U.S. Department of Transportation
Federal Highway Administration

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Value of Instrumentation Systems and Real-Time Monitoring: An Owner's Perspective

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FHWA NATIONAL GEOTECHNICAL PROGRAM

www.fhwa.dot.gov/engineering/geotech

Why Geotechnical Instrumentation?

Provide warning of impending failure

Evaluate/verify critical design assumptions

Protection of adjacent structures

Control construction operations

Provide data for remediation solutions

Document geotechnical feature performance

Advance state of knowledge

Why Automated Real-Time Monitoring?

Immediate notification of potential issues and problems

Cost effective for remote or difficult to access locations

Allows for increased reading frequency

No overhead for labor to read and reduce data

Reduced data can be easily communicated to Stakeholders

Longwall Mining at I-79 and I-70 – Washington, PA

Geotechnical Issues

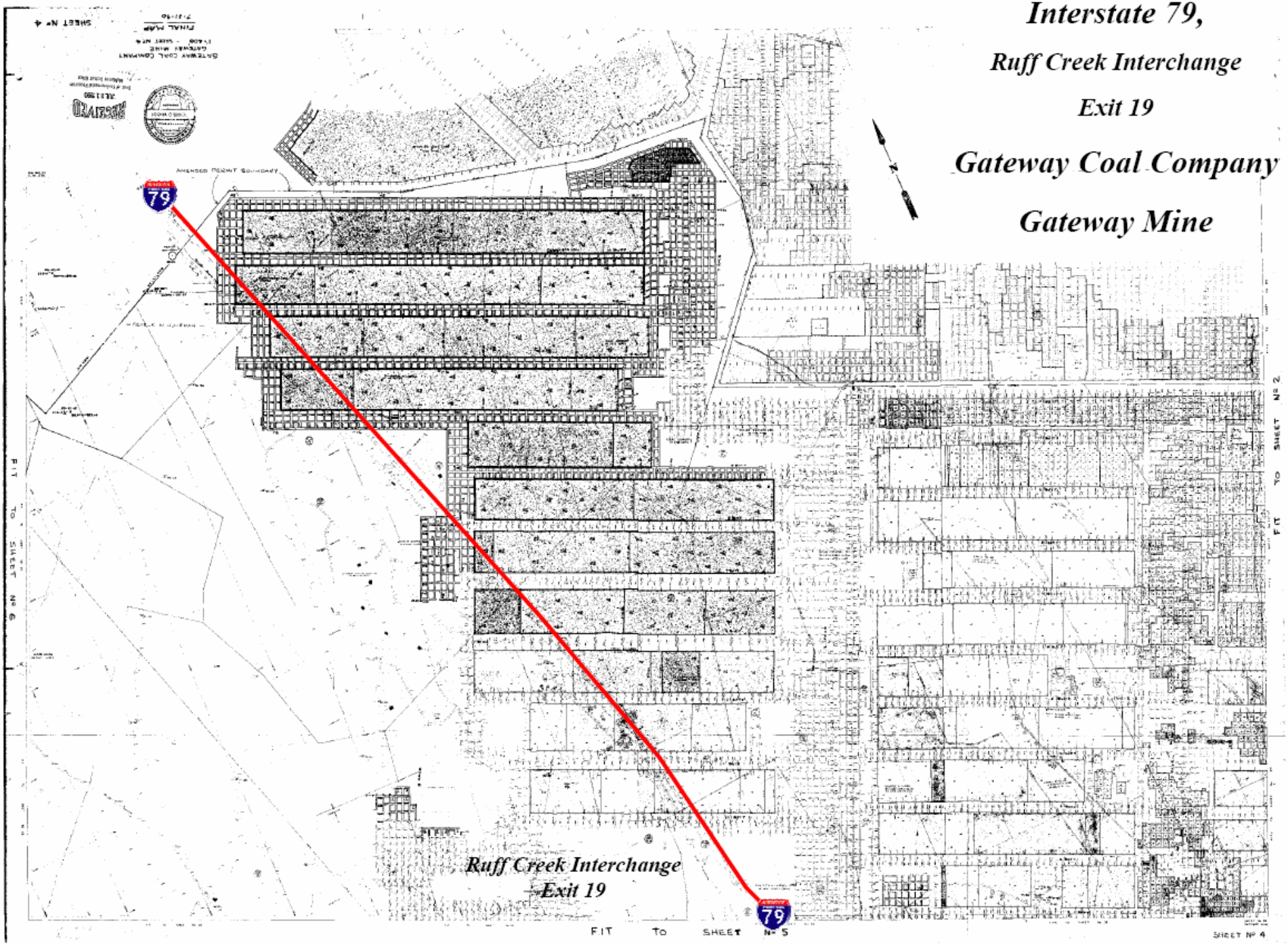
Longwall mining operations several hundred feet below I-70 and I-79

Far more costly to purchase coal supports (~$40 million) than to repair highway damage (~$2 million)

Primary focus is automated, real-time monitoring with alarms for protection of driving public

Significant surface subsidence affecting roads and structures

- Pavement subsidence and cracking
- Underpinning or abandonment of bridges
- Removal of overhead sign structures
- Monitor performance of box culverts


Interstate 79,
Ruff Creek Interchange
Exit 19
Gateway Coal Company
Gateway Mine
79
Ruff Creek Interchange
Exit 19
79
FIT TO SHEET Nº 5
FIT TO SHEET Nº 6
FIT TO SHEET Nº 2
SHEET Nº 4

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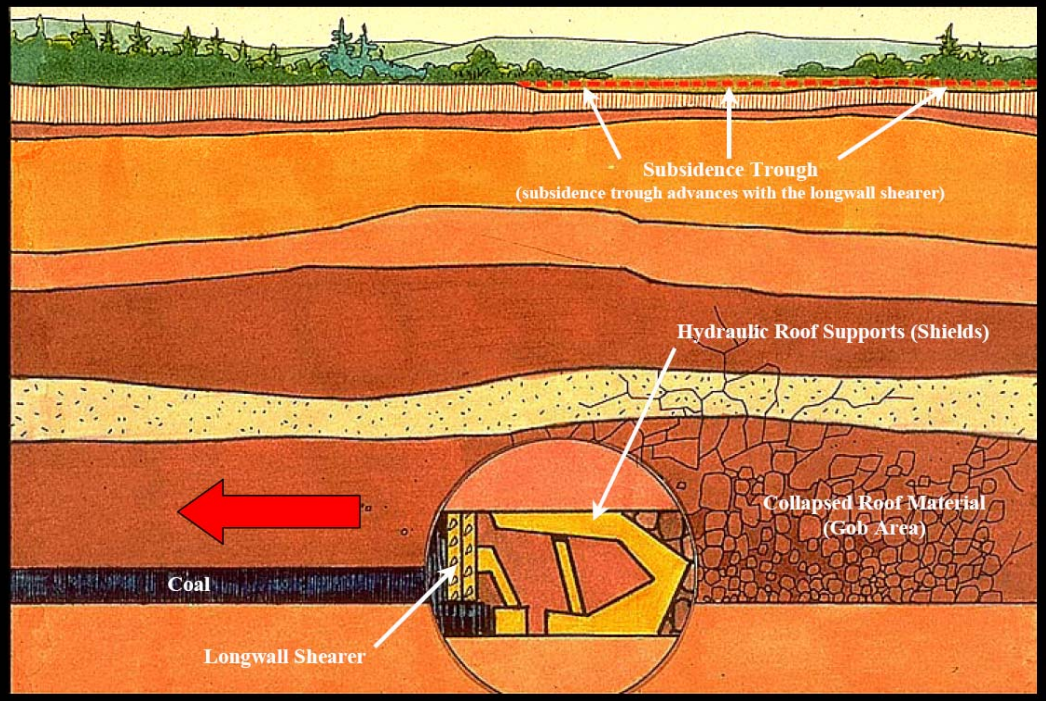
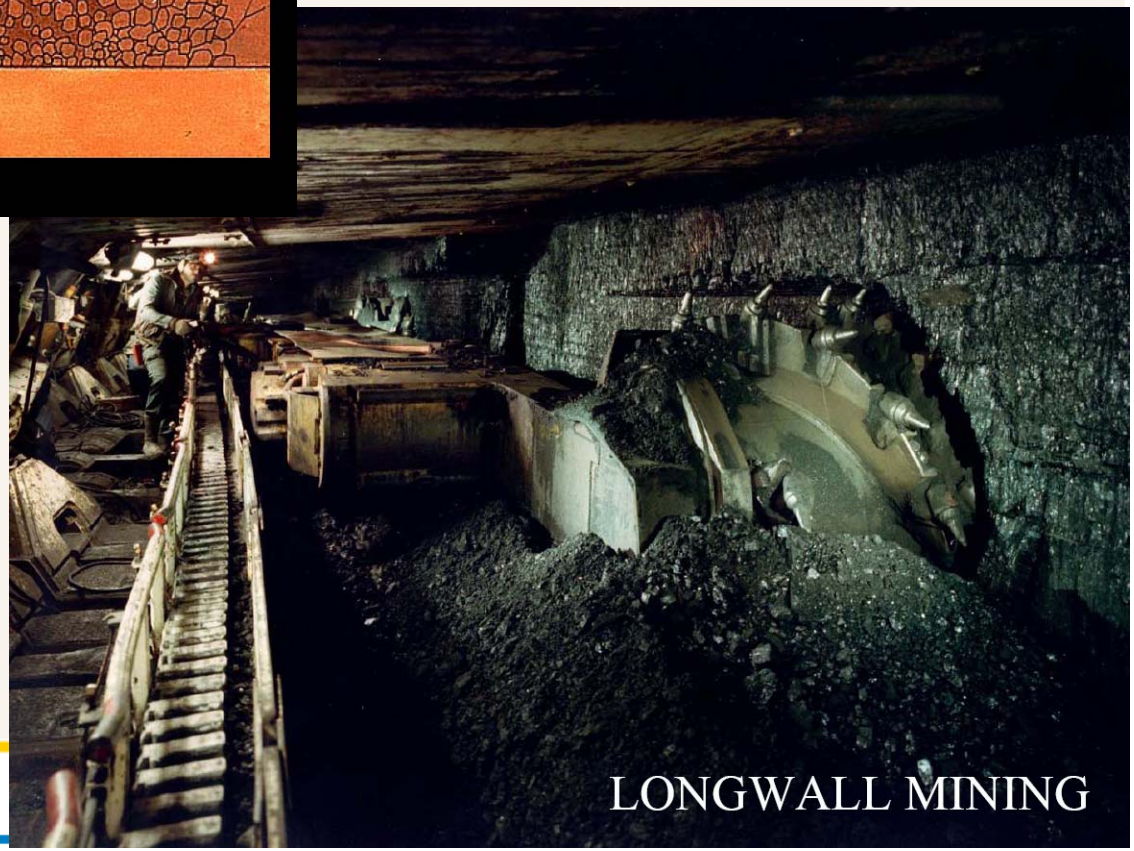


Longwall Mining




Longwall Subsidence
WEST NORTH
70 79
Washington
LEFT LANE
79 SOUTH
Morgantow
RIGHT LANE
8/25/2000


Skid Loader with Milling Head
(high areas were milled down)
Asphalt Overlay
(low areas were built up with asphalt)

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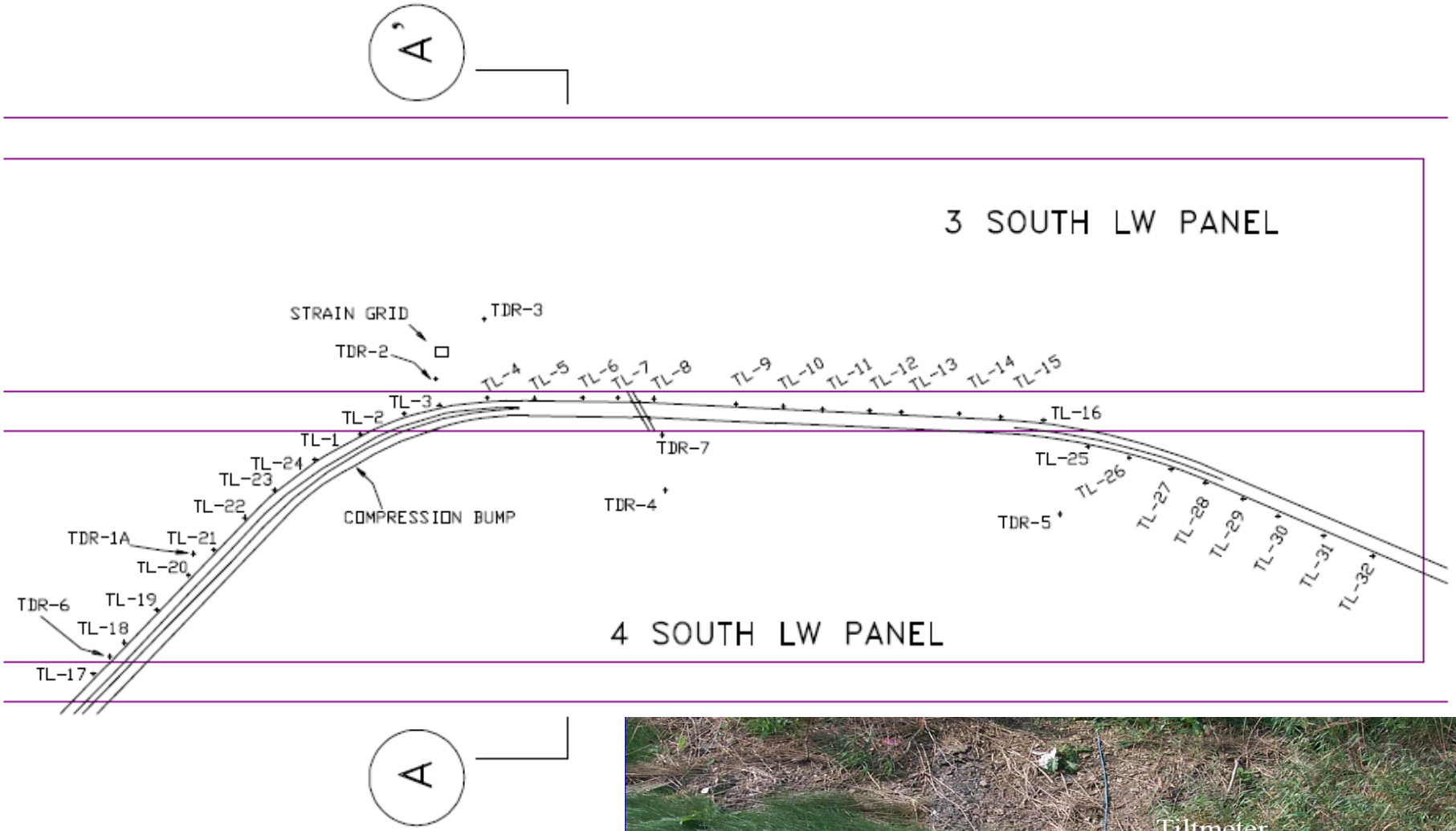
STOP


SAND BAGS
I-BEAM
WOODEN CRIBBING
CONCRETE BLOCKS



I-70 Instrumentation Plan

Owner Benefits

Monitoring of deformations and changes in highway conditions allowed PennDOT to make rational decisions on speed limits and temporary maintenance on I-70 and I-79

Alarms were triggered at when anticipated movements were exceeded

Alarms automatically notified PennDOT personnel to the problem

I-235 over University Avenue – Des Moines, IA

Geotechnical Issues

Two stage widening of I-235 over University Avenue

20 ft approach embankment constructed over a soft silty clay (~ 46 ft thick)

DOT wanted to eliminate bump at end of bridge and downdrag on piles from phase 1 construction

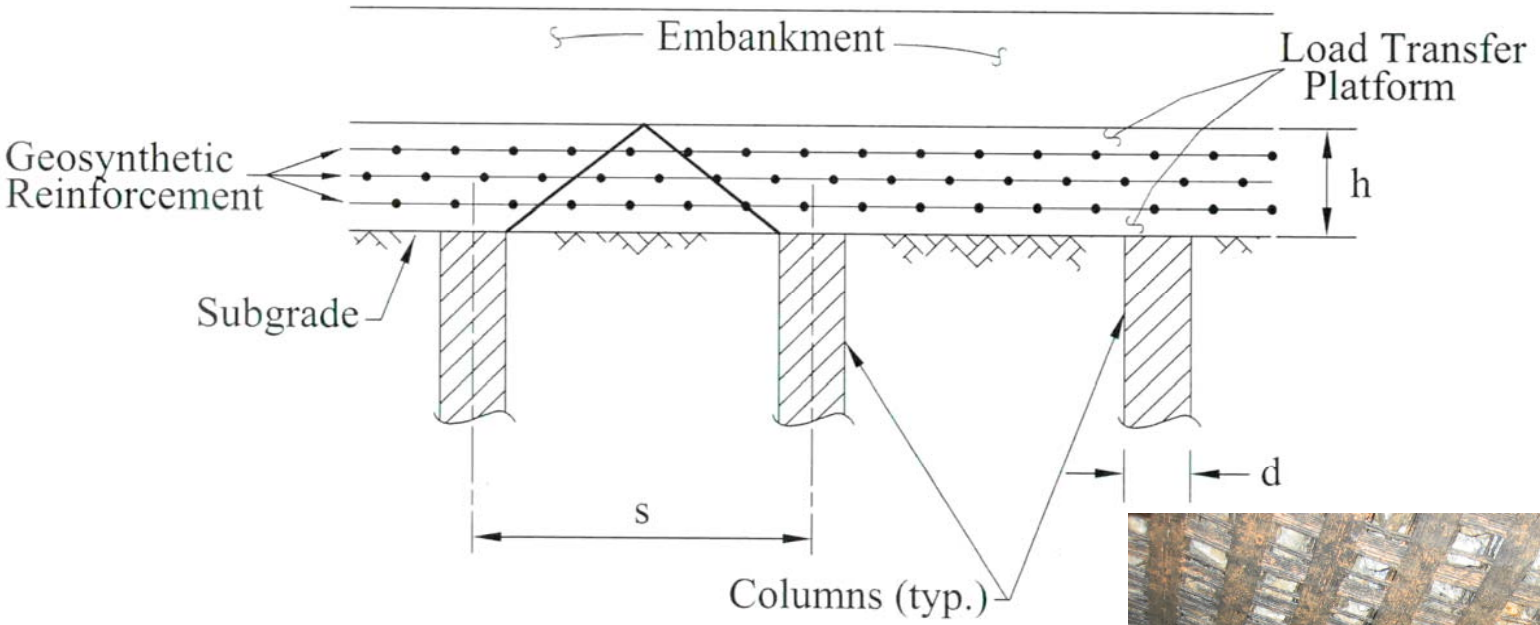
New Technologies and Development of Specifications

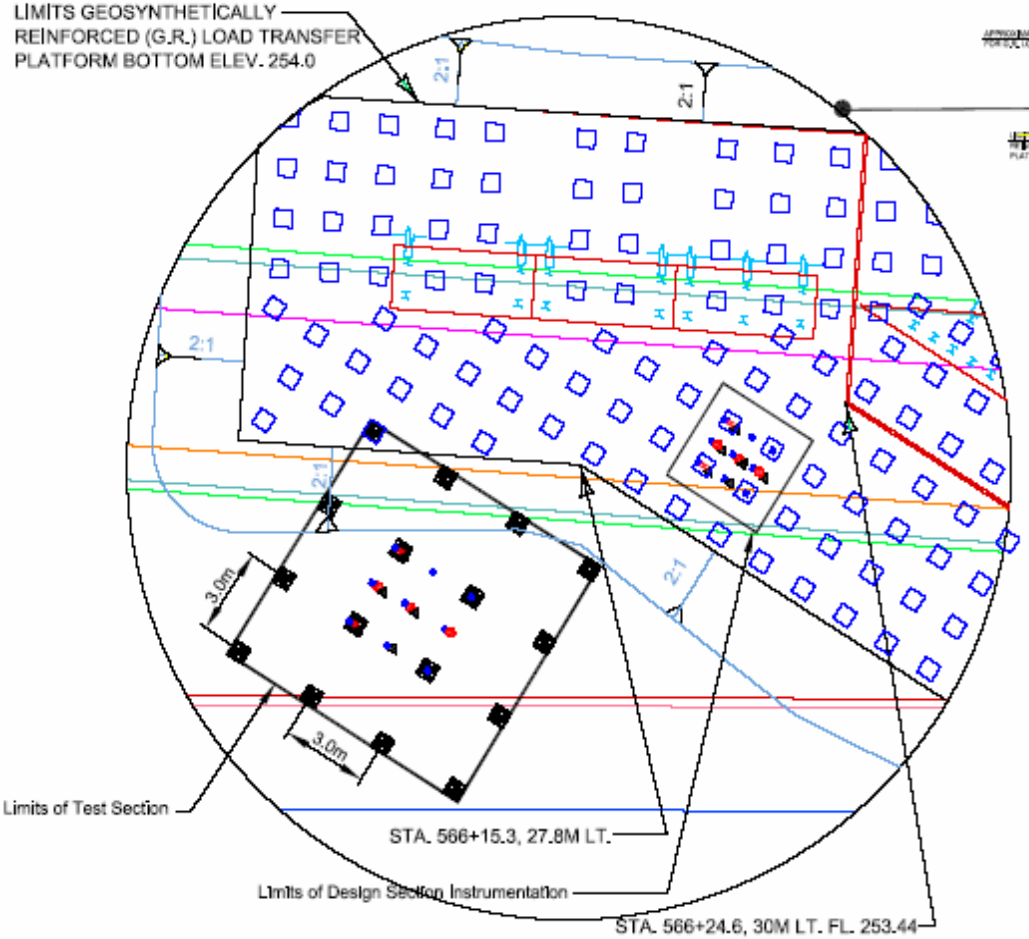
Objectives of Instrumentation Program

Evaluate/verify beam theory design methodology

Evaluate larger spacing between columns

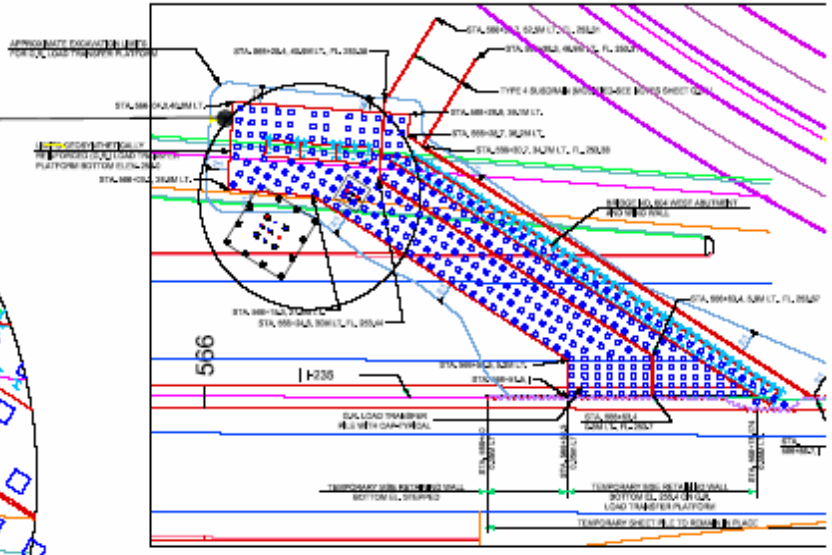
- Column spacing 3.0 m
- LTP thickness 1.2 m
- Four (4) layers of geosynthetic reinforcement


Embankment
Load Transfer Platform
Geosynthetic Reinforcement
h
Subgrade
d
s
Columns (typ.)



ENLARGED PLAN VIEW AT INSTRUMENTATION

N.T.S.



PLAN VIEW – ORIGINAL DESIGN

N.T.S.

NOTES:
1. Refer to Sheets 3 and 4 for Instrumentation and Load Transfer Platform Details.
2. Refer to Project Plans for Roadway and Pile Layout Information.

THE COLLIN GROUP LTD
7445 Arlington Road
Bethesda, MD 20814
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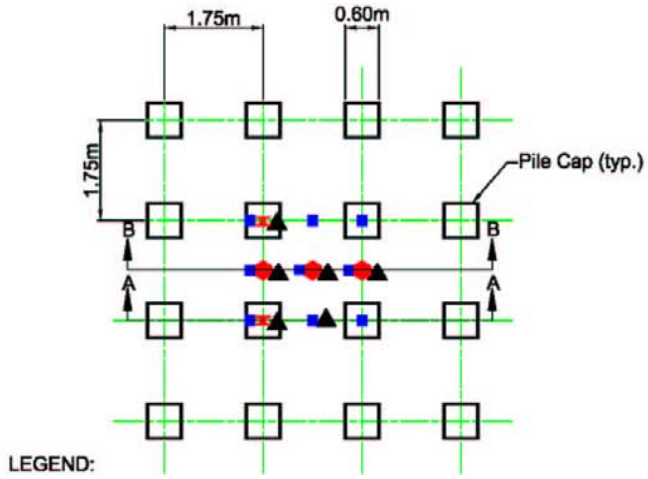
INSTRUMENTATION PLAN ORIGINAL DESIGN SECTION and ALTERNATIVE DESIGN TEST SECTION
I-235 DES MOINES, IOWA

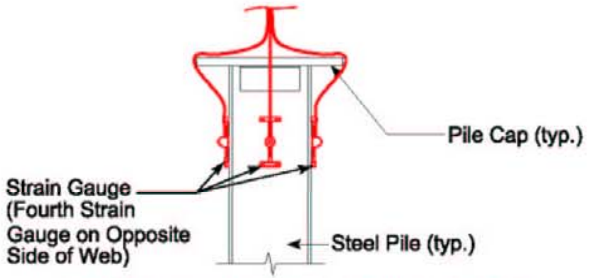
Sheet Number
2 OF 4



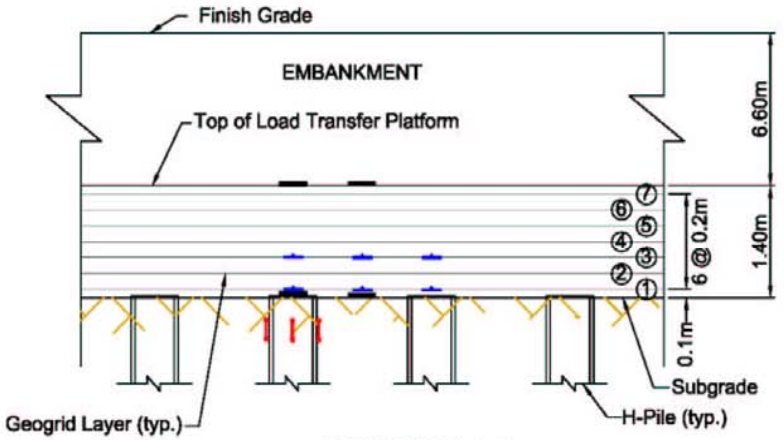
LEGEND:

- Pressure Cell
- Settlement Cell
- Strain Gauge On Geogrid
- Four (4) Strain Gauges On (See Detail This Sheet)

PLAN VIEW
N.T.S.



STRAIN GAUGES ON PILE DETAIL
N.T.S.



SECTION A-A
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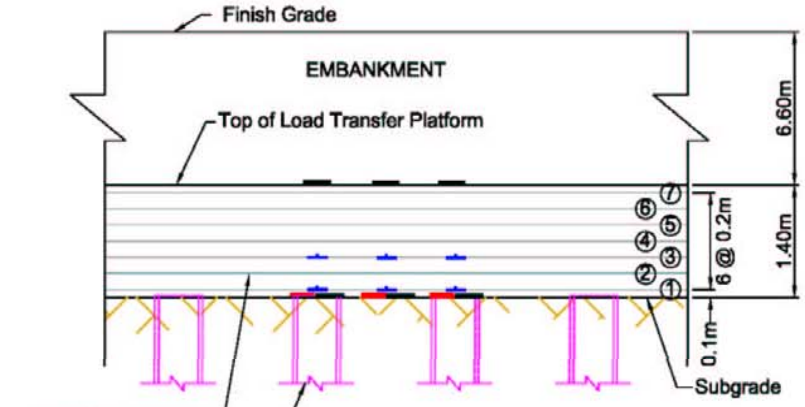

SECTION B-B
N.T.S.

LEGEND:

- Pressure Cell
- Settlement Cell
- Strain Gauge On Geogrid
- Strain Gauge On Geogrid
- ① Geogrid Layer Number

NOTE: All Geogrid to be TENSAR BX1200

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Date Drawn 1/21/04
Scale None
Designed By JCC
Drawn By CHW

INSTRUMENTATION LAYOUT - ORIGINAL DESIGN SECTION
I-235 DES MOINES, IOWA

Sheet Number 3 OF 4

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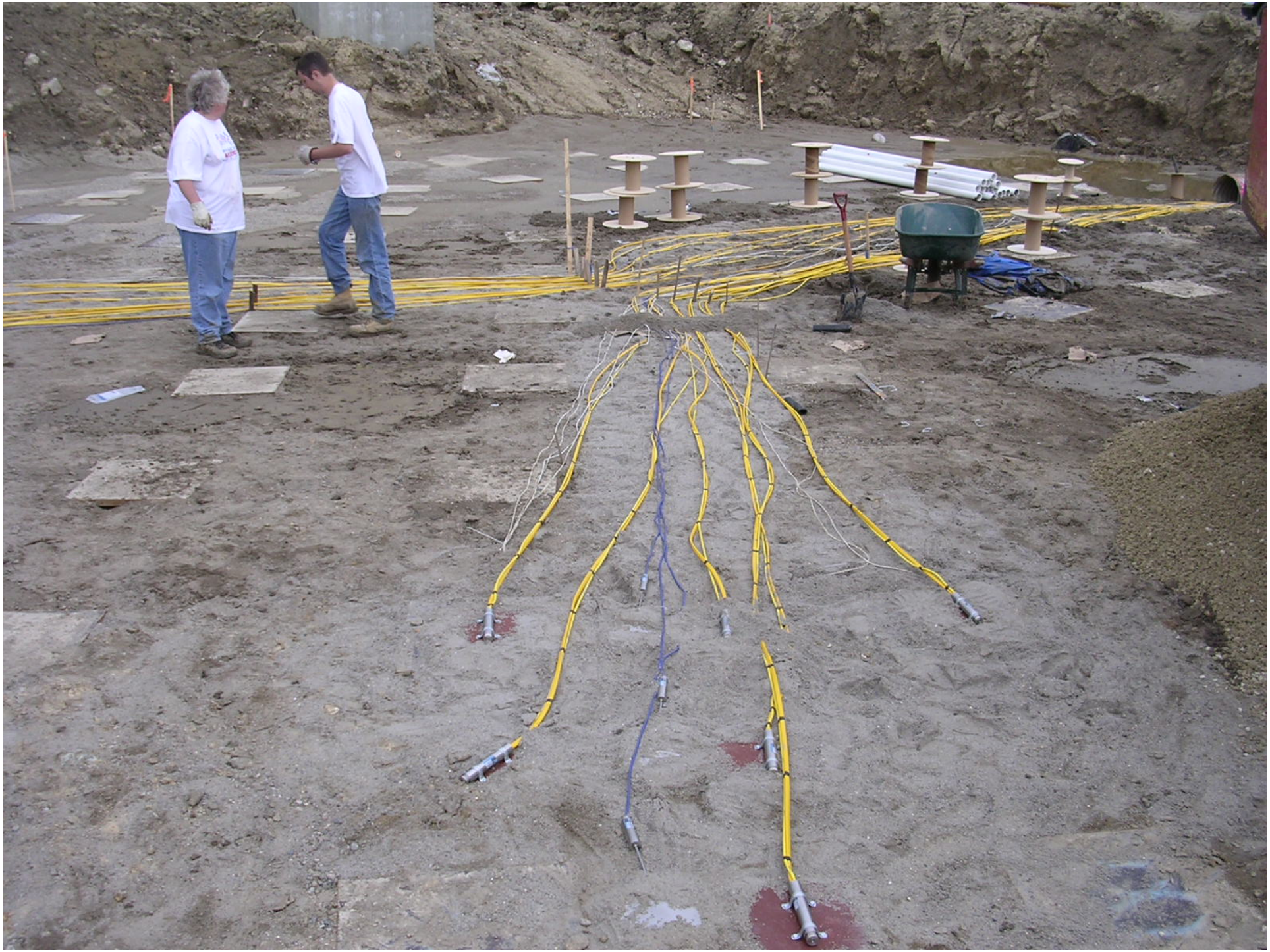


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Geocomp consulting
Geo-engineering:
the groundwork for success
Alarm Report
Status Report
Log Out
Ok Reading
Threshold Low
Threshold High
Limit Value
OK & Old
Low Threshold & Old
High Threshold & Old
Limit & Old
powered by iSite Central
S1-8V 120 Ohm Strain Gage --- Sensor is not active
Sensor Group : S3_GAGES
Sensor Name | Description | Low Alarm | High Alarm | Status | Date/Time | Temperature (C) | Reading | Units
S3-1H | 120 Ohm Strain Gage | -20.6 | -20.6 | 7/29/2004 2:00:00 AM | (NA) | -0.107 | %Strain
S3-1V | 120 Ohm Strain Gage | -20.1 | -20.1 | 7/29/2004 2:00:00 AM | (NA) | 0.164 | %Strain
S3-2H 120 Ohm Strain Gage --- Sensor is not active
S3-2V 120 Ohm Strain Gage --- Sensor is not active
S3-3H | 120 Ohm Strain Gage | -20.8 | -20.8 | 7/29/2004 2:00:00 AM | (NA) | 0.188 | %Strain
S3-3V | 120 Ohm Strain Gage | -20.9 | -20.9 | 7/29/2004 2:00:00 AM | (NA) | 0.498 | %Strain
S3-4H 120 Ohm Strain Gage --- Sensor is not active
S3-4V | 120 Ohm Strain Gage | -20.7 | -20.7 | 7/29/2004 1:00:00 AM | (NA) | 0.115 | %Strain
S3-5H | 120 Ohm Strain Gage | -20.4 | -20.4 | 7/29/2004 1:00:00 AM | (NA) | -0.026 | %Strain
S3-5V 120 Ohm Strain Gage --- Sensor is not active
S3-6H | 120 Ohm Strain Gage | -20.6 | -20.6 | 7/29/2004 1:00:00 AM | (NA) | 0.216 | %Strain
S3-6V | 120 Ohm Strain Gage | -20.4 | -20.4 | 7/29/2004 1:00:00 AM | (NA) | -0.111 | %Strain
Sensor Group : SP_Gages
Internet

iSiteCentral - Microsoft Internet Explorer

File Edit View Favorites Tools Help

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Geocomp consulting

Geo-engineering: the groundwork for success

Report Settings

Prior Day
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Start Date: 6/1/2004
End Date: 6/23/2004
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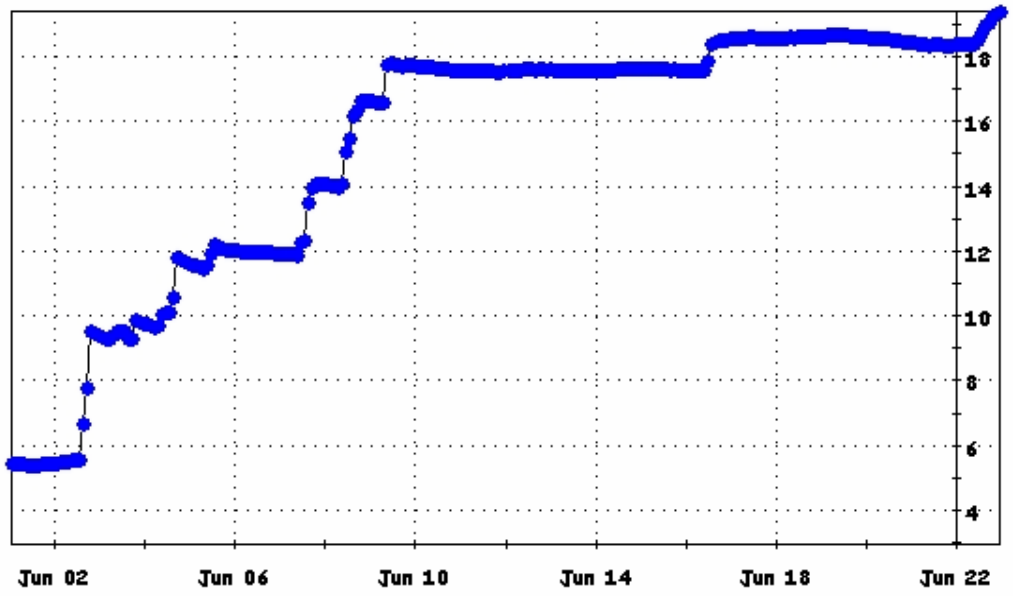
SUMMARY OF DATA FROM 6/1/2004 TO 6/23/2004

Project Name : I-295

Project Description : Column supported embankment

PCB-1R VW Pressure Cell (s/n 04-1376) - June 2004



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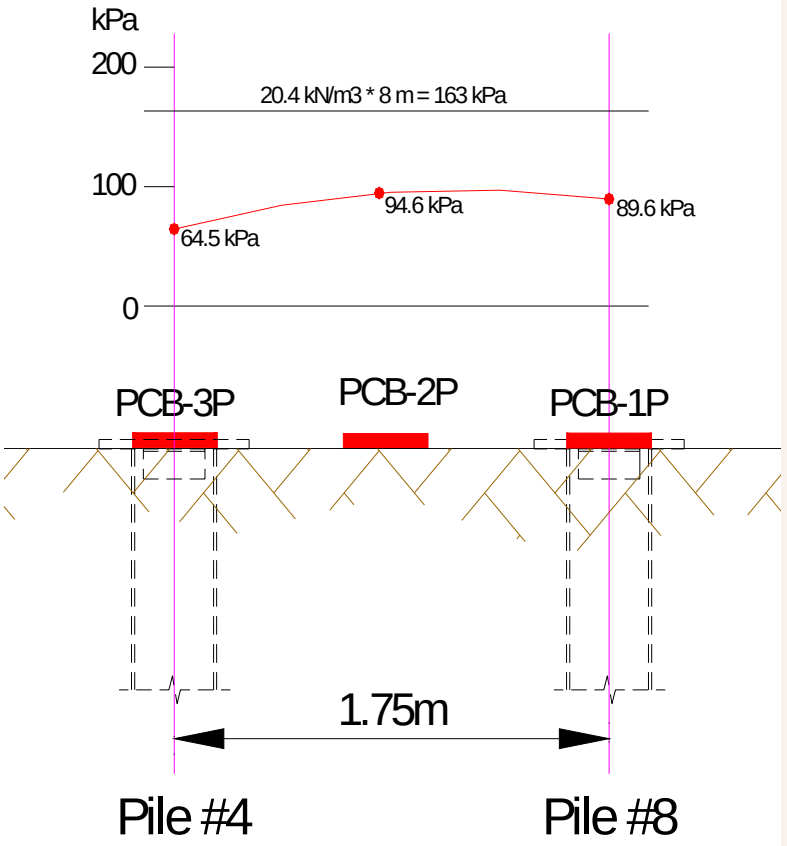
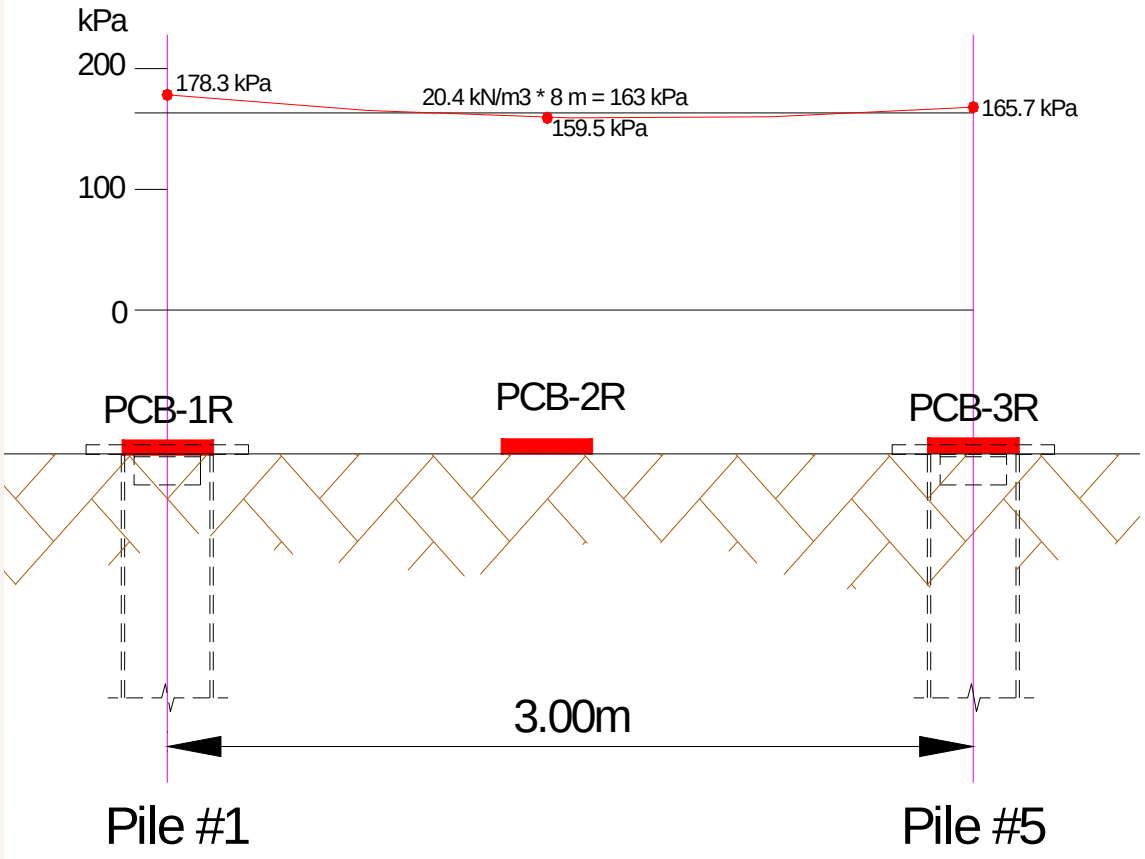
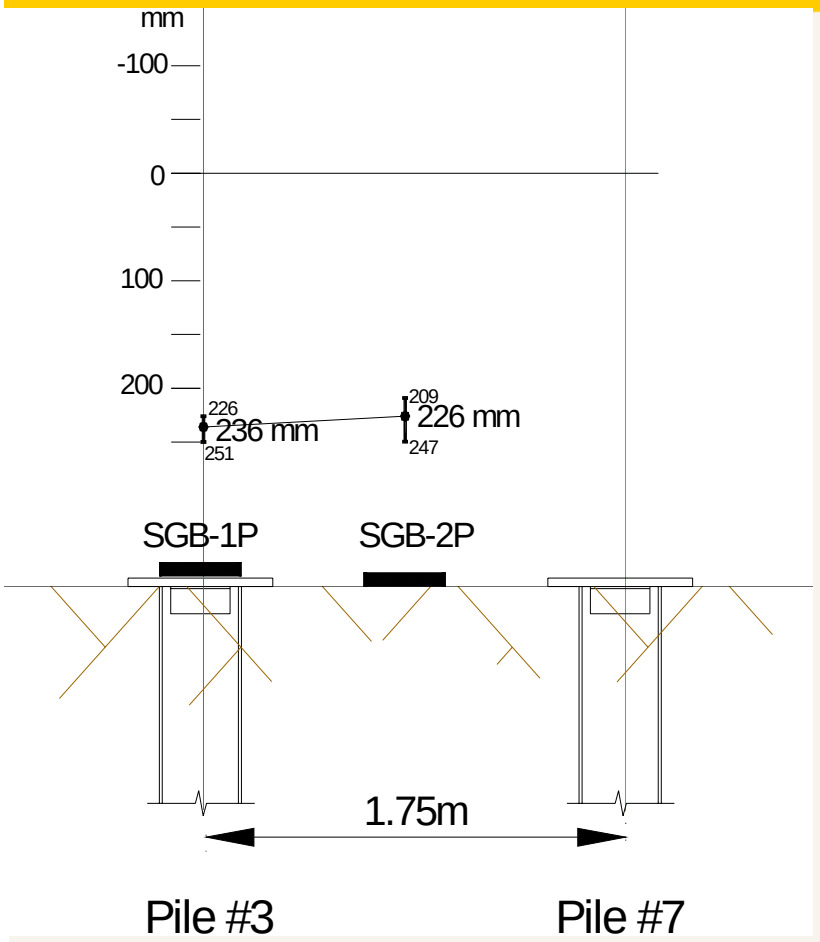


Pressure Cell Results
Production Section

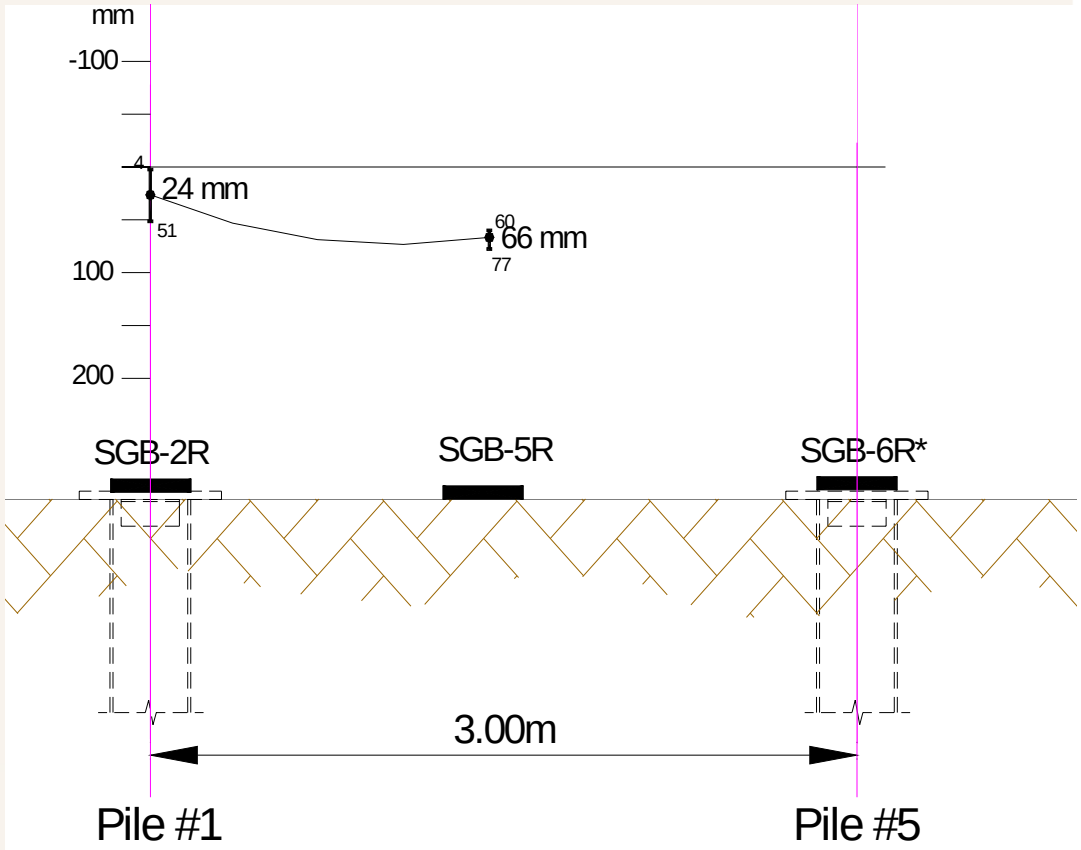
Pressure Cell Results
Research Section



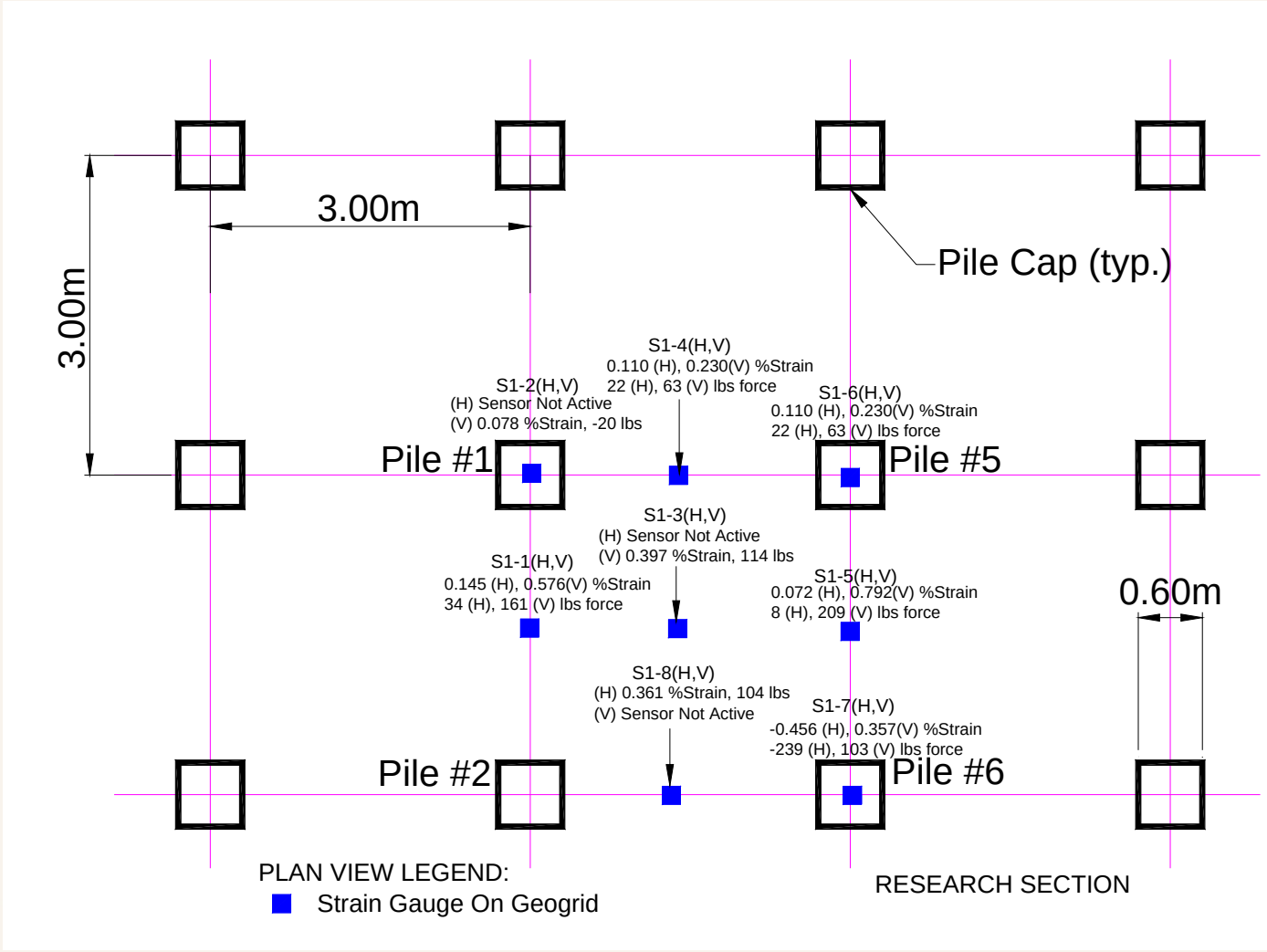


Settlement Results
Production Section

Settlement Results
Research Section



* SENSOR NOT WORKING



Strain Gage Layout

Owner Benefits:

IA DOT able to increase pile spacing for second phase of work (reduced number of piles by factor of 3)

Total project savings of approximately $500,000

Allowed for evaluation of real-time data acquisition application

Data for verification of numerical codes for design of CSE

Better understanding of load transfer in beam system

I-15 Reconstruction Project - Salt Lake City, UT

Geotechnical Issues

Large Primary Consolidation Settlement (3 to 5 ft)

Time Rate of Consolidation (2 years to end of primary)

Creep Settlement (Bump at Bridge)

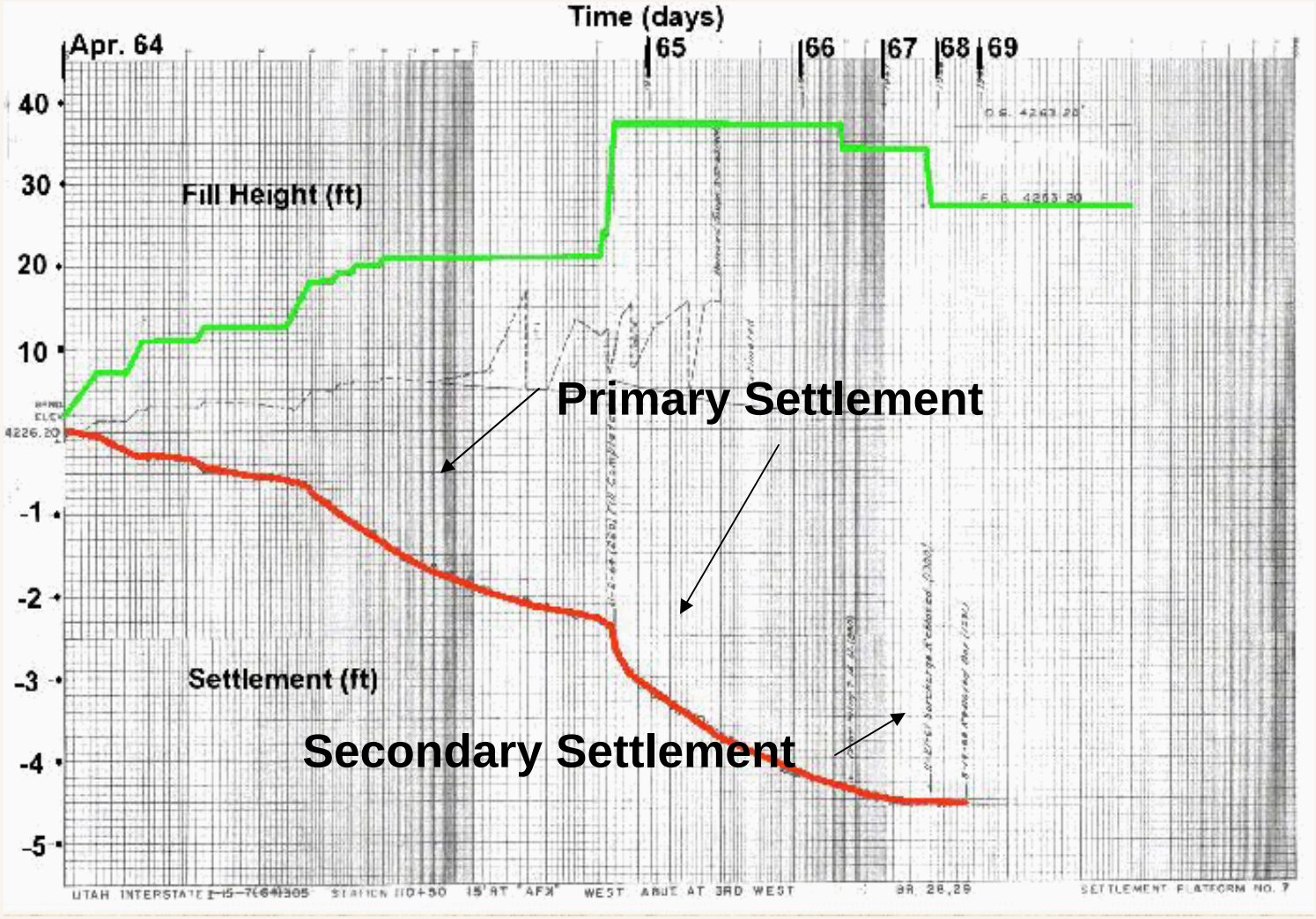
Foundation Stability (Large Embankments on Soft Soils)

Schedule Constraints (two 2-year projects)

Maintenance of Traffic (Had to be maintained)

New Technologies and Development of Specifications

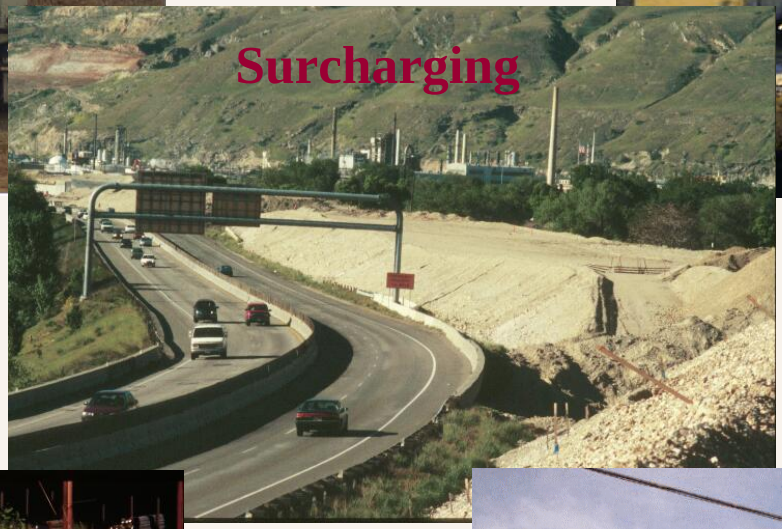
Settlement of Soft Clays in Salt Lake Valley

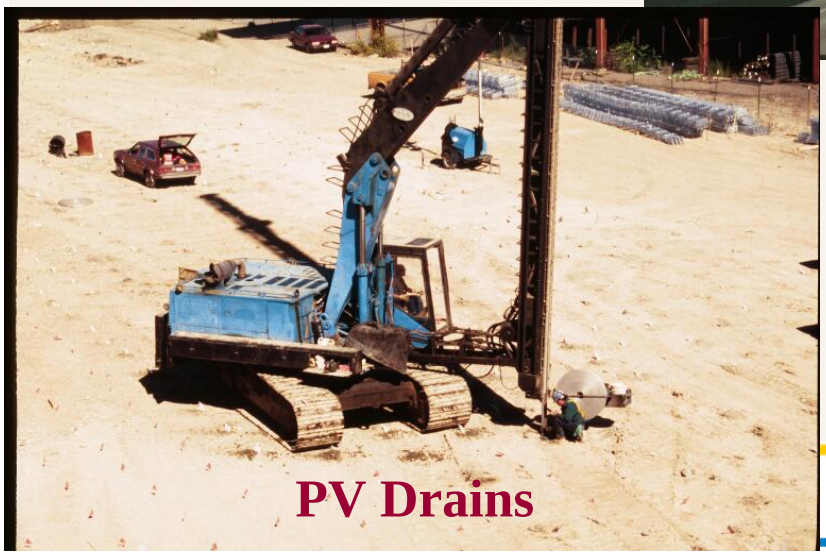


Geofoam – Light Weight Fill

Lime Cement Columns

Surcharging





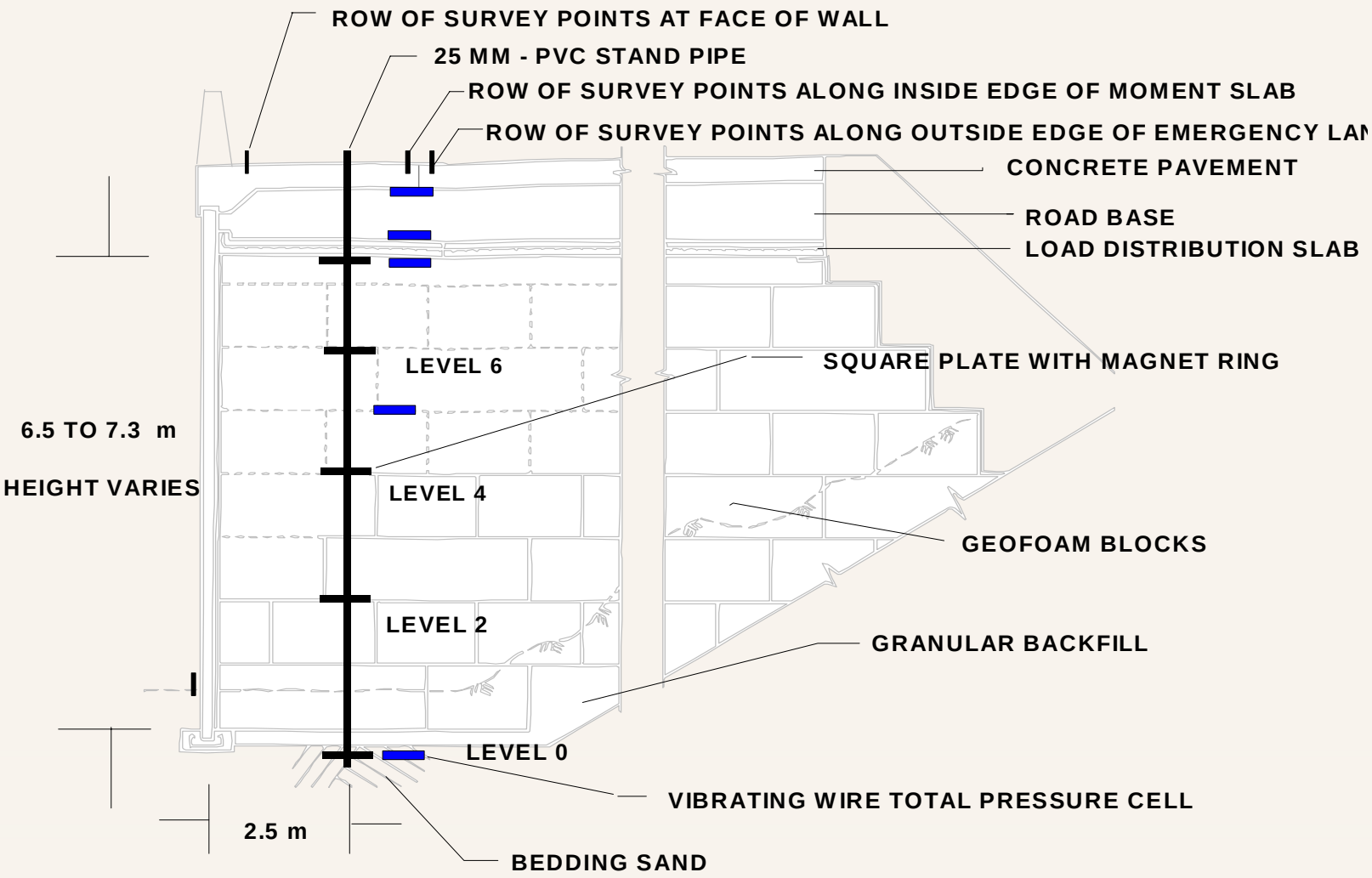
PV Drains

2-Stage MSE Walls

Geofoam Embankment

Geofoam Embankment from State St. to 200 W. Along Interstate I-80, Salt Lake City, Utah

Geofoam Array



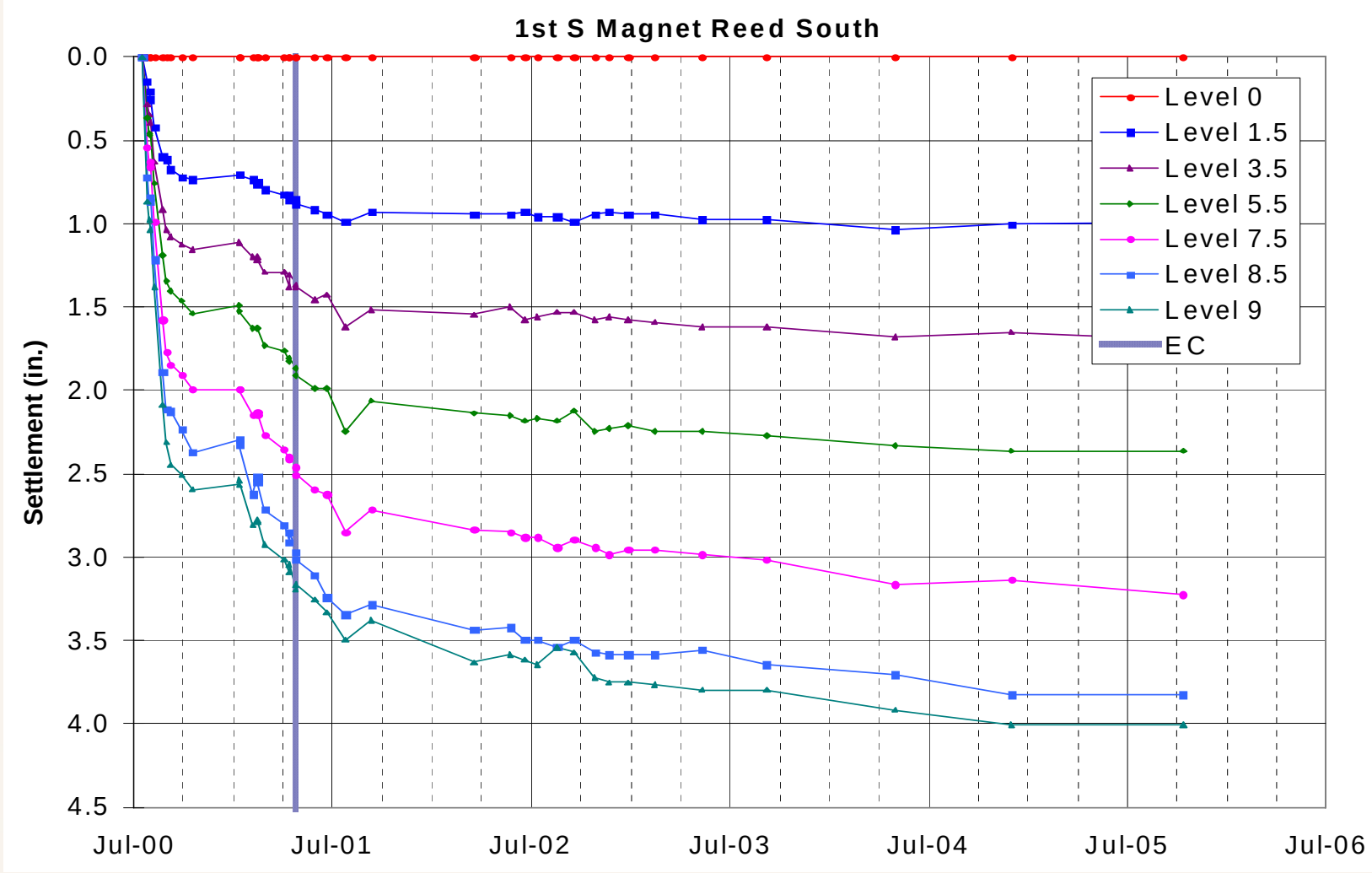
Geofoam Array Installation

Magnet Extensometer and Pressure Cell Installation

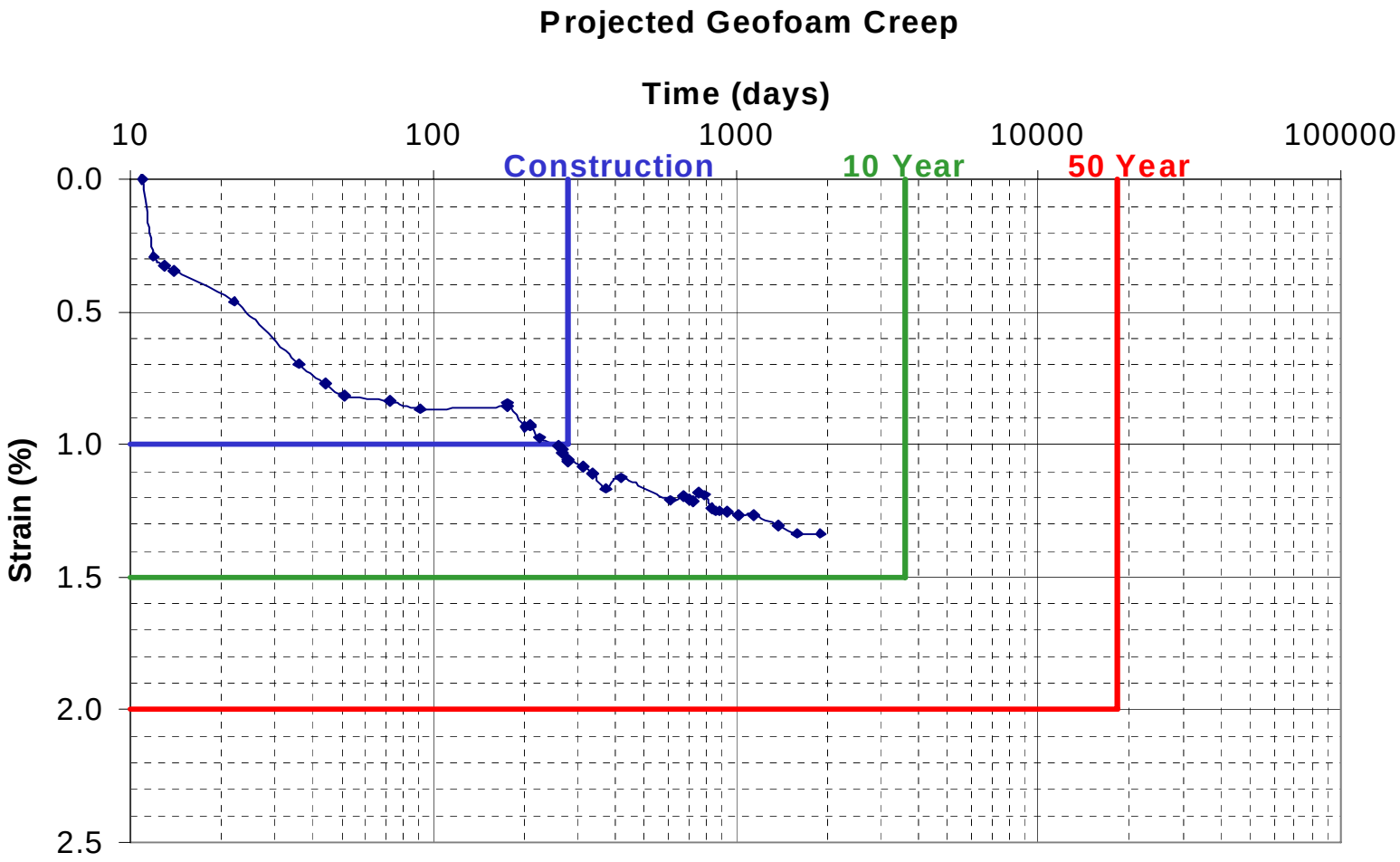
Pressure Cell in Base Sand

Pressure Cell Cast in Bridge Abutment

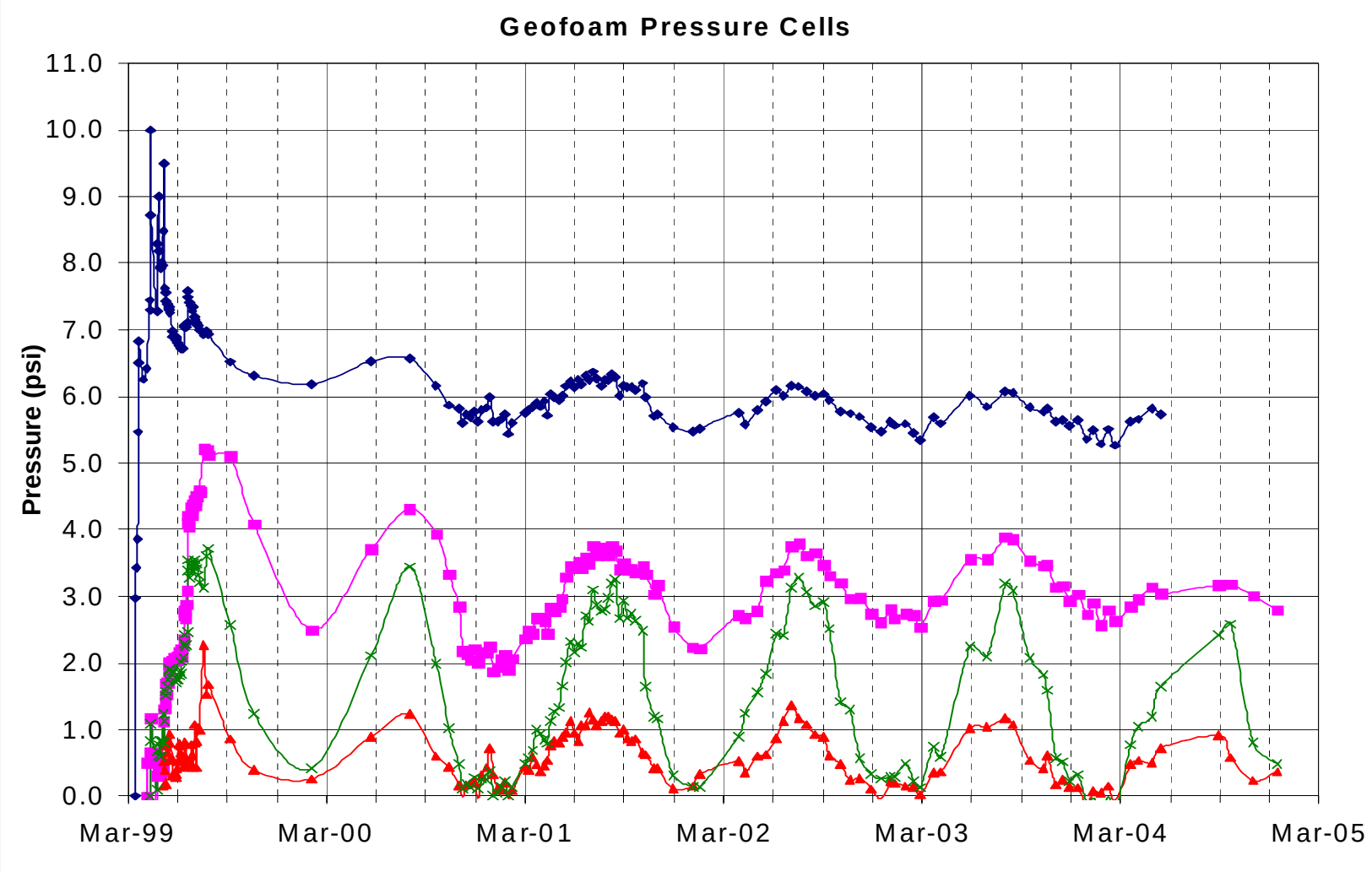
Geofoam Magnet Extensometer Data



Geofoam Magnet Extensometer Data



Geofoam Pressure Cell Measurements



Owner Benefits

Geofoam fills are performing as expected with no major issues

Performance monitoring led to the following conclusions:

- Approximately 1 percent vertical strain occurred during construction
- Approximately 0.3 percent creep strain (1.3 inches) has occurred in a 4-year post construction period
- Creep strain in a 10 year post-construction period is expected to be about .4 percent (about 1.7 inches)

Instrumentation allowed for additional evaluation of the complex vertical stress distribution that develops in a geofoam wedge fill

Thank you!

Contact Information:

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