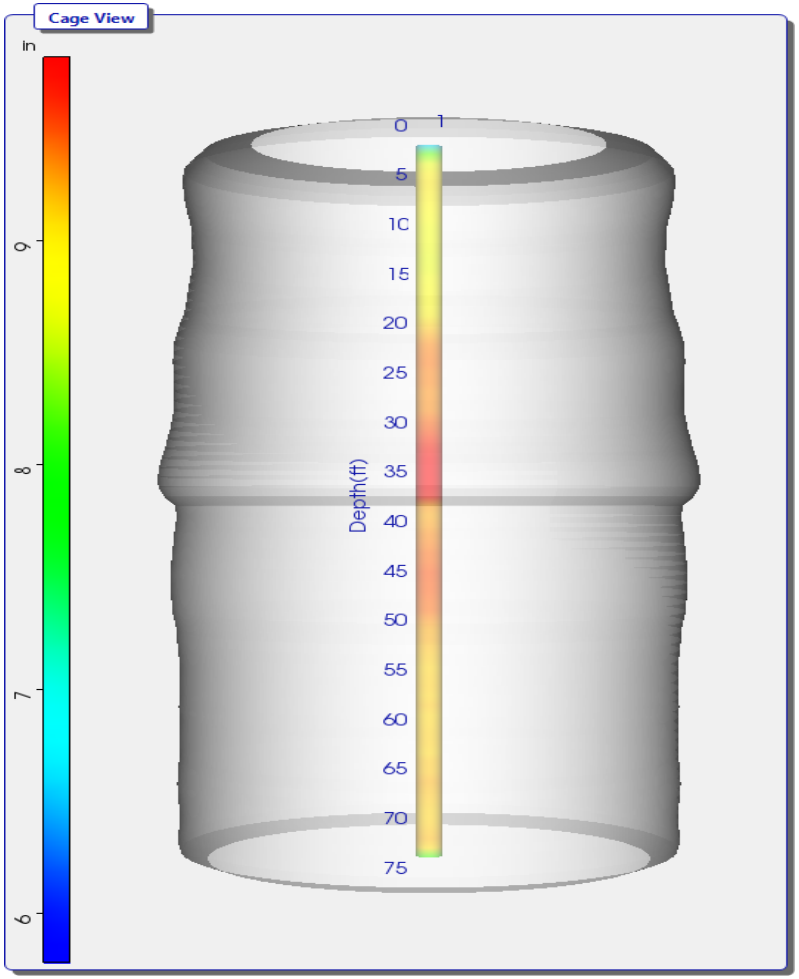
Terracon

# AUGER CAST PILE




16 in diameter ACIP piles
#10 bar with centralizing spacers

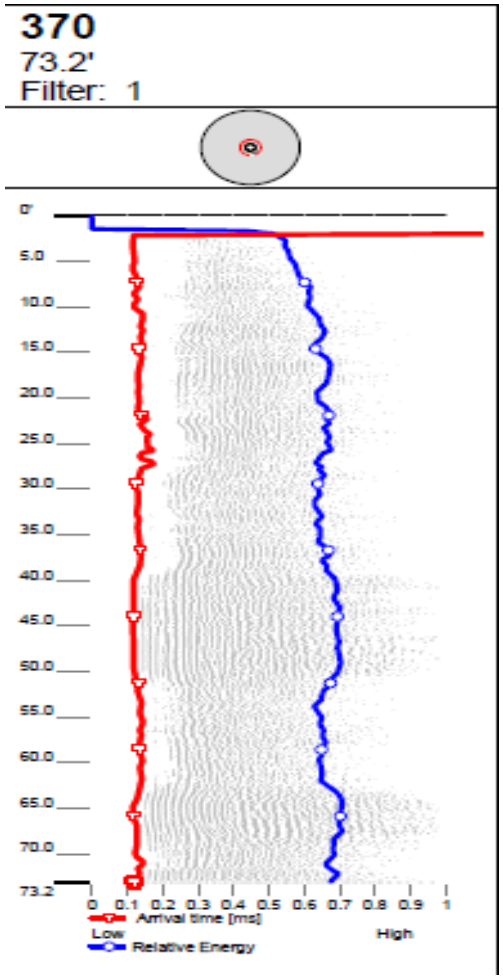
# AUGER CAST PILE



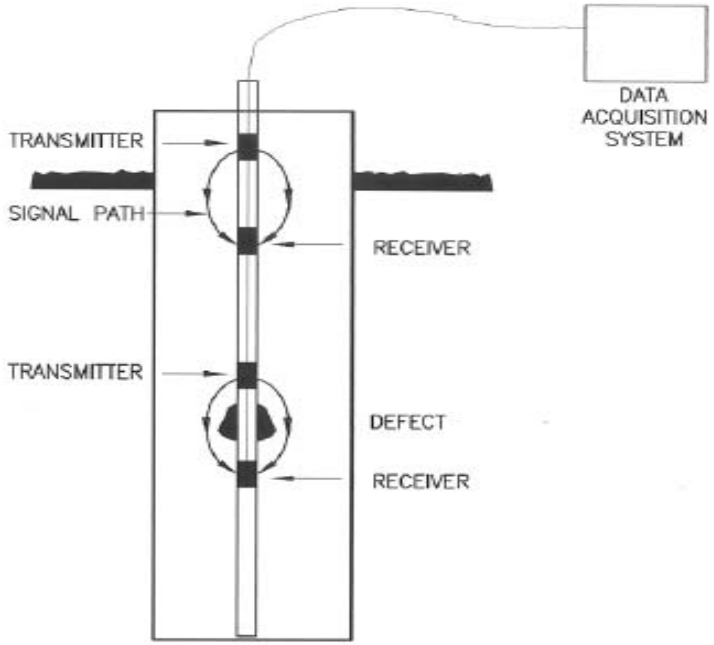

3D rendering with colors corresponding to radius

Terracon

# AUGER CAST PILE




No anomalies detected with SSL test

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