GEOTECHNICAL DESIGN MEMORANDUM
US 52/IL 64 BRIDGE OVER
THE MISSISSIPPI RIVER
EXISTING SN 008-6000, PROPOSED SN 008-0052
IDOT Job No. P-92-001-11 / D-92-001-11
PTB 158/18
CARROL (IL) AND JACKSON (IA) COUNTIES

for

PARSONS

10 South Riverside Plaza, Suite 400

Chicago, IL 60606

(312) 930-5100

submitted by

Wang Engineering, Inc.

1145 North Main Street

Lombard, IL 60148

(630) 953-9928

January 5, 2015

TABLE OF CONTENTS

Wang Engineering

1145 North Main Street
Lombard, Illinois 60148
Phone (630) 953-9928
www.wangeng.com

GEOTECHNICAL DESIGN MEMORANDUM
US 52/IL 64 BRIDGE OVER THE MISSISSIPPI RIVER
EXISTING SN 008-6000, PROPOSED SN 008-0052
IDOT JOB NO. P-92-001-11/D-92-001-11, PTB 158-18
CARROL, ILLINOIS AND JACKSON, IOWA COUNTIES

FOR

PARSONS TRANSPORTATION

1.0 INTRODUCTION

This Geotechnical Design Memorandum (GDM) presents the results of Wang Engineering, Inc. (Wang) geotechnical engineering analysis for the proposed US 52/IL 64 Bridge over the Mississippi River in Carroll County, Illinois and Jackson County, Iowa. This GDM is prepared based on IDOT approved Structure Geotechnical Report (SGR) dated September 4, 2014. The purpose of GDM is to provide geotechnical design data for the design of the substructure foundations and preparation of the final plan. The GDM also considers results of cone penetration tests and geophysical survey in the foundation analysis. A *Site Location Map* is presented as Exhibit 1.

2.0 Proposed Structure

The proposed bridge structure will be a 12-span steel tied-arch bridge with cast-in-place concrete deck. The bridge will carry one 12-foot wide lane and one 8-foot shoulder in each direction with parapet and bicycle railing, and no median barrier. The structure will be 43’-2” wide out-to-out and 2462’-9” long back-to-back abutments. The lengths of spans vary from 125’-0” to 240’-0” and main navigation channel span of 546’-0” measured along the Profile Grade Line (PGL). Two piers (numbers 4 and 5) will be located on an existing island on the Iowa side, and Pier 11 on land just east of the river shore line on the Illinois side. All other piers will be located within the river water. The substructure locations are shown in Exhibit 2, *Boring Location Plan*. Both abutments will be retained by end slope at 1:2 (V:H) maximum. The IDOT approved TSL plan dated July 16, 2014, provided by the designer (Parsons), is included in Appendix A.

Preliminary service and factored loads provided by Parsons were included in IDOT approved SGR dated September 4, 2014. The updated vertical loads and lateral load due to vessel collision provided by Parsons are shown in Tables 1 and 2.

3.0 Field Testing

3.1 Cone Penetration Testing

The subsurface conditions were verified by eight piezocone penetration (CPTu) tests, designated as CPT-02 through CPT-08, advanced in November 2012 and BSB-24 CPT-02 in July 2013. The CPT locations are shown in Exhibit 2.

Sounding CPT-01 was advanced behind the west abutment to a depth of 112 feet by Minnesota Geoservices of St. Paul, Minnesota using a 20-ton, truck-mounted system. Soundings CPT-02 through CPT-08 were advanced at the pier locations with a barge-mounted system by STRATIGRAPHICS of Hillpoint, Wisconsin. The soundings were pushed through 3 to 29 feet of surface water and 2 to 84 feet of soil for total sounding lengths of 17 to 87 feet. Soundings CPT-07 and 08, performed on either side of proposed Pier 9, encountered refusal within 2 feet below the river bottom. By contrast, Sounding CPT-02 was advanced south of proposed Pier 1 and tested an overburden thickness of 84 feet prior to refusal. It should be noted that CPTu refusal is not equivalent to auger or rotary-bit refusal, and it should not be used to identify the top of bedrock elevation. The results of the CPT testing and the estimated lithologies interpolated from the data are summarized in Tables 3 through 6 for use at the west abutment and Piers 1 through 8. The layer elevations are taken from visual soil identifications in the borings, whereas the soil parameters are taken from the results of the CPT soundings. The piers east of Pier 8 will encounter bedrock at very shallow depths below the river bottom.

The CPT tests were performed according to ASTM D 5778. Continuous measurement of penetration resistance on the cone tip (q_c), friction sleeve (f_s), and pore pressure (u_2) transducer were recorded during penetration. The results of the CPT probes are included in Appendix B of this report.

Sounding BSB-24 CPT-02 included 29 seismic piezocone tests (SCPTu) in addition to the continuous penetration test data. The results of the seismic cone testing at Sounding BSB-24 CPT-

02 are summarized in Table 7. The soils between 12 and 112 feet bgs have a weighted average seismic shear wave velocity (v_s) of 620 feet per second in accordance with Table C3.10.3.1-1 of the 2012 AASHTO *LRFD Bridge Design Specifications*.

3.2 Geophysical Survey

Since the borings drilled for Pier 7 and Pier 8 revealed highly variable bedrock conditions, a geophysical survey was considered to get a better grasp of rock mass properties at these piers location. Cored near Pier 7, Boring BSB-17 recorded 20% recovery and 8% RQD at 30 feet below the top of bedrock. Thus, to exclude the possible existance of voids, geophysical logging was performed in Borehole GEO-01, which was drilled between Borings BSB-17 and BSB-18. For Pier 8, among the five borings (BSB-15, -15A, -15B, -15C, and -16) drilled to investigate the bedrock, Borings BSB-15 and BSB-15A recorded low recover (10, 13, 15, 25%) and 0% RQD starting at 20 feet below the top of bedrock. Borehole GEO-02, drilled at the south end of Pier 8, logged geophysically the rock mass properties.

The geophysical survey was performend by Geotechnology, Inc., and the submited report, dated July 10, 2014, including geophysical logs, is attached as Appendix C. The locations of geophysical boreholes are shown in Exhibit 2 – *Boring Location Plan.*

Four main geophysical methods were envisioned for this investigation: geophysical acustic televiewer (ATV), natural gamma, spontaneous potential (SP), and resistivity.

- The ATV log collected a continuous image of the borehole wall, and processed data provided joints depths and orientation;
- Natural gamma log data recorded variation of natural gamma radiation identifying clay-rich zones or shale partings within dolomite bedrock;
- SP log data recorded differences in resistivity, determined permeable and impermeable zones, noticing gross differences between shale/clay compared to dolostone; and
- Resistivity logs data recorded conductivity/resistivity variation within geologic material, separating lower resistivity associated with clay, shale, and saturated and highly fractured dolostone and higher resistivity associated with dense and non-fractured dolostone.

In addition, a caliper log recorded variation of borehole diameter. However, due to the unstable sidewall conditions encountered in Borehole GEO-02, a 2-inch PVC pipe was installed within the borehole, and that precluded SP and resistivity logging and reduced the resolution of the ATV signal. The natural gamma log was not affected by the casing.

Boring GEO-01 findings revealed high angle, conjugated joint sets, with dip angles ranging from 45 to 80 degrees that appear to be clustered in four intervals 93 to 106, 115 to 120, 134 to 139, and 151 to 155 feet. These four intervals also exhibit low angle joints too (mainly bedding). However, the top two intervals are within a 95 to 120 feet interval of compact dolostone bedrock with narrow discontinuities having no or very little clay/shale infill. The bottom two intervals exhibit more frequent shale intercalations. The low recovery interval encountered in Boring BSB-17 at 30 feet below rock surface, matches the second highly jointed interval that shows no voids.

Geophysical interpretation for Boring GEO-02 was limited by the PVC casing. However, the logs revealed a high-angle, conjugated joint set dipping at approximately 45 to 80 degrees with an evident cluster interval between 80 and 90 feet. Greater amounts of joint infill were found at 93 feet and between 135 and 139 feet. The latter may be correlated with Boring BSB-15 last run low recovery and RQD.

Both the geological and geophysical findings fit published descriptions of the Ordovician-age, Galena-Platteville dolostone: brown and gray, thin horizontally bedded, with some cherty, argillaceous, and clay beds, fit. It is worth mentioning that none of the borings experienced a drop of the rods during drilling, and a constant drilling pace of 45 seconds to 2 minutes per foot at an average down pressure of 850 psi was recorded for borings drilled at these two piers.

4.0 FOUNDATION DESIGN RECOMMENDATIONS

Wang understands that the bridge structure will be designed following the 2012 AASHTO LRFD Bridge Design Specifications with 2013 Interims except modified by the 2012 IDOT Bridge Manual. The following sections present geotechnical engineering design recommendations for the bridge substructures foundation.

4.1 West Abutment and Piers 1 through 4

Driven Piles

The abutment will be supported on driven closed-ended metal shell piles filled with concrete. The metal shell piles should be in accordance with IDOT Standard Specifications for Road and Bridge Construction. The estimated pile lengths for various pile sizes and capacities are shown in Tables 8 through 17. The estimated lengths for capacities other than shown in the tables may be provided if required during the design. The estimated pile lengths were calculated in accordance with IDOT AGMU Memo 10.2 Geotechnical Pile Design Guide and using IDOT spread sheet Modified IDOT Static Method of Estimating Pile Length dated October 18, 2011. The estimated pile lengths include one foot of embedment into the pile footing. We accounted for losses in geotechnical resistance that occurs after driving due to downdrag loads at the west abutment and due to scour at Piers 1 through 4. The Factored Resistance Available (FRA) values include losses due to downdrag or scour and therefore FRA values should be used for the design.

The most economical pile sizes should be selected. The maximum structural design capacity of the pile and the spacing should be as per IDOT 2012 Bridge Manual. Two test piles (one for each bound of traffic) should be identified on the plans for each substructures which should be installed prior to production pile installation. There is no need for a full scale load test. There is no need for pile shoes.

Permanent Steel Sheet Pile Wall

A permanent steel sheet piling near existing embankment toe at the proposed west abutment will be provided. The top of the sheet piling will be one foot above EWSE (582.3 feet). The sheet pile wall will be 10 feet from the toe of existing embankment on the south and east side between approximate Stations 1560+00 and 1561+00 except under the new west abutment. However, location of sheet pile wall should be such that it does not interfere with the battered abutment piles. Steel sheet piles can be driven before driving abutment piles. Exsiting muck should be removed to elevation 575.0 feet (approximately one to two feet below existing river bed. The excavation depth could be different at the time of construction due to water flow current and scouring.) Tip of steel sheet pile wall should be to a minimum elevation 559.0 feet for the embankment slope stability. Steel sheet pile size and final tip elevation should be based on structural design.

The soil parameters shown in Table 18 should be used for the design of the steel sheet pile wall based on the soil conditions encountered in the borings. In developing the design lateral pressure, the lateral surcharge pressure due to construction equipment should be added to the lateral earth pressure. The simplified lateral earth pressure distributions shown in AASHTO LRFD Bridge Design Specifications or other suitable earth pressure distributions should be used. Design considerations should include deflection control at the top of the wall.

4.2 Piers 5 through 11

Drilled Shafts

Drilled shafts established into dolostone bedrock will be used to support Piers 5 through 11. It is understood that 8-foot diameter drilled shafts will be used. The socket shaft diameter in the rock should be at least 6 inches less than the shaft diameter in the overburden soils. We recommend that a permanent casing with teeth at the bottom be installed in order to provide a good seal at top of the bedrock. Permanent casing should be extended to top of rock or into rock as needed. The minimum thickness of the casing should be specified on the plan for a long-term structural requirement. The Contractor may need to increase the thickness and/or size to withstand his installation process.

Even though permanent casing will be provided, there is still a concern of structural integrity of large diameter shaft concrete. To verify structural integrity of concrete, non-destructing integrity testing on completed drilled shafts should be performed using the Crosshole Sonic Logging (CSL) method. IDOT special provision “Crosshole Sonic Logging” dated March 9, 2010 or latest edition should be included for this inspection and testing requirements. Wang recommends providing CSL access tubes in all drilled shafts on the project. Eight tubes should be installed in all 8-foot or larger diameter drilled shafts. The CSL testing should be performed in one shaft for every two shafts for each pier supported on drilled shafts. Additional CSL testing should be performed in the event the construction QC/QA documentation indicates a problem may exist.

Based on 2012 AASHTO LRFD Bridge Design Specifications, nominal and factored unit tip resistances for the drilled shaft socketed 8, 12 and 16 feet into bedrock are shown in Table 19. The unit tip resistance is a function of compressive strength of intact rock (Q_u), Rock Mass Rating (RMR) and Rock Quality Designation (RQD). The variations in unit tip resistances are due to variation in RMR, RQD and unconfined compressive strength of the rock. Since the rock is stronger than concrete, the concrete compressive strength controls the available side resistance. The 2012 IDOT Standard Specifications requires concrete compressive strength of 4,000 psi for the drilled shafts. The nominal unit side resistance is 22.7 ksf considering concrete compressive strength (Qu) of 4,000 psi. The factored unit side resistance is 11.35 ksf considering resistance factor of 0.50. Side resistance from the overburden soils should be neglected. As per 2012 IDOT Bridge Manual drilled shafts extending into rock, in most cases, should be designed utilizing only end bearing or side resistance in rock, whichever is larger. The rock core data at Piers 1 through 11 is shown in Exhibits 3-1 through 3-11.

4.3 East Abutment

Driven Piles

The abutment will be supported on driven H-piles. The most common types of H-piles used for a bridge structure are steel H-piles designed as friction piles or driven to the bedrock. The H-piles designed as friction piles could be considered. However, by driving a few more feet to the top of or several inches into the bedrock, the Maximum NRB (maximum allowable structural pile capacity) can also be obtained.

The Maximum NRB and Factored Resistance Available (FRA) for the most common H-pile sizes are shown in Table 20 for LRFD design as per IDOT 2012 Bridge Manual. H-pile length estimates are considering one foot into the pile footing and assuming that H-piles would penetrate 2.5 feet into the shale bedrock. Since no increase in roadway profile is proposed, there will not be any settlements of the soil surrounding the piles and thus allowance for downdrag load and precoring will not be required. There will not be any pile capacity reduction due to the scour. All H-piles should be driven with pile shoe.

The most economical pile sizes should be selected. Two test piles (one for each bound of traffic) should be identified on the plans which should be installed prior to production pile installation. There is no need for a full scale load test.

4.4 Resistance to Lateral Loads

Lateral loads on piles and drilled shafts should be analyzed for maximum moments and lateral deflections. A geotechnical resistance factor of 1.0 should be used. No allowance should be made for the frictional resistance of the concrete cap on soil. The lateral load capacity analysis can be performed using a computer program such as COMP 624P, LPILE, LATPILE, or any other similar programs. The estimated soil parameters that may be used to analyze stresses and deflections of piles and drilled shafts under lateral loads are presented in Tables 21 through 33.

Group action should be considered for piles in soils in calculating total lateral load resistance of the substructures. Group action is not needed for drilled shafts socketed into bedrock.

The drilled shafts for the piers should be designed so that the shaft length after the design scour event satisfies the required axial and lateral resistance. The soil lost due to scour should not be considered in contributing the overburden stress.

The analysis and recommendations submitted in this memorandum are based upon the data obtained from the borings drilled and field tests performed at the locations shown in Exhibit 2. This memorandum does not reflect any variations that may occur between the borings or elsewhere on the site, variations whose nature and extent may not become evident until the course of construction. In the event that any changes in the design and/or location of the bridge are planned, we should be timely informed so that our recommendations can be adjusted accordingly.

It has been a pleasure to assist Parsons and the Illinois Department of Transportation on this project. Please call if there are any questions, or if we can be of further service.

Respectfully Submitted,

WANG ENGINEERING, INC.

Mohammed A. Kothawala, P.E., D.GE	Jerry W.H. Wang, PhD., P.E.
Sr. Project Manager/Sr. Geotechnical Engineer	QA/QC Reviewer

REFERENCES

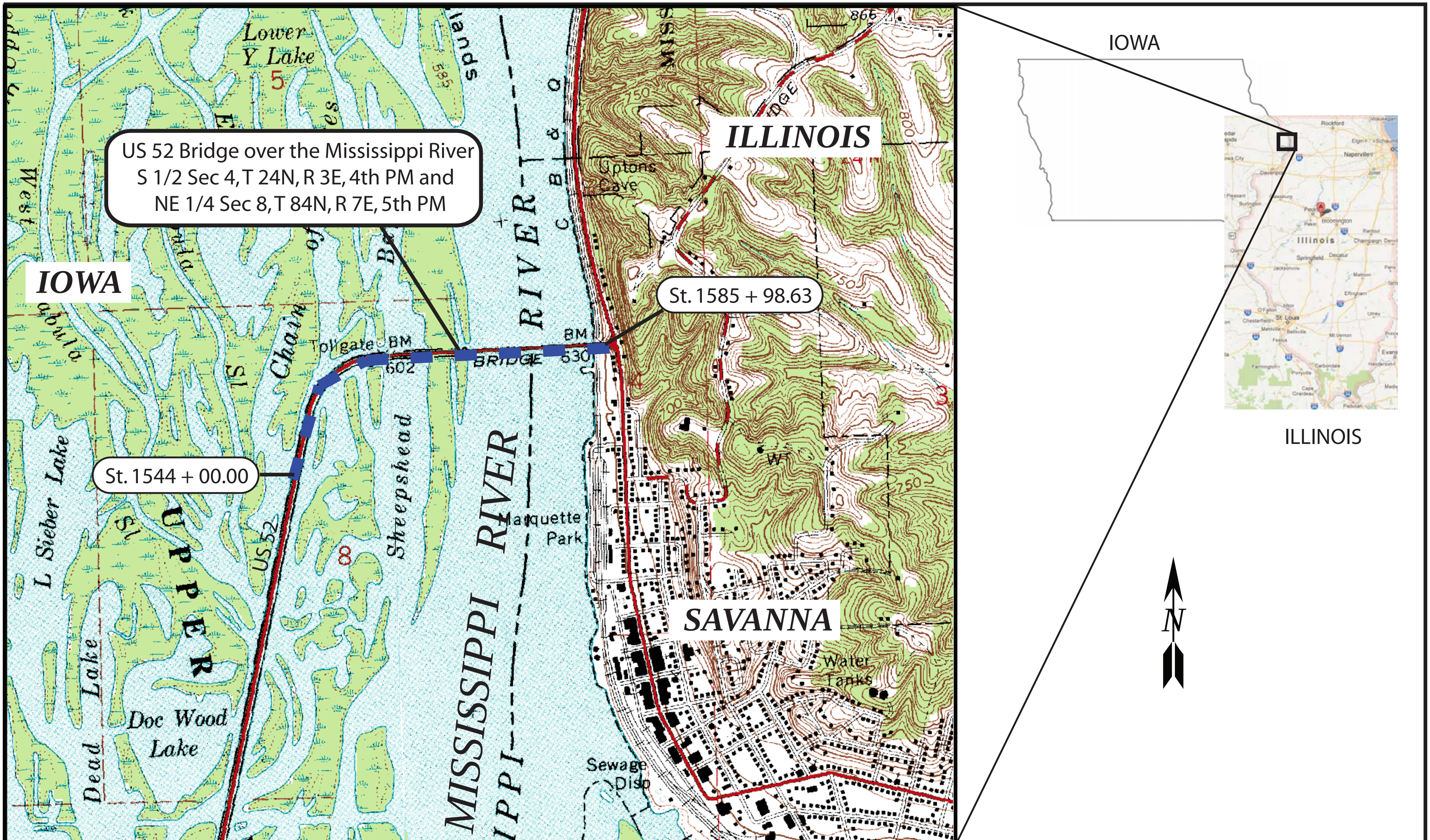
AMERICAN ASSOCIATION OF STATE HIGHWAY TRANSPORTATION OFFICIALS (2012) *LRFD Bridge Design Specifications*. United States Department of Transportation, Washington, D.C.

ILLINOIS DEPARTMENT OF TRANSPORTATION (1999) *Geotechnical Manual.* IDOT Bureau of Materials and Physical Research, Springfield, IL.

ILLINOIS DEPARTMENT OF TRANSPORTATION (2012) *Standard Specifications for Road and Bridge Construction.* IDOT Division of Highways, Springfield, IL.

ILLINOIS DEPARTMENT OF TRANSPORTATION (2012) *Bridge Manual.* IDOT Bureau of Bridges and Structures, Springfield, IL.

EXHIBITS



0 0.25 0.5 0.75 1 miles

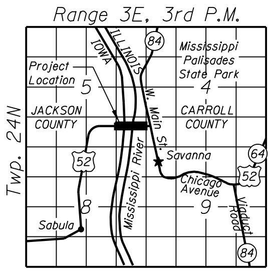
SITE LOCATION MAP: US 52 OVER THE MISSISSIPPI RIVER, CARROLL COUNTY, ILLINOIS and JACKSON COUNTY, IOWA		
SCALE: GRAPHICAL	EXHIBIT 1	DRAWN BY: A. Happel CHECKED BY: C. Marin
Wang Engineering		1145 N. Main Street Lombard, IL 60148 www.wangeng.com
FOR PARSONS		342-06-01

THIS EXHIBIT IS TO BE USED FOR BORING LOCATION ONLY

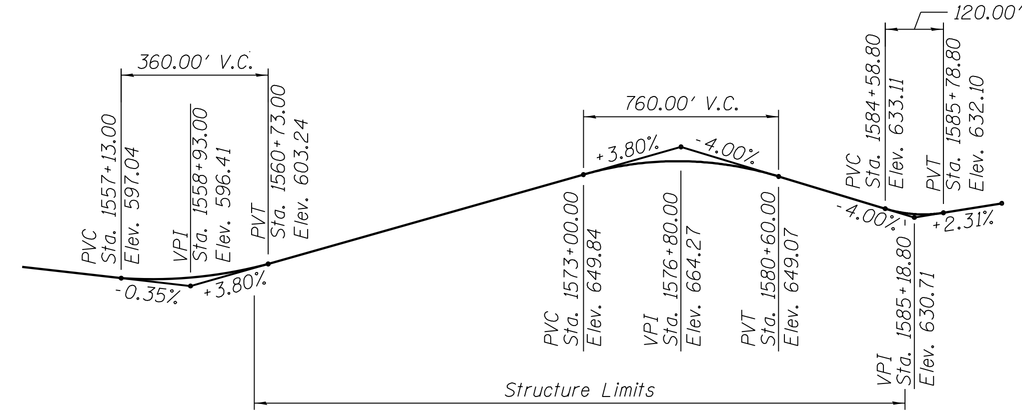
Benchmark:
BM CP5 - Concrete pedestal set south of the west abutment of Illinois River Bridge SN 008-6000 on US 52 @ Savanna @ Sta. 1560+65.46; Offset 24.85' Lt. NAVD 88 = 597.891 Ft.

Existing Structure: SN 008-6000 Steel girder, steel truss and concrete slab superstructure bridge on pile bents and piers. Approximately 50' to 100' upstream. Approximately 2470' long by 20' wide. Constructed in 1932.
To be removed after new structure is complete.
Traffic Control: none
No Salvage

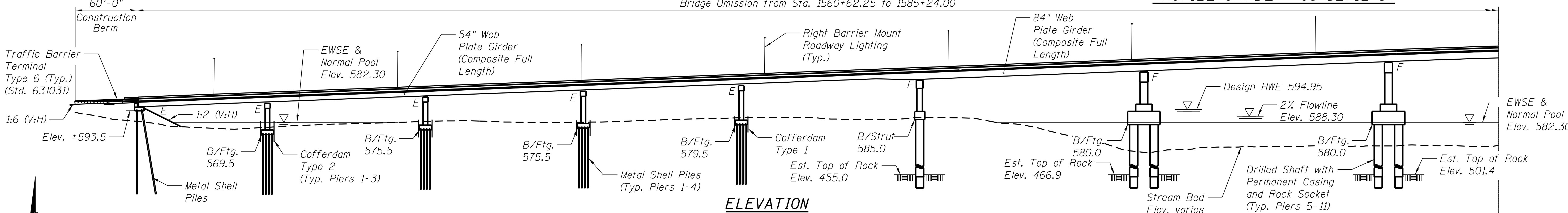
Notes:
1. All Elevations are given in NAVD 1988 Datum unless noted. NAVD 1988 = NGVD 1929 - 0.10'.
2. EWSE = Estimated Water Surface Elevation.
3. HWE = High Water Elevation.
4. For ground elevations see Sheet 5.
5. Denotes soil boring
   Cone Penetration Test (CPT)
   Geophysical survey
6. For scupper type see Cross Sections on Sheet 3 & 4.
7. Proposed lighting unit: 35 ft. aluminum pole, 8 ft. davit arm, 250W HPS luminaire, MC2 distribution, mounted on bridge parapet wall.
8. Lighting unit is subject to refinement during the design phase.
9. For Section A-A see Sheet 5.



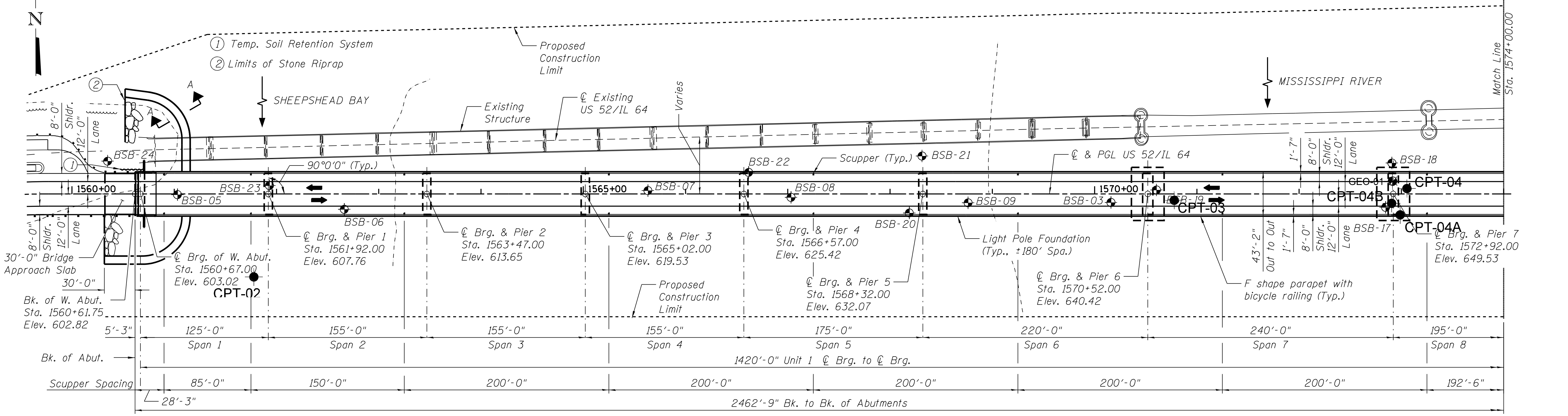
LOCATION SKETCH



PROFILE GRADE - US 52/IL 64



ELEVATION



PLAN

SEISMIC DATA

Seismic Performance Zone (SPZ) = 1
Design Spectral Acceleration at 1.0 sec. (S_{D1}) = 0.119g
Design Spectral Acceleration at 0.2 sec. (S_{DS}) = 0.161g
Soil Site Class = D (West Abut., Piers 1-8)
Design Spectral Acceleration at 1.0 sec. (S_{D1}) = 0.084g
Design Spectral Acceleration at 0.2 sec. (S_{DS}) = 0.121g
Soil Site Class = C (Piers 9-11, East Abut.)

HIGHWAY CLASSIFICATION

US 52/IL 64 (FAP 17)
Functional Class: Minor Arterial (Non-urban)
ADT: 2200 (2015); 2400 (2035)
ADTT: 230 (2015); 250 (2035)
DHV: 240
Design Speed: 45 m.p.h.
Posted Speed: 40 m.p.h.
Two-Way Traffic
Directional Distribution: 50/50

BORING LOCATION PLAN: US 52/IL 64 OVER THE MISSISSIPPI RIVER, CARROLL COUNTY, ILLINOIS and JACKSON COUNTY, IOWA

Date: 10/30/14	EXHIBIT 2-1	DRAWN BY: C. Marin CHECKED BY: M. Kothawala

Wang Engineering
1145 N. Main Street
Lombard, IL 60148
www.wangeng.com

FOR PARSONS ENGINEERING GROUP, INC — 342-06-01

GENERAL PLAN & ELEVATION - 1
US 52/IL 64 OVER THE MISSISSIPPI RIVER
PUBLIC WATER
F.A.P. RTE. 17 - SEC. 104B-2
CARROLL (IL) AND JACKSON (IA) COUNTIES
STATION 1577+60.00
STRUCTURE NO. 008-0052

FILE NAME =	USER NAME =	DESIGNED - TSB	REVISED
PARSONS	DATE = 2/10/2014	CHECKED - GTH	REVISED
	PLOT SCALE =	DRAWN - TSB	REVISED
	PLOT DATE =	CHECKED - GTH	REVISED

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

SHEET NO. 1 OF 5 SHEETS

F.A. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
17	104B-2	Carroll		

CONTRACT NO. 64G59
ILLINOIS FED. AID PROJECT

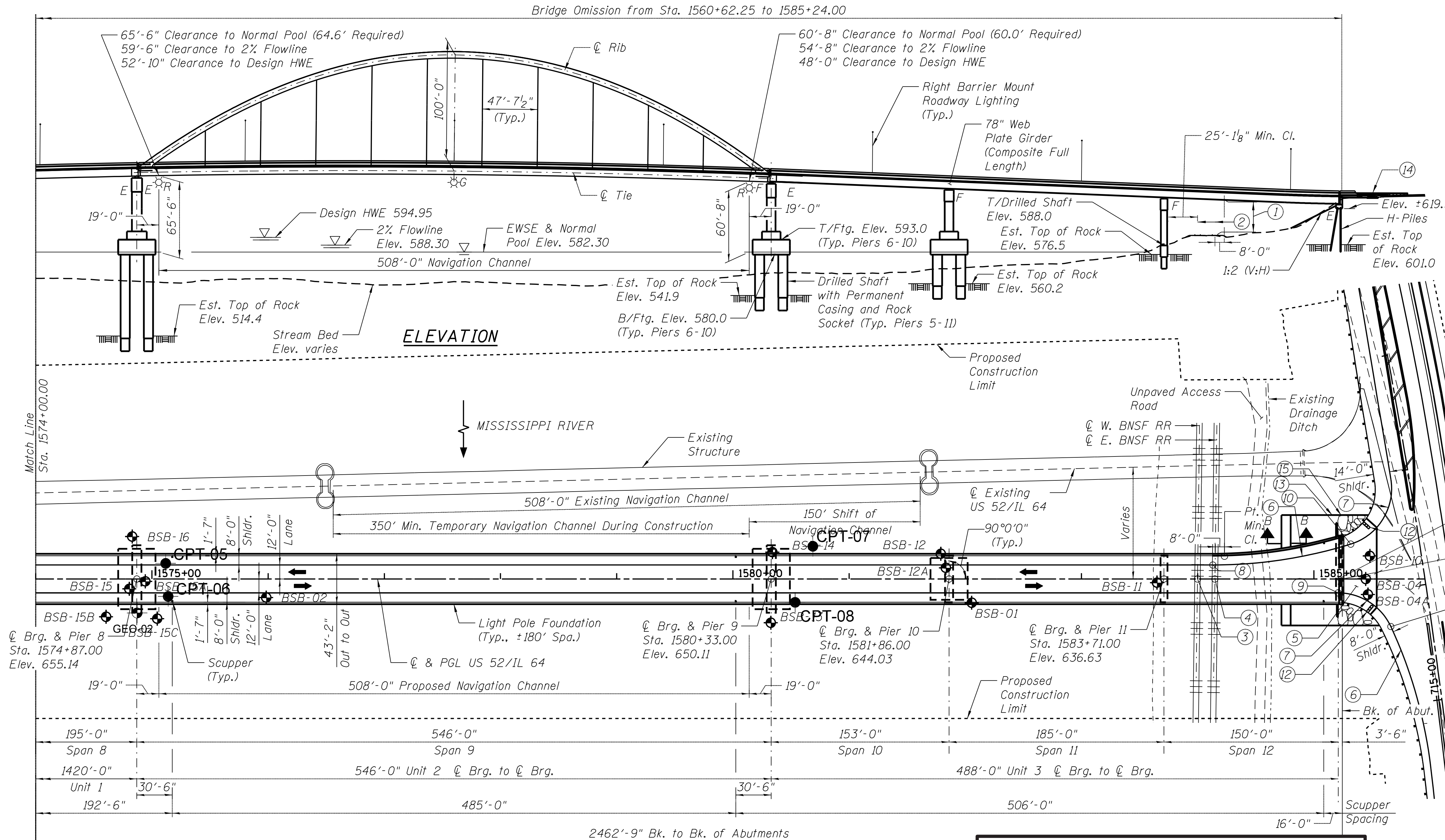
THIS EXHIBIT IS TO BE USED FOR BORING LOCATION ONLY

Notes:
1. All Elevations are given in NAVD 1988 Datum unless noted.
2. EWSE = Estimated Water Surface Elevation.
3. HWE = High Water Elevation.
4. For ground elevations see Sheet 5.
5. Denotes soil boring.
Cone Penetration Test (CPT)
Geophysical survey
6. For scupper type see Cross Sections on Sheet 3 & 4.
7. Proposed lighting unit: 35 ft. aluminum pole, 8 ft. davit arm, 250W HPS luminaire, MC2 distribution, mounted on bridge parapet wall.
8. Lighting unit is subject to refinement during the design phase.
9. No freefall deck drains will be permitted in the span over the tracks or within 10 ft. of cross arms of a railroad pole line.
10. For Section B-B see Sheet 5.

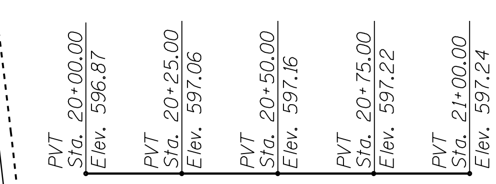
WATERWAY INFORMATION

Drainage Area = 85,500 sq. mi. Low Grade Elev. 596.98 @ Sta. 1557+43.0

Flood	Freq. Yr.	Q C.F.S.	Opening Sq. Ft. Exist.	Opening Sq. Ft. Prop.	Nat. H.W.E.	Head - Ft. Exist.	Head - Ft. Prop.	Headwater El. Exist.	Headwater El. Prop.
Ten-Year	10	202,000	93,196.8	93,292.9	591.67	0.00	0.01	591.68	591.69
Design	50	259,000	122,842.9	122,919.8	594.94	0.00	0.01	594.94	594.95
Base	100	281,290	133,150.7	133,204.0	596.07	0.00	0.00	596.07	596.07
Max. Calc.	500	337,000	154,320.5	154,357.4	598.21	0.00	0.00	598.21	598.21



(1) 29'-0" Min. Cl.
(2) ℄ BNSF RR
(3) Sta. 1583+99.86 US 52/IL 64 = Sta. 20+50.00 W. BNSF RR
(4) Sta. 1584+14.86 US 52/IL 64 = Sta. 10+50.00 E. BNSF RR
(5) 30'-0" Bridge Approach Slab
(6) 400' Radius
(7) 50' Radius
(8) Sta. 1584+13.02; Offset 12.00' Lt., Begin Lane Taper
(9) Sta. 1585+20.87; Offset 12.00' Rt., Begin Lane Taper
(10) Sta. 1585+31.71; Offset 30.01' Lt., Lane Taper Radius Transition
(11) Sta. 1585+66.22; Offset 40.95' Rt., Lane Taper Radius Transition
(12) Bridge Approach Pavement Drain (Standard 609006-05)
(13) Limits of Stone Riprap
(14) Traffic Barrier Terminal Type 6 (Typ.) (Std. 631031)
(15) Riprap extended 20' perpendicular to roadway at back of abutment (Typ.)



PROFILE GRADE - W. BNSF RR

DESIGN SCOUR ELEVATION TABLE

Design Scour Elevation (ft.)	West Abut.	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5	Pier 6	Pier 7	Pier 8	Pier 9	Pier 10	Pier 11	East Abut.
Q100	593.5	555.4	558.1	565.7	567.0	520.6	505.8	509.1	520.6	541.9	560.2	576.5	619.3
Q500	593.5	553.4	556.2	563.7	565.0	519.6	503.8	507.1	519.6	541.9	560.2	576.5	619.3

BORING LOCATION PLAN: US 52/IL 64 OVER THE MISSISSIPPI RIVER, CARROLL COUNTY, ILLINOIS and JACKSON COUNTY, IOWA

Date: 10/30/14 | **EXHIBIT 2-2** | DRAWN BY: C. Marin | CHECKED BY: M. Kothawala

Wang Engineering
1145 N. Main Street
Lombard, IL 60148
www.wangeng.com

FOR PARSONS ENGINEERING GROUP, INC | 342-06-01

GENERAL PLAN & ELEVATION - 2
US 52/IL 64 OVER THE MISSISSIPPI RIVER
PUBLIC WATER
F.A.P. RTE. 17 - SEC. 104B-2
CARROLL (IL) AND JACKSON (IA) COUNTIES
STATION 1577+60.00
STRUCTURE NO. 008-0052

FILE NAME =
PARSONS
USER NAME = | DESIGNED - PY | REVISED
DATE = 2/10/2014 | CHECKED - GTH | REVISED
PLOT SCALE = | DRAWN - TSB | REVISED
PLOT DATE = | CHECKED - GTH | REVISED

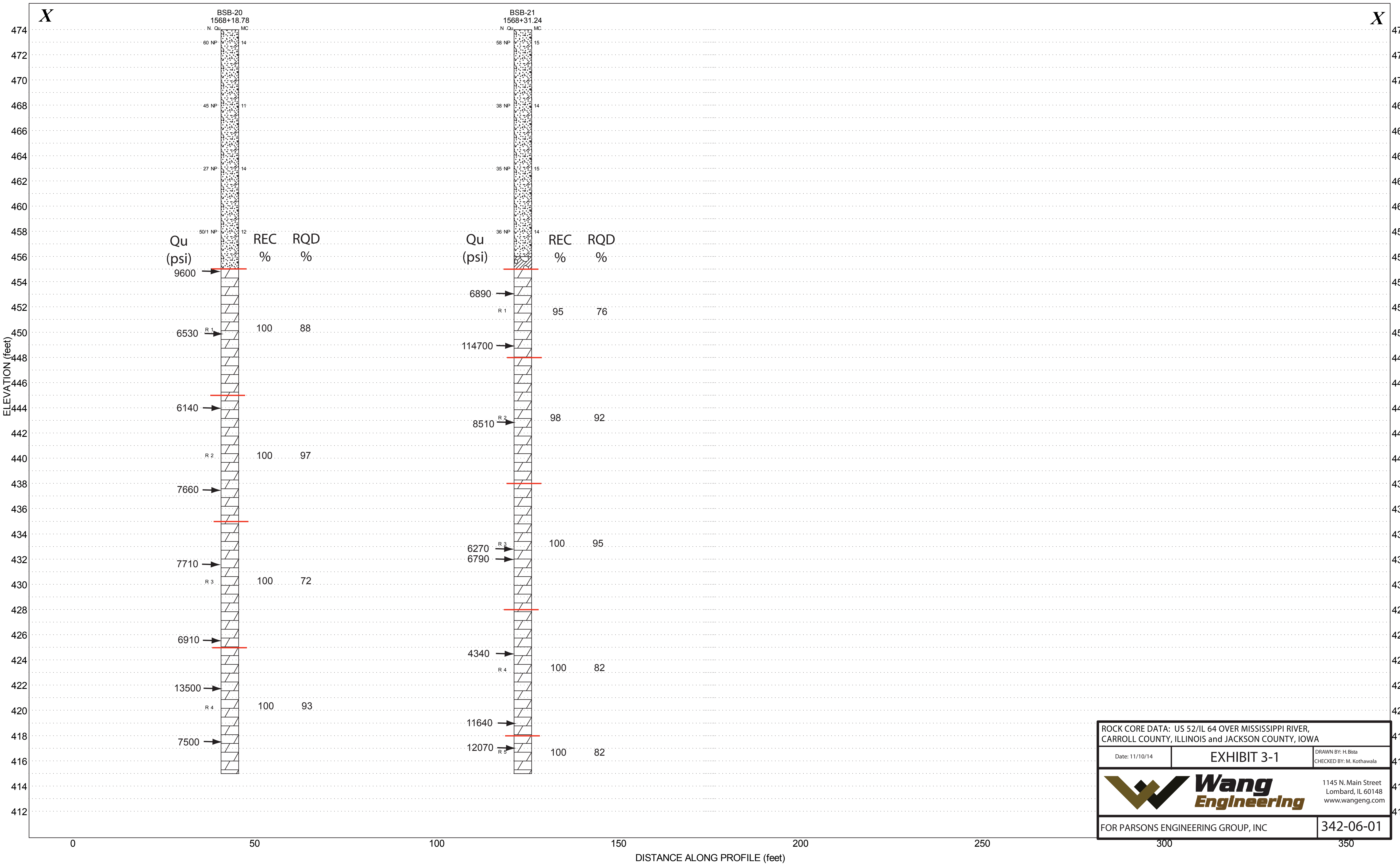
STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

SHEET NO. 2 OF 5 SHEETS

F.A. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
17	104B-2	Carroll		

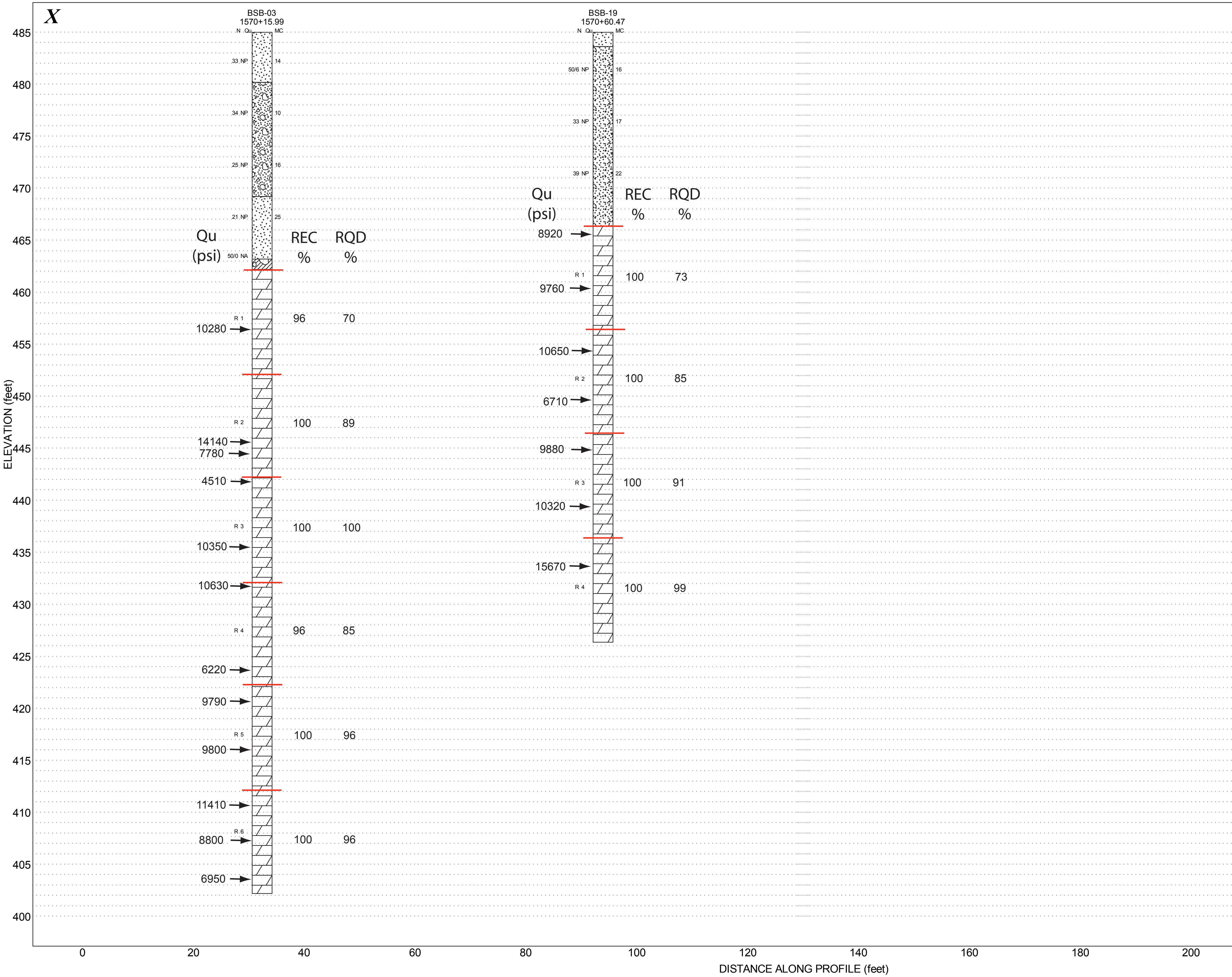
CONTRACT NO. 64G59
ILLINOIS FED. AID PROJECT

PIER 5



BSB-20
1568+18.78
BSB-21
1568+31.24
Qu (psi)
REC %
RQD %
9600
6530
6140
7660
7710
6910
13500
7500
R 1
R 2
R 3
R 4
100 88
100 97
100 72
100 93
6890
114700
8510
6270
6790
4340
11640
12070
R 1
R 2
R 3
R 4
R 5
95 76
98 92
100 95
100 82
100 82
ELEVATION (feet)
DISTANCE ALONG PROFILE (feet)
ROCK CORE DATA: US 52/IL 64 OVER MISSISSIPPI RIVER, CARROLL COUNTY, ILLINOIS and JACKSON COUNTY, IOWA
Date: 11/10/14
EXHIBIT 3-1
DRAWN BY: H.Bista
CHECKED BY: M. Kothawala
Wang Engineering
1145 N. Main Street
Lombard, IL 60148
www.wangeng.com
FOR PARSONS ENGINEERING GROUP, INC
342-06-01

PIER 6



ROCK CORE DATA: US 52/IL 64 OVER MISSISSIPPI RIVER, CARROLL COUNTY, ILLINOIS and JACKSON COUNTY, IOWA

Date: 11/10/14

EXHIBIT 3-2

DRAWN BY: H.Bista
CHECKED BY: C. Marin

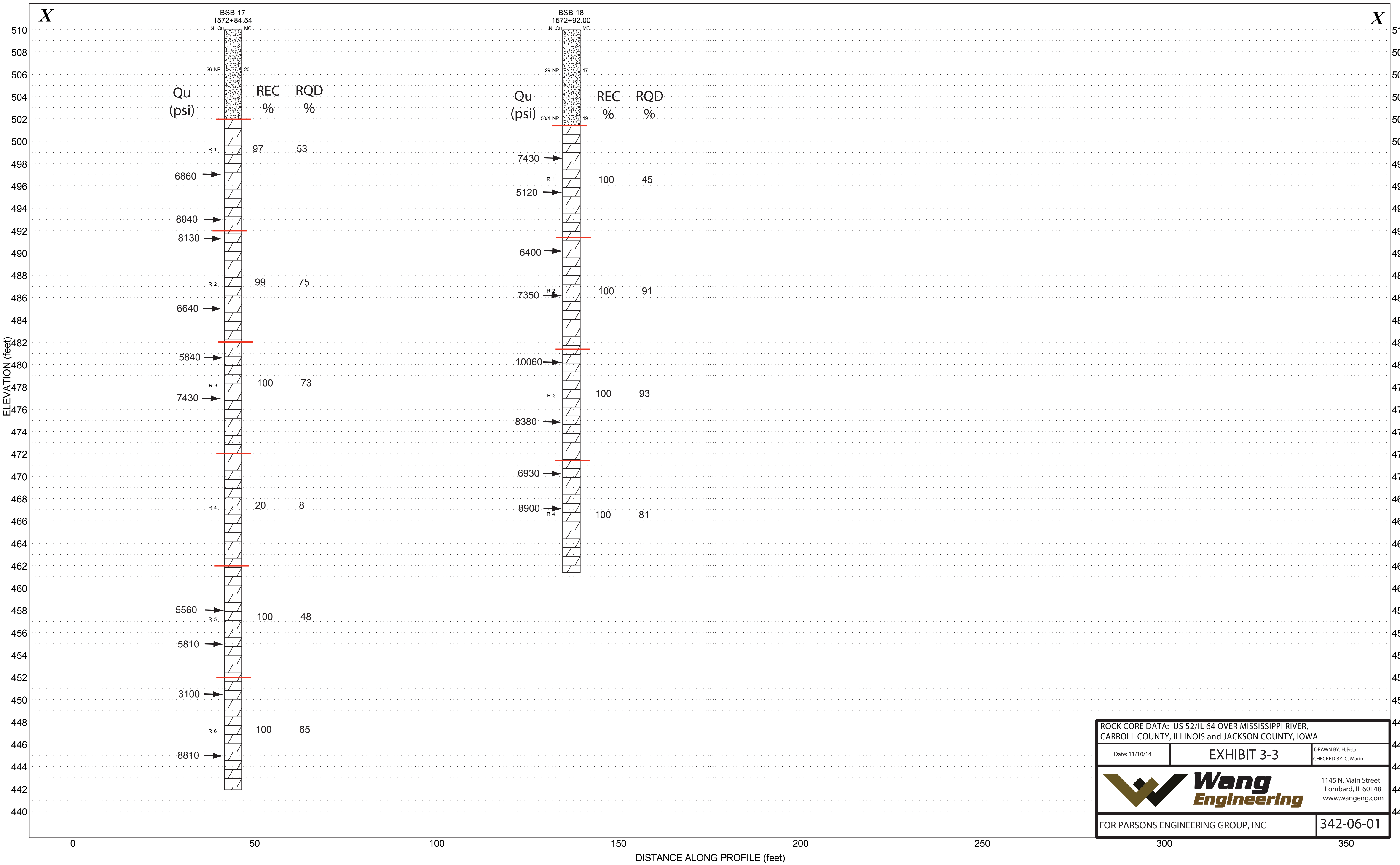
Wang Engineering

1145 N. Main Street
Lombard, IL 60148
www.wangeng.com

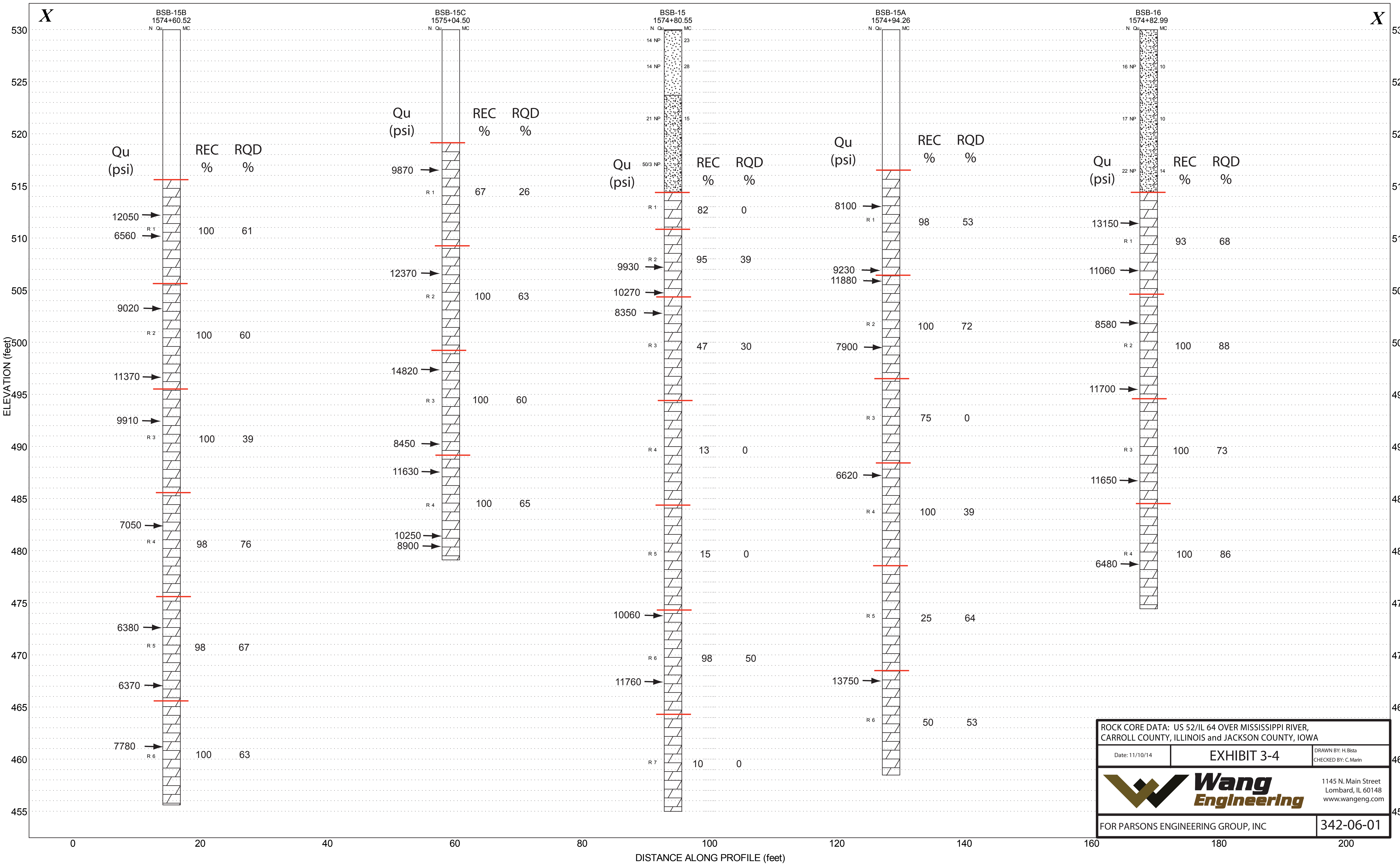
FOR PARSONS ENGINEERING GROUP, INC

342-06-01

PIER 7

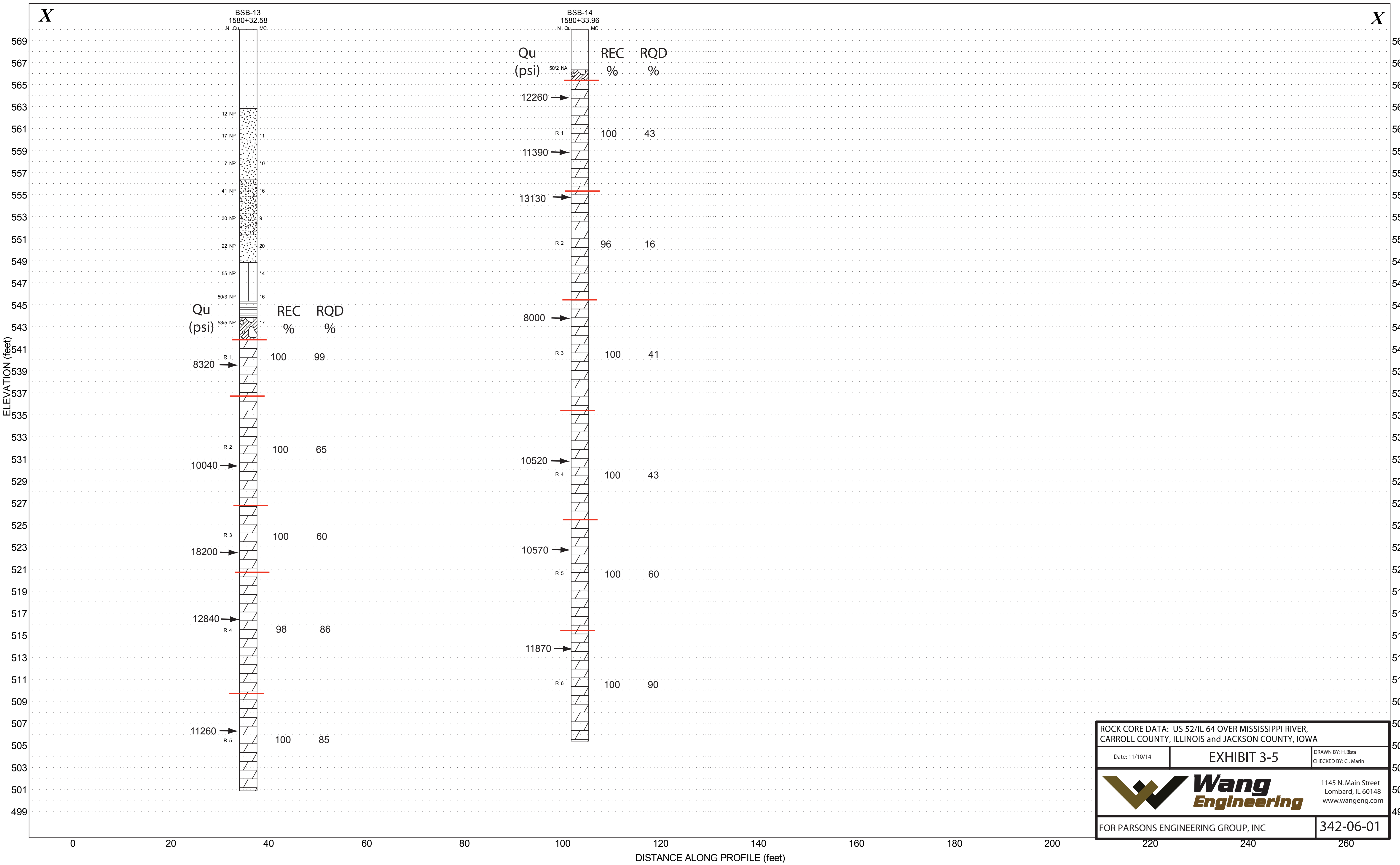

X
X
BSB-17
1572+84.54
BSB-18
1572+92.00
Qu (psi)
REC %
RQD %
R 1 97 53
6860
8040
8130
R 2 99 75
6640
5840
R 3 100 73
7430
R 4 20 8
5560
R 5 100 48
5810
3100
R 6 100 65
8810
7430
R 1 100 45
5120
6400
R 2 100 91
7350
10060
R 3 100 93
8380
6930
8900
R 4 100 81
ELEVATION (feet)
DISTANCE ALONG PROFILE (feet)
ROCK CORE DATA: US 52/IL 64 OVER MISSISSIPPI RIVER, CARROLL COUNTY, ILLINOIS and JACKSON COUNTY, IOWA
Date: 11/10/14
EXHIBIT 3-3
DRAWN BY: H.Bista
CHECKED BY: C. Marin
Wang Engineering
1145 N. Main Street
Lombard, IL 60148
www.wangeng.com
FOR PARSONS ENGINEERING GROUP, INC
342-06-01

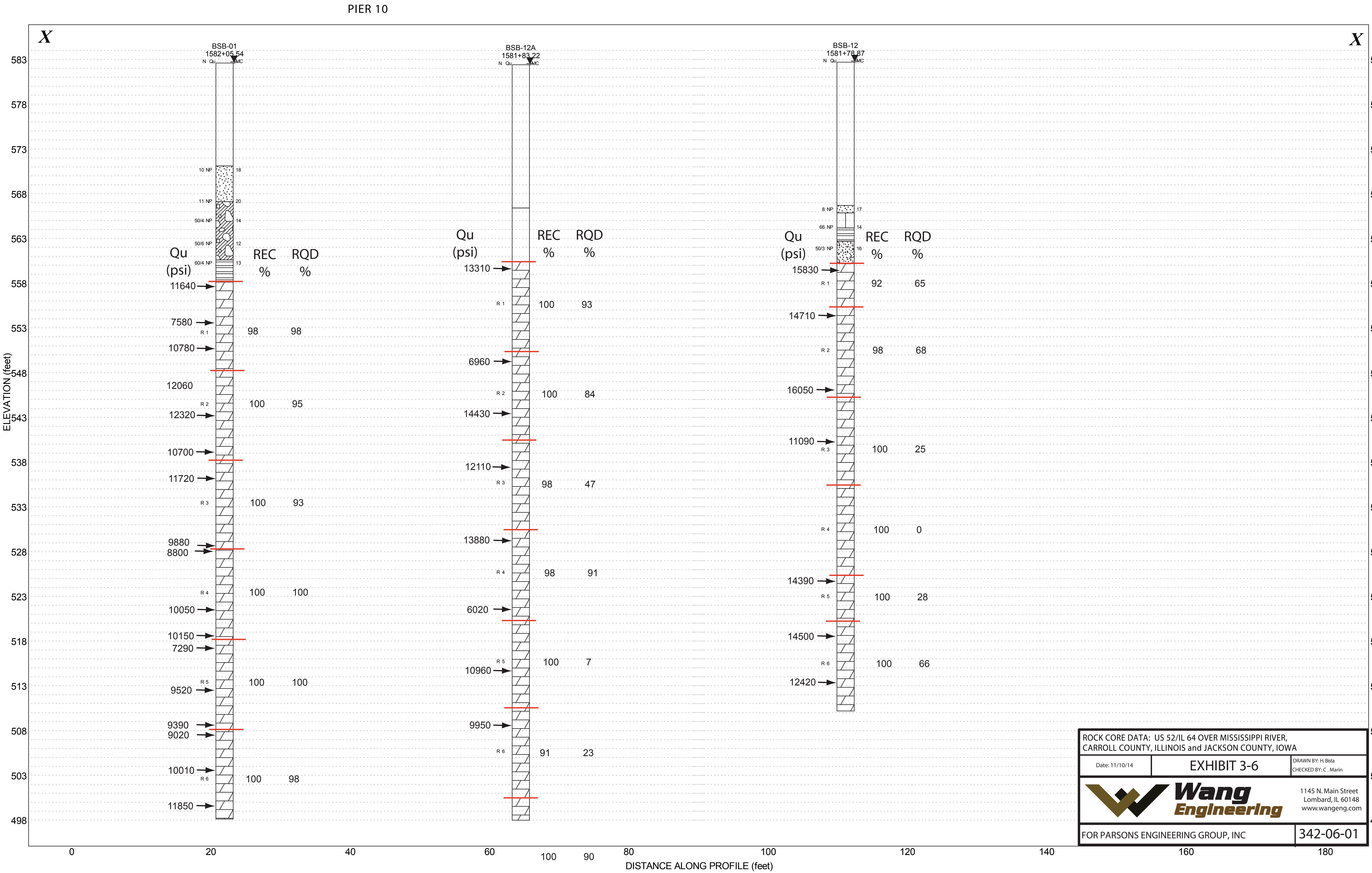
PIER 8



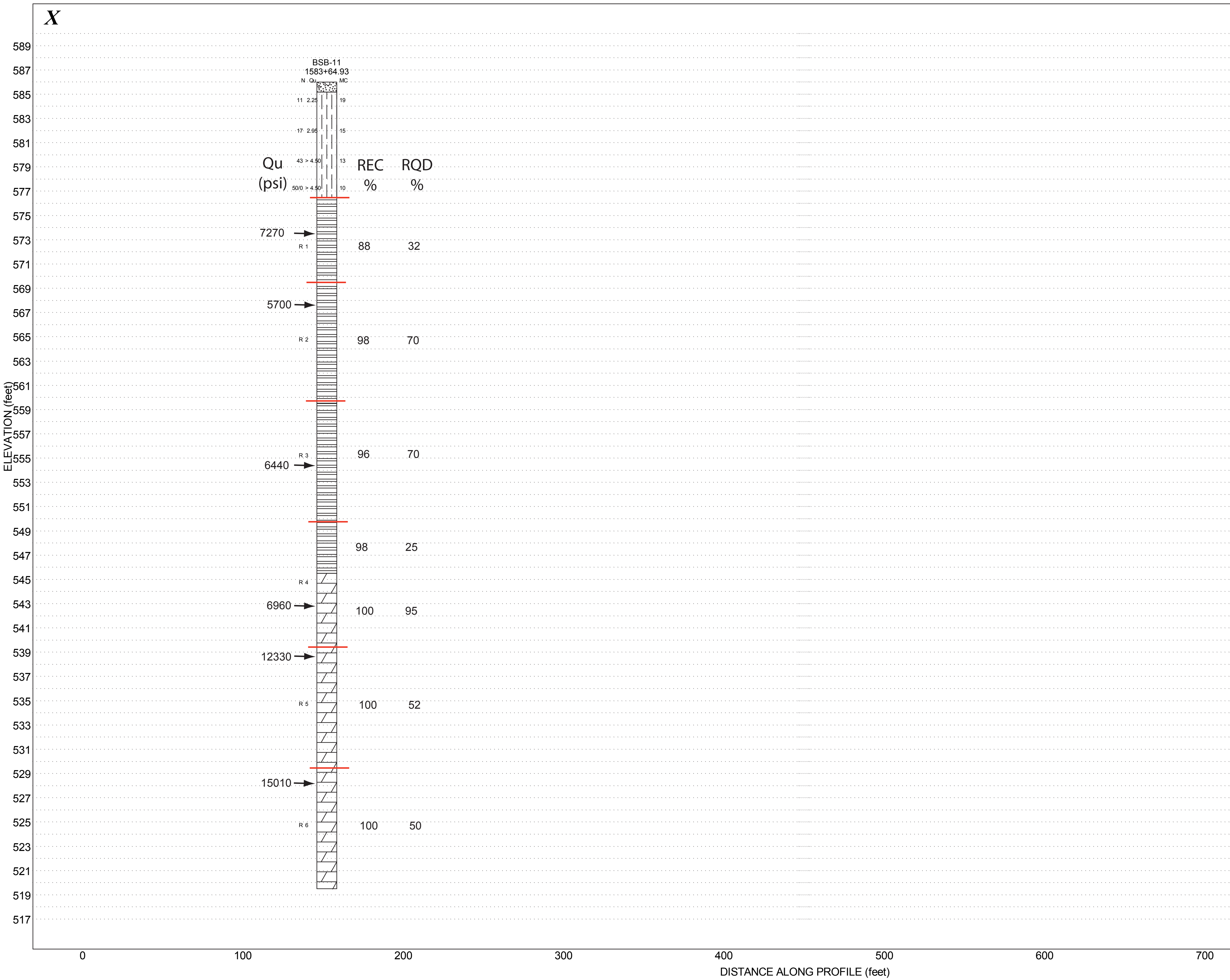
X
BSB-15B
1574+60.52
BSB-15C
1575+04.50
BSB-15
1574+80.55
BSB-15A
1574+94.26
BSB-16
1574+82.99
Qu (psi)
REC %
RQD %
ELEVATION (feet)
DISTANCE ALONG PROFILE (feet)
ROCK CORE DATA: US 52/IL 64 OVER MISSISSIPPI RIVER,
CARROLL COUNTY, ILLINOIS and JACKSON COUNTY, IOWA
Date: 11/10/14
EXHIBIT 3-4
DRAWN BY: H.Bista
CHECKED BY: C.Marin
Wang Engineering
1145 N. Main Street
Lombard, IL 60148
www.wangeng.com
FOR PARSONS ENGINEERING GROUP, INC
342-06-01

PIER 9


X
X
BSB-13
1580+32.58
BSB-14
1580+33.96
Qu
(psi)
REC
%
RQD
%
8320
100
99
10040
100
65
18200
100
60
12840
98
86
11260
100
85
12260
100
43
11390
13130
96
16
8000
100
41
10520
100
43
10570
100
60
11870
100
90
ELEVATION (feet)
DISTANCE ALONG PROFILE (feet)
ROCK CORE DATA: US 52/IL 64 OVER MISSISSIPPI RIVER,
CARROLL COUNTY, ILLINOIS and JACKSON COUNTY, IOWA
Date: 11/10/14
EXHIBIT 3-5
DRAWN BY: H.Bista
CHECKED BY: C. Marin
Wang Engineering
1145 N. Main Street
Lombard, IL 60148
www.wangeng.com
FOR PARSONS ENGINEERING GROUP, INC
342-06-01


PIER 10
X
X
BSB-01
1582+05.54
BSB-12A
1581+83.22
BSB-12
1581+78.87
ELEVATION (feet)
583
578
573
568
563
558
553
548
543
538
533
528
523
518
513
508
503
498
Qu (psi)
REC %
RQD %
11640
7580
R 1
98
98
10780
12060
R 2
100
95
12320
10700
11720
R 3
100
93
9880
8800
R 4
100
100
10050
10150
7290
R 5
100
100
9520
9390
9020
10010
R 6
100
98
11850
13310
R 1
100
93
6960
R 2
100
84
14430
12110
R 3
98
47
13880
R 4
98
91
6020
R 5
100
7
10960
9950
R 6
91
23
15830
R 1
92
65
14710
R 2
98
68
16050
11090
R 3
100
25
R 4
100
0
14390
R 5
100
28
14500
R 6
100
66
12420
0
20
40
60
80
100
120
140
160
180
100
90
DISTANCE ALONG PROFILE (feet)
ROCK CORE DATA: US 52/IL 64 OVER MISSISSIPPI RIVER, CARROLL COUNTY, ILLINOIS and JACKSON COUNTY, IOWA
Date: 11/10/14
EXHIBIT 3-6
DRAWN BY: H.Bista
CHECKED BY: C. Marin
Wang Engineering
1145 N. Main Street
Lombard, IL 60148
www.wangeng.com
FOR PARSONS ENGINEERING GROUP, INC
342-06-01

PIER 11



ROCK CORE DATA: US 52/IL 64 OVER MISSISSIPPI RIVER, CARROLL COUNTY, ILLINOIS and JACKSON COUNTY, IOWA

Date: 11/10/14	EXHIBIT 3-7	DRAWN BY: H.Bista CHECKED BY: C. Marin

Wang Engineering
1145 N. Main Street
Lombard, IL 60148
www.wangeng.com

FOR PARSONS ENGINEERING GROUP, INC | 342-06-01

TABLES

Wang Engineering

Table 1: Preliminary Foundation Loads

Location	***Estimated Total Service DL (kips)***	***Estimated Total Service LL (kips)***	***Estimated Total Service Load (DL + LL) (kips)***	***Estimated Total Factored DL (kips)***	***Estimated Total Factored LL (kips)***	***Estimated Total Factored Load (DL + LL) (kips)***
W Abut	905	265	1170	1155	460	1615
Pier 1	2690	560	3250	3450	980	4430
Pier 2	2640	570	3210	3380	1000	4380
Pier 3	2700	580	3280	3460	1020	4480
Pier 4	2740	600	3340	3510	1050	4560
Pier 5	2630	680	3310	3390	1190	4580
Pier 6	6630	720	7350	8420	1260	9680
Pier 7	6910	715	7625	8780	1255	10035
Pier 8	10370	855	11225	13230	1500	14730
Pier 9	10135	825	10960	12925	1445	14370
Pier 10	5160	595	5755	6555	1045	7600
Pier 11	2450	595	3045	3170	1045	4215
E Abut	1220	295	1515	1525	510	2035

Notes:

DL and LL are approximate.

DL and LL are calculated at the top of drilled shafts and pile

Table 2: Lateral Vessel Collision Loads

Pier	**Vessel Collision Load (kips)**	**Elevation of Load (feet)**
6	2600	588.3
7	2800	588.3
8	3000	588.3
9	3000	588.3
10	2800	588.3
11	600	596.1

Table 3: Estimated Soil Parameters from Sounding CPT-01/Boring BSB-24
West Abutment

Soil ID	Elevation Range (feet)	Relative Density (%)	Correlated SPT Value (blow/foot)	Estimated Friction Angle (°)	Estimated Young's Modulus (ksf)
Soft CLAYEY SILT	Surface to 577 feet	NA	0 to 4	NA	0.6
Loose SILTY SAND	577 to 562 feet	20 to 30	5 to 10	32	300
M Dense to Dense SAND	562 to 540 feet	50 to 60	20 to 25	36	2000
Loose to M Dense SILTY SAND	540 to 528 feet	30 to 40	5 to 7	32	300
M Dense to Dense SAND	528 feet to Bottom	50 to 60	20 to 25	36	2000

Table 4: Estimated Soil Parameters from Sounding CPT-02/Boring BSB-06
Piers 1 through 5

Soil ID	Elevation Range (feet)	Relative Density (%)	Correlated SPT Value (blow/foot)	Estimated Friction Angle (°)	Estimated Young's Modulus (ksf)
V Soft SILT (Sediment)	Surface to 568 feet	NA	0 to 1	NA	0.6
Loose SANDY SILT	568 to 561 feet	20 to 30	4 to 6	30	300
M Dense to Dense SAND	561 to 532 feet	50 to 60	20 to 25	36	2000
Loose SANDY SILT	532 to 525 feet	30 to 40	5 to 7	32	300
M Dense to Dense SAND	525 feet to Bottom	50 to 60	20 to 25	36	2000

Table 5: Estimated Soil Parameters from Sounding CPT-03/Boring BSB-03
Piers 6 and 7

Soil ID	Elevation Range (feet)	Relative Density (%)	Correlated SPT Value (blow/foot)	Estimated Friction Angle (°)	Estimated Young's Modulus (ksf)
Loose SANDY SILT (Sediment)	Surface to 552 feet	NA	2 to 4	NA	120
M Dense SAND	552 to 540 feet	30 to 40	15 to 20	34	1000
M Dense to Dense SAND	540 to 535 feet	50 to 60	20 to 25	36	2000
M Dense SAND	535 to 526 feet	30 to 40	15 to 20	34	1000
M Dense to Dense SAND	526 to 517 feet	50 to 60	20 to 25	36	2000

Table 6: Estimated Soil Parameters from Sounding CPT-05 and CPT-06/Boring BSB-02
Pier 8

Soil ID	Elevation Range (feet)	Relative Density (%)	Correlated SPT Value (blow/foot)	Estimated Friction Angle (°)	Estimated Young's Modulus (ksf)
Loose SANDY SILT (Sediment)	Surface to 551 feet	NA	2 to 4	NA	120
M Dense SAND	551 to 540 feet	30 to 40	15 to 20	34	1000
M Dense to Dense SAND	540 feet to Bottom	50 to 60	20 to 25	36	2000

Table 7: Summary of Seismic Shear Wave Velocity Testing in Sounding BSB-24 CPT-02

Seismic Test ID	Depth Range (feet)	Elevation Range (feet)	Seismic Velocity Range, v_s (feet/second)	Seismic Velocity Average, v_s (feet/second)
1 through 9	11 to 38	587 to 560	288 to 483	359
10 and 11	38 to 51	560 to 547	608 to 645	627
12 through 29	51 to 112	547 to 486	688 to 1231	921

Table 8: Estimated Pile Lengths and Tip Elevations
West Abutment
Bottom of Footing Elevation: 593.50
12-inch Dia. Metal Shell Pile

Pile Size	Nominal Required Bearing (kips)	Factored Geotechnical Loss from Downdrag (kips)	Factored Geotechnical Loss Load from Downdrag (kips)	Factored Resistance Available (kips)	Total Estimated Pile Length (feet)	Estimated Pile Tip Elevation (feet)
0.179-inch wall	215	13	26	80	63	531.5
	233	13	26	90	68	526.5
	254*	13	26	101	74	520.5
0.250-inch wall	215	13	26	80	63	531.5
	233	13	26	90	68	526.5
	251	13	26	100	73	521.5
	270	13	26	110	76	518.5
	288	13	26	120	79	515.5
	306	13	26	130	81	513.5
	325	13	26	140	82	512.5
	353**	13	26	157	86	508.5

* Maximum NRB for 0.179-inch wall

** Maximum NRB for 0.250-inch wall

Wang Engineering

Table 9: Estimated Pile Lengths and Tip Elevations
West Abutment, Bottom of Footing Elevation: 593.5
14-inch Dia. Metal Shell Pile

Pile Size	Nominal Required Bearing (kips)	Factored Geotechnical Loss from Downdrag (kips)	Factored Geotechnical Loss Load from Downdrag (kips)	Factored Resistance Available (kips)	Total Estimated Pile Length (feet)	Estimated Pile Tip Elevation (feet)
0.250-inch wall	227	15	30	80	58	536.5
	245	15	30	90	61	533.5
	263	15	30	100	62	532.5
	281	15	30	110	67	527.5
	299	15	30	120	72	522.5
	317	15	30	130	75	519.5
	336	15	30	140	77	517.5
	354	15	30	150	80	514.5
	372	15	30	160	81	513.5
	390	15	30	170	82	512.5
	413*	15	30	183	84	510.5
0.312-inch wall	227	15	30	80	58	536.5
	245	15	30	90	61	533.5
	263	15	30	100	62	532.5
	281	15	30	110	67	527.5
	299	15	30	120	72	522.5
	317	15	30	130	75	519.5
	336	15	30	140	77	517.5
	354	15	30	150	80	514.5
	372	15	30	160	81	513.5
	390	15	30	170	82	512.5
	408	15	30	180	83	511.5
	427	15	30	190	85	509.5
	445	15	30	200	86	508.5
	481	15	30	220	87	507.5
	513**	15	30	238	88	506.5

* Maximum NRB for 0.250-inch wall, ** Maximum NRB for 0.312-inch wall

Table 10: Estimated Pile Lengths and Tip Elevations
Pier 1
Bottom of Footing Elevation: 569.5
Pier 1 Scour Elevation (Q500): 553.4
12-inch Dia. Metal Shell Pile

Pile Size	Nominal Required Bearing (kips)	Factored Geotechnical Loss (kips)	Factored Geotechnical Loss Load (kips)	Factored Resistance Available (kips)	Total Estimated Pile Length (feet)	Estimated Pile Tip Elevation (feet)
0.179-inch wall	201	11	0	100	51	519.5
	219	11	0	110	52	518.5
	237	11	0	120	53	517.5
	254*	11	0	129	56	514.5
0.250-inch wall	201	11	0	100	50	520.5
	219	11	0	110	51	519.5
	237	11	0	120	53	517.5
	255	11	0	130	56	514.5
	274	11	0	140	59	511.5
	292	11	0	150	60	510.5
	310	11	0	160	61	509.5
	328	11	0	170	63	507.5
	346	11	0	180	65	505.5
	353**	11	0	184	67	503.5

* Maximum NRB for 0.179-inch wall

** Maximum NRB for 0.250-inch wall

Table 11A: Estimated Pile Lengths and Tip Elevations
Pier 1
Bottom of Footing Elevation: 569.5
Pier 1 Scour Elevation (Q500): 553.4
14-inch Dia. Metal Shell Pile

Pile Size	Nominal Required Bearing (kips)	Factored Geotechnical Loss (kips)	Factored Geotechnical Loss Load (kips)	Factored Resistance Available (kips)	Total Estimated Pile Length (feet)	Estimated Pile Tip Elevation (feet)
0.250-inch wall	204	12	0	100	49	521.5
	222	12	0	110	50	520.5
	240	12	0	120	51	519.5
	259	12	0	130	52	518.5
	277	12	0	140	53	517.5
	295	12	0	150	54	516.5
	313	12	0	160	56	514.5
	331	12	0	170	59	511.5
	350	12	0	180	60	510.5
	368	12	0	190	61	509.5
	386	12	0	200	62	508.5
	404	12	0	210	63	507.5
	413*	12	0	215	64	506.5

* Maximum NRB for 0.250-inch wall

Table 11B: Estimated Pile Lengths and Tip Elevations
Pier 1
Bottom of Footing Elevation: 569.5
Pier 1 Scour Elevation (Q500): 553.4
14-inch Dia. Metal Shell Pile

Pile Size	Nominal Required Bearing (kips)	Factored Geotechnical Loss (kips)	Factored Geotechnical Loss Load (kips)	Factored Resistance Available (kips)	Total Estimated Pile Length (feet)	Estimated Pile Tip Elevation (feet)
0.312-inch wall	204	12	0	100	49	521.5
	222	12	0	110	50	520.5
	240	12	0	120	51	519.5
	259	12	0	130	52	518.5
	277	12	0	140	53	517.5
	295	12	0	150	54	516.5
	313	12	0	160	56	514.5
	331	12	0	170	59	511.5
	350	12	0	180	60	510.5
	368	12	0	190	61	509.5
	386	12	0	200	62	508.5
	404	12	0	210	63	507.5
	422	12	0	220	64	506.5
	440	12	0	230	73	497.5
	459	12	0	240	74	496.5
	477	12	0	250	75	495.5
	495	12	0	260	76	494.5
	513**	12	0	270	77	493.5

** Maximum NRB for 0.312-inch wall

Table 12: Estimated Pile Lengths and Tip Elevations
Pier 2
Bottom of Footing Elevation: 575.5
Pier 2 Scour Elevation (Q500): 556.2
12-inch Dia. Metal Shell Pile

Pile Size	Nominal Required Bearing (kips)	Factored Geotechnical Loss (kips)	Factored Geotechnical Loss Load (kips)	Factored Resistance Available (kips)	Total Estimated Pile Length (feet)	Estimated Pile Tip Elevation (feet)
0.179-inch wall	194	7	0	100	53	523.5
	213	7	0	110	54	522.5
	231	7	0	120	57	519.5
	254*	7	0	133	59	517.5
0.250-inch wall	194	7	0	100	53	523.5
	213	7	0	110	54	522.5
	231	7	0	120	57	519.5
	249	7	0	130	58	518.5
	267	7	0	140	62	514.5
	285	7	0	150	63	513.5
	303	7	0	160	65	511.5
	322	7	0	170	68	508.5
	340	7	0	180	69	507.5
	353**	7	0	187	70	506.5

* Max. NRB for 0.179-inch wall

** Max. NRB for 0.250-inch wall

Table 13A: Estimated Pile Lengths and Tip Elevations
Pier 2
Bottom of Footing Elevation: 575.5
Pier 2 Scour Elevation (Q500): 556.2
14-inch Dia. Metal Shell Pile

Pile Size	Nominal Required Bearing (kips)	Factored Geotechnical Loss (kips)	Factored Geotechnical Loss Load (kips)	Factored Resistance Available (kips)	Total Estimated Pile Length (feet)	Estimated Pile Tip Elevation (feet)
0.250-inch wall	196	8	0	100	47	529.5
	215	8	0	110	52	524.5
	233	8	0	120	53	523.5
	251	8	0	130	54	522.5
	269	8	0	140	55	521.5
	287	8	0	150	58	518.5
	306	8	0	160	59	517.5
	324	8	0	170	61	515.5
	342	8	0	180	63	513.5
	360	8	0	190	64	512.5
	378	8	0	200	65	511.5
	396	8	0	210	68	508.5
	413*	8	0	219	69	507.5

* Max. NRB for 0.250-inch wall

Table 13B: Estimated Pile Lengths and Tip Elevations
Pier 2
Bottom of Footing Elevation: 575.5
Pier 2 Scour Elevation (Q500): 556.2
14-inch Dia. Metal Shell Pile

Pile Size	Nominal Required Bearing (kips)	Factored Geotechnical Loss (kips)	Factored Geotechnical Loss Load (kips)	Factored Resistance Available (kips)	Total Estimated Pile Length (feet)	Estimated Pile Tip Elevation (feet)
0.312-inch wall	196	8	0	100	47	529.5
	215	8	0	110	52	524.5
	233	8	0	120	53	523.5
	251	8	0	130	54	522.5
	269	8	0	140	55	521.5
	287	8	0	150	58	518.5
	306	8	0	160	59	517.5
	324	8	0	170	61	515.5
	342	8	0	180	63	513.5
	360	8	0	190	64	512.5
	378	8	0	200	65	511.5
	396	8	0	210	68	508.5
	415	8	0	220	69	507.5
	433	8	0	230	70	506.5
	451	8	0	240	78	498.5
	469	8	0	250	79	497.5
	487	8	0	260	81	495.5
	513**	8	0	274	83	493.5

** Max. NRB for 0.312-inch wall

Table 14: Estimated Pile Lengths and Tip Elevations
Pier 3
Bottom of Footing Elevation: 575.5
Pier 3 Scour Elevation (Q500): 563.7
12-inch Dia. Metal Shell Pile

Pile Size	Nominal Required Bearing (kips)	Factored Geotechnical Loss (kips)	Factored Geotechnical Loss Load (kips)	Factored Resistance Available (kips)	Total Estimated Pile Length (feet)	Estimated Pile Tip Elevation (feet)
0.179-inch wall	194	7	0	100	32	544.5
	213	7	0	110	34	542.5
	231	7	0	120	35	541.5
	254*	7	0	133	36	540.5
0.250-inch wall	194	7	0	100	32	544.5
	213	7	0	110	34	542.5
	231	7	0	120	35	541.5
	249	7	0	130	36	540.5
	267	7	0	140	37	539.5
	285	7	0	150	38	538.5
	303	7	0	160	39	537.5
	322	7	0	170	40	536.5
	340	7	0	180	43	533.5
	353**	7	0	187	44	532.5

* Maximum NRB for 0.179-inch wall

** Maximum NRB for 0.250-inch wall

Table 15A: Estimated Pile Lengths and Tip Elevations
Pier 3 Bottom of Footing Elevation: 575.5
Pier 3 Scour Elevation (Q500): 563.7
14-inch Dia. Metal Shell Pile

Pile Size	Nominal Required Bearing (kips)	Factored Geotechnical Loss (kips)	Factored Geotechnical Loss Load (kips)	Factored Resistance Available (kips)	Total Estimated Pile Length (feet)	Estimated Pile Tip Elevation (feet)
0.250-inch wall	197	8	0	100	28	548.5
	215	8	0	110	29	547.5
	233	8	0	120	31	545.5
	251	8	0	130	32	544.5
	269	8	0	140	33	543.5
	288	8	0	150	34	542.5
	306	8	0	160	35	541.5
	324	8	0	170	36	540.5
	342	8	0	180	37	539.5
	360	8	0	190	38	538.5
	378	8	0	200	39	537.5
	397	8	0	210	41	535.5
	413*	8	0	219	43	533.5

* Maximum NRB for 0.250-inch wall

Table 15B: Estimated Pile Lengths and Tip Elevations
Pier 3 Bottom of Footing Elevation: 575.5
Pier 3 Scour Elevation (Q500): 563.7
14-inch Dia. Metal Shell Pile

Pile Size	Nominal Required Bearing (kips)	Factored Geotechnical Loss (kips)	Factored Geotechnical Loss Load (kips)	Factored Resistance Available (kips)	Total Estimated Pile Length (feet)	Estimated Pile Tip Elevation (feet)
0.312-inch wall	197	8	0	100	28	548.5
	215	8	0	110	29	547.5
	233	8	0	120	31	545.5
	251	8	0	130	32	544.5
	269	8	0	140	33	543.5
	288	8	0	150	34	542.5
	306	8	0	160	35	541.5
	324	8	0	170	36	540.5
	342	8	0	180	37	539.5
	360	8	0	190	38	538.5
	378	8	0	200	39	537.5
	397	8	0	210	41	535.5
	415	8	0	220	43	533.5
	433	8	0	230	45	531.5
	451	8	0	240	49	527.5
	469	8	0	250	52	524.5
	487	8	0	260	54	522.5
	506	8	0	270	56	520.5
	513**	8	0	274	57	519.5

** Maximum NRB for 0.312-inch wall

Table 16: Estimated Pile Lengths and Tip Elevations
Pier 4
Bottom of Footing Elevation: 579.5
Pier 4 Scour Elevation (Q500): 565.0
12-inch Dia. Metal Shell Pile

Pile Size	Nominal Required Bearing (kips)	Factored Geotechnical Loss (kips)	Factored Geotechnical Loss Load (kips)	Factored Resistance Available, (kips)	Total Estimated Pile Length (feet)	Estimated Pile Tip Elevation (feet)
0.179-inch wall	206	13	0	100	28	552.5
	224	13	0	110	29	551.5
	242	13	0	120	30	550.5
	254*	13	0	127	31	549.5
0.250-inch wall	206	13	0	100	28	552.5
	224	13	0	110	29	551.5
	242	13	0	120	30	550.5
	260	13	0	130	32	548.5
	278	13	0	140	34	546.5
	296	13	0	150	36	544.5
	315	13	0	160	38	542.5
	333	13	0	170	40	540.5
	353**	13	0	181	42	538.5

* Max. NRB for 0.179-inch wall

** Max. NRB for 0.250-inch wall

Table 17A: Estimated Pile Lengths and Tip Elevations

Pier 4

Bottom of Footing Elevation: 579.5

Pier 4 Scour Elevation (Q500): 565.0

14-inch Dia. Metal Shell Pile

Pile Size	Nominal Required Bearing (kips)	Factored Geotechnical Loss (kips)	Factored Geotechnical Loss Load (kips)	Factored Resistance Available (kips)	Total Estimated Pile Length (feet)	Estimated Pile Tip Elevation (feet)
0.250-inch wall	209	15	0	100	22	558.5
	228	15	0	110	23	557.5
	246	15	0	120	27	553.5
	264	15	0	130	29	551.5
	319	15	0	160	30	550.5
	337	15	0	170	32	548.5
	355	15	0	180	34	546.5
	413*	15	0	212	35	545.5

* Max. NRB for 0.250-inch wall

Table 17B: Estimated Pile Lengths and Tip Elevations
Pier 4
Bottom of Footing Elevation: 579.5
Pier 4 Scour Elevation (Q500): 565.0
14-inch Dia. Metal Shell Pile

Pile Size	Nominal Required Bearing (kips)	Factored Geotechnical Loss (kips)	Factored Geotechnical Loss Load (kips)	Factored Resistance Available (kips)	Total Estimated Pile Length (feet)	Estimated Pile Tip Elevation (feet)
0.312-inch wall	209	15	0	100	22	558.5
	228	15	0	110	23	557.5
	246	15	0	120	27	553.5
	264	15	0	130	28	552.5
	319	15	0	160	30	550.5
	337	15	0	170	32	548.5
	355	15	0	180	33	547.5
	464	15	0	240	35	545.5
	482	15	0	250	36	544.5
	500	15	0	260	40	540.5
	513**	15	0	267	41	539.5

** Max. NRB for 0.312-inch wall

Table 18: Geotechnical Parameters for Design of Steel Sheet Pile Wall West Abutment

Soil Description Elevation Range	Moist Unit Weight (pcf)	Shear Strength Properties: Short Term Cohesion C_u (psf)	Short Term Friction Angle, φ (Degree)	Long Term Friction Angle, φ' (Degree)	Earth Pressure Coefficients*: Active Coefficient, K_a	Passive Coefficient, K_p
Stone Rip-Rap 583.3 to 575.0	125	0	40	40	0.22	4.60
Soft SILTY CLAY to SILTY LOAM 575.0 to 568.4	110	250	0	30	0.33	3.00
Very Loose to Loose SAND to SANDY LOAM 568.4 to 557.2	110	0	28	28	0.36	2.77
Medium Dense SAND to GRAVELLY SAND 557.2 to 502.4	115	0	33	33	0.29	3.39
Dense GRAVELLY SAND 502.4 to 464.0	120	0	36	36	0.26	3.85

-Unconfined Compressive Strength values of the cohesive soils are shown as Qu on the boring logs.

-Boring logs show SPT values for three consecutive 6 inches of penetration. N value is the sum of the second and third numbers.

-Moist unit weight and Friction Angle estimated from SPT numbers.

* k_a and k_p for straight backfill behind the wall.

Table 19: Recommended Rock Unit Tip Resistance

Pier ID	Reference Borings	Top of Bedrock Elevation (feet)	Bottom of Footing Elevation (feet)	Drilled Shaft Tip Elevation (feet)	Depth Below Footing Bottom (feet)	Rock Socket Length (feet)	Nominal Unit Tip Resistance (ksf)	Factored Unit Tip Resistance (ksf)
Pier 5	BSB-20, BSB-21	455.0	585.0	447.0 443.0 439.0	138.0 142.0 146.0	8 12 16	530 576 528	265 288 264
Pier 6	BSB-03, BSB-19	466.9	580.0	458.9 454.9 450.9	121.1 125.1 129.1	8 12 16	730 656 686	365 328 343
Pier 7	BSB-17, BSB-18	501.4	580.0	493.4 489.4 485.4	86.6 90.6 94.6	8 12 16	192 174 190	96 87 95
Pier 8	BSB-15,-15A, -15B, -15C, -16, GEO-02	514.4	580.0	506.4 502.4 498.4	73.6 77.6 81.6	8 12 16	122 122 130	61 61 65
Pier 9	(upstream) BSB-14	565.4	580.0	557.4 553.4 549.4	22.6 26.6 30.6	8 12 16	160 160 162	80 80 81
	(downstream) BSB-13	541.9	580.0	533.9 529.9 525.9	46.1 50.1 54.1	8 12 16	262 368 494	131 184 247
Pier 10	BSB-01, BSB-12, BSB-12A	560.2	580.0	552.2 548.2 544.2	27.8 31.8 35.8	8 12 16	274 264 242	137 132 121
Pier 11	BSB-11	576.5	588.0 (top of shaft)	568.5 564.5 543.5	19.5 23.5 44.5	8 12 33	60 80 324	30 40 162

Resistance factor for tip resistance in rock = 0.50

Table 20: Estimated Pile Lengths and Tip Elevations
East Abutment
Bottom of Footing Elevation: 619.3

H-pile size	Maximum Nominal Required Bearing $R_{N\text{-}Max}$ (kips)	Factored Resistance Available R_F (kips)	Total Estimated Pile Length (feet)	Estimated Pile Tip Elevation (feet)
10x42	335	184	21	599.7
12x53	419	230	21	599.7
12x63	497	273	21	599.7
14x73	578	318	21	599.7
14x89	705	388	21	599.7

Table 21: Recommended Soil Parameters for Lateral Load Analysis
West Abutment, Borings BSB-05 and BSB-24
Bottom of Footing Elevation: 593.5 feet*

Soil Layer Elevation Range (feet)	Effective Unit Weight (pcf)	Undrained Shear Strength C_u (psf)	Friction Angle φ (Degree)	Estimated Lateral Soil Modulus Parameter k (pci)	Estimated Soil Strain Parameter ε_{50}
593.5* to 587.8 Very Loose Sand Fill	110	0	28	20	--
587.8 to 583.4 Soft Silty Loam Fill	110	300	0	20	0.02
583.4 to 577.0 Medium Stiff Silty Clay	53	700	0	90	0.01
577.0 to 558.4 Very Loose to Loose Silty Loam to Sandy Loam	48	0	28	20	--
558.4 to 502.4 Medium Dense Sand to Sandy Gravel	53	0	33	60	--
502.4 to 464 Medium Dense to Dense Gravelly Sand	58	0	36	125	--

Table 22: Recommended Soil Parameters for Lateral Load Analysis
Pier 1, Borings BSB-23
Bottom of Footing Elevation: 569.5 feet*

Soil Layer Elevation Range (feet)	Effective Unit Weight (pcf)	Undrained Shear Strength C_u (psf)	Friction Angle φ (Degree)	Estimated Lateral Soil Modulus Parameter k (pci)	Estimated Soil Strain Parameter ε_{50}
569.5* to 567.4 Very Soft Silty Clay	48	250	0	20	0.02
567.4 to 552.4 Very Loose to Loose Sandy Loam to Sand	48	0	28	20	--
552.4 to 533.7 Medium Dense Sand	53	0	33	60	--
533.7 to 528.7 Very Loose Sandy Loam	48	0	28	20	--
528.7 to 465.4 Medium Dense to Dense Sand	53	0	35	100	--

Table 23 Recommended Soil Parameters for Lateral Load Analysis
Pier 2, Borings BSB-06
Bottom of Footing Elevation: 575.5 feet*

Soil Layer Elevation Range (feet)	Effective Unit Weight (pcf)	Undrained Shear Strength C_u (psf)	Friction Angle φ (Degree)	Estimated Lateral Soil Modulus Parameter k (pci)	Estimated Soil Strain Parameter ε_{50}
575.5* to 569.9 Very Soft Silty Clay Loam	48	250	0	20	0.02
569.9 to 556.4 Very Loose Sand	48	0	28	20	--
556.4 to 531.9 Medium Dense Sand	53	0	33	60	--
531.9 to 529.4 Soft Silty Clay Loam	48	250	0	20	0.02
529.4 to 521.9 Loose Sand	48	0	28	20	--
521.9 to 463.9 Medium Dense to Dense Sand	53	0	33	60	--

Table 24: Recommended Soil Parameters for Lateral Load Analysis
Pier 3, Borings BSB-07
Bottom of Footing Elevation: 575.5 feet*

Soil Layer Elevation Range (feet)	Effective Unit Weight (pcf)	Undrained Shear Strength C_u (psf)	Friction Angle φ (Degree)	Estimated Lateral Soil Modulus Parameter k (pci)	Estimated Soil Strain Parameter ε_{50}
575.5* to 563.7 Very Loose to Loose Sand	48	0	28	20	--
563.7 to 517.7 Medium Dense Sand to Gravelly Sand	53	0	33	60	--
517.7 to 464.2 Dense to Very Dense Sand	58	0	36	125	--

Table 25: Recommended Soil Parameters for Lateral Load Analysis
Pier 4, Borings BSB-08 and BSB-22
Bottom of Footing Elevation: 579.5 feet*

Soil Layer Elevation Range (feet)	Effective Unit Weight (pcf)	Undrained Shear Strength C_u (psf)	Friction Angle φ (Degree)	Estimated Lateral Soil Modulus Parameter k (pci)	Estimated Soil Strain Parameter ε_{50}
579.5* to 566.3 Very Loose to Loose Sand	48	0	28	20	--
566.3 to 550.0 Medium Dense Sand	53	0	33	60	--
550.0 to 514.8 Medium Dense to Dense Sand to Gravelly Sand	53	0	34	60	--
514.8 to 456.8 Dense Sand	58	0	36	125	--

Table 26A: Recommended Soil Parameters for Lateral Load Analysis
Pier 5, Borings BSB-20 and BSB-21
Bottom of Footing Elevation: 585.0 feet*

Soil Layer Elevation Range (feet)	Effective Unit Weight (pcf)	Undrained Shear Strength C_u (psf)	Friction Angle φ (Degree)	Estimated Lateral Soil Modulus Parameter k (pci)	Estimated Soil Strain Parameter ε_{50}
585.0* to 555.3 Very Loose to Loose Sand to Silty Loam	48	0	28	20	--
555.3 to 490.0 Medium Dense to Dense Sandy Loam to Sand	53	0	34	60	--
490.0 to 455.0 Dense to Very Dense Sand	53	0	36	125	--

Table 26B: Recommended Rock Parameters for Lateral Load Analysis
Pier 5, Borings BSB-20 and BSB-21
Bottom of Footing Elevation: 585.0 feet

Rock Type Elevation Range (feet)	Effective Unit Weight (pcf)	Modulus of Rock Mass (ksi)	Uniaxial Compressive Strength Qu (psi)	RQD (%)	Strain Factor k_{rm}
455.0 to 447.0 Bedrock (Dolostone)	73	850	6,500	76	0.0005
447.0 to 443.0 Bedrock (Dolostone)	73	1,900	7,000	92	0.0005
443.0 to 439.0 Bedrock (Dolostone)	73	2,100	7,500	95	0.0005

Table 27A: Recommended Soil Parameters for Lateral Load Analysis
Pier 6, Borings BSB-03 and BSB-19
Bottom of Footing Elevation: 580.0 feet

Soil Layer Elevation Range (feet)	Effective Unit Weight (pcf)	Undrained Shear Strength C_u (psf)	Friction Angle φ (Degree)	Estimated Lateral Soil Modulus Parameter k (pci)	Estimated Soil Strain Parameter ε_{50}
561.2* to 541.0 Very Loose to Loose Sand to Sandy Gravel	48	0	28	20	--
541.0 to 480.0 Medium Dense Sand to Gravelly Sand	53	0	34	60	--
480.0 to 466.9 Medium Dense to Dense Gravelly Sand to Sand	58	0	35	100	--

*Riverbed at the time of borings

Table 27B: Recommended Rock Parameters for Lateral Load Analysis
Pier 6, Borings BSB-03 and BSB-19
Bottom of Footing Elevation: 580.0 feet

Rock Type Elevation Range (feet)	Effective Unit Weight (pcf)	Modulus of Rock Mass (ksi)	Uniaxial Compressive Strength Qu (psi)	RQD (%)	Strain Factor k_{rm}
466.9 to 458.9 Bedrock (Dolostone)	73	600	8,900	72	0.0005
458.9 to 454.9 Bedrock (Dolostone)	73	600	9,700	72	0.0005
454.9 to 450.9 Bedrock (Dolostone)	73	1,400	6,700	85	0.0005

Table 28A: Recommended Soil Parameters for Lateral Load Analysis
Pier 7, Borings BSB-17 and BSB-18
Bottom of Footing Elevation: 580.0 feet

Soil Layer Elevation Range (feet)	Effective Unit Weight (pcf)	Undrained Shear Strength C_u (psf)	Friction Angle φ (Degree)	Estimated Lateral Soil Modulus Parameter k (pci)	Estimated Soil Strain Parameter ε_{50}
560.0* to 523.6 Very Loose to Loose Sand to Sandy Loam	48	0	28	20	--
523.6 to 501.4.0 Medium Dense to Dense Gravelly Sand to Sand	53	0	35	100	--

*Riverbed at time of borings

Table 28B: Recommended Rock Parameters for Lateral Load Analysis
Pier 7, Borings BSB-17 and BSB-18
Bottom of Footing Elevation: 580.0 feet

Rock Type Elevation Range (feet)	Effective Unit Weight (pcf)	Modulus of Rock Mass (ksi)	Uniaxial Compressive Strength Qu (psi)	RQD (%)	Strain Factor k_{rm}
501.4 to 493.4 Bedrock (Dolostone)	73	400	5,100	49	0.0005
493.4 to 489.4 Bedrock (Dolostone)	73	420	6,400	60	0.0005
489.4 to 485.4 Bedrock (Dolostone)	73	750	6,600	75	0.0005

Table 29A: Recommended Soil Parameters for Lateral Load Analysis
Pier 8, Borings BSB-15, BSB-15A, BSB-15B, BSB-15C, and BSB-16
Bottom of Footing Elevation: 580.0 feet

Soil Layer Elevation Range (feet)	Effective Unit Weight (pcf)	Undrained Shear Strength C_u (psf)	Friction Angle φ (Degree)	Estimated Lateral Soil Modulus Parameter k (pci)	Estimated Soil Strain Parameter ε_{50}
559.0* to 536.0 Loose to Medium Dense Sand to Gravelly Sand	53	0	31	40	--
536.0 to 514.4 Medium Dense Gravelly Sand to Sand	53	0	35	100	--

*Riverbed at time of boring

Table 29B: Recommended Rock Parameters for Lateral Load Analysis
Pier 8, Borings BSB-15, BSB-15A, BSB-15B, and BSB-15C
Bottom of Footing Elevation: 580.0 feet

Rock Type Elevation Range (feet)	Effective Unit Weight (pcf)	Modulus of Rock Mass (ksi)	Uniaxial Compressive Strength Qu (psi)	RQD (%)	Strain Factor k_{rm}
514.4 to 506.4 Bedrock (Dolostone)	135	420	8,000	50	0.005
506.4 to 502.4 Bedrock (Dolostone)	135	420	8,300	63	0.005
502.4 to 498.4 Bedrock (Dolostone)	135	300	7,900	30	0.005

Table 30A: Recommended Soil Parameters for Lateral Load Analysis
Pier 9, Boring BSB-13
Bottom of Footing Elevation: 580.0 feet

Soil Layer Elevation Range (feet)	Unit Weight (pcf)	Undrained Shear Strength C_u (psf)	Friction Angle φ (Degree)	Estimated Lateral Soil Modulus Parameter k (pci)	Estimated Soil Strain Parameter ε_{50}
562.9* to 556.4 Loose to Medium Dense Sand	53	0	31	40	--
556.4 to 548.9 Medium Dense to Dense Sand	58	0	35	100	--
548.9 to 541.9 Very Dense Silty Loam	58	0	36	125	--

*Riverbed at time of boring

Table 30B: Recommended Rock Parameters for Lateral Load Analysis
Pier 9, Boring BSB-13
Bottom of Footing Elevation: 580.0 feet

Rock Type Elevation Range (feet)	Effective Unit Weight (pcf)	Modulus of Rock Mass (ksi)	Uniaxial Compressive Strength Qu (psi)	RQD (%)	Strain Factor k_{rm}
541.9 to 533.9 Bedrock (Dolostone)	73	2,400	8,300	99	0.0005
533.9 to 529.9 Bedrock (Dolostone)	73	420	10,000	65	0.0005
529.9 to 525.9 Bedrock (Dolostone)	73	420	10,000	60	0.0005

Table 30C: Recommended Rock Parameters for Lateral Load Analysis
Pier 9, Boring BSB-14
Bottom of Footing Elevation: 580.0 feet

Rock Type Elevation Range (feet)	Effective Unit Weight (pcf)	Modulus of Rock Mass (ksi)	Uniaxial Compressive Strength Qu (psi)	RQD (%)	Strain Factor k_{rm}
565.4 to 557.4 Bedrock (Dolostone)	73	380	11,300	43	0.0005
557.4 to 553.4 Bedrock (Dolostone)	73	300	12,000	30	0.0005
553.4 to 549.4 Bedrock (Dolostone)	73	250	10,500	16	0.0005

Table 31A: Recommended Soil Parameters for Lateral Load Analysis
Pier 10, Borings BSB-01 and BSB-12
Bottom of Footing Elevation: 580.0 feet

Soil Layer Elevation Range (feet)	Unit Weight (pcf)	Undrained Shear Strength C_u (psf)	Friction Angle φ (Degree)	Estimated Lateral Soil Modulus Parameter k (pci)	Estimated Soil Strain Parameter ε_{50}
571.1* to 565.9 Medium Dense Sand to Silty Loam	53	0	30	60	--
565.9 to 560.2 Very Dense Silty Loam to Sand	58	0	36	125	--

*Riverbed at time of boring

Table 31B: Recommended Rock Parameters for Lateral Load Analysis
Pier 10, Borings BSB-01, BSB-12, and BSB-12A
Bottom of Footing Elevation: 580.0 feet

Rock Type Elevation Range (feet)	Effective Unit Weight (pcf)	Modulus of Rock Mass (ksi)	Uniaxial Compressive Strength Qu (psi)	RQD (%)	Strain Factor k_{rm}
560.2 to 552.2 Bedrock (Dolostone)	73	1,400	11,600	85	0.0005
552.2 to 548.2 Bedrock (Dolostone)	73	420	10,700	68	0.005
548.2 to 544.2 Bedrock (Dolostone)	73	1,400	12,000	84	0.005

Table 32A: Recommended Soil Parameters for Lateral Load Analysis
Pier 11, Boring BSB-11
Top of Drilled Shaft Elevation: 588.0 feet

Soil Layer Elevation Range (feet)	Unit Weight (pcf)	Undrained Shear Strength C_u (psf)	Friction Angle φ (Degree)	Estimated Lateral Soil Modulus Parameter k (pci)	Estimated Soil Strain Parameter ε_{50}
586.0* to 576.5 Very Stiff to Hard Silty Clay	120	3,600	0	1,200	0.0048

*Top of Boring

Table 32B: Recommended Rock Parameters for Lateral Load Analysis
Pier 11, Boring BSB-11
Top of Drilled Shaft Elevation: 588.0 feet

Rock Type Elevation Range (feet)	Unit Weight (pcf)	Modulus of Rock Mass (ksi)	Uniaxial Compressive Strength Qu (psi)	RQD (%)	Strain Factor k_{rm}
576.5 to 568.5 Bedrock (Shale)	135	100	7,200	32	0.0005
568.5 to 564.5 Bedrock (Shale)	135	140	5,700	70	0.0005
564.5 to 543.5 Bedrock (Shale)	135	140	6,400	70	0.0005
543.5 to 519.5 Bedrock (Dolostone)	135	420	12,000	50	0.0005

Wang Engineering

Table 33A: Recommended Soil Parameters for Lateral Load Analysis
East Abutment, Boring BSB-04, BSB-04A and BSB-10
Bottom of Footing Elevation: 619.3 feet*

Soil Layer Elevation Range (feet)	Unit Weight (pcf)	Undrained Shear Strength C_u (psf)	Friction Angle φ (Degree)	Estimated Lateral Soil Modulus Parameter k (pci)	Estimated Soil Strain Parameter ε_{50}
Very Stiff to Hard Silty Clay 619.3*-607.1	120	4,900	0	1,600	0.0043
Very Dense Sandy Loam to Sand 607.1-601.1	120	0	36	125	--

Table 33B: Recommended Rock Parameters for Lateral Load Analysis
East Abutment, Boring BSB-04, BSB-04A and BSB-10
Bottom of Footing Elevation: 619.3 feet

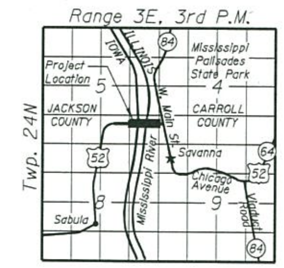
Rock Type Elevation Range (feet)	Unit Weight (pcf)	Modulus of Rock Mass (ksi)	Uniaxial Compressive Strength Qu (psi)	RQD (%)	Strain Factor k_{rm}
Bedrock (Shale) 601.1-540.2	135	380	6,000	80	0.0005
Bedrock (Dolostone) 540.2-517.7	135	420	8,000	50	0.0005

APPENDIX A

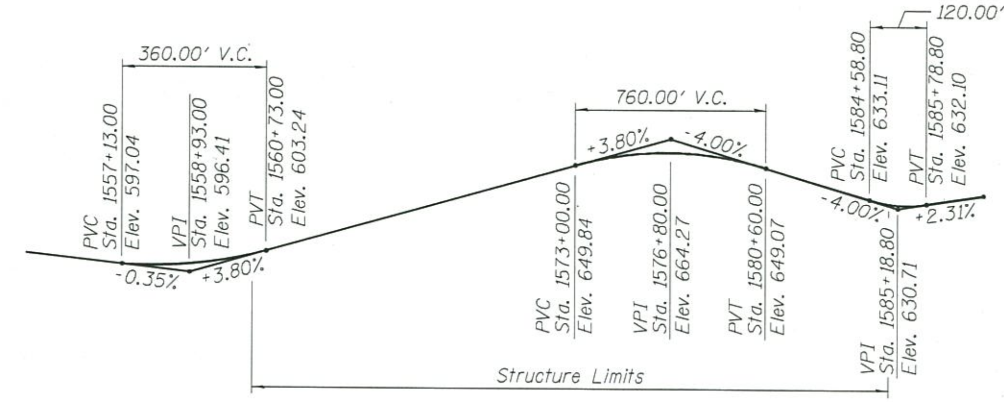
Benchmark:
BM CP5 - Concrete pedestal set south of the west abutment of Illinois River Bridge SN 008-6000 on US 52 @ Savanna @ Sta. 1560+65.46; Offset 24.85' Lt. NAVD 88 = 597.891 Ft.

Existing Structure: SN 008-6000 Steel girder, steel truss and concrete slab superstructure bridge on pile bents and piers. Approximately 50' to 100' upstream. Approximately 2470' long by 20' wide. Constructed in 1932.
To be removed after new structure is complete.
Traffic Control: none
No Salvage

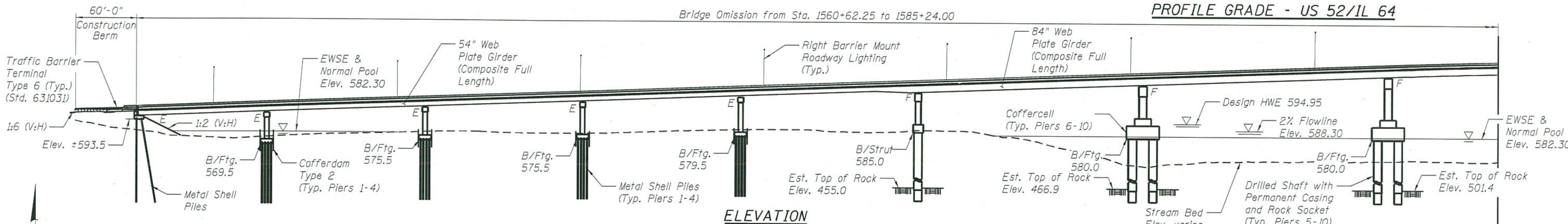
Notes:
1. All Elevations are given in NAVD 1988 Datum unless noted. NAVD 1988 = NGVD 1929 - 0.10'.
2. EWSE = Estimated Water Surface Elevation.
3. HWE = High Water Elevation.
4. For ground elevations see Sheet 5.
5. ⊕ Denotes soil boring.
6. For scupper type see Cross Sections on Sheet 3 & 4.
7. Proposed lighting unit: 35 ft. aluminum pole, 8 ft. davit arm, 250W HPS luminaire, MC2 distribution, mounted on bridge parapet wall.
8. Lighting unit is subject to refinement during the design phase.
9. For Section A-A see Sheet 5.



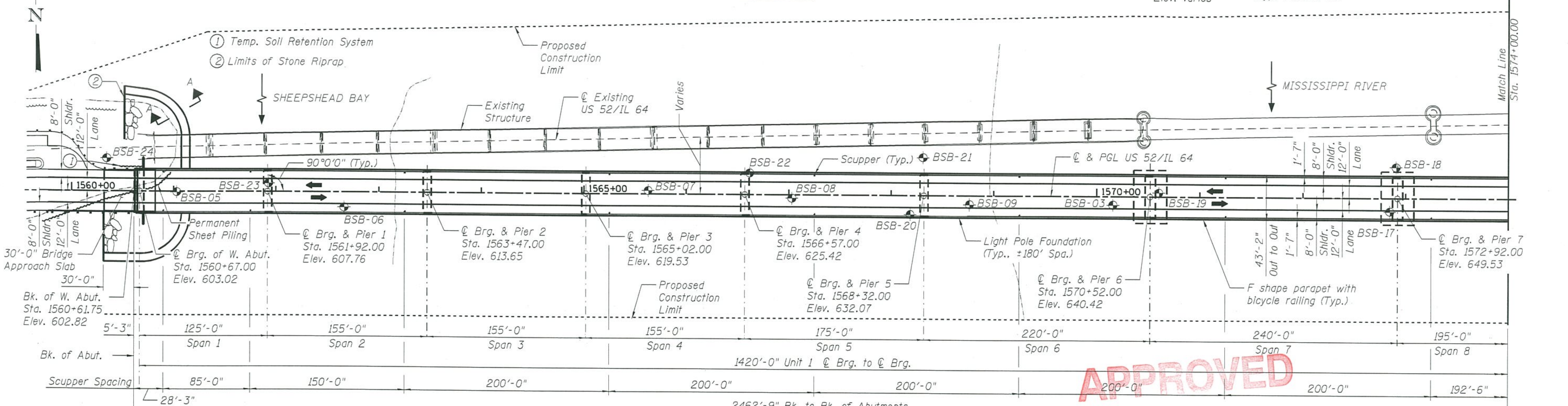
LOCATION SKETCH



PROFILE GRADE - US 52/IL 64



ELEVATION



PLAN

APPROVED
JUL 30 2014
AS A BASIS FOR PREPARATION OF DETAILED PLANS

SEISMIC DATA

Seismic Performance Zone (SPZ) = 1
Design Spectral Acceleration at 1.0 sec. (S_{D1}) = 0.119g
Design Spectral Acceleration at 0.2 sec. (S_{DS}) = 0.161g
Soil Site Class = D (West Abut., Piers 1-8)
Design Spectral Acceleration at 1.0 sec. (S_{D1}) = 0.084g
Design Spectral Acceleration at 0.2 sec. (S_{DS}) = 0.121g
Soil Site Class = C (Piers 9-11, East Abut.)

HIGHWAY CLASSIFICATION

US 52/IL 64 (FAP 17)
Functional Class: Minor Arterial (Non-urban)
ADT: 2200 (2015); 2400 (2035)
ADTT: 230 (2015); 250 (2035)
DHV: 240
Design Speed: 45 m.p.h.
Posted Speed: 40 m.p.h.
Two-Way Traffic
Directional Distribution: 50/50

DESIGN STRESSES

FIELD UNITS

f'c = 3,500 psi
f'c = 4,000 psi (Drilled Shafts)
fy = 60,000 psi (Reinforcement)
fy = 50,000 psi (M270 Grade 50)
fy = 50,000 psi (M270 Grade HPS50W, Unit 2 Hanger Plates, Ties & Knuckles)

LOADING HL-93

Allow 50#/sq. ft. for future wearing surface.

DESIGN SPECIFICATIONS

2012 AASHTO LRFD Bridge Design Specifications, 6th Edition with 2013 Interims

GENERAL PLAN & ELEVATION - 1
US 52/IL 64 OVER THE MISSISSIPPI RIVER
PUBLIC WATER
F.A.P. RTE. 17 - SEC. 104B-2
CARROLL (IL) AND JACKSON (IA) COUNTIES
STATION 1577+60.00
STRUCTURE NO. 008-0052

FILE NAME =	USER NAME =	DESIGNED - TSB	REVISED
PARSONS	DATE = 7/16/2014	CHECKED - GTH	REVISED
	PLOT SCALE =	DRAWN - TSB	REVISED
	PLOT DATE =	CHECKED - GTH	REVISED

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

SHEET NO. 1 OF 5 SHEETS

F.A. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
17	104B-2	Carroll		

CONTRACT NO. 64G59
ILLINOIS | FED. AID PROJECT

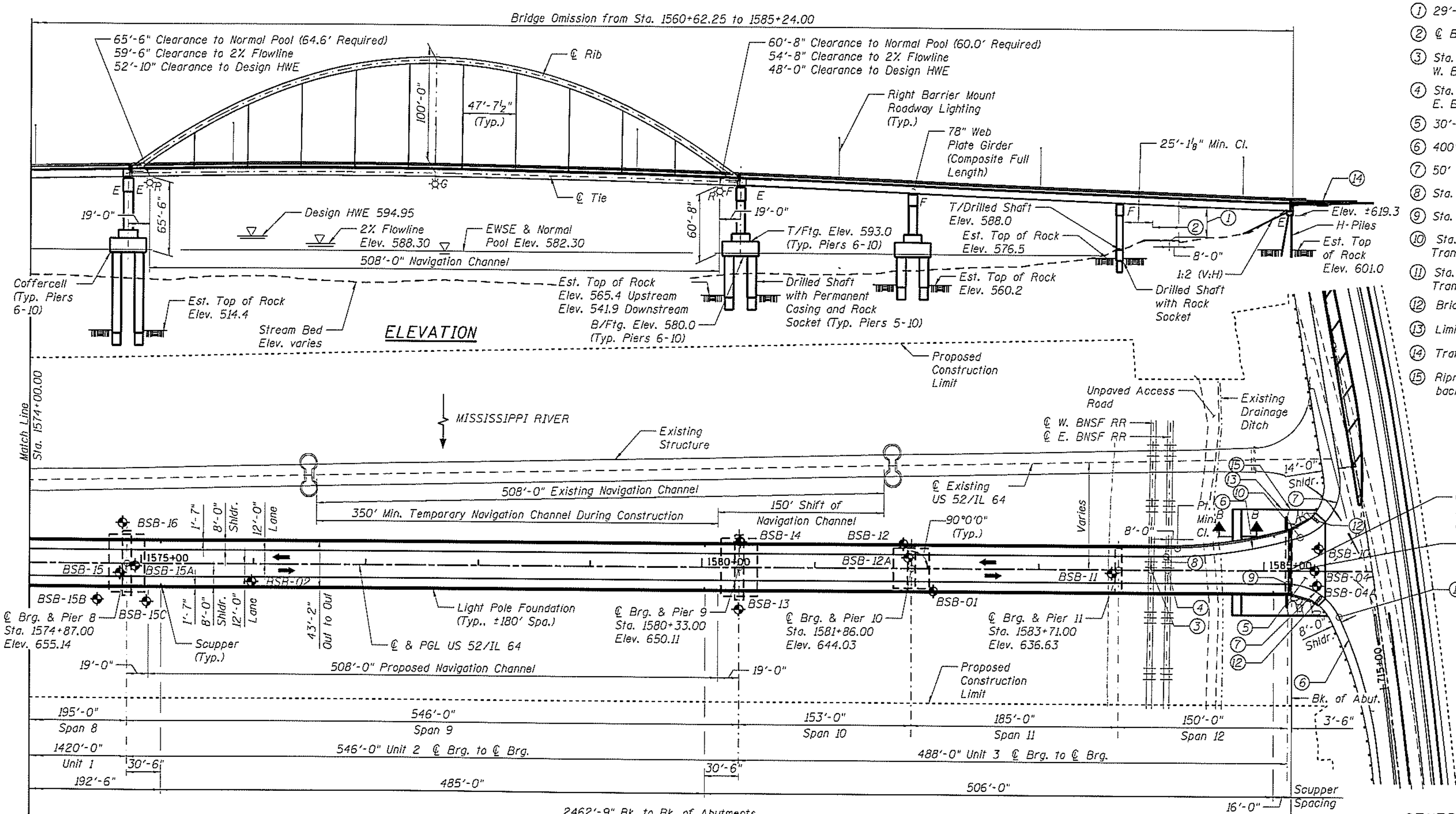
Notes:
1. All Elevations are given in NAVD 1988 Datum unless noted.
2. EWSE = Estimated Water Surface Elevation.
3. HWE = High Water Elevation.
4. For ground elevations see Sheet 5.
5. ⊕ Denotes soil boring.
6. For scupper type see Cross Sections on Sheet 3 & 4.
7. Proposed lighting unit: 35 ft. aluminum pole, 8 ft. davit arm, 250W HPS luminaire, MC2 distribution, mounted on bridge parapet wall.
8. Lighting unit is subject to refinement during the design phase.
9. No freefall deck drains will be permitted in the span over the tracks or within 10 ft. of cross arms of a railroad pole line.
10. For Section B-B see Sheet 5.

WATERWAY INFORMATION

Drainage Area = 85,500 sq. mi. Low Grade Elev. 596.98 @ Sta. 1557+43.0

Flood	Freq. Yr.	Q C.F.S.	Opening Sq. Ft. Exist.	Opening Sq. Ft. Prop.	Nat. H.W.E.	Head - Ft. Exist.	Head - Ft. Prop.	Headwater El. Exist.	Headwater El. Prop.
Ten-Year	10	202,000	93,196.8	93,292.9	591.67	0.00	0.01	591.68	591.69
Design	50	259,000	122,842.9	122,919.8	594.94	0.00	0.01	594.94	594.95
Base	100	281,290	133,150.7	133,204.0	596.07	0.00	0.00	596.07	596.07
Max. Calc.	500	337,000	154,320.5	154,357.4	598.21	0.00	0.00	598.21	598.21

(1) 29'-0" Min. Cl.
(2) ℄ BNSF RR
(3) Sta. 1583+99.86 US 52/IL 64 = Sta. 20+50.00 W. BNSF RR
(4) Sta. 1584+14.86 US 52/IL 64 = Sta. 10+50.00 E. BNSF RR
(5) 30'-0" Bridge Approach Slab
(6) 400' Radius
(7) 50' Radius
(8) Sta. 1584+13.02; Offset 12.00' Lt., Begin Lane Taper
(9) Sta. 1585+20.87; Offset 12.00' Rt., Begin Lane Taper
(10) Sta. 1585+31.71; Offset 30.01' Lt., Lane Taper Radius Transition
(11) Sta. 1585+66.22; Offset 40.95' Rt., Lane Taper Radius Transition
(12) Bridge Approach Pavement Drain (Standard 609006-05)
(13) Limits of Stone Riprap
(14) Traffic Barrier Terminal Type 6 (Typ.) (Std. 631031)
(15) Riprap extended 20' perpendicular to roadway at back of abutment (Typ.)



PLAN

PVT Sta. 20+00.00 Elev. 596.87
PVT Sta. 20+25.00 Elev. 597.06
PVT Sta. 20+50.00 Elev. 597.16
PVT Sta. 20+75.00 Elev. 597.22
PVT Sta. 21+00.00 Elev. 597.24

PROFILE GRADE - W. BNSF RR

PVT Sta. 10+00.00 Elev. 597.09
PVT Sta. 10+25.00 Elev. 596.92
PVT Sta. 10+50.00 Elev. 597.06
PVT Sta. 10+75.00 Elev. 597.20
PVT Sta. 11+00.00 Elev. 597.14

PROFILE GRADE - E. BNSF RR

DESIGN SCOUR ELEVATION TABLE

Design Scour Elevation (ft.)	West Abut.	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5	Pier 6	Pier 7	Pier 8	Pier 9	Pier 10	Pier 11	East Abut.
Q100	593.5	555.4	558.1	565.7	567.0	520.6	505.8	509.1	520.6	541.9	560.2	576.5	619.3
Q500	593.5	553.4	556.2	563.7	565.0	519.6	503.8	507.1	519.6	541.9	560.2	576.5	619.3

GENERAL PLAN & ELEVATION - 2
US 52/IL 64 OVER THE MISSISSIPPI RIVER
PUBLIC WATER
F.A.P. RTE. 17 - SEC. 104B-2
CARROLL (IL) AND JACKSON (IA) COUNTIES
STATION 1577+60.00
STRUCTURE NO. 008-0052

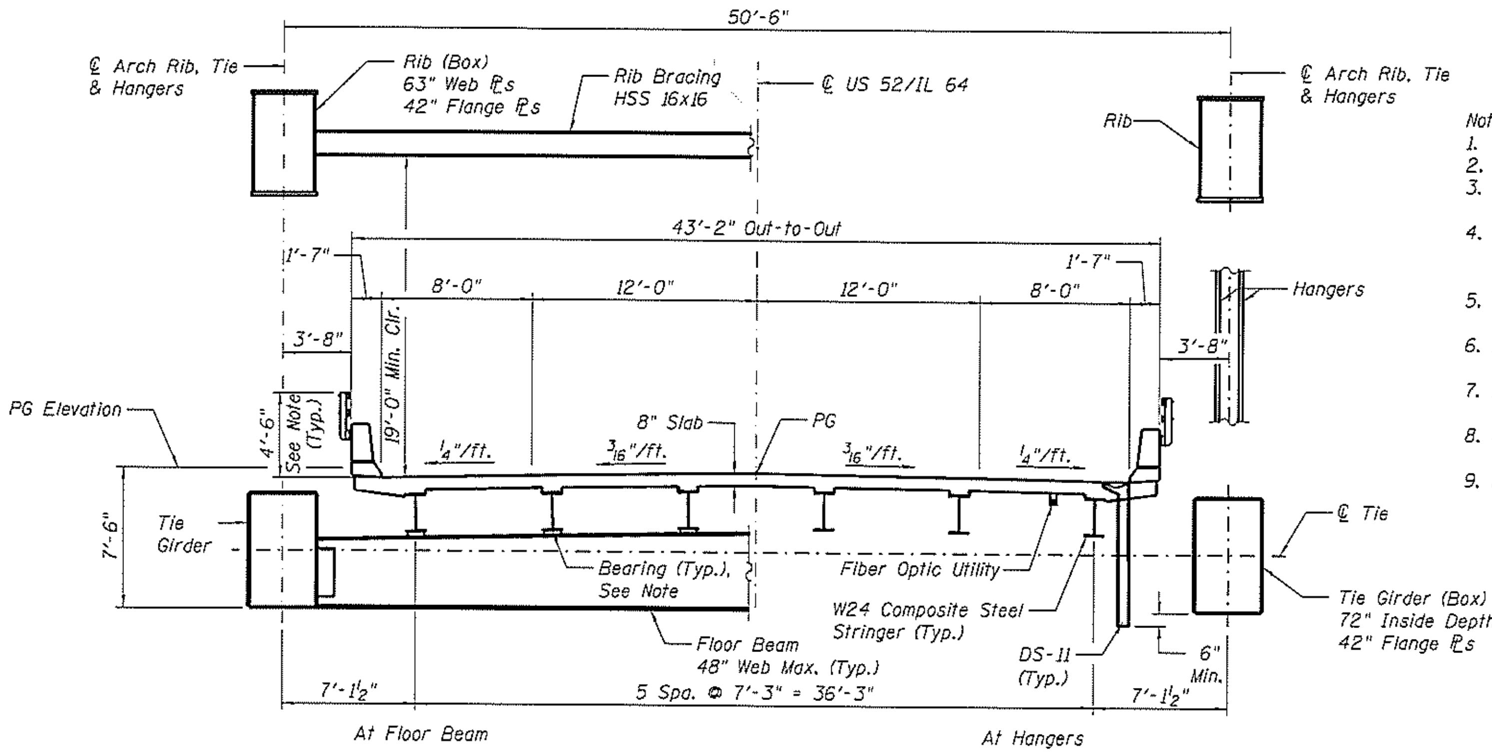
FILE NAME =	USER NAME =	DESIGNED - PY	REVISED
PARSONS	DATE = 7/16/2014	CHECKED - GTH	REVISED
	PLOT SCALE =	DRAWN - TSB	REVISED
	PLOT DATE =	CHECKED - GTH	REVISED

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

SHEET NO. 2 OF 5 SHEETS

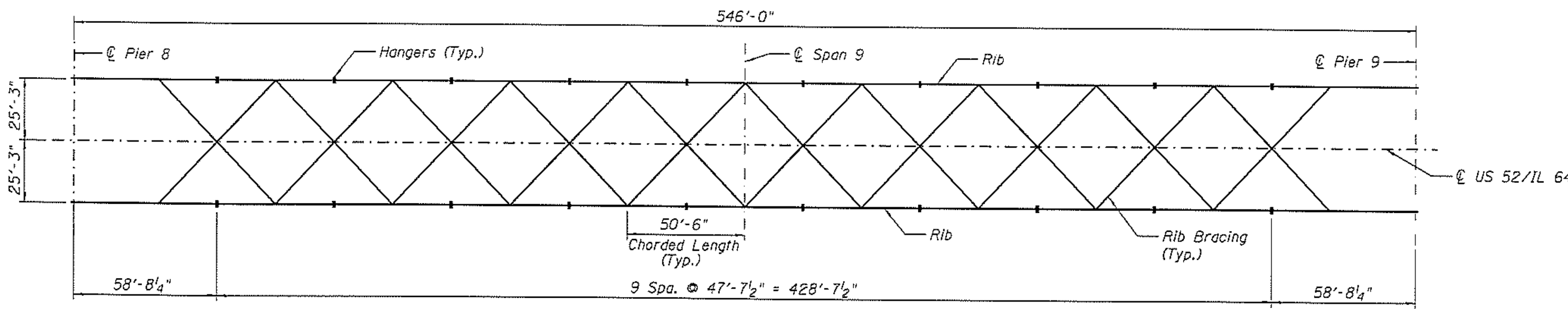
F.A. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
17	104B-2	Carroll		

CONTRACT NO. 64G59
ILLINOIS FED. AID PROJECT

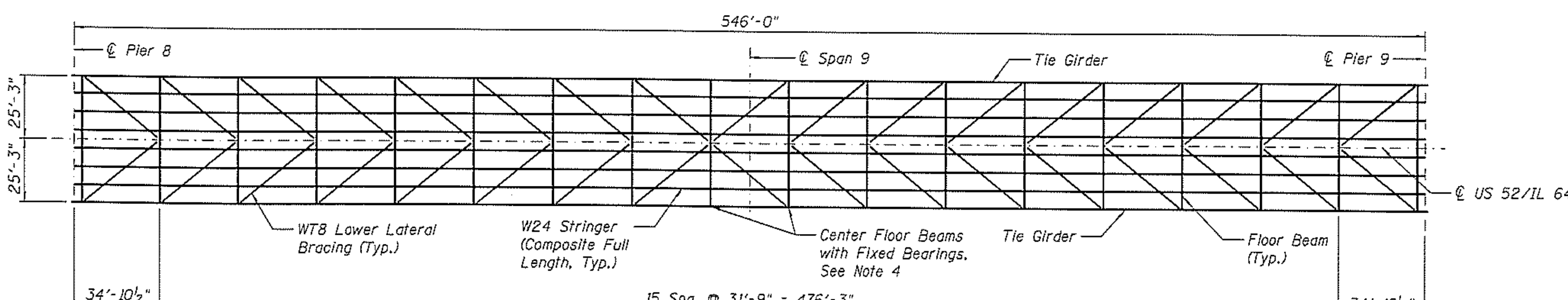


CROSS SECTION - UNIT 2
(Looking East)

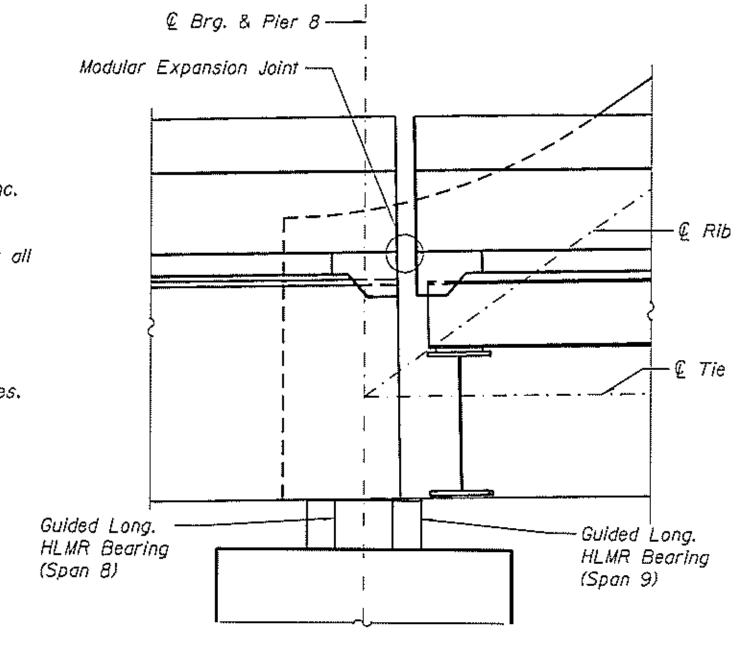
Notes:
1. For Parapet Detail see Sheet 4.
2. Fiber Optic Utility - 2"ϕ conduit for Windstream - KDL, Inc.
3. Provide downspout brace to floor beam at 1'-9" distance from the bottom of the downspout.
4. Fixed bearing at center floor beams. Expansion bearing at all others. Side retainers along center two stringers at every floor beam.
5. Investigate cost effectiveness of galvanizing floor beams, stringers, diaphragms and bracing of the tied arch.
6. Investigate galvanizing end section of tied arch chord / rib due to water accumulation problems in similar structures.
7. Investigate cost effectiveness of metalizing for tied arch chord / rib.
8. Use 1.5 to 2 inch diameter drain holes for tied arch chord / rib. Evaluate screens for holes.
9. Provide special attention to the access details and ventilation requirements for the tied arch chord / rib and contact inspection unit personnel for recommendations and comments on the design plans.



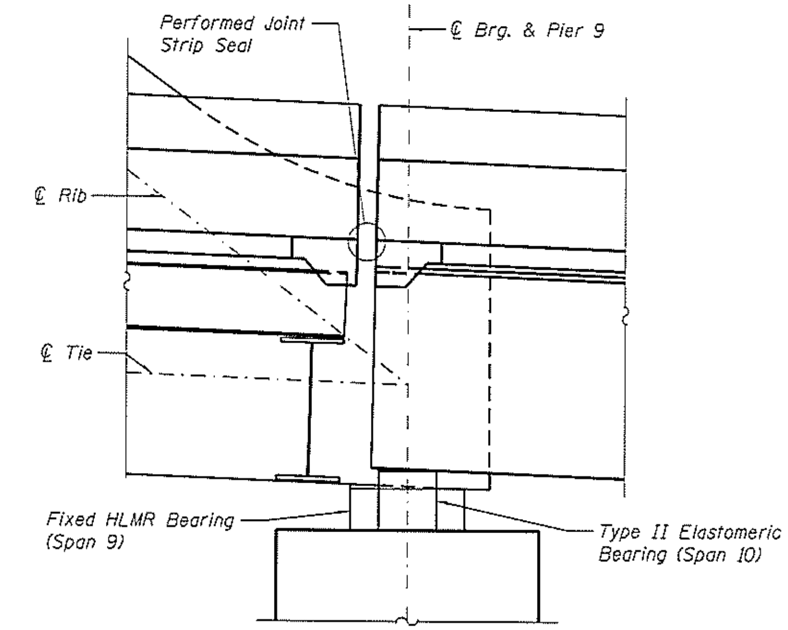
RIB CROSS BRACING PLAN - UNIT 2



FRAMING PLAN - UNIT 2



SECTION THROUGH EXPANSION JOINT
PIER 8



SECTION THROUGH EXPANSION JOINT
PIER 9

DETAILS - 1
US 52/IL 64 OVER THE MISSISSIPPI RIVER
PUBLIC WATER
F.A.P. RTE. 17 - SEC. 104B-2
CARROLL (IL) AND JACKSON (IA) COUNTIES
STATION 1577+60.00
STRUCTURE NO. 008-0052

FILE NAME =	USER NAME =	DESIGNED - PY	REVISED
PARSONS	DATE = 7/16/2014	CHECKED - GTH	REVISED
	PLOT SCALE =	DRAWN - PY	REVISED
	PLOT DATE =	CHECKED - GTH	REVISED

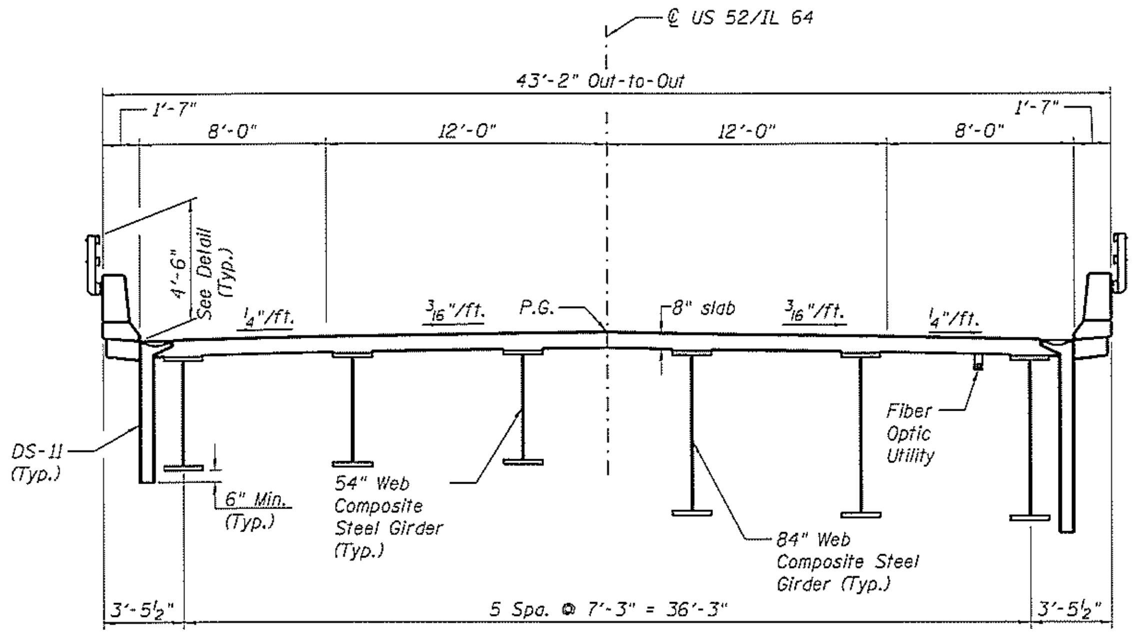
STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

SHEET NO. 3 OF 5 SHEETS

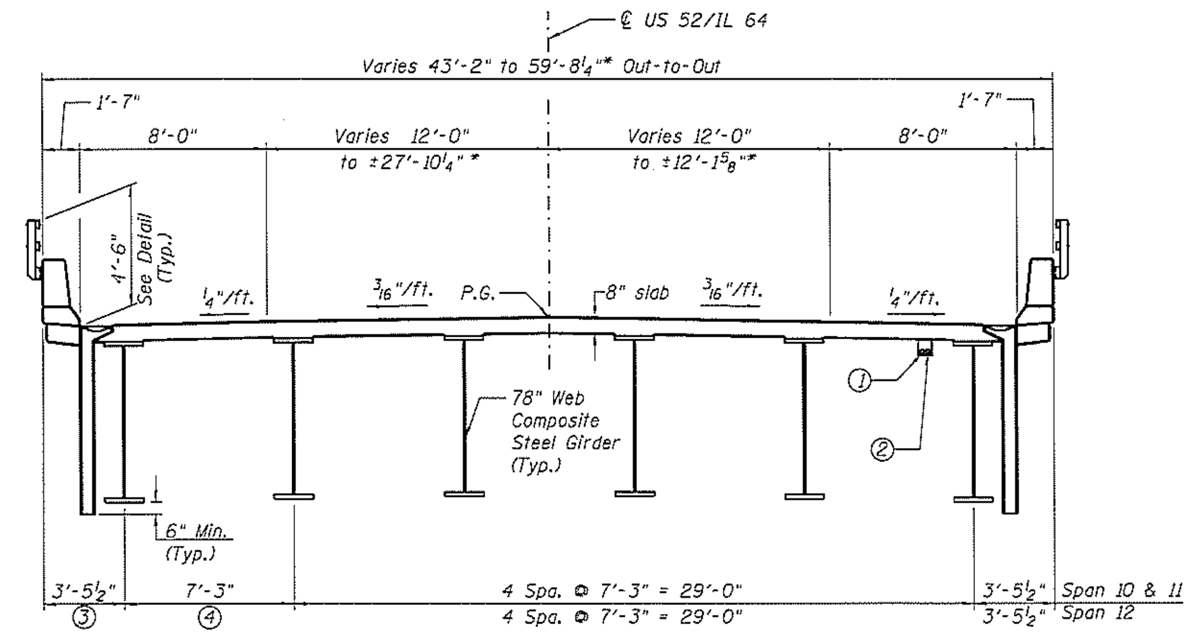
F.A. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
17	104B-2	Carroll		
		CONTRACT NO. 64C59		

ILLINOIS FED. AID PROJECT

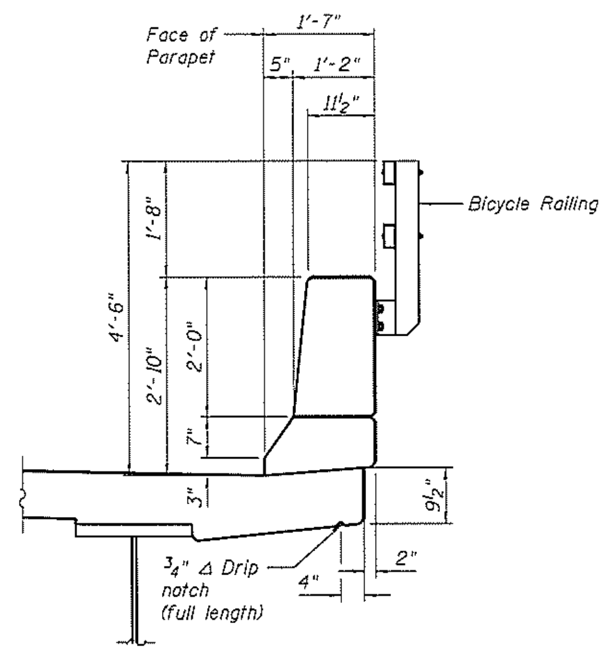
① Fiber Optic Utility
② Bridge Electrical Utility
③ Varies 1'-6" min. to 3'-8" max.
④ Varies, see Partial Framing Plan



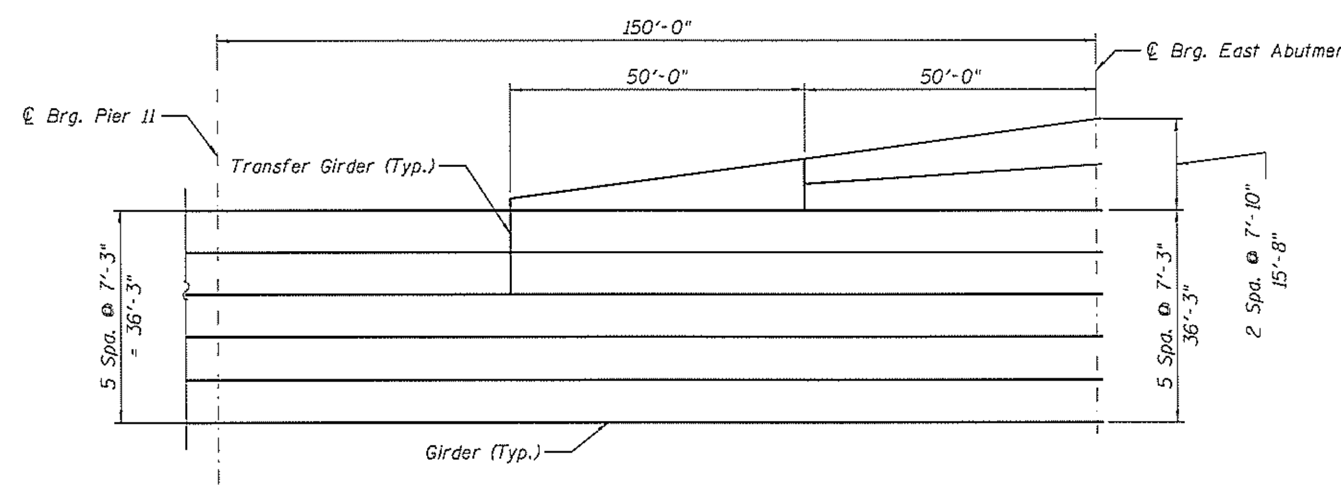
CROSS SECTION - UNIT 1
(Looking East)



CROSS SECTION - UNIT 3
(Looking East)
* Dimension ⊥ to ℄ US 52/IL 64 @ Bk. of E. Abut.



PARAPET DETAIL
(F Shape Parapet with Bicycle Railing R-38)

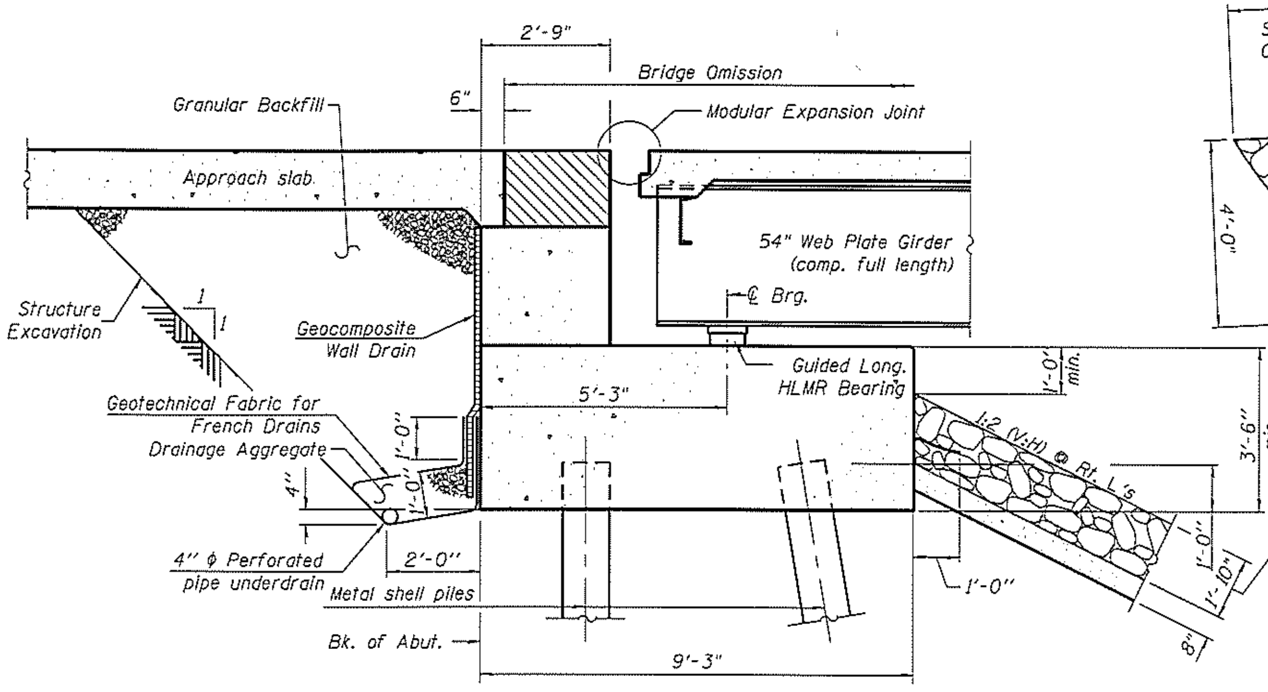


PARTIAL FRAMING PLAN - UNIT 3

Notes:
1. Fiber Optic Utility - 2"φ Conduit for Windstream - KDL, Inc.
2. Bridge Electrical Utility - 2"φ Conduit for Span 9 interior maintenance electrical and lighting and navigation lighting.
3. Galvanize the end diaphragms at the open joints for the approach spans.
4. Investigate the cost effectiveness of metalizing the girders of the approach spans.

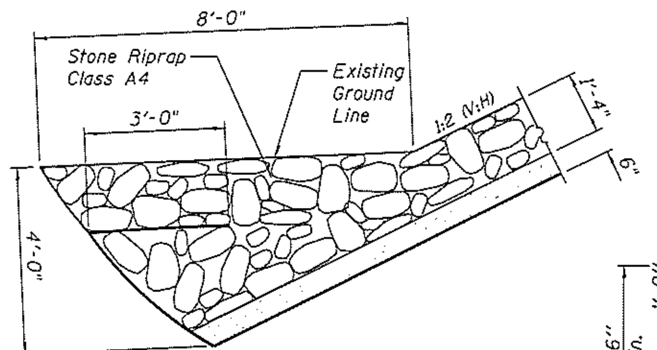
DETAILS - 2
US 52/IL 64 OVER THE MISSISSIPPI RIVER
PUBLIC WATER
F.A.P. RTE. 17 - SEC. 104B-2
CARROLL (IL) AND JACKSON (IA) COUNTIES
STATION 1577+60.00
STRUCTURE NO. 008-0052

FILE NAME =	USER NAME =	DESIGNED - TMB	REVISED	STATE OF ILLINOIS		F.A. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
PARSONS	DATE = 7/16/2014	CHECKED - TSB	REVISED	DEPARTMENT OF TRANSPORTATION		17	104B-2	Carroll		
	PLOT SCALE =	DRAWN - TSB	REVISED					CONTRACT NO. 64G59		
	PLOT DATE =	CHECKED - GTH	REVISED		SHEET NO. 4 OF 5 SHEETS		ILLINOIS FED. AID PROJECT			

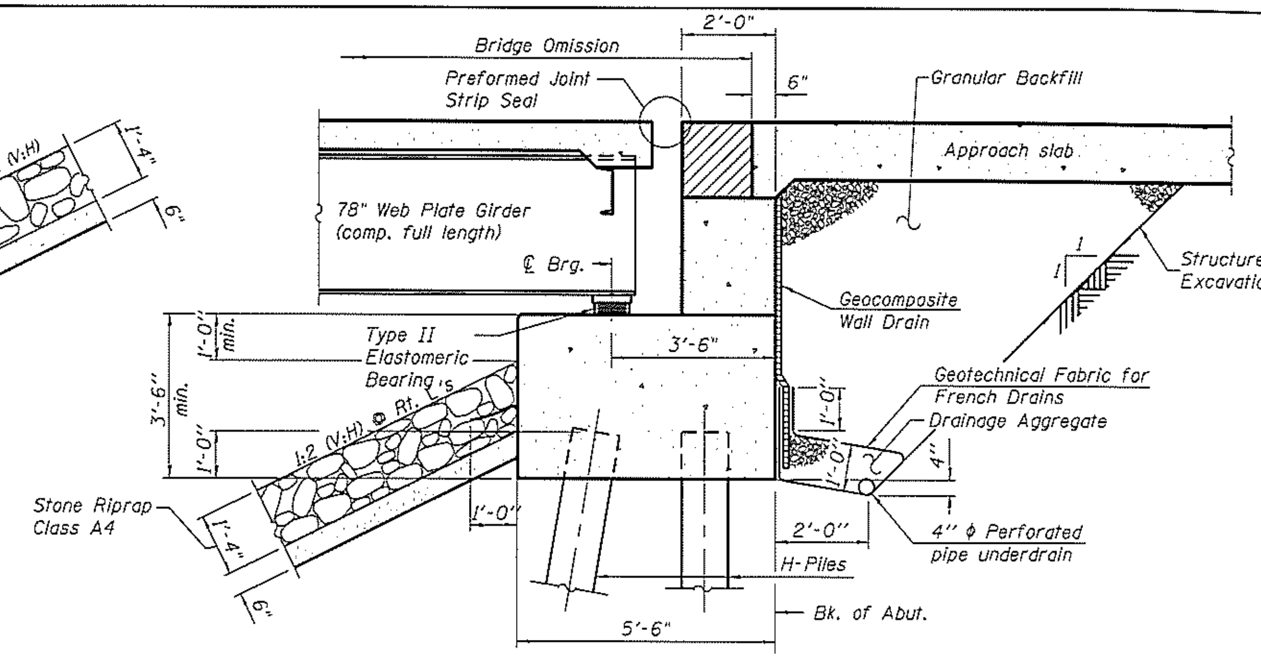


SECTION THRU PILE SUPPORTED WEST ABUTMENT

(Horiz. dim. @ Rt. L's)

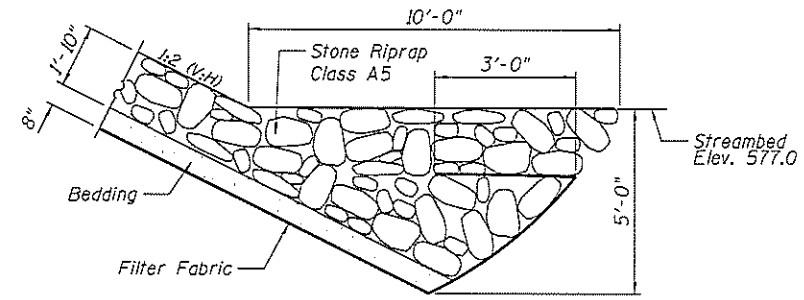


SECTION B-B



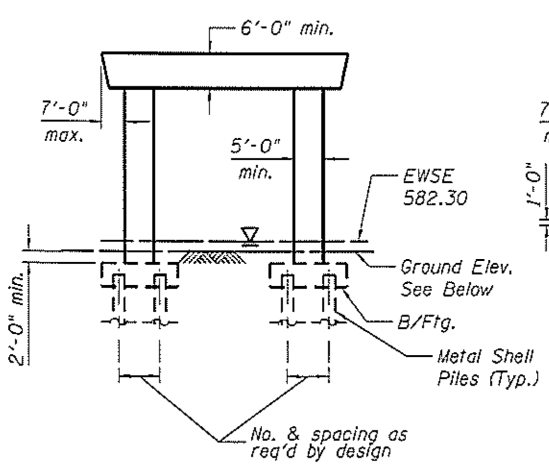
SECTION THRU PILE SUPPORTED EAST ABUTMENT

(Horiz. dim. @ Rt. L's)



SECTION A-A

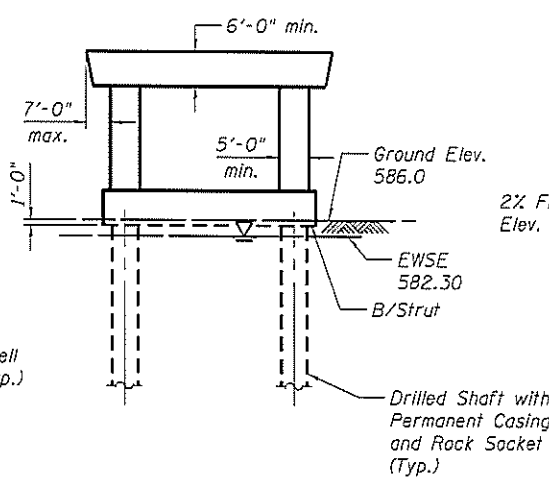
Notes:
1. EWSE = Estimated Water Surface Elevation = Normal Pool.
2. For location of Section A-A see Sheet 1.
3. For location of Section B-B see Sheet 2.
4. Min. W. Abut. Stone Riprap shown for scour protection. W. Abut. Stone Riprap required for slope stability to be determined in final design.



PIER SKETCH

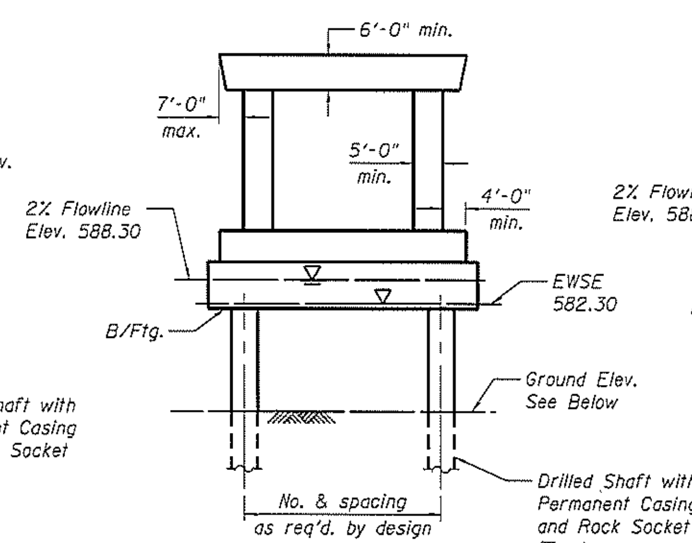
(Piers 1-4)

Pier	Ground Elev.
1	576.0
2	582.0
3	582.0
4	586.0



PIER SKETCH

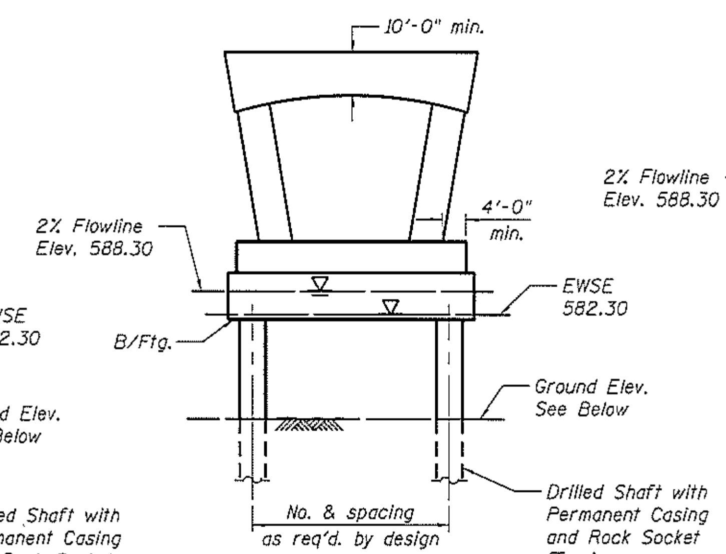
(Pier 5)



PIER SKETCH

(Piers 6, 7 & 10)

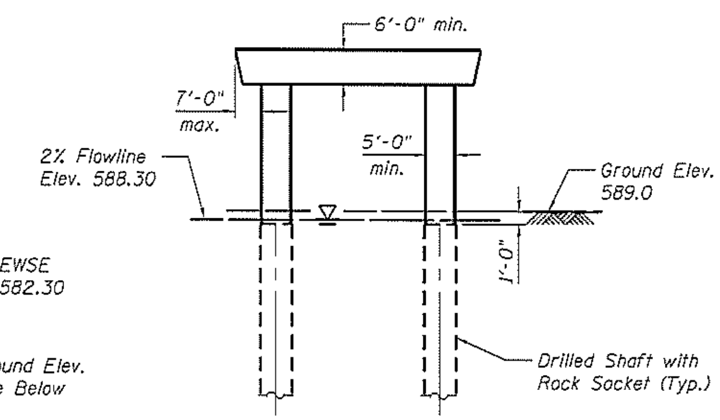
Pier	Ground Elev.
6	552.0
7	559.0
10	567.0



PIER SKETCH

(Piers 8 & 9)

Pier	Ground Elev.
8	556.0
9	563.0



PIER SKETCH

(Pier 11)

DETAILS - 3
US 52/IL 64 OVER THE MISSISSIPPI RIVER
PUBLIC WATER
F.A.P. RTE. 17 - SEC. 104B-2
CARROLL (IL) AND JACKSON (IA) COUNTIES
STATION 1577+60.00
STRUCTURE NO. 008-0052

FILE NAME =	USER NAME =	DESIGNED - TMB	REVISED
PARSONS	DATE = 7/16/2014	CHECKED - TSB	REVISED
	PLOT SCALE =	DRAWN - TSB	REVISED
	PLOT DATE =	CHECKED - GTH	REVISED

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

SHEET NO. 5 OF 5 SHEETS

F.A. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
17	104B-2	Carroll		

CONTRACT NO. 64G59

ILLINOIS | FED. AID PROJECT

APPENDIX B

OVERWATER
PIEZOMETRIC CONE PENETRATION TESTING
US 52 IL 64 Bridge over the Mississippi River
Savanna, Illinois

Prepared for:

Wang Engineering , Inc
1145 North Main Street
Lombard, Illinois 60148

Prepared by:

STRATIGRAPHICS
The Geotechnical Data Acquisition Corporation
26798 County T
Hillpoint, WI 53937
Phone: 888.790.CPTU
www.STRATIGRAPHICS.com

December, 2013
12-130-100

TABLE OF CONTENTS

FIGURES AND TABULATIONS

1.0 EXECUTIVE SUMMARY

STRATIGRAPHICS, The Geotechnical Data Acquisition Corporation, performed overwater geotechnical cone penetrometer exploration for Wang Engineering, Inc. at the US52/IL64 Bridge over the Mississippi River Site near Savanna, Illinois. The purpose of the exploration was to provide supplemental geotechnical data on subsurface soil conditions at the Site.

The exploration work was performed on November 1, 2012 and then between November 7 and 13, 2012. Nine CPTU soundings were attempted at 7 locations. Total CPT footage from the water surface was 366.1 ft. Total soil penetration was about 150 ft. All CPTU soundings were taken to refusal.

This report includes the CPT sounding logs and tabulations of recorded data and correlated geotechnical parameters. Details of penetrometer exploration techniques are included in the main body of the report. Additional details of CPT data evaluation are presented in the report appendices.

2.0 PENETROMETER EQUIPMENT AND DATA ACQUISITION

2.1 Procedure The Cone Penetration Test (CPT) consists of smoothly and continuously pushing an instrumented probe (penetrometer) deep into the ground while recording the soil response to penetration (Figure 1). The CPT penetrometer models a foundation pile under plunging failure load conditions. CPT data are used to develop continuous, high resolution profiles of in situ soil conditions rapidly, accurately and economically.

The soil resistance to penetration acting on the tip and along the sides of the penetrometer is measured during CPT. CPT soil resistance measurements are accurate and highly repeatable. The measurements are used for the evaluation of stratigraphy and various geotechnical parameters. Performance of CPT is specified by ASTM Standard D5778. A fluid pressure transducer is added to acquire hydrogeologic data (Saines and others, 1989) and is called a Piezometric Cone Penetration Test (CPTU). A soil electrical conductivity sensor is added to the penetrometer (CPTU-EC) to acquire qualitative moisture information in vadose zone soils and general groundwater quality data (Strutynsky and others, 1991, 1998). Penetrometer groundwater, soil, and soil gas samplers are used for direct sampling (Strutynsky and Sainey, 1990, Strutynsky and others, 1998). Other sensors, described in the report text, are often included during CPT.

The penetrometer is mounted at the tip of a string of sounding rods. A hydraulic ram is used to push the rod string into the ground at a constant rate of 4 ft per minute. Electronic signals from downhole sensors are transmitted to a data acquisition system for display and recording. Heavy trucks or other deployment systems are used to perform CPT. Truck weight and ballast serve to counteract the thrust of the hydraulic ram. Enclosed truck rig work areas allow all-weather operations. Computers, samplers, electrical power, lighting, compressed air, pressure washer, grout pump, and water tank are included on truck mounted rigs, providing for self-contained operations. Onboard GPS receivers are used to record location positions.

No borehole is required during CPT because penetrometers are directly thrust into the soil. Pressures of over 3 million pounds per square foot can be applied to the tip of the penetrometer for penetration of most soils finer than medium gravel. Asphalt pavements up to 6 inches thick can often be penetrated by penetrometer methods without pre drilling. Site disturbance is reduced since no borehole cuttings or drilling fluids are generated during penetrometer operations. Personnel exposure to contaminated soil is less than exposures during drilling and sampling operations. CPT equipment can be decontaminated during retrieval.

Four to thirteen hundred feet of CPT can be performed in a day, depending on site access. Depths of more than 200 ft can be achieved depending on stratigraphy. Where soils are exceptionally dense, gravelly or rubble filled, an uninstrumented prepunch tool can be used for probing. Information obtained using the prepunch tool can be similar to mechanical (Dutch) cone data, and are indicative of subsurface conditions.

2.1.1 Signal Conditioning and Recording CPT data are acquired using a high channel count, 16 bit (resolution of 1 part in 32,768) industrial data logger and an MS Windows computer. Data are recorded on multiple hard and solid state disks for backup, data processing and archiving. Data are graphically displayed during field testing using commercially available Labview software. CPT data processing is performed using a proprietary software package STRATIGRAPHER (tm) developed by STRATIGRAPHICS.

2.2 Soil Shear Resistance Measurements The soil penetration resistance is measured on the tip and along the sides of the CPT penetrometer using strain gage loadcells (Figure 1, Strutynsky and others, 1985). The conical tip of the penetrometer has a projected cross-sectional area of 15 square centimeters (2.3 sq. in.) and a diameter of 1.7 inches. The cone tip resistance reflects the deep bearing capacity of a soil. Soil friction is measured along a cylindrical sleeve mounted behind the cone tip. The friction sleeve has a surface area of 200 square centimeters (31.0 sq. in.), a length of 5.8 inches, and a diameter slightly larger than the cone tip. The cone tip measurement has a layer resolution of about 2 to 4 inches, while the friction sleeve resolution is about 6 inches.

2.3 Piezometric Measurements A fluid pressure transducer is mounted inside the CPTU penetrometer to measure the soil pore water pressure response to penetration. The advance of the penetrometer causes local, intense volumetric distortion of surrounding soil. This generates a localized pore water pressure field in saturated soils. These generated pressures dissipate almost instantaneously (drained loading) in soils of high permeability, so equilibrium water pressures are typically measured during CPTU in coarse sand and gravel. In medium or low permeability soils, the generated pore water pressure field is sustained for a substantial period of time (partially drained to undrained loading) and can be either negative (dilative) or positive (compressive) relative to the equilibrium (hydrostatic) water pressure field existing before penetration.

The dissipation of generated pore water pressures is recorded during pauses in penetration. The rate of dissipation can be used to estimate soil hydraulic conductivity and consolidation characteristics. If the pauses are long enough for all of the generated water pressures to dissipate, equilibrium potentiometric surface measurements can be obtained at multiple depths in a single CPTU sounding. The CPTU piezometric measurement has a layer resolution of about 1 inch.

2.3.1 Piezometer Saturation The CPTU piezometric measurement system is saturated fully assembled in a 15-50 micron Hg vacuum chamber using silicon oil. This procedure is used to remove as much air as practically possible from the piezometric assembly, to provide as near to an incompressible condition as possible so that near instantaneous responses (zero lag time) to rapidly changing generated pore water pressures are measured during CPTU. High piezometric system saturation levels are indicated by sharp responses at soil interfaces and immediate regeneration of piezometric pressures after pauses in penetration.

Low piezometric measurement system saturation levels leading to poor (lagging) measurements can be caused by inadequate system preparation. Soil suction above the water table, cavitation in highly dilative soils, filter clogging in fine grained soils and filter damage on coarse soil particles or pavement can also occur and cause less than ideal measurements. These problems are beyond the control of the operator and occur with some frequency when testing soils on land. Overwater work provides a more benign environment for CPTU measurements. CPTU piezometric measurements are often less repeatable than CPT tip and friction sleeve resistance measurements.

2.4 Electrical Conductivity and Thermal Measurements A CPTU-EC penetrometer including tip, sleeve, piezometric, temperature, and electrical conductivity (EC) sensors can be used to simultaneously acquire geotechnical, hydrogeological and qualitative geochemical information. Soil EC is measured using a two electrode array, energized with a 3 kHz signal, mounted on the penetrometer tip. The EC measurement has a resolution of about 1 inch. The CPT thermal sensor is used to acquire soil thermal properties.

2.5 Natural Gamma Measurements A CPTU-EC-G penetrometer incorporating cone, friction, piezometric, soil electrical conductivity and natural gamma (G) sensors can be used to simultaneously acquire geotechnical, hydrogeological, qualitative geochemical and radiological information. Gamma measurements can be used to detect radionuclide contamination and to enhance lithologic evaluation.

2.6 UV Fluorescence A CPTU-EC-UVF penetrometer incorporating cone, friction, piezometric, soil electrical conductivity, and Ultraviolet Fluorescence (UVF) sensors can be used to simultaneously acquire geotechnical, hydrogeological, and qualitative geochemical information. The UVF system consists of a sapphire window in the penetrometer, a monochromatic LED UV excitation light source, and photodiode light detectors. UV light is transmitted through the window into the adjacent soil. If the soil contains compounds such as petroleum hydrocarbons that fluoresce, the photodiodes are used to detect the resulting light. The UV excitation has a wavelength of 250 nm. The photodiode sensors are longpass filtered to monitor resulting fluorescent light emissions above 280 nm.

2.7 CPT Seismic Wave Velocity Measurements A vibration receiver module is attached to the penetrometer to acquire seismic (vibration) wave velocity data. CPT vibration sensors have exceptionally good coupling to the surrounding soil resulting in good reception of the high amplitude shear S-wave arrival. Sensor coupling using packers in cemented and cased boreholes, in contrast, is typically much poorer than that using CPT deployment methods. The low-amplitude compression P-waves, in contrast, are often difficult to acquire with CPT deployment because of the good coupling - low amplitude vibrations can travel up and down the steel CPT rod string, making the low-amplitude P-wave arrival hard to detect from background noise.

The STRATIGRAPHICS CPT seismic system consists of downhole vibration sensors, an uphole manual or autohammer impulse wave source with timing trigger, multi-channel, high speed analog to digital converter, and PC signal acquisition and analysis software. The CPT seismic test procedure is as follows: 1) the CPT penetrometer and vibration sensor module are pushed to depth and penetration is paused at the seismic test interval. This is most effectively done when a CPT rod must be added to the rod string. CPT rods typically come in 1 meter lengths, so seismic testing should be specified at some integral meter interval, typically 1 to 3 meters. Occasionally, if a highly trained CPT operator is available, seismic testing can also be performed at CPT identified strata breaks; 2) the impulse seismic source wave is generated at the surface; 3) the vibration sensor output is recorded as a function of time starting when the impulse source is triggered; and 4) a consistent high amplitude reference point on the recorded wave form is picked to indicate wave arrival. This seismic test procedure is repeated at multiple increasing depth intervals during the CPT penetration process to allow calculation of pseudo-interval wave velocities between adjacent tests.

Two types of vibration sensors are most often used for CPT seismic testing. A low frequency response geophone can be used to acquire data at sites where background environmental noise levels are high. Highly sensitive multi-axis accelerometer sensors are used to acquire multi-channel S-wave data at most sites. The accelerometers have a much wider frequency response as compared to the geophones, and are much more sensitive to vibrations. This sensitivity can result in noisy recordings which can preclude good picks of wave arrivals at some industrial sites. The use of high sensitivity accelerometers, on the other hand, can be an advantage where background noise is random, as signal-stacking techniques are often very well applied at noisy sites to synthetically increase seismic signal-to-noise ratios.

CPT seismic wave velocities are most often computed using pseudo-interval techniques. In concept, an arrival at the immediately shallower interval is used as the start of the wave for the next deeper interval. Since the distance between the two tested intervals is known, a velocity can be computed across the interval.

2.8 CPT-EMOD Measurements The standard CPT procedure is conducted as a constant rate of strain test, resulting in a continuous measurement of soil ultimate bearing and frictional strength. By conducting CPT under monotonically increasing stress conditions, soil deformation properties can be evaluated. The CPT-EMOD test is conducted during short pauses in the continuous push process. Load/settlement data are analyzed using elastic theory, as is done for a plate load test for evaluation of Young's Modulus at various stress levels.

2.9 MIP Testing A MIP (Membrane Interface Probe) adapter can be added to the CPT rod string to allow geochemical testing. The MIP consists of a permeable membrane, heater block with thermocouple and gas carrier tubing. The heater block is heated to a temperature of 120-130 degrees C, heating up the surrounding soil, and volatilizing contaminants potentially in the soil. The volatiles pass through the permeable membrane and are swept to the surface by a carrier gas, typically nitrogen, which passes across the back of the membrane.

Once the carrier gas brings the volatiles to the surface, various detectors can be used to characterize the contaminants. A simple photoionization detector (PID) sensor suite is available for rapid screening studies. Two PID sensors, one with a lamp of 10.6 eV energy, and the second with a 9.6 eV lamp, are included in this simple screening suite. More sophisticated analytical equipment, such as GC-MS, can also be used for analysis.

2.10 Penetrometer Geometry The CPT penetrometer external geometry is specified by ASTM standards. Differences in penetrometer internal design can lead to some variability in response between penetrometers of different manufacture, especially in very soft clays. STRATIGRAPHICS uses a cone with a 15 sq cm tip and a 200 sq cm sleeve. The CPTU measurement of generated water pressure depends on external filter geometry. Measurements of equilibrium water pressures after pauses in the penetration process are not sensitive to geometry, and reflect undisturbed conditions.

CPTU piezometric filters are typically mounted on either the cone tip (U1 position) or just ahead of the friction sleeve (U2 position). Each position has advantages and disadvantages. Measurements taken with the cone tip U1 filter are at a maximum and show high resolution of thin soil seams. The cone tip U1 filter is prone to damage on coarse soil particles. Negative pressures are often measured in dense, silty or clayey sands and hard clays when using the U2 friction sleeve filter. These low pressures are probably caused by soil elastic rebound (expansion) as the soil moves from the intensely loaded region beneath the cone tip to the less loaded region next to the friction sleeve. Soil expansion can induce large suction forces on the U2 friction sleeve filter, which can result in decreased filter saturation levels.

Site characteristics and data usage determine which piezometric filter geometry is appropriate. The piezometric filter is placed at the U2 friction sleeve position on the STRATIGRAPHICS CPTU-EC penetrometer. The filter housing is internal to the cone tip. Generally good results can be obtained using this geometry when proper filter preparation techniques are followed.

2.11 Equipment Decontamination and Grouting The rod string is retrieved through a rodwasher mounted on the hydraulic ram assembly. A pressure washer is used to spray water from internal nozzles within the rod washer to clean the rod string. Wash water (about ½ gallon per 10 ft of rod) can be captured for disposal.

The STRATIGRAPHICS grouting system can be used to seal open hole. As penetrometers are being advanced, bentonite grout (about ¼ gallon per 10 ft of open hole) is pumped into the annular space formed between the smaller diameter sounding rods and the larger diameter penetrometer. A bypass is opened and additional grout is pumped to seal the hole during rod string retrieval. Pressure grouting during sounding advance can control cross-contamination between different strata. The grout also can decrease the contact of downhole equipment with contaminated soil. The grout can sometimes decrease rod friction which may allow deeper penetration. Grout levels are checked after sounding completion, and more grout can be added to account for the flow of grout into more permeable strata.

3.0 PENETROMETER SAMPLING EQUIPMENT

Groundwater, soil gas, and soil samplers are deployed in the same manner as CPT penetrometers. Good sample isolation is achieved because no open hole exists during penetrometer operations.

3.1 Groundwater Sampler The STRATIGRAPHICS groundwater sampler is a shielded wellpoint sampler of heavy construction. The shield controls cross contamination of the sampler while penetrating soils above the sampling depth. Where LNAPL or DNAPL is expected, the sampler and rod string can be prefilled with distilled water during deployment, to provide positive pressure within the sampler, which prevents any product from entering the sampler prior to sampler opening. The DI water is pumped out immediately before opening the sampler. After shield retraction and sampler opening, groundwater flows under in situ pressure conditions, through a 20 inch long screen, into the 350 ml sample barrel, and up the rod string. Small diameter pumps can be used with the sampler to acquire large volumes of sample. This sampler can be deployed in most soils capable of being penetrated by the CPTU-EC penetrometer (Strutynsky and others, 1998).

For the best isolation of samples, the groundwater sampler is first deployed to the shallowest sampling interval, opened, and sample is acquired. The sampler is retrieved to pour off the sample and for decontamination. This process is repeated at each subsequently deeper sampling interval (top/down sampling).

A less expensive method of groundwater sampling is to use a “bottom/up” deployment mode. The groundwater sampler is deployed to the deepest interval, opened, and sample is pumped to the surface. The sampler is then pulled up to the next shallower interval, purged, and sample is pumped again. This procedure is repeated until the shallowest sample has been obtained. If the sampler screen clogs due to fines in the sampled formations, the sampler must be tripped out, deconned, and re-deployed. Bottom/up sampling is most often used at sites with very dense sands and gravels where deep deployment is a problem. The sampler is typically deployed down the same pathway created by the CPTU-EC stratigraphy tool. Since sands cannot maintain an open hole below the water table, good isolation of sampling intervals can be achieved using the bottom/up method.

A pressure transducer can be placed inside the groundwater sampler barrel. This allows the measurement of sample inflow rate. Analysis of inflow data using rising head slug test methods can provide a means of estimating soil hydraulic conductivities. If equilibrium conditions are reached, a measurement of the static water pressure head is obtained during groundwater sampling.

3.2 Soil Gas Sampler The STRATIGRAPHICS soil gas sampler is a shielded screen sampler, similar to the groundwater sampler. The shield is opened by pulling back the rod string during sampling, and soil gases are then purged and extracted. The shield can be closed, and the rod string advanced to another depth, allowing multiple samples during a single rod trip. A vacuum box can be used to inflate Tedlar bags for off site analysis. Portable analytical equipment can be used to allow immediate soil gas profiling.

3.3 Soil Samplers Fixed piston samplers are used to obtain soil samples during penetrometer exploration. A piston, locked into the tip of the barrel to prevent soil from entering the sampler prematurely, is released at the sampling depth. The barrel is then advanced to the bottom of the sampling interval. The soil enters the 1.25 inch diameter, 14 inch long barrel and is retained by a core catcher. The sampler is retrieved to remove the sample and for sampler decontamination. The sampler can be pushed into soils as dense as about 350-400 TSF cone tip resistance, or about 50 to 80 blows per foot SPT.

4.0 PIEZOMETER INSTALLATION TECHNIQUES

Penetrometer methods can be used to install piezometers for water level measurements, slug testing, groundwater sampling, and for remediation activities, such as sparging and soil vapor extraction (SVE). Various installation techniques are available (Saines and others, 1989). Proprietary, low volume change piezometers also can be installed using penetrometer equipment. These piezometers are often used for long term water pressure measurements during geotechnical projects. PVC piezometers are installed using a steel casing pushed to depth. The casing is sealed with an expendable tip which prevents soil from entering the casing during deployment. The PVC screen and risers are lowered into the casing, the casing is then withdrawn, leaving the PVC in place.

5.0 DATA REDUCTION

Test data are monitored as the soundings are performed. Data are recorded on hard disk and may consist of: depth, time, tip and sleeve resistance, generated water pressure, EC, UVF, temperature and natural gamma. Data are processed in-house and undergo quality control review prior to final reporting.

Several parameters can be computed to enhance data correlation:

friction ratio, FR (in %):

FR = fs/qc * 100 (Eq. 1); and

pore pressure ratio, Bq (dimensionless):

Bq = (U-Ue)/(qc-Sv) (Eq. 2);

where: *fs* is the measured friction sleeve resistance, in TSF;
qc is the measured cone end bearing resistance, in TSF;
U is the measured generated pore water pressure, in TSF;
Ue is the measured or estimated equilibrium pore water pressure, in TSF; and
Sv is the total soil overburden pressure, in TSF.

Measured data, computed and correlated parameters are presented in a graphical sounding log format for each sounding; numerical data are typically tabulated at 0.5 ft intervals. Digital data are also included on disk.

CPTU dissipation test data are recorded as a function of time during pauses in the penetration process. Dissipation data are normalized using the following equation:

normalized dissipation level, U* (dimensionless):

(Ut - Ue) / (U0 - Ue) (Eq. 3);

where: *Ut* is the excess pore water pressure at time t, in TSF;
Ue is the measured or estimated equilibrium, undisturbed pore water pressure (in situ pore water pressure before penetrometer insertion), in TSF; and
U0 is the excess pore water pressure at time equal to zero, at the start of the dissipation test, in TSF

The normalized dissipation level is plotted versus log time. In uniform soils, the plot takes the shape of a reverse S-curve, beginning at one at zero time (at the instant the penetration process is stopped) and falling to zero when equilibrium pressures are achieved. Boundary effects in interbedded deposits can cause deviation from this ideal.

An estimate of the horizontal coefficient of soil consolidation can be calculated (Baligh and Levadoux, 1980) using: Ch (in cm**2/sec) = (r**2*T)/t (Eq. 4a).

Estimates of soil hydraulic conductivity in the horizontal direction can be calculated using:

kh (in cm/s) = ((r**2*T)/t)*RR*(Gw/(2.3*Sv')) (Eq. 4b);

where: *r* is the penetrometer radial dimension at the plane of the piezometric filter, equal to 2.2 cm for the U2 friction sleeve filter and 1.9 cm for the U1 cone tip filter;
T is a dimensionless time factor at the 50% normalized dissipation level, equal to 5.5 for the U2 friction sleeve filter and 3.8 for the U1 cone tip filter;
t is the measured time, in seconds, at which the normalized dissipation level is 50%;
RR is a dimensionless soil compressibility parameter;
Gw is the unit weight of water, in kg/cm***3; and
Sv' is the effective soil vertical overburden pressure, in kg/cm**2.

Dissipation test data can be presented in graphical plots and are summarized in tabular form.

6.0 GENERAL DATA EVALUATION

6.1 Sounding Log The CPT sounding logs provide high resolution information on subsurface conditions. Soil layering is often highly apparent. Soil relative strength and saturation levels can also be evaluated. Zones of anomalous soil electrical conductivity can be identified. Apparent lateral continuity of conditions can be evaluated by comparing adjacent soundings. Digital CPT data files can be used in two and three dimensional data visualization, CAD or GIS software programs.

6.2 Soil Type Classification Correlations between penetrometer data and soil classification have been developed from geotechnical bearing capacity theory and a relational database on adjacent CPT soundings and drilled boreholes (Douglas and Olsen, 1981). A CPT soil type chart based on cone tip resistance and friction ratio is presented in Appendix A.

The CPT tip resistance increases exponentially with soil grain size. For example, tip resistance in dense sands ranges from about 100 to 400 tons per square foot (TSF), while tip resistance in a stiff clay ranges from about 5 to 15 TSF. The friction ratio (Section 5.0) is also used for indication of soil type. The friction ratio increases with the fines content and compressibility of a soil. The friction ratio is less than about 1% in a sand and greater than about 3% in a clay. CPT soil types reflect the soil shear resistance to penetration. Soil shear resistance is not entirely controlled by grain size distribution. However, CPT soil types generally agree with classifications based on grain size distribution methods, such as the Unified Soil Classification System (USCS).

The generated pore water pressure measurement is also useful for evaluation of saturated soils. Penetration of coarse sand and gravel occurs under drained loading conditions, and thus equilibrium pressures are measured during CPTU. The pore pressure ratio (Section 5.0) is zero in high permeability soils. For saturated soils of permeability less than about 1*10E-2 cm/sec, undrained loading with significant excess water pressure generation occurs during CPTU. Positive excess water pressures are generally measured during penetration of silt or clay soils when using either the U1 cone tip or U2 friction sleeve filter penetrometer (Section 2.7). Pore pressure ratios of fine grained soils typically range from about 0.4 to 1.0.

Positive excess water pressures are also usually measured in dense, silty or clayey sands when using the U1 filter penetrometer, with pore pressure ratios from about 0 to 0.3. Due to geometric effects (Section 2.7), negative pressures are usually measured in dense, silty or clayey sands, sandy silts, or hard sandy clays with the U2 filter penetrometer. Thus, it is important to note the type of piezometer filter in use. The CPTU-EC penetrometer uses a U2 friction sleeve piezometric filter.

6.3 Potentiometric Surfaces Equilibrium water pressures are measured during penetrometer advance in saturated, coarse sand and gravel. Measurements of equilibrium water pressures can be obtained during CPTU in lower permeability soils by pausing during penetration and allowing generated water pressures to dissipate.

6.4 Soil Saturation Soil saturation often can be evaluated using the CPTU sounding log. Atmospheric (zero) pressure is measured during CPTU in unsaturated soils. Hydrostatic pressures are measured in saturated, high permeability soils. Significant water pressures are generated in saturated, low permeability soils due to penetrometer advance. Decreased levels of water pressure generation can be indicative of partially saturated soils. Decreased water pressure generation also may occur in organic soils due to the high compressibility of organic soil particles and the presence of biogenic gases, such as methane and hydrogen sulfide.

6.5 Soil Hydraulic Conductivity Excess water pressures are generated by penetrometer advance in saturated soils with permeability of less than about 1*10E-2 cm/sec. These generated pressures can be allowed to dissipate during pauses in the penetration process. The CPTU dissipation test is similar to a slug test and can be used to estimate soil hydraulic conductivity in the horizontal direction. Very high water pressures are typically generated in low permeability soils by penetrometer advance, so soil compressibility (storage) effects must be included in analyses. The CPTU tip resistance provides an index of soil compressibility for these computations.

6.6 Soil Electrical Conductivity Behavior Soil electrical conductivity (EC) is controlled by the conductance of both the soil particles and soil pore fluids. The ratio between pore fluid and soil-pore fluid electrical conductivity is termed the formation factor (Archie, 1942). Clays can be electrically conductive due to adsorbed water and ionic electrical charges on the clay platelets. Thus, clay EC depends on mineralogy, porosity and pore fluid characteristics. Sand grains are typically non-conductive, so granular soil conductance is primarily dependent on the conductance of pore fluids and the sand’s porosity.

Pore fluids play a major role in sand EC. A dry sand has low EC since both the sand grains and the air in the pore space have very low conductance. Sands saturated with conductive liquids, such as brine or landfill leachates, have high EC. Hydrocarbons typically decrease EC because of their low conductance. **Soil saturation** has a pronounced effect on sand EC, as conductance increases with water saturation. Low saturation is typically associated with low EC. The low **porosity** of a dense sand results in less pore fluid available for electrical conductance and thus lower EC; the high porosity of a loose sand is often associated with higher EC. Formation factors vary as an inverse function of porosity, from about 3 at high porosity to about 4.5 at low porosity. The addition of as little as 5% clay to a sand can increase soil EC (Windle, 1977).

The high resolution of the STRATIGRAPHICS CPTU-EC electrode array makes measurements sensitive to gravel content. Two behaviors can occur when penetrating gravelly soils. One can occur when a large particle is crushed against an electrode, masking it from the pore fluids, which results in low EC values. An opposite behavior is observed in gravel deposits which contain few fine grained intersticial soils. The high resolution EC measurement can result in electrical conductance paths within the soil pore space. In this situation, high EC measurements more closely reflect pore fluid EC, rather than soil EC.

<u>6.7 EC Evaluation</u> EC data are evaluated in conjunction with CPTU-EC piezometric data and soil types for qualitative geochemical characteristics. Anomalous zones possibly indicative of contaminants can be directly sampled for quantitative chemical analysis.

Vadose Zone Low or zero EC values are typically measured in dry sandy soils. Increased EC in vadose zone sands may indicate moisture infiltration. Low EC data in vadose zone silty or clayey soils can be anomalous as fine grained soils often retain significant amounts of moisture within their pore spaces due to capillarity. Elevated EC values in the vadose zone may be associated with road deicing salts, buried metals and rusted metal objects, flyash and cinders, among others.

Saturated Soils Low EC values in saturated soils can be indicative of anomalous geochemistry. In particular, depressed EC zones immediately at the water table may be associated with floating (LNAPL) compounds. Very low EC zones at interfaces between aquifers and aquitards may be associated with either LNAPL or DNAPL compounds. Gravel interference must be considered when evaluating depressed EC zones in saturated soils.

Elevated EC values in saturated soils can be due to increased soil clay content or to increased dissolved salts in the ground water. Increased clay contents are evaluated based on the CPTU-EC piezometric data and soil type information. Zones of elevated EC immediately above an aquiclude may be associated with brines or landfill leachates (Strutynsky and others, 1998).

<u>6.8 UV Fluorescence Behavior</u> Fluorimetry (measurement of fluorescence) has been used for many years for the detection and identification of various compounds and minerals. An excitation light of short wavelength is used to expose the specimen. If fluorescent compounds or minerals are present, light of longer wavelength, as compared to the excitation wavelength, will be emitted from the specimen. This resulting light can be monitored for intensity and spectral distribution.

Compounds that fluoresce include a wide range of hydrocarbon and other organic compounds. Heavy hydrocarbons (e.g. fuel oil and coal tars) fluoresce at relatively long wavelength excitation. As excitation wavelength decreases below about 300 nm, fluorescence from lighter hydrocarbons (e.g. jet fuel and gasoline) is observed. In addition to hydrocarbons, other compounds and minerals, such as fluorites and other carbonates, also exhibit fluorescence. Compounds that fluoresce include dyes and optical brighteners, used in paints, detergents, antifreeze compounds, some food additives and cosmetics, among others. UVF response will be affected by the presence of any such compounds.

<u>6.9 CPT-SPT Correlation</u> Since most geoscientists are familiar with drilling and split spoon sampling, CPT data have been correlated with SPT blowcount N-values. The SPT N-value is defined by ASTM to be the number of blows of a 140 lb hammer, dropped 30 inches, required to drive a 2 inch outside diameter sampler 12 inches into the bottom of the borehole, after an initial seating drive of 6 inches. Correlations of CPT to the crude SPT have been based on numerical modeling of the two penetration processes and on side by side comparisons (Douglas and others, 1981). Additional details on CPT-SPT correlations are included in Appendix A.

7.0 GEOTECHNICAL DATA CORRELATION

CPT data have been correlated with soil type, drained friction angle, undrained shear strength, relative density and SPT blowcounts, among others. A correlation scheme including tip resistance and friction ratio has generally proved most useful for evaluating CPT data. Correlation of CPT data with other parameters has been developed using: 1) comparisons between CPT data and results of other in situ and laboratory tests in adjacent boreholes; 2) CPT testing on large scale soil samples of known composition; and 3) geotechnical bearing capacity and cavity expansion theory. Site specific information can be used to fine tune correlations. Additional information on correlation techniques, including overburden pressure normalization, test drainage conditions and recommended practices, is presented in Appendix A.

8.0 PROGRAM RESULTS

Acquired data are presented following the report text and consist of: 1) sounding logs with lithologic evaluation; 2) data presentation sounding logs; and 3) tabulations of correlated geotechnical parameters, including soil classifications. Digital data are presented on the attached disk, and include statistical summaries of evaluated strata for each sounding, among other data presentations. It should be noted that the computerized evaluations of soil types and other geotechnical properties were generated using a global rather than site specific data base. Use of site specific data was beyond the scope of this study.

9.0 STATEMENT OF LIMITATIONS

Subsurface information was gathered only at the sounding locations. Extrapolation of sounding data to develop stratigraphic continuity is conjectural. Actual site conditions between sounding locations may differ. Evaluation of soil saturation and potentiometric surfaces is only representative of conditions encountered during the field program. Seasonal variation must be expected.

Correlation of penetrometer data with other parameters was performed using generalized, global charts rather than on site specific information. Site specific correlation work based on results of detailed, complementary laboratory testing was beyond the scope of this study.

Data gathering for this study was attempted to be performed in general accordance with accepted procedures and practices. Correlation of penetrometer data with other parameters is empirical and should not be considered as the exact equivalent of laboratory testing. STRATIGRAPHICS shall not be responsible for another's interpretation of the information obtained for this study.

10.0 REFERENCES

Archie, G.E.,1942. The Electrical Resistivity Log as an Aid in Determining some Reservoir Characteristics. AIME Vol. 146.

Baligh, M.M. and J. Levadoux, "Pore Pressure Dissipation After Cone Penetration," Department of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1980.

Davidson, J.L., A. Boghrat, 1983. Displacement and Strains around Probes in Sand. Geotechnical Practice in Offshore Engineering, ASCE.

Douglas, B.J., G. Martin, 1981. Evaluation of the Cone Penetrometer for Liquefaction Studies, Imperial Valley Earthquake, California. Fugro, Inc., report for U.S. Geological Survey, No. 81-502.

Douglas, B.J., R. Olsen, 1981. Soil Classification using the Electric Cone Penetrometer. Cone Penetrometer Testing and Experience, ASCE.

Douglas, B.J., R. Olsen, G. Martin, 1981. Evaluation of the Cone Penetrometer Test for use in SPT Liquefaction Potential Assessment. In Situ Testing for Liquefaction Evaluation, ASCE.

Douglas, B.J., A. Strutynsky, 1984. Cone Penetration Test, Pore Pressure Measurements, and SPT Hammer Energy Calibration for Liquefaction Hazard Assessment. The Earth Technology Corporation, report for U.S. Geological Survey, No. 14-08-0001-19105.

Douglas, B.J., A. Strutynsky, S. Brown, 1984. In Situ Testing II, Peoples' Republic of China. The Earth Technology Corporation, report to the National Science Foundation, No. CEE 8311873.

Douglas, B.J., A. Strutynsky, L. Mahar, J. Weaver, 1985. Soil Strength Determinations from the Cone Penetrometer Test. Civil Engineering in the Arctic Offshore, ASCE.

Durgunoglu, H.T., J. Mitchell, 1974. Influence of Penetrometer Characteristics on Static Penetration Resistance. First European Symposium on Penetration Testing.

Lunne, T., O. Eide, J. de Ruiter, 1976. Correlations between Cone Resistance and Vane Shear Strength in Scandinavian Soft to Medium Stiff Clays. Canadian Geotechnical Journal, Vol. 13.

Mayne, P.W.,1988. Determining OCR in Clays from Laboratory Strength. ASCE Journal of Geotechnical Engineering, Vol.114, No. 1.

Mayne, P.W., 1991. Determination of OCR in clays by piezocone tests using cavity expansion and critical state concepts. Soils and Foundations, 31(2), 65-76.

Mayne, P.W., 1993. In-situ Determination of Clay Stress History by Piezocone. Predictive Soil Mechanics. Proceedings of the Wroth Memorial Symposium.

Olsen, R.S., J. Farr, 1986. Site Characterization using the Cone Penetrometer Test. Use of In Situ Tests in Geotechnical Engineering, ASCE.

Rocha-Filho, P., 1979. Behavior of Cone Penetrometer in Saturated Sands. Ph.D. Thesis, Imperial College, London, England.

Saines, M., A. Strutynsky and G. Lytwynyshyn, 1989. Use of Piezometric Cone Penetration Testing In Hydrogeologic Investigations. First USA/USSR Conference on Hydrogeology, Moscow, USSR.

Sanglerat, G., 1972. The Penetrometer and Soil Exploration. Elsevier Publishing Co.
Schmertmann, J.H., 1978. Guidelines for Cone Penetration Testing, Performance and Design. U.S. Department of Transportation, FHWA-TS78-209.

Seed, H.B., K. Mori, C. Chan, 1977. Influence of Seismic History on Liquefaction of Sands. ASCE Journal of Geotechnical Engineering, Vol. 103, No. GT4.Seed, H.B., K. Tokimatsu, L. Harder, R. Chung, 1984. The Influence of SPT Procedures in Soil Liquefaction Resistance Evaluations. University of California, report to the National Science Foundation and National Bureau of Standards, No. UCB/EERC84/15.

Strutynsky, A.I., 1988. Stress History and Normalized Soil Behavior from CPT. Presented at the session on site characterization, First International Symposium on Penetration Testing.

Strutynsky, A.I., B. Douglas, L. Mahar, G. Edmonds, E. Hencey, 1985. Arctic Penetration Test Systems. Civil Engineering in the Arctic Offshore, ASCE.

Strutynsky, A.I., R. Sandiford, D. Cavaliere, 1991. Use of Piezometric Cone Penetration Testing with Electrical Conductivity Measurements (CPTU-EC) for Detection of Hydrocarbon Contamination in Saturated Granular Soils. Current Practices in Ground Water and Vadose Zone Investigations, ASTM.

Strutynsky, A.I., T. Sainey, 1990. Use of the Piezometric Cone Penetration Test and Penetrometer Groundwater Sampling for Volatile Organic Contaminant Plume Detection. Petroleum Hydrocarbons and Organic Chemicals in Groundwater: Prevention, Detection and Restoration. API/NWWA.

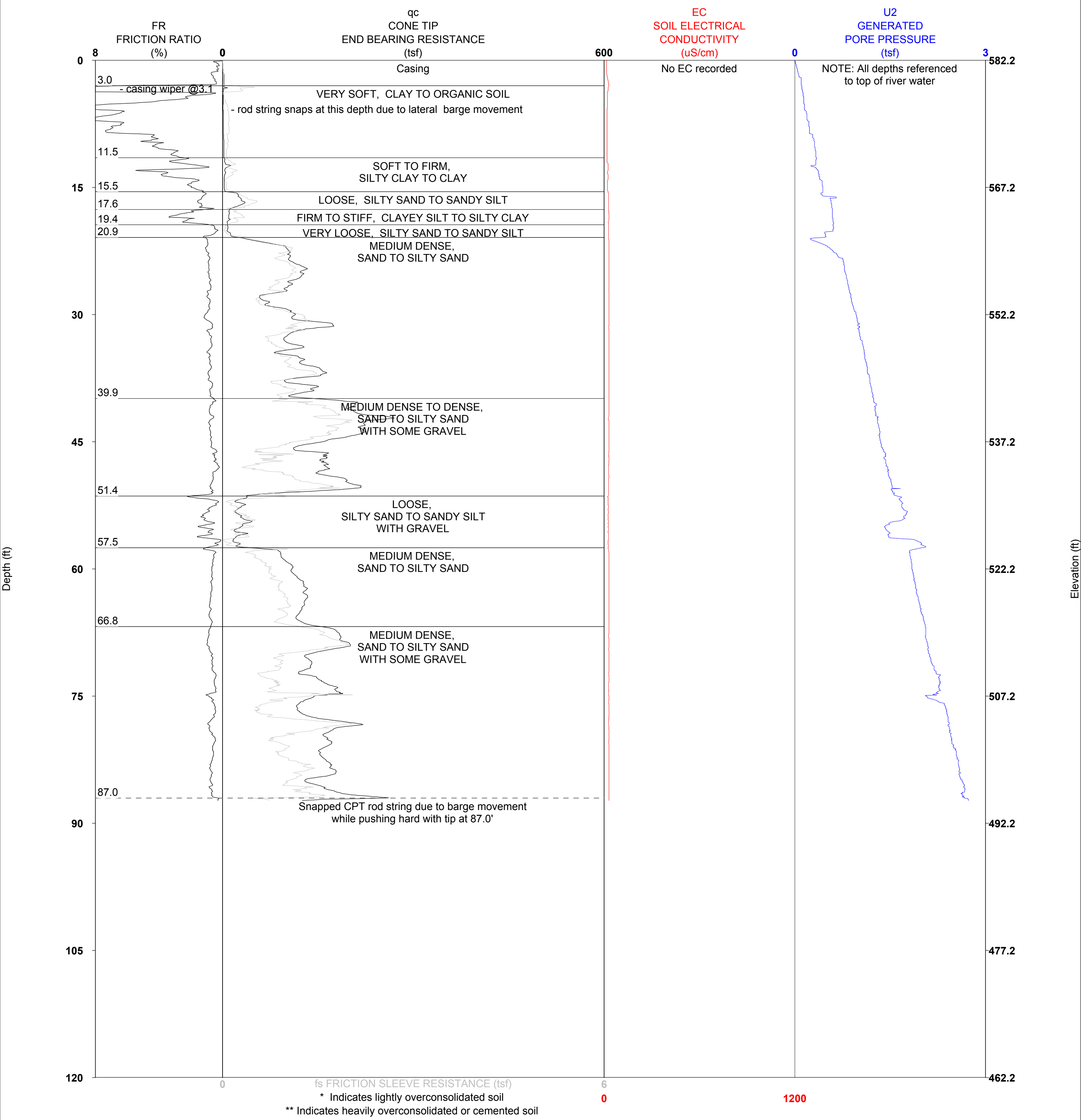
Villet, W.C.B., J. Mitchell, 1981. Cone Resistance, Relative Density and Friction Angle. Cone Penetrometer Testing and Experience, ASCE.

STRATIGRAPHICS

TABLE 1
SUMMARY OF CPT SOUNDINGS
US52 IL64 over Mississippi River
12-130-100

SOUNDING NUMBER	DATE PERFORMED	SOUNDING TYPE	SOUNDING DEPTH (feet)	COMMENTS	COORDINATES LATITUDE (dec. deg)	COORDINATES LONGITUDE (dec. deg)
CPT-02	11/01/12	CPTU	87.4	About 84.5 ft through soil, barge moved, snapped CPT rod string	N 42 deg 6.233	W 90 deg 9.998
CPT-03	11/12/12	CPTU	25.8	Casing pushed into river bottom to try to laterally anchor barge, soil inside casing, no CPT penetration		
CPT-03A	11/13/12	CPTU	66.3	About 40.5 ft through soil to refusal		
CPT-04	11/12/12	CPTU	19.5	Obstruction at river bottom, +500 tsf CPT refusal, little or no penetration		
CPT-04A	11/12/12	CPTU	27.9	About 7 ft through very loose soil, no support on CPT rod string, no fixity in barge lateral anchoring		
CPT-05	11/08/12	CPTU	41.0	About 15.3 ft through soil to refusal		
CPT-06	11/09/12	CPTU	63.4	About 1 ft through soil to refusal		
CPT-07	11/07/12	CPTU	17.2	About 1 ft through soil to refusal		
CPT-08	11/07/12	CPTU	17.6	Obstruction or weathered rock at river bottom, +360 tsf CPT refusal, little or no penetration		
Total footage from water surface			366.1	About 150 ft soil penetration		

CPTU LOG WITH LITHOLOGIC EVALUATION CPT02



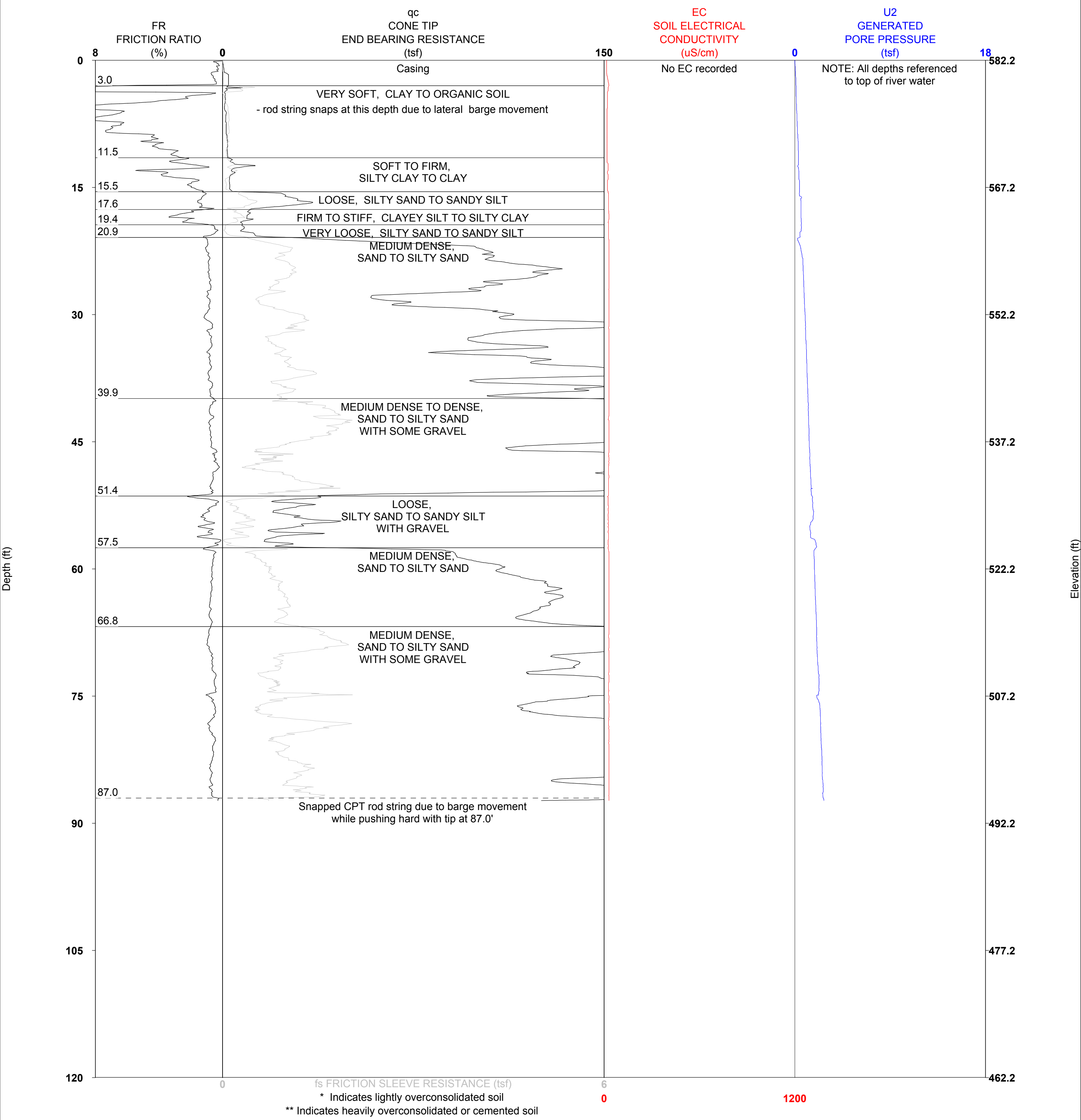
Latitude: N 42 deg 6.2333' Longitude: W 90 deg 9.9980" EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

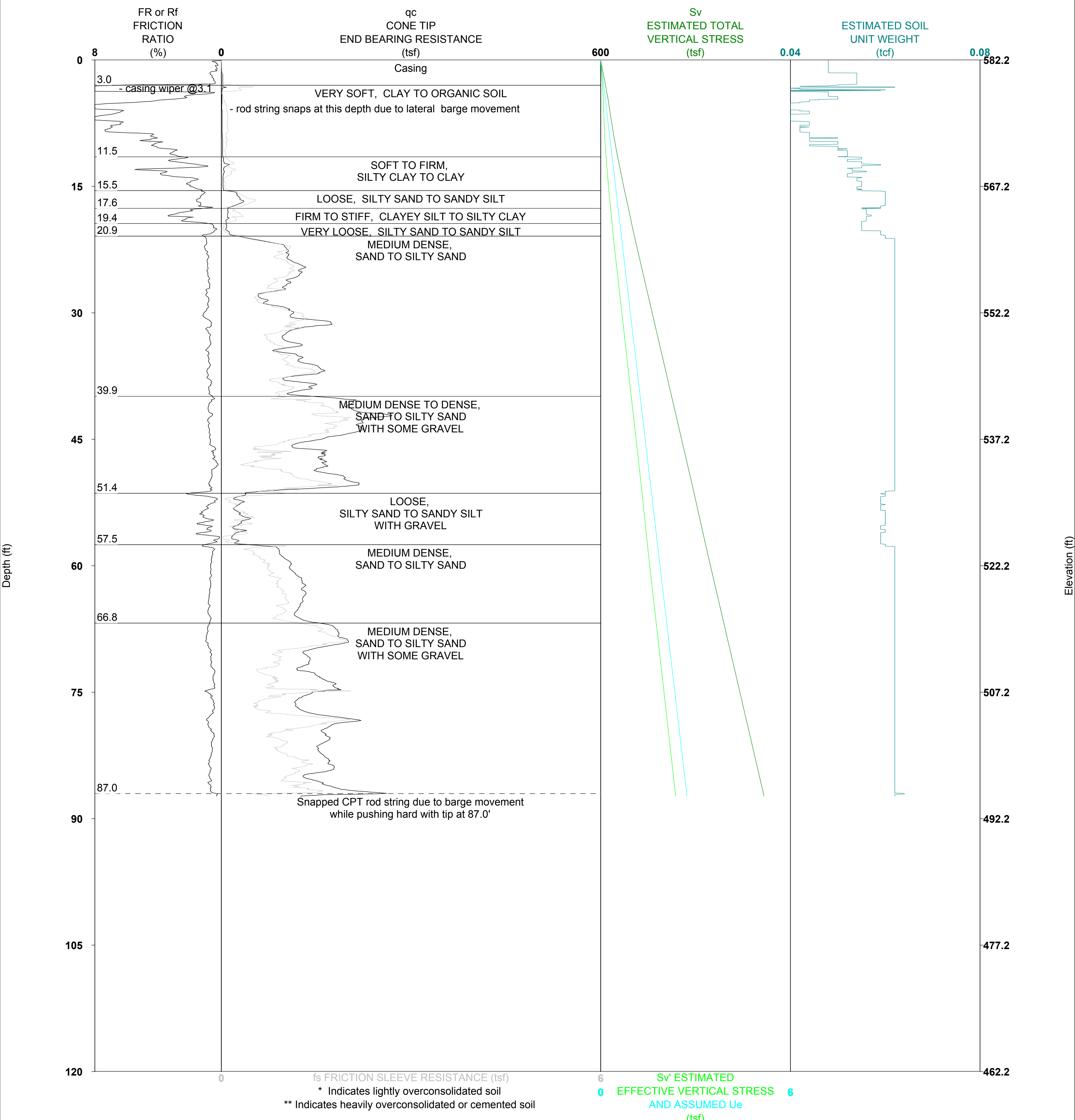
R1 DATE:11/1/2012 TIME:11:21 AM
SOUNDING NUMBER:CPT-02

CPTU LOG WITH LITHOLOGIC EVALUATION CPT02



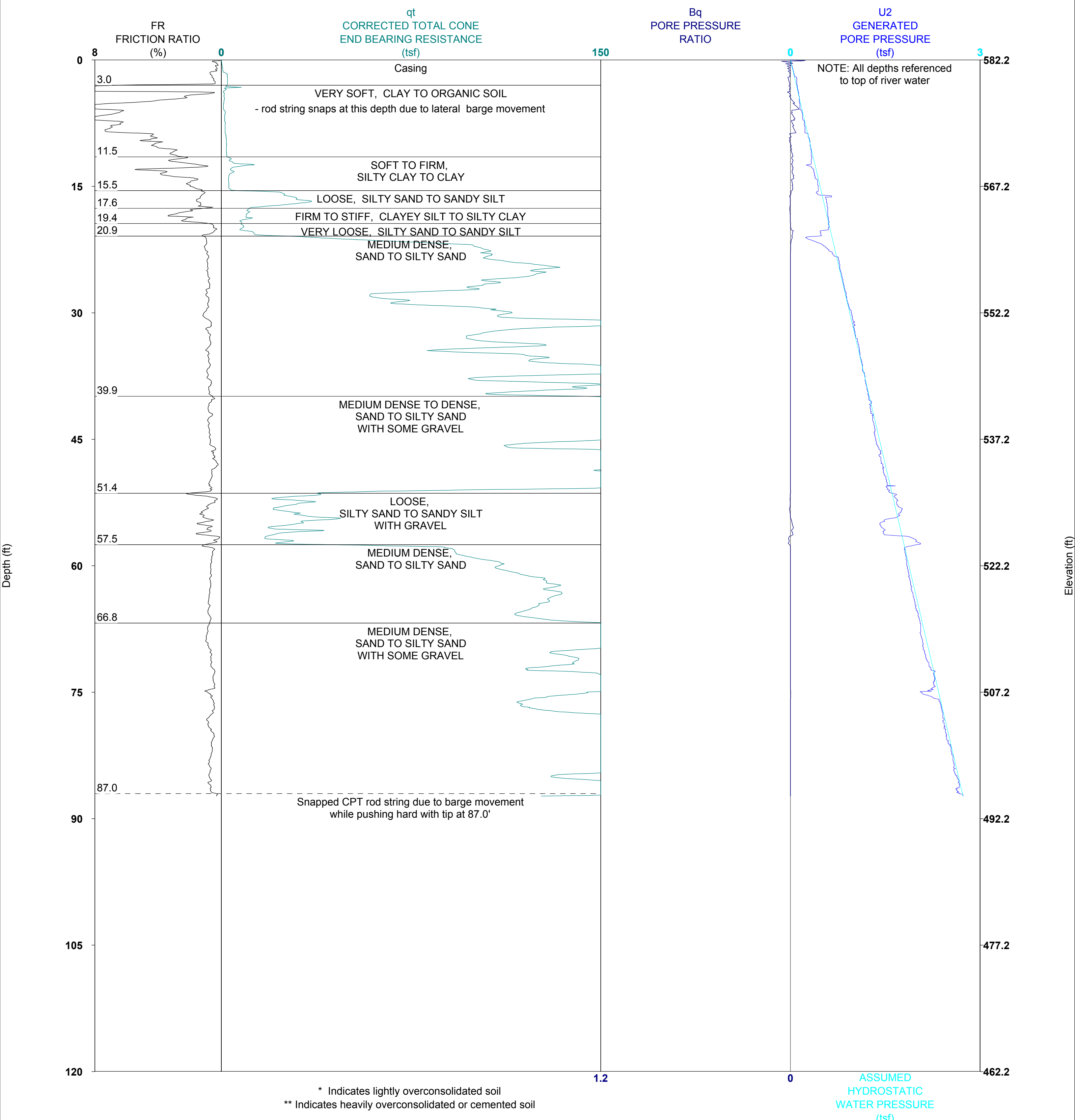
Latitude: N 42 deg 6.2333' Longitude: W 90 deg 9.9980" EL (ft): 582.2

CPT LOG WITH LITHOLOGIC EVALUATION CPT02



Latitude: N 42 deg 6.2333' Longitude: W 90 deg 9.9980" EL (ft): 582.2

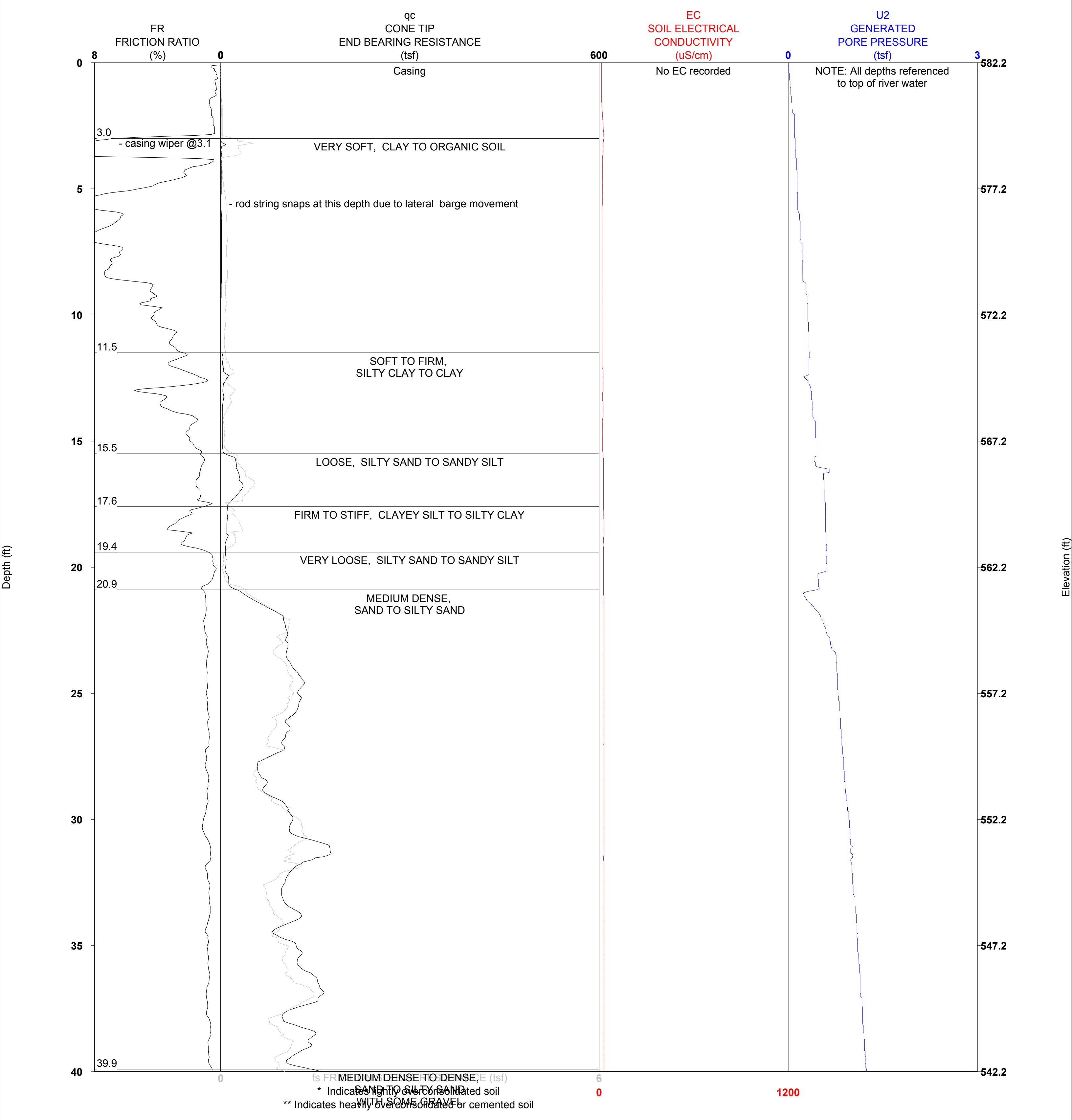
CPTU LOG WITH LITHOLOGIC EVALUATION CPT02



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

Latitude: N 42 deg 6.2333' Longitude: W 90 deg 9.9980" EL (ft): 582.2

CPTU LOG WITH LITHOLOGIC EVALUATION CPT02



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

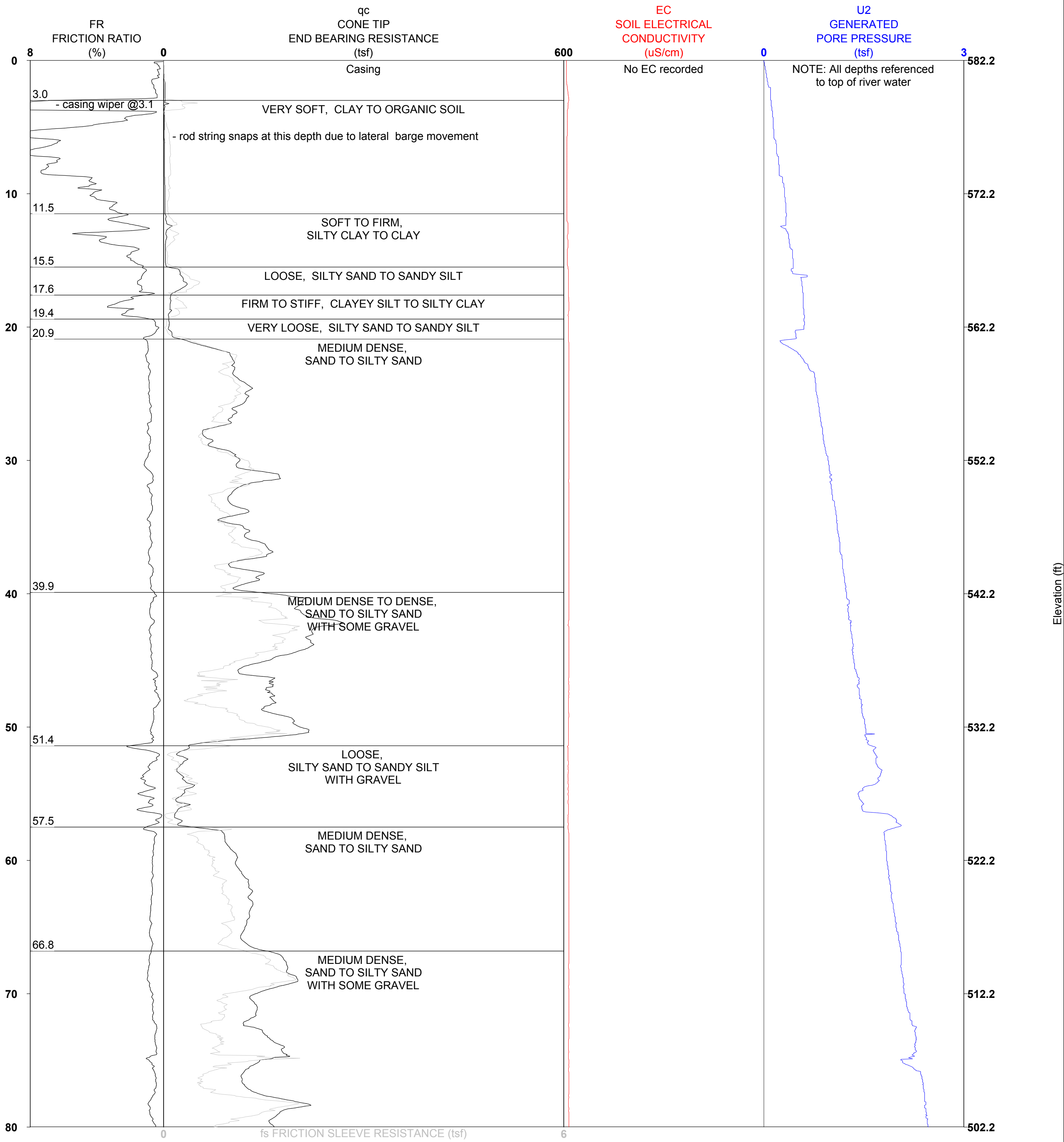
Latitude: N 42 deg 6.2333' Longitude: W 90 deg 9.9980" EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/1/2012 TIME:11:21 AM
SOUNDING NUMBER:CPT-02

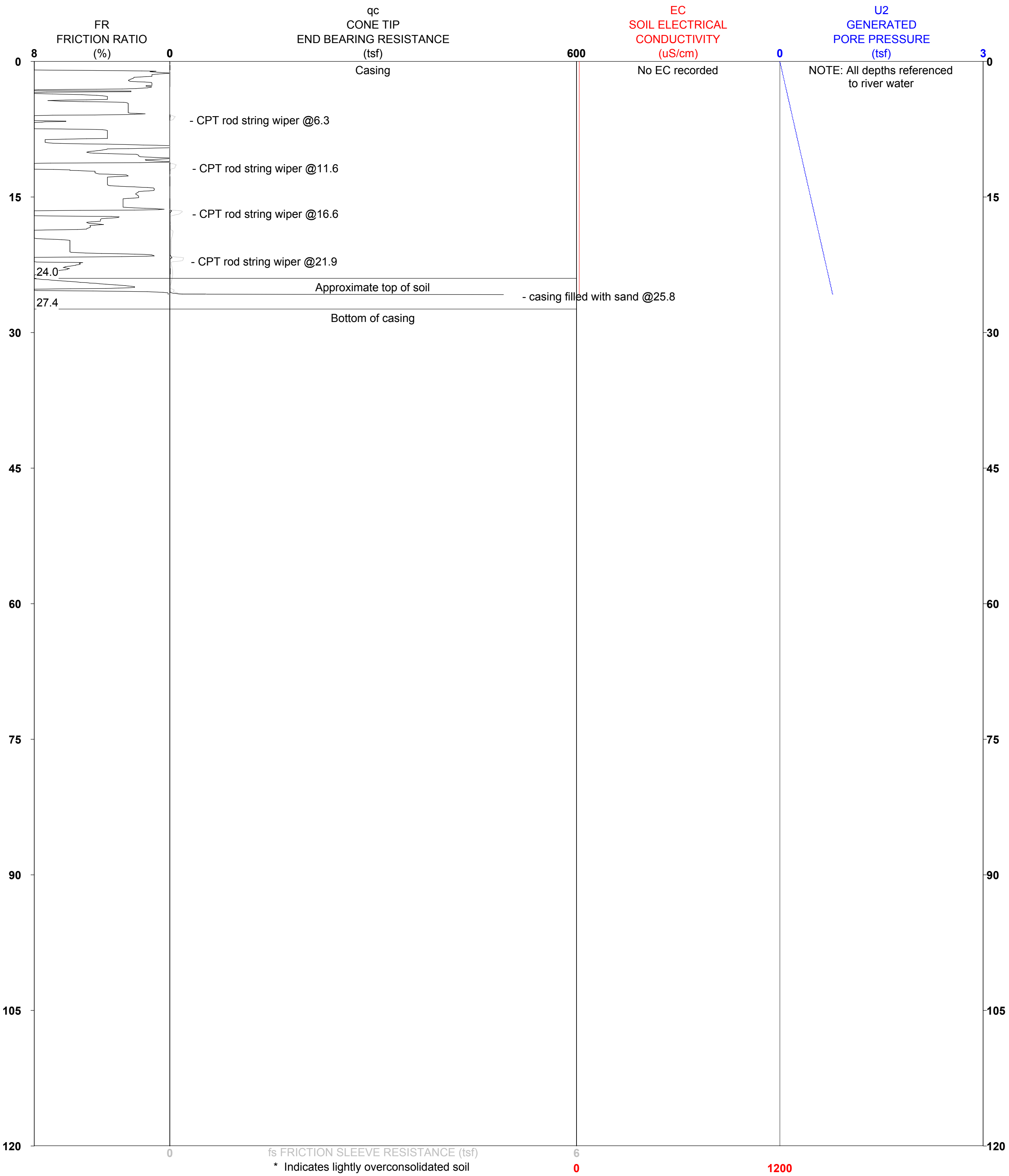
CPTU LOG WITH LITHOLOGIC EVALUATION CPT02



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

Latitude: N 42 deg 6.2333' Longitude: W 90 deg 9.9980" EL (ft): 582.2

CPTU LOG WITH LITHOLOGIC EVALUATION CPT03

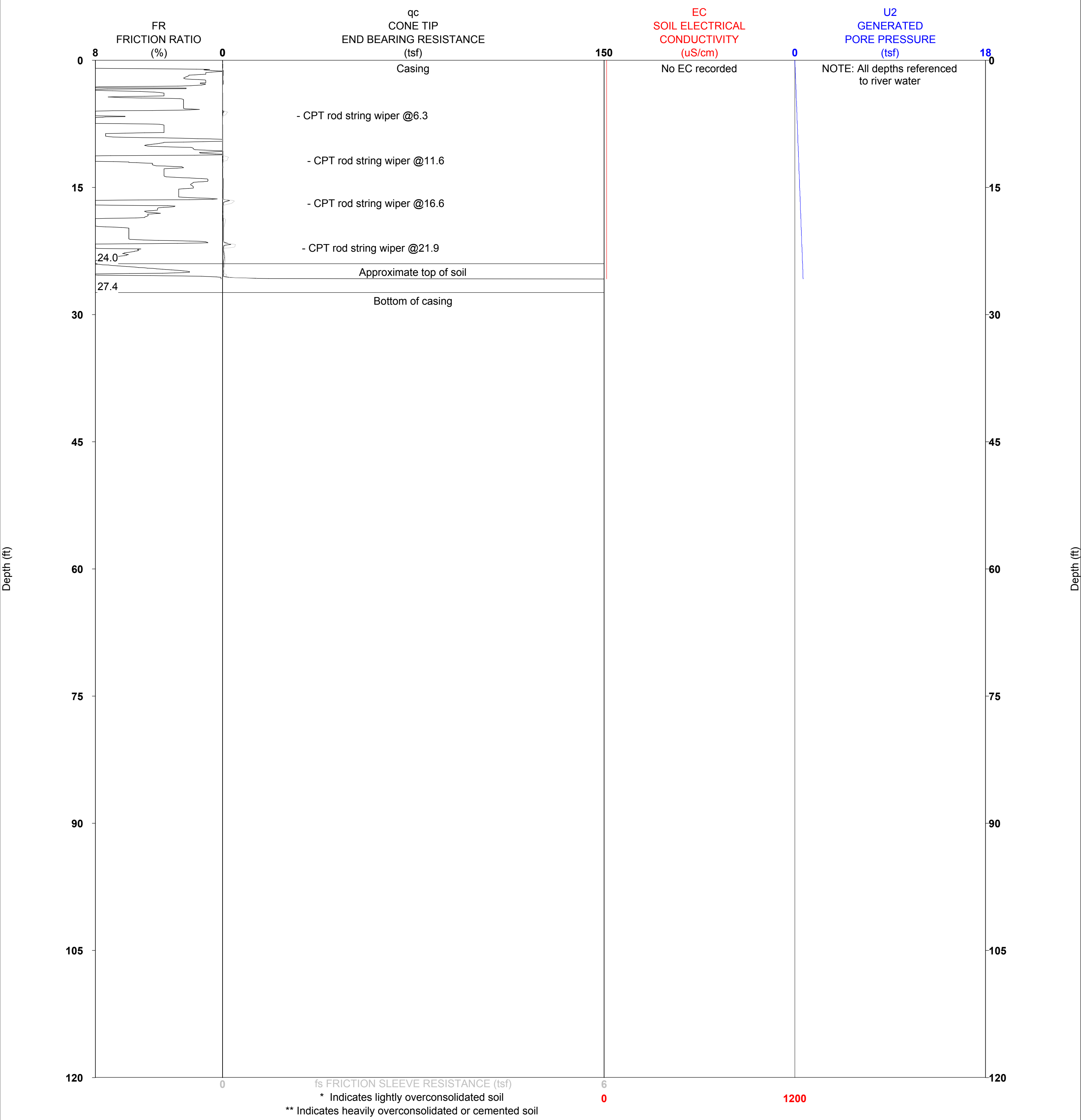


* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

NOTE:Casing lowered and pushed into soil in inadvertant attempt to stabilize barge

Latitude: 0.00000 Longitude: 0.00000

CPTU LOG WITH LITHOLOGIC EVALUATION CPT03

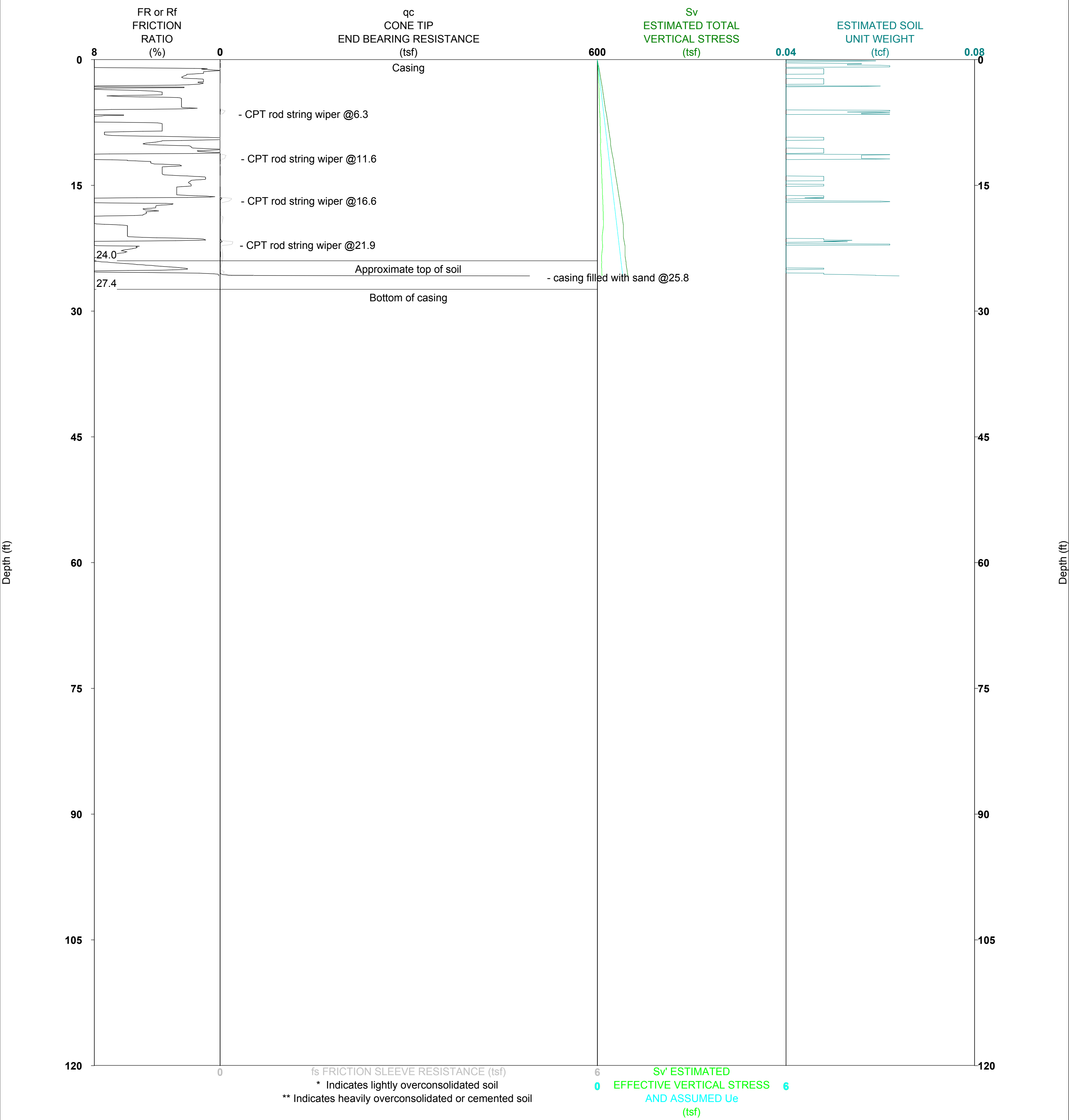


* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

NOTE:Casing lowered and pushed into soil in inadvertant attempt to stabilize barge

Latitude: 0.00000 Longitude: 0.00000

CPT LOG WITH LITHOLOGIC EVALUATION CPT03



* Indicates lightly overconsolidated soil

** Indicates heavily overconsolidated or cemented soil

NOTE:Casing lowered and pushed into soil in inadvertant attempt to stabilize barge

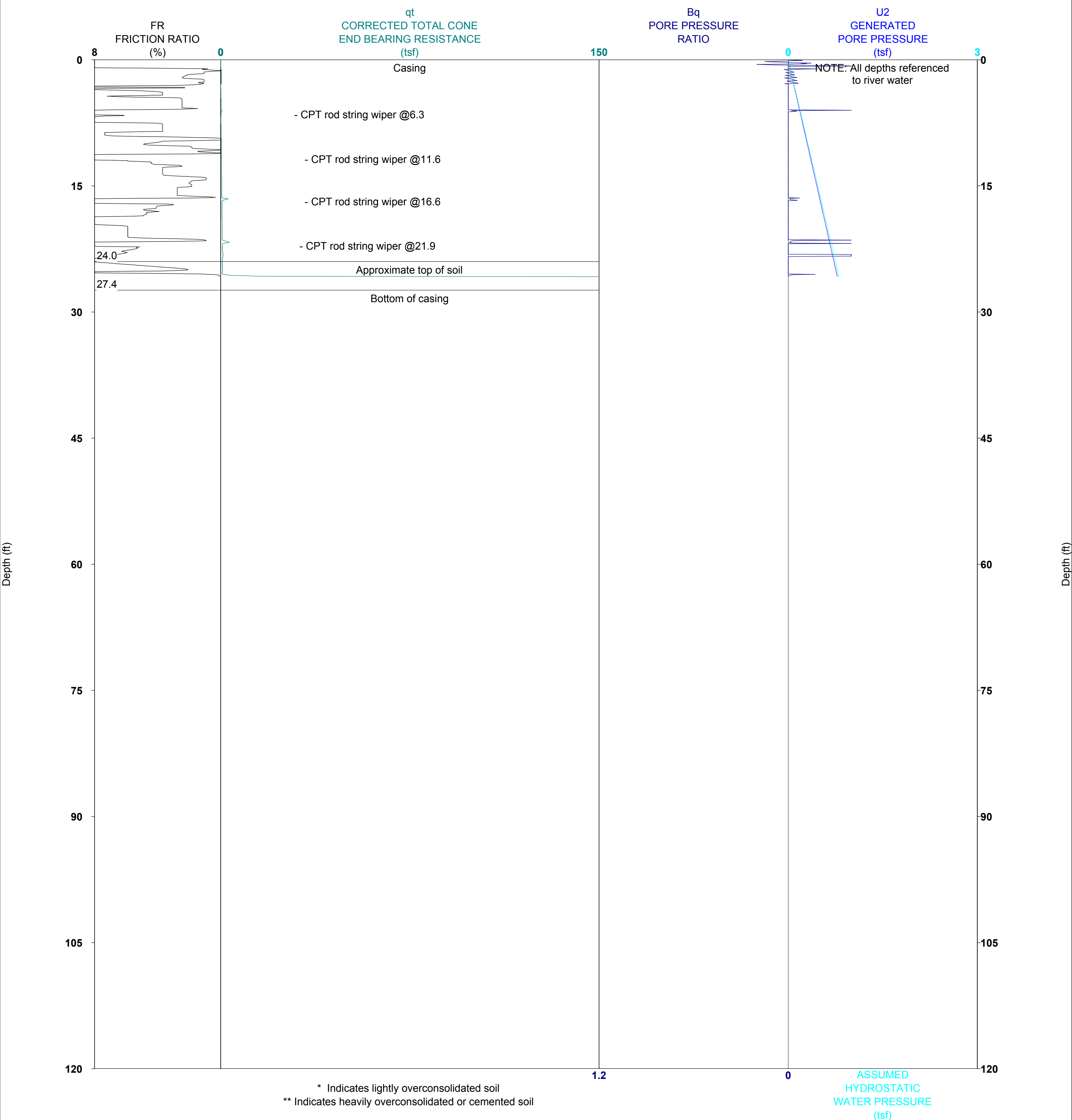
Latitude: 0.00000 Longitude: 0.00000

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/12/2012 TIME:2:04 PM
SOUNDING NUMBER:CPT-03

CPTU LOG WITH LITHOLOGIC EVALUATION CPT03



NOTE:Casing lowered and pushed into soil in inadvertant attempt to stabilize barge

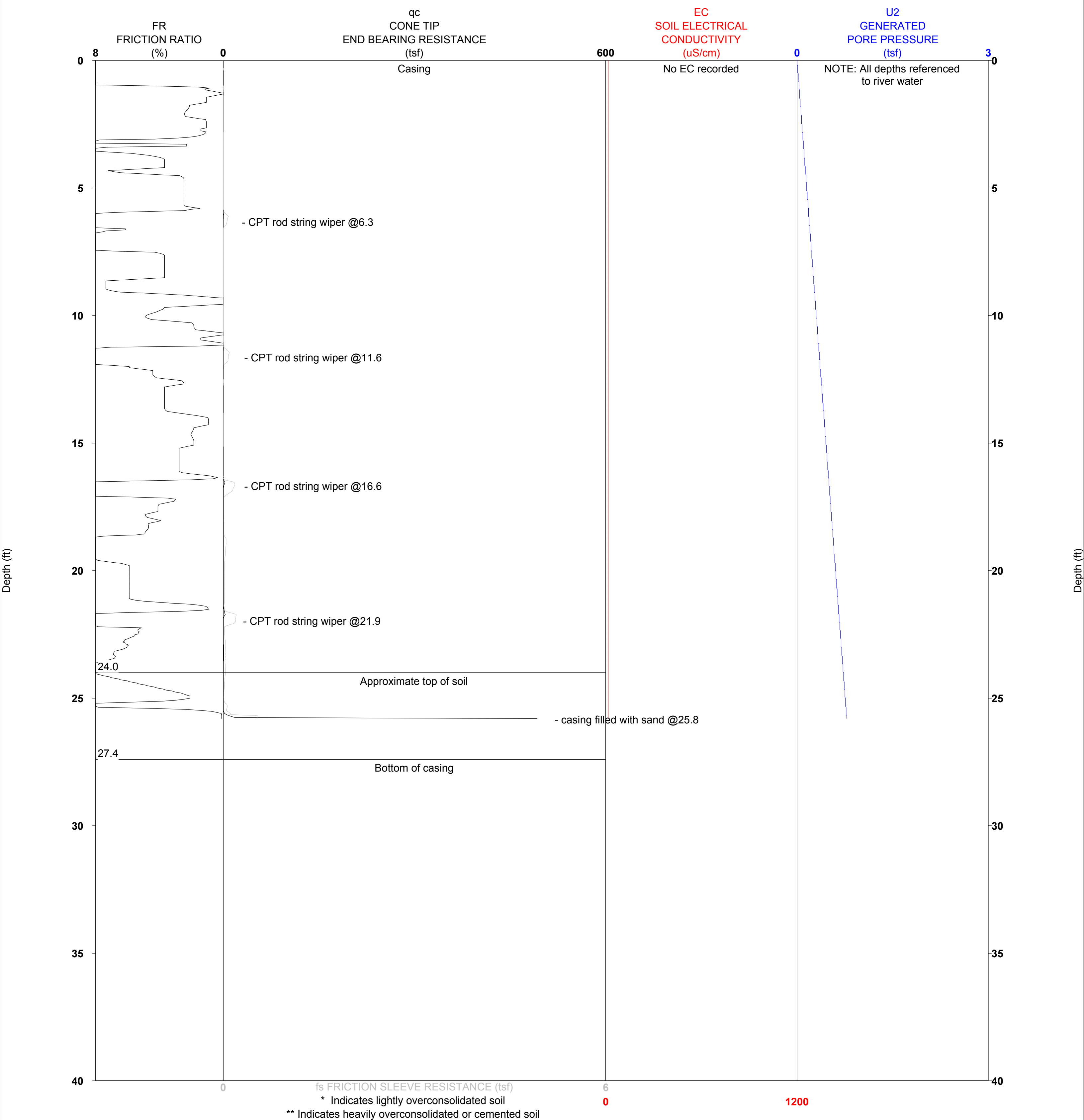
Latitude: 0.00000 Longitude: 0.00000

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/12/2012 TIME:2:04 PM
SOUNDING NUMBER:CPT-03

CPTU LOG WITH LITHOLOGIC EVALUATION CPT03



* Indicates lightly overconsolidated soil

** Indicates heavily overconsolidated or cemented soil

NOTE:Casing lowered and pushed into soil in inadvertant attempt to stabilize barge

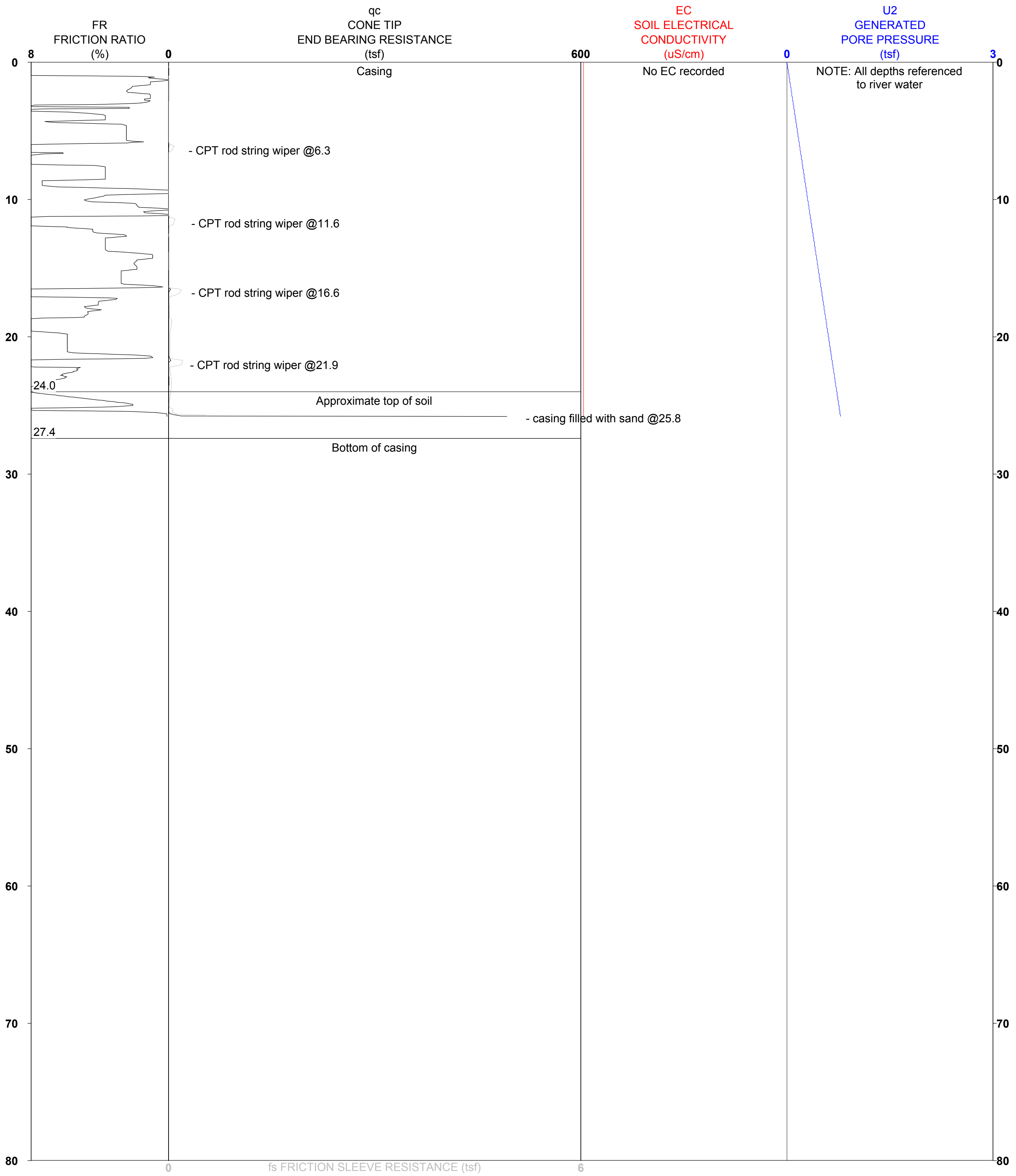
Latitude: 0.00000 Longitude: 0.00000

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/12/2012 TIME:2:04 PM
SOUNDING NUMBER:CPT-03

CPTU LOG WITH LITHOLOGIC EVALUATION CPT03



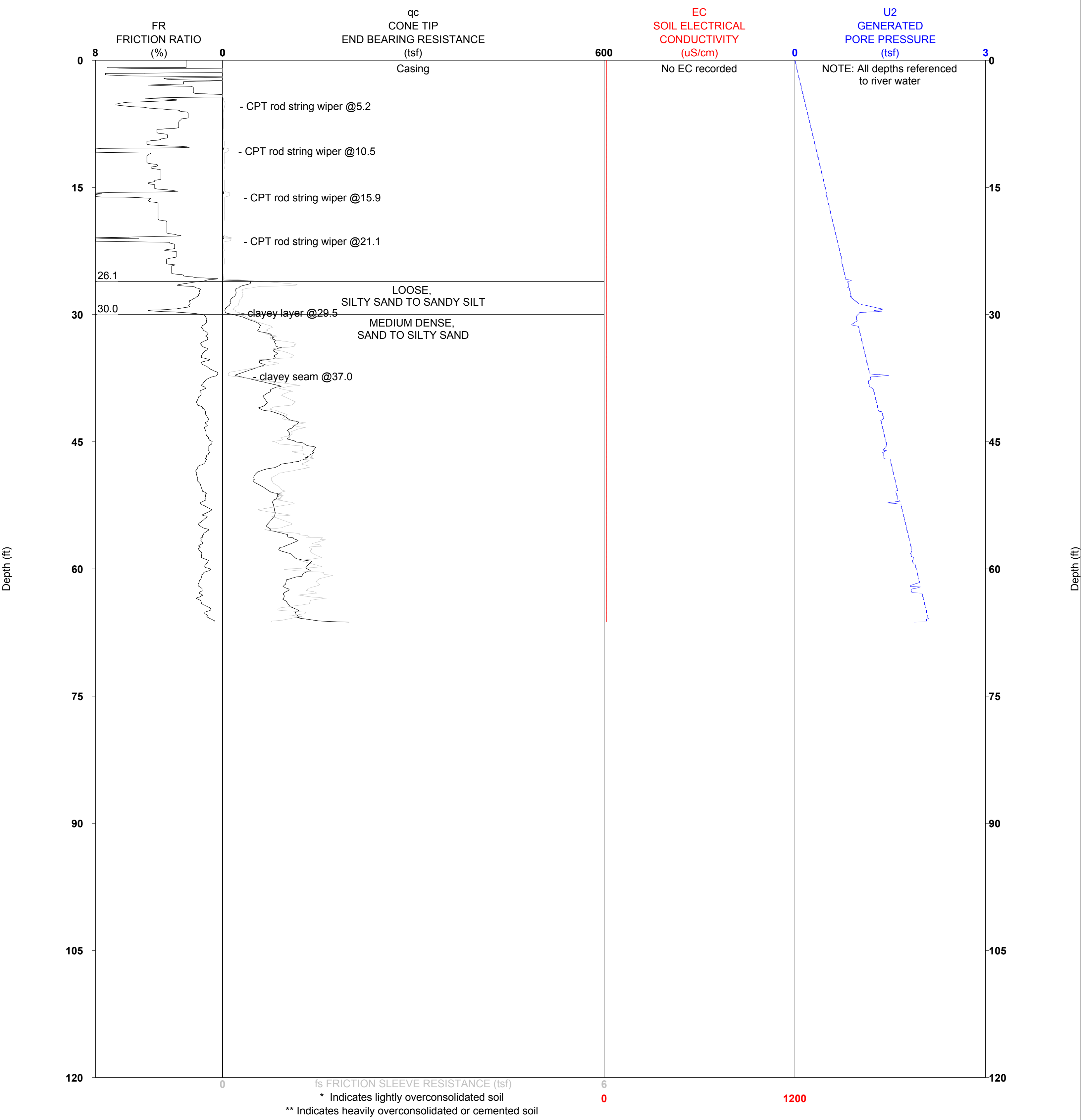
* Indicates lightly overconsolidated soil

** Indicates heavily overconsolidated or cemented soil

NOTE:Casing lowered and pushed into soil in inadvertant attempt to stabilize barge

Latitude: 0.00000 Longitude: 0.00000

CPTU LOG WITH LITHOLOGIC EVALUATION CPT03a



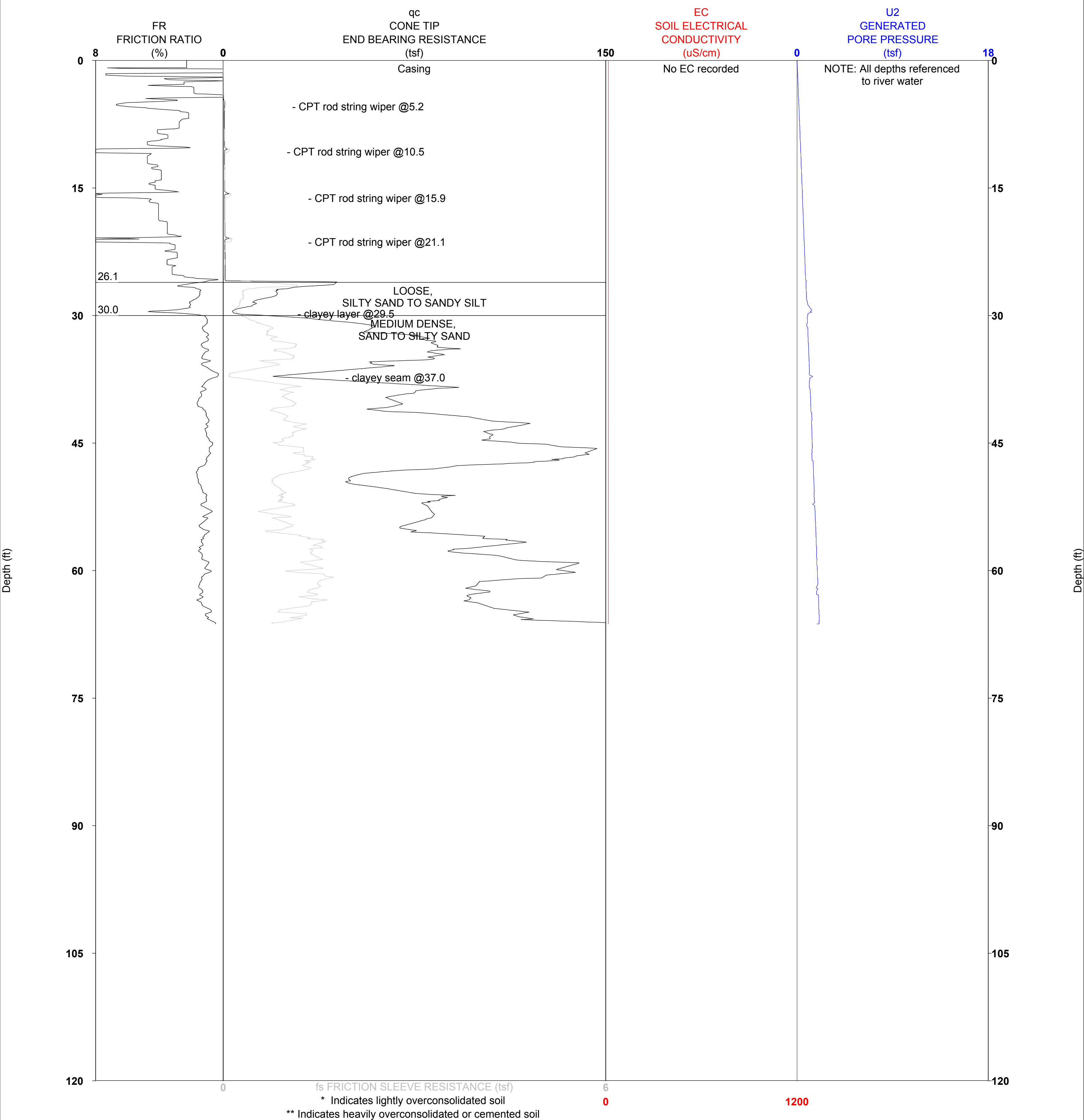
Latitude: 0.00000 Longitude: 0.00000

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/13/2012 TIME:9:55 AM
SOUNDING NUMBER:CPT-03 ()

CPTU LOG WITH LITHOLOGIC EVALUATION CPT03a



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

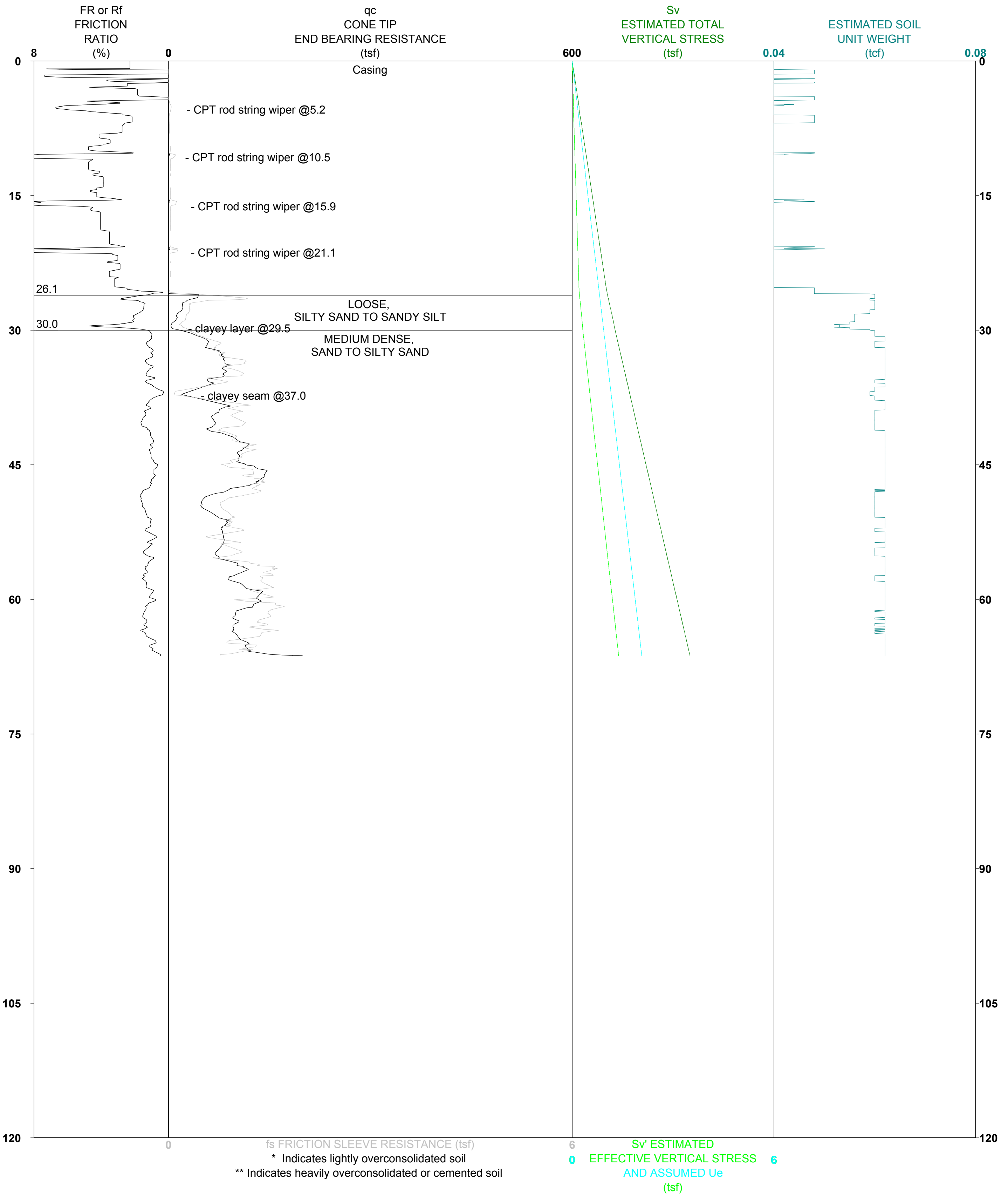
Latitude: 0.00000 Longitude: 0.00000

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/13/2012 TIME:9:55 AM
SOUNDING NUMBER:CPT-03 ()

CPT LOG WITH LITHOLOGIC EVALUATION CPT03a



* Indicates lightly overconsolidated soil

** Indicates heavily overconsolidated or cemented soil

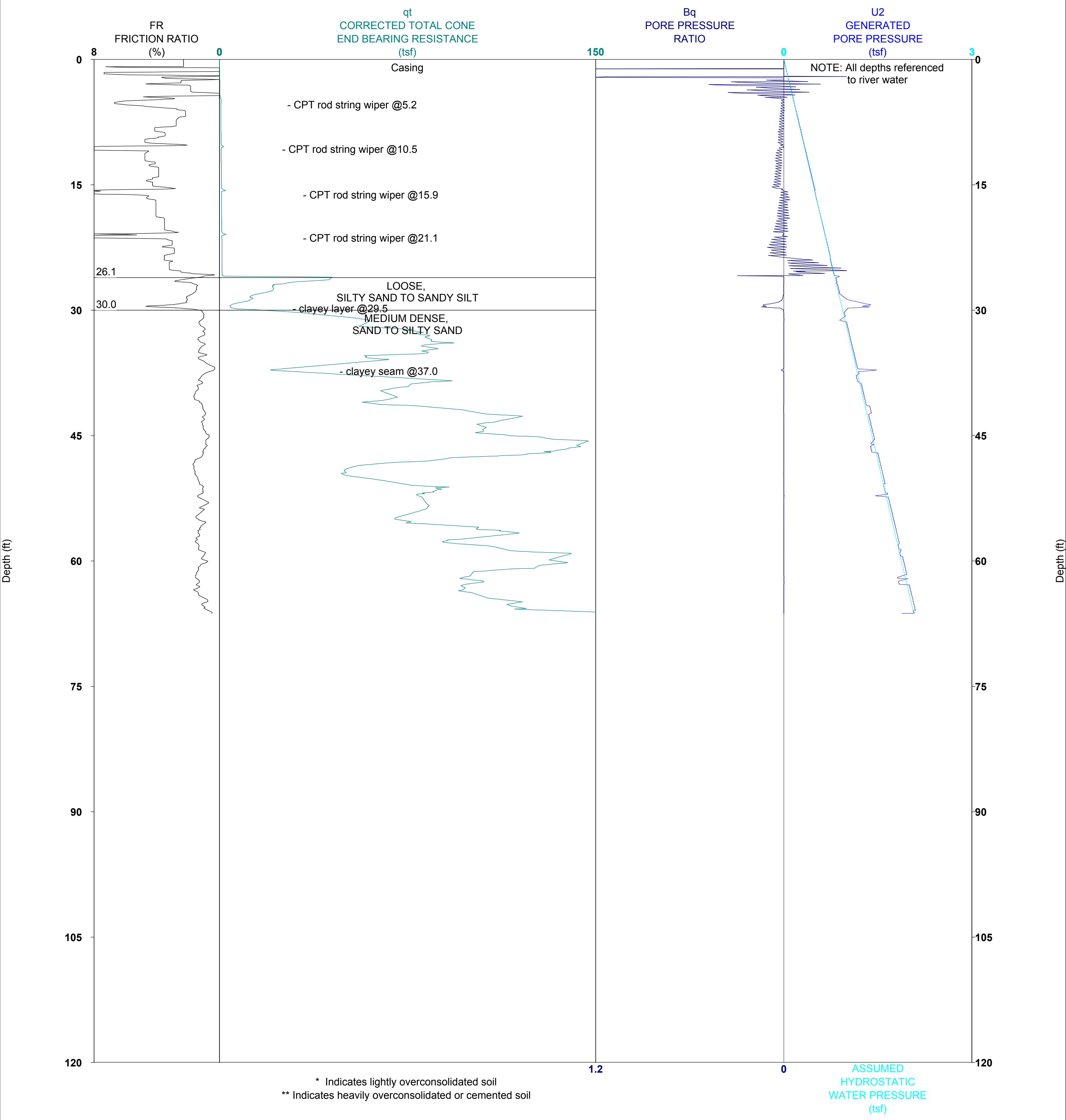
Latitude: 0.00000 Longitude: 0.00000

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/13/2012 TIME:9:55 AM
SOUNDING NUMBER:CPT-03 ()

CPTU LOG WITH LITHOLOGIC EVALUATION CPT03a



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

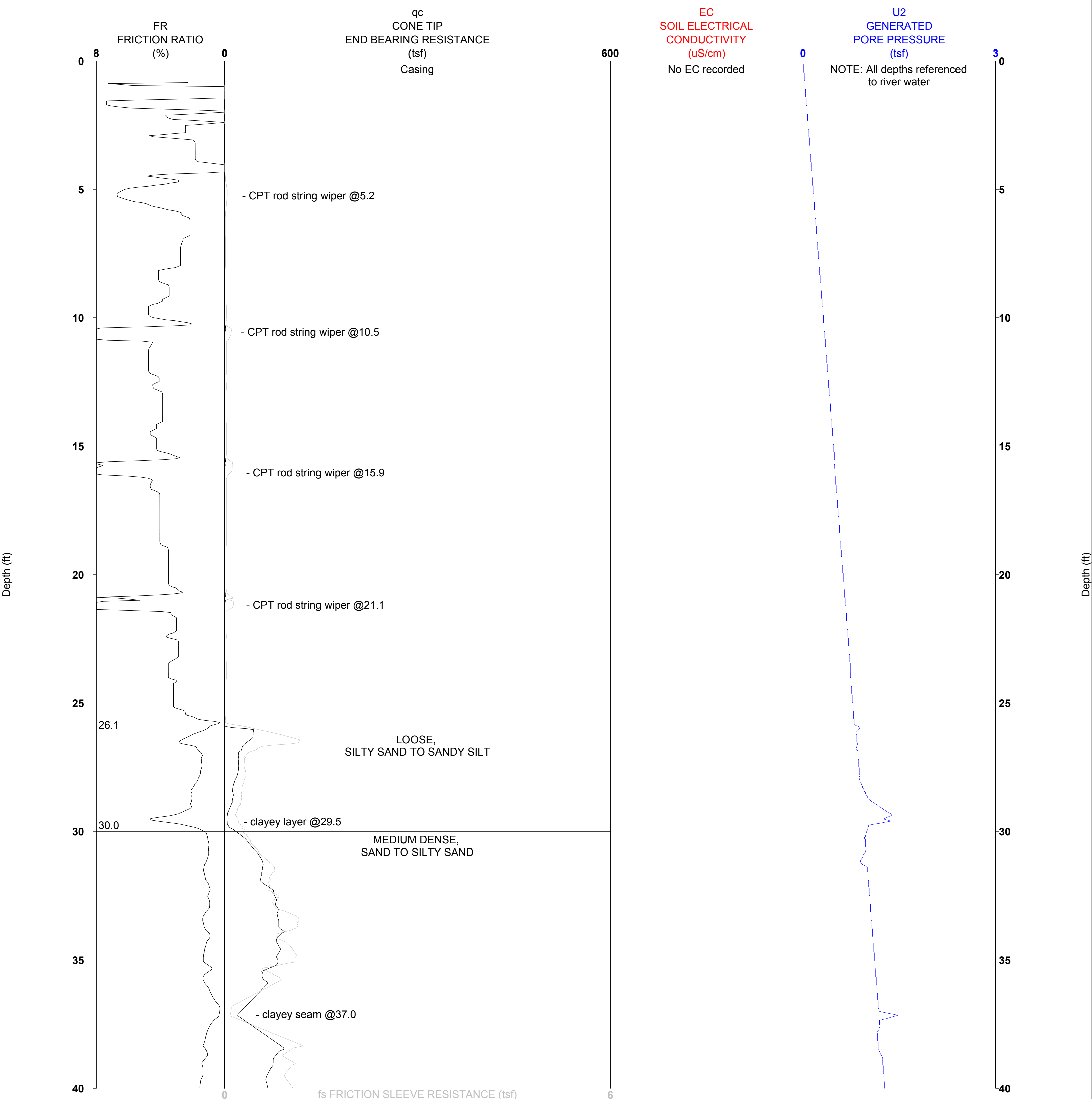
Latitude: 0.00000 Longitude: 0.00000

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/13/2012 TIME:9:55 AM
SOUNDING NUMBER:CPT-03 ()

CPTU LOG WITH LITHOLOGIC EVALUATION CPT03a



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

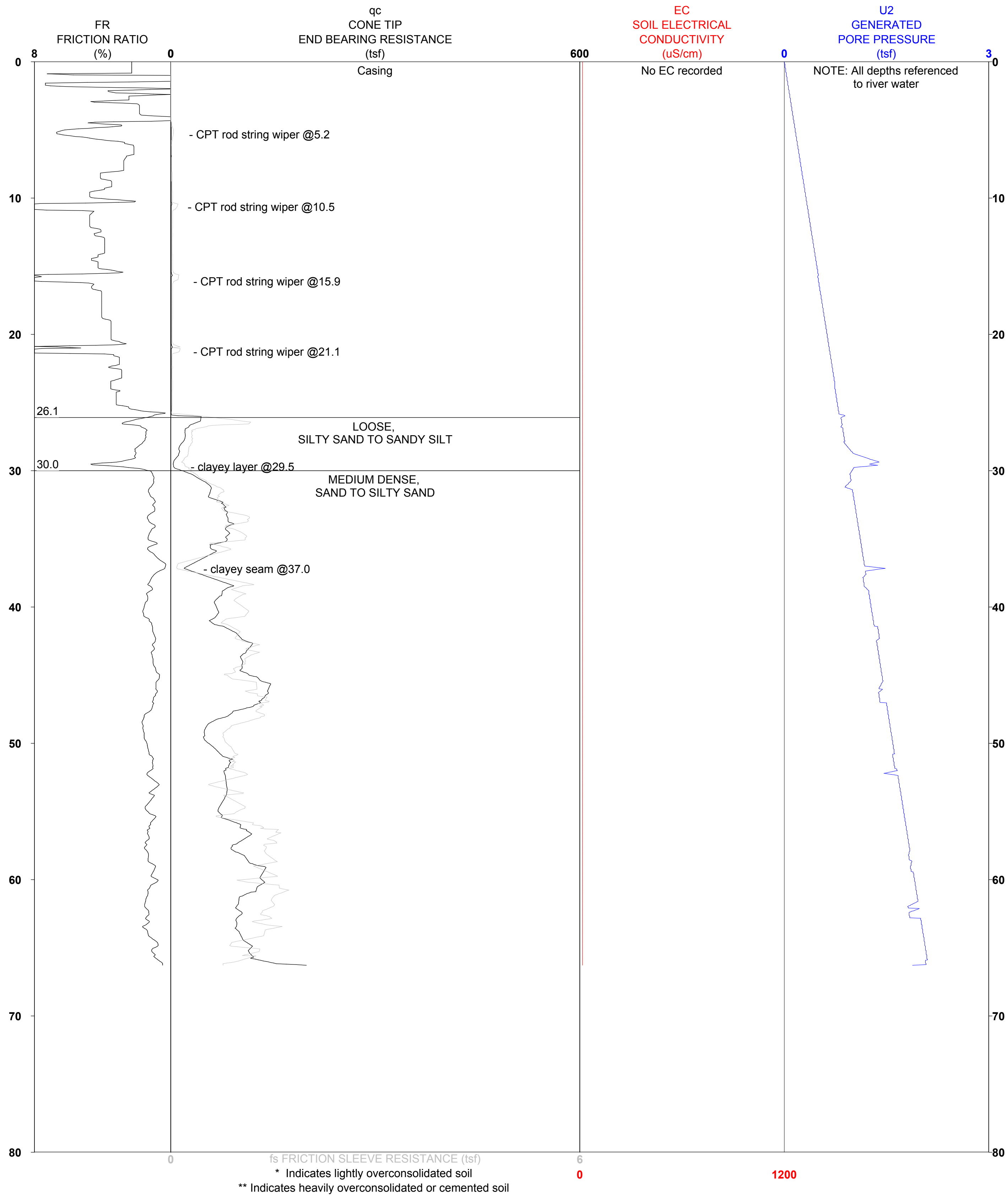
Latitude: 0.00000 Longitude: 0.00000

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/13/2012 TIME:9:55 AM
SOUNDING NUMBER:CPT-03 ()

CPTU LOG WITH LITHOLOGIC EVALUATION CPT03a



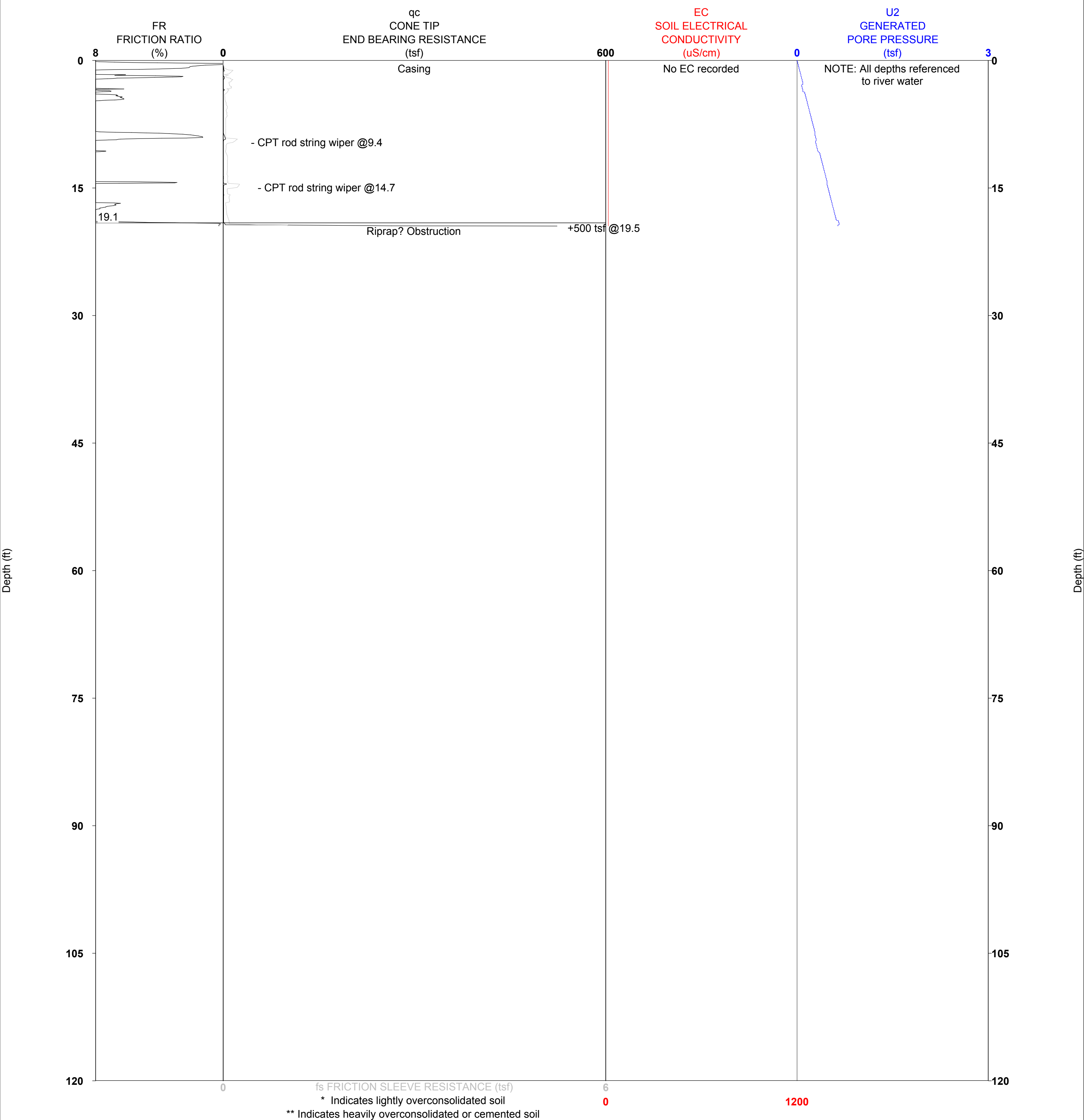
Latitude: 0.00000 Longitude: 0.00000

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/13/2012 TIME:9:55 AM
SOUNDING NUMBER:CPT-03 ()

CPTU LOG WITH LITHOLOGIC EVALUATION CPT04



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

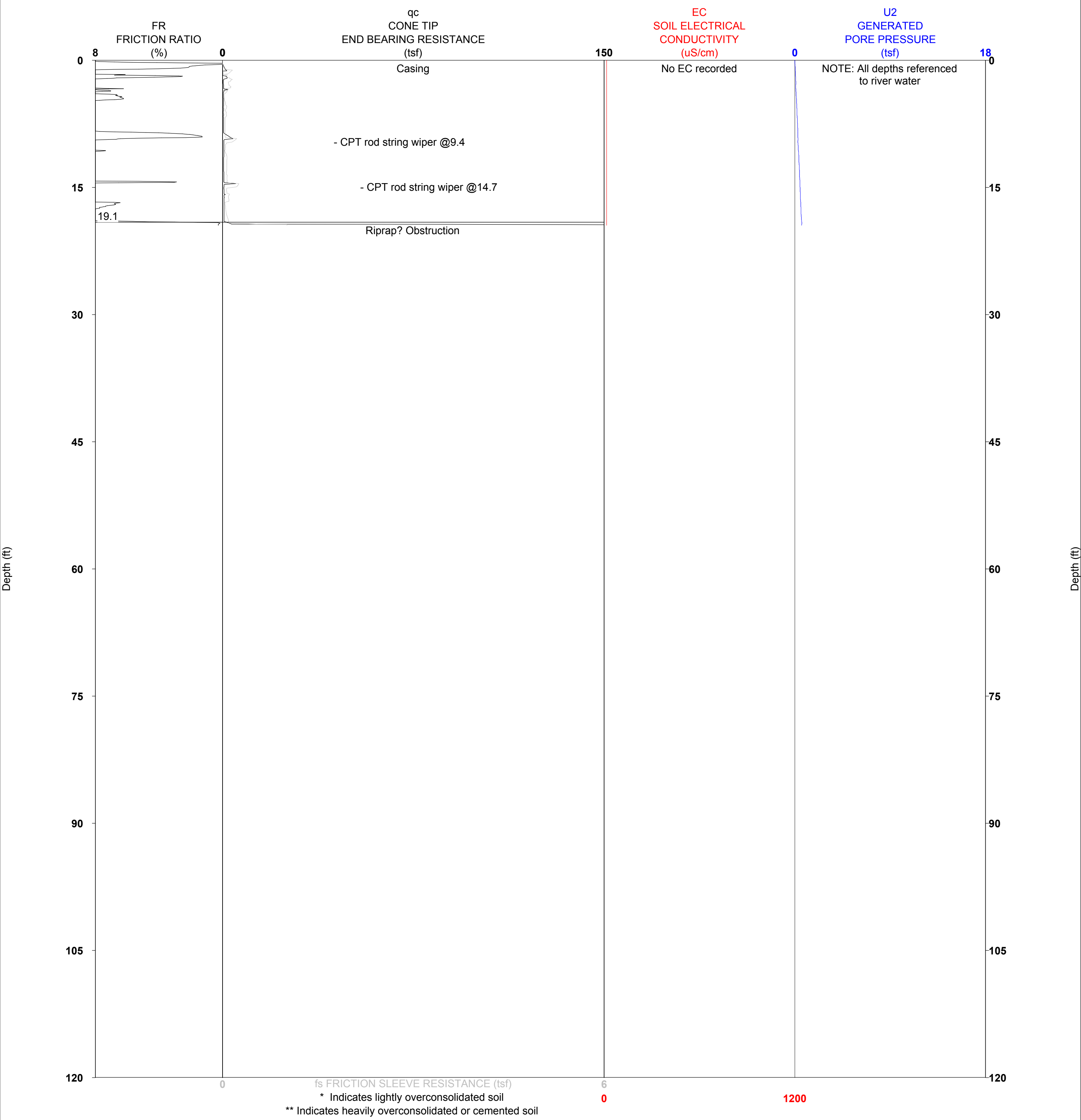
Latitude: 0.00000 Longitude: 0.00000

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/12/2012 TIME:10:31 AM
SOUNDING NUMBER:CPT-04 ()

CPTU LOG WITH LITHOLOGIC EVALUATION CPT04



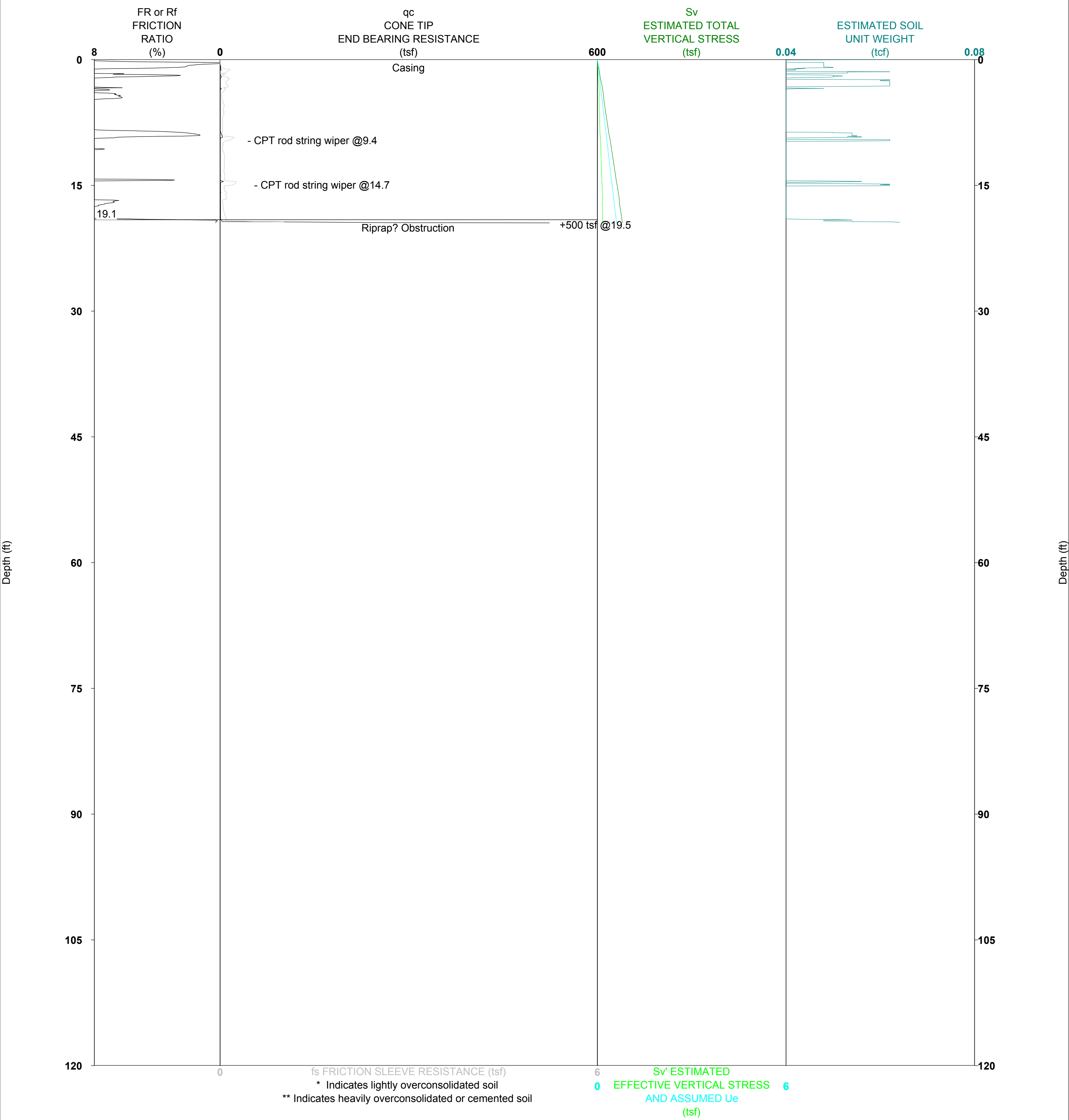
Latitude: 0.00000 Longitude: 0.00000

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

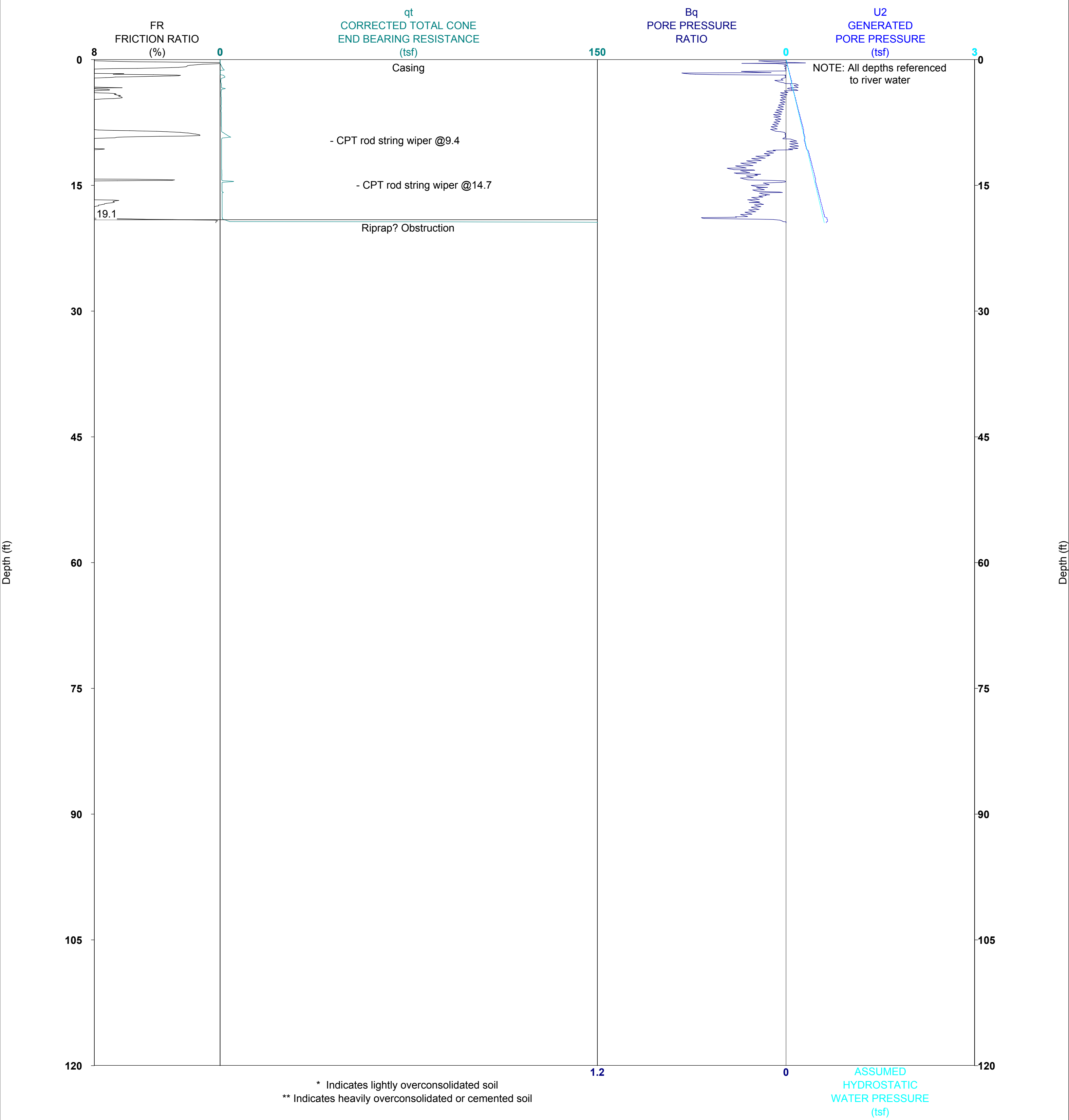
R1 DATE:11/12/2012 TIME:10:31 AM
SOUNDING NUMBER:CPT-04 ()

CPT LOG WITH LITHOLOGIC EVALUATION CPT04



Latitude: 0.00000 Longitude: 0.00000

CPTU LOG WITH LITHOLOGIC EVALUATION CPT04



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

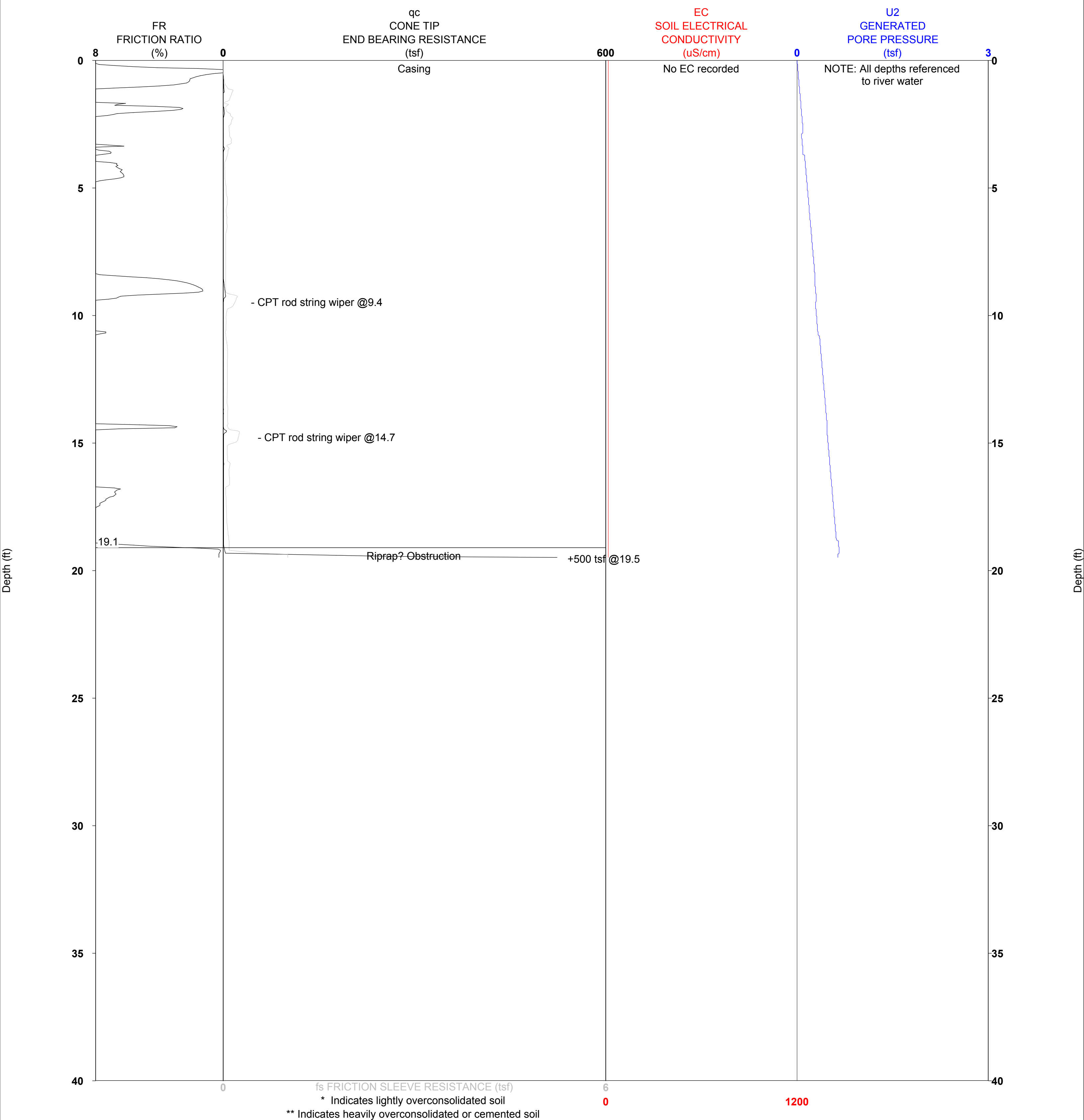
Latitude: 0.00000 Longitude: 0.00000

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/12/2012 TIME:10:31 AM
SOUNDING NUMBER:CPT-04 ()

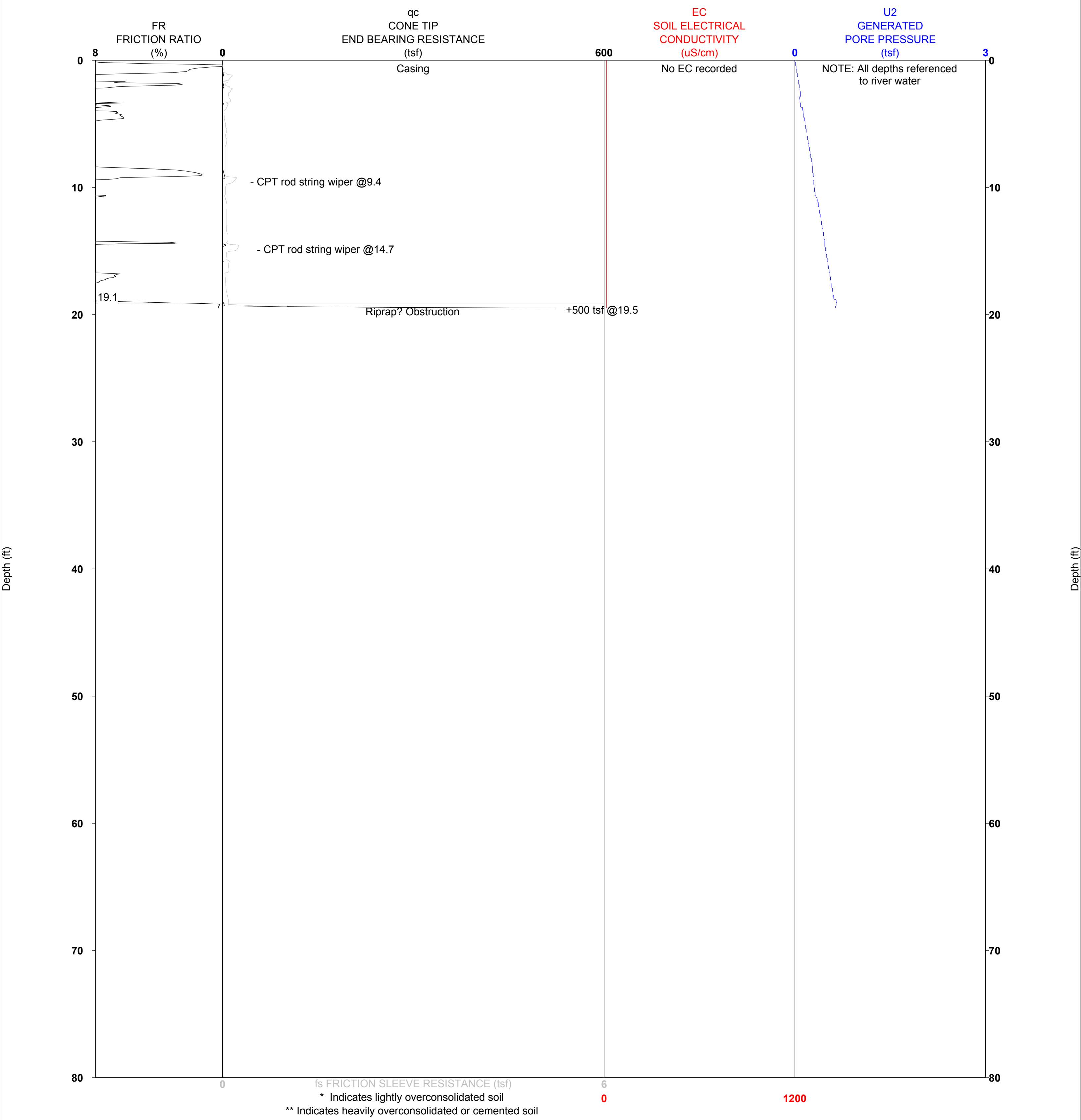
CPTU LOG WITH LITHOLOGIC EVALUATION CPT04



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

Latitude: 0.00000 Longitude: 0.00000

CPTU LOG WITH LITHOLOGIC EVALUATION CPT04



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

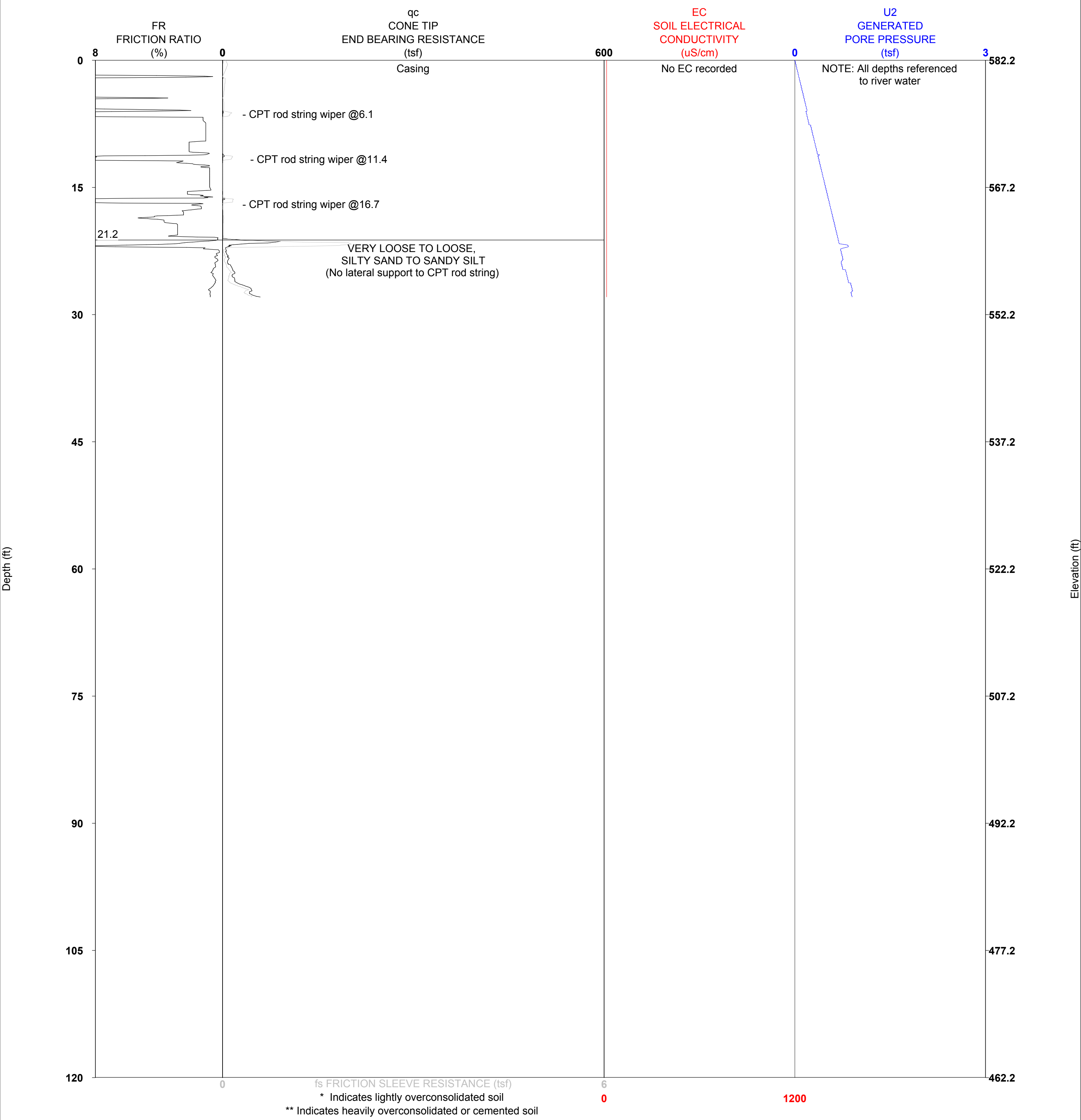
Latitude: 0.00000 Longitude: 0.00000

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/12/2012 TIME:10:31 AM
SOUNDING NUMBER:CPT-04 ()

CPTU-EC LOG WITH LITHOLOGIC EVALUATION CPT04a



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

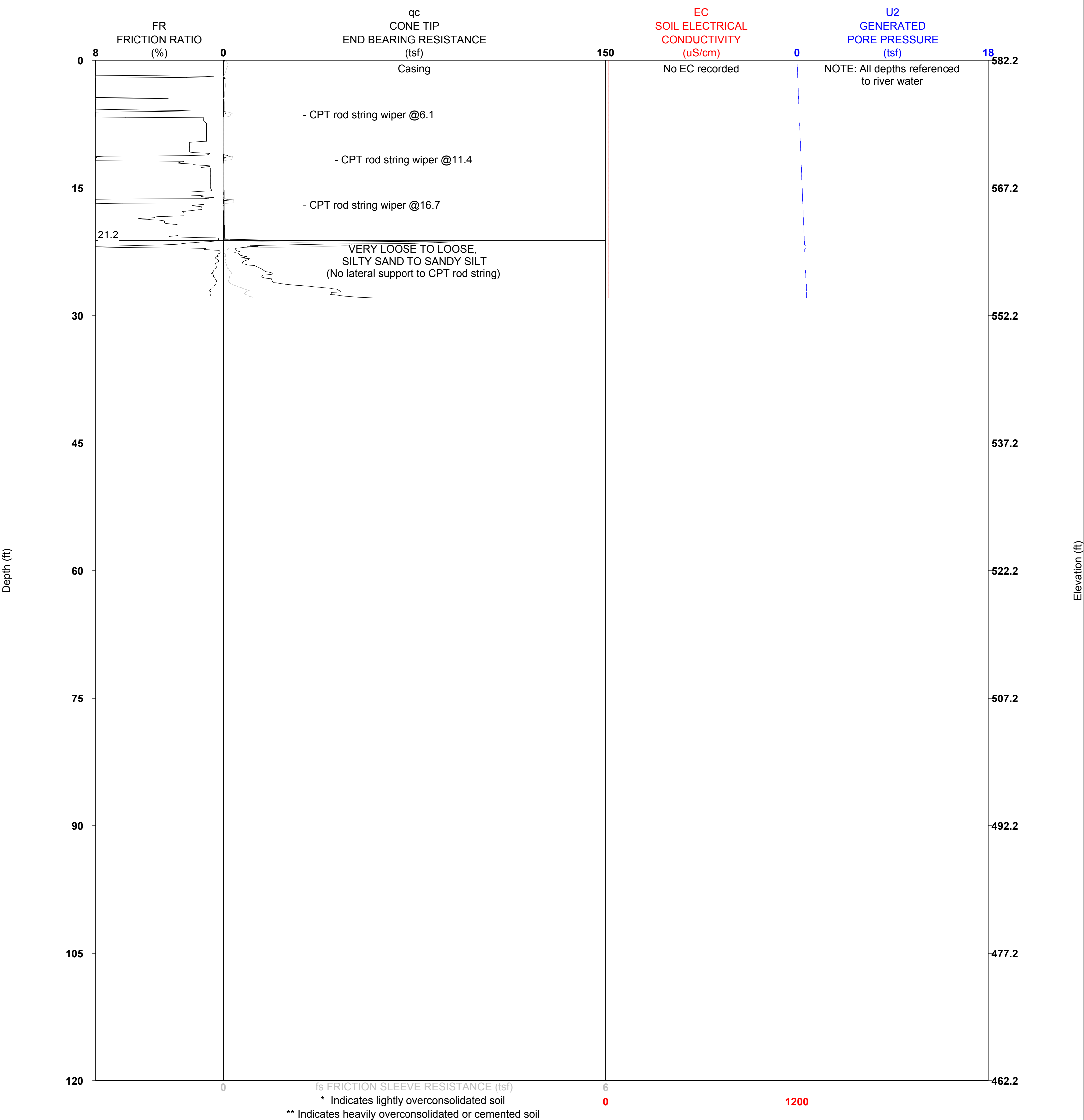
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

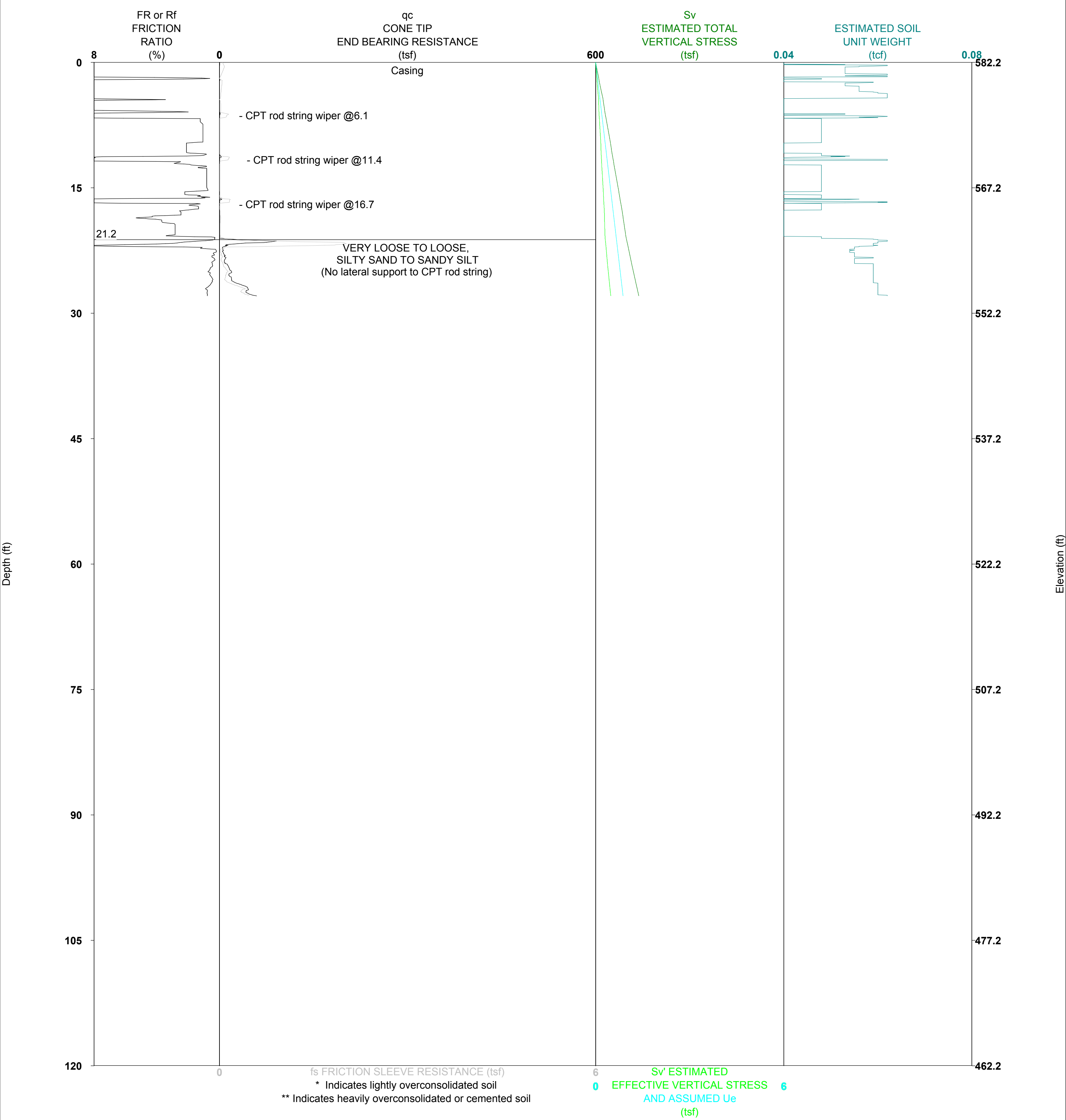
R1 DATE:11/12/2012 TIME:12:05 PM
SOUNDING NUMBER:CPT-04a ()

CPTU-EC LOG WITH LITHOLOGIC EVALUATION CPT04a



Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

CPT LOG WITH LITHOLOGIC EVALUATION CPT04a



* Indicates lightly overconsolidated soil

** Indicates heavily overconsolidated or cemented soil

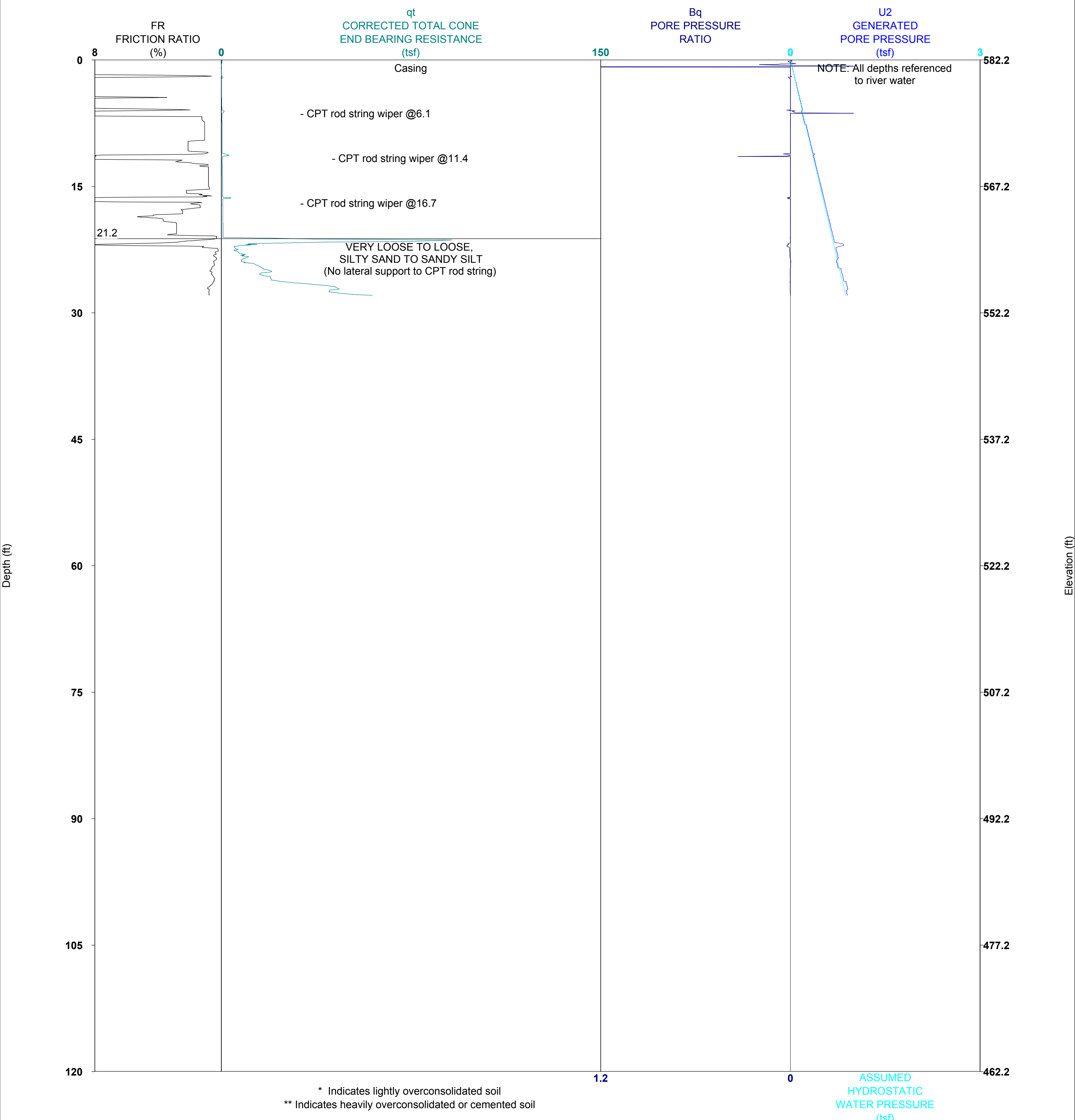
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/12/2012 TIME:12:05 PM
SOUNDING NUMBER:CPT-04a ()

CPTU-EC LOG WITH LITHOLOGIC EVALUATION CPT04a



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

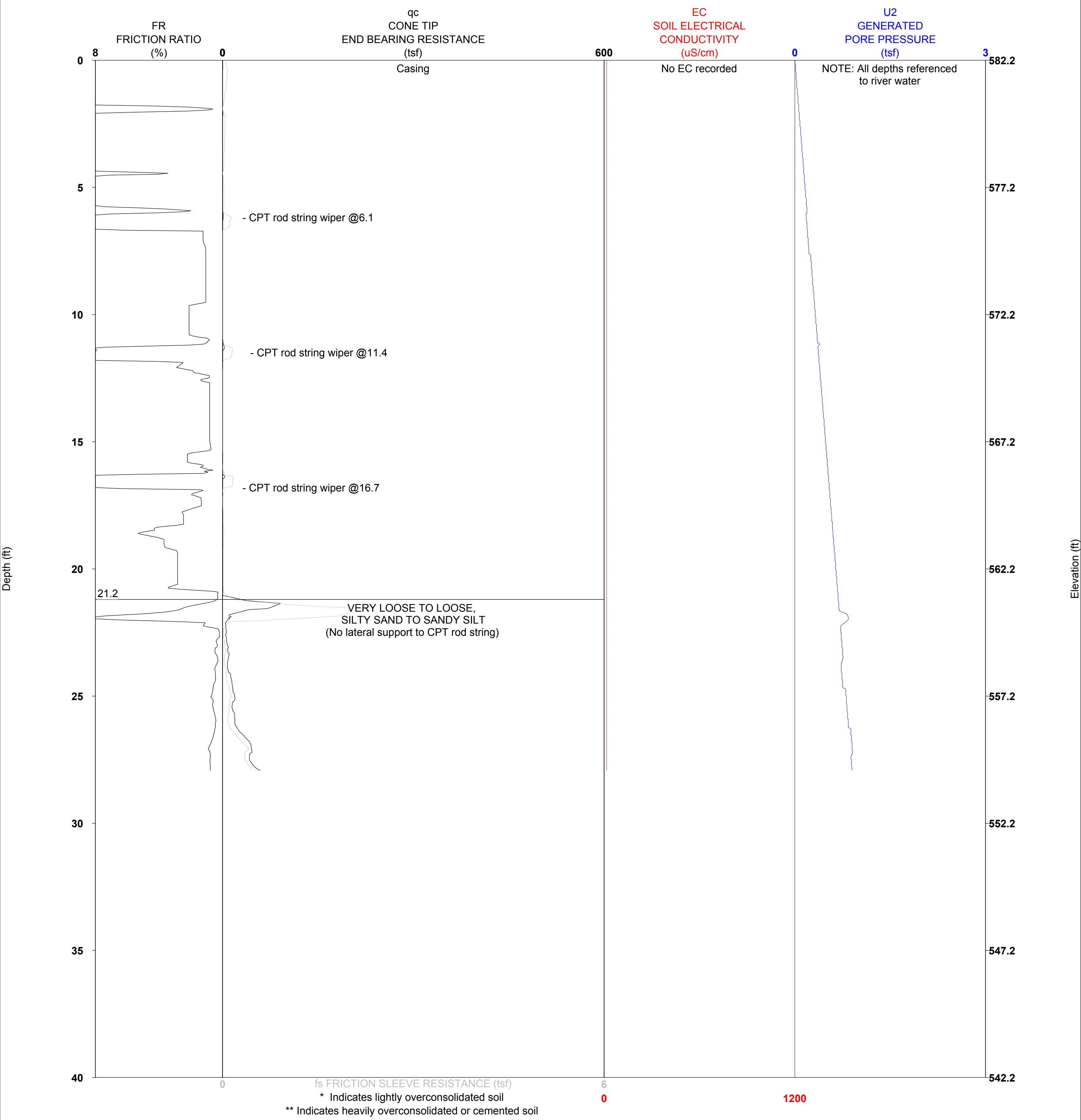
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/12/2012 TIME:12:05 PM
SOUNDING NUMBER:CPT-04a ()

CPTU-EC LOG WITH LITHOLOGIC EVALUATION CPT04a



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

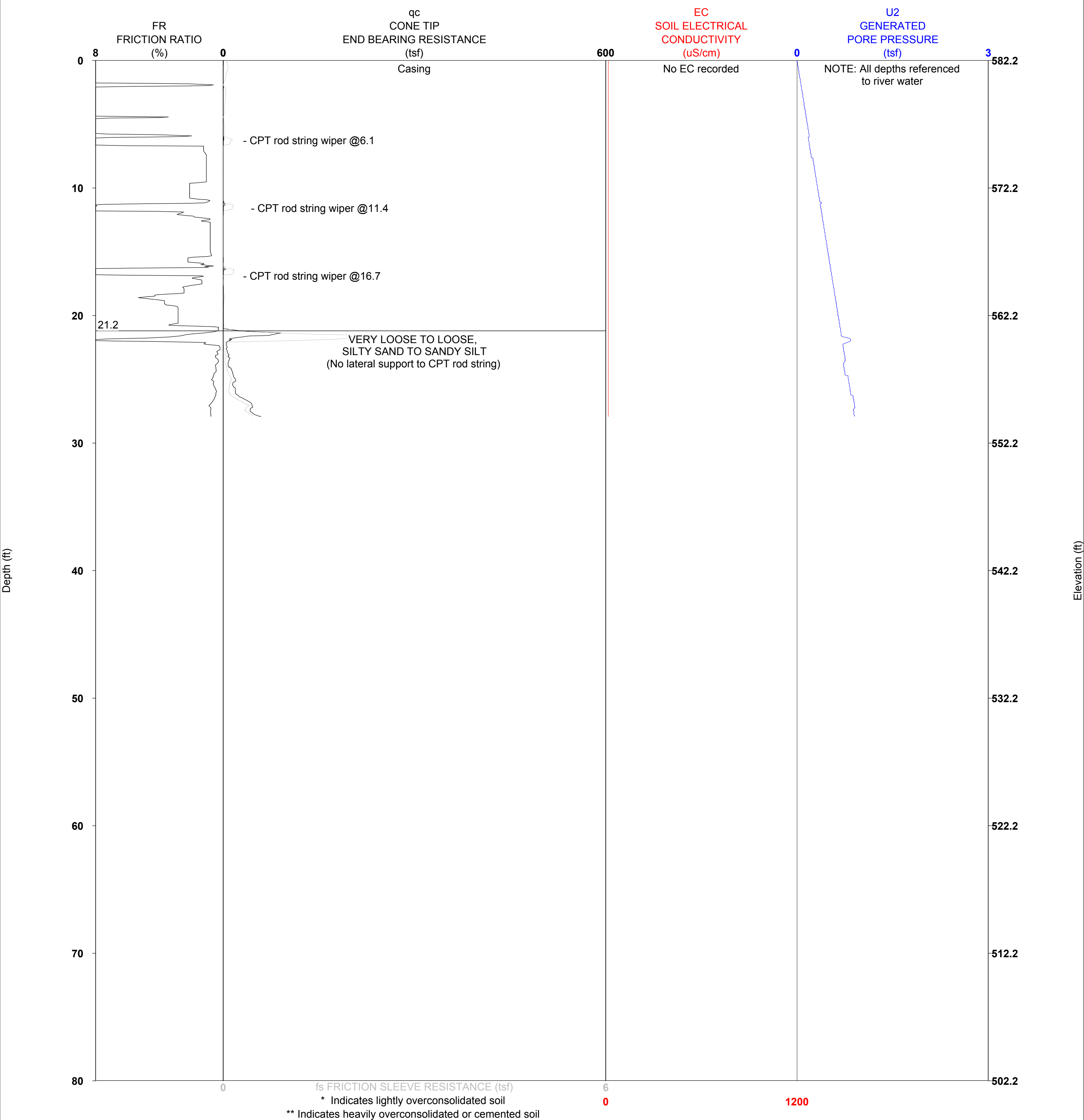
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/12/2012 TIME:12:05 PM
SOUNDING NUMBER:CPT-04a ()

CPTU-EC LOG WITH LITHOLOGIC EVALUATION CPT04a



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

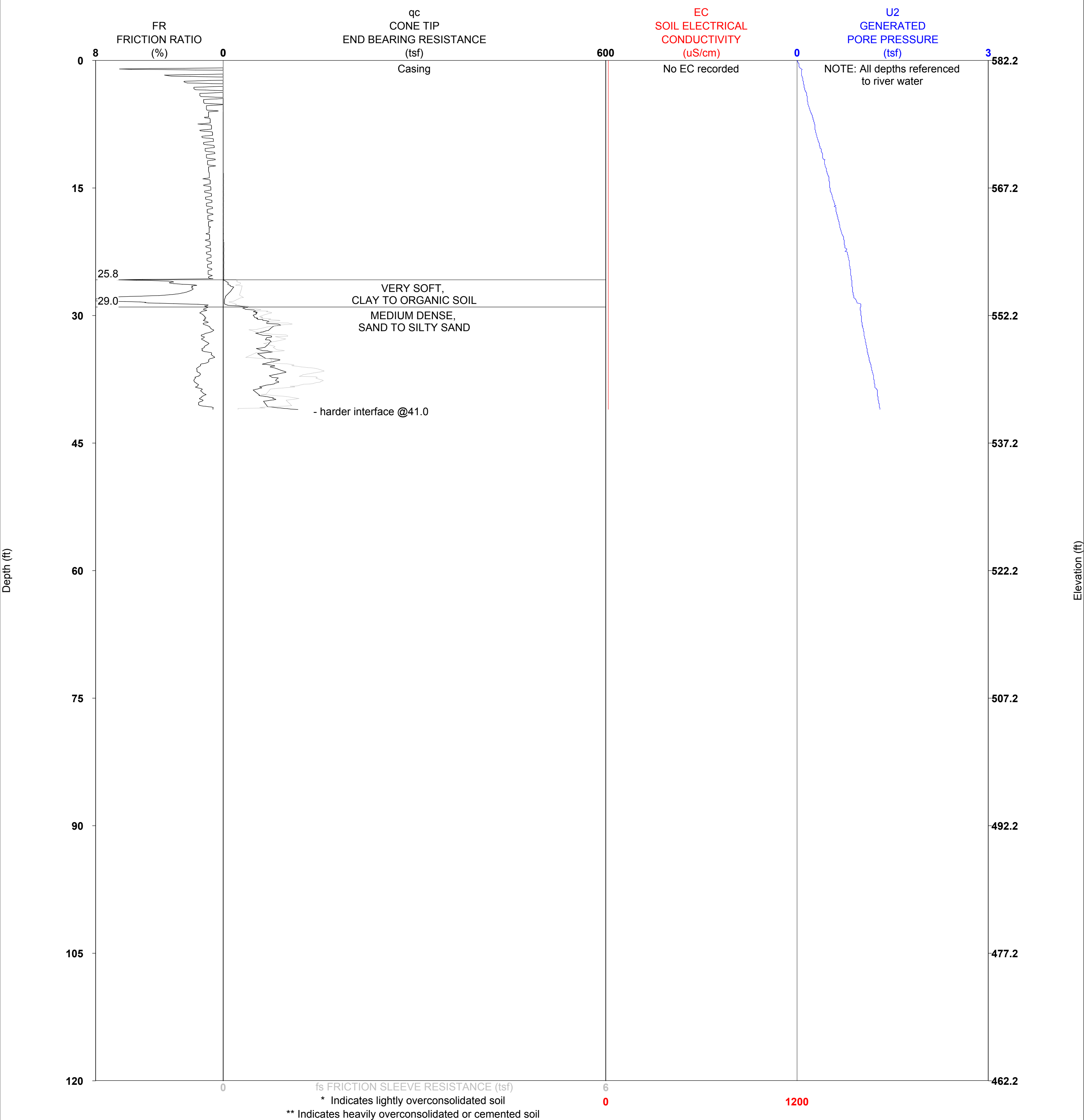
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/12/2012 TIME:12:05 PM
SOUNDING NUMBER:CPT-04a ()

CPTU LOG WITH LITHOLOGIC EVALUATION CPT05

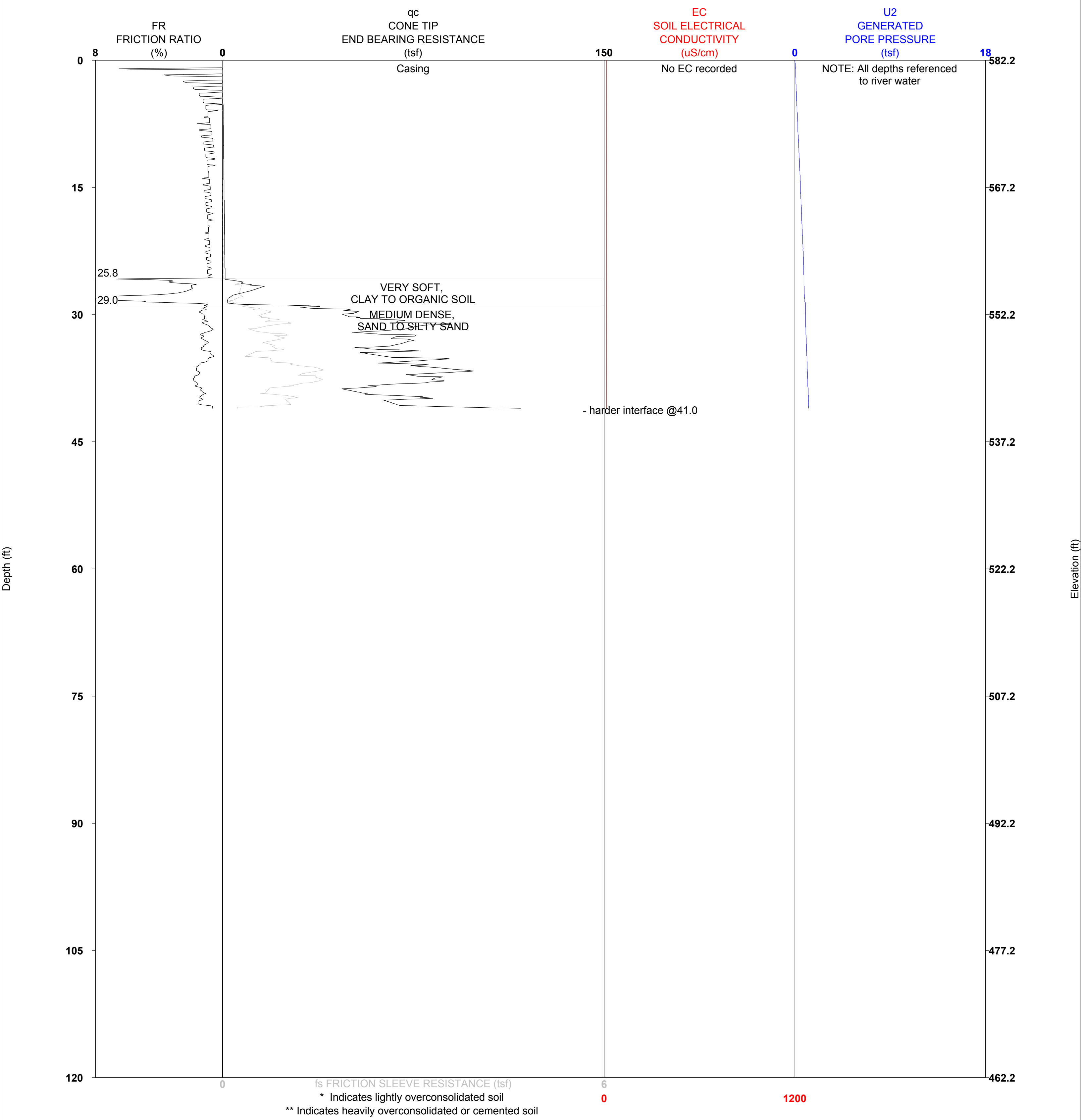


* Indicates lightly overconsolidated soil

** Indicates heavily overconsolidated or cemented soil

Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

CPTU LOG WITH LITHOLOGIC EVALUATION CPT05



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

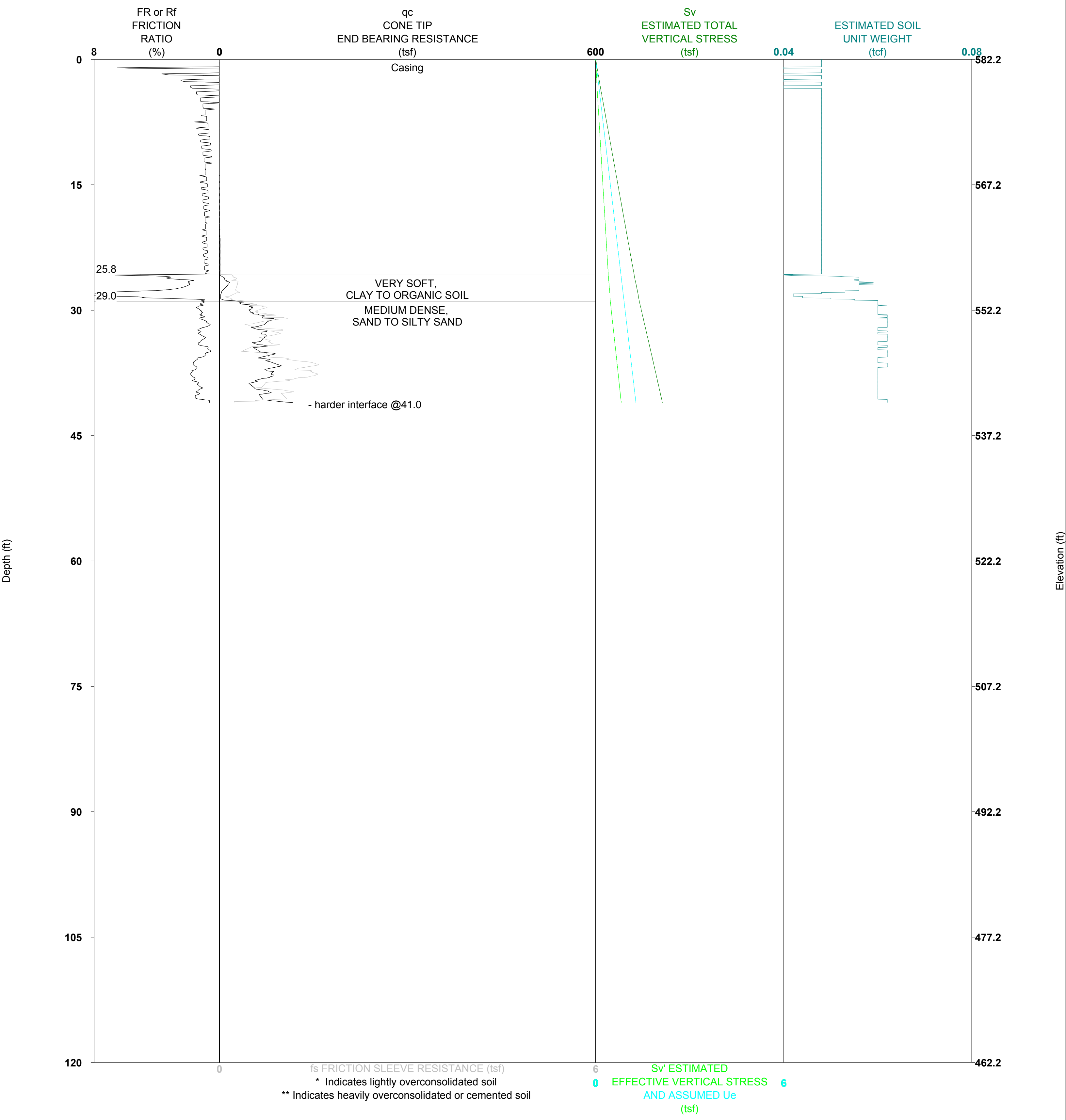
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/8/2012 TIME:9:24 AM
SOUNDING NUMBER:CPT-05 ()

CPT LOG WITH LITHOLOGIC EVALUATION CPT05



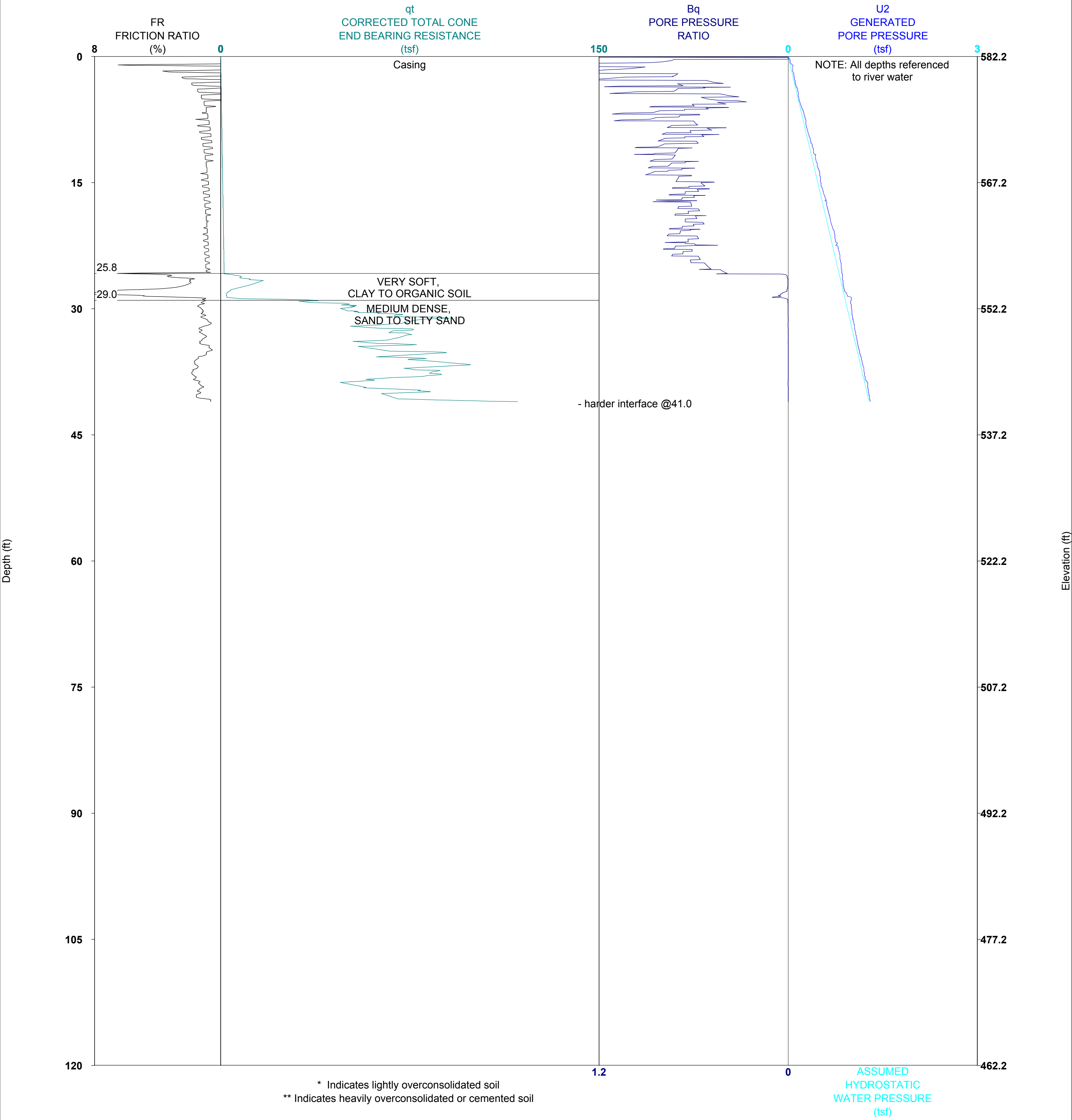
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/8/2012 TIME:9:24 AM
SOUNDING NUMBER:CPT-05 ()

CPTU LOG WITH LITHOLOGIC EVALUATION CPT05



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

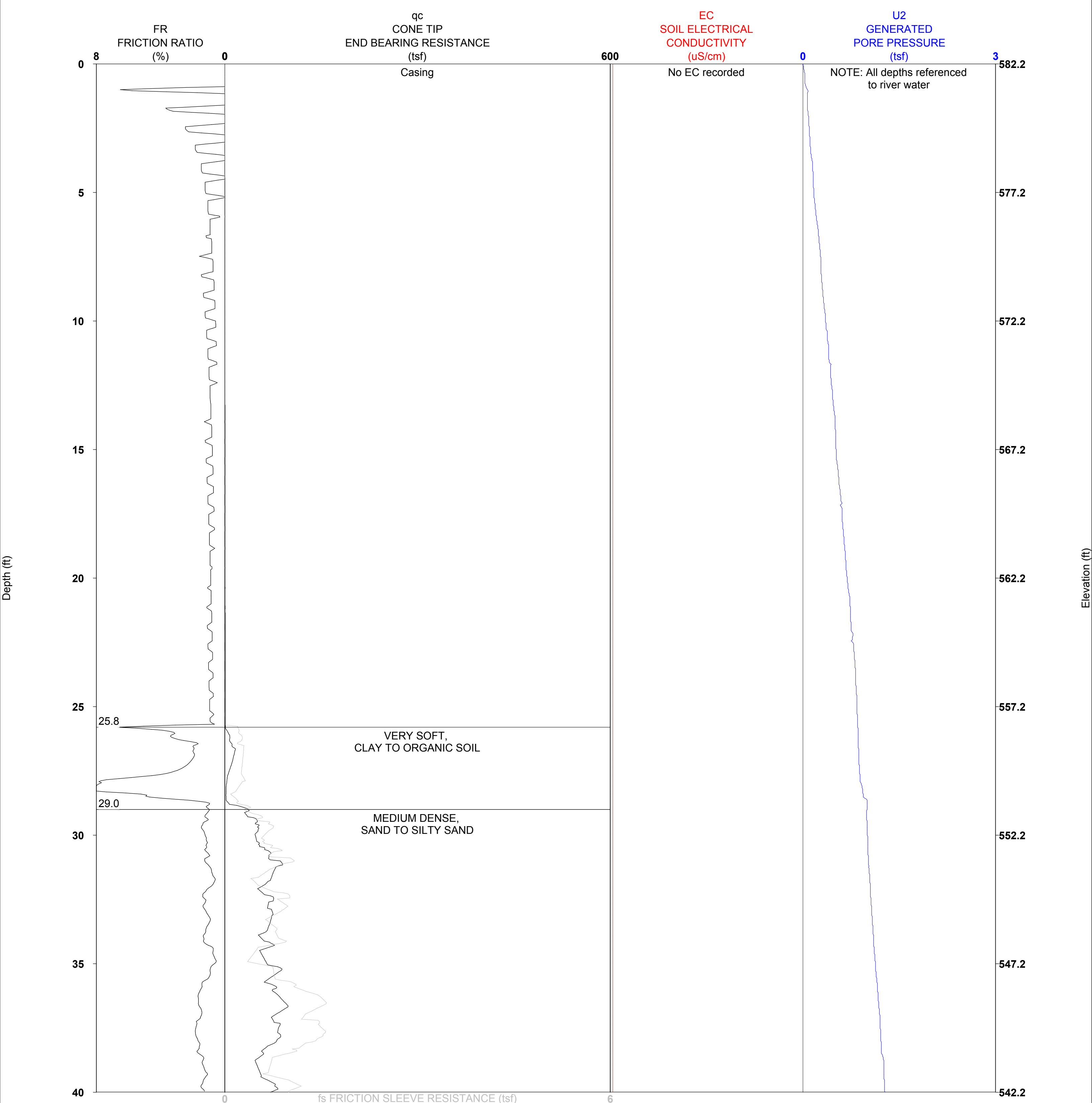
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/8/2012 TIME:9:24 AM
SOUNDING NUMBER:CPT-05 ()

CPTU LOG WITH LITHOLOGIC EVALUATION CPT05



* Indicates lightly overconsolidated soil

** Indicates heavily overconsolidated or cemented soil

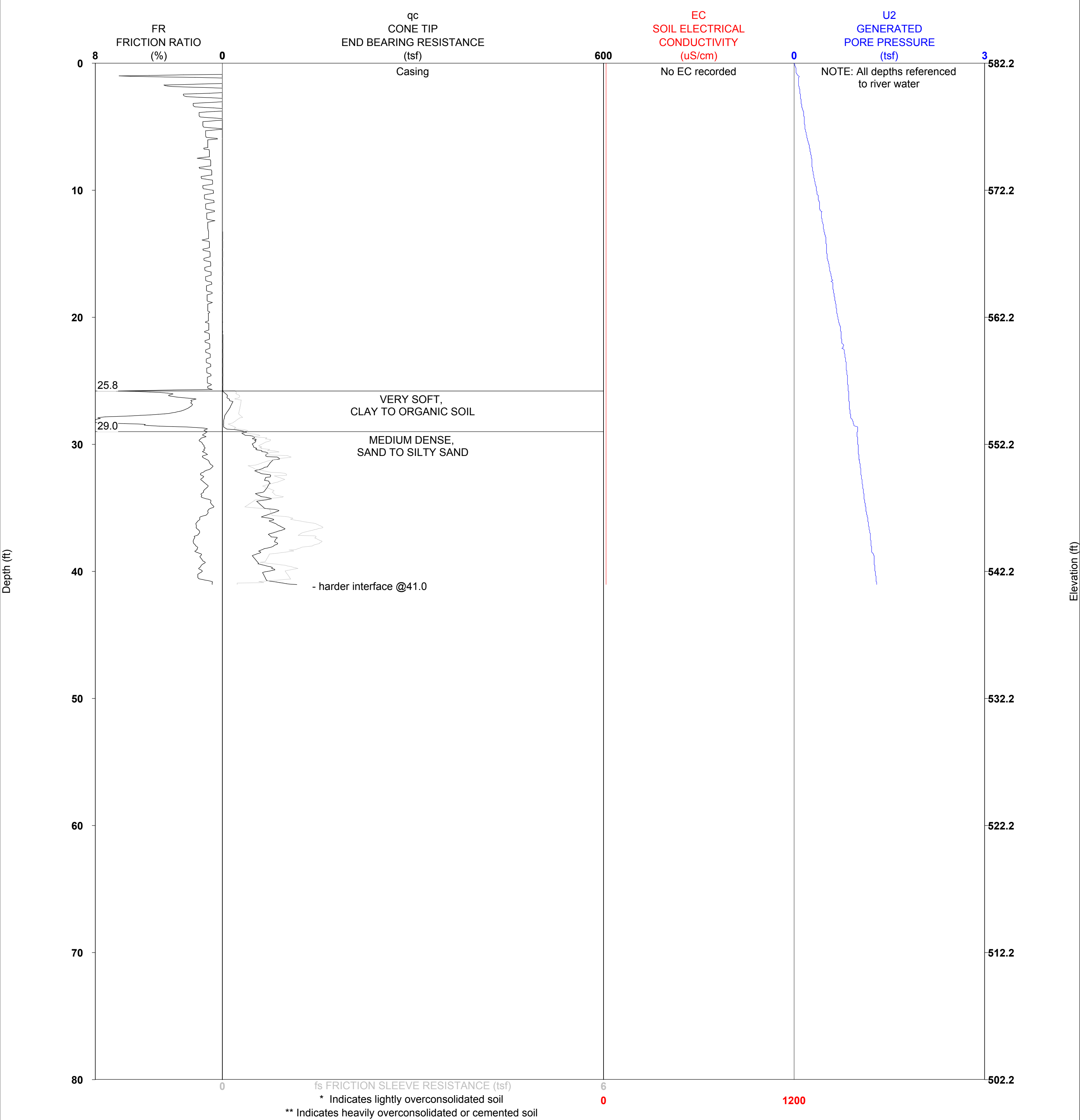
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/8/2012 TIME:9:24 AM
SOUNDING NUMBER:CPT-05 ()

CPTU LOG WITH LITHOLOGIC EVALUATION CPT05



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

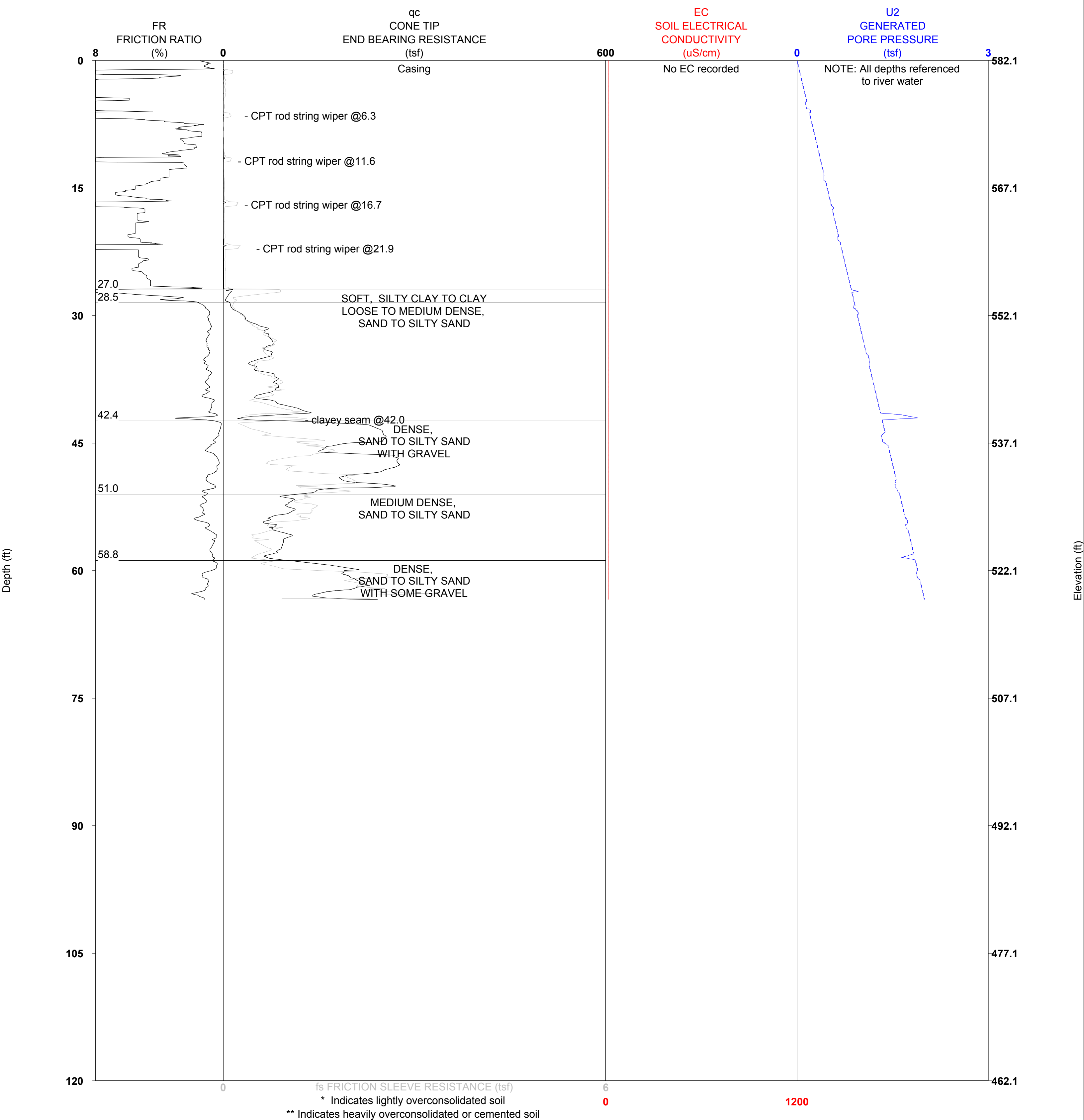
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/8/2012 TIME:9:24 AM
SOUNDING NUMBER:CPT-05 ()

CPTU LOG WITH LITHOLOGIC EVALUATION CPT06



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

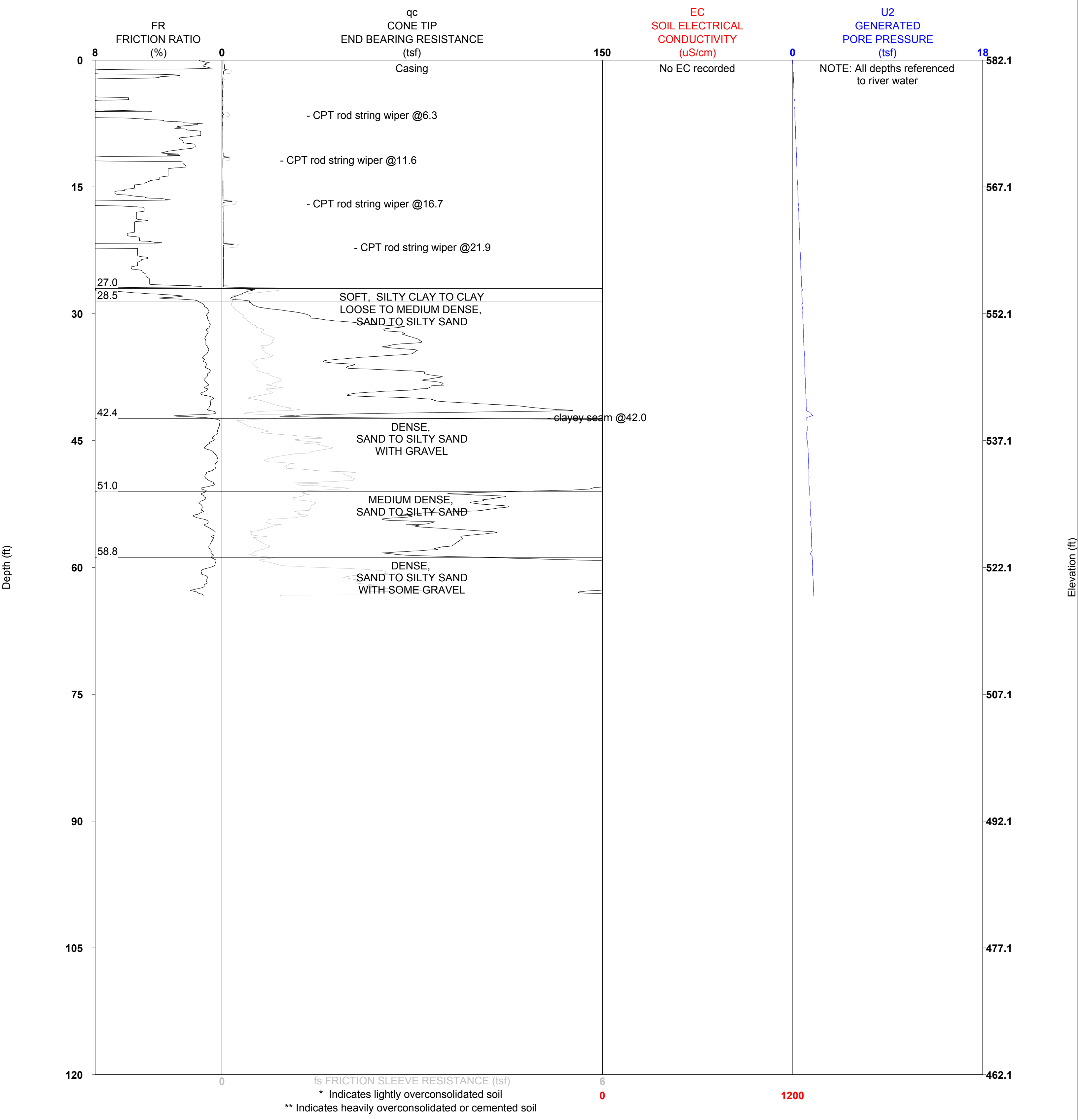
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.1

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/9/2012 TIME:2:13 PM
SOUNDING NUMBER:CPT-06 ()

CPTU LOG WITH LITHOLOGIC EVALUATION CPT06



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

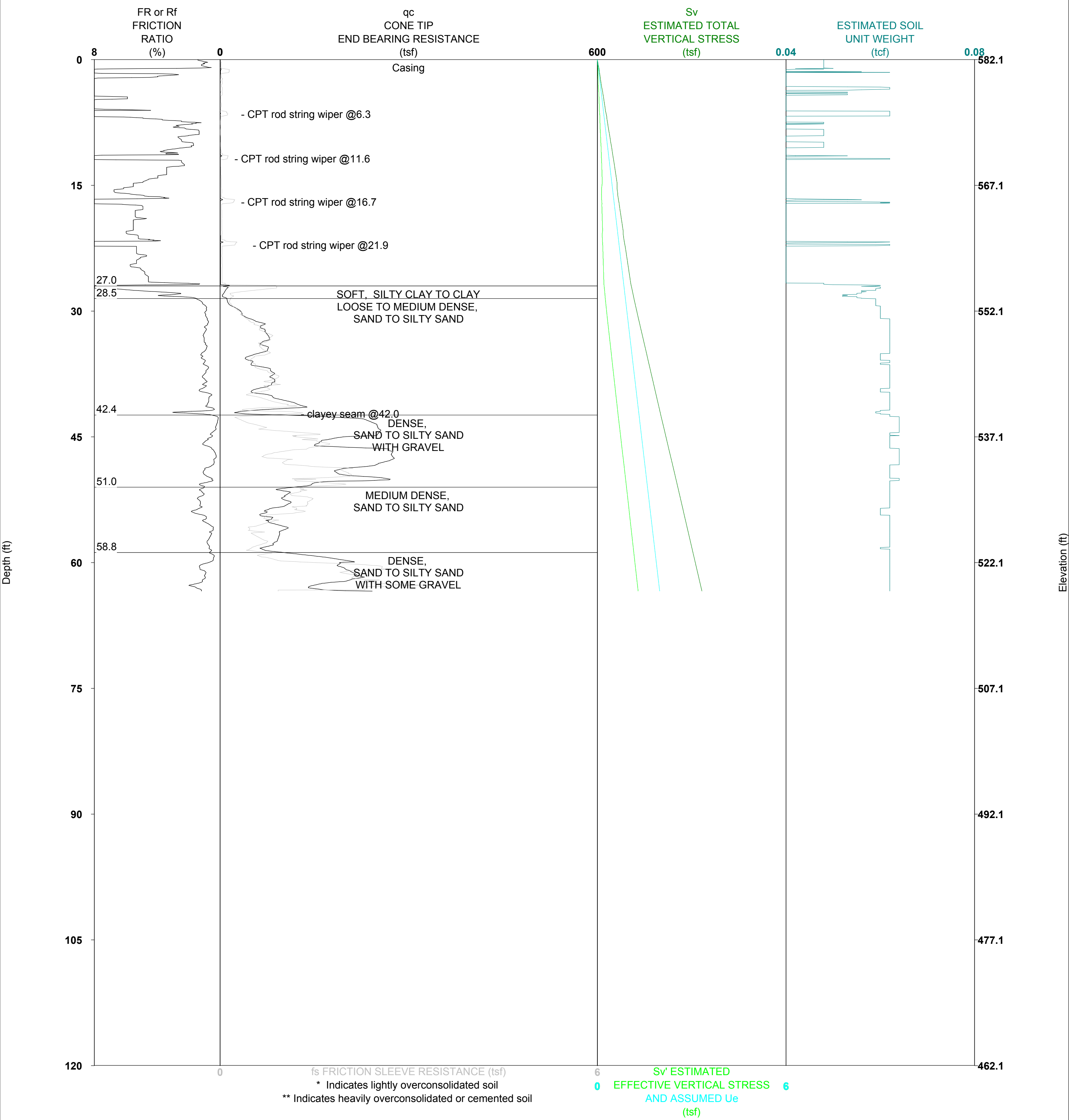
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.1

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/9/2012 TIME:2:13 PM
SOUNDING NUMBER:CPT-06 ()

CPT LOG WITH LITHOLOGIC EVALUATION CPT06



* Indicates lightly overconsolidated soil

** Indicates heavily overconsolidated or cemented soil

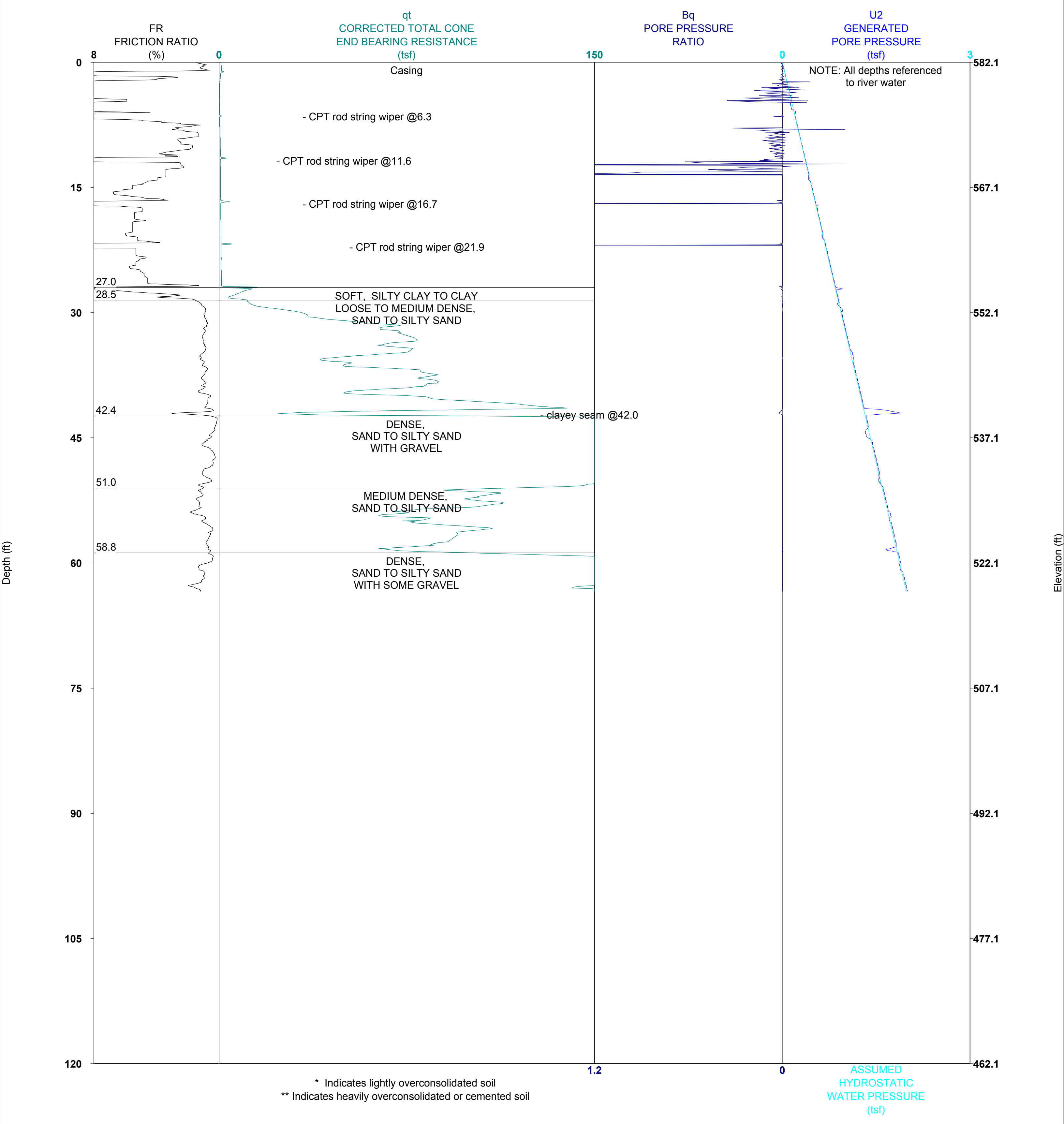
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.1

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/9/2012 TIME:2:13 PM
SOUNDING NUMBER:CPT-06 ()

CPTU LOG WITH LITHOLOGIC EVALUATION CPT06



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

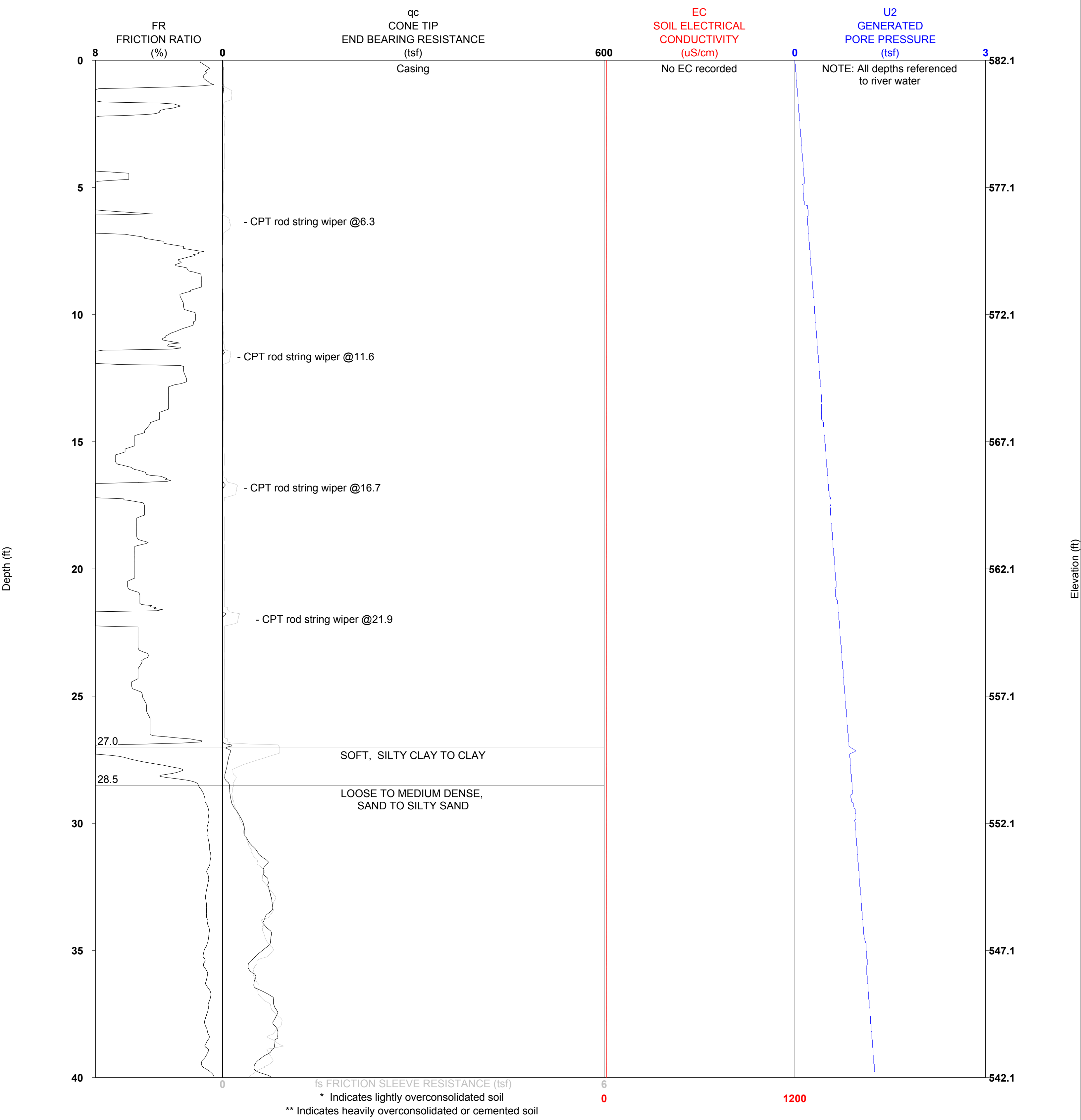
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.1

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/9/2012 TIME:2:13 PM
SOUNDING NUMBER:CPT-06 ()

CPTU LOG WITH LITHOLOGIC EVALUATION CPT06



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

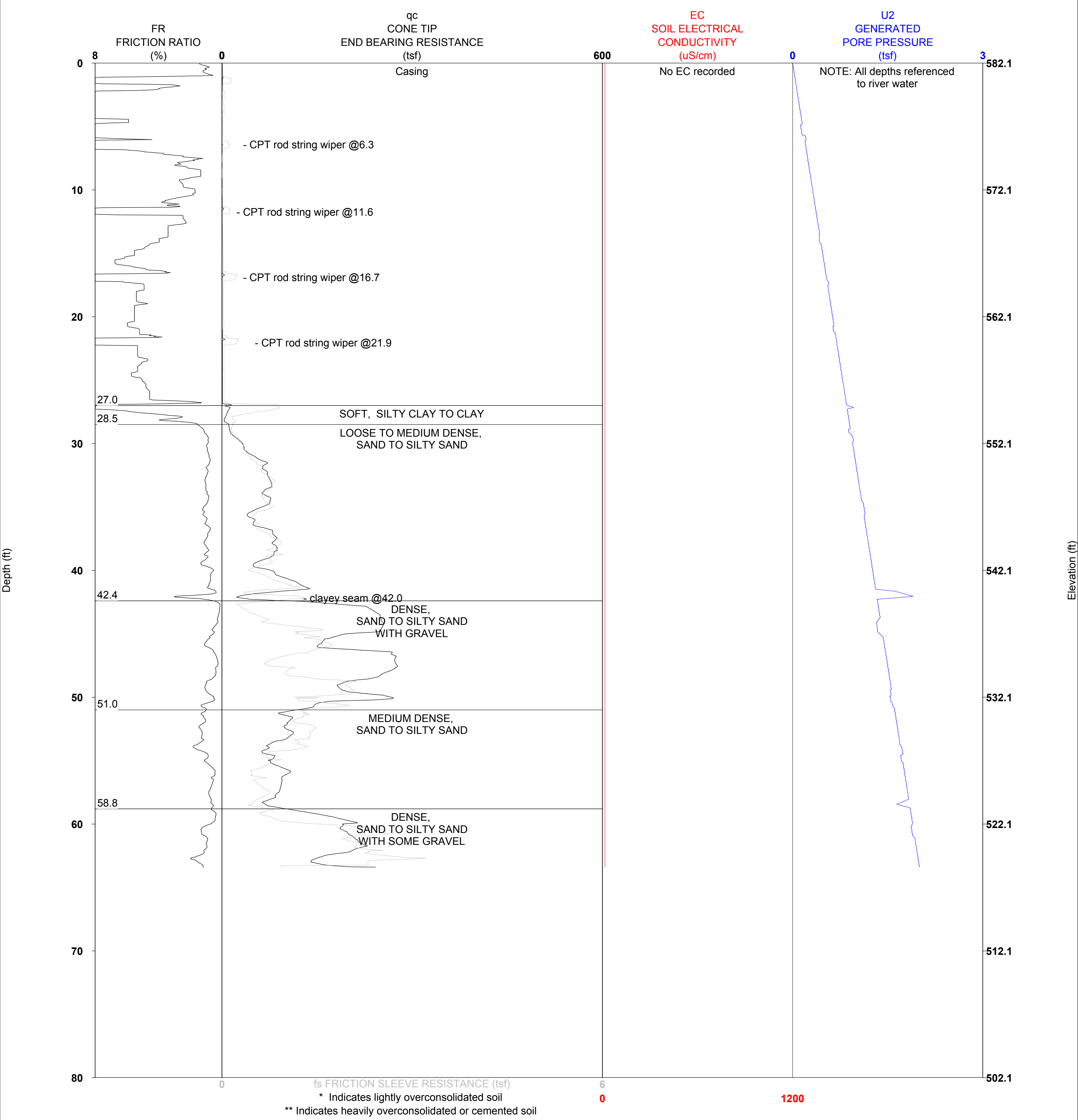
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.1

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/9/2012 TIME:2:13 PM
SOUNDING NUMBER:CPT-06 ()

CPTU LOG WITH LITHOLOGIC EVALUATION CPT06



* Indicates lightly overconsolidated soil

** Indicates heavily overconsolidated or cemented soil

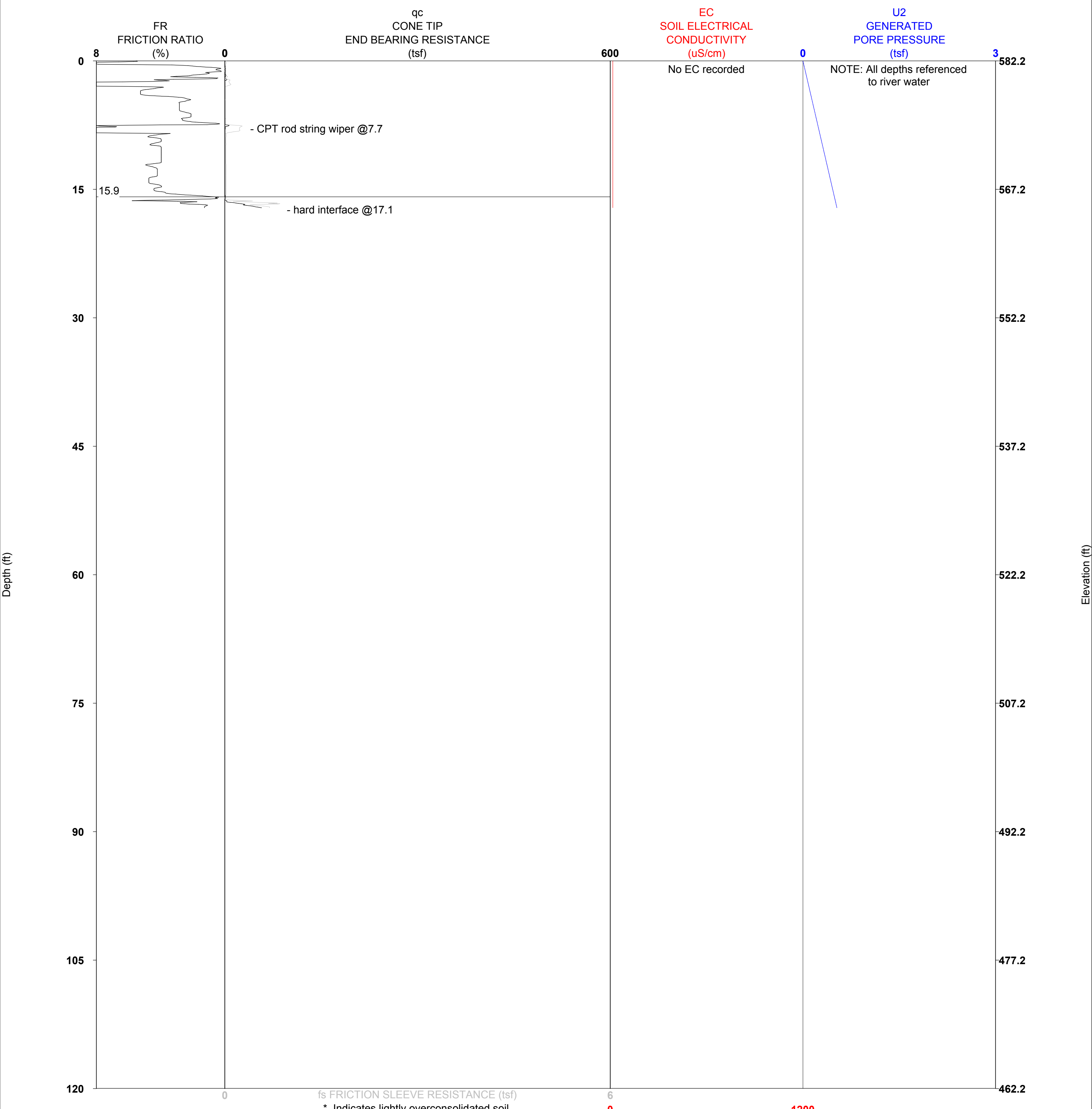
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.1

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/9/2012 TIME:2:13 PM
SOUNDING NUMBER:CPT-06 ()

CPTU LOG WITH LITHOLOGIC EVALUATION CPT07



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

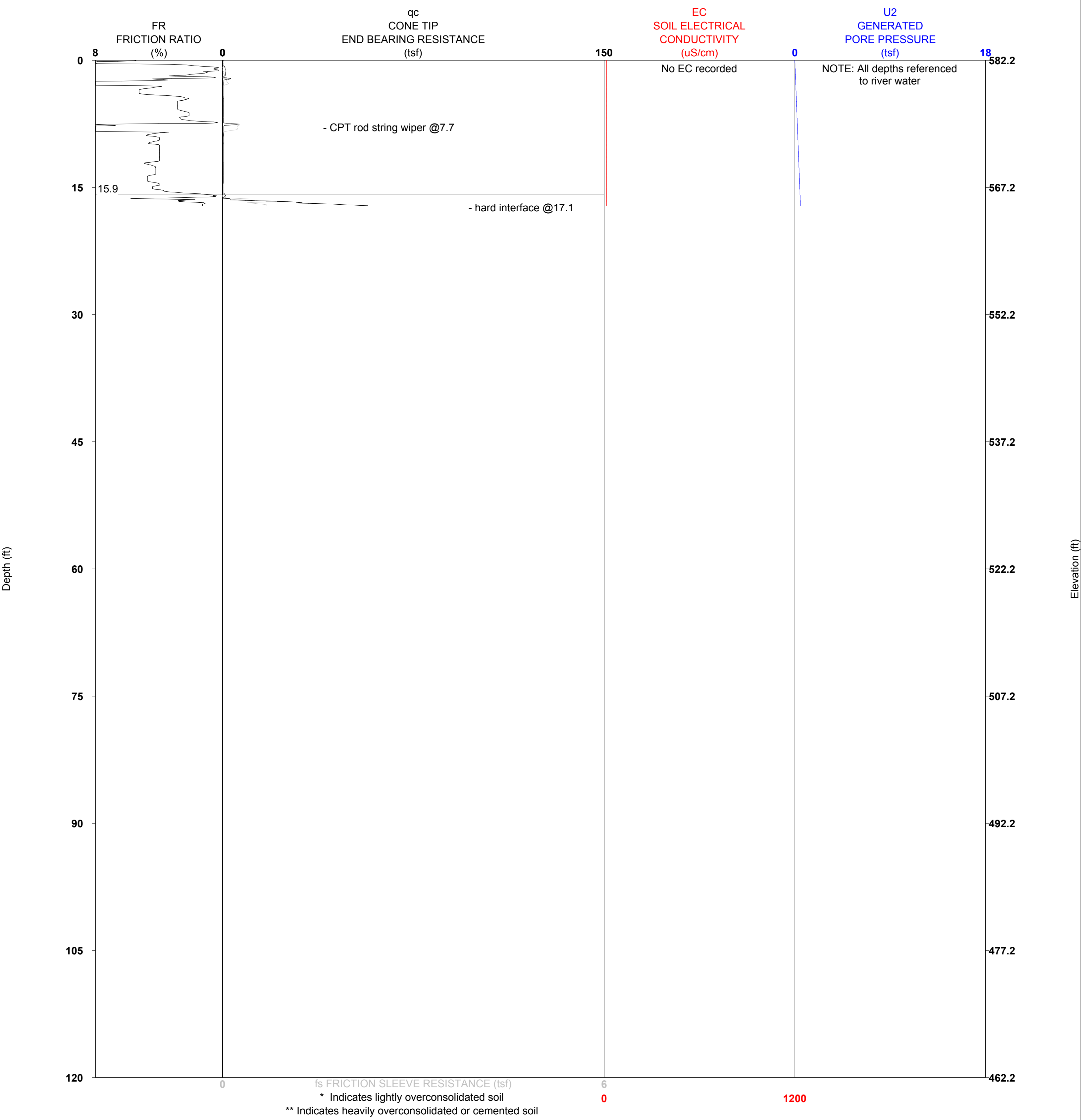
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/7/2012 TIME:3:44 PM
SOUNDING NUMBER:CPT-07

CPTU LOG WITH LITHOLOGIC EVALUATION CPT07



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

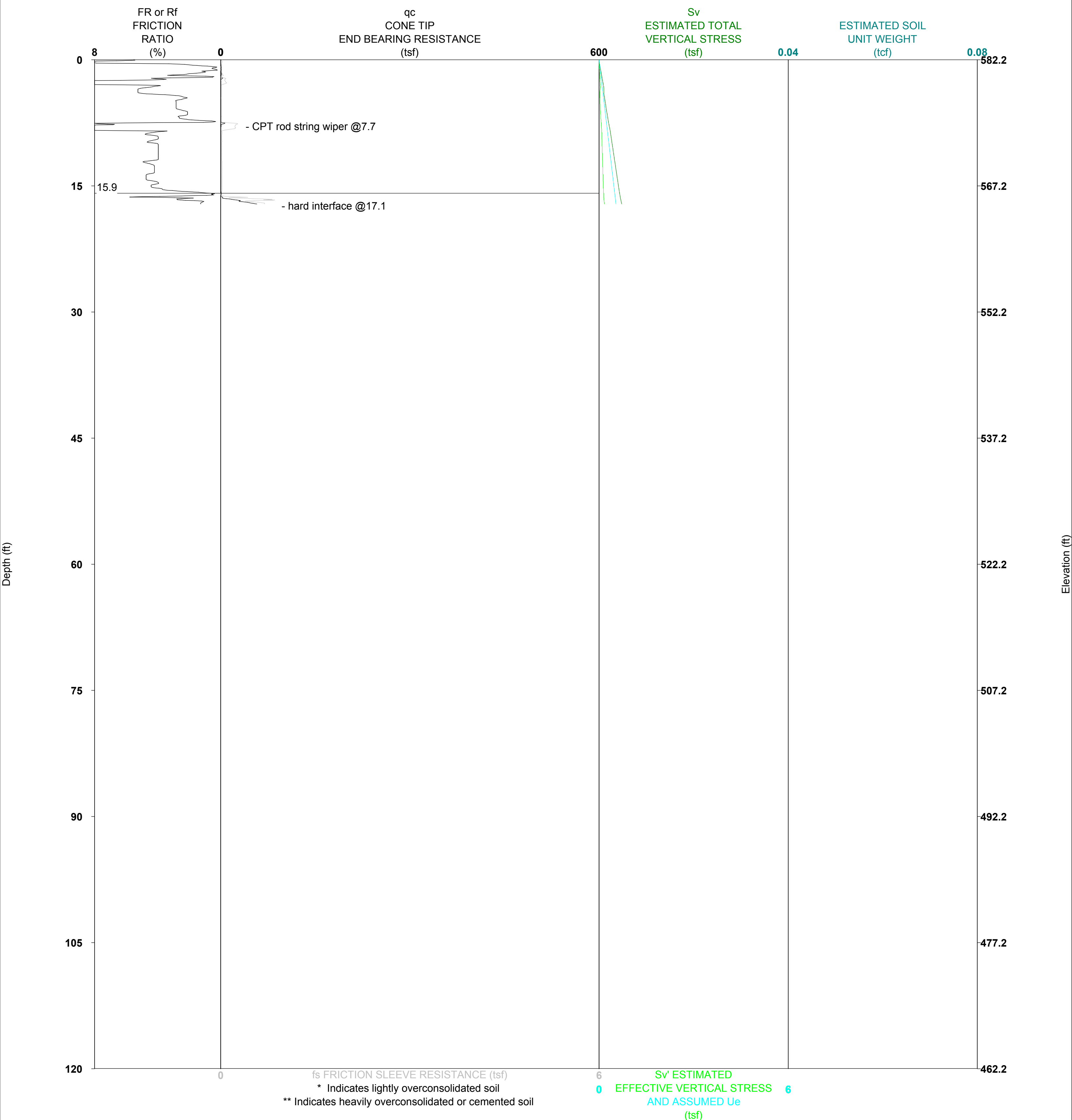
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/7/2012 TIME:3:44 PM
SOUNDING NUMBER:CPT-07

CPT LOG WITH LITHOLOGIC EVALUATION CPT07



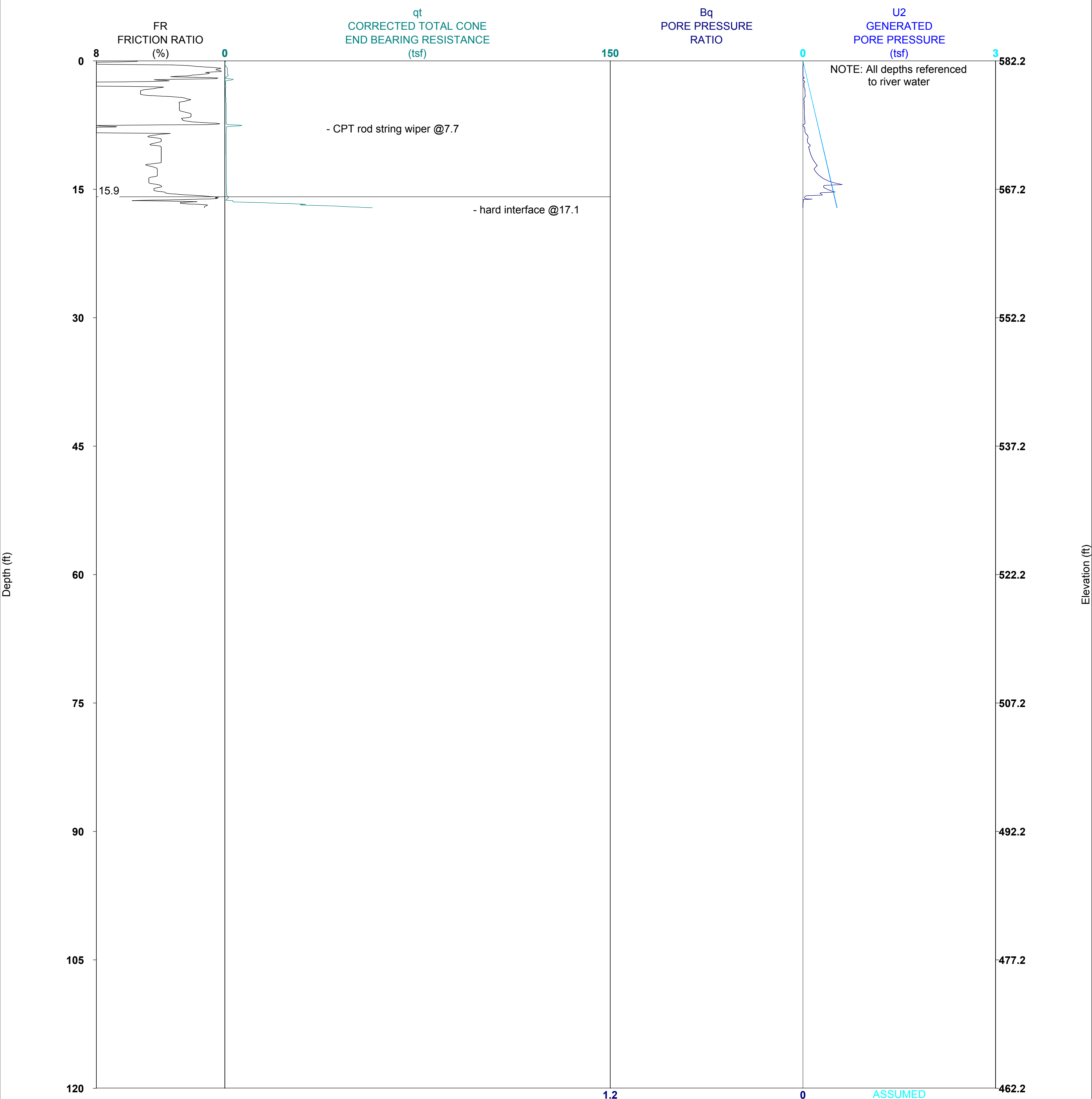
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/7/2012 TIME:3:44 PM
SOUNDING NUMBER:CPT-07

CPTU LOG WITH LITHOLOGIC EVALUATION CPT07



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

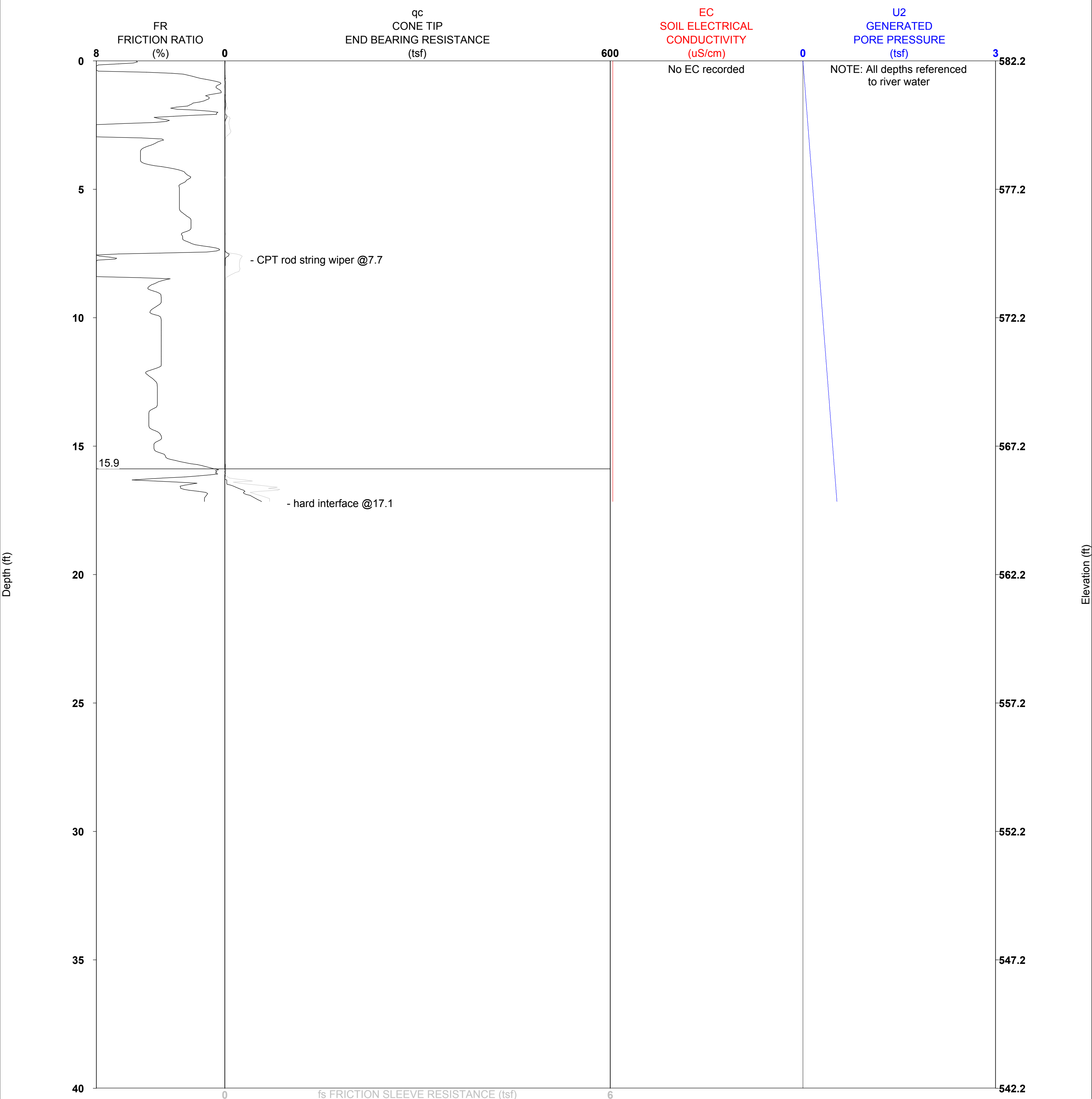
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/7/2012 TIME:3:44 PM
SOUNDING NUMBER:CPT-07

CPTU LOG WITH LITHOLOGIC EVALUATION CPT07



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

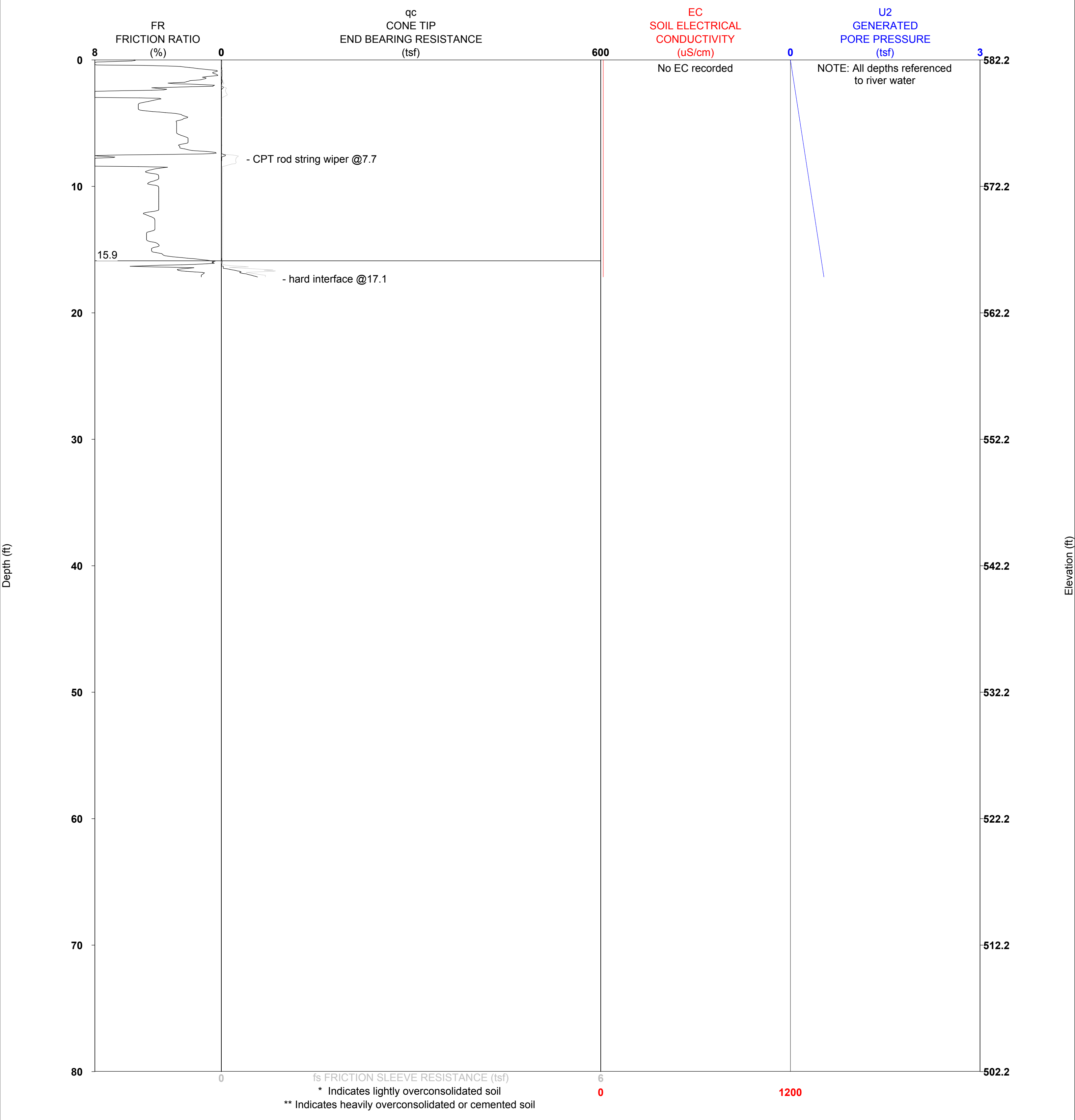
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/7/2012 TIME:3:44 PM
SOUNDING NUMBER:CPT-07

CPTU LOG WITH LITHOLOGIC EVALUATION CPT07



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

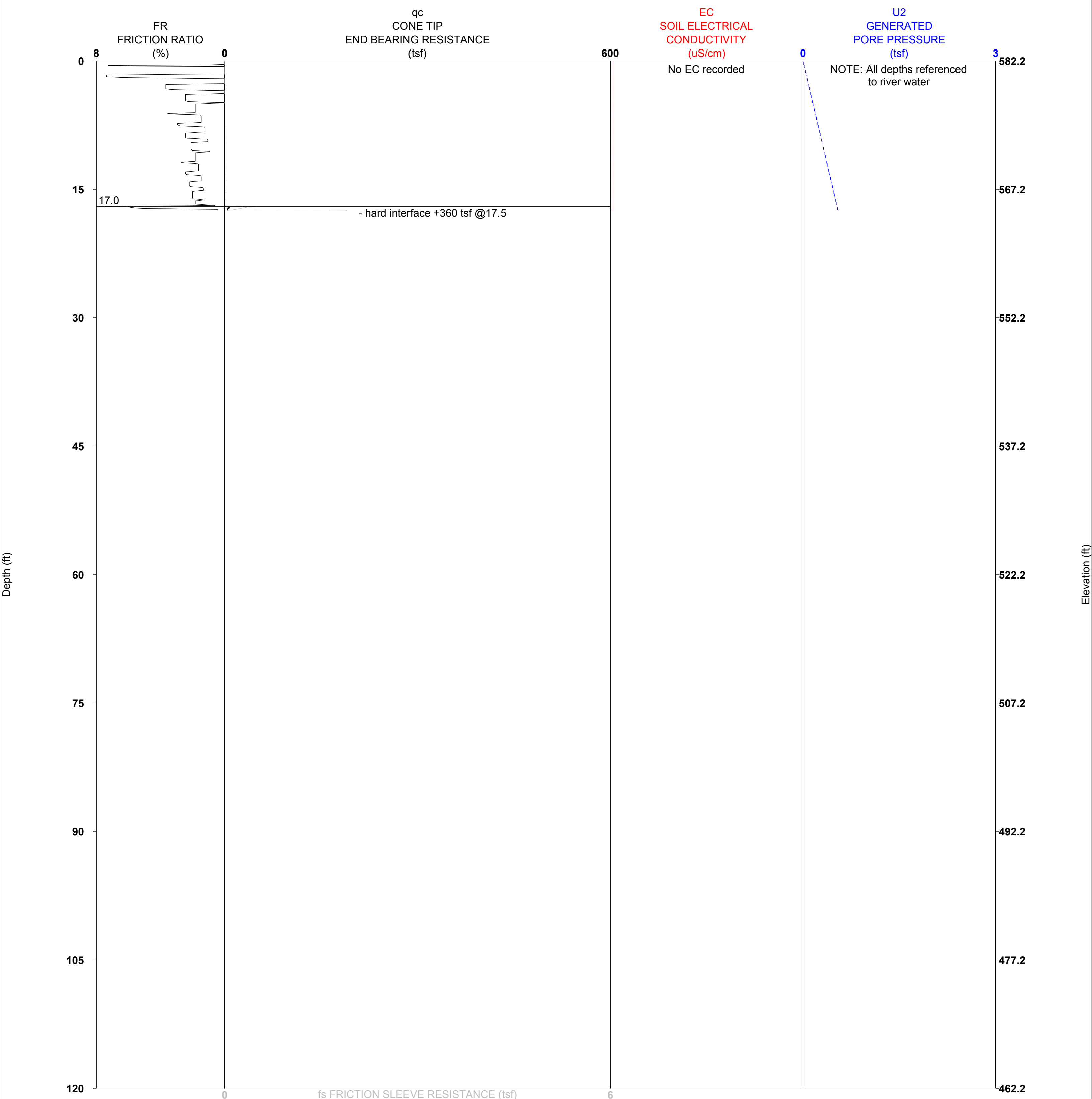
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/7/2012 TIME:3:44 PM
SOUNDING NUMBER:CPT-07

CPTU LOG WITH LITHOLOGIC EVALUATION CPT08



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

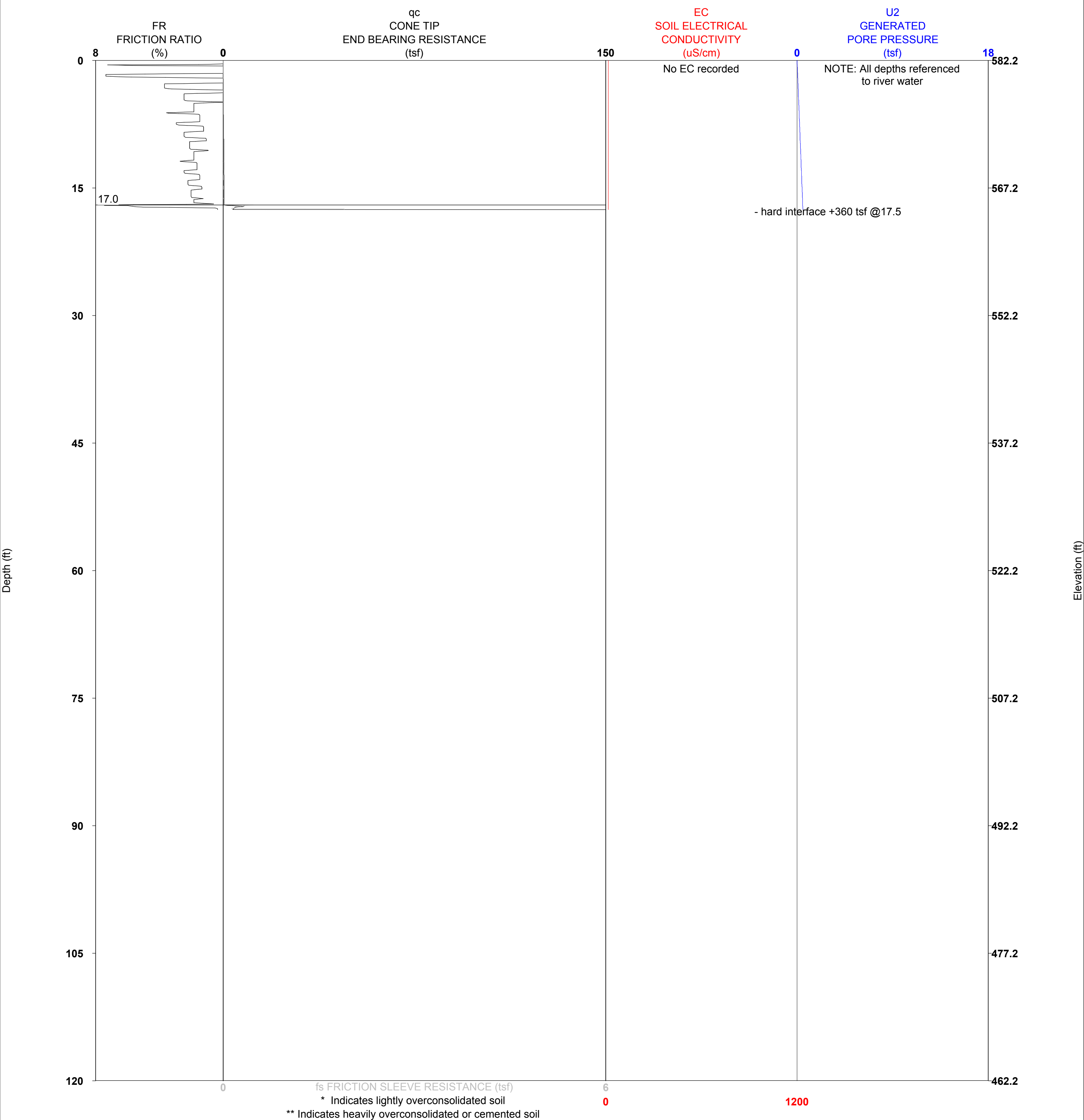
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/7/2012 TIME:5:18 PM
SOUNDING NUMBER:CPT-08 ()

CPTU LOG WITH LITHOLOGIC EVALUATION CPT08



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

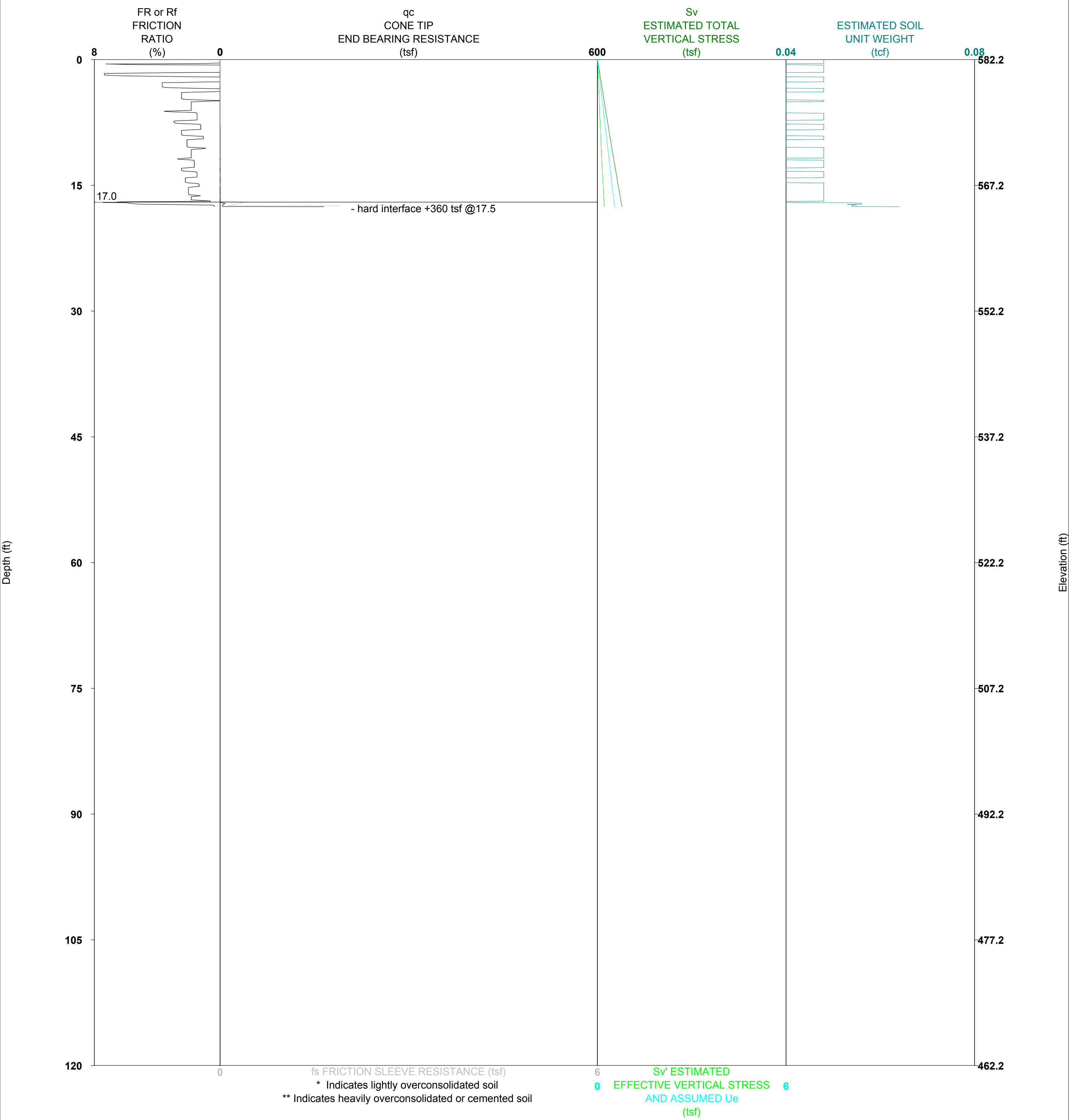
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/7/2012 TIME:5:18 PM
SOUNDING NUMBER:CPT-08 ()

CPT LOG WITH LITHOLOGIC EVALUATION CPT08



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

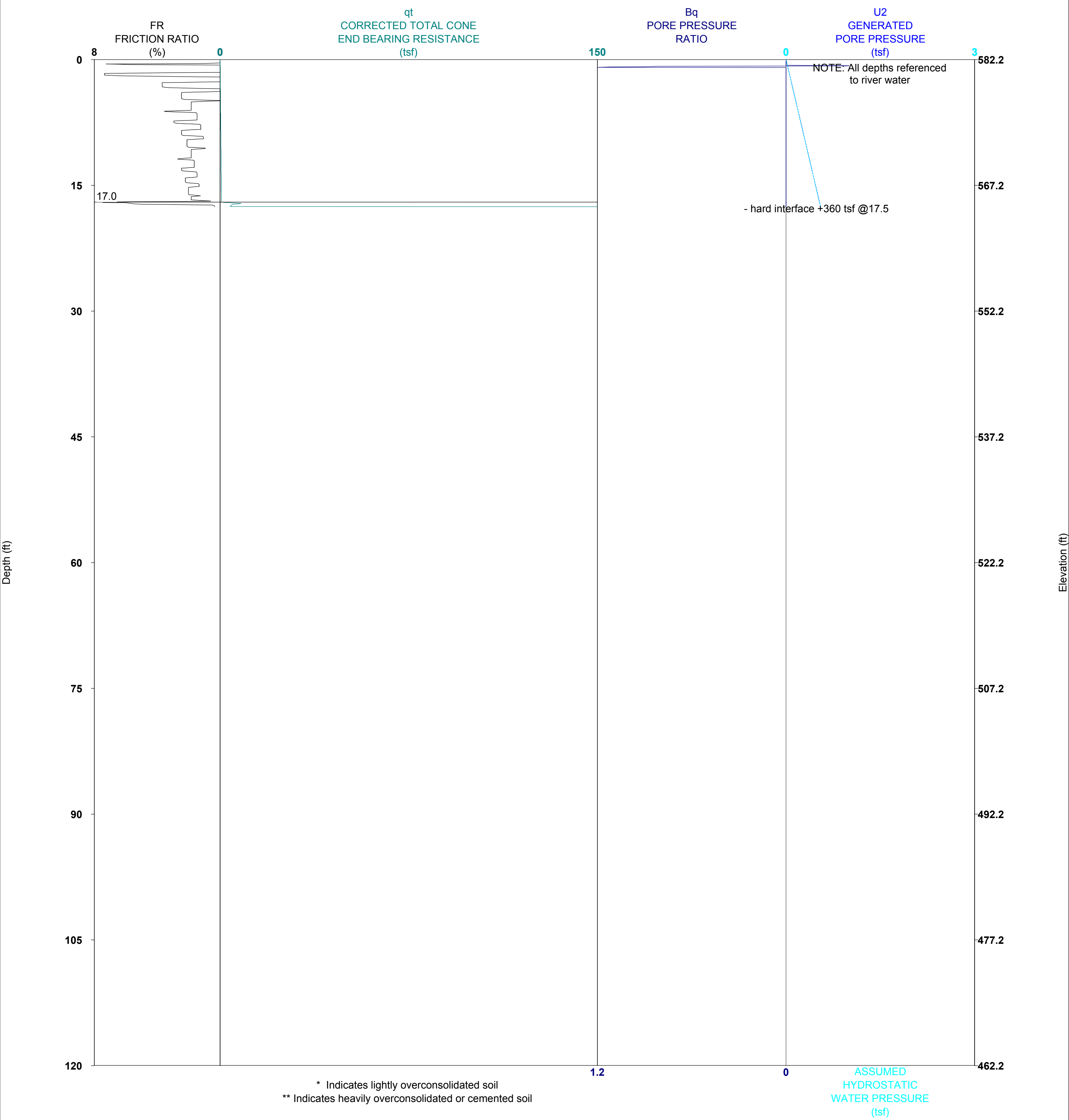
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/7/2012 TIME:5:18 PM
SOUNDING NUMBER:CPT-08 ()

CPTU LOG WITH LITHOLOGIC EVALUATION CPT08



* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

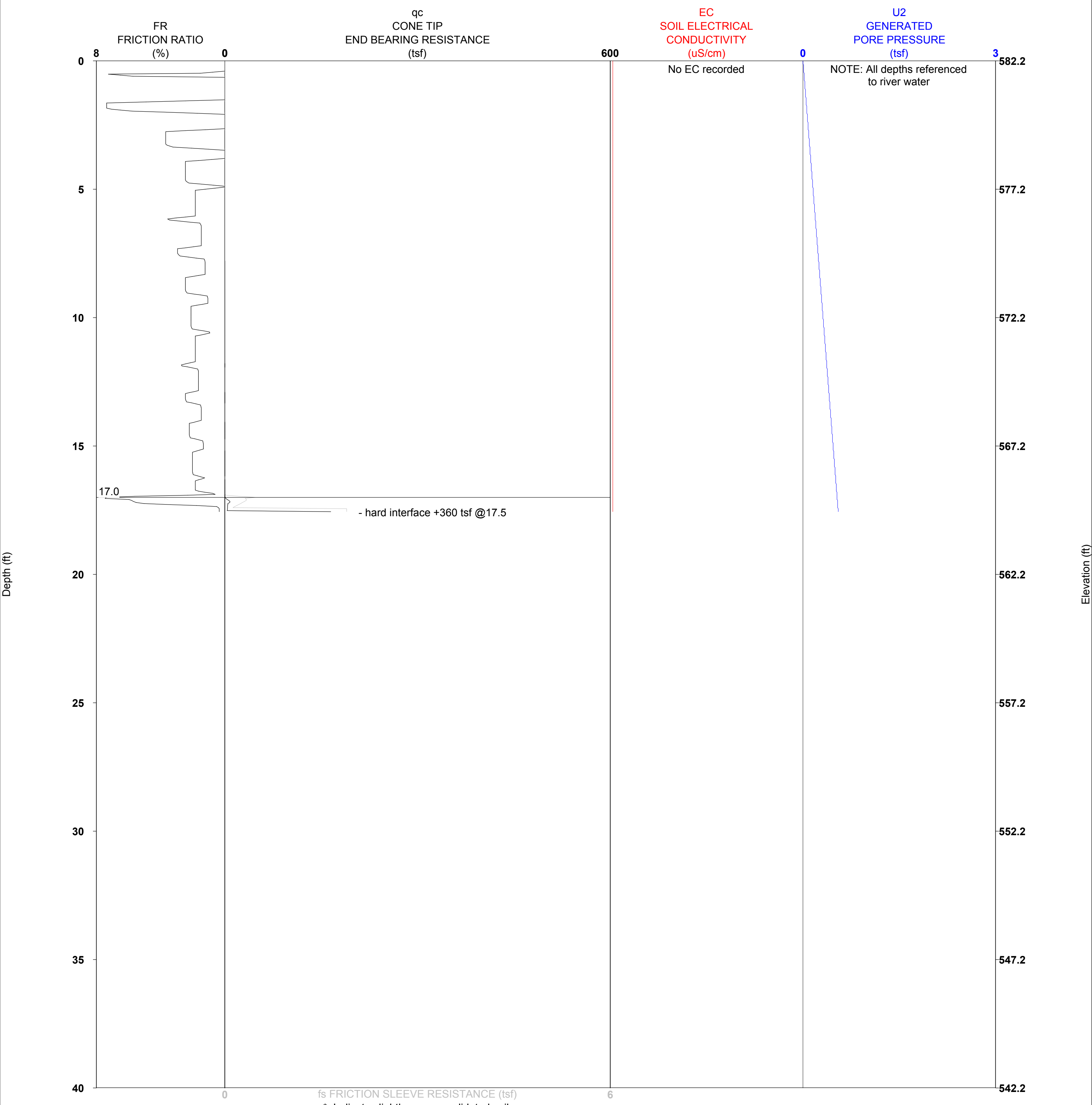
Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/7/2012 TIME:5:18 PM
SOUNDING NUMBER:CPT-08 ()

CPTU LOG WITH LITHOLOGIC EVALUATION CPT08

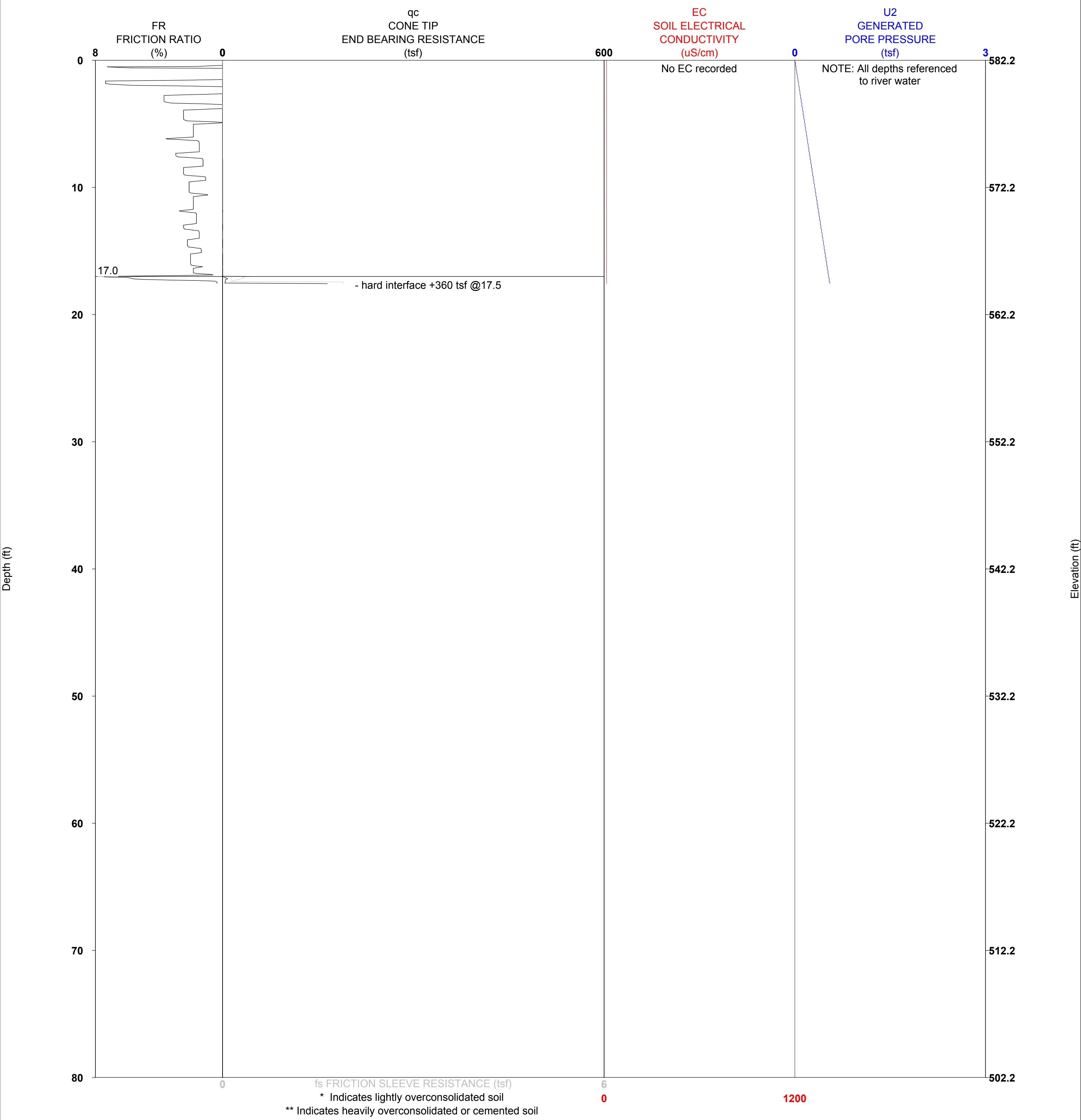


* Indicates lightly overconsolidated soil

** Indicates heavily overconsolidated or cemented soil

Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

CPTU LOG WITH LITHOLOGIC EVALUATION CPT08



Latitude: 0.00000 Longitude: 0.00000 EL (ft): 582.2

PROJECT NAME:US52 IL64 over Mississippi River
PROJECT NUMBER:12-130-100

STRATIGRAPHICS

R1 DATE:11/7/2012 TIME:5:18 PM
SOUNDING NUMBER:CPT-08 ()

Minnesota GeoServices
1549 Minnehaha Avenue West / Saint Paul, MN 55104
p 651.261.2072 / f 651.645.7854

Project	Sabula Hwy 52 Bridge
Sounding Location	BSB-24 CPT-02
Test #	3
Project #	15130004
Site Location	Sabula, IA
Date (day/month/year)	17-1-2014
Time	12:44
Source Offset (ft):	30.00
Source Depth (ft):	0.00
Geophone Offset (ft):	1.75

SEISMIC TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Depth Interval (ft)	Time Interval (ms)	Mid-Interval Depth (ft)	Vs Interval Velocity (ft/s)
9.8	8.1	31.1				
13.1	11.4	32.1	3.3	3.35	9.7	302
16.6	14.8	33.5	3.4	2.85	13.1	483
19.7	17.9	34.9	3.1	3.75	16.4	398
23.1	21.4	36.8	3.4	6.55	19.7	288
27.7	26.0	39.7	4.6	9.10	23.7	315
29.9	28.1	41.1	2.1	4.95	27.1	288
32.8	31.1	43.2	2.9	5.60	29.6	366
36.1	34.4	45.6	3.3	6.85	32.7	356
39.6	37.8	48.3	3.4	6.10	36.1	434
42.6	40.9	50.7	3.1	3.80	39.3	645
46.0	44.2	53.4	3.3	4.45	42.5	608
52.5	50.7	58.9	6.5	6.55	47.5	842
55.8	54.0	61.8	3.3	2.80	52.4	1027
59.0	57.3	64.7	3.2	3.85	55.7	742
62.3	60.6	67.6	3.3	4.25	58.9	688
65.6	63.9	70.5	3.3	2.40	62.2	1231
68.9	67.1	73.5	3.3	3.75	65.5	795
72.2	70.4	76.6	3.3	3.35	68.8	906
75.4	73.7	79.6	3.2	3.20	72.1	937
78.7	77.0	82.6	3.3	3.40	75.3	896
82.0	80.3	85.7	3.3	3.60	78.6	851
85.3	83.5	88.8	3.3	4.00	81.9	770
88.6	86.8	91.9	3.3	3.55	85.2	880
91.9	90.1	95.0	3.3	4.05	88.5	767
95.4	93.7	98.4	3.6	3.55	91.9	957
98.5	96.7	101.3	3.0	3.00	95.2	959

101.7	100.0	104.4	3.2	3.10	98.3	1002
108.5	106.8	110.9	6.8	5.45	103.4	1202
111.5	109.8	113.8	3.0	2.55	108.3	1128

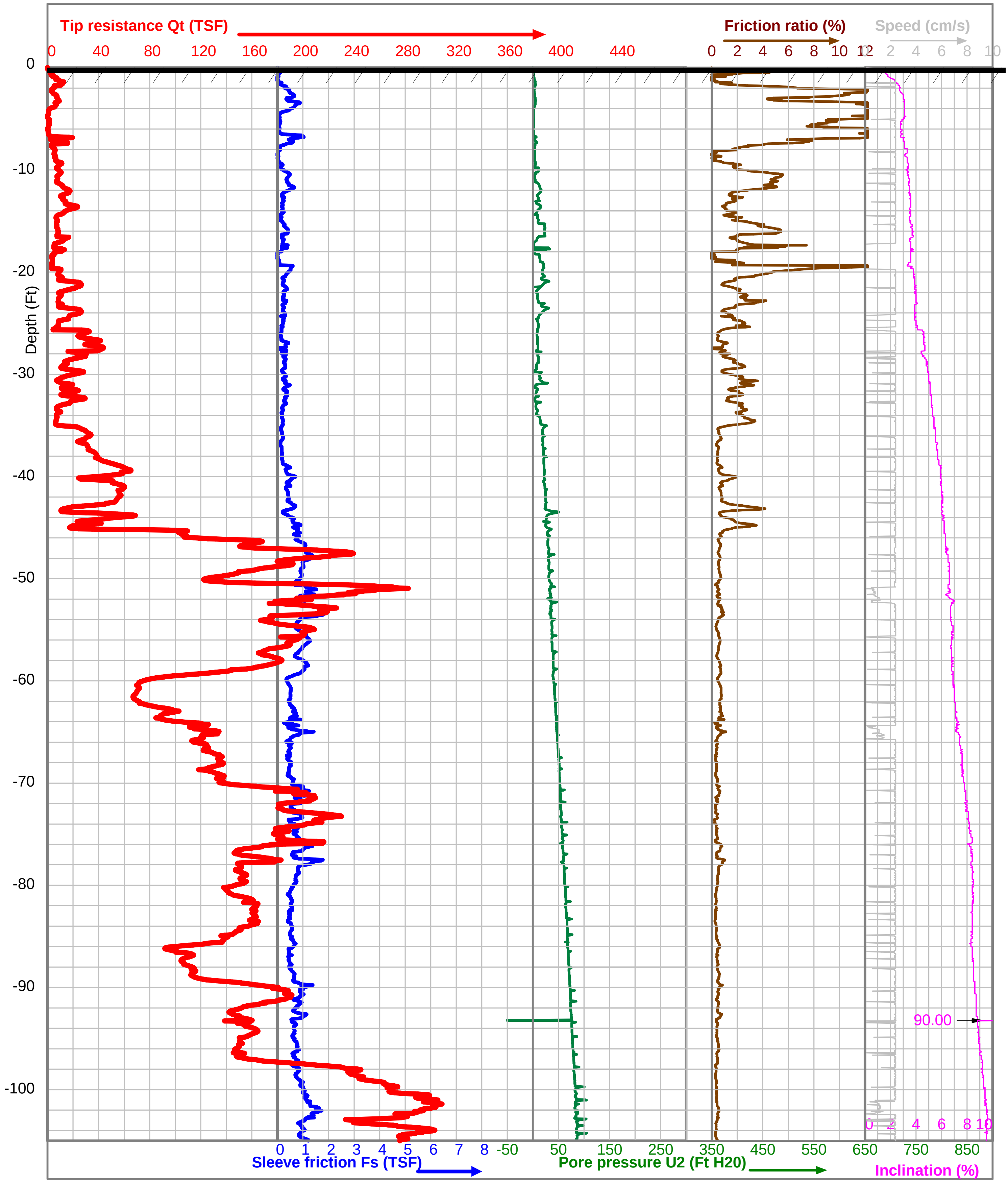
Notes:

The Vs Interval velocity is the approximate estimated velocity across the previous Tip Depth interval.

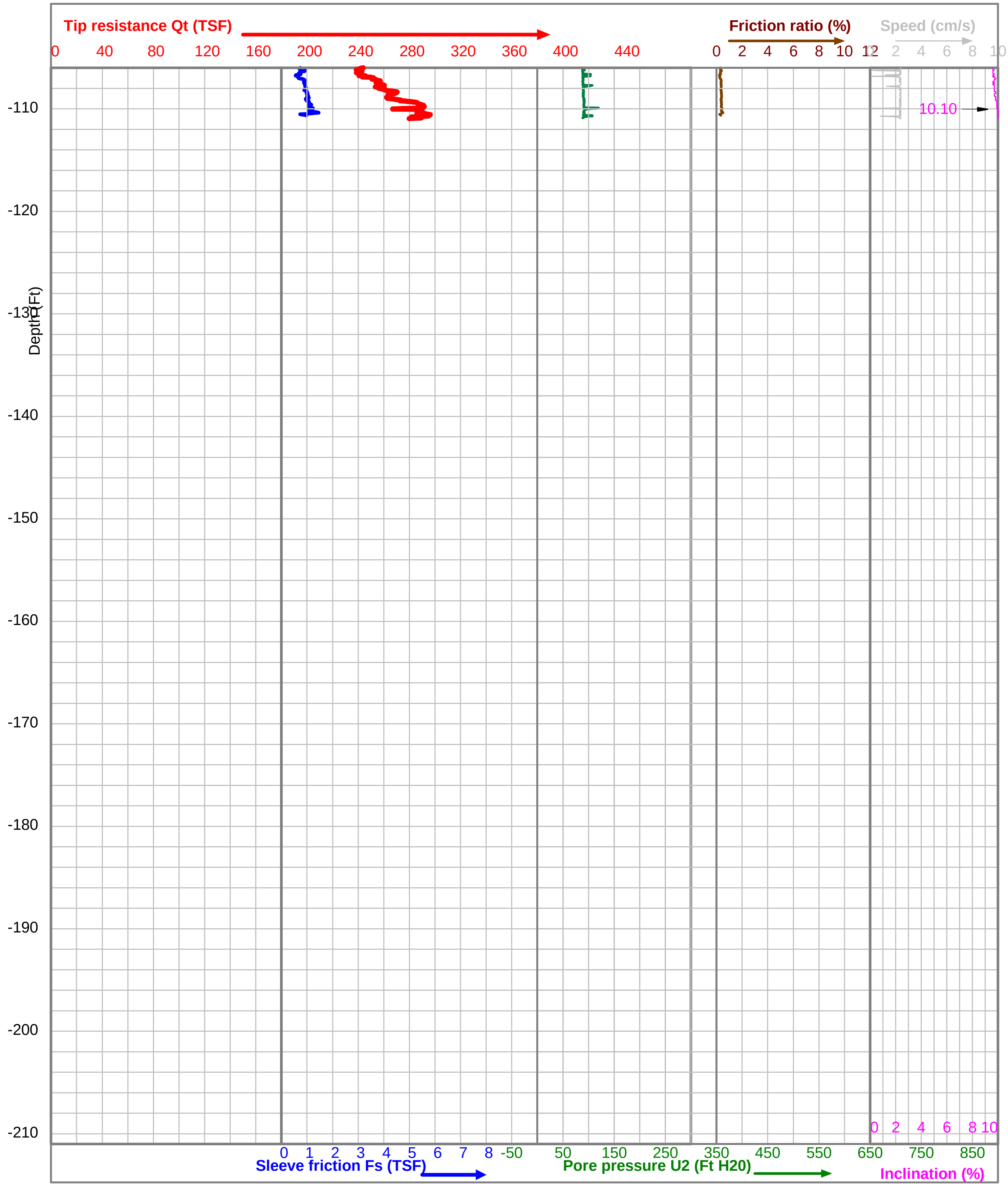
Reduce the significant figures for the calculated Vs to 3 figures based on the precision of the depth interval.

The combined error of the depth measurement and time cross-correlation estimate is generally +-50ft/s.

N/A indicates a value which MNGS, Inc. cannot determine by the data.



Project #	15130004	CPT Operator	H. Garcia	Elevation (Ft MSL)
Description	BSB-24 CPT-02	Cone Type	I-CFXYP20-15	
Test Number	3	Cone ID	130717	X-Coord
Client	Wang Engineering, Inc.	Start Time	12:44	Y-Coord
Boring Type	CPTU Sounding	Date	17-1-2014	Elev. Datum: WGS 84



Project #	15130004	CPT Operator	H. Garcia	Elevation (Ft MSL)
Description	BSB-24 CPT-02	Cone Type	I-CFXYP20-15	
Test Number	3	Cone ID	130717	X-Coord
Client	Wang Engineering, Inc.	Start Time	12:44	Y-Coord
Boring Type	CPTU Sounding	Date	17-1-2014	Elev. Datum: WGS 84

Wang Engineering

APPENDIX C

BOREHOLE GEOPHYSICAL SURVEY
US52/IL64 BRIDGE OVER MISSISSIPPI RIVER
CARROLL COUNTY, ILLINOIS AND
JACKSON COUNTY, IOWA

Prepared for:

WANG ENGINEERING, INC.
Lombard, Illinois

Prepared by:

GEOTECHNOLOGY, INC.
St. Louis, Missouri

Geotechnology, Inc. Project No. J022836.01

July 10, 2014

July 10, 2014 J022836.01

Mr. Mike Kothawala, P.E.
Wang Engineering, Inc.
1145 North Main Street
Lombard, Illinois 60148

Re: Borehole Geophysical Survey
US52/IL64 Bridge over Mississippi River
Carroll County, Illinois and Jackson County, Iowa

Dear Mr. Kothawala:

Geotechnology, Inc. is pleased to submit this report for borehole geophysical surveying at the US52/IL64 bridge over the Mississippi River in Carroll County, Illinois and Jackson County, Iowa. This work was performed in general accordance with our revised Proposal P022836.01 dated February 26, 2014.

It is a pleasure to be of service to you on this project. If you have any questions or comments, please contact me at (314) 997-7440 or via email at d_lambert@geotechnology.com.

Very truly yours,

GEOTECHNOLOGY, INC.

Douglas W. Lambert

Douglas W. Lambert, P.G.-Illinois
Senior Project Manager - Geophysics

DWL/DTK:dwl/jsj

Copies submitted: 1 electronic version in pdf format

J022836.01

BOREHOLE GEOPHYSICAL SURVEY
US52/IL64 BRIDGE OVER MISSISSIPPI RIVER
CARROLL COUNTY, ILLINOIS AND JACKSON COUNTY, IOWA

TABLE OF CONTENTS

ILLUSTRATIONS

APPENDICES

BOREHOLE GEOPHYSICAL SURVEY
US52/IL64 BRIDGE OVER MISSISSIPPI RIVER
CARROLL COUNTY, ILLINOIS AND JACKSON COUNTY, IOWA

1.0 INTRODUCTION

1.1 Project and Site Description. Wang Engineering, Inc. is providing geotechnical recommendations for the construction of a new bridge to replace the existing US52/IL64 Bridge across the Mississippi River in Carroll County, Illinois and Jackson County, Iowa. A site location map is show on Plate 1. The proposed bridge location is suspected to be within the Plum River Fault Zone which generally extends east-west through the area. Stratigraphy at the site is comprised of approximately 60 feet of fluvial sand and gravel underlain by dolomite. Previous boring data indicates highly variable bedrock conditions particularly at the proposed locations of Piers 7 and 8 within the river. Boring logs indicate highly fractured rock and rock quality designation (RQD) values less than 10 percent within 25 feet of borings with very good rock quality and RQD values ranging from 90 to 100 percent. Borehole geophysical logging was performed to provide additional information regarding rock conditions at the locations of Piers 7 and 8.

1.2 Scope of Work. The project included borehole geophysical logging within two boreholes drilled to a depth of approximately 80 feet within bedrock by others. The geophysical logs included acoustic televiewer (ATV), natural gamma, spontaneous potential (SP) and resistivity. The ATV data were processed to provide caliper results and joint depths and orientations. The recorded logs and processed data were plotted using WellCAD software and are reported herein.

2.0 GEOPHYSICAL METHODS

Presented below are brief descriptions of the ATV, natural gamma, SP, and resistivity logging methods and how these methods typically respond to fractured dolomite such as the bedrock at the subject site.

ATV. The ATV is used to collect a continuous image of the borehole wall by recording the travel time and amplitude of emitted sonic waves reflected off the interior of the borehole. Internal magnetic compass and inclinometer readings are collected with the data. The image can be analyzed to determine lithology, characterize voids (or core loss zones), and calculate strike and dip of planar features that intersect the boring such as bedding planes, fractures, joints, and foliation. The borehole must be filled with water or drilling fluid and the hole should be uncased. However, some material behind the casing may be imaged by analyzing secondary arrivals (echoes from the casing).

Natural Gamma. Natural gamma logging involves measuring the natural gamma radiation emitted by material surrounding the borehole. The primary radioactive elements within geologic materials are potassium-40, thorium-232, uranium-238, and the daughter products in their decay series. These elements typically reside in clays and shales and are not prevalent in clean sands and dolomite. Therefore, natural gamma data is useful for identifying clay-rich zones or shale partings within dolomite. Natural gamma data represent total gamma ray emissions in units of counts per second (cps). The data can be collected in cased or uncased holes.

SP. SP logging is a measure of the direct current voltage, or potential, between a downhole electrode and a reference electrode at the ground surface. Measurements are made in millivolts (mV) and are related to the differences in resistivity between the borehole fluid and fluid within the adjacent formation. The SP log is used to determine permeable zones from impermeable zones and can, therefore, be used to establish gross lithology, such as shale or clay compared to dolomite. The data must be collected in uncased holes.

Resistivity. Resistivity logging is used to evaluate conductivity/resistivity variations within geologic materials that are often related to mineralogy, water content, and porosity. The resistivity probe contains electrodes at various separations, each providing a different lateral distance of penetration into the formation. Readings are recorded in ohm-meters (ohm-m) and, for this project, were acquired with electrodes separated by 8, 16, and 32 inches. Lower resistivities are associated with conductive materials such as clay, shale and saturated and highly fractured dolomite. Higher resistivities are associated with dense and non-fractured dolomite. The data must be collected in uncased holes. Included are single point resistance measurements recorded in ohms.

3.0 DATA ACQUISITION AND PROCESSING

Borehole geophysical logging was performed in Borings GEO-01 and GEO-02 on April 24, 2014 and June 4, 2014, respectively. The locations of the borings with respect to the bridge alignment are shown on Plate 2.

The borings were drilled and logged by Wang Testing Service. Boring GEO-01 was drilled within the northern portion of proposed Pier 7 and Boring GEO-02 was drilled within the southern portion of proposed Pier 8, as shown on the boring location plan on Plate 3. The water depth was approximately 30 feet at the time of drilling each boring. Both borings were advanced through the fluvial sediments without sampling. Sediment thickness was approximately 58 feet and 43 feet for Borings GEO-01 and -02, respectively. Top of bedrock elevations were approximately El 505[1] and El 521, respectively.

[1] Elevations presented herein are in feet NAVD 88.

Each boring was cored approximately 80 feet into dolomite bedrock. The bedrock in Boring GEO-01 was comprised of slightly weathered to fresh, moderately vuggy dolostone with 6-inch spaced joints noted in the top 30 feet and 1.5-foot spaced joints in the bottom 50 feet. The joints were horizontally and vertically oriented with less than 0.2-inch infilling. Recovery ranged between 85 and 100 percent with RQDs ranging between 39 and 91 percent. A boring log for Boring GEO-02 was not available, however, a log of adjacent Boring GEO-02-C exhibited weathered bedrock with recovery ranging between 43 and 66 percent with RQDs ranging between 0 and 40 percent. Due to the unstable sidewall conditions of Boring GEO-02, 2-inch poly-vinyl chloride (PVC) pipe was installed within the boring to prevent potential damage to the borehole logging tools.

The following probes were used to collect the borehole geophysical data:

ATV	Mt. Sopris QL40 ABI-1000
Natural Gamma	Mt. Sopris QL40 GRA-1000
SP and Resistivity	Mt. Sopris Q40 RES-1000

Geophysical logging was performed similarly at each borehole. The boreholes were open and water-filled with steel casing through the sediments. Data were collected by lowering each probe to the bottom of borehole. After recording the bottom elevation, logging commenced as the probe was slowly raised up the hole. The ATV probe was raised at a rate of approximately 4.5 feet per minute and the natural gamma, resistivity, and SP probes were raised at a rate of approximately 15 feet per minute.

The geophysical data collected in Borings GEO-01 and -02 were plotted using WellCAD software (Rockware) and are presented in Appendices A and B, respectively. The ATV logs are presented separately from the other logs in order to display the graphical acoustic image at an expanded vertical scale. ATV data were further processed by identifying bedding planes and joints that intersect the boring. The attitudes and widths of these planar features are presented on the logs and summarized in accompanying stereonets.

4.0 BOREHOLE GEOPHYSICAL LOGS

4.1 ATV. The acoustic televiewer amplitudes and projections are plotted with respect to true north, 0 degrees being north. The acoustic amplitude log represents the magnitude of the sonic wave reflection off the corehole wall. The brighter yellow colors are locations on the corehole wall that are competent and generally reflect the sonic wave with little scatter. The darker colors represent scattered sonic wave reflections related to a rough corehole wall surface or lack of reflections at the location of a cavity. The projections log represents planar features that intersect the corehole and are summarized using the tadpoles.

The tadpole logs represent planar features identified within the acoustic amplitude logs. The dip of a planar feature is represented by the location of the tadpole on the horizontal line, ranging from zero degrees (horizontal) on the left edge to 90 degrees (vertical) on the right edge. The orientation of the tail of the tadpole represents the direction of the dipping feature. Tadpoles shown as blue squares represent joints with separations less than 0.03 inches and tadpoles shown as red circles represent joints with separations greater than 0.03 inches. The tadpole logs are included on the borehole geophysical logs for direct comparison with the natural gamma, SP, and resistivity logs.

Caliper and natural gamma data are plotted in the left-most column of the ATV logs. The caliper data is plotted at a scale of +/- 0.05 inches from the nominal core diameter of 2.98 inches. The natural gamma data is plotted for reference to the natural gamma, SP and resistivity logs which are plotted separately.

4.2 Stereonets. The stereonets of the joint orientations were made based on the Schmidt Equal Area Projection. The stereonets show the poles for each oriented joint. A pole is the point where the normal (perpendicular line) to the joint plane intersects the lower hemisphere of the stereonet. A pole that plots along the edge of the stereonet indicates a vertical joint. If the pole plots to the north then the vertical joint strikes east to west. A pole that plots in the center of the stereonet indicates a horizontal joint. A pole that plots two-thirds of the way from the center to the northeast indicates a joint that dips about 60 degrees to the southwest.

The stereonets show contour lines that indicate the relative abundance of concentrations of the poles on the graph. Contours were drawn using the Schmidt one percent area method, where the counting circle for contouring is one percent of the total net area.

4.3 Natural Gamma, SP and Resistivity. For each boring, the natural gamma log is plotted in counts per second with zero on the left and 50 on the right. Within Boring GEO-01, the log for SP is plotted in mV ranging from zero to 500, and the resistivity logs are plotted on a logarithmic scale in ohm-m (except for single-point resistance which is plotted in ohm) ranging from 500 to 5,000. The number following the R in the title indicates the spacing in inches between the electrodes. The SP and resistivity data collected in Boring GEO-02 are not valid due to the presence of PVC casing throughout the length of the boring.

5.0 BOREHOLE GEOPHYSICAL LOG SUMMARIES

5.1 Boring GEO-01. High angle joints ranging in dip between approximately 45 to 80 degrees, are evident throughout the boring, but appear to be clustered between the following depth intervals: 93 to 106 feet, 115 to 120 feet, 134 to 139 feet, and 151 to 155 feet. These depth intervals also exhibit numerous low angle joints dipping between approximately 10 and 45 degrees. The high angle joints appear to be dipping in directions generally centered about N45W and S45E as illustrated on the stereonet.

Between depths of approximately 95 and 120 feet, the natural gamma log indicates slightly less clay content and the SP log suggests a zone of slightly lower permeability. These readings may indicate that dolomite within this interval is more dense or contains predominantly narrow joints.

The zone of high angle fractures from depths of 134 to 139 feet and 151 to 155 feet exhibit higher natural gamma responses and lower resistivity responses compared to the remainder of the log suggesting these fractures have greater clay or shale infilling than other areas of the boring. Conversely, a zone of lower resistivity is evident between depths of 120 and 125 feet but does not appear to correspond to an increase in natural gamma response and corresponds with two joints dipping approximately 40 degrees. These joints are likely water-filled with less clay or shale infilling.

The caliper data appears to exhibit vugs and joints where values are greater than the nominal corehole diameter). In addition, occasional zones with caliper values less than the nominal corehole diameter are present which likely indicates clays within joints swelling into the corehole. These zones of suspected swelling clay are evident at depths of approximately 98, 131, 137, 145, 147, and 153 feet.

<u>5.2 Boring GEO-02</u>. Numerous joints were observed in the ATV data, though fewer in number than were observed in Boring GEO-01 due to PVC casing which reduced the resolution of the ATV signal. The separation of the joints could not be resolved. High angle joints ranging in dip between approximately 45 and 80 degrees are evident throughout the boring, with a cluster evident between depths of approximately 80 and 90 feet. The high angle joints plotted on the stereonet appear to be dipping in directions generally centered about N45W which is a similar direction as one of the dominant dip directions observed in the data for Boring GEO-01.

The natural gamma data exhibited peaks suggesting greater amounts of clay in-filling at depths of approximately 93 feet and between 135 and 139 feet.

NOTES

1. Plan adapted from a 7.5 minute U.S.G.S. map for Savanna, Illinois-Iowa quadrangle, last revised in 2012.

0 2,000 4,000

SCALE IN FEET

N

Drawn By: WAH	Ck'd By: [signature]	App'vd By: DTK
Date: 6-13-14	Date: 7/10/14	Date: 7-10-14

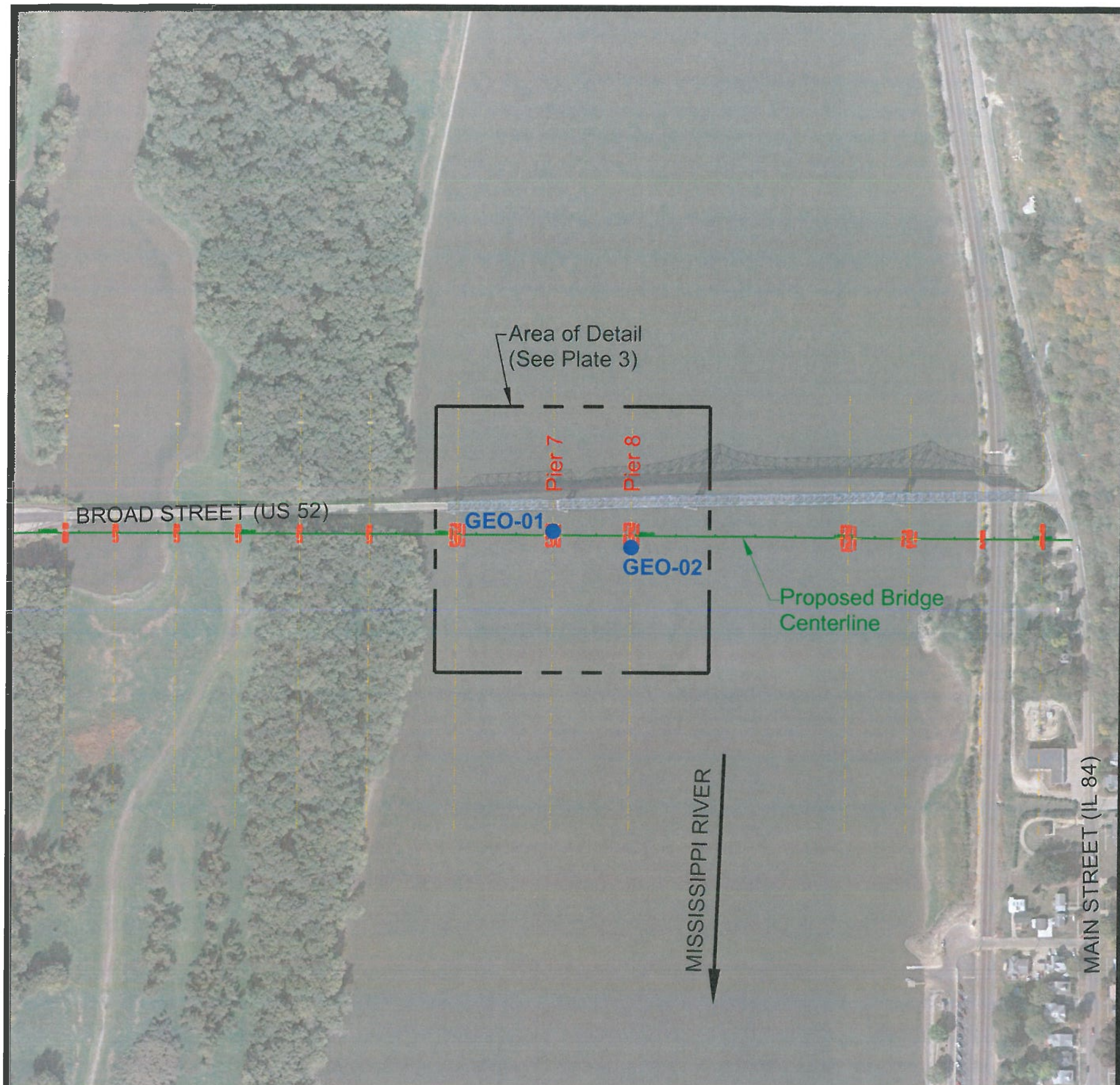
GEOTECHNOLOGY INC
FROM THE GROUND UP

Borehole Geophysical Survey
US 52/IL 84 Bridge Over Mississippi River
Carroll County, Illinois and
Jackson County, Iowa

SITE LOCATION
AND TOPOGRAPHY

Project Number J022836.01

PLATE 1



NOTES

1. Plan adapted from a September 27, 2012 aerial photograph courtesy of Google Earth and a drawing dated January 29, 2014 titled "Exhibit 1" prepared by Wang Engineering.

2. Borings were located by the project surveyor.

LEGEND

● Boring Location (Geophysical Survey)

0 200 400 800

SCALE IN FEET

N

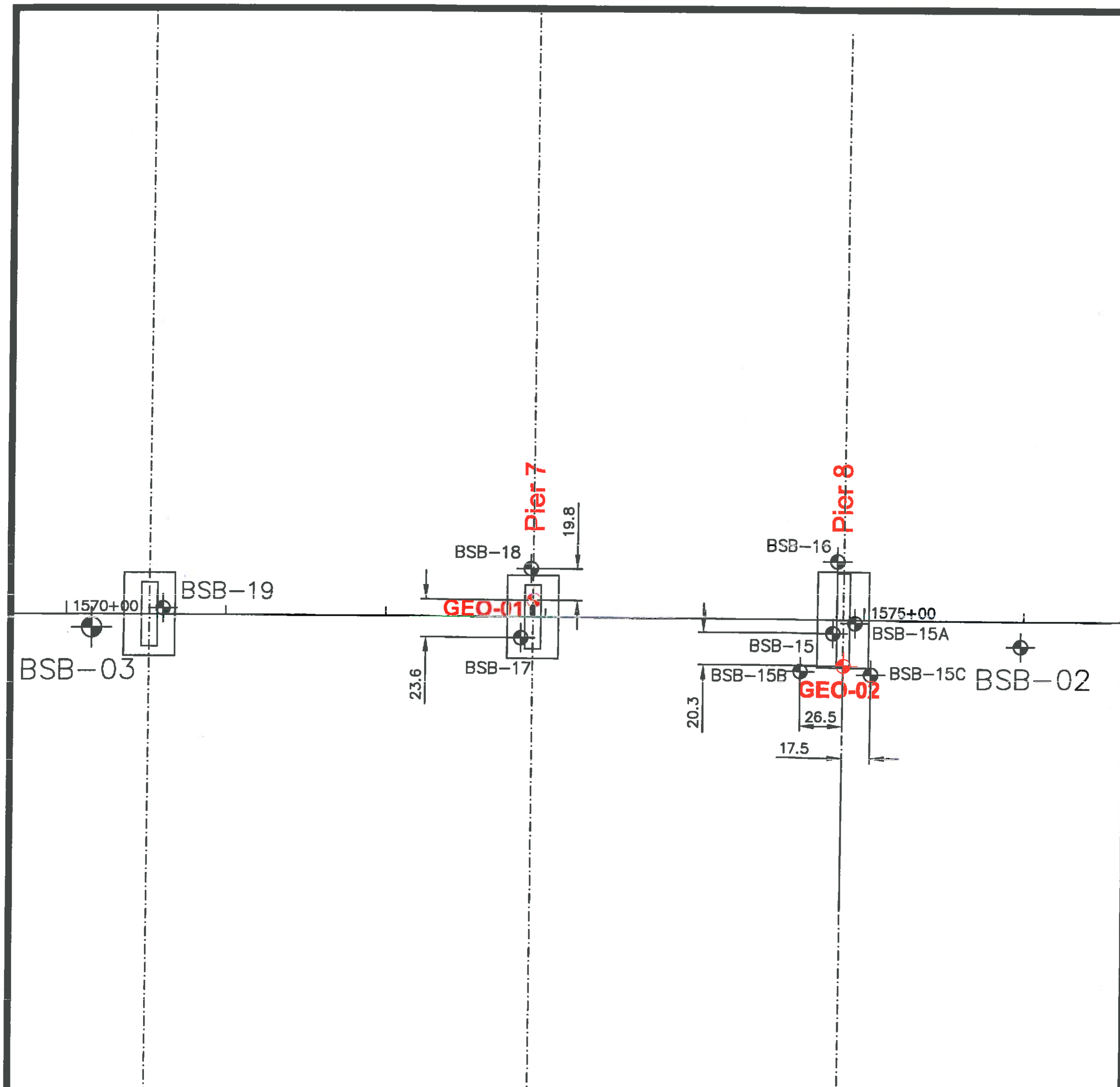
Drawn By: WAH	Ck'd By: DWZ	App'vd By: DTK
Date: 6-13-14	Date: 7/10/14	Date: 7-10-14

GEOTECHNOLOGY INC
FROM THE GROUND UP

Borehole Geophysical Survey
US 52/IL 84 Bridge Over Mississippi River
Carroll County, Illinois and
Jackson County, Iowa

AERIAL PHOTOGRAPH OF SITE AND BORING LOCATIONS

Project Number J022836.01	PLATE 2



NOTES

1. Plan adapted from a drawing dated January 29, 2104 titled "Exhibit 1" prepared by Wang Engineering.

2. Borings were located by the project surveyor.

LEGEND

Boring Location (Geophysical Survey)

Drawn By: WAH	Ck'd By: DWK	App'vd By: DTK
Date: 6-13-14	Date: 7/10/14	Date: 7-10-14

GEOTECHNOLOGY INC
FROM THE GROUND UP

Borehole Geophysical Survey
US 52/IL 84 Bridge Over Mississippi River
Carroll County, Illinois and
Jackson County, Iowa

BORING LOCATION PLAN

Project Number J022836.01	PLATE 3

APPENDIX A

Boring GEO-01
Geophysical Logs and Stereonet

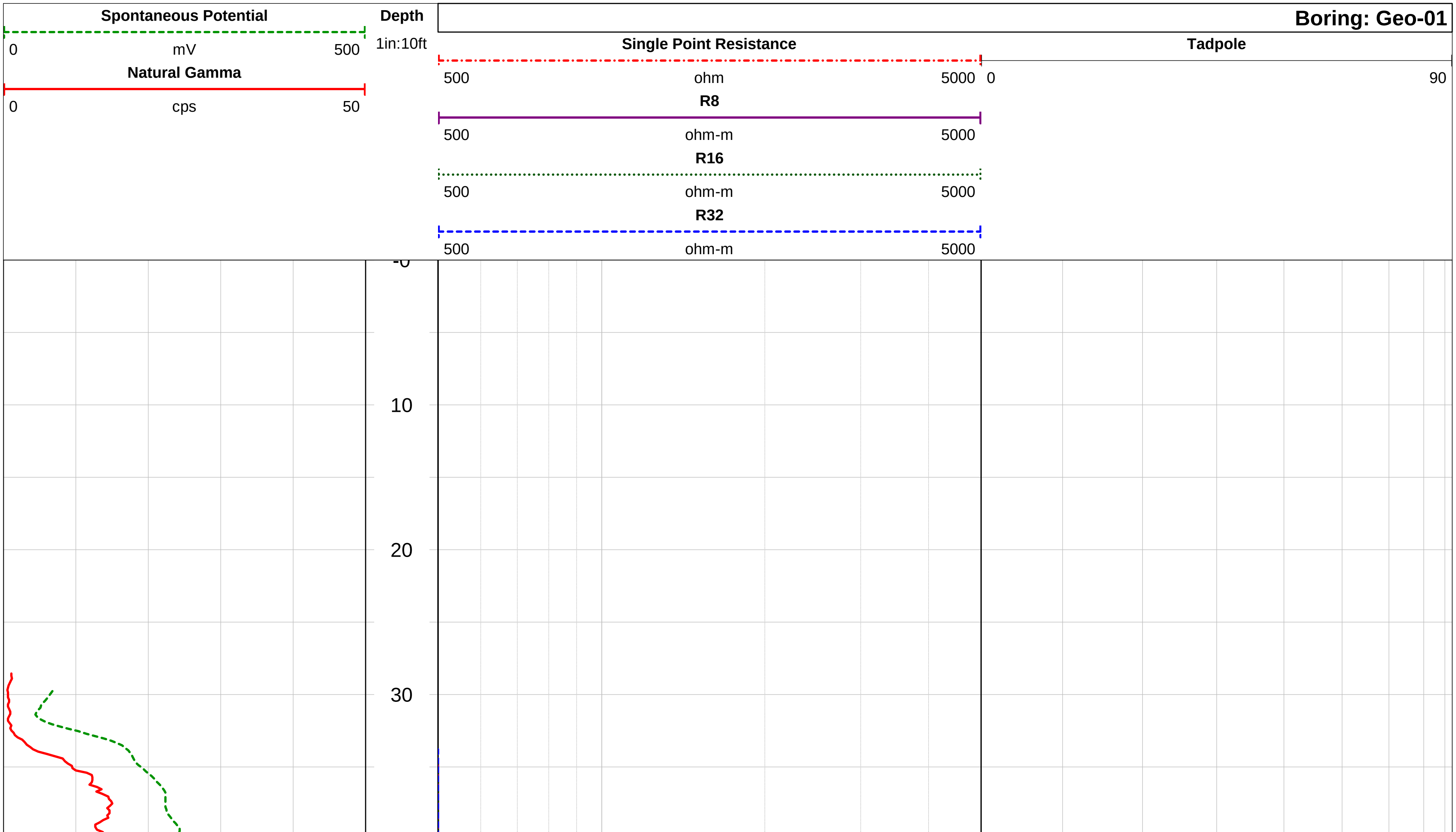
Geophysical Log

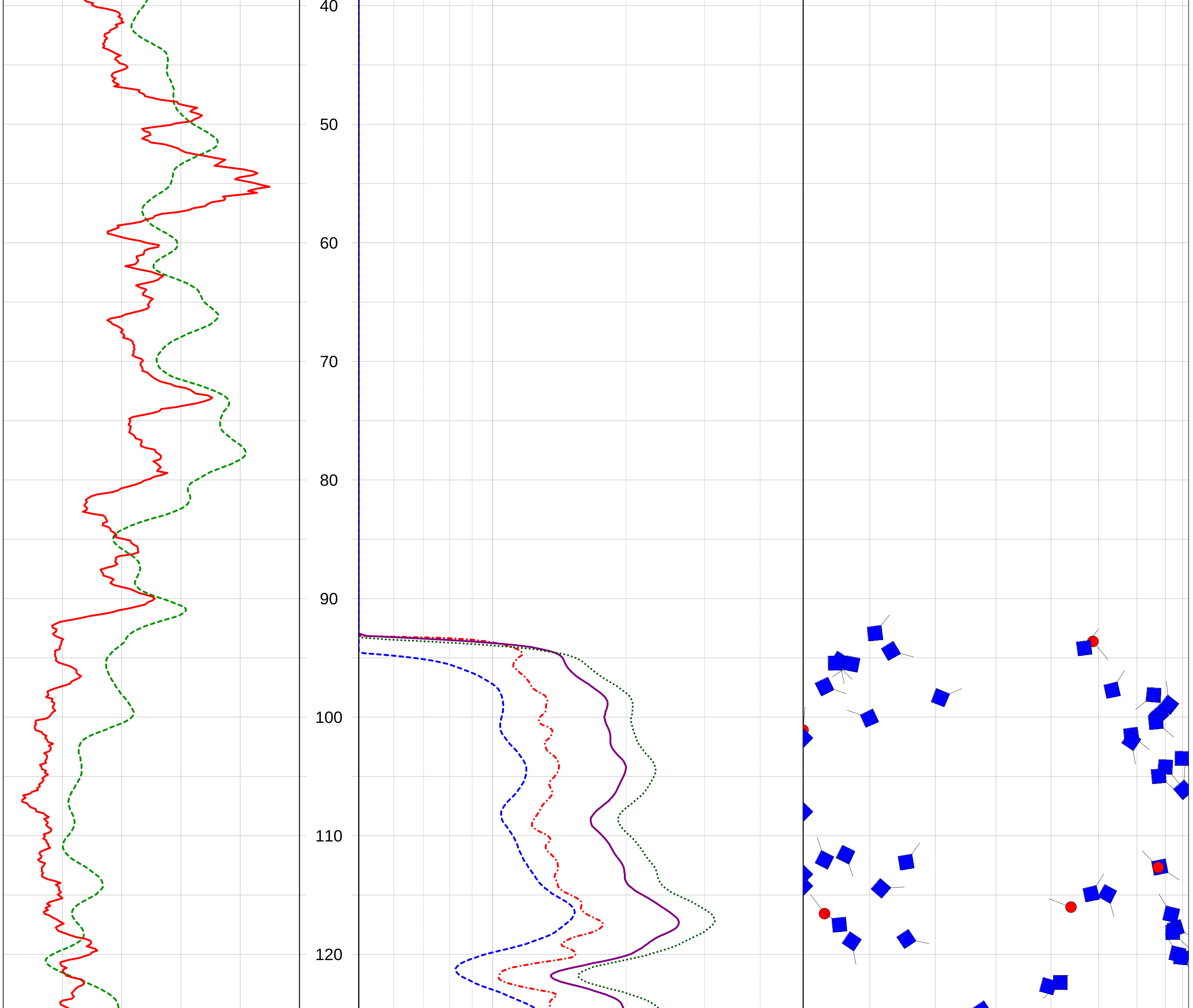
Project:	US52/IL64 Bridge over Mississippi River
Location:	Carroll County, IL, and Jackson County, IA
Project Number:	J022836.01
Client:	Wang Engineering

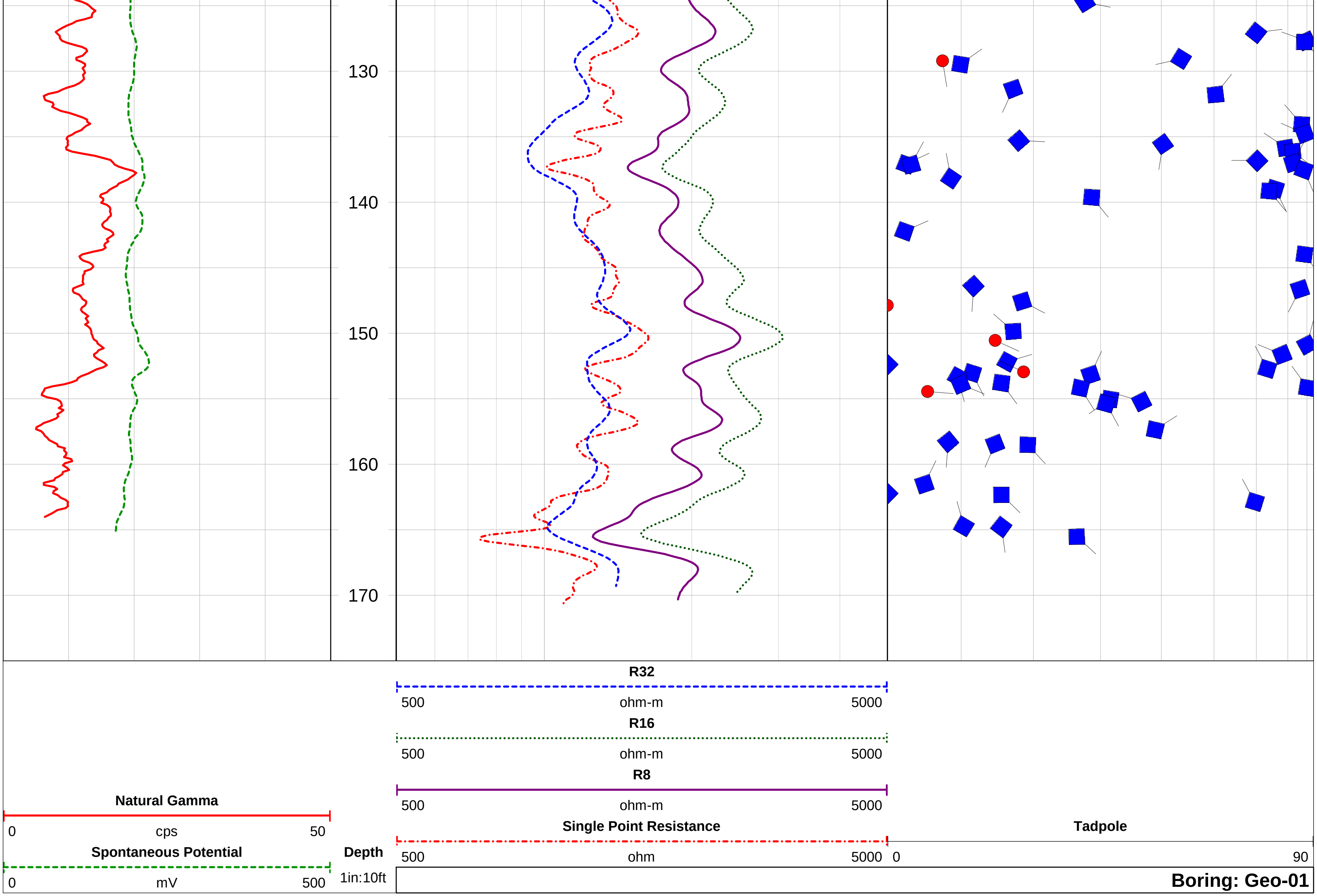
Boring:	Geo-01	Datum:	NAVD 88
Date Logged:	24 April 2014	Elevation:	593.37 ft
Water Depth During Logging:	NA - Drilled from Barge	North:	1980455.16 ft
Logger:	TAW	East:	2297701.54 ft
Driller:	Wang Testing Service	Station:	1572 + 91.89
Depths Presented From:	Water Surface	Offset:	10.48 LT

Tadpole Legend

Narrow Fracture/Bedding Feature   Wide Fracture/Bedding Feature




40
50
60
70
80
90
100
110
120

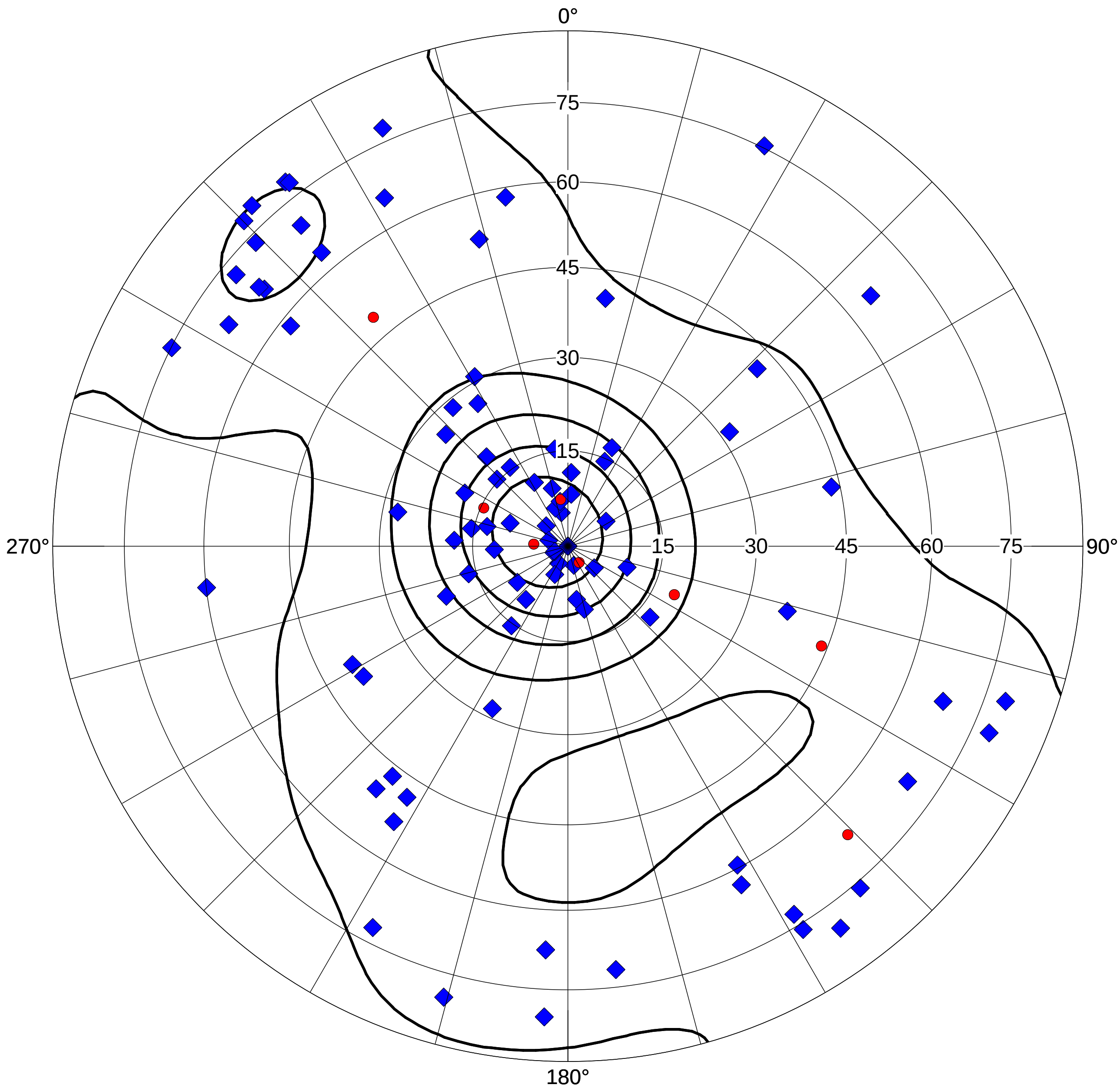


130
140
150
160
170
R32
500 ohm-m 5000
R16
500 ohm-m 5000
R8
500 ohm-m 5000
Natural Gamma
0 cps 50
Single Point Resistance
500 ohm 5000
Tadpole
0 90
Spontaneous Potential
0 mV 500
Depth
1in:10ft
Boring: Geo-01

US52 Bridge over the Mississippi River
Carroll County, IL, and Jackson County, IA
Boring Geo-01

Schmidt Plot (Dip) - LH - Wang Engineering
Plot: Tadpoles
Depth: from 92.93 to 165.50 [ft]

Schmidt (1% Area) Contouring - 5% Contour Intervals



Symbol	Code - Description	Nb Points	Azi Mean	Dip Mean
◆	Feature - Narrow Fracture/Bedding Feature	96	123.22	10.65
●	Wide Feature - Wide Fracture/Bedding Feature	10	277.43	3.19

Attribute : Wang Engineering

Acoustic Televiewer Log

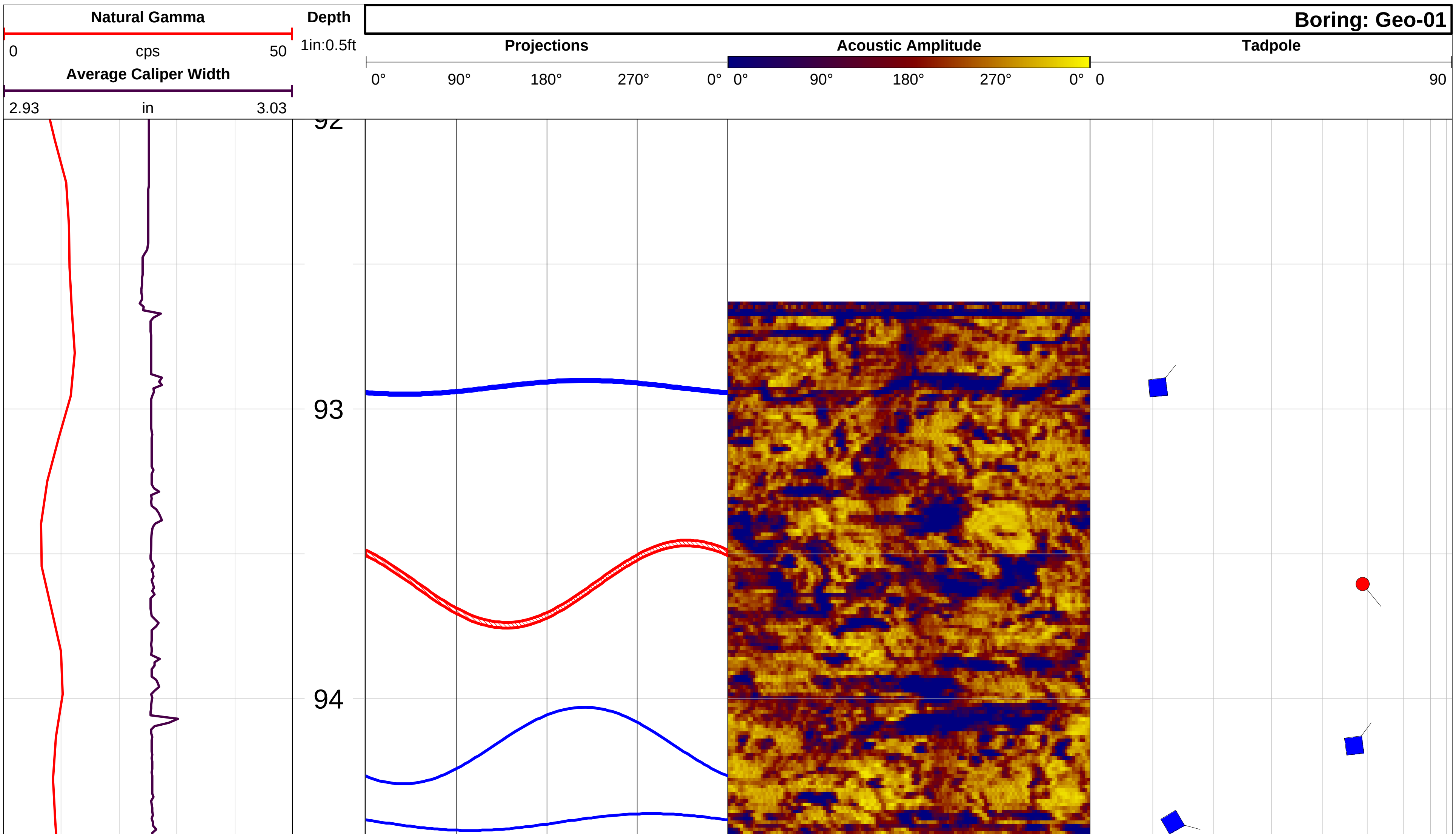
GEOTECHNOLOGY INC
FROM THE GROUND UP

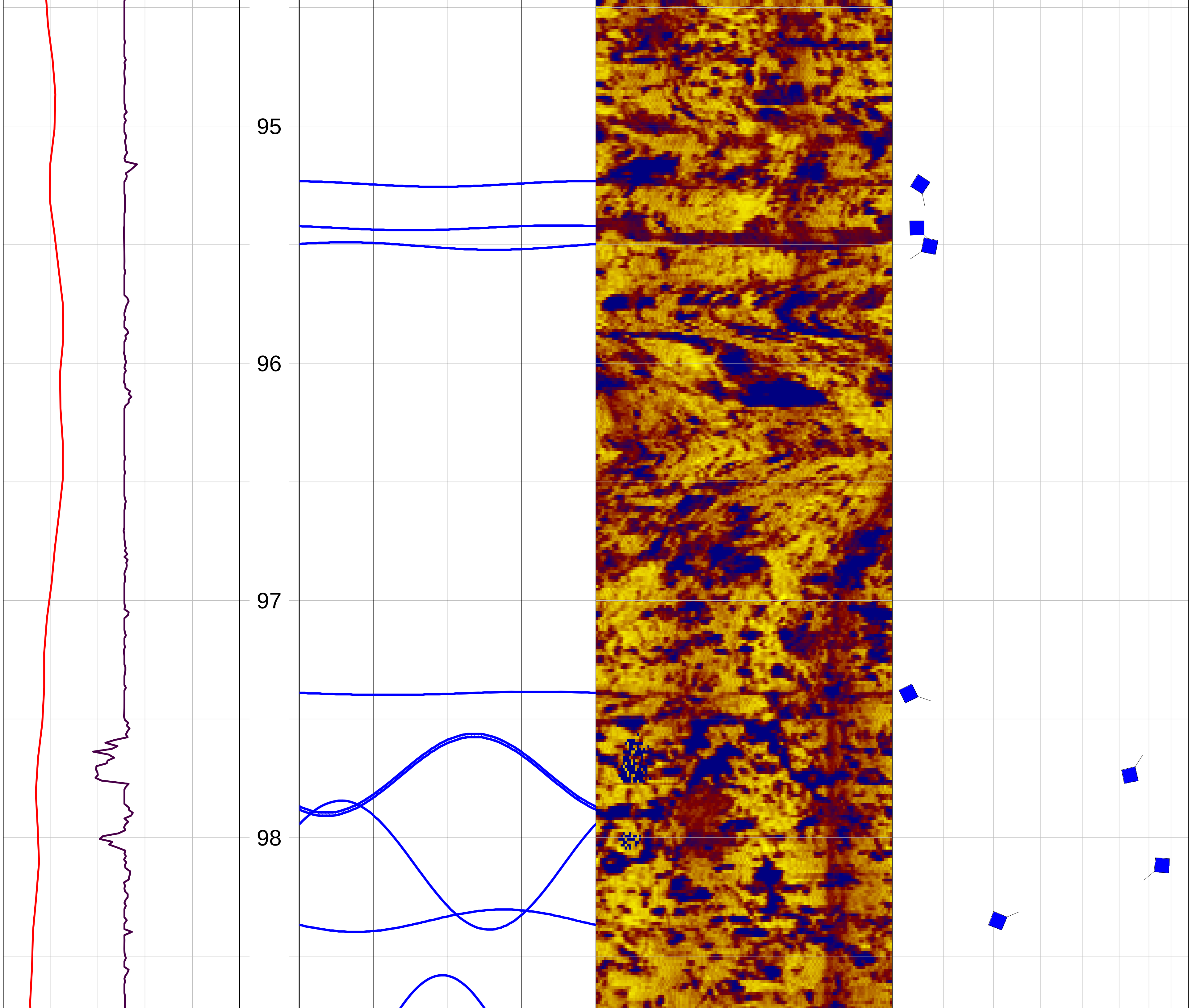
Project:	US52/IL64 Bridge over Mississippi River
Location:	Carroll County, IL, and Jackson County, IA
Project Number:	J022836.01
Client:	Wang Engineering

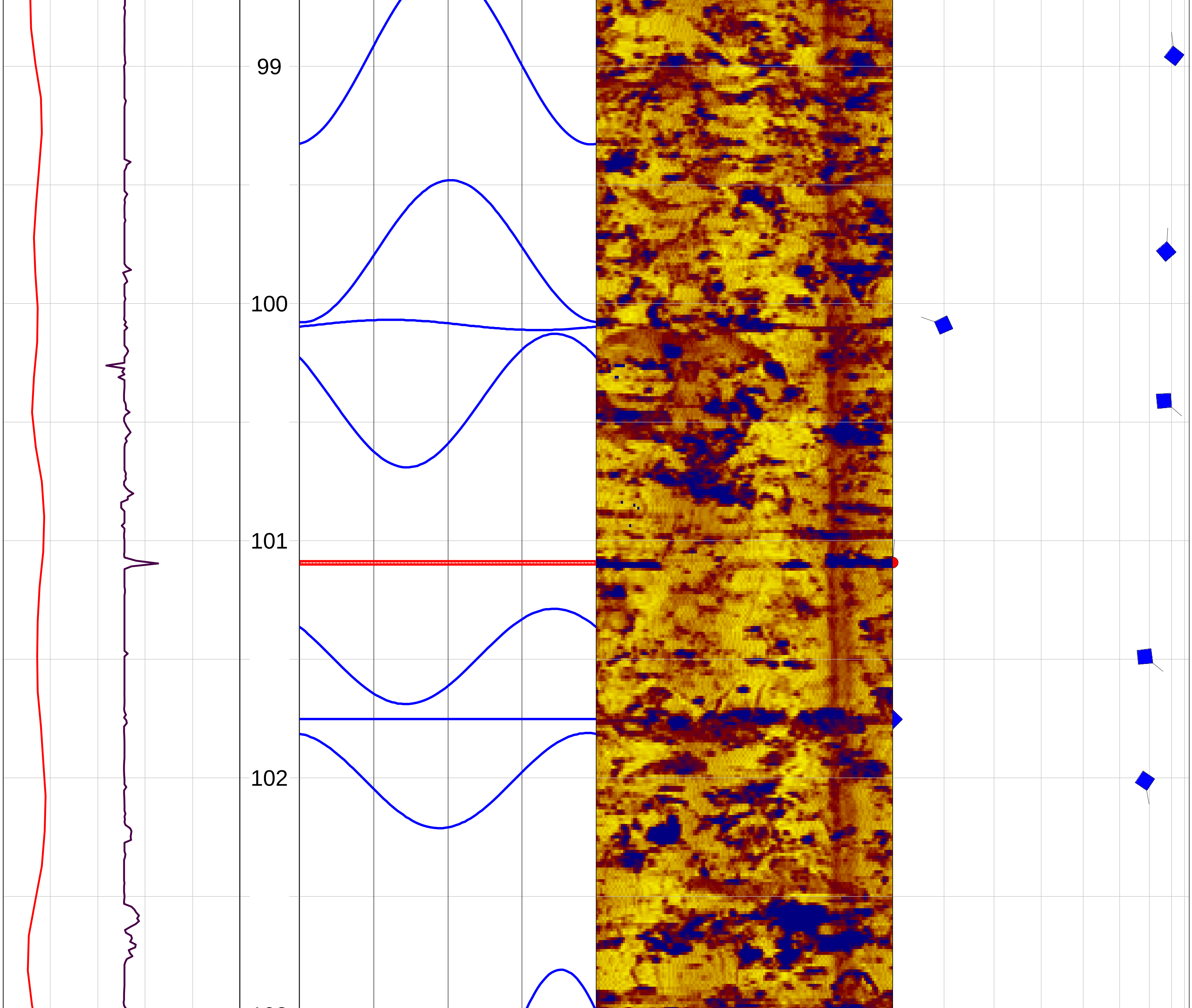
Boring:	Geo-01	Datum:	NAVD 88
Date Logged:	24 April 2014	Elevation:	593.37 ft
Water Depth During Logging:	NA - Drilled From Barge	North:	1980455.16 ft
Logger:	TAW	East:	2297701.54 ft
Driller:	Wang Testing Service	Station:	1572 + 91.89
Depths Presented From:	Water Surface	Offset:	10.48 LT

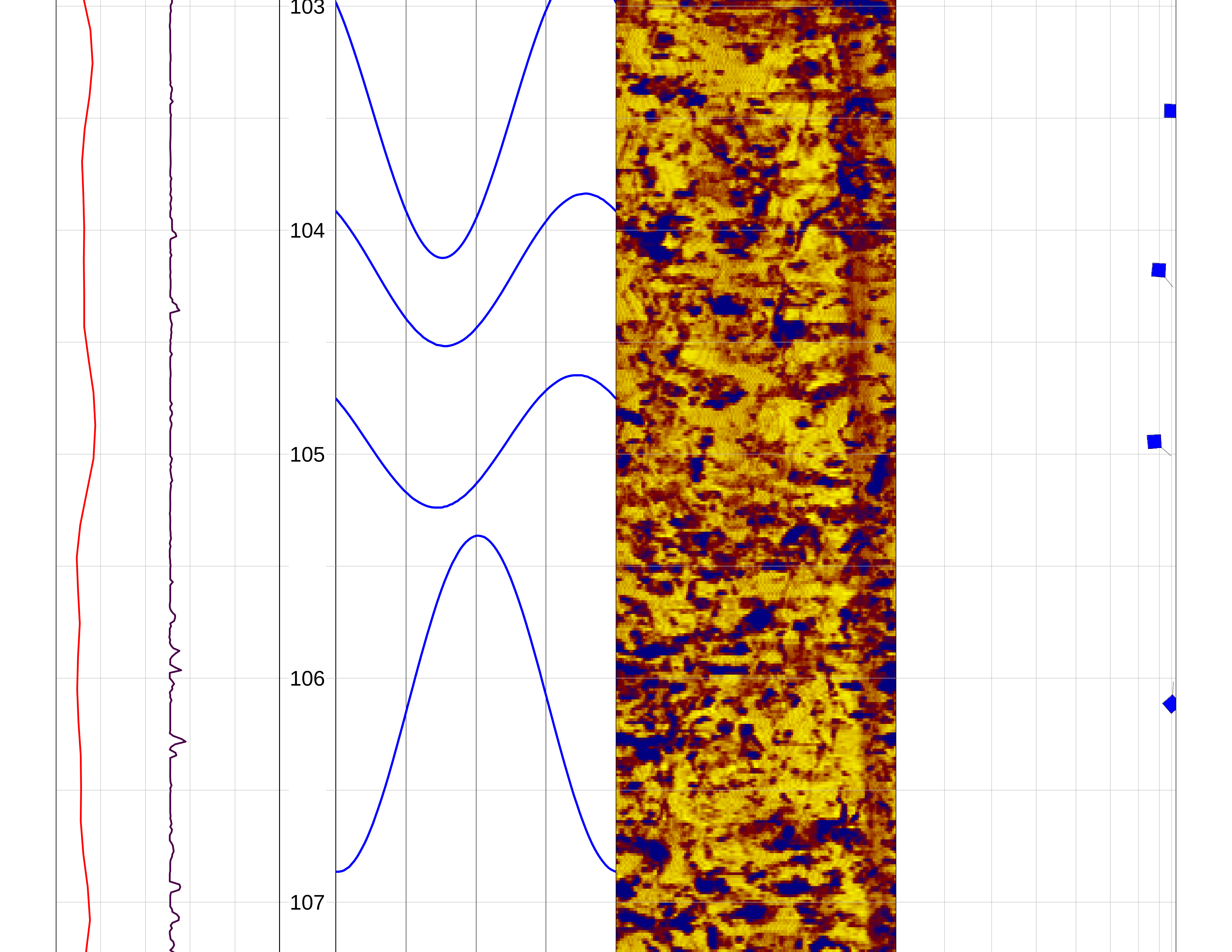
Tadpole Legend

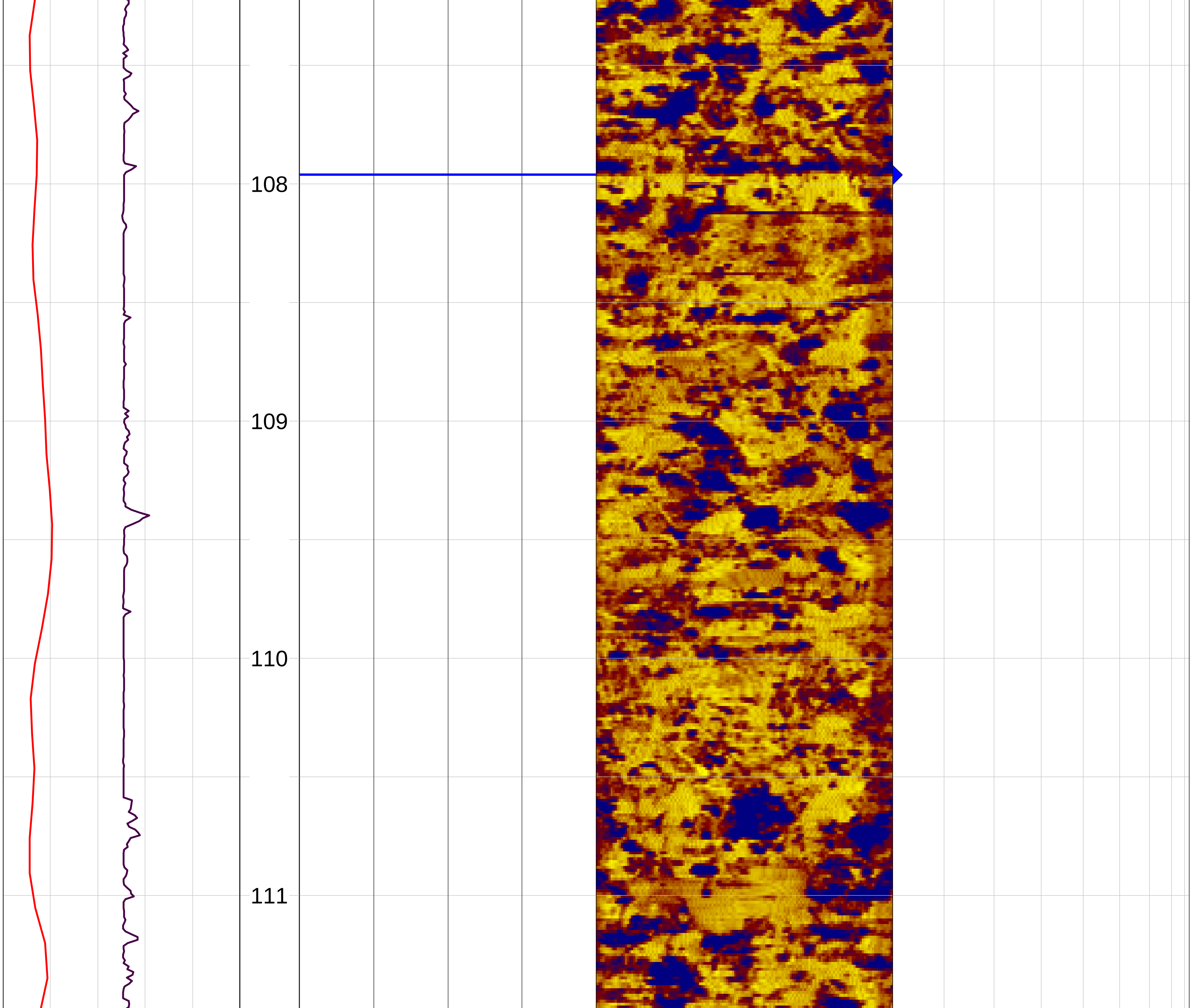
Narrow Fracture/Bedding Feature   Wide Fracture/Bedding Feature

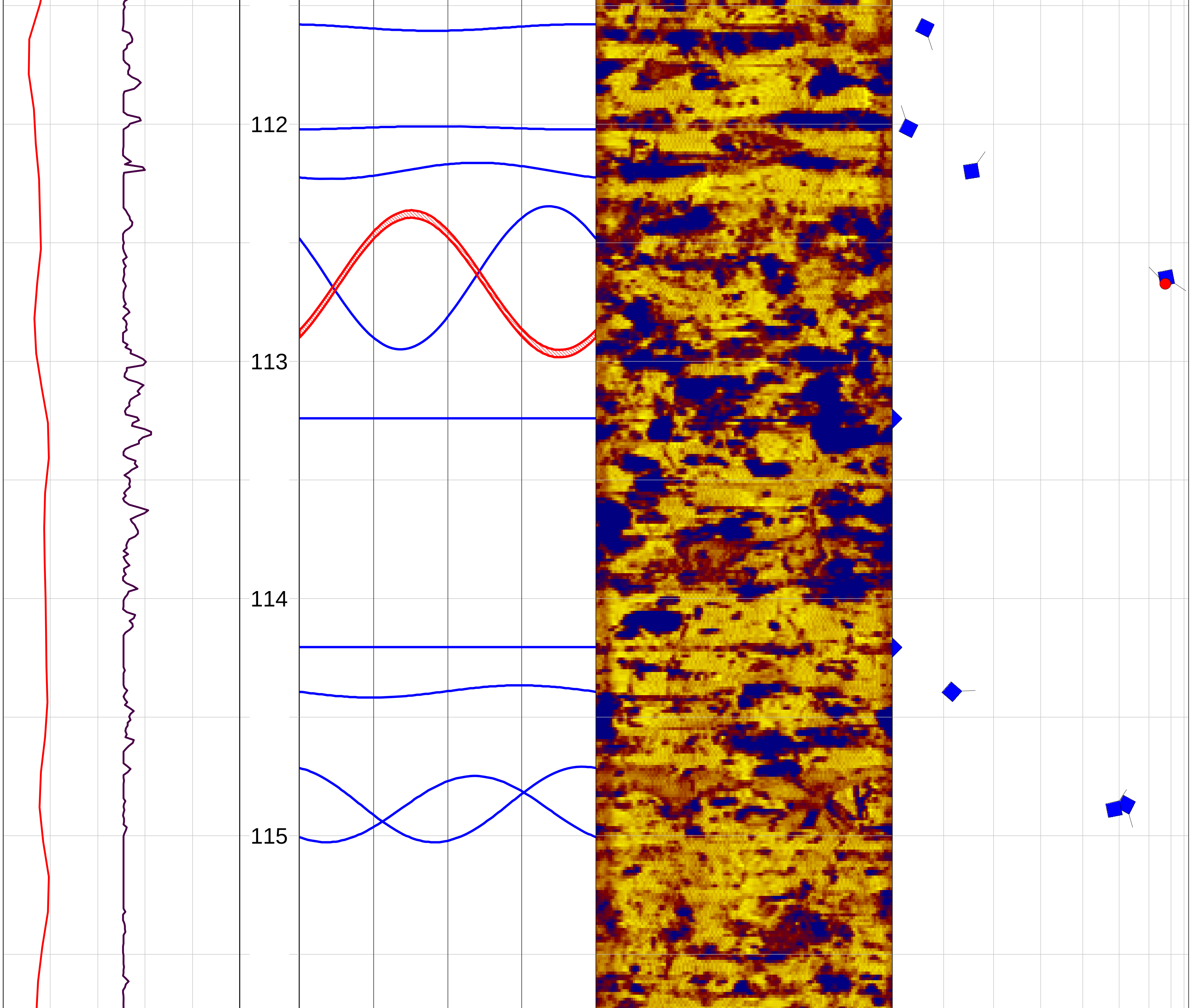


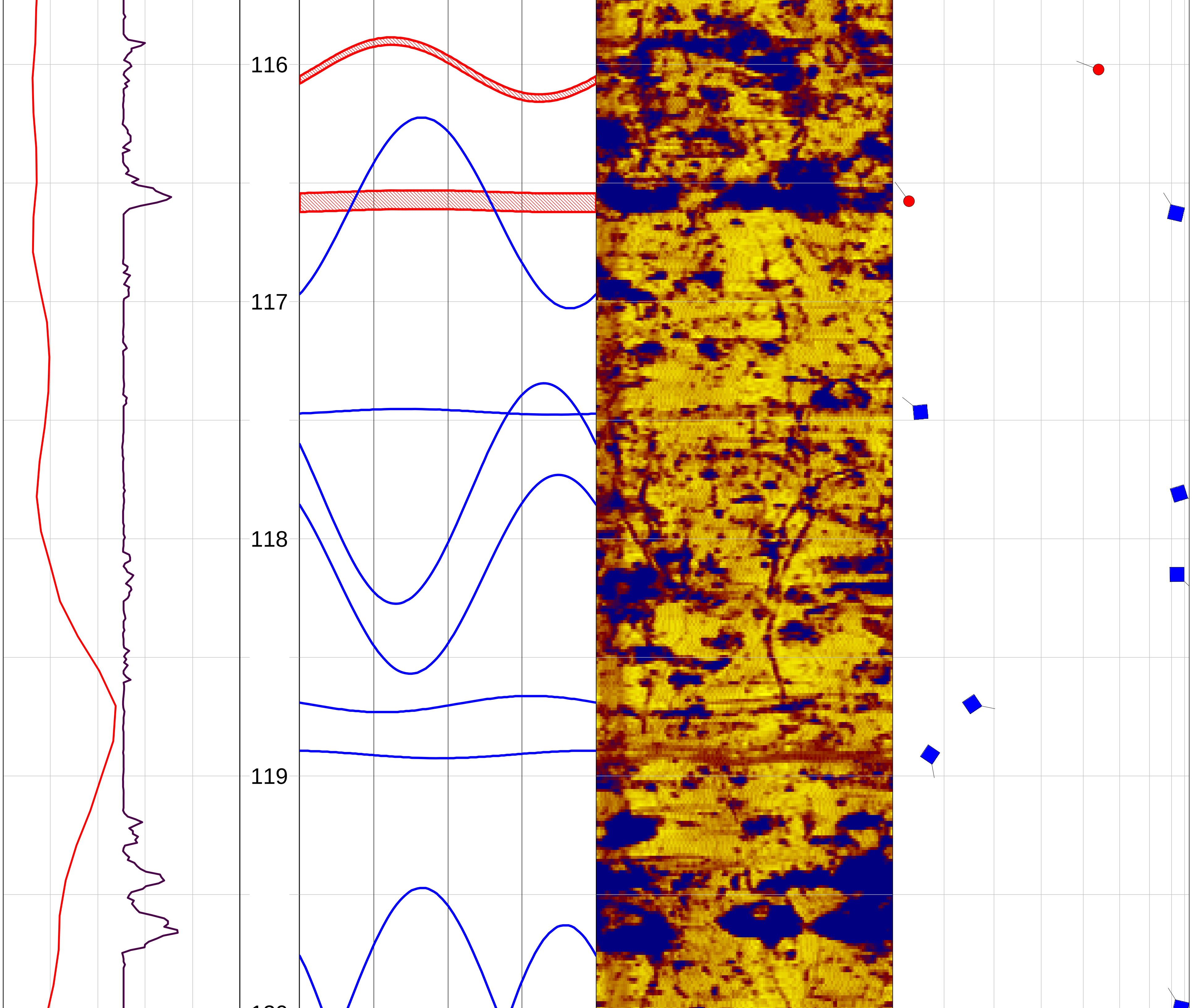

95
96
97
98

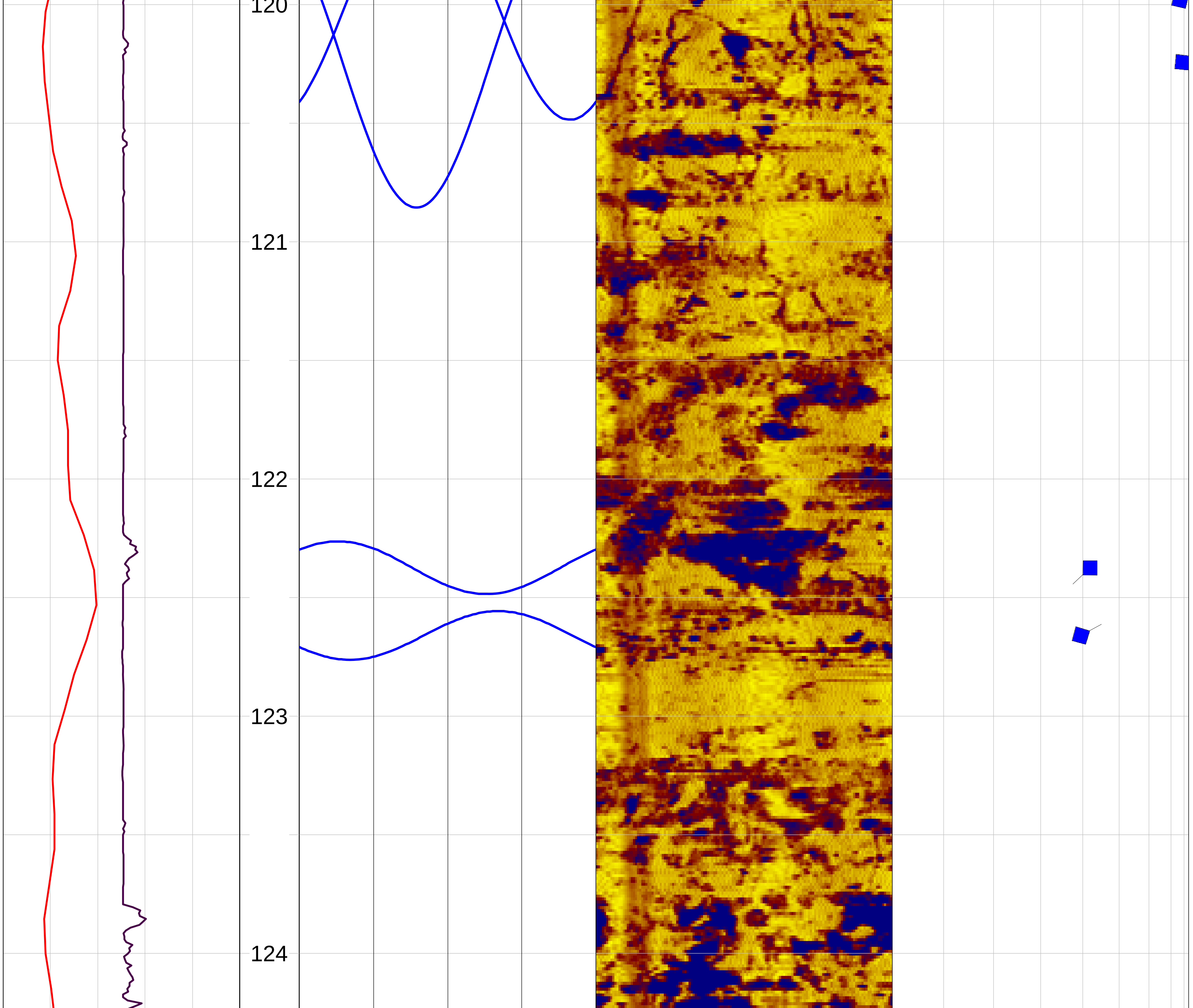

99
100
101
102

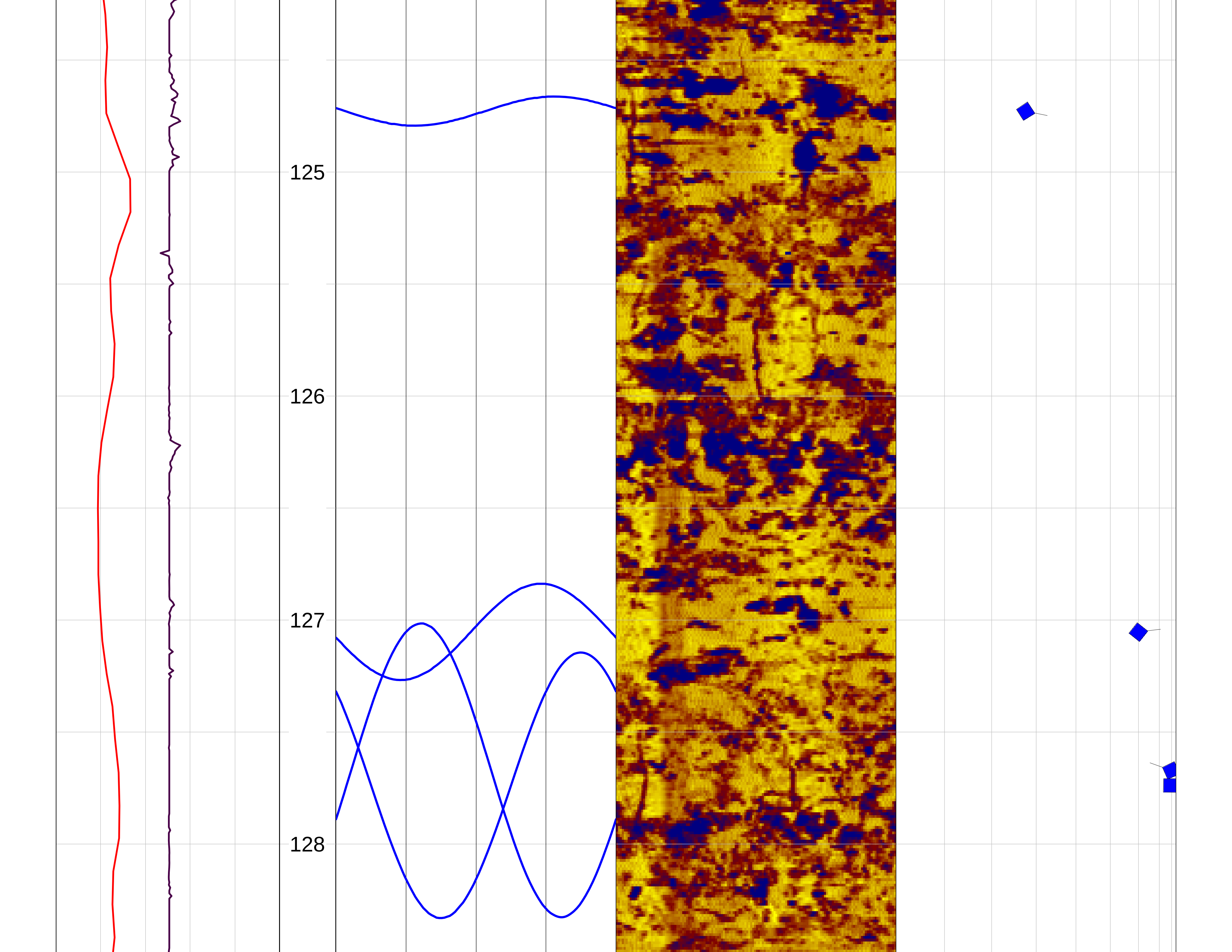

103
104
105
106
107

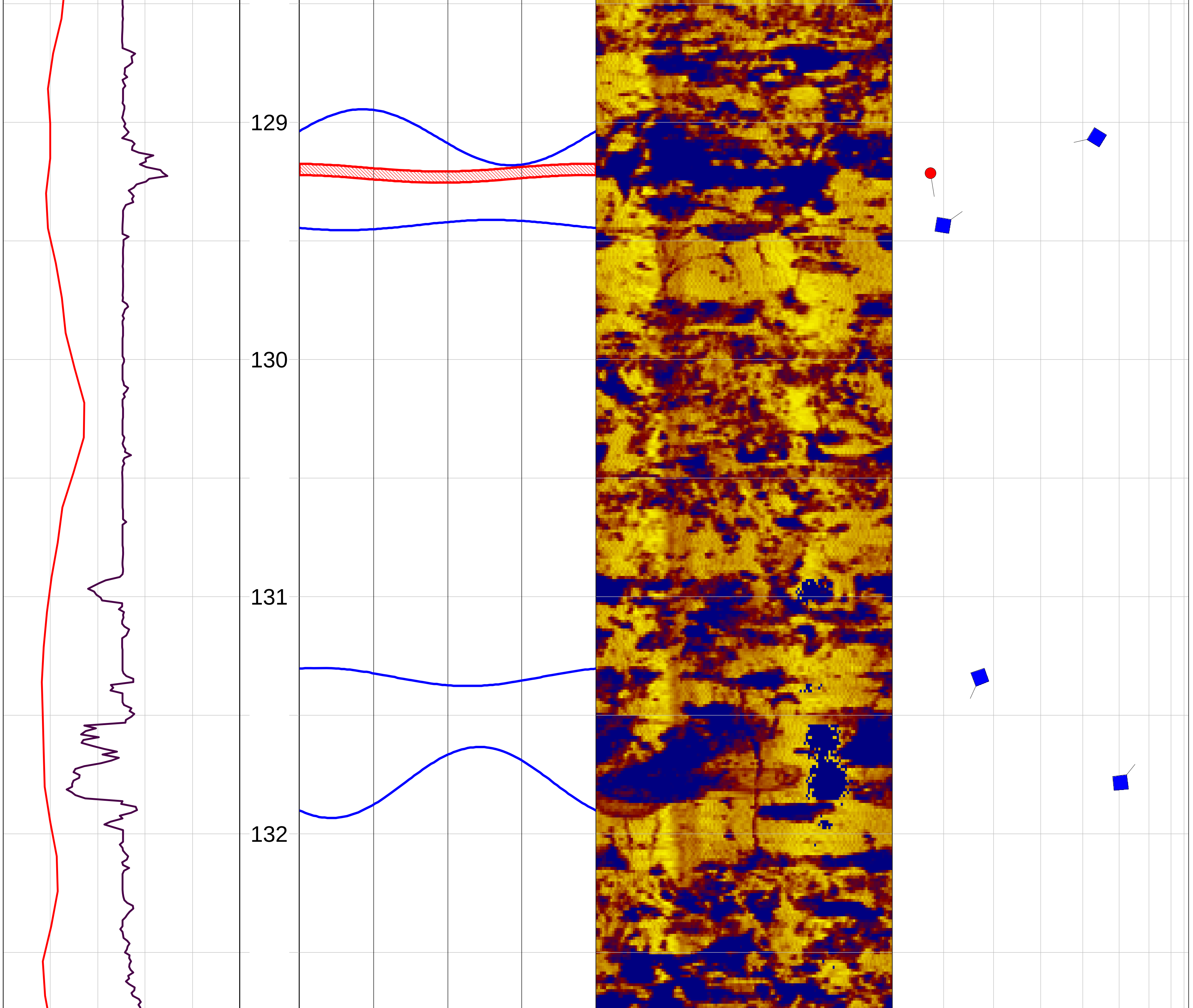

108
109
110
111

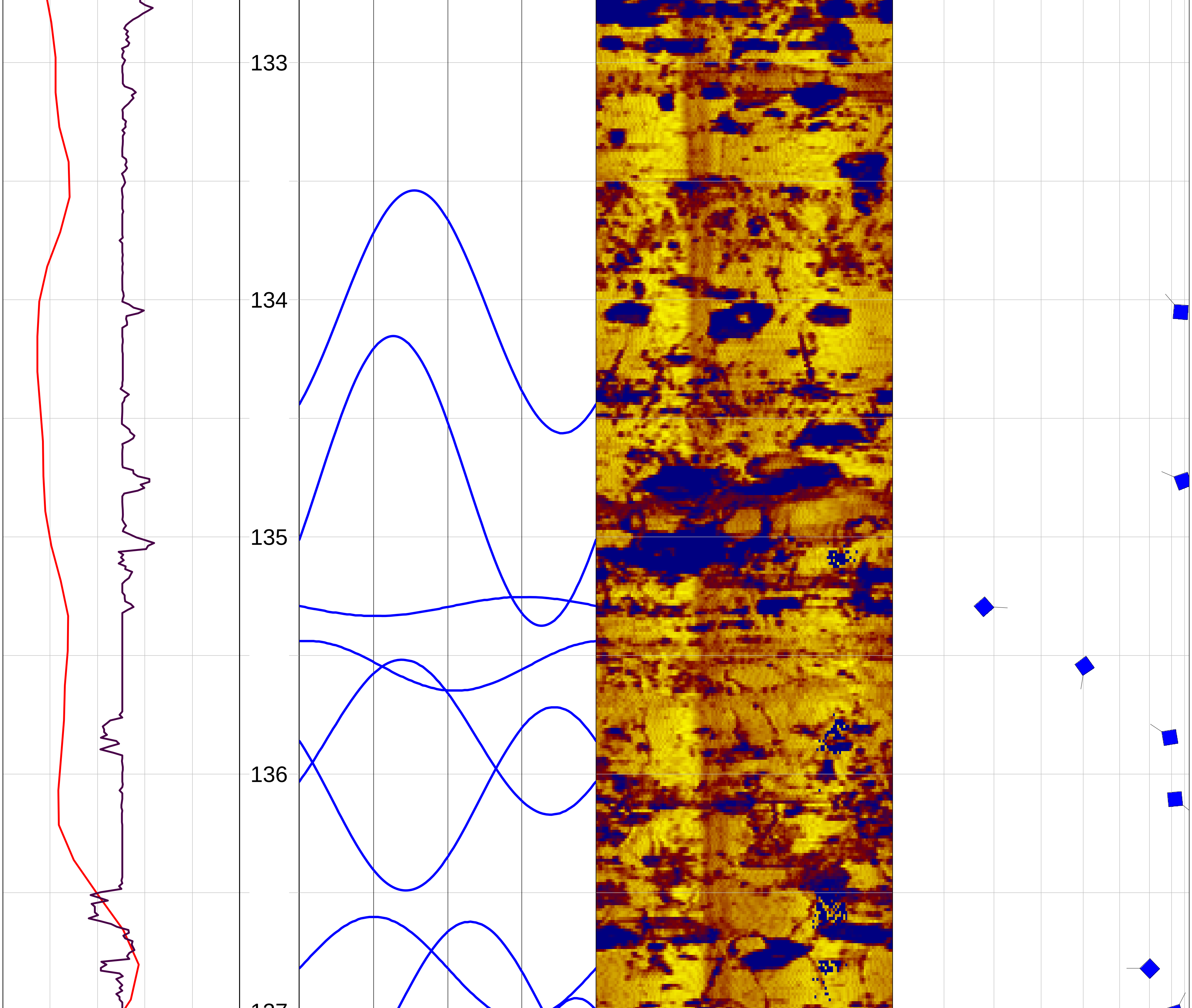

112
113
114
115


116
117
118
119

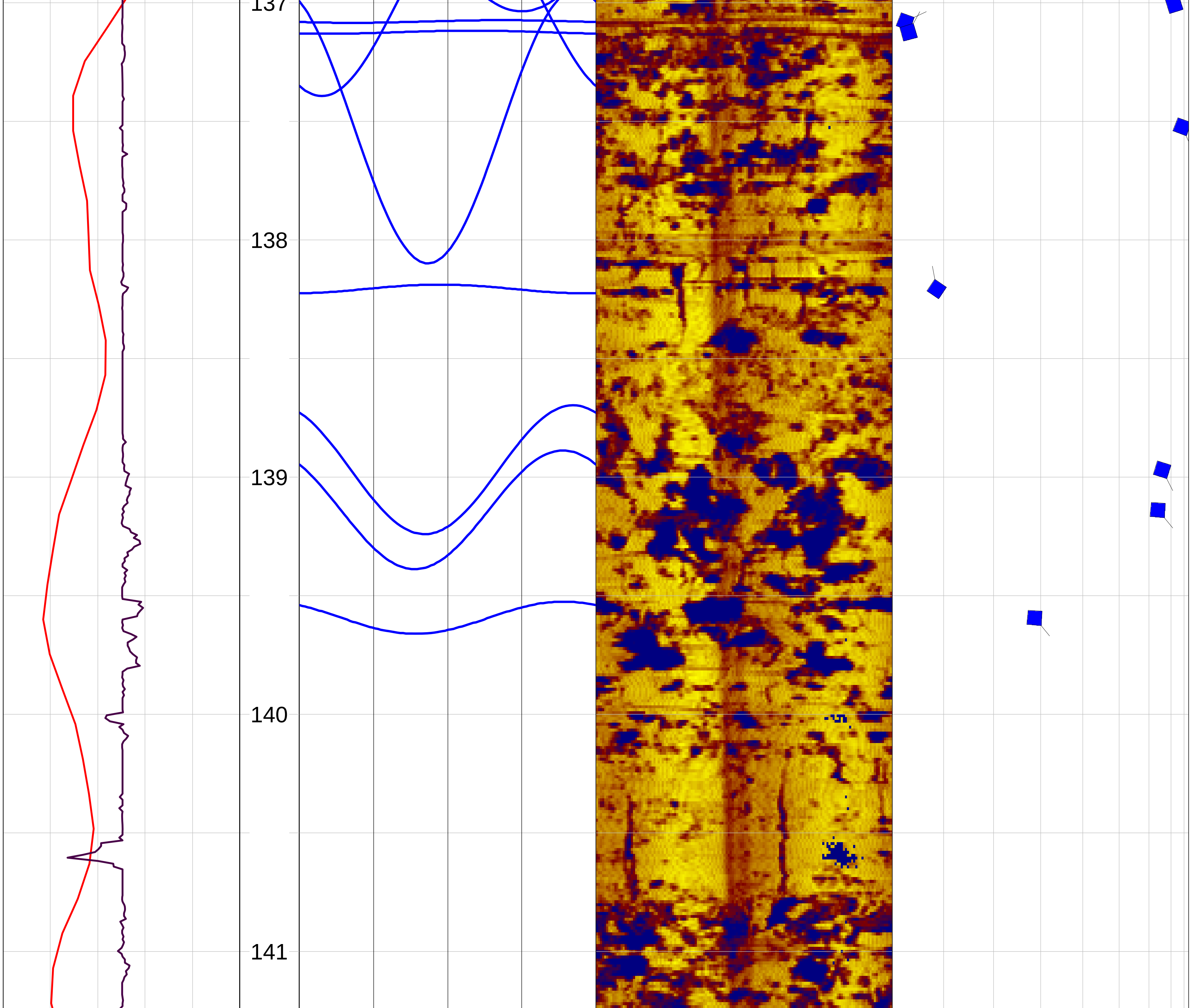

120
121
122
123
124


125
126
127
128

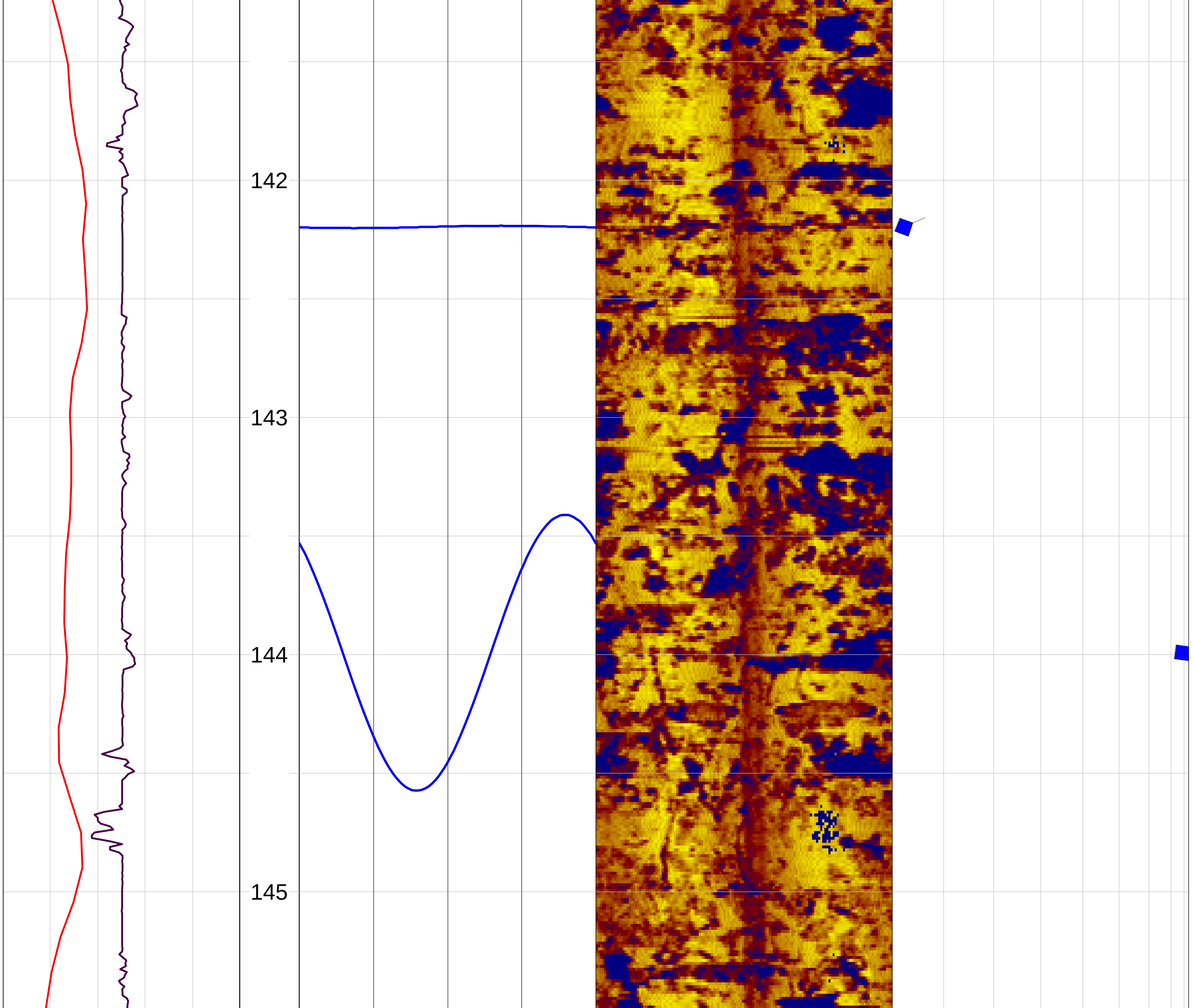

129
130
131
132



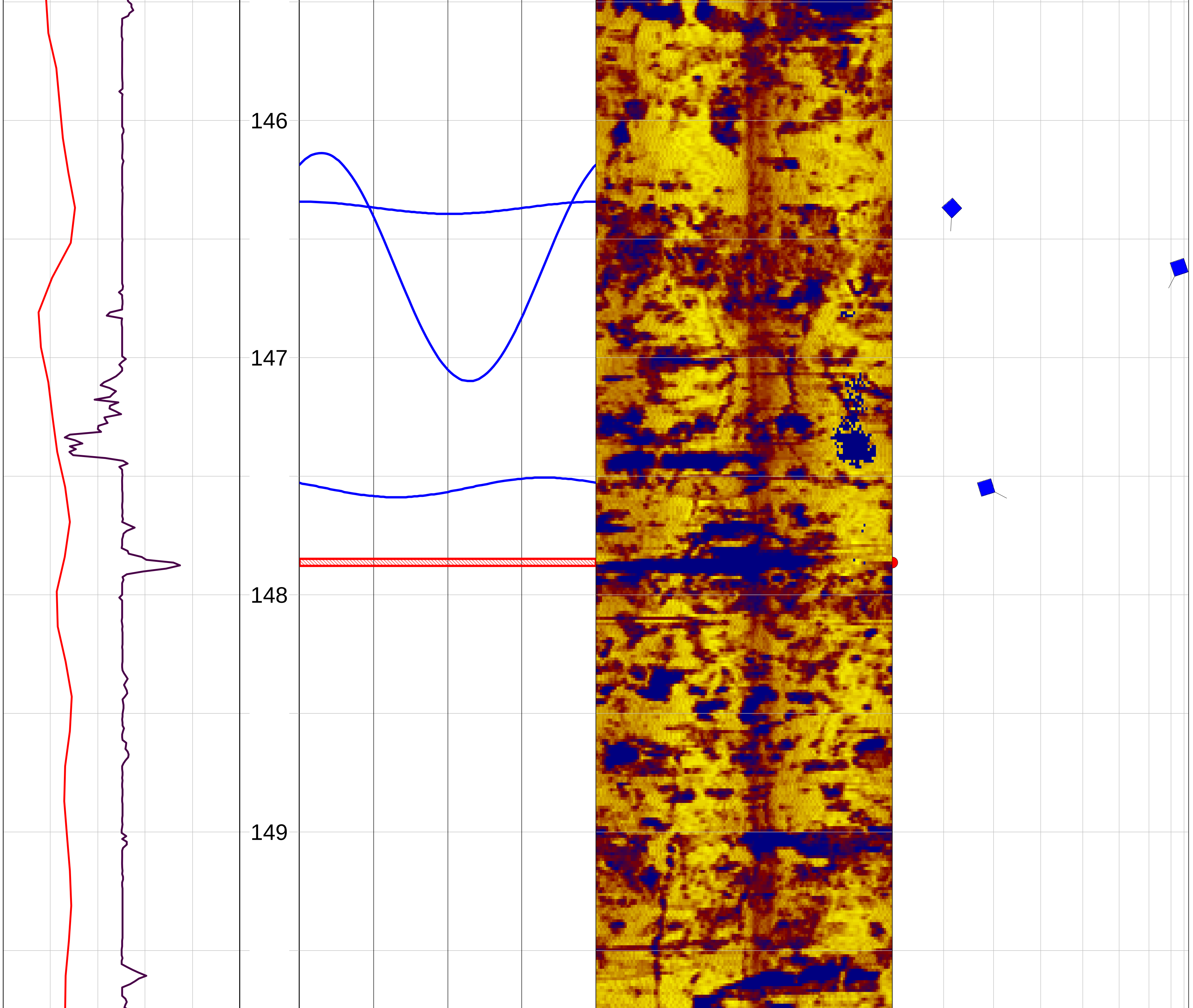
133
134
135
136

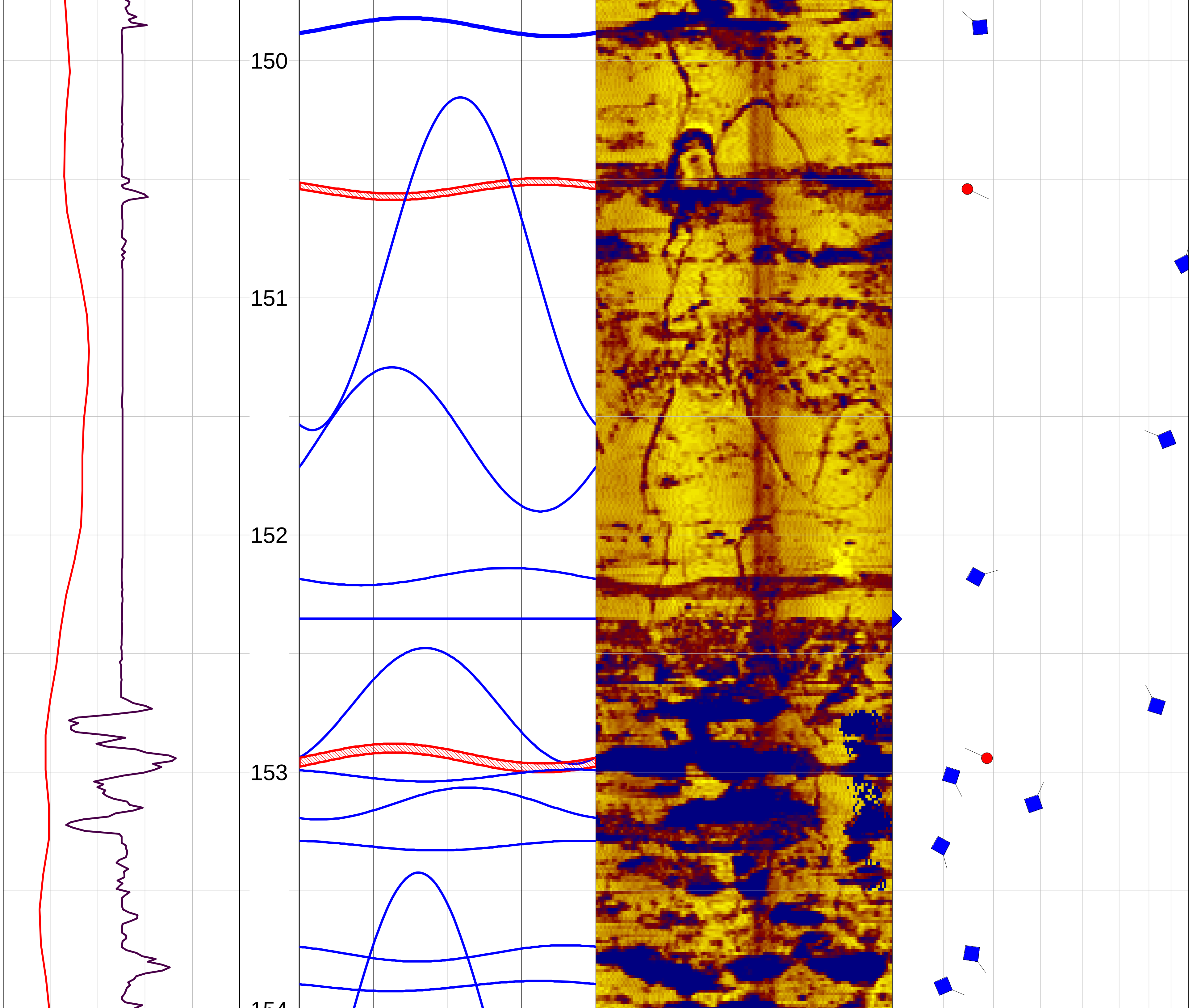


137
138
139
140
141

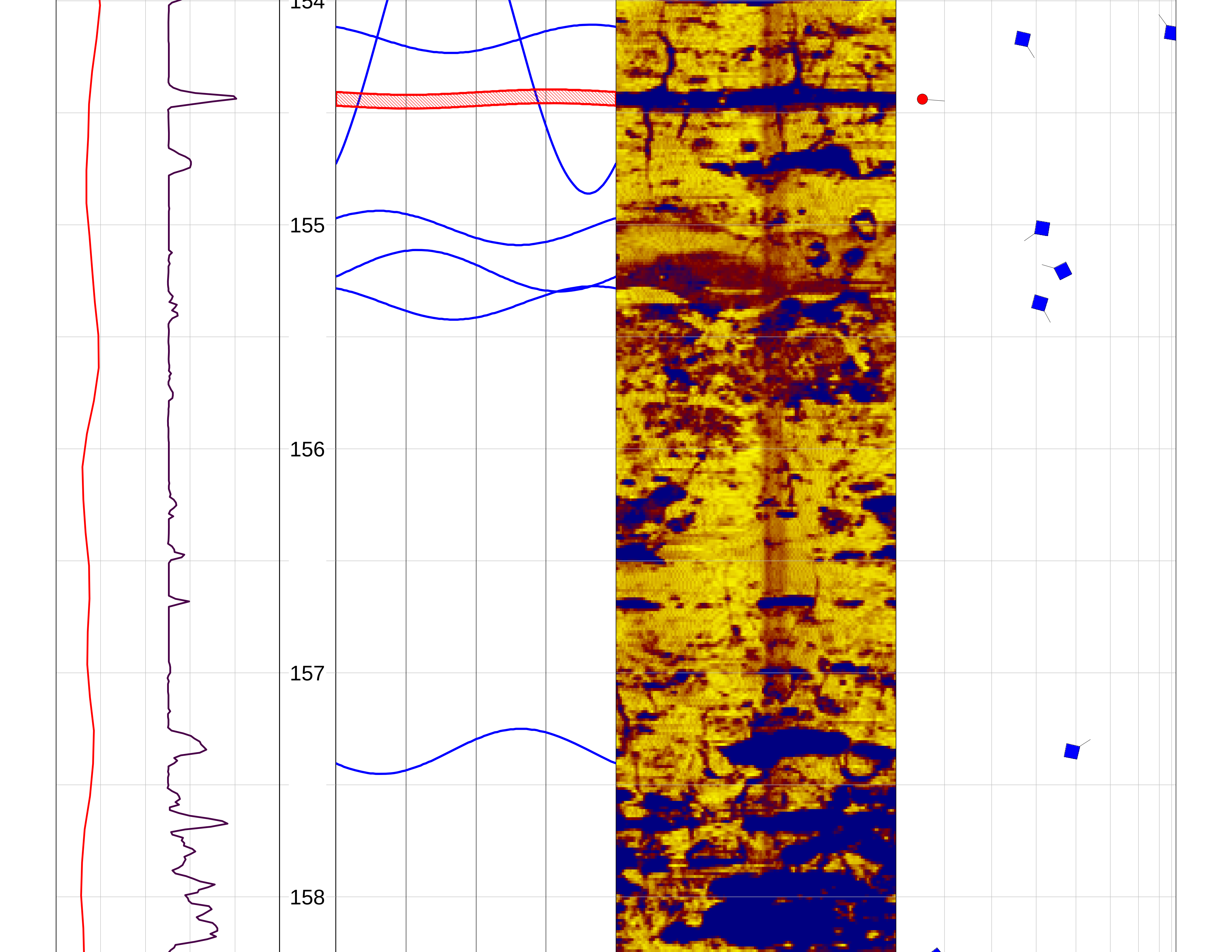


142
143
144
145

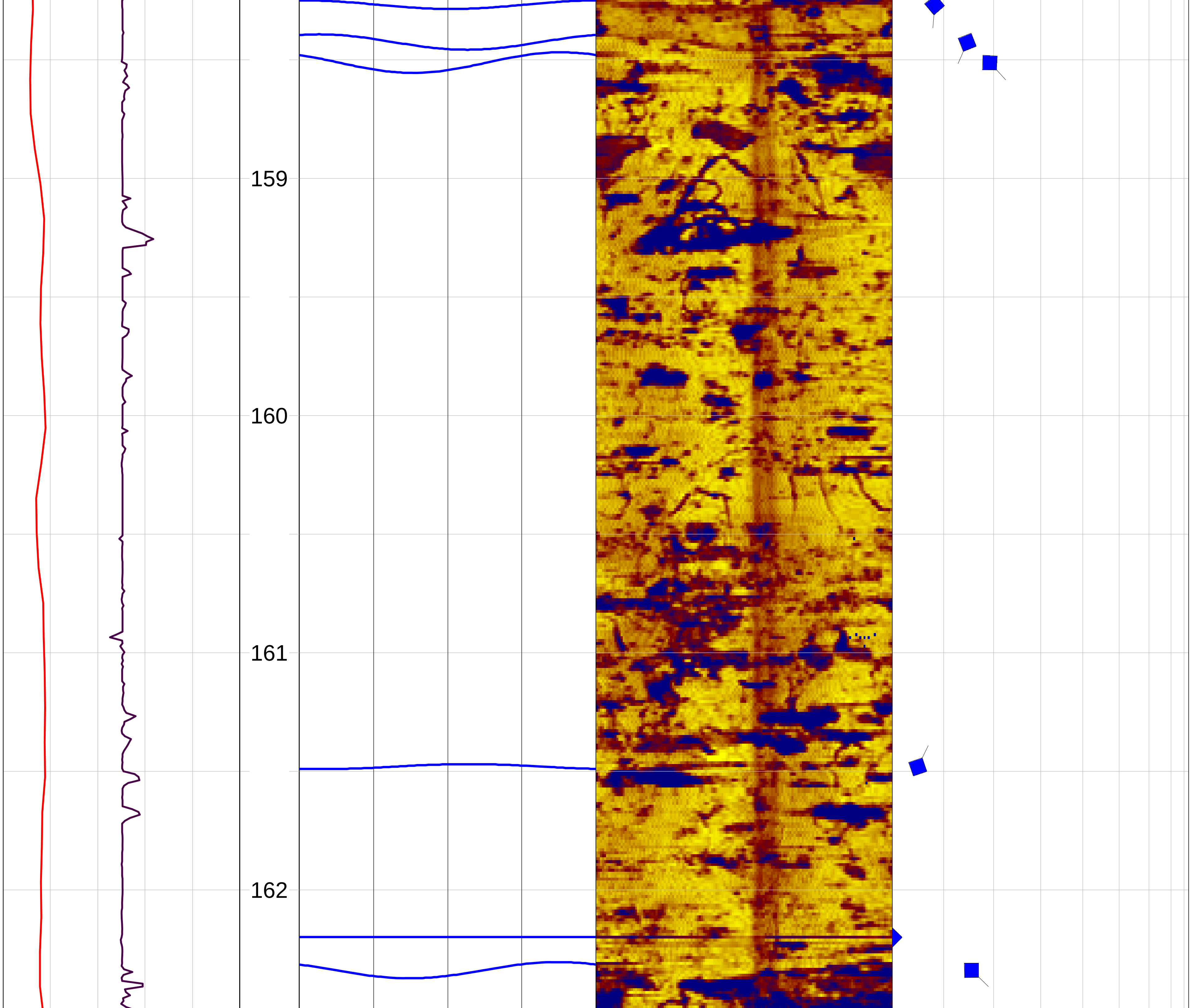

146
147
148
149

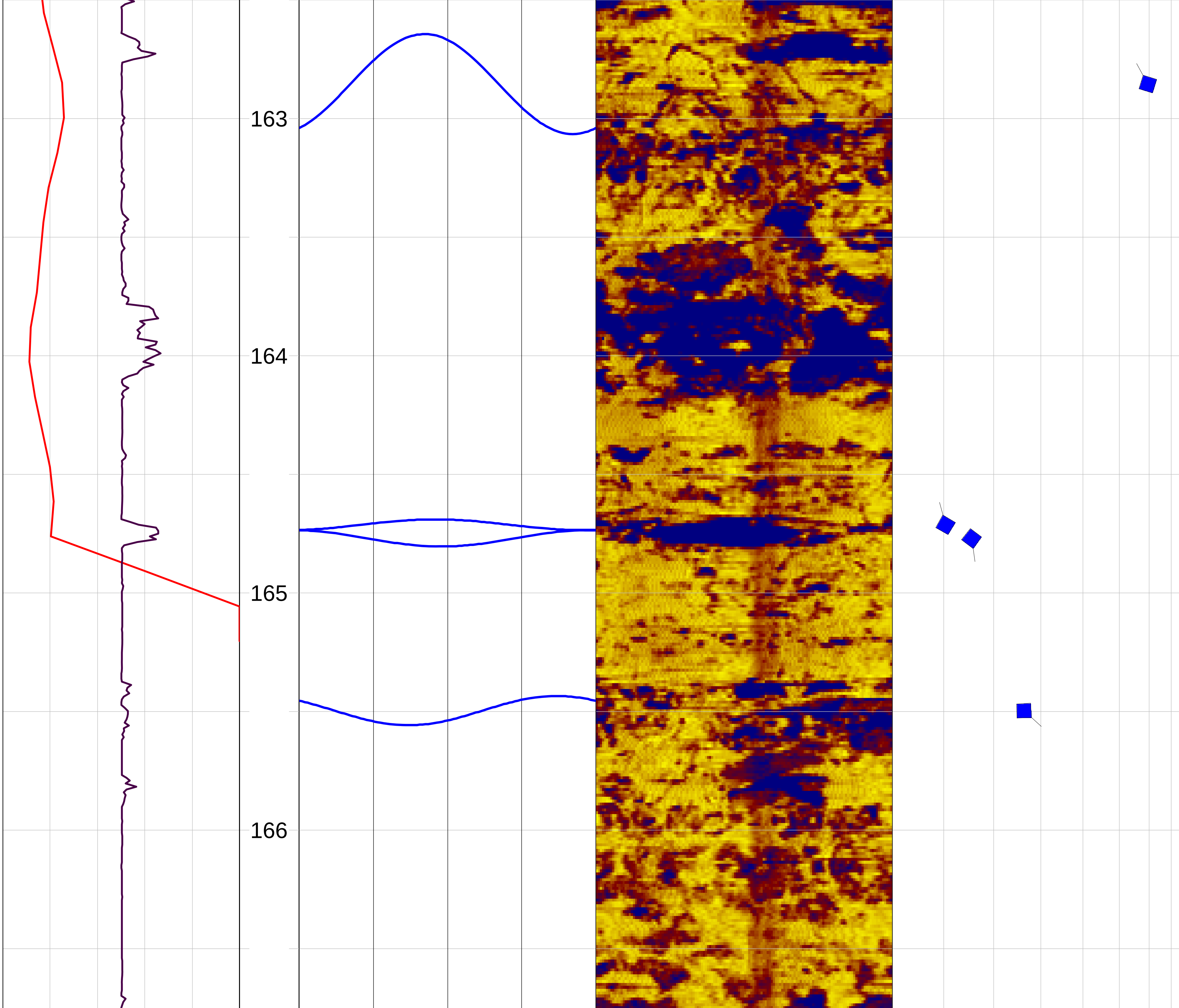


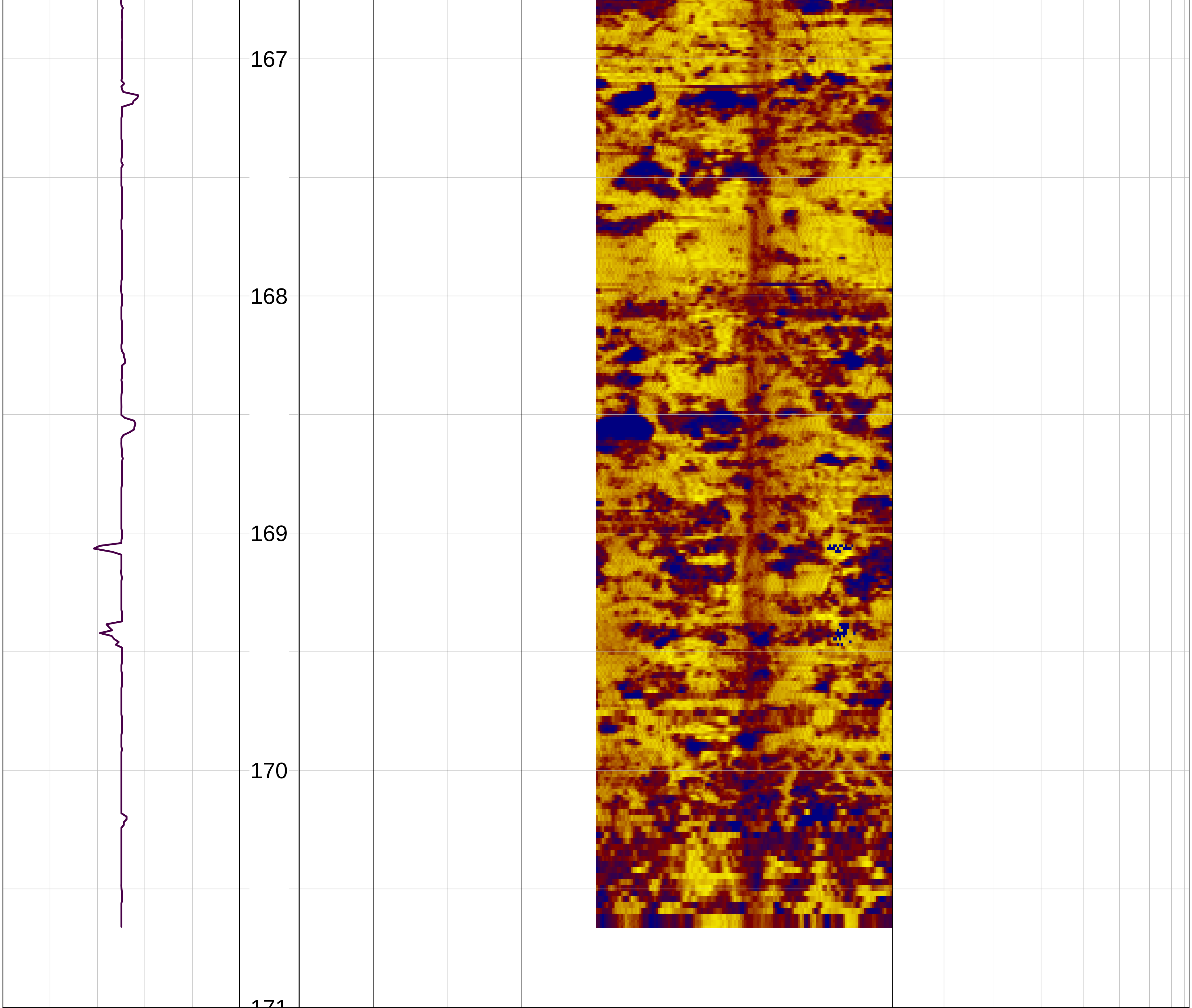
150
151
152
153
154



154
155
156
157
158


159
160
161
162


163
164
165
166


167
168
169
170
171

Average Caliper Width		Projections	Acoustic Amplitude	Tadpole
2.93 in 3.03				
Natural Gamma	Depth	0° 90° 180° 270° 0°	0° 90° 180° 270° 0°	0 90
0 cps 50	1in:0.5ft			Boring: Geo-01

APPENDIX B

Boring GEO-02
Geophysical Logs and Stereonet

GEOTECHNOLOGY INC
FROM THE GROUND UP

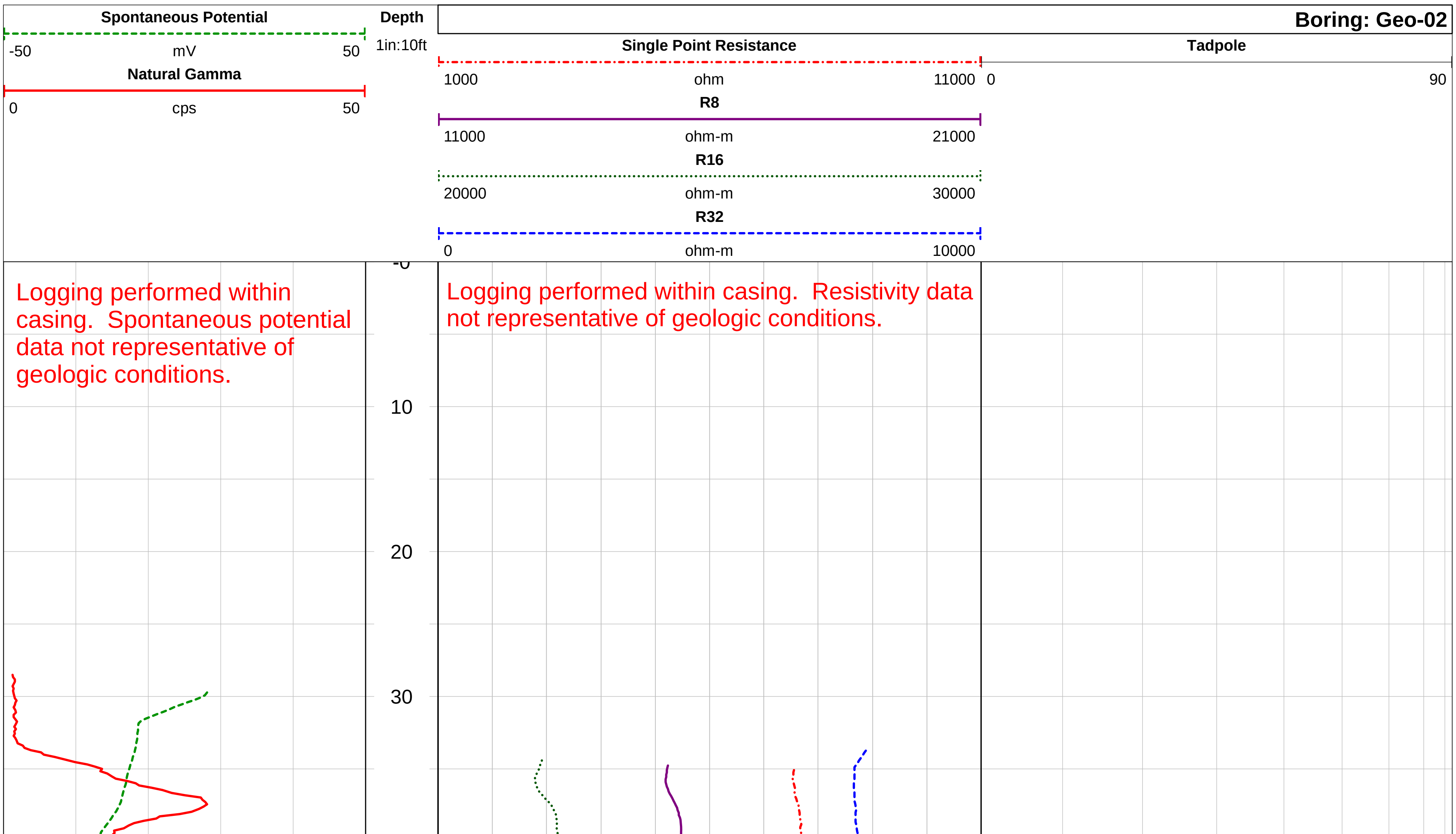
Geophysical Log

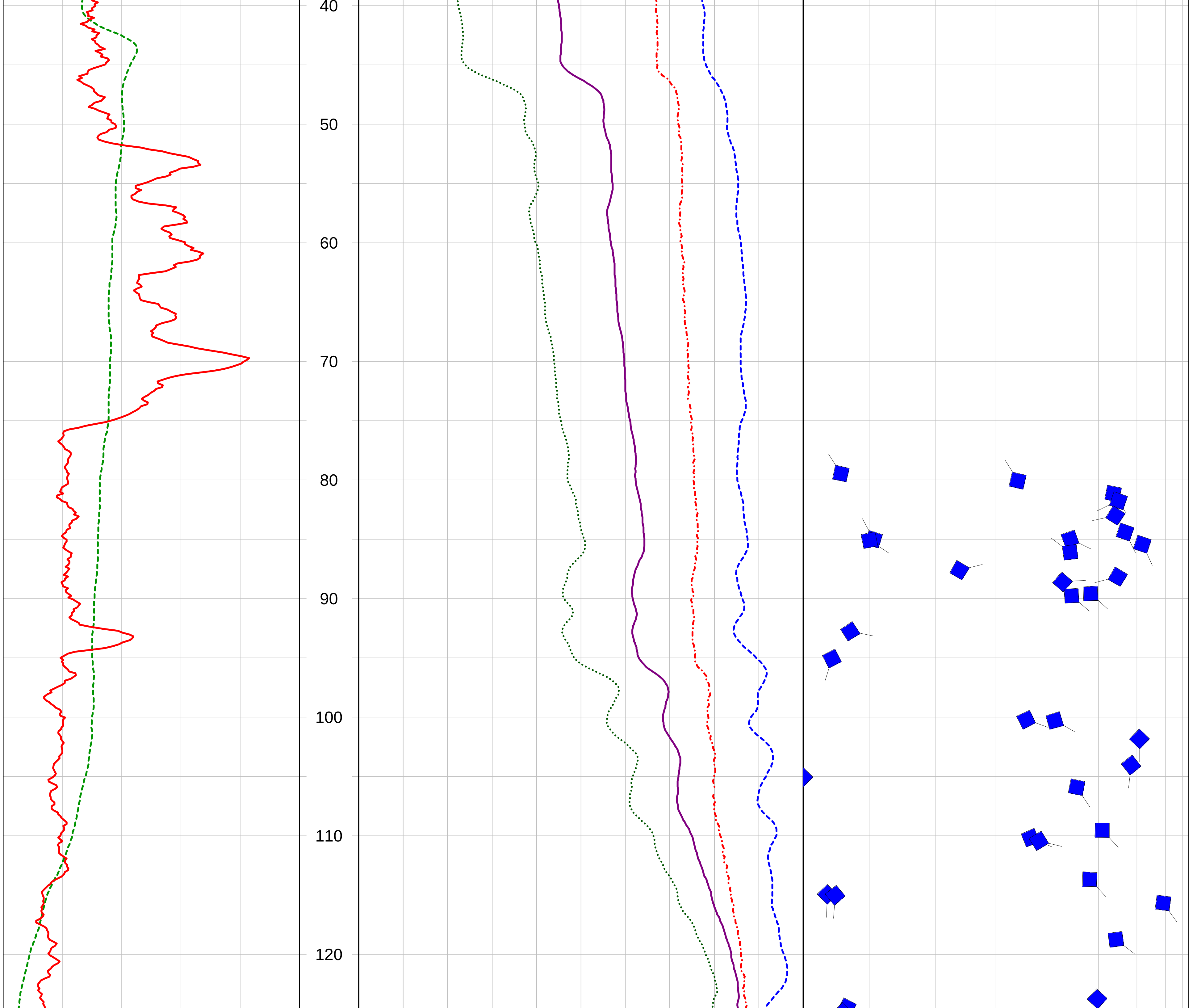
Project:	US52/IL64 Bridge over Mississippi River
Location:	Carroll County, IL, and Jackson County, IA
Project Number:	J022836.01
Client:	Wang Engineering

Boring:	Geo-02	Datum:	NAVD 88
Date Logged:	4 June 2014	Elevation:	593.37 ft
Water Depth During Logging:	NA - Drilled from Barge	North:	1980455.16 ft
Logger:	TAW	East:	2297701.54 ft
Driller:	Wang Testing Service	Station:	1572 + 91.89
Depths Presented From:	Water Surface	Offset:	10.48 LT

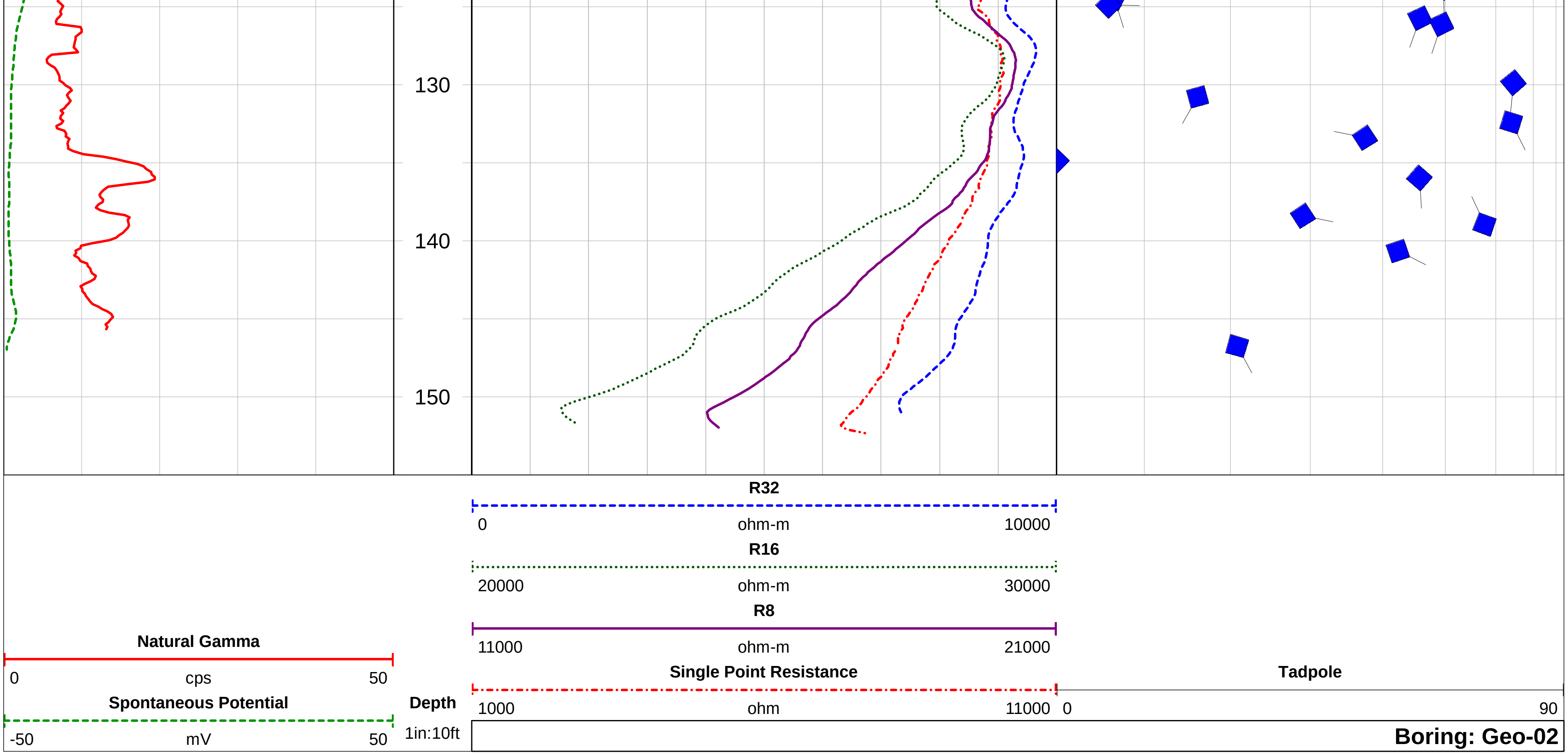
Tadpole Legend

Narrow Fracture/Bedding Feature





40
50
60
70
80
90
100
110
120



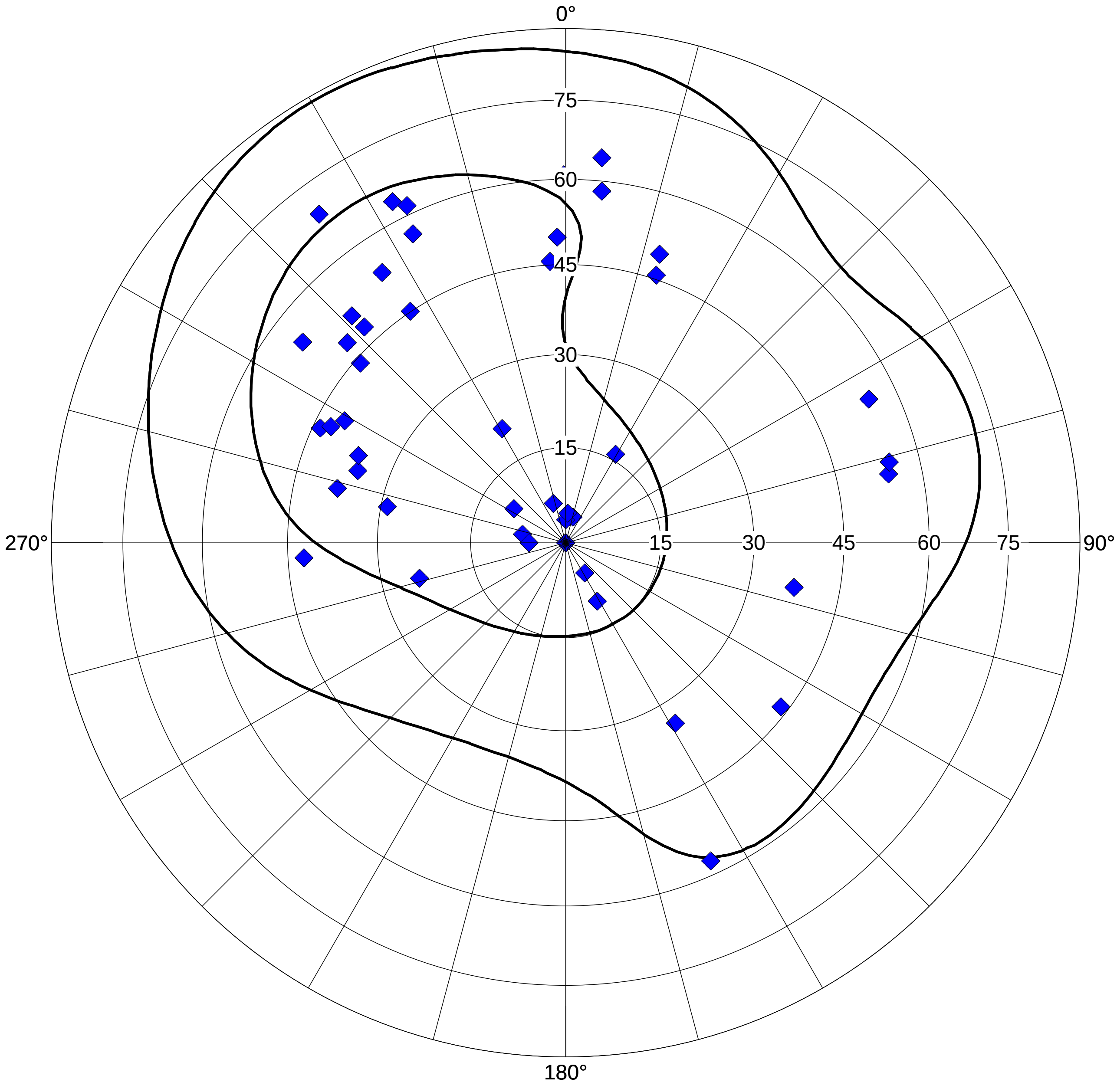
130
140
150
R32
0
ohm-m
10000
R16
20000
ohm-m
30000
R8
11000
ohm-m
21000
Natural Gamma
0
cps
50
Single Point Resistance
1000
ohm
11000
Tadpole
0
90
Spontaneous Potential
-50
mV
50
Depth
1in:10ft
Boring: Geo-02

US52 Bridge over the Mississippi River
Carroll County, IL, and Jackson County, IA
Boring Geo-02

GEOTECHNOLOGY INC
FROM THE GROUND UP

Schmidt Plot (Dip) - LH - Wang Engineering
Plot: Tadpoles
Depth: from 79.45 to 146.75 [ft]

Schmidt (1% Area) Contouring - 5% Contour Intervals



Attribute : Wang Engineering

Symbol	Code - Description	Nb Points	Azi Mean	Dip Mean
◆	Feature - Narrow Fracture/Bedding Feature	47	149.31	25.95

Acoustic Televiewer Log

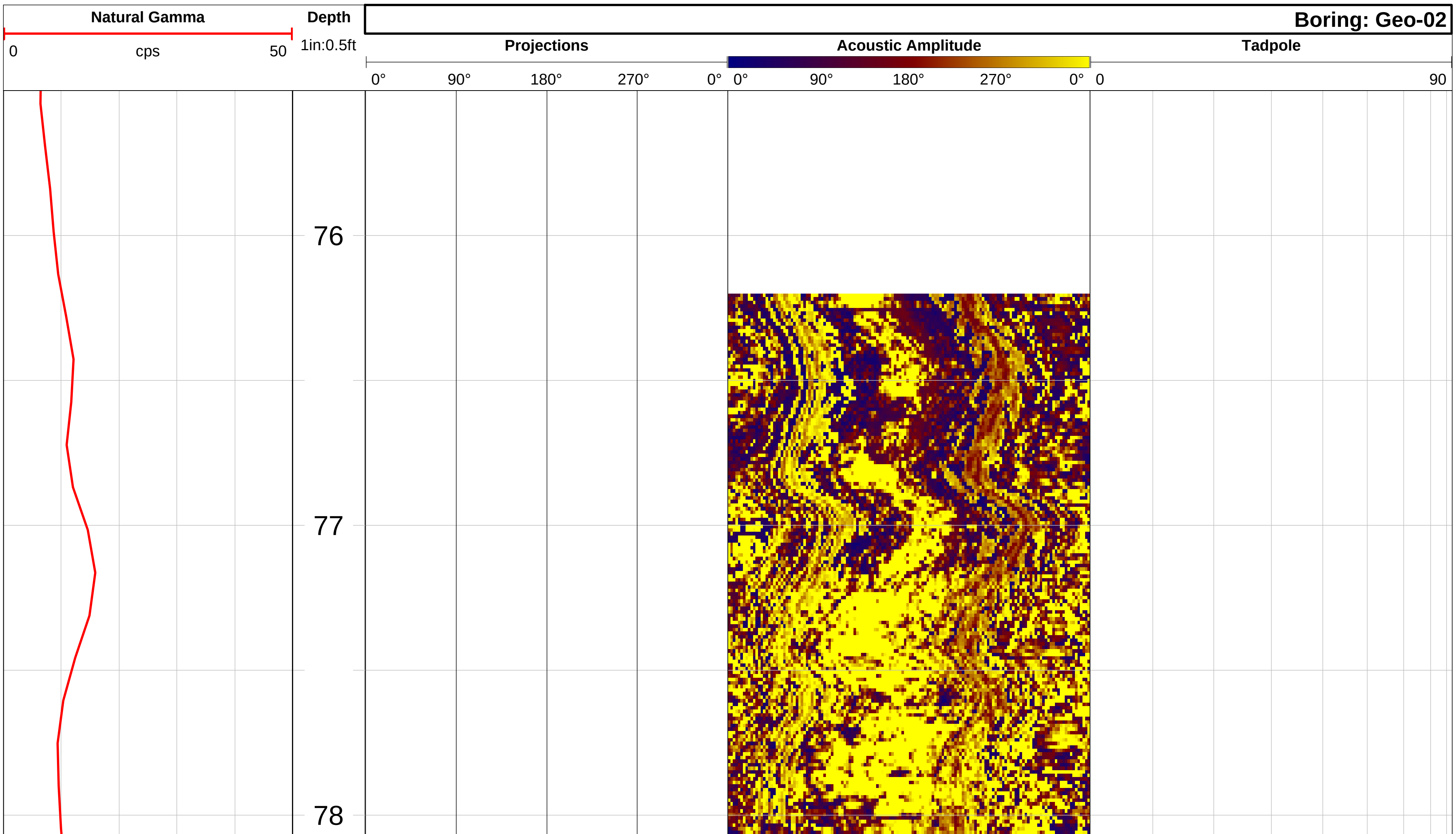
GEOTECHNOLOGY INC
FROM THE GROUND UP

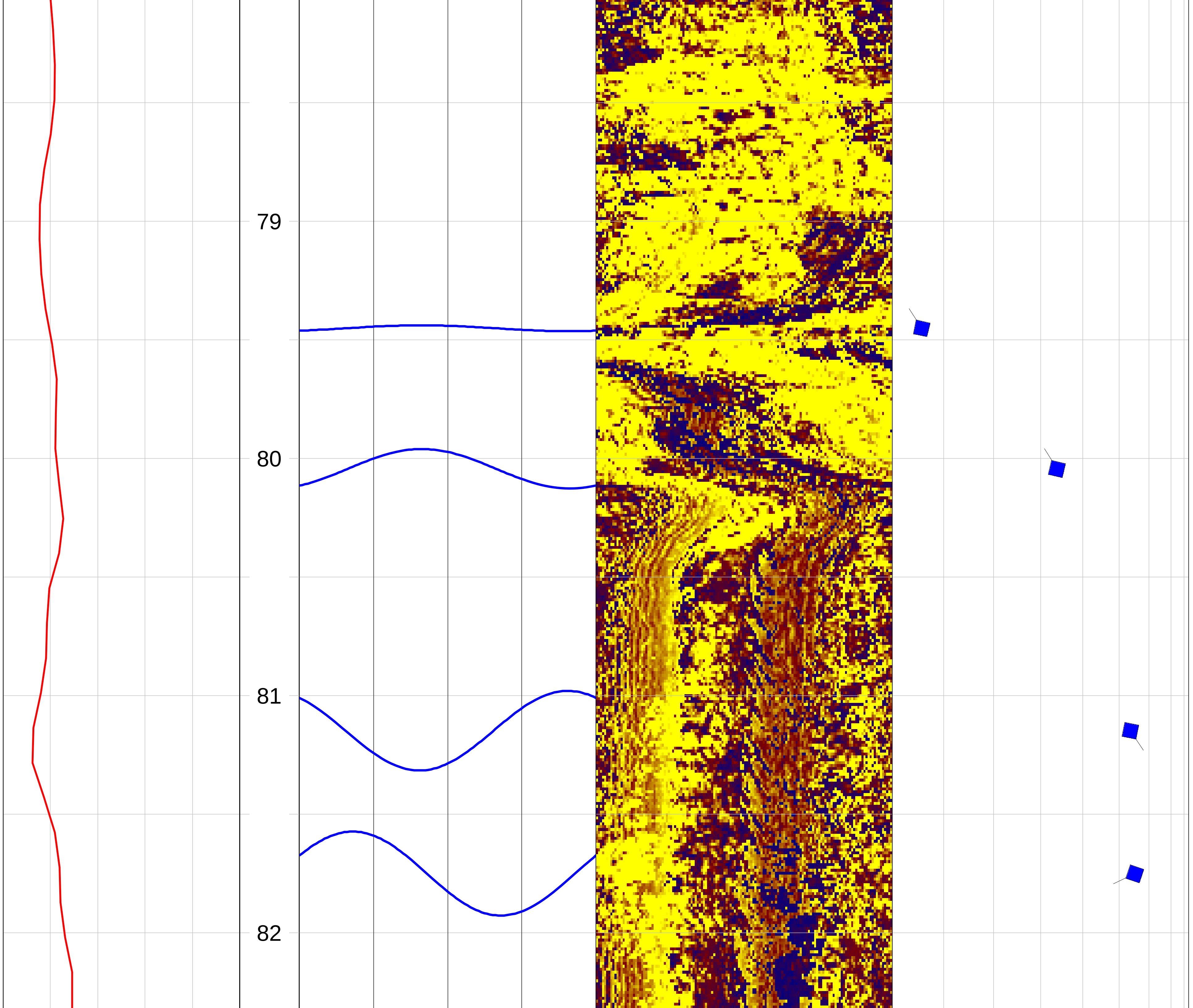
Project:	US52/IL64 Bridge over Mississippi River
Location:	Carroll County, IL, and Jackson County, IA
Project Number:	J022836.01
Client:	Wang Engineering

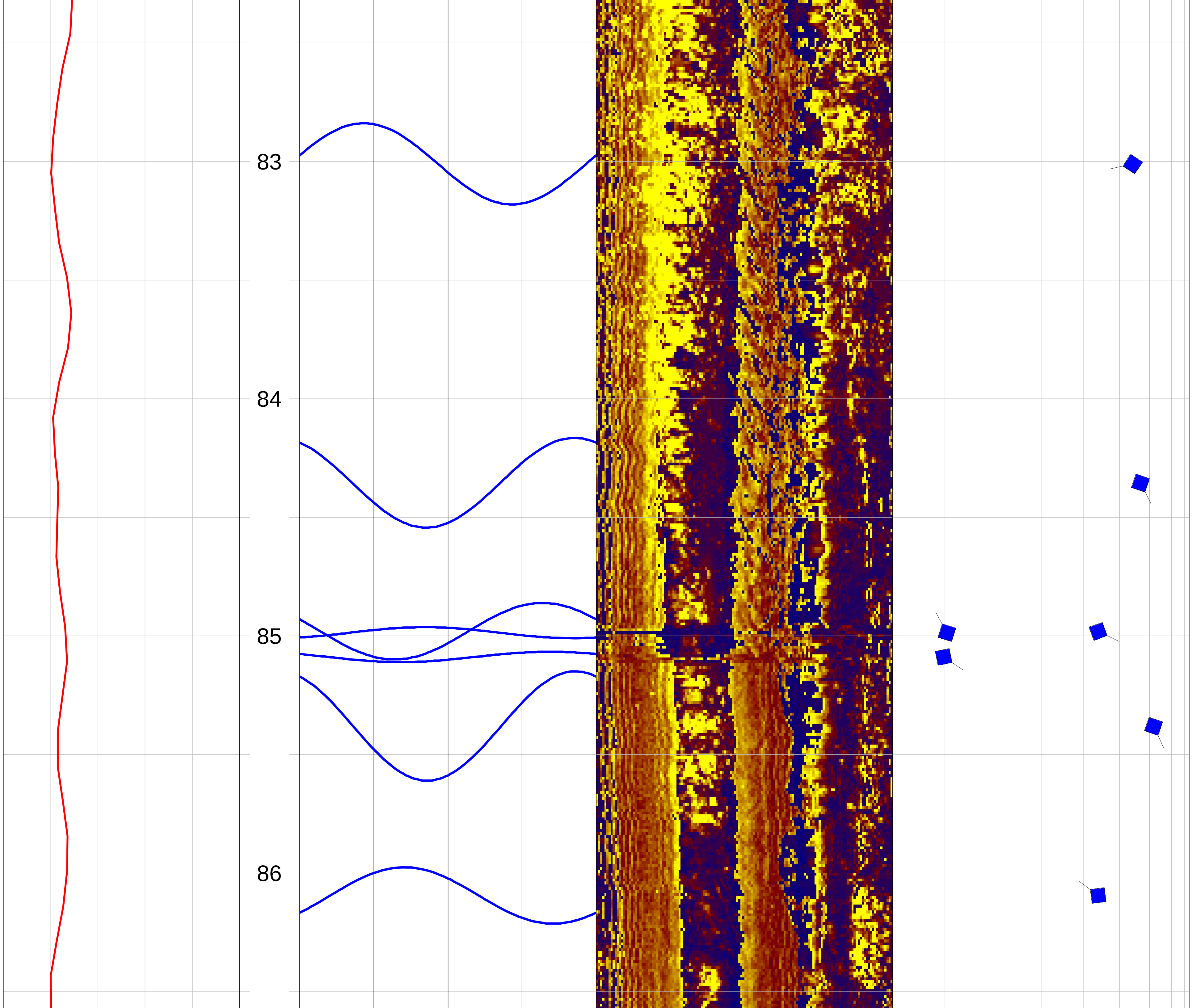
Boring:	Geo-02	Datum:	NAVD 88
Date Logged:	4 June 2014	Elevation:	593.37 ft
Water Depth During Logging:	NA - Drilled From Barge	North:	1980455.16 ft
Logger:	TAW	East:	2297701.54 ft
Driller:	Wang Testing Service	Station:	1572 91.89
Depths Presented From:	Water Surface	Offset:	10.48 LT

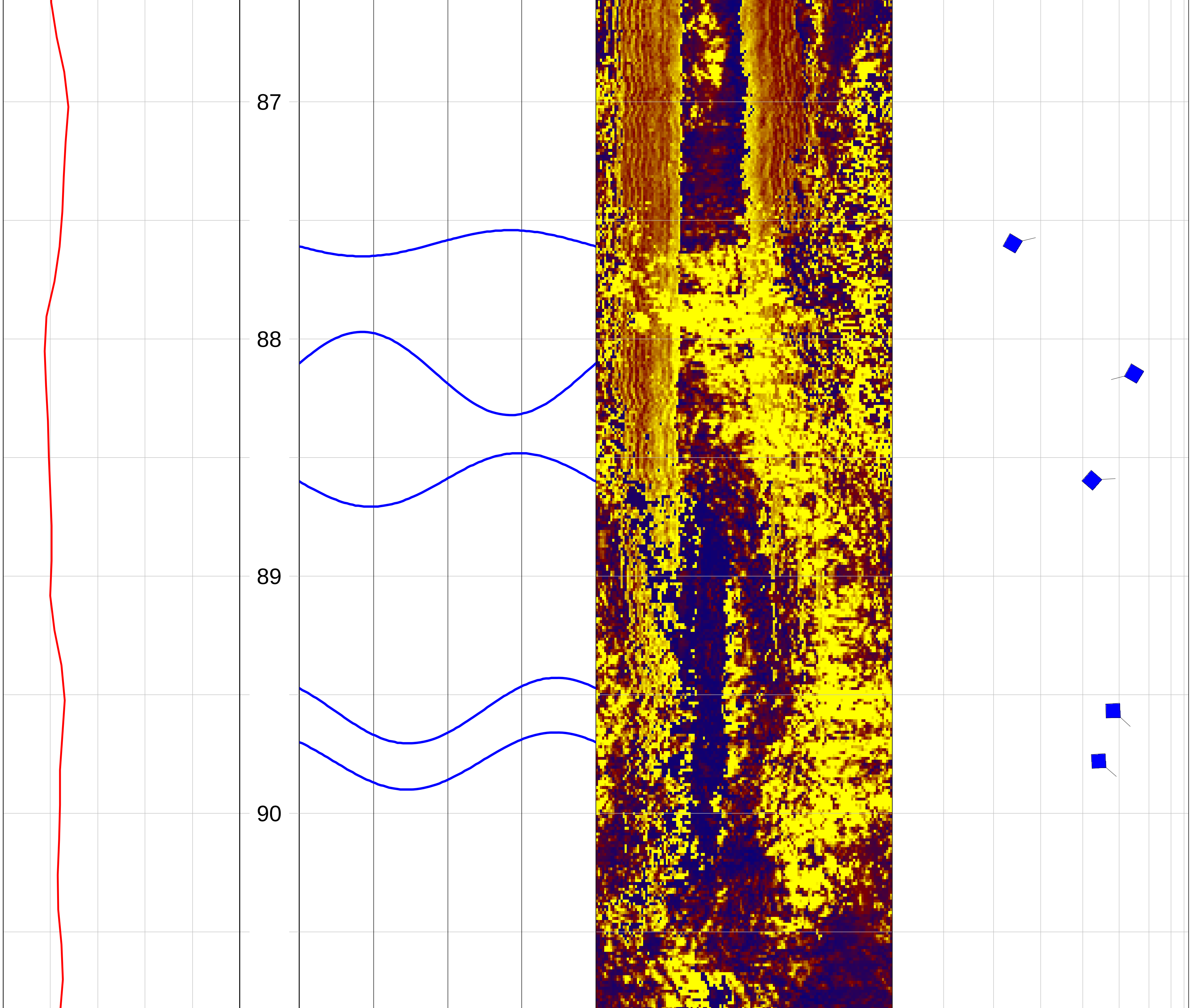
Tadpole Legend

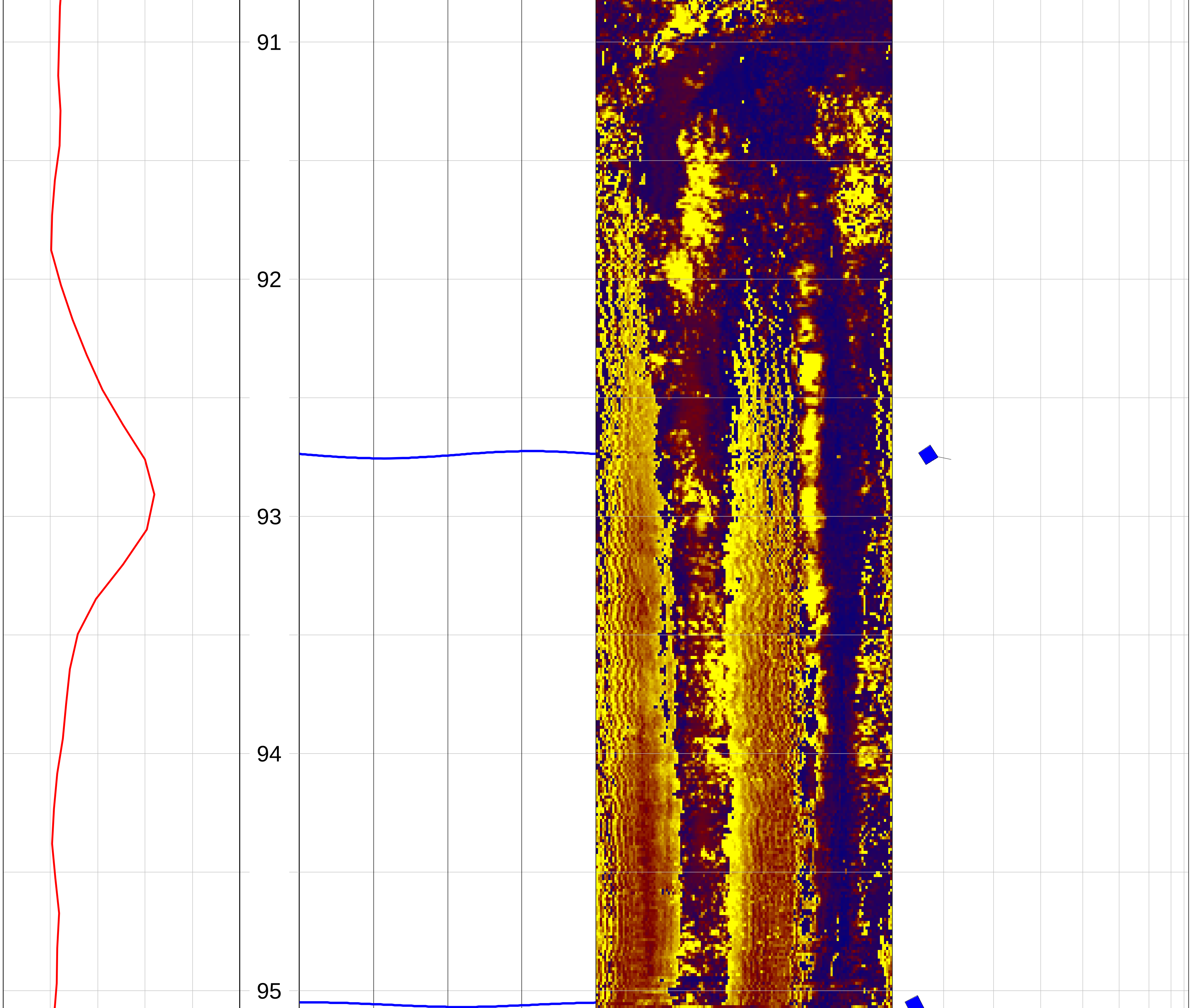
Narrow Fracture/Bedding Feature

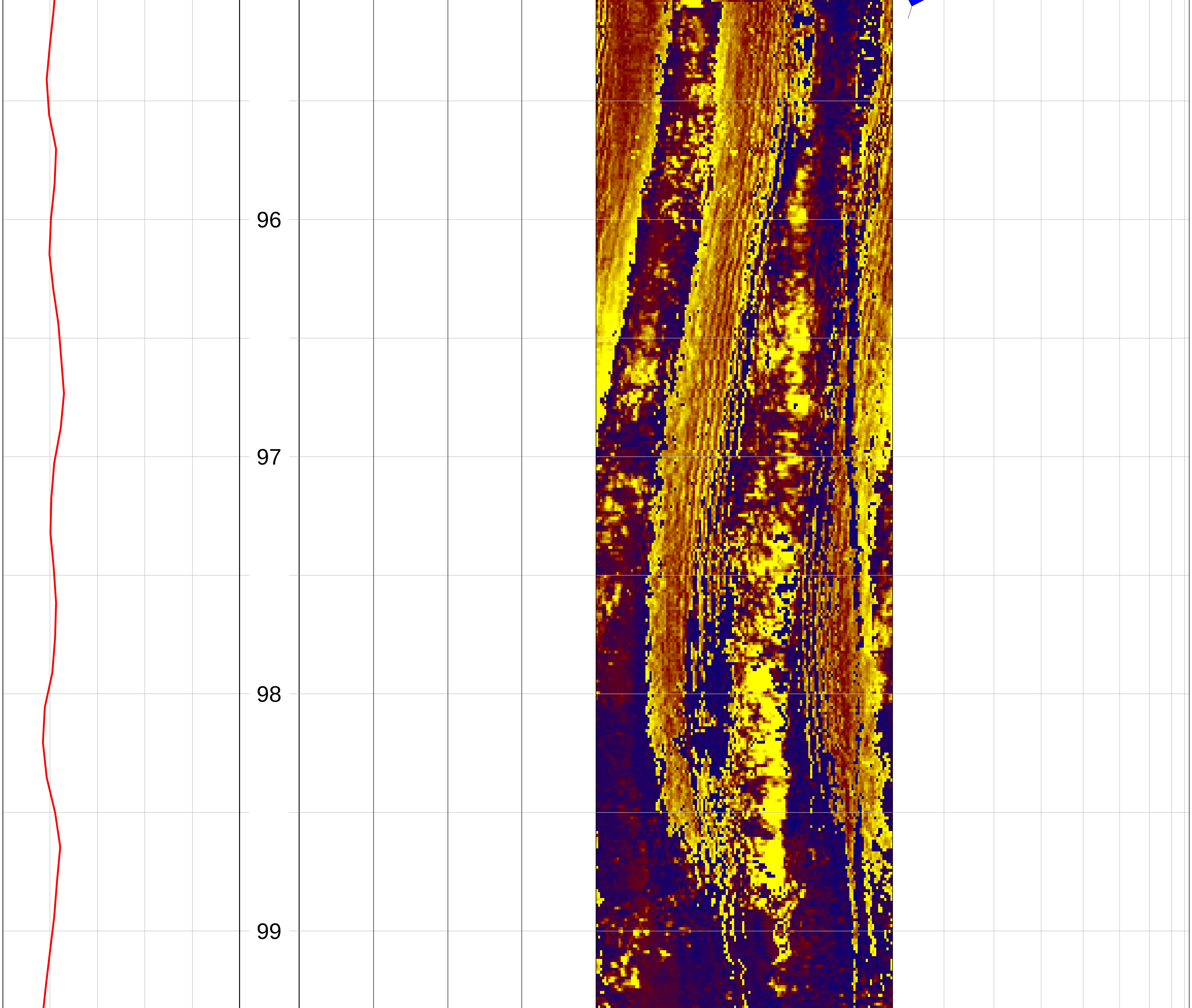


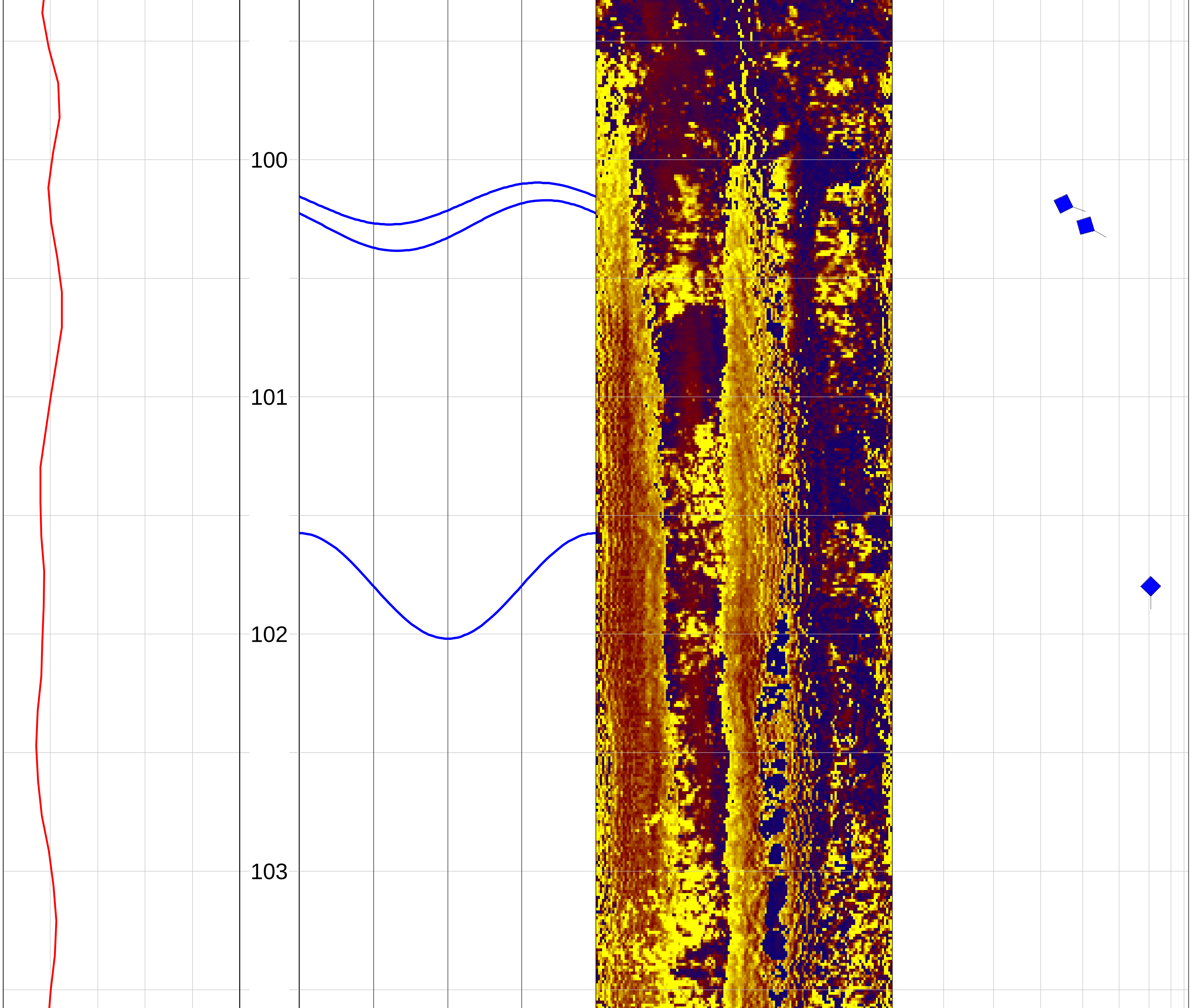

79
80
81
82


83
84
85
86

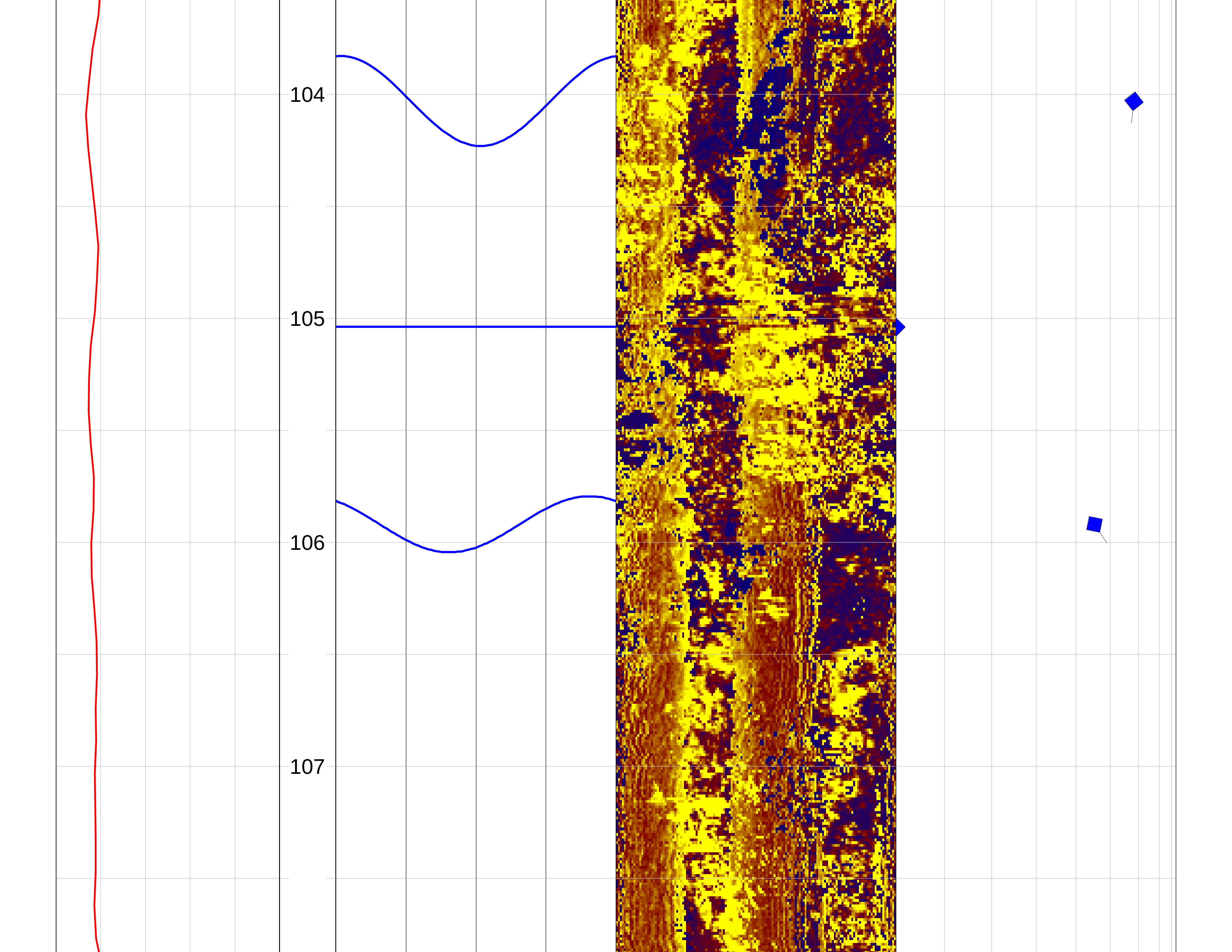

87
88
89
90

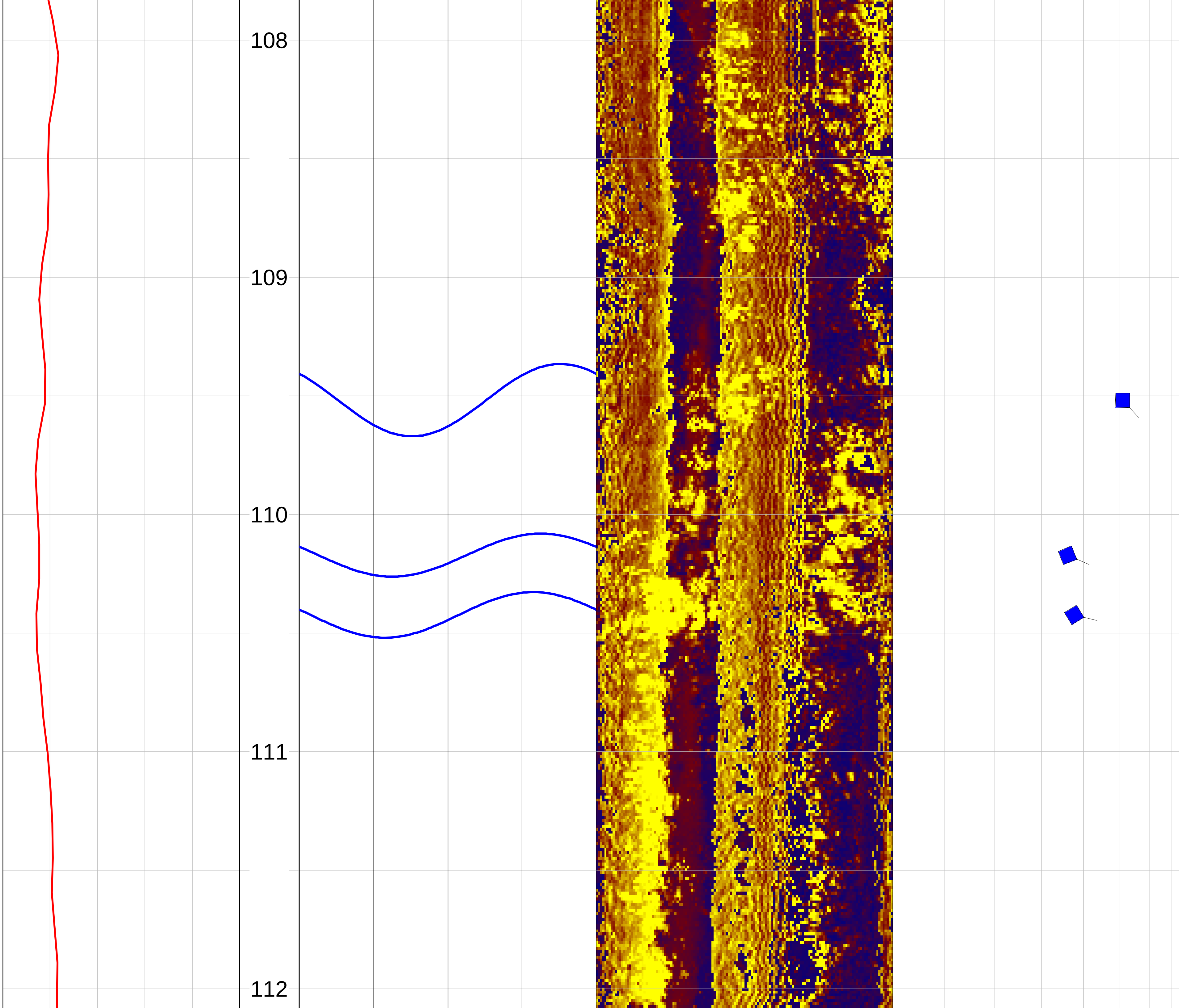

91
92
93
94
95

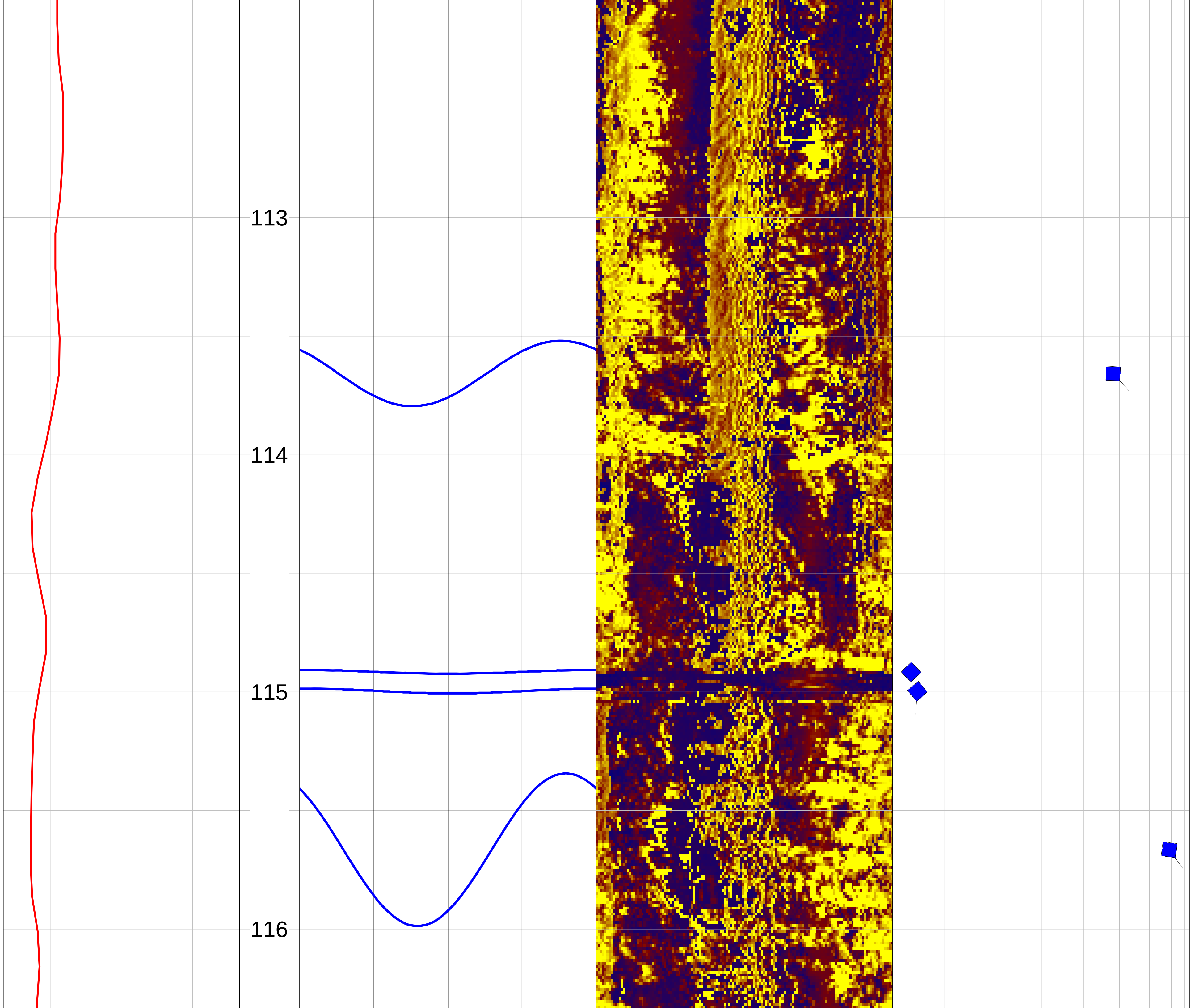

96
97
98
99



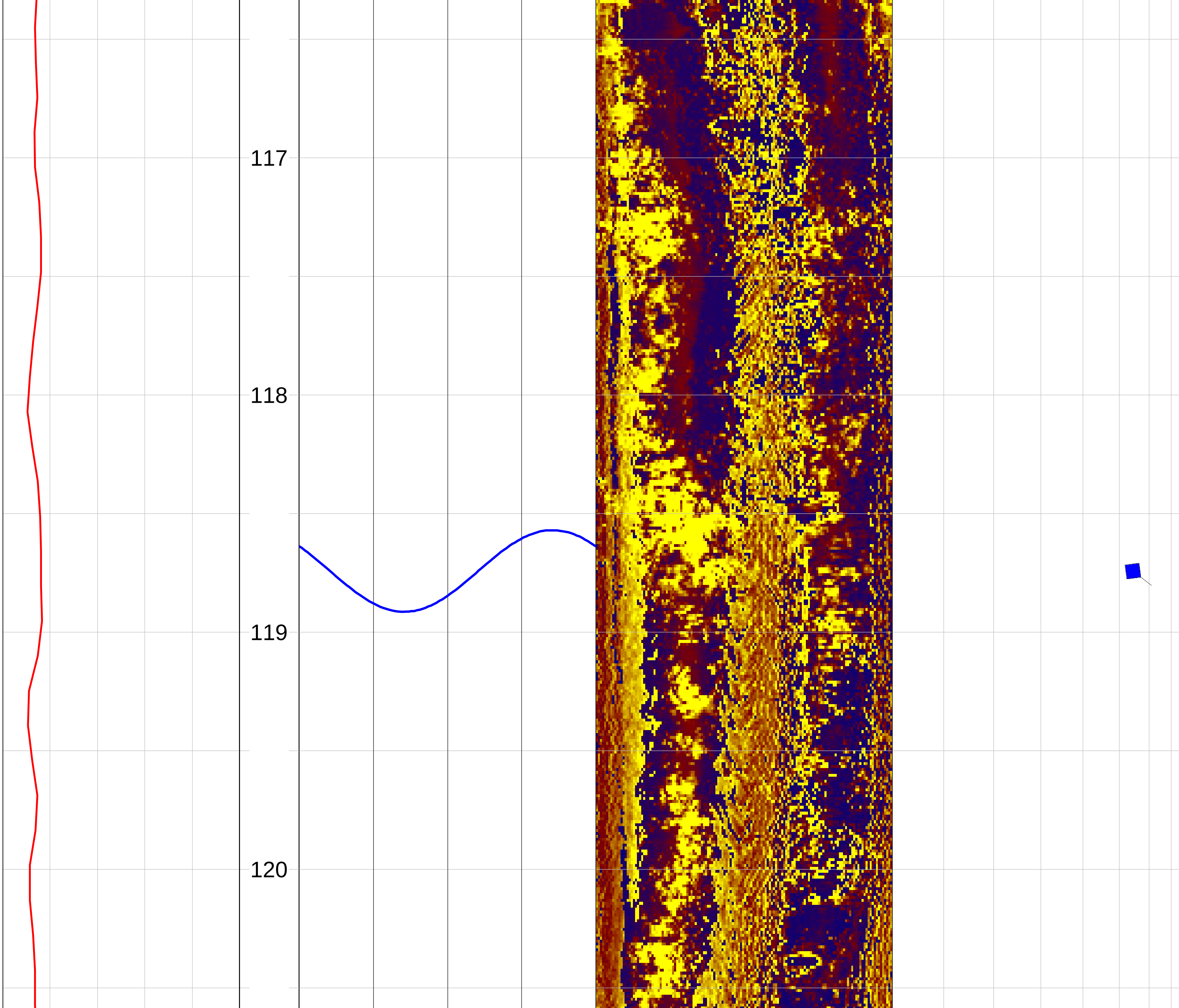
100
101
102
103

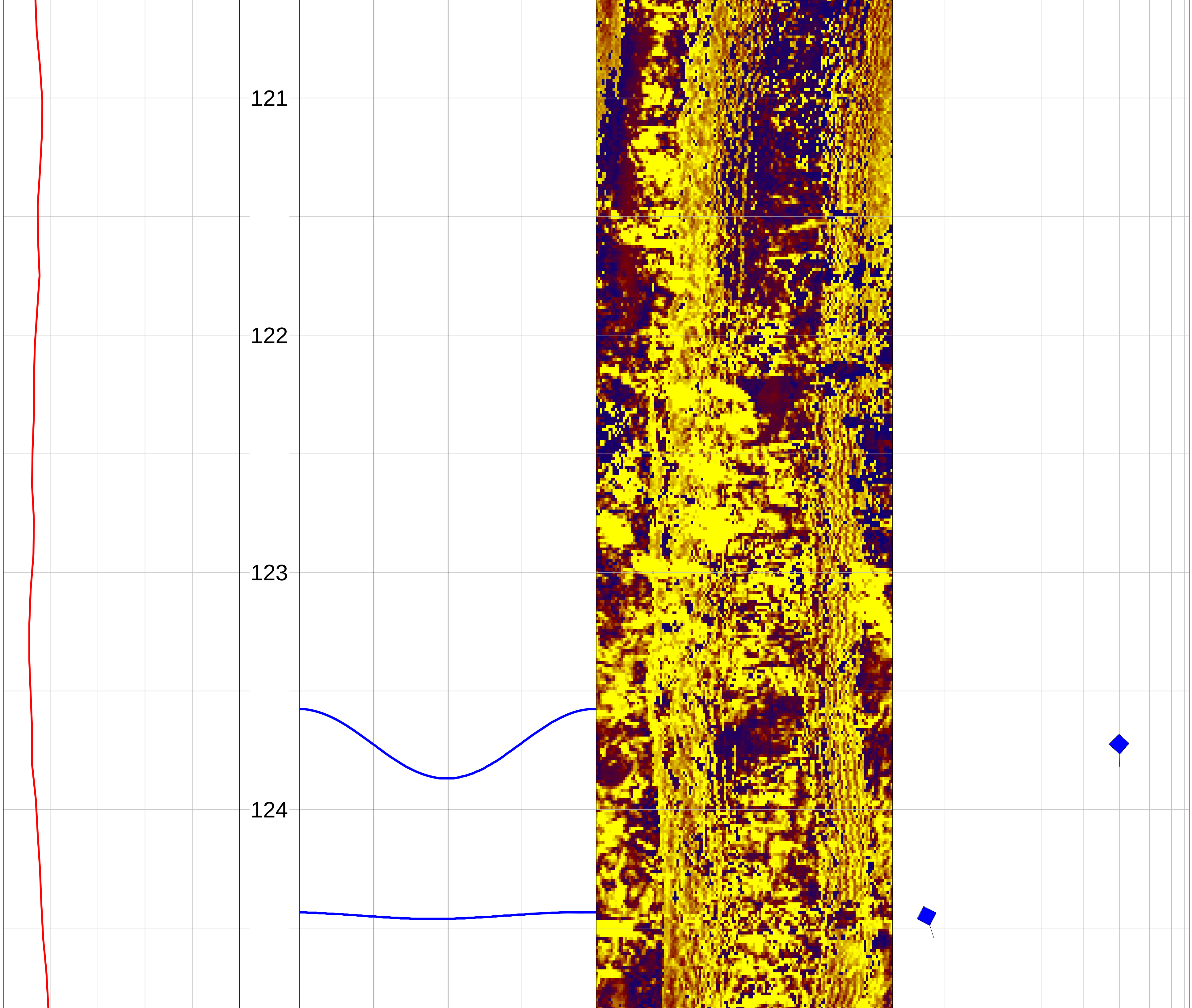

104
105
106
107

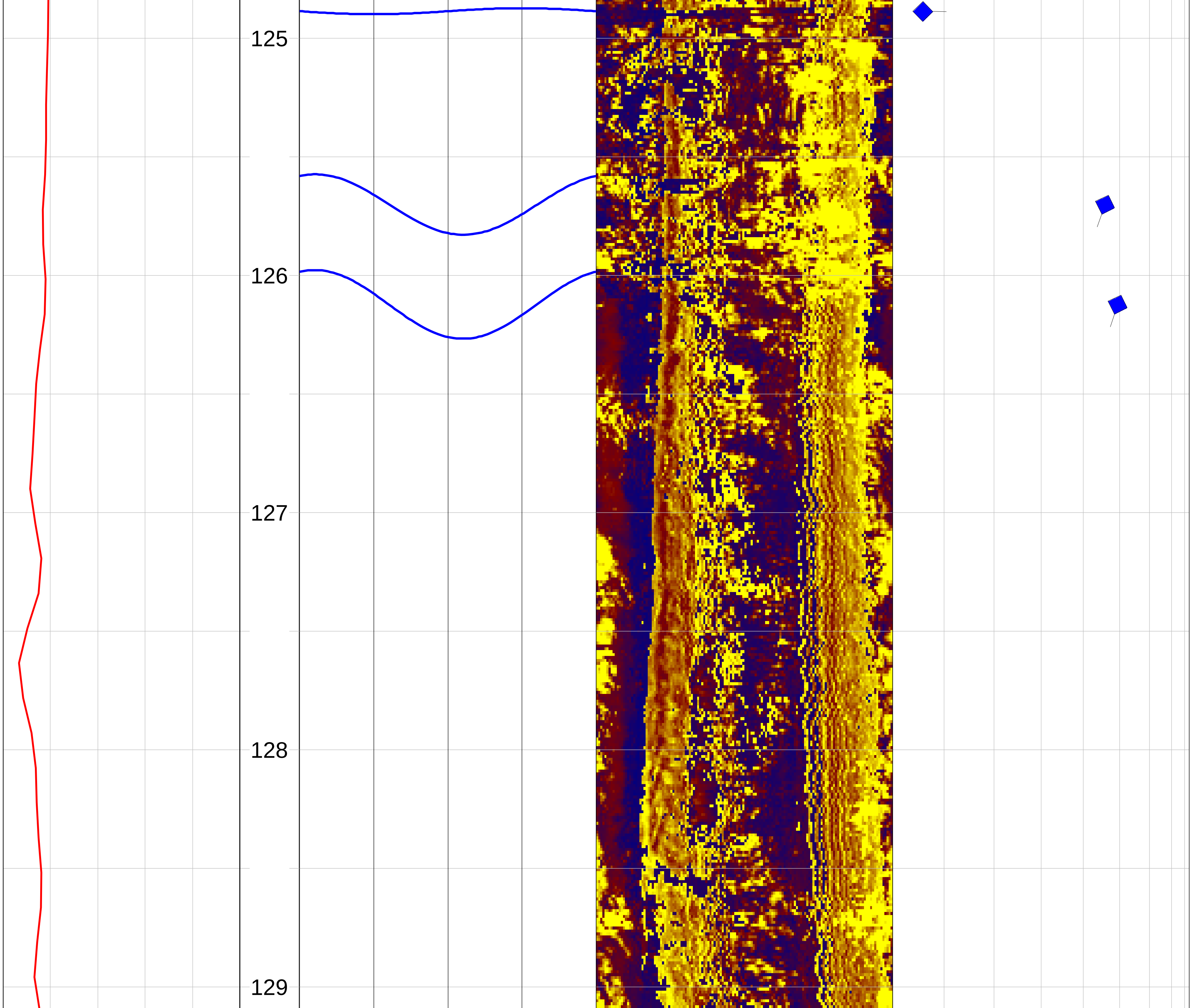

108
109
110
111
112



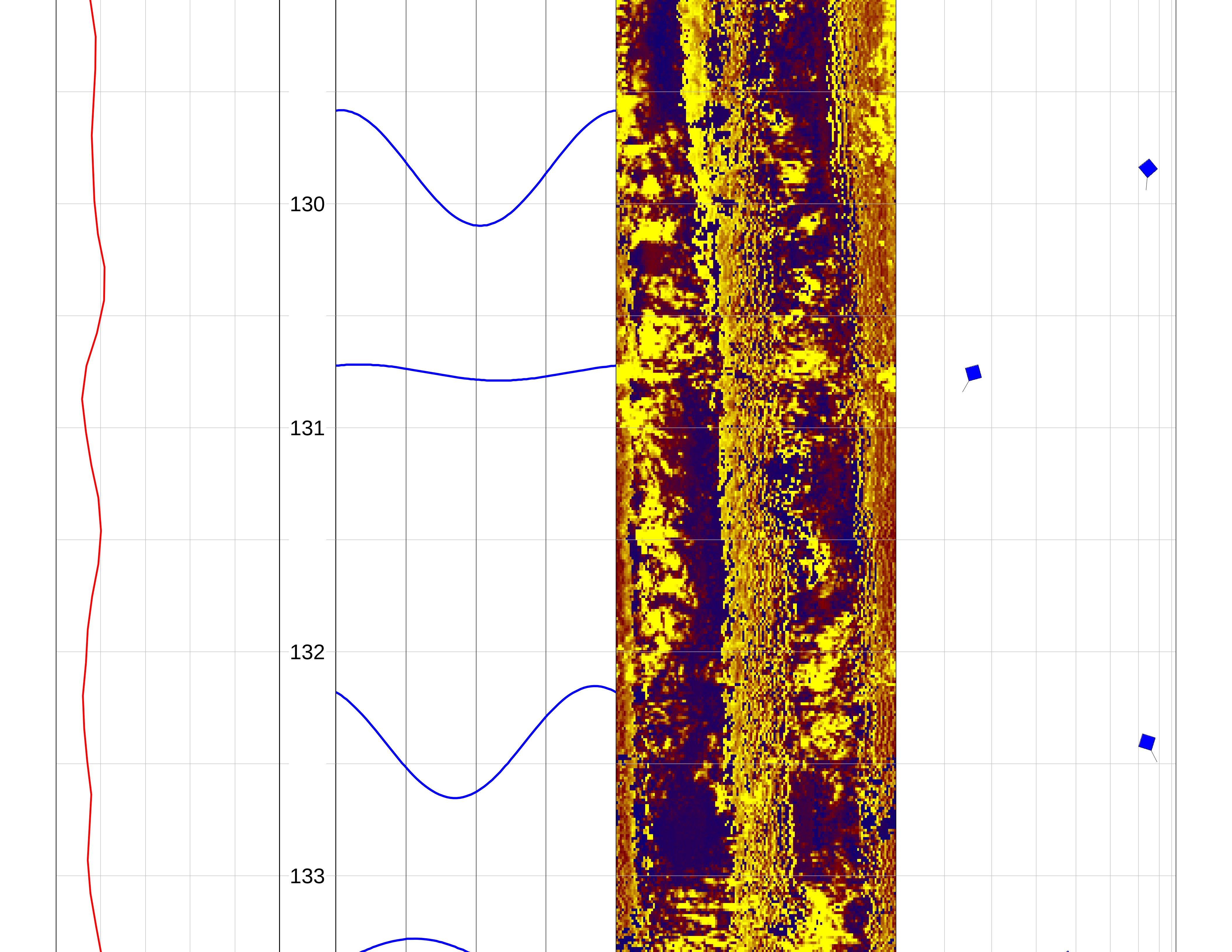
113
114
115
116

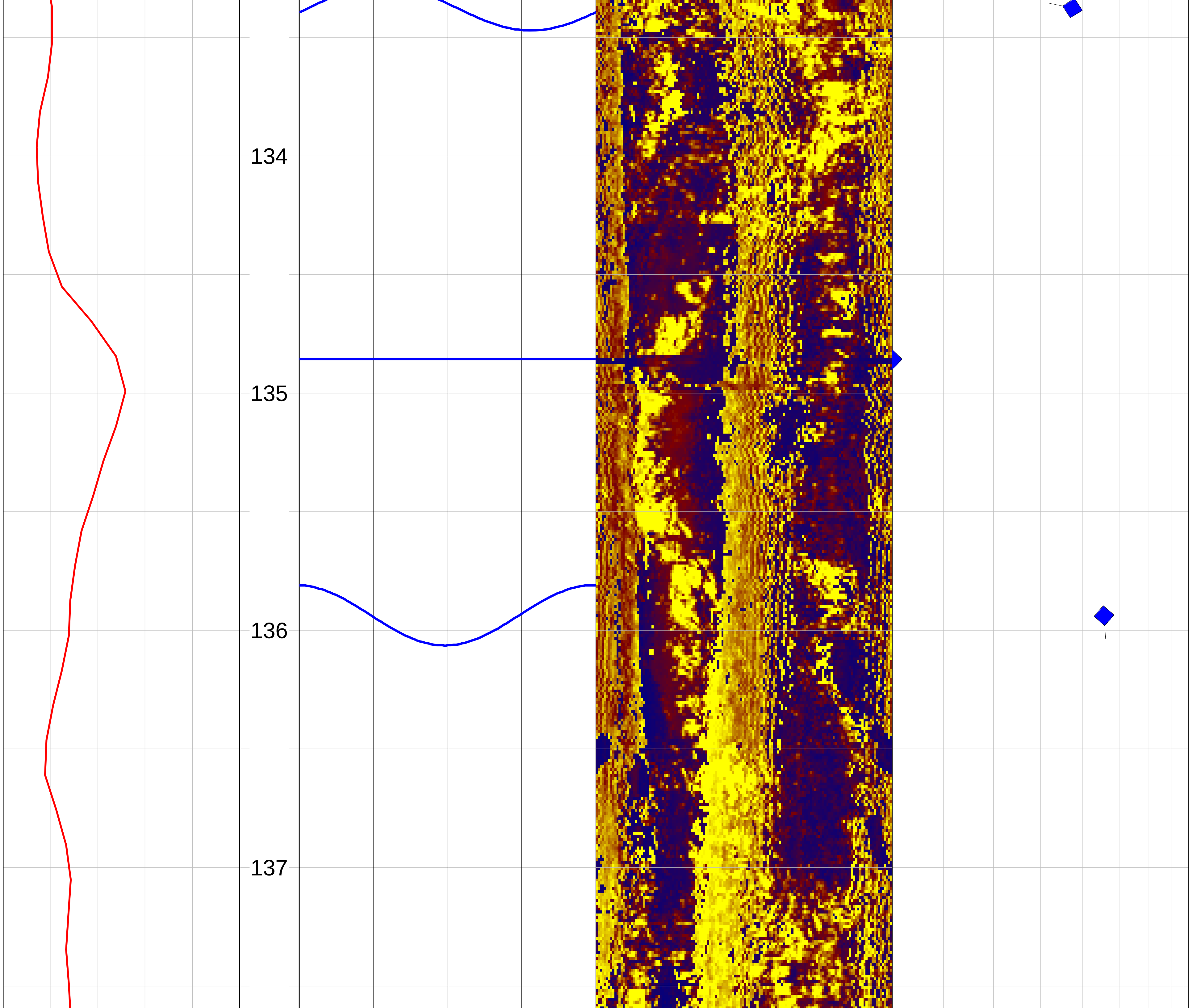

117
118
119
120

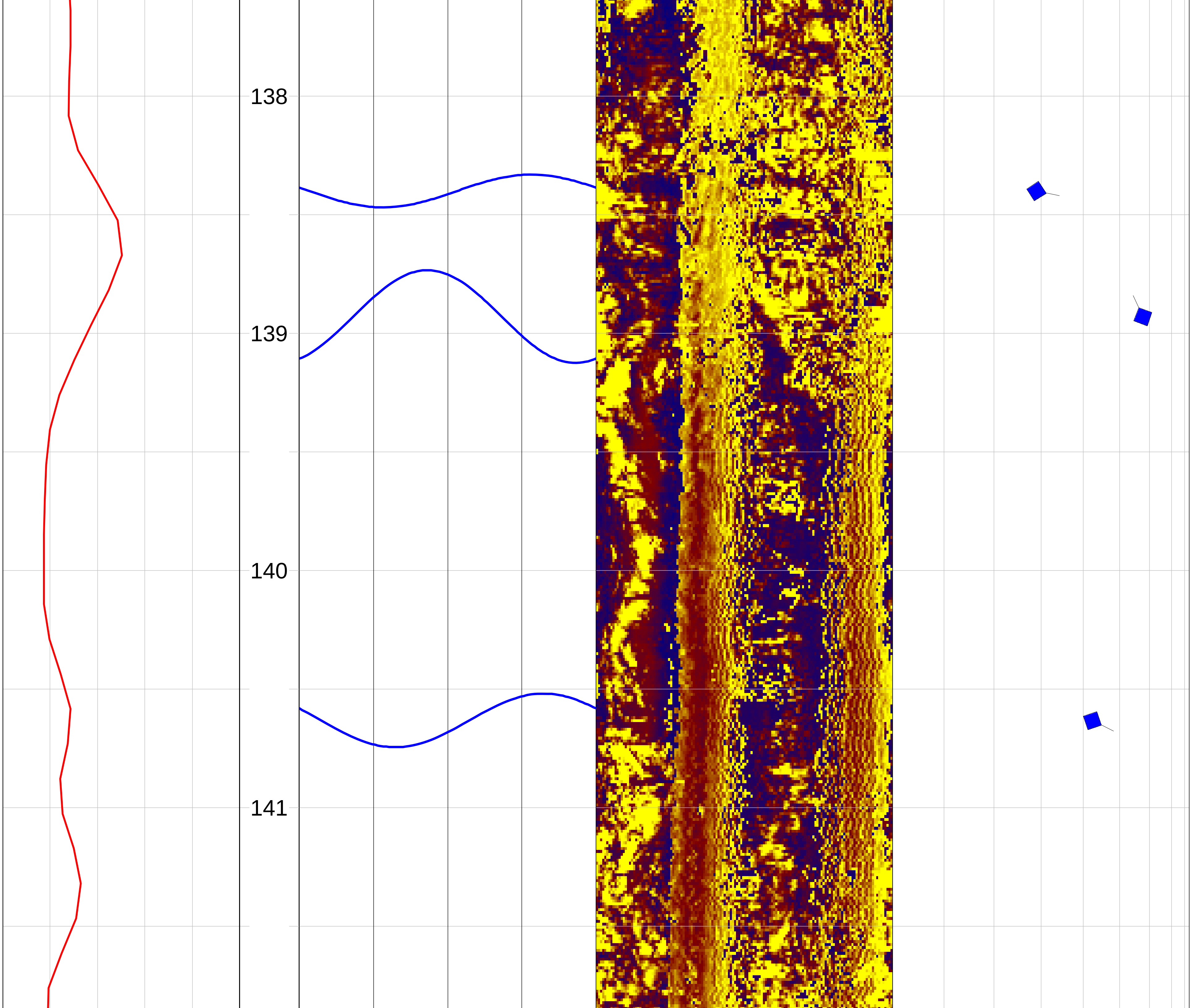

121
122
123
124



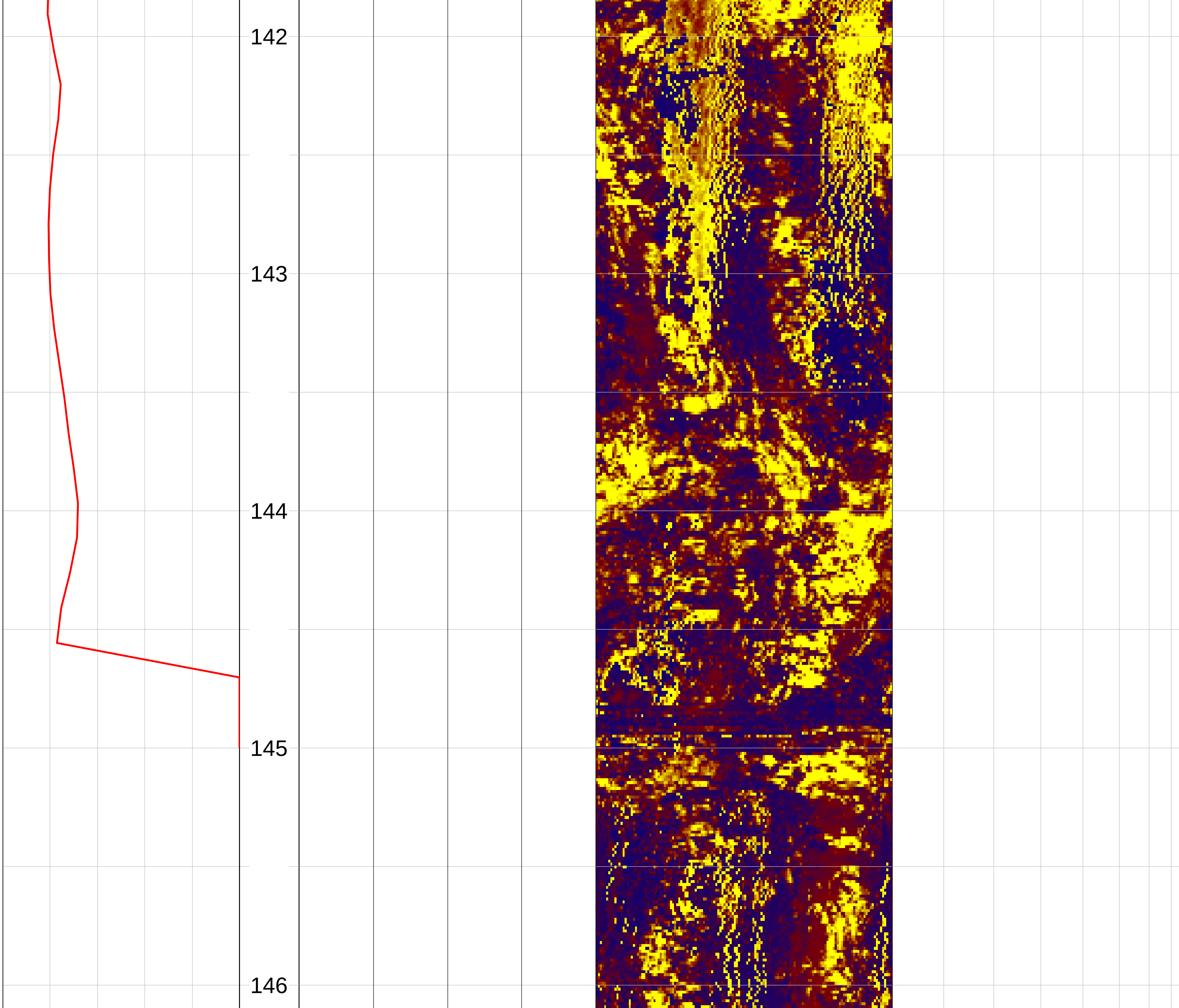
125
126
127
128
129

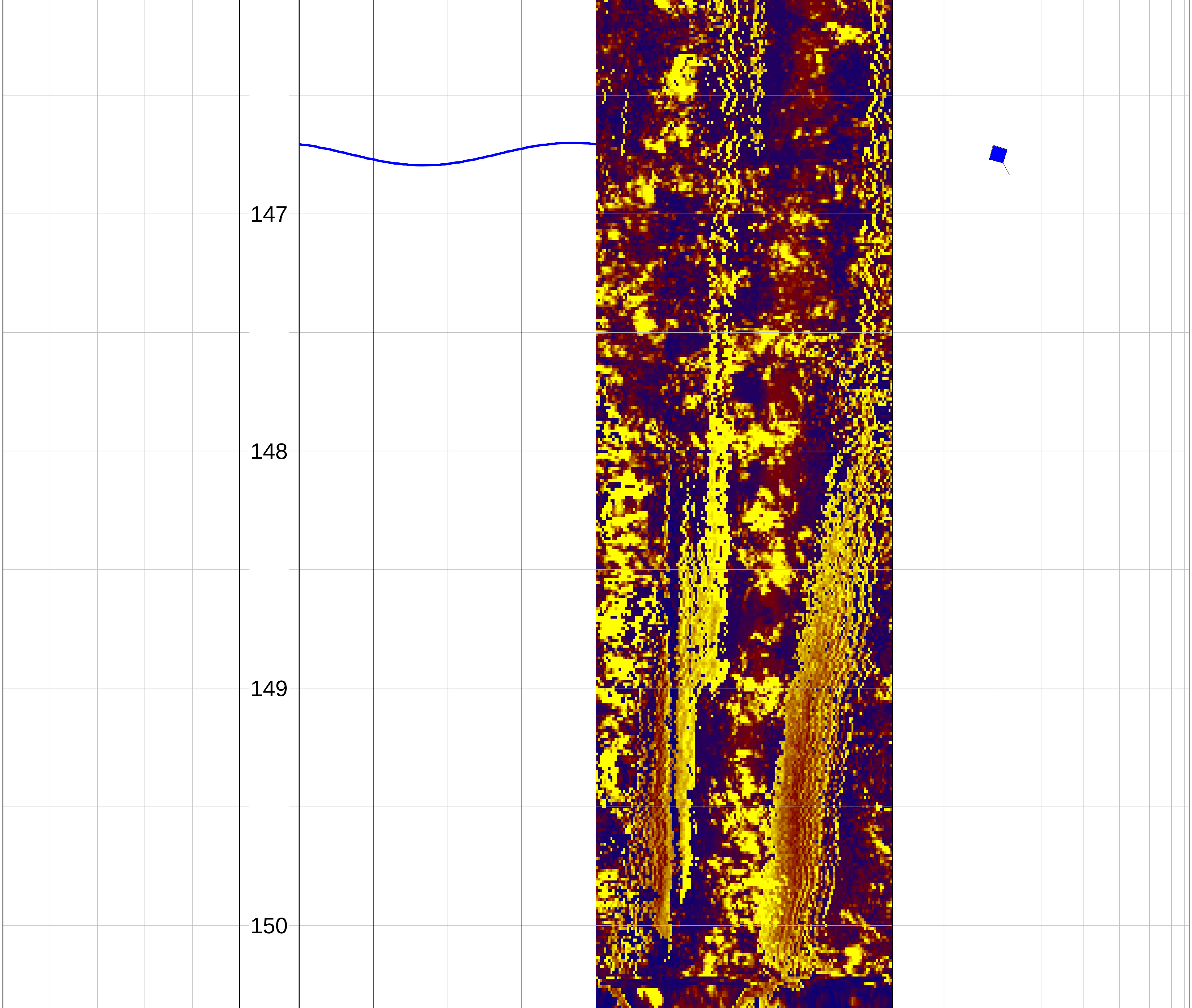

130
131
132
133

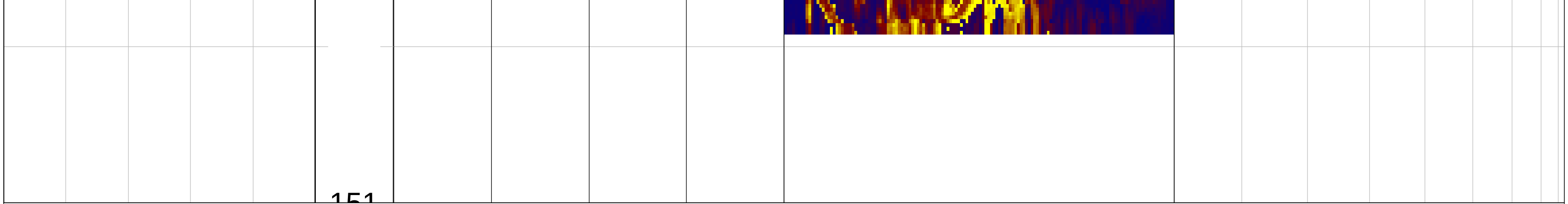

134
135
136
137



138
139
140
141


142
143
144
145
146


147
148
149
150



Natural Gamma	Depth	Projections	Acoustic Amplitude	Tadpole
0 cps 50	1in:0.5ft	0° 90° 180° 270° 0°	0° 90° 180° 270° 0°	0 90

Boring: Geo-02

APPENDIX C

LIMITATIONS OF REPORT

GEOPHYSICAL SERVICES

LIMITATIONS OF REPORT

1. This report was prepared for the exclusive use of the owner, architect, and engineer for evaluating the project as it relates to the technical aspects discussed herein. It can be made available to prospective contractors for information on factual data only and not as a warranty of subsurface conditions included in this report. Unless other contractual agreements were made, the services described in this report were carried out in accordance with the Terms for Geotechnology's Services that were attached to the proposal.

2. Geotechnology endeavored to perform the survey in accordance with generally accepted practices of other consultants undertaking similar studies at the same time and in the same geographical area. The findings and conclusions stated herein must be considered not as scientific certainties, but rather as professional opinions concerning the significance of the limited data gathered during the course of the survey. No warranty, express or implied, is made.

3. The geophysical analyses and conclusions contained in this report are based on the site conditions, project layout, grid size, geophysical data, and interpretive procedures described herein and are for preliminary planning purposes only. Geotechnology can make no interpretation as to the presence of underground features at locations beyond the survey lines.

4. Geophysical exploration methods are non-intrusive, indirect, and potentially influenced by a variety of natural or man-made conditions. The potential for detecting the presence or absence of underground objects or voids is based on the quality of the recorded data as limited by site conditions, and on the interpretation of the data received; hence, there will always be the potential of not observing a subsurface object or void or interpreting the presence of a subsurface object or void where one does not exist.