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December 20, 2019

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Oil Control Barrier and Bank Control
Draft Basis of Design Report - 30% Submission
Former ECI Refinery, East Chicago, Indiana

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Dear Dan and Natalie:

On behalf of Atlantic Richfield Company (ARC), please find attached the Draft 30% Basis of Design Report (BODR) for the Former Energy Cooperative, Inc. (ECI) Site in East Chicago, Indiana ("the Site") that describes a Remedial Action (RA) design for two parcels within the Site that will isolate oil in the South Tank Farm (STF) and the West Tank Farm (WTF) from the Lake George Canal (Canal). The Project is being developed in accordance with requirements of ARC and Stakeholders, and in accordance with the requirements of a 2018 Administrative Order on Consent (AOC). The proposed design is also consistent with the planned Great Lakes Legacy Act (GLLA) work in the Canal under a 2018 Project Agreement. The Project, as required in the AOC, shall at a minimum include the design of an oil control barrier at the STF and bank control at the WTF. As you will see, the proposed design would be a betterment as it not only meets but exceeds the requirements of the AOC.

We look forward to you review and if you have any questions, please don't hesitate to contact me at (832) 619-5825.

Sincerely,

Paul G. Johnson
Operations Project Manager

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Draft Oil Control Barrier and Bank Control Basis of Design Report

30% Submission
Former ECI Refinery

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OIL CONTROL BARRIER AND BANK CONTROL
BASIS OF DESIGN REPORT
30% SUBMISSION

FORMER ECI REFINERY
EAST CHICAGO, INDIANA

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December 2019

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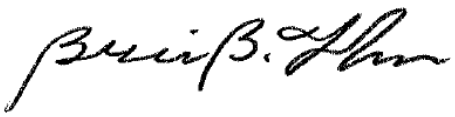

Brian B. Johnson
Associate Geotechnical Engineer

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LIST OF ACRONYMS AND ABBREVIATIONS

AOC	Administrative Order of Consent
ARAR	Applicable or Relevant and Appropriate Requirement
ARC	Atlantic Richfield Company
ASTM	American Standard Test Method
bgs	Below ground surface
bls	Below land surface
BODR	Basis of Design Report
C-HASP	Construction Health and Safety Plan
Canal	Lake George Canal
CDF	Confined Disposal Facility
CFR	Code of Federal Regulations
cm/sec	centimeters per second
CWA	Clean Water Act
DRO	diesel range organic
ECI	Energy Cooperative, Inc.
ECWMD	East Chicago Waterway Management District
El.	Elevation, in NAVD88
EMP	Emergency Management Plan
EOR	Engineer of Record
ERM	Environmental Resources Management
FS	Factor of Safety
ft	feet
ft/d	feet per day
ft/ft	feet per foot
gpm	gallons per minute
GLLA	Great Lakes Legacy Act
GLNPO	Great Lakes National Program Office
HASP	Health and Safety Plan
HTF	Hammond Tank Farm
HSE	Health Safety and Environment
H&S	Health and Safety

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IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
IFC	Issued for construction
IHC	Indian Harbor Canal
in/yr	inches per year
IP	Individual Permit
IRB	iron-related bacteria
K	hydraulic conductivity
lb	pounds
LF	linear feet
LLDPE	linear low density polyethylene
LNAPL	Light non-aqueous phase liquid
µg/L	micrograms per liter
NAVD88	North American Vertical Datum of 1988
NEPA	National Environmental Policy Act
NGVD29	National Geodetic Vertical Datum of 1929
NPDES	National Pollutant Discharge Elimination System
O&M	Operation & Maintenance
OC	Organoclay
PCA	Pollution Control Area
P-HASP	Project-Specific Health and Safety Plan
%	Percent
PRW	product recovery well
psf	pounds per square foot
psi	pounds per square foot
PVC	polyvinyl chloride
RA	Remedial Action
RCG	Remediation Closure Guide
RCM	reactive core mat
SI	Site Investigation
Site	The Former Energy Cooperative, Inc. Site in East Chicago, Indiana

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STF	South Tank Farm
SWTF	Southwest Tank Farm
SSWTF	South of Southwest Tank Farm
SWPPP	Stormwater Pollution Prevention Plan
Su	undrained shear strength
TBD	to be determined
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WOOD	Wood Environmental and Infrastructure Solutions, Inc.
WQC	Water Quality Certification
WTF	West Tank Farm

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EXECUTIVE SUMMARY

On behalf of Atlantic Richfield Company (ARC), Wood Environment and Infrastructure Solutions, Inc. (Wood) has prepared this 30% Basis of Design Report for the Former Energy Cooperative, Inc. (ECI) Site in East Chicago, Indiana ("the Site"; **Figure 1-1**) to describe a Remedial Action (RA) design for two parcels within the Site. The RA that will isolate oil in the South Tank Farm (STF) and the West Tank Farm (WTF) from the Lake George Canal (Canal) (**Figure 1-1**). The Project is being developed in accordance with requirements of Atlantic Richfield and the Stakeholders, and in accordance with the requirements of a 2018 Administrative Order on Consent (AOC). The Project, as required in the AOC, shall at a minimum include the design of an oil control barrier at the STF and bank control at the WTF. This proposed design includes a barrier wall system with robust environmental features, which enhances property value and use by stabilizing the existing bank. Thus, this proposed design increases ARC's costs, however, would be a betterment as it not only meets but exceeds the requirements of the AOC.

Starting in about 1917, the Sinclair Refining Company and its predecessor, Cudahy Refining Company, constructed the original refinery at the Site. Sinclair operated the refinery until 1969, when it merged into Atlantic Richfield. Atlantic Richfield continued to operate the refinery until 1976, when it was sold to C.F. Petroleum, a cooperative association that later changed its name to ECI. ECI continued to actively operate and expand the refinery related operations until approximately 1981, when ECI went into bankruptcy. A bankruptcy Trustee was appointed and took charge of the refinery operations, and the Special Master was then retained, in part, to assist with the dismantling of the refinery, disposition of the remaining oil, equipment and scrap, and to remove or flush, cap and close the remaining pipelines. It was subsequently determined that significant amounts of below grade piping were not properly cleaned, capped or removed by the Special Master, however, were left and still contained oil. Residual oil identified in the STF and WTF is now old and generally degraded oil based on historical records. These records indicate that hydrocarbon products typically stored on the STF and the WTF included diesel fuel, heating oils, gasoline, and lubricants which have become degraded and have limited environmental mobility (Arcadis, 2016 Site Investigation [SI]). Today, the East Chicago Waterway Management District (ECWMD) owns the Site.

As described in the 2016 SI (Arcadis, 2016a), the groundwater at the Site is not being used for drinking water nor will it be used as a source of potable water in the future. Dissolved groundwater concentrations at the STF and WTF do not pose a threat to surface water quality and do not require treatment. The remedial action objective of the base design is to isolate oil in upland areas of the STF and WTF from the Canal through passive remediation.

The proposed design is consistent with the planned Great Lakes Legacy Act work in the Canal under a 2018 Project Agreement, however, provides increased environmental and site benefits. The proposed STF oil control barrier betterment is conceptually planned as a fully penetrating sealed anchored bulkhead wall system (barrier wall system) in the Canal and the WTF bank controls are conceptually planned as a layered reactive cap system buried in the canal bank. The

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proposed design includes enhancements to the base design required by the AOC, including: a stable and usable waterfront at the STF, passive groundwater controls at the STF and appurtenances to accommodate potential active groundwater/stormwater pumping and controls should they be required in the future.

After this 30% Draft submission to United States Environmental Protection Agency (USEPA), a 90% Draft will be issued for their review and comment prior to the development of an issued for construction design, which is currently anticipated to be ready for delivery to USEPA on or about the spring of 2021 provided that the schedule is achievable and not influenced by factors beyond the control of ARC. Potential factors include potential changes in the location and depth of anticipated canal dredging and new geotechnical data.

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1.0 INTRODUCTION

On behalf of Atlantic Richfield Company (ARC), Wood Environment and Infrastructure Solutions, Inc. (Wood) has prepared this Basis of Design Report (BODR) for the Former Energy Cooperative, Inc. (ECI) Site in East Chicago, Indiana ("the Site"; **Figure 1-1**) to describe a Remedial Action (RA) design for two parcels within the Site. The RA that will isolate oil in the South Tank Farm (STF) and the West Tank Farm (WTF) from the Lake George Canal (Canal) (**Figure 1-1**) is hereafter referred to as "the Project". The Project described herein is being developed in accordance with requirements of ARC and the Stakeholders, and in accordance with the requirements of the Administrative Order on Consent (AOC) signed by the United States Environmental Protection Agency (USEPA) on December 13, 2018. The Project, as required in the AOC, shall at a minimum include the design of an oil control barrier at the STF and bank control at the WTF. A conceptual design has been advanced for the Oil Control Barrier that addresses the oil discharge. From the remedial options in the 2015 AOC work, a hanging wall barrier conceptual option for the STF and bank control for the WTF were identified as appropriate for addressing the oil discharge and are consistent with source control removal and remediation strategies that may be developed for the Site. This proposed design includes a different barrier system that would be a betterment to the required AOC design.

The proposed design is consistent with the planned Great Lakes Legacy Act (GLLA) work in the Canal under a 2018 Project Agreement (USEPA, 2018a). The STF oil control barrier betterment is conceptually planned as a fully penetrating sealed anchored bulkhead wall system (barrier wall system) in the Canal and the WTF bank controls are conceptually planned as a layered reactive cap system buried in the canal bank. The design may include enhancements to the minimum design required by the AOC, including: a usable waterfront at the STF, passive groundwater controls at the STF and appurtenances to accommodate potential active groundwater/stormwater pumping and controls should they be required in the future. Residual oil in the STF and WTF is generally old and degraded based on historical records which indicate that hydrocarbon products typically stored on the STF and the WTF included diesel fuel, heating oils, gasoline, and lubricants which have degraded and have limited environmental mobility (Arcadis, 2016 Site Investigation [SI]).

This BODR presents information used to support the proposed design of the Project for the STF and WTF to a 30% design level. At the 30% level, the proposed design is considered conceptual in nature and describes the scope of the Project and how the components relate to each other. Consequently, details and evaluations are not complete in this submission and will be expanded as the design progresses from 30% to 90% and finally Issued for Construction (IFC). The next design submission will be the 90% design, which is anticipated to include most design details and evaluations.

Following this Introductory Section, **Section 2** provides general project background information and **Section 3** describes the characteristics of the soils, groundwater and light non-aqueous phase liquid (LNAPL) historically identified at the STF and WTF. Evaluations and design parameters for the barrier wall and bank controls are presented in **Sections 4 and 5**, respectively. Construction permit

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requirements are presented in **Section 6** and Project specific controls are described in **Section 7**. Requirements for operation and maintenance (O&M) for the completed Project will be included as **Section 8** in the 90% submission along with design life for the Project elements. **Section 9** provides the proposed design schedule with review and delivery dates for the 90% and IFC submissions, each of which will include an updated design report. The technical specifications and design drawings that will ultimately be used in contracting the Project work are presented in **Sections 10 and 11**, respectively. All referenced sources of information used in the development of the design are identified throughout this BODR and summarized in **Section 12**, References.

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2.0 PROJECT BACKGROUND

Between 1916 and 1918 Sinclair Refining Company and its predecessor, Cudahy Refining Company, constructed the original refinery at the Site. Sinclair operated the refinery until 1969, when it merged into ARC. ARC continued to operate the refinery until 1976, when it was sold to C.F. Petroleum, a cooperative association that later changed its name to ECI. ECI to actively operate and expand the refinery related operations until approximately 1981, when ECI went into bankruptcy. A bankruptcy Trustee was appointed and took charge of the refinery operations, and the Special Master was then retained , in part, to assist with the dismantling of the refinery, disposition of the remaining oil, equipment and scrap, and to remove or flush, cap and close the remaining pipelines. It was subsequently determined that significant amounts of below grade piping were not properly cleaned, capped or removed by the Special Master, however, were left and still contained oil. Residual oil identified in the STF and WTF is now old and generally degraded oil based on historical records. These records indicate that hydrocarbon products typically stored on the STF and the WTF included diesel fuel, heating oils, gasoline, and lubricants which have become degraded and have limited environmental mobility (Arcadis, 2016 Site Investigation [SI]). Today, the East Chicago Waterway Management District (ECWMD) owns the Site. The Site has a USEPA ID of IND082547803 and complies with the 2018 AOC.

In 2002, Arcadis prepared an ECI Site Investigation Report (2002 Report; Arcadis G&M, Inc. 2002) to present site characterization data collected from various parcels. As described in the 2002 Report, LNAPL has been identified only on the STF and WTF parcels. The 2015-16 AOC Site Investigation Report (2016 Report; Arcadis) describes the collection of supplemental characterization data needed to design a remedy or remedies to isolate oil in the STF and the WTF.

Interim actions have been taken on the Site, including, but not limited to: the 1992 installation and continuing operation of an LNAPL recovery well system to recover free product from atop groundwater at the WTF and STF; maintenance of oil collection booms across the Canal to contain and remove sheens found on the Canal's surface; removal of petroleum found in surface soils on site; investigation and sampling work; and development of proposed final remedy options. Removal and capping of approximately 70,000 linear feet (LF) of relic abandoned pipeline (which the bankruptcy court contractor had failed to perform) began in August 2019 and the STF work was completed in November 2019. The WTF pipe removal work is scheduled for Spring 2020.

Regarding the operation of the product removal systems on the STF and WTF, Arcadis concluded:

"*In general, since LNAPL recovery is declining and LNAPL exhibits potential mobility characteristics near the Canal in only localized areas, sheens in the Canal are not likely originating as a result of LNAPL seepage from the bank; the sheens are most likely generated by interaction of groundwater and surface water with soils and sediments near the Canal bank and groundwater/surface water interface.*" (Arcadis, 2016 SI, Pg 29)

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Due to this, after barrier wall system installation at the STF and bank controls at the WTF, sheens may be expected to continue until Canal dredging of oil impacted materials occurs, capping is complete, and remaining saturated materials achieve a new equilibrium in the Canal.

As described in the 2016 SI (Arcadis, 2016a), the groundwater at the Site is not being used for drinking water nor will it be used as a source of potable water in the future. Nevertheless, groundwater analytical results were compared to Indiana Department of Environmental Management (IDEM) Remediation Closure Guide (RCG) screening levels for tap water ingestion as they provide a conservative reference point. In general, dissolved-phase groundwater constituents at the Site are low in concentration and groundwater largely meets the drinking water standards. Exceedances of the 1-methylnaphthalene RCG screening level (11 micrograms per liter [µg/L]) were observed in five wells, ranging from 12.4 to 49.8 µg/L. The maximum benzene and 1-methylnaphthalene groundwater concentrations are significantly below respective Human Cancer Criteria / human cancer value surface water criteria. Therefore, dissolved groundwater concentrations at the STF and WTF do not pose a threat to surface water quality. Evaluations in Arcadis 2016 show that dissolved benzene and dissolved polynuclear aromatic hydrocarbons at the STF and WTF do not require specific RA. Based on infrequent and very low dissolved concentration detections of benzene, toluene, ethylbenzene, and xylenes, and naphthalene in groundwater and the permeable surface soils at the Site, which do not typically restrict infiltration into groundwater encountered at shallow depth, existing soil impacts do not pose a significant risk to groundwater, as any leaching from soils which would lead to significant groundwater impacts would be expected to have already occurred and been reflected in the groundwater monitoring wells. Based on the above lines of evidence and as agreed to by the USEPA, current soil and groundwater conditions do not require remediation to protect groundwater, and the remediation efforts should be focused on addressing potential migration of LNAPL/sheens. (Arcadis, 2016).

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2.1 Project Goals

The Project is being implemented to achieve the following goals:

- The remedial action objective of the base design is to isolate oil in upland areas of the STF and WTF from the Canal through passive remediation.
- The Project will provide enhancements to the base design, consistent with the AOC. To further isolate oil in the STF, these will passively mitigate effects of potential groundwater mounding behind the wall and flow around the ends of the wall and provide appurtenances to efficiently upgrade the remedy to potentially include optional active water and oil control.
- The Project will be consistent with the currently planned GLLA canal improvements, including dredging and capping, based on information provided by Tetra Tech on behalf of the United States Army Corps of Engineers (USACE) and GLLA Partners.

- The Project will "prevent, minimize and/or mitigate damage to public health or welfare, including but not limited to, fish, shellfish, wildlife, and public and private property, shorelines, and beaches, habitat, and other living or nonliving natural resources under the jurisdiction or control of the United States", as required by the AOC, by isolating oil in the STF and WTF.
- The Project will be "consistent with the National Contingency Plan to protect public health and the environment and to abate, prevent, minimize, stabilize, mitigate or eliminate the discharge or threat of a discharge at or from the facility to navigable waters, adjoining shorelines or which may affect natural resources of the United States", as required by the AOC, by isolating oil in the STF and WTF.

2.2 Regional Geology

The following description of the regional geology is taken from the United States Geological Survey (USGS) Water Resources Investigation Report 92-4115 (Fenelon and Watson, 1993). This report described a study area covering approximately 70 square miles and including the cities of East Chicago, Gary, Hammond and Whiting in northern Lake County, Indiana, and along the southern shore of Lake Michigan.

> "The following is a brief summary of the study area *[i.e., covering the drainage basins of the Little and Grand Calumet Rivers]*. A detailed description that includes maps of the underlying bedrock surface, the base of the Calumet Aquifer, the saturated thickness of the Calumet aquifer, and the surficial geology was written by Watson and others (1989) (provided as **Appendix A**).
>
> The Calumet aquifer consists primarily of dune, beach, and lacustrine sands with thin (generally less than 1 ft) interbeds of peat and organic materials of small areal extent and scattered lenses of silt and fine gravel. Watson and others (1989) included slag fill when they mapped the Calumet aquifer because, in general, the slag fill is not vertically extensive. The thickness of the aquifer sand ranges from 0 to 65 ft. The aquifer is thickest in the east, where the maximum saturated thickness is about 45 ft. The aquifer thins to the west and pinches out in lacustrine clay near the Indiana-Illinois State line. The aquifer also pinches out in glacial till in the southwestern part of the study area, in the valley of the little Calumet River.
>
> Glacial till and lacustrine clay immediately underlie the Calumet aquifer. This till and lacustrine clay unit ranges in thickness from 50 to 140 ft and forms a confining unit between the Calumet aquifer and the underlying carbonate bedrock. Lithologic logs indicate that the top of the clay unit slopes gently toward Lake Michigan and, in the area of the Indiana Harbor Canal, forms a depression that is 5 to 10 ft deep. In the area of this depression, the upper 20 ft of the clay unit is loosely consolidated lacustrine or paludal clay.
>
> Carbonate bedrock of the Silurian and Devonian age underlies the clay unit. The erosional bedrock surface has about 70 ft of relief in the study area and slopes gently toward Lake Michigan. The most prominent feature on the bedrock surface is a north-trending bedrock

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valley in the area of the Indiana Harbor Canal where the canal flows to the northeast." (Fenelon and Watson, 1993)

2.3 Site Description

The ECI Site is a former refinery and petroleum storage facility located in East Chicago and Hammond, Lake County, Indiana (**Figure 1-1**). The surrounding areas include other oil refineries, steel mills, and other heavily industrialized facilities. The former Main Refinery parcel of the Site was converted into a USACE Confined Disposal Facility (CDF) in 2009. The CDF receives dredged sediments from the surrounding waterways. USACE is planning to raise the berms at the CDF between 2021 and 2023 to increase the capacity of the CDF). The Site is comprised of generally flat properties that have been subdivided into the following eight parcels for identification purposes (**Figure 1-1**):

- CDF, formerly the Main Refinery and North Tank Farm;
- Hammond Tank Farm (HTF);
- Pollution Control Area (PCA);
- Southwest Tank Farm (SWTF);
- South of Southwest Tank Farm (SSWTF);
- STF (included in this design);
- South of South Tank Farm; and
- WTF (included in this design).

The Canal bisects the Site, separating the northern part from the southern part. It is approximately 1.25 miles long and considered a navigable-in-fact waterway that extends westward from the Indiana Harbor Canal (IHC) and currently used to access the CDF. The Canal was created in or after 1888 when the Calumet Canal and Improvement Company and the Standard Steel and Iron Company conveyed a right of way for a Canal to the United States of America. Currently, the Canal is the only significant surface water feature at the Site. In addition to local groundwater recharge and stormwater runoff, industrial discharges from upstream sources in the Grand Calumet River and IHC also flow to the Canal, which may contribute to sheens observed in the Canal.

The Site is bounded to the east by Indianapolis Boulevard, and located beyond that are a Safety Kleen used oil recycling facility, Tierra Environmental & Industrial (an environmental waste control contractor) and a former ExxonMobil petroleum storage and refining facility that is currently a Buckeye bulk oil storage and terminal facility. The Baltimore Ohio Railroad (currently owned by CSX Railway) runs north-south across the Site and separates the eastern and western parts of the Site and crosses the Canal on a railroad bridge (**Figure 1-1**). A variety of pipelines, both active and inactive were removed from the STF in 2019. An operating petroleum pipeline alley is also located on the south side of the STF that contains numerous pipelines owned by various petroleum companies and the pipelines not associated with the ECI Site are to remain after this Project is complete. Beyond the pipeline alley

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to the south is the Mac Arthur Golf Course owned by the City of East Chicago and the East Chicago Central High School buildings and athletic fields.

Although some historical information regarding locations of tanks and other equipment in place during active Site operations is available, a comprehensive record of Site structures, petroleum storage facilities, and handling facilities is not available. As part of Site demolition activities conducted under bankruptcy court supervision, underground piping was reportedly cut below land surface and has since been removed in the STF as previously stated.

Geophysical survey and test pitting activities were conducted in 2002, 2013, and 2015 to evaluate the reliability of historical mapping information and to attempt to identify pipes or other subsurface structures on the STF adjacent to the Canal. These activities generally provided confirmation of historical pipeline mapping and located some water lines not identified on historical maps. A collective summary of geophysical investigation and test pitting work to date, as it relates to location and characterization of buried piping, is provided below.

The 2002 Arcadis SI was conducted in selected areas of the upland portion of the STF and WTF parcels and concluded that significant portions of the historical piping likely remain in place. The geophysical survey results and trench locations are presented on figures in **Appendix B.1.1** (Arcadis G&M, Inc., 2002). Test trenching completed in 2002 identified buried piping at four of six trenches on the STF and at two of three trenches on the WTF. Additional details are discussed in Section 4.5 of the 2002 Site Investigation Report (Attached in **Appendix B.1.1**).

The 2013 Arcadis investigation was conducted in a focused area of the STF near the Canal, as described in the text and shown on the figures included in **Appendix B.2.** This investigation was designed specifically to identify the presence of any buried pipelines extending in a north-south direction that may pass under the Canal. The 2013 survey identified several linear piping features, extending in an east-west direction near the Canal, inside the perimeter fence; however, these features were identified to be water lines, based on exposure and visual observation of the piping, and which are shown on the Existing Conditions Plans for the STF in **Appendix I**. An eight-inch diameter water line was found near the northeastern corner of the STF, which is shown stopping; and this will be further researched to show its extent. In 2002, an 8-inch water line was identified and reportedly 15 feet (ft) of it below the Canal was removed (Weston, 2002). Historical records also have indicated the presence of buried water lines at the STF (there are no active water lines known to exist in the STF, proximal to expected Project work limits) consistent with this conclusion. No evidence of pipelines traversing the Canal, or buried pipelines containing petroleum products, was identified in the study area. Additional details are provided in the 2013 Geophysical Survey and Test Pit Investigation Report (Arcadis 2013).

The 2015 AOC Site Investigation focused on detailed characterization of potential buried piping along the northern portion of the STF, adjacent to the Canal, with emphasis on an area in the northwestern portion of the STF that was not included in the 2013 investigation. The evaluation provided detailed information on several areas of geophysical anomalies and confirmed the presence of several buried

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piping runs. While some staining of soil in test pits was noted, no direct evidence of leaking piping was observed.

The following subsections describe physical features of the STF and WTF. Geology, hydrogeology, geotechnical and LNAPL are described in **Sections 3 through 5** in general and related to the barrier wall and bank controls, respectively.

2.3.1 South Tank Farm – Physical Description

The STF extends about 2,050 ft along the Canal and about 1,075 ft north-south, covering approximately 53.5 acres. The STF is bounded to the north by the Canal, to the east by Indianapolis Boulevard, to the south by an unimproved extension of McShane Avenue and to the west by the CSX railroad tracks with the SWTF and SSWTF beyond (**Figure 1-1**). Surface grades range from approximately elevation (El.) 588 ft in the central part of the STF to about El. 580 to 585 ft at the top of the Canal bank. The current slope of the bank ranges from approximately 2.5 horizontal to 1 vertical (2.5H:1V) to 4H:1V between El. 584 and El. 574 ft south of the navigation channel and 2.5H:1V to 9H:1V to the west with the steepest slopes near the under-canal pipe crossing. A 6-ft tall chain link perimeter fence surrounds the STF and has been identified by ARC to be coincident with the property line. The STF is accessed through a gate at the southeast corner, off Indianapolis Boulevard, and by the north-south gravel drive that ends near the northeast corner of the STF.

Existing conditions at the STF are shown on the Existing Conditions – STF Plans (**Drawings C-101, 102 and 103**) in **Appendix I**, including topography, utilities, existing wells and STF surface features (before pipeline removal work began in 2019, as approved by USEPA [USEPA, 2018b]), relevant historic subsurface explorations, surface infrastructure, and adjacent areas. These existing conditions will change following the pipeline removal work; consequently, as-built documents will need to be reviewed to update these conditions following pipeline removal activities.

A concrete channel with asphalt shoulders exists east of the STF and receives stormwater run-off from the STF, roadway and from a pumped discharge southeast of the Site (believed to be area stormwater). The remainder of the STF stormwater flows to the Canal as sheet flow, with minimal concentrated flow along the western side, beyond the Perimeter Fence where it discharges to and through a "concrete tunnel" below the railroad tracks and discharges to the west. The details of the abutments for the rail road and Indianapolis Boulevard are unknown at this time.

Known utilities at the STF include underground gas, inactive underground water, overhead utility lines, a wildlife deterrent system, and the Product Recovery System including an underground electric line, as described below:

- Four operating gas lines are shown on the existing conditions plan, based on information provided by Stantec, as on **Drawings C-102 and 103** in **Appendix I**).
    - An underground gas line (G-1), owned by BP exists along the western side of the STF, approximately 20 ft east of the perimeter fence adjacent to the rail road

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tracks, which turns southeast and ultimately west near the southern side of the perimeter fence. Gas line G-1 is to be determined (TBD)-inches in diameter, TBD (type) pipe, approximately TBD ft deep, installed in approximately TBD. Gas line G-1 is not known to exit the STF in the northwest corner but it is unknown if it continues under the canal; however, this will need to be confirmed as the design progresses.

  - Two additional underground gas lines (G-2 and G-3) exist along the eastern side of the STF, approximately 60 ft west of the perimeter fence. Gas line G-2 is owned by NIPSCO, is 16-inches in diameter, TBD (type) pipe, approximately TBD ft deep. Gas line G-3 is owned by Buckeye, is TBD-inches in diameter, TBD (type) pipe, approximately TBD ft deep, installed in approximately TBD. Gas line G-3 continues from the STF to the north, travels below the Canal and will bisect the barrier wall, while G-2 turns eastward just south of the existing Product Recovery System.

- An inactive underground water line (and possibly 3 separate lines), W-1, is reportedly located along the northern side of the STF, just north of the Product Recovery System.
- Overhead utilities exist in the northeastern and northern portions of the STF. OHU-1, extends from near PRW-38/39 to the east and continues off the STF. OHU-1 is expected to be removed prior to Project implementation and its existence will be confirmed and **Drawings C-101 and C-103** modified as appropriate. Other Overhead utilities in the northeastern corner of the STF will remain and provide power to the Product Recovery System as well as temporary trailers
- A wildlife deterrent system owned and operated by ARC is located north of the perimeter fence along the Canal, north of PRW-TBD. The system is a wetland wailer that is operated by battery and other various deterrents and the operation is outlined in the approved Waterfowl Mitigation Plan (Arcadis, 2015).
- The Product Recovery System includes 41 wells and an aboveground header pipe, which are insulated, and heat traced. Power to each well is supplied by an adjacent electrical conduit, south of the header pipe. Details are available in the O&M Plan for the Site. Available information on the rate of oil recovery is provided in **Appendix B.5**.

An existing wooden bulkhead exists near the northwestern corner of the STF, which is approximately 28 ft long (west to east) (Weston, 2002, provided as **Appendix B.6**). The top elevation of this wall is at approximately El. 580 ft, based on the Site Datum which is North American Vertical Datum of 1988

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(NAVD88) (El. 580 ft)[1]. The details of the wooden bulkhead construction are unknown, and its remnants will be removed to the degree necessary to install the barrier wall system. The wall coincides with a group of nine buried pipes that exist below the Canal, penetrate the wall and extend approximately 50 ft south of the wall/Canal and into the STF. Nine of these steel pipes, ranging from 8 to 14-inches in diameter and ¼-inch-thick, were abandoned in-place below the Canal, as documented in the Indiana Harbor Pipeline Removal Report for Indiana Harbor Canal Pilot Project Site in East Chicago, Indiana, by Roy F. Weston for the USEPA (Weston, 2002). These nine pipes (Pipes 1 through 9) were capped and grouted where they remain below the Canal. Four additional pipes existed about 100 ft east of the railroad bridge and one 8-inch water line also existed about 1,000 ft east of these four pipes (Pipes A through E). The remaining nine pipes have been described (Weston, 2002) as "*from approximately 45 feet north of the canal wall* (on the main refinery parcel)*, the pipelines descend at a 45 degree angle down toward the bottom of the canal. The pipelines cross through the canal-wall steel sheetpiling (*on the Maine Parcel [CDF facility]) *approximately 35 ft bgs, lie in the bottom of the Canal in a pipeline alley crossing the STF Parcel, pass through the wooden bulkhead, ascend at a 45 degree angle, and surface*(ed) *approximately 60 feet south of the wooden bulkhead on the STF parcel*." In 2002, only the pipes below the canal (1 to 9), which were abandoned except the portions that extended about 50 ft south onto the STF remained and were fitted with 2-inch diameter riser pipes to mark their locations, with pipes A to D removed below the canal and south onto the STF by about 50 ft. The pipe "E", which is the "*8-inch diameter pipeline* (water line)*, located approximately 1,000 feet east (*of the railroad bridge)*, was collared, drilled, cut, contents pumped, and an approximately 15-foot section removed*" and the rest was capped and filled with concrete grout and remains below the canal after an attempt to pull it with a crane was unsuccessful. Subsequent work to remove more of these pipes is understood to be part of the recently completed pipeline removal work and based on expected as-built documents their extension into the STF will be better known and reflected on **Drawing C-102** in **Appendix I** when available.

Existing structures include a 4,000 gallon storage tank with containment and one permanent building in the northeastern corner of the STF. Temporary buildings and construction contractor temporary facilities may be located in this area for this Project. Former tank foundations exist across the STF, with unknown conditions that are not currently conflicting with the Project and are not planned for demolition. Based on the current design, none of the known tank foundations will require removal to install the barrier wall system.

2.3.2 West Tank Farm – Physical Description

The WTF extends about 350 ft along the Canal and about 2,300 ft north of the Canal, covering approximately 18.3 acres. The WTF is bounded to the east by the CSX railroad tracks followed by the CDF, to the south by the Canal, and to the west by the PCA, owned by the ECWMD, and a tank farm

[1] Elevations used throughout this design refer to North American Vertical Datum of 1988 (NAVD88) and are identified as El. X ft, unless otherwise noted. Historic documents either did not identify datum or used "ASL or amsl" which is unknown or NGVD29.

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owned by the BP Whiting Business Unit (**Figure 1-1**). Surface grades at the southern end of the WTF range from approximately El. 585 ft to about El. 582 ft at the top of the Canal bank. The current slope of the bank ranges from approximately 3.5H:1V to 5H:1V between El. 582 and El. 573 ft (i.e., where the majority of bank controls will be constructed). The southern portion of the WTF is accessed via a gravel road west of the WTF, with equipment access off that road to the southern portion of the WTF where this Project will occur.

Existing conditions at the WTF are shown on the Existing Conditions – WTF Plan (**Drawings C-104 and 105**) in **Appendix I**. Drawing C-104 shows general parcel features, topography and Project access. **Drawing C-105** is a more focused view of the southern portion of the WTF where the bank control measures will be installed and includes topography, utilities, existing wells and surface features, relevant historic subsurface explorations, surface infrastructure, and adjacent areas.

A surface berm at about El. 585 ft exists north of the Product Recovery System, direct runoff toward the eastern side of the WTF. Two 10-inch diameter polyvinyl chloride (PVC) pipes exist near the southeastern corner of the WTF and four 6-inch diameter exist to the west, which direct stormwater toward the Canal. The topography down slope of these pipes is unclear at this time; however, they would direct flow toward the Canal, which may be altered as part of this Project.

Known utilities in the southern portion of the WTF include the Product Recovery System. The Product Recovery System includes six wells and an above ground header pipe. The presence of an electrical conduit is expected, similar to that at the STF. The electric feed and product discharge location is assumed to be from the northwest, with product stored historically in an above ground tank. The layout of electrical and piping is unknown near the building and storage tank and beyond the expected limits of work for this Project. There are no known underground utilities exiting the WTF and continuing to the south under the Canal.

Existing structures in the southern portion of the WTF include the Product Recovery System building and storage tank and two concrete ramps to the south, and an above ground structure which provides access to the old pipeline tunnel under the canal is located at the southwestern corner surrounded by a fence is owned by BP Pipelines (details are TBD).

2.4 Anticipated Canal and Upland Redevelopment

The current bathymetry (as of 2017) was provided by Tetra Tech on Drawings LGE-001 to 005 (Attached in **Appendix B.3.1** and shown on **Drawings C-101 through 105 in Appendix I**). The Canal is anticipated to be dredged or capped, in accordance with the October 25, 2018 Project Agreement (USEPA, 2018a), the October 25, 2018 Statement of Work (SOW, 2018) and the GLLA planned bathymetry (Tetra Tech, 2015d, **Appendix B.3.2**).

Canal redevelopment is assumed to result in the GLLA planned bathymetry which will be shown on the **Drawings in Appendix I** (NOTE: Complete information is not yet available to Wood/ARC, only 2/10 drawings as pdfs are available). North of the STF, this bathymetry includes a bottom of canal at El. 560

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ft[2]. For this proposed design, it is assumed that dredging will be to El. 559 ft. Dredged side slopes, where the bottom of the dredge cut slopes up to the upland is assumed to be as planned by GLLA. At the north slope of STF the side slope is shown as 1H:1V (i.e., a 45-degree angle). The current north slope of the STF, below the water-line generally exists at slopes between approximately 3H:1V and 4H:1V from Tetra Tech station 0+00 to 13+00 (the current channel) to approximately 13H:1V to 21H:1V west of the canal and approximately 3H:1V east of the railroad bridge, which are flatter and more stable than the planned 1H:1V slope (**Appendix B.3.1**). No dredging is planned by GLLA to the south of the WTF; however, a 6-ft-thick sand based cap supported at its east end by a sheet pile wall is planned to be installed on existing sediments, resulting in the GLLA planned bathymetry (i.e., dredging plan) shown on **Drawings C-104, 105 and 111 in Appendix I** (Tetra Tech, 2015d, Attached as **Appendix B.3.2**). No Canal-side redevelopment is accommodated in this proposed design, south of the WTF.

Upland development at the STF and WTF has not been defined at this time. This proposed design accommodates modest redevelopment south of the STF bulkhead, by allowing an optional surcharge load of approximately 250 pounds per square foot (psf), which is comparable to two (2) ft of soil, a lightly loaded building or heavy equipment use within about 100 ft south of the deadman with little to no limitations further south expected. The buried tiebacks at the STF will be approximately 3 to 6ft bgs (at El. 580 ft); consequently, buried utilities perpendicular to tiebacks or below their elevation is generally not feasible because tiebacks can't be removed for utility maintenance. Buried utilities and foundations may be accommodated following wall installation, provided they are consistent with wall design assumptions. At the WTF, an optional surcharge load of 250 psf will also be applied in stability evaluations and is expected to be limited within about 100 ft north of the top of the bank. These optional surcharge loads influence global slope stability of the bank, which will be evaluated in the 90% submission and if changed to accommodate future redevelopment will require the developer to perform supplemental stability evaluations.

Previous conceptual designs included a hanging or perforated barrier wall (as identified in the 2018 AOC), to allow oil-free groundwater to flow beneath the upper barrier which would isolate the oil. These openings would be in the sandy soils above the clay and required to pass approximately 50-100 gallons per minute (gpm) on an annual average basis. Due to the decision to install the barrier as a bulkhead, the vertical face of the wall will extend down to the clay or just above the clay, with the sheets continuing into the clay approximately 23 to 25 ft (**Figure 2-1**). If openings were installed above the clay, the flow through those openings would be expected to erode the soils from behind the bulkhead into the Canal through the openings due to high velocities, very likely resulting in excessive geotechnical stability concerns, including settlement south of the bulkhead and very likely an eventual structural failure of the barrier wall system. Therefore, perforations in the lower portion of the barrier wall are expected to not be incorporated into this proposed design, requiring potential enhancements to manage and mitigate water behind the bulkhead. Evaluations to demonstrate the seepage velocities that would be expected

[2] The conversion from NAVD88 to NGVD29 is add 0.35 feet to the NAVD88.

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have been performed in a preliminarily fashion to inform this decision and will be included in subsequent submissions of this document, as appropriate.

2.5 Description of Remedial Action

The remedies for the WTF and STF were generally described in the AOC. The selected remedy for the STF is an oil control barrier using a barrier wall system that is a betterment to the initial conceptual design with enhancements and the selected remedy for the WTF is bank controls. The Project goals are presented in **Section 2.1,** the project feature and proposed design elements to achieve each goal are summarized in **Table 2-1**. The following subsections present an overview of the proposed design at the STF and WTF and the following subsequent sections provide supporting information and additional details.

Table 2-1 – Project Features and Design Elements

Location, Goal	Project Feature	Design Element
STF, Oil Isolation	Physical barrier, to effectively stop future oil seepage into the Canal	Steel sheet pile with welded/sealed joints
STF, Betterment	Provide a barrier that will provide geotechnical stability; allow canal dredging and cutoff impacts from bank	Elimination of perforations in the barrier wall, with enhancements
STF, Enhancements	Mitigate groundwater effects behind the wall (mounding and flow around the ends)	Drains on the STF side of the wall mitigate mounding and direct flow to treatment areas before discharge of oil-free water to the Canal
	Mitigate oil in groundwater before it enters the Canal	Passive water isolation and treatment with oil/water separators and coalescing filters prior to release to the Canal, with O&M
	Optional, active oil control/recovery	Features added to allow rapid change to active treatment, if required
STF, Canal Side Development	Accommodate GLLA Dredging	Accommodates dredging to a minimum El. of 559 ft (NAVD88)
	Optional Mooring	Appurtenances that may include: fenders, mooring posts, etc.
STF, Upland Redevelopment	Optional Allowable Surcharge	An allowable uniform surcharge load of 250 pounds psf to about 100 ft south of deadman
	Underground Utilities	No provisions for underground utilities are included, excavation depths up no deeper

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Location, Goal	Project Feature	Design Element
		than El. 581 ft allowed within the barrier wall system
WTF, Oil Isolation	Physical barrier, to effectively stop future oil seepage into the canal	Bedding media evens-out seepage, reactive media adsorbs oil and both are protected by an overlying armoring system
WTF Canal Side Redevelopment	GLLA Capping	Cap provides seepage control of sediments (below low water level). Bank controls to prevent oil seepage from bank soils above low water level. Construction sequencing required to ensure integrity of both GLLA Cap and WTF bank controls.
	GLLA sheet pile wall	Sheet pile wall stabilizes the GLLA Cap. WTF bank controls above El. 576 ft to provide seal around sheet pile to mitigate oil seepage.
WTF Upland Development	Optional Allowable Surcharge	An allowable uniform surcharge load of 250 psf to about 100 ft north of the top of bank
	Underground Utilities	No provisions for underground utilities are included
	Excavation Limitations	No excavation in bank control area without approval, remainder of WTF has no limitations.

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2.5.1 South Tank Farm – Design Overview

The barrier wall system at the STF is expected to be an anchored sheet pile bulkhead with sheet pile deadman anchors and includes the bulkhead, tiebacks and deadmen, as illustrated in **Figure 2-1**. A preliminary evaluation is provided as **Appendix D** and summarized here. The top of the bulkhead (along the Canal) may be at El. 585 ft and use AZ40-700N sheet pile sections approximately 53 ft long. The interlocks (seams) between the individual sheet pile sections will be welded or sealed down to approximately El. 567 ft and the wall may be provided with appurtenances for ship mooring. High strength steel tieback rods, approximately 100 to 120 ft long and anticipated to be 2-1/4 to 2-1/2 inches in diameter, will connect the bulkhead to the deadmen to hold up the bulkhead. A waler along the north side of the bulkhead will transfer anchor loads from the bulkhead to the tiebacks, to provide system stability. The deadmen may consist of unsealed AZ type sheet pile sections that will be about 100 to 120 ft south of the bulkhead and extend from about 40 to 50 ft bgs. Fill will be placed between the bulkhead and the existing bank, which will likely include enhancements to mitigate the effects of

groundwater and surface water behind the wall and occupy a total of approximately 16,000 cubic yards.

The barrier wall system at the STF may be located as conceptually shown on **Drawings C-106 to 108 in Appendix I.** The bulkhead may be located within the existing Canal, approximately 0 to 25 ft and average about 15 ft north of the existing top of bank (i.e., El. 578 ft). It will extend 2,039 LF between the western to eastern parcel perimeter fences[3] and include wing-walls extending approximately 200 ft (TBD in 900% design) south of the bulkhead. One known underground utility crosses the wall alignment (a gas line), which will be sealed with the bulkhead to form a continuous barrier and coordinated with the pipeline owner.

Likely enhancements to the barrier wall at the STF may include features to mitigate the effects of groundwater mounding behind the wall and flow around the ends of the wall using a passive system which can be efficiently upgraded to an active system with minimal added infrastructure. To mitigate mounding, a system of perforated pipes in granular backfill may be installed behind the wall. Prior to water release to the Canal, these pipes would pass flow through underground passive treatment systems to further isolate any remaining mobile oil and separate it from groundwater using American Petroleum Institute oil water separators and coalescing filters capable of isolating LNAPL on the STF under 5-year storm events. Back-flow preventors will be provided, to prevent Canal water from flowing into the STF, while allowing flow from the STF through the treatment systems. Infrastructure will be included to allow for pump installation to provide positive outflow. It is anticipated that the operating head for these systems may be less than a one ft differential (i.e., less than 0.5 pounds per square foot [psi]). Should conditions where the passive system cannot operate due to high water levels in the Canal, an active system may be needed, with infrastructure expected to be included in the design without equipment. The systems may include sensors for breakthrough of oil and require periodic maintenance and inspection. A potentiometric monitoring network will likely be installed behind and at the ends of the wall to facilitate monitoring of possible mounded water and its flow to document system effectiveness and assess the need for active operations.

2.5.2 West Tank Farm – Design Overview

Oil control and isolation at the WTF likely involves a sand bedding material to serve as a base, overlain by a combination of an impermeable and a reactive mat followed by a protective armor layer as shown in **Figure 2-1 and 2-3**. Two types (with and without the sand cap) are shown on **Figure 2-1**, with the with sand cap starting at El. 582 ft extending down the bank to where the sand cap armor layer (i.e., the upper 2 ft) full thickness is present. The without sand cap bank control would extend beyond the with sand cap and below the sand cap, to supplement the thinning portion of the 2 ft thick sand layer with 1% organoclay (OC) and end such that no gaps exist in the OC layers. The planned footprint is approximately 300 ft along the canal and approximately 45 ft horizontally below El. 582 ft for a total

[3] ARC has identified the existing perimeter fences as the parcel property boundaries, which represents the Project limits.

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install area of about 0.3 to 0.4 acre, as shown on **Drawing C-111 in Appendix I**. The existing product recovery wells at the WTF may remain as a supplemental system (TBD as design progresses).

The proposed install area requires a surface preparation for effective installation of the 3 layers (bedding material, reactive media, and armor protection). However, to mitigate impacts to the flow/capacity of the Canal, an excavation extending 2.5 ft from the surface would be performed, resulting in no net encroachment to the Canal. After the surface is ready, a 6-inch sand bedding layer will be installed. The bedding would be overlain by the reactive media and a geomembrane. Depending on the manufacturer's product specifications, LNAPL seepage estimates to be used for design, and the anticipated life of the barrier, the reactive media may consist of one or more active layers of OC and may be used in combination with an oil absorptive polymer. Details on the basis of design and sample calculations based on assumptions of field conditions are attached as **Appendix E**. The reactive media to be used in the design are geofabrics containing oil-adsorbent melt-blown polymers. These polymers have a structure and surface properties that are suitable to separate oil from water in oil/water mixtures such as LNAPL in groundwater. The OC is an engineered product consisting of clay (typically bentonite) that has been organically modified to improve its oleophilic sorption capacity. These media are integrated into a mechanically reinforced non-woven geotextile (reactive core mat (RCM)). The OC layer is meant to absorb oil but requires contact time for optimal efficiency. So, the oil absorbing polymer layer is bundled with the OC mat to accommodate this residence time as it absorbs oil immediately upon contact. This combination of reactive media has previously been implemented to isolate sheen and provide bank control at a different site in East Chicago. A summary of this case study is included as **Attachment E.1**.

A linear low density polyethylene (LLDPE) liner is proposed at the top of the bank, extending to approximately 2-3 ft below measured GW level (to isolate residual oil within the capillary fringe. The liner and the reactive media would be overlain on top of one another, and the seams sealed in accordance with the product manufacturer recommendations. Finally, a protective armor layer potentially consisting of 6-inch #57 stone and 18-inches of standard rip-rap would finish the bank. The bank controls will be integrated with the GLLA sediment cap as appropriate. A typical cross section detail showing all components as described in this section is shown in **Figure 2-1**.

In summary, the proposed bank control consists of the following components:

With(2.5 ft thick) sand cap:

- Excavate 2.5 ft cut into the bank to accommodate bank controls – no net impact into canal.
- 6-inch sand bedding.
- LLDPE Liner (or equivalent that is compatible with oil) from top of bank to approximately El. 577 ft and overlap the RCM by one-ft.
- Reactive media and oil-absorbing polymer from El. 577 to 573 ft within bottom anchor trench.

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- Armor layer (6-inch #57 stone for filter layer).
- Armor layer (18-inches of Riprap).

Without sand cap:

- Excavate 1 ft cut into the bank to accommodate bank controls – no net impact into canal.
- 6-inch sand bedding.
- Reactive media and oil-absorbing polymer from El. 573 to 571 ft within bottom anchor trench.
- 6-inch sand.

Transition details will be further developed in the 90% submission, as appropriate.

2.5.3 Summary of Construction Activities

A summary of major construction activities required to complete the Project, after pre-construction preparation, includes the following which are described and bounded by the Technical Specifications in **Section 12** and Drawings in **Section 13**:

- Site Preparation:
  - Establish access (uplands and Canal)
  - Establish health and safety infrastructure
  - Establish temporary facilities
  - Establish monitoring
  - Establish temporary stormwater controls
  - Establish temporary Canal water quality controls
  - Establish materials handling facilities
  - Establish Site survey control and perform layout
- Barrier Wall System Installation (STF)
  - Equipment and crew mobilization
  - Alignment preparation and obstruction removal
  - Off-Site material fabrication and testing
  - Borrow source testing
  - Materials shipping and delivery
  - Material receiving and acceptance

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- Canal monitoring and sheen control
- Bulkhead and anchor installation
- Upland construction phase water management
- Bulkhead fabrication and seam sealing
- Backfilling and water management installation
- Tie-back installation and tensioning
- Installation of mooring appurtenances
- Installation of monitoring system
- Water treatment system prove-out
- Finalization of the O&M Manual

- Bank Control (WTF)
  - Equipment and crew mobilization
  - Off-Site material fabrication and testing
  - Borrow source testing
  - Materials shipping and delivery
  - Site preparation and install of turbidity controls/cofferdam
  - Canal monitoring and sheen control
  - Upland construction phase water management
  - Excavation and obstruction removal
  - Material receiving and acceptance
  - Bank controls installation
  - Installation of monitoring system
  - Finalization of the O&M Manual
- Project Closeout
  - Site Restoration
  - Demobilization
  - Documentation

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2.6 Project Team and Stakeholders

Contact information for project team members and stakeholders is included in **Table 2-2**.

Table 2-2 - Project Contact List and Roles

Group/Employer	Person	Role	Phone and email
ARC	Paul Johnson	Project Manager	832-619-5825 Paul.johnson4@bp.com
ARC	Eric Hritsuk	Commercial Project Manager	331-702-3245 eric.hritsuk1@bp.com
Wood	David Tully	Project Manager	630-724-8531 david.tully@woodplc.com
Wood	Brian Johnson	Design Lead	207-828-3483 brian.johnson@woodplc.com
Wood	Don Dotson	Engineer of Record Indiana PE	615-577-7012 don.dotson@woodplc.com
Wood	Rich Pletz	Health and Safety	309-692-4422 rich.pletz@woodplc.com
USEPA	Rick Nagle	Counsel	312-353-8222 nagle.richard@epa.gov
USEPA	Dan Haag	On-Scene Coordinator	312-886-6906 haag.daniel@epa.gov
USEPA	Kristen Isom	Great Lakes National Program Office (GLNPO) Project Manager	312-353-6318 isom.kristen@epa.gov
ECWMD	Fernando Trevinio	Project Manager	219-741-7741 fmtconsulting@aol.com
USACE	Natalie Mills	GLLA Project Manager	312-846-5561 Natalie.R.Mills@usace.army.mil
USACE	Ben O'Neil	Design Engineer	312-846-5509 benjamin.r.oneil@usace.army.mil

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2.7 Applicable or Relevant and Appropriate Requirements

In addition to the overall project goal of isolating oil on the STF and WTF, compliance with applicable regulations and permitting requirements and approvals must also be achieved during the implementation of the Project.

While there are numerous regulations that are potentially applicable, the most substantive requirements are likely to be associated with permitting and regulatory compliance for waste characterization and disposal; work in open water, in navigable waters, in wetlands, and along shorelines; discharge of water resulting from remediation processes; and compliance with the National Environmental Policy Act (NEPA).

There are numerous regulations that are potentially applicable; given the current understanding of the Project, there are key potential requirements associated with permitting and regulatory compliance for the following:

- Waste characterization and disposal, which is regulated under the Toxic Substances Control Act and Resource Conservation and Recovery Act;
- Work in open water, in navigable waters, in wetlands, and along shorelines, which must comply with specific statutes of the Clean Water Act (CWA) and specific statutes of IDEM and Indiana Department of Natural Resources (IDNR), such as:
    - Section 311(b) of the Clean Water Act, 33 U.S.C. § 1321(b) Oil and Hazardous Substance Liability, which prohibits the discharge of oil or hazardous substances in harmful quantities into or upon, among other things, the navigable waters of the United States, adjoining shorelines, or which may affect natural resources belonging to, appertaining to, or under the exclusive management authority of the United States.
- Discharge of water resulting from remediation processes, which is regulated under the CWA and will likely require National Pollutant Discharge Elimination System (NPDES) permitting;
- Evaluation of the potential environmental and cultural effects of remediation under NEPA;
- Spill reporting and appropriate actions to prevent, abate or minimize the discharge or endangerment, in accordance with local, state and federal requirements.

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3.0 SUBSURFACE CONDITIONS

Subsurface conditions in the Site and vicinity have been the subject of regional studies by the USGS and Site-specific investigations of the various identified parcels, e.g., the STF and the WTF. The following subsections deal with overburden soils, bedrock, groundwater, and LNAPLs, focusing mainly on the STF and the WTF parcels.

3.1 Overburden Soils

Overburden soils at these parcels reflect the general conceptual site geologic model for the region. These soils consist of peat where low-lying marshy areas existed before development, the fill materials that were used to bring up the land surface primarily for industrial development, the beach/dune sands that constitute the majority of the Calumet Aquifer, underlying lacustrine clays and clayey tills which overlie the carbonate bedrock which constitutes a generally confined aquifer.

Overburden soil type descriptions are derived here mainly from the 2002 Arcadis SI Report, supplemented by USGS reports. The descriptions are here simplified, and for further detail, the reader is directed to the specific USGS reports (Fenelon and Watson, 1993; Cohen, et al., 2002; Rosenshein and Hunn, 1968; Watson, et al., 1989; Greeman, 1995; Duwelius, et al., 1993; Kay, et al., 1996; and Kay, et al., 1997).

3.1.1 Fill and Peat

As indicated above, peat deposits were mainly formed in marshy areas prior to filling operations and extensive industrial development. There are no known substantial peat deposits at either the STF or WTF.

Fill materials emplaced during the course of area development have consisted of a wide variety of materials, e.g., municipal wastes and other industrial wastes. The principal type of fill has been steel industry wastes (e.g., slag). Fill thicknesses have varied from 0 to 100 ft over the larger regional area, and in the STF and WTF are on the order of 2 to 4 ft (Kay, et al., 1997). Hydraulic properties of the fill vary over a wide range with Kay, et al., (1997) citing a range indicative of grain sizes ranging from clean sands to silts/clays.

Arcadis (2002) summarizes the fill in the ECI area as:

" *… (generally 0 to 5 ft below land surface [bls]). Black material mixed with broken concrete, brick and other demolition debris. The fill is a highly variable unit with fine to coarse sand, little to trace gravel, trace silt, trace clay, construction debris, slag, and a color variation of gray to black. The fill appears thickest on the STF and south of Southwest Tank Farm*."

3.1.2 Beach/Dune Sands

These soils comprise the bulk of the Calumet aquifer. As indicated in the description of the regional geology, there may be locally limited interbedded lenses of lesser hydraulic conductivity (K), but these

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have no practical effect on groundwater flow in the Calumet aquifer. Arcadis (2002) describes the sands as:

"*Gray sand (generally 5 to 30 ft bls) ….: The gray to brown sand is composed of fine to medium sand with coarse sand and pebble lenses. The sand generally becomes finer-grained with depth.*"

The sands are noted as fining with depth, and Arcadis separates out this finer presentation of the lower Calumet sands as a "sandy silt and silt":

"*(generally 30 to 34 ft bgs): A laterally discontinuous silty sand to silt unit was identified in soil borings from the STF, Southwest Tank Farm, South of Southwest Tank Farm, and Hammond Tank Farm. This unit ranges from silty very fine sand with silt laminations to gray silt. Trace amounts of shell fragments have been noted from this unit. The silty sand to silt unit is typically encountered at or near the base of the sand unit just above the clay discussed below. The unit ranges in thickness from 0 to 4 ft*"

3.1.3 Lacustrine Clay

The description for the confining unit between the Calumet and Carbonate bedrock aquifer typically includes both the lacustrine clay and the clay tills. The USGS (1996) describes the confining unit as:

"*…composed of the Antrim Shale, the silt and clay tills of the Lemont Drift and the Wadsworth Till, the silt and clay lacustrine deposits of the Carmi Member of the Equality Formation, and the fine-grained fill deposits*."

3.1.4 Clay Till

As indicated in the previous subsection, the clay till is considered a part of the confining layer in concert with the lacustrine clay.

3.2 Bedrock

Locally (in the vicinities of STF and WTF) the description of bedrock is not expected to be different than cited in the Regional Geology section. The top of the bedrock lies at elevations ranging from about 478 to 484 (Watson et al., 1989, assumed National Geodetic Vertical Datum of 1929 [NGVD29]). While the bedrock carbonate aquifer is hundreds of ft thick, typically wells tapping the bedrock aquifer are mainly no deeper than 100 ft into rock.

3.3 Groundwater

Regionally, as described in Fenelon and Watson (1993), "*the groundwater system in the study area* (see **Section 2.2**) *consists of the bedrock aquifer, overlain by low permeability clays and silts which act as an aquitard and which in turn is overlain by the Calumet aquifer. The bedrock aquifer probably discharges some water up through the clay unit in the eastern half of the study area (R.J. Shedlock, U.S. Geological Survey, written communication, 1985); however, in the central and western parts of the study area, heads in the bedrock and the Calumet aquifers indicate downward discharge of groundwater through the clay unit to the underlying bedrock aquifer*."

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Hydrogeologic properties of the various units and subunits are presented in past USGS reports, but much of the available data for the units now comes from explorations advanced in the ECI site investigations. These estimates of hydraulic properties have been summarized in the 2002 and 2016 Arcadis SI reports.

Beach/dune sands: Estimates of Calumet aquifer sands Ks have ranged from 10 to 130 feet per day (ft/d), and, in the 2016 SI, an average K of 51.5 ft/d was presented. These are point estimates.

Lower silty sands of the Calumet aquifer: Estimates of K for the lower, silty sand are sparse. A USGS report (Kay, et al., 1996) cites three results of 4.8, 6.2, and 22 ft/d. The Arcadis 2016 SI report cites two samples: 2.8 ft/d (OW-109) and 16.5 ft/d (OW-117). The geometric mean of these five samples is 7.9 ft/d.

Lacustrine clay aquitard (including clay/till): The 1996 USGS report indicates estimated values of K ranging from 0.000017 to 0.55 ft/d. The median value for the weathered part of the confining unit was 0.058 ft/d, whereas that for the un-weathered portion was 0.0028 ft/d. In Lake County, an average value of vertical K for the confining unit was 0.0004 ft/d. Environmental Resources Management (ERM) reported vertical Ks in the confining unit as 8.8×10^{-5} to 5.4×10^{-4} ft/d. In all cases, the Ks determined for the confining unit were about three to five orders of magnitude lower than those in the Calumet aquifer, again confirming that no significant flow occurs through the confining layer relative to the Calumet aquifer. Consideration of the effects, related to hydraulic control, due to installing some type of barrier at either the STF or WTF need not consider either the confining unit (other than knowing at what elevation it occurs along the proposed line of the barrier) or the underlying bedrock.

Bedrock: USGS (Kay, et al., 1996) provided estimates of K ranging from 0.02 to 1 ft/d with a median value of 0.16 ft/d.

In the Arcadis 2002 modeling, a uniform 38 ft/d K was assigned to sands above the clay aquitard.

It should be noted, however, that due to the very low K of the clay confining unit, very little horizontal or vertical flow of groundwater through the clay unit is expected to occur. For all practical purposes, modeling of groundwater flow in the Calumet aquifer need only concern that unit alone (see **Appendix C**).

The groundwater system described in this Report rests solely with conditions in the Calumet aquifer as described above.

The remainder of this section, however, focuses more on data available for the STF and WTF parcels. In general, groundwater is encountered at about 4 ft below ground surface, based on available data (Arcadis, 2002, 2016). However, as the elevation of the water table is dependent on recharge to ground surface and elevation of receiving waters, the water table elevation is expected to vary by a few ft over the course of the year and dependent on wet or dry year precipitation and frost-out conditions. In

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some cases, the Site groundwater discharge to surface water, the Canal for both parcels, is currently affected by the existence of sheet pile or wooden shoring along the canal (principally on south side of the CDF and west of the WTF). The recent commencement of the removal of underground piping pipe may change STF recharge characteristics. Groundwater horizontal hydraulic gradients in the uplands are typically relatively small (0.003 to 0.005 feet per foot [ft/ft]) given the limited upgradient recharge areas and the relatively high hydraulic conductivity of the Calumet aquifer. Gradients may increase as groundwater approaches discharge locations and take on a more vertical component.

3.3.1 South Tank Farm

Groundwater flow through the STF (extending about 2,150 ft east-west and about 1,075 ft north-south and covering about 53.5 acres) derives from recharge of precipitation over an area defined by a groundwater divide determined by surface water influences of the Canal, the IHC, and the Grand Calumet River. Groundwater water table iso-contours through the STF are more frequently parallel to the Canal as might be expected, but water level data collected at various dates (see Figures 4-1 to 4-3 of the 2016 Arcadis SI report, in **Appendix B.4.1**) show the influence of transient conditions as well as water level in the Canal (historically on average about 578 ft) and the presence of pipelines (now removed). Ground surface at the STF ranges from about El. 583 to 585 ft based on Lidar data and the water table contours on the referenced figures have varied from about El. 582 to about 584 ft at the southern perimeter of the STF and about El. 577 to 580 ft near the edge of the Canal. (Note: SI water level data has been reported using an NGVD29 datum. However, the conversion to NAVD88 is to subtract 0.35 ft from the NGVD value. For purposes of citing approximate ranges of elevations, these are considered to be equivalent. Where more accuracy is required elevations in NGVD29 have been converted to NAVD88 and the appropriate datum referenced.) A typically cited horizontal hydraulic gradient for the STF is 0.003 ft/ft irrespective of datum.

Geologic section B-B' (Figure 30, Arcadis, 2016, Attached in **Appendix B.4.2**) along the northern edge of the STF indicates a bottom elevation to the Calumet aquifer ranging from about 557 to 561 ft and a saturated thickness of the Calumet aquifer here is about 14 (minimum water level and highest bottom elevation) to 25 ft (maximum water level and lowest bottom elevation). The aquifer would be a few ft thicker in the upgradient direction (south of the Canal). However, the section does not appear to take into consideration data from the 2016 soil borings, SB-2016-01 to -09, on the STF along the top of the bank as shown on Figure 28, Arcadis, 2016, Attached in **Appendix B.4.2**. Top of clay in these borings appears to be about El. 555 ft with some decrease in the eastern side of the STF. This appears to agree with USGS interpretation of top of clay (see **Figure 2-2**, **Appendix B**, Arcadis 2002 SI report, Attached in **Appendix B.1.2**). With these borings taken into consideration, the saturated thickness of the aquifer near the Canal would be from about 22 to 27 ft thick, low water to high water, and, as above, may be a bit thicker further upgradient (south of the Canal). Groundwater has historically approached ground surface at the western end of the STF along the Canal, and at more upgradient locations (Arcadis, 2016). The geologic section B-B' shows the aquifer to consist mainly of silty sand with some near surficial lenses of small deposits of peat and clay and with interbedded lenses of limited extent of coarser sands and gravels. The boring logs for the 2016 borings show the presence of thicknesses of

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silty sand above the clay. These silty sands likely have a lower K than the coarser overlying sands as presented in the description above. The surficial or near surficial lenses of lower permeable materials need not be represented in the groundwater flow model. Their effect would be included in deriving an effective K for the sand unit during model calibration. Since these lenses are discontinuous and their full extents not defined, it would be impossible to include them as known features at the present time.

The Arcadis (2016) report presents summaries of available K data and suggests a value of 51.5 ft/d as a representative average for the Calumet aquifer. Using this K, a gradient of 0.003, and an effective porosity of 0.2 (Arcadis, 2016), the estimated average porewater groundwater velocity through the STF is about 0.77 ft/d or about 280 ft/yr. The estimated volumetric rate of discharge of groundwater to the Canal has therefore ranged from about 50,000 to nearly 100,000 gallons per day (about 35 to 70 gpm). We note that due to the presence of LNAPL in the smear zone that the hydraulic properties of the upper aquifer where this LNAPL exists may be somewhat different (lower) in this upper zone. While an LNAPL removal system has been present along the canal extent over the years, there still appears to be limited presence of mobile (apparent in monitoring wells) LNAPL on STF (see **Section 3.4**).

3.3.2 West Tank Farm

The WTF is an elongated strip of land extending about 2,300 ft in a north-south direction and 350 ft wide along the north side of the Canal, occupying an area of about 18 acres. Groundwater through the WTF derives from a recharge area determined by a groundwater divide established by the interplay of the Canal, Lake Michigan to the north and northeast and Lake George and Lake Calumet to the northwest. Discharge of groundwater at the WTF is affected by sheet pile wall and wooden shoring along the Canal to the east and west of the WTF. Water table elevations at the north end of the WTF have been interpreted to range from 583 to 585.3 at the north end and 577 to 581 (NGVD29) at the south end near the Canal (see Figures 4-1 to 4-3, respectively in the Arcadis 2016 SI report, Attached as **Appendix B.4.1**). Figures 4-2 and 4-3 show interpreted water table elevation contours parallel to the Canal, based on data from the WTF alone. **Figure 2-3**, which includes data from the neighboring parcels as well is likely a better depiction of actual flow and is supported by the Arcadis (2002) regional groundwater model. Since sheet pile or wooden shoring extends westward along the Canal at the PCA and HTF, and sheetpile eastward along the CDF, the effect of these restrictions is to divert some lateral flow through the WTF. A definite mounding is apparent centered more on the PCA parcel. As a result of the barriers, the mounding produces higher gradients near the Canal.

Geologic section A-A' (Figure 29, Arcadis, 2016, Attached as **Appendix B.4.2**) cuts along the western edge of the WTF, then slants over to the east side before crossing the Canal (Figure 27, Arcadis, 2016, Attached as **Appendix B.4.2**) and depicting a portion of the west perimeter of the STF. Part of section B-B' cuts across the WTF along the Canal. These geologic sections depict much the same aquifer characteristic as for the STF, with some interbedding or presence of relatively thin and discontinuous clay or gravel seams. The base of the aquifer appears to be at about El. 556 to 557 ft, although no explorations reached this depth along much of section A-A'. Along the canal, the base of the aquifer appears to be about El. 560 ft. The saturated thickness of the aquifer appears to range from 26 to 28 ft

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at the north end to 17 to 21 ft at the Canal. The two soil borings installed at the WTF in 2016, SB-2016-10 and SB-2016-11, encountered top of clay at 27.5 and 23.7 ft bgs. At the maximum water table condition, groundwater may approach ground surface at the north end.

Limited K data exist for the WTF and what there is appears to be consistent with that determined for the STF. Employing the same K and effective porosity as for the STF, but a somewhat lesser gradient of 0.002 (Figure 4-2), an estimated pore space groundwater velocity for the WTF would be on the order of 0.5 ft/d or about 185 ft/yr. As groundwater discharge to the Canal is somewhat inhibited by sheet pile or shoring on either side of the WTF, a volumetric discharge rate is difficult to directly calculate using a simple calculation, and some flow through the WTF may originate from east or west of the WTF. Using the Arcadis model, an estimated average flow through the approximate 350-ft width of the WTF at the Canal is about 20 to 21 gpm.

3.3.3 Prior Groundwater Modeling

Wood reviewed two USGS reports that provided regional scale early version MODFLOW groundwater flow models for the Little and Grand Calumet River watersheds in Lake County. These reports were "Preliminary Analysis of the Shallow Ground-Water System in the Vicinity of the Calumet River/Indiana Harbor Canal, Northern Lake County, Indiana" (Watson, et al., 1989) and "Geohydrology and Water Quality of the Calumet Aquifer in the vicinity of the Grand Calumet River/Indiana Harbor Canal, Northwest Indiana" (Fenelon and Watson, 1993). In each, the emphasis was on attaining a better understanding of water balance flows in the model domain, i.e., sources and sinks for water introduced to groundwater. In addition to receiving water bodies, the modeling included water supply well losses and losses to leaky municipal sewers. While the modeling explored sensitivity to these boundary conditions as well as to recharge and aquifer hydrogeologic properties, the models were too coarse (large grid block size) to be of much use to the objectives of this design except in the most general terms.

In the ECI Site Investigation Report (Arcadis, 2002), Arcadis provided documentation (Attached in **Appendix B.1.2**) for the development of a detailed model of the study area. The model domain was extended out to natural groundwater divides and/or watershed boundaries and included the inner canal network. The model domain covered approximately 8.7 square miles and the variable grid, with smallest cells at 25x25 ft, consisted of 320 columns and 273 rows. Vertically the model representation of the Calumet aquifer consisted of four layers to allow for vertical variations in aquifer materials and the representation of proposed remedial alternative scenarios (e.g., pumping to restrict discharge to the Canal and types of vertical barriers to flow). The underlying clay layer was considered impermeable and not represented in the model. The model was calibrated in steady-state mode to a set of 29 water level points. Recharge and Ks were adjusted to optimize the calibration. This resulted in four K zones of 47 ft/d (upper clean, coarse sands), 38 ft/d (siltier sands), 1 ft/d (fill in main refinery areas), and 200 ft/d (gravel backfill areas). Model derived aquifer-wide K values can be expected to vary from point estimates provided by slug tests. Three recharge rates were assigned – 0 inches per year (in/yr) for impermeable areas, 8 in/yr for urban areas, and 16.5 in/yr for open areas. In the areas of the STF and

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WTF, and over much of the Arcadis model domain a calibrated 8 inches of recharge per year was assigned. Sensitivities of the model to extremes of lake/canal water levels and reasonable variations in Ks and recharge were assessed.

The model results indicated annual average volumetric flux rates of groundwater to the Canal as follows: the PCA/WTF at 26.8 gpm; the STF/SWTF at 85.3 gpm; and the HTF at 4.8 gpm. In a 2016 simulation, the model estimated flux for the STF alone (no barrier) was 69.4 gpm. Arcadis used variations in the assigned conductance to the horizontal flow barrier package on MODFLOW to represent various degrees of perforated area in the barrier wall in model layer three. For a solid wall, a mounding of up to 6.6 ft could be expected with significant areas behind the wall likely to experience rise of groundwater above ground surface. At 5 % and 10 % area of perforations (model layer 3), mounding of up to 1.1 and 0.9 ft could occur, but with much less potential for flooding at ground surface under steady-state conditions.

The above summary was based mainly on the model documentation contained in Appendix B of the 2002 SI (Attached as **Appendix B.1.2**). Arcadis subsequently provided Wood with their MODFLOW model input/output files for the barrier wall scenario simulations they had run in 2016. While this was all useful information, upon further review of the model files, and in conjunction with other information, several factors, most prominently the coarse discretization preclude using the Arcadis model for this Basis of Design Report.

With these factors and the limited K data on the STF proper, and in order to proceed in support of the 30% design schedule, Wood believed a better approach was to construct a model local to the STF, more finely discretized to more accurately represent possible barrier wall designs and using projected maximum gradients across the site, simulate a range of potential fluxes through the wall section to generate a range of potential mounding effects, and possible required groundwater collection and/or treatment rates. In this way, concerns for potential mounding could be addressed within the available data and determine how mitigation measures can reduce potential risks. The results of the modeling conducted for the 30% design are summarized in **Section 3.3.4** and detailed in **Appendix C**.

3.3.4 Basis of Design Groundwater Modeling

As indicated above, Wood decided that the Arcadis model had too many uncertainties and covered a much larger area than necessary for aiding in the design of the barrier wall for the STF. Wood then proceeded to construct a model more local to the STF and more finely discretized. The development, construction, calibration and final simulations conducted at this stage of design are detailed in **Appendix C** of this 30% Basis of Design Report submittal. Only the results of that modeling are summarized in this section of the report.

Due to remaining uncertainties in the input parameters of the model, Wood developed a range of probable average flow rates through the STF, that is, groundwater flows that must be addressed as a result of the decision to design and implement a solid, fully penetrating barrier wall to isolate LNAPL on the STF and to cut off residual LNAPL in the smear zone of the STF at the edge of the Canal.

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Wood's estimate of average flows through the STF range from about 10,000 to 16,000 cubic ft per day, or equivalently about 50 to 80 gpm. The best fit model constructed to date provided an estimate of about 54 gpm, somewhat less than the Arcadis model average output of 69 gpm. It would be expected that during seasonal variations or wet or dry years or during storm events, the actual flow through the STF could vary considerably. Also, of some concern is the recent upward trend of the water level in the Canal and potential impacts in generally restricting groundwater flow through the aquifer both south and north of the Canal.

Wood simulated the installation of a fully penetrating barrier wall with a drain system behind it to manage the groundwater flux. Setting the control elevation at the same elevation of the Canal (about 578 ft) as in the calibrated model, no mounding was observed, and the flow rate captured by the drain system was essentially the same as for the simulation with no wall.

Wood attempted to use the calibrated model in a simulation of a 24-hour, 25-year storm event, but the model could not handle the influx of water, resulting in inundation of much of the model domain, and casting doubt on the results which indicated rate of flow to the drain system behind the wall, potentially in excess of 300 gpm. No such inundation reportedly occurs during observed storm events, suggesting that there may be other surficial or subsurface controls, such as drainage ways or sewers, that have not yet been identified that come into play before local flooding occurs.

However, the model, as it is, appears to be adequate when evaluating more normal conditions of flow. Further refinement, if possible, may make its simulation results more accurate. Primarily lacking are explorations across the STF that determine depth to clay, post pipeline removal synoptic water level measurements under various conditions, the presence of a silty transition zone, and estimates of hydraulic conductivity over a wider area and with depth. If other potential sinks or surface water features that relieve the potential infiltration during storm events would also be helpful as water levels in the Canal and across the STF appear to be rising according to available data from the USGS gaging station and more recent water level measurement events.

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3.4 Light Non-Aqueous Phase Liquid

Releases of petroleum products have occurred during the periods of operation of oil refineries in the area. USGS produced a 1996 report ("Geohydrology, Water Levels and Directions of Flow, and Occurrence of Light Nonaqueous Liquids on Ground Water in Northwestern Indiana and the Lake Calumet Area of Northeastern Illinois") produced in cooperation with the USEPA. With respect to LNAPLs, the report did little other than note the presence of LNAPLs in the area, and the presence of films to greater thicknesses of LNAPLs in some monitoring wells. The major concern has been the presence of sheens on the navigable waters of the Canal.

Arcadis (2016) took samples of the LNAPL from three wells (MW-03, OW-107, and OW-124) for analysis and characterization. In summary, the samples suggested a weathered diesel range organic (DRO) oil composition, two with minor (5 to 10%) gasoline range organic components. This is consistent with the age of the residuals which would have undergone volatilization and decomposition

of the lighter phases from the original composition. Samples of sheen taken by Tetra Tech on behalf of the USEPA in 2014 were also characterized as indicative of "moderately biodegraded intermediate to heavy petroleum oil"; samples were predominantly of DRO. The Tetra Tech samples were also compared to LNAPL obtained from nearby observation wells and showed no correlation.

Arcadis (2016) summarizes the characteristics of the LNAPL at 70 degrees Fahrenheit: density – 0.8613 to 0.9087 g/cc; viscosity – 4.62 to 20.4 centipoise; and with water-LNAPL interfacial tension of 10.4 to 11.7 dynes/centimeter.

3.4.1 South Tank Farm

Studies for the presence of LNAPL (i.e., free product and the extent of petroleum residues) on soil have included Rapid Optical Screening Tool (Arcadis, 2016, Section 5.3.2, Table 2, Figures 2, 3, 5 and 6, Appendix A and M, Attached as **Appendix B.4.3**) and Laser Induced Fluorescence (LIF) (Attached in **Appendix B.4.3**) technologies as well as visual observation (Arcadis, 2016). The LIF probes indicated a smear zone through the STF ranging in thickness from a couple of ft to a maximum of about 12 ft and extending to a maximum of about 12.5 ft bgs. Arcadis (2016) reports the extents of smear zones as "*generally 6 to 8 ft*" in thickness, beginning at "*2 or 4 ft bgs and extending to 8 to 10 ft bgs*". Smear zone extents along cross sections were depicted on Figures 29, 30, and 31 (Arcadis, 2016, Attached in **Appendix B.4.2**). Studies at the STF included assessment of mobility of the petroleum products (see **Section 5.4**). In general, mobile LNAPL was determined to flow into three observation wells on the STF in the 2015 investigation. Water level measurements in October 2015 indicated the presence of 0.8 ft of product in OW-124, 0.13 ft in MW-08, and 0.06 ft in OW-103. These wells were screened to depths between 12 and 13 ft bgs. A line of 41 product recovery wells (PRW-01 through PRW-41) has operated along the STF Canal perimeter, but with decreasing returns over time.

Parsons collects measurement of product thickness and records product recovery volumes and reports these monthly to IDEM. Each monthly report contains the record of volume removed for each of the preceding months. Early years of operation yielded high annual recoveries (10,050 gallons in 1996 and 4,600 gallons in each of 1993 and 1997). However, yields have been decreasing and only an average of about 8 gallons per year were collected in 2015 through 2018. In 2019 only two to three of the recovery wells had more than 0.02 ft of measurable product. As of August 2019, 27,305.25 gallons of product had been recovered. The August 2019 Parsons report is provided as **Appendix B.5**, with a plot of the data showing trends.

3.4.2 West Tank Farm

Similar to activities on the STF, investigations have determined the presence of free product on the WTF and of similar characteristics. Water level measurements in October 2015 indicated 1.47 ft of product in MW-03 and 3.09 ft in OW-107. Depths to bottom of screen were 11 and 12 ft, respectively. Smear zone extents are depicted along sections A-A' and B-B', Figures 29 and 30 (Arcadis, 2016). These extents do not appear to be as thick as on the STF.

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There are six product recovery wells at the WTF (PRW-42 through -47). As with the STF, and in the same monthly reports, Parsons collects data to assess system condition and record volume of recovery. Recoveries at the WTF have been much smaller. Maximum recoveries occurred in 1994 with about 850 gallons recovered. The recovery leveled off at a total of 2,492 gallons and the system was shut off until there would be a measurable thickness in the recovery wells. This has not happened, and the system at the WTF has remained off. The August 2019 Parsons report and plots of product recovery quantity and rates are provided as **Appendix B.5**.

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4.0 BARRIER WALL EVALUATIONS

Wood performed a preliminary geotechnical stability evaluation of the internal and external (i.e., deep-seated) barrier wall system stability and to establish structural barrier wall components that will allow for future GLLA planned dredging adjacent to the STF in the Canal and accommodate identified future canal and upland redevelopment. The barrier wall system at the STF will likely consist of an anchored sheet pile bulkhead with a sheet pile deadman anchor, as described in **Section 2.5**.

The following sections summarize the selected design parameters, loads, and loading cases utilized in the analyses, presents results, and provides preliminary recommendations.

4.1 Design Input Parameters

The following sub-sections describe the proposed design input parameters, including subsurface stratigraphy, selected soil properties, groundwater conditions, loads, and loading cases considered for the barrier wall evaluation herein.

4.1.1 Subsurface Stratigraphy

Subsurface stratigraphy utilized in the geotechnical analyses, including primary soil strata type, depth, thickness, etc., proximate to the proposed barrier wall system was based on available subsurface information obtained through regional studies by the USGS and limited Site-specific geotechnical investigations (Arcadis U.S., Inc., 2016a; Tetra Tech, 2015c), as discussed in **Section 3.0**. In general, the subsurface stratigraphy from the ground surface downward beneath the STF consists of granular fill, beach/dune sands (i.e., the Calumet aquifer), lacustrine clay, clay till, and bedrock; subsurface stratigraphy from the mudline downward beneath the Canal consists of granular canal sediments, possible debris, lacustrine clay, clay till, and bedrock.

A conceptual cross-section depicting subsurface stratigraphy assumptions used in the analyses is provided in **Figure 2-1**. Available subsurface information utilized for this evaluation is provided for reference in **Appendix D**.

4.1.2 Soil Parameters

Wood reviewed and evaluated available Site-specific geotechnical information and data (CELRC-TS-DG, 2012; Tetra Tech, 2015c; and Arcadis U.S., Inc., 2016a). Available geotechnical information and data used to support this evaluation are provided in **Appendix D**. Wood assigned soil parameters based on soil type, in-situ conditions (e.g., relative density or consistency, above/below water table, etc.), empirical correlations to published literature values, available Site-specific geotechnical information and laboratory testing results, demonstrated stress-strain relationships, and engineering judgment. **Table 4-1** summarizes the selected design soil parameters beneath the STF and beneath the Canal. Additional detail is provided in **Appendix D**.

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Table 4-1 – Summary of Preliminary Design Soil Parameters

Site Parcel	Stratum	Soil Type	Unit Weight		Total Stress Strength Parameters			Effective Stress Strength Parameters	
			Total γ_t (pcf)[1]	Saturated γ_s (pcf)	Friction Angle ϕ (deg)[3]	Cohesion c (psf)[2]	Undrained Shear Strength S_u (psf)	Friction Angle ϕ' (deg)	Cohesion c′ (psf)
STF (Upland)	**Bank Sand[4]**	Free-Draining	110	115	-	-	-	30	0
	Clay[5]	Fine-Grained	130	130	14	500	1,100	24	0
Canal	**Canal Sediment**	Free-Draining	90	90	-	-	-	26	0
	Clay[5]	Fine-Grained	130	130	14	500	850	24	0

Notes:
1. pcf = pounds per cubic foot.
2. psf = pounds per square foot.
3. deg = degrees.
4. Bank sand includes existing fill, existing fill to be excavated/reworked and replaced during construction, new backfill to be placed to the south of the bulkhead during construction, and existing beach/dune sands (Calumet aquifer).
5. Clay includes lacustrine clay and clay till (pending collection of additional data).

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4.1.3 Groundwater and Surface Water Conditions

Arcadis (2002) indicates historic high, typical, and historic low surface water elevations in Canal of El. 582.4, 578.0, and 575.5 ft, respectively, based on NGVD29 datum. These elevations correspond to El. 582.05, 577.65, and 575.15 ft, respectively. (NOTE: Water levels in the Canal have recently been rising and long-term trends need to be investigated. This design will be adjusted to accommodate reasonably expected rises in Canal level.)

As demonstrated and described in Arcadis 2016 and approved by USEPA, dissolved groundwater concentrations at the STF and WTF do not pose a threat to surface water quality. As such it has, and is expected to continue to, discharge to Canal with mitigation as needed to isolate the oil on the STF. However, groundwater levels will be impacted by installation of the barrier wall system and existing groundwater elevations are not representative of post-construction conditions (**Section 3.0**). The design needs to include enhancements to mitigate the anticipated effects of groundwater mounding behind the bulkhead and minimize the potential differential water pressure between the STF and the Canal.

4.1.4 Representative Cross-Sections

A representative cross-section (not specific to a barrier wall alignment station) was considered for this 30% evaluation and was based on existing and planned topographic/bathymetric configurations (post-dredge conditions, Tetra Tech, 2015d, Attached as **Appendix B.3.2**). The schematic cross-section is illustrated in **Figure 2-1**.

Additional/supplemental barrier wall cross-sections (station-specific topography and bathymetry) may be identified and evaluated as the design progresses.

4.2 Barrier Wall Loads

The following subsections describe the bulkhead loads and loading cases considered in the barrier wall system stability analyses. The barrier wall system includes the bulkhead and the deadman, which have been independently evaluated as well as evaluated as a system.

4.2.1 Loads

The following barrier wall system loads, in addition to lateral earth pressures from soil, were considered in the analyses (refer to **Appendix D** for additional detail):

- Hydrostatic Differential Water Pressure Across Bulkhead
    - It is anticipated that groundwater levels to the south of the bulkhead will fluctuate with seasonality, storm events, etc. The results of the groundwater model (**Section 3.0**) was completed (at this 30% stage) assuming that the average anticipated hydrostatic water pressure differential across the bulkhead is approximately 1-ft (i.e., groundwater is 1-ft above the Canal water surface elevation which was set at El. 578 ft) under steady-

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state/usual conditions. The groundwater model also indicates that groundwater levels south of the barrier wall system will increase temporarily during storm events. High water conditions will be evaluated in the 90% submission.

- Optional Upland Surcharge Load
    - Future upland development at the STF is unknown; however, as described in **Section 2.4**, this proposed design accommodates modest redevelopment south of the STF bulkhead. A surcharge load of 250 psf at ground surface was applied in all loading cases, which is approximately equivalent to 2 ft of soil, a lightly loaded building or heavy equipment use within about 100 ft south of the bulkhead with little to no limitations further south (to be refined during 90% design).
- Seismic Loading (Earthquake)
    - The design of the barrier wall system accounts for earthquake (seismic) loading during the service life (i.e., 50-years, refer to **Section 8.3**) of the wall systems steel components. For long-term conditions, the design earthquake loading was based on a peak ground acceleration associated with a probability of exceedance of 2% in 50 years.

4.2.2 Loading Cases

Loads applied will fluctuate during the service life of the barrier wall system. The following three types of loading cases were identified, consistent with USACE EM 1110-2-2504 (1994) as applicable to the barrier wall system design, based on **Section 2.4** and engineering judgment.

- Usual Load Case: Loads associated with this case are the most frequently experienced by the system in performing its primary function. The loads may be of a long-term sustained nature or of an intermittent but repetitive nature.
- Unusual Load Case: Loads associated with this case are infrequent in occurrence and/or of short duration.
- Extreme Load Case: Loads associated with this case have a low-probability of occurrence and/or are extremely short in duration relative to the service life of the system.

In total, five loading cases were evaluated herein. The components of each loading case are summarized in **Table 4-2**.

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Table 4-2 – Components of Loading Cases

Loading Case[1]	Description	Top of Wall/Backfill Elevation[3] (ft)	Top of Sediment Elevation[3] (ft)	STF Groundwater Elevation[3] (ft)	Canal Elevation (ft)	Upland Optional Surcharge Load	Canal Barge Loading	Earthquake Event
Usual	Long-Term/Steady State	585	559	579.0	578.0	Yes	No	No
Unusual 1	High Groundwater (Significant Storm Event)[2]	585	559	582.0	578.0	Yes	No	No
Unusual 2	Barge Mooring	585	559	579.0	578.0	Yes	Yes	No
Extreme 1	Flooded Upland (Extreme Storm Event)	585	559	585.0	578.0	Yes	No	No
Extreme 2	Earthquake (Seismic Event)	585	559	579.0	578.0	Yes	No	Yes

Notes: 1. Additional loading cases may be considered as the design progresses.
2. Significant Storm Event – TBD and to be based on model simulations and engineering judgement.
3. Elevations are in NAVD88.

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4.3 Barrier Wall Evaluation and Results

The geotechnical and structural evaluation of the barrier wall system considers the barrier wall system's ability to provide a stable condition where loads are applied to the system such that unacceptable movements (i.e., failures) are managed through the design of the barrier wall system to limit those movements. Analyses for the barrier wall system address different types of possible failure modes, including internal and deep-seated stability.

4.3.1 Internal Barrier Wall Stability Analysis

The internal barrier wall system stability analysis addresses the following potential failure modes (**Figure 4-1**):

- Rotational failure due to inadequate sheet pile penetration; and
- Structural component failure (i.e., over stressing of sheet pile, tieback (i.e., tie rod), wale system, or deadman (i.e., anchor).

The analysis results indicate that the minimum required bulkhead length (top to bottom) is 52 ft and the minimum required initial bulkhead section modulus is 73.57 in^3 (per ft of wall), assuming American Standard Test Method (ASTM) A572 Grade 50 steel and accounting for steel loss due to corrosion over the service life. This section modulus corresponds to an AZ40-700N steel sheet pile section (or equivalent). It is anticipated that maximum bulkhead deflection (near the dredge line) would range from approximately 1.5 to 3 inches over the service life. Additional details are provided in **Appendix D**. The barrier wall system includes an anchorage system that would consist of a sheet pile anchor deadman and tieback rods connecting the bulkhead to the deadman (**Figure 2-1**). It is anticipated that the deadman would be on the order of 40 to 50 ft in length and the required setback from the bulkhead (for system stability) may be approximately 100 to 120 ft, as shown on **Drawing S-101 and 102 in Appendix I**. The tiebacks may consist of ASTM A722 (150,00 psi ultimate stress) steel threaded rods. Rod diameters on the order of 2-1/4 inches to 2-1/2 inches (nominal) are anticipated based on previous experience. Tiebacks will be encased in larger diameter, flexible PVC conduits from the bulkhead to the deadman to allow for consolidation settlement to occur in the clay soil beneath the tiebacks (due to new backfill placement between the existing top of bank and the bulkhead) without impacting the axial capacity of the tieback. Other barrier wall system structural components, such as walers and bolted/welded connections, will be evaluated as the design progresses. Preliminary structural details are provided on **Drawing S-201 in Appendix I.**

4.3.2 Deep-Seated Stability

The slope stability analysis of the barrier wall system and the STF-Canal bank addresses the deep-seated potential failure mode of the barrier wall system (**Figure 4-1**). This potential failure mode is dependent on the length/penetration of the bulkhead but independent of the structural characteristics of the bulkhead and/or anchors.

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For this analysis, the Usual Loading Case (**Table 4-2**) was analyzed for deep-seated stability. For this Project, a minimum factor of safety (FS) of 1.5 is considered acceptable for long-term static stability under normal (usual) loading conditions; this minimum FS is typically required by most state and federal regulatory agencies for embankments where personal and/or environmental safety is a concern. Critical failure/slip surfaces, as illustrated above, starting in the upland of the STF, extending below the bottom of the bulkhead, and exiting from below the dredged sediment in the Canal (i.e., at the dredge line), were considered in assessing deep-seated stability in **Appendix D**.

The results in **Appendix D** indicate that the FS for the Usual Loading Case critical failure surface is 1.44 considering a 52-ft long bulkhead. To increase the deep-seated stability FS, the bulkhead length has been increased by 1-ft in the analysis (to 53 ft) to force the critical failure surface to extend slightly deeper into the underlying clay. The results indicate that the critical failure surface FS increases to 1.51 in this case, which meets the minimum acceptable FS of 1.5 for the Usual Loading Case.

4.4 Summary and Recommendations

The stability evaluation presented in **Appendix D** indicates that the bulkhead may typically consist of a 53-ft long AZ40-700N sheet pile. The evaluation will be refined and anchor deadman, tiebacks, walers, and other structural components will be evaluated as the design progresses.

Wood performed a limited sensitivity analysis to evaluate the impact of soil unit weight and strength parameters on the bulkhead design requirements (i.e., length, bending moment, anchor load). The results indicate that the strength properties of the clay soil (lacustrine clay and clay till) have a significant impact on the analysis results (**Appendix D**). It is necessary to obtain supplemental Project-specific geotechnical data to finalize soil engineering parameters to support design. It is proposed that ideally, prior to the 90% submittal, supplemental geotechnical data will be generated by completing additional geotechnical explorations (i.e., borings, cores, cone penetrometers, etc.). The explorations would be likely be located in the Canal, along the proposed bulkhead alignment, and in the STF upland (proximate to proposed deadman alignment). Testing would likely include in-situ testing (i.e., standard penetration, shear vanes, and undisturbed sample collection), index tests and strength tests on undisturbed and possibly disturbed samples at various depths to supplement existing data.

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5.0 BANK CONTROL EVALUATIONS

The following section provides the proposed design considerations to address the presence of sheens in the Canal adjacent to the WTF. The installation of reactive mats, which are geotextile sheets that encapsulate an active media are proposed to isolate residual oil on the WTF and will be compatible with future sediment capping adjacent to the WTF.

Several vendors, such as CETCO™ and Huesker, Inc. (Huesker) have developed products that use OC that is enclosed within a geotextile envelope to provide LNAPL sorption in thin rolls that are readily transported and installed and are referred to as RCMs. Further details on the reactive mats are provided in **Section 5.2**.

5.1 Mass Flux Rates

Design of the RCM requires estimation of the sheen mass flux migrating into the canal. Processes for sheen flux include 1) seeps, 2) ebullition, and 3) erosion. These processes are described below.

5.1.1 Light Non-Aqueous Phase Liquid Seepage

Previous investigations have not been conducted that quantify LNAPL seepage into the canal. Estimation of LNAPL seepage into the canal is needed to design the bank controls such that an estimate of design life can be provided, and maintenance planned. The sheen in the canal is, in-part, believed to be caused by the rapid water level fluctuation that occurs in the canal due to the seiche associated with Lake Michigan. During low water elevations the residual LNAPL in bank soils/sediments spreads across the air-water interface. A preliminary estimate of sheen flux is provided in **Appendix E** and used in this submission.

5.1.2 Gas Ebullition

Gas ebullition is when gas formed within sediments mobilizes contaminants through the sediment and into the water column. Ebullition results from methanogenesis of organic constituents including LNAPL causing potential fracture on sediment surfaces and subsequently releasing sheen producing materials.

No data has been collected or reported in prior investigations thus far, to evaluate and assess the potential impact of gas ebullition within the banks of WTF.

5.2 Reactive Materials

An RCM or layers of RCMs are expected to be installed on the bank of WTF, which would be comprised of one or more types of materials in the “reactive layer”, encapsulated in non-woven or woven geotextile fabric layers. Each of the potential materials in the “reactive layer” of the RCM are described below.

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5.2.1 Organophilic Clay

OC is an engineered product consisting of clay (typically bentonite) that has been organically modified to improve its oleophilic sorption capacity. In this instance, the OC would be used to sorb LNAPL and/or sheen-bearing residuals, thereby mitigating the potential for LNAPL seepage toward the Canal. Two products (RCM™ with Organoclay® and Tektoseal Active OC) that contain OC as an active layer are being considered. In terms of construction-both the products are available in rolls, so they are convenient to transport and install. The encapsulating geotextiles add mechanical stability to the OC layer and achieve a stable, constant minimum layer thickness over the installed area.

In terms of performance, the efficiency (i.e., ability to mitigate potential LNAPL migration toward the Canal), and a minimum 30-year life expectancy of the system would be provided, by layering or increasing the reactive materials in the system, based on expected flux rates and absorptive capacity that may be determined through Site-specific testing. Both products contain 0.8 pounds (lb) OC/ft^2 and have a vendor reported oil absorption capacity of 0.5 lb oil/lb OC (min).

Additional laboratory bench-scale pre-design testing may be conducted to determine WTF-specific OC sorption capacity. Using site-specific density of LNAPL, and the parameters of OC, the layers of product for various fluxes likely needed to provide the required 30-year life will be estimated as described in **Appendix E.**

5.2.2 Oil Absorbing Polymers

Geofabrics containing oil-adsorbent melt-blown polymers are similar to the OC mats in that they are mechanically reinforced by non-woven geotextile and provide a minimum thickness of the reactive material. These polymers have a structure and surface properties that are suitable to separate oil from water in oil/water mixtures such as LNAPL in groundwater. Further, some of these polymers are appropriate for reliably binding petrochemical products like gasoline & diesel which have been reported to be the primary constituents in the LNAPL on the Site (2002 SI report).

The product being considered is Tektoseal® Active AS supplied by Huesker Inc. AS is an engineered geocomposite comprised of two nonwoven geotextiles with an inner layer of oil-adsorbent melt-blown polymer which are bonded together by a needle punch process. Tektoseal® Active AS has been developed as an environmental geocomposite used for contaminated runoff, contaminant capping and turbidity curtain applications.

Vendor provided oil-absorption capacity is reported at 0.15 US gal/ft^2 at a mass per unit area of 27 oz/yd^2. Like the OC product, bench scale testing can provide WTF-specific oil adsorption. A primary difference between Tektoseal's OC & AS products are that OC requires contact time with LNAPL for adsorption while the AS adsorbs LNAPL immediately upon contact. Hence, to achieve efficiency and prolonged life, this product may be used in combination with the OC fabric.

The AS layer would be used on-top-of the OC layer(s), to serve as a polishing step and to address materials not retained by the OC and would not be included in the design life calculations.

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5.2.3 Product Selection and Construction Feasibility

Based on the manufacturer's product specifications, LNAPL seepage estimates, WTF-specific bench testing and material costs, a reactive mat with one or more active layers of OC may be used in combination with AS.

While the geotextile layers are convenient to handle and install, some work needs to be done for bank surface preparation. In order to install the geotextile, the surface would need to be smooth and free of vegetation, sharp-edged rocks, stones, sticks, construction debris, and any material that could potentially puncture the geotextile fabric. In such cases, the obstructions would be removed and/or the bank would be graded or leveled with a layer of sand. For seams in and around protruding structures (like pipe penetrations and the proposed sheet pile wall for the GLLA sediment cap (Tetra Tech, 2015d), sodium bentonite is typically recommended. However, if there are high concentrations of divalent cations in the groundwater, bulk organo-clay may be used as a sealant. Finally, a cover of sand, stone, riprap or articulated mats may be placed over the "reactive layer" as the armor layer.

A case-study of a previous implementation by Huesker in 2018 on a different site in East Chicago to prevent oil migration into a canal is included in **Appendix E.1**.

A materials processing and staging area is expected to be necessary to appropriately manage materials generated as part of the Project. This area will likely be north of the bank control area and designed to meet applicable standards for stormwater, erosion and liquid management. The area is expected to be lined ; constructed with aggregates/geotextiles and a durable drainable working surface. Excavated materials may be segregated into appropriate categories for either offsite disposal, recycling, or relocated within the ECI Site.

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5.3 Permeability

The K of these geotextile products is reported by vendor(s) to be greater than 1 $\times 10^{-3}$ cm/s. As described in **Section 3.3.1 and 3.3.2**, the approximate K of the surficial soils (i.e., sands and fill) are on the order of 51.5 ft/day (2 x 10^{-2} centimeters per second [cm/sec]). Therefore, some degree of groundwater mounding may be possible; however, it is not expected to be significant enough to result in ponding or surficial discharge and will be evaluated in subsequent submissions. A two-dimensional finite element flow model, using SEEP/W (GeoStudios) is expected to be used to evaluate the effects of the bank control system on seepage at the bank with attention to mounding, potential short-circuits and unintended diversion of flow around the bank controls. The Arcadis groundwater model provided an estimate of flow through the WTF, which will be further evaluated and may be used to inform the 2-D modeling.

5.3.1 Geochemistry

Bank soils/sediments are typically subject to significant groundwater-surface water exchange which can induce oxidation/precipitation of metals. This can reduce the K of the bank stabilization system

components, including the sand and reactive mat, which can impact performance of the reactive mat. The Seep/W model and the Arcadis model would be used to assess the potential impacts of reduced system K values.

5.3.2 Biofouling

The potential for biofouling at the WTF can be from iron-related bacteria (IRB) and LNAPL microbial degradation. No assessment of biological activity has been reported in previous investigation reports and is expected to be required to adequately design the bank controls at the WTF.

However, there are some analytical data and information from field sampling logs that can be used to assess potential fouling from IRB. From the groundwater sampling data included in the 2016 SI report, the pH is approximate 7.0, and dissolved oxygen is less than 1 mg/L. IRB can thrive in these conditions of 10-15 degree Celsius, and >0.1 mg/L of iron (WDEQ, 2018). Therefore, there is potential for biofouling from IRB, and the design would account for the potential for biofouling by using the bedding material to distribute groundwater seepage.

5.4 Break-Through Estimates

Break-through estimate of the selected RCM are preliminarily estimated, to estimate the amount of OC needed to provide a 30-year life. The assumptions and preliminary estimates are provided in **Appendix E**.

5.5 Other Design Considerations

5.5.1 Armoring requirements

To protect the reactive mat from flow velocities, ice floes and wave action during low and high water periods an armor layer will be installed over the reactive mat. The bank control barrier is expected to consist of, from bottom up, a sand layer, filter layer, and armor layer. The calculation of riprap sizing will be provided in a future design submittal and is shown as 18" in this 30% submission.

5.5.2 Integration with Sediment Remedy

The bank control and GLLA sediment capping remedy will be integrated to provide protection from sheen flux from bank soils and sediments. The GLLA sediment cap is believed to provide control of oil seepage from sediments below El. 571 ft based on the fact that the cap starts at elevation 575 and the base of the reactive layer is 4 ft below that, or at El. 571 ft. Bank controls to be installed as part of this Project at the WTF will mitigate oil seepage from bank soils above this elevation, as illustrated in **Figure 2-2** using the with and without sand cap bank controls (and an as yet designed transition). Where no sand cap exists (east of the sheetpile) (east of approximately Station 302+75 on **Drawing C-111 in Appendix I**), a with the sand cap bank control system would be installed, as illustrated in **Figure 2-3**. Careful sequencing of the bank controls and sediment cap installation will be required to ensure integrity of both the GLLA sediment cap and these bank controls, which will be developed based on information not yet available and included in subsequent design submissions.

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5.5.3 Performance Monitoring

Performance monitoring of the bank controls will be completed periodically and after major flood events TBD. The inspections may include the following:

- Visual observation of erosion or other physical disturbance;
- Visual observation of sheens; and
- If necessary, perform periodic passive sheen sampling.

5.6 Light Non-Aqueous Phase Liquid Fate and Transport

In addition to the investigations and analyses described above, i.e., to determine LNAPL extent and characteristics, Arcadis (2016) performed additional testing to answer the stated SI goal relative to the LNAPL of: "Assess mobility and hydraulic recoverability of LNAPL near the Canal and in upland area relevant to the remedy evaluation."

To achieve this goal, Arcadis performed tests to determine "LNAPL transmissivity (T) via baildown testing or manual skimming at existing monitoring wells" (Arcadis, 2016). The baildown tests using a peristaltic pump were conducted on wells with 0.5-ft or more of LNAPL. These wells were OW-107 and MW-03 on the WTF and OW-124 and PRW-37, a recovery well, on the STF. In these tests, LNAPL levels in wells were drawn down to a minimum and the subsequent flow rate of LNAPL back into the well monitored. These data were then analyzed much as a slug test, primarily using methods of Bouwer and Rice and curve matching.

Peristaltic pumped tests: At OW-107 on the WTF, two tests provided estimates of T of 0.08 and 0.14 square ft per day (ft^2/d), and at MW-03 (with reservations on the accuracy of this result), curve type results of T from 0.3 to 0.6 ft^2/d were estimated. On the STF, tests for OW-124 generated results of 6.3 to 8.4 ft^2/d. This relatively high result was deemed due to a locally limited area. At recovery well PRW-37, the estimated T values ranged from 0.03 to 0.18 ft^2/d.

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6.0 PERMITTING

6.1 Clean Water Act Section 10/404 permit (USACE)

Due to the amount of linear impacts [approximately 2,500 LF for both the WTF and STF] and the amount of materials discharged at and below the ordinary high water mark of Lake George Canal, the project may likely need to be permitted as an Individual Permit (IP) by the USACE Chicago District. Lake George Canal is a navigable water and alterations of the bank lines will be subject to authorization under Section 10 of the Rivers and Harbors Act of 1899. Additionally, the project will likely need authorized under Section 404 of the CWA for the discharge of fill materials associated with backfill for the STF barrier wall as well as bank stabilization measures along the WTF. The Section 10 and 404 authorizations would be combined under the IP.

Acquisition of an IP would require submittal of supporting documents or narratives addressing the purpose and need of the project; avoidance and minimization efforts taken to reduce impacts to Waters of the United States; alternative analysis; and mitigation. Due to the federal action of obtaining the IP, additional environmental work and agency coordination would likely need to be addressed, including a cultural resource survey and coordination with the IDNR Division of Historic Preservation and Archaeology pursuant to Section 106 and 110 of the National Historic Preservation Act, 36 Code of Federal Regulations (CFR) 800, the National Environmental Protection Act, and Indiana Code 14-21-1. Additionally, the United States Fish and Wildlife Service and the IDNR Natural Heritage Program would likely need to be consulted regarding protected flora and fauna.

The IP process requires a public notice period of 21 to 30 days. Any comments received during this time would need to be addressed by the USACE. However, the applicant may need to assist the USACE in providing responses. The typical timeframe for acquisition of an IP for this type of project is two to three months.

6.2 Section 401 Water Quality Certification (IDEM)

In association with the USACE Section 404 permit, a Section 401 Water Quality Certification (401 WQC) will likely be required from the IDEM. The 401 WQC would be applied for in conjunction with the USACE IP.

6.3 NPDES Rule 5 Stormwater Runoff Associated with Construction Activity (IDEM)

If greater than one acre of land is disturbed for construction purposes, an NPDES Rule 5 stormwater permit would need to be obtained from IDEM pursuit to 327 IAC 15-5 (Rule 5). However, if an individual NPDES permit is required for sediment dewatering (see **Section 6.4** below), the Rule 5 construction permit may be included as part of the larger NPDES. Rule 5 requires a stormwater pollution prevention plan (SWPPP) and approval of local stormwater agencies such as Lake County Soil and Water Conservation District and local Municipal Separate Storm Sewer System programs, such as the City of East Chicago Stormwater Quality Management.

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6.4 NPDES Discharge Permit (if needed for sediment dewatering)

There will likely be considerable dewatering and stormwater management once the bulkhead wall is installed. As such, an NPDES permit for dewatering activities would need approved and acquired from the IDEM Office of Water Quality. Baseline supernatant testing or other analytics would need to be conducted to determine if hydrocarbons or other contaminants of concern may be present. The applicant would need to prove antidegradation from discharged water. The general industrial NPDES development procedures from IDEM's website are as follows:

1. *Identification of all pollutants known or believed to be present in the effluent. Review of all existing information in the application and the IDEM files such as effluent quality data, current permit conditions, inspections, construction permits, and compliance status.*
2. *Determining applicability of U.S. EPA technology-based effluent guidelines for a discharger and the limits based on the guidelines. If U.S. EPA guidelines don't exist, development of effluent limits based on best professional judgement of the technology representing the best available treatment.*
3. *Determining water quality-based effluent limits for pollutants required by U.S. EPA guidelines as well as any additional pollutants believed to be present in the effluent. Water quality- based effluent limits take into account characteristics of the receiving stream such as the low flow value and hardness of the stream at the point of discharge.*
4. *The permit is drafted with the effluent limits based on either the technology-based limits or water quality-based effluent limits, whichever are more stringent.*
5. *The permit may contain a time schedule for the permittee to achieve compliance with effluent limits that were either not included in the previous permit or are more stringent than the effluent limits in the previous permit. This schedule of compliance must be requested and sufficiently justified by the permittee. This schedule of compliance is included in the permit only if it is determined that the permittee is unable to meet the limits at the time of permit issuance. If the permit applicant is a new facility or an existing facility that is recommencing its discharge, they are not allowed a schedule of compliance.*

The NPDES also requires a 30-day public notice period. Any comments received following the period would need to be addressed.

6.5 Applicable local permits

Additional floodplain, construction, and grading permits will likely be required. More information on local permits will be presented as detailed plans are prepared, as appropriate.

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7.0 PROJECT CONTROLS

The design will include Project controls to be implemented by the contractor during remedy implementation related to worker safety, emergency response, work area security, stormwater generated sediments, and Canal surface water quality.

7.1 Worker Health and Safety Protections

A Project-specific Health and Safety Plan (P-HASP) will be included as **Appendix G.1** in the 90% BODR (an outline is attached as **Appendix G.1**). The construction contractor will be required to develop a Construction-HASP (C-HASP) to protect its workers during the implementation of the Project, based on their selected means and methods and in accordance with their policies as well as that of the P-HASP. The C-HASP shall be approved by ARC prior to mobilization to the Site and updated as necessary throughout the Project.

The P-HASP will establish project specific requirements which the construction contractor will be required to include in their C-HASP. The P-HASP is expected to include the following minimum requirements and follow the outline below:

- The HASP shall comply with the requirements of 29 CFR 1910.120 and 29 CFR 1926.
- All workers shall be required to have demonstrated health and safety training and be enrolled in a medical monitoring program in conformance with OSHA Standards 29 CFR 1910.120.
- The construction contractor shall be responsible for the health and safety of its workers, subcontractors and protection of the general public and shall utilize personnel with appropriate training as required or specified in the HASP.
- Appropriate personal protective equipment shall be identified, provided and worn during Project work to mitigate exposure to identified safety risks.
- Establish clear Health Safety and Environment (HSE) objectives, responsibilities and lines of communication.
- Empowering and encouraging anyone to stop work on any task if they perceive any safety related shortfall.
- Identifying, installing, monitoring and routinely maintaining for the duration of the Project, all safety related Project Controls.
- Identify and manage hazards to eliminate or mitigate resultant risks, using a standard approved form
- Prevent injury, ill-health, pollution and loss resulting from project activities.
- Ensuring assignment of qualified and competent HSE leadership and management.
- Provide and apply effective HSE management systems.

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- Comply with legal, regulatory, industry and other external requirements of authorities having jurisdiction.
- Learning lessons from incidents and preventing reoccurrence.
- Providing daily assessment and training of workers to be competent and safe in performing specific work tasks.

The P-HASP is anticipated to follow the outline provided in **Appendix G.1**.

7.2 Wildlife Protections

Wildlife protection and management is an important part of the implementation of the Project. The work will be performed in accordance with applicable regulations and utilize the existing Waterfowl Management Plan (Arcadis, 2015) or an updated version.

7.3 Design Phase Roles and Responsibilities

Project Job Title	General Project Responsibilities
Atlantic Richfield, Project Manager	Provide known project data, used to support Design. Person in Charge. Respondents Representative.
Project Coordinator	Oversees Atlantic Richfield's actions required by the AOC. Interacts with Stakeholders.
Wood Project Manager	Directs all Wood Resources on the Project. Primary point of contact to Atlantic Richfield
Wood Design Lead	Leads the design effort, informs Wood Project Manager and Engineer of Record (EOR).
Wood EOR	In responsible charge of the design. Stamps Issued for Construction design documents.
Wood Program Support	Health and Safety (H&S) Manager – Ensures consistency with Owner H&S requirements.

7.4 Local Emergency Management

The Contractor will be required to develop a Project-Specific Emergency Management Plan (EMP). The EMP will supplement the P-HASP and relates to local emergency management within the construction limits and will contain contacts for local, state and federal emergency responders and organizations. Emergency management assessment will identify response to identified or potential incidents.

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The Project will require conducting business in complex and challenging operating environments that may present unique challenges and require project staff to address emergencies or incidents. The EMP will clearly identify project HSE personnel (e.g., Emergency Coordinators) sufficiently prepared to respond and communicate with respect to emergencies and incidents; and to communicate to appropriate Owner and Stakeholder personnel for assistance and for potential escalation of an event to a response level beyond project personnel capabilities as well as to provide required regulatory notifications.

The EMP's key objectives are expected to be to:

- protect people including staff, visitors, adjacent communities, the environment and business assets;
- provide planning for and prevention of emergencies;
- provide guidance to manage response to emergencies;
- advise Project, Owner and Stakeholder management of immediate response actions to any incident;
- ensure impacted services are reinstated/reimplemented as soon as practical; and
- comply with relevant regulations and standards.

The EMP is expected to include but not be limited to discussion of the following:

- Medical emergency response
- First-aid for non-life-threatening injuries
- Project personnel response actions
- Bloodborne pathogen exposure control
- Emergency chemical decontamination
- Emergency equipment to be maintained in the field
- Evacuation procedures
- Identifying areas of safe refuge and sheltering in place
- Weather-related emergencies
- Control and response to spills and/or discharge of hazardous materials
- Fire or explosion
- Civil disturbances and security threats
- Accident reporting and record keeping

Draft

7.5 Security Barriers

Security refers to personal safety and freedom from theft or violence and deterrence of unauthorized access by vandals/trespassers to the Project area. In addition to security barriers, all excavations and hazardous areas will be protected as described in the Technical Specifications. The following features exist at the Site, and considered components of Site Security:

- Historical industrial and recent construction activities inform the public of on-going Site use; and
- A perimeter chain-link fence and locked gates provide physical barriers around the STF and WTF.

The following additional features are expected to be required of the construction contractor:

- Public notifications TBD;
- Signage near the construction entrance to inform the public of the remedial activities and provide contact information;
- The construction contractor will be responsible for the security of equipment and supplies and may elect to install or implement additional security measures such as security guard(s), lighting, signage, closing the gate(s) during work hours, etc., which will be reviewed and approved by the Owner.

7.6 Sediment Control Systems

Activities required to complete the RAs have the potential to liberate sediments which may impact surface water quality of the Canal. Project activities in the uplands may change surface characteristics and allow storm water to convey sediments into the Canal. Project activities in the Canal may liberate semi-stable sediments in the Canal which may cause their relocation within the Canal. Both types of activities may be regulated by permits, as described in **Section 6**. In addition, Project specific plans will be required to guide the construction contractor's activities throughout their implementation of the Project.

As described in **Section 6**, a stormwater permit will likely be required for upland activities related to this project, to reduce discharge of pollutants resulting from soil erosion and other upland construction into adjacent water bodies (i.e., the Canal). The construction contractor will be provided with a copy of the SWPPP (submitted with the permit application) and allowed to make recommendations for changes to the construction phase erosion and sediment controls in the SWPPP, to coincide with their means and methods. Recommended changes to the SWPPP should be reviewed and approved by the Owner, Stakeholders and permit agencies before mobilization. Once changes are approved, the permit will be secured, as appropriate, before construction activities start. The construction contractor will be responsible for compliance with the permit, as appropriate.

Draft

8.0 OPERATIONS AND MAINTENANCE

O&M includes inspection schedule and routine maintenance criteria and if necessary, operational plans. This Section is expected to be expanded as part of the 90% Submission.

8.1 Barrier Wall

Barrier wall maintenance would be minimal. Perhaps the most important item will be to inspect the actual depth in-front of the bulkhead periodically. The barrier wall system design will consider a temporary condition where over-dredging to the top of clay or revetment erosion occurs. Sediment accumulation in-front of the bulkhead would not be detrimental to the performance of the system.

8.2 Bank Control Elements

The planned bank controls are expected to be responsible from top of bank to El. 575 ft (~low water level). The USACE cap, which is expected to be installed after these bank controls, extends below El. 575 ft. Below El. 575 ft we will need to discuss shared maintenance. We will also need to discuss construction sequencing, there may be tasks, like debris removal that should be completed prior to install of our bank controls to minimize residual contamination.

8.3 Design Life

The design life represents the period over which the designed element is expected to provide the as designed conditions. For instance, the barrier wall is made of steel, which corrodes so a corrosion allowance is applied for the design life and extra steel is provided above what is required, such that after the design period ends the steel is expected to have rusted and the steel is as thick as it needs to ne to meet the design assumptions. The following provides the design life for the various elements of the Project:

Barrier Wall System:

- All steel elements: 50-years based on a corrosion rate of TBD, in accordance with TBD.
- Sealants – manufacturer warranty.
- Seismic return period: A peak ground acceleration associated with a probability of exceedance of 2% in 50 years.

Bank Controls:

- Armor Layer: TBD (possibly 18" of riprap)
- Reactive Core Mat: Manufacturer's warranty and a required estimated 30-yr life on the RCM based on an estimated (in the 30% submission) flux rate, as described in **Section 5**.

Draft

9.0 SCHEDULE

9.1 Design Schedule

The proposed design schedule is provided as required in the AOC and attached in **Appendix G.2**. This Draft schedule includes several assumed durations and external factors not specifically shown on the schedule that are beyond the control of ARC; therefore, modifications are anticipated. The schedule includes the following anticipated major milestones with anticipated delivery dates, assuming no change to the schedule:

- Issuance the revised 30% BODR to USEPA and Stakeholders 30-days after receipt of USEPA comments on Draft 30% BODR.
- Issue 90% BODR to USEPA and Stakeholders
- Issue Health and Safety Plan to USEPA and Stakeholders
- Issue Quality Assurance Project Plan to USEPA and Stakeholders
- Issue Additional Field Data Deliverable to USEPA and Stakeholders.

9.2 Implementation Schedule

The currently anticipated implementation schedule developed by GLLA and dated October 3, 2019 is provided in **Appendix G.2**. This Draft schedule is subject to change and is beyond the control of ARC and may affect the Design Schedule presented in **Section 9.1**.

Draft

10.0 TECHNICAL SPECIFICATIONS

Technical Specifications (Specifications) will be used in contract documents to describe the work to be completed by the remediation contractor. **Table 10-1** provides a list of anticipated specifications and identifies in which submission the specification is expected to first appear in the BODR. The Specifications identified in **Table 10-1** as part of this 30% submission are provided in **Appendix H.**

Table 10-1 - Technical Specifications List

#	SUMMARY OF SECTION	30	90	IFC
	COVER SHEET	X		
	SIGNATURE SHEET			X
	TABLE OF CONTENTS		X	
01 10 00	SUMMARY OF WORK	X		
01 31 00	PROJECT MANAGEMENT AND COORDINATION		X	
01 32 00	CONSTRUCTION PROGRESS DOCUMENTATION		X	
01 33 00	SUBMITTAL PROCEDURES		X	
01 35 29	HEALTH, SAFETY, AND EMERGENCY RESPONSE PROCEDURES		X	
01 35 43	ENVIRONMENTAL PROCEDURES	X		
01 35 63.13	SUSTAINABILITY REQUIREMENTS	X		
01 41 00	REGULATORY REQUIREMENTS	X		
01 45 16	QUALITY CONTROL	X		
01 50 00	TEMPORARY FACILITIES AND CONTROLS		X	
01 70 00	EXECUTION AND CLOSEOUT REQUIREMENTS		X	
01 74 19	CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL	X		
01 81 16	FACILITY ENVIRONMENTAL REQUIREMENTS		X	
02 21 00	SURVEY AND GRADE CONTROL		X	
02 41 19	SELECTIVE SITE DEMOLITION		X	
02 61 13	EXCAVATION AND HANDLING OF CONTAMINATED MATERIALS	X		
02 72 00	WATER TREATMENT	X		
13 50 00	SPECIAL INSTRUMENTATION		TBD	
31 10 00	CLEARING AND GRUBBING		X	
31 20 00	EARTHWORK		X	
31 21 40	DEWATERING - UPLAND	X		
31 23 23	SUBAQUEOUS CAPPING		X	
31 25 00	EROSION AND SEDIMENTATION CONTROL		X	
31 41 16	STEEL SHEET PILING AND SEALING	X		
32 92 19	SEEDING		X	
35 20 23	ENVIRONMENTAL DREDGING		X	

Draft

#	SUMMARY OF SECTION	30	90	IFC
35 20 25	WATER QUALITY MONITORING		X	
35 42 00	WATERWAY BANK PROTECTION		X	
35 51 13	MARINE SIGNALING AND CONTROL EQUIPMENT	X		
46 01 07	OPERATION AND MAINTENANCE OF PACKAGED TREATMENT EQUIPMENT		TBD	
46 07 13	PACKAGED WATER TREATMENT EQUIPMENT		TBD	

X – Indicates the design submittal the specification is expected to first appear.

Draft

11.0 DRAWINGS

Table 11-1 provides a complete list of design drawings and identifies those included in this 30% Submission, see **Appendix I**.

Table 11 – Drawing List

INCLUDED THIS SUBMITTAL	SHEET NUMBER	DRAWING ID	DRAWING TITLE
X	1	G-001	COVER SHEET
X	2	G-002	LEGEND AND ABBREVIATIONS
X	3	G-003	GENERAL CONDITIONS
X	4	C-101	EXISTING CONDITIONS - STF OVERVIEW
X	5	C-102	EXISTING CONDITIONS - STF (NW)
X	6	C-103	EXISTING CONDITIONS - STF (NE)
X	7	C-104	EXISTING CONDITIONS - WTF OVERVIEW
X	8	C-105	EXISTING CONDITIONS - WTF (S)
	9	C-106	FINAL GRADING PLAN - STF (NE)
	10	C-107	FINAL GRADING PLAN - STF (NW)
	11	C-108	FINAL GRADING PLAN - WTF (S)
	12	C-109	BARRIER WALL BACKFILL PLAN - STF (NW)
	13	C-110	BARRIER WALL BACKFILL PLAN - STF (NE)
X	14	C-111	BANK CONTROL PLAN - WTF (S)
X	15	C-301	SOIL EROSION AND SEDIMENT CONTROL NOTES
	16	C-302	SOIL EROSION AND SEDIMENT CONTROL PLAN - STF
	17	C-303	SOIL EROSION AND SEDIMENT CONTROL PLAN - WTF
X	18	C-304	SOIL EROSION AND SEDIMENT CONTROL DETAILS
X	19	C-401	STF BARRIER WALL CROSS-SECTIONS STA 0+00 TO 5+00
X	20	C-402	STF BARRIER WALL CROSS-SECTIONS STA 6+00 TO 11+00
X	21	C-403	STF BARRIER WALL CROSS-SECTIONS STA 12+00 TO 17+00

Draft

INCLUDED THIS SUBMITTAL	SHEET NUMBER	DRAWING ID	DRAWING TITLE
X	22	C-404	STF BARRIER WALL CROSS-SECTIONS STA 18+00 TO 20+39
X	23	C-405	WTF BANK CONTROL CROSS-SECTIONS STA 300+00 TO 303+17
	24	C-501	CIVIL DETAILS
	25	S-001	STRUCTURAL NOTES
X	26	S-101	BARRIER WALL PLAN AND PROFILES - STF (NW)
X	27	S-102	BARRIER WALL PLAN AND PROFILES - STF (NE)
X	28	S-201	BARRIER WALL DETAILS I
	29	S-202	BARRIER WALL DETAILS II

Notes:

Additions, deletions or modifications to this table may occur in subsequent submissions.

X – Indicates the drawing is included in this submission

Draft

12.0 REFERENCES

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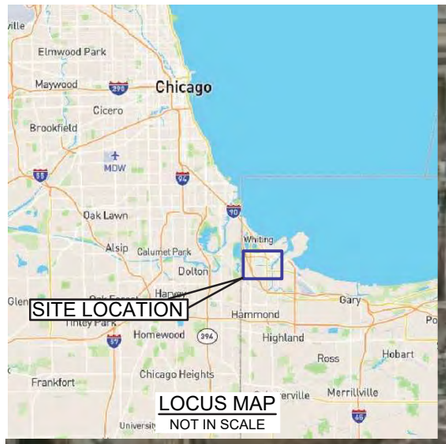
Draft

Draft

FIGURES



CSX RAILROAD

INDIANAPOLIS BOULEVARD

ROUTE 912

PCA

WTF

HTF

HTW

US ARMY OF ENGINEERS CONFINED DISPOSAL FACILITY (CDF)

IHSC

OIL CONTROL BARRIER WALL

LAKE GORGE CANAL

BANK CONTROL

RAILROAD BRIDGE

SWTF

STF

ROAD BRIDGE

IHC

SSTF

MAC ARTHUR GOLF COURSE

I-90

SSWTF

EAST CHICAGO CENTRAL HIGH SCHOOL

N

LEGEND:

PARCEL BOUNDARY

SUBJECT LOCATIONS (REMEDIAL ACTION LOCATION)

HTF -	HAMMOND TANK FARM
IHS -	INDIANA HARBOR CANAL
PCA -	POLLUTION CONTROL AREA
SSTF -	SOUTH OF SOUTH TANK FARM
SSWTF -	SOUTH OF SOUTHWEST TANK FARM
STF -	SOUTH TANK FARM
SWTF -	SOUTHWEST TANK FARM
WTF -	WEST TANK FARM

SOUTH TANK FARM: 53.5 ACRES
WEST TANK FARM: 18.3 ACRES

Prepared/Date: BRT 12/17/19
Checked/Date: BBJ 12/17/19

REFERENCE: BING MAP 2019

DRAFT

0 400 800 1600
HORIZONTAL SCALE IN FEET

OIL CONTROL BARRIER AND BANK CONTROL DESIGN
ECI SITE
EAST CHICAGO, INDIANA

wood.
Environment & Infrastructure Solutions, Inc.
511 Congress St., Suite 200, Portland ME 04101
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OIL CONTROL BARRIER WALL AND BANK CONTROL DESIGN (Site Overview)
Project 3205-19-1698
Figure 1-1

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LAKE GEORGE CANAL

STF UPLAND

BULKHEAD WALL

FILL

TIEBACK

EXISTING GRADE

DEADMAN ANCHOR WALL

HISTORICAL HIGH WL. ELEV. (582.05')

TYPICAL WL. ELEV. (577.65')

HISTORICAL LOW WL. ELEV. (575.15')

TETRA TECH LGE-203

TOE ARMORING TBD

100' - 120'

BOTTOM AT ELEV.532' ±

BEDROCK SURFACE CURRENTLY UNKNOWN MAY BE AT ELEV. 480' TO 500'

ELEVATION, FEET (NAVD88)

590 580 570 560 550 540 530 520 510 500 490 480

-100 -50 0 50 100

LEGEND:

- SAND AND SILT
- CLAY UNIT
- WATER LINE
- SHEET PILE
- EXISTING GROUND
- LNAPL SMEAR ZONE
- 5 FT BELOW SMEAR

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Prepared/Date: BRT 12/17/19
Checked/Date: NDL 12/17/19

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0 10 20 40 HORIZONTAL SCALE IN FEET

0 10 20 40 VERTICAL SCALE IN FEET

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BARRIER WALL
SYSTEM SCHEMATIC
Project 3205-19-1698
FIGURE 2-1

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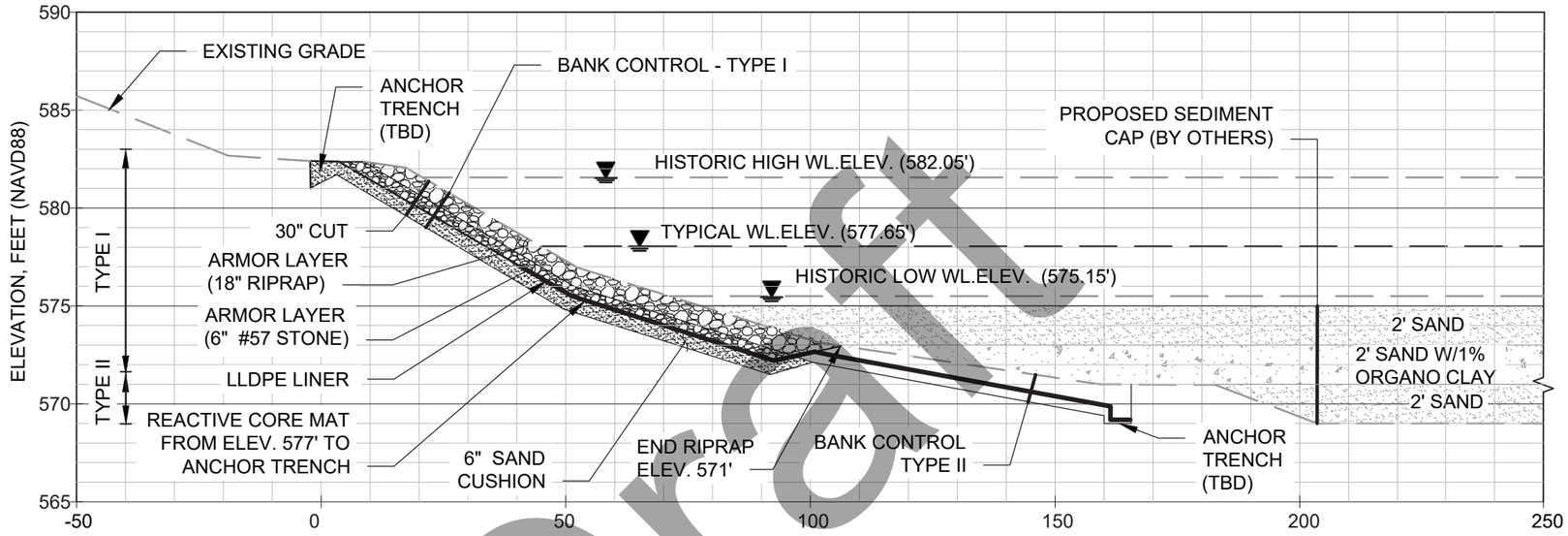
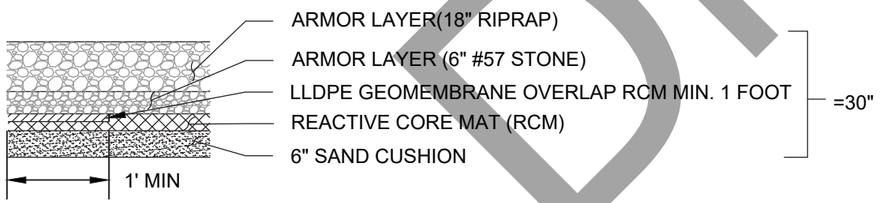
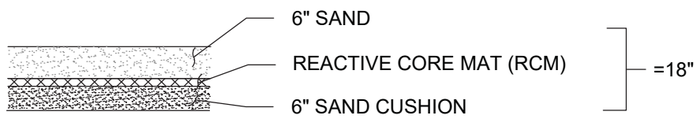




BANK CONTROL - WITHOUT SAND CAP

NOT TO SCALE



BANK CONTROL - WITH SAND CAP

NOT TO SCALE

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0 15 30 60
HORIZONTAL SCALE IN FEET

0 7.5 15 30
VERTICAL SCALE IN FEET

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BANK CONTROL CROSS-SECTION
SAND CAP
Project 3205-19-1698
Figure 2-2

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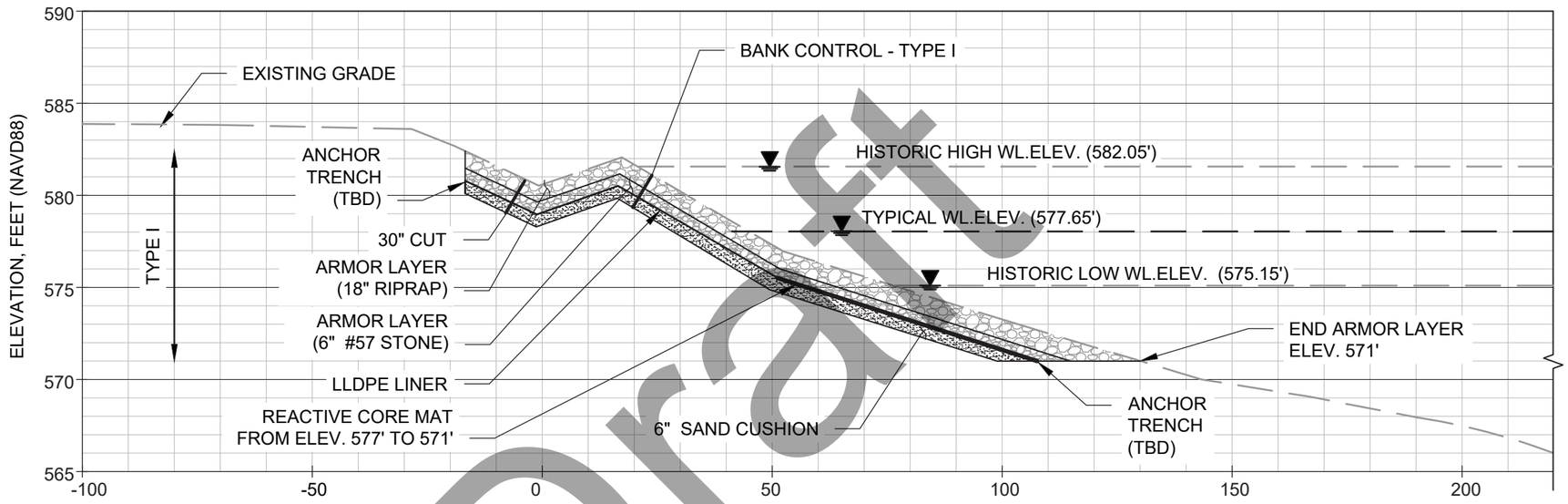

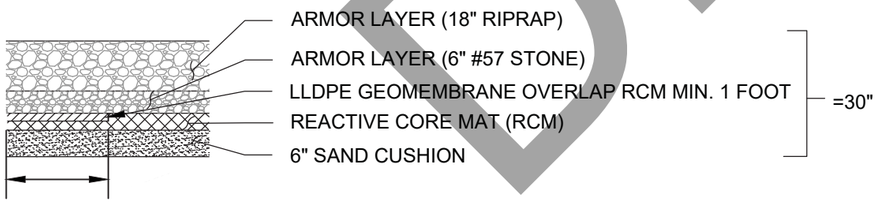

BANK CONTROL -

WITHOUT SAND CAP

Draft

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0 15 30 60 HORIZONTAL SCALE IN FEET

0 7.5 15 30 VERTICAL SCALE IN FEET

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BANK CONTROL CROSS-SECTION
NO SAND CAP
Project 3205-19-1698
Figure 2-3

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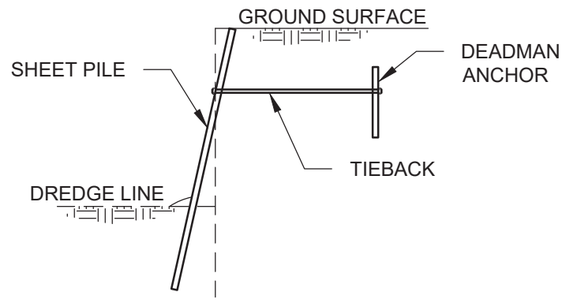
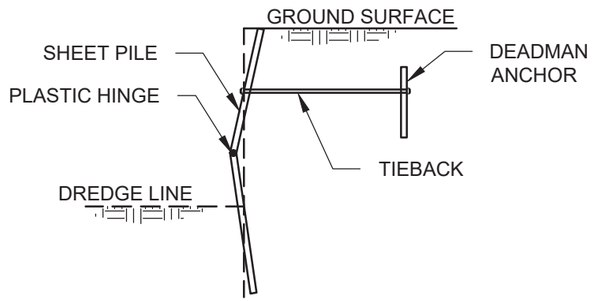
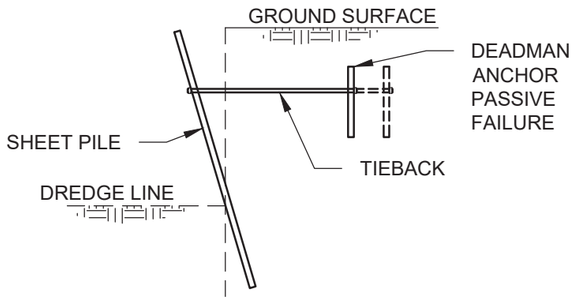


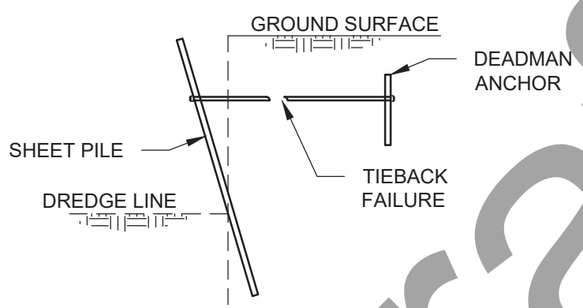
1. ROTATIONAL (PASSIVE) FAILURE



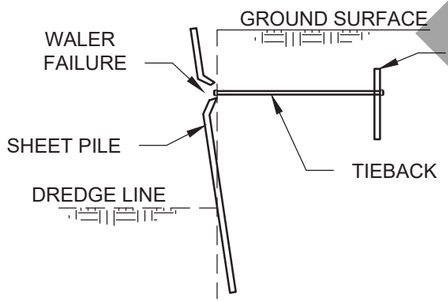
2. SHEET PILE FAILURE (YIELD)



3. DEADMAN ANCHOR PASSIVE FAILURE



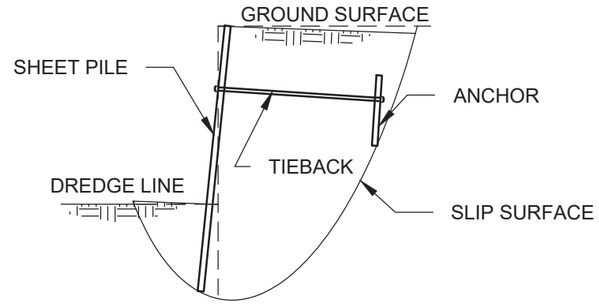
4. TIEBACK FAILURE



5. WALE SYSTEM FAILURE

A INTERNAL STABILITY

NOT TO SCALE



B DEEP-SEATED STABILITY

NOT TO SCALE

Draft

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APPENDIX A

WATSON ET AL., 1988 "PRELIMINARY ANALYSIS OF THE SHALLOW GROUND-WATER SYSTEM IN THE VICINITY OF THE GRAND CALUMET RIVER/INDIANA HARBOR CANAL, NORTHWESTERN INDIANA". USGS OPEN-FILE REPORT 88-492

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PRELIMINARY ANALYSIS OF THE SHALLOW GROUND-WATER SYSTEM IN THE VICINITY OF THE GRAND CALUMET RIVER/INDIANA HARBOR CANAL, NORTHWESTERN INDIANA

U.S. GEOLOGICAL SURVEY
Open-File Report 88-492

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Prepared in cooperation with the
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U.S. ENVIRONMENTAL PROTECTION AGENCY

DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

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CONVERSION FACTORS AND ABBREVIATIONS

Inch-pound units in this report may be converted to metric (International System) units by using the following conversion factors:

Multiply inch-pound unit	By	To obtain metric unit
foot	0.3048	meter
foot per day	0.3048	meter per day
inch	25.4	millimeter
mile	1.609	kilometer

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called "Sea Level Datum of 1929."

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PRELIMINARY ANALYSIS OF THE SHALLOW GROUND-WATER SYSTEM IN THE VICINITY OF THE GRAND CALUMET RIVER/INDIANA HARBOR CANAL, NORTHWESTERN INDIANA

By Lee R. Watson, Robert J. Shedlock, Konrad J. Banaszak,

Leslie D. Arihood, and Paul K. Doss

ABSTRACT

The shallow ground-water system in the vicinity of the Grand Calumet River/Indiana Harbor Canal and the surrounding area was analyzed from June 1985 through May 1986. This analysis was the preliminary phase of a study, the main objective of which was to assess the potential for ground-water contaminants to migrate to Lake Michigan or to the Grand Calumet River/Indiana Harbor Canal. This preliminary analysis was done to obtain more detailed information about the physical characteristics and thickness of the Calumet aquifer and the shallow flow regime in that aquifer and to select the best sites for ground-water-quality monitoring.

During this preliminary analysis, 36 shallow wells were installed, 19 continuous sediment cores ranging from 4 to 18 feet long were collected, and 7 test holes were drilled to the bottom of the surficial aquifer. In addition to water-level measurements made in the 36 shallow wells, measurements also were made in 9 privately-owned wells. These measurements and other available data indicate that the surficial aquifer consists of fine- to medium-grained sand, which is locally overlain by slag fill. Total aquifer thickness ranges from 0 to 65 feet. This aquifer is underlain by a mantle of till and lacustrine clay about 100 feet thick that overlies carbonate bedrock of Silurian age.

Based on measurements in these 45 shallow wells, broad water-table mounds of low relief underlie the area between Lake Michigan and the Grand Calumet River/Indiana Harbor Canal and between the Grand Calumet River/Indiana Harbor Canal and the Little Calumet River to the south. The crests of these mounds form major water-table divides that trend east-west in the study area. Northwest of the Indiana Harbor Canal, a narrow water-table ridge extends along the Lake Michigan shoreline and connects to a somewhat circular, mound northwest of the Indiana Harbor Canal.

The direction of flow generally is from these water-table mounds to the major streams or to Lake Michigan. Ground water locally discharges to small ditches, wetlands, and sewer lines. Ground water discharges directly to Lake Michigan north of the first water-table divide that is inland from the lake.

Stream/aquifer relations along the Grand Calumet River/Indiana Harbor Canal also were examined. Water-table fluctuations near the stream banks are complex and need to be monitored further.

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Digital-model simulations of a north-south geologic section through the middle of the study area indicate that discharge of water to small ditches and leaky sewer lines has lowered the water table by several feet from pre-development levels. Simulated drains create fully penetrating local flow systems in the Calumet aquifer. The digital-model simulations also indicate that downward leakage to the bedrock through the intervening till layer could contribute to the decline in the water table.

INTRODUCTION

The southern shoreline of Lake Michigan, in northwestern Indiana, is one of the major urban and industrial centers in the Great Lakes region and includes the cities of East Chicago, Gary, Hammond, and Whiting, in Lake County, Indiana (fig. 1). The heavy industry in the area includes several large steel mills, a major petrochemical plant, several large petroleum-tank farms, several forging and foundry plants, several food and paper industriea, and a coal-fired electric-generating plant.

The study area is entirely within the physiographic province known as the Calumet Lacustrine Plain (Schneider, 1966) which extends from the shoreline of Lake Michigan to the Valparaiso moraine 11 miles south of Lake Michigan. Several distinct dune-beach complexes were formed in this province during the Pleistocene and Holocene Epochs (Leverett and Taylor, 1915; Bretz, 1951; Hansel and others, 1985) when levels of ancestral Lake Michigan were higher than levels of modern Lake Michigan. The dune, beach, and lacustrine silts, sands, and gravels (fig. 2) that were deposited formed a thin (saturated thickness less than 50 feet) but extensive surficial aquifer in this area (Rosenshein and Hunn, 1968) known as the Calumet aquifer (Hartke and others, 1975). This aquifer is not a major source of water supply in the study area because all the municipalities obtain their water from Lake Michigan. However, a few thousand domestic wells for older homes that are outside municipal corporation limits and outside the study area probably penetrate the Calumet aquifer.

Although its use as a water supply is limited, the water quality of the Calumet aquifer is of great concern to the U.S. Environmental Protection Agency and the International Joint Commission on the Great Lakes because of the great contamination potential of the aquifer (Hartke and others, 1975) and because of the potential discharge of ground-water contaminants to Lake Michigan. More than 80 sites in the vicinity of this study area are on the Emergency Remedial Response Inventory Site (ERRIS) list and 4 waste-disposal sites are on the National Priority List (NPL) (fig. 1) (Dean Nygard, Indiana Department of Environmental Management, written commun., 1986). Most of the heavy industry, three of the NPL sites, and most of the ERRIS sites are in the vicinity of the Grand Calumet River/Indiana Harbor Canal (GCR/IHC) drainage system (fig. 1), which discharges into Lake Michigan.

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Discharge of contaminants from the Calumet aquifer into the GCR/IHC also is of concern. Recent field studies of the water quality of the streams have indicated that the chemical loads cannot be explained completely by the known industrial and municipal discharges to the streams (HydroQual, 1984; Crawford and Wangsness, 1987). However, no studies of sufficient detail about the shallow flow system in the Calumet aquifer have been conducted to determine the potential for discharge of contaminants into the GCR/IHC.

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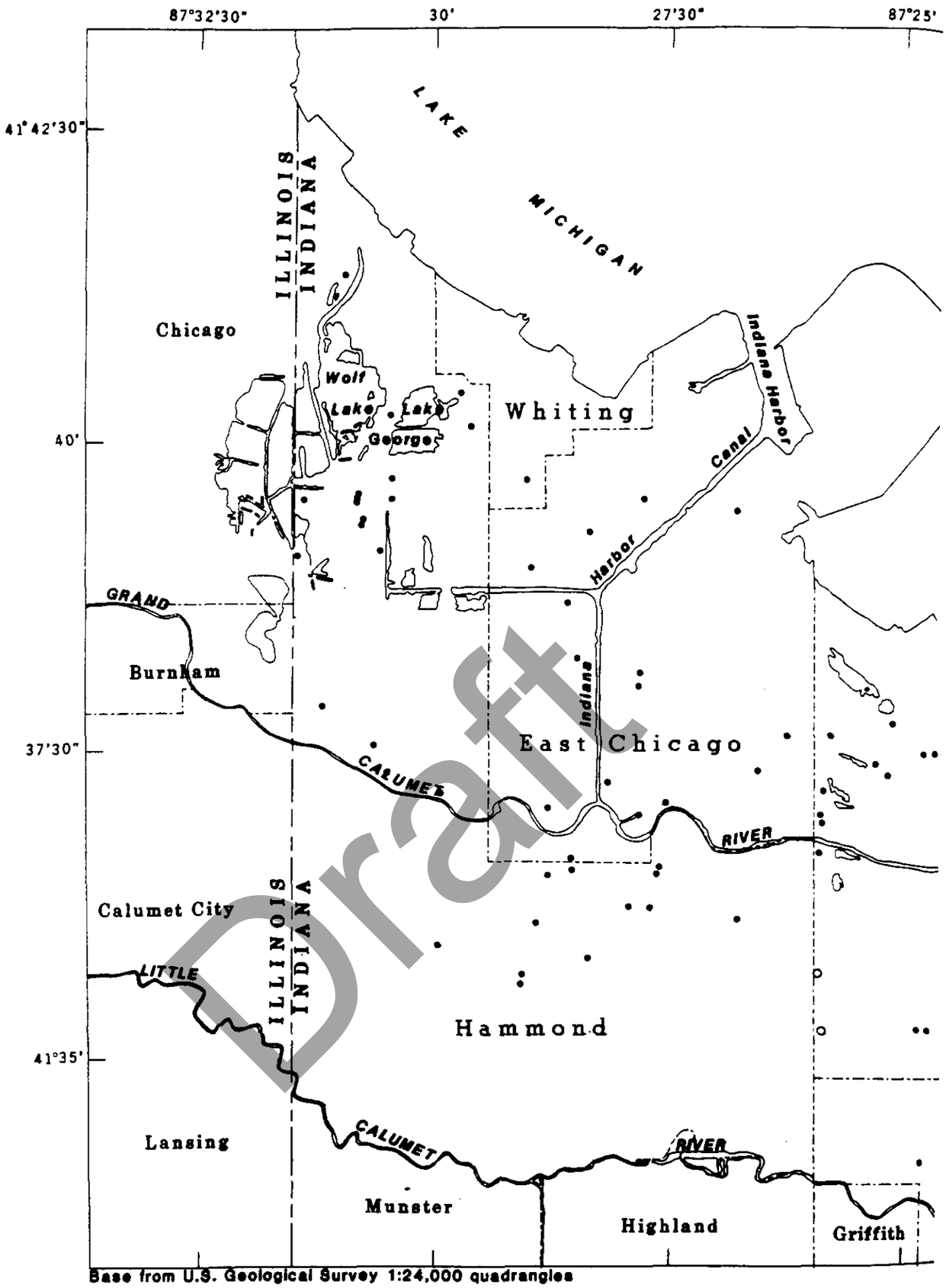
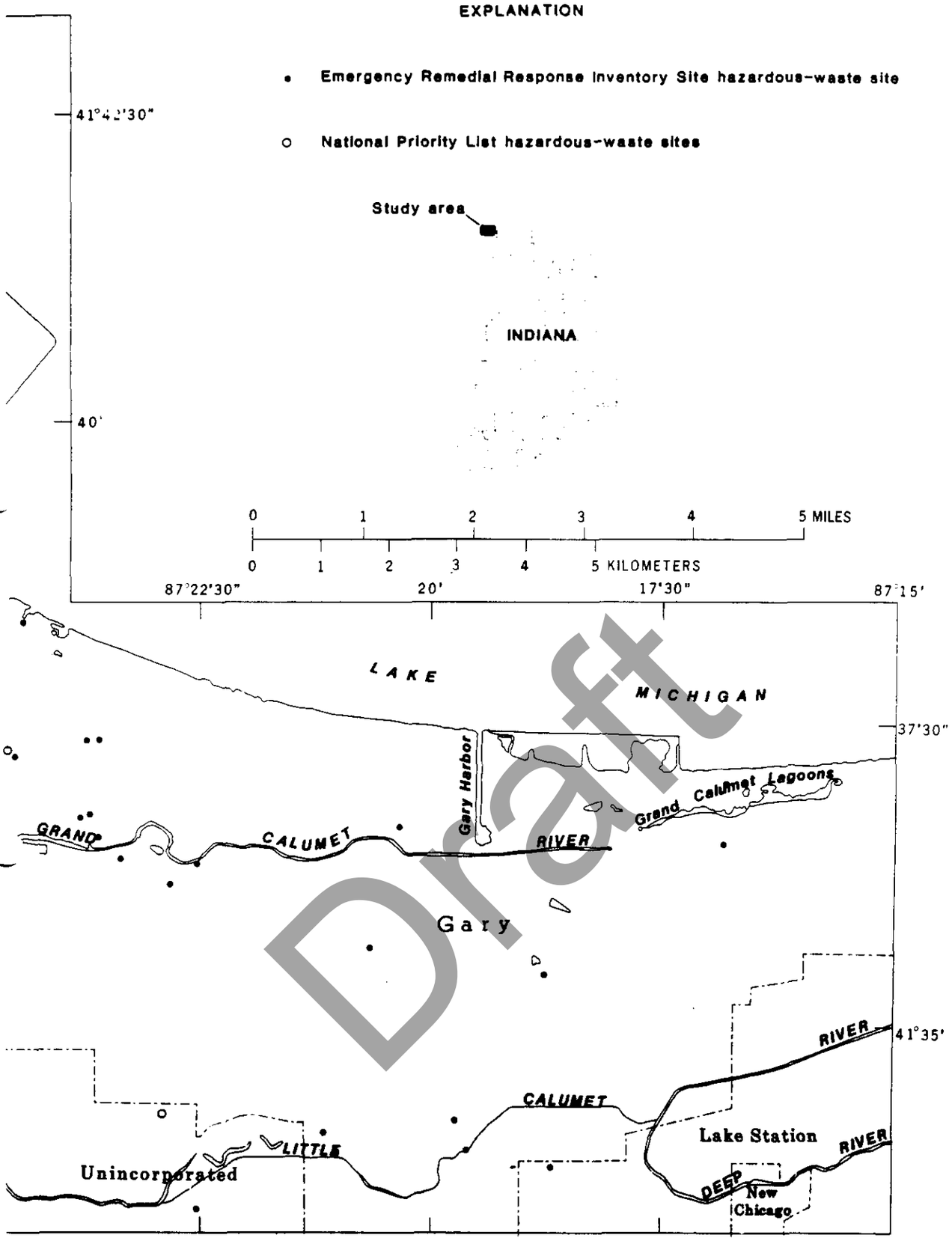


Base from U.S. Geological Survey 1:24,000 quadrangles

Figure 1.-- Study area and locations of hazardous-waste sites.


EXPLANATION
Emergency Remedial Response Inventory Site hazardous-waste site
National Priority List hazardous-waste sites
Study area
INDIANA
41°42'30"
40'
0 1 2 3 4 5 MILES
0 1 2 3 4 5 KILOMETERS
87°22'30"
20'
17'30"
87°15'
LAKE MICHIGAN
37'30"
Gary Harbor
Grand Calumet Lagoons
GRAND CALUMET RIVER
Gary
CALUMET RIVER
41°35'
LITTLE CALUMET RIVER
Unincorporated
Lake Station
DEEP RIVER
New Chicago

Draft

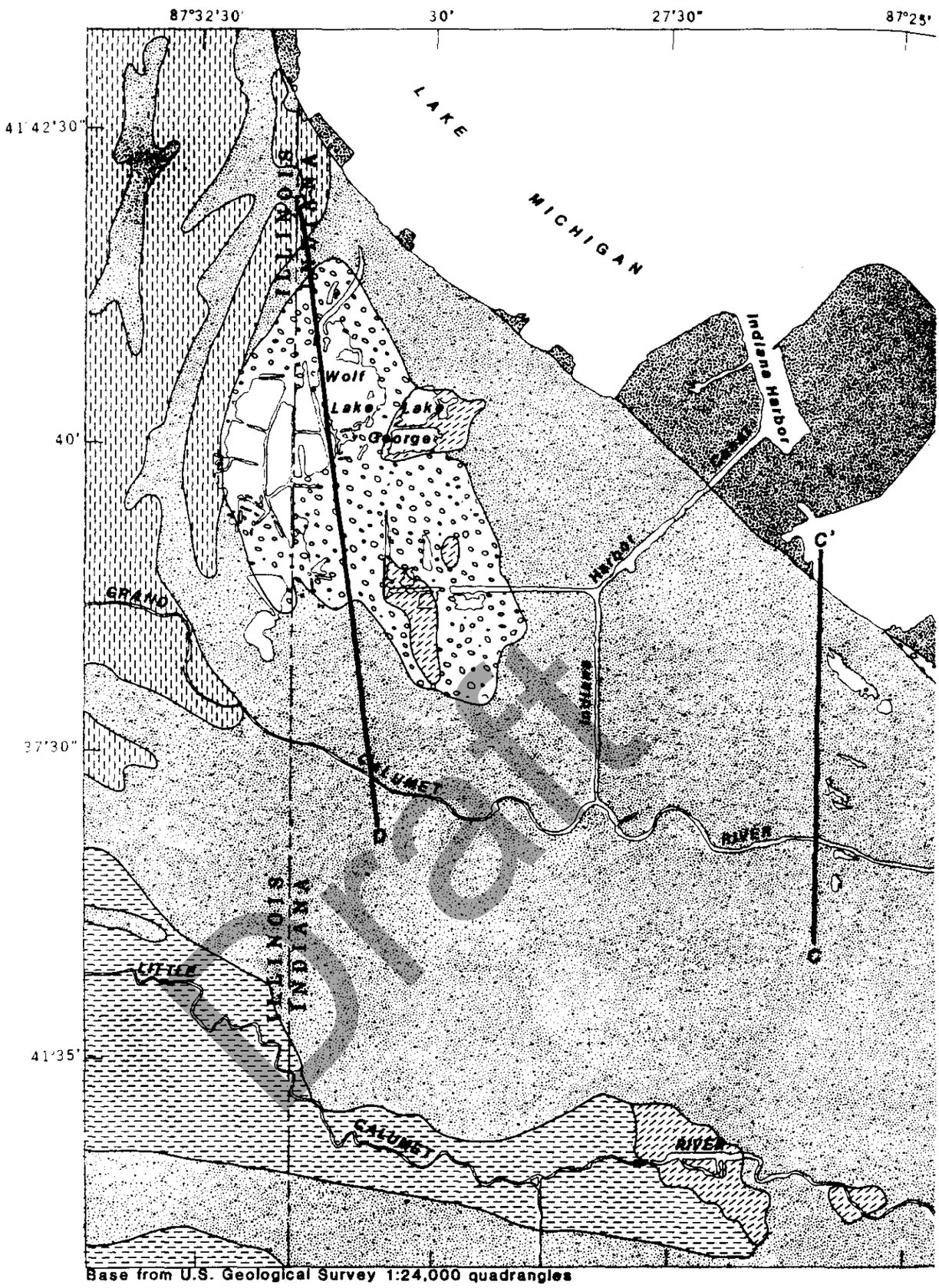
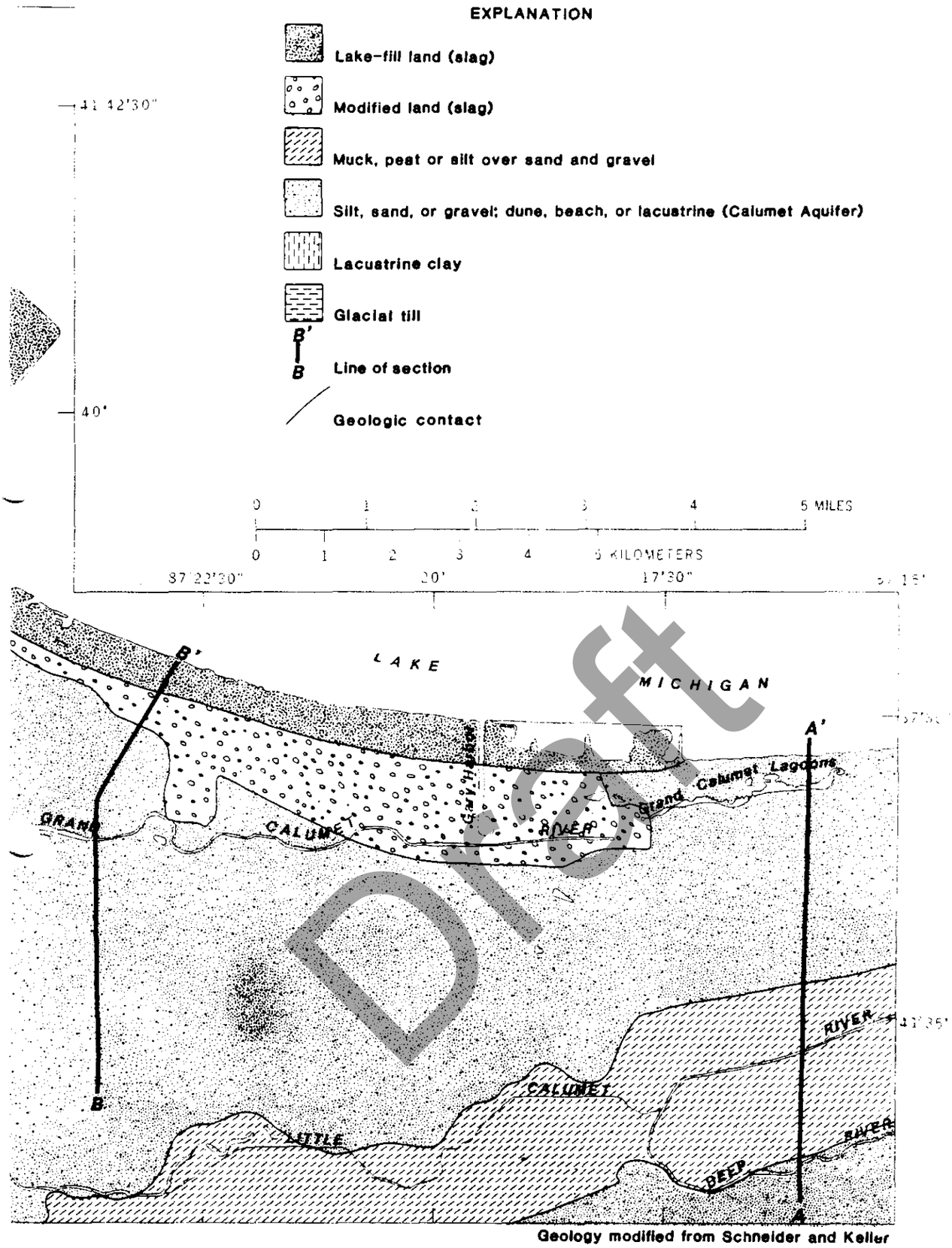


Figure 2.-- Surficial geology of the study area.



Geology modified from Schneider and Keller

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Purpose and Scope

The purpose of this report is to present methods used in and results from a preliminary analysis of the shallow flow system of the Calumet aquifer in the vicinity of the GCR/IHC and surrounding area. The results of this analysis will be used to select ground-water-quality monitoring sites in a subsequent study to determine the potential for ground-water contaminants to migrate directly to Lake Michigan or to the GCR/IHC.

This analysis was based on previously published and unpublished data, which have been supplemented by data from a network of sediment cores, test holes, and water-table wells that were installed in the summer and fall of 1985. Maps of the altitude of the base of the aquifer, saturated thickness of the aquifer, and the water-table altitude and hydrogeologic sections that are roughly perpendicular to the Grand Calumet River have been included. Flow patterns along hydrogeologic section designated C-C' were simulated using a finite-difference digital model.

Physical Setting

The study area is in the northern one-quarter of Lake County, which is the northwesternmost county in Indiana, and is situated at the southern end of Lake Michigan (fig. 1). The study area originally was covered by sand dunes and by linear ridges of sand that were remnants of past shorelines and high levels of Lake Michigan (Schneider, 1966). The long, narrow lowlands between the sand ridges were wetlands or ponds, a result of the poor drainage from the sluggish Grand Calumet River and Little Calumet River (Moore and Trusty, 1977).

Late in the 19th century, as industrial land in Chicago was developed, the nearby lakeshore lands in Indiana also became desirable areas for development. Construction of petroleum refineries and steel mills was started, and development of one of the most intensely industrialized regions in the world began. This development required draining of wetland areas and leveling many of the sand dunes and beach ridges. Ditches were dug, and excess sand from the dunes and slag from the steel-making process were used to fill in the wetlands (Moore and Trusty, 1977).

The Indiana Harbor Canal was constructed during 1901-06, and Gary Harbor was constructed in 1906. Locally, the course of the Grand Calumet River was changed during this construction and later was changed during the construction of major highways. In the vicinity of U.S. Steel's Gary Harbor (fig. 1), the river channel was moved south about 1,000 feet, and part of the flow was diverted through the Indiana Harbor Canal. For additional details about these changes, refer to Cook and Jackson (1978).

Draft

Another important change to the region, the extension of the lakeshore with fill land, occurred for two reasons. First, inexpensive industrial land adjacent to existing manufacturing facilities was needed; and, second, vast quantities of slag were being produced. Legislation passed by the 1907 Indiana General Assembly permitted the building of land into Lake Michigan and, in 1986, much heavy industry is located on such land, which is composed mainly of slag and is referred to as lake-fill land. The surficial geology map (fig. 2) differentiates between major areas of lake-fill land and modified land. Slag still is the aggregate of choice for filling operations and for the road-building base in the region.

In 1986, much of the land is used for steel-making and petroleum-related activities (fig. 3). Most of the steel industry is located along the lakeshore or on lake-fill land, and much of the petroleum industry is located adjacent to or near the Indiana Harbor Canal. Much of the other industrial land is used for manufacturing that is related to the steel industry such as rail-car building, foundries, and forging plants. Chemical-processing plants occupy a large part of the land and supply products for manufacturing and the retail market.

Residential areas are located primarily to the south of the Grand Calumet River and to the west of the Indiana Harbor Canal (fig. 3). Population trends in the 1950's were toward the southern part of the county, away from the immediate vicinity of the heavy industry (Moore and Trusty, 1977). Many small areas or pockets of natural land remain essentially unaltered in 1986. The original topography of linear ridges separated by wetlands still exist, and diverse natural plant communities can be observed by traversing these areas. Efforts are being made to save these areas for nature preserves.

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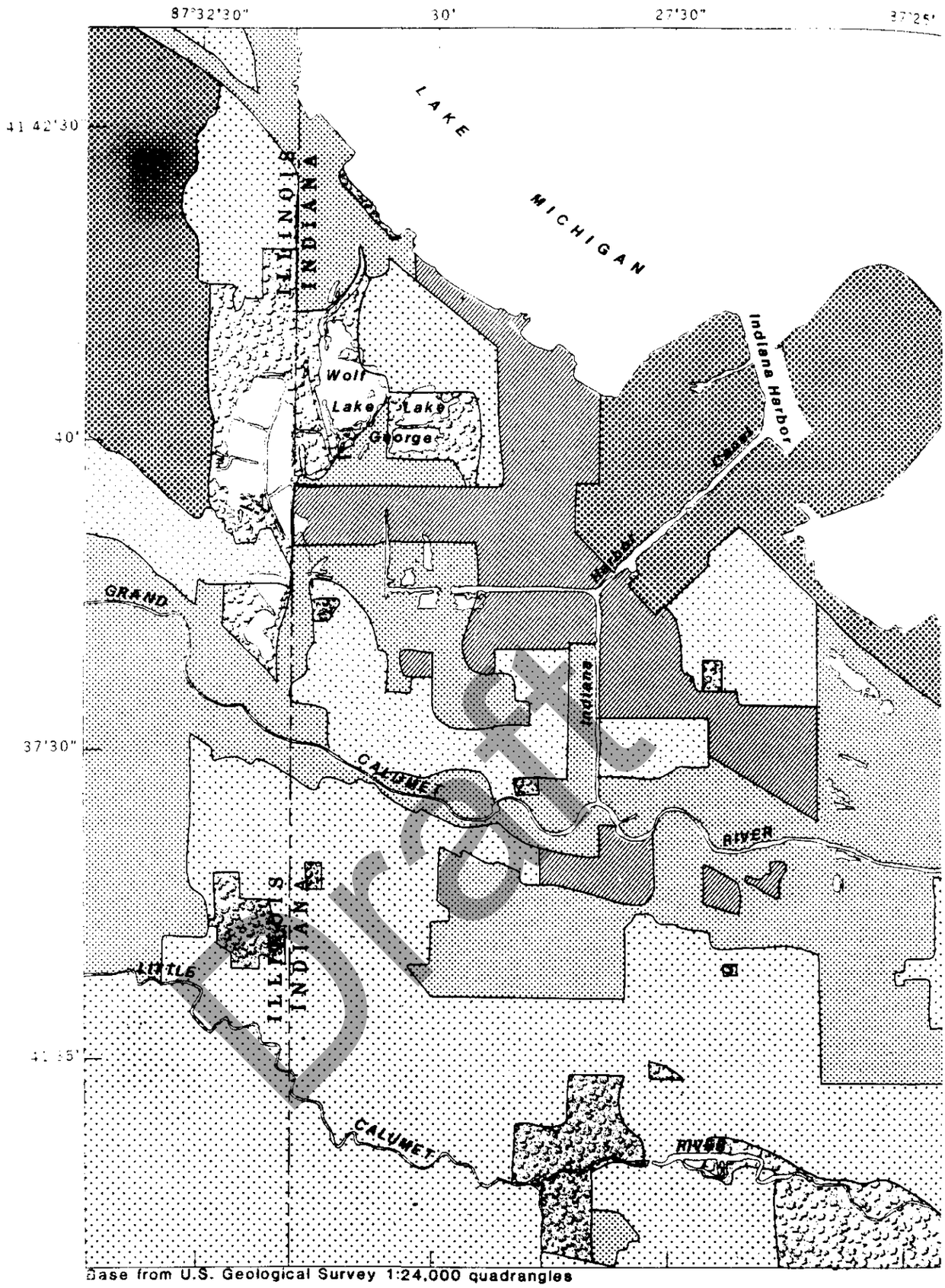
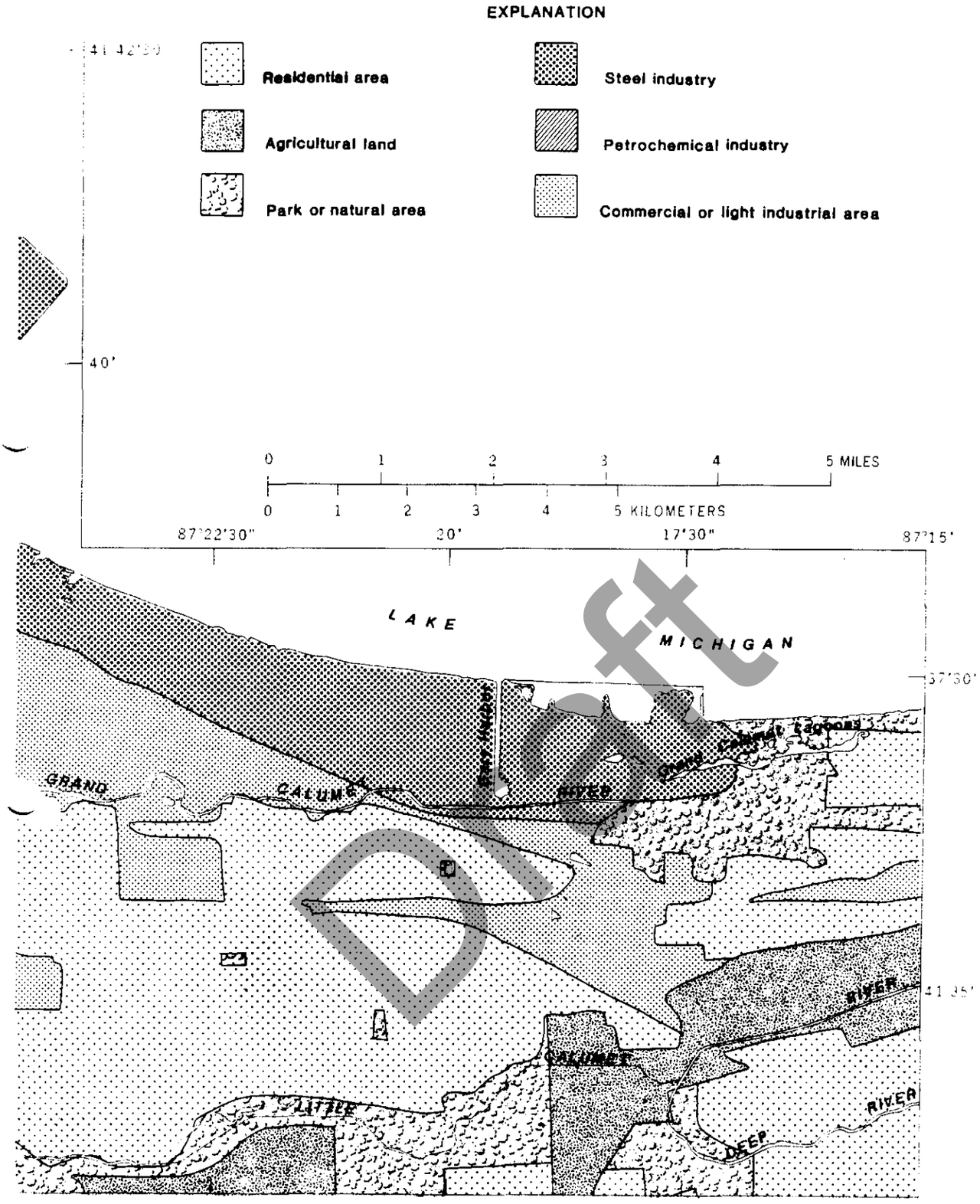


Base from U.S. Geological Survey 1:24,000 quadrangles

Figure 3.-- Major land use in the study area.


EXPLANATION
Residential area
Agricultural land
Park or natural area
Steel industry
Petrochemical industry
Commercial or light industrial area
41°42'30"
40'
0 1 2 3 4 5 MILES
0 1 2 3 4 5 KILOMETERS
87°22'30"
20'
17'30"
87°15'
LAKE MICHIGAN
37'30"
GRAND CALUMET RIVER
Grand Calumet Lagoons
CALUMET RIVER
41°35'
LITTLE CALUMET RIVER
DEEP RIVER

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East Chicago, Indiana, Public Schools
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Gary, Indiana, Parks Department
Gary, Indiana, Public Schools
Hammond, Indiana, Parks Department
Hammond, Indiana, Public Schools
Indiana Department of Highways
Indiana Department of Environmental Management
Indiana Department of Natural Resources, Division of Nature Preserves
Indiana Department of Natural Resources, Division of Water
Lake County Parks and Recreation
National Park Service, Indiana Dunes National Lakeshore
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United States Steel, USX Corporation, Gary, Indiana
Whiting, Indiana, Parks Department
Whiting, Indiana, Street Department

We also wish to thank Dr. Todd Thompson who split the vibracores and provided descriptions of the sedimentological features and bedforms.

Draft

METHODS

Compilation of Existing Data

Existing data from published and unpublished sources were used in this analysis. Published sources include Rosenshein and Hunn (1968), Hartke and others (1975), and Weisa (1982). Unpublished data include the following:

1. Lithologic logs from water wells in the study area, which were in the files of "located water wells" at the Indiana Department of Natural Resources, Division of Water, Indianapolis.

2. Lithologic logs from numerous soil borings in the surficial sand, which were made for major State and federal highway projects that cross the study area. These logs were made available by the Indiana Department of Highways and the Indiana Toll Road Commission.

3. The Remedial Planning/Field Investigation Team Report for the Lake Sandy Jo site (a Superfund or NPL site). The Lake Sandy Jo site is located in the south-central part of the study area in an unincorporated area. Informal discussions with technical teams assessing the other three NPL sites in the study area affected the interpretation of conditions around these sites.

4. A current (1985) listing of NPL and ERRIS sites, which was provided by the Division of Land Pollution Control of the Indiana Department of Environmental Management. (The locations of these sites are shown in figure 1.)

Field Methods

During the summer and fall of 1985, 36 observation wells were installed and used to measure water levels in the study area (fig. 4). Additionally, water levels were measured in nine privately-owned observation wells. During the same time, 26 sites were chosen and samples of the underlying sedimentary material were obtained. Vertical control, using standard surveying techniques, was established at all observation well and sedimentary material sites so that water levels and stratigraphic information could be correlated. Measuring points that had vertical control also were established at 13 surface sites so that surface-water stage could be measured.

All new wells were constructed completely of Type 304 stainless steel and were 2 inches in inside diameter. The well screens were continuous-slot, wire-wound design with an opening size of 0.010 inch. Each well screen had 3 feet of open section and had a drive point at the base. Where possible, the wells were hand driven using a fence-post driver. Four wells were installed using a power auger. All wells were installed in the uppermost part of the saturated zone of the aquifer. After completion, the wells were developed using a hand-operated piston pump. Concrete aprons were constructed, and locking caps were installed at each well.

Each of the nine privately-owned wells was constructed of 2-inch inside-diameter polyvinyl chloride pipe and well screens. Six wells had screens that were open to the entire saturated aquifer and three had screens that were 10 feet long.

The primary method by which shallow samples of the underlying sedimentary material was obtained was a process called vibracoring (Finkelstein and Prins, 1981). The vibracoring process uses a concrete vibrator to vibrate a 3-inch diameter vertical aluminum tube into loose, moist sediments. When penetration of the tube stops, the vibrator is stopped and the tube containing the core sample is withdrawn from the ground. Vibracoring worked well to collect core samples to depths of as much as 18 feet at many locations. However, at some locations, dry soil and coarse aggregate fill prevented successful sampling using the vibracoring process. At these sites, a power auger was used to drill a hole and retrieve sediment samples that stuck to the auger flights. Sediment samples could be obtained from the full depth of the surficial aquifer using the power auger, and these samples then were used to improve definition of the base of the aquifer on the map.

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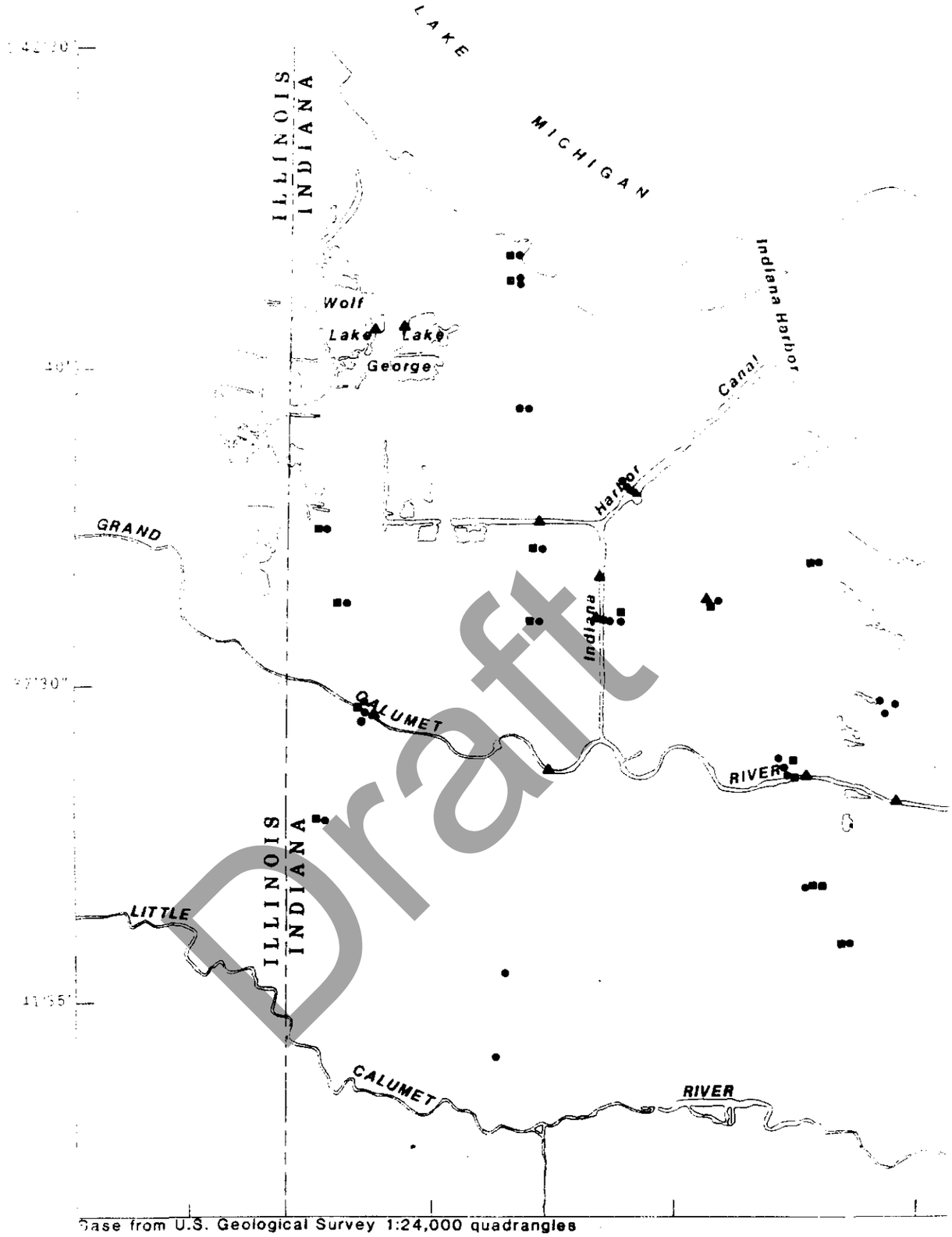

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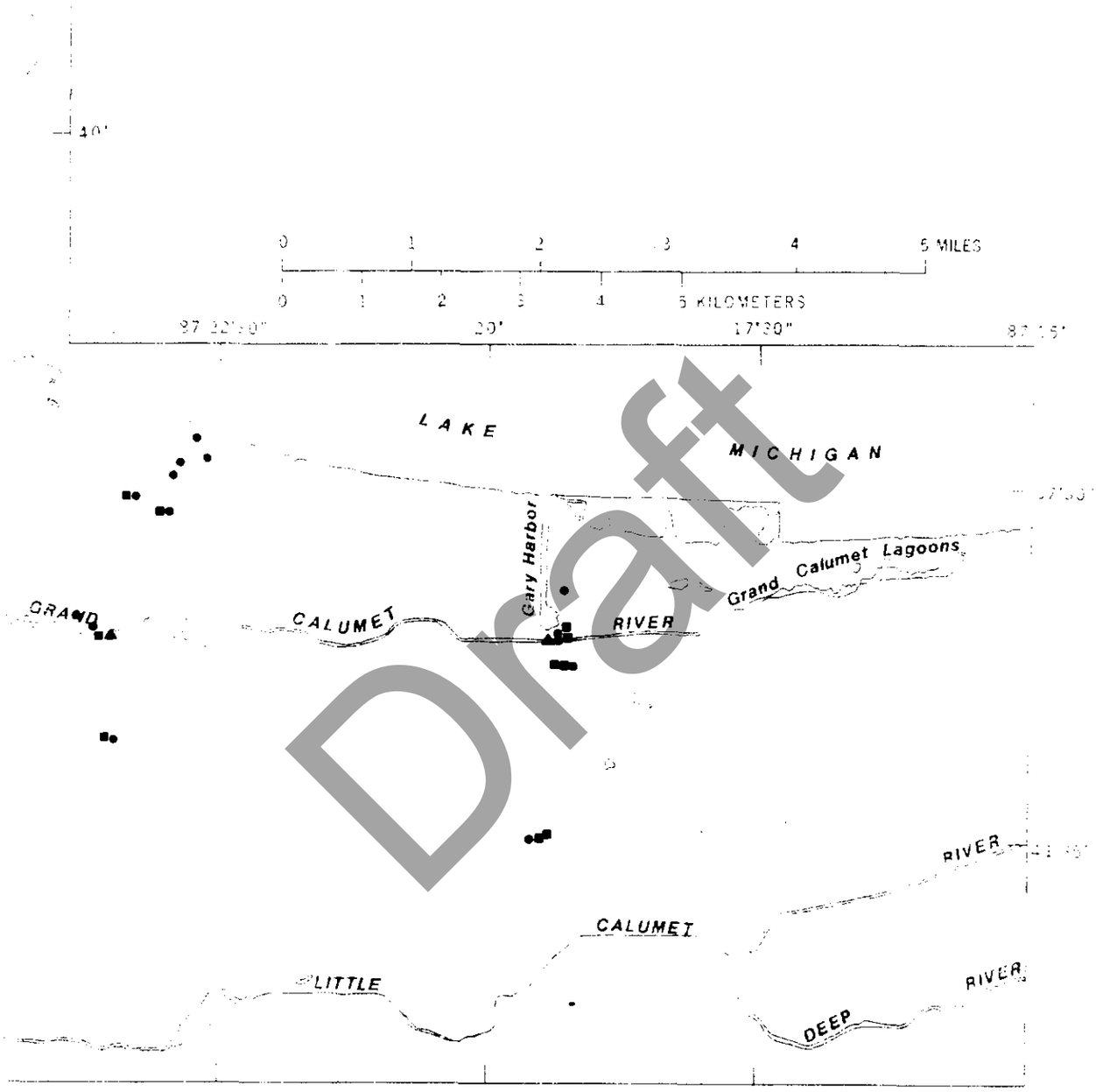
Figure 4.-- Data-collection network in the study area.

EXPLANATION

- Observation well
- Sedimentary material site
- Surface-water measuring site



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Model Construction

A finite-difference digital model (McDonald and Harbaugh, 1984) was used to study flow patterns in the Calumet aquifer and the interaction between ground water and surface water. About 20 model analyses were necessary to make a preliminary calibration of model results and a preliminary analysis of model sensitivity.

The finite-difference digital model was used to study flow in a vertical section of the Calumet aquifer. Studying a vertical section simplifies model construction and analysis of results but still provides a basic understanding of flow in areas of the aquifer that are similar to that of the modeled section. The conceptual geologic section modeled roughly corresponds to the hydrogeologic section designated by line C-C' (fig. 2) from about 1 mile south of the Grand Calumet River to Lake Michigan (fig. 5).

Features of the model design, specifically the grid system and the locations of river and drain nodes, also are shown in figure 5. Ten rows and 60 columns were used to simulate vertical and horizontal gradients. The grid blocks around the Grand Calumet River were small enough to indicate details of the flow expected in that area. This smaller grid spacing will be used in future simulations to study the effect of transient changes in the water table on patterns of ground-water flow to the river.

Simulation of Ground-Water Flow

Water flow was simulated for a north-south section through the Calumet aquifer in the middle of the study area. Although the model is based on a real section, the simulations were generalized somewhat, and comprehensive calibrstion and sensitivity analysis were not done. Instead, the model was used as a study tool to obtain a general understanding of the ground-water flow system and to identify the factors that could affect the water-table profile and the size and depth of the local flow cells near the streams and drains. This preliminary model analysis was done primarily to select well sites to sample and to monitor ground-water quality. A more detailed areal model of part of the study area is planned for the next phase of the investigation.

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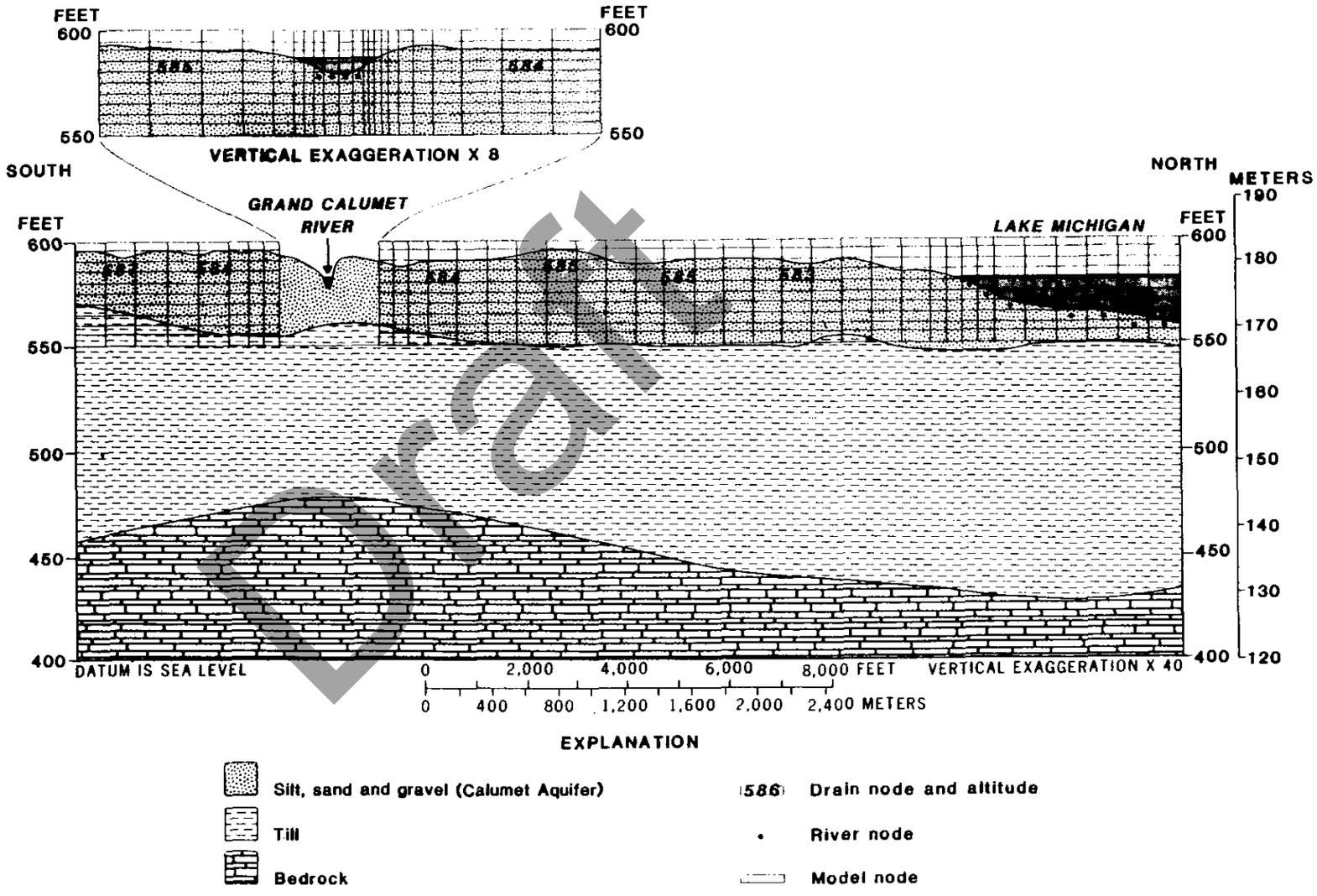

Figure 5.-- Conceptual geologic section and digital-model grid based on hydrogeologic section C-C'.

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PRELIMINARY ANALYSIS OF THE SHALLOW GROUND-WATER SYSTEM

Physical Characteristics

The Calumet aquifer is underlain by 100 to 150 feet of unconsolidated glacial and lacustrine sediments that were deposited on an erosional surface of bedrock consisting of carbonate rock of Silurian age. The bedrock surface has about 70 feet of relief in the study area (fig. 6). The most prominent feature of the bedrock surface is a north-trending valley in the area of the Indiana Harbor Canal where the canal trends northeast-southwest.

The unconsolidated sediments can be divided into two major units, the lower unit consists mainly of glacial till that has some lacustrine clays or weathered till at the top. These clays and glacial till form a confining unit between the Calumet aquifer and the underlying bedrock. The upper surface of this confining unit (fig. 7) slopes gently toward Lake Michigan. Although there is a depression in this surface above the north-trending bedrock valley, it has only about 5 to 10 feet of closure and trends east-west. Another noteworthy feature in the area of this depression is that the upper 20 feet of the lower unit is loosely conaolidated lacustrine or paludal clay as indicated by lithologic logs. Lithologic logs indicate that the top of this confining unit generally is a more compacted and competent till than this lacustrine clay.

The upper unit of the unconsolidated sediments consists primarily of dune, beach, and lacustrine sands and also of thin layers of peat and organic sediments of small areal extent. These sands and organic deposits comprise the Calumet aquifer. At the steel mills along the shoreline and in many former inland depressiona, crushed and hot-poured slag overlie the sands. Thickness of the aquifer ranges from 0 to 65 feet. The aquifer generally is thickest in the east. The unit thins to the west and pinches out a short distance west of the Illinois-Indiana border. It also pinches out in the southwestern part of the study area in the valley of the Little Calumet River (fig. 7).

The sands of the upper unit comprise the Unit 1 described by Rosenshein and Hunn (1968) and the Calumet aquifer described by Hartke and others (1975). Rosenshein and Hunn also reported an average hydraulic conductivity of 60 feet per day for these sands. In our report, slag fill also is included as part of the Calumet aquifer. Generally, slag fill is not areally or vertically extensive and no attempt was made to measure or estimate its hydraulic properties separately from those of the rest of the Calumet aquifer. Although the carbonate bedrock of Silurian age is not a substantial aquifer in the study area, some discharge probably occurs from it to the Calumet aquifer by upward leakage through the clays of the confining unit in the eastern one-half of the study area (R. J. Shedlock, U.S. Geological Survey, written commun., 1985). However, near line of section C-C', water levels in the bedrock that were obtained from NPL site investigations indicate that discharge occurs from the Calumet aquifer to the bedrock aquifer.

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The saturated thickness of the Calumet aquifer in the study area is shown in figure 8. This map is based on the difference in altitude between the water-table map for spring 1986 conditions and the map of the base of the upper unit (fig. 7). The contours are subparallel to the Lake Michigan shoreline and generally indicate the thinning of the aquifer from east to west and north to south. From the topographic highs between the rivers, the saturated thickness decreases to the south toward the Little Calumet River and increases toward the lakeshore north of the Grand Calumet River. Both trends result from the gentle slope toward Lake Michigan of the surface of the underlying confining unit. The large saturated thickness between the Grand Calumet and Little Calumet Rivers in Gary is caused by a broad water-table mound that is discussed in the section "Ground-Water Flow System."

Notable geometric features of the Calumet aquifer are shown in the hydrogeologic sections in figures 9 through 12. The eastern end of the study area, where the aquifer is thickest, is shown in figure 9 (line of section A-A' in fig. 2). At the southern end of this section, is a back-barrier, calcareous clay lens, one of several such deposits that occur within the surficial sands east of the study area. In the study area, no such clay lenses were found in the vibracores, test-hole data, or existing boring logs.

A noteworthy geomorphic feature in figure 9 is the location of the Grand Calumet Lagoons. These ponded lowlands represent the former distal end of the undisturbed Grand Calumet River when it flowed east to discharge into Lake Michigan during pre-development times. These lagoons are connected by a buried culvert to the upstream end of the modern Grand Calumet River channel and represent the headwaters of the river.

West of the headwaters, the distance between the channel of the Grand Calumet River and the lakeshore increases, as indicated by comparing figures 9 and 10 (line of section B-B' in fig. 2). A section of lake-fill land (slag) along the shoreline also is shown in figure 10. The lakeward edge of this slag body primarily is hot-poured slag that cooled shortly after exposure to water and air. Farther landward, crushed slag probably functions hydraulically as a poorly sorted, unconsolidated sediment. However, the physical and hydraulic properties of the hot-poured slag are similar to those of lava. The authors have observed typical lava-like features, such as ropy surfaces and hexagonal jointing in the slag along the shoreline. Ground-water flow in the hot-poured slag probably is along the hexagonal joints; however, the permeability of the hot-poured slag was not determined because of insufficient data.

The next section (line of section C-C' in fig. 2) to the west (fig. 11) shows a more natural lakeshore. Also shown are several discrete bodies of sand and gravel, presumably representing beach deposits. Although these bodies are not extensive and probably do not differ dramatically in hydraulic properties from the other sands, they do indicate important local subtleties in the sediment that may be significant to ground-water transport problems. This section also shows the small difference in altitude between the Grand Calumet River and Lake Michigan and the general slope of the underlying till surface (interrupted by local highs) toward the lake. This section was used as the basis for digital-model simulations of flow because of its central location in the study area and also because it probably is most representative of pre-development conditions.

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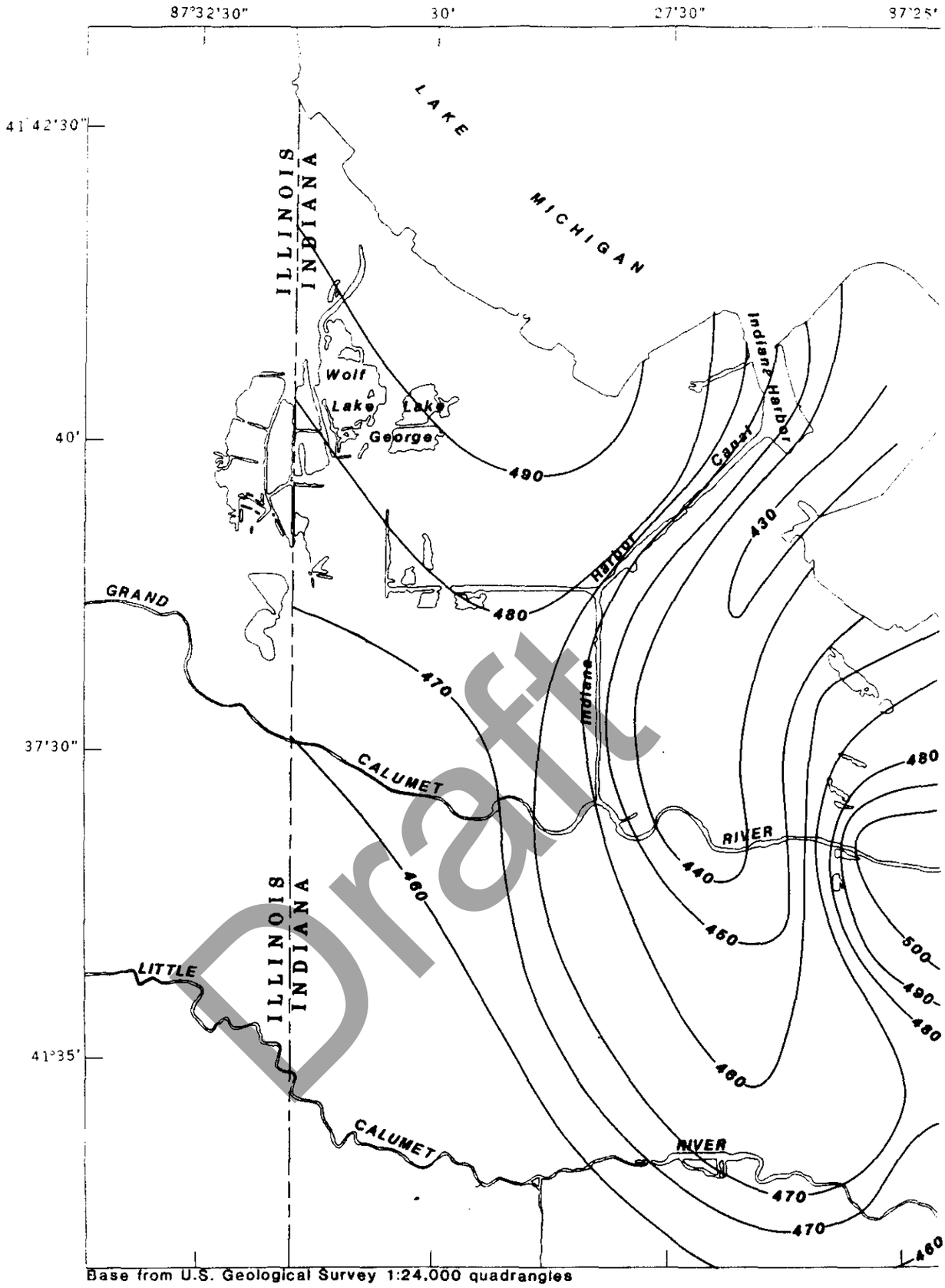
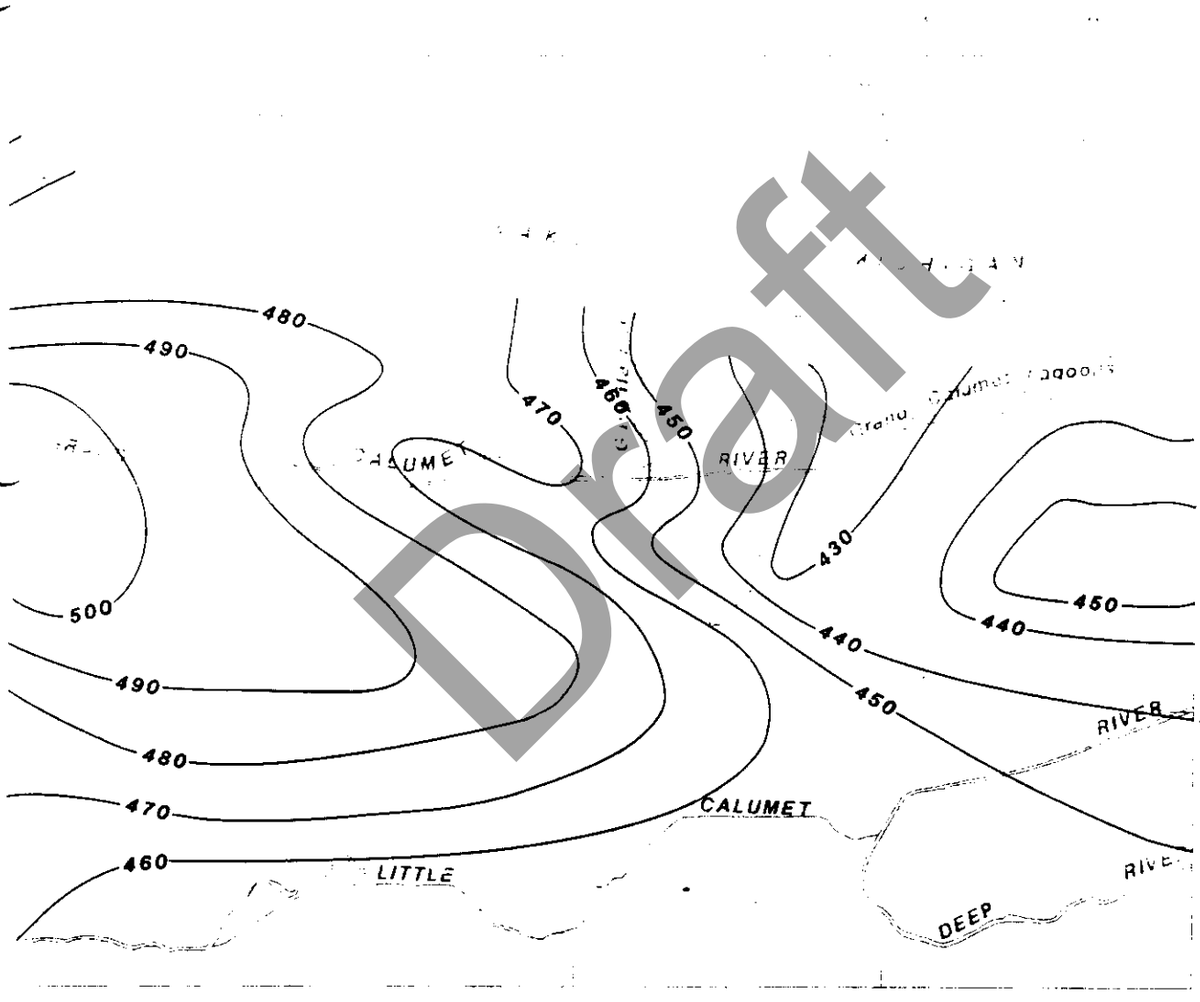


Base from U.S. Geological Survey 1:24,000 quadrangles

Figure 6.-- Configuration and altitude of bedrock surface

EXPLANATION

—440— BEDROCK-SURFACE CONTOUR--shows altitude of bedrock. Interval 10 feet. Datum is sea level



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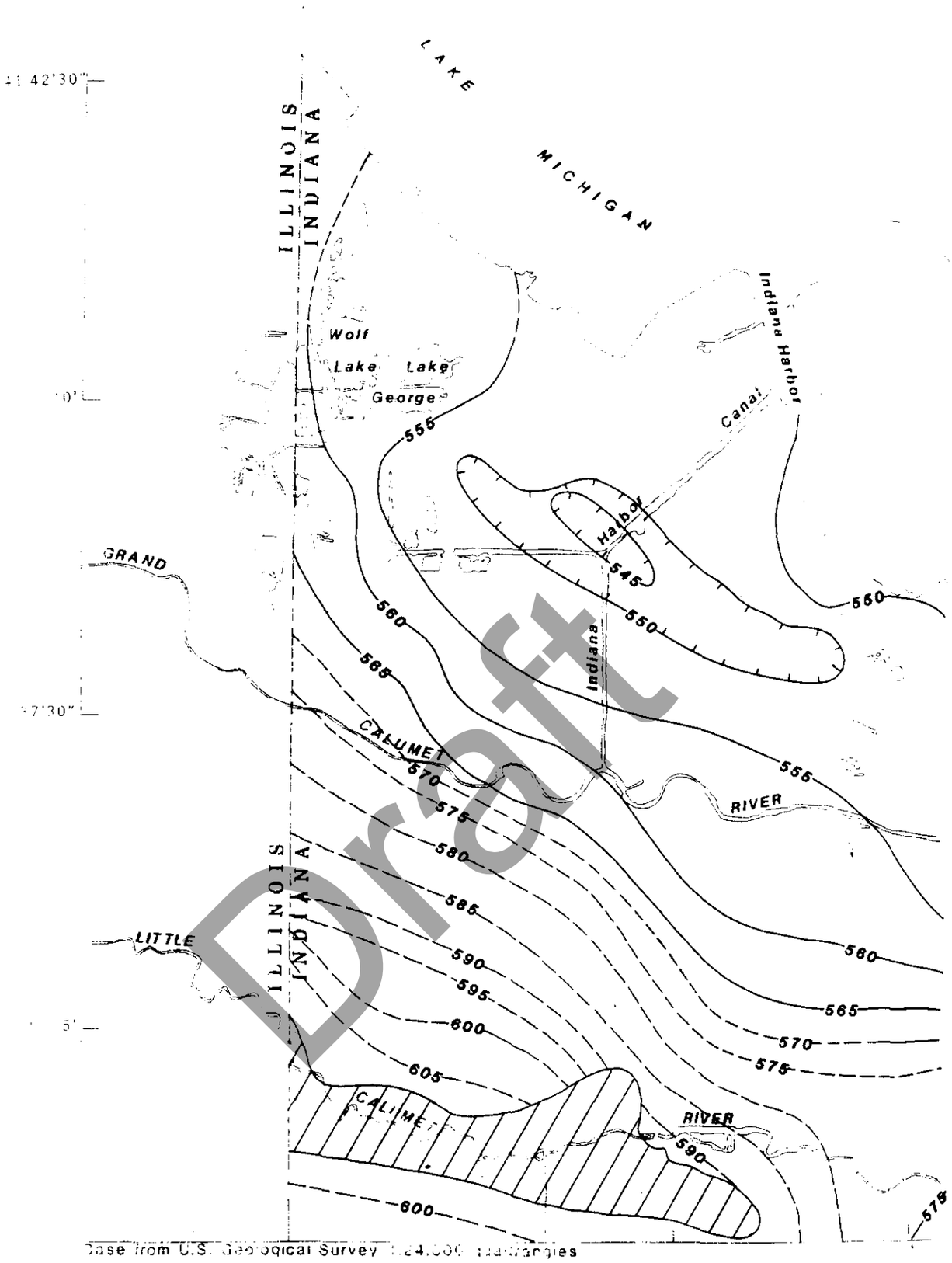


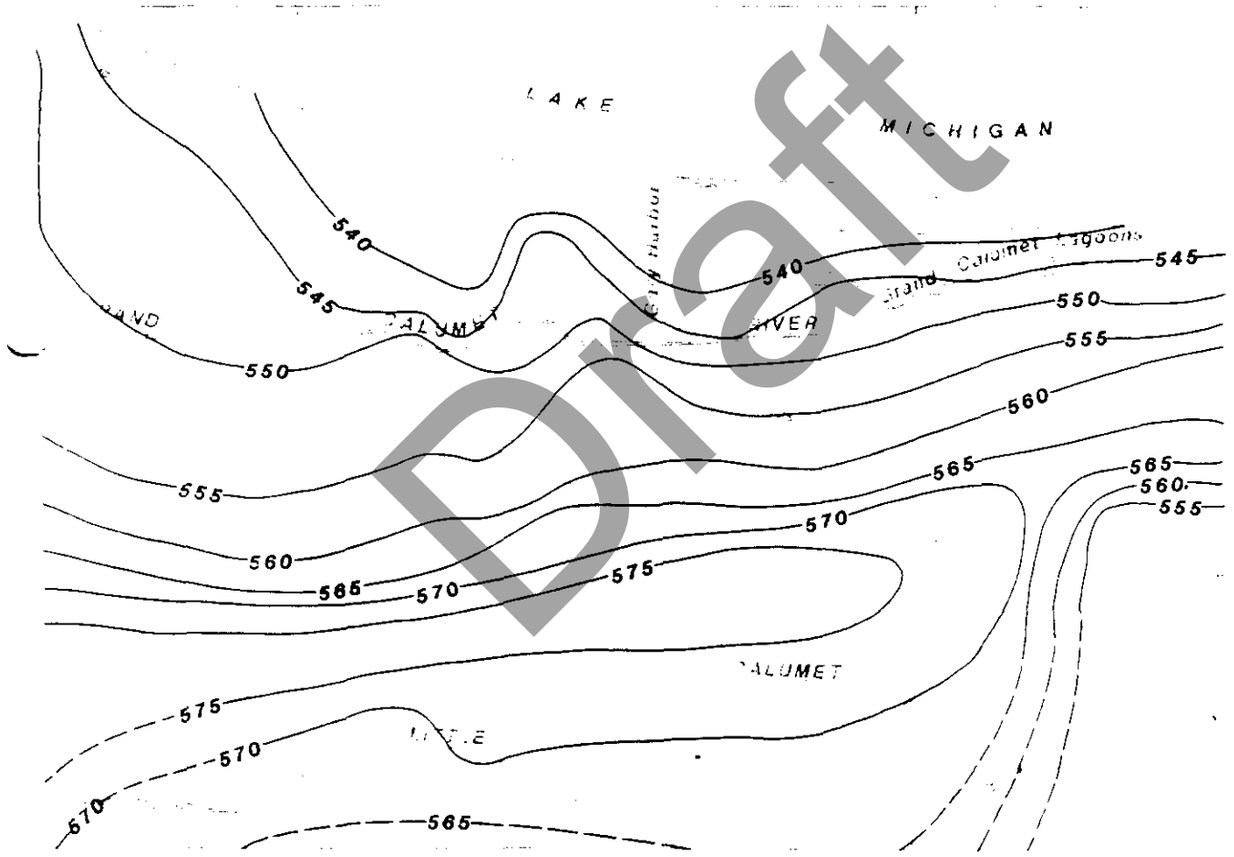
Base from U.S. Geological Survey 1:24,000 quadrangles

Figure 7.-- Configuration and altitude of base of the Calumet aquifer.

EXPLANATION

550 BASE-OF-AQUIFER CONTOUR--shows altitude of base of Calumet aquifer. Hachures indicate depression. Interval 5 feet. Dashed where approximate. Datum is sea level

AQUIFER ABSENT



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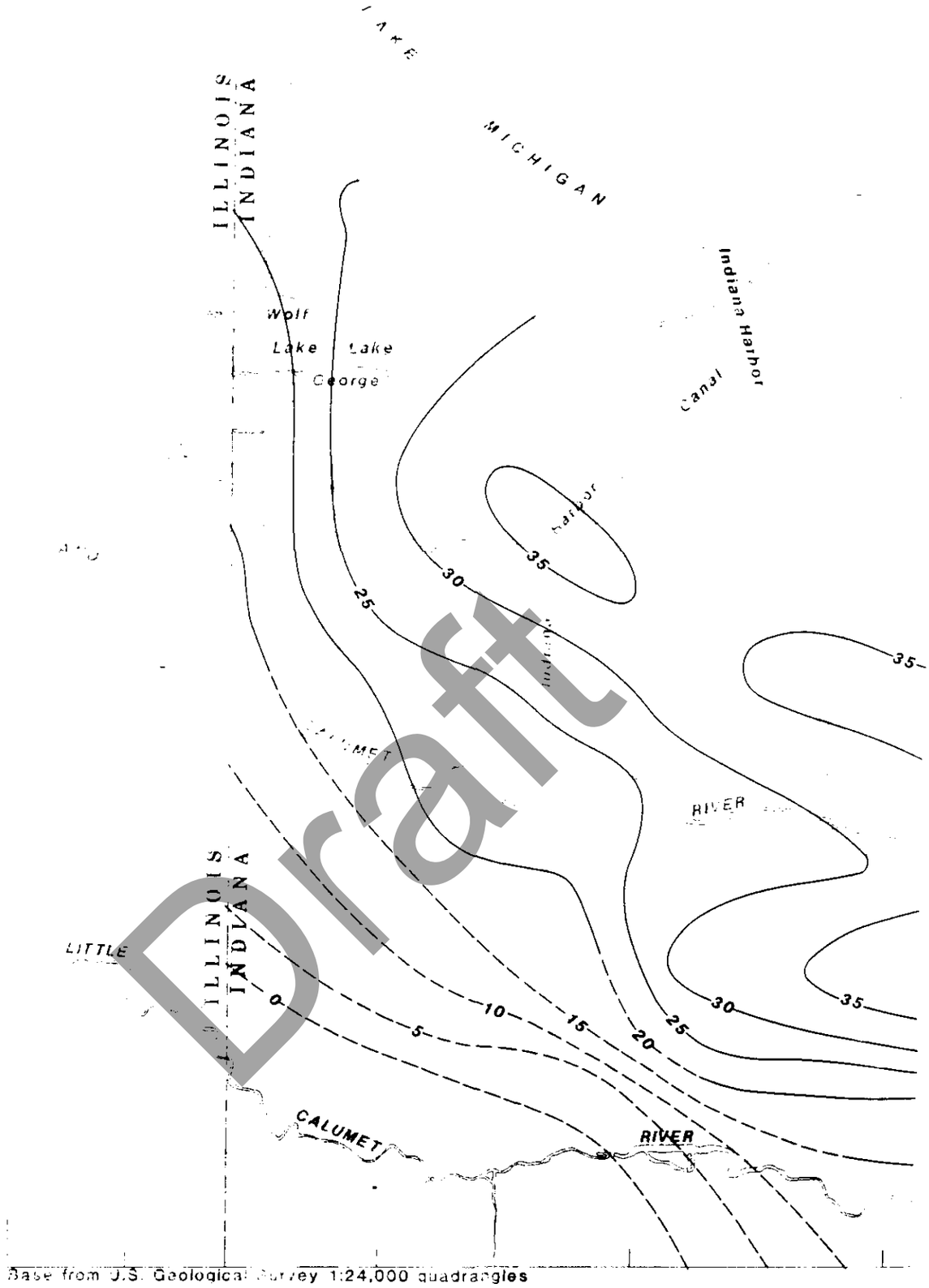

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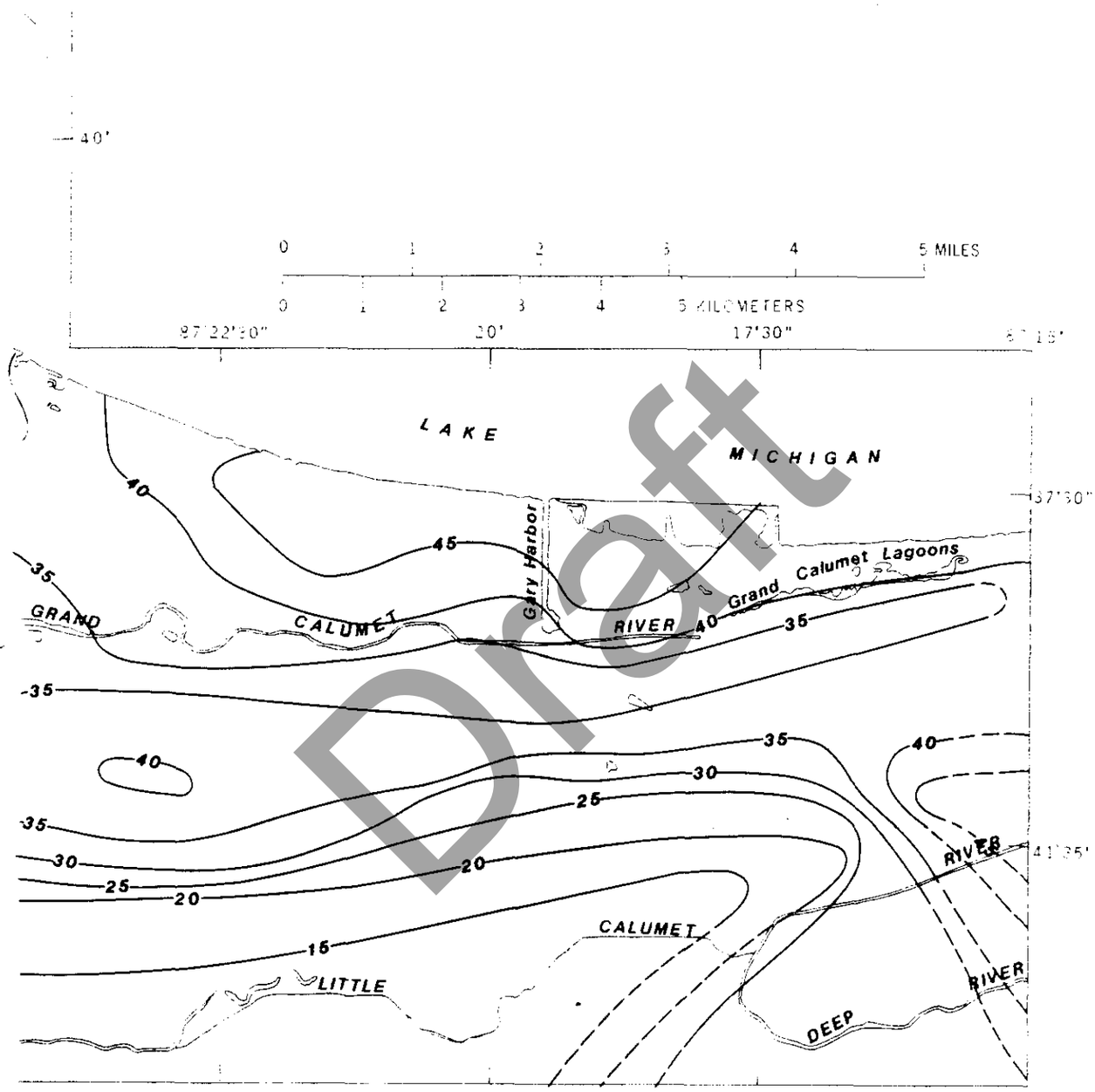
Figure 8.-- Saturated thickness of the Calumet

EXPLANATION

41°42'30" —20— SATURATED-THICKNESS CONTOUR--shows saturated thickness of the Calumet aquifer. Interval 5 feet. Dashed where approximate



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aquifer, March 31 through April 4, 1986.

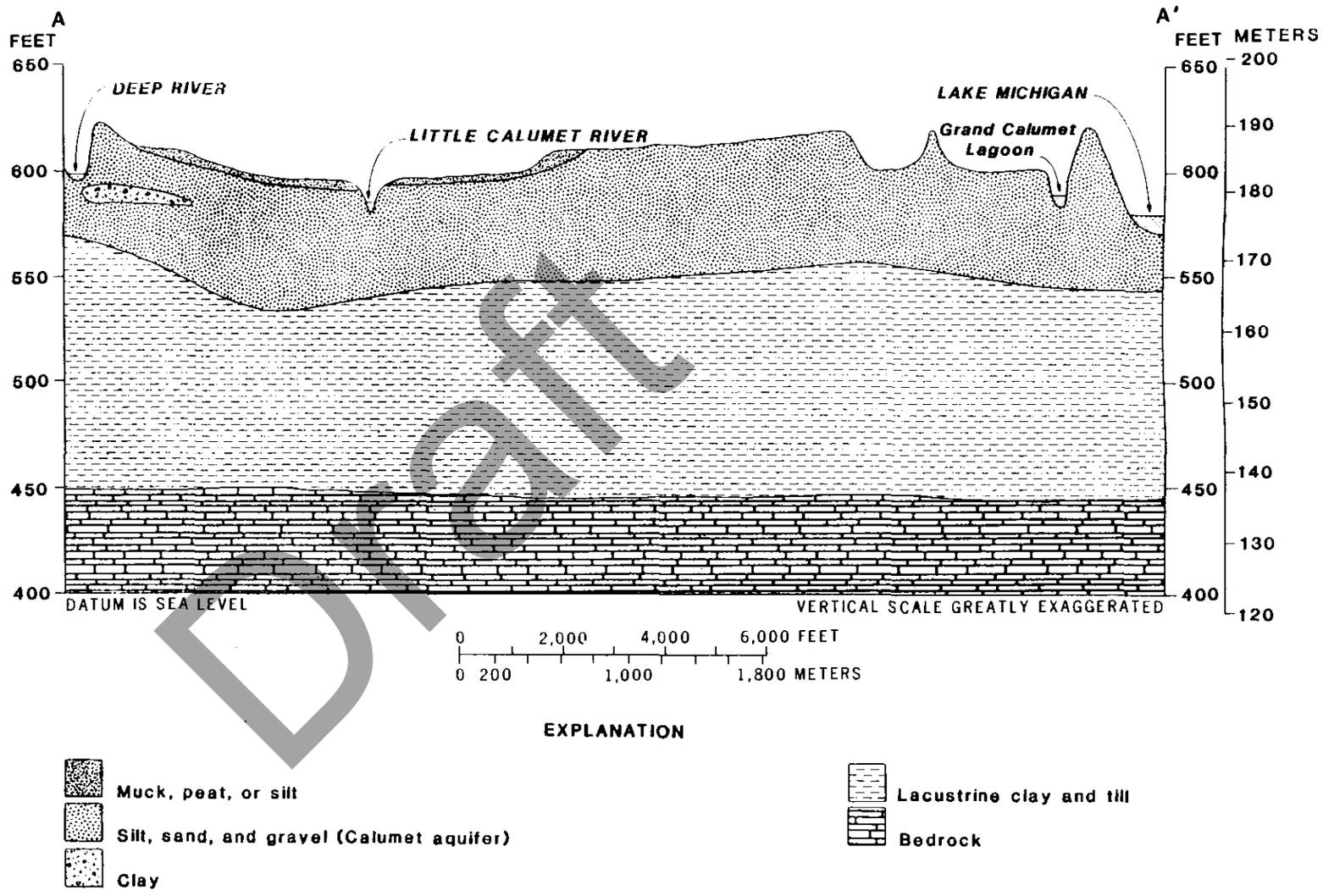

Figure 9.-- Hydrogeologic section A-A'.

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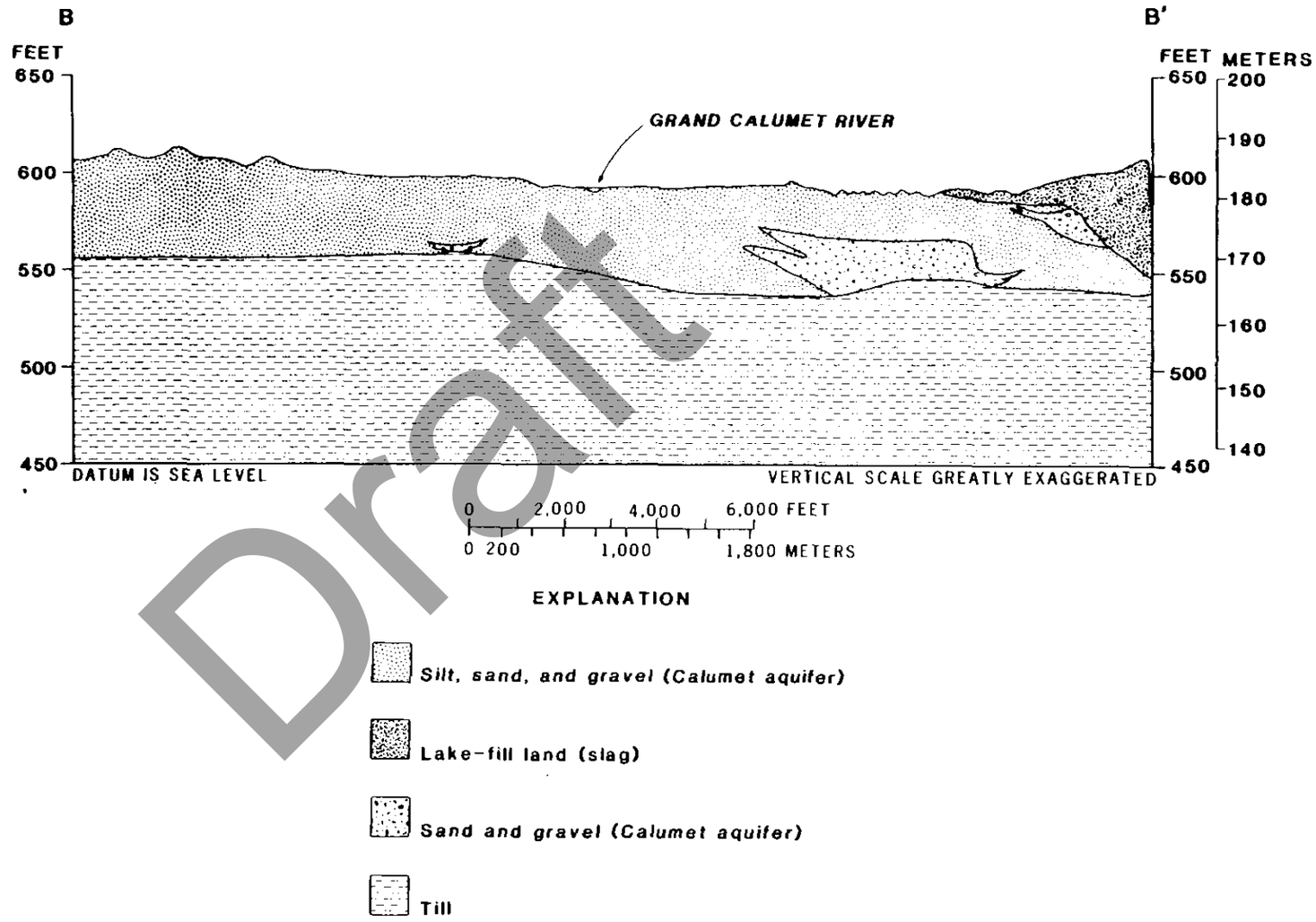

Figure 10.-- *Hydrogeologic section B-B'.*

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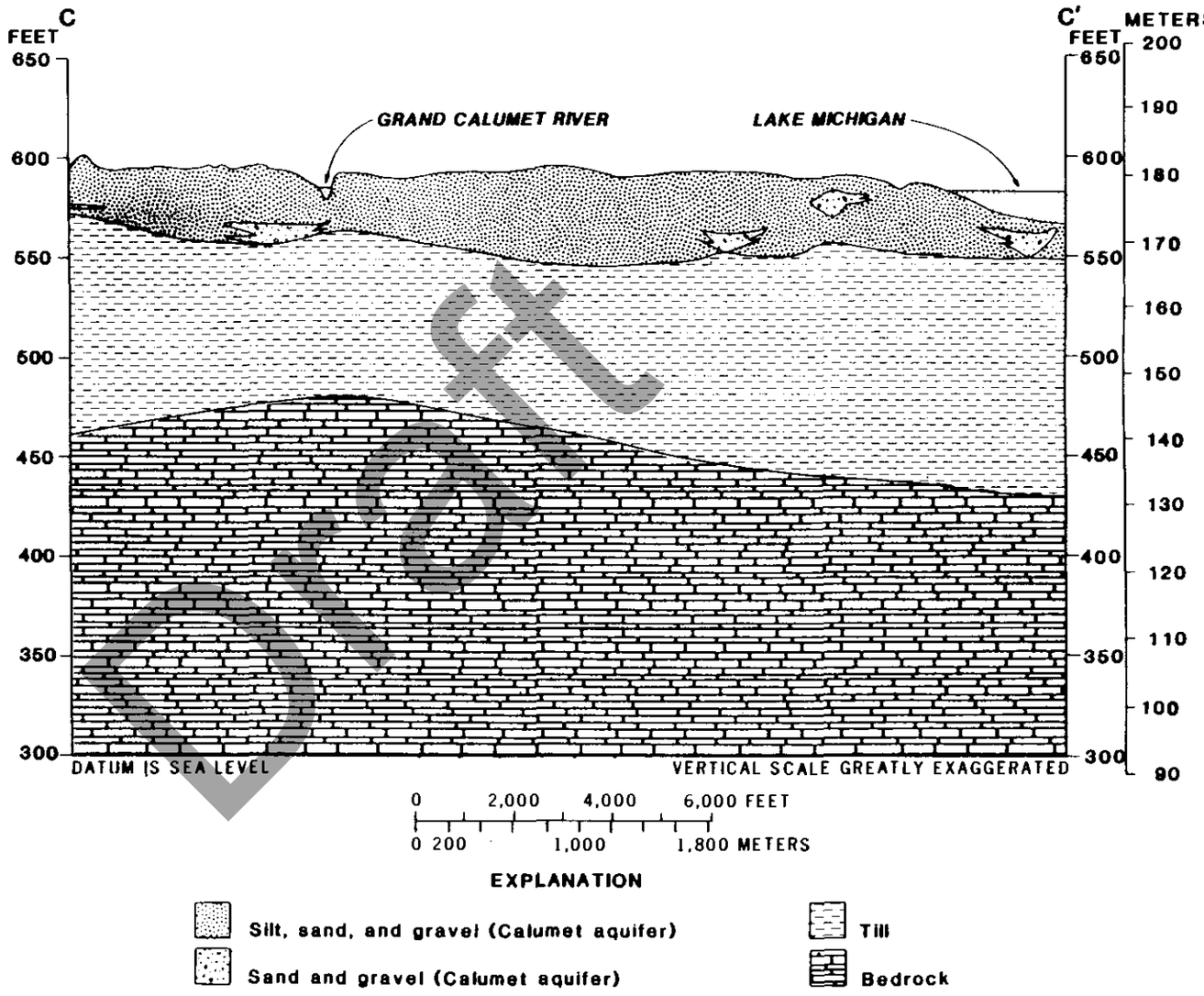

Figure 11.-- Hydrogeologic section C-C'.

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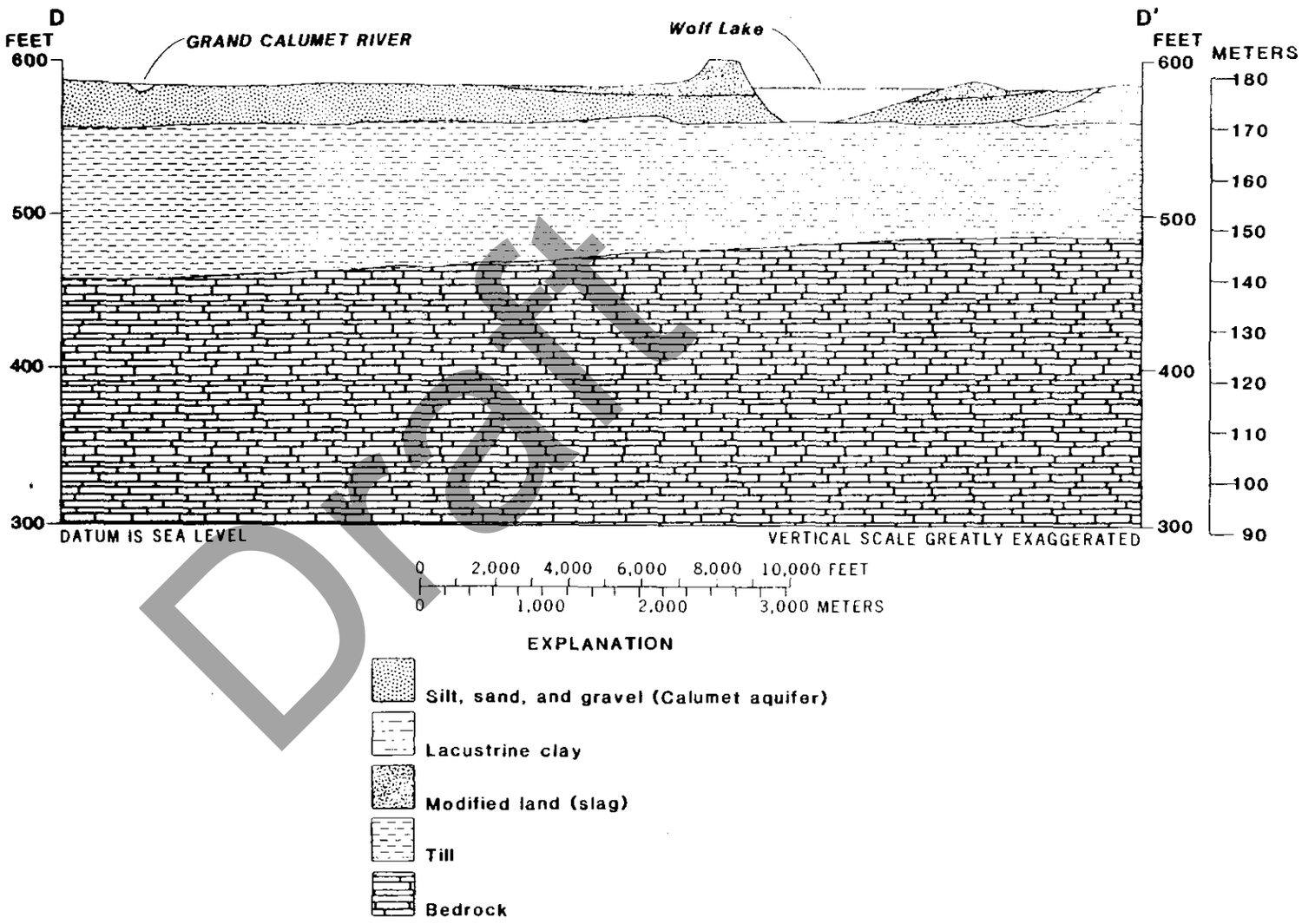

Figure 12.-- Hydrogeologic section D-D'.

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The westernmost section (line of section D-D' in fig. 2) (fig. 12) shows no slope in the underlying till surface because of the direction of the section. As in the other sections, however, the till surface slopes gently toward Lake Michigan. This section also shows a thinner Calumet aquifer and Wolf Lake whose bed has been dredged for fill for the adjacent roadbed. The dredging has exposed the till surface as the bed in part of the lake. This section also shows fill in former wetlands near the lake, a condition common throughout the study area. Lacustrine clay is shown to the north end of the section.

Ground-Water Flow System

Water-table altitudes from March 31 through April 4, 1986, are shown in figure 13. Altitudes are based on water-level measurements from each shallow observation well and at each surface-water measuring point shown in figure 4. Two broad water-table mounds are shown in the study area. The more extensive of the two trends east-west through the study area between the Little Calumet River and the Grand Calumet River and corresponds approximately to the surface drainage divide between these two rivers. Altitudes along this mound are more than 600 feet at each end of the study area with a shallow sag in the middle of the mound. This mound forms a water-table divide that essentially is the southern boundary of the ground-water basin of the GCR/IHC.

The other broad water-table mound is north of the Grand Calumet River between Gary Harbor and the Indiana Harbor Canal. This mound forms a divide that represents the southern boundary of that part of the shallow ground-water flow system that discharges directly to Lake Michigan.

Northwest of the Indiana Harbor Canal, a broad, low water-table mound is connected to a long, narrow ridge that parallels the Lake Michigan shoreline. This narrow ridge may exist because many sets of railroad tracks parallel the shoreline in a narrow area. This area probably receives greater than normal recharge because the coarse slag used for railroad ballast on the surface prevents runoff and because ditches in the area cause depression-focused recharge (Lissey, 1968). Minimal evapotranspiration also occurs because the railroad companies keep the right-of-way cleared of almost all vegetation.

Several small depressions also are shown in figure 13. These depressions are near major sewer lines and probably are caused by local drainage of ground water to the sewer. There probably are more of these local depressions that were not detected through the observation-well network.

Although not shown in figure 13, there are a number of small drainage ditches in the study area to which shallow ground water discharges locally. Such drainage cannot be indicated by the contours at the scale and contour interval used for this map. The importance of such drainage is discussed in the section "Simulations of Ground-Water Flow."

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Water-table fluctuations near the GCR/IHC were monitored in six sets of closely spaced observation wells located along transects perpendicular to the stream. Five of these sets of wells had water-level recording equipment so short-term fluctuations could be detected. A typical well placement is shown in figure 14. The close spacing of near-stream wells and of the stream-stage well was done to enable study of shallow ground-water and surface-water interactions.

In 1986, analysis of aquifer/stream interactions was incomplete, but enough data had been collected to indicate that interactions were complex. The interactions varied with time and space. In the reach of the Grand Calumet River near and east of the hydrogeologic section designated by line B-B' (fig. 2), the stream lost water to the Calumet aquifer most of the time. Throughout the rest of the GCR/IHC, the stream usually gained water from the aquifer. Normal and natural hydrologic factors caused flow patterns to reverse for varying periods of time. Bank storage affected the stream/aquifer interaction; and locally variable recharge, such as that produced by summer thunderstorms, also may have affected these interactions. Storms on Lake Michigan caused estuary-like effects on the Indiana Harbor Canal that could be detected as far as 4 miles upstream from the lake. These estuary-like effects caused the stage in the Indiana Harbor Canal to rise. When the stage in the Indiana Harbor Canal rose rapidly because of the estuary-like effects, the flow gradient was reversed, and the Indiana Harbor Canal lost water to the Calumet aquifer.

An example of how human activities may reverse the normal stream/aquifer interaction is apparent in the upper reach of the Grand Calumet River, east of the hydrogeologic section designated B-B' (fig. 2). In this reach, much of the streamflow is water obtained from Lake Michigan, used for cooling and processing at a large steel mill, and then discharged to the river. A shutdown at the steel mill causes a substantial decrease in discharge to the river, and the normal stream/aquifer interaction can be reversed. This reversal causes the stream to gain water from the Calumet aquifer.

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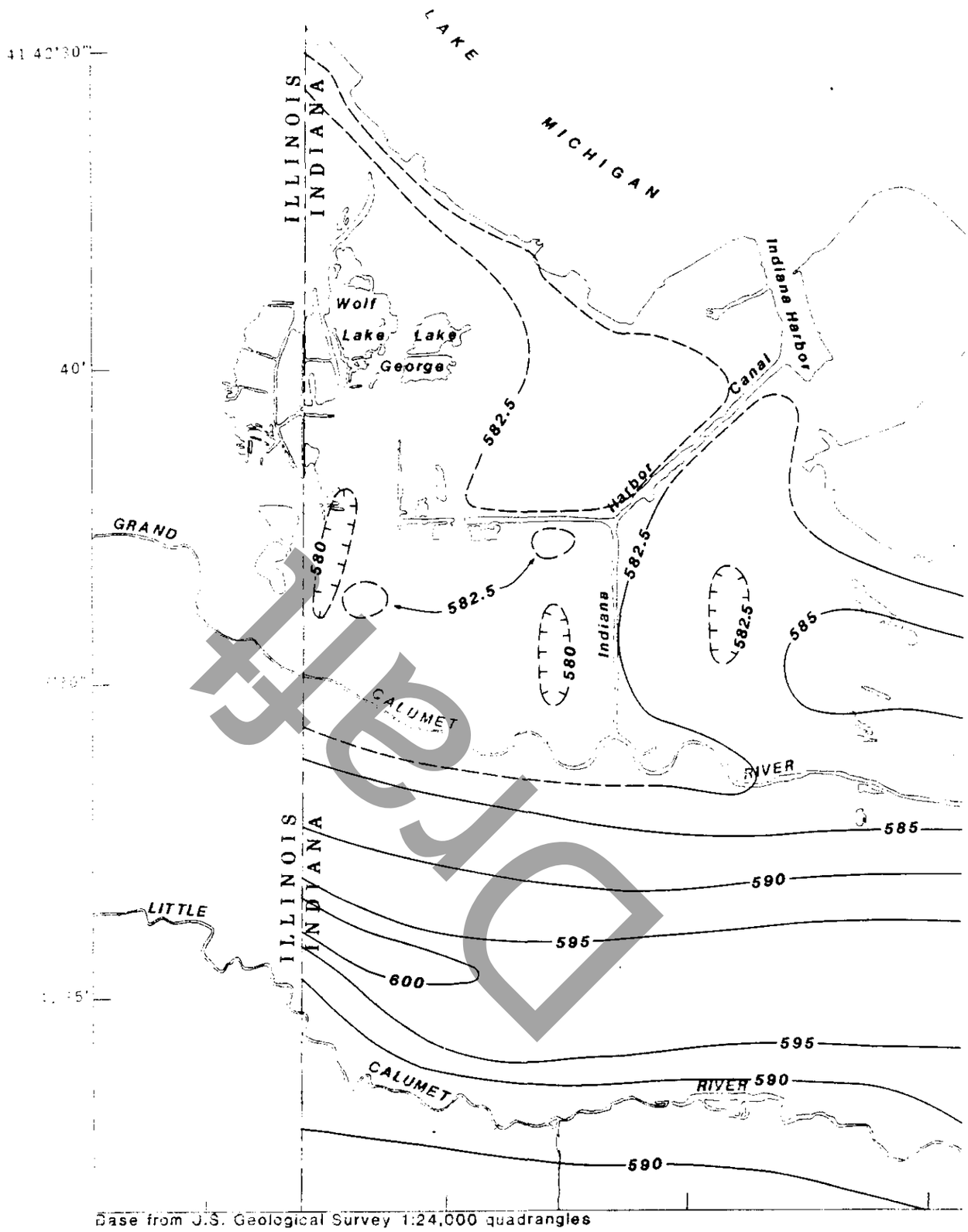
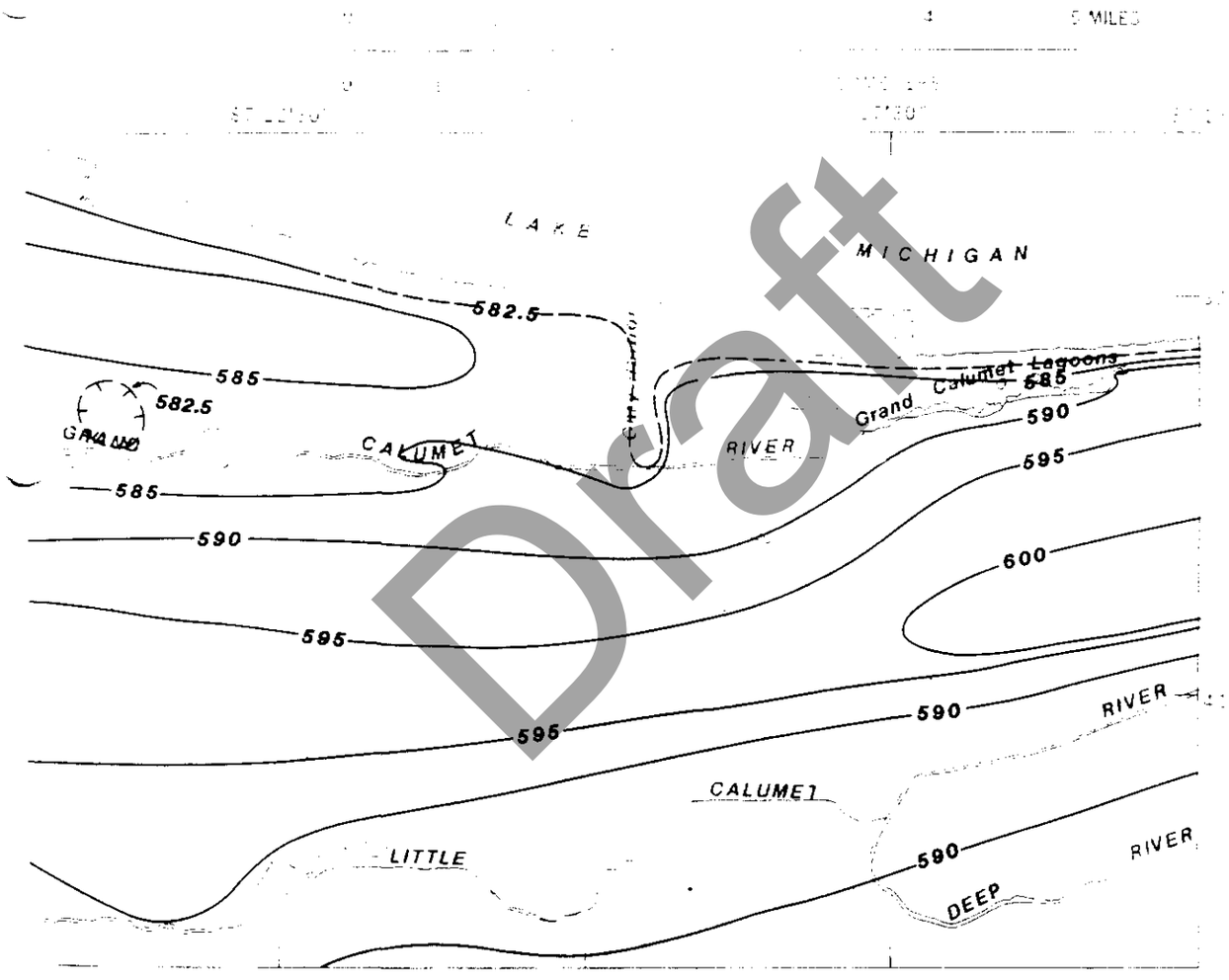


Figure 13.-- Configuration and altitude of the water table in

EXPLANATION

585 WATER-TABLE CONTOUR--shows water-table altitude. Hachures indicate depression. Intervals 2.5 and 5 feet. Dashed where approximate. Datum is sea level



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the Calumet aquifer, March 31 through April 4, 1986.

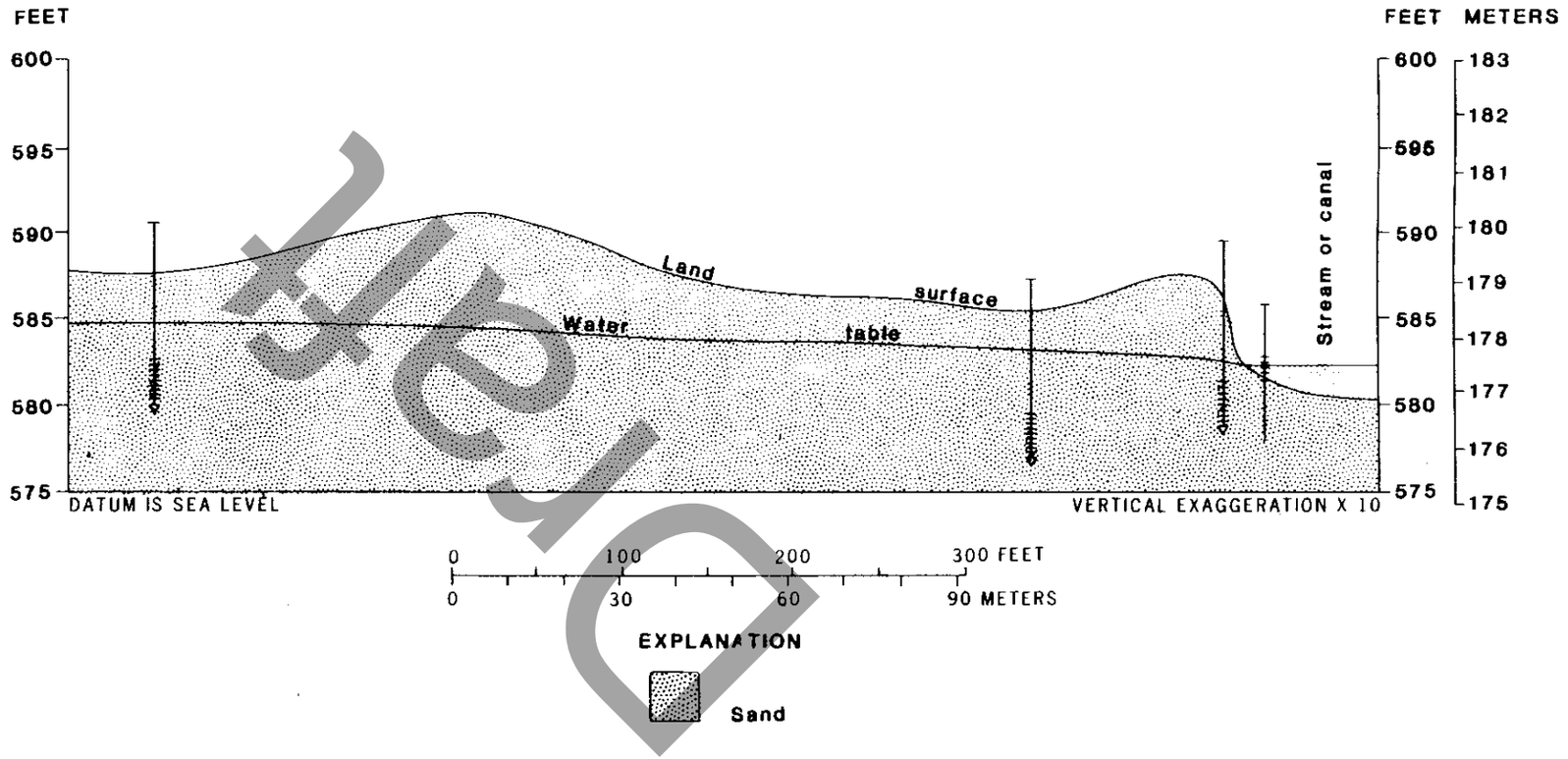

Figure 14.-- Generalized geologic section showing typical well placement.

Simulations of Ground-Water Flow

The conceptual section (fig. 5), along which ground-water flow was simulated, roughly parallels the hydrogeologic section designated C-C' (fig. 11) from 1 mile south of the Grand Calumet River to Lake Michigan. Features of the conceptual section, specifically the grid system and the locations of the river and drain nodes are shown in figure 5. Ten rows and 60 columns were used to represent vertical and horizontal gradients. Around the Grand Calumet River, the blocks are small and are shown enlarged in the inset in figure 5.

Several different boundary conditions were used along the margins of the digital model (fig. 5). The various boundary conditions were simulated using the appropriate part or package from the model. Specified fluxes were assigned to the uppermost active nodes to simulate recharge to the water table. The general-head boundary package was used to simulate boundary conditions at the southern end and the base of the model. A ground-water flux was calculated across a general-head boundary based on a known or estimated hydraulic head outside the modeled area and on an average value of hydraulic conductivity near the model boundary. The specified head at the southern end of the model was the water-table altitude of 600 feet, 1 mile south of the Grand Calumet River at the ground-water divide between the Grand Calumet and Little Calumet Rivers. The hydraulic conductivity was the same as that used within the modeled area. For the base of the model, several specified head distributions in the bedrock were used to simulate the general-head boundary. The bedrock was separated from the Calumet aquifer by about 100 feet of till that was assigned an assumed hydraulic conductivity of 0.01 foot per day for all simulations.

The river package was used to simulate the Grand Calumet River and also the boundary at Lake Michigan so different values of hydraulic conductivity of the lake bed could be simulated. Hypothetical drains were simulated in some model experiments using the drain package. These drains were spaced about 2,000 feet apart and at a depth of 6 feet below the land surface. The hypothetical drains simulate the discharge of ground water to leaky sewer lines, drain tiles, and small unmapped ditches that exist throughout the study area, although their exact locations in the area of the conceptual section are not known.

Two major conceptual models of the ground-water flow system were simulated using steady-state conditions. Rigorous calibration and sensitivity analysis were not attempted. However, a basic understanding of the important parameters of the physical flow system was obtained. A listing of the simulations and their parameters are shown in table 1.

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Table 1.--List of simulations and significant hydraulic parameters

[GCR, Grand Calumet River; A, variable, about 4 feet above the water table in the Calumet aquifer; NA, not applicable; B, see figure 5]

Simulation number	Hydraulic conductivity of Calumet aquifer (feet per day)	Hydraulic conductivity of confining layer (feet per day)	Anistropy factor of Calumet aquifer	Hydraulic conductivity of GCR streambed (feet per day)	Hydraulic conductivity of Lake Michigan "streambed" (feet per day)	Bedrock head distribution (feet above sea level)	Recharge (feet per day)	Stage of Lake Michigan (feet above sea level)	Stage of GCR (feet above sea level)	Number of conceptual drains	Hydraulic conductivity of drains (feet per day)	Location and altitude of drains (feet above sea level)	Diameter of drains (feet)
1	25	0.01	0.1	1	1	A	0.00342	582.6	583	0	NA	NA	NA
2	25	.01	.1	1	1	A	.00114	582.6	583	0	NA	NA	NA
3	40	.01	.1	1	1	A	.00114	582.6	583	0	NA	NA	NA
4	40	.01	.1	1	10	A	.00114	582.6	583	0	NA	NA	NA
5	60	.01	.1	1	10	A	.00114	582.6	583	0	NA	NA	NA
6	100	.01	.1	1	10	A	.00114	582.6	583	0	NA	NA	NA
7	100	.01	.1	1	10	A	.00114	580.6	583	0	NA	NA	NA
8	50	.01	.1	1	10	A	.00228	580.6	583	8	200	B	2
9	50	.01	.01	1	10	A	.00228	580.6	583	8	200	B	2
10	50	.01	.01	1	10	A	.00228	580.6	583	0	NA	NA	NA
11	50	.01	.01	1	10	575	.00228	580.6	583	0	NA	NA	NA
12	50	.01	.01	1	10	575	.00228	580.6	583	8	200	B	2
13	50	.01	.01	1	10	570	.00228	580.6	583	8	200	B	2

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In the first basic conceptual model, only two surface-discharge zones were simulated, the Grand Calumet River and Lake Michigan. This is essentially the flow system as it had been in pre-development times. The model-generated head distributions have almost horizontal flow paths between the ground-water divide and the two discharge points (fig. 15). Two vertical zones of flow, into the river and the lake, also are shown in figure 15. One zone consists of recharge from precipitation that flows downward and laterally, and the other consists of water from the bedrock that flows upward and laterally. This upward flow from the bedrock is the result of specifying heads in the bedrock (using the general-head boundary) that are several feet higher than the water table in the Calumet aquifer. The upward flow creates a small upward flux from the till at the base of the surficial aquifer and a stagnation point on the ground-water divide that defines the boundary of the two flow systems. Water below the stagnation point (fig. 15) flows to the Grand Calumet River and to Lake Michigan, as does the water above the stagnation point. Water from these two different flow paths may not substantially mix, which may be important in later studies of vertical changes in ground-water quality.

Another important feature of the first conceptual model is that the simulated water level is about 5 to 10 feet higher than that indicated by measured values. Lowering the water level by increasing the hydraulic conductivity did not seem reasonable because the value of 100 feet per day is about the largest value of the range for the study area reported by Rosenshein and Hunn (1968, p. 29). Alternatively, decreaaing the recharge rate further did not seem realistic for a sand aquifer in a temperate climate that receives more than 30 inches per year of precipitation. These results indicate that the first conceptual model probably is a reasonable representation of the pre-development, natural flow-system when the water table was at or very near the land surface. The results also indicate that other discharges from the system, such as discharges to ditches and tile drains or downward leakage to the bedrock, are necessary to lower the simulated water level to the observed modern profile.

Additional model experiments, using the first conceptual model, indicated that simulated decreases in the ratio of vertical to horizontal hydraulic conductivity do not substantially affect the position of the water table. Changing the ratio from 1:10 to 1:100 causes an increase in the water level of no more than 0.2 foot. The change in simulated anisotropy did not affect the flow pattern, particularly the location of the stagnation point (fig. 15) and the two associated zones of flow. Ratios smaller than 1:100 probably are not reasonable for the Calumet aquifer and, therefore, were not used. Because of the results of the first conceptual-model simulations and because ditches and tile drains are prevalent in the modeled area, a second conceptual model was developed.

The second conceptual model contained a series of eight drains that were about 2,000 feet apart. The drains removed water from the flow system and lowered the water level. Also, because there were more discharge points in the modeled section, a reasonable fit of the simulated to observed water-table profiles could be obtained using values of hydraulic conductivity of 50 feet per day and values of recharge of 10 inches per year. These values probably are more representative of the Calumet aquifer (Rosenshein and Hunn, 1968).

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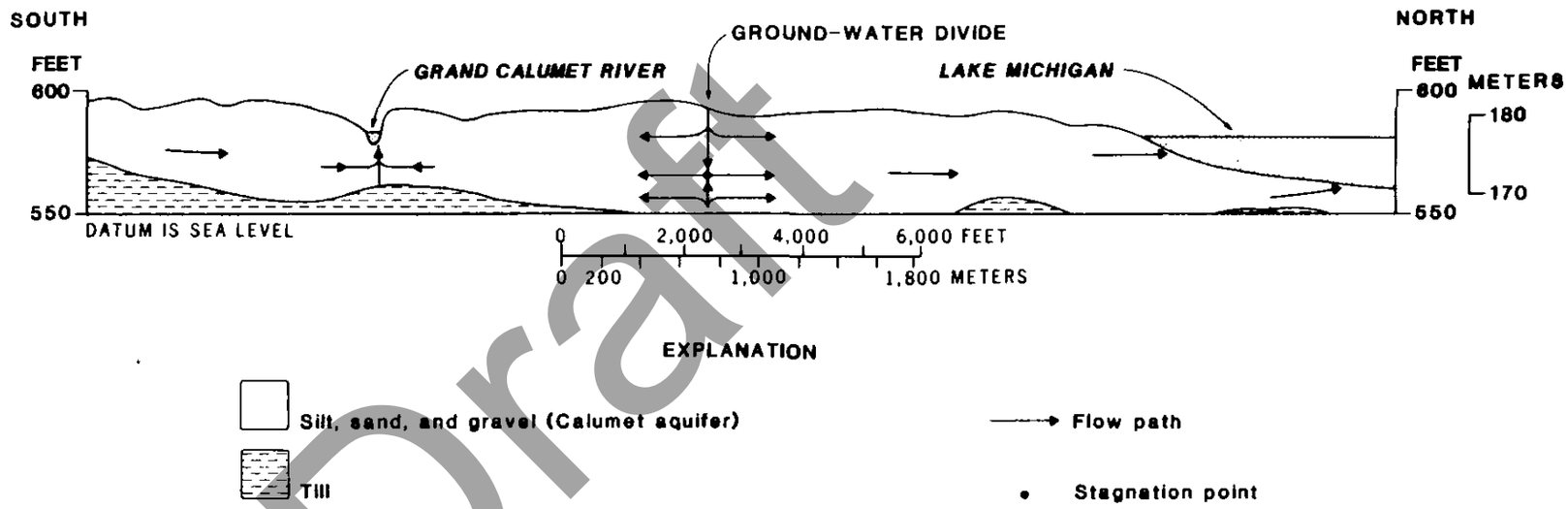

Figure 15.-- Conceptual geologic section showing the first conceptual-model-simulated flow system with two surface drains.

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The resulting flow pattern, indicated by the second conceptual model (fig. 16), is more complex than that in the first conceptual model (fig. 15) because individual flow cells developed around most of the drains. The area around the Grand Calumet River continued to have the same flow pattern as before, but five of the drains, farther from the river, caused local water divides and flow patterns that fully penetrated the aquifer. Several more stagnation points also resulted; but, unlike the first conceptual model, the upward flow from the deep part of the aquifer mixed with water from the upper part of the aquifer in the regions under the drains.

The second conceptual model was modified further by testing the effect of hydraulic heads in the underlying bedrock that were 1 to 20 feet lower than the water table. Many bedrock wells in northeastern Illinois have sections open to the carbonate rocks of Silurian age. Pumpage from these wells probably has caused drawdowns in water levels in the Silurian carbonates that extend into northwestern Indiana, although the extent of the drawdowns is uncertain and possibly is controlled by the distribution of fractures.

Several simulations that had bedrock hydraulic heads below the water table were done; and, in each simulation, enough water was drawn out of the Calumet aquifer to lower the water table a few feet more. Flow patterns were not altered appreciably, although the location of the stagnation zones in the lower part of the aquifer were changed (fig. 17). These results indicate that the general lowering of the water table in the study area from pre-development times to the present (1985) may be caused by surface drainage and downward leakage to the bedrock.

A few general sensitivity analyses were done for the second conceptual model. Changing the ratio of the vertical to horizontal conductivity from 1:10 to 1:100 in the second conceptual model increased water levels by no more than 0.3 foot. This slight increase did cause a shallow flow cell to develop around the first drain north of the Grand Calumet River. However, flow between the drains and flow near the Grand Calumet River and Lake Michigan essentially was horizontal.

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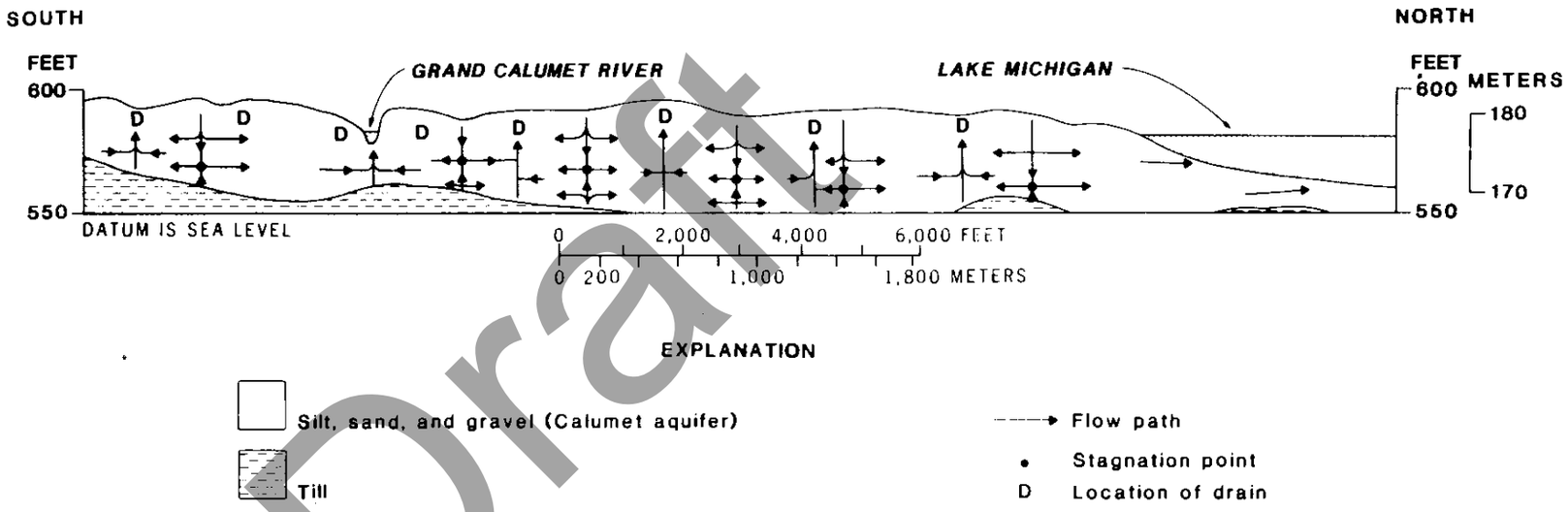

Figure 16.-- Conceptual geologic section showing the second conceptual-model-simulated flow system with eight drain nodes.

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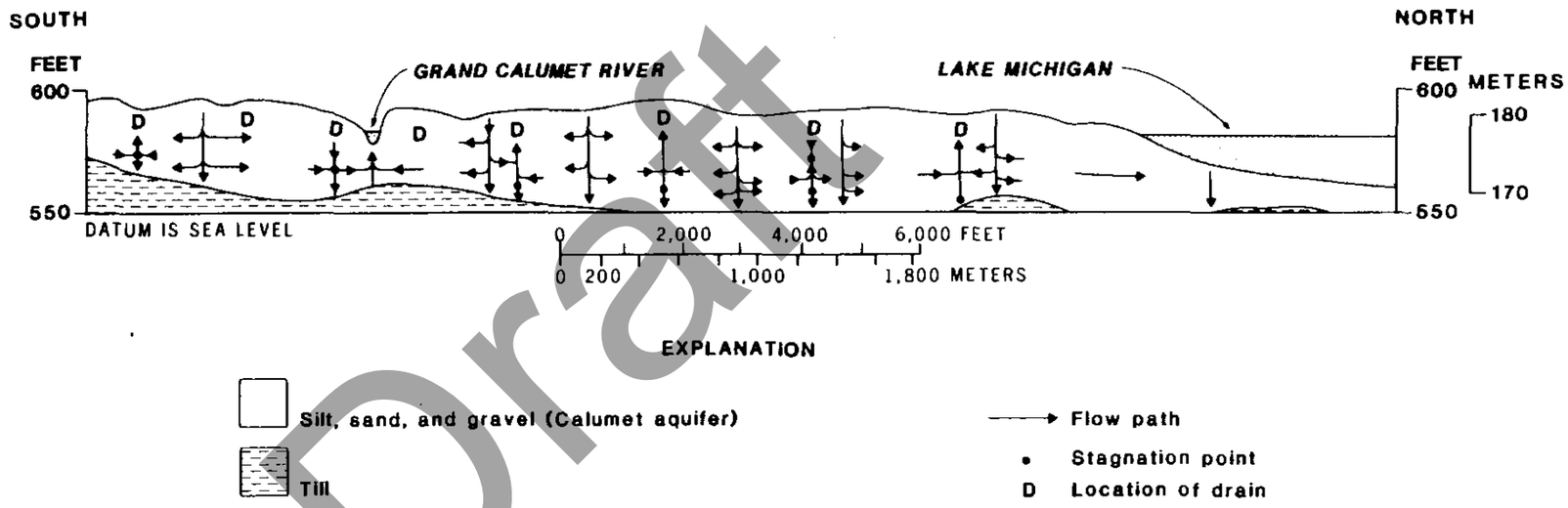

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Figure 17.-- Conceptual geologic section showing simulated flow system with eight drain nodes and downward leakage to bedrock.

SUMMARY AND CONCLUSIONS

A preliminary analysis was done of the shallow ground-water system in the vicinity of the Grand Calumet River/Indiana Harbor Canal (GCR/IHC) in Lake County, northwestern Indiana. This analysis was done to develop a more detailed understanding of this ground-water system so water-quality monitoring sites could be selected to assess the potential for contaminants to migrate to Lake Michigan or to the GCR/IHC.

The analysis was done using data from previous work, supplemented by new data collected from August 1985 to May 1986, during which 36 water-table wells were installed, access was obtained to measure water levels in 9 privately-owned wells, 19 continuous sediment cores were obtained and described, and 7 test holes were drilled in which sediments from the surficial aquifer, known as the Calumet aquifer, were sampled. Measurements in the water-table wells and measurements on the GCR/IHC were used to compile the most detailed water-table map of this area as of 1986. The lithologic data were used to compile refined maps of the saturated thickness of the Calumet aquifer, maps of altitude of the bedrock surface and the surface of the till that forms the base of the aquifer. Several hydrogeologic sections perpendicular to the lakeshore were produced, and flow along one of these sections was simulated using a digital model.

Based on analyses of these data and the simulations using the digital model, the following preliminary interpretations have been made:

1. In the vicinity of the GCR/IHC, the Calumet aquifer consists mainly of fine- to medium-grained sand that is overlain locally by slag fill that, in this report, is considered part of the aquifer. Aquifer thickness ranges from 0 to 65 feet, and the maximum saturated thickness is 45 feet. No extensive lacustrine clay or paludal deposits, which could be local confining layers, occur in the aquifer. The aquifer is underlain by till except in an area near the IHC where the aquifer is underlain by a local accumulation of lacustrine clay over the till. The till and lacustrine clay form a confining layer between the Calumet aquifer and the underlying carbonate bedrock of Silurian age.

2. Broad water-table mounds of low relief form major shallow ground-water flow divides between Lake Michigan and the GCR/IHC and between the GCR/IHC and the Little Calumet River to the south. However, in the northwestern corner of the study area, there is no broad water-table mound, but a narrow water-table ridge that extends along the Lake Michigan shoreline and connects to a somewhat circular, low mound northwest of the Indiana Harbor Canal. These patterns indicate that: 1) Shallow ground water discharges directly north to Lake Michigan from the water-table divide that is north of the Grand Calumet River between Gary Harbor and Indiana Harbor Canal; 2) the ground-water mound between the Grand Calumet and Little Calumet Rivers is the southern boundary of the GCR/IHC ground-water basin; and 3) greater than normal recharge and minimal evapotranspiration along railroad tracks have caused the linear ground-water mound northwest of the Indiana Harbor Canal.

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3. Data collected from transects of closely spaced wells near the stream banks of the GCR/IHC indicate that water-table fluctuations near the streams are complex. Reversals in normal stream/aquifer interactions have been observed.

4. Digital-model simulations indicate that the water table in the Calumet aquifer has been lowered by several feet from pre-development levels by drainage to sewer lines and small ditches and by downward leakage to the bedrock through the underlying till and lacustrine clay. Without such drains or leakage, and using recharge rates that are reasonable for this area, the water table is raised to land surface, reflecting the pre-development wetland conditions of the study area. The model analysis further indicates that drainage to sewers and small ditches creates fully penetrating, local flow systems in the Calumet aquifer.

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APPENDIX B
HISTORIC SITE INFORMATION

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B.1 – EXCEPTS FROM 2002 SI REPORT

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B.1.1: SECTION 4.5 - GEOPHYSICAL AND TRENCHING SURVEY, FIGURES 4-3 AND 4-5 AND APPENDIX C.

4.4.4 Results of Groundwater Modeling

Because three constituents in groundwater exceeded screening criteria, an assessment of risk to the Canal was conducted using a groundwater model. Included in Appendix B is a groundwater modeling report for the ECI Site. This three-dimensional numerical groundwater model was calibrated with water levels measured at the ECI Site, and used to evaluate groundwater discharge to surface water of the Lake George Branch Canal. The effect of dissolved constituents in groundwater mixing with the Canal was evaluated.

Surface water concentrations were calculated based on constituent loading from different areas of the ECI Site followed by a cumulative calculation that considered all of the parcels. Three areas of the ECI Site, with parcels bordering the Lake George Branch Canal, have been defined for modeling purposes as follows: Pollution Control Area/West Tank Farm, South Tank Farm/Southwest Tank Farm, and Hammond Tank Farm. In each of these areas, the representative groundwater concentration discharging into the Lake George Branch Canal was calculated by averaging the GSI wells in an area that did not contain product. The average concentrations for the three COCs in each of the areas are summarized on Table 4-15.

The rate of groundwater flow into the Canal in each of the areas was calculated using the model. Additionally, the total flow of the system was calculated. Using these relative flow rates, a mixing factor was calculated, which allowed for a calculation of the surface water concentration of each constituent in the Canal, based on the area being addressed. The predicted Canal concentration for each of the constituents based on the contribution from each of the areas is presented in Table 4-16. The cumulative effect from all three of these areas is presented in Table 4-17. As shown in Table 4-17, none of the constituents of interest have predicted surface water concentrations that exceed the applicable water quality standards.

4.5 Buried Pipeline Investigation

The two phases of the buried pipeline investigation are presented below. The geophysical results were followed by actual field observation of the trenching.

4.5.1 Geophysical Investigation

The findings of the geophysical surveys are presented for each of the parcels investigated.

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4.5.1.1 South Tank Farm

Data from twenty parallel transects was collected at five locations on the South Tank Farm. The locations were selected based on where piping shown on historical maps was considered likely to be found, if still present. The surveys were performed on January 21, 2002 in the following grid locations: H-I, 14-15; H-I, 15-16; H-I, 17-18; H-I, 19-20; and G-H, 19-20. An additional 26 transects were collected on January 24, 2002 at G-H, 14-15. (See Figure 4-3).

The surveys performed at the west end of South Tank Farm identified a large pipeline which crosses the area at an angle and helps to confirm the trend and location of pipes from the historical maps. This angled pipe passes through a location where several valves are visible at the surface. Several other pipes were identified and two locations were marked in the field for excavation.

Geophysical transects were also collected at the east end of South Tank Farm where piping was expected to be encountered. Several locations in the data set were identified where east-west trending pipes are very likely to exist based on their linear signature across adjacent transects.

Based on the survey, it appears that a significant portion of the original product piping remains in place at South Tank Farm. The South Tank Farm results are presented in Figure 4-3.

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4.5.1.2 Southwest Tank Farm

On January 22, 2002 a survey grid was established in the section H-I, 11-12; and 6 transects were collected at 20-foot spacings in the north-south direction on the east-central portion of the Southwest Tank Farm. A strong north-south trending anomaly was observed which roughly corresponds with piping from historic maps. There are also several surface features on the ground where the piping was identified. The Southwest Tank Farm results are presented in Figure 4-4.

4.5.1.3 West Tank Farm

Fifteen transects were collected at 20-foot separation at the central (O-P, 11-12) and northern (Q-R, 11-12) portion of West Tank Farm on January 30, 2002. A north-south trending pipe was found to run just west of the grid line along the eastern edge of the survey grid. An east-west trending anomaly was noted in the center of the northern

survey area as well as north-south trending anomalies at either end. These features are likely pipelines, and were marked out in the field for confirmatory excavation. The West Tank Farm results are presented in Figure 4-5.

4.5.1.4 Hammond Tank Farm

The Hammond Tank Farm had tanks constructed, but it never became operational and no storage or operations took place there. Extremely rough terrain precluded the establishment of a large survey grid, due to the tall wetland grasses, standing water, and fill material near the center of the property. On January 30, 2002, data transects were collected from the N grid line towards the south where fill material drops off to the standing water and three long transects were performed across the central portion of the property. A high amplitude anomaly was noted near Hammond Tank Farm stake N-8. This anomaly does not continue outside the geophysical survey area and does not have a linear trend. Five high amplitude anomalies were noted on two transects at the east end of the survey. These anomalies are twenty feet apart and are parallel to each other. It is likely that these anomalies are reinforced concrete pipe racks. Similar pipe racks have been identified along the southern edge of the marsh at Hammond Tank Farm and continue eastward until they turn north to the fill area surveyed. The regular spacing of these anomalies and the fact that the signature extends past the survey area suggests that they are isolated features and are not connected to anything outside the survey area. The Hammond Tank Farm results are presented in Figure 4-6.

4.5.1.5 Pollution Control Area

On January 23, 2002 six parallel transects were performed at the south end of the Pollution Control Area to the west of the marsh (K-M, 8-9). These transects were 500 feet long and were collected in the north-south direction. Background readings were slightly elevated, possibly due to slag gravel present at the parcel. Overall, no piping or metallic debris was noted except for a railroad rail at the south end of the survey. The Pollution Control Area results are presented in Figure 4-7.

4.5.2 Test Trench Investigation

Test trench locations were chosen based on the findings of the geophysical survey. The trenching locations were selected based upon the identification of anomalous features, including linear appearing features. Six (6) locations were selected on the south tank farm parcel, 3 on the southwest tank farm parcel and 2 on the west tank farm parcel.

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The following discussion provides a detailed description of each test trench. A map showing the locations of the test trenches is included as Figure 4-8. Pictures from the trenches are included in Appendix C.

4.5.2.1 South Tank Farm

Test trench #1 uncovered a bumper post at 2.5 feet below land surface (bls). No pipeline was found.

Test trench #2 uncovered a 12-inch diameter pipeline at 4 feet bls. The pipeline runs east and west, and appeared to be in good condition.

Test trench #3 uncovered a 24-inch diameter pipeline at 2.5 feet bls. The pipeline runs east and west, and appeared to be in good condition.

Test trench #4 uncovered a concrete wall and miscellaneous metal pieces. The excavation was 5 feet by 9 feet and was 5 feet deep.

Test trench #5 uncovered a 4-inch diameter pipe at 2 feet bls. The pipeline runs north and south, and appeared to be in good condition. Random scrap metal was also uncovered. No line was found that corresponded to the east-west trend of the geophysical survey. The excavation was 5 feet by 7 feet and was 5 feet deep.

Test trench #6 uncovered two (2) 12-inch diameter pipes. Both pipes have 90° flanged ends, one facing west and bending into the ground and the other end is facing north and bending to the west. The ends of the pipe are approximately one foot apart and appear to be in good condition.

4.5.2.2 West Tank Farm

Test trench #7 uncovered slag and metal scrap, no pipelines were found at this location.

Test trench #8 uncovered a 12-inch diameter pipeline at 2.5 feet bls with a 4-inch diameter pipe intersecting it at 90°. The 12-inch diameter pipeline runs north and south and the 4-inch diameter pipeline runs east and west. Both pipelines appear to be in good condition.

Test trench #9 uncovered a 12-inch diameter pipeline at 2.5 feet bls. The pipeline runs north and south, and appeared to be in good condition. In the excavation, a 4-inch

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diameter pipe was found at 6 inches bls. The pipe runs east and west and is sheared and crimped on the east side.

4.5.2.3 Southwest Tank Farm

Test trench #10 uncovered a 12-inch diameter pipeline at 3 feet bls. The pipeline runs north and south, and appeared to be in good condition.

Test trench #11 uncovered a 12-inch diameter pipeline at 3 feet bls. The pipeline runs north and south, and appeared to be in good condition. This pipeline is possibly the same pipe found in test trench #10 directly to the north.

4.5.3 Summary

The results of the geophysical survey supplemented with the test trenches confirm the presence of buried pipes in the areas tested and described above. It should be noted that test trenches where pipe locations were confirmed were at relatively shallow depths (generally less than 3 feet). Groundwater was not observed and not expected at shallow these shallow depths. The integrity of the pipelines appeared to be good in areas that were visually observed. No significantly stained soils were observed and the pipelines appeared to be in tact.

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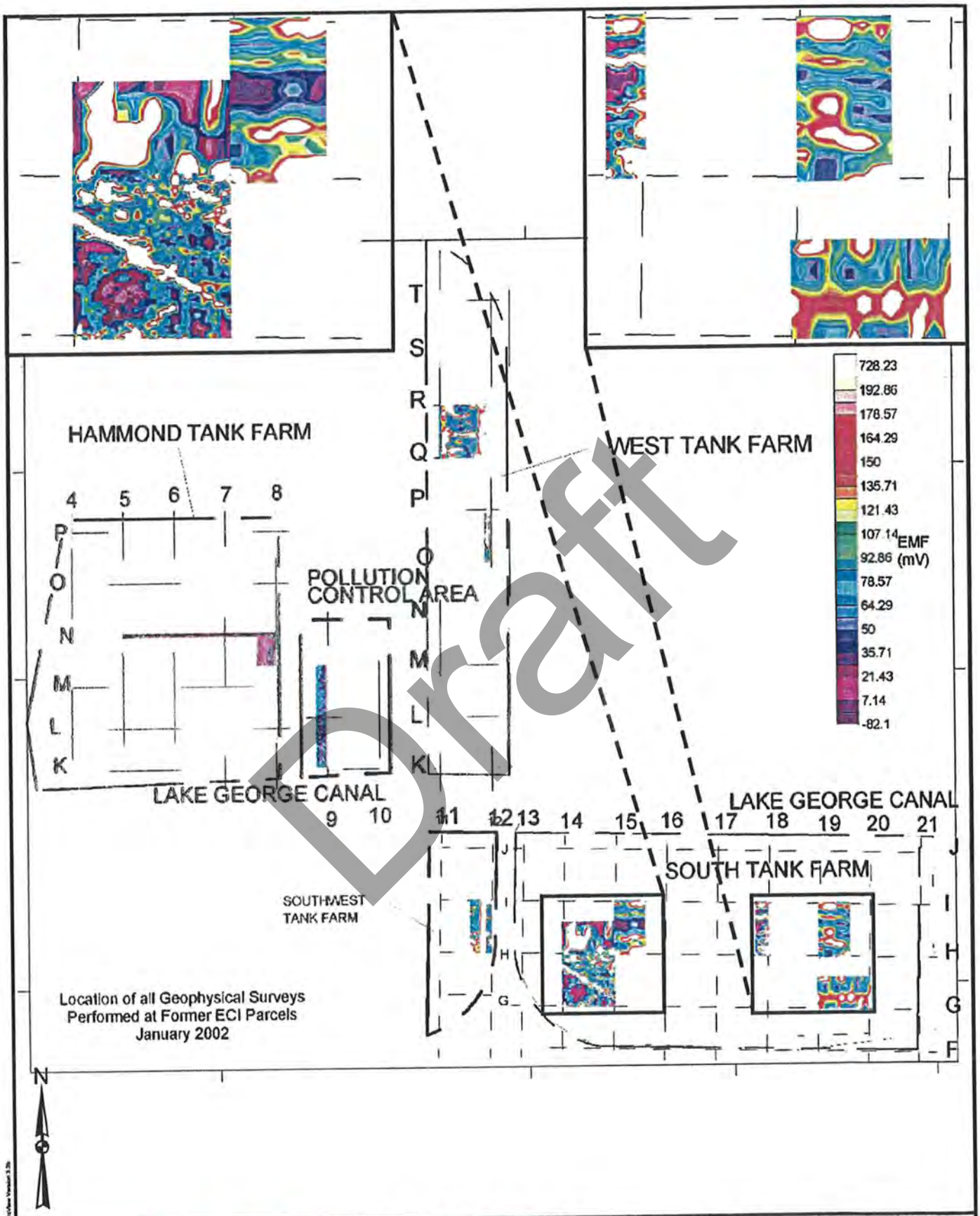

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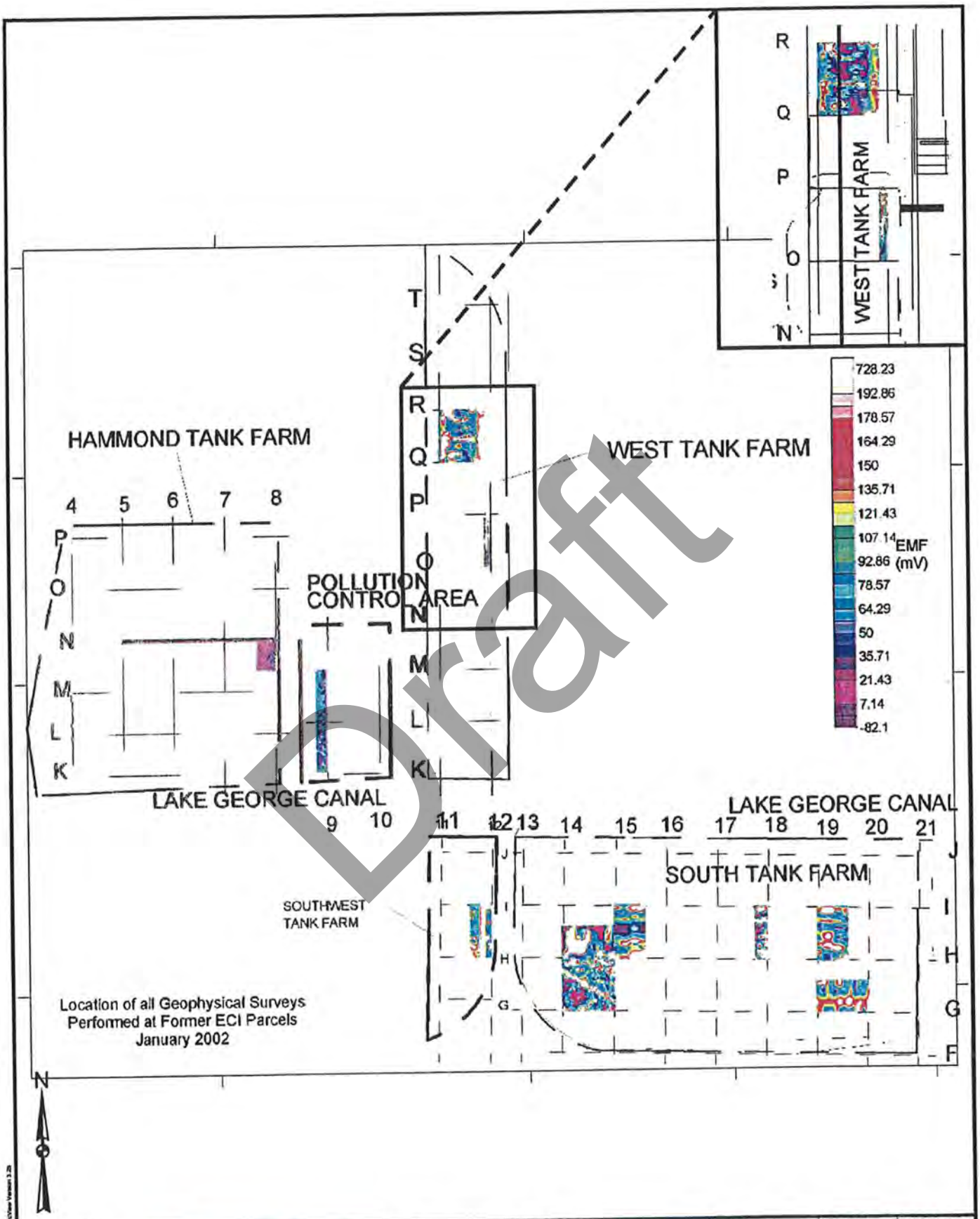
Former ECI Refinery

South Tank Farm Geophysics Results

East Chicago, Indiana

Dept. Manager:	View: Geophysical\ Geophysics Inset
Project Number: C1001067.0008	Figure: 4-3



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Former ECI Refinery

West Tank Farm Geophysics Results

East Chicago, Indiana

Dept. Manager:	View: Geophysics\ Geophysics Inset
Project Number: C0001067.0008	Figure: 4-5

Appendix C

Test Trench Photographs

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Test Trench #1: Bumper post. No piping identified.

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Test Trench #2: Pipeline (12-inch diameter) running east-west.

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Test Trench #3: View to the West. Pipeline (24-inch diameter) running east-west.

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Test Trench #4; Concrete wall with miscellaneous metal pieces. No piping identified.

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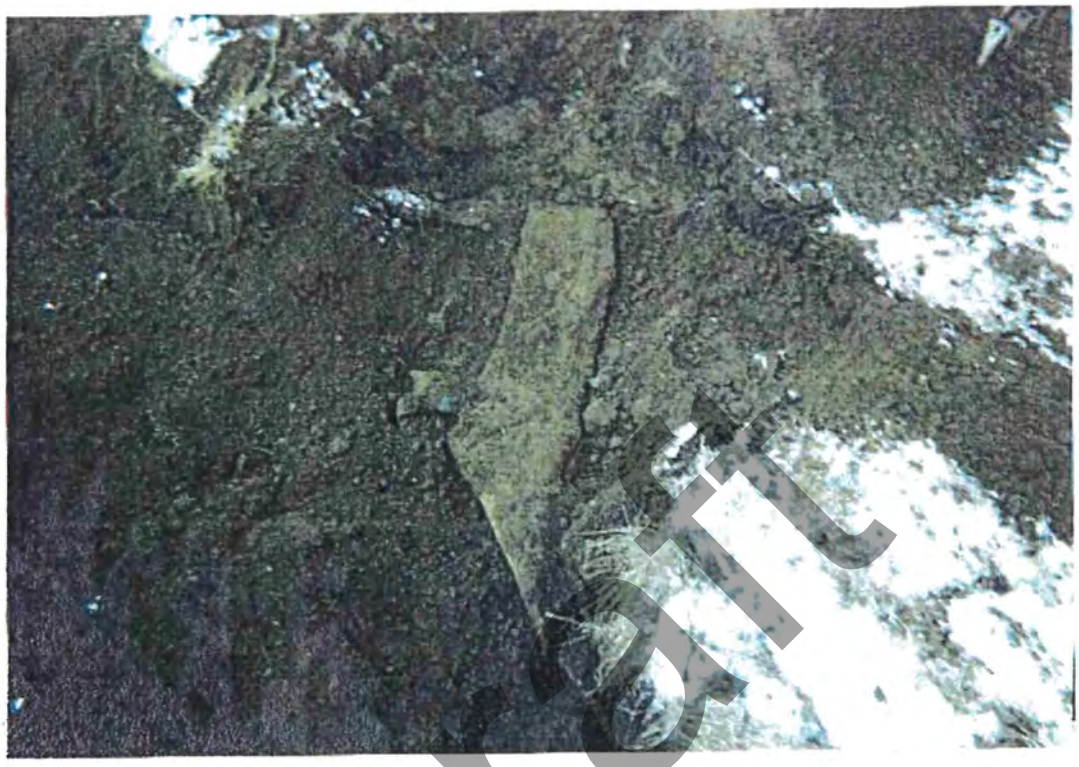

Test Trench #5: Scrap metal.

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Test Trench #6: View to the West. Pipe (12-inch diameter) with flange facing west and bending 90° down. Pipe (12-inch diameter) with flange facing north and bending 90° west.

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Test Trench #8: View to the East. Pipeline (12-inch diameter) running north-south. Pipeline (4-inch diameter) running east-west.

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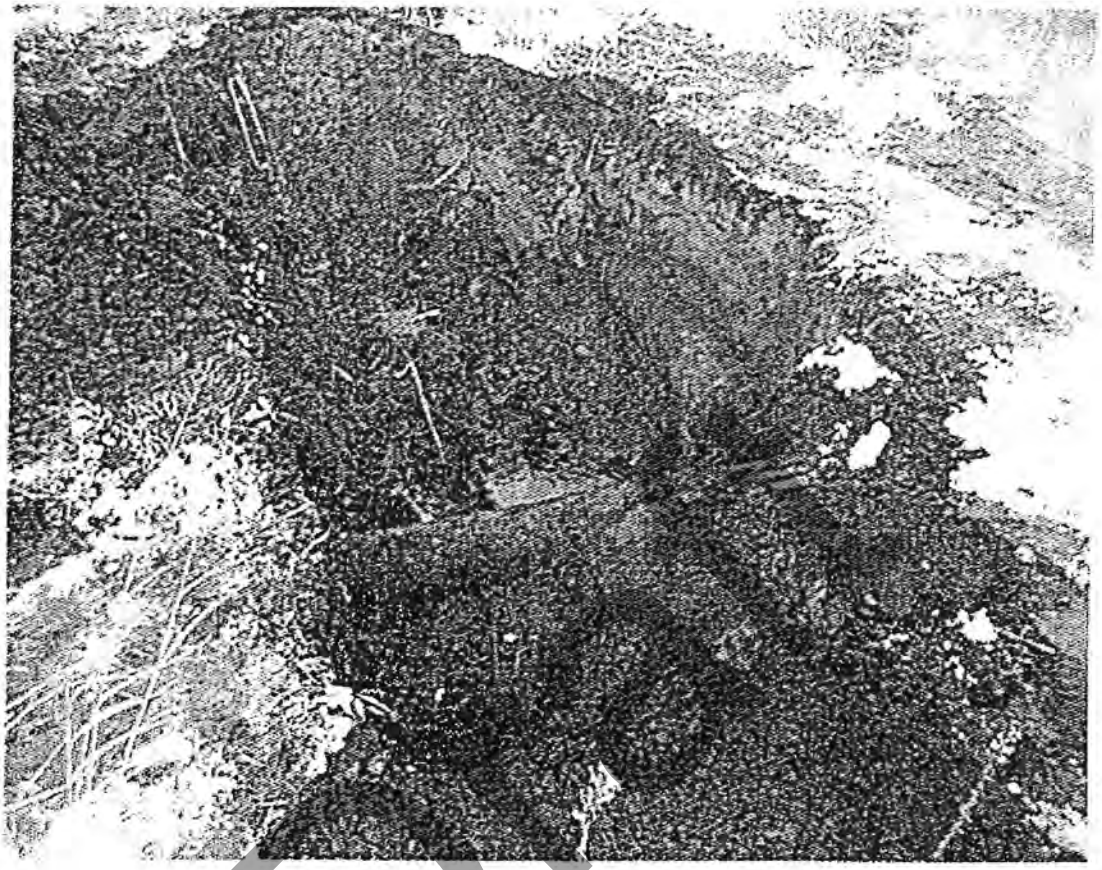
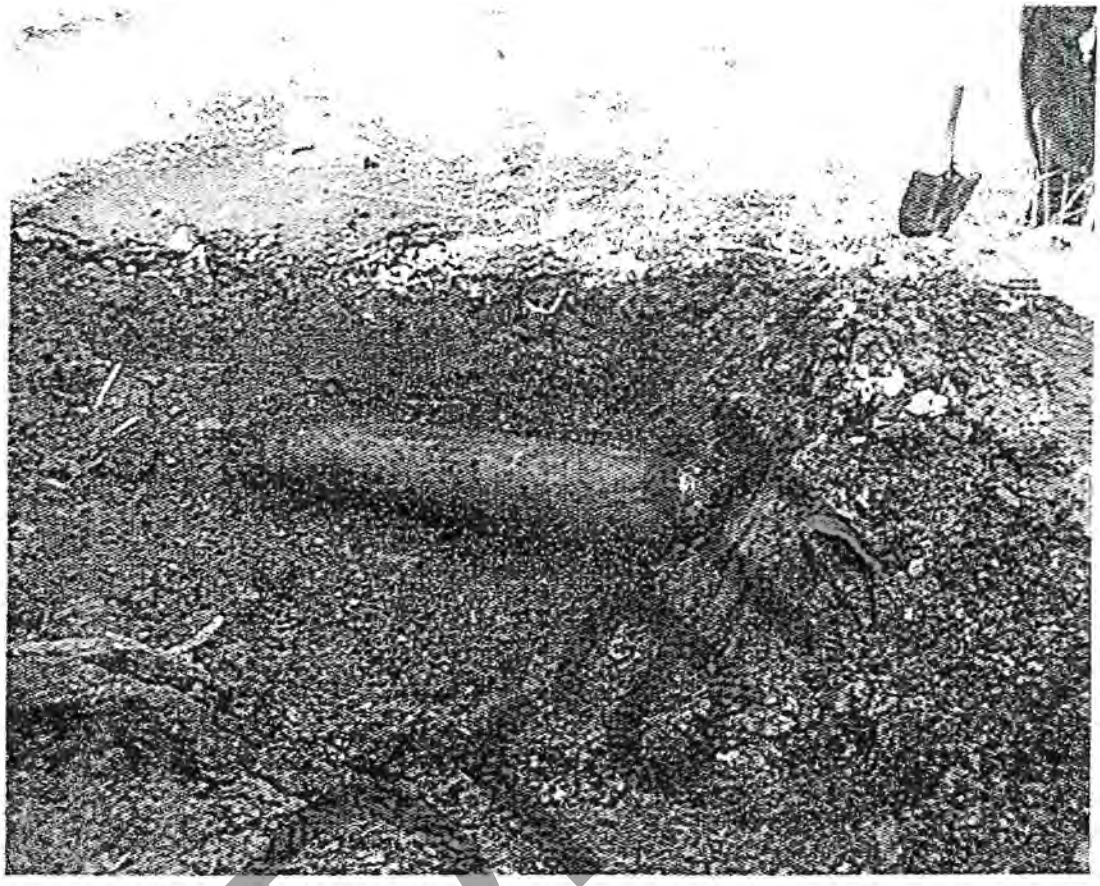


Test Trench #9: View to the North/North-East. Pipeline (12-inch diameter) running north-south. Pipeline (4-inch diameter) running east-west.



Test Trench #10: View to the East. Pipeline (12-inch diameter) running north-south.

Test Trench #11: Pipeline (12-inch diameter) running north-south.

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B.1.2: APPENDIX B – GROUNDWATER MODEL AND ASSOCIATED TABLES AND FIGURES

Appendix B

Groundwater Model

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ECI Groundwater Model Report

East Chicago-Hammond, Indiana

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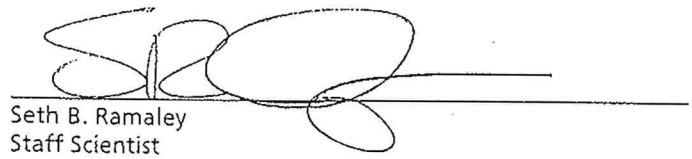

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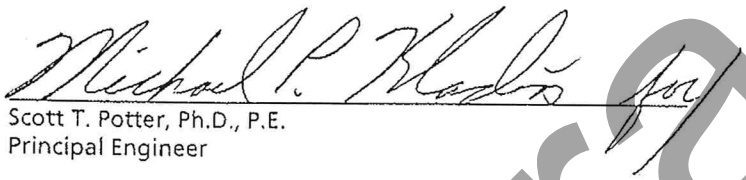
Staff Scientist



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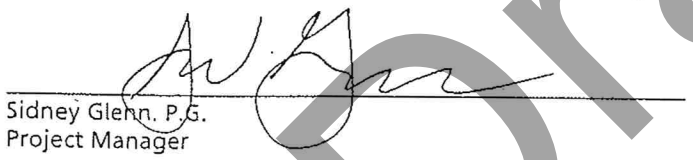

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ECI Groundwater Model Report

East Chicago-Hammond, Indiana

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A. Data Management Plan

B. Groundwater Model

C. Test Trench Photographs

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1. Introduction

Atlantic Richfield Company retained ARCADIS G&M, Inc. (ARCADIS) to develop a three-dimensional numerical groundwater model for simulating groundwater flow conditions at the former Energy Cooperative, Inc. (ECI) refinery site (ECI Site) in East Chicago and Hammond, Indiana. This modeling is part of the evaluation to assess groundwater flow conditions at the ECI Site and potential migration of dissolved constituents in groundwater to adjacent surface water. Project activities associated with the modeling of groundwater flow conditions are summarized in this report. Additional information about the ECI Site and recent investigation activities is included in the ECI Site Investigation Report (ARCADIS, June 2000).

1.1 ECI Site Location

The ECI Site is located in East Chicago and Hammond, Lake County, Indiana (Figure 1-1). The ECI Site includes 8 parcels: South Tank Farm (STF), West Tank Farm (WTF), the Hammond Tank Farm (HTF), Southwest Tank Farm (SWTF), Riley Road Parking Lot (RR), South of South Tank Farm (SSTF), South of Southwest Tank Farm (SSWTF), and Pollution Control Area (PCA) (Figure 1-2). Two other parcels, the Main Refinery Area and the North Tank Farm, are proposed for confined disposal facility (CDF) development by the United States Army Corps of Engineers (US ACE). Available data from all ten of the parcels was used to develop the groundwater model. The ECI Site is divided by the Lake George Branch of the Indiana Harbor Canal (Lake George Branch Canal).

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1.2 Objectives And Scope

The objective of this modeling study was to develop a groundwater flow model of the ECI Site that could be used to further understand the ECI Site hydrogeology and evaluate the loading of dissolved constituents from the ECI Site into the Lake George Branch Canal. The existing hydrogeologic data collected at the ECI Site, supplemented with regional information found in the literature, were used to develop the current model.

The major components of this modeling study are as follows:

- Development of a conceptual model of groundwater flow beneath the ECI Site based on site data and regional information from literature;

- Construction of a three-dimensional numerical groundwater flow model;
- Calibration of the numerical groundwater flow model to measured water levels; and
- Evaluation of surface water concentrations from constituent loading via groundwater discharge.

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2. Conceptual Model

A conceptual groundwater flow model describes the principal components of a groundwater flow system and is developed from regional, local, and site-specific data. The primary components of a groundwater flow system includes: (1) areal extent, configuration, and type of aquifers and aquitards, (2) hydraulic properties of aquifers and aquitards, (3) natural groundwater recharge and discharge zones, (4) anthropogenic groundwater recharge and discharge, and (5) areal and vertical distribution of groundwater elevations (i.e., water table). These aquifer system components serve as the framework for the construction of a numerical groundwater flow model.

2.1 Study Area Geology

The ECI Site is located within the Calumet Lacustrine Plain subdivision of the Northern Moraine and Lake Region (Malott, 1922; Schneider, 1966). The Calumet Lacustrine Plain is characterized by unconsolidated glacial sediments deposited during the Pleistocene and Holocene epochs. The unconsolidated deposits are composed mainly of sand; including dune, beach, and lacustrine sediments that contain thin discontinuous layers of muck, peat, and organic materials. A layer of glacial till and lacustrine clay underlie the Calumet sediments. The glacial till and clay are underlain by carbonate bedrock of Silurian and Devonian age that dips slightly to the north and northeast.

Historically, the Study Area was low-lying and poorly drained. Consequently, drainage and filling projects were a common practice that has resulted in much of the area around and including the ECI Site being filled. The fill thickness is variable across the region. The fill sits directly on top of the sand deposits of the Calumet Lacustrine Plain (Kay et al., 1995; Kay et al., 1997).

Two regional aquifers underlie the ECI Site: an unconsolidated surficial sand aquifer (Calumet Aquifer) and the Silurian and Devonian carbonate-bedrock aquifer. These aquifers are separated by a confining clay unit. Discharge from the Calumet Aquifer is primarily to surface water, including rivers, ditches, wetlands. It is important to note that the principal aquifer of concern for this study is the Calumet Aquifer. The deeper carbonate aquifer is not a focal point for this study.

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2.2 ECI Site Geology

The shallow geology of the ECI Site is composed of the following 4 unconsolidated units: Fill, Gray Sand, Sandy silt and Silt, and Clay. This geologic sequence is presented in Figure 2-1 and is summarized as follows:

- Fill (generally 0 to 5 feet below land surface [bls])- *Layer 1*: Black material mixed with broken concrete, brick, and other demolition debris. The fill is a highly variable unit with fine to course sand, little to trace gravel, trace silt, trace clay, construction debris, slag, and a color variation of gray to black. Fill and organic rich topsoil was encountered on each of the eight parcels investigated in this study. The fill appears to be thickest on the South Tank Farm and South of Southwest Tank Farm with the exception of an elevated road constructed on to the Hammond Tank Farm that projects from the East side. The fill thickness increases toward the center of the ECI Site and thins along the boundaries.

- Gray sand (generally 5 to 30 feet bls)- *Layers 2 and 3*: The gray to brown sand is composed of fine to medium sand with coarse sand and pebble lenses. The sand generally becomes finer grained with depth.

- Sandy Silt and Silt (generally 30 to 34 feet bls)- *Layer 4*: A laterally discontinuous silty sand to silt unit was identified in soil borings from the South Tank Farm, Southwest Tank Farm, South of Southwest Tank Farm, and Hammond Tank Farm. This unit ranges from silty very fine sand with silt laminations to gray silt. Trace amounts of shell fragments have been noted from this unit. The silty sand to silt unit is typically encountered at or near the base of the sand unit just above the clay discussed below. The unit ranges in thickness from 0 to 4 feet.

- Clay (generally >35 feet bls)-*Confining Unit*: Massive, non-plastic clay that is approximately 60 feet thick. This unit is composed of clay with some to trace silt, trace sand, trace gravel, and tan to gray. The top of the clay unit has a change in relief of approximately four feet from the north end of the West Tank Farm (top) to the south end of the South of Southwest Tank Farm (bottom).

Figure 2-2 shows the regional elevation of the clay unit across the Study Area. The trend of the clay surface is consistent with the underlying carbonate bedrock and dips

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to the northeast. For a better understanding of the ECI Site geology, geologic cross-sections of the ECI Site are presented in the ECI Site Investigation Report (ARCADIS, June 2002).

2.3 Regional Hydrogeology

The principal aquifer that underlies the ECI Site is an unconsolidated surficial sand aquifer (Calumet Aquifer). Regional groundwater flow conditions in the Calumet Aquifer correspond to the surface water bodies in the Study Area.

The Grand Calumet, Little Calumet, and the Calumet Rivers are the principal streams that effect groundwater flow in the Study Area. Lake Michigan forms the northern boundary to the Study Area. Other important water bodies in the Study Area are Lake George, Wolf Lake, and the Indiana Harbor Canal system.

Groundwater south of the ECI Site discharges to both the Lake George Branch Canal and the Indiana Harbor Canal. North of the Lake George Branch Canal, groundwater flows to Lake Michigan, Lake George, Wolf Lake, the Lake George Branch Canal, and the Indiana Harbor Canal.

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2.4 ECI Site Hydrogeology

Figure 2-3 shows the observed flow conditions for the ECI Site. Groundwater beneath all parcels of the ECI Site discharges to the Lake George Branch Canal from both the south and the north. Groundwater flow from the Hammond Tank Farm to the Lake George Branch Canal is impeded by wooden shoring, while groundwater flow from the Main Refinery to the Lake George Branch Canal is impeded by metal sheet pile. The effect of the barriers is evident by groundwater-surface water level differences of 3 to 6 feet next to the Lake George Branch Canal. Sheet pile and wooden shoring is not present on portions of the Pollution Control Area and the West Tank Farm parcels that border the Lake George Branch Canal. The gap in the walls in these areas permits groundwater to preferentially discharge through this area to the Lake George Branch Canal. This flow pathway is shown on Figure 2-3 by the deflected contours in the observed water levels. Groundwater flows from MW31 to the sheet pile and then flows laterally around the sheet pile to the west and to the east where it then discharges to the Lake George Branch Canal.

The hydraulic conductivity results from slug tests performed by ARCADIS (2002) in shallow observation wells screened across the water table, ranged from 1.91×10^{-2}

cm/sec (54.1 ft/day) to 3.87 x 10^{-2} cm/sec (109.7 ft/day) with a geometric mean of 2.55 x 10^{-2} cm/sec (72.3 ft/day). The hydraulic conductivity results for the shallow observation wells screened across the water table performed by ERM (1992) ranged from 2.20 x 10^{-3} cm/sec (6.23 ft/day) to 8.40 x 10^{-2} cm/sec (238.1 ft/day) with a geometric mean of 1.33 x 10^{-2} cm/sec (37.7 ft/day). Analysis of the pumping test data performed by ERM (1992) yielded a hydraulic conductivity range for the shallow sediments of 3.53 x 10^{-3} cm/sec (10 ft/day) to 3.53 x 10^{-2} cm/sec (100 ft/day) and had a geometric mean of 1.76 x 10^{-2} cm/sec (50 ft/day). The combined results from the three sets of hydraulic conductivity data across the ECI Site are consistent with an overall range of 2.20 x 10^{-3} cm/sec (6.23 ft/day) to 8.40 x 10^{-2} cm/sec (238 ft/day), and having a geometric mean of 1.82 x 10^{-2} (51.5 ft/day).

The observed groundwater gradients at the ECI Site are 0.003 ft/ft from both the south and the north toward the Lake George Branch Canal. Using the range of hydraulic conductivity values and assuming an effective porosity of 0.20 (USEPA, 1989), the groundwater velocities at the ECI Site range from 0.06 ft/day to 35.7 ft /day. The observed water levels indicate there are no significant vertical gradients within the Calumet Aquifer at the ECI Site.

There are approximately 80 pumping wells located on the bp Whiting Refinery (URS, Pers. Comm., Winter 2002). The locations of off-site pumping wells are shown by Figure 2-4. Pumping rates for these wells are listed in Table 2-1. These 80 wells extract a total of 887 gallons per minute from the Calumet Aquifer.

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3. Groundwater Flow Model Construction

ARCADIS used the simulation program MODFLOW to develop a numerical groundwater flow model for the ECI Site. The primary phases in the development of a numerical groundwater flow model include the construction of a finite-difference grid for the model area, specification of model layer top and bottom elevations, assignment of boundary conditions, specification of hydraulic parameter values and extents, and selection of appropriate water-level measurements for model calibration. This information forms the basis for subsequent calibration of the numerical model to observed groundwater flow conditions at the ECI Site.

3.1 Code Selection

MODFLOW is a publicly available groundwater flow simulation program developed by the U.S. Geological Survey (McDonald and Harbaugh 1988). The program is thoroughly documented, widely used by consultants, government agencies and researchers, and is consistently accepted in regulatory and litigation proceedings. Given the intended use for the groundwater flow model to evaluate potential environmental impacts, regulatory acceptance is vital for the code selected for this study.

In addition to its attributes of widespread use and acceptance, MODFLOW was also chosen because of its versatile simulation features. MODFLOW can simulate transient or steady-state saturated groundwater flow in one, two, or three dimensions and offers a variety of boundary conditions including specified head, areal recharge, injection or extraction wells, evapotranspiration, drains, and rivers or streams. Aquifers simulated by MODFLOW can be confined or unconfined, or convertible between confined and unconfined conditions. Regarding the hydrostratigraphy of ECI, which consists of a multi-layered geologic system with variable unit thicknesses and boundary conditions, MODFLOW's three-dimensional capability and boundary condition versatility are essential for the proper simulation of groundwater flow conditions.

MODFLOW simulates transient, three-dimensional groundwater flow through porous media described by the following partial differential equation for a constant density fluid:

$$\frac{\partial}{\partial x}\left(K_{xx}\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_{yy}\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_{zz}\frac{\partial h}{\partial z}\right)-W=S_s\frac{\partial h}{\partial t} \qquad (3\text{-}1)$$

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where

> $\mathbf{K_{xx}}$, $\mathbf{K_{yy}}$ and $\mathbf{K_{zz}}$ are values of hydraulic conductivity along the x, y, and z coordinate axes, which are assumed to be parallel to the major axes of hydraulic conductivity [L/T];
>
> **h** is the potentiometric head [L];
>
> **W** is a volumetric flux per unit volume and represents sources and/or sinks of water [1/T];
>
> $\mathbf{S_s}$ is the specific storage of the porous material [1/L]; and
>
> **t** is time [T];

In Equation (3-1), the hydraulic parameters (i.e., K_{xx}, K_{yy}, K_{zz} and S_s) may vary in space but not in time; the source/sink (W) terms may vary in both space and time.

MODFLOW uses a numerical approximation technique known as the method of finite differences to solve Equation 3-1 on a computer. Using a block-centered finite-difference approach, MODFLOW replaces the continuous system represented in Equation 3-1 by a set of discrete points in space and time. This process of discretization ultimately leads to a system of simultaneous linear algebraic equations. MODFLOW solves these finite-difference equations with one of the following three iterative solution techniques: strongly implicit procedure (SIP), slice-successive over-relaxation (SSOR), or preconditioned conjugate gradients (PCG). The solution of the finite-difference equations produces time-varying values of head at each of the discrete points representing the real aquifer system. Given a sufficient number of discrete points, the simulated values of head yield close approximations of the head distributions given by exact analytical solutions to Equation 3-1.

3.2 Model Description

The finite-difference technique employed in MODFLOW to simulate hydraulic head distributions in multi-aquifer systems requires areal and vertical discretization or subdivision of the continuous aquifer system into a set of discrete blocks that form a three-dimensional model grid. In the block-centered finite-difference formulation used in MODFLOW, the center of each grid block corresponds to a computational point or node. When MODFLOW solves the set of linear algebraic finite-difference equations

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for the complete set of blocks, the solution yields values of hydraulic head at each node in the three-dimensional grid.

Water levels computed for each block represent an average water level over the volume of the block. Thus, adequate discretization (i.e., a sufficiently fine grid) is required to resolve features of interest, and yet not be computationally burdensome. MODFLOW allows the use of variable grid spacing such that a model may have a finer grid in areas of interest where greater accuracy is required and a coarser grid in areas requiring less detail.

The three-dimensional model grid developed for the Study Area that contains the ECI Site covers approximately 8.7 square miles. The boundaries of the model grid are extended to natural boundaries, where possible, to minimize the influence of model boundaries on simulation results at the ECI Site. The finite-difference grid is composed of 320 columns and 273 rows with 4 vertical layers for a total of 349,440 nodes. The model grid uses 20-foot areal grid spacing in the ECI Site area to provide increased computational detail in the area of interest and grades to larger grid spacing at the limits of the model domain. Figures 3-1 through Figure 3-4 show the finite difference grid and boundary conditions for the Study Area.

The extent of the finite-difference grid and the areal grid spacing were selected for the purpose of simulating both regional groundwater flow conditions around the ECI Site and detailed hydraulic head distributions on-site. The extent chosen for the grid also ensures adequate incorporation of regional groundwater flow features that affect conditions at the ECI Site. The areal grid spacing over the ECI Site area allows for detailed simulations of hydraulic heads to match water levels and groundwater flow directions that have been measured. Meeting both of these objectives was needed for the calibration of the three-dimensional groundwater flow model.

Site-specific hydrogeologic data were used to construct structural contour elevation maps of the hydrostratigraphic units. The contours of the site-specific map were developed based upon the well borings at the ECI Site. The surface contours developed using these data were then digitized and interpolated values were specified for each corresponding cell in the model grid in order to define the vertical discretization of the model layer interfaces.

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3.3 Boundary Conditions

Boundary conditions must be imposed to define the spatial boundaries of the model. In addition to these boundary conditions, sources and sinks of groundwater such as wells and rivers can be included within the model's external boundaries. A boundary condition can represent different types of physical boundaries, depending on what effects groundwater flow across the boundary. The groundwater model includes six types of boundary conditions: hydrologic flow barrier (HFB), wells (constant flux), no-flow, recharge (constant flux), constant head (head dependent flux), and river (head dependant flux). The location and types of boundary conditions are shown by Figures 3-1 through 3-4.

Lake Michigan and the canals are modeled using constant head cells. The stage of the Lake George Branch Canal, the Indiana Harbor Canal, and Lake Michigan were determined using a United States Geological (USGS) staff gauge referred to as the Indian Harbor Canal at East Chicago, IN (Station Number 04092750). The staff gauge is located east of the ECI Site along the stretch of the canal system that enters the Indiana Harbor. The water level elevation in the Indiana Harbor Canal equals the reference elevation of the gauge (570 feet) plus the reported gauge height. The measured stage for the Indiana Harbor Canal on March 5, 2002 was generally 578 feet NGVD (± 0.1 feet). This stage corresponds to the time period when the water level measurements used for the model calibration targets were taken.

Sheet piling and wooden shoring is present on portions of the northern edge of the Lake George Branch Canal bordering the ECI Site. The effect of the sheet piling and wooden shoring on groundwater flow was modeled using HFBs. The integrity (or the effective permeability) of sheet piling and wooden shoring is site-specific and the permeability is influenced by a number of factors including the installation method, construction materials, and weathering of the sheet piling and wooden shoring at the ECI Site. For this reason, the conductance of the sheet piling and wood shoring was varied until a reasonable fit was established between the simulated groundwater levels next to the Lake George Branch Canal and measured value. Presently, there is a 6-foot difference between the observed water levels behind the sheet piling and the stage of the Lake George Branch Canal. To match this head difference, a conductance of 0.0001 day^{-1} was necessary for the HFBs representing the sheet piling. The conductance for the HFBs is calculated by diving the hydraulic conductivity by the thickness of the wall. Assuming the wall is 4 inches thick, the resulting permeability of the sheet piling is 1 x 10^{-8} cm/sec (3 x 10^{-5} ft/day).

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Wolf Lake, Lake George, and the water retention ditch located to the west of the Hammond Tank Farm parcel is modeled using river cells (Figure 3-1). River cells allow for the specification of a river stage and a conductance term, which regulate the amount of the groundwater discharge from, or recharge to, the river. The stage elevations are based on stage data and USGS quadrangle sheets (Whiting, 1991; Lake Calumet, 1997; Highland, 1991; and Calumet City, 1991). The stage for Wolf Lake and Lake George was set at 582 ft NGVD. The stage of the water retention ditch was set at 584 ft NGVD. The conductance terms were calculated from the model grid cell dimensions and modeled estimates of the hydraulic conductivity of the aquifer and riverbed material (47 ft/day).

The lesser surface water bodies in the model domain do not have inlet or outlet streams. These lakes and ponds receive groundwater along the upgradient shore and drain along the opposite shore. They were modeled in MODFLOW using high K zones (10000 ft/day) to represent the water in the lakes, permitting groundwater to flow through. This method, referred to as the high K method, allows the lake to be modeled without precisely knowing the stage of the lake and produces uniform water levels across the lake (Anderson et al., 2002).

No-flow boundaries were set to correspond with the topographic ridges and represented inferred groundwater flow lines. Well cells were used to simulate the 80 off-site extraction wells at the bp Whiting Refinery.

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3.4 Hydraulic Parameters and Zonation

In constructing the model for the ECI Site, representative values for model parameters were selected based on site-specific data. These model parameters included aquifer recharge and the horizontal and vertical hydraulic conductivity of the aquifers. Initially, a single value of recharge was used in the model to represent the fraction of total precipitation reaching the water table. The model also included separate zones of hydraulic conductivity for each aquifer material encountered at the ECI Site, with initial parameter values based on site-specific aquifer test data. During the calibration of the model, parameter values and the extents of zones of similar hydrogeologic properties were adjusted to minimize the difference between observed and simulated groundwater elevations.

Two parameters, recharge and the hydraulic conductivity of the aquifers, were varied during the calibration of the model from their initial values to match measured and simulated water-level elevations at the calibration targets. Table 3-1 summarizes the

final calibrated hydraulic conductivity values and the range of estimated or field values gathered during the development of the conceptual model. Figures 3-5, 3-6, and 3-7 show the configuration of these zones. Figure 3-8 shows the configuration of the two recharge zones and their values.

There are 4 hydraulic conductivity zones in the model. Zone 1 (47 ft/day) and Zone 2 (38 ft/day) correspond to the medium to coarse sand found above the clay unit and are the bulk of the model layers 1,2, 3, and 4.

Zone 3 (1 ft/day) corresponds to the fill material in the Main Refinery area as indicated on cross sections by ERM (1992). These cross-sections indicated that the fill material was relatively shallow and this zone is only in layer 1. Due to limited detailed information on the extent of the fill, this zone was limited to the observed extents in the geologic cross-sections prepared by ERM (1992) where it locally influences water levels on-site. Zone 4 (200 ft/day) corresponds to the gravel backfill that was used to fill an excavation pit. Zone 4 is in layer 1 and 2.

Recharge for the model consisted of two zones. Zone 1 (16.5 in/yr) corresponded to the portions of the ECI Site covered by the bp Whiting Refinery. This zone includes recharge from precipitation and infrastructure leakage. Zone 1 also reflects the increased induced recharge due to water level drawdown that would otherwise be intercepted in the drainage swales under non-pumping conditions. Zone 2 (8 in/yr) covered the site and the surrounding area other than the bp Whiting Refinery. This value is about 24% of the local precipitation value (34 in/yr).

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4. Groundwater Flow Model Calibration

Calibration of a groundwater flow model refers to the process of adjusting model parameters to obtain a reasonable match between observed and simulated water levels. In general, model calibration is an iterative procedure that involves variation of hydraulic properties or boundary conditions to achieve the best match between observed and simulated water levels. During model calibration, site-specific data and slug test data were used as the primary constraints for the calibrated values of hydraulic conductivity based on the greater reliability of the data.

Table 4-1 lists the monitoring wells and water-level elevations chosen for the calibration of the groundwater flow model. This list of calibration targets is the full set of water-level elevations measured in March 5, 2002. There are a total of 29 calibration targets.

4.1 Calibration Procedure

For best results, the calibration of a model should rely on discrete measurements to produce answers free of contouring interpretations. In the calibration of a groundwater flow model, use of point data eliminates the potential for interpretive bias that may result from attempting to match a contoured potentiometric surface (Konikow, 1978; Anderson and Woessner, 1992). The groundwater flow model for the ECI Site is calibrated using 29 water-level calibration targets measured in monitoring wells distributed throughout the hydrogeologic units identified.

As a further goal for the calibration of a model, the principle of parameter parsimony is applied to achieve an adequate calibration of the model through the use of the fewest number of model parameters. It should be noted that the use of more model parameters during model calibration creates a situation in which different combinations of model parameter values produce similar calibration results. In this case, the model calibration parameters are called non-unique. Following the principal of parameter parsimony reduces the degree of non-uniqueness and results in more reliable calibrated parameter values. The information gathered for the conceptual model guides any decision to add model parameters (e.g., zones of hydraulic conductivity) to the model during the calibration process. Therefore, in the absence of hydrogeologic evidence, the simpler model is preferred.

ARCADIS routinely uses an automatic parameter estimation procedure to calibrate groundwater flow models. Starting with a set of initial estimates for the model

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parameters, the procedure systematically updates the parameter estimates to minimize the difference between simulated and observed water levels at a set of calibration targets. Compared to trial-and-error procedures for model calibration, automatic parameter estimation can greatly reduce the time required for model calibration and generally provide a better overall calibration. The general algorithm applied in conjunction with the MODFLOW code is known as the Gauss-Newton method and is described in greater detail by Duffield et al. (1987) and Hill (1992).

The primary criterion for evaluating the calibration of a groundwater flow model is the difference between simulated and observed water levels at a set of calibration targets. A residual or model error, e_i, is defined as the difference between the observed and simulated hydraulic head measured a target location:

$$e_i = h_i - \hat{h}_i \qquad (4\text{-}1)$$

where h_i is the measured value of hydraulic head and $\hat{h}_i$ is the simulated value at a specific target location. A residual with a negative sign indicates overprediction by the model (i.e., the simulated head is higher than the measured value). Conversely, a positive residual indicates underprediction.

The automatic parameter estimation procedure seeks to minimize an objective function defined by the residual sum of squares (RSS):

$$RSS = \sum_{i=1}^{n} \left(h_i - \hat{h}_i\right)^2 \qquad (4\text{-}2)$$

where n is the total number of calibration targets. The RSS is the primary measure of model fit. The residual standard deviation (RSTD), which normalizes the RSS by the number of calibration targets and number of estimated parameters (P), is defined as follows:

$$RSTD = \sqrt{\frac{RSS}{n - p}} \qquad (4\text{-}3)$$

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The RSTD is useful for comparing model calibrations with different numbers of calibration targets and estimated parameters. Another calibration measure is the mean of all residuals ($\bar{e}$):

$$\bar{e} = \frac{1}{n} \sum_{i=1}^{n} e_i \qquad (4\text{-}4)$$

A mean residual significantly different from zero indicates model bias. The Gauss-Newton parameter estimation procedure produces a near zero mean residual at the minimum RSS.

4.2 Calibration Results

The groundwater flow model calibration required numerous individual computer simulations. The values and shapes of the various parameter zones in the model were gradually varied until a reasonable solution was achieved in agreement with the conceptual model. The 29 water-level targets selected for the calibration of the groundwater flow model were used to evaluate the calibration of the model through the analysis of (1) simulated hydraulic head distributions in the model layers, (2) residual statistics and (3) estimated hydraulic parameters.

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4.2.1 Simulated Calibrated Head Distributions

As a part of evaluating the calibration of the numerical model, simulated potentiometric surface maps are prepared for each of the model layers to depict groundwater flow conditions in the vicinity of the ECI Site (Figures 4-1 and 4-2).

Figure 4-1 shows the regional water levels for the model and groundwater discharges to Lake Michigan, Lake George, and the Indiana Harbor Canal. Figure 4-2 shows the local flow conditions for the ECI Site. The simulated water levels show that groundwater from the ECI Site discharges to the Lake George Branch Canal from both the south and north portions of the ECI Site. The sheet pile and wooden shoring acts a hydraulic barrier and causes groundwater to flow laterally around the wall to the east and to the west. Where the walls are absent in the Pollution Control Area and the West Tank Farm, groundwater discharges directly to the Lake George Branch Canal.

4.2.2 Analysis of Residuals

Calibration of the groundwater flow model for the ECI Site sought to minimize the residual sum of squares (Equation 4-2) computed for the 29 water-level calibration targets. Table 4-1 lists the simulated water elevations and model residuals for each of the calibration targets. Figure 4-2 shows the spatial distribution of these residuals in the model. Seventy-three percent of the targets have residuals of 0.75 ft or less. Overall, the model shows a very good match to the measured water levels at the ECI Site. Figure 4-3 shows graphically the agreement between observed and simulated water levels at the calibration targets. As shown in Figure 4-3, 76 % of all residuals fall within the 10% range of observed water-level elevations.

Residual statistics for the calibrated groundwater flow model indicate good agreement between simulated and measured groundwater elevations. The residual mean and residual sum of squares for the calibrated model are also shown in Figure 4-3. The residual standard deviation was calculated to be 0.84 ft and the mean is close to zero (0.10 ft).

4.3 Sensitivity Analysis

A sensitivity analysis was performed to examine the effects of uncertainties in each of the model calibration parameters. The response of the calibrated model (as indicated by the RSS) to changes in the horizontal hydraulic conductivity and recharge for each parameter zone was evaluated through a discrete sensitivity analysis. In this analysis, one parameter at a time was varied while all other parameters were held constant. Each calibrated parameter value was, in turn, multiplied by factors between 0.1 and 3.0 (a multiplier of 1.0 corresponds to the calibrated value of the parameter). No significant improvement was achieved in the model calibration by these parameter changes.

The results of the sensitivity analysis for horizontal hydraulic conductivities and precipitation recharge are shown graphically in Figures 4-4 to 4-7. Horizontal conductivity zone 3 (model layer 1) and horizontal conductivity zone 4 (model layers 1 and 2) as wells as the vertical conductivity zones for the model were not sensitive and were not shown. The insensitivity of the vertical conductivity zones was anticipated because vertical head gradients are insignificant at the ECI Site; the Calumet Aquifer has good vertical hydraulic communication.

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The most sensitive parameters were the horizontal conductivity zones 1 and 2 and precipitation recharge zones 1 and 2. Changes in these parameters affect the calibration throughout the full range of multipliers used (Figures 4-4, 4-5, 4-6, and 4-7). As recharge is a significant source of water in the model, model sensitivity to this parameter is expected.

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5. Surface Water Concentrations From Groundwater Loading

The calibrated groundwater flow model was used to evaluate to the migration of constituents in groundwater from the ECI Site to the Lake George Branch Canal. Groundwater data collected from observation wells were compared directly to State of Indiana surface water quality values to identify constituents that warranted additional evaluation (i.e., constituents in groundwater that exceed surface water quality values designed to protect human health and the environment). Only three constituents exceeded these benchmarks in one or more groundwater wells adjacent to the Lake George Branch Canal (i.e., ammonia-nitrogen, barium, and selenium). No surface water values protective of human health (non-drinking) were exceeded in any groundwater well adjacent to the Lake George Branch Canal. Therefore, the focus of this evaluation was the protection of ecological populations and communities that may someday inhabit the Lake George Branch Canal.

Currently, the Lake George Branch Canal does not support a balanced ecological community due to human induced conditions. The on-going restoration of the Lake George Branch Canal and the surrounding watershed is designed to improve habitat and water quality and create conditions suitable for establishing and the maintaining a balanced ecological community. This modeling effort was designed to evaluate the migration of dissolved constituents to the Lake George Branch Canal, account for mixing under a range of water levels, and ensure the discharge of groundwater at the ECI Site does not pose a threat to the future restoration activities in the Lake George Branch Canal.

The ECI Site has five parcels that are hydraulically connected to the Lake George Branch Canal: Hammond Tank Farm, Pollution Control Area, and West Tank Farm to the north of the Lake George Branch Canal; and Southwest Tank Farm and South Tank Farm to the south of the Lake George Branch Canal. For the analysis, these five parcels were grouped according to their hydraulic communication with the Lake George Branch Canal, i.e., presence or absence of sheet pile and wooden shoring. The South and the Southwest Tank Farms were grouped together because there is no sheet pile present at the shore of the Lake George Branch Canal. Likewise, the Pollution Control Area and the West Tank Farm were grouped together. Because the Hammond Tank Farm has wood shoring present along the Lake George Branch Canal shoreline, it was analyzed by itself. The groundwater flow model is used to quantify the flow of groundwater to the Lake George Branch Canal, account for mixing with surface water, and ultimately predict the surface water concentrations for the three constituents of potential concern at the ECI Site (i.e., ammonia-nitrogen,

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barium and selenium). In addition to current conditions, two other factors are evaluated to determine the model's sensitivity to changes in Lake George Branch Canal level and depth to sediment. The groundwater model is used to predict surface water concentrations from groundwater loading to the Lake George Branch Canal. The predicted surface water concentrations are compared to surface water quality values to assess potential risks to aquatic organisms in the Lake George Branch Canal.

5.1 Influence of the Lake George Branch Canal Stage on the Groundwater Flow System

The calibrated groundwater model was used to assess the effects of changes in the stage of the Lake George Branch Canal on constituent loading via groundwater discharge from the ECI Site to the Lake George Branch Canal. Using the calibrated model stage (578 ft) as a baseline, groundwater discharge to the Lake George Branch Canal was evaluated at four different stages: 582.4 ft (Historical High), 575.5 ft (Historical Low), 581.5 ft (Sale by Atlantic Richfield to ECI - 1976), and 580.1 (End of Refining Operations at ECI - 1981).

Changes in the stage of the Lake George Branch Canal do not change groundwater discharge to the Lake George Branch Canal by more than 1 %. This is because groundwater discharge to the Lake George Branch Canal is a function of the local hydrogeology, geology, and precipitation recharge and not the stage of the Lake George Branch Canal. Changes of 1 % are not significant enough to evaluate changes in constituent loading under different stages. Therefore, only the calibrated model with a stage of 578 ft NGVD was used to quantify constituent loading via groundwater discharge.

However, fluctuations in the stage of the Lake George Branch Canal do affect water levels under the ECI Site adjacent to the Lake George Branch Canal where there is no sheet pile or wooden shoring along the shore. Where the sheet pile and wooden shoring is absent, the groundwater beneath the ECI Site is in good hydraulic communication with the Lake George Branch Canal. Consequently, water levels in the monitoring wells that border the Lake George Branch Canal will be only slightly higher than the Lake George Branch Canal. For example, the measured stage of the Lake George Branch Canal for the March 5, 2002 water levels was 578.0 ft. The average water level in the monitoring wells bordering the Lake George Branch Canal measured on March 5, 2002 was 578.33 ft. Therefore, a change in the stage of the Lake George Branch Canal should cause an equivalent corresponding change (increase or decrease) in ECI Site water levels next to the Lake George Branch Canal.

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5.2 Effects of Lake George Branch Canal Penetration on the Local Flow System

The present estimated bottom of the Lake George Branch Canal is at an elevation of approximately 570 ft NGVD. The calibrated groundwater flow model for the ECI Site has the bottom of the Lake George Branch Canal at an elevation of 561 ft NGVD, based on the original construction of the Lake George Branch Canal, and likely future dredged depth. Model simulations were performed to determine if raising the bottom of the Lake George Branch Canal from 561 feet to 570 would change the groundwater flow system of the calibrated model. Because the Lake George Branch Canal is the primary discharge point for the ECI Site, and groundwater does not flow under the Lake George Branch Canal from one side to the other, the elevation difference of the bottom of the Lake George Branch Canal did not have an effect on groundwater flow beneath any parcel of the ECI Site.

The bottom of the Lake George Branch Canal contains approximately 9 feet of sediment that lies above 5 feet of the sandy sediment that rests on the confining clay unit. The sediment that overlies the sandy aquifer is loosely compacted and is in good hydraulic communication with the sandy aquifer along the sides and bottom of the Lake George Branch Canal. Therefore, the Lake George Branch Canal is hydraulically connected to the aquifer and the calibrated model is appropriate with the bottom of 561 feet or 570 feet.

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5.3 Quantification of the Predicted Surface Water Concentrations

The calibrated flow model was used to evaluate the potential surface water impacts from constituent loading via groundwater discharge. The following equation was used to determine the average concentration in the Lake George Branch Canal given (C_{SW}) the mass discharge rate to the Lake George Branch Canal:

$$C_{SW} = \frac{C_{GW} \cdot Q_{GW}}{Q_T}$$

where: Q_{GW} = the groundwater discharge rate through the selected land parcel [gpm];

Q_T = the total base flow through the Lake George Branch Canal [gpm];

and

C_{GW} = the average constituent concentration along the shoreline of the selected land parcel [mg/L].

The base flow discharge to the Lake George Branch Canal equals the groundwater discharge rate to the Lake George Branch Canal and was computed from the MODFLOW output (cell by cell water balance).

The groundwater discharge rates, average constituent concentration, and the computed Lake George Branch Canal flow rate are summarized in Table 5-1. The groundwater discharge was lowest from the Hammond Tank Farm (4.8 gpm) because of the wooden shoring, which restricts flow from the land parcel to the Lake George Branch Canal. Due to the absence of wooden shoring or sheet piling along the shoreline of the Pollution Control Area and West Tank Farm, the groundwater north of the Lake George Branch Canal preferentially discharges through this parcel to the Lake George Branch Canal with a discharge rate of 26.8 gpm. The South Tank Farm and Southwest Tank Farm has a groundwater discharge of 85.3 gpm to the Lake George Branch Canal. The total base flow of the Lake George Branch Canal was computed to be 1153 gpm.

Table 5-1 summarizes the surface water concentrations of the constituents in the Lake George Branch Canal via groundwater loading. The model evaluated whether concentrations of the three constituents of concern would be above surface water quality standards under current conditions, under fluctuations in Lake George Branch Canal Stage, and under alterations to the elevation of the Lake George Branch Canal bottom. Under the three scenarios modeled, all of the computed surface water concentrations were below the water quality standards for the three constituents. Given the present conditions and the computed flow rates, constituent loading via groundwater discharge to the Lake George Branch Canal should not cause the concentration of the constituents in the Lake George Branch Canal to exceed surface water standards.

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Table 2-1. Summary of the Off-site Pumping Well Extraction Rates, BP Whiting Refinery.

Well	Rate GPM	Well	Rate GPM	Well	Rate GPM
J-136	20.00	J-157/156(9)	5.00	J-138(2)	18.55
J-136(2)	20.00	J-157/156(10)	5.00	J-138(3)	18.55
J-136(3)	20.00	J-157/156(11)	5.00	J-138(4)	18.55
J-136(4)	20.00	J-157/156(12)	5.00	J-138(5)	18.55
J-136(5)	20.00	J-158/159	9.14	J-138(6)	18.55
J-136(6)	20.00	J-158/159(2)	9.14	J-138(7)	18.55
J-136(7)	20.00	J-158/159(3)	9.14	J-138(8)	18.55
J-136(8)	20.00	J-158/159(4)	9.14	J-138(9)	18.55
J-136(9)	20.00	J-158/159(5)	9.14	J-139	1.25
J-140	5.77	J-158/159(6)	9.14	J-139(2)	1.25
J-140(2)	5.77	J-158/159(7)	9.14	J-139(3)	1.25
J-140(3)	5.77	J-158159(8)	9.14	J-139(4)	1.25
J-140(4)	5.77	J-158/159(9)	9.14	J-139(5)	1.25
J-137	12.99	J-158/159(10)	9.14	J-139(6)	1.25
J-137(2)	12.99	J-158/159(11)	9.14	J-139(7)	4.50
J-137(3)	12.99	J-158/159(12)	9.14	J-139(8)	1.25
J-137(4)	12.99	J-158/159(13)	9.14		
J-137(5)	12.99	J-158/159(14)	9.14		
J-141	2.33	J-161	23.79		
J-141(2)	2.33	J-161(2)	23.79		
J-141(3)	2.33	J-161(3)	23.79		
J-141(4)	2.33	J-161(4)	23.79		
J-141(5)	2.33	J-161(5)	23.79		
J-141(6)	2.33	J-160	8.42		
J-157/156	5.00	J-160(2)	8.42		
J-157/156(2)	5.00	J-160(3)	8.42		
J-157/156(3)	5.00	J-160(4)	8.42		
J-157/156(4)	5.00	J-160(5)	8.42		
J-157/156(5)	5.00	J-162	34.03		
J-157/156(6)	5.00	J-163	20.99		
J-157/156(7)	5.00	J-163(2)	20.99		
J-157/156(8)	5.00	J-138	18.55		
Total Wells			**80**		
Total Groundwater Withdrawal			**887**	**GPM**	

Source: URS (Pers. Comm., Winter 2002)

Draft

Table 3-1. Final Calibrated Hydraulic Conductivity Model Parameters and the Observed Field Values.

Model Zone	Hydraulic Conductivity (ft/day)		Geologic Material
	Kh	Kv	
1	47.0	4.7	Sand
2	38.0	3.8	Sand
3	1.0	0.1	Sand Mixed With Slag and Cinders
4	200.0	30.0	Gravel Backfill

Site	Type Of Test	Hydraulic Conductivity Values (ft/day)	
		High	Low
ECI	Slug Tests	4	238
BP-Whiting	Pumping Tests	10	100

Draft

Table 4-1. Summary of Observed and Simulated Water Levels and Calculated Residuals.

Well	Layer	Row	Column	Observed Water Level (ft NGVD)	Simulated Water Level (ft NGVD)	Water Level Residual (ft)
MW-10	1	207	174	582.69	583.77	1.08
MW-20	1	160	168	583.97	581.46	-2.51
MW-31	1	92	200	586.82	586.07	-0.75
P-04	1	160	189	584.35	583.86	-0.49
P-05	1	160	197	583.64	583.61	-0.03
P-06	1	160	205	584.25	583.11	-1.14
P-10	1	161	237	583.61	582.56	-1.05
P-25	1	174	212	578.13	578.80	0.67
OW-106	1	171	229	577.82	578.06	0.24
MW-37	1	180	242	579.62	579.63	0.01
OW-123	1	204	234	581.62	582.83	1.21
OW-101	1	192	180	581.89	581.80	-0.09
OW-104	1	204	174	582.64	583.41	0.77
MW-34	1	186	150	580.76	580.90	0.14
OW-118	1	197	147	581.49	582.15	0.66
OW-116	1	171	152	578.44	578.60	0.16
OW-117	1	171	152	578.38	578.60	0.22
OW-122	1	157	150	578.87	578.70	-0.18
OW-115	1	96	147	585.00	586.21	1.21
OW-114	1	96	147	585.02	586.20	1.18
OW-120	1	146	128	581.70	581.11	-0.59
OW-119	1	119	117	583.93	584.10	0.17
OW-112	1	108	76	583.88	584.05	0.17
OW-113	1	108	76	584.08	584.05	-0.03
OW-111	1	155	74	582.53	582.09	-0.44
OW-110	1	139	72	583.70	583.47	-0.23
OW-108	1	156	95	582.11	582.54	0.43
OW-109	1	156	95	582.22	582.54	0.32
MW-33	1	90	240	583.13	584.78	1.65

Total Targets	29
Mean	0.10
Standard Deviation	0.84
Sum of Squares Residual	20.16

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Table 5-1. Summary of Potential Surface Water Concentrations in the Lake George Branch Canal from Groundwater Loading from the ECI Site.

Site Parcel	Groundwater Discharge to the Canal (GPM) [1]	Total Flow Rate of System (GPM) [2]	Reduction Factor	Average Constituent Concentrations (mg/L)			Resulting Canal Surface Water Concentrations (mg/L)			Cumulative Loading (mg/L)		
				Selenium	Barium	Ammonia	Selenium[4]	Barium[5]	Ammonia[6]	Selenium	Barium	Ammonia
PCA/WTF	26.82	1152.77	43	0.018	0.180	19.045	0.0004	0.004	0.443	0.001	0.073	0.763
STF/SWTF	85.34	1152.77	14	0.014	0.929	4.270	0.0010	0.069	0.316			
HTF	4.75	1152.77	243	0.010	0.102	1.011	0.00004	0.0004	0.004			

[1] Calculated groundwater discharge rate from the model
[2] Calculated base flow of the Lake George Branch Canal from the model
[3] Total Flow/Groundwater Discharge
[4] Water Quality Standard for Selenium is 0.005 mg/L
[5] Water Quality Standard for Barium is 0.910 mg/L
[6] Water Quality Standard for Ammonia is 1.71 mg/L

PCA= Pollution Control Area
HTF = Hammond Tank Farm
STF = South Tank Farm
SWTF = Southwest Tank Farm
WTF = West Tank Farm

Note:
STF/SWTF Average Concentrations Based on Wells MW9, OW106, OW116, OW117, and OW125
PCA/WTF Average Concentrations Based on Wells OW120 and OW122
HTF Average Concentrations Based on Wells OW108, OW109, and OW111

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Figures

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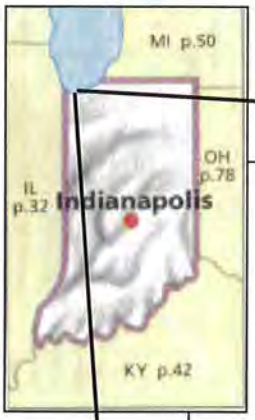

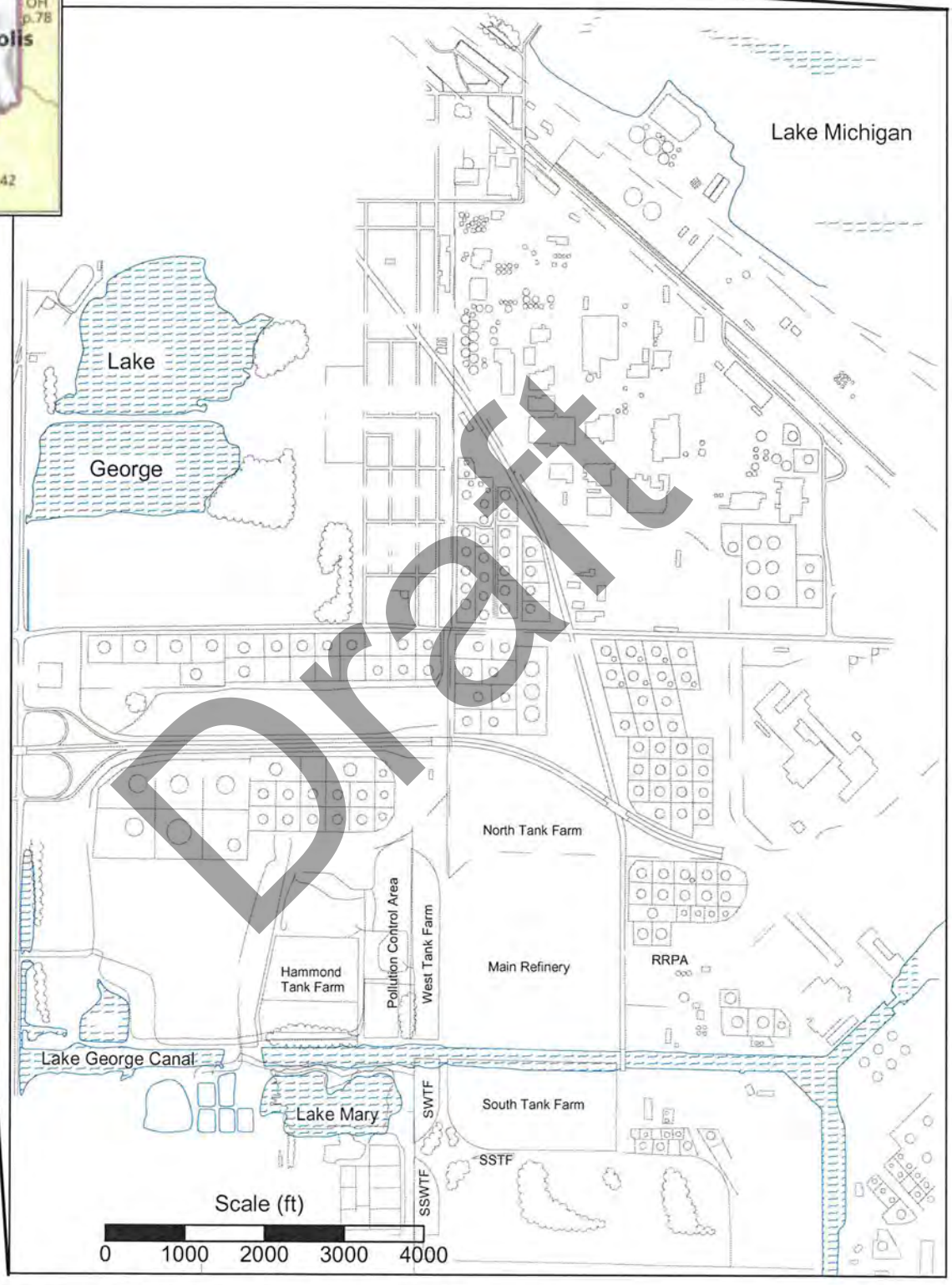

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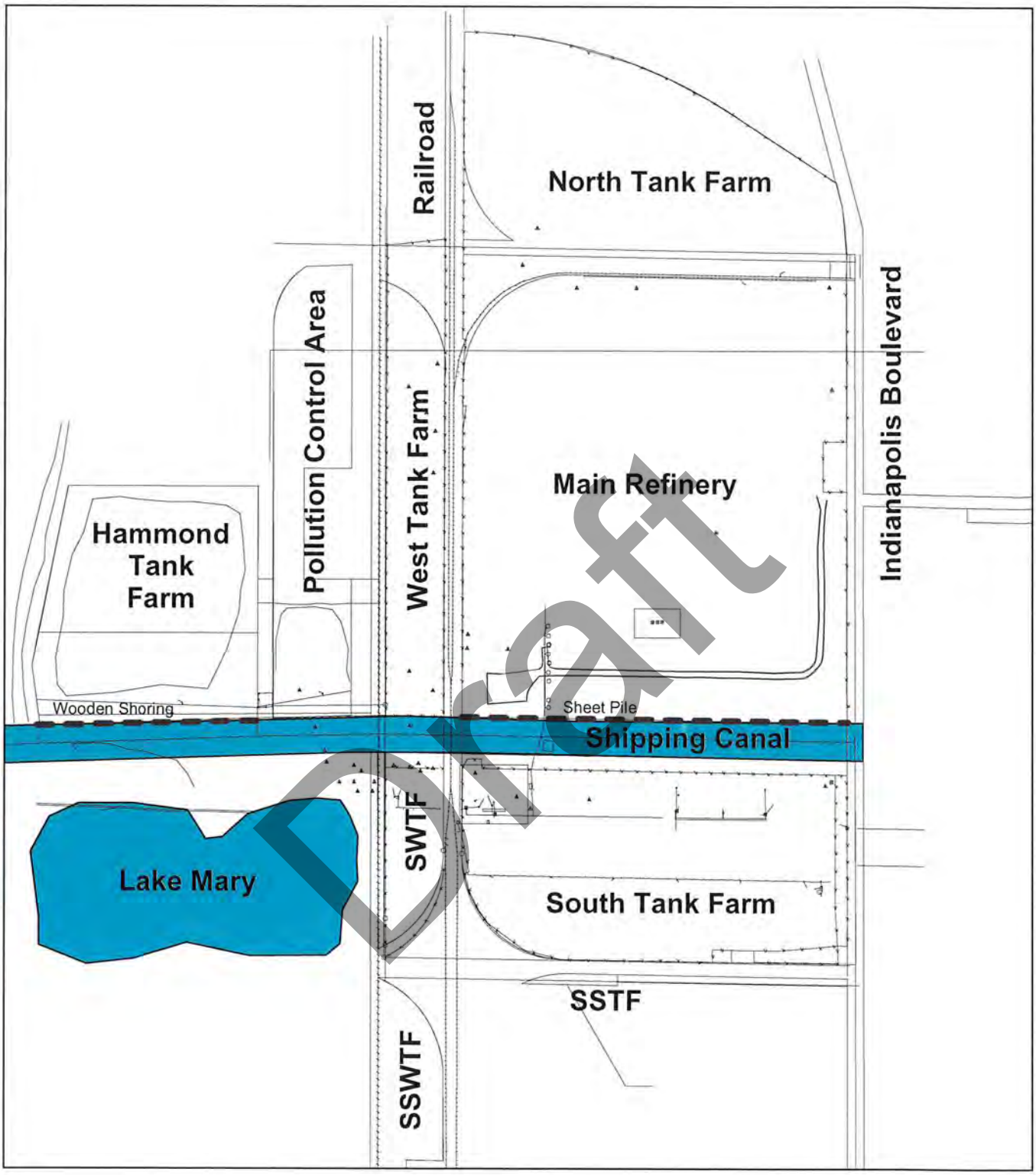
Site Location

ECI
East Chicago, Indiana

FIGURE
1-1



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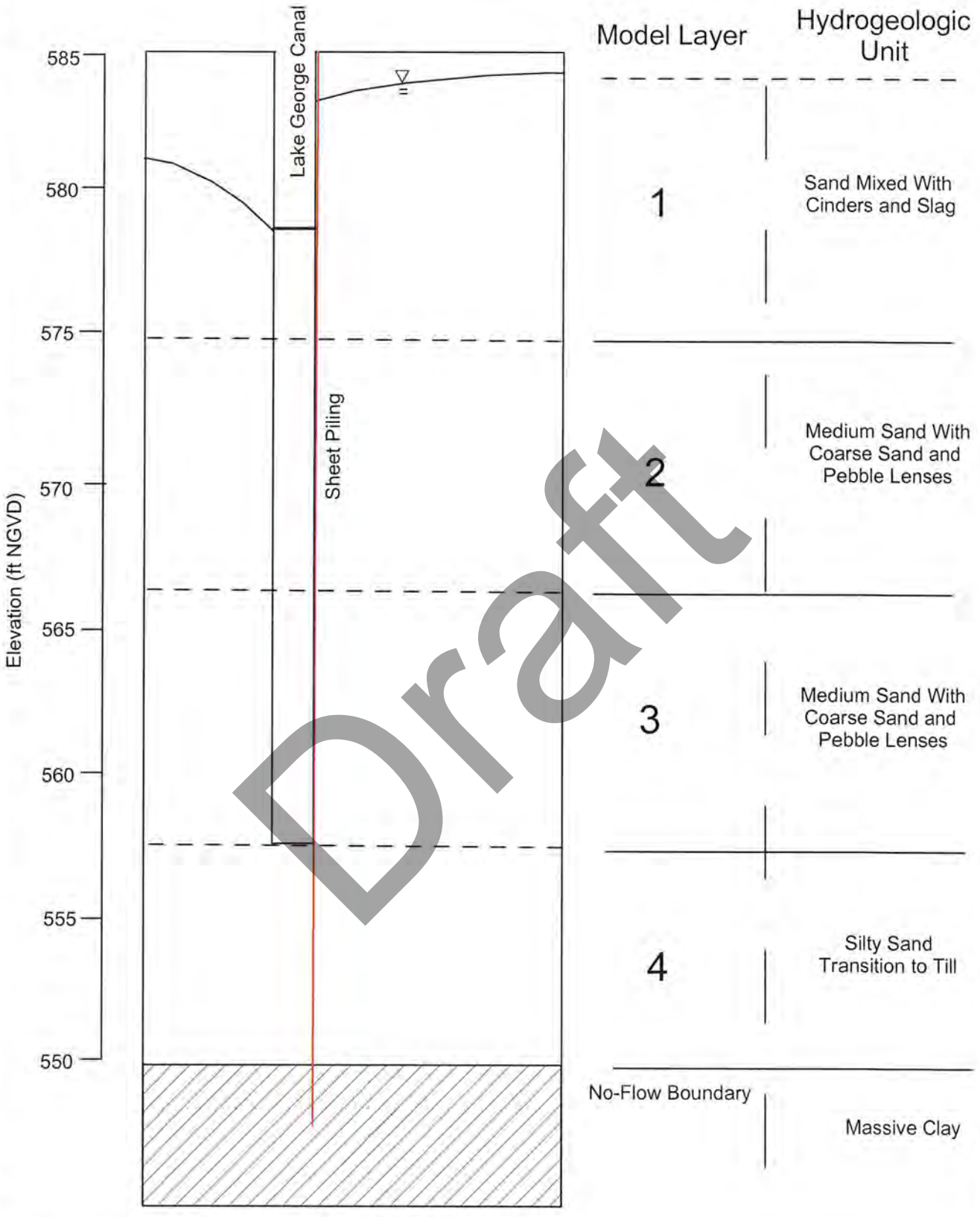
Local Map of the ECI Site

ECI
East Chicago, Indiana

FIGURE
1-2



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FILE NO.:
PRJCT NO.: CI0010670008
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Site Hydrostratigaphy

ECI
East Chicago, Indiana

FIGURE
2-1

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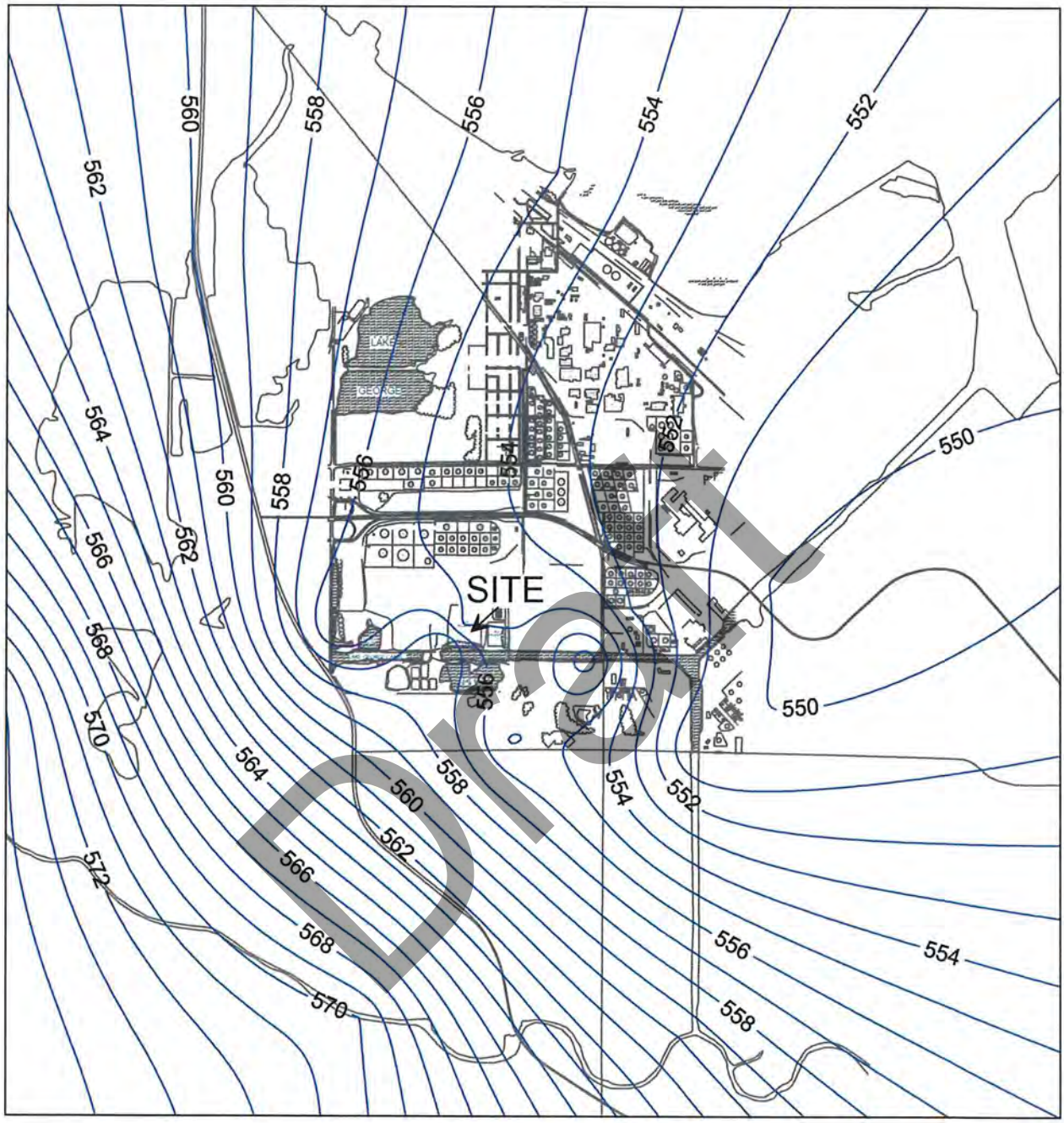
FILE NO.:
PRJCT NO.: CI0010670008
DWG DATE: 3/22/2002



550 Elevation Contour ft (NGVD)

Scale (ft)
0 2000 4000 6000 8000

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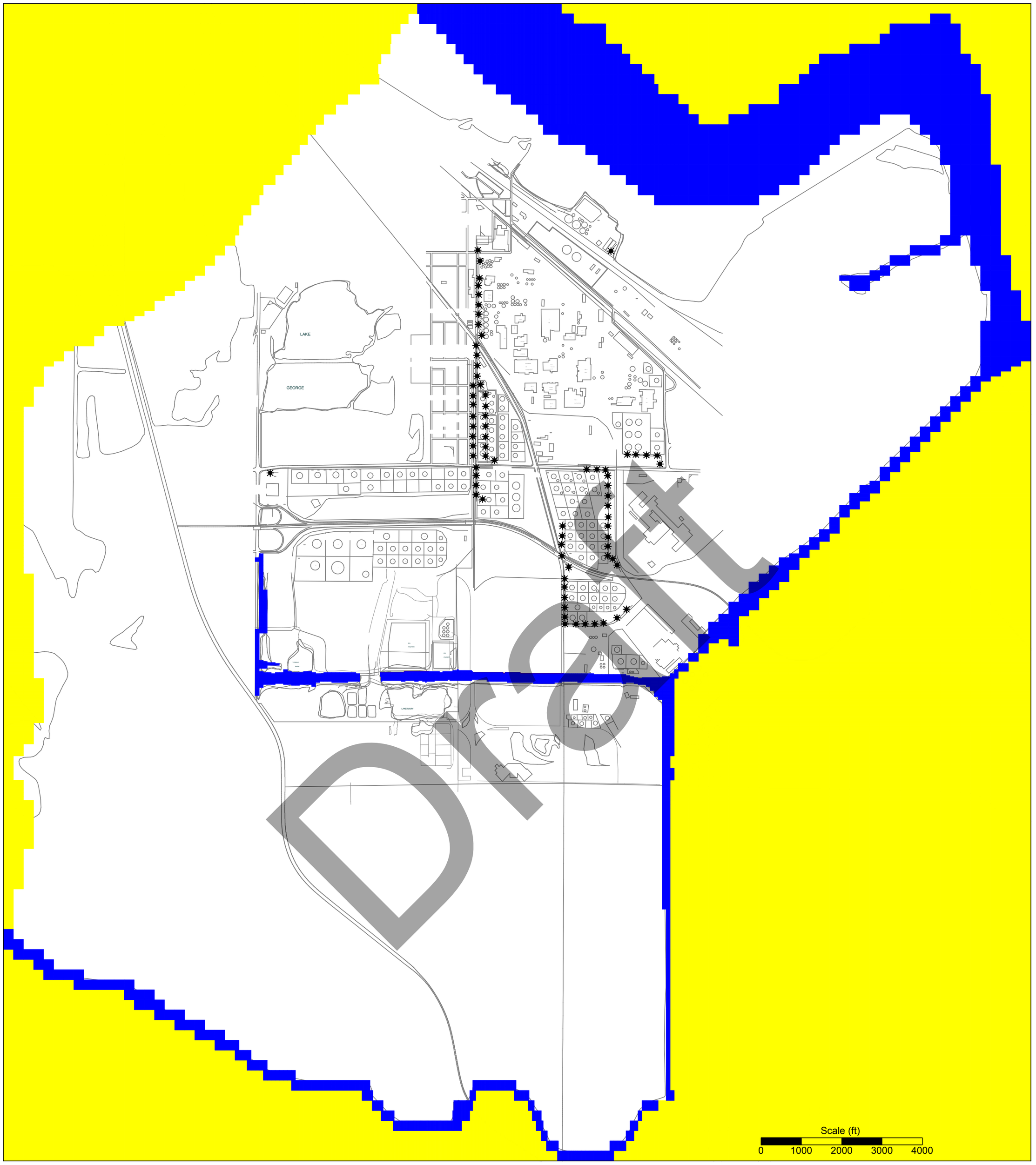
Elevation Contour Map of the Bottom of Layer 4 (Top of Clay)

ECI
East Chicago, Indiana

FIGURE
2-2



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Legend

- No-Flow Cell
- Extraction Well
- Note: Some Well locations Denote Multiple Extraction Points
- Constant Head Cell

Extraction Well Source: URS (2002)

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FILE NO: ECI	
PLOT SIZE: D size	
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Location of the Off-Site Extraction Wells

ECI
East Chicago, Indiana

FIGURE
2-4

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Legend

- No-Flow Cell
- River Cell
- Constant Head Cell

Scale (ft)

0 1000 2000 3000 4000

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PROJECT NO.: CI001067008	
DRAWING: Fig 3-1	
FILE NO: ECI	
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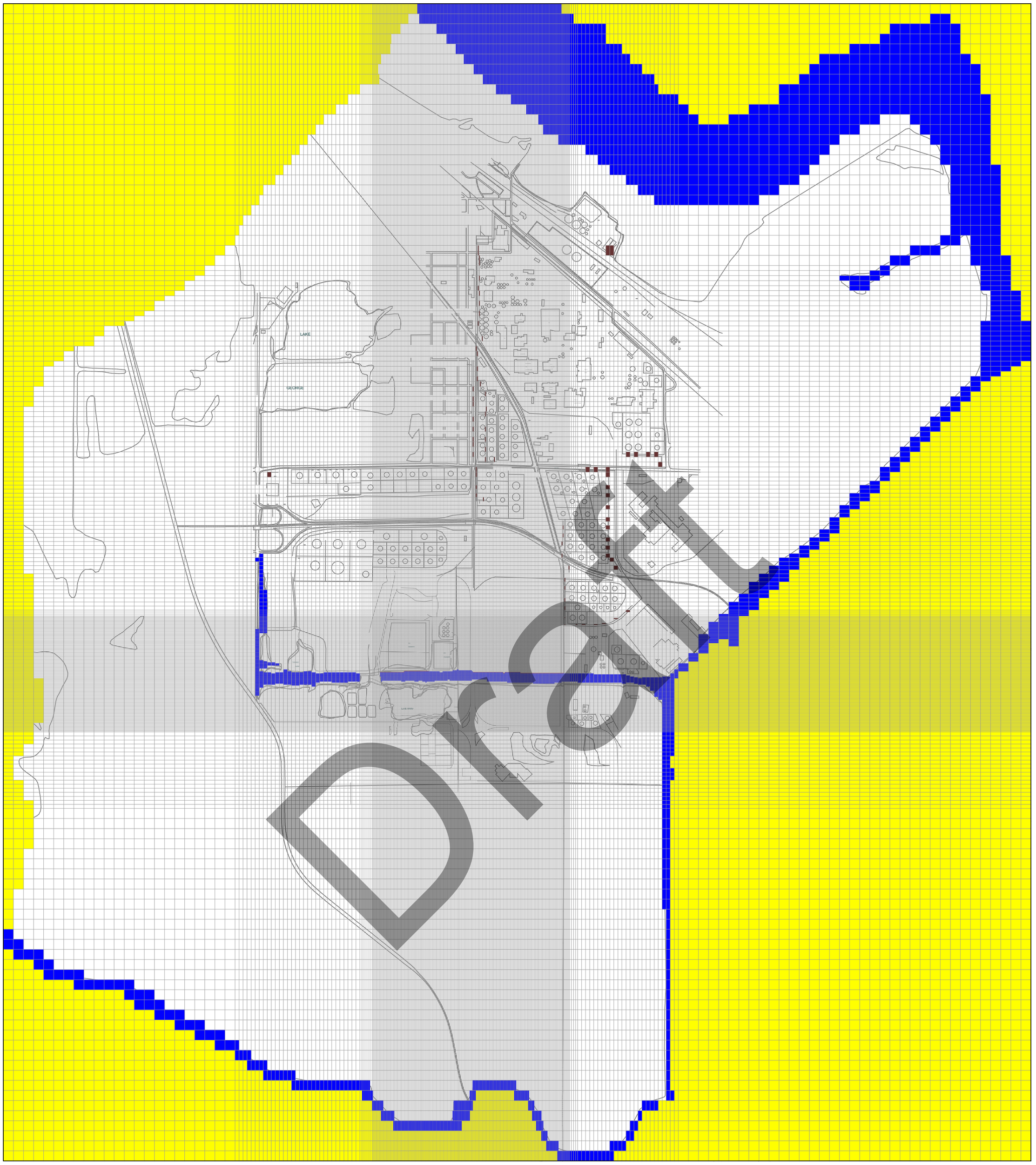
Finite Difference Grid and Boundary Conditions (Model Layer 1)

ECI
East Chicago, Indiana

FIGURE
3-1



Legend

- No-Flow Cell
- Well Cell
- Constant Head Cell
- Hydraulic Flow Barrier (HFB)

Scale (ft)

0 1000 2000 3000 4000

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PROJECT NO.: CI001067008	
DRAWING: Fig 3 - 2	
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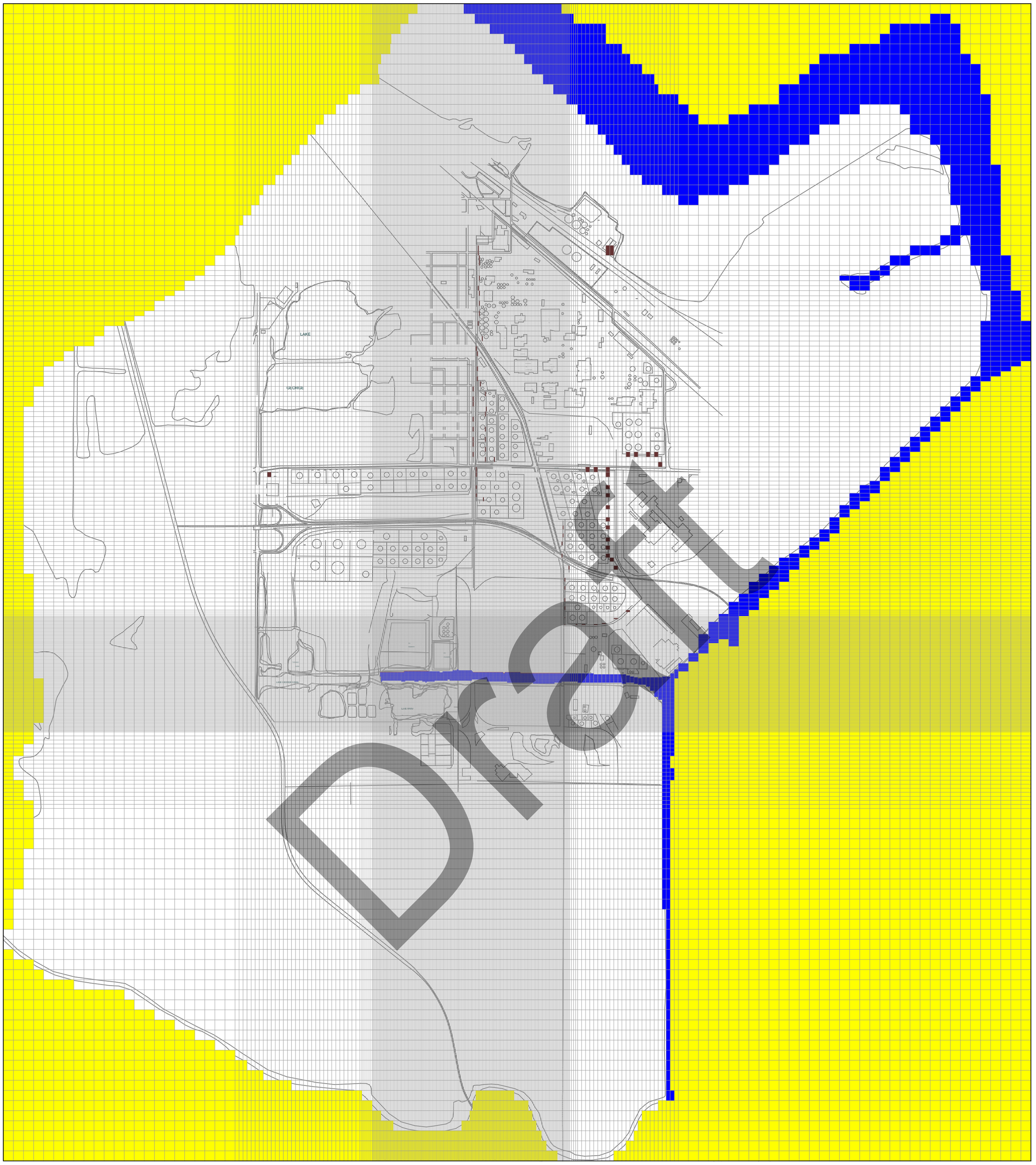
Finite Difference Grid and Boundary Conditions (Model Layer 2)

ECI
East Chicago, Indiana

FIGURE
3-2



Legend

- No-Flow Cell
- Well Cell
- Constant Head Cell
- Hydraulic Flow Barrier (HFB)

Scale (ft)

0 1000 2000 3000 4000

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PROJECT NO.: CI001067008	
DRAWING: Fig 3 - 3	
FILE NO: ECI	
PLOT SIZE: D size	
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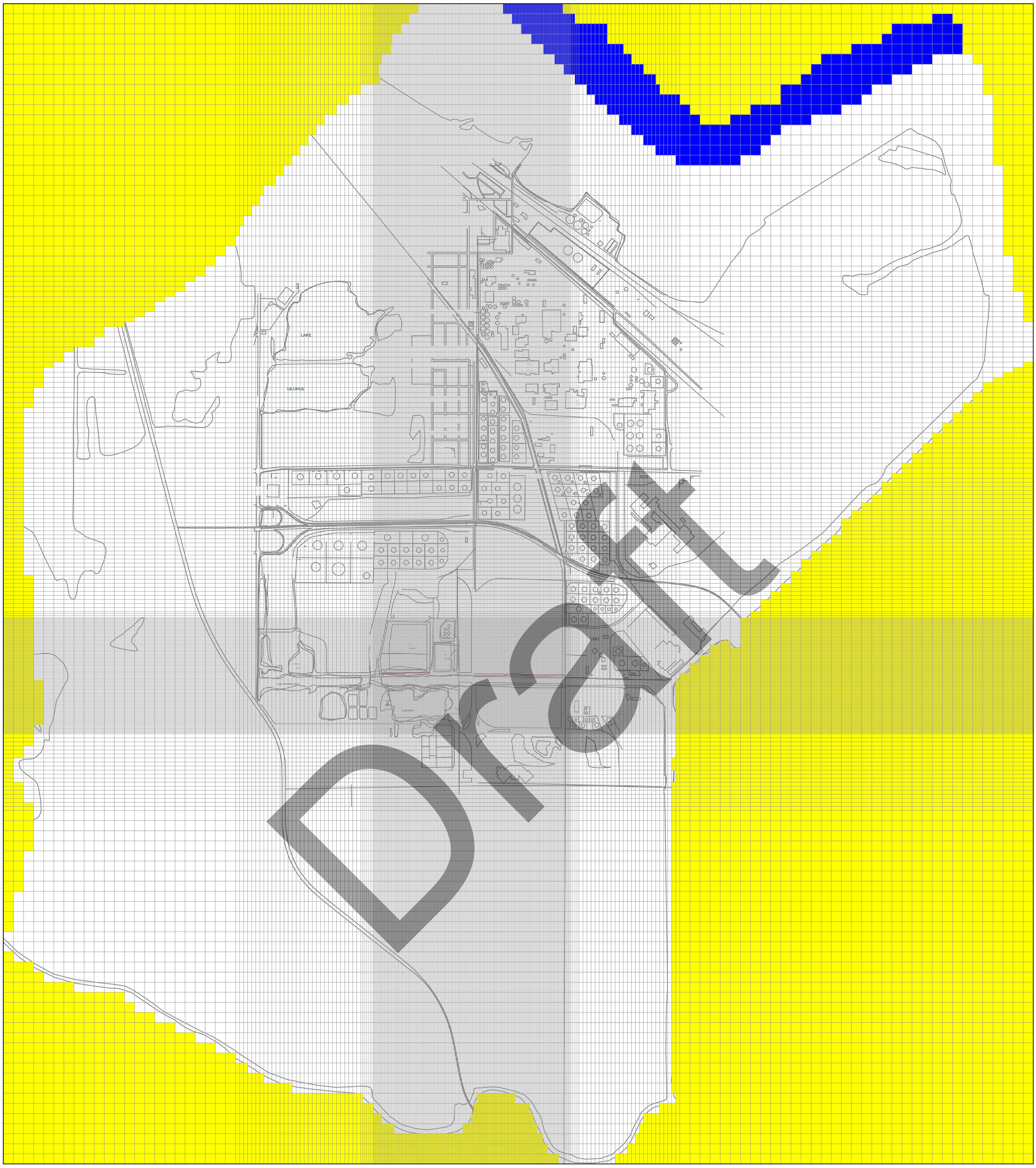
CHECKED BY:SBR	DATE:
APPROVED BY:STP	DATE:

Finite Difference Grid and Boundary Conditions (Model Layer 3)

ECI
East Chicago, Indiana

FIGURE
3-3



Legend

- No-Flow Cell
- Constant Head Cell
- Hydraulic Flow Barrier (HFB)

Scale (ft)

0 1000 2000 3000 4000

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PROJECT NO.: CI001067008	
DRAWING: Fig 3 - 4	
FILE NO: ECI	
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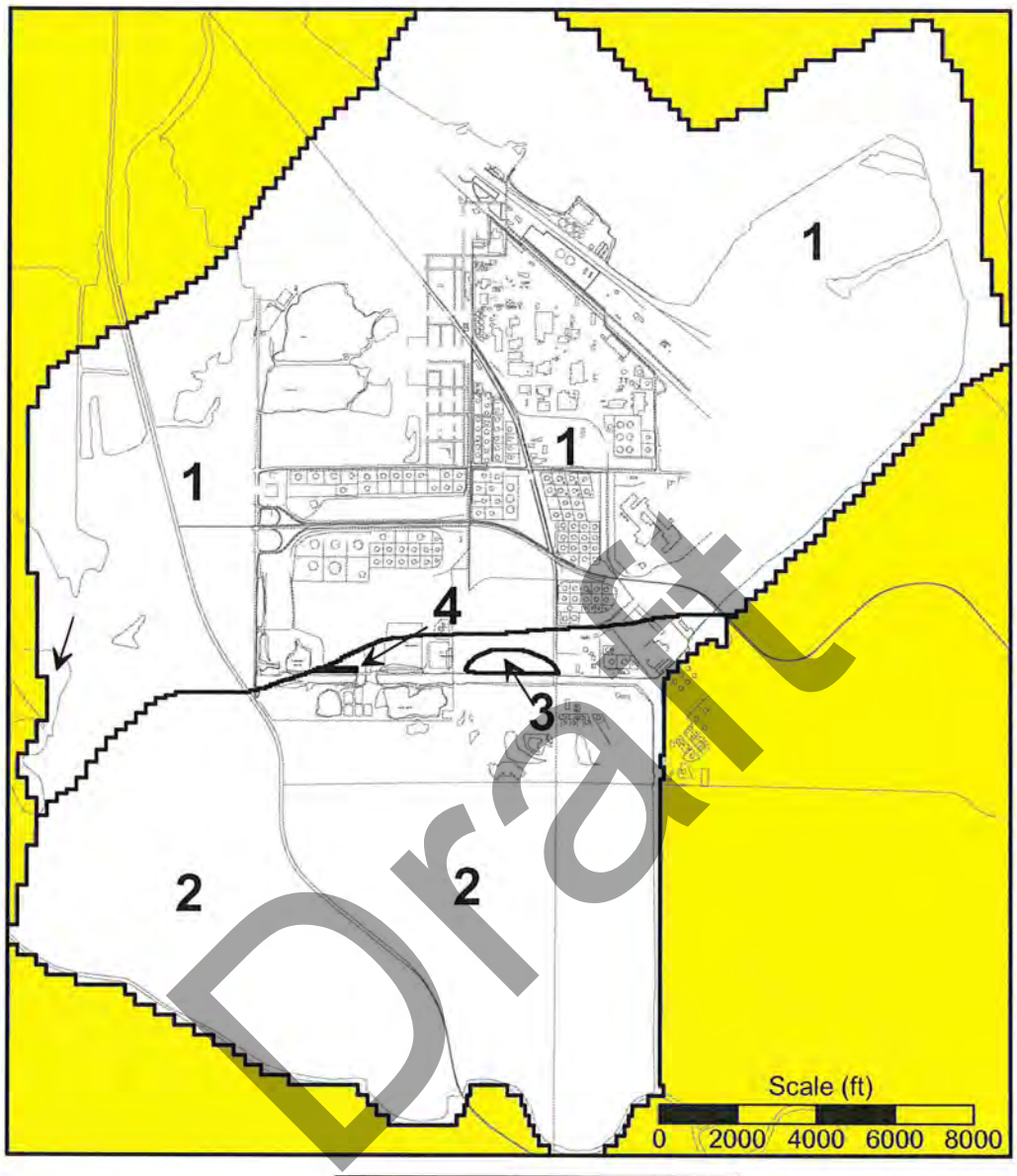
APPROVED BY:STP	DATE:

Finite Difference Grid and Boundary Conditions (Model Layer 4)

ECI
East Chicago, Indiana

FIGURE
3-4



Legend

Zone Number	Kh/Kv (ft/day)
1	47/4.7
2	38/3.8
3	1/0.1
4	200/20
	Inactive Region

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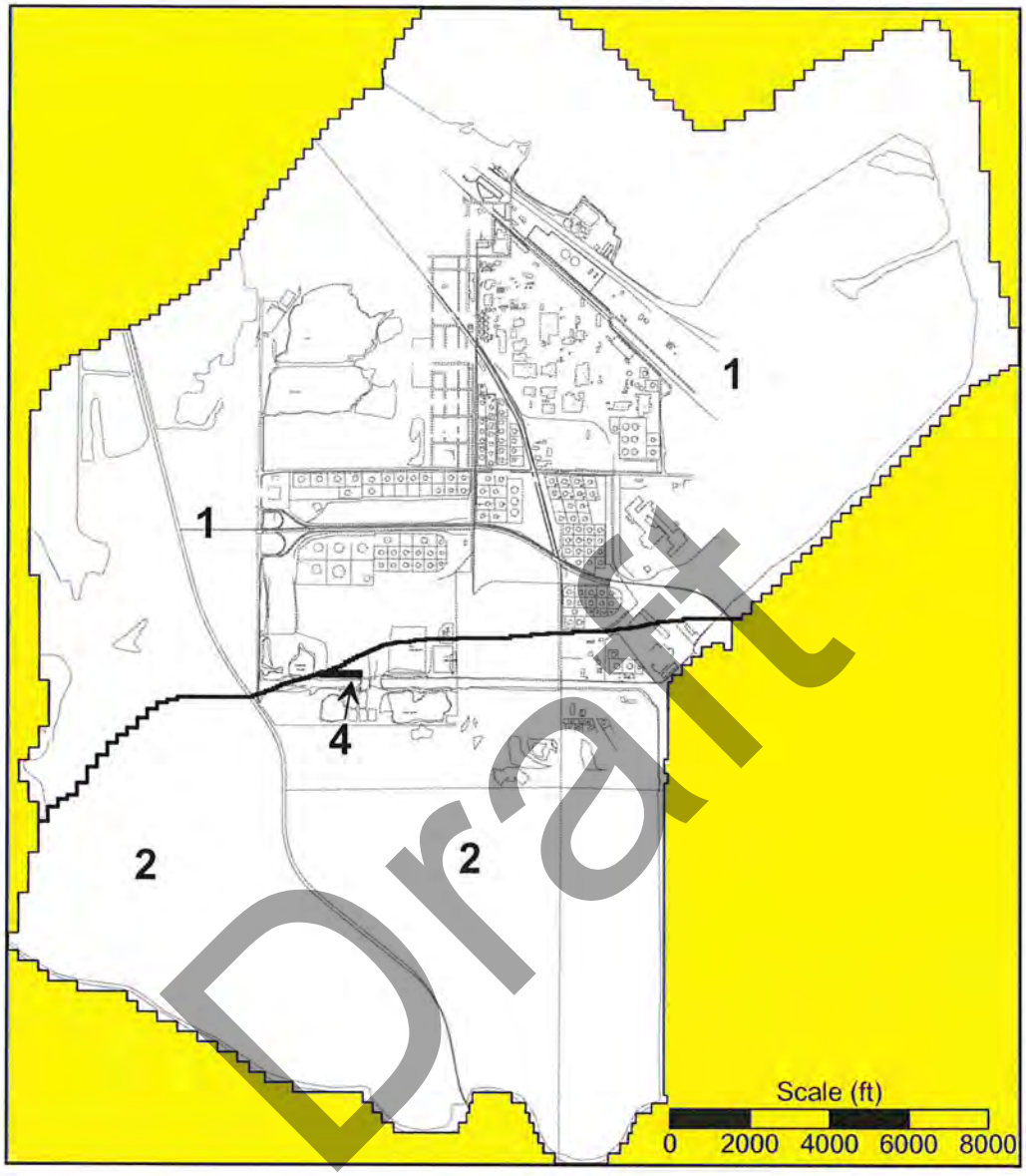
Hydraulic Conductivity Zonation for Model Layer 1

ECI
East Chicago, Indiana

FIGURE
3-5



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Legend

Zone Number	Kh/Kv (ft/day)
1	47/4.7
2	38/3.8
4	200/20
	Inactive Region

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Hydraulic Conductivity Zonation for Model Layer 2

ECI
East Chicago, Indiana

FIGURE
3-6

DRAFTER: SBR
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FILE NO.: ECI
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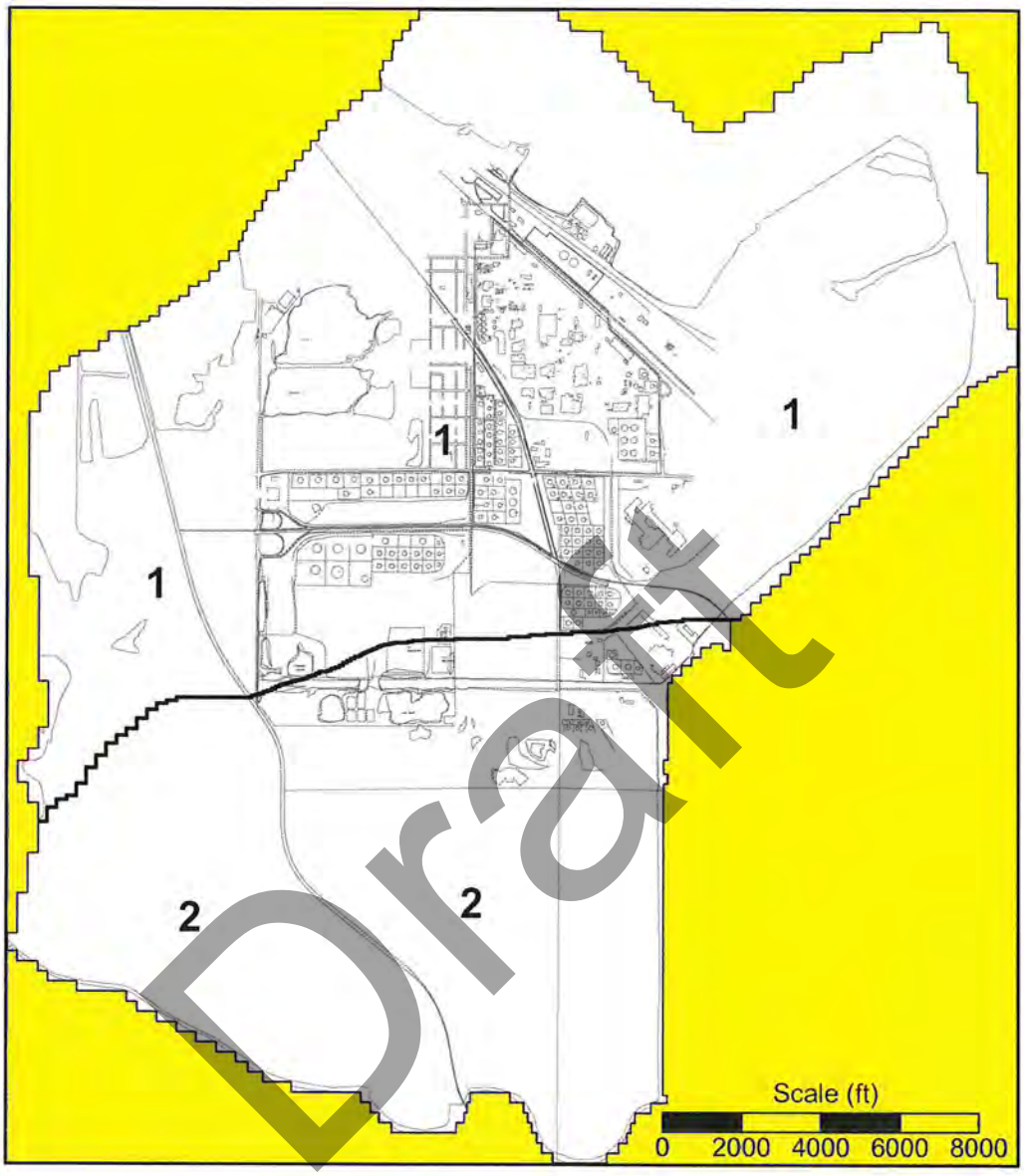
DWG DATE: 3/22/2002



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Legend

Zone Number	Kh/Kv (ft/day)
1	47/4.7
2	38/3.8
	Inactive Region

Hydraulic Conductivity Zonation for Model Layer 3 and 4

ECI
East Chicago, Indiana

FIGURE
3-7

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FILE NO.: ECI
PRJCT NO.: CI0010670008
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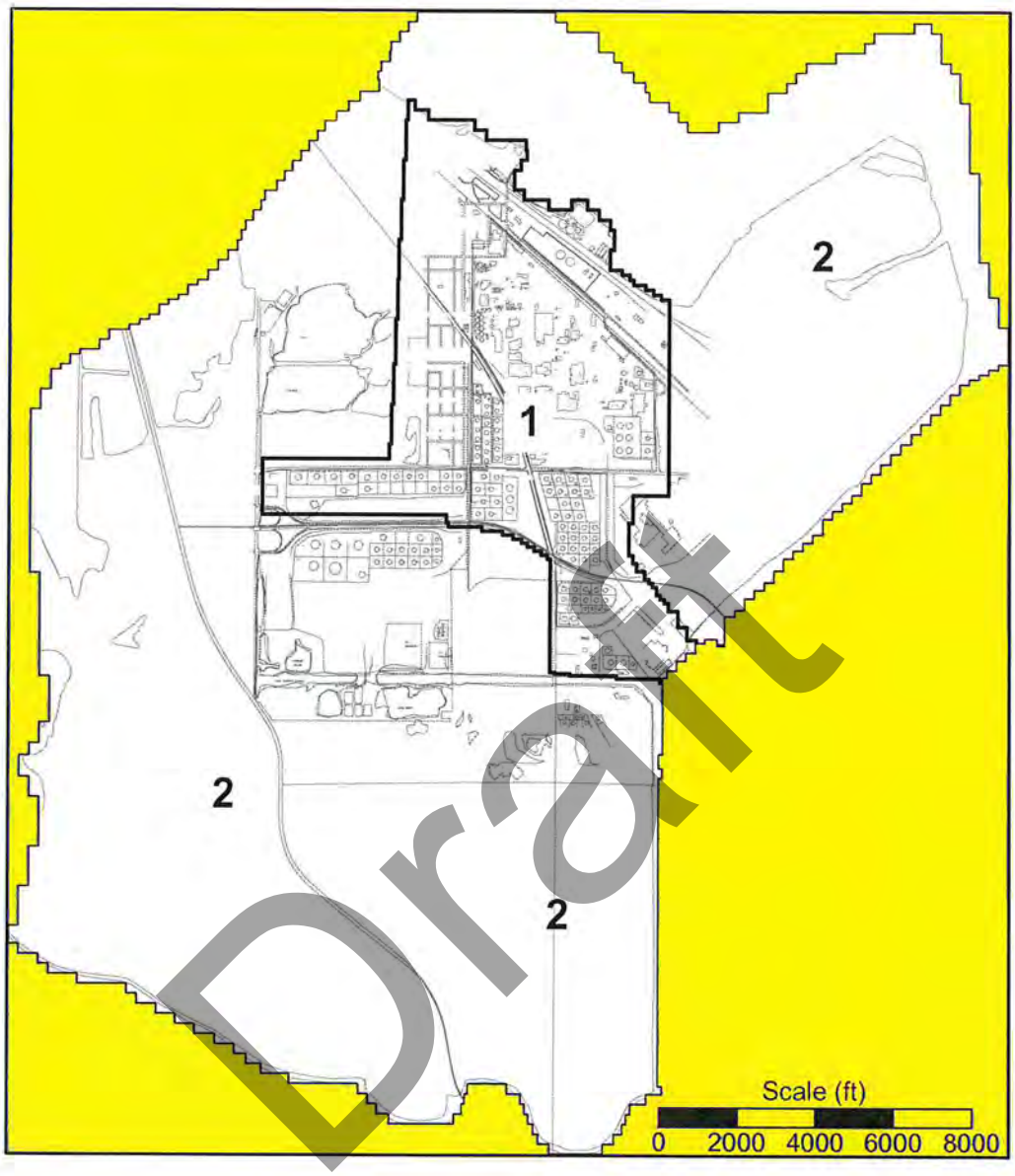

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Legend	
Zone	Recharge (in/yr)
1	16.5
2	8
	Inactive Region

Precipitation Recharge Zonation

ECI
East Chicago, Indiana

FIGURE
3-8

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DRAFTER: SBR
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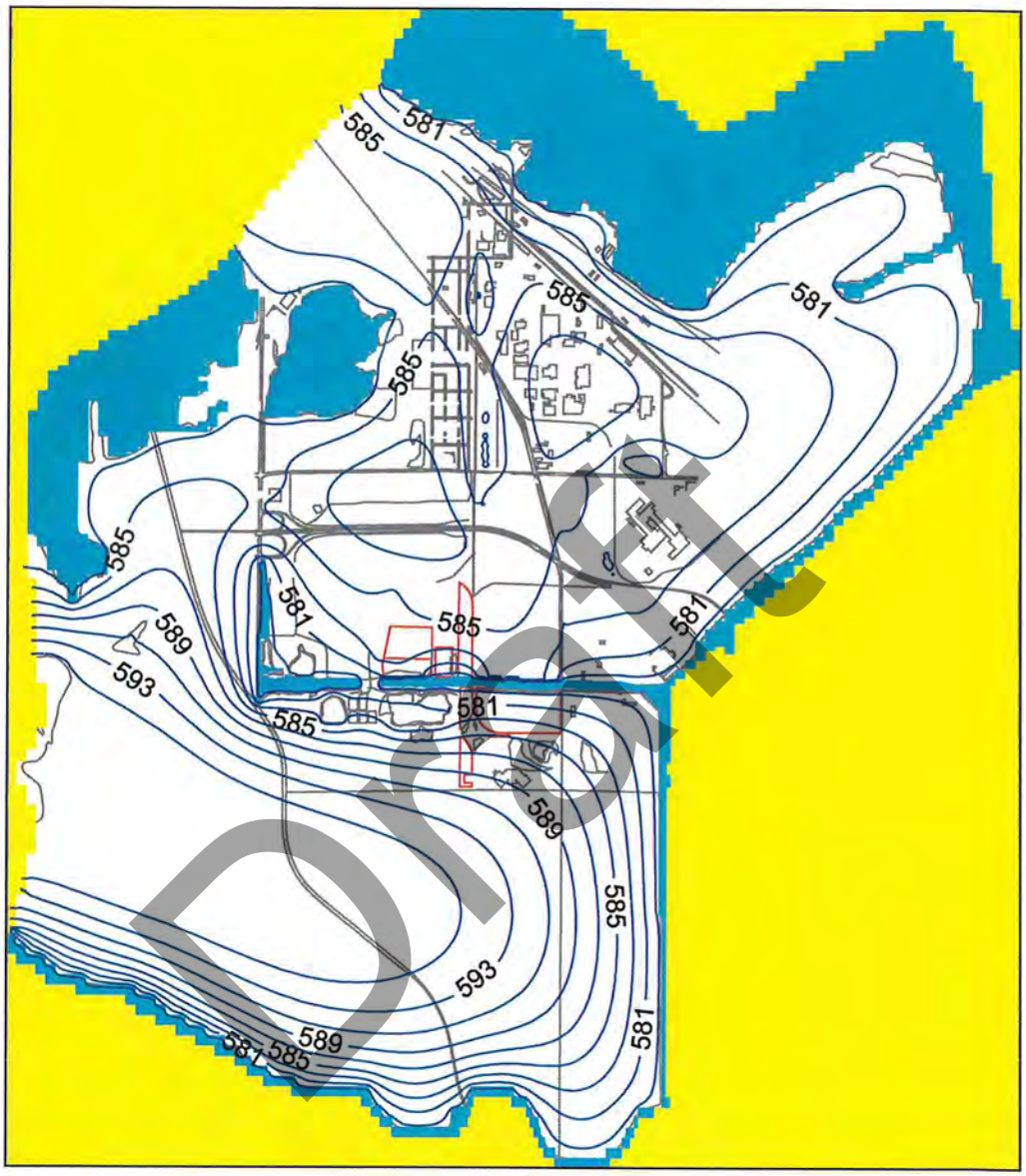
FILE NO.: ECI
PRJCT NO.: CI0010670008
DWG DATE: 3/22/2002



— 580 — Groundwater Level Contour (ft NGVD)

Contour Interval = 2 feet

0 2000 4000 6000 8000

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Regional Simulated Water Table

ECI
East Chicago, Indiana

FIGURE
4-1

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CHECKED: SBR
FILE NO.: ECI
PRJCT NO.: CI0010670008
DWG DATE: 3/22/2002

DRAFTED: SBR

APPROVED: STP

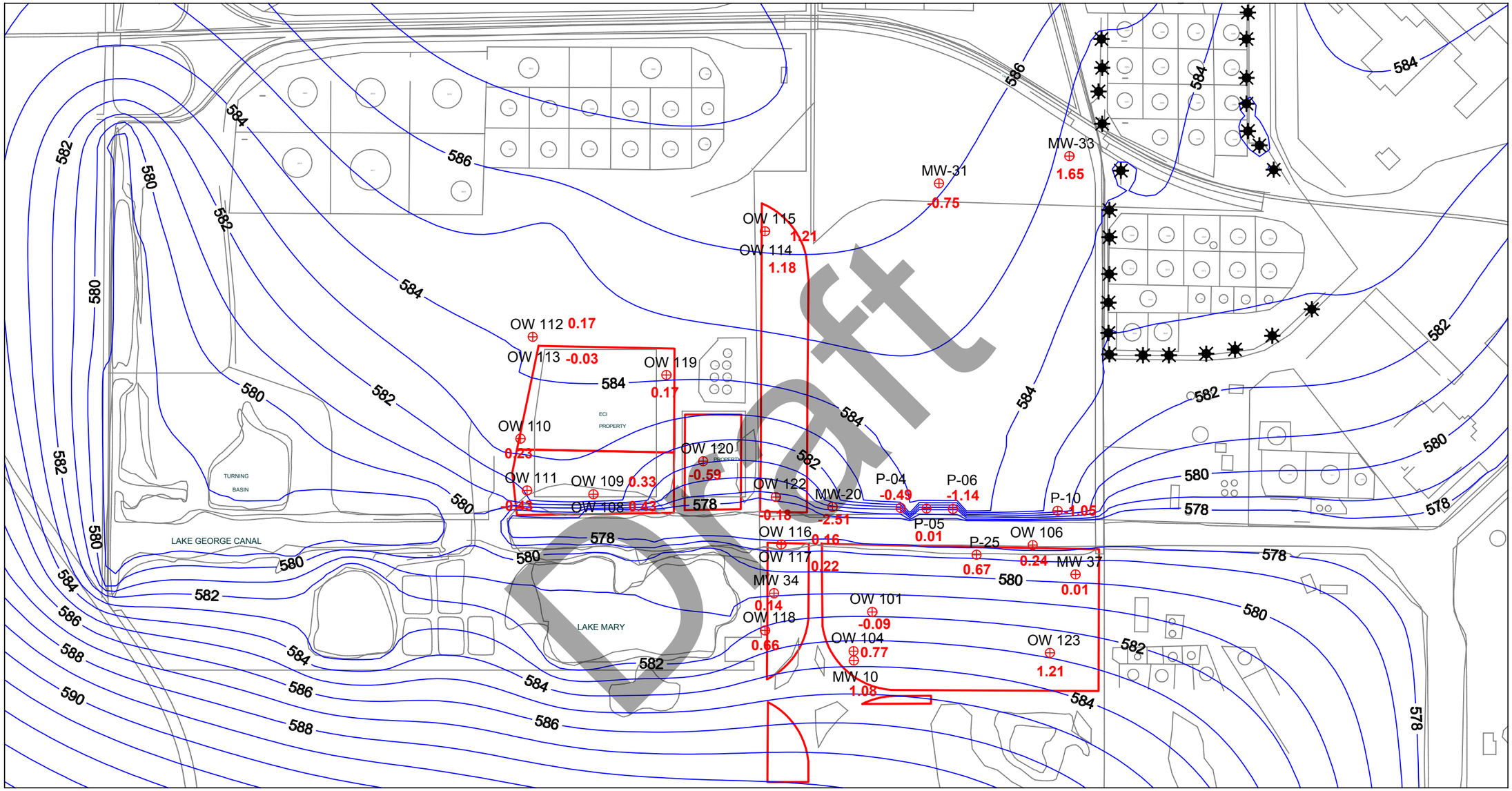
CHECKED: SBR

DRAWING:Fig 4-4

FILE NO: ECI

PRJCT NO: CI0010670008

DWG DATE: DATE



578 — Water Level Contour (ft NGVD)	MW-20 Well ID
Offsite Extraction Well	Monitoring Well
	0.10 Water Level Residual (Observed - Simulated)

Scale (ft)

0 500 1000 1500 2000

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Simulated Water Levels and Residuals (Model Layer 1)

ECI
East Chicago, Indiana

FIGURE
4-2

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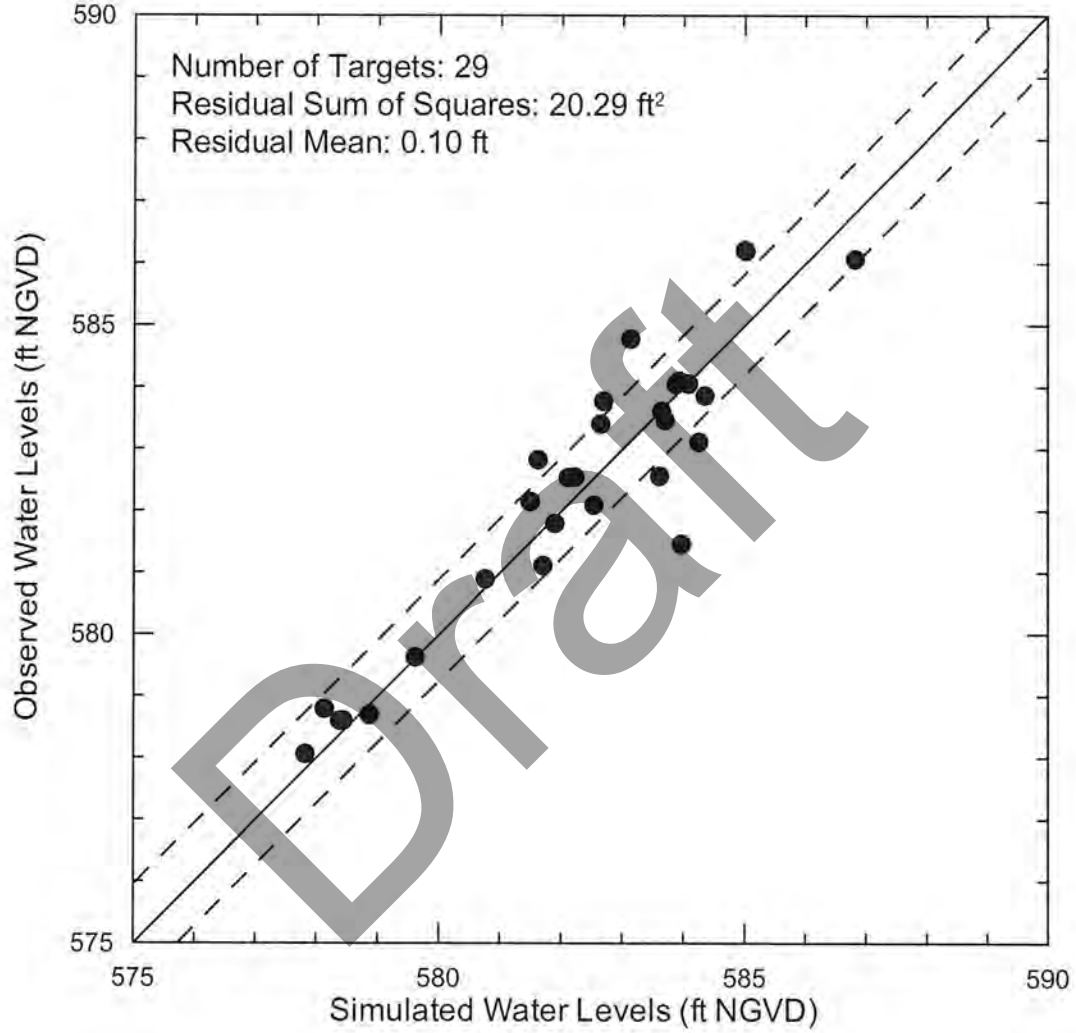
APPROVED: STP
CHECKED: SBR
FILE NO.: ECI
PRJCT NO.:
DWG DATE: DATE



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Plot of Observed versus Simulated Water Levels With Calibration Statistics

ECI
East Chicago, Inidana

FIGURE
4-3

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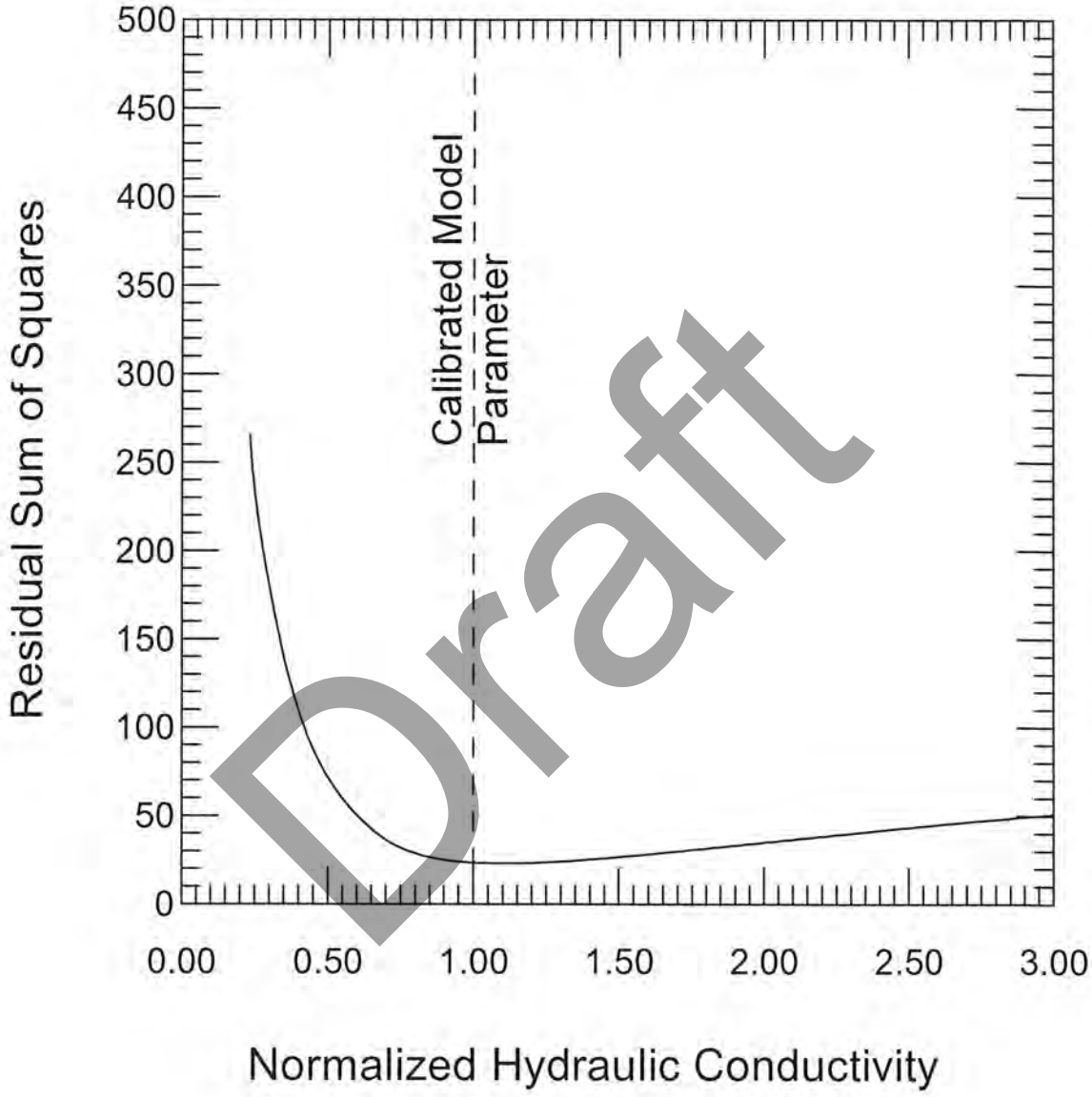
APPROVED: STP
CHECKED: SBR
FILE NO.: ECI
PRJCT NO.: CI0010670008
DWG DATE: DATE



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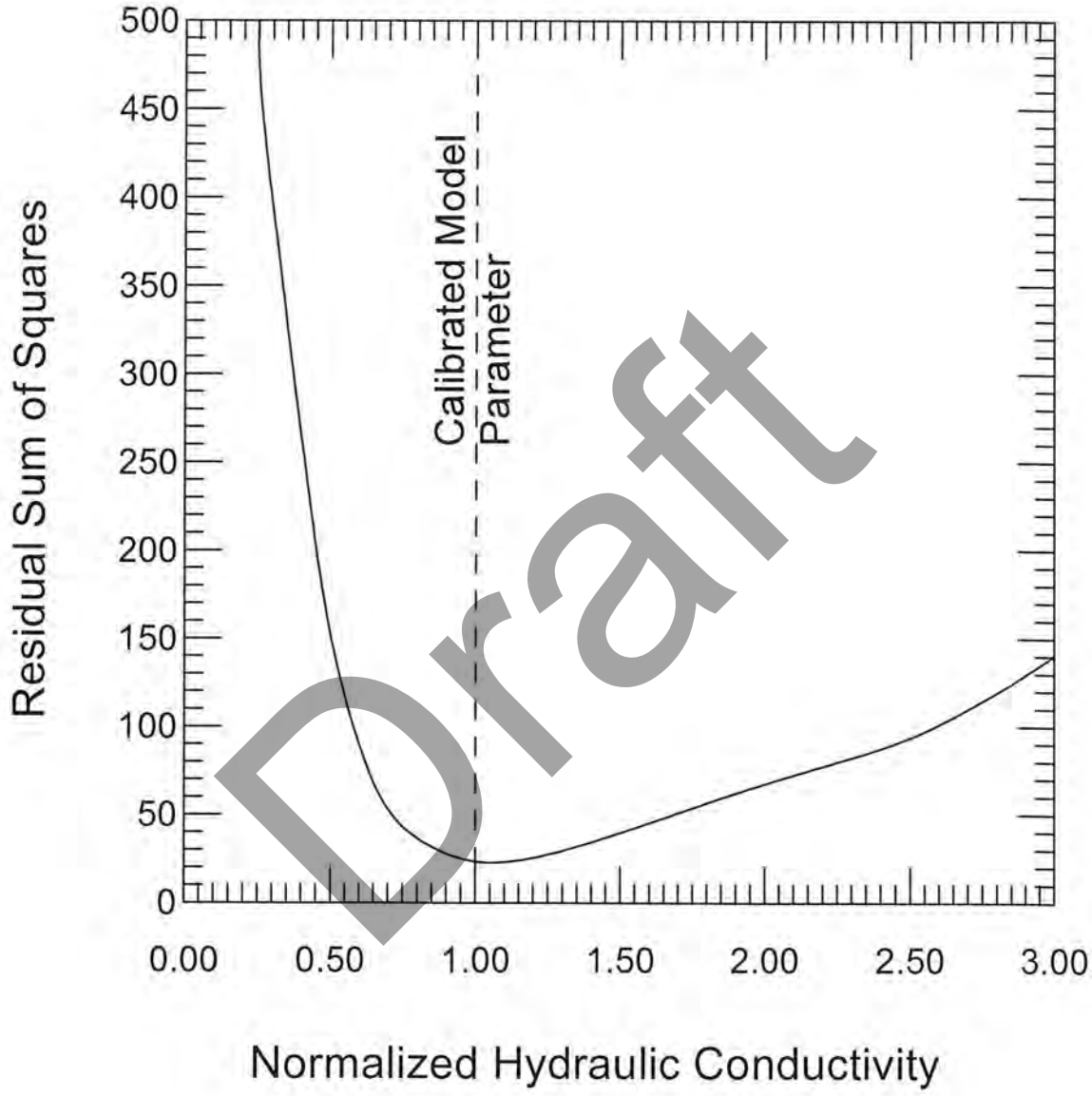
Results of Sensitivity Analysis
on Hydraulic Conductivity Zone 1

ECI
East Chicago, Indiana

FIGURE
4-4



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APPROVED: STP
CHECKED: SBR
FILE NO.: ECI
PRJCT NO.: CI0010670008
DWG DATE: DATE

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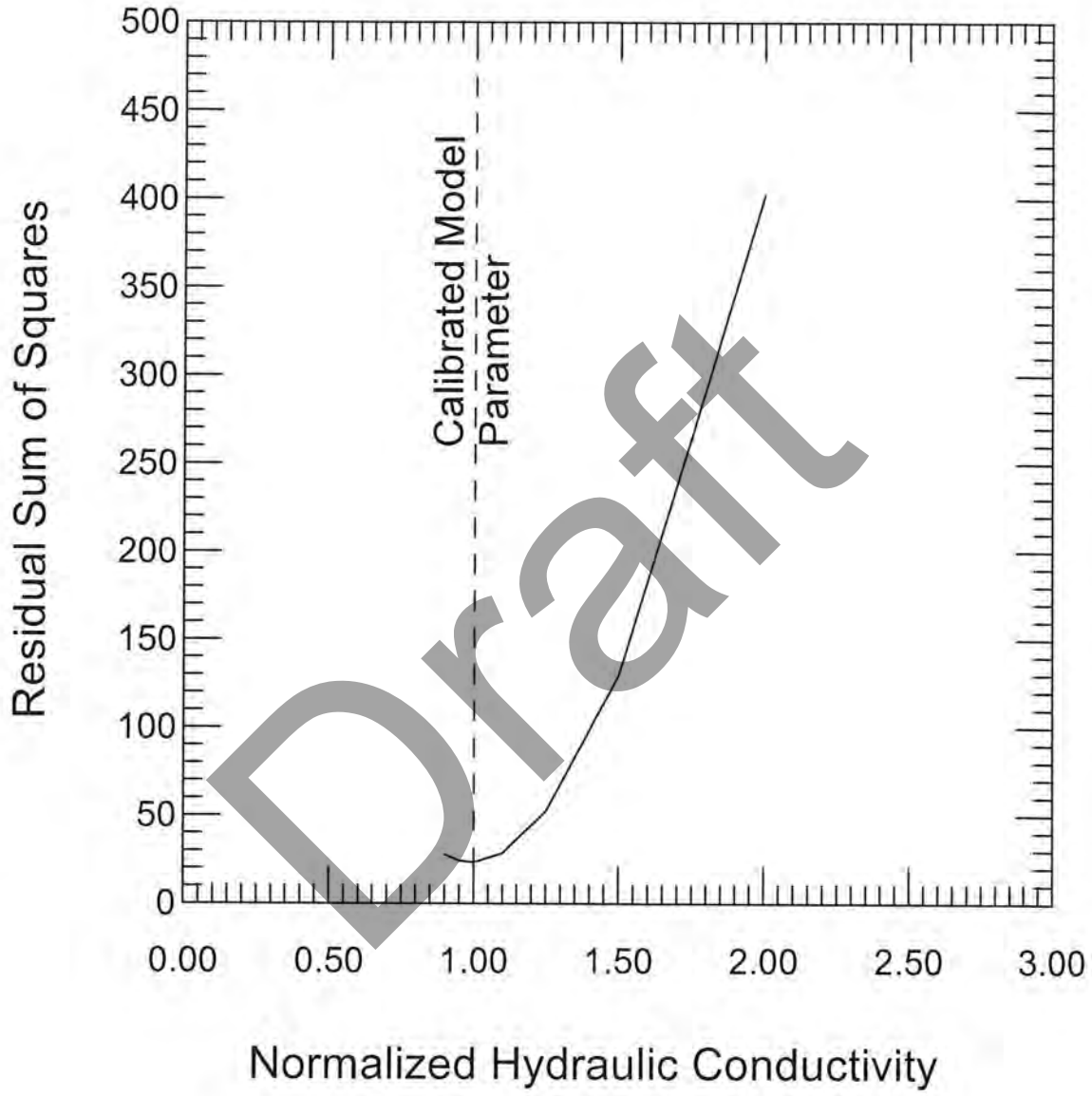
Results of Sensitivity Analysis
on Hydraulic Conductivity Zone 2

ECI
East Chicago, Indiana

FIGURE
4-5

DRAFTER: SBR
APPROVED: STP
CHECKED: SBR
FILE NO.: ECI
PRJCT NO.: CI0010670008
DWG DATE: DATE



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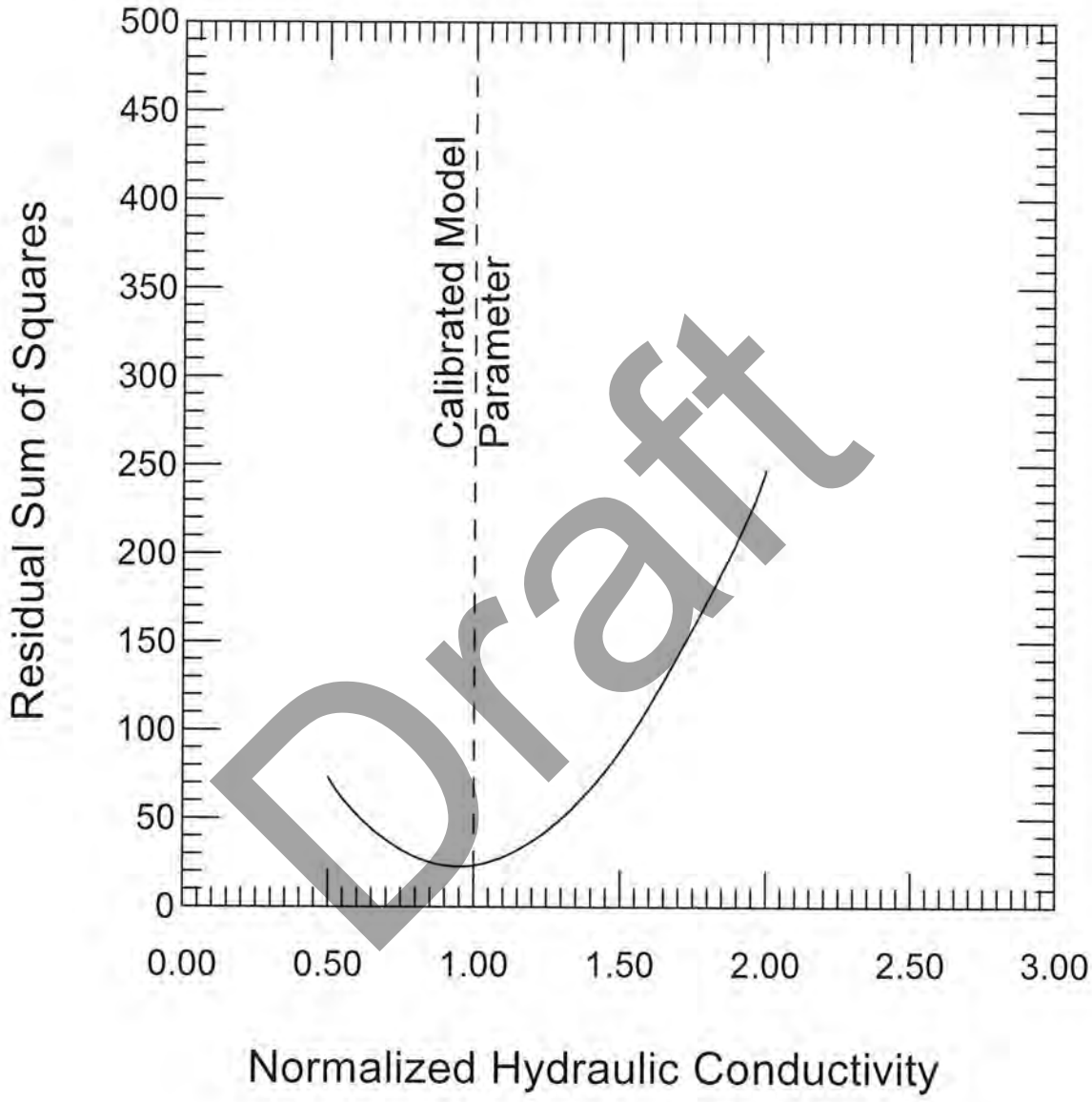
Results of Sensitivity Analysis
on Precipitation Recharge Zone 1

ECI
East Chicago, Indiana

FIGURE
4-6

DRAFTER: SBR
APPROVED: STP
CHECKED: SBR
FILE NO.: ECI
PRJCT NO.: CI0010670008
DWG DATE: DATE



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Results of Sensitivity Analysis
on Precipitation Recharge Zone 2

ECI
East Chicago, Indiana

FIGURE
4-7

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B.2 – EXCERPTS FROM 2013 SITE INVESTIGATION. TEXT AND FIGURES 1 TO 5

ARCADIS
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ENVIRONMENT

Paul Johnson
Operations Manager
Atlantic Richfield Company
BP Remediation Management
150 W. Warrenville Road, Building 200
Naperville, IL 60563

Subject:
2013 Geophysical Survey and Test Pit Investigation Report
Former ECI Refinery
3500 Indianapolis Boulevard
East Chicago, Indiana

Date:
August 6, 2013

Contact:
Adam Tokarski

Phone:
312-575-3705

Email:
adam.tokarski@arcadis-us.com

Our ref:
CI001067.0037

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Dear Paul:

ARCADIS has prepared the following letter report detailing the June 2013 investigation of the northern portion of the South Tank Farm (STF) for pipelines which may cross the Lake George Branch of the Indiana Harbor Canal (the Canal) within the recently dredged navigation channel at the former ECI refinery located at 3500 Indianapolis Boulevard in East Chicago, Indiana (Site). The area of investigation (AOI) addressed in this report is within the STF as depicted on **Figure 1**.

The western boundary of the AOI is defined as UTM Easting 459460m (approximately the western extent of dredging completed in 2012), and the north-south margins are approximated by the Canal to the north and the east-west access road inside the fence to the south. This scope of work was outlined in a work plan submitted to Mr. Mike Beslow of the USEPA on April 11, 2013.

Background

In 2012, the US Army Corps of Engineers began dredging of the Canal including areas adjacent to the STF. During the dredging activities, there was speculation that buried pipelines and/or utilities relating to the former refinery operations may be present in the dredged area of the Canal. The purpose of this investigation was to ascertain the presence or absence of buried pipes that may cross the Canal in the vicinity of the STF adjacent to the dredged areas.

Investigation Activities

In order to ascertain the presence or absence of pipes in the vicinity of the dredging activities, a multistep investigation process was performed as follows:

1. Desktop review of historic maps;
2. Observation for indications of utilities and pipelines on the ground surface;
3. Performance of a geophysical survey to confirm findings of first two steps; and
4. Subsurface exploration of findings from steps 1 through 3.

Desktop Review of Historic Maps

The primary source of historically documented STF piping is the ECI Pipe Map, Wolder Engineering and Constructors, 22-SEP-1992. This map provides the locations of piping within the STF site in 1992, including pipelines and water lines.

Surface Observations

Piping within the AOI is exposed at one location along the Canal. This pipe appears to be a cut-off water line that once crossed the canal and is now out of service. Other features of possible interest included several water hydrants which are still present on the STF. These features are shown on **Figure 2**.

Geophysical Survey

The primary purpose of the geophysical survey was to search for buried pipes north of the perimeter fence (between the fence line and the Canal) within the AOI in **Figure 1**. The premise behind this approach was that these pipes would be evident as metallic features in the upper 0 to 20 feet of the subsurface. As an aid to interpreting the geophysical data collected north of the fence, a complementary set of data was also collected south of the fence line to provide additional imaging of buried pipes, if they were found, on the STF property. Electromagnetic Induction (EMI), also known as frequency domain electromagnetics, was chosen as the primary method of investigation, and ground penetrating radar (GPR) was used to supplement the EMI survey. On May 9, 2013, Mr. Gregory Byer of ARCADIS performed an Electromagnetic Induction (EMI) and Ground Penetrating Radar (GPR) Survey.

The EMI survey was the primary method chosen because it is well established as a mobile, effective means for detecting metal pipes. Unlike GPR, the EMI method has

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a greater chance of detecting pipes, and can generally reach a depth of approximately 6 meters, depending on site conditions. GPR, on the other hand, can be limited in penetration depth and can miss anamolies at greater depths. The GPR was utilized primarily for the objective of verifying EMI results and providing a depth estimate.

The locations of the individual EMI and GPR traverses are shown on **Figure 2**. Because the primary objective of this survey was to detect pipes oriented perpendicular to the canal, the majority of the data collection traverses were oriented parallel to the canal which maximizes the probability of detecting buried pipes, should they exist.

Electromagnetic Survey Method

ARCADIS utilized a Geonics EM31-MK2 to gather the EMI data. The position of the instrument was documented with a backpack mounted Novatel Smart V-1 global position system (GPS). A stream of GPS data with a nominal accuracy of 0.7 meters was streamed at the rate of 1 Hz to a portable hand-held data logging computer used to control the EM31-MK2. The EM31-MK2 streamed data to the computer at a rate of 10 Hz. The EMI instrument was carried parallel to the canal at waist-height by the operator in the vertical dipole orientation. A series of six EMI profiles were gathered between the bank of the canal and the south edge of the roadway – two were north of the fence line and four were south of the fence line.

Ground Penetrating Radar Method

For the GPR Survey, a Sensors & Software Noggin250 mounted to a SmartCart was used. The same GPS receiver discussed above was used to record the position of the GPR cart as it was pushed along traverses. The GPS receiver was mounted to the center of the cart above the 250 MHz antenna. The GPR traverses were limited to the south side of the fence line due to rough ground conditions north of the fence line. The GPR data was viewed as it was collected and was stored in memory for later evaluation. The GPR was primarily used to confirm pipe depths and also to look for non-metallic evidence of utilities or pipes (possibly removed) in the form of ground disturbances.

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Results of Geophysical Survey

Figure 3, Figure 4 and **Figure 5** are the graphical results of the EMI survey. The X-axis is the UTM Easting in meters and the Y-axis is the apparent electrical conductivity in milliSiemens per meter (mS/m). It is important to understand the meaning of an anomaly of interest for a given site. Since the focus of this survey was to identify metal pipes, the definition of an anomaly in this context is restricted to that associated with a metal pipe. This type of anomaly is well known and has an appearance as shown to the right when the pipe is crossed with the instrument at or near a right angle to the pipe. The anomaly consists of a small peak, a large trough[1], and a small peak (+/-/+, or p-n-p). The trough is generally a factor of 3 or more times the magnitude of the flanking peaks. The pipe is located in the center of the trough. Factors which affect the magnitude of the peaks and trough (i.e., amplitude) include depth of burial, pipe diameter, and electrical conductivity of the metal. Background readings can vary with soil type and/or presence of electrically conductive or resistivity chemical contaminants in the soil. Traversing parallel to above ground metal objects such as fences or buried pipes can also have a broad effect on the conductivity readings, positive or negative.

The EMI results were compared to the documented locations of pipes discussed above. Based on surface observations of buried water lines including hydrants, valves, and one cut-off line located at water's edge of the canal, and EMI results corresponding to these surface features, water lines were interpreted to be present as shown on **Figure 2** (blue dot-dash lines). The water lines consist of lines both parallel and perpendicular to the canal. The EMI results agreed reasonably well with the documented locations. TP-01 (**Figure 3** and **Figure 6**) and TP-03 (**Figure 5** and **Figure 8**) were located to confirm anomalies suspected of being documented water lines, and are discussed in the following sections. TP-02 (**Figure 4** and **Figure 7**) and TP-04 (**Figure 5** and **Figure 9**) were selected based on GPR responses that did not appear to coincide well with known water lines or EMI anomalies.

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[1] The reason for the negative response over a highly conductive metal object is related to the assumptions that go into calculating electric conductivity of soils, for which the EM31 and similar instruments are designed. This type of instrument can quantify the electrical conductivity of soils up to about 1000 mS/m, above which there will be an underestimate. At extremely high conductivity values associated for example with metals, the EM31 response yields a negative value relative to background.

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Several GPR anomalies were noted, some of which are consistent with the appearance of piping and/or associated ground disturbances (i.e., backfilled trenches). Addressing the question of whether buried pipes are present that may span the Canal from the interior of the STF site within the specific AOI discussed in this report; there do not appear to be significant p-n-p type EMI anomalies on Profiles 1 and 2, the profiles closest to the canal's edge. From this information it appears there are no pipes that extend to the Canal within the AOI, regardless of the number of known or possible existence of pipes within the STF site south of the fence.

Subsurface Exploration Activities

Based on data gathered during the geophysical survey, ARCADIS directed the excavation of four test pits in order to verify subsurface anomalies which were most likely indicative of buried metallic objects such as pipes.

Pipeline Locating and Utility Clearance

On June 14, 2013, Environmental Restoration (ER) contacted the Indiana One Call known as Indiana 811. Indiana 811 member companies marked public utilities prior to performing any intrusive subsurface work utilizing locate # 1306142151.

Additionally, Bloodhound, Inc. of Brownsburg, Indiana (Bloodhound) was retained by ER to conduct a private utility locate and clearance of pipelines, subsurface utilities and site features. ARCADIS identified the four locations of interest during the geophysical survey as discussed above. ARCADIS marked each proposed test pit location utilizing a Trimble GeoExplorer GPS unit.

On June 18, 2013 Bloodhound utilized electromagnetic locating and air knife equipment to locate and uncover potential anomalies found during the EM/GPR survey and to clear proposed test pit locations. Surface soils were removed utilizing hand digging tools. Following removal of surface soils, Bloodhound utilized a two man team to operate the air knife and vacuum hose to uncover each suspected anomaly. TP-01 was cleared in three locations along the entire 37' length of the proposed test pit area.

Soil from each location was contained within the airknife trailer vacuum storage tank. Once each pothole location was complete, spoils were emptied onto plastic visquene sheeting for visual inspection by an ARCADIS geologist. Once the soil inspection

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was complete, the excavated soil was returned into the excavation and was compacted.

Test Pit Completion

On June 19, 2013, ARCADIS completed four (4) test pits at the Site in order to assess the shallow soil and verify the presence or absence of suspected buried pipes identified in the geophysical survey.

A test trench was completed at each location utilizing a Link-Belt 160 excavator equipped with a 2' bucket to a depth of five (5) feet bgs or until an anomaly was encountered. Each test pit location was visually described using the United Soil Classification System by an ARCADIS geologist. Test pit locations are depicted on **Figure 1**.

During the excavation activities, the breathing zone was continuously monitored for volatile organic compounds, Oxygen, Lower Explosive Limit, Hydrogen Sulfide and Carbon Monoxide with a photoionization detector and 4-gas meter. Air monitoring logs are included as **Attachment 1**.

Surface soils encountered during test pitting activities included topsoil or loamy topsoil containing roots, organics and some sand. Subsurface soils included silt and loam at shallow depths with native sand at greater depths. Soils observed at TP-03 and TP-04 at depths ranging from 3.0 to 5.0' bgs consisted of black or gray, medium grained, well sorted sand with some odors. Subsurface soils observed at TP-01 and TP-02 consisted of loamy topsoil, loamy silt, followed by a yellow or tan, medium grained, well sorted sand.

Upon completion of each test pit, total depths, dimension measurements and photographs were collected. Additionally, GPS points were collected at each test pit to accurately represent its orientation and note any pipelines or utilities encountered.

Test Pit Results

Test Pit #1 – Two metallic lines were encountered in test pit #1. Based on the surface features in the vicinity of test pit #1, the lines were interpreted to be former water lines that are located parallel to the canal. Bloodhound confirmed that the metallic lines were former water supply lines during the airknife activities and lines

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were traced to nearby surface features such as fire hydrants and water valves using EM locating equipment.

Test Pit #2 – Fill material was encountered in test pit #2. No utilities or pipes were encountered.

Test Pit #3 – Two metallic lines were found in test pit #3. One line was oriented parallel to the Canal, and the other was oriented perpendicular to the Canal. Tracing of the line perpendicular to the Canal indicated that the line has a 90-degree bend south of the fence and continues east to the eastern property line. The lines were interpreted to be former water lines based on EM locating to nearby surface features such as fire hydrants and water valves.

Test Pit #4 – One 6-8" diameter metallic line was encountered in test pit #4. The metallic line was traced to nearby surface features (fire hydrants and water valves) indicating this line was associated with the former water supply system.

A photographic log, detailing the test pit activities is included as **Attachment 2**.

Correlations and Conclusions

ARCADIS has completed an investigation to determine if buried pipelines within the northern portion of the STF adjacent to the dredged area of the Canal may be present under the Canal. The investigation consisted of a desktop review of available documents and maps regarding former pipelines, completion of an EMI and supplemental GPR survey, Utility Clearance/Potholing and Test Pitting activities. The following conclusions are based on the investigation completed:

- Historical documentation and surface observations indicate that in the AOI several former water lines are present.
- EMI results indicate that there are no indications of pipes traversing the Canal in the area north of the fence line and within the AOI.
- EMI and GPR results indicate that buried water lines continue to exist inside the perimeter fence, but no indications of other pipes were found.
- Shallow soils uncovered during test pit activities consist of organic loam and topsoil and medium grained well sorted native sand.

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- Through the desktop review, EMI/GPR survey and test pitting activities, no buried pipelines were identified in the STF adjacent to the dredged portion of the Canal which may remain under the Canal.

ARCADIS appreciates the opportunity to provide Atlantic Richfield Company with this report. If you have any questions or comments, please do not hesitate to contact us.
Sincerely,

ARCADIS U.S., Inc.

Adam Tokarski
Client Program Manager

Doug Etscheid, P.G.
Project Geologist

Enclosure(s):
Figures

Attachment 1 – Air Monitoring Logs
Attachment 2 – Test Pit Photo Log

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Figures

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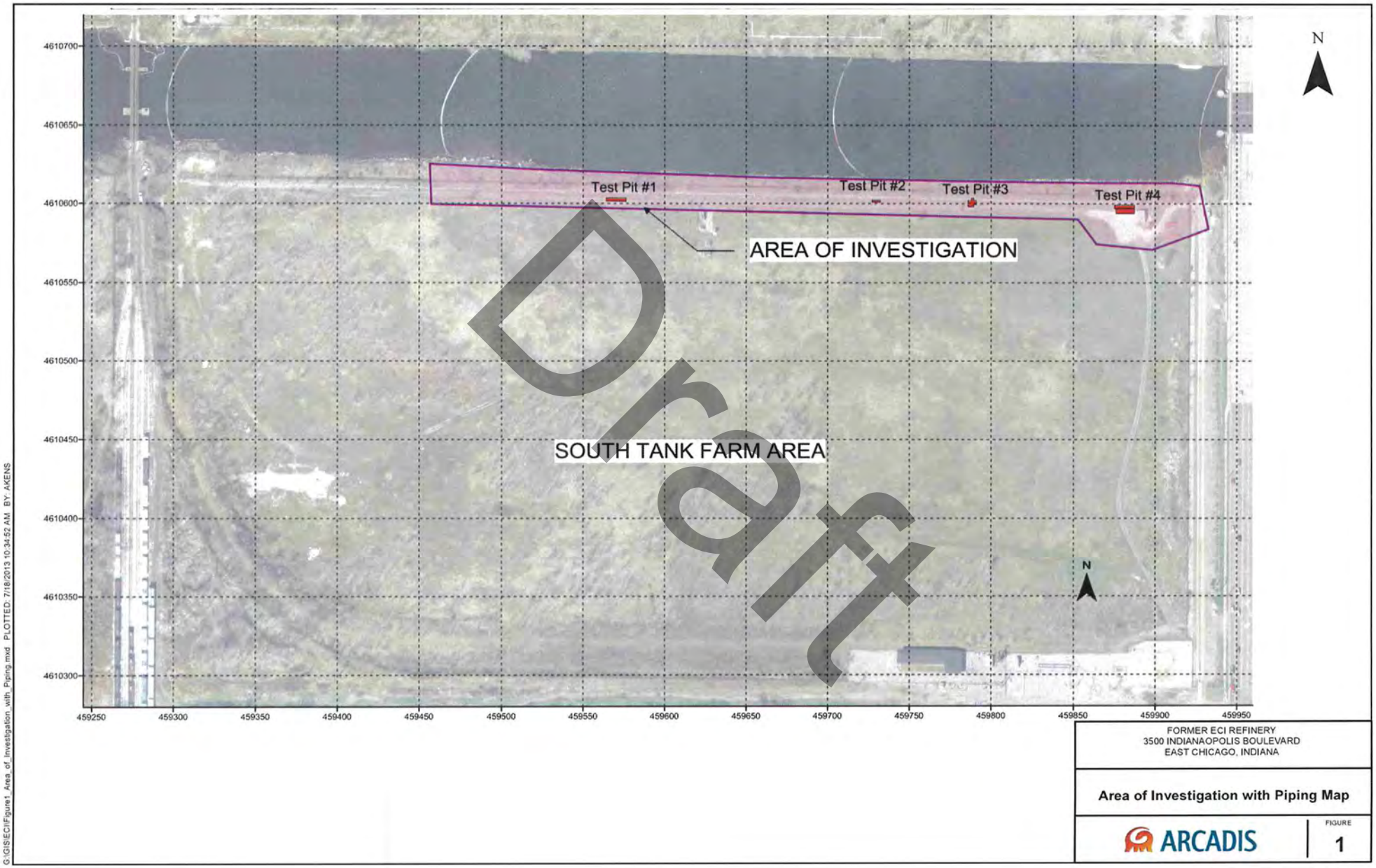

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3500 INDIANAOPOLIS BOULEVARD
EAST CHICAGO, INDIANA

Area of Investigation with Piping Map

ARCADIS

FIGURE 1

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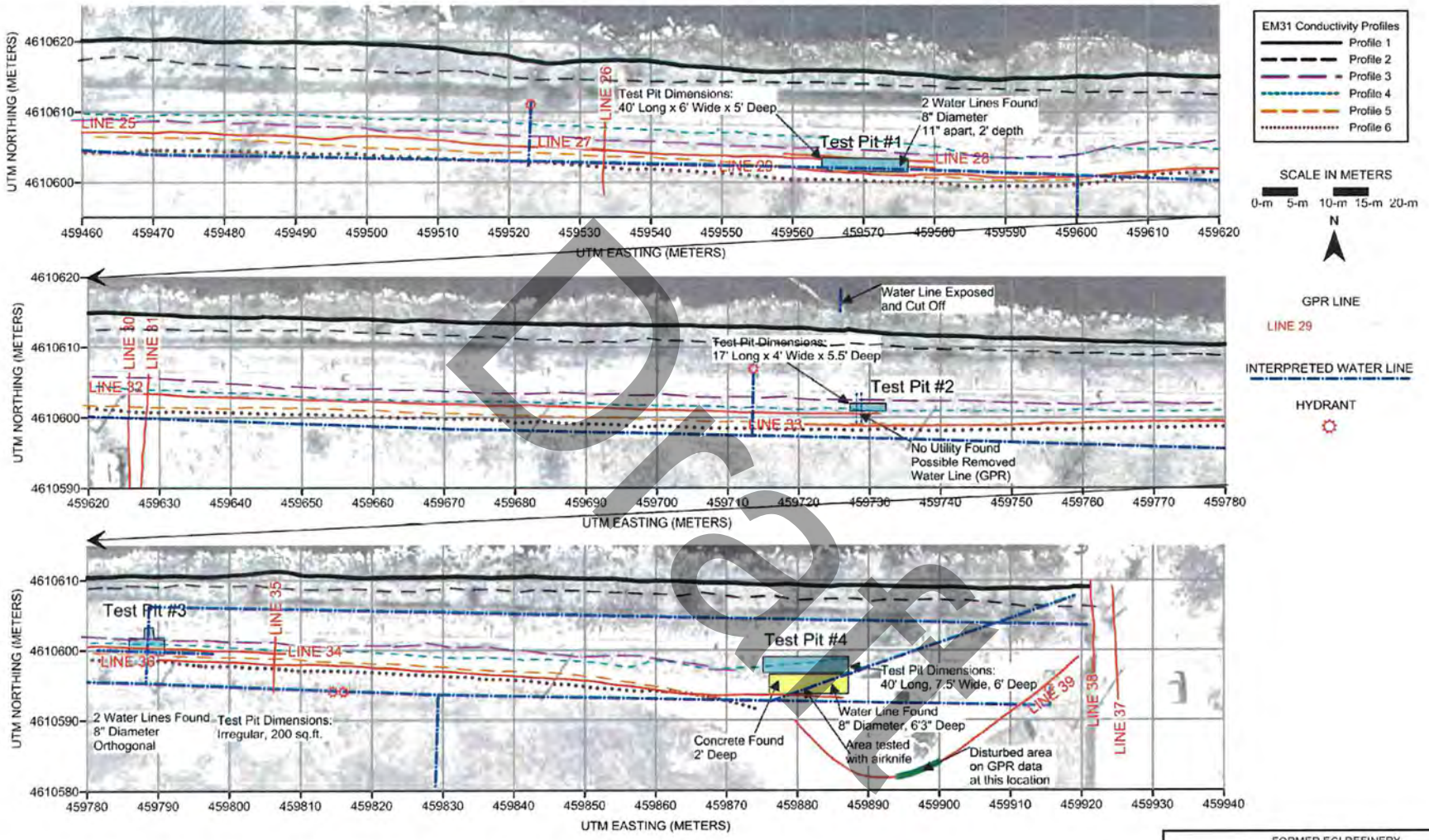

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EAST CHICAGO, INDIANA

EM31 Data Collection Area

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FIGURE
2

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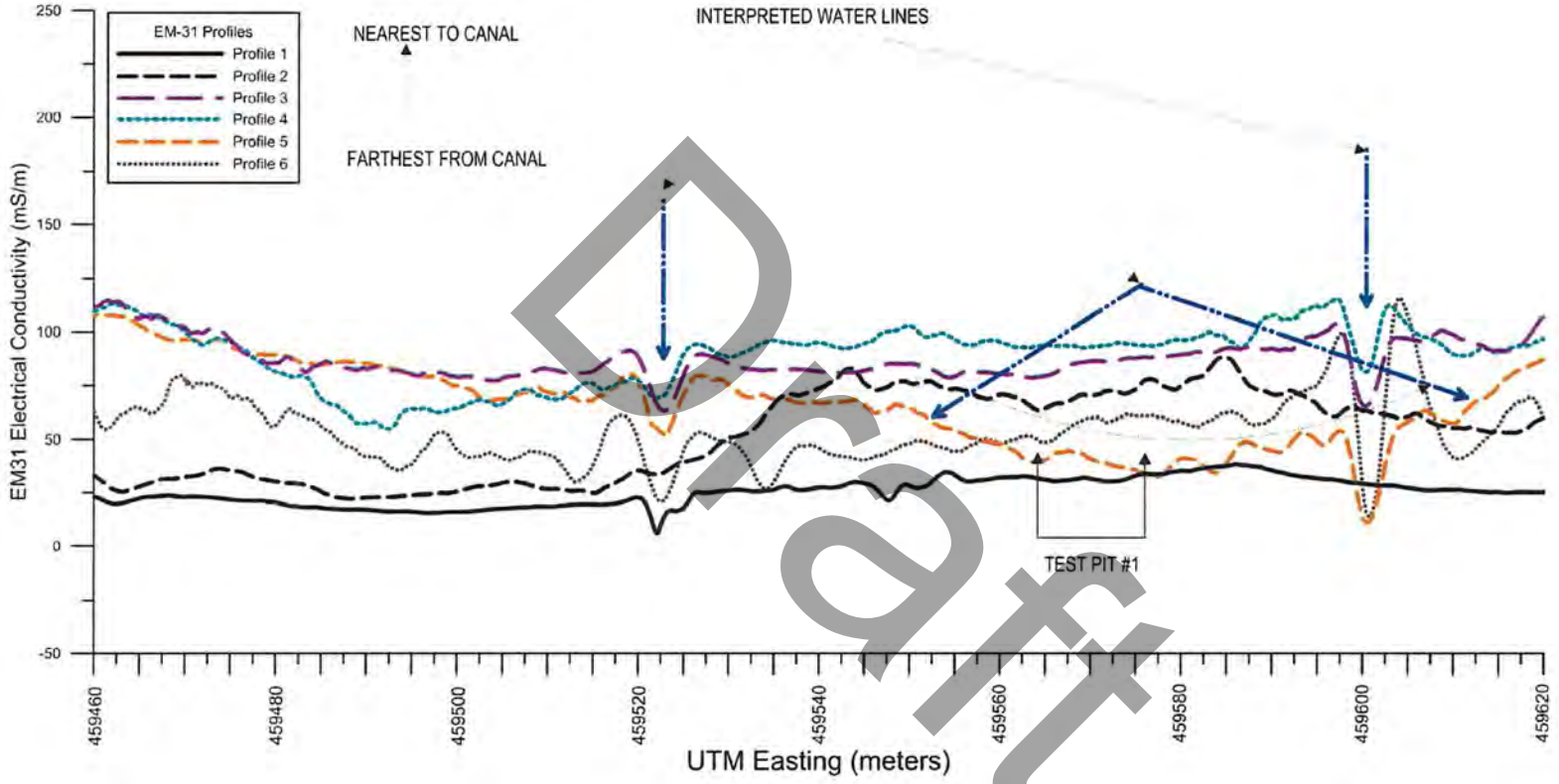

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EAST CHICAGO, INDIANA

EM31 Profiles - East Panel 1

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FIGURE
3

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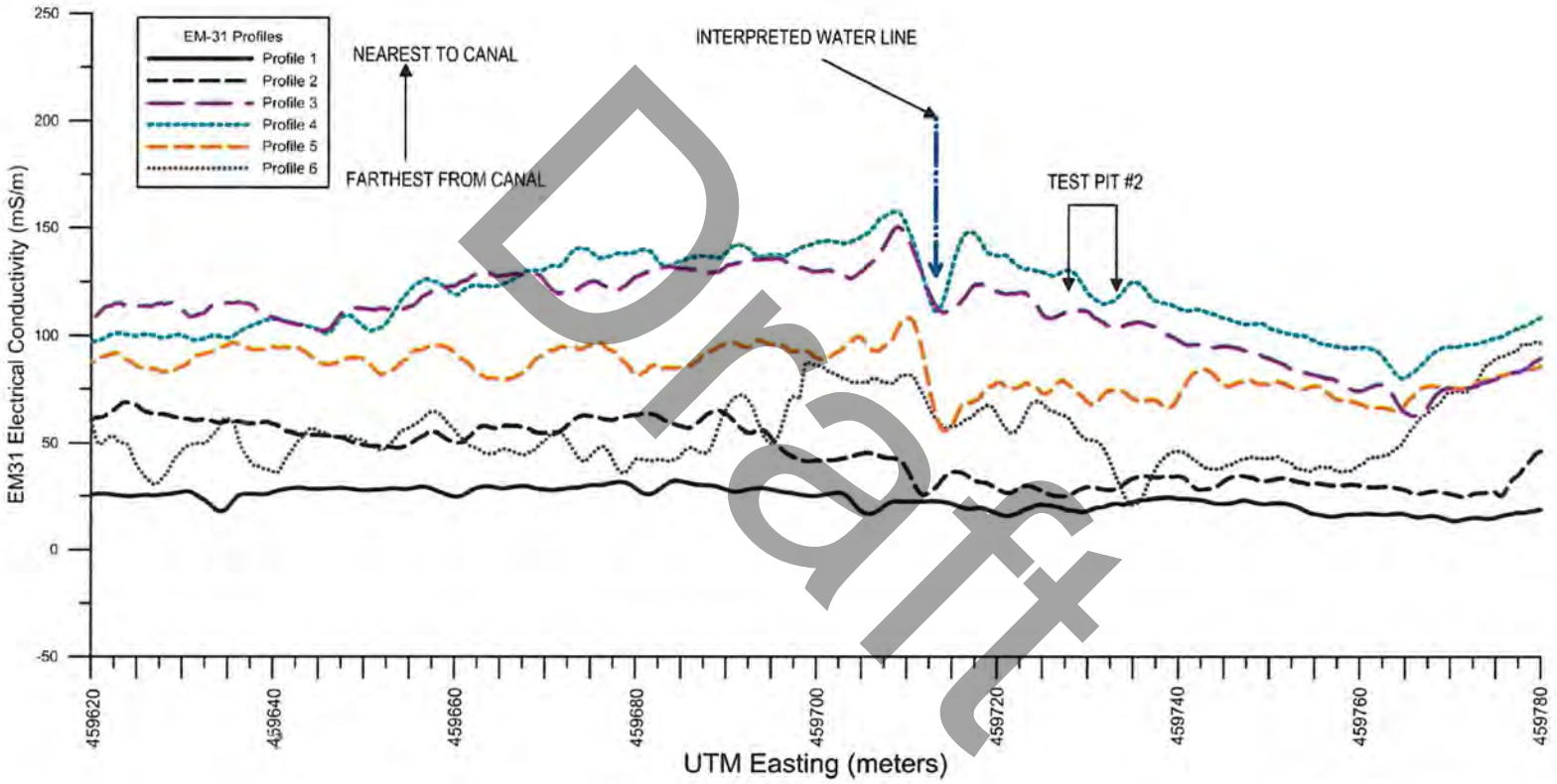

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EM31 Profiles - East Panel 2

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FIGURE
4

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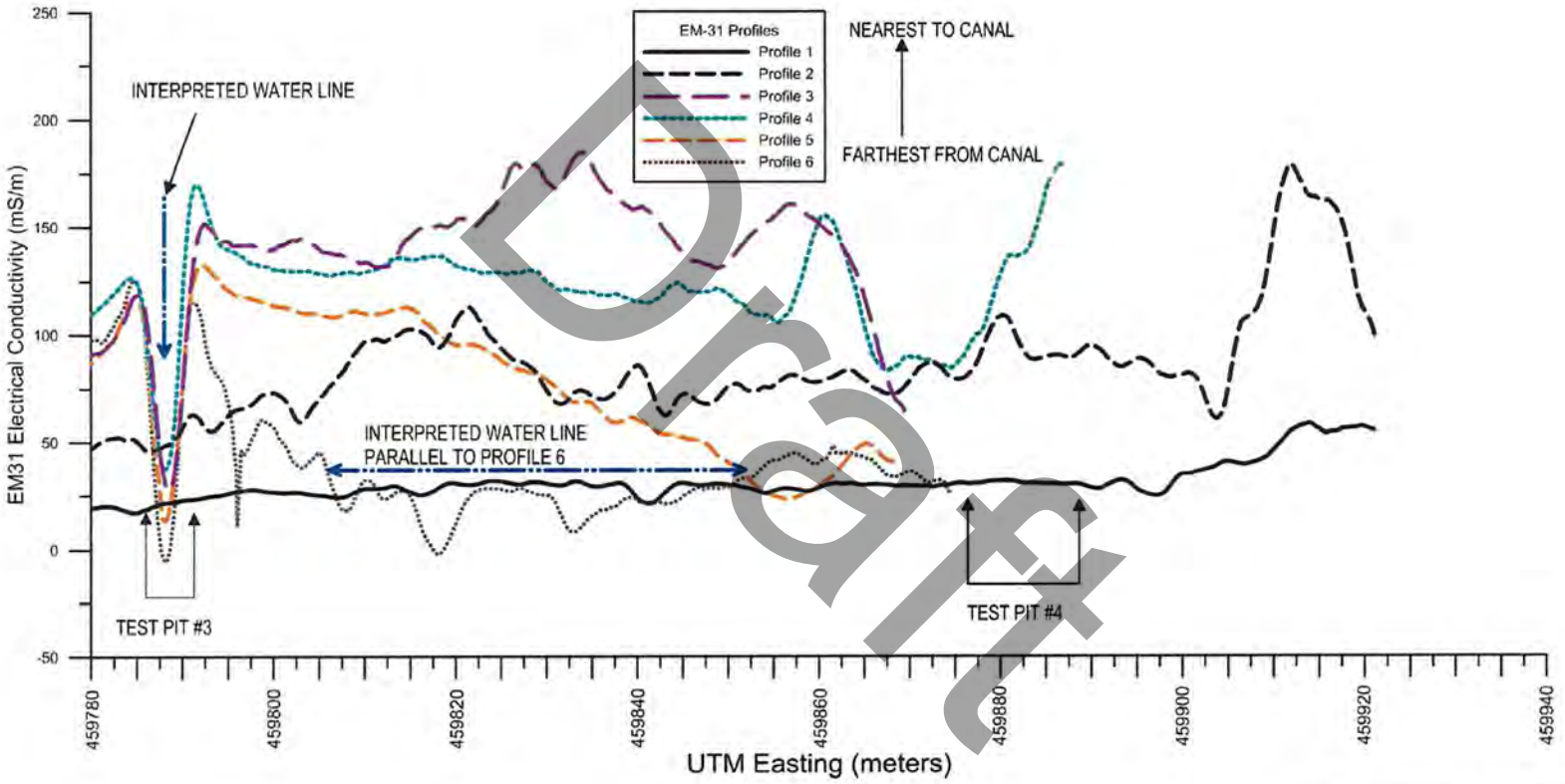

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EM31 Profiles - East Panel 3

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FIGURE
5

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B.3 – EXCERPTS FROM TETRA TECH DRAWINGS

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B.3.1: BATHYMETRY (TETRA TECH, 2017)

KEY
(NOT TO SCALE)

LEGEND

- 585 — EXISTING 5' CONTOUR INTERVAL (FEET, MSL)
- 581 — EXISTING 1' CONTOUR INTERVAL (FEET, MSL)
- × SURVEY POINT LOCATION
- ▼ LGC-1 SAMPLE POINT LOCATION AND NUMBER

JAMES B. WESCOTT
REGISTERED
PE10707857
STATE OF INDIANA
PROFESSIONAL ENGINEER

SIGNATURE DATE

REVISIONS		
NO.	DATE	DESCRIPTION

DESIGNED JW
DRAWN DKK
CHECKED SDD
DATE

Tetra Tech Inc.
1 S. Wacker Dr. Ste. 3700
Chicago, Illinois 60606
(312) 201-7700

NORTH

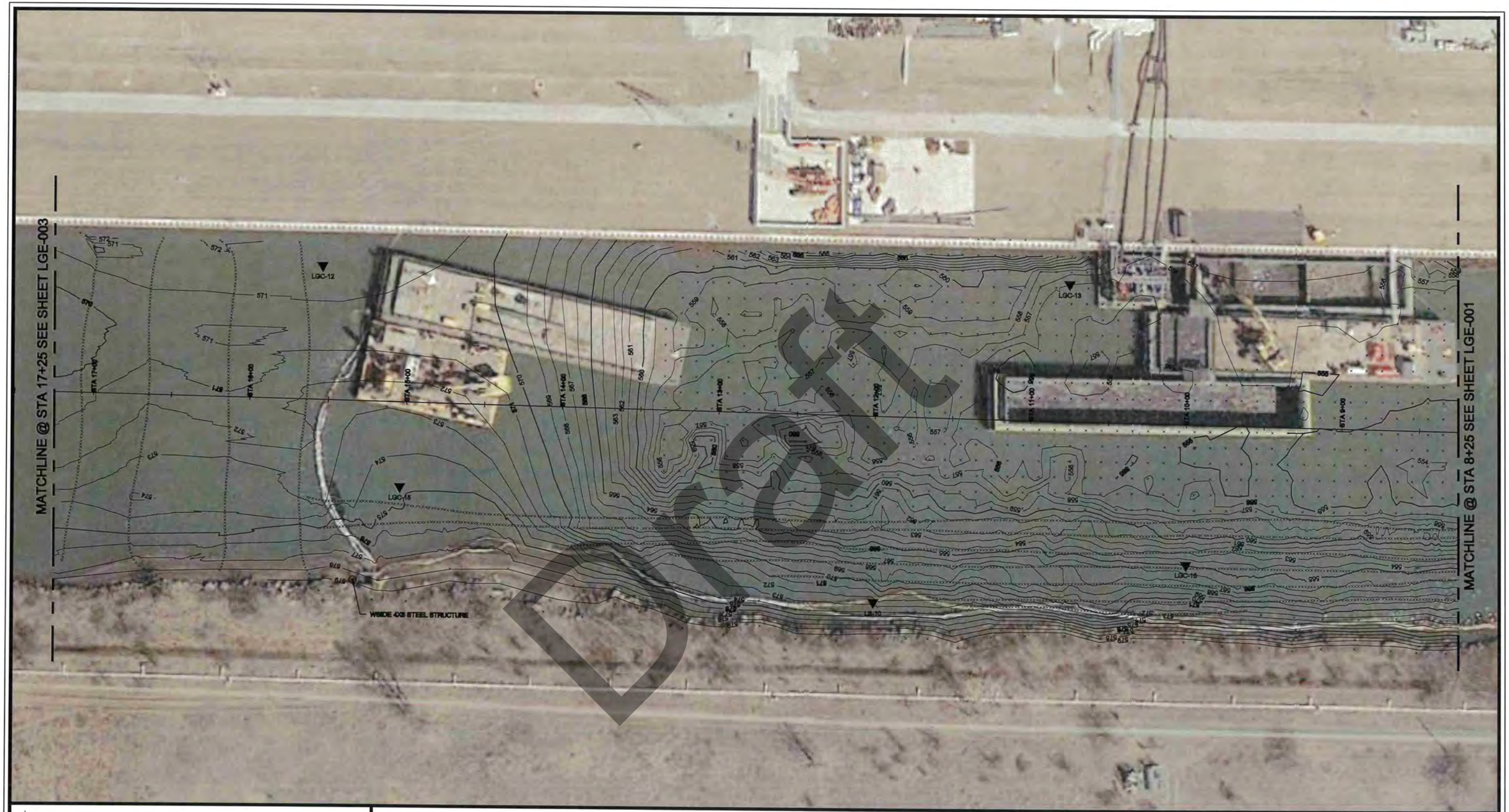
GRAND CALUMET and INDIANA HARBOR CANAL
REMEDIAL DESIGN
EAST CHICAGO WATERWAY MANAGEMENT DISTRICT
EAST CHICAGO, INDIANA 46312

VERIFY SCALE
BAR IS ONE (1) INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE (1) INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

SCALES:
HORIZONTAL SCALE: 1" = 80'
VERTICAL SCALE: NA

EXISTING SITE CONDITIONS
STA 0+00 THRU STA 8+25
LAKE GEORGE EAST & MIDDLE CANAL
REMEDIAL DESIGN

PROJECT NO. 103S3132
DRAWING NO. LGE-001
SHEET NO. 1 OF 5



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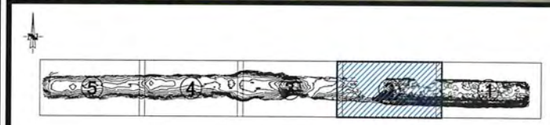

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- 581 — EXISTING 1' CONTOUR INTERVAL (FEET, MSL)
- × SURVEY POINT LOCATION
- ▼ LGC-1 SAMPLE POINT LOCATION AND NUMBER

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0 1"
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SCALES:
HORIZONTAL SCALE: 1" = 20'
VERTICAL SCALE: NA

EXISTING SITE CONDITIONS
STA 8+25 THRU STA 17+25
LAKE GEORGE EAST & MIDDLE CANAL
REMEDIAL DESIGN

PROJECT NO. 103S3132
DRAWING NO. LGE-002
SHEET NO. 2 OF 5

MATCHLINE @ STA 26+25 SEE SHEET LGE-004

MATCHLINE @ STA 17+25 SEE SHEET LGE-002

PILES EXTENDING OUT FROM SHORE FENDERING

FENDERING

(10) ABANDONED PIPELINES IN CANAL – DIA'S VARIES FROM 4" TO 10" ELEVAION VARIES FROM 848.32' - 852.83'

(4) ABANDONED PIPELINES IN CANAL – 14" DIA ELEVAION VARIES FROM 857.43' - 857.82'

UW 1 FOOT CLUSTER OF TIMBER PILES LIKELY FENDERING

CLUSTER OF PILES 1 FOOT UW EXTENDING UNDER BRIDGE FENDERING

FENDERING

FENDERING

TIMBERS FROM HERE TO SHORE UW 8 INCHES

ABANDONED 16 INCH PIPELINE

LGC-9B

LGC-9

LS-8

LGC-16A

STA 24+00

STA 23+50

STA 23+00

STA 22+50

STA 21+50

STA 20+00

STA 19+00

STA 18+00

KEY
(NOT TO SCALE)

LEGEND

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- 581 — EXISTING 1' CONTOUR INTERVAL (FEET, MSL)
- PIPELINE
- RAILROAD TRACKS
- × SURVEY POINT LOCATION
- LGC-1 SAMPLE POINT LOCATION AND NUMBER

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VERTICAL SCALE: NA

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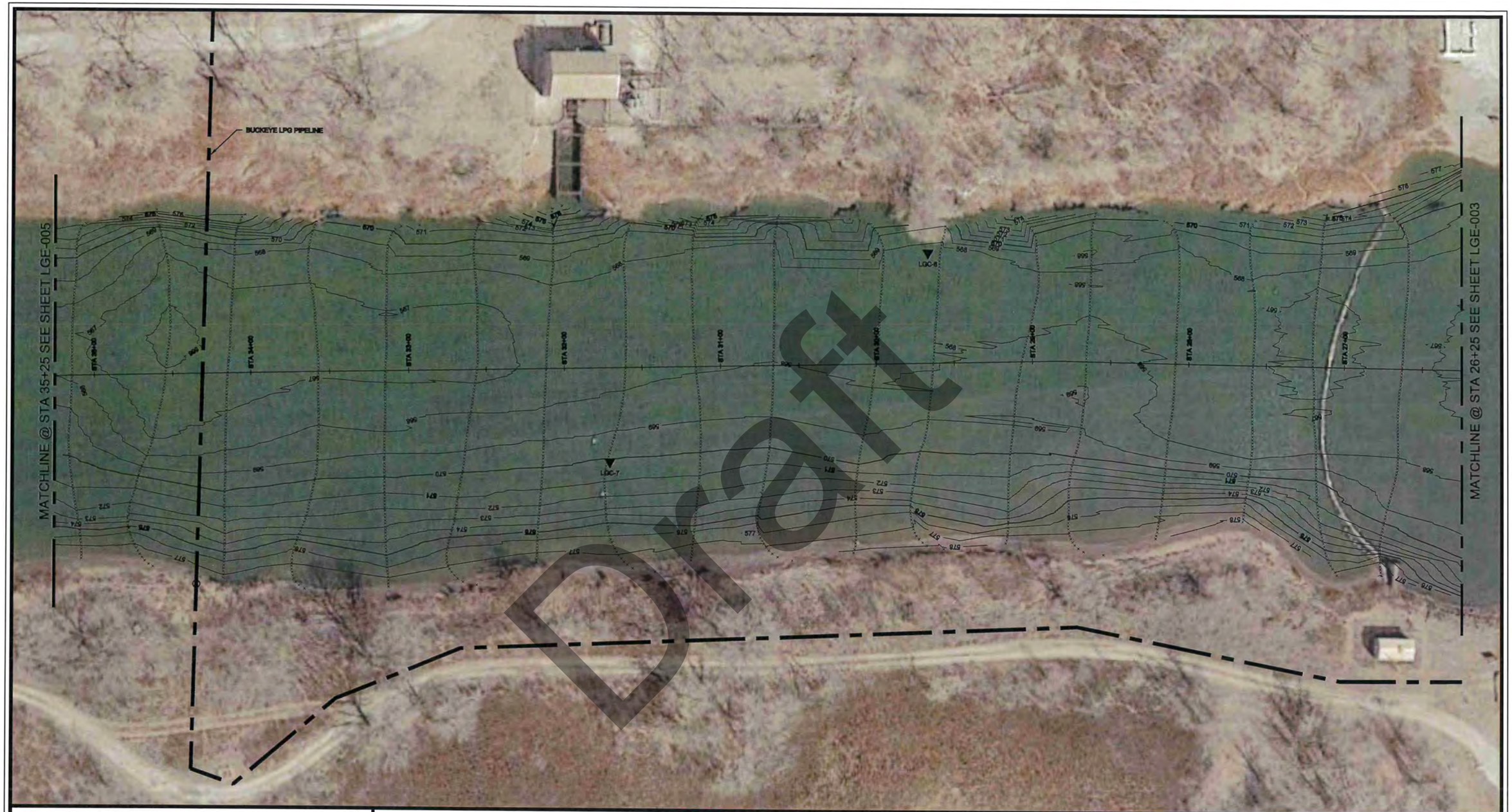

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- 581 — EXISTING 1' CONTOUR INTERVAL (FEET, MSL)
- PIPELINE
- × SURVEY POINT LOCATION
- ▼ LGC-1 SAMPLE POINT LOCATION AND NUMBER

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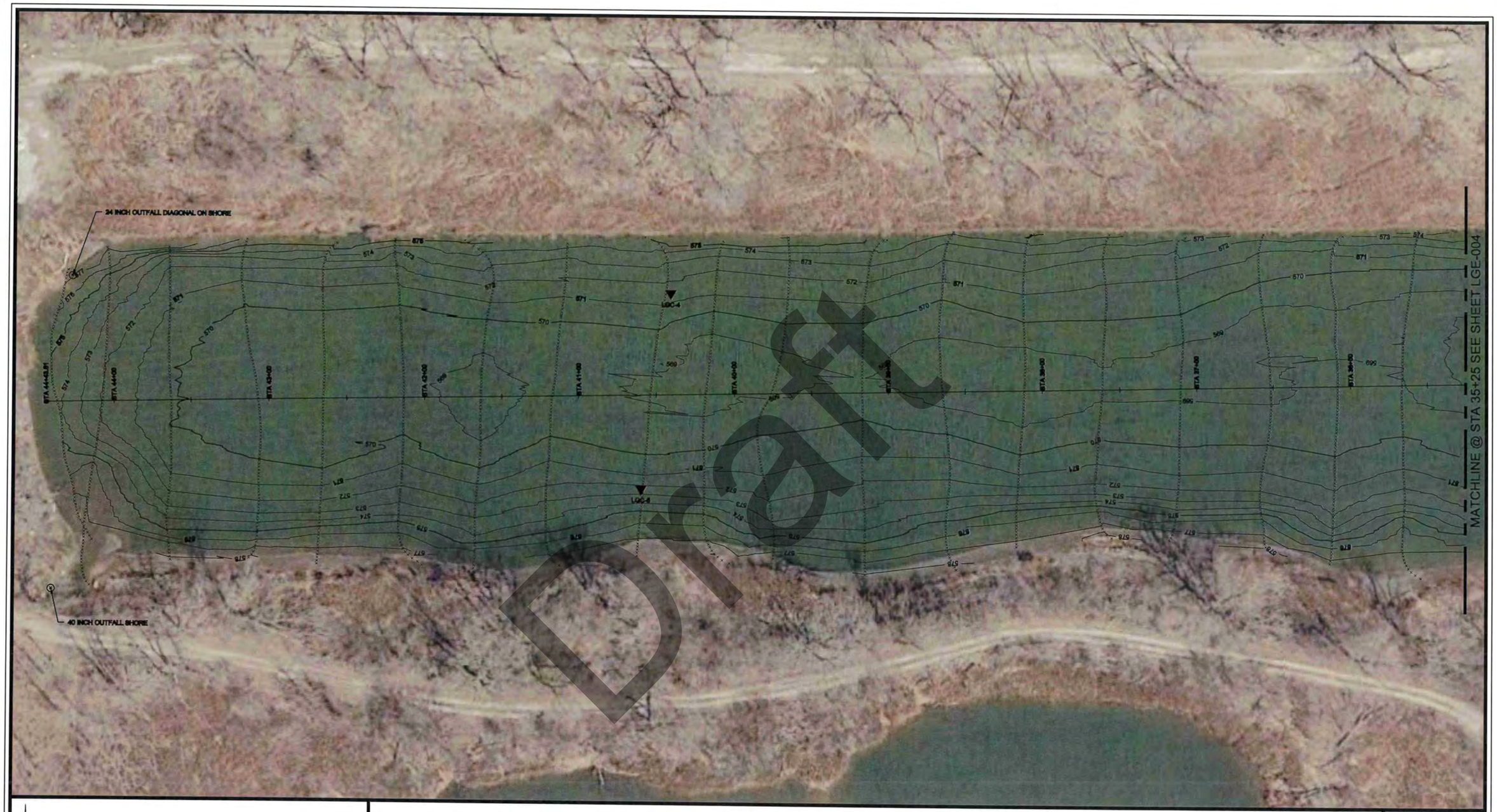

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- 581 — EXISTING 1' CONTOUR INTERVAL (FEET, MSL)
- × SURVEY POINT LOCATION
- ▼ LGC-1 SAMPLE POINT LOCATION AND NUMBER

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EXISTING SITE CONDITIONS
STA 35+25 THRU STA 44+43.61
LAKE GEORGE EAST & MIDDLE CANAL
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PROJECT NO. 10353132
DRAWING NO. LGE-005
SHEET NO. 5 OF 5

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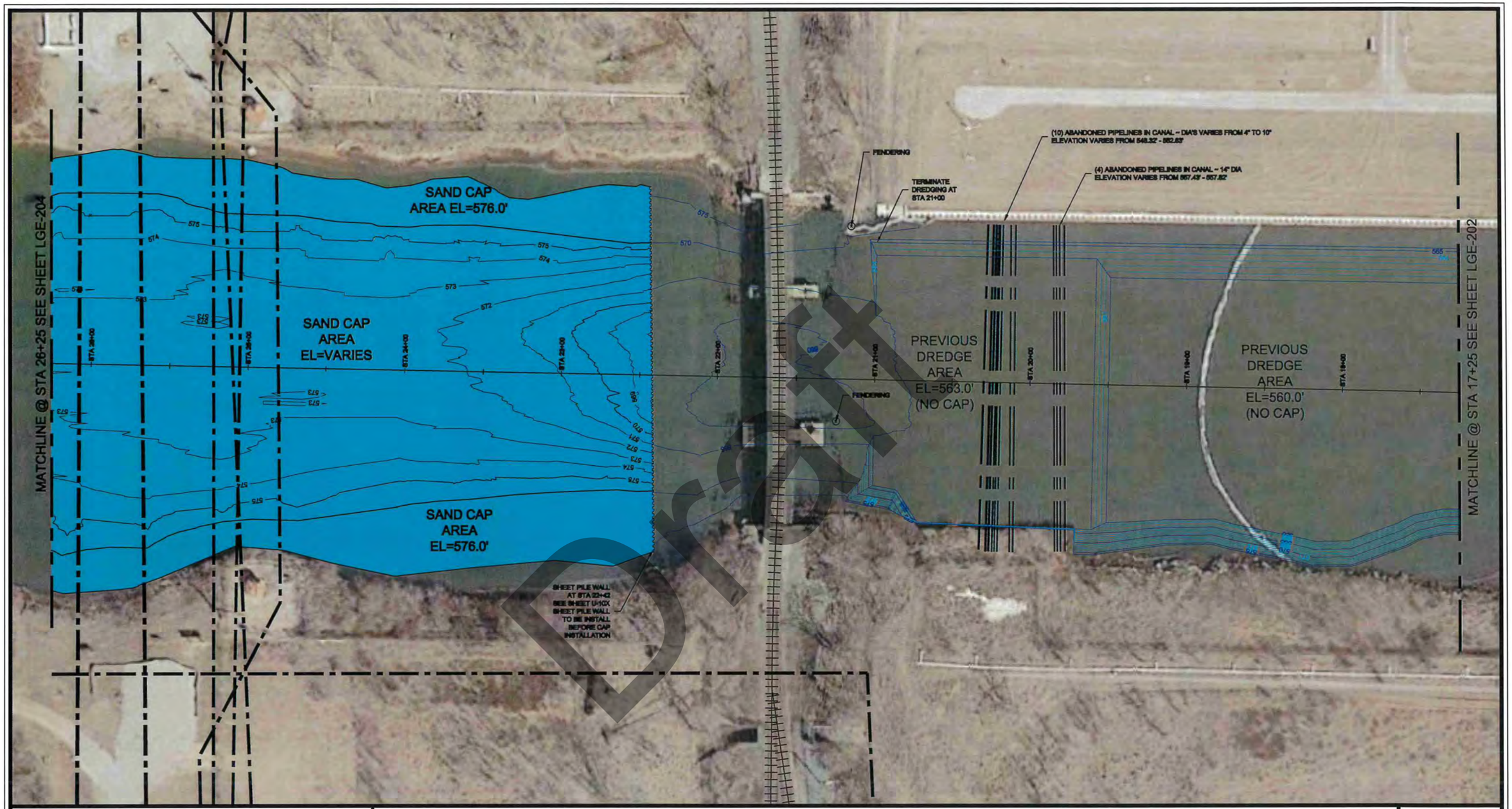
B.3.2: DREDGE PLAN (TETRA TECH, 2015D) (ONLY 2/10 SHEETS ARE CURRENTLY AVAILABLE)



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KEY
(NOT TO SCALE)

SAND CAP AREA
STA 22+42 THRU STA 44+43.61
AREA = 10.5030 ACRES
6' SAND VOLUME = 86,035 Cu. Yd.

NOTES
1. SAND WILL BE PLACED IN 1-FOOT LIFTS FOR THE FIRST 2 FEET AND 2-FOOT LIFTS THEREAFTER
2. ADD 1% ORGANOCLAY TO THE FIRST 2-FOOT THICK LIFT.

LEGEND
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- PROPOSED 1' CONTOUR INTERVAL (FEET, MSL)
- 585 — EXISTING 5' CONTOUR INTERVAL (FEET, MSL)
- 581 — EXISTING 1' CONTOUR INTERVAL (FEET, MSL)
- LIMITS OF CAPPING
- PIPELINE
- RAILROAD TRACKS

JAMES B. WESCOTT
REGISTERED
PE10707857
STATE OF
INDIANA
PROFESSIONAL ENGINEER
SIGNATURE DATE

REVISIONS		
NO.	DATE	DESCRIPTION

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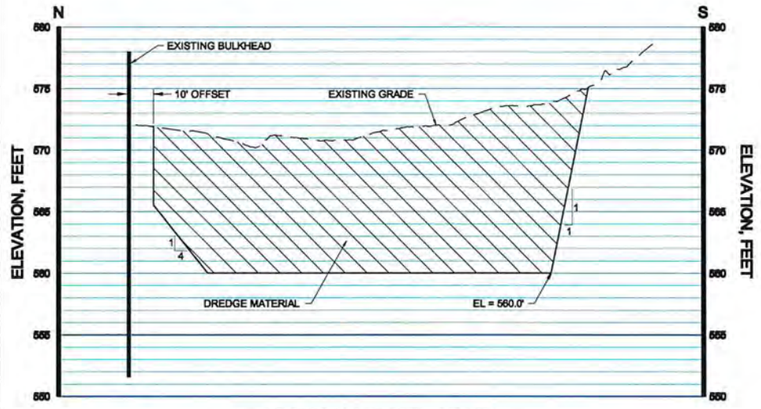
GRAND CALUMET and INDIANA HARBOR CANAL
REMEDIAL DESIGN
EAST CHICAGO WATERWAY MANAGEMENT DISTRICT
EAST CHICAGO, INDIANA 46312

VERIFY SCALE
BAR IS ONE (1) INCH ON ORIGINAL DRAWING.
0 — 1"
IF NOT ONE (1) INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

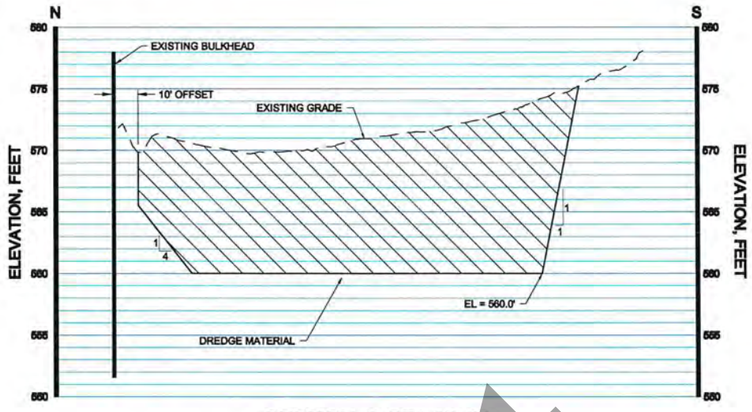
SCALES:
HORIZONTAL SCALE: 1" = 20'
VERTICAL SCALE: NA

CANAL CAP PLAN
STA 17+25 THRU STA 26+25
LAKE GEORGE EAST & MIDDLE CANAL
REMEDIAL DESIGN

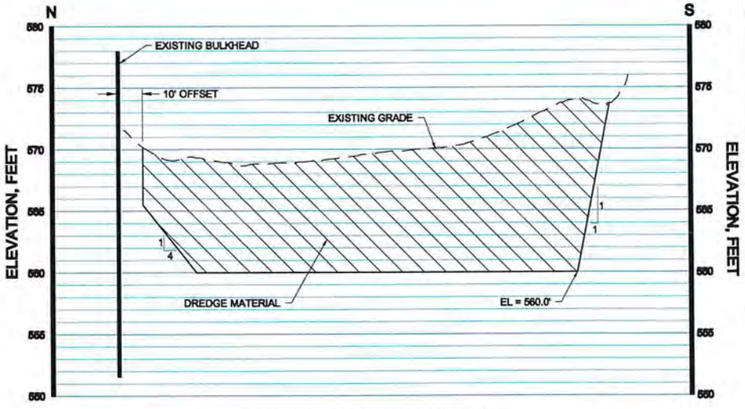
PROJECT NO. 103S3132
DRAWING NO. LGE-203
SHEET NO. 3 OF 5



SECTION @ STA 17+00



SECTION @ STA 18+00



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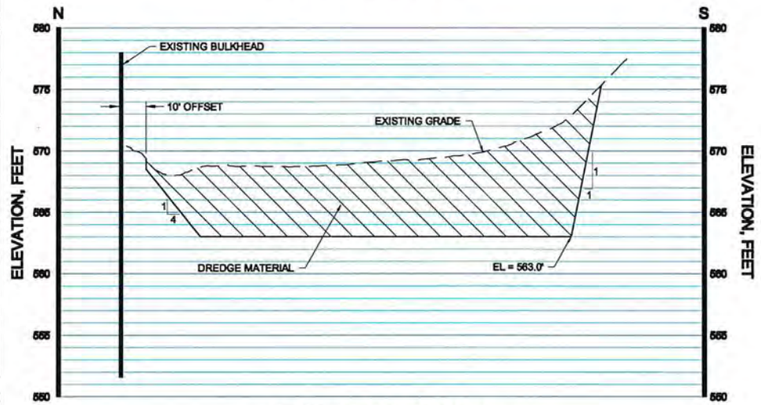

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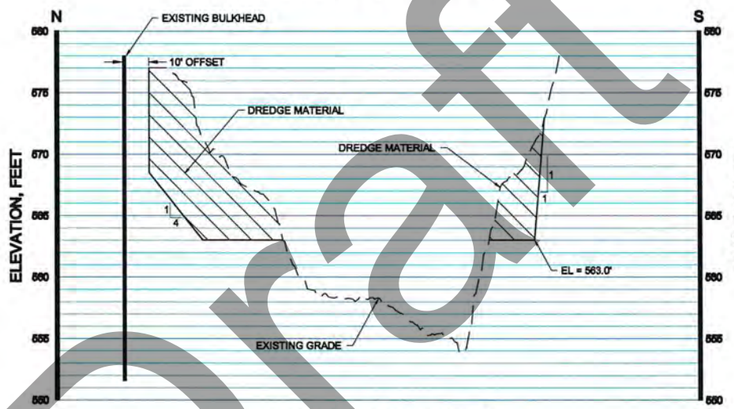
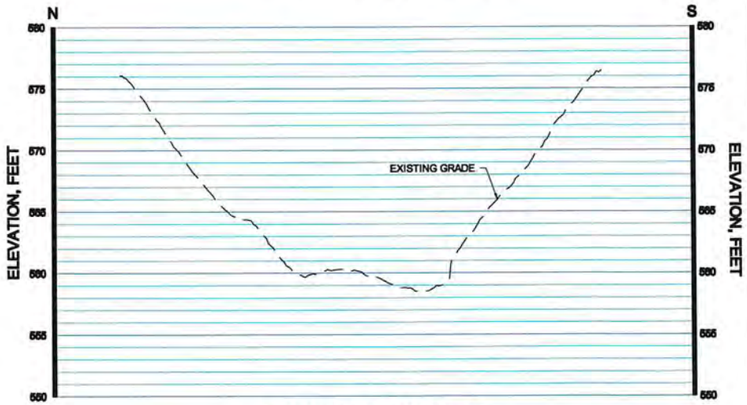
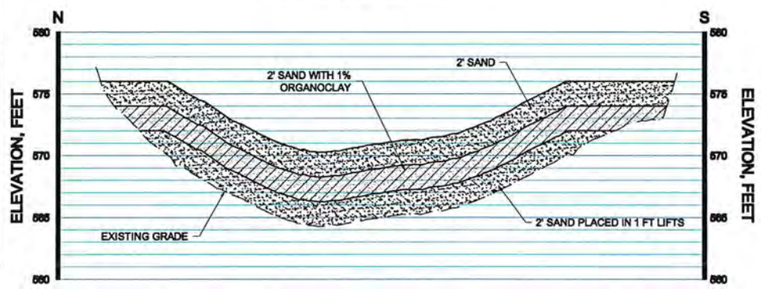


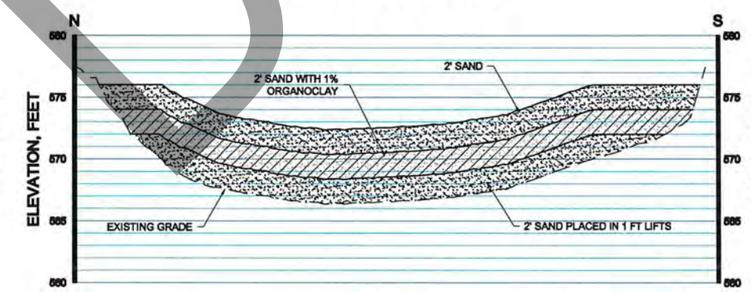
SECTION @ STA 21+00



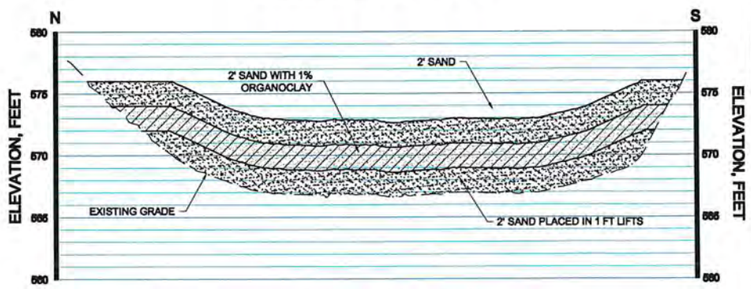
SECTION @ STA 22+00



SECTION @ STA 23+00



SECTION @ STA 24+00



SECTION @ STA 25+00

NOTES

1. SAND WILL BE PLACED IN 1-FOOT LIFTS FOR THE FIRST 2 FEET AND 2-FOOT LIFTS THEREAFTER
2. ADD 1% ORGANOCLAY TO THE FIRST 2-FOOT THICK LIFT

KEY

- DREDGE MATERIAL
- SAND WITH 1% ORGANOCLAY
- SAND

JAMES B. WESCOTT REGISTERED PE10707857 STATE OF INDIANA PROFESSIONAL ENGINEER

SIGNATURE DATE

Draft

REVISIONS		
NO.	DATE	DESCRIPTION

DESIGNED JW
DRAWN DKK
CHECKED SDD
DATE 12/15

Tetra Tech Inc.
1 S. Wacker Dr. Ste. 3700
Chicago, Illinois 60606
(312) 201-7700

NORTH

GRAND CALUMET and INDIANA HARBOR CANAL
REMEDIAL DESIGN
EAST CHICAGO WATERWAY MANAGEMENT DISTRICT
EAST CHICAGO, INDIANA 46312

VERIFY SCALE
BAR IS ONE (1) INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE (1) INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

SCALES:
HORIZONTAL SCALE: 1" = 30'
VERTICAL SCALE: NA

CANAL CROSS-SECTIONS STA 17+00 THRU STA 25 +00 LAKE GEORGE EAST & MIDDLE CANAL REMEDIAL DESIGN

PROJECT NO. 10333132
DRAWING NO. LGE-303
SHEET NO. 3 OF 5

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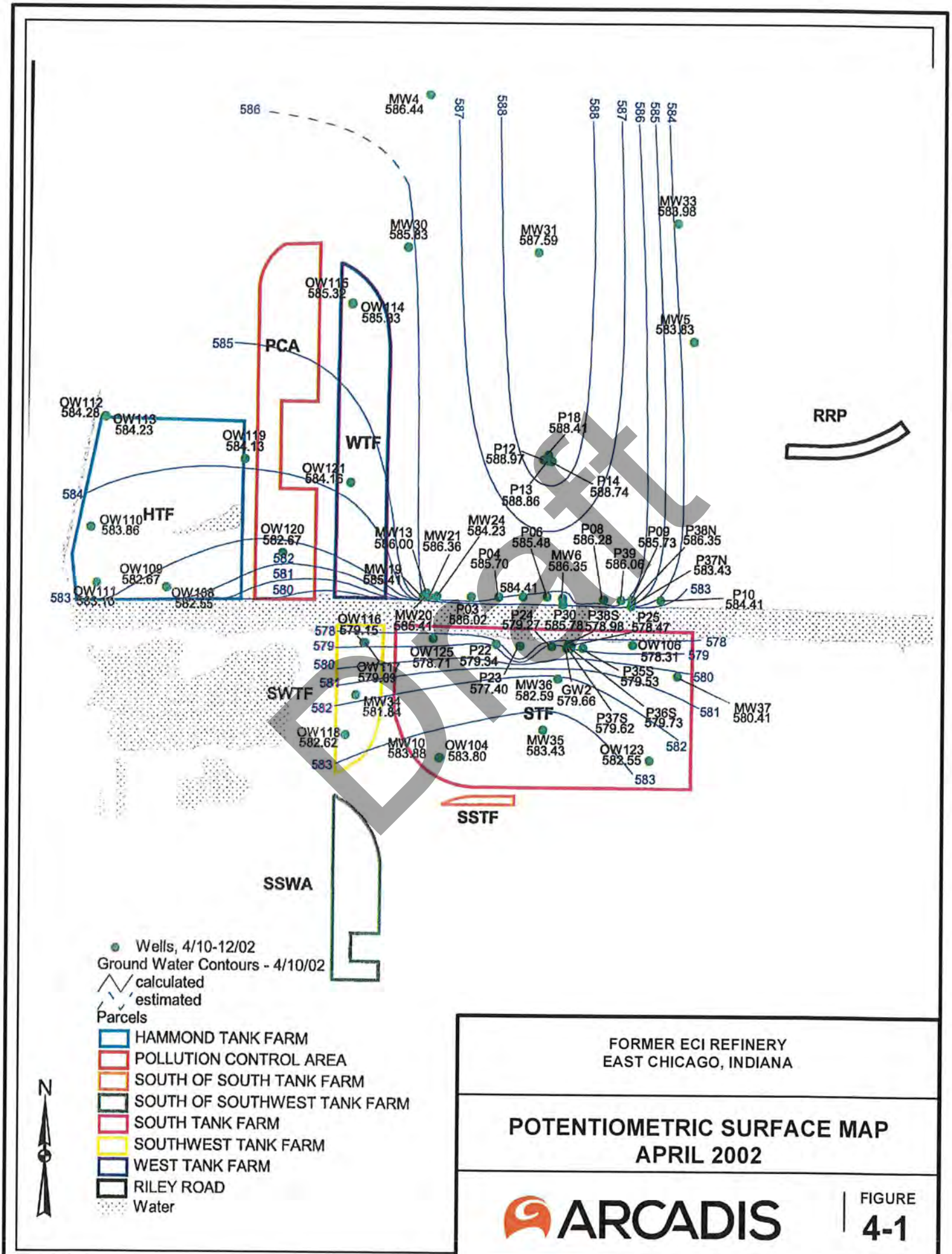
B.4 – EXCERPTS FROM 2016 SITE INVESTIGATION REPORT

Draft

B.4.1: FIGURES 4-1 TO 4-3



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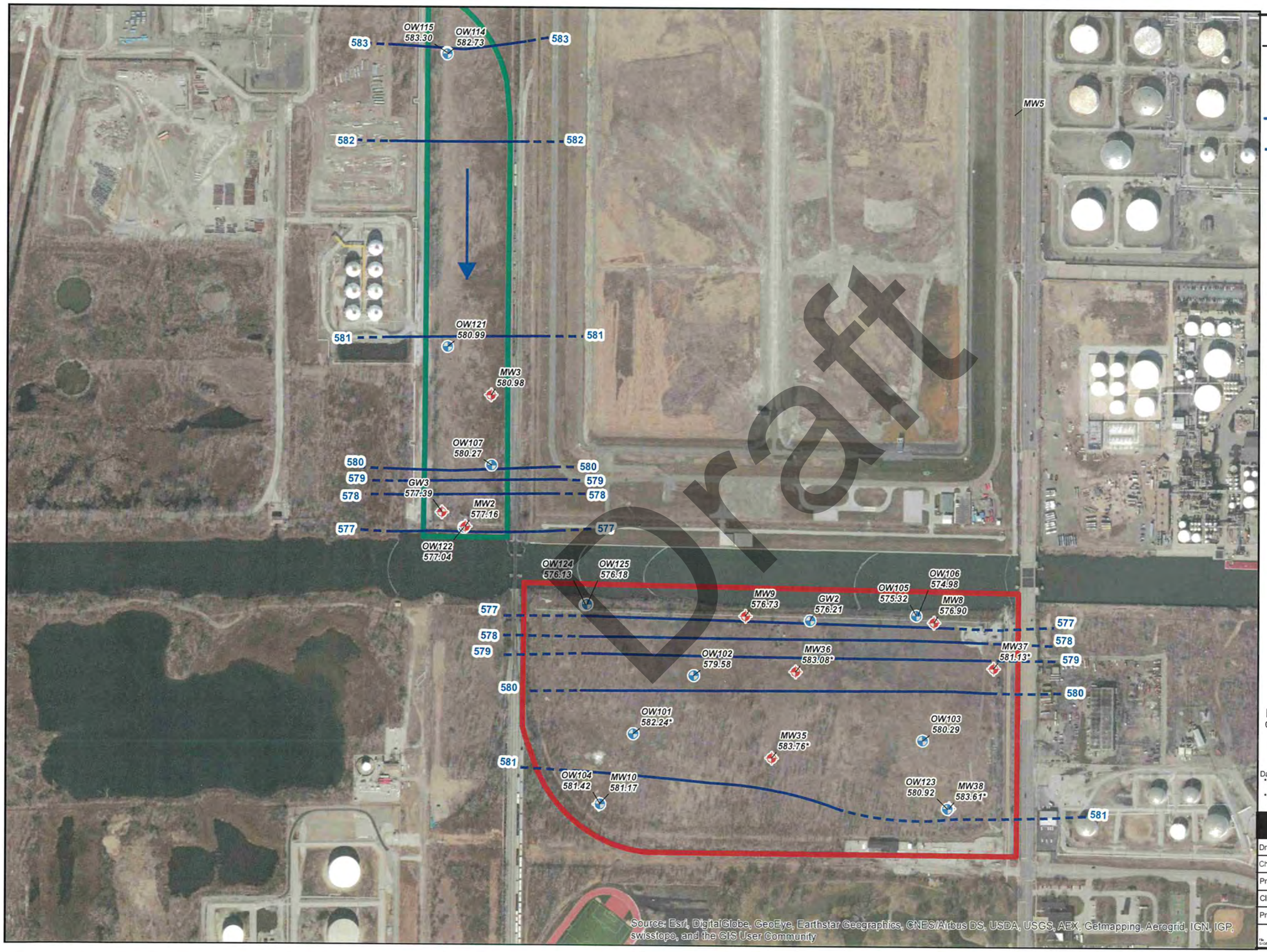
FORMER ECI REFINERY
EAST CHICAGO, INDIANA

POTENTIOMETRIC SURFACE MAP
APRIL 2002

ARCADIS

FIGURE
4-1



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Legend

- Monitoring Well
- Observation Well
- Potentiometric Surface (Dashed where inferred)
- Groundwater Flow Direction

Parcels

- South Tank Farm (STF)
- West Tank Farm (WTF)

Note:
*Wells not used for groundwater contouring

Groundwater elevations have been corrected for the presence of LNAPL using an estimated LNAPL specific gravity of 0.9.

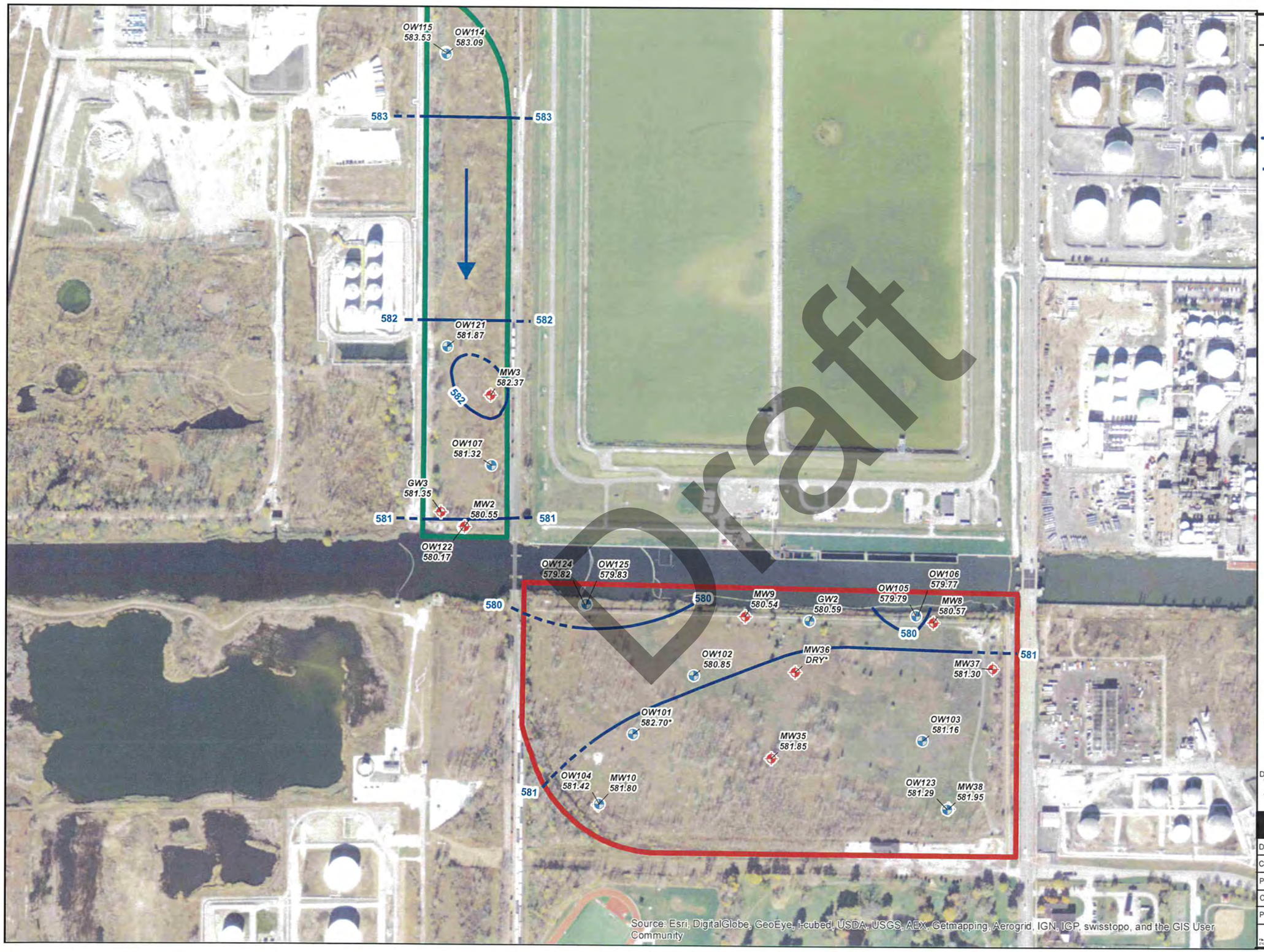
N
W E
S

0 100 200 400 600 Feet

Data Sources:
* Tank locations: AEPT Environmental Technologies. 1992. 1977 Inventory Content, Figure 4-2.
* Tank locations: AEPT Environmental Technologies. 1992. ECI Pipe Map.

Potentiometric Surface Map March 2014

Drawn By: B. Griffith	Date Drawn: 4/29/2015
Checked By:	Scale: 1" = 400'
Project Manager:	Figure: 4-2
Client: ECI	
Project #: CI001067.0020	ARCADIS



Draft

Legend

- Monitoring Well
- Observation Well
- Potentiometric Surface (Dashed where inferred)
- Groundwater Flow Direction

Parcels

- South Tank Farm (STF)
- West Tank Farm (WTF)

Note:
*Wells not used for groundwater contouring

N
W E
S

0 100 200 400 600 Feet

Data Sources:
* Tank locations: AEPT Environmental Technologies, 1992. 1977 Inventory Content, Figure 4-2.
* Tank locations: AEPT Environmental Technologies, 1992. ECI Pipe Map.

Potentiometric Surface Map October 2015

Drawn By: B. Griffith	Date Drawn: 5/2/2016
Checked By:	Scale: 1" = 400'
Project Manager:	Figure: 4-3
Client: ECI	ARCADIS
Project #: CI001067.8996	35 E. Wacker Dr. Suite 1000 Chicago, IL 60601 Tel: 312-263-6703 Fax: 312-263-7897 www.arcadis-us.com

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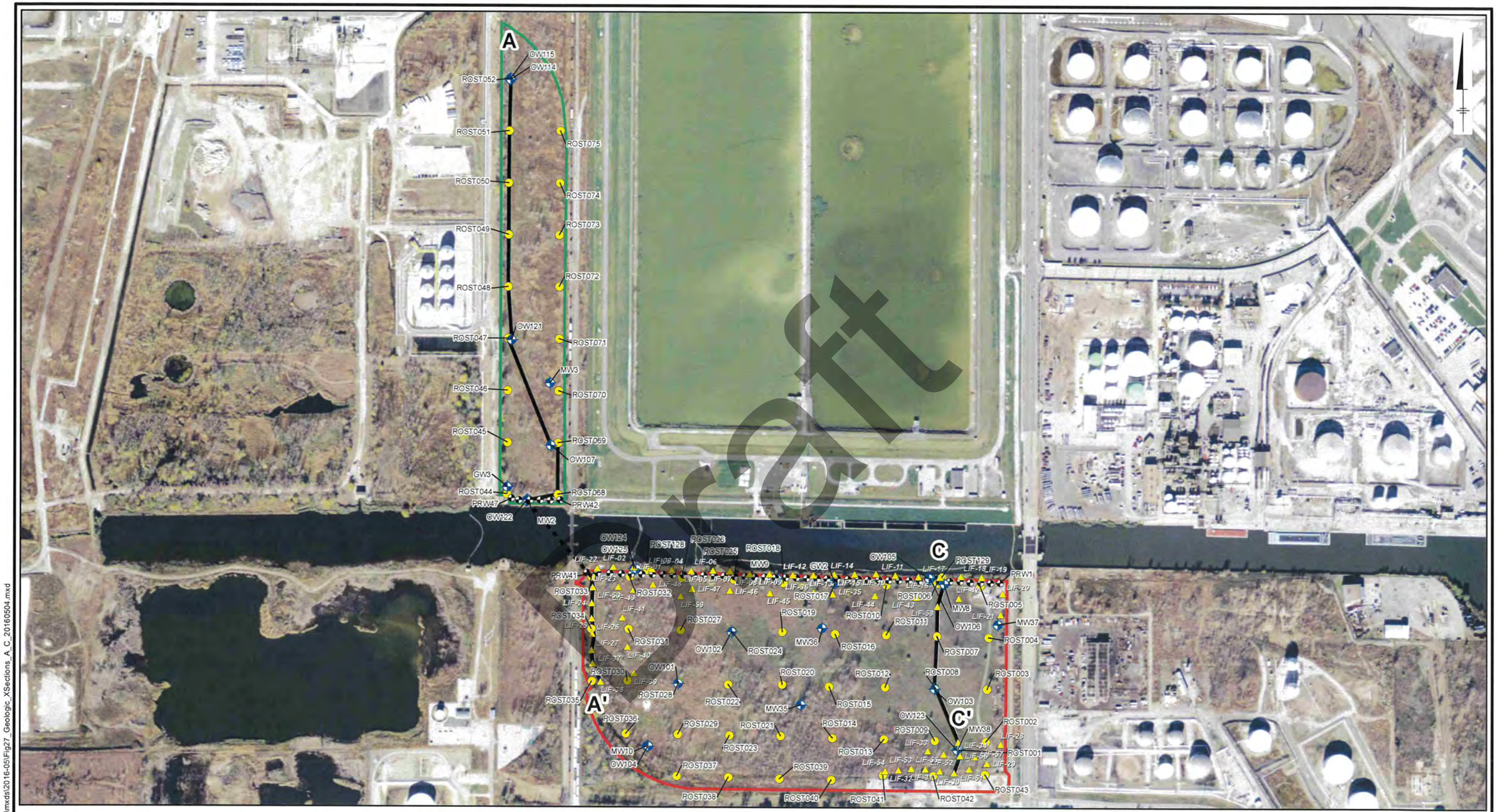
B.4.2: GEOLOGIC SECTIONS (FIGURES 27, 28, 29, 30 AND 31)



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LEGEND:

- LIF Boring
- ROST Boring
- Monitoring Well
- Product Recovery Well
- Cross Section Location
- South Tank Farm
- West Tank Farm

0 400 800 Feet

GRAPHIC SCALE

NOTES:

1) PRODUCT RECOVERY WELLS (PRW) ARE NUMBERED SEQUENTIALLY EAST TO WEST. PRW1 THROUGH PRW41 IN THE SOUTH TANK FARM, PRW42 THROUGH 47 IN THE WEST TANK FARM.

2) AERIAL IMAGE: ARCGIS ONLINE BASEMAP, 3/2012 IMAGE ACCESSED ON 5/4/2016

FORMER ECI REFINERY
EAST CHICAGO, INDIANA

LOCATION OF GEOLOGIC CROSS SECTIONS A-A' AND C-C'

ARCADIS

FIGURE 27

CITY: MPLS DIV/GROUP: IM/DV DB: MG LD: JK
ECI
Document Path: Z:\GISPROJECTS_ENVECI\mxds\2016-05\Fig27_Geologic_XSections_A_C_20160504.mxd

Draft

LEGEND:

- LIF Boring
- ROST Boring
- Monitoring Well
- Product Recovery Well
- Cross Section Location
- South Tank Farm
- West Tank Farm

0 180 360 Feet

GRAPHIC SCALE

NOTES:

1) PRODUCT RECOVERY WELLS (PRW) ARE NUMBERED SEQUENTIALLY EAST TO WEST. PRW1 THROUGH PRW41 IN THE SOUTH TANK FARM, PRW42 THROUGH 47 IN THE WEST TANK FARM.

2) AERIAL IMAGE: ARCGIS ONLINE BASEMAP, 3/2012 IMAGE ACCESSED ON 5/4/2016

FORMER ECI REFINERY
EAST CHICAGO, INDIANA

LOCATION OF GEOLOGIC CROSS SECTION B-B'

ARCADIS

FIGURE
28

CITY: MPLS DIV/GROUP: IM/DV DB: MG LD: JK
ECI
Document Path: Z:\GIS\PROJECTS_ENV\ECI\mxds\2016-05\Fig28_Geologic_XSections_B_20160504.mxd

CITY:COSTA MESA DIV/GROUP:ENVICAD DB:ENVICAD.bar PM:
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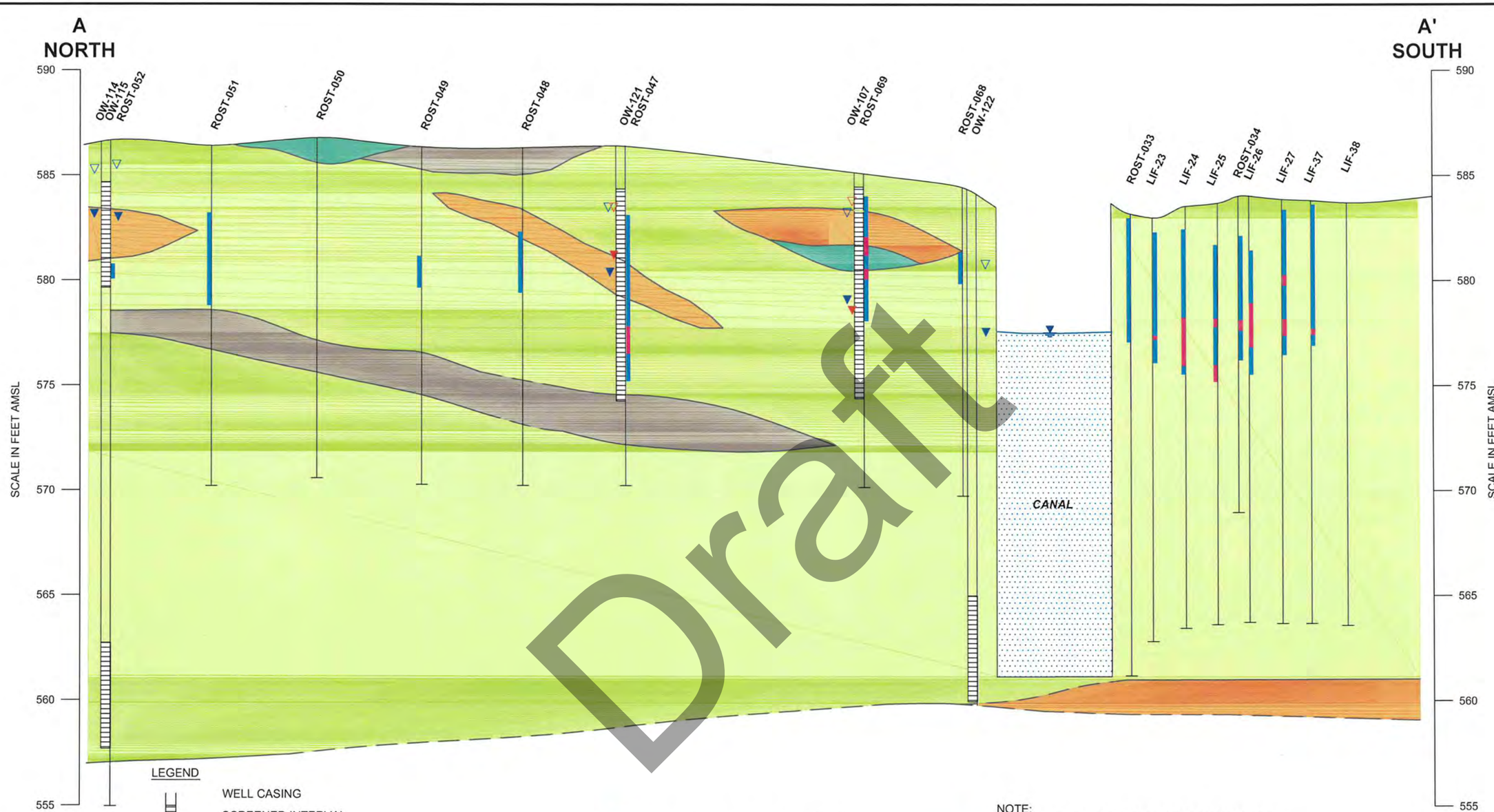

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LEGEND

- WELL CASING
- SCREENED INTERVAL
- END OF ROST BORING
- AVERAGE WATER LEVEL IN CANAL (DECEMBER 2015)
- MINIMUM GROUNDWATER ELEVATION
- MAXIMUM GROUNDWATER ELEVATION
- APPROXIMATE HISTORICAL HIGH WATER LEVEL IN CANAL
- MINIMUM LNAPL ELEVATION
- MAXIMUM LNAPL ELEVATION
- LIF/ROST LOCATION WITH PEAK FLUORESCENCE BETWEEN 10% AND 100% RE
- LIF/ROST LOCATION WITH PEAK FLUORESCENCE BETWEEN 100% AND 200% RE
- LIF/ROST LOCATION WITH PEAK FLUORESCENCE ABOVE 200% RE

- **PEAT:** HUMUS, SWAMP SOIL WITH HIGH ORGANIC CONTENT
- **SAND:** POORLY GRADED, LOOSE, FINE TO COARSE GRAINED
- **CLAY:**LOW TO HIGH PLASTICITY, SILTY CLAY
- **GRAVEL:** GRAVEL SAND MIXTURES, LITTLE TO NO FINES

INFERRED CONTACT

AMSL = ABOVE MEAN SEA LEVEL

ELEVATIONS BASED OFF OF NAVD 1988 BENCHMARK

NOTE:
BOTTOM OF CANAL IS APPROXIMATE BASED ON REPORTED DEPTH.

0 5 10
VERTICAL SCALE IN FEET

0 250 500
HORIZONTAL SCALE IN FEET

FORMER BP/AMOCO REFINERY
INDIANA HARBOR AND SHIP CANAL, EAST CHICAGO, ILLINOIS

GEOLOGIC CROSS SECTION A-A'

ARCADIS Design & Consultancy for natural and built assets

FIGURE
29

B
WEST

B'
EAST

590
585
580
575
570
565
560
555

SCALE IN FEET AMSL

CANAL

ROST-044 PRW47 PRW46 OW-122 MW-27 PRW45 PRW44 PRW43 ROST-068 PRW42 PRW41 ROST-033 LIF-22 PRW40 PRW39 LIF-02 PRW38 PRW37 LIF-01 OW-124 PRW36 ROST-128 LIF-03 PRW35 PRW34 LIF-04 PRW33 PRW32 ROST-026 LIF-05 PRW31 PRW30 LIF-06 PRW29 PRW28 LIF-07 PRW27 ROST-025 PRW26 LIF-08 PRW25 PRW24 LIF-09 PRW23 MW-9 ROST-018 PRW22 LIF-12 PRW21 PRW20 LIF-13 PRW19 PRW18 LIF-14 ROST-017 GW-2* PRW17 PRW16 LIF-15 PRW15 PRW14 LIF-10 PRW13 ROST-010 PRW12 LIF-11 PRW11 PRW10 LIF-16 PRW9 PRW8 OW-105 PRW7 OW-106 LIF-17 ROST-129 PRW6 PRW5 LIF-18 PRW4 PRW3 LIF-19 PRW2 PRW1 LIF-20

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LEGEND

- WELL CASING
- SCREENED INTERVAL
- END OF ROST BORING
- MINIMUM GROUNDWATER ELEVATION
- MAXIMUM GROUNDWATER ELEVATION
- MINIMUM LNAPL ELEVATION
- MAXIMUM LNAPL ELEVATION
- LIF/ROST LOCATION WITH PEAK FLUORESCENCE BETWEEN 10% AND 100% RE
- LIF/ROST LOCATION WITH PEAK FLUORESCENCE BETWEEN 100% AND 200% RE
- LIF/ROST LOCATION WITH PEAK FLUORESCENCE ABOVE 200% RE
- AMSL = ABOVE MEAN SEA LEVEL
- INFERRED CONTACT
- BREAK IN CONTINUOUS SECTION

ELEVATIONS BASED OFF OF NAVD 1988 BENCHMARK

- **PEAT:** HUMUS, SWAMP SOIL WITH HIGH ORGANIC CONTENT
- **SAND:** POORLY GRADED, LOOSE, FINE TO COARSE GRAINED
- **SILTY SAND:** FINE TO VERY FINE GRAINED, TRACE COARSE SAND
- **CLAY:** LOW TO HIGH PLASTICITY, SILTY CLAY
- **GRAVEL:** GRAVEL SAND MIXTURES, LITTLE TO NO FINES

0 7.5 14
VERTICAL SCALE IN FEET

0 250 500
HORIZONTAL SCALE IN FEET

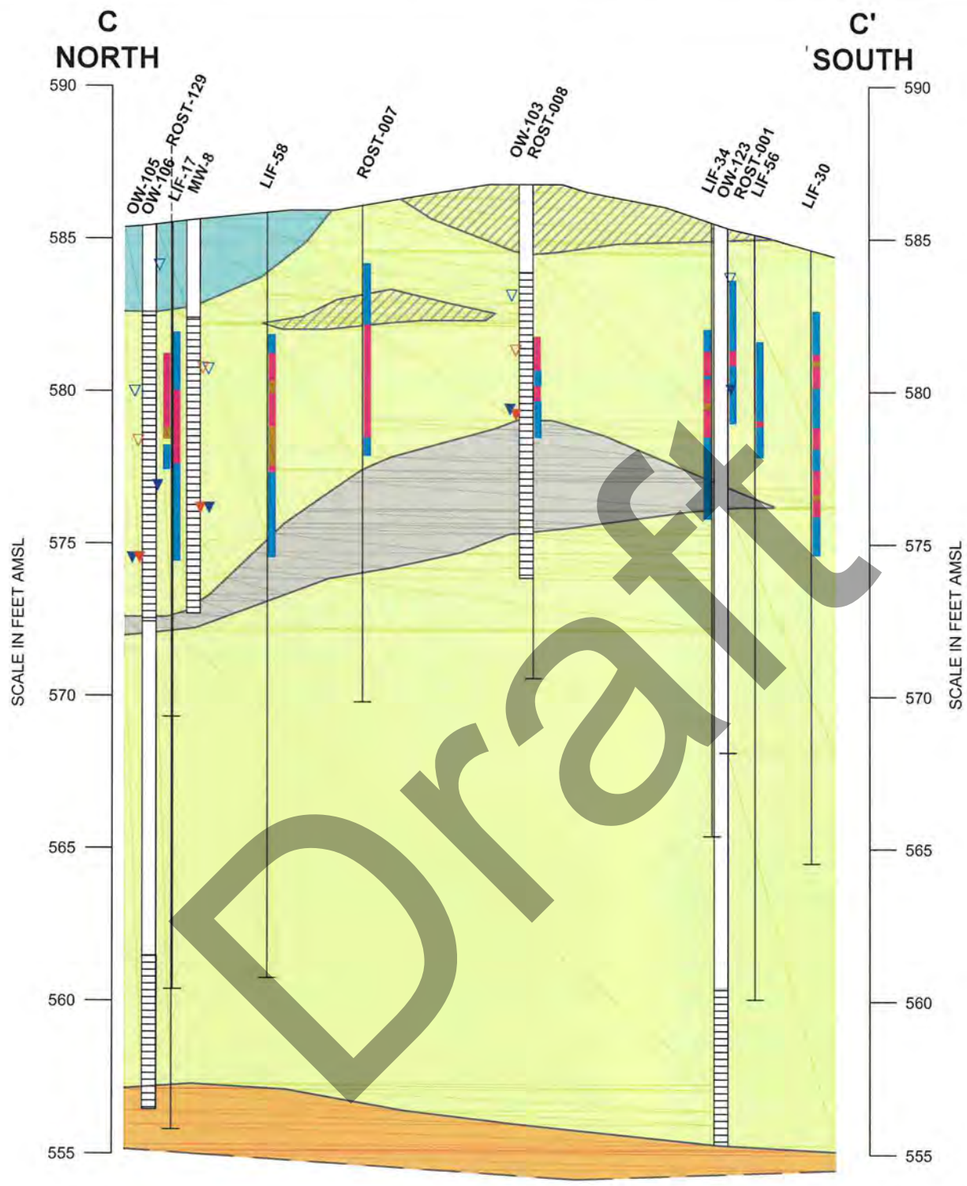
FORMER BP/AMOCO REFINERY
INDIANA HARBOR AND SHIP CANAL, EAST CHICAGO, ILLINOIS

GEOLOGIC CROSS SECTION B-B'

ARCADIS Design & Consultancy for natural and built assets

FIGURE 30

CITY:COSTA MESA DIV/GROUP:ENV/CAD DB:ENVCAD.bar PM:
G:\ENV\CAD\Irvine\RETURN TO\Manuscripts\IRVI001067\0034\00001\ICI001067.0034 XSects V4.dwg LAYOUT: 30 SAVED: 5/5/2016 12:39 PM ACADVER: 19.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 5/5/2016 2:21 PM BY: LOVING, JEFF



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LEGEND

- WELL CASING
- SCREENED INTERVAL
- END OF ROST BORING
- MINIMUM GROUNDWATER ELEVATION
- MAXIMUM GROUNDWATER ELEVATION
- MINIMUM LNAPL ELEVATION
- MAXIMUM LNAPL ELEVATION
- LIF/ROST LOCATION WITH PEAK FLUORESCENCE BETWEEN 10% AND 100% RE
- LIF/ROST LOCATION WITH PEAK FLUORESCENCE BETWEEN 100% AND 200% RE
- LIF/ROST LOCATION WITH PEAK FLUORESCENCE ABOVE 200% RE

- **PEAT:** HUMUS, SWAMP SOIL WITH HIGH ORGANIC CONTENT
- **SAND:** POORLY GRADED, LOOSE, FINE TO COARSE GRAINED
- **SILTY SAND:** FINE TO VERY FINE GRAINED, TRACE COARSE SAND
- **CLAY:** LOW TO HIGH PLASTICITY, SILTY CLAY
- **GRAVEL:** GRAVEL SAND MIXTURES, LITTLE TO NO FINES

- INFERRED CONTACT
- AMSL = ABOVE MEAN SEA LEVEL
- ELEVATIONS BASED OFF OF NAVD 1988 BENCHMARK

0 5 10
VERTICAL SCALE IN FEET
0 250 500
HORIZONTAL SCALE IN FEET

FORMER BP/AMOCO REFINERY
INDIANA HARBOR AND SHIP CANAL, EAST CHICAGO, ILLINOIS

GEOLOGIC CROSS SECTION C-C'

ARCADIS Design & Consultancy for natural and built assets

FIGURE 31

CITY:COSTA MESA DIV/GROUP:ENVCAD DB:ENVCAD.bar PM:
G:\ENVCAD\Irvine\RETURN-TO\Milwaukee-WI\CI001067\0034\0001\CI001067.0034 XSects V4.dwg LAYOUT: 31 SAVED: 5/5/2016 12:04 PM ACADVER: 19.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 5/5/2016 12:12 PM BY: LOVING, JEFF

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B.4.3: LNAPL DISTRIBUTION (ARCADIS, 2016)
SECTION 5.3.2, TABLE 2, FIGURES 2, 3, 5 AND 6 AND APPENDIX A AND M

- GW-02
- GW-03
- MW-02
- MW-09
- MW-10
- MW-35
- MW-37
- MW-38
- OW-101
- OW-102
- OW-104
- OW-105
- OW-106
- OW-114
- OW-115
- OW-121
- OW-122
- OW-123
- OW-125

Following fluid level measurement collection, a submersible pump and dedicated tubing were used at each monitoring well location to purge at least 10 well volumes.

3.1.3 Groundwater and Surface Water Fluid Measurement Activities

From December 18, 2015 through January 18, 2016, Arcadis deployed two data-logging pressure transducers to evaluate the difference between groundwater and surface water elevations. One transducer was deployed in monitoring well OW-125 (located at the northern extent of the STF) and the second transducer was deployed in the Canal approximately 120 feet west of OW-125, at the location of wooden pilings that provided an accessible and stable point to secure the transducer. Both transducers were placed at an approximate depth of 5 feet below the water elevation at the time of deployment, as confirmed by initial field readings. After the transducers were placed, the monitoring well groundwater elevation and the Canal surface water elevation were surveyed.

The transducers collected groundwater and surface water level measurements over a one-month time period, recording data at 15-minute intervals. The collected data were used to construct long-term groundwater and surface water elevation profiles. The profile data show that the groundwater elevation in monitoring well OW-125 was consistently higher than the surface water elevation in the Canal indicating that groundwater flow direction has been consistently towards the Canal.

3.2 LNAPL – Laser Induced Fluorescence

LIF allows for rapid high-resolution assessment of LNAPL distribution. The technology is based on fluorescent properties of PAH compounds, which are found in the complex hydrocarbon mixtures that make up petroleum products. LIF can be used to delineate the extent of a wide range of petroleum LNAPLs, including gasoline, diesel fuel, lubricating oil, hydraulic oil, and other petroleum distillates. Historical records indicate that hydrocarbon products typically stored on the STF and the WTF included diesel fuel, heating oils, gasoline, and lubricants (ARCO 1992). Each of these product categories

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generally provides a suitable fluorescence response for use of LIF technology. LIF results are expressed as the intensity of fluorescence measured by the instrument as it passes through the subsurface, relative to the fluorescence measured for a standard calibration solution (the reference emitter [RE]). Because LNAPL-impacted soils may exhibit greater fluorescence than the RE, results greater than 100% RE are often observed. The specific percentage RE value is influenced by soil properties, LNAPL composition, and environmental factors such as oxidation reduction potential (ORP). As a result, the LIF results do not correlate precisely to the degree of LNAPL saturation at a given location. Additionally, LIF results cannot be used to distinguish between mobile and residual LNAPL (residual LNAPL is immobile and trapped within pore spaces). Despite these limitations, the following general relationship between fluorescence and LNAPL saturation is typically observed:

- Fluorescence results close to background levels are typically indicative of low LNAPL saturation and residual LNAPL only.
- Locations of strongly elevated fluorescence typically coincide with higher LNAPL saturations which may be indicative of mobile LNAPL (capable of moving through soil pore spaces).
- LNAPL with higher molecular weights will fluoresce more intensely for a given saturation due to presence of a higher fraction of PAH compounds.

LIF borings were advanced by Matrix Environmental, LLC (Matrix) using the Ultraviolet Optical Screening Tool (UVOST) developed by Dakota Technologies. LIF borings were advanced directly from the ground surface into undisturbed soil, without using a pilot borehole to confirm absence of subsurface obstructions, i.e., hand-clearing. Three lines of evidence were used to confirm absence of subsurface obstructions prior to the drilling. Advancing the LIF boring into undisturbed soils from the ground surface allowed acquisition of shallow LIF data as well. The investigation was performed between November 9, 2015 and November 13, 2015. LIF data are presented in **Table 2** and in **Appendix A**. LIF locations are presented on **Figures 5 & 6**.

Horizontal locations of each LIF boring were recorded using sub-meter global positioning system (GPS) equipment. LIF boring vertical elevations were obtained from the horizontal locations and a January 2015 topographic survey conducted by DLZ Associates, Inc., referenced to the North American Vertical Datum of 1988 (NAVD 88). All vertical elevations reported in this document are referenced to the NAVD 88.

Based on the LIF data, the vertical thickness of the LNAPL-impacted "smear zone" is generally 6 to 8 feet. The smear zone was generally observed beginning at 2 to 4 feet bgs and extending to 8 to 10 feet bgs (corresponding to an approximate elevation range of 575 feet to 583 feet, with some local variations). The smear zone, as characterized by LIF data and historical fluid levels, is depicted in cross-section view on **Figures 29, 30, and 31**. Characterization of the LIF waveforms indicates that the LNAPL onsite primarily includes weathered diesel or heating oil products, which is consistent with historical use records and previous investigation results.

3.3 Transmissivity Measurement

LNAPL transmissivity assessment provides a method to evaluate LNAPL mobility and recoverability. LNAPL transmissivity represents a potential volumetric rate of LNAPL flow through a unit width of porous media per unit time under a unit gradient. LNAPL transmissivity is used for assessing LNAPL

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LNAPL physical properties and analytical results, obtained during the 2015 AOC Site Investigation, are consistent with this historical information as variability in LNAPL composition between the WTF and STF parcels has been observed (based on samples collected from monitoring wells exhibiting LNAPL accumulation). Fingerprinting data indicate that each of the three LNAPL samples characterized (collected at wells MW-03, OW-107, and OW-124) consist predominantly of diesel-type petroleum products, with smaller amounts of gasoline-range products (up to 10% of the sample in OW-124) and heavier products (1 to 2% in MW-03). The variations observed in fingerprinting results are likely due to a combination of factors, including different product releases contributing to subsurface impacts, and differences in the degrees and mechanisms of weathering across the site.

5.3.2 LNAPL Distribution and Movement

During the previous investigation activities, ROST was used to map LNAPL throughout the STF and WTF. During the 2002 investigation, 17 ROST borings were completed on the WTF and 45 ROST borings were completed on the STF. Borings were generally located in a grid pattern across the parcels investigated as shown on **Figures 2 and 3**, with approximately 250-foot spacing between boring locations. The ROST investigation identified two areas of increased LNAPL response in the west-central and east-central portions of the STF.

The 2015 UVOST investigation focused on the northern portion of the STF adjacent to the Canal, with the objective of mapping LNAPL distribution at a higher resolution than the 2002 ROST data and evaluating whether any minimally impacted or non-impacted areas were present along the Canal that could influence a future remedial design. Although the UVOST data indicate a lower degree of fluorescence in the central portion of the STF Canal frontage, some degree of LNAPL impact appears to be present for the entirety of the frontage.

Secondary objectives of the 2015 UVOST investigation included improved delineation of impacts near the eastern and western parcel boundaries of the STF and characterization of LNAPL variation in the southeast corner of the STF. UVOST data indicate that impacts along the western boundary of the STF are bounded to the south by ROST-035 and LIF-38. LNAPL impacts to the west of the STF are delineated by ROST-098, ROST-099, and ROST-100. Fluorescence less than 20%RE was observed in the northeastern corner of the STF (at LIF-20 and LIF-21), suggesting that the boundary of hydrocarbon impacts is within or near the parcel boundary. LNAPL impacts south of the STF in the adjacent pipeline rights-of-way are not delineated. While some variation in fluorescence waveforms was observed in this area, a boundary between two distinct waveform types was not observed.

The locations and results of the ROST and UVOST borings are depicted graphically on **Figures 5 and 6**, and individual ROST logs are presented in **Appendix M,** and UVOST logs are presented in **Appendix A**.

Conceptual representations of Site geology and the distribution of LNAPL are depicted on cross sections on **Figures 27 through 31**.

Based on observed declines in LNAPL recovery, overall decreases in the frequency and magnitude of in-well LNAPL accumulation since early investigation and remediation activities in the 1990s, and LNAPL transmissivity data, LNAPL in the majority of the Site is expected to exhibit a low degree of mobility. In significant portions of the Site, LNAPL impacts may be present (as indicated by LIF response) but at residual saturation levels, where LNAPL is not capable of moving through soil pore spaces or

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accumulating in monitoring wells. Small areas of mobile LNAPL (that is, LNAPL capable of moving through pore spaces and accumulating in monitoring wells) are present; however, the extent of mobile LNAPL appears to have decreased over time, particularly near the locations of previous recovery efforts near the Canal. In mature LNAPL bodies such as those present at the Site, LNAPL movement is often balanced by LNAPL mass losses due to natural source zone depletion processes.

In general, since LNAPL recovery is declining and LNAPL exhibits potential mobility characteristics near the Canal in only localized areas, sheens in the Canal are not likely originating as a result of LNAPL seepage from the bank; the sheens are most likely generated by interaction of groundwater and surface water with soils and sediments near the Canal bank and groundwater/surface water interface.

As potentially mobile LNAPL is observed in only localized areas, implementation of targeted remedies such as a barrier type remedies, should be sufficient to mitigate LNAPL migration in a groundwater flow direction towards the Canal.

5.3.3 Soil Constituents of Concern

Surface soil sampling was conducted as part of the 2002 investigation, targeting a depth interval of 0 to 2 feet bgs. Eighteen soil samples were collected from each of the STF and WTF parcels in a grid pattern developed for each parcel. Each surface soil sample analyzed for SVOCs, pesticides/ PCBs, and metals was a composite sample from four discrete subsamples, collected from the middle of a grid section. Each surface soil sample analyzed for TCL VOCs was a discrete sample collected at one of the four surface soil locations in each grid section, chosen randomly.

A detailed discussion of soil sampling results is presented in the 2002 Site Investigation Report. In general, significant concentrations of VOCs, PCBs, and pesticide COCs were not detected. Detections of arsenic were noted at levels consistent with regional background conditions, and some detections of benzo(a)pyrene and other PAH compounds were noted in surface soil, again at levels generally consistent with regional background conditions.

Additional soil sampling activities in 2015 were performed to characterize subsurface conditions. Consistent with the 2002 results, significant impacts were not identified with no exceedances of current RCG direct contact screening levels detected.

5.3.4 Groundwater Constituents of Concern

This section presents the evaluation of groundwater conditions at the STF and WTF. This evaluation includes fate and transport analysis of VOCs and SVOCs migrating dissolved in groundwater, discussion of current groundwater concentrations, and discussion of potential future groundwater impacts as a result of COC migration from soil to groundwater.

5.3.4.1 Hydrogeologic Data Used in Evaluation

As discussed in Section 1.2, representative hydraulic conductivity and hydraulic gradient for the STF and WTF parcels are 51.5 ft/day and 0.003 ft/ft, respectively. Assuming an effective porosity of 0.20 (USEPA 1989), the groundwater velocity at the Site, using equation 1 below, is 0.77 ft/day.

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Table 2. LIF Data Summary
Former ECI Refinery
East Chicago, Indiana

Location ID	Site Location	*Approximate Ground Surface Elevation (ft amsl)	Total Depth (ft bgs)	Smear Zone		Max Signal		Notes
				Start (ft bgs)	End (ft bgs)	%RE	Depth (ft bgs)	
LIF-2015-01	STF	584	30.09	2.5	10.0	923.1	4.38	
LIF-2015-02	STF	584	25.10	3.5	9.0	132.5	6.86	
LIF-2015-03	STF	584	25.04	2.5	10.0	173.5	7.55	
LIF-2015-04	STF	584	25.06	3.5	9.5	107.3	4.86	
LIF-2015-05	STF	584	25.01	2.5	10.0	177.3	4.40	
LIF-2015-06	STF	584	20.37	3.0	11.0	154.8	3.98	
LIF-2015-07	STF	584	25.11	4.5	11.0	117.8	6.73	
LIF-2015-08	STF	583	25.06	6.5	11.5	244.2	10.04	
LIF-2015-09	STF	583	25.11	5.5	11.0	165.1	8.87	
LIF-2015-10	STF	584	25.11	4.5	8.5	58.1	6.55	
LIF-2015-11	STF	584	25.13	4.5	10.0	194.8	5.81	
LIF-2015-12	STF	583	25.11	3.5	9.5	102.8	7.29	
LIF-2015-13	STF	583	25.09	5.5	8.5	18.0	6.73	
LIF-2015-14	STF	583	25.01	4.0	8.5	19.0	4.20	
LIF-2015-15	STF	583	25.06	2.5	8.5	116.5	6.66	
LIF-2015-16	STF	585	25.12	5.0	11.0	175.7	6.44	
LIF-2015-17	STF	584	25.14	3.5	11.0	180.6	5.73	
LIF-2015-18	STF	584	25.11	4.5	7.5	92.7	4.78	
LIF-2015-19	STF	584	25.14	3.5	7.0	180.6	3.97	
LIF-2015-20	STF	584	20.10	0.0	2.5	12.0	1.41	
LIF-2015-21	STF	584	20.17	1.5	4.0	17.2	3.44	
LIF-2015-22	STF	582	25.10	2.0	11.0	91.8	4.49	
LIF-2015-23	STF	583	20.17	0.5	7.5	112.5	5.64	
LIF-2015-24	STF	583	20.09	1.0	9.0	187.6	6.05	
LIF-2015-25	STF	583	20.07	2.0	9.0	205.9	5.87	
LIF-2015-26	STF	583	20.30	2.5	8.5	174.2	6.81	
LIF-2015-27	STF	583	20.19	0.5	8.0	181.9	6.12	
LIF-2015-28	STF	585	20.08	3.5	8.5	86.1	6.44	
LIF-2015-29	STF	586	20.13	1.5	9.0	151.8	4.29	Possible damage to EC fiber Fiber changed after boring
LIF-2015-30	STF	586	20.12	2.0	10.0	233.9	3.59	
LIF-2015-31	STF	585	20.18	1.5	11.5	261.7	8.73	
LIF-2015-32	STF	585	20.12	3.0	7.5	127.5	5.56	
LIF-2015-33	STF	585	20.10	3.0	9.0	172.0	6.45	
LIF-2015-34	STF	585	20.12	3.5	10.0	209.3	6.07	
LIF-2015-35	STF	584	20.12	3.5	8.5	90.6	6.30	
LIF-2015-36	STF	584	20.16	3.0	9.0	77.2	6.80	
LIF-2015-37	STF	583	20.13	2.5	7.0	103.8	6.20	
LIF-2015-38	STF	583	20.12	-	-	3.0	0.38	
LIF-2015-39	STF	584	30.08	1.5	7.0	31.5	5.55	
LIF-2015-40	STF	584	30.15	3.5	11.0	194.3	9.00	
LIF-2015-41	STF	584	30.12	3.0	11.5	226.5	4.65	
LIF-2015-42	STF	585	43.02	3.5	10.0	243.3	5.06	

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Table 2. LIF Data Summary
Former ECI Refinery
East Chicago, Indiana

Location ID	Site Location	*Approximate Ground Surface Elevation (ft amsl)	Total Depth (ft bgs)	Smear Zone		Max Signal		Notes
				Start (ft bgs)	End (ft bgs)	%RE	Depth (ft bgs)	
LIF-2015-43	STF	585	42.12	5.5	10.0	209.6	6.44	EC spikes due to possible fiber damage
LIF-2015-44	STF	585	42.05	3.5	8.5	79.2	7.62	EC spikes due to possible fiber damage
LIF-2015-45	STF	584	30.07	1.5	9.0	325.7	5.02	EC spikes due to possible fiber damage
LIF-2015-46	STF	584	34.07	2.5	11.5	234.8	5.84	EC spikes due to possible fiber damage Fiber changed after boring
LIF-2015-47	STF	584	30.08	4.0	11.0	481.4	5.69	
LIF-2015-48	STF	584	30.10	1.0	12.0	377.1	6.24	
LIF-2015-49	STF	584	32.24	0.0	12.0	383.1	4.65	
LIF-2015-50	STF	583	30.08	0.5	10.0	235.3	6.93	
LIF-2015-51	STF	585	42.10	0.0	9.0	531.9	5.38	
LIF-2015-52	STF	585	42.09	2.5	15.0	283.6	12.19	
LIF-2015-53	STF	585	42.06	2.0	9.0	302.0	5.20	
LIF-2015-54	STF	585	42.08	3.0	7.0	67.2	4.60	
LIF-2015-55	STF	585	42.06	2.0	5.0	55.2	4.17	Possible damaged fluorescence fiber
LIF-2015-56	STF	585	25.08	3.5	8.0	112.6	6.15	Fluorescence fiber replaced prior to boring No EC data
LIF-2015-57	STF	585	25.06	1.0	8.0	110.3	5.34	No EC data
LIF-2015-58	STF	585	25.10	3.5	11.5	266.4	8.05	No EC data
LIF-2015-59	STF	584	25.06	1.5	12.5	209.0	7.20	No EC data

Notes:
LIF = Laser induced fluorescence
STF = South Tank Farm
ft bgs = feet below ground surface
ft amsl = feet above mean sea level
%RE = percent of reference emitter
EC = electrical conductivity
*Ground surface elevations estimated based on historical site survey information

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LEGEND:

- ROST Boring
- Monitoring Well
- Product Recovery Well
- 2015-16 Pressure Transducer
- Buried Pipelines
- South Tank Farm
- Southwest Tank Farm

0 200 400 Feet

GRAPHIC SCALE

NOTES:

1) AERIAL IMAGE: ARCGIS ONLINE BASEMAP, 3/2012 IMAGE ACCESSED ON 5/2/2016
2) BURIED PIPELINE LOCATIONS BASED ON HISTORICAL MAPPING INFORMATION

FORMER ECI REFINERY
EAST CHICAGO, INDIANA

SITE LAYOUT - SOUTH TANK FARM AREA

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FIGURE
2

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CITY: MPLS DIV/GROUP: IM/DV DB: MG LD: JK
ECI
Document Path: Z:\GIS\PROJECTS_ENVIECI\mxds\2016-06\Fig2_South_Tank_Farm_20160502.mxd

Draft

LEGEND:

- ROST Boring
- Monitoring Well
- Product Recovery Well
- Buried Pipelines
- West Tank Farm

0 300 600 Feet

GRAPHIC SCALE

NOTES:

1) AERIAL IMAGE: ARCGIS ONLINE BASEMAP, 3/2012 IMAGE ACCESSED ON 4/20/2016
2) BURIED PIPELINE LOCATIONS BASED ON HISTORICAL MAPPING INFORMATION

FORMER ECI REFINERY
EAST CHICAGO, INDIANA

SITE LAYOUT - WEST TANK FARM AREA

ARCADIS

FIGURE
3

CITY: MPLS DIV/GROUP: IM/DV DB: MG LD: JK
ECI
Document Path: Z:\GIS\PROJECTS_ENVECI\mxds\2016-04\West_Tank_Farm_20160420.mxd

LEGEND:

- LIF/ROST location with peak fluorescence above 100% RE
- LIF/ROST location with peak fluorescence between 10% and 100% RE
- 0.03 Monitoring well with LNAPL accumulation (Oct. 2015); in-well thickness shown in feet
- Monitoring well dry or not gauged in Oct. 2015
- ROST Boring
- Monitoring Well
- LIF Location
- 2015-16 Pressure Transducer
- Buried Pipelines
- South Tank Farm

0 200 400 Feet
GRAPHIC SCALE

NOTES:
1) AERIAL IMAGE: ARCGIS ONLINE BASEMAP, 3/2012 IMAGE ACCESSED ON 5/3/2016
2) BURIED PIPELINE LOCATIONS BASED ON HISTORICAL MAPPING INFORMATION
3) % RE: % RESPONSE RELATIVE TO REFERENCE EMITTER

FORMER ECI REFINERY
EAST CHICAGO, INDIANA

LNAPL CHARACTERIZATION AND MONITORING WELL DATA - SOUTH TANK FARM AREA

ARCADIS | FIGURE 5

CITY: MPLS DIV/GROUP: IM/DV DB: MG LD: JK
ECI
Document Path: Z:\GISPROJECTS_ENVIEC\mxds\2016-05\Fig5_STF_ROST_MW_Data_20160502.mxd

Draft

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LEGEND:

- ROST location with peak fluorescence above 100% RE
- ROST location with peak fluorescence between 10% and 100% RE
- 1.47 Monitoring well with LNAPL accumulation (Oct. 2015); in-well thickness shown in feet
- ROST Boring
- Monitoring Well
- Buried Pipelines
- West Tank Farm

0 300 600 Feet
GRAPHIC SCALE

NOTES:
1) AERIAL IMAGE: ARCGIS ONLINE BASEMAP, 3/2012 IMAGE ACCESSED ON 4/26/2016
2) BURIED PIPELINE LOCATIONS BASED ON HISTORICAL MAPPING INFORMATION
3) % RE: % RESPONSE RELATIVE TO REFERENCE EMITTER

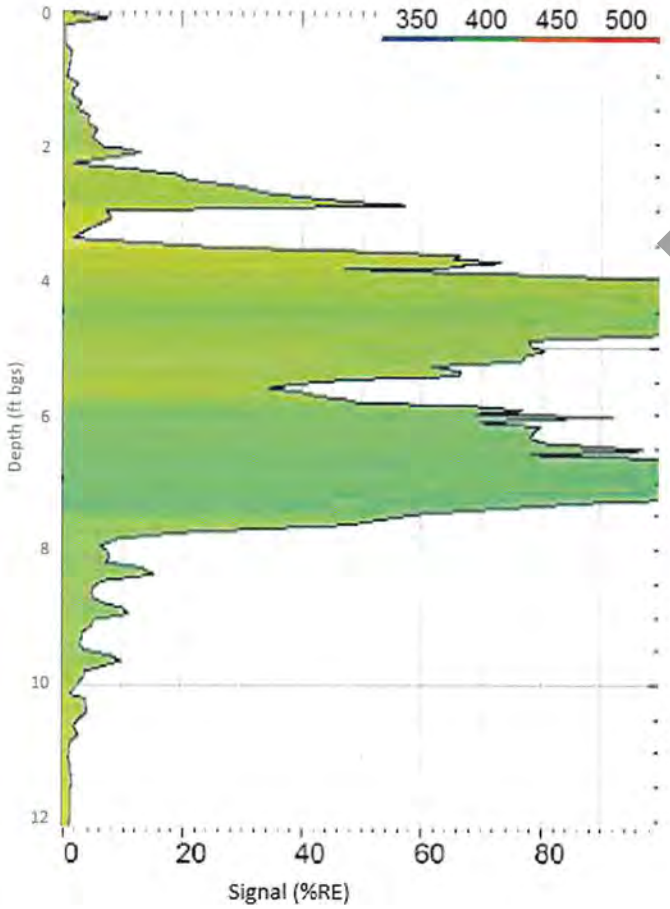
FORMER ECI REFINERY
EAST CHICAGO, INDIANA

LNAPL CHARACTERIZATION AND MONITORING WELL DATA - WEST TANK FARM AREA

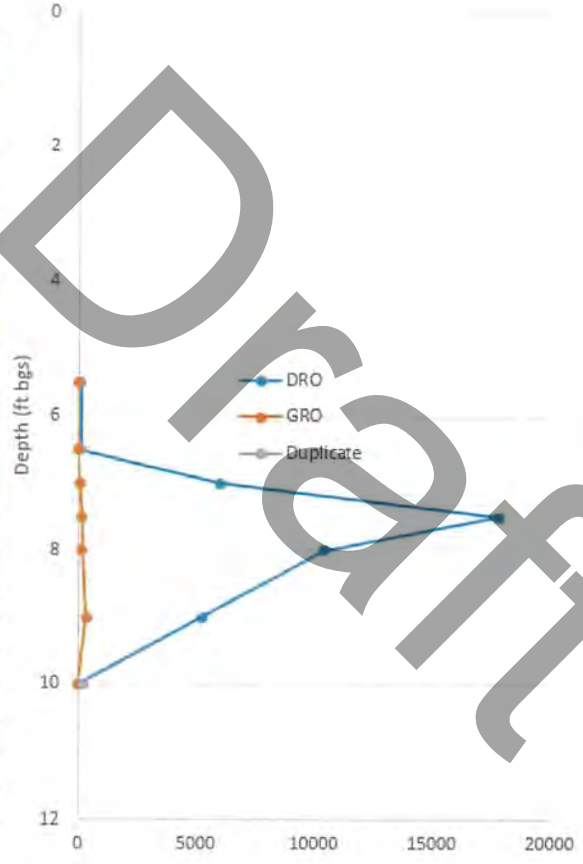
ARCADIS | FIGURE 6

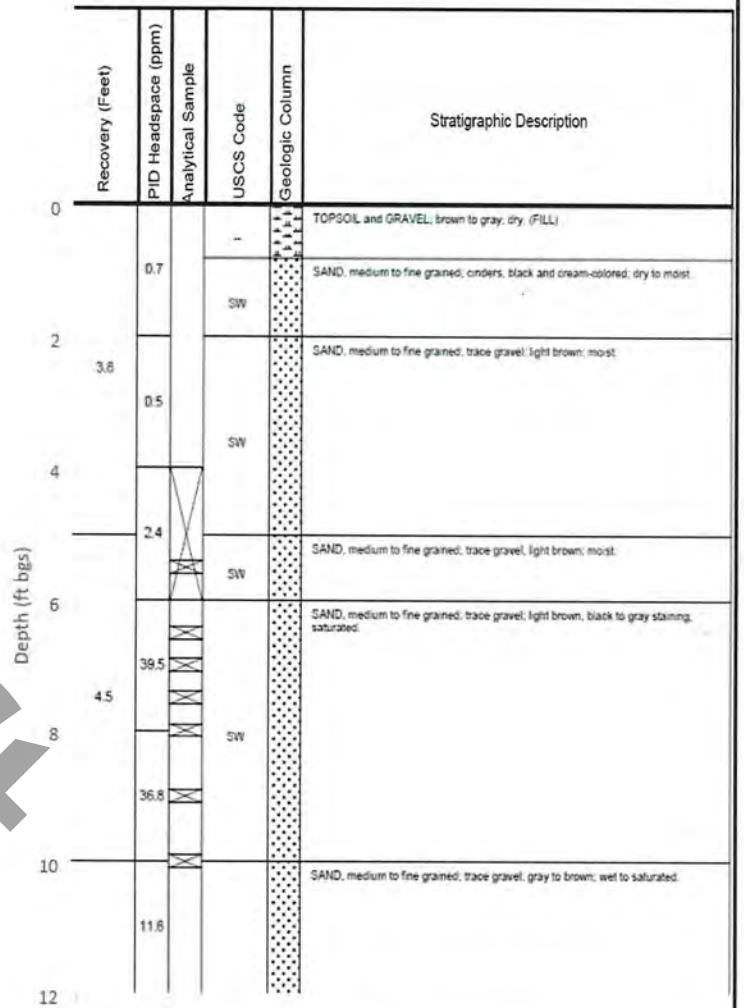
CITY: MPLS DIV/GROUP: IM/DV DB: MG LD: JK
ECI
Document Path: Z:\GIS\PROJECTS_ENV\ECI\mxds\2016-04\Fig6_WTF_ROST_MW_Data_20160426.mxd

LIF-2015-05



TPH Data





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FORMER ECI REFINERY
EAST CHICAGO, INDIANA

TPH Vertical Profiling – SB-2016-03

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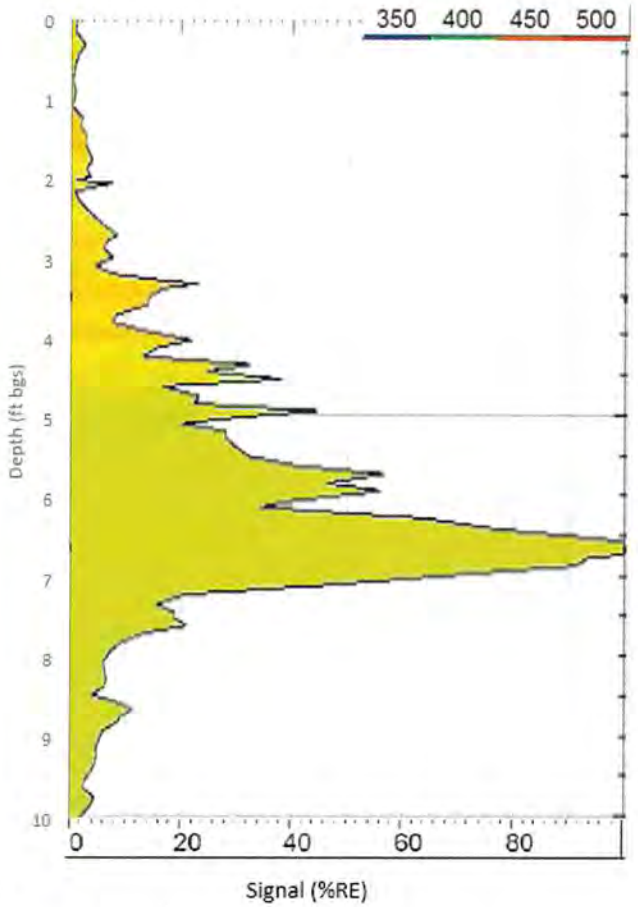
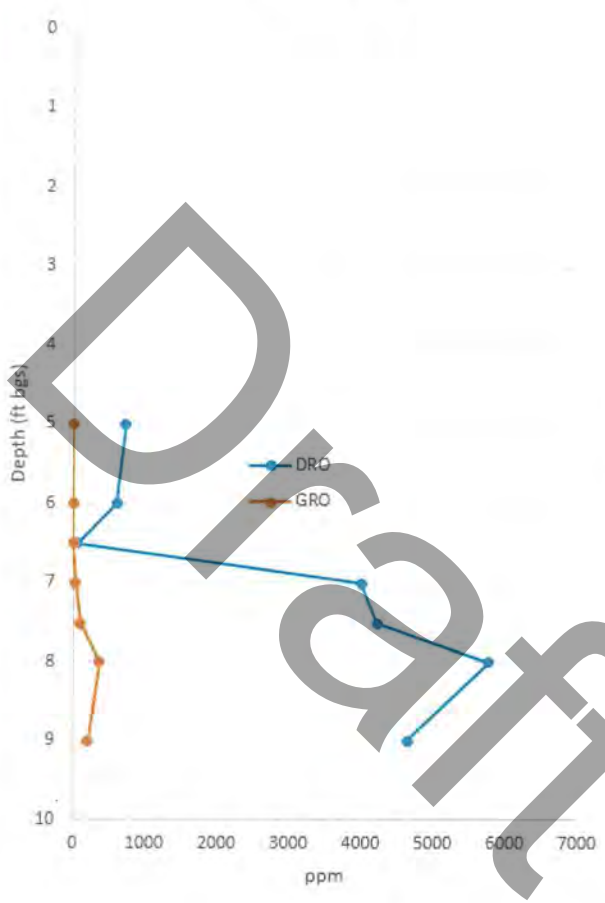
FIGURE 22

LIF-2015-15



TPH Data



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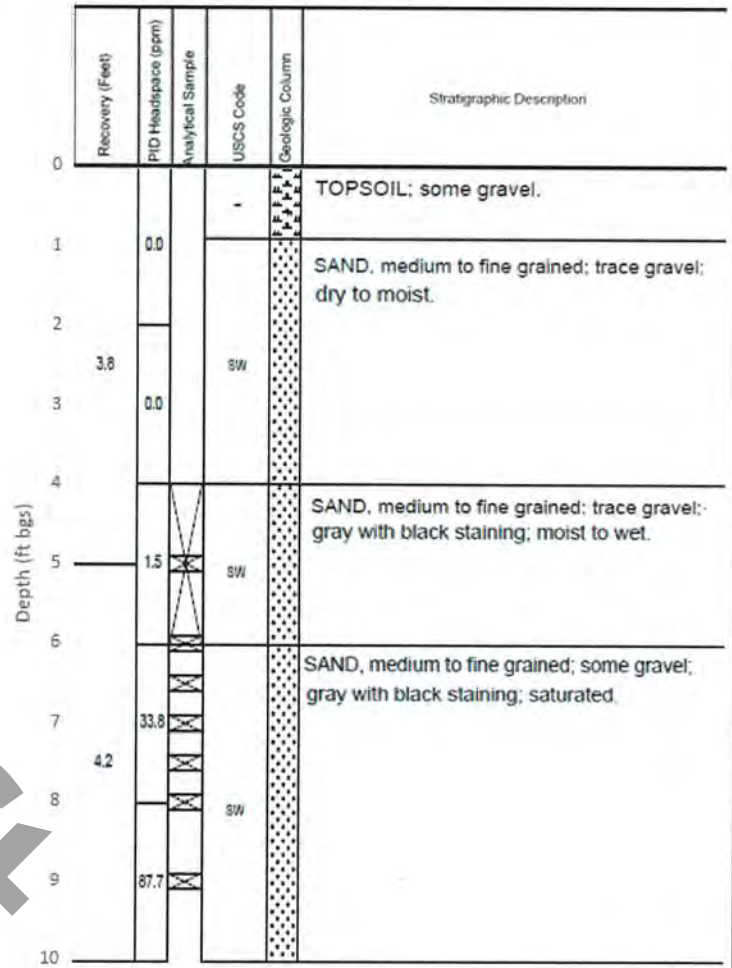
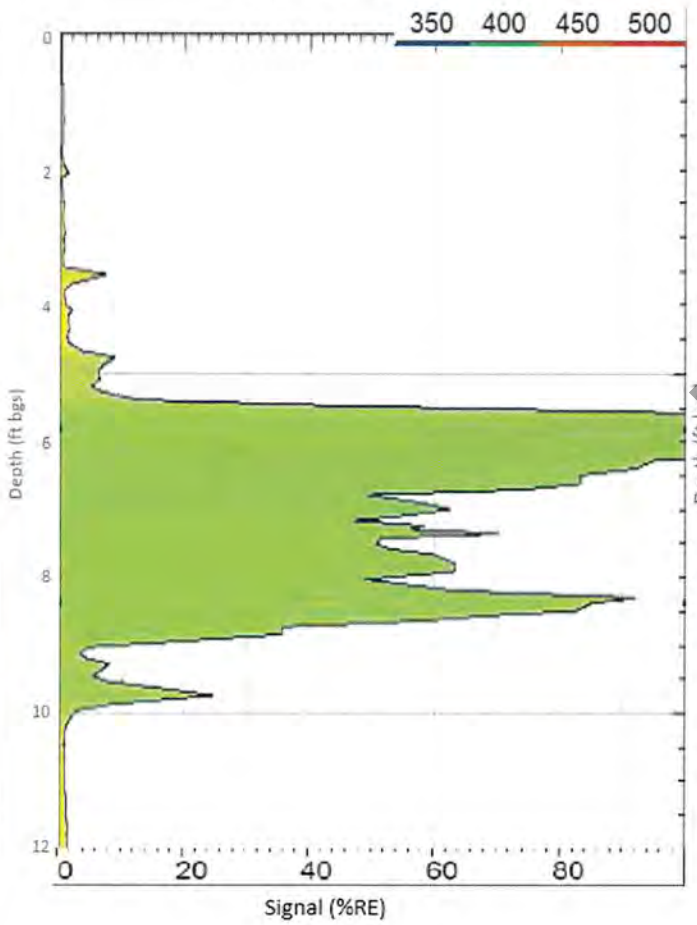


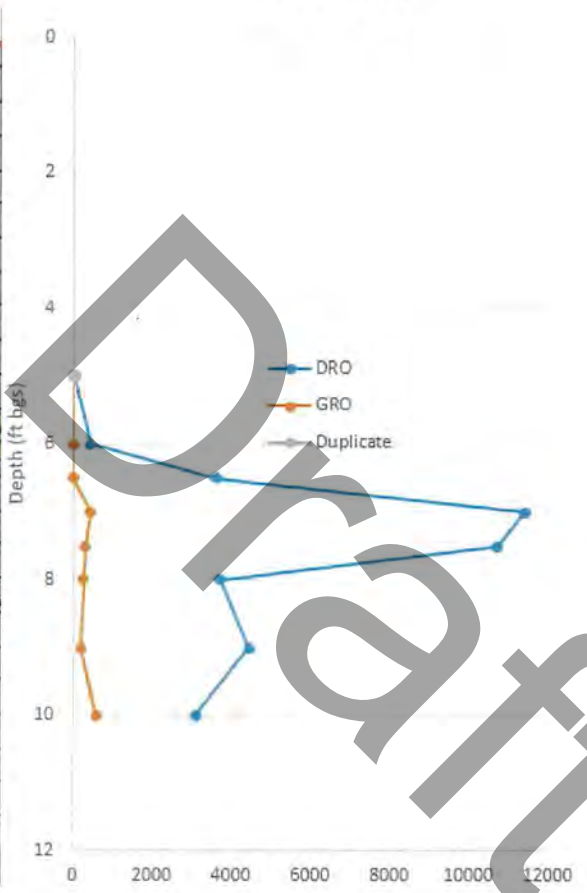
FORMER ECI REFINERY
EAST CHICAGO, INDIANA

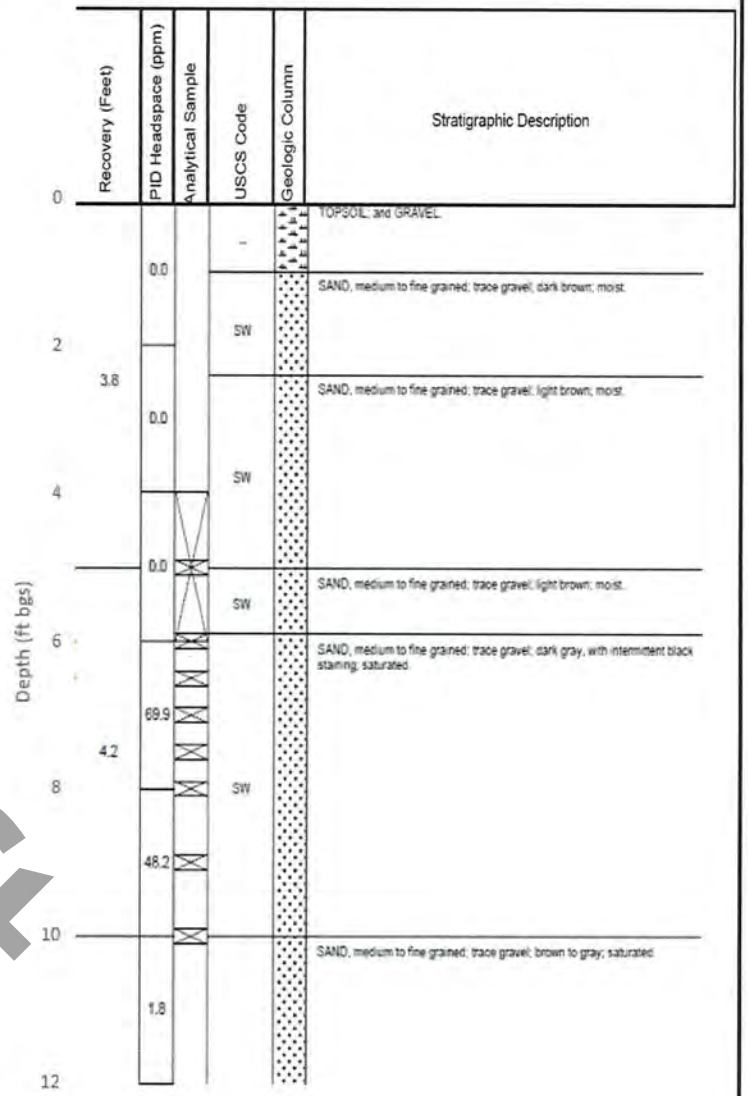
TPH Vertical Profiling – SB-2016-06

ARCADIS

FIGURE 23







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EAST CHICAGO, INDIANA

TPH Vertical Profiling – SB-2016-07

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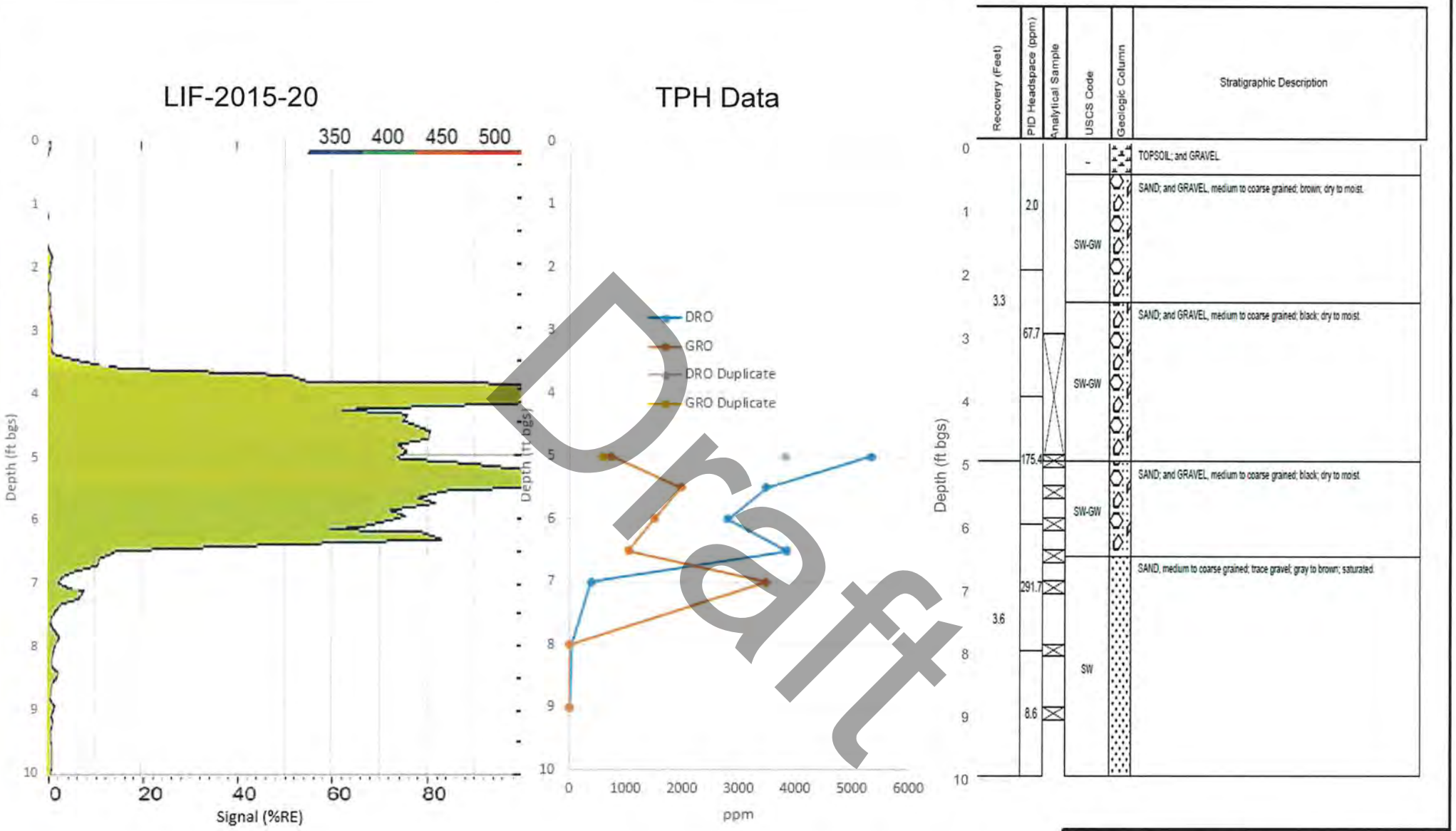
FIGURE
24



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Note: LIF-2015-19 is approximately 50 feet west of SB-2016-09

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EAST CHICAGO, INDIANA

TPH Vertical Profiling – SB-2016-09

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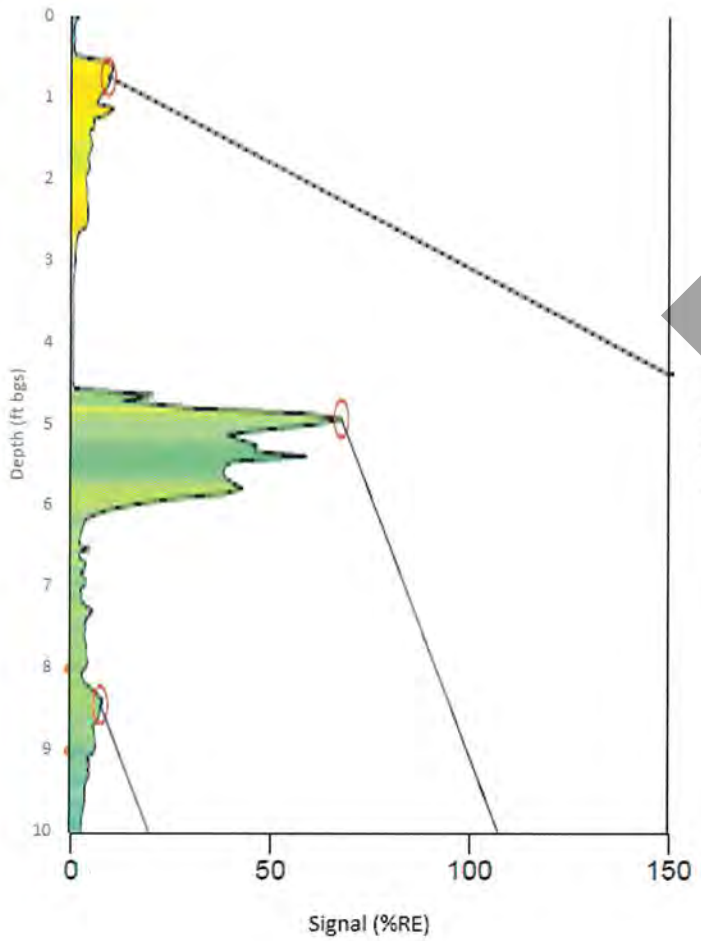
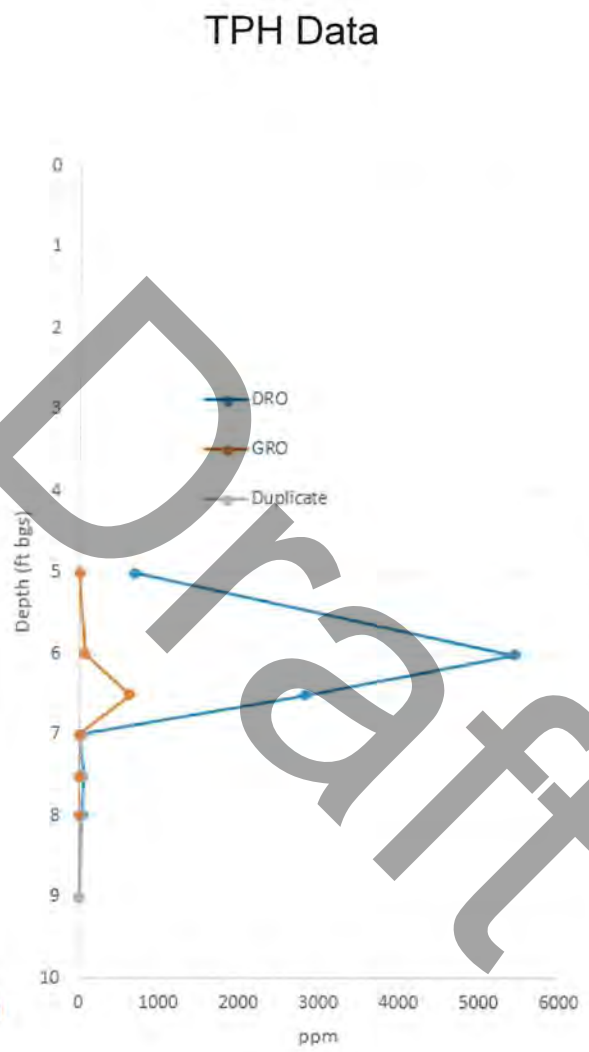
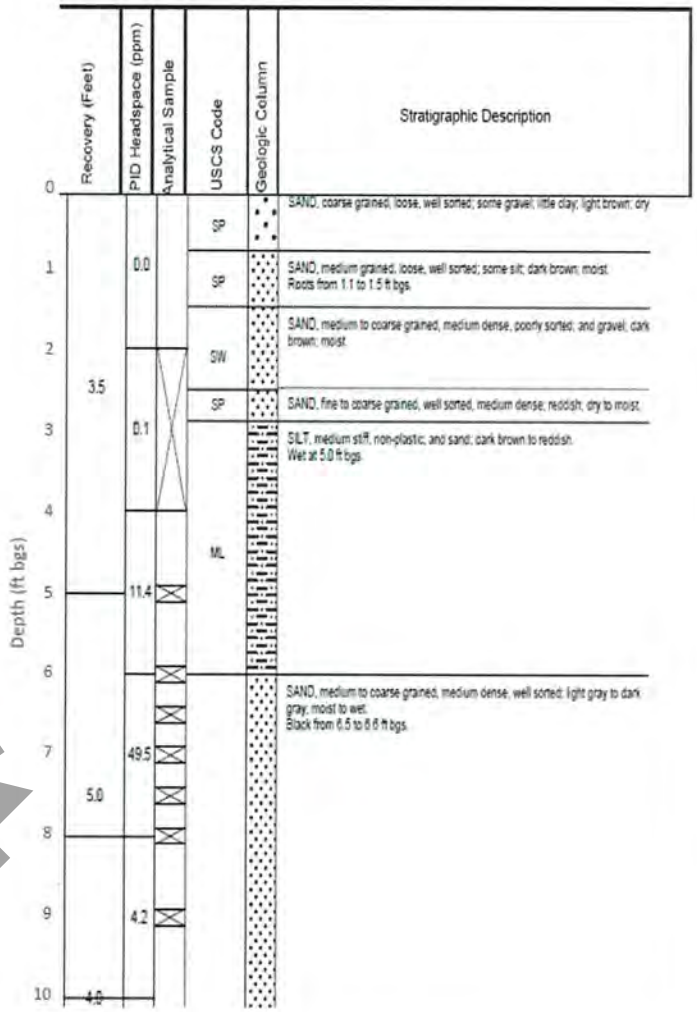
FIGURE
25







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EAST CHICAGO, INDIANA

TPH Vertical Profiling – SB-2016-10

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FIGURE
26

APPENDIX A

Matrix UVOST Report

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MATRIX ENVIRONMENTAL LLC

11253 91st Ave N
Maple Grove, MN 55369
763-424-4803
FAX: 763-424-9452

-Direct Sensing Report-

Client:	**Arcadis**
Project Name:	**Former ECI Refinery**
Location:	**East Chicago, IN**
Project Number:	**289.15**

Draft

The analysis and opinions expressed in this report are based upon data obtained from UVOST logs generated (and samples collected for emulations if applicable) at the location specified, and from other information discussed in this report. Exceptions, if any, are discussed in the accompanying discussion if applicable. This report is prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted practices. Reported results shall not be reproduced, except in full, without written approval of the lab. The sample results relate only to the analytes of interest tested. No warranties, expressed or implied are intended or made.

I certify that the data contained in this final report has been generated and reviewed in accordance with approved methods and our Standard Operating Procedure. Release of this final report is authorized by Laboratory management, which is verified by the following signature.

11/19/15

Approval Signature

Date

LIF SYSTEM DESCRIPTION & ANALYSIS

UVOST

Fluorescence is a property of some compounds where absorbed UV light stimulates the emission of photons (light) of a longer wavelength relative to the source emission. The release of the photons can be used to detect small amounts of substance (i.e. polycyclic aromatic hydrocarbons or PAHs) in a larger matrix (soil). This method of detection has been used in laboratories for decades. Now, with the availability of lasers and optical fibers, this technology can be applied down hole in the field.

The UVOST system sends light (via 308 nm laser) through a fiber optic cable strung within probe rods. The light, reflected by a parabolic mirror, then exits through a sapphire window in the side of the probe. As the probe is advanced, the soil is exposed to the UV laser light. If PAHs are present (compounds in POLs that fluoresce, i.e. LNAPL) longer wavelength light is emitted by the contaminants. This "signal" light is transmitted through a fiber, back up hole to be analyzed. Responses are indicated in real-time on a graph of signal vs. depth. The UVOST log displays "color mixed" signal logs (contributions from 4 channels) and waveforms ("fingerprint" of multi-wavelength) to aid in identification of the contaminant present.

Prior to every log the UVOST system is checked for optical quality by observing the background signal for sources of signal in the fiber, filter, mirror and sapphire window. Also, the reference emitter (a standard proprietary NAPL mixture called the "RE") is placed on the window to determine the qualitative and semi-quantitative properties of the laser system. This is to assure that the RE response has the correct shape and intensity and that the UVOST system is ready to log. Typically the RE will fall between 10,000 and 12,000 pVs (picovolt-seconds, a measure of waveform area) and the background can vary from 0.1% to 1% (area of about 0-100 pVs). It is important to remember that the relationship between the NAPL in the ground and the RE depends on that particular NAPL. The calibration of the system is not to a concentration, but to a known fluorescence signature.

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EC (Electrical Conductivity)

Electrical Conductivity (EC) is a measure of the soils ability to conduct an electrical current between two dipoles on the LIF/EC probe. Conductivity is the reciprocal of electrical resistivity and has the units (in our application) of millisiemens per meter (mS/m). Since soil is in the pathway of the charge flow, the grain size can be determined by comparing the EC log to a soil boring. Conductivity readings in the 100s indicate smaller grain (size such as clay). Larger grain size (sand and gravels) are typically in the 10s of mS/m range. Prior to every log the EC point of the UVOST probe is checked for proper operation by performing a voltage test with a voltage meter and a conductivity test with a test block.

Discussion

All locations were pre-cleared using a pre-probe to various depths, due to debris. All locations were abandoned with Benseal, (bentonite crumbles), poured from the ground surface.

LIF-2015-42 is a stitched together log of LIF-2015-42a and LIF-2015-42b, because logging was stopped at 30 feet. It was determined that the log needed to be advanced to a depth of 43 feet.

During the field work QAQC was performed on the UVOST system before each boring to ensure accurate data collection. The lithology of the soil was very hard throughout the site and the pounding of the probe was excessive at times. This caused some problems with the EC data at times. This was discovered on subsequent log's QAQC and the cable was switched out for a new cable set. This happened two times after logs LIF-2015-29 and LIF-2015-46. The logs of LIF-2015-43, LIF-2015-44, LIF-2015-45, and LIF-2015-46 have spikes due to possible wire shorting.

Prior to LIF-2015-56, during QAQC, it was determined that there was no fluorescence signal. The cable set was switched out for a cable set that had been switched out earlier, due to EC problems. The final four LIF logs were completed without reliable EC data, these are LIF-2015-56, LIF-2015-57, LIF-2015-58 and LIF-2015-59.

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Matrix Environmental, LLC
UVOST Reference Log

Main Plot:

Signal (total fluorescence) versus depth where signal is relative to the Reference Emitter (RE). The total area of the waveform is divided by the total area of the Reference Emitter yielding the %RE. This %RE scales with the NAPL fluorescence. The fill color is based on relative contribution of each channel's area to the total waveform area (see callout waveform). The channel-to-color relationship and corresponding wavelengths are given in the upper right corner of the main plot.

Callouts:

Waveforms from selected depths or depth ranges showing the multi-wavelength waveform for that depth. The four peaks are due to fluorescence at four wavelengths and referred to as "channels". Each channel is assigned a color.

Various NAPLs will have a unique waveform "fingerprint" due to the relative amplitude of the four channels and/or broadening of one or more channels. Basic waveform statistics and any operator notes are given below the callout.

Conductivity Plot:

The Electrical Conductivity (EC) of the soil can be logged simultaneously with the UVOST data. EC often provides insight into the stratigraphy. Note the drop in EC from 10 to 13 feet, indicating a shift from finer (clay) to larger grain size (sand) stratigraphy. This correlates with the observed NAPL distribution.

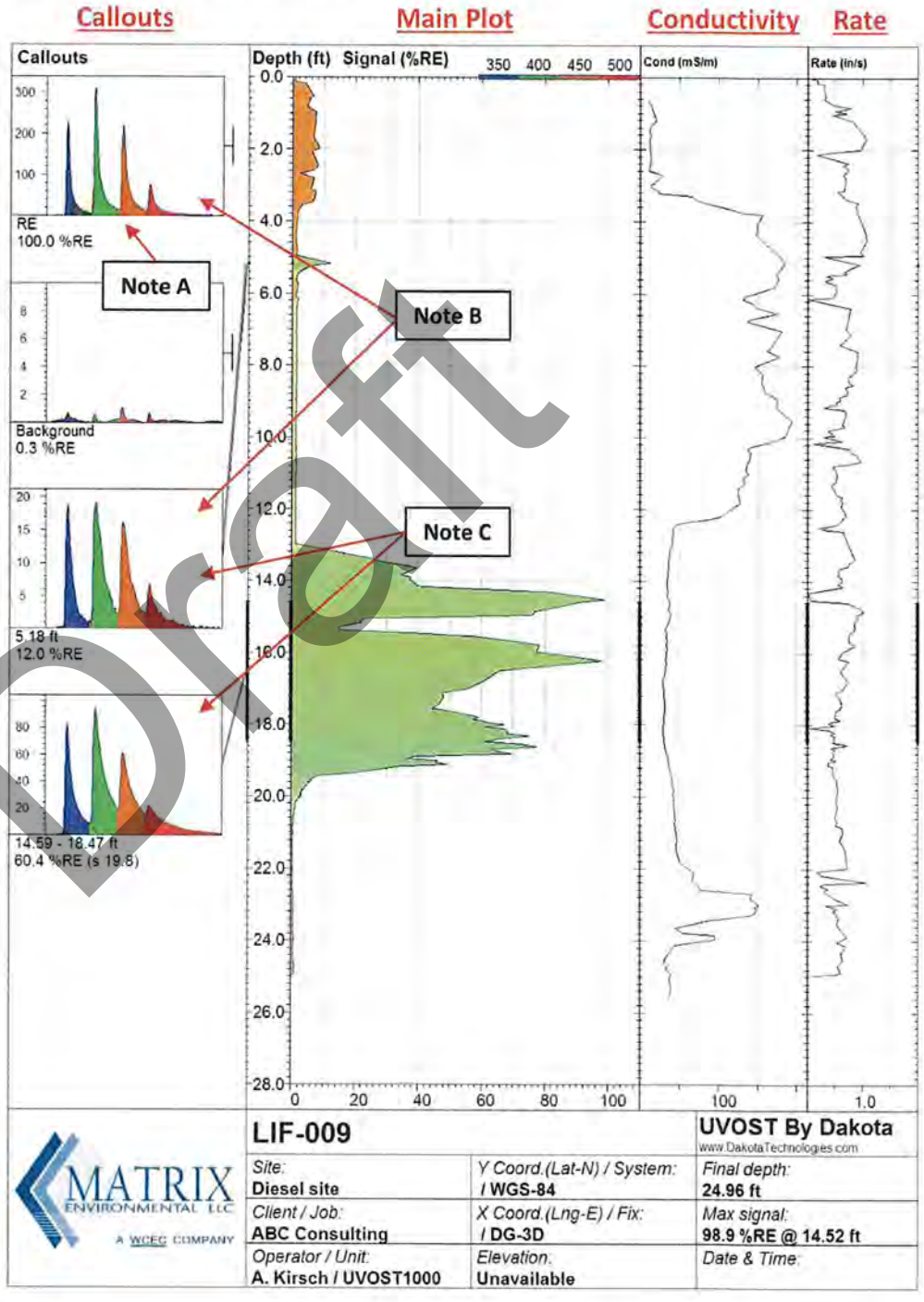
Rate:

The rate of probe advancement. Approx. 0.8 inches (2cm) per second is preferred. A noticeable decrease in the rate of advancement may be indicative of difficult probing conditions (gravel, angular sands, etc.) such as that seen here at approx. 5 ft.

Note that this log was terminated arbitrarily, not due to "refusal," which would have been indicated by a sudden rate drop at final depth.

Information Box:

Contains pertinent log information, including name and location.



Draft

Note A:

Time is along the x axis. No scale is given on callouts, but it is a consistent 320ns wide. The y axis is in mV and directly corresponds to the amount of light striking the photodetector.

Note B:

These two waveforms are clearly different. The top box is the Reference Emitter (a blend of NAPLs) always taken before each log for calibration, and the lower box is weathered diesel from the log itself.

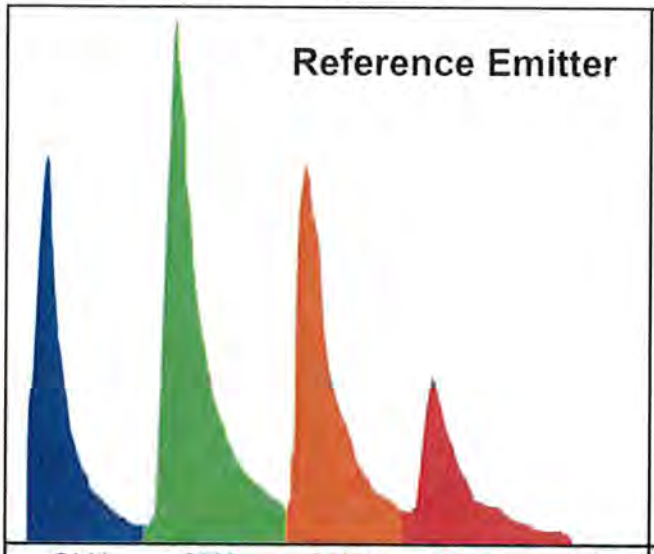
Note C:

Callouts can be a single depth (see 3rd callout) or a range (see 4th callout). The range is noted on the depth axis by a bold line. When the callout is a range, the average and standard deviation in %RE is given below the callout.

Matrix Environmental, LLC
UVOST Reference Log

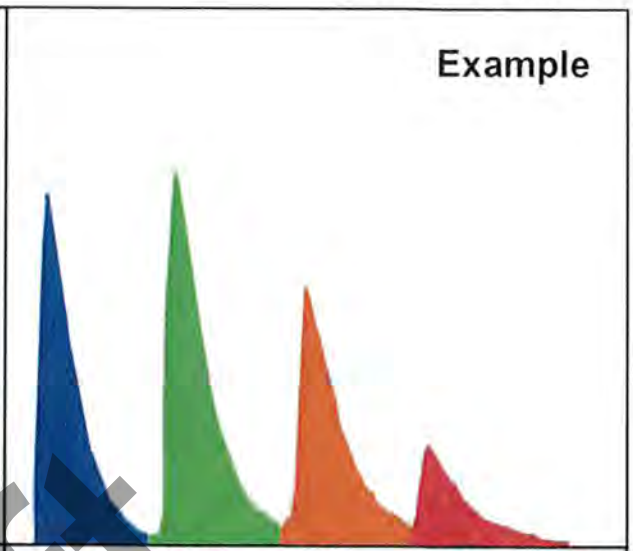
Waveform Signal Calculation

Dakota Technologies, Inc.



CH1		CH2		CH3		CH4		Total
4820	+	8108	+	6249	+	2984	=	22161
21.7		36.6		28.2		13.5		100%

Channel
Area (pVs)
Percent RE



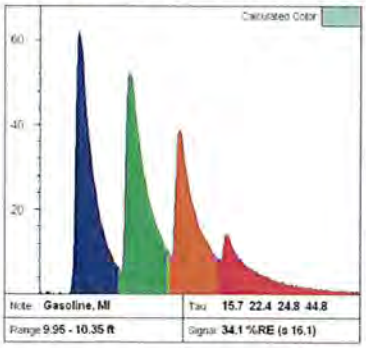
CH1		CH2		CH3		CH4		Total
4923	+	5743	+	4166	+	1735	=	16587
22.3		25.9		18.8		7.8		75%

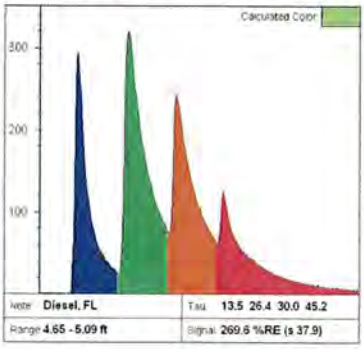
Data Files

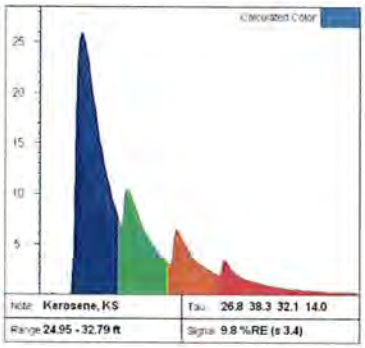
***.lif.raw.bin**	Raw data file. Header is ASCII format and contains information stored when the file was initially written (e.g. date, total depth, max signal, gps, etc., and any information entered by the operator). All raw waveforms are appended to the bottom of the file in a binary format.
***.lif.plt**	Stores the plot scheme history (e.g. callout depths) for associated Raw file. Transfer along with the raw file in order to recall previous plots.
***.lif.jpg**	A jpg image of the OST log including the main signal vs. depth plot, callouts, information, etc.
***.lif.dat.txt**	Data export of a single Raw file. Tab delimited format. No string header is provided for the columns to make importing into some programs easier. Each row is a unique depth reading. The columns are: 1-Depth; 2-Total Signal (%RE); 3-Ch1%; 4-Ch2%; 5-Ch3%; 6-Ch4%; 7-Rate; 8-EC Depth; 9-EC Signal; 10-Hammer Rate Depth; 11-Hammer Rate; 12-Color (RRGGBB). Summing channels 1 to 4 yields the Total Signal.
***.lif.sum.txt**	A summary file for a number of Raw files. ASCII tab delimited format. The file contains a string header. The summary includes one row for each Raw file and contains information for each file including: the file name, gps coordinates, max depth, max signal, and depth at which the max signal occurred.
***.lif.log.txt**	An activity log generated autmatically located in the OST application directory in the 'log' subfolder. Each OST unit the computer operates will generate a separate log file per month. A log file contains much of the header information contained within each seprate raw file, including: date, total depth, max signal, etc.

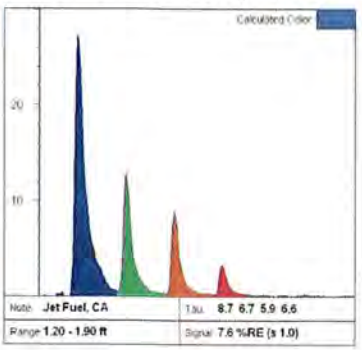
Common Waveforms (highly dependent on soil, weathering, etc.)

Dakota Technologies, Inc.









Draft

Field Summary Log

MATRIX ENVIRONMENTAL LLC

11253 91st Ave. N.
Maple Grove, Minnesota 55369
(763) 424-4803
fax (763) 424-9452

Client	Arcadis
Contact	Ellyn Gates
Services	UVOST Logging
Date	11/9/2015-11/13/2015
Project	Former ECI Refinery
Project #	289.15
Address	East Chicago, IN

UVOST Log Summary

File	Date/Time	Pre-probe (ft)	Final Depth (ft)	Max Signal (%RE)	Max. Signal Depth (ft)	Initial RE Area (pVs)	Background Area (pVs)	Fluorescence * (Signal @ 0-variable feet is questionable due to pre-probe) Top - Bottom (ft)
LIF-2015-01	11/9/2015 9:58	3.0	30.1	923.1	4.4	11378	76	3.0-30.0
LIF-2015-02	11/9/2015 10:43	4.5	25.1	132.5	6.9	11265	16	4.5-9.5
LIF-2015-03	11/9/2015 12:21	4.0	25.0	173.5	7.5	11227	6	4.0-25.0
LIF-2015-04	11/9/2015 12:49	3.0	25.1	107.3	4.9	11369	5	3.0-10.3, 14.9-15.9
LIF-2015-05	11/9/2015 13:18	3.0	25.0	177.3	4.4	11136	21	3.0-11.0
LIF-2015-06	11/9/2015 13:45	3.0	20.4	154.8	4.0	11787	7	3.0-10.9
LIF-2015-07	11/9/2015 14:12	3.0	25.1	117.8	6.7	11507	19	4.6-12.0
LIF-2015-08	11/9/2015 14:40	3.0	25.1	244.2	10.0	11447	19	6.3-12.9
LIF-2015-09	11/9/2015 15:07	2.0	25.1	165.1	8.9	11041	7	5.4-11.4
LIF-2015-10	11/9/2015 15:38	2.0	25.1	58.1	6.6	11404	8	4.5-9.4
LIF-2015-11	11/9/2015 16:03	2.0	25.1	194.8	5.8	11444	1	3.6-10.3
LIF-2015-12	11/10/2015 7:51	2.0	25.1	102.8	7.3	11300	39	3.5-9.8, 10.2-11.1, 12.2-13.0
LIF-2015-13	11/10/2015 8:17	3.0	25.1	18.0	6.7	11490	34	5.4-10.0
LIF-2015-14	11/10/2015 8:44	4.0	25.0	19.0	4.2	11219	32	3.8-8.3
LIF-2015-15	11/10/2015 9:12	4.0	25.1	116.5	6.7	11382	7	4.0-13.2
LIF-2015-16	11/10/2015 9:41	3.0	25.1	175.7	6.4	11519	20	4.8-11.7
LIF-2015-17	11/10/2015 10:10	3.0	25.1	180.6	5.7	11417	0	3.6-11.3, 15.0-15.5
LIF-2015-18	11/10/2015 10:36	3.0	25.1	92.7	4.8	11129	44	4.4-9.9
LIF-2015-19	11/10/2015 11:04	3.0	25.1	180.6	4.0	11067	13	3.3-9.5, 11.6-12.2
LIF-2015-20	11/10/2015 12:35	3.0	20.1	12.0	1.4	11577	9	3.1-4.1
LIF-2015-21	11/10/2015 12:59	3.0	20.2	17.2	3.4	11637	14	3.0-5.4
LIF-2015-22	11/10/2015 13:45	3.0	25.1	91.8	4.5	11261	-4	3.0-12.3
LIF-2015-23	11/10/2015 14:11	3.0	20.2	112.5	5.6	11520	5	3.0-7.4
LIF-2015-24	11/10/2015 14:34	3.0	20.1	187.6	6.1	11122	-2	3.0-9.8
LIF-2015-25	11/10/2015 14:55	3.0	20.1	205.9	5.9	11283	17	3.0-9.4, 12.1-13.8
LIF-2015-26	11/10/2015 15:14	3.0	20.3	174.2	6.8	11114	-3	3.0-10.0, 15.1-16.0
LIF-2015-27	11/10/2015 15:36	3.0	20.2	181.9	6.1	11627	0	3.0-9.3, 10.0-10.9
LIF-2015-28	11/11/2015 8:22	3.0	20.1	86.1	6.4	11703	20	3.0-9.8
LIF-2015-29	11/11/2015 9:46	3.0	20.1	151.8	4.3	11454	8	3.0-8.8
LIF-2015-30	11/11/2015 10:11	3.0	20.1	233.9	3.6	11309	10	3.0-15.4

Draft

Field Summary Log

MATRIX ENVIRONMENTAL LLC

11253 91st Ave. N.
Maple Grove, Minnesota 55369
(763) 424-4803
fax (763) 424-9452

Client: Arcadis
Contact: Ellyn Gates
Services: UVOST Logging

Date: 11/9/2015-11/13/2015
Project: Former ECI Refinery
Project #: 289.15
Address: East Chicago, IN

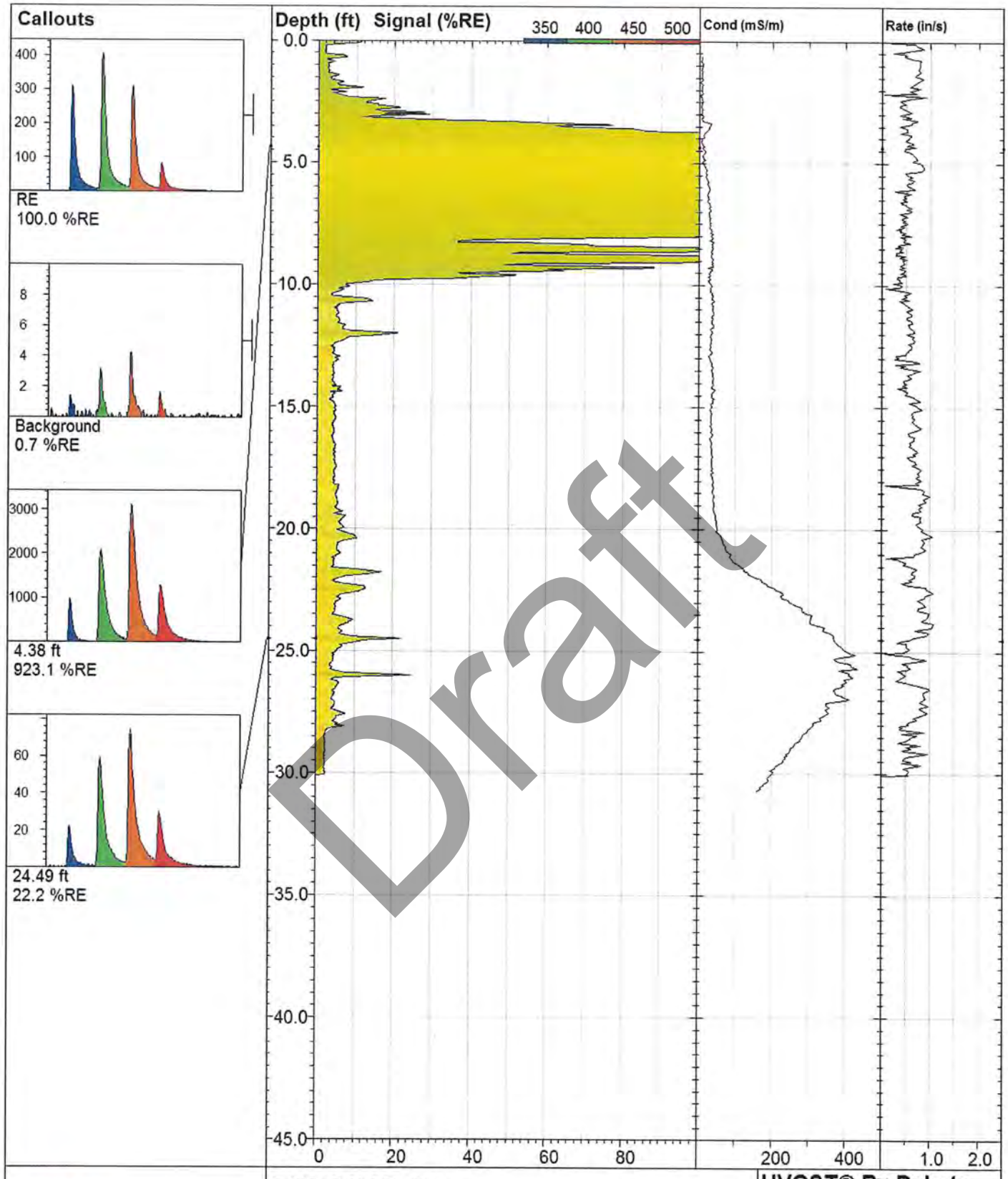
UVOST Log Summary

File	Date/Time	Pre-probe (ft)	Final Depth (ft)	Max Signal (%RE)	Max. Signal Depth (ft)	Initial RE Area (pVs)	Background Area (pVs)	Fluorescence *(Signal @ 0-variable feet is questionable due to pre-probe) Top - Bottom (ft)
LIF-2015-31	11/11/2015 10:33	3.0	20.2	261.7	8.7	11312	16	3.0-14.4
LIF-2015-32	11/11/2015 10:56	3.0	20.1	127.5	5.8	11512	31	3.0-8.6
LIF-2015-33	11/11/2015 11:18	4.0	20.1	172.0	6.5	11615	41	4.0-10.1
LIF-2015-34	11/11/2015 11:46	3.0	20.1	209.3	6.1	11729	27	3.0-10.0
LIF-2015-35	11/11/2015 13:12	3.0	20.1	90.6	6.3	11536	10	3.0-9.0
LIF-2015-36	11/11/2015 13:33	3.0	20.2	77.2	6.8	11524	6	3.0-10.7
LIF-2015-37	11/11/2015 14:12	3.0	20.1	103.6	6.2	11118	3	3.0-7.7
LIF-2015-38	11/11/2015 14:34	3.0	20.1	3.0	0.4	11819	18	NA
LIF-2015-39	11/11/2015 15:06	3.0	30.1	31.5	5.6	11485	14	3.0-7.5
LIF-2015-40	11/11/2015 15:35	3.0	30.1	194.3	9.0	11238	36	3.0-13.4, 15.0-15.9
LIF-2015-41	11/11/2015 16:04	3.0	30.1	226.5	4.6	11801	12	3.0-13.7
LIF-2015-42	11/12/2015 8:15	3.0	43.0	243.3	5.1	11900	11	3.0-13.5
LIF-2015-43	11/12/2015 9:14	3.0	42.1	209.6	6.4	11209	6	3.0-10.0
LIF-2015-44	11/12/2015 9:56	3.0	42.1	79.2	7.6	11372	18	3.0-12.4
LIF-2015-45	11/12/2015 11:17	3.0	30.1	325.7	5.0	11394	7	3.0-9.1
LIF-2015-46	11/12/2015 11:50	3.0	34.1	234.8	5.8	11957	16	3.0-11.5, 21.8-22.7
LIF-2015-47	11/12/2015 14:00	3.0	30.1	481.4	5.7	11814	40	3.0-11.8
LIF-2015-48	11/12/2015 14:32	3.0	30.1	377.1	6.2	11656	43	3.0-12.0
LIF-2015-49	11/12/2015 14:59	3.0	32.2	383.1	4.7	11524	44	3.0-13.5
LIF-2015-50	11/12/2015 15:29	3.0	30.1	235.3	6.9	11229	36	3.0-10.3
LIF-2015-51	11/12/2015 16:13	3.0	42.1	531.9	5.4	11651	51	3.0-10.2
LIF-2015-52	11/13/2015 7:50	3.0	42.1	283.6	12.2	11287	41	3.0-15.6, 23.9-26.2, 28.9-30.0
LIF-2015-53	11/13/2015 8:29	3.0	42.1	302.0	5.2	11200	50	3.0-10.2, 17.1-17.5, 20.9-22.3
LIF-2015-54	11/13/2015 9:22	3.0	42.1	67.2	4.6	11811	45	3.0-10.8
LIF-2015-55	11/13/2015 10:04	3.0	42.1	55.2	4.2	11572	49	3.0-5.0
LIF-2015-56	11/13/2015 11:24	3.0	25.1	112.6	6.1	11528	9	3.0-8.3, 8.9-9.6
LIF-2015-57	11/13/2015 11:47	3.0	25.1	110.3	5.3	11595	44	3.0-8.4
LIF-2015-58	11/13/2015 12:24	3.0	25.1	266.4	8.1	11496	31	3.0-11.6
LIF-2015-59	11/13/2015 12:55	3.0	25.1	209.0	7.2	11875	32	3.0-12.8

Draft

UVOST LOGS
@ 100% RE

Draft

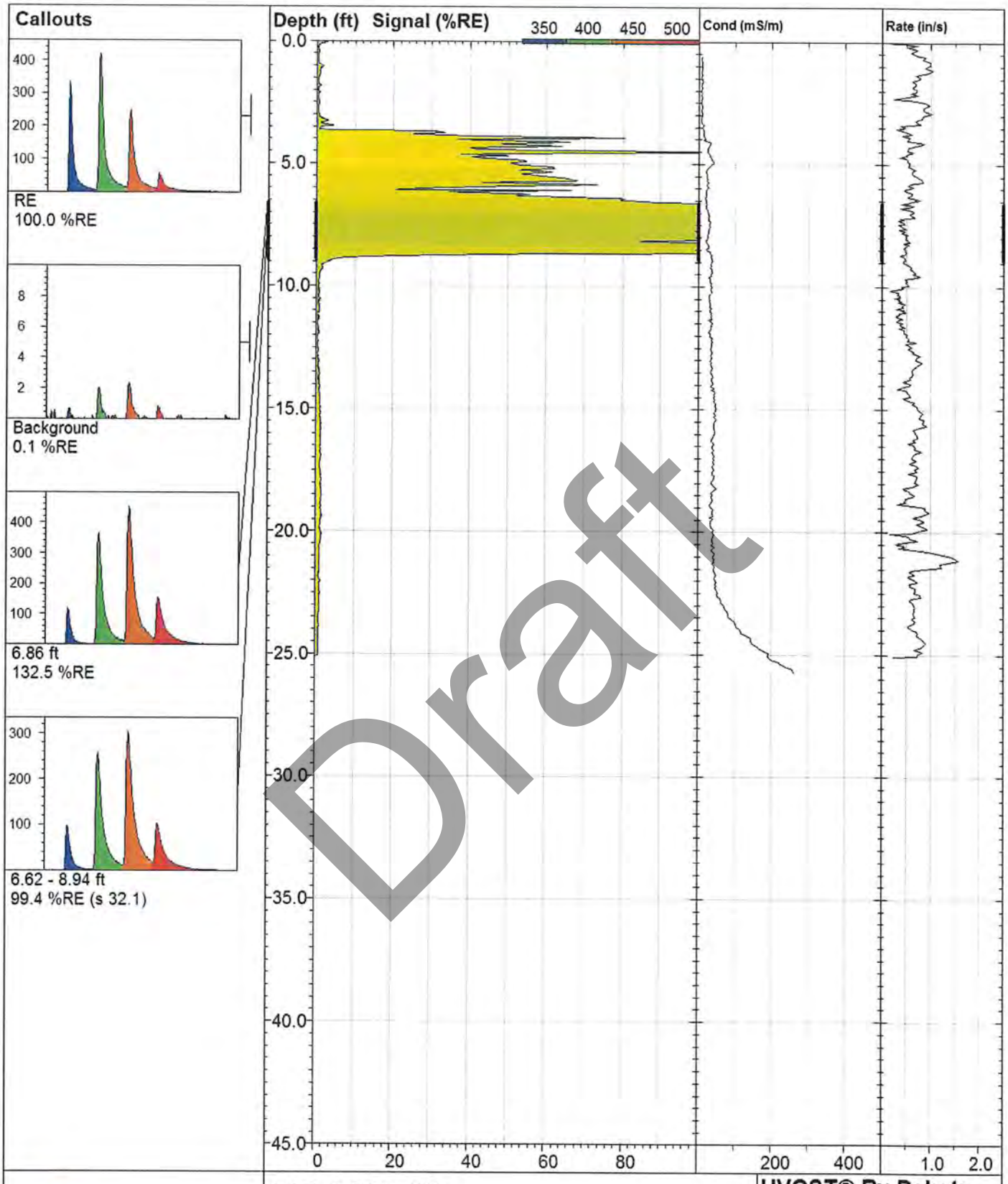


MATRIX ENVIRONMENTAL LLC
www.matrixenv.com

LIF-2015-01

UVOST® By Dakota
www.DakotaTechnologies.com

Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.09 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **923.1 %RE @ 4.38 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 09:58 CST**

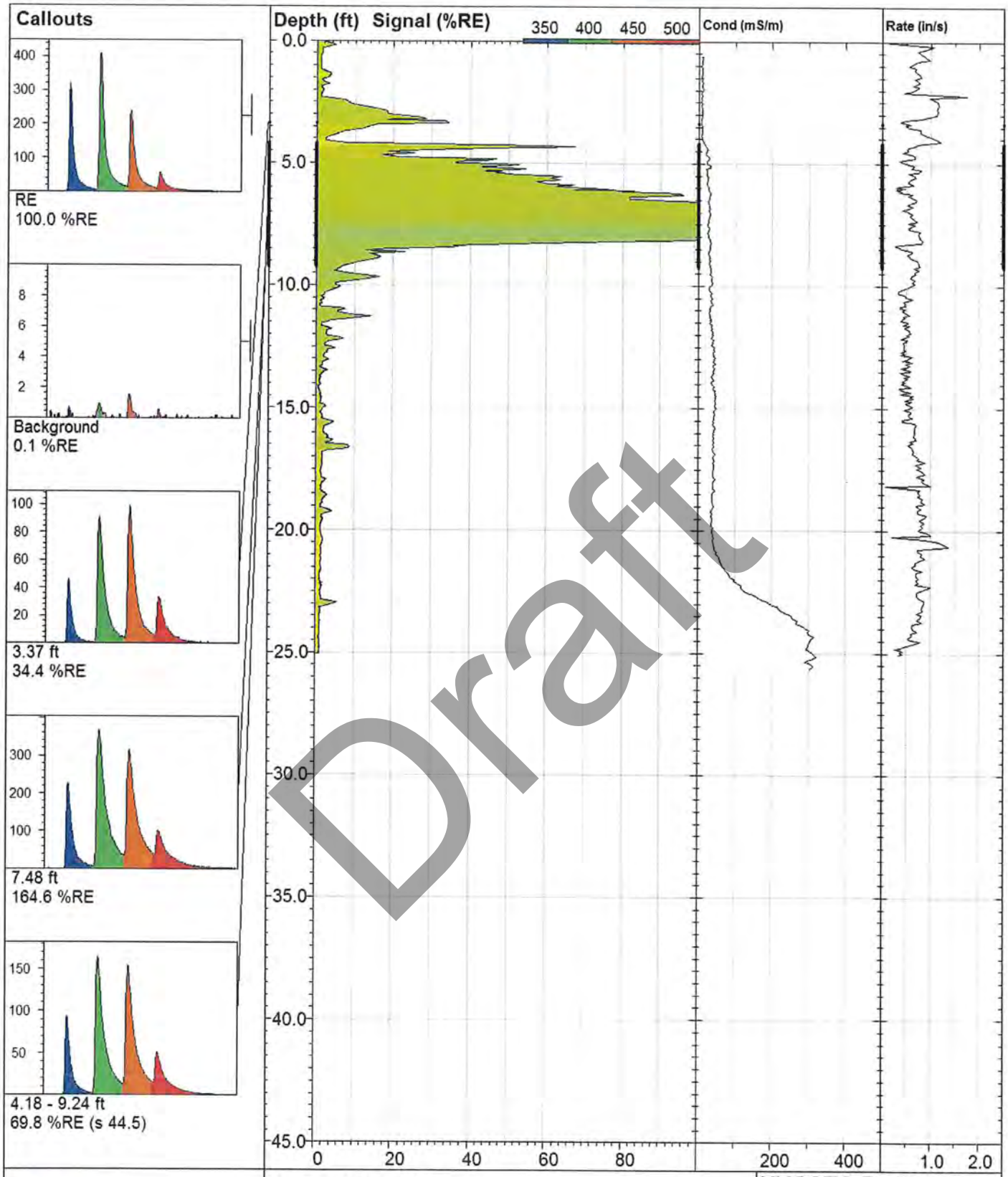


LIF-2015-02

UVOST® By Dakota
www.DakotaTechnologies.com

MATRIX ENVIRONMENTAL LLC
www.matrixenv.com

Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.10 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **132.5 %RE @ 6.86 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 10:43 CST**

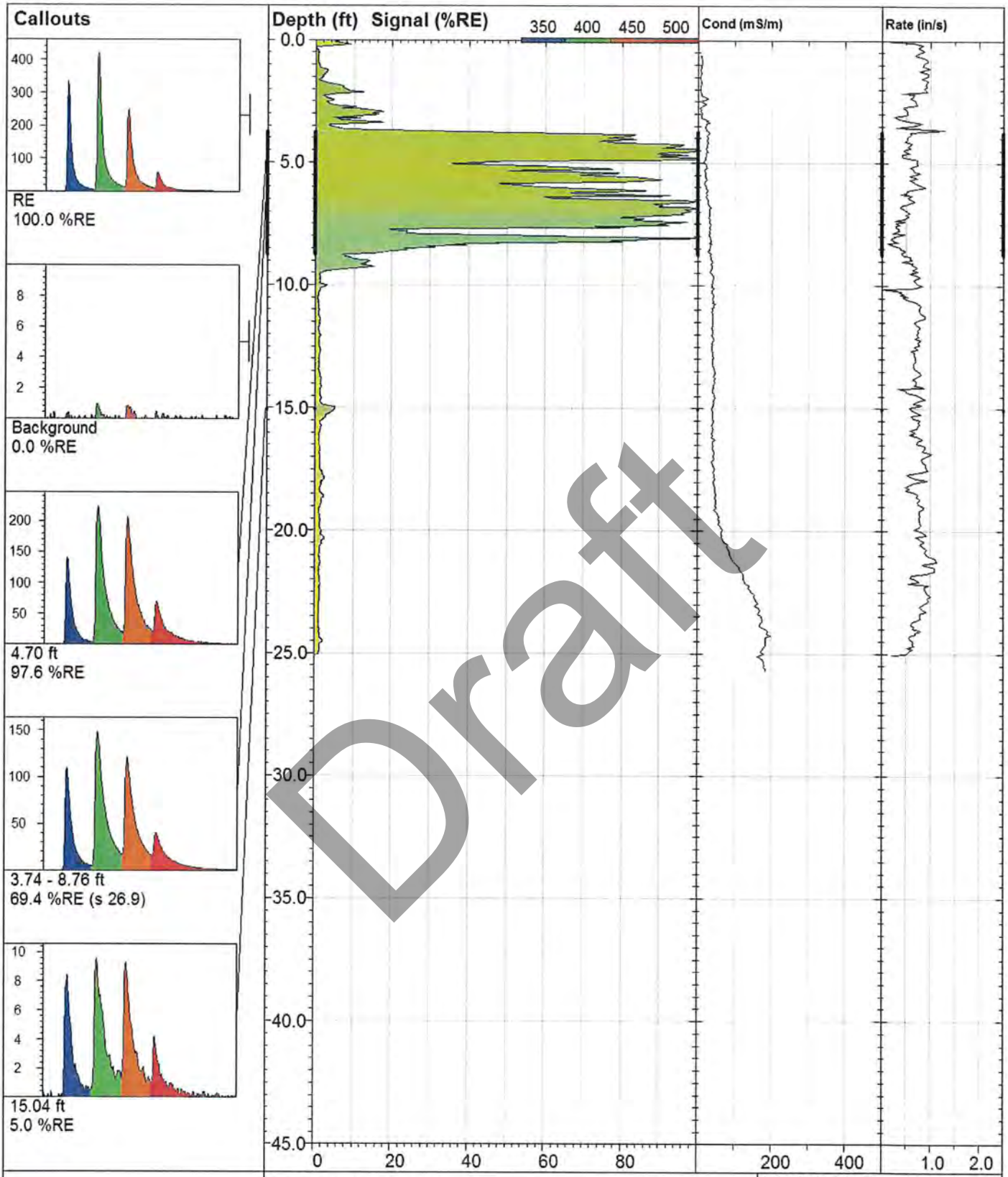


MATRIX ENVIRONMENTAL LLC
www.matrixenv.com

LIF-2015-03

UVOST® By Dakota
www.DakotaTechnologies.com

Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.04 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **173.5 %RE @ 7.55 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 12:21 CST**

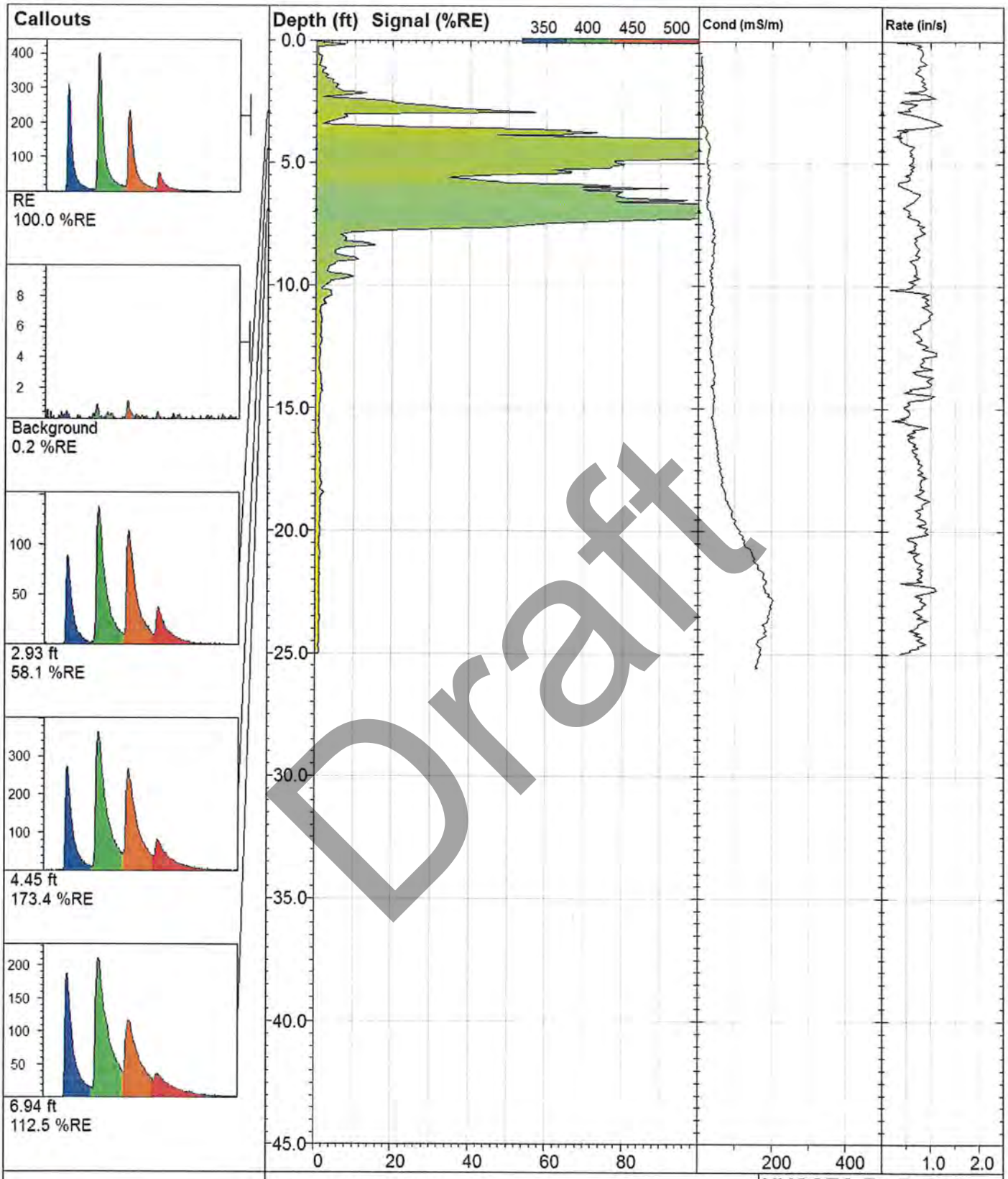


MATRIX ENVIRONMENTAL LLC
www.matrixenv.com

LIF-2015-04

UVOST® By Dakota
www.DakotaTechnologies.com

Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.06 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **107.3 %RE @ 4.86 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 12:49 CST**

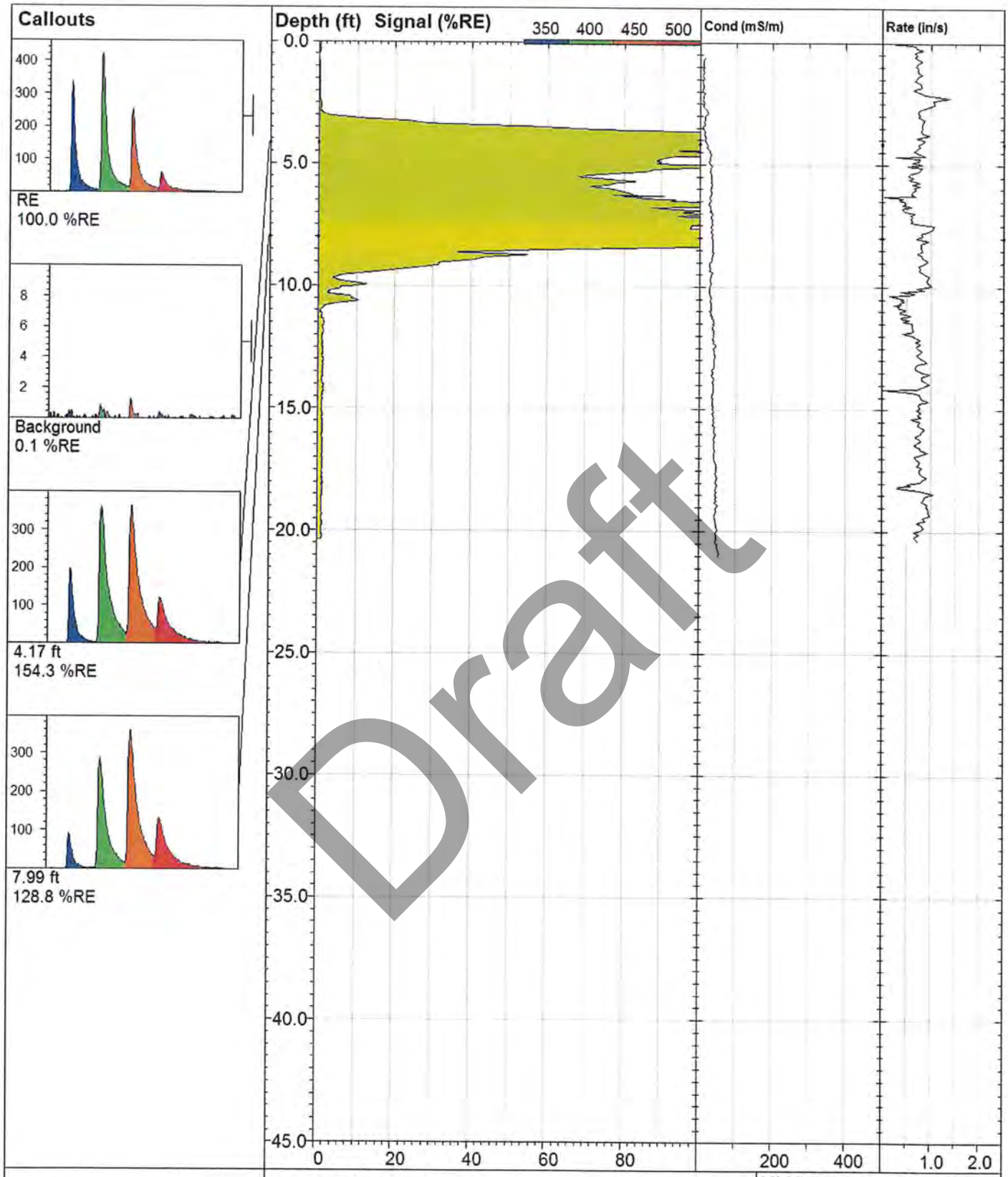


MATRIX ENVIRONMENTAL LLC
www.matrixenv.com

LIF-2015-05

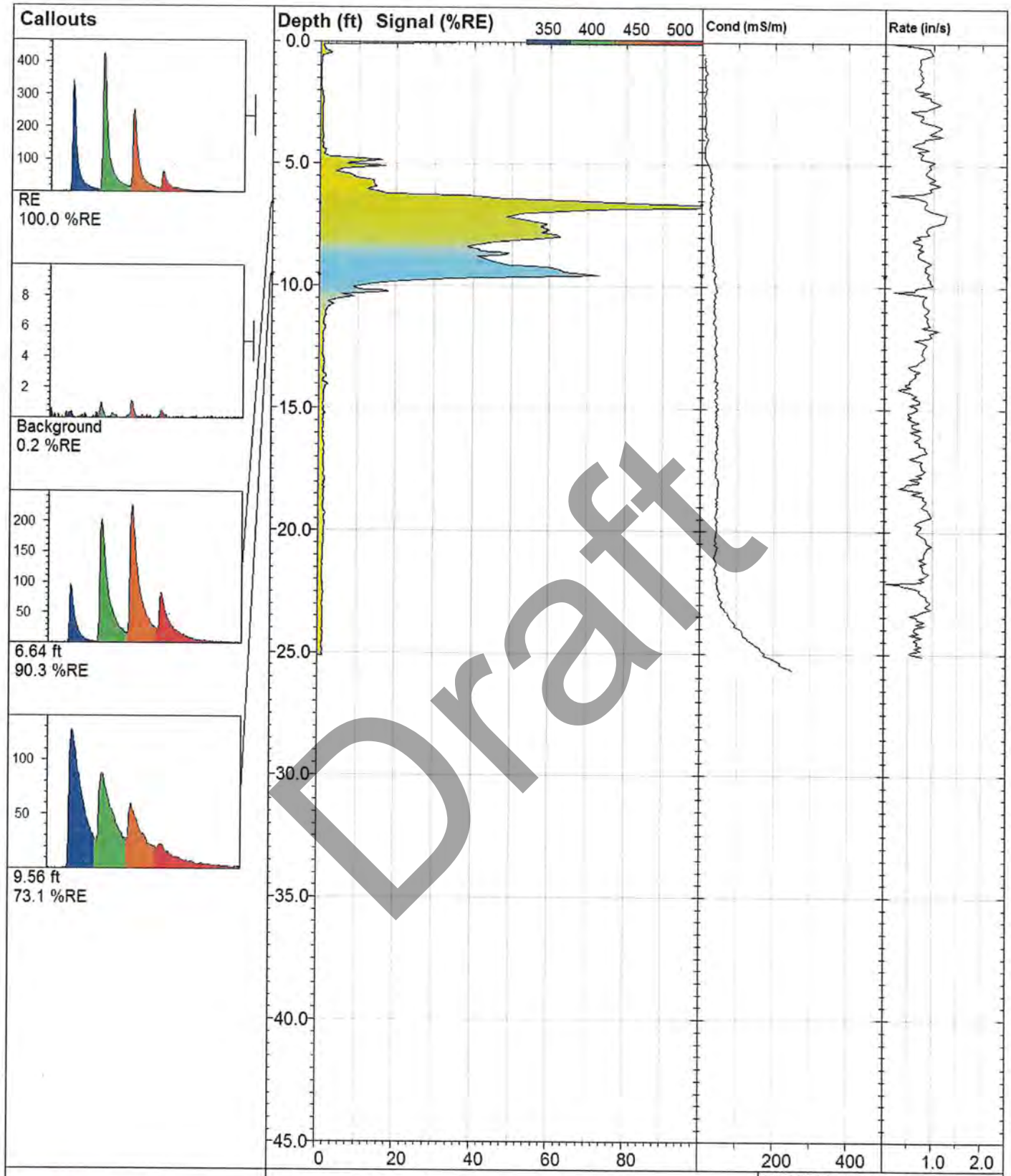
UVOST® By Dakota
www.DakotaTechnologies.com

Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.01 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **177.3 %RE @ 4.40 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 13:18 CST**



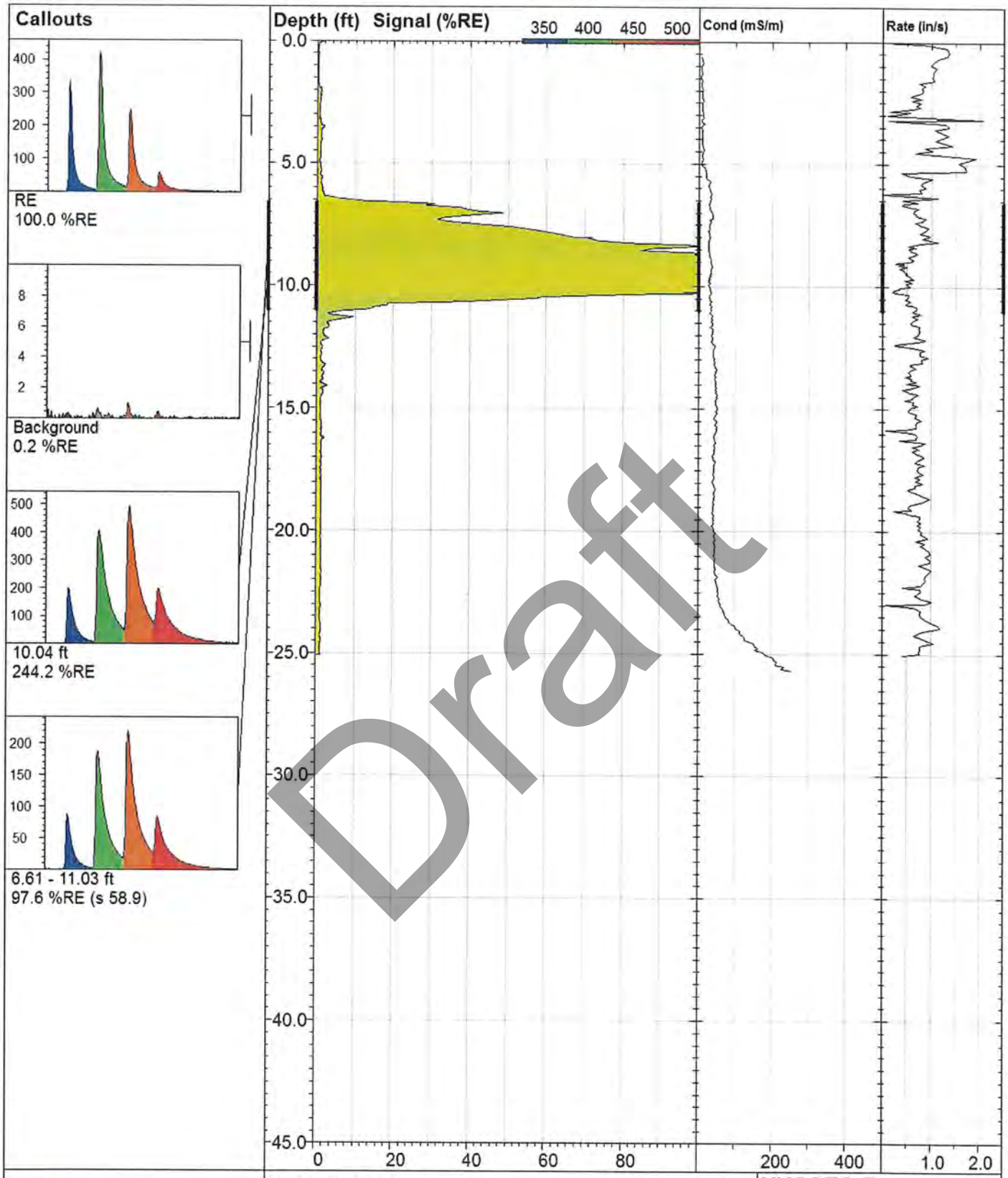
LIF-2015-06		**UVOST® By Dakota** www.DakotaTechnologies.com
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.37 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **154.8 %RE @ 3.98 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 13:45 CST**

MATRIX ENVIRONMENTAL LLC
www.matrixenv.com



LIF-2015-07		**UVOST® By Dakota** www.DakotaTechnologies.com
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.11 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **117.8 %RE @ 6.73 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 14:12 CST**

MATRIX ENVIRONMENTAL LLC
www.matrixenv.com



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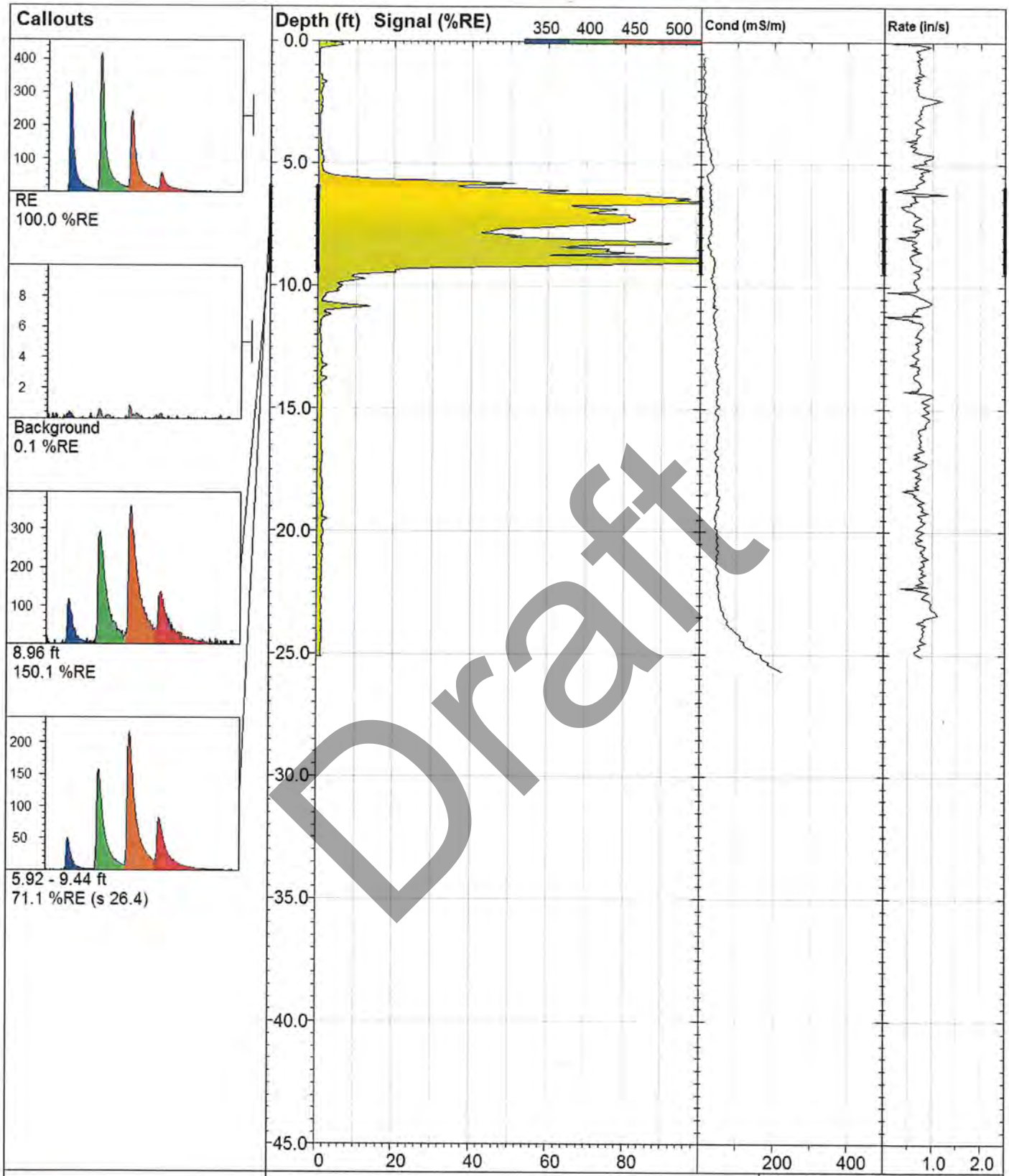
MATRIX ENVIRONMENTAL LLC
www.matrixenv.com

LIF-2015-08

UVOST® By Dakota
www.DakotaTechnologies.com

Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.06 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **244.2 %RE @ 10.04 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 14:40 CST**

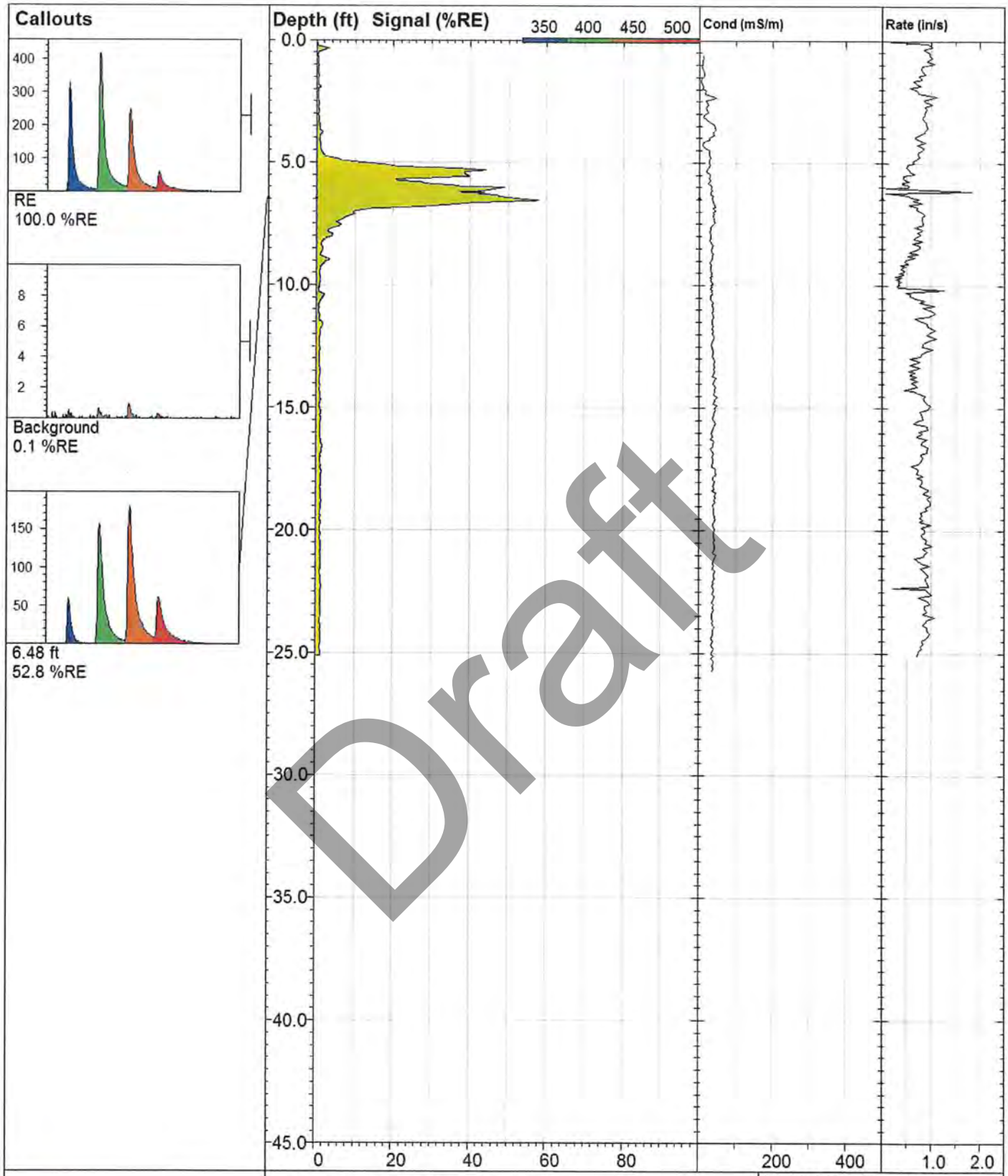


MATRIX ENVIRONMENTAL LLC
www.matrixenv.com

LIF-2015-09

UVOST® By Dakota
www.DakotaTechnologies.com

Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.11 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **165.1 %RE @ 8.87 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 15:07 CST**



Draft

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LIF-2015-10

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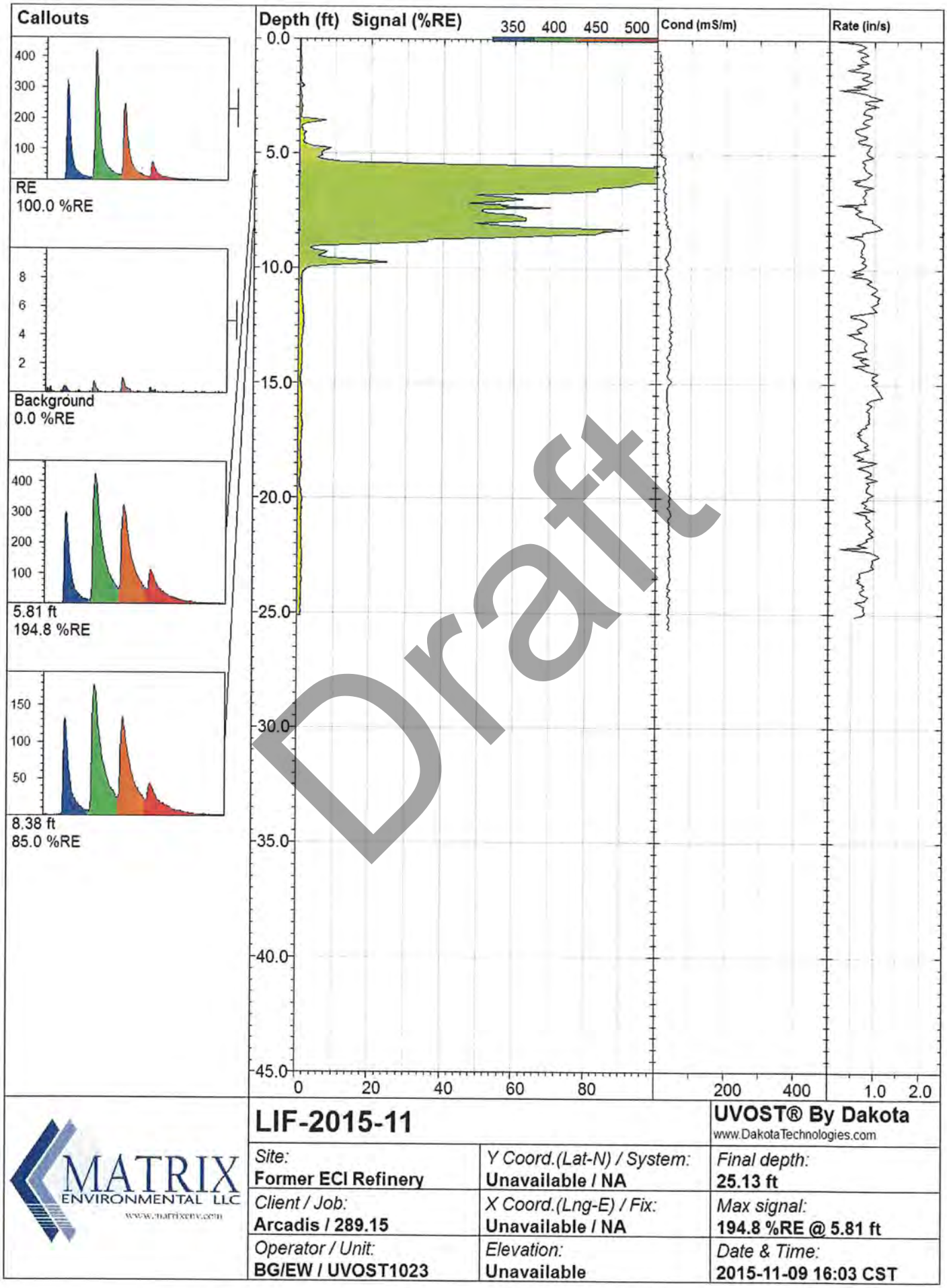
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.11 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **58.1 %RE @ 6.55 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 15:38 CST**



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UVOST® By Dakota
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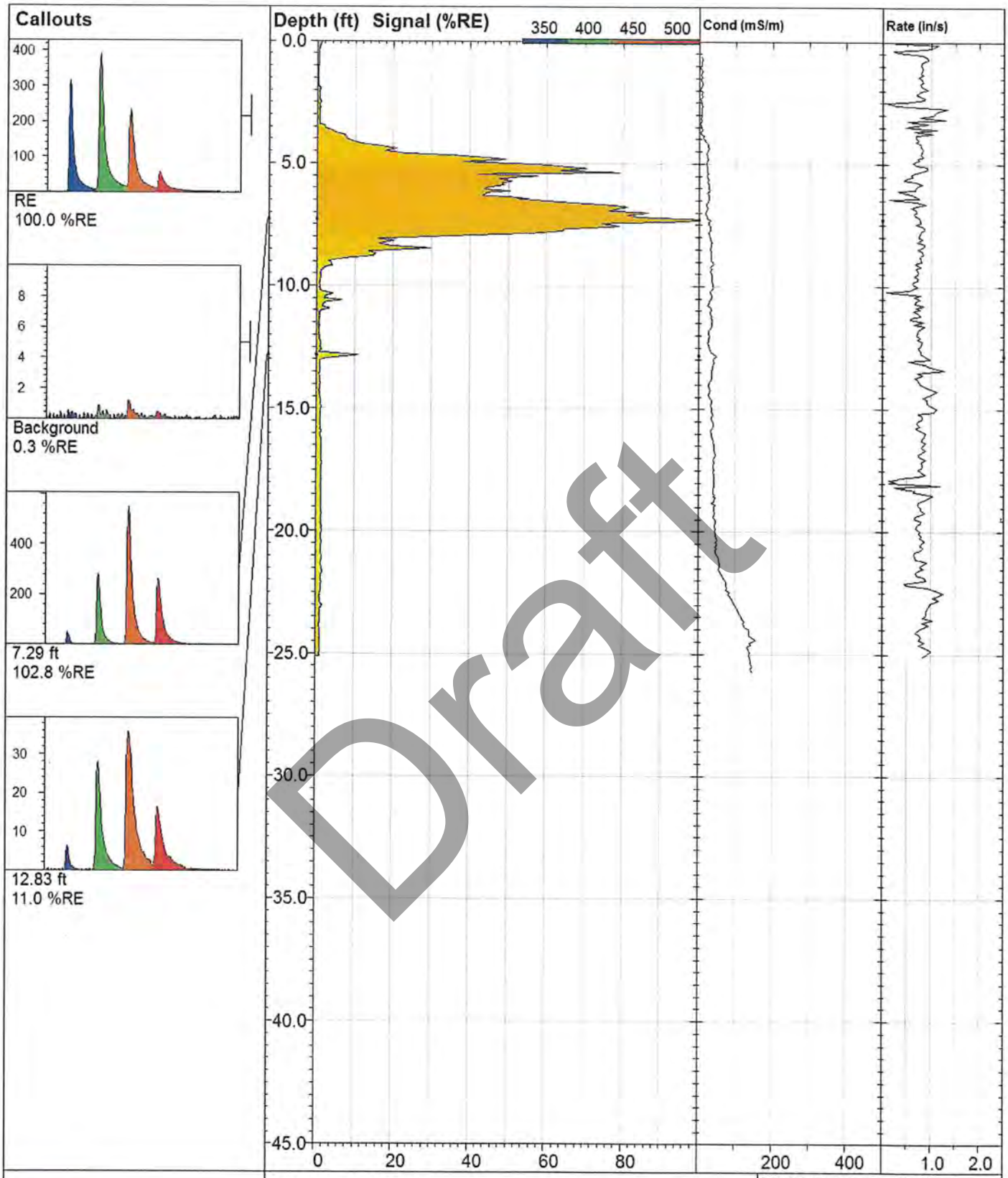
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.13 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **194.8 %RE @ 5.81 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 16:03 CST**



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UVOST® By Dakota
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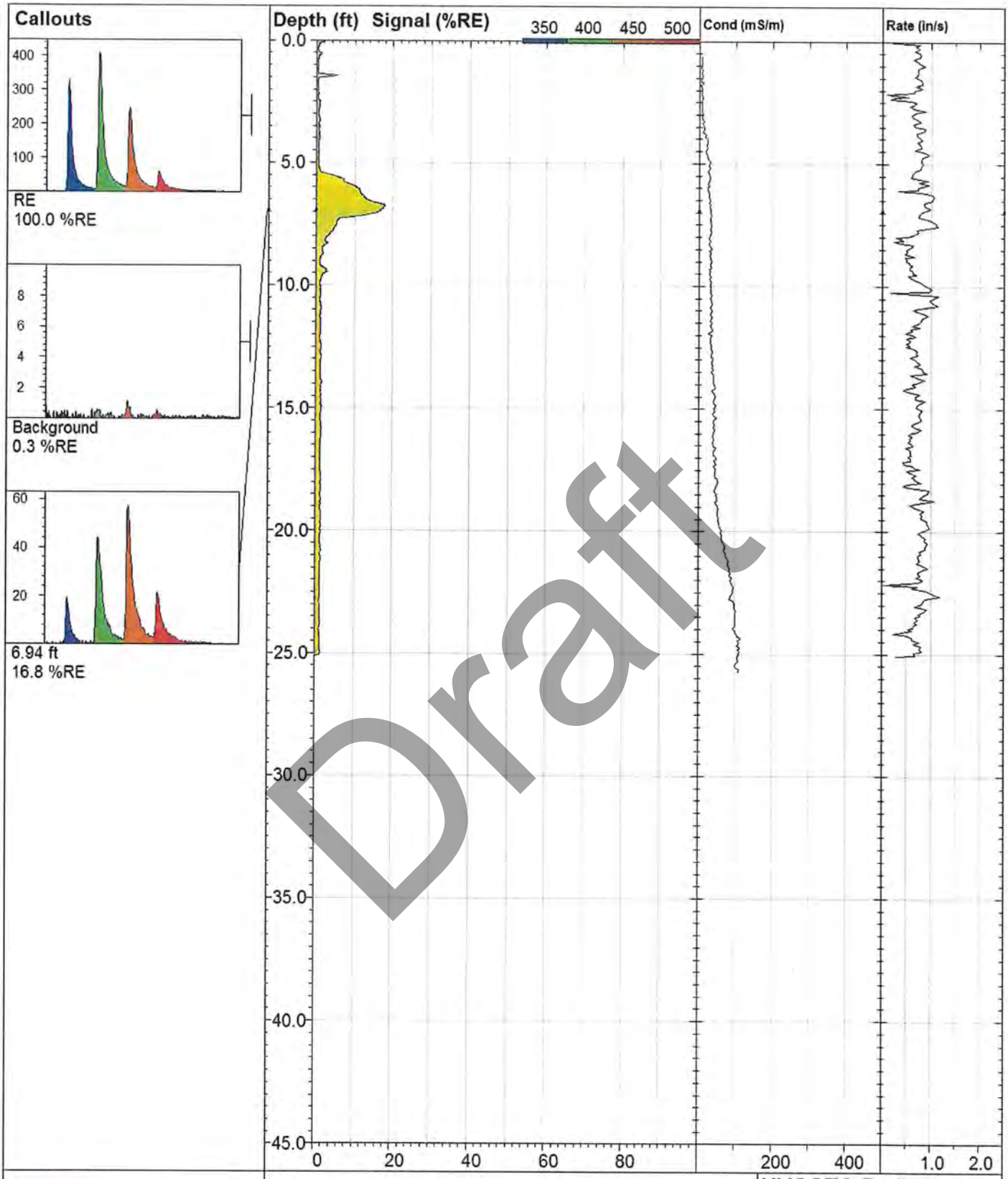
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.11 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **102.8 %RE @ 7.29 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 07:51 CST**



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UVOST® By Dakota
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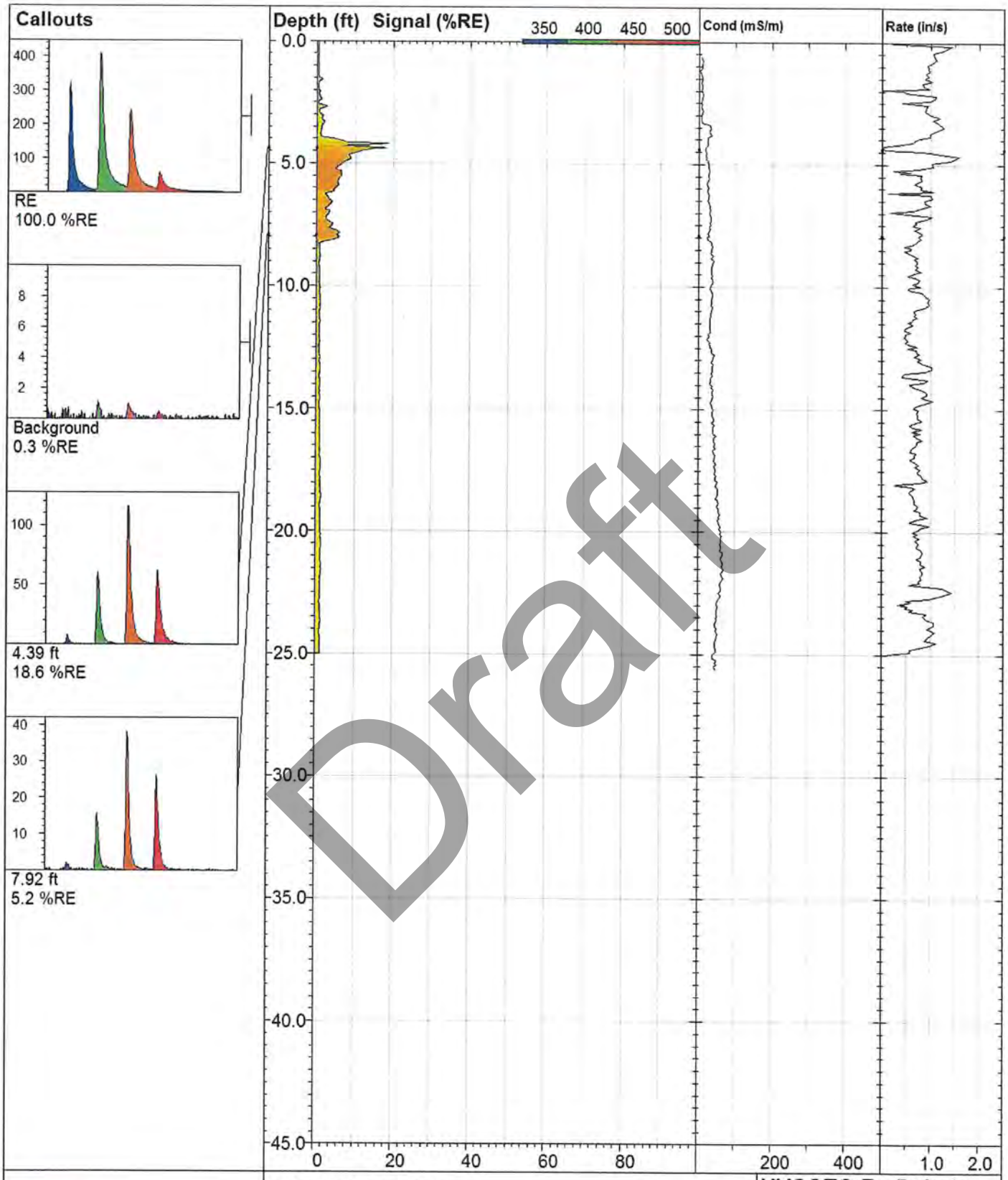
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.09 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **18.0 %RE @ 6.73 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 08:17 CST**



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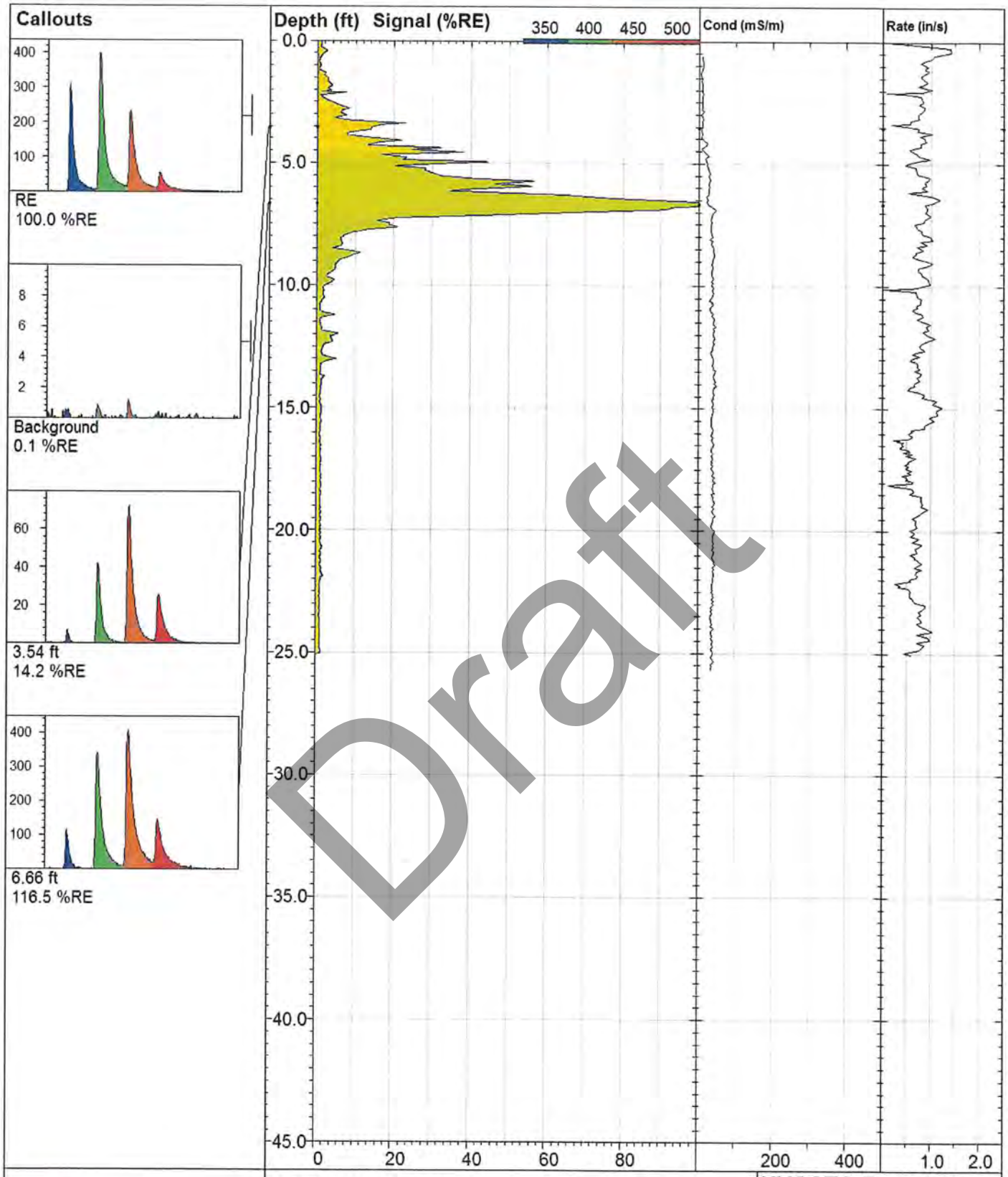
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.01 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **19.0 %RE @ 4.20 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 08:44 CST**



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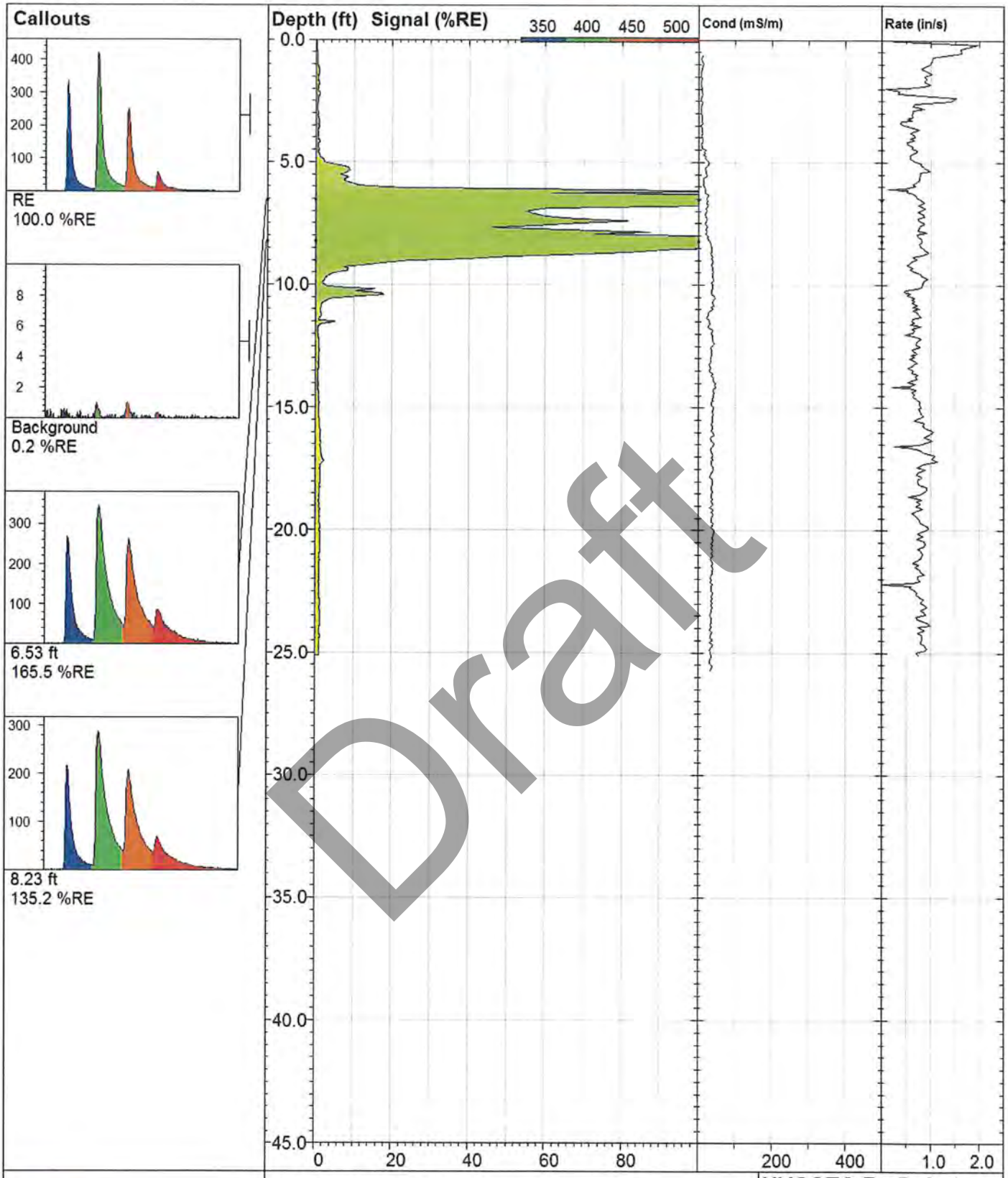
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.06 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **116.5 %RE @ 6.66 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 09:12 CST**



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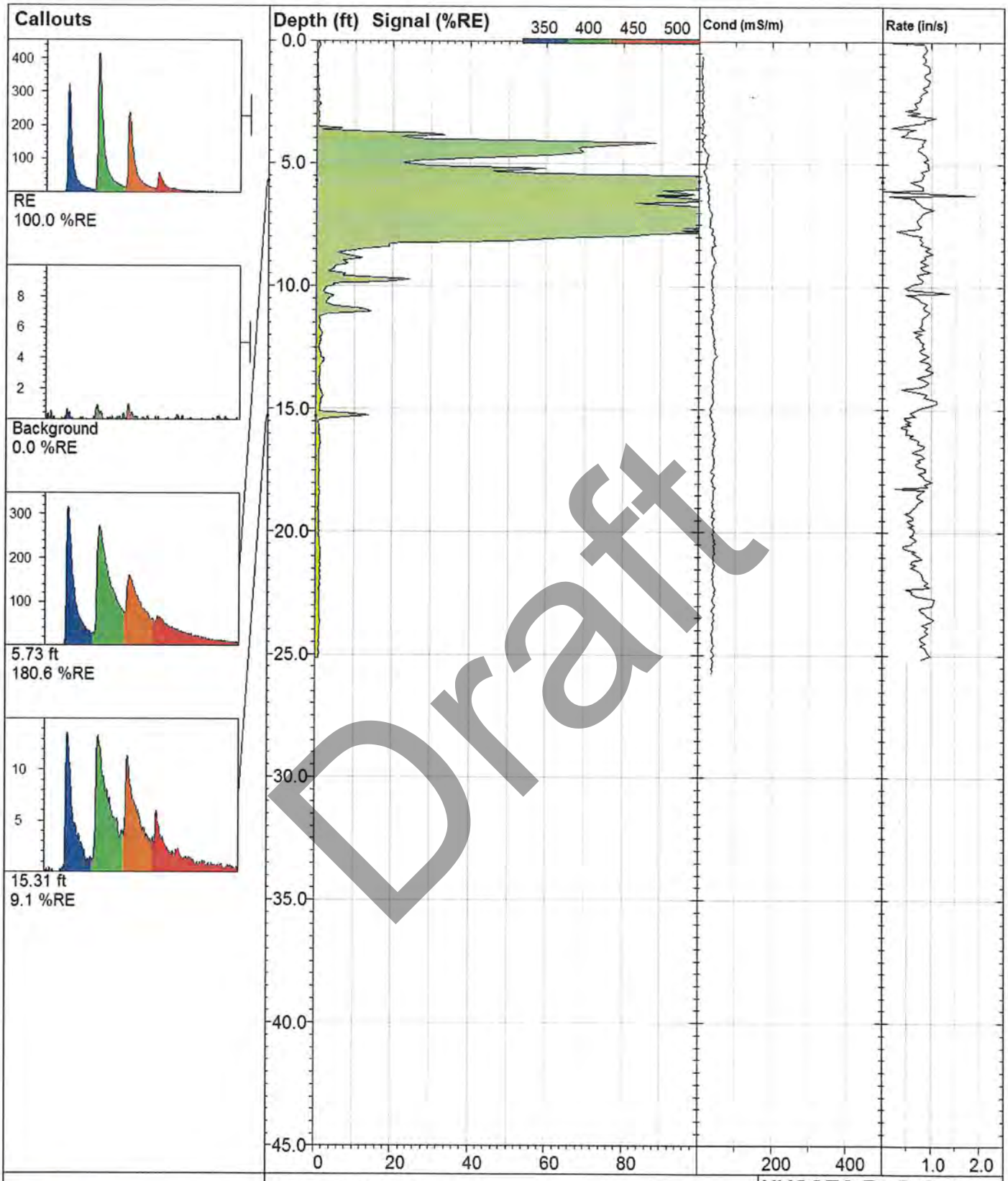
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **175.7 %RE @ 6.44 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 09:41 CST**



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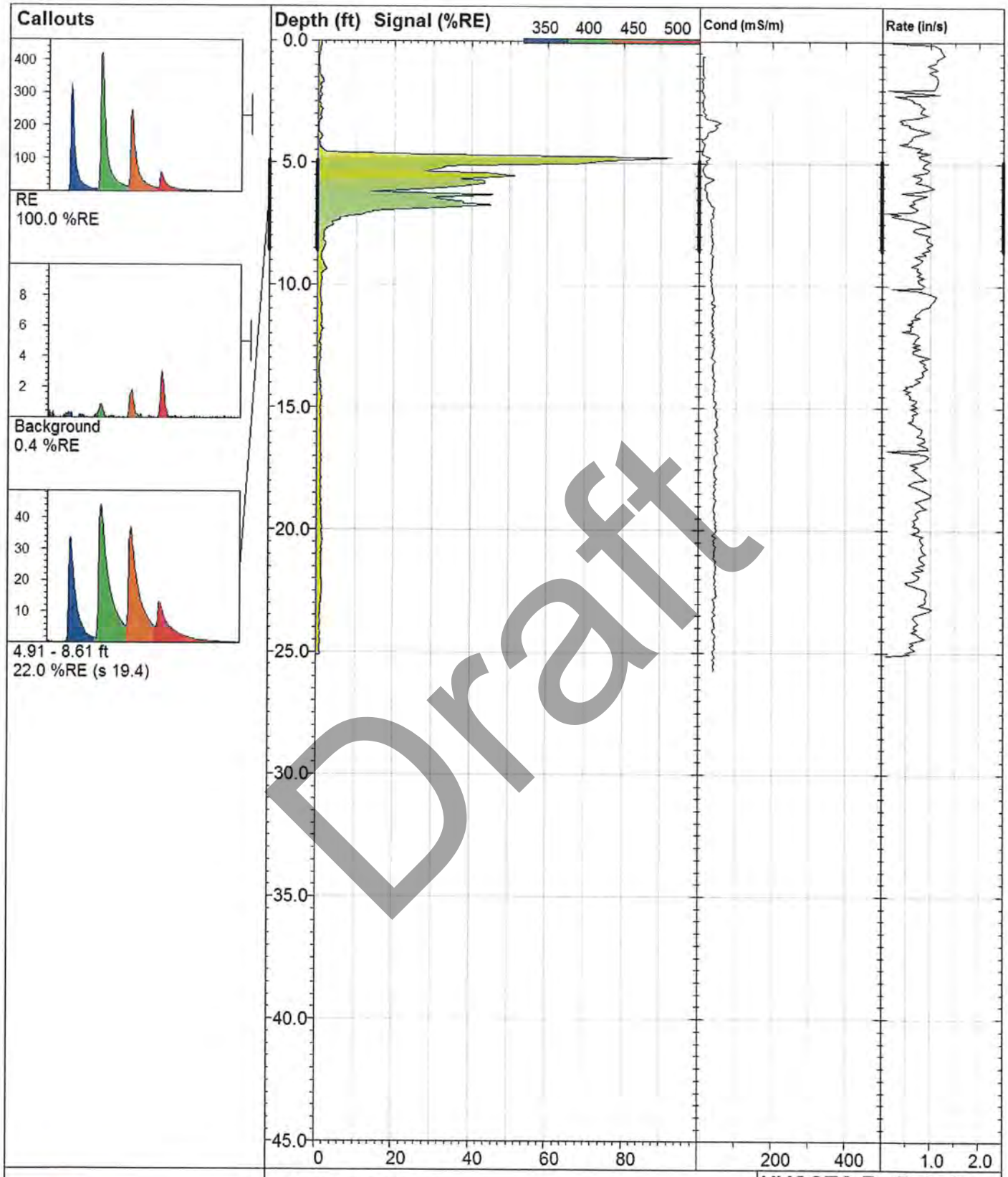
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.14 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **180.6 %RE @ 5.73 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 10:10 CST**



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LIF-2015-18

UVOST® By Dakota
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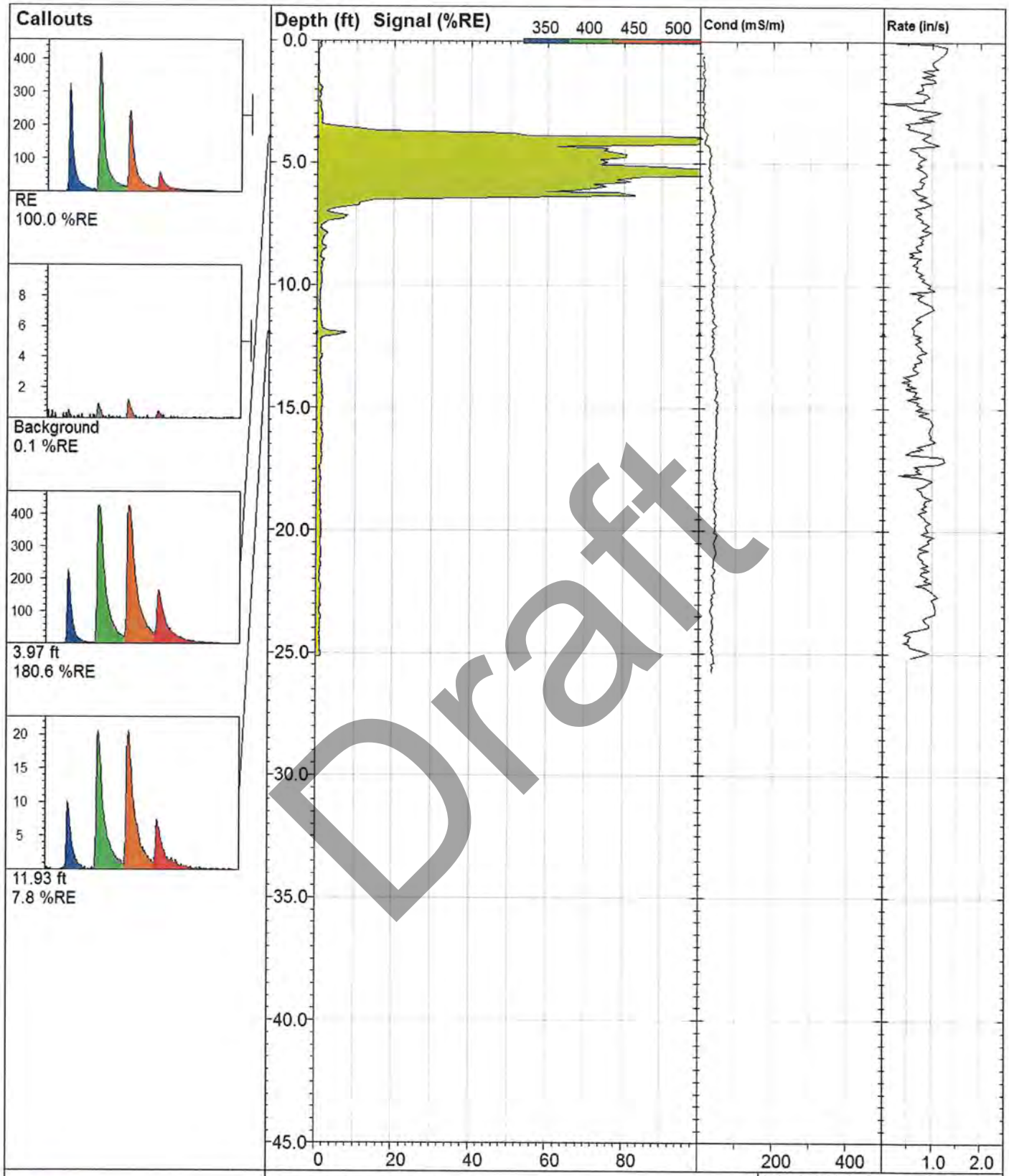
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.11 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **92.7 %RE @ 4.78 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 10:36 CST**



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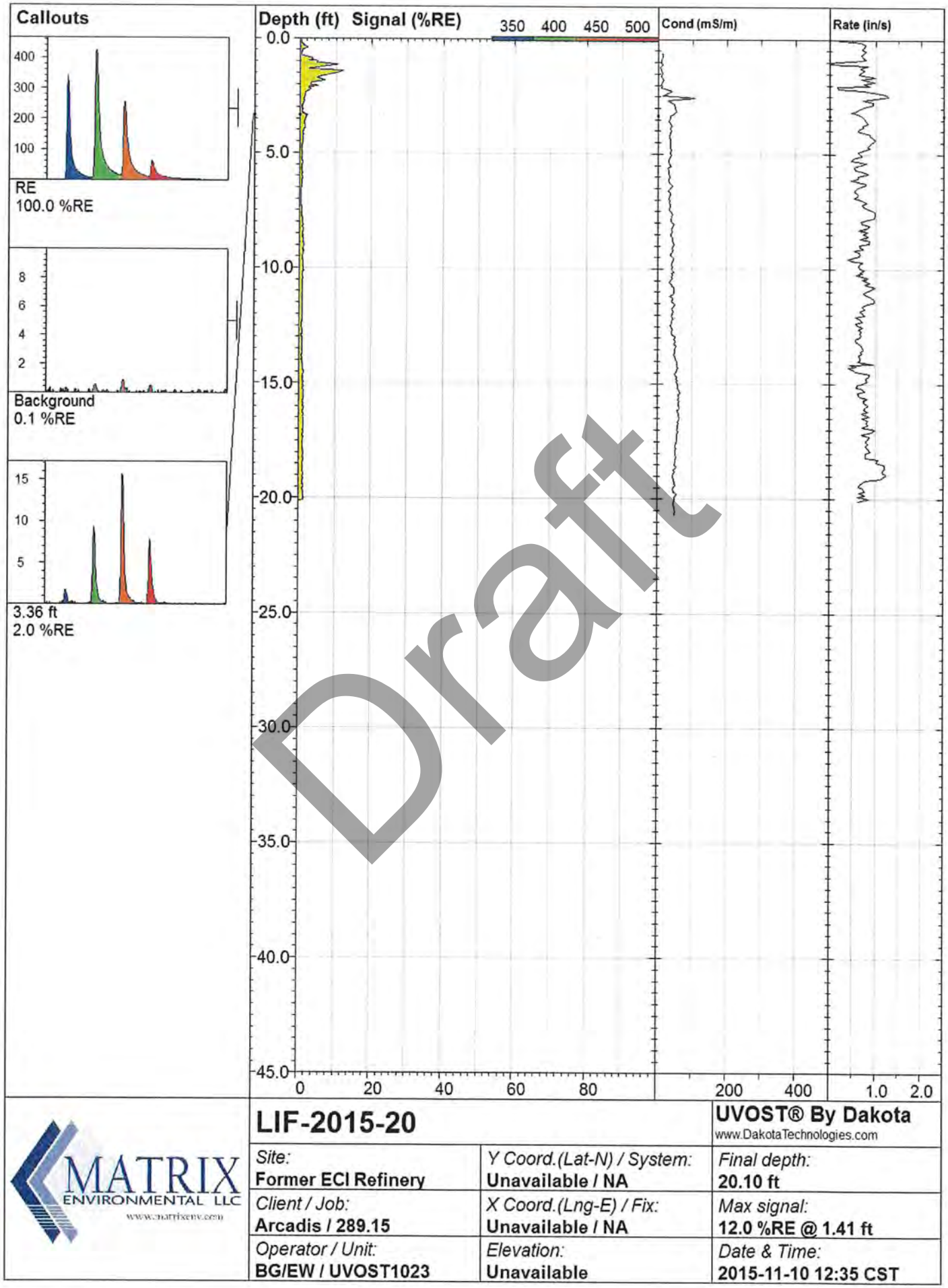
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.14 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **180.6 %RE @ 3.97 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 11:04 CST**



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LIF-2015-20

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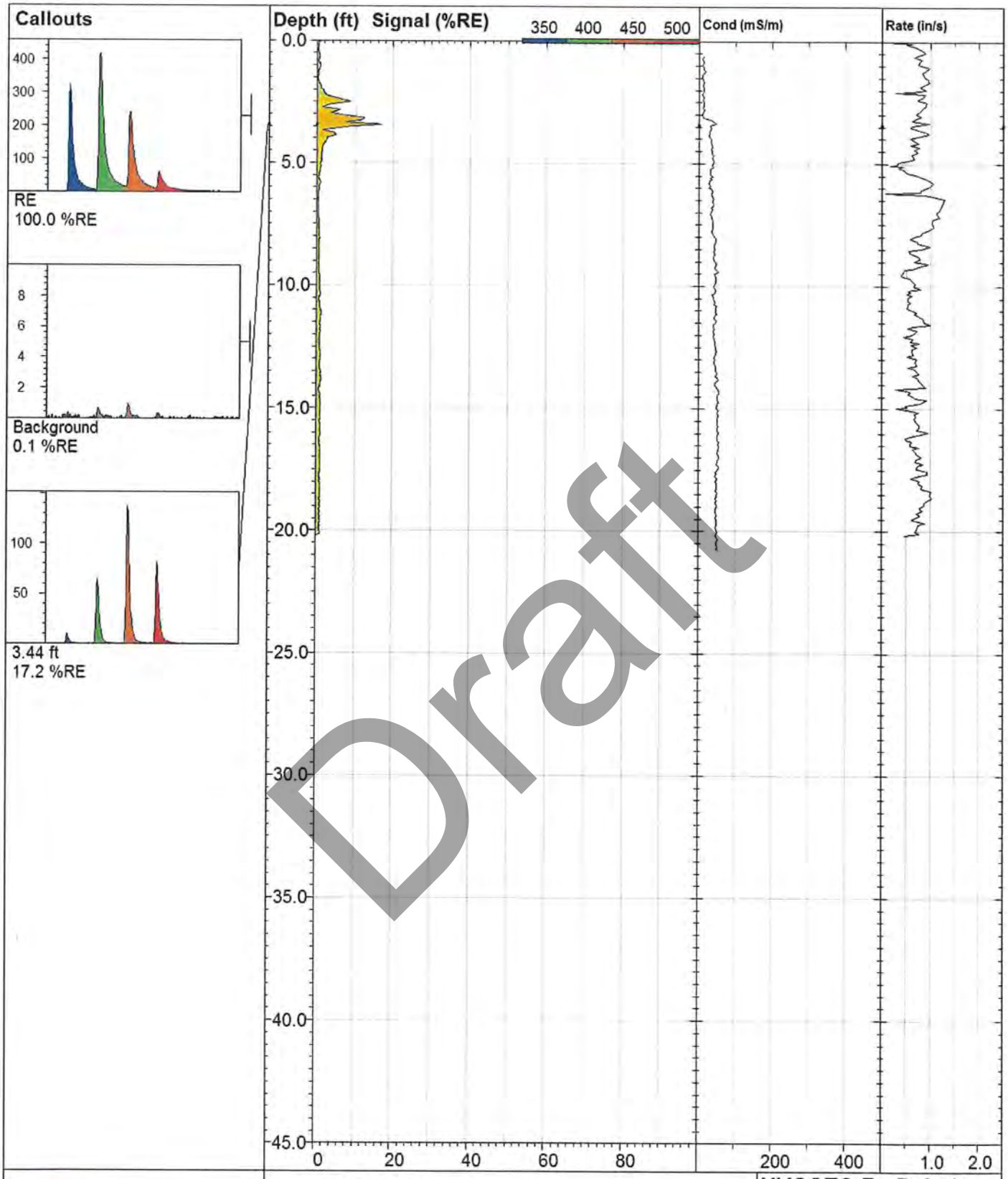
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.10 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **12.0 %RE @ 1.41 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 12:35 CST**



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LIF-2015-21

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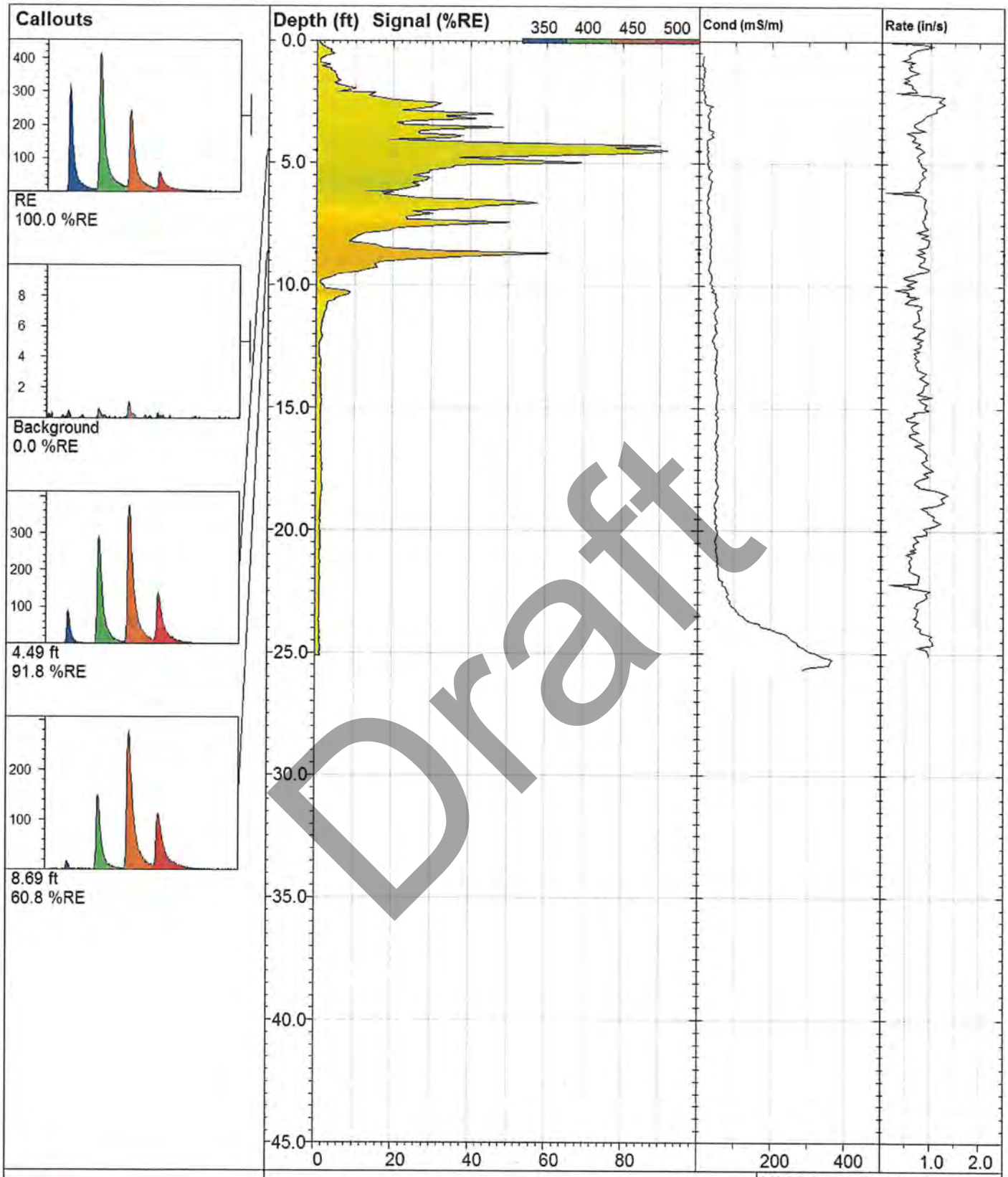
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.17 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **17.2 %RE @ 3.44 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 12:59 CST**



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LIF-2015-22

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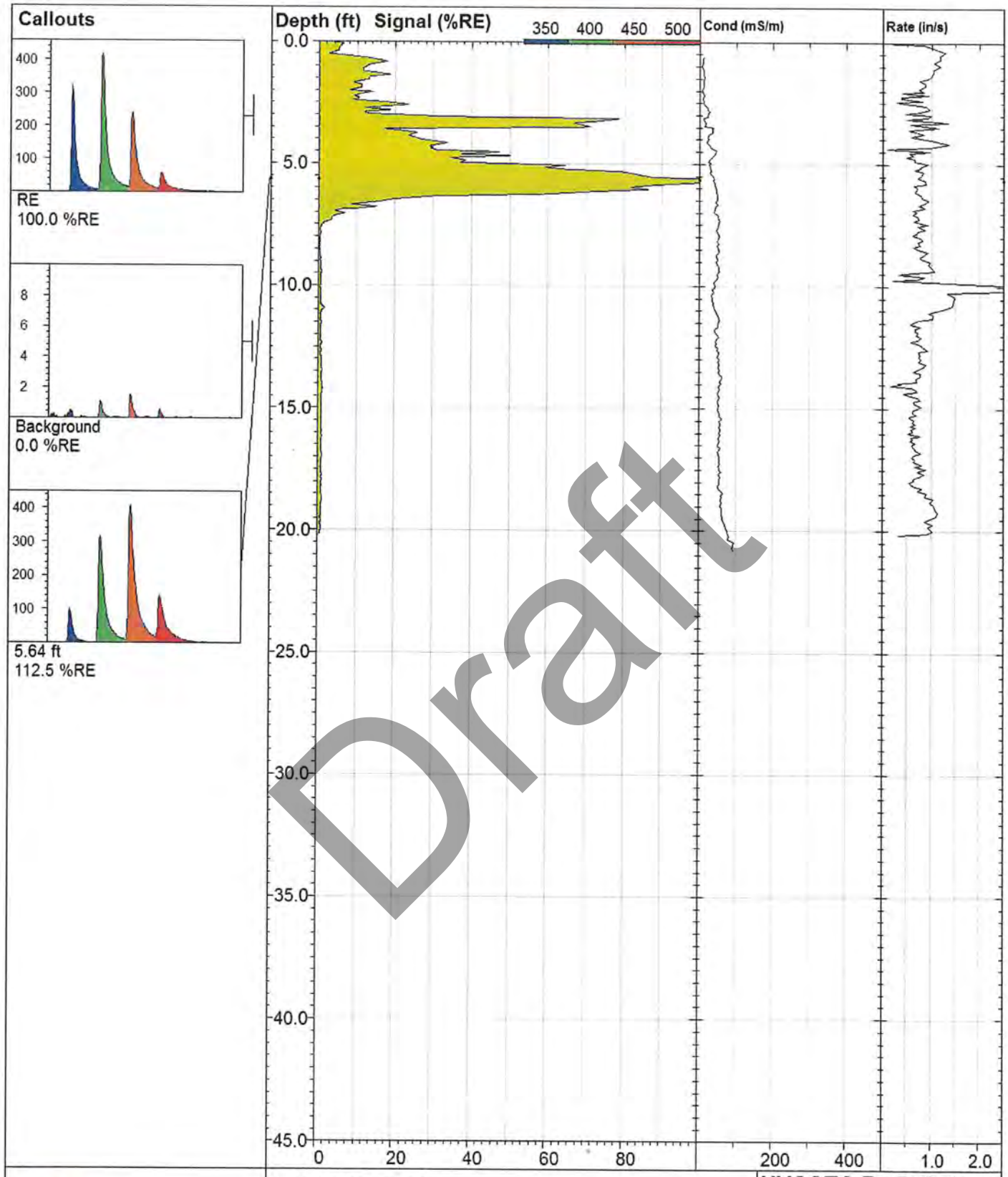
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.10 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **91.8 %RE @ 4.49 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 13:45 CST**



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LIF-2015-23

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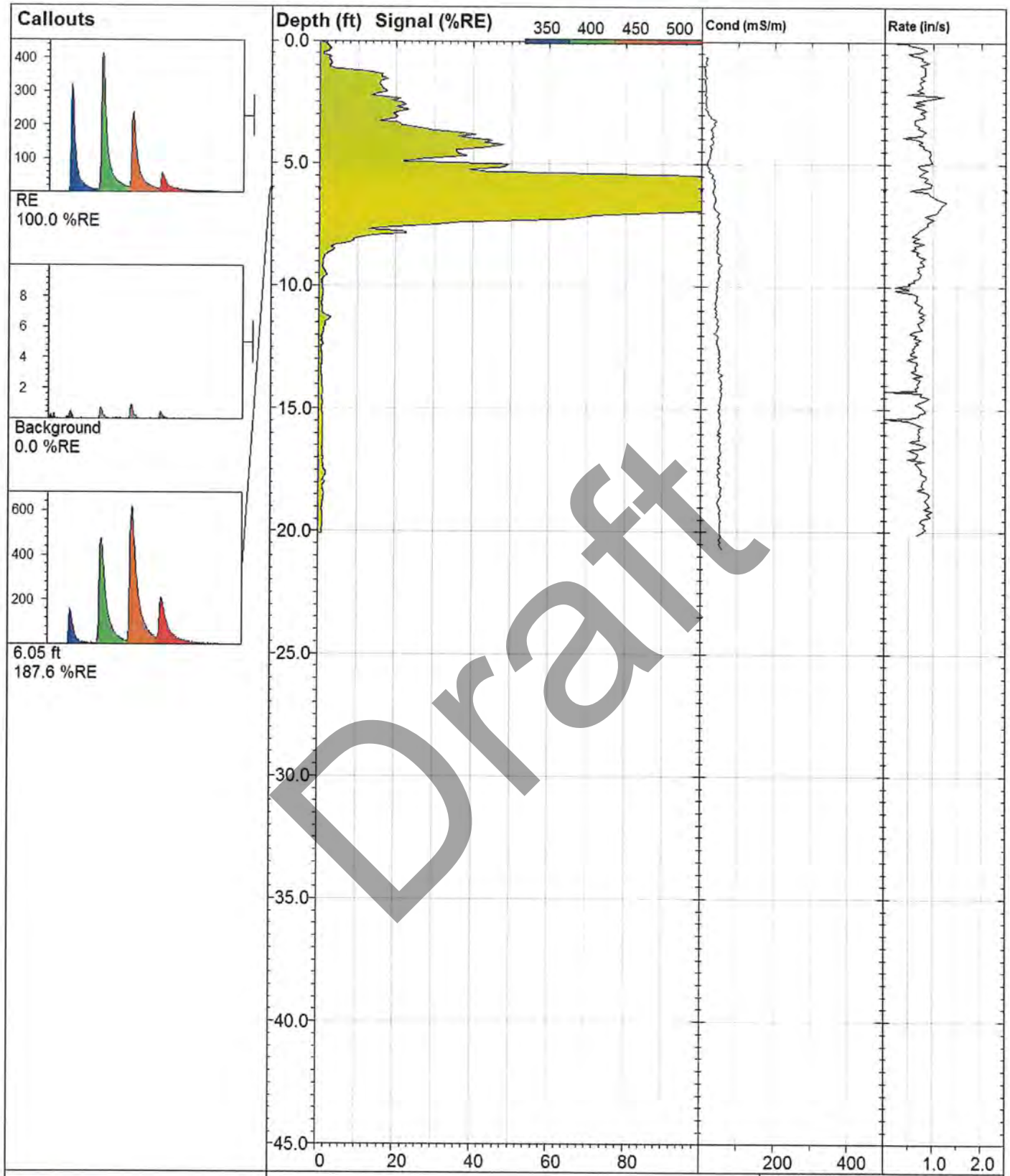
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.17 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **112.5 %RE @ 5.64 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 14:11 CST**



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LIF-2015-24

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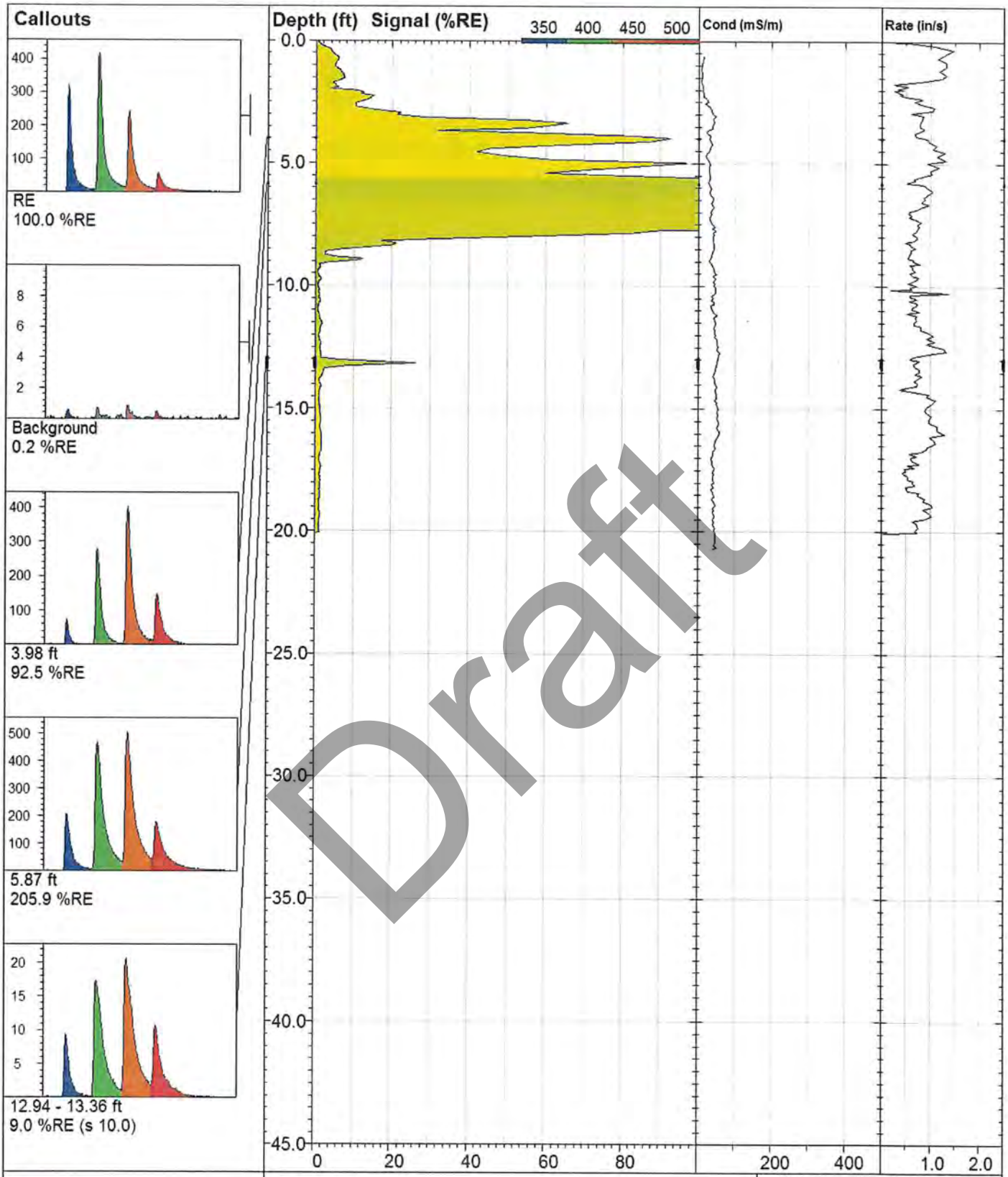
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.09 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **187.6 %RE @ 6.05 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 14:34 CST**



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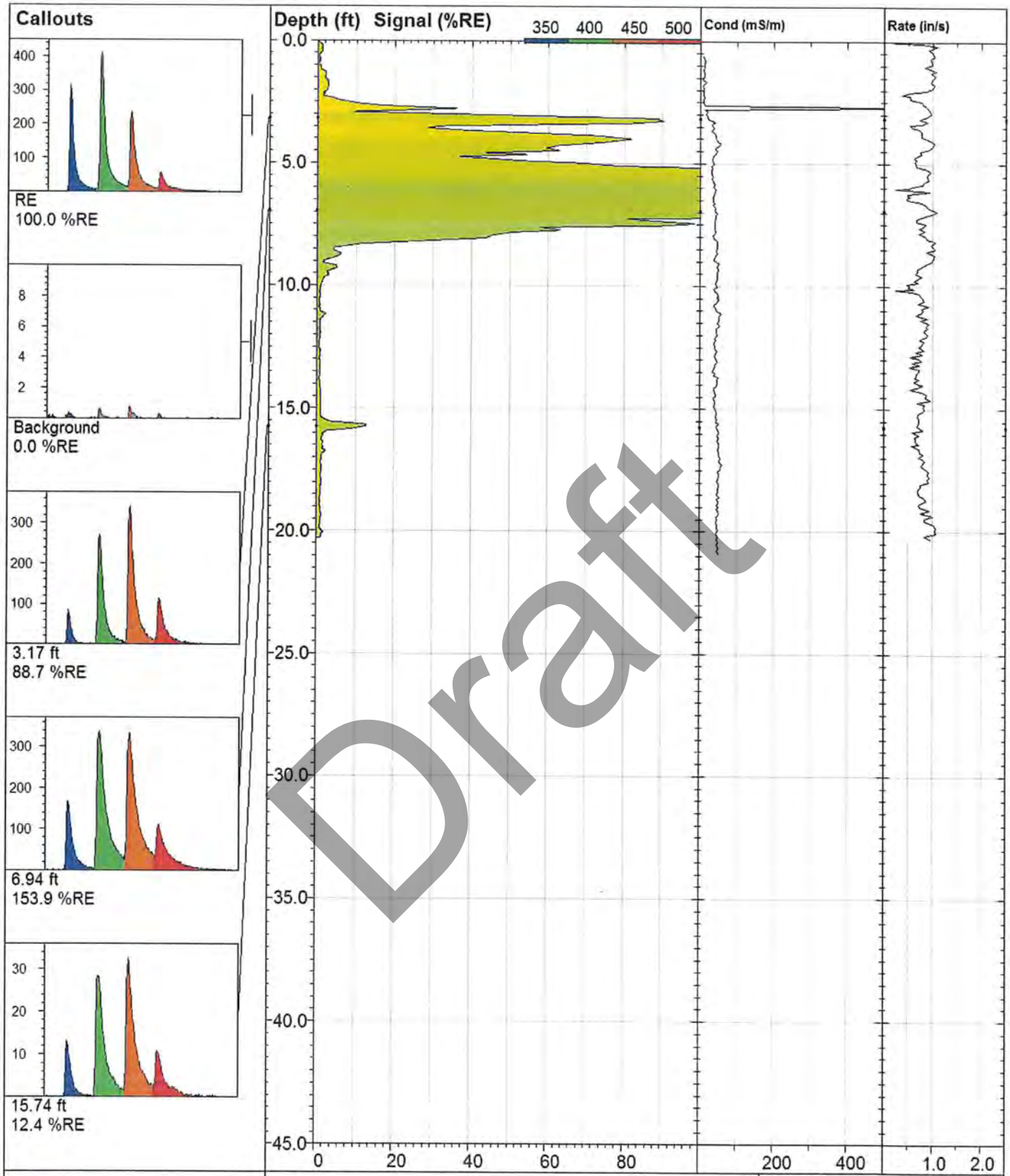
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.07 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **205.9 %RE @ 5.87 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 14:55 CST**



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LIF-2015-26

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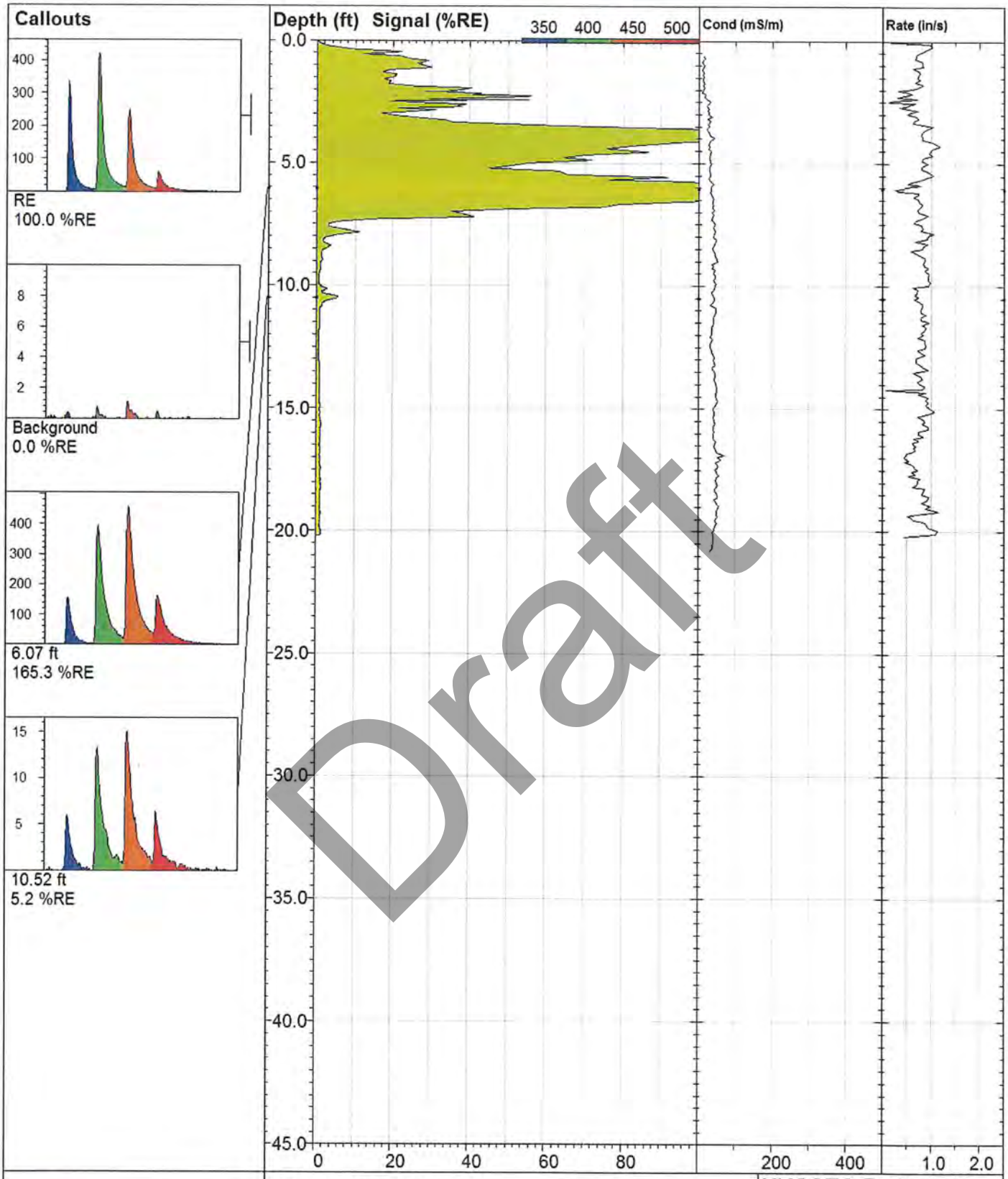
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.30 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **174.2 %RE @ 6.81 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 15:14 CST**



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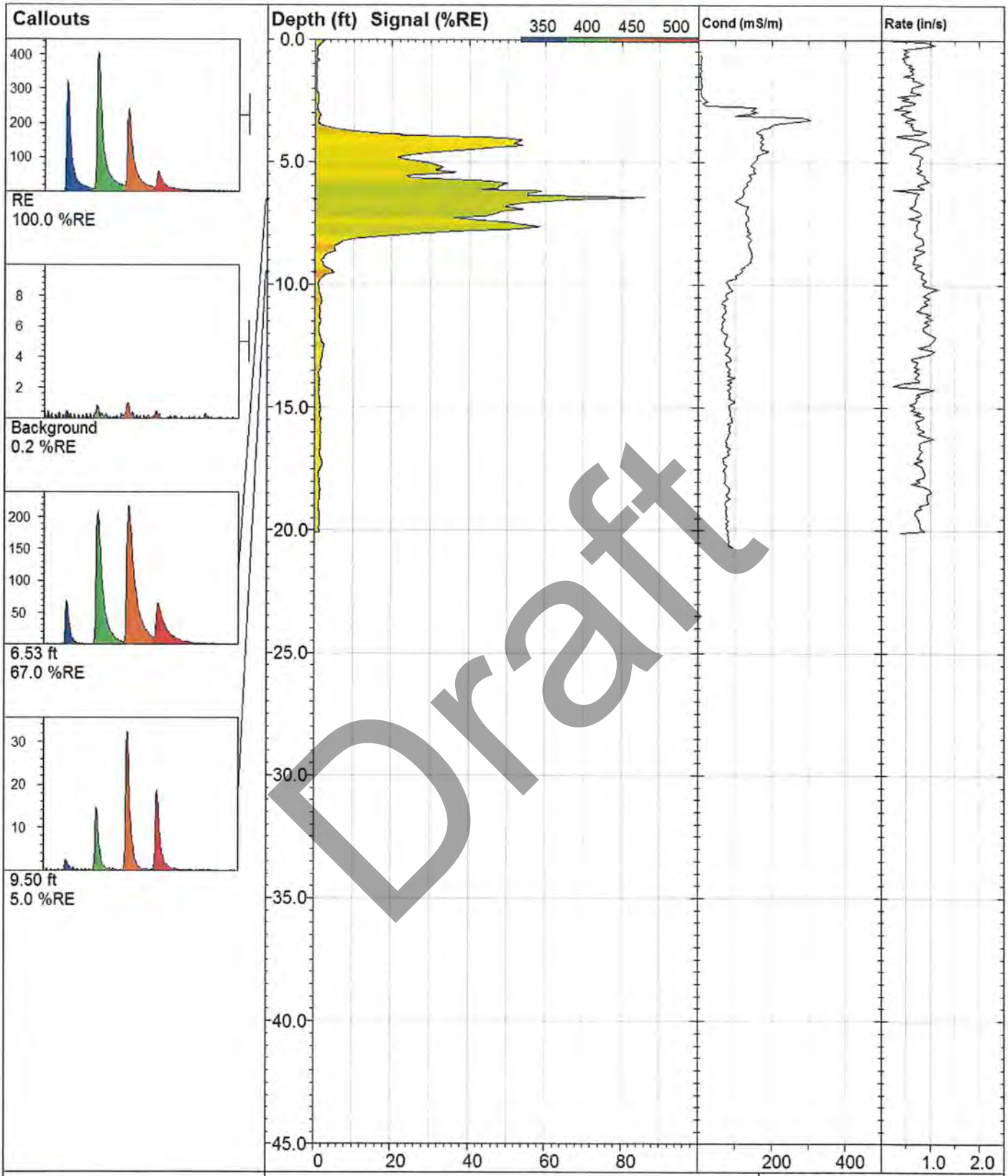
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.19 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **181.9 %RE @ 6.12 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 15:36 CST**



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LIF-2015-28

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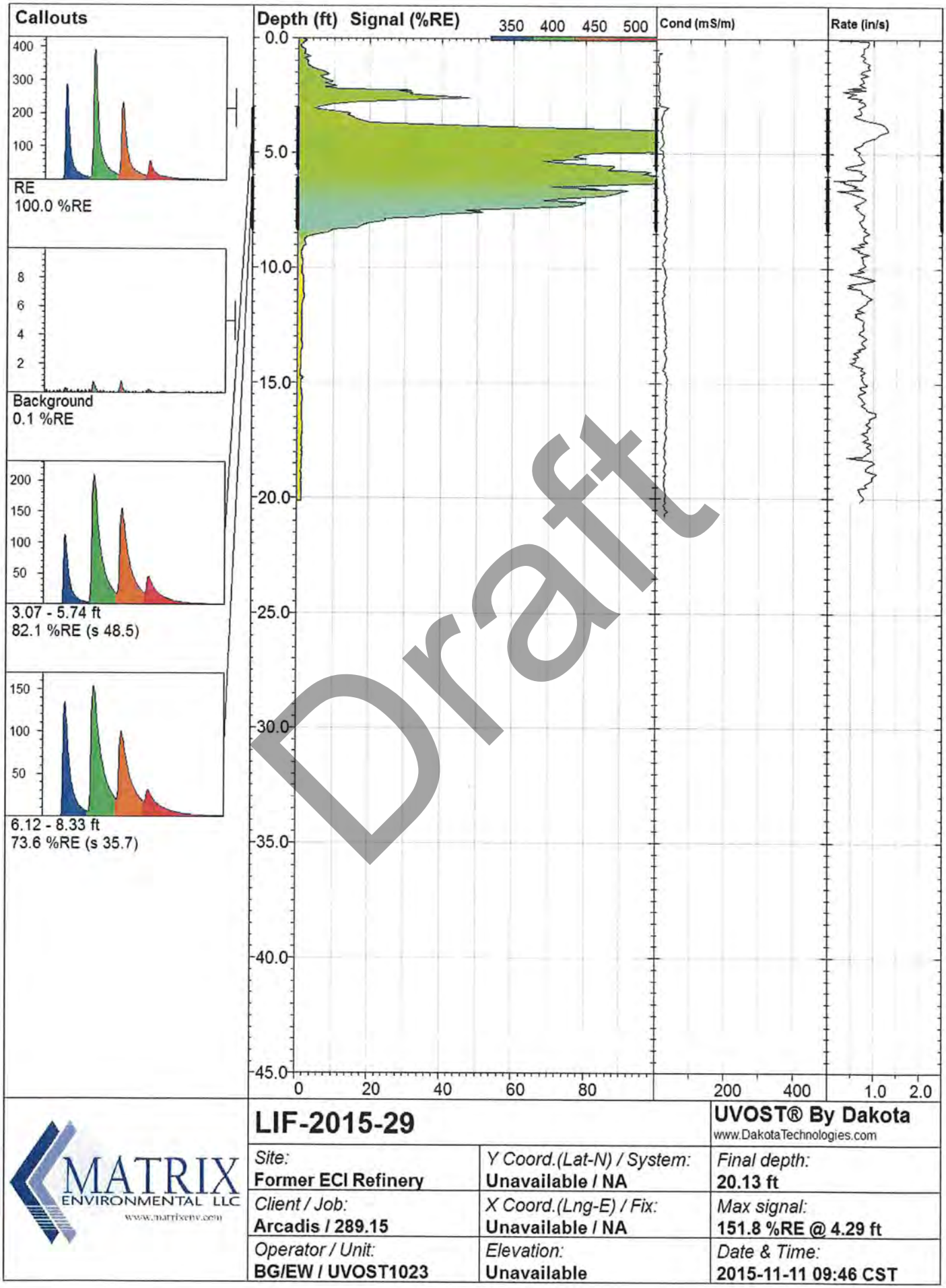
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.08 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **86.1 %RE @ 6.44 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 08:22 CST**



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LIF-2015-29

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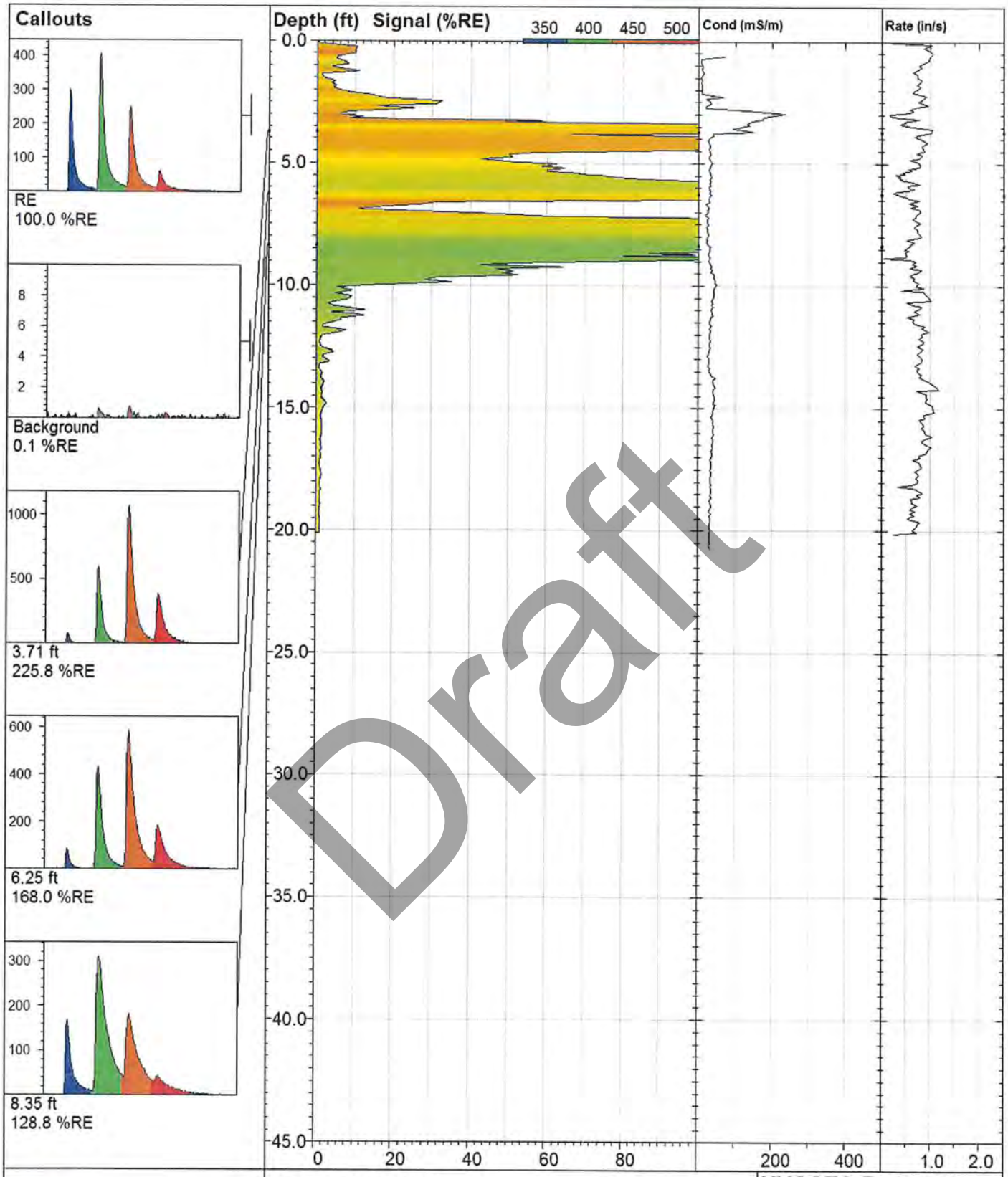
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.13 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **151.8 %RE @ 4.29 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 09:46 CST**



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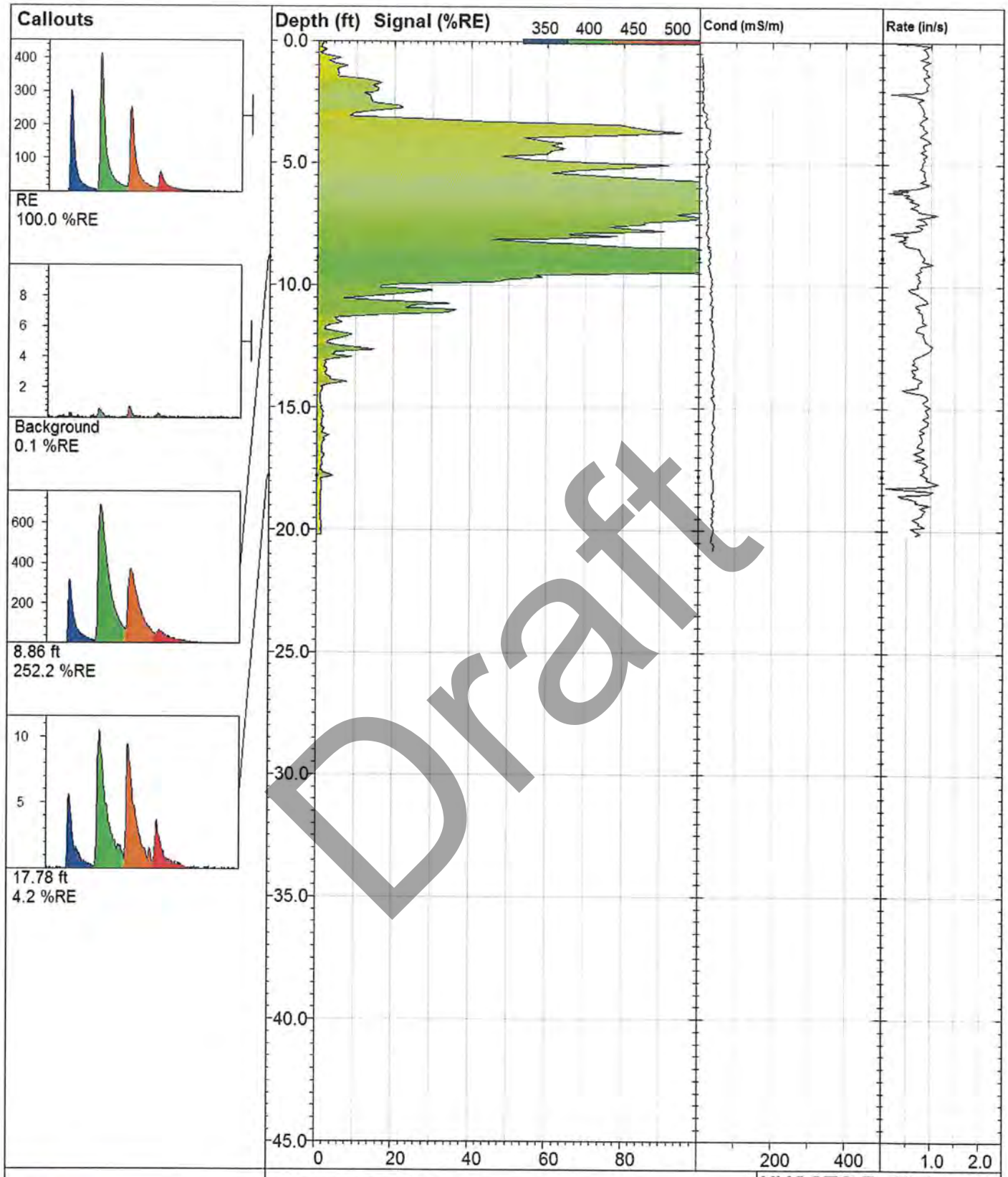
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **233.9 %RE @ 3.59 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 10:11 CST**



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LIF-2015-31

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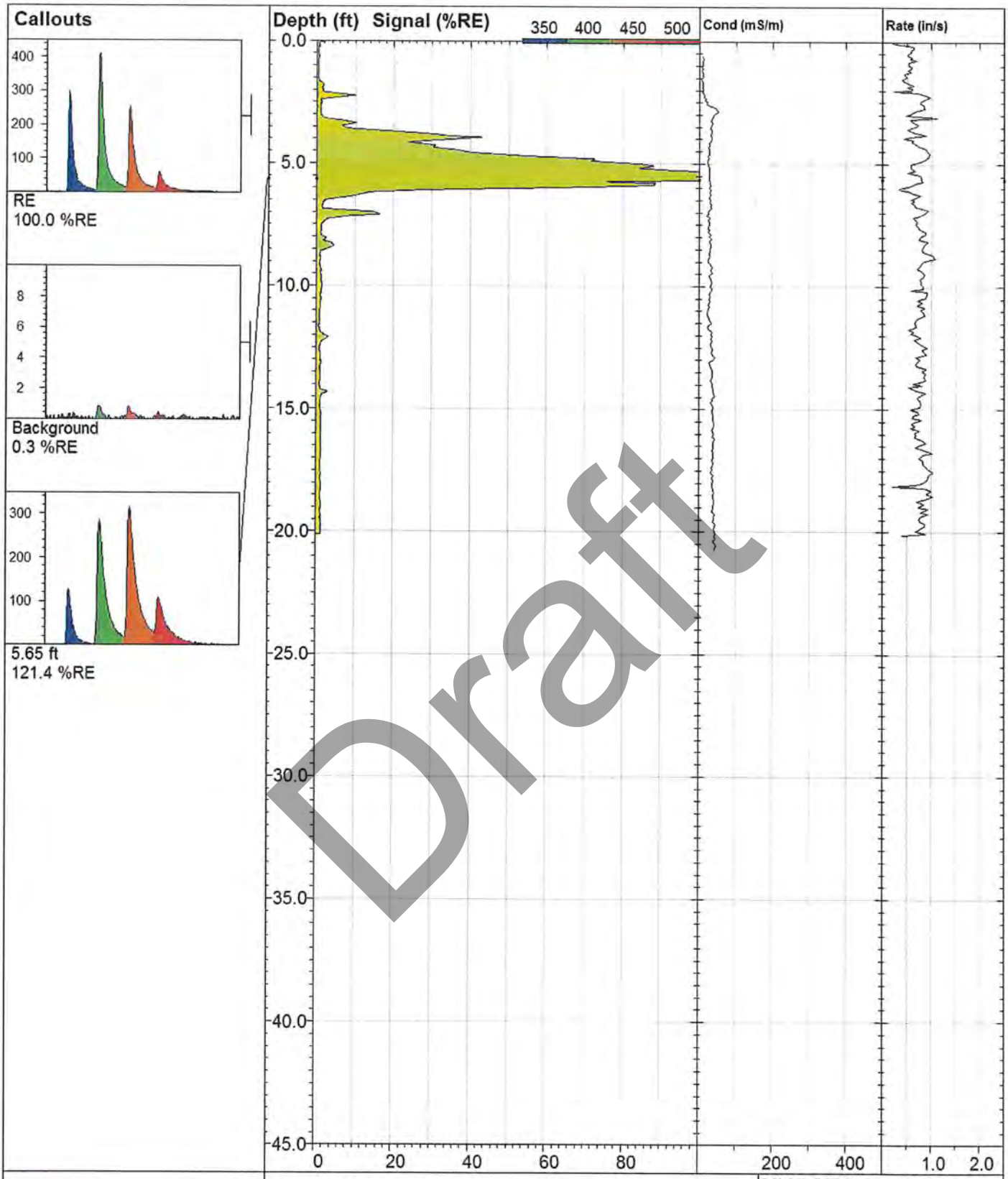
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.18 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **261.7 %RE @ 8.73 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 10:33 CST**



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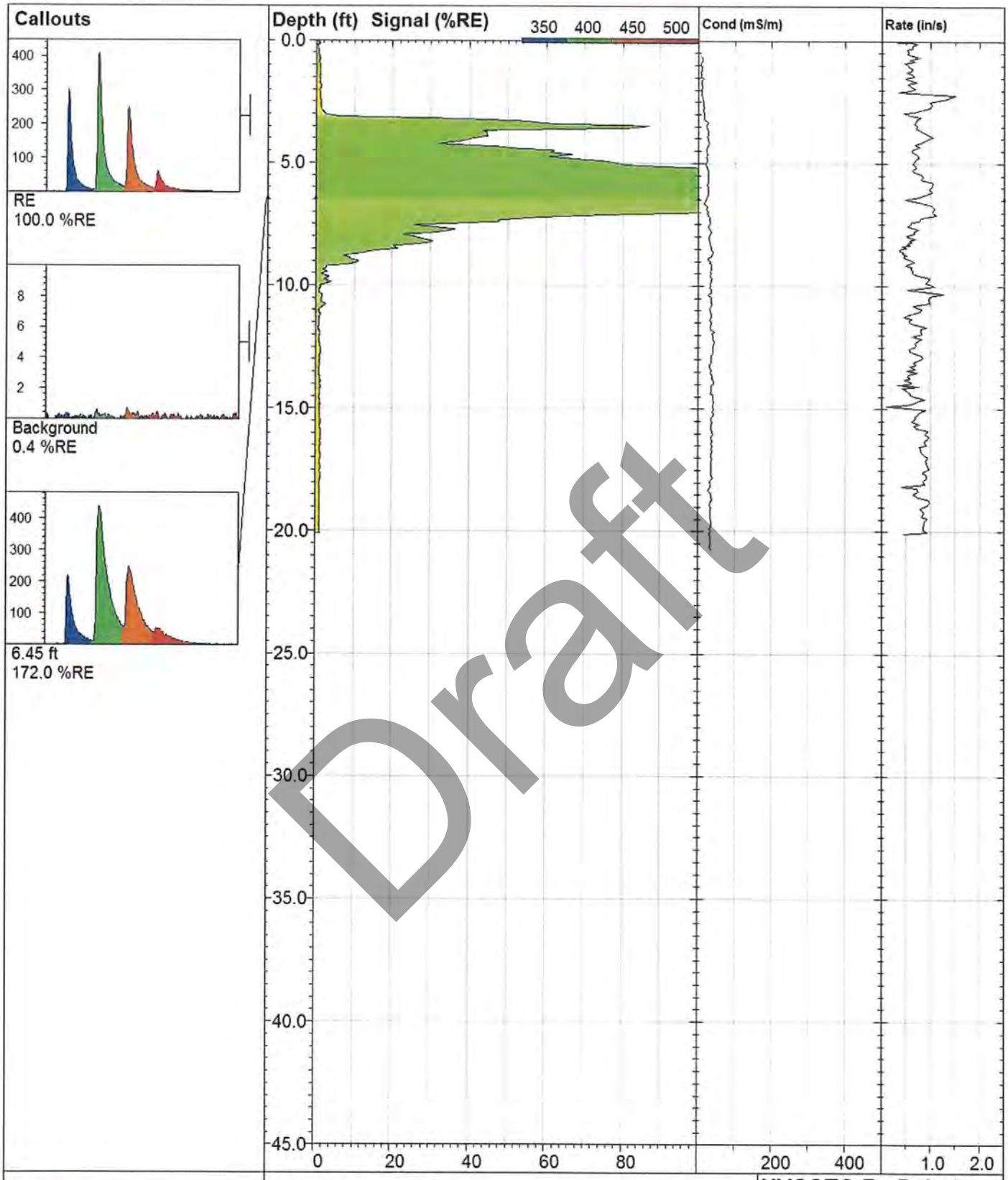
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **127.5 %RE @ 5.56 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 10:56 CST**



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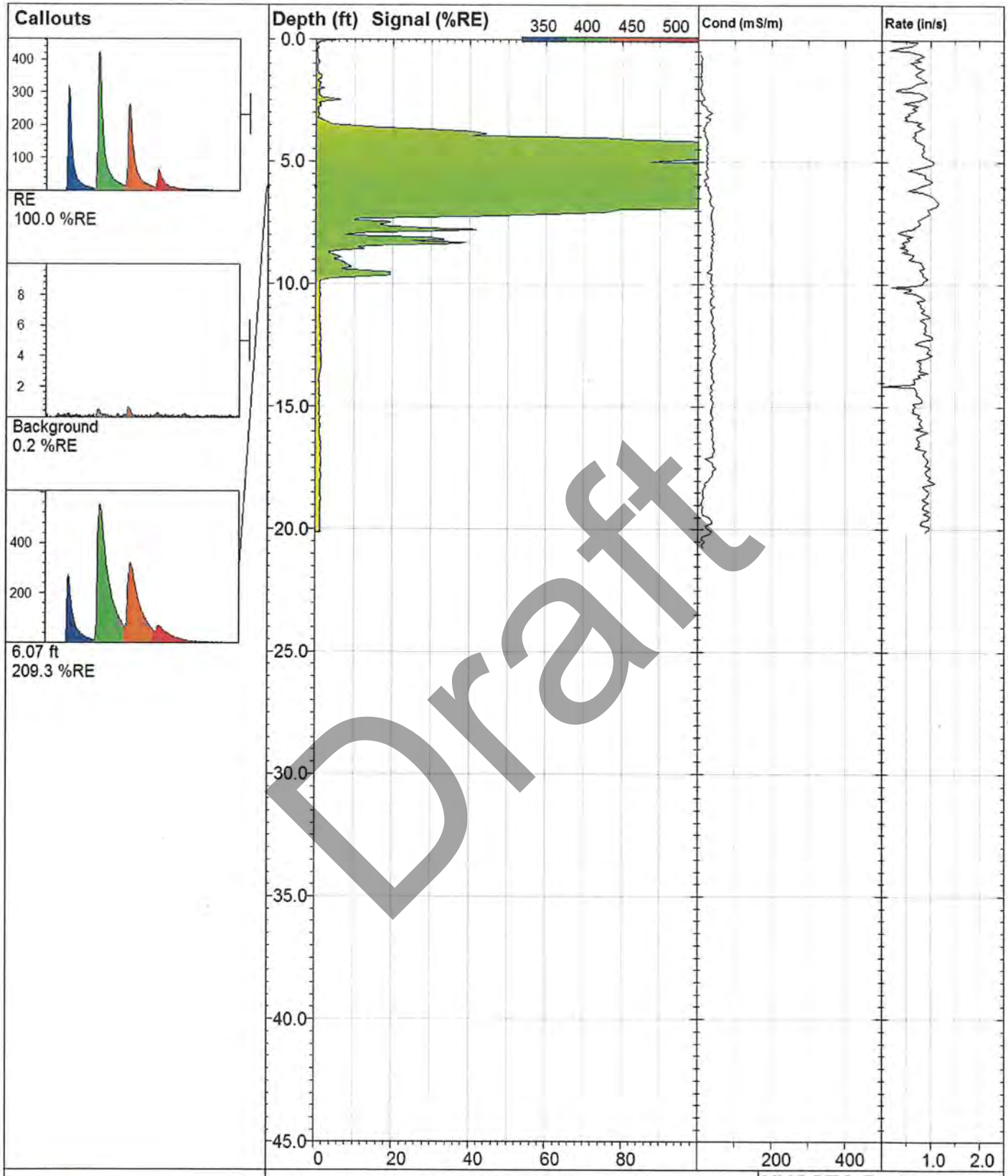
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.10 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **172.0 %RE @ 6.45 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 11:18 CST**



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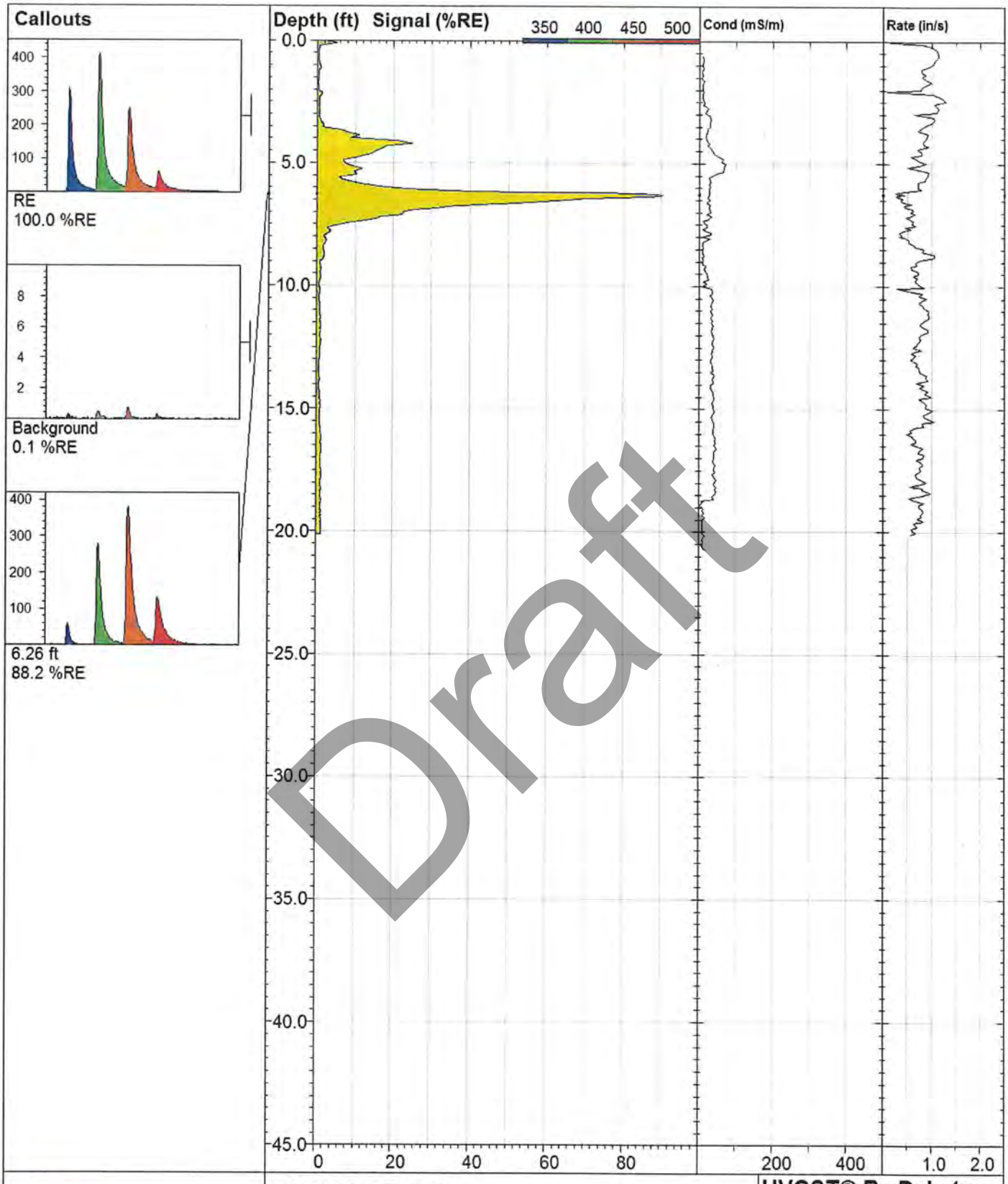
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **209.3 %RE @ 6.07 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 11:46 CST**



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LIF-2015-35

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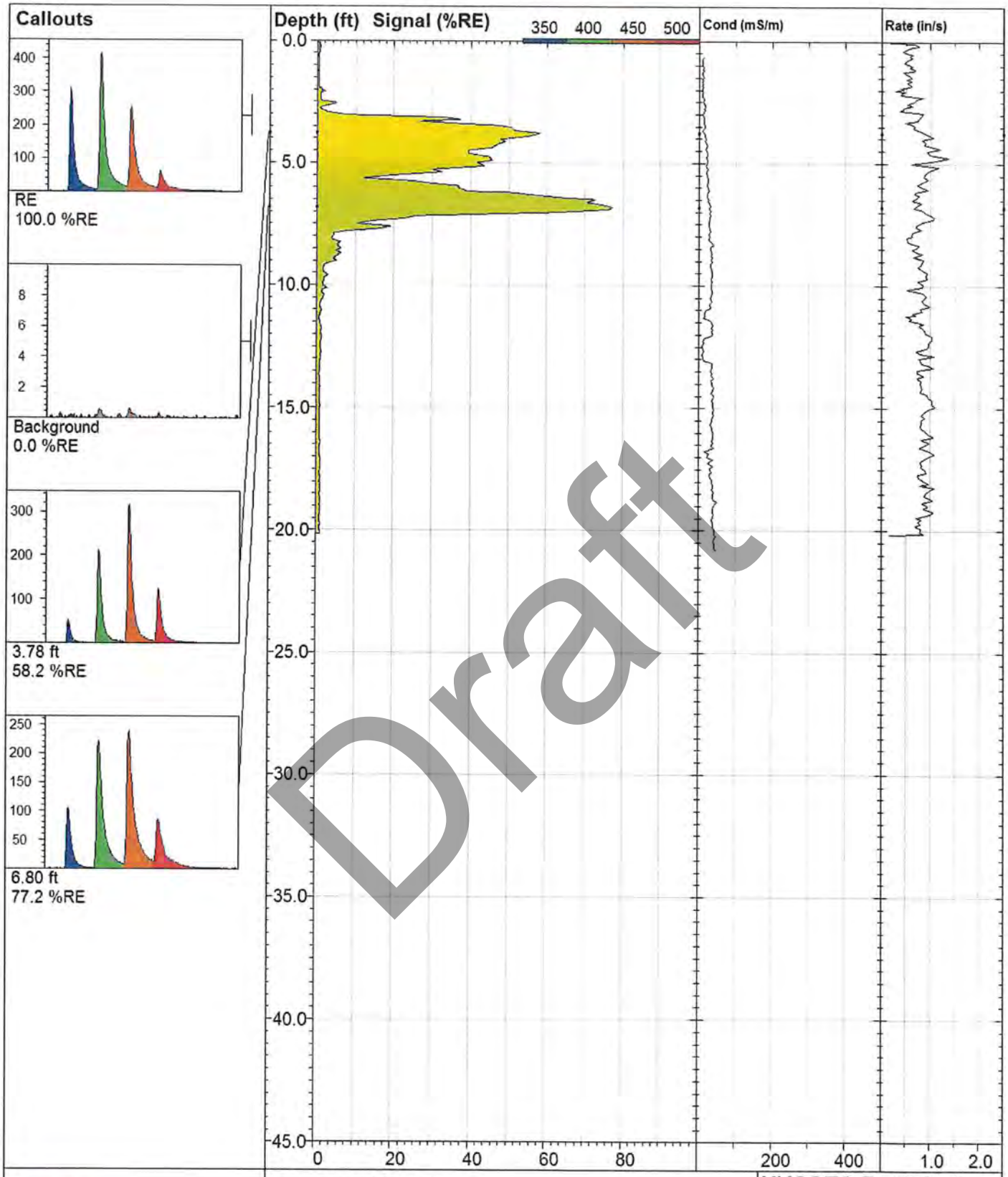
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **90.6 %RE @ 6.30 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 13:12 CST**



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LIF-2015-36

UVOST® By Dakota
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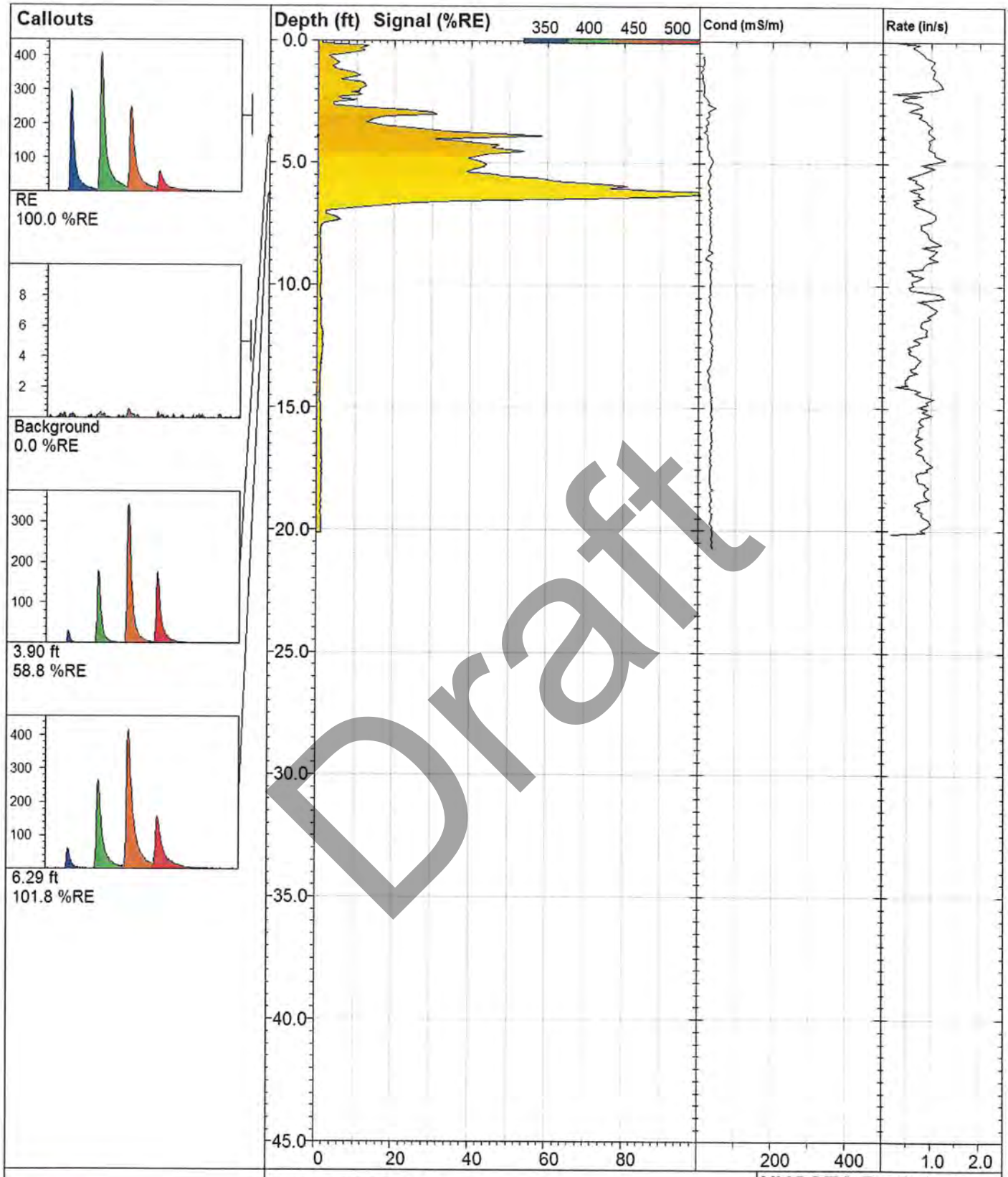
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.16 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **77.2 %RE @ 6.80 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 13:33 CST**



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LIF-2015-37

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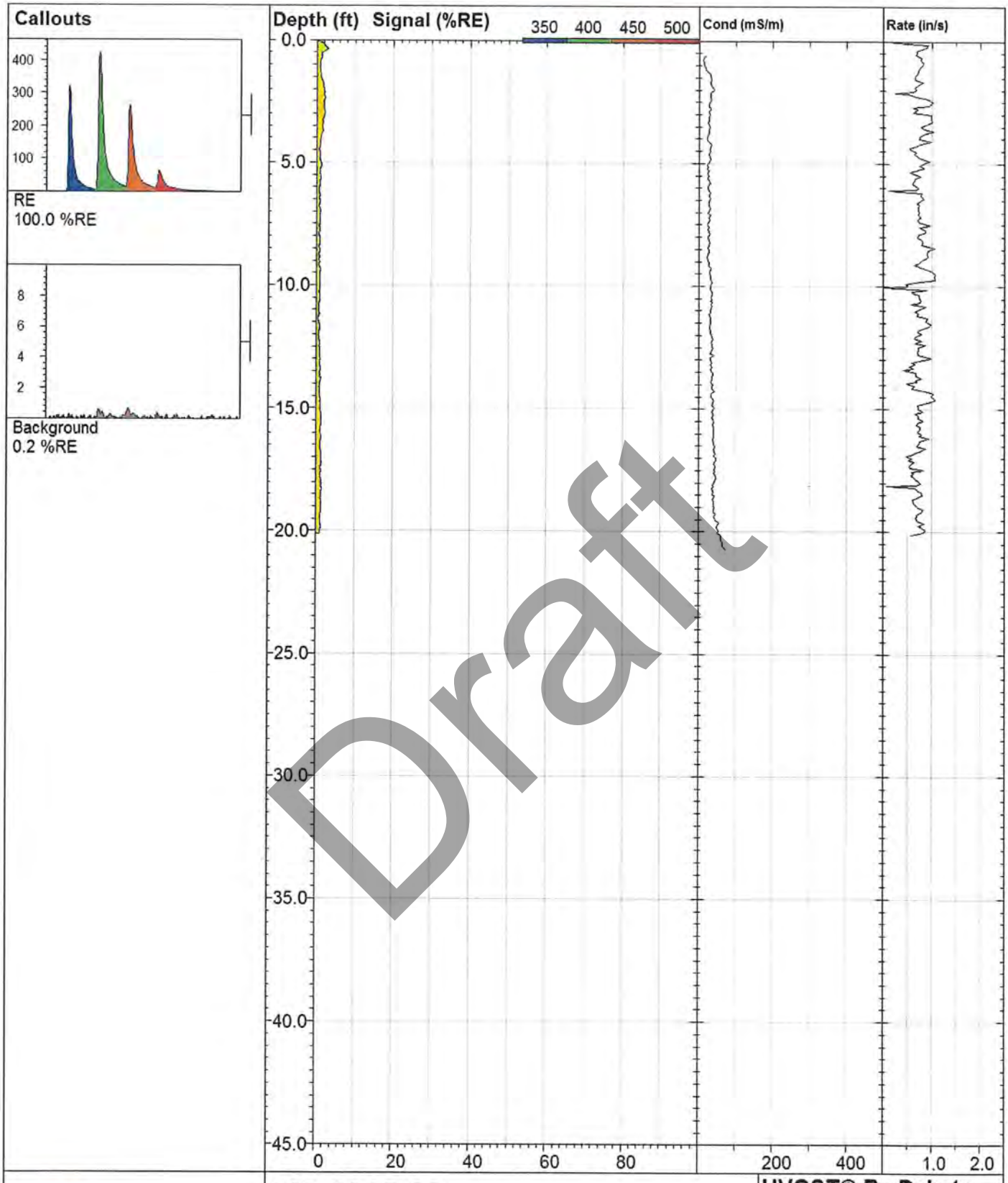
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.13 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **103.8 %RE @ 6.20 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 14:12 CST**



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LIF-2015-38

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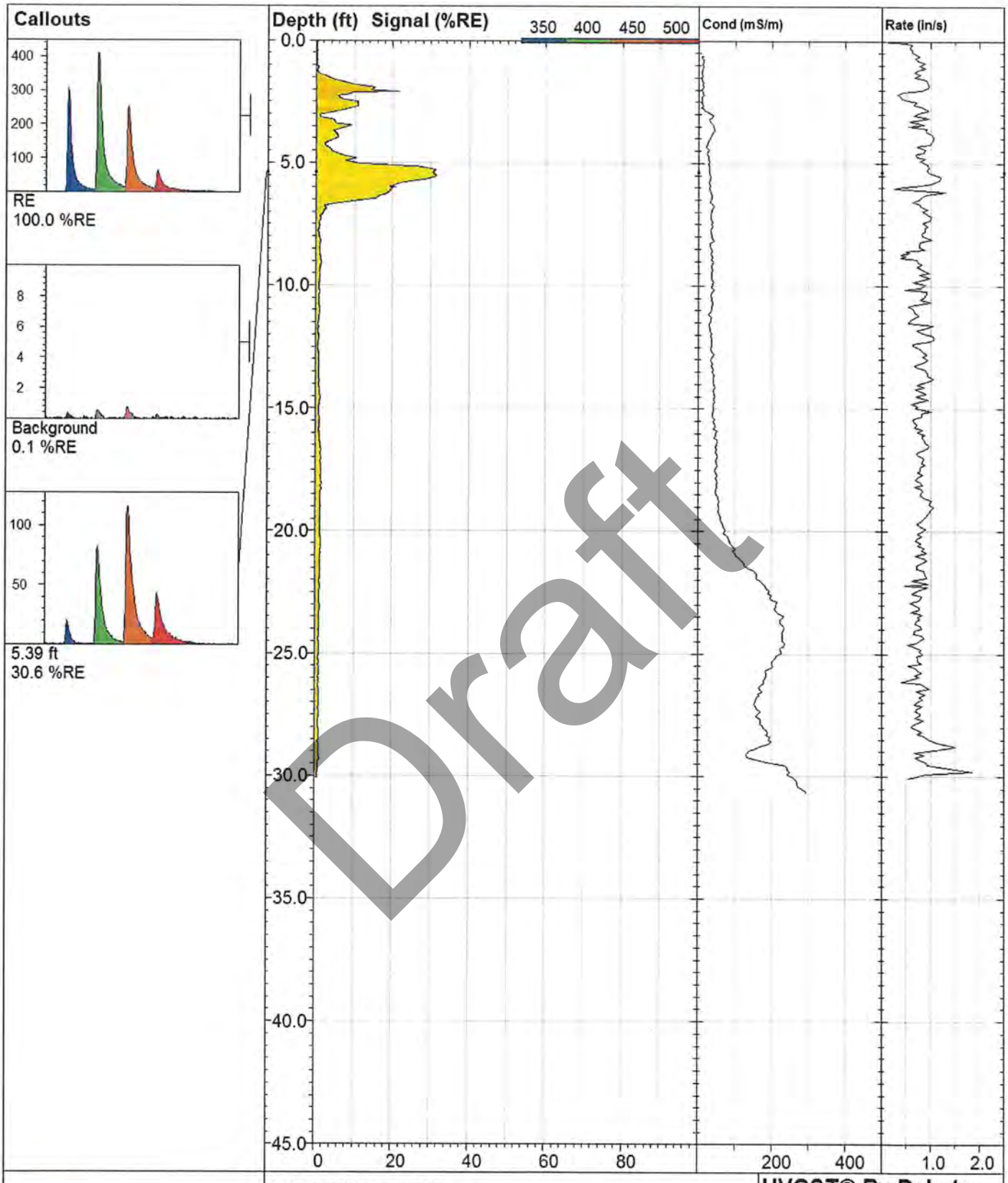
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.0 %RE @ 0.38 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 14:34 CST**



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LIF-2015-39

UVOST® By Dakota
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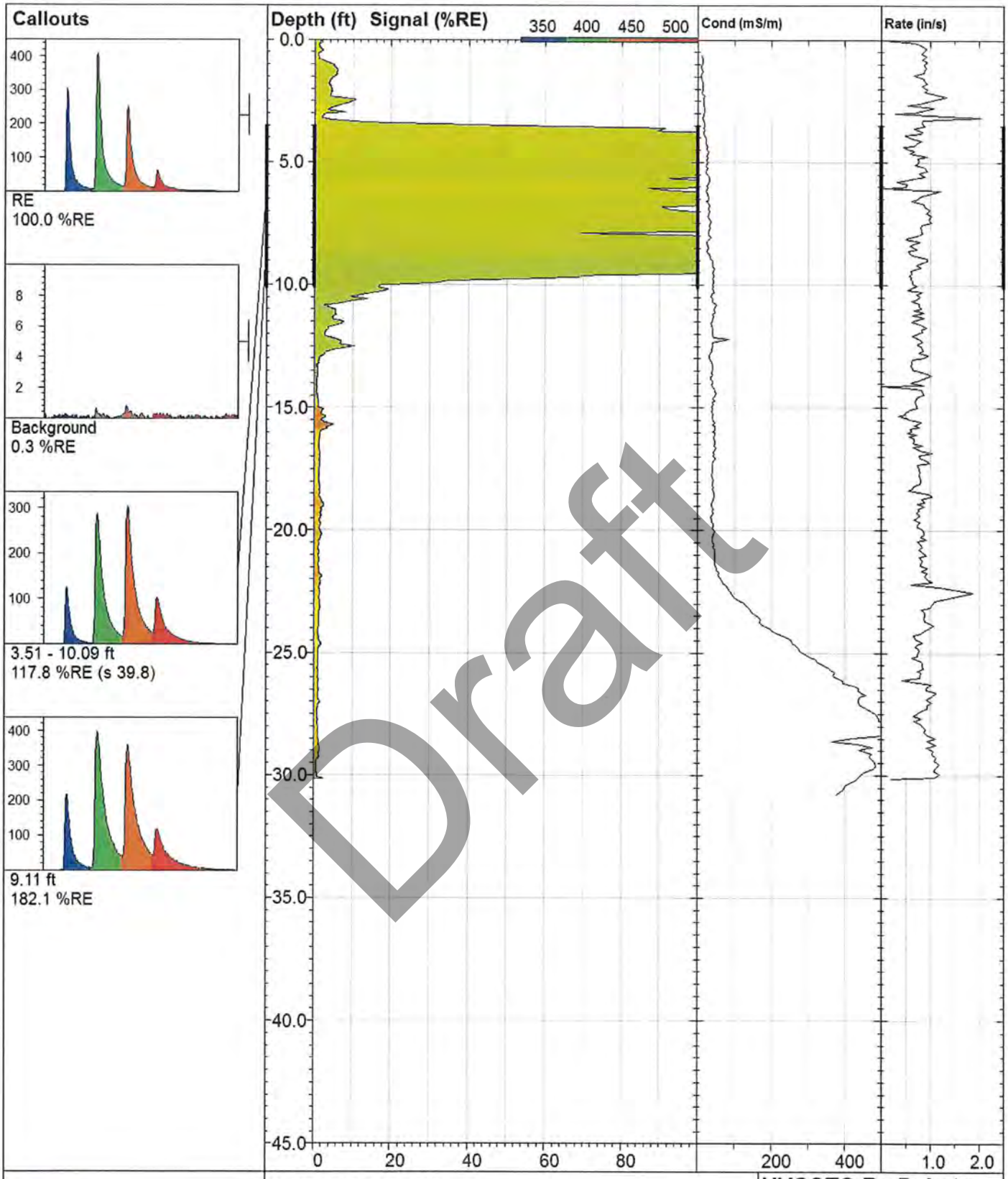
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.08 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **31.5 %RE @ 5.55 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 15:06 CST**



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LIF-2015-40

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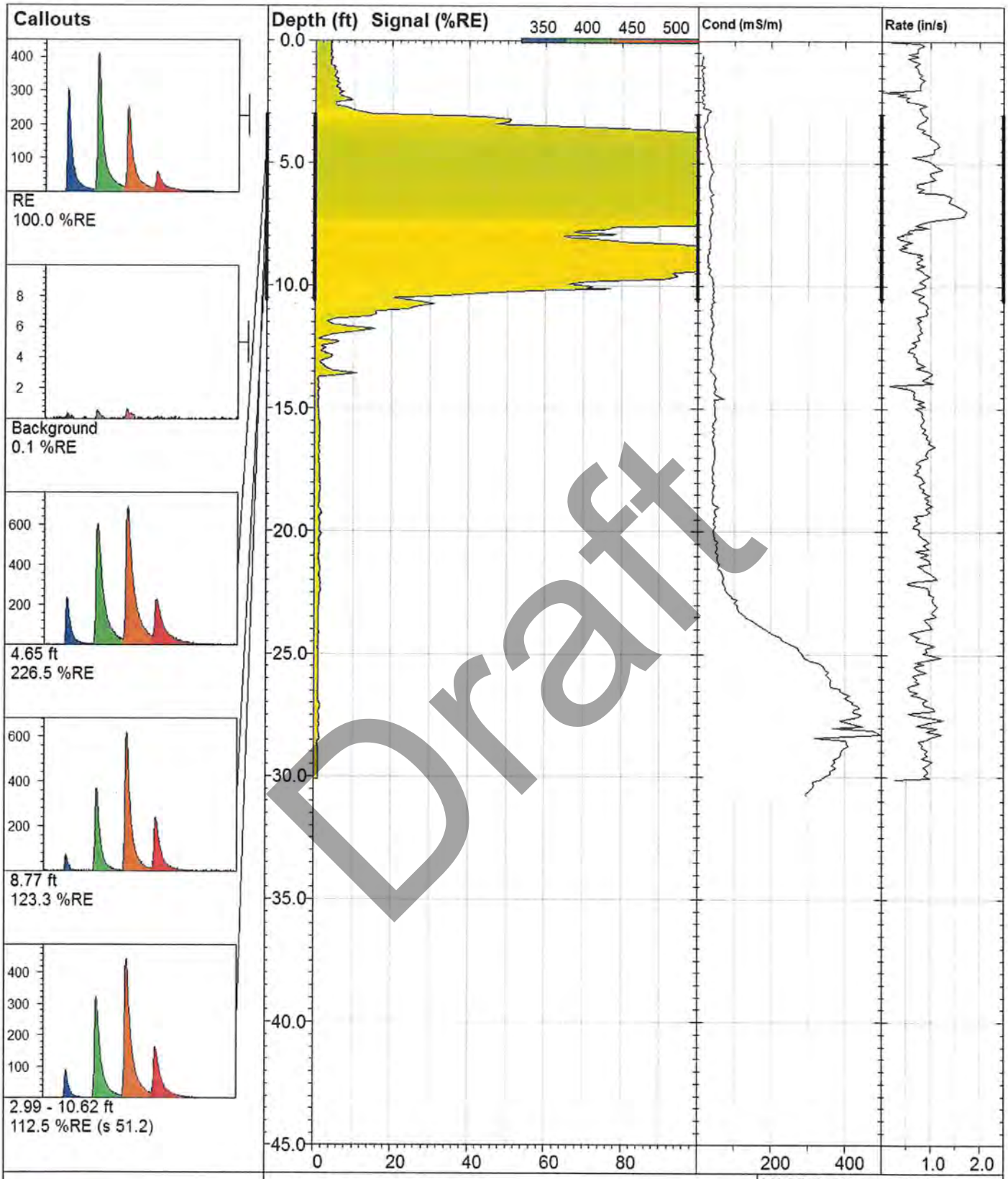
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.15 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **194.3 %RE @ 9.00 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 15:35 CST**



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LIF-2015-41

UVOST® By Dakota
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Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **226.5 %RE @ 4.65 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 16:04 CST**

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LIF-2015-42

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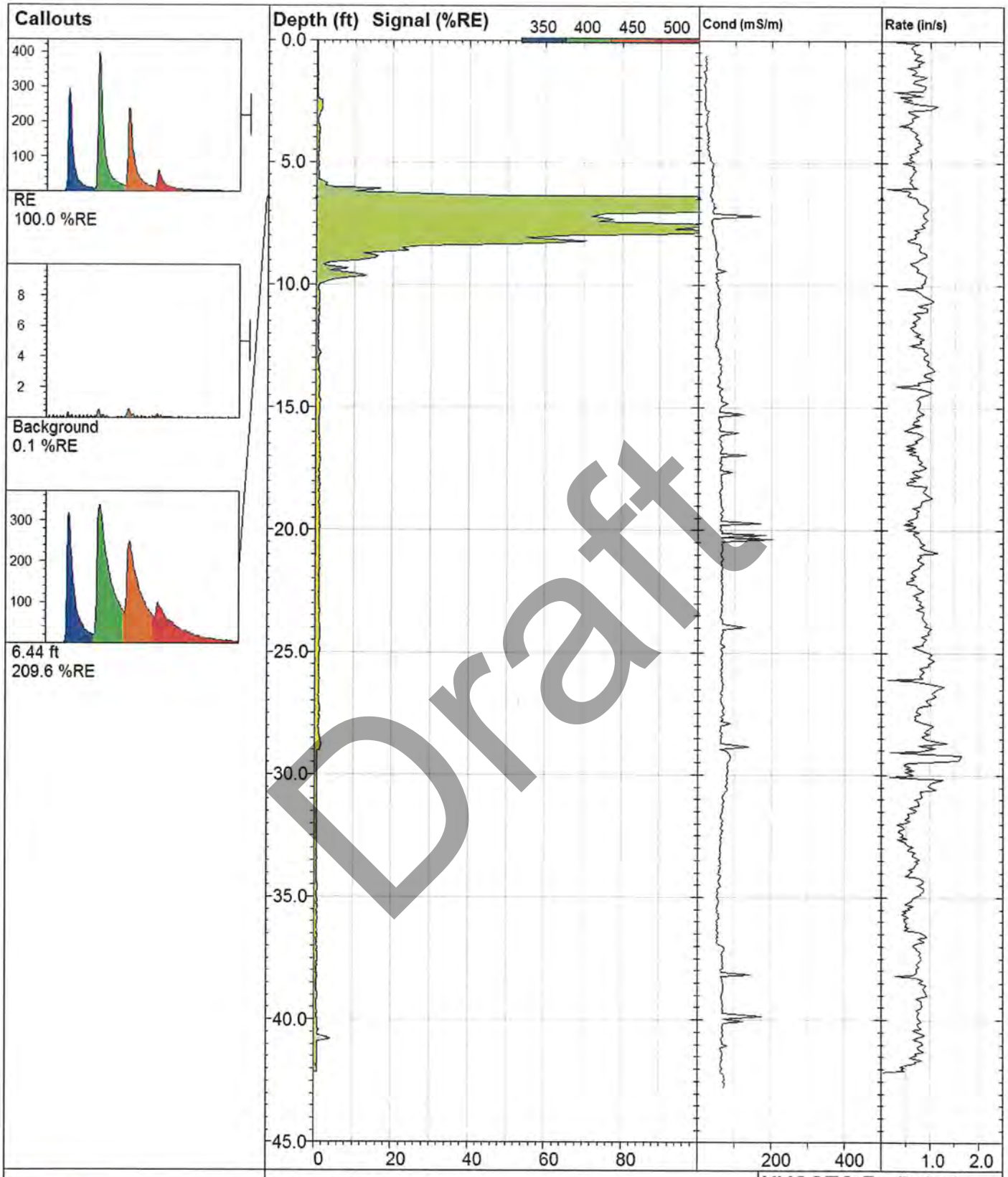
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **43.02 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **243.3 %RE @ 5.06 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 08:15 CST**



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LIF-2015-43

UVOST® By Dakota
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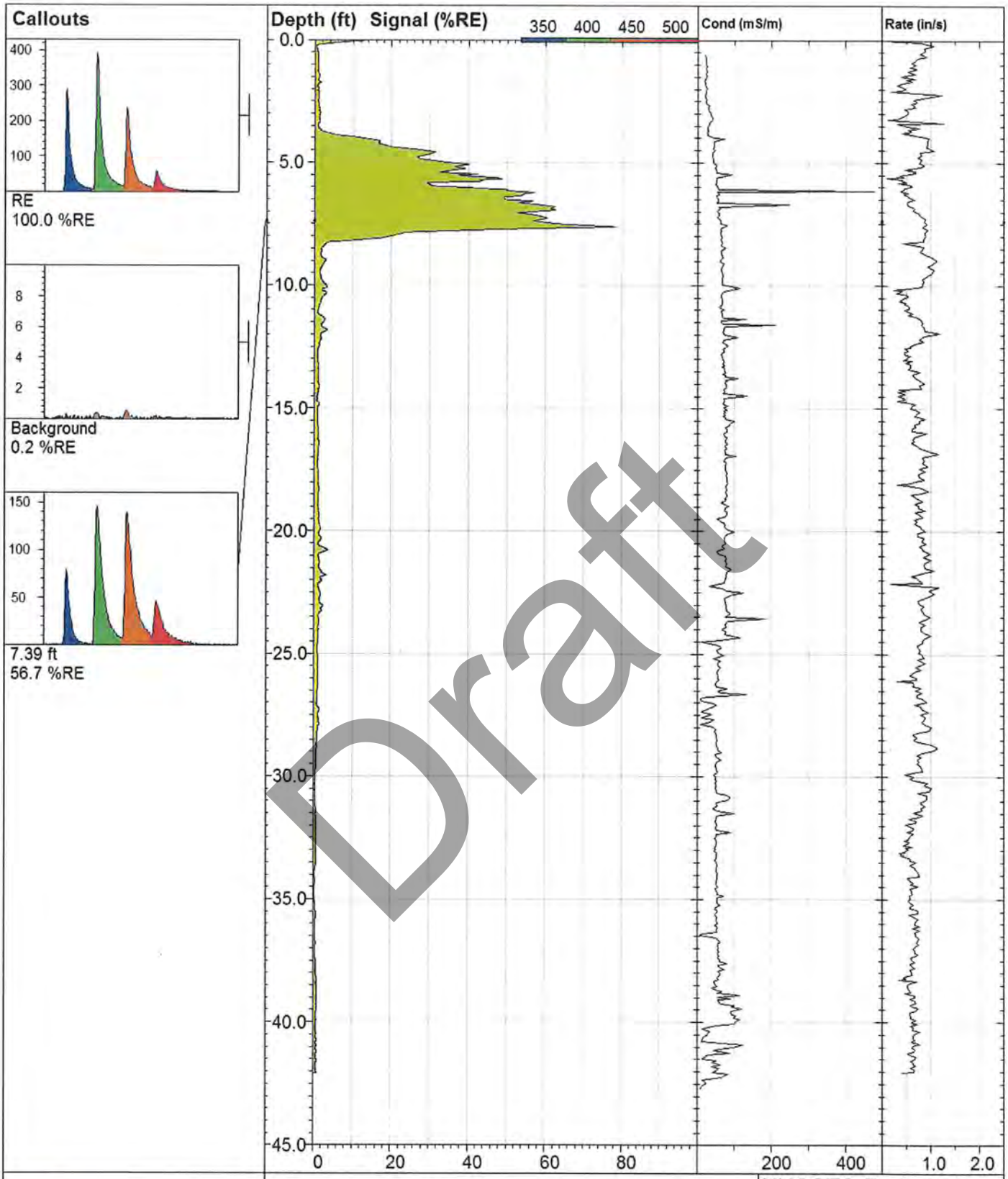
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **42.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **209.6 %RE @ 6.44 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 09:14 CST**



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LIF-2015-44

UVOST® By Dakota
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Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **42.05 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **79.2 %RE @ 7.62 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 09:56 CST**

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LIF-2015-45

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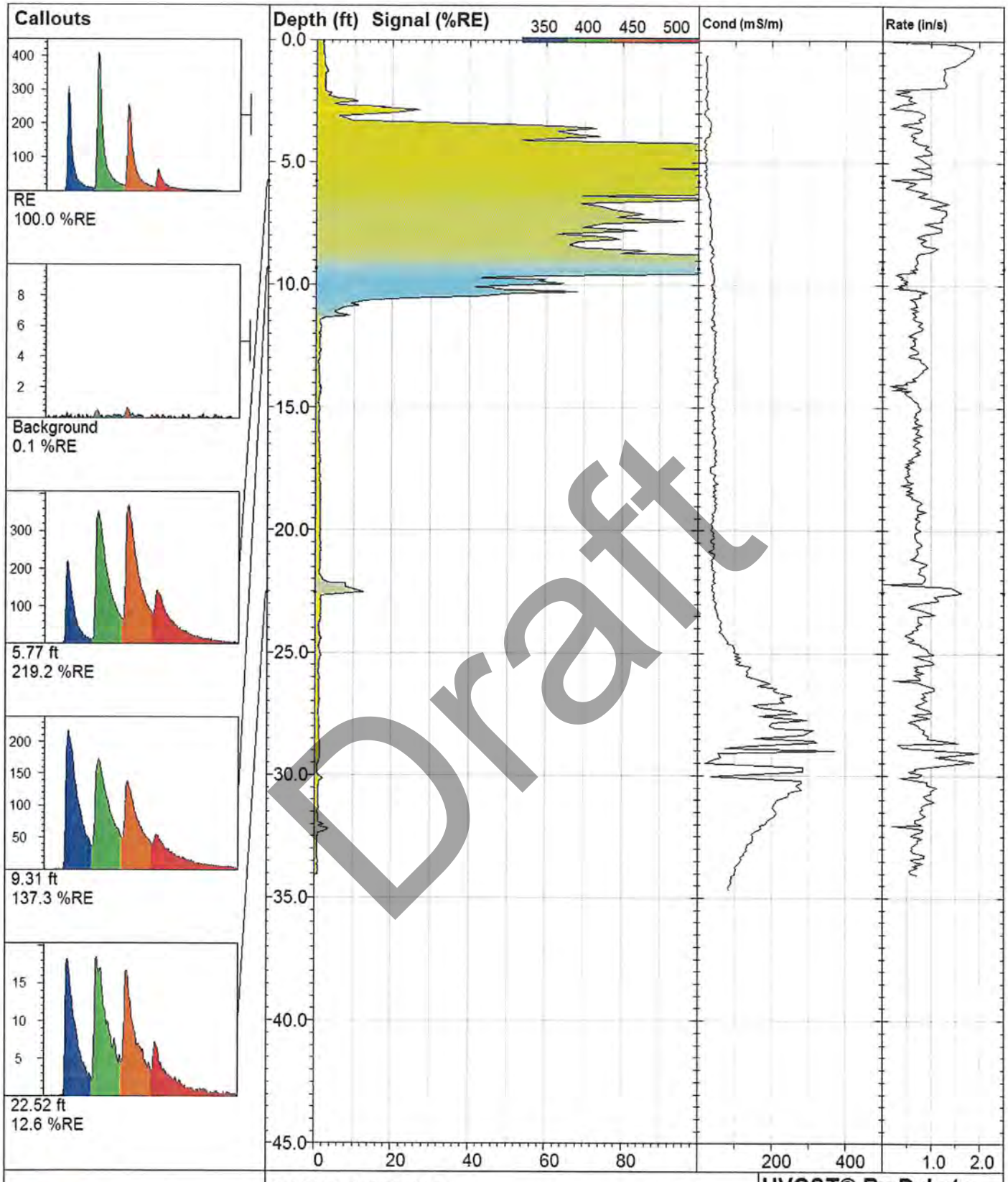
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.07 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **325.7 %RE @ 5.02 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 11:17 CST**



LIF-2015-46

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Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **34.07 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **234.8 %RE @ 5.84 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 11:50 CST**

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LIF-2015-47

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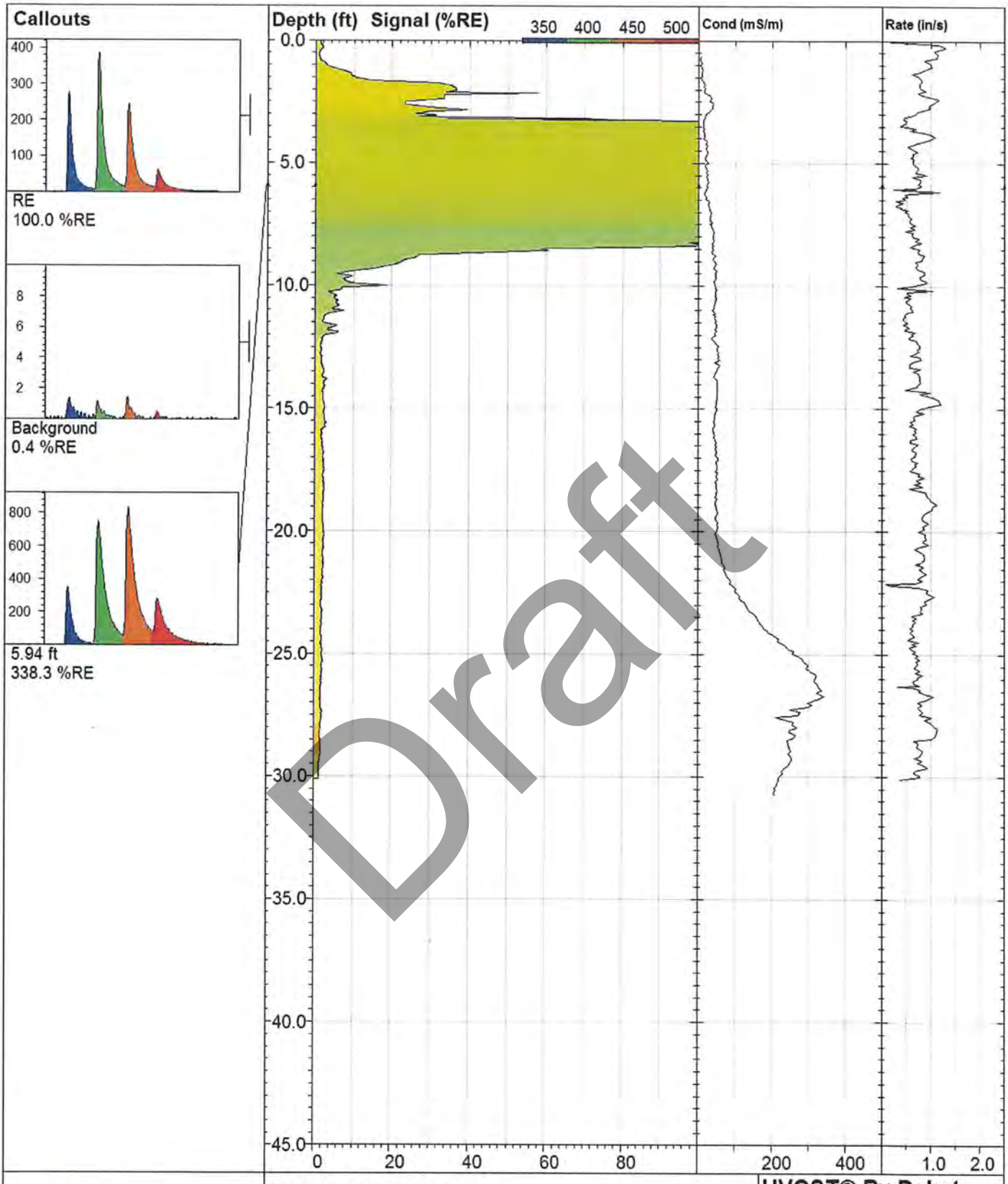
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.08 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **481.4 %RE @ 5.69 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 14:00 CST**



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LIF-2015-48

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Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.10 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **377.1 %RE @ 6.24 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 14:32 CST**

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LIF-2015-49

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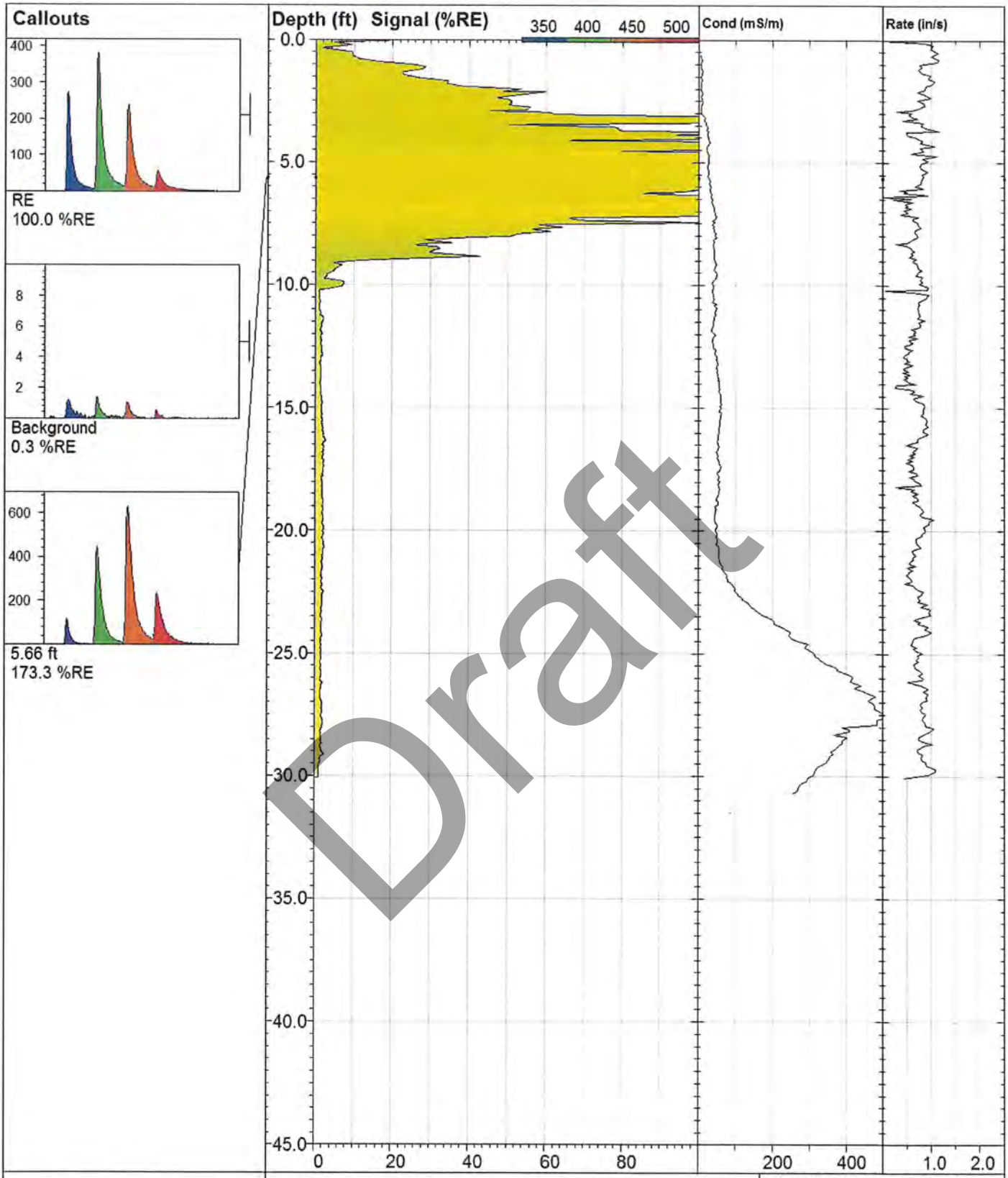
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **32.24 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **383.1 %RE @ 4.65 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 14:59 CST**



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LIF-2015-50

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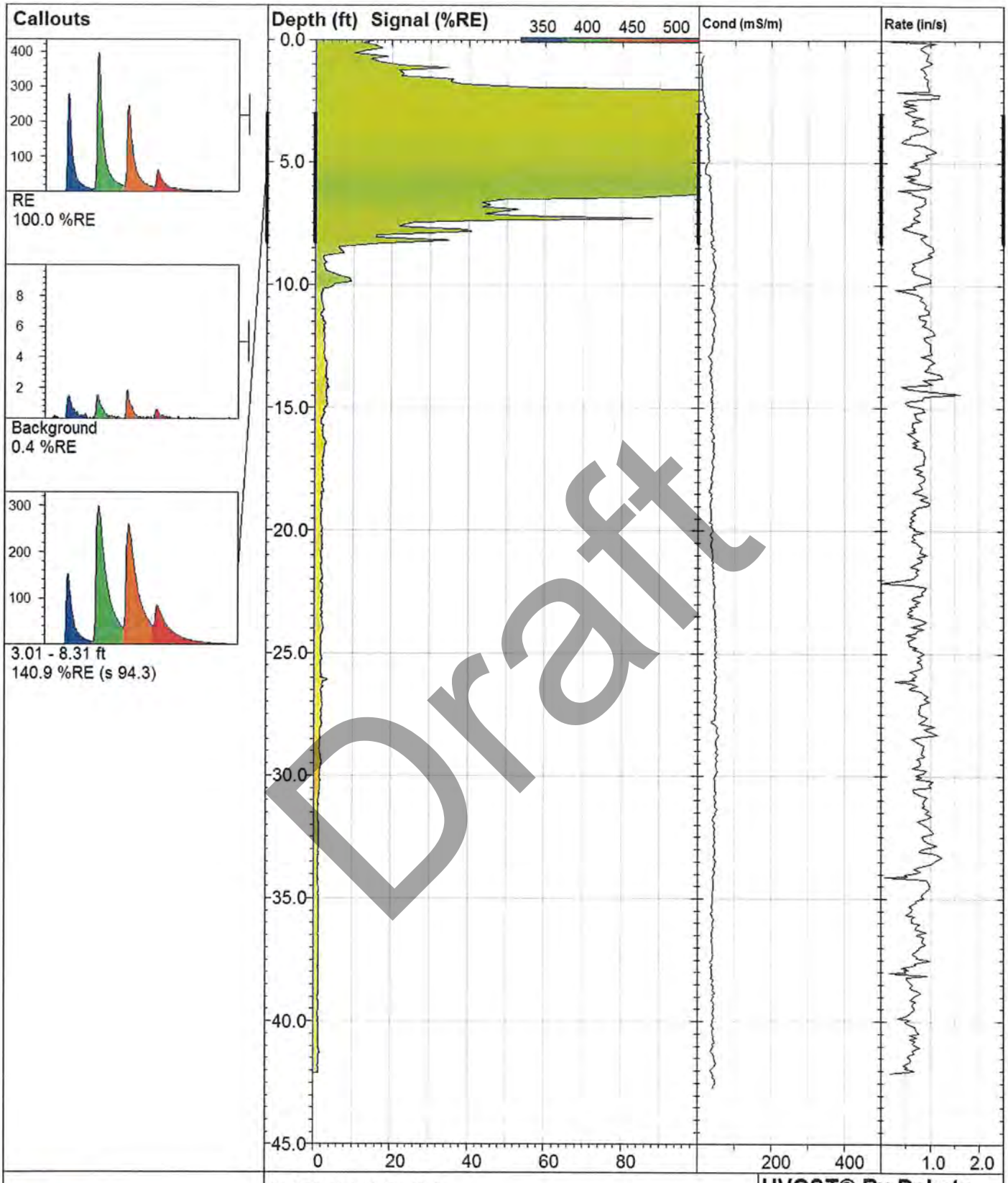
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.08 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **235.3 %RE @ 6.93 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 15:29 CST**



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LIF-2015-51

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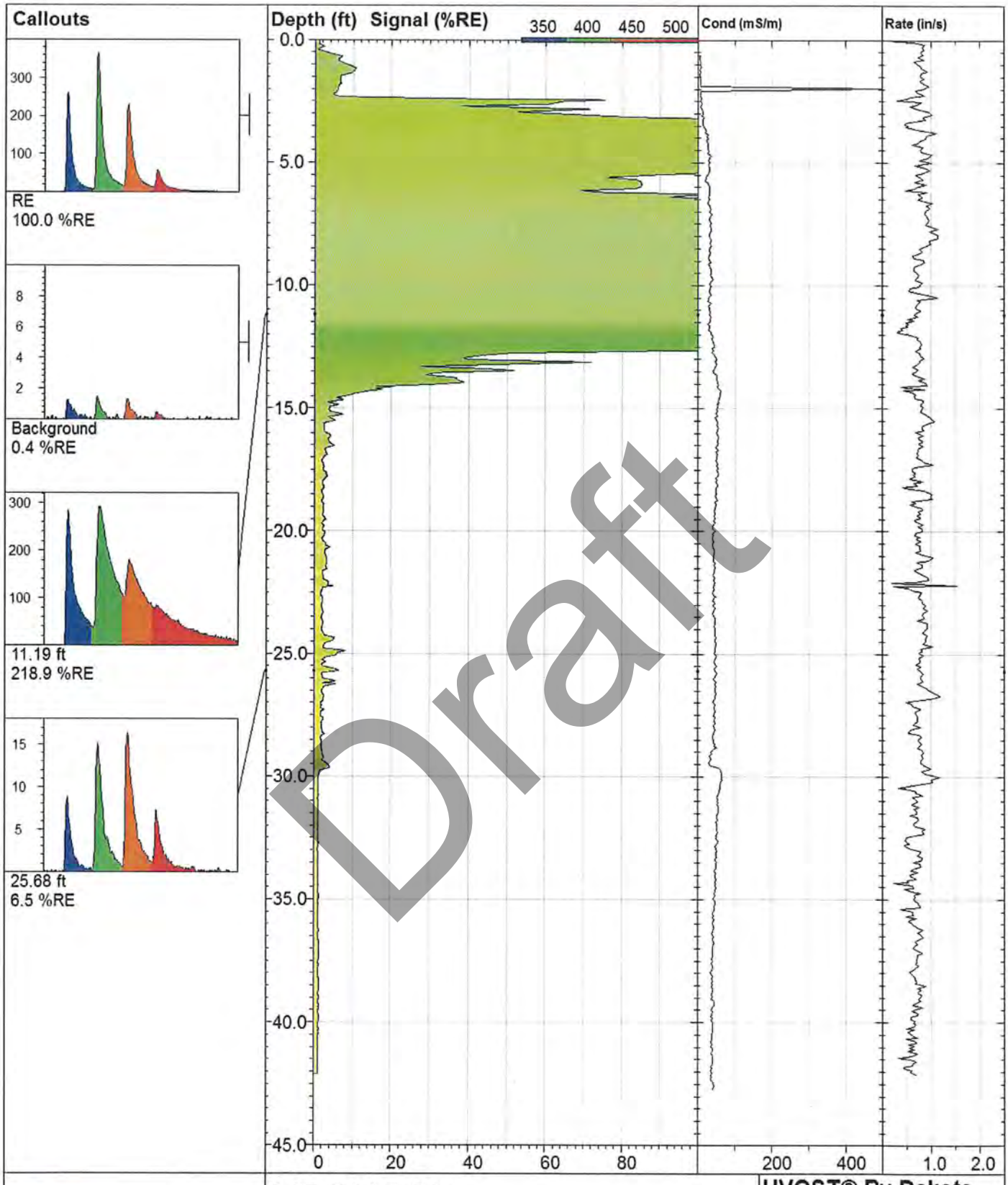
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **42.10 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **531.9 %RE @ 5.38 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 16:13 CST**



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LIF-2015-52

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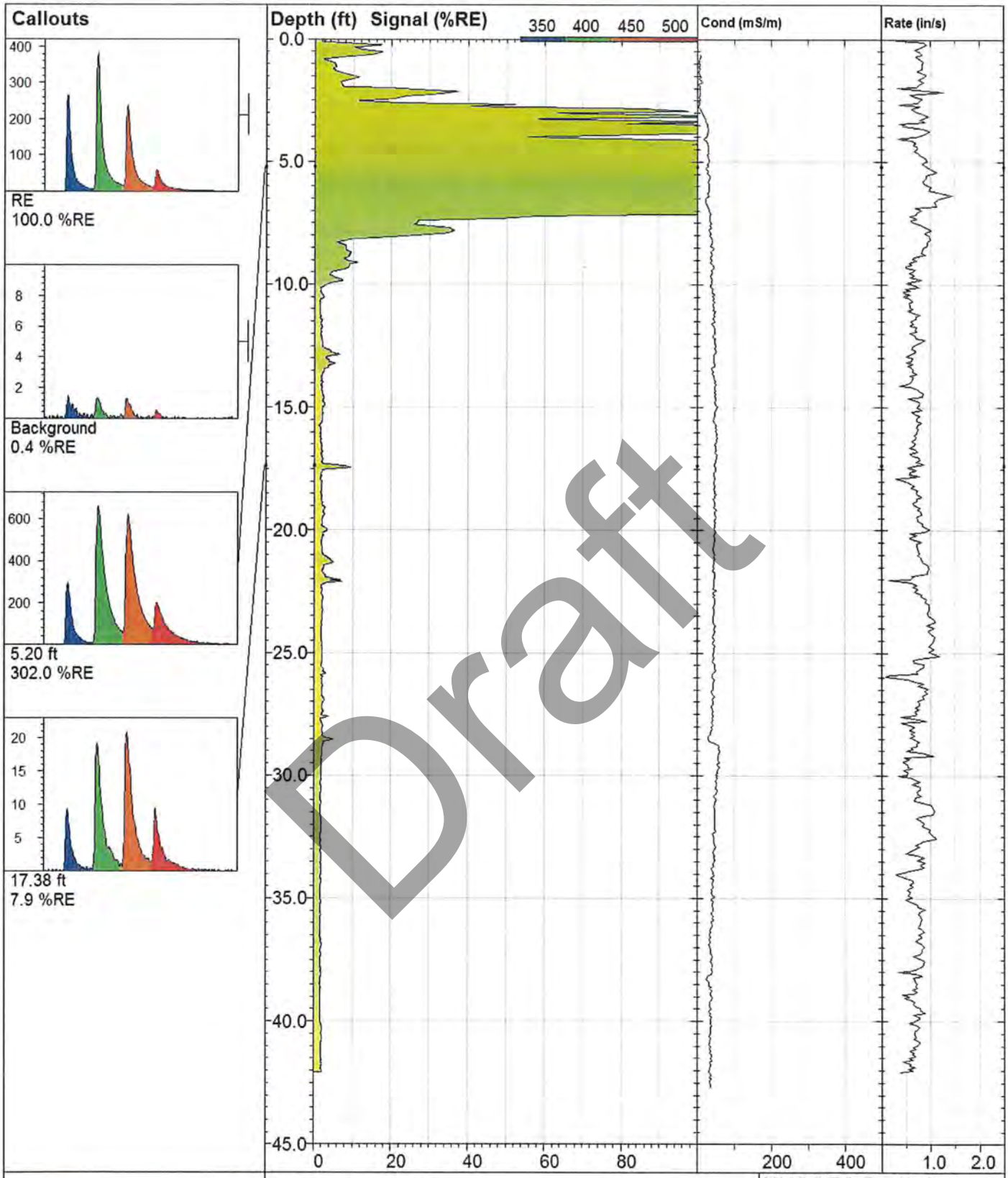
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **42.09 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **283.6 %RE @ 12.19 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 07:50 CST**



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LIF-2015-53

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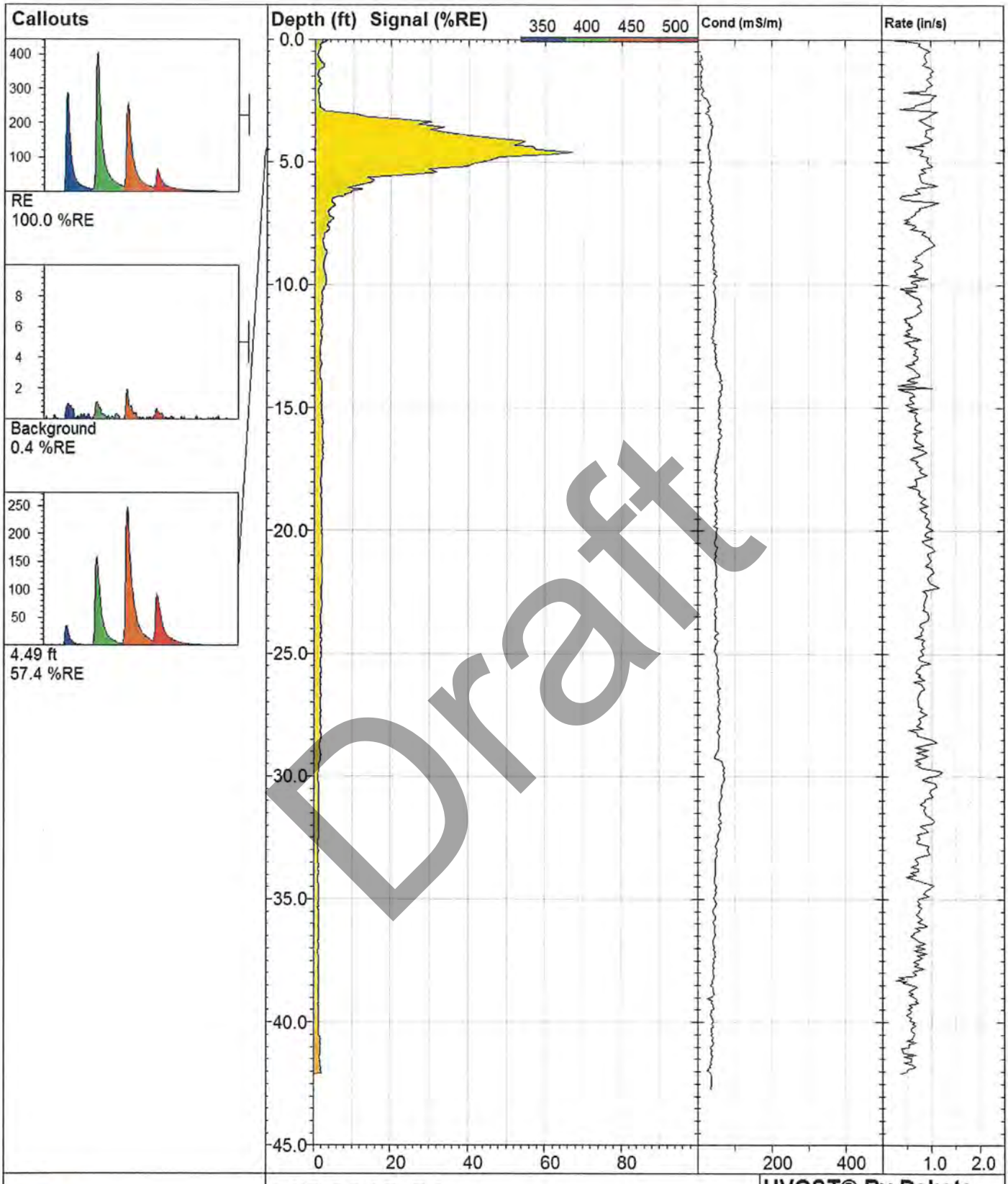
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **42.06 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **302.0 %RE @ 5.20 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 08:29 CST**



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LIF-2015-54

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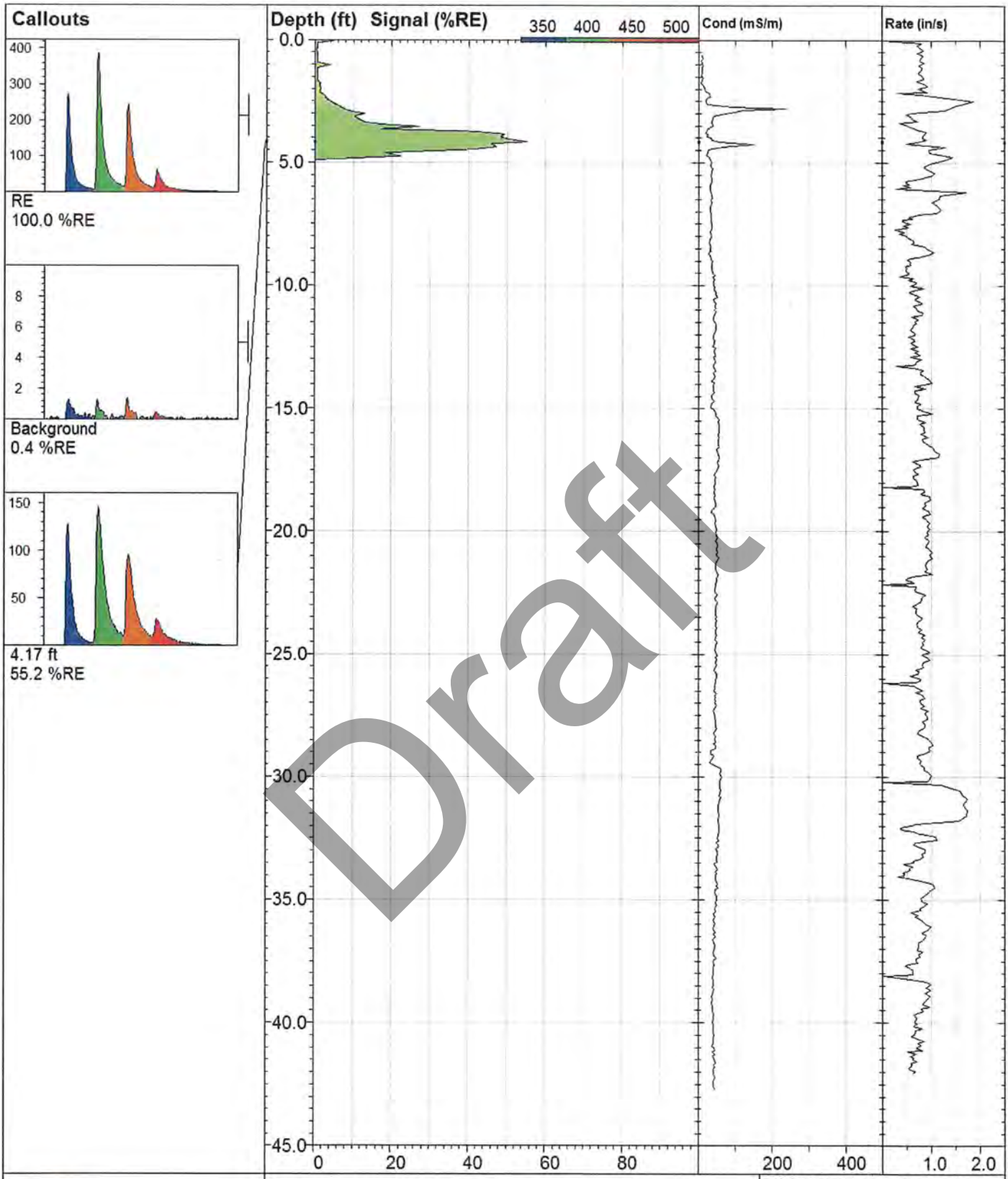
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **42.08 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **67.2 %RE @ 4.60 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 09:22 CST**



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LIF-2015-55

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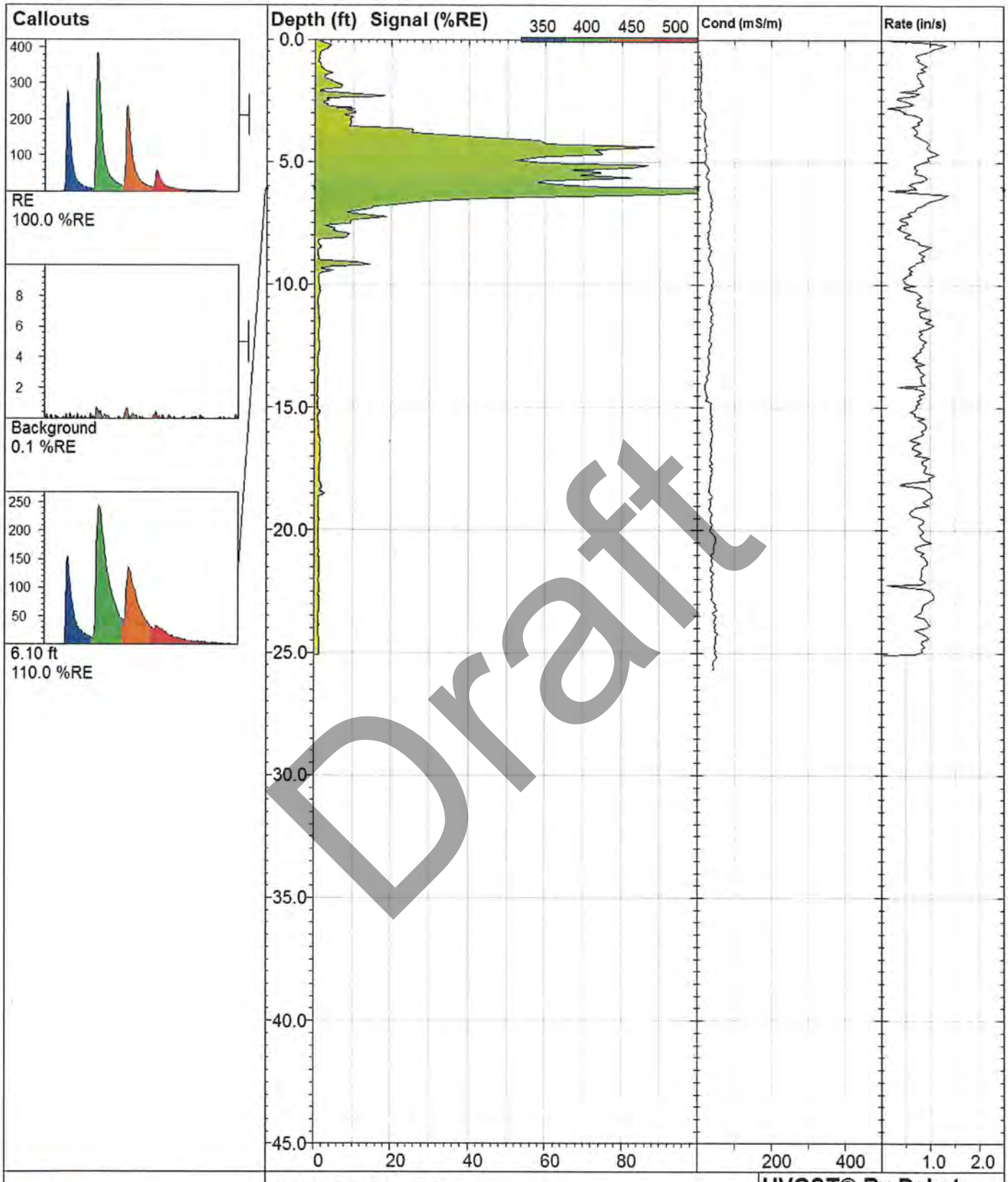
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **42.06 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **55.2 %RE @ 4.17 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 10:04 CST**



LIF-2015-56		**UVOST® By Dakota** www.DakotaTechnologies.com
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.08 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **112.6 %RE @ 6.15 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 11:24 CST**

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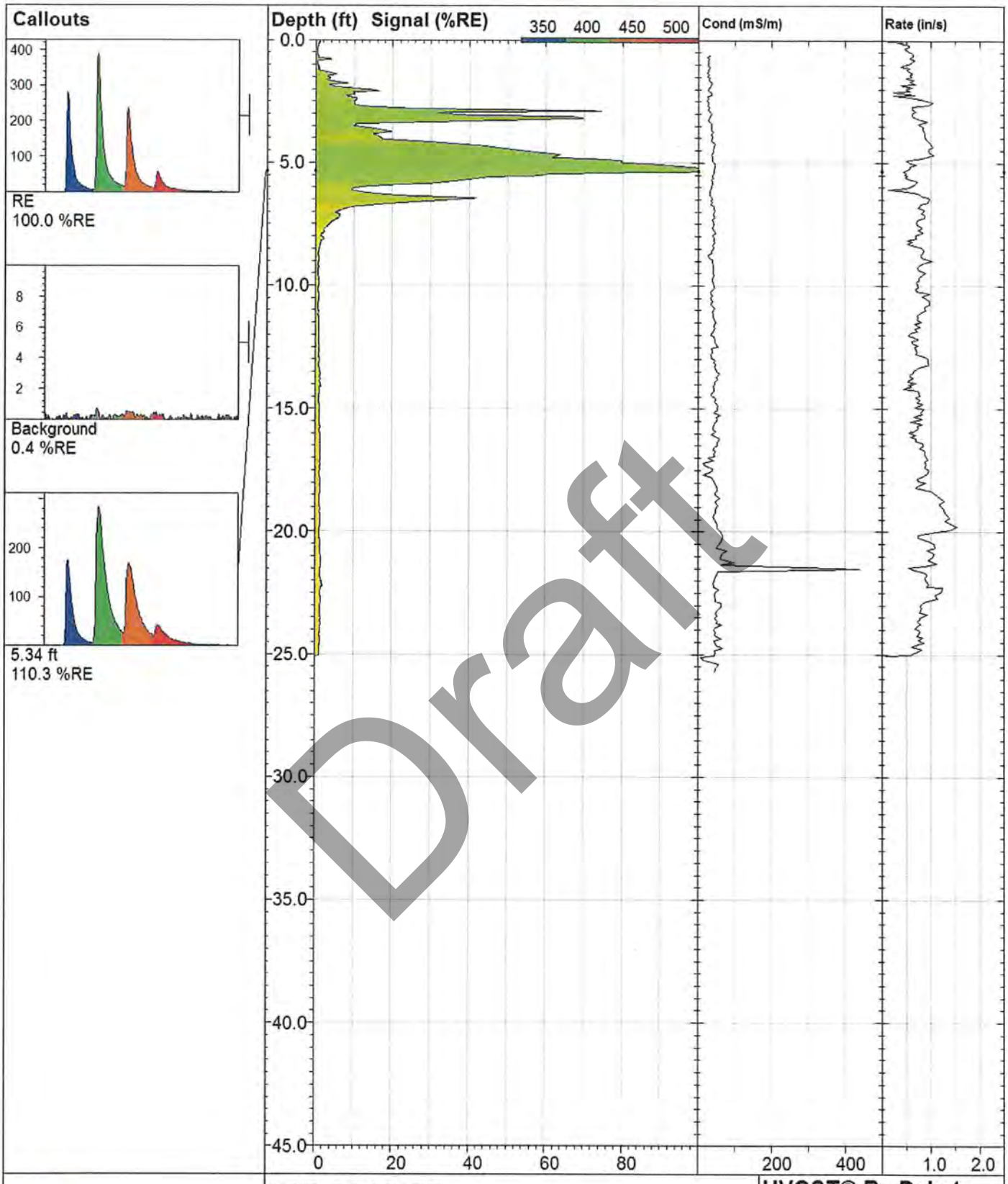

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LIF-2015-57

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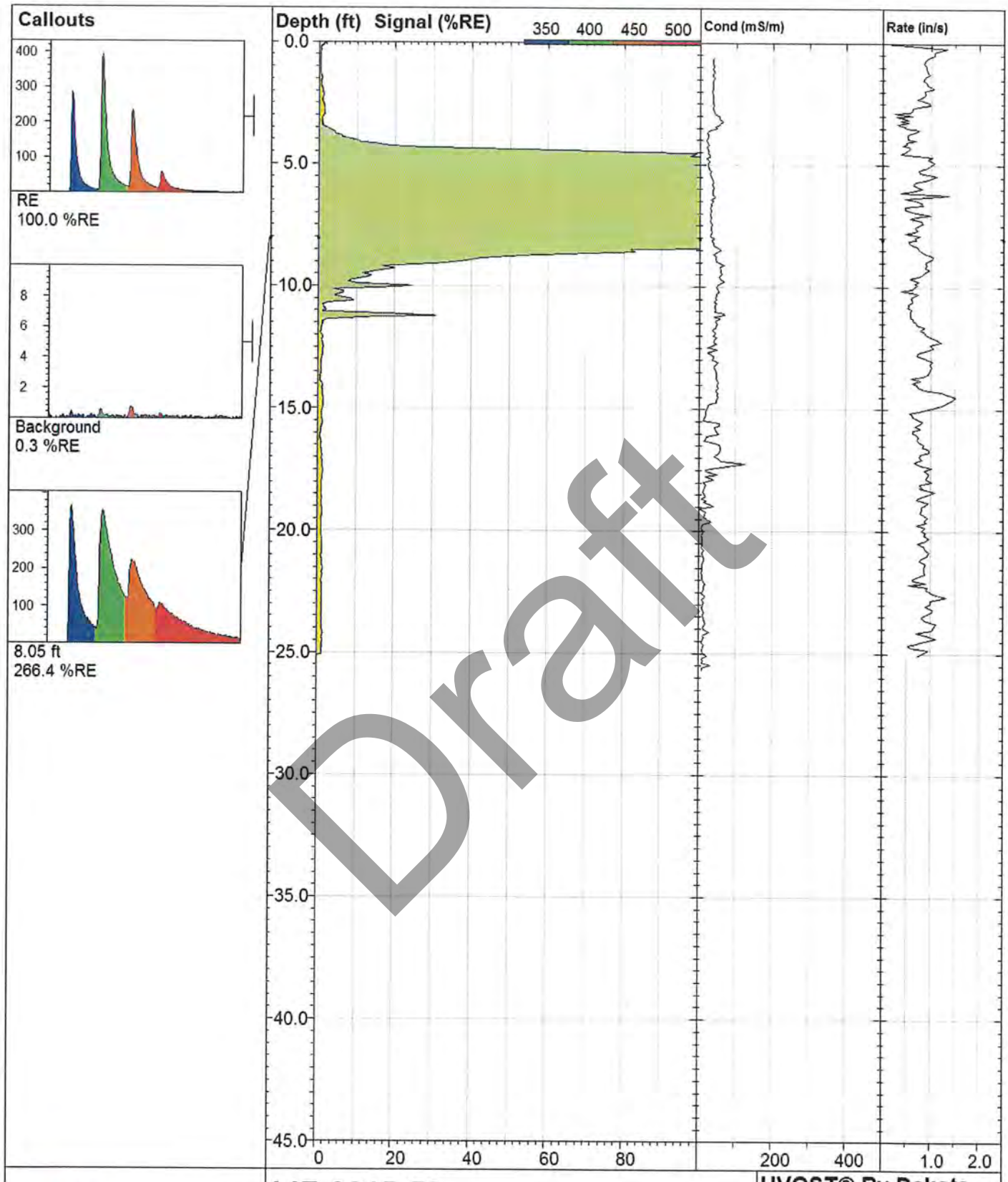
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.06 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **110.3 %RE @ 5.34 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 11:47 CST**



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LIF-2015-58

UVOST® By Dakota
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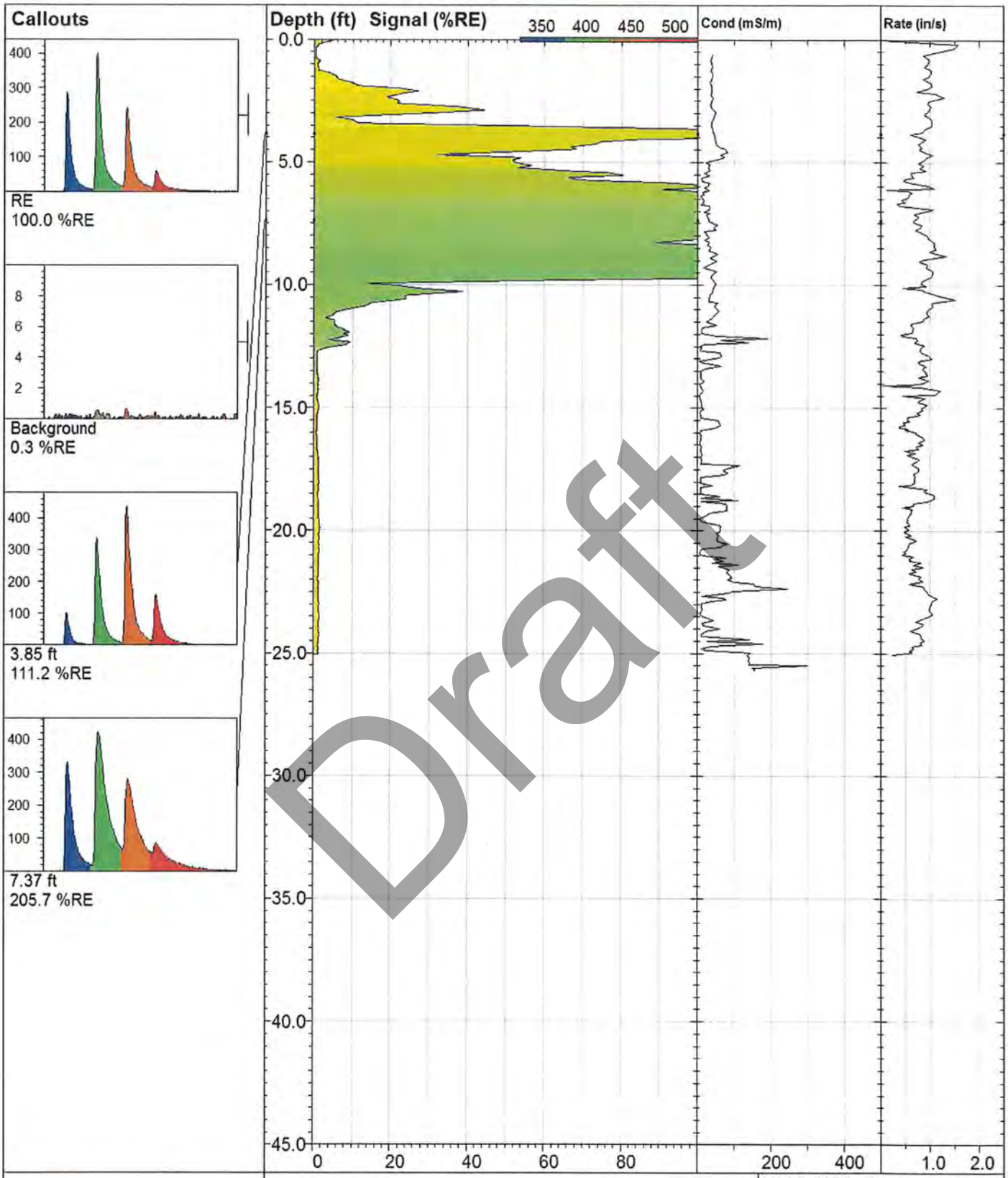
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.10 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **266.4 %RE @ 8.05 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 12:24 CST**



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LIF-2015-59

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Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.06 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **209.0 %RE @ 7.20 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 12:55 CST**

UVOST LOGS
@ 950% RE

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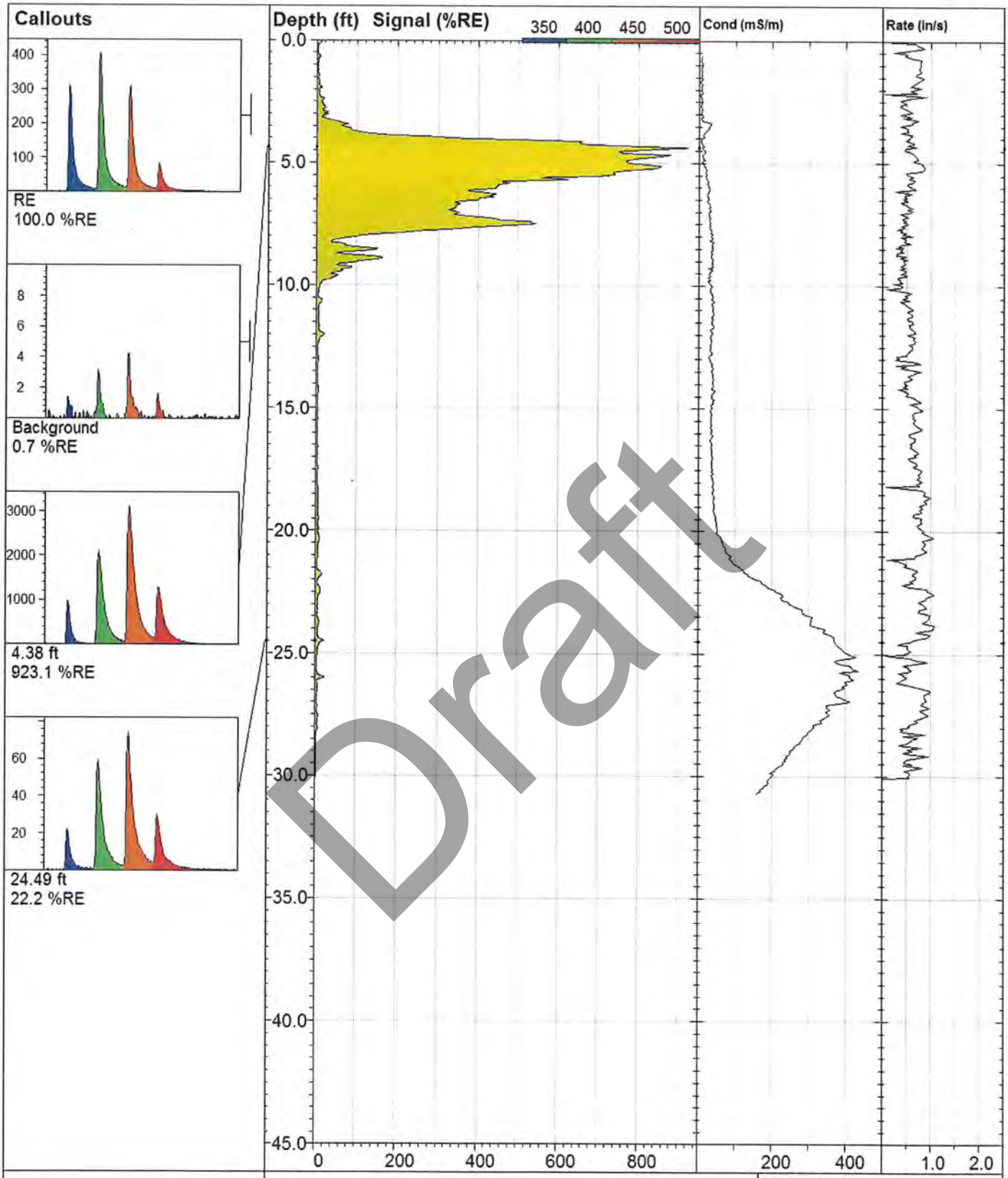

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LIF-2015-01

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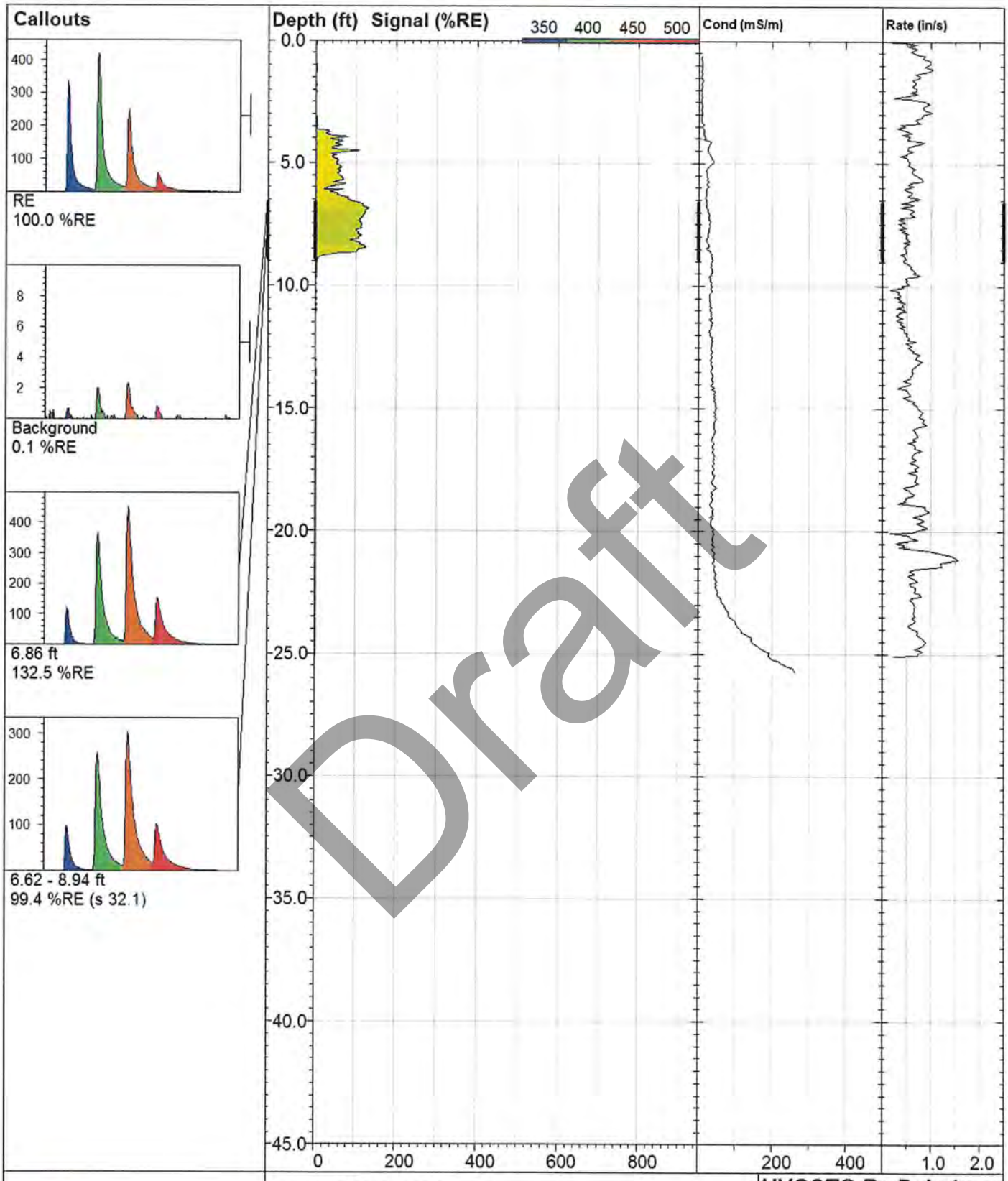
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.09 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **923.1 %RE @ 4.38 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 09:58 CST**



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LIF-2015-02

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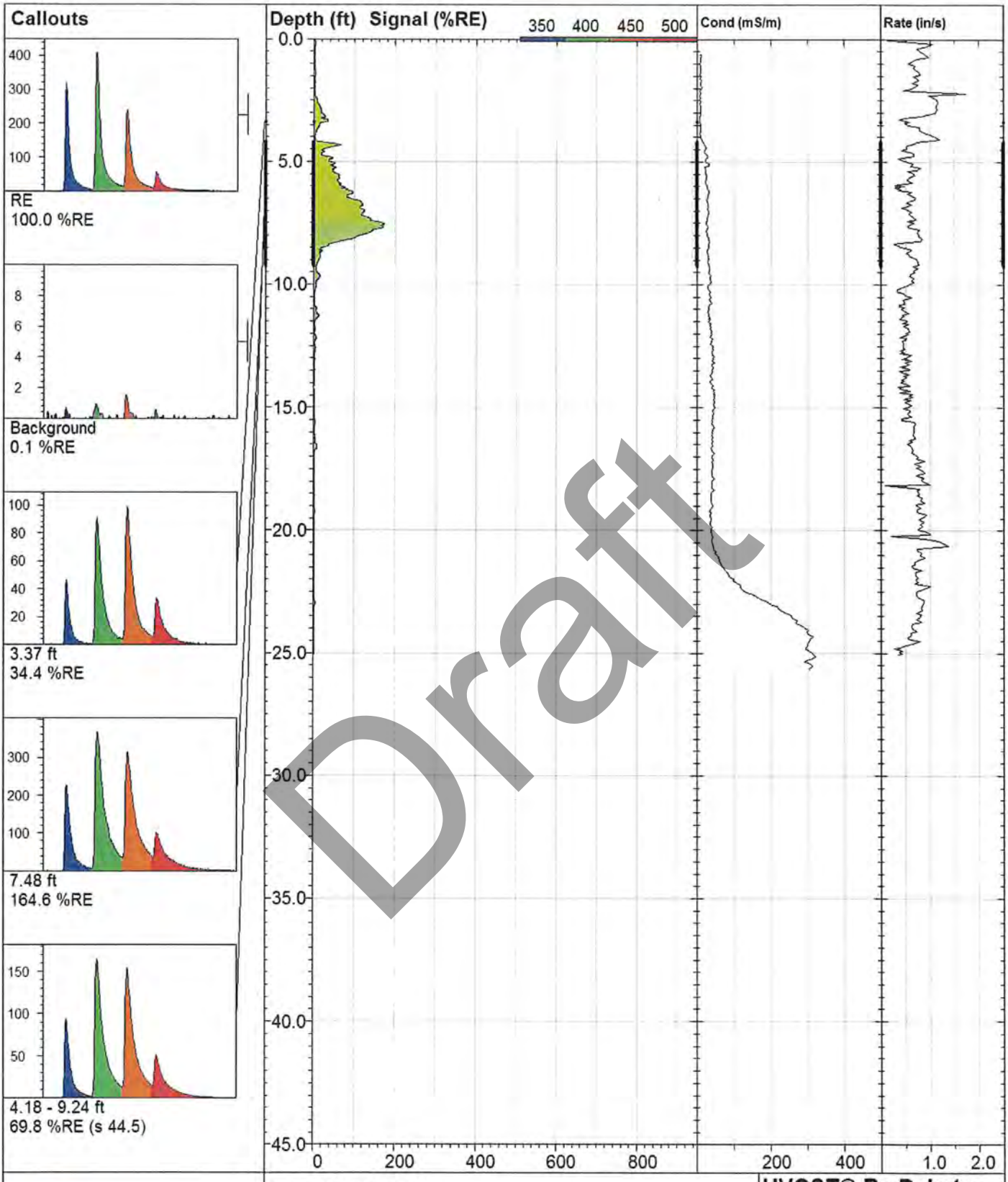
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.10 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **132.5 %RE @ 6.86 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 10:43 CST**



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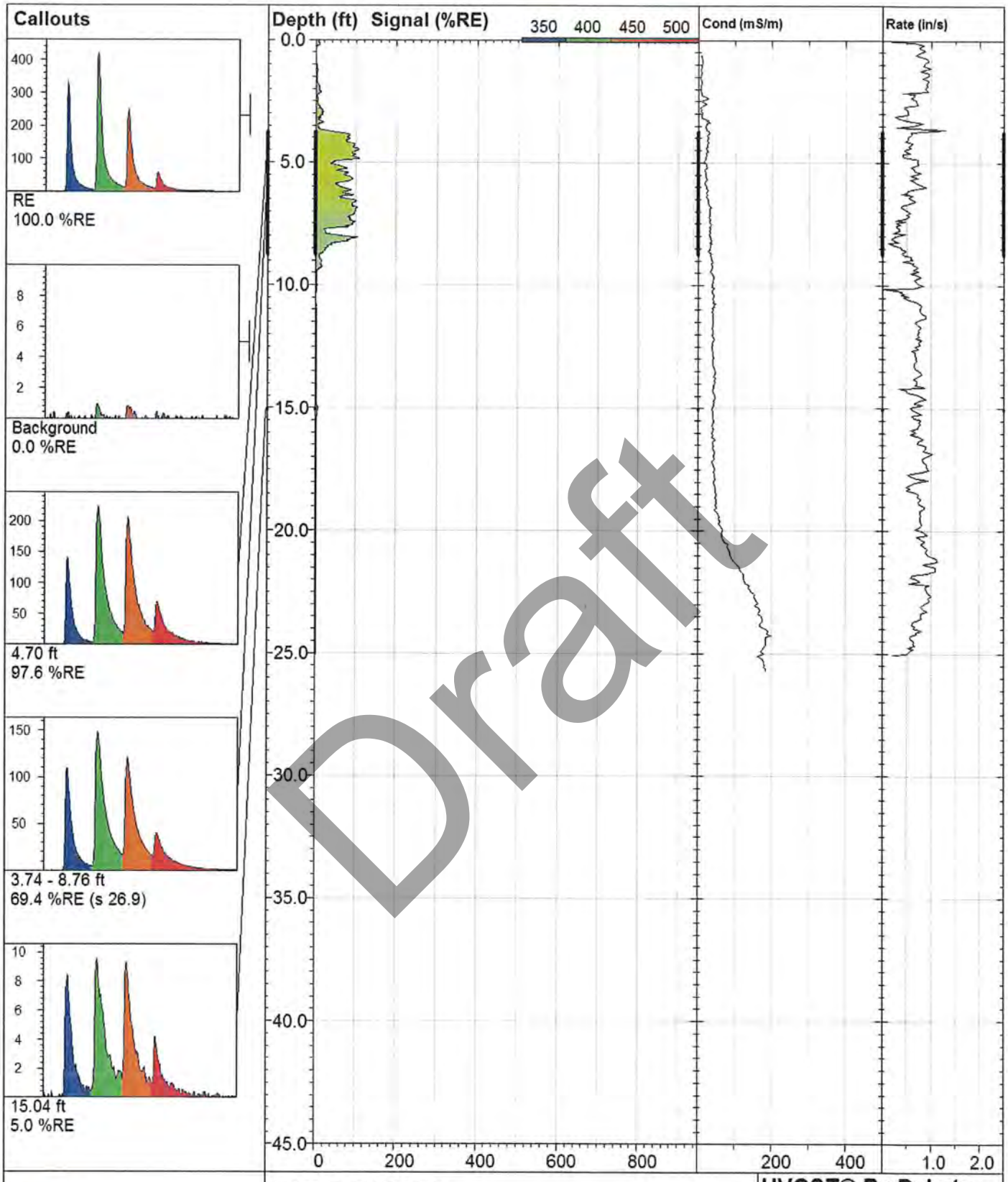
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.04 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **173.5 %RE @ 7.55 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 12:21 CST**



Draft

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LIF-2015-04

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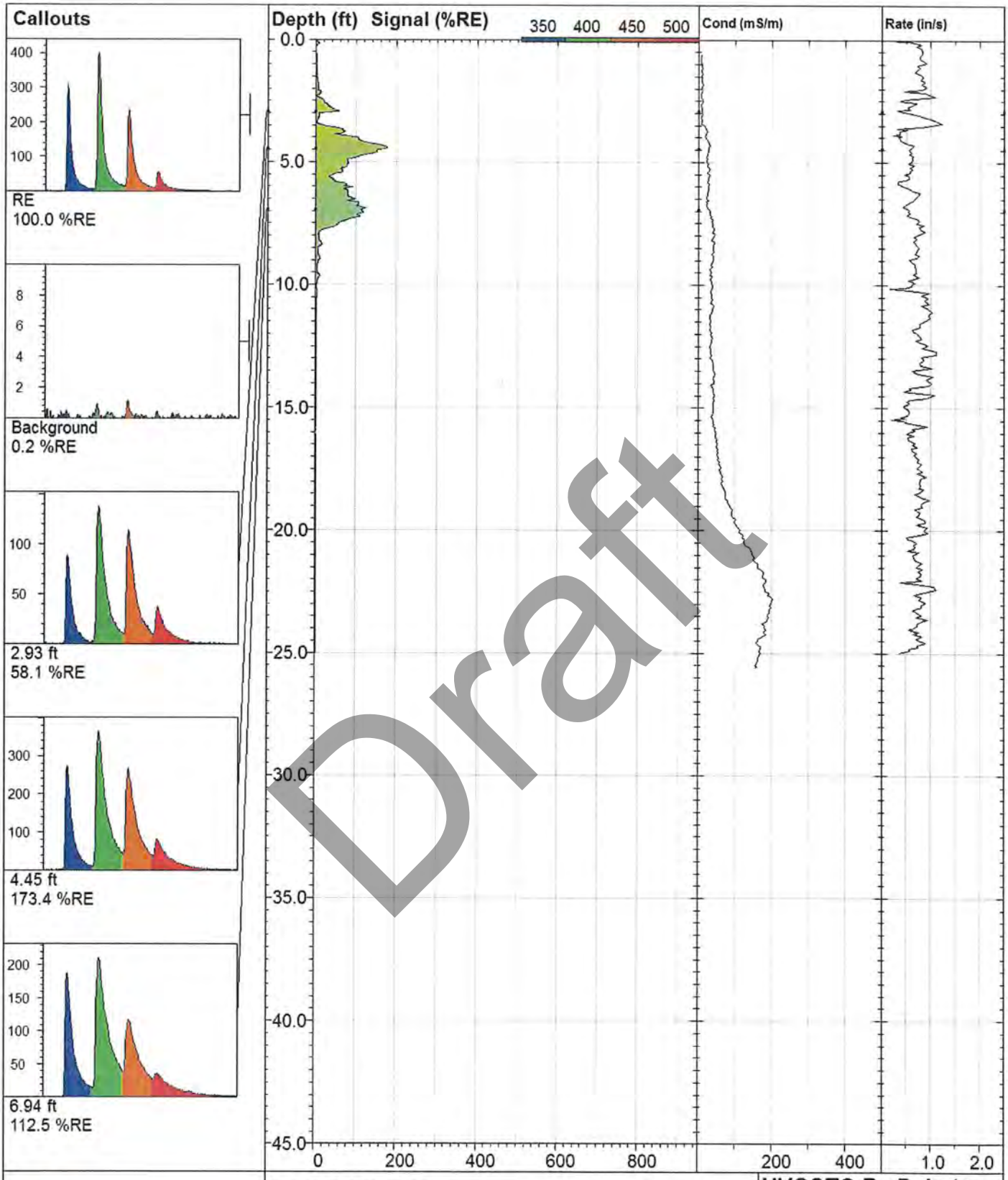
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.06 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **107.3 %RE @ 4.86 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 12:49 CST**



Draft

MATRIX ENVIRONMENTAL LLC

LIF-2015-05

UVOST® By Dakota
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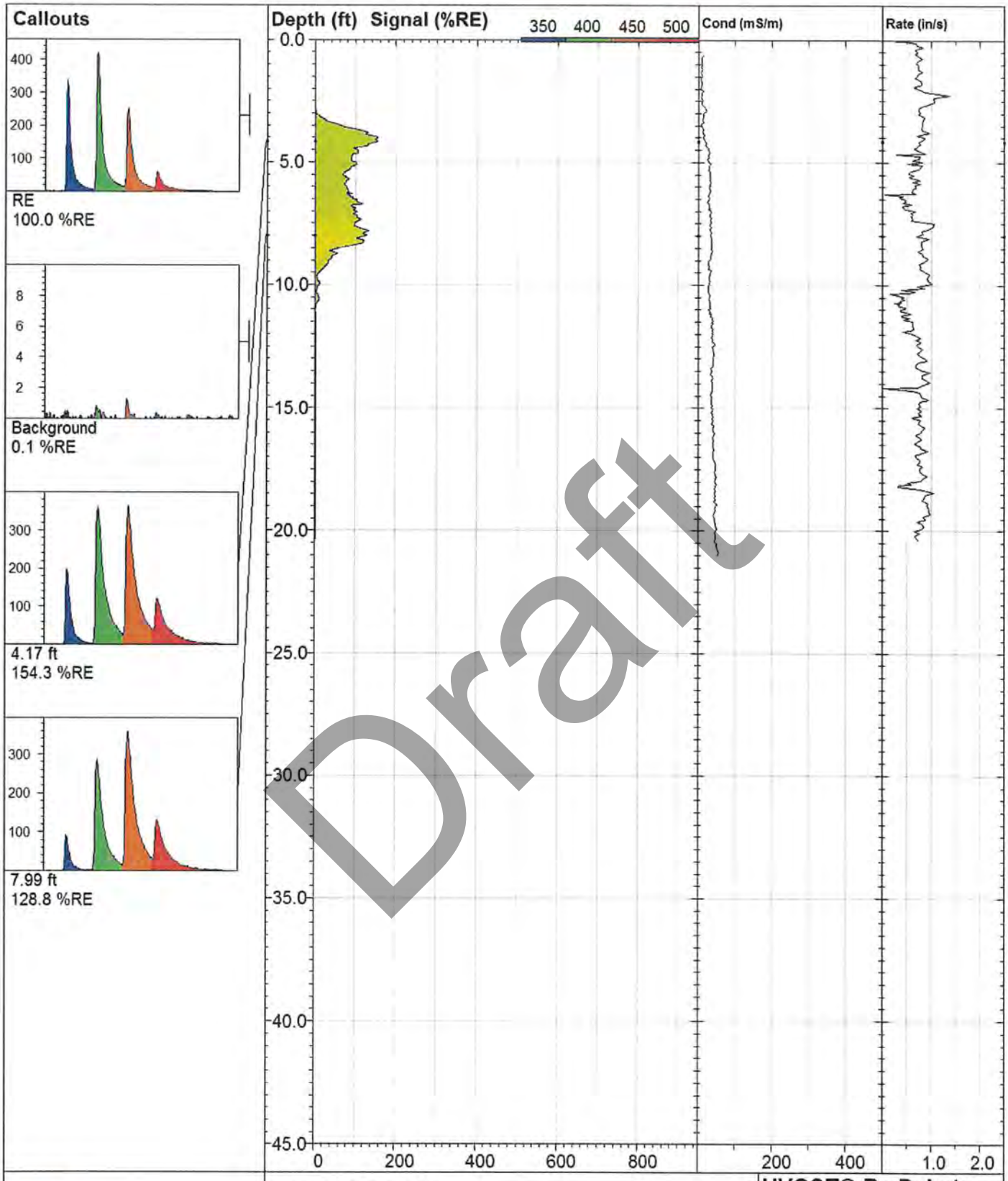
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.01 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **177.3 %RE @ 4.40 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 13:18 CST**



Draft

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LIF-2015-06

UVOST® By Dakota
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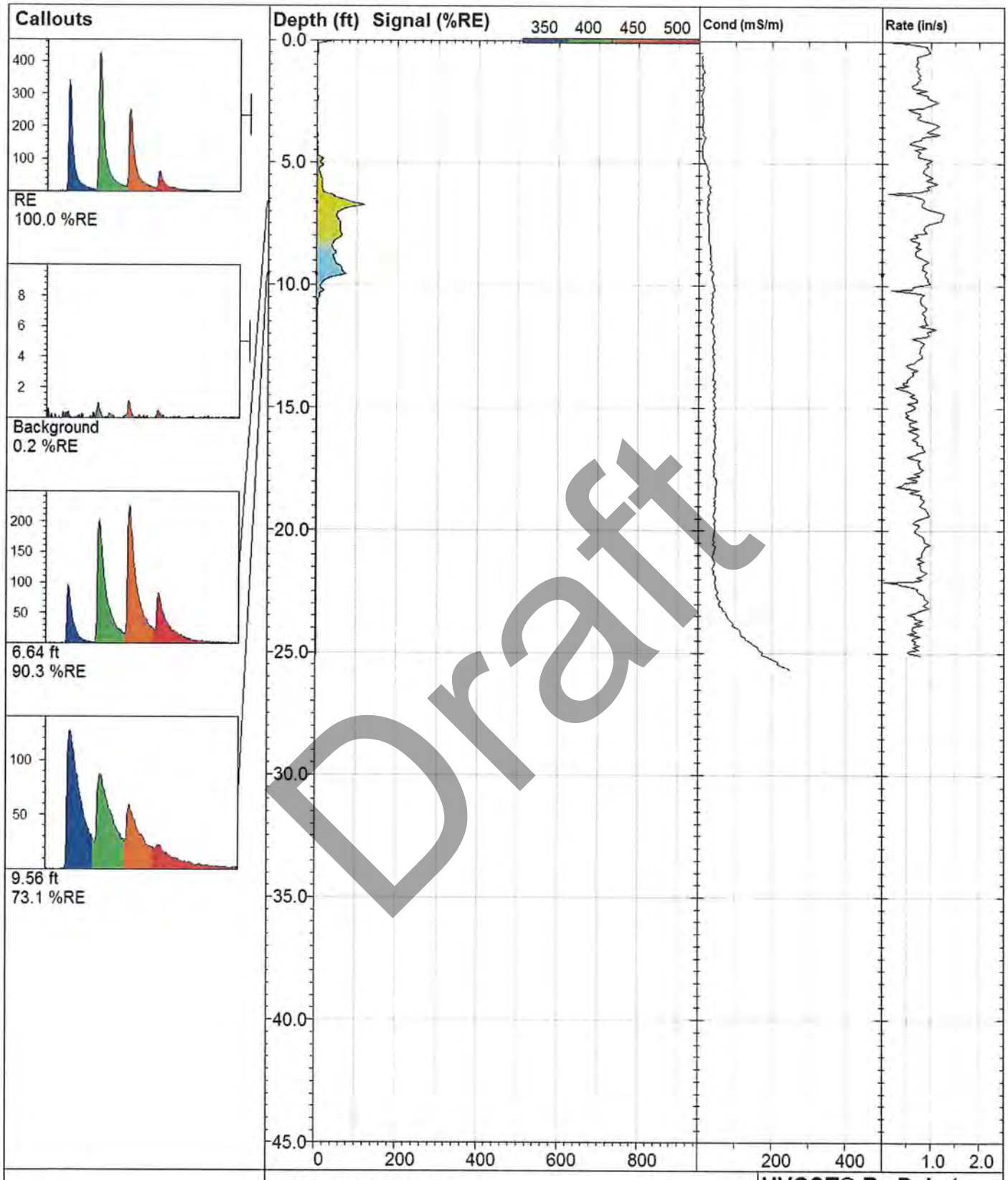
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.37 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **154.8 %RE @ 3.98 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 13:45 CST**



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LIF-2015-07

UVOST® By Dakota
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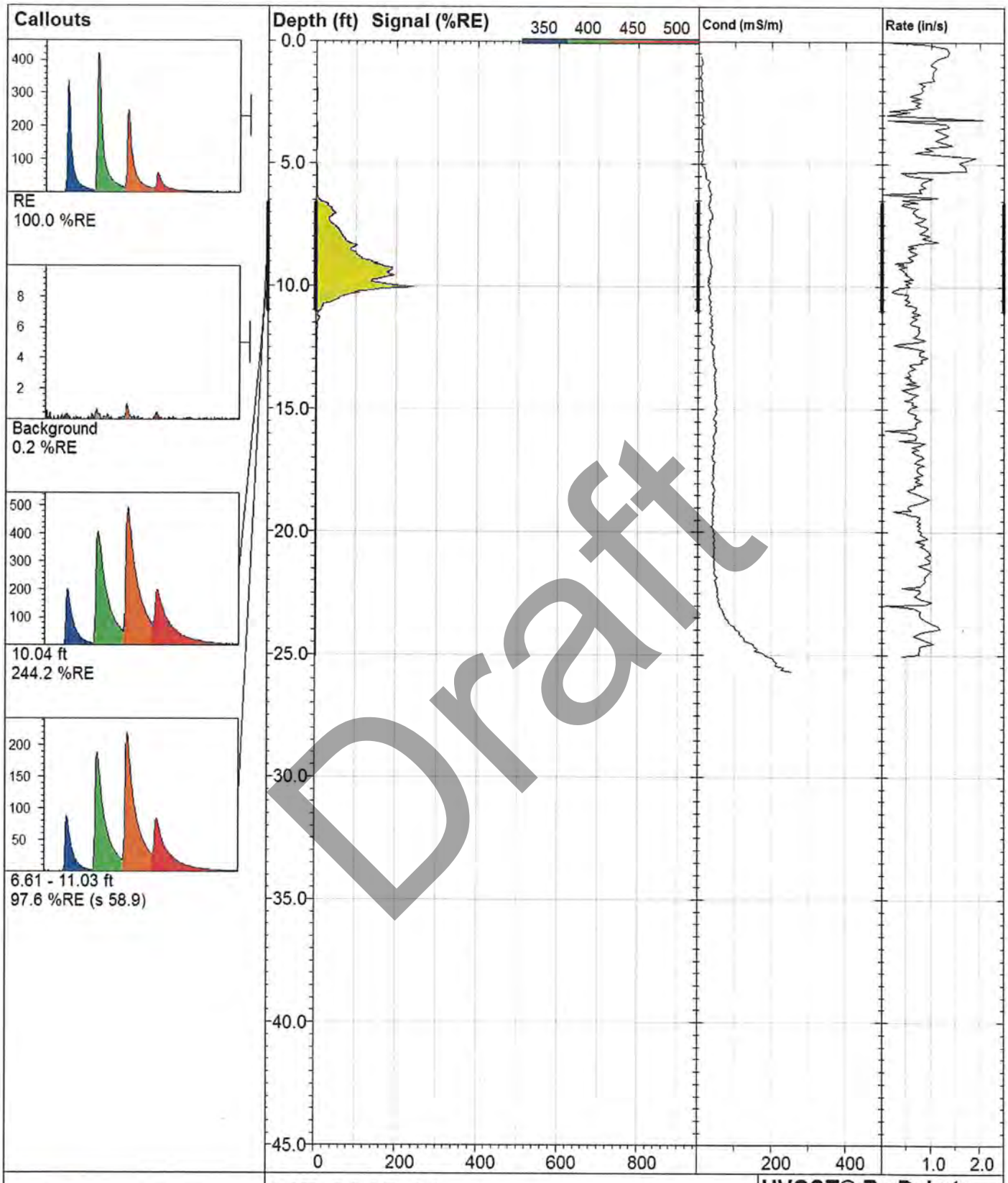
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.11 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **117.8 %RE @ 6.73 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 14:12 CST**



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LIF-2015-08

UVOST® By Dakota
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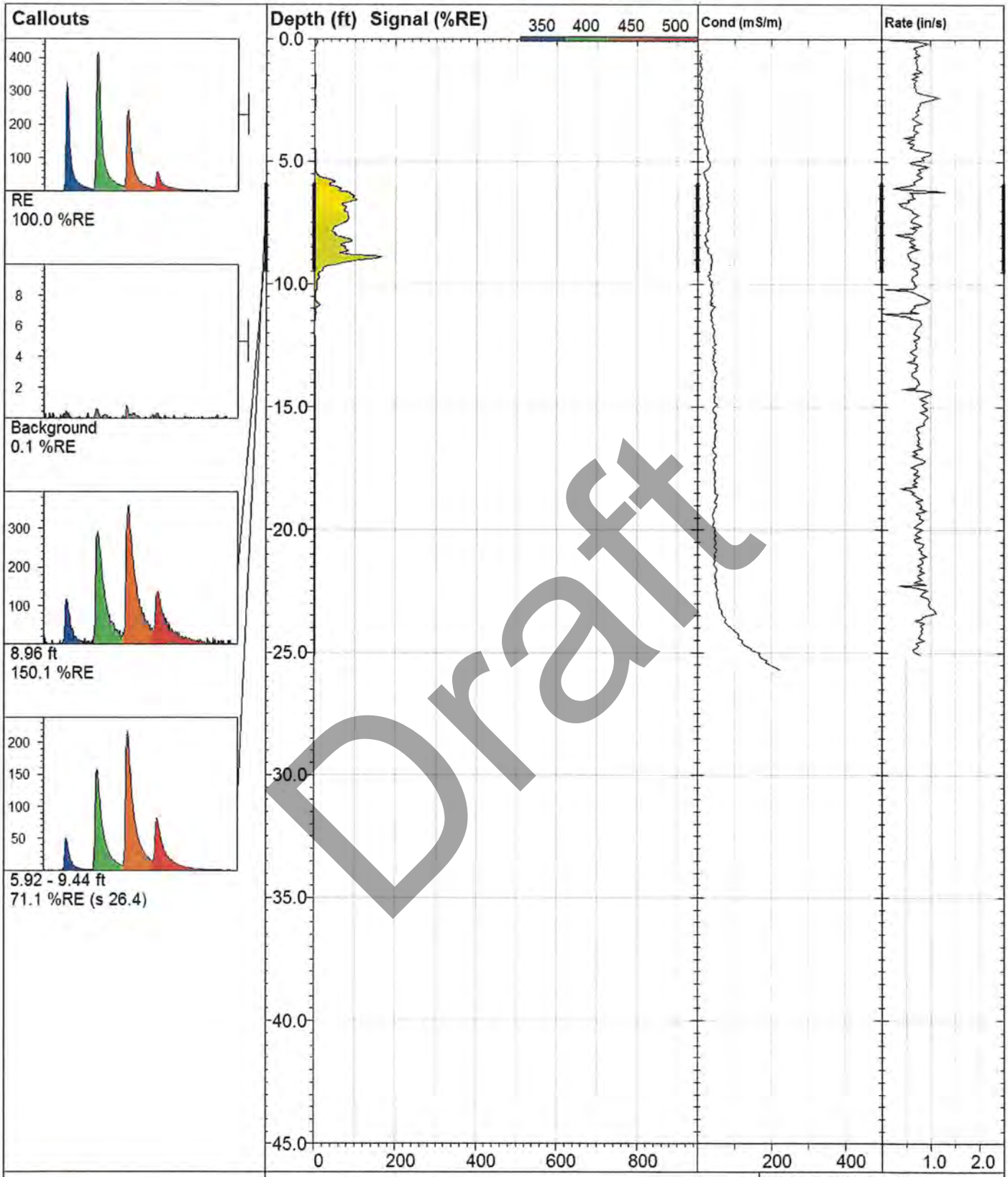
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.06 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **244.2 %RE @ 10.04 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 14:40 CST**



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LIF-2015-09

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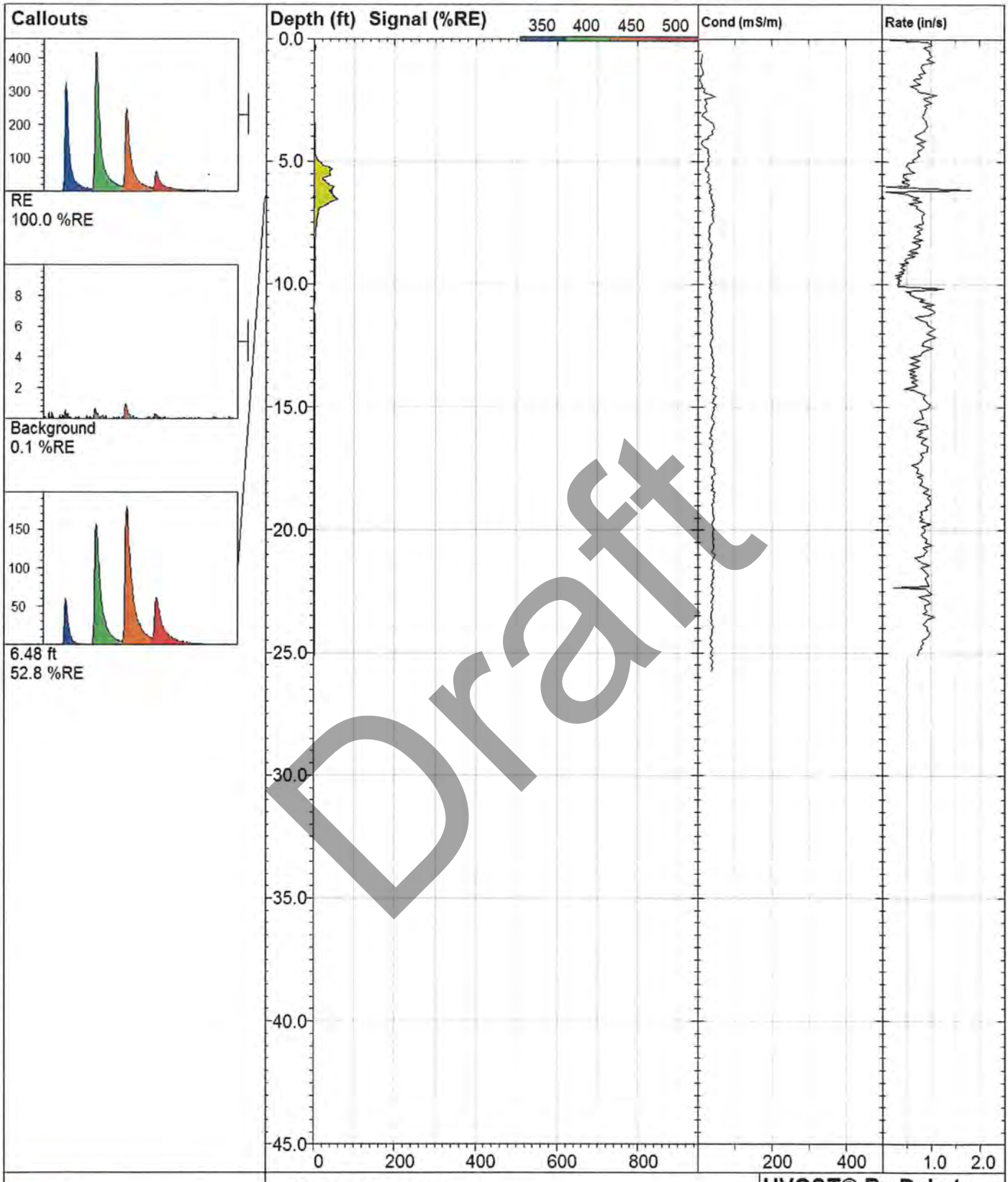
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.11 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **165.1 %RE @ 8.87 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 15:07 CST**



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LIF-2015-10

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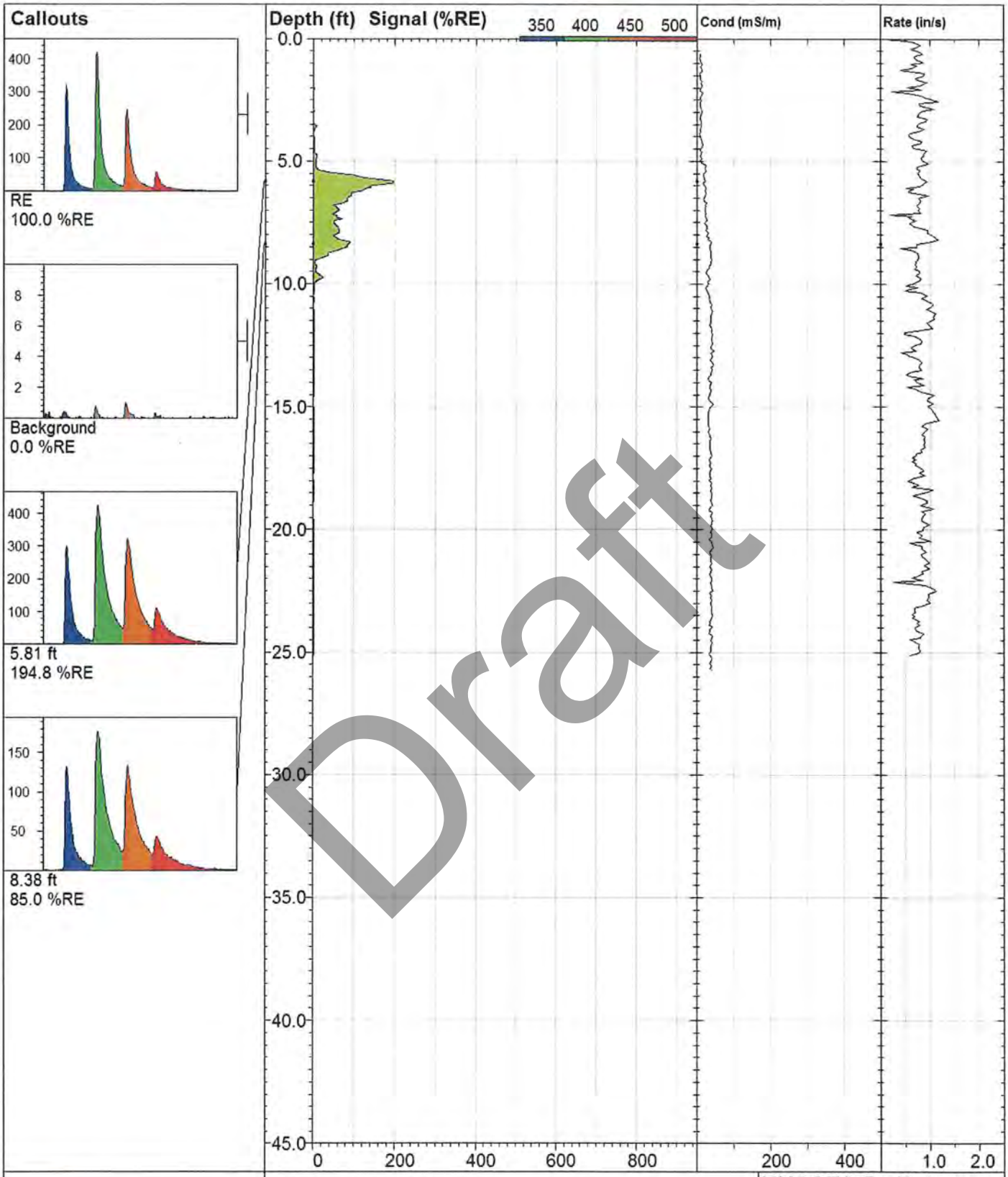
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.11 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **58.1 %RE @ 6.55 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 15:38 CST**



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LIF-2015-11

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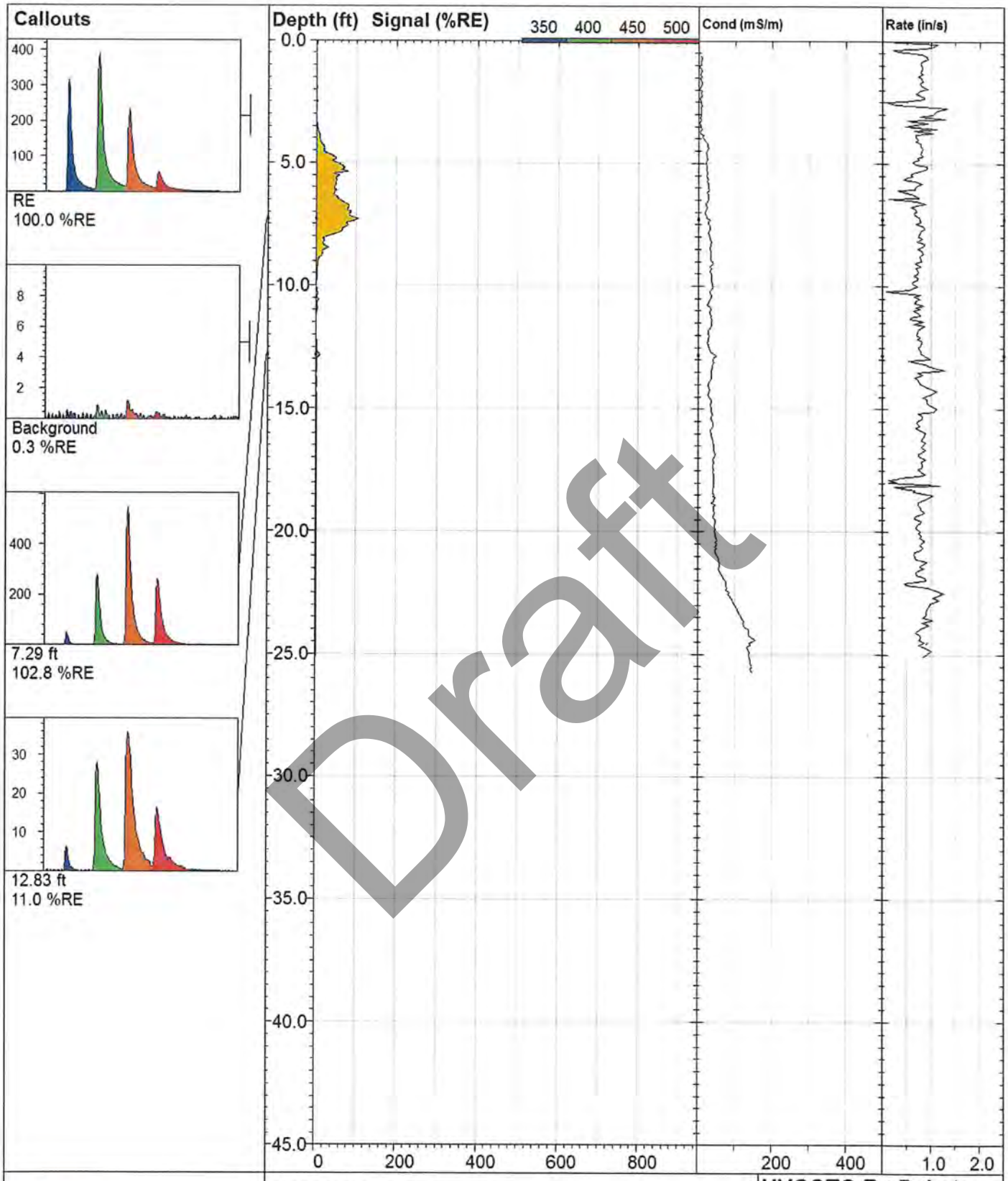
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.13 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **194.8 %RE @ 5.81 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 16:03 CST**



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LIF-2015-12

UVOST® By Dakota
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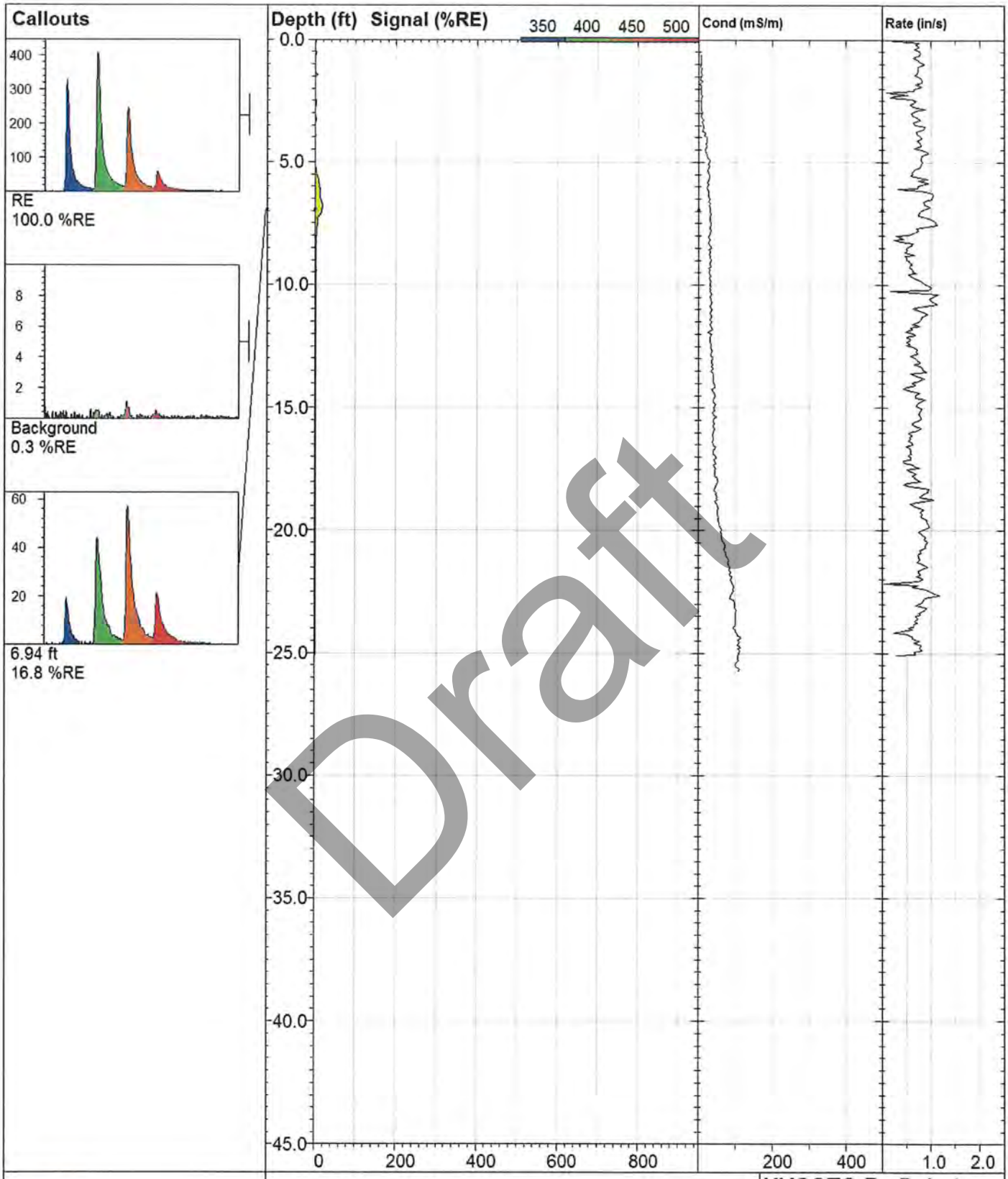
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.11 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **102.8 %RE @ 7.29 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 07:51 CST**



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LIF-2015-13

UVOST® By Dakota
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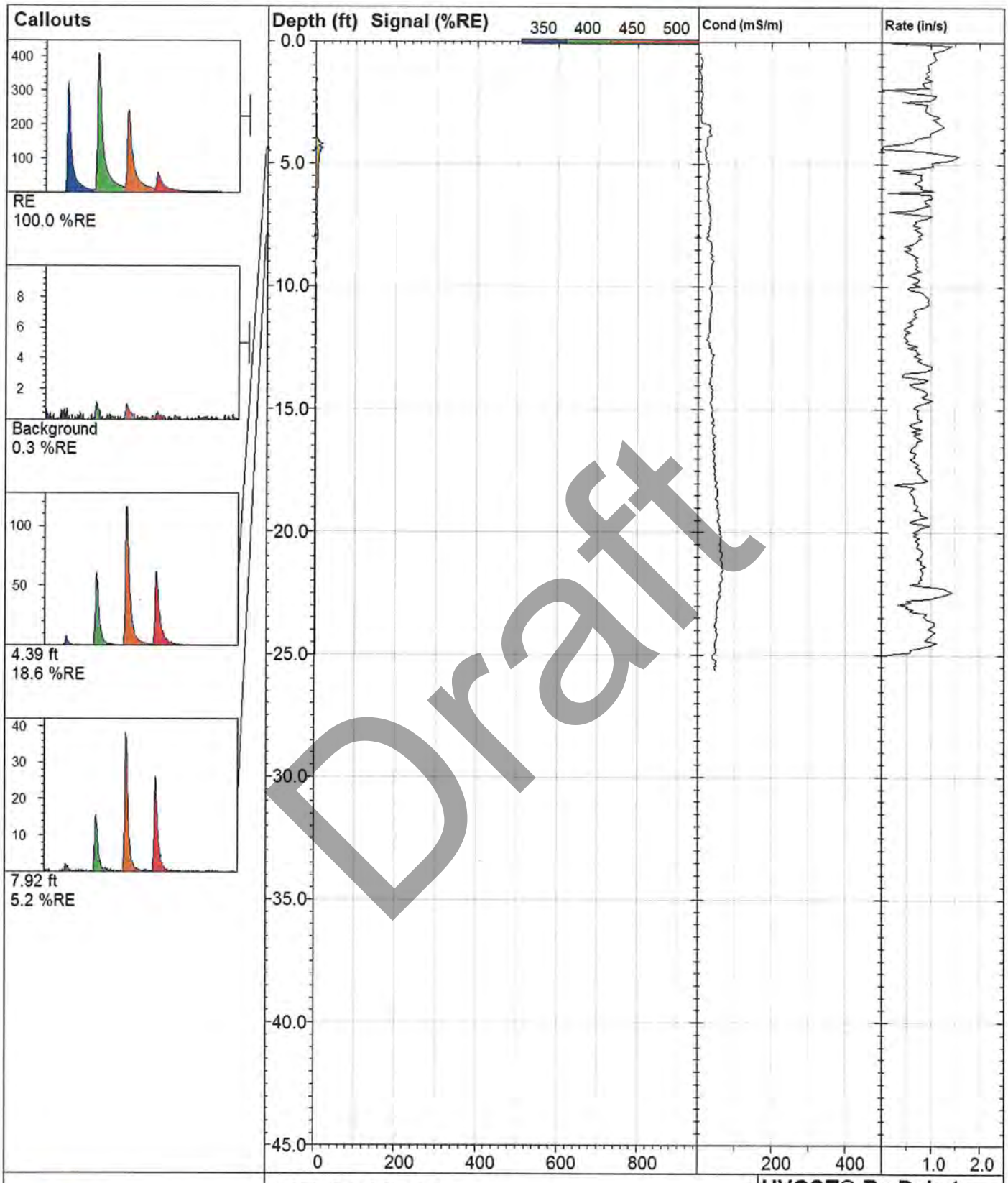
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.09 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **18.0 %RE @ 6.73 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 08:17 CST**



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LIF-2015-14

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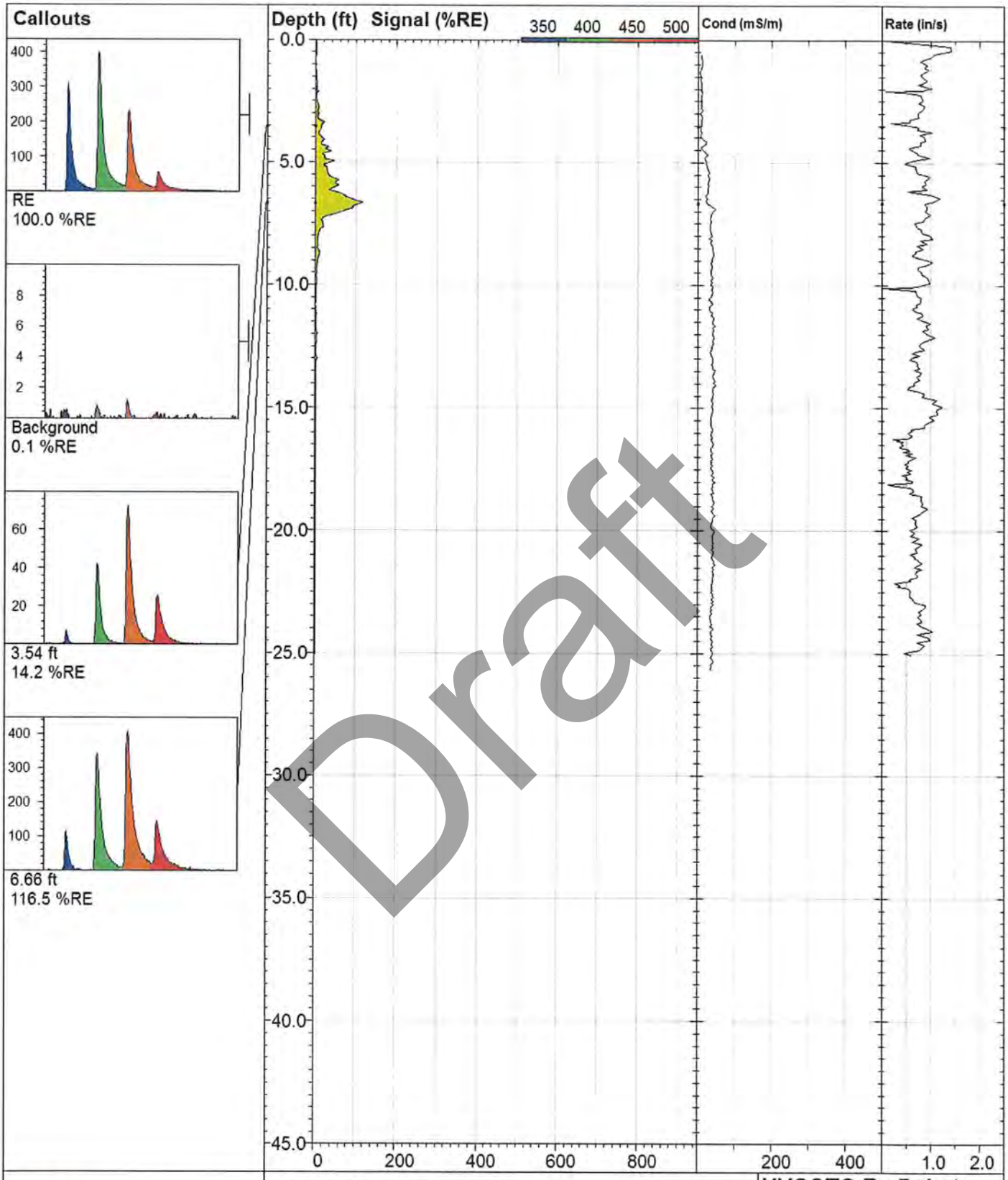
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.01 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **19.0 %RE @ 4.20 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 08:44 CST**



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LIF-2015-15

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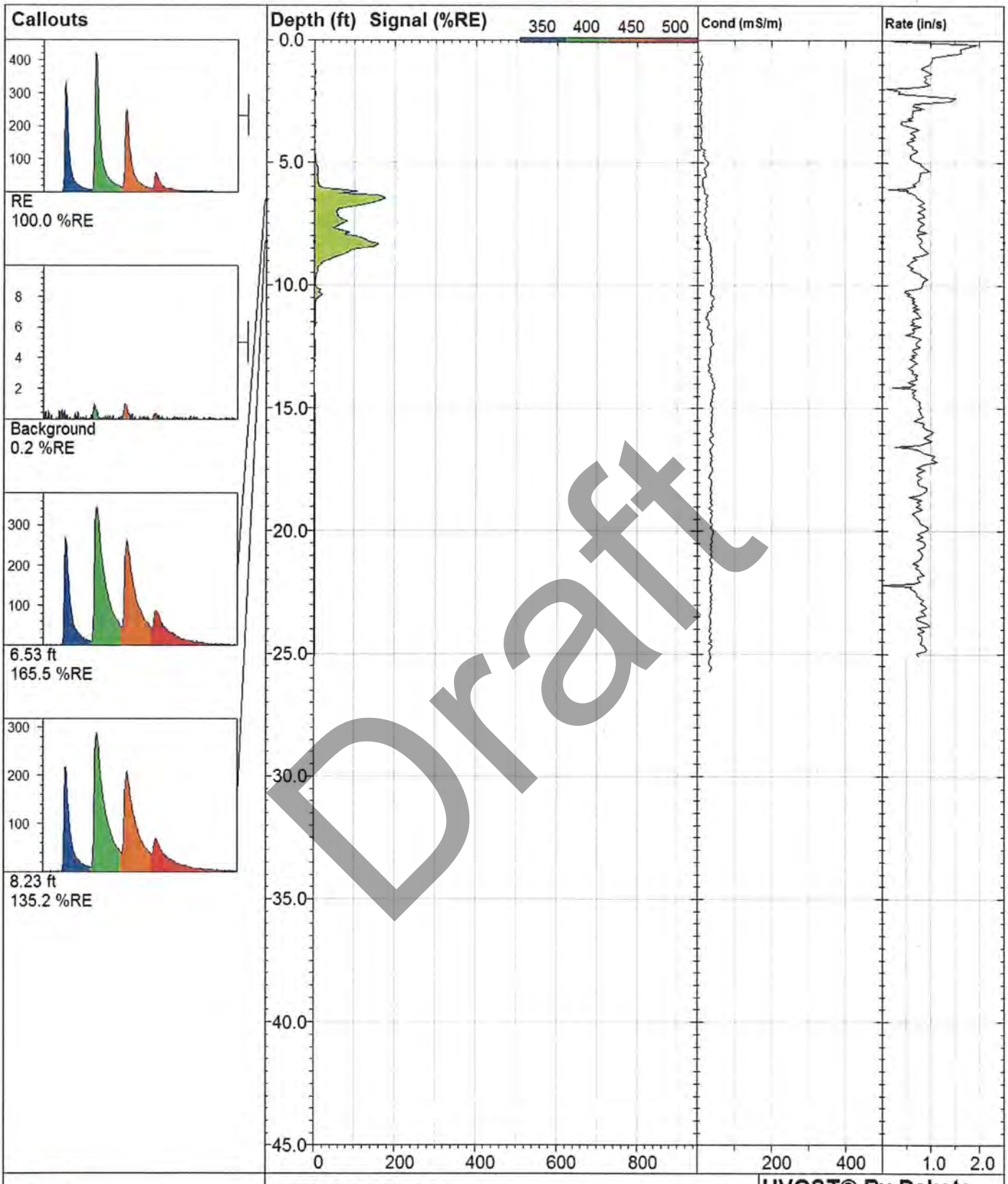
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.06 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **116.5 %RE @ 6.66 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 09:12 CST**



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LIF-2015-16

UVOST® By Dakota
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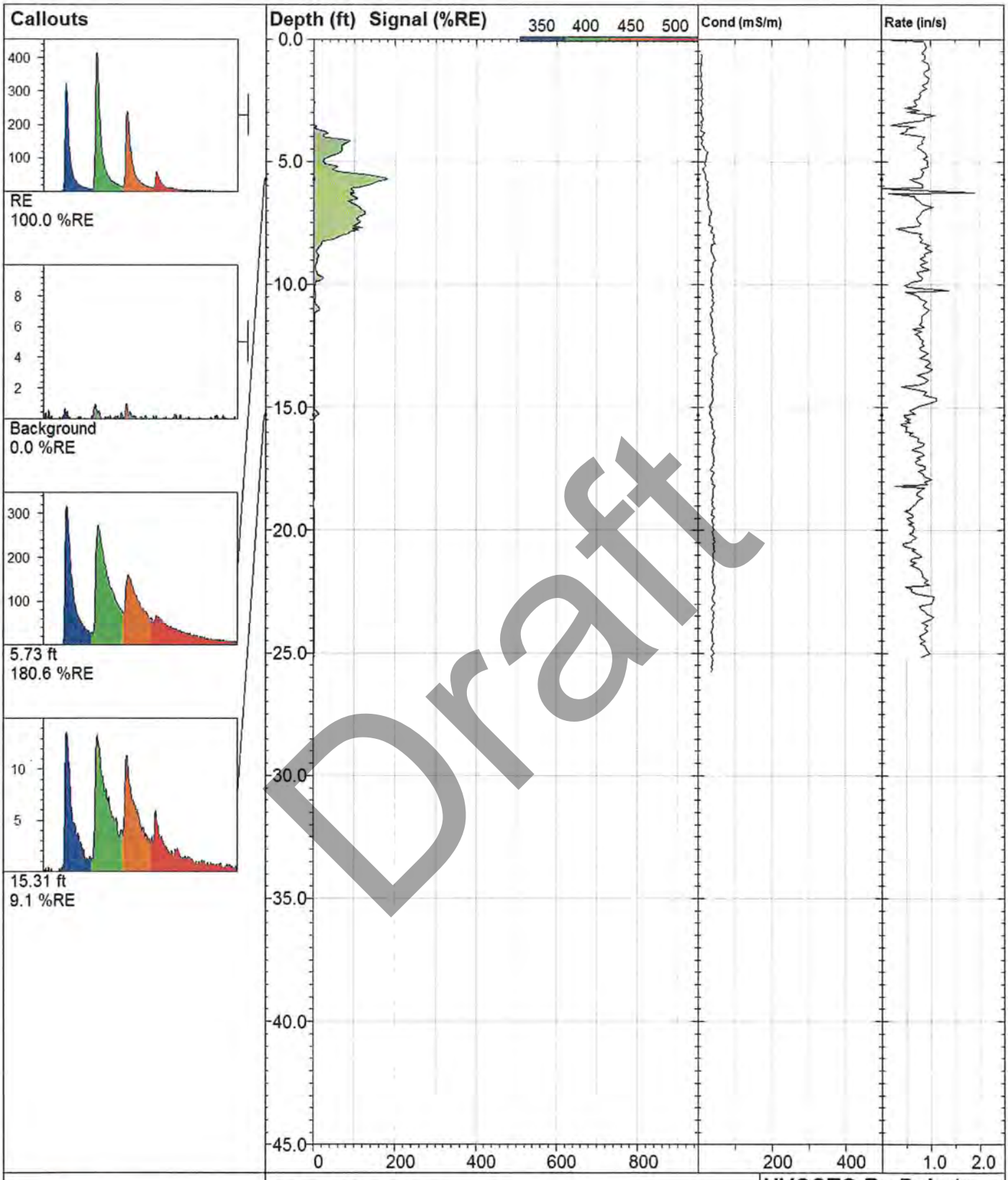
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **175.7 %RE @ 6.44 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 09:41 CST**



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LIF-2015-17

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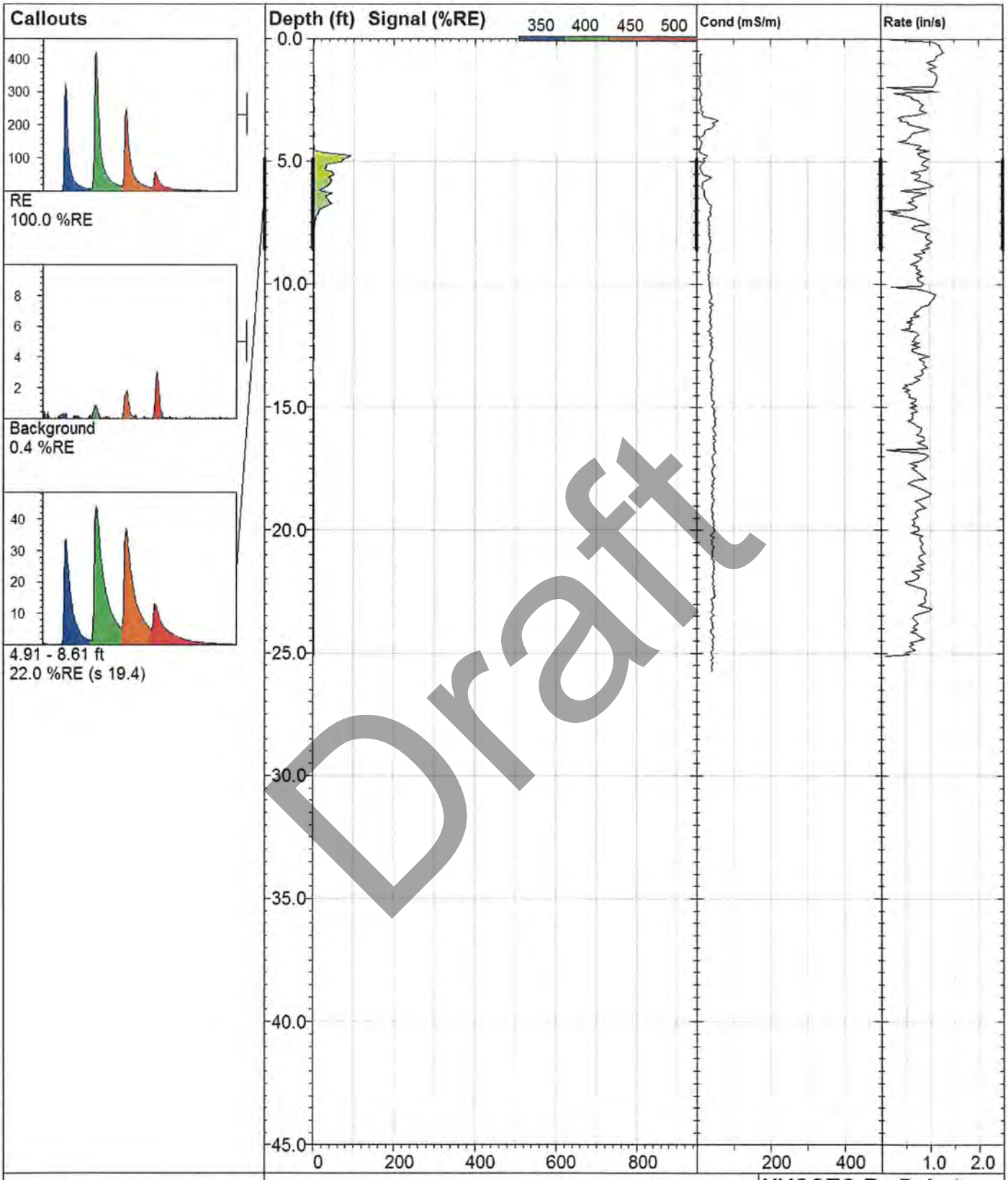
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.14 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **180.6 %RE @ 5.73 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 10:10 CST**



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LIF-2015-18

UVOST® By Dakota
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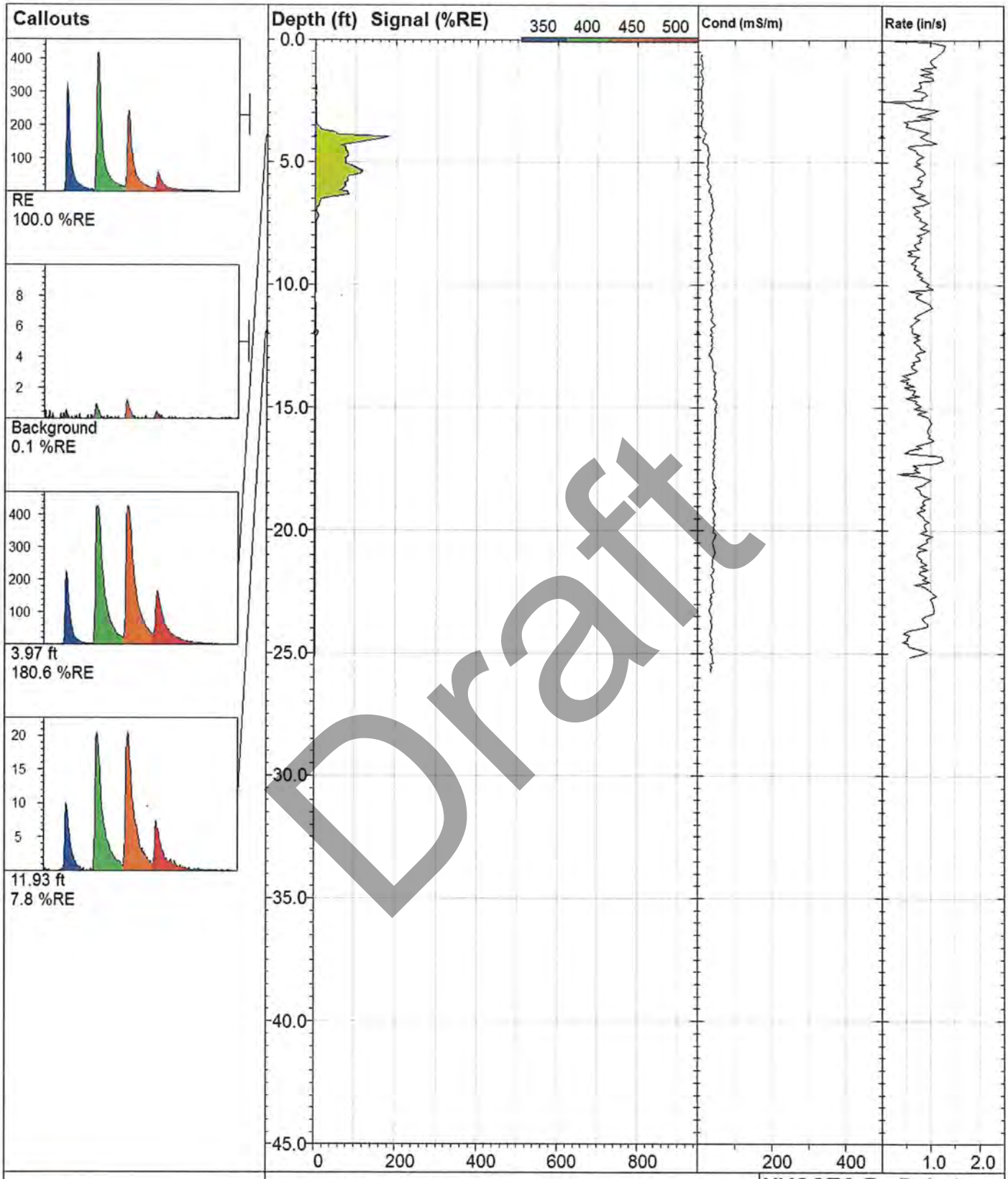
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.11 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **92.7 %RE @ 4.78 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 10:36 CST**



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LIF-2015-19

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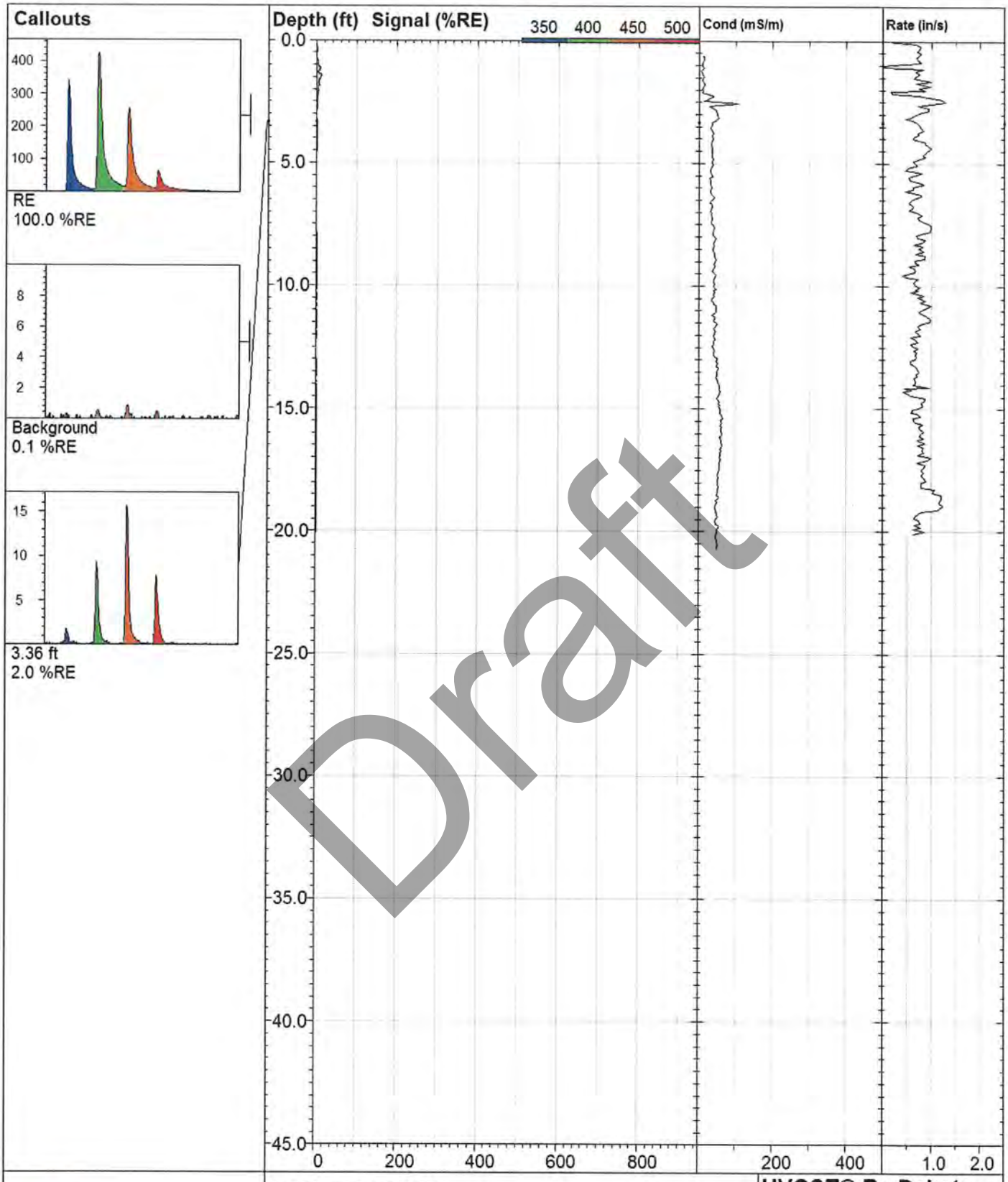
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.14 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **180.6 %RE @ 3.97 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 11:04 CST**



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LIF-2015-20

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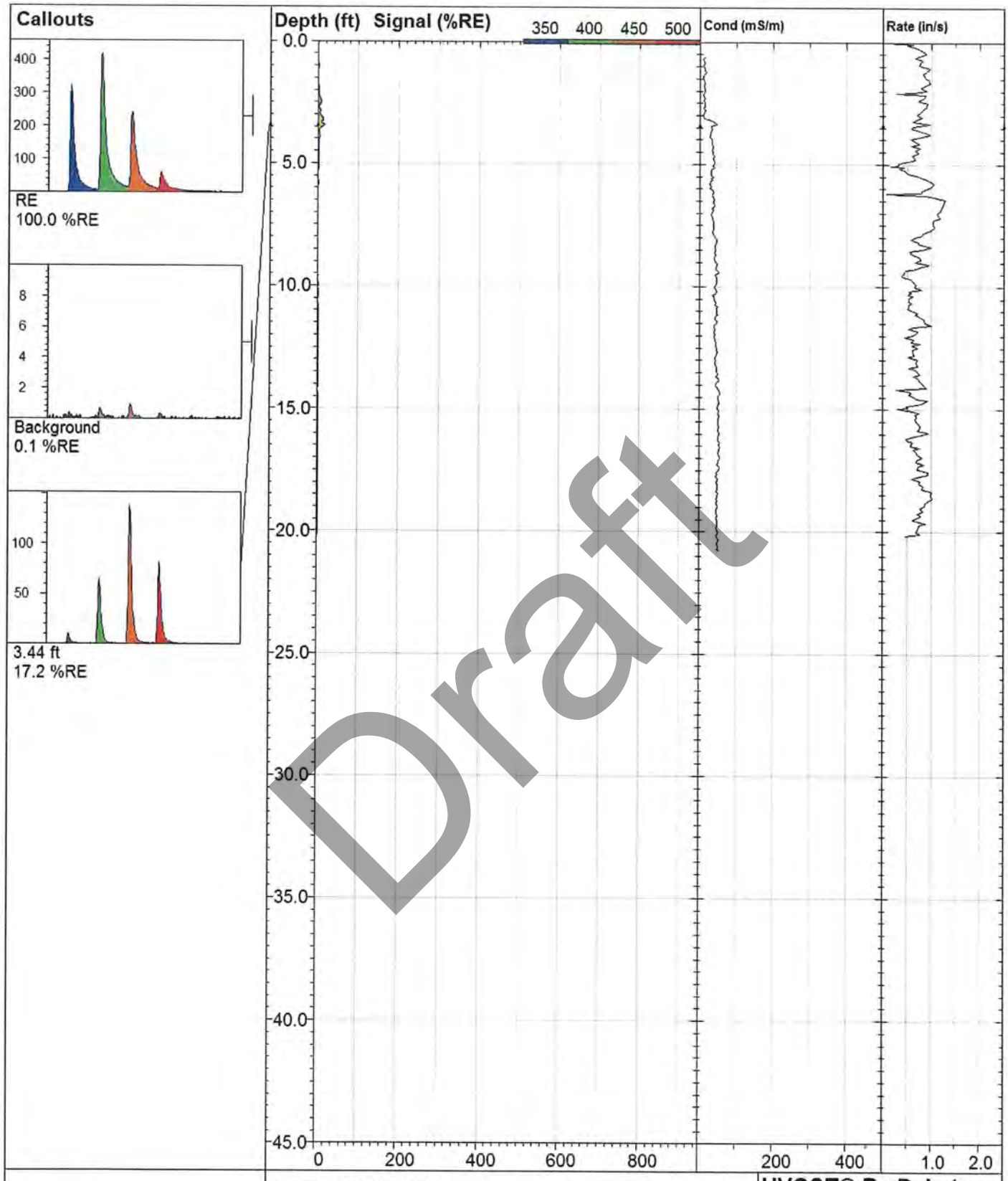
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.10 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **12.0 %RE @ 1.41 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 12:35 CST**



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LIF-2015-21

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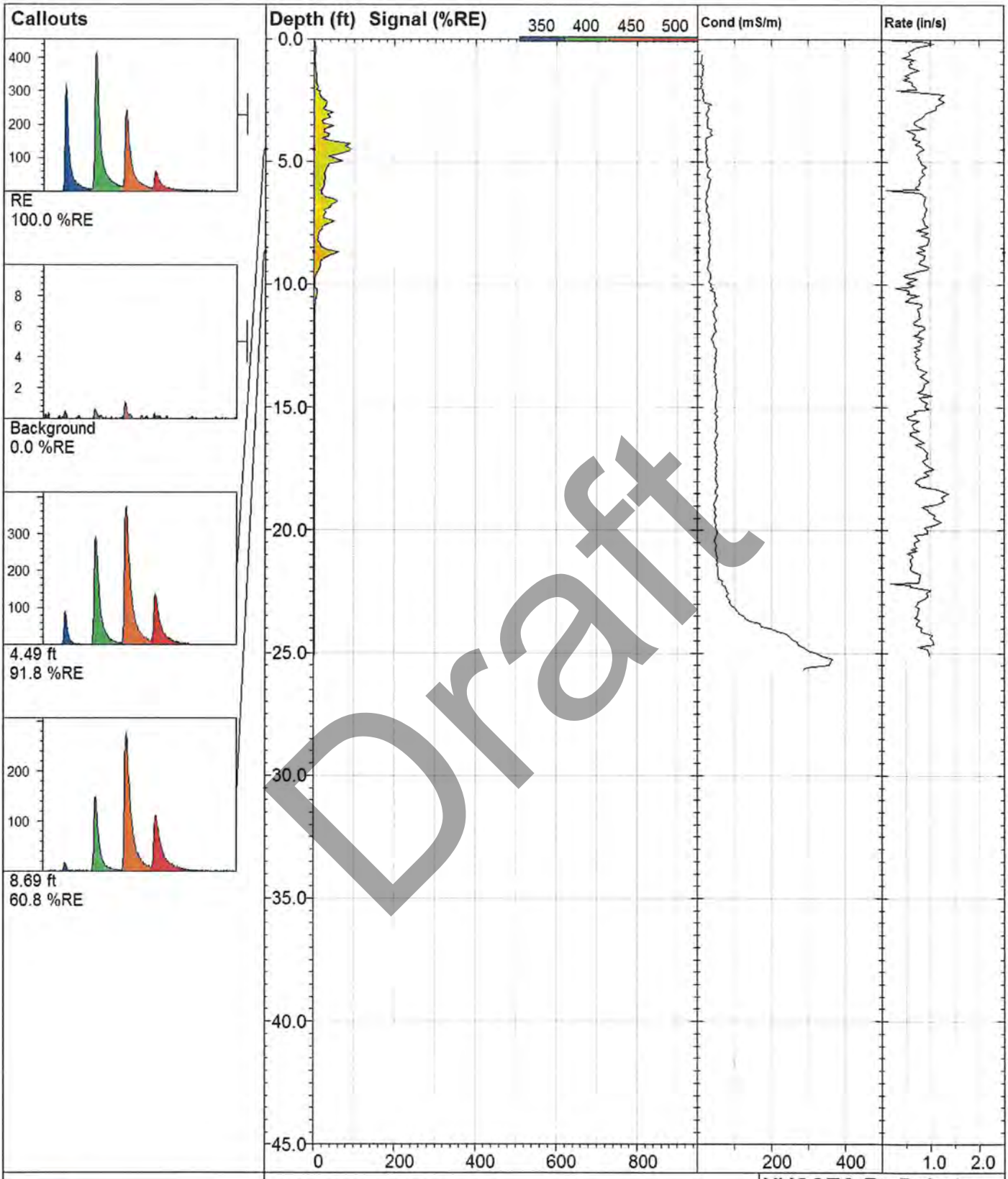
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.17 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **17.2 %RE @ 3.44 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 12:59 CST**



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LIF-2015-22

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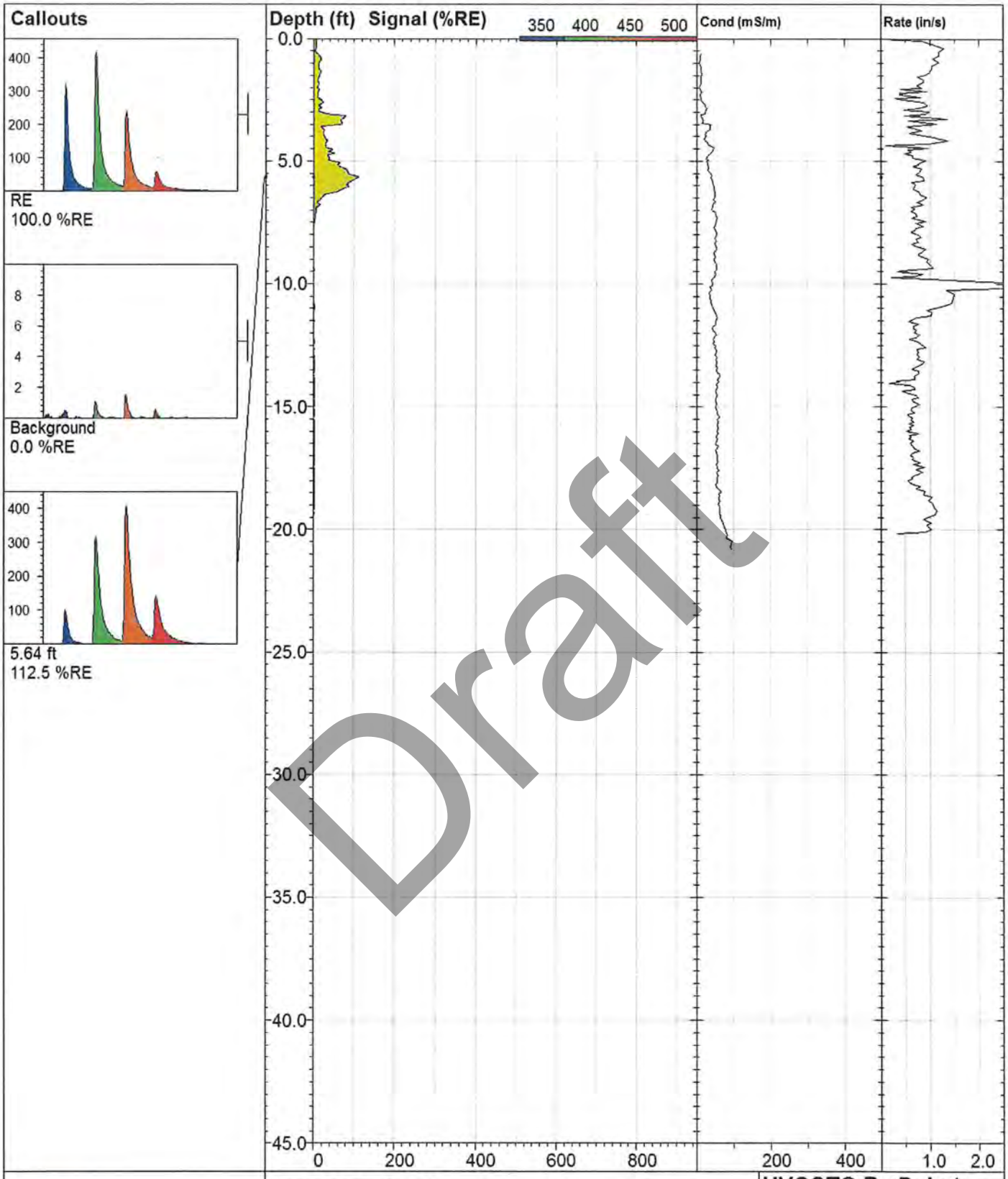
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.10 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **91.8 %RE @ 4.49 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 13:45 CST**



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LIF-2015-23

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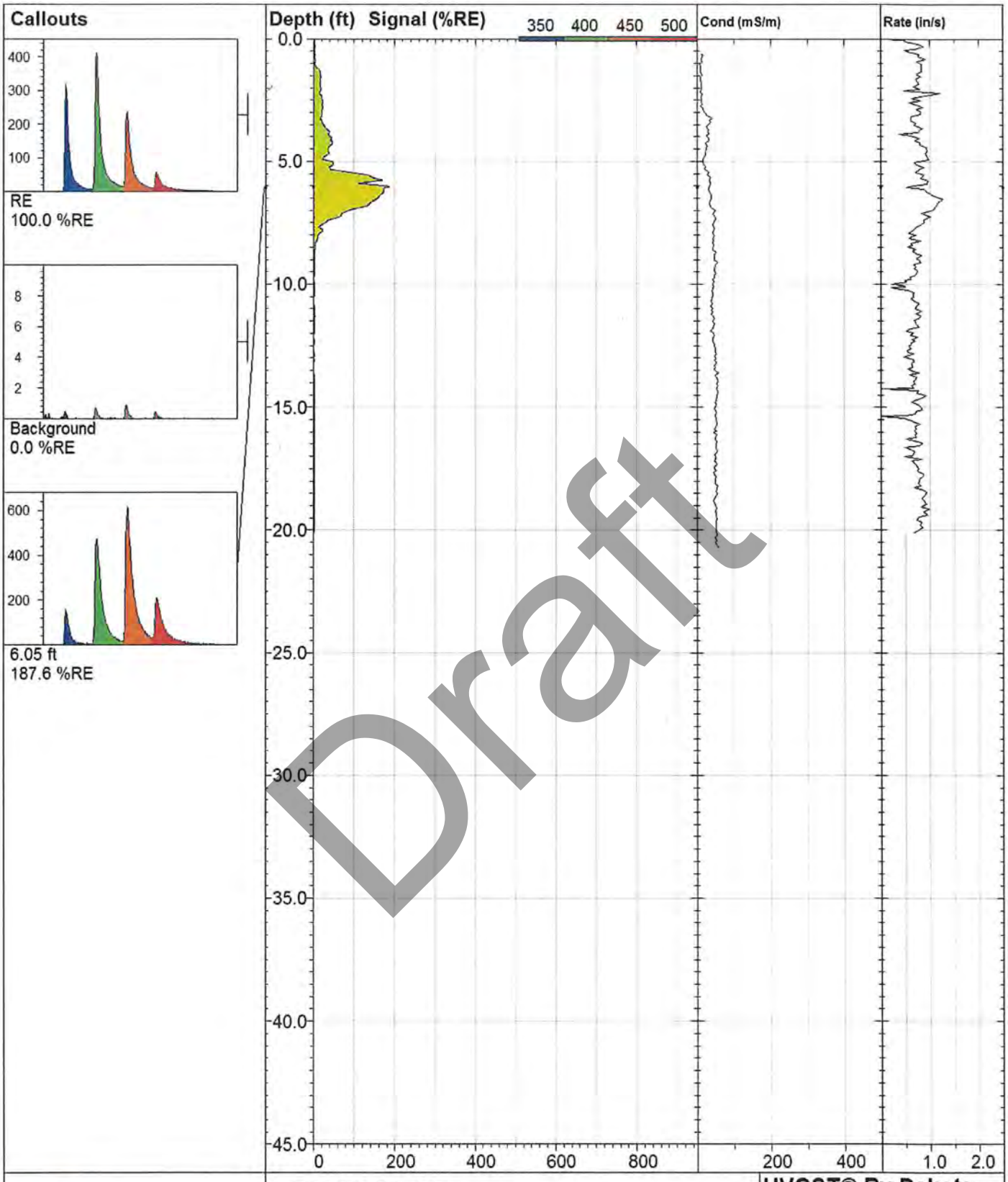
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.17 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **112.5 %RE @ 5.64 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 14:11 CST**



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LIF-2015-24

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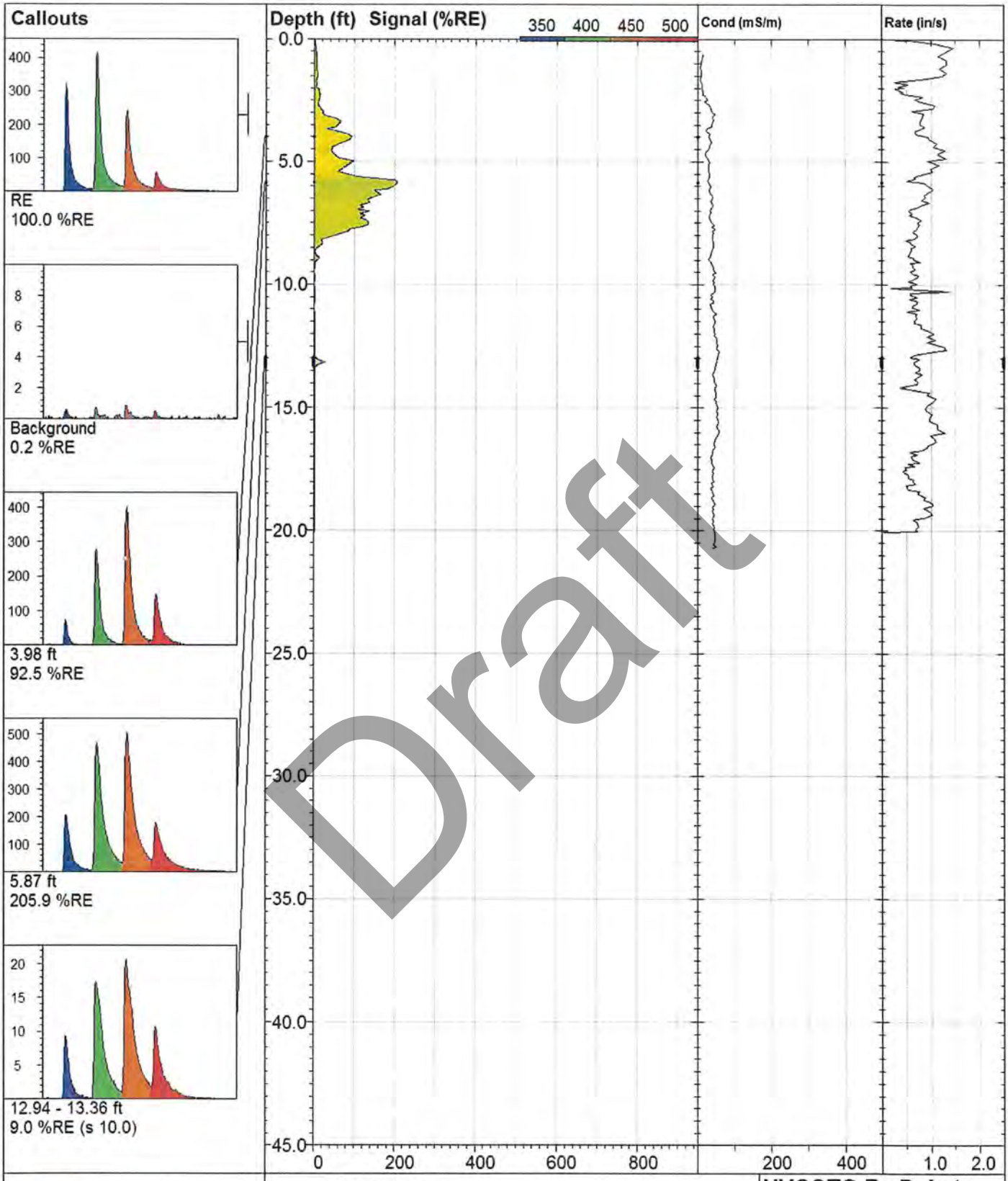
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.09 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **187.6 %RE @ 6.05 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 14:34 CST**



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LIF-2015-25

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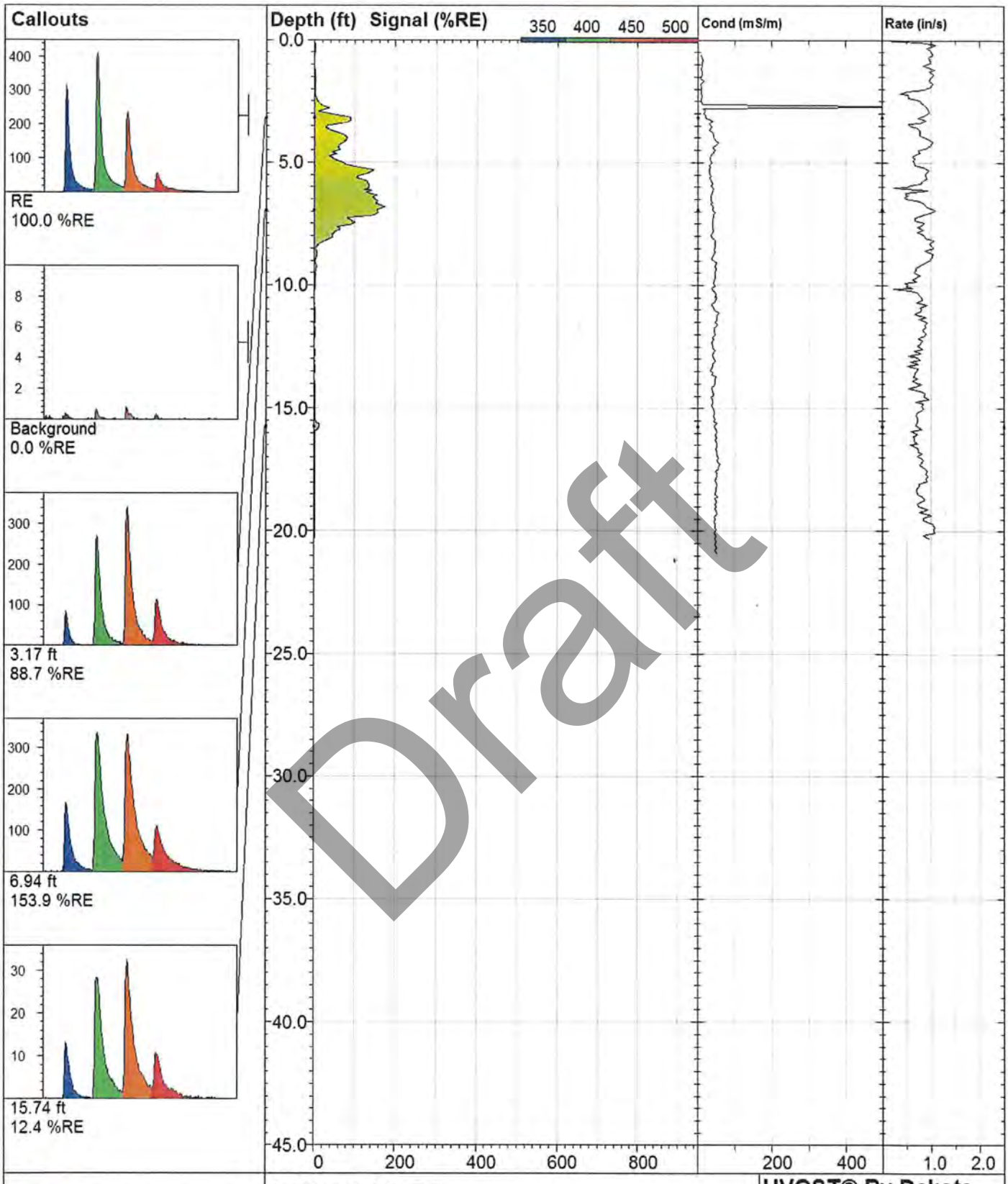
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.07 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **205.9 %RE @ 5.87 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 14:55 CST**



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LIF-2015-26

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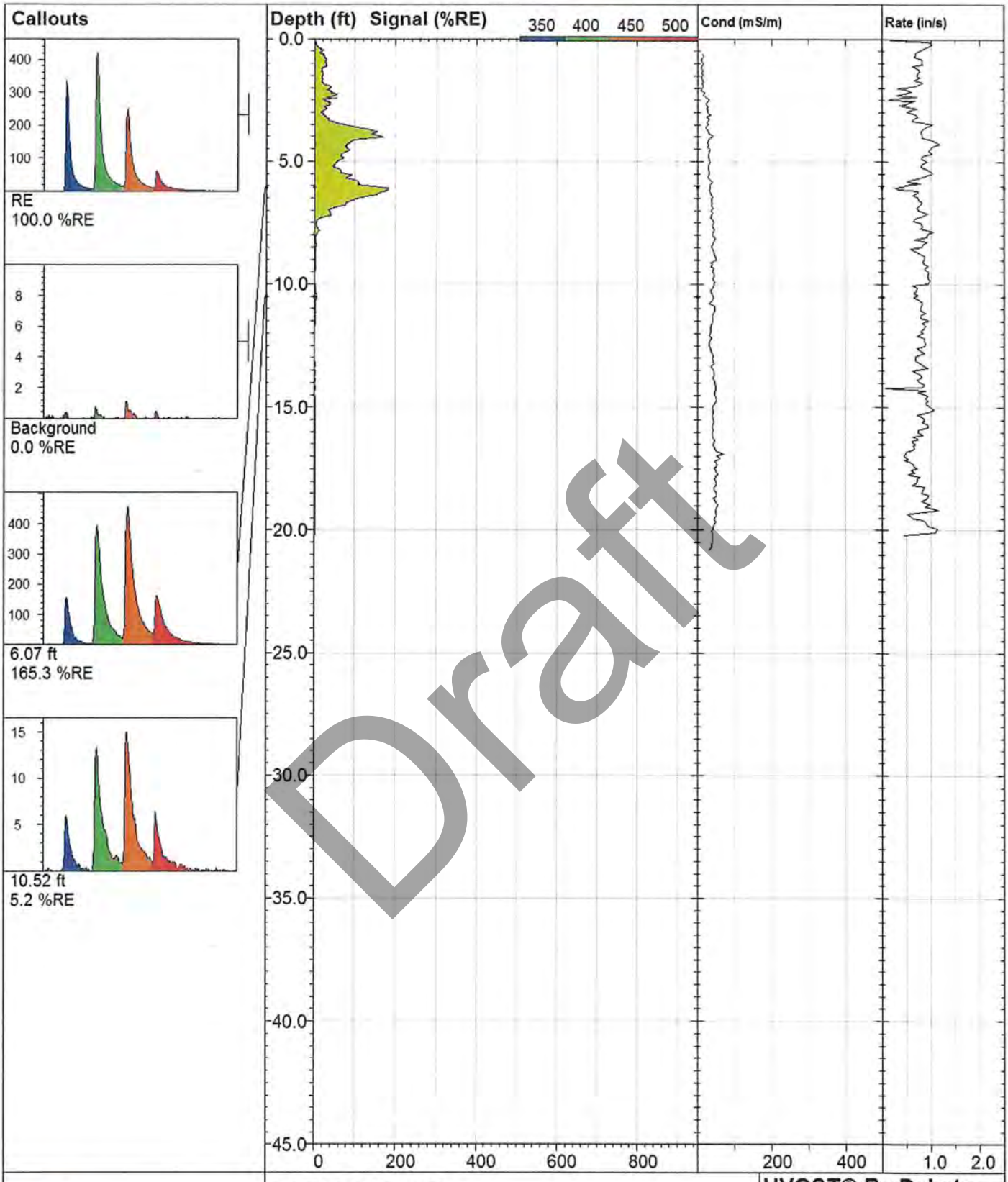
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.30 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **174.2 %RE @ 6.81 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 15:14 CST**



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LIF-2015-27

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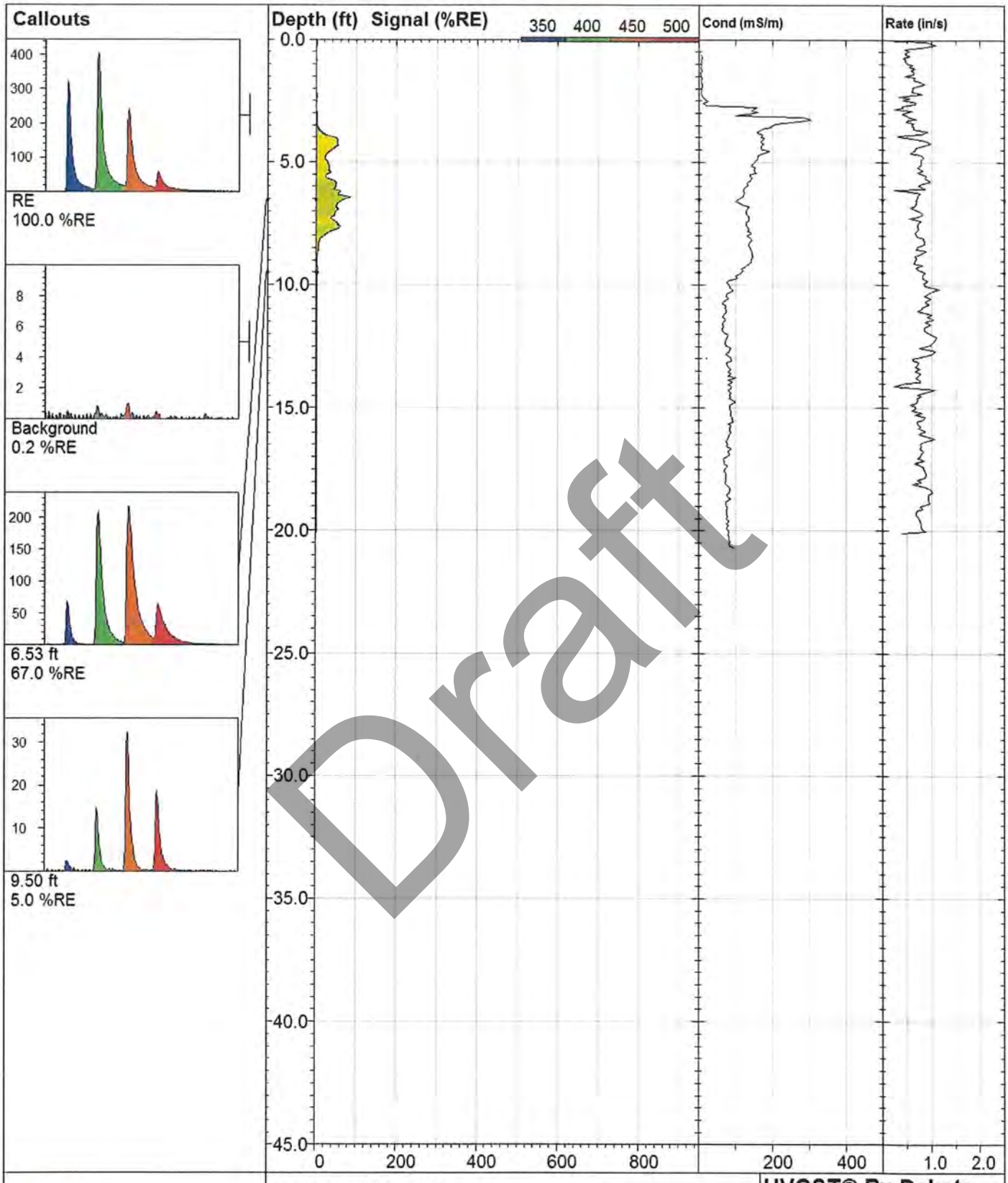
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.19 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **181.9 %RE @ 6.12 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 15:36 CST**



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LIF-2015-28

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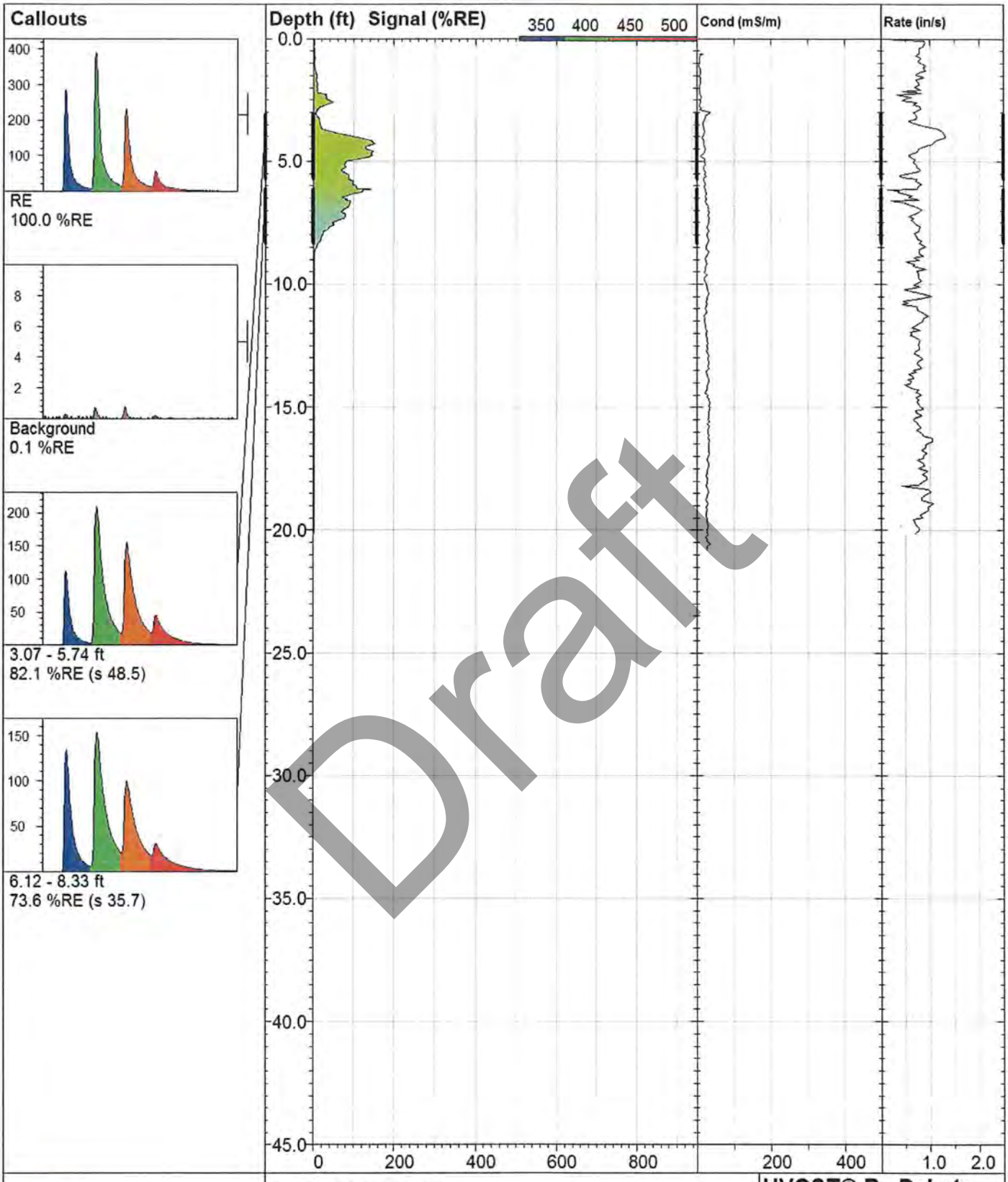
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.08 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **86.1 %RE @ 6.44 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 08:22 CST**



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LIF-2015-29

UVOST® By Dakota
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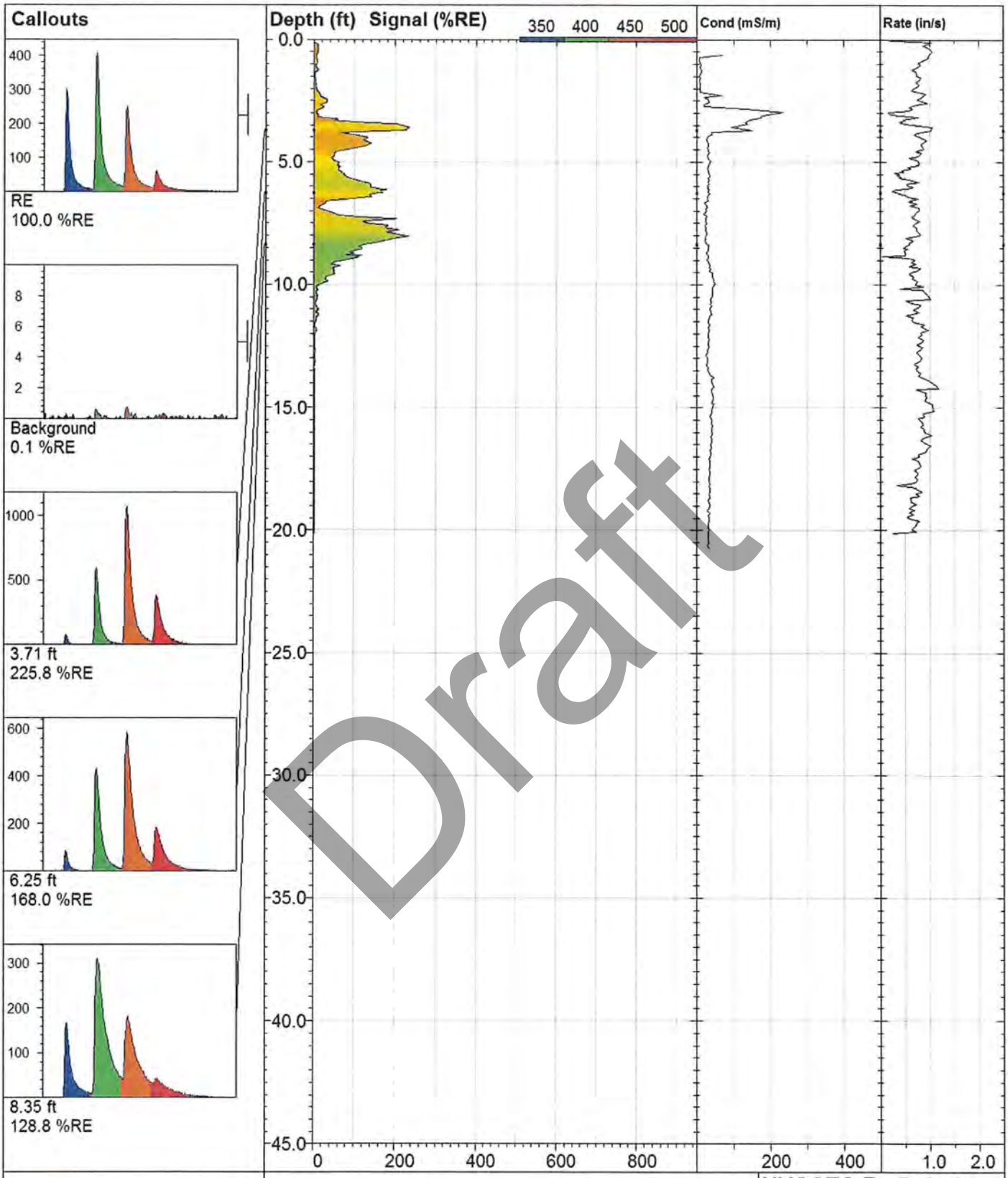
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.13 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **151.8 %RE @ 4.29 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 09:46 CST**



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LIF-2015-30

UVOST® By Dakota
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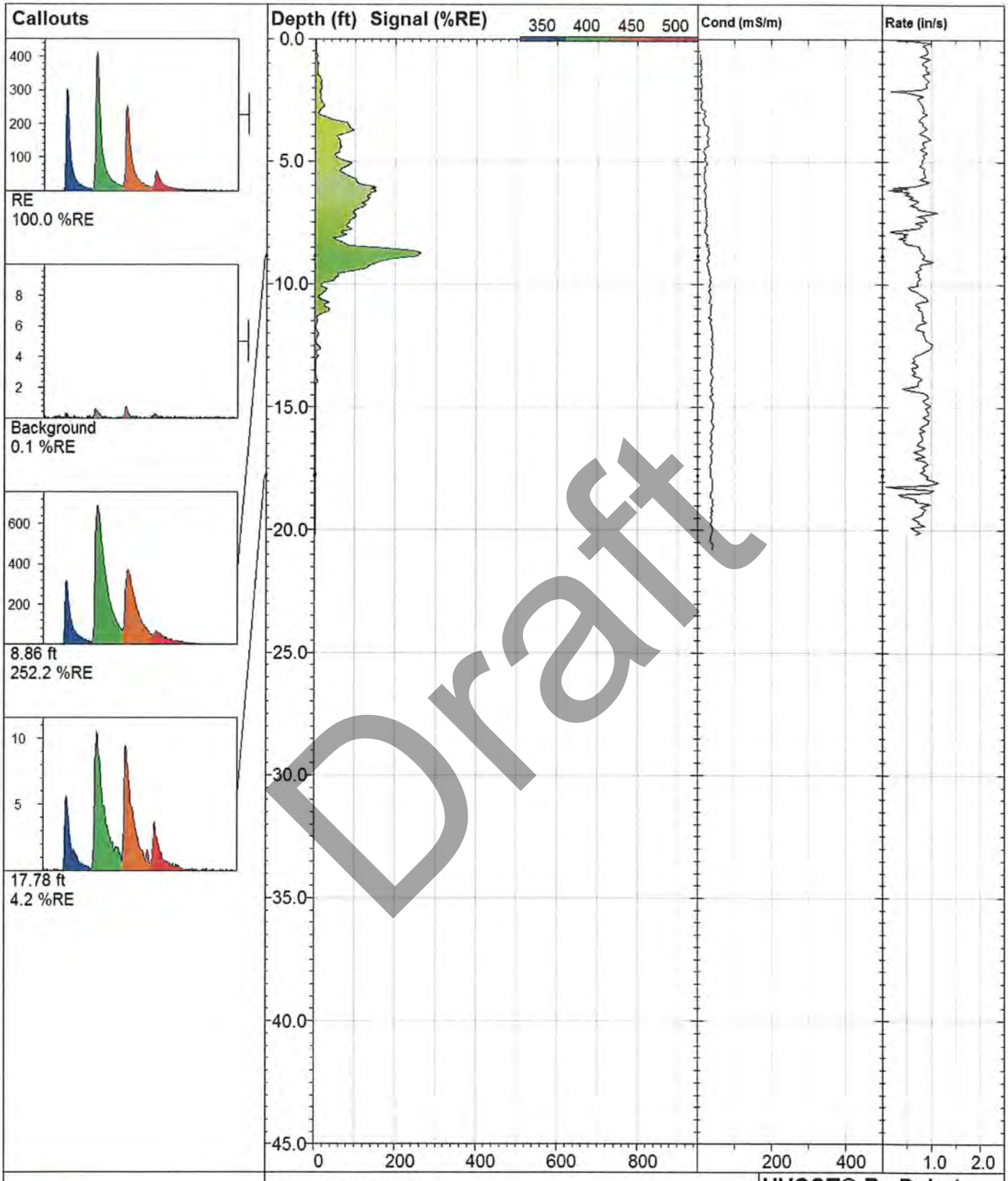
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **233.9 %RE @ 3.59 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 10:11 CST**



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LIF-2015-31

UVOST® By Dakota
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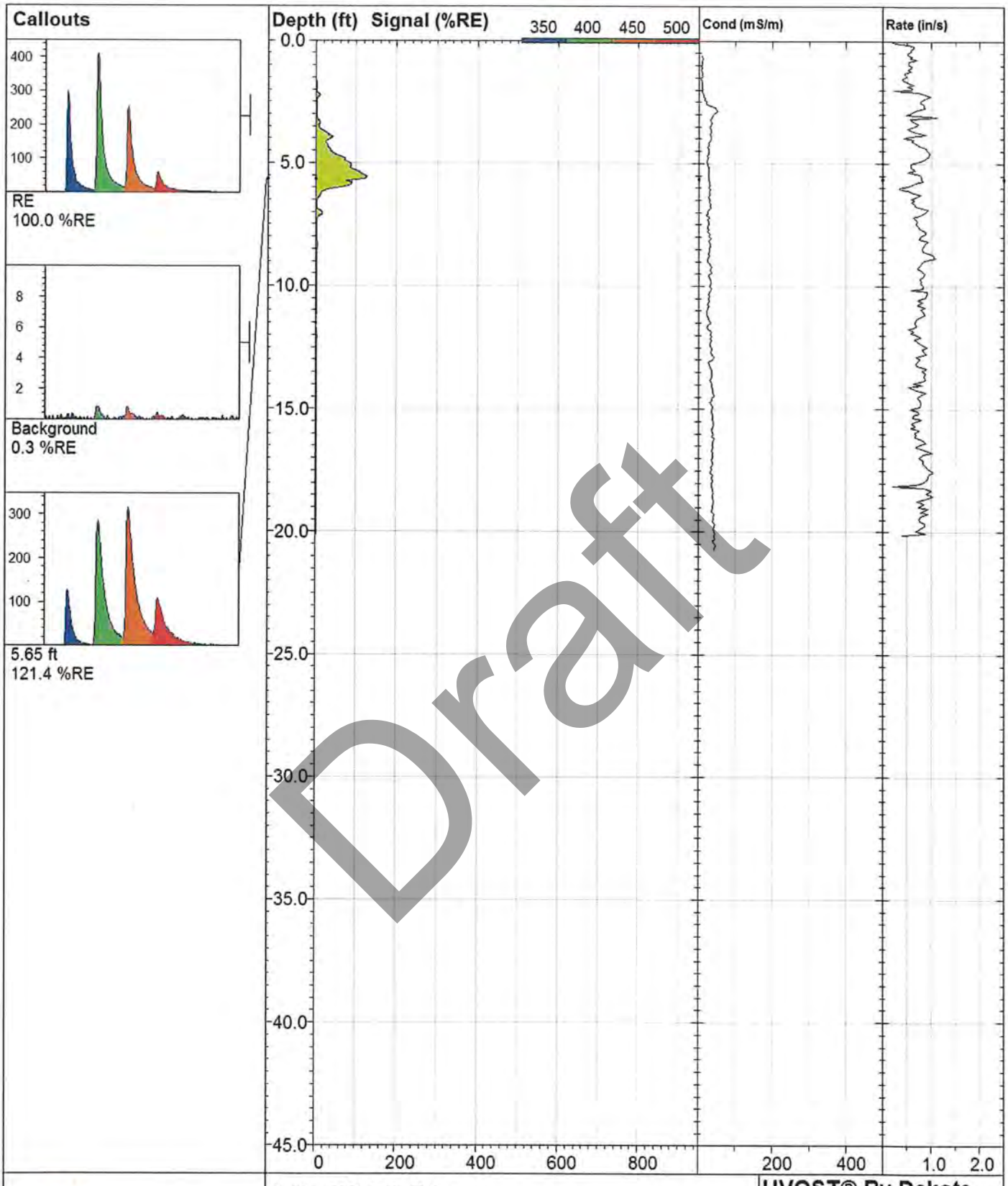
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.18 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **261.7 %RE @ 8.73 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 10:33 CST**



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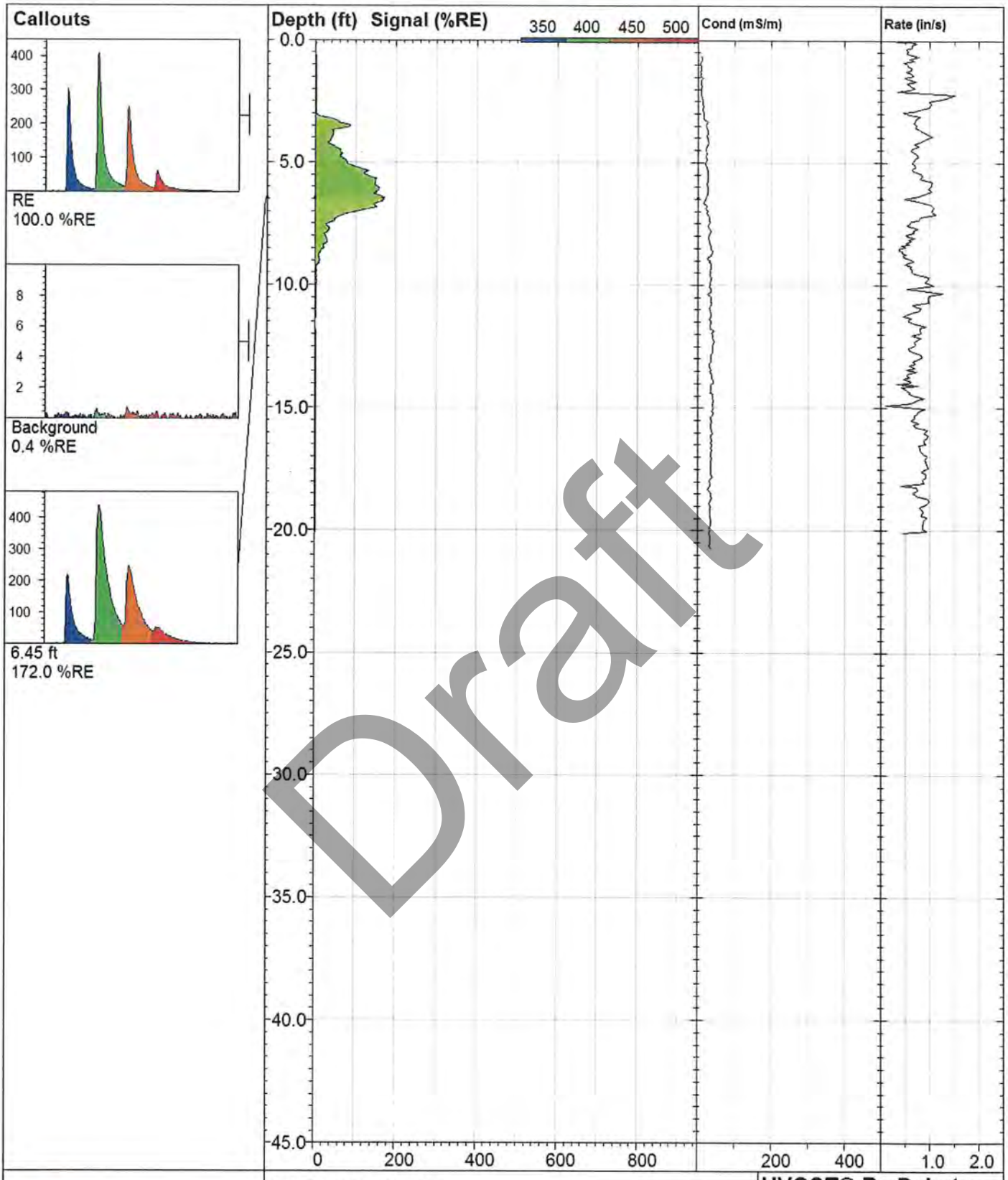
LIF-2015-32

UVOST® By Dakota
www.DakotaTechnologies.com

Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **127.5 %RE @ 5.56 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 10:56 CST**



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LIF-2015-33

UVOST® By Dakota
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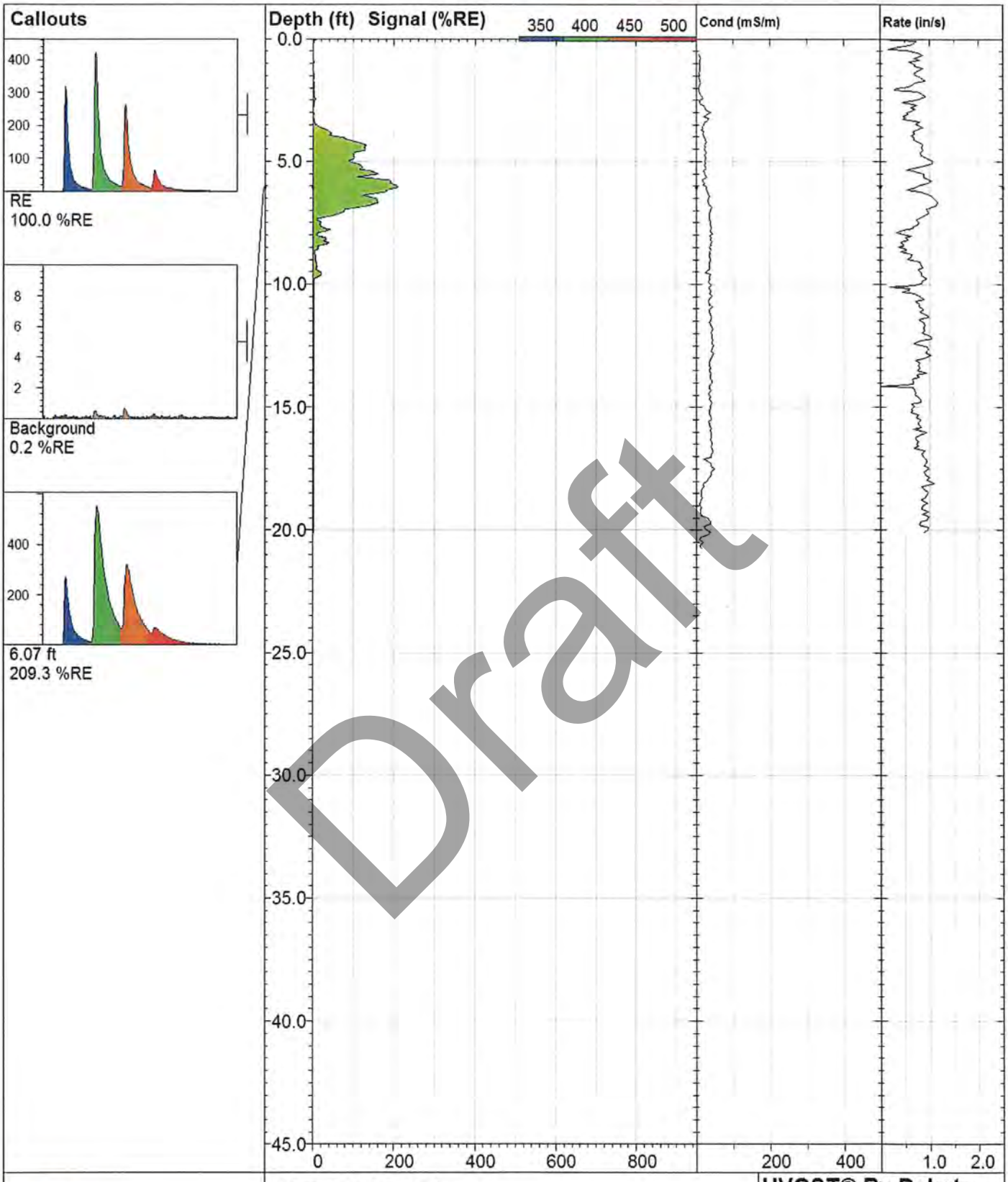
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.10 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **172.0 %RE @ 6.45 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 11:18 CST**



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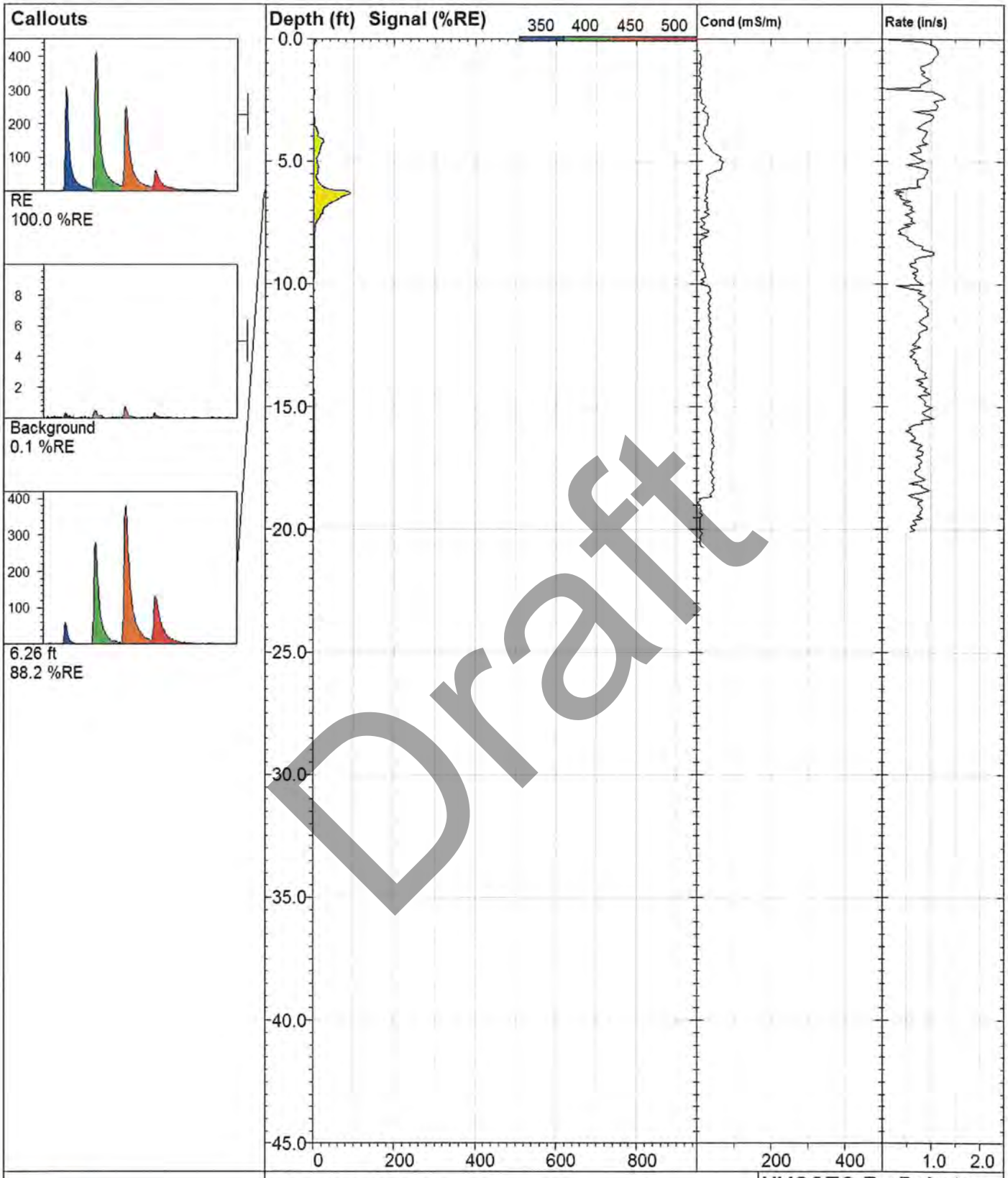
LIF-2015-34

UVOST® By Dakota
www.DakotaTechnologies.com

Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **209.3 %RE @ 6.07 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 11:46 CST**



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LIF-2015-35

UVOST® By Dakota
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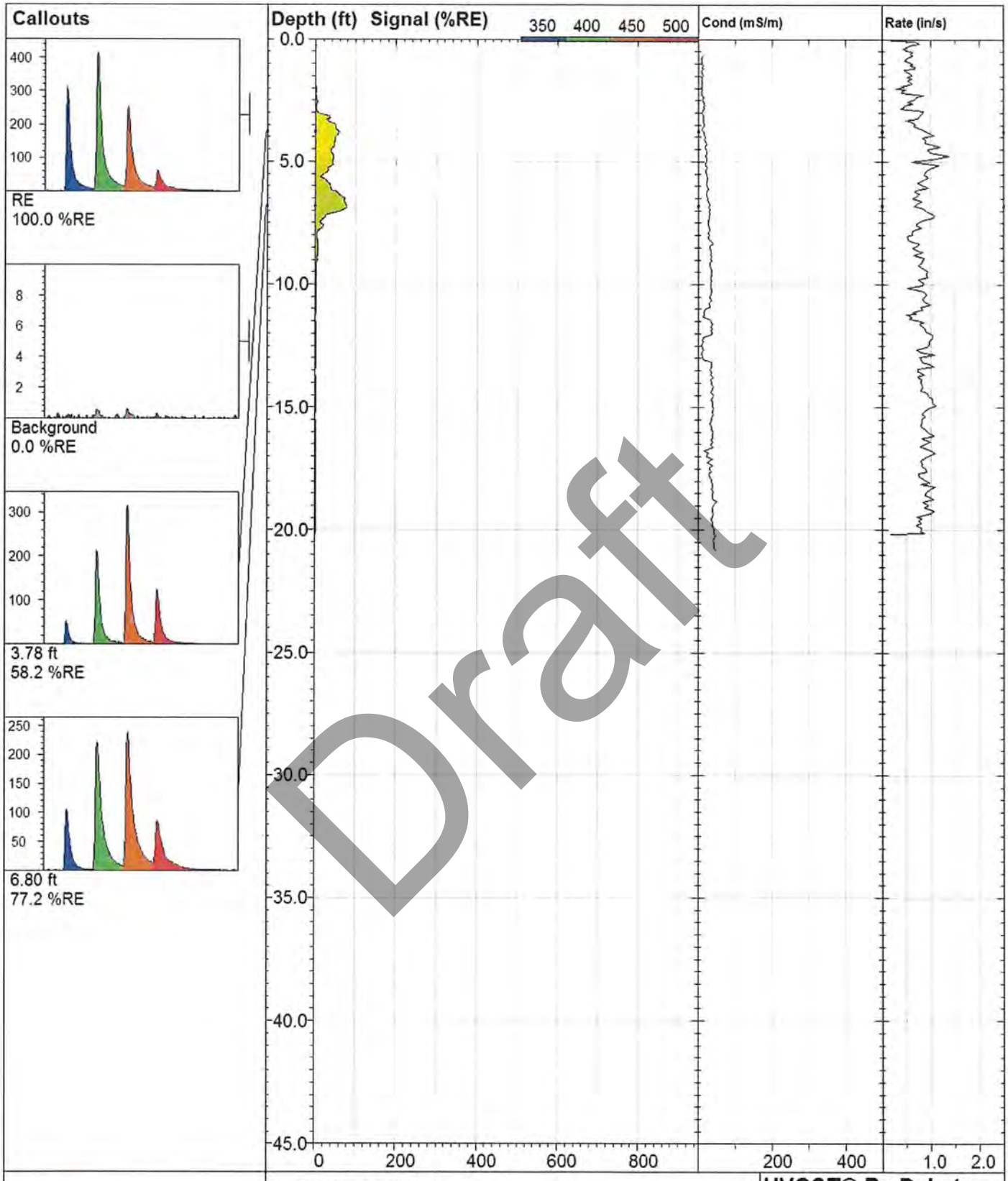
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **90.6 %RE @ 6.30 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 13:12 CST**



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LIF-2015-36

UVOST® By Dakota
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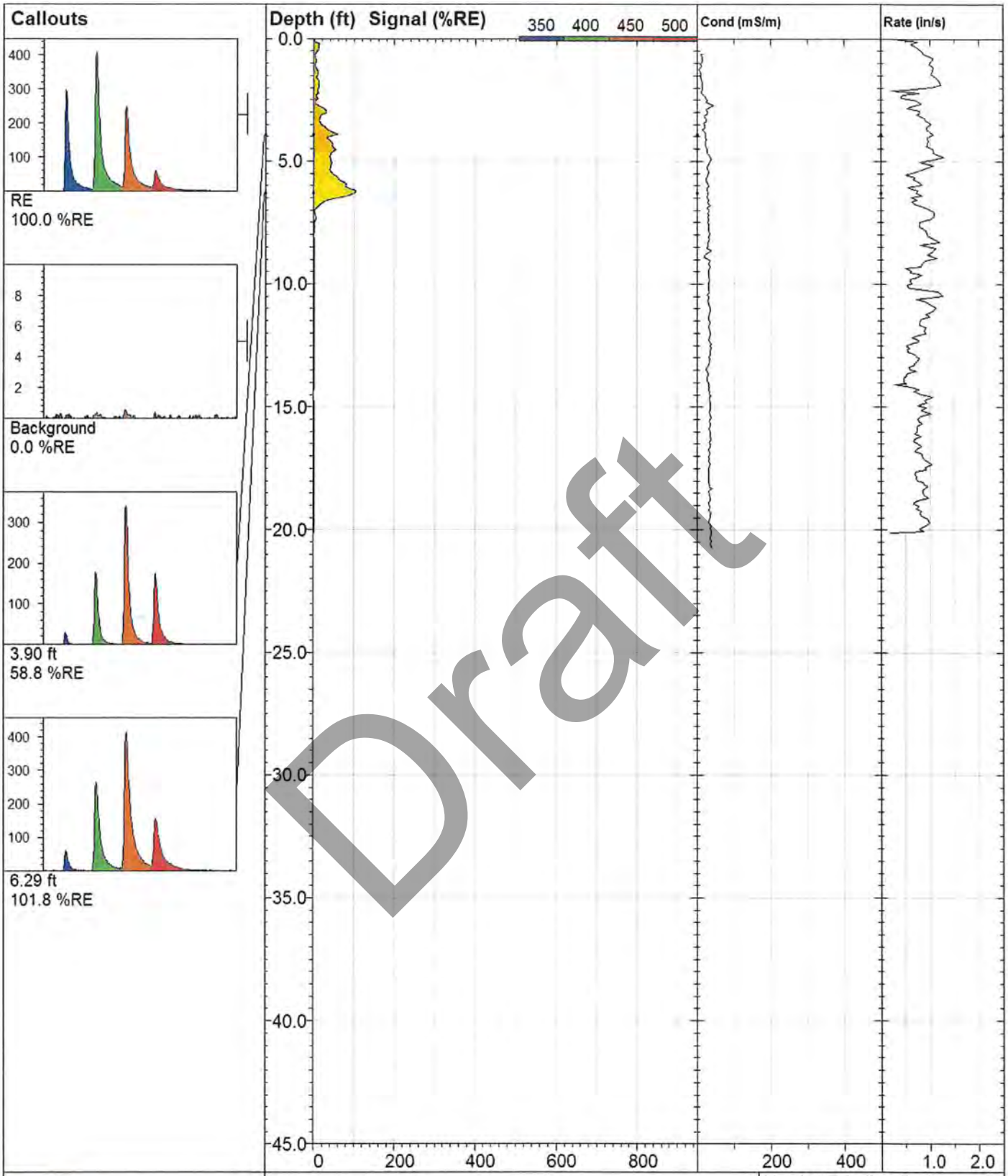
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.16 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **77.2 %RE @ 6.80 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 13:33 CST**



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LIF-2015-37

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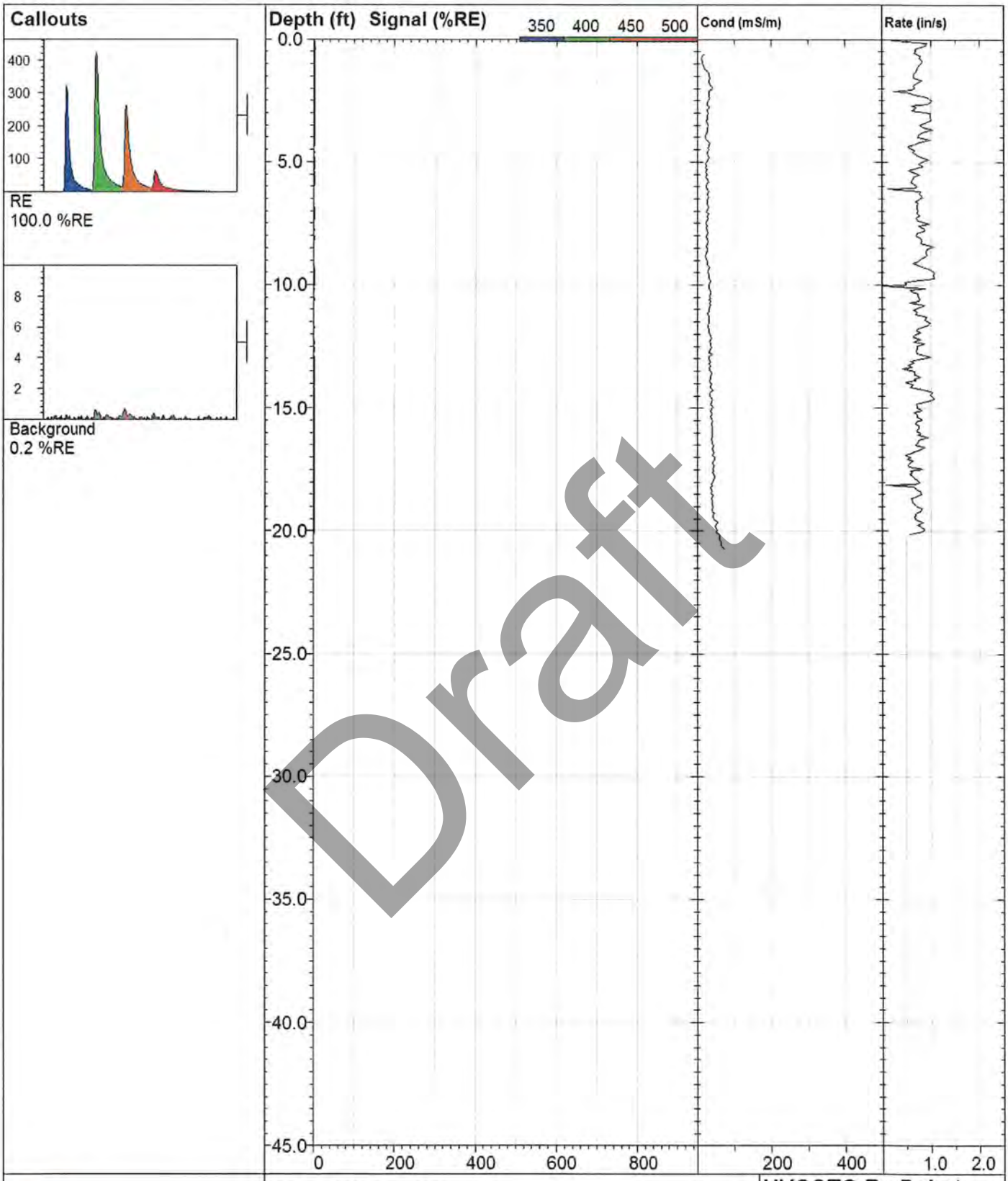
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.13 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **103.8 %RE @ 6.20 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 14:12 CST**



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LIF-2015-38

UVOST® By Dakota
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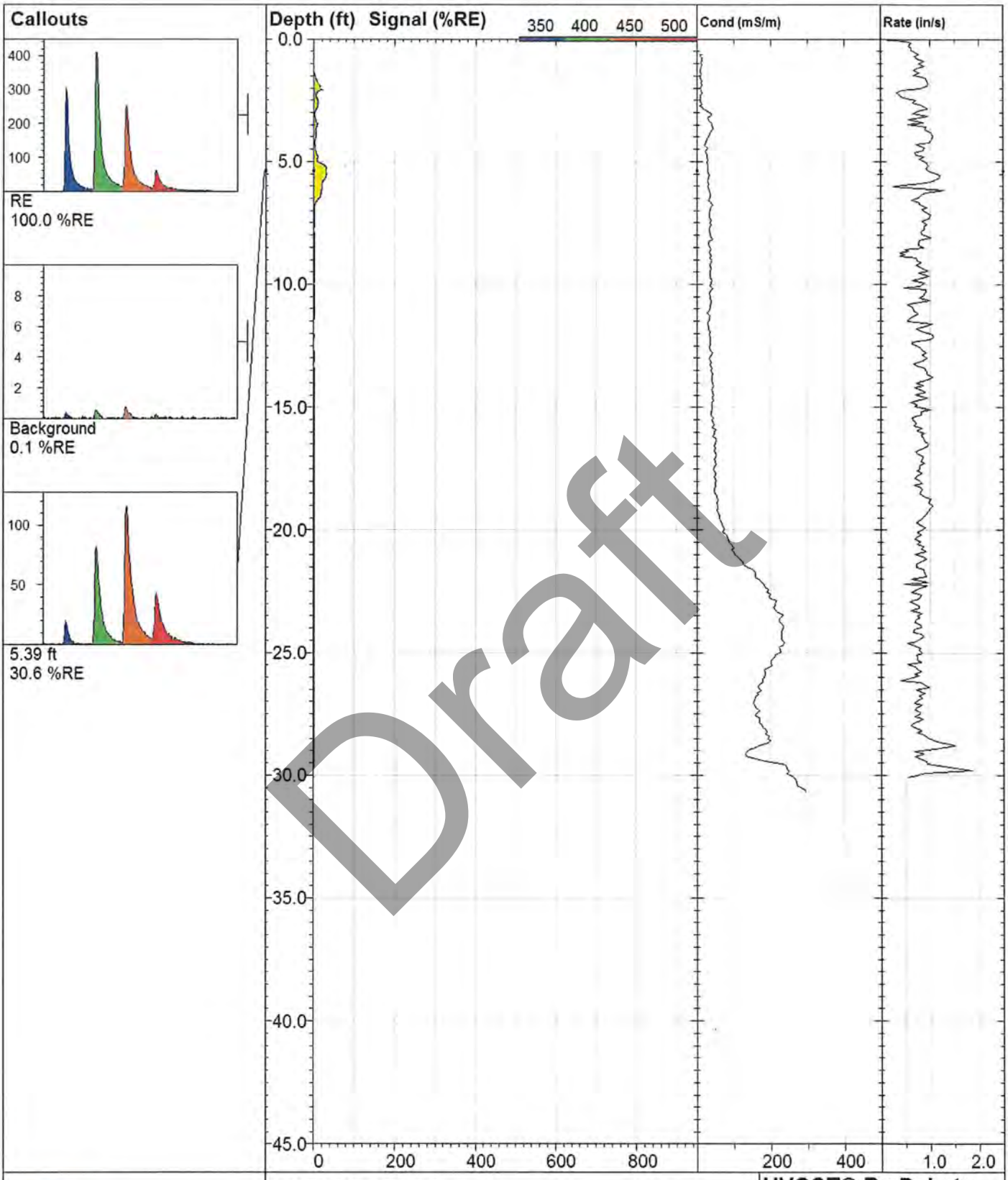
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.0 %RE @ 0.38 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 14:34 CST**



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LIF-2015-39

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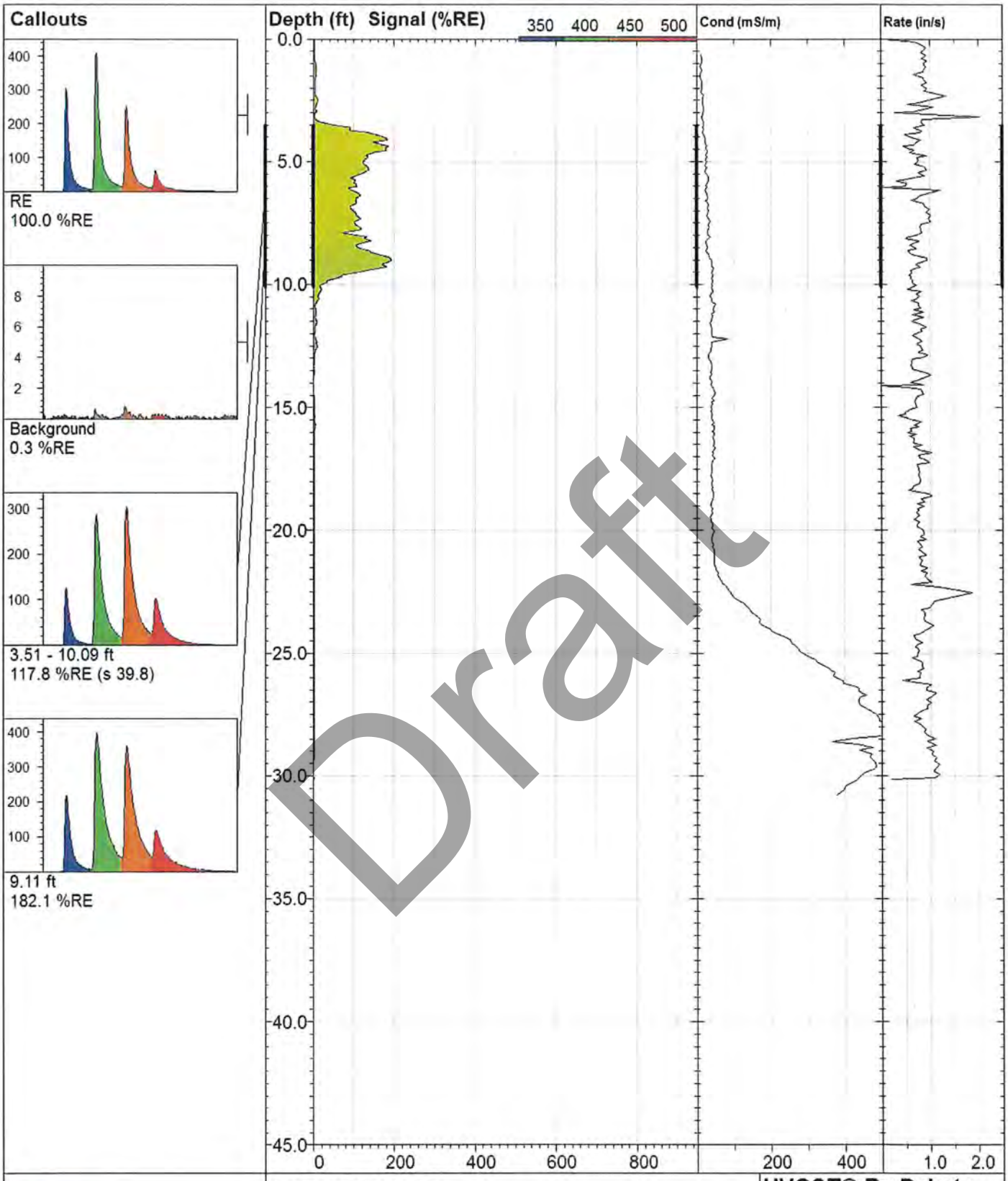
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.08 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **31.5 %RE @ 5.55 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 15:06 CST**



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LIF-2015-40

UVOST® By Dakota
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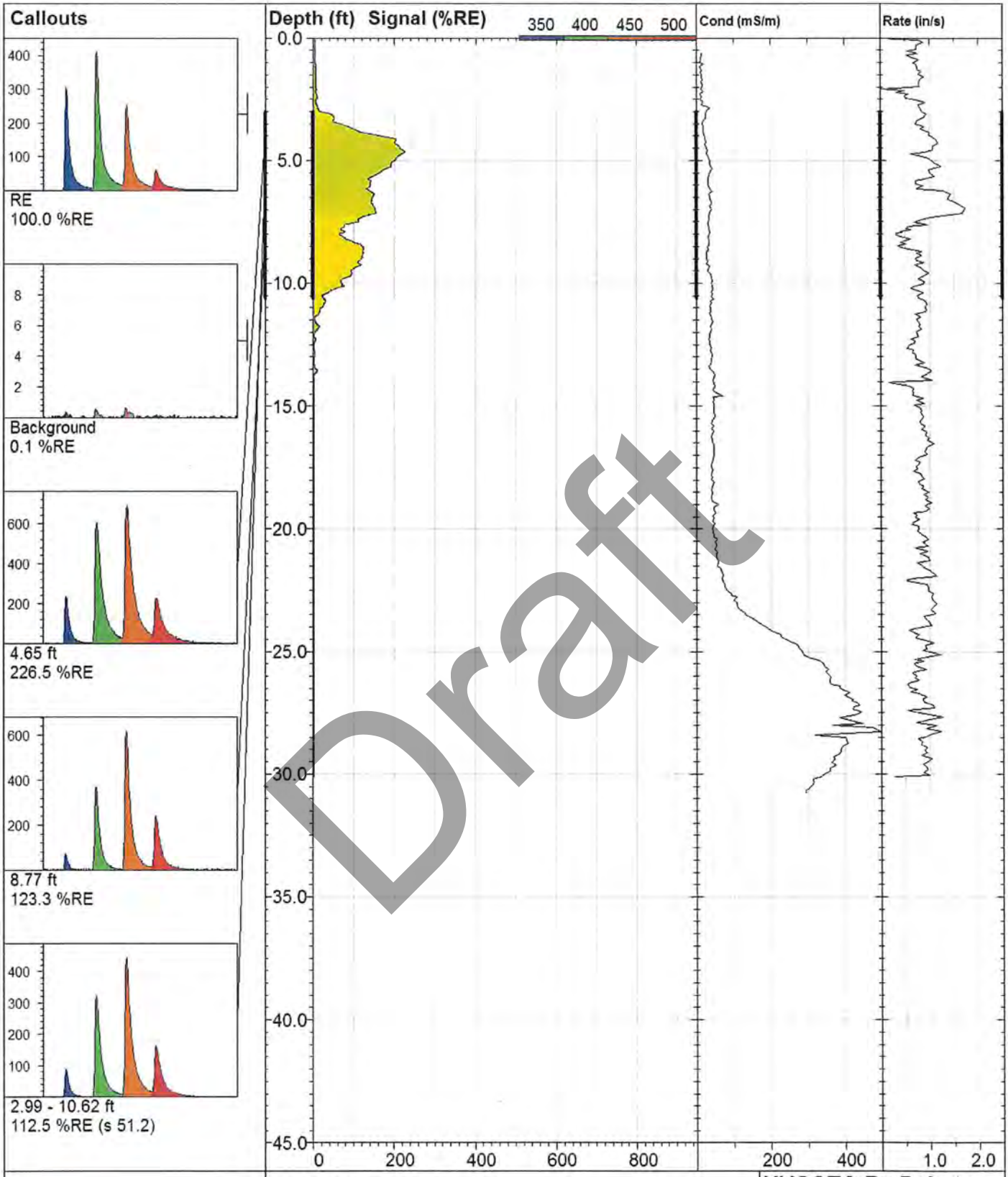
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.15 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **194.3 %RE @ 9.00 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 15:35 CST**



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LIF-2015-41

UVOST® By Dakota
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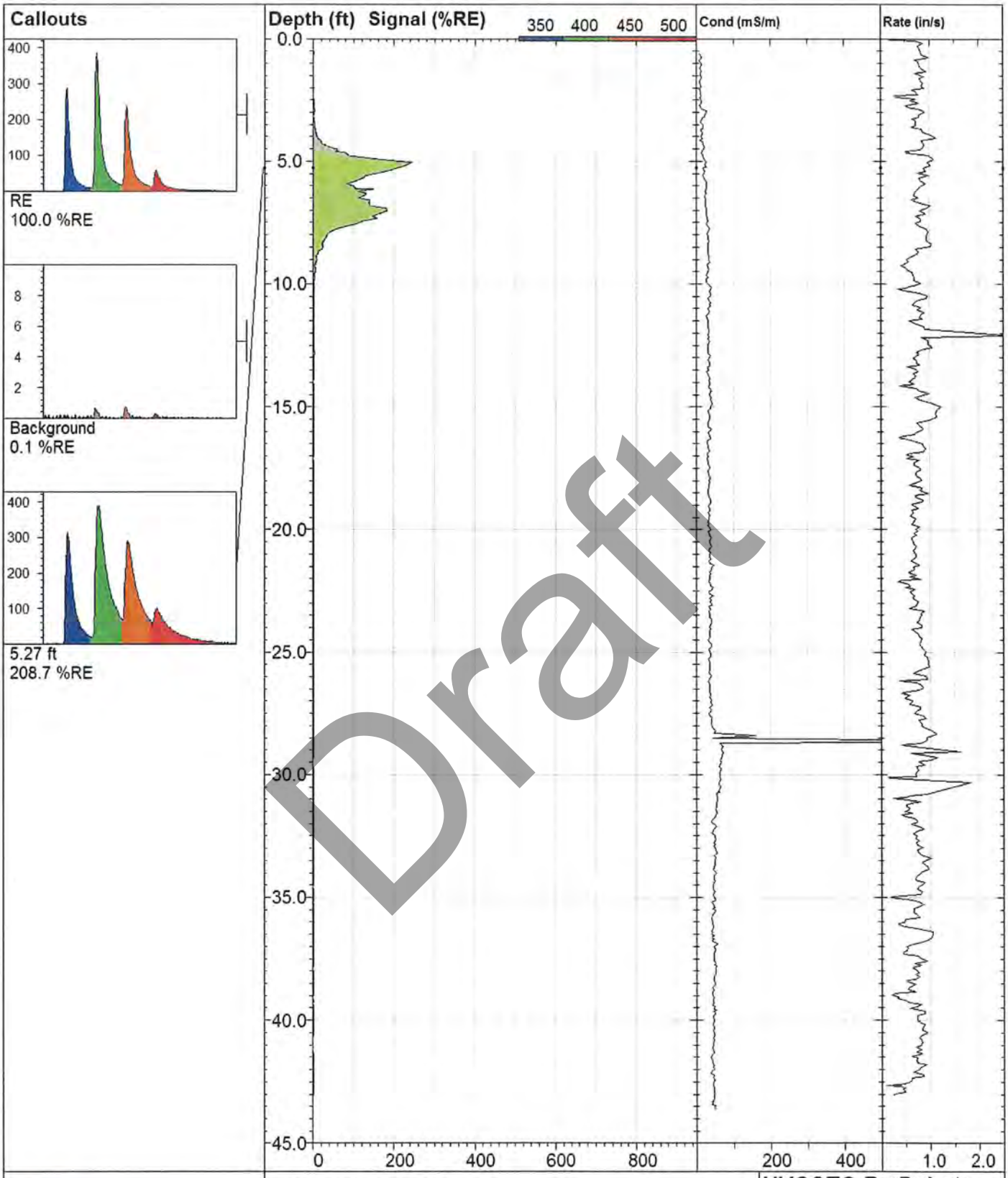
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **226.5 %RE @ 4.65 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 16:04 CST**



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LIF-2015-42

UVOST® By Dakota
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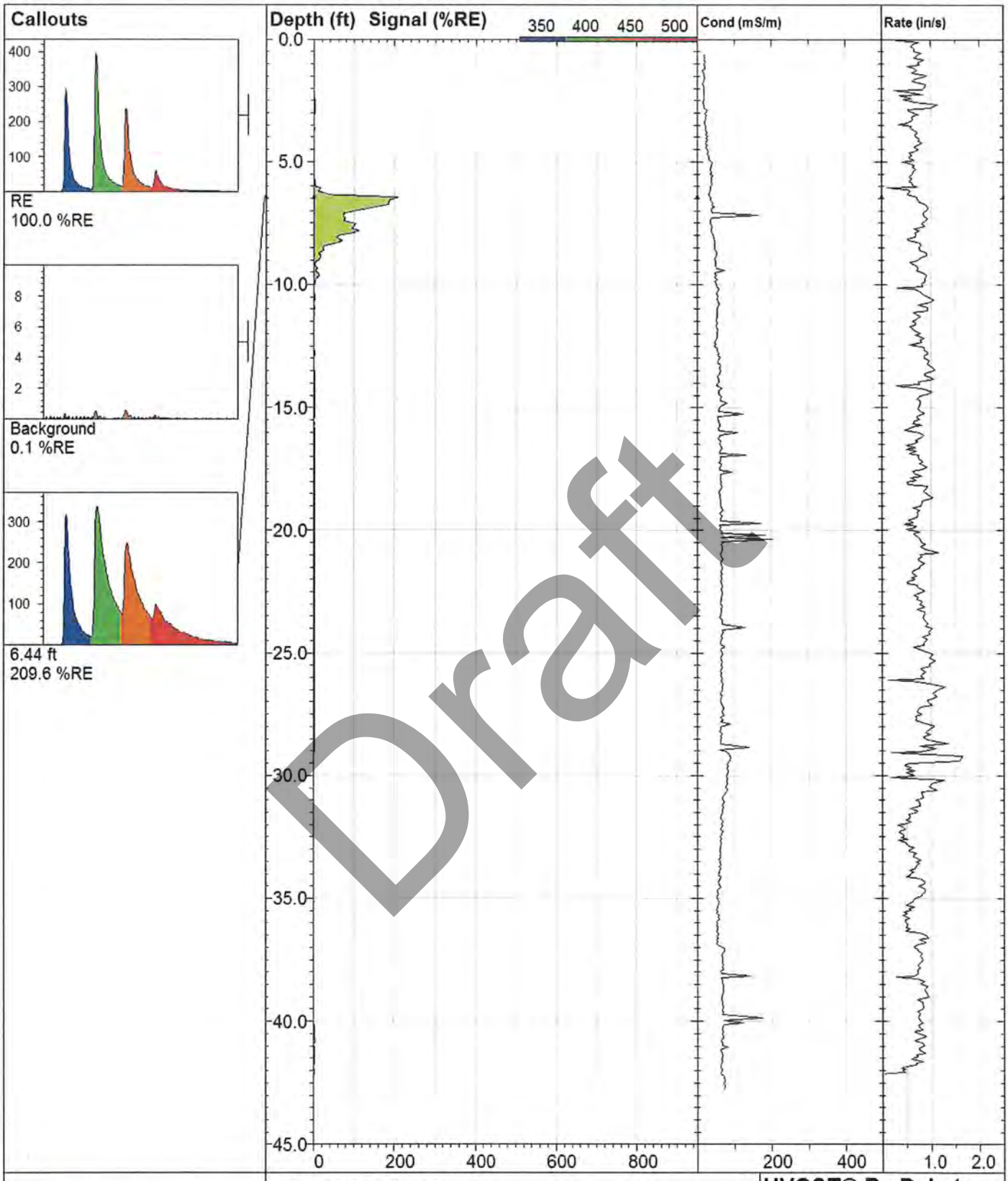
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **43.02 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **243.3 %RE @ 5.06 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 08:15 CST**



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LIF-2015-43

UVOST® By Dakota
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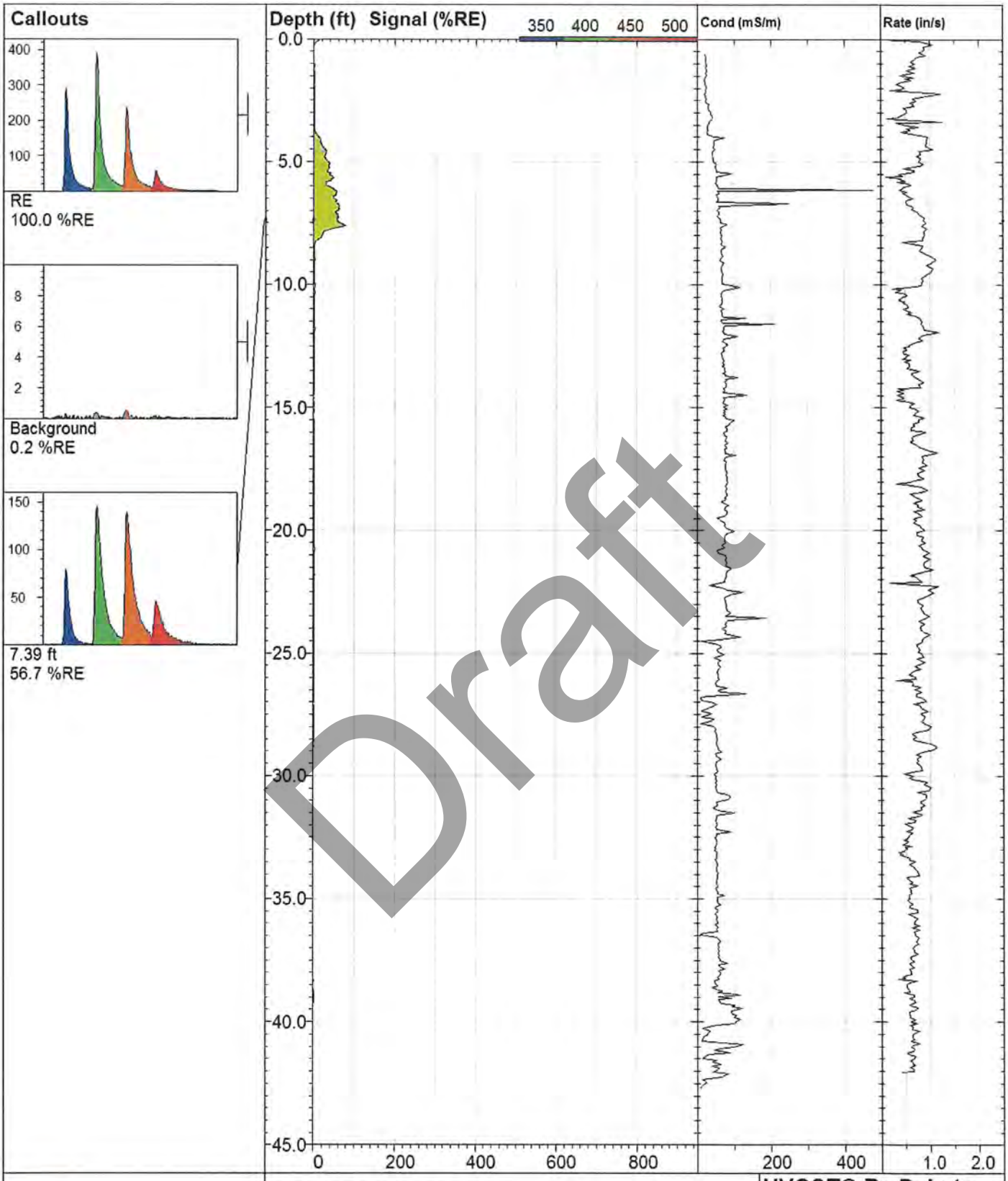
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **42.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **209.6 %RE @ 6.44 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 09:14 CST**



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LIF-2015-44

UVOST® By Dakota
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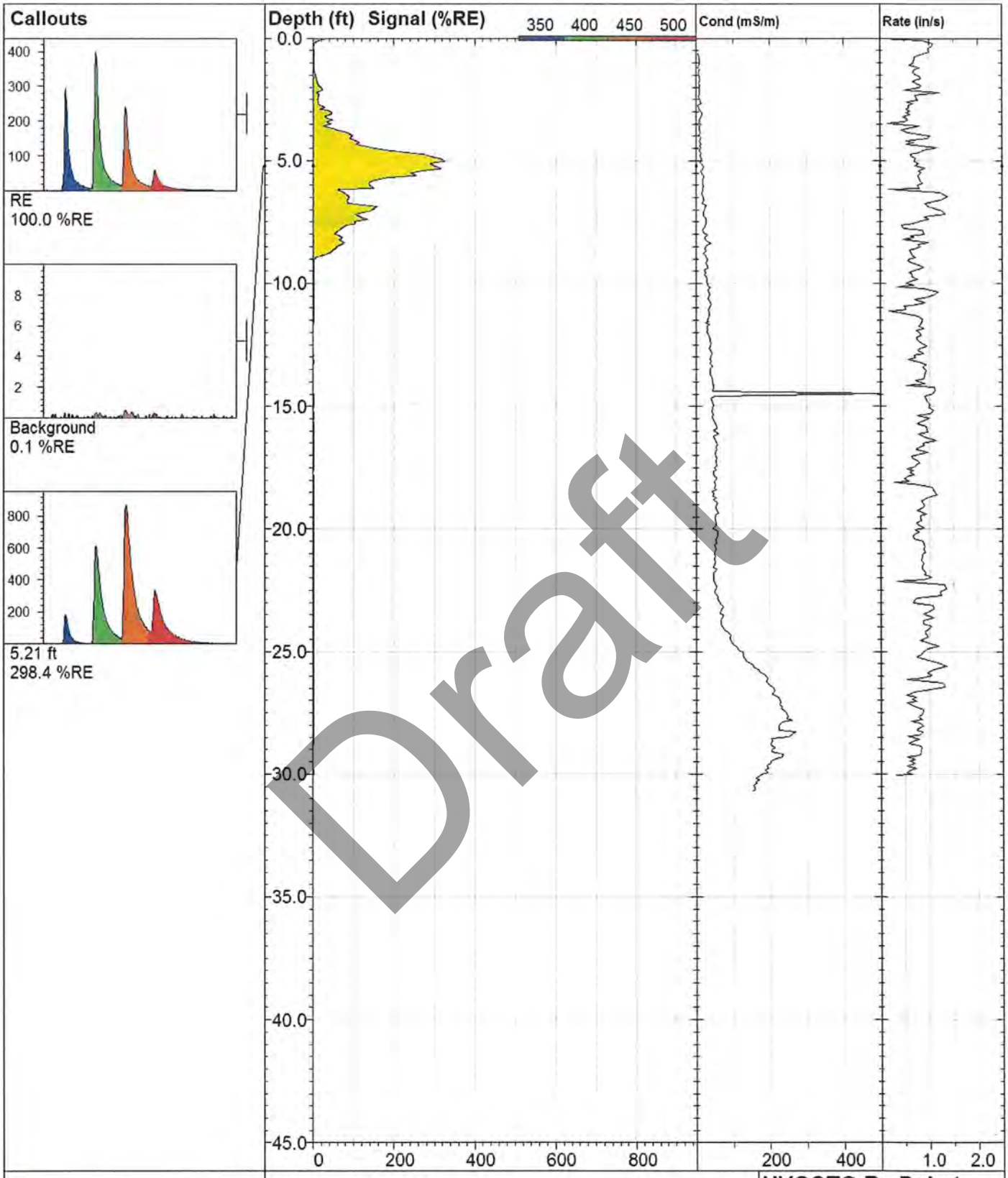
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **42.05 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **79.2 %RE @ 7.62 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 09:56 CST**



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LIF-2015-45

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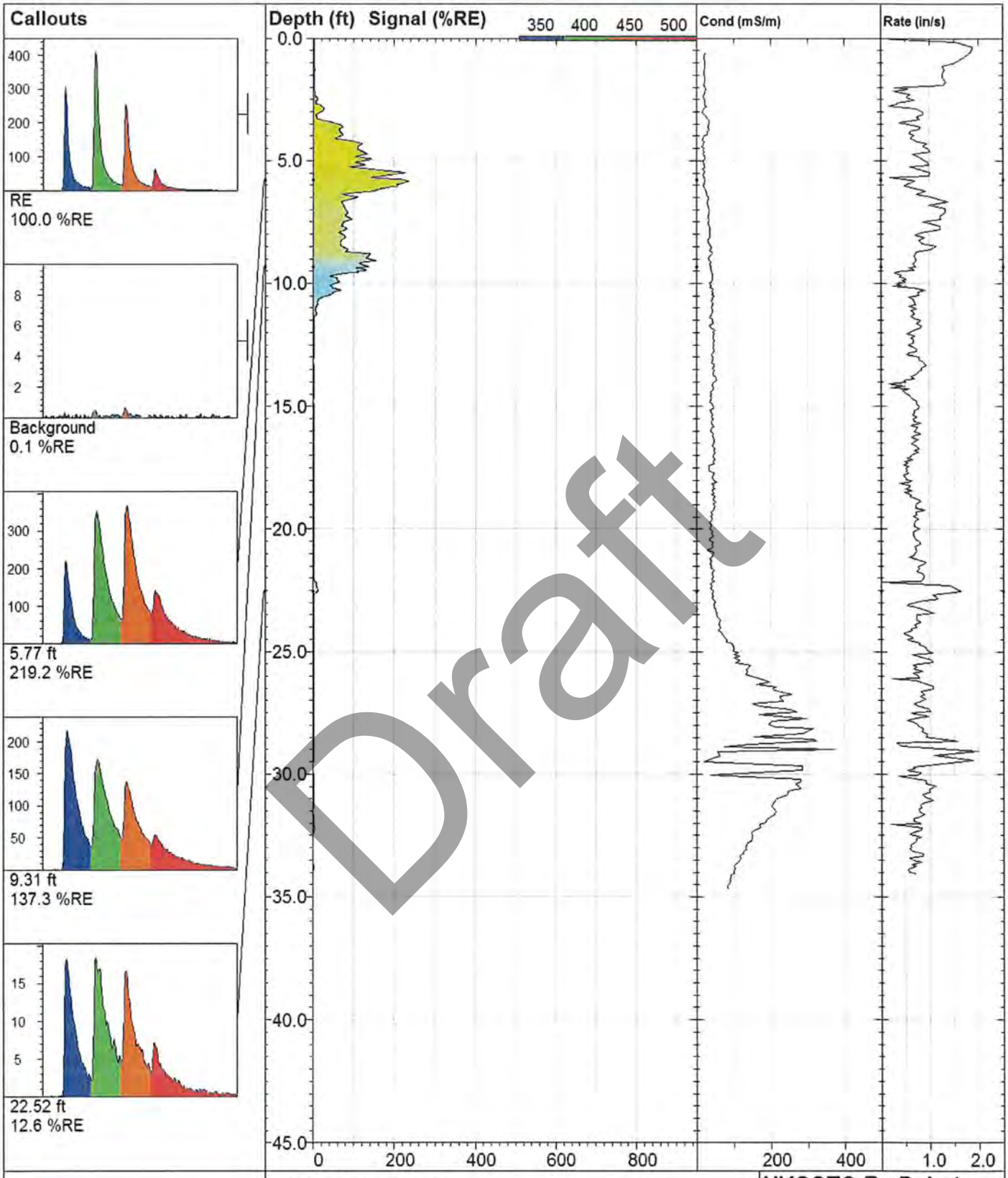
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.07 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **325.7 %RE @ 5.02 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 11:17 CST**



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LIF-2015-46

UVOST® By Dakota
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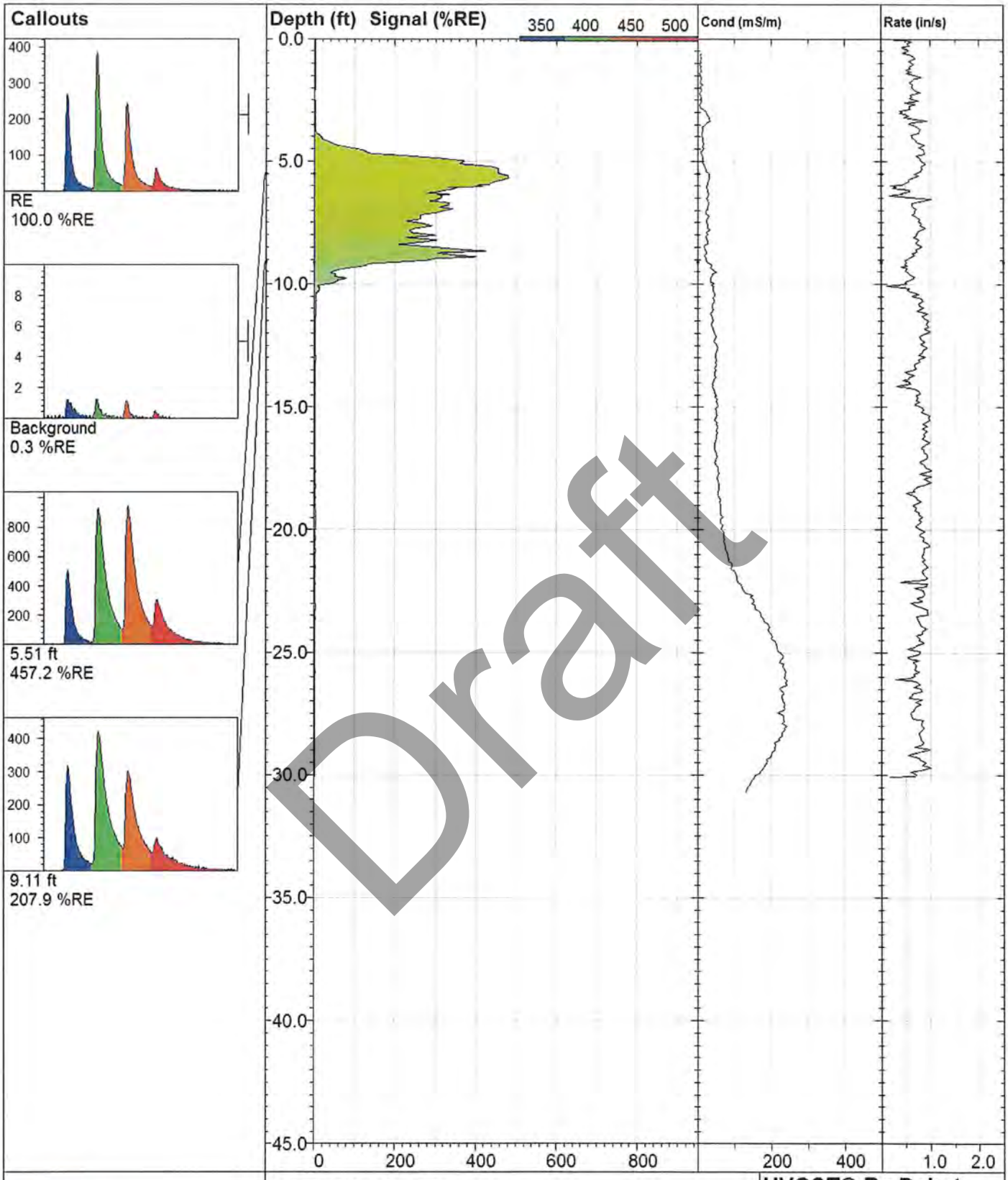
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **34.07 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **234.8 %RE @ 5.84 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 11:50 CST**



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LIF-2015-47

UVOST® By Dakota
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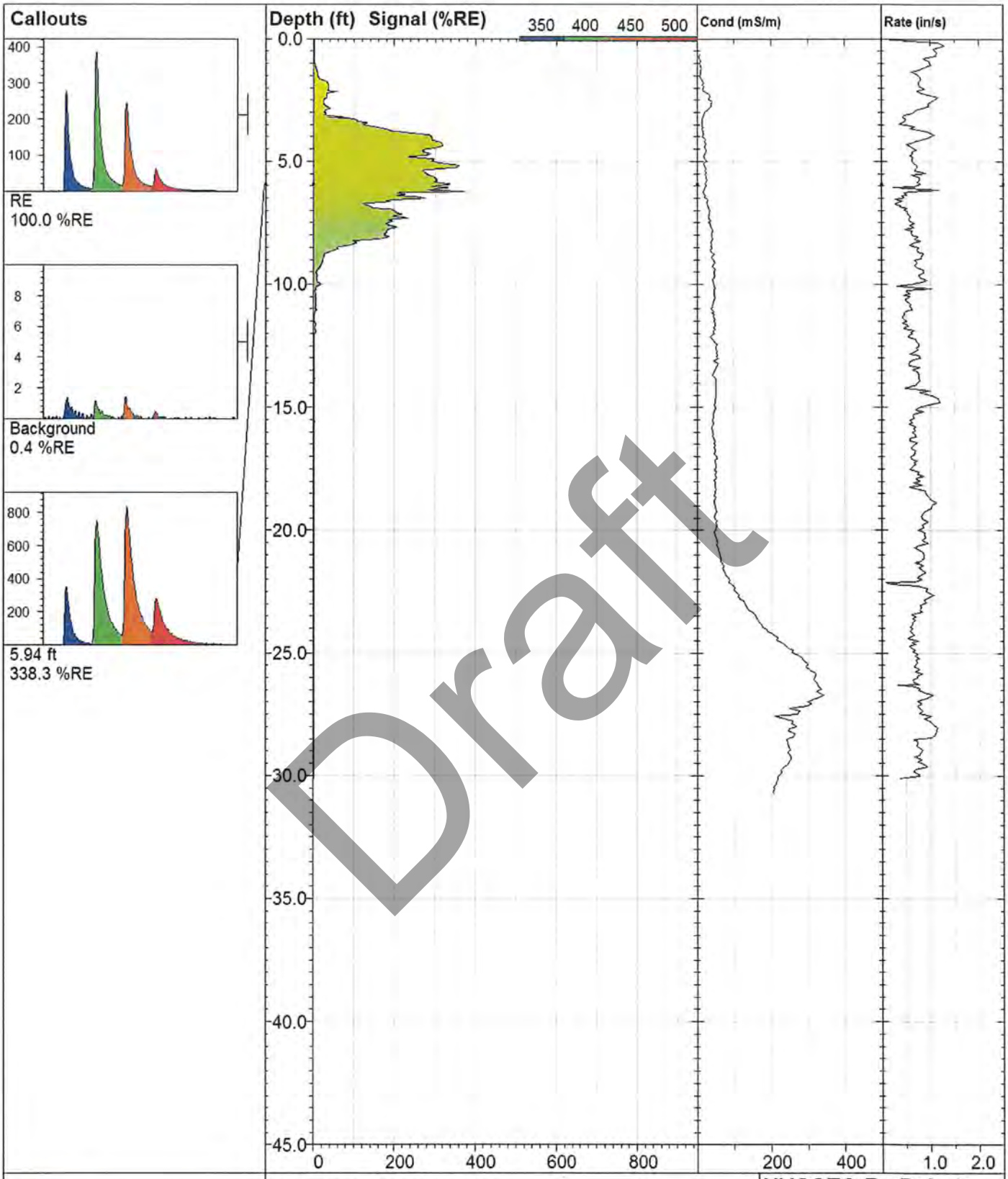
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.08 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **481.4 %RE @ 5.69 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 14:00 CST**



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LIF-2015-48

UVOST® By Dakota
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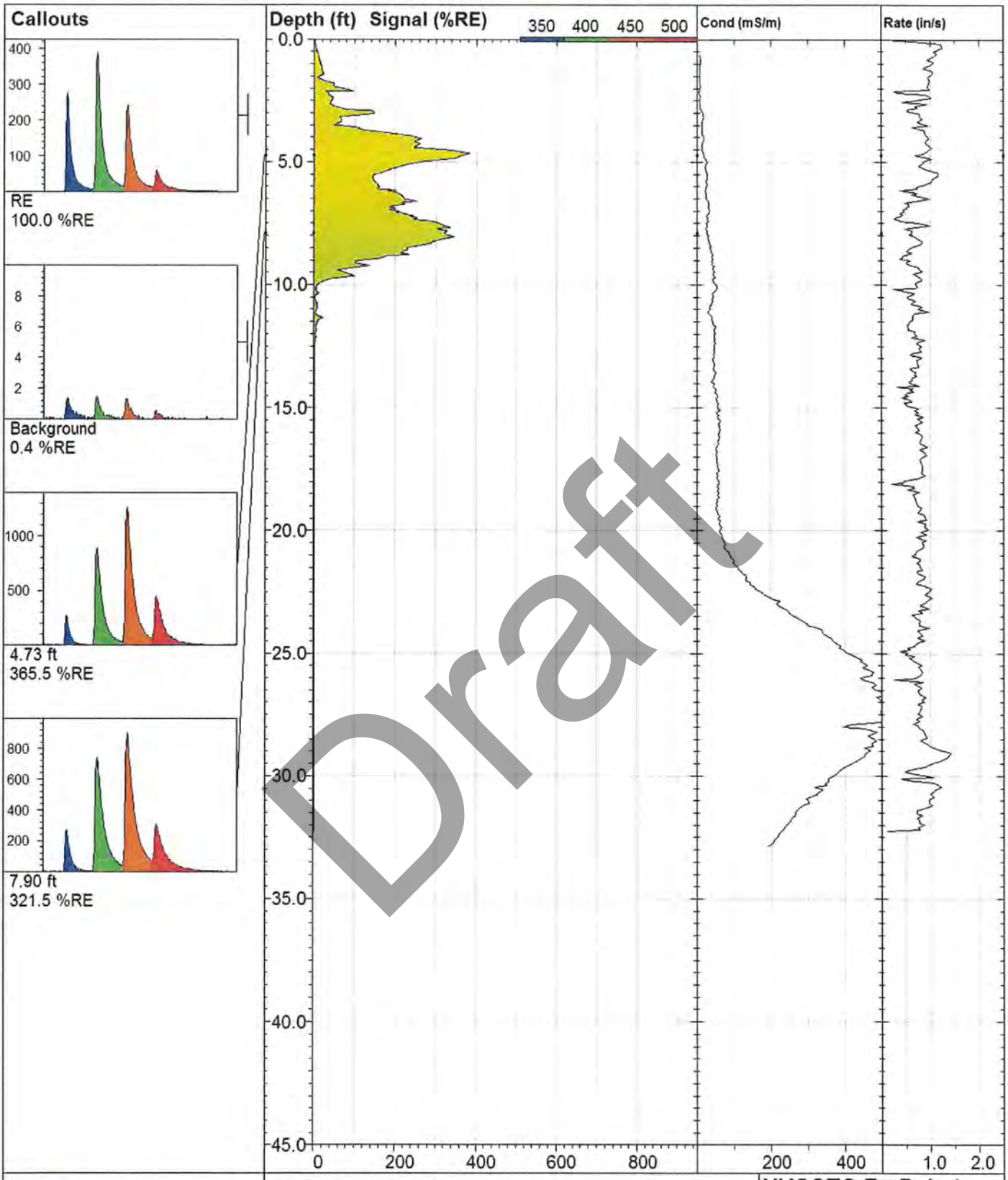
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.10 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **377.1 %RE @ 6.24 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 14:32 CST**



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LIF-2015-49

UVOST® By Dakota
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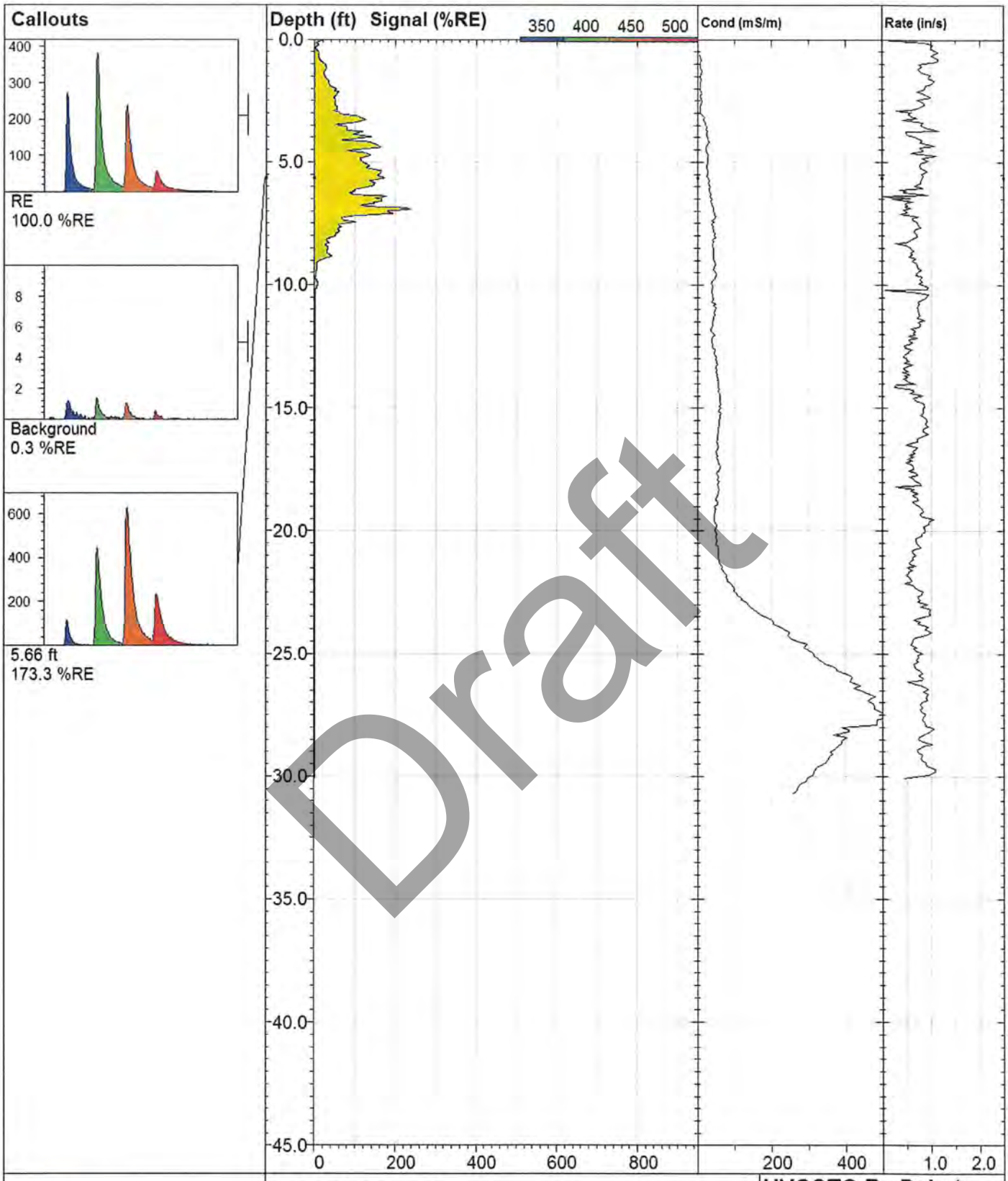
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **32.24 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **383.1 %RE @ 4.65 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 14:59 CST**



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LIF-2015-50

UVOST® By Dakota
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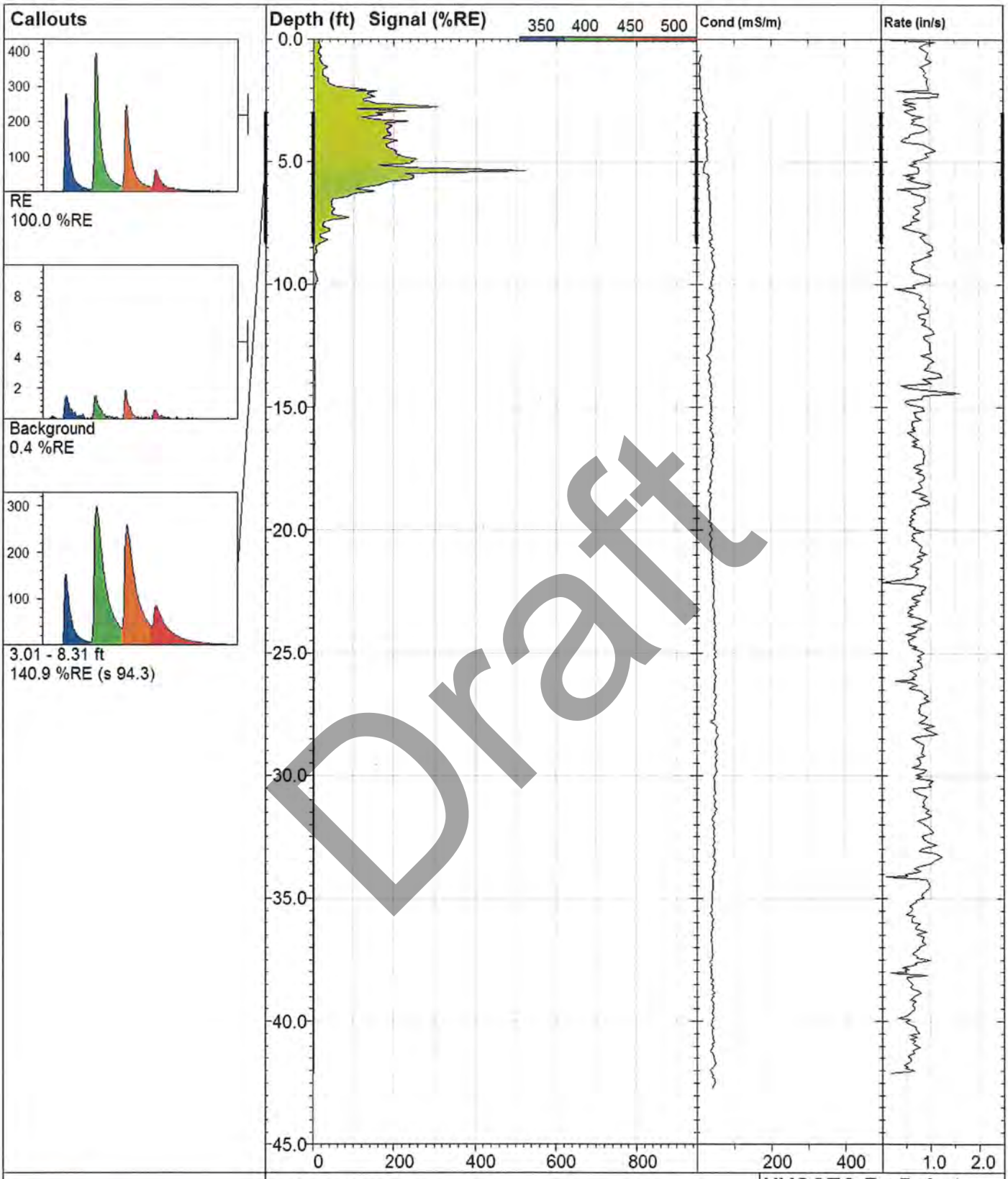
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.08 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **235.3 %RE @ 6.93 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 15:29 CST**



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LIF-2015-51

UVOST® By Dakota
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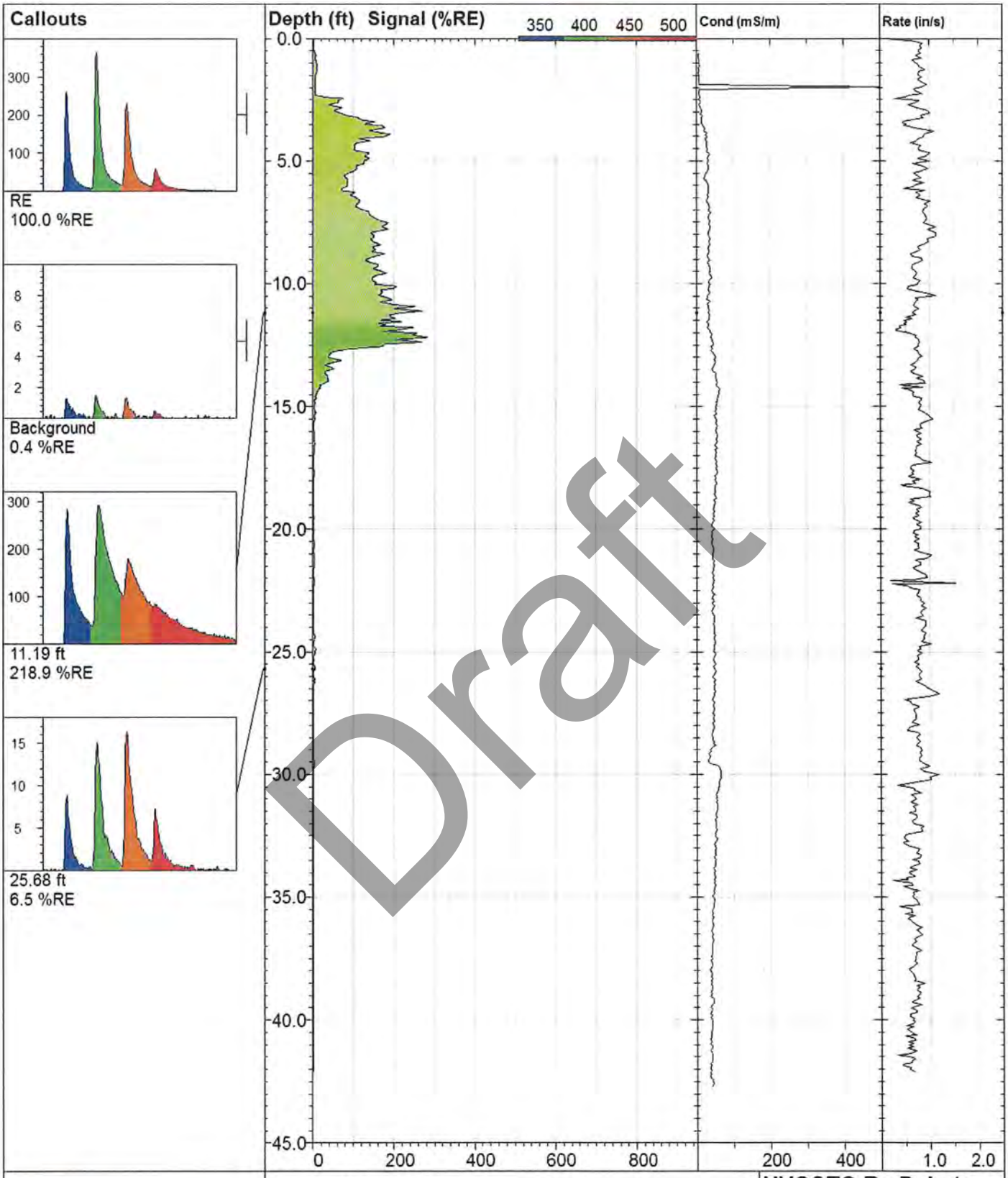
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **42.10 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **531.9 %RE @ 5.38 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 16:13 CST**



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LIF-2015-52

UVOST® By Dakota
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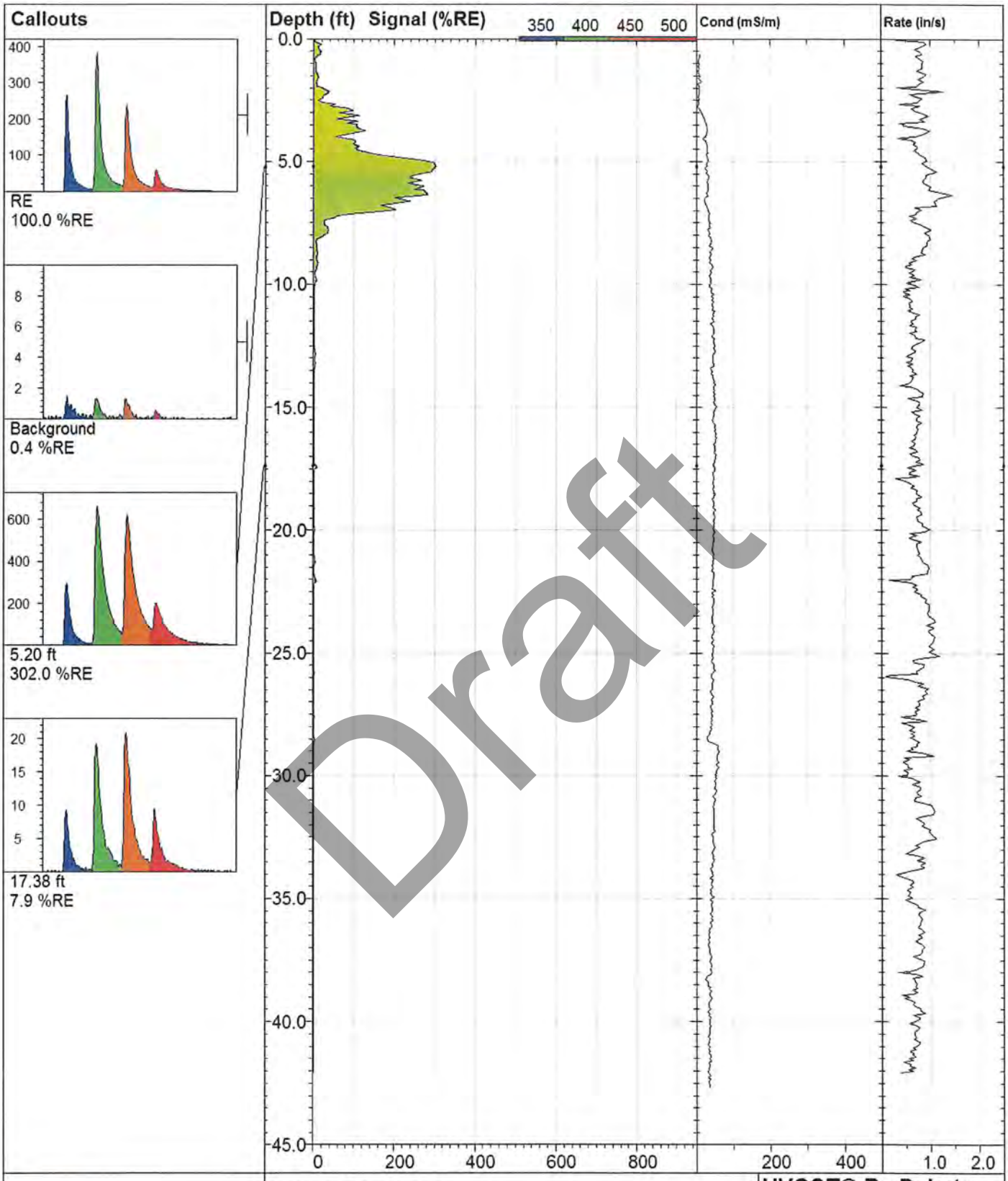
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **42.09 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **283.6 %RE @ 12.19 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 07:50 CST**



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LIF-2015-53

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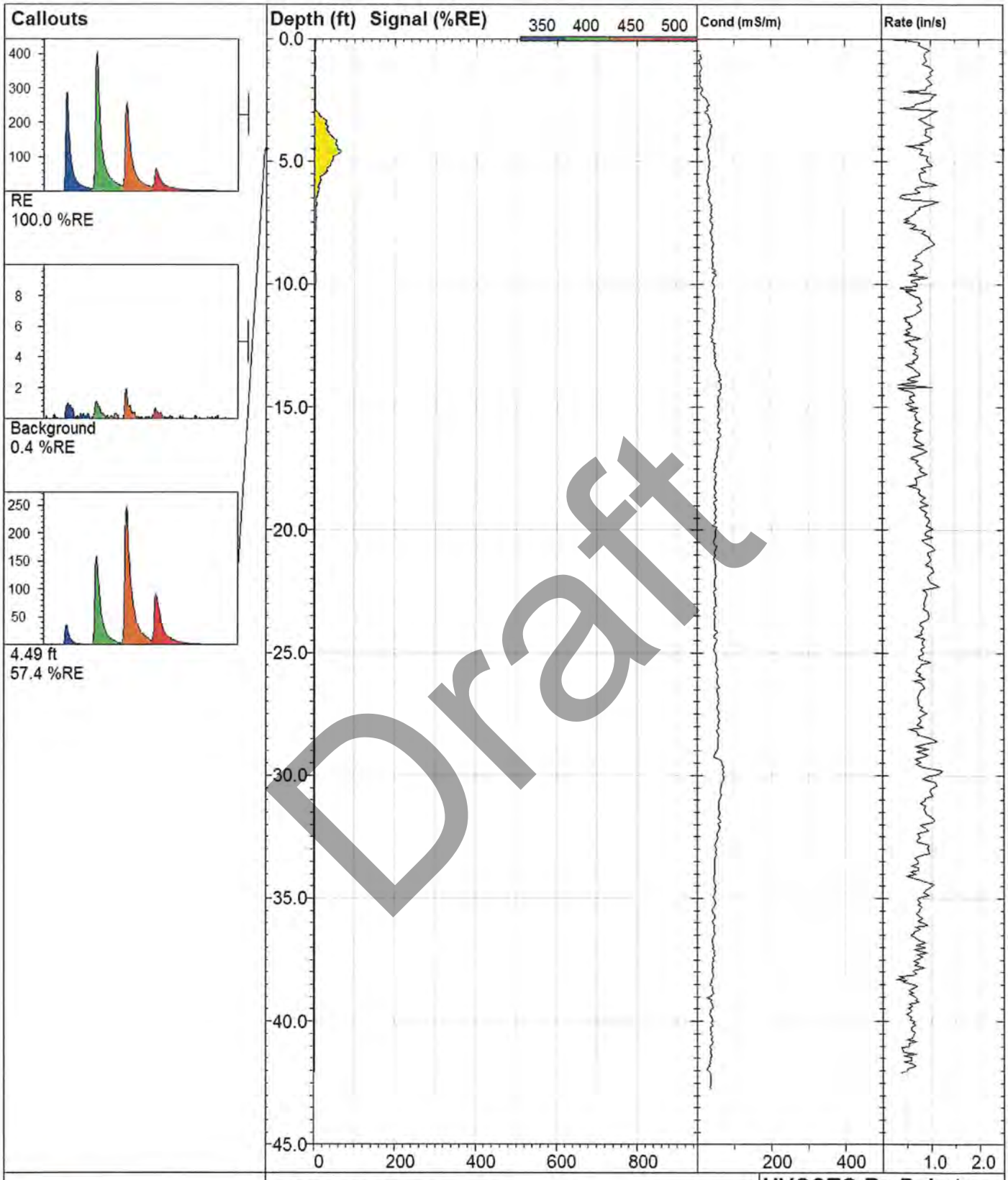
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **42.06 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **302.0 %RE @ 5.20 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 08:29 CST**



Draft

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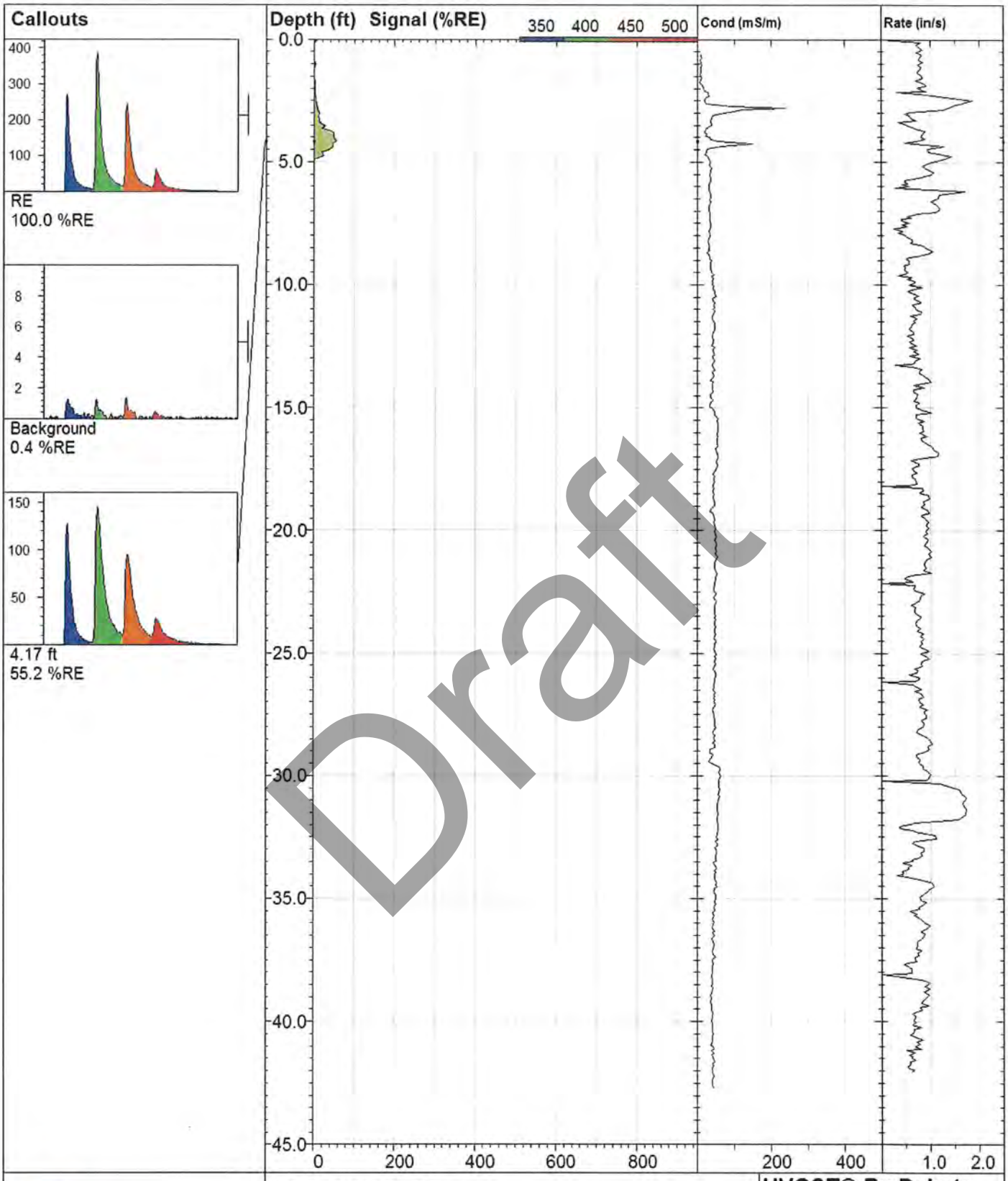
LIF-2015-54

UVOST® By Dakota
www.DakotaTechnologies.com

Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **42.08 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **67.2 %RE @ 4.60 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 09:22 CST**



Draft

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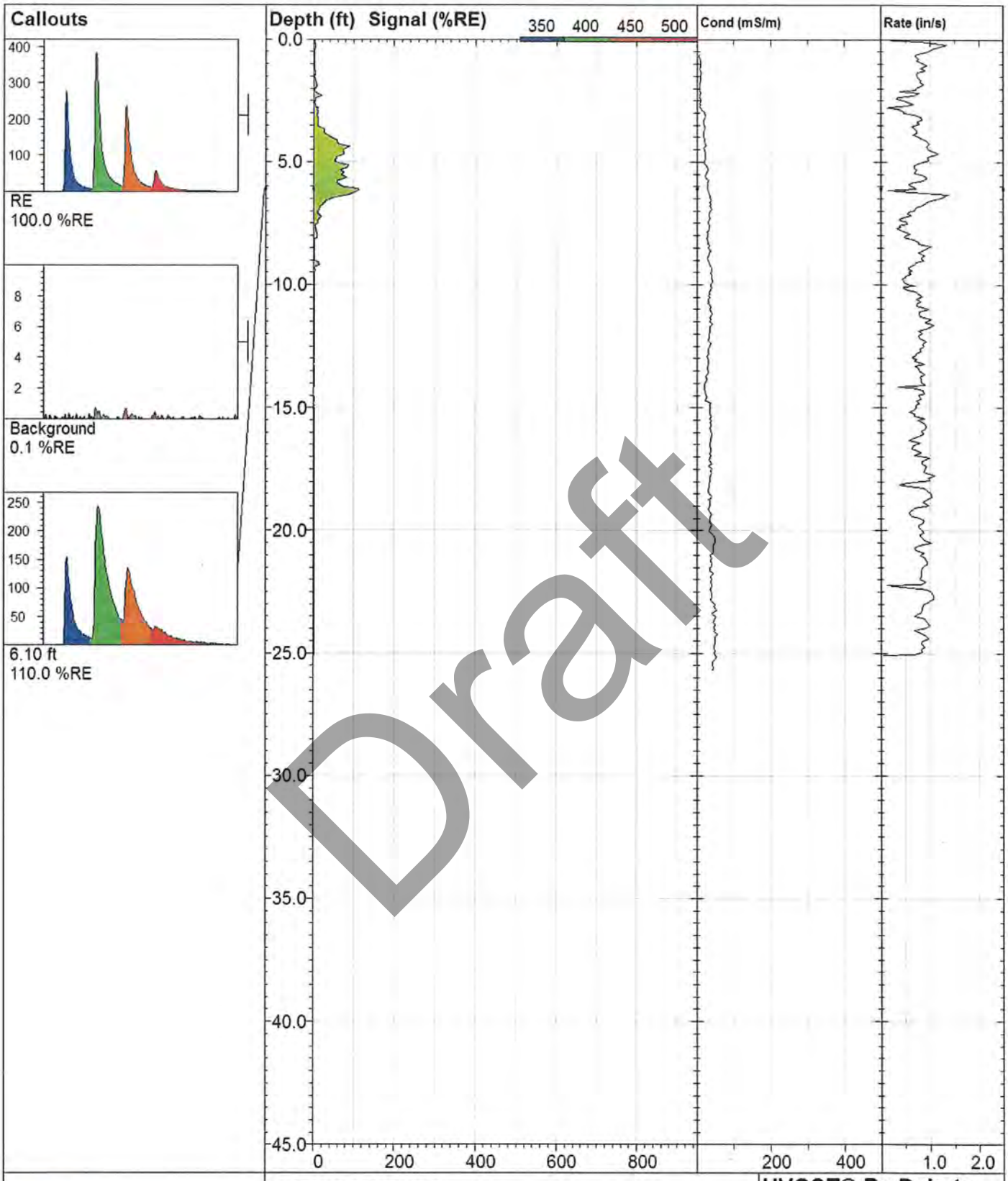
LIF-2015-55

UVOST® By Dakota
www.DakotaTechnologies.com

Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **42.06 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **55.2 %RE @ 4.17 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 10:04 CST**



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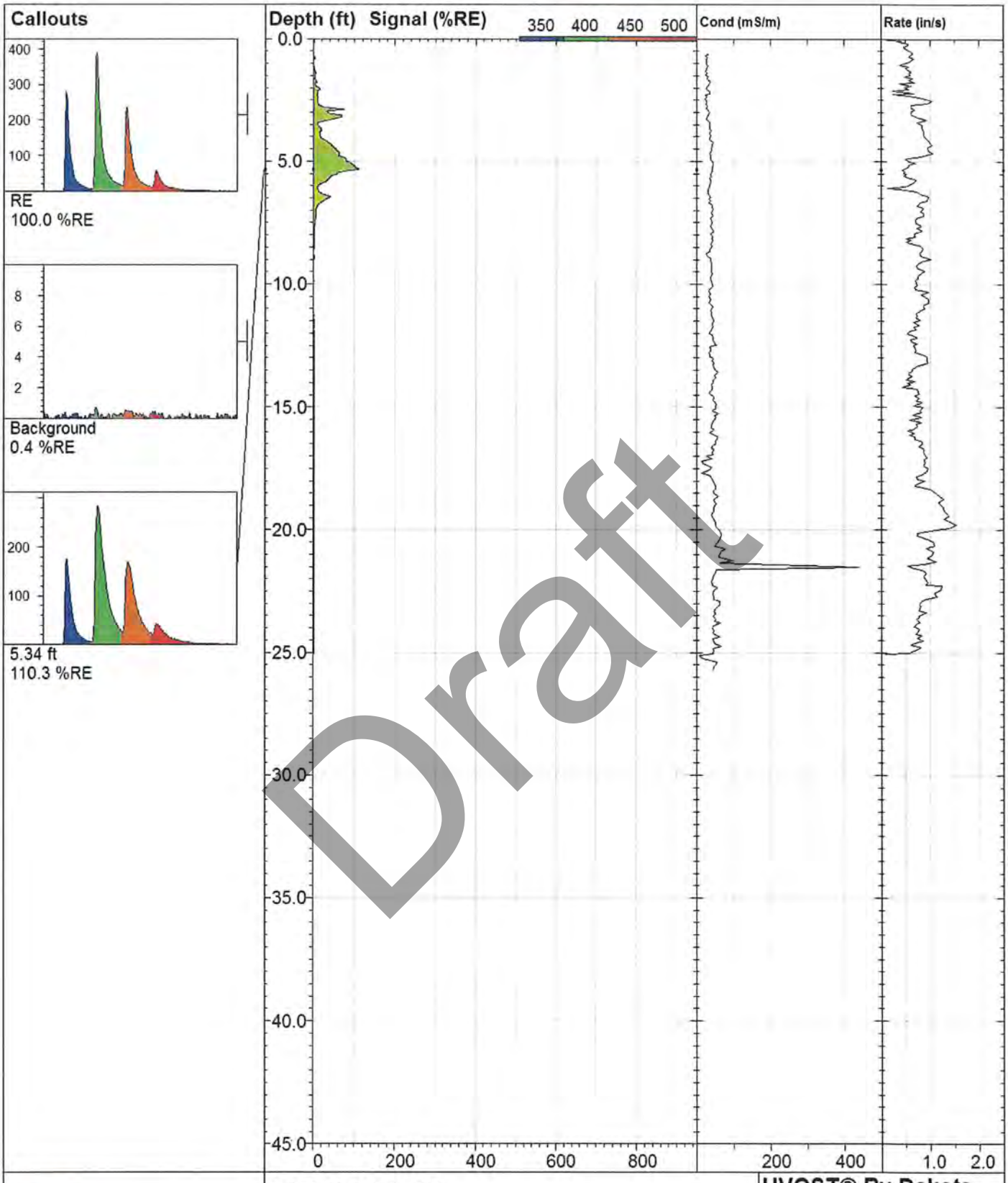
LIF-2015-56

UVOST® By Dakota
www.DakotaTechnologies.com

Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.08 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **112.6 %RE @ 6.15 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 11:24 CST**



Draft

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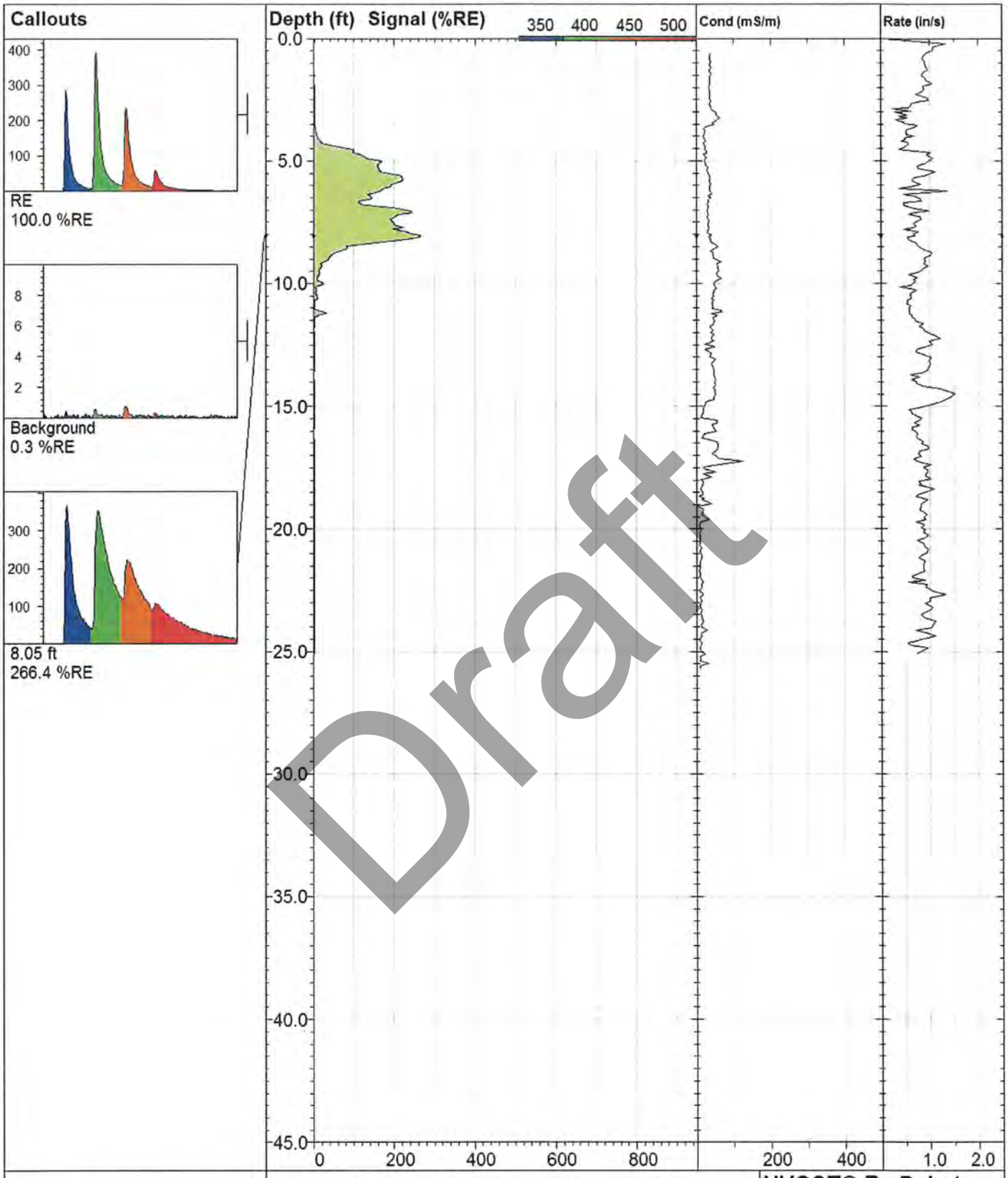
LIF-2015-57

UVOST® By Dakota
www.DakotaTechnologies.com

Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.06 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **110.3 %RE @ 5.34 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 11:47 CST**



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LIF-2015-58

UVOST® By Dakota
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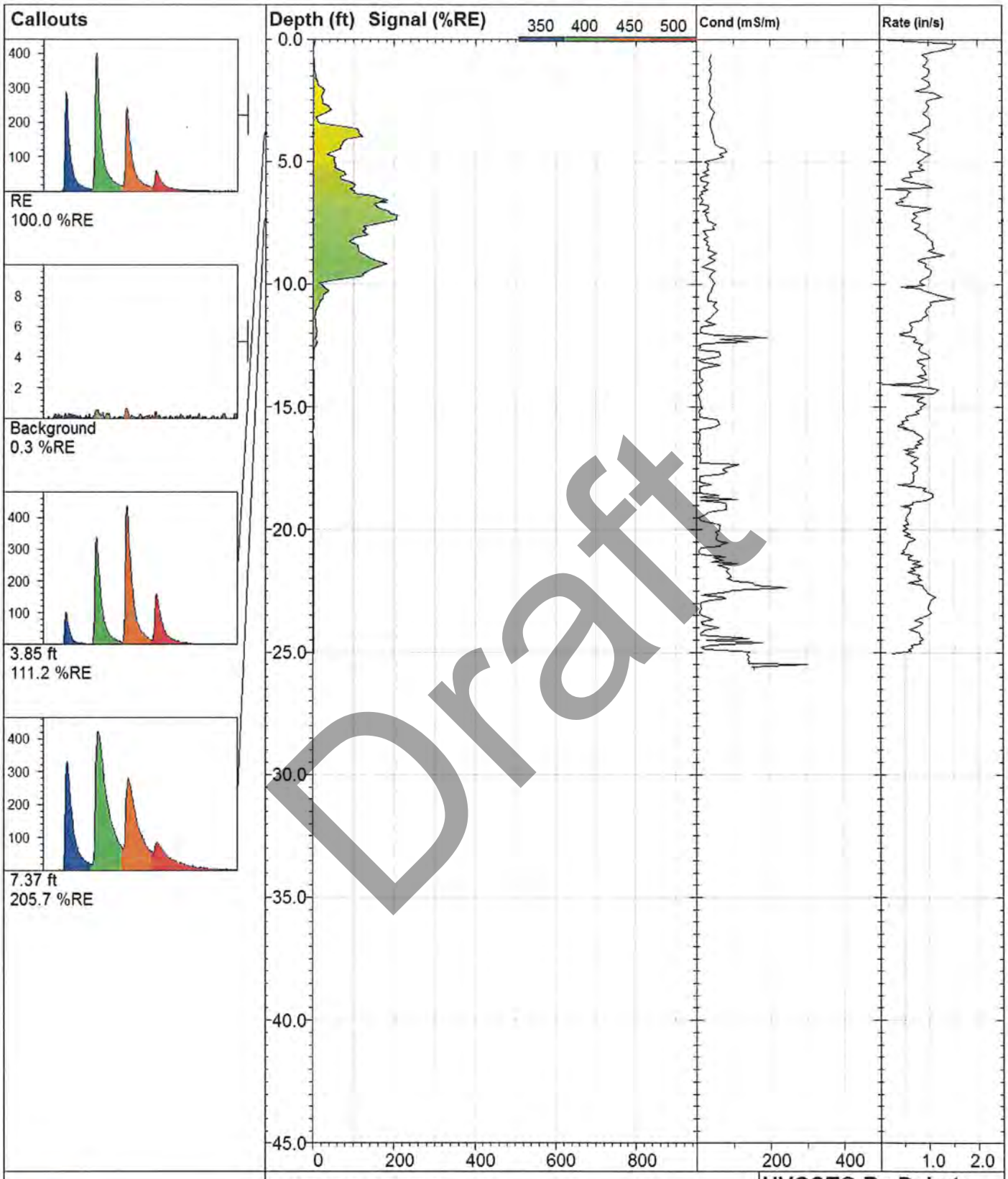
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.10 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **266.4 %RE @ 8.05 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 12:24 CST**



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LIF-2015-59

UVOST® By Dakota
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Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.06 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **209.0 %RE @ 7.20 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 12:55 CST**

UVOST LOGS
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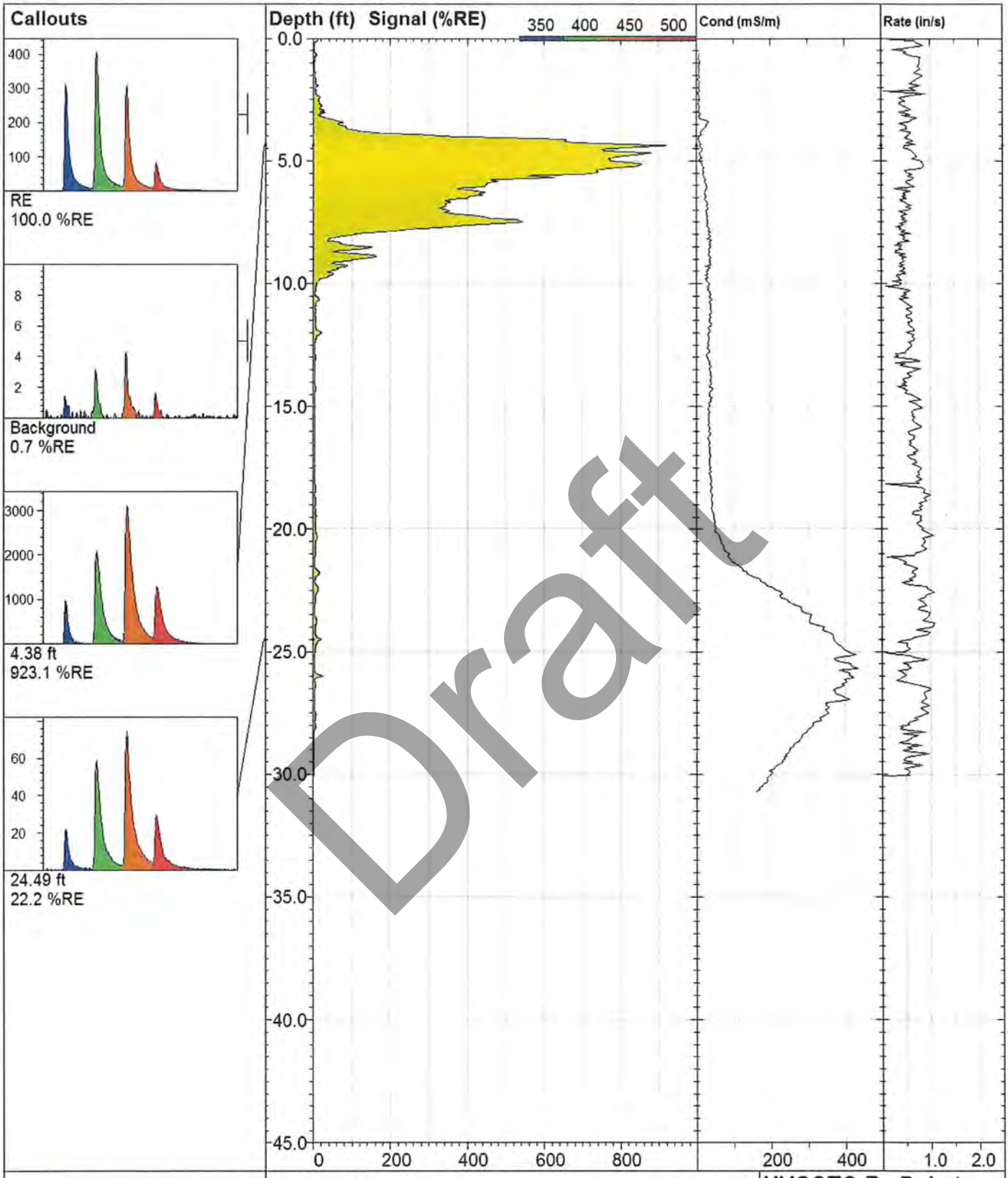

Draft

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LIF-2015-01

UVOST® By Dakota
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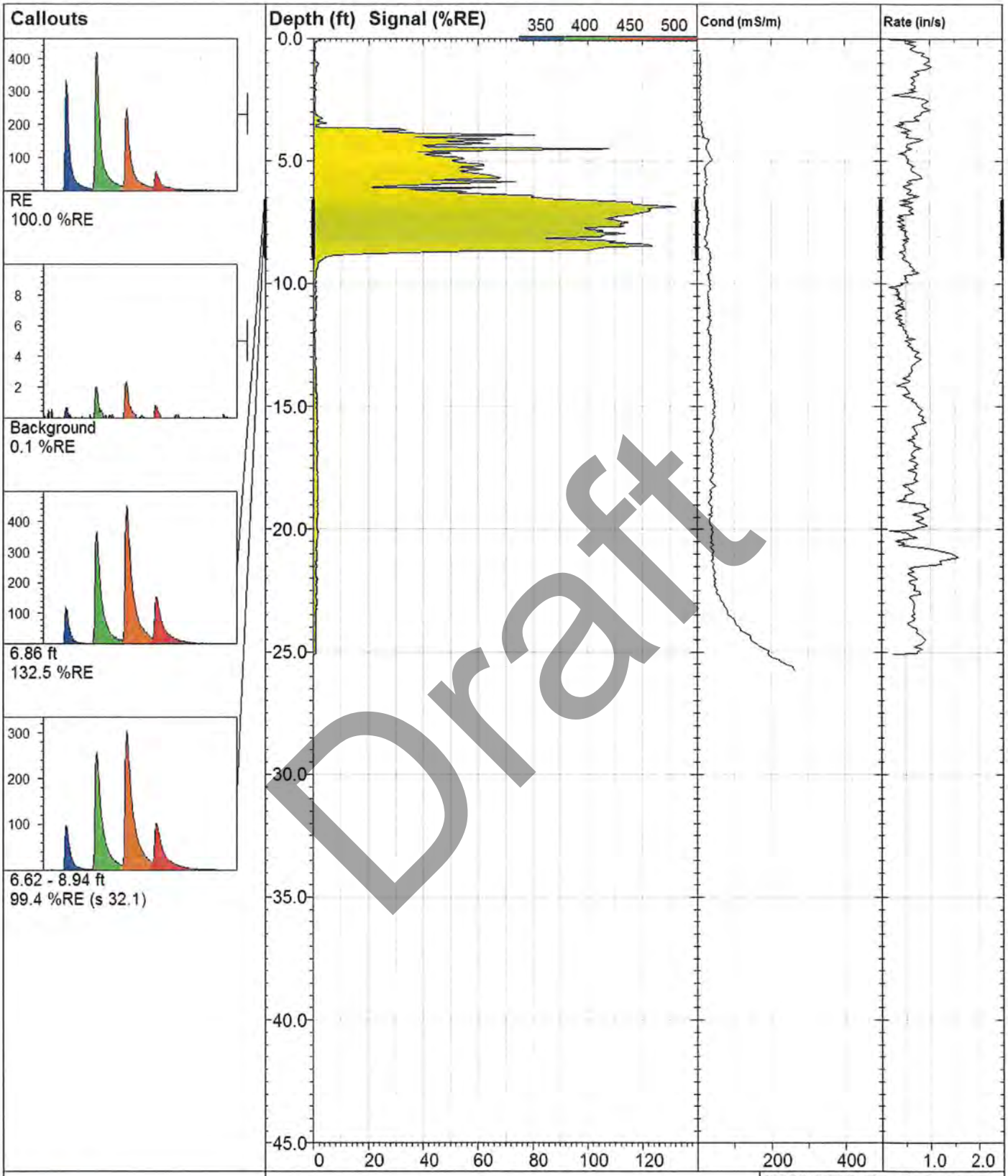
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.09 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **923.1 %RE @ 4.38 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 09:58 CST**



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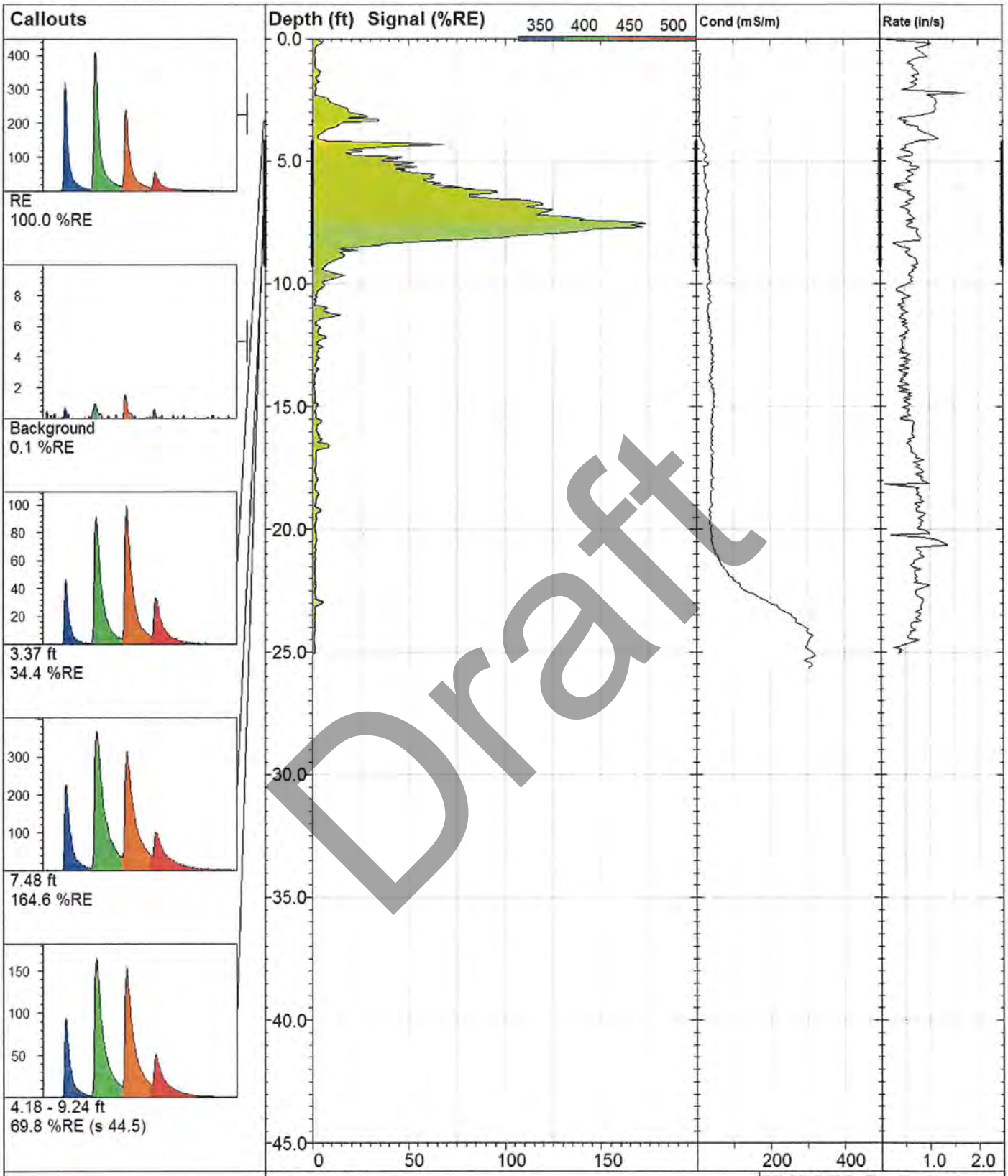
LIF-2015-02

UVOST® By Dakota
www.DakotaTechnologies.com

Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.10 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **132.5 %RE @ 6.86 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 10:43 CST**



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LIF-2015-03

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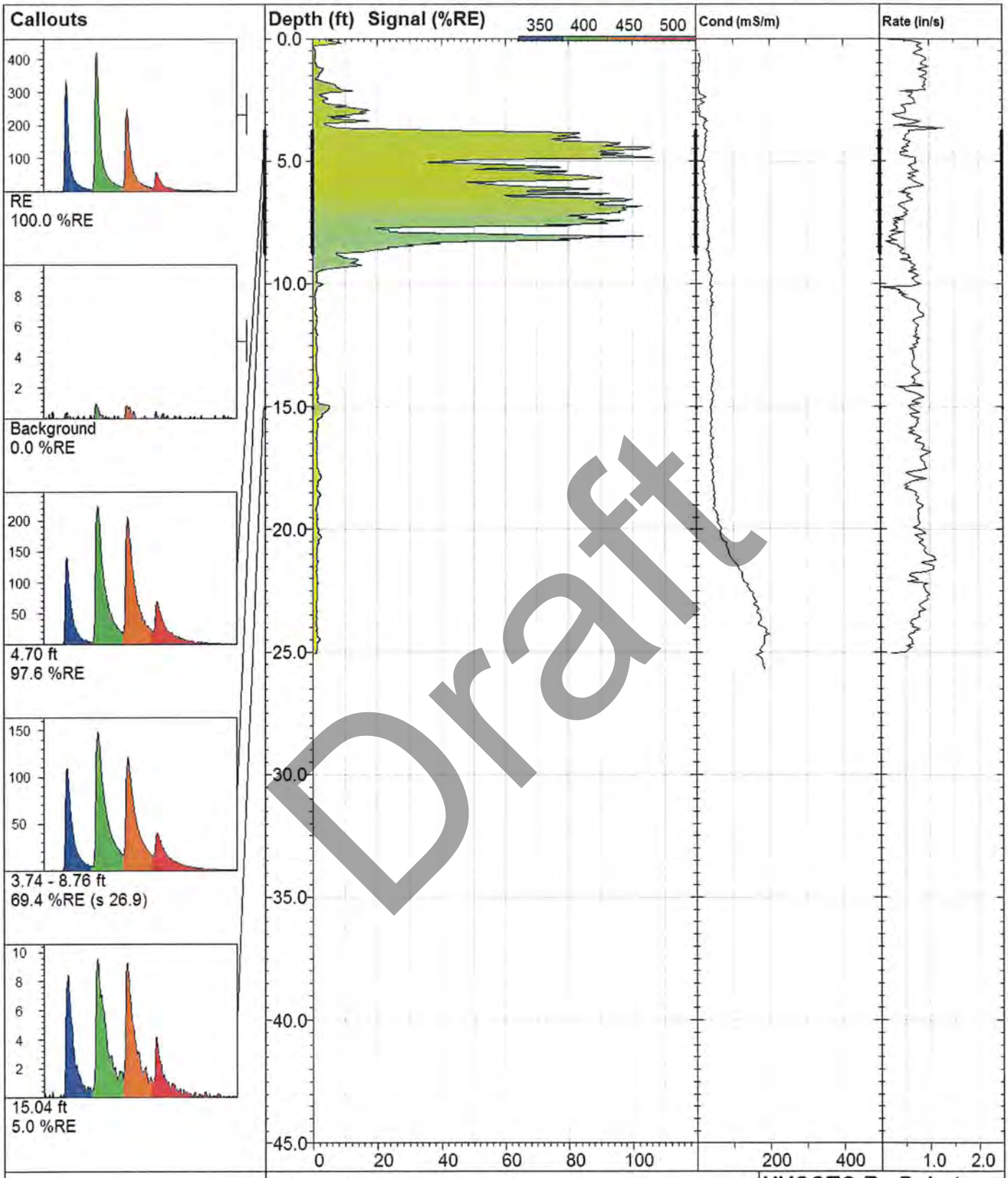
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.04 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **173.5 %RE @ 7.55 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 12:21 CST**



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LIF-2015-04

UVOST® By Dakota
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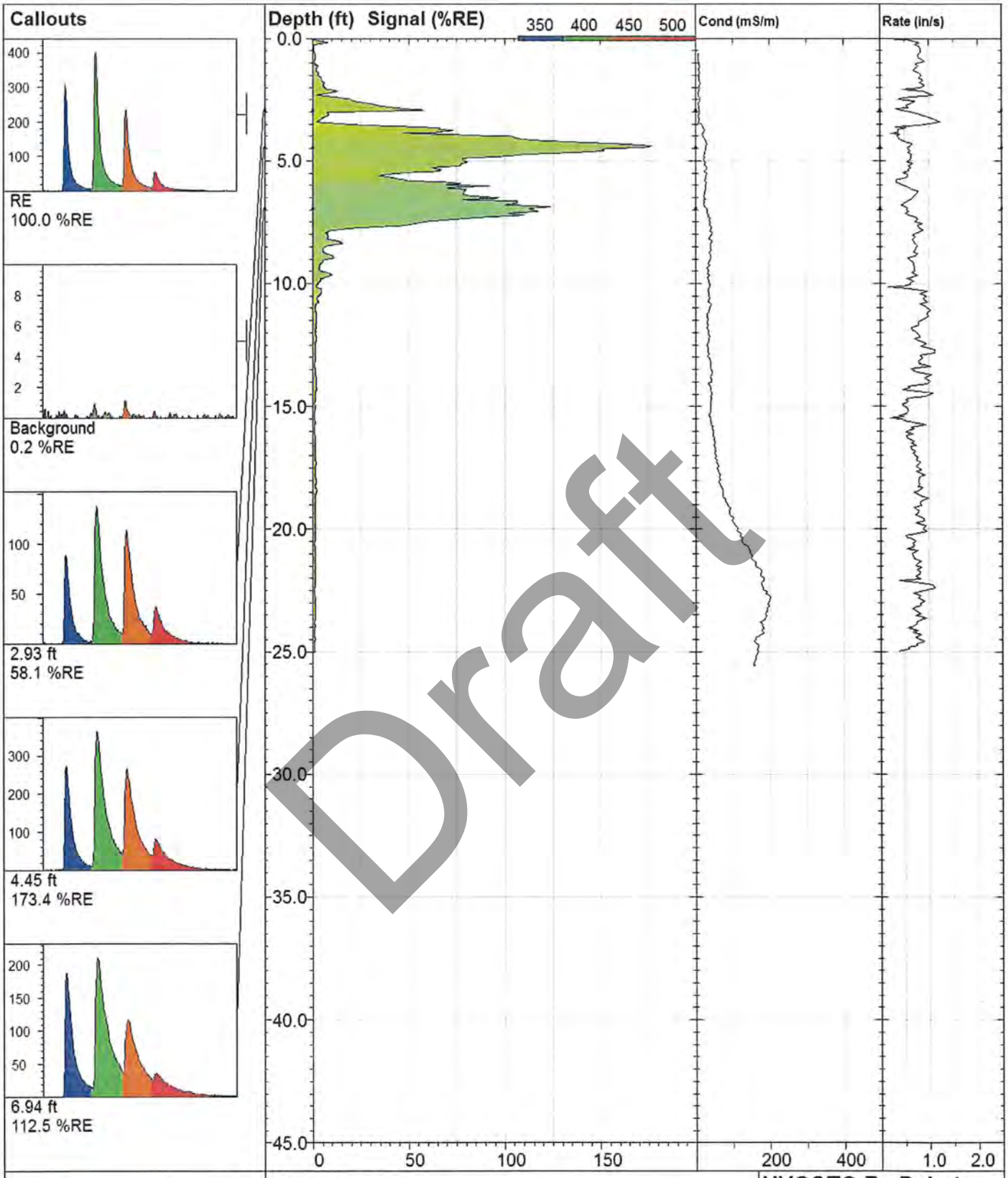
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.06 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **107.3 %RE @ 4.86 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 12:49 CST**



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LIF-2015-05

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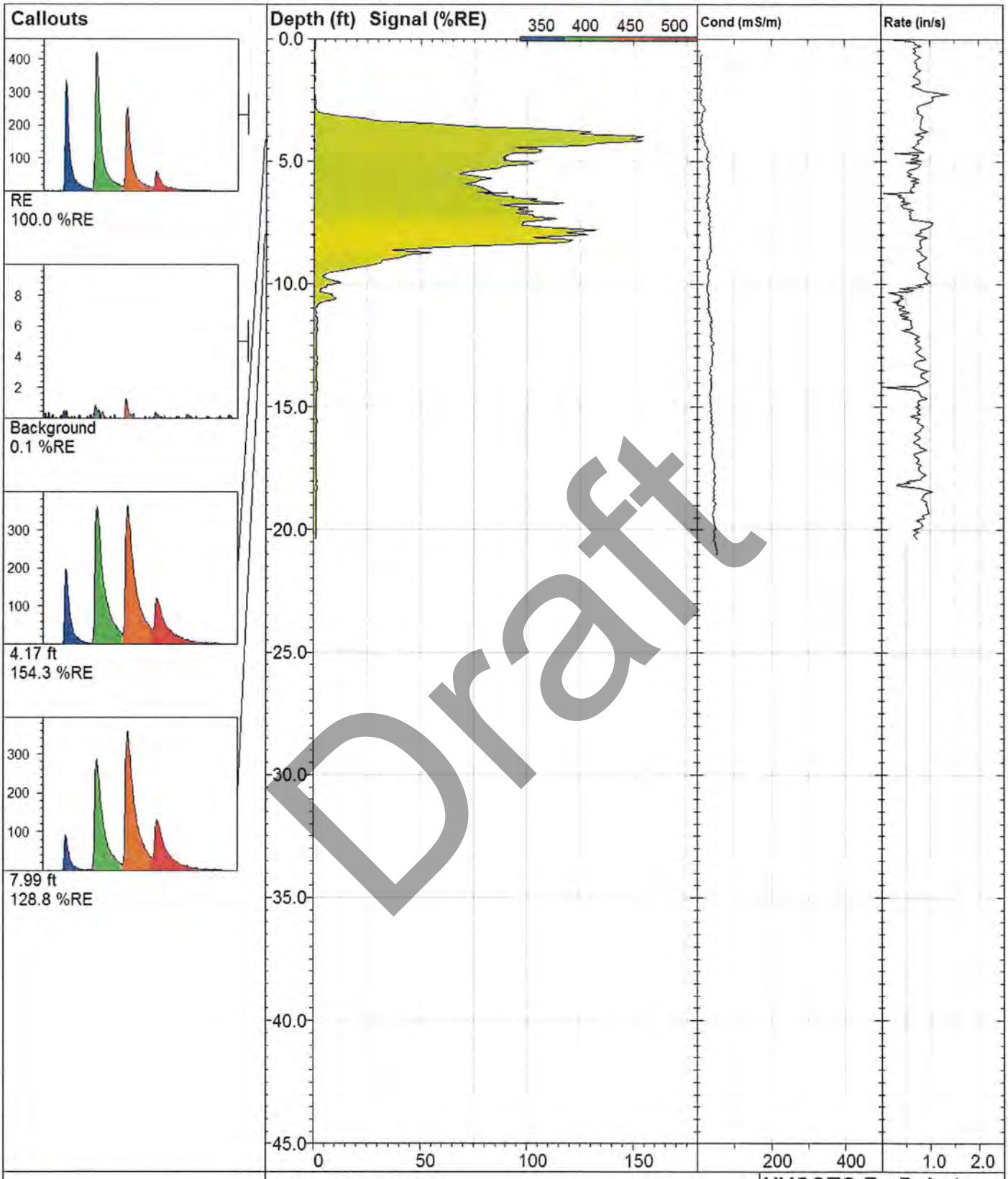
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.01 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **177.3 %RE @ 4.40 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 13:18 CST**



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LIF-2015-06

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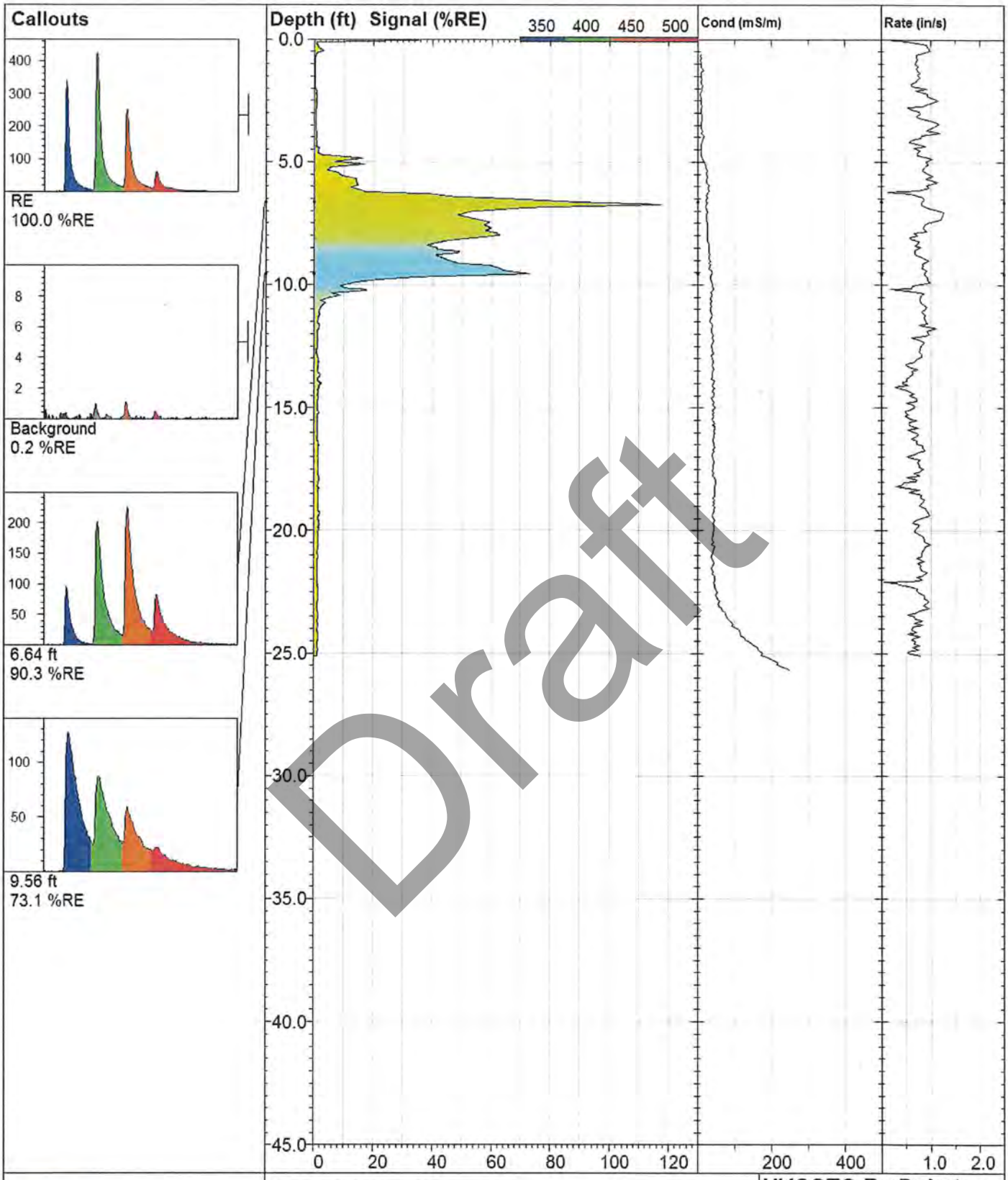
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.37 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **154.8 %RE @ 3.98 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 13:45 CST**



Draft

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LIF-2015-07

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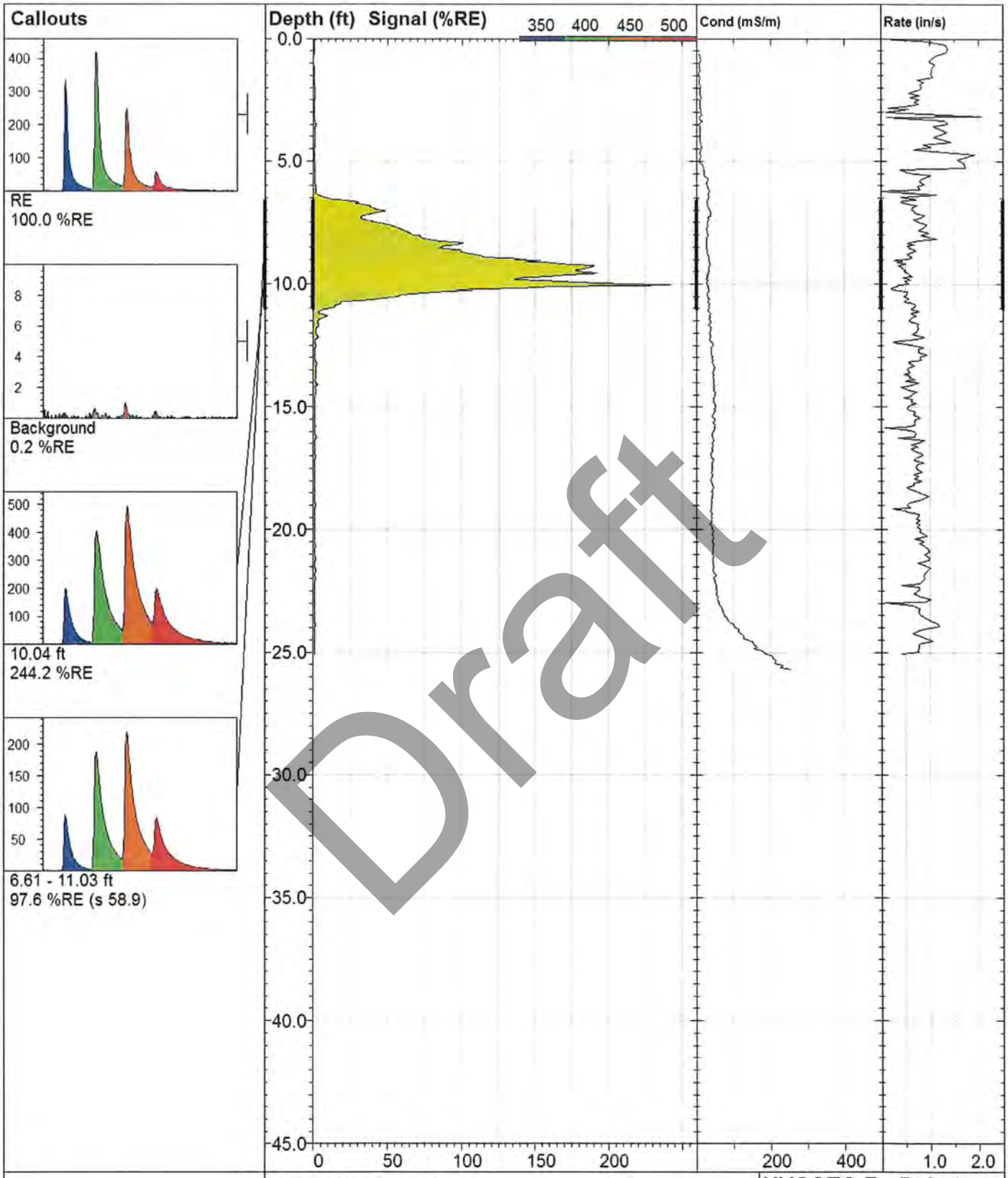
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.11 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **117.8 %RE @ 6.73 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 14:12 CST**



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LIF-2015-08

UVOST® By Dakota
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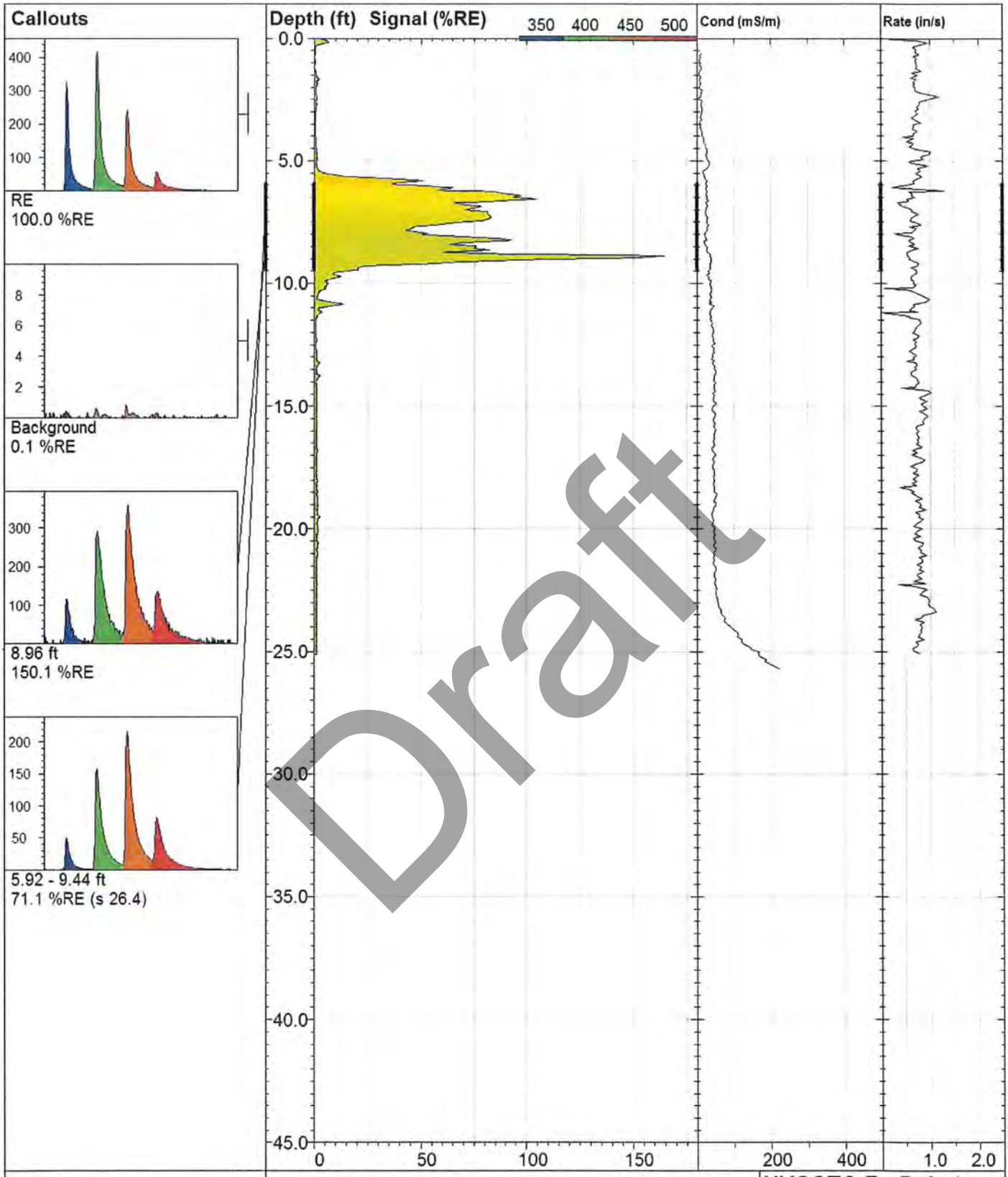
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.06 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **244.2 %RE @ 10.04 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 14:40 CST**



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LIF-2015-09

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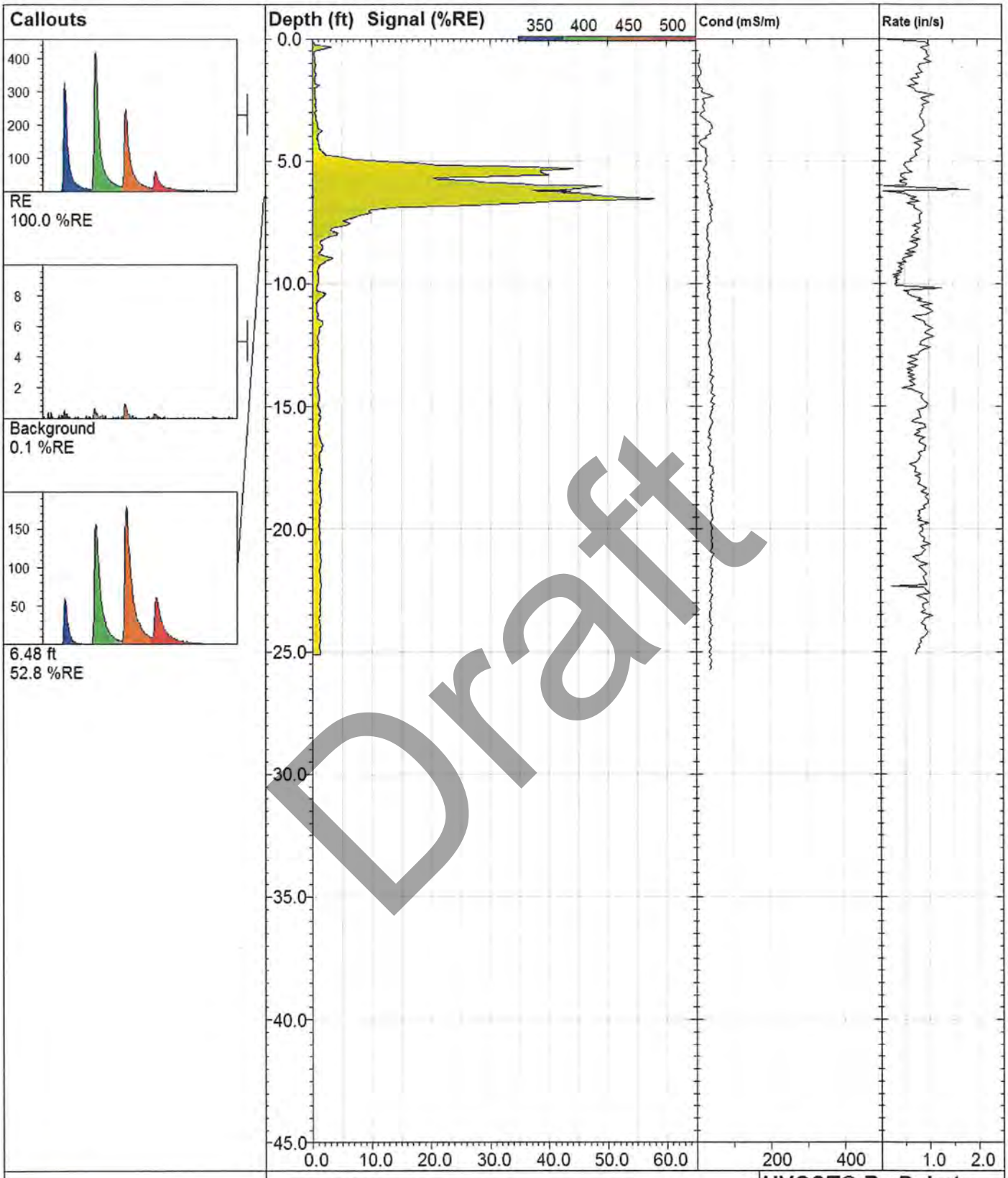
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.11 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **165.1 %RE @ 8.87 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 15:07 CST**



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LIF-2015-10

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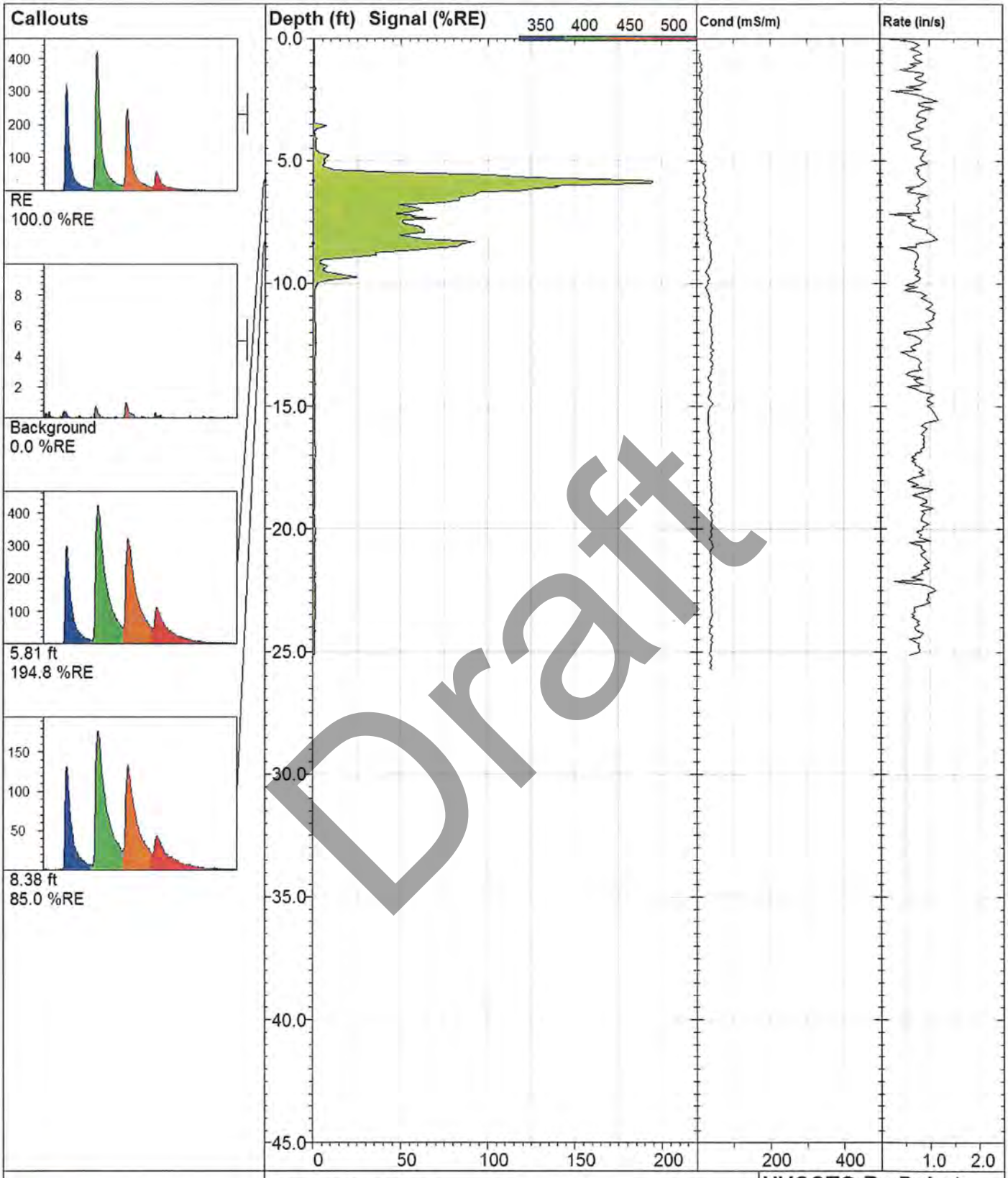
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.11 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **58.1 %RE @ 6.55 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 15:38 CST**



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LIF-2015-11

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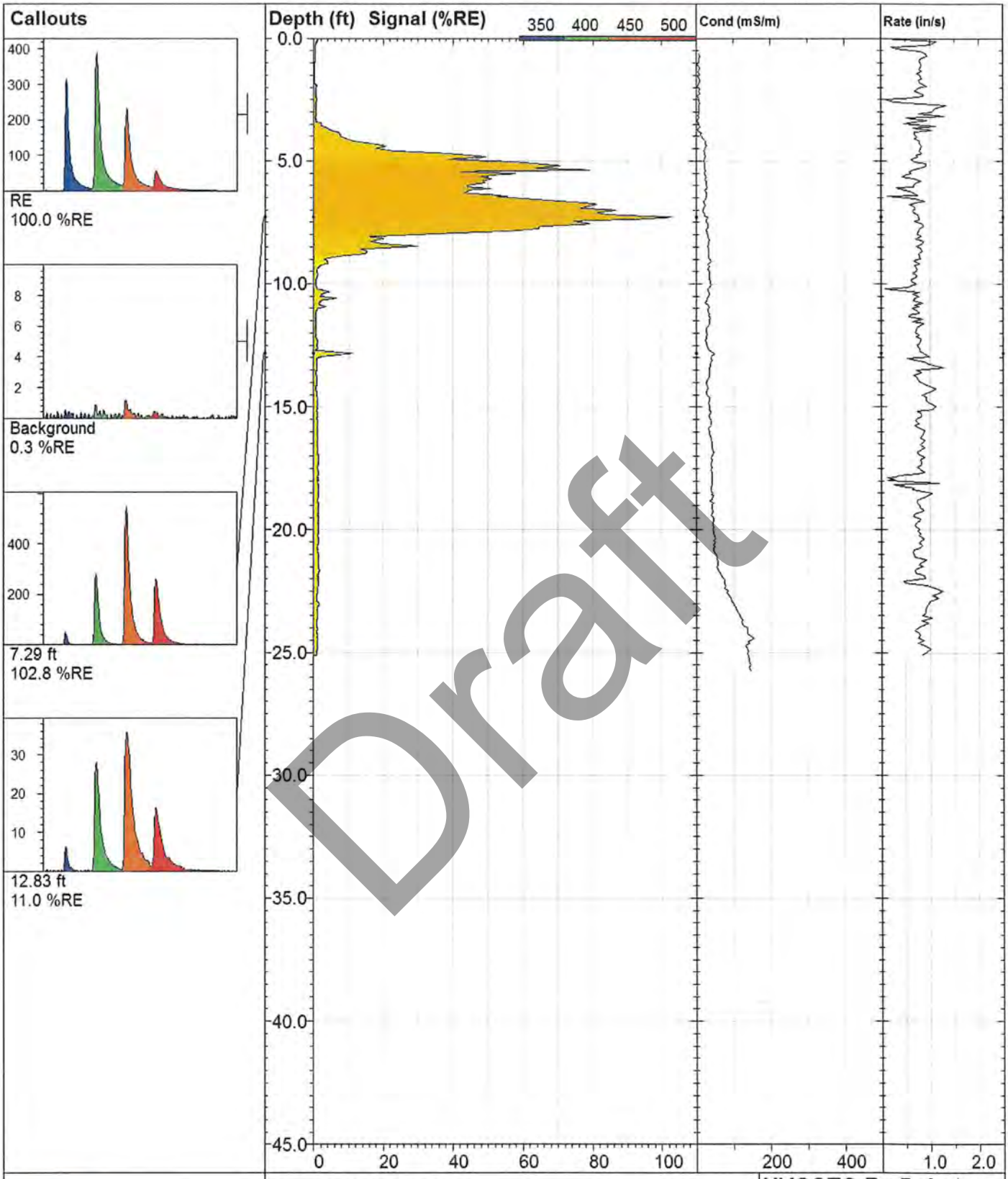
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.13 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **194.8 %RE @ 5.81 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-09 16:03 CST**



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LIF-2015-12

UVOST® By Dakota
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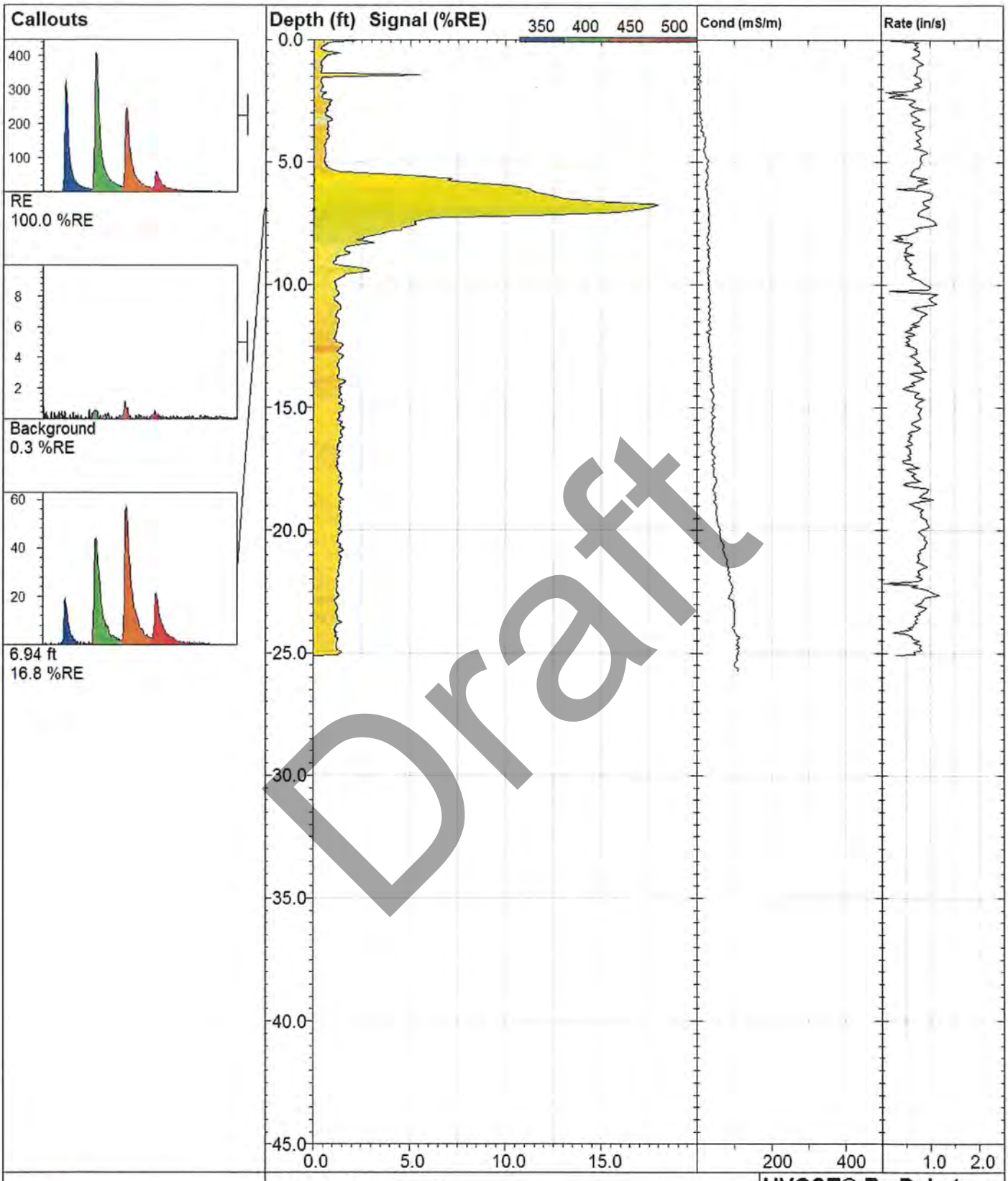
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.11 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **102.8 %RE @ 7.29 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 07:51 CST**



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LIF-2015-13

UVOST® By Dakota
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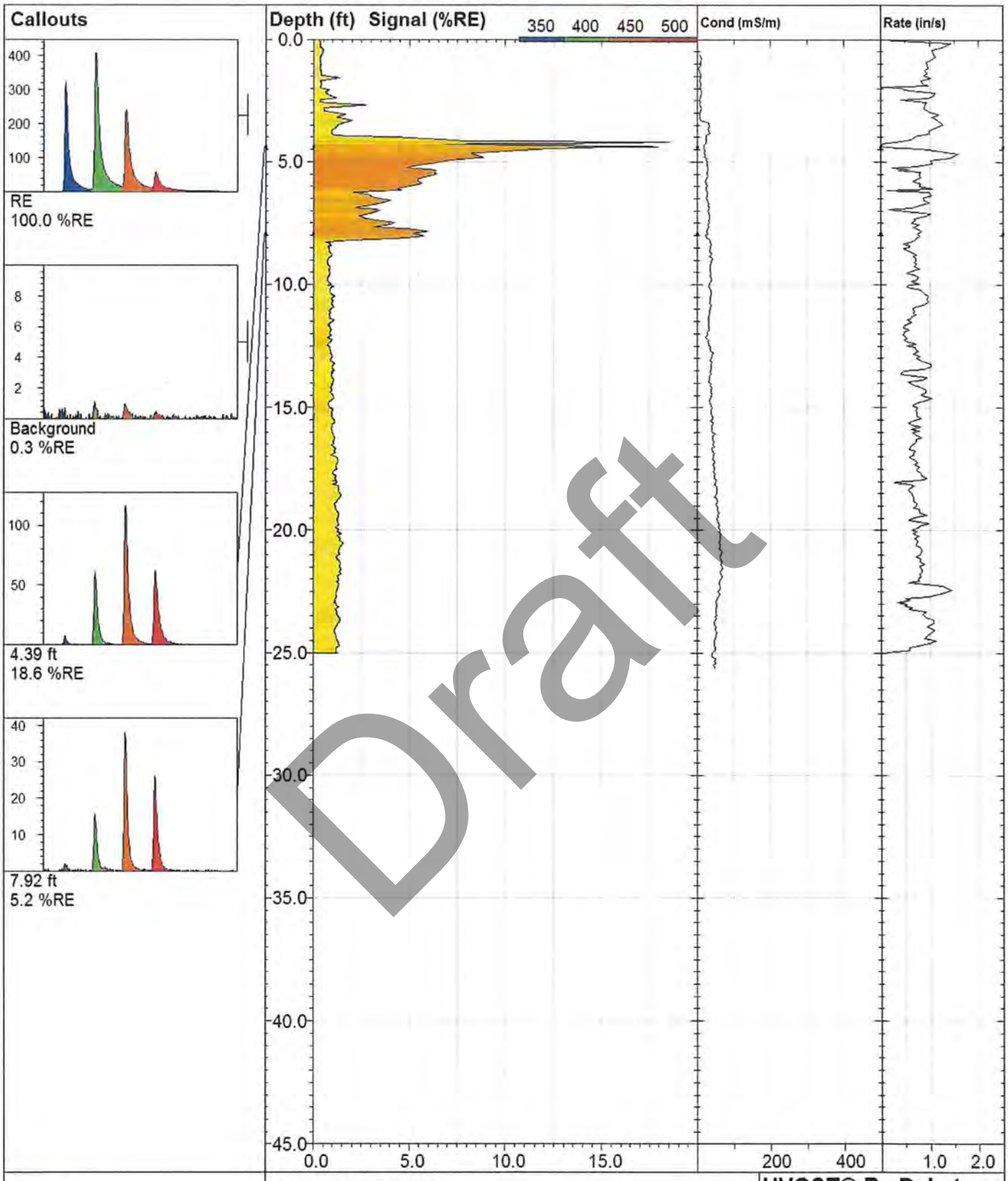
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.09 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **18.0 %RE @ 6.73 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 08:17 CST**



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LIF-2015-14

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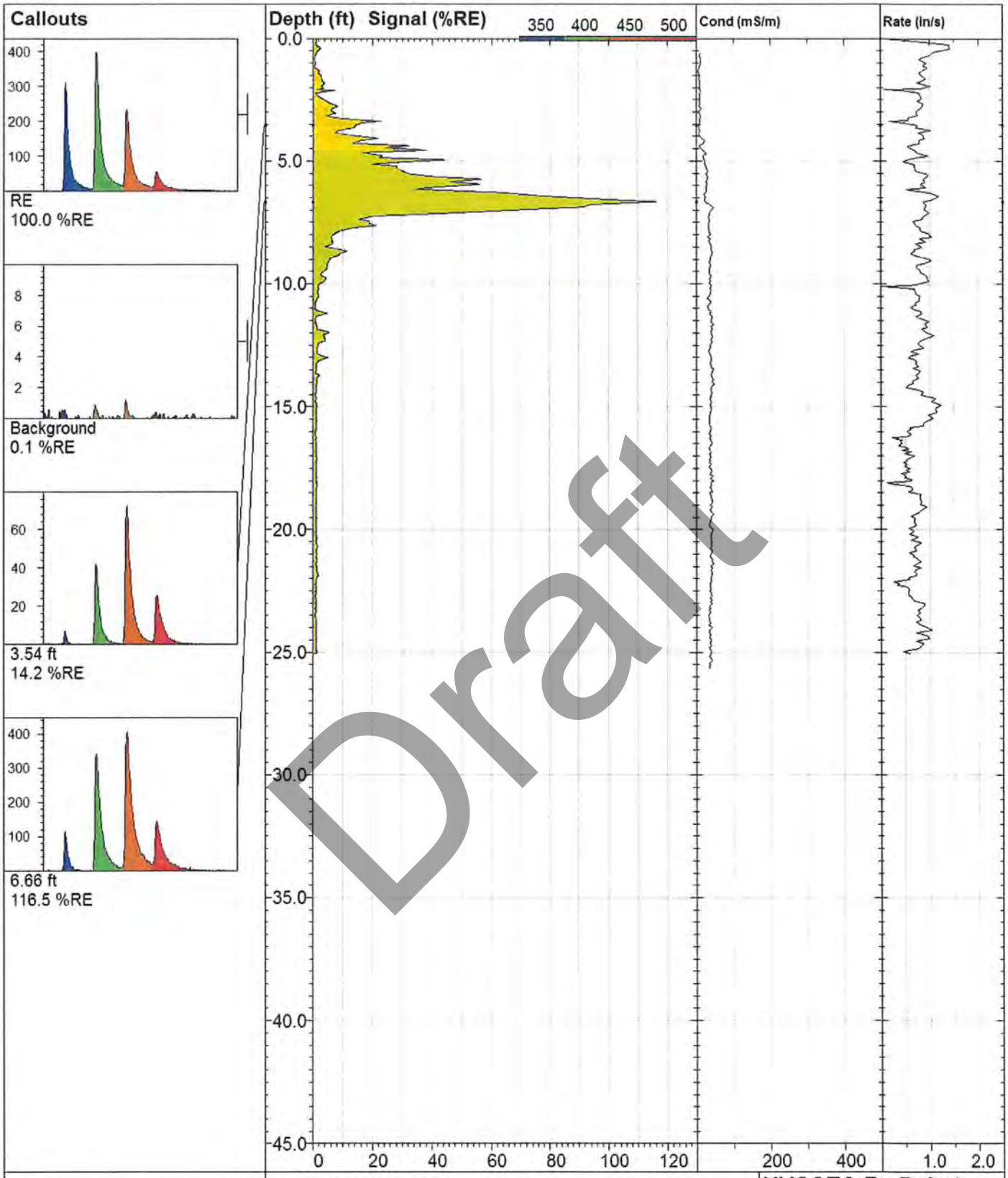
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.01 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **19.0 %RE @ 4.20 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 08:44 CST**



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LIF-2015-15

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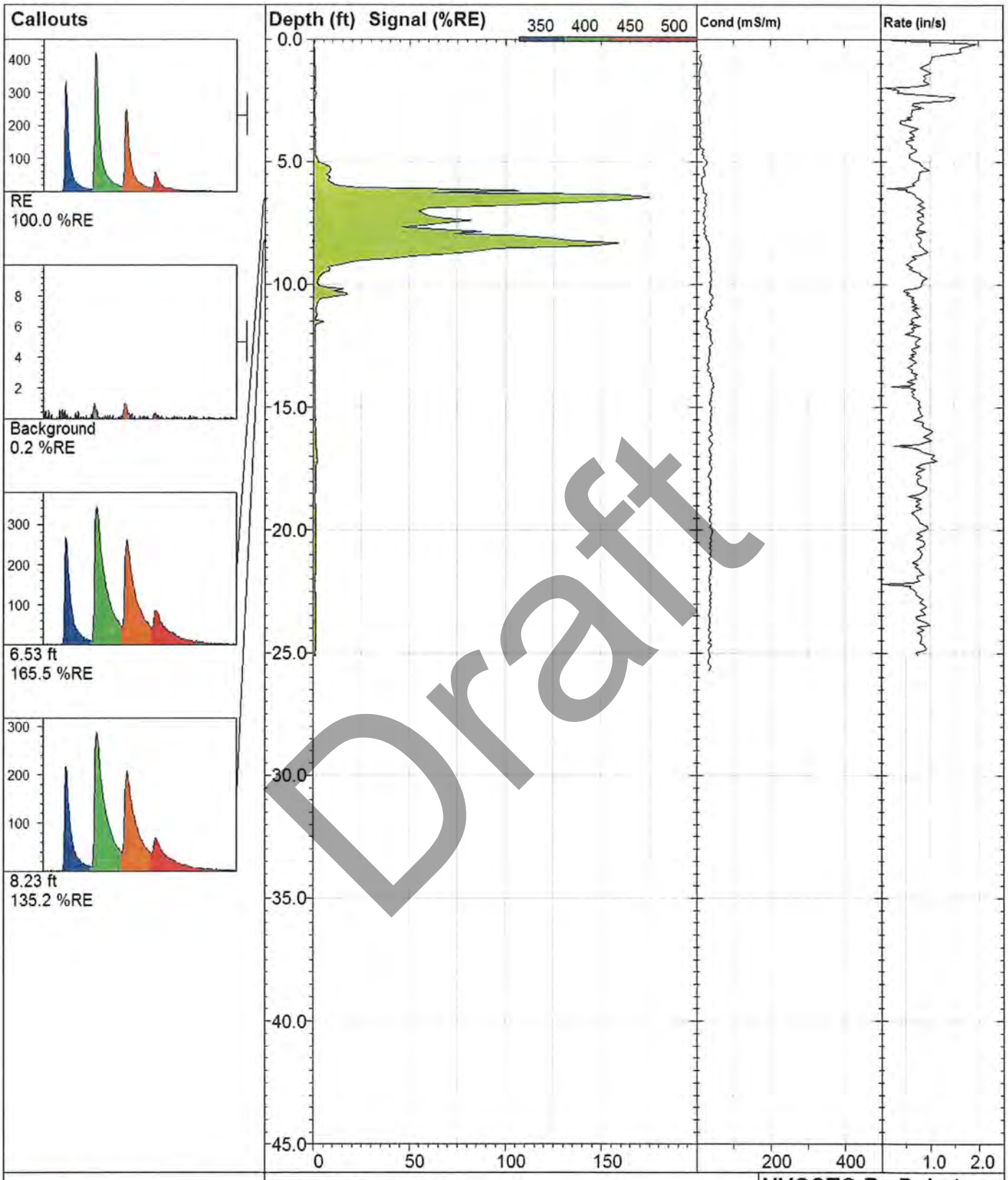
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.06 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **116.5 %RE @ 6.66 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 09:12 CST**



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LIF-2015-16

UVOST® By Dakota
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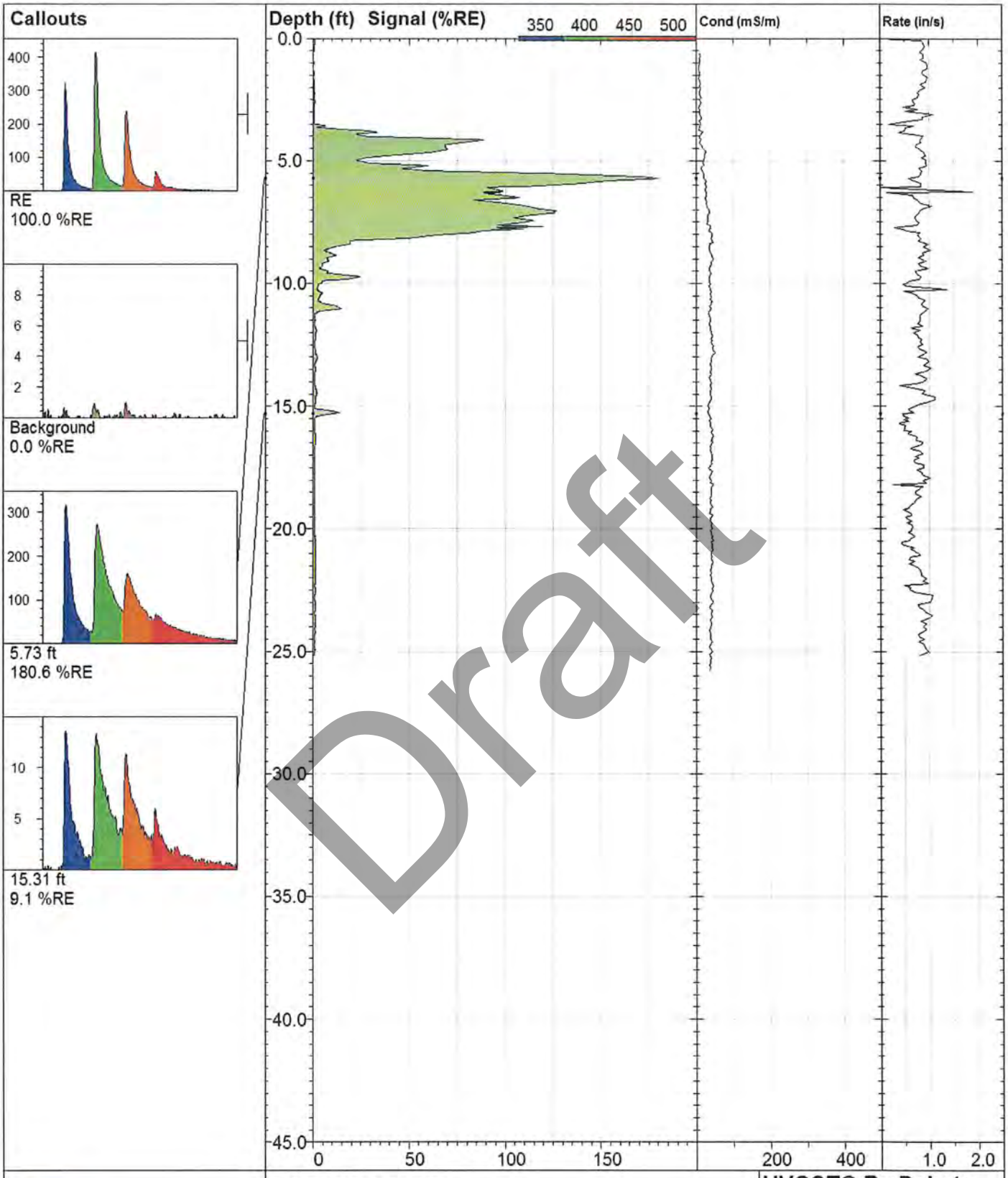
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **175.7 %RE @ 6.44 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 09:41 CST**



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LIF-2015-17

UVOST® By Dakota
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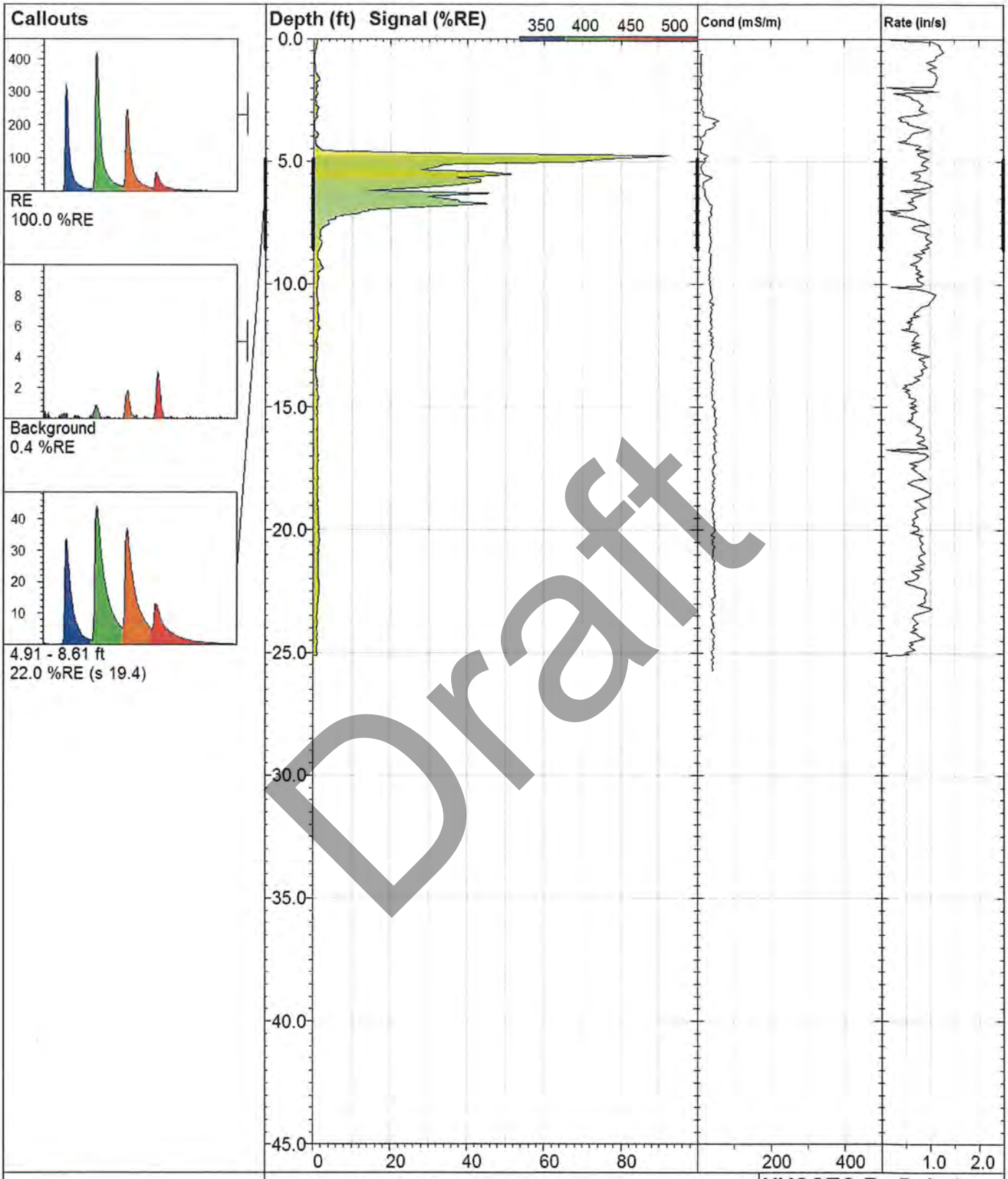
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.14 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **180.6 %RE @ 5.73 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 10:10 CST**



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LIF-2015-18

UVOST® By Dakota
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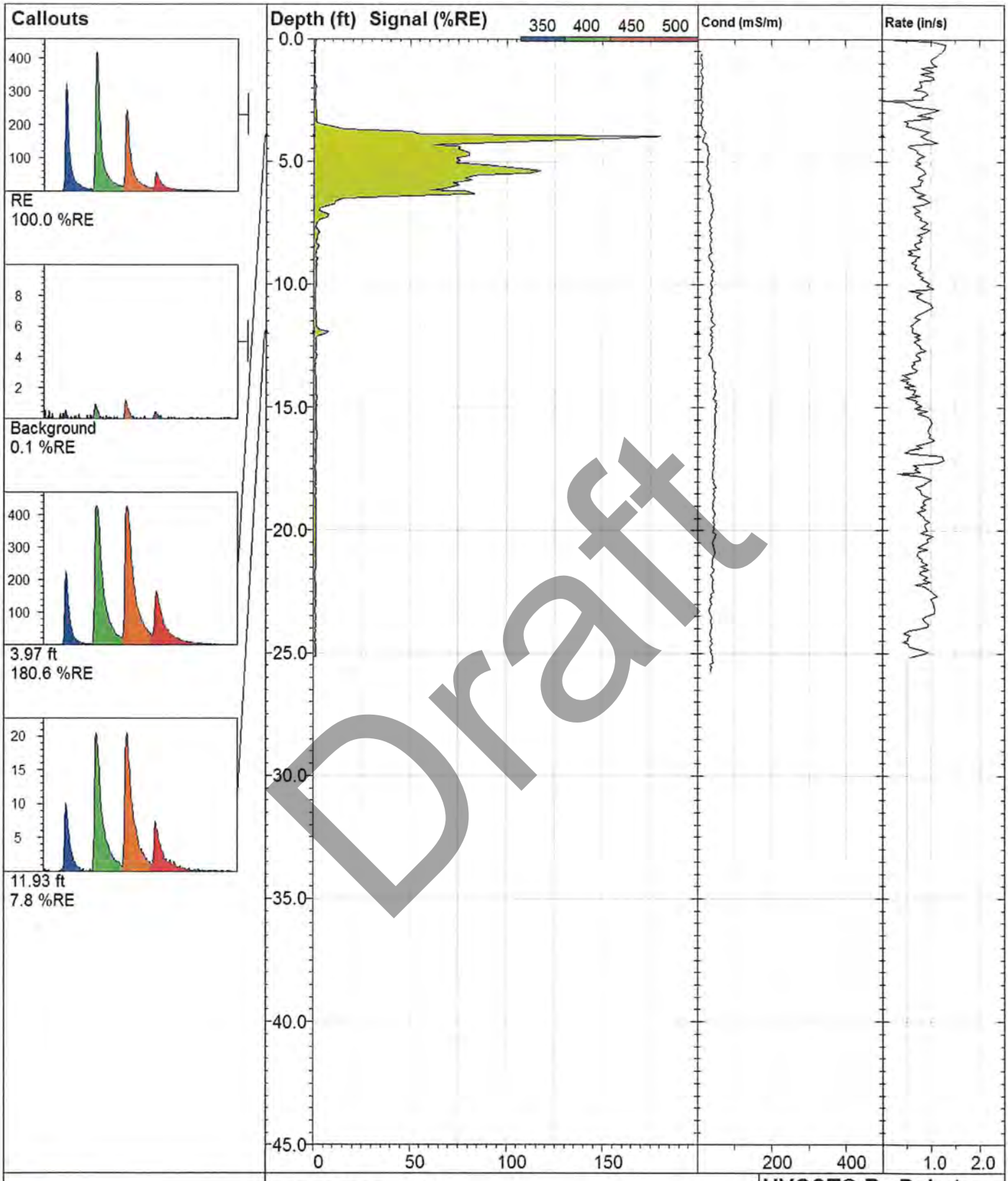
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.11 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **92.7 %RE @ 4.78 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 10:36 CST**



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LIF-2015-19

UVOST® By Dakota
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Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.14 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **180.6 %RE @ 3.97 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 11:04 CST**

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LIF-2015-20

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Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.10 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **12.0 %RE @ 1.41 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 12:35 CST**

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LIF-2015-21

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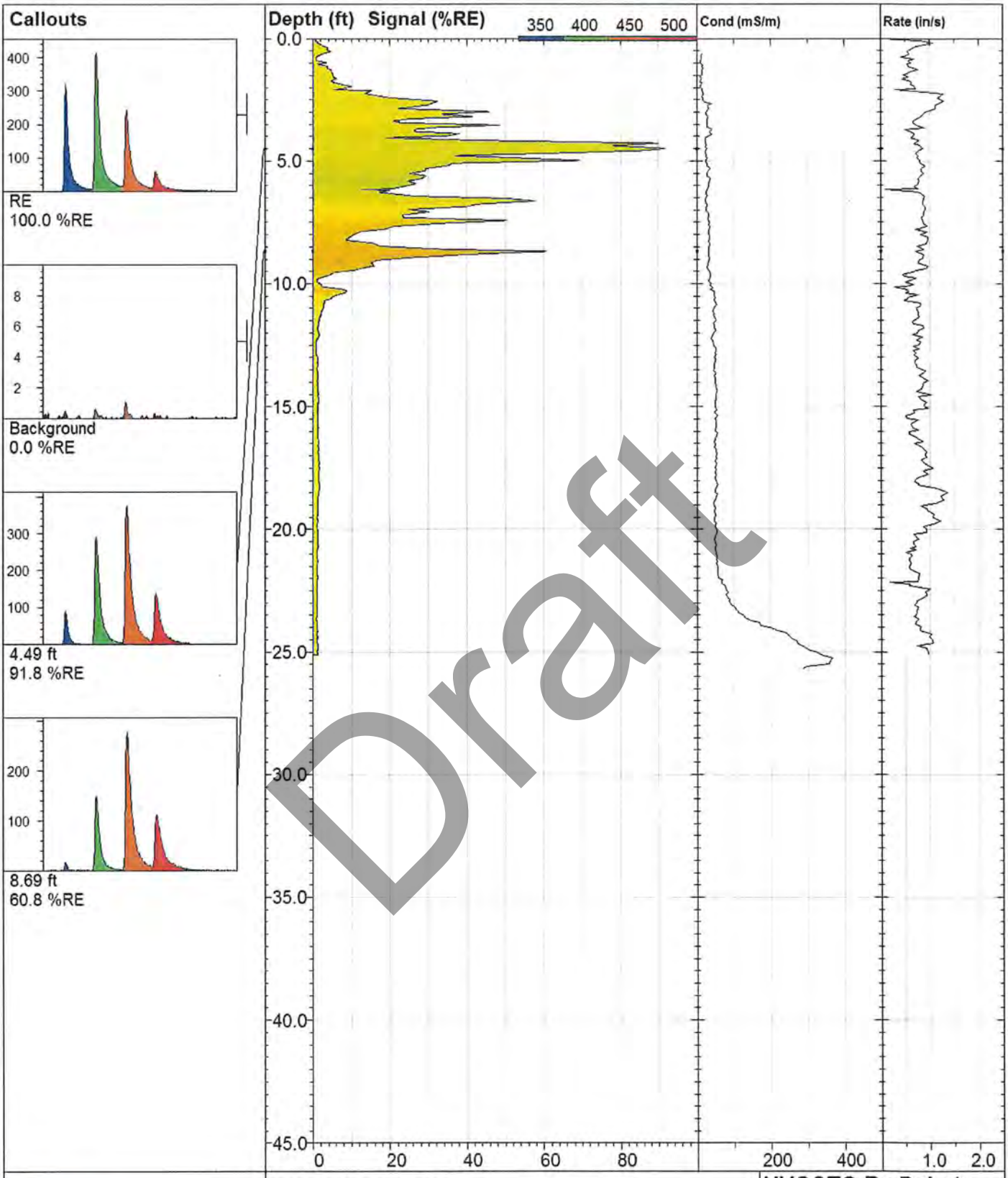
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.17 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **17.2 %RE @ 3.44 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 12:59 CST**



Draft

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LIF-2015-22

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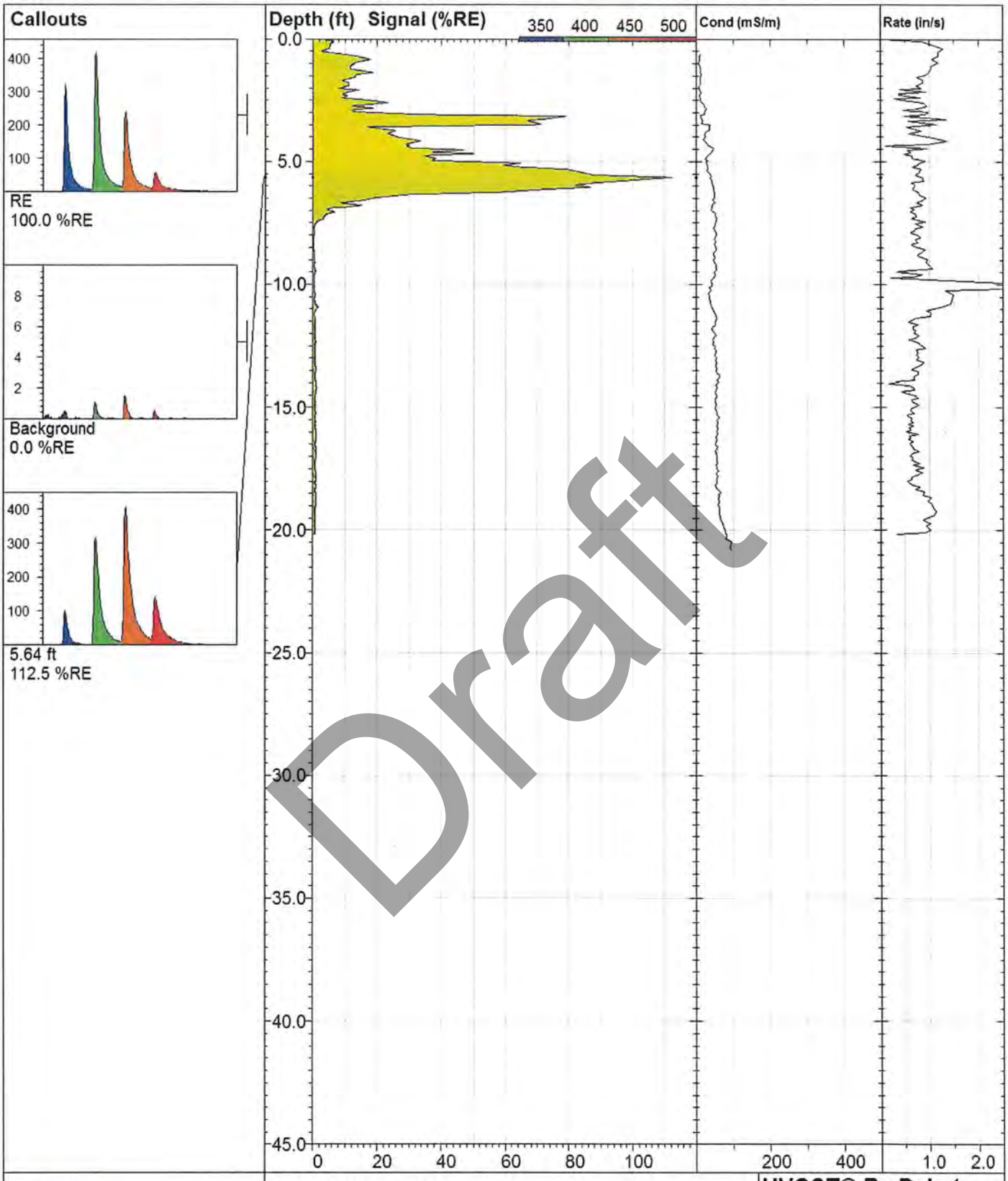
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.10 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **91.8 %RE @ 4.49 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 13:45 CST**



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LIF-2015-23

UVOST® By Dakota
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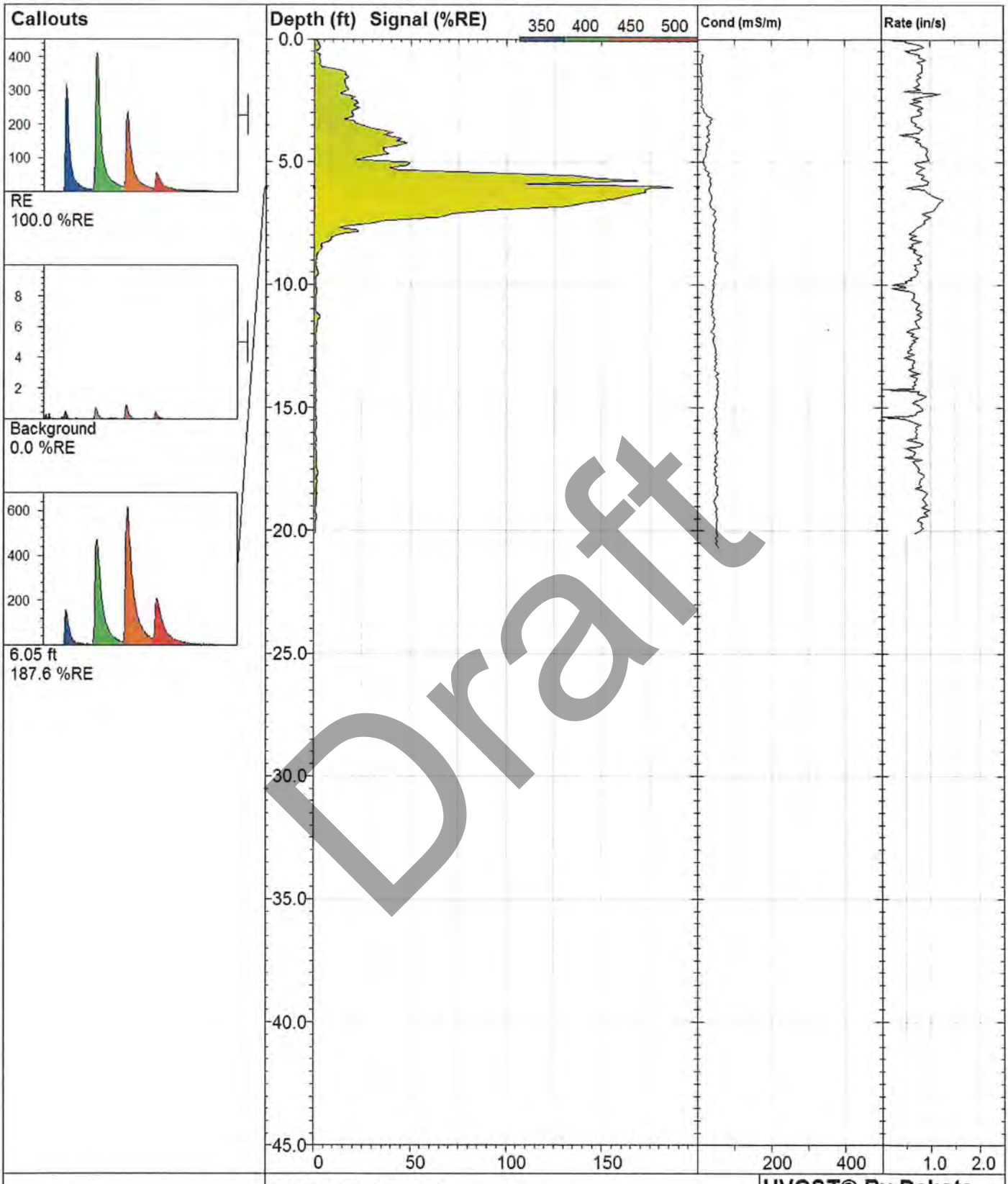
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.17 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **112.5 %RE @ 5.64 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 14:11 CST**



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LIF-2015-24

UVOST® By Dakota
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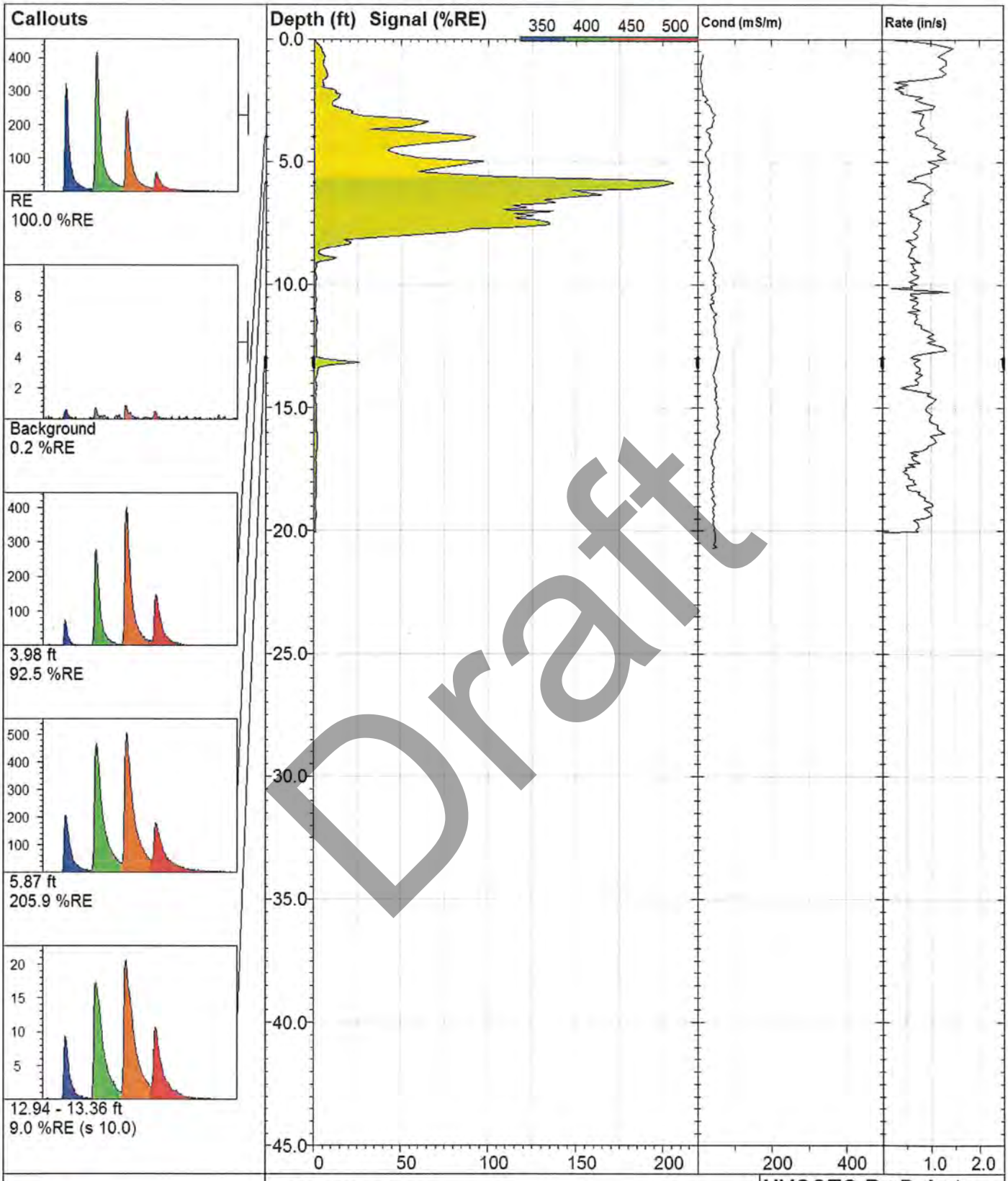
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.09 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **187.6 %RE @ 6.05 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 14:34 CST**



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LIF-2015-25

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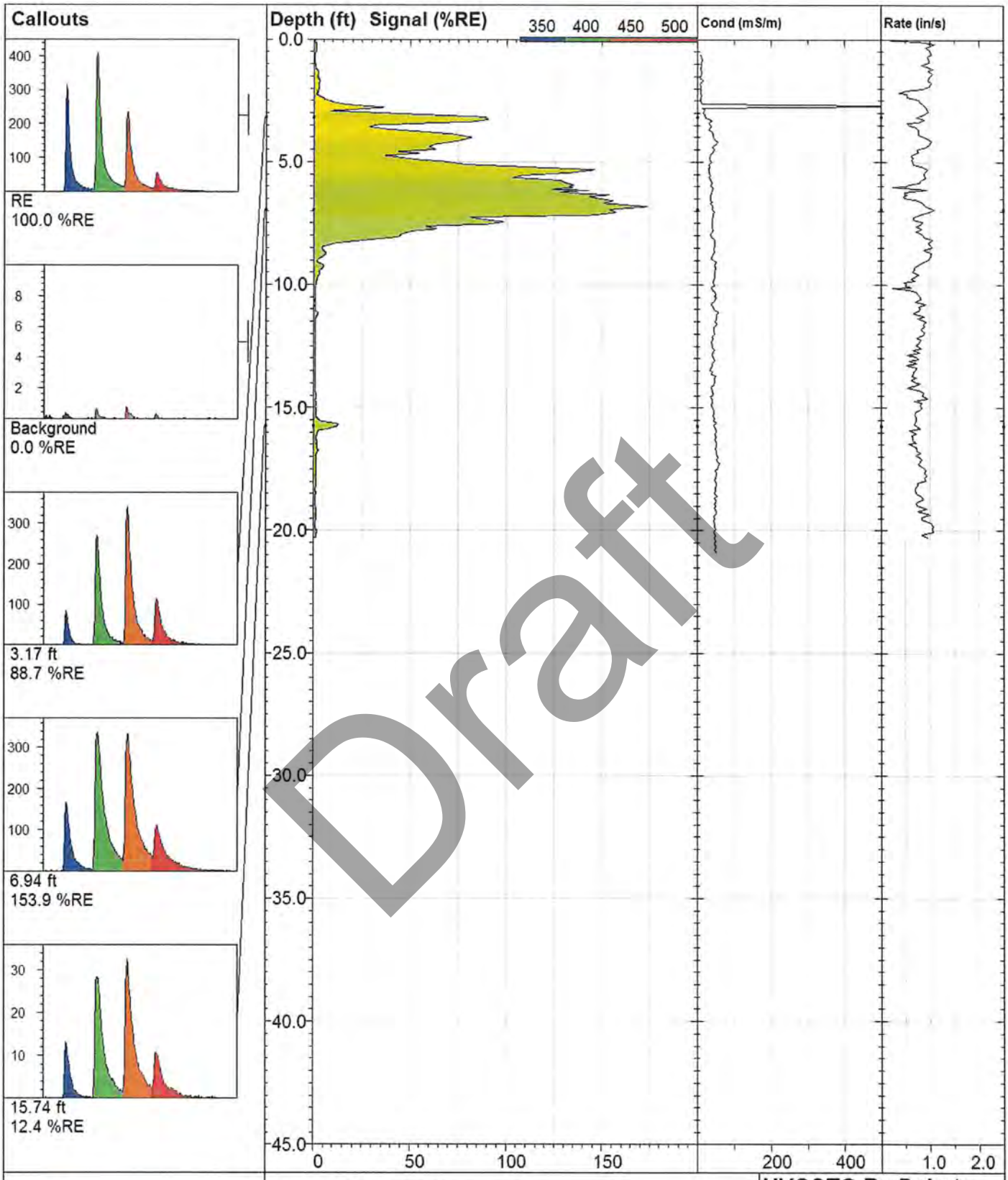
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.07 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **205.9 %RE @ 5.87 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 14:55 CST**



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LIF-2015-26

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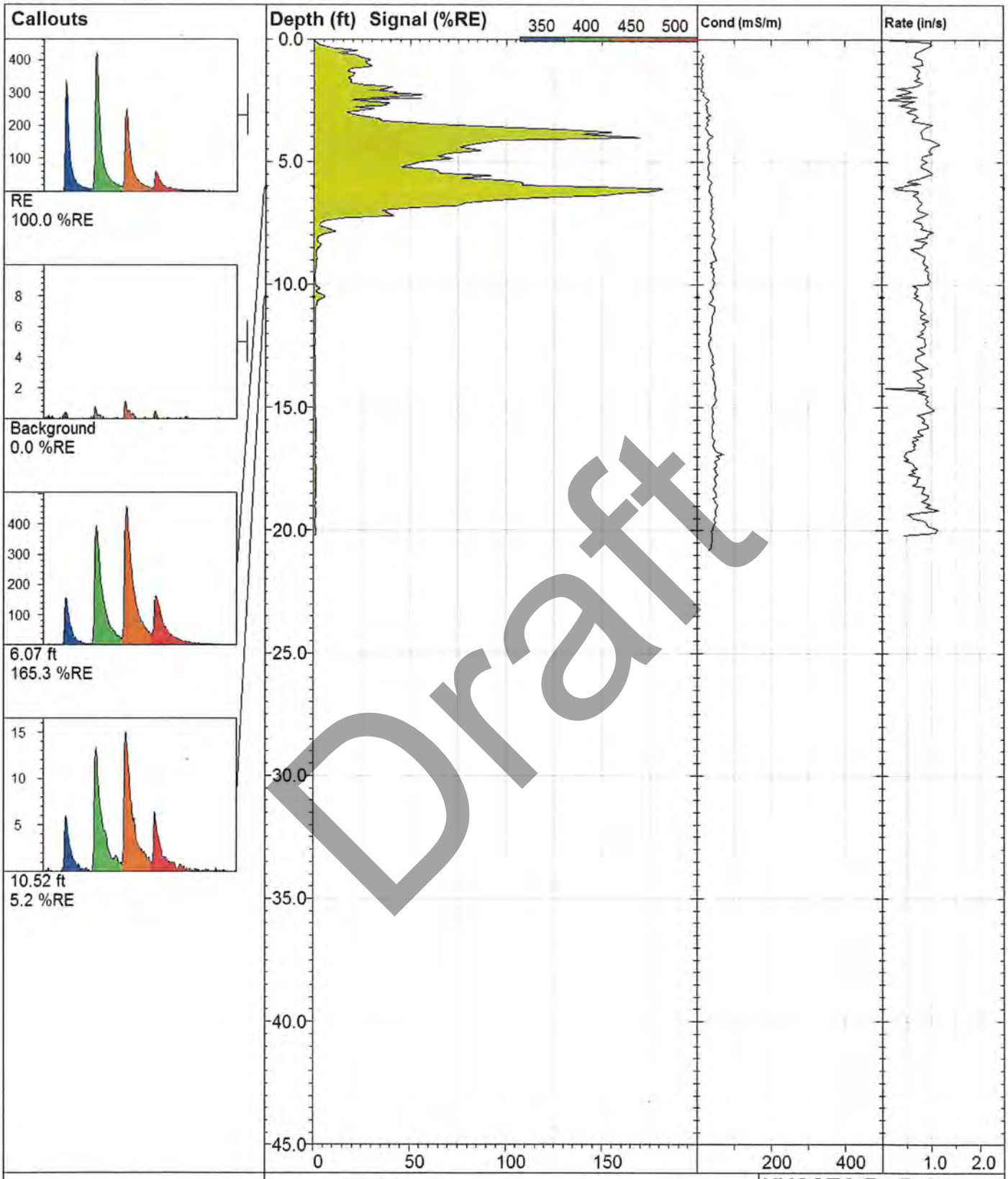
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.30 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **174.2 %RE @ 6.81 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 15:14 CST**



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LIF-2015-27

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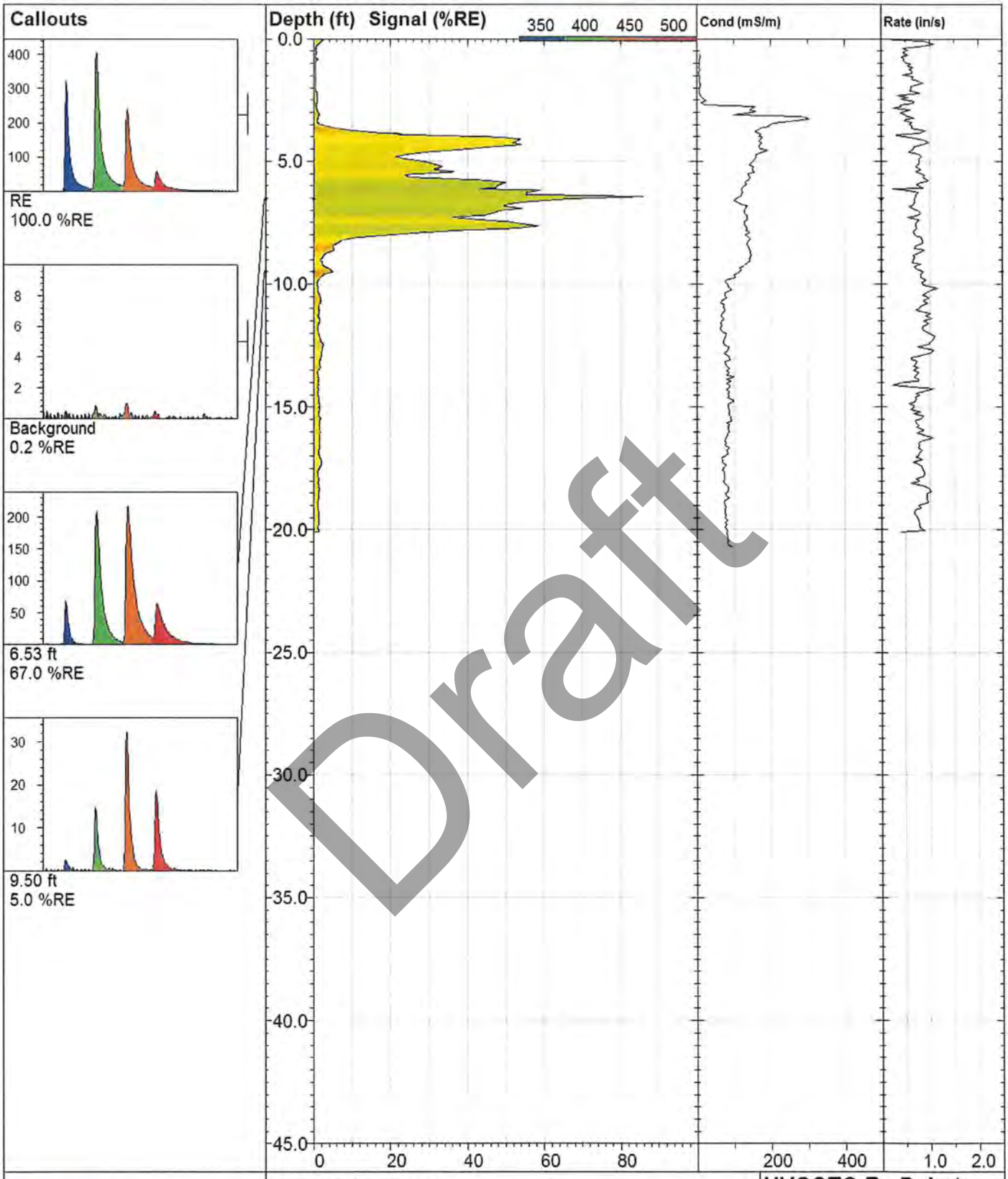
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.19 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **181.9 %RE @ 6.12 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-10 15:36 CST**



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LIF-2015-28

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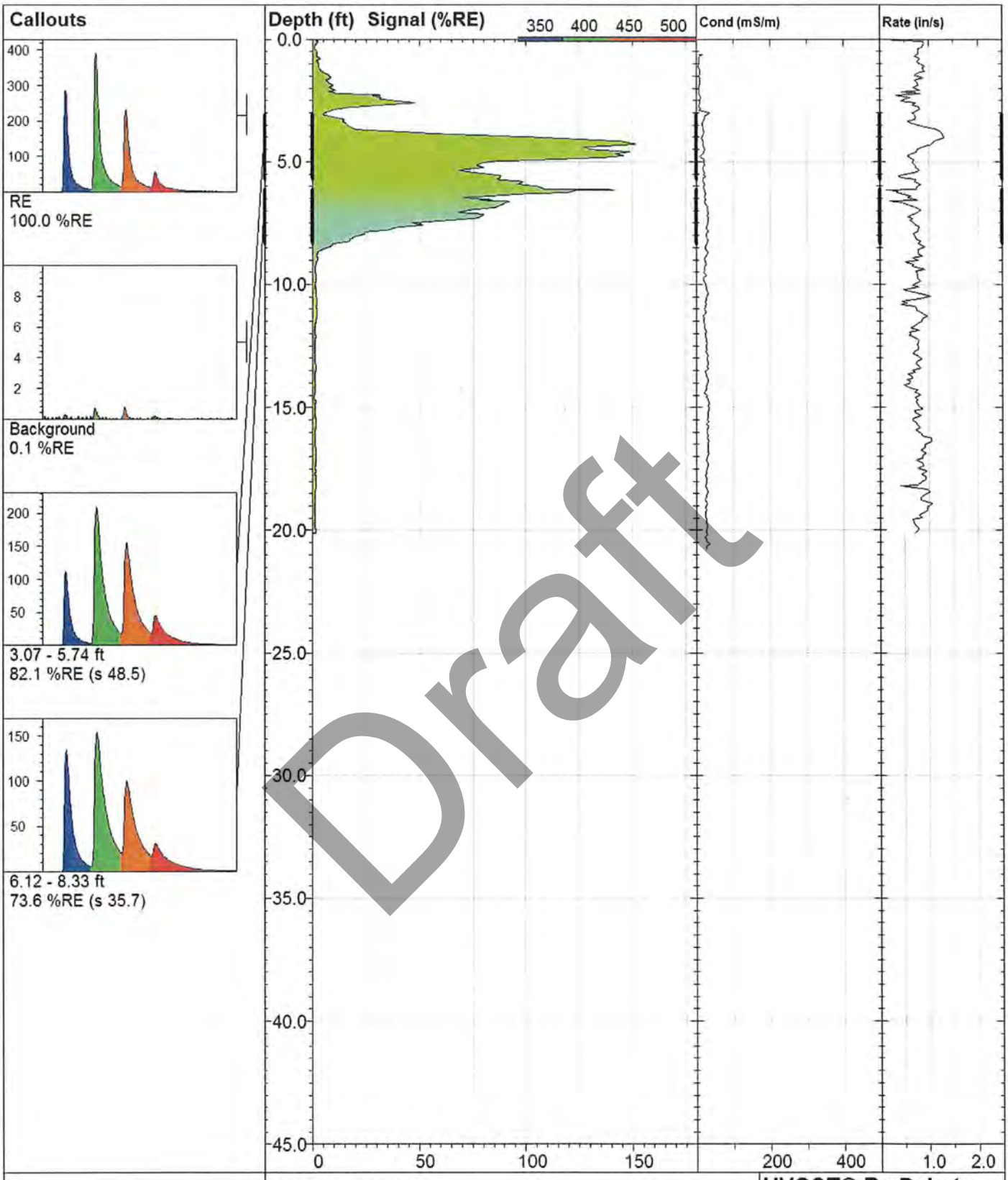
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.08 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **86.1 %RE @ 6.44 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 08:22 CST**



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LIF-2015-29

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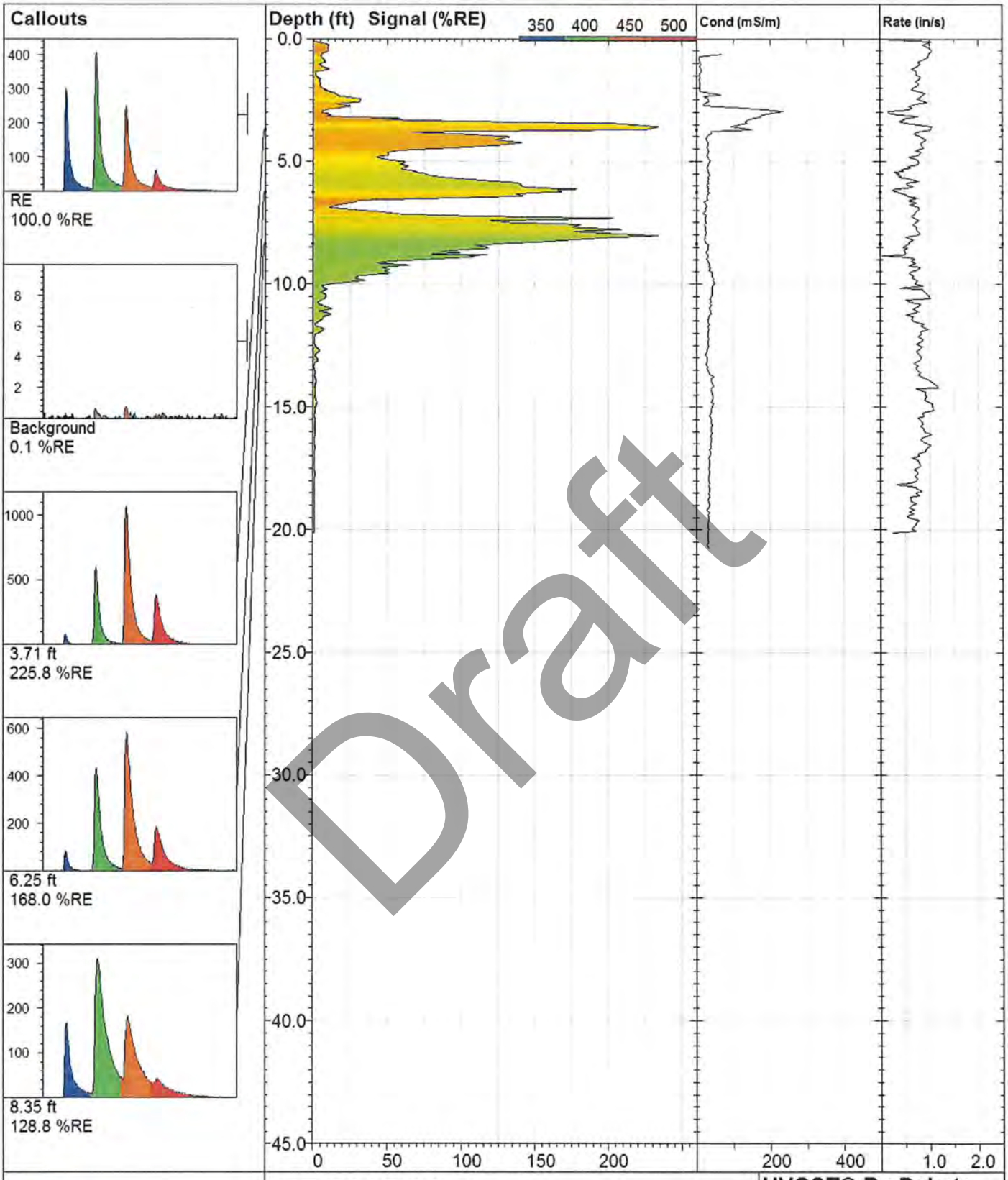
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.13 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **151.8 %RE @ 4.29 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 09:46 CST**



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LIF-2015-30

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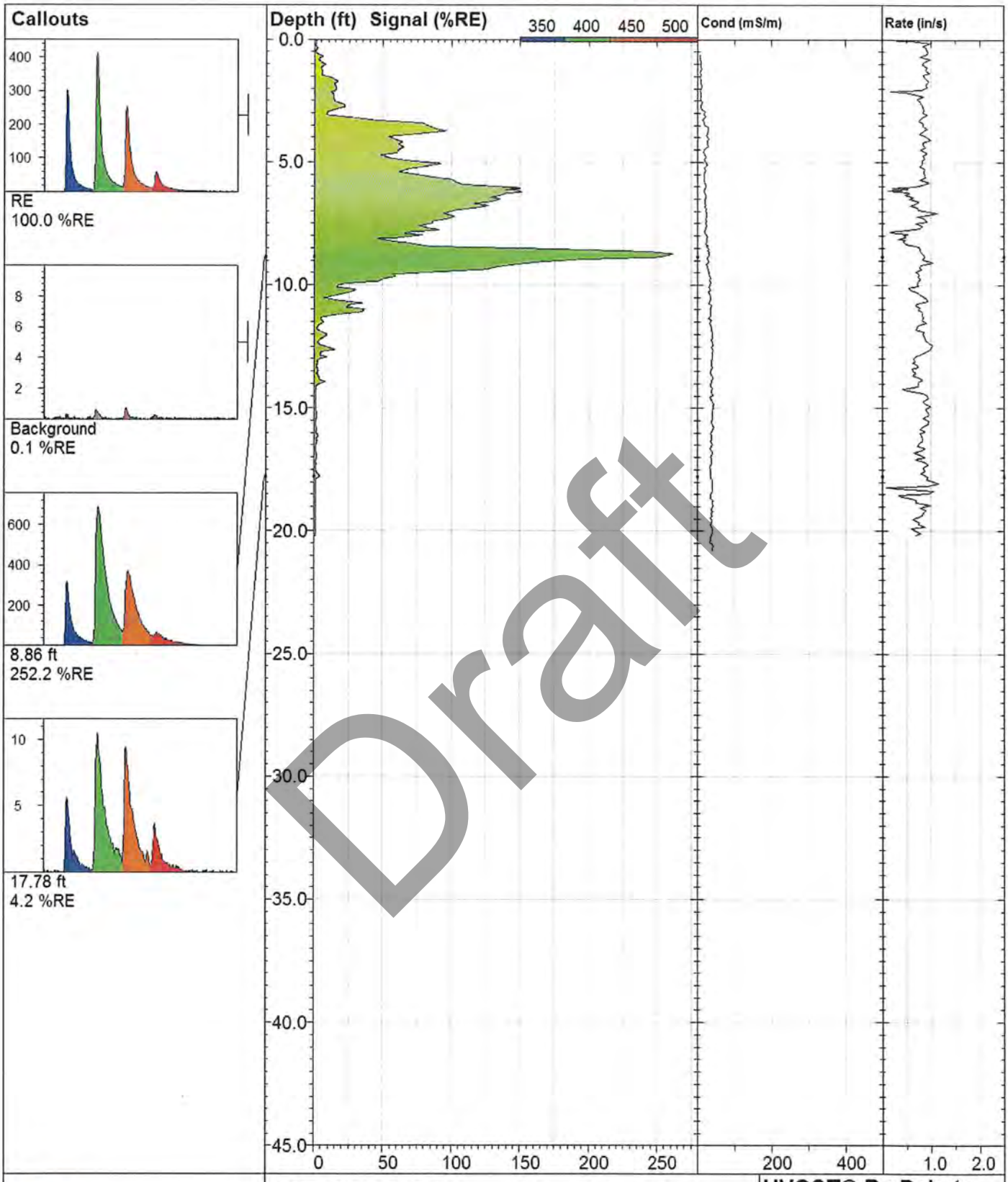
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **233.9 %RE @ 3.59 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 10:11 CST**



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LIF-2015-31

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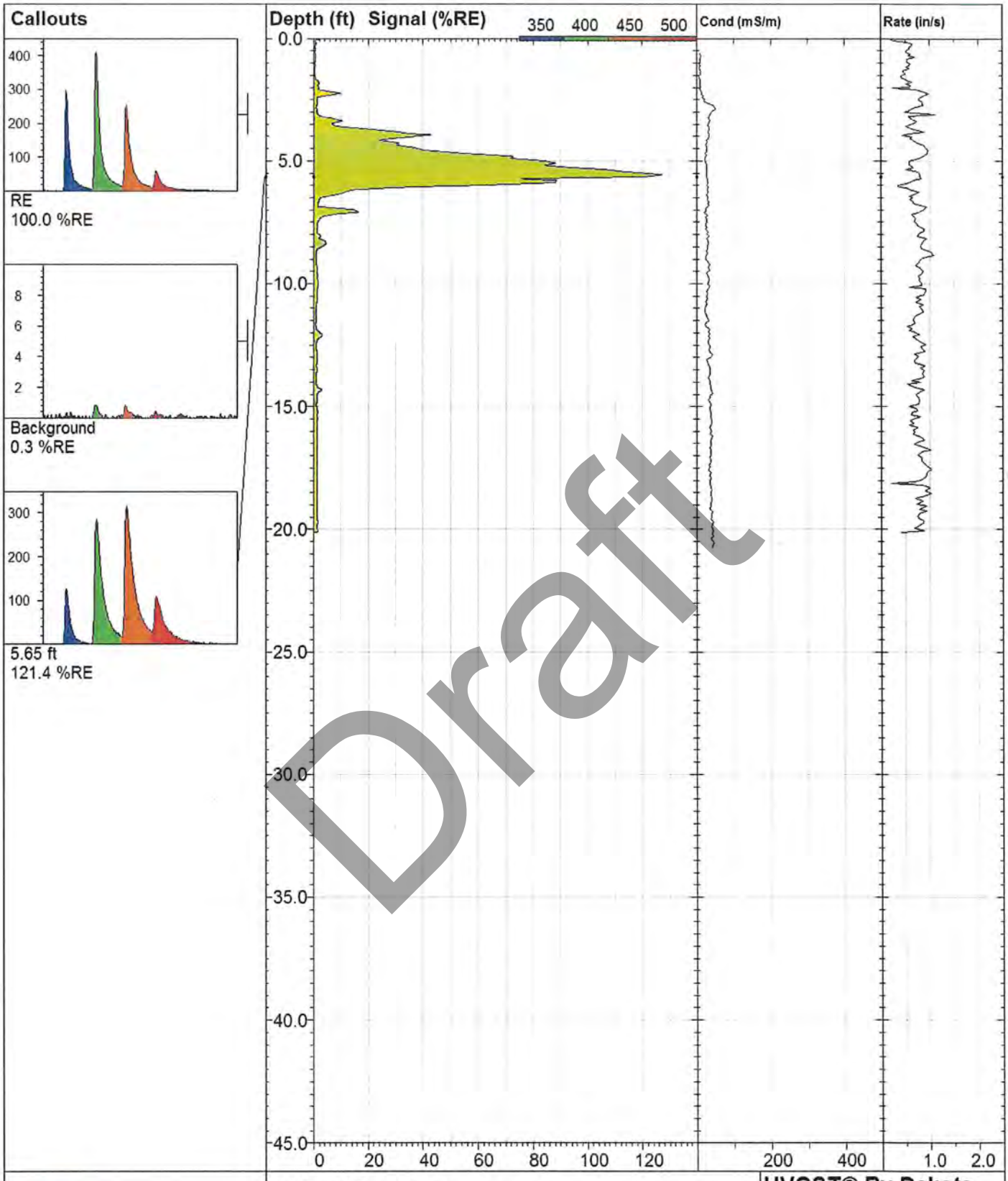
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.18 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **261.7 %RE @ 8.73 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 10:33 CST**



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LIF-2015-32

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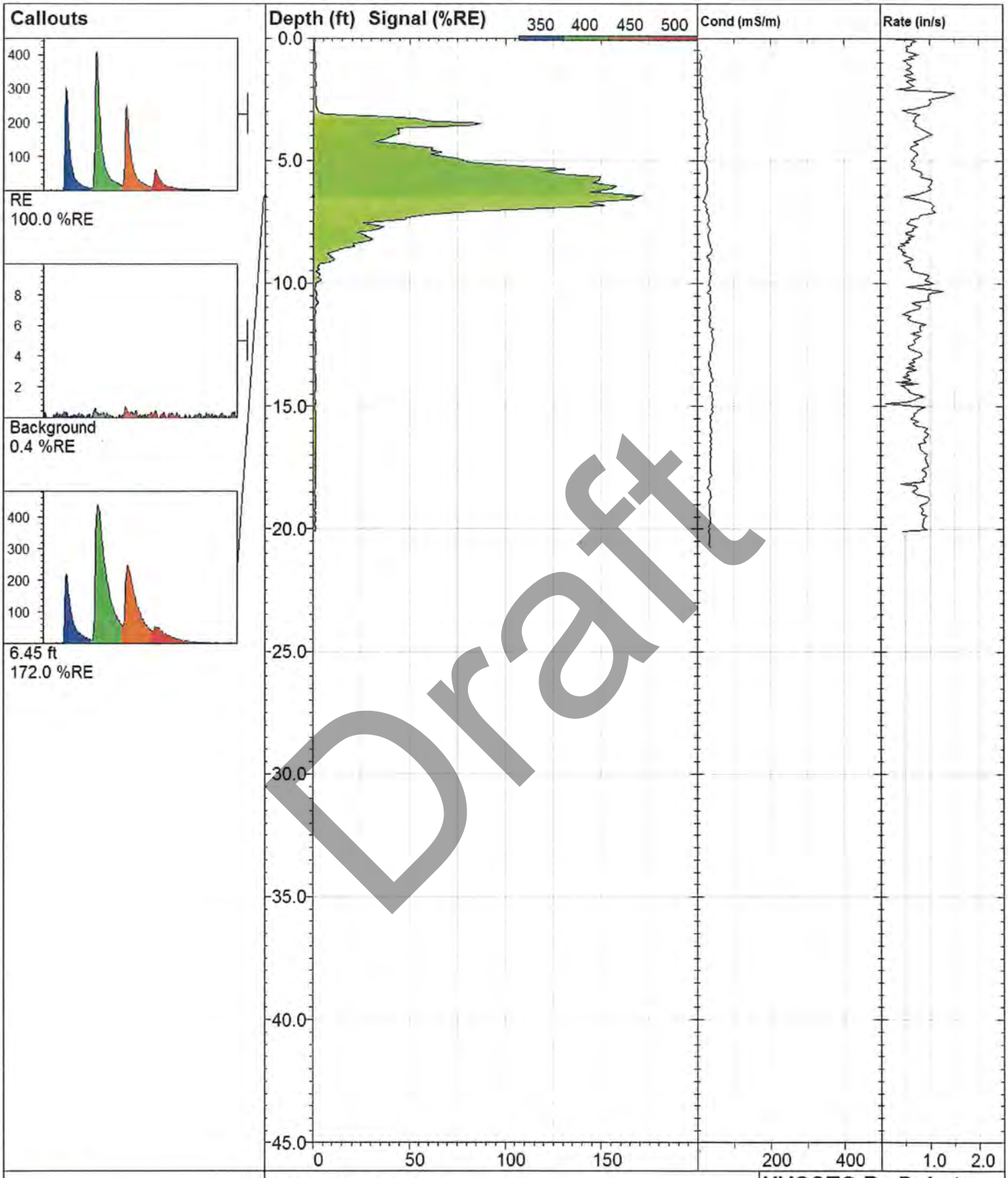
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **127.5 %RE @ 5.56 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 10:56 CST**



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LIF-2015-33

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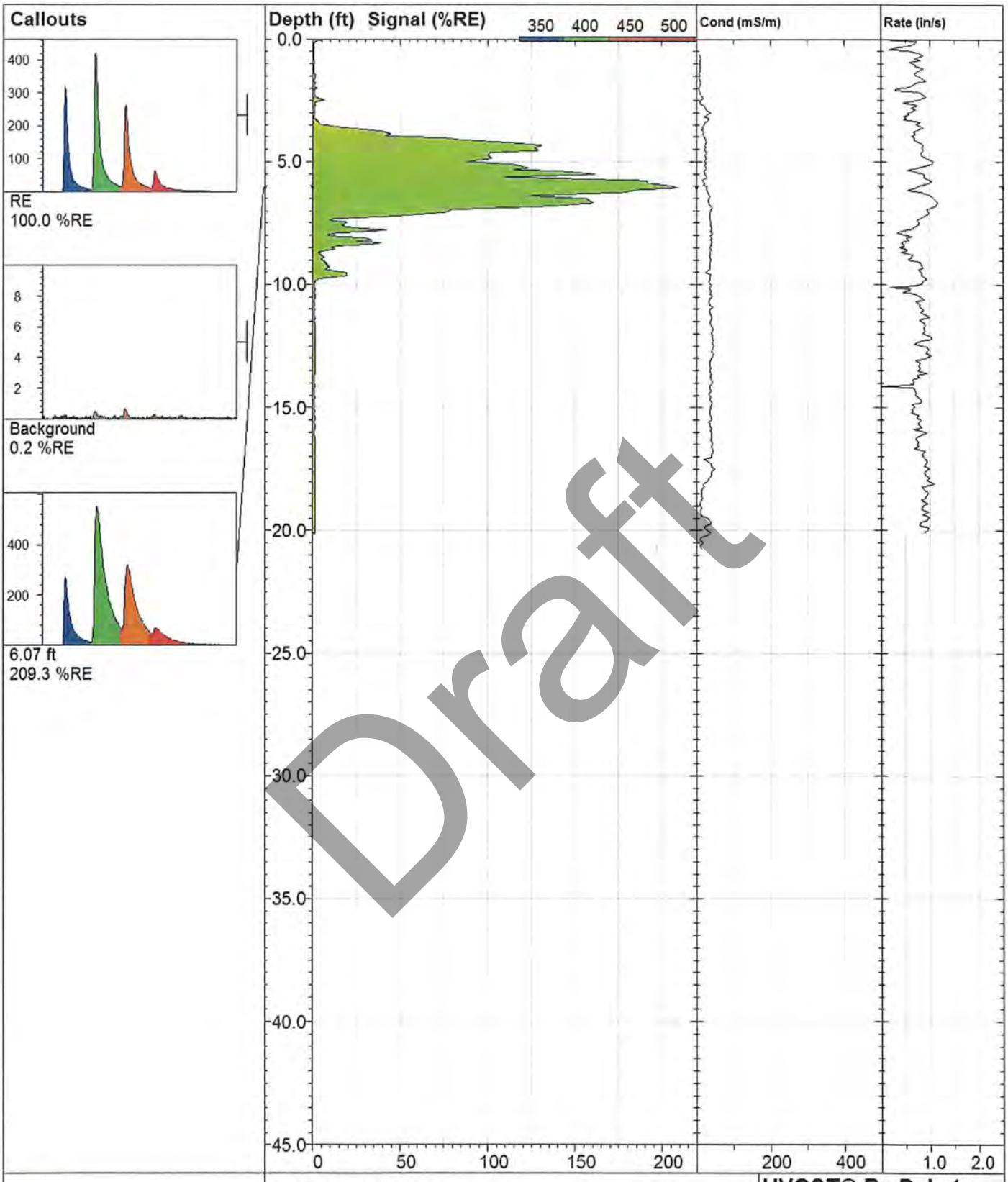
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.10 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **172.0 %RE @ 6.45 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 11:18 CST**



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LIF-2015-34

UVOST® By Dakota
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Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **209.3 %RE @ 6.07 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 11:46 CST**

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LIF-2015-35

UVOST® By Dakota
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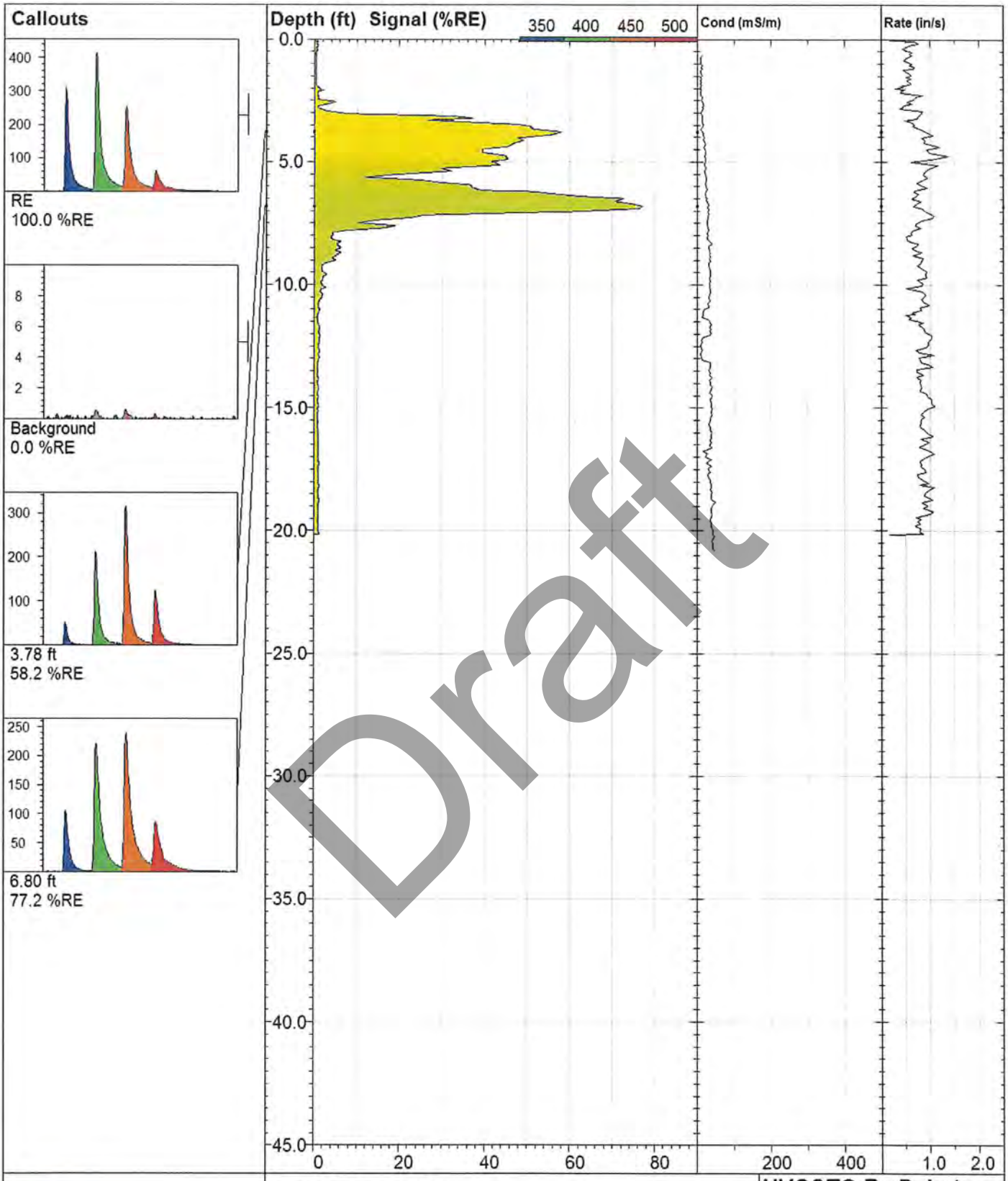
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **90.6 %RE @ 6.30 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 13:12 CST**



LIF-2015-36		**UVOST® By Dakota** www.DakotaTechnologies.com
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.16 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **77.2 %RE @ 6.80 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 13:33 CST**

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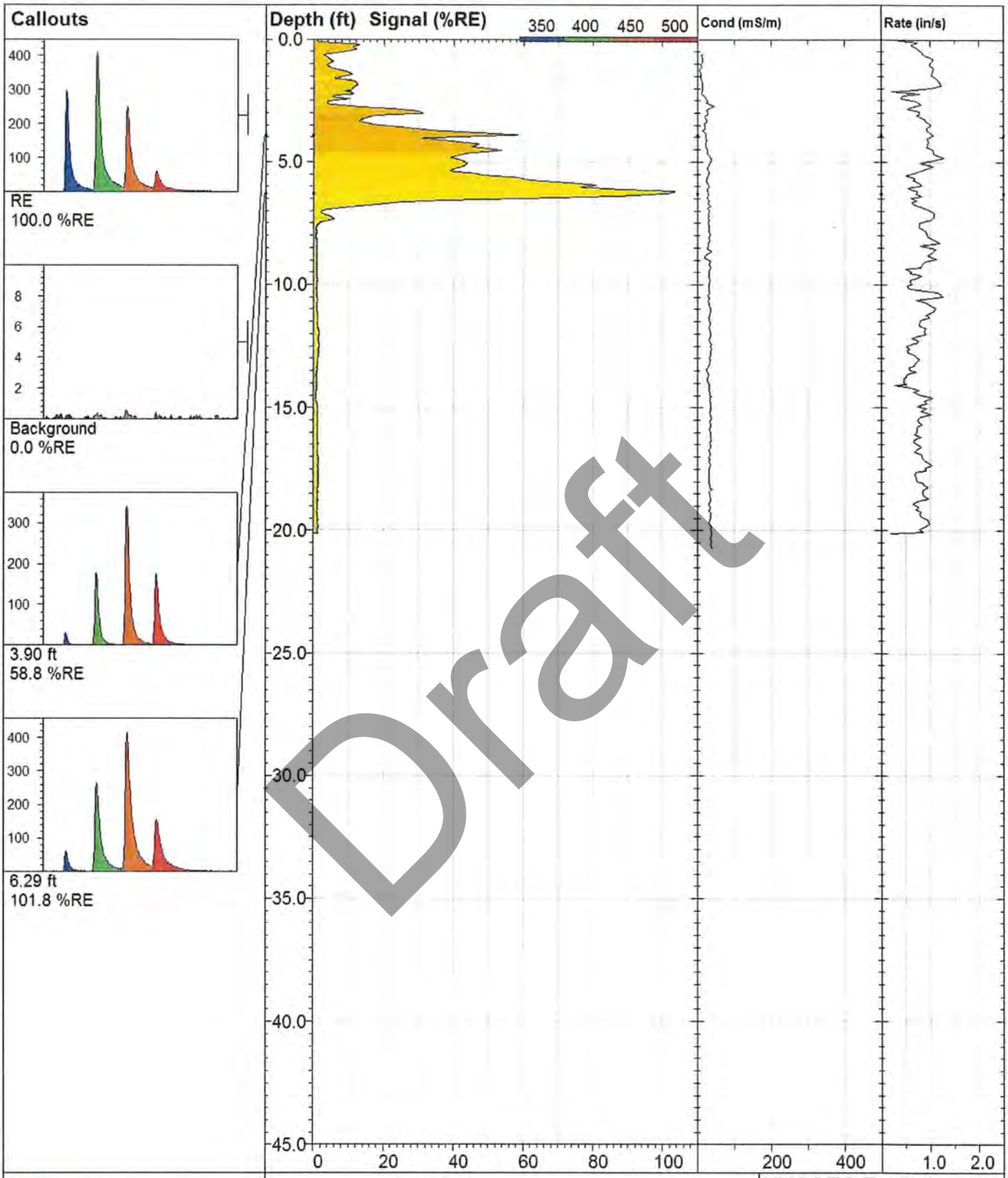

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LIF-2015-37

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Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.13 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **103.8 %RE @ 6.20 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 14:12 CST**

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LIF-2015-38

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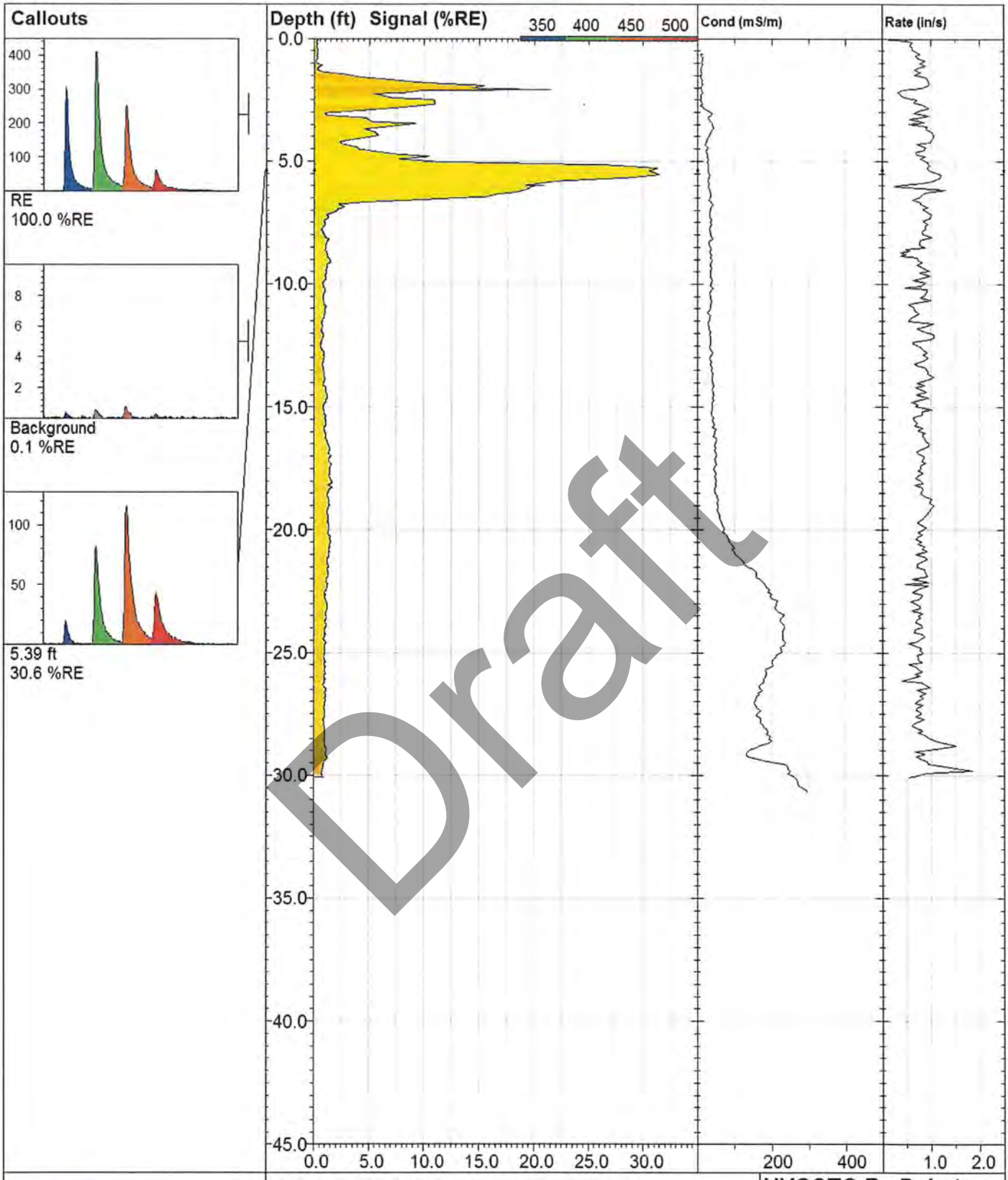
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **20.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **3.0 %RE @ 0.38 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 14:34 CST**



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LIF-2015-39

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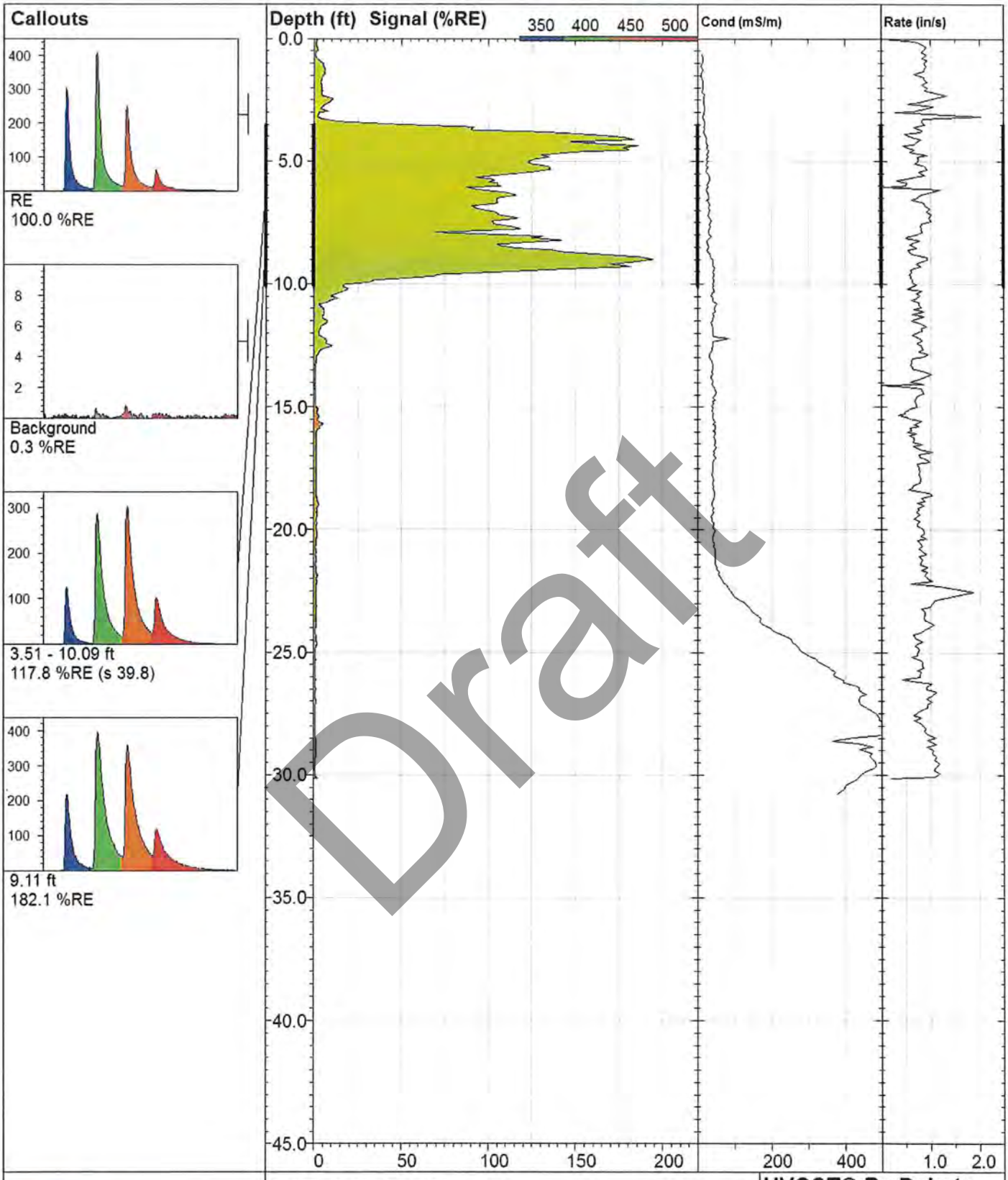
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.08 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **31.5 %RE @ 5.55 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 15:06 CST**



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LIF-2015-40

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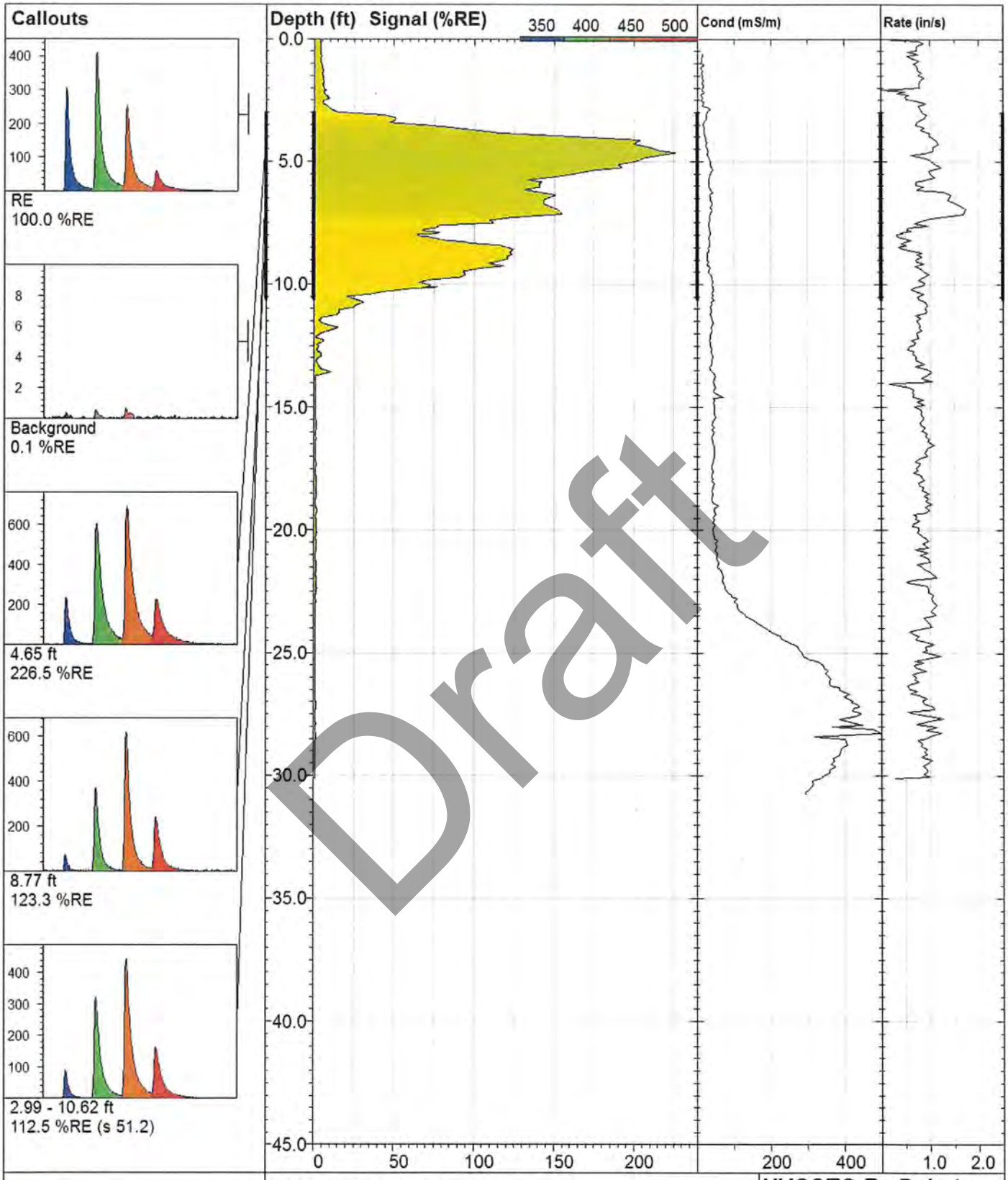
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.15 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **194.3 %RE @ 9.00 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 15:35 CST**



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LIF-2015-41

UVOST® By Dakota
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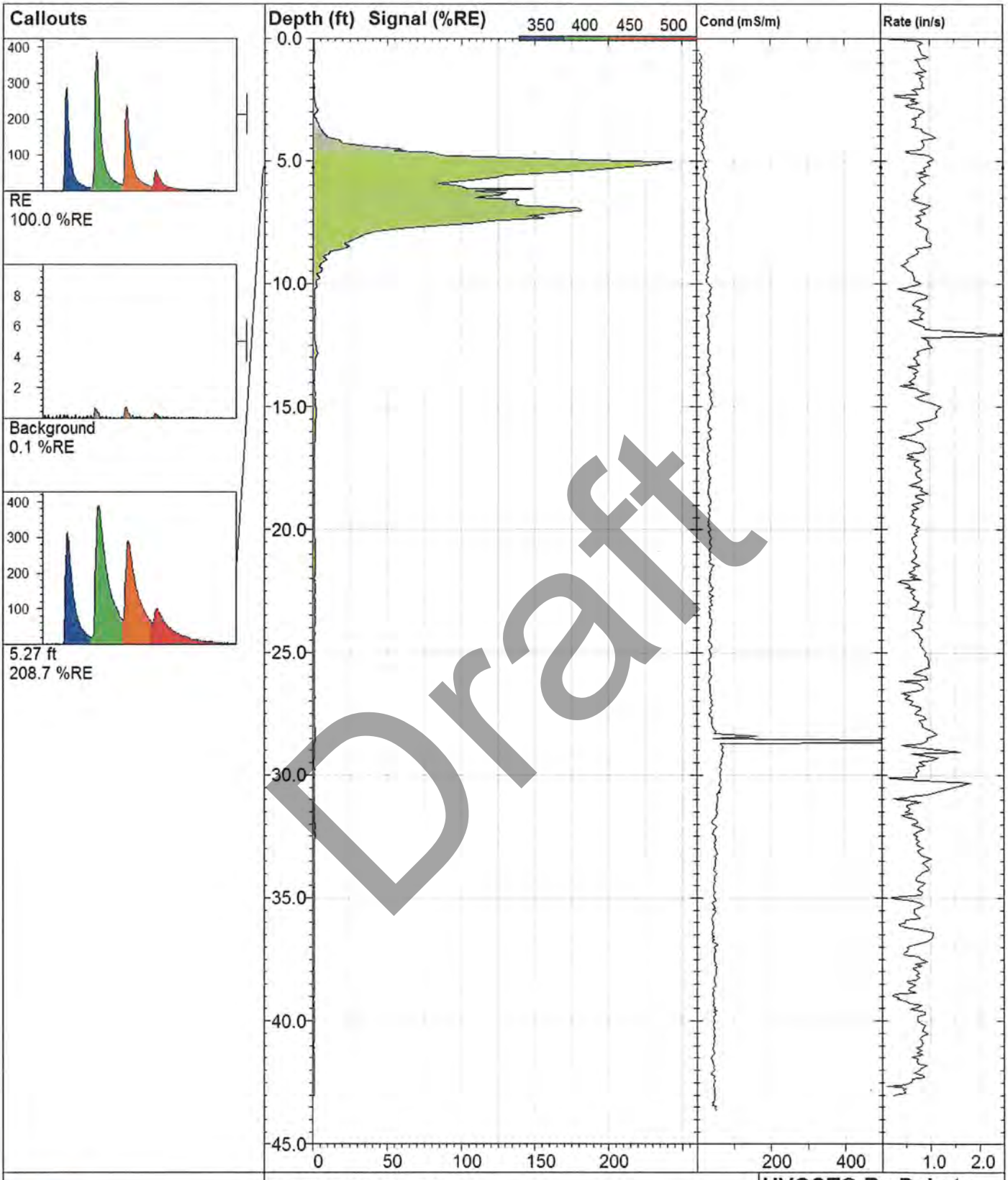
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **226.5 %RE @ 4.65 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-11 16:04 CST**



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LIF-2015-42

UVOST® By Dakota
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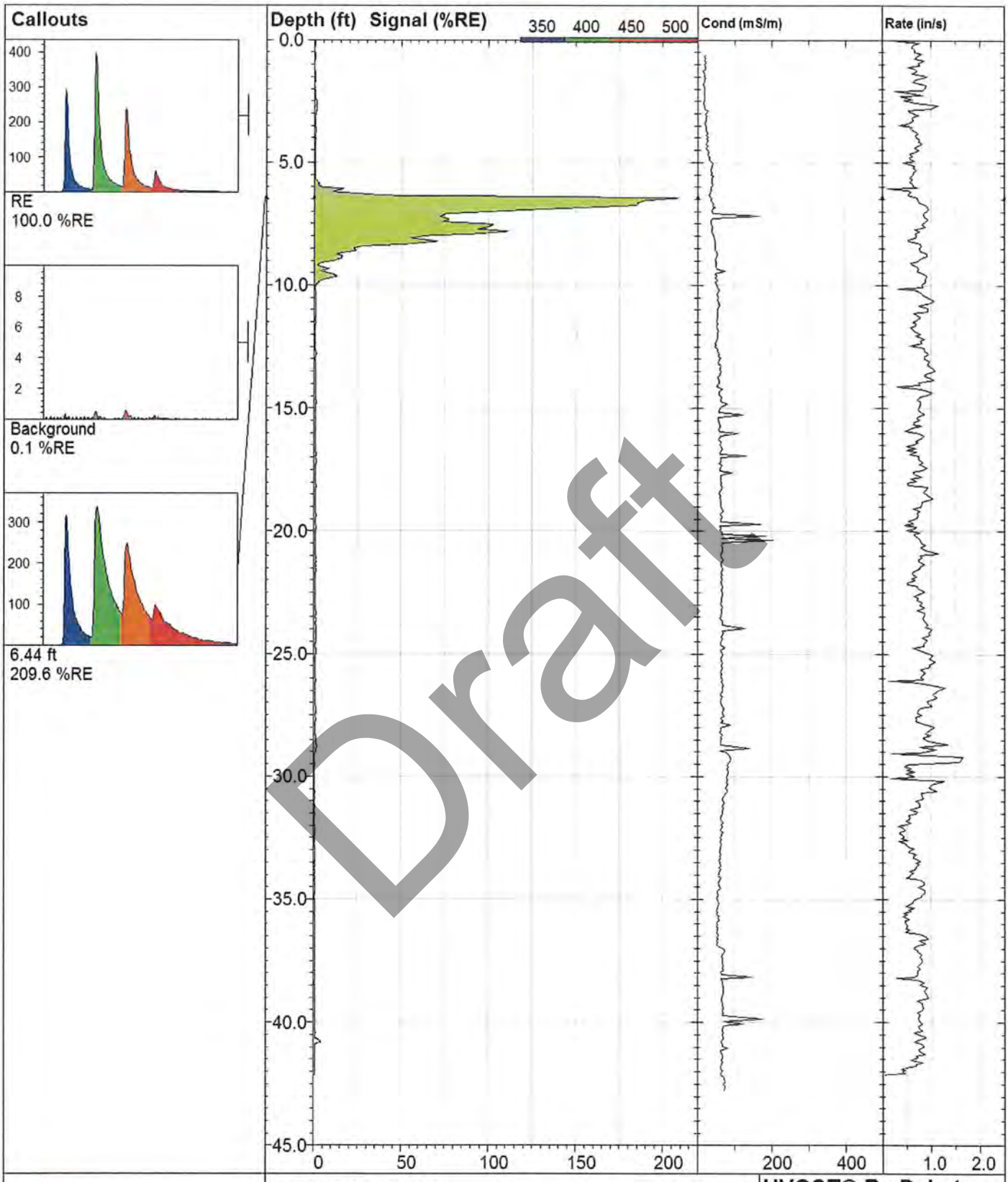
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **43.02 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **243.3 %RE @ 5.06 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 08:15 CST**



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LIF-2015-43

UVOST® By Dakota
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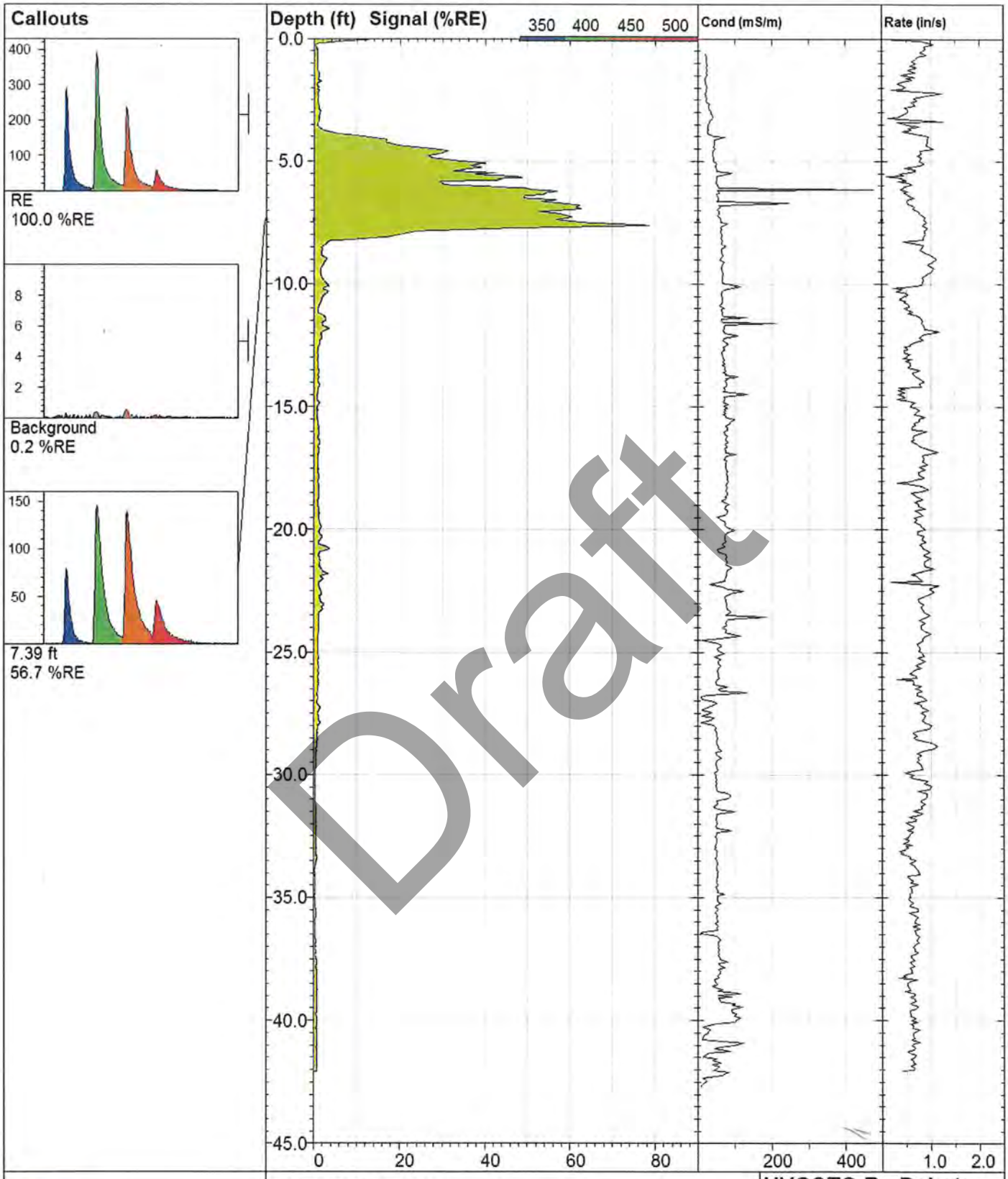
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **42.12 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **209.6 %RE @ 6.44 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 09:14 CST**



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LIF-2015-44

UVOST® By Dakota
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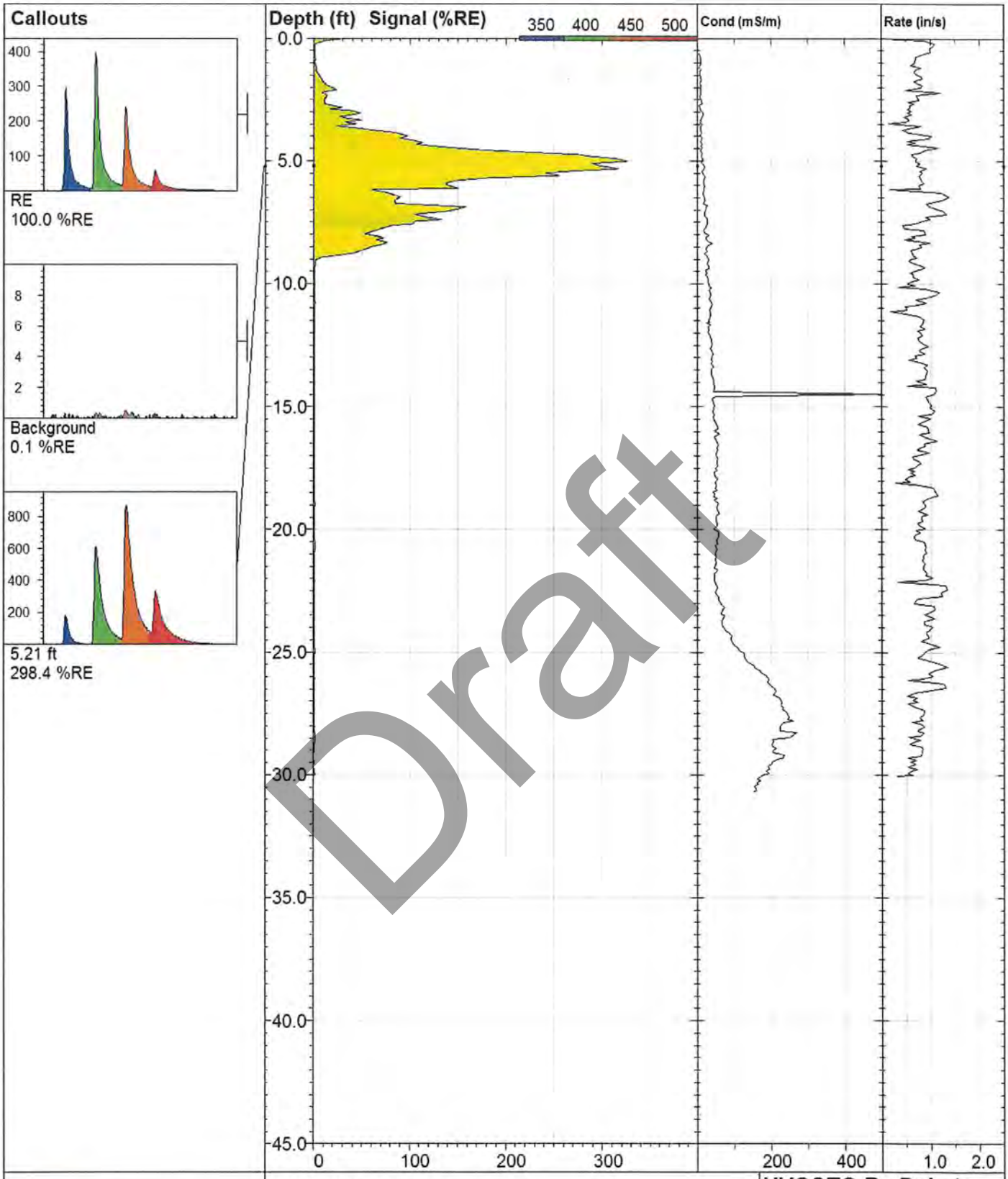
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **42.05 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **79.2 %RE @ 7.62 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 09:56 CST**



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LIF-2015-45

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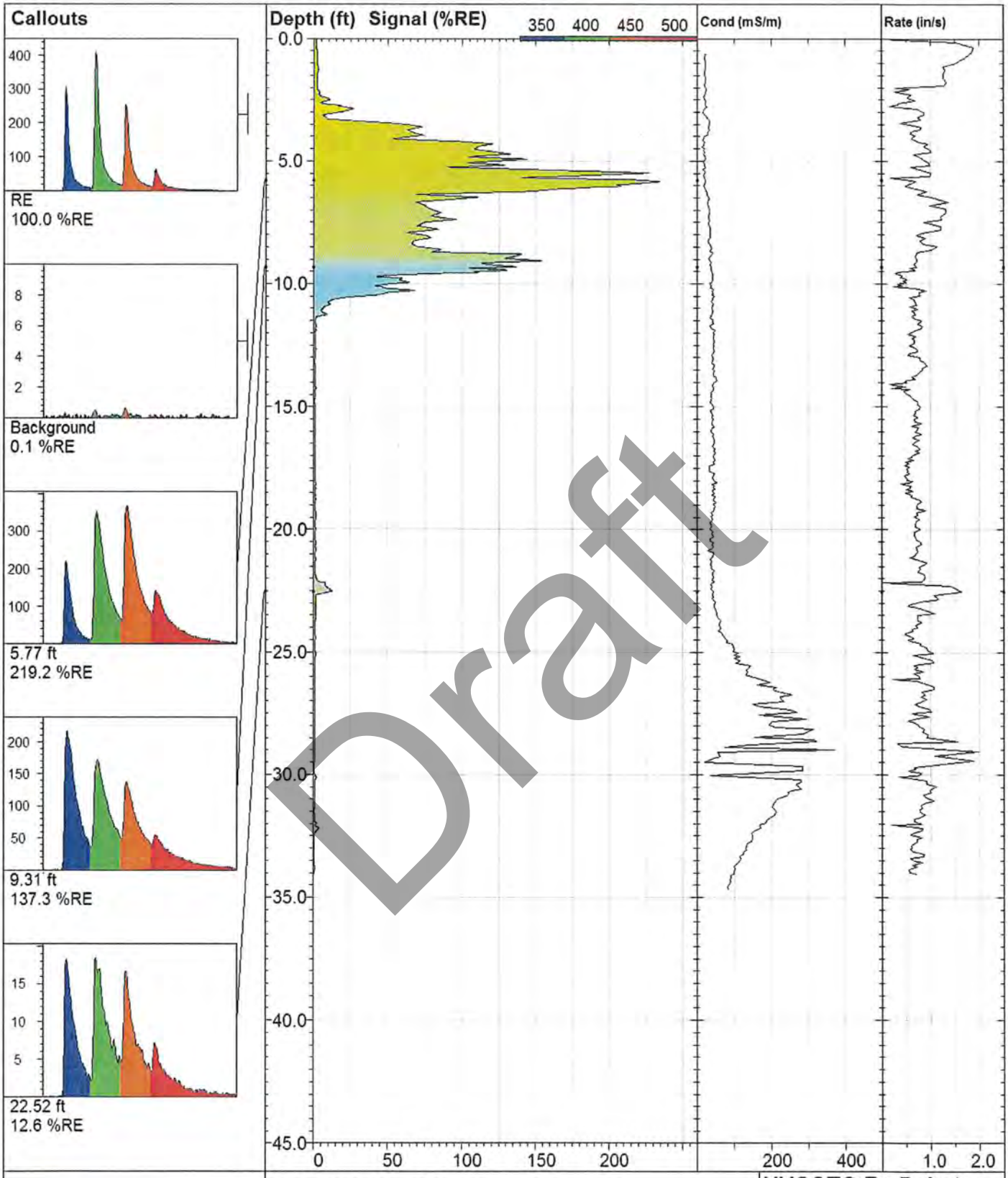
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.07 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **325.7 %RE @ 5.02 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 11:17 CST**



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LIF-2015-46

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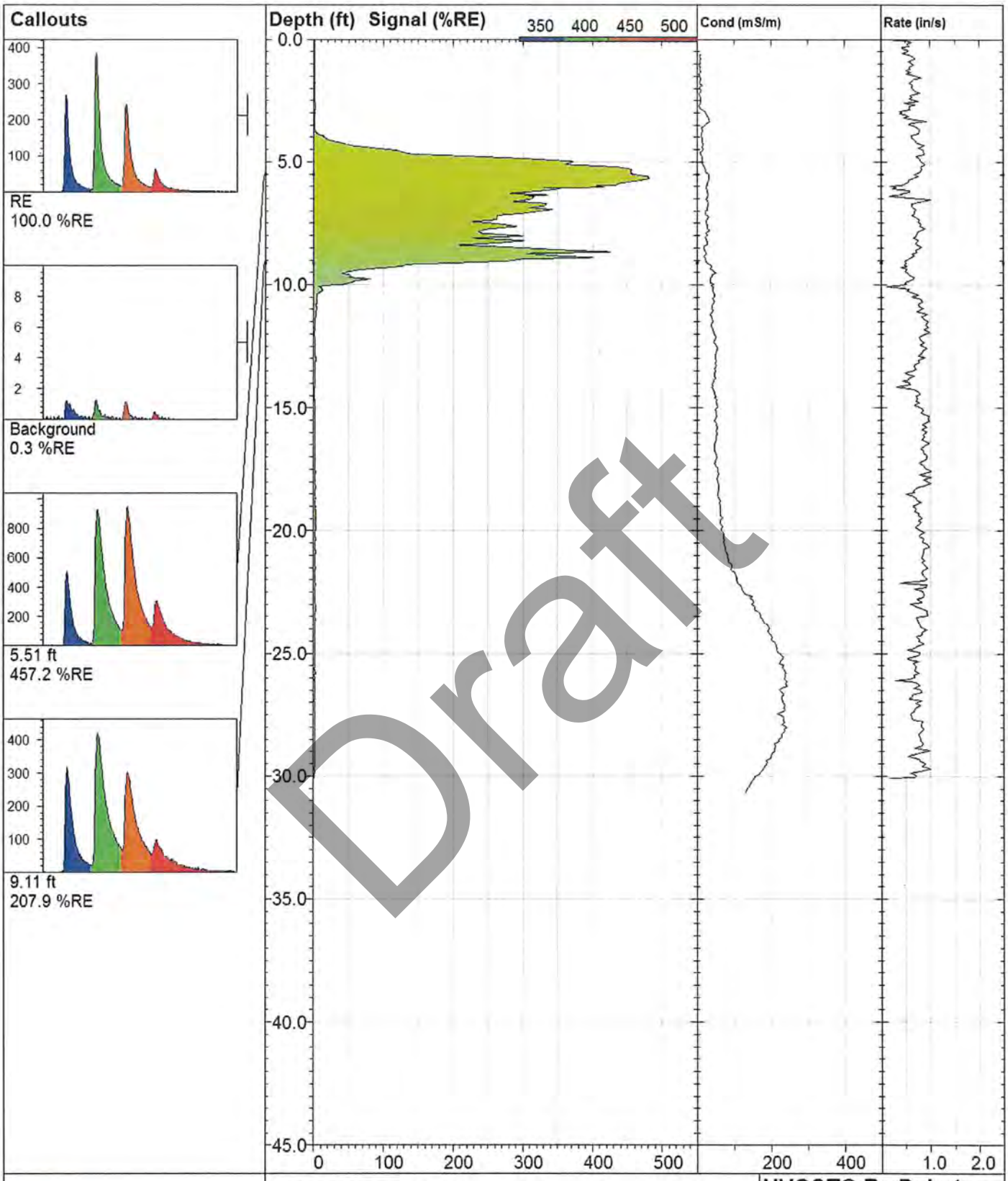
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **34.07 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **234.8 %RE @ 5.84 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 11:50 CST**



LIF-2015-47

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MATRIX ENVIRONMENTAL LLC
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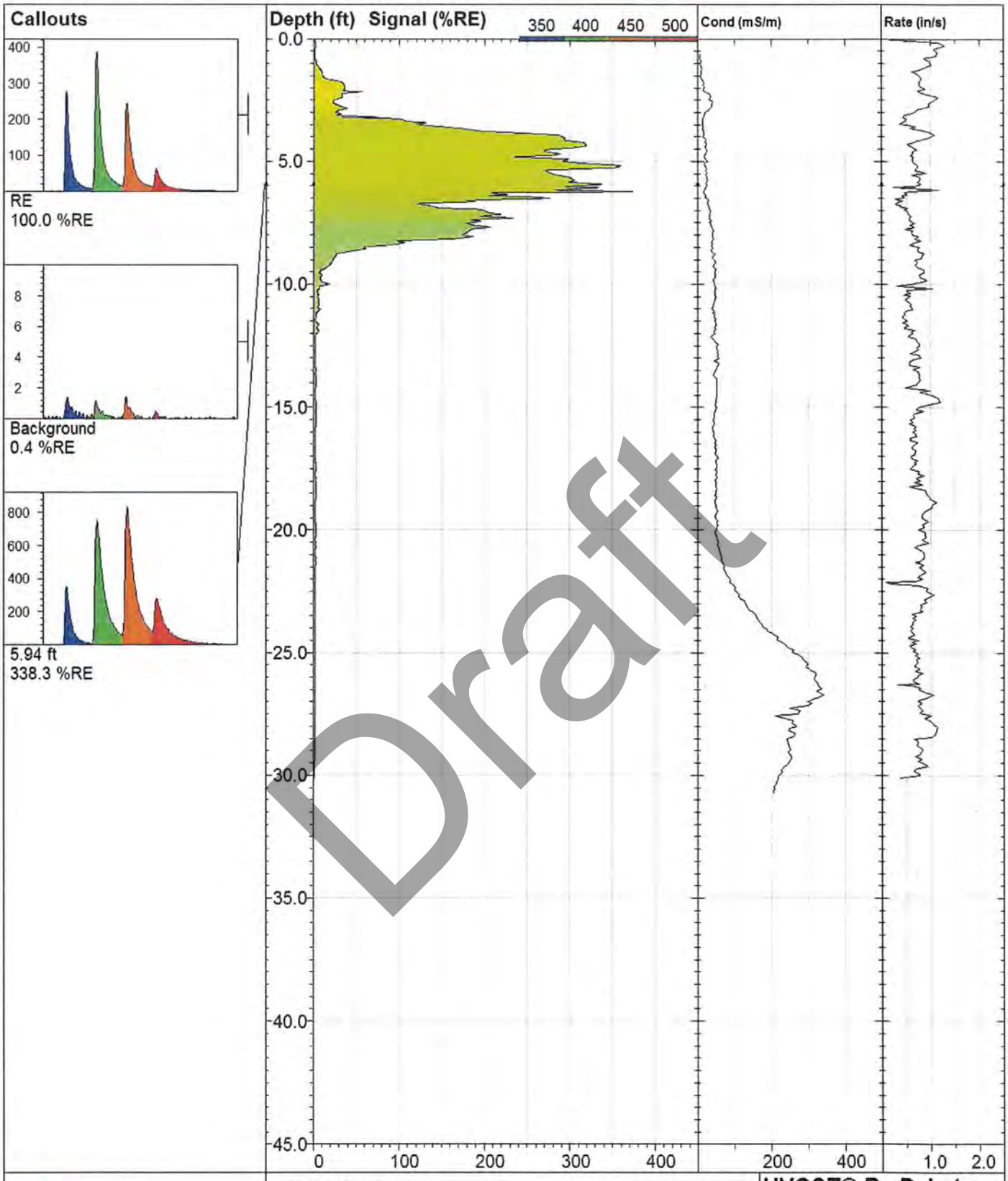
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.08 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **481.4 %RE @ 5.69 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 14:00 CST**



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MATRIX ENVIRONMENTAL LLC
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LIF-2015-48

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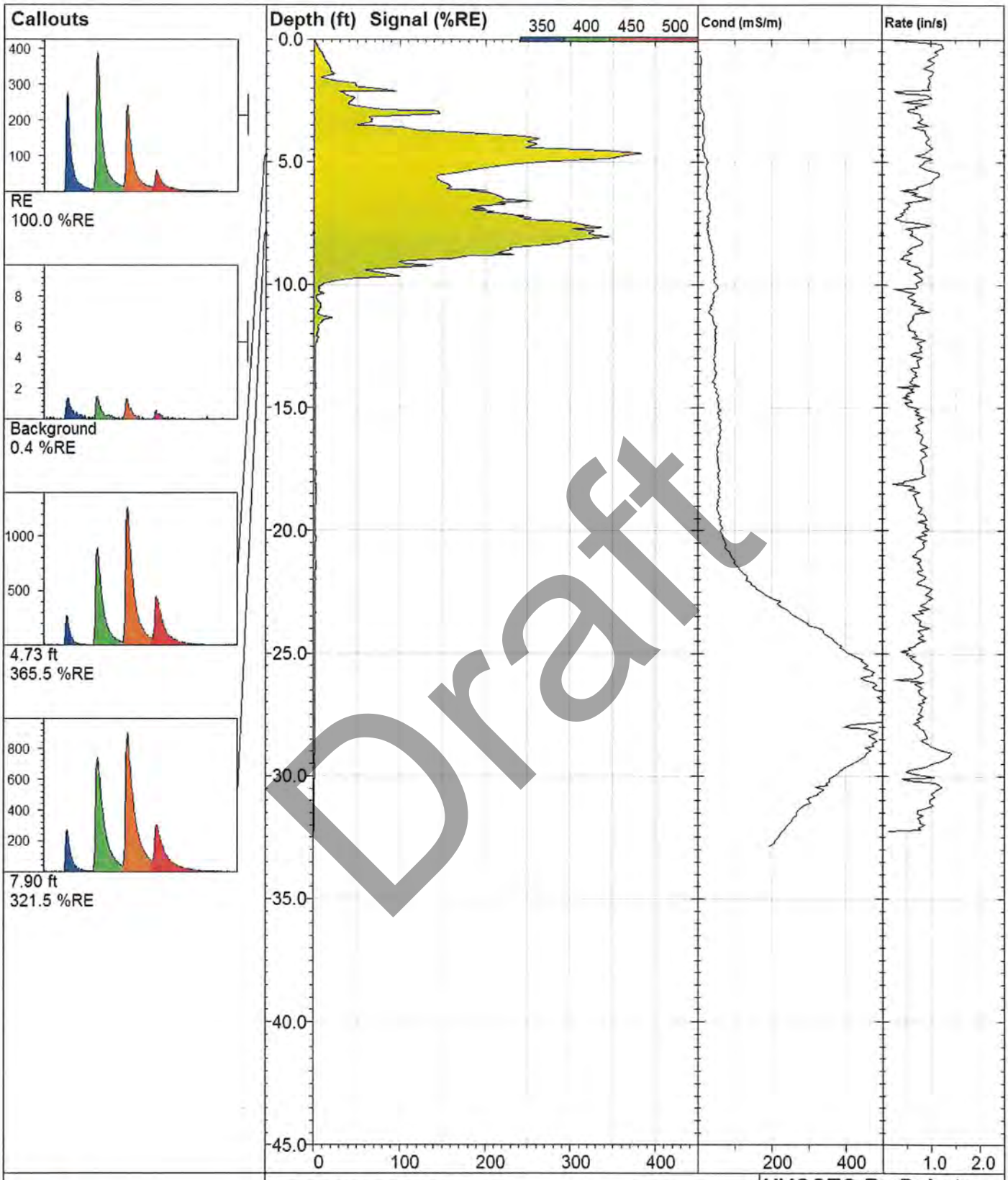
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.10 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **377.1 %RE @ 6.24 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 14:32 CST**



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LIF-2015-49

UVOST® By Dakota
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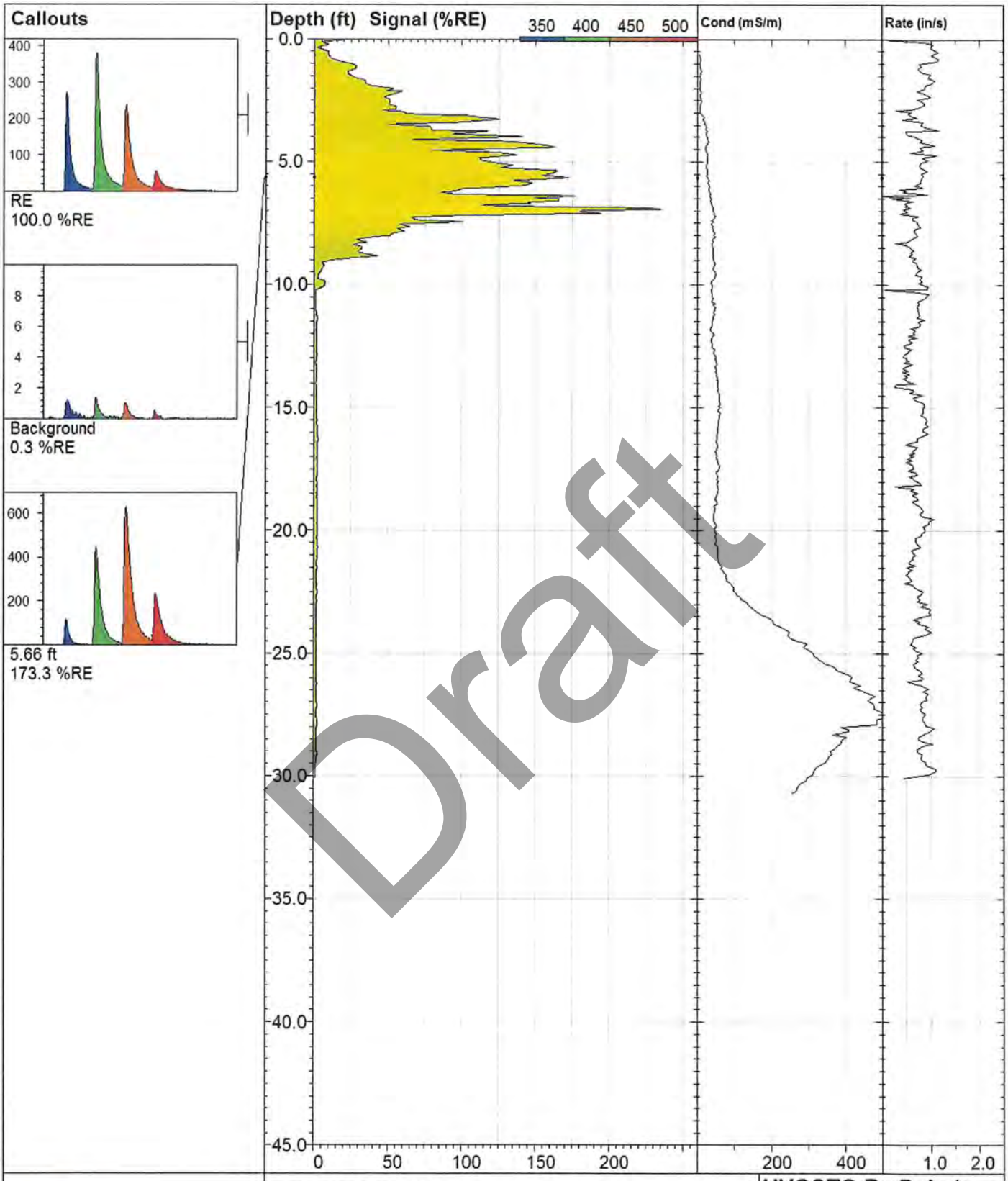
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **32.24 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **383.1 %RE @ 4.65 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 14:59 CST**



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LIF-2015-50

UVOST® By Dakota
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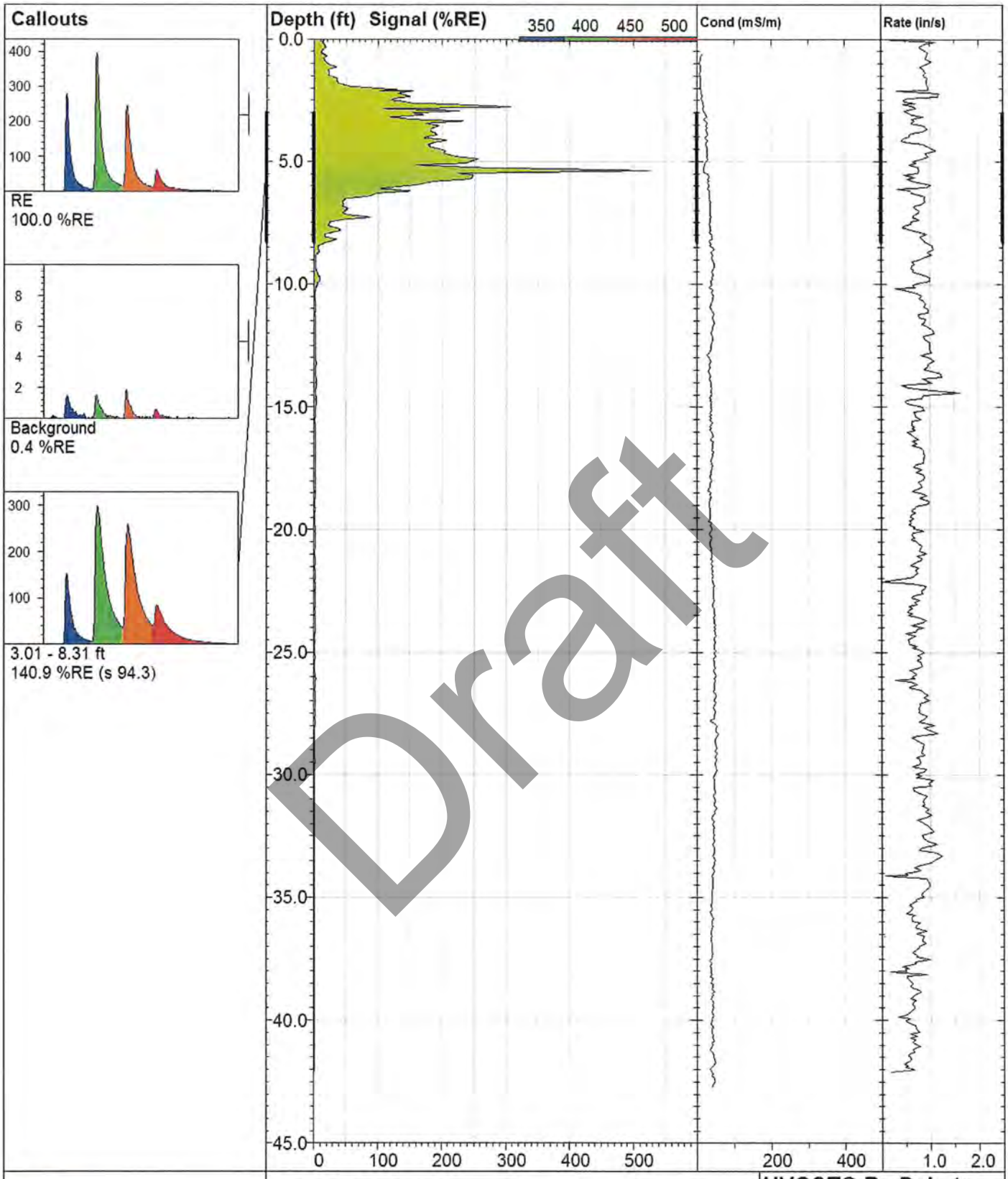
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **30.08 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **235.3 %RE @ 6.93 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 15:29 CST**



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LIF-2015-51

UVOST® By Dakota
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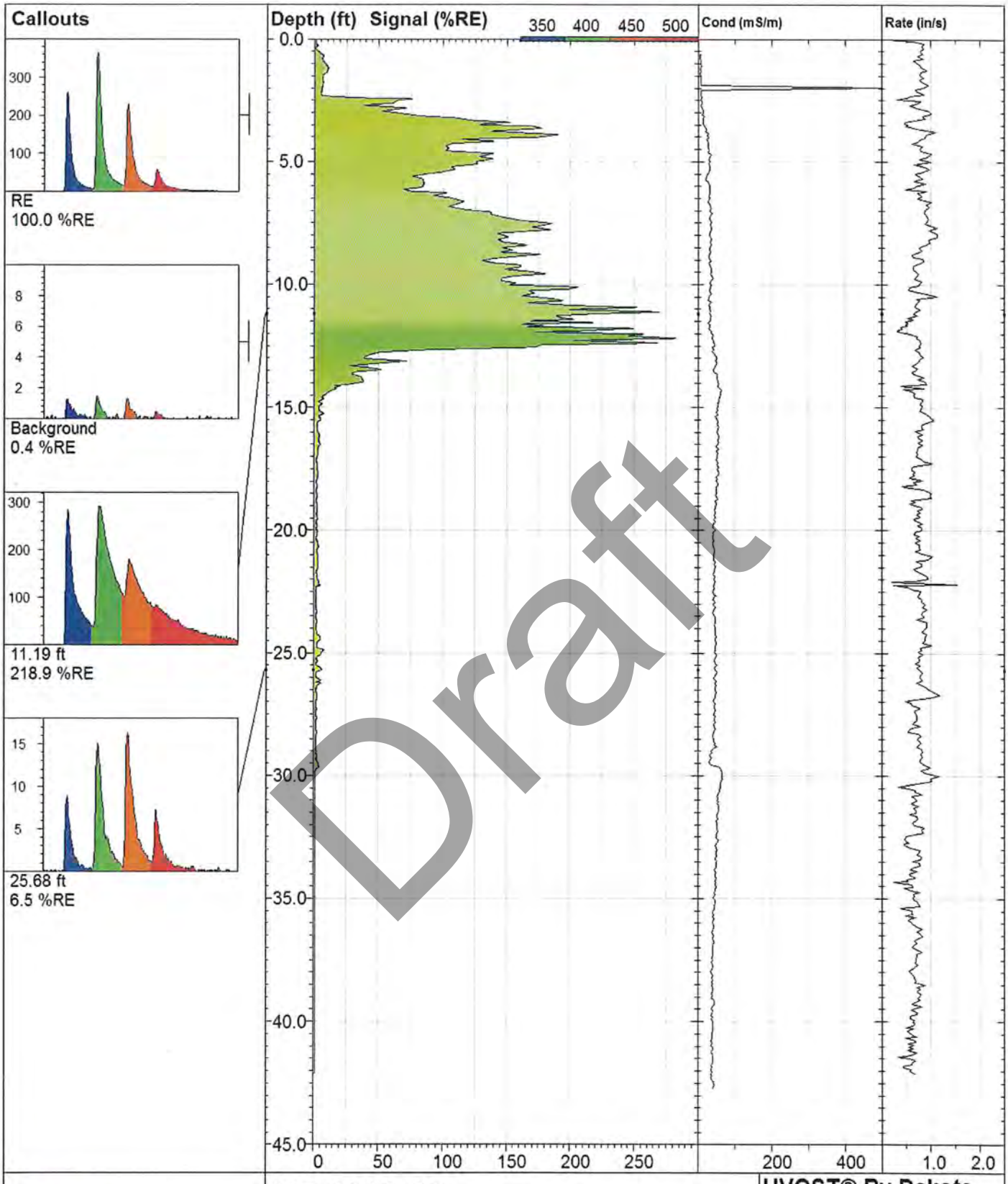
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **42.10 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **531.9 %RE @ 5.38 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-12 16:13 CST**



Draft

MATRIX ENVIRONMENTAL LLC
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LIF-2015-52

UVOST® By Dakota
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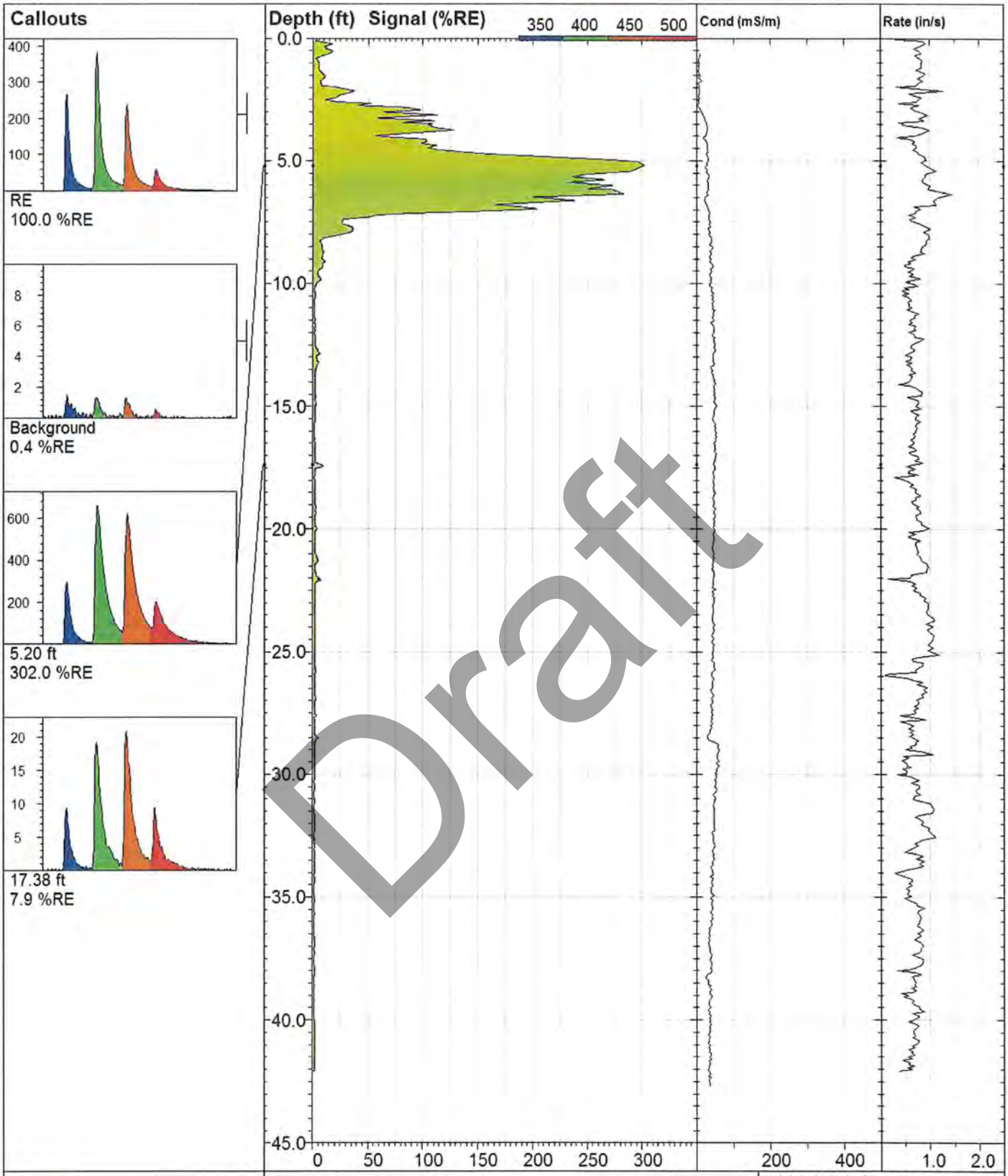
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **42.09 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **283.6 %RE @ 12.19 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 07:50 CST**



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LIF-2015-53

UVOST® By Dakota
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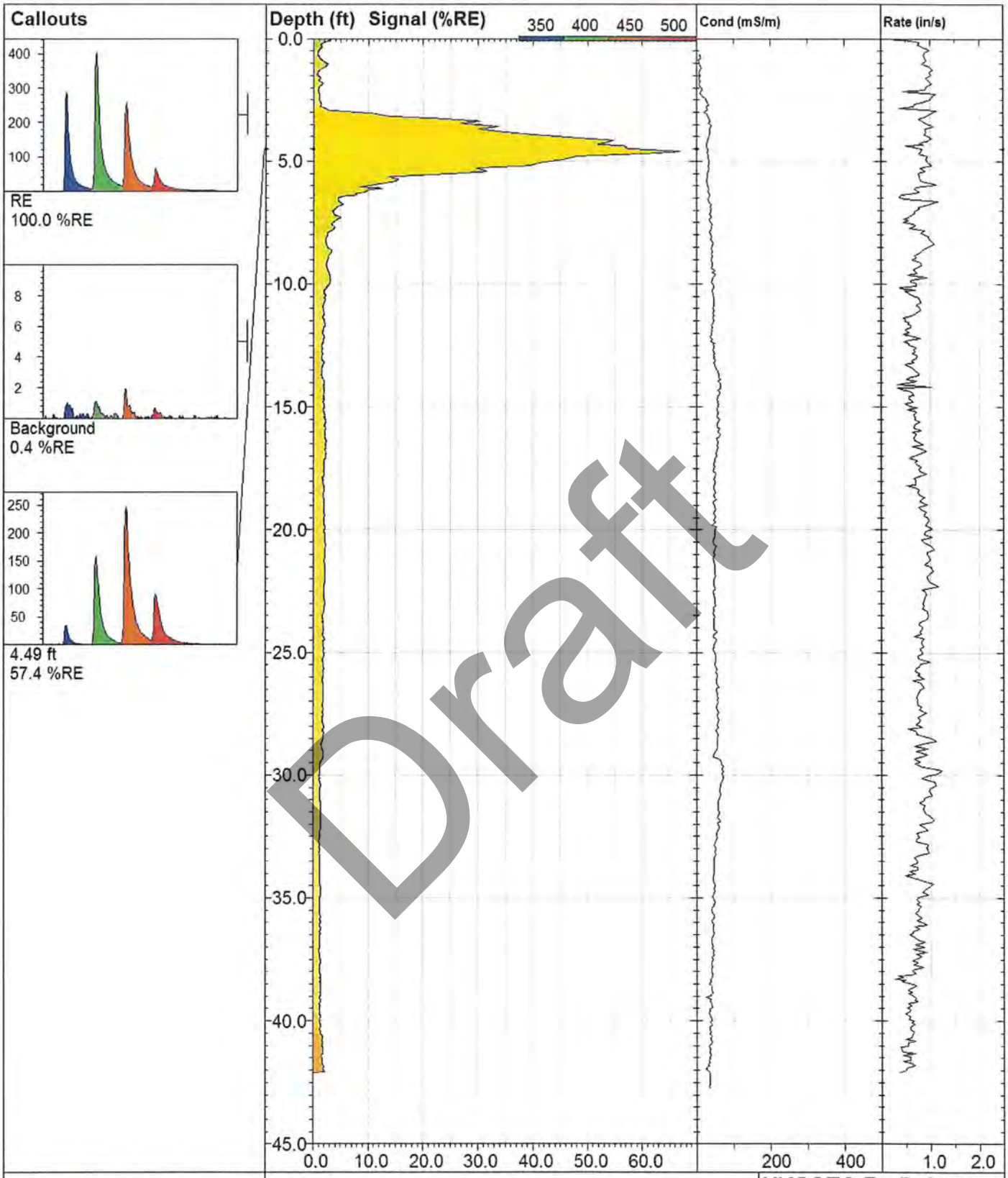
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **42.06 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **302.0 %RE @ 5.20 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 08:29 CST**



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LIF-2015-54

UVOST® By Dakota
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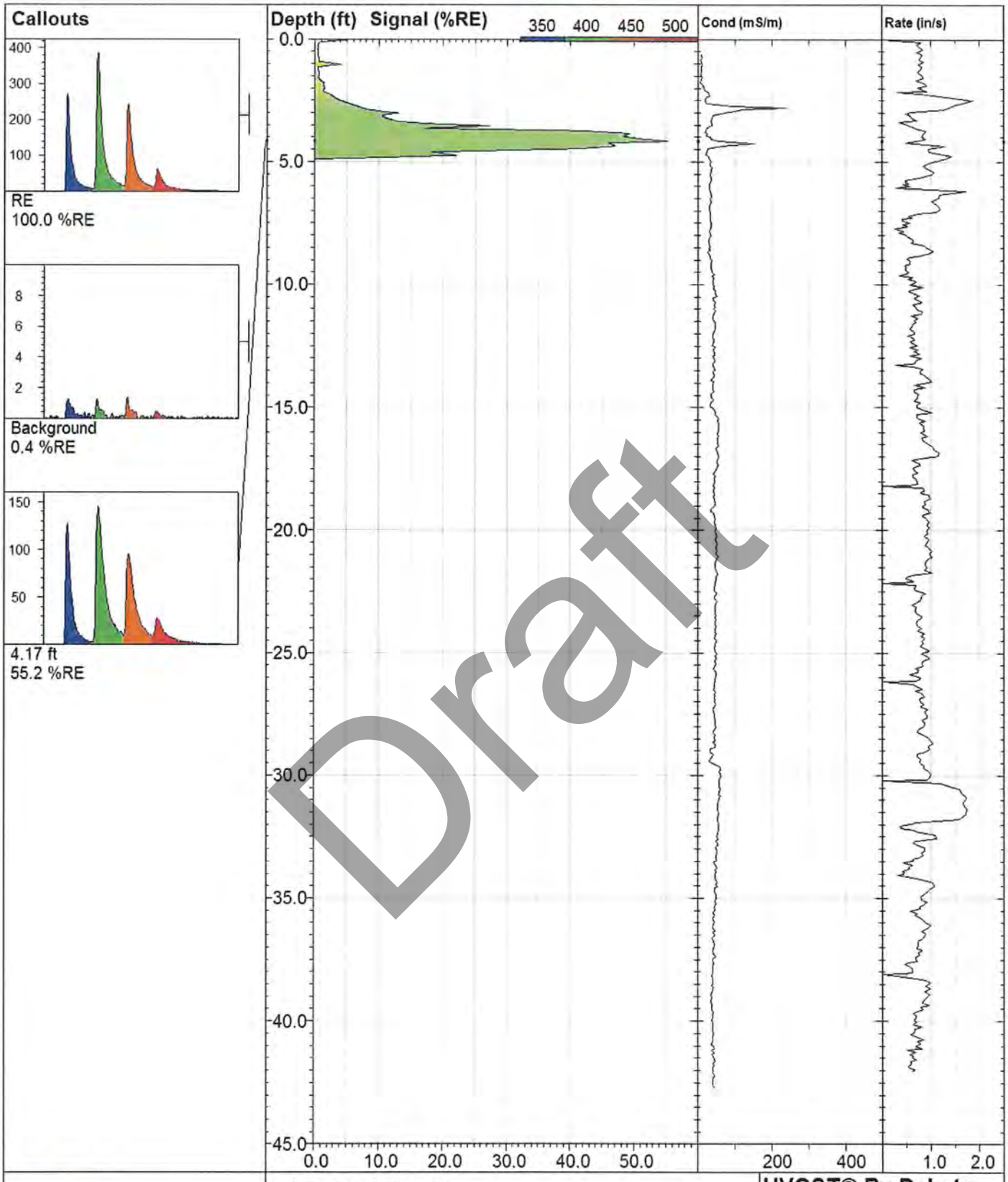
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **42.08 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **67.2 %RE @ 4.60 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 09:22 CST**



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LIF-2015-55

UVOST® By Dakota
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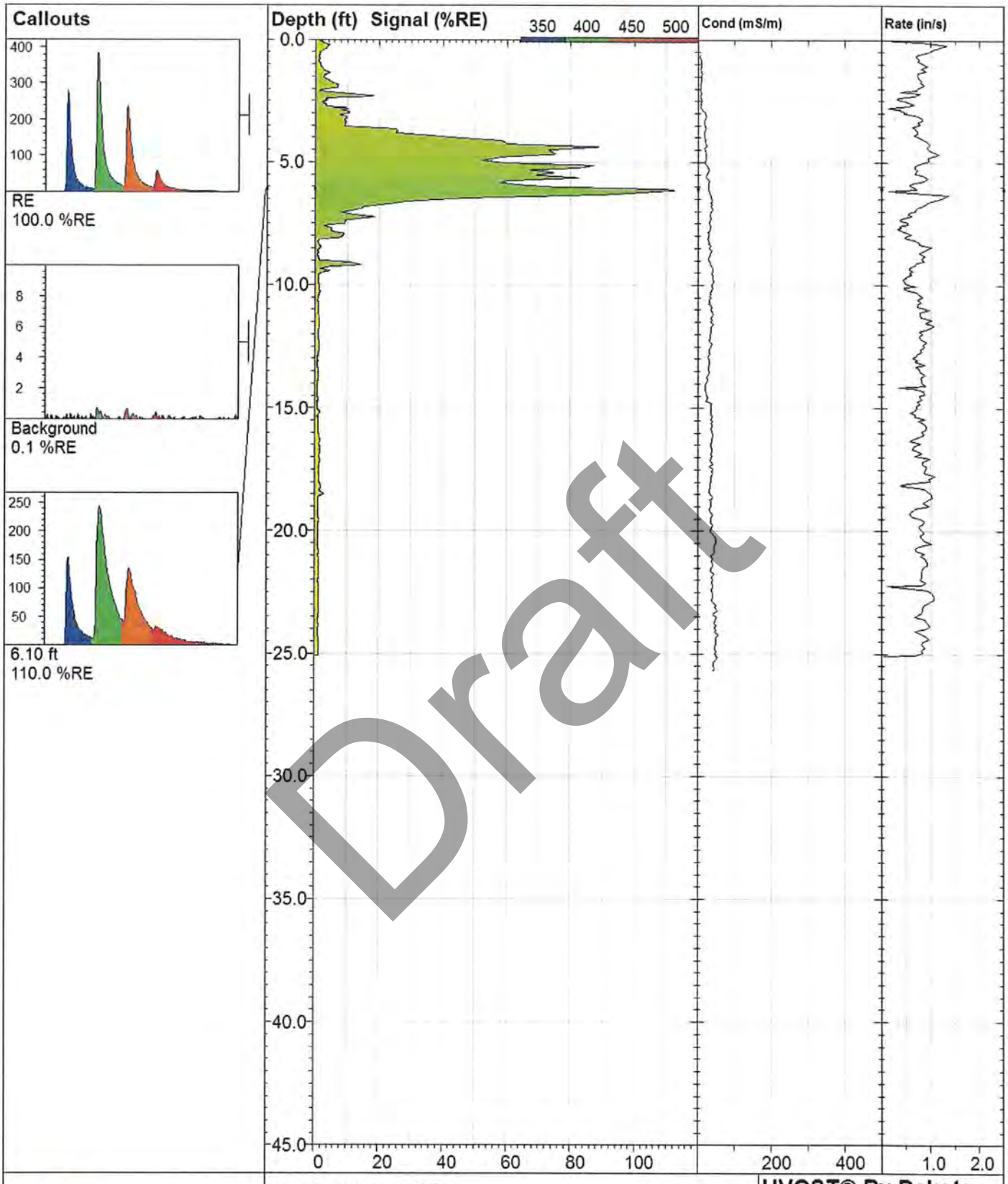
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **42.06 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **55.2 %RE @ 4.17 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 10:04 CST**



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LIF-2015-56

UVOST® By Dakota
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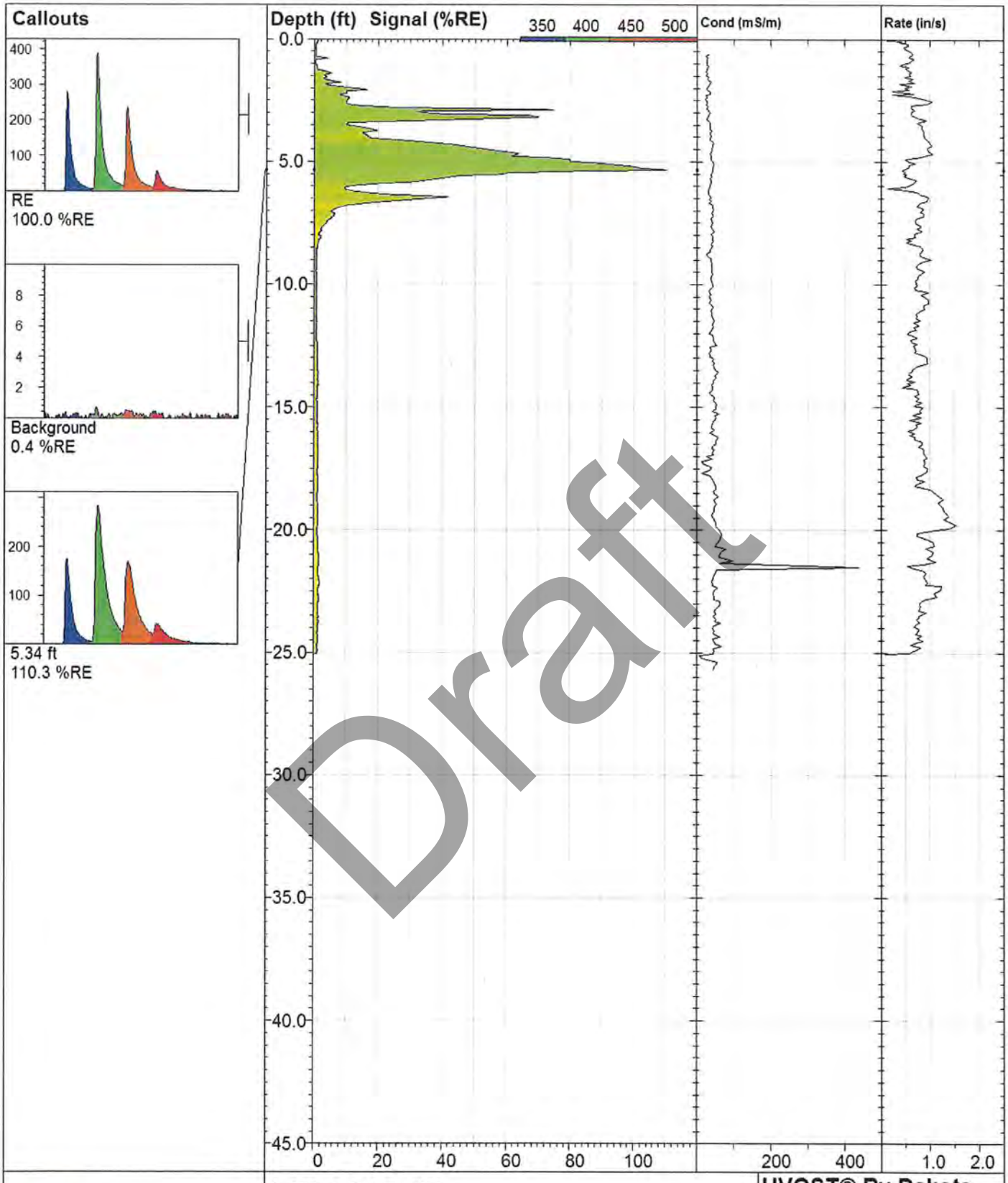
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.08 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **112.6 %RE @ 6.15 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 11:24 CST**



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LIF-2015-57

UVOST® By Dakota
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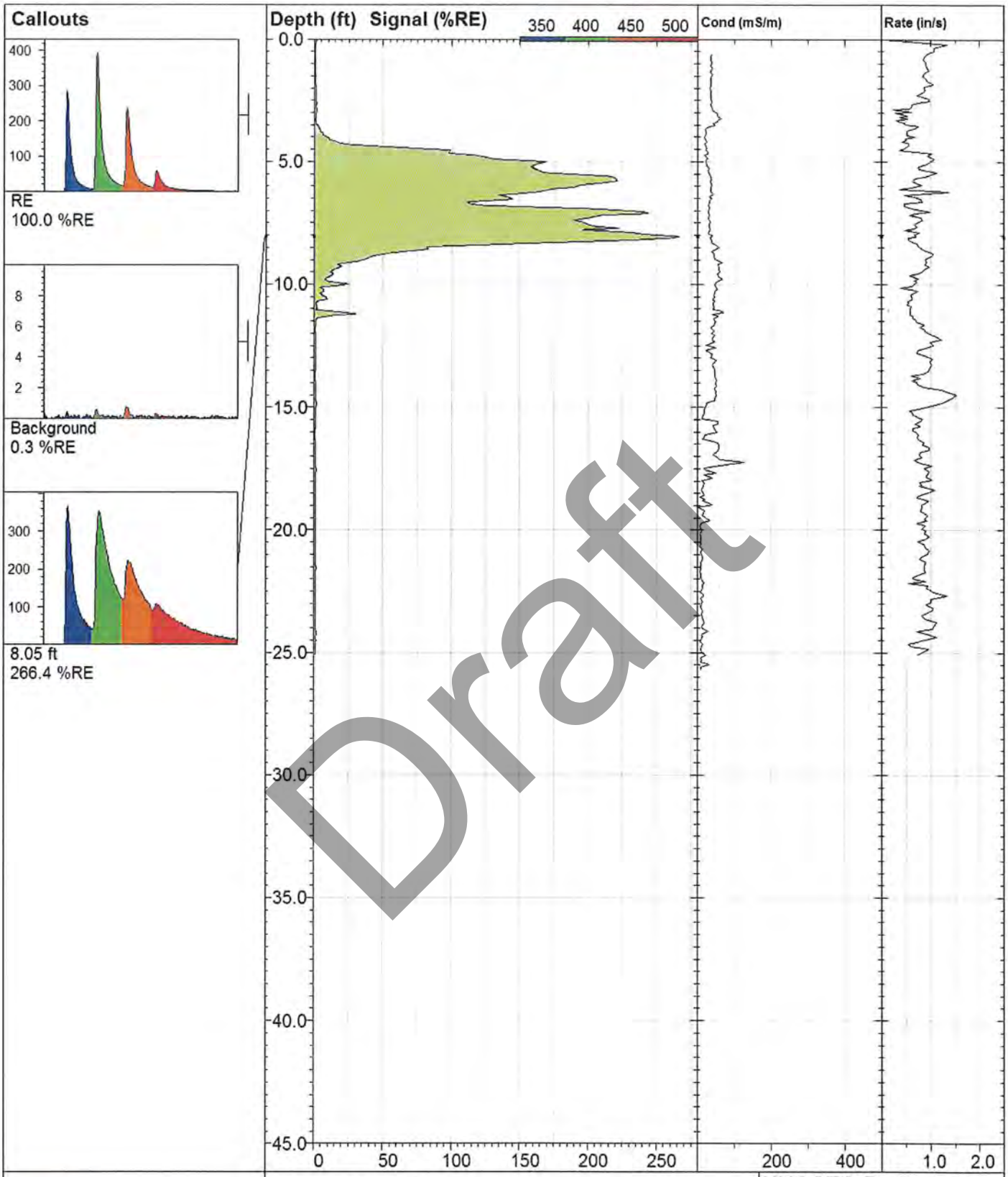
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.06 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **110.3 %RE @ 5.34 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 11:47 CST**



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LIF-2015-58

UVOST® By Dakota
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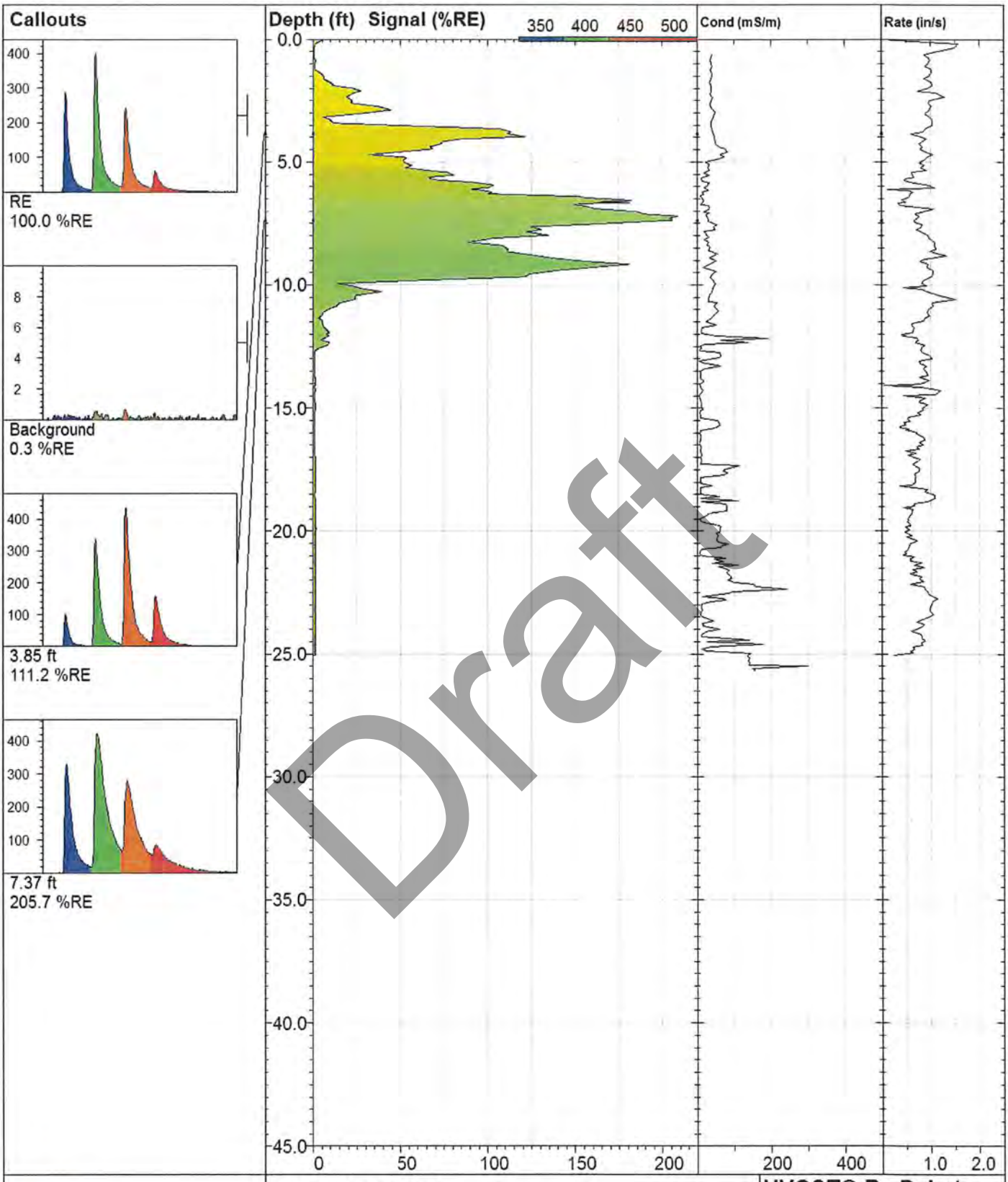
Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.10 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **266.4 %RE @ 8.05 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 12:24 CST**



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LIF-2015-59

UVOST® By Dakota
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Site: **Former ECI Refinery**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **25.06 ft**
Client / Job: **Arcadis / 289.15**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **209.0 %RE @ 7.20 ft**
Operator / Unit: **BG/EW / UVOST1023**	*Elevation:* **Unavailable**	*Date & Time:* **2015-11-13 12:55 CST**

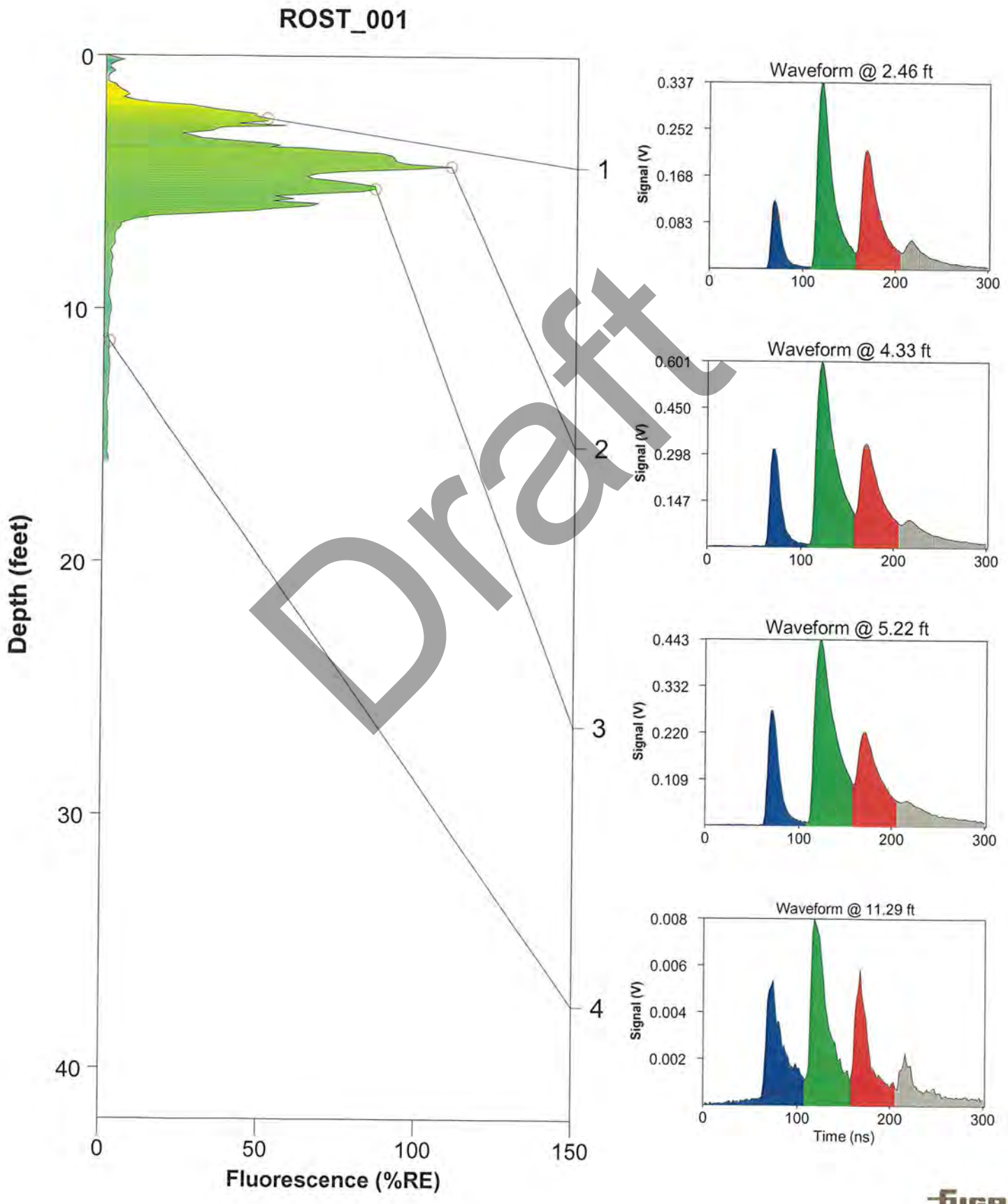
APPENDIX M

ROST Logs

Draft

ROST Fluorescence Response Data

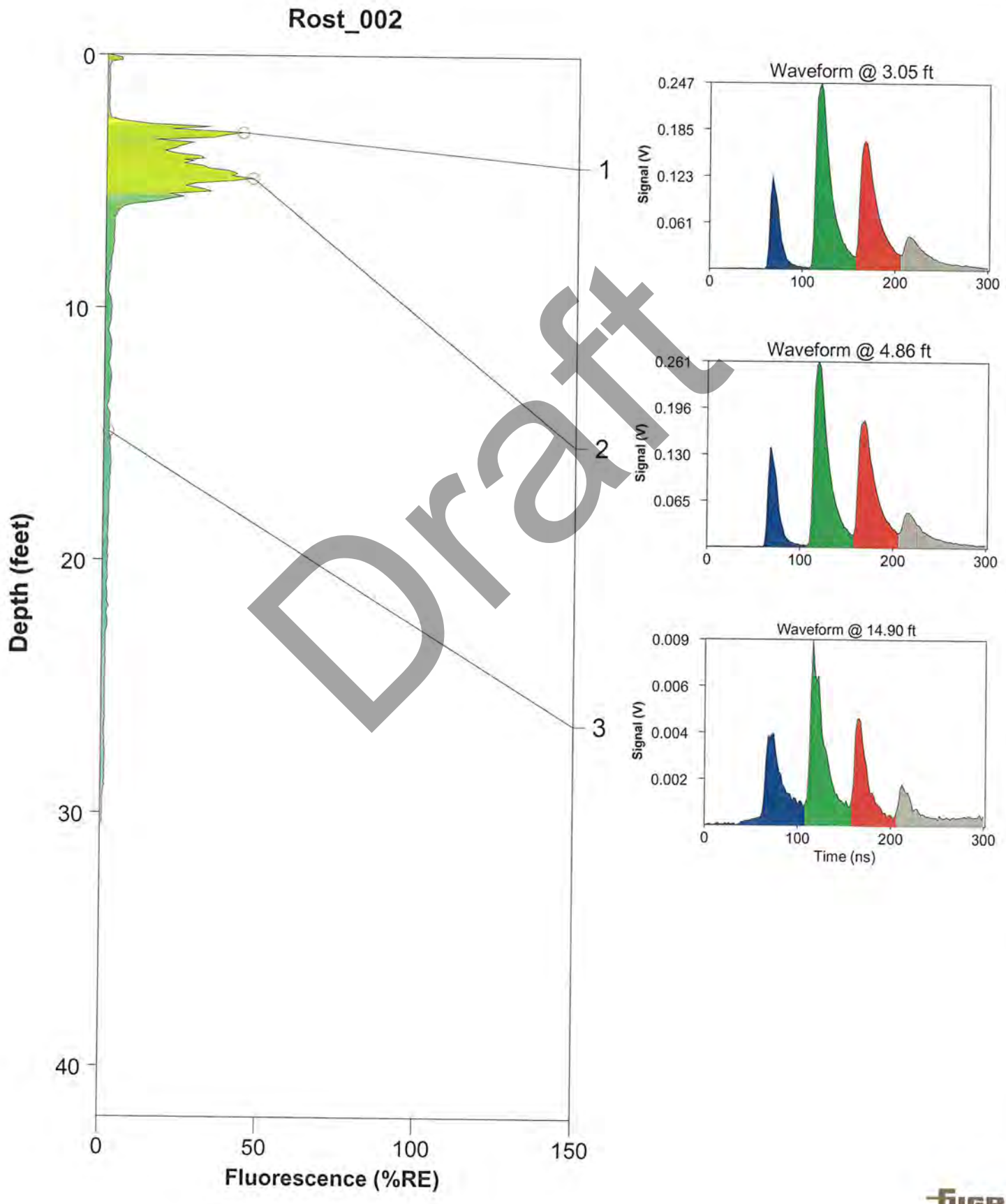
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-22-2002 @ 11:33:55	Max fluorescence: 109.89% @ 4.33 ft
ROST Unit: ?	Final depth BGS: 16.04 ft



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-22-2002 @ 12:58:14	Max fluorescence: 46.68% @ 4.86 ft
ROST Unit: ?	Final depth BGS: 30.41 ft

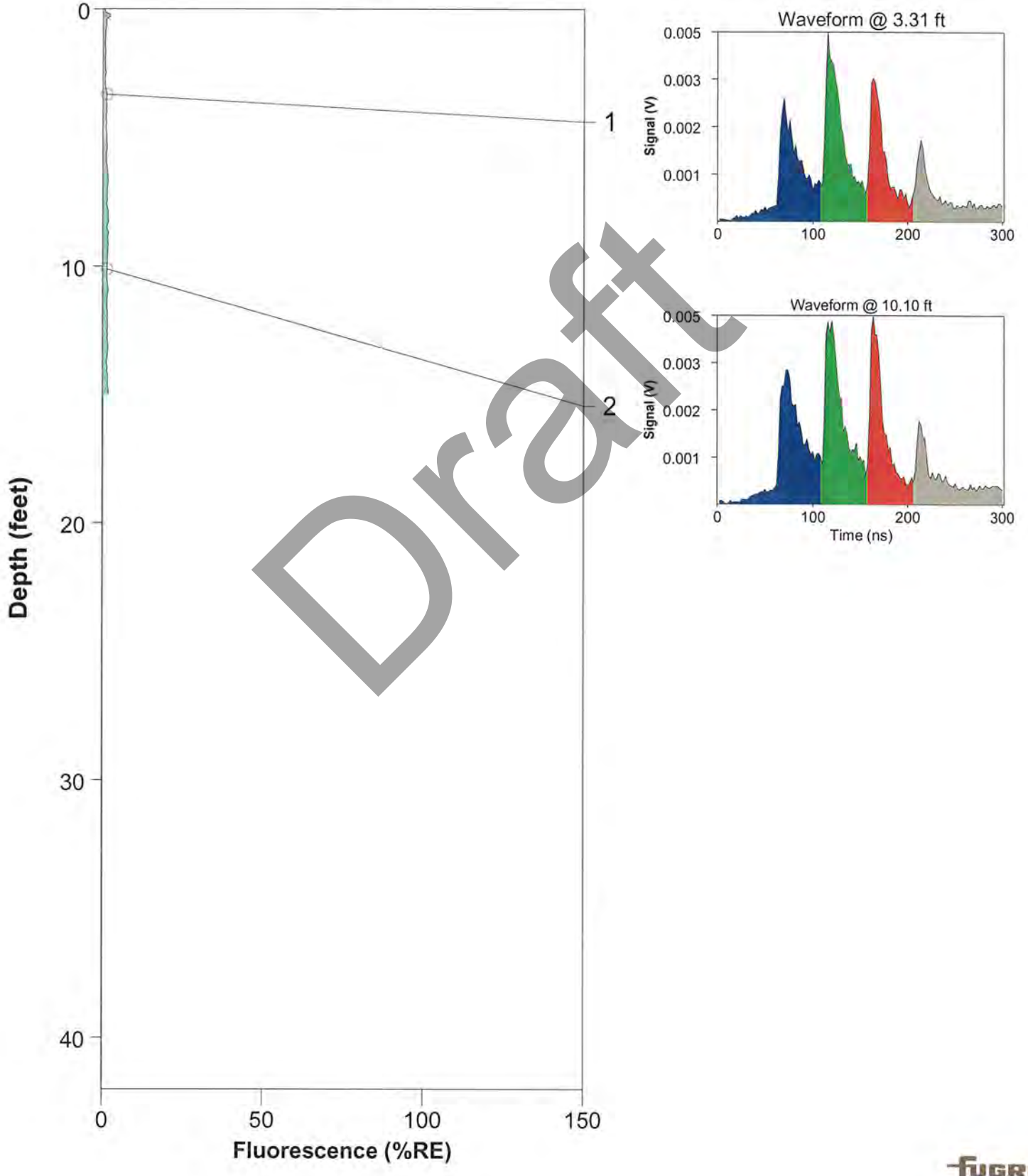


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-22-2002 @ 16:00:38	Max fluorescence: 2.14% @ 0.30 ft
ROST Unit: ?	Final depth BGS: 14.99 ft

ROST_003

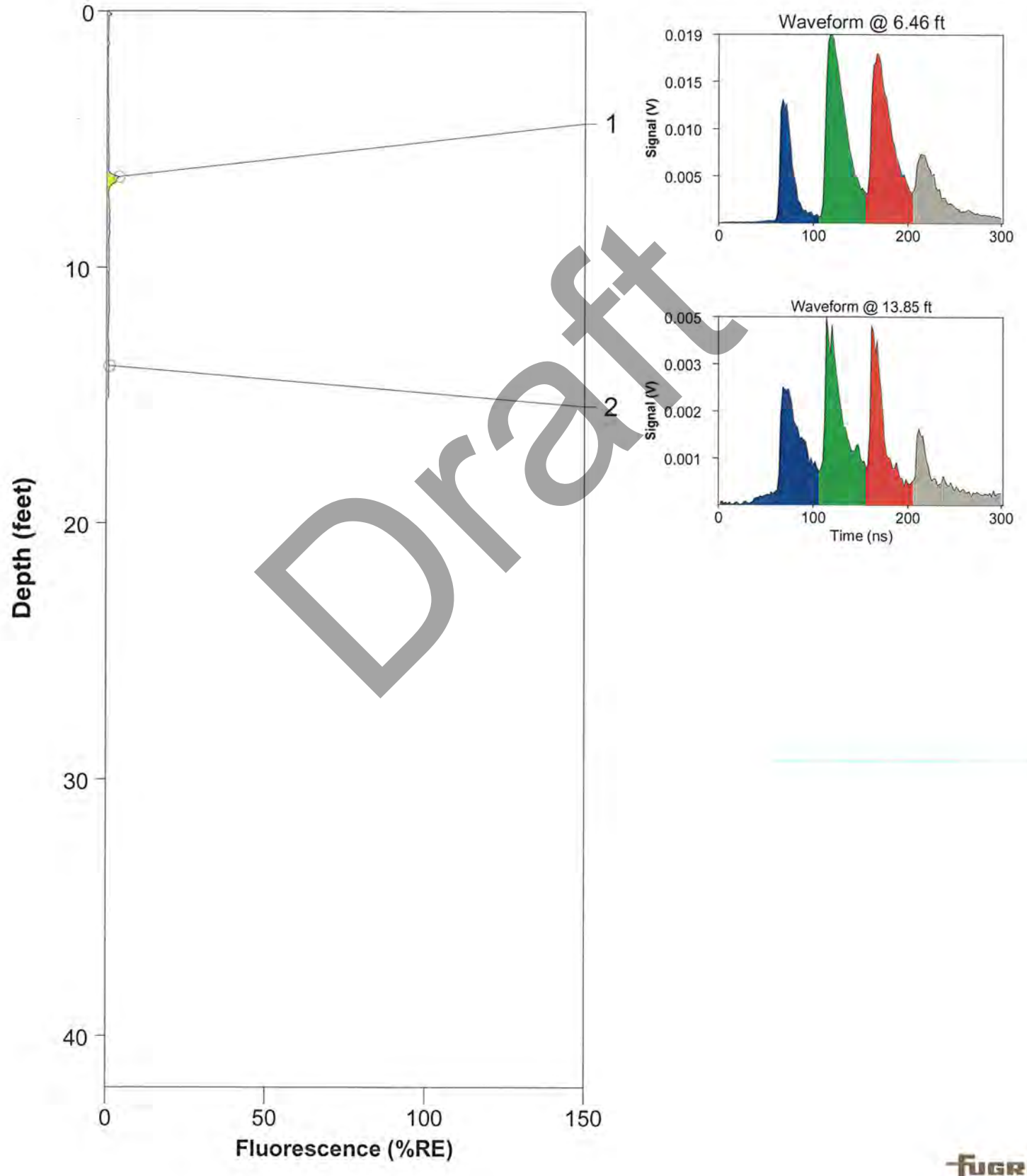


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-22-2002 @ 16:25:15	Max fluorescence: 3.76% @ 6.46 ft
ROST Unit: ?	Final depth BGS: 15.12 ft

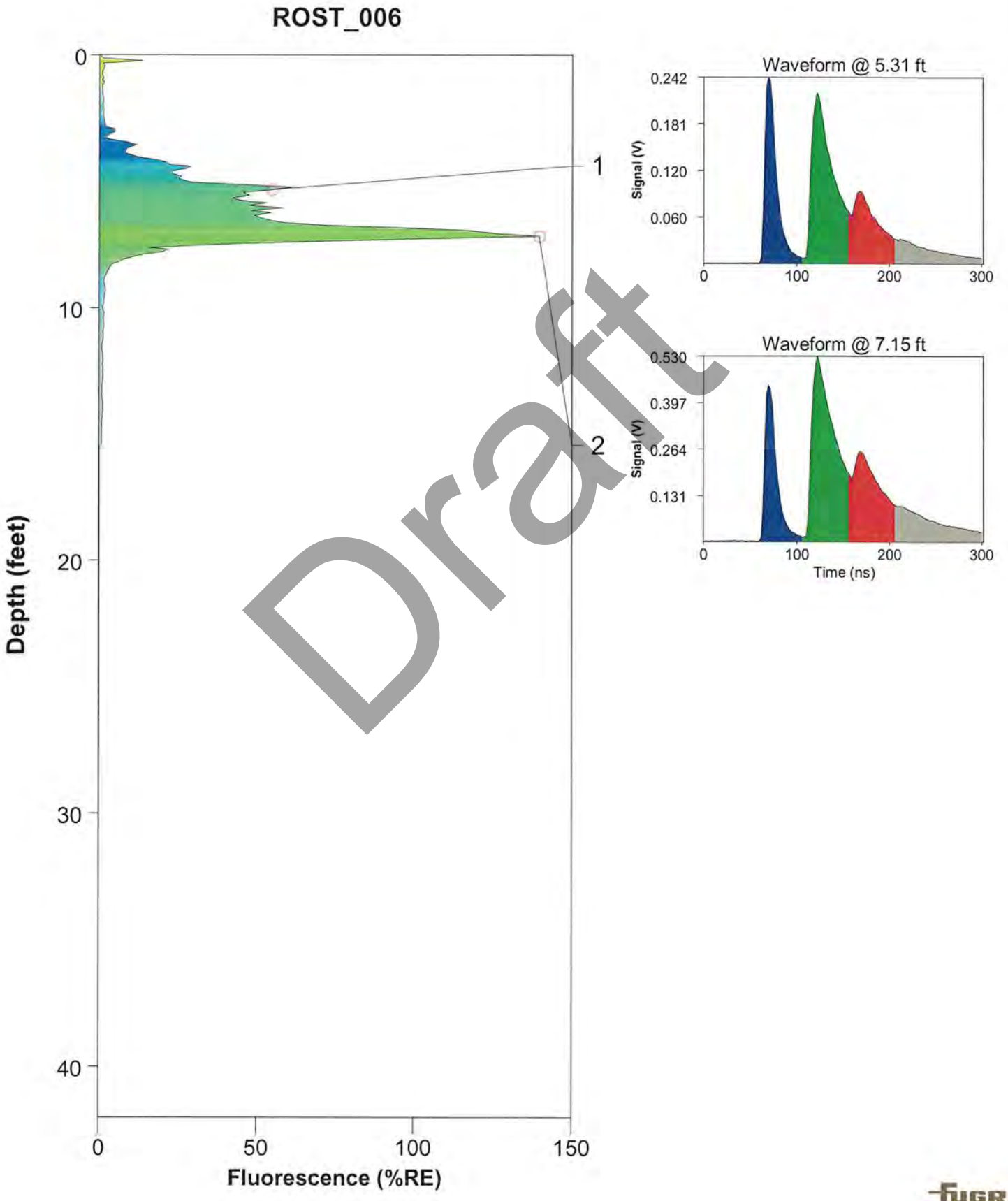
ROST_004



Draft

ROST Fluorescence Response Data

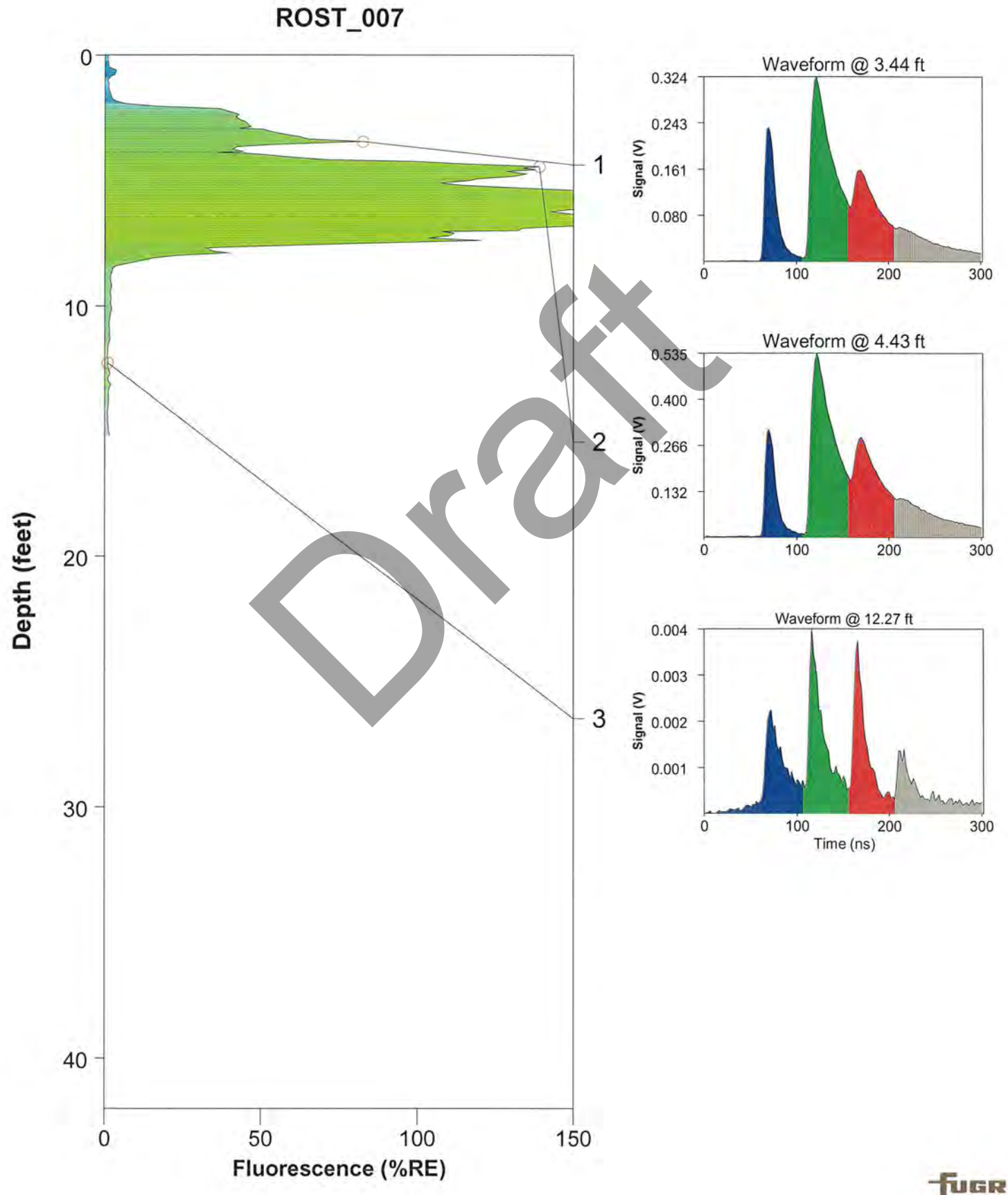
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-22-2002 @ 17:09:34	Max fluorescence: 139.61% @ 7.15 ft
ROST Unit: ?	Final depth BGS: 15.42 ft



Draft

ROST Fluorescence Response Data

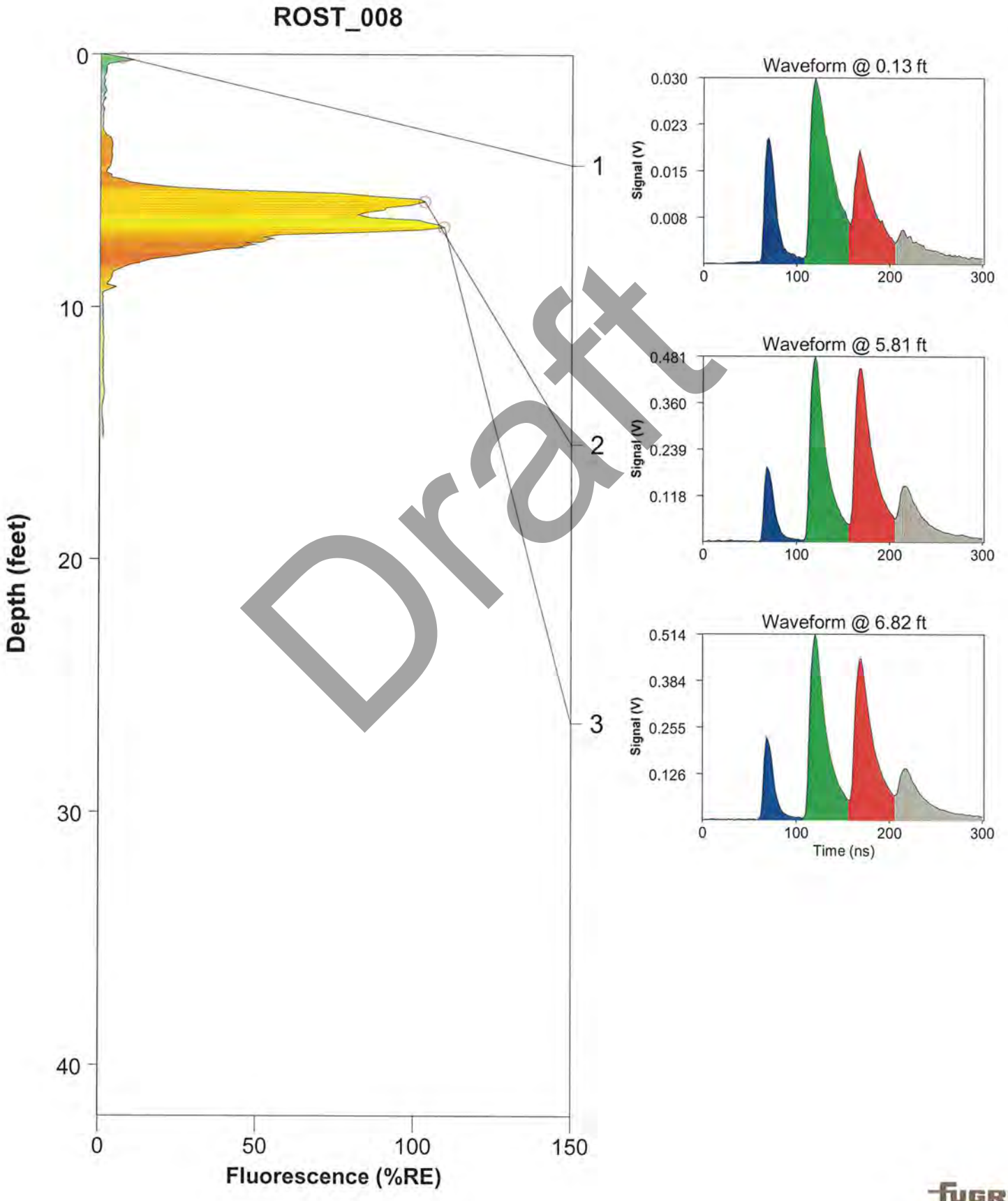
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-22-2002 @ 17:28:36	Max fluorescence: 194.93% @ 6.53 ft
ROST Unit: ?	Final depth BGS: 15.16 ft



Draft

ROST Fluorescence Response Data

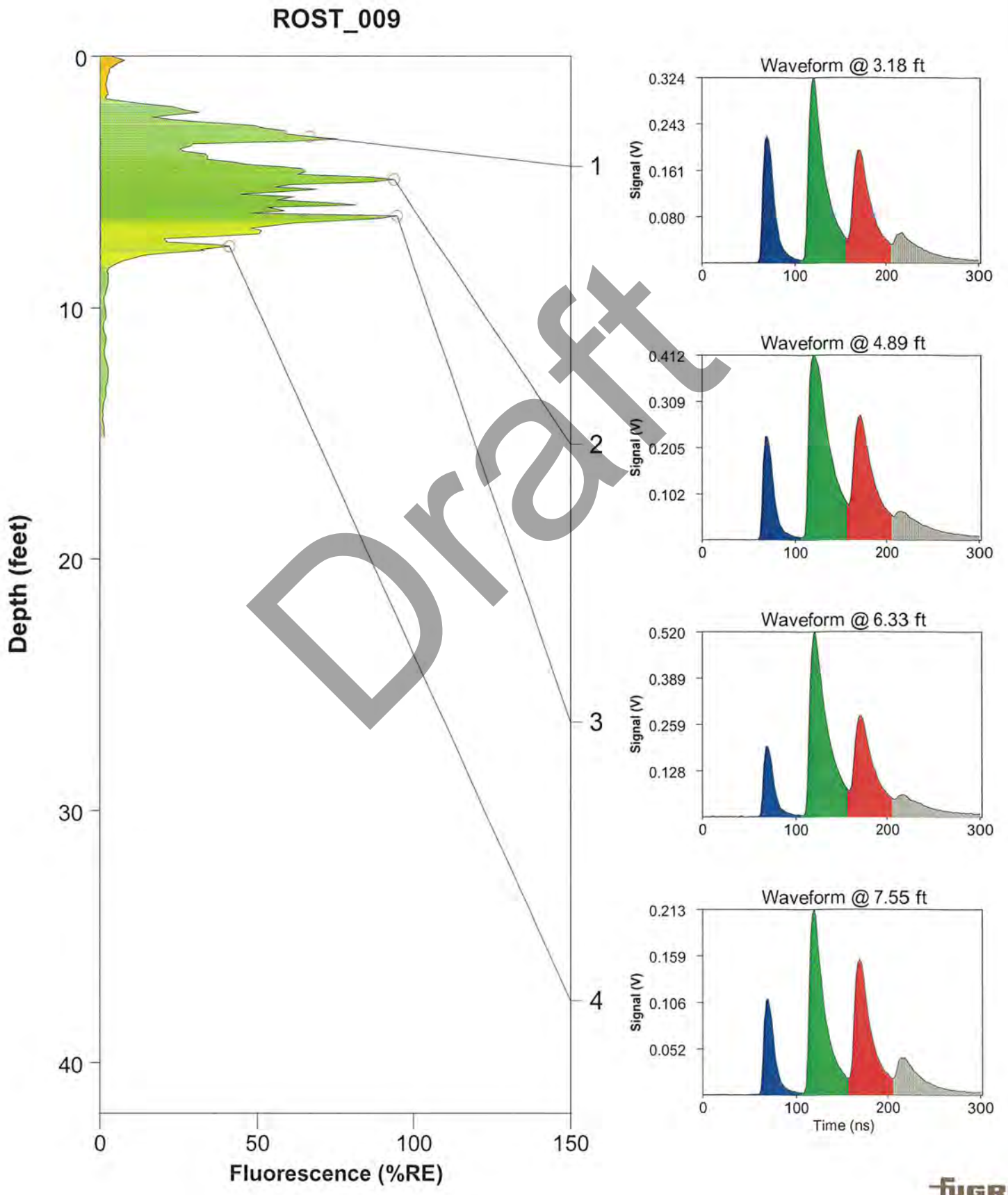
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-22-2002 @ 17:54:02	Max fluorescence: 109.14% @ 6.82 ft
ROST Unit: ?	Final depth BGS: 15.16 ft



Draft

ROST Fluorescence Response Data

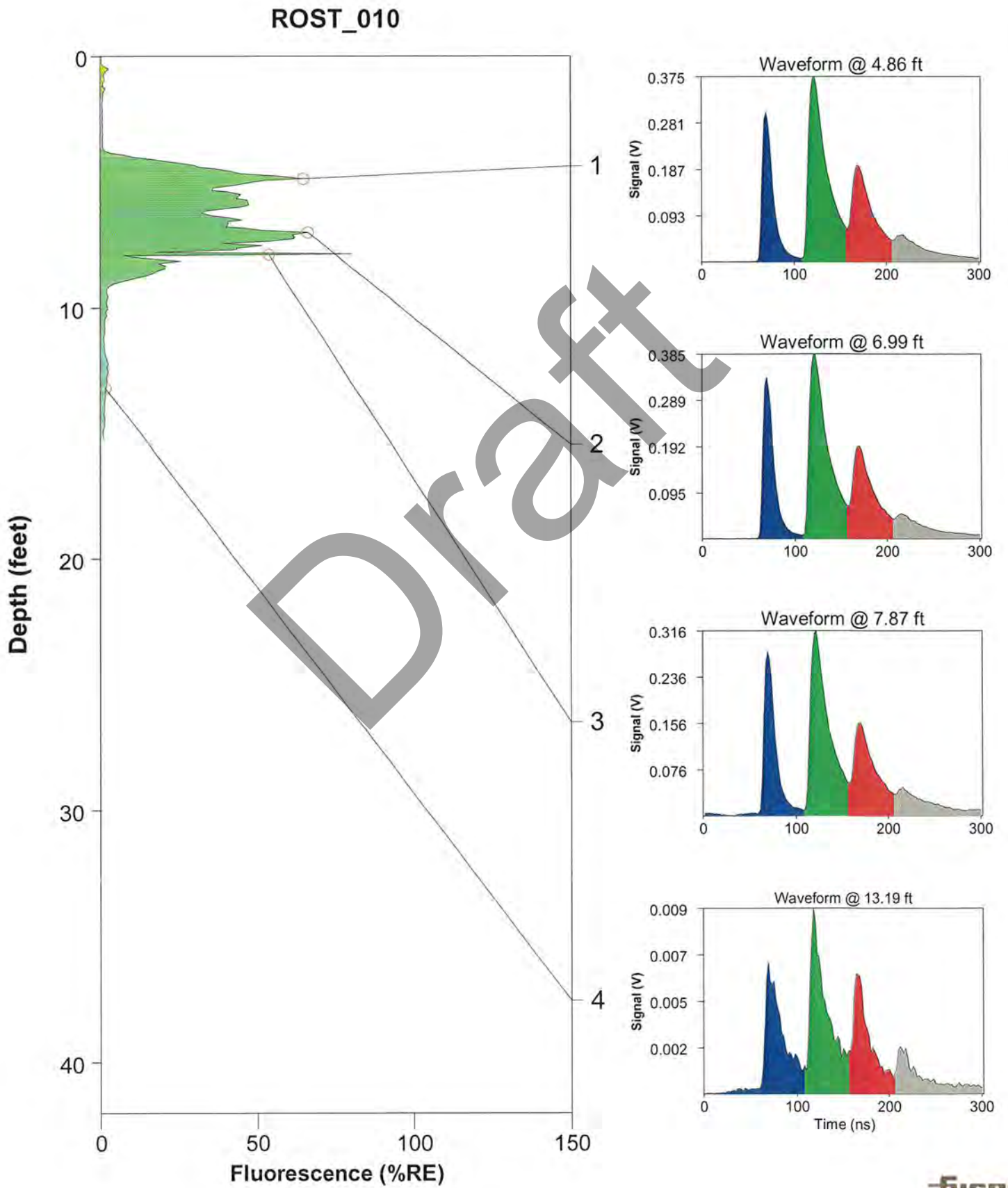
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-22-2002 @ 18:11:01	Max fluorescence: 94.52% @ 6.33 ft
ROST Unit: ?	Final depth BGS: 15.16 ft



Draft

ROST Fluorescence Response Data

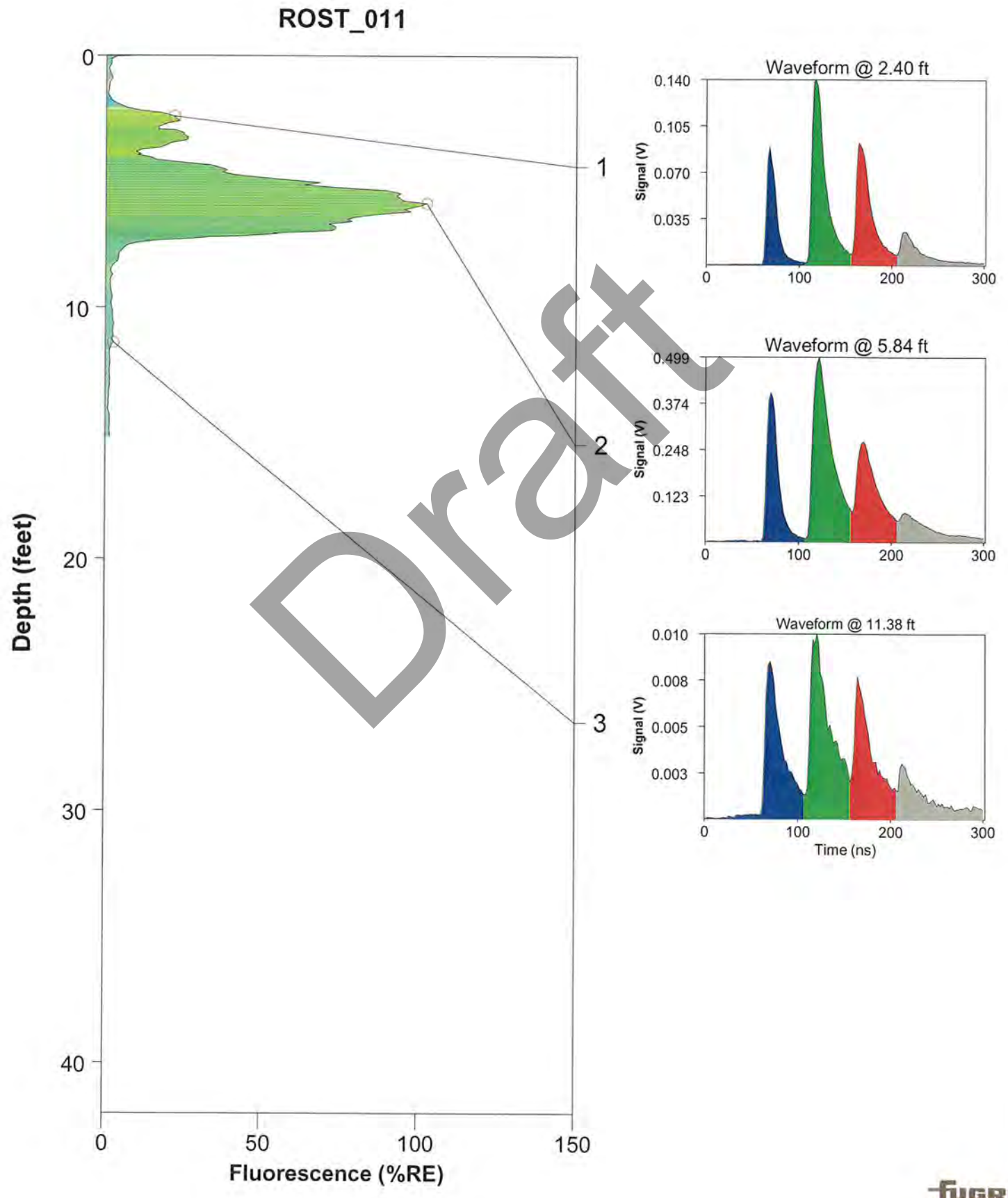
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 09:03:50	Max fluorescence: 80.52% @ 7.84 ft
ROST Unit: ?	Final depth BGS: 15.19 ft



Draft

ROST Fluorescence Response Data

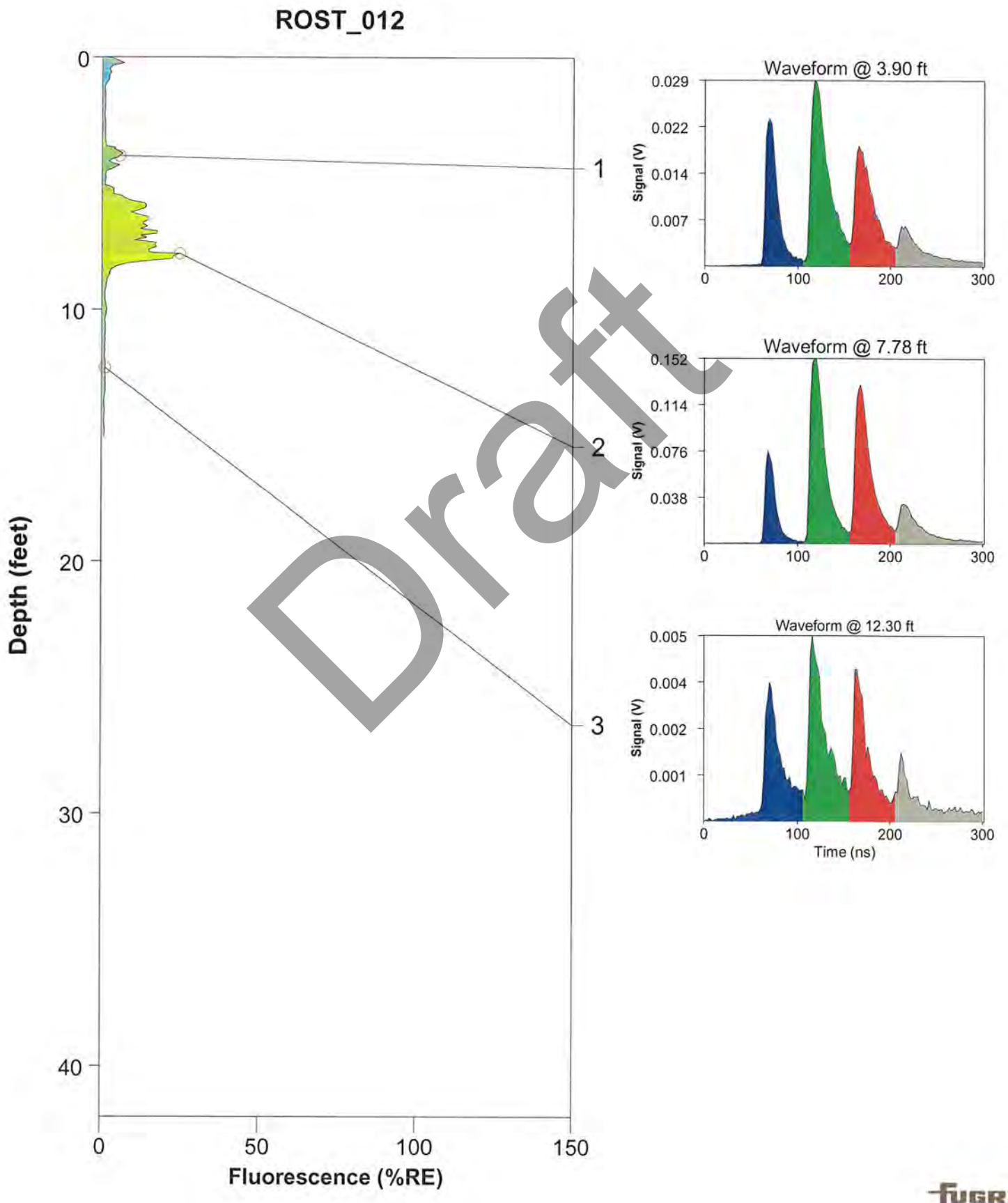
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 09:27:47	Max fluorescence: 102.45% @ 5.84 ft
ROST Unit: ?	Final depth BGS: 15.16 ft



Draft

ROST Fluorescence Response Data

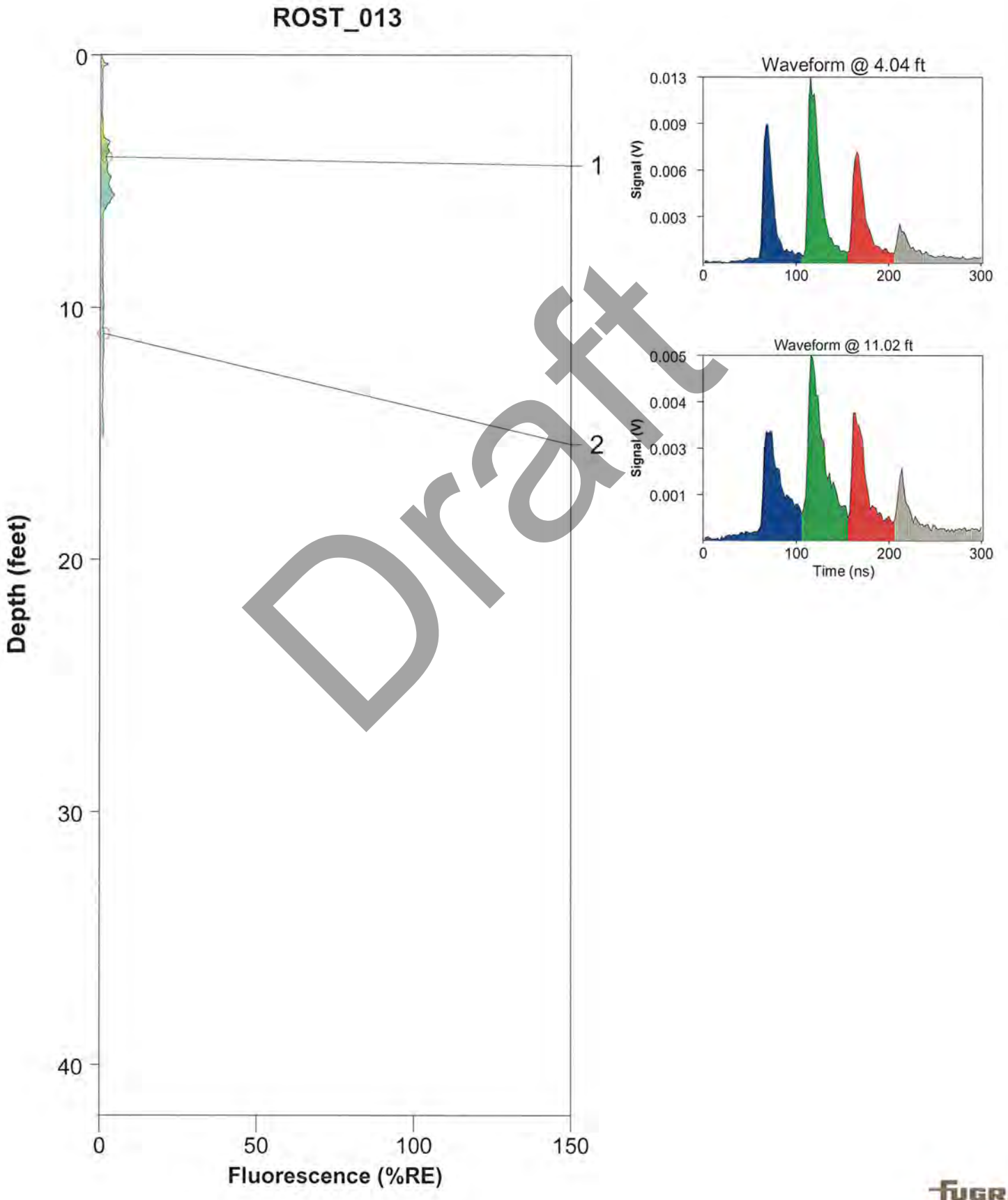
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 09:48:23	Max fluorescence: 24.65% @ 7.78 ft
ROST Unit: ?	Final depth BGS: 15.06 ft



Draft

ROST Fluorescence Response Data

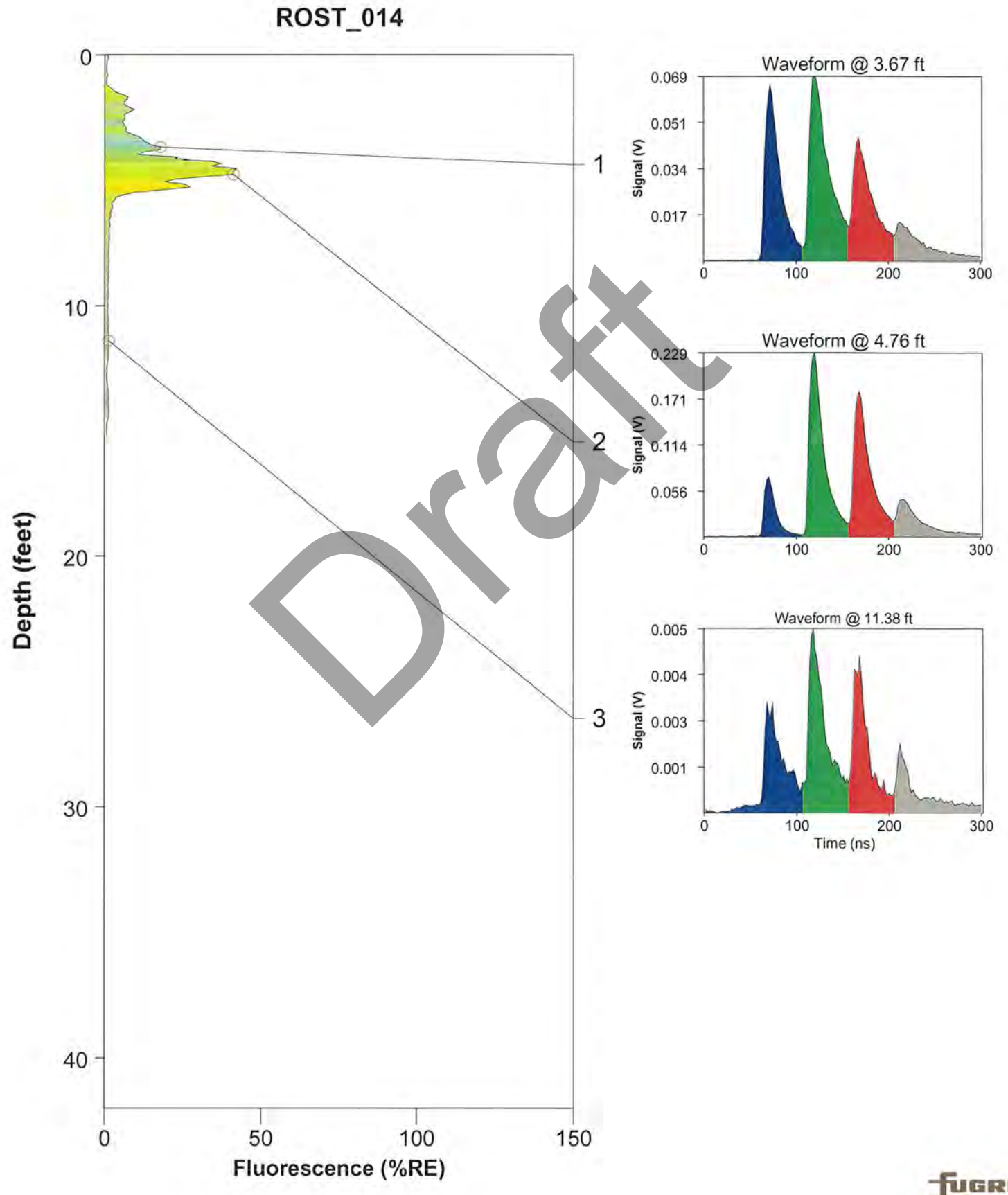
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 10:07:05	Max fluorescence: 4.46% @ 5.54 ft
ROST Unit: ?	Final depth BGS: 15.12 ft



Draft

ROST Fluorescence Response Data

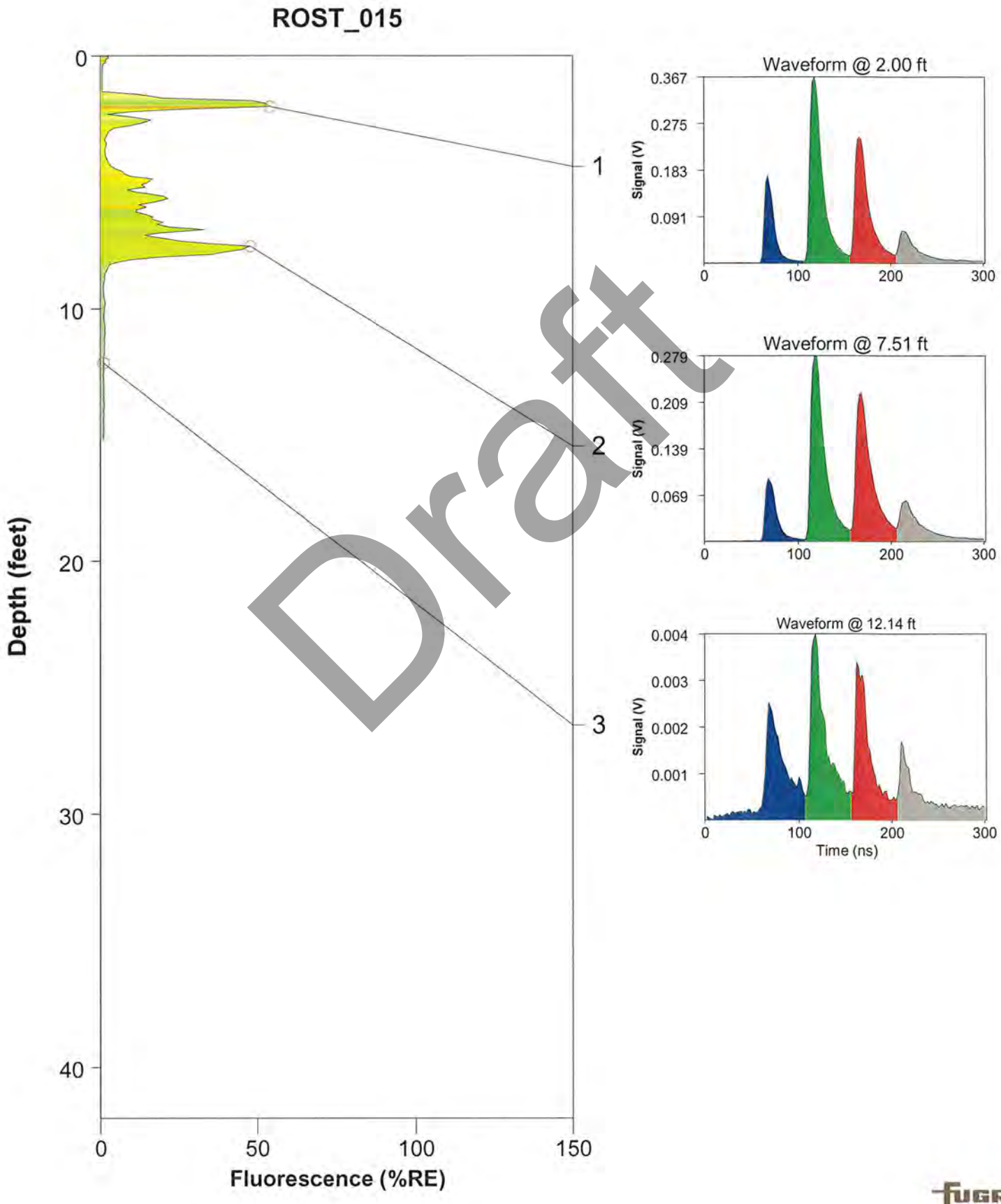
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 10:28:48	Max fluorescence: 42.11% @ 4.53 ft
ROST Unit: ?	Final depth BGS: 15.19 ft



Draft

ROST Fluorescence Response Data

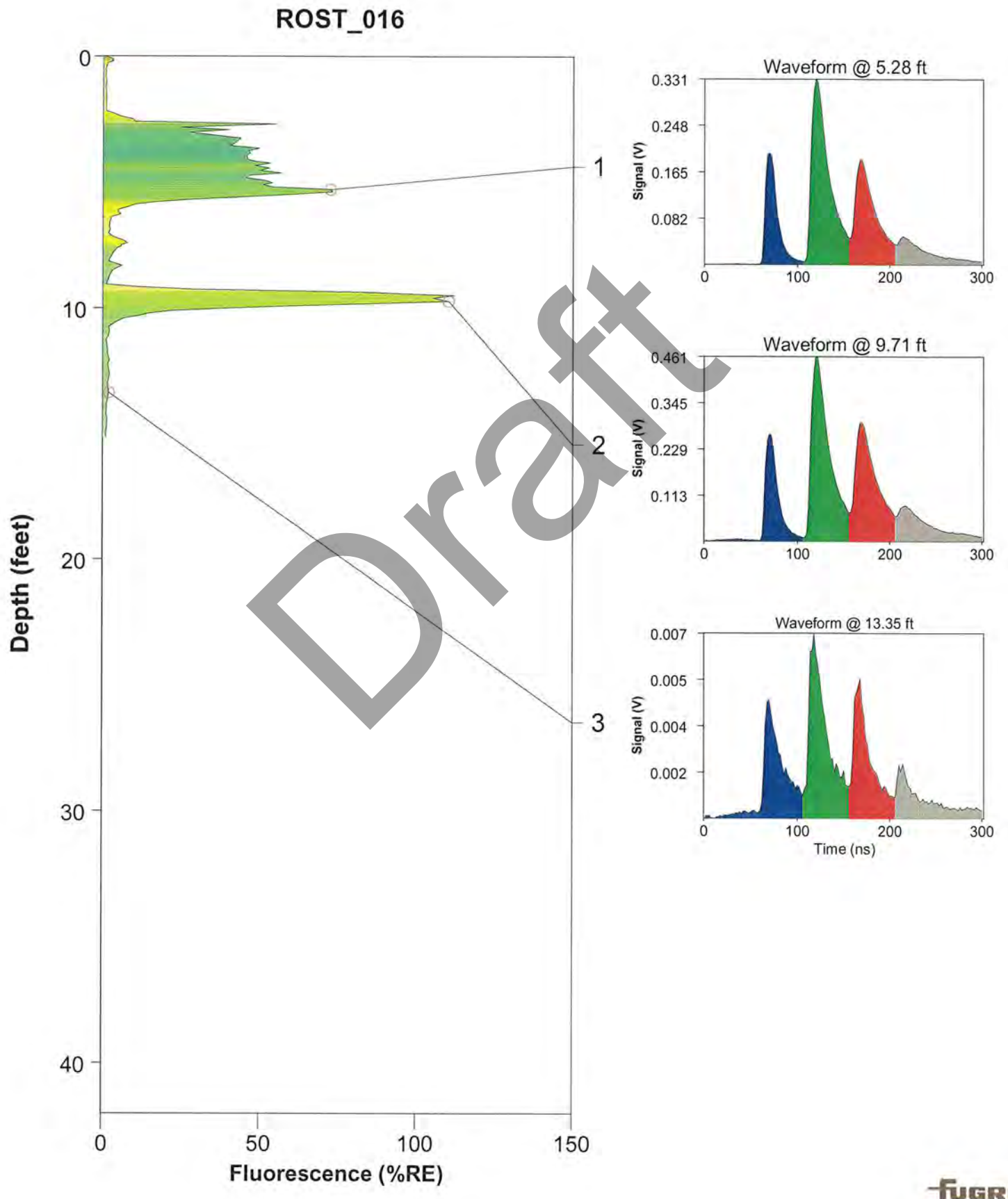
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 10:58:31	Max fluorescence: 53.84% @ 2.00 ft
ROST Unit: ?	Final depth BGS: 15.19 ft



Draft

ROST Fluorescence Response Data

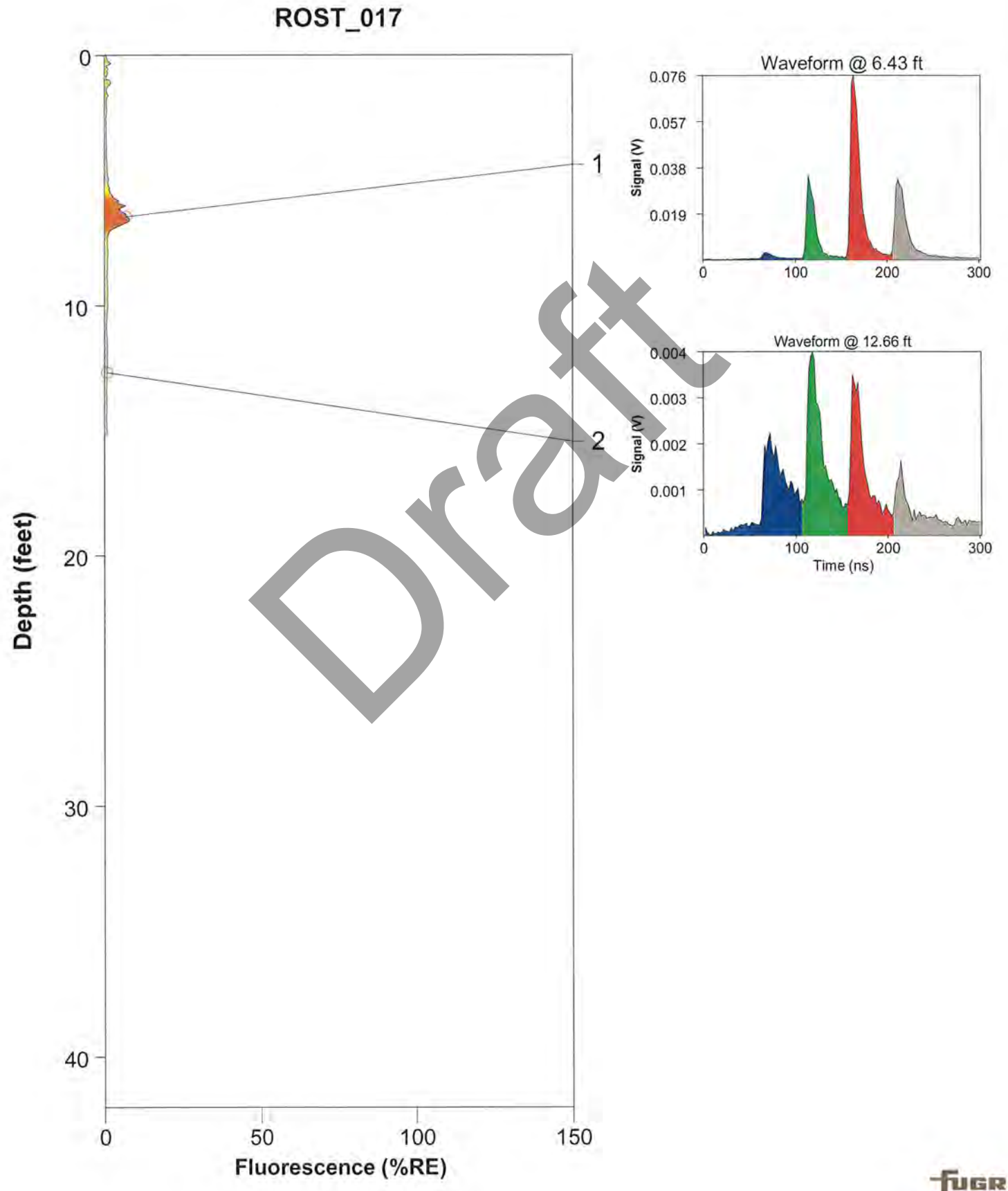
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 11:23:02	Max fluorescence: 112.06% @ 9.48 ft
ROST Unit: ?	Final depth BGS: 15.16 ft



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 11:48:59	Max fluorescence: 8.12% @ 6.53 ft
ROST Unit: ?	Final depth BGS: 15.12 ft

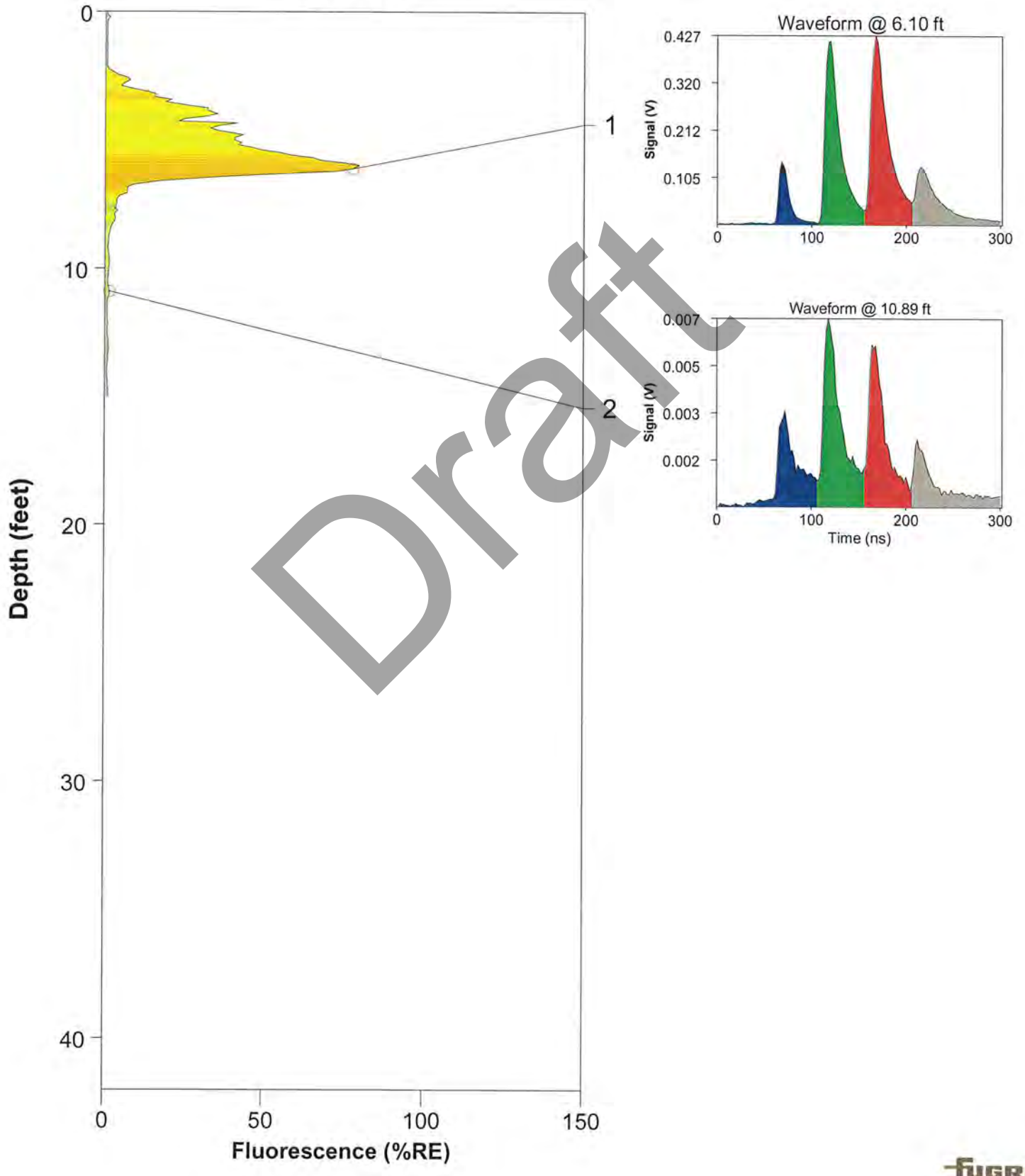


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 12:07:37	Max fluorescence: 79.60% @ 5.97 ft
ROST Unit: ?	Final depth BGS: 15.03 ft

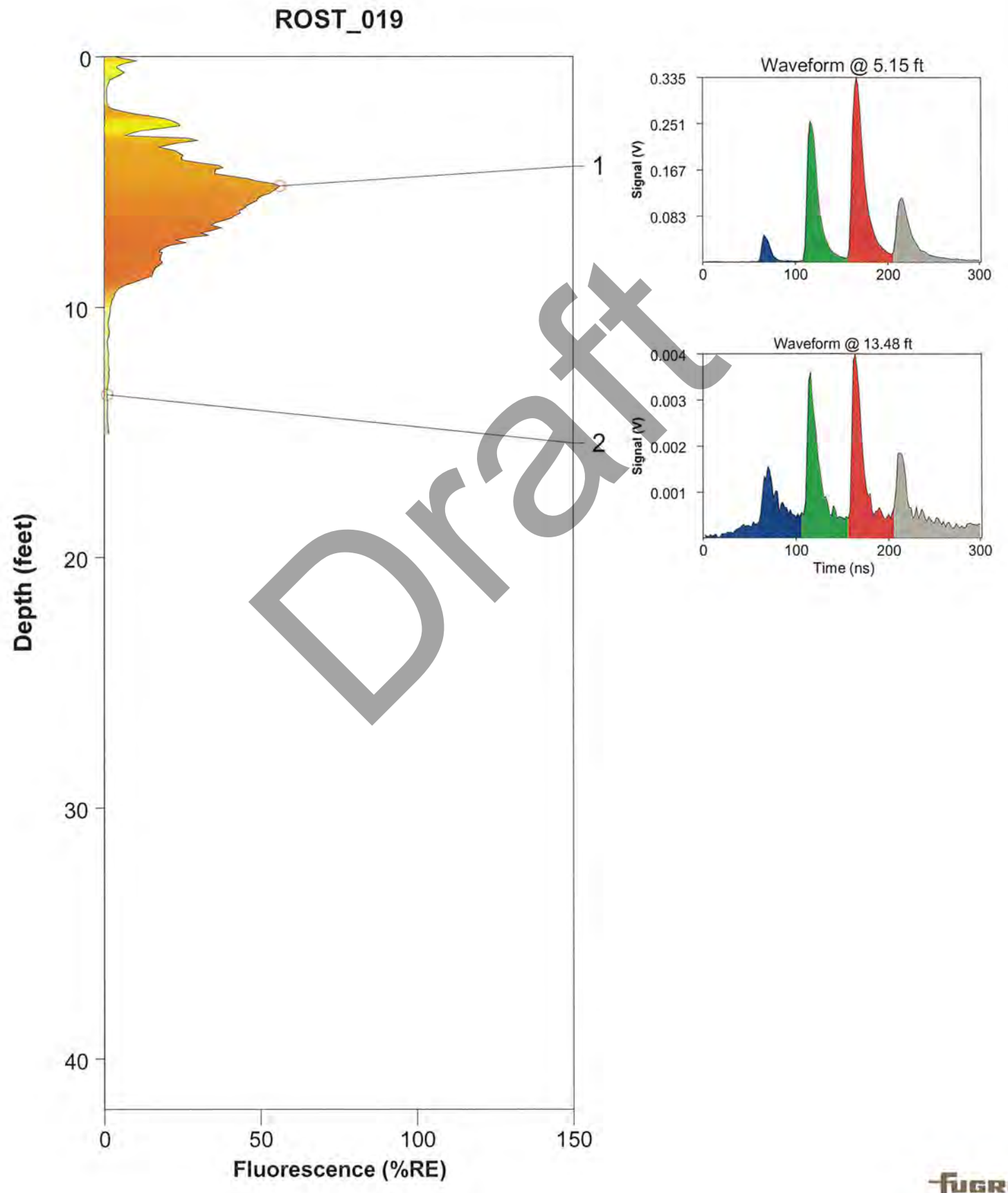
ROST_018



Draft

ROST Fluorescence Response Data

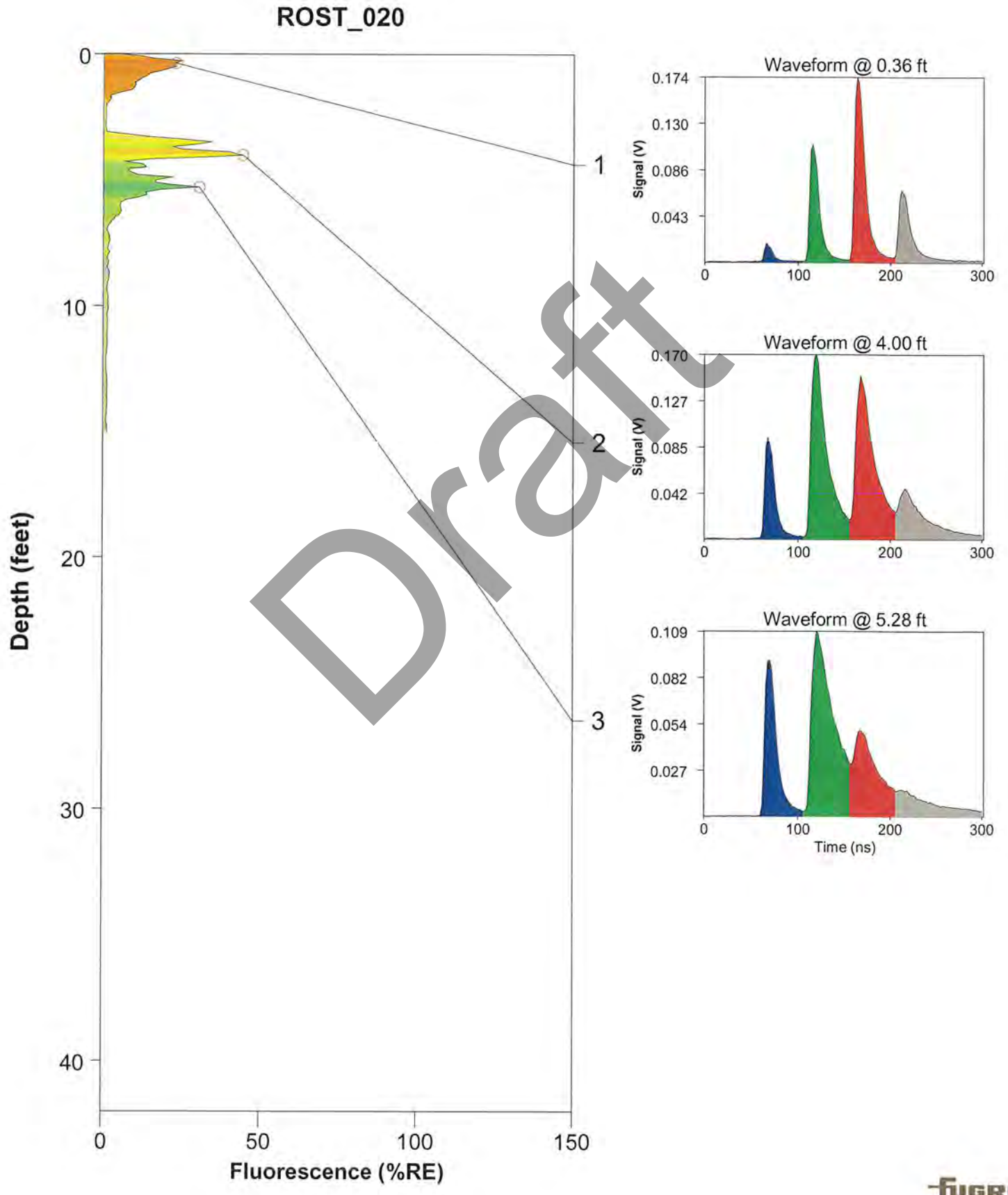
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 12:35:43	Max fluorescence: 56.10% @ 5.15 ft
ROST Unit: ?	Final depth BGS: 15.06 ft



Draft

ROST Fluorescence Response Data

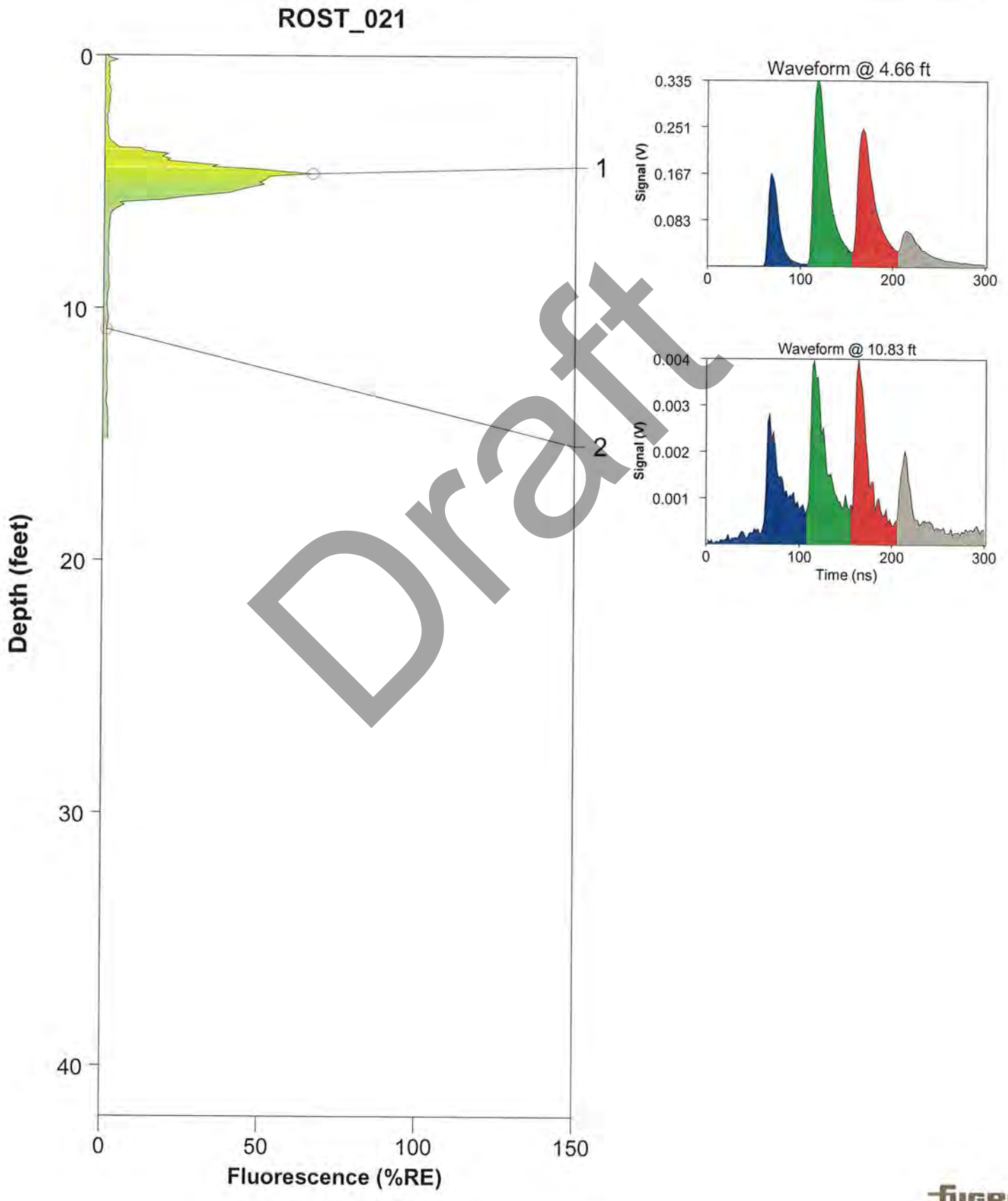
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 12:58:48	Max fluorescence: 44.20% @ 4.00 ft
ROST Unit: ?	Final depth BGS: 15.03 ft



Draft

ROST Fluorescence Response Data

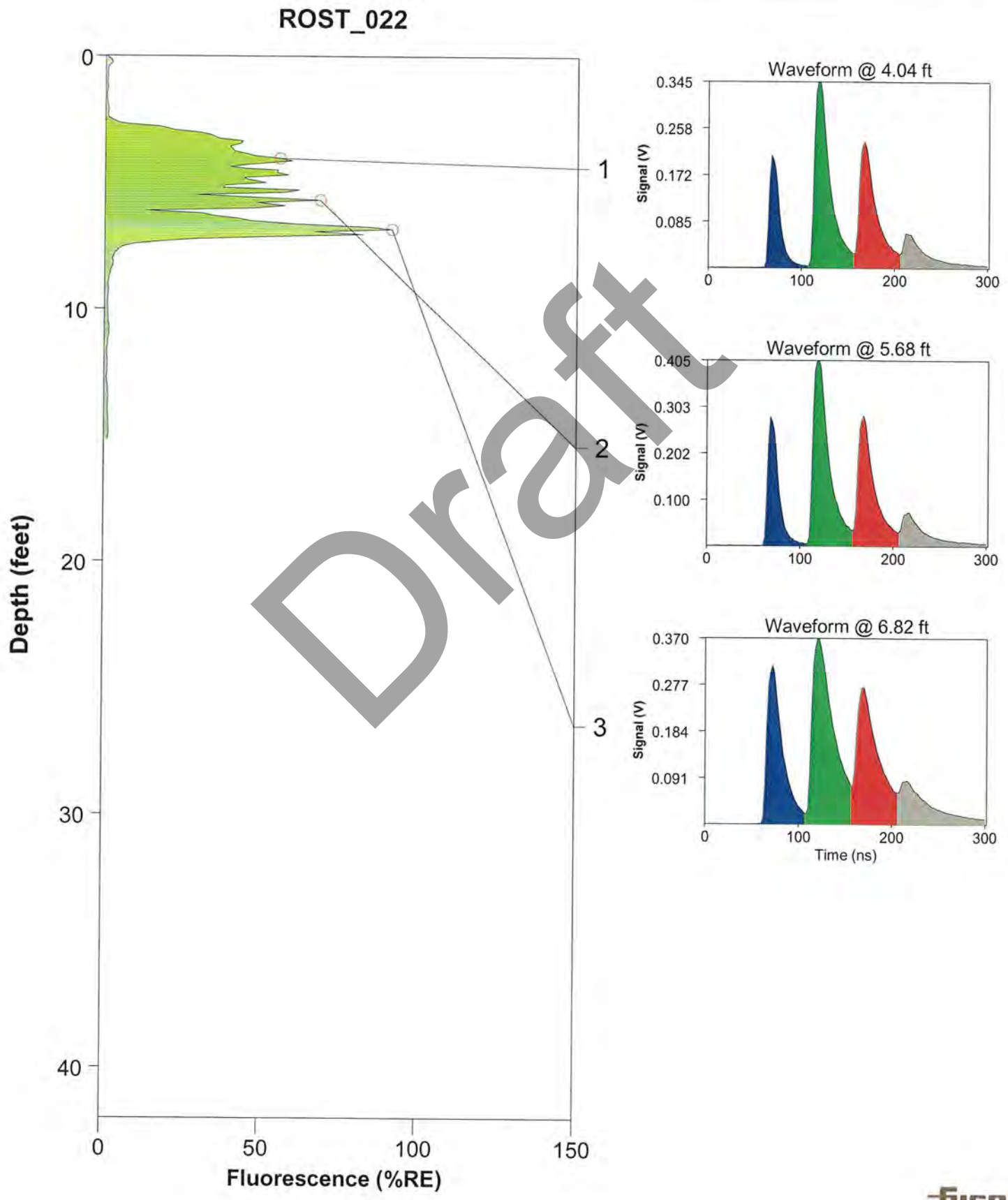
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 14:09:57	Max fluorescence: 66.31% @ 4.66 ft
ROST Unit: ?	Final depth BGS: 15.19 ft



Draft

ROST Fluorescence Response Data

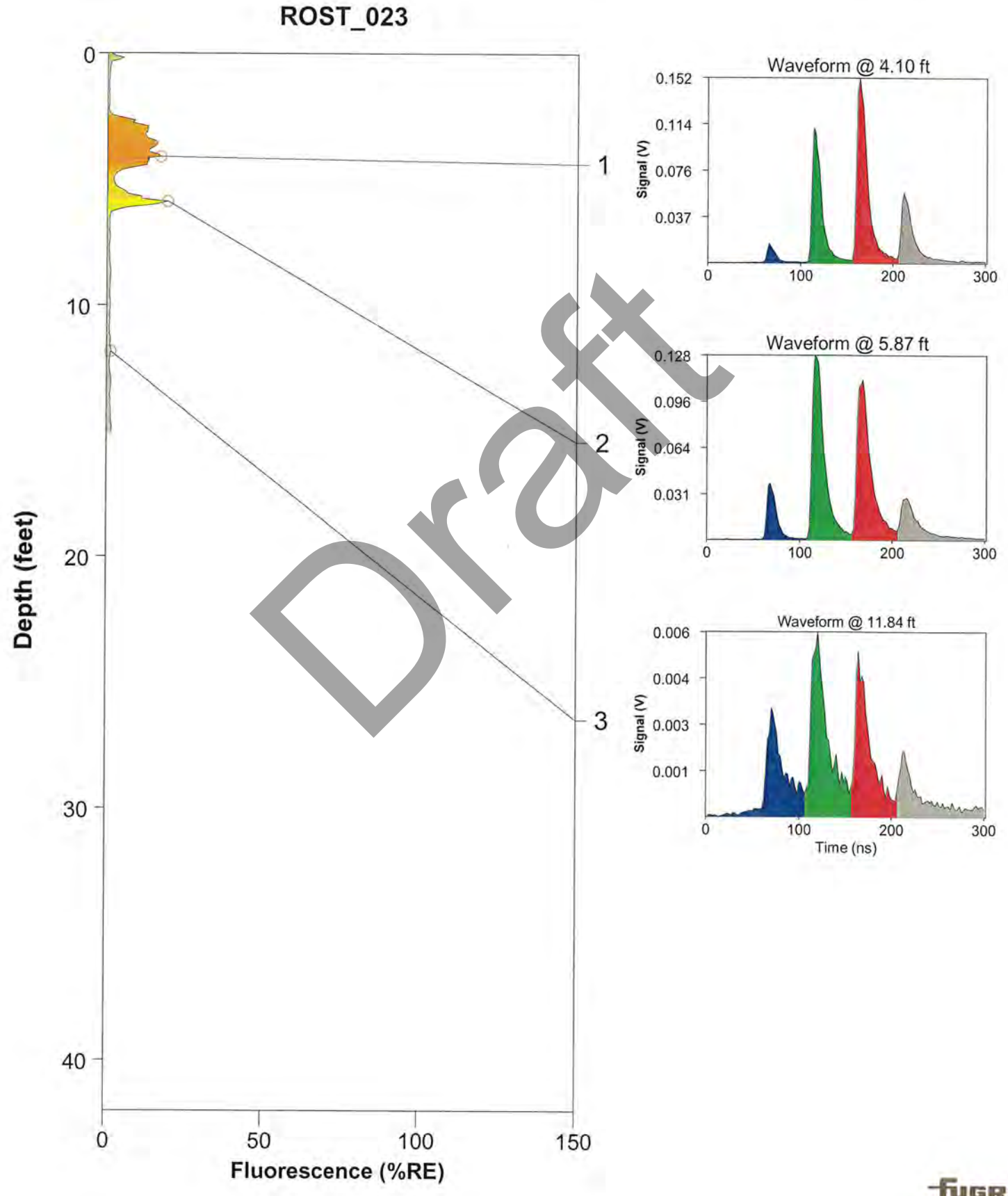
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 14:30:43	Max fluorescence: 91.28% @ 6.82 ft
ROST Unit: ?	Final depth BGS: 15.19 ft



Draft

ROST Fluorescence Response Data

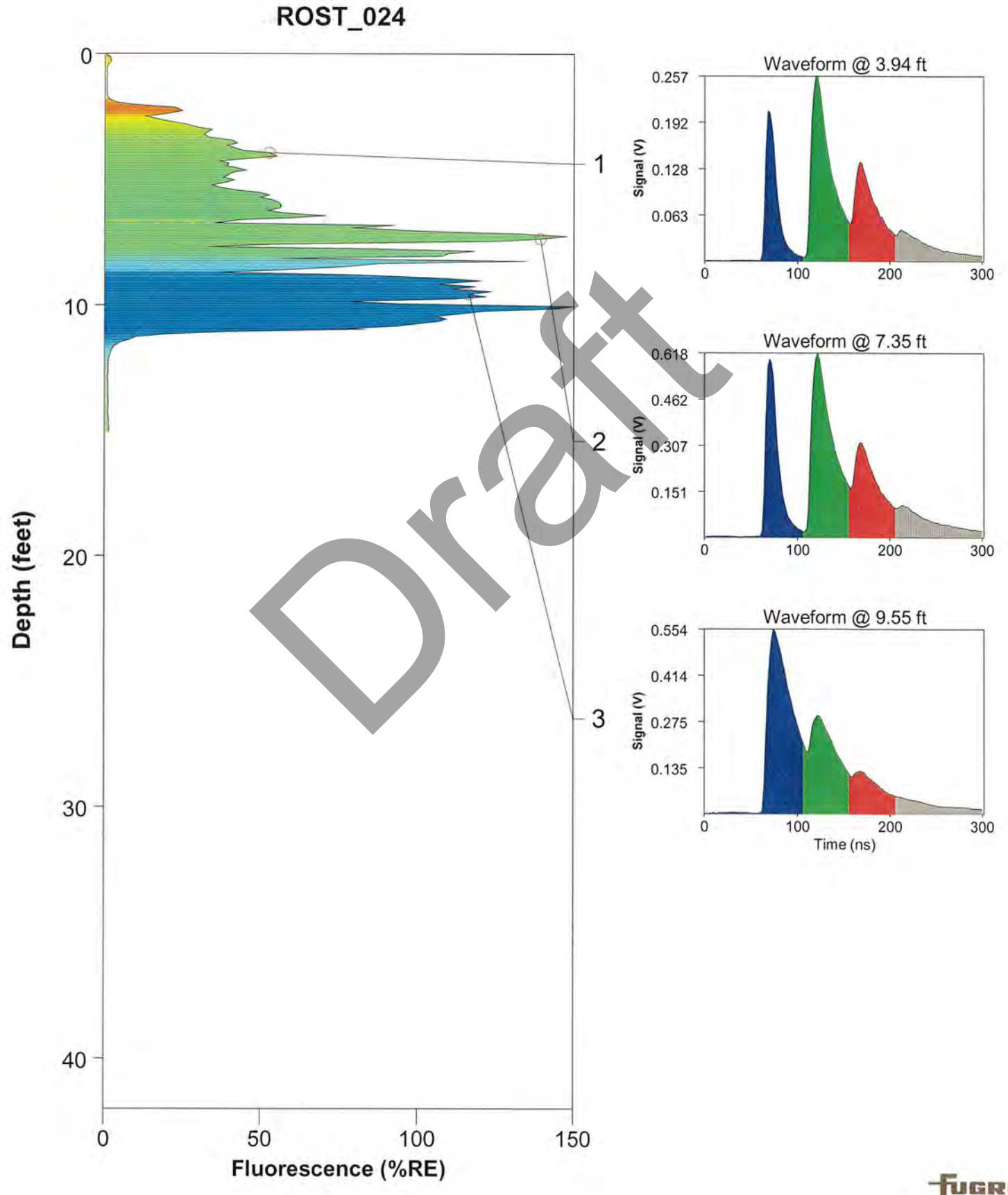
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 14:46:59	Max fluorescence: 19.50% @ 5.87 ft
ROST Unit: ?	Final depth BGS: 15.09 ft



Draft

ROST Fluorescence Response Data

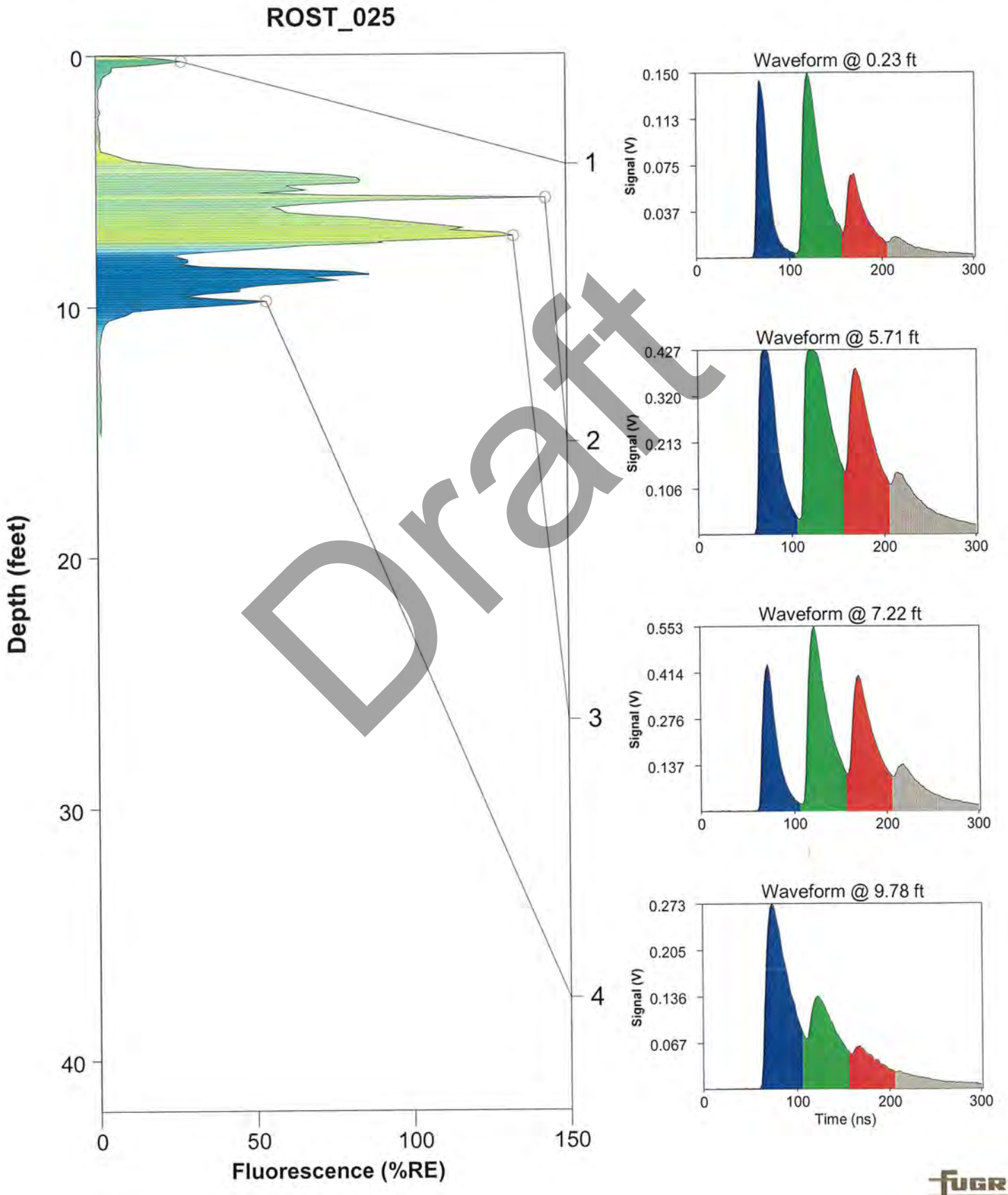
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 15:12:10	Max fluorescence: 191.77% @ 10.04 ft
ROST Unit: ?	Final depth BGS: 15.06 ft



Draft

ROST Fluorescence Response Data

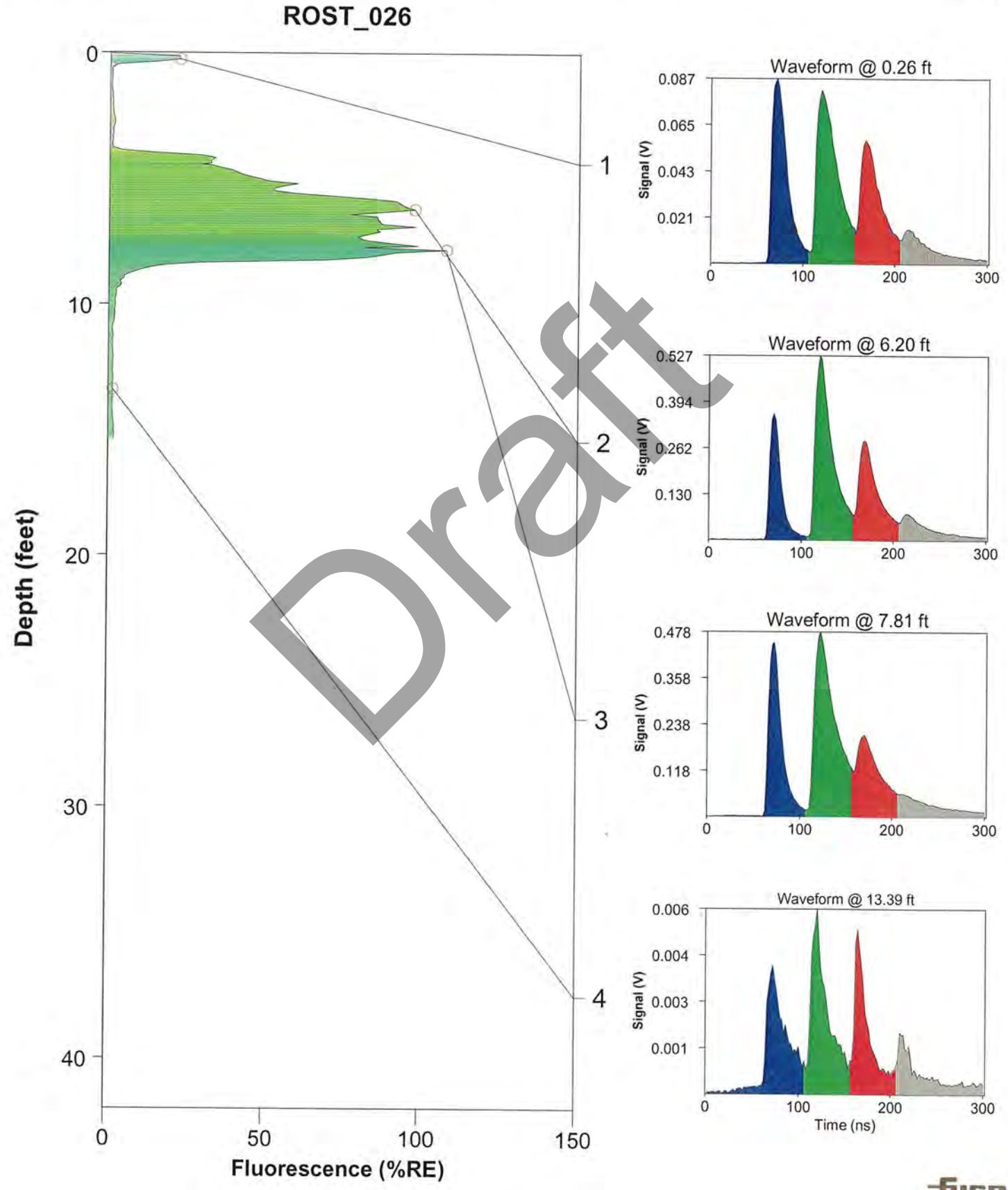
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 15:27:52	Max fluorescence: 143.33% @ 5.71 ft
ROST Unit: ?	Final depth BGS: 15.09 ft



Draft

ROST Fluorescence Response Data

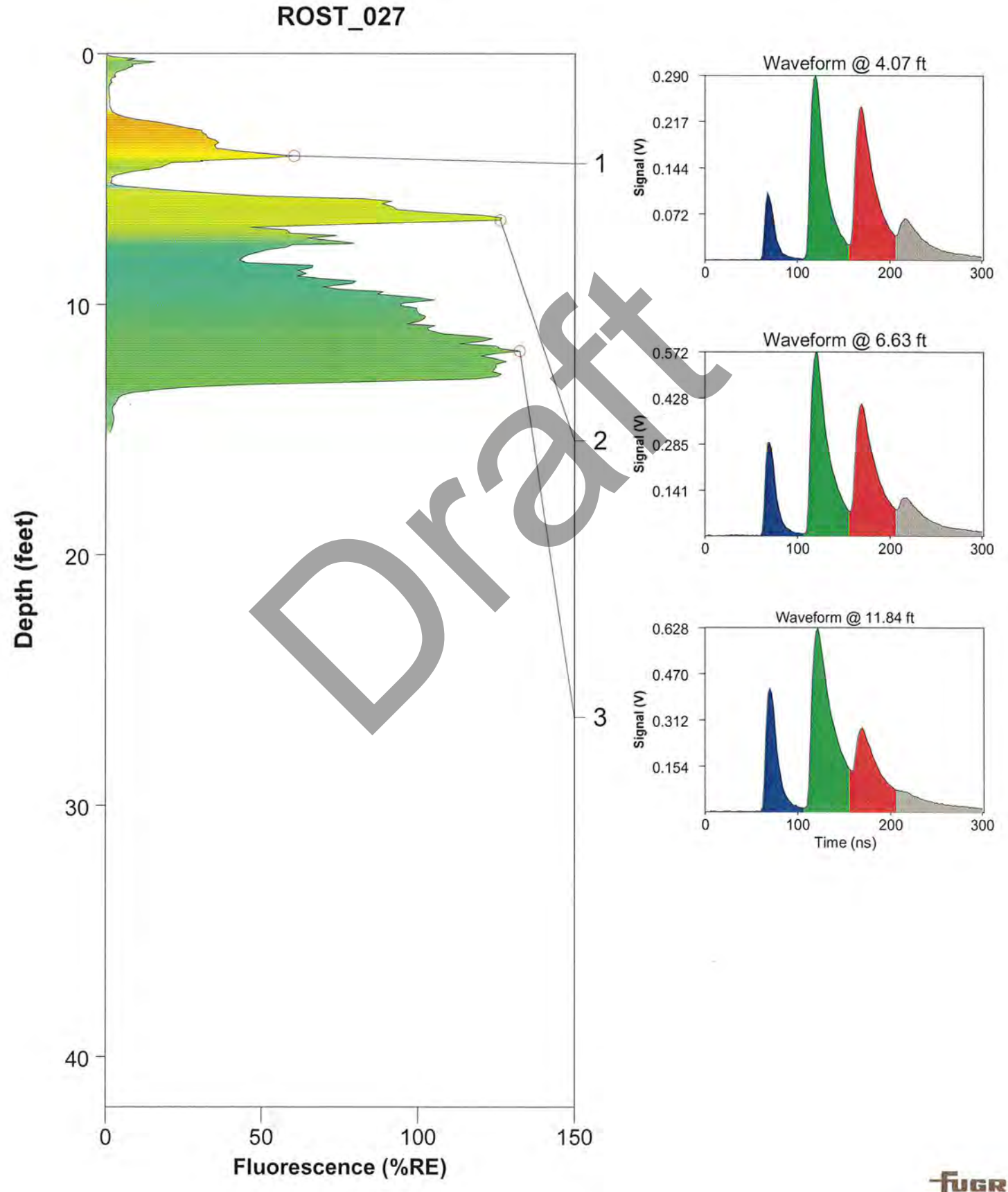
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 15:43:26	Max fluorescence: 107.49% @ 7.81 ft
ROST Unit: ?	Final depth BGS: 15.35 ft



Draft

ROST Fluorescence Response Data

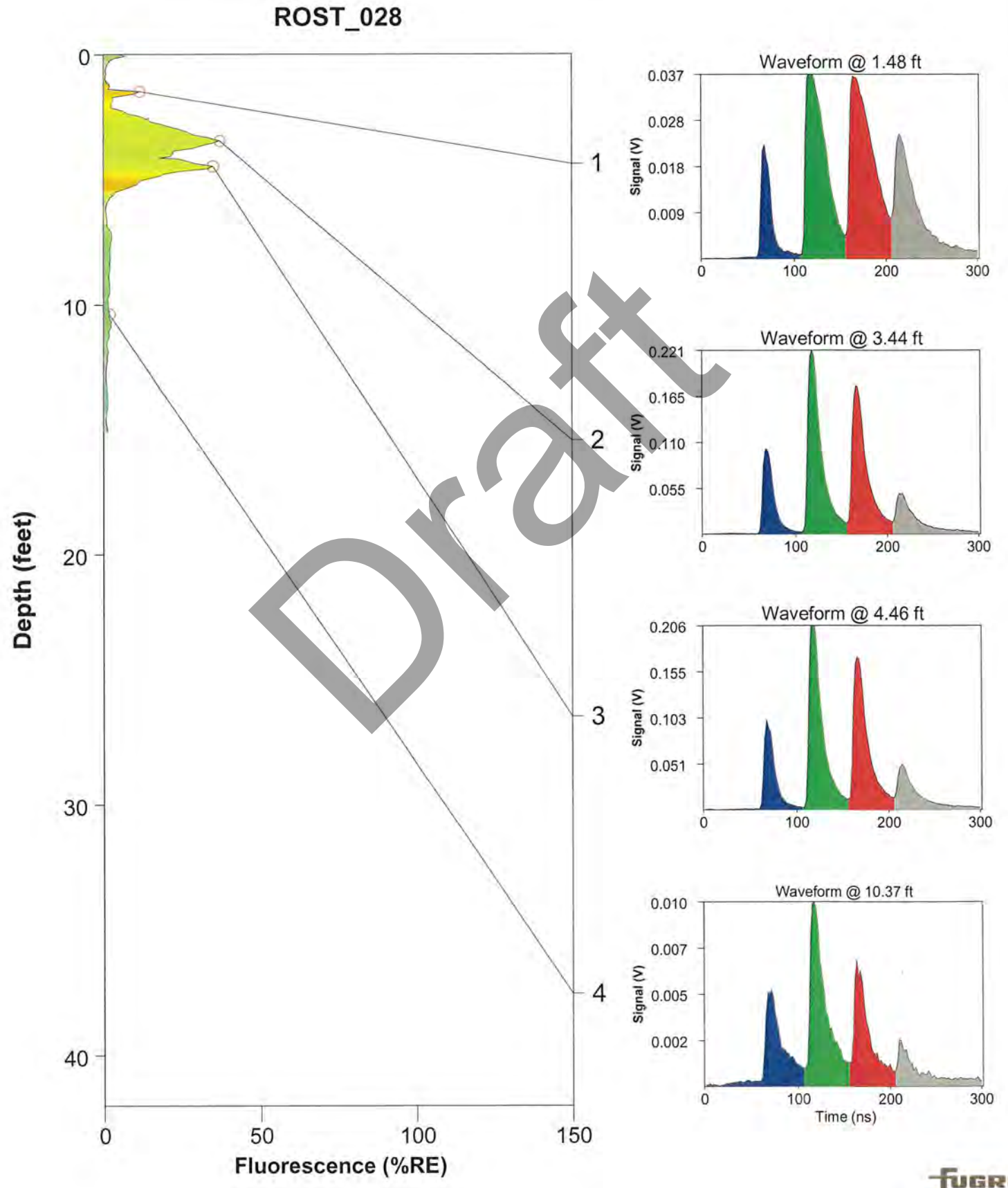
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 16:05:45	Max fluorescence: 132.50% @ 11.84 ft
ROST Unit: ?	Final depth BGS: 15.09 ft



Draft

ROST Fluorescence Response Data

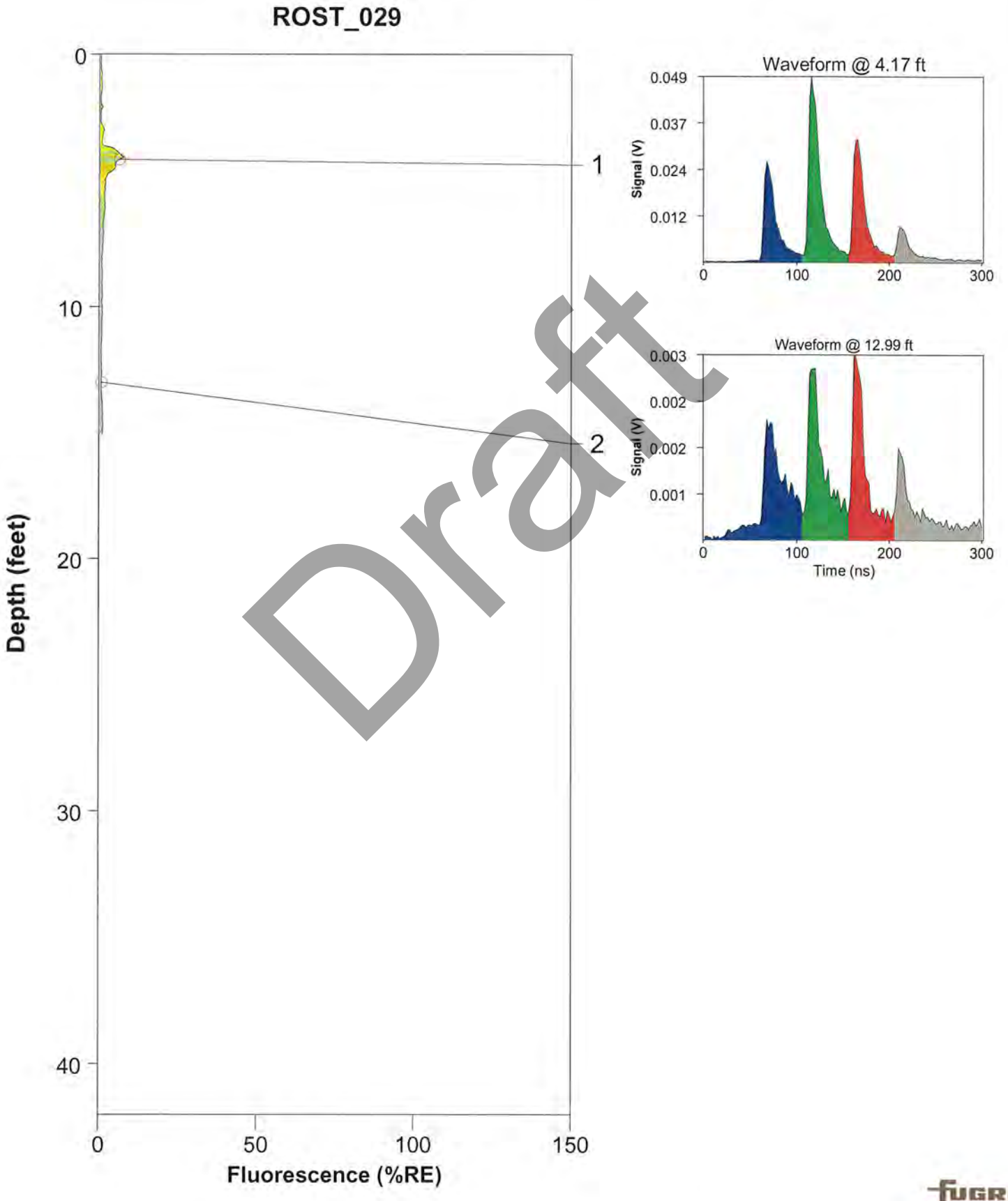
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 16:24:12	Max fluorescence: 36.97% @ 3.44 ft
ROST Unit: ?	Final depth BGS: 15.09 ft



Draft

ROST Fluorescence Response Data

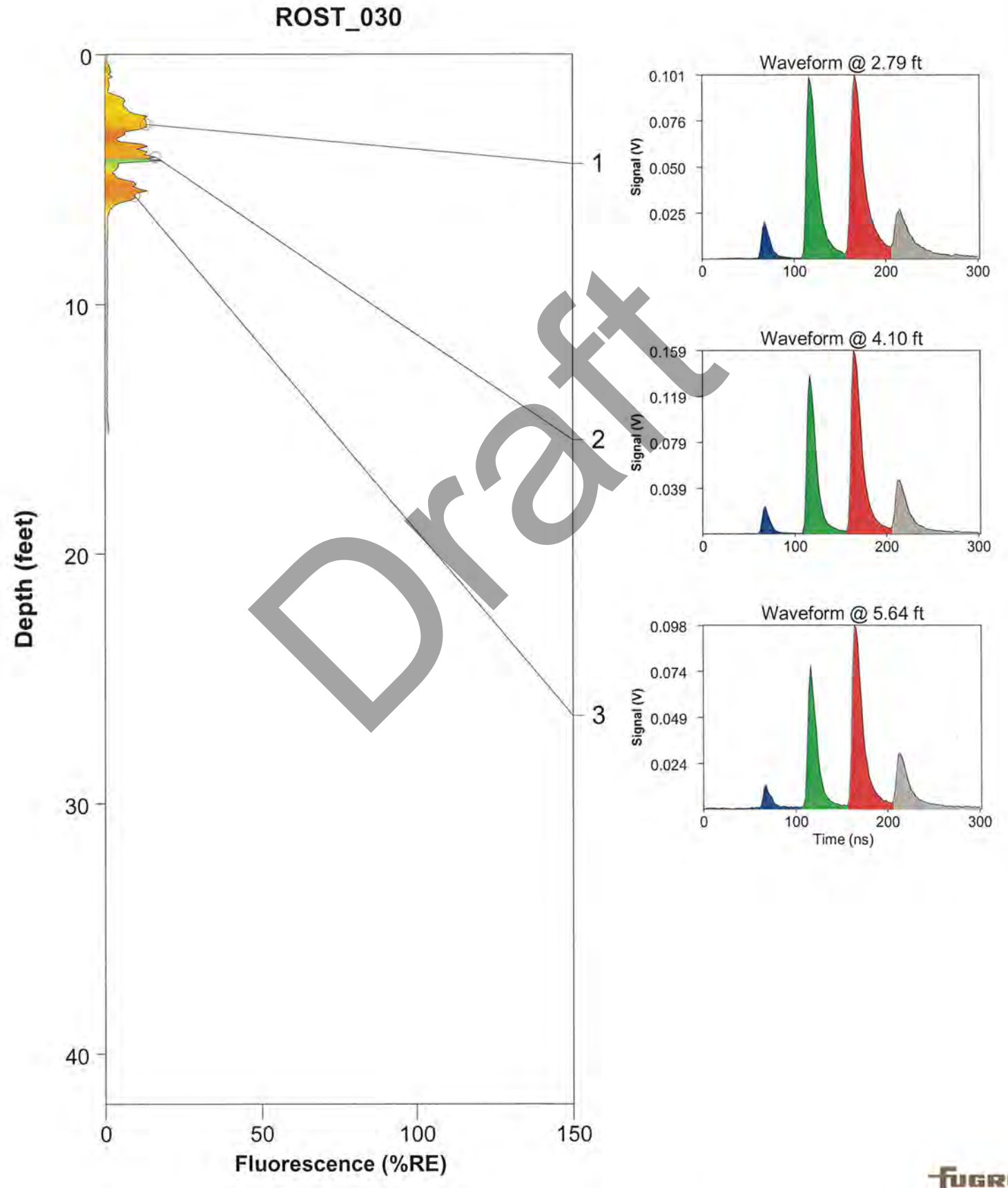
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 16:40:35	Max fluorescence: 7.74% @ 4.07 ft
ROST Unit: ?	Final depth BGS: 15.06 ft



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 17:08:47	Max fluorescence: 18.42% @ 4.23 ft
ROST Unit: ?	Final depth BGS: 15.16 ft

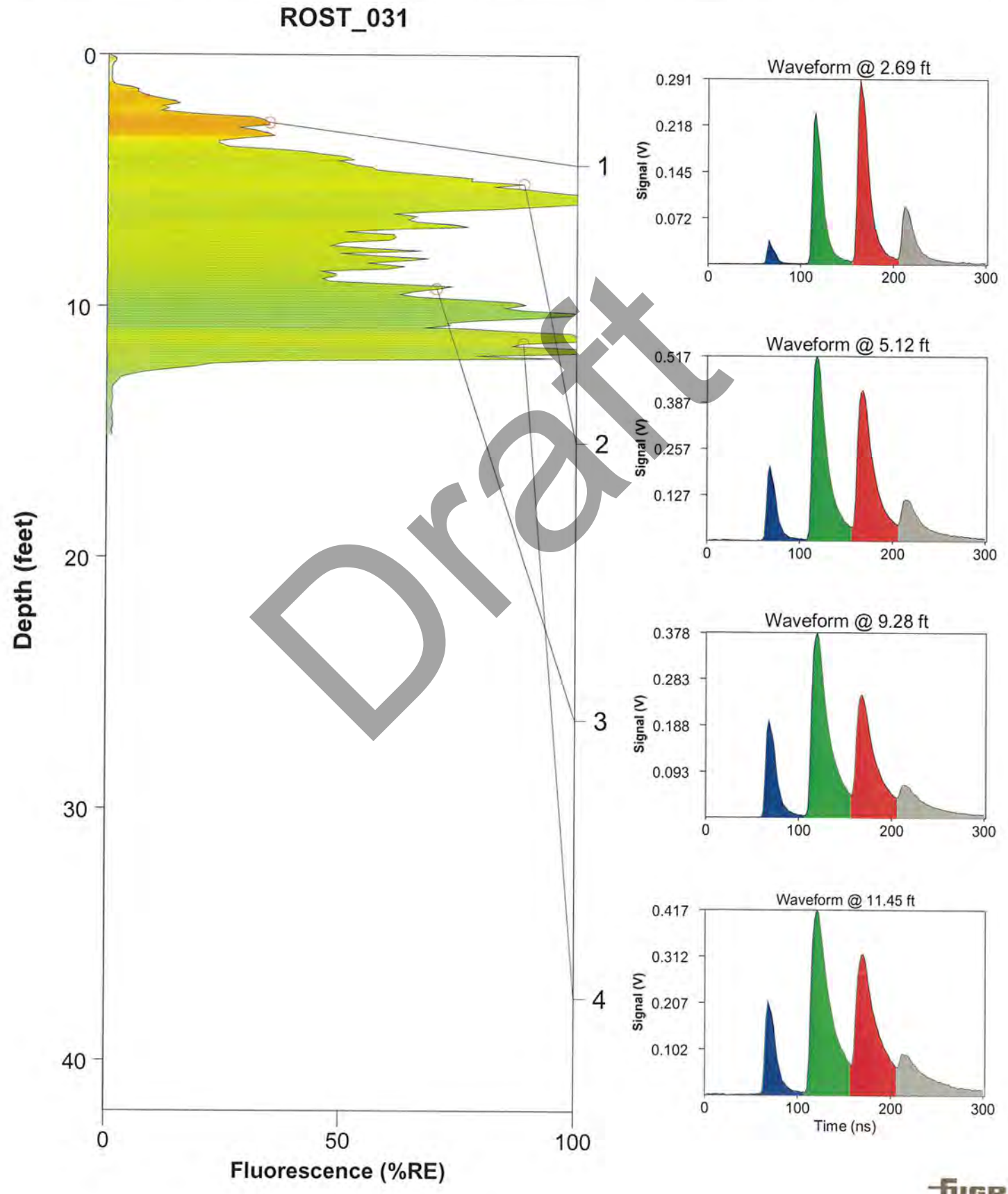


Draft

FUGRO

ROST Fluorescence Response Data

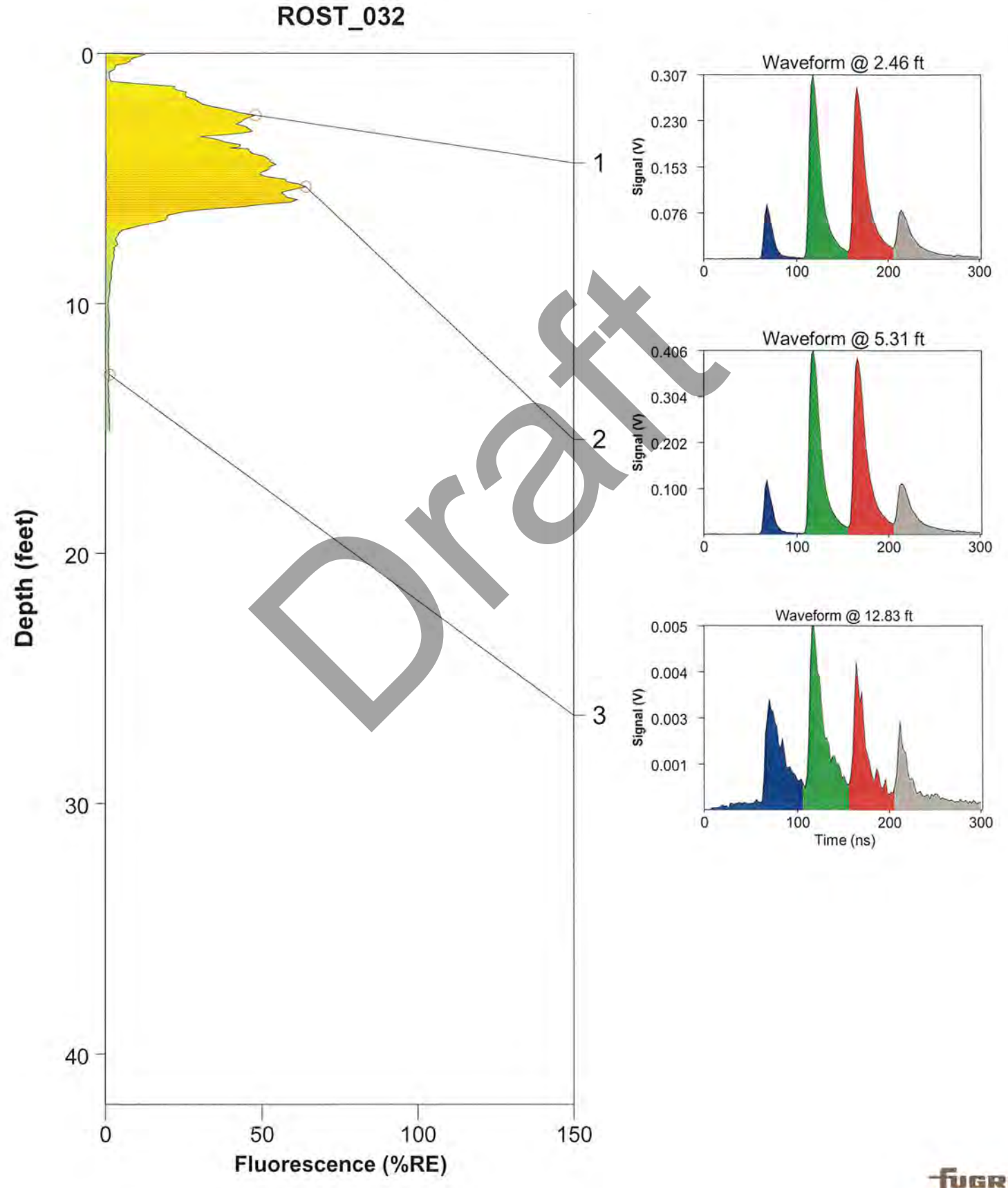
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 17:26:56	Max fluorescence: 126.13% @ 11.75 ft
ROST Unit: ?	Final depth BGS: 15.12 ft



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-23-2002 @ 17:50:55	Max fluorescence: 63.86% @ 5.31 ft
ROST Unit: ?	Final depth BGS: 15.09 ft

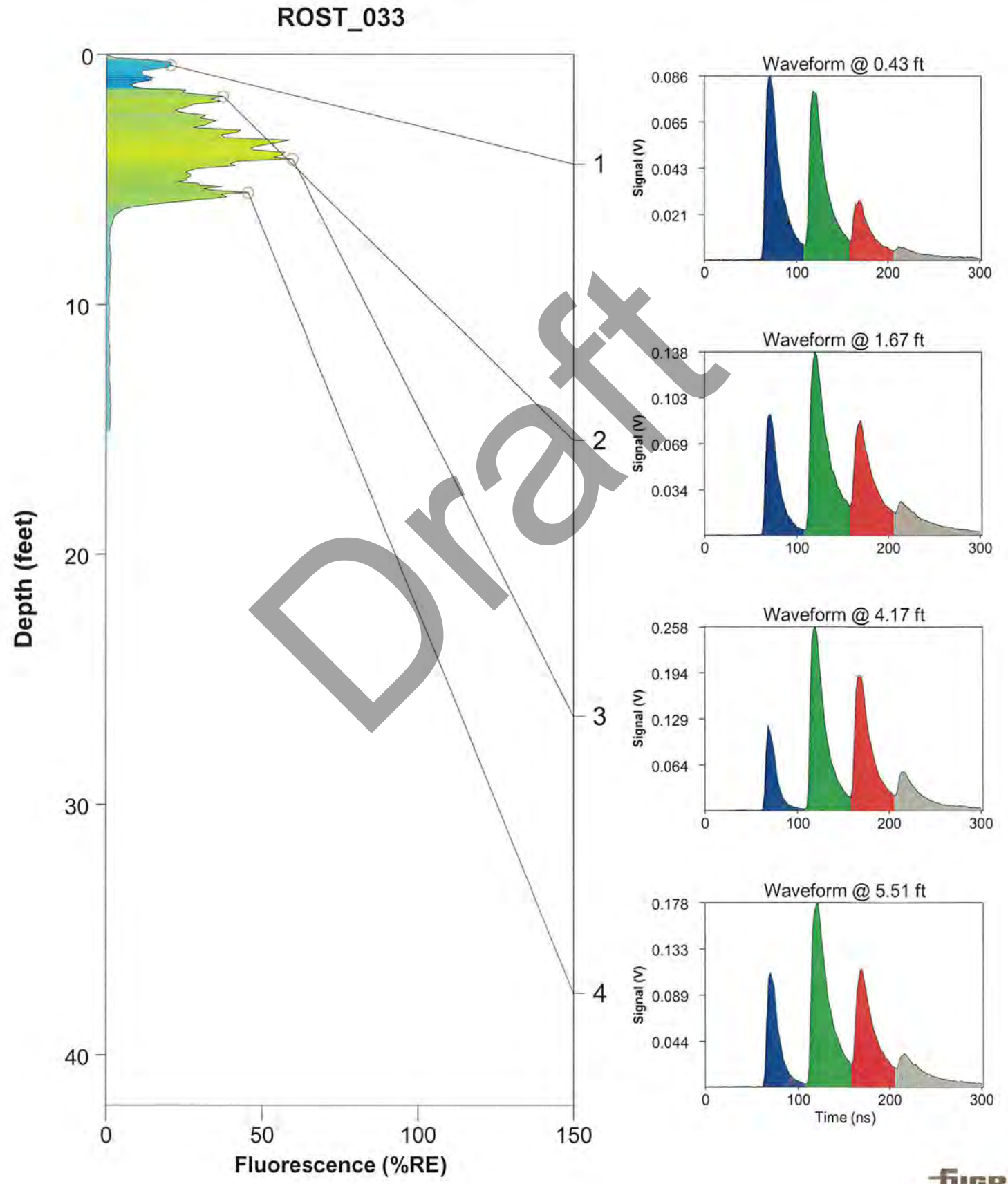


Draft

FUGRO

ROST Fluorescence Response Data

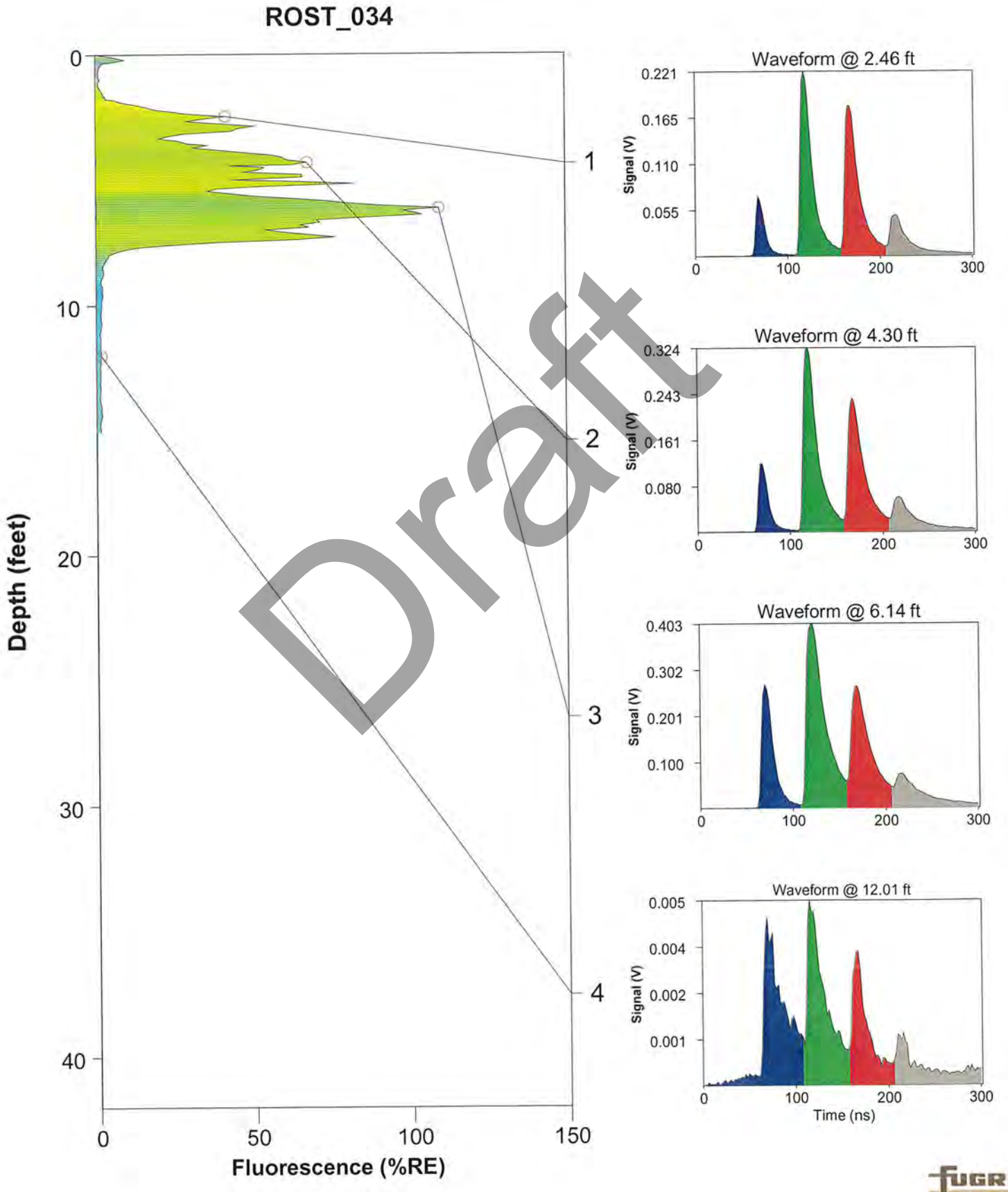
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-24-2002 @ 09:44:08	Max fluorescence: 59.63% @ 4.17 ft
ROST Unit: ?	Final depth BGS: 15.03 ft



Draft

ROST Fluorescence Response Data

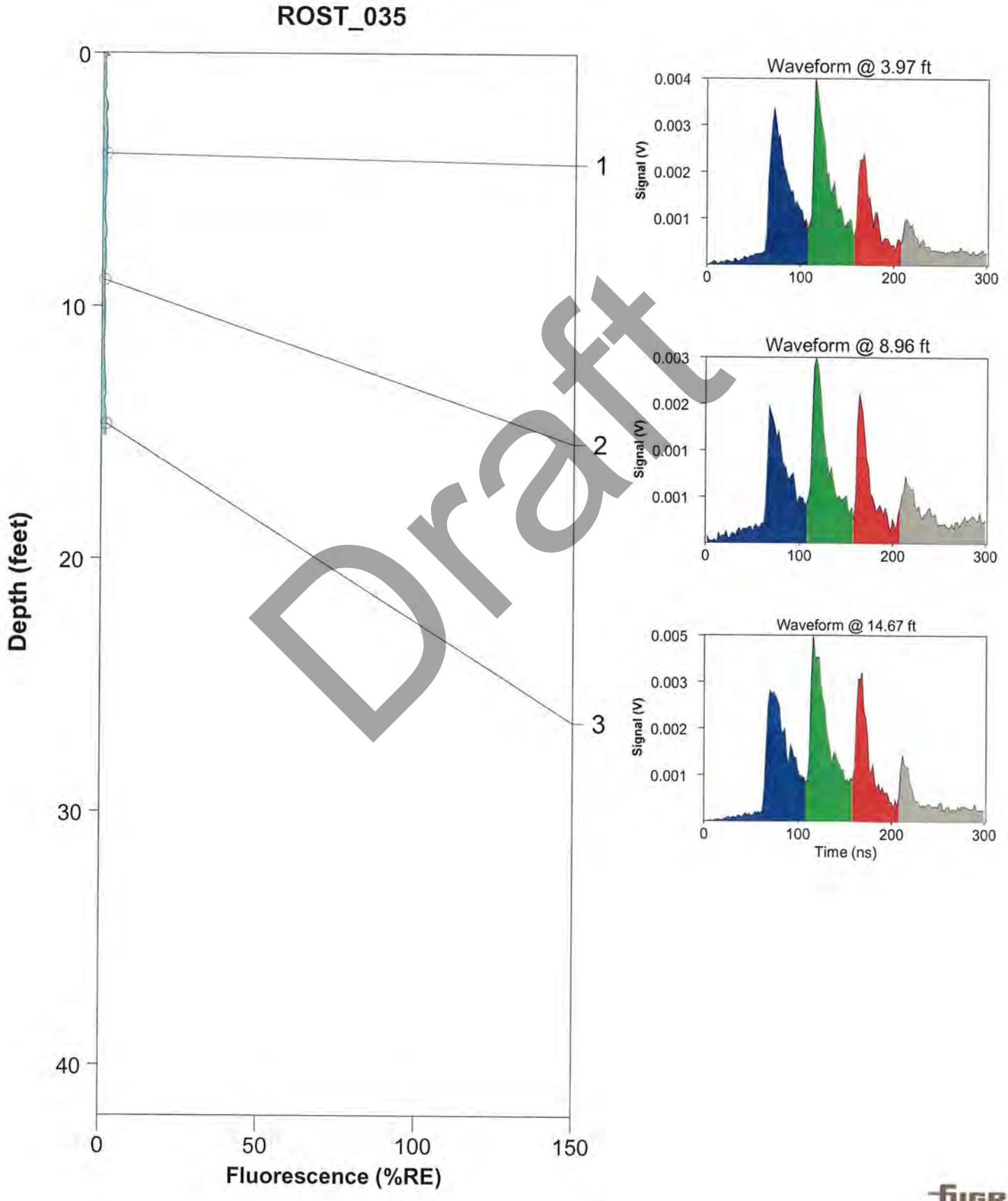
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-24-2002 @ 10:03:45	Max fluorescence: 109.39% @ 6.14 ft
ROST Unit: ?	Final depth BGS: 15.06 ft



Draft

ROST Fluorescence Response Data

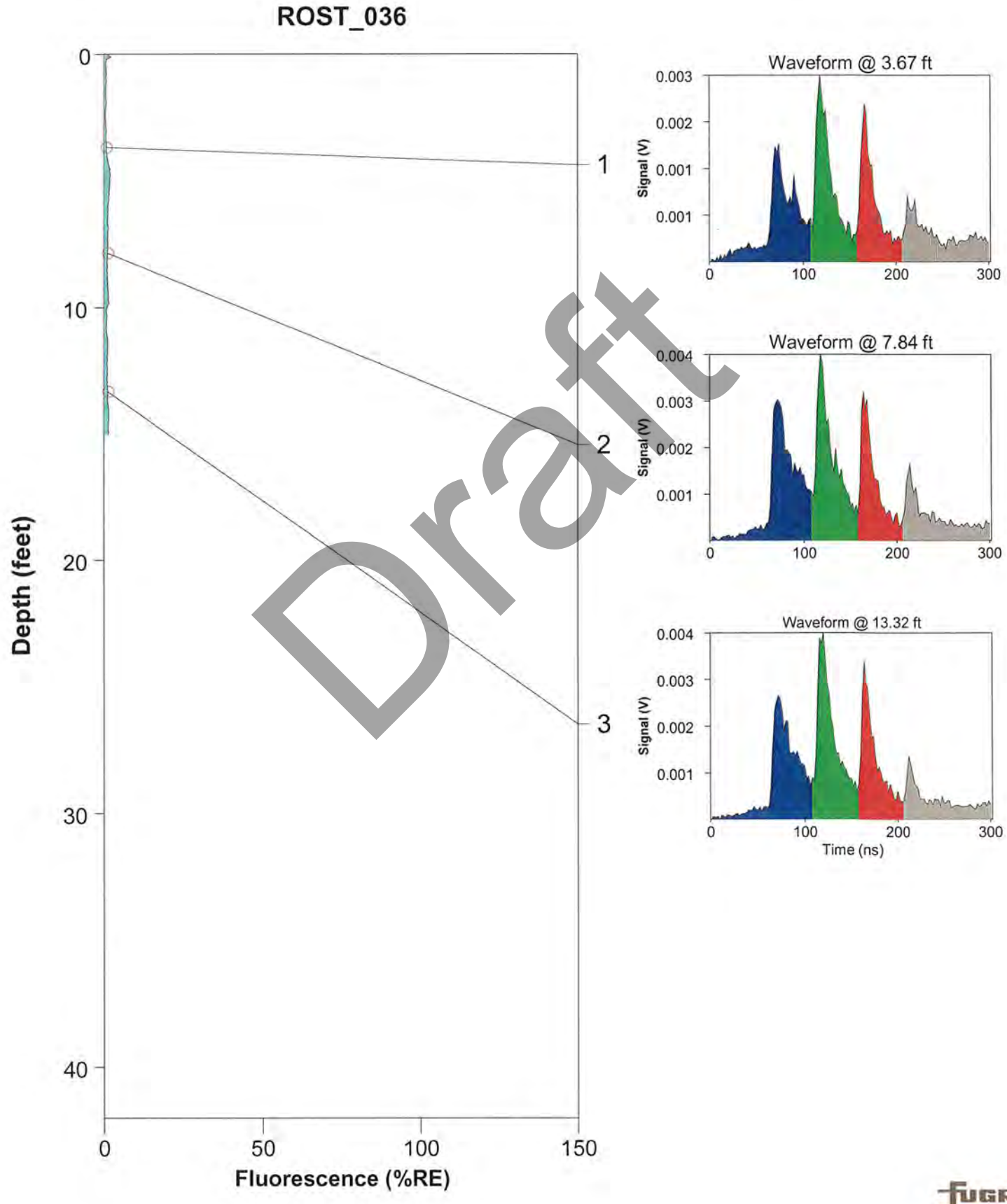
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-24-2002 @ 10:36:11	Max fluorescence: 1.84% @ 0.10 ft
ROST Unit: ?	Final depth BGS: 15.12 ft



Draft

ROST Fluorescence Response Data

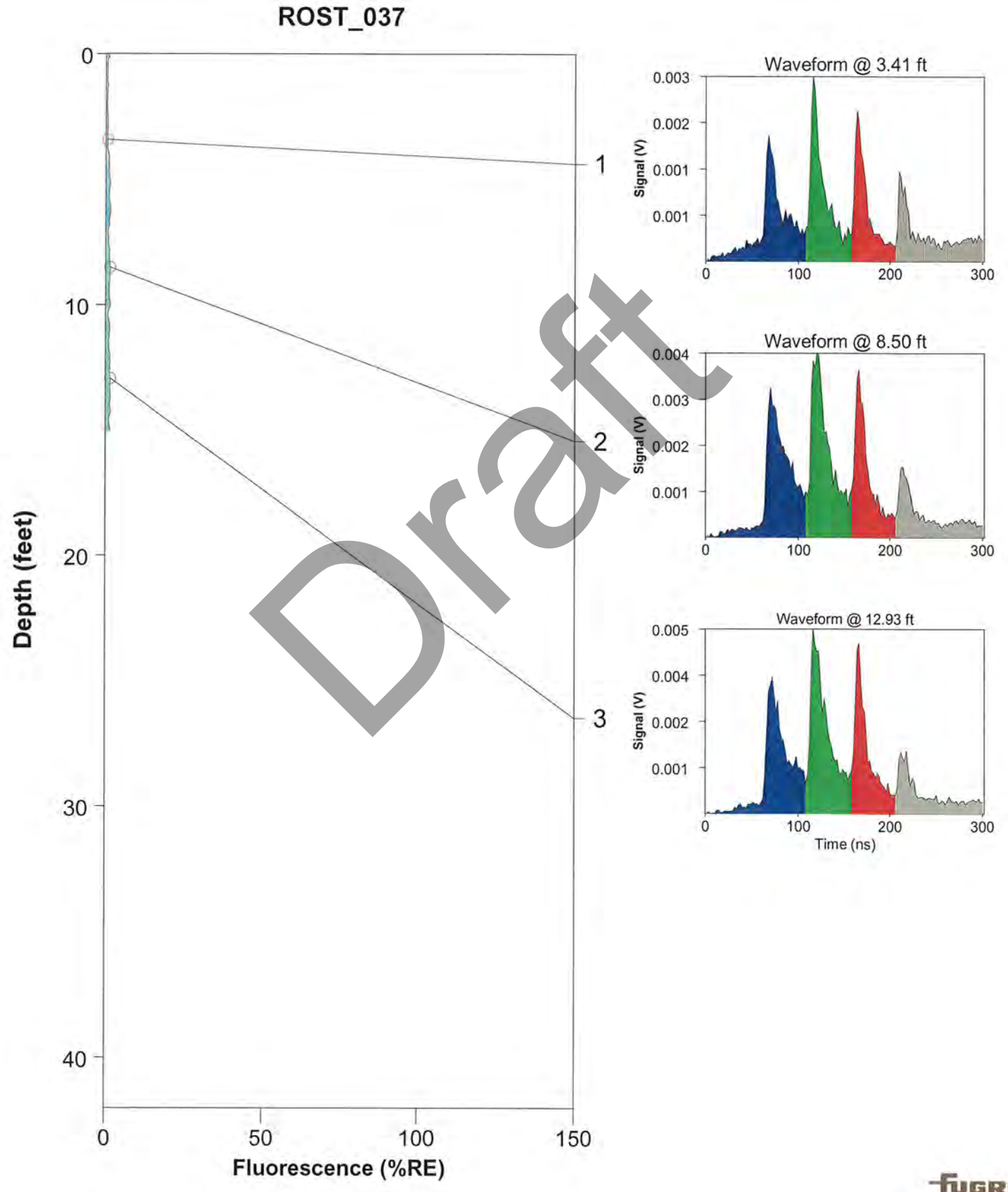
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-24-2002 @ 10:57:08	Max fluorescence: 2.09% @ 0.10 ft
ROST Unit: ?	Final depth BGS: 15.03 ft



Draft

ROST Fluorescence Response Data

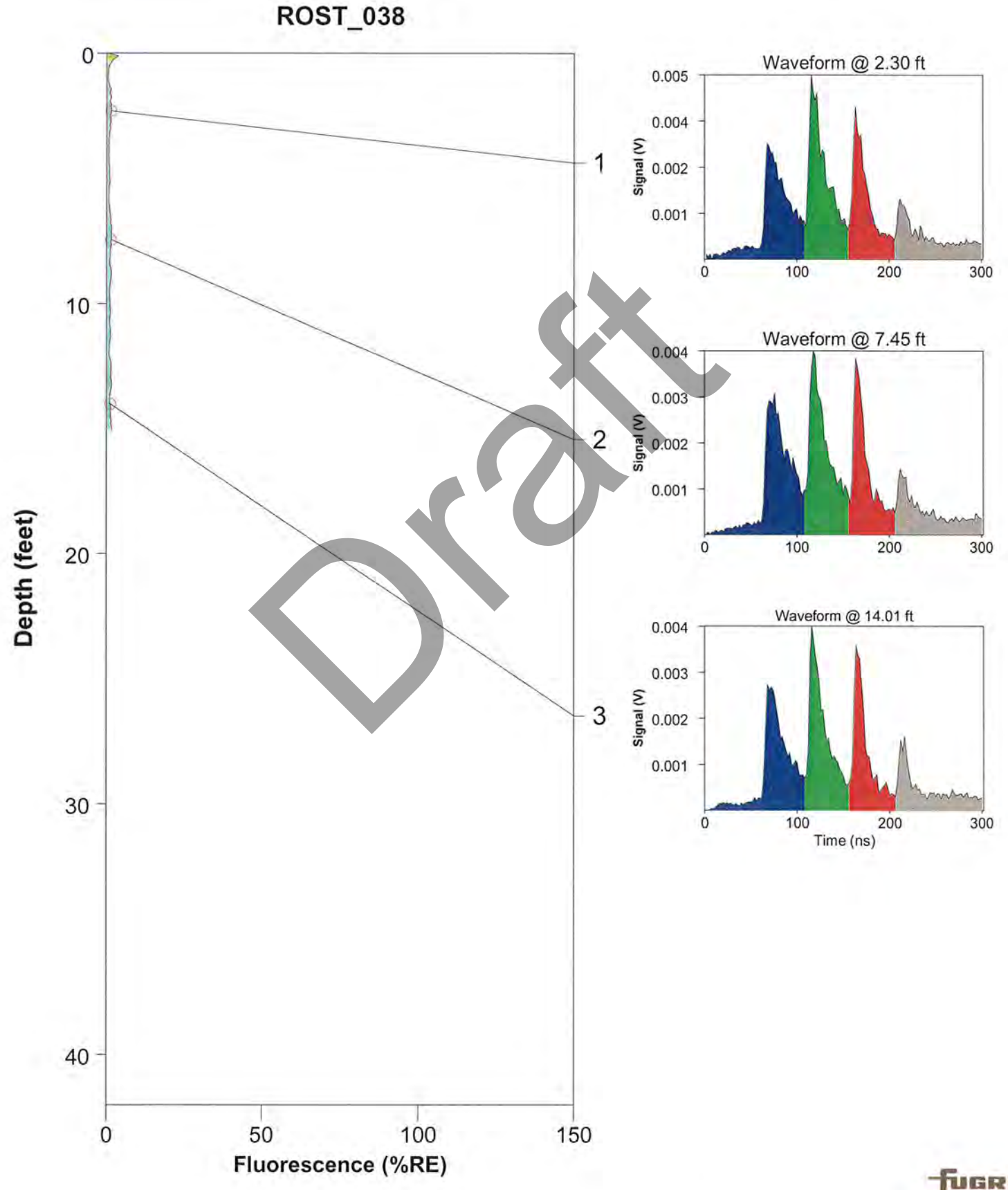
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-24-2002 @ 11:18:28	Max fluorescence: 1.66% @ 14.30 ft
ROST Unit: ?	Final depth BGS: 15.06 ft



Draft

ROST Fluorescence Response Data

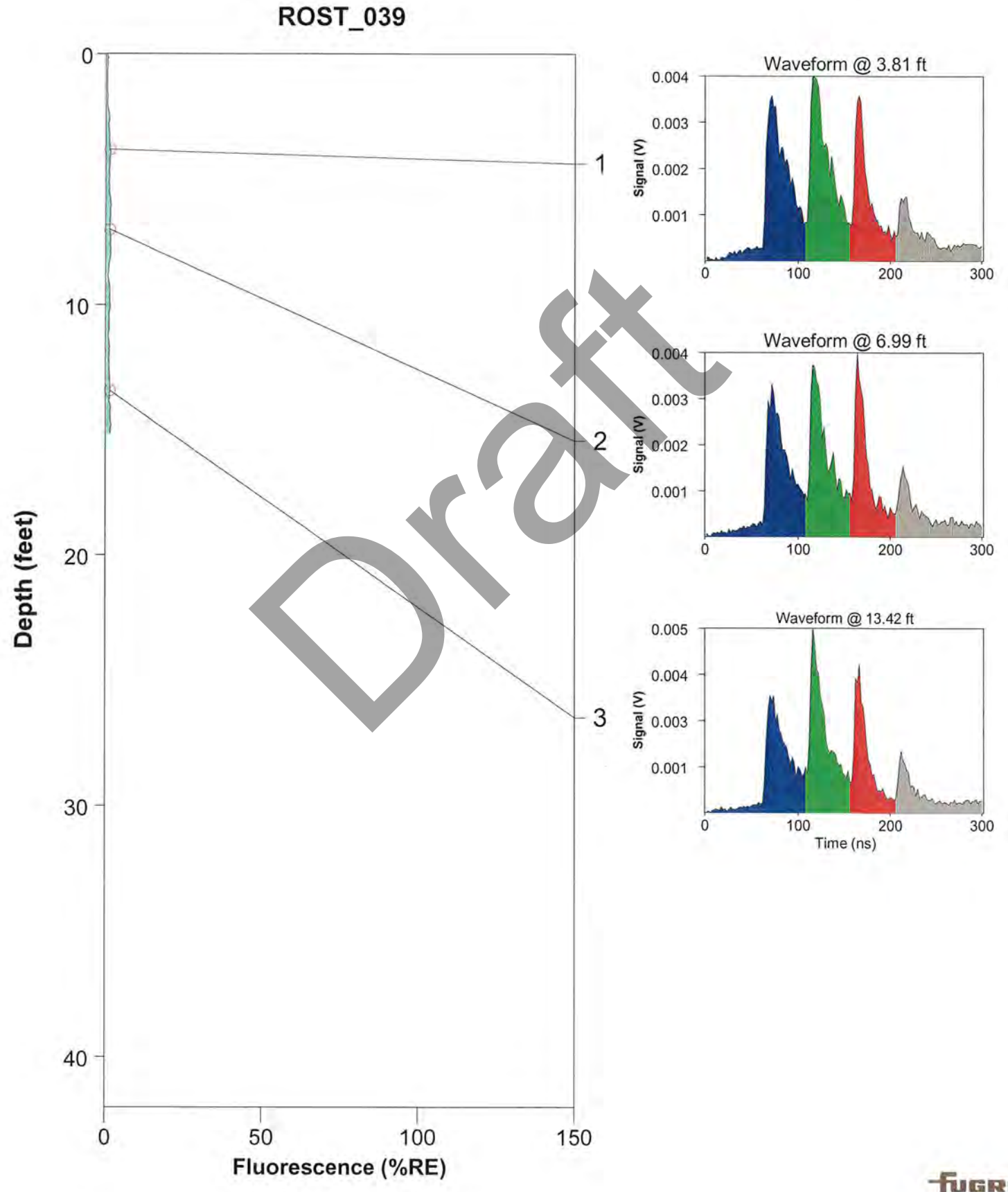
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-24-2002 @ 11:54:44	Max fluorescence: 3.73% @ 0.10 ft
ROST Unit: ?	Final depth BGS: 15.06 ft



Draft

ROST Fluorescence Response Data

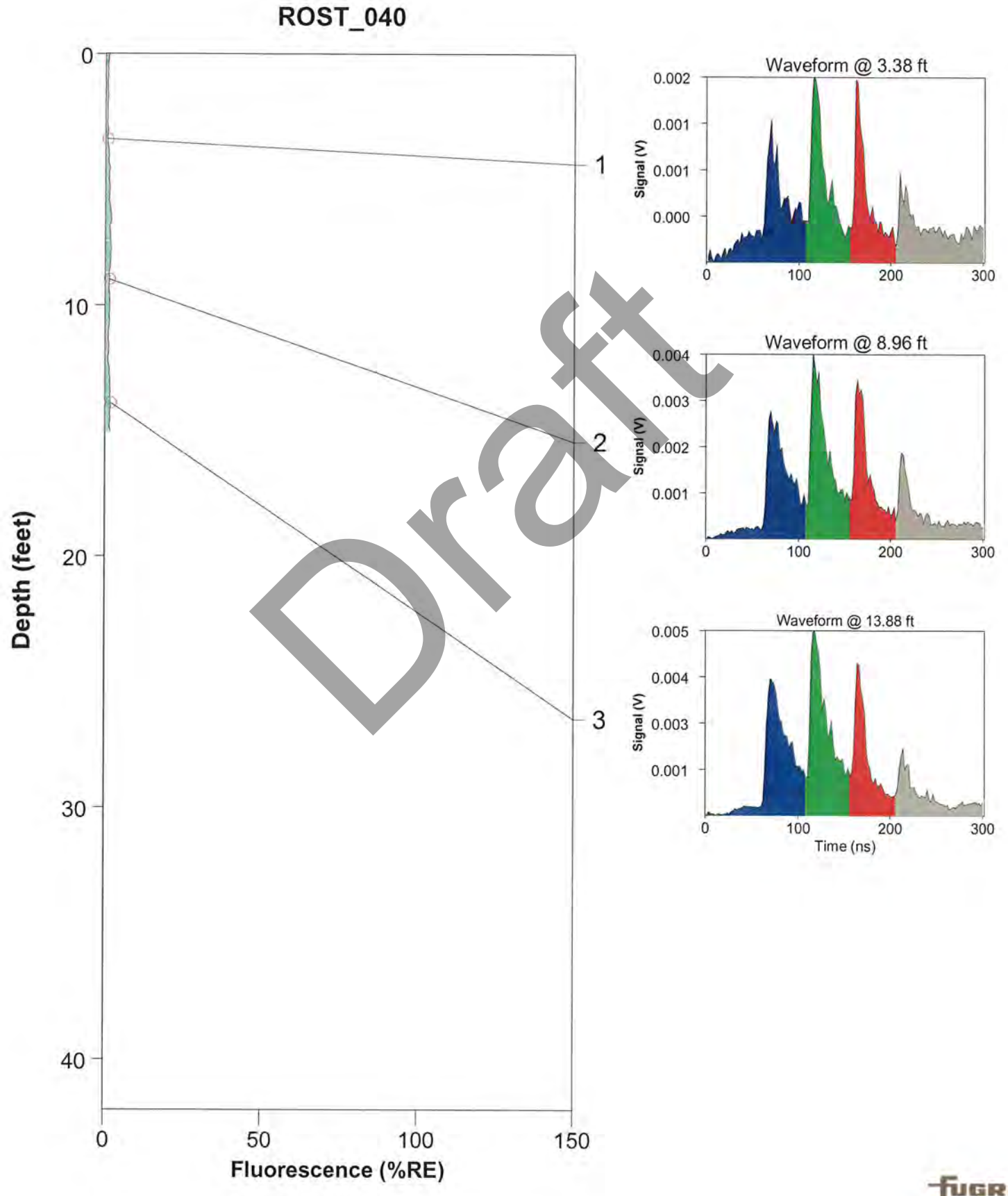
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-24-2002 @ 12:13:56	Max fluorescence: 1.89% @ 14.76 ft
ROST Unit: ?	Final depth BGS: 15.16 ft



Draft

ROST Fluorescence Response Data

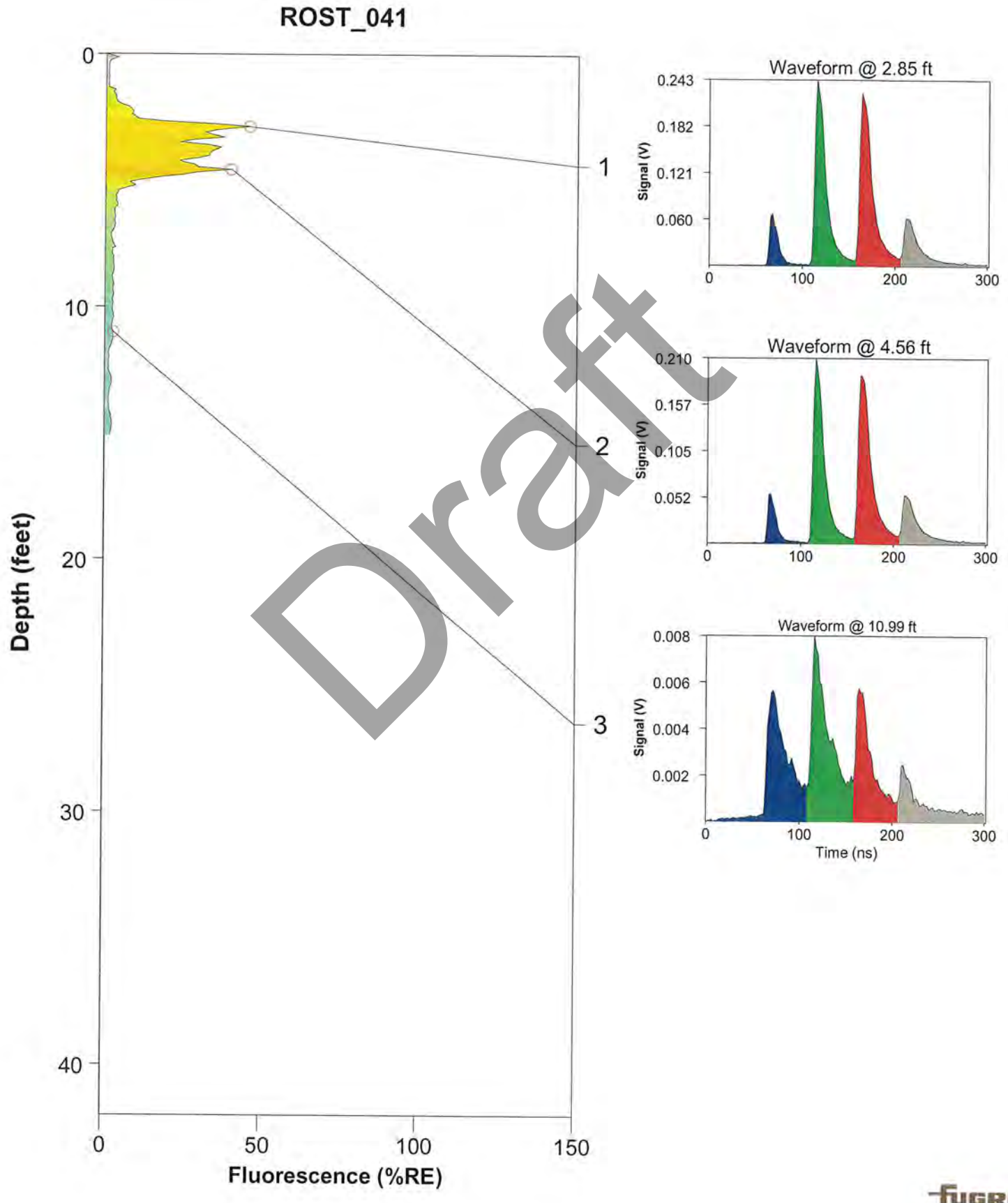
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-24-2002 @ 12:33:28	Max fluorescence: 1.89% @ 6.53 ft
ROST Unit: ?	Final depth BGS: 15.03 ft



Draft

ROST Fluorescence Response Data

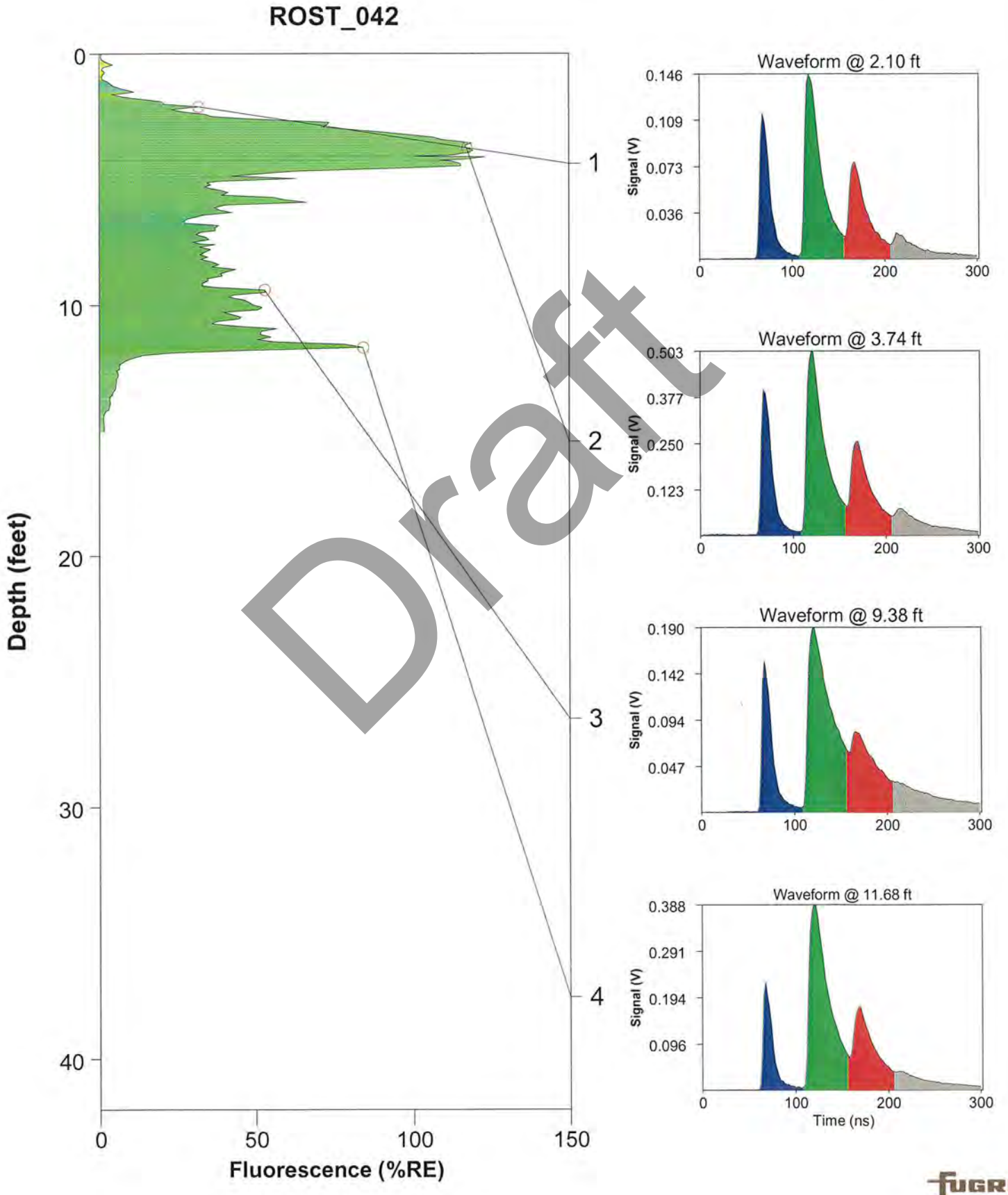
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-24-2002 @ 13:43:33	Max fluorescence: 45.53% @ 2.85 ft
ROST Unit: ?	Final depth BGS: 15.09 ft



Draft

ROST Fluorescence Response Data

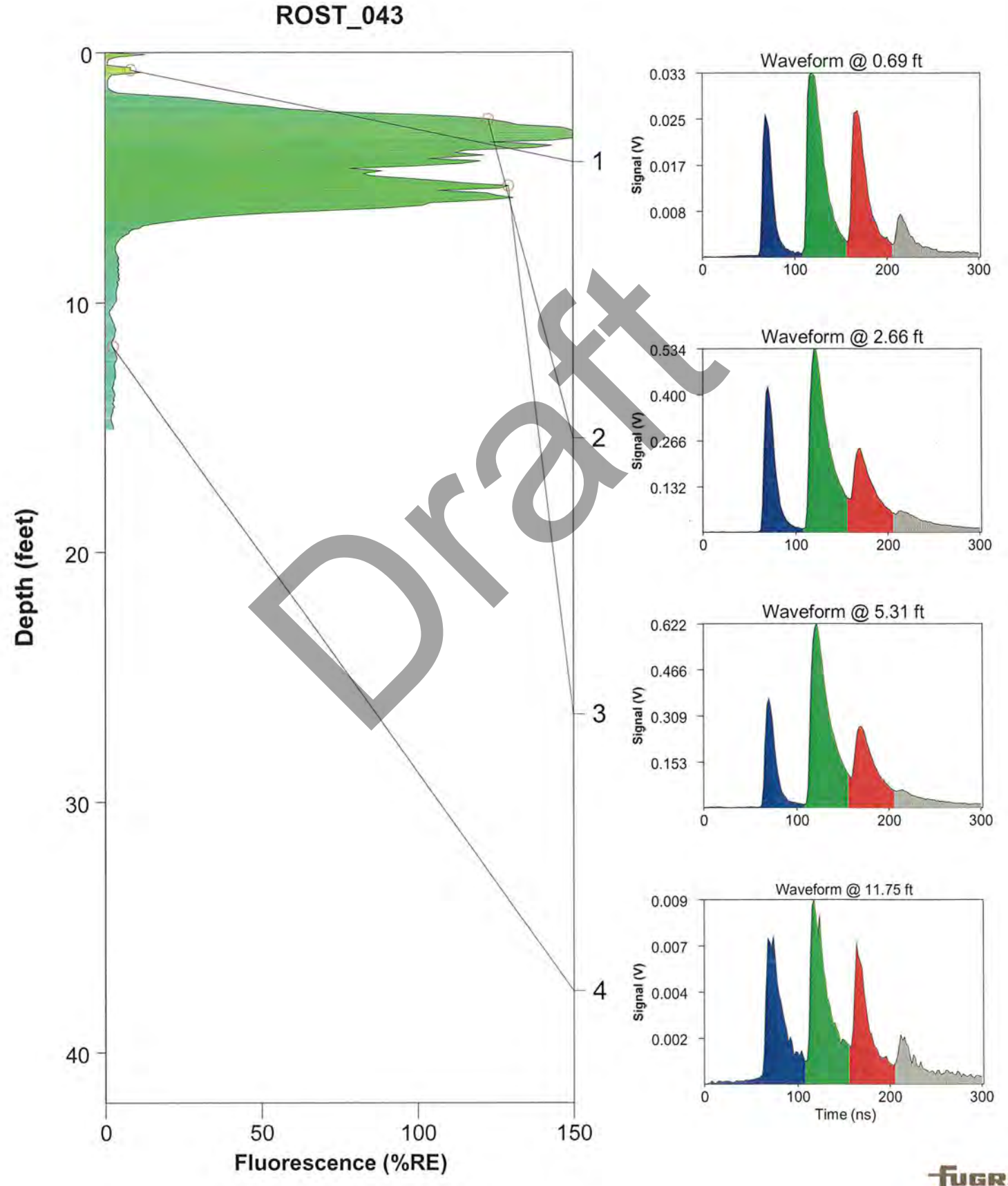
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-24-2002 @ 14:00:08	Max fluorescence: 122.99% @ 4.10 ft
ROST Unit: ?	Final depth BGS: 15.03 ft



Draft

ROST Fluorescence Response Data

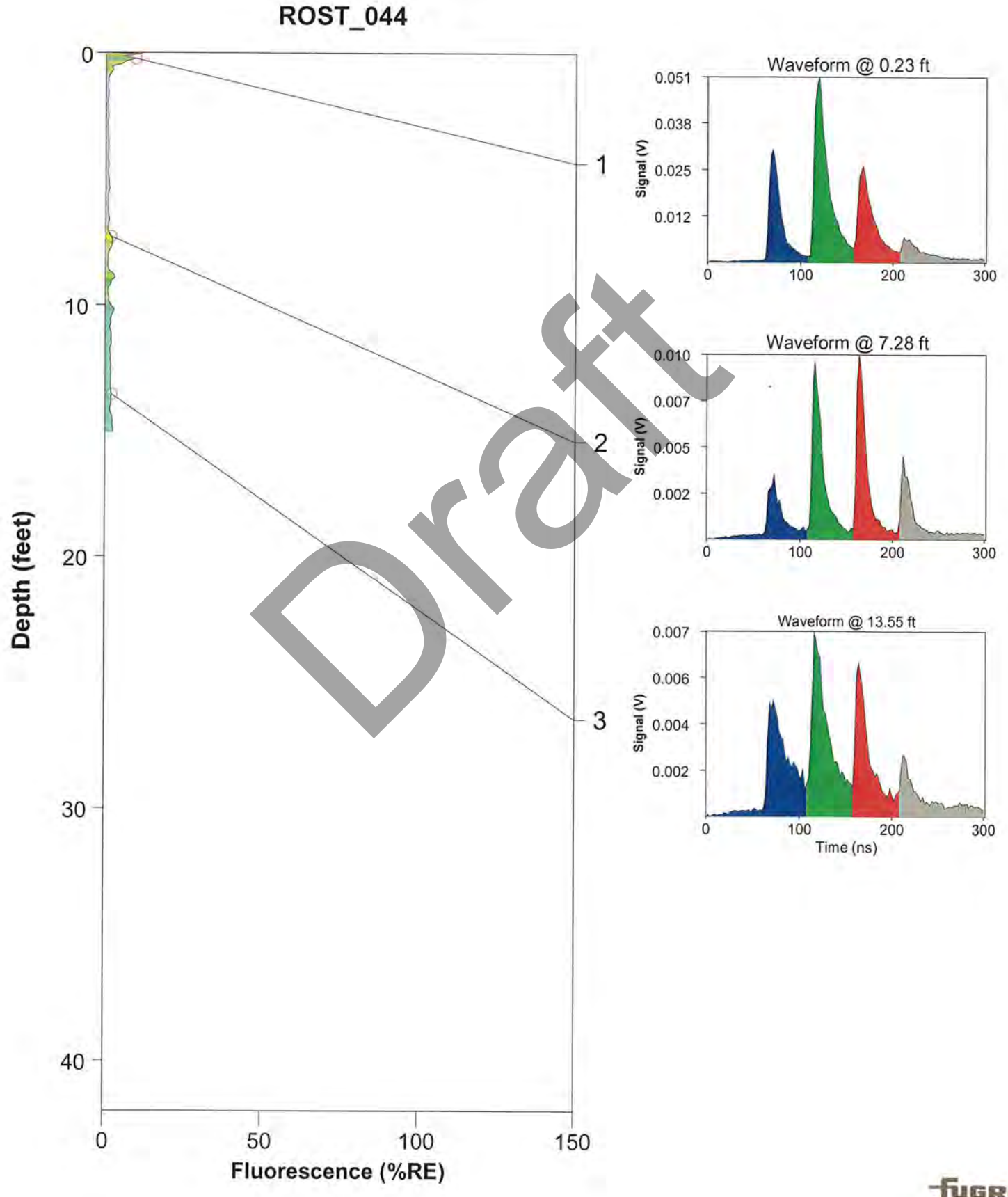
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-24-2002 @ 14:17:27	Max fluorescence: 171.73% @ 3.22 ft
ROST Unit: ?	Final depth BGS: 15.06 ft



Draft

ROST Fluorescence Response Data

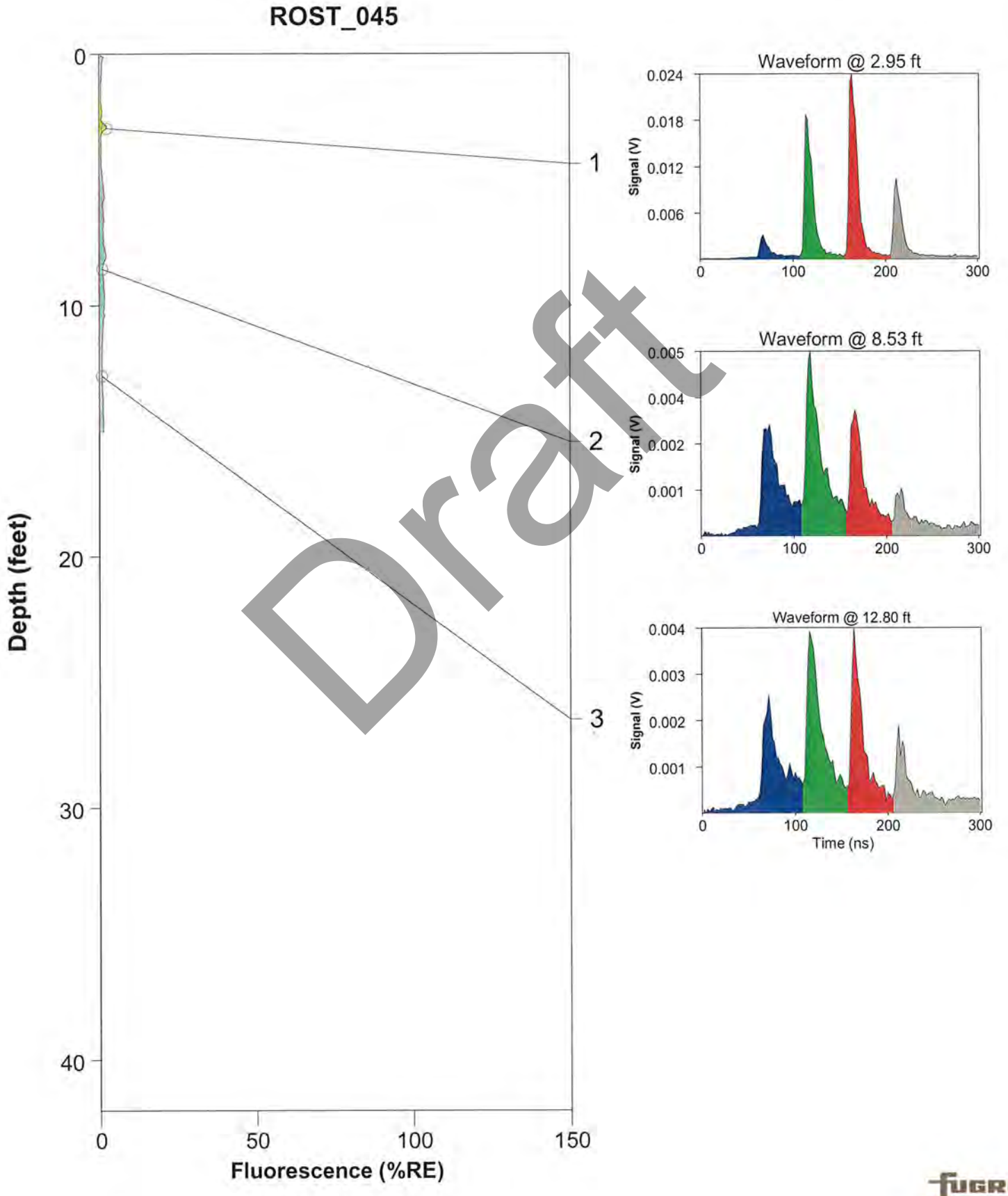
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-24-2002 @ 16:09:01	Max fluorescence: 11.11% @ 0.03 ft
ROST Unit: ?	Final depth BGS: 15.06 ft



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-24-2002 @ 16:25:18	Max fluorescence: 2.41% @ 2.95 ft
ROST Unit: ?	Final depth BGS: 15.03 ft

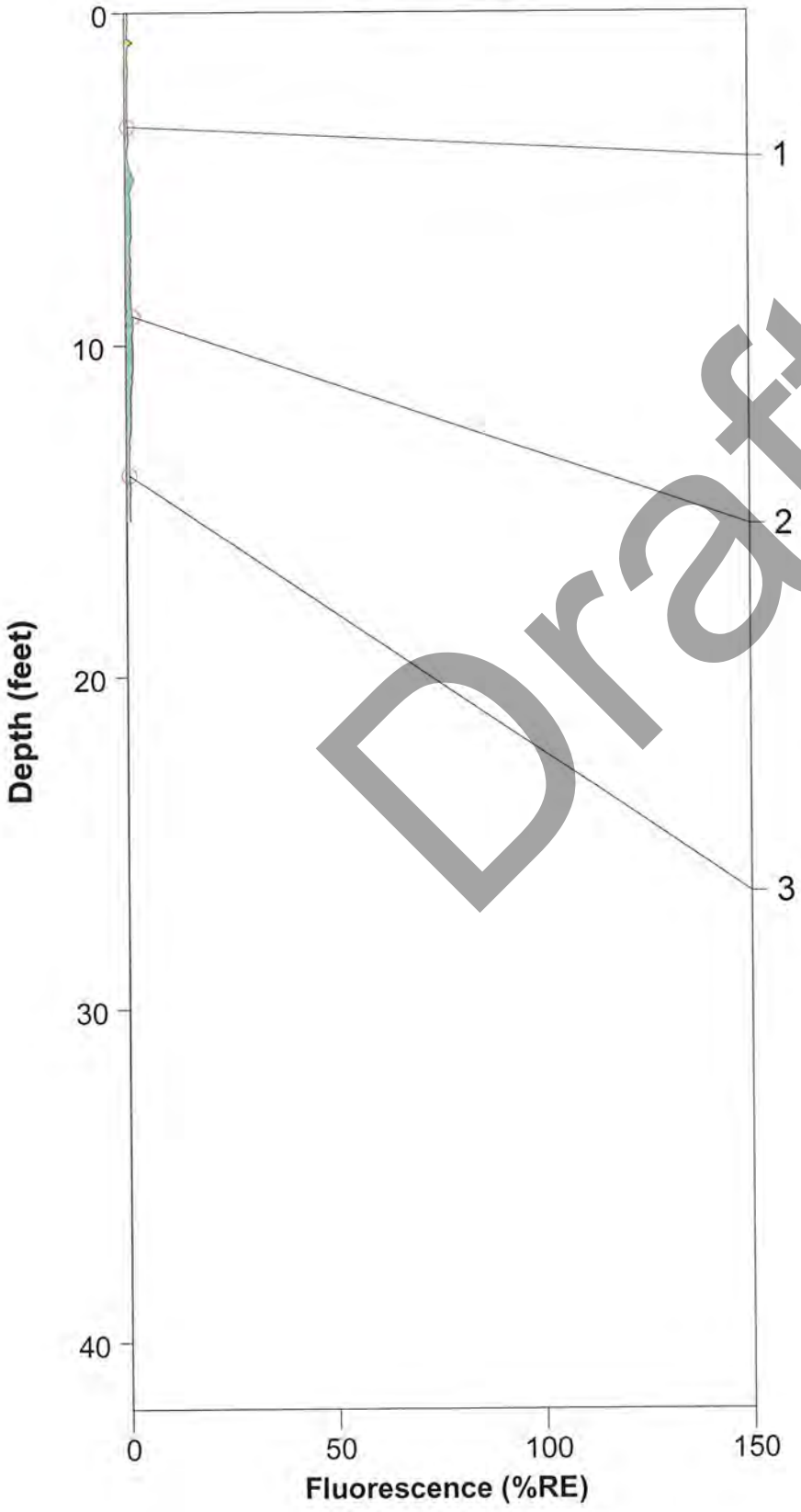


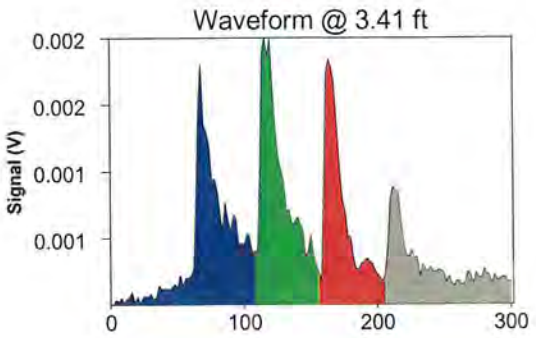
Draft

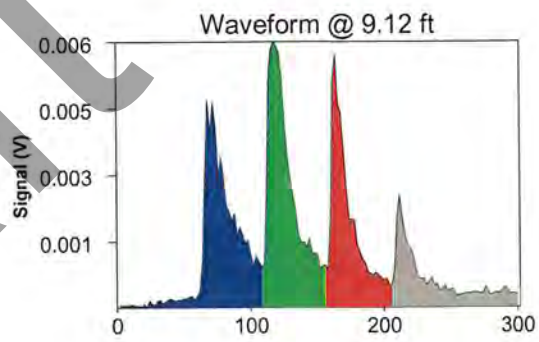
ROST Fluorescence Response Data

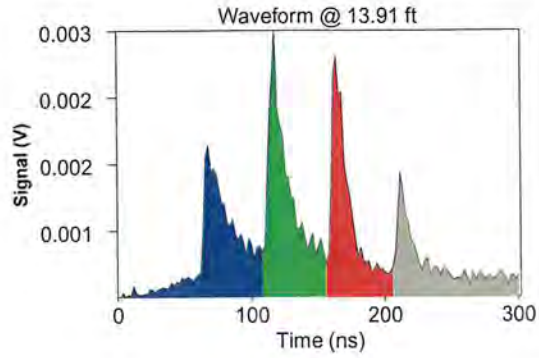
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-24-2002 @ 16:41:00	Max fluorescence: 2.15% @ 4.99 ft
ROST Unit: ?	Final depth BGS: 15.29 ft

ROST_046





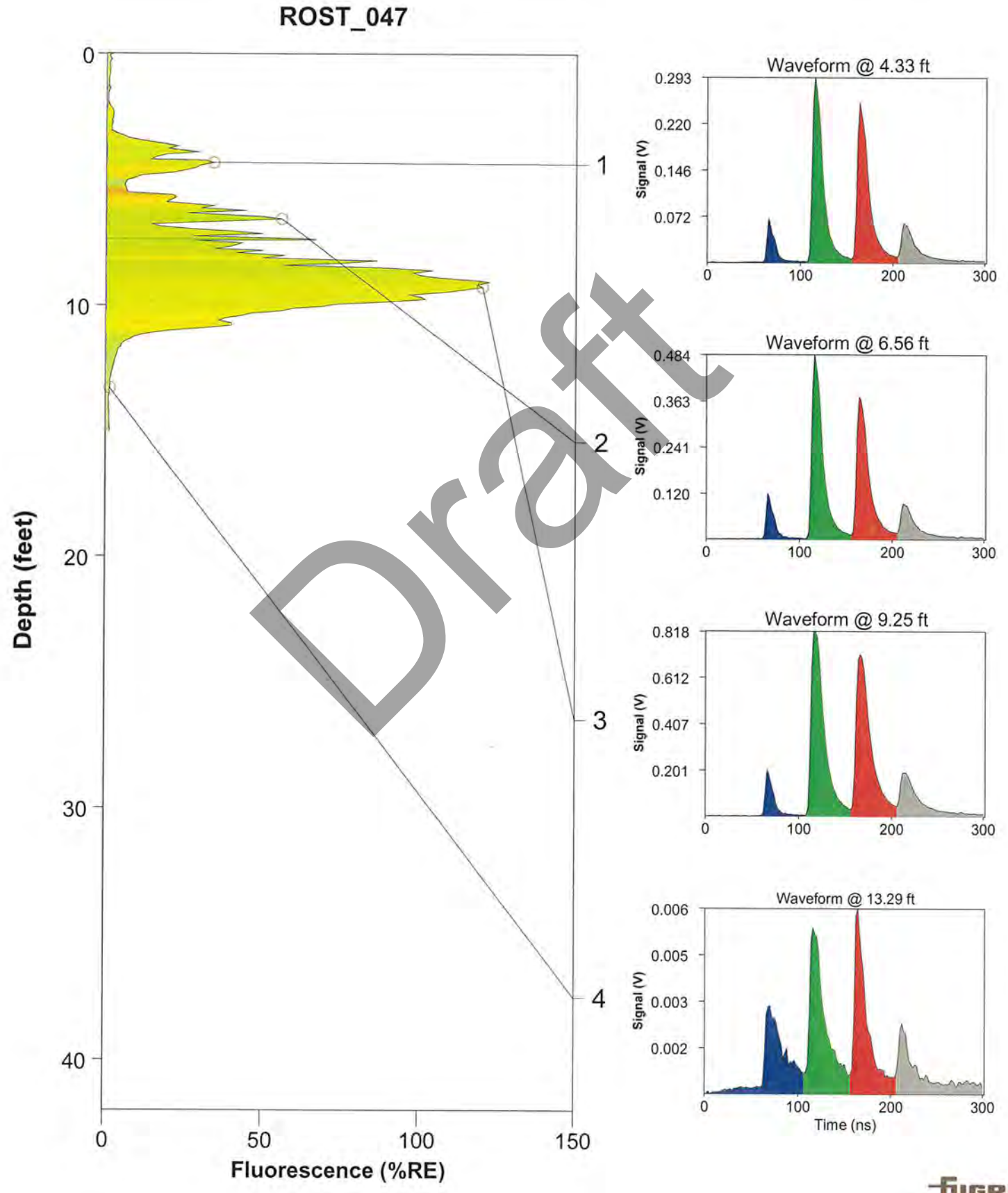




Draft

ROST Fluorescence Response Data

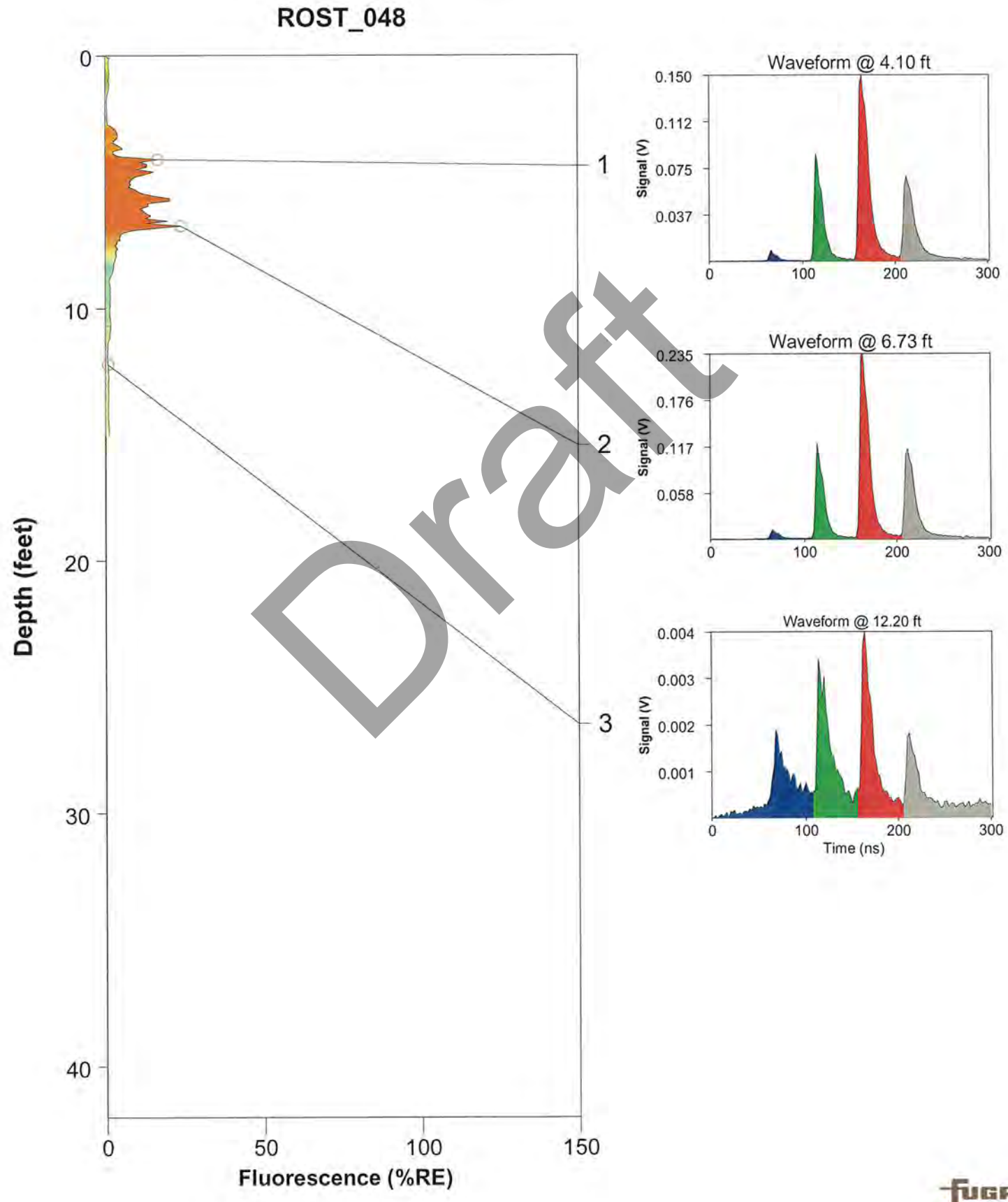
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-25-2002 @ 12:19:30	Max fluorescence: 122.31% @ 9.06 ft
ROST Unit: ?	Final depth BGS: 15.03 ft



Draft

ROST Fluorescence Response Data

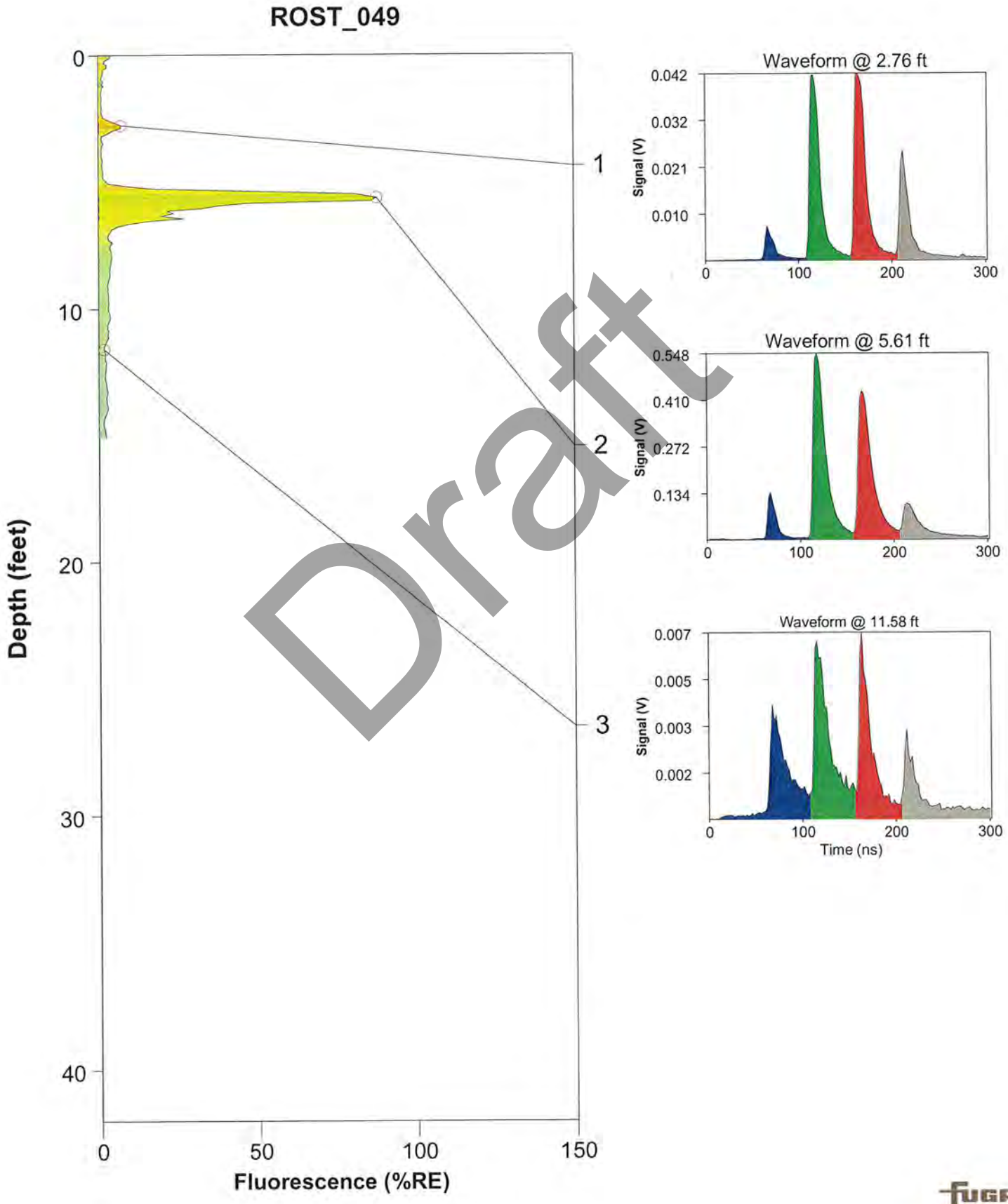
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-24-2002 @ 17:21:04	Max fluorescence: 23.77% @ 6.73 ft
ROST Unit: ?	Final depth BGS: 15.03 ft



Draft

ROST Fluorescence Response Data

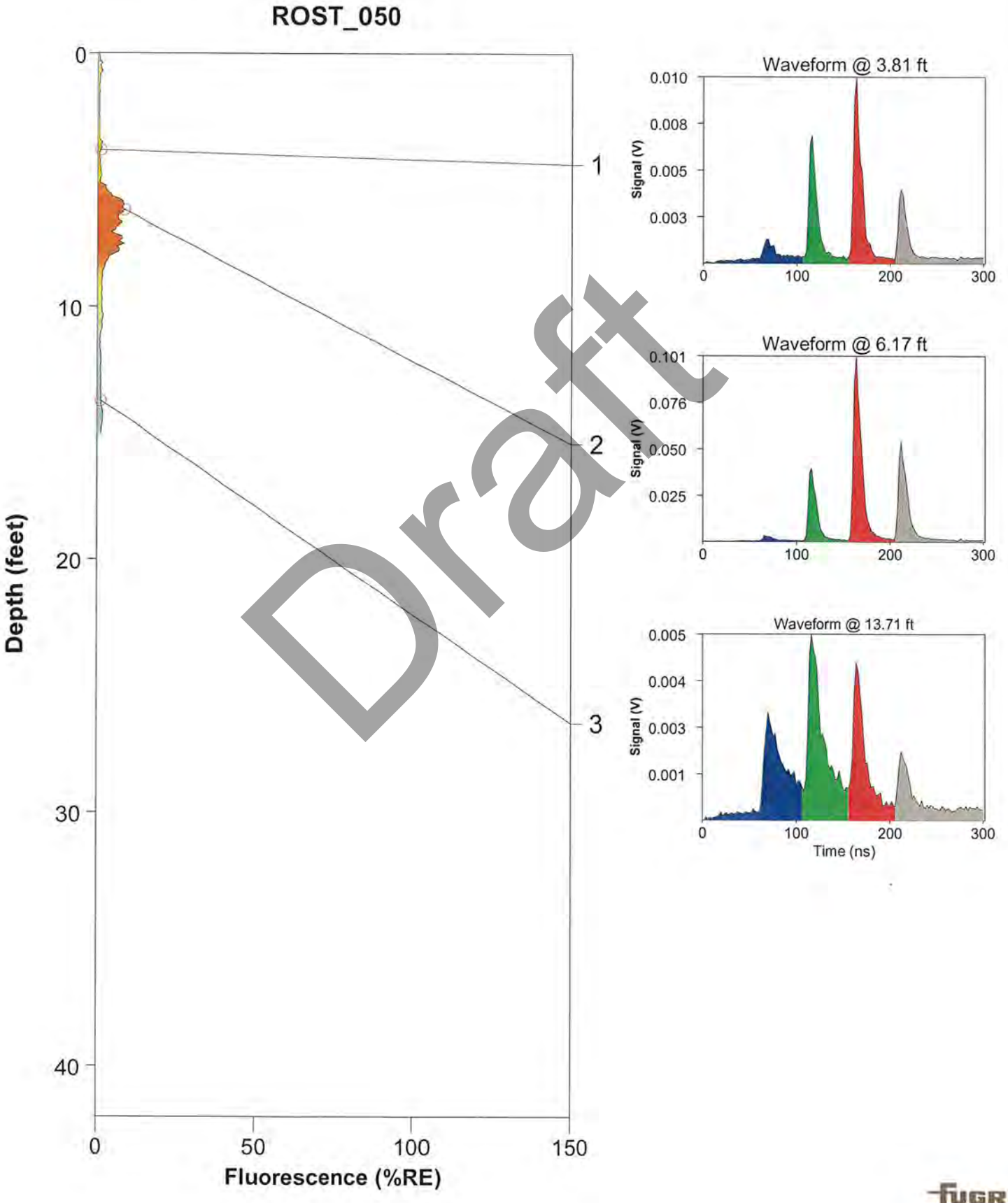
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-25-2002 @ 11:56:55	Max fluorescence: 87.71% @ 5.61 ft
ROST Unit: ?	Final depth BGS: 15.09 ft



Draft

ROST Fluorescence Response Data

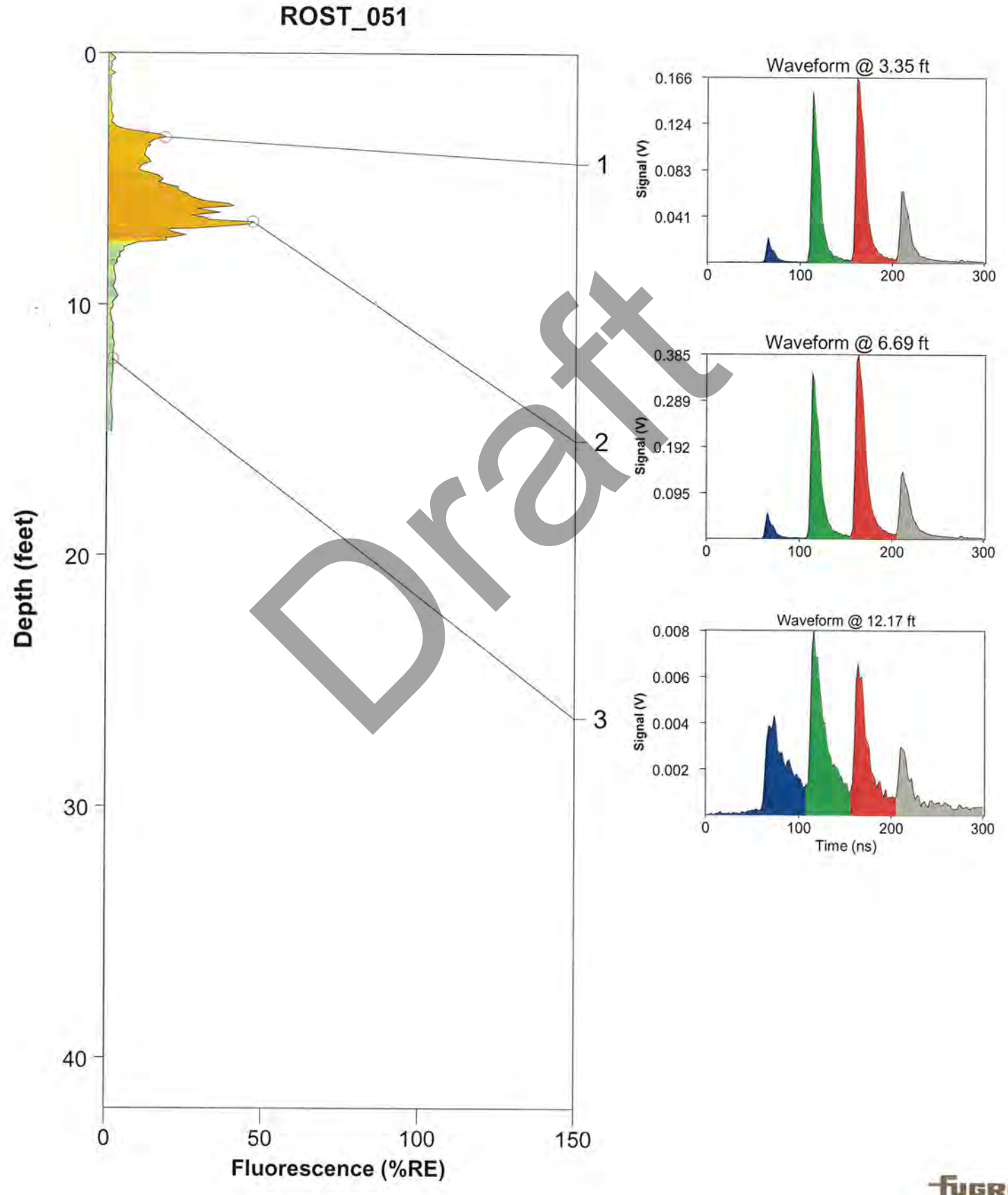
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-24-2002 @ 18:12:33	Max fluorescence: 7.99% @ 6.17 ft
ROST Unit: ?	Final depth BGS: 15.03 ft



Draft

ROST Fluorescence Response Data

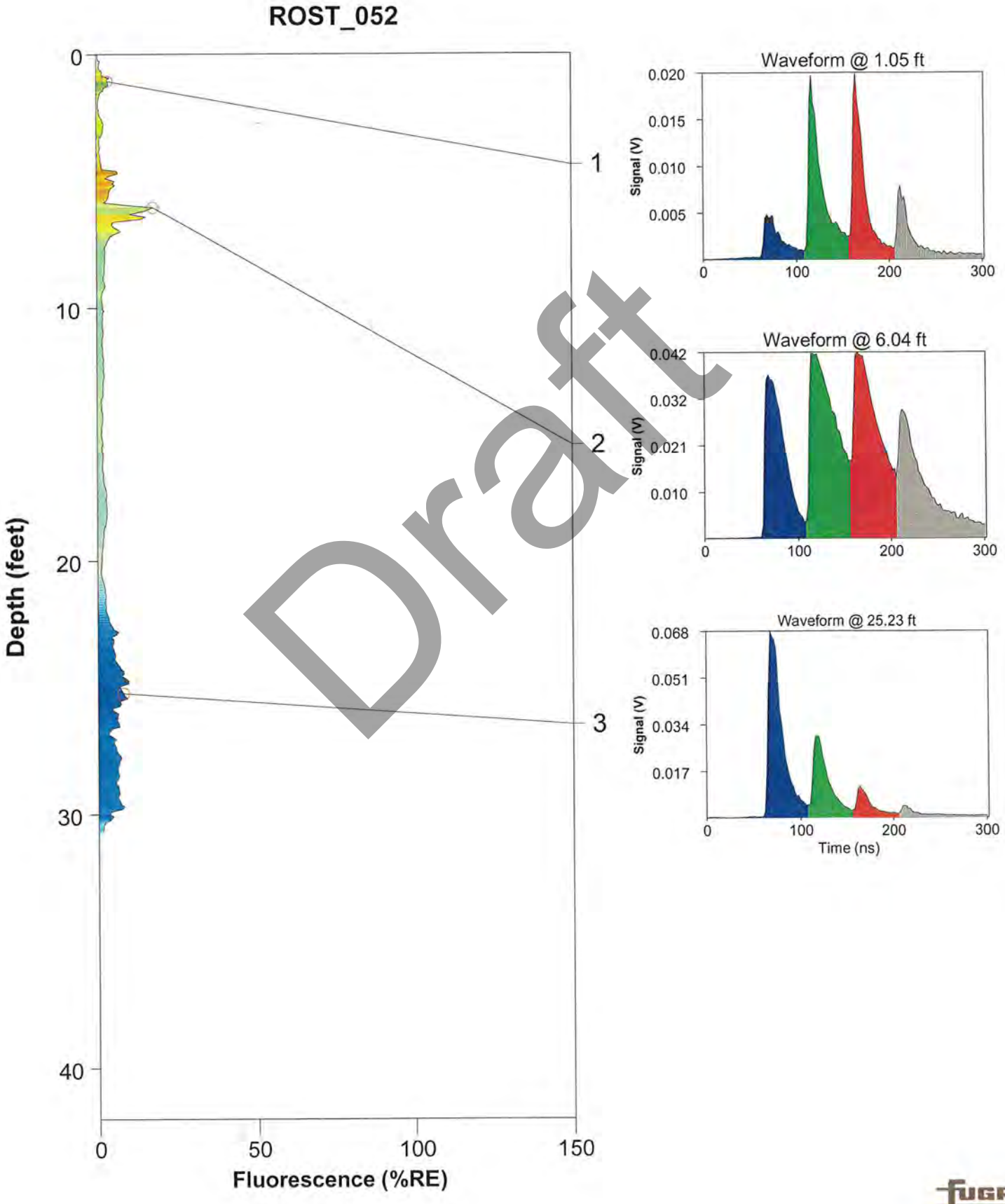
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-25-2002 @ 11:25:27	Max fluorescence: 46.40% @ 6.69 ft
ROST Unit: ?	Final depth BGS: 15.09 ft



Draft

ROST Fluorescence Response Data

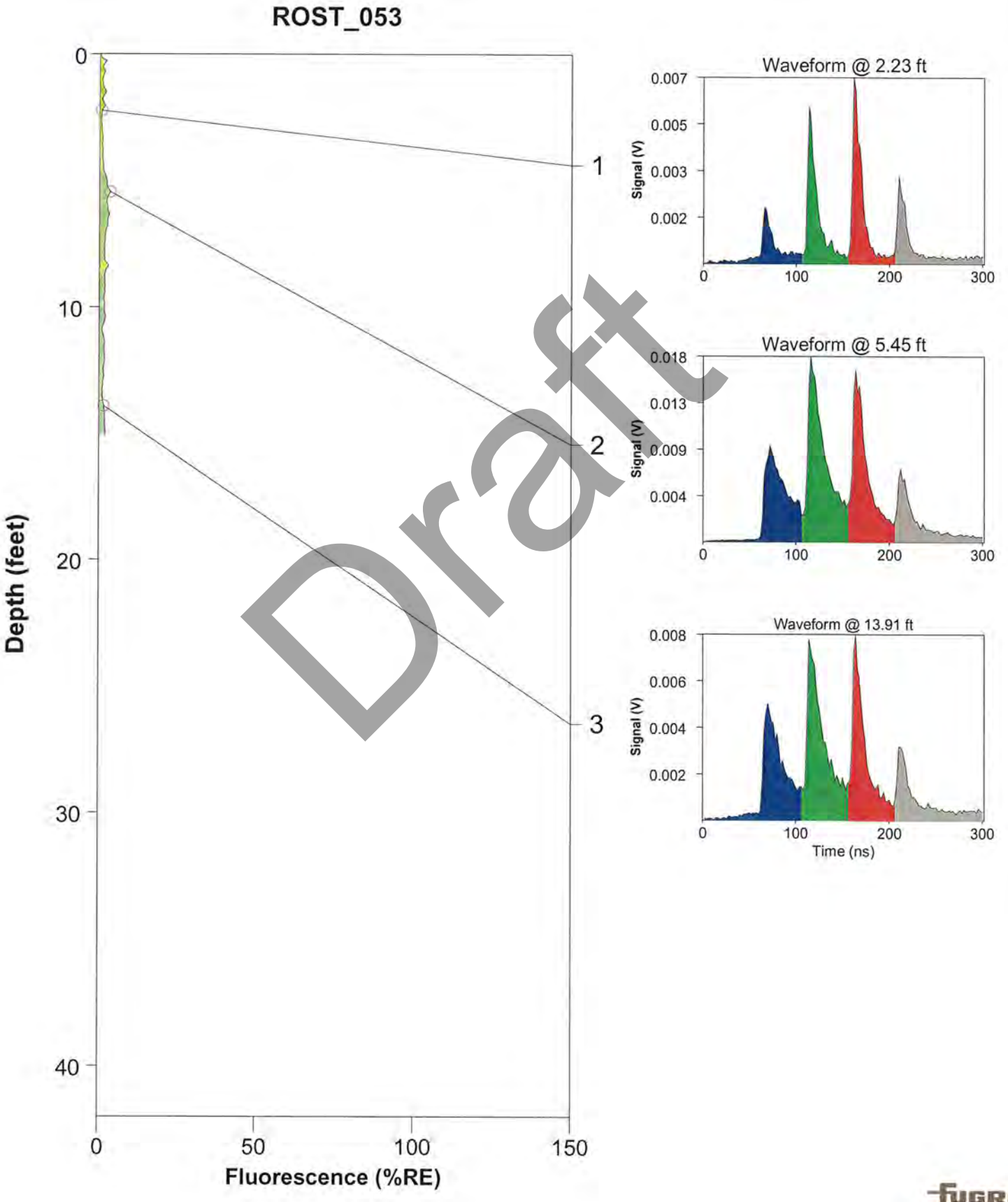
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-25-2002 @ 11:07:09	Max fluorescence: 17.70% @ 6.04 ft
ROST Unit: ?	Final depth BGS: 30.71 ft



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-25-2002 @ 10:37:36	Max fluorescence: 3.46% @ 5.45 ft
ROST Unit: ?	Final depth BGS: 15.06 ft

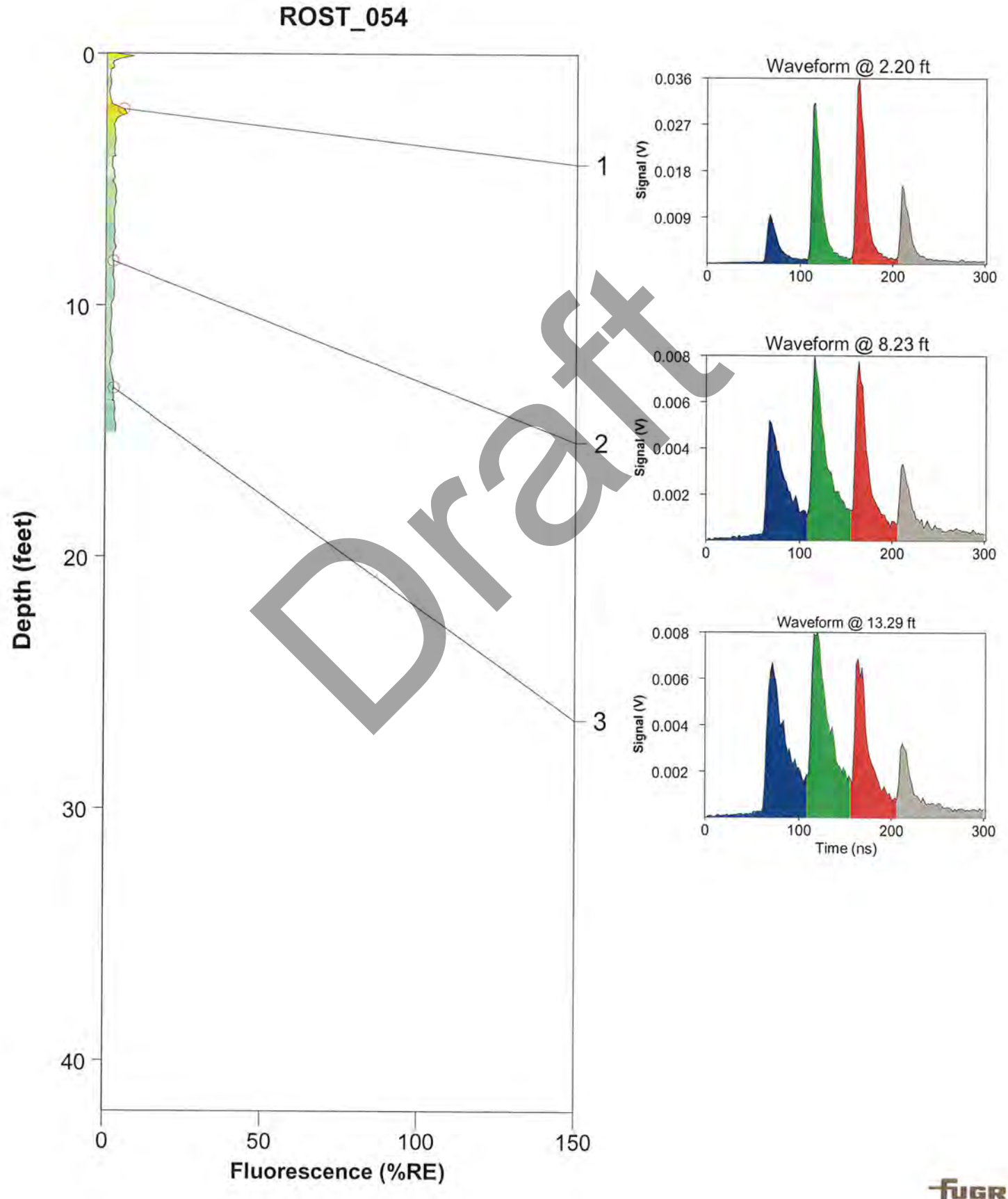


Draft

FUGRO

ROST Fluorescence Response Data

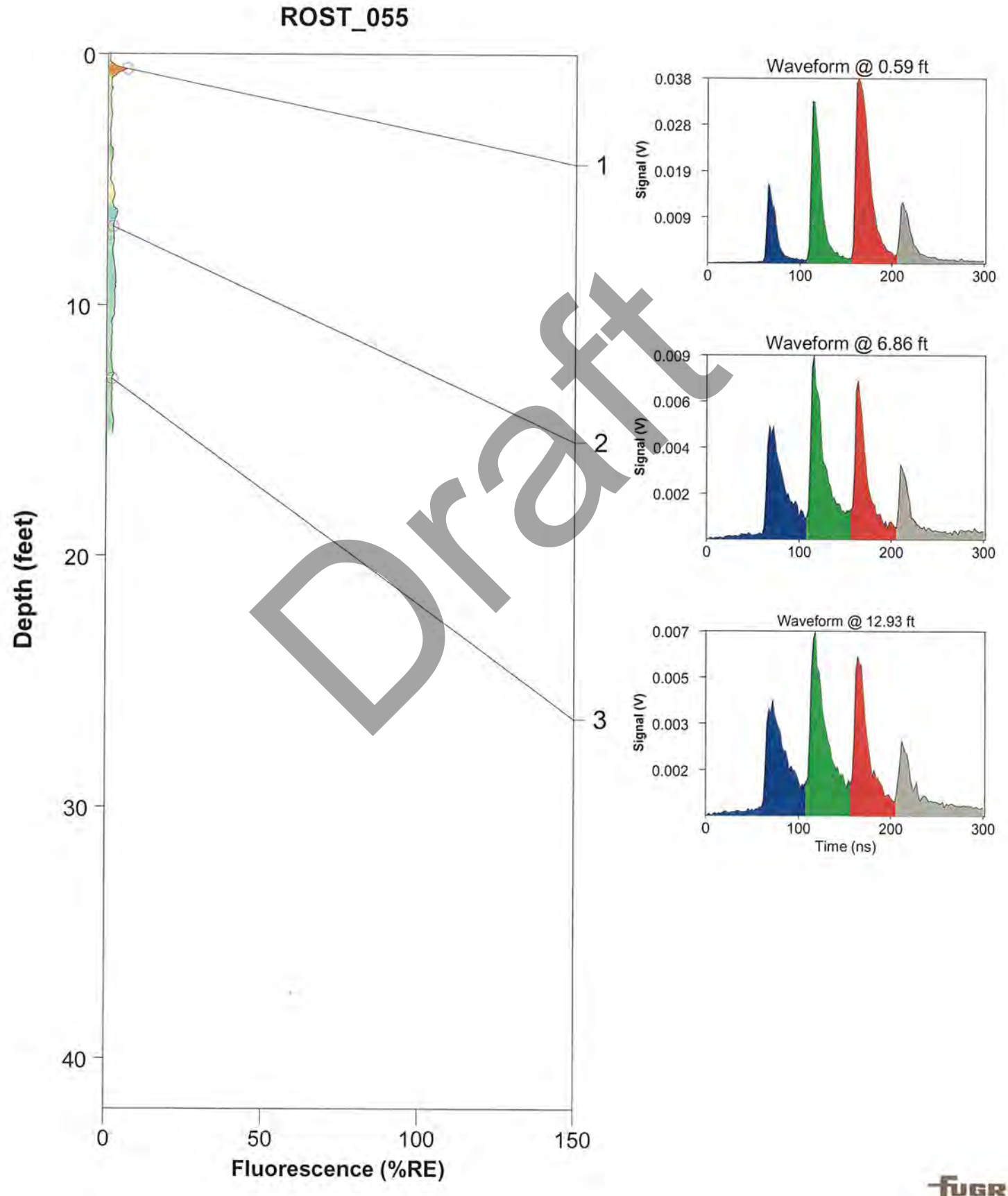
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-25-2002 @ 14:01:53	Max fluorescence: 8.38% @ 0.10 ft
ROST Unit: ?	Final depth BGS: 15.06 ft



Draft

ROST Fluorescence Response Data

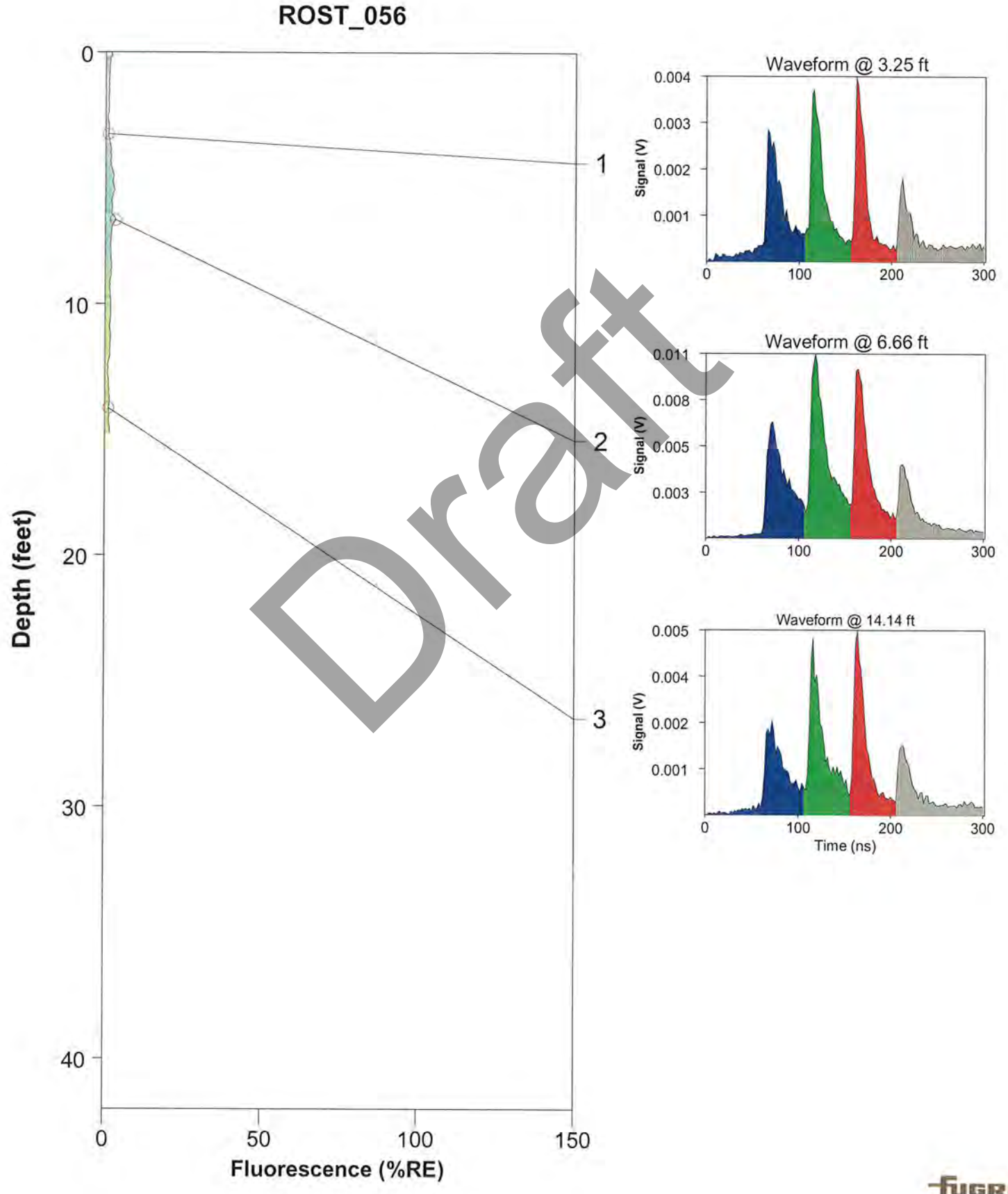
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-25-2002 @ 14:18:57	Max fluorescence: 6.14% @ 0.59 ft
ROST Unit: ?	Final depth BGS: 15.06 ft



Draft

ROST Fluorescence Response Data

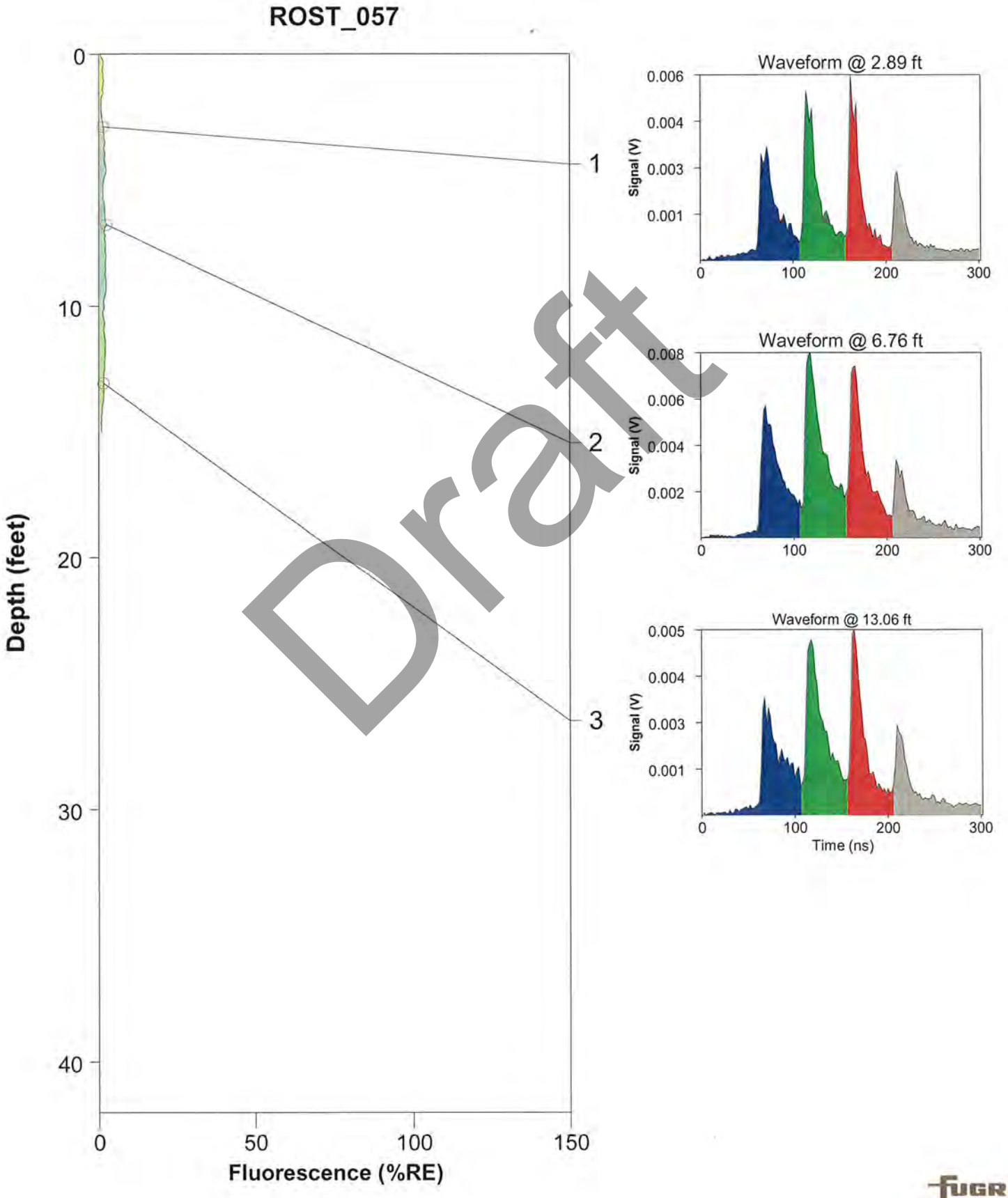
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-25-2002 @ 14:35:00	Max fluorescence: 3.24% @ 6.66 ft
ROST Unit: ?	Final depth BGS: 15.12 ft



Draft

ROST Fluorescence Response Data

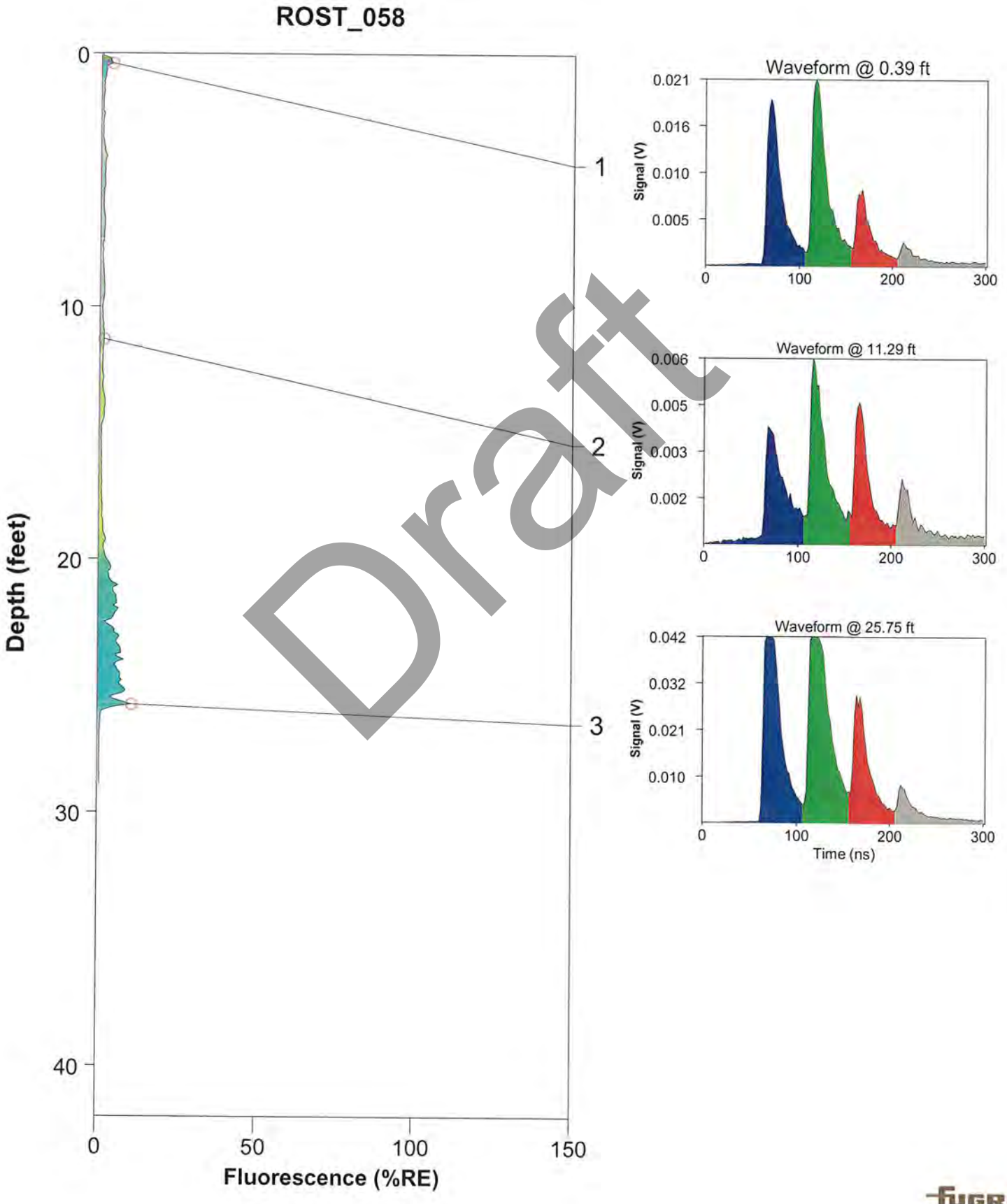
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-25-2002 @ 14:50:24	Max fluorescence: 2.46% @ 6.76 ft
ROST Unit: ?	Final depth BGS: 15.03 ft



Draft

ROST Fluorescence Response Data

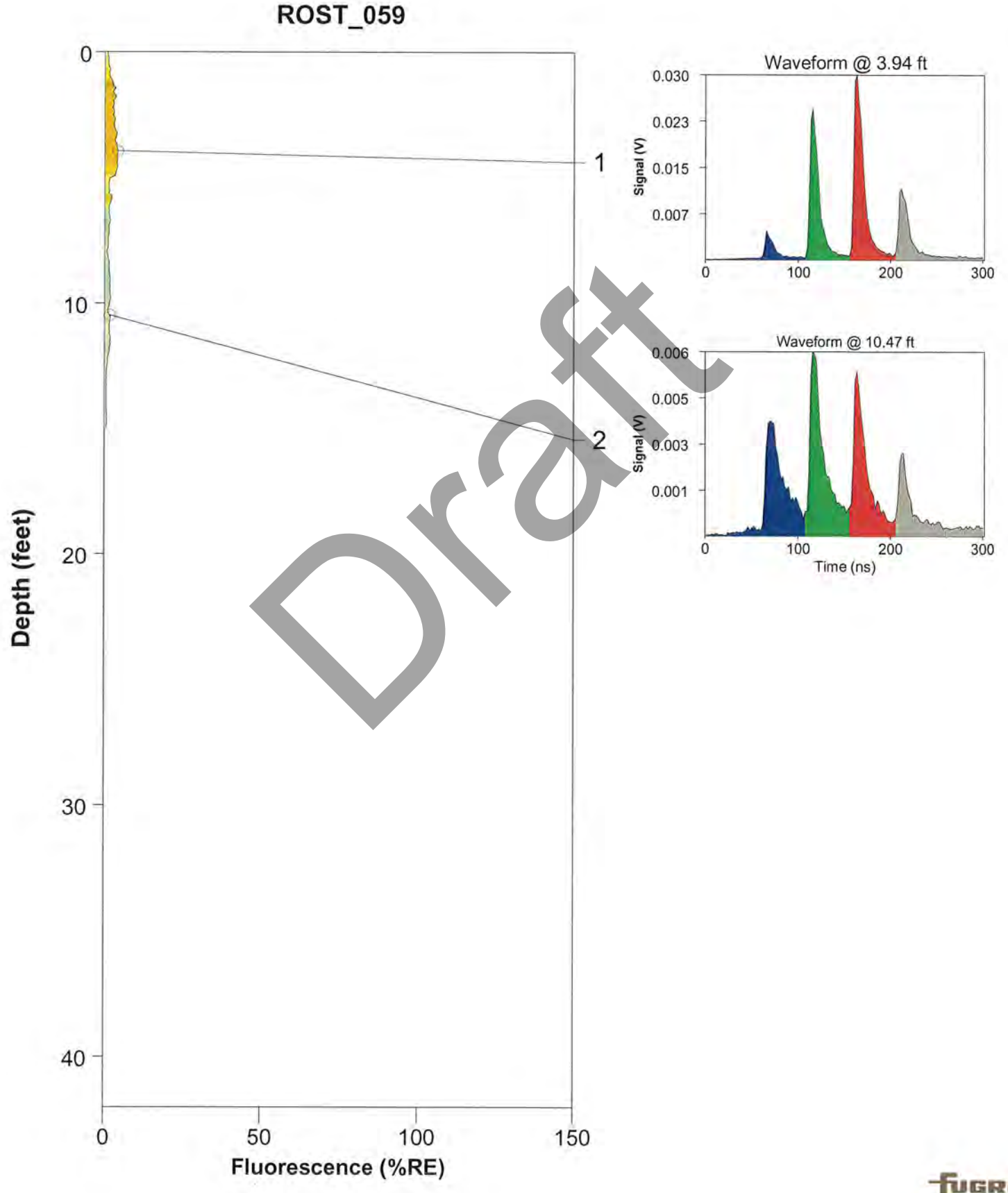
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-25-2002 @ 16:05:33	Max fluorescence: 10.66% @ 25.75 ft
ROST Unit: ?	Final depth BGS: 28.90 ft



Draft

ROST Fluorescence Response Data

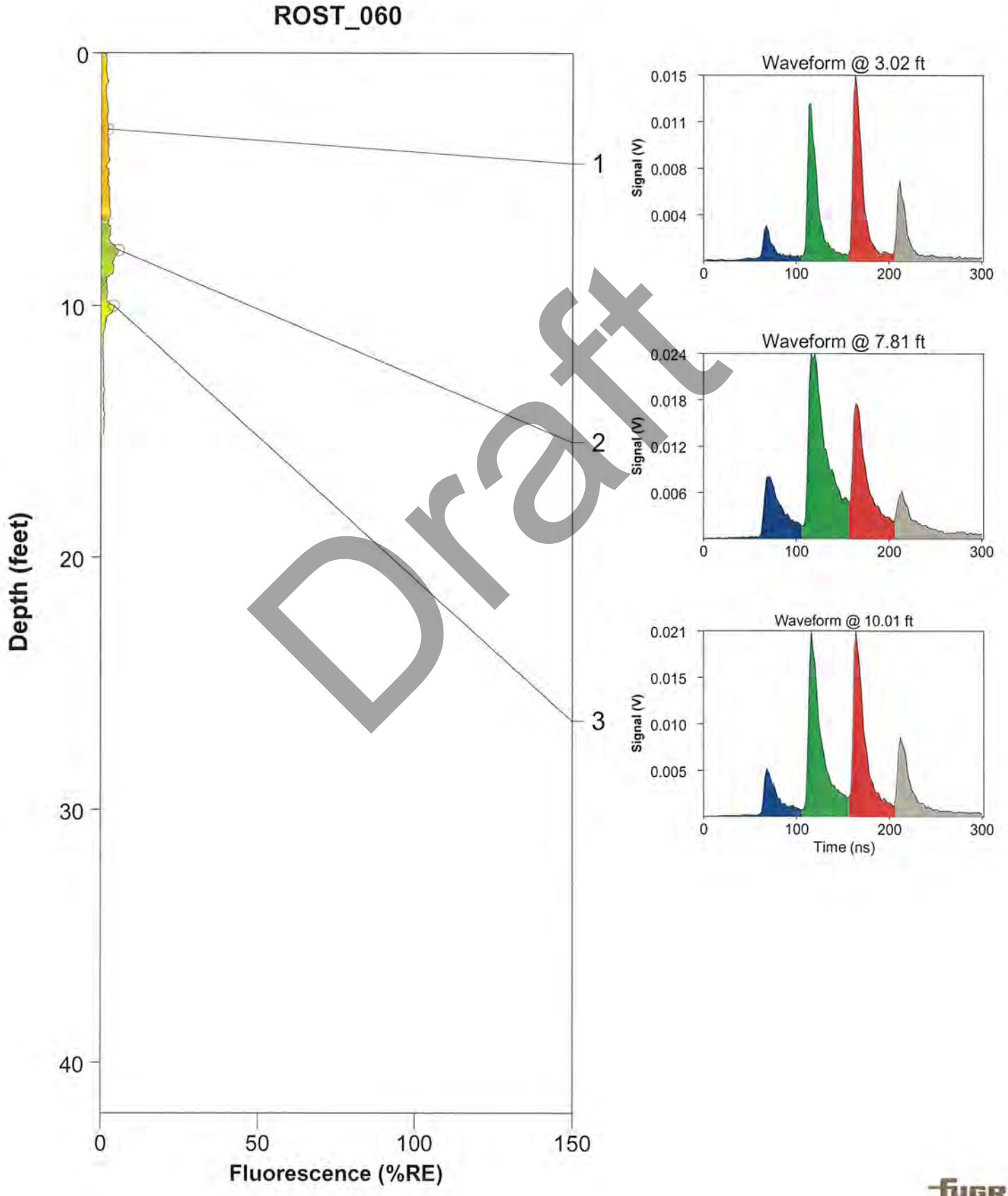
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-25-2002 @ 16:30:33	Max fluorescence: 4.08% @ 3.94 ft
ROST Unit: ?	Final depth BGS: 14.99 ft



Draft

ROST Fluorescence Response Data

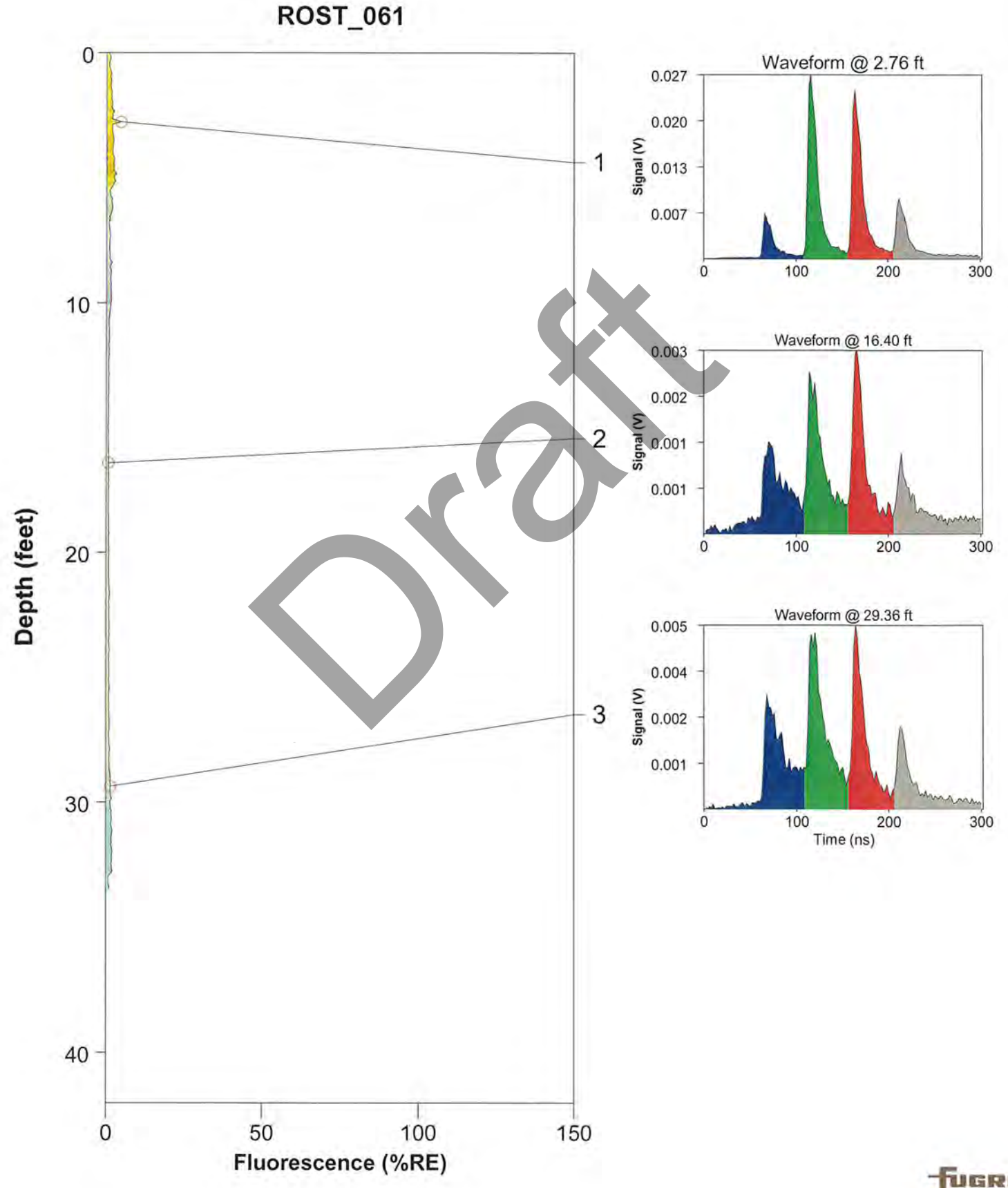
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-25-2002 @ 16:44:51	Max fluorescence: 5.67% @ 7.81 ft
ROST Unit: ?	Final depth BGS: 15.12 ft



Draft

ROST Fluorescence Response Data

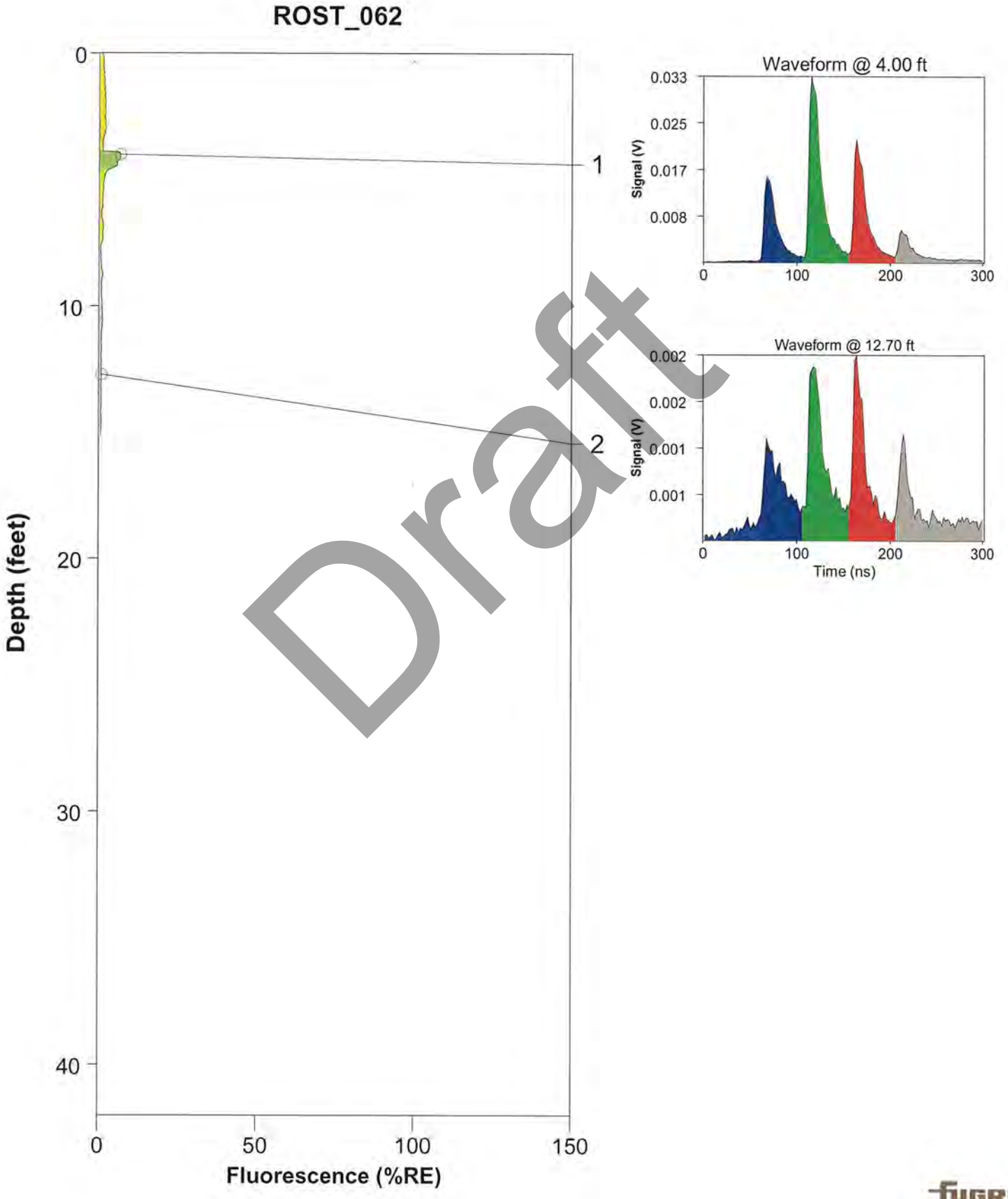
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-25-2002 @ 17:07:46	Max fluorescence: 4.61% @ 2.76 ft
ROST Unit: ?	Final depth BGS: 33.46 ft



Draft

ROST Fluorescence Response Data

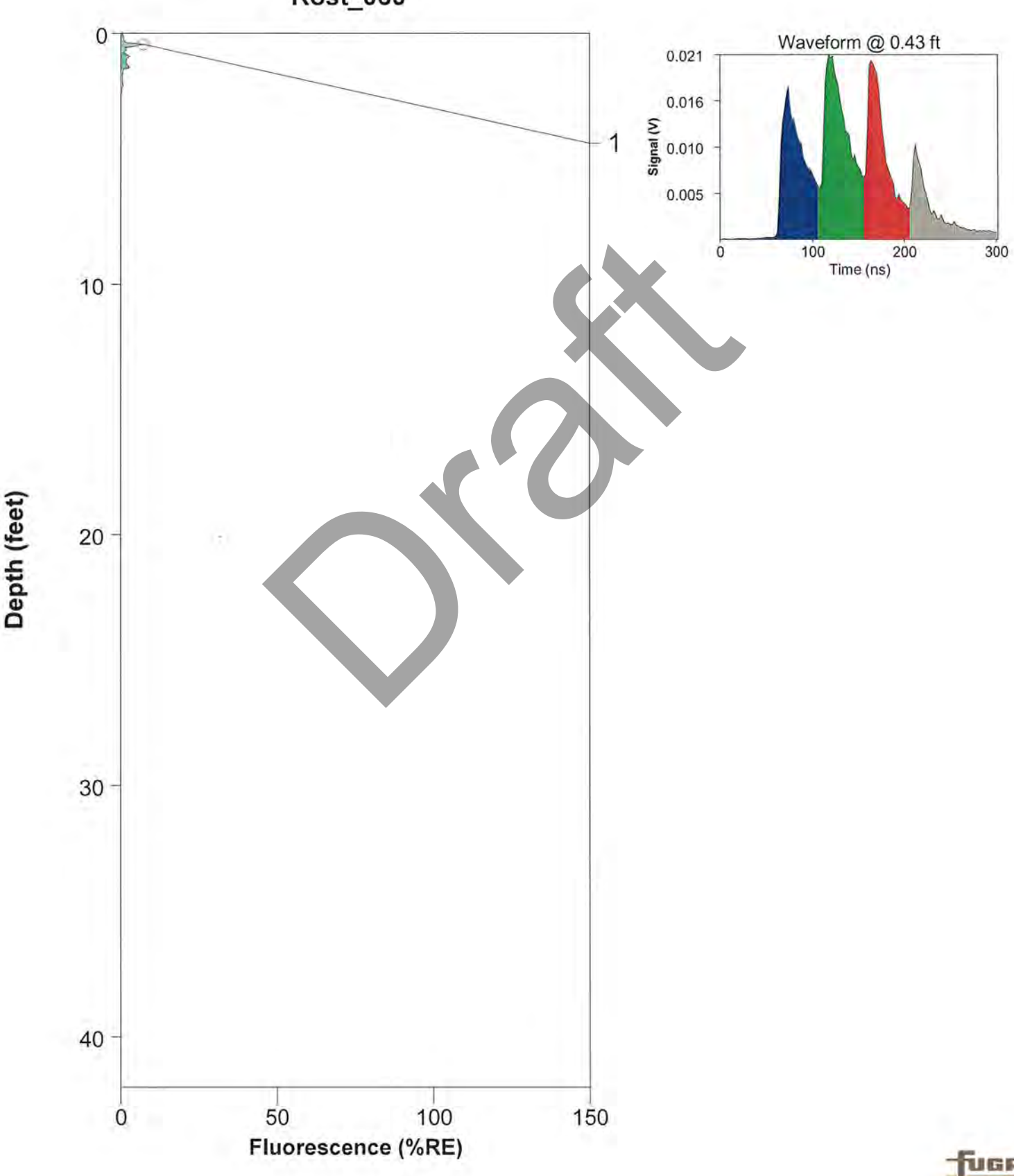
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-25-2002 @ 17:34:40	Max fluorescence: 6.72% @ 4.00 ft
ROST Unit: ?	Final depth BGS: 15.12 ft



Draft

ROST Fluorescence Response Data

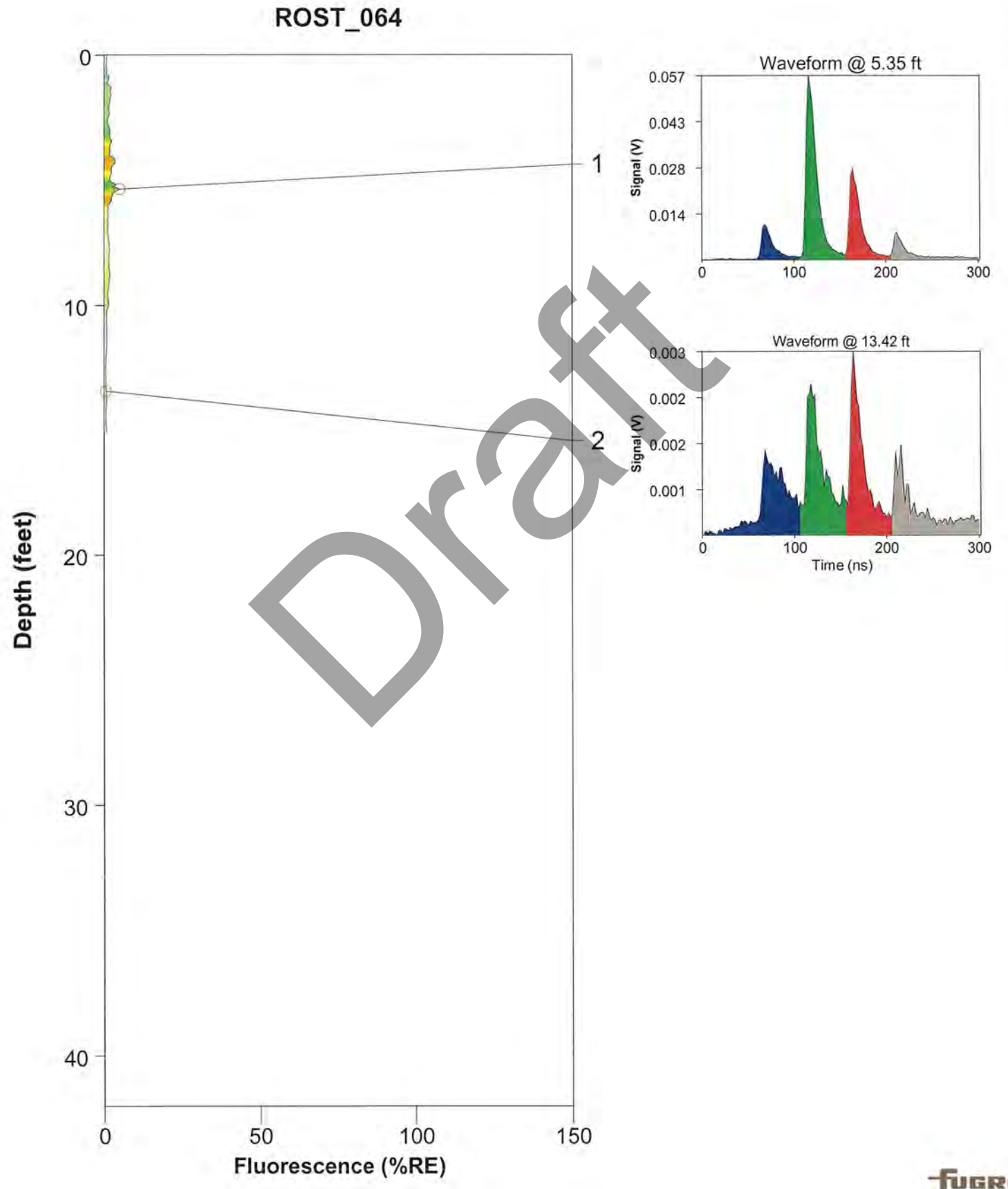
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-26-2002 @ 12:10:40	Max fluorescence: 7.12% @ 0.43 ft
ROST Unit: ?	Final depth BGS: 2.43 ft



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-26-2002 @ 12:43:12	Max fluorescence: 4.97% @ 5.35 ft
ROST Unit: ?	Final depth BGS: 15.06 ft

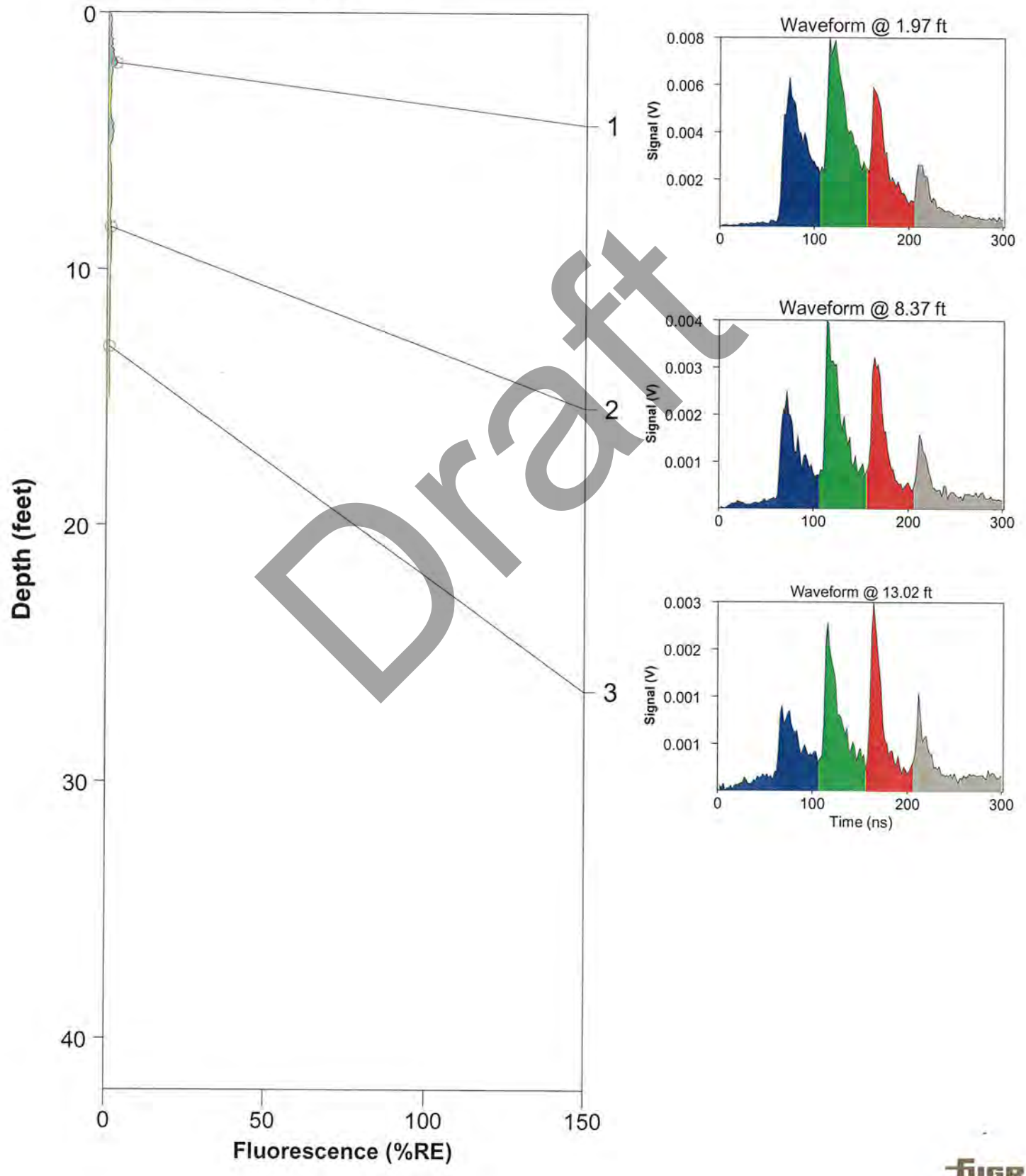


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-26-2002 @ 13:21:42	Max fluorescence: 2.73% @ 1.97 ft
ROST Unit: ?	Final depth BGS: 15.06 ft

ROST_065

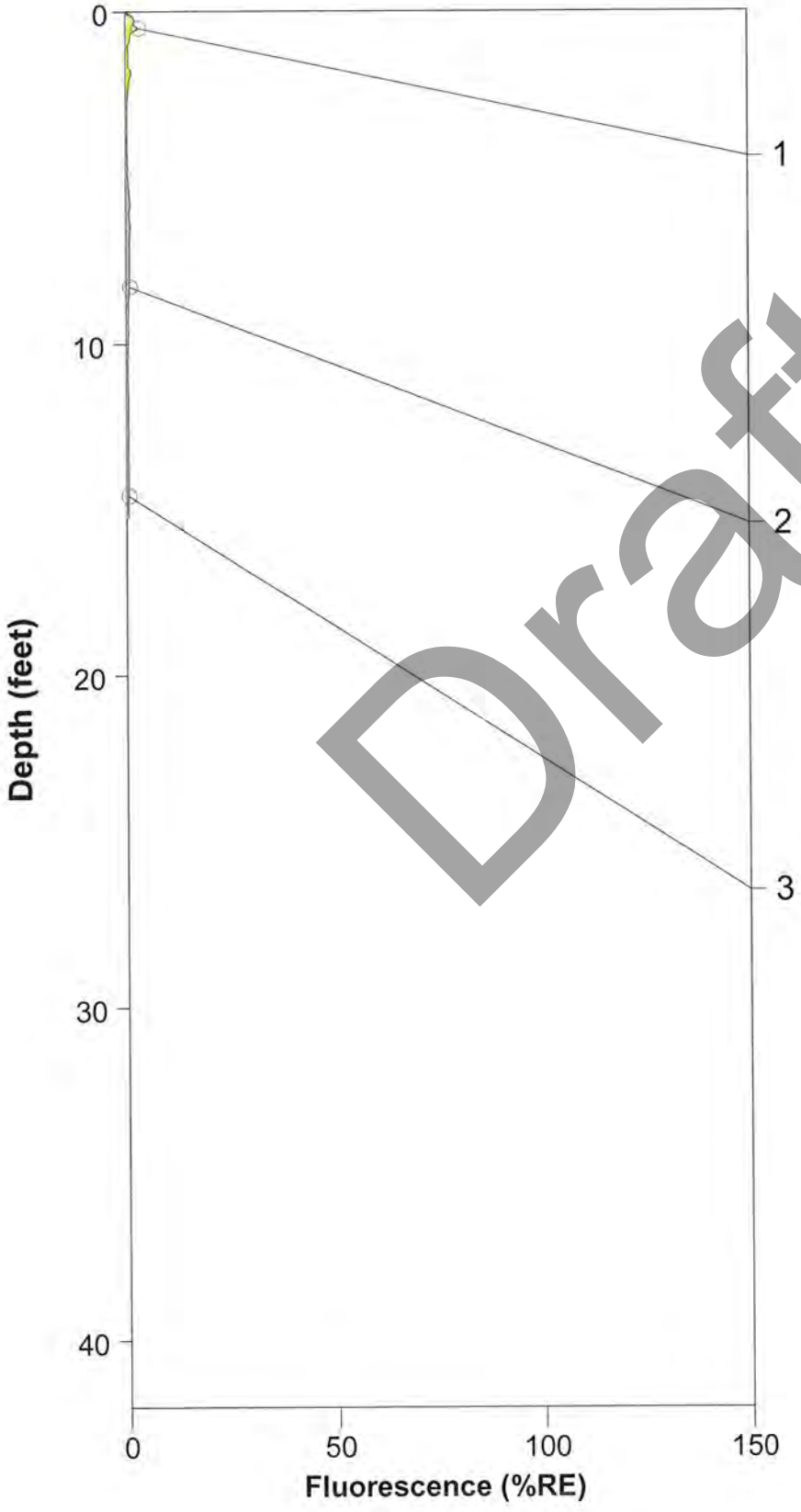


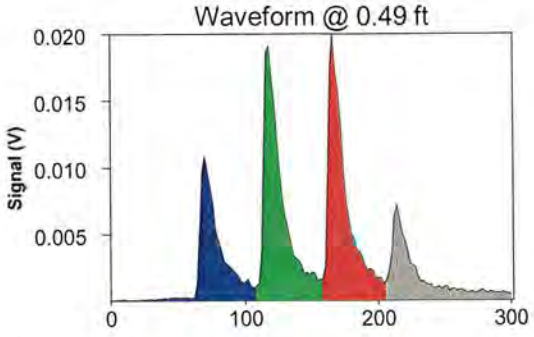
Draft

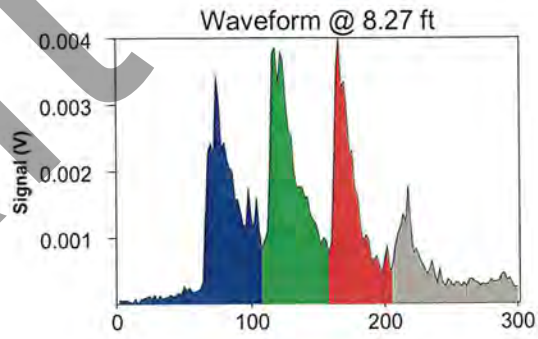
ROST Fluorescence Response Data

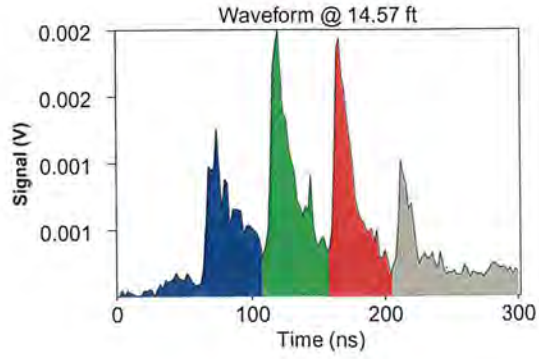
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-28-2002 @ 17:42:07	Max fluorescence: 3.17% @ 0.49 ft
ROST Unit: ?	Final depth BGS: 15.22 ft

ROST_066





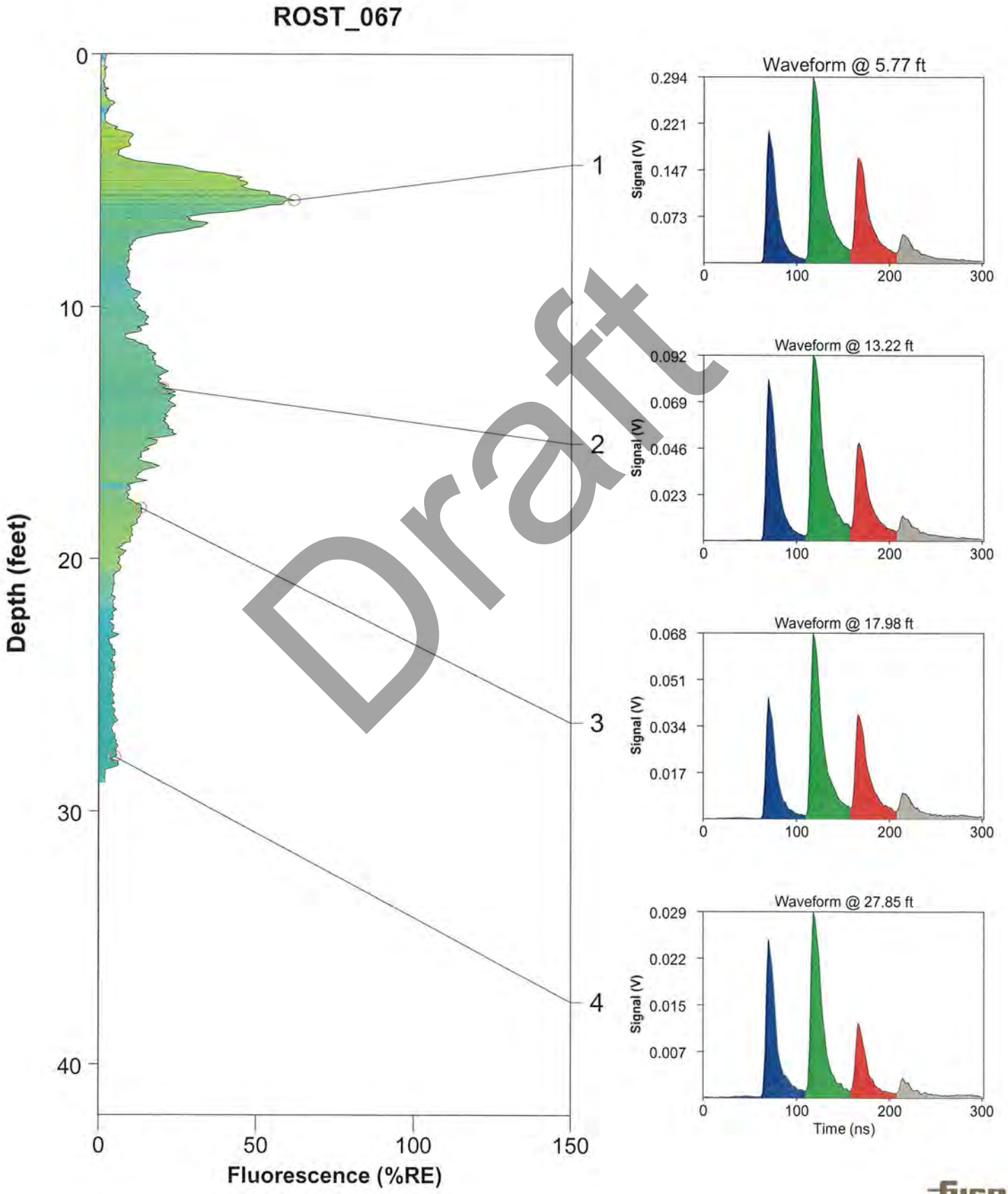




Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-29-2002 @ 09:40:10	Max fluorescence: 61.53% @ 5.77 ft
ROST Unit: ?	Final depth BGS: 28.87 ft

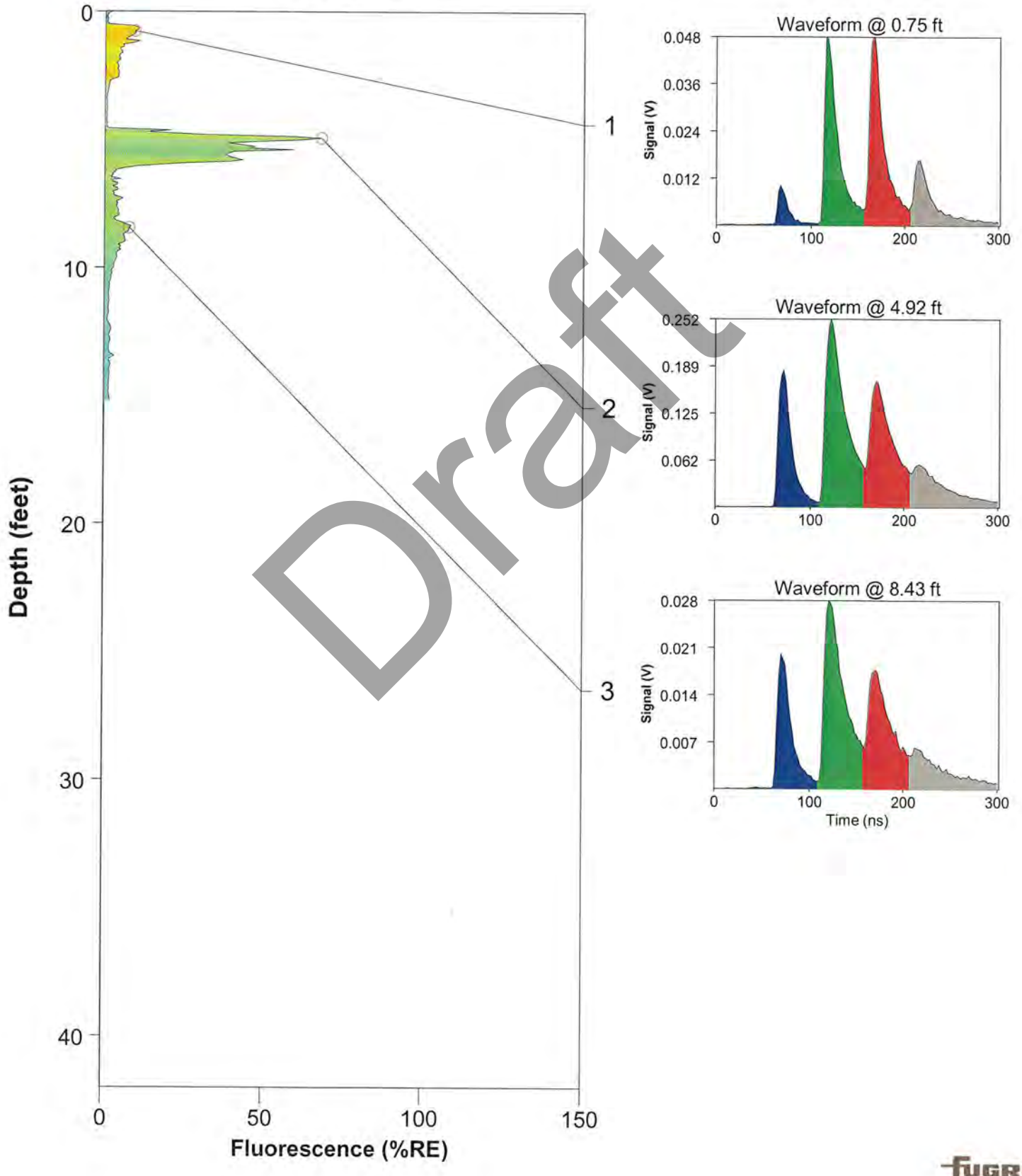


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-27-2002 @ 10:29:32	Max fluorescence: 67.92% @ 4.92 ft
ROST Unit: ?	Final depth BGS: 15.19 ft

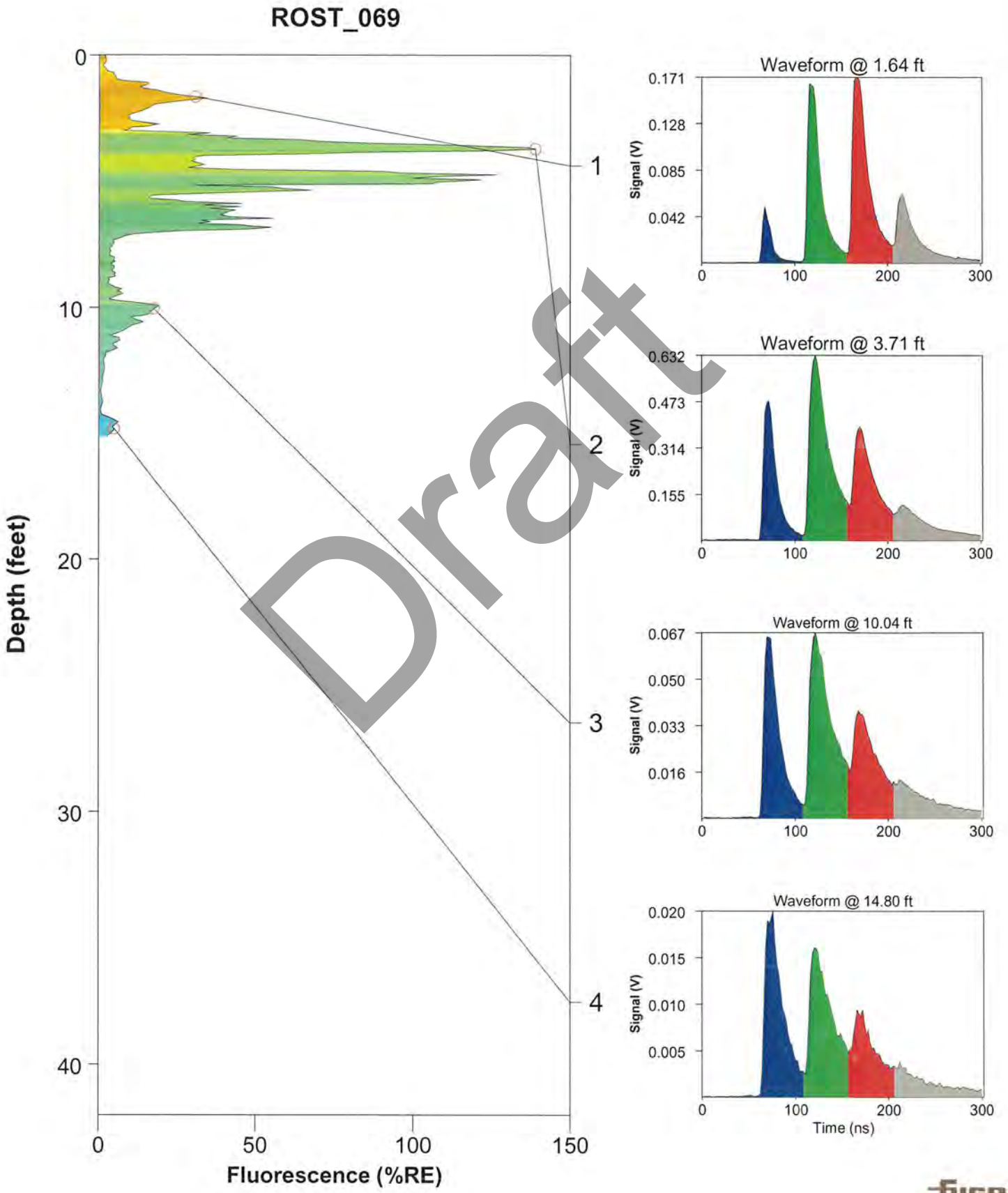
ROST_068



Draft

ROST Fluorescence Response Data

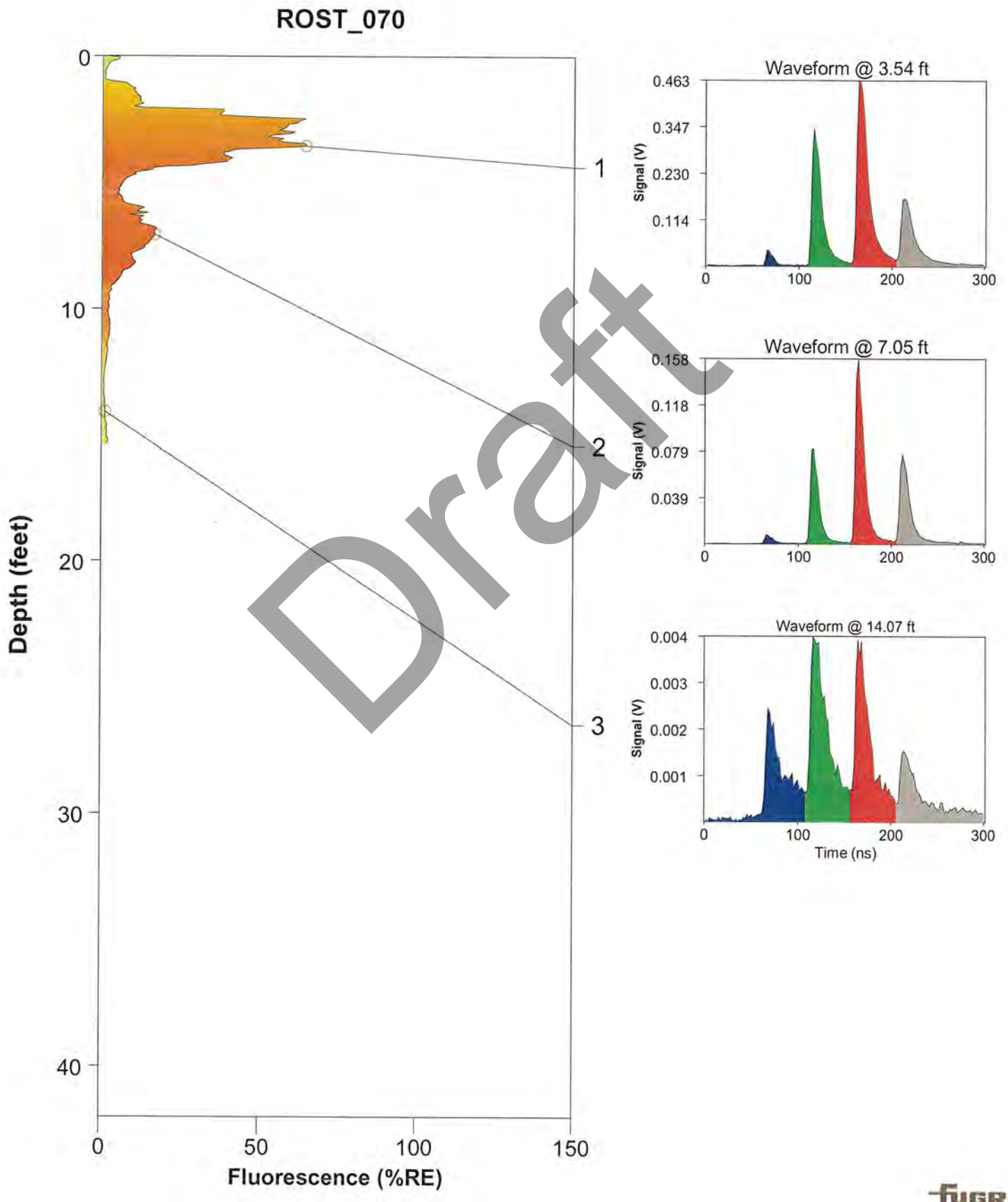
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-27-2002 @ 11:32:00	Max fluorescence: 138.89% @ 3.71 ft
ROST Unit: ?	Final depth BGS: 15.12 ft



Draft

ROST Fluorescence Response Data

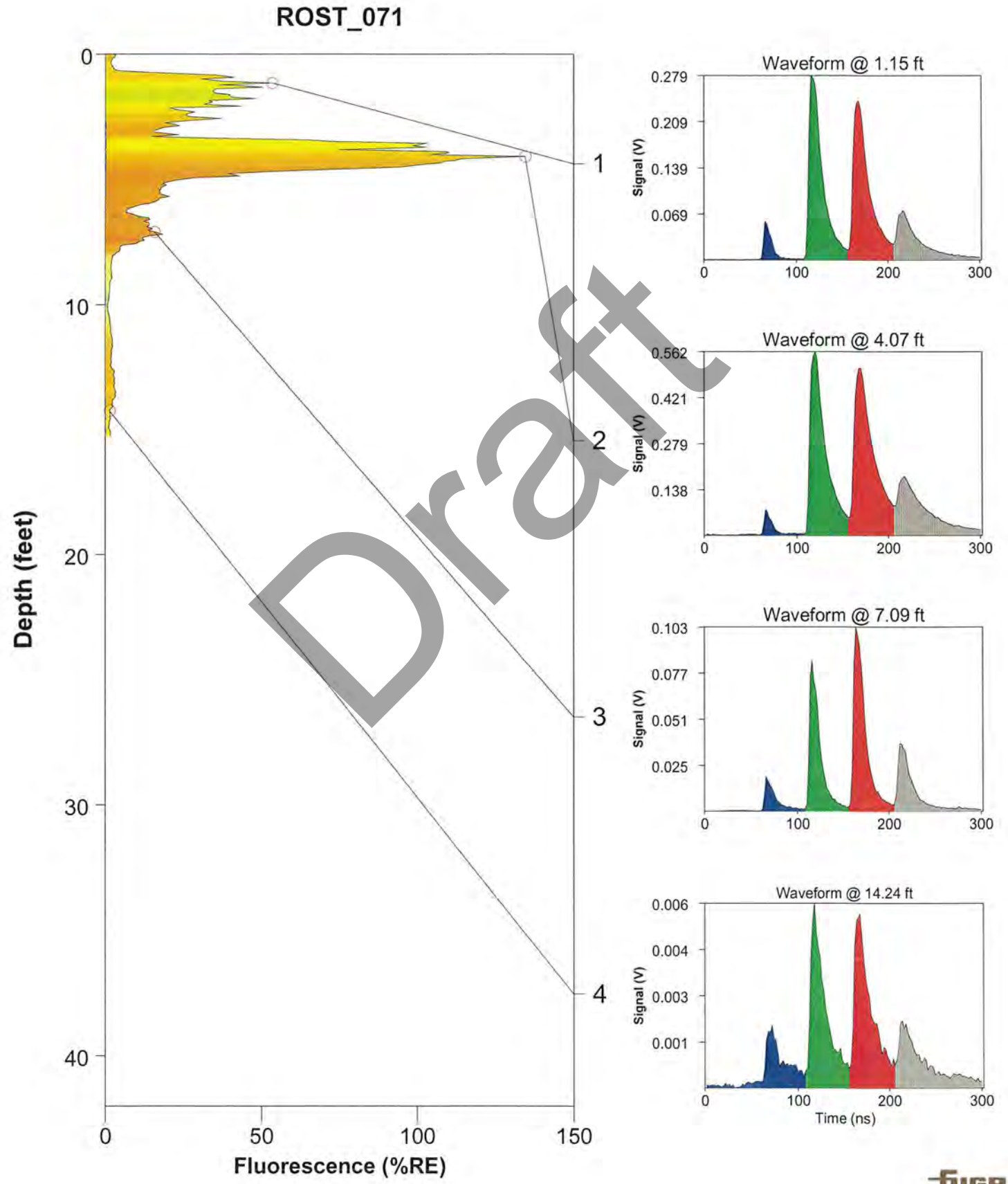
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-27-2002 @ 12:02:41	Max fluorescence: 64.58% @ 3.54 ft
ROST Unit: ?	Final depth BGS: 15.35 ft



Draft

ROST Fluorescence Response Data

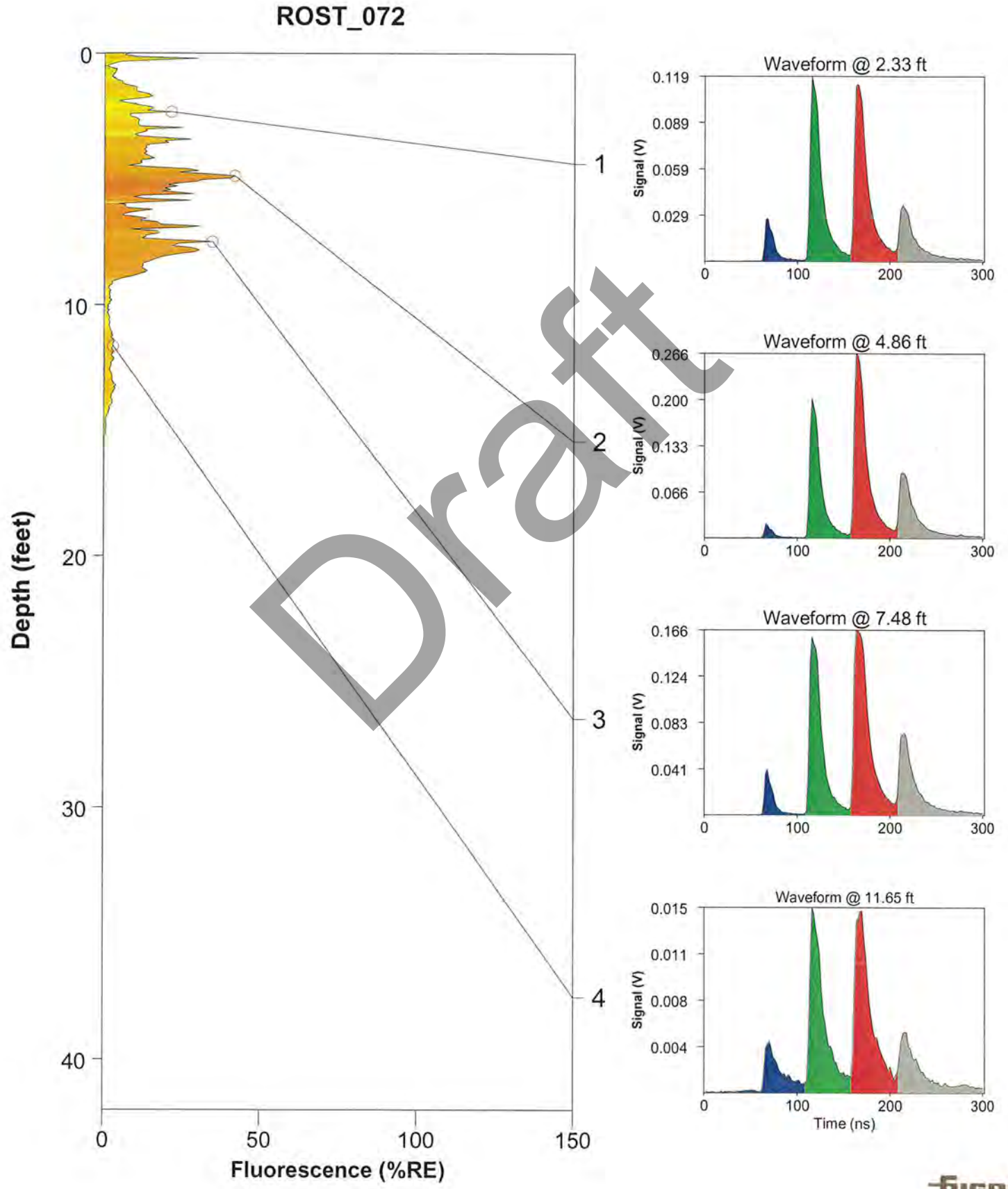
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-27-2002 @ 12:28:49	Max fluorescence: 134.52% @ 4.07 ft
ROST Unit: ?	Final depth BGS: 15.26 ft



Draft

ROST Fluorescence Response Data

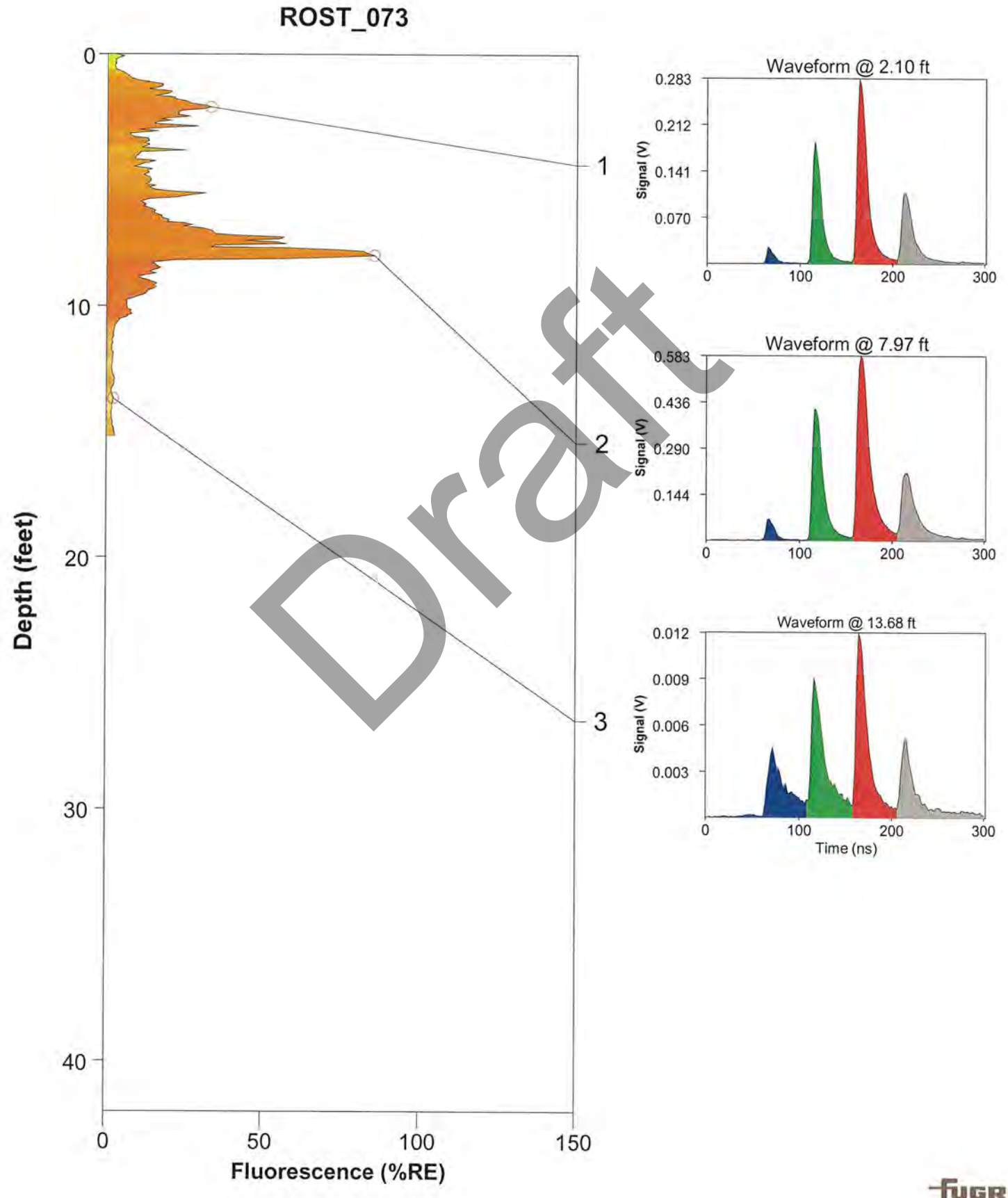
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-27-2002 @ 14:13:31	Max fluorescence: 41.52% @ 4.86 ft
ROST Unit: ?	Final depth BGS: 15.19 ft



Draft

ROST Fluorescence Response Data

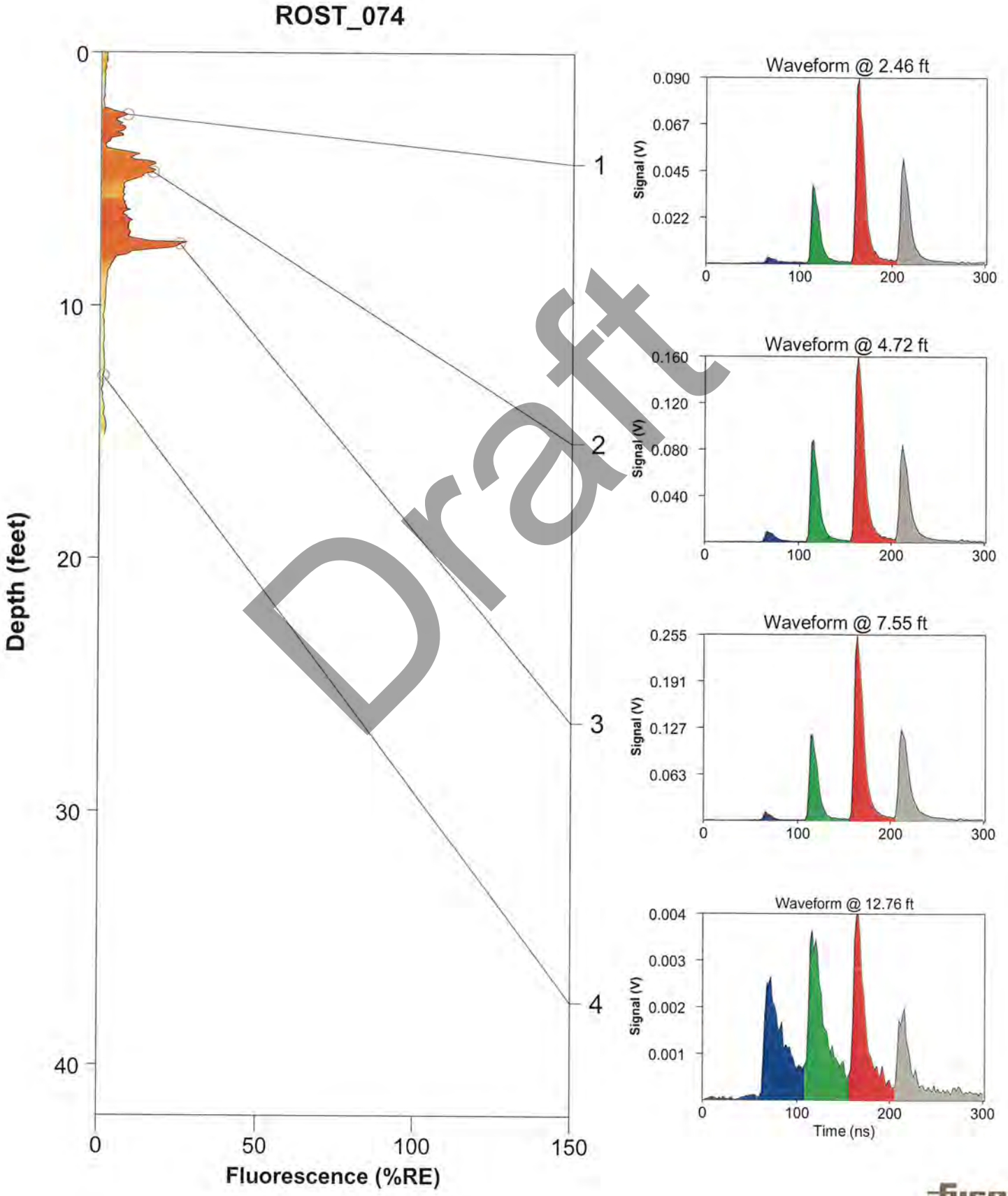
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-27-2002 @ 14:46:31	Max fluorescence: 85.20% @ 7.97 ft
ROST Unit: ?	Final depth BGS: 15.19 ft



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-27-2002 @ 15:11:18	Max fluorescence: 27.24% @ 7.48 ft
ROST Unit: ?	Final depth BGS: 15.12 ft

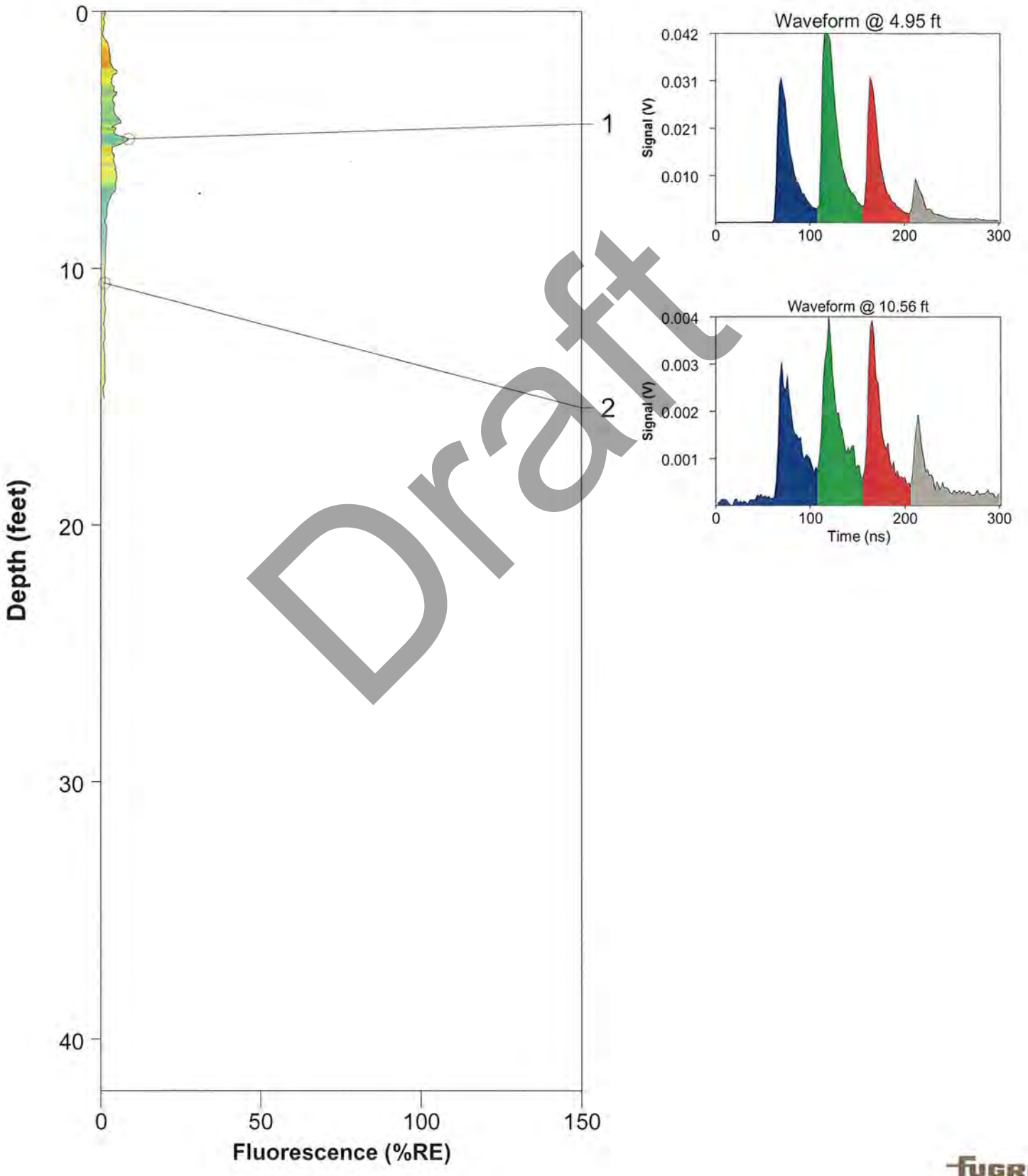


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-27-2002 @ 15:35:25	Max fluorescence: 8.56% @ 4.95 ft
ROST Unit: ?	Final depth BGS: 15.06 ft

ROST_075

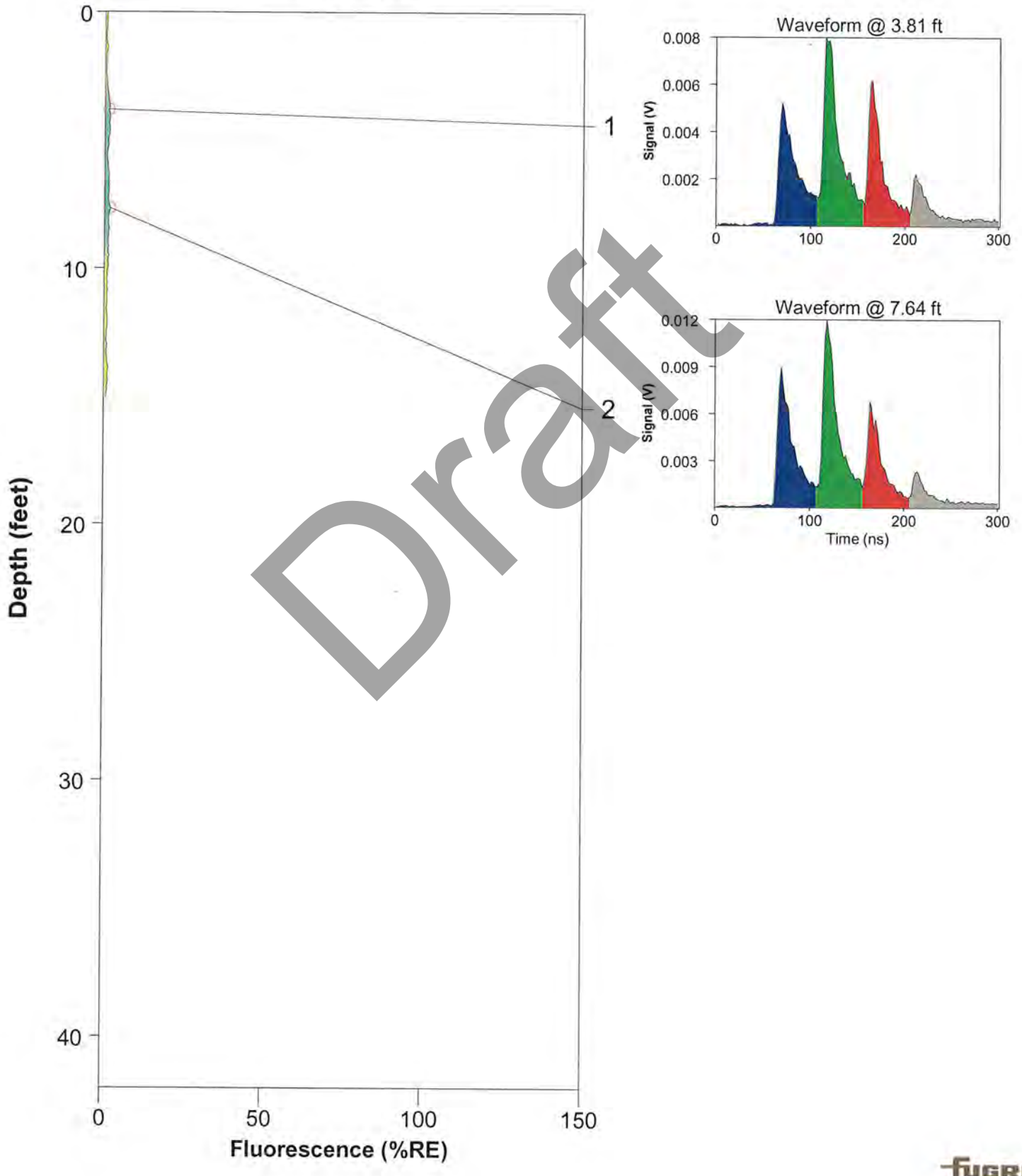


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-27-2002 @ 15:56:43	Max fluorescence: 1.78% @ 7.64 ft
ROST Unit: ?	Final depth BGS: 15.06 ft

ROST_076

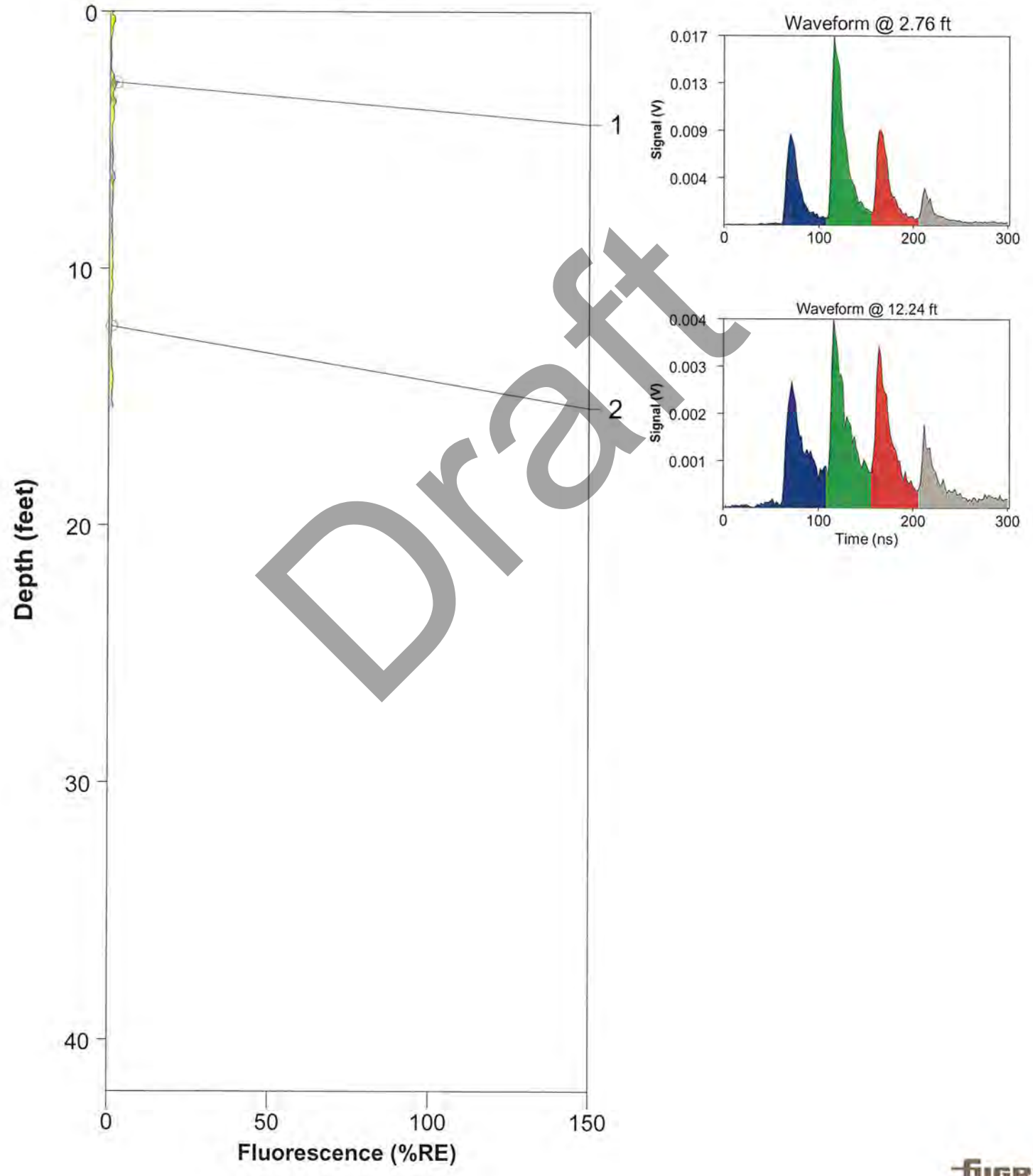


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-27-2002 @ 16:20:16	Max fluorescence: 2.31% @ 2.76 ft
ROST Unit: ?	Final depth BGS: 15.42 ft

ROST_077

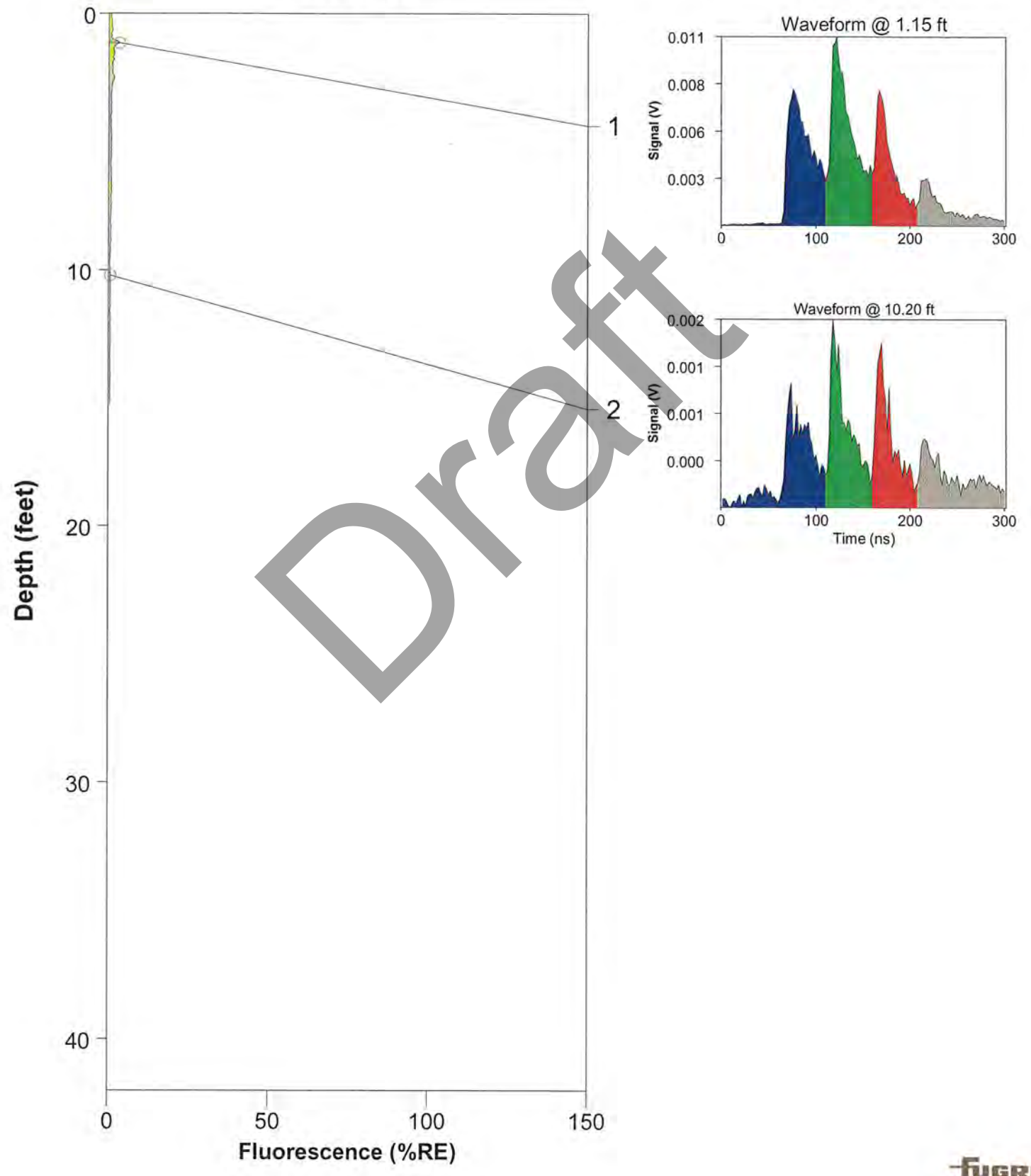


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-28-2002 @ 08:58:11	Max fluorescence: 3.26% @ 1.15 ft
ROST Unit: ?	Final depth BGS: 15.26 ft

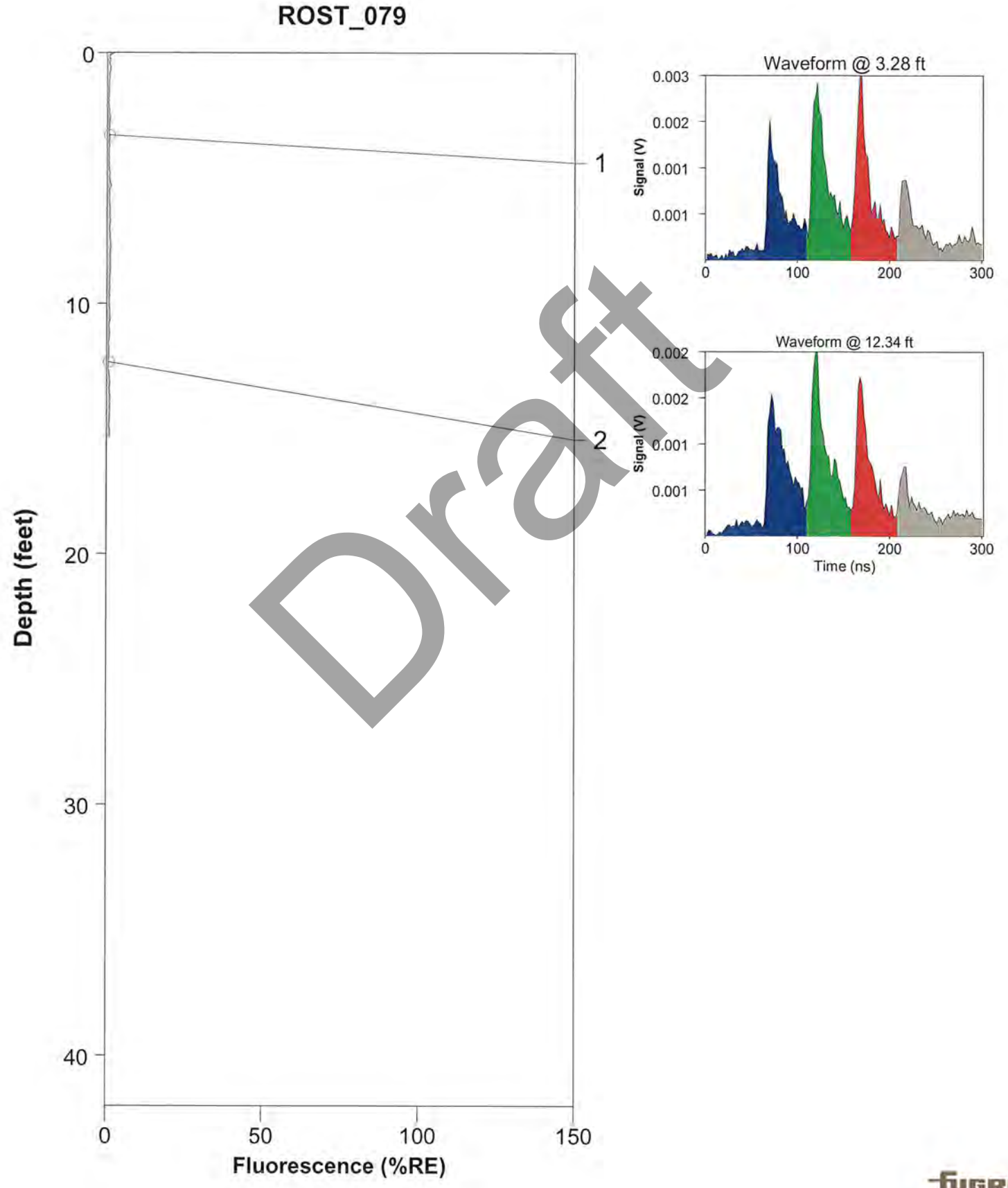
ROST_078



Draft

ROST Fluorescence Response Data

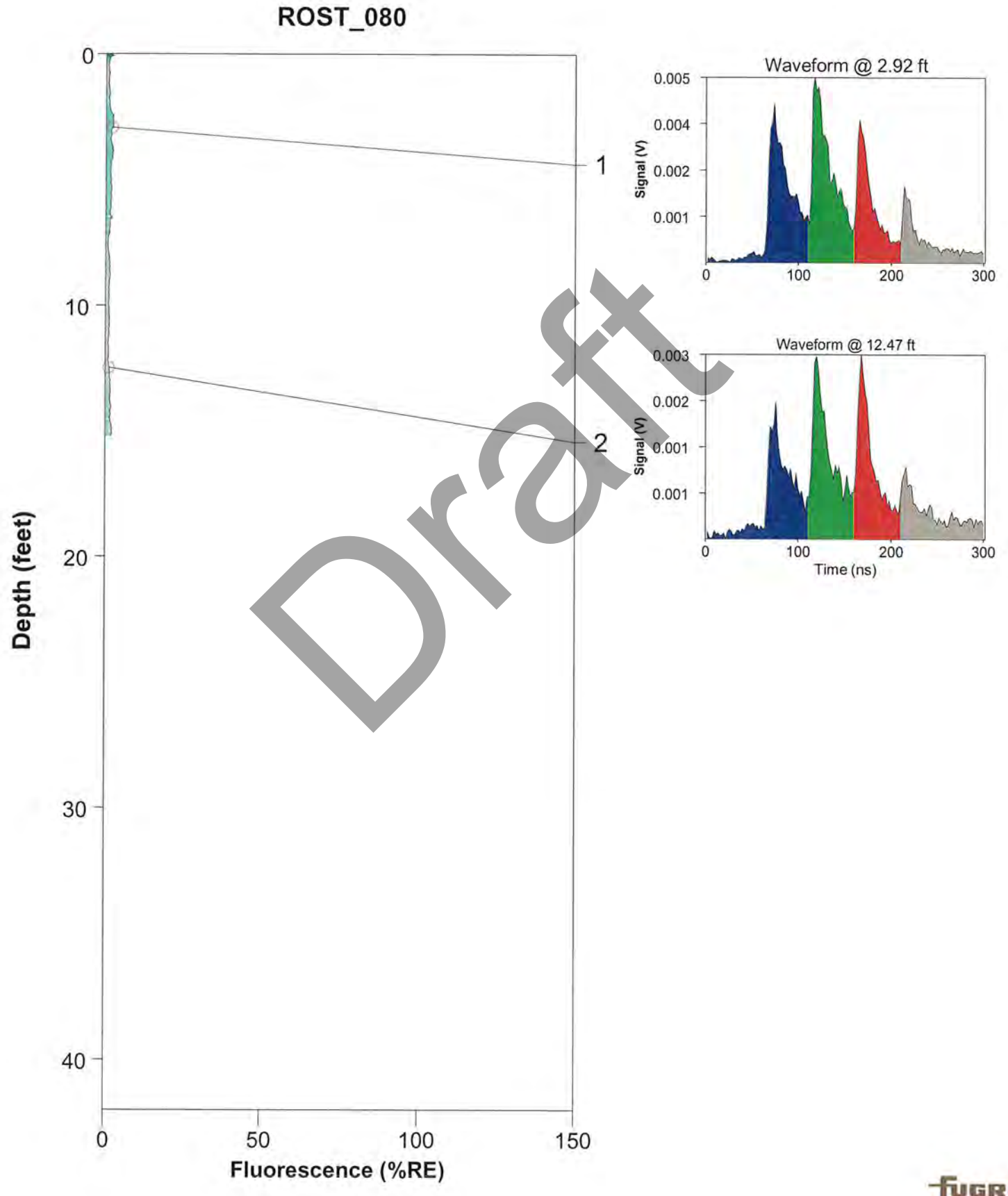
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-28-2002 @ 09:39:25	Max fluorescence: 3.00% @ 0.00 ft
ROST Unit: ?	Final depth BGS: 15.35 ft



Draft

ROST Fluorescence Response Data

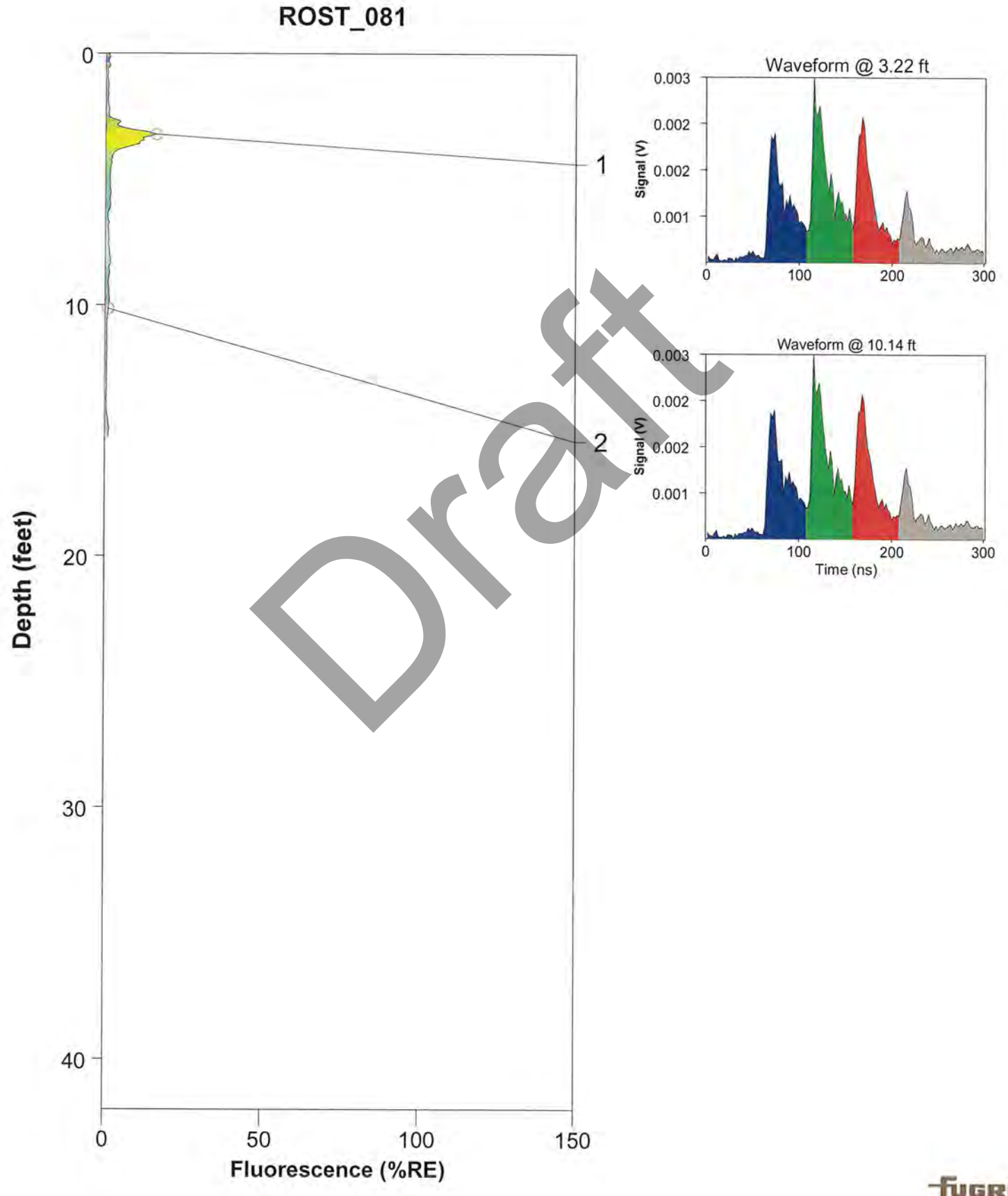
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-28-2002 @ 10:09:04	Max fluorescence: 2.40% @ 0.07 ft
ROST Unit: ?	Final depth BGS: 15.19 ft



Draft

ROST Fluorescence Response Data

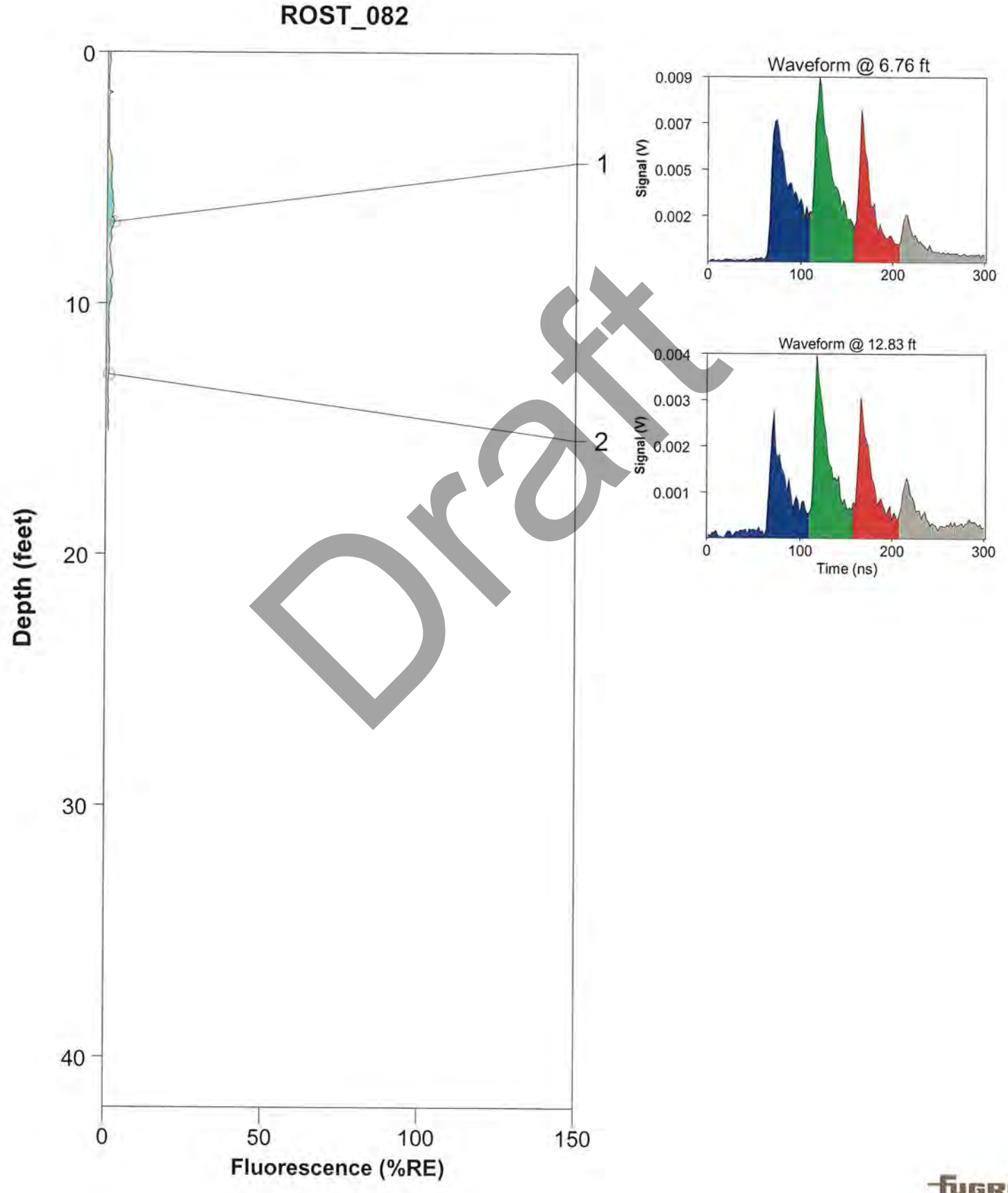
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-28-2002 @ 11:16:26	Max fluorescence: 16.07% @ 3.22 ft
ROST Unit: ?	Final depth BGS: 15.26 ft



Draft

ROST Fluorescence Response Data

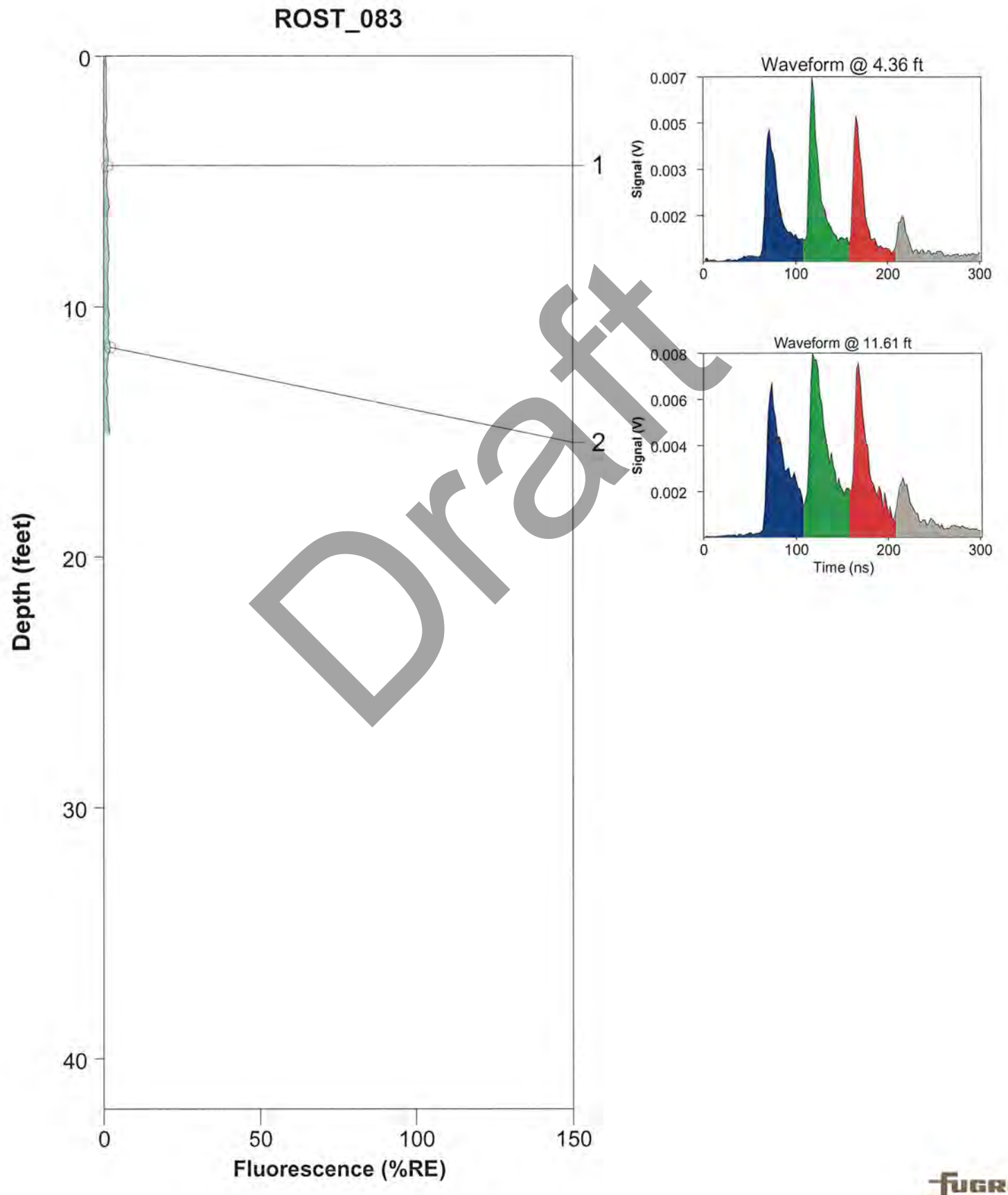
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-28-2002 @ 11:53:27	Max fluorescence: 2.42% @ 6.76 ft
ROST Unit: ?	Final depth BGS: 15.09 ft



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-28-2002 @ 12:14:02	Max fluorescence: 2.10% @ 11.61 ft
ROST Unit: ?	Final depth BGS: 15.06 ft

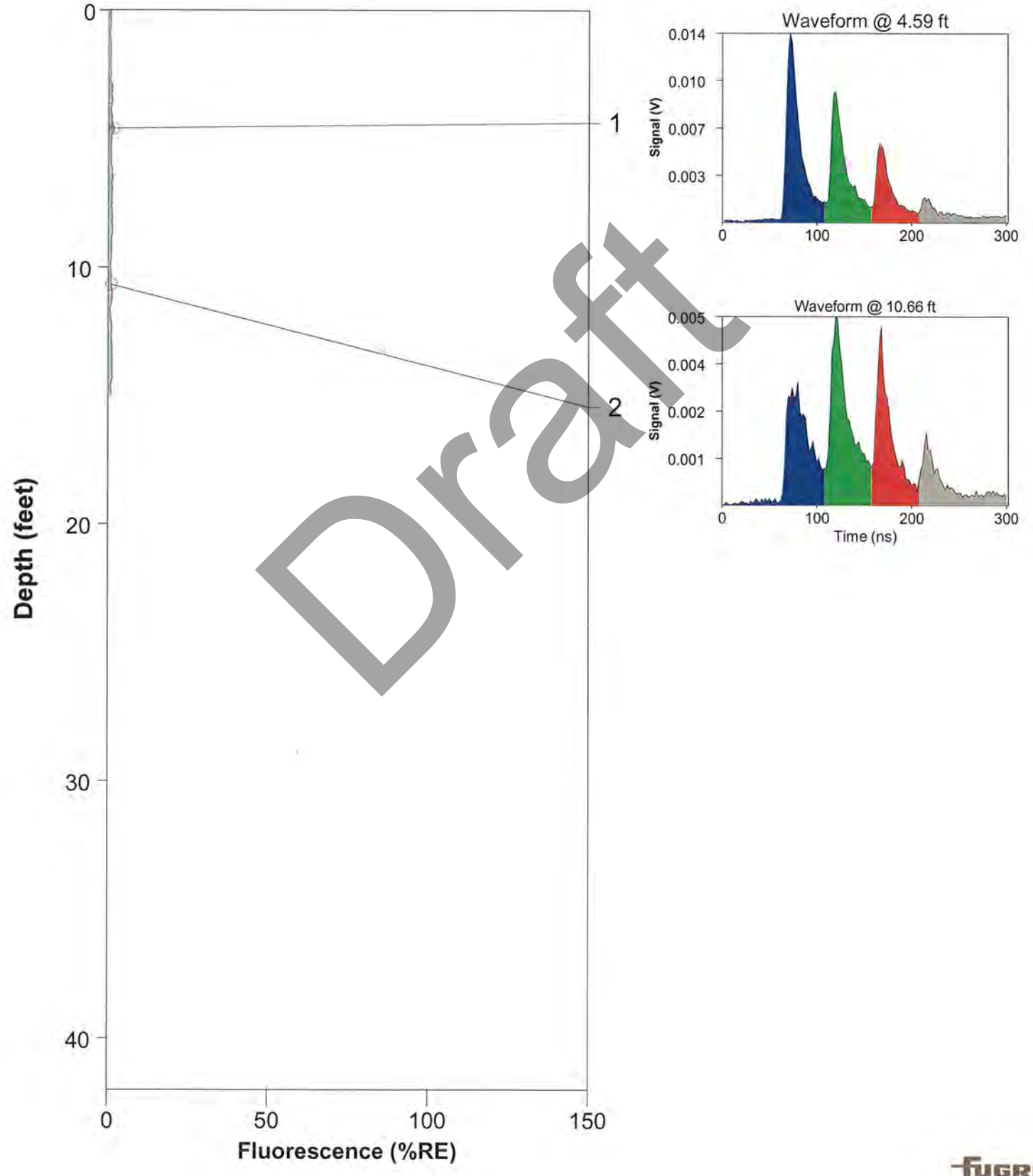


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-28-2002 @ 12:29:54	Max fluorescence: 1.86% @ 4.59 ft
ROST Unit: ?	Final depth BGS: 14.99 ft

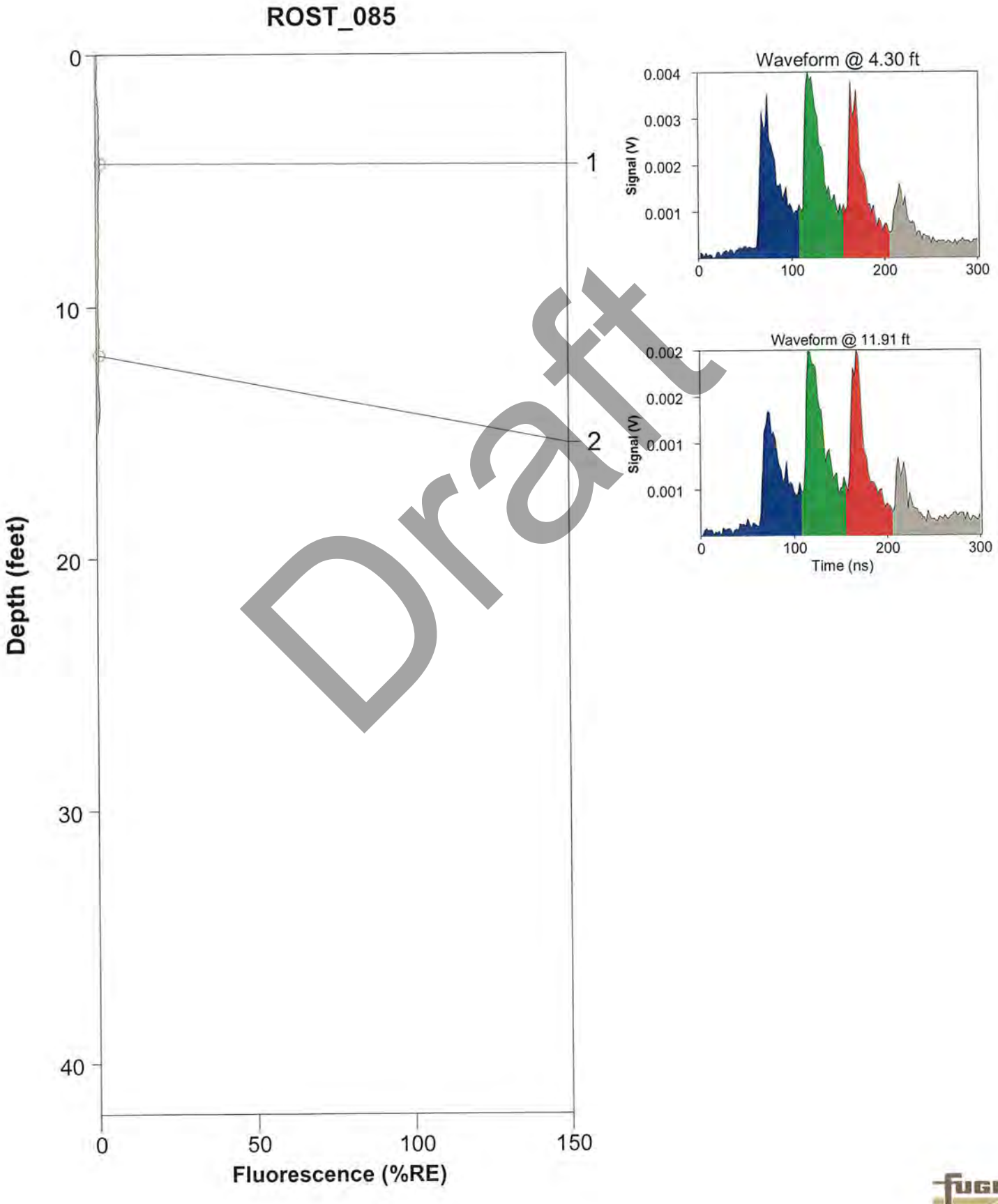
ROST_084



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-28-2002 @ 13:31:43	Max fluorescence: 1.32% @ 4.30 ft
ROST Unit: ?	Final depth BGS: 14.99 ft

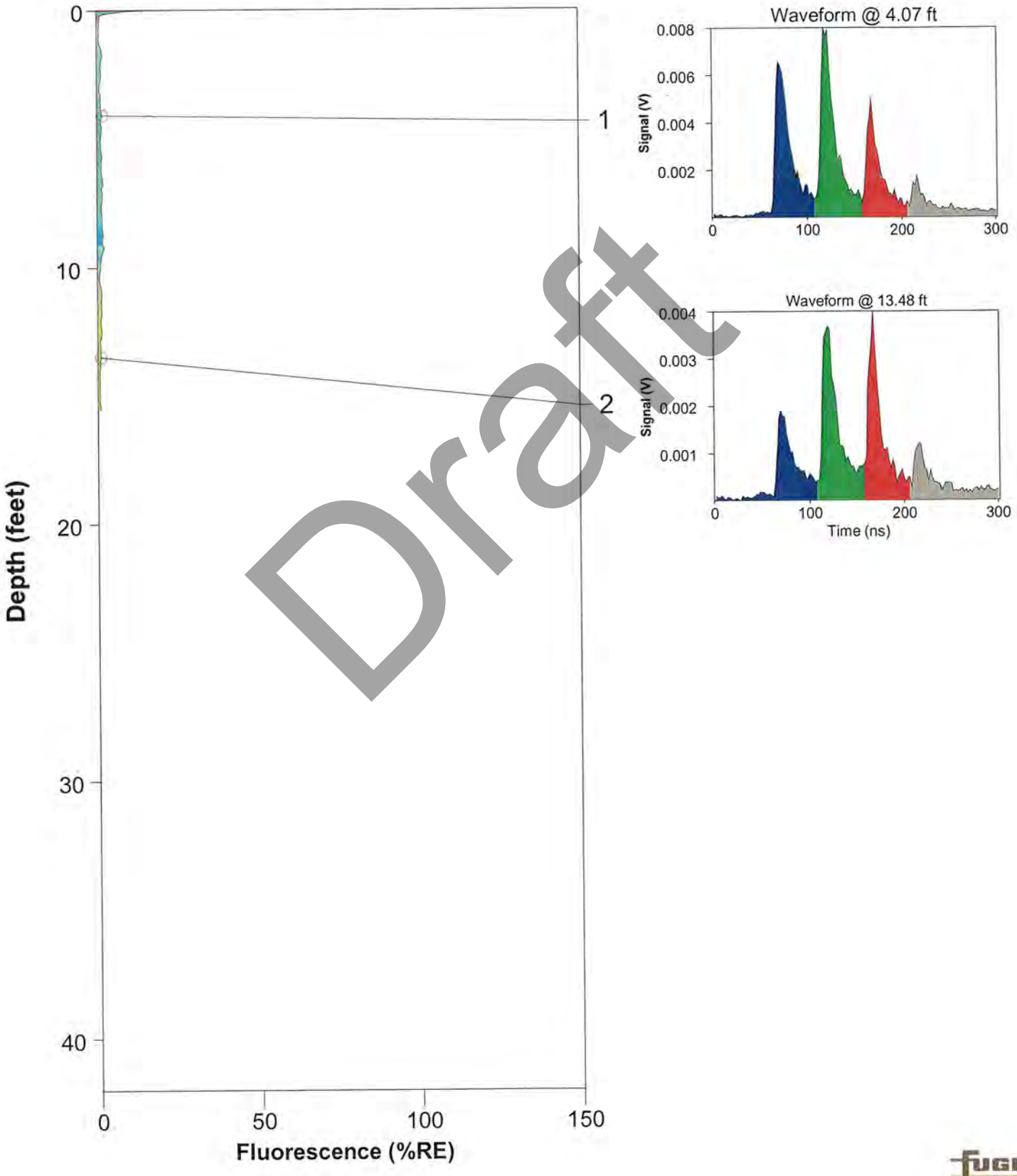


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-28-2002 @ 15:38:59	Max fluorescence: 14.43% @ 0.00 ft
ROST Unit: ?	Final depth BGS: 15.49 ft

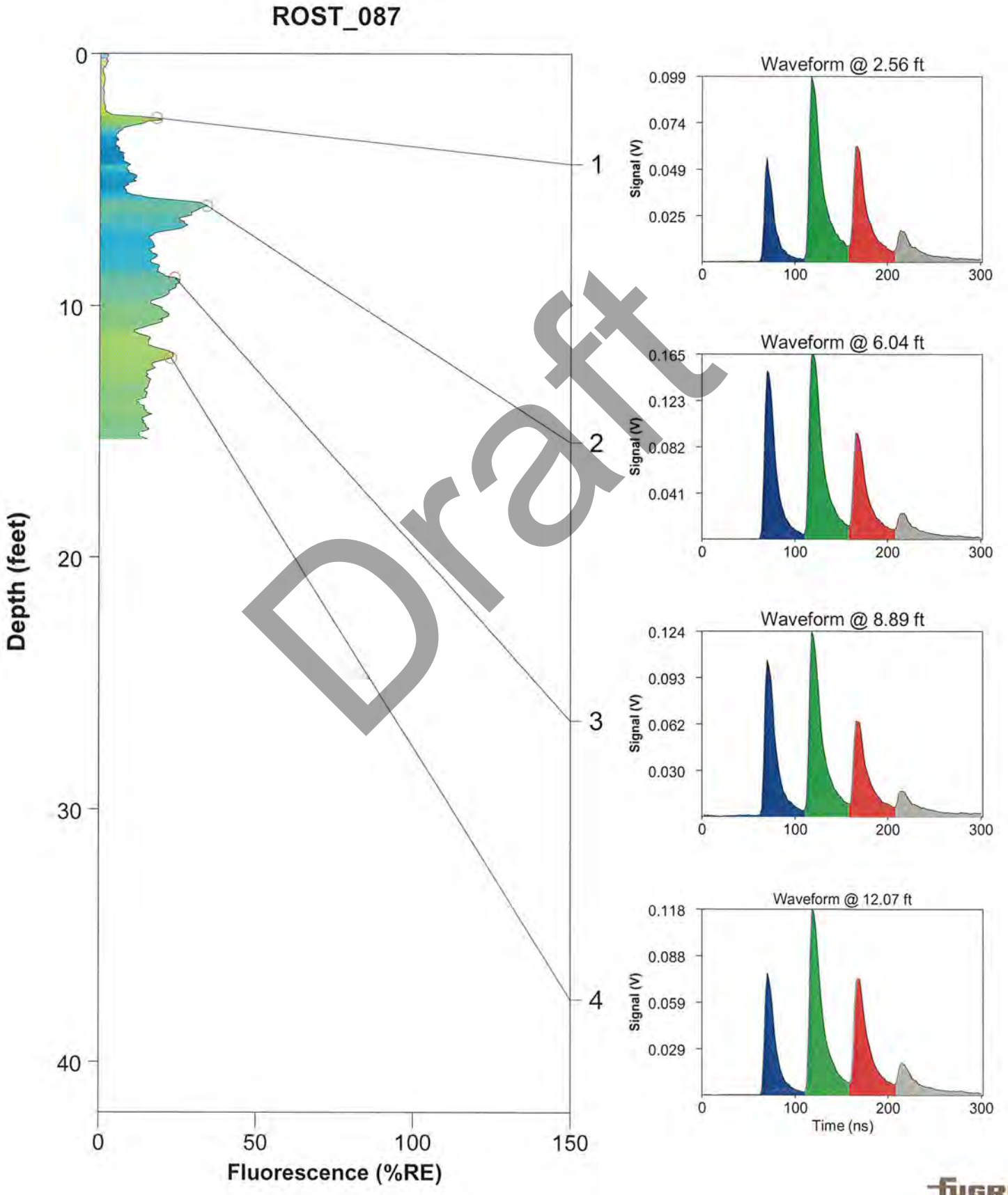
ROST_086



Draft

ROST Fluorescence Response Data

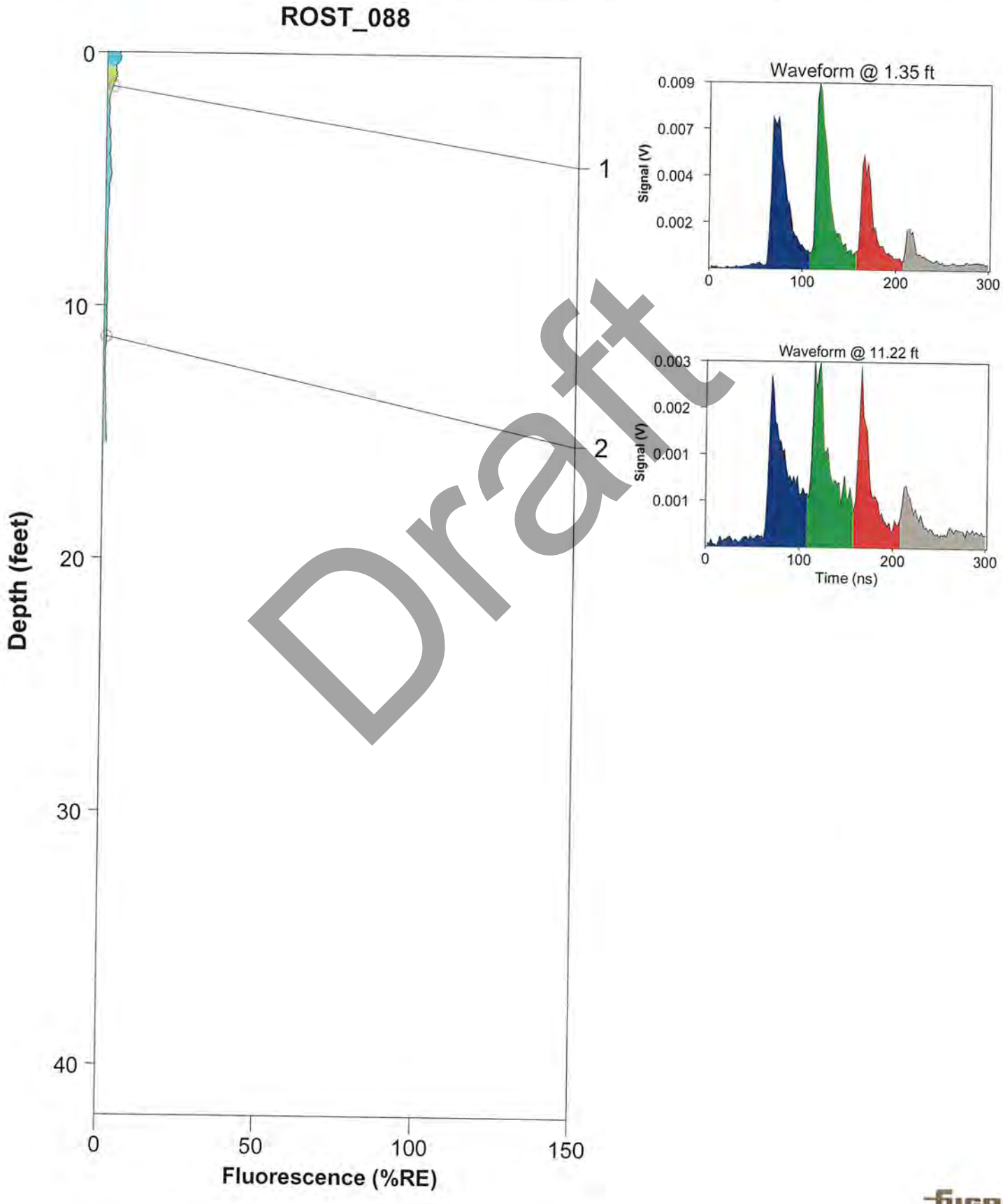
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-29-2002 @ 10:26:07	Max fluorescence: 34.00% @ 6.04 ft
ROST Unit: ?	Final depth BGS: 15.29 ft



Draft

ROST Fluorescence Response Data

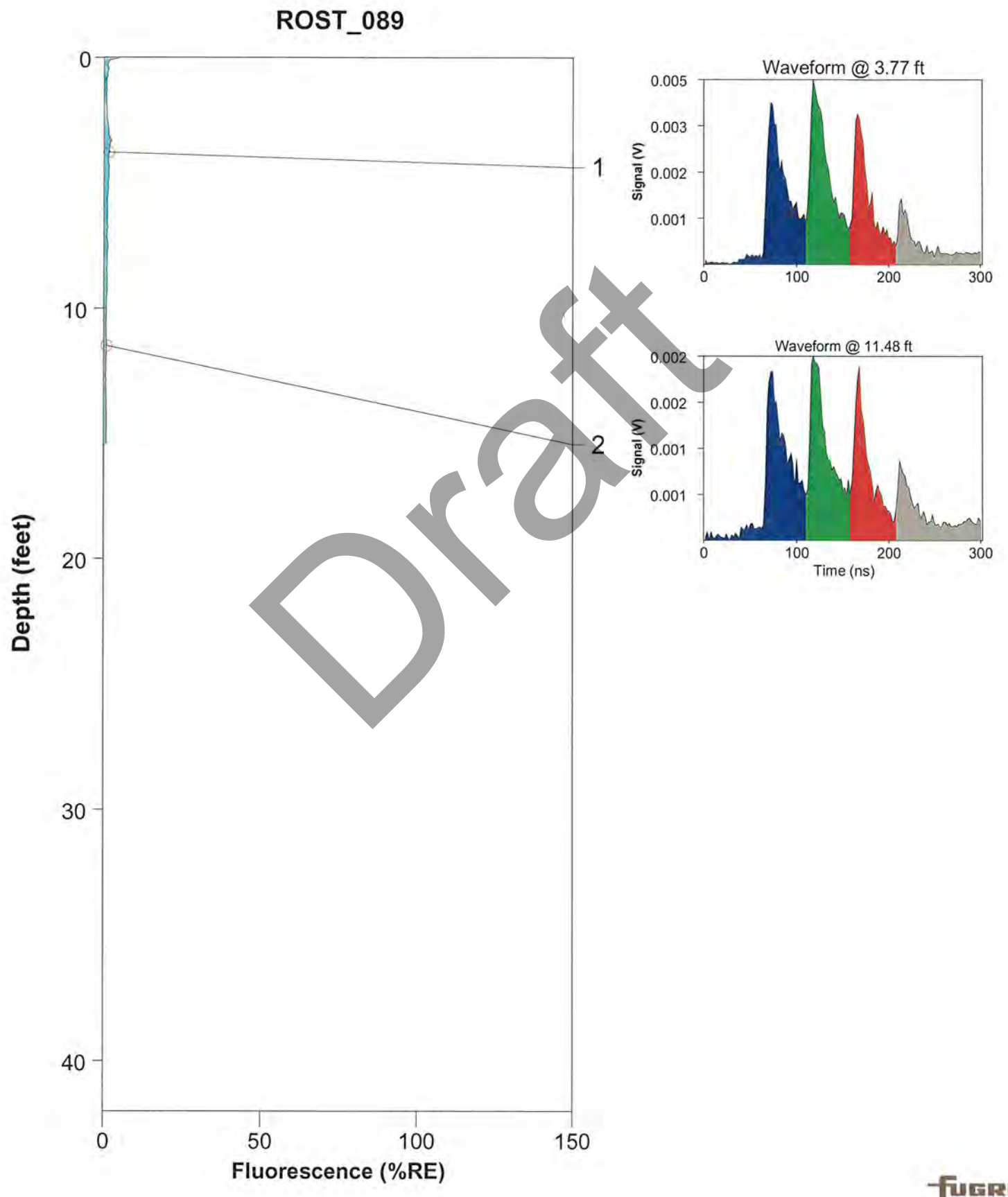
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-29-2002 @ 11:23:04	Max fluorescence: 4.53% @ 0.16 ft
ROST Unit: ?	Final depth BGS: 15.42 ft



Draft

ROST Fluorescence Response Data

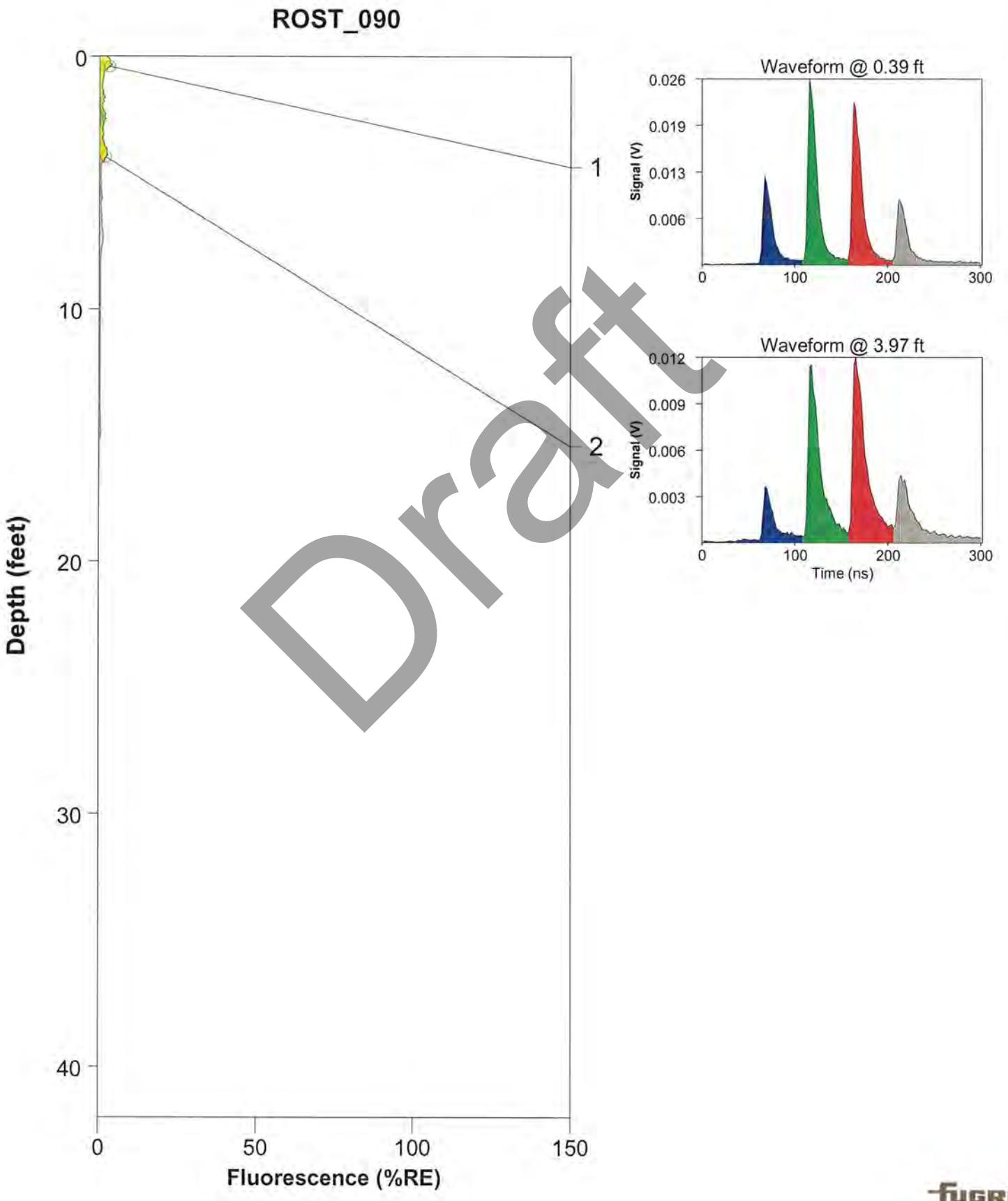
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-29-2002 @ 12:14:06	Max fluorescence: 4.49% @ 0.00 ft
ROST Unit: ?	Final depth BGS: 15.42 ft



Draft

ROST Fluorescence Response Data

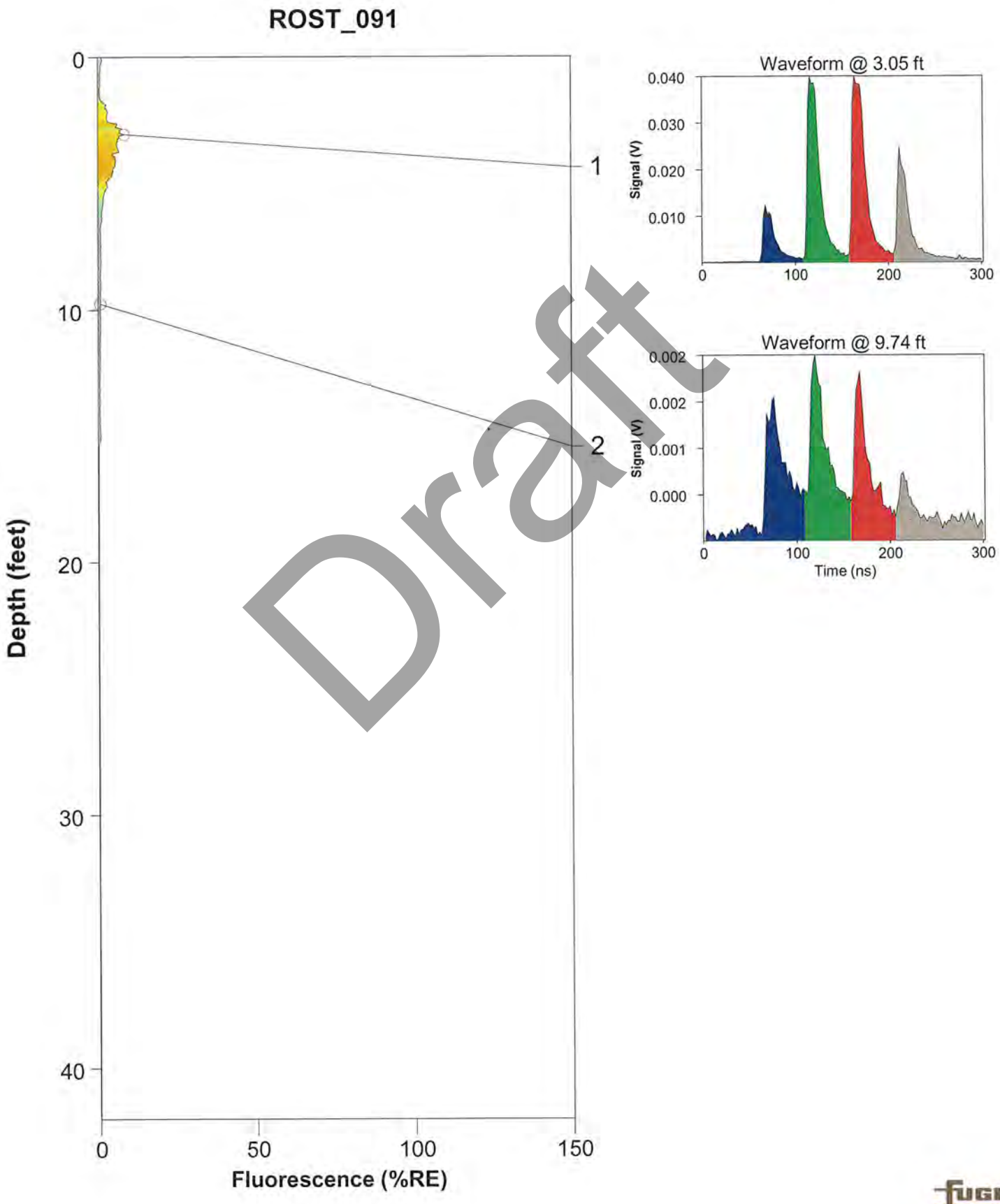
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-29-2002 @ 13:55:33	Max fluorescence: 3.98% @ 0.33 ft
ROST Unit: ?	Final depth BGS: 15.19 ft



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-29-2002 @ 14:30:46	Max fluorescence: 8.29% @ 3.05 ft
ROST Unit: ?	Final depth BGS: 15.26 ft

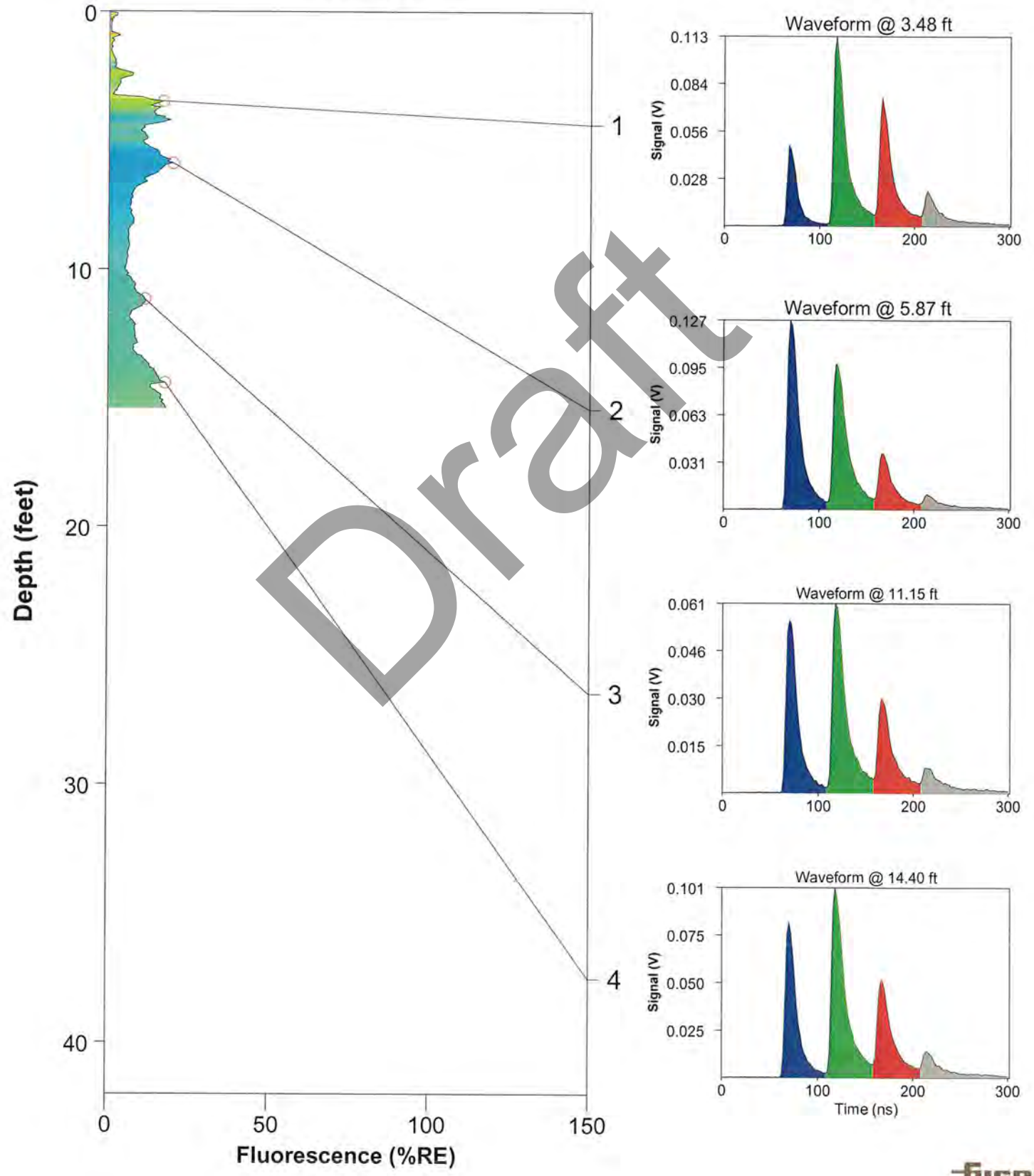


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-29-2002 @ 15:42:04	Max fluorescence: 20.10% @ 5.87 ft
ROST Unit: ?	Final depth BGS: 15.39 ft

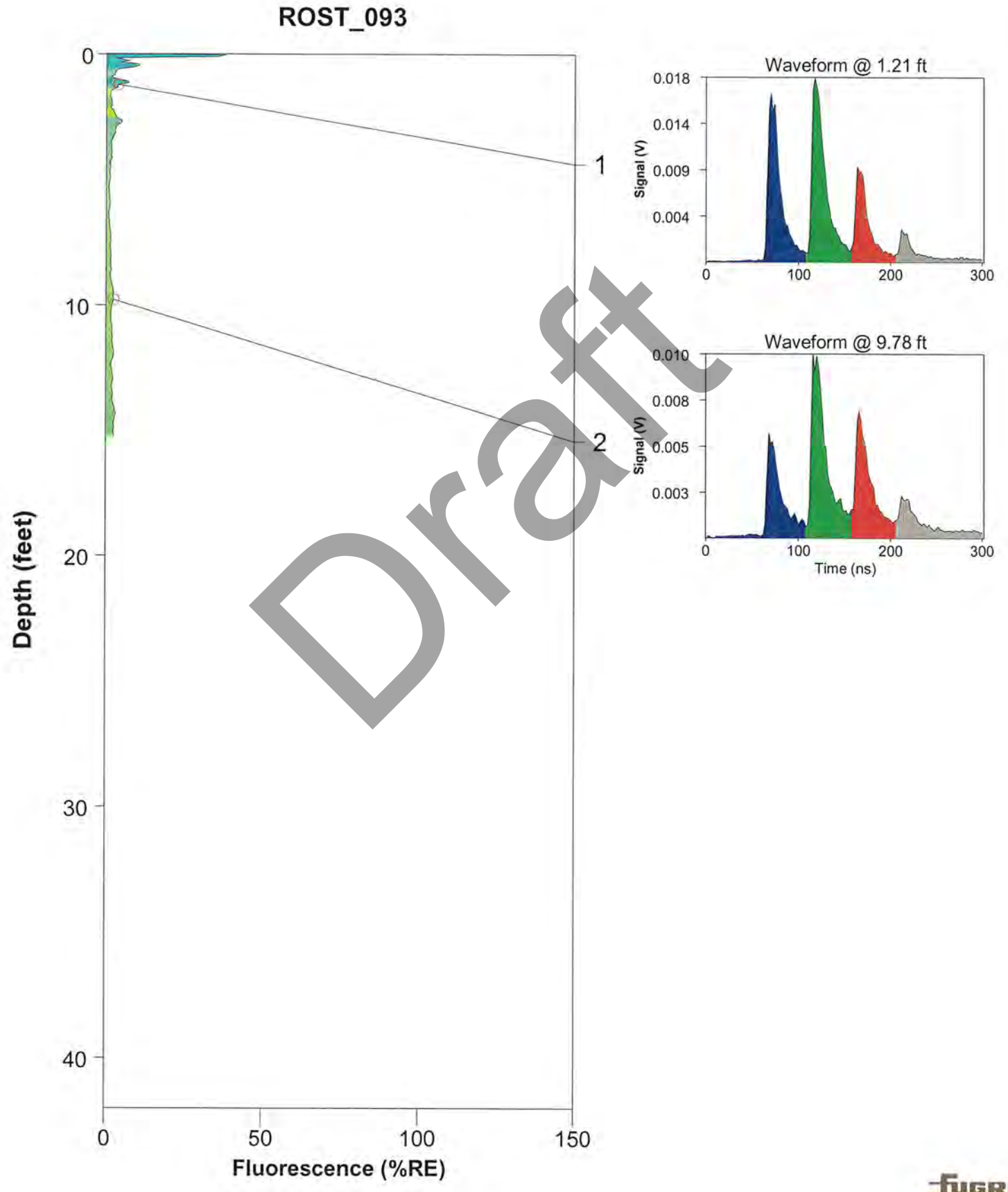
ROST_092



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-29-2002 @ 16:28:17	Max fluorescence: 37.99% @ 0.03 ft
ROST Unit: ?	Final depth BGS: 15.22 ft

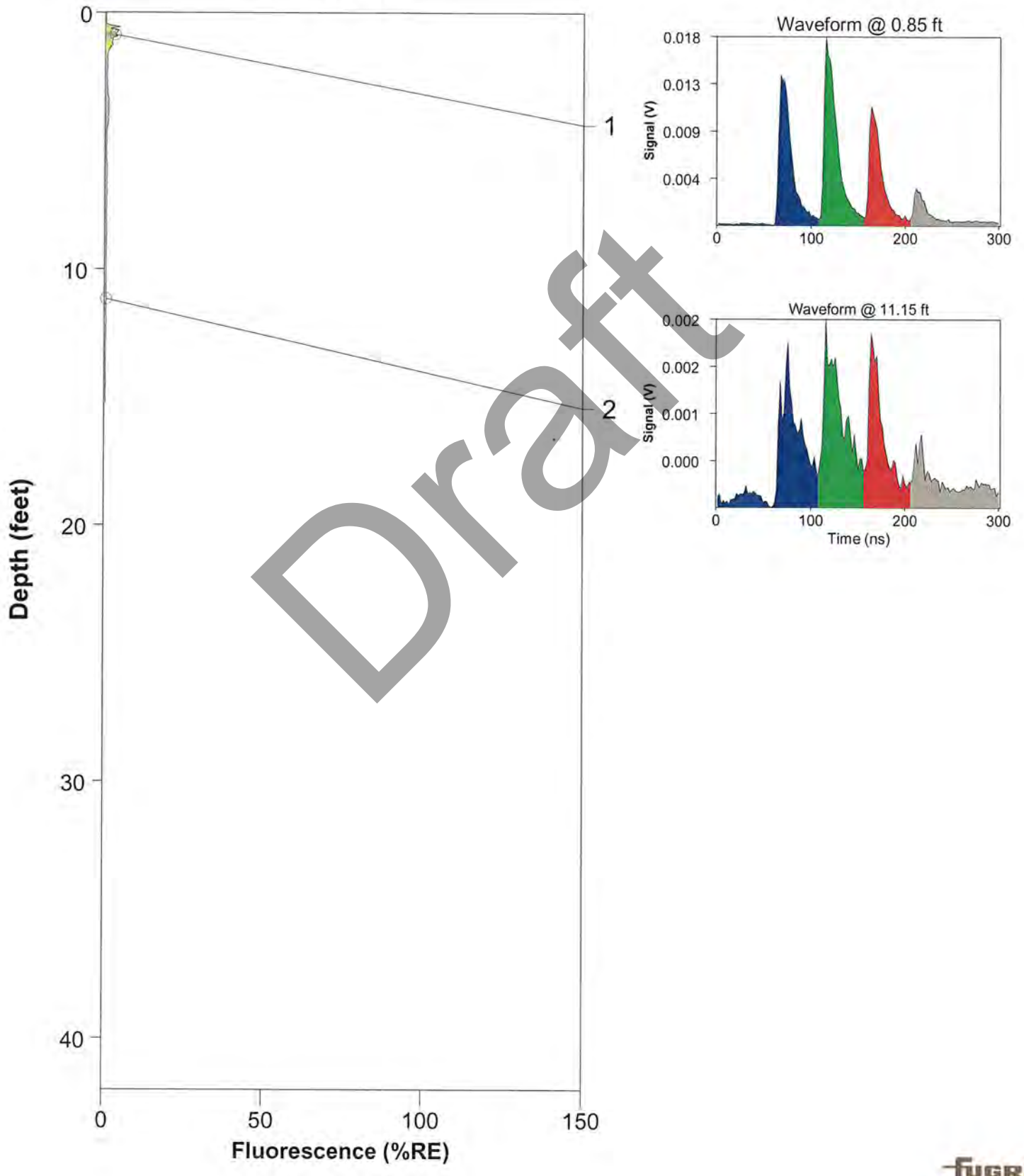


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-29-2002 @ 16:59:39	Max fluorescence: 4.68% @ 0.56 ft
ROST Unit: ?	Final depth BGS: 15.22 ft

ROST_094

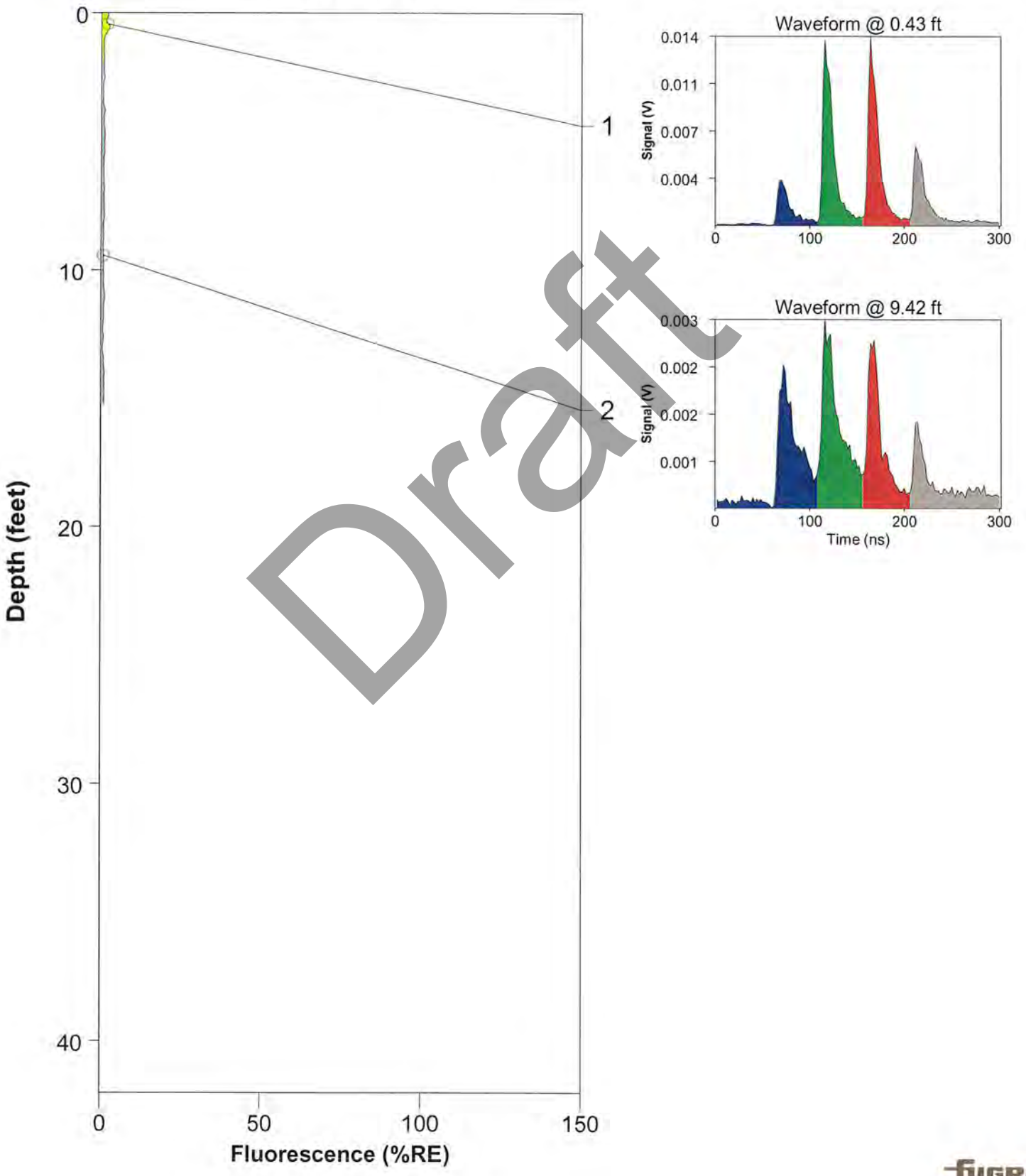


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-29-2002 @ 17:24:41	Max fluorescence: 2.52% @ 0.56 ft
ROST Unit: ?	Final depth BGS: 15.22 ft

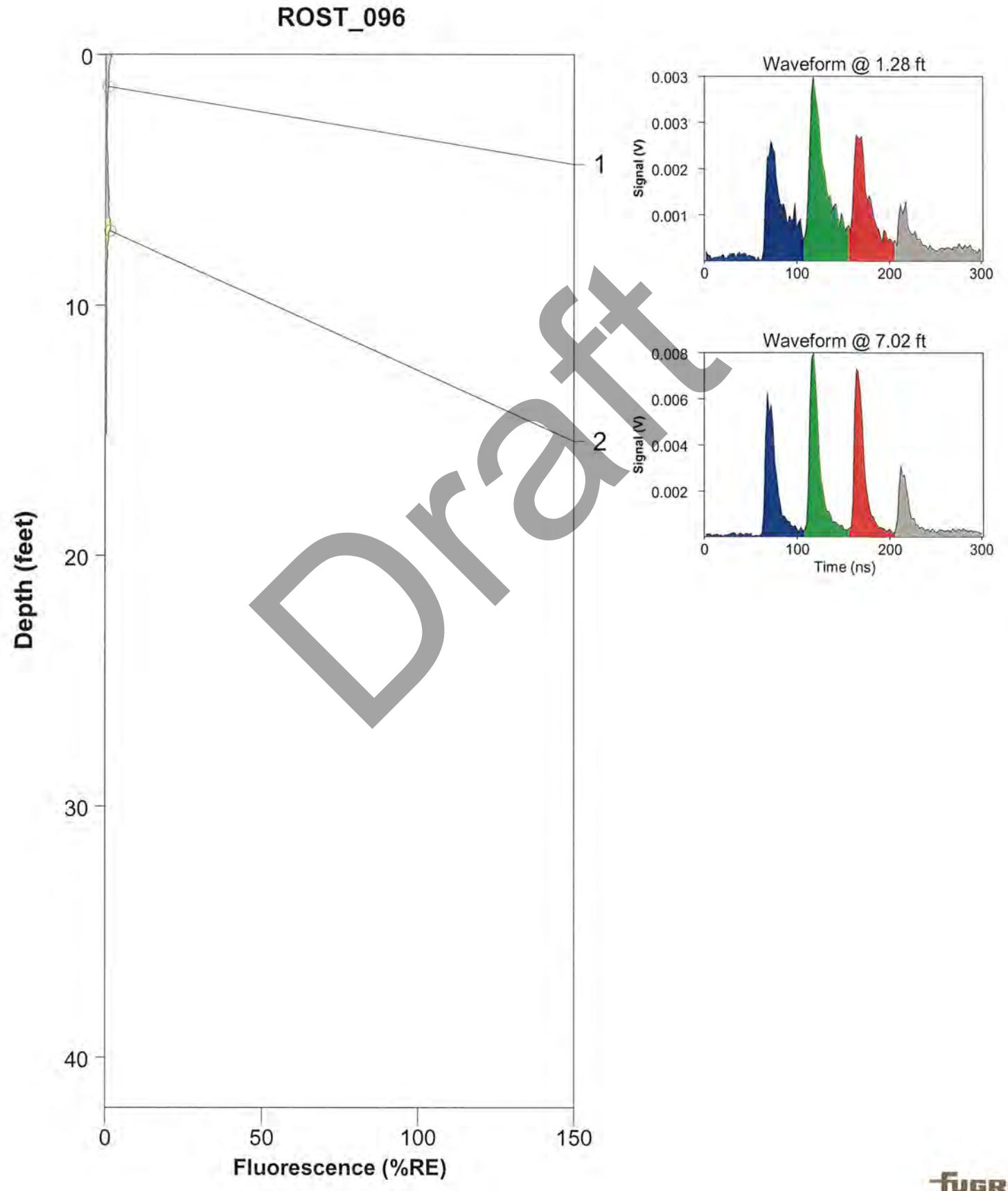
ROST_095



Draft

ROST Fluorescence Response Data

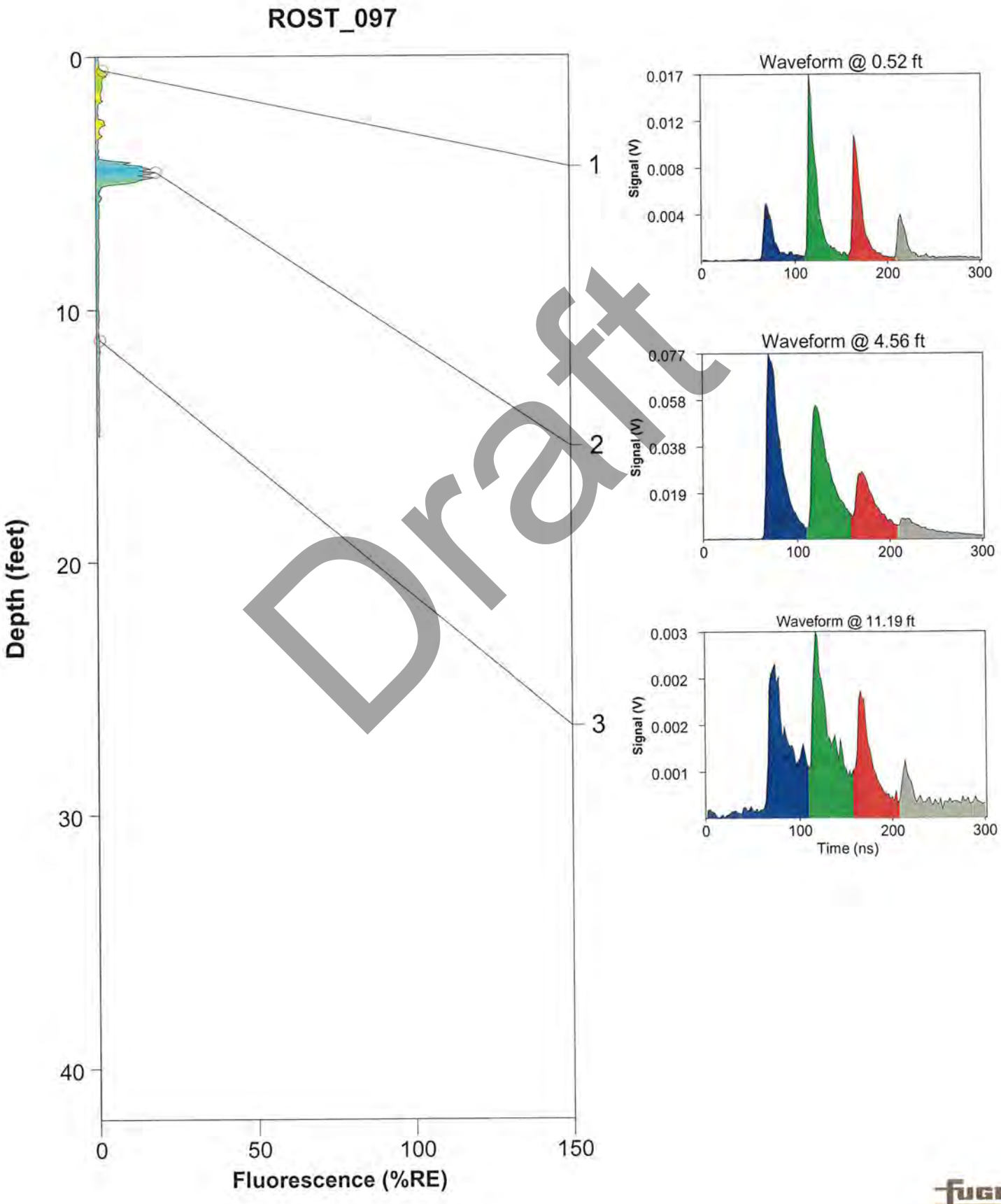
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-29-2002 @ 17:52:10	Max fluorescence: 1.95% @ 0.07 ft
ROST Unit: ?	Final depth BGS: 15.16 ft



Draft

ROST Fluorescence Response Data

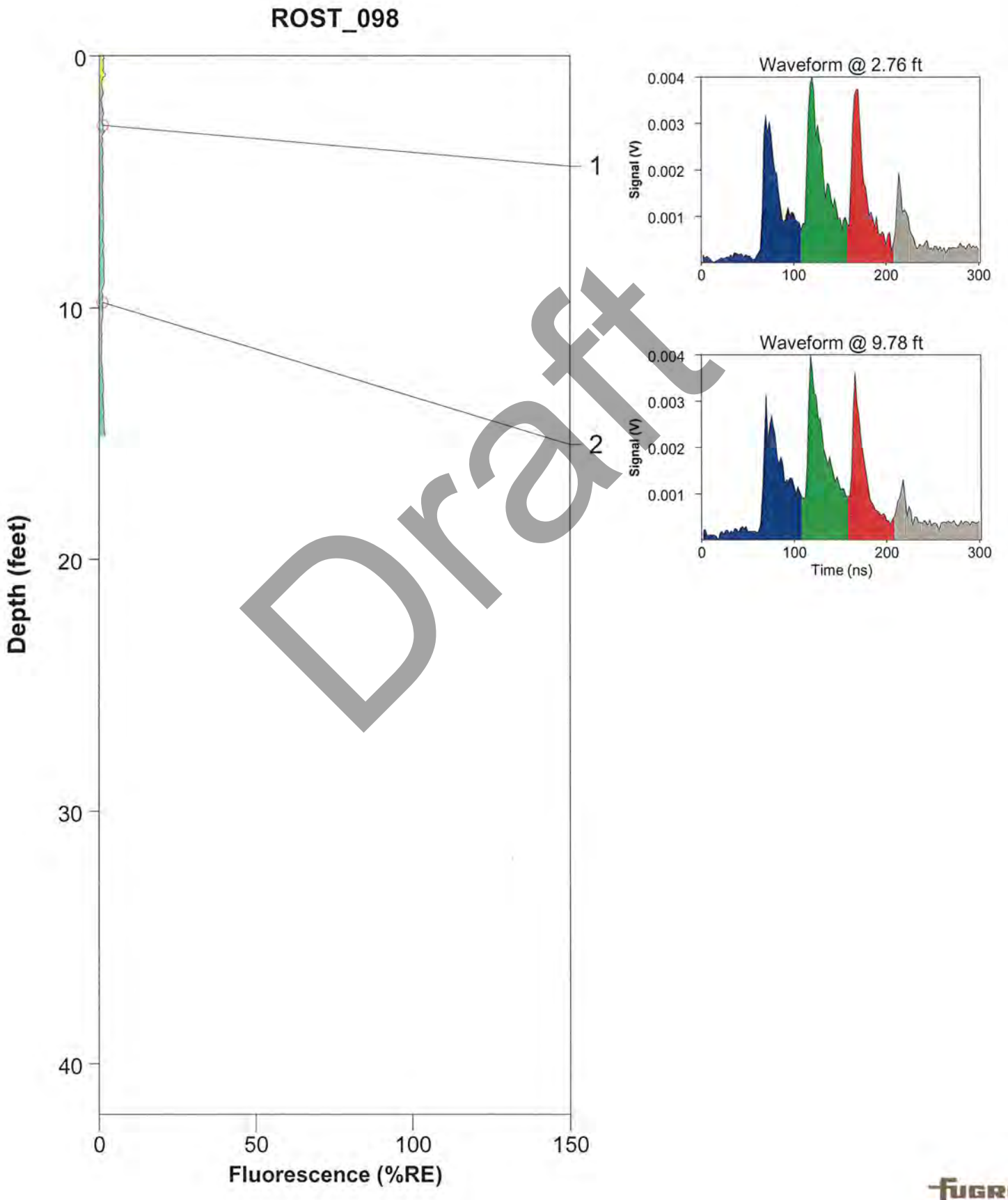
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-30-2002 @ 12:08:46	Max fluorescence: 18.83% @ 4.56 ft
ROST Unit: ?	Final depth BGS: 15.03 ft



Draft

ROST Fluorescence Response Data

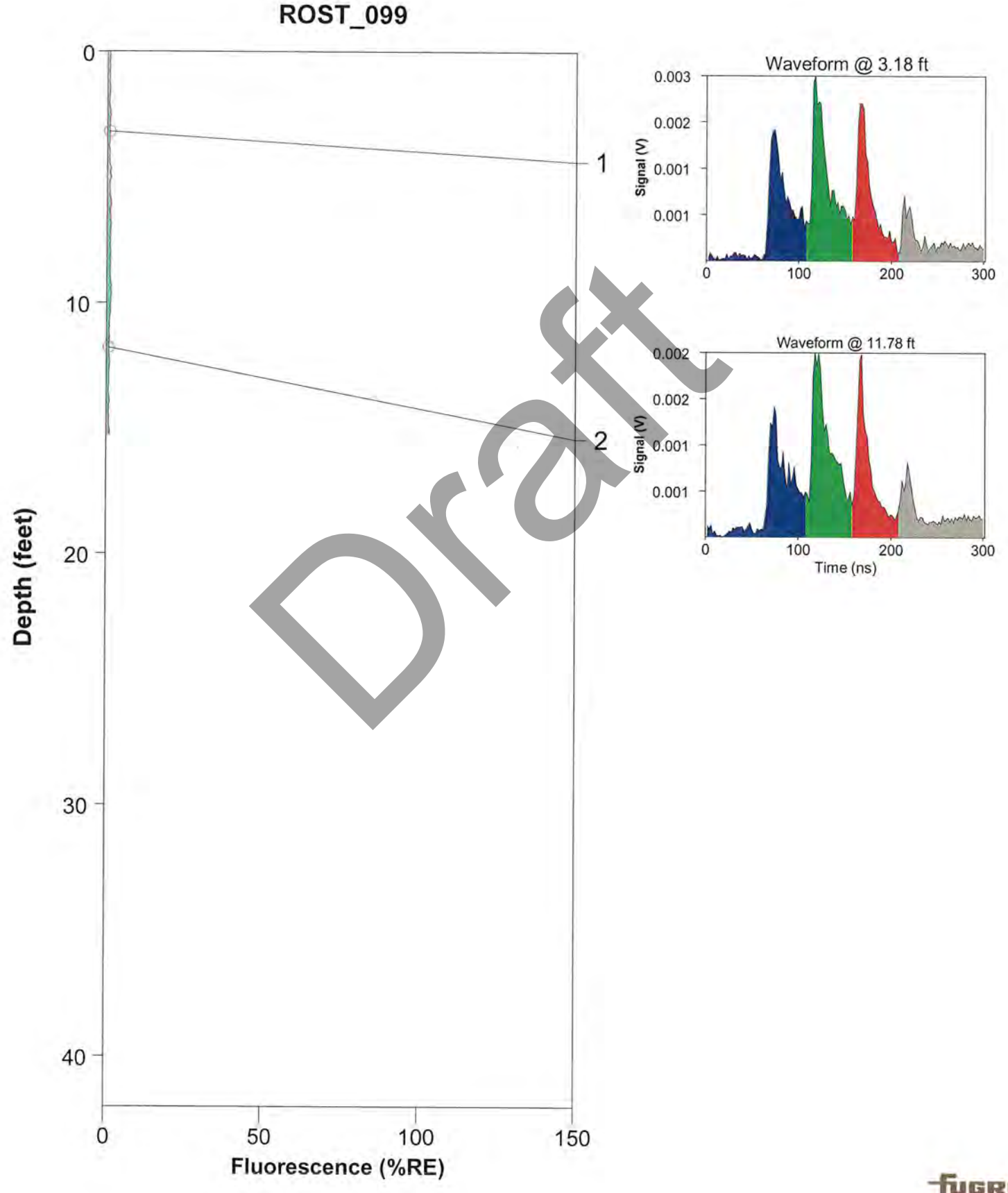
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-30-2002 @ 12:30:05	Max fluorescence: 2.05% @ 0.72 ft
ROST Unit: ?	Final depth BGS: 15.09 ft



Draft

ROST Fluorescence Response Data

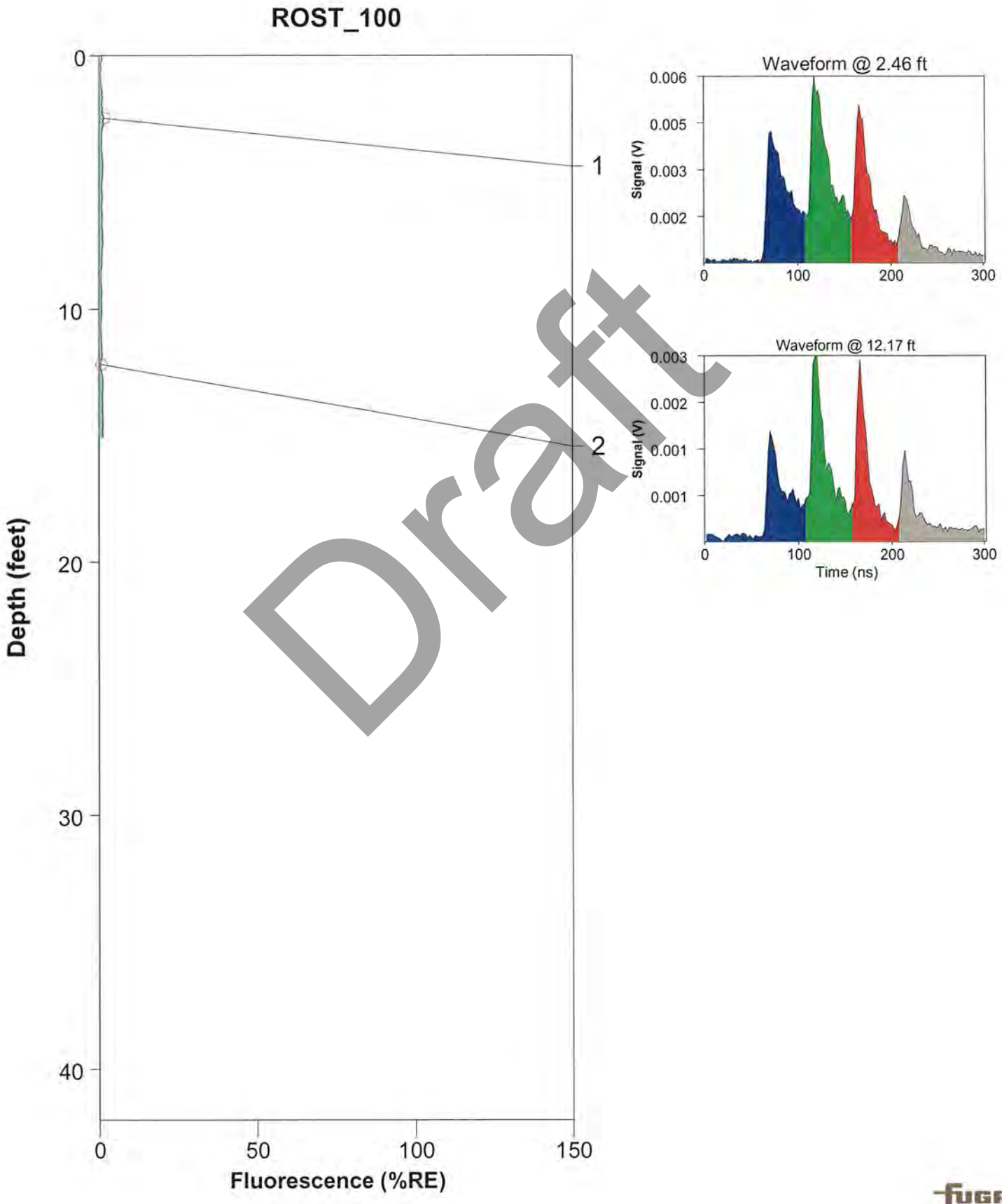
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-30-2002 @ 12:53:26	Max fluorescence: 1.53% @ 9.32 ft
ROST Unit: ?	Final depth BGS: 15.26 ft



Draft

ROST Fluorescence Response Data

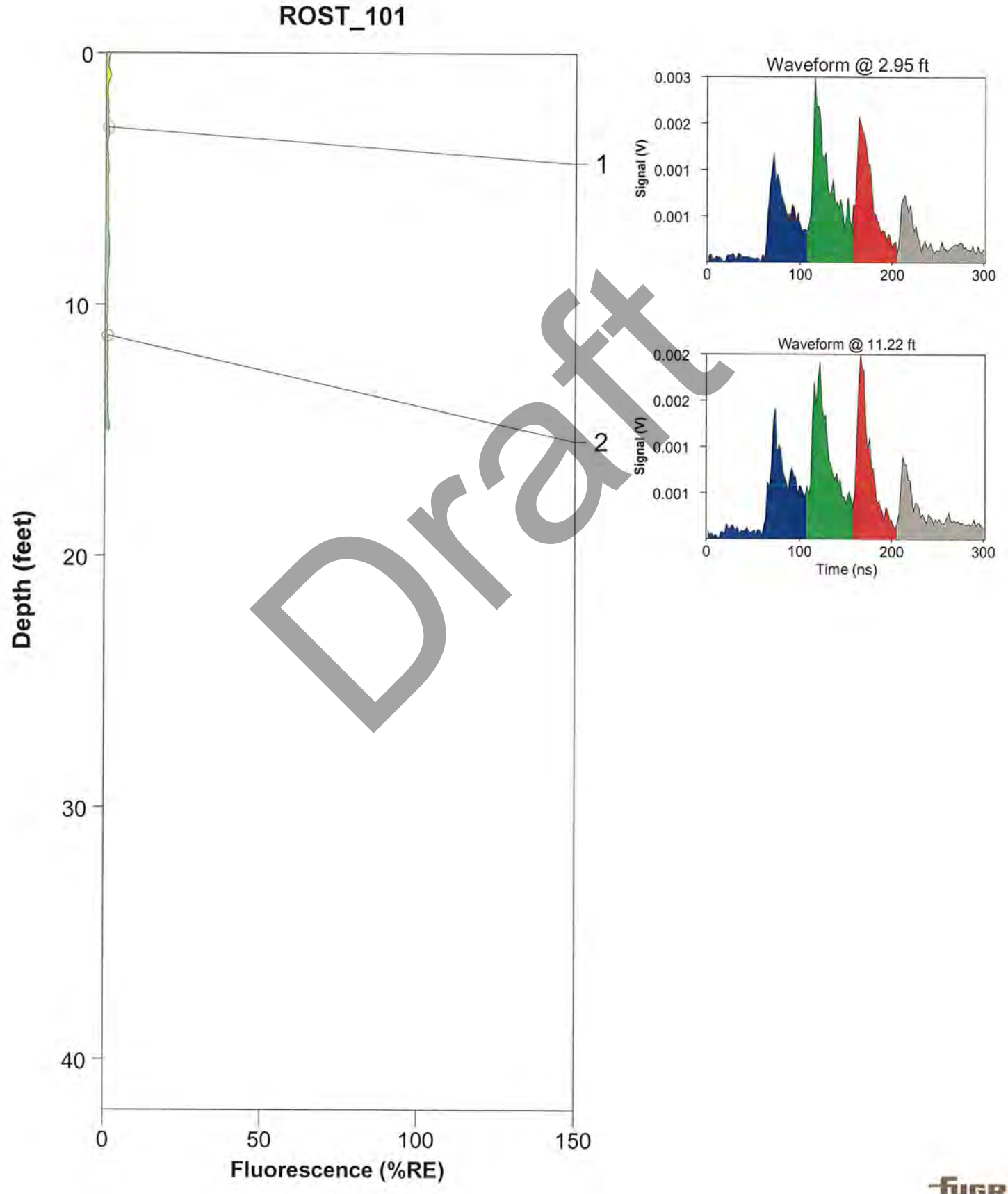
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-30-2002 @ 13:17:55	Max fluorescence: 1.59% @ 2.46 ft
ROST Unit: ?	Final depth BGS: 15.06 ft



Draft

ROST Fluorescence Response Data

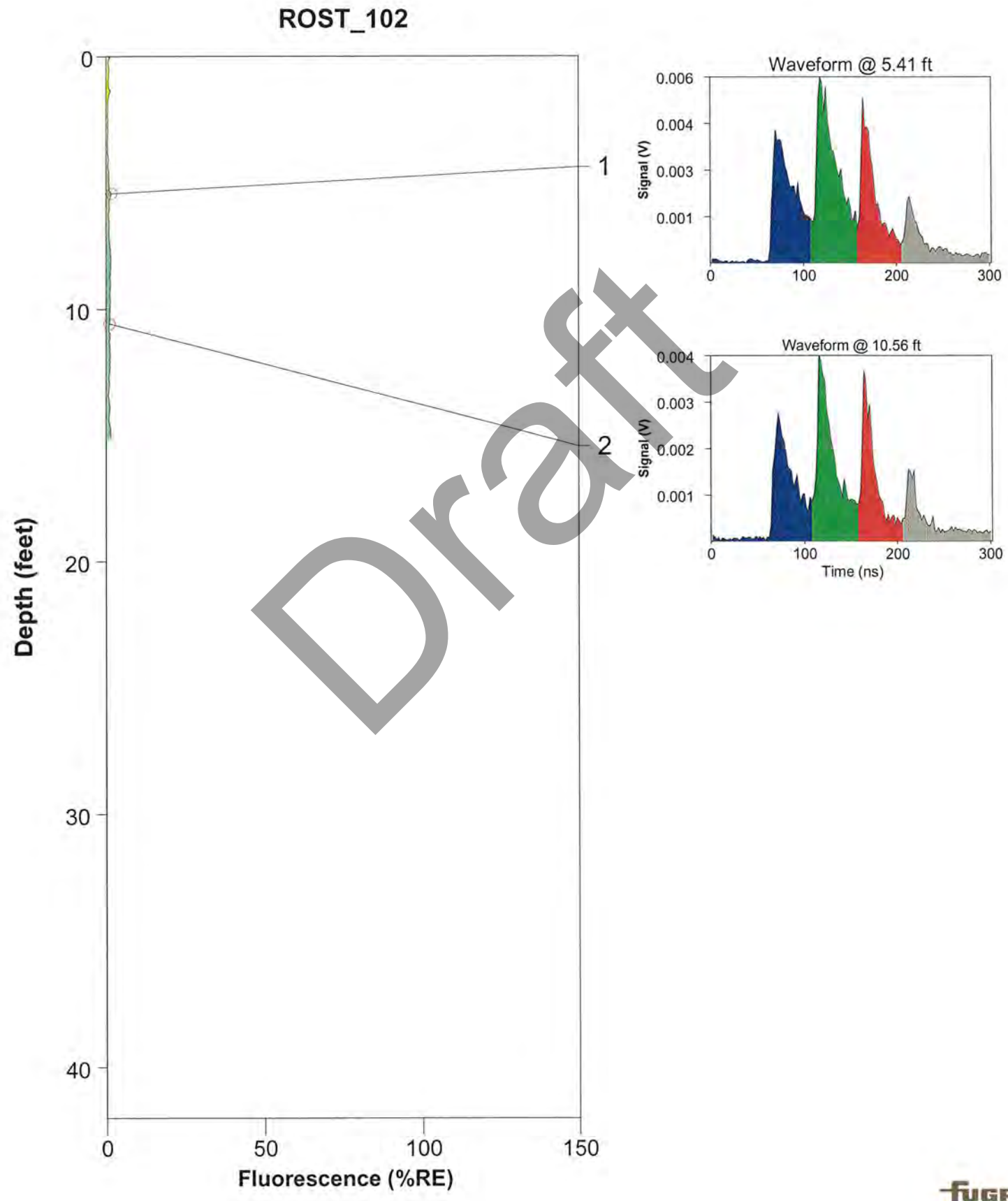
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-30-2002 @ 13:44:45	Max fluorescence: 1.55% @ 0.00 ft
ROST Unit: ?	Final depth BGS: 15.03 ft



Draft

ROST Fluorescence Response Data

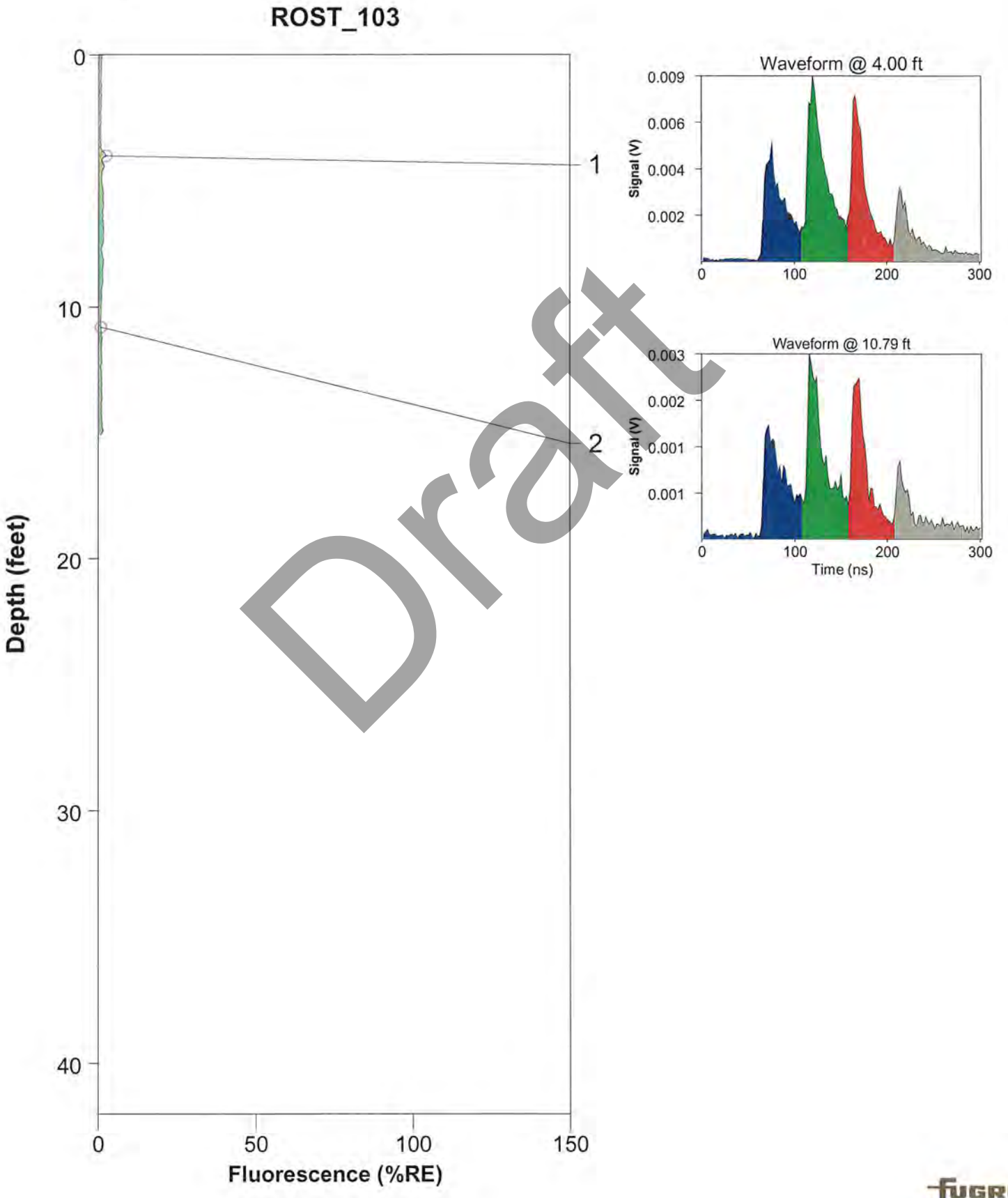
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-30-2002 @ 14:11:27	Max fluorescence: 1.60% @ 5.41 ft
ROST Unit: ?	Final depth BGS: 15.12 ft



Draft

ROST Fluorescence Response Data

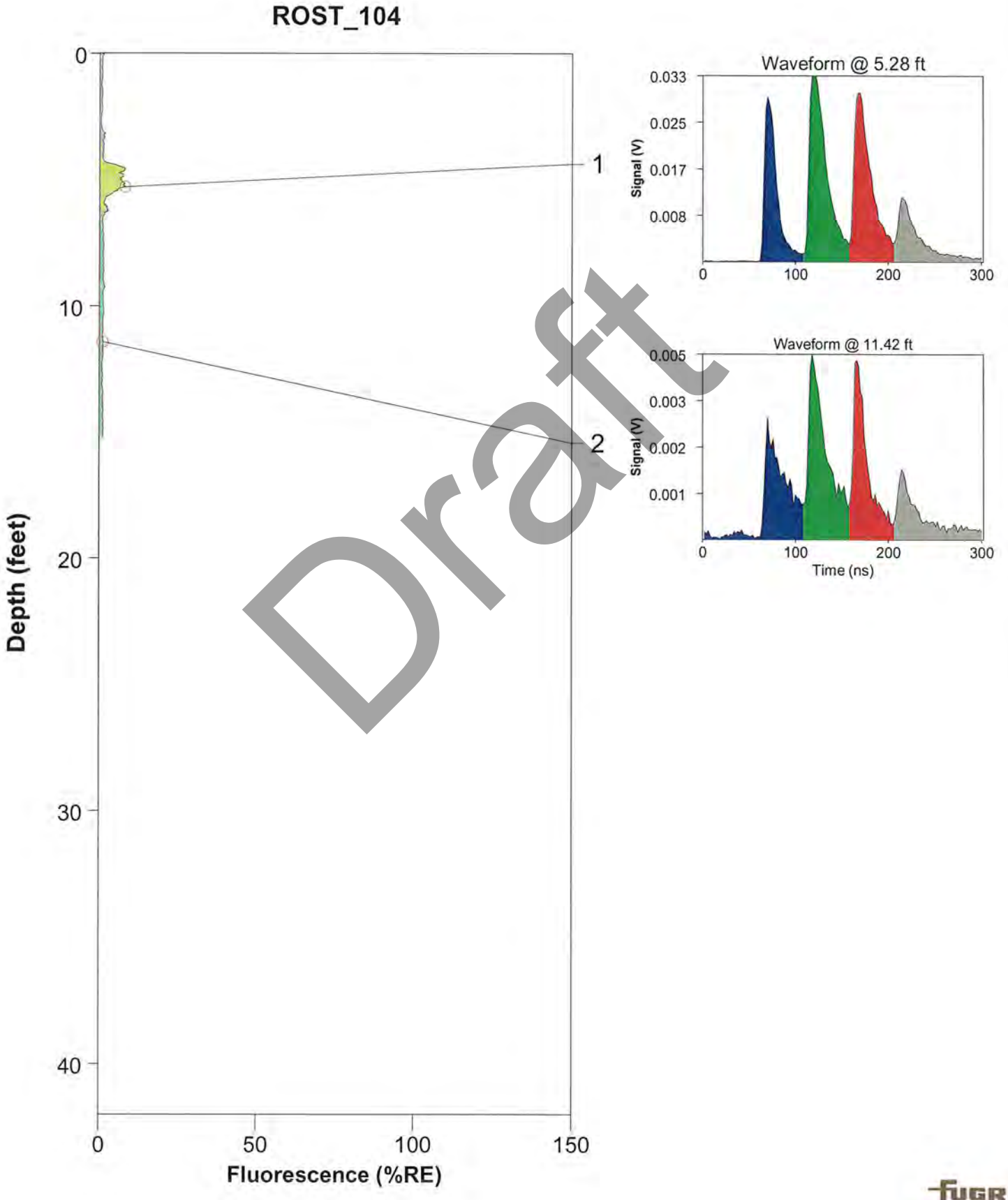
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-30-2002 @ 14:55:55	Max fluorescence: 2.28% @ 4.00 ft
ROST Unit: ?	Final depth BGS: 15.06 ft



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-30-2002 @ 15:19:51	Max fluorescence: 8.25% @ 5.28 ft
ROST Unit: ?	Final depth BGS: 15.19 ft

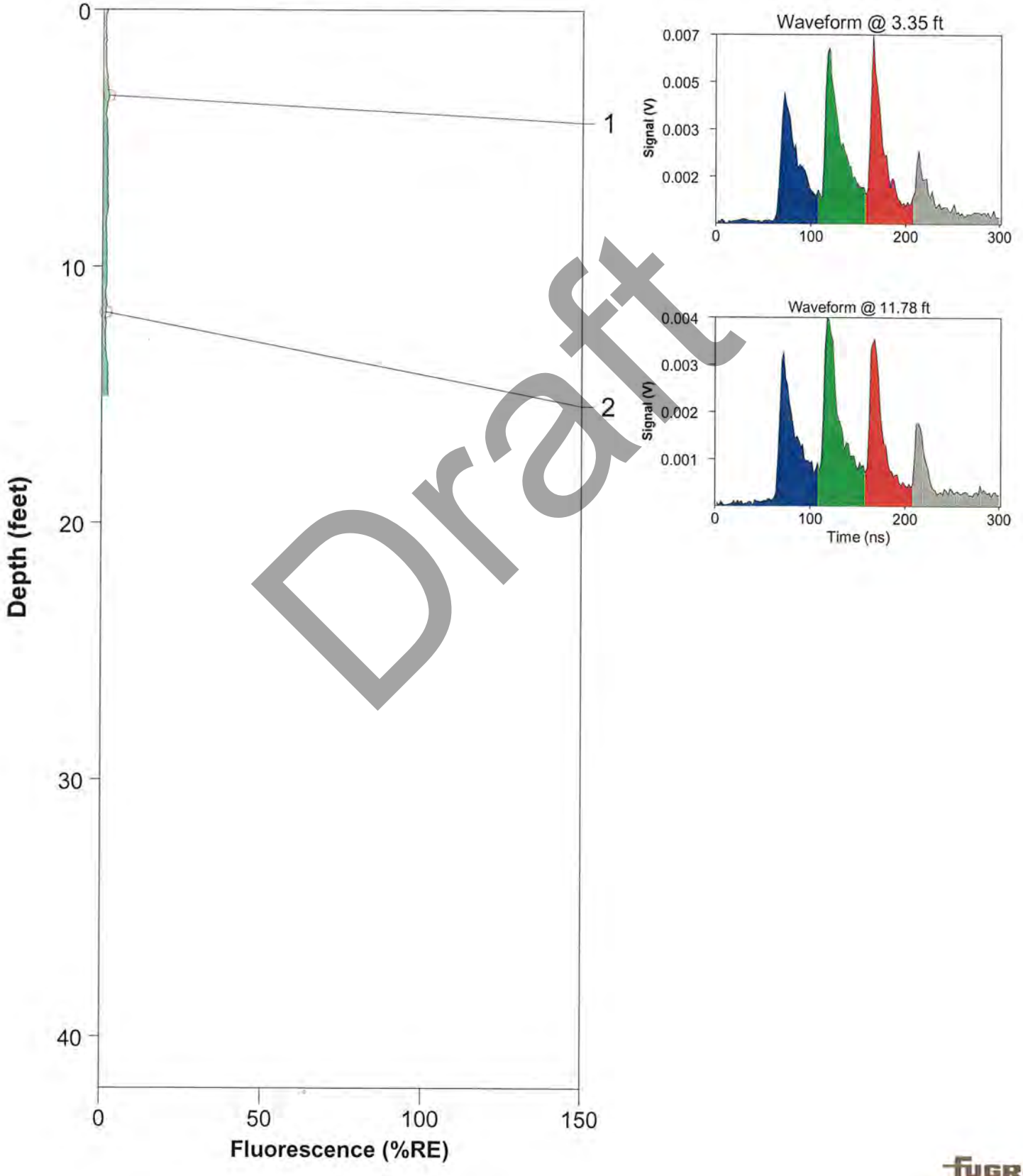


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-30-2002 @ 17:02:51	Max fluorescence: 1.95% @ 14.99 ft
ROST Unit: ?	Final depth BGS: 15.06 ft

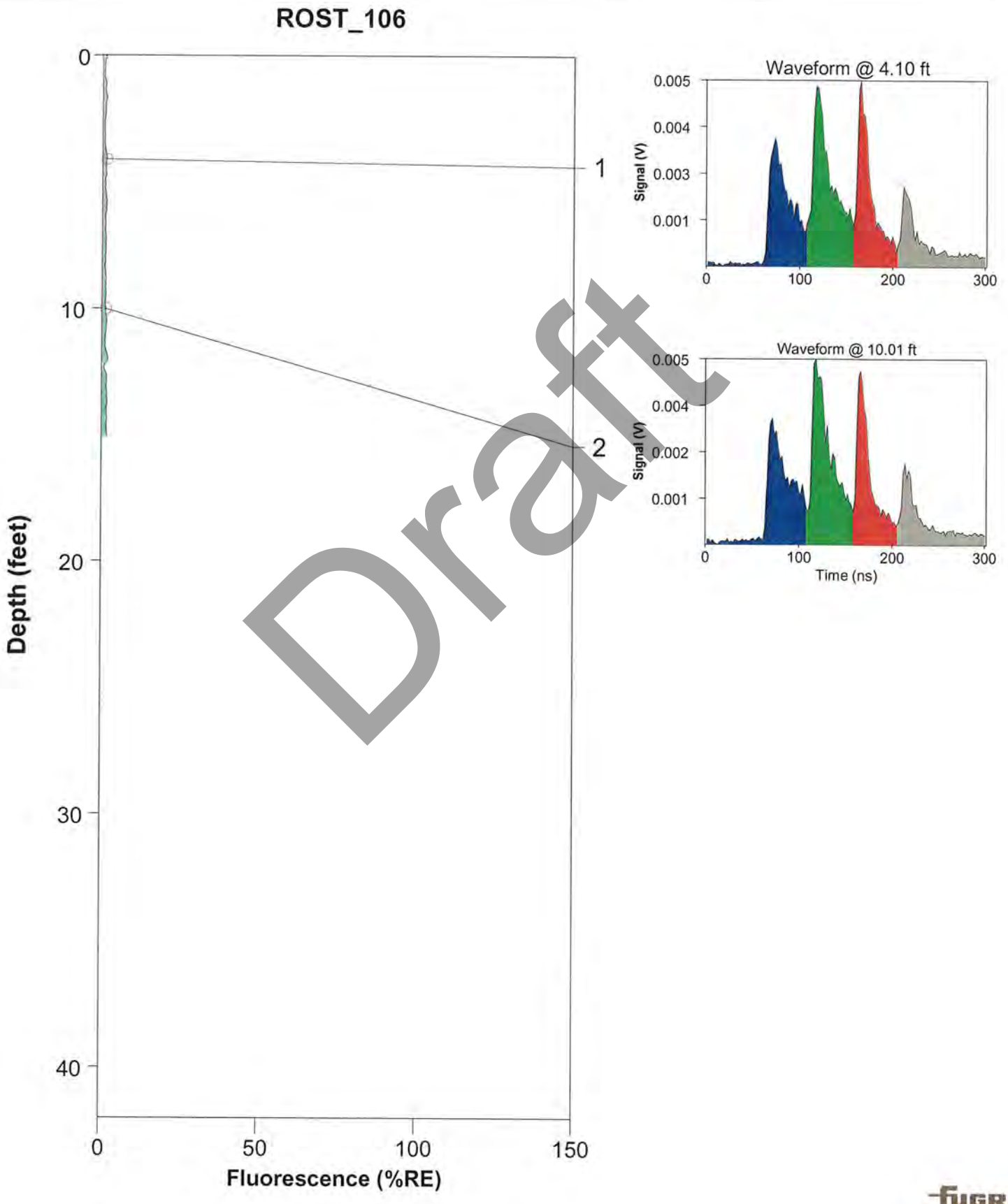
ROST_105



Draft

ROST Fluorescence Response Data

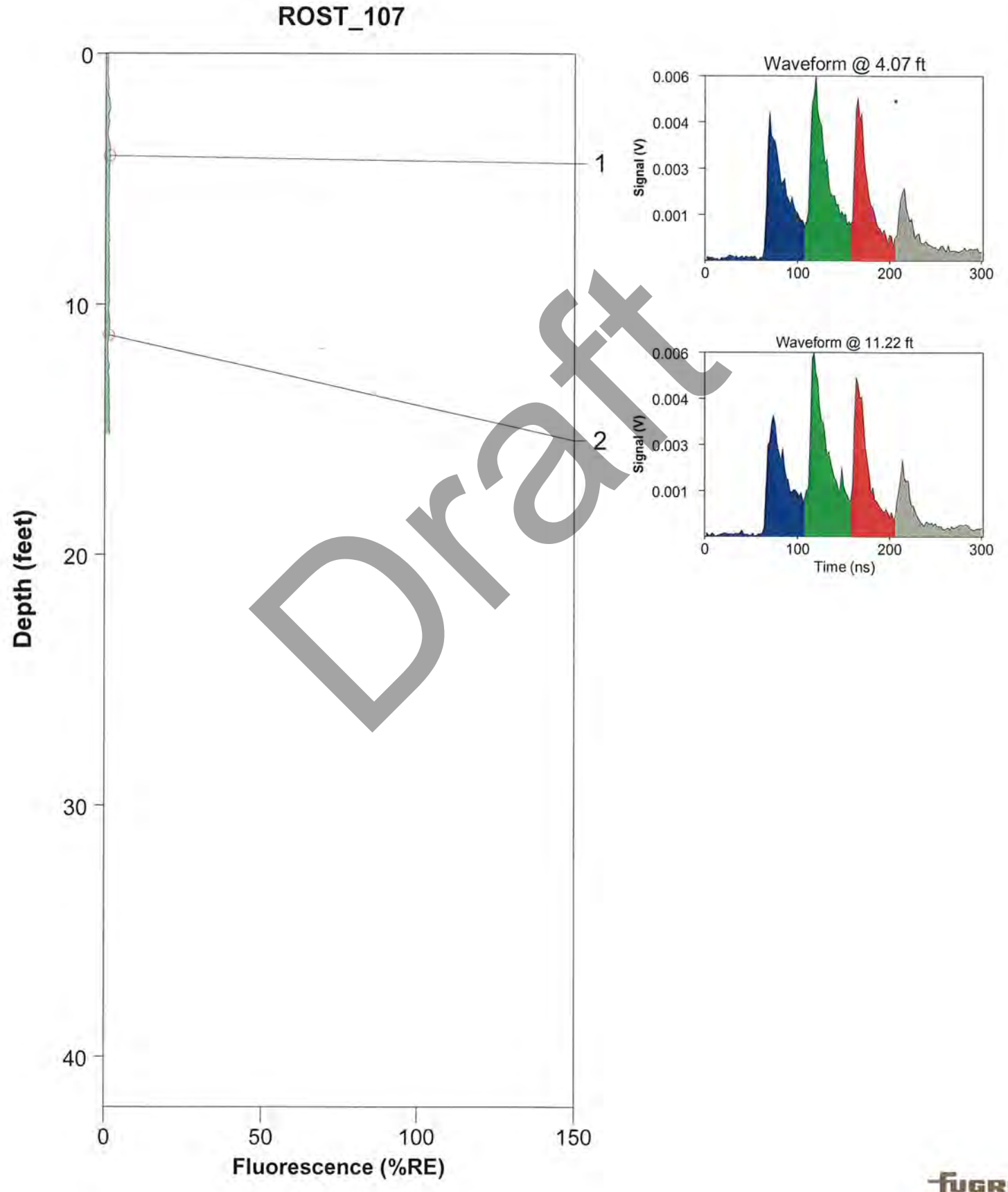
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-30-2002 @ 17:19:51	Max fluorescence: 2.00% @ 12.01 ft
ROST Unit: ?	Final depth BGS: 15.06 ft



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-30-2002 @ 17:35:40	Max fluorescence: 1.49% @ 14.70 ft
ROST Unit: ?	Final depth BGS: 15.19 ft

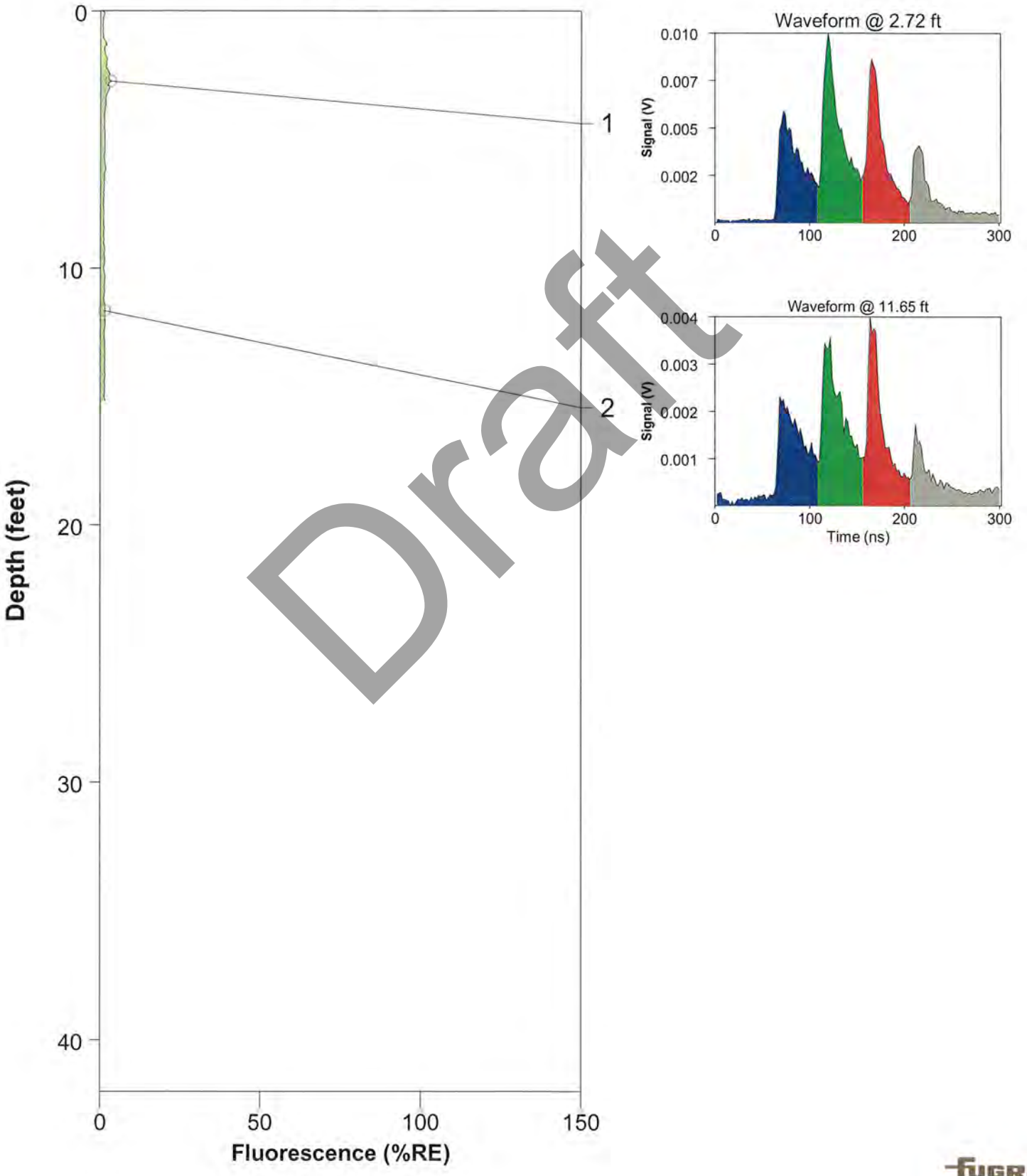


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-30-2002 @ 17:56:30	Max fluorescence: 3.30% @ 2.72 ft
ROST Unit: ?	Final depth BGS: 15.16 ft

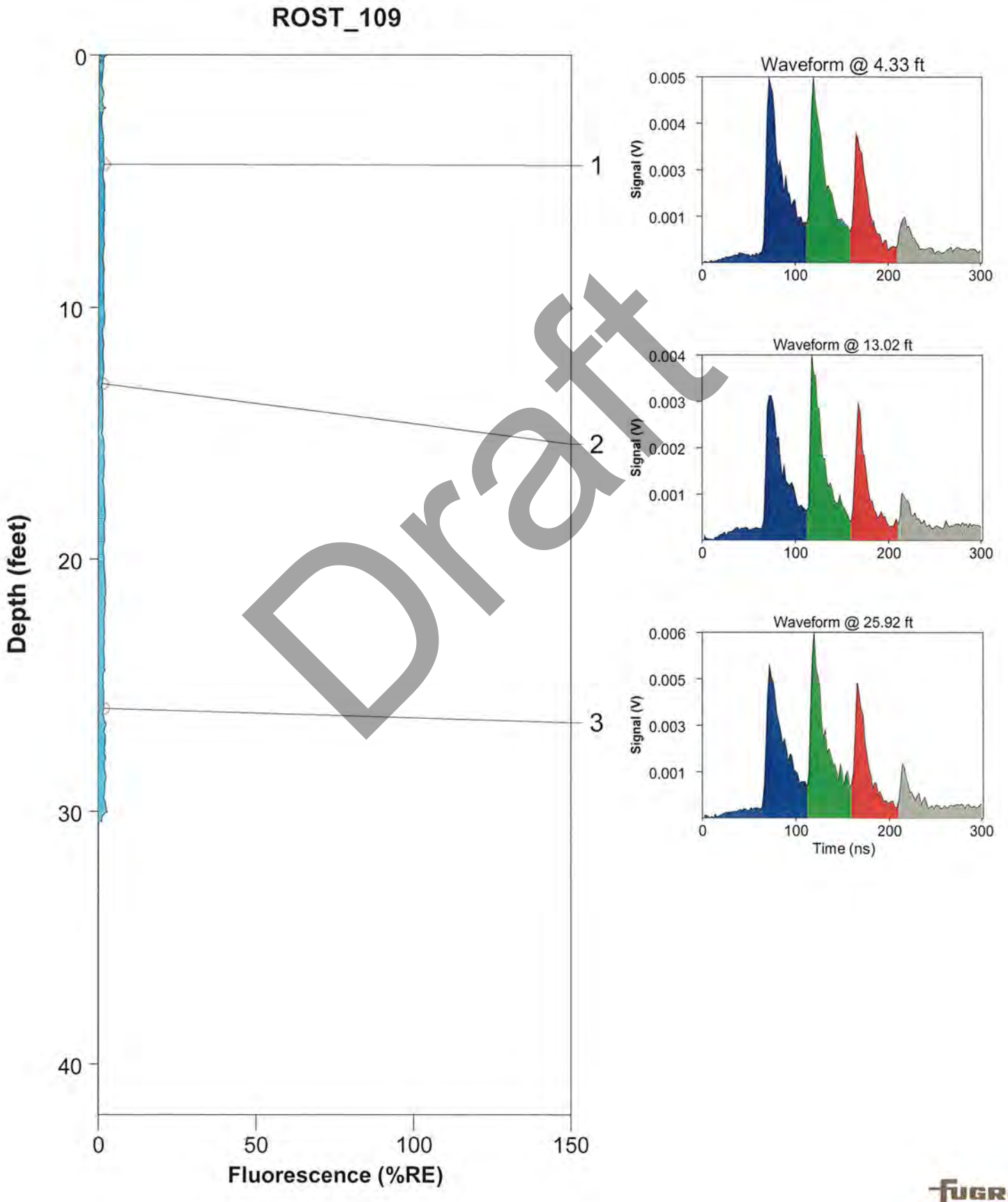
ROST_108



Draft

ROST Fluorescence Response Data

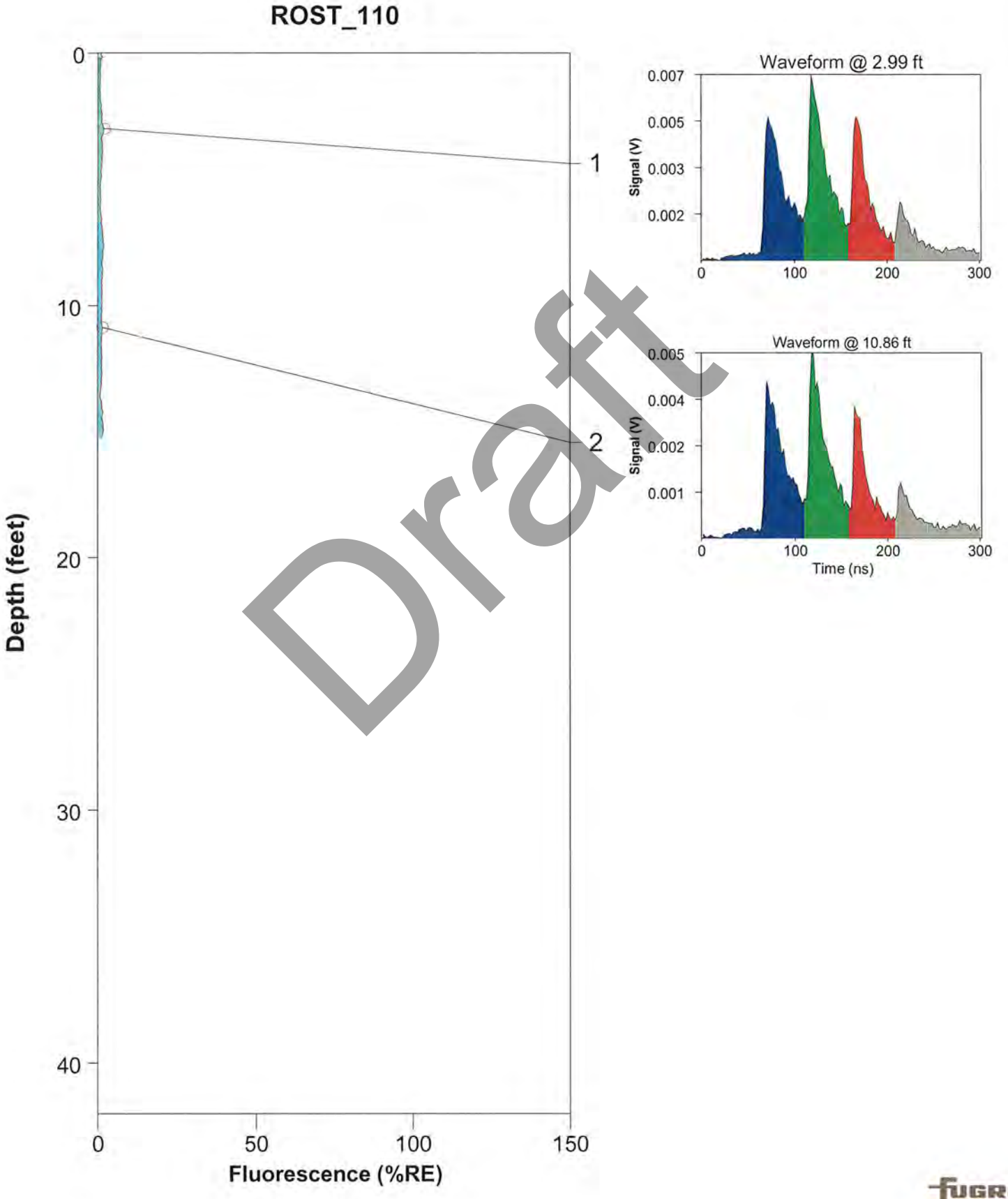
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-31-2002 @ 09:56:40	Max fluorescence: 2.92% @ 30.02 ft
ROST Unit: ?	Final depth BGS: 30.41 ft



Draft

ROST Fluorescence Response Data

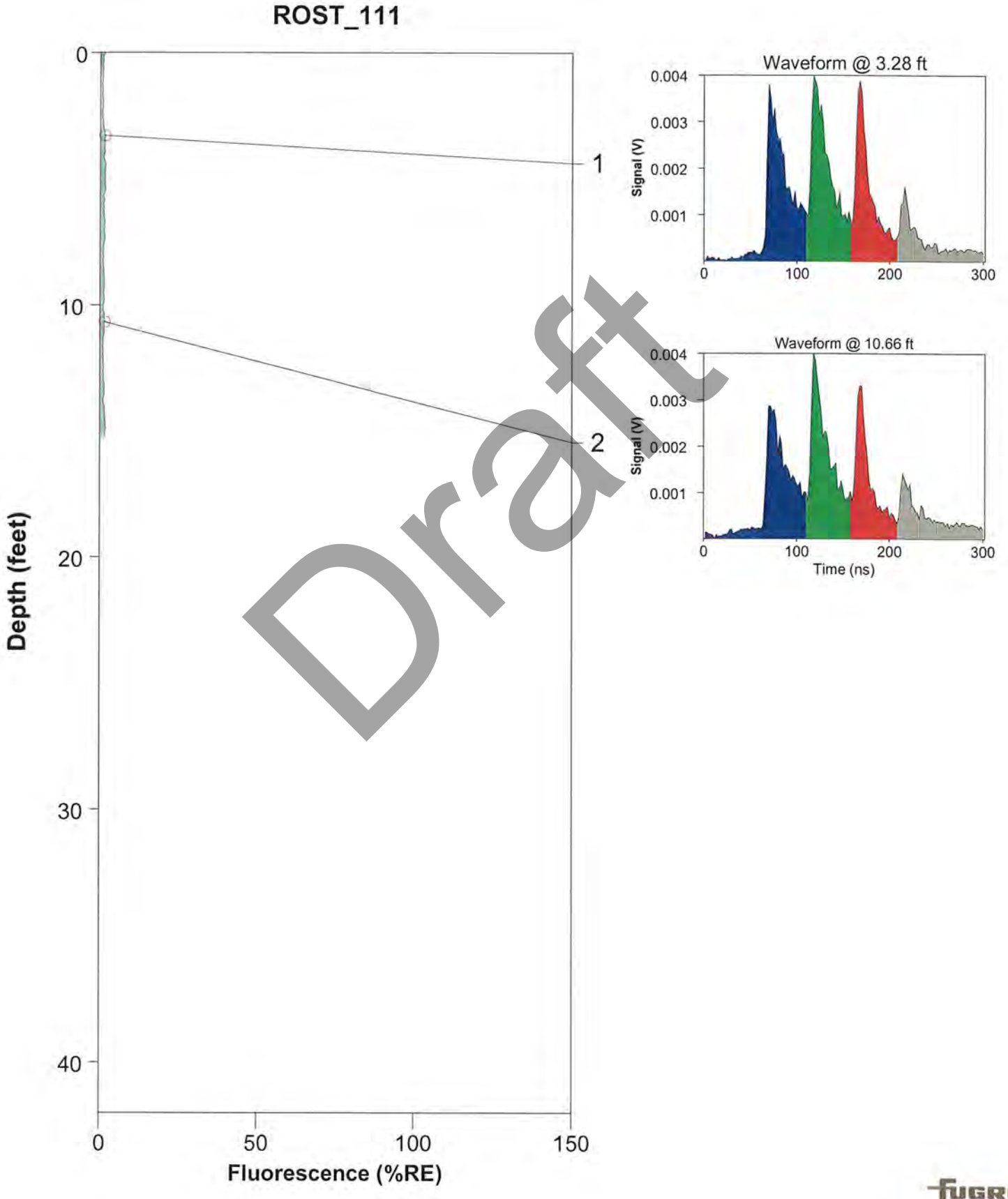
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-31-2002 @ 10:25:31	Max fluorescence: 1.95% @ 2.99 ft
ROST Unit: ?	Final depth BGS: 15.22 ft



Draft

ROST Fluorescence Response Data

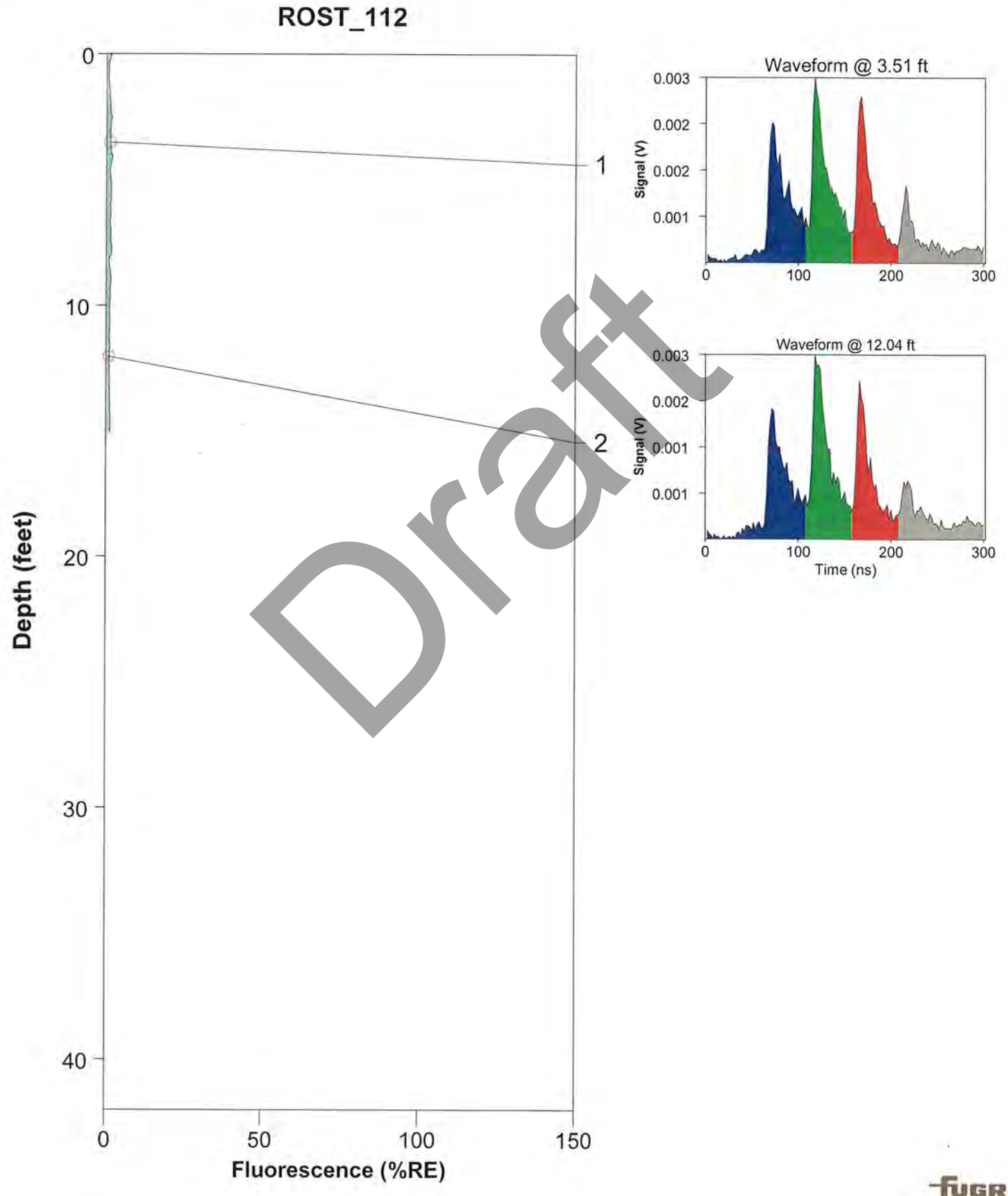
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-31-2002 @ 10:53:08	Max fluorescence: 1.86% @ 14.90 ft
ROST Unit: ?	Final depth BGS: 15.19 ft



Draft

ROST Fluorescence Response Data

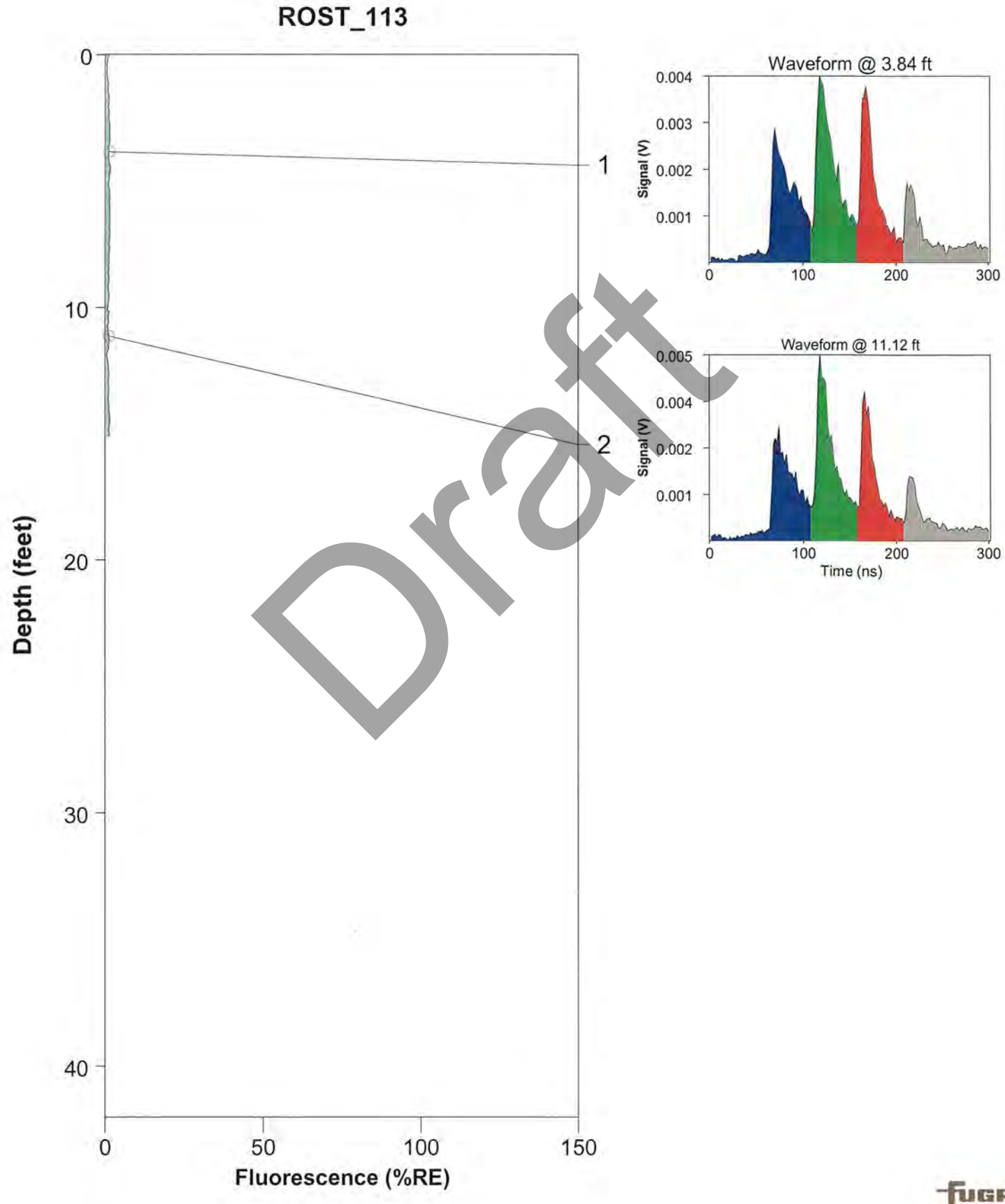
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-31-2002 @ 11:12:41	Max fluorescence: 1.97% @ 4.10 ft
ROST Unit: ?	Final depth BGS: 15.06 ft



Draft

ROST Fluorescence Response Data

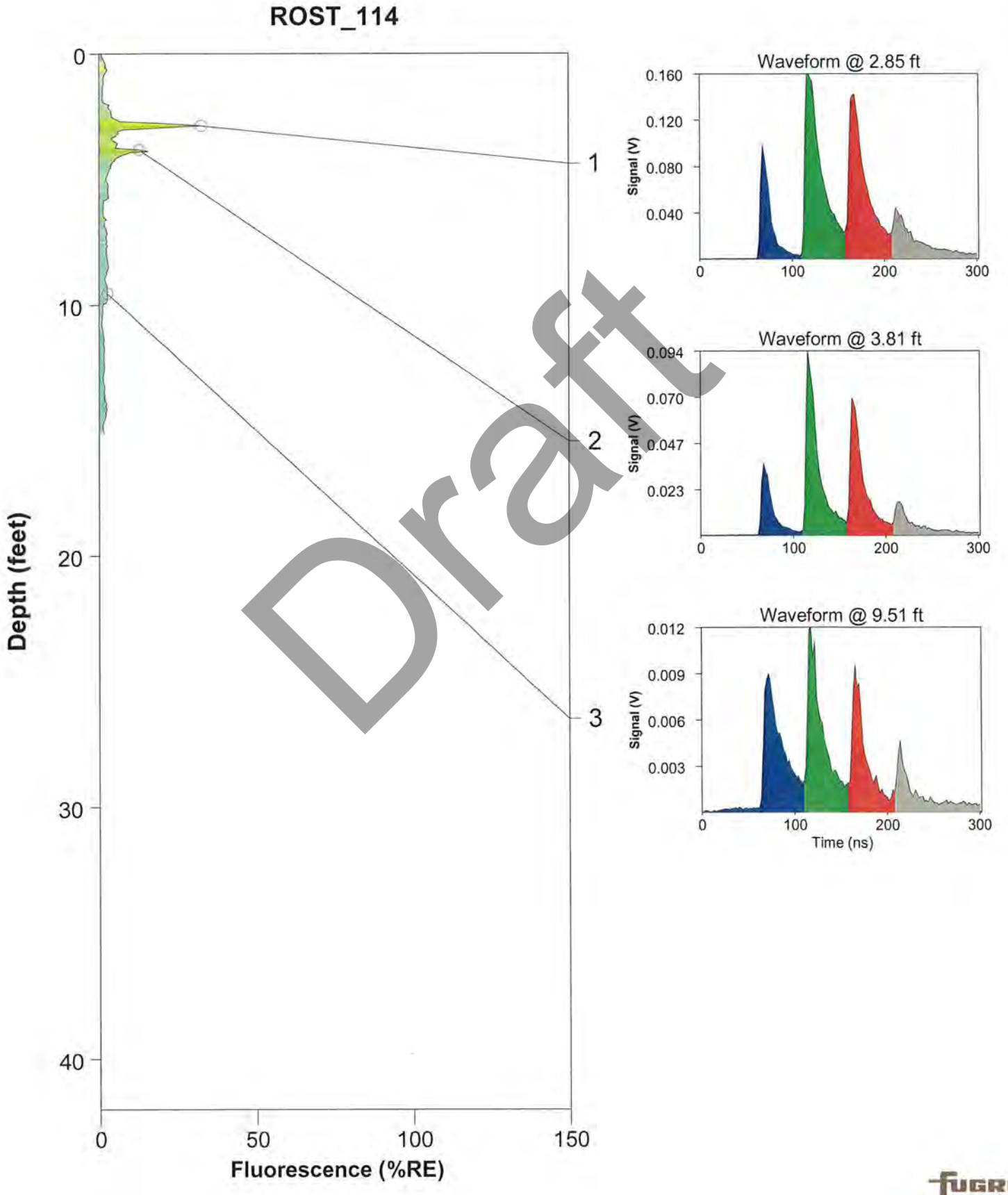
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-31-2002 @ 11:40:14	Max fluorescence: 1.72% @ 4.49 ft
ROST Unit: ?	Final depth BGS: 15.09 ft



Draft

ROST Fluorescence Response Data

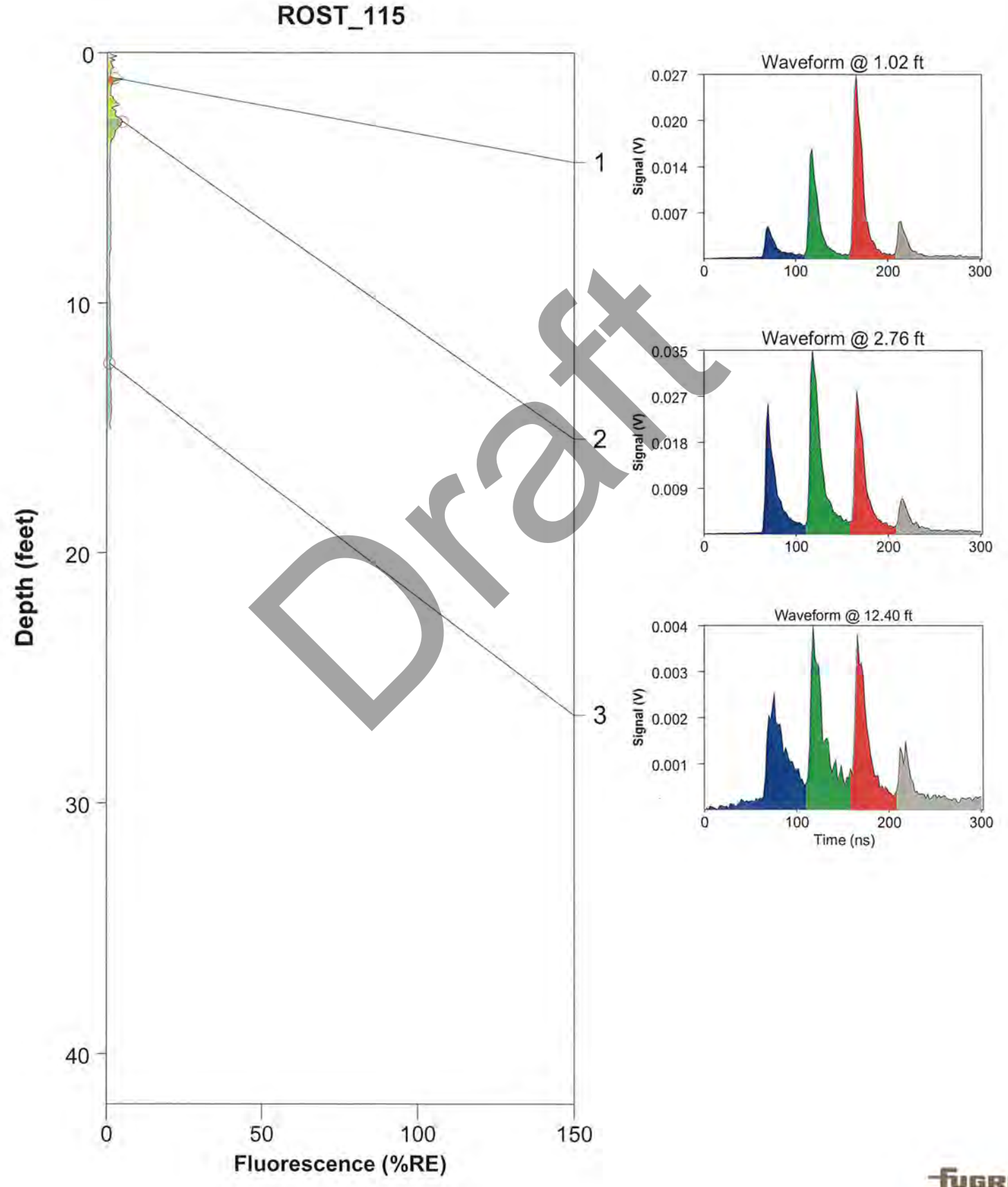
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-31-2002 @ 14:26:25	Max fluorescence: 32.51% @ 2.85 ft
ROST Unit: ?	Final depth BGS: 15.09 ft



Draft

ROST Fluorescence Response Data

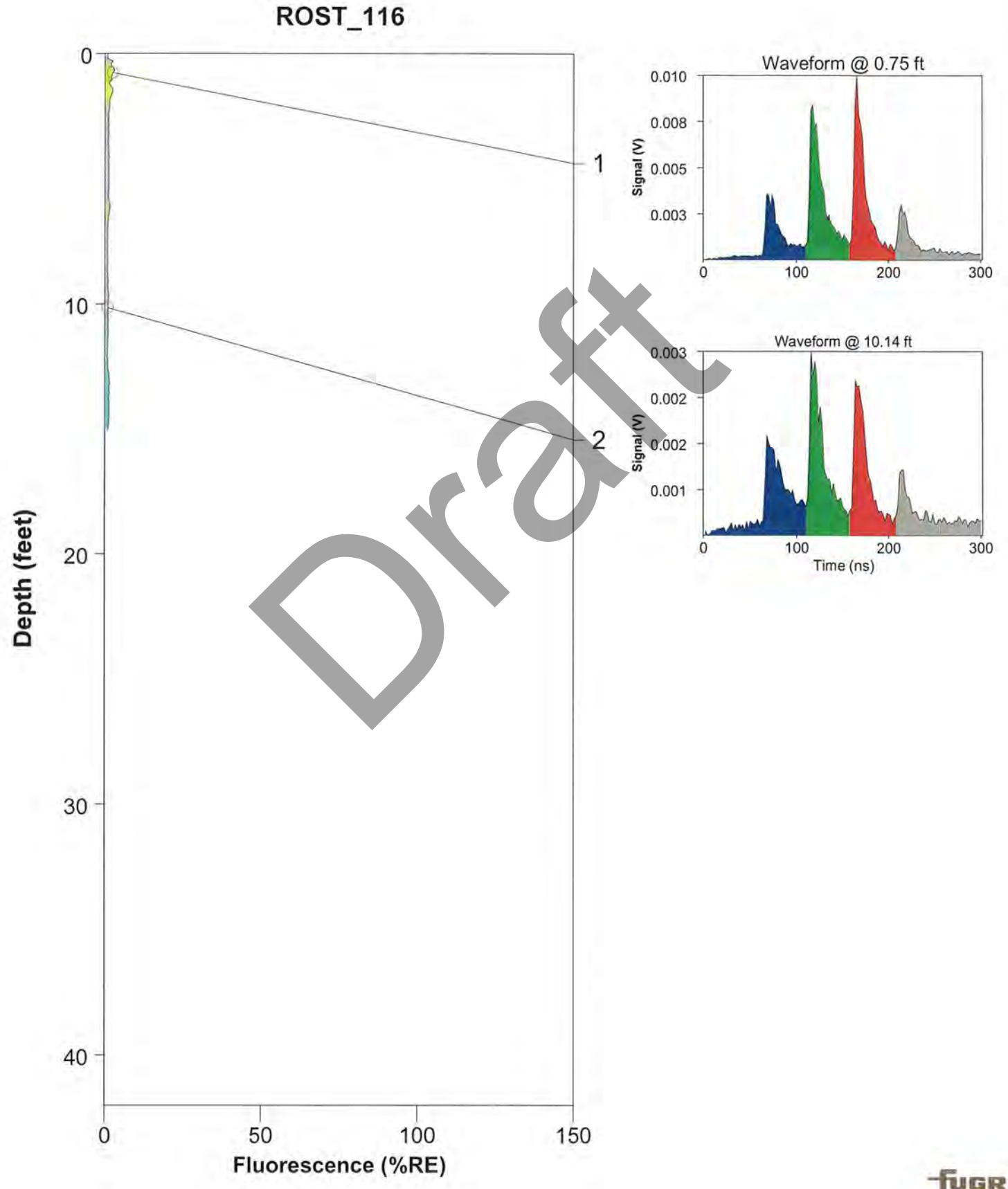
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-31-2002 @ 15:15:41	Max fluorescence: 5.03% @ 2.76 ft
ROST Unit: ?	Final depth BGS: 15.03 ft



Draft

ROST Fluorescence Response Data

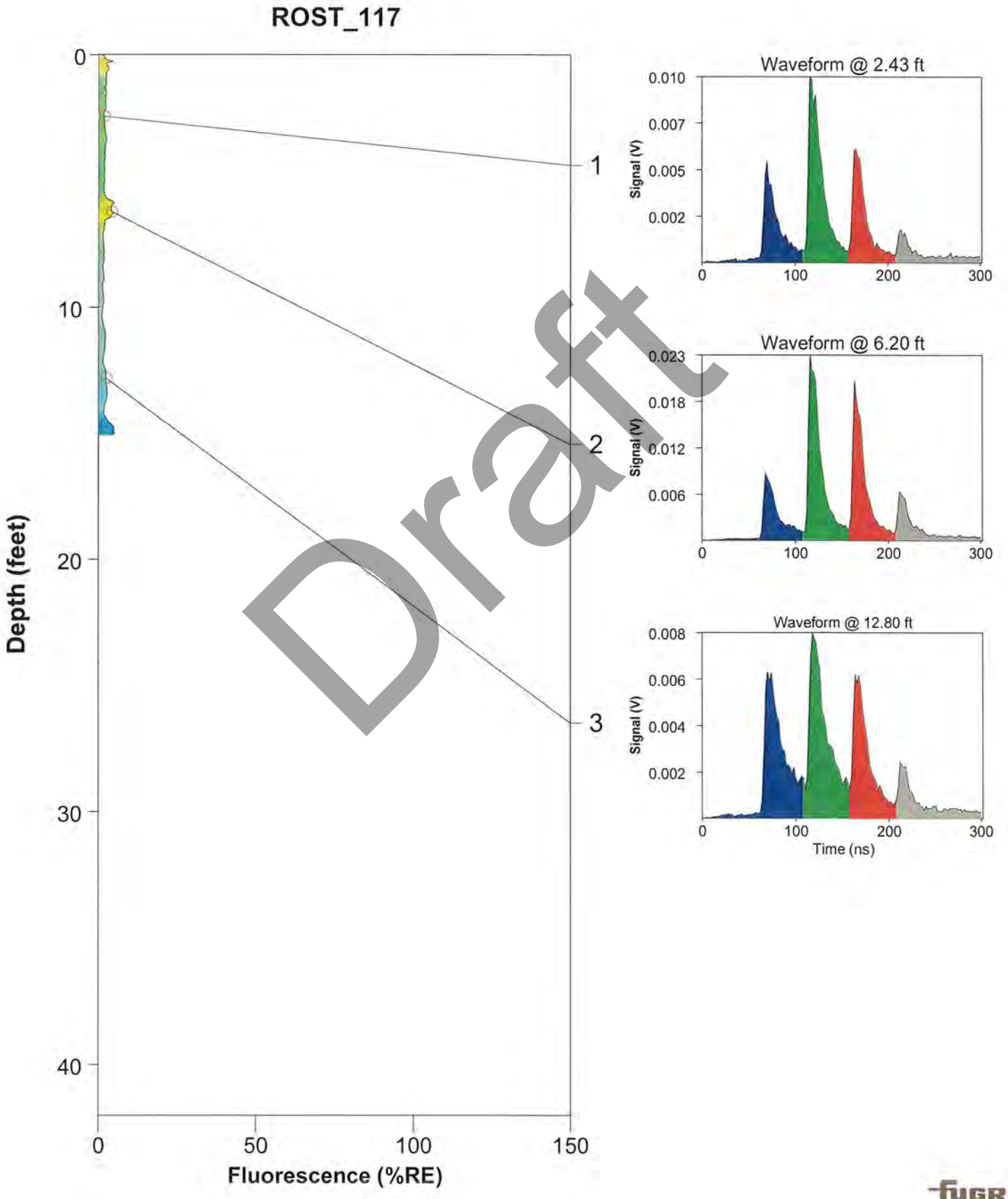
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-31-2002 @ 15:41:44	Max fluorescence: 3.02% @ 0.69 ft
ROST Unit: ?	Final depth BGS: 15.03 ft



Draft

ROST Fluorescence Response Data

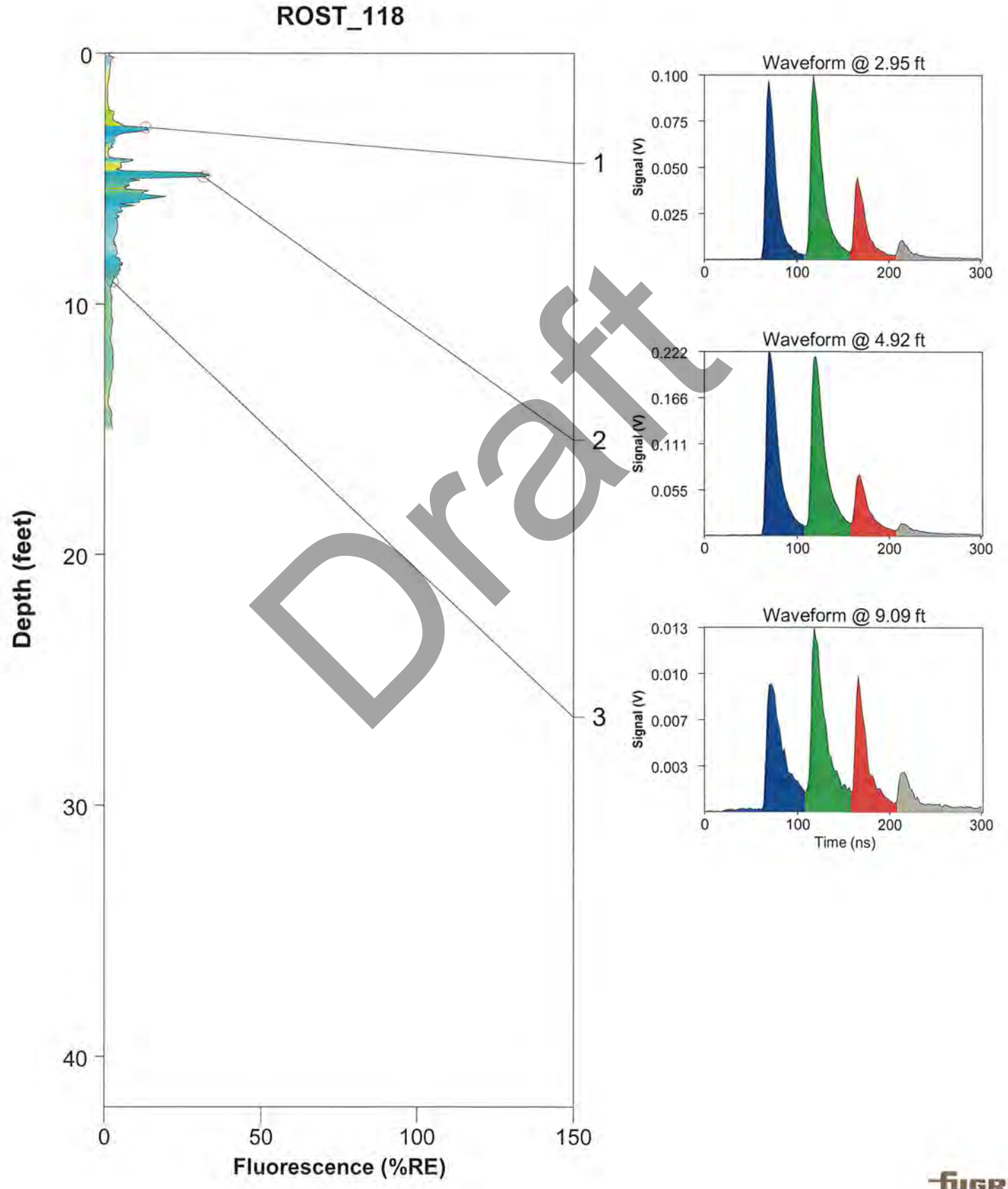
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-31-2002 @ 16:14:54	Max fluorescence: 5.13% @ 14.99 ft
ROST Unit: ?	Final depth BGS: 15.06 ft



Draft

ROST Fluorescence Response Data

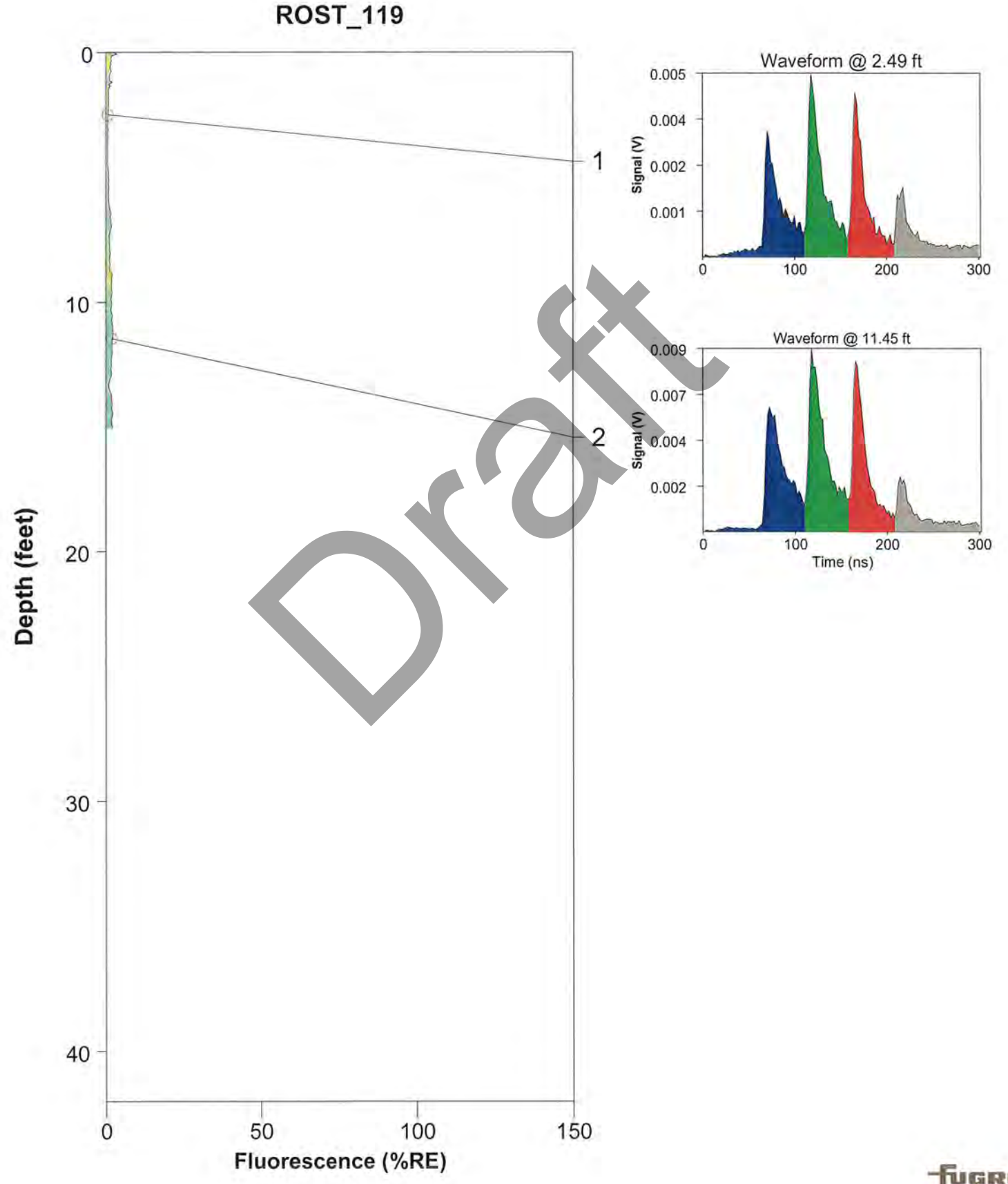
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-31-2002 @ 16:47:12	Max fluorescence: 33.43% @ 4.86 ft
ROST Unit: ?	Final depth BGS: 14.96 ft



Draft

ROST Fluorescence Response Data

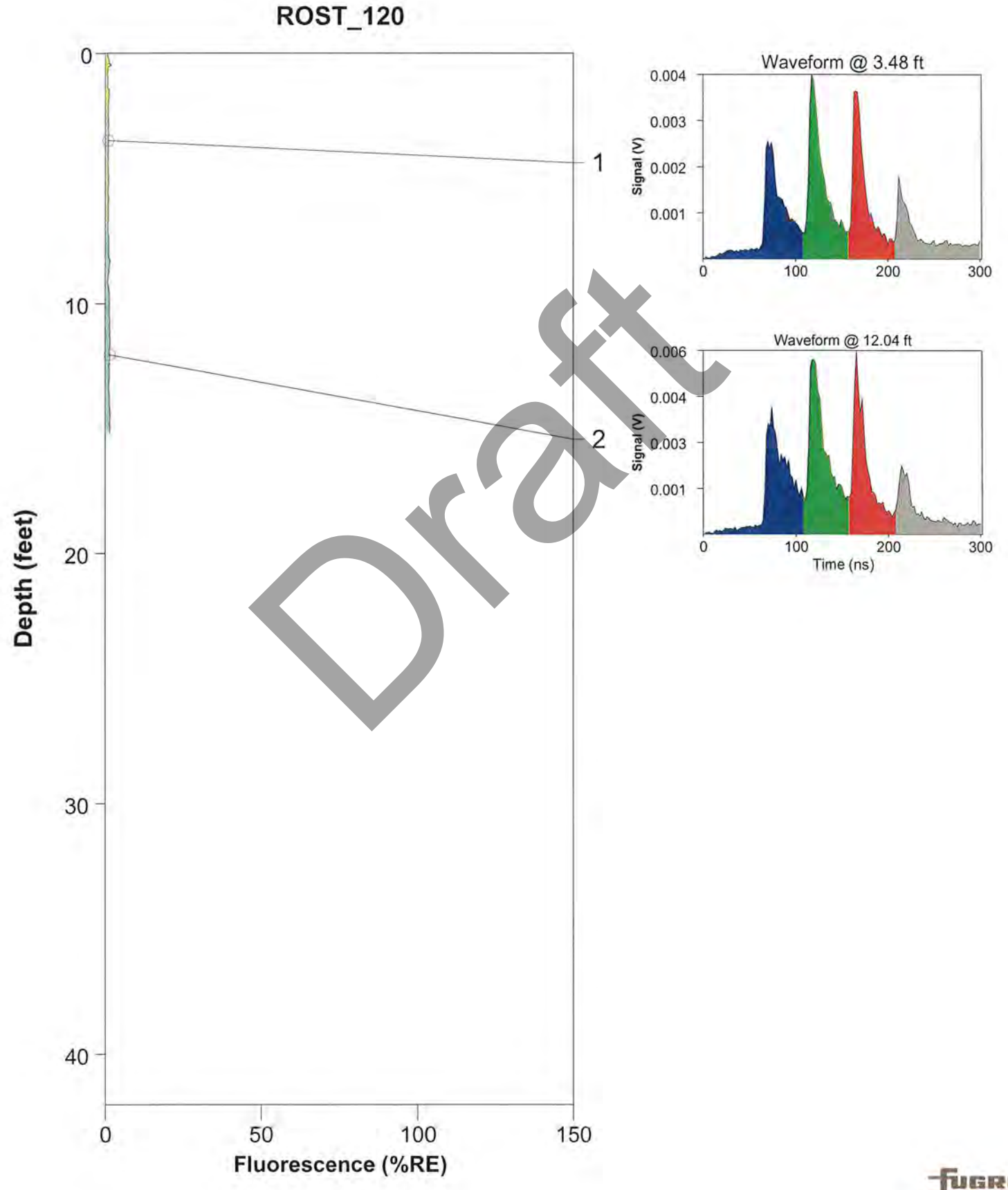
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-31-2002 @ 17:13:26	Max fluorescence: 3.57% @ 0.07 ft
ROST Unit: ?	Final depth BGS: 15.06 ft



Draft

ROST Fluorescence Response Data

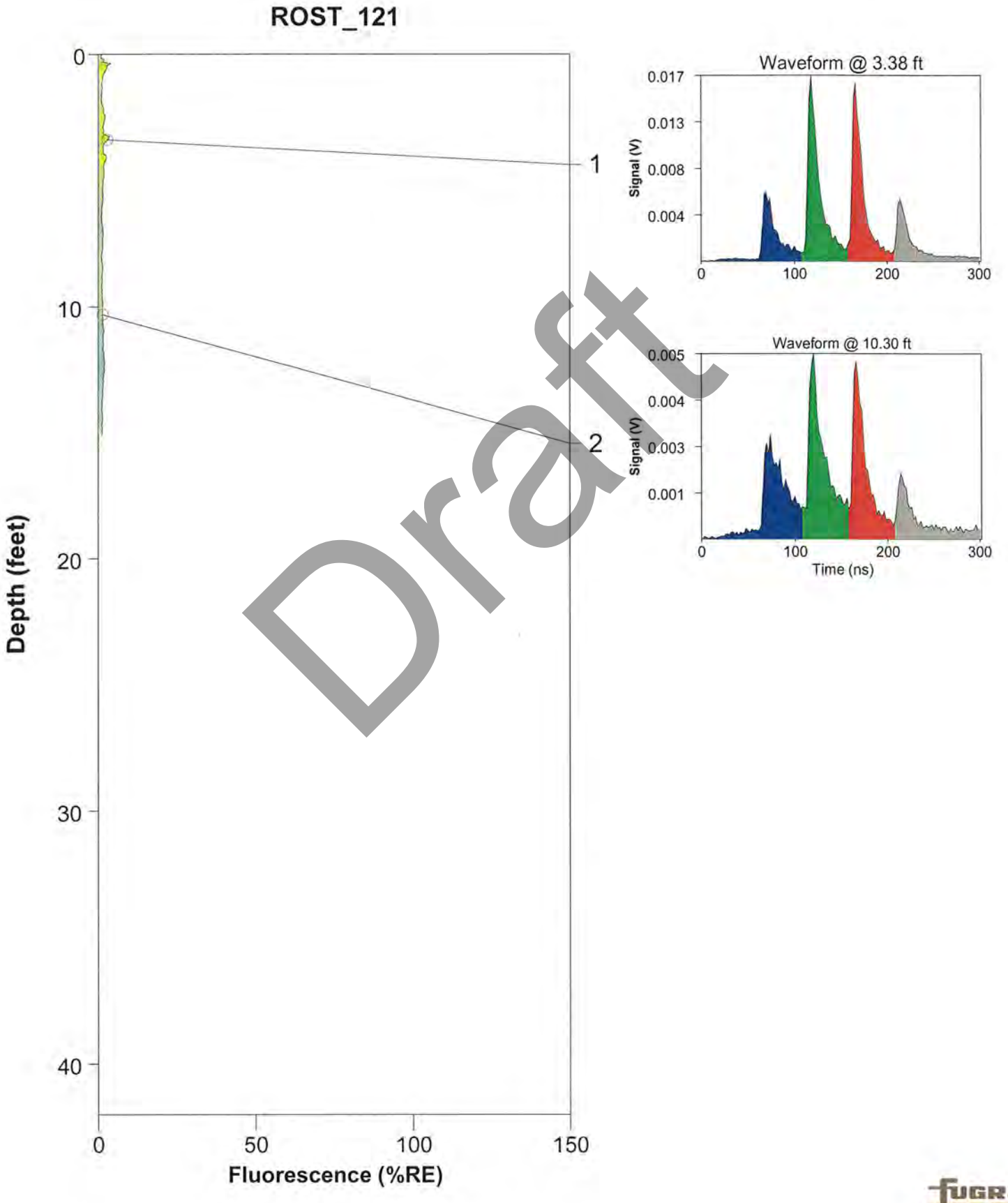
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-31-2002 @ 17:34:43	Max fluorescence: 1.93% @ 0.46 ft
ROST Unit: ?	Final depth BGS: 15.19 ft



Draft

ROST Fluorescence Response Data

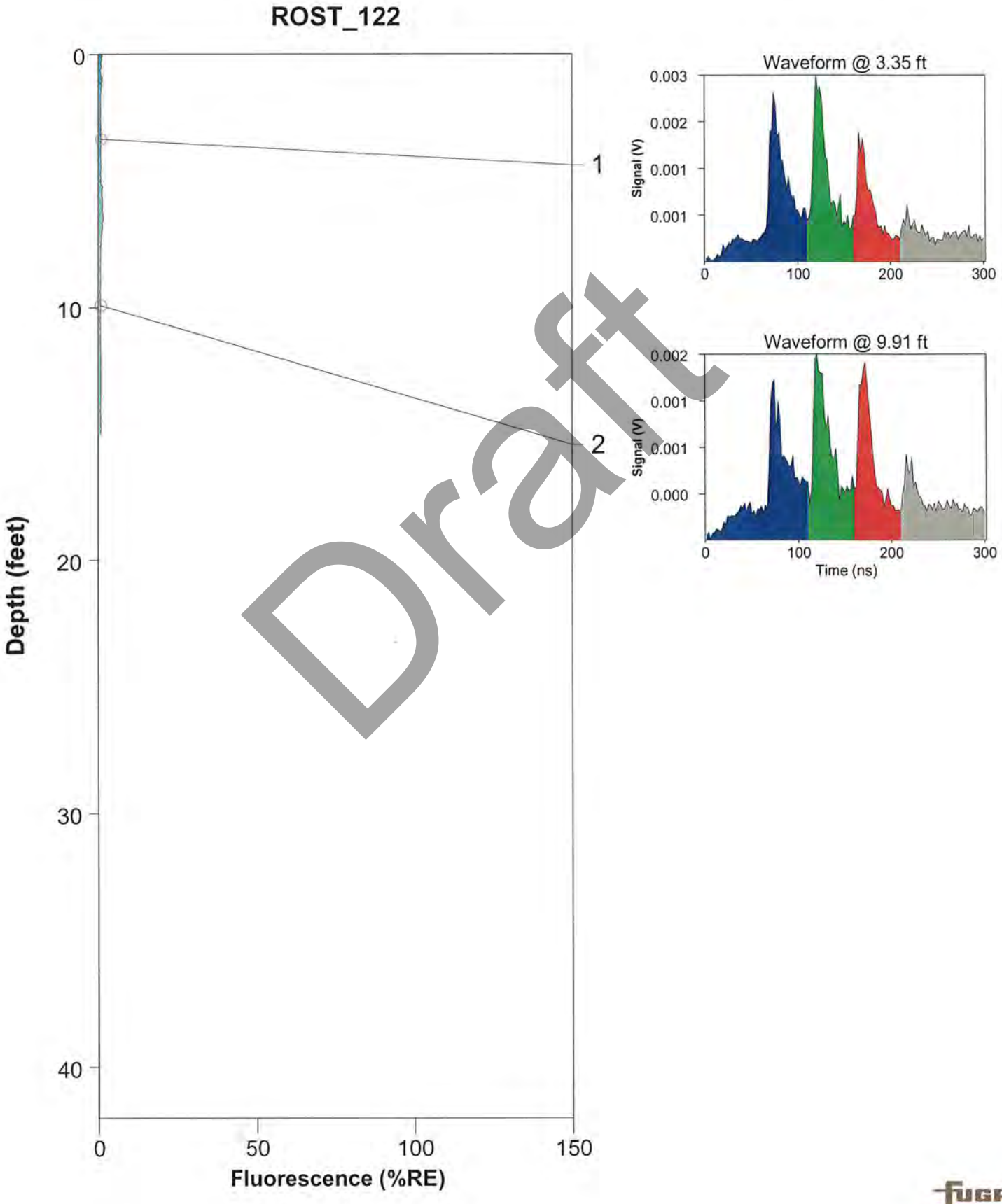
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 01-31-2002 @ 18:04:26	Max fluorescence: 3.94% @ 0.36 ft
ROST Unit: ?	Final depth BGS: 15.06 ft



Draft

ROST Fluorescence Response Data

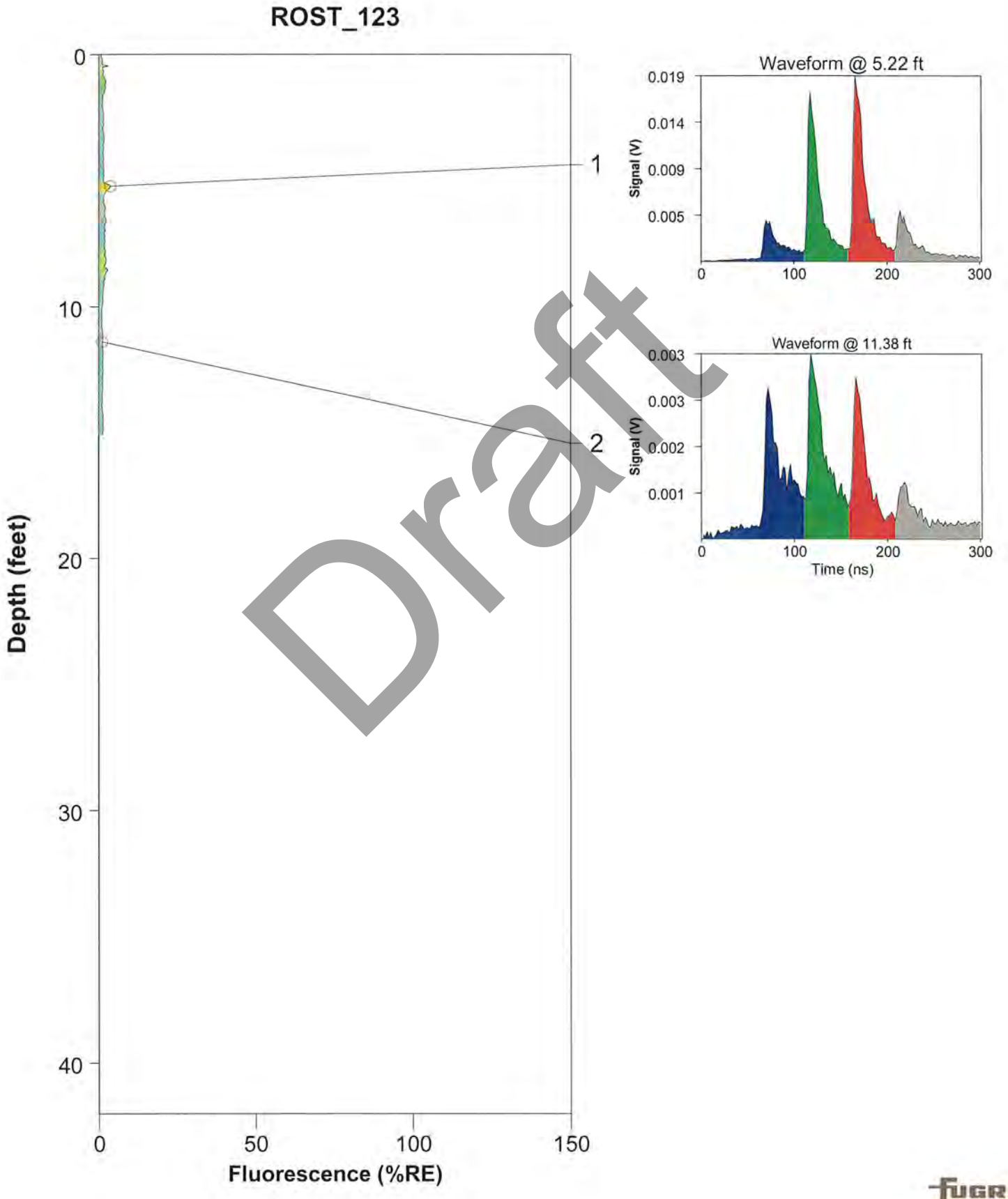
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-01-2002 @ 09:50:35	Max fluorescence: 1.90% @ 0.00 ft
ROST Unit: ?	Final depth BGS: 15.03 ft



Draft

ROST Fluorescence Response Data

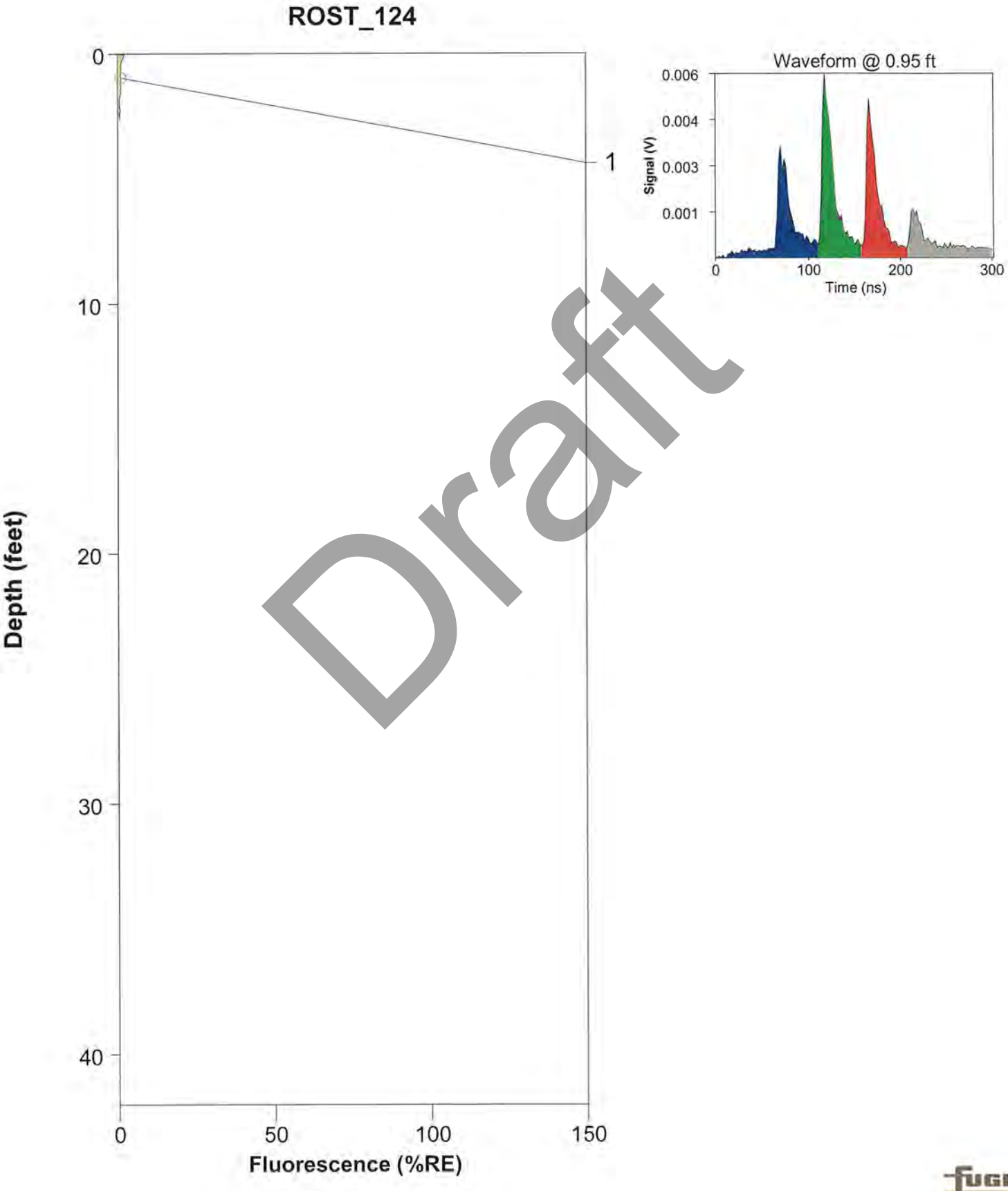
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-01-2002 @ 10:15:49	Max fluorescence: 3.67% @ 5.22 ft
ROST Unit: ?	Final depth BGS: 15.09 ft



Draft

ROST Fluorescence Response Data

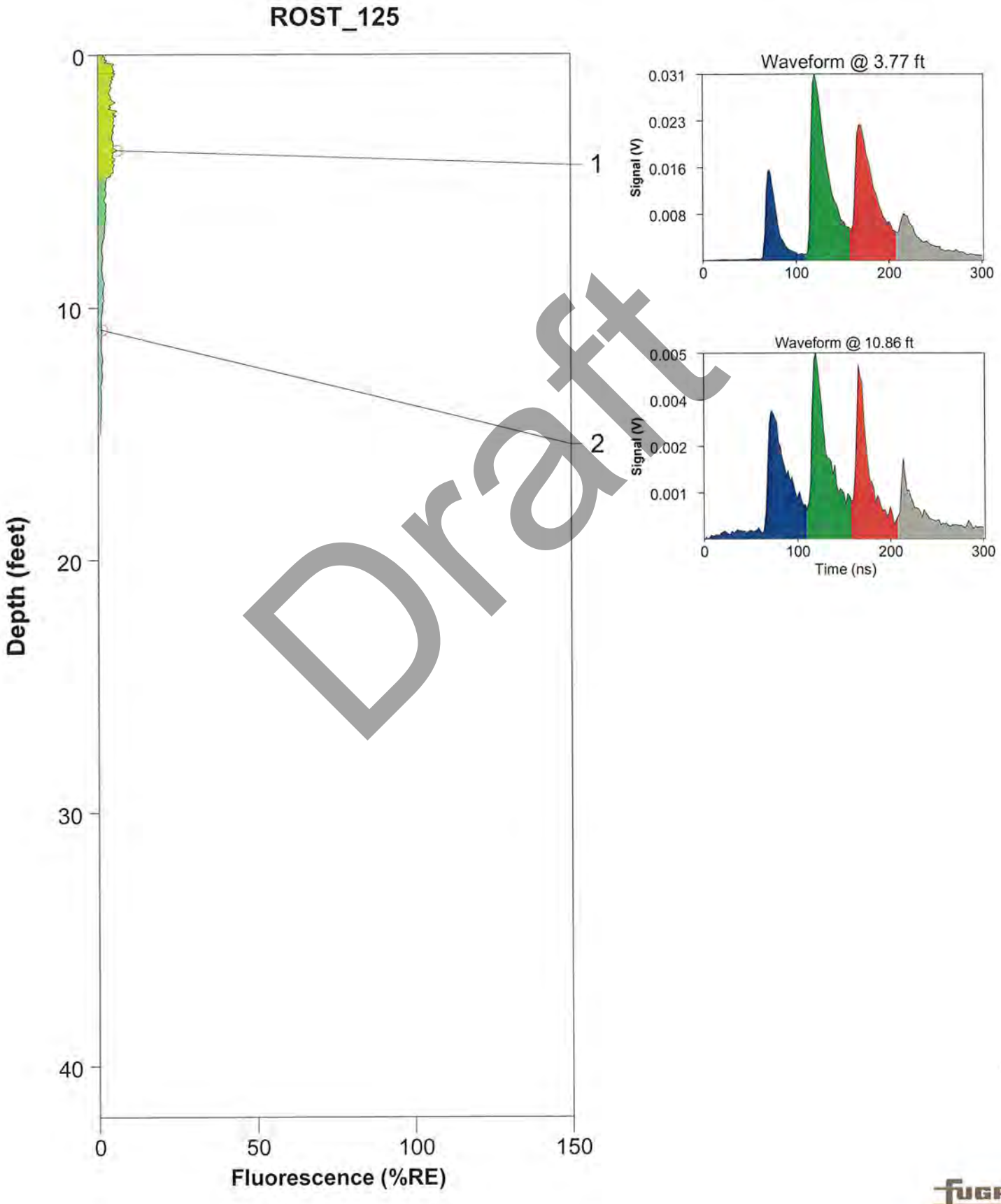
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-01-2002 @ 11:04:40	Max fluorescence: 2.04% @ 0.03 ft
ROST Unit: ?	Final depth BGS: 2.66 ft



Draft

ROST Fluorescence Response Data

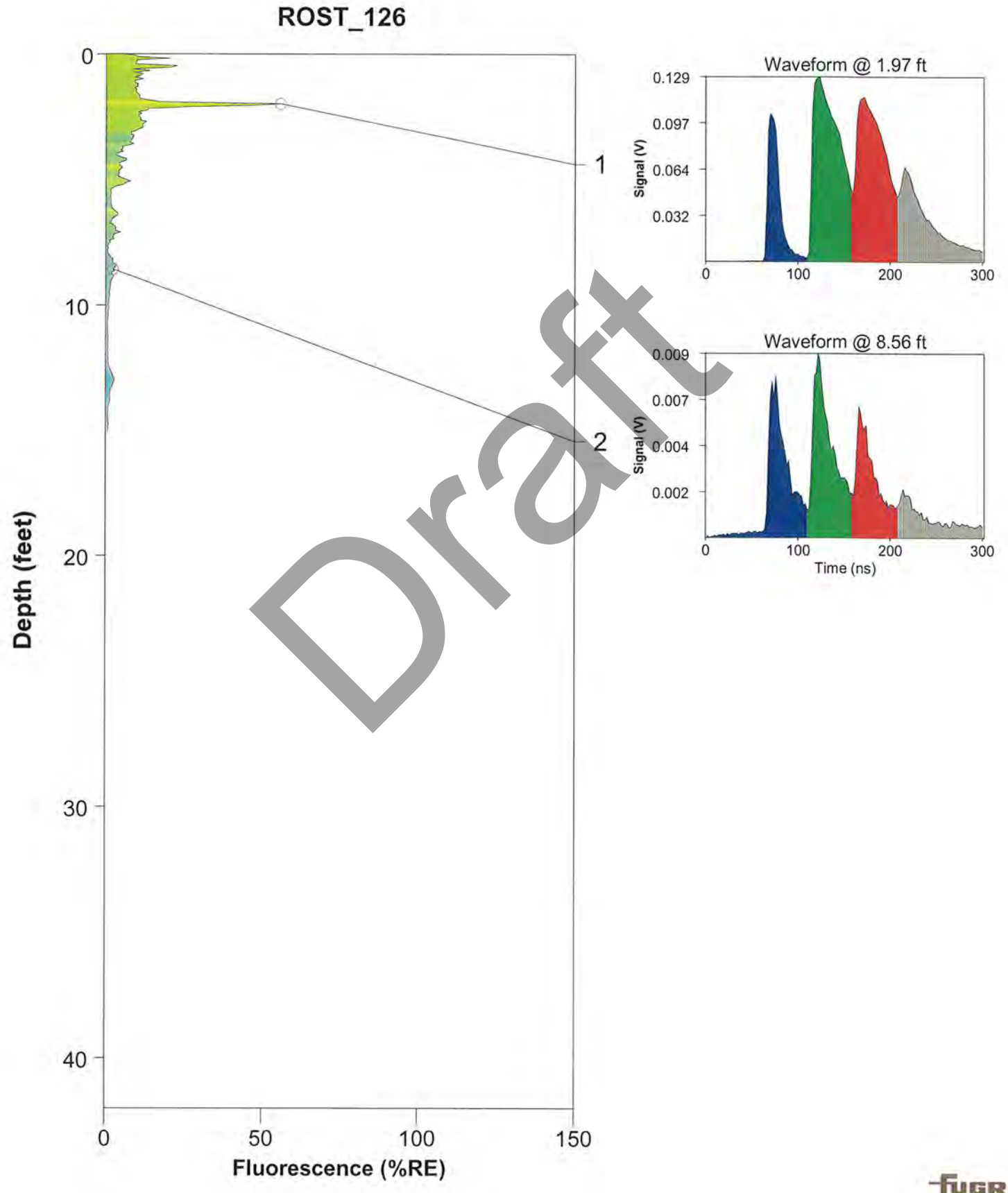
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-01-2002 @ 11:16:04	Max fluorescence: 6.10% @ 3.77 ft
ROST Unit: ?	Final depth BGS: 14.99 ft



Draft

ROST Fluorescence Response Data

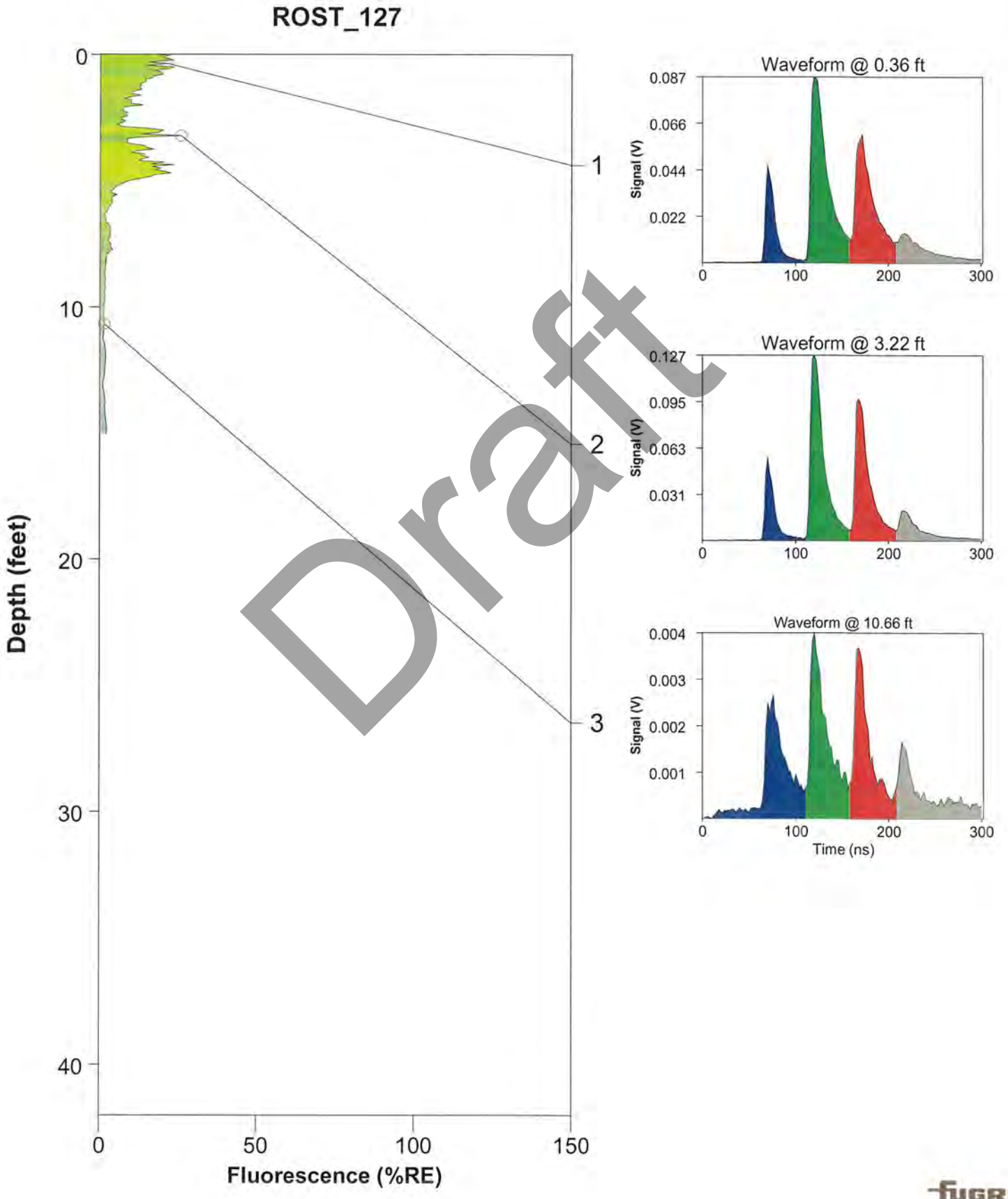
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-01-2002 @ 11:47:29	Max fluorescence: 55.85% @ 1.97 ft
ROST Unit: ?	Final depth BGS: 15.03 ft



Draft

ROST Fluorescence Response Data

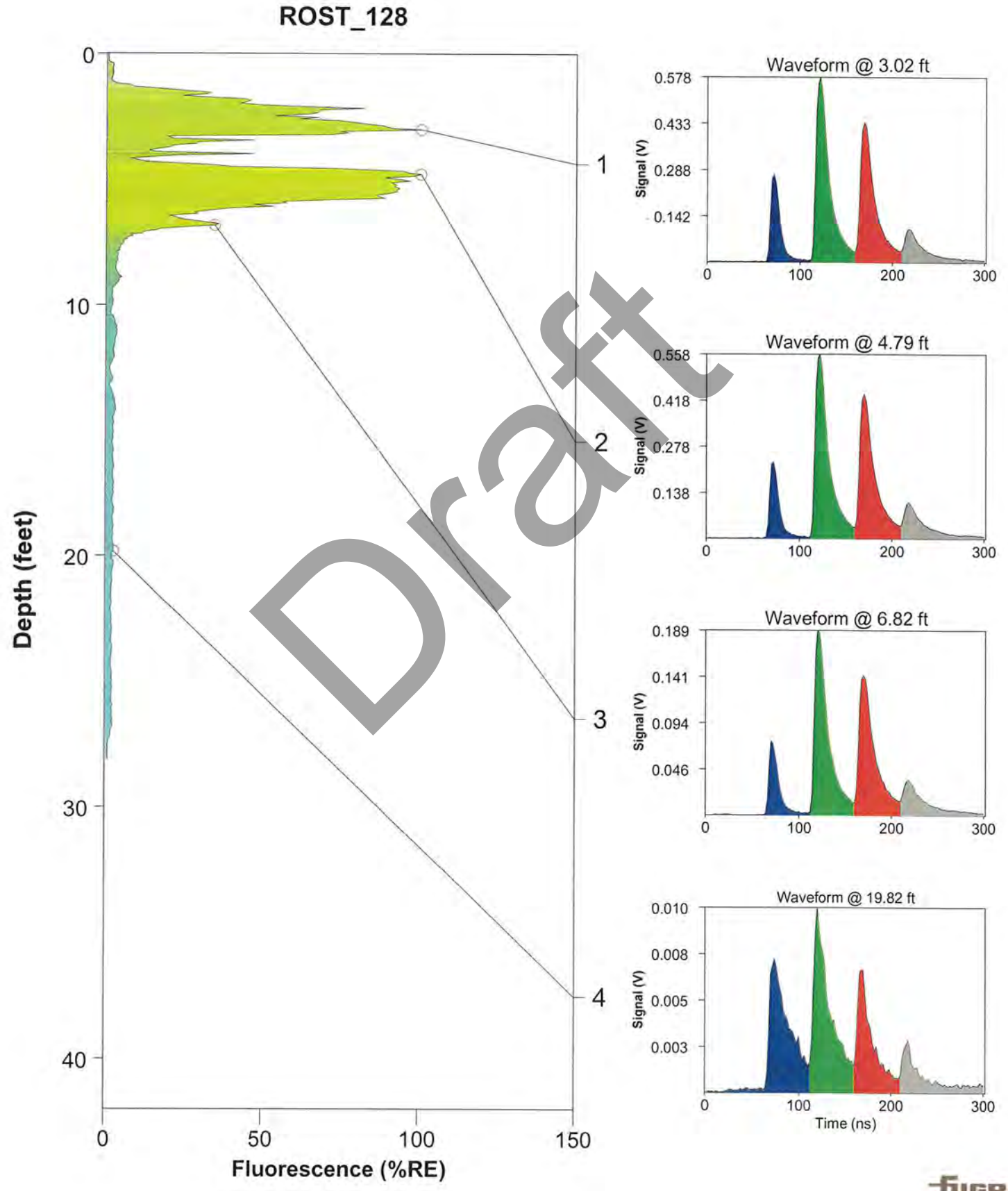
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-01-2002 @ 12:09:16	Max fluorescence: 25.87% @ 3.22 ft
ROST Unit: ?	Final depth BGS: 15.03 ft



Draft

ROST Fluorescence Response Data

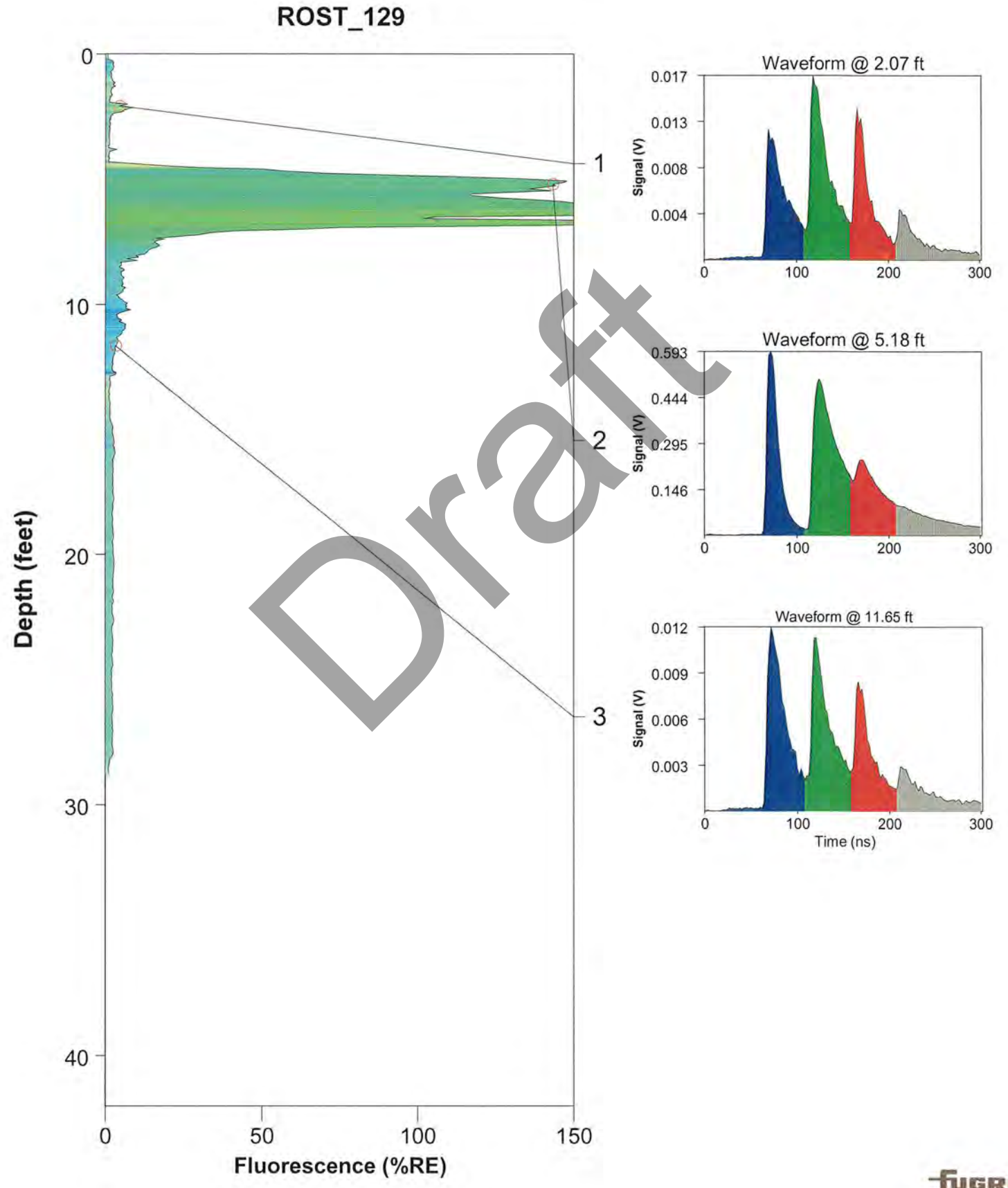
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-01-2002 @ 14:52:51	Max fluorescence: 100.36% @ 3.02 ft
ROST Unit: ?	Final depth BGS: 28.12 ft



Draft

ROST Fluorescence Response Data

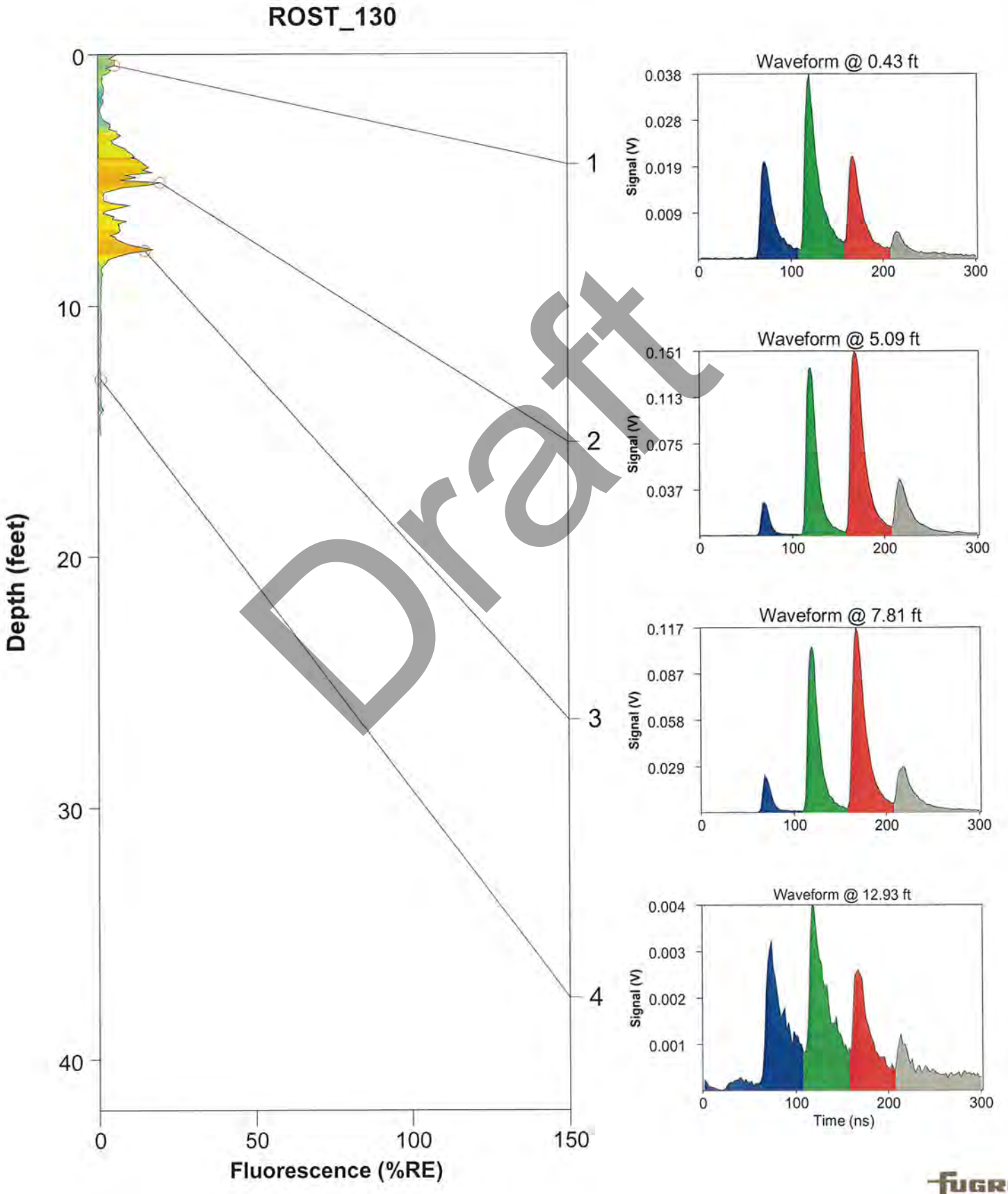
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-01-2002 @ 16:00:39	Max fluorescence: 288.14% @ 6.69 ft
ROST Unit: ?	Final depth BGS: 28.81 ft



Draft

ROST Fluorescence Response Data

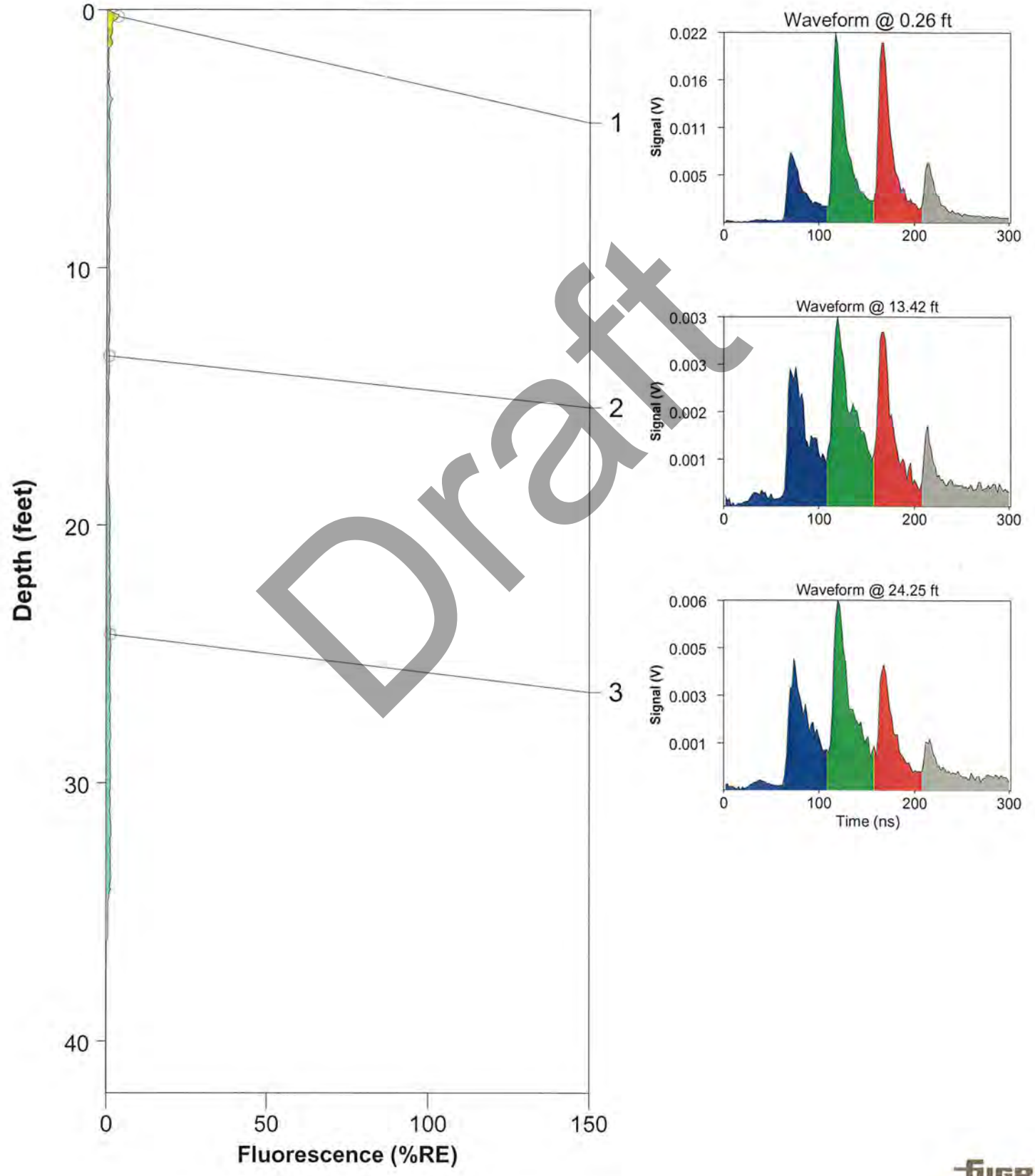
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 12:42:08	Max fluorescence: 19.93% @ 5.09 ft
ROST Unit: ?	Final depth BGS: 15.16 ft



Draft

ROST Fluorescence Response Data

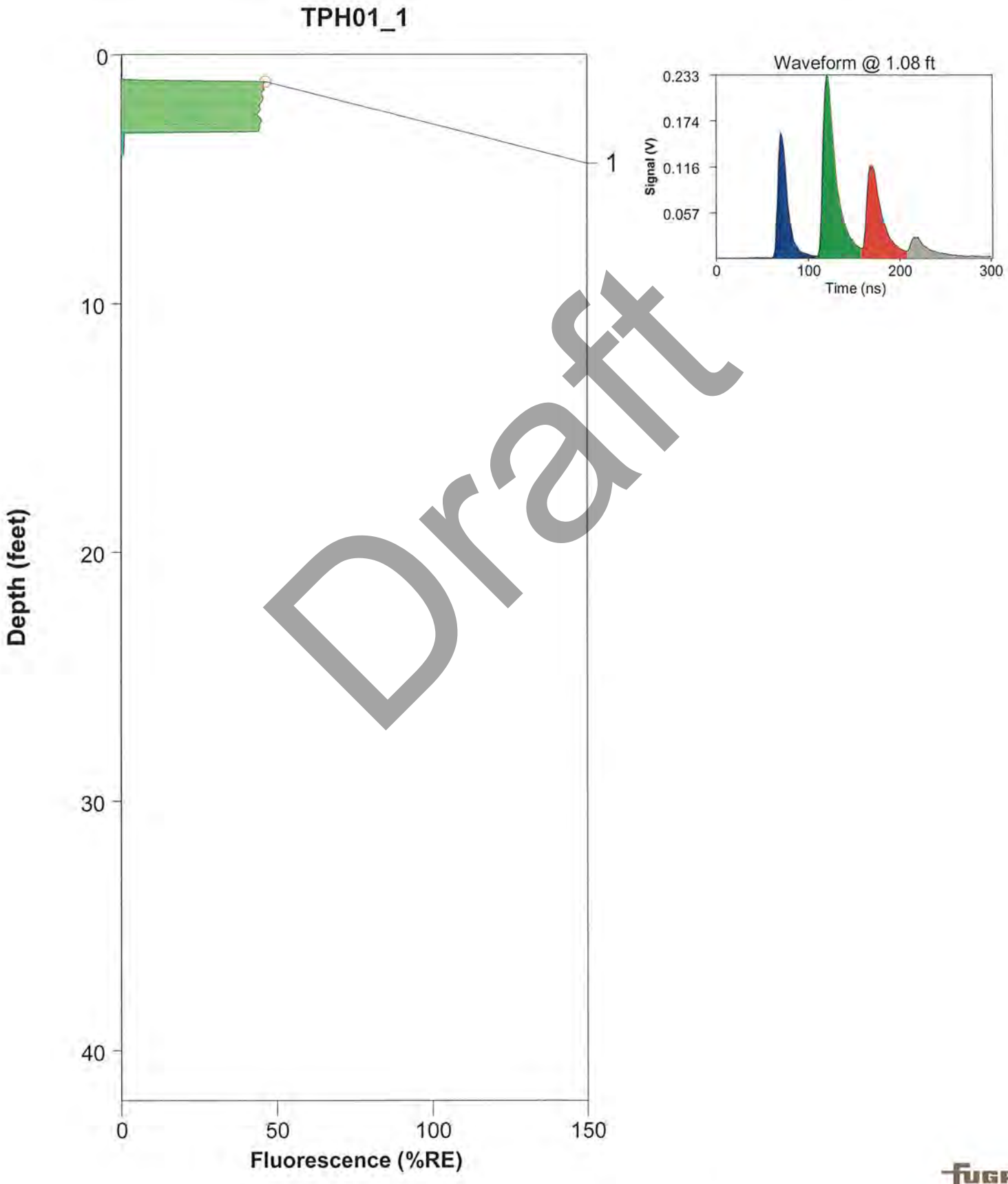
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 13:10:36	Max fluorescence: 3.54% @ 0.20 ft
ROST Unit: ?	Final depth BGS: 36.09 ft



Draft

ROST Fluorescence Response Data

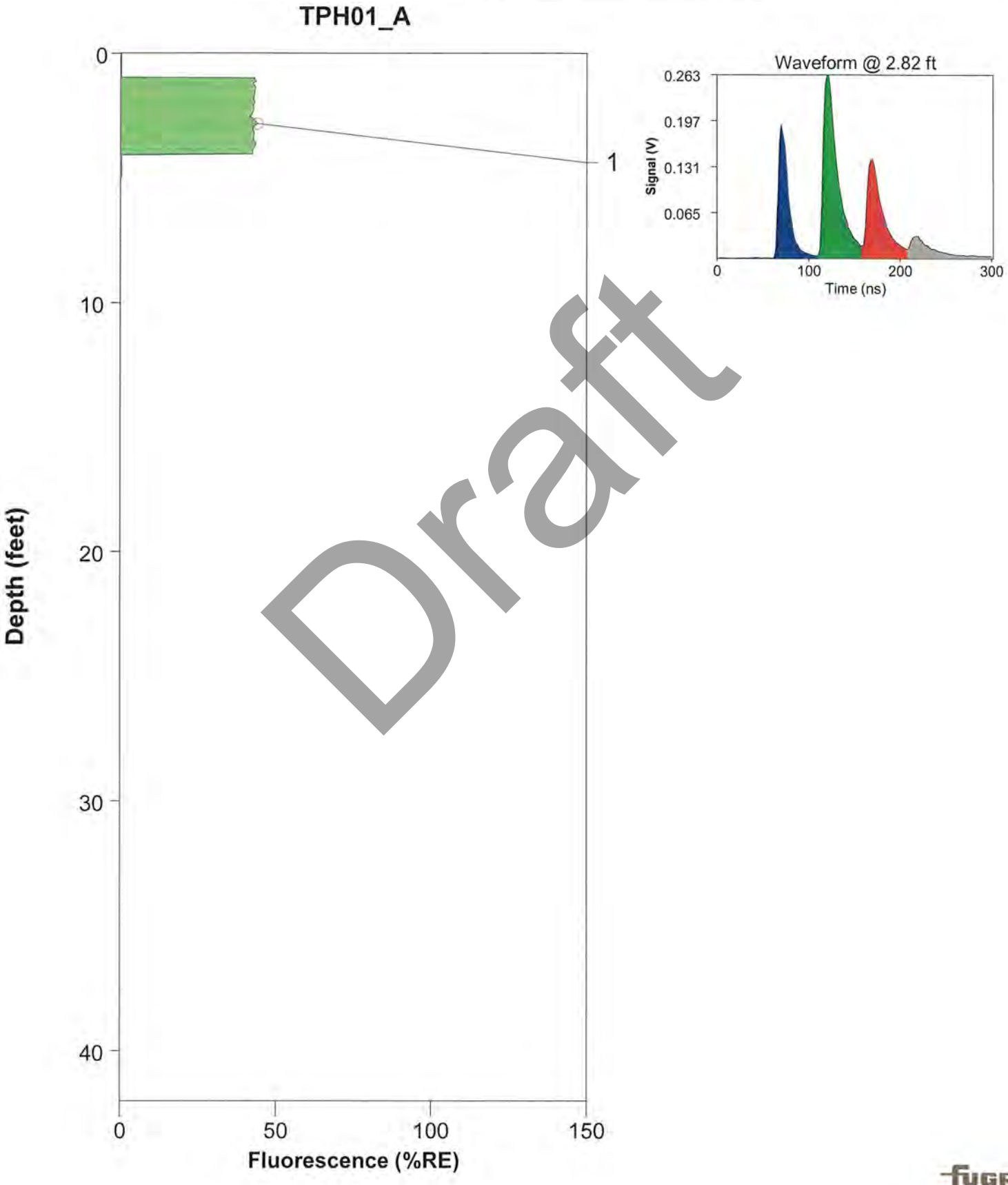
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 14:59:14	Max fluorescence: 46.26% @ 1.08 ft
ROST Unit: ?	Final depth BGS: 4.04 ft



Draft

ROST Fluorescence Response Data

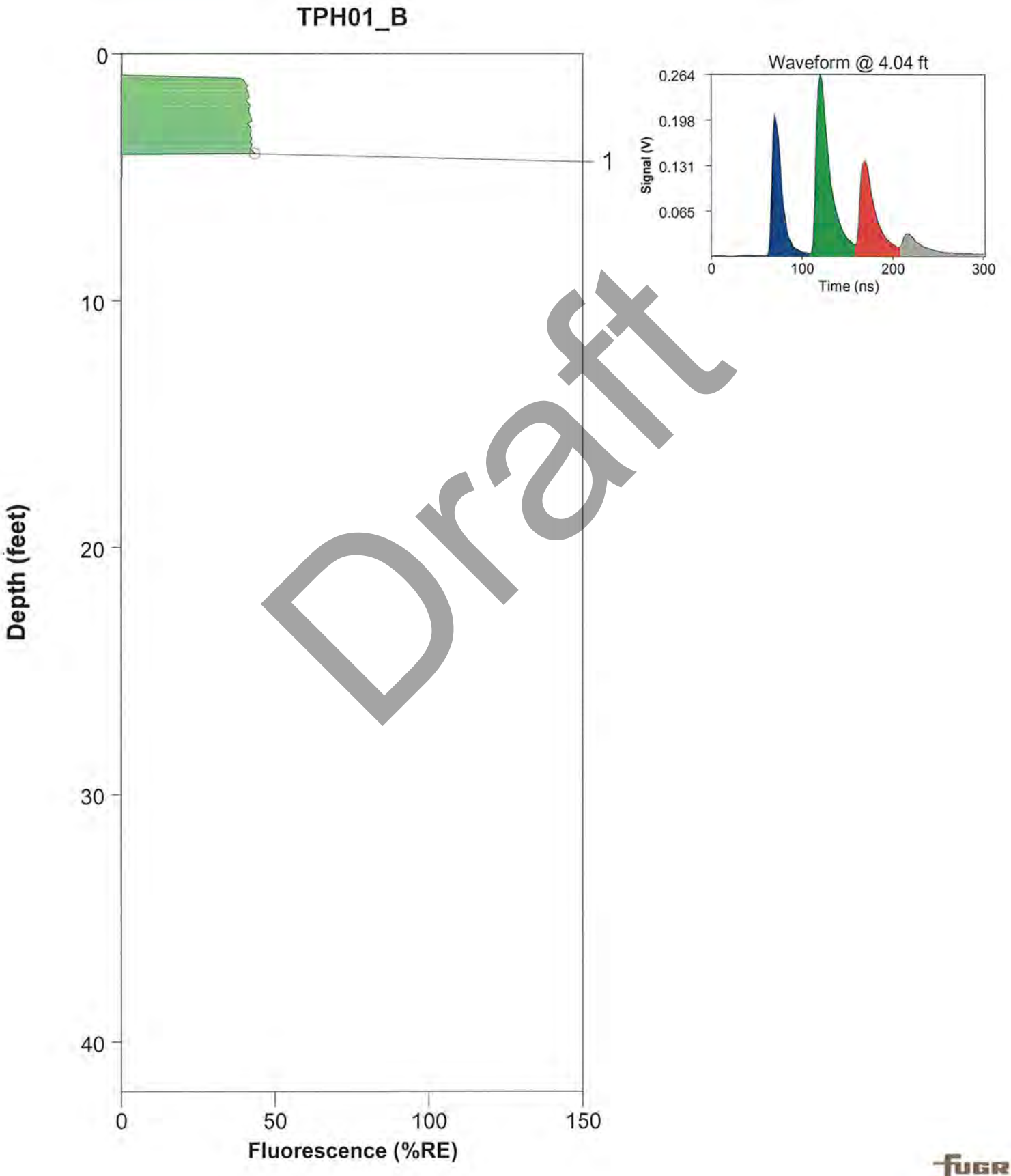
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 15:53:09	Max fluorescence: 43.85% @ 2.82 ft
ROST Unit: ?	Final depth BGS: 4.99 ft



Draft

ROST Fluorescence Response Data

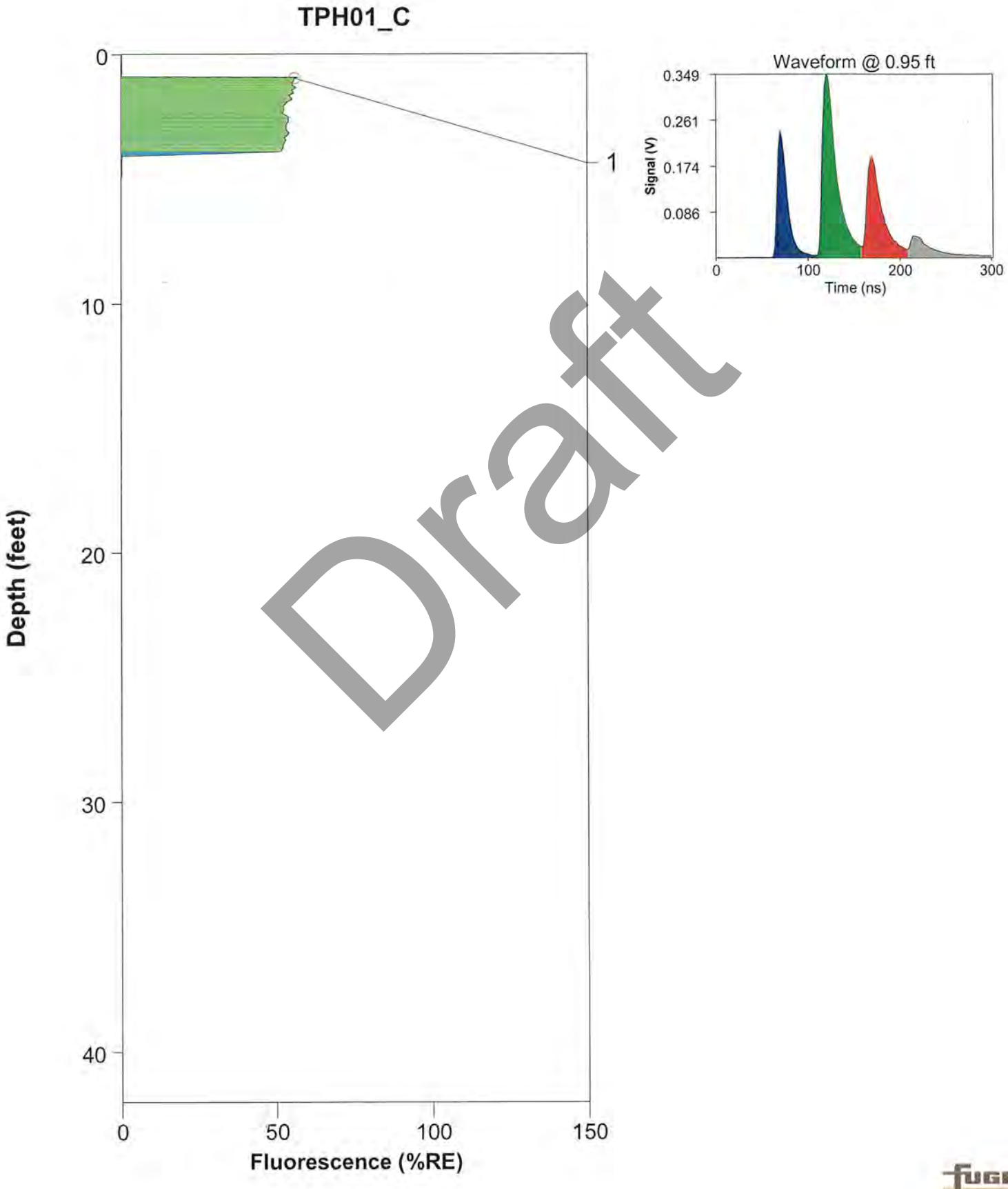
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 15:56:15	Max fluorescence: 43.47% @ 4.04 ft
ROST Unit: ?	Final depth BGS: 4.99 ft



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 15:58:59	Max fluorescence: 57.00% @ 0.92 ft
ROST Unit: ?	Final depth BGS: 4.92 ft

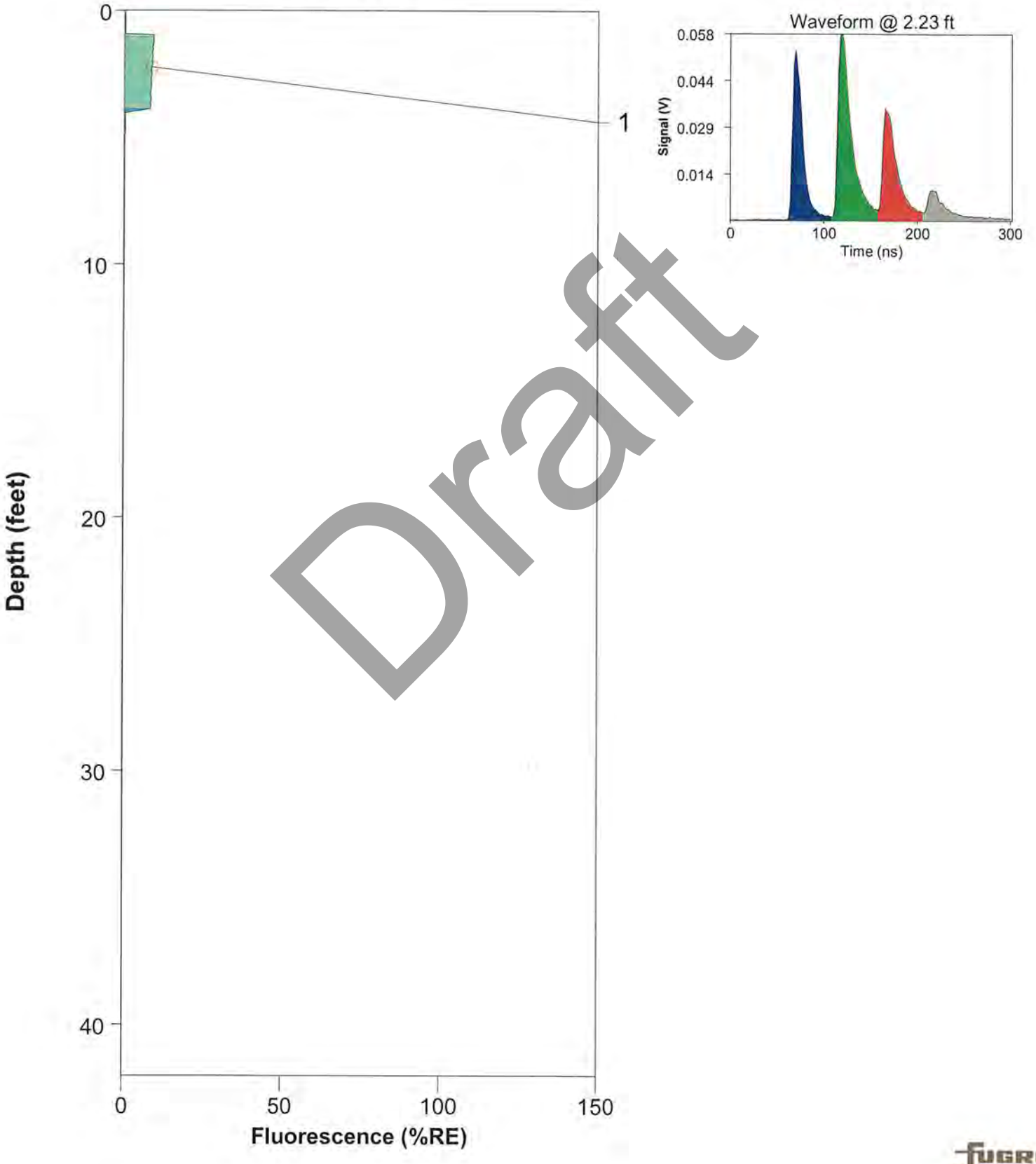


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:04:09	Max fluorescence: 9.22% @ 0.95 ft
ROST Unit: ?	Final depth BGS: 4.89 ft

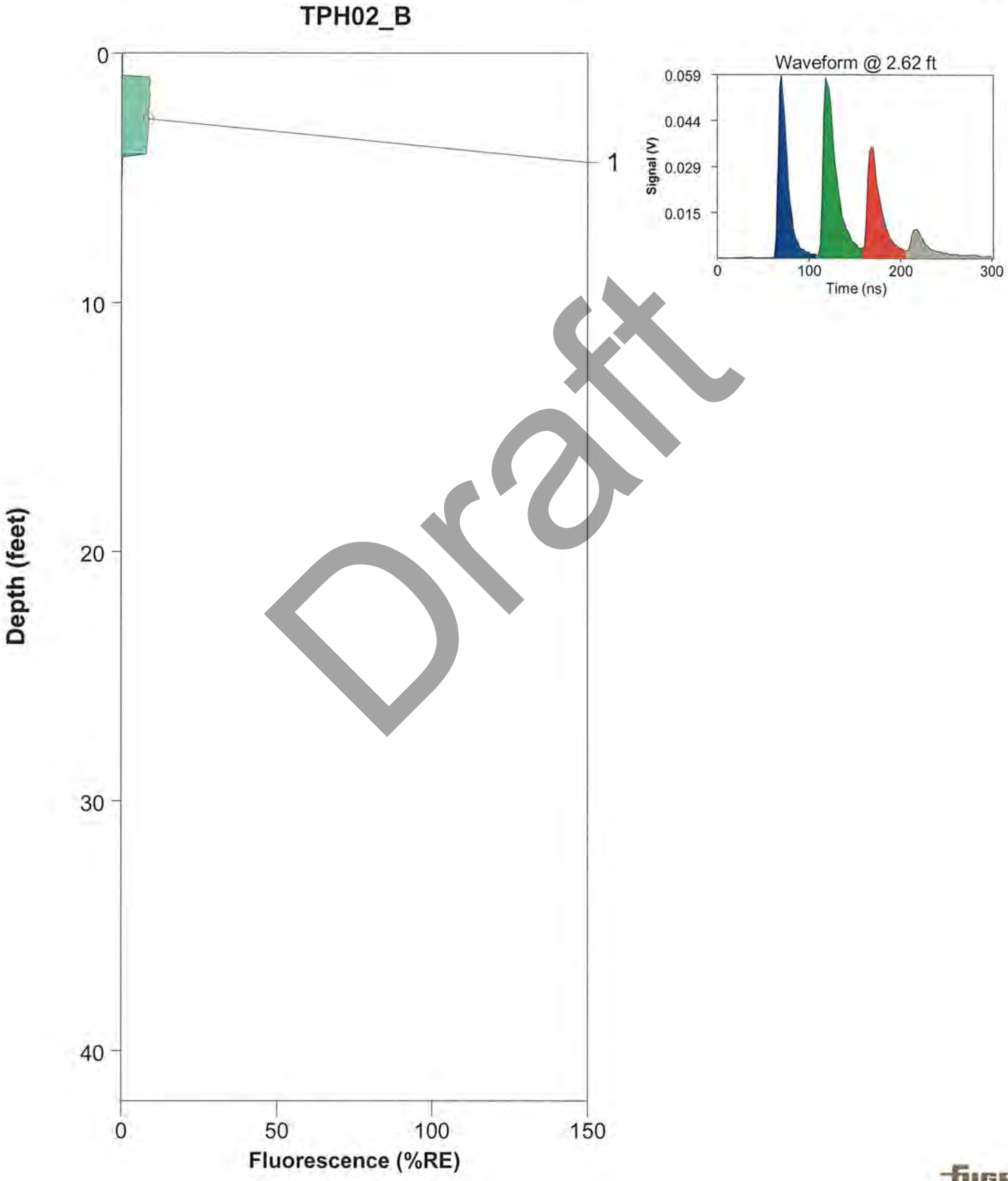
TPH02_A



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:07:04	Max fluorescence: 9.13% @ 1.67 ft
ROST Unit: ?	Final depth BGS: 4.92 ft

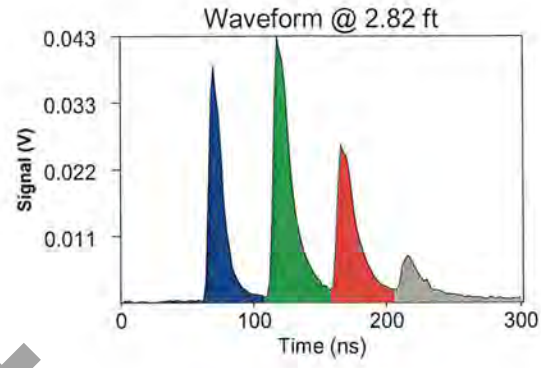


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:09:24	Max fluorescence: 6.47% @ 1.48 ft
ROST Unit: ?	Final depth BGS: 4.89 ft

TPH02_C

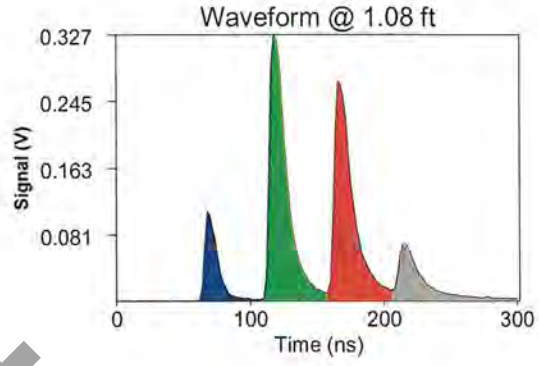


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:13:32	Max fluorescence: 42.83% @ 0.95 ft
ROST Unit: ?	Final depth BGS: 4.95 ft

TPH03_A

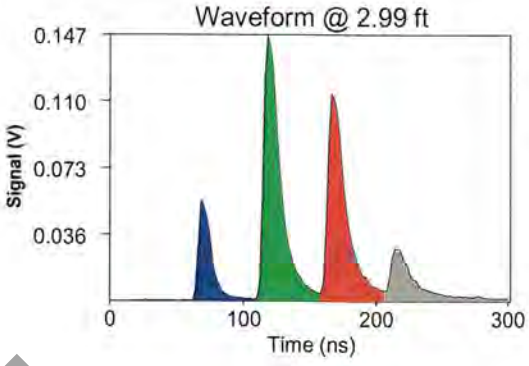


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:15:51	Max fluorescence: 18.78% @ 1.18 ft
ROST Unit: ?	Final depth BGS: 4.89 ft

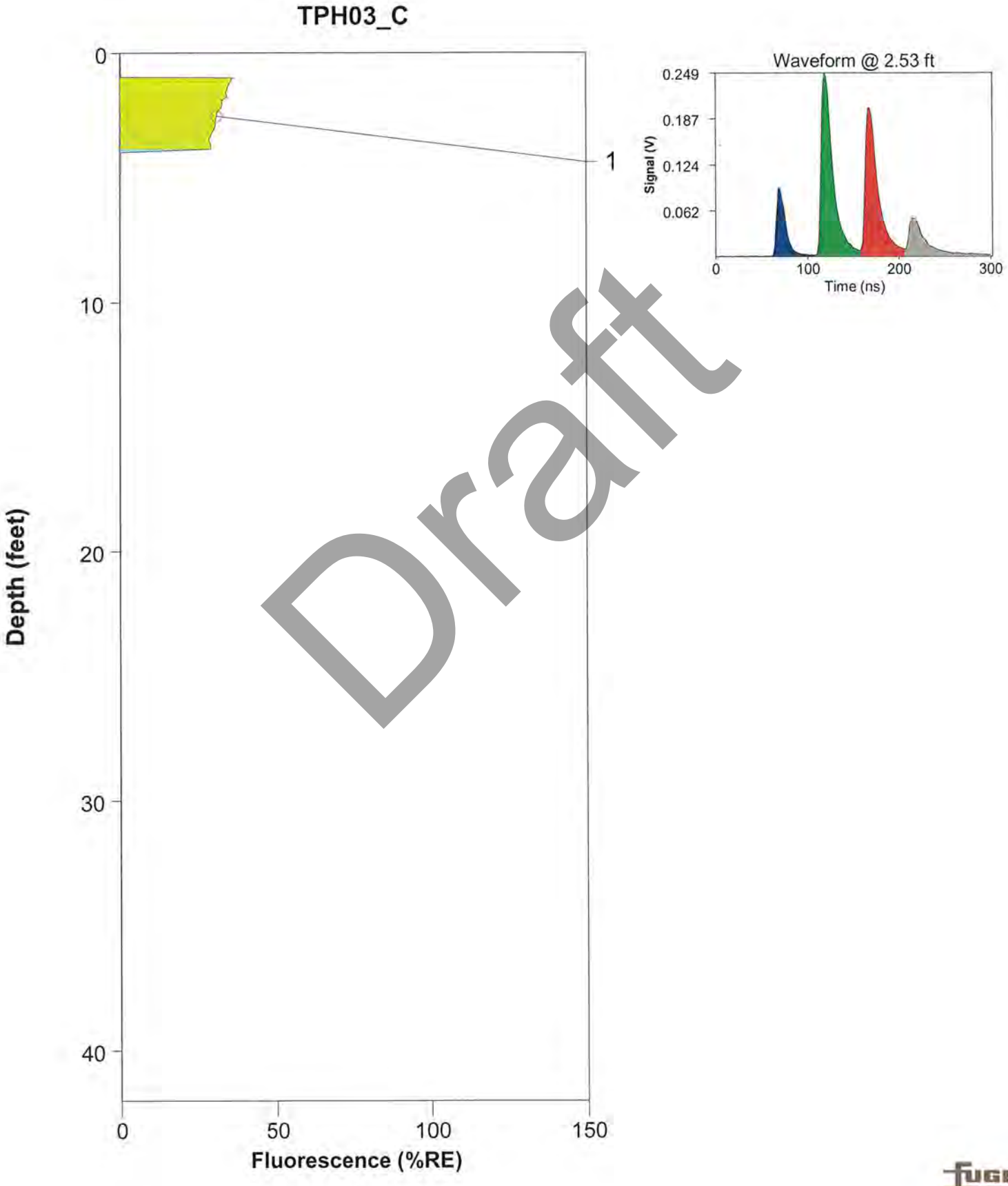
TPH03_B



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:18:00	Max fluorescence: 36.50% @ 0.98 ft
ROST Unit: ?	Final depth BGS: 4.86 ft

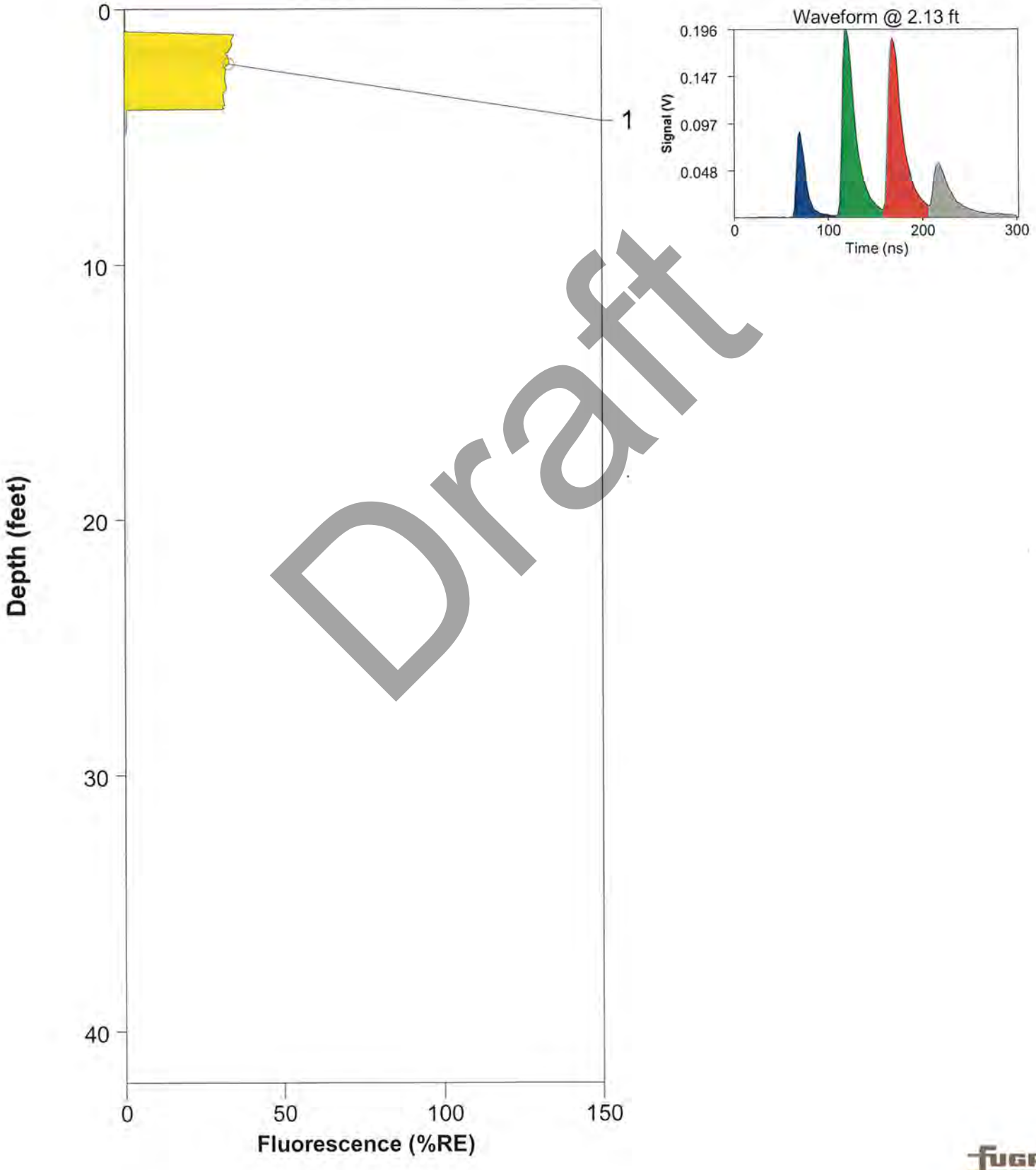


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:21:20	Max fluorescence: 34.67% @ 0.98 ft
ROST Unit: ?	Final depth BGS: 4.89 ft

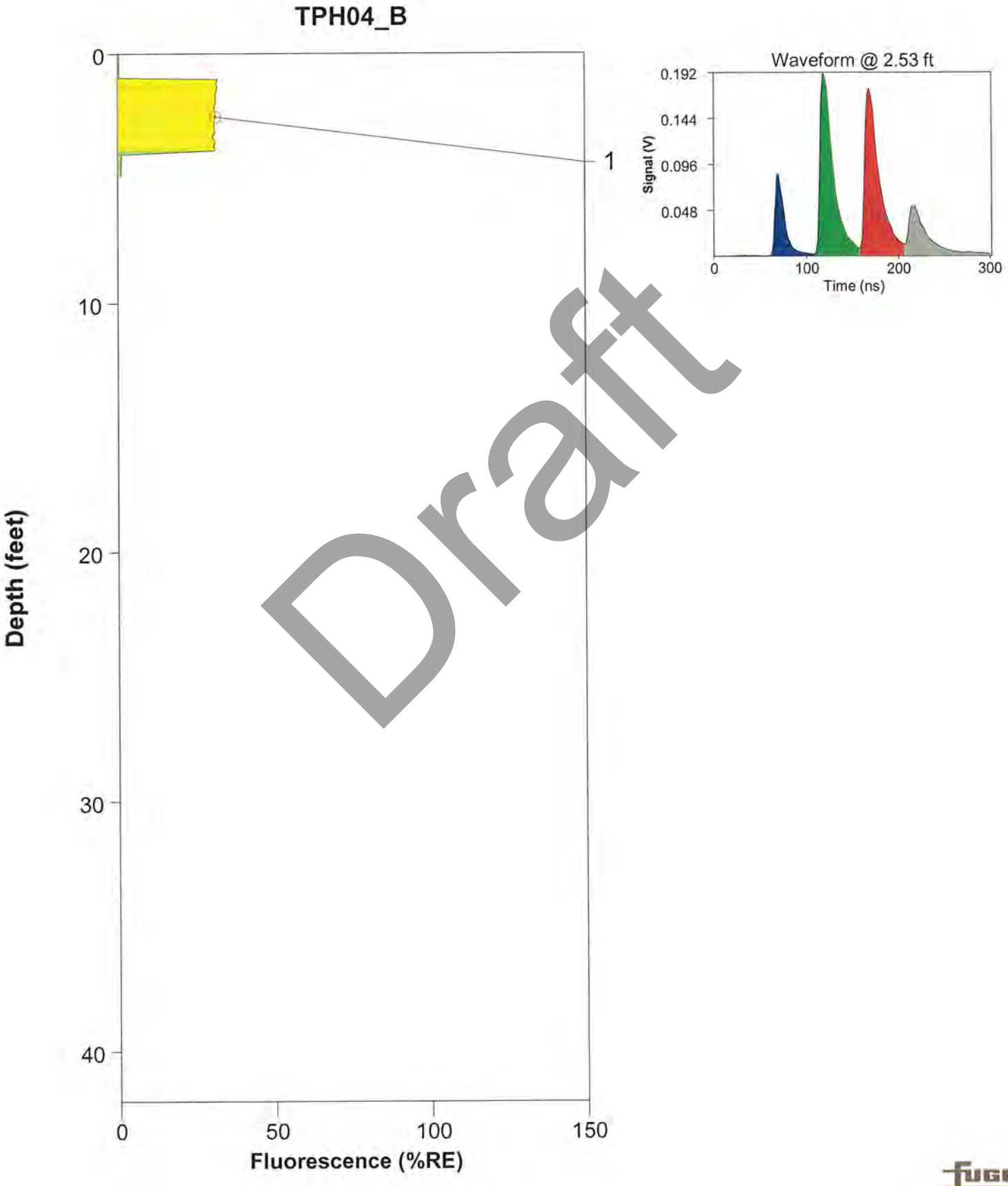
TPH04_A



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:23:22	Max fluorescence: 32.31% @ 1.28 ft
ROST Unit: ?	Final depth BGS: 4.89 ft

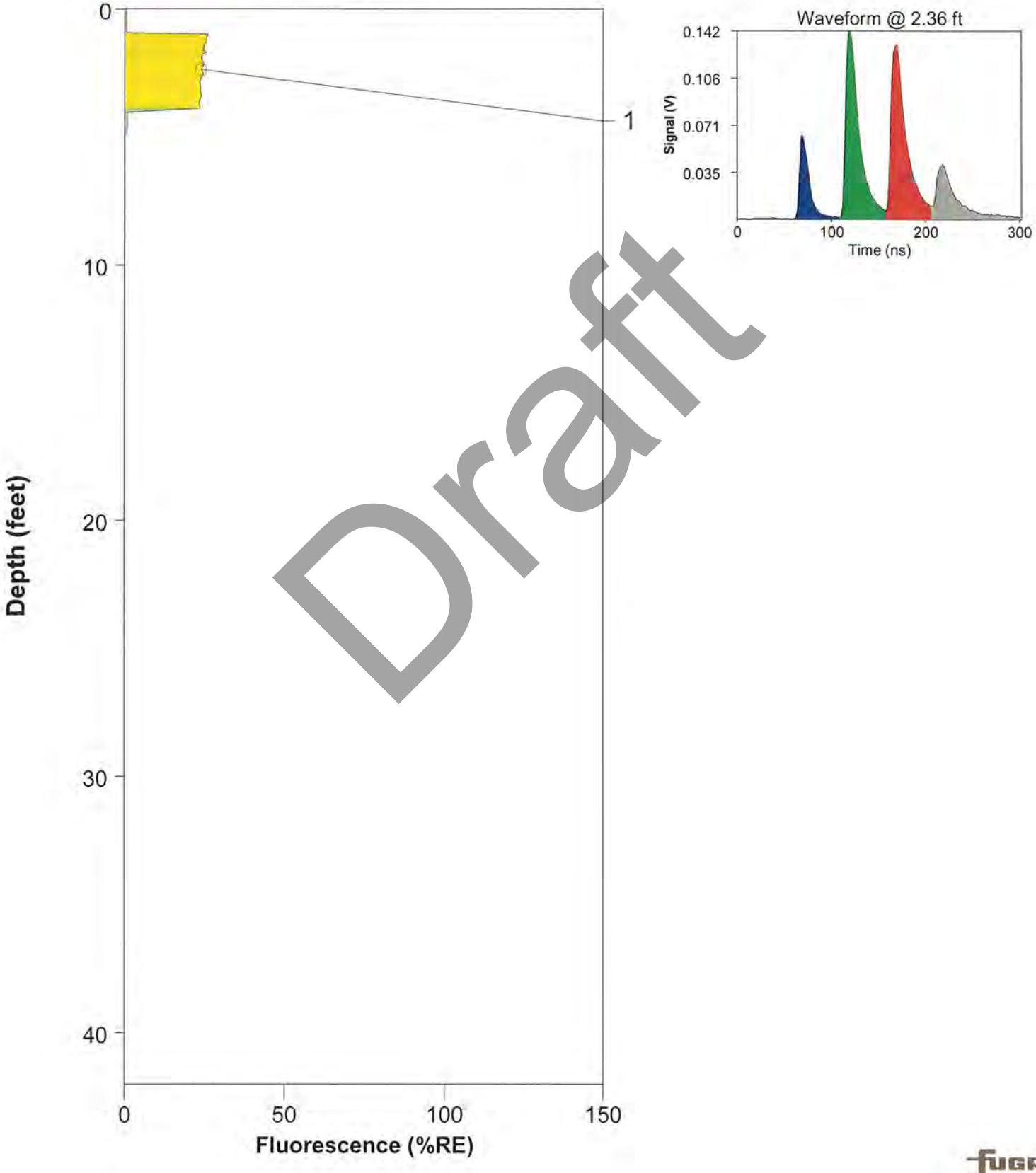


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:25:18	Max fluorescence: 26.13% @ 0.98 ft
ROST Unit: ?	Final depth BGS: 4.86 ft

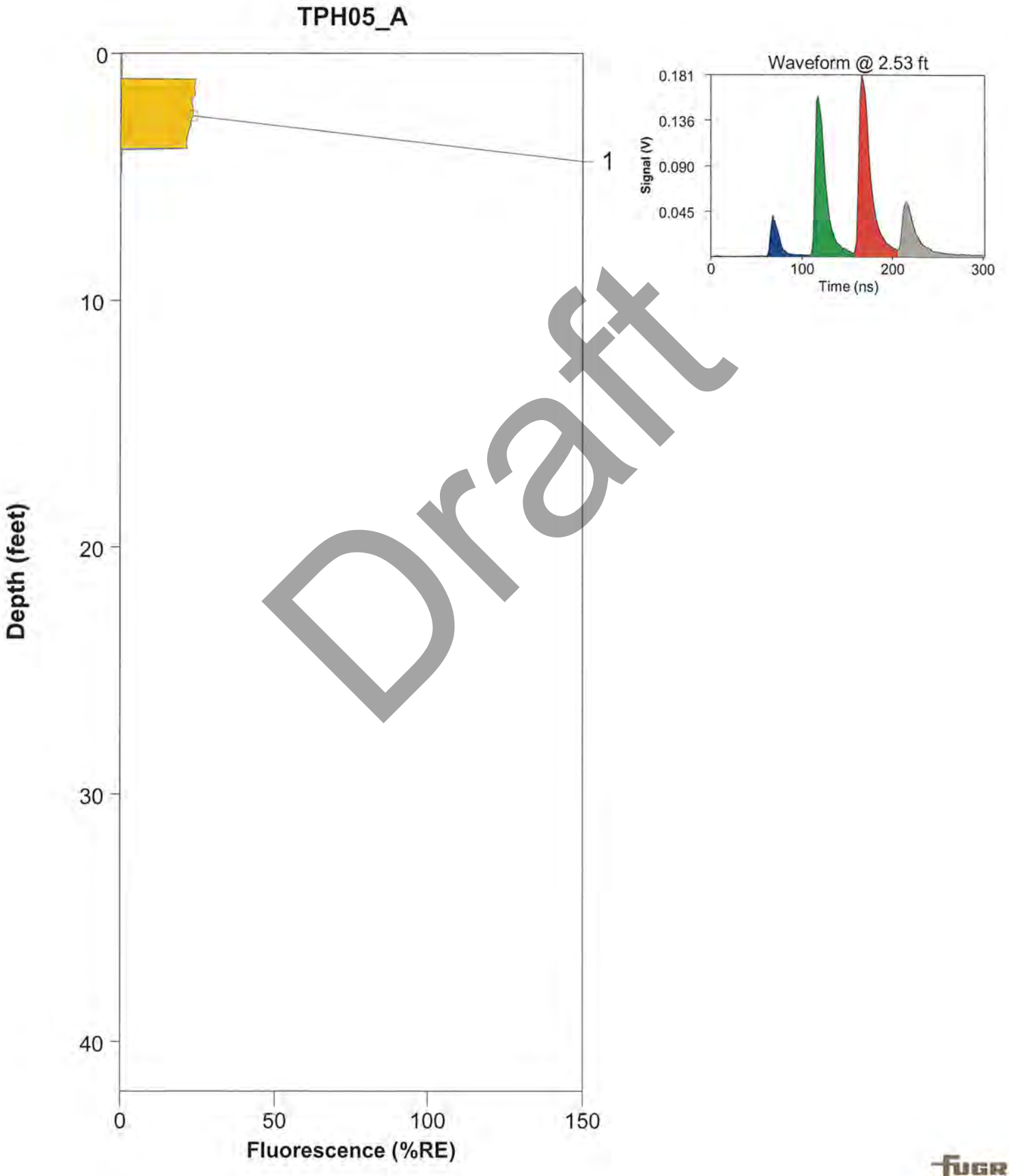
TPH04_C



Draft

ROST Fluorescence Response Data

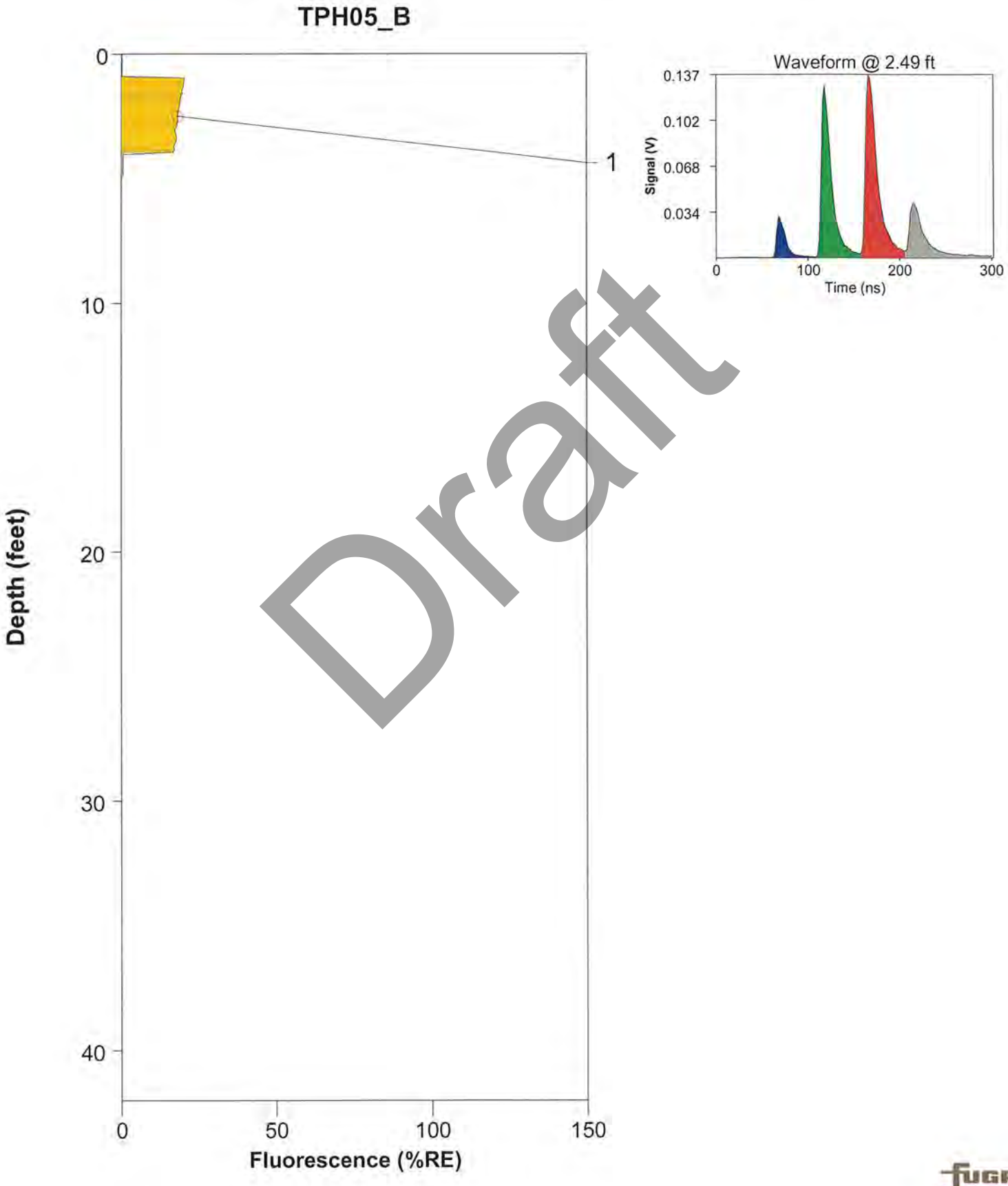
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:28:28	Max fluorescence: 24.23% @ 1.05 ft
ROST Unit: ?	Final depth BGS: 4.86 ft



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:30:11	Max fluorescence: 20.30% @ 0.95 ft
ROST Unit: ?	Final depth BGS: 4.89 ft

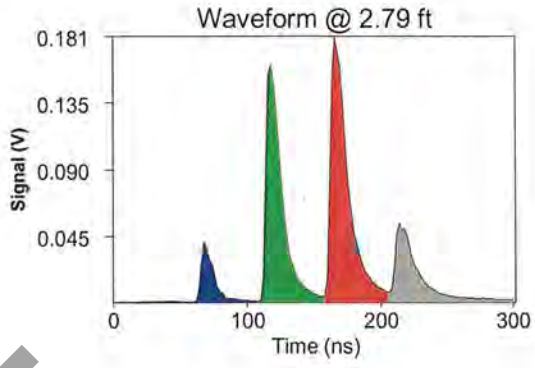


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:32:01	Max fluorescence: 26.47% @ 1.05 ft
ROST Unit: ?	Final depth BGS: 4.82 ft

TPH05_C

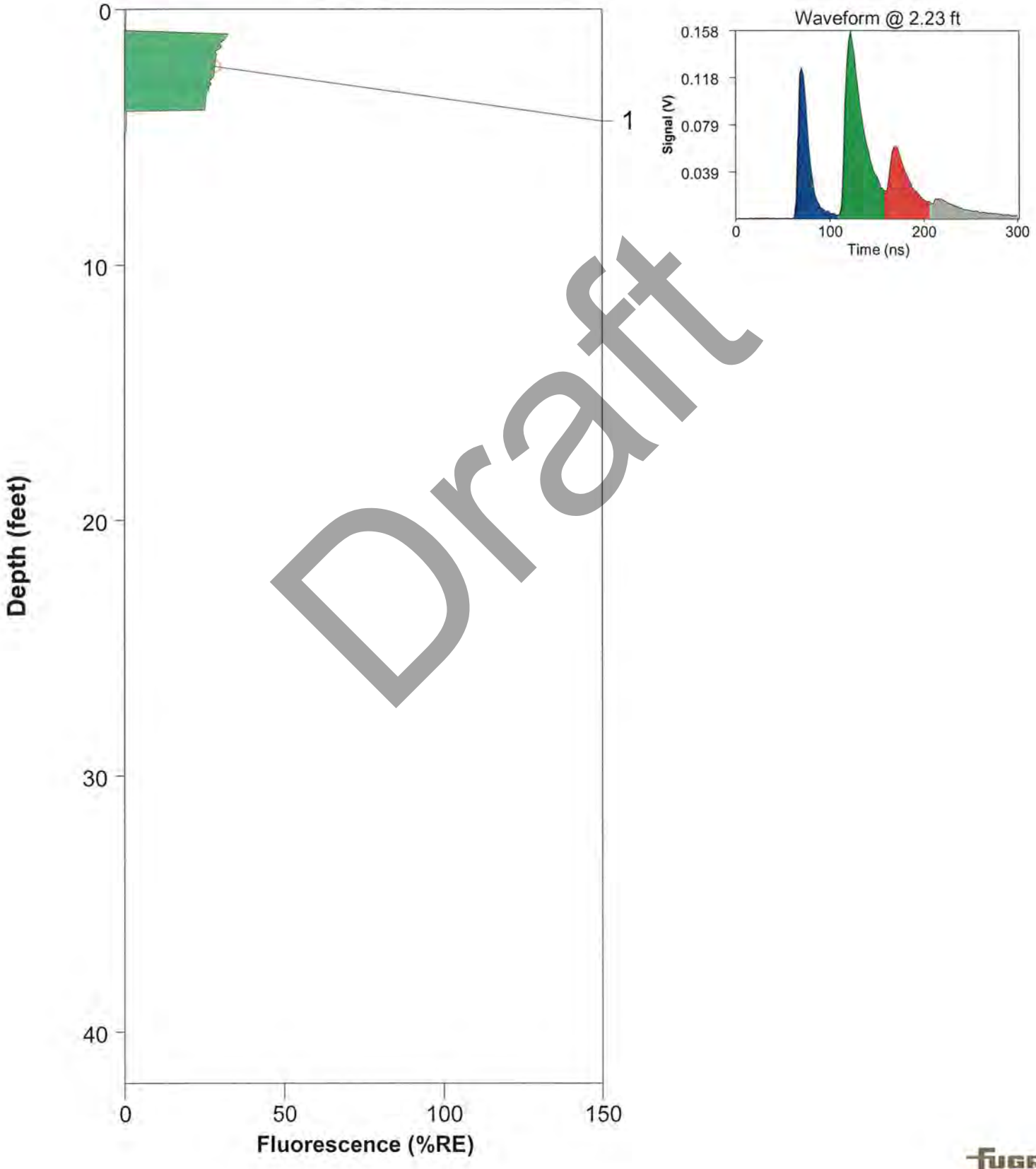


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:35:10	Max fluorescence: 32.27% @ 0.95 ft
ROST Unit: ?	Final depth BGS: 4.79 ft

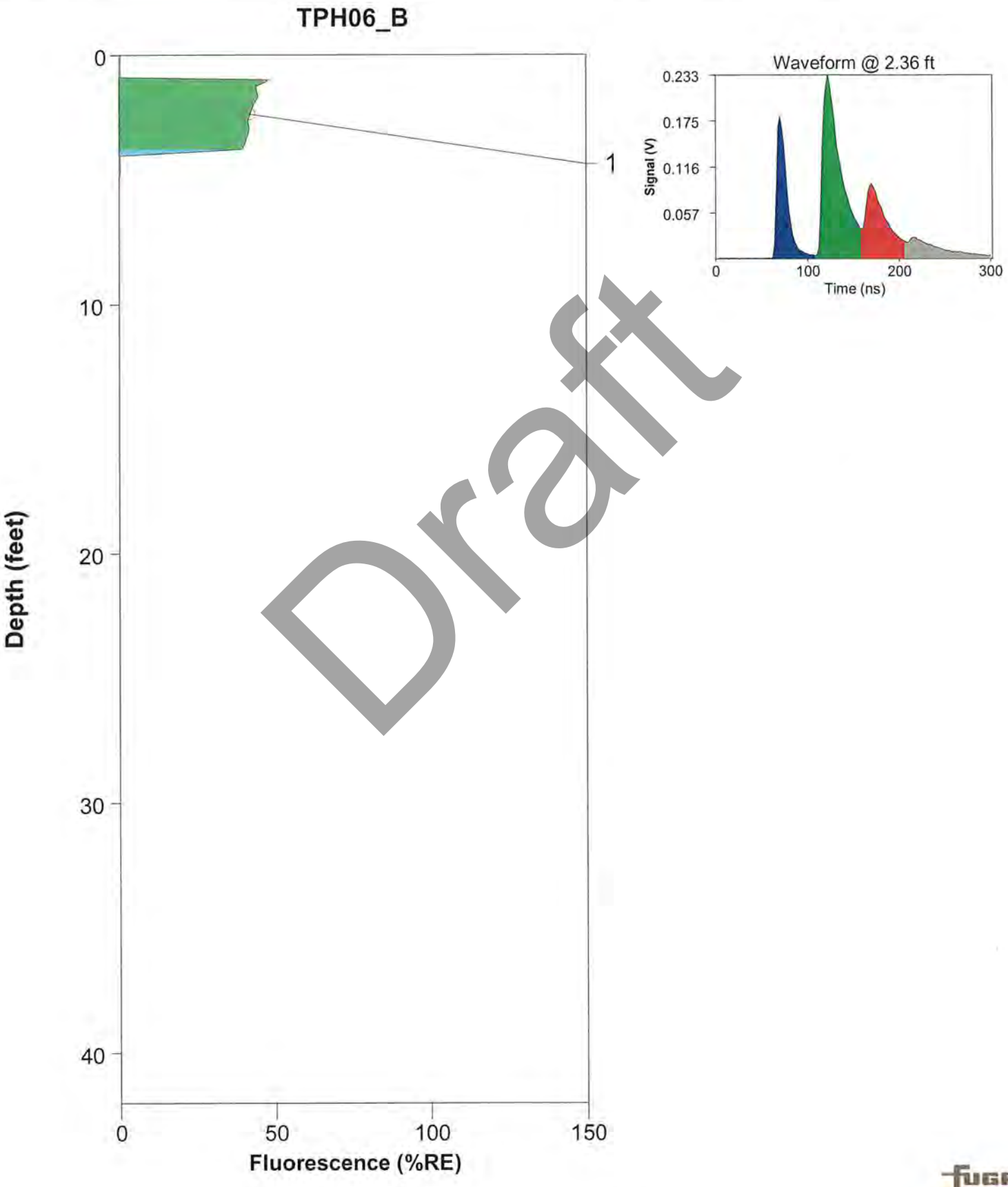
TPH06_A



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:36:36	Max fluorescence: 47.91% @ 0.98 ft
ROST Unit: ?	Final depth BGS: 4.86 ft

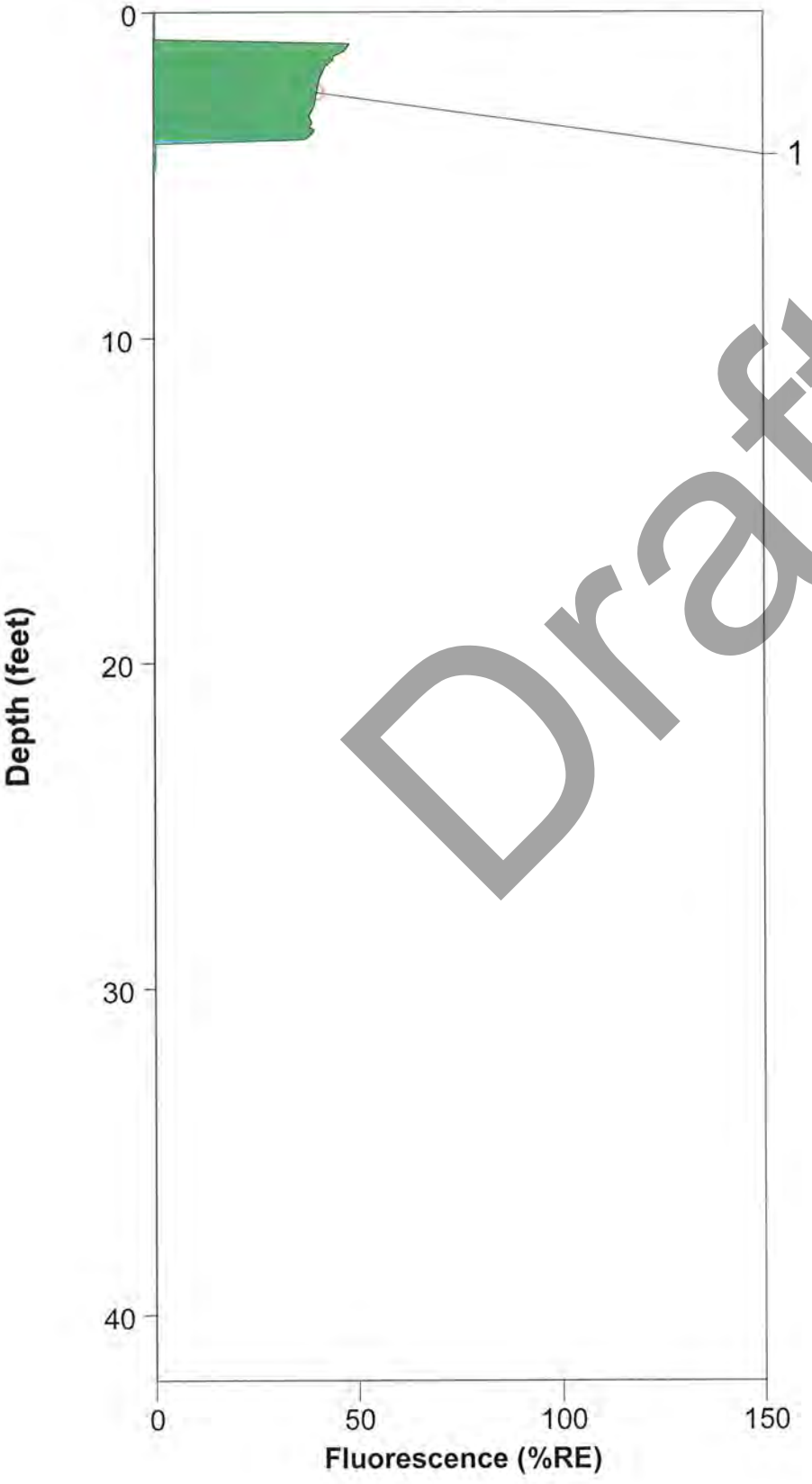


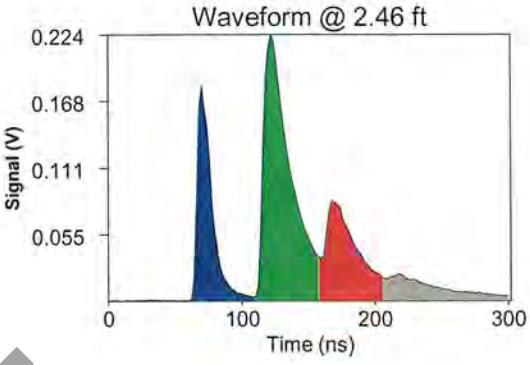
Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:38:09	Max fluorescence: 48.21% @ 0.95 ft
ROST Unit: ?	Final depth BGS: 4.86 ft

TPH06_C

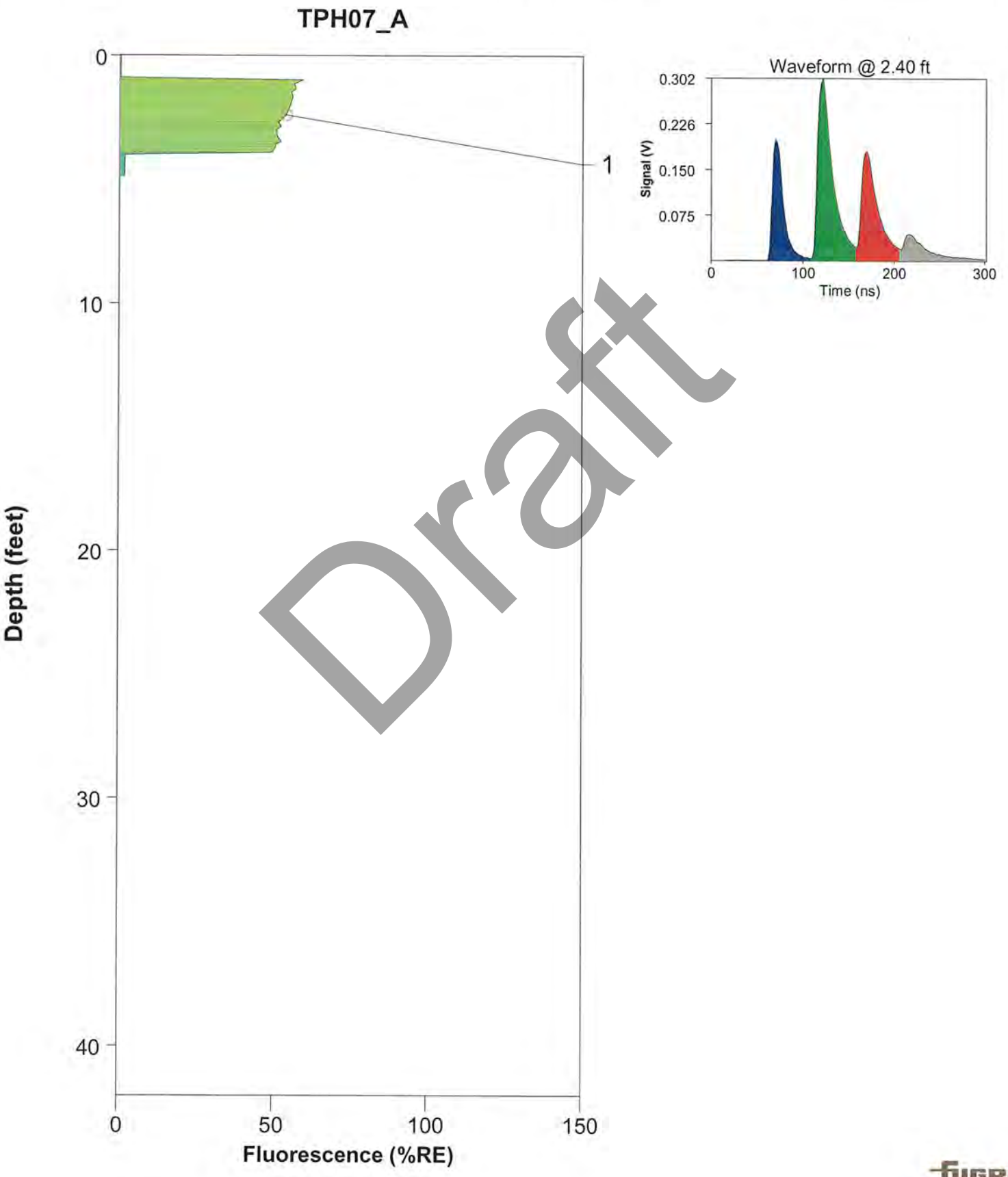




Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:40:40	Max fluorescence: 59.02% @ 0.98 ft
ROST Unit: ?	Final depth BGS: 4.89 ft

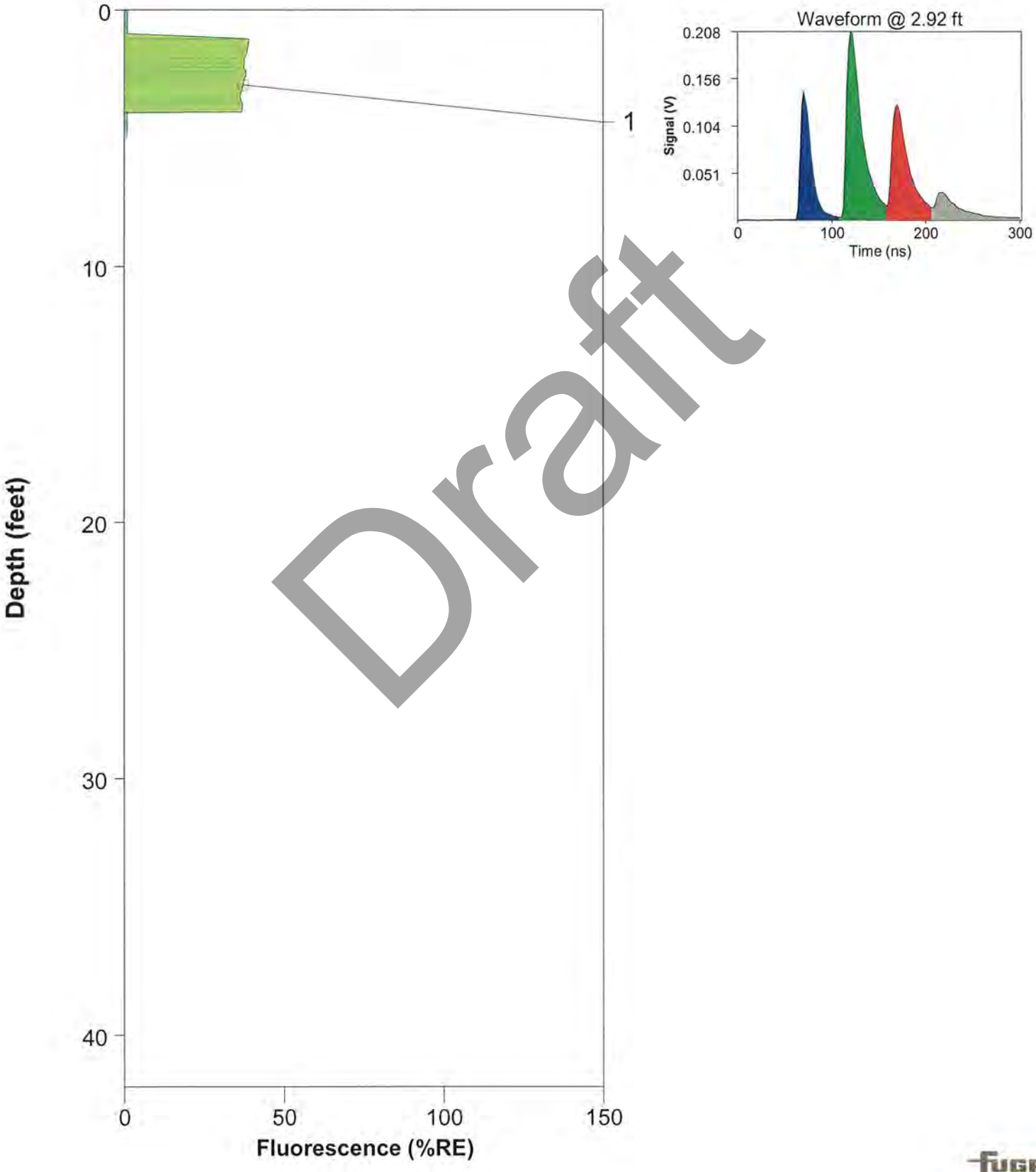


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:42:07	Max fluorescence: 38.98% @ 1.15 ft
ROST Unit: ?	Final depth BGS: 4.92 ft

TPH07_B

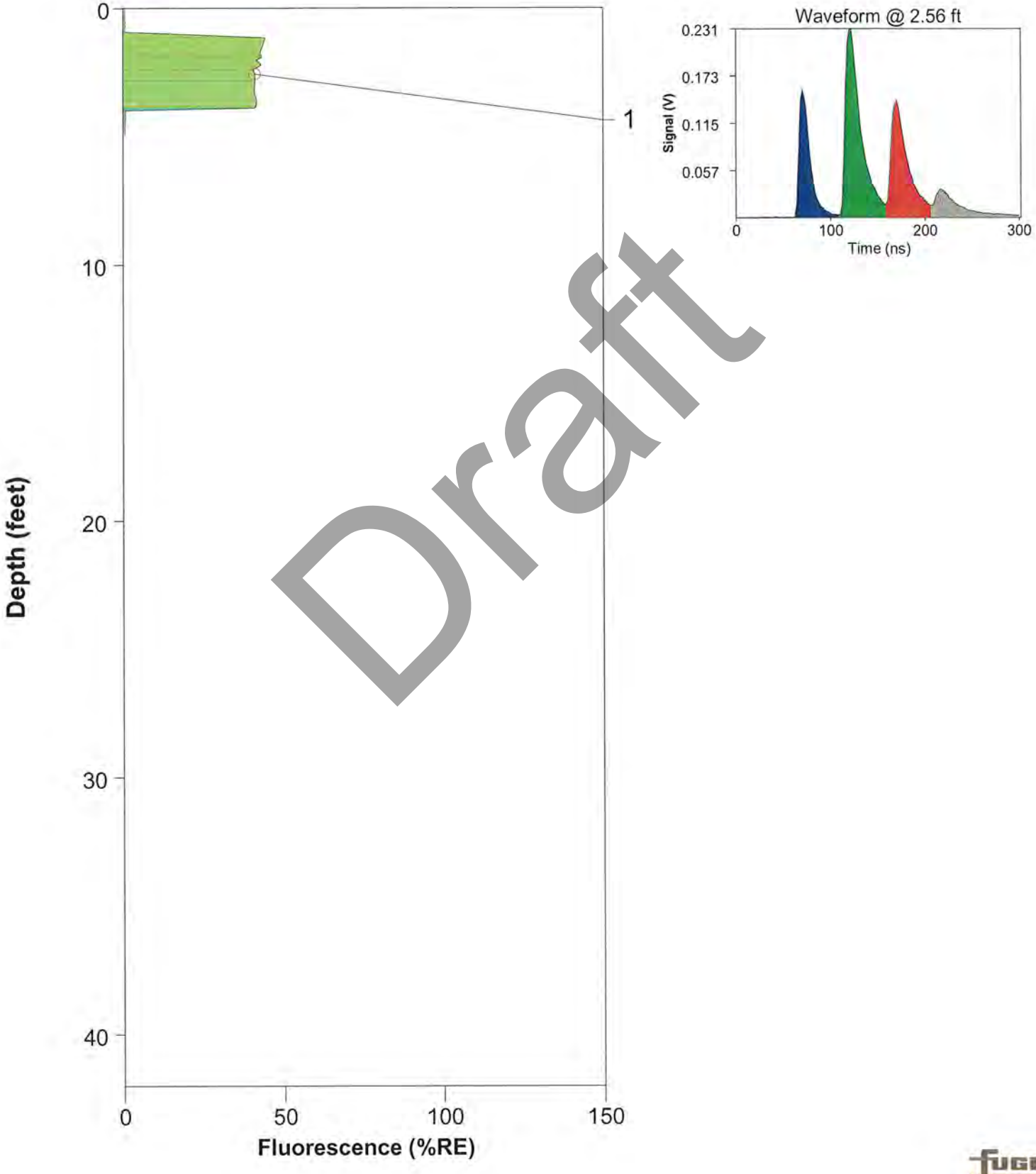


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:43:23	Max fluorescence: 44.38% @ 1.15 ft
ROST Unit: ?	Final depth BGS: 4.92 ft

TPH07_C

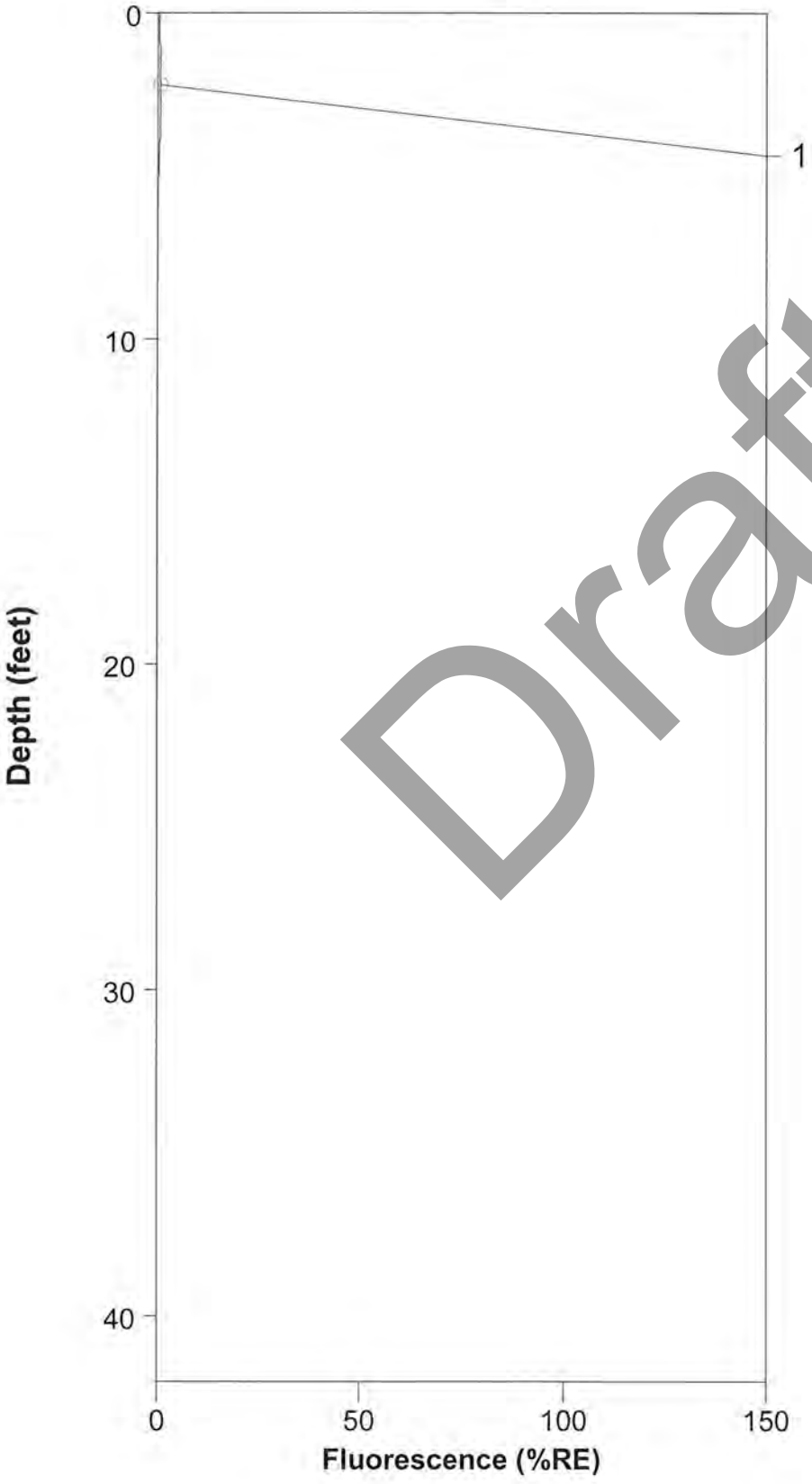


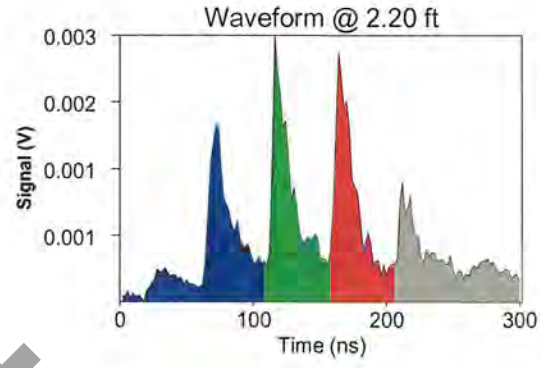
Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:46:10	Max fluorescence: 0.69% @ 1.64 ft
ROST Unit: ?	Final depth BGS: 5.02 ft

TPH08_A

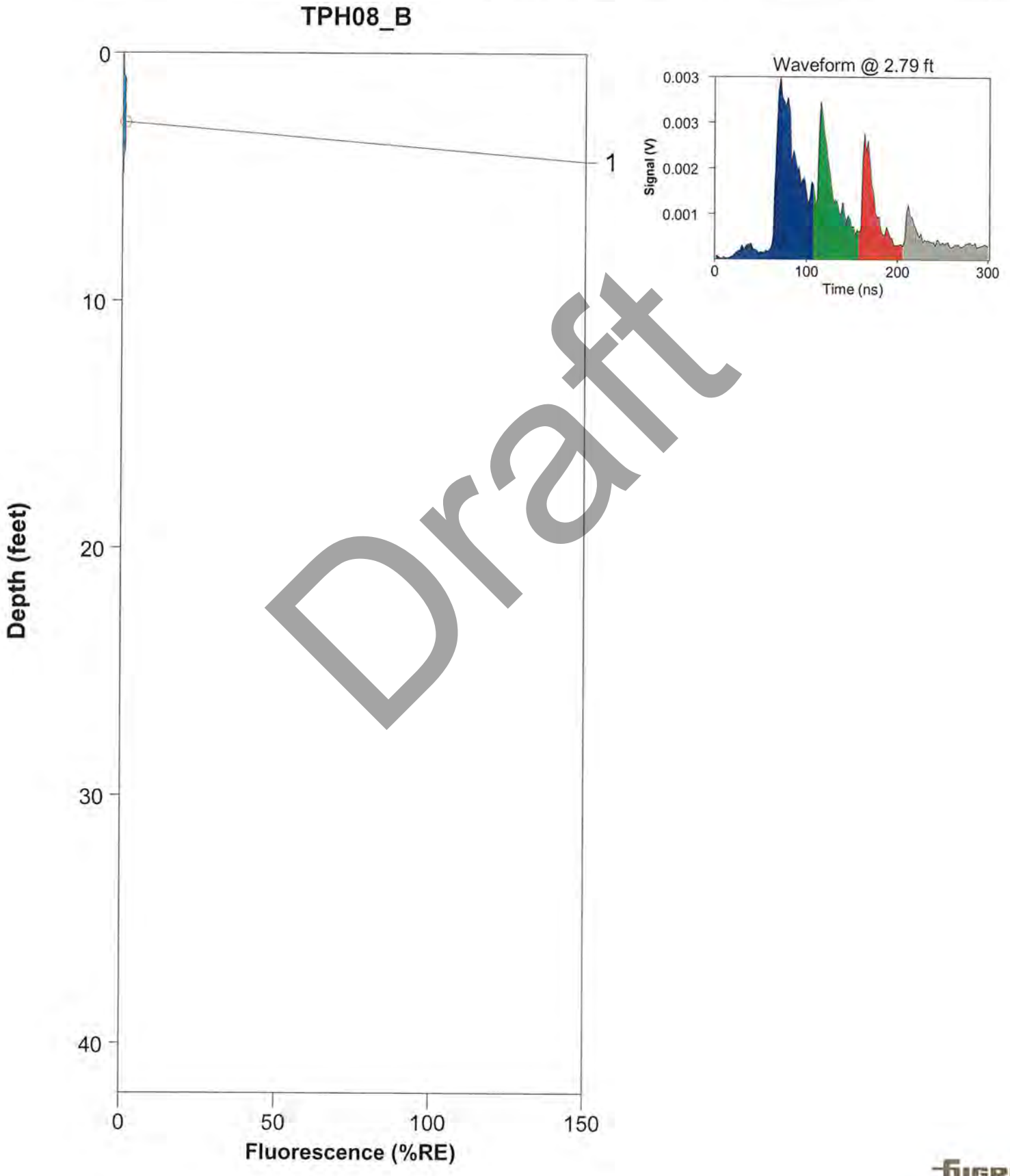




Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:47:36	Max fluorescence: 0.95% @ 2.13 ft
ROST Unit: ?	Final depth BGS: 4.86 ft

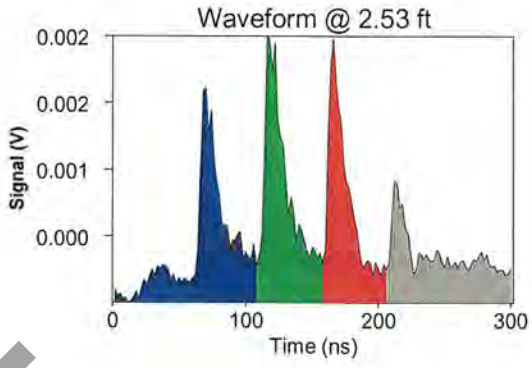


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:49:48	Max fluorescence: 0.59% @ 3.94 ft
ROST Unit: ?	Final depth BGS: 4.89 ft

TPH08_C

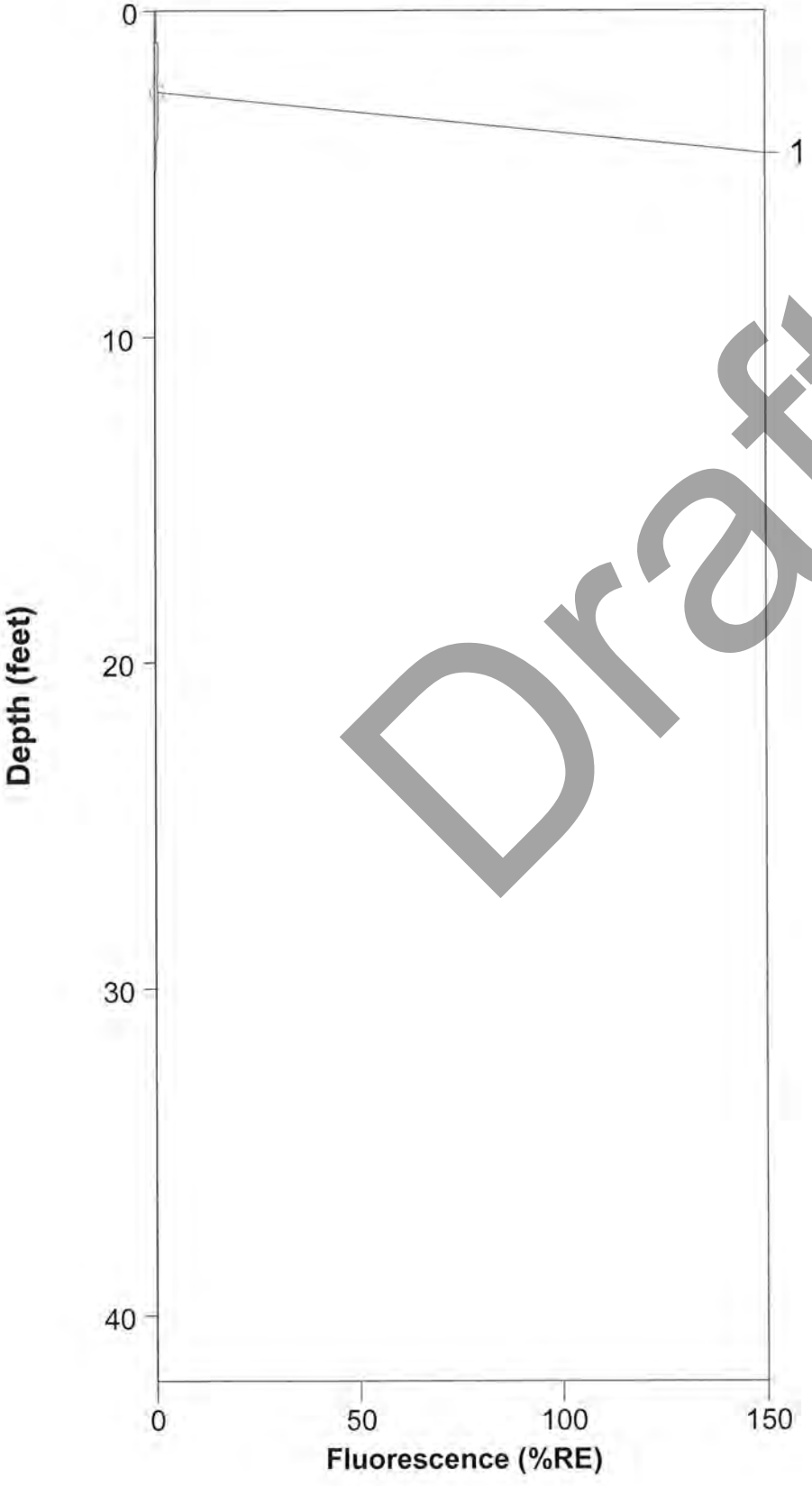


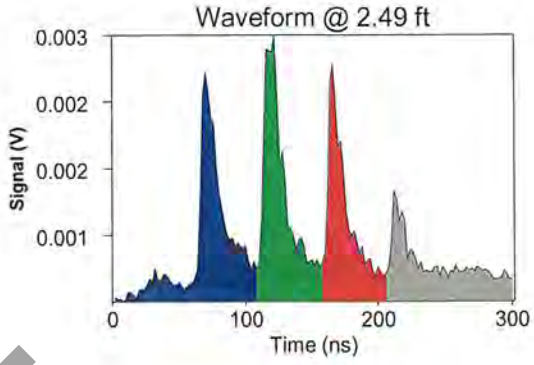
Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:52:30	Max fluorescence: 0.79% @ 0.98 ft
ROST Unit: ?	Final depth BGS: 4.89 ft

TPH09_A



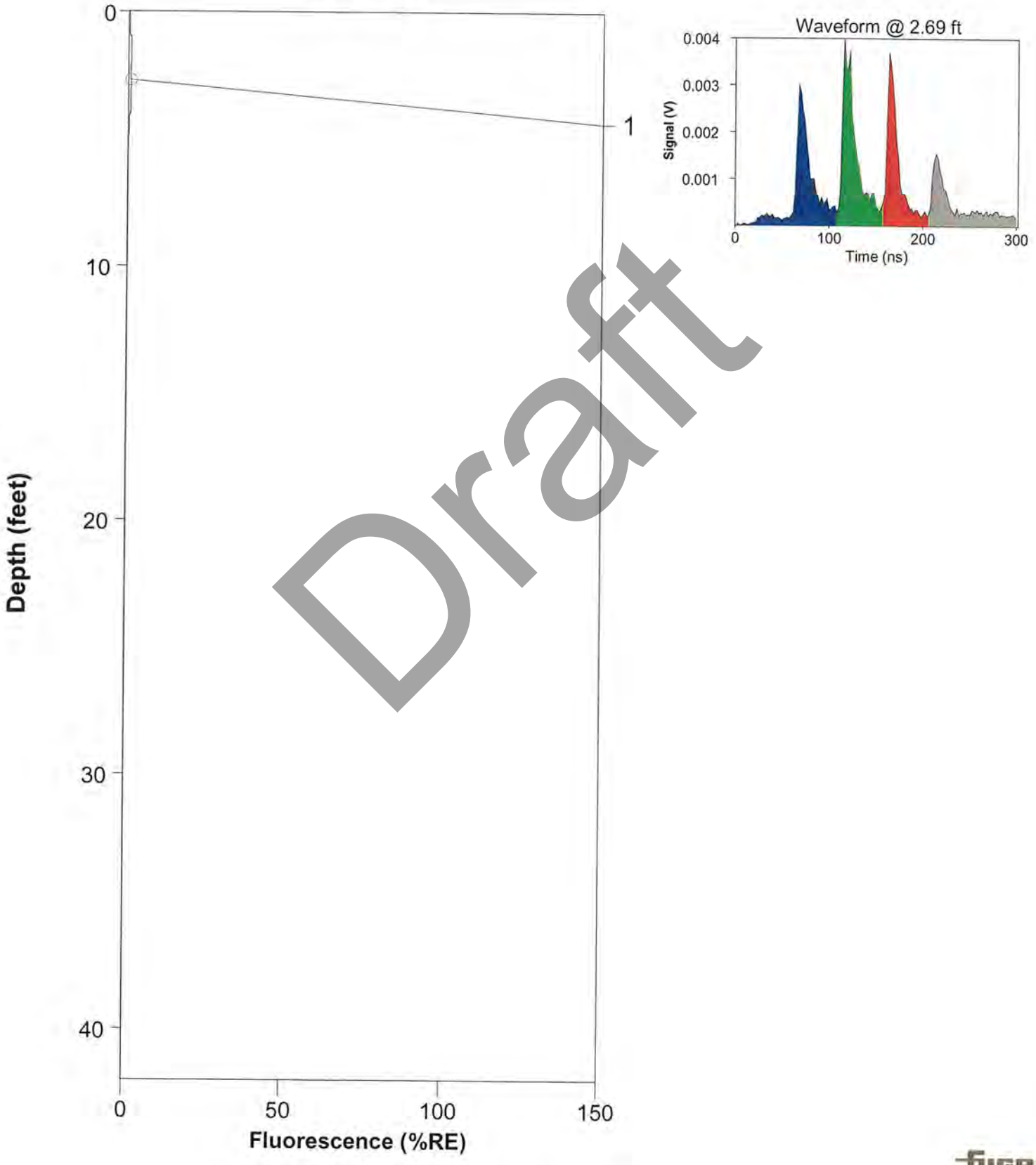


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:54:17	Max fluorescence: 0.94% @ 1.12 ft
ROST Unit: ?	Final depth BGS: 4.89 ft

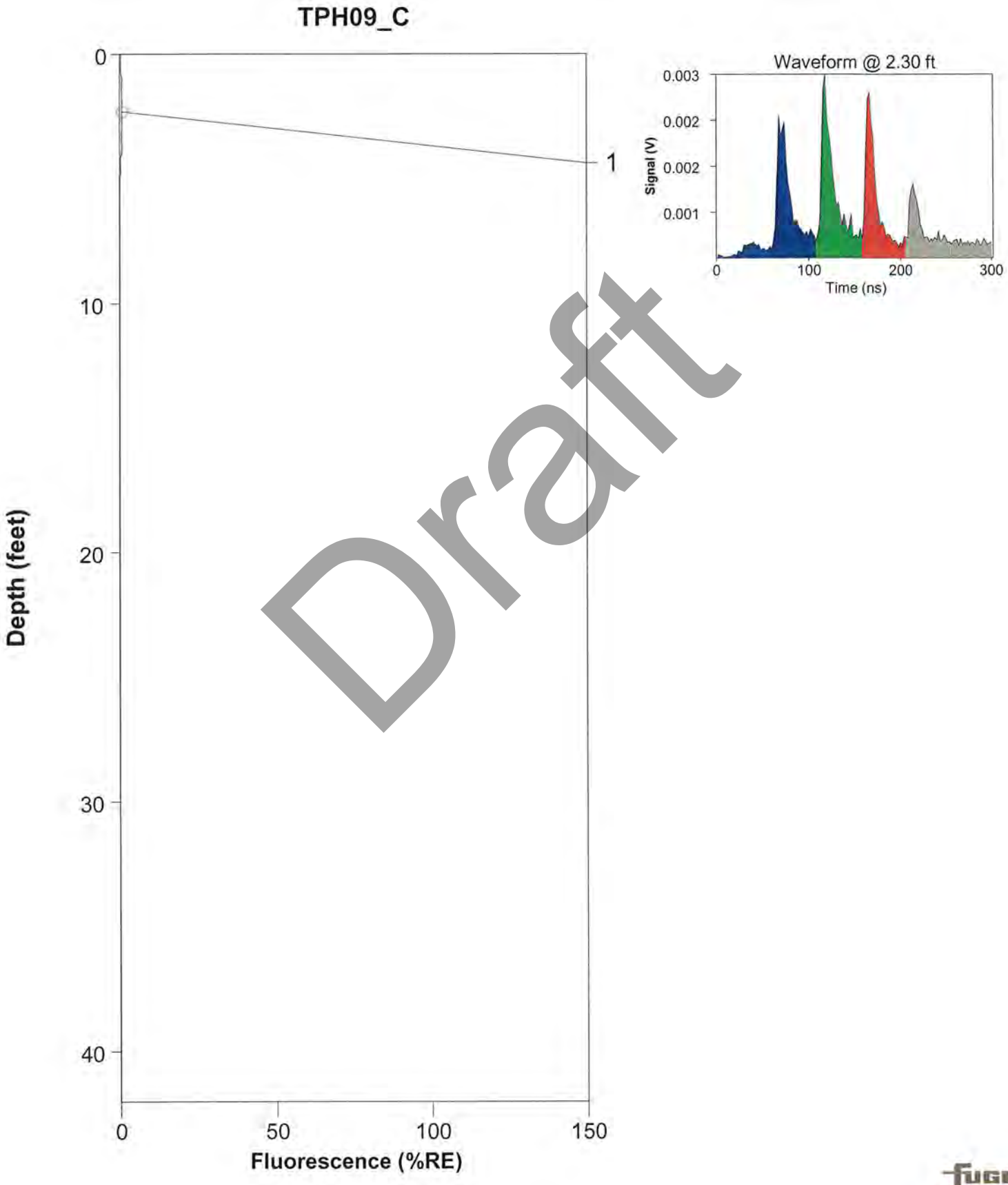
TPH09_B



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:55:51	Max fluorescence: 0.74% @ 2.72 ft
ROST Unit: ?	Final depth BGS: 4.86 ft

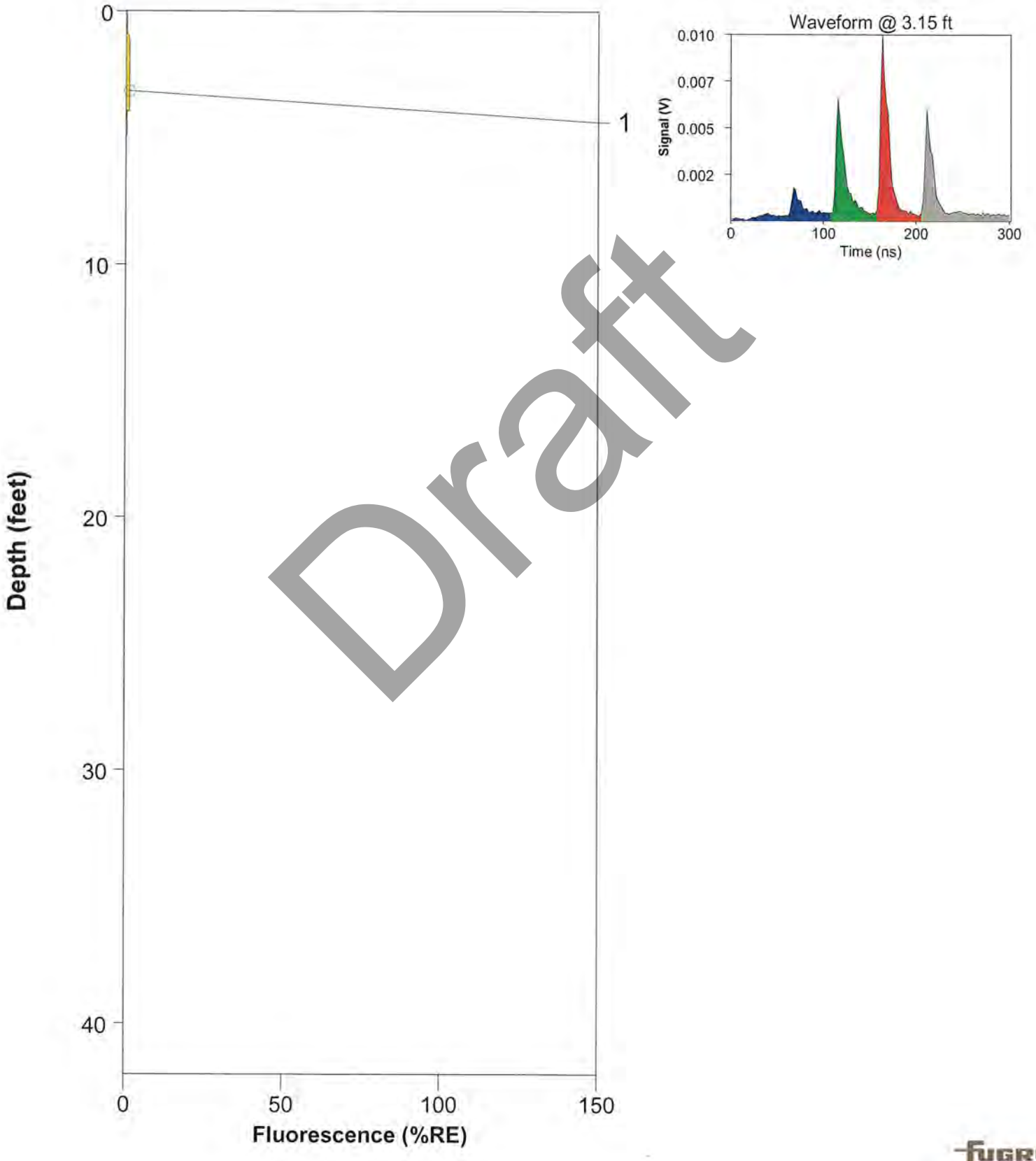


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 16:59:33	Max fluorescence: 1.14% @ 1.64 ft
ROST Unit: ?	Final depth BGS: 4.89 ft

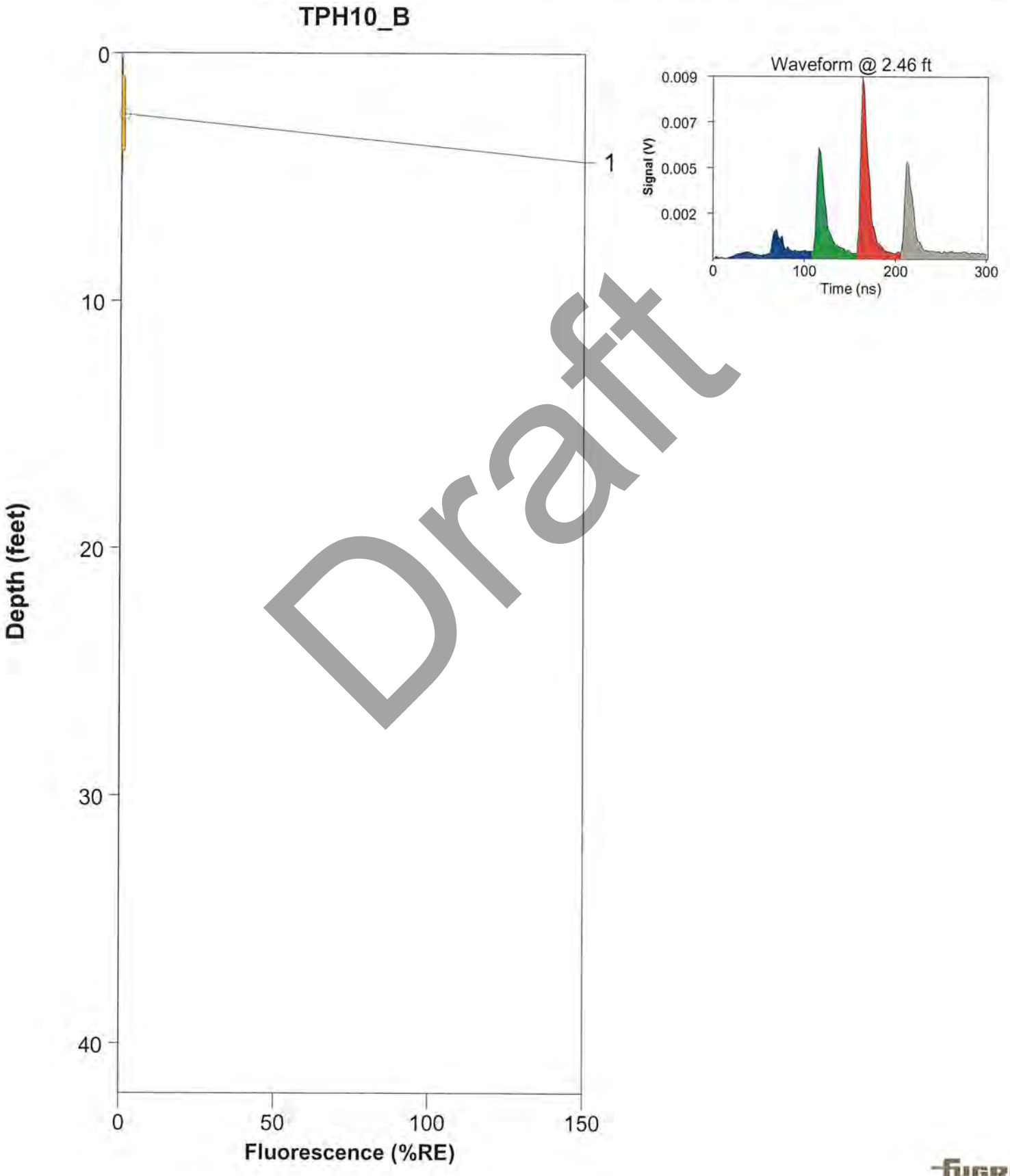
TPH10_A



Draft

ROST Fluorescence Response Data

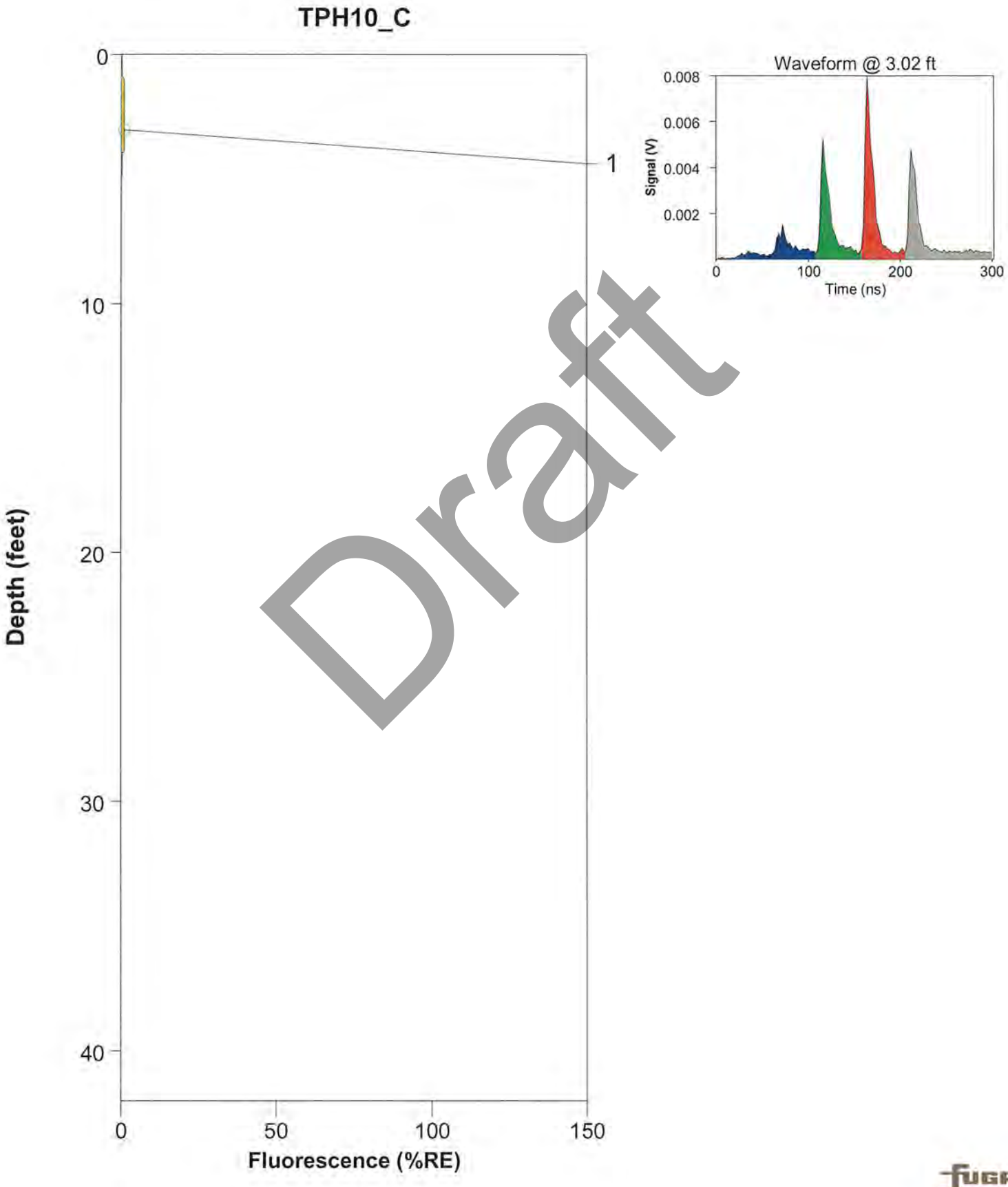
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 17:01:38	Max fluorescence: 1.15% @ 3.61 ft
ROST Unit: ?	Final depth BGS: 4.92 ft



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 17:03:32	Max fluorescence: 0.98% @ 2.92 ft
ROST Unit: ?	Final depth BGS: 4.86 ft

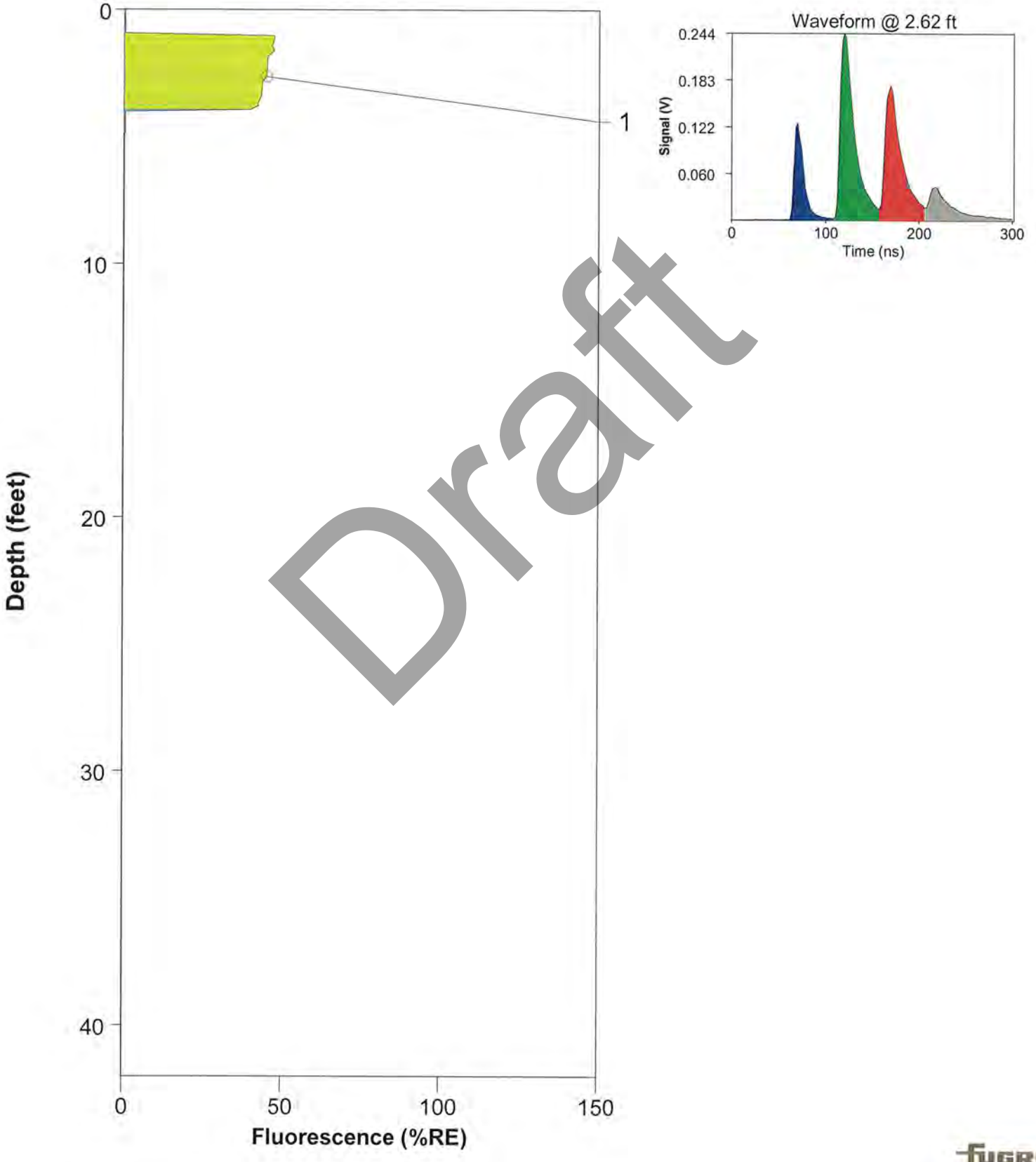


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 17:06:02	Max fluorescence: 47.16% @ 1.02 ft
ROST Unit: ?	Final depth BGS: 4.86 ft

TPH11_A

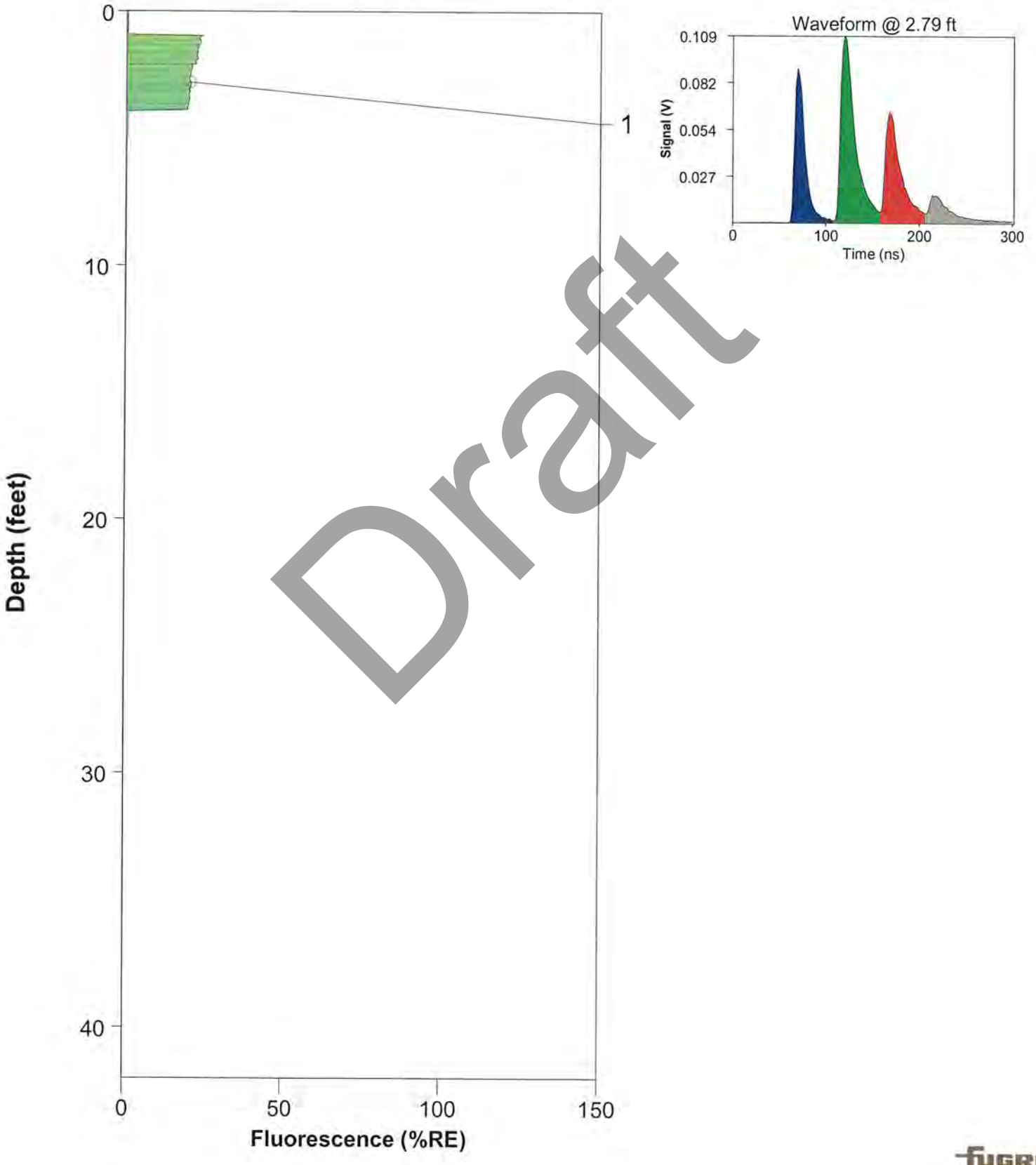


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 17:09:03	Max fluorescence: 23.99% @ 0.95 ft
ROST Unit: ?	Final depth BGS: 4.92 ft

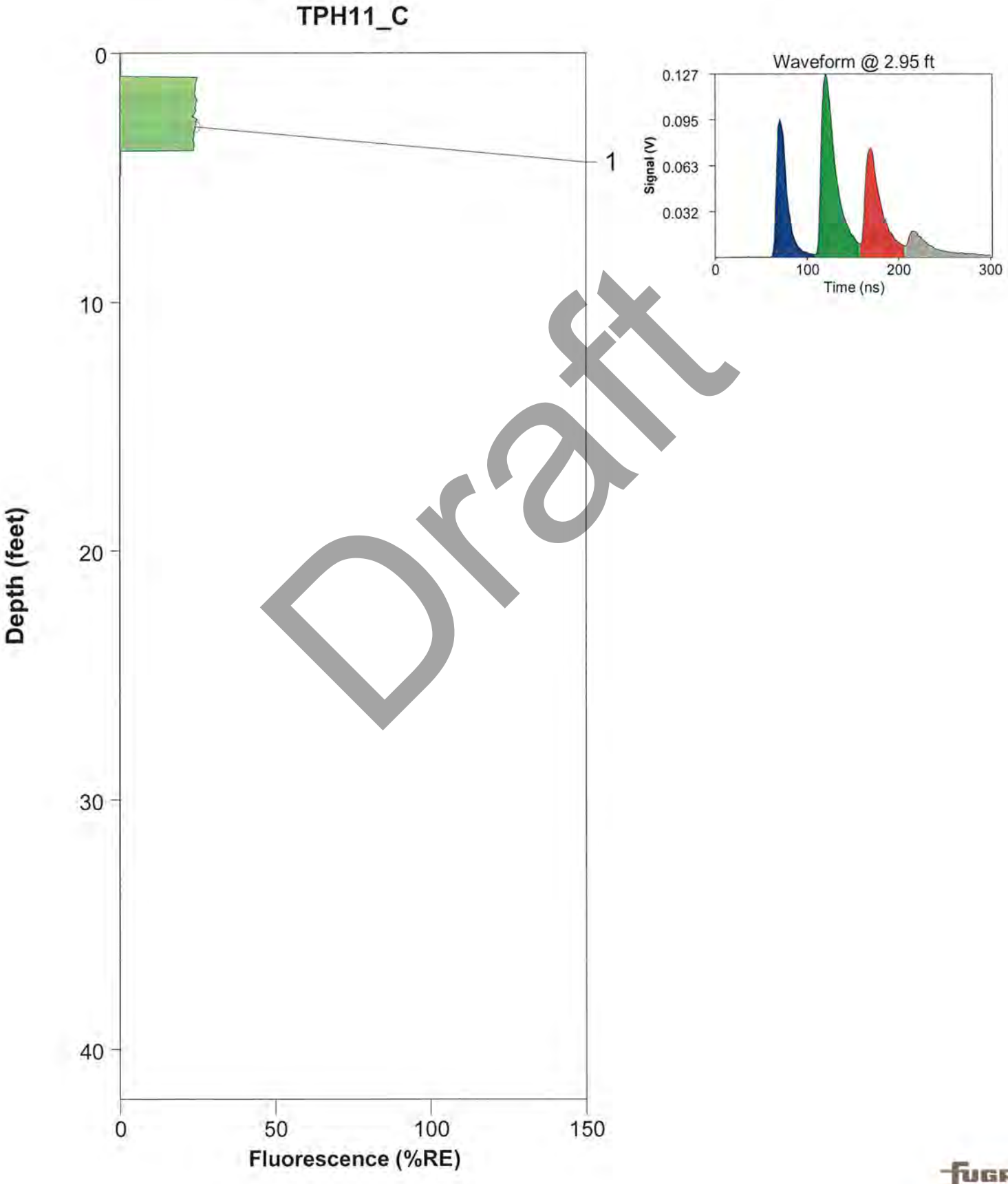
TPH11_B



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 17:12:19	Max fluorescence: 24.95% @ 0.95 ft
ROST Unit: ?	Final depth BGS: 4.92 ft

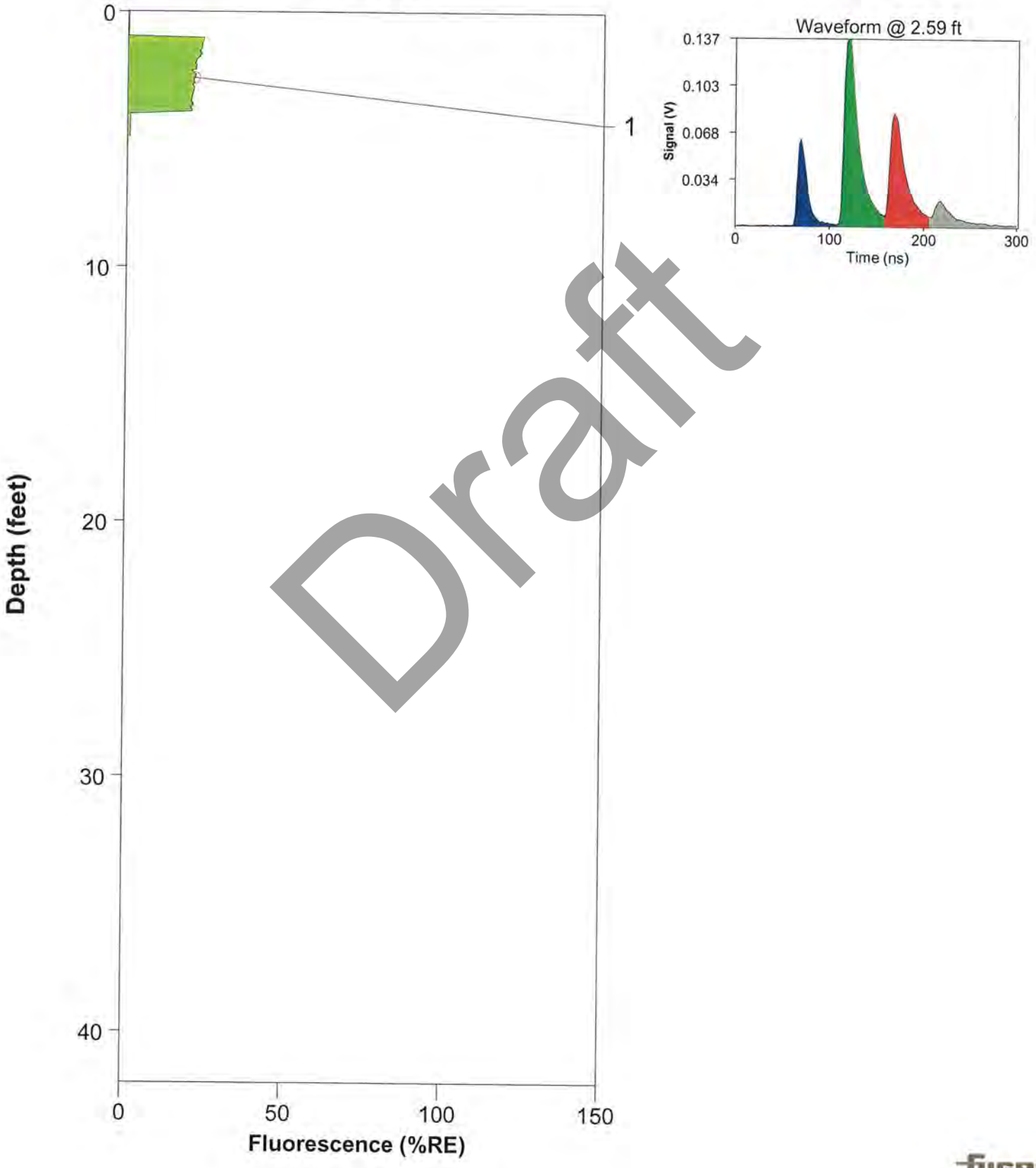


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 17:17:25	Max fluorescence: 24.18% @ 1.02 ft
ROST Unit: ?	Final depth BGS: 4.92 ft

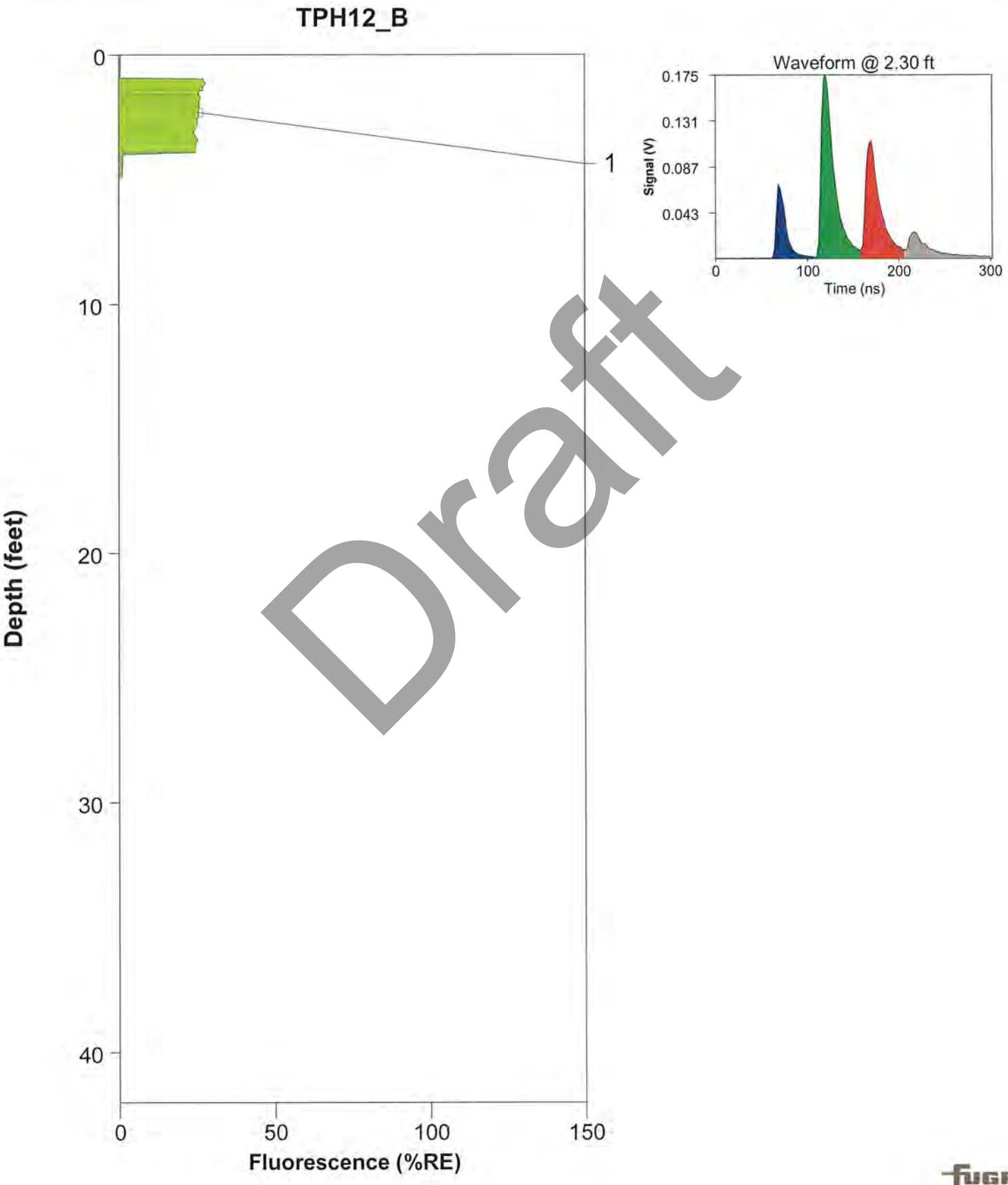
TPH12_A



Draft

ROST Fluorescence Response Data

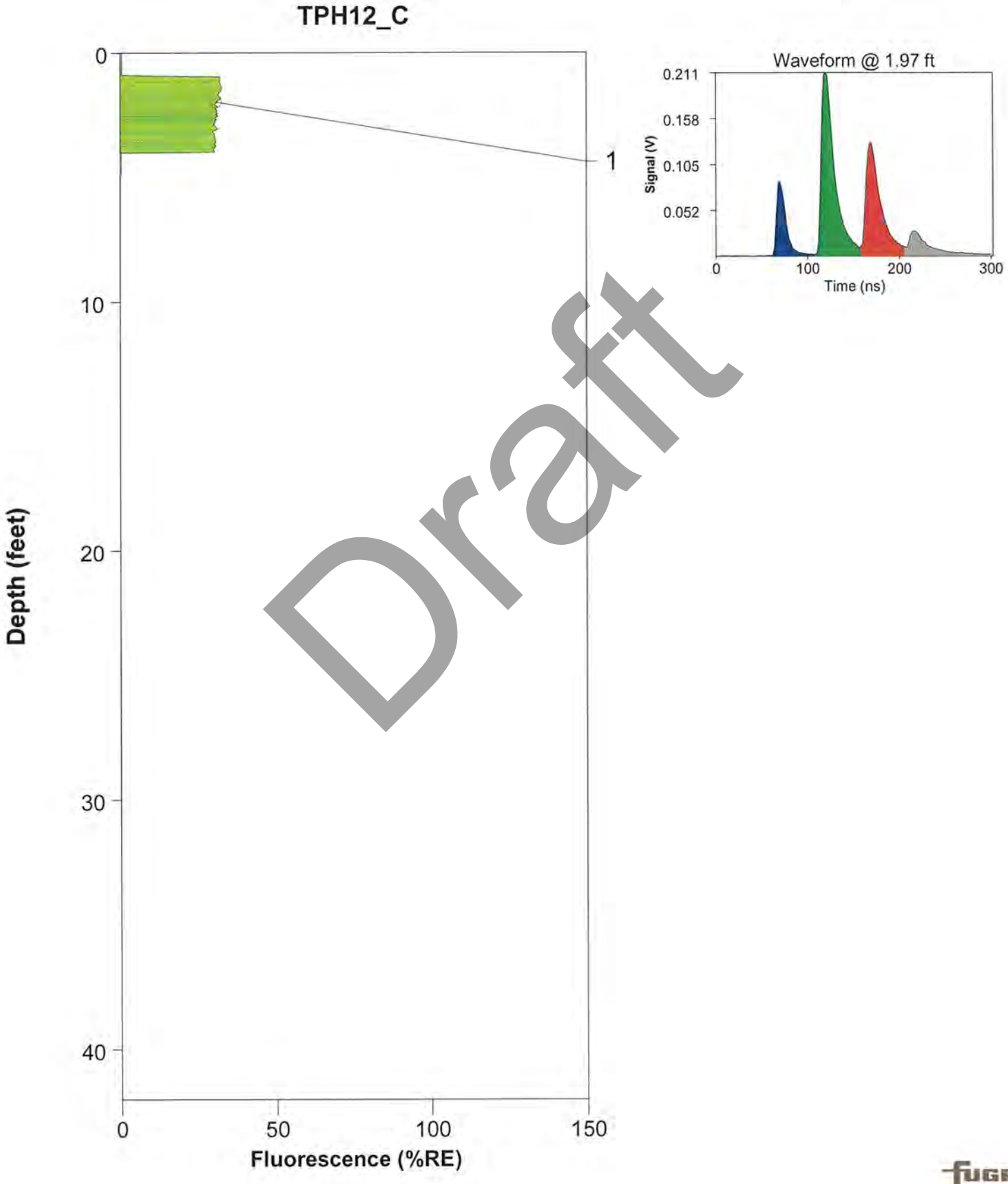
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 17:20:04	Max fluorescence: 27.78% @ 1.12 ft
ROST Unit: ?	Final depth BGS: 4.92 ft



Draft

ROST Fluorescence Response Data

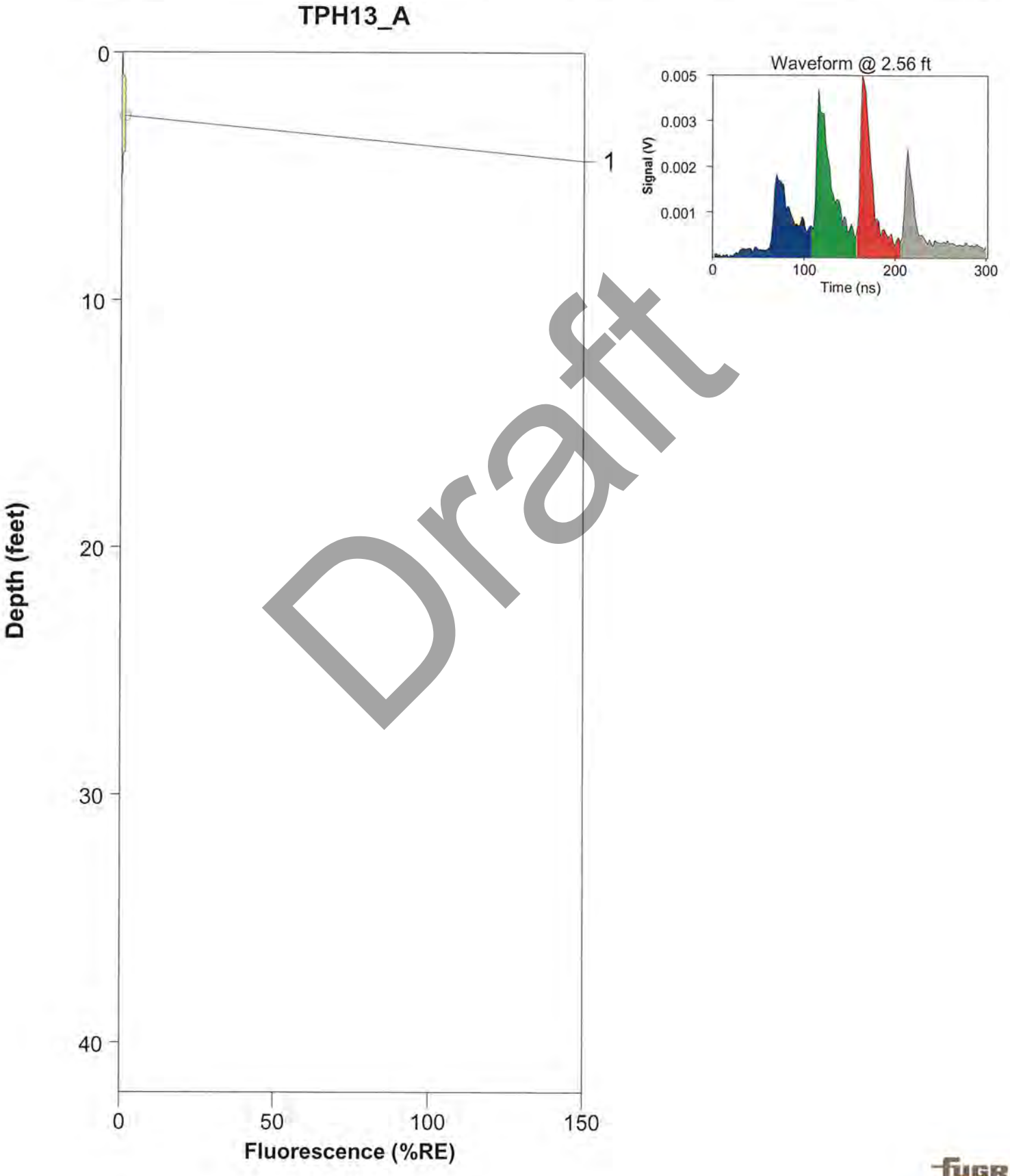
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 17:24:11	Max fluorescence: 32.48% @ 1.51 ft
ROST Unit: ?	Final depth BGS: 4.89 ft



Draft

ROST Fluorescence Response Data

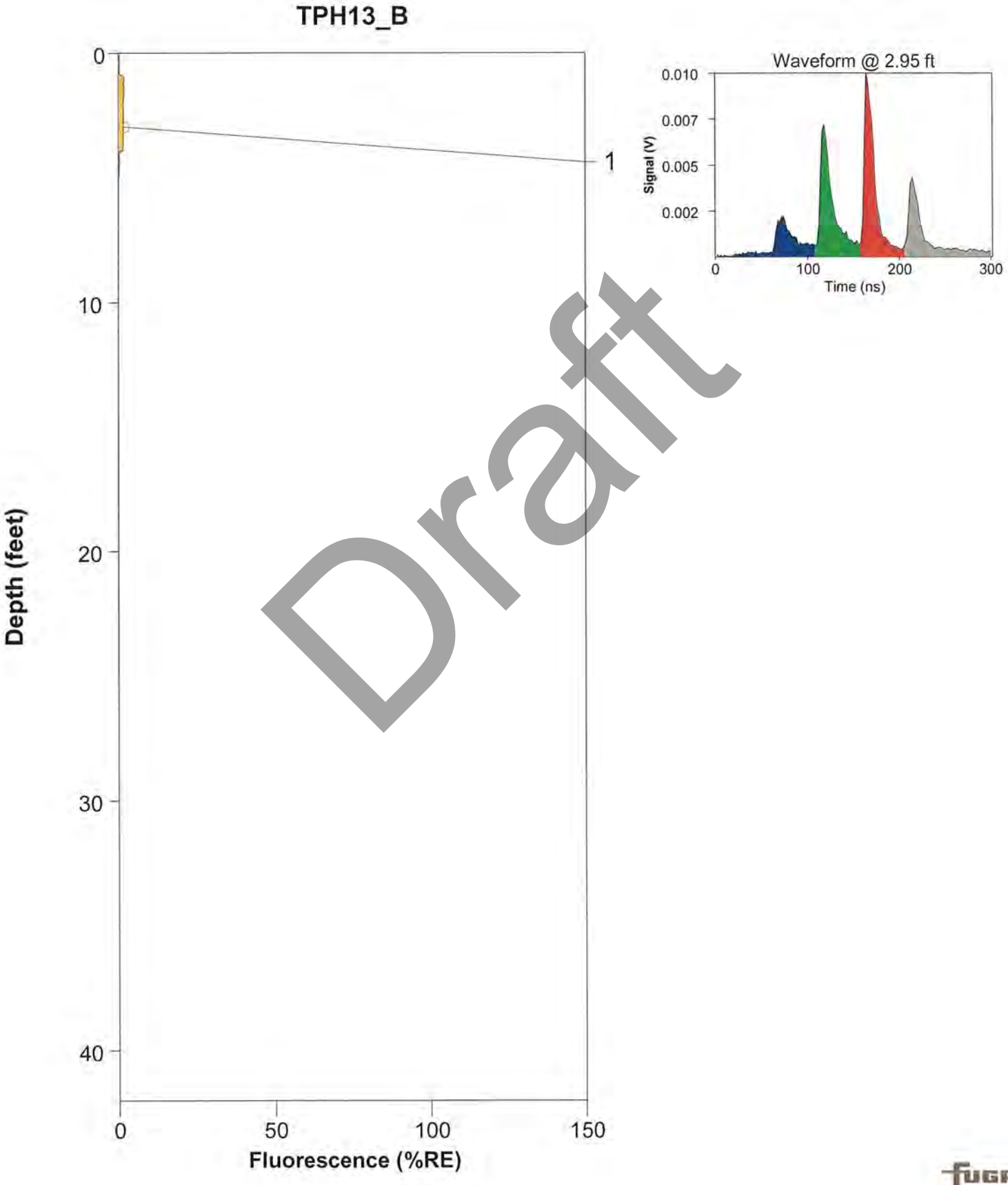
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 17:28:17	Max fluorescence: 1.31% @ 2.03 ft
ROST Unit: ?	Final depth BGS: 4.92 ft



Draft

ROST Fluorescence Response Data

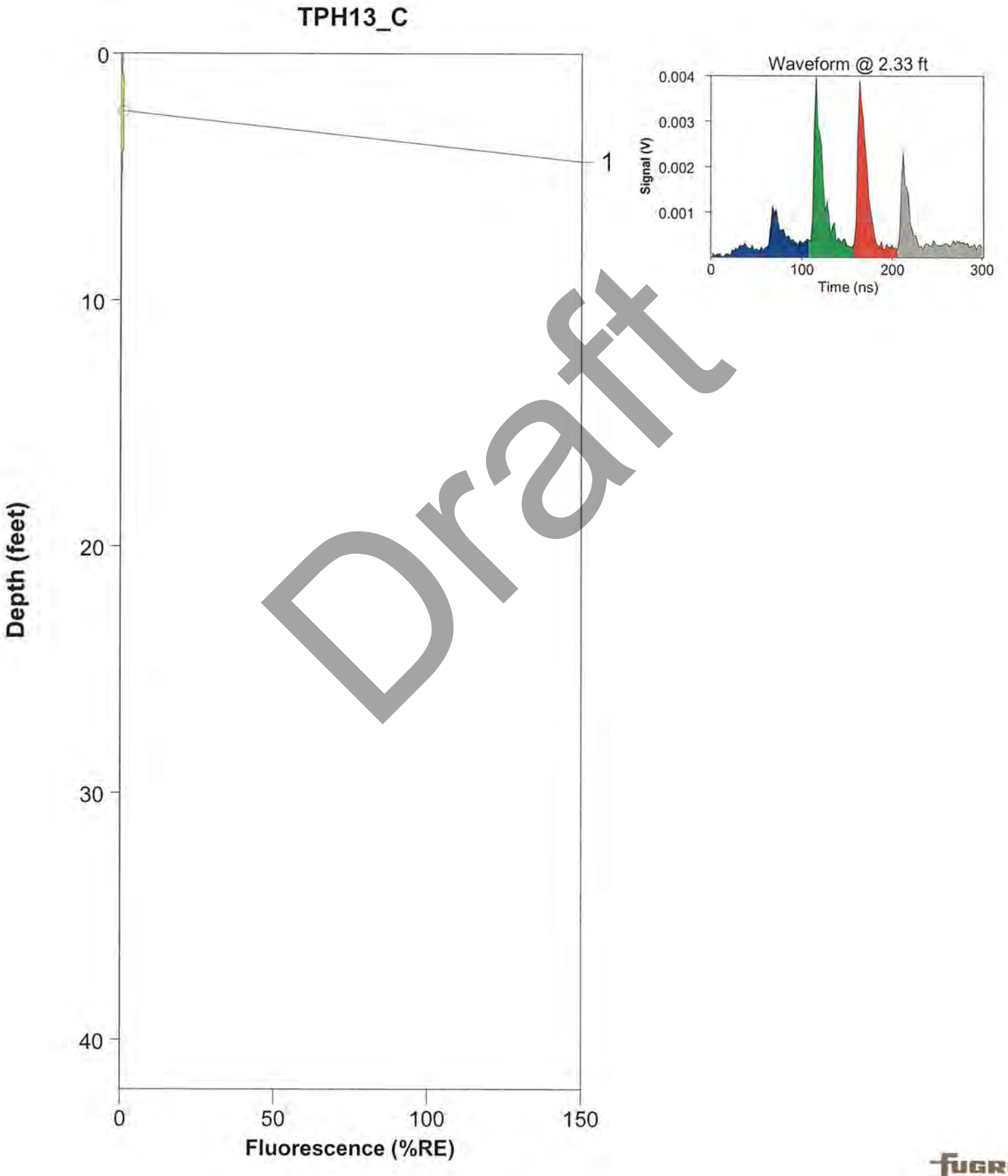
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 17:30:18	Max fluorescence: 1.86% @ 1.15 ft
ROST Unit: ?	Final depth BGS: 4.95 ft



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 17:32:27	Max fluorescence: 0.72% @ 1.21 ft
ROST Unit: ?	Final depth BGS: 4.86 ft

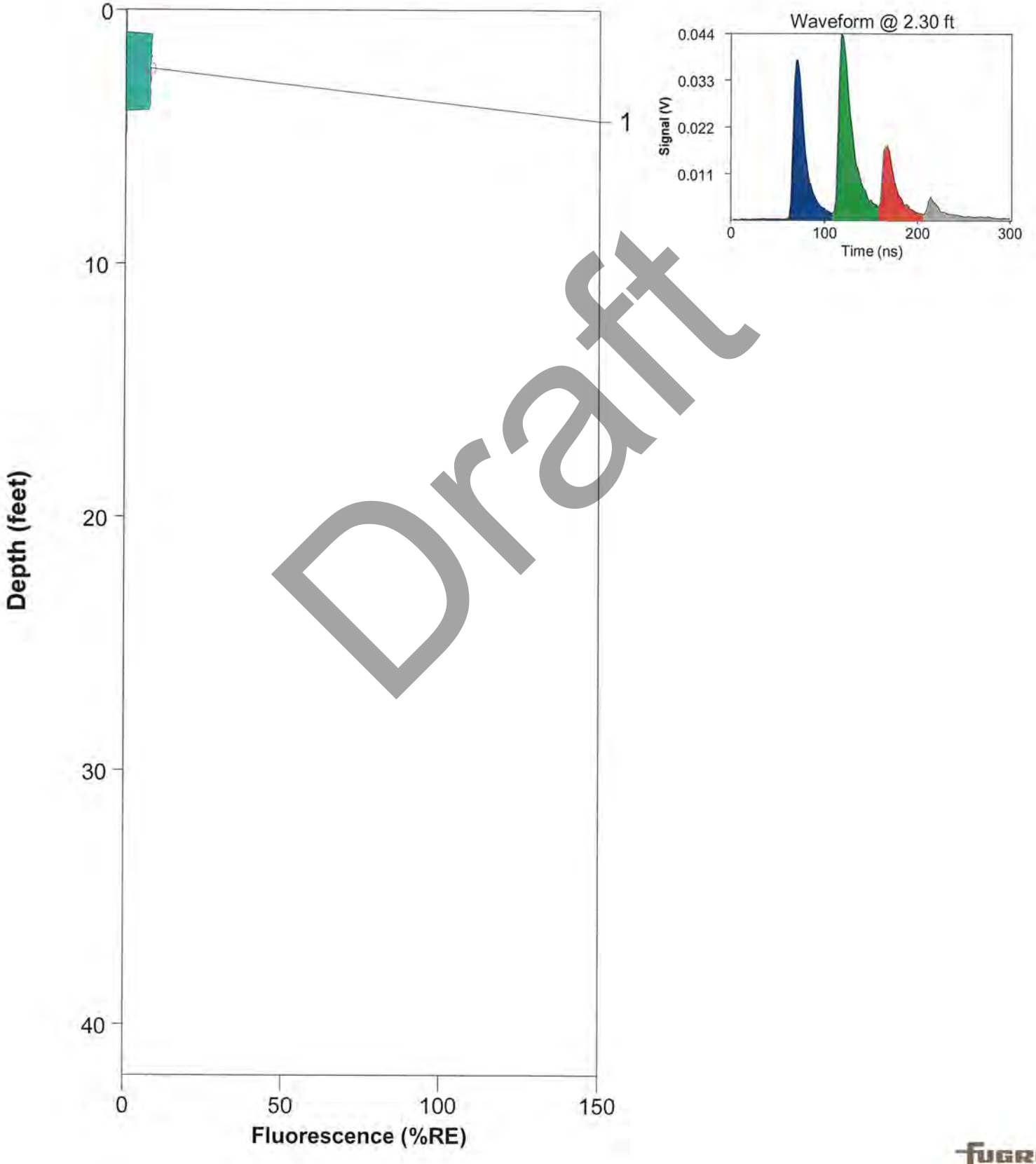


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 17:36:29	Max fluorescence: 8.39% @ 1.84 ft
ROST Unit: ?	Final depth BGS: 4.86 ft

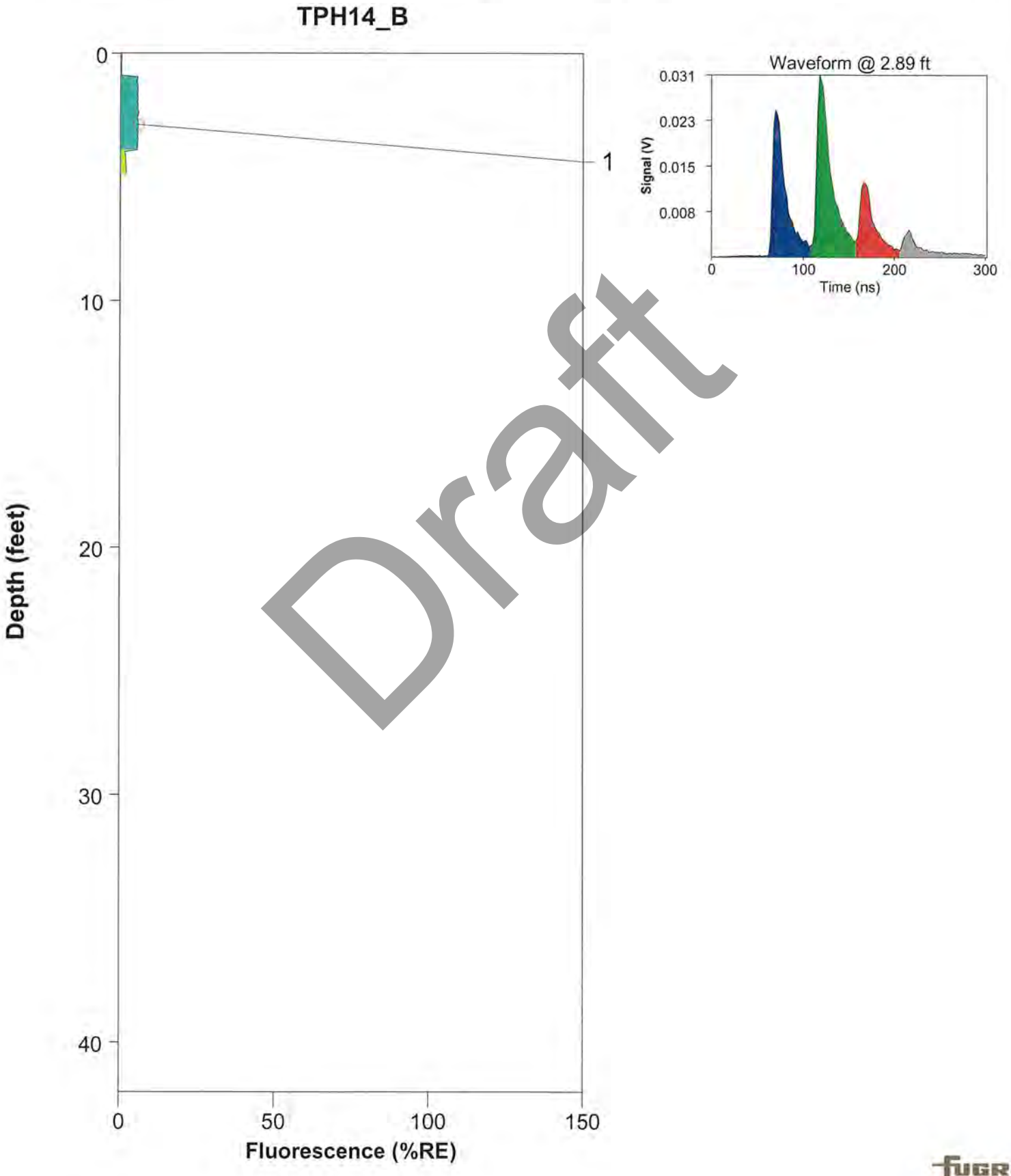
TPH14_A



Draft

ROST Fluorescence Response Data

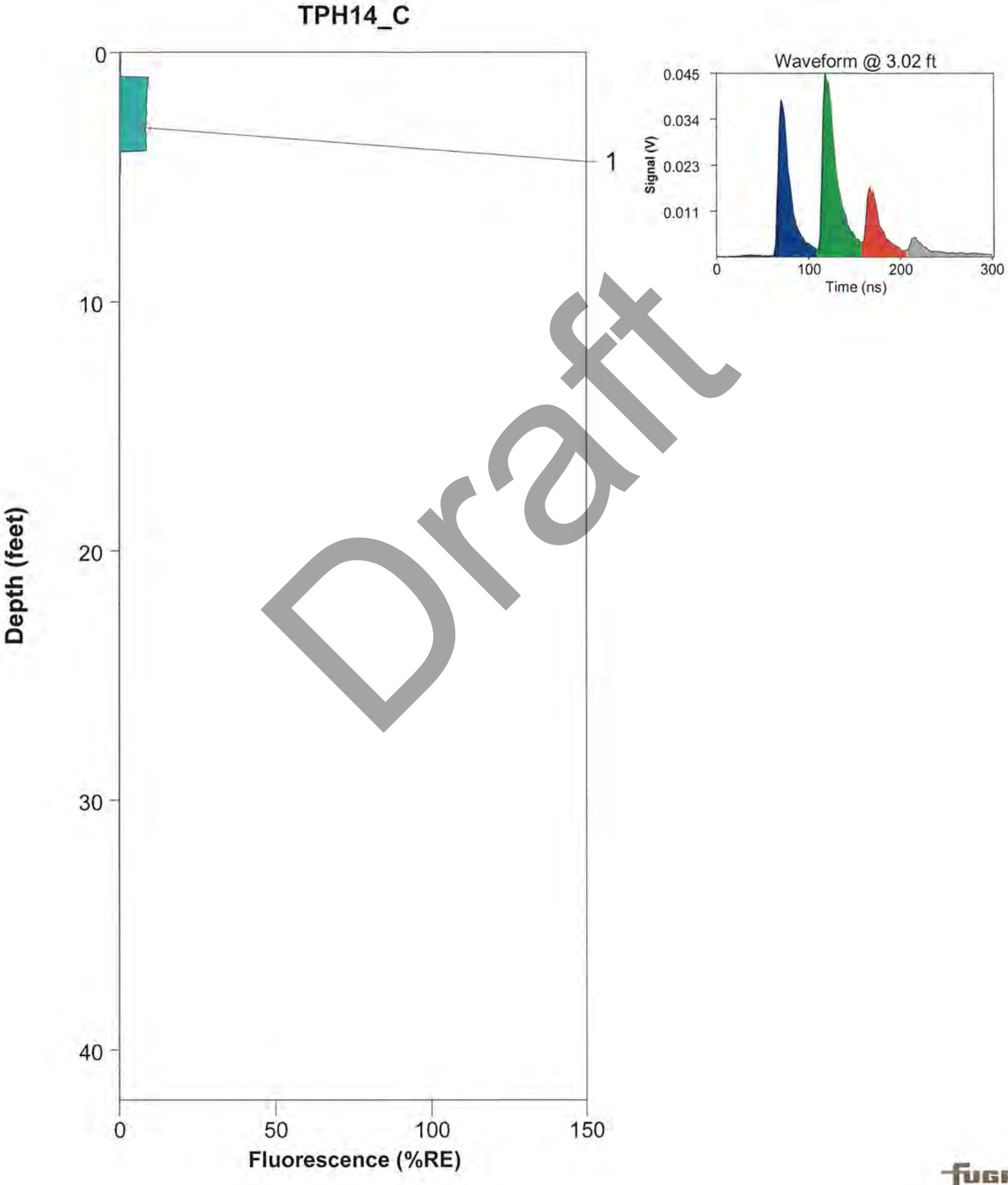
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 17:38:35	Max fluorescence: 5.92% @ 2.40 ft
ROST Unit: ?	Final depth BGS: 4.86 ft



Draft

ROST Fluorescence Response Data

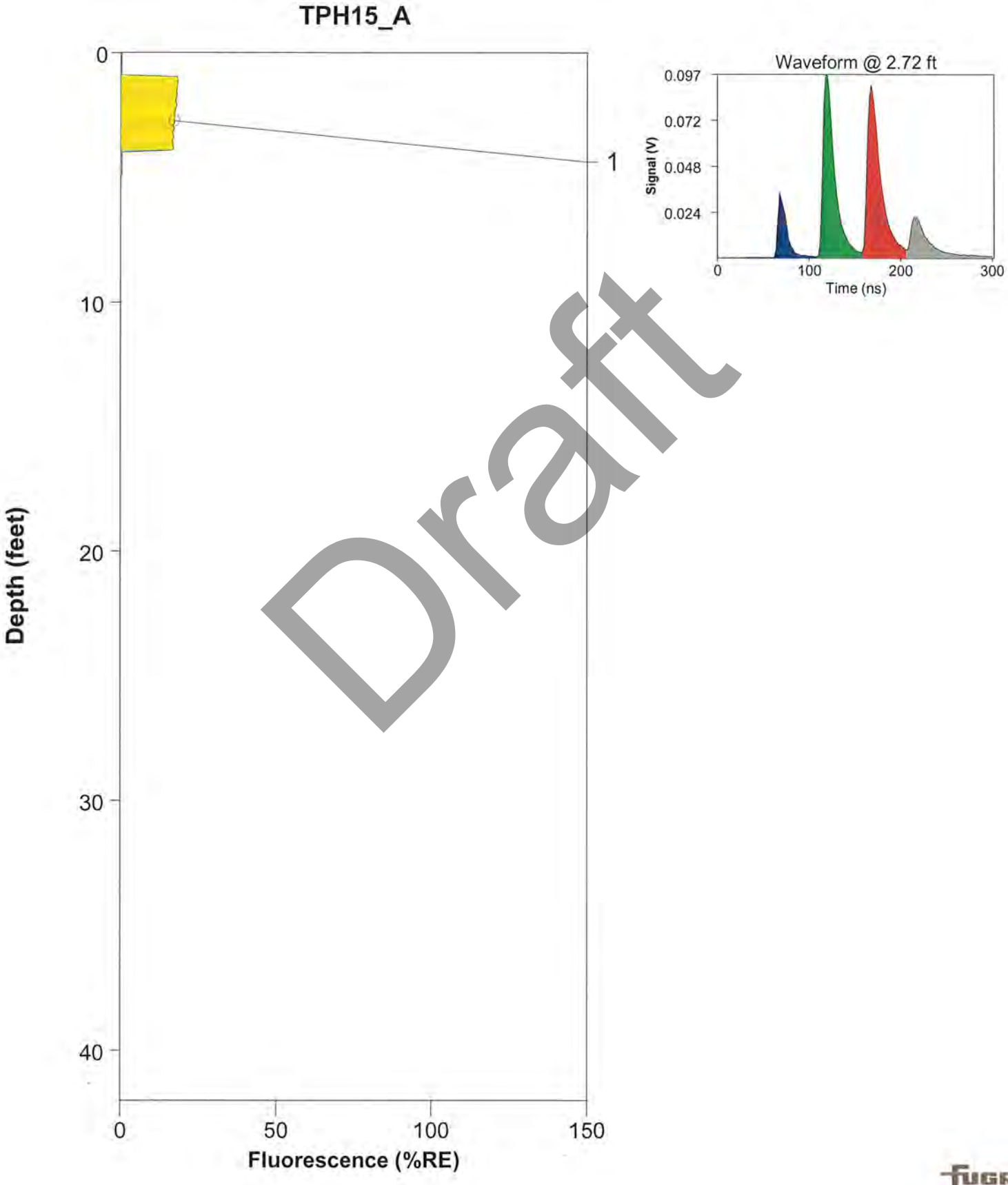
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 17:40:32	Max fluorescence: 9.22% @ 0.98 ft
ROST Unit: ?	Final depth BGS: 4.89 ft



Draft

ROST Fluorescence Response Data

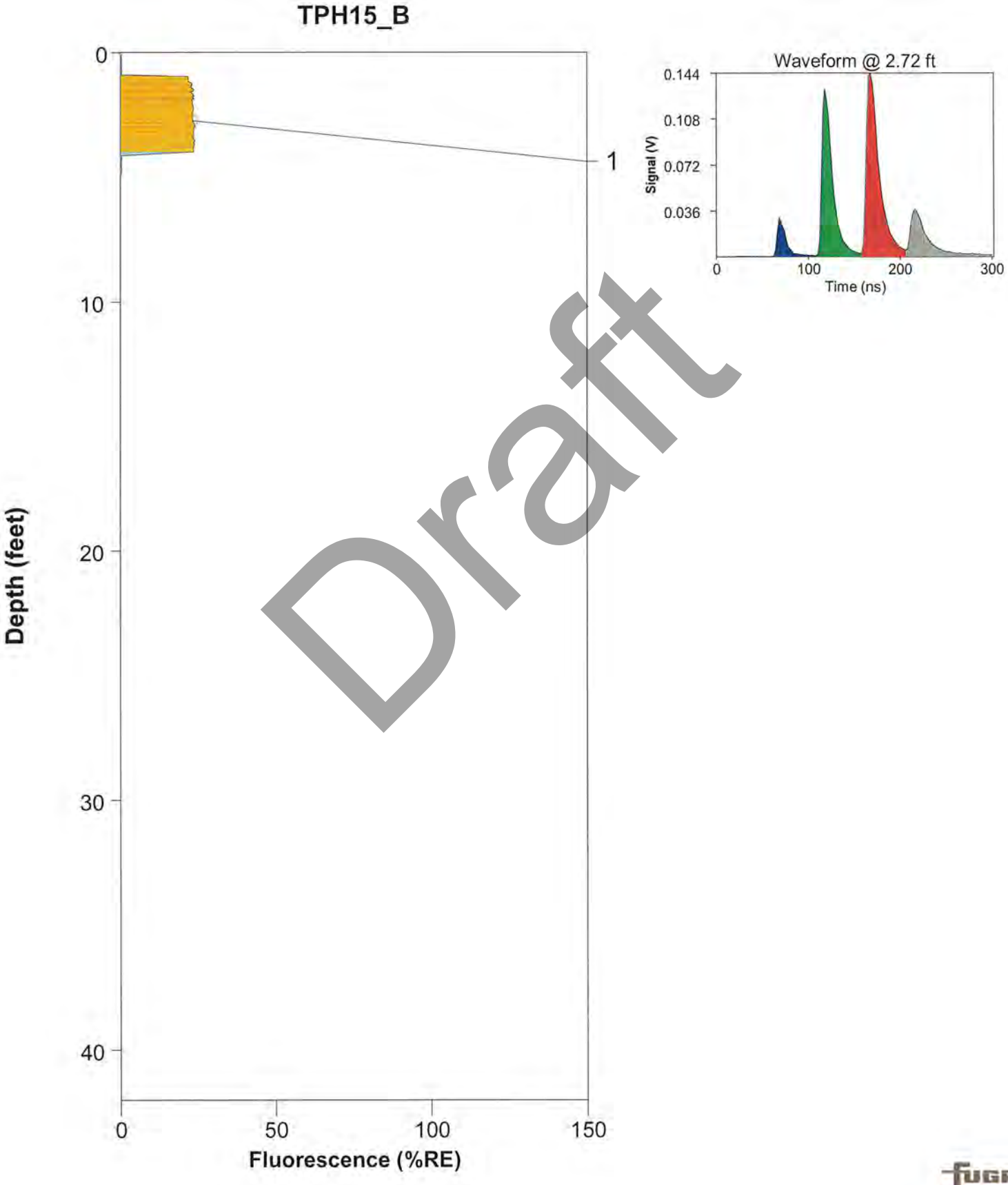
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 17:43:18	Max fluorescence: 18.42% @ 1.21 ft
ROST Unit: ?	Final depth BGS: 4.92 ft



Draft

ROST Fluorescence Response Data

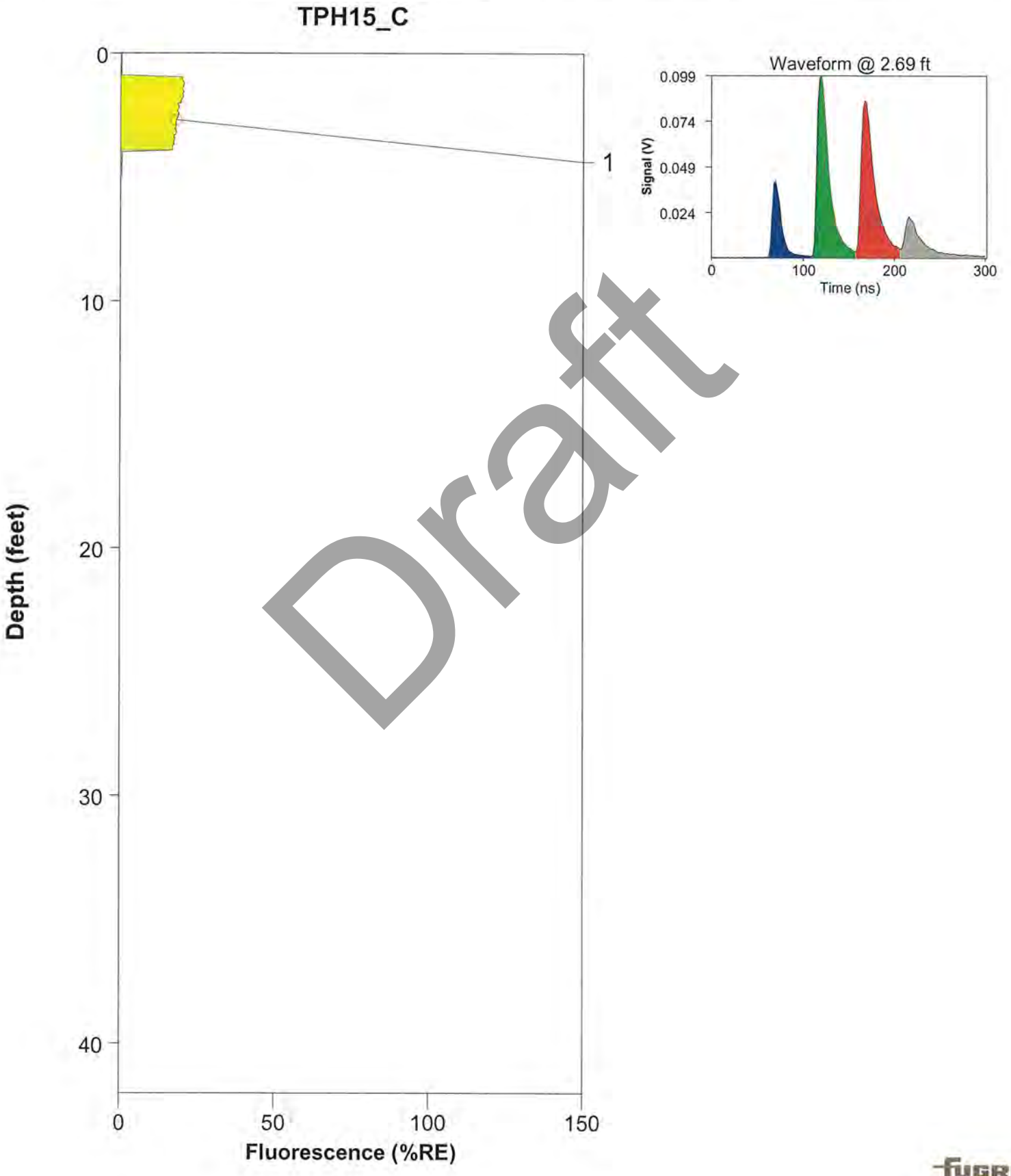
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 17:45:16	Max fluorescence: 24.24% @ 2.95 ft
ROST Unit: ?	Final depth BGS: 4.92 ft



Draft

ROST Fluorescence Response Data

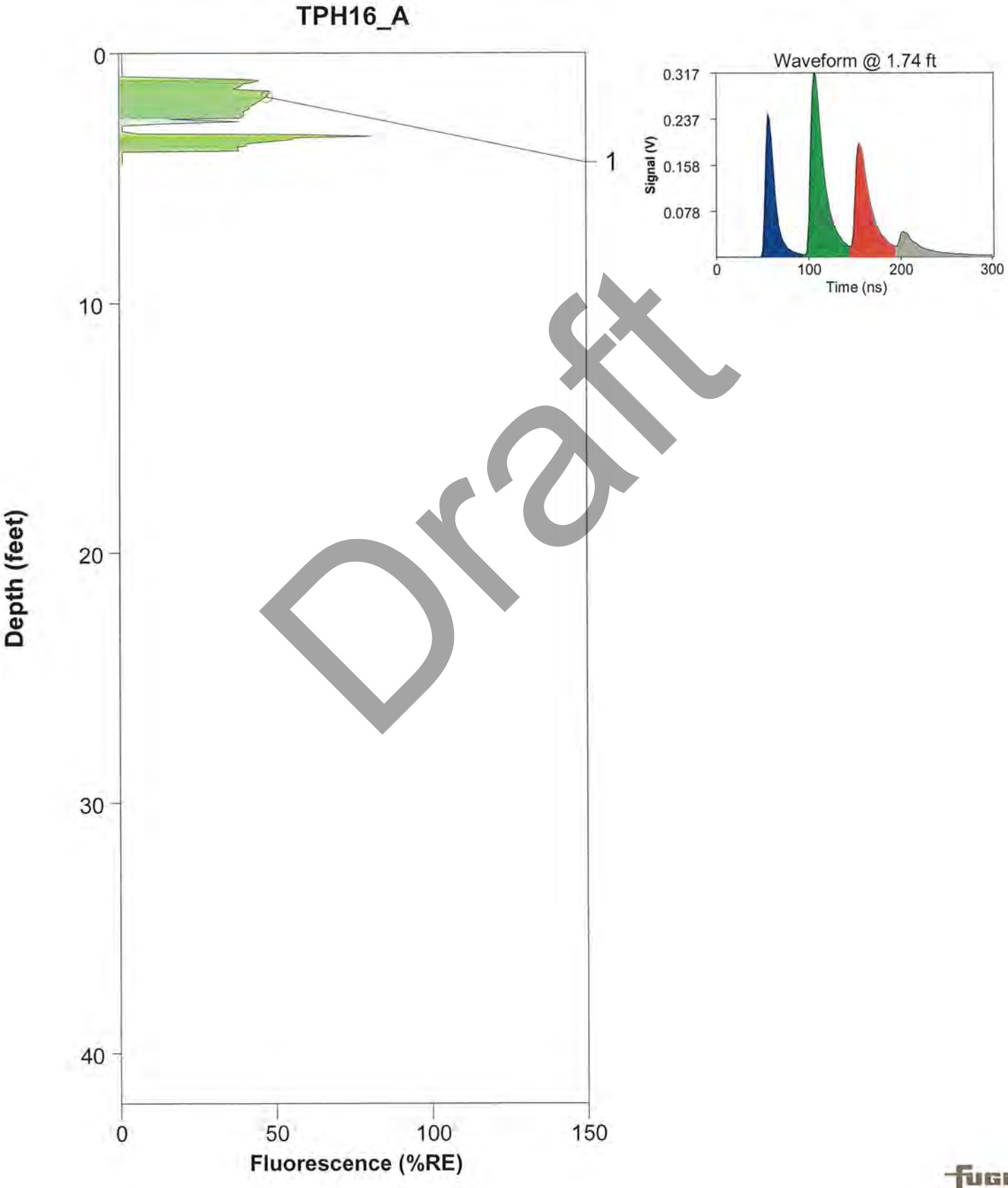
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 17:47:17	Max fluorescence: 20.60% @ 1.21 ft
ROST Unit: ?	Final depth BGS: 4.99 ft



Draft

ROST Fluorescence Response Data

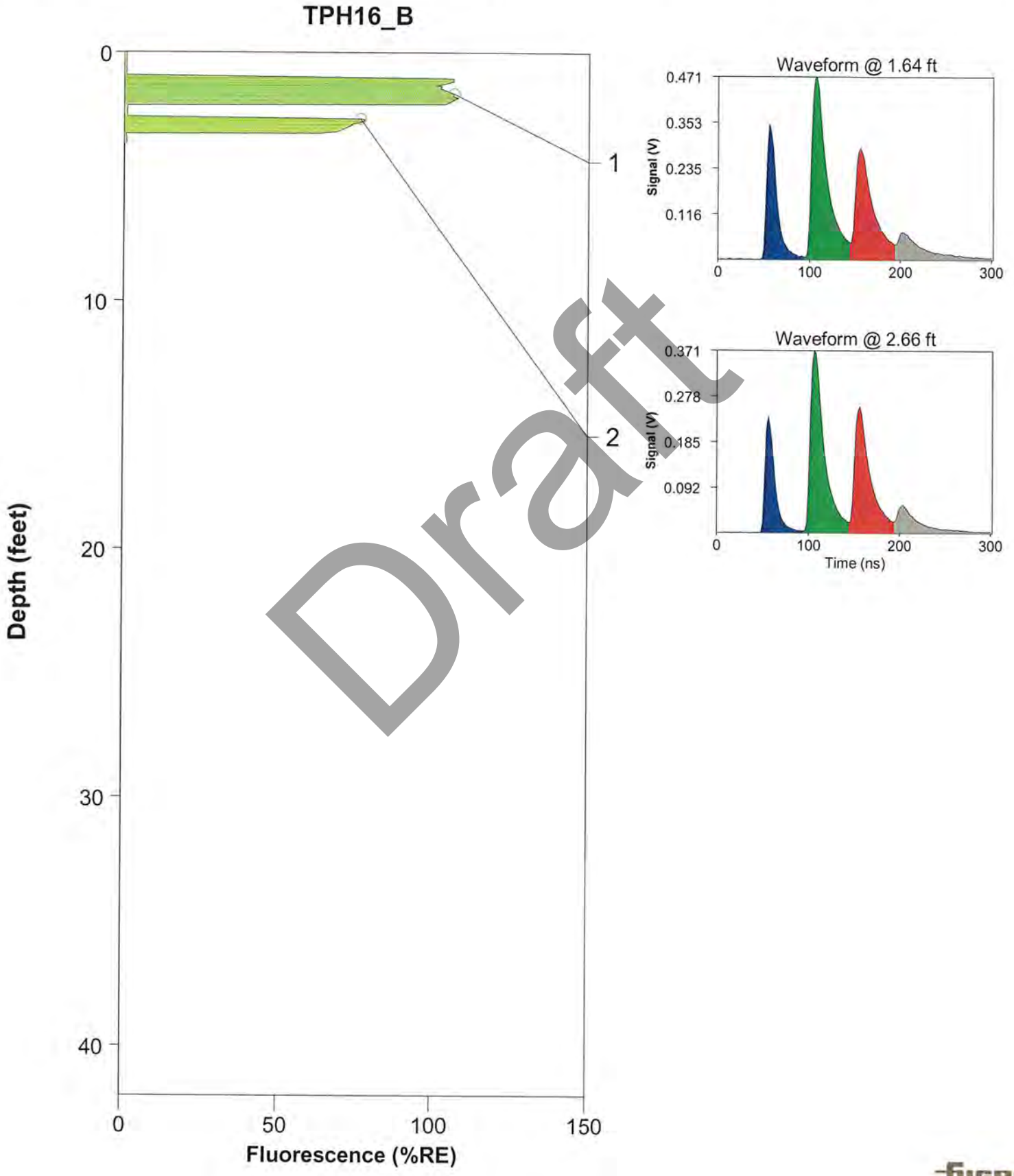
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-20-2002 @ 14:10:37	Max fluorescence: 80.85% @ 3.31 ft
ROST Unit: ?	Final depth BGS: 4.43 ft



Draft

ROST Fluorescence Response Data

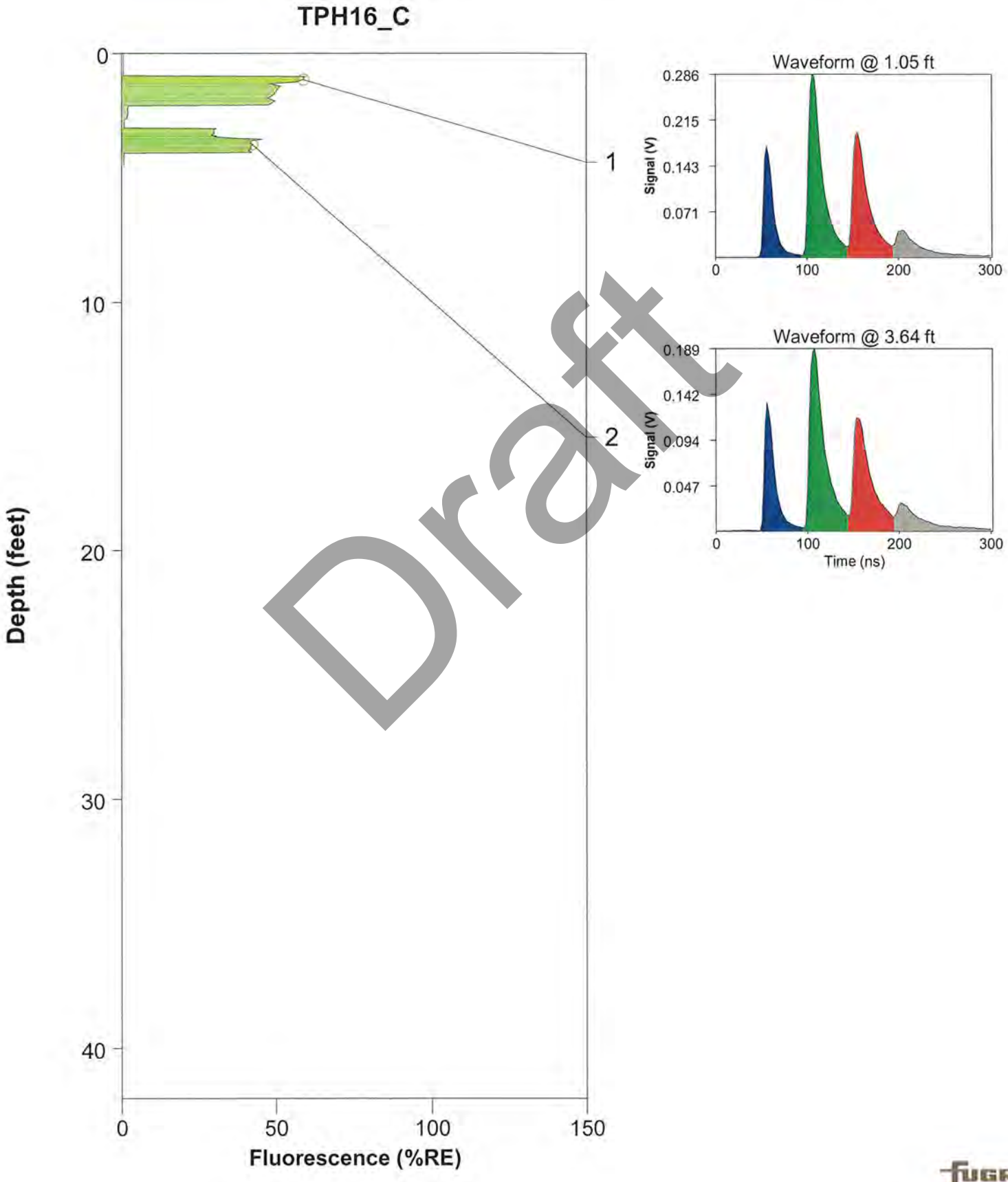
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-20-2002 @ 16:58:41	Max fluorescence: 107.54% @ 1.80 ft
ROST Unit: ?	Final depth BGS: 3.67 ft



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-20-2002 @ 17:03:47	Max fluorescence: 59.39% @ 0.92 ft
ROST Unit: ?	Final depth BGS: 4.49 ft

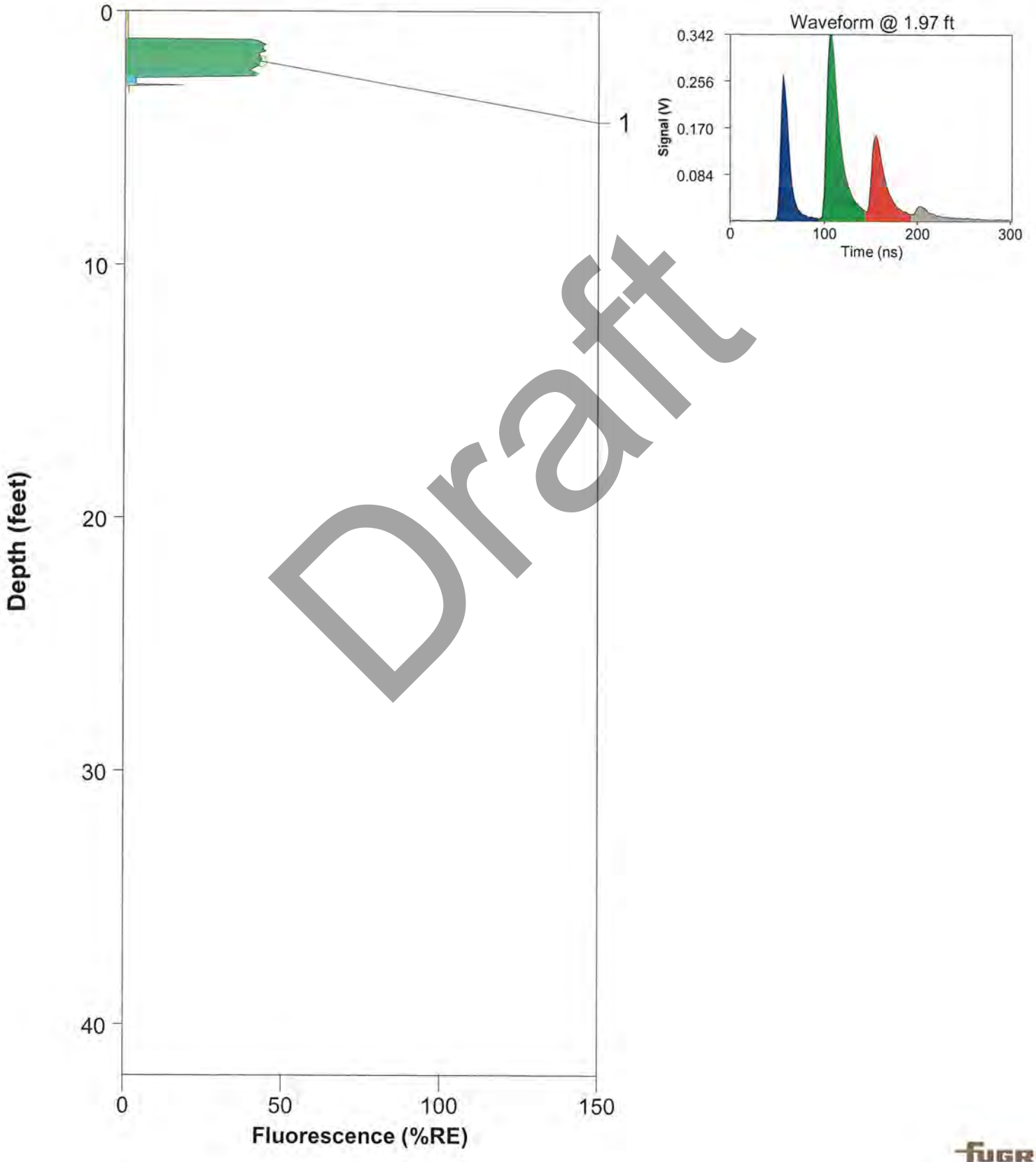


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-20-2002 @ 14:08:22	Max fluorescence: 44.50% @ 1.31 ft
ROST Unit: ?	Final depth BGS: 3.25 ft

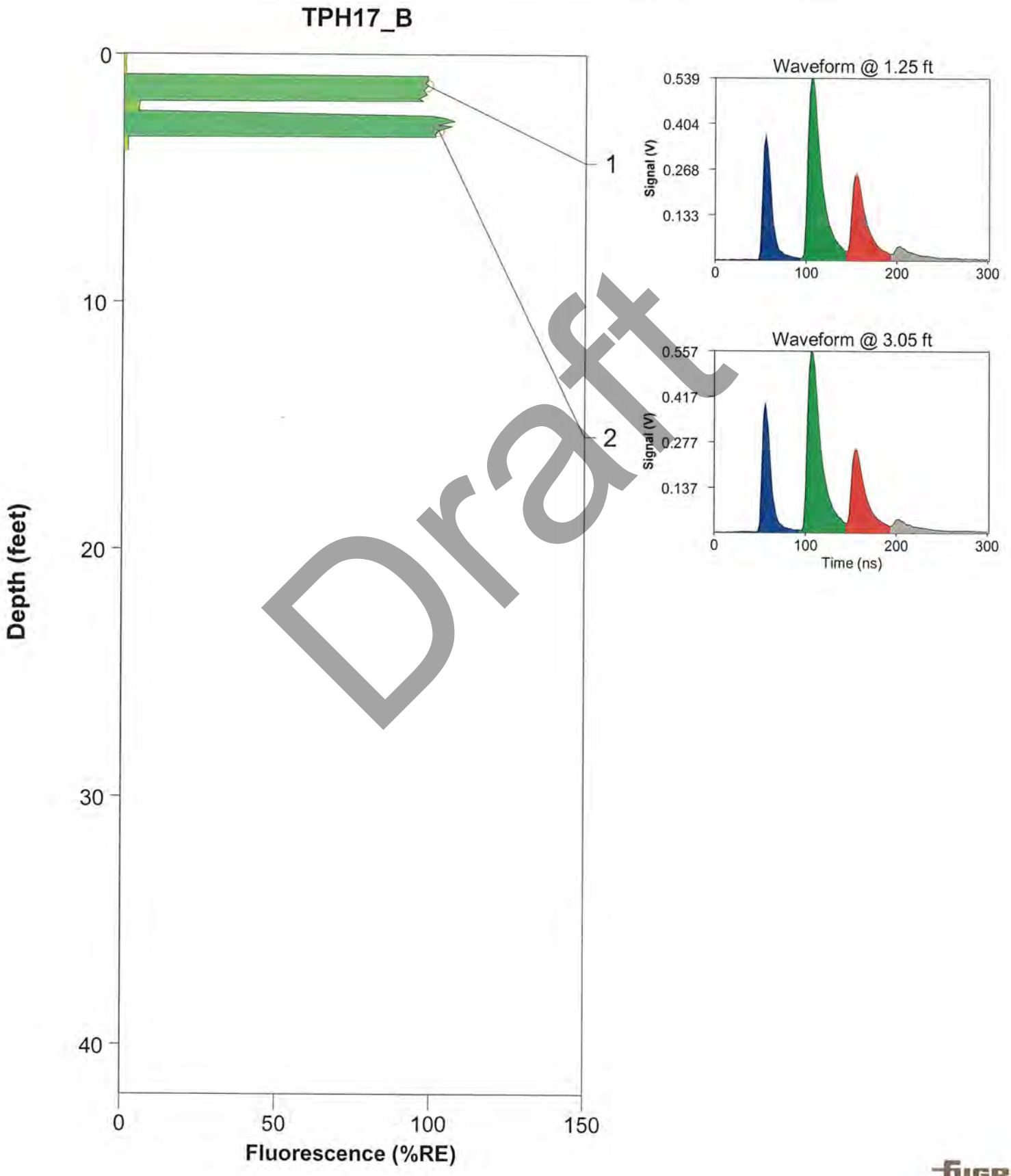
TPH17_A



Draft

ROST Fluorescence Response Data

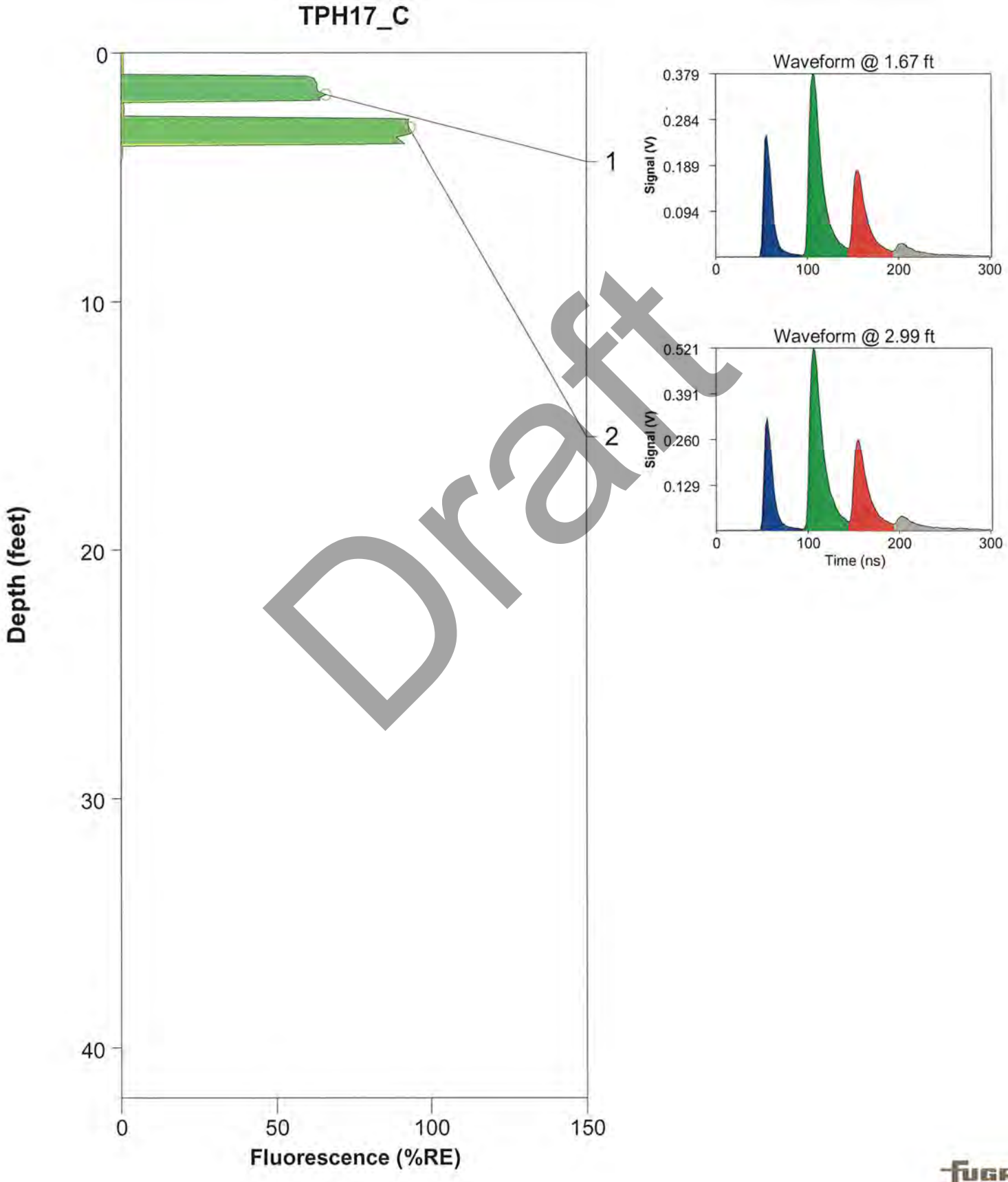
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-20-2002 @ 17:16:05	Max fluorescence: 107.15% @ 2.69 ft
ROST Unit: ?	Final depth BGS: 3.90 ft



Draft

ROST Fluorescence Response Data

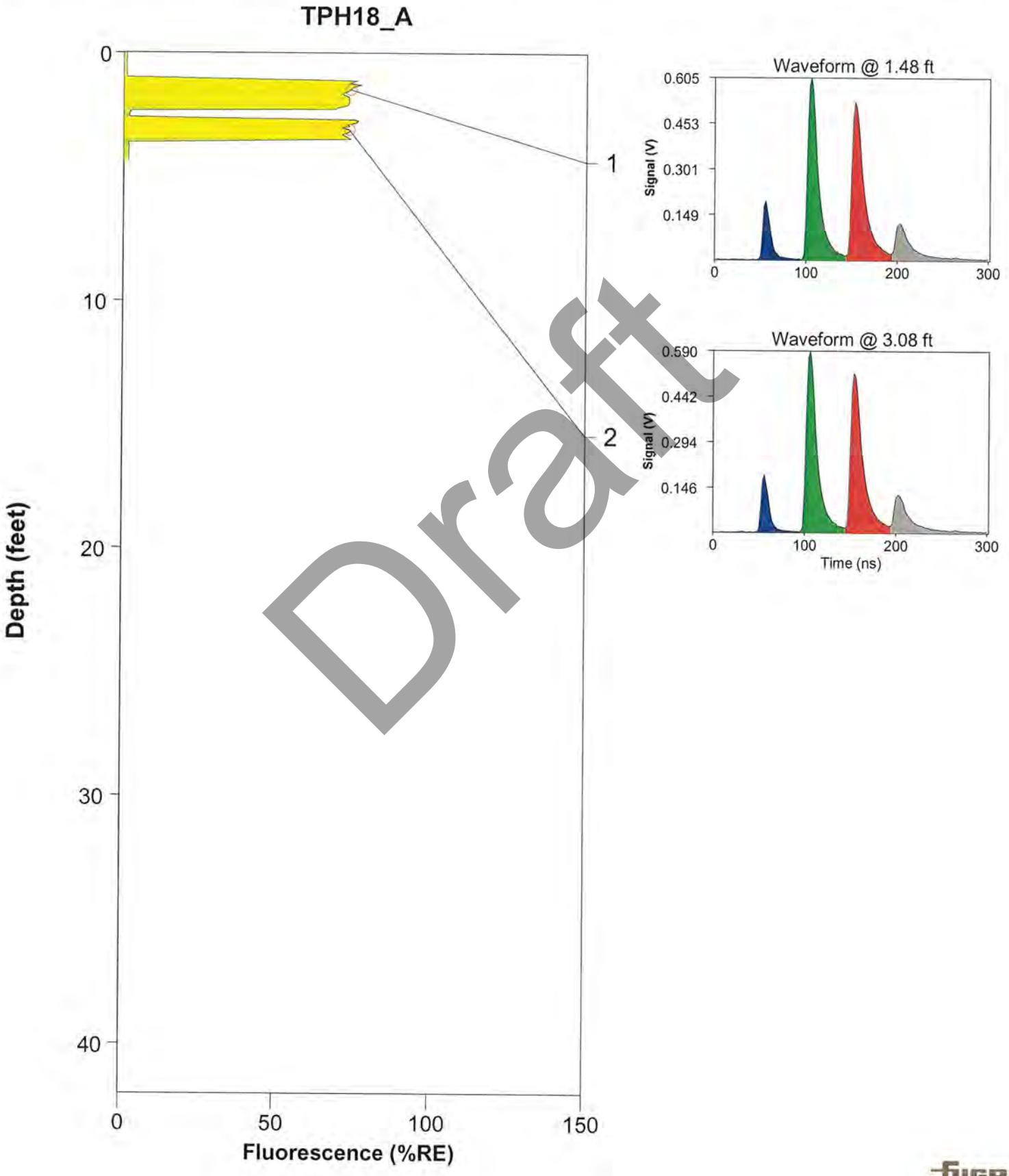
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-20-2002 @ 17:17:45	Max fluorescence: 93.49% @ 3.25 ft
ROST Unit: ?	Final depth BGS: 4.27 ft



Draft

ROST Fluorescence Response Data

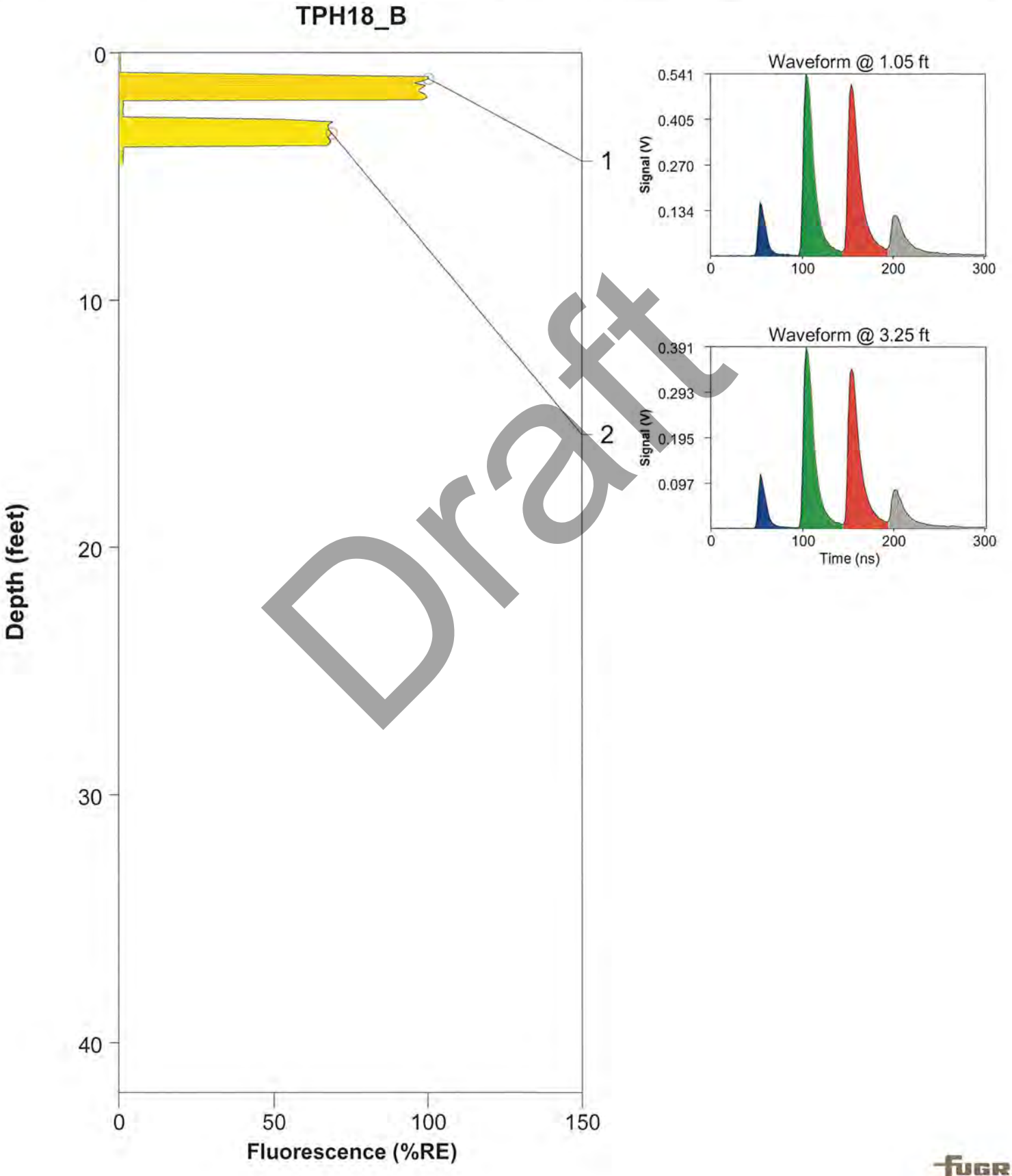
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-20-2002 @ 14:14:04	Max fluorescence: 76.91% @ 1.28 ft
ROST Unit: ?	Final depth BGS: 4.40 ft



Draft

ROST Fluorescence Response Data

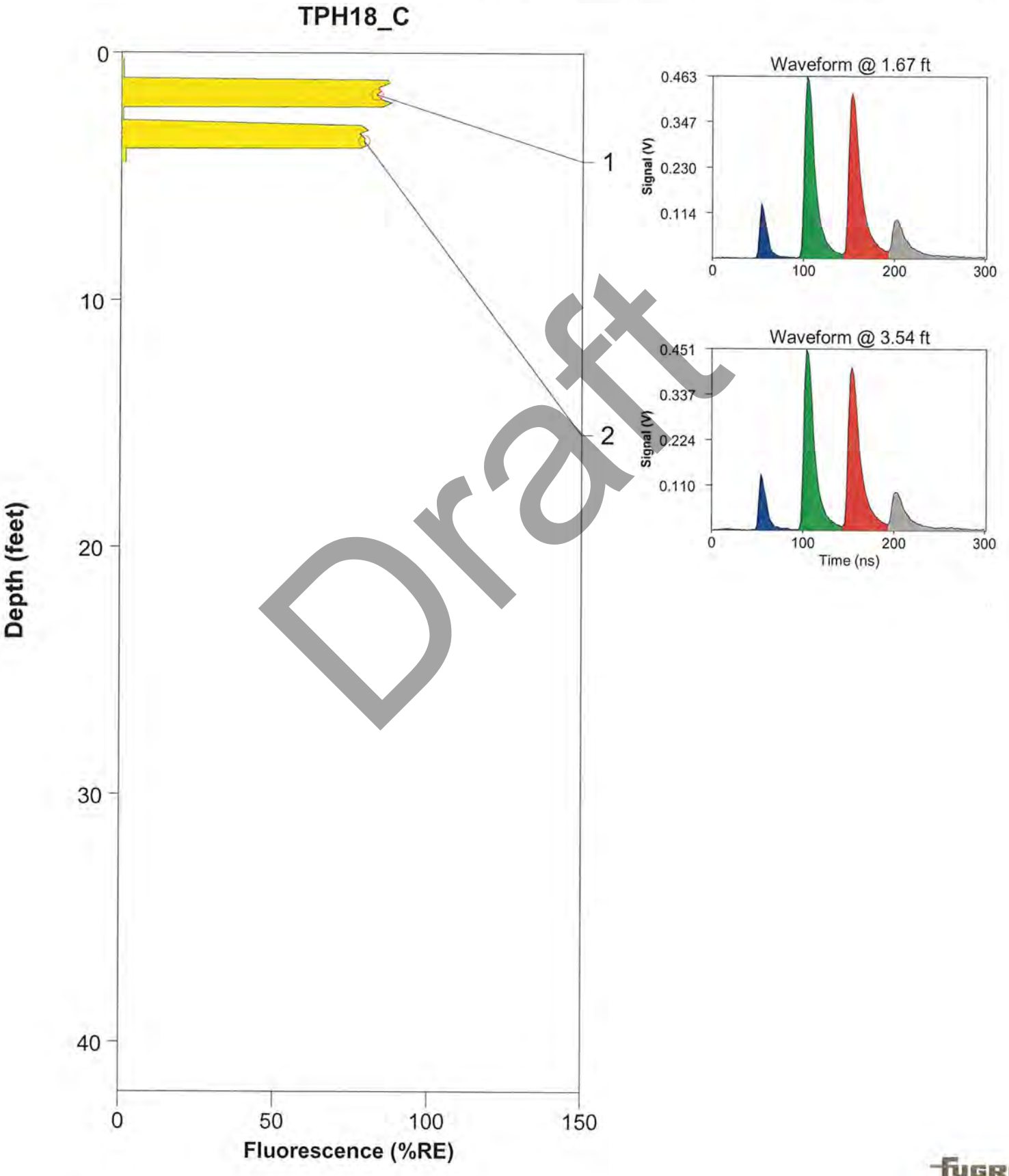
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-20-2002 @ 17:12:54	Max fluorescence: 100.29% @ 1.05 ft
ROST Unit: ?	Final depth BGS: 4.49 ft



Draft

ROST Fluorescence Response Data

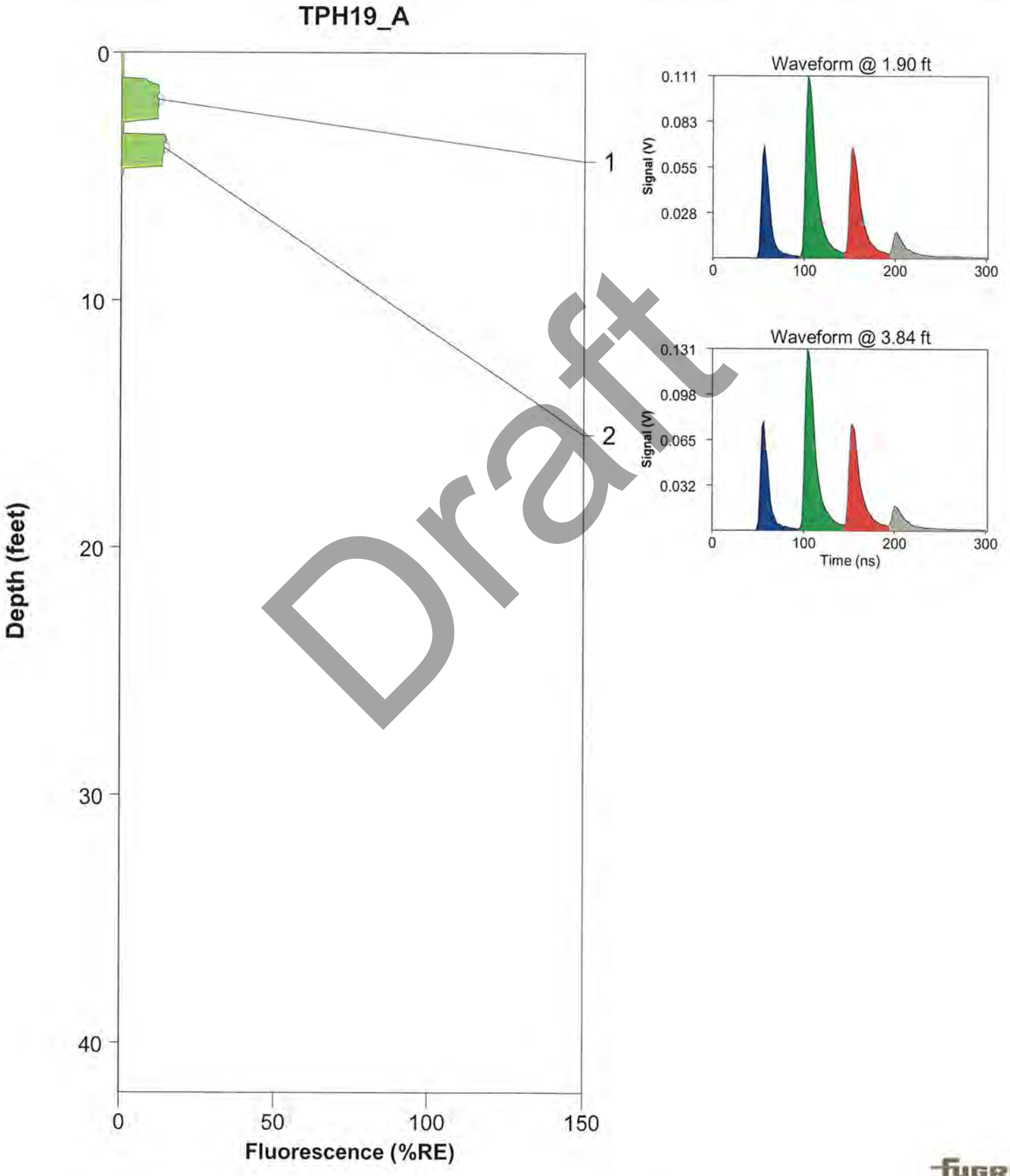
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-20-2002 @ 17:14:24	Max fluorescence: 87.51% @ 2.00 ft
ROST Unit: ?	Final depth BGS: 4.46 ft



Draft

ROST Fluorescence Response Data

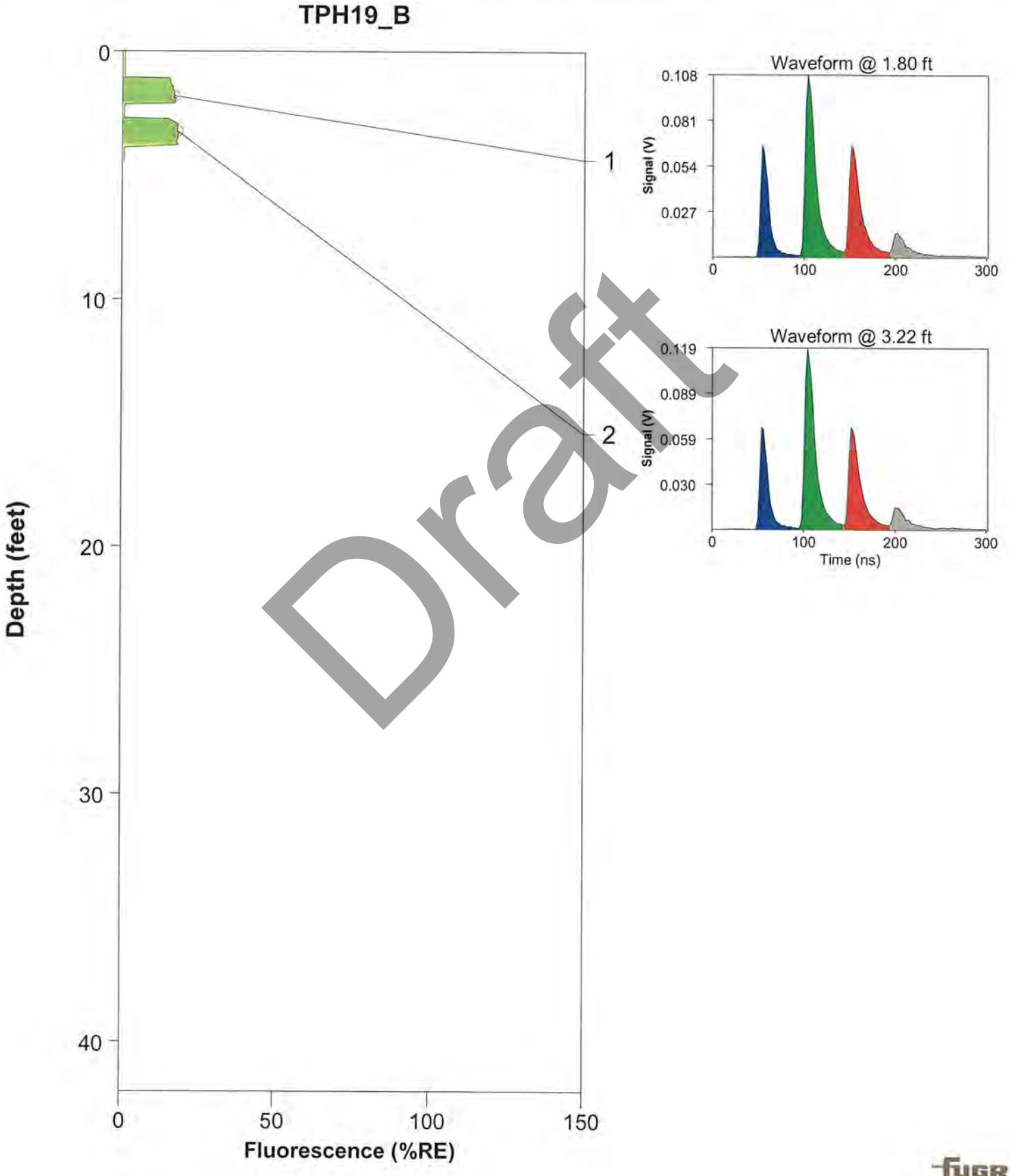
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-20-2002 @ 14:16:21	Max fluorescence: 14.55% @ 3.54 ft
ROST Unit: ?	Final depth BGS: 4.95 ft



Draft

ROST Fluorescence Response Data

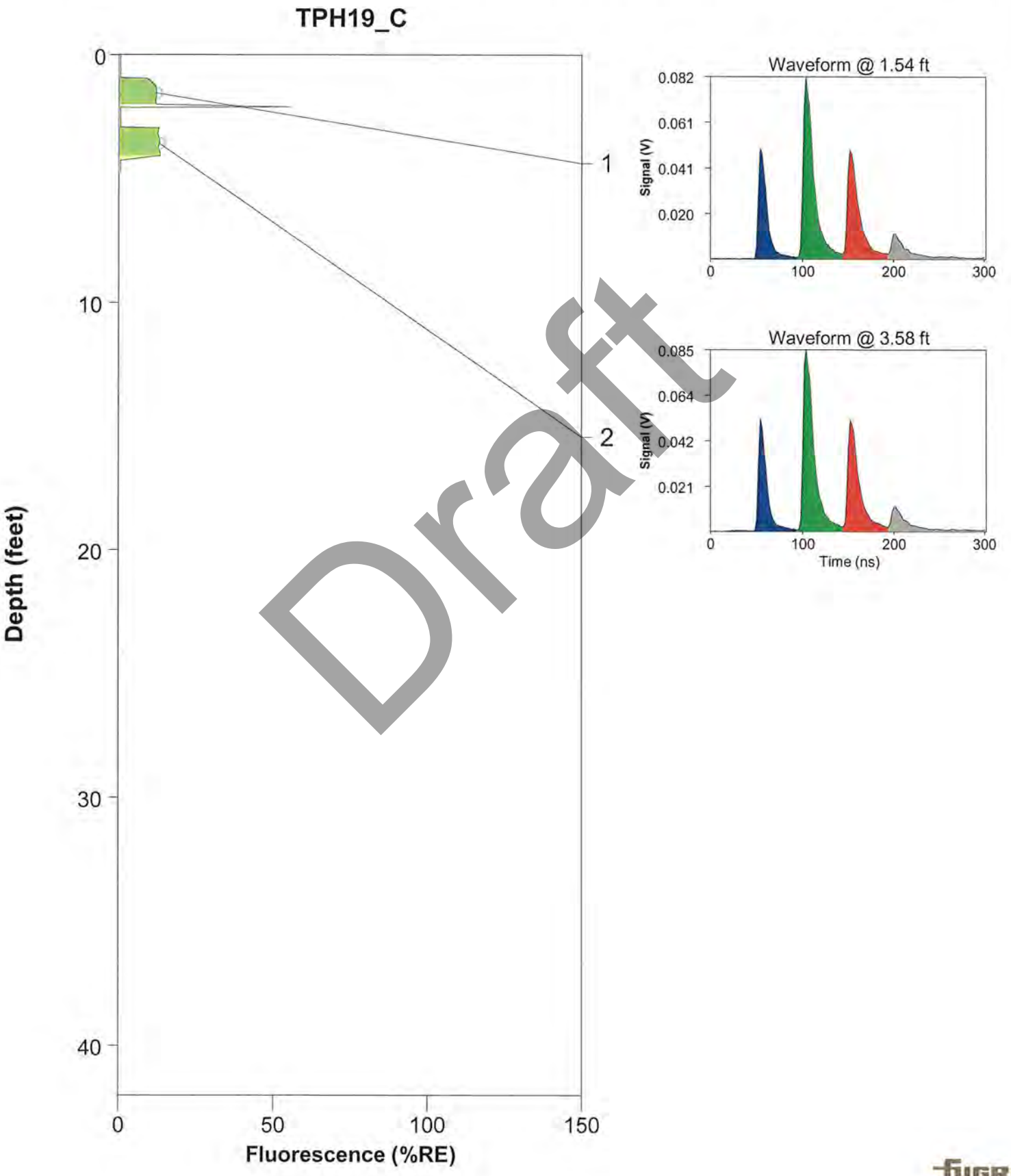
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-20-2002 @ 17:06:20	Max fluorescence: 18.62% @ 3.28 ft
ROST Unit: ?	Final depth BGS: 4.46 ft



Draft

ROST Fluorescence Response Data

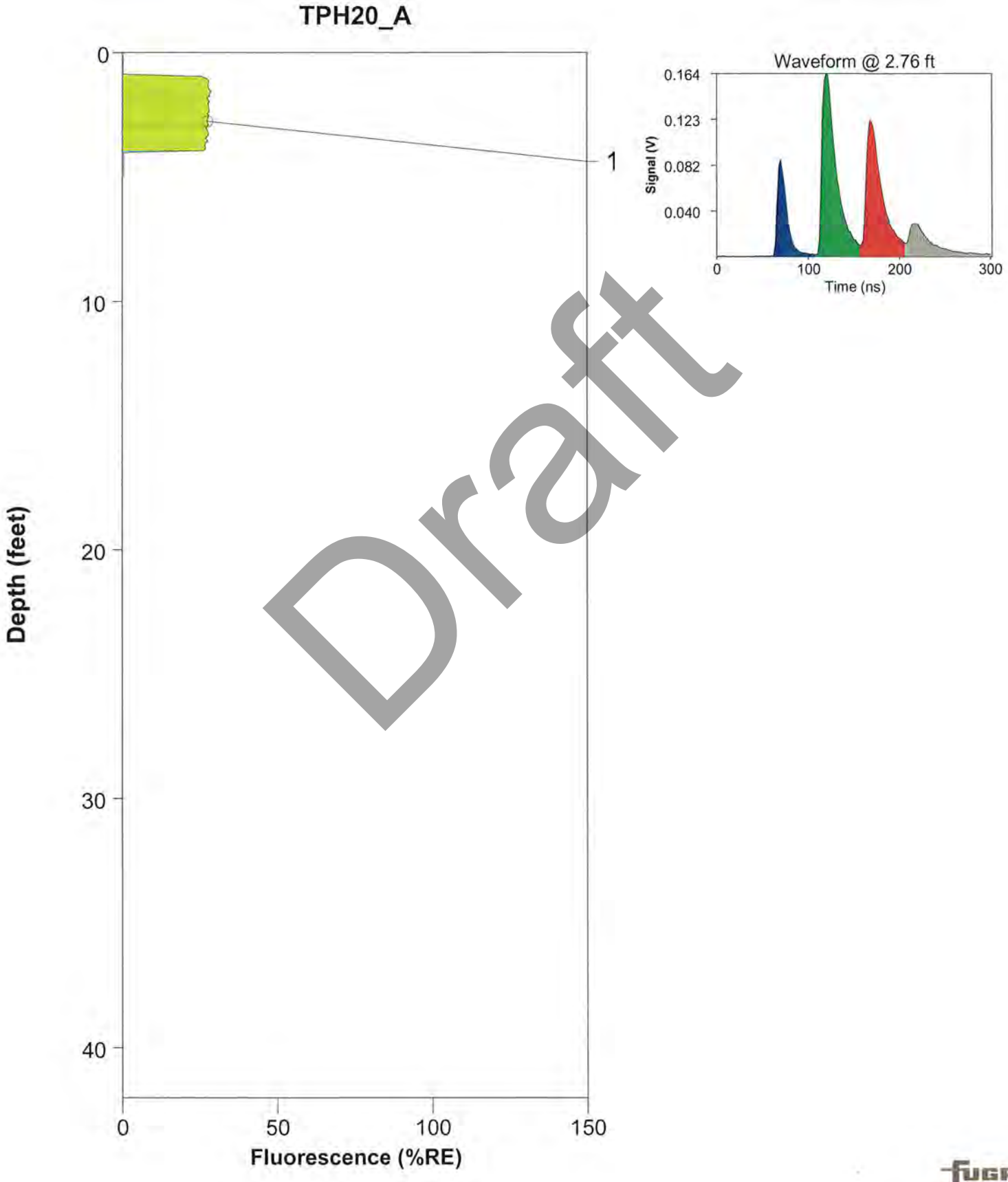
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-20-2002 @ 17:10:37	Max fluorescence: 55.33% @ 2.10 ft
ROST Unit: ?	Final depth BGS: 4.76 ft



Draft

ROST Fluorescence Response Data

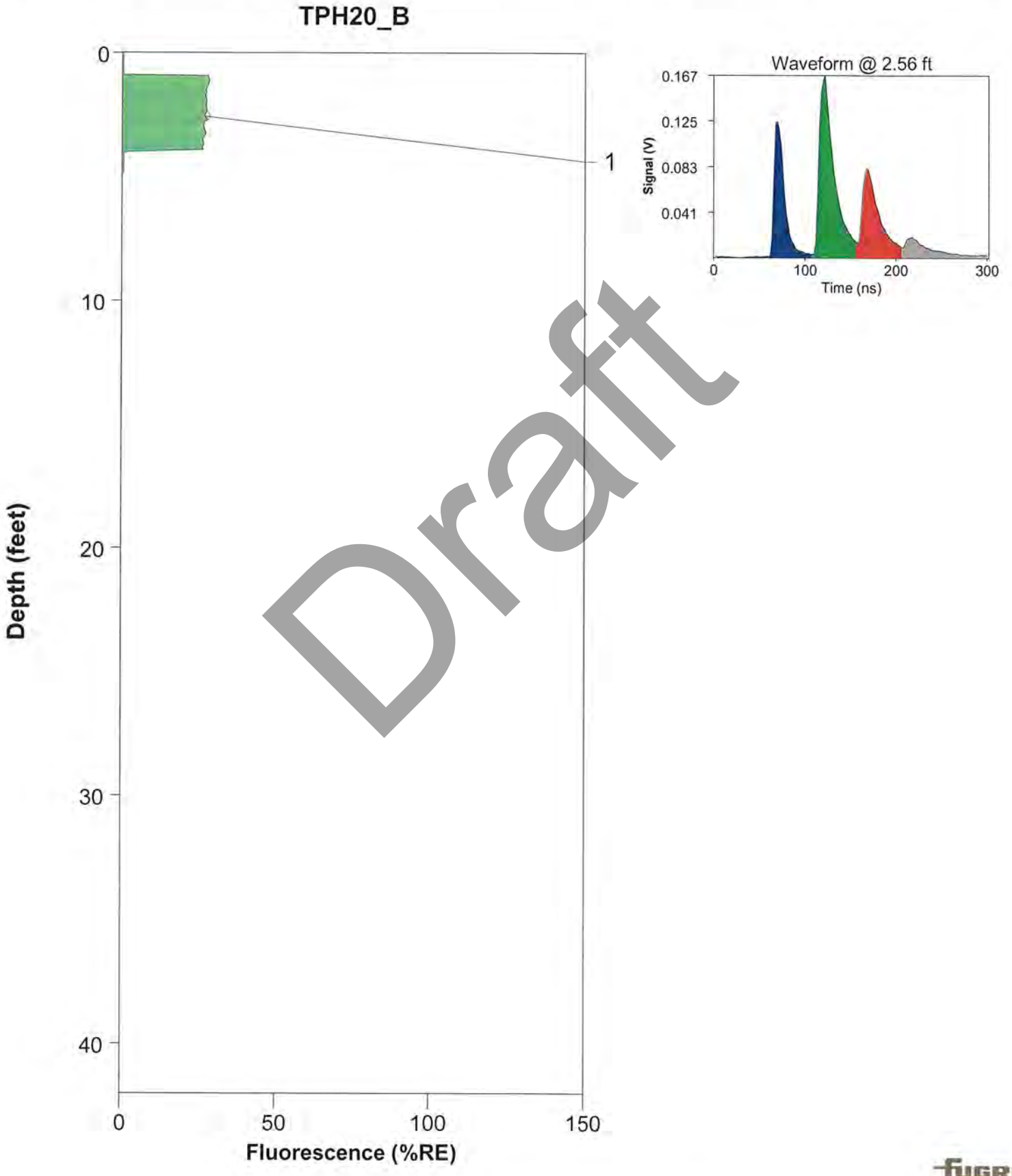
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 18:21:02	Max fluorescence: 28.70% @ 1.57 ft
ROST Unit: ?	Final depth BGS: 4.95 ft



Draft

ROST Fluorescence Response Data

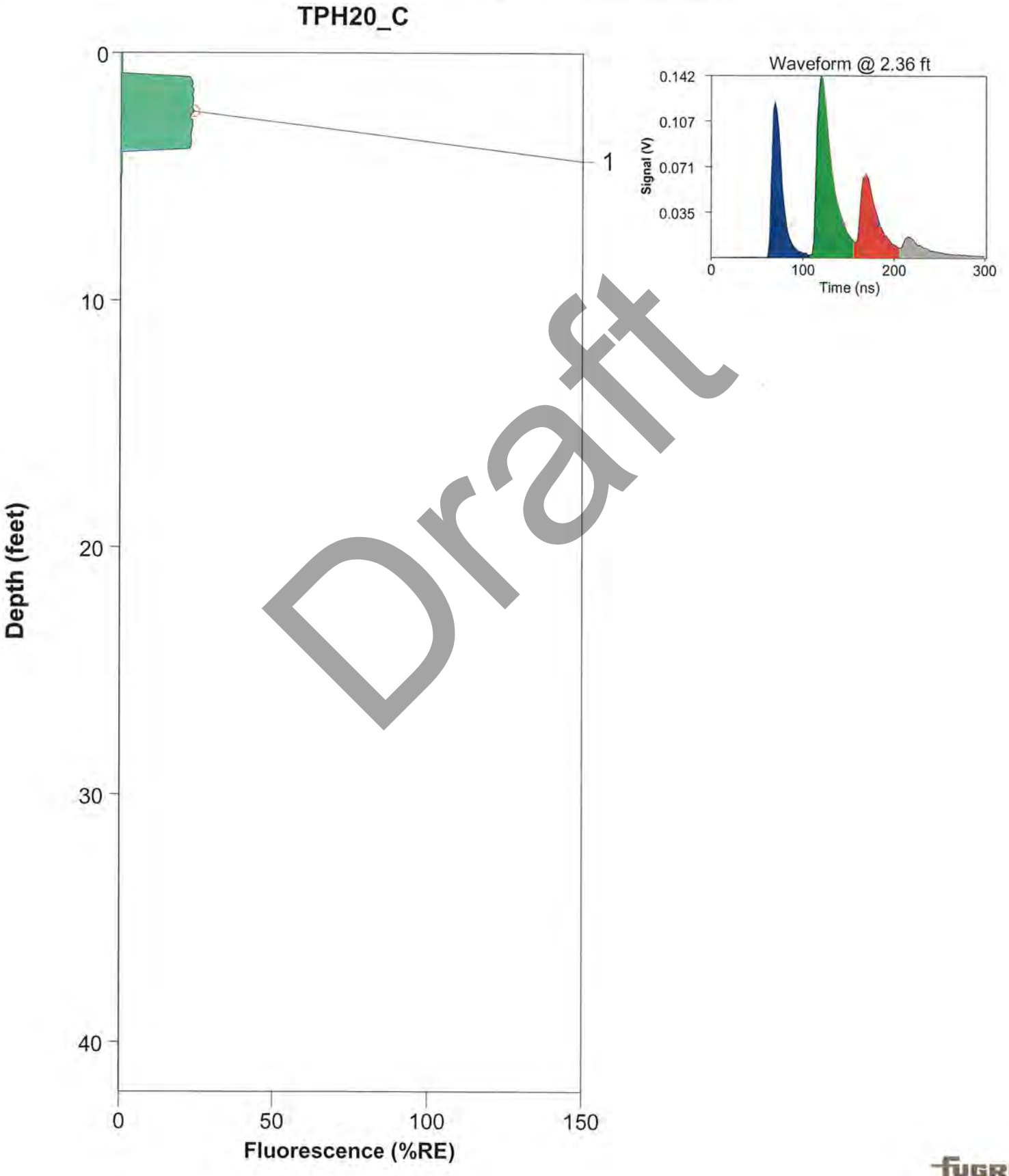
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 18:22:42	Max fluorescence: 28.25% @ 1.08 ft
ROST Unit: ?	Final depth BGS: 4.86 ft



Draft

ROST Fluorescence Response Data

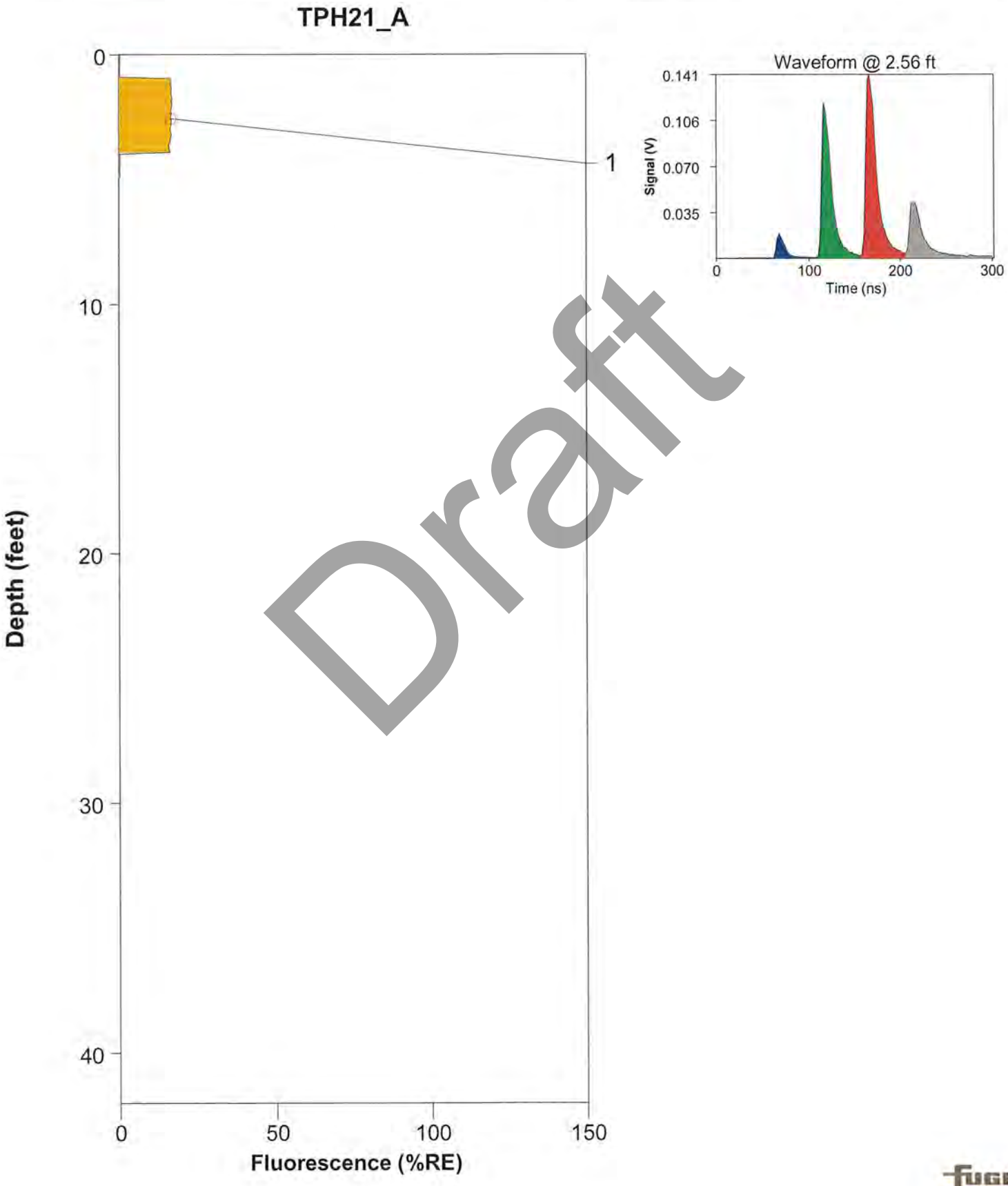
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 18:24:23	Max fluorescence: 23.81% @ 2.36 ft
ROST Unit: ?	Final depth BGS: 4.92 ft



Draft

ROST Fluorescence Response Data

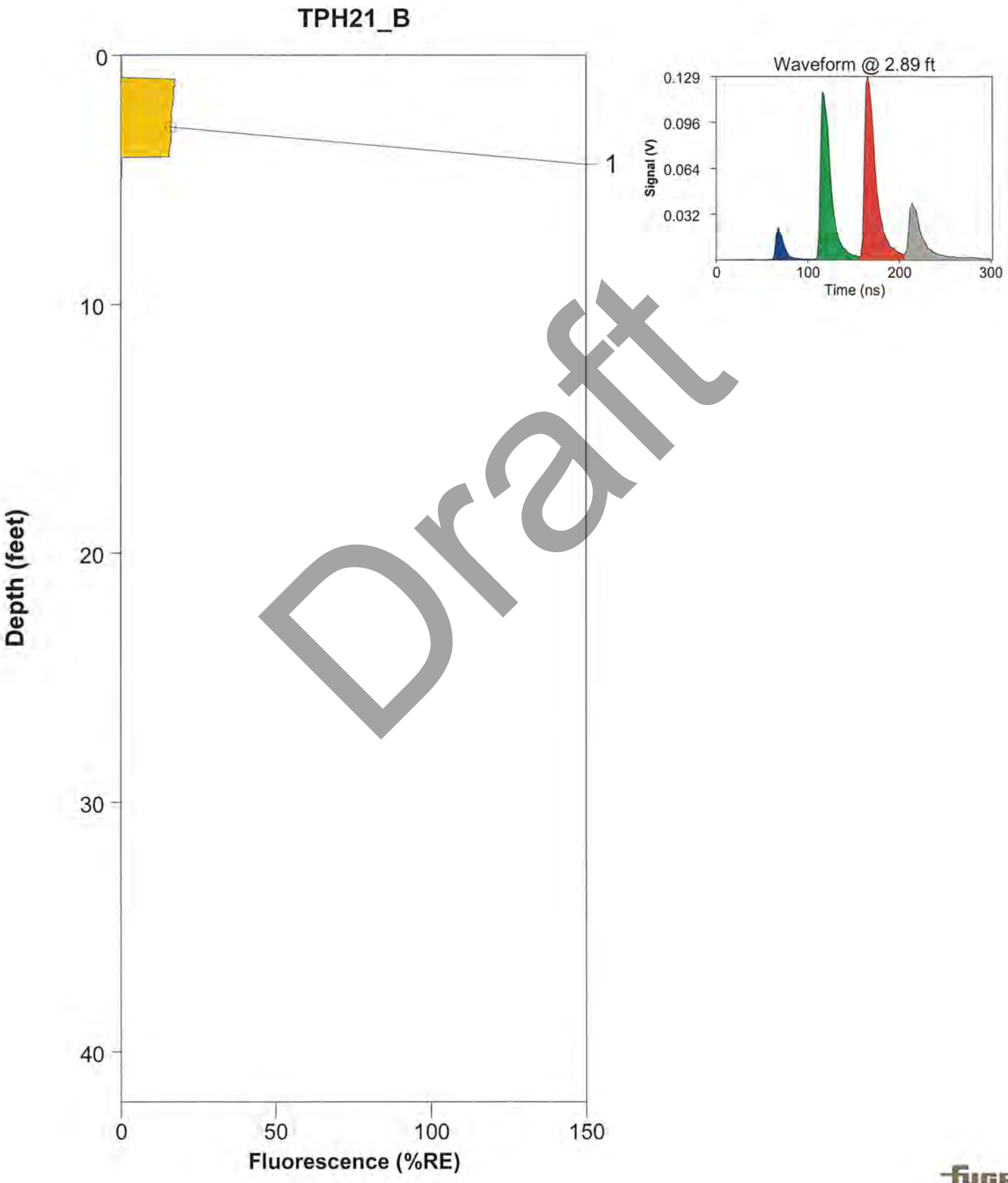
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 18:27:11	Max fluorescence: 17.12% @ 1.77 ft
ROST Unit: ?	Final depth BGS: 4.92 ft



Draft

ROST Fluorescence Response Data

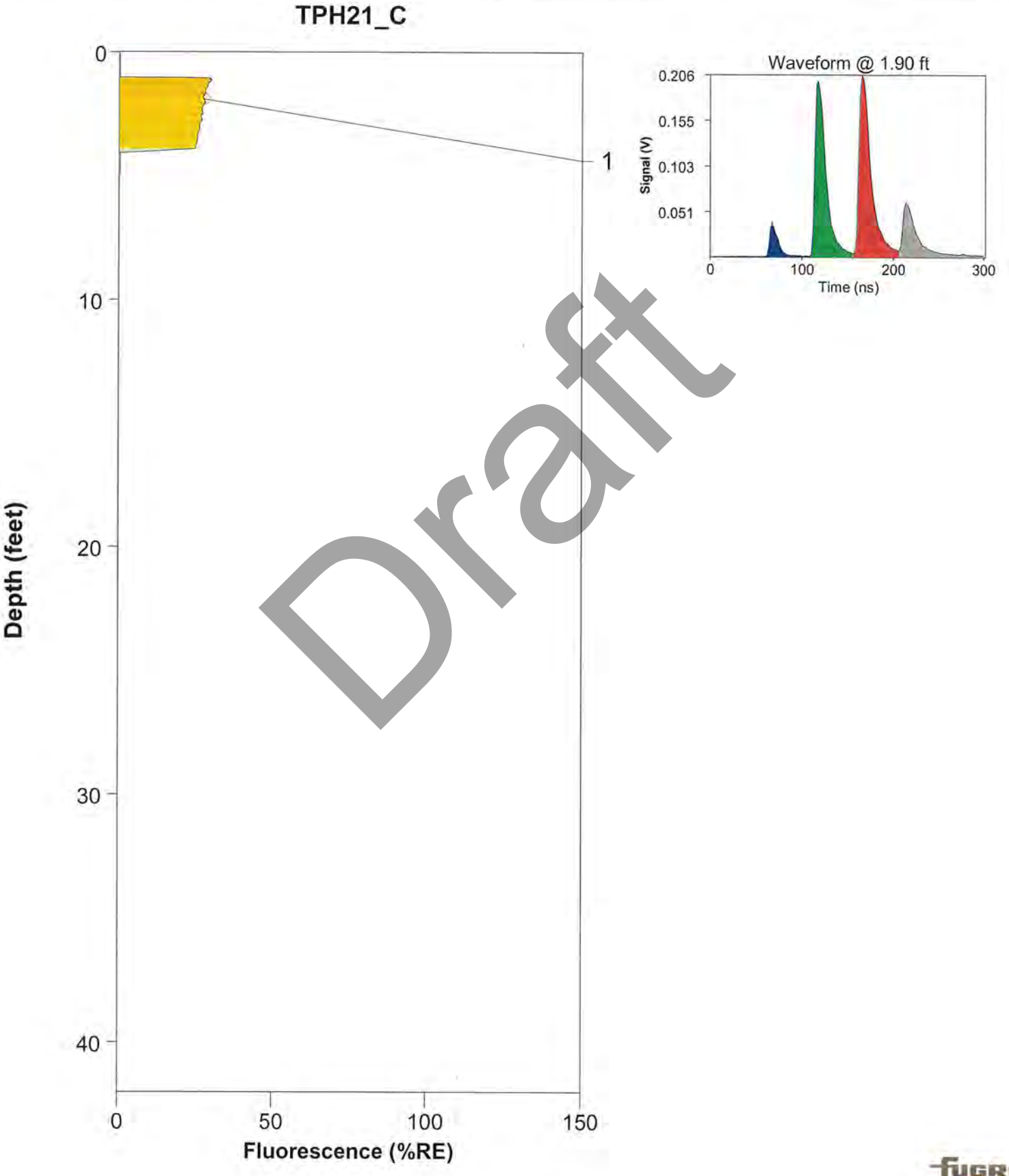
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 18:29:38	Max fluorescence: 17.61% @ 0.95 ft
ROST Unit: ?	Final depth BGS: 4.92 ft



Draft

ROST Fluorescence Response Data

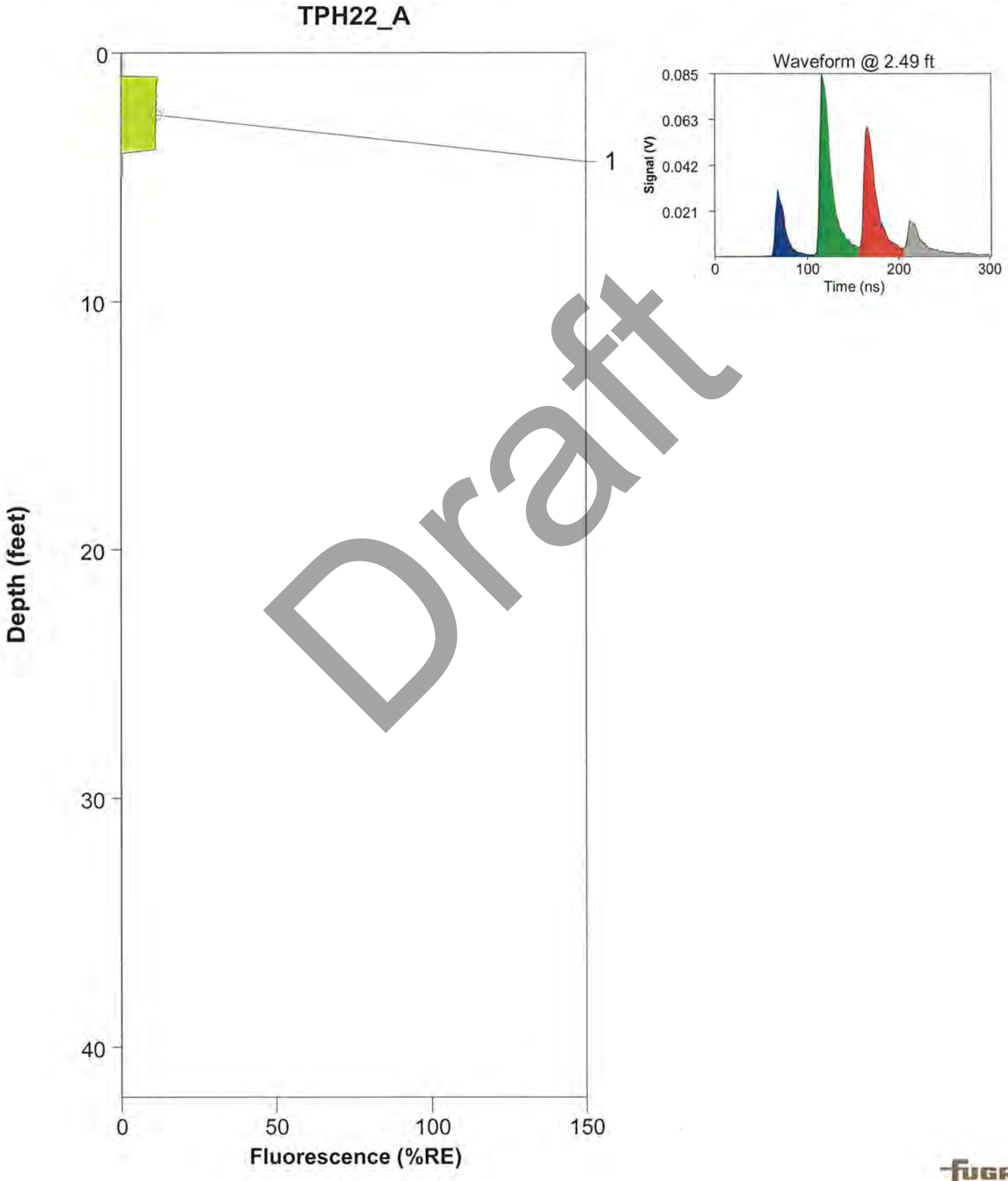
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 18:31:39	Max fluorescence: 30.05% @ 1.12 ft
ROST Unit: ?	Final depth BGS: 4.95 ft



Draft

ROST Fluorescence Response Data

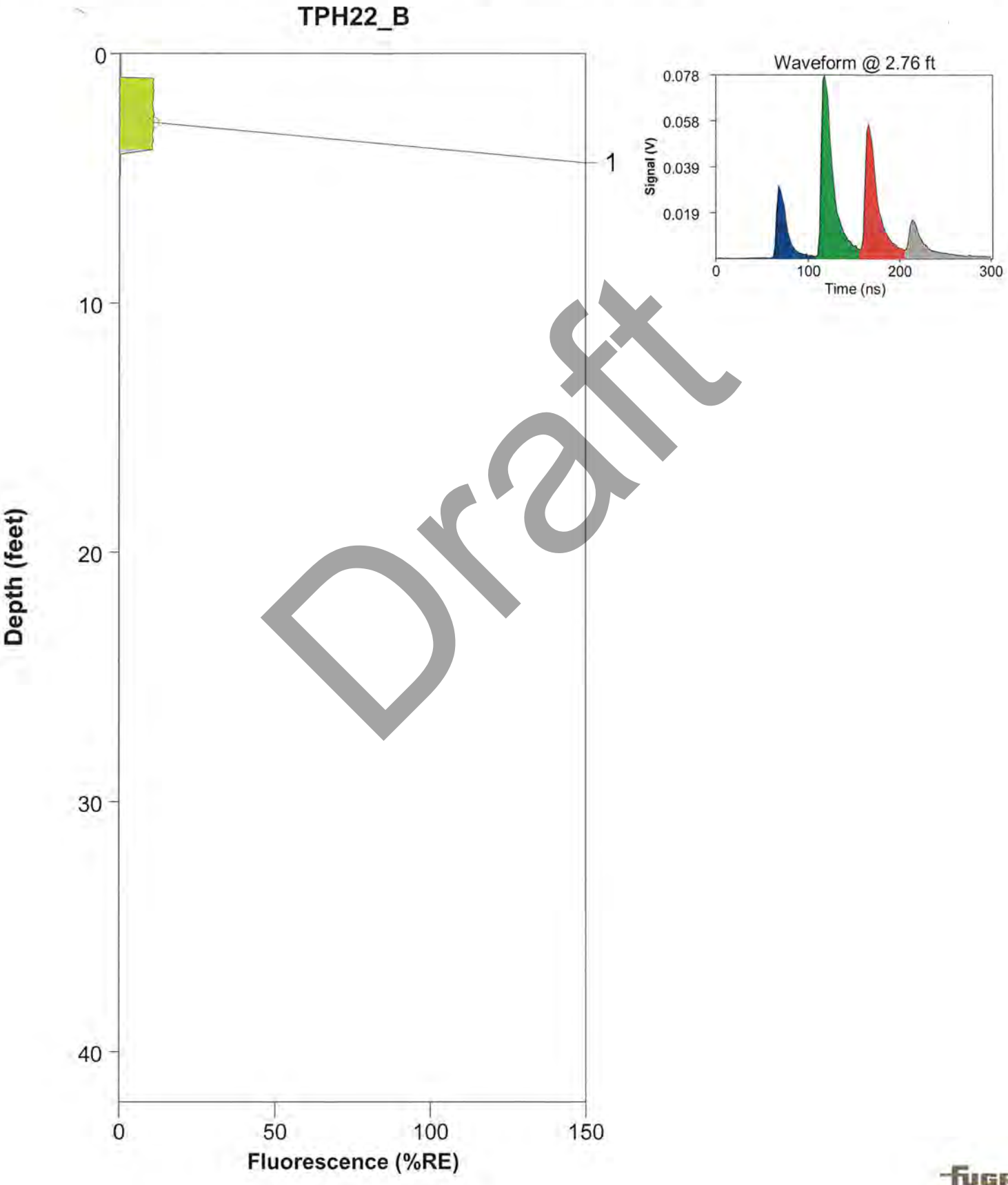
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 18:35:07	Max fluorescence: 11.72% @ 0.95 ft
ROST Unit: ?	Final depth BGS: 4.99 ft



Draft

ROST Fluorescence Response Data

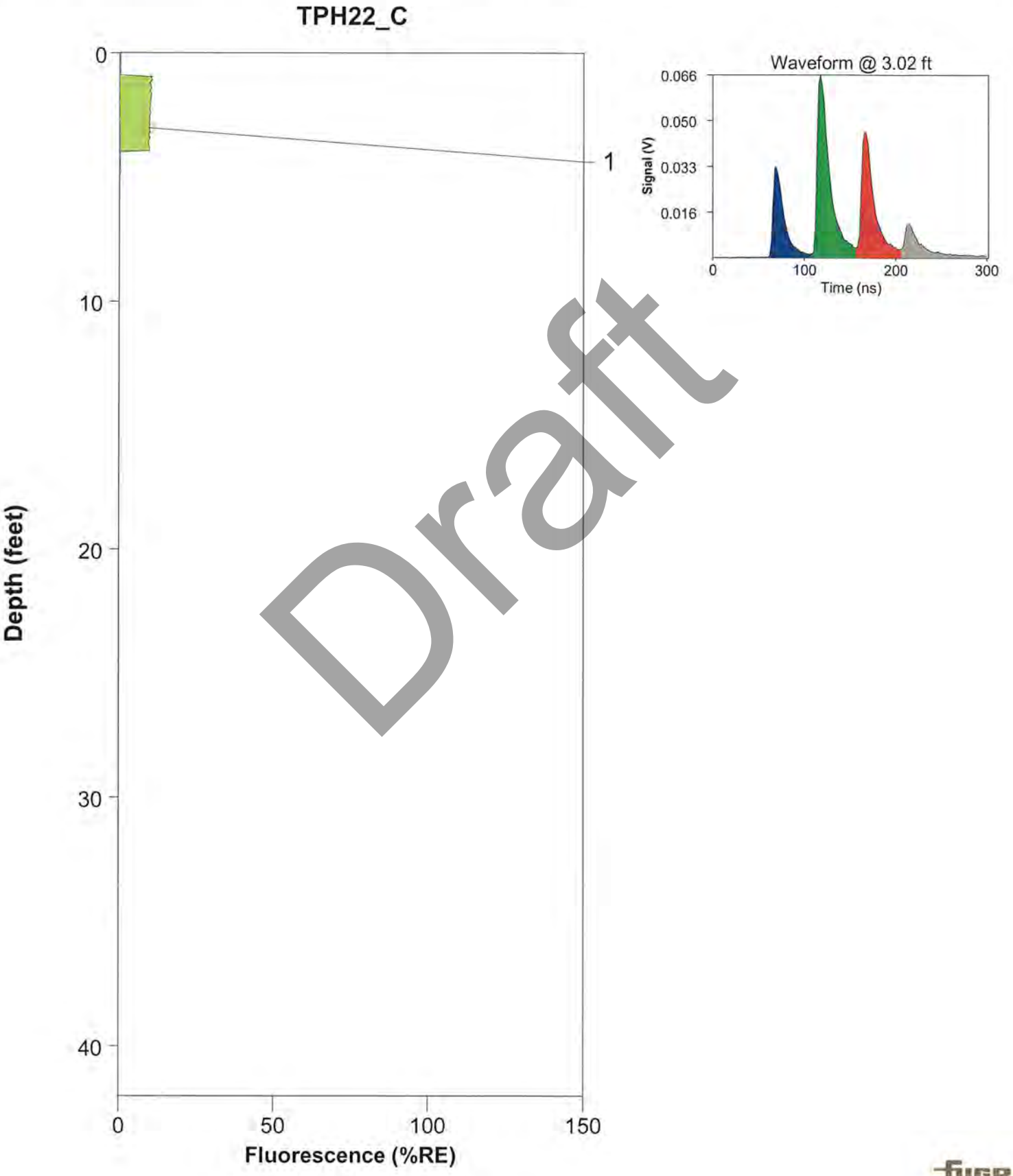
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 18:37:04	Max fluorescence: 11.26% @ 2.43 ft
ROST Unit: ?	Final depth BGS: 4.89 ft



Draft

ROST Fluorescence Response Data

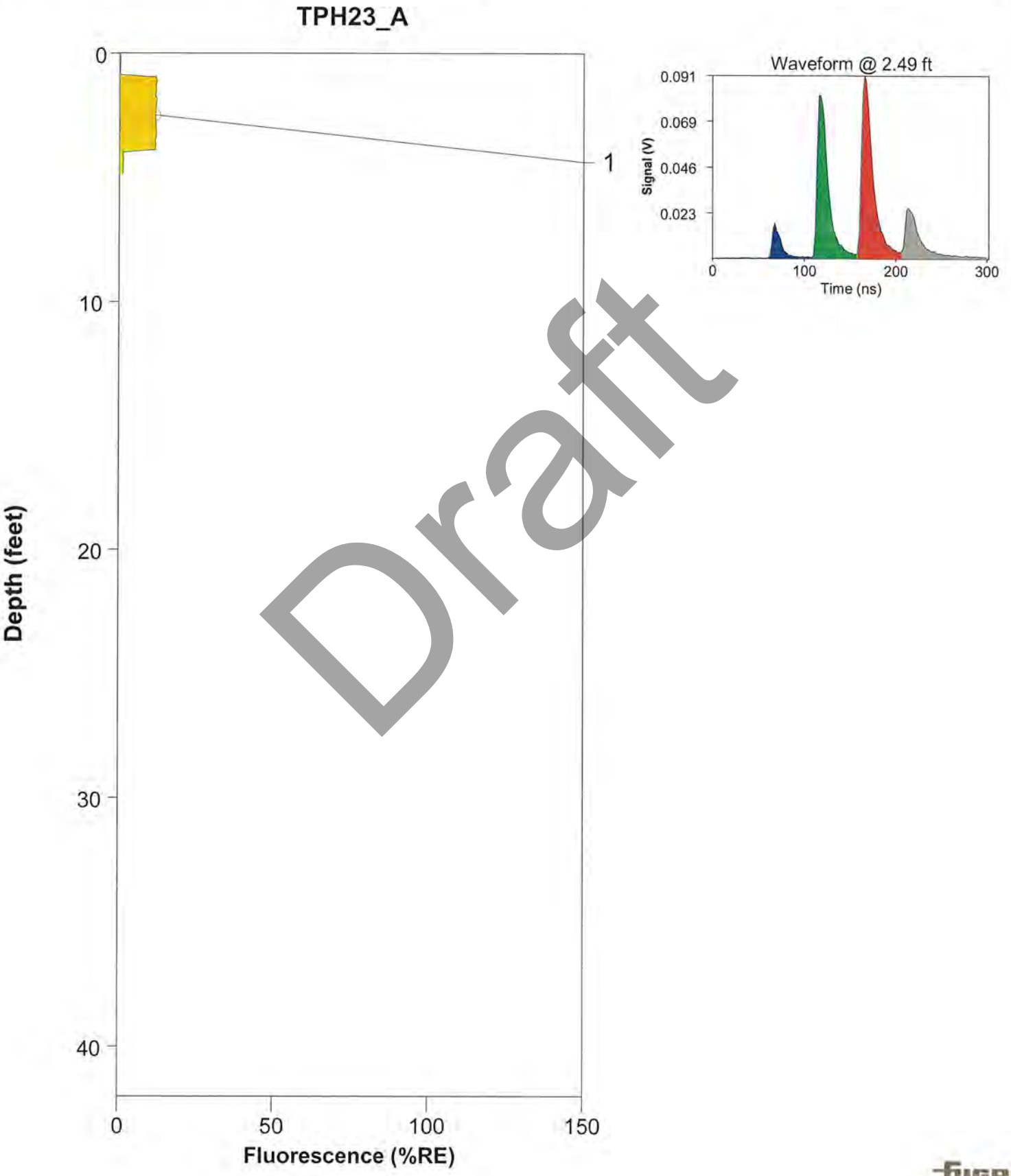
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 18:38:50	Max fluorescence: 10.65% @ 0.95 ft
ROST Unit: ?	Final depth BGS: 4.89 ft



Draft

ROST Fluorescence Response Data

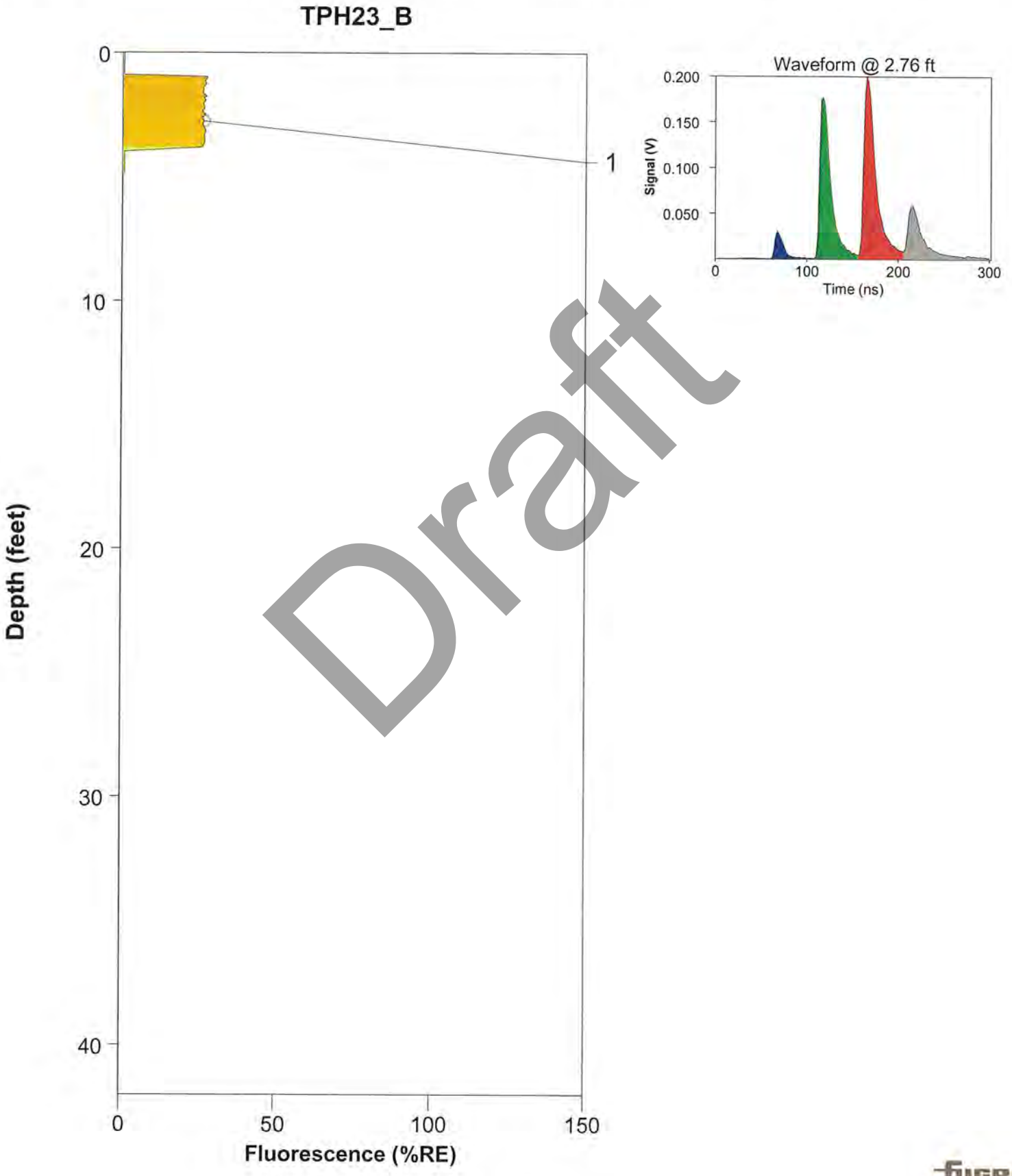
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 18:41:45	Max fluorescence: 12.27% @ 1.84 ft
ROST Unit: ?	Final depth BGS: 4.89 ft



Draft

ROST Fluorescence Response Data

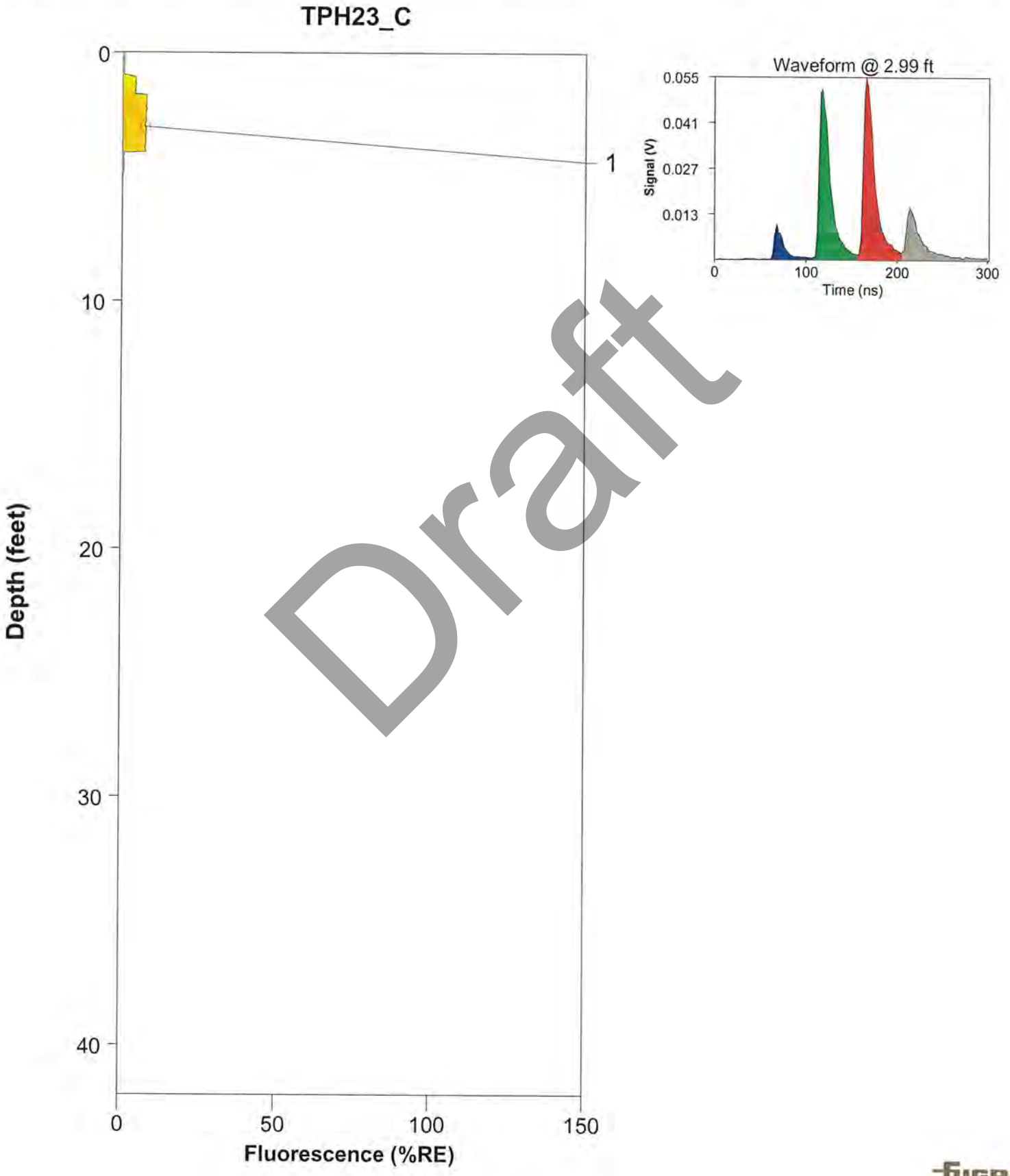
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 18:45:59	Max fluorescence: 27.45% @ 0.98 ft
ROST Unit: ?	Final depth BGS: 4.89 ft



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 18:49:09	Max fluorescence: 7.83% @ 2.30 ft
ROST Unit: ?	Final depth BGS: 4.89 ft

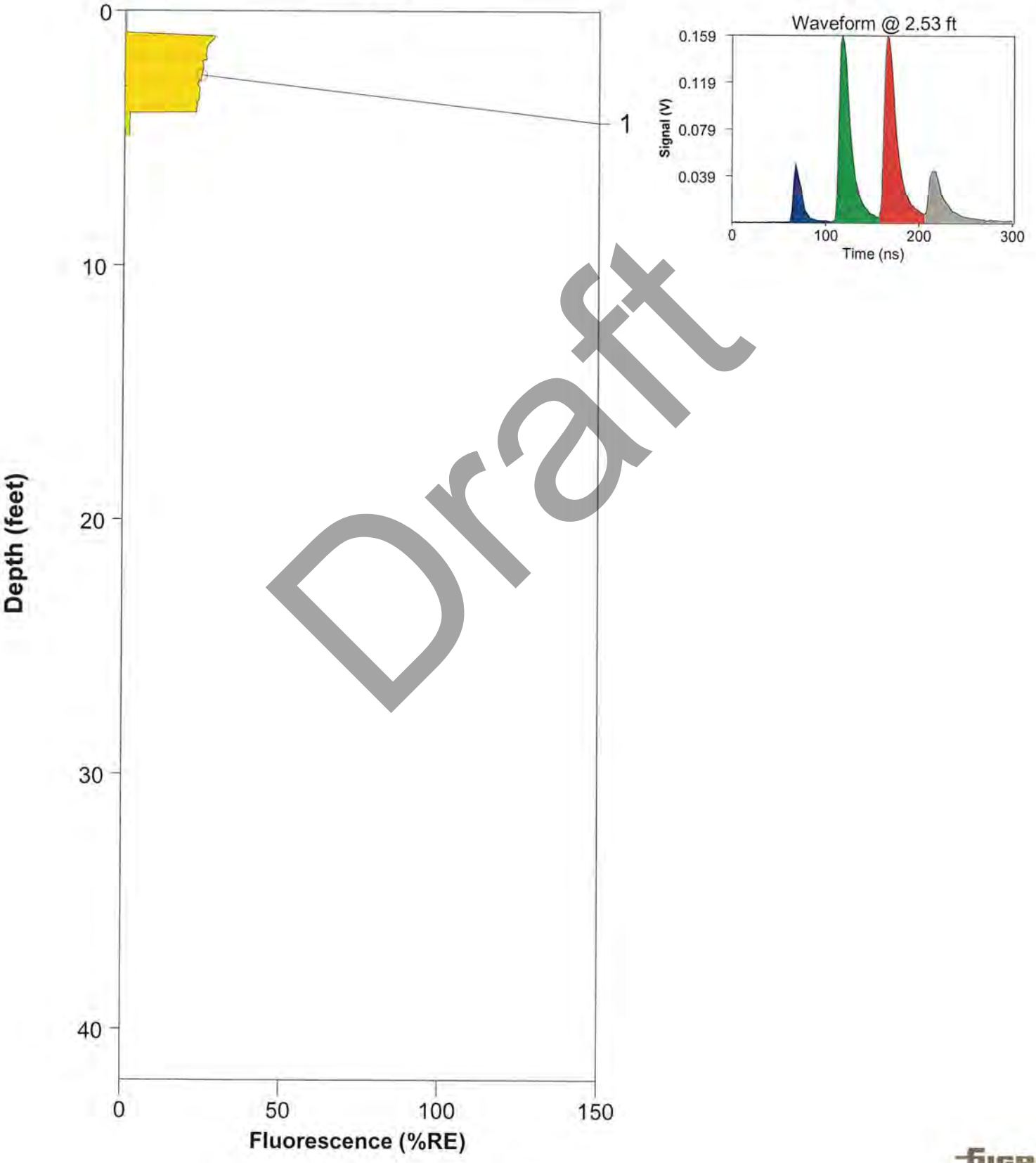


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 18:52:34	Max fluorescence: 28.34% @ 0.98 ft
ROST Unit: ?	Final depth BGS: 4.92 ft

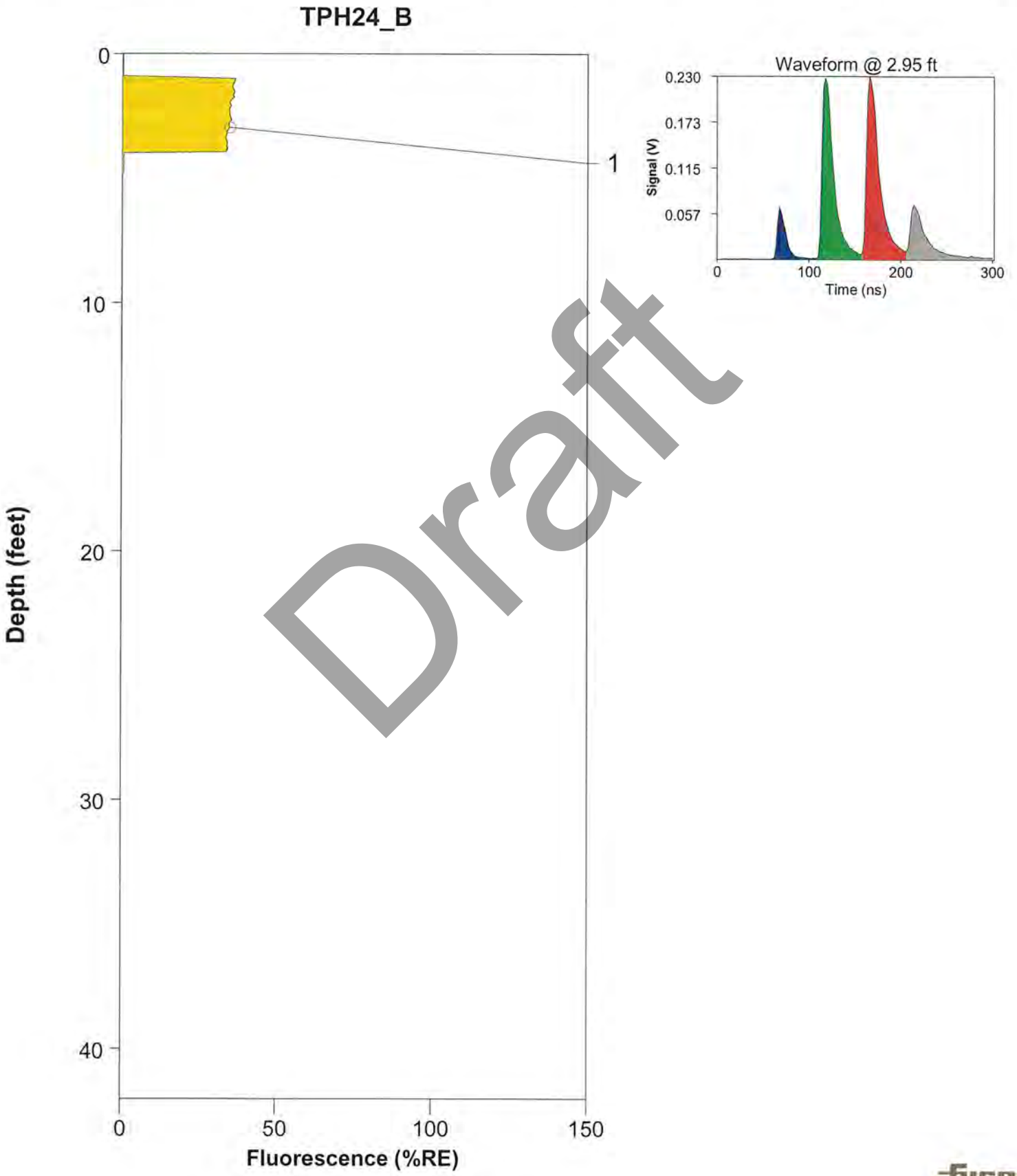
TPH24_A



Draft

ROST Fluorescence Response Data

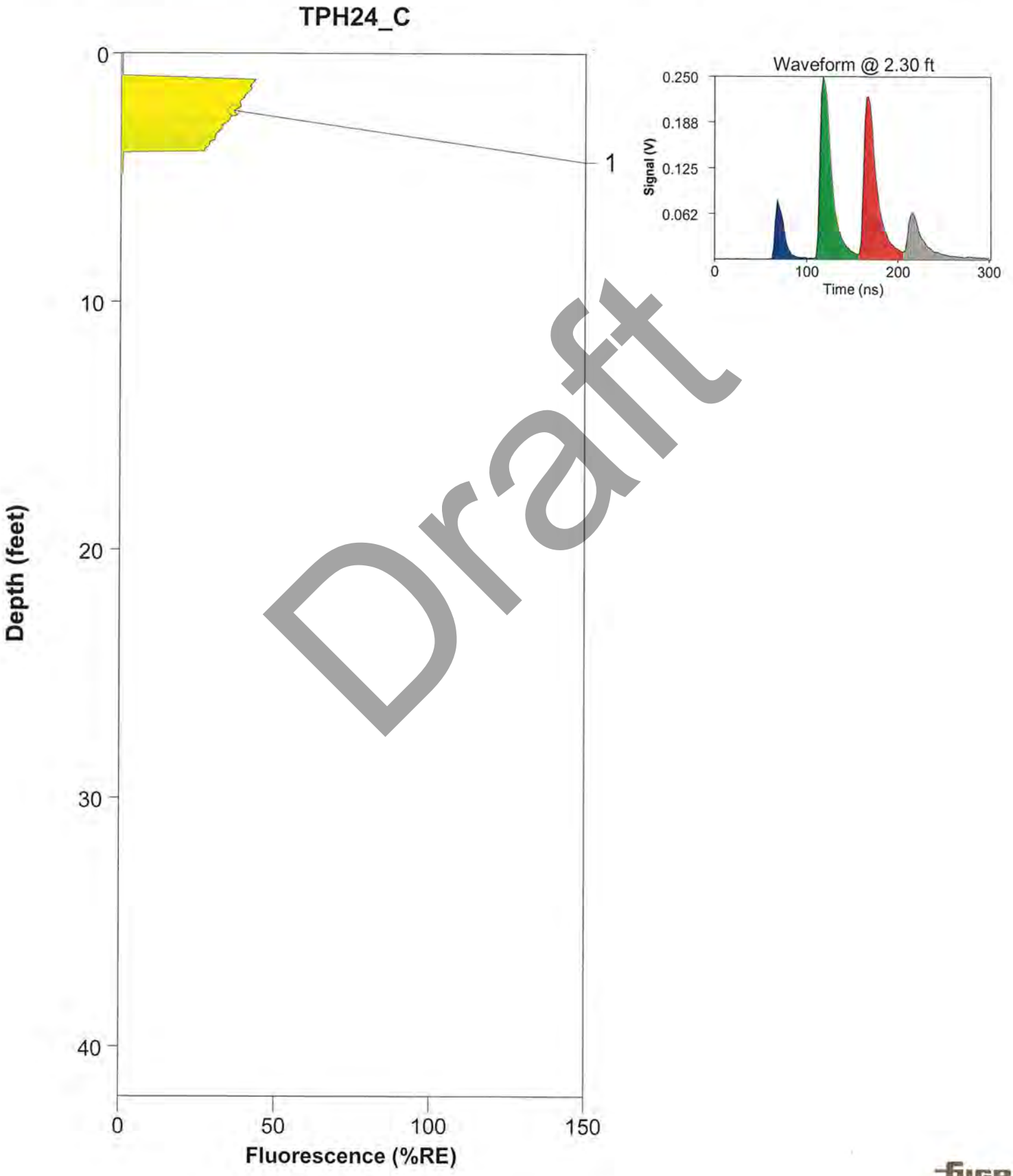
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 18:55:04	Max fluorescence: 36.52% @ 0.98 ft
ROST Unit: ?	Final depth BGS: 4.82 ft



Draft

ROST Fluorescence Response Data

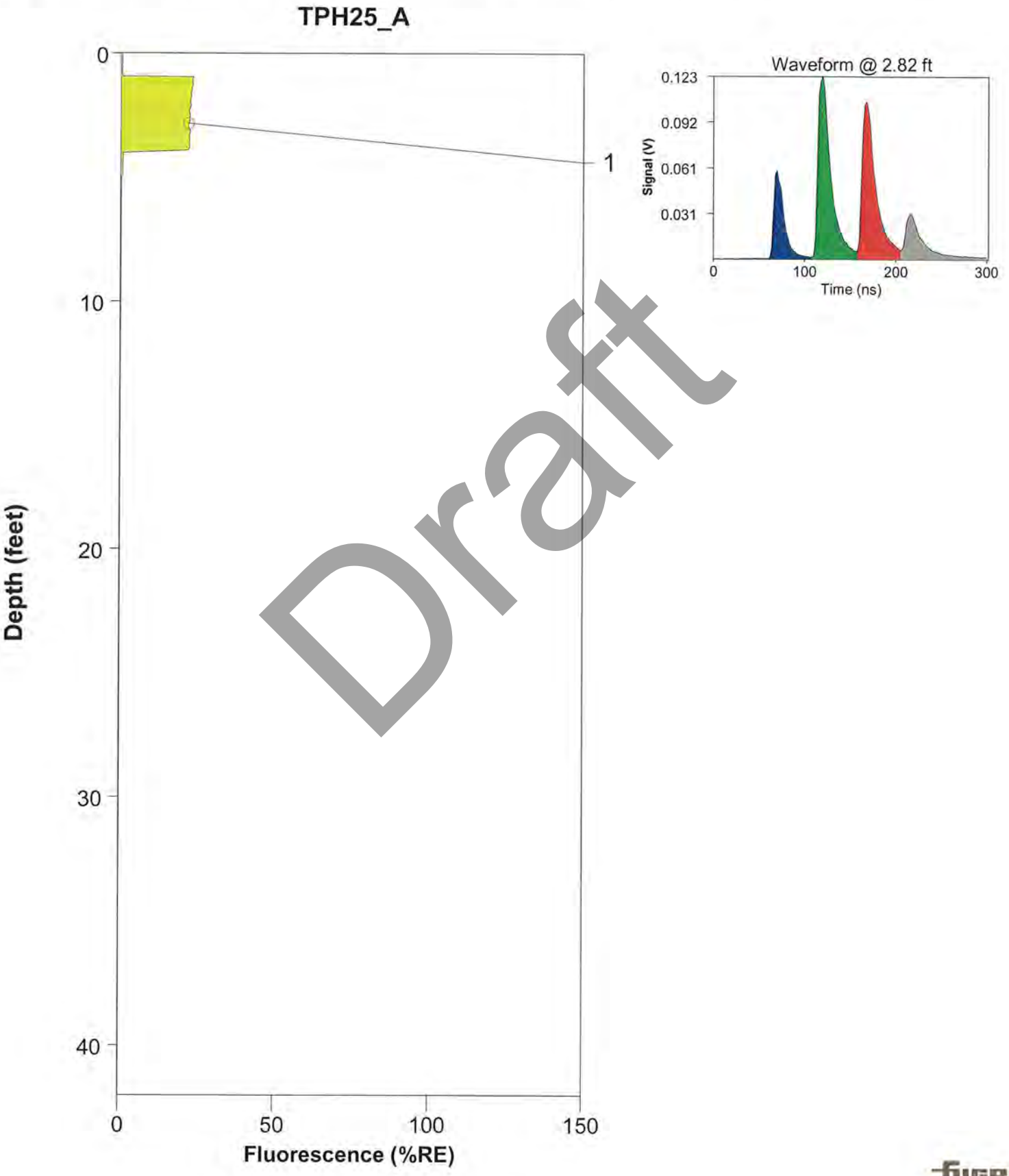
Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 18:57:02	Max fluorescence: 43.22% @ 1.05 ft
ROST Unit: ?	Final depth BGS: 4.89 ft



Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 19:00:26	Max fluorescence: 23.52% @ 0.95 ft
ROST Unit: ?	Final depth BGS: 4.95 ft

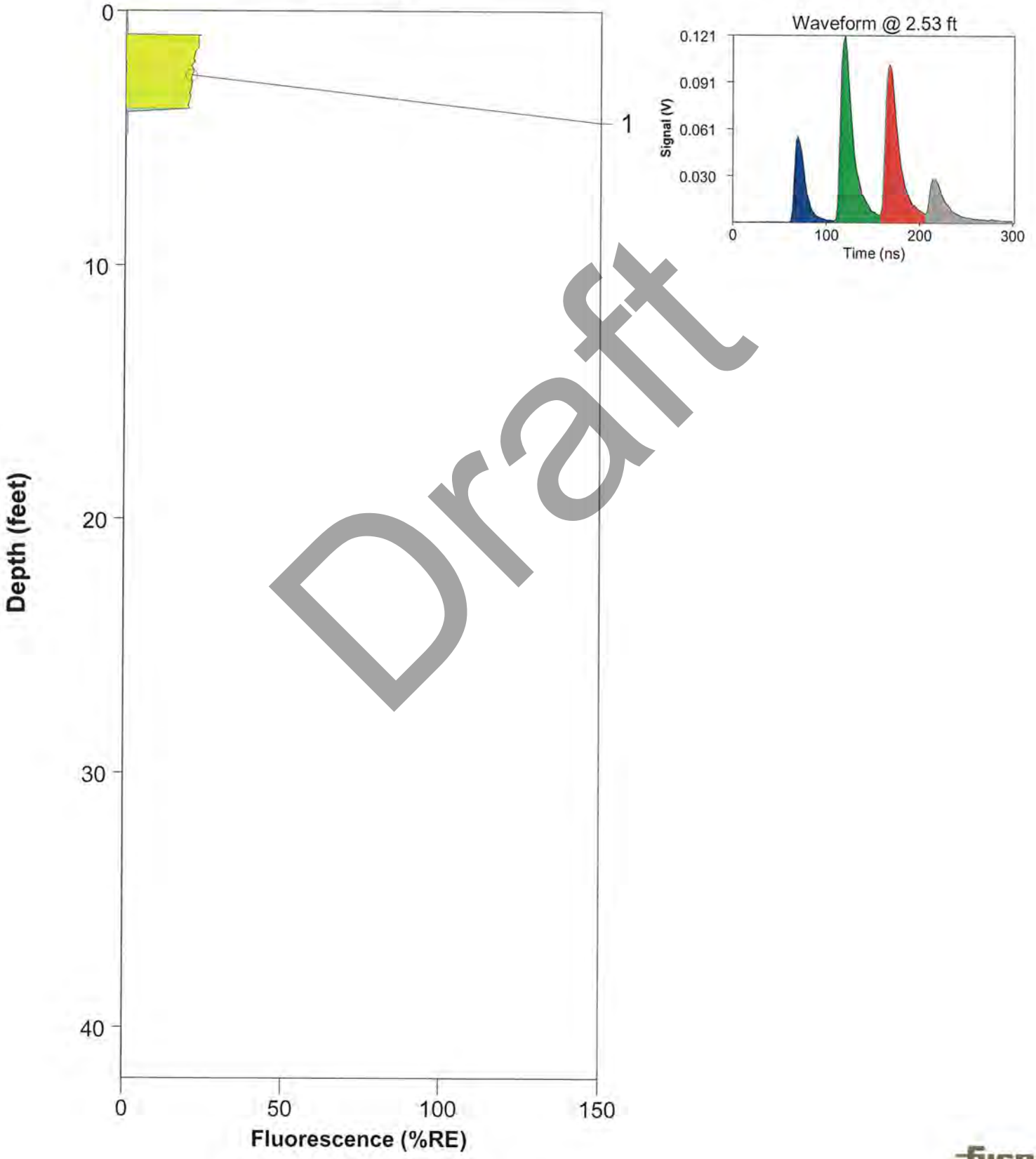


Draft

ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 19:02:43	Max fluorescence: 23.71% @ 0.95 ft
ROST Unit: ?	Final depth BGS: 4.89 ft

TPH25_B



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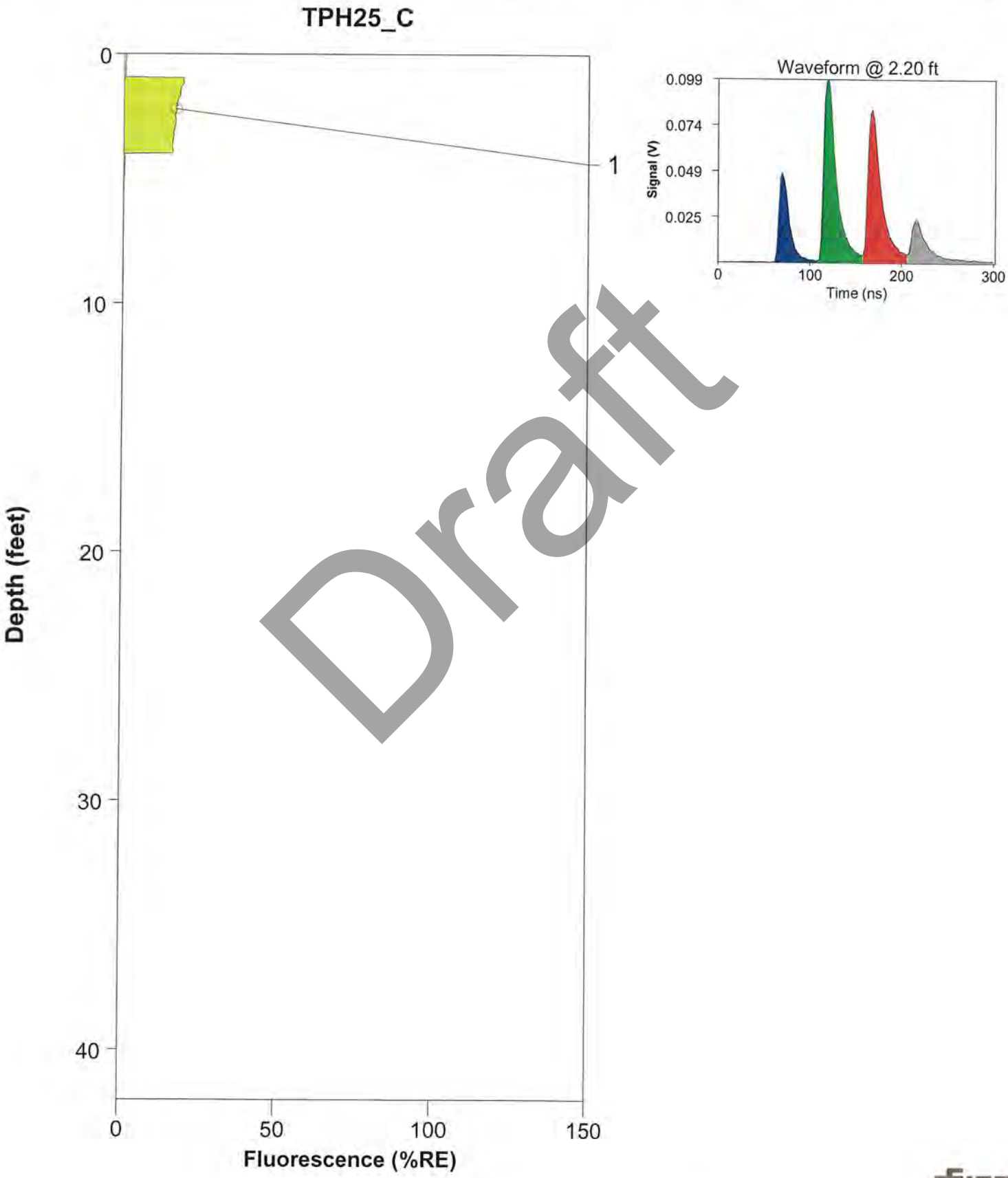
ROST Fluorescence Response Data

Site: Unavailable	Operator: Unavailable
Client: Unavailable	Fugro Job #: Unavailable
Date/Time: 02-02-2002 @ 19:08:47	Max fluorescence: 19.19% @ 0.95 ft
ROST Unit: ?	Final depth BGS: 4.89 ft



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B.5 - AUGUST 2019 PRODUCT RECOVERY SYSTEM REPORT (PARSONS, 2019) (WITH PLOT)

PARSONS

envision more

Harry Atkinson
Indiana Department of Environmental Management
100 North Senate Avenue
MC 66-30 IGCN 1101
Indianapolis, IN 46204-2251

Parsons
10 S. Riverside Plaza Ste 400
Chicago, IL 60606
Tel 312 930 5100
Fax 312 930 0018

Subject:

Progress Report No. 335 August 1, 2019 through August 31, 2019
Former Energy Cooperative, Inc. (ECI) Refinery Project
East Chicago, Indiana

ENVIRONMENT

Date:
October 3, 2019

Contact:
Florin Savin

Phone:
312-930-5104

Email:
Florin.Savin@parsons.com

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Dear Mr. Atkinson:

The Project Progress Report No. 335 for the Former ECI Refinery is presented in this letter report. This Project Progress Report covers the period August 1, 2019 through August 31, 2019.

Recovery/Containment System Operation

The following table summarizes product recovery for August 2019 and cumulative product recovery from the South Tank Farm and West Tank Farm for the period since August 1992. Monthly product recovery and cumulative product recovery volumes for the South Tank Farm and West Tank Farm are shown in **Table 1**.

	Gallons of Product Recovered	
	August 2019	Cumulative
South Tank Farm	0.5	27,305.25
West Tank Farm	0	2,492
TOTAL	0	29,797.25

Note: The Main Refinery system was decommissioned in September 2007 to make way for the construction of the Confined Disposal Facility by US Army Corps of Engineers. Total product recovered from the Main Refinery was 18,977 gallons.

The South Tank Farm system operated normally through the month of August 2019. The West Tank Farm system remains idle and will not be restarted until recoverable product is detected in the recovery wells.

Field Work

On-site system surveillance was performed at least twice weekly and Parsons conducted product well gauging on August 27, 2019. Product recovery wells PRW-1 through PRW-47 were gauged during these visits. Product levels and groundwater levels are shown in **Table 2** and **Table 3**.

Boom Maintenance

Through the month of August, eight containment booms were maintained on the Lake George Branch of the Indiana Harbor Shipping Canal within the area of the Former ECI Refinery. These booms were configured and operated in accordance with the approved USACE permit LRC-2012-00516.

Inspections of the eight booms in the canal were performed on August 5, 12, 19, and 26, 2019. The condition of each boom was recorded, and digital photographs were taken. Boom maintenance activities were performed on August 6, 13, 20, and 27, 2019. The sections of sorbent boom that had become saturated with product, as documented by the weekly boom inspections, were replaced with fresh sorbent booms. The debris that accumulated along the booms was removed during the boom maintenance events. The spent sorbent booms and debris were placed in a roll-off container onsite for off-site disposal. BP has increased boom inspections to twice weekly with the initial inspection at the beginning of each week to document boom conditions for maintenance activities and an additional inspection later in the week. The additional boom maintenance and inspection events were performed on August 2, 9, 16, 23, and 30, 2019. These events consisted of adding additional sorbent boom, removing debris, and absorbing accumulations with sorbent material.

If you have any questions or require further clarification, please do not hesitate to call Paul Johnson of Atlantic Richfield Company or the undersigned.

Sincerely,

Florin Savin

Project Manager

Copies:
Dan Haag – U.S. Environmental Protection Agency, Chicago, IL
Mike Elam – Barnes and Thornburg LLP, Chicago, IL
Paul Johnson – Atlantic Richfield Company, Naperville, IL
Allison Crane – Atlantic Richfield Company, Naperville, IL
Anne Remek – Indiana Department of Environmental Management
Fernando Trevino – East Chicago Waterway Management District, East Chicago, IN

Draft

Enclosures:

Tables

1 Cumulative Product Recovery Data
2 Well Gauging Data – South Tank Farm
3 Well Gauging Data – West Tank Farm

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Table 1. Cumulative Product Recovery Data - Gallons
South Tank Farm and West Tank Farm Containment Systems
Former ECI Refinery Site, East Chicago, Indiana

Date	South Tank Farm	West Tank Farm	Total
01/16/93	648	27	675
04/05/93	1,526	121	1,647
07/06/93	2,793	250	3,043
10/04/93	4,082	252	4,334
01/03/94	4,647	307	4,954
04/04/94	4,655	453	5,108
07/05/94	4,681	753	5,434
10/03/94	4,681	977	5,658
01/02/95	4,681	1,168	5,849
04/17/95	4,681	1,337	6,018
07/06/95	4,681	1,451	6,132
01/09/96	5,545	1,518	7,063
04/02/96	7,734	1,592	9,326
07/01/96	13,073	1,712	14,785
10/02/96	15,469	1,770	17,239
01/07/97	16,596	1,770	18,366
04/02/97	17,772	1,770	19,542
07/01/97	19,042	1,919	20,961
10/08/97	19,775	1,995	21,770
01/06/98	21,122	2,012	23,134
04/03/98	21,613	2,012	23,625
07/17/98	21,811	2,096	23,907
11/13/98	22,079	2,156	24,235
03/19/99	22,250	2,211	24,461
05/21/99	22,552	2,226	24,778
07/07/99	22,552	2,226	24,778
07/21/99	22,552	2,234	24,786
08/20/99	22,810	2,234	25,044
09/25/99	23,144	2,237	25,381
10/31/99	23,176	2,239	25,415
11/24/99	23,205	2,241	25,446
01/21/00	23,205	2,249	25,454
02/17/00	23,210	2,249	25,459
03/13/00	23,210	2,249	25,459
03/30/00	23,210	2,249	25,459
04/12/00	23,210	2,249	25,459
04/26/00	23,210	2,249	25,459
05/12/00	23,348	2,266	25,614
06/26/00	23,354	2,266	25,620
07/13/00	23,359	2,276	25,635
08/25/00	23,391	2,276	25,667
09/28/00	23,398	2,291	25,689
11/03/00	23,398	2,291	25,689
11/16/00	23,430	2,291	25,721
01/25/01	23,430	2,291	25,721
02/22/01	23,430	2,291	25,721
03/22/01	23,430	2,291	25,721
04/24/01	23,430	2,299	25,729
05/22/01	23,430	2,299	25,729
06/19/01	23,444	2,299	25,743
07/17/01	23,465	2,299	25,764
08/21/01	23,491	2,299	25,790
09/25/01	23,531	2,299	25,830
10/23/01	23,660	2,302	25,962
11/29/01	23,660	2,302	25,962

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Table 1. Cumulative Product Recovery Data - Gallons
South Tank Farm and West Tank Farm Containment Systems
Former ECI Refinery Site, East Chicago, Indiana

Date	South Tank Farm	West Tank Farm	Total
01/21/02	23,660	2,302	25,962
02/14/02	23,704	2,302	26,006
03/27/02	23,741	2,302	26,043
04/10/02	23,741	2,302	26,043
05/28/02	23,853	2,302	26,155
06/25/02	23,992	2,302	26,294
07/16/02	24,035	2,302	26,337
08/27/02	24,121	2,302	26,423
09/24/02	24,150	2,302	26,452
10/15/02	24,205	2,302	26,507
11/26/02	24,205	2,302	26,507
12/31/02	24,205	2,302	26,507
01/28/03	24,366	2,302	26,668
02/11/03	24,383	2,302	26,685
03/11/03	24,409	2,302	26,711
04/01/03	24,430	2,302	26,732
05/06/03	24,494	2,302	26,796
06/24/03	24,509	2,302	26,811
07/22/03	24,523	2,302	26,825
08/26/03	24,635	2,302	26,937
09/22/03	24,693	2,302	26,995
10/14/03	24,860	2,302	27,162
11/20/03	24,938	2,302	27,240
12/16/03	24,949	2,302	27,251
01/13/04	24,949	2,302	27,251
02/10/04	24,949	2,302	27,251
03/16/04	24,978	2,302	27,280
04/08/04	25,013	2,302	27,315
05/25/04	25,039	2,312	27,351
06/29/04	25,122	2,322	27,444
07/29/04	25,353	2,349	27,702
08/24/04	25,361	2,353	27,714
09/21/04	25,367	2,356	27,723
10/05/04	25,384	2,356	27,740
11/23/04	25,430	2,358	27,788
12/28/04	25,439	2,358	27,797
01/21/05	25,439	2,358	27,797
02/15/05	25,445	2,358	27,803
03/15/05	25,479	2,358	27,837
04/12/05	25,494	2,367	27,861
05/18/05	25,499	2,379	27,878
06/28/05	25,517	2,389	27,906
07/26/05	25,525	2,392	27,917
08/30/05	25,534	2,399	27,933
09/27/05	25,543	2,403	27,946
10/18/05	25,557	2,415	27,972
11/29/05	25,566	2,421	27,987
12/30/05	25,592	2,421	28,013
01/17/06	25,603	2,421	28,024
02/28/06	25,661	2,421	28,082
03/14/06	25,672	2,421	28,093
04/25/06	25,687	2,421	28,108
05/30/06	25,764	2,421	28,185
06/27/06	25,862	2,421	28,283
07/25/06	25,920	2,421	28,341

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Table 1. Cumulative Product Recovery Data - Gallons
South Tank Farm and West Tank Farm Containment Systems
Former ECI Refinery Site, East Chicago, Indiana

Date	South Tank Farm	West Tank Farm	Total
08/15/06	25,957	2,447	28,404
09/29/06	25,979	2,449	28,428
10/31/06	26,011	2,453	28,464
11/21/06	26,062	2,453	28,515
12/19/06	26,077	2,453	28,530
01/09/07	26,080	2,453	28,533
02/14/07	26,090	2,453	28,543
03/06/07	26,096	2,456	28,552
04/10/07	26,096	2,458	28,554
05/22/07	26,110	2,460	28,570
06/22/07	26,252	2,460	28,712
07/24/07	26,259	2,460	28,719
08/28/07	26,284	2,460	28,744
09/25/07	26,292	2,460	28,752
10/23/07	26,292	2,460	28,752
11/27/07	26,299	2,460	28,759
12/31/07	26,307	2,460	28,767
01/22/08	26,324	2,460	28,784
02/26/08	26,348	2,460	28,808
03/25/08	26,355	2,460	28,815
04/22/08	26,367	2,460	28,827
05/23/08	26,377	2,460	28,837
06/24/08	26,377	2,462	28,839
07/29/08	26,386	2,466	28,852
08/26/08	26,392	2,469	28,861
09/23/08	26,398	2,471	28,869
10/21/08	26,402	2,475	28,877
11/21/08	26,405	2,477	28,882
12/16/08	26,407	2,478	28,885
01/23/09	26,407	2,478	28,885
02/17/09	26,424	2,478	28,902
03/24/09	26,559	2,478	29,037
04/21/09	26,559	2,480	29,039
05/19/09	26,570	2,480	29,050
06/23/09	26,578	2,482	29,060
07/21/09	26,578	2,482	29,060
08/04/09	26,578	2,485	29,063
09/22/09	26,593	2,485	29,078
10/06/09	26,600	2,487	29,087
11/17/09	26,600	2,487	29,087
12/15/09	26,606	2,487	29,093
01/19/10	26,609	2,489	29,098
02/16/10	26,611	2,489	29,100
03/16/10	26,611	2,489	29,100
04/27/10	26,614	2,489	29,103
05/11/10	26,614	2,489	29,103
06/15/10	26,617	2,492	29,109
07/13/10	26,617	2,492	29,109
08/17/10	26,617	2,492	29,109
09/10/10	26,617	2,492	29,109
10/19/10	26,619	2,492	29,111
11/16/10	26,619	2,492	29,111
12/14/10	26,619	2,492	29,111
01/11/11	26,628	2,492	29,120
02/15/11	26,634	2,492	29,126

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Table 1. Cumulative Product Recovery Data - Gallons
South Tank Farm and West Tank Farm Containment Systems
Former ECI Refinery Site, East Chicago, Indiana

Date	South Tank Farm	West Tank Farm	Total
03/15/11	26,637	2,492	29,129
04/19/11	26,639	2,492	29,131
05/17/11	26,652	2,492	29,144
06/14/11	26,657	2,492	29,149
07/19/11	26,671	2,492	29,163
08/16/11	26,678	2,492	29,170
09/13/11	26,678	2,492	29,170
10/11/11	26,691	2,492	29,183
11/15/11	26,691	2,492	29,183
12/13/11	26,691	2,492	29,183
01/10/12	26,697	2,492	29,189
02/06/12	26,700	2,492	29,192
03/13/12	26,704	2,492	29,196
04/10/12	26,707	2,492	29,199
05/15/12	26,713	2,492	29,205
06/12/12	26,717	2,492	29,209
07/10/12	26,720	2,492	29,212
08/09/12	26,722	2,492	29,214
09/18/12	26,765	2,492	29,257
10/16/12	26,794	2,492	29,286
11/13/12	26,828	2,492	29,320
12/18/13	26,883	2,492	29,375
01/11/13	27,050	2,492	29,542
02/12/13	27,171	2,492	29,663
03/12/13	27,188	2,492	29,680
04/23/13	27,209	2,492	29,701
05/14/13	27,220	2,492	29,712
06/11/13	27,226	2,492	29,718
07/15/13	27,237	2,492	29,729
08/13/13	27,240	2,492	29,732
09/10/13	27,240	2,492	29,732
10/29/13	27,240	2,492	29,732
11/19/13	27,240	2,492	29,732
12/17/13	27,240	2,492	29,732
01/21/14	27,240	2,492	29,732
02/18/14	27,240	2,492	29,732
03/18/14	27,240	2,492	29,732
04/15/14	27,247	2,492	29,739
05/13/14	27,247	2,492	29,739
06/17/14	27,255	2,492	29,747
07/29/14	27,258	2,492	29,750
08/26/14	27,261	2,492	29,753
09/15/14	27,264	2,492	29,756
10/21/14	27,267	2,492	29,759
11/25/14	27,267	2,492	29,759
12/23/14	27,269	2,492	29,761
01/27/15	27,269	2,492	29,761
02/23/15	27,269	2,492	29,761
03/31/15	27,269	2,492	29,761
04/28/15	27,272	2,492	29,764
05/26/15	27,275	2,492	29,767
06/30/15	27,275	2,492	29,767
07/28/15	27,278	2,492	29,770
08/25/15	27,278	2,492	29,770
09/29/15	27,278	2,492	29,770
10/26/15	27,278	2,492	29,770
11/24/15	27,281	2,492	29,773
12/29/15	27,281	2,492	29,773

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Table 1. Cumulative Product Recovery Data - Gallons
South Tank Farm and West Tank Farm Containment Systems
Former ECI Refinery Site, East Chicago, Indiana

Date	South Tank Farm	West Tank Farm	Total
01/27/16	27,281	2,492	29,773
02/23/16	27,281	2,492	29,773
03/22/16	27,281	2,492	29,773
04/26/16	27,281	2,492	29,773
05/24/16	27,283	2,492	29,775
06/28/16	27,283	2,492	29,775
07/26/16	27,286	2,492	29,778
08/30/16	27,286	2,492	29,778
09/27/16	27,286	2,492	29,778
10/25/16	27,286	2,492	29,778
11/22/16	27,287.50	2,492	29,779.50
12/27/16	27,288.50	2,492	29,780.50
01/24/17	27,289.00	2,492	29,781.00
02/28/17	27,289.50	2,492	29,781.50
03/28/17	27,290.00	2,492	29,782.00
04/25/17	27,290.50	2,492	29,782.50
05/23/17	27,291.00	2,492	29,783.00
06/27/17	27,291.50	2,492	29,783.50
07/25/17	27,292.00	2,492	29,784.00
08/22/17	27,292.50	2,492	29,784.50
09/26/17	27,295.25	2,492	29,787.25
10/24/17	27,295.75	2,492	29,787.75
11/28/17	27,296.25	2,492	29,788.25
12/19/17	27,296.75	2,492	29,788.75
01/23/18	27,297.25	2,492	29,789.25
02/27/18	27,297.75	2,492	29,789.75
03/27/18	27,298.25	2,492	29,790.25
04/24/18	27,298.75	2,492	29,790.75
05/22/18	27,299.25	2,492	29,791.25
06/19/18	27,299.75	2,492	29,791.75
07/24/18	27,299.75	2,492	29,791.75
08/28/18	27,299.75	2,492	29,791.75
09/25/18	27,300.25	2,492	29,792.25
10/23/18	27,300.75	2,492	29,792.75
11/27/18	27,300.75	2,492	29,792.75
12/26/18	27,301.25	2,492	29,793.25
01/22/19	27,301.75	2,492	29,793.75
02/26/19	27,302.25	2,492	29,794.25
03/26/19	27,302.75	2,492	29,794.75
04/23/19	27,303.25	2,492	29,795.25
05/28/19	27,303.75	2,492	29,795.75
06/18/19	27,304.25	2,492	29,796.25
07/26/19	27,304.75	2,492	29,796.75
08/27/19	27,305.25	2,492	29,797.25

* Main Refinery System (RW-1, 2, & 3) removed from service in September 2007, total accumulated product from the Main Refinery System was 18,977 gallons (August 1992 to September 2007).

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Table 2.
Well Gauging Data, South Tank Farm Recovery Wells, ECI Refinery Project, East Chicago, Indiana.

Well ID	Date Gauged	TOC Elevation	Depth to Product	Depth to Water	Product Thickness	Groundwater Elevation	Product Elevation
PRW-01	8/27/2019	586.47	3.60	3.60	0.00	582.87	582.87
PRW-02	8/27/2019	586.45	3.76	3.76	0.00	582.69	582.69
PRW-03	8/27/2019	586.39	3.99	3.99	0.00	582.40	582.40
PRW-04	8/27/2019	586.50	4.14	4.14	0.00	582.36	582.36
PRW-05	8/27/2019	586.76	4.67	4.67	0.00	582.09	582.09
PRW-06	8/27/2019	587.16	4.73	4.73	0.00	582.43	582.43
PRW-07	8/27/2019	587.56	5.00	5.00	0.00	582.56	582.56
PRW-08	8/27/2019	587.70	5.00	5.00	0.00	582.70	582.70
PRW-09	8/27/2019	587.55	4.91	4.91	0.00	582.64	582.64
PRW-10	8/27/2019	587.43	5.00	5.00	0.00	582.43	582.43
PRW-11	8/27/2019	587.76	5.01	5.01	0.00	582.75	582.75
PRW-12	8/27/2019	587.29	4.50	4.50	0.00	582.79	582.79
PRW-13	8/27/2019	587.23	4.41	4.41	0.00	582.82	582.82
PRW-14	8/27/2019	586.55	4.53	4.53	0.00	582.02	582.02
PRW-15	8/27/2019	586.74	4.17	4.17	0.00	582.57	582.57
PRW-16	8/27/2019	586.71	4.16	4.16	0.00	582.55	582.55
PRW-17	8/27/2019	586.63	3.96	3.96	0.00	582.67	582.67
PRW-18	8/27/2019	586.77	4.01	4.01	0.00	582.76	582.76
PRW-19	8/27/2019	586.60	3.99	3.99	0.00	582.61	582.61
PRW-20	8/27/2019	587.14	4.07	4.07	0.00	583.07	583.07
PRW-21	8/27/2019	586.76	4.36	4.36	0.00	582.40	582.40
PRW-22	8/27/2019	587.09	4.13	4.13	0.00	582.96	582.96
PRW-23	8/27/2019	587.35	3.60	3.60	0.00	583.75	583.75
PRW-24	8/27/2019	587.81	3.76	3.76	0.00	584.05	584.05
PRW-25	8/27/2019	587.94	5.46	5.46	0.00	582.48	582.48
PRW-26	8/27/2019	588.07	5.20	5.20	0.00	582.87	582.87
PRW-27	8/27/2019	588.11	5.53	5.53	0.00	582.58	582.58
PRW-28	8/27/2019	588.47	5.75	6.05	0.30	582.42	582.72
PRW-29	8/27/2019	588.24	5.48	5.72	0.24	582.52	582.76
PRW-30	8/27/2019	588.05	5.18	5.18	0.00	582.87	582.87
PRW-31	8/27/2019	587.58	4.85	4.85	0.00	582.73	582.73
PRW-32	8/27/2019	586.96	4.43	4.43	0.00	582.53	582.53
PRW-33	8/27/2019	586.60	4.30	4.30	0.00	582.30	582.30
PRW-34	8/27/2019	586.68	4.09	4.09	0.00	582.59	582.59
PRW-35	8/27/2019	587.24	3.95	3.95	0.00	583.29	583.29
PRW-36	8/27/2019	586.85	4.05	4.05	0.00	582.80	582.80
PRW-37	8/27/2019	586.85	4.21	4.25	0.04	582.60	582.64
PRW-38	8/27/2019	586.56	3.96	3.96	0.00	582.60	582.60

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Table 2.
Well Gauging Data, South Tank Farm Recovery Wells, ECI Refinery Project, East Chicago, Indiana.

Well ID	Date Gauged	TOC Elevation	Depth to Product	Depth to Water	Product Thickness	Groundwater Elevation	Product Elevation
PRW-39	8/27/2019	586.14	4.84	4.84	0.00	581.30	581.30
PRW-40	8/27/2019	585.57	4.64	4.64	0.00	580.93	580.93
PRW-41	8/27/2019	585.36	4.70	4.70	0.00	580.66	580.66

Elevation Data are presented in feet above mean sea level (MSL).
Depth to product, depth to water, and product thickness data are presented in feet.

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Table 3.
Well Gauging Data, West Tank Farm Recovery Wells, ECI Refinery Project, East Chicago, Indiana.

Well ID	Date Gauged	TOC Elevation	Depth to Product	Depth to Water	Product Thickness	Groundwater Elevation	Product Elevation
PRW-42	8/27/2019	586.01	5.55	5.55	0.00	580.46	580.46
PRW-43	8/27/2019	585.69	5.93	5.93	0.00	579.76	579.76
PRW-44	8/27/2019	585.42	1.93	1.93	0.00	583.49	583.49
PRW-45	8/27/2019	585.66	5.60	5.60	0.00	580.06	580.06
PRW-46	8/27/2019	585.87	5.50	5.50	0.00	580.37	580.37
PRW-47	8/27/2019	586.44	5.66	5.66	0.00	580.78	580.78

Elevation Data are presented in feet above mean sea level (MSL).
Depth to product, depth to water, and product thickness data are presented in feet.

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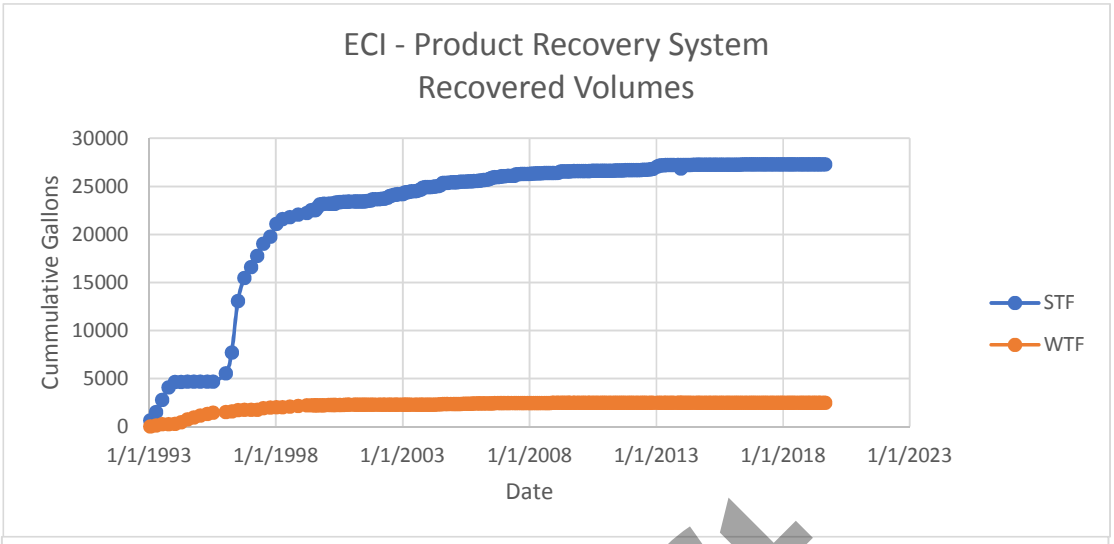
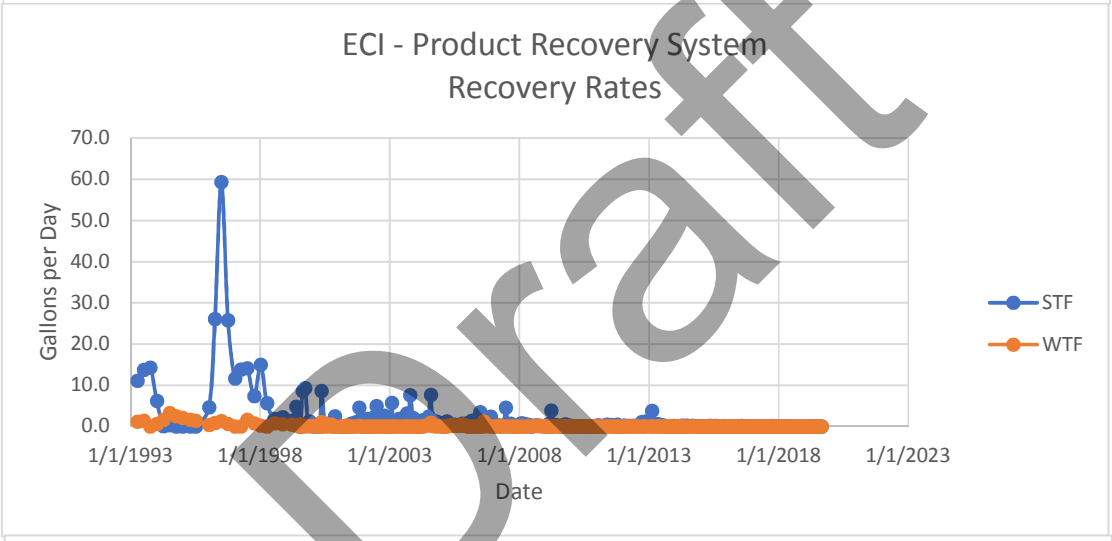
Source: Parsons Progress Report No. 335 August 1, 2019 through August 31, 2019 ECI Refinery Project (October 3, 2019)





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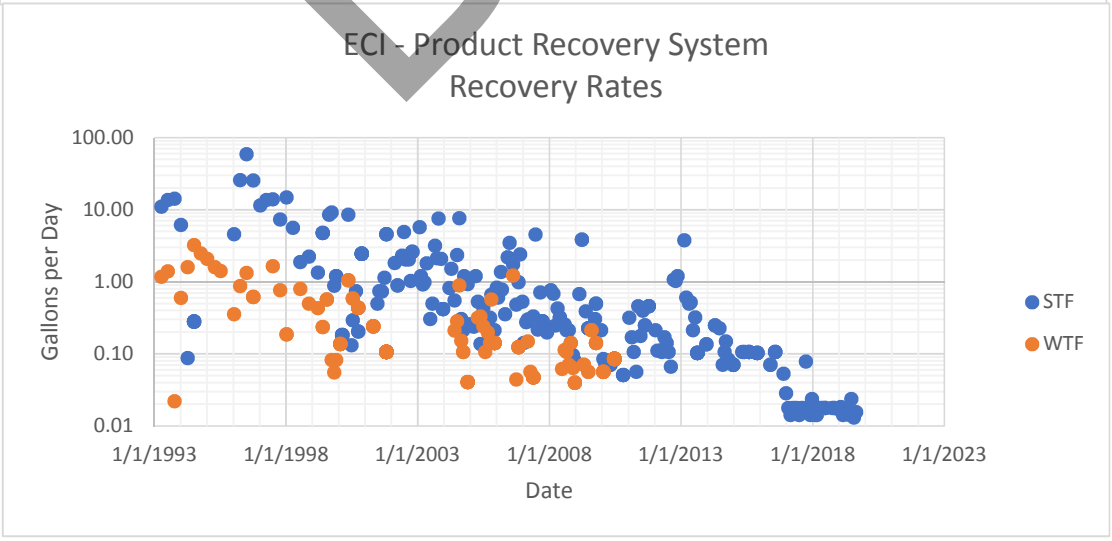

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B.6 – INDIANA HARBOR PIPELINE REMOVAL REPORT (WESTON, 2002)

INDIANA HARBOR PIPELINE REMOVAL REPORT
FOR
INDIANA HARBOR CANAL PILOT PROJECT SITE
EAST CHICAGO, INDIANA

Draft

TDD No. 0110-001
Document Control No. 175-2A-ABOZ

April 2002

Approved By: _____ Date: 4-2-02
Don Paxton
Site Leader

Approved By: _____ Date: 4/2/02
Heidi Gorrill
Project Manager

Approved By: _____ Date: 4/2/02
Dean Geers
Program Manager

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1.0 INTRODUCTION

U.S. Environmental Protection Agency Region V On-Scene Coordinator (OSC) Betty Lavis tasked Environmental Rapid Response Services (ERRS) contractor Environmental Quality Management (EQ) to perform a removal/closeout of selected pipelines on the Main Refinery (MR) and South Tank Farm (STF) parcels of the ARCO/ECI property located in East Chicago, Lake County, Indiana. The OSC directed the Roy F. Weston, Inc. (WESTON®) Superfund Technical Assessment and Response Team (START) to provide oversight and document site activities. The pipeline removal/closeout was performed as part of the Indiana Harbor Canal Pilot Project Site during 9 October 2001 through 13 December 2001. The OSC initiated the closeout of the pipelines to address the recurring oil sheens and product that were observed in the canal between containment booms which section off portions of the Lake George Branch of the Indiana Harbor Ship Canal between parcels of the former ARCO/ECI refinery.

2.0 SITE DESCRIPTION

2.1 LOCATION

The ARCO/ECI property is located along Indianapolis Boulevard in East Chicago, Lake County, Indiana. The property is bisected into north and south portions by the Lake George Branch of the Indiana Harbor Ship Canal as illustrated on Figure 1, Site Location Map. The geographical coordinates of the ARCO/ECI property are N 41° 38' 47.29134" latitude and W 87° 29' 20.39883" longitude with an altitude of 482.293 feet above mean sea level. These coordinates were determined on-site with a Trimble Pathfinder Global Positioning System unit.

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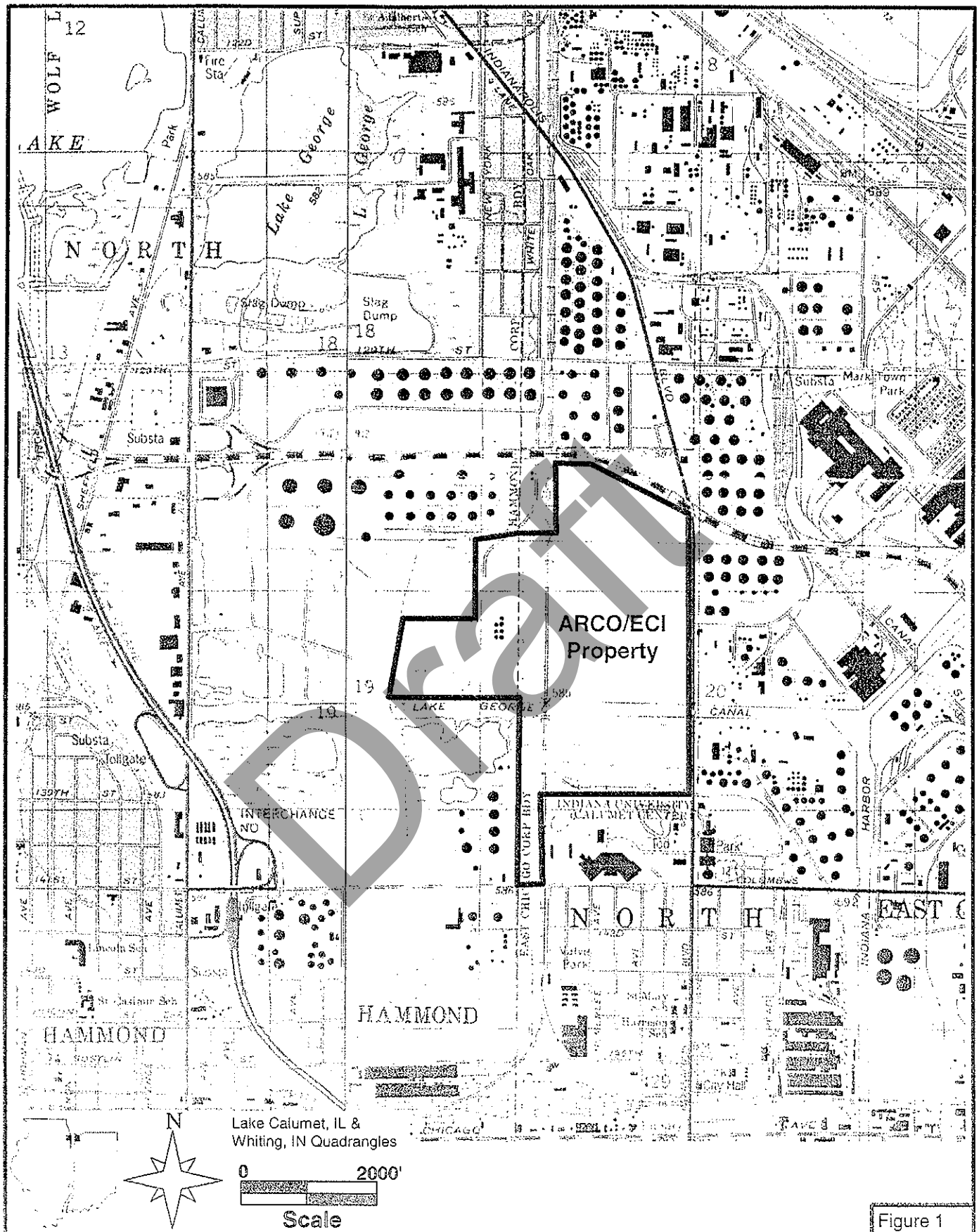

Figure 1

WESTON
MANAGERS DESIGNERS/CONSULTANTS
750 E. Bunker Ct.
Suite 500
Vernon Hills, Illinois
60061

SITE LOCATION MAP

INDIANA HARBOR CANAL PILOT PROJECT

East Chicago, Lake County, Indiana

2.2 SITE CONDITIONS

The ARCO/ECI site is a former petroleum refinery which was active from 1918 to1984. The facility was decommissioned and demolished between 1986 and 1990 (ARCADIS, 2000). The ARCO/ECI property is enclosed by chain link fence that encompasses the former Main Refinery (MR), South Tank Farm, Southwest Tank Farm, and the West Tank Farm parcels. The property is intersected by the Lake George Branch of the Indiana Harbor Ship Canal, which separates the Main Refinery and West Tank Farm parcels from the South Tank Farm (STF) and Southwest Tank Farm parcels. The site is also intersected by the Baltimore and Ohio Railroad, which separates the Main Refinery and South Tank Farm parcels from the West Tank Farm and Southwest Tank Farm parcels, respectively. Adjacent to the South Tank Farm to the south is East Chicago High School and a residential area. Indianapolis Boulevard borders the property to the east. ARCO/ECI parcel locations are illustrated in Figure 2.

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The MR parcel consists of approximately 118 acres and is located north of the Lake George Branch of the Indiana Harbor Ship Canal. The MR contained all of the primary processing units for the former ARCO/ECI refinery. Currently, the vacant parcel has revegetated with grasses and trees. A product recovery system operates on the parcel along the canal and is maintained by ARCO's contractor ARCADIS. The canal mean pool elevation level (average between lake effect levels) is approximately 10 feet below the ground elevation of the MR parcel. The southern wall of the MR parcel is constructed of corrugated steel sheetpiling that was driven to a 60-foot depth below ground surface (bgs).

The STF parcel consists of approximately 53.5 acres and is located south of the MR and the Lake George Branch of the Indiana Harbor Ship Canal. The STF was formerly an above ground storage tank (AST) field with metering stations and pipeline pump stations. It was historically used for bulk storage of a wide variety of petroleum products, including crude oil, diesel fuel, fuel oil, leaded gasoline, unleaded gasoline, sludge/slop, and other miscellaneous products (ARCADIS, 2000). This vacant parcel has also revegetated with grasses and trees. A product recovery system operates on

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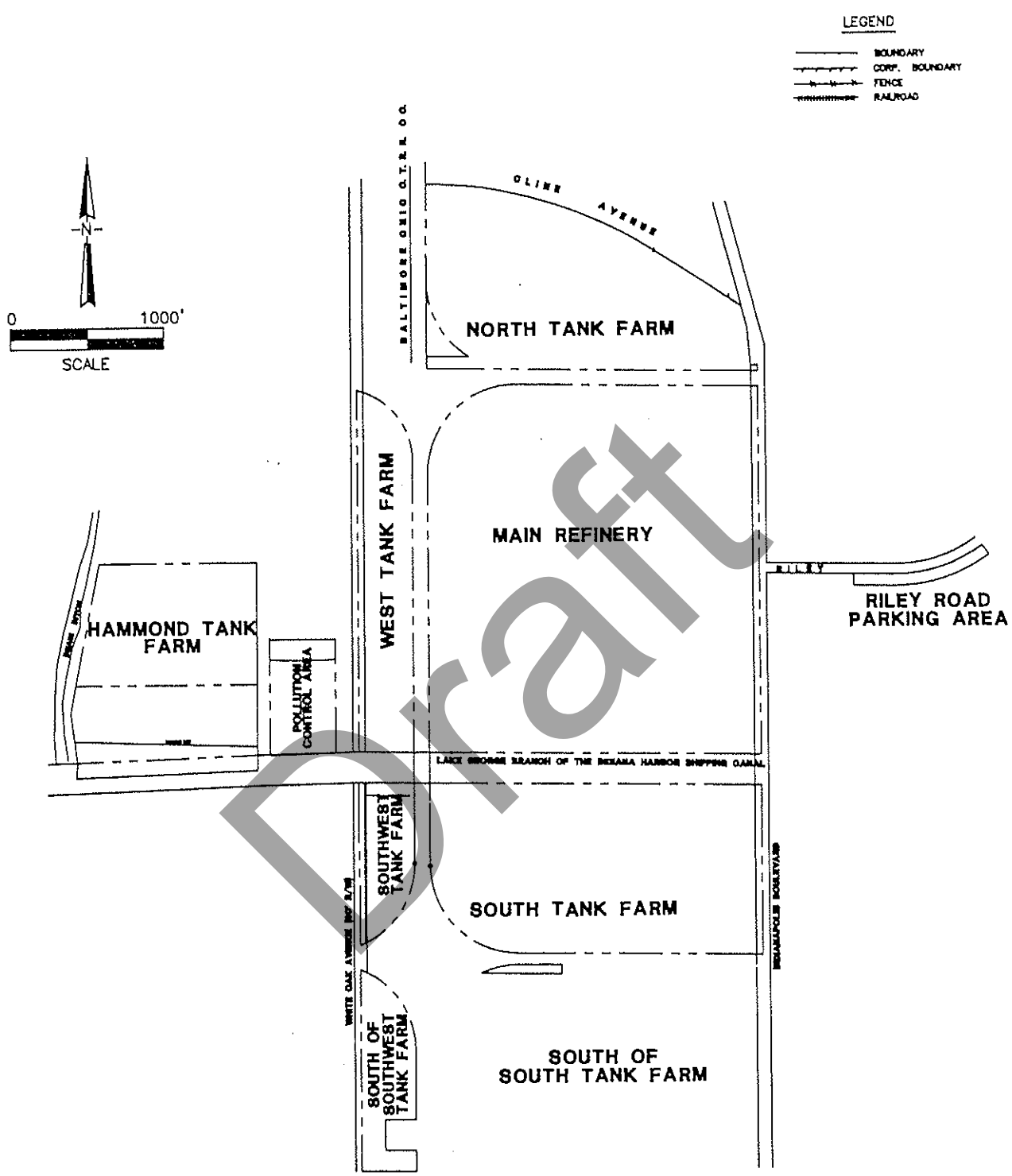

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SOURCE: ARCADIS

FIGURE 2

WESTON MANAGERS DESIGNERS/CONSULTANTS

750 E. Bunker Ct.
Suite 500
Vernon Hills, Illinois
60061

PARCEL LOCATION MAP
INDIANA HARBOR CANAL PILOT PROJECT SITE
USEPA
East Chicago, Indiana

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the parcel along the canal and is also maintained by ARCADIS. The northern boundary of the STF consists of concrete and re-bar demolition debris, which serves as a rip-rap type of embankment. The canal mean pool elevation level (average between lake effect levels) is approximately 6 feet below the ground elevation of the STF parcel.

During refinery operations, petroleum products were transported from the MR to the STF via pipelines that crossed under the Lake George Branch of the Indiana Harbor Ship Canal and pumped into the ASTs that occupied the STF parcel. These pipelines are constructed of approximately quarter-inch steel and ranged in diameter from 8 inches to 14 inches. Initially, the OSC tasked ERRS to remove five of the exposed pipelines that were visible via the canal during site walks and canal inspections START and the OSCs performed. Four approximately 14-inch-diameter exposed pipelines are located approximately 100 feet east of the Baltimore and Ohio Railroad bridge, and one approximately 8-inch exposed pipeline is located approximately 1,000 feet east of the four 14-inch-diameter pipelines and approximately 500 feet west of the Indianapolis Boulevard bridge (See Figure 3).

During pipeline removal activities, the U.S. Army Corps of Engineers and ARCADIS provided the OSC with pipeline blueprints, which revealed that there were up to 10 additional pipelines in a sheetpile bulkhead located approximately 22 feet west of the four exposed 14-inch-diameter pipelines on the MR parcel. From the dates listed on the blueprints ARCADIS provided, the bulkhead pipelines appeared to be older than the four 14-inch-diameter exposed pipelines. The bulkhead measures approximately 28 feet in width. From approximately 45 feet north of the canal wall, the pipelines descend at a 45 degree angle down towards the bottom of the canal. The pipelines cross through the canal-wall steel sheetpiling approximately 35 feet bgs, lie on the bottom of the canal in a pipeline alley crossing to the STF parcel, pass through a wooden bulkhead, ascend at a 45 degree angle, and surface approximately 60 feet south of the canal wall (wooden bulkhead) on the STF parcel.

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BOXED TEXT IS INSERTED BY WOOD FOR THE BASIS OF DESIGN REPORT

WEST TANK FARM

BALTIMORE AND OHIO C.T.R.R. CO.

BULKHEAD PIPELINES ON MAIN REFINERY PARCEL
1 – 11" DIA. CONTAINING CRUDE OIL
2 – 11" DIA. CONTAINING A LIGHT FUEL (VOC + LEL READINGS OBSERVED)
3 – 12" DIA. CONTAINING SOME CRUDE OIL RESIDUE/SLUDGE
4 – 9" DIA. EMPTY (VOC + LEL READINGS OBSERVED)
5 – 11" DIA. CONTAINING CRUDE OIL, 50% FULL (VOC READINGS)
6 – 7" DIA. WITH WHITE POWDER RESIDUE (LEL READINGS OBSERVED)
7 – 7" DIA. UNIDENTIFIED PETROLEUM PRODUCT (LOW VOC READINGS OBSERVED)

EXPOSED PIPELINES ON MAIN REFINERY PARCEL
1 – 14" DIA. CONTAINING CRUDE OIL (VOC + LEL READINGS OBSERVED)
2 – 14" DIA. CONTAINING A FUEL/WATER MIXTURE (VOC + LEL READINGS OBSERVED)
3 – 14" DIA. REDUCED TO 6" DIA. AND CUT, EMPTY
4 – 14" DIA. CONTAINING WATER/SOME FUEL
5 – 8" DIA. WATER LINE FROM CONCRETE VAULT

1 2 3 4 5 6 7
10'
65'
1 2 3 4
50'
LAKE GEORGE BRANCH OF THE INDIANA HARBOR SHIPPING CANAL

PIPELINE SECTIONS REMOVED (TYP.)
Solid lines represent removed sections

NOTE
DISTANCES INDICATED ARE APPROXIMATE.

CONCRETE VAULT
5
15'
CANAL
15'
15' removed, as per text
15'

MAIN REFINERY

CONCRETE VAULT
8" DIAMETER WATER PIPELINE

LAKE GEORGE BRANCH OF THE INDIANA HARBOR SHIPPING CANAL

INDIANAPOLIS BOULEVARD

SOUTH TANK FARM

Pipe E

NOTE: GAS LINES ARE NOT SHOWN

SOUTHWEST TANK FARM

LAKE GEORGE BRANCH OF THE INDIANA HARBOR SHIPPING CANAL
8 9
50'
15'
50'
1 2 3 4 5 6 7
1 2 3 4
Pipes 1 2 3 4 5 8 9 6 7 A B C D

EXPOSED PIPELINES ON SOUTH TANK FARM PARCEL
1 – 14" DIA. CONTAINING CRUDE OIL (VOC READINGS OBSERVED)
2 – 14" DIA. CONTAINING A FUEL/WATER MIXTURE (VOC READINGS OBSERVED)
3 – 14" DIA. CONTAINING YELLOW–COLORED FUEL AND SOME WATER (HIGH VOC READINGS)
4 – 14" DIA. CONTAINING A SMALL AMOUNT OF WATER/FUEL MIXTURE
5 – 8" DIA. WATER LINE FROM CONCRETE VAULT (HIGH VOC READINGS IN SURROUNDING SOILS)

PIPELINE SECTIONS REMOVED (TYP.)
Solid lines represent removed sections

BULKHEAD PIPELINES ON SOUTH TANK FARM PARCEL
1 – 11" DIA. CONTAINING WATER AND SLUDGE
2 – 11" DIA. EMPTY
3 – 11" DIA. CONTAINING CRUDE OIL, FULL
4 – 11" DIA. EMPTY (HIGH LEL READINGS OBSERVED)
5 – 11" DIA. CONTAINING CRUDE OIL, 90% FULL
6 – 7" DIA. AIR, MOST LIKELY (VOC=28PPM)
7 – 9" DIA. PRESSURIZED WATER LINE (LIKELY CONNECTED TO SITE FIRE HYDRANTS)
8 – 4" DIA. ELECTRICAL HOUSING
9 – 4" DIA. AIR OR GAS (VOC=61PPM)

N

0 200'
SCALE

FIGURE 3

WESTON MANAGERS DESIGNERS/CONSULTANTS
750 E. Bunker Ct.
Suite 500
Vernon Hills, Illinois
60061

PIPELINE LOCATION MAP
U.S. EPA
INDIANA HARBOR CANAL PILOT PROJECT
East Chicago, Indiana

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3.0 PIPELINE REMOVAL

The OSC initiated the closeout of the pipelines to address the recurring oil sheens and product that were observed in the canal. The goal of the removal was to stop the pipelines from acting as a direct conduit for petroleum products to migrate from the STF and MR parcels into the canal. To accomplish this goal, the OSC planned a full removal of the pipelines from the canal. Due to anchoring, the pipeline sections that lie at the bottom of the canal could not be removed in a cost-effective manner. To close the conduit the pipelines created, the OSC alternately chose the removal of pipeline contents, decontamination, removal of pipeline sections on the parcels, and capping or grouting of the pipelines. The initial five exposed pipelines were closed out first, and then when the bulkhead pipelines were identified, the OSC continued removal operations to include the additional pipelines. The pipeline contents and locations are illustrated in Figure 3, and photo documentation of removal activities is located in Appendix A.

3.1 EXPOSED PIPELINE REMOVAL

The exposed pipeline removal was conducted from 9 October 2001 through 20 November 2001. ERRS began work by unearthing the four 14-inch-diameter pipelines on both sides of the canal using an excavator for the bulk of the cover soil and then by hand, with shovels.

3.1.1 South Tank Farm (STF) Parcel

On the STF, the pipelines were unearthed approximately 50 feet south of the canal. ERRS placed plastic sheeting in the excavation trenches to provide containment in the event of a spill. After the pipelines were wire-brushed on the top surface, threaded collars were welded onto each pipeline. A 1-foot section of pipe was used to connect the collar to a ball valve, and a pneumatic drill fitted with a quarter-inch drill bit was used to penetrate the pipeline. Cutting oil was used to reduce friction and potential sparking.

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The 8-inch diameter pipeline located approximately 1,000 feet to the east was collared, drilled, cut, contents pumped, and an approximately 15-foot section removed in the same manner as the four previously mentioned pipelines. Concrete grout was placed in both pipeline sections.

3.1.2 Main Refinery (MR) Parcel

The pipelines on the MR parcel were unearthed approximately 20 feet north of the canal. The same vacuuming, cutting, and grouting procedures used on the STF parcel were implemented on the MR to remove the contents of the pipelines. Approximately 25-foot sections of each of the four 14-inch-diameter pipelines were removed north of the canal. On the MR parcel, a concrete vault connected to the 8-inch pipeline was grouted closed, and a section approximately 15 feet in length was removed from between the canal wall and the vault.

3.1.3 Decontamination and Exposed Pipeline Closure

For the sections of pipeline which run along the bottom of the canal and were to remain in place, jetting with a high-pressure self-propulsion system was used for gross decontamination of the insides of the pipelines. This was used in conjunction with a vacuum truck to remove the decontamination water. After the pipelines were jetted, steel caps were placed over the ends of the pipelines on the STF parcel. On the MR parcel, the section of pipeline from the pipe fitting that connects the vertical portion of the pipeline extending out of the canal with the 90 degree angle and connects to the horizontal pipeline on the parcel was removed. Steel pipe caps were then bolted to the existing fitting on the portion of the pipeline remaining in the canal. Sections of 2-inch-diameter pipe were threaded vertically onto the collars of the remaining pipelines to mark the location and to allow for future monitoring of pipeline contents. After backfilling the excavation trenches with soil, the pipe sections threaded into the collars extended above the ground surface. Steel caps were threaded onto the tops of the pipeline markers. This procedure was done on both the MR and STF parcels to mark the locations of the pipelines.

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4.0 PROJECT CLOSURE ACTIVITIES

On 12 December 2001, a crane was mobilized to the site in an attempt to remove the 8-inch-diameter pipeline that is approximately 500 feet west of the Indianapolis Boulevard Bridge and 1,000 feet east of the four exposed 14-inch-diameter pipelines. The OSC had initially planned for the removal of each whole pipeline from the canal but wanted to determine if this was feasible, since ARCO pipeline blueprints indicated anchoring underneath the canal. Several attempts made to pull the pipeline out of the canal failed and the pipeline was left grouted in place. No attempts were made on other pipelines.

During the pipeline removal operations, product and water vacuum pumped into vacuum trucks from the pipelines was transferred into fractioning tanks on both the MR and STF parcels. The contents of the fractioning tank on the STF parcel were removed using a vacuum truck and pumped into the fractioning tank on the MR parcel and allowed to settle. On 14 December 2001, approximately 5,000 gallons of product were removed from the tank and shipped off-site for disposal by Pollution Control Industries (PCI), located in East Chicago, Indiana. Approximately 2,500 gallons that remained in the fractioning tank were disposed of during the week of 17 December 2001 by PCI.

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5.0 REFERENCES

U.S. Geological Survey (USGS) 7.5-Minute Topographic map, Lake Calumet Quadrangle Illinois 1997 and Whiting Quadrangle Indiana, 1997 and 1991.

ARCADIS, 2000. *Current Conditions Report - ARCO-ECI(Former Refinery) - East Chicago, Lake County, Indiana,* June 2000.

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APPENDIX A

PHOTO DOCUMENTATION

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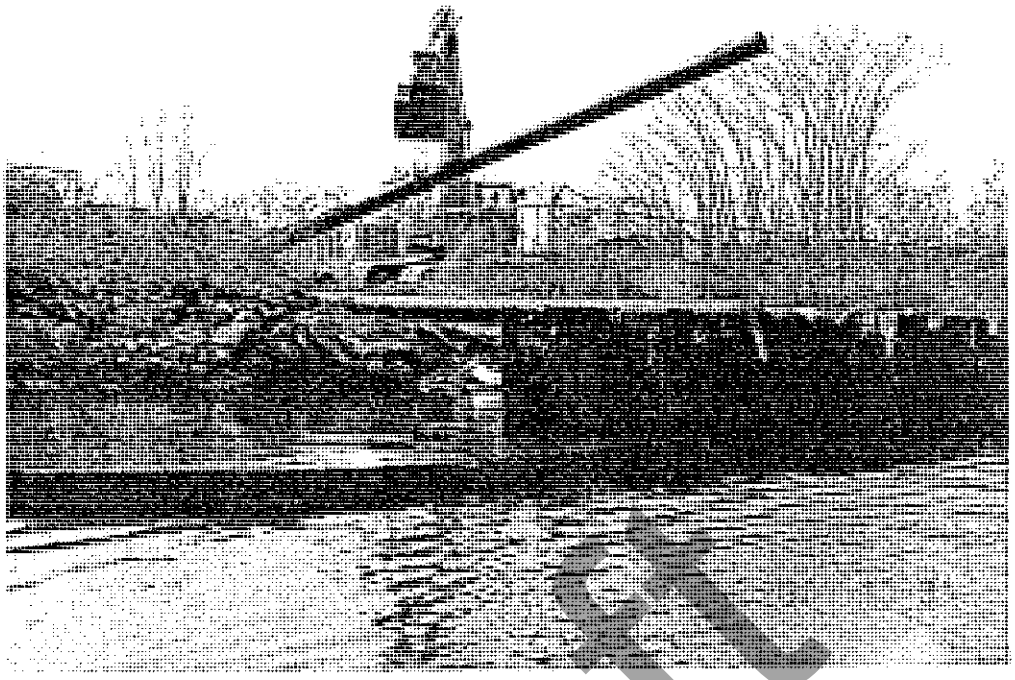
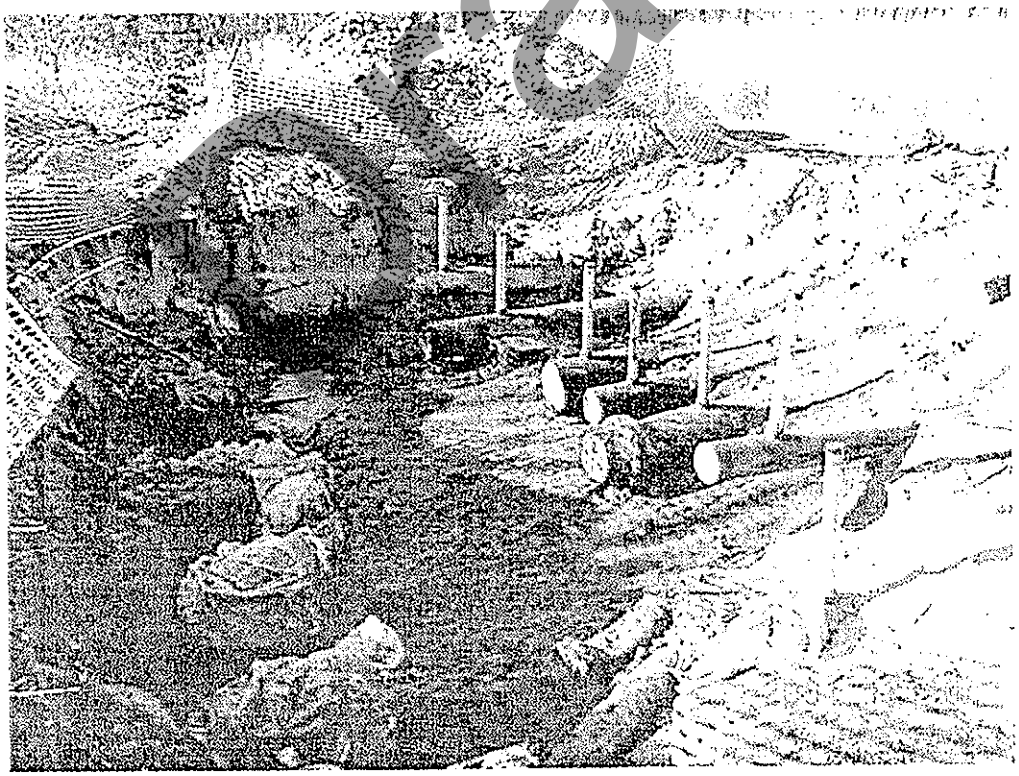


ERRS removing 50 foot section of 14-inch diameter pipeline on the South Tank Farm parcel.



Bulkhead pipelines (on right) are grouted and have marker pipes in place for backfilling after canal side (on left) of pipelines are jet-washed and grouted.

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750 E. Bunker Ct.
Suite 500
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60061

PHOTO DOCUMENTATION

INDIANA HARBOR CANAL PILOT PROJECT

East Chicago, Lake County, Indiana

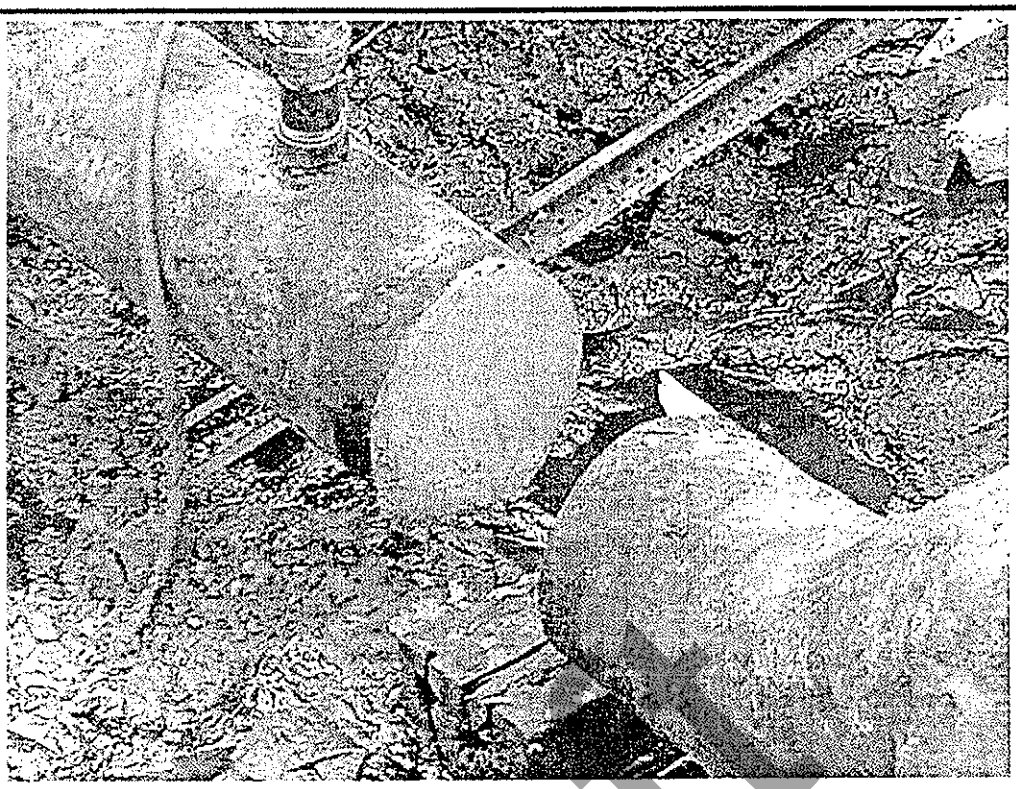
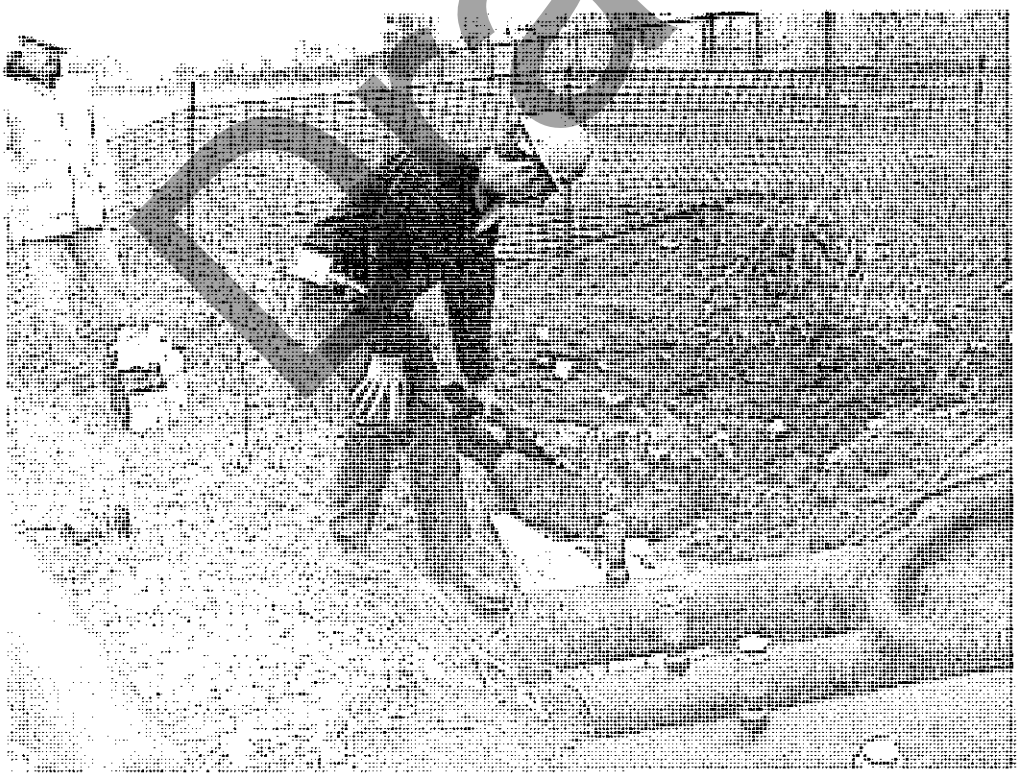


Photo shows a Grouted pipeline on the Main Refinery parcel.



START performing air monitoring in pipeline with Micro FID and MultiRAE units to Determine the presence of volatile organic compounds or explosive vapors.

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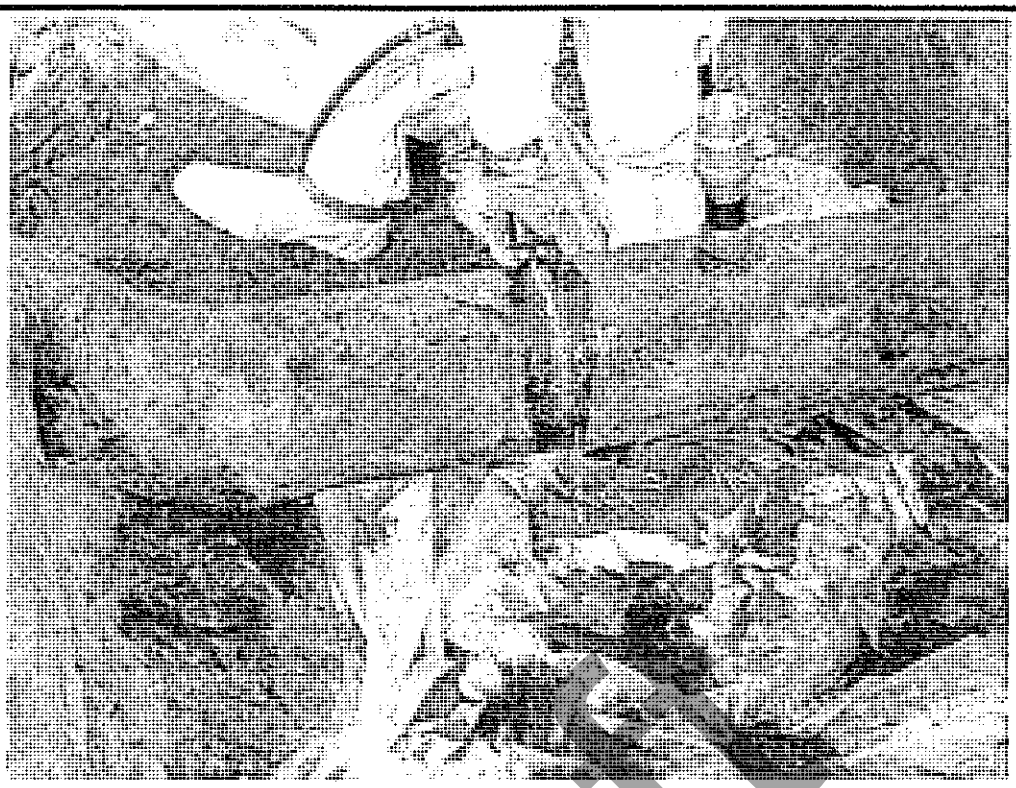
PHOTO DOCUMENTATION

INDIANA HARBOR CANAL PILOT PROJECT

East Chicago, Lake County, Indiana



ERRS making initial cut to create a square hole with pneumatic saw.

Contents of pipeline being vacuum pumped.

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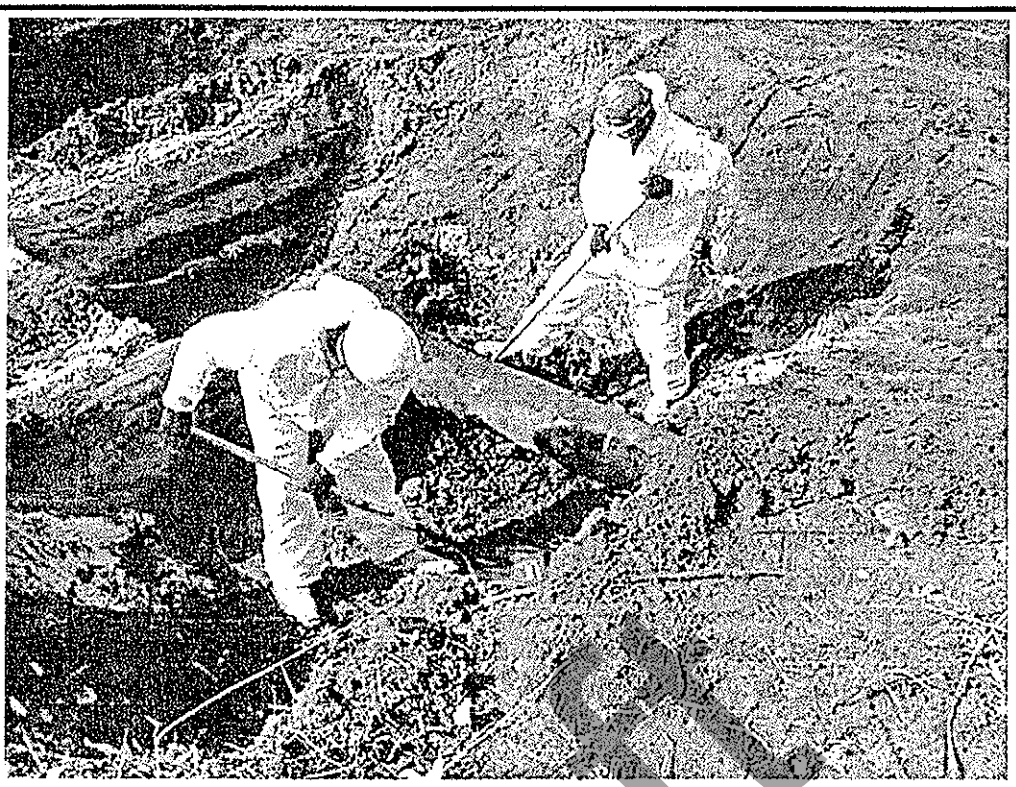

ERRS removing soil surrounding pipelines on the Main Refinery parcel.

Welded collar with threading to receive pipe section and ball-valve.

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APPENDIX C GROUNDWATER MODELING

TECHNICAL MEMORANDUM

DATE: December 2019

TO: Project File

FROM: Ronald Lewis

REVIEWED BY: James Field, Brian B. Johnson, P.E. (ME)

SUBJECT: Development of Groundwater Flow Model to Support ECI Barrier Wall Design at the STF

PROJECT: 3205191698

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INTRODUCTION

Wood has been tasked to provide a design of a barrier wall system at the South Tank Farm (STF) at the former Energy Cooperative, Inc., (ECI) site in East Chicago, Indiana. Preliminary conceptual designs of such a barrier have been presented by Arcadis in site investigation (SI) reports of 2002 and 2016. Arcadis also evaluated other alternatives, such as an air sparge curtain with or without extraction well interception of groundwater to increase the thickness of the exposed smear zone. Atlantic Richfield Company (ARC) determined that a barrier wall was the preferred alternative and the 2018 Administrative Order on Consent formalized that determination. Further, Arcadis presented calculations to estimate the effect of a perforated zone of such a barrier, i.e., to mitigate potential mounding of groundwater and breakout at ground surface. These latter calculations assumed various degrees of perforation (zero, five, ten, and 100 percent of open area in the perforated zone) for comparison of the preliminary conceptual designs, and utilized a groundwater model developed by them and documented in Appendix B of the 2002 SI report (Attached to the BODR as **Appendix B.1.2**). Arcadis located and provided the MODFLOW groundwater model input/output files to Wood for each of these scenarios. It was hoped that the model could be used with minor modification to support Wood's basis of design through its 30%, 60%, 90% and Issued for Construction stages. However, as described below, Wood determined that the model as provided would need significant modification and revision in order to support these increasing levels of barrier wall design. Wood's assessment of the existing model and rationale for modifications are discussed as general and specific concerns in the next two sections.

It should be noted that Arcadis had some reservations as to the function and ability of the previously proposed barrier wall to entirely prevent the formation of oily sheens in the Lage George Canal (Canal). While the solid section of the conceptual design would cut off the potential for residual light non-aqueous phase liquids (LNAPLs) migrating directly into the canal, Arcadis questioned the mechanism for the formation of the sheens in the Canal that were the impetus for the perceived necessity of such a barrier (or equivalent means) of preventing groundwater discharge to the canal or of treating such a discharge to prevent sheens. Quoting Arcadis (2016):

> "In general, since LNAPL recovery is declining and LNAPL exhibits potential mobility characteristics near the Canal in only localized areas, sheens in the Canal are not likely originating as a result of LNAPL seepage from the bank; the sheens are most likely generated by interaction of groundwater and surface water with soils and sediments near the Canal bank and groundwater/surface water interface."

WOOD'S REVIEW OF THE ARCADIS MODEL

Wood has reviewed the Arcadis model documentation. The Arcadis model covered a large area relative to the ECI Site due to the desire to define the model domain mainly through natural watershed boundaries. These included Lake Michigan, the Indiana Harbor Canal (IHC), and the Grand Calumet River. This model covered an area of about 8.7 square miles (**Figure C-1)**. Most of the water level data used to calibrate the model was generated in and about the ECI parcels bordering the Canal. The model was calibrated to a water level data set of March 5, 2002, which consisted of 29 water level targets, only 7 of which were on the STF proper, and 4 on the adjacent Southwest Tank Farm (SWTF). (See below for further discussion of water level data sets.) While this was all useful information, upon further review of the model files, Wood had several concerns that likely precluded using the Arcadis model as is. The major ones include:

- The Arcadis model assumed water table conditions in model layer 1, which did not consider the computed water table elevation relative to ground surface. When Wood imported Lidar ground surface elevation data for the Arcadis model interpreted recharge area to the Canal from the south into the Arcadis model, it showed that the model-generated a water table elevation that was significantly above ground surface, a condition known as cell flooding, over a large portion of the model domain and especially relative to origins of flow through the STF.
- Review of USGS preliminary modeling in 1989 (Watson, et al.) and 19932 (Fenelon and Watson) indicated that the USGS believed that there was significant loss of groundwater to sewer lines, a major sink for groundwater unaccounted for in the Arcadis model. These sewer lines were only roughly modeled by the USGS and there are no good data regarding their full effect.
- The result is that the calibration of the model recharge and K for the STF area may not be accurate, and subsequently, as well, estimates of potential mounding.
- The hydraulic conductivity for the STF area is uniform, aerially and with depth, in the Arcadis model, but 2016 SI borings (the SB-2016 series) show a general presence of silty

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fine sand above the clay along the alignment of the borings. With a hanging wall, this lower K at depth could cause a greater mounding than the Arcadis model might indicate because the perforations are actually in silty sand.

Wood believed that to provide a better basis to support design was to construct a model local to the STF, more finely discretized to more accurately represent possible barrier wall system designs and using projected maximum gradients across the STF, simulate a range of potential fluxes through the wall section to generate a range of potential mounding effects and groundwater velocities through open sections of the barrier. In this way, concerns for potential mounding could be addressed within the available data and determine if potential risks might occur. The results of the model might also indicate critical data needs to refine the model and reduce uncertainty for later design stages.

SPECIFIC CONCERNS FOR THE USE OF THE ARCADIS MODEL TO SUPPORT DESIGN

1. The model computed head contours south and southwest of the STF continue to increase, generating a large area that is flooded, i.e., the model head is greater than the ground surface elevation. Apparently, Arcadis assigned the model layer 1 condition as unconfined, hence the model did not need to use a top of layer 1 and Arcadis may not have been aware that much of the model domain was flooded.
2. The a priori assigned K of 38 ft/d to the Calumet aquifer sands fixed the recharge rate (through calibration) at 8 in/yr. Given the flat terrain and the sandy nature of the aquifer, this rate seems unnaturally low considering the local annual precipitation.
3. The model south of the Canal has very few calibration targets whereas the entire model domain is quite large. The calibration over large areas of the model is questionable.
4. The USGS preliminary modeling was concerned with the water balance in the EC/Hammond/Gary area, and concluded that leaky sewer lines throughout the area accounted for up to an estimated 40 percent of the total water balance. Two large sewer lines south of the Canal produced large interpreted depressions in the water table. Those, coupled with other sewer lines and drainages produced a water table that rarely exceeded 583 ft rather than going up to about 597 ft as in the Arcadis model SW of the STF.
5. There may be some inconsistency with vertical datums. Much of the earlier work and the model cite NGVD29 and may have to be converted to NAVD88. While this is a potential concern, the conversion between datums is on the order of only 4 inches, so for purposes of the modeling, this is not likely a concern. However, efforts have been made to be consistent throughout the BODR.
6. The cross-section B-B' across the STF (Attached in **Appendix B.4.2** of the BODR) seems to have several errors. Both horizonal and vertical scale bars seem inconsistent with the known dimensions. In addition, this cross section does not appear to include the results of the 2016 series of borings to top of clay (SB-2016-01 to -09). This inclusion would seem to imply that the bottom of the aquifer along the alignment of the barrier is fairly

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uniformly at elevation 555, slightly dipping at the east end. The assigned soil types seem reversed, with the majority as silty sand rather than dune or beach sand, and doesn't show the silty sand in the west half as the 2016 borings encountered.

7. The model assigns a uniform 38 ft/d K over all four layers – no hint of any transitioning to siltier soils above the clay. These may actually be tighter and the lower portion of the aquifer may not be able to pass as much water as the Arcadis model suggests (i.e., through perforations in a wall).

It appears that the Arcadis model has a number of uncertainties and it may not be possible, with the data available to really be able to accurately predict what the base flow is through the STF. Although it would appear from the fact that the water table is actually below ground surface and the USGS work on probable sewer sink effects, the recharge area to the STF may be smaller than the Arcadis model would suggest; however, the recharge may actually be greater than modeled, as well as the K assigned for the limited calibration fit, and still allow a Q on the order of those Arcadis estimated. The following discussion involves the development of a reduced area model and the conduct of sensitivity analyses to try to bracket probable effects of the barrier design. This may generate useful ranges of resultant velocities, and flows that might develop

WOOD'S MODIFICATIONS AND REVISIONS TO THE ARCADIS MODEL

Wood completed a detailed review of the Arcadis 2002 model, coupled with the realization that as the focus was solely on the STF for this exercise, that the full 2002 model domain was not needed. A preliminary model was established by using the Arcadis model output head contours from the 2002 SI report **(see Figure C-2**) and estimating what appeared to be the model domain area whose recharge would discharge to the Canal. This inferred recharge area corresponds to the reduced model domain shown on **Figure C-3**. Lidar data for ground surface elevations and a digitization of Figure 2-2 in Appendix B of the 2002 SI (contour map of top of clay, Attached in **Appendix B.1.2** of the BODR) of the Arcadis model documentation were used to establish the upper and lower model surfaces, respectively – the top of clay as the base of the model assuming that no significant flow occurs in the massive clay unit. The domain of the Wood modified model at this stage, extended about 12,000 feet (ft) east-west and 5,000 ft north-south. A groundwater divide resulting from groundwater flow to the Canal or IHC was assumed in the interpretation. Wood implemented construction and running of the model as the USGS code MODFLOW 2000 within the Groundwater Vistas version 6 pre- and post-processor. Other input parameter values from the Arcadis calibrated model (e.g., hydraulic conductivity (K) of 38 ft per day (ft/d)) were input into this one-layer model and the model run. It was quickly apparent that the steady-state model generated heads that were above ground surface over a large portion of the model, as indicated above; these are referred to as flooded cells and are also shown on **Figure C-3**. Further, this model run generated an estimate of about 15,192 cubic feet per day (cuft/d) as opposed to the Arcadis estimate of 13,358 cuft/d. This model did not include Lake Mary, so likely this flux rate was a bit high, but given simplicity of model it was judged not a bad first result. Prior USGS modeling of groundwater flow in the area was reviewed in greater detail (Watson, et al., 1988; Fenelon, 1992) to see if there were indications of why such large heads were being generated. The USGS survey of water balances

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in the area indicated that leaky sewer lines were likely the primary receptors of groundwater throughout the area. These were not included in the Arcadis model and major depressions in the water table were also interpreted by USGS in these areas (Watson, 1988). This suggested that the recharge area for the Arcadis model discharging through the STF may have been over-estimated.

Consequently, in a second preliminary model, Wood decided to further reduce the domain of the model to north of West Columbus Drive and 141st Street, west to about Route 41 and the west end of the Canal, and east to the Indiana Harbor Canal (IHC) – there is also an inferred groundwater divide extending at a 45-degree angle with the intersection of the Canal and IHC. This extent of the further reduced area model is shown on **Figure C-4**. Still, even with modified recharge area extents, it was difficult to obtain decent fits to water levels (the more complete April 10, 2002 data set was now being used as a basis for calibration) using the auto-calibration routine in Groundwater Vistas, used by Wood here as the model pre- and post-processor. The initial grid spacing was set at 100x100 ft, but this was subdivided to 25x25-ft grid blocks in the STF area as in the Arcadis model to better define the border with the Canal and the outline of Lake Mary. The model origin is at State Planar coordinates of (2839550E, 2328260N) and the domain extends about 7300 feet E-W and 2700 ft N-S. Additional layers were added to make a 5-layer model to potentially include the presence of a lower-K silty sand unit overlying the massive clay as indicated in most SB-2016 boring log series (Arcadis, 2016) and to prepare for possible vertical subdivisions to accommodate possible alternate wall designs. Lake Mary was assigned a K of10,000 ft/d as a flow-through water body as Arcadis had, and a series of drain nodes were added (at reference elevation 581) to represent the water hazards and ponds at the McArthur Golf Course. Unoptimized, this gave a flux through the STF of 10,790 cuft/d. Optimization of this setup resulted in a best fit with K of 24 ft/d, and increased recharge rate of 16 inches per year. This increased the estimate of flux through the STF to 16,300 cuft/d. Note that the USGS assessment of K estimates for the Calumet aquifer were given as 20 to 30 ft/d (Kay, et al., 1996).

In the next iteration, the initial K for the 3-foot silty sand layer was set as 8 ft/d as indicated by average slug tests in some deeper wells. Starting with K of overlying sands at 38 ft/d, and the overall recharge at 12 inches per year, this setup was optimized and yielded an estimated sand K of 25.4 ft/d, 0.8 ft/d for silty sand, and a recharge of 15.15 inches per year. Flow through the STF was 10,264 cuft/d.

The next stage of improvement was to provide different recharge area values. The USGS reports for the larger study area (70 square miles including East Chicago, Hammond, Gary and Whiting) had suggested recharge rates of 9 to 17 inches per year for undeveloped areas, 2 to 4 inches for areas with slag, 0 to 2 inches per year for oil refineries, and 7 to 12 inches per year at pavement and buildings (to account for runoff). In addition, in order to reduce the area of flooded cells, it was noted that there were indications of standing water in two areas south of Lake Mary; at least one of these had an apparent outlet to Lake Mary. Drain nodes were assigned to these areas assuming reference elevations for the water or basin surface elevation. Using the best fit initial values from the previous run resulted in a flux through the STF of 9815 cuft/d. Optimizing on these recharge rates and the two K values produced a relatively good fit (average residual of

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0.09 ft, a standard deviation of 0.67 ft, and a sum of the squares of the residuals of 9.2 ft^2). The recharge zones are shown on **Figure C-5**. The new values for recharge were 22.5, 3, and 4 inches per year, and for sand and silty sand optimized Ks of 26 and 4 ft/d, respectively, were indicated. The flux rate through the STF was 11,877 cu ft/d.

An even slightly better fit was obtained by raising the drain reference elevation from 581 to 582 ft at the golf course ponds. Optimized, the new Ks were 22.9 and 4.12 ft/d, the recharge zones 18.7, 1, and 4 inches per year. The flux through the STF was 10,423 cubic feet per day (ft^3/d), or about 54 gpm. Here the average residual was 0.07, the standard deviation 0.65 ft, and the SSR 8.59 ft. The output of this run (Setup_7) is shown on **Figure C-6,** zoomed in on the STF and SWTF area**. Table C-1** summarizes the residuals analysis, while **Figure C-7** plots the model computed head versus the observed heads. The fit is good with the possible exception of MW-36, as discussed below. The reduction in the area of flooded cells in the model is as shown on **Figure C-8** (Wood model) versus **Figure C-3** (Arcadis model)**.** Discharge to the Canal through the STF was about 54 gpm as compared to about 44 gpm through the golf course pond system.

Other runs were made to include a thicker silty sand and to specify a K of 50 ft/d for the sands (in accord with the often-reported average K of the site sandy unit), but these could not produce reasonably good fits for the residuals analysis, and which also required unreasonably high recharge rates for calibration.

In all, the K and recharge values obtained in the calibration run for model run Setup_7 fall closely to or within ranges cited for the Calumet aquifer area by USGS, and the 18.7 inches per year recharge is more consistent with a flat grassy sandy undeveloped area.

PARTICLE TRACKING

Using run Setup_7 as a basis, particle tracking was performed by assigning one particle to each model cell in the first complete row (having no constant head boundary nodes) south of the Canal, and in each layer, and specifying reverse tracking for the USGS particle tracking program MODPATH. This process defines an approximate recharge area for the STF under normal recharge conditions. The results of this particle tracking run are shown on **Figure C-9**. For the particle tracking run, the particles were seeded (placed) at the midpoint of each cell including the midpoint elevation of each cell, and the option of passing through weak sinks was invoked. The apparent capture zone for this model run covered most of the STF with a tail on the west perimeter extending southward.

Recharge falling in the area south of the STF recharge zone would discharge mainly to the golf course ponds.

SIMULATIONS

Two simulations are considered here, first the effect of a solid barrier wall, and the second a storm event on water arriving at groundwater controls behind the wall.

Barrier wall: Recently the decision has been made to design a barrier wall running along the full length of the STF at the Canal, and simulated here as positioned about 25 feet into the Canal to

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account for intersecting an elevation of 567 of the STF slope into the canal, with an equivalent assumed thickness of 1 foot and a K of $1x10^{-6}$ cm/sec. A drain line is assumed positioned behind the wall to intercept groundwater moving to it, and a relatively high K backfill in the new space behind the wall of 100 ft/d. The invert elevation was set at 578 ft for comparison to the wall-less run. This simulation run was identified as Setup_8. The barrier wall was given wingwalls extending perpendicularly 200 feet back into the STF.

As expected, the drain, although not extending deep into the backfill, was effective in capturing flow coming to it. The drain captured 10,348 ft^3/d, a difference of less than one percent, essentially identical, and water levels across the STF were not different than simulated under current conditions.

Simulation of a storm event: A 24-hour, 25-year storm for the East Chicago area is estimated as 5.32 inches of rain. Watershed calculations suggested that only about 0.27 inches of this would run off, leaving about 5 inches of infiltration. Evapotranspiration would decrease this, but only during the growing season. As a worst case, Wood modeled a storm event of 5 inches reaching the water table over one day followed by a return of average recharge rates over a subsequent 30-day period in a transient model run using Setup_7 as a basis. Since there were three recharge zones, wood assigned proportionately lower recharge rates for the storm period for the other two zones, i.e., 0.28 and 1.14 inches for the storm event.

This run basically blew up. While the water table conditions near the Canal and in particular near the STF barrier wall and drain system and the golf course ponds remained subsurface, model heads over much of the area rose above ground surface elevations. The rate of water collected by drain nodes behind the wall was approximately 260 gpm, returning to about 100 gpm at the end of the 31-day simulation period.

A second run was made using the higher 38 ft/d K for the sands. While this resulted in slightly lower heads overall, much of the model domain was still inundated. The maximum rate at the drains rose slightly to 305 gpm, dropping to about 120 gpm at the end of the 31-day simulation period.

Since such a degree of inundation has never occurred at the STF, clearly there must be other sinks for the amount of precipitation that occurs during storm events. These may be surface water drainage features, or subsurface conditions that come into play as the water table rises, or, possibly, flow may occur to the south toward the system of leaky sewer lines. These features are not apparent at this time.

DISCUSSION OF WATER LEVEL DATA SETS

To date, we have data from seven water level measuring events, three in 2002, one in 2014, one in 2015, and two in 2017 (but the latter only separated by 2 days). Only the three in 2002 include measurements of wells in the SWTF. The initial set on 3/5/2002, and the one Arcadis used to calibrate the model, only had measurements at seven STF wells. The data set on 4/10/2002 appears to be the most complete set. The two sets reported in the 2016 SI both had several rejected measurements (see plotted figures in the SI) and contained only wells in the STF and WTF, which is to the detriment of the interpretation of groundwater flow at the WTF since

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shoring or sheet pile along the Canal at the Hammond Tank Farm and the Main Refinery sites direct flow through the PCA and WTF. The 2/28/2017 event included measurements at several product recovery wells (PRW) and piezometers that were within a short distance of the Canal, but we do not have the reference elevations to reduce the reported depths to water. These data (TOC elevations) must exist somewhere, perhaps in the ERM report, but we have not seen these as yet. Even if we had these, the additional points may only serve to further bias the calibration since they would give additional, and perhaps excessive, weight to conditions proximate to the canal rather than over a wider area which is more useful.

Another missing datum in the reports is a measure of the water level in the Canal at the date of each water level measurement event. We may have recourse to providing this datum via the USGS gaging station, but it would have been helpful if this had been taken via staff gage at each event.

So far, Wood would go with the 4/10/2002 data set as it appears more diverse and apparently less subject to apparent anomalous readings. Only one measurement point seems problematic and that is MW-36. Here the residual for the preliminary best calibrated Wood model is 1.97 ft, and that represents nearly 50 percent of the SSR (8.59 ft^2) in the model residuals analysis. However, the measurements at MW-36 show that well to typically have a high reading. There may be some local reason for that or some survey error, but it would seem it cannot be ignored.

SUMMARY OF MODEL RUNS AND UNCERTAINTIES AND LIMITS

Consideration of some other features, e.g., the ponds at the golf course and the water bodies south of Lake Mary, the redefining of the recharge area and recharge zones, have led to a more defensible and coherent representation of probable groundwater flow through the STF. However, this process has involved many assumptions and still may not provide a definitive assessment of groundwater flow through the STF or accurate depictions of the effects on groundwater flow when a barrier is installed. The estimates of flow through the STF have ranged from about 10,000 to 16,000 cuft/d, or from about 52 to 83 gallons per minute (gpm). This brackets the Arcadis estimate of 13,358 cuft/d or about 69 gpm. In neither case, however, do we have a guarantee of maximum flow rates that might be encountered during a particularly wet year, or of groundwater velocities that might result from alternate barrier designs. It is possible, however, that these measures might be approximated and bracketed.

Another uncertainty lies in the presence, but unknown characteristics of drainage features proximate to the STF, i.e., apparent outlets from the golf course ponds. One to the east may lead into a concrete lined drainageway along the east side of the STF, but the other stream heads toward the STF, and goes along its southern and western perimeters, ostensibly to discharge into the Canal. This may offer additional groundwater control preventing excessively higher heads in the STF, particularly along the SW edge of the STF where the model shows some flooded cells. The present representation (or its lack) thereby adds a greater degree of conservatism to the model.

Additional data on all these features would help firm up the reliability of the model. We also lack boring logs for most of the well installations at the WTF, STF, and SWTF parcels.

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The simulation of the 24-hour/25-year storm event basically blew up (with model heads way above ground surface), and results (estimates of maximum flow rates picked up by the drain from this run) are suspect. The problem is that the aquifer does not have the capacity with low gradients at the Canal, STF near the wall, and in the vicinity of the golf course ponds to carry away all the precipitation which becomes infiltration and recharge. What likely occurs is that there are ground surface drainageways and storm runoff collection system that come into play during storm events that are not included in the model because we have no data to locate or represent them properly. It is known that there are no apparent breakouts of groundwater at the STF during storm events of the magnitude that the current model cannot properly represent. It is possible that the recharge near the southern perimeter of the model may go south under the influence of extensive leaky storm sewers in the developed areas south of W. Columbus Drive.

Further development of the model may help relieve the problem, but only reasonably if such features or alternate sinks can be identified. If not, the model's usefulness may be limited to recharge ranges exclusive of storm events exceeding 1 or more inches per day.

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TABLES

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			Table C-1					
			Residuals Analysis Setup_7 Model Run					
Name	**X**	**Y**	**Layer**	**Observed**	**Computed**	**Weight**	**Group**	**Residual**
GW-02	2843098	2330655	5	579.66	578.94	1	1	0.72
MW-09	2842811	2330697	1	578.44	578.64	1	1	-0.2
MW-35	2842985	2330095	1	583.43	582.81	1	1	0.62
MW-36	2843036	2330463	1	582.59	580.62	1	1	1.97
MW-37	2843943	2330481	1	580.41	579.98	1	1	0.43
MW-38	2843753	2329884	1	582.21	582.42	1	1	-0.21
OW-103	2843636	2330173	1	581.72	581.75	1	1	-0.03
OW-101	2842386	2330195	1	581.99	582.84	1	1	-0.85
MW-10	2842243	2329895	1	583.88	584.29	1	1	-0.41
OW-104	2842238	2329894	5	583.8	584.29	1	1	-0.49
OW-105	2843606	2330705	1	577.77	578.41	1	1	-0.64
OW-106	2843614	2330705	5	578.31	578.39	1	1	-0.08
OW-123	2843746	2329882	4	582.55	582.42	1	1	0.13
OW-124	2842174	2330745	2	577.74	578.56	1	1	-0.82
OW-125	2842182	2330746	5	578.71	578.54	1	1	0.17
P25	2843136	2330659	1	578.47	578.91	1	1	-0.44
OW-116	2841641	2330736	1	579.15	578.44	1	1	0.71
OW-117	2841641	2330736	4	579.09	578.43	1	1	0.66
OW-118	2841514	2330081	1	582.62	582.79	1	1	-0.17

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			Table C-1					
			Residuals Analysis Setup_7 Model Run					
Name	**X**	**Y**	**Layer**	**Observed**	**Computed**	**Weight**	**Group**	**Residual**
MW-34	2841588	2330360	1	581.84	581.51	1	1	0.33
				Residual Mean				0.07
				Absolute Residual Mean				0.5
				Residual Std. Deviation				0.65
				Sum of Squares				8.59
				RMS Error				0.66
				Min. Residual				-0.85
				Max. Residual				1.97
				Number of Observations				20
				Range in Observations				6.14
				Scaled Residual Std. Deviation				0.11
				Scaled Absolute Residual Mean				0.08
				Scaled RMS Error				0.11
				Scaled Residual Mean				0.01

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FIGURES

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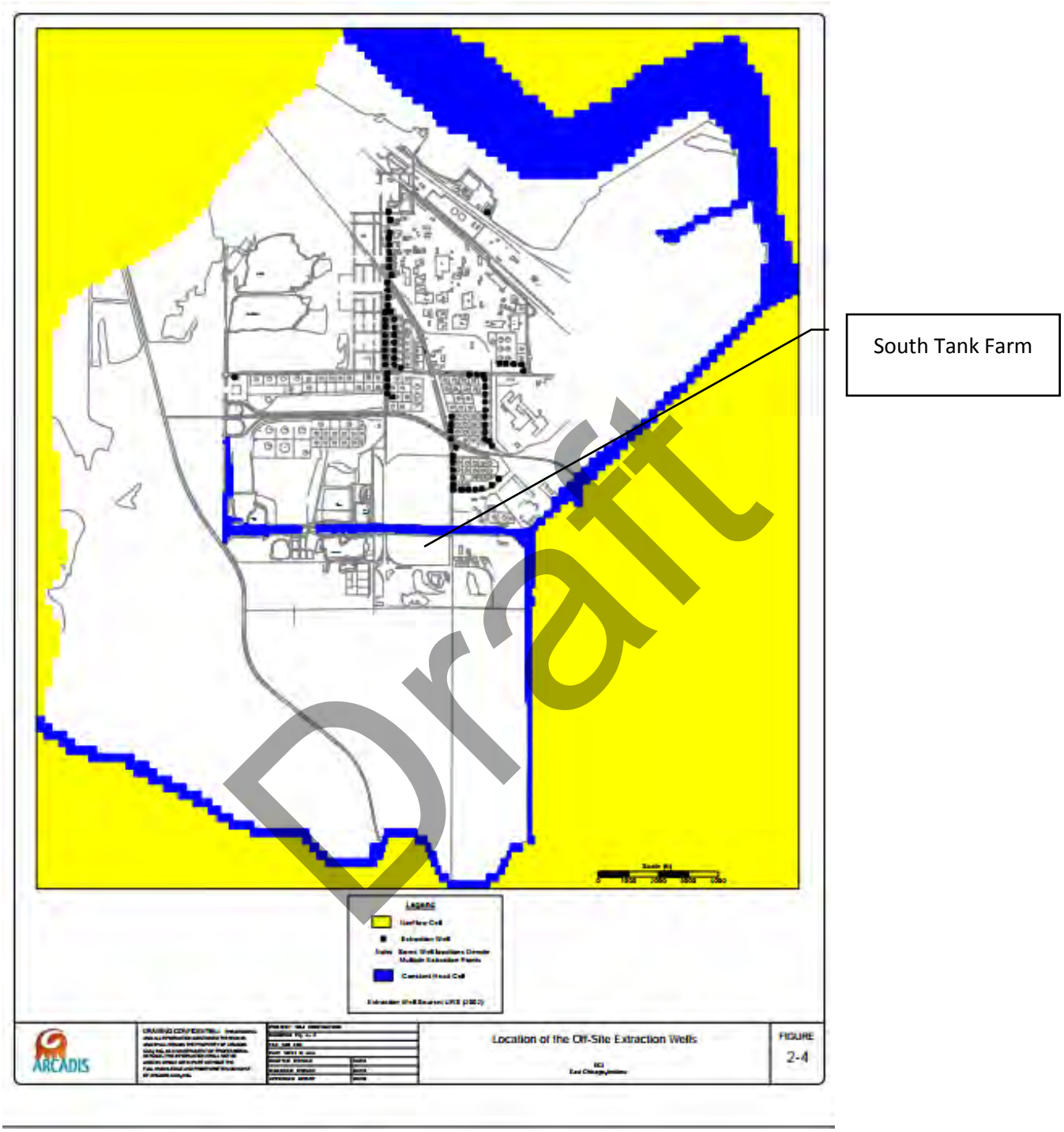

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Figure C-1: Figure 2-4 of Appendix B of the Arcadis 2002 SI Report showing the model domain. Yellow areas indicate no-flow areas and blue the waterways.

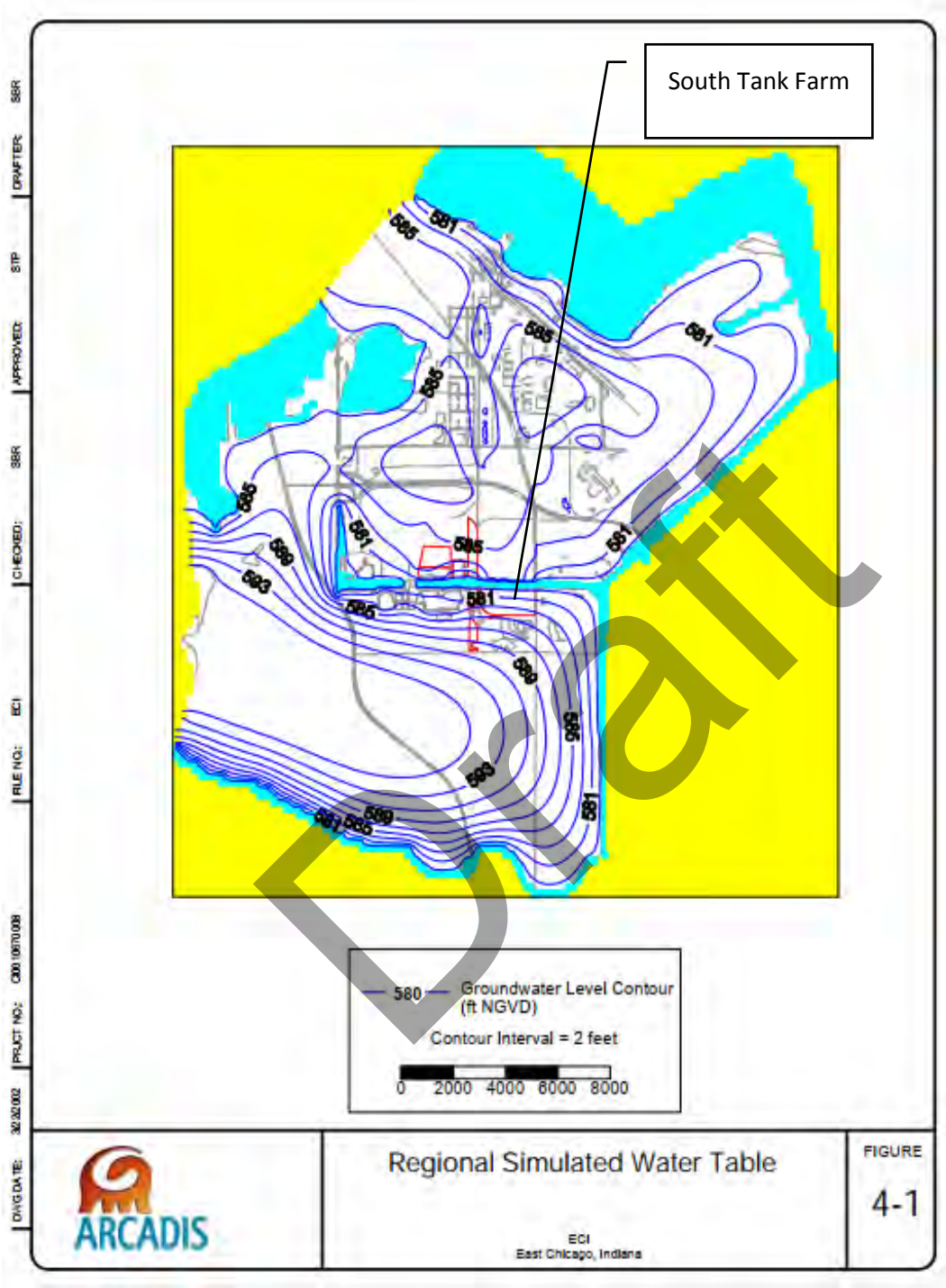

Figure C-2: Arcadis model simulated water levels. This figure was used to estimate, based on this output, a reasonable interpreted recharge area for groundwater discharge to the Canal. Note how small the STF area is to the model domain. Maximum head values at the southern extent of this recharge area may be approaching 597 feet.

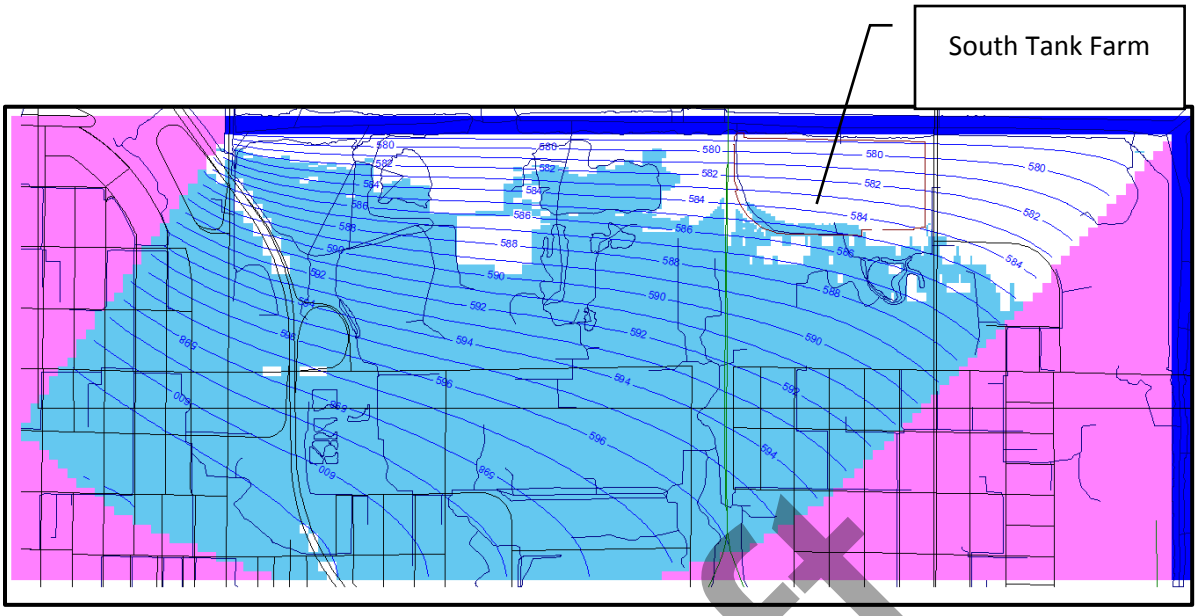

Figure C-3: Reduced domain model with Arcadis model input parameter values. The inferred recharge area excludes the magenta and dark blue shaded areas. The light blue areas are flooded cells, i.e., the model computed head is above ground surface. The ground surface was input from Lidar data over this area. Upgradient heads are about 4 feet higher than shown on the previous figure, but heads even at even 597 are still several feet above ground surface.

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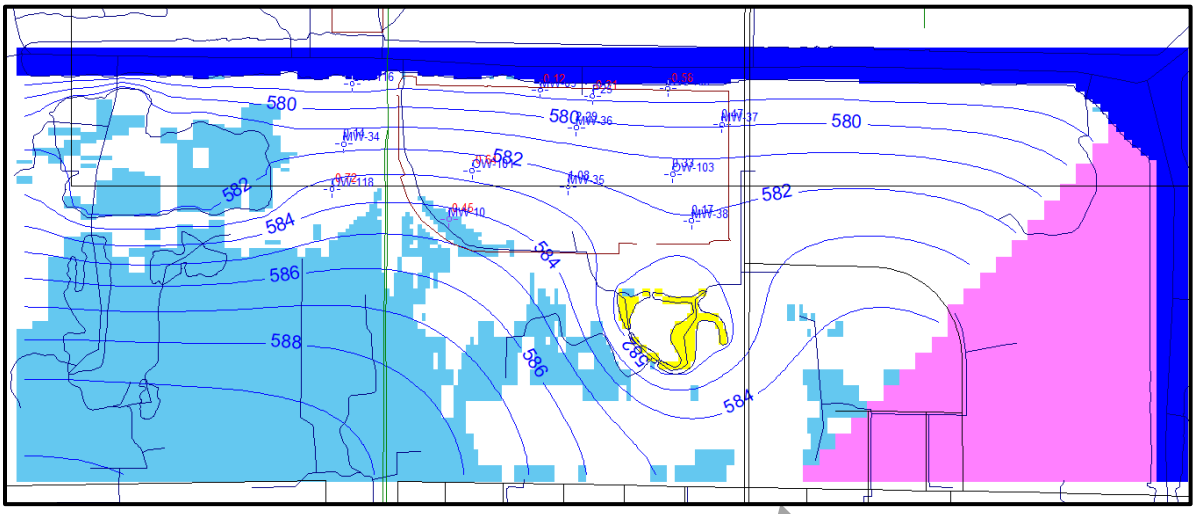

Figure C-4: The reduced Wood model domain showing optimized head contours, and the effects of including the golf course ponds. Lake Mary is shown as having flooded cells, but this is actually an area of ponded water. The area of the flooded cells is reduced from the previous figure and model setup. This model is calibrated to 20 target water level values on the STF and the SWTF, the data set of April 10, 2002, the most complete and consistent data set available. Residuals are posted.

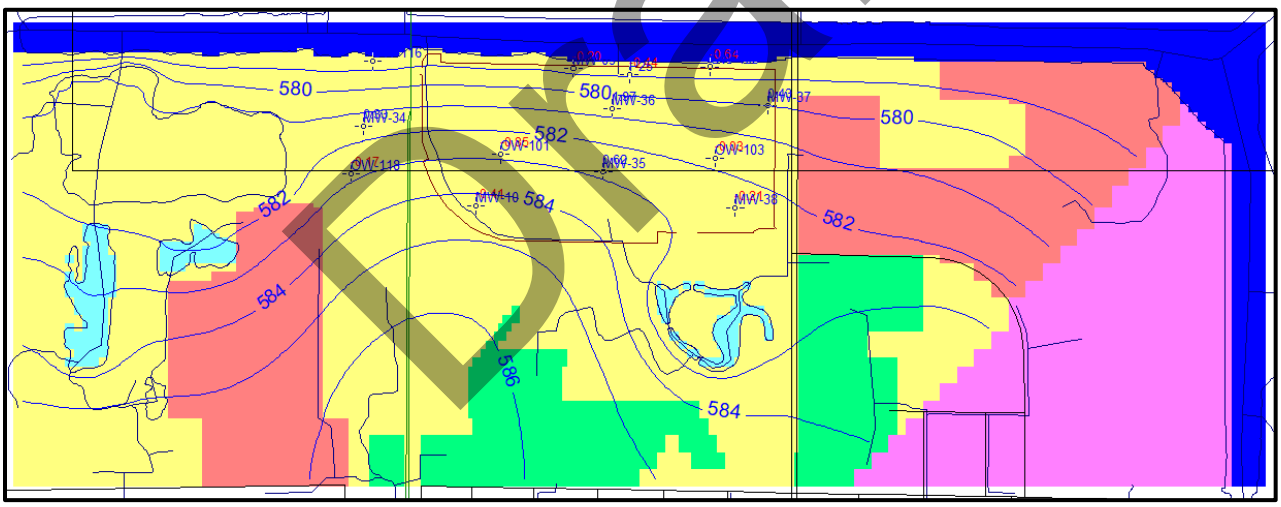

Figure C-5: Assigned recharge zones. Yellow represents open areas (18.7 in/yr); green - paved areas and buildings (4 in/yr); and orange – oil refineries (1 in/yr). The light blue areas are drain nodes assigned to represent more minor water bodies and possible sinks for groundwater discharge.

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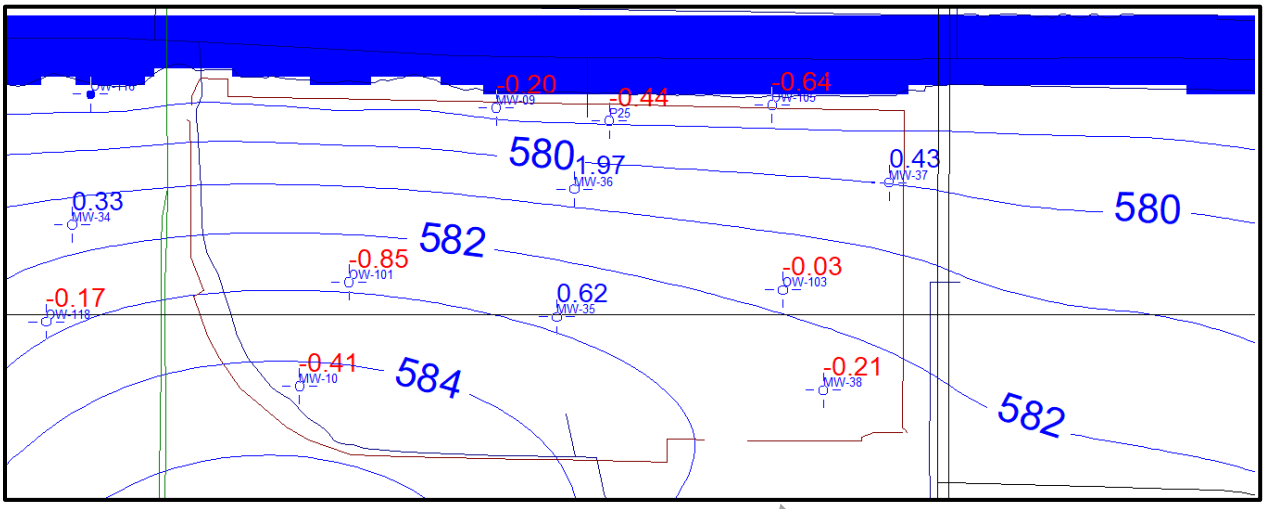

Figure C-6: Best fit model to date. Residuals for model layer one are posted. Red indicates model head greater than observed, in blue, model simulated head less than observed. Average residual here is 0.07 ft, with an SSR of 8.6 ft^2. K of sands at 22.9 ft/d, and 4.12 ft/d for silty sands.

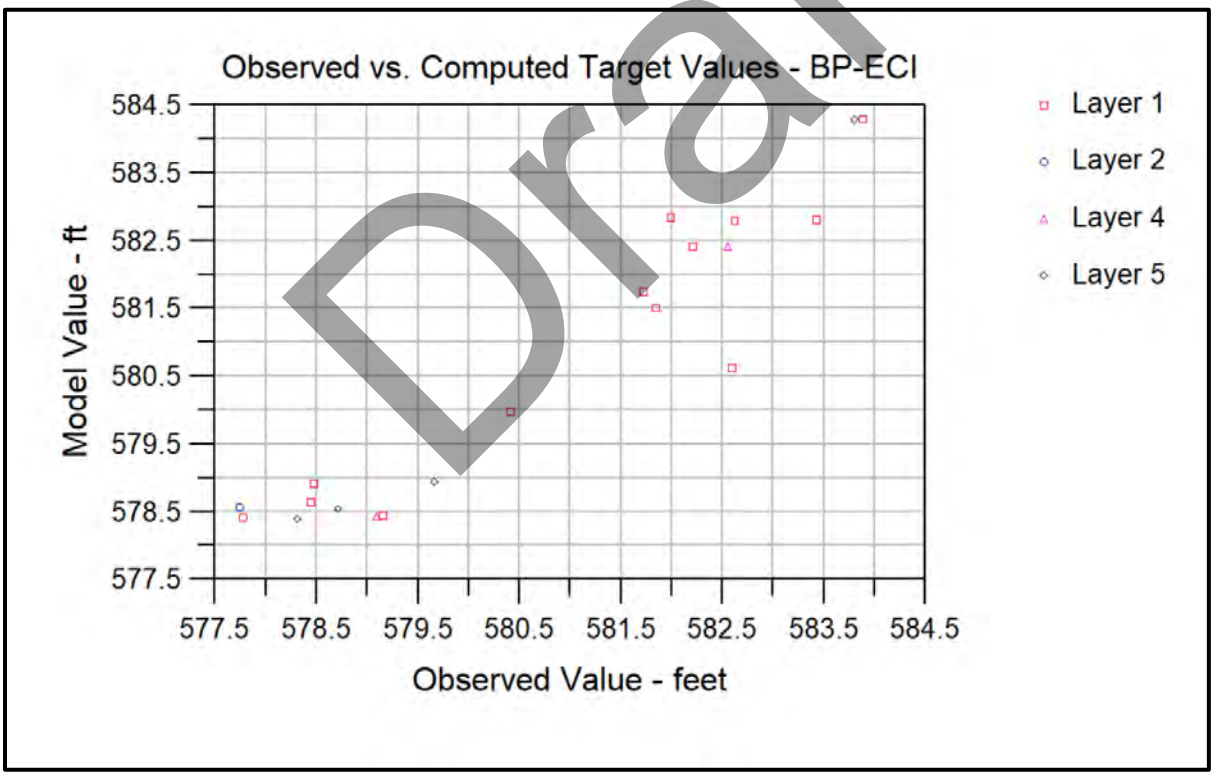

Figure C-7: Plotted model heads versus observed heads (April 10, 2002 water level data set).

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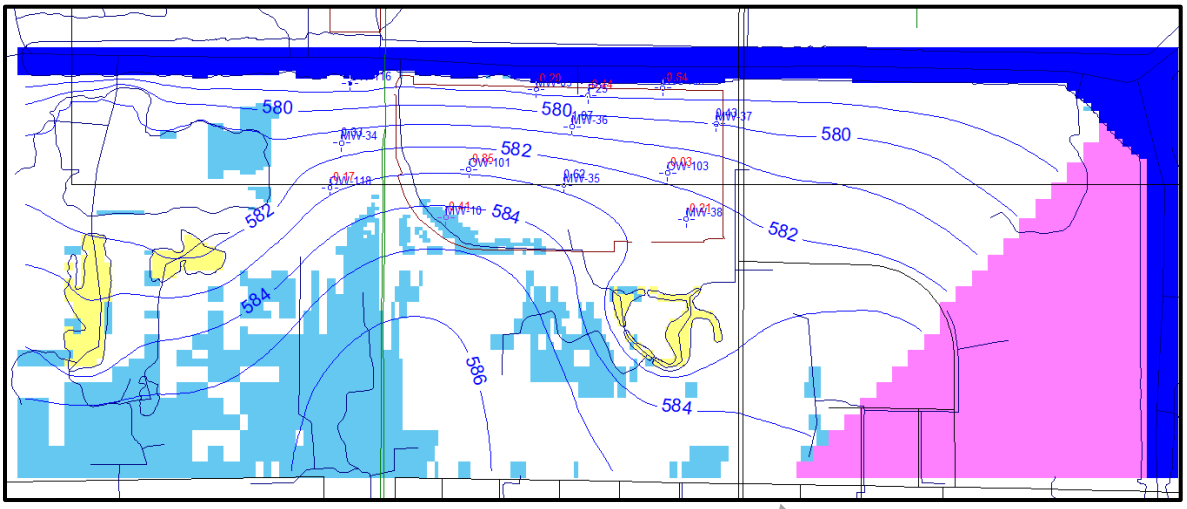

Figure C-8: Showing flooded cells in this latest version (Setup_7) of the model. These are largely confined to areas west of the STF and still represents an improvement in lessening the area of flooded cells relative to the Arcadis and Wood's earlier revisions of the model. Flooded cells along the SW corner of the STF may reflect the absence of the drainage feature from the golf course in this vicinity.

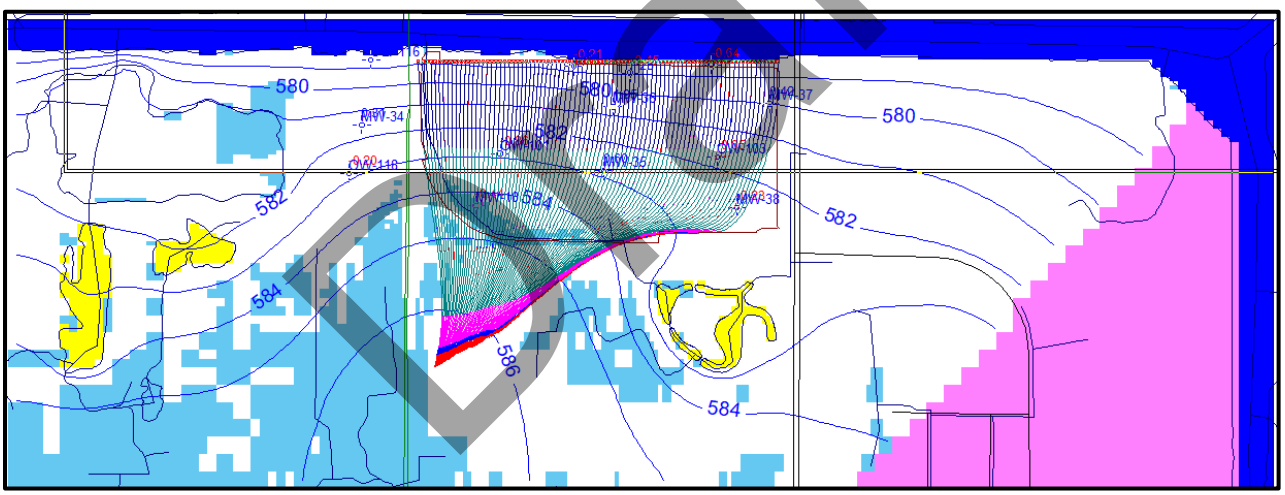

Figure C-9: Showing the estimated recharge area for the STF under conditions of model run Setup_7 and using reverse particle tracking.

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APPENDIX D BARRIER WALL SYSTEM EVALUATION

TECHNICAL MEMORANDUM

DATE: December 2019

TO: Project File

FROM: Nicholas Langlais, P.E. (ME)

REVIEWED BY: Don Dotson, P.E. & Brian B. Johnson, P.E. (ME)

SUBJECT: Barrier Wall System Evaluation

PROJECT: 3205191698

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INTRODUCTION

The proposed barrier wall system at the STF is expected to consist of an anchored sheet pile bulkhead with a sheet pile deadman anchor. System components would include the bulkhead, tiebacks, and deadman, as illustrated in **Figure 2-1 of the 30% Basis of Design Report (BODR)**. The barrier wall system at the STF will likely be located as shown on **Drawings S-101 and S-102 in Appendix I of the BODR.** The bulkhead will be located within the existing canal, approximately 15 feet north of the existing top of STF bank.

Wood performed these preliminary geotechnical stability analyses to evaluate internal and external (i.e., deep-seated) barrier wall system stability and to preliminarily establish structural components of the wall system to accommodate planned future Great Lages Legacy Act (GLLA) dredging adjacent to the South Tank Farm (STF) in Lake George Canal (Canal) and accommodate potential future development at the STF.

This evaluation and its attachments constitute **Appendix D** of the BODR. This appendix summarizes the design parameters, loads, and loading cases utilized in the analyses, along with results and preliminary recommendations. Elevations herein refer to NAVD88 datum, unless otherwise noted.

DESIGN INPUT PARAMETERS

This section describes the design input parameters, including subsurface stratigraphy, selected soil properties, groundwater conditions, loads, and loading cases considered for the barrier wall system evaluation herein.

SUBSURFACE STRATIGRAPHY

Subsurface stratigraphy utilized in the geotechnical analyses, including primary soil strata type, depth, thickness, etc., proximate to the proposed barrier wall system was based on available subsurface information obtained through regional studies by the USGS and limited Site-specific

geotechnical investigations (Arcadis U.S., Inc., 2016; Tetra Tech, 2015), as discussed in **Section 3.0 of the BODR**. In general, the subsurface stratigraphy from the ground surface downward beneath the STF consists of granular fill, beach/dune sand (i.e., the Calumet aquifer), lacustrine clay, clay till, and bedrock; subsurface stratigraphy from the mudline downward beneath the Canal consists of granular canal sediments, possible debris, lacustrine clay, clay till, and bedrock.

For the system geotechnical and structural analyses, the existing fill and beach/dune sand beneath the STF was considered as a single layer with similar geotechnical properties (referred to as 'bank sand' henceforth in this section). Bank sand also included new backfill to be placed south of the proposed bulkhead during construction. The top of the lacustrine clay deposit was encountered at approximate elevation 555 to 557 feet at the STF and Canal (Arcadis U.S., Inc., 2016; Tetra Tech, 2015). For the purposes of this evaluation, the top of the lacustrine clay was modeled at elevation 555 feet beneath the STF and the Canal. Based on available information, the lacustrine clay and clay till deposits (referred to as 'clay' henceforth in this section) extend to the top of bedrock, approximately elevation 480 feet (Watson et al., 1988).

A cross-section depicting subsurface stratigraphy assumptions used in the analyses is provided in **Figure 2-1 of the BODR**. Available subsurface information utilized for this evaluation is provided for reference in **Attachment D-1**.

SOIL PARAMETERS

Wood reviewed and evaluated available Site-specific geotechnical information and data (CELRC-TS-DG, 2012; Tetra Tech, 2015; and Arcadis U.S., Inc., 2016), provided in **Attachment D-1**. Wood assigned soil parameters based on soil type, in-situ conditions (e.g., relative density or consistency, above/below water table, etc.), empirical correlations to published literature values, available Site-specific geotechnical information laboratory testing results, demonstrated stress-strain relationships, and engineering judgment. Wood believes that the selected design soil parameters herein are generally representative of "average" soil properties/conditions, based on the available information. **Table D-1** summarizes the selected design soil parameters beneath the STF and the Canal.

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Table D-1 – Summary of Design Soil Parameters[7]

Site Parcel	Stratum	Soil Type	Unit Weight		Total Stress Strength Parameters[4,6]			Effective Stress Strength Parameters[5]	
			Total γ_t (pcf)[1]	Saturated γ_s (pcf)	Friction Angle ϕ (deg)[3]	Cohesion c (psf)[2]	Undrained Shear Strength s_u (psf)	Friction Angle ϕ' (deg)	Cohesion c′ (psf)
STF (Upland)	**Bank Sand[9]**	Free-Draining	110	115	-	-	-	30	0
	Clay[8]	Fine-Grained	130	130	14	500	1,100	24	0
Canal (Canal)	**Canal Sediment**	Free-Draining	90	90	-	-	-	26	0
	Clay[8]	Fine-Grained	130	130	14	500	850	24	0

Notes:
1. pcf = pounds per cubic foot.
2. psf = pounds per square foot.
3. deg = degrees.
4. Total stress includes pore water pressure and is generally representative of an "undrained" or short-term strength condition for fine-grained soils (i.e., silt and/or clay). Not applicable for coarse-grained or "free-draining" soils.
5. Effective stress does not include pore water pressure and is generally representative of a "drained" condition for all soils. For fine-grained soils, this would be considered a long-term strength condition.
6. Total stress strength parameters for the clay were applied/modeled two different ways in this evaluation: Mohr-Coulomb ϕ–c and undrained shear strength, s_u (ϕ=0).
7. Based on CELRC-TS-DG, 2012, Tetra Tech, 2015, and Arcadis U.S., Inc., 2016.
8. In general, laboratory testing results indicate that clay strength increases with increasing strain. For the purposes of this evaluation and strain compatibility, strength values used for clay were selected considering a maximum strain of 5 percent.
9. Bank sand includes existing fill, existing fill to be excavated/reworked and replaced during construction, new backfill to be placed to the south of the bulkhead during construction, and existing beach/dune sand (Calumet aquifer).

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SURFACE WATER AND GROUNDWATER CONDITIONS

Arcadis (2002) indicates historic high, typical, and historic low surface water elevations in Canal of 582.4 feet, 578.0 feet, and 575.5 feet, respectively, based on NGVD29 datum. These elevations correspond to 582.05 feet, 577.65 feet, and 575.15 feet, respectively, based on NAVD88 datum.

Groundwater at the STF has been characterized by others and is not considered to meet the regulatory requirements necessary to be classified as 'contaminated', as described in **Section 2 of the BODR**. As such it has, and will continue to, discharge to Canal with treatment only to prevent sheens in the Canal. However, groundwater levels will likely be impacted by installation of the barrier wall system (**Section 3.0 of BODR**) and existing groundwater elevations are not representative of post-construction conditions. The design will include features to mitigate the effects of groundwater mounding behind the bulkhead and minimize the differential water pressure between the STF and Canal.

REPRESENTATIVE CROSS-SECTION GEOMETRY

A conceptual cross-section (not specific to a barrier wall system alignment station) was considered for this 30% evaluation and was based on existing and planned topographic/bathymetric configurations. The conceptual cross-section is illustrated in **Figure 2-1 of the BODR**.

Based on existing STF topography, the crest of the STF bank elevation generally ranges from approximately 584 to 585 feet. Wood assumed that the top of the bulkhead may approximately match existing crest elevation and new backfill may be placed behind the bulkhead to tie into existing STF grade to the south. As such, a top of bulkhead elevation (and top of backfill elevation) of 585 feet was utilized.

According to drawings developed by Tetra Tech (**Appendix B.3.2**), the proposed Canal post-dredge elevation is approximately 560 feet NGVD29 (559.65 feet NAVD88). This design will be consistent with planned canal improvements. As such, a dredge/top of sediment elevation of 559 feet in Canal was utilized, resulting in an 'exposed' bulkhead height of 26 feet (top elevation 585 feet to post-dredge sediment elevation 559 feet).

Additional/supplemental barrier wall system cross-sections (station-specific topography and bathymetry) will be identified and evaluated as the design progresses.

BARRIER WALL SYSTEM LOADS AND LOADING CASES

The following subsections describe the loads and loading cases considered in the analyses.

LOADS

The following barrier wall system loads (non-soil pressure loads) were considered in the analyses:

- Hydrostatic Water Pressure Differential Across Bulkhead

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- For the purposes of evaluating barrier wall system stability, a typical Canal water elevation of 578.0 feet was assumed for all loading cases considered.
- It is anticipated that groundwater levels to the south of the bulkhead will fluctuate with seasonality, storm events, etc. The results of the groundwater model (**Section 3.0 of the BODR**) indicate that the anticipated hydrostatic water pressure differential across the bulkhead is approximately 1-foot (i.e., groundwater 1-foot above Canal water surface elevation) under steady-state/usual conditions, and that the differential may temporarily increase during storm events.

- Upland Surcharge Load
  - Future upland development at the STF is unknown; however, as requested by Atlantic Richfield Company (ARCO) this design accommodates moderate development south of the STF barrier wall system. A surcharge load of 250 pounds per square foot (psf) at ground surface was applied in all loading cases, which is approximately equivalent to 2 feet of soil. Surcharge loading will be refined as the design progresses and as STF/Canal development plans becomes available.

- Canal Barge Loading
  - Future barge access at the STF is unknown; however, as requested by ARCO this design accommodates optional horizontal mooring point (bollard) loading (toward the Canal) at the top of the bulkhead. Wood assumed a vessel displacement of 10,000 tons. According to Gaythwaite (1990), bollard loads that have been tentatively considered are on the order of 300 kN (67 kips). Applying a nominal 1.5 factor of safety to the bollard load (100 kips) and assuming a bollard spacing of no less than 30 feet, the horizontal applied load at the top of the bulkhead is approximately 3 kips per foot of bulkhead. (**Attachment D-2**.) Barge loading will be refined as the design progresses and as future STF/Canal development and/or proposed vessel information becomes available.
  - Wood assumed that inboard lateral loading due to vessel impacts can be minimized through design and installation of energy-absorbent fender elements and would be negligible compared to the passive resistance of the backfill. As such, inboard lateral loading due to vessel impacts was not considered herein.

- Seismic Loading (Earthquake)
  - The design of the barrier wall system accounts for code specified earthquake (seismic) loading during the service life (i.e., 50-years) of the system. A pseudo-static analysis method (FHWA, 1994) simulates earthquake-induced loads via the inclusion of a static horizontal force. The horizontal force is assumed to be proportional to the weight of the soil times a seismic coefficient, k_h, expressed in terms of the acceleration (in units of *g*) of the underlying earth. For long-term

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conditions, the design earthquake loading was based on a peak ground acceleration (PGA) associated with a probability of exceedance (PE) of 2% in 50 years. The PGA is the maximum amplitude of the ground acceleration time-history. According to the United States Geological Survey's (USGS) 2014 seismic hazards mapping data (**Attachment D-3**), the applicable PGA for the STF is approximately 0.06*g*. FHWA (1994) recommends that use of a seismic coefficient between one-half to two-thirds of the PGA to provide a design that would be expected to limit deformations in the design earthquake to values acceptable for highway facilities. However, for this evaluation, the seismic coefficient was conservatively determined using the full STF-specific PGA of 0.06*g*.

Other loads were considered (i.e., ice floes, wave impacts, frozen soil pressures) but were not deemed critical to the design of the barrier wall system.

LOADING CASES

Loads applied will likely fluctuate during the service life of the barrier wall system. The following loading cases were identified as applicable to the barrier wall system design for the STF, based on ARCO provided information and engineering judgment. The USACE (1994) manual was used as a guide in preparing the barrier wall system evaluation. That manual identifies three types of loading cases which consider the likelihood and/or duration of occurrence based on relative probability.

- Usual Load Case: Loads associated with this case are the most frequently experienced by the system in performing its primary function. The loads may be of a long-term sustained nature or of an intermittent but repetitive nature.
- Unusual Load Case: Loads associated with this case are infrequent in occurrence and/or of short duration.
- Extreme Load Case: Loads associated with this case have a low-probability of occurrence and/or are extremely short in duration relative to the service life of the system.

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In total, five loading cases were evaluated herein. The components of each loading case are summarized in **Table D-2**.

Table D-2 – Components of Loading Cases[1]

Loading Case	Description	Top of Bulkhead/Backfill Elevation (ft)	Top of Sediment Elevation (ft)	STF Groundwater Elevation (ft)	Canal Elevation (ft)	Upland Surcharge Load[2] (psf)	Canal Barge Load (kip/ft)	Earthquake (Seismic) Coefficient (-)
Usual	Long-Term/Steady State	585	559	579.0	578.0	250	NA	NA
Unusual 1	High Groundwater (Storm Event)	585	559	582.0	578.0	250	NA	NA
Unusual 2	Barge Mooring	585	559	579.0	578.0	250	3.0	NA
Extreme 1	Flooded Upland (Large Storm Event)	585	559	585.0	578.0	250	NA	NA
Extreme 2	Earthquake (Seismic Event)	585	559	579.0	578.0	250	NA	0.06*g*

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Notes: 1. Additional loading cases may be considered as the design progresses.
2. Anchored bulkhead assumed to be "semi-flexible" for the application of upland surcharge load. Surcharge modeled as infinite in length and width to the south of the bulkhead.

BARRIER WALL SYSTEM EVALUATION AND RESULTS

The geotechnical and structural evaluations of the barrier wall system consider the system's ability to provide a stable condition when loads are applied to the system such that unacceptable movements (i.e., failures) are mitigated by design.

The following sections describe the analysis methodologies and results. Analyses for the barrier wall system address different types of possible failure modes, including internal and deep-seated stability.

INTERNAL BARRIER WALL SYSTEM STABILITY ANALYSIS

The internal barrier wall system stability analysis addresses the following potential failure modes (see **Figure 4-1 of BODR**):

- Rotational failure due to inadequate pile penetration; and
- Structural failure (i.e., over stressing of steel sheet pile, anchorage, or components).

Wood performed a limit equilibrium analysis using Shoring Suite Version 8.12n (Shoring Suite), an industry-standard shoring design software developed by CivilTech Software USA, to evaluate rotational stability and the design of structural components of the system. A limit equilibrium analysis evaluates stability with respect to both moment and horizontal force equilibrium and considers material (soil) unit weight and strength, differential water pressures across the bulkhead, and other applied loads (refer to **Section 3.1** herein). Lateral earth pressures were calculated using Rankine theory. An anchorage (i.e., tieback) elevation of 579.0 feet was assumed.

Since passive pressures (Canal side of the bulkhead) calculated using lateral earth pressure theory are dependent on bulkhead deflection and are less likely to be fully developed than active pressures on the retaining side of the bulkhead (STF side), maximum bending moment and required bulkhead length/penetration were determined using a strength reduction factor (SRF) applied to soil strengths on the passive (Canal) side of the bulkhead. The reduction factors were selected in accordance with minimum values recommended by USACE (1994). The SRFs are dependent upon load case, soil type, and soil strength parameters utilized. In **Table D-3** below, the S-case represents effective stress strength parameters (i.e., "drained"), and the Q-case represents total stress strength parameters (i.e., "undrained").

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Table D-3 – Minimum Safety Factors, (USACE, 1994)

Table 5-1
Minimum Safety Factors for Determining the Depth of Penetration Applied to the Passive Pressures

Loading Case	Fine-Grain Soils	Free-Draining Soils
Retaining Walls		
Usual	2.00 Q-Case 1.50 S-Case	1.50 S-Case
Unusual	1.75 Q-Case 1.25 S-Case	1.25 S-Case
Extreme	1.50 Q-Case 1.10 S-Case	1.10 S-Case

In accordance with USACE (1994), the passive SRF was applied to the tangent of the soil friction angle, such that tan(ϕ or ϕ')/SRF, and to the soil cohesion or undrained shear strength, such that c or c'/SRF and s_u/SRF.

Table D-4 summarizes the passive pressure strength reductions utilized for each loading case and soil stratum.

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Table D-4 - Passive Soil Pressure Strength Reduction Summary

Loading Case	Passive Soil Stratum	Soil Type	Strength Parameter [2,3]	Case (USACE, 1994)	Design Passive Strength	Strength Reduction Factor[5]	Reduced Passive Strength
Usual	Sediment	Free-Draining	Effective	S-Case	ϕ' = 26 deg	1.50	ϕ' = 18 deg
	Clay	Fine-Grained	Effective	S-Case	ϕ' = 24 deg	1.50	ϕ' = 16.5 deg
Unusual	Sediment	Free-Draining	Effective	S-Case	ϕ' = 26 deg	1.25	ϕ' = 21.3 deg
	Clay	Fine-Grained	Total	Q-Case	ϕ = 14 deg c = 500 psf	1.75	ϕ = 8.1 deg c = 285 psf
					s_u = 850 psf		s_u = 485 psf
			Effective	S-Case	ϕ' = 24 deg	1.25	ϕ' = 19.6 deg
Extreme[1]	Sediment	Free-Draining	Effective	S-Case	ϕ' = 26 deg	1.10	ϕ' = 23.9 deg
	Clay	Fine-Grained	Total	Q-Case	ϕ = 14 deg c = 500 psf	1.50	ϕ = 9.4 deg c = 333 psf
					s_u = 850 psf		s_u = 566 psf
			Effective	S-Case	ϕ' = 24 deg	1.10	ϕ' = 22 deg

Notes:
1. Application of the seismic load has a compound effect of increasing active pressure, and decreasing/reducing available passive pressure resistance, in addition to the strength reduction applied to the passive soil strength.
2. Effective stress does not include pore water pressure and is generally representative of a "drained" condition for all soils. For fine-grained soils, this would be considered a long-term strength condition.
3. Total stress includes pore water pressure and is generally representative of an "undrained" or short-term strength condition for fine-grained soils (i.e., silt and/or clay). Not applicable for coarse-grained or "free-draining" soils.
4. Design active soil pressure strengths are summarized in Table D-1.
5. Based on Table D-3, from USACE (1994).

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Table D-5 summarizes the results of the internal stability analysis based on the design parameters and assumptions described herein. The results in **bold** indicate the controlling conditions for design of the bulkhead at this stage of design. Shoring Suite output files for each loading case are provided in **Attachment D-4**.

Table D-5 - Summary of Results for Internal Wall System Stability Analysis

Loading Case	Minimum Bulkhead Embedment[2] (ft)	Total Bulkhead Length[3] (ft)	Maximum Bending Moment (ft-kip)	Anchorage Load (kip/ft)
Usual	**25.95**	**51.95**	**127.73**	**14.1**
Unusual 1a[4]	19.38	45.38	97.54	13.7
Unusual 1b[5]	12.90	38.90	79.07	12.5
Unusual 1c[6]	25.48	51.48	**145.89**	16.5
Unusual 2a[4]	16.39	42.39	66.38	14.7
Unusual 2b[5]	10.49	36.49	52.70	13.8
Unusual 2c[6]	23.10	49.10	105.75	**16.9**
Extreme 1a[4]	19.18	45.18	110.89	16.3
Extreme 1b[5]	13.80	39.80	93.80	15.2
Extreme 1c[6]	25.37	51.37	**165.04**	**19.4**
Extreme 2a[4]	17.49	43.49	84.52	12.7
Extreme 2b[5]	10.44	36.44	66.53	11.5
Extreme 2c[6]	24.10	50.10	129.60	15.3

Notes:
1. 1 kip = 1,000 pounds.
2. Below dredge/mudline.
3. Embedment plus the presumed exposed bulkhead height of 26 feet.
4. Clay strength modeled as total stress Mohr-Coulomb ϕ–c envelope.
5. Clay strength modeled as undrained shear strength (ϕ = 0).
6. Clay strength modeled as effective stress Mohr-Coulomb (c = 0).

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The results indicate that the Usual Load Case controls minimum bulkhead depth, 51.95 feet.

The minimum required section modulus for the bulkhead was determined based on the following equation:

$$S = M / f_a$$

Where:

S = Section modulus of the bulkhead

M = Maximum moment applied to the bulkhead

f_a = Allowable bending stress in the bulkhead

The bulkhead will likely consist of steel sheet pile. USACE (1994) recommends applying reduction factors to the yield stress (f_y) of the steel based on loading case, such that f_a is less than f_y. The following reduction factors are recommended and were applied herein for each loading case:

- Usual: $f_a = 0.50*f_y$
- Unusual: $f_a = 0.66*f_y$
- Extreme: $f_a = 0.87*f_y$

Yield stress of steel sheet pile typically ranges between 50,000 psi and 65,000 psi (i.e., 50 ksi to 65 ksi) for ASTM A572 steel. For this design, f_y = 50 ksi was assumed. **Table D-6** summarizes the required bulkhead section modulus based on maximum calculated bending moment and allowable stress for each load case.

Table D-6 - Summary of Required Bulkhead Section Modulus

Loading Case	Maximum Calculated Bending Moment (kip-ft)	Maximum Calculated Bending Moment (kip-in)	Yield Stress, f_y (ksi)	Allowable Stress, f_a (ksi)	Required Section Modulus[2] (in^3/ft)
Usual	127.73	1532.76	50	25.0	**61.31**
Unusual	145.89	1750.68	50	33.0	53.05
Extreme	165.04	1980.36	50	43.5	45.53

Notes: 1. 1 ksi = 1,000 psi.
2. Prior to corrosion protection considerations.

The results indicate that the Usual Load Case controls minimum bulkhead section modulus. For this design, it was assumed that the bulkhead would potentially lose approximately $^1/_8$- to ¼-inch in thickness (section modulus and moment of inertia reduction of approximately 20 percent) over its service life of 50 years due to corrosion. Corrosion can be dealt with/accounted

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for in design of steel sheet pile by selecting a larger section than required, using higher yield strength steel, or by adding protective coating to the steel. For this design, the bulkhead is expected to be "oversized", in terms of section modulus, by 20 percent to account for steel loss due to corrosion, pending Site-specific data. As such, the minimum required section modulus increases to **73.57 in^3/ft**, which corresponds to an **AZ40-700N** steel sheet pile section (or equivalent).

Table D-7 summarizes anticipated bulkhead deflections for each loading case and AZ 40-700N sheet pile. Deflection plots are provided in **Attachment D-5**

Table D-7 - Summary of Anticipated Horizontal Bulkhead Deflection

Loading Case	Maximum Calculated Bending Moment (kip-ft)	Maximum Anticipated Deflection[3] t = 0[1] (inches)	Maximum Anticipated Deflection[3] t = 50 years[2] (inches)
Usual	127.73	1.79	2.24
Unusual	145.89	2.01	2.51
Extreme	165.04	2.26	2.83

Notes:
1. Initial condition of steel sheet pile.
2. Assumes 20% section modulus and moment of inertia loss due to corrosion over service life of bulkhead.
3. Maximum deflection is expected to occur proximate to the dredge-line/mudline.

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The barrier wall system includes an anchorage system that would consist of a sheet pile anchor deadman and tieback rods connecting the bulkhead to the deadman. The required length of the deadman will be determined by satisfying force and moment equilibrium at the toe of the sheet pile deadman. The deadman will be set back from the bulkhead, to the south, at a distance such that the active soil pressure wedge acting on the bulkhead and the passive soil pressure wedge providing lateral resistance to the deadman do not intersect/overlap; this setback is intended to prevent deadman loads from applying pressure to the active bulkhead wedge and to allow passive pressures to fully develop on the deadman.

The deadman can be configured as a continuous single span deadman or as a discontinuous deadman. For this design, the deadman are expected to be discontinuous to allow groundwater to flow in between and minimize mounding to the south of the deadman. It is anticipated that the deadman would be on the order of approximately 40 to 50 feet in length and the setback is expected to be approximately 100 to 120 feet to the south of the bulkhead alignment (and parallel to the bulkhead alignment). The length, setback, and structural requirements for the deadman anchor sheet piles will be evaluated further as the design progresses.

The required tieback diameter will likely be determined using the following equation:

$$T = \pi d^2/4 * 0.6 * f_{guts}$$

Where:

d = Nominal diameter of the tieback rod

f_{guts} = Guaranteed ultimate tensile strength of tieback

T = Applied axial load per tieback

The tiebacks may consist of ASTM A722 (150 ksi ultimate stress) threaded steel rods. Designed tieback sizes will consider a long-term reduction in rod diameter to account for corrosion. Alternatively, the rods may be hot-dip galvanized to protect against corrosion. Tiebacks will be evaluated as the design progresses, but rod diameters on the order of 2-1/4 inches to 2-1/2 inches (nominal) are anticipated based on experience. Tiebacks will also likely be encased in larger diameter, flexible PVC conduits from the bulkhead to the deadman to allow for consolidation settlement to occur in the clay soil beneath the tiebacks (due to new backfill placement between the existing top of bank and the bulkhead) without impacting the axial capacity of the tieback. Anticipated settlement in the underlying clay soils will be estimated and the conduits will be appropriately sized as the design progresses.

Other barrier wall system structural components, such as walers and bolted/welded connections, will be evaluated as the design progresses.

DEEP-SEATED STABILITY

The slope stability analysis of the barrier wall system and STF/Canal bank addresses the deep-seated potential failure mode of the barrier wall system (see **Figure 4-1 of BODR**). This potential failure mode is dependent on the length/penetration of the bulkhead but independent of the structural characteristics of the bulkhead and/or anchors.

Wood performed the slope stability analysis using SLOPE/W (GeoStudio 2012, Version 8.12.3.7901), an industry-standard two-dimensional slope stability software program developed and distributed by Geo-Slope International, Ltd. The Spencer Method was used in the evaluation, which satisfies both moment and force equilibrium.

In assessment of the stability, the calculated minimum FS was compared to an industry acceptable FS for each loading case. The industry acceptable FS is dependent upon the risks and implications of failure, the confidence or uncertainty in the definition of existing conditions (e.g., topography, subsurface soil and groundwater conditions, soil strength parameters, etc.), as well as the proposed property use changes (e.g., equipment loading, post-dredge conditions, etc.).

For this evaluation, Usual Load Case was analyzed for deep-seated stability. For most embankments, a minimum FS of 1.5 is considered acceptable for long-term static stability under normal (usual) loading conditions; this minimum FS is typically required by most state and federal regulatory agencies for embankments where personal and/or environmental safety is a

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concern. Additional loading cases and barrier wall system station-specific cross-sections will be analyzed for deep-seated stability as the design progresses.

Based on the results of the internal stability analysis, the minimum required bulkhead sheet pile length is 51.95 feet (top elevation 585 feet, bottom elevation approximately 533 feet). The internal stability analysis results also indicate an anchorage load of 14.1 kips per foot of bulkhead may develop for the bulkhead to achieve equilibrium. As such, a point load of 14.1 kips per foot was input at the face of the bulkhead (acting in the southerly direction toward the deadman anchor) at elevation 579.0 feet to simulate this anchorage load in the slope stability model. The sheet pile anchor deadman was also modeled in the deep-seated analysis and assumed to be 40 feet in length and set back 100 feet to the south of the bulkhead.

Both circular and non-circular (i.e., "optimized") critical failure/slip surfaces, starting in the upland (STF), extending below the bottom of the bulkhead, and exiting in the dredged sediment (Canal), were considered in assessing deep-seated stability. Applied soil strengths are consistent with strengths presented in **Table D-1** for the Usual Load Case (strength reduction factors do not apply for the deep-seated analysis).

The results indicate that the FS for the Usual Load Case is 2.09 for the critical circular slip/failure surface and 1.44 for the critical non-circular slip/failure surface, considering the bottom of the bulkhead at elevation 533 feet. The critical circular slip surface FS of 2.09 meets the minimum acceptable FS of 1.5; however, the critical non-circular slip surface FS of 1.44 does not meet the minimum acceptable FS of 1.5.

To increase the deep-seated stability FS, the bulkhead length was increased by 1-foot in the analysis (bottom elevation 552 feet) to force the critical slip surface to extend slightly deeper into the underlying clay. The results indicate that the critical non-circular slip surface FS increases to 1.51 in this case, which meets the minimum acceptable FS of 1.5 for the Usual Load Case.

SLOPE/W output files are provided in **Attachment D-6**.

SUMMARY AND RECOMMENDATIONS

Based on available geotechnical information and data, this 30% Design barrier wall system evaluation indicates that the bulkhead may consist of a 53-feet long AZ40-700N sheet pile. The bulkhead evaluation will be refined and anchor deadman, tiebacks, walers, and other structural components will be evaluated as the design progresses.

Wood performed a limited sensitivity analysis to evaluate the impact of soil unit weight and strength parameters on the bulkhead design requirements (i.e., length, bending moment, anchor load). The results indicate that the strength properties of the clay soil (lacustrine clay and clay till) have a significant impact on the analysis results. Clay strength modifications may have the following relative impacts on bulkhead design parameters, considering the "average" effective stress strength parameter of □ ′ = 24 degrees (**Table D-1**) for clay utilized herein and the Usual Load Case:

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- ϕ' = 22 degrees (-2 degrees, 8% reduction)
  - Length – 6% Increase
  - Bending Moment – 13% Increase
  - Anchor Load – 6% Increase

- ϕ' = 26 degrees (+2 degrees, 8% increase)
  - Length – 5% Reduction
  - Bending Moment – 9% Reduction
  - Anchor Load – 5% Reduction

Thus, Wood believes that it is necessary to obtain supplemental Site-specific and barrier wall system location- and type-specific geotechnical data to confirm soil engineering parameters to develop an appropriately conservative, cost-effective, barrier wall system design. Wood proposes completing additional geotechnical borings, prior to the 60% submittal, in Canal, along the proposed bulkhead alignment, and in the STF upland (proximate to proposed deadman alignment). The following supplemental data would be obtained:

- Relative density and strength properties of upland embankment soils (existing fill and beach/dune sand).
- Relative density and strength properties of canal sediments.
- Engineering properties of clay (index, strength, and consolidation) beneath Canal and beneath STF with increasing depth below existing ground.
- Depth to/elevation of bedrock.

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ATTACHMENT D-1: AVAILABLE SUBSURFACE INFORMATION

CELRC-TS-DG 23 MAY 2012

MEMORANDUM FOR: CELRC-PM-PM (M. Nguyen)

THROUGH CELRC-TS-DG JAR 5/23/12

SUBJECT: Stability Analyses of South Bank of Lake George Canal after Proposed Federal Channel Dredging

1. TS-DG was asked by the Project Manager to analyze the stability of the south bank of Lake George Canal across from the CDF site assuming that the Federal Channel was dredged to -22 ft Low Water Datum (LWD). This information was requested for use in configuring the proposed L-shaped oil boom by BP's engineering consultant.

2. The south bank of Lake George Canal across from the CDF is relatively parallel to the Federal Channel although it undulates between 60 and 80 feet from the southern limit of the Federal Channel. A cross section was generated for a location approximately 200 feet west of the centerline of Indianapolis Boulevard where the distance between the south edge of the Federal Channel and the existing south bank is relatively narrow at approximately 63 feet measured at the waterline shown in the drawing (see Figure 1 in the attached calculations).

3. The two cross section geometries that were analyzed are depicted in the analysis results in Appendices A through F of the attached calculations. The first set of analyses in Appendices A through C of the calculations are for an assumed 1.5H:1V sloped canal bank. The second set of analyses in Appendices D through F in the calculations assume a 2H:1V sloped canal bank. An explanation of how the two cross section geometries were derived is provided in Paragraphs 6 through 8 of the calculations.

4. The assumed soil profile of the canal bank is discussed in Paragraphs 1 through 5 of the attached calculations and is summarized in Table 1 of the calculations. The soil profile was assumed from soil boring information including borings from the CDF on the north side of the canal given the lack of deeper soil borings on the south side of the canal. The soil stratigraphy in the region is relatively uniform. Since the canal was manmade by excavating a channel through these soil layers and is not a natural water feature, it is reasonable to assume that the soil stratigraphy remains relatively constant to either side of the canal except for surficial fill materials. From air photographs of the site, rip rap is visible along the shoreline. A 1-foot thick layer of rip rap has been assumed to exist parallel to the bank slope and extending to the bottom of the canal (assumed to coincide with the top of the clay layer).

5. Water levels were varied in the various analyses. Select analyses were performed at water levels of -2 ft LWD (≈576 ft NGVD 1929), +2 ft LWD (≈580 ft NGVD 1929) and a rapid drawdown from +2 to -2 ft LWD. Selection of these levels is discussed in Paragraphs 9 and 10 of the attached calculations.

6. Slope stability analyses were performed using the Spencer Method in the Slope/W program module of the software GeoStudio. The analyses are discussed in Paragraph 11 of the calculations and the program output reports are presented in Appendices A through F of the

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calculations. The results of the analyses are summarized in the following table (also in Table 2 of the calculations):

SUMMARY OF SLOPE STABILITY ANALYSIS RESULTS

Bank Slope	Water Level (ft NGVD 1929)	Analyzed FOS	Recommended Min. FOS
1.5H:1V	580	1.30	1.3
	576	1.21	1.3
	RDD 580-576	1.00	1.1
2H:1V	580	1.50	1.3
	576	1.40	1.3
	RDD 580-576	1.21	1.2

7. A discussion of the results and conclusions are presented in Paragraphs 12 through 15 of the calculations. Most notably, although the 1.5H:1V bank slope assumed in the first set of analyses did not meet the recommended factors of safety for the low water level and for rapid drawdown, they are considered to be valid cases considering that the canal was constructed in the early 1900s before the advent of modern soil mechanics and slope stability analysis. It is likely that the canal was constructed at slopes as steep as could be excavated without regard to formal factors of safety. This assumption is supported by the observed undulations of the shoreline along the canal which could be evidence of past slope failures.

8. Given the marginal long-term stability under the rapid drawdown scenario and the assumed geometry of 1.5H:1V, dredging operations should be restricted to the Federal Channel limits. No dredging should be allowed south of the southern Federal Channel limit unless the actual geometry is found to be flatter than assumed and reanalysis of a cross section including an expanded dredge area yields adequate factors of safety. Stabilizing measures could also be designed and implemented that would allow an expanded dredge area, but these are beyond the scope of the present analysis.

9. During the dredging operations in this segment of the Federal Channel, the south bank should be inspected daily for signs of distress (e.g., development of tension cracks and evidence of new settlement) that would indicate new slope failures along the bank. Stabilizing measures may be required such as rip rap placement on the slope, or removal of material from the top of bank above a slide to reduce the driving force for additional failures. Alternately, the depth of dredging along the south limit of the Federal Channel could be reduced to improve stability.

10. TS-DG should be notified immediately of new slope failures so that recommended corrective action can be designed and implemented.

Jan Merl, P.E.
Geotechnical Engineer
CELRC-TS-DG

Attachment: Slope Stability Calculations

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US Army Corps of Engineers, Chicago District	PROJECT TITLE: IHC CDF FACILITY OPS	COMPUTED BY: JHM	DATE: 5/17/2012	SHEET: 1 of 40
	COMPUTATION TITLE: Stability of Lk. Geo. Canal South Bank	CHECKED BY: JWS	DATE: 5/18/2012	

Problem

Determine the stability of the south bank of Lake George Canal across from the CDF site if the sediment is dredged to -22 LWD up to the southern limit of the Federal Channel and from that point slopes back at a 4H:1V slope towards the south bank.

Soil Information

1. Limited soil boring information is available in the DDR for the property south of the canal. Monitoring wells MW-36 and MW-37 were installed by ERM in 1991 but only extended to 11 and 12 feet below ground surface (bgs) respectively. The ground surface at the borings ranged from approximately 585 to 586 feet NGVD 1929. The borings encountered about 4 feet of medium dense, urban fill (sand with slag [SP] and silty sand with slag [SM]) below a thin surface layer of topsoil. (The topsoil is being ignored in this analysis.) Below the fill was medium dense to dense sand (SP). Ground water was encountered at approximately 582 feet at the time that the borings were performed.
2. Deeper soil information was obtained from the 4 June 2004 design memorandum for the structural analysis of the South Cutoff Wall sheetpile. The surface fill and sand (SP) layers observed in the monitoring well borings south of the canal were also present in boring CLB-01 referenced in the memo and were underlain by medium dense silty sand (SM) at approximate elevation 568 ft NGVD 1929, medium dense silt (ML) at approximately 558 ft and stiff silty clay (CL) at 557 ft. Soil borings (SWB-1-02 through SWB-4-02) performed on the canal side of the old sheetpile cutoff wall along the CDF site indicated the top of clay layer varied between 558 and 553 feet. Loose to medium dense organic silt (OL) (assumed herein to be sediment) was encountered immediately above the clay layer in the canal borings.
3. In the DDR, borings in the footprint of the CDF indicate that the silt layer overlying the clay layer is up to 5-ft thick (borings CE-108 and CE-111). These observations corresponded to the top of the silt layer at a nominal elevation of 561 ft NGVD 1929 overlying the silty clay layer at 556 to 557 ft. Experience at this site and at nearby sites indicate that the silt layer is generally of a similar thickness as in these borings. Based on the data available, this layer was assumed to be 4 feet thick below elevation 560 ft NGVD 1929 with the silty clay layer at elevation 556 ft.
4. A layer of riprap was observed along the south canal bank in aerial photographs of the Lake George Canal and was assumed in the analyses to be 1-foot wide from the top of the bank to the bottom of the canal. It is unknown what shape the riprap is in and verification is recommended in the field.
5. The soil parameters assumed for the analysis are summarized in Table 1.

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Table 1 – Assumed Soil Stratigraphy and Parameters

Top Elev. (ft NGVD)	Soil Description	Total Unit Weight (pcf)	φ (deg)	c (psf)	φ' (deg)	c' (psf)
585	Urban Fill: Medium dense, sand with slag and silt	115	26	0	26	0
583	Medium dense, sand (SP)	115	34	0	34	0
568	Medium dense, silty sand (SM)	120	32	0	32	0
560	Medium dense, silt (ML)	125	30	0	30	0
556	Stiff, silty clay (CL)	130	0	1,250	32[1]	0
Varies	Rip rap on south bank slope	130	45	0	45	0
Varies	Sediment	100	22	0	22	0

Assumed Geometry and Water Levels

6. Information about the original canal construction (built in the early 1900s) was not readily available, including side slope angles. Soundings of the canal bottom were available but only indicate the sediment depths, not the depth to the soil banks. As a result, the slope of the underwater soil banks had to be assumed. Two slope angles were analyzed: 1.5H:1V and 2H:1V. These are depicted on the outputs of the slope stability analysis. As a rule of thumb, a slope angle of 1.5H:1V is assumed for stability in Class C soil (in this case, cohesionless soil) per OSHA 26 Subpart P, Appendix B.
7. The proposed maximum dredge depth is -22 ft Low Water Datum (LWD) including an overdredge depth of 2 ft. This corresponds approximately to elevation 556 ft NGVD 1929 (0 LWD = 577.5 ft International Great Lakes Datum [IGLD 1985]; locally add 0.752 ft to IGLD 1985 to get elevation in ft NGVD 1929 so 0 LWD = 577.5 ft + 0.7 ft = 578.2 ft NGVD 1929). Per contract drawings for the facility operations contract, the sediment is assumed back from the work limits at a slope of 4H:1V. The analyses assumed that the sediment slopes back from -22 LWD (556 ft) at the southern limit of the Federal Channel and extends at the 4H:1V slope southward to the soil bank.
8. The slope of the banks was estimated from the topographic base map of the CDF site which covered part of the property south of the bank. The elevation contours were from an aerial photograph dated 21 October 1994. The topography with the Federal Channel Limits is shown in the attached drawing. A typical cross section was taken along line A-A' as shown in Figure 1. The distance from the southern edge of the Federal Channel to the approximate water line on the drawing was on the order of 60 ft.
9. The water levels for the analyses were assumed based on Indiana Harbor Staff Gage #04092750 which were available online from USGS's "National Water Information System: Web Interface" for October 2008 through present. This staff gage is referenced to 570.20 ft NGVD 1929. A graph of the available levels is presented in the Figure 2.
10. The general range of the water levels was on the order of 576 to 580 ft NGVD 1929. These levels were assumed as the high and low water levels and rapid drawdown levels for the project.

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TETRA TECH

July 13, 2015

Jennifer Miller, PhD, PE
Chief, Environmental Engineering Team, Chicago District U.S. Army Corps of Engineers, Chicago District
231 S. LaSalle St., Suite 1500
Chicago, Illinois 60604

TECHNICAL MEMORANDUM: Geotechnical Results

Ms. Miller,

Tetra Tech has prepared this technical memorandum to document the geotechnical investigation for the Grand Calumet River and Indiana Harbor Canal. The geotechnical investigation included sediment within the river and canal as well as the South Tank Farm area south of the Lake George Canal.

Four soil and sediment borings were installed in the Lake George Canal. Locations are shown in Figure 1. Field logs are provided in Attachment A and lab results in Attachment B.

Multiple test pits were installed on the South Tank Farm. Pit locations are shown in Figure 2. Pits were excavated to 7 feet, which corresponded to the groundwater level for many of the pit locations. A summary of the visual observation for each pit is provided in Table 1. A photographic record of the test pits is shown in Attachment C.

Geotechnical results for sediment samples collected as part of the sediment characterization are provided in Attachment D.

Sincerely,

Tetra Tech, Inc.

James Wescott, PE
Environmental Engineer

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Legend

- Lake George Canal Soil Boring Location

N

0 200 400 Feet

ECWMD GRAND CALUMET RIVER AND INDIANA HARBOR SHIP CANAL
GRAND CALUMET RIVER AREA OF CONCERN
EAST CHICAGO, INDIANA

FIGURE 1
LAKE GEORGE CANAL
SOIL BORING LOCATIONS

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Legend

- South Tank Farm Test Pit Location

N

0 200 400 Feet

ECWMD GRAND CALUMET RIVER AND INDIANA HARBOR SHIP CANAL GRAND CALUMET RIVER AREA OF CONCERN EAST CHICAGO, INDIANA

FIGURE 2
SOUTH TANK FARM TEST PIT LOCATIONS

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Table 1. South Tank Farm Test Pits

Location	Comments
Test Pit 1	Topsoil top 18 inches Brown Sand 19-36 inches Gray Fill 37-72 inches
Test Pit 2	Topsoil top 20 inches Brown Sand 21-78 inches Gray Fill 79-80 inches Groundwater and petroleum odor at bottom of pit
Test Pit 3	Topsoil top 16 inches Brown Sand 17-40 inches Gray Fill 41-80 inches Groundwater and petroleum odor at bottom of pit
Test Pit 4	Topsoil top 12 inches Brown Sand 13-37 inches Gray Fill 38-80 inches Groundwater and petroleum odor at bottom of pit
Test Pit 5	Topsoil top 15 inches Brown Sand 16-30 inches Encountered 8-inch pipeline running east/west. Stopped excavation
Test Pit 5A	Topsoil top 18 inches Bricks 19-24 inches Brown Sand 25-40 inches. Light petroleum odor Encountered 12-inch pipeline running east/west. Stopped excavation
Test Pit 6	Topsoil top 12 inches Brick and concrete 13-36 inches Brown Sand 37-48 inches Gray Fill 49-88 inches. Petroleum odor at bottom of pit
Test Pit 7	Topsoil top 14 inches Brown Sand 15-34 inches Gray Fill 35-8 inches Petroleum odor at 48 inches. Groundwater at 72 inches
Test Pit 8	Topsoil top 16 inches Brown Sand 17-46 inches Gray Fill and larger slag 47-84 inches. Petroleum odor Groundwater at 80 inches
Test Pit 9	Topsoil top 8 inches Brown Sand 96-40 inches Gray Fill 41-76 inches. Petroleum odor Groundwater at 74 inches

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Table 1 (Continued). South Tank Farm Test Pits

Location	Comments
Test Pit 10	Topsoil top 12 inches Brick and concrete 13-32 Brown Sand 33-45 inches Encountered 12-inch pipeline running east/west. Stopped excavation
Test Pit 11	Topsoil top 10 inches Brown Sand 11-27 inches Encountered 12-inch pipeline running east/west. Stopped excavation
Test Pit 12	Topsoil top 36 inches Brown Sand 37-70 inches Gray Fill 71-84 inches Petroleum odor Groundwater at 66 inches
Test Pit 13	Topsoil top 12 inches Brown Sand 13-36 inches Gray Fill 36-72 inches Water line encountered at 40 inches running north/south.
Test Pit 14	Topsoil top 24 inches Brown Sand 25-72 inches

Draft

TETRA TECH

Attachment A

Lake George Canal Boring Logs

Draft

STRATA
EARTH SERVICES, LLC

FIELD BORING LOG

SHEET_____ OF _____

Driller: BILL	Surface Elevation:	Hammer Type: 140 lb	Water Level Observations:
Helper: MARC	Boring Started: 4/22/15	Automatic ☐	WL: WS or WD
Technician: REED (CE1)	Boring Completed:	Safety ☐	WL: AB HR AB
Rig MFG/Model:	Station:	Donut ☐	WL: 24 HR AB
Weather:	Offset:	Casing Used: 30' Size: 4"	WL: BCR ACR

JOB NO._____ BORING NO. LCC-8 CLIENT _____ CLIENT PROJ NO._____

SAMPLE NO.	DEPTH OR ELEVATION FROM	DEPTH OR ELEVATION TO	SAMPLE METHOD	PENETRATION RECORD SPLIT SPOON BLOWS 6"	6"	6"	6"	R LENGTH RECOVERED IN FEET	QP PENETROMETER TEST IN TSF	HNU PHOTO-IONIZATION DETECTION	STRATA CHANGE	SAMPLE DESCRIPTION
	0	1.5										BARGE DECK
	1.5	12.5										WATER
1	12.5	15	SS	W	O	R						NO REC.
2	15	17.5	SS	W	O	R		10"	—			BLACK PETROLEUM
3	17.5	20	SS	W	O	H		12"	—			GREY SAND W/ PETROLEUM
4	20	21.5	SS	1	1	1		8"	—			SILTY SAND + GRAVEL
	20	25	RB									
5	25	26.5	SS	2	4	5		8"	—			SILTY CLAY SAMPLE DISTURBED TR S+G
	25	30	RB									
6	30	31.5	SS	2	3	4		6"	—			" SAMPLE DISTURBED
	30	35	RB									
7	35	36.5	SS	3	3	4		18"	1.5			"
	35	40	RB									
8	40	41.5	SS	1	3	3		18"	1.5			"
	40	45	RB									
9	45	46.5	SS	3	4	4		16"	1.0			"

ABBREVIATIONS

ST – SHELBY TUBE
SS – SPLIT SPOON
DB – DIAMOND BIT
PA – POWER AUGER
HSA – HOLLOW STEM AUGER
HA – HAND AUGER
RB – ROCK BIT
WS – WHILE SAMPLING
WD – WHILE DRILLING
BCR – BEFORE CASING REMOVAL
ACR – AFTER CASING REMOVAL
AB – AFTER BORING

DRILL CREW CHECKLIST

Topsoil Thickness:_____
Fill Thickness:_____

Cave-In Level:
While Drilling & Sampling_____
After Boring Completion_____

Water Loss:
At_____To_____
Percent Loss:_____
At_____To_____
Percent Loss:_____

Boulders or Obstructions:
At_____To_____
At_____To_____

Artesian Pressure:
Depth_____
Height in Soil Rise In Casing:
_____

Field

STRATA EARTH SERVICES, LLC

FIELD BORING LOG

SHEET 2 OF 2

Driller: BILL	Surface Elevation:	Hammer Type: 140 lb	Water Level Observations:
Helper: MARC	Boring Started: 4/22/15	Automatic ☐	WL: WS or WD
Technician: REED (GEI)	Boring Completed: 4/22/15	Safety ☐	WL: AB HR AB
Rig MFG/Model:	Station:	Donut ☐	WL: 24 HR AB
Weather:	Offset:	Casing Used: 30' Size: 4"	WL: BCR ACR

JOB NO. _____ BORING NO. LBG-8 CLIENT _____ CLIENT PROJ NO. _____

SAMPLE NO.	DEPTH OR ELEVATION FROM	TO	SAMPLE METHOD	PENETRATION RECORD SPLIT SPOON BLOWS 6"	6"	6"	6"	R LENGTH RECOVERED IN FEET	QP PENETROMETER TEST IN TSF	HNU PHOTO-IONIZATION DETECTION	STRATA CHANGE	SAMPLE DESCRIPTION
	45	50	RB									
10	50	51.5	SS	3	4	5		18"	1.5			11
	50	55	RB									
11	55	56.5	SS	3	4	6		18"	1.5			11
	55	60	RB									
12	60	61.5	SS	5	7	7		18"	1.5			11
	60	65	RB									
13	65	66.5	SS	6	10	12		18"	3.0			11
						EOB - GROUTED						

ABBREVIATIONS

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RB – ROCK BIT
WS – WHILE SAMPLING
WD – WHILE DRILLING
BCR – BEFORE CASING REMOVAL
ACR – AFTER CASING REMOVAL
AB – AFTER BORING

DRILL CREW CHECKLIST

Topsoil Thickness: _____
Fill Thickness: _____

Cave-In Level:
While Drilling & Sampling _____
After Boring Completion _____

Water Loss:
At _____ To _____
Percent Loss: _____
At _____ To _____
Percent Loss: _____

Boulders or Obstructions:
At _____ To _____
At _____ To _____

Artesian Pressure:
Depth _____
Height in Soil Rise In Casing: _____

Field

132021.ai

STRATA EARTH SERVICES, LLC

FIELD BORING LOG

SHEET_____ OF _____

Driller: BILL	Surface Elevation:	Hammer Type: 140 lb	Water Level Observations:
Helper: MARC	Boring Started: 4/22/15	Automatic ☐	WL: 1.5 WS or WD
Technician: REED (GEI)	Boring Completed: 4/22/15	Safety ☐	WL: AB HR AB
Rig MFG/Model:	Station:	Donut ☐	WL: 24 HR AB
Weather:	Offset:	Casing Used: 30' Size: 4"	WL: BCR ACR

JOB NO._____ BORING NO. LGC9 CLIENT _____ CLIENT PROJ NO._____

SAMPLE NO.	DEPTH OR ELEVATION FROM	TO	SAMPLE METHOD	PENETRATION RECORD SPLIT SPOON BLOWS 6"	6"	6"	6"	R LENGTH RECOVERED IN FEET	QP PENETROMETER TEST IN TSF	HNU PHOTO-IONIZATION DETECTION	STRATA CHANGE	SAMPLE DESCRIPTION
	0	1.5										BARGE DECK
	1.5	14.5										WATER
1	14.5	16.0	SS 3"	W	O	R						NO RECOVERY BLACK PETROL AND SPOON
2	17.5	20	SS	WOR	WOR	WOR						BLACK PETROL
3	20	22.5	SS	W	O	R						~~SILT~~ AT TIP CLAY
	20	22.5	RB									
4	22.5	24.0	SS	WOH	1	2		7"	0.5			GREY SILTY CLAY
	22.5	25	RB									
5	25	26.5	SS	1	1	2		8"	—			GRAY SANDY SILT
	25.0	30.0	RB									
6	30	32.5	SS	1	1	2		8"	—			GRAY SILTY SAND
	30	35	RB									
7	35		SS	2	2	3		14"	0.5			GRAY SILTY CLAY
	35		HD RB	2								
8	40	41.5	SS	2	5	7		18"	2.0			11
	40	45	RB									

ABBREVIATIONS

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HA – HAND AUGER
RB – ROCK BIT
WS – WHILE SAMPLING
WD – WHILE DRILLING
BCR – BEFORE CASING REMOVAL
ACR – AFTER CASING REMOVAL
AB – AFTER BORING

DRILL CREW CHECKLIST

Topsoil Thickness:_____
Fill Thickness:_____

Cave-In Level:
While Drilling & Sampling_____
After Boring Completion_____

Water Loss:
At_____ To_____
Percent Loss:_____
At_____ To_____
Percent Loss:_____

Boulders or Obstructions:
At_____ To_____
At_____ To_____

Artesian Pressure:
Depth_____
Height in Soil Rise In Casing:
_____

Field

132021.ai

STRATA EARTH SERVICES, LLC

FIELD BORING LOG

SHEET_____ OF_____

Driller: BILL	Surface Elevation:	Hammer Type: 140 lb	Water Level Observations:
Helper: MARC	Boring Started: 4/22/15	Automatic ☐	WL: 1.5 WS or WD
Technician: REED (GEI)	Boring Completed: 4/22/15	Safety ☐	WL: AB HR AB
Rig MFG/Model:	Station:	Donut ☐	WL: 24 HR AB
Weather:	Offset:	Casing Used: 30' Size: 4"	WL: BCR ACR

JOB NO._____ BORING NO. GGC 9 CLIENT _____ CLIENT PROJ NO._____

SAMPLE NO.	DEPTH OR ELEVATION FROM	DEPTH OR ELEVATION TO	SAMPLE METHOD	PENETRATION RECORD SPLIT SPOON BLOWS 6"	6"	6"	6"	R LENGTH RECOVERED IN FEET	QP PENETROMETER TEST IN TSF	HNU PHOTO-IONIZATION DETECTION	STRATA CHANGE	SAMPLE DESCRIPTION
9	45	46.5	SS	3	6	7		6"	–			SAMPLE DISTURBED - GRAVEL
	45	50	RB									
10	50	51.5	SS	3	5	7		18"	1.5			"
	50	55	RB									
11	55	56.5	SS	4	6	7		12"	1.5			"
					E.O.B - CROOTED							

ABBREVIATIONS

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HA – HAND AUGER
RB – ROCK BIT
WS – WHILE SAMPLING
WD – WHILE DRILLING
BCR – BEFORE CASING REMOVAL
ACR – AFTER CASING REMOVAL
AB – AFTER BORING

DRILL CREW CHECKLIST

Topsoil Thickness:_____
Fill Thickness:_____

Cave-In Level:
While Drilling & Sampling_____
After Boring Completion_____

Water Loss:
At_____To_____
Percent Loss:_____
At_____To_____
Percent Loss:_____

Boulders or Obstructions:
At_____To_____
At_____To_____

Artesian Pressure:
Depth_____
Height in Soil Rise In Casing:
_____

Field

132021.ai

STRATA EARTH SERVICES, LLC

FIELD BORING LOG

SHEET 1 OF ____

Driller: BILL	Surface Elevation:	Hammer Type: 140 lb	Water Level Observations:
Helper: MARC	Boring Started: 4/23/15	Automatic ☐	WL: WS or WD
Technician: REED (GEI)	Boring Completed:	Safety ☐	WL: AB HR AB
Rig MFG/Model:	Station:	Donut ☐	WL: 24 HR AB
Weather:	Offset:	Casing Used: Size: 4"	WL: BCR ACR

JOB NO. _____ BORING NO. LGC-10 CLIENT _____ CLIENT PROJ NO. _____

SAMPLE NO.	DEPTH OR ELEVATION FROM	DEPTH OR ELEVATION TO	SAMPLE METHOD	PENETRATION RECORD SPLIT SPOON BLOWS 6"	6"	6"	6"	R LENGTH RECOVERED IN FEET	QP PENETROMETER TEST IN TSF	HNU PHOTO-IONIZATION DETECTION	STRATA CHANGE	SAMPLE DESCRIPTION
	0	1.5										BARGE DECK
	1.5	8.75										WATER
1	8.5	10.5	SS	WOR	WOR	~~5~~	~~5~~	5"	—			BLK + GRY SAND
1A	9.5	10.5	SS			5	5	5"	—			GRY WAT SAND
	10.5	12.5	3" SS									
2	12.5	14	SS	1	~~7~~	9		16"	—			"
	12.5	15	RB									
3	15	16.5	SS	9	9	12		12"	—			"
	15	20	RB									
4	20	21.5	SS	5	5	6		14"	—			"
	20	25	RB								23.5	
5	25	26.5	SS	3	7	9		12"	3.0			GRY SILTY CLAY
	25	30	RB									
6	30	31.5	SS	4	7	8		18"	3.0			"
	30	35	RB									
7	35	36.5	SS	4	8	10		18"	3.0			"

ABBREVIATIONS

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WS – WHILE SAMPLING
WD – WHILE DRILLING
BCR – BEFORE CASING REMOVAL
ACR – AFTER CASING REMOVAL
AB – AFTER BORING

DRILL CREW CHECKLIST

Topsoil Thickness: _____
Fill Thickness: _____

Cave-In Level:
While Drilling & Sampling _____
After Boring Completion _____

Water Loss:
At _____ To _____
Percent Loss: _____
At _____ To _____
Percent Loss: _____

Boulders or Obstructions:
At _____ To _____
At _____ To _____

Artesian Pressure:
Depth _____
Height in Soil Rise In Casing: _____

Red

132021.ai

STRATA
EARTH SERVICES, LLC

FIELD BORING LOG

SHEET 2 OF 2

Driller: BILL	Surface Elevation:	Hammer Type: 140 lb	Water Level Observations:
Helper: MARC	Boring Started: 4/23/15	Automatic ☐	WL: WS or WD
Technician: REED (CEI)	Boring Completed: 4/23/15	Safety ☐	WL: AB HR AB
Rig MFG/Model:	Station:	Donut ☐	WL: 24 HR AB
Weather:	Offset:	Casing Used: Size: 4"	WL: BCR ACR

JOB NO. _____ BORING NO. LBC-10 CLIENT _____ CLIENT PROJ NO. _____

SAMPLE NO.	DEPTH OR ELEVATION FROM	DEPTH OR ELEVATION TO	SAMPLE METHOD	PENETRATION RECORD SPLIT SPOON BLOWS 6"	6"	6"	6"	R LENGTH RECOVERED IN FEET	QP PENETROMETER TEST IN TSF	HNU PHOTO-IONIZATION DETECTION	STRATA CHANGE	SAMPLE DESCRIPTION
	35	40	RB									
8	40	41.5	SS	3	6	9						
						E.O.B. — CAVED						

ABBREVIATIONS

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HA – HAND AUGER
RB – ROCK BIT
WS – WHILE SAMPLING
WD – WHILE DRILLING
BCR – BEFORE CASING REMOVAL
ACR – AFTER CASING REMOVAL
AB – AFTER BORING

DRILL CREW CHECKLIST

Topsoil Thickness: _____
Fill Thickness: _____

Cave-In Level:
While Drilling & Sampling _____
After Boring Completion _____

Water Loss:
At _____ To _____
Percent Loss: _____
At _____ To _____
Percent Loss: _____

Boulders or Obstructions:
At _____ To _____
At _____ To _____

Artesian Pressure:
Depth _____
Height in Soil Rise In Casing: _____

Field

132021.ai

STRATA EARTH SERVICES, LLC

FIELD BORING LOG

SHEET 1 OF _____

Driller: BILL	Surface Elevation:	Hammer Type: 140 lb	Water Level Observations:
Helper: MARC	Boring Started: 4/23/15	Automatic ☐	WL: WS or WD
Technician: REED (GEI)	Boring Completed:	Safety ☐	WL: AB HR AB
Rig MFG/Model:	Station:	Donut ☐	WL: 24 HR AB
Weather:	Offset:	Casing Used: Size: 4"	WL: BCR ACR

JOB NO. _____ BORING NO. LGC-11 CLIENT _____ CLIENT PROJ NO. _____

SAMPLE NO.	DEPTH OR ELEVATION FROM	DEPTH OR ELEVATION TO	SAMPLE METHOD	PENETRATION RECORD SPLIT SPOON BLOWS 6"	6"	6"	6"	R LENGTH RECOVERED IN FEET	QP PENETROMETER TEST IN TSF	HNU PHOTO-IONIZATION DETECTION	STRATA CHANGE	SAMPLE DESCRIPTION
	0	1.5										BARGE DECK
	1.5	11.5										WATER
1	11.5	13	SS	15	6	8		10"	—			FILL/S+G/ PETROL ODOR/CONC/BLK GRY
2	13.5	15	SS	6	5	6		10"	—			GRY WET SAND
	13.5	15	RB									
3	15	16.5	SS	5	7	8		12"	—			11
	15	20	RB									
4	20	21.5	SS	6	7	8		14"	—			SILTY SAND
	20	25	RB									
5	25	26.5	SS	2	3	4		18"	1.5		24	GRY SILTY CLAY
	25	30	RB									
6	30	31.5	SS	3	6	8		18"	3.5		30	CLAYEY SILT
	30	35	RB									
7	35	36.5	SS	2	5	6		18"	1.5		35	GRY SILTY CLAY
	35	40	RB									
8	40	41.5	SS	2	2	4		18"	1.5			11

ABBREVIATIONS

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HA – HAND AUGER
RB – ROCK BIT
WS – WHILE SAMPLING
WD – WHILE DRILLING
BCR – BEFORE CASING REMOVAL
ACR – AFTER CASING REMOVAL
AB – AFTER BORING

DRILL CREW CHECKLIST

Topsoil Thickness: _____
Fill Thickness: _____

Cave-In Level:
While Drilling & Sampling _____
After Boring Completion _____

Water Loss:
At _____ To _____
Percent Loss: _____
At _____ To _____
Percent Loss: _____

Boulders or Obstructions:
At _____ To _____
At _____ To _____

Artesian Pressure:
Depth _____
Height in Soil Rise In Casing: _____

REVISED

132021.ai

STRATA EARTH SERVICES, LLC

FIELD BORING LOG

SHEET 2 OF 2

Driller: BILL	Surface Elevation:	Hammer Type: 140 lb	Water Level Observations:
Helper: MARC	Boring Started: 4/23/15	Automatic ☐	WL: WS or WD
Technician: REED (GEI)	Boring Completed: 4/23/15	Safety ☐	WL: AB HR AB
Rig MFG/Model:	Station:	Donut ☐	WL: 24 HR AB
Weather:	Offset:	Casing Used: 20' Size: 4"	WL: BCR ACR

JOB NO._____ BORING NO. LGC-11 CLIENT _____ CLIENT PROJ NO._____

SAMPLE NO.	DEPTH OR ELEVATION FROM	DEPTH OR ELEVATION TO	SAMPLE METHOD	PENETRATION RECORD SPLIT SPOON BLOWS 6"	6"	6"	6"	R LENGTH RECOVERED IN FEET	QP PENETROMETER TEST IN TSF	HNU PHOTO-IONIZATION DETECTION	STRATA CHANGE	SAMPLE DESCRIPTION
	40	45	RB									
9	45	465	SS	3	5	7		18"	1.5			CL
	45	50	RB									
10	50	57.5	SS	4	5	6		18"	1.5			"

ABBREVIATIONS

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AB – AFTER BORING

DRILL CREW CHECKLIST

Topsoil Thickness:_____
Fill Thickness:_____

Cave-In Level:
While Drilling & Sampling_____
After Boring Completion_____

Water Loss:
At_____To_____
Percent Loss:_____
At_____To_____
Percent Loss:_____

Boulders or Obstructions:
At_____To_____
At_____To_____

Artesian Pressure:
Depth_____
Height in Soil Rise In Casing:
_____

Field

132021.al

TETRA TECH

Attachment B

Lake George Canal Test Results

Draft

July 7, 2015
Revised July 8, 2015

Ms. Sara Knight
Strata Earth Services
530 W. Colfax Street
Palatine, IL 60067

RE: Laboratory Testing Program for the Lake George Canal Project – Terracon Project No. MR155106

Dear Ms. Knight,

We are pleased to transmit our laboratory report pertaining to the testing of soil samples received in our Vernon Hills, IL laboratory. The samples were in reference to the Lake George Canal Project located in East Chicago, IN. Terracon performed the following tests on samples selected by GEI Consultants:

- Particle Size Analysis of Soils – ASTM D 422
- Water Content of Soil and Rock – ASTM D 2216
- Unconfined Compressive Strength of Cohesive Soils – ASTM D 2166
- Visual Engineering Classification of Soils – ASTM D 2488
- Direct Shear Test of Soils Under Consolidated Drained Conditions – ASTM D 3080
- Liquid Limit, Plastic Limit, and Plasticity Index of Soils – ASTM D 4318
- Unconfined Compressive Strength by Penetrometer

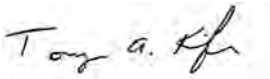
The test data included in our report, only represent the samples tested and may not reflect actual site materials and/or conditions. Values of ϕ and c were determined based upon the procedures outlined in the ASTM standard, and/or current standards of practice. Information, not made available to Terracon, may influence these determinations. The scope of services provided by Terracon did not included interpretation of the laboratory test data and therefore we are not liable for any interpretation performed by others. If you wish us to provide you with this service, we would be happy to discuss this matter with you at your convenience. Any reproduction of this report must be done in its entirety.

We are pleased to have the opportunity to provide you with our testing services. Should you have any questions, or require additional assistance, please feel free to contact us at any time.

Draft

Sincerely,
Terracon Consultants, Inc.

William P. Quinn
Department Manager
Laboratory Services



Tony A. Kiefer, P.E.
Senior Consultant
Geotechnical Services

cc: Mr. Ryan Rusk
GEI Consultants
400 N. Lakewood Parkway
Suite 140
Vernon Hills, IL 60061

Draft

LABORATORY TESTING SUMMARY

PROJECT NAME: Lake George Canal | PROJECT NUMBER: MR155106 | CLIENT: STRATA Earth Services

Boring Number	Sample Number	Depth	Description	USCS	WC %	Qp (tsf)	GRAVEL	SAND	SILT	CLAY	LL	PL	PI
LGC-8	S-5	25.0'-26.5'	GRAY LEAN CLAY TRACE F SAND	CL	30.9	0.25					38	16	22
LGC-8	S-6	30.0'-31.5'	GRAY LEAN CLAY TRACE F SAND	CL	38.1	DISTURBED							
LGC-8	S-7	35.0'-36.5'	GRAY LEAN CLAY TRACE F SAND	CL	23.2	2.50							
LGC-8	S-8	40.0'-41.5'	GRAY LEAN CLAY TRACE F SAND	CL	24.3	1.50					43	19	24
LGC-8	S-9	45.0'-46.5'	BROWN AND GRAY LEAN CLAY LITTLE F-C SAND	CL	21.4	2.00	1.4	10.6	33.7	54.3			
LGC-8	S-10	50.0'-51.5'	GRAY LEAN CLAY TRACE F SAND	CL	23.5	1.00							
LGC-8	S-11	55.0'-56.5'	GRAY LEAN CLAY TRACE F SAND	CL	20.3	3.25							
LGC-8	S-12	60.0'-61.5'	GRAY LEAN CLAY TRACE F SANDY	CL	19.3	3.50							
LGC-8	S-13	65.0'-66.5'	GRAY LEAN CLAY TRACE F-C SAND AND F GRAVEL	CL	18.4	4.25							
LGC-9	S-4	22.0'-24.5'	GRAY LEAN CLAY TRACE F-C SAND	CL	25.0	1.25							
LGC-9	S-5	25.0'-26.5'	GRAY AND BROWN FINE SAND WITH SILT	SM	25.7						19	25	NP
LGC-9	S-6	30.0'-31.5'	GRAY AND BROWN FINE SAND WITH SILT	SM	35.5								
LGC-9	S-7	35.0'-36.5'	GRAY LEAN CLAY TRACE F SAND	CL	27.1	1.50							
LGC-9	S-8	40.0'-41.5'	GRAY LEAN CLAY TRACE F SAND	CL	20.1	2.25							
LGC-9	S-9	45.0'-46.5'	GRAY LEAN CLAY TRACE F SAND	CL	27.4	DISTURBED							
LGC-9	S-10	50.0'-51.5'	GRAY LEAN CLAY LITTLE F-C SAND	CL	18.2	3.50	0.0	14.7	32.8	52.5			
LGC-9	S-11	55.0'-56.5'	GRAY LEAN CLAY TRACE F SAND	CL	20.9	1.50					34	17	17
LGC-10	S-5	25.0'-26.5'	GRAY LEAN CLAY TRACE F-C SAND	CL	17.9	2.75							
LGC-10	S-6	30.0'-31.5'	GRAY LEAN CLAY TRACE F-C SAND	CL	16.9	3.00	Combined Samples 5,6,7,8						
LGC-10	S-7	35.0'-36.5'	GRAY LEAN CLAY TRACE F-C SAND	CL	18.5	2.50	0.0	9.9	37.2	52.9	36	16	20
LGC-10	S-8	40.0'-41.5'	GRAY LEAN CLAY TRACE F-C SAND	CL	17.6	2.75							
LGC-11	S-4	20.0'-21.5'	BROWN AND GRAY SILTY SAND	SM	24.2		0.0	50.9	46.1	3.0			
LGC-11	S-5	25.0'-26.5'	GRAY LEAN CLAY TRACE F SAND	CL	24.7	1.50					38	17	21
LGC-11	S-6	30.0'-31.5'	DARK GRAY LEAN CLAY WITH SILT TRACE F SAND	CL-ML	20.9	4.50+							
LGC-11	S-7	35.0'-36.5'	GRAY LEAN CLAY TRACE F SAND	CL	20.5	1.50							
LGC-11	S-8	40.0'-41.5'	GRAY LEAN CLAY TRACE F SAND	CL	19.5	1.50					33	16	17
LGC-11	S-9	45.0'-46.5'	GRAY LEAN CLAY TRACE F SAND	CL	21.4	1.50							
LGC-11	S-10	50.0'-51.5'	GRAY LEAN CLAY TRACE F SAND	CL	20.9	2.00							

Draft

PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422

% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	1.4	1.9	3.1	5.6	33.7	54.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375	100.0		
#4	98.6		
#10	96.7		
#20	95.3		
#40	93.6		
#60	91.9		
#100	90.0		
#200	88.0		

* (no specification provided)

BROWN AND GRAY LEAN CLAY LITTLE F-C SAND

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.1493 D_{85}= 0.0475 D_{60}= 0.0073
D_{50}= 0.0040 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO=

Remarks

F.M.=0.32

Source of Sample: LGC-8 **Depth:** 45.0'-46.5'
Sample Number: S-9

Date: 6-29-15

Terracon

Client: STRATA EARTH SERVICES
Project: LAKE GEORGE CANAL

Project No: MR155106 **Figure**

Tested By: SJH **Checked By:** WPQ

Draft

PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422

% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	2.2	5.6	6.9	32.8	52.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	97.8		
#20	94.5		
#40	92.2		
#60	90.0		
#100	87.7		
#200	85.3		

* (no specification provided)

GRAY LEAN CLAY LITTLE F-C SAND

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.2504 D_{85}= 0.0713 D_{60}= 0.0070
D_{50}= 0.0045 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO=

Remarks

F.M.=0.34

Source of Sample: LGC-9 **Depth:** 50.0'-51.5'
Sample Number: S-10 **Date:** 7-2-15

Terracon

Client: STRATA EARTH SERVICES
Project: LAKE GEORGE CANAL

Project No: MR155106 **Figure**

Tested By: SJH **Checked By:** WPQ

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PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422

Draft

% Gravel		% Sand			% Fines	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	1.5	3.6	4.8	37.2	52.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	98.5		
#20	96.5		
#40	94.9		
#60	93.2		
#100	91.6		
#200	90.1		

* (no specification provided)

GRAY LEAN CLAY TRACE F SAND

Atterberg Limits

PL= 16 LL= 36 PI= 20

Coefficients

D_{90}= 0.0737 D_{85}= 0.0336 D_{60}= 0.0068
D_{50}= 0.0044 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(17)

Remarks

F.M.=0.23

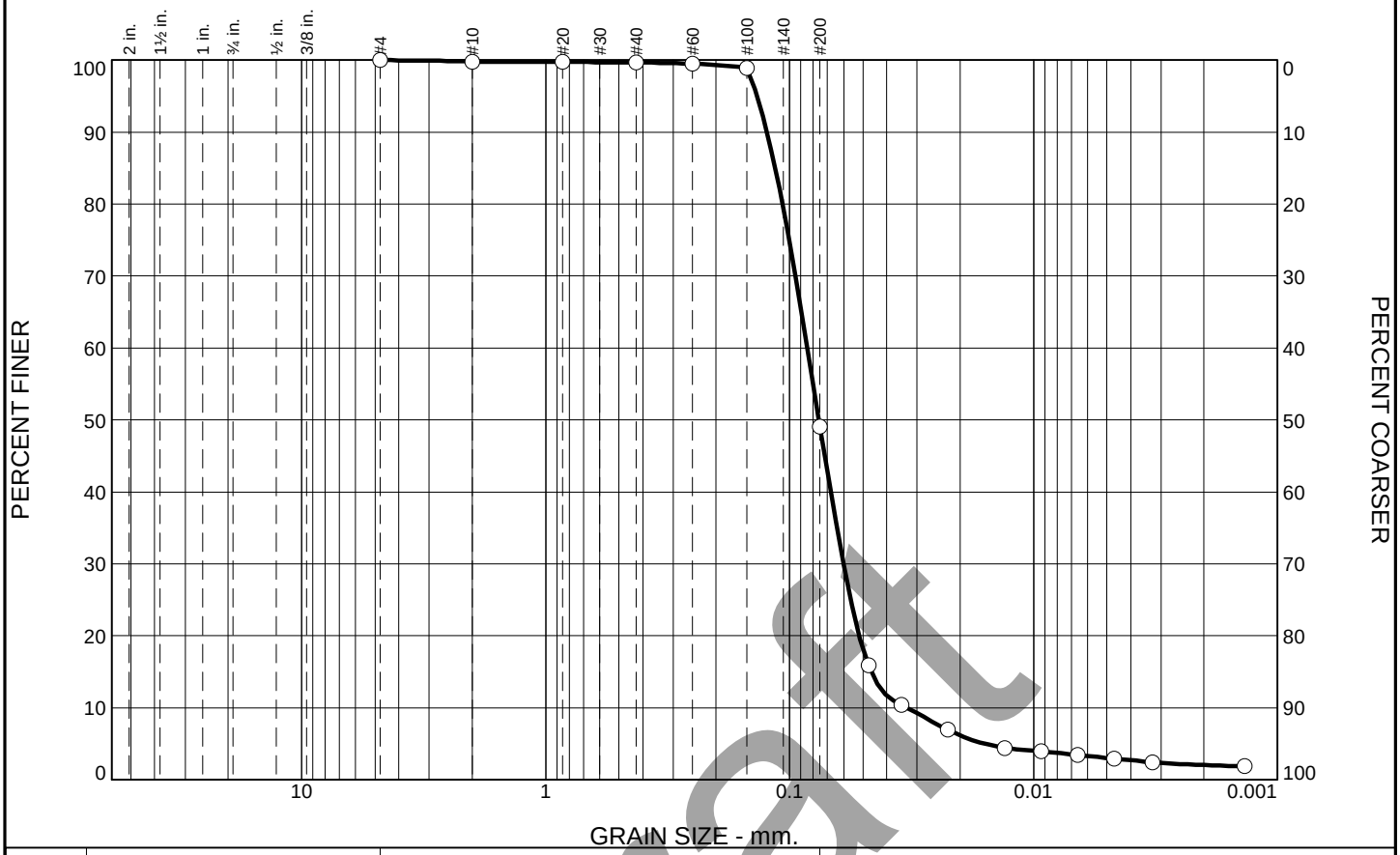
Source of Sample: LGC-10 **Depth:** 25.0'-41.5'
Sample Number: Combined 5,6,7,8 **Date:**

Terracon

Client: STRATA EARTH SERVICES
Project: LAKE GEORGE CANAL

Project No: MR155106 **Figure**

PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.2	0.1	50.6	46.1	3.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	99.8		
#20	99.7		
#40	99.7		
#60	99.5		
#100	98.9		
#200	49.1		

* (no specification provided)

BROWN AND GRAY SILTY SAND

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.1236 D_{85}= 0.1145 D_{60}= 0.0846
D_{50}= 0.0758 D_{30}= 0.0600 D_{15}= 0.0463
D_{10}= 0.0329 C_u= 2.57 C_c= 1.30

Classification

USCS= SM AASHTO=

Remarks

F.M.=0.02

Source of Sample: LGC-11 **Depth:** 20.0'-21.5'
Sample Number: S-4

Date: 6-29-15

Terracon

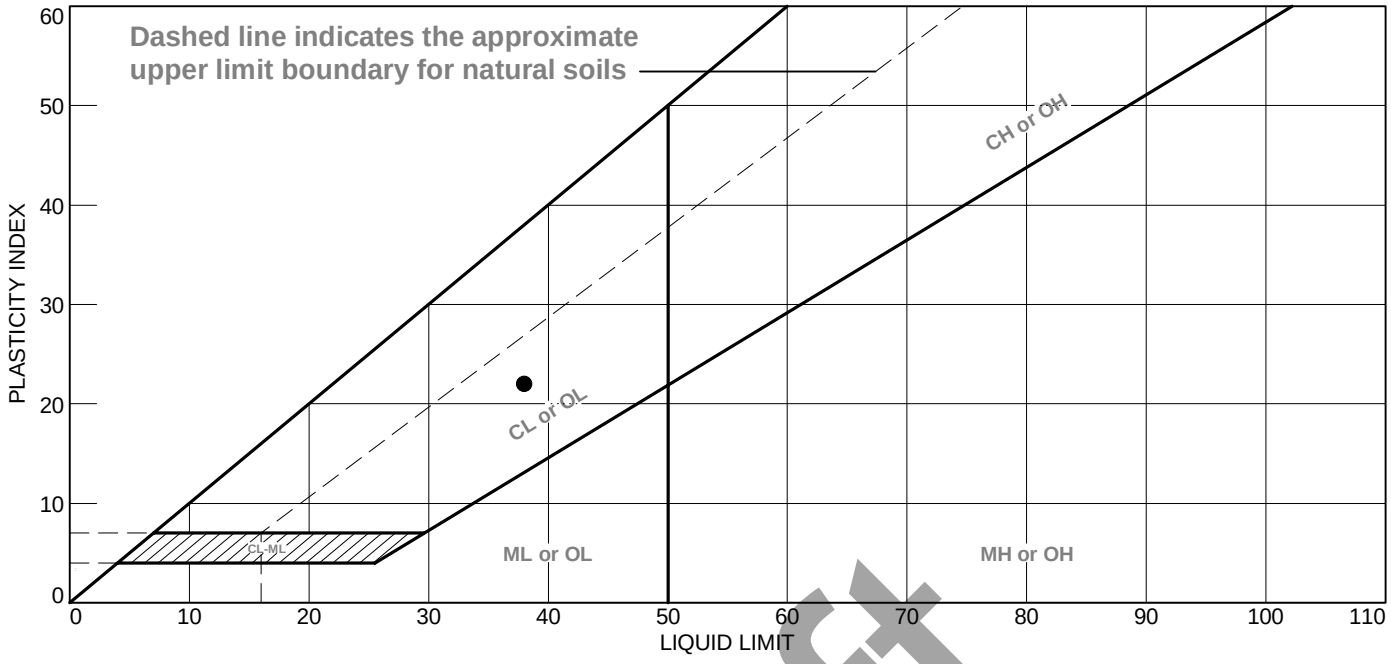
Client: STRATA EARTH SERVICES
Project: LAKE GEORGE CANAL

Project No: MR155106 **Figure**

Tested By: SJH **Checked By:** WPQ

Draft

LIQUID AND PLASTIC LIMITS ASTM D4318



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	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	GRAY LEAN CLAY TRACE F SAND	38	16	22			CL

Project No. MR155106 **Client:** STRATA EARTH SERVICES

Project: LAKE GEORGE CANAL

Source of Sample: LGC-8 **Depth:** 25.0'-26.5'
Sample Number: S-5

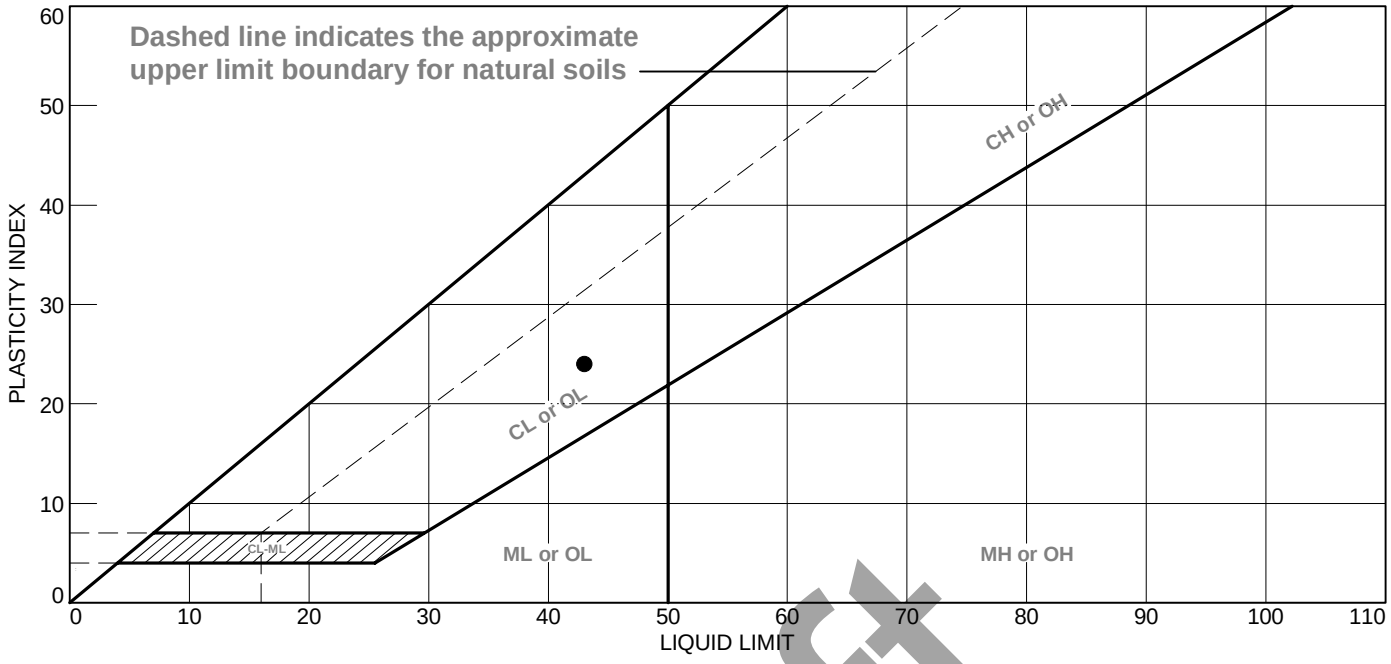
Remarks:

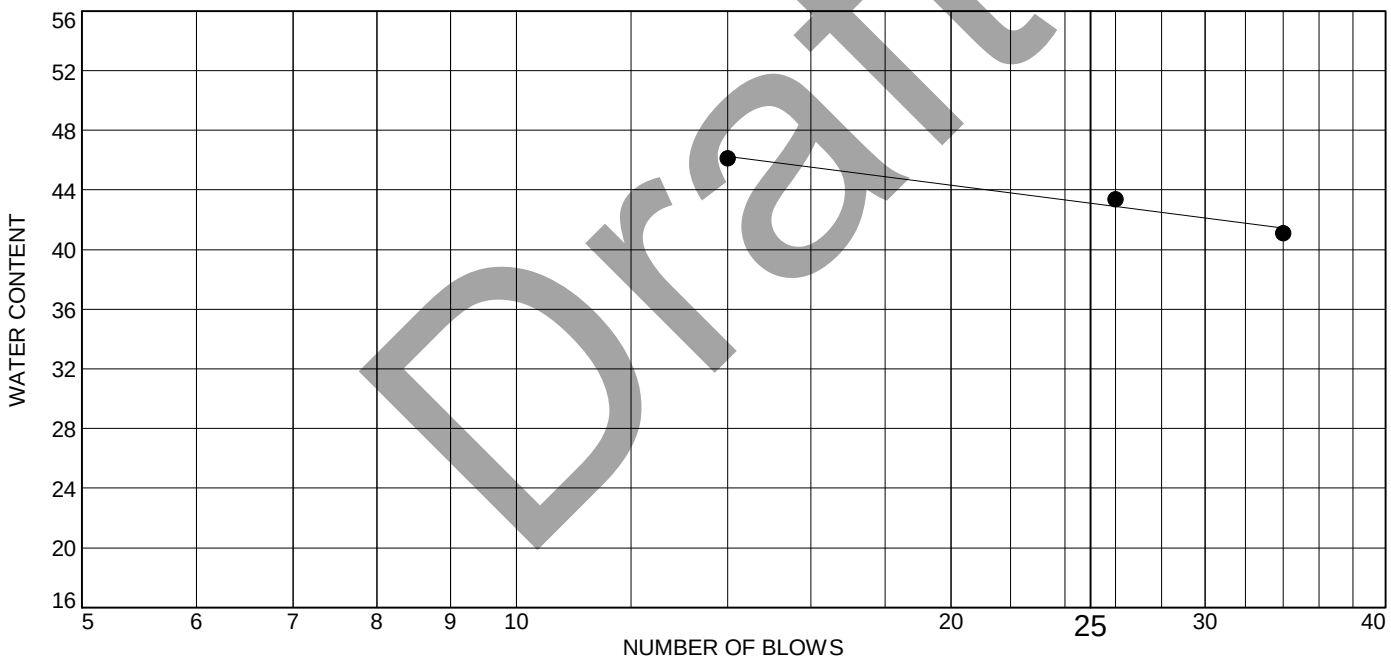
Terracon

Figure

Tested By: SJH **Checked By:** WPQ

LIQUID AND PLASTIC LIMITS ASTM D4318





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	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	GRAY LEAN CLAY TRACE F SAND	43	19	24			CL

Project No. MR155106 **Client:** STRATA EARTH SERVICES

Project: LAKE GEORGE CANAL

Source of Sample: LGC-8 **Depth:** 40.0'-41.5'
Sample Number: S-8

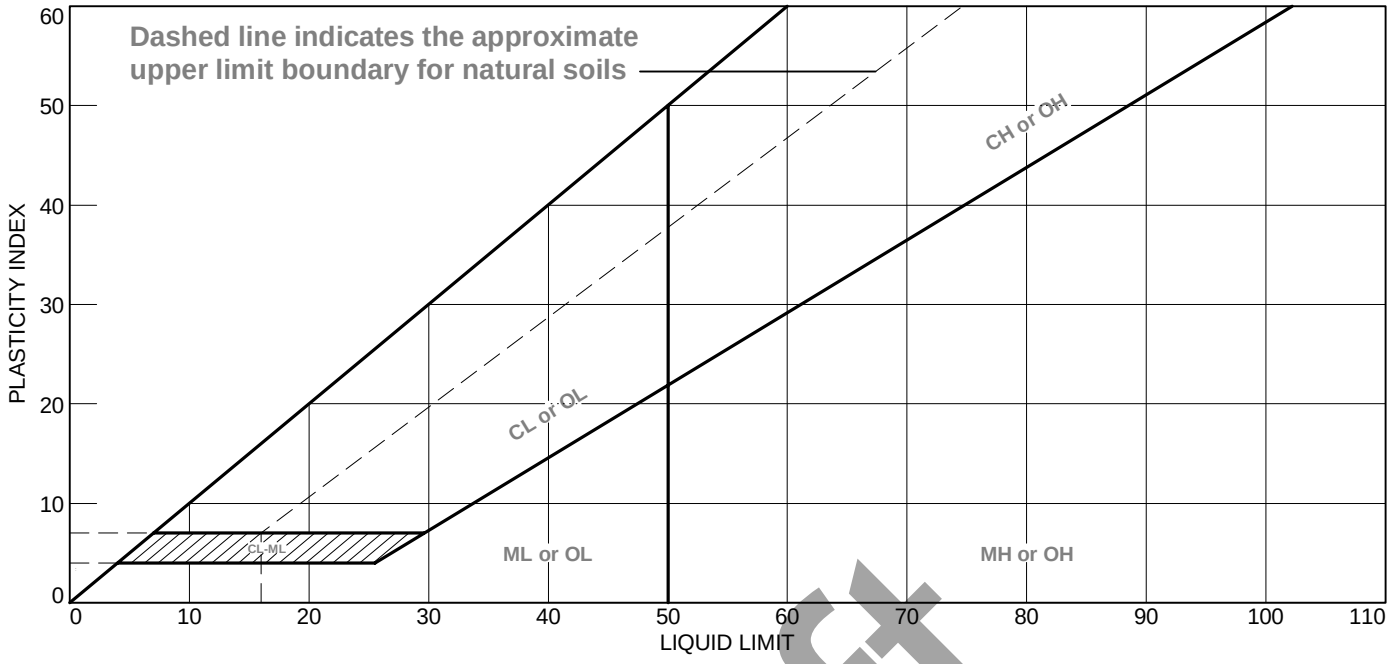
Remarks:

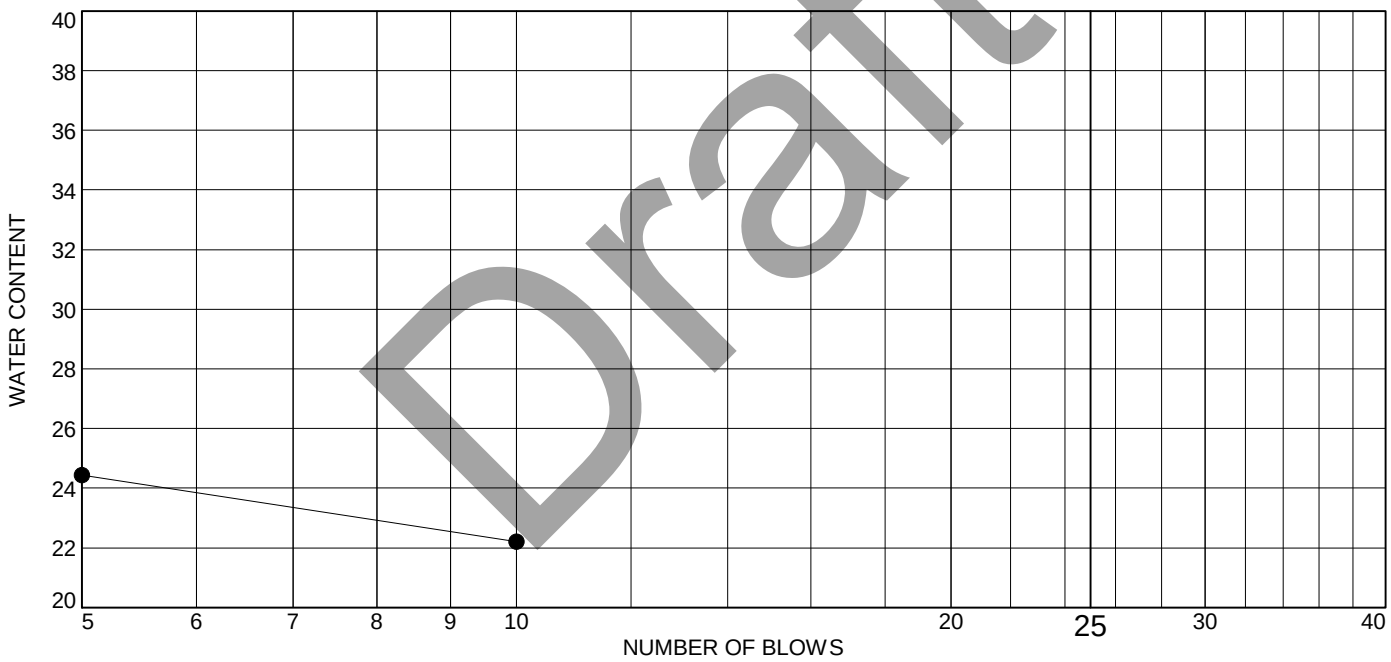
Terracon

Figure

Tested By: SJH **Checked By:** WPQ

LIQUID AND PLASTIC LIMITS ASTM D4318





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	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	GRAY AND BROWN FINE SAND WITH SILT	19	25	NP			SM

Project No. MR155106 **Client:** STRATA EARTH SERVICES

Project: LAKE GEORGE CANAL

Source of Sample: LGC-9 **Depth:** 25.0'-26.5'
Sample Number: S-5

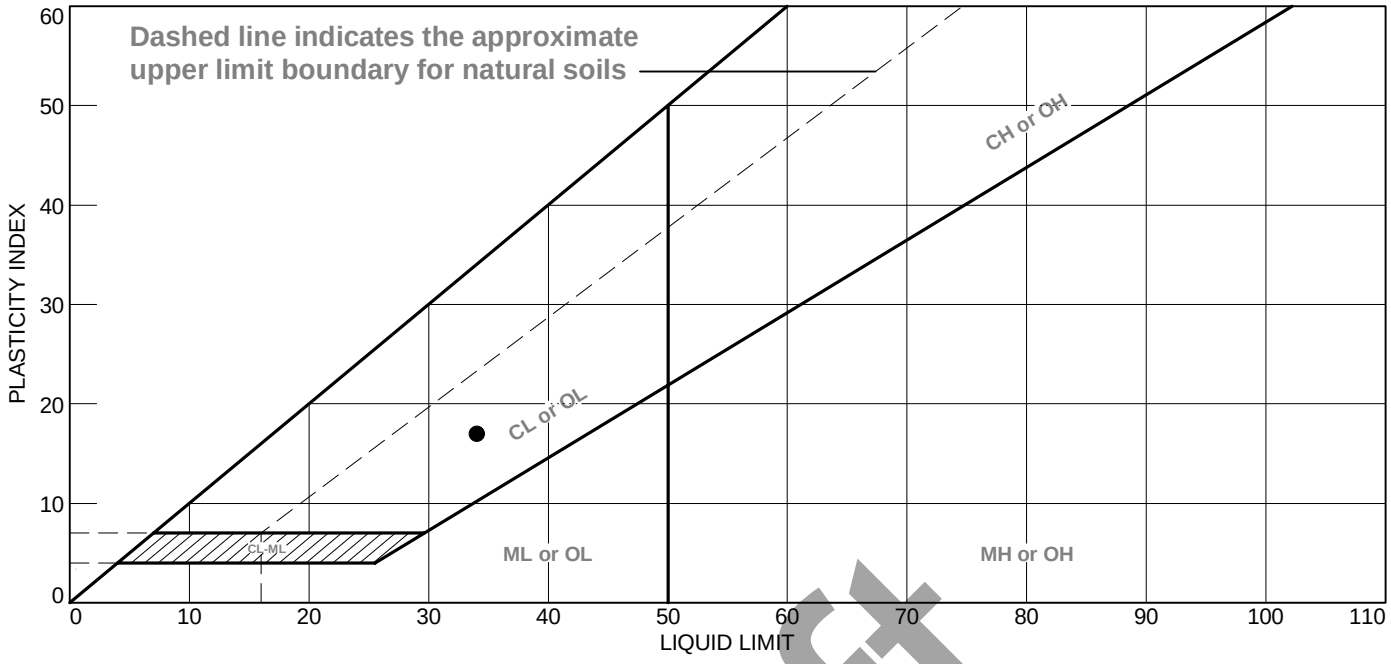
Remarks:

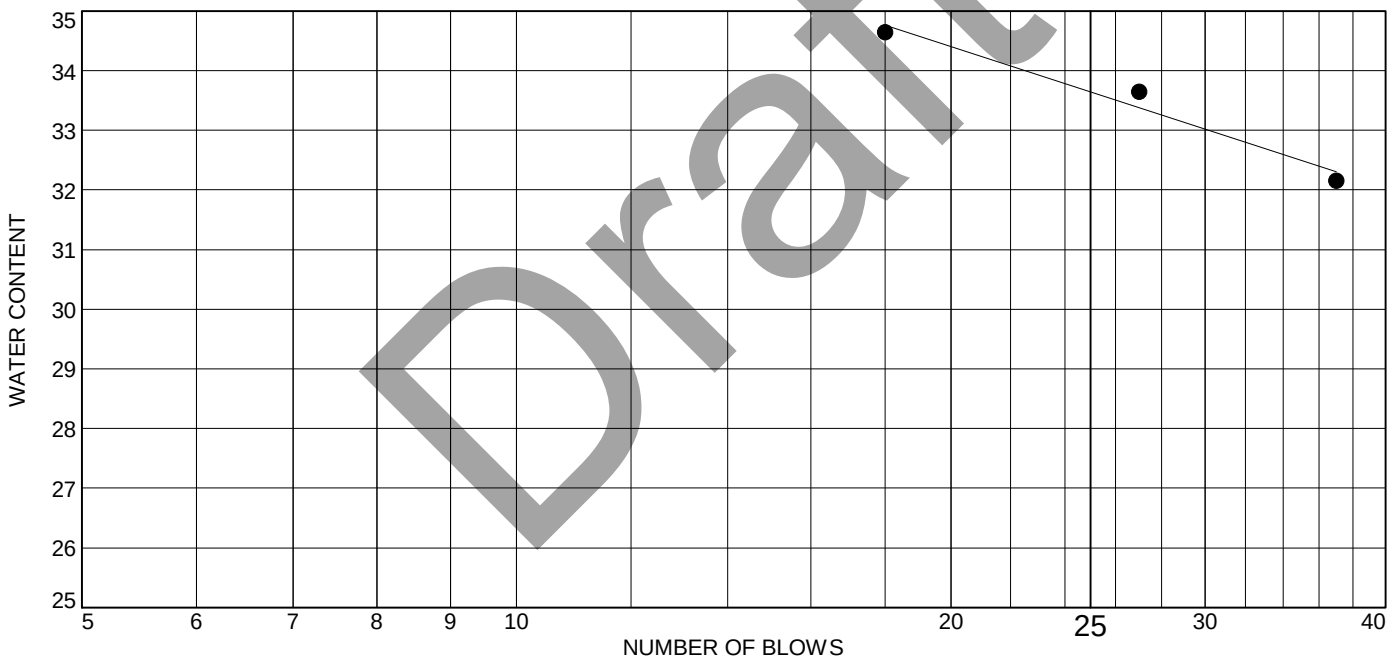
Terracon

Figure

Tested By: SJH **Checked By:** WPQ

LIQUID AND PLASTIC LIMITS ASTM D4318





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	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	GRAY LEAN CLAY TRACE F SAND	34	17	17			CL

Project No. MR155106 **Client:** STRATA EARTH SERVICES

Project: LAKE GEORGE CANAL

Source of Sample: LGC-9 **Depth:** 55.0'-56.5'

Sample Number: S-11

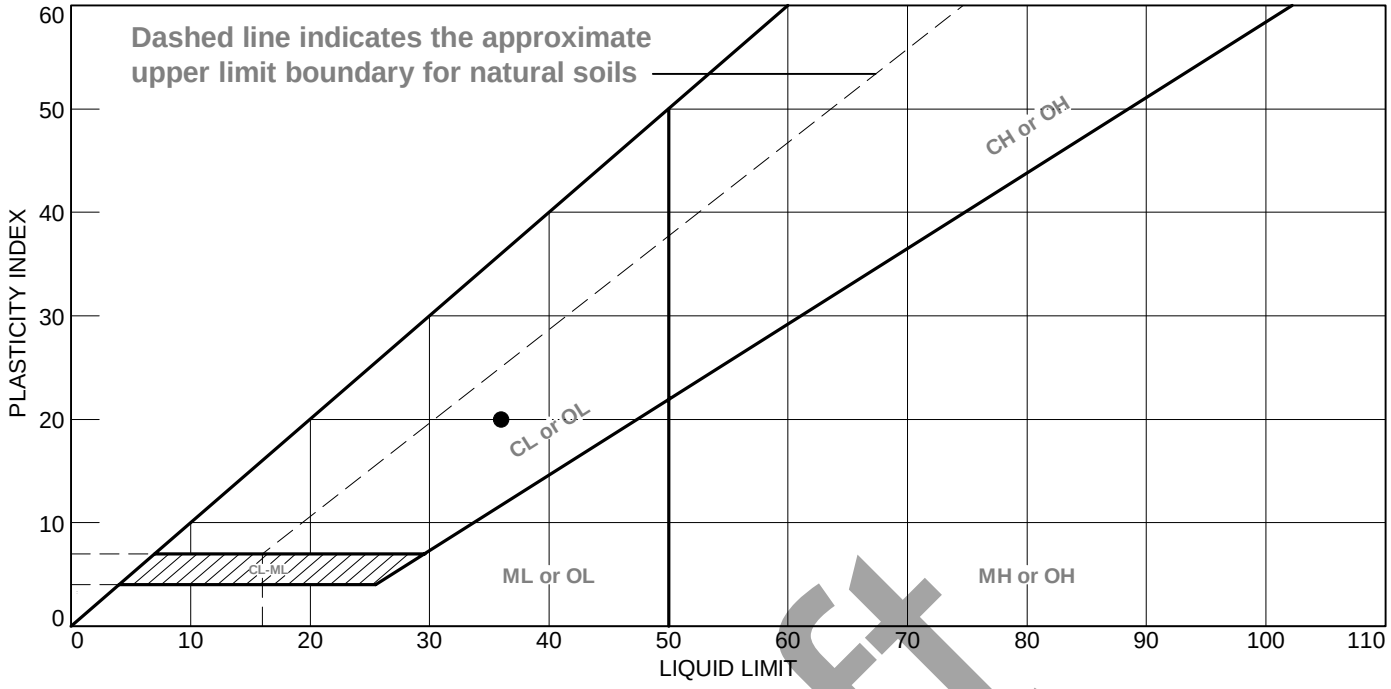
Remarks:

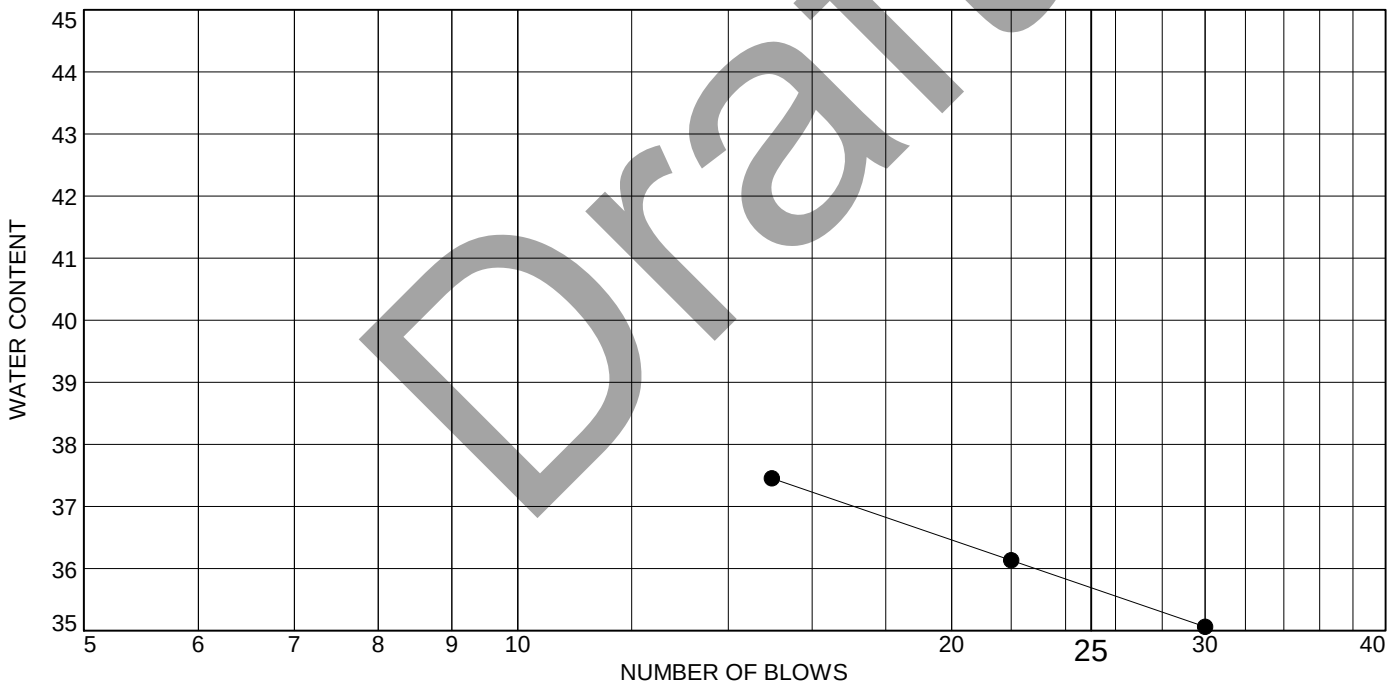
Terracon

Figure

Tested By: SJH **Checked By:** WPQ

LIQUID AND PLASTIC LIMITS ASTM D4318





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	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	GRAY LEAN CLAY TRACE F SAND	36	16	20	94.9	90.1	CL

Project No. MR155106 **Client:** STRATA EARTH SERVICES

Project: LAKE GEORGE CANAL

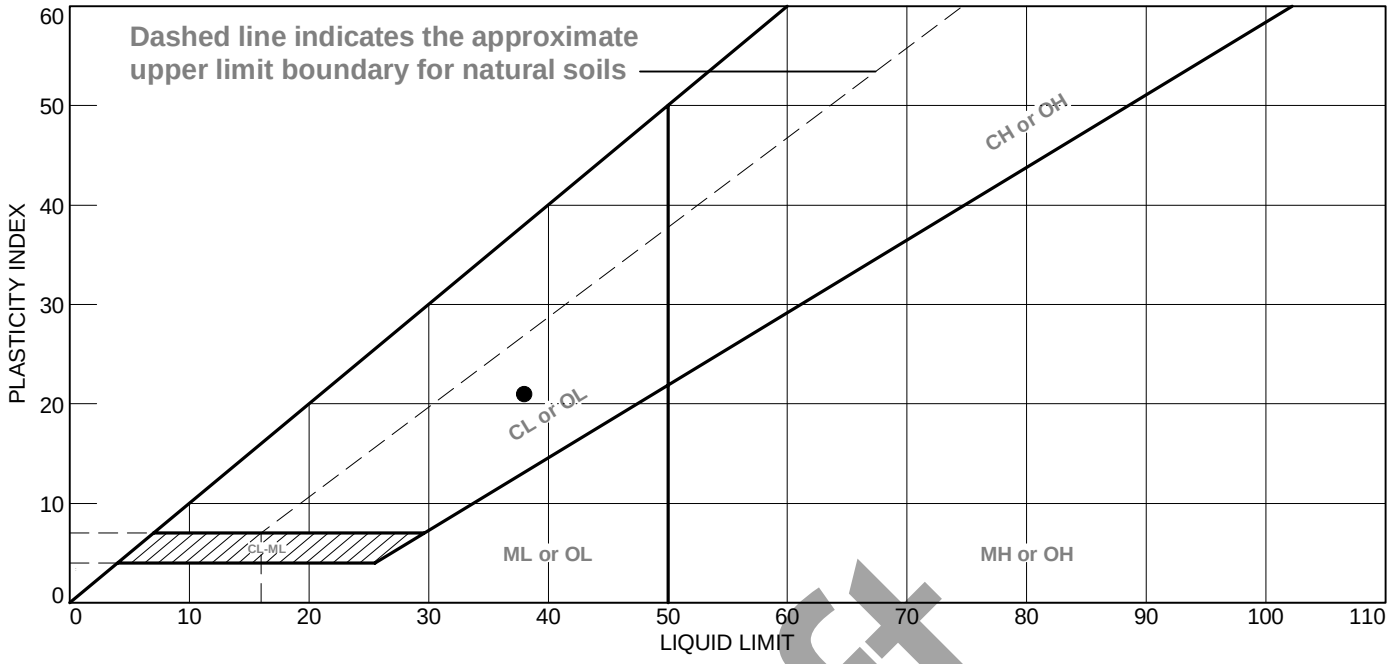
Source of Sample: LGC-10 **Depth:** 25.0'-41.5'
Sample Number: Combined 5,6,7,8

Remarks:

Terracon

Figure

LIQUID AND PLASTIC LIMITS ASTM D4318



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	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	GRAY LEAN CLAY TRACE F SAND	38	17	21			CL

Project No. MR155106 **Client:** STRATA EARTH SERVICES

Project: LAKE GEORGE CANAL

Source of Sample: LGC-11 **Depth:** 25.0'-26.5'
Sample Number: S-5

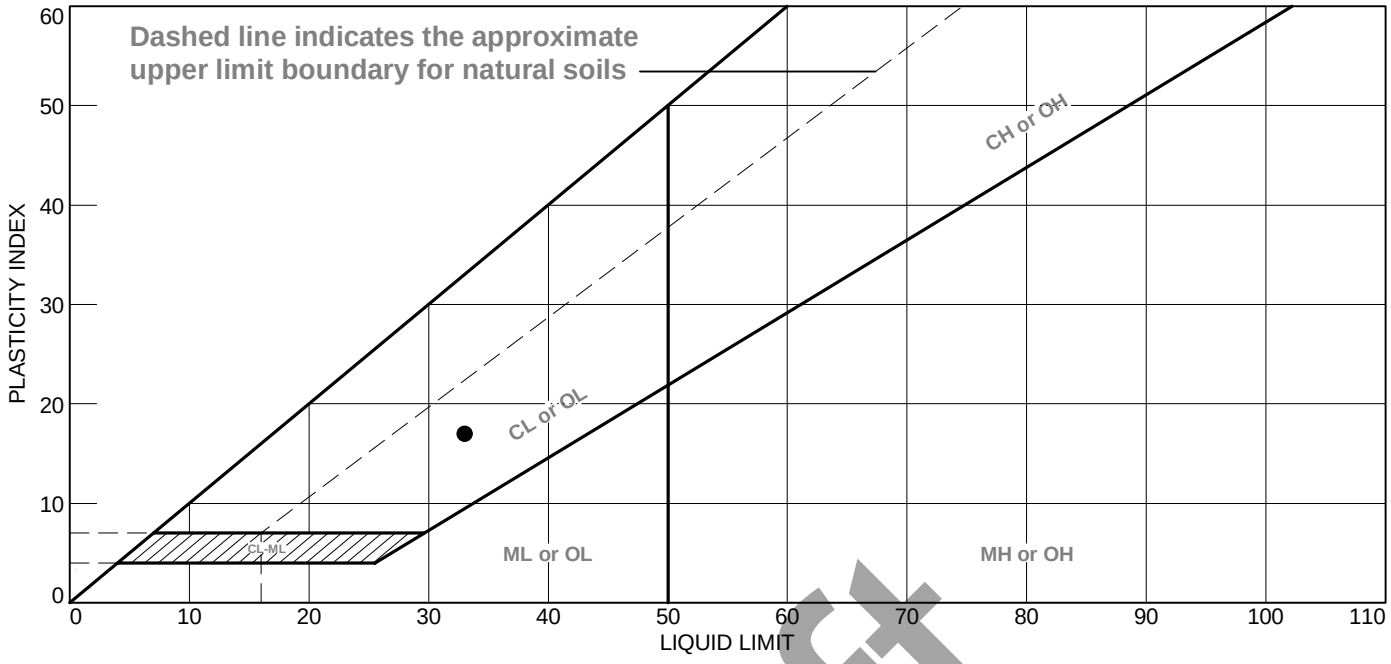
Remarks:

Terracon

Figure

Tested By: SJH **Checked By:** WPQ

LIQUID AND PLASTIC LIMITS ASTM D4318



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	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	GRAY LEAN CLAY TRACE F SAND	33	16	17			CL

Project No. MR155106 **Client:** STRATA EARTH SERVICES

Project: LAKE GEORGE CANAL

Source of Sample: LGC-11 **Depth:** 40.0'-41.5'
Sample Number: S-8

Remarks:

Terracon

Figure

Tested By: SJH **Checked By:** WPQ

UNCONFINED COMPRESSION TEST REPORT

Terracon
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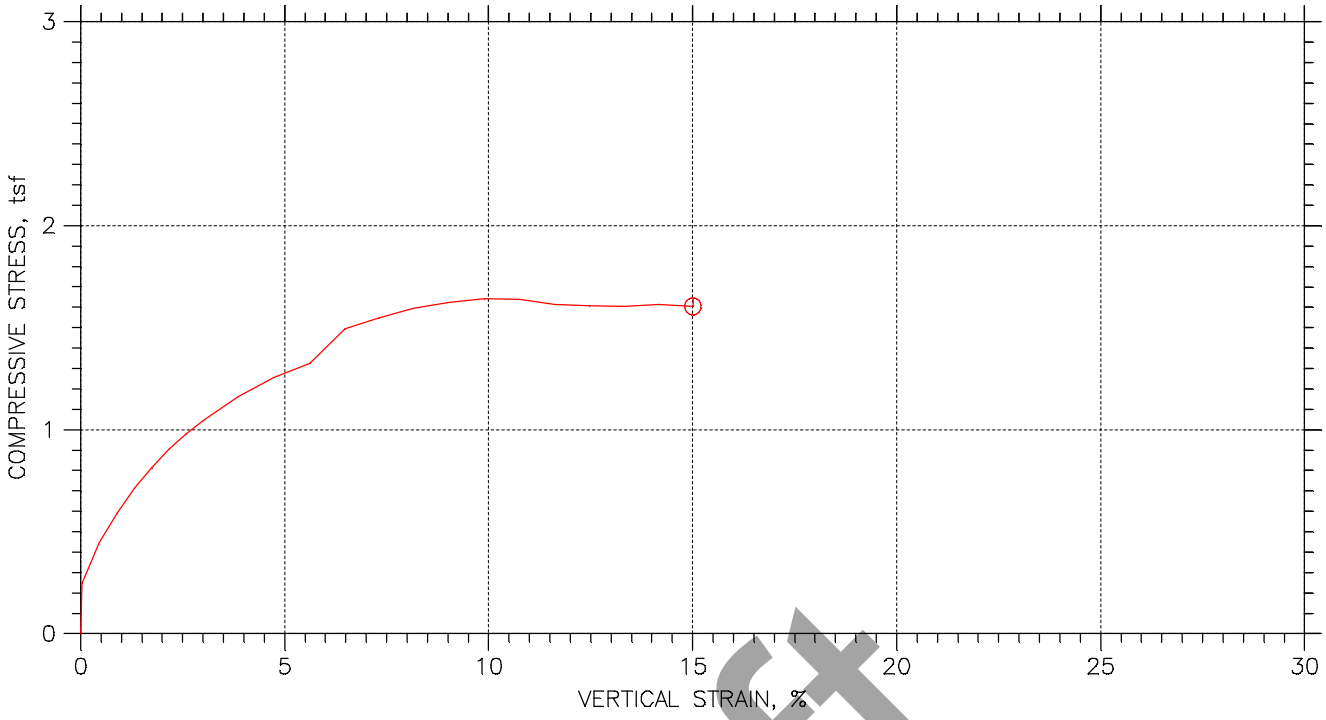

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Symbol		⏲			
Test No.		LGC8S8Qu			
Initial	Diameter, in	1.4213			
	Height, in	2.7382			
	Water Content, %	24.32			
	Dry Density, pcf	97.72			
	Saturation, %	89.68			
	Void Ratio	0.7377			
Unconfined Compressive Strength, tsf		1.6432			
Undrained Shear Strength, tsf		0.82158			
Time to Failure, min		6.004			
Strain Rate, %/min		1.14			
Estimated Specific Gravity		2.72			
Liquid Limit		43			
Plastic Limit		19			
Plasticity Index		24			
Failure Sketch					

Project: LAKE GEORGE CANAL
Location: EAST CHICAGO, IN
Project No.: MR155106
Boring No.: LGC-8 S-8
Sample Type: 40.0'-41.5'
Description: GRAY LEAN CLAY TRACE FINE SAND
Remarks: TEST PERFORMED AS PER ASTM D 2166.

UNCONFINED COMPRESSION TEST

Project: LAKE GEORGE CANAL
Boring No.: LGC-8 S-8
Sample No.: 8
Test No.: LGC8S8Qu

Location: EAST CHICAGO, IN
Tested By: WPQ
Test Date: 6/30/15
Sample Type: 40.0'-41.5'

Project No.: MR155106
Checked By: BCM
Depth: 40.0'-41.5'
Elevation: -----

Terracon
Consulting Engineers & Scientists

Soil Description: GRAY LEAN CLAY TRACE FINE SAND
Remarks: TEST PERFORMED AS PER ASTM D 2166.

Specimen Height: 2.74 in
Specimen Area: 1.59 in^2
Specimen Volume: 4.34 in^3

Liquid Limit: 43
Plastic Limit: 19
Estimated Specific Gravity: 2.72

Cap Mass: 0 gm

	Time min	Axial Displacement in	Axial Strain %	Load lb	Corrected Area in^2	Vertical Stress tsf	Shear Stress tsf
1	0	0	0	0	1.5865	0	0
2	0.25397	0.00073798	0.026951	5.4023	1.5869	0.24511	0.12255
3	0.50397	0.012546	0.45817	9.8604	1.5938	0.44545	0.22272
4	0.75397	0.024353	0.88939	13.165	1.6007	0.59214	0.29607
5	1.004	0.035976	1.3139	15.945	1.6076	0.71411	0.35705
6	1.254	0.047599	1.7384	18.252	1.6146	0.81395	0.40697
7	1.504	0.05913	2.1595	20.35	1.6215	0.90362	0.45181
8	1.754	0.070753	2.584	22.186	1.6286	0.98085	0.49043
9	2.004	0.082377	3.0084	23.759	1.6357	1.0458	0.52292
10	2.504	0.10581	3.8641	26.644	1.6503	1.1625	0.58124
11	3.004	0.1297	4.7367	29.057	1.6654	1.2562	0.62811
12	3.504	0.15359	5.6092	30.945	1.6808	1.3256	0.6628
13	4.004	0.1773	6.475	35.246	1.6963	1.496	0.748
14	4.504	0.20036	7.3173	36.819	1.7117	1.5487	0.77435
15	5.004	0.22351	8.1629	38.235	1.7275	1.5936	0.7968
16	5.504	0.24676	9.0118	39.284	1.7436	1.6222	0.81109
17	6.004	0.27056	9.881	40.176	1.7604	1.6432	0.82158
18	6.504	0.29482	10.767	40.491	1.7779	1.6397	0.81987
19	7.004	0.31844	11.629	40.228	1.7953	1.6134	0.80669
20	7.504	0.34168	12.478	40.491	1.8127	1.6083	0.80415
21	8.004	0.36474	13.321	40.805	1.8303	1.6052	0.8026
22	9.004	0.38781	14.163	41.435	1.8483	1.6141	0.80706
23	9.504	0.41087	15.005	41.592	1.8666	1.6044	0.80218

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UNCONFINED COMPRESSION TEST REPORT

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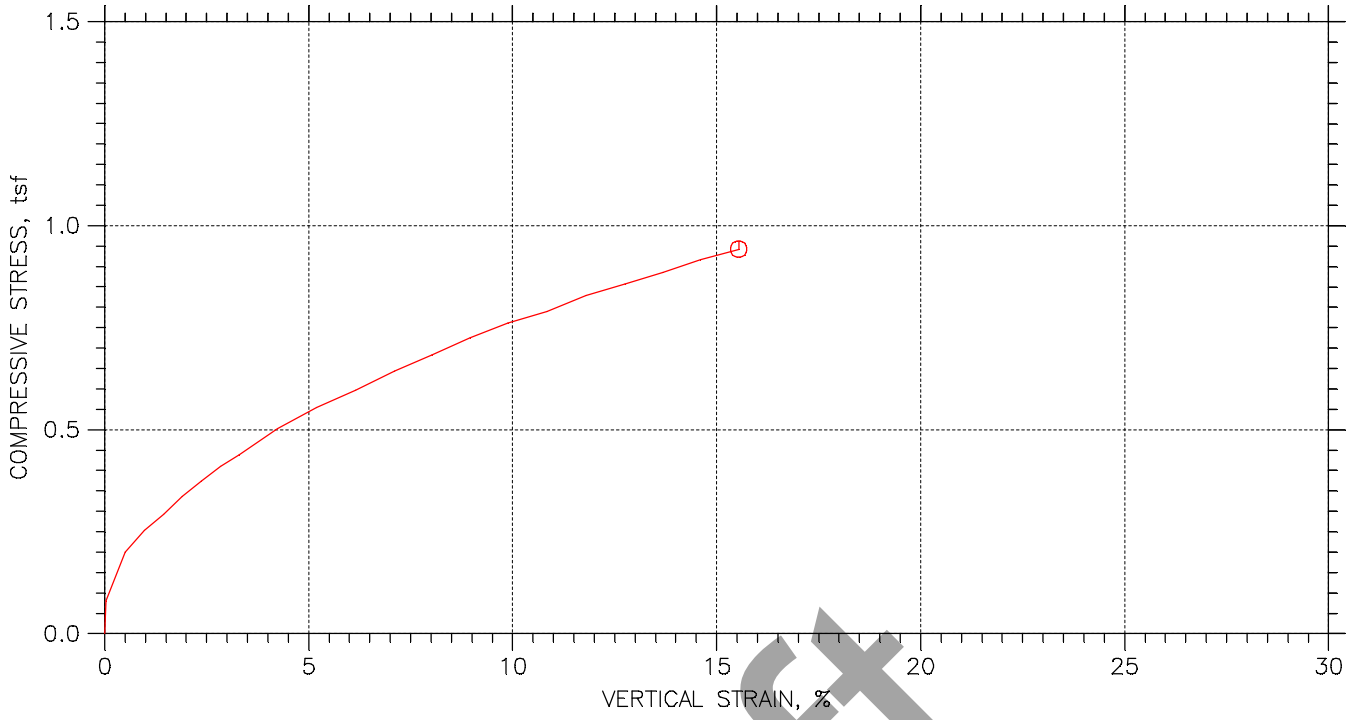

Symbol		⏲			
Test No.		LGC9S11Qu			
Initial	Diameter, in	1.2264			
	Height, in	2.4972			
	Water Content, %	20.90			
	Dry Density, pcf	103.3			
	Saturation, %	88.38			
	Void Ratio	0.6432			
Unconfined Compressive Strength, tsf		0.94234			
Undrained Shear Strength, tsf		0.47117			
Time to Failure, min		8.5039			
Strain Rate, %/min		1.14			
Estimated Specific Gravity		2.72			
Liquid Limit		34			
Plastic Limit		17			
Plasticity Index		17			
Failure Sketch					

Draft

Project: LAKE GEORGE CANAL
Location: EAST CHICAGO, IN
Project No.: MR155106
Boring No.: LGC-9 S-11
Sample Type: 55.0'-56.5'
Description: GRAY LEAN CLAY TRACE FINE SAND
Remarks: TEST PERFORMED AS PER ASTM D 2166.

UNCONFINED COMPRESSION TEST

Project: LAKE GEORGE CANAL
Boring No.: LGC-9 S-11
Sample No.: 11
Test No.: LGC9S11Qu

Location: EAST CHICAGO, IN
Tested By: WPQ
Test Date: 6/30/15
Sample Type: 55.0'-56.5'

Project No.: MR155106
Checked By: BCM
Depth: 55.0'-56.5'
Elevation: -----

Terracon
Consulting Engineers & Scientists

Soil Description: GRAY LEAN CLAY TRACE FINE SAND
Remarks: TEST PERFORMED AS PER ASTM D 2166.

Specimen Height: 2.50 in
Specimen Area: 1.18 in^2
Specimen Volume: 2.95 in^3

Liquid Limit: 34
Plastic Limit: 17
Estimated Specific Gravity: 2.72

Cap Mass: 0 gm

	Time min	Axial Displacement in	Axial Strain %	Load lb	Corrected Area in^2	Vertical Stress tsf	Shear Stress tsf
1	0	0	0	0	1.1812	0	0
2	0.25392	0.00073798	0.029552	1.3112	1.1816	0.079899	0.03995
3	0.50392	0.012546	0.50238	3.3043	1.1872	0.20039	0.1002
4	0.75392	0.024353	0.9752	4.1959	1.1929	0.25326	0.12663
5	1.0039	0.035976	1.4406	4.8778	1.1985	0.29303	0.14652
6	1.2539	0.047599	1.9061	5.6121	1.2042	0.33555	0.16778
7	1.5039	0.05913	2.3678	6.2939	1.2099	0.37455	0.18727
8	1.7539	0.070753	2.8333	6.9233	1.2157	0.41004	0.20502
9	2.0039	0.082377	3.2987	7.4478	1.2215	0.43899	0.21949
10	2.5039	0.10581	4.237	8.6017	1.2335	0.50208	0.25104
11	3.0039	0.1297	5.1937	9.5982	1.246	0.55465	0.27733
12	3.5039	0.15359	6.1504	10.437	1.2587	0.59706	0.29853
13	4.0039	0.1773	7.0998	11.381	1.2715	0.64448	0.32224
14	4.5039	0.20036	8.0233	12.168	1.2843	0.68218	0.34109
15	5.0039	0.22351	8.9504	13.06	1.2974	0.72478	0.36239
16	5.5039	0.24676	9.8813	13.847	1.3108	0.76059	0.3803
17	6.0039	0.27056	10.834	14.528	1.3248	0.7896	0.3948
18	6.5039	0.29464	11.798	15.42	1.3393	0.829	0.4145
19	7.0039	0.31844	12.752	16.102	1.3539	0.8563	0.42815
20	7.5039	0.34168	13.682	16.836	1.3685	0.8858	0.4429
21	8.0039	0.36474	14.606	17.623	1.3833	0.91727	0.45864
22	8.5039	0.38808	15.54	18.305	1.3986	0.94234	0.47117

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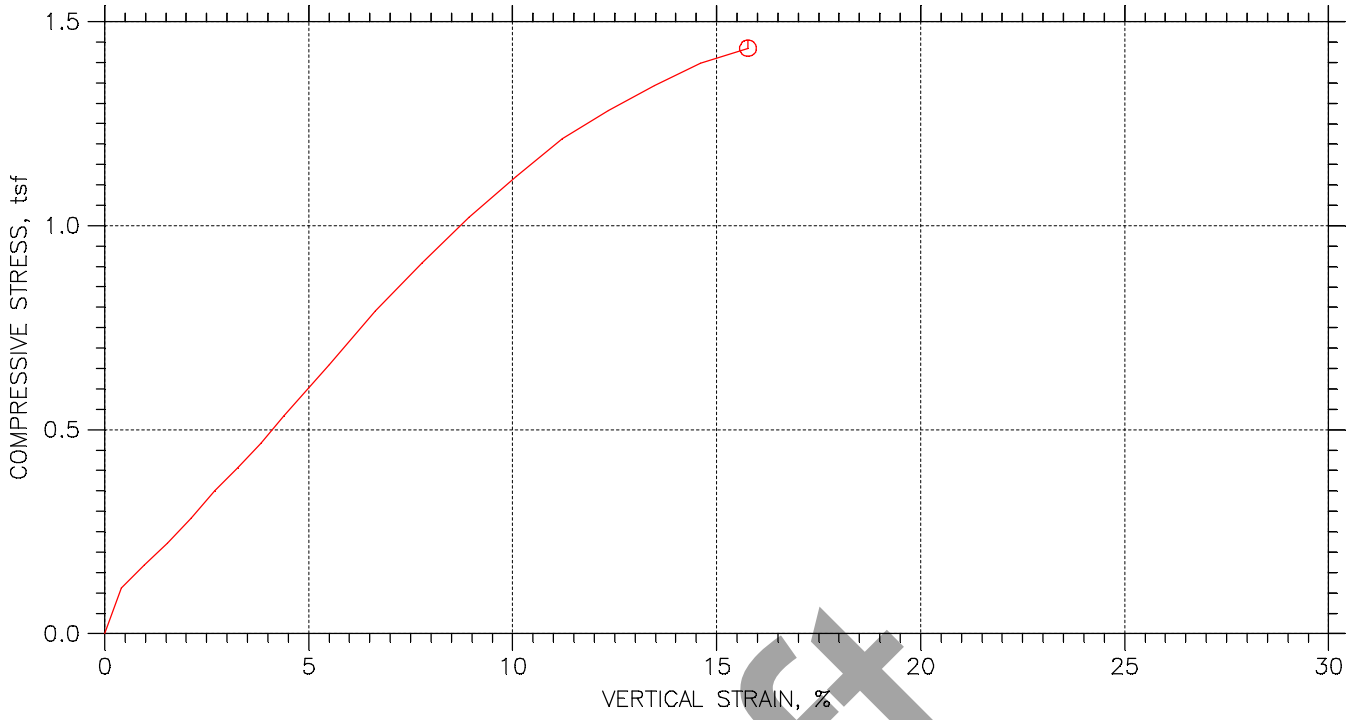
UNCONFINED COMPRESSION TEST REPORT

Terracon
Consulting Engineers & Scientists



Symbol		⏲			
Test No.		LGC11S8Qu			
Initial	Diameter, in	1.4472			
	Height, in	2.0669			
	Water Content, %	19.52			
	Dry Density, pcf	105.9			
	Saturation, %	88.01			
	Void Ratio	0.60325			
Unconfined Compressive Strength, tsf		1.4348			
Undrained Shear Strength, tsf		0.71738			
Time to Failure, min		7.004			
Strain Rate, %/min		1.14			
Estimated Specific Gravity		2.72			
Liquid Limit		33			
Plastic Limit		16			
Plasticity Index		17			
Failure Sketch					

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Project: LAKE GEORGE CANAL
Location: EAST CHICAGO, IN
Project No.: MR155106
Boring No.: LGC-11 S-8
Sample Type: 40.0'-41.5'
Description: GRAY LEAN CLAY TRACE FINE SAND
Remarks: TEST PERFORMED AS PER ASTM D 2166.

UNCONFINED COMPRESSION TEST

Project: LAKE GEORGE CANAL
Boring No.: LGC-11 S-8
Sample No.: 8
Test No.: LGC11S8Qu

Location: EAST CHICAGO, IN
Tested By: WPQ
Test Date: 6/30/15
Sample Type: 40.0'-41.5'

Project No.: MR155106
Checked By: BCM
Depth: 40.0'-41.5'
Elevation: -----

Terracon Consulting Engineers & Scientists

Soil Description: GRAY LEAN CLAY TRACE FINE SAND
Remarks: TEST PERFORMED AS PER ASTM D 2166.

Specimen Height: 2.07 in
Specimen Area: 1.65 in^2
Specimen Volume: 3.40 in^3

Liquid Limit: 33
Plastic Limit: 16
Estimated Specific Gravity: 2.72

Cap Mass: 0 gm

	Time min	Axial Displacement in	Axial Strain %	Load lb	Corrected Area in^2	Vertical Stress tsf	Shear Stress tsf
1	0	0	0	0	1.645	0	0
2	0.25395	0.0083945	0.40613	2.57	1.6517	0.11203	0.056014
3	0.50395	0.020202	0.9774	3.8812	1.6613	0.16821	0.084107
4	0.75395	0.031917	1.5442	5.14	1.6708	0.2215	0.11075
5	1.004	0.04391	2.1244	6.6086	1.6807	0.2831	0.14155
6	1.254	0.055717	2.6957	8.2345	1.6906	0.35069	0.17535
7	1.504	0.067433	3.2625	9.5982	1.7005	0.40639	0.2032
8	1.754	0.079056	3.8248	11.067	1.7104	0.46585	0.23292
9	2.004	0.090679	4.3871	12.745	1.7205	0.53336	0.26668
10	2.504	0.11374	5.5029	15.945	1.7408	0.65946	0.32973
11	3.004	0.13717	6.6365	19.354	1.762	0.79086	0.39543
12	3.504	0.16079	7.779	22.501	1.7838	0.90821	0.4541
13	4.004	0.18459	8.9305	25.595	1.8063	1.0202	0.51011
14	4.504	0.20839	10.082	28.48	1.8295	1.1208	0.56042
15	5.004	0.23191	11.22	31.207	1.8529	1.2126	0.60632
16	5.504	0.25516	12.345	33.41	1.8767	1.2818	0.64089
17	6.004	0.27849	13.474	35.456	1.9012	1.3427	0.67137
18	6.504	0.30202	14.612	37.396	1.9265	1.3976	0.6988
19	7.004	0.32591	15.768	38.917	1.953	1.4348	0.71738

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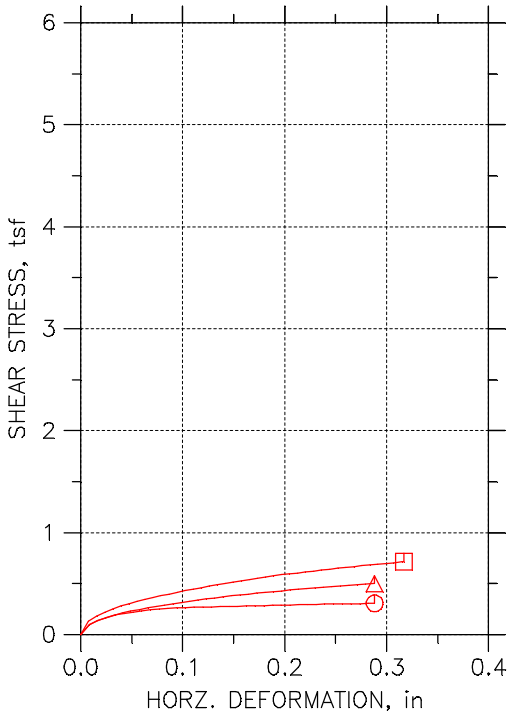
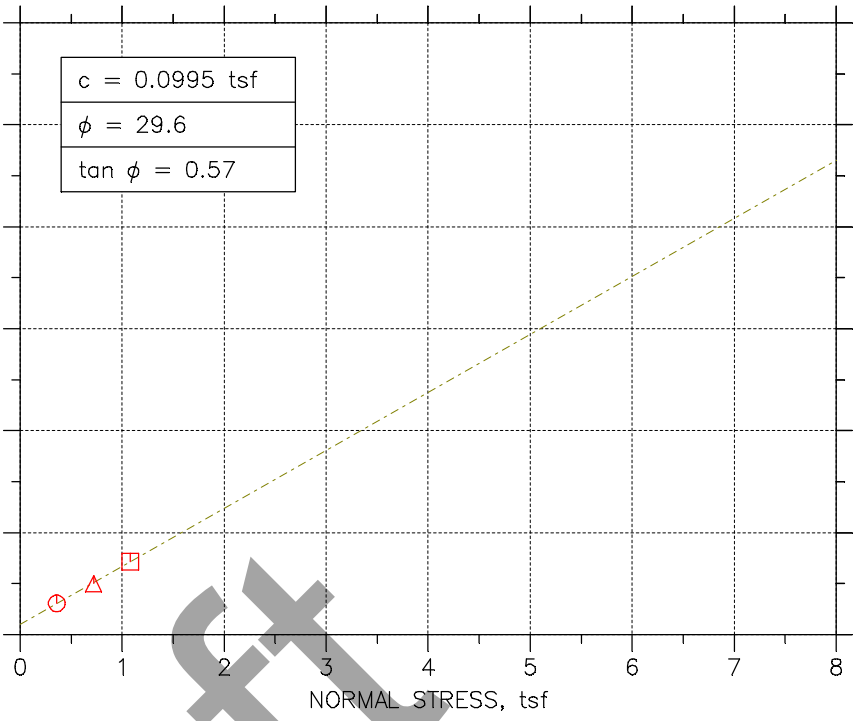
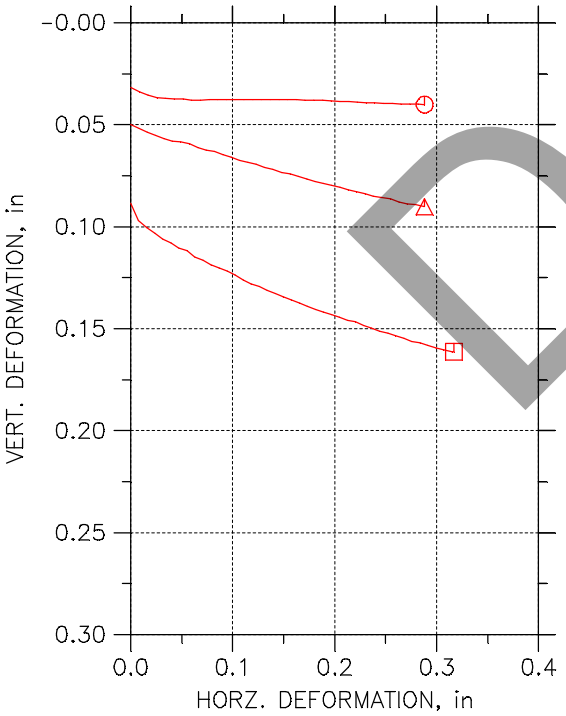
DIRECT SHEAR TEST REPORT







Symbol		○	△	□	
Test No.		5 PSI	10 PSI	15 PSI	
Sample No.		S-7-9	S-7-9	S-7-9	
Shape		Circular	Circular	Circular	
Initial	Dimension, in	2.5031	2.5055	2.4976	
	Area, in^2	4.9211	4.9304	4.8995	
	Height, in	0.98937	0.98465	0.99567	
	Water Content, %	22.33	22.10	22.50	
	Dry Density, pcf	104.41	105	103.62	
	Saturation, %	95.86	96.27	94.75	
	Void Ratio	0.63823	0.62906	0.6507	
Consol. Height, in		0.95785	0.93617	0.91075	
Consol. Void Ratio		0.58604	0.54885	0.50992	
Final	Water Content, %	20.50	16.90	14.00	
	Dry Density, pcf	108.83	115.59	123.67	
	Saturation, %	98.24	96.51	100.12	
	Void Ratio	0.57174	0.47981	0.38314	
Normal Stress, tsf		0.35883	0.71867	1.0796	
Max. Shear Stress, tsf		0.30724	0.50038	0.71695	
Ult. Shear Stress, tsf		0.30724	0.50038	0.71695	
Time to Failure, min		980.58	336.25	3700.2	
Disp. Rate, in/min		0.000277	0.000834	8.77e-005	
Estimated Specific Gravity		2.74	2.74	2.74	
Liquid Limit		---	---	---	
Plastic Limit		---	---	---	
Plasticity Index		---	---	---	

Project: LAKE GEORGE	
Location: LAKE GEORGE, NY	
Project No.: MR155106	
Boring No.: LGC-9 S-7-9	
Sample Type: REMOLDED	
Description: GRAY LEAN CLAY TRACE FINE SAND CL	
Remarks: TEST PERFORMED AS PER ASTM D3080 SPECIMENS RECONSTITUTED TO AVERAGE AS RECEIVED DENSITY AND WC	

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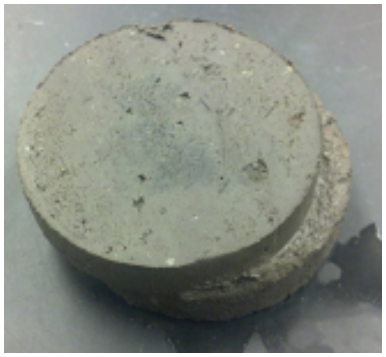
DIRECT SHEAR TEST DATA

Project: LAKE GEORGE
Boring No.: LGC-9 S-7-9
Sample No.: S-7-9
Test No.: 5 PSI

Location: LAKE GEORGE, NY
Tested By: WPQ
Test Date: 6/26/15
Sample Type: REMOLDED

Project No.: MR155106
Checked By: BCM
Depth: 35.0'-46.5'
Elevation: ----

Soil Description: GRAY LEAN CLAY TRACE FINE SAND CL
Remarks: TEST PERFORMED AS PER ASTM D3080 SPECIMENS RECONSTITUTED TO AVERAGE AS RECEIVED DENSITY AND WC



	Elapsed Time min	Vertical Stress tsf	Vertical Displacement in	Horizontal Stress tsf	Horizontal Displacement in
1	0.00	0.358	0.03184	0	0
2	54.13	0.358	0.03392	0.1024	0.008548
3	84.32	0.3588	0.03562	0.1398	0.0171
4	113.69	0.3588	0.03675	0.168	0.02564
5	143.00	0.3588	0.037	0.1918	0.03419
6	171.07	0.3588	0.03732	0.2088	0.04274
7	198.35	0.358	0.03751	0.2229	0.05129
8	225.64	0.3588	0.03789	0.2354	0.05983
9	254.44	0.3588	0.03789	0.2456	0.06838
10	282.88	0.3588	0.03782	0.2535	0.07693
11	310.57	0.3588	0.03782	0.2586	0.08548
12	339.08	0.3588	0.0377	0.2614	0.09403
13	368.77	0.3588	0.0377	0.2659	0.1026
14	396.65	0.3588	0.03776	0.2682	0.1111
15	423.51	0.3588	0.03776	0.2699	0.1197
16	451.40	0.3588	0.03776	0.2722	0.1282
17	479.72	0.3588	0.0377	0.2744	0.1368
18	509.08	0.3588	0.0377	0.2761	0.1453
19	535.55	0.3588	0.03776	0.2784	0.1539
20	563.87	0.3588	0.03782	0.2801	0.1624
21	592.29	0.3588	0.03795	0.2823	0.171
22	623.21	0.3588	0.03808	0.284	0.1795
23	650.86	0.3588	0.03814	0.2869	0.1881
24	678.02	0.3588	0.03839	0.2886	0.1966
25	703.41	0.3588	0.03852	0.2903	0.2051
26	734.29	0.3596	0.03852	0.2931	0.2137
27	762.26	0.3588	0.0389	0.2948	0.2222
28	789.74	0.3588	0.03921	0.2965	0.2307
29	819.72	0.3588	0.03921	0.2993	0.2393
30	848.72	0.3588	0.03959	0.301	0.2478
31	876.28	0.3588	0.03959	0.3033	0.2564
32	901.70	0.3588	0.03978	0.3033	0.2649
33	932.32	0.3588	0.04003	0.3044	0.2735
34	961.11	0.3588	0.03997	0.3067	0.282
35	980.58	0.3588	0.04016	0.3072	0.2882

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DIRECT SHEAR TEST DATA

Project: LAKE GEORGE
Boring No.: LGC-9
Sample No.: S-7-9
Test No.: 10 PSI

Location: LAKE GEORGE, NY
Tested By: WPQ
Test Date: 6/26/15
Sample Type: REMOLDED

Project No.: MR155106
Checked By: BCM
Depth: 35.0'-46.5'
Elevation: ----

Soil Description: GRAY LEAN CLAY TRACE FINE SAND CL
Remarks: TEST PERFORMED AS PER ASTM D3080 SPECIMENS RECONSTITUTED TO AVERAGE AS RECEIVED DENSITY AND WC

	Elapsed Time min	Vertical Stress tsf	Vertical Displacement in	Horizontal Stress tsf	Horizontal Displacement in
1	0.00	0.7195	0.0498	0	0
2	15.44	0.7187	0.05188	0.09488	0.008212
3	25.30	0.7187	0.05377	0.1355	0.01642
4	34.55	0.7187	0.05516	0.1627	0.02464
5	44.24	0.7187	0.05686	0.1892	0.03285
6	53.82	0.7187	0.05812	0.2107	0.04106
7	63.27	0.7187	0.05844	0.2299	0.04927
8	72.21	0.7187	0.05945	0.2451	0.05748
9	81.60	0.7187	0.06121	0.2615	0.06569
10	91.09	0.7195	0.06247	0.2756	0.07391
11	100.65	0.7187	0.06317	0.2903	0.08212
12	110.12	0.7187	0.06481	0.3033	0.09033
13	120.36	0.7187	0.06607	0.3168	0.09854
14	129.12	0.7187	0.06739	0.3276	0.1068
15	138.79	0.7187	0.06852	0.34	0.115
16	147.75	0.7187	0.06953	0.3496	0.1232
17	157.54	0.7187	0.07098	0.3603	0.1314
18	167.15	0.7187	0.07206	0.3705	0.1396
19	176.96	0.7187	0.07351	0.3806	0.1478
20	185.50	0.7187	0.07407	0.3886	0.156
21	194.96	0.7187	0.07527	0.397	0.1642
22	204.87	0.7179	0.07659	0.4061	0.1724
23	213.83	0.7187	0.07773	0.4134	0.1807
24	223.15	0.7187	0.07874	0.4213	0.1889
25	233.43	0.7187	0.07981	0.4292	0.1971
26	242.68	0.7187	0.08082	0.4371	0.2053
27	251.50	0.7187	0.08189	0.445	0.2135
28	260.75	0.7187	0.0829	0.4529	0.2217
29	271.25	0.7195	0.08391	0.4603	0.2299
30	279.90	0.7187	0.0851	0.4659	0.2381
31	288.58	0.7195	0.0858	0.4716	0.2463
32	299.30	0.7187	0.08643	0.4778	0.2545
33	308.32	0.7195	0.08775	0.4834	0.2627
34	317.12	0.7187	0.08876	0.4891	0.2709
35	326.80	0.7187	0.08927	0.4936	0.2792
36	335.32	0.7187	0.09015	0.4992	0.2874
37	336.25	0.7187	0.09021	0.5004	0.288

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DIRECT SHEAR TEST DATA

Project: LAKE GEORGE
Boring No.: LGC-9
Sample No.: S-7-9
Test No.: 15 PSI

Location: LAKE GEORGE, NY
Tested By: WPQ
Test Date: 6/26/15
Sample Type: REMOLDED

Project No.: MR155106
Checked By: BCM
Depth: 35.0'-46.5'
Elevation: ----

Soil Description: GRAY LEAN CLAY TRACE FINE SAND CL
Remarks: TEST PERFORMED AS PER ASTM D3080 SPECIMENS RECONSTITUTED TO AVERAGE AS RECEIVED DENSITY AND WC

	Elapsed Time min	Vertical Stress tsf	Vertical Displacement in	Horizontal Stress tsf	Horizontal Displacement in
1	0.00	1.079	0.08863	0	0
2	200.69	1.079	0.09702	0.1326	0.007876
3	288.88	1.08	0.1005	0.1815	0.01575
4	381.76	1.08	0.1031	0.2203	0.02363
5	472.43	1.079	0.1061	0.2512	0.0315
6	565.06	1.08	0.1079	0.2821	0.03938
7	655.38	1.08	0.1104	0.3045	0.04725
8	740.44	1.08	0.1119	0.3242	0.05513
9	836.44	1.08	0.1149	0.345	0.06301
10	925.75	1.079	0.1164	0.3647	0.07088
11	1011.75	1.08	0.1185	0.3826	0.07876
12	1105.72	1.079	0.1202	0.3961	0.08663
13	1196.42	1.079	0.1219	0.4124	0.09451
14	1285.86	1.08	0.1238	0.4304	0.1024
15	1369.40	1.08	0.1263	0.4456	0.1103
16	1455.42	1.08	0.1282	0.4613	0.1181
17	1542.32	1.08	0.1294	0.4748	0.126
18	1627.15	1.079	0.1311	0.4877	0.1339
19	1723.28	1.079	0.1329	0.5023	0.1418
20	1817.29	1.079	0.1344	0.5169	0.1496
21	1902.92	1.08	0.1358	0.5287	0.1575
22	1989.09	1.08	0.1376	0.5416	0.1654
23	2081.04	1.08	0.1392	0.5546	0.1733
24	2169.35	1.08	0.1405	0.5658	0.1811
25	2259.00	1.08	0.1419	0.5759	0.189
26	2350.60	1.08	0.143	0.5883	0.1969
27	2437.92	1.08	0.1444	0.5961	0.2048
28	2527.20	1.08	0.146	0.6046	0.2126
29	2618.74	1.08	0.1466	0.6141	0.2205
30	2707.43	1.08	0.1486	0.6226	0.2284
31	2788.73	1.08	0.1497	0.6321	0.2362
32	2879.43	1.08	0.1512	0.6405	0.2441
33	2977.61	1.079	0.1523	0.6512	0.252
34	3061.00	1.08	0.1536	0.658	0.2599
35	3145.98	1.08	0.1547	0.6664	0.2677
36	3240.15	1.08	0.1562	0.6754	0.2756
37	3326.97	1.08	0.1569	0.6816	0.2835
38	3415.19	1.08	0.1583	0.6894	0.2914
39	3496.87	1.08	0.1594	0.695	0.2992
40	3594.11	1.08	0.1602	0.704	0.3071
41	3678.33	1.08	0.1612	0.713	0.315
42	3700.24	1.08	0.1614	0.717	0.3169

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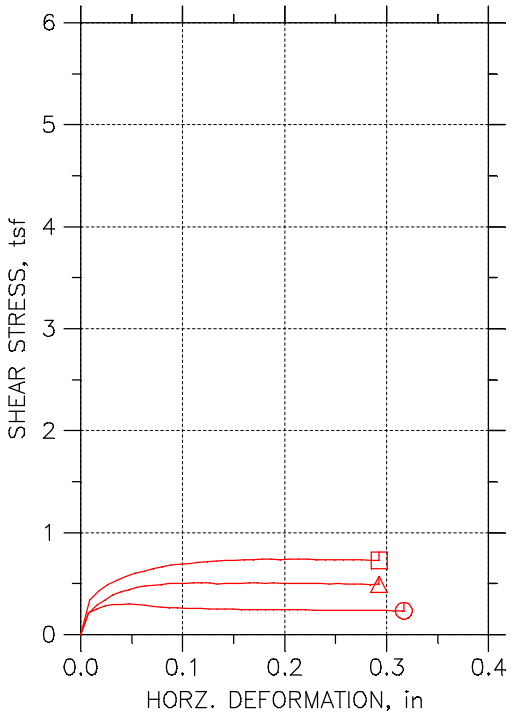
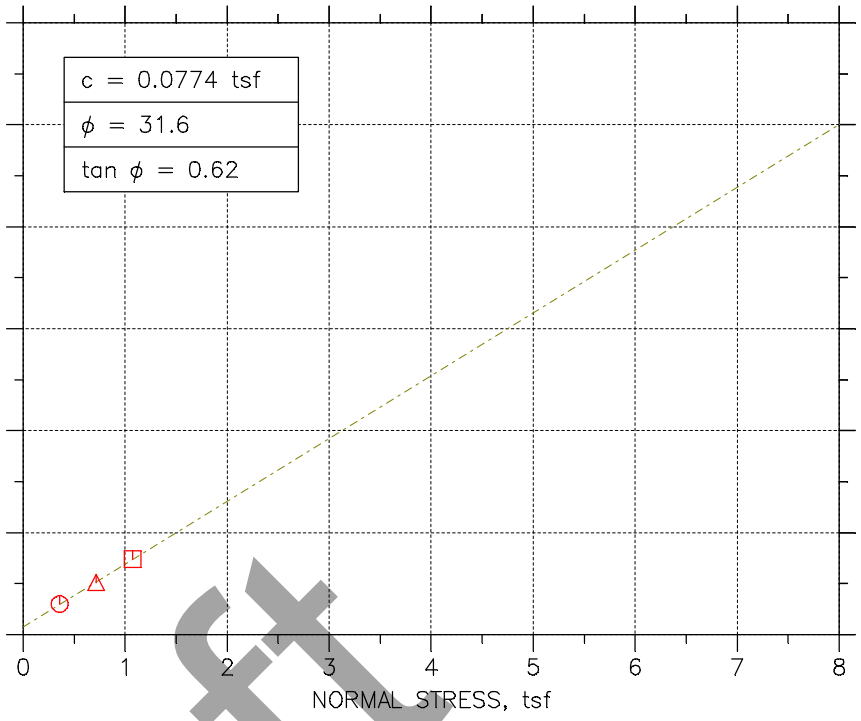
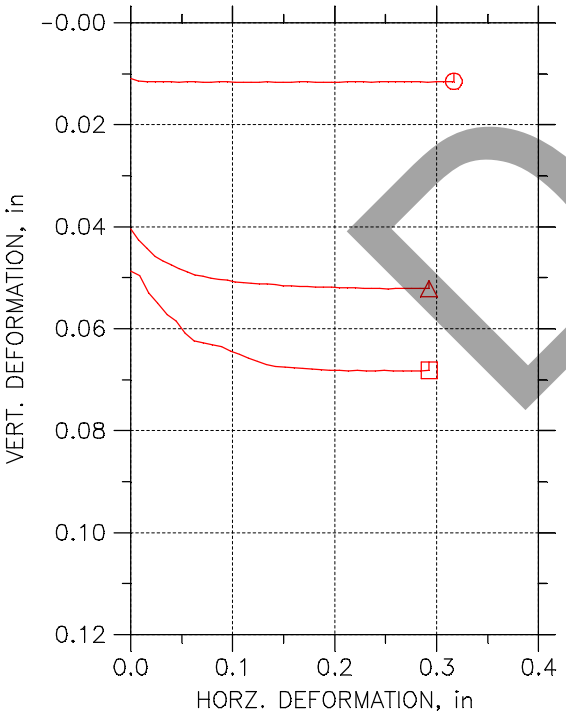
DIRECT SHEAR TEST REPORT







Symbol		⏲	△	⊡	
Test No.		5 PSI	10 PSI	15 PSI	
Sample No.		S-5-9	S-5-9	S-5-9	
Shape		Circular	Circular	Circular	
Initial	Dimension, in	2.511	2.5079	2.5071	
	Area, in^2	4.9521	4.9397	4.9366	
	Height, in	1.1457	1.1496	1.1524	
	Water Content, %	17.90	17.50	17.60	
	Dry Density, pcf	113.96	114.27	114.02	
	Saturation, %	99.36	97.96	97.87	
	Void Ratio	0.49001	0.48596	0.48919	
Consol. Height, in		1.1351	1.1104	1.106	
Consol. Void Ratio		0.47627	0.43522	0.42931	
Final	Water Content, %	17.50	15.10	14.80	
	Dry Density, pcf	115.12	119.7	121.2	
	Saturation, %	100.21	98.13	100.37	
	Void Ratio	0.47502	0.41853	0.40107	
Normal Stress, tsf		0.35815	0.71416	1.0739	
Max. Shear Stress, tsf		0.30044	0.51143	0.74082	
Ult. Shear Stress, tsf		0.23411	0.49317	0.72714	
Time to Failure, min		62.184	433.84	291.21	
Disp. Rate, in/min		0.00085	0.000277	0.000719	
Estimated Specific Gravity		2.72	2.72	2.72	
Liquid Limit		36	36	36	
Plastic Limit		16	16	16	
Plasticity Index		20	20	20	

Project: LAKE GEORGE	
Location: LAKE GEORGE, NY	
Project No.: MR155106	
Boring No.: LGC10 S 5-8	
Sample Type: REMOLDED	
Description: GRAY LEAN CLAY TRACE F-C SAND CL	
Remarks: TEST PERFORMED AS PER ASTM D3080 SPECIMENS RECONSTITUTED TO AVERAGE AS RECEIVED DENSITY AND WC	

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Wed, 08-JUL-2015 13:20:54

DIRECT SHEAR TEST DATA

Project: LAKE GEORGE
Boring No.: LGC10 S 5-8
Sample No.: S-5-9
Test No.: 5 PSI

Location: LAKE GEORGE, NY
Tested By: WPQ
Test Date: 6/26/15
Sample Type: REMOLDED

Project No.: MR155106
Checked By: BCM
Depth: 25.0'-41.5'
Elevation: ----

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Consulting Engineers & Scientists

Soil Description: GRAY LEAN CLAY TRACE F-C SAND CL
Remarks: TEST PERFORMED AS PER ASTM D3080 SPECIMENS RECONSTITUTED TO AVERAGE AS RECEIVED DENSITY AND WC

	Elapsed Time min	Vertical Stress tsf	Vertical Displacement in	Horizontal Stress tsf	Horizontal Displacement in
1	0.00	0.3574	0.01098	0	0
2	16.29	0.3566	0.01146	0.213	0.007876
3	25.27	0.3574	0.01153	0.2536	0.01575
4	34.92	0.3574	0.01153	0.2802	0.02363
5	43.88	0.3574	0.01153	0.2926	0.0315
6	53.32	0.3574	0.0116	0.2981	0.03938
7	62.18	0.3582	0.01174	0.3004	0.04725
8	70.76	0.3566	0.0116	0.2965	0.05513
9	80.36	0.3574	0.0116	0.288	0.06301
10	90.64	0.3574	0.01174	0.2786	0.07088
11	98.64	0.3574	0.01167	0.2731	0.07876
12	108.71	0.3574	0.0116	0.2669	0.08663
13	118.06	0.3574	0.0116	0.263	0.09451
14	126.85	0.3574	0.01167	0.2599	0.1024
15	136.57	0.3574	0.01167	0.2567	0.1103
16	144.54	0.3574	0.01167	0.2552	0.1181
17	154.74	0.3574	0.01167	0.2544	0.126
18	163.81	0.3582	0.0116	0.2528	0.1339
19	172.76	0.3574	0.01167	0.2513	0.1418
20	182.38	0.3574	0.01174	0.2489	0.1496
21	191.54	0.3574	0.01167	0.2482	0.1575
22	201.17	0.3582	0.0116	0.2474	0.1654
23	209.40	0.3574	0.0116	0.2458	0.1733
24	218.94	0.3574	0.01167	0.245	0.1811
25	227.83	0.3574	0.01174	0.2458	0.189
26	237.89	0.3574	0.01167	0.2443	0.1969
27	246.46	0.3582	0.01167	0.2435	0.2048
28	255.35	0.3574	0.0116	0.2435	0.2126
29	264.56	0.3582	0.0116	0.2427	0.2205
30	274.27	0.3574	0.0116	0.2404	0.2284
31	283.31	0.3574	0.01167	0.2411	0.2362
32	292.39	0.3574	0.0116	0.2404	0.2441
33	301.73	0.3574	0.0116	0.2404	0.252
34	310.98	0.3574	0.0116	0.2388	0.2599
35	319.41	0.3582	0.0116	0.2388	0.2677
36	329.85	0.3574	0.0116	0.238	0.2756
37	338.15	0.3574	0.0116	0.238	0.2835
38	347.88	0.3574	0.01167	0.2372	0.2914
39	356.01	0.3566	0.0116	0.2365	0.2992
40	366.31	0.3574	0.0116	0.2357	0.3071
41	374.78	0.3574	0.01153	0.2341	0.315
42	377.63	0.3574	0.01153	0.2341	0.3168

Draft

DIRECT SHEAR TEST DATA

Project: LAKE GEORGE
Boring No.: LGC10 S 5-8
Sample No.: S-5-9
Test No.: 10 PSI

Location: LAKE GEORGE, NY
Tested By: WPQ
Test Date: 6/26/15
Sample Type: REMOLDED

Project No.: MR155106
Checked By: BCM
Depth: 25.0'-41.5'
Elevation: ----

Soil Description: GRAY LEAN CLAY TRACE F-C SAND CL
Remarks: TEST PERFORMED AS PER ASTM D3080 SPECIMENS RECONSTITUTED TO AVERAGE AS RECEIVED DENSITY AND WC

	Elapsed Time min	Vertical Stress tsf	Vertical Displacement in	Horizontal Stress tsf	Horizontal Displacement in
1	0.00	0.7142	0.04048	0	0
2	33.21	0.7142	0.04261	0.207	0.007876
3	62.42	0.7149	0.04417	0.2862	0.01575
4	91.65	0.7142	0.04583	0.3383	0.02363
5	120.42	0.7149	0.04668	0.3871	0.0315
6	150.75	0.7142	0.04743	0.4184	0.03938
7	179.10	0.7149	0.04824	0.4375	0.04725
8	206.39	0.7149	0.0489	0.4627	0.05513
9	234.28	0.7149	0.04952	0.4749	0.06301
10	263.09	0.7149	0.04975	0.4853	0.07088
11	291.00	0.7149	0.05008	0.4914	0.07876
12	322.18	0.7149	0.05032	0.501	0.08663
13	346.89	0.7149	0.05051	0.4993	0.09451
14	374.66	0.7149	0.05079	0.5001	0.1024
15	405.87	0.7149	0.05103	0.508	0.1103
16	433.84	0.7142	0.05112	0.5114	0.1181
17	461.10	0.7149	0.05117	0.5097	0.126
18	488.01	0.7149	0.05126	0.4966	0.1339
19	516.09	0.7149	0.05141	0.5019	0.1418
20	546.01	0.7149	0.05155	0.5019	0.1496
21	573.06	0.7149	0.05164	0.5045	0.1575
22	602.51	0.7149	0.05169	0.5088	0.1654
23	630.77	0.7149	0.05174	0.5071	0.1733
24	658.16	0.7157	0.05188	0.5053	0.1811
25	684.66	0.7149	0.05188	0.508	0.189
26	716.05	0.7149	0.05188	0.5045	0.1969
27	743.14	0.7149	0.05202	0.5053	0.2048
28	770.32	0.7149	0.05202	0.5036	0.2126
29	800.73	0.7142	0.05202	0.5019	0.2205
30	827.79	0.7149	0.05207	0.5027	0.2284
31	855.32	0.7149	0.05207	0.4993	0.2362
32	882.22	0.7149	0.05212	0.4975	0.2441
33	910.37	0.7149	0.05221	0.5001	0.252
34	941.66	0.7149	0.05216	0.4975	0.2599
35	967.72	0.7149	0.05216	0.4984	0.2677
36	998.91	0.7149	0.05216	0.4958	0.2756
37	1027.01	0.7149	0.05216	0.4871	0.2835
38	1053.74	0.7149	0.05216	0.4932	0.2914
39	1056.38	0.7149	0.05216	0.4932	0.2924

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DIRECT SHEAR TEST DATA

Project: LAKE GEORGE
Boring No.: LGC10 S 5-8
Sample No.: S-5-9
Test No.: 15 PSI

Location: LAKE GEORGE, NY
Tested By: WPQ
Test Date: 6/26/15
Sample Type: REMOLDED

Project No.: MR155106
Checked By: BCM
Depth: 25.0'-41.5'
Elevation: ----

Soil Description: GRAY LEAN CLAY TRACE F-C SAND CL
Remarks: TEST PERFORMED AS PER ASTM D3080 SPECIMENS RECONSTITUTED TO AVERAGE AS RECEIVED DENSITY AND WC

	Elapsed Time min	Vertical Stress tsf	Vertical Displacement in	Horizontal Stress tsf	Horizontal Displacement in
1	0.00	1.073	0.04865	0	0
2	38.66	1.072	0.04963	0.3395	0.008884
3	50.28	1.072	0.05292	0.43	0.01777
4	61.20	1.072	0.05502	0.4874	0.02665
5	72.31	1.072	0.05726	0.5356	0.03554
6	83.31	1.072	0.05853	0.5701	0.04442
7	94.52	1.072	0.06085	0.6033	0.0533
8	105.23	1.073	0.06243	0.6242	0.06219
9	115.45	1.072	0.06273	0.6483	0.07107
10	126.78	1.073	0.0631	0.6685	0.07995
11	138.49	1.073	0.06347	0.6841	0.08884
12	148.57	1.073	0.06445	0.6926	0.09772
13	160.11	1.073	0.06497	0.6991	0.1066
14	171.42	1.073	0.06579	0.7082	0.1155
15	182.20	1.072	0.06647	0.7167	0.1244
16	193.25	1.072	0.06699	0.7226	0.1333
17	203.30	1.073	0.06737	0.7271	0.1421
18	214.91	1.073	0.06752	0.7297	0.151
19	225.77	1.073	0.06767	0.7337	0.1599
20	236.42	1.073	0.06774	0.7376	0.1688
21	247.87	1.073	0.06789	0.7382	0.1777
22	258.79	1.073	0.06804	0.7395	0.1866
23	270.09	1.073	0.06811	0.7376	0.1954
24	279.91	1.073	0.06811	0.7395	0.2043
25	291.21	1.074	0.06826	0.7408	0.2132
26	301.58	1.072	0.06819	0.7389	0.2221
27	313.12	1.073	0.06834	0.7376	0.231
28	323.19	1.073	0.06826	0.7356	0.2398
29	334.13	1.073	0.06819	0.735	0.2487
30	344.87	1.073	0.06826	0.7337	0.2576
31	356.47	1.073	0.06826	0.7337	0.2665
32	367.17	1.073	0.06826	0.733	0.2753
33	377.97	1.073	0.06826	0.731	0.2842
34	388.77	1.073	0.06819	0.7271	0.2927

Draft

Attachment C

Test Pit Photographs

Draft

Test Pit 1

Test Pit 2

Draft

Test Pit 3

Test Pit 4

Draft

Test Pit 5

Test Pit 5A

Draft

Test Pit 6

Test Pit 7

Draft

Test Pit 8

Test Pit 9

Draft

Test Pit 10

Test Pit 11

Draft

Test Pit 12

Test Pit 13

Draft

Test Pit 14

Draft

TETRA TECH

Attachment D

Sediment Geotechnical Results

Draft

K&S ENGINEERS, INC.
9715 KENNEDY AVENUE • HIGHLAND, INDIANA 46322
(219) 924-5231 • (773) 734-5900 • FAX (219) 924-5271
www.kandsengineers.com • info@kandsengineers.com

January 22, 2015

File No. 11231

Tetra Tech
1 South Wacker Drive, 37th Floor
Chicago, Illinois 60606

Attn: Mr. James Wescott

RE: Laboratory Testing Results
Composite Material Samples
Grand Calumet River and Indiana Harbor Canal
East Chicago, Indiana

Draft

Dear Mr. Wescott:

Please find the laboratory test results of eleven (11) soil samples delivered to our laboratory from the above mentioned site in East Chicago, Indiana. As requested, grain size analyses with hydrometer (ASTM D 422), Bulk Density (USACE EM 1110-2, Appendix II) and moisture content (ASTM D 2216) tests were performed. Due to non-plastic nature of the materials, Atterberg Limits (ASTM D 4318) tests were not performed. Test results are summarized in the attached table 1 and gradation curves are attached with this report.

We appreciate the opportunity to work with you on this project. If you have any questions or need additional information, please do not hesitate to call us at (219) 924-5231.

Very truly yours,
K & S Engineers, Inc.

Tahir (Tony) Munawar
Project Engineer

Dibakar Sundi, P.E.
Senior Engineer

Attachments:
Table 1-Summary of Laboratory Test Results
Gradation Curves

File No. 11231
Table 1 : Summary of Laboratory Test Results
Grand Calumet River & Indiana Harbor Canal, East Chicago, Indiana

Saple No.	Sample ID & Sample Classification	Moisture Content (As Received) (%)	Grain Size Analysis (ASTM D422)				Bulk Density (lb/cubic-ft)		Atterberg Limits	
			Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Wet	Dry	LL	PL
1	**GCR-1/3-SE-GEO** Poorly Graded Sand with Silt (SP-SM)	38.8	0.2	93.4	5.9	0.5	104.5	75.3	NP*	NP*
2	**GCR-4/7-SE-GEO** Silty Sand (SM)	53.2	0.0	75.2	22.2	2.6	100.4	65.5	NP	NP
3	**GCR-8/11-SE-GEO** Sandy Silt (ML)	117.8	0.0	49.0	48.4	2.6	81.6	37.5	NP	NP
4	**GCR-12/15-SE-GEO** Silty Sand (SM)	66.7	4.8	72.3	18.4	4.1	111.2	66.7	NP	NP
5	**GCR-16/17-SE-GEO** Silt with Sand (ML)	300.2	0.0	27.8	69.3	2.9	69.1	17.3	NP	NP
6	**IHC-1/5-SE-GEO** Silty Sand (SM)	41.9	0.0	85.9	12.5	1.6	102.8	72.4	NP	NP
7	**IHC-6/9-SE-GEO** Silty Sand (SM)	39.5	0.6	85.9	10.1	3.5	108.1	77.5	NP	NP
8	**LGC-1/3-SE-GEO** Silt with Collides (ML)	707.0	0.0	10.1	76.9	13.0	64.3	8.0	NP	NP
9	**LGC-4/7-SE-GEO** Silty Sand (SM)	177.8	0.0	55.1	41.0	3.9	70.8	25.5	NP	NP
10	**LGC-12/14-SE-GEO** Sandy Silt (ML)	123.0	5.3	37.3	56.5	0.9	80.6	36.2	NP	NP
11	**LGC-15/17-SE-GEO** Poorly Graded Sand with Silt and Gravel (SP-SM)	43.2	15.4	77.4	6.5	0.7	104.6	73.1	NP	NP

* NP = Non Plastic

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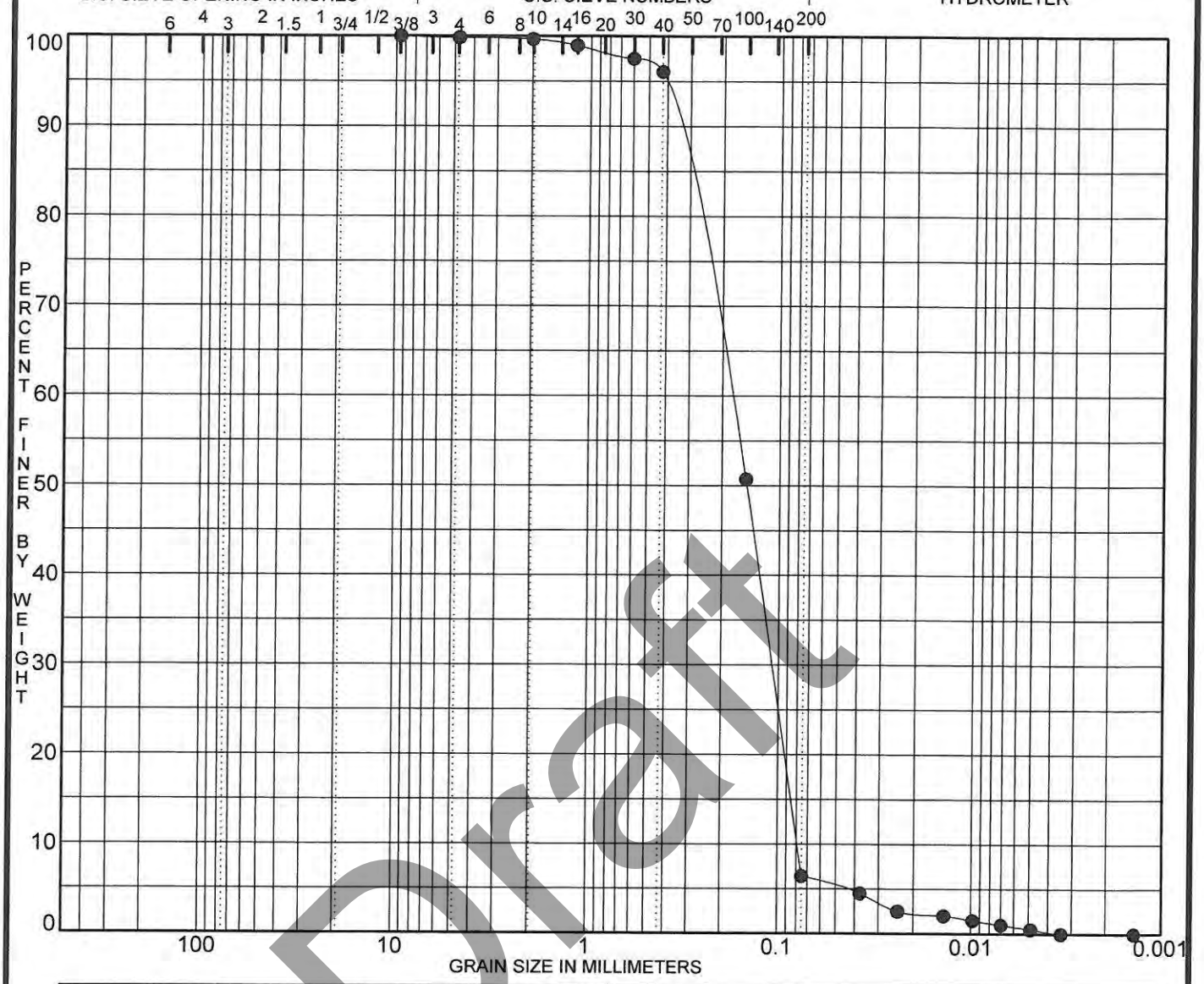

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COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
● **GCR-1/3-SE 0.0**	**POORLY GRADED SAND with SILT SP-SM**		**NP**	**NP**	**NP**	**0.80**	**2.3**

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **GCR-1/3-SE 0.0**	**9.50**	**0.19**	**0.108**	**0.0793**	**0.2**	**93.4**	**5.9**	**0.5**

PROJECT **Grand Calumet River and Burns Harbor - East Chicago, IN**

DES. NO.

PROJ. NO.

JOB NO. **11231**

DATE **1/19/15**

GRADATION CURVES

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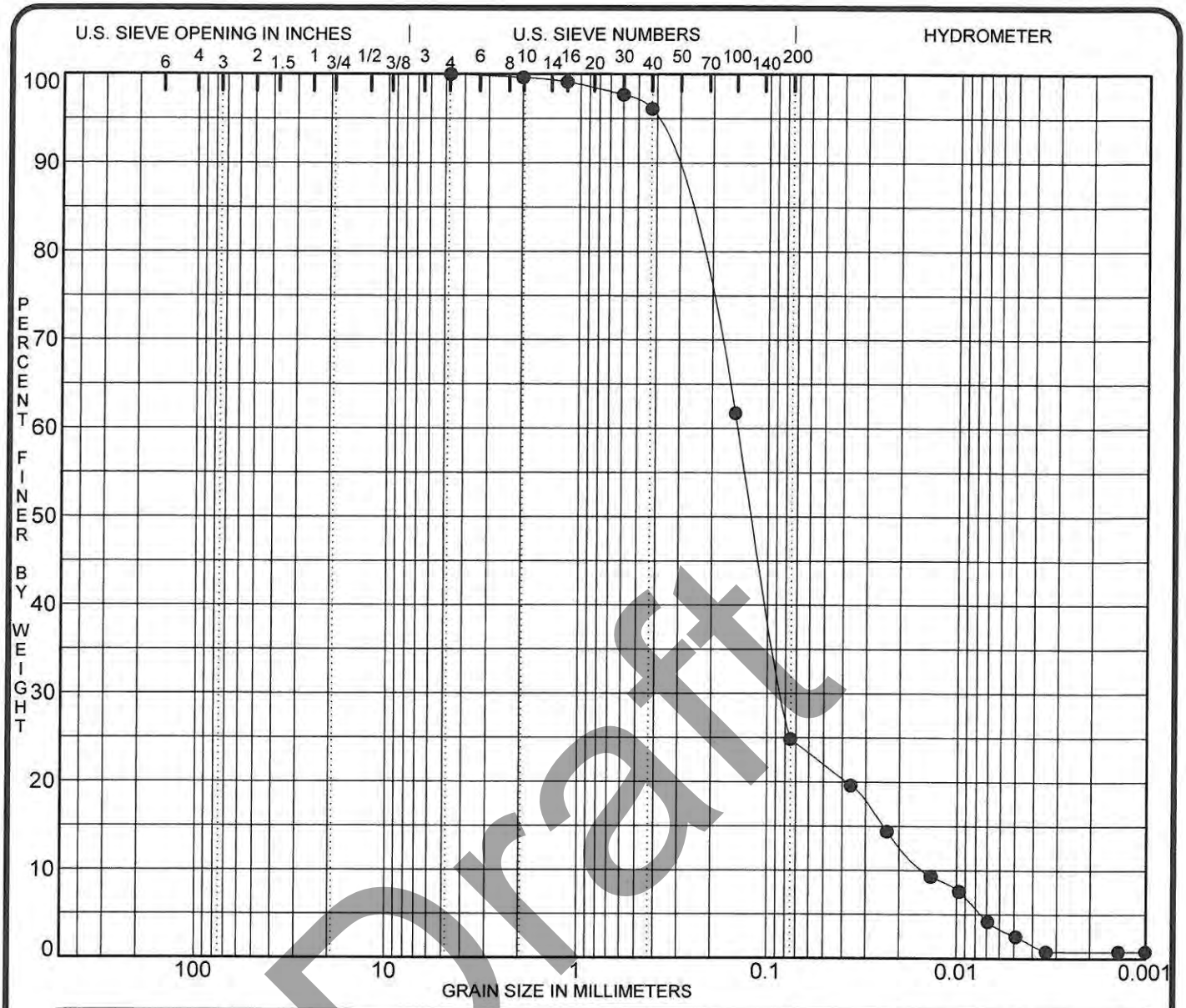

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COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
● GCR-4/7-SE 0.0	SILTY SAND SM		NP	NP	NP	3.21	9.9

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● GCR-4/7-SE 0.0	4.75	0.15	0.083	0.0146	0.0	75.2	22.2	2.6

PROJECT **Grand Calumet River and Burns Harbor - East Chicago, IN**
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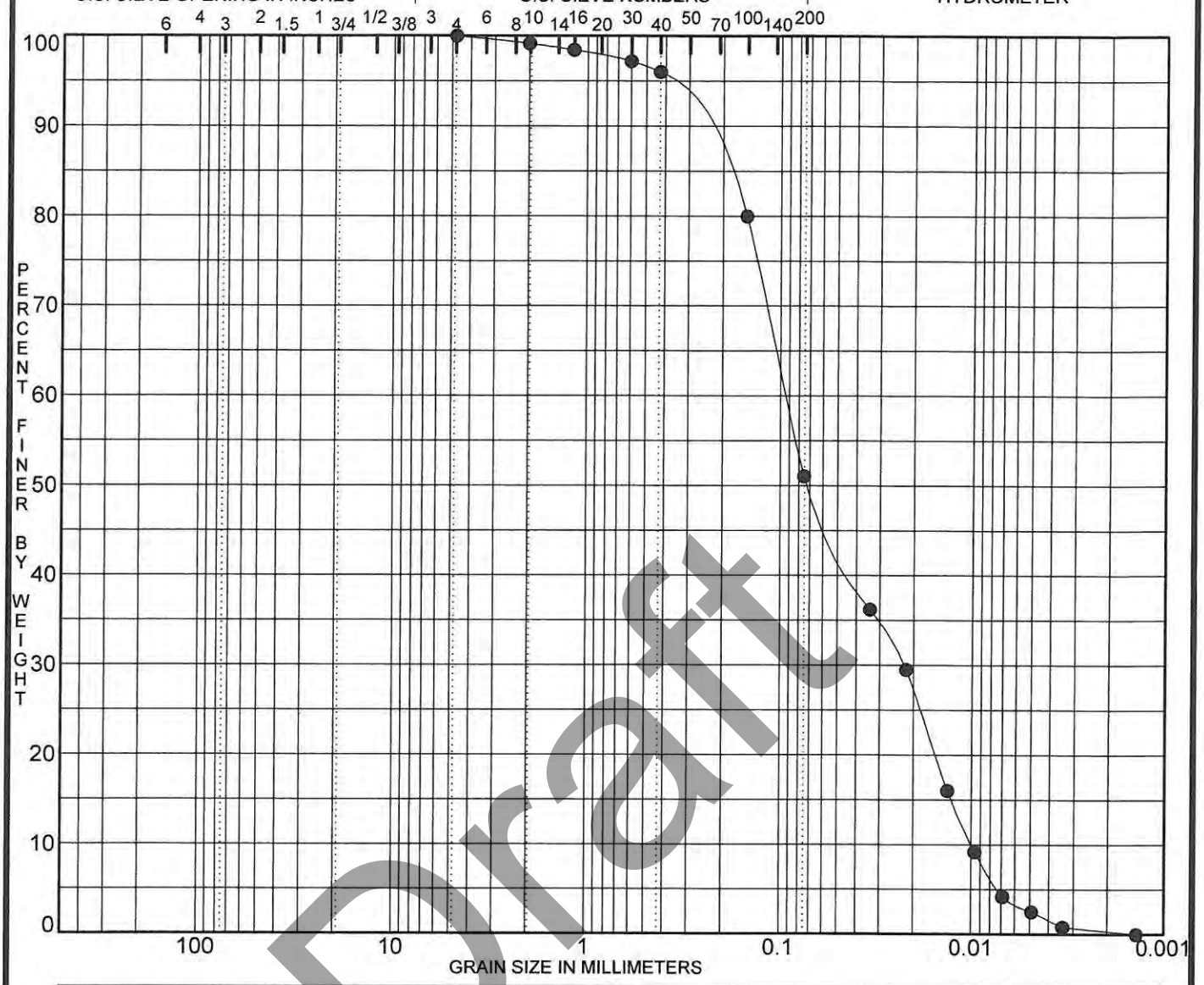

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COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
●	**GCR-8/11-SE 0.0**	**SANDY SILT ML**		**NP**	**NP**	**NP**	**0.55**	**9.3**

	Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**GCR-8/11-SE 0.0**	**4.75**	**0.09**	**0.023**	**0.0100**	**0.0**	**49.0**	**48.4**	**2.6**

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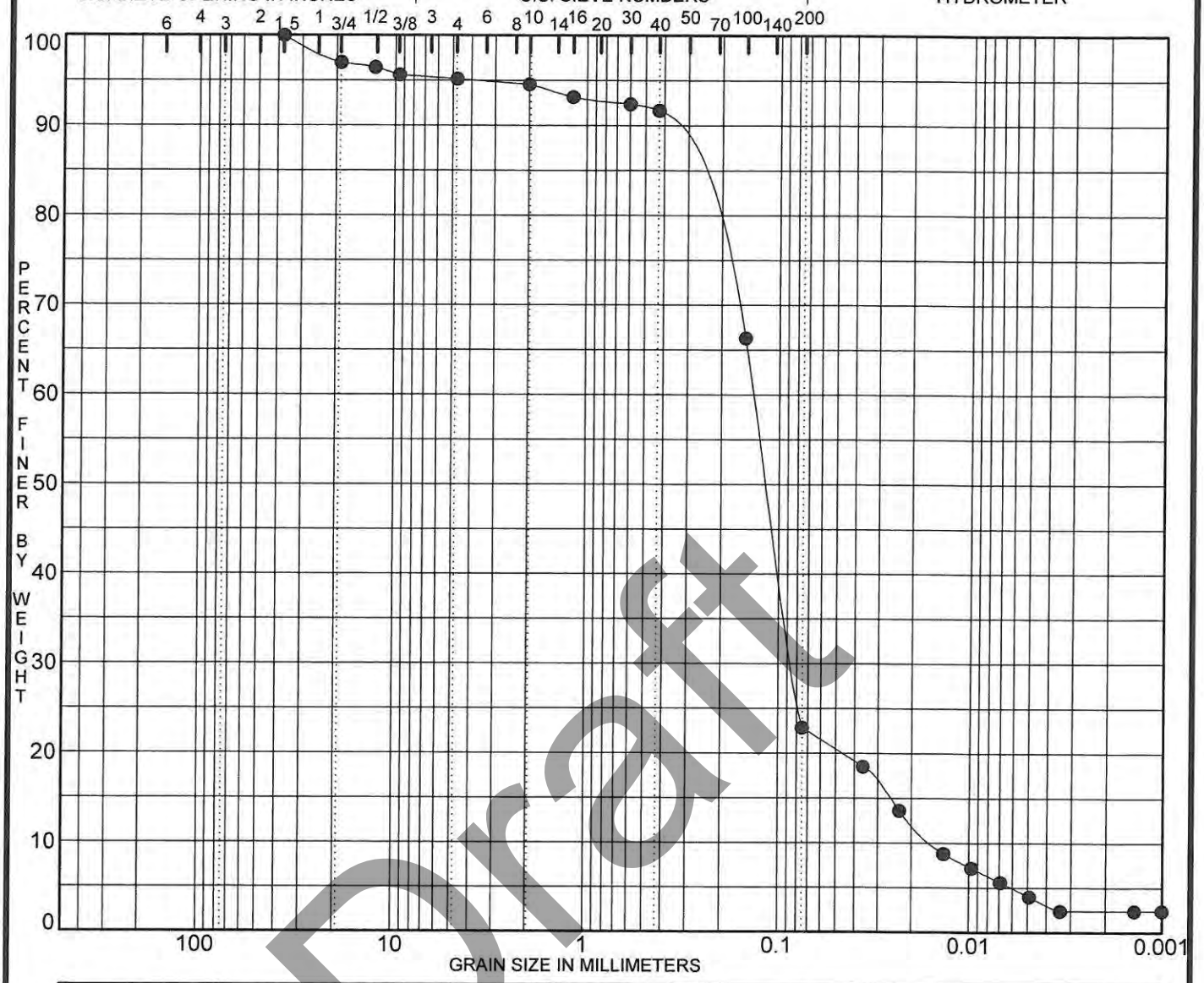

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COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
● **GCR-12/15-SE 0.0**	**SILTY SAND SM**		**NP**	**NP**	**NP**	**3.35**	**8.7**

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **GCR-12/15-SE 0.0**	**37.50**	**0.14**	**0.084**	**0.0155**	**4.8**	**72.3**	**18.7**	**4.1**

PROJECT **Grand Calumet River and Burns Harbor - East Chicago, IN**
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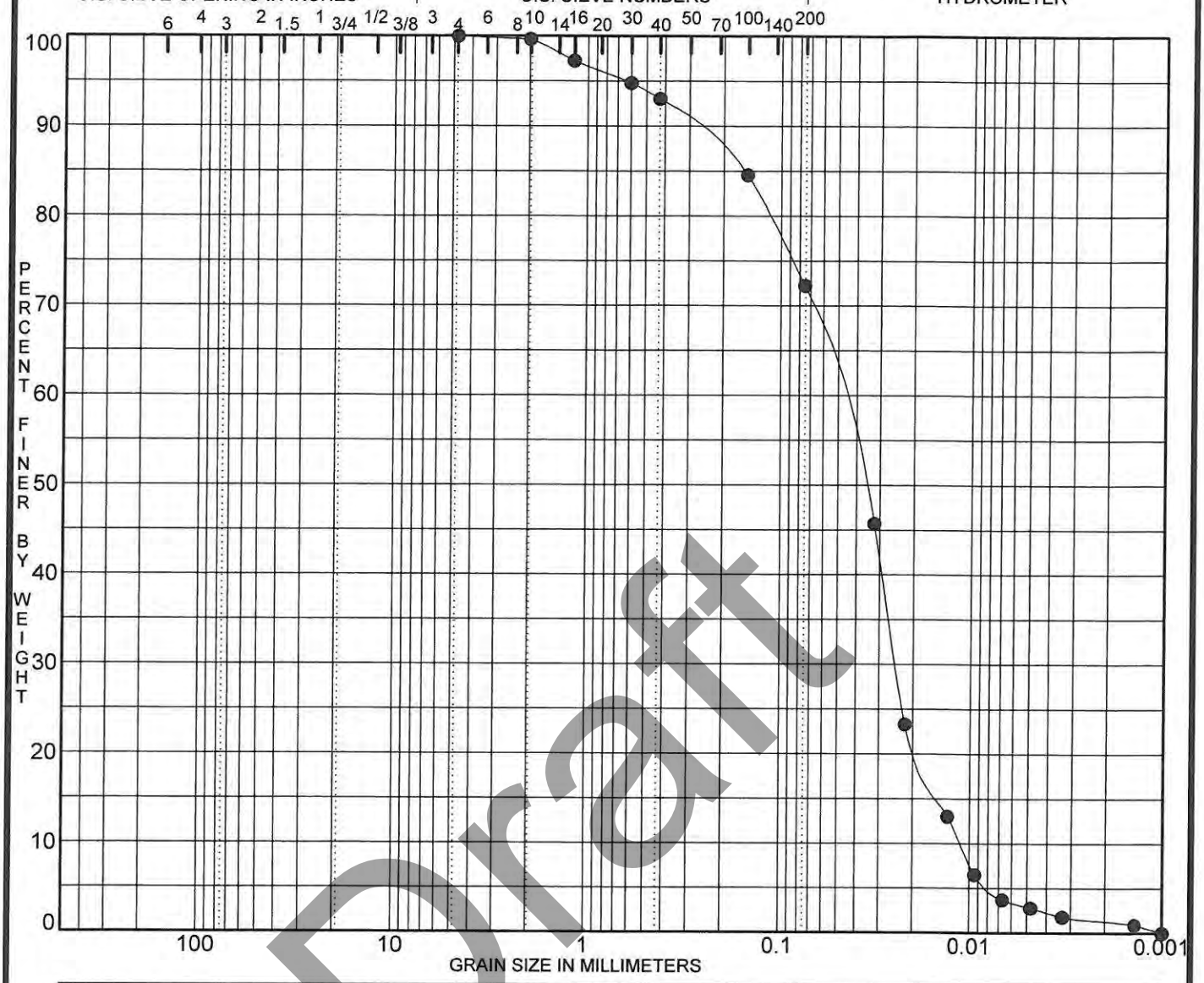

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COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
● **GCR-16/17 0.0**	**SILT with SAND ML**		**NP**	**NP**	**NP**	**1.06**	**4.5**

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **GCR-16/17 0.0**	**4.75**	**0.05**	**0.025**	**0.0112**	**0.0**	**27.8**	**69.3**	**2.9**

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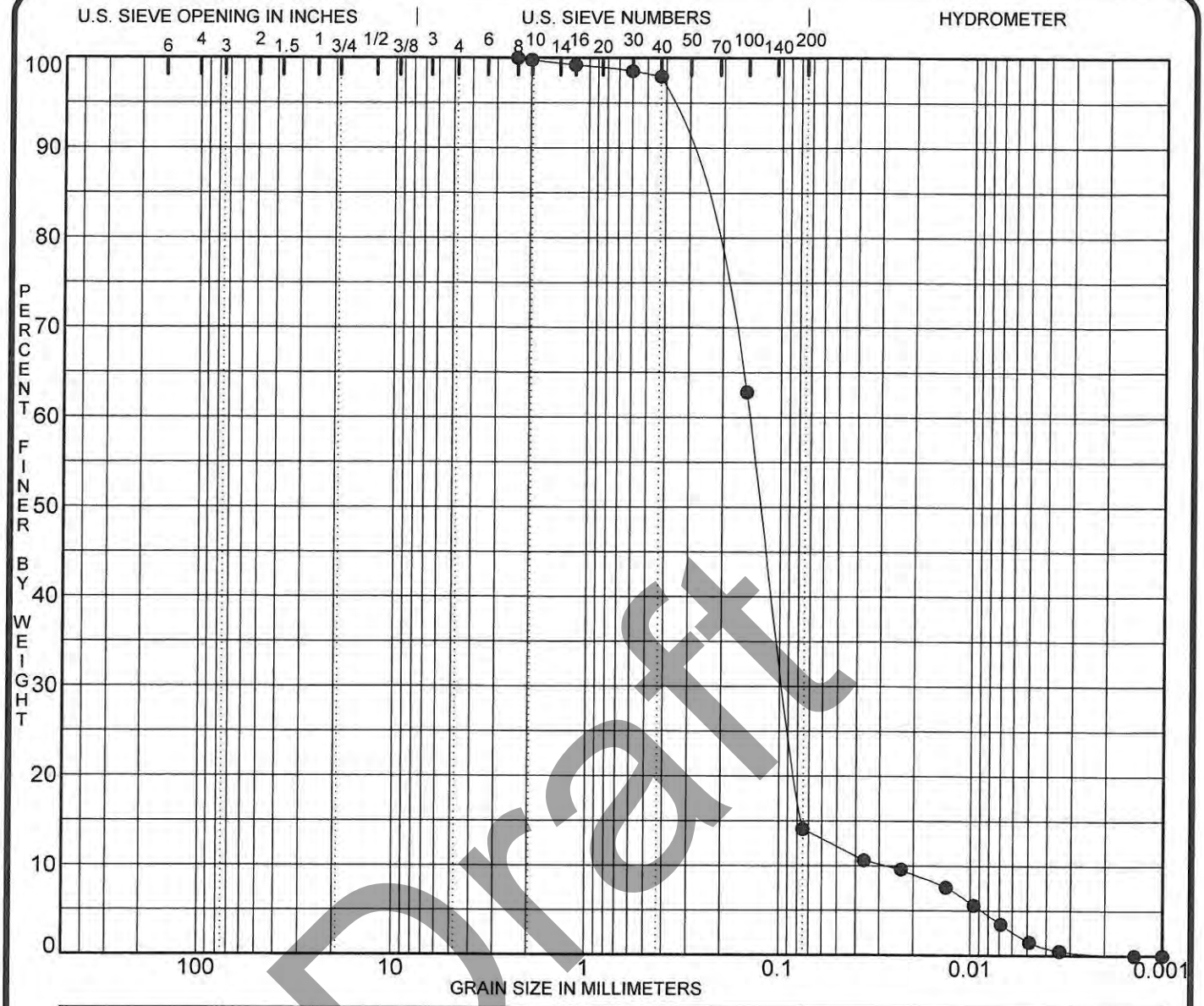

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COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
● IHC-1/5-SE 0.0	SILTY SAND SM		NP	NP	NP	2.22	5.2

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● IHC-1/5-SE 0.0	2.36	0.14	0.094	0.0276	0.0	85.9	12.5	1.6

PROJECT **Grand Calumet River and Burns Harbor - East Chicago, IN**

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JOB NO. **11231**

DATE **1/19/15**

GRADATION CURVES

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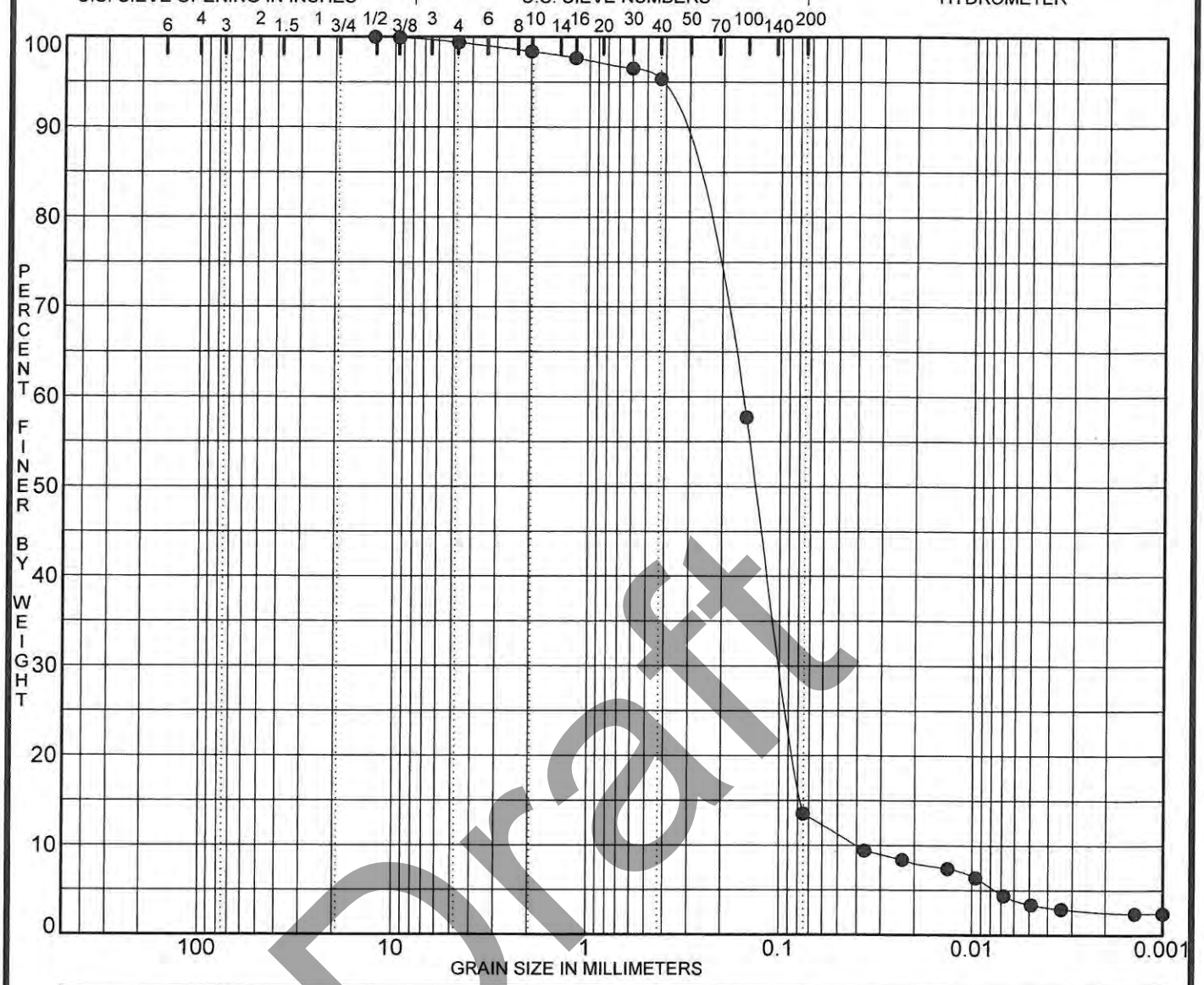

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COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
● **IHC-6/9-SE 0.0**	**SILTY SAND SM**		**NP**	**NP**	**NP**	**1.46**	**4.0**

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **IHC-6/9-SE 0.0**	**12.70**	**0.16**	**0.097**	**0.0404**	**0.6**	**85.9**	**10.1**	**3.5**

PROJECT **Grand Calumet River and Burns Harbor - East Chicago, IN**
DES. NO.
PROJ. NO.
JOB NO. **11231**
DATE **1/19/15**

GRADATION CURVES

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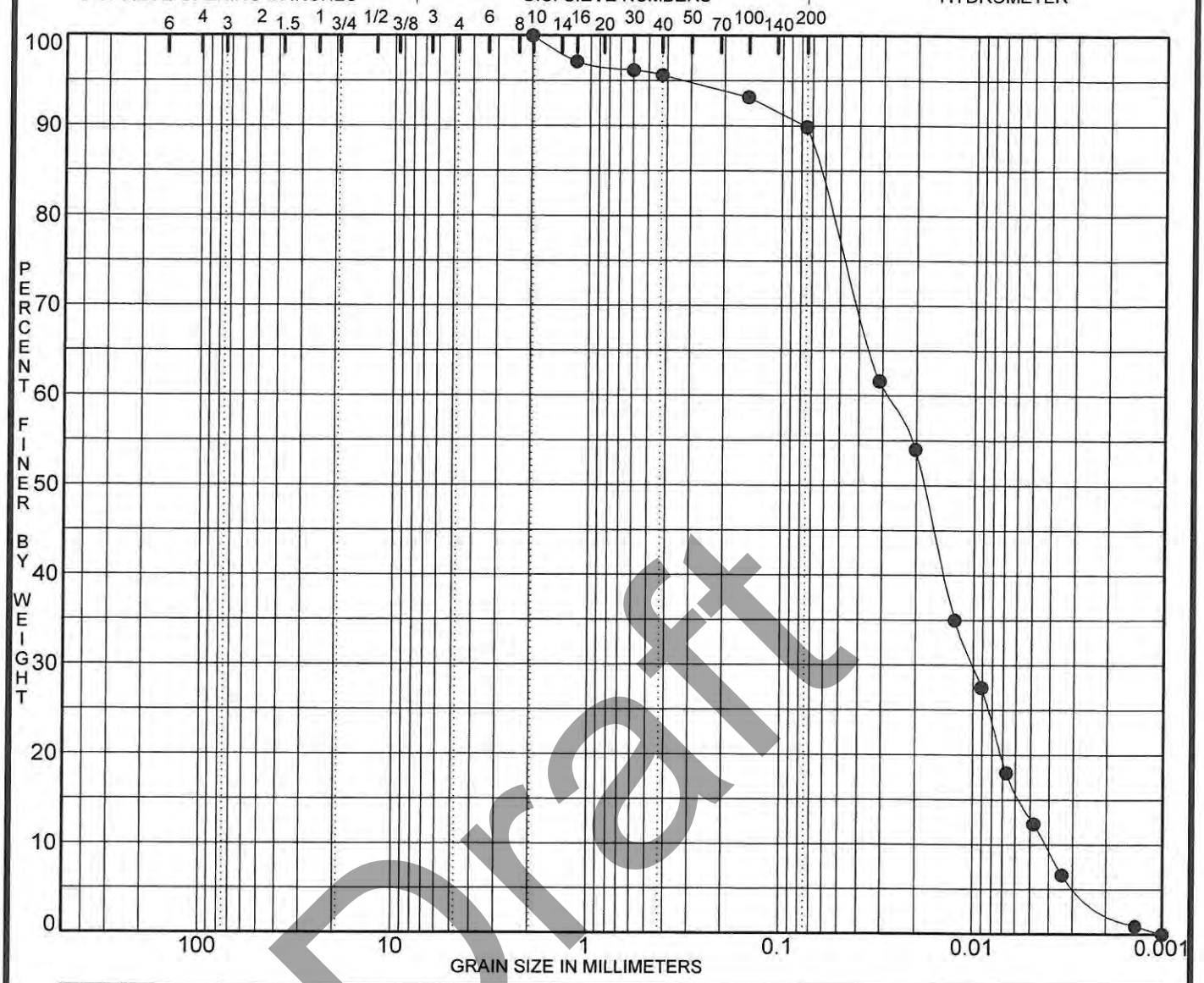

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COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

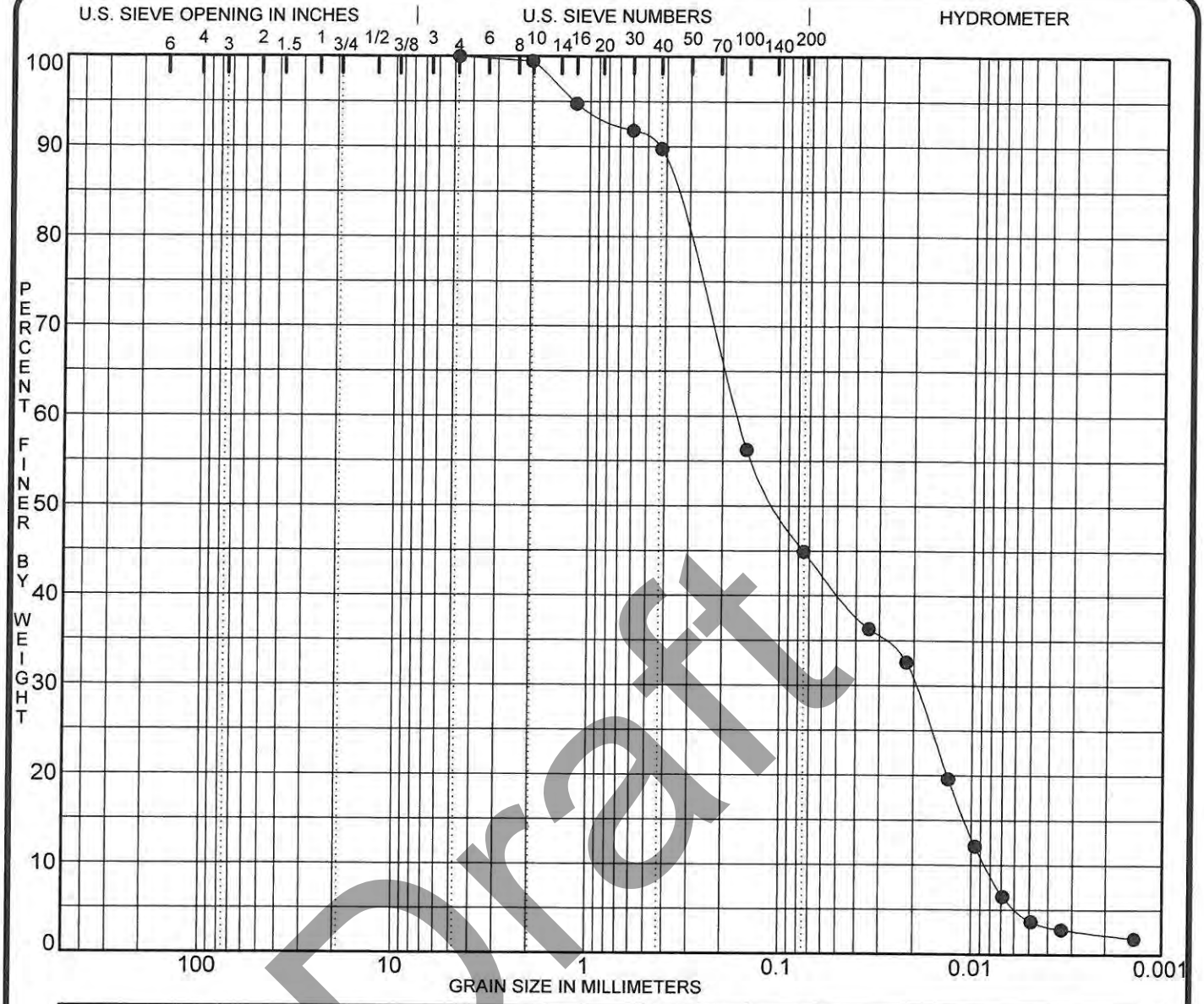
	Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
●	**LGC-1/3-SE 0.0**	**SILT ML**		**NP**	**NP**	**NP**	**0.87**	**6.8**

	Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**LGC-1/3-SE 0.0**	**2.00**	**0.03**	**0.010**	**0.0042**	**0.0**	**10.1**	**76.9**	**13.0**

PROJECT **Grand Calumet River and Burns Harbor - East Chicago, IN**
DES. NO.
PROJ. NO.
JOB NO. **11231**
DATE **1/19/15**

GRADATION CURVES

K & S ENGINEERS, INC.



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COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
●	**LGC-4/7-SE 0.0**	**SILTY SAND SM**		**NP**	**NP**	**NP**	**0.27**	**19.9**

	Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**LGC-4/7-SE 0.0**	**4.75**	**0.17**	**0.020**	**0.0085**	**0.0**	**55.1**	**41.0**	**3.9**

PROJECT **Grand Calumet River and Burns Harbor - East Chicago, IN**

DES. NO.

PROJ. NO.

JOB NO. **11231**

DATE **1/19/15**

GRADATION CURVES

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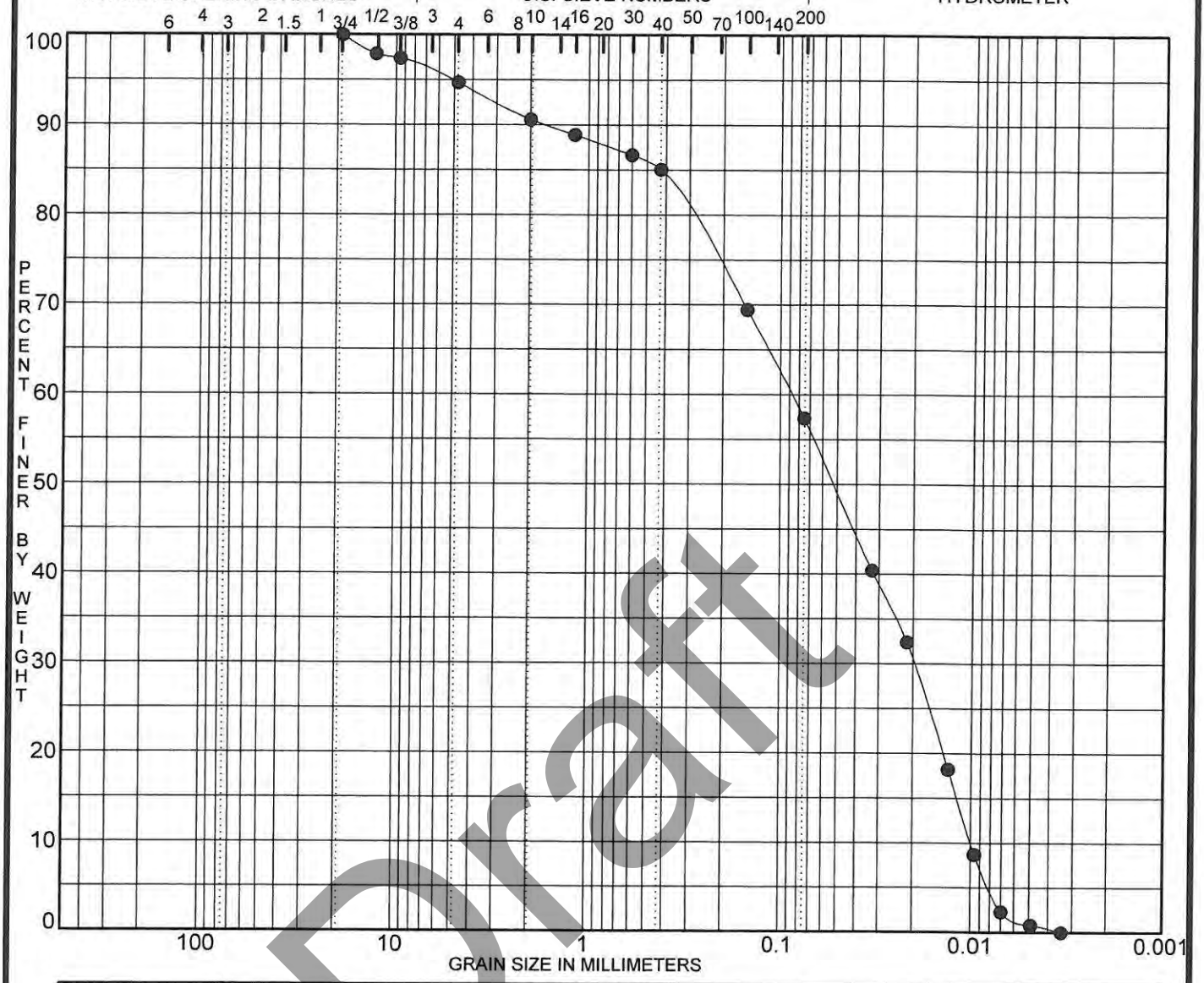

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COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
● **LGC-12/14-SE 0.0**	**SANDY SILT ML**		**NP**	**NP**	**NP**	**0.45**	**8.7**

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **LGC-12/14-SE 0.0**	**19.00**	**0.09**	**0.020**	**0.0100**	**5.3**	**37.3**	**56.5**	**0.9**

PROJECT **Grand Calumet River and Burns Harbor - East Chicago, IN**

DES. NO.

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DATE **1/19/15**

GRADATION CURVES

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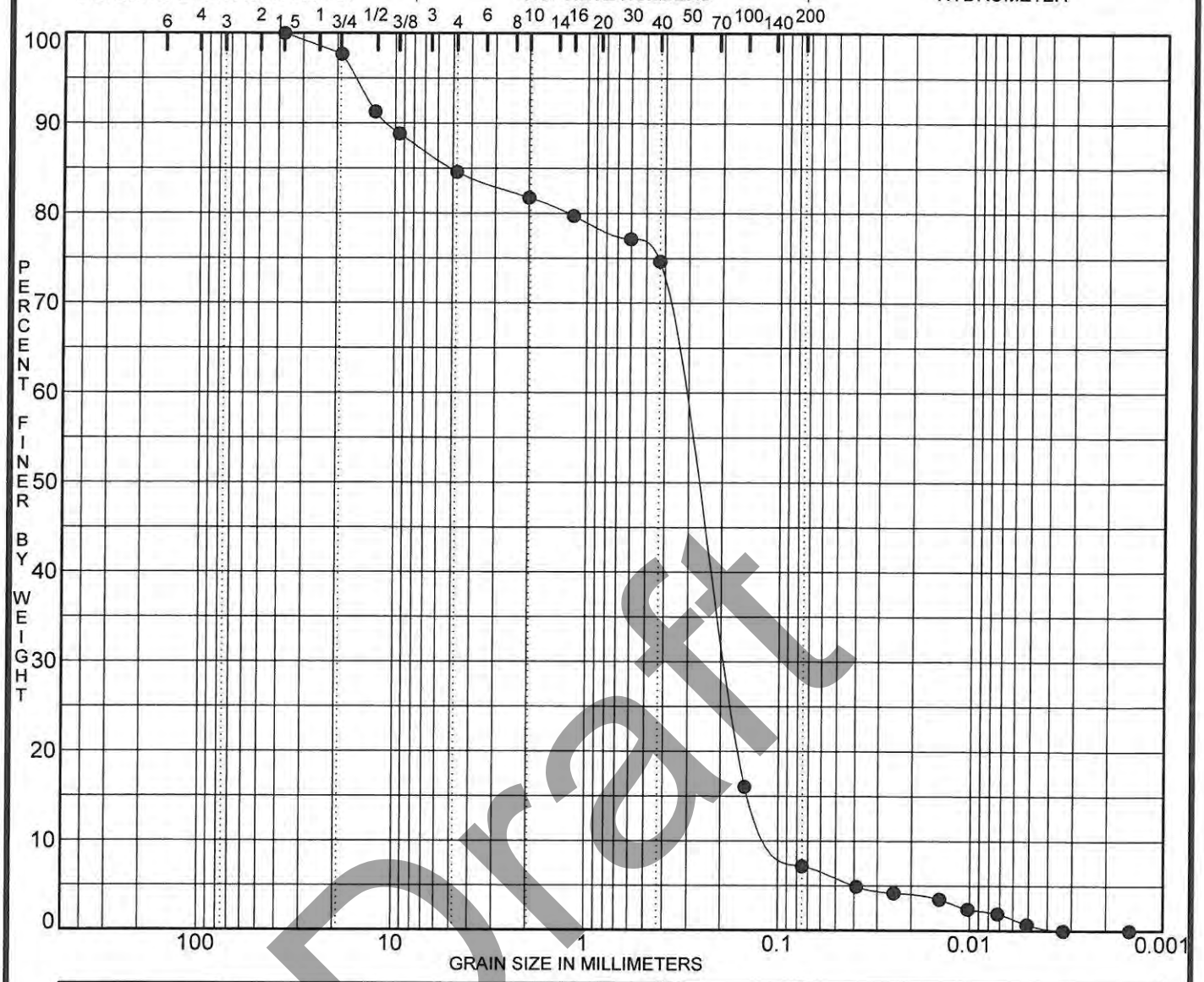

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COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
●	**LGC-15/17-SE 0.0**	**POORLY GRADED SAND with SILT and GRAVEL SP-SM**		**NP**	**NP**	**NP**	**1.20**	**3.5**

	Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**LGC-15/17-SE 0.0**	**37.50**	**0.33**	**0.192**	**0.0936**	**15.4**	**77.4**	**6.5**	**0.7**

PROJECT **Grand Calumet River and Burns Harbor - East Chicago, IN**
DES. NO.
PROJ. NO.
JOB NO. **11231**
DATE **1/19/15**

GRADATION CURVES

K & S ENGINEERS, INC.

ARCADIS Design & Consultancy for natural and built assets

Atlantic Richfield Company

AOC SITE INVESTIGATION REPORT

Former ECI Refinery
East Chicago, Indiana

May 6, 2016

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- The laboratory control sample analysis exhibited recoveries outside the control limits for several sample locations. Associated sample results were qualified as estimated.
- The matrix spike/matrix spike duplicate (MS/MSD) analysis for several compounds/analytes were outside the control limits resulting in qualification of several sample results as estimated. Sample location SB-2016-11 (2-4')(01222016) results for 2,4-dinitrophenol, 4,6-dinitro-2-methylphenol, fluorene, hexachlorocyclopentadiene, phenanthrene, and pyrene exhibited MS and/or MSD recoveries less than the control limit and less than 10% resulting in rejection for the associated sample results.
- The relative percent difference (RPD) between the MS and MSD recoveries was outside the control limit for sample SB-2016-11 (2-4')(01222016) for naphthalene resulting in qualification of the sample result as estimated.
- The field duplicate RPD was greater than the control limit for several compounds. Associated sample results were qualified as estimated.
- Several compounds in the original analysis of the samples were outside calibration range and flagged with an “E” qualifier and required reanalysis at a higher dilution. These compounds were flagged with a ‘D’ qualifier on the result forms to indicate the result was reported from a diluted run.

Detailed discussion of the data validation and annotated laboratory analytical reports are presented in the memoranda included as **Appendix I**. The data validation results and added qualifiers have been incorporated into the tables and figures included in this SI Report.

Completeness is defined as the percentage of measurements that are judged to be valid or usable to meet the prescribed data quality objectives. The completeness criterion is essentially the same for all data uses -- the generation of a sufficient amount of valid data. A total of 2,131 sample results were reviewed as part of the data validation effort. Of that total, 21 individual analyte results (or <1.0%) were qualified as rejected. The actual completeness of the validated data set had an overall usability of >99.0%.

4.5 Soil Sampling – Geotechnical Analysis

From January 19 through January 22, 2016, Arcadis collected subsurface samples for geotechnical testing as outlined in the Work Plan (Arcadis 2015). Soil borings for geotechnical testing were advanced with a hollow-stem auger drill rig through the sand unit and into the underlying clay till unit.

Two clay unit samples were collected per each geotechnical boring; the samples were submitted to CGC, Inc. of Madison, Wisconsin for laboratory analysis. Additionally, composite samples were collected at each boring over 10- to 15-foot intervals within the sand unit to support generalized characterization of the properties of the sand unit. The specific intervals at which the samples were collected were identified in the field based on observed variations in soil properties and soil classification. Shelby tube samplers were used to collect undisturbed samples from the clay unit.

Geotechnical soil samples were submitted for laboratory analysis of the following parameters:

- Grain size distribution (ASTM Method D422)

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APPENDIX G

Soil Boring Logs

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Date Start/Finish: 1/19/16
Drilling Company: Enviro-Dynamics
Driller's Name: R. Mores and S. Bolts
Drilling Method: Geoprobe - Direct Push
Sampling Method: Dual Tube

Northing: NA
Easting: NA
Casing Elevation: NA

Borehole Depth: 36 ft bgs
Surface Elevation: NA

Descriptions By: J. Parker

Well/Boring ID: **SB-2016-01**

Client: ECI

Location: East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
0	0							
					GW		GRAVEL; gray; dry. (FILL)	
			0.8		SW		SAND, medium to fine grained; some clay; trace gravel; gray to dark brown; moist.	
		3.7		X				
			1.2					
					SW		SAND, medium to fine grained; light brown; moist.	
					SW		SAND, medium to fine grained; light brown; moist to wet.	
5	-5		4.2					
		3.2			SW		SAND, medium to fine grained; trace gravel; gray with intermittent staining; saturated.	Boring backfilled with Bentonite.
			4.8					
					SW		SAND, medium to fine grained; trace gravel; gray; saturated.	
			2.7					
10	-10	3.9						
			2.7					
					SW		SAND, medium to fine grained; trace gravel; gray; saturated.	

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and cyanide: SB-01(2-4').

Date Start/Finish: 1/19/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 36 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Parker	**Well/Boring ID:** **SB-2016-01** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
		4.0			SW		SAND medium to fine grained; trace gravel; gray; saturated.	
15	-15							
		4.0			SW		SAND, medium to fine grained, trace gravel; gray; saturated.	
20	-20							Boring backfilled with Bentonite.
		4.0	3.9		SW		SAND, medium to fine grained, trace gravel; gray; saturated.	
			3.6					
25	-25	4.0	14.6		SW		SAND, medium to fine grained, trace gravel; gray; saturated.	
			3.1					

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and cyanide: SB-01(2-4').

Date Start/Finish: 1/19/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 36 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Parker	**Well/Boring ID:** **SB-2016-01** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
							Trace clay begins at 27 ft bgs.	
			2.7		SW		SAND, medium to fine grained, trace gravel; trace clay; gray; saturated.	
30	-30	4.0						
			2.1		CL		CLAY, medium density, high plasticity; gray; wet.	Boring backfilled with Bentonite.
			1.3		CL		CLAY, medium density, high plasticity; gray; wet.	
		4.0						
35	-35		2.4					
							END OF BORING AT 36 FT BGS	

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and cyanide: SB-01(2-4').

Date Start/Finish: 1/19/16
Drilling Company: Enviro-Dynamics
Driller's Name: R. Mores and S. Bolts
Drilling Method: Geoprobe - Direct Push
Sampling Method: Dual Tube

Northing: NA
Easting: NA
Casing Elevation: NA

Borehole Depth: 32 ft bgs
Surface Elevation: NA

Descriptions By: J. Parker

Well/Boring ID: **SB-2016-02**

Client: ECI

Location: East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
0	0							
					--		TOPSOIL.	
			2.3		SW		SAND, medium to fine grained; cinders; black; dry.	
		2.7						
					SW		SAND, medium to fine grained; light brown; dry to moist.	
			177.1		SW		SAND, medium to fine grained; black, staining; dry to moist.	
5	-5		117.6		SW		SAND, medium to fine grained; dark gray to black; dry to moist.	
		2.4					Saturated at 6.0 ft bgs.	Boring backfilled with Bentonite.
			159.2					
			134.3		SW		SAND, medium to fine grained; dark gray to black; saturated.	
10	-10	3.8					Heavy staining at 9.0 to 10.0 ft bgs.	
			36.7					
							SAND, medium to fine grained; light gray; saturated.	
			7.2					

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for BTEX and PAH: SB-02(2-4').

Date Start/Finish: 1/19/16
Drilling Company: Enviro-Dynamics
Driller's Name: R. Mores and S. Bolts
Drilling Method: Geoprobe - Direct Push
Sampling Method: Dual Tube

Northing: NA
Easting: NA
Casing Elevation: NA

Borehole Depth: 32 ft bgs
Surface Elevation: NA

Descriptions By: J. Parker

Well/Boring ID: **SB-2016-02**

Client: ECI

Location: East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
		3.9			SW			
15	-15		29.0					
		4.0	3.8		SW		SAND, medium to fine grained; light gray; saturated.	
			2.1					
20	-20	4.0	1.9		SW		SAND, medium to fine grained; light gray; saturated.	Boring backfilled with Bentonite.
			1.7					
25	-25	3.8	0.6		SW		SAND, medium to fine grained; light gray; saturated.	
			0.5				SILTY SAND, fine grained; light gray; saturated.	

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for BTEX and PAH: SB-02(2-4').

Date Start/Finish: 1/19/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 32 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Parker	**Well/Boring ID:** **SB-2016-02** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
					SM			
					SM		SILTY SAND, fine grained; light gray; saturated.	
30	-30	1.3						Boring backfilled with Bentonite.
					CL		CLAY, medium density, high plasticity; gray; wet.	
							END OF BORING AT 32 FT BGS	

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for BTEX and PAH: SB-02(2-4').

Date Start/Finish: 1/19/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Macrocore and Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 32 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Parker	**Well/Boring ID:** **SB-2016-03** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
0	0				--		TOPSOIL and GRAVEL; brown to gray; dry. (FILL)	
			0.7		SW		SAND, medium to fine grained; cinders, black and cream-colored; dry to moist.	
		3.8	0.5		SW		SAND, medium to fine grained; trace gravel; light brown; moist.	
5	-5		2.4	X	SW		SAND, medium to fine grained; trace gravel; light brown; moist.	
		4.5	39.5	X	SW		SAND, medium to fine grained; trace gravel; light brown, black to gray staining; saturated.	Boring backfilled with Bentonite.
			36.8	X				
10	-10		11.6	X	SW		SAND, medium to fine grained; trace gravel; gray to brown; wet to saturated.	
		3.9	2.5					

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for BTEX and PAH: SB-03(4-6')
and TPH: SB-03(5.5'), SB-03(6.5'), SB-03(7.0'), SB-03(7.5'), SB-03(8.0'), SB-03(9.0'), and SB-03(10.0').

Date Start/Finish: 1/19/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Macrocore and Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 32 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Parker	**Well/Boring ID:** **SB-2016-03** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
			2.1					
15	-15						SAND, medium to fine grained; gray to brown; wet to saturated.	
			2.4					
		4.6			SW			
			4.1					
20	-20						SAND, medium to fine grained; gray to brown; wet to saturated.	Boring backfilled with Bentonite.
			3.9					
		4.0			SW			
			1.1					
							SAND, medium to fine grained; gray to brown; wet to saturated.	
25	-25		6.8		SW			
		3.9						
			15.3				SILTY SAND; fine grained; gray to brown; wet to saturated.	

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for BTEX and PAH: SB-03(4-6')
and TPH: SB-03(5.5'), SB-03(6.5'), SB-03(7.0'), SB-03(7.5'), SB-03(8.0'), SB-03(9.0'), and SB-03(10.0').

Date Start/Finish: 1/19/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Macrocore and Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 32 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Parker	**Well/Boring ID:** **SB-2016-03** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
					SM			
			11.8		SM		SILTY SAND; fine grained; gray to brown; wet to saturated.	
30	-30	3.5						Boring backfilled with Bentonite.
			2.6		CL		CLAY, medium dense, high plasticity; brown to gray; moist.	
							END OF BORING AT 32 FT BGS	

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for BTEX and PAH: SB-03(4-6')
and TPH: SB-03(5.5'), SB-03(6.5'), SB-03(7.0'), SB-03(7.5'), SB-03(8.0'), SB-03(9.0'), and SB-03(10.0').

Date Start/Finish: 1/19/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Macrocore and Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 32 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Parker	**Well/Boring ID:** **SB-2016-04** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
0	0				--		TOPSOIL.	
			1.1		SW		SAND, medium to fine grained; trace gravel; brown to dark gray; dry.	
		3.6	115.2		SW		SAND, medium to fine grained; trace gravel; dark gray to black, staining; moist.	
5	-5		117.6	X	SW		SAND, medium to fine grained; trace gravel; dark gray; moist. Saturated at 6.0 ft bgs.	Boring backfilled with Bentonite.
		4.2	136.7		SW			
			9.1					
10	-10		7.5				SAND, medium to fine grained; trace gravel; gray to brown; saturated.	
			2.5		SW			

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and cyanide: SB-04(4-6').

Date Start/Finish: 1/19/16
Drilling Company: Enviro-Dynamics
Driller's Name: R. Mores and S. Bolts
Drilling Method: Geoprobe - Direct Push
Sampling Method: Macrocore and Dual Tube

Northing: NA
Easting: NA
Casing Elevation: NA

Borehole Depth: 32 ft bgs
Surface Elevation: NA

Descriptions By: J. Parker

Well/Boring ID: **SB-2016-04**

Client: ECI

Location: East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
15	-15	4.7	1.7				SAND, medium to fine grained; trace gravel; gray to brown; saturated.	
			1.7		SW			
			0.5					
20	-20						SAND, medium to fine grained; trace gravel; gray to brown; saturated.	Boring backfilled with Bentonite.
		4.0	2.5		SW			
			1.3					
							SAND, medium to fine grained; trace gravel; gray to brown; saturated.	
25	-25		1.4					
		3.7			SW			
			5.9					

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and cyanide: SB-04(4-6').

Date Start/Finish: 1/19/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Macrocore and Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 32 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Parker	**Well/Boring ID:** **SB-2016-04** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
			1.7		SW		SAND, medium to fine grained; trace gravel; gray to brown; saturated.	
30	-30	3.8						Boring backfilled with Bentonite.
			1.0		CL		CLAY, low to medium density, high plasticity; brown to gray; wet to saturated.	
							END OF BORING AT 32 FT BGS	

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and cyanide: SB-04(4-6').

Date Start/Finish: 1/19/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Macrocore and Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 36 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Parker	**Well/Boring ID:** **SB-2016-05** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
0	0							
			0.2		--		TOPSOIL; roots.	
		3.5	0.4		SW		SAND, medium to fine grained; trace gravel; light brown; dry to moist.	
5	-5		2.0	X	SW		SAND, medium to fine grained; trace gravel; light brown; moist to wet.	
		4.1	0.5		SW		SAND, medium to fine grained; trace gravel; brown transitioning to brownish gray; saturated.	Boring backfilled with Bentonite.
			2.1					
10	-10		0.8				SAND, medium to fine grained; trace gravel; brown transitioning to brownish gray; saturated.	
		3.2	0.3		SW			

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for BTEX and PAH: SB-05(4-6').

Date Start/Finish: 1/19/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Macrocore and Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 36 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Parker	**Well/Boring ID:** **SB-2016-05** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
							Some gravel at 13.0 to 14.0 ft bgs.	
15	-15		0.4				SAND, medium to fine grained; brown transitioning to brownish gray; saturated.	
		4.5	0.4		SW			
			0.3					
20	-20		0.2				SILTY SAND, medium to fine grained; brown transitioning to brownish gray; saturated.	Boring backfilled with Bentonite.
		3.8	0.4		SM			
25	-25		0.6				SILTY SAND, medium to fine grained; brown transitioning to brownish gray; saturated.	
		3.7	0.4		SM			

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for BTEX and PAH: SB-05(4-6').

Date Start/Finish: 1/19/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Macrocore and Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 36 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Parker	**Well/Boring ID:** **SB-2016-05** **Client:** ECI **Location:** East Chicago, IN

DEPTH / ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
		1.3				CLAY, medium to high density, high plasticity; brown to gray, wet to saturated.	
30 -30	4.0	0.2		CL			
	4.0	--		CL		CLAY, medium to high density, high plasticity; brown to gray, wet to saturated.	
35 -35							
						END OF BORING AT 36 FT BGS	

Boring backfilled with Bentonite.

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ARCADIS

Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for BTEX and PAH: SB-05(4-6').

Date Start/Finish: 1/20/16
Drilling Company: Enviro-Dynamics
Driller's Name: R. Mores and S. Bolts
Drilling Method: Geoprobe - Direct Push
Sampling Method: Macrocore and Dual Tube

Northing: NA
Easting: NA
Casing Elevation: NA

Borehole Depth: 32 ft bgs
Surface Elevation: NA

Descriptions By: J. Parker

Well/Boring ID: **SB-2016-06**

Client: ECI

Location: East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
0	0							
					--		TOPSOIL; some gravel.	
			0.0				SAND, medium to fine grained; trace gravel; light brown; dry to moist.	
		3.8			SW			
			0.0					
							SAND, medium to fine grained; trace gravel; gray with black staining; moist to wet.	
5	-5		1.5		SW			
							SAND, medium to fine grained; some gravel; gray with black staining; saturated.	Boring backfilled with Bentonite.
			33.8					
		4.2			SW			
			87.7					
10	-10						SAND, medium to fine grained; trace gravel; brown to gray; wet to saturated.	
			2.7					
		4.3			SW			
			2.9					

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and cyanide: SB-06(4-6')
and TPH: SB-06(5.0'), SB-06(6.0'), SB-06(6.5'), SB-06(7.0'), SB-06(7.5'), SB-06(8.0'), and SB-06(9.0').

Date Start/Finish: 1/20/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Macrocore and Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 32 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Parker	**Well/Boring ID:** **SB-2016-06** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
15	-15		4.7				SAND, medium to fine grained; trace gravel; brown to gray; wet to saturated.	
		4.8	7.2		SW			
			11.7					
20	-20						SAND, fine grained; brown to gray; wet to saturated.	Boring backfilled with Bentonite.
		--	0.0		SW			
			0.0					
							SAND, fine grained; brown to gray; wet to saturated.	
25	-25		0.2		SW			
		--						
			0.1				SILTY SAND, fine grained; brown to gray; saturated.	

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and cyanide: SB-06(4-6')
and TPH: SB-06(5.0'), SB-06(6.0'), SB-06(6.5'), SB-06(7.0'), SB-06(7.5'), SB-06(8.0'), and SB-06(9.0').

Date Start/Finish: 1/20/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Macrocore and Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 32 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Parker	**Well/Boring ID:** **SB-2016-06** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
					SM			
			0.2		SM		SILTY SAND, fine grained; brown to gray; saturated.	Boring backfilled with Bentonite.
30	-30	--						
			0.0		CL		CLAY, medium to high density, high plasticity; gray to brown; moist.	
							END OF BORING AT 32 FT BGS	

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and cyanide: SB-06(4-6')
and TPH: SB-06(5.0'), SB-06(6.0'), SB-06(6.5'), SB-06(7.0'), SB-06(7.5'), SB-06(8.0'), and SB-06(9.0').

Date Start/Finish: 1/20/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Macrocore and Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 36 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Parker	**Well/Boring ID:** **SB-2016-07** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
0	0							
					--		TOPSOIL; and GRAVEL.	
			0.0		SW		SAND, medium to fine grained; trace gravel; dark brown; moist.	
		3.8	0.0		SW		SAND, medium to fine grained; trace gravel; light brown; moist.	
5	-5		0.0		SW		SAND, medium to fine grained; trace gravel; light brown; moist.	
			69.9		SW		SAND, medium to fine grained; trace gravel; dark gray, with intermittent black staining; saturated.	Boring backfilled with Bentonite.
		4.2	48.2		SW			
10	-10		1.8		SW		SAND, medium to fine grained; trace gravel; brown to gray; saturated.	
		4.6	2.8		SW			

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and cyanide: SB-07(4-6')
and TPH: SB-07(5.0'), SB-07(6.0'), SB-07(6.5'), SB-07(7.0'), SB-07(7.5'), SB-07(8.0'), SB-07(9.0'), and SB-07(10.0').

Date Start/Finish: 1/20/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Macrocore and Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 36 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Parker	**Well/Boring ID:** **SB-2016-07** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
15	-15		1.0				SAND, medium to fine grained; trace gravel; brown to gray; saturated.	
		4.7	1.6		SW			
			0.5					
20	-20						SILTY SAND, fine grained; trace gravel; brown to gray; saturated.	Boring backfilled with Bentonite.
		3.8	0.0		SM			
			0.1					
							SILTY SAND, fine grained; trace gravel; brown to gray; saturated.	
25	-25		0.6					
		4.0			SM			
			0.6					

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and cyanide: SB-07(4-6')
and TPH: SB-07(5.0'), SB-07(6.0'), SB-07(6.5'), SB-07(7.0'), SB-07(7.5'), SB-07(8.0'), SB-07(9.0'), and SB-07(10.0').

Date Start/Finish: 1/20/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Macrocore and Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 36 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Parker	**Well/Boring ID:** **SB-2016-07** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
			0.0		SM		SILTY SAND, fine grained; trace gravel; brown to gray; saturated.	
30	-30	4.0						
			0.0		CL		CLAY, medium to high density, high plasticity; gray; moist.	Boring backfilled with Bentonite.
			--				CLAY, medium to high density, high plasticity; gray; moist.	
		--			CL			
35	-35		--					
							END OF BORING AT 36 FT BGS	

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and cyanide: SB-07(4-6')
and TPH: SB-07(5.0'), SB-07(6.0'), SB-07(6.5'), SB-07(7.0'), SB-07(7.5'), SB-07(8.0'), SB-07(9.0'), and SB-07(10.0').

Date Start/Finish: 1/20/16
Drilling Company: Enviro-Dynamics
Driller's Name: R. Mores and S. Bolts
Drilling Method: Geoprobe - Direct Push
Sampling Method: Macrocore and Dual Tube

Northing: NA
Easting: NA
Casing Elevation: NA

Borehole Depth: 30 ft bgs
Surface Elevation: NA

Descriptions By: J. Parker

Well/Boring ID: **SB-2016-08**

Client: ECI

Location: East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
0	0							
					--		TOPSOIL; and GRAVEL.	
			0.0		SW		SAND, medium to fine grained; trace gravel; light brown; moist.	
		3.0						
			43.3		SW		SAND, medium to fine grained; trace gravel; dark gray, with black staining; moist.	
5	-5		74.3	X	SW		SAND, medium to fine grained; trace gravel; dark gray, with black staining; moist.	
					SW		SAND, medium to fine grained; trace gravel; dark gray, with black staining; wet.	
		3.0						
			56.7		SW		SAND, medium to fine grained; trace gravel; dark gray, with black staining; saturated.	Boring backfilled with Bentonite.
			4.4				SAND, medium to fine grained; trace gravel; gray to brown; saturated.	
10	-10	4.0			SW			
			10.4					
							SAND, medium to fine grained; trace gravel; gray to brown; saturated.	
			6.8					

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for BTEX and PAH: SB-08(4-6').

Date Start/Finish: 1/20/16
Drilling Company: Enviro-Dynamics
Driller's Name: R. Mores and S. Bolts
Drilling Method: Geoprobe - Direct Push
Sampling Method: Macrocore and Dual Tube

Northing: NA
Easting: NA
Casing Elevation: NA

Borehole Depth: 30 ft bgs
Surface Elevation: NA

Descriptions By: J. Parker

Well/Boring ID: **SB-2016-08**

Client: ECI

Location: East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
		4.0			SW			
15	-15		4.4					
							SAND, medium to fine grained; trace gravel; gray to brown; saturated.	
		4.0	2.2		SW			
			2.7					
20	-20						SILTY SAND, fine grained; trace gravel; gray to brown; saturated.	Boring backfilled with Bentonite.
			0.7					
		4.8			SM			
			1.4					
25	-25		1.2				SILTY SAND, fine grained; trace gravel; gray to brown; saturated.	
			14.4		SM			

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for BTEX and PAH: SB-08(4-6').

Date Start/Finish: 1/20/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Macrocore and Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 30 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Parker	**Well/Boring ID:** **SB-2016-08** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
		--					CLAY, medium to high density, high plasticity; gray; moist to wet.	Boring backfilled with Bentonite.
			12.2		CL			
30	30						END OF BORING AT 30 FT BGS	

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for BTEX and PAH: SB-08(4-6').

Date Start/Finish: 1/20/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Macrocore and Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 30 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Parker	**Well/Boring ID:** **SB-2016-09** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
0	0				--		TOPSOIL; and GRAVEL.	
		3.3	2.0		SW-GW		SAND; and GRAVEL, medium to coarse grained; brown; dry to moist.	
			67.7		SW-GW		SAND; and GRAVEL, medium to coarse grained; black; dry to moist.	
5	-5		175.4		SW-GW		SAND; and GRAVEL, medium to coarse grained; black; dry to moist.	
		3.6	291.7		SW		SAND, medium to coarse grained; trace gravel; gray to brown; saturated.	Boring backfilled with Bentonite.
			8.6					
10	-10		3.1		SW		SAND, medium to coarse grained; trace gravel; gray to brown; saturated.	
		5.0	2.5					

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ARCADIS

Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and cyanide: SB-09(3-5')
and TPH: SB-09(5.0'), SB-09(5.5'), SB-09(6.0'), SB-09(6.5'), SB-09(7.0'), SB-09(8.0'), and SB-09(9.0').

Date Start/Finish: 1/20/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Macrocore and Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 30 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Parker	**Well/Boring ID:** **SB-2016-09** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
15	-15	3.8	3.5		SM		SILTY SAND, fine grained; trace gravel; gray to brown; saturated.	Boring backfilled with Bentonite.
			3.5					
			2.7					
20	-20	5.0	1.2		SM		SILTY SAND, fine grained; trace gravel; gray to brown; saturated.	
			0.8					
25	-25		2.8		SM		SILTY SAND, fine grained; trace gravel; gray to brown; saturated.	
			3.9					

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ARCADIS

Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and cyanide: SB-09(3-5')
and TPH: SB-09(5.0'), SB-09(5.5'), SB-09(6.0'), SB-09(6.5'), SB-09(7.0'), SB-09(8.0'), and SB-09(9.0').

Date Start/Finish: 1/20/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Macrocore and Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 30 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Parker	**Well/Boring ID:** **SB-2016-09** **Client:** ECI **Location:** East Chicago, IN

DEPTH / ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
	5.0	4.9		CL		CLAY, medium to high density, high plasticity; gray; wet.	Boring backfilled with Bentonite.
30 30						END OF BORING AT 30 FT BGS	

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ARCADIS

Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and cyanide: SB-09(3-5')
and TPH: SB-09(5.0'), SB-09(5.5'), SB-09(6.0'), SB-09(6.5'), SB-09(7.0'), SB-09(8.0'), and SB-09(9.0').

Date Start/Finish: 1/22/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Macrocore and Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 32 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Yuen	**Well/Boring ID:** **SB-2016-10** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
0	0							
			0.0		SP		SAND, coarse grained, loose, well sorted; some gravel; little clay; light brown; dry.	
					SP		SAND, medium grained, loose, well sorted; some silt; dark brown; moist. Roots from 1.1 to 1.5 ft bgs.	
		3.5			SW		SAND, medium to coarse grained, medium dense, poorly sorted; and gravel; dark brown; moist.	
					SP		SAND, fine to coarse grained, well sorted, medium dense; reddish; dry to moist.	
			0.1		ML		SILT, medium stiff, non-plastic; and sand; dark brown to reddish. Wet at 5.0 ft bgs.	
5	-5		11.4					
			49.5				SAND, medium to coarse grained, medium dense, well sorted; light gray to dark gray; moist to wet. Black from 6.5 to 6.6 ft bgs.	Boring backfilled with Bentonite.
		5.0						
			4.2					
10	-10	4.0					Gravel from 10.4 to 10.7 ft bgs.	
			0.4					
			0.2					

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and cyanide: SB-10(2-4')
and TPH: SB-10(5.0'), SB-10(6.0'), SB-10(6.5'), SB-10(7.0'), SB-10(7.5'), SB-10(8.0'), and SB-10(9.0').

Date Start/Finish: 1/22/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Macrocore and Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 32 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Yuen	**Well/Boring ID:** **SB-2016-10** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
		4.0						
15	-15		0.3					
					SP		Grades to very fine SAND; some silt; dense trace clay at 16.0 ft bgs. SILTY CLAY content increases with depth.	
			0.3					
		3.8						
			0.1					
20	-20							Boring backfilled with Bentonite.
			0.1					
		4.0						
			0.1					
25	-25		0.1					
		3.8						
			0.1					

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and cyanide: SB-10(2-4')
and TPH: SB-10(5.0'), SB-10(6.0'), SB-10(6.5'), SB-10(7.0'), SB-10(7.5'), SB-10(8.0'), and SB-10(9.0').

Date Start/Finish: 1/22/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Macrocore and Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 32 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Yuen	**Well/Boring ID:** **SB-2016-10** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
							CLAY, medium stiff, medium plastic; little silt; brown; moist to wet.	Boring backfilled with Bentonite.
30	-30	4.0	0.7 0.3		CL			
							END OF BORING AT 32 FT BGS	

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and cyanide: SB-10(2-4')
and TPH: SB-10(5.0'), SB-10(6.0'), SB-10(6.5'), SB-10(7.0'), SB-10(7.5'), SB-10(8.0'), and SB-10(9.0').

Date Start/Finish: 1/22/16
Drilling Company: Enviro-Dynamics
Driller's Name: R. Mores and S. Bolts
Drilling Method: Geoprobe - Direct Push
Sampling Method: Macrocore and Dual Tube

Northing: NA
Easting: NA
Casing Elevation: NA

Borehole Depth: 28 ft bgs
Surface Elevation: NA

Descriptions By: J. Yuen

Well/Boring ID: **SB-2016-11**

Client: ECI

Location: East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
0	0				--		TOPSOIL; some gravel; dark brown to light brown; dry.	
		4.0	3.1		SW-SP		SAND, fine to coarse grained, medium dense; moist to wet.	
			66.7	X			Stained from 1.7 to 2.3 ft bgs.	
							Some gravel; light brown to dark brown from 3.0 to 3.5 ft bgs.	
							Stained from 3.3 to 3.6 ft bgs.	
							Wet at 4.0 ft bgs.	
5	-5	3.0	356.7				SAND, fine to coarse grained, medium dense, well sorted; little gravel; trace silt; dark brown to gray; wet. Stained from 5.0 to 7.2 ft bgs.	
			60.0				Brown, petroleum-like liquid observed from 6.0 to 6.3 ft bgs.	Boring backfilled with Bentonite.
			42.7					
10	-10	4.0	0.2		SP			
			4.8					

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Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and cyanide: SB-11(2-4').

Date Start/Finish: 1/22/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Macrocore and Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 28 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Yuen	**Well/Boring ID:** **SB-2016-11** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
		4.0					SAND, fine to coarse grained, medium dense, well sorted; little gravel; trace silt; dark brown to gray; wet.	
			0.1					
15	-15							
		4.0	0.3					
			0.2					
20	-20							
		4.0	0.0		SP		SAND, fine to coarse grained, well sorted, medium dense; some silt; some clay; dark gray to brown; wet. Clay content increases with depth.	Boring backfilled with Bentonite.
			0.1					
					CL		CLAY, medium stiff, medium plasticity; some sand; dark gray to brown; moist to wet.	
					CL		CLAY; medium stiff, non-plastic; and sand; light brown; wet.	
25	-25		0.4					
		2.3						
			0.5				No recovery.	

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ARCADIS

Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and cyanide: SB-11(2-4').

Date Start/Finish: 1/22/16 **Drilling Company:** Enviro-Dynamics **Driller's Name:** R. Mores and S. Bolts **Drilling Method:** Geoprobe - Direct Push **Sampling Method:** Macrocore and Dual Tube	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 28 ft bgs **Surface Elevation:** NA **Descriptions By:** J. Yuen	**Well/Boring ID:** **SB-2016-11** **Client:** ECI **Location:** East Chicago, IN

DEPTH	ELEVATION	Recovery (Feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
					--		No recovery.	Boring backfilled with Bentonite.
30	-30						END OF BORING AT 28 FT BGS	

Draft

Remarks: ft = feet; bgs = below ground surface; ppm = parts per million; NA = not available; amsl = above mean sea level.

X = Environmental soil sample collected from interval and analyzed for VOCs, SVOCs, metals, pesticides, PCBs, and cyanide: SB-11(2-4').

APPENDIX J

Soil Geotechnical Results

Draft

CGC, Geotechnical Laboratory
Test Results

Date: 2/11/2016
CGC Job # C16033-1
Tests by: DRW
Test No.

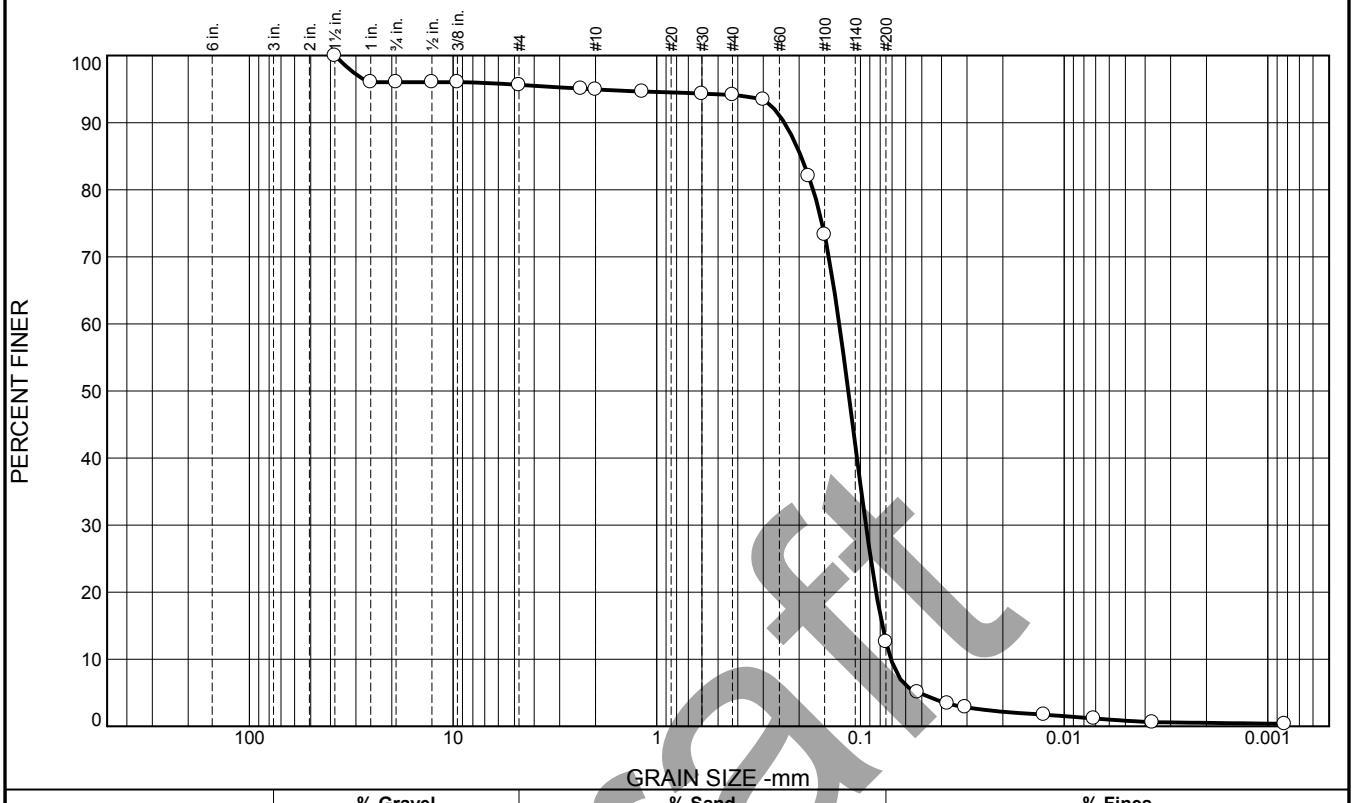
Job: East Chicago, IN CI001067.1643 **Client:** ARCADIS

Sample No.	Depth (ft)	Color	Natural Moisture (%)	Atterberg Limits			Organic Content (%)	Specific Gravity	P200 Content (%)
				Liquid Limit (%)	Plastic Limit (%)	PI			
SB-2016-01	10-20'	Gray	22.7	NV	NP	NP	0.4	2.69	12.6
SB-2016-02	10-20'	Gray	20.7	NV	NP	NP	0.4	2.69	15.6
SB-2016-03	10-20'	Gray	23.6	NV	NP	NP	0.4	2.68	5.0
SB-2016-04	10-20'	Gray	24.7	NV	NP	NP	0.4	2.71	9.6
SB-2016-05	5-20'	Gray	21.4	NV	NP	NP	0.4	2.68	4.9
SB-2016-06	10-20'	Gray	24.3	NV	NP	NP	0.4	2.70	3.4
SB-2016-07	10-20'	Gray	24.2	NV	NP	NP	0.5	2.71	4.5
SB-2016-08	20-30'	Gray	22.6	NV	NP	NP	0.8	2.71	33.0
SB-2016-09	15-25'	Gray	25.6	NV	NP	NP	0.5	2.72	20.3
SB-2016-10	20-30'	Gray	25.7	NV	NP	NP	0.6	2.70	30.4
SB-2016-11	20-30'	Gray	24.3	NV	NP	NP	0.7	2.72	39.2

Notes:
* - Not tested

Draft

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	4.0	0.4	0.6	0.9	81.5	11.8	0.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5	100.0		
1	96.0		
3/4	96.0		
1/2	96.0		
3/8	96.0		
#4	95.6		
#8	95.1		
#10	95.0		
#16	94.6		
#30	94.3		
#40	94.1		
#50	93.5		
#80	82.1		
#100	73.3		
#200	12.6		

* (no specification provided)

Material Description

Gray Fine Sand, Little Silt, Trace Gravel and Clay

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 0.2363 D_{85}= 0.1958 D_{60}= 0.1271
D_{50}= 0.1147 D_{30}= 0.0940 D_{15}= 0.0781
D_{10}= 0.0708 C_u= 1.79 C_c= 0.98

Classification

USCS= SM AASHTO= A-2-4(0)

Remarks

Natural Moisture = 22.7%; Loss-on-Ignition = 0.4%
Specific Gravity = 2.69

Sample Number: SB-2016-01 **Depth:** 10-20'

Date: 2/9/16

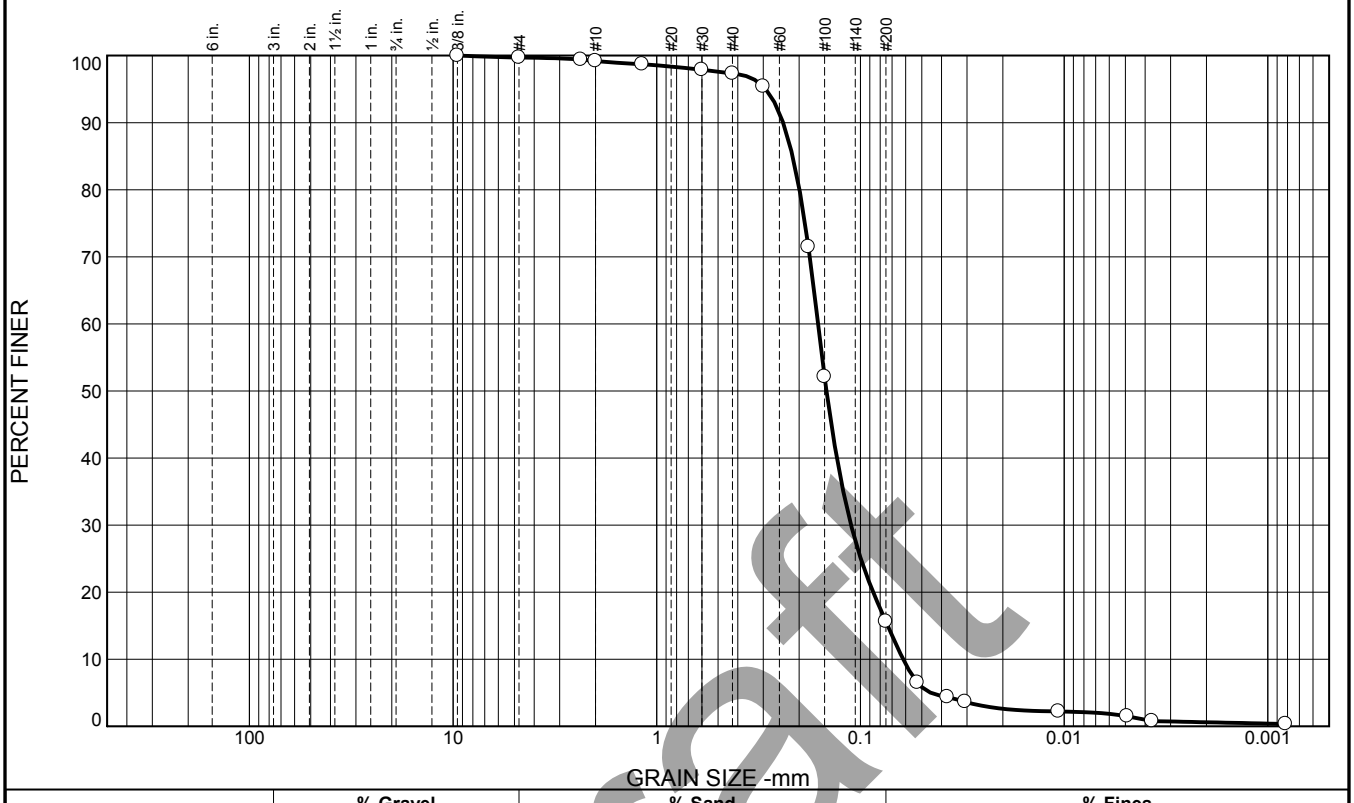
CGC,Inc.

Client: ARCADIS
Project: ECI/East Chicago, IN
ARCADIS# CI001067.1643
Project No: C16033-1 **Figure**

Tested By: DRW **Checked By:** DAS

Draft

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.3	0.5	1.9	81.7	14.1	1.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/8	100.0		
#4	99.7		
#8	99.4		
#10	99.2		
#16	98.7		
#30	97.9		
#40	97.3		
#50	95.4		
#80	71.5		
#100	52.1		
#200	15.6		

* (no specification provided)

Material Description

Gray Fine Sand, Some Silt, Trace Clay and Gravel

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 0.2396 D_{85}= 0.2153 D_{60}= 0.1615
D_{50}= 0.1468 D_{30}= 0.1112 D_{15}= 0.0735
D_{10}= 0.0617 C_u= 2.62 C_c= 1.24

Classification

USCS= SM AASHTO= A-2-4(0)

Remarks

Natural Moisture = 20.7%; Loss-on-Ignition = 0.4%
Specific Gravity = 2.69

Sample Number: SB-2016-02 **Depth:** 10-20'

Date: 2/9/16

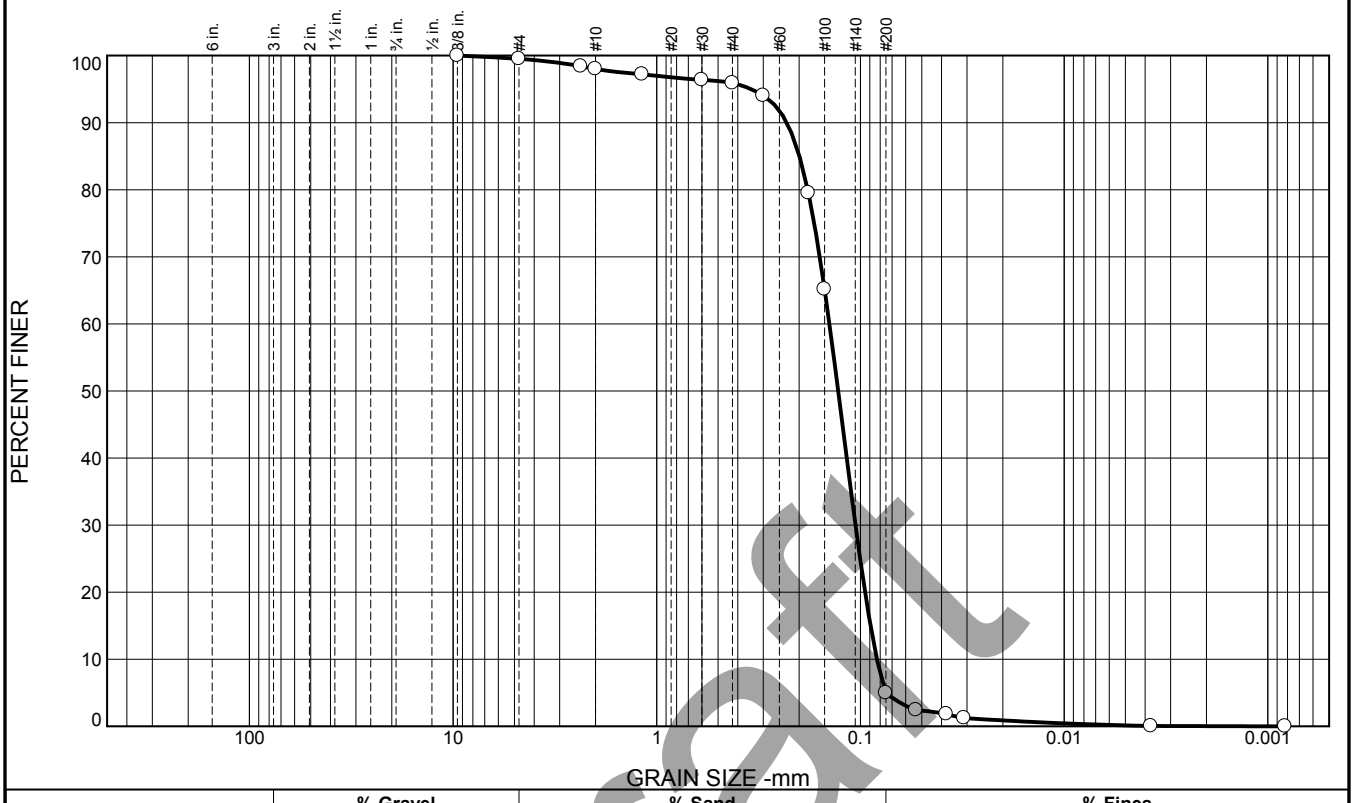
CGC,Inc.

Client: ARCADIS
Project: ECI/East Chicago, IN
ARCADIS# CI001067.1643
Project No: C16033-1 **Figure**

Tested By: DRW **Checked By:** DAS

Draft

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.5	1.5	2.1	90.9	4.9	0.1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/8	100.0		
#4	99.5		
#8	98.4		
#10	98.0		
#16	97.2		
#30	96.4		
#40	95.9		
#50	94.0		
#80	79.5		
#100	65.2		
#200	5.0		

* (no specification provided)

Material Description

Gray Fine Sand, Trace Silt, Gravel, and Clay

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 0.2300 D_{85}= 0.1993 D_{60}= 0.1420
D_{50}= 0.1286 D_{30}= 0.1058 D_{15}= 0.0893
D_{10}= 0.0830 C_u= 1.71 C_c= 0.95

Classification

USCS= SP-SM AASHTO= A-3

Remarks

Natural Moisture = 23.6%; Loss-on-Ignition = 0.4%
Specific Gravity = 2.68

Sample Number: SB-2016-03 **Depth:** 10-20'

Date: 2/9/16

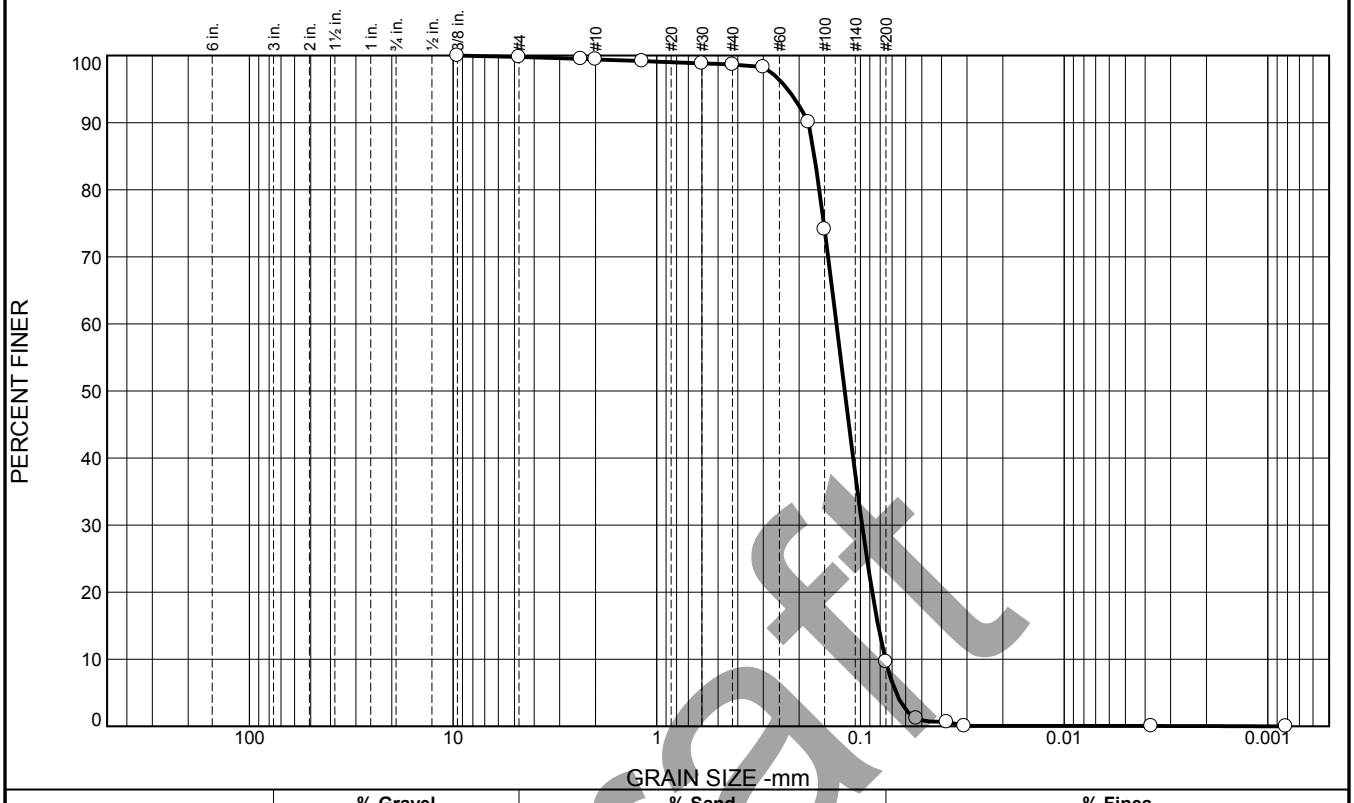
CGC,Inc.

Client: ARCADIS
Project: ECI/East Chicago, IN
ARCADIS# CI001067.1643
Project No: C16033-1 **Figure**

Tested By: DRW **Checked By:** DAS

Draft

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.2	0.4	0.7	89.1	9.5	0.1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/8	100.0		
#4	99.8		
#8	99.5		
#10	99.4		
#16	99.2		
#30	98.8		
#40	98.7		
#50	98.3		
#80	90.1		
#100	74.1		
#200	9.6		

* (no specification provided)

Material Description

Gray Fine Sand, Little Silt, Trace Gravel and Clay

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 0.1798 D_{85}= 0.1683 D_{60}= 0.1311
D_{50}= 0.1195 D_{30}= 0.0982 D_{15}= 0.0819
D_{10}= 0.0755 C_u= 1.74 C_c= 0.97

Classification

USCS= SP-SM AASHTO= A-3

Remarks

Natural Moisture = 24.7%; Loss-on-Ignition = 0.4%
Specific Gravity = 2.71

Sample Number: SB-2016-04 **Depth:** 10-20'

Date: 2/9/16

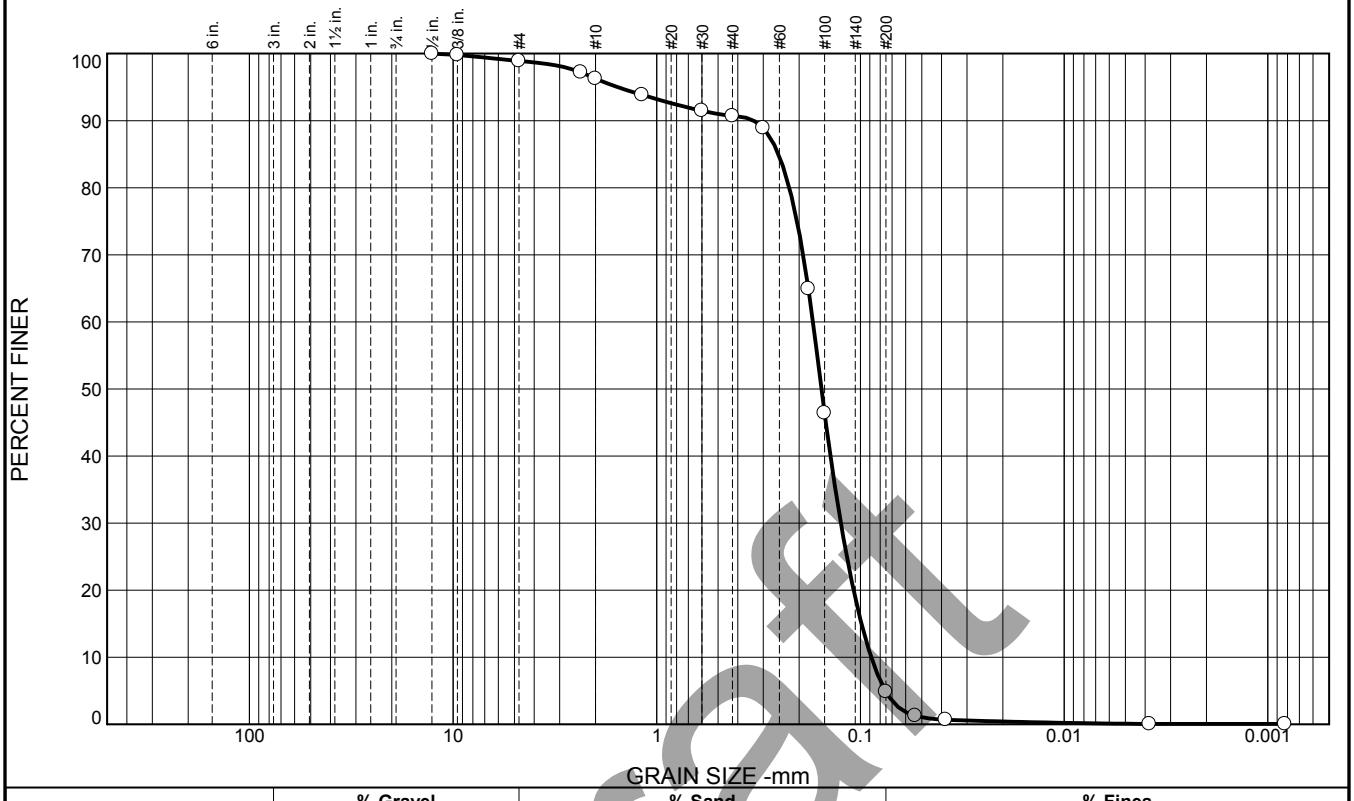
CGC,Inc.

Client: ARCADIS
Project: ECI/East Chicago, IN
ARCADIS# CI001067.1643
Project No: C16033-1 **Figure**

Tested By: DRW **Checked By:** DAS

Draft

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	1.1	2.6	5.6	85.8	4.8	0.1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/2	100.0		
3/8	99.8		
#4	98.9		
#8	97.2		
#10	96.3		
#16	93.8		
#30	91.5		
#40	90.7		
#50	88.9		
#80	64.9		
#100	46.4		
#200	4.9		

* (no specification provided)

Material Description

Gray Fine Sand, Trace Silt, Gravel, and Clay

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 0.3344 D_{85}= 0.2524 D_{60}= 0.1711
D_{50}= 0.1554 D_{30}= 0.1248 D_{15}= 0.0989
D_{10}= 0.0886 C_u= 1.93 C_c= 1.03

Classification

USCS= SP AASHTO= A-3

Remarks

Natural Moisture = 21.4%; Loss-on-Ignition = 0.4%
Specific Gravity = 2.68

Sample Number: SB-2016-05 **Depth:** 5-20'

Date: 2/9/16

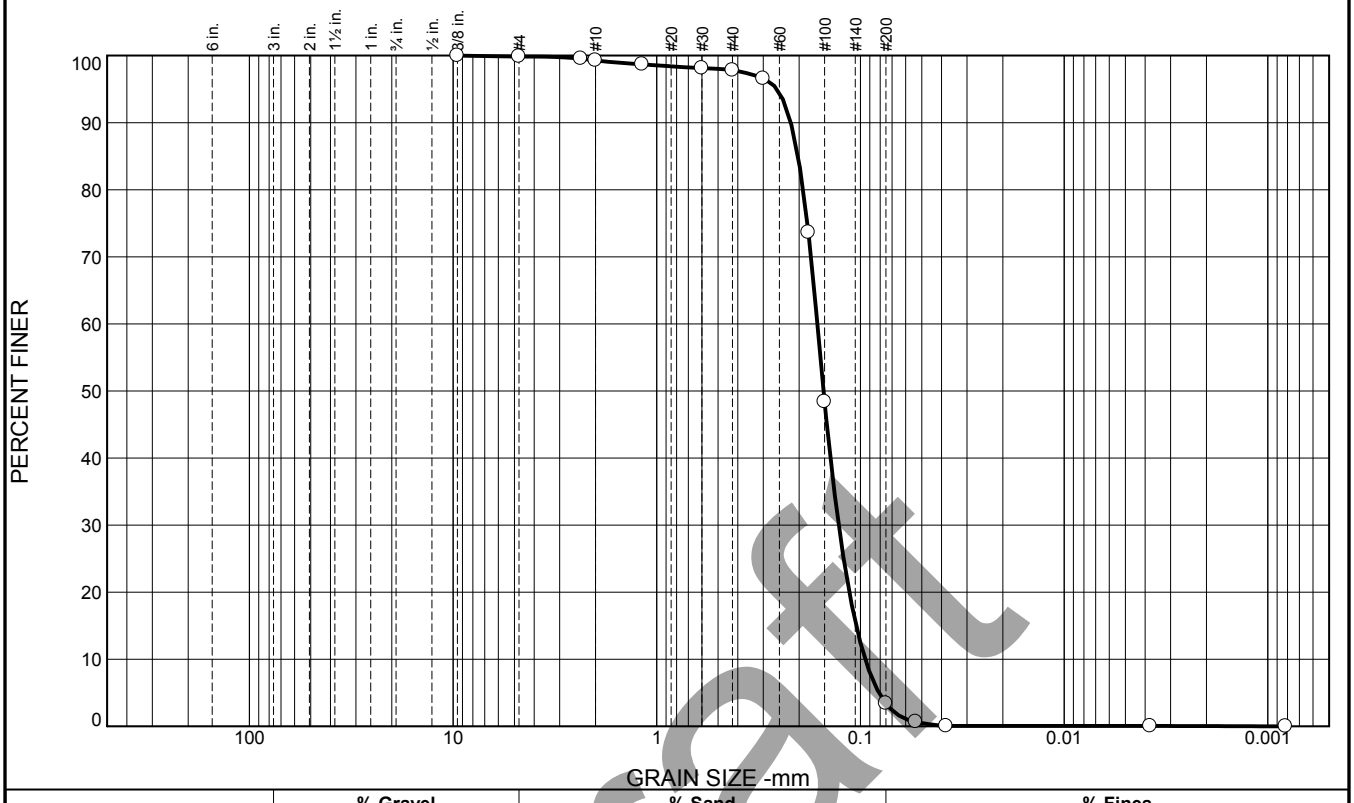
CGC,Inc.

Client: ARCADIS
Project: ECI/East Chicago, IN
ARCADIS# CI001067.1643
Project No: C16033-1 **Figure**

Tested By: DRW **Checked By:** DAS

Draft

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.1	0.6	1.5	94.4	3.3	0.1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/8	100.0		
#4	99.9		
#8	99.5		
#10	99.3		
#16	98.7		
#30	98.1		
#40	97.8		
#50	96.6		
#80	73.6		
#100	48.4		
#200	3.4		

* (no specification provided)

Material Description

Gray Fine Sand, Trace Silt, Gravel, and Clay

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 0.2197 D_{85}= 0.2026 D_{60}= 0.1628
D_{50}= 0.1518 D_{30}= 0.1279 D_{15}= 0.1049
D_{10}= 0.0948 C_u= 1.72 C_c= 1.06

Classification

USCS= SP AASHTO= A-3

Remarks

Natural Moisture = 24.3%; Loss-on-Ignition = 0.4%
Specific Gravity = 2.70

Sample Number: SB-2016-06 **Depth:** 10-20'

Date: 2/9/16

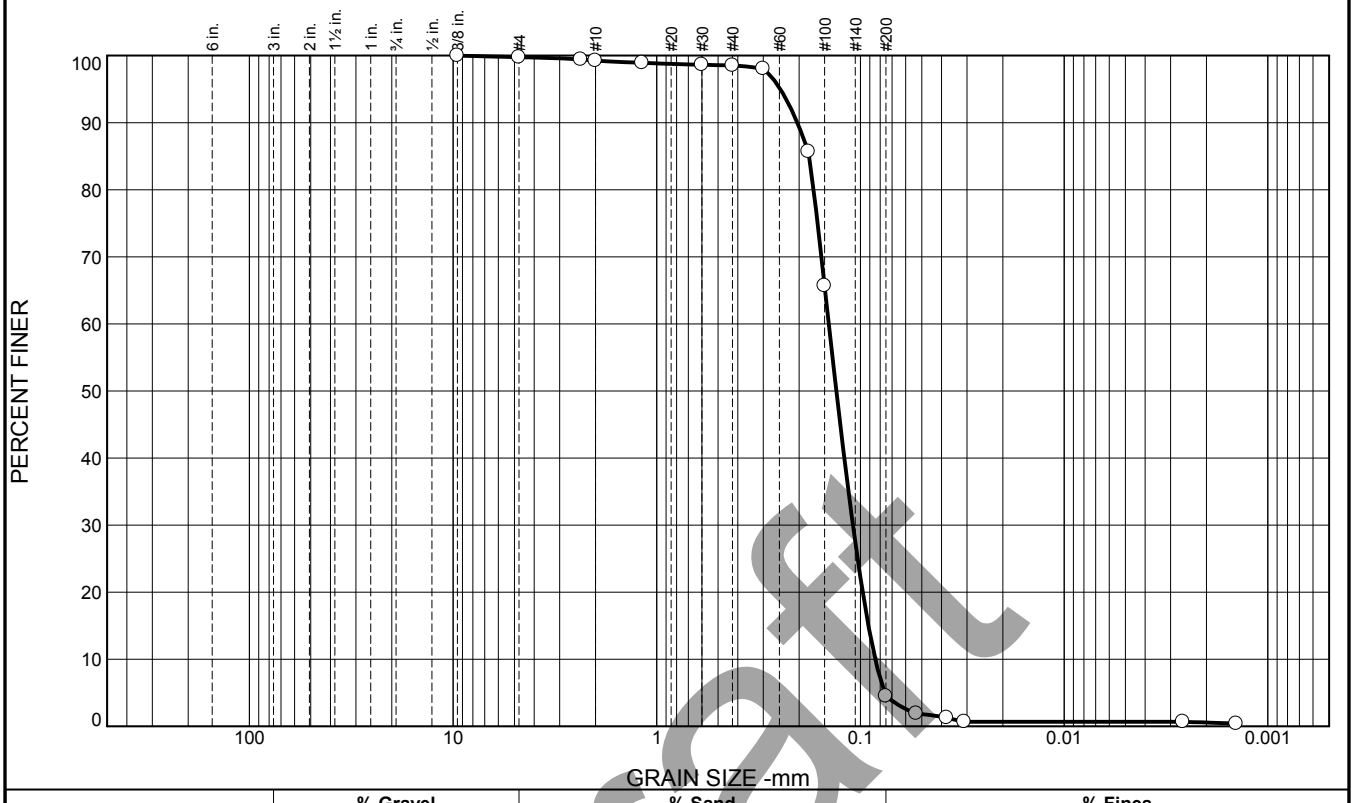
CGC,Inc.

Client: ARCADIS
Project: ECI/East Chicago, IN
ARCADIS# CI001067.1643
Project No: C16033-1 **Figure**

Tested By: DRW **Checked By:** DAS

Draft

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.2	0.6	0.7	94.0	3.8	0.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/8	100.0		
#4	99.8		
#8	99.4		
#10	99.2		
#16	98.9		
#30	98.6		
#40	98.5		
#50	98.1		
#80	85.7		
#100	65.7		
#200	4.5		

* (no specification provided)

Material Description

Gray Fine Sand, Trace Silt, Clay, and Gravel

Atterberg Limits

PL= NP LL= NV PI=

Coefficients

D_{90}= 0.2041 D_{85}= 0.1787 D_{60}= 0.1431
D_{50}= 0.1313 D_{30}= 0.1089 D_{15}= 0.0914
D_{10}= 0.0847 C_u= 1.69 C_c= 0.98

Classification

USCS= SP AASHTO= A-3

Remarks

Natural Moisture = 24.2%; Loss-on-Ignition = 0.5%
Specific Gravity = 2.71

Sample Number: SB-2016-07 **Depth:** 10-20'

Date: 2/10/16

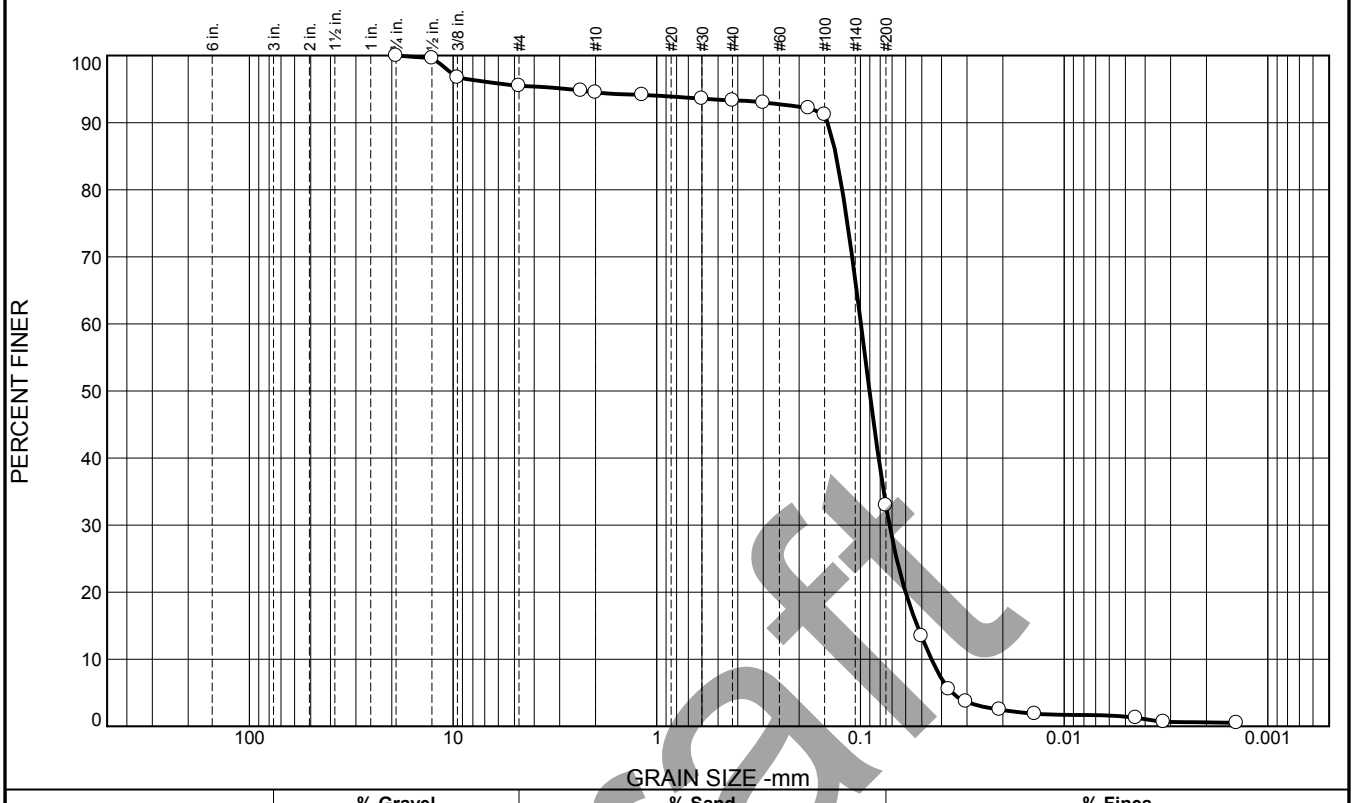
CGC,Inc.

Client: ARCADIS
Project: ECI/East Chicago, IN
ARCADIS# CI001067.1643
Project No: C16033-1 **Figure**

Tested By: DRW **Checked By:** DAS

Draft

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	4.5	1.0	1.2	60.3	31.6	1.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4	100.0		
1/2	99.6		
3/8	96.7		
#4	95.5		
#8	94.8		
#10	94.5		
#16	94.1		
#30	93.6		
#40	93.3		
#50	93.0		
#80	92.2		
#100	91.2		
#200	33.0		

* (no specification provided)

Material Description

Gray Fine Sand, Some Silt, Trace Gravel and Clay

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 0.1445 D_{85}= 0.1314 D_{60}= 0.0995
D_{50}= 0.0903 D_{30}= 0.0720 D_{15}= 0.0526
D_{10}= 0.0448 C_u= 2.22 C_c= 1.16

Classification

USCS= SM AASHTO= A-2-4(0)

Remarks

Natural Moisture = 22.6%; Loss-on-Ignition = 0.8%
Specific Gravity = 2.71

Sample Number: SB-2016-08 **Depth:** 20-30'

Date: 2/10/16

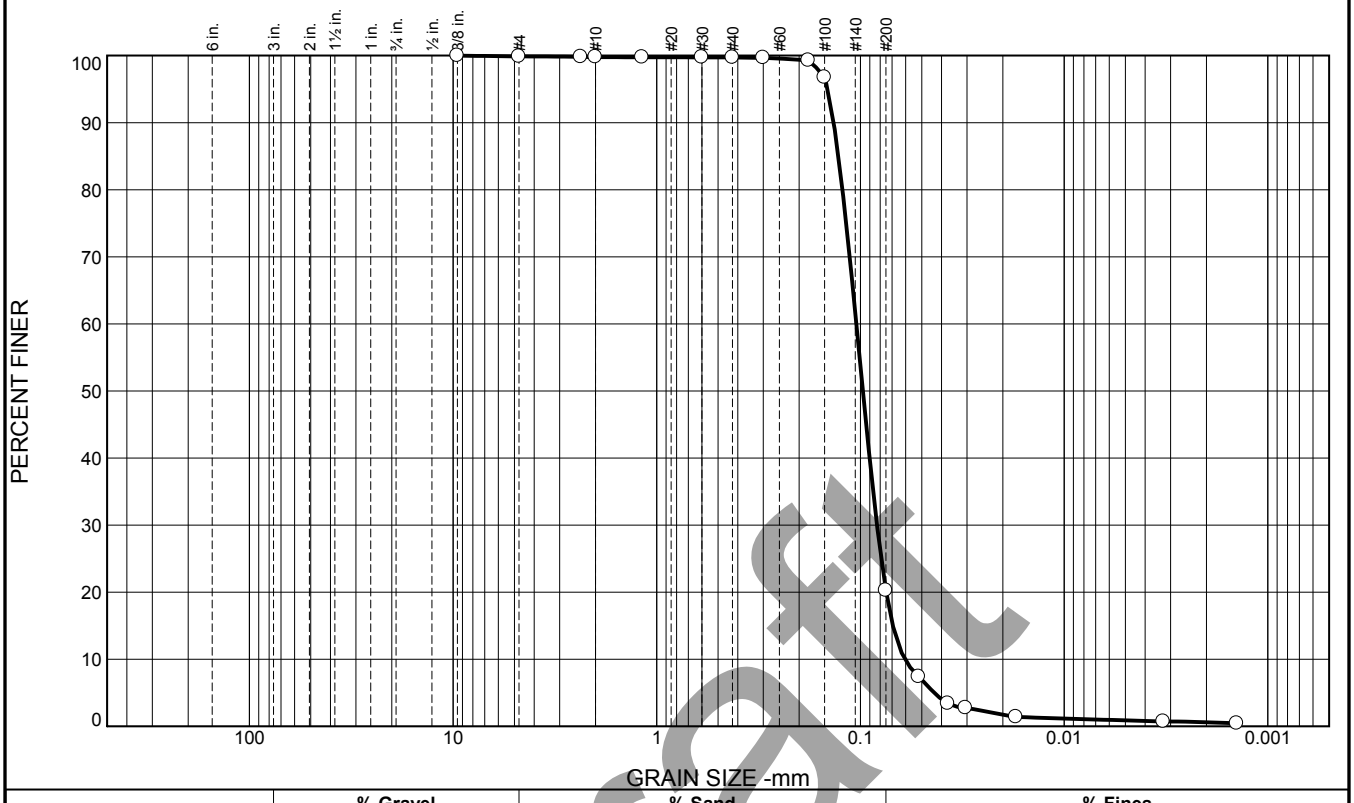
CGC,Inc.

Client: ARCADIS
Project: ECI/East Chicago, IN
ARCADIS# CI001067.1643
Project No: C16033-1 **Figure**

Tested By: DRW **Checked By:** DAS

Draft

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.1	0.1	0.1	79.4	19.4	0.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/8	100.0		
#4	99.9		
#8	99.8		
#10	99.8		
#16	99.8		
#30	99.7		
#40	99.7		
#50	99.7		
#80	99.3		
#100	96.8		
#200	20.3		

* (no specification provided)

Material Description

Gray Fine Sand, Some Silt, Trace Clay and Gravel

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 0.1353 D_{85}= 0.1283 D_{60}= 0.1047
D_{50}= 0.0973 D_{30}= 0.0830 D_{15}= 0.0693
D_{10}= 0.0605 C_u= 1.73 C_c= 1.09

Classification

USCS= SM AASHTO= A-2-4(0)

Remarks

Natural Moisture = 25.6%; Loss-on-Ignition = 0.5%
Specific Gravity = 2.72

Sample Number: SB-2016-09 **Depth:** 15-25'

Date: 2/10/16

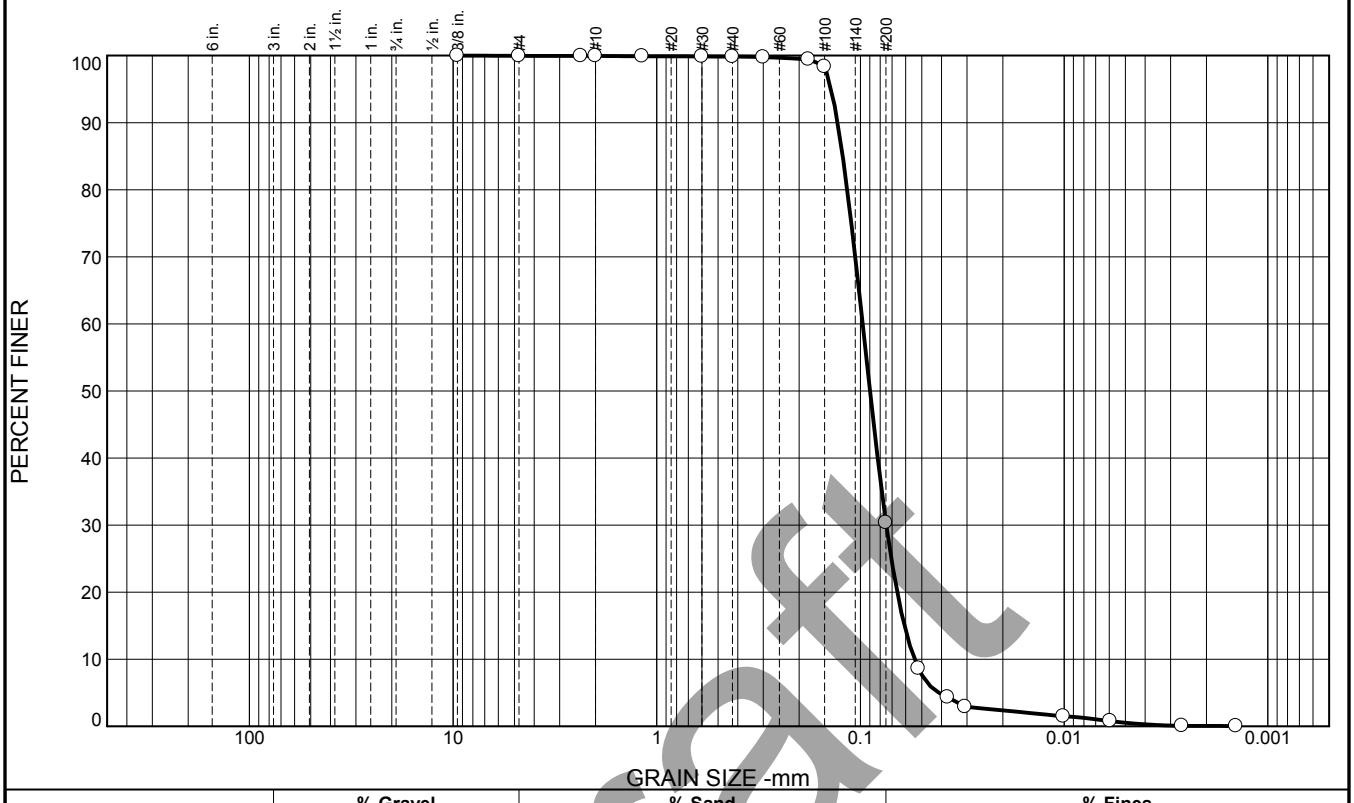
CGC,Inc.

Client: ARCADIS
Project: ECI/East Chicago, IN
ARCADIS# CI001067.1643
Project No: C16033-1 **Figure**

Tested By: DRW **Checked By:** DAS

Draft

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.1	0.1	69.4	29.9	0.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/8	100.0		
#4	100.0		
#8	99.9		
#10	99.9		
#16	99.9		
#30	99.9		
#40	99.8		
#50	99.8		
#80	99.4		
#100	98.3		
#200	30.4		

* (no specification provided)

Material Description

Gray Fine Sand, Some Silt, Trace Clay

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 0.1294 D_{85}= 0.1221 D_{60}= 0.0975
D_{50}= 0.0898 D_{30}= 0.0747 D_{15}= 0.0608
D_{10}= 0.0542 C_u= 1.80 C_c= 1.06

Classification

USCS= SM AASHTO= A-2-4(0)

Remarks

Natural Moisture = 25.7%; Loss-on-Ignition = 0.6%
Specific Gravity = 2.70

Sample Number: SB-2016-10 **Depth:** 20-30'

Date: 2/10/16

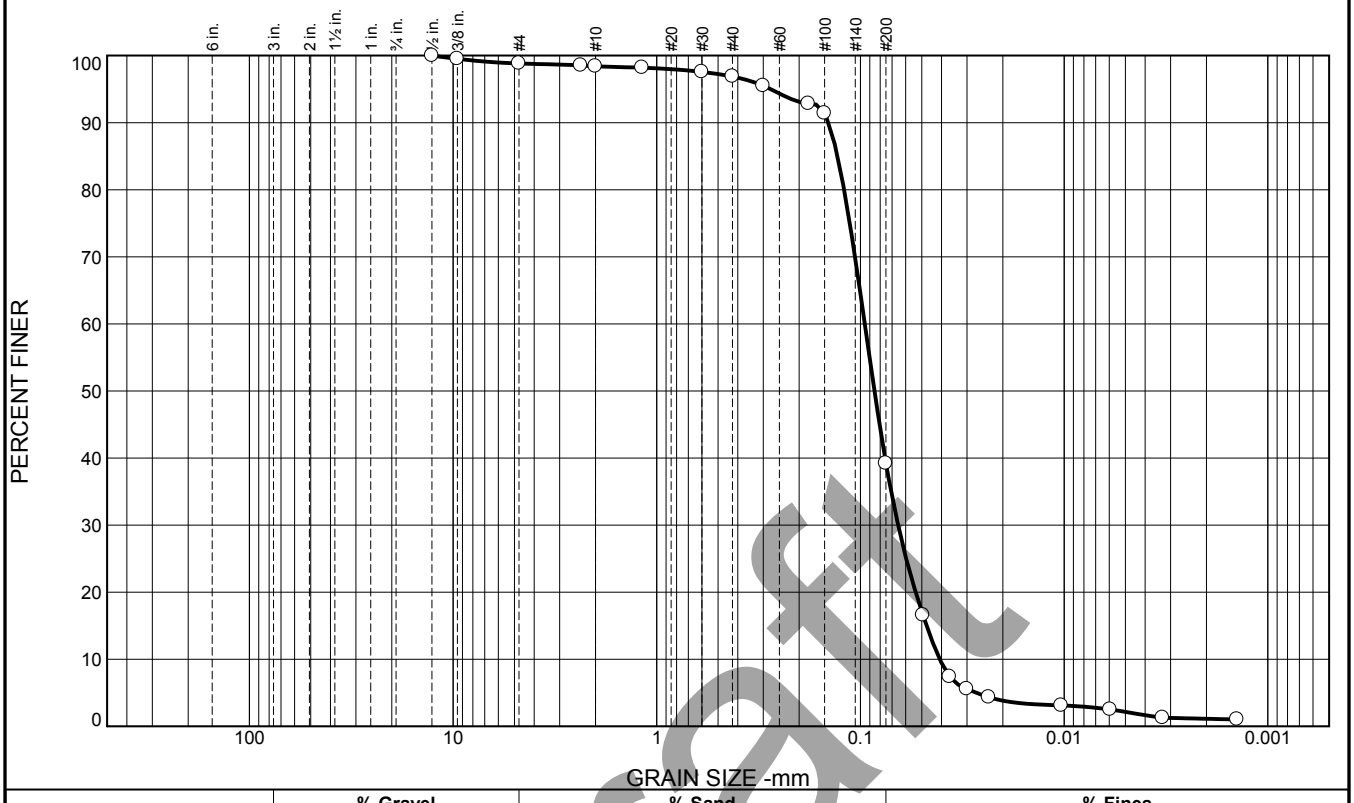
CGC,Inc.

Client: ARCADIS
Project: ECI/East Chicago, IN
ARCADIS# CI001067.1643
Project No: C16033-1 **Figure**

Tested By: DRW **Checked By:** DAS

Draft

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	1.2	0.4	1.5	57.7	37.0	2.2

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/2	100.0		
3/8	99.5		
#4	98.8		
#8	98.5		
#10	98.4		
#16	98.2		
#30	97.6		
#40	96.9		
#50	95.5		
#80	92.8		
#100	91.4		
#200	39.2		

* (no specification provided)

Material Description

Gray Silty Fine Sand, Trace Clay and Gravel

Atterberg Limits

PL= NP LL= NV PI=

Coefficients

D_{90}= 0.1434 D_{85}= 0.1295 D_{60}= 0.0952
D_{50}= 0.0853 D_{30}= 0.0654 D_{15}= 0.0473
D_{10}= 0.0408 C_u= 2.33 C_c= 1.10

Classification

USCS= SM AASHTO= A-4(0)

Remarks

Natural Moisture = 24.3%; Loss-on-Ignition 0.7%
Specific Gravity = 2.72

Sample Number: SB-2016-11 **Depth:** 20-30'

Date: 2/10/16

CGC,Inc.

Client: ARCADIS
Project: ECI/East Chicago, IN
ARCADIS# CI001067.1643
Project No: C16033-1 **Figure**

Tested By: DRW **Checked By:** DAS

Draft

TRC Environmental Corporation

Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH

QA: JPH

Project Name: ECI - E. Chicago, IN.

Project #: C16033-4

Sample Name: SB-02, 34.5-39.5'

Visual Descript: Gray Lean Clay, Trace Sand and Gravel

Cell #: 3

USCS Description: Gray Lean Clay, Trace Sand and Gravel

USCS Classification: CL

Average Kv = 1.7E-07 cm/s

Sample Type: Undisturbed

	Initial Values	Final Values
Sample Dia. (in)	2.85	2.85
Sample Ht. (in)	2.84	2.83
Tare & Wet (g)	596.08	684.20
Tare & Dry (g)	479.77	568.30
Tare (g)	0.00	88.53
Sample Wt. (g)	596.08	595.67
Moisture (%)	24.2	24.2
Wet Density (pcf)	125.6	125.7
Dry Density (pcf)	101.1	101.2
Saturation (%)	99.9	100.0

Permeant: Water

Permeant Specific Gravity: 1.00

Sample Specific Gravity: 2.67 Est.

Confining Pressure (psi): 100.0

Burette Diameter (in): 0.250

Burette Zero (cm): 100.0

Max. Effect. Stress (psi): 6.0

Min. Effect. Stress (psi): 4.3

Ave. Effect. Stress (psi): 5.1

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	3	21	12	14.00		0.0	95	95	30.80		2.00		104.10				
2	2016	3	21	15	15.00	10860	23.0	95	95	32.90	2.10	8.15	6.15	97.40	6.70	-4.3	3.2E-07	
3	2016	3	21	19	33.00	15480	23.0	95	95	34.80	1.90	15.50	7.35	90.60	6.80	3.9	2.9E-07	
4	2016	3	21	21	30.00	7020	23.0	95	95	34.60	-0.20	18.40	2.90	87.80	2.80	1.8	2.9E-07	
5	2016	3	22	5	55.00	30300	25.0	95	95	37.95	3.35	28.20	9.80	78.35	9.45	1.8	2.6E-07	
6	2016	3	22	10	33.00	16680	23.0	95	95	37.90	-0.05	32.30	4.10	74.40	3.95	1.9	2.7E-07	
7	2016	3	22	16	1.00	19680	24.0	95	95	39.20	1.30	36.35	4.05	70.75	3.65	5.2	2.6E-07	
8	2016	3	22	22	31.00	23400	24.0	95	95	39.90	0.70	40.20	3.85	67.30	3.45	5.5	2.6E-07	
9	2016	3	23	4	24.00	21180	25.0	95	95	40.40	0.50	42.85	2.65	64.65	2.65	0.0	2.5E-07	
10	2016	3	23	4	26.00		0.0	95	95	40.40		1.70		103.60				
11	2016	3	23	5	33.00	4020	25.0	95	95	41.15	0.75	4.35	2.65	100.65	2.95	-5.4	3.5E-07	
12	2016	3	23	7	27.00	6840	23.0	95	95	40.95	-0.20	8.45	4.10	96.35	4.30	-2.4	3.4E-07	
13	2016	3	23	9	27.00	7200	23.0	95	95	41.20	0.25	12.50	4.05	92.40	3.95	1.3	3.4E-07	
14	2016	3	23	13	27.00	14400	23.0	95	95	41.45	0.25	19.25	6.75	85.55	6.85	-0.7	3.3E-07	
15	2016	3	23	14	40.00	4380	23.0	95	95	41.75	0.30	21.10	1.85	83.70	1.85	0.0	3.4E-07	
16	2016	3	24	4	50.00	51000	22.0	95	95	43.75	2.00	35.85	14.75	69.10	14.60	0.5	3.3E-07	
17	2016	3	24	10	11.00	19260	25.0	95	95	45.75	2.00	39.30	3.45	66.80	2.30	20.0	2.4E-07	
18	2016	3	24	14	35.00		0.0	95	95	45.30		1.95		103.70				
19	2016	3	24	18	43.00	14880	24.0	95	95	45.40	0.10	10.85	8.90	94.25	9.45	-3.0	3.4E-07	
20	2016	3	25	5	26.00	38580	25.0	95	95	47.25	1.85	26.50	15.65	78.30	15.95	-0.9	3.0E-07	
21	2016	3	25	9	27.00	14460	23.0	95	95	47.40	0.15	30.65	4.15	74.40	3.90	3.1	3.0E-07	
22	2016	3	25	11	22.00	6900	23.0	95	95	47.50	0.10	32.35	1.70	72.70	1.70	0.0	3.0E-07	
23	2016	3	25	14	26.00	11040	23.0	95	95	47.50	0.00	34.80	2.45	70.25	2.45	0.0	3.0E-07	
24	2016	3	28	4	8.00		0.0	95	95	52.40		1.70		103.80				
25	2016	3	28	8	37.00	16140	23.0	95	95	53.20	0.80	10.65	8.95	94.25	9.55	-3.2	3.2E-07	
26	2016	3	28	11	9.00	9120	23.0	95	95	53.00	-0.20	14.75	4.10	90.00	4.25	-1.8	3.0E-07	

**A zero in this column starts a series of measurements.

*Average Kv for those rows with a 1 in the Ave. column.

(Termination determined by stable Kv and low flow differential.)

***Kv adjusted for temperature.

Draft

TRC Environmental Corporation

Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH

QA: JPH

Project Name:	ECI - E. Chicago, IN.	Cell #:	3
Project #:	C16033-1	USCS Description:	Gray Lean Clay, Trace Sand and Gravel
Sample Name:	SB-02, 34.5-39.5'	USCS Classification:	CL
Visual Descript:	Gray Lean Clay, Trace Sand and Gravel		

		Initial Values	Final Values			
Sample Type:	Undisturbed					
Sample Dia. (in)		2.85	2.85	Permeant:	Water	
Sample Ht. (in)		2.84	2.83	Permeant Specific Gravity:	1.00	
Tare & Wet (g)		596.08	684.20	Sample Specific Gravity:	2.67	Est.
Tare & Dry (g)		479.77	568.30	Confining Pressure (psi):	100.0	
Tare (g)		0.00	88.53	Burette Diameter (in):	0.250	
Sample Wt. (g)		596.08	595.67	Burette Zero (cm):	100.0	
Moisture (%)		24.2	24.2	Maximum Gradient:	7.3	
Wet Density (pcf)		125.6	125.7	Average Gradient:	5.4	
Dry Density (pcf)		101.1	101.2	Max. Effect. Stress (psi):	5.7	
Saturation (%)		99.9	100.0	Min. Effect. Stress (psi):	4.1	
				Ave. Effect. Stress (psi):	4.9	

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°***	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	3	28	11	9.00		0.0	95	95	53.00		14.75		90.00				
2	2016	3	28	15	5.00	14160	23.0	95	95	53.10	0.10	20.40	5.65	84.20	5.80	-1.3	3.0E-07	
3	2016	3	29	5	14.00	50940	24.0	95	95	53.80	0.70	34.25	13.85	70.25	13.95	-0.4	2.8E-07	
4	2016	3	29	10	2.00	17280	23.0	95	95	54.05	0.25	37.35	3.10	67.05	3.20	-1.6	2.9E-07	
5	2016	3	29	14	41.00	16740	23.0	95	95	54.35	0.30	39.85	2.50	64.70	2.35	3.1	2.7E-07	
6	2016	3	30	5	8.00		0.0	95	95	55.40		1.70		103.50				
7	2016	3	30	11	52.00	24240	23.0	95	95	55.60	0.20	13.65	11.95	90.65	12.85	-3.6	3.0E-07	
8	2016	3	30	14	54.00	10920	23.0	95	95	55.90	0.30	17.95	4.30	86.25	4.40	-1.1	2.8E-07	
9	2016	3	31	5	33.00	52740	23.0	95	95	57.15	1.25	32.35	14.40	71.75	14.50	-0.3	2.7E-07	
10	2016	3	31	11	59.00	23160	23.0	95	95	57.50	0.35	36.50	4.15	67.70	4.05	1.2	2.6E-07	
11	2016	3	31	21	7.00	32880	23.0	95	95	58.05	0.55	40.80	4.30	63.35	4.35	-0.6	2.5E-07	
12	2016	4	1	5	26.00		0.0	95	95	58.30		1.60		103.50				
13	2016	4	1	9	43.00	15420	23.0	95	95	58.60	0.30	8.70	7.10	95.65	7.85	-5.0	2.6E-07	
14	2016	4	1	18	14.00	30660	23.0	95	95	58.50	-0.10	19.60	10.90	84.70	10.95	-0.2	2.4E-07	
15	2016	4	4	5	46.00		0.0	95	95	62.80		1.80		103.25				
16	2016	4	4	8	48.00	10920	24.0	95	95	62.40	-0.40	6.25	4.45	98.20	5.05	-6.3	2.3E-07	
17	2016	4	4	12	5.00	11820	24.0	95	95	61.80	-0.60	10.40	4.15	93.85	4.35	-2.4	2.1E-07	
18	2016	4	4	19	53.00	28080	24.0	95	95	61.85	0.05	18.60	8.20	85.55	8.30	-0.6	2.0E-07	
19	2016	4	5	5	5.00	33120	21.0	95	95	61.70	-0.15	25.85	7.25	78.10	7.45	-1.4	2.0E-07	
20	2016	4	5	10	1.00	17760	23.0	95	95	62.75	1.05	29.00	3.15	75.05	3.05	1.6	1.8E-07	1
21	2016	4	5	13	49.00	13680	23.0	95	95	62.30	-0.45	31.00	2.00	72.90	2.15	-3.6	1.8E-07	1
22	2016	4	5	19	23.00	20040	23.0	95	95	62.70	0.40	33.70	2.70	70.35	2.55	2.9	1.7E-07	1
23	2016	4	6	5	7.00	35040	25.0	95	95	63.80	1.10	37.35	3.65	66.55	3.80	-2.0	1.6E-07	1
24	2016	4	6	6	47.00	6000	25.0	95	95	63.80	0.00	37.95	0.60	66.10	0.45	14.3	1.5E-07	1
25																		
26																		

**A zero in this column starts a series of measurements.

*Average Kv for those rows with a 1 in the Ave. column.

1.7E-07 cm/s

(Termination determined by stable Kv and low flow differential.)

***Kv adjusted for temperature.

Draft

TRC Environmental Corporation

Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH

QA: JPH

Project Name:	ECI - E. Chicago, IN.	Cell #:	9
Project #:	C16033-4	USCS Description:	Gray Lean Clay, Trace Sand and Gravel
Sample Name:	SB-04, 34.5-39.5'	USCS Classification:	CL
Visual Descript:	Gray Lean Clay, Trace Sand and Gravel	Average Kv =	1.4E-08 cm/s

		Initial Values	Final Values			
Sample Type:	Undisturbed					
Sample Dia. (in)		2.87	2.87	Permeant:	Water	
Sample Ht. (in)		1.72	1.72	Permeant Specific Gravity:	1.00	
Tare & Wet (g)		383.08	470.50	Sample Specific Gravity:	2.78	Est.
Tare & Dry (g)		313.36	401.20	Confining Pressure (psi):	100.0	
Tare (g)		0.00	87.84	Burette Diameter (in):	0.250	
Sample Wt. (g)		383.08	382.66	Burette Zero (cm):	100.0	
Moisture (%)		22.2	22.1	Maximum Gradient:	12.7	
Wet Density (pcf)		130.9	131.2	Average Gradient:	11.8	
Dry Density (pcf)		107.1	107.4	Max. Effect. Stress (psi):	5.9	
Saturation (%)		99.8	100.0	Min. Effect. Stress (psi):	4.4	
				Ave. Effect. Stress (psi):	4.9	

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	3	28	15	5.00		0.0	95	95	39.85		2.35		101.65				
2	2016	3	29	5	15.00	51000	24.0	95	95	47.60	7.75	5.45	3.10	97.85	3.80	-10.1	2.1E-08	
3	2016	3	29	10	2.00	17220	23.0	95	95	48.60	1.00	6.30	0.85	97.05	0.80	3.0	1.6E-08	
4	2016	3	29	14	43.00	16860	23.0	95	95	49.75	1.15	7.20	0.90	96.30	0.75	9.1	1.7E-08	
5	2016	3	30	5	3.00	51600	24.0	95	95	52.20	2.45	9.65	2.45	94.15	2.15	6.5	1.5E-08	
6	2016	3	30	11	53.00	24600	23.0	95	95	53.20	1.00	10.75	1.10	93.15	1.00	4.8	1.6E-08	
7	2016	3	30	14	54.00	10860	23.0	95	95	53.75	0.55	11.25	0.50	92.75	0.40	11.1	1.6E-08	
8	2016	3	31	5	35.00	52860	23.0	95	95	55.70	1.95	13.40	2.15	90.85	1.90	6.2	1.5E-08	
9	2016	3	31	12	1.00	23160	23.0	95	95	56.40	0.70	14.40	1.00	90.20	0.65	21.2	1.4E-08	
10	2016	3	31	21	10.00	32940	24.0	95	95	57.30	0.90	15.60	1.20	89.05	1.15	2.1	1.5E-08	
11	2016	4	1	5	21.00	29460	23.0	95	95	57.75	0.45	16.60	1.00	88.00	1.05	-2.4	1.5E-08	
12	2016	4	1	9	41.00	15600	23.0	95	95	58.15	0.40	17.15	0.55	87.50	0.50	4.8	1.5E-08	
13	2016	4	1	18	15.00	30840	23.0	95	95	58.55	0.40	18.25	1.10	86.50	1.00	4.8	1.5E-08	
14	2016	4	4	5	39.00	213840	25.0	95	95	62.00	3.45	24.60	6.35	80.50	6.00	2.8	1.4E-08	
15	2016	4	4	8	47.00	11280	24.0	95	95	61.90	-0.10	24.90	0.30	80.20	0.30	0.0	1.4E-08	
16	2016	4	4	12	4.00	11820	24.0	95	95	61.85	-0.05	25.20	0.30	79.85	0.35	-7.7	1.5E-08	1
17	2016	4	4	19	54.00	28200	24.0	95	95	62.05	0.20	25.95	0.75	79.30	0.55	15.4	1.3E-08	1
18	2016	4	5	5	3.00	32940	21.0	95	95	62.15	0.10	26.70	0.75	78.40	0.90	-9.1	1.5E-08	1
19	2016	4	5	10	0.00	17820	23.0	95	95	62.70	0.55	27.25	0.55	78.05	0.35	22.2	1.5E-08	1
20	2016	4	5	13	47.00	13620	23.0	95	95	62.70	0.00	27.55	0.30	77.70	0.35	-7.7	1.5E-08	1
21	2016	4	5	19	25.00	20280	23.0	95	95	63.10	0.40	28.10	0.55	77.40	0.30	29.4	1.3E-08	1
22	2016	4	6	5	6.00	34860	25.0	95	95	63.80	0.70	28.90	0.80	76.55	0.85	-3.0	1.4E-08	1
23																		
24																		
25																		
26																		

**A zero in this column starts a series of measurements.

*Average Kv for those rows with a 1 in the Ave. column. 1.4E-08 cm/s

(Termination determined by stable Kv and low flow differential.)

***Kv adjusted for temperature.

Draft

TRC Environmental Corporation

Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH

QA: JPH

Project Name: ECI - E. Chicago, IN.

Project #: C16033-1

Sample Name: SB-08, 33-38'

Visual Descript: Gray Lean Clay, Little Sand, Trace Gravel

Cell #: 10

USCS Description: Gray Lean Clay, Little Sand, Trace Gravel

USCS Classification: CL

Average Kv = 1.6E-07 cm/s

Sample Type: Undisturbed

	Initial Values	Final Values
Sample Dia. (in)	2.86	2.85
Sample Ht. (in)	2.57	2.56
Tare & Wet (g)	540.03	797.50
Tare & Dry (g)	428.51	687.40
Tare (g)	0.00	258.89
Sample Wt. (g)	540.03	538.61
Moisture (%)	26.0	25.7
Wet Density (pcf)	125.0	125.5
Dry Density (pcf)	99.2	99.9
Saturation (%)	99.7	100.0

Permeant: Water

Permeant Specific Gravity: 1.00

Sample Specific Gravity: 2.72 Est.

Confining Pressure (psi): 100.0

Burette Diameter (in): 0.250

Burette Zero (cm): 100.0

Max. Effect. Stress (psi): 5.6

Min. Effect. Stress (psi): 3.9

Ave. Effect. Stress (psi): 4.6

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	3	31	5	38.00		0.0	95	95	62.20		2.70		101.65				
2	2016	3	31	12	3.00	23100	23.0	95	95	64.10	1.90	40.45	37.75	63.85	37.80	-0.1	1.5E-06	
3	2016	3	31	18	8.00	21900	23.0	95	95	65.35	1.25	48.60	8.15	55.90	7.95	1.2	1.2E-06	
4	2016	3	31	21	9.00	10860	23.0	95	95	65.85	0.50	50.25	1.65	54.30	1.60	1.5	1.3E-06	
5	2016	4	1	5	23.00		0.0	95	95	67.85		2.05		102.90				
6	2016	4	1	9	41.00	15480	23.0	95	95	68.40	0.55	22.40	20.35	82.00	20.90	-1.3	7.9E-07	
7	2016	4	1	18	16.00	30900	23.0	95	95	69.70	1.30	37.40	15.00	67.30	14.70	1.0	5.2E-07	
8	2016	4	4	5	42.00		0.0	95	95	75.30		1.60		100.10				
9	2016	4	4	8	47.00	11100	24.0	95	95	73.80	-1.50	10.65	9.05	91.10	9.00	0.3	4.2E-07	
10	2016	4	4	12	4.00	11820	24.0	95	95	73.90	0.10	17.35	6.70	84.30	6.80	-0.7	3.5E-07	
11	2016	4	4	19	55.00	28260	24.0	95	95	74.10	0.20	28.00	10.65	74.05	10.25	1.9	3.0E-07	
12	2016	4	5	5	4.00	32940	21.0	95	95	76.25	2.15	34.30	6.30	67.35	6.70	-3.1	2.5E-07	
13	2016	4	5	10	0.00	17760	23.0	95	95	75.10	-1.15	37.15	2.85	65.15	2.20	12.9	2.2E-07	
14	2016	4	5	13	48.00	13680	23.0	95	95	75.50	0.40	38.70	1.55	63.45	1.70	-4.6	2.1E-07	
15	2016	4	6	5	9.00		0.0	95	95	77.50		1.65		103.60				
16	2016	4	6	8	12.00	10980	24.0	95	95	77.00	-0.50	7.30	5.65	97.55	6.05	-3.4	2.5E-07	
17	2016	4	6	11	14.00	10920	23.0	95	95	77.00	0.00	12.05	4.75	92.75	4.80	-0.5	2.4E-07	
18	2016	4	6	14	15.00	10860	23.0	95	95	77.40	0.40	16.10	4.05	88.80	3.95	1.2	2.2E-07	
19	2016	4	6	19	57.00	20520	23.0	95	95	77.40	0.00	22.75	6.65	82.40	6.40	1.9	2.2E-07	
20	2016	4	7	4	59.00	32520	23.0	95	95	78.40	1.00	29.90	7.15	75.25	7.15	0.0	2.0E-07	
21	2016	4	7	8	8.00	11340	24.0	95	95	78.30	-0.10	31.90	2.00	73.50	1.75	6.7	1.7E-07	
22	2016	4	7	11	38.00	12600	23.0	95	95	78.30	0.00	33.80	1.90	71.55	1.95	-1.3	1.8E-07	
23	2016	4	8	0	38.00	46800	23.0	95	95	79.30	1.00	38.70	4.90	66.75	4.80	1.0	1.5E-07	
24	2016	4	8	4	55.00	15420	23.0	95	95	80.25	0.95	39.55	0.85	65.65	1.10	-12.8	1.1E-07	
25	2016	4	8	4	57.00		0.0	95	95	80.30		1.65		102.90				
26	2016	4	8	7	55.00	10680	23.0	95	95	79.40	-0.90	5.65	4.00	99.00	3.90	1.3	1.8E-07	

**A zero in this column starts a series of measurements.

(Termination determined by stable Kv and low flow differential.)

*Average Kv for those rows with a 1 in the Ave. column.

***Kv adjusted for temperature.

Draft

TRC Environmental Corporation

Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH

QA: JPH

Project Name:	ECI - E. Chicago, IN.	Cell #:	10
Project #:	C16033-1	USCS Description:	Gray Lean Clay, Little Sand, Trace Gravel
Sample Name:	SB-08, 33-38'	USCS Classification:	CL
Visual Descript:	Gray Lean Clay, Little Sand, Trace Gravel		

Sample Type:	Undisturbed	Initial Values	Final Values		
Sample Dia. (in)		2.86	2.85	Permeant:	Water
Sample Ht. (in)		2.57	2.56	Permeant Specific Gravity:	1.00
Tare & Wet (g)		540.03	797.50	Sample Specific Gravity:	2.72 Est.
Tare & Dry (g)		428.51	687.40	Confining Pressure (psi):	100.0
Tare (g)		0.00	258.89	Burette Diameter (in):	0.250
Sample Wt. (g)		540.03	538.61	Burette Zero (cm):	100.0
Moisture (%)		26.0	25.7	Maximum Gradient:	15.6
Wet Density (pcf)		125.0	125.5	Average Gradient:	11.3
Dry Density (pcf)		99.2	99.9	Max. Effect. Stress (psi):	6.1
Saturation (%)		99.7	100.0	Min. Effect. Stress (psi):	4.0
				Ave. Effect. Stress (psi):	4.7

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	4	8	7	55.00		0.0	95	95	79.40		5.65		99.80				
2	2016	4	8	10	59.00	11040	23.0	95	95	79.60	0.20	9.20	3.55	95.20	3.80	-3.4	1.7E-07	
3	2016	4	8	13	57.00	10680	23.0	95	95	79.80	0.20	12.35	3.15	92.10	3.10	0.8	1.6E-07	
4	2016	4	8	18	13.00	15360	23.0	95	95	79.90	0.10	16.20	3.85	88.30	3.80	0.7	1.5E-07	
5	2016	4	11	4	3.00	208200	24.0	95	95	84.30	4.40	37.00	20.80	67.90	20.40	1.0	9.3E-08	
6	2016	4	11	4	5.00		0.0	95	95	24.70		1.85		103.55				
7	2016	4	11	7	8.00	10980	23.0	95	95	24.65	-0.05	5.30	3.45	99.50	4.05	-8.0	1.6E-07	1
8	2016	4	11	13	38.00	23400	23.0	95	95	24.95	0.30	12.30	7.00	92.35	7.15	-1.1	1.6E-07	1
9	2016	4	11	16	38.00	10800	23.0	95	95	24.85	-0.10	15.30	3.00	89.50	2.85	2.6	1.6E-07	1
10	2016	4	11	22	44.00	21960	23.0	95	95	24.95	0.10	20.70	5.40	84.10	5.40	0.0	1.7E-07	1
11	2016	4	12	5	0.00	22560	22.0	95	95	26.25	1.30	24.75	4.05	79.75	4.35	-3.6	1.5E-07	1
12	2016	4	12	8	10.00	11400	24.0	95	95	25.50	-0.75	26.75	2.00	78.15	1.60	11.1	1.4E-07	1
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		
21																		
22																		
23																		
24																		
25																		
26																		

**A zero in this column starts a series of measurements.

*Average Kv for those rows with a 1 in the Ave. column.

1.6E-07 cm/s

(Termination determined by stable Kv and low flow differential.)

***Kv adjusted for temperature.

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TRC Environmental Corporation

Falling Head, Rising Tailwater Permeability Test (ASTM D5084, Method C)

QC: JPH

QA: JPH

Project Name:	ECI - E. Chicago, IN.	Cell #:	11
Project #:	C16033-1	USCS Description:	Gray Lean Clay, Little Sand
Sample Name:	SB-11, 32-37'	USCS Classification:	CL
Visual Descript:	Gray Lean Clay, Little Sand	Average Kv =	4.1E-08 cm/s

		Initial Values	Final Values			
Sample Type:	Undisturbed					
Sample Dia. (in)		2.84	2.84	Permeant:	Water	
Sample Ht. (in)		2.13	2.13	Permeant Specific Gravity:	1.00	
Tare & Wet (g)		463.82	557.10	Sample Specific Gravity:	2.75	Est.
Tare & Dry (g)		382.08	475.50	Confining Pressure (psi):	100.0	
Tare (g)		0.00	93.42	Burette Diameter (in):	0.250	
Sample Wt. (g)		463.82	463.68	Burette Zero (cm):	100.0	
Moisture (%)		21.4	21.4	Maximum Gradient:	9.1	
Wet Density (pcf)		131.0	131.2	Average Gradient:	7.7	
Dry Density (pcf)		107.9	108.1	Max. Effect. Stress (psi):	5.9	
Saturation (%)		99.5	100.0	Min. Effect. Stress (psi):	4.2	
				Ave. Effect. Stress (psi):	4.9	

	Date			Time		Run	Temp	Pressure (psi)		Cham	Cham.	Bot	Bot.	Top	Top	Flow	Kv ***	Ave.*
	Yr.	Mo.	Day	Hr.	Min.	Time (s)	C°**	Bot	Top	(cm)	Dif.(cm)	(cm)	Dif.(cm)	(cm)	Dif.(cm)	Dif.(%)	cm/s	0,1
1	2016	3	31	5	39.00		0.0	95	95	40.60		2.85		102.30				
2	2016	3	31	11	58.00	22740	23.0	95	95	43.05	2.45	36.40	33.55	67.85	34.45	-1.3	9.9E-07	
3	2016	3	31	18	7.00	22140	23.0	95	95	45.05	2.00	43.50	7.10	60.85	7.00	0.7	5.2E-07	
4	2016	3	31	21	6.00	10740	23.0	95	95	45.85	0.80	45.20	1.70	59.20	1.65	1.5	3.9E-07	
5	2016	4	1	5	26.00		0.0	95	95	47.70		1.60		102.70				
6	2016	4	1	9	42.00	15360	23.0	95	95	48.40	0.70	21.10	19.50	82.55	20.15	-1.6	6.3E-07	
7	2016	4	1	18	13.00	30660	23.0	95	95	49.95	1.55	35.50	14.40	70.00	12.55	6.9	3.7E-07	
8	2016	4	4	5	44.00		0.0	95	95	58.60		1.15		102.75				
9	2016	4	4	8	47.00	10980	24.0	95	95	58.70	0.10	5.15	4.00	99.85	2.90	15.9	1.2E-07	
10	2016	4	4	12	5.00	11880	24.0	95	95	58.80	0.10	8.50	3.35	97.65	2.20	20.7	9.7E-08	
11	2016	4	4	19	52.00	28020	24.0	95	95	59.35	0.55	14.45	5.95	91.90	5.75	1.7	9.6E-08	
12	2016	4	5	5	5.00	33180	21.0	95	95	59.70	0.35	19.55	5.10	86.55	5.35	-2.4	8.9E-08	
13	2016	4	5	10	0.00	17700	23.0	95	95	60.50	0.80	21.75	2.20	84.45	2.10	2.3	7.3E-08	
14	2016	4	5	13	49.00	13740	23.0	95	95	60.80	0.30	23.15	1.40	83.05	1.40	0.0	6.5E-08	
15	2016	4	5	19	22.00	19980	23.0	95	95	61.30	0.50	25.10	1.95	81.20	1.85	2.6	6.4E-08	
16	2016	4	6	5	6.00	35040	25.0	95	95	62.30	1.00	27.80	2.70	78.35	2.85	-2.7	5.5E-08	
17	2016	4	6	8	12.00	11160	24.0	95	95	62.80	0.50	28.55	0.75	77.70	0.65	7.1	4.8E-08	
18	2016	4	6	11	14.00	10920	23.0	95	95	63.15	0.35	29.25	0.70	77.00	0.70	0.0	5.2E-08	1
19	2016	4	6	14	12.00	10680	23.0	95	95	63.40	0.25	29.85	0.60	76.40	0.60	0.0	4.6E-08	1
20	2016	4	6	19	55.00	20580	23.0	95	95	64.00	0.60	30.90	1.05	75.40	1.00	2.4	4.3E-08	1
21	2016	4	7	5	0.00	32700	23.0	95	95	64.70	0.70	32.40	1.50	73.80	1.60	-3.2	4.3E-08	1
22	2016	4	7	8	9.00	11340	24.0	95	95	65.10	0.40	32.85	0.45	73.45	0.35	12.5	3.3E-08	1
23	2016	4	7	11	38.00	12540	23.0	95	95	65.20	0.10	33.30	0.45	72.95	0.50	-5.3	3.7E-08	1
24	2016	4	7	24	35.00	46620	23.0	95	95	65.80	0.60	35.10	1.80	71.20	1.75	1.4	3.9E-08	1
25	2016	4	8	4	56.00	15660	23.0	95	95	66.05	0.25	35.60	0.50	70.60	0.60	-9.1	3.8E-08	1
26																		

**A zero in this column starts a series of measurements.

*Average Kv for those rows with a 1 in the Ave. column. 4.1E-08 cm/s

(Termination determined by stable Kv and low flow differential.)

***Kv adjusted for temperature.

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CONSOLIDATION TEST REPORT

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Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
97.8 %	24.0 %	103.4			2.75	CL		0.674

MATERIAL DESCRIPTION

Gray Lean Clay, Trace Sand and Gravel

Project No. C16033-1 **Client:**

Project: ECI - E. Chicago, IN.

Source: SB-02 **Sample No.:** SB-02, 34.5-39.5'

TRC Environmental Corp.

Madison, Wisconsin

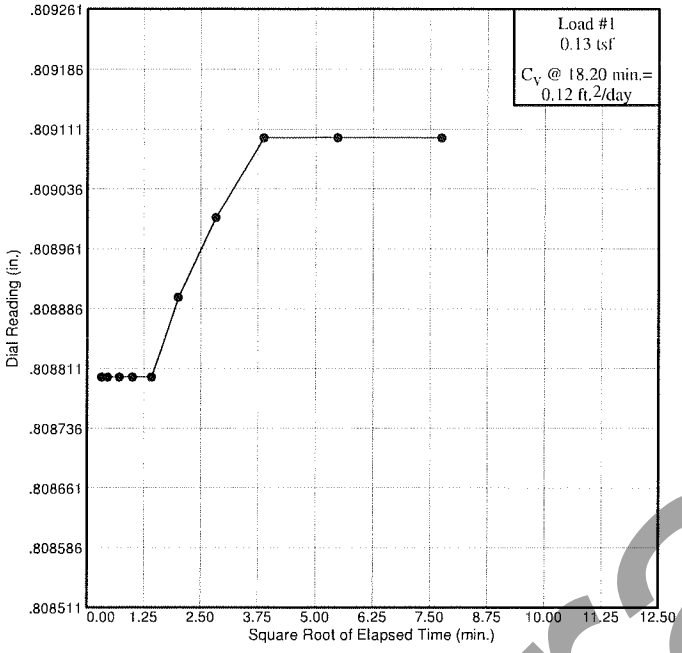
Remarks:

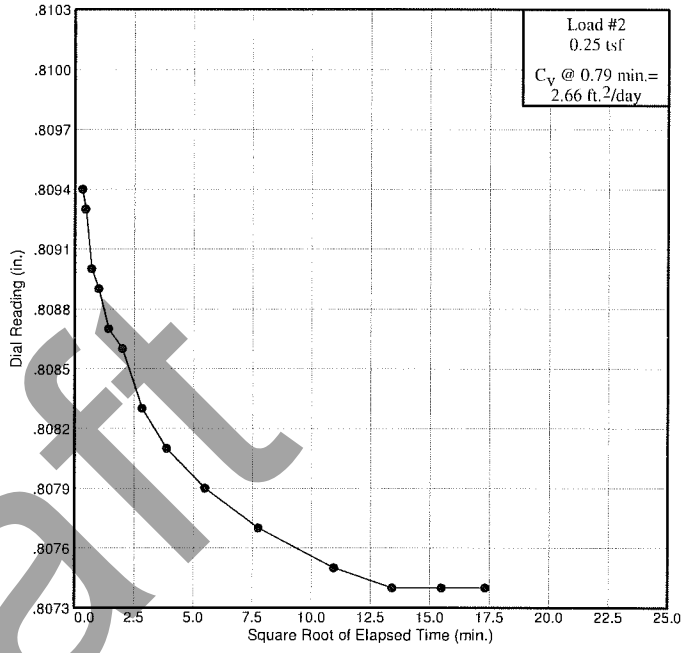
Figure

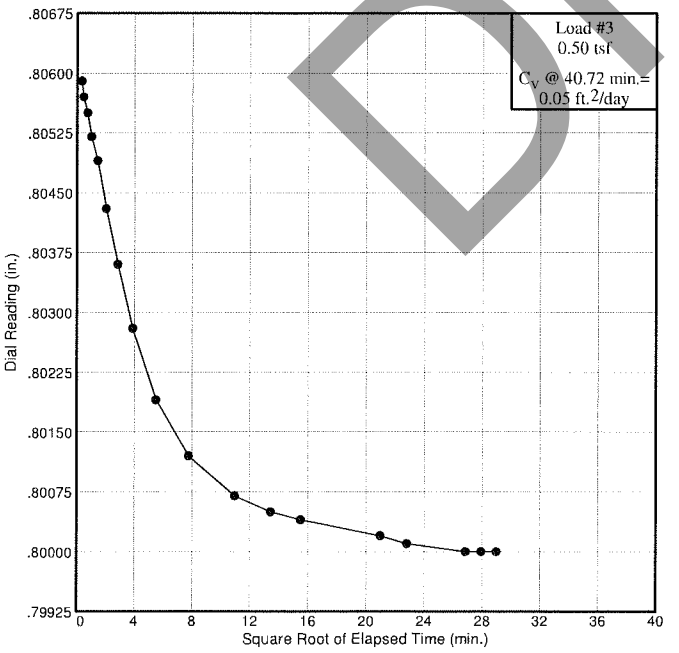
Dial Reading vs. Time

Project No.: C16033-1
Project: ECI - E. Chicago, IN.

Source: SB-02 Sample No.: SB-02, 34.5-39.5'







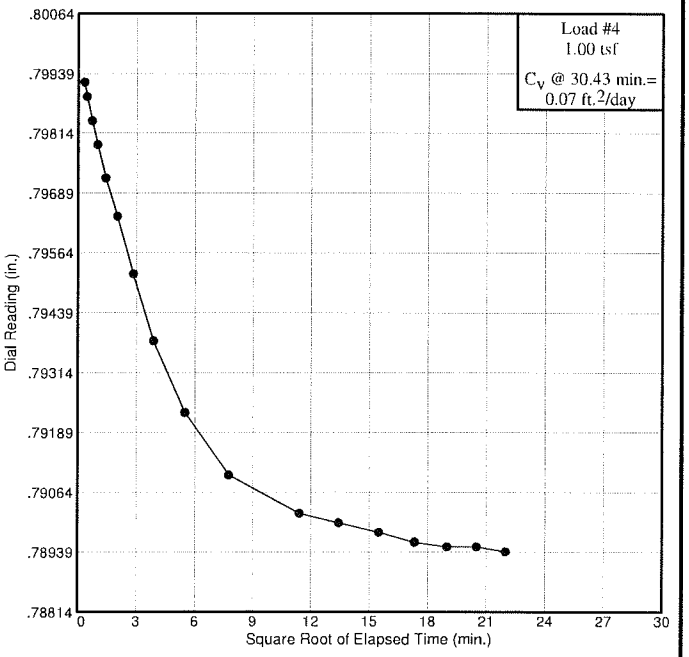


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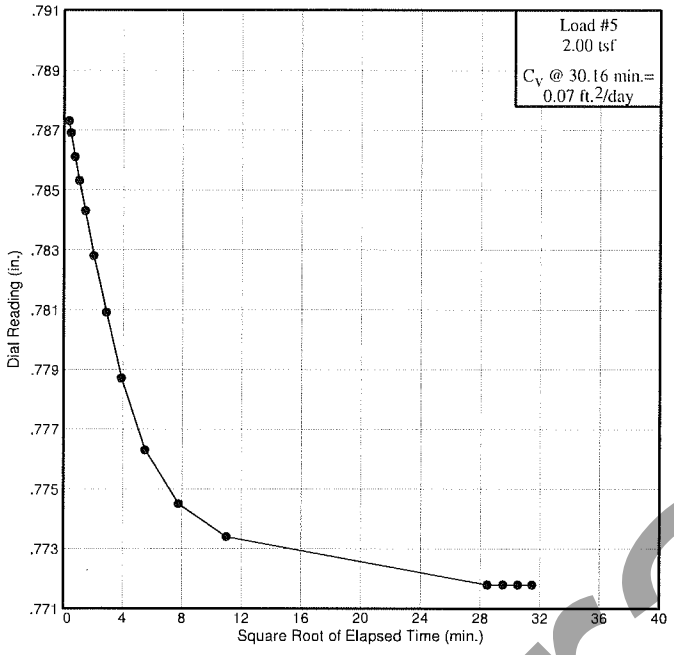
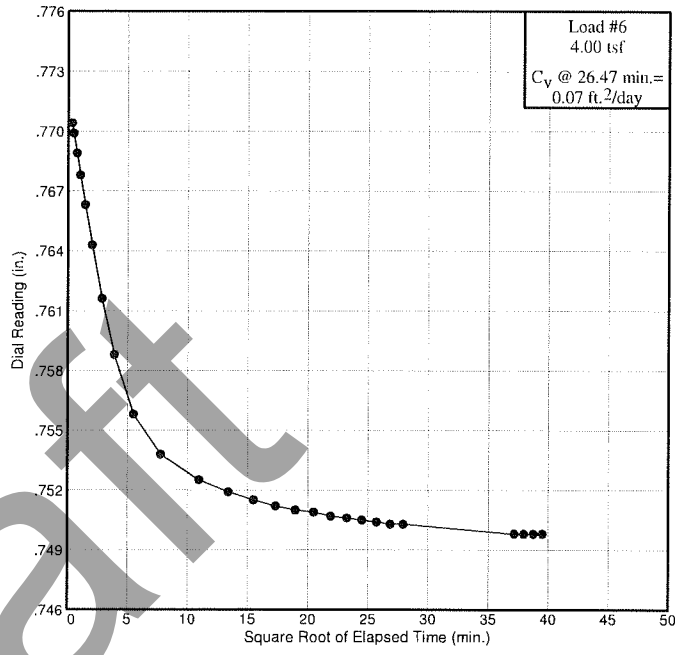
Figure

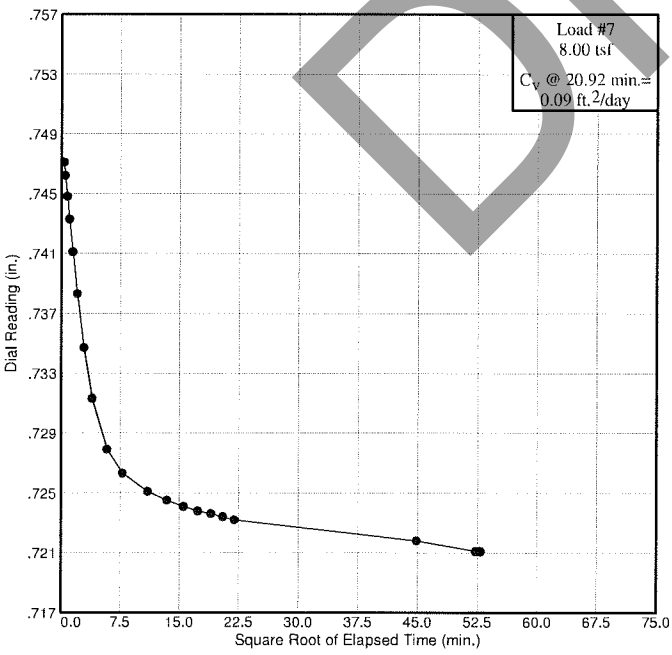
Dial Reading vs. Time

Project No.: C16033-1
Project: ECI - E. Chicago, IN.

Source: SB-02 Sample No.: SB-02, 34.5-39.5'







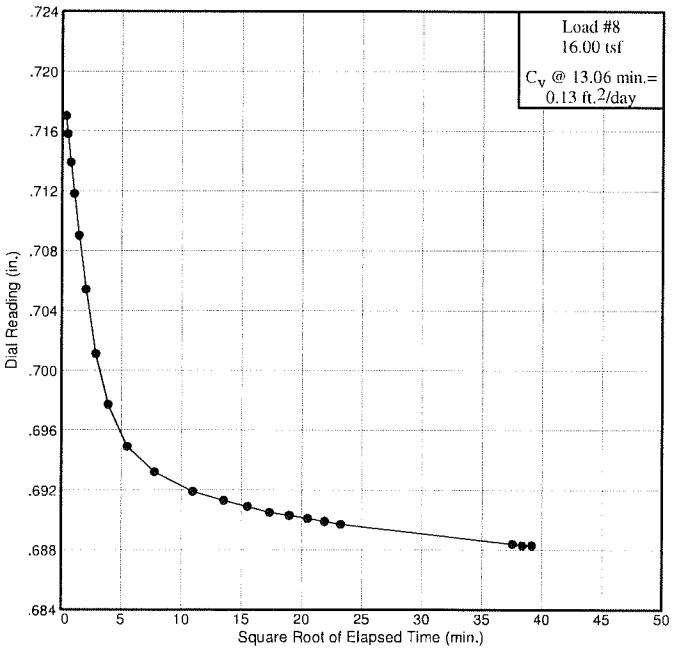


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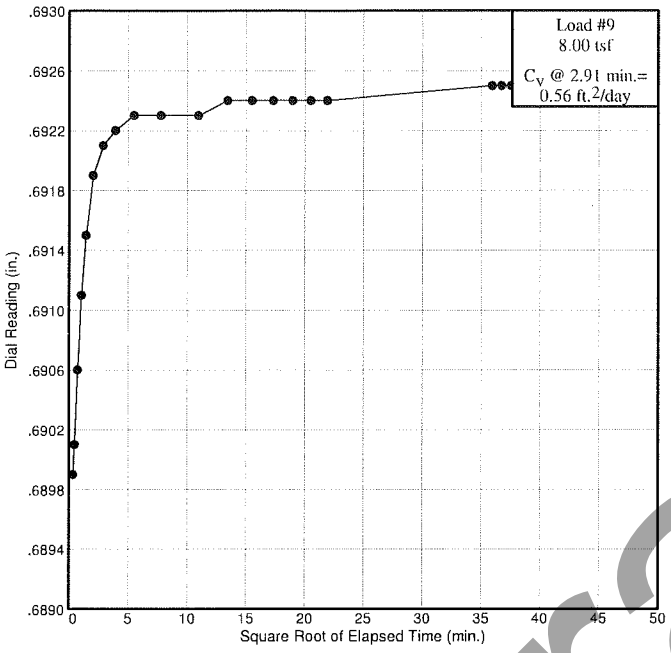
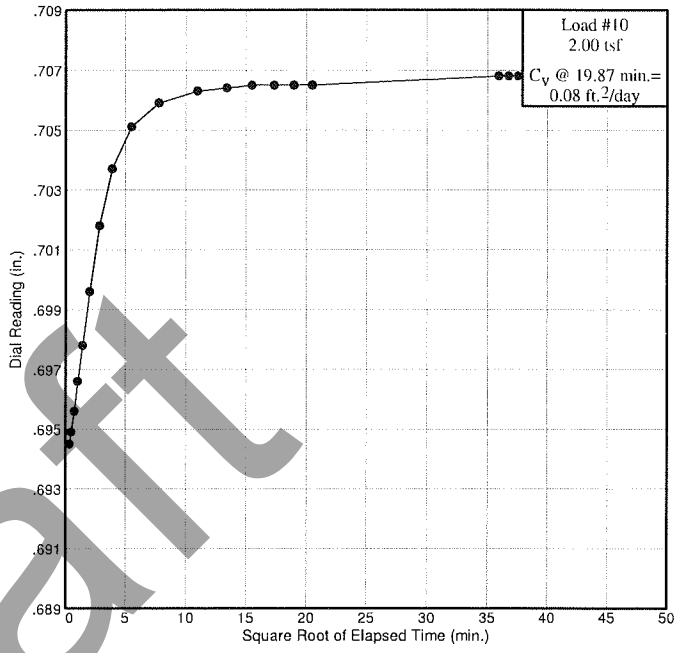
Figure

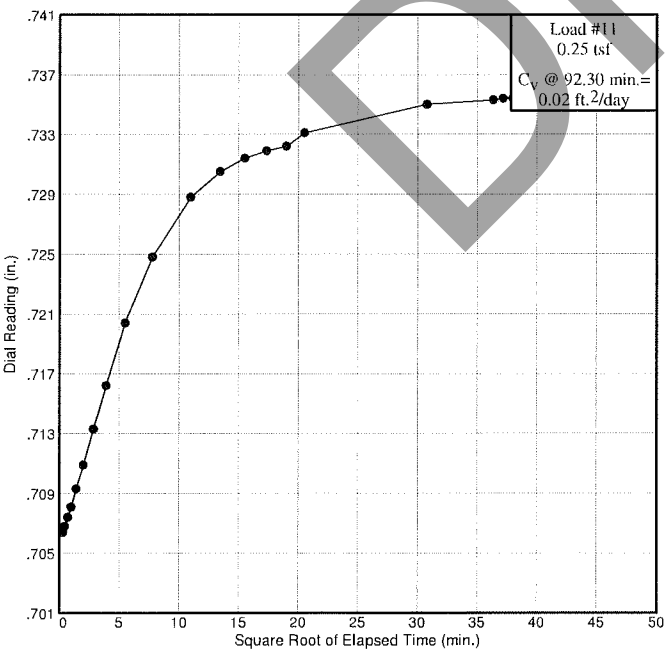
Dial Reading vs. Time

Project No.: C16033-1
Project: ECI - E. Chicago, IN.

Source: SB-02 Sample No.: SB-02, 34.5-39.5'







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Madison, Wisconsin

Figure

CONSOLIDATION TEST DATA

Client:
Project: ECI - E. Chicago, IN.
Project Number: C16033-1

Sample Data

Source: SB-02
Liquid Limit: **Plasticity Index:**
USCS: CL **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE	BEFORE TEST	AFTER TEST
Wet w+t = 771.60 g.	**Consolidometer #** = 1	**Wet w+t** = 256.13 g.
Dry w+t = 639.50 g.		**Dry w+t** = 228.05 g.
Tare Wt. = 88.15 g.	**Spec. Gravity** = 2.75	**Tare Wt.** = 95.87 g.
Height = 1.00 in.	**Height** = 1.00 in.	
Diameter = 2.50 in.	**Diameter** = 2.50 in.	
Weight = 165.20 g.	**Defl. Table** = 1	
Moisture = 24.0 %	**Ht. Solids** = 0.5975 in.	**Moisture** = 21.2 %
Wet Den. = 128.2 pcf	**Dry Wt.** = 133.27 g.	**Dry Wt.** = 132.18 g.*
Dry Den. = 103.4 pcf	**Void Ratio** = 0.674	**Void Ratio** = 0.549
	Saturation = 97.8 %	

*** Final dry weight used in calculations**

End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v ($ft.^2$/day)	C_α	Void Ratio	% Compression /Swell
start	0.81010				0.674	
0.13	0.80740	0.00170	0.12		0.672	0.1 Comprs.
0.25	0.80470	0.00270	2.66		0.669	0.3 Comprs.
0.50	0.79610	0.00390	0.05		0.657	1.0 Comprs.
1.00	0.78400	0.00540	0.07		0.639	2.1 Comprs.
2.00	0.76470	0.00710	0.07		0.609	3.8 Comprs.
4.00	0.73980	0.01000	0.07		0.573	6.0 Comprs.
8.00	0.70750	0.01360	0.09		0.525	8.9 Comprs.
16.00	0.66880	0.01950	0.13		0.470	12.2 Comprs.
8.00	0.67890	0.01360	0.56		0.477	11.8 Comprs.
2.00	0.69970	0.00710	0.08		0.501	10.3 Comprs.
0.25	0.73270	0.00270	0.02		0.549	7.5 Comprs.

C_c = 0.18 P_c = 1.48 tsf C_r = 0.04

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CONSOLIDATION TEST REPORT

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Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
99.5 %	19.7 %	110.8			2.71	CL		0.536

MATERIAL DESCRIPTION

Gray Lean Clay, Trace Sand and Gravel

Project No. C16033-1 **Client:**

Project: ECI - E. Chicago, IN.

Source: SB-04 **Sample No.:** SB-04, 34.5-39.5'

TRC Environmental Corp.

Madison, Wisconsin

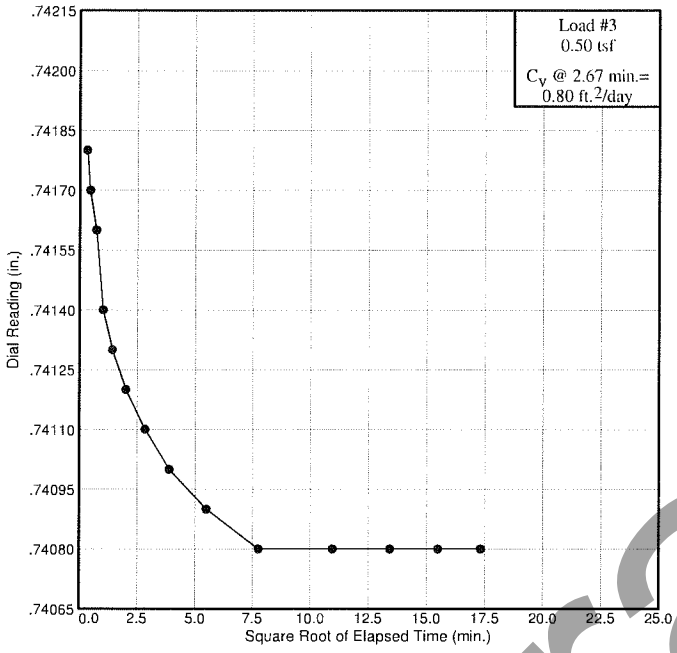
Remarks:

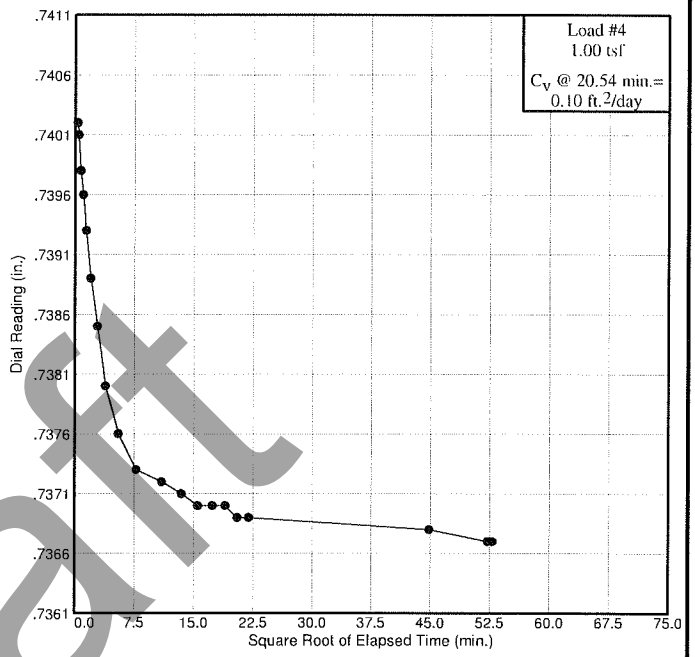
Figure

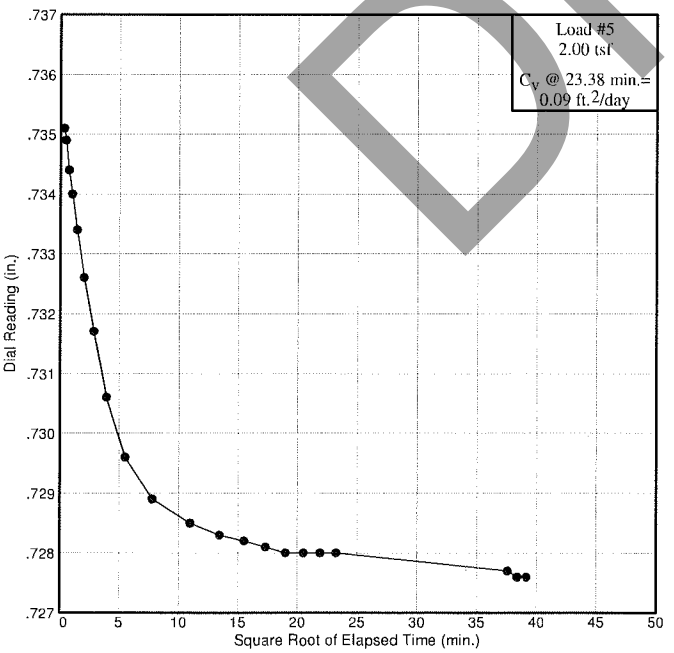
Dial Reading vs. Time

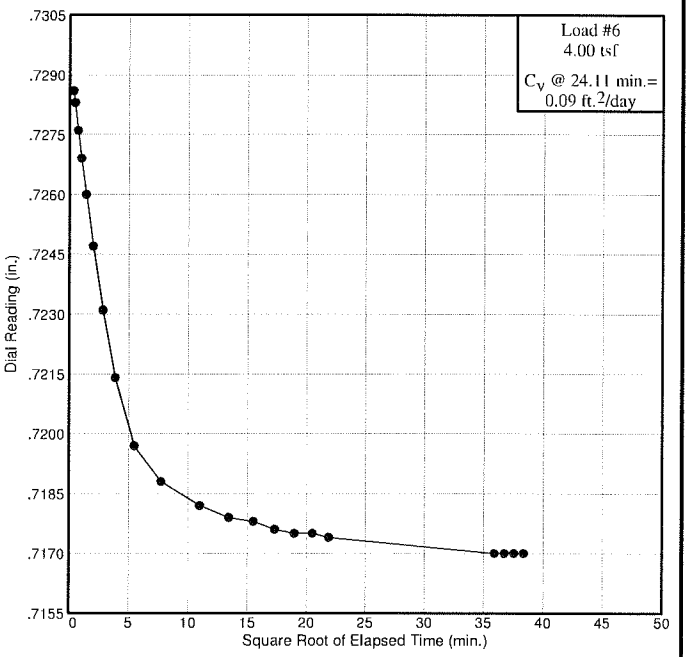
Project No.: C16033-1
Project: ECI - E. Chicago, IN.

Source: SB-04 Sample No.: SB-04, 34.5-39.5'









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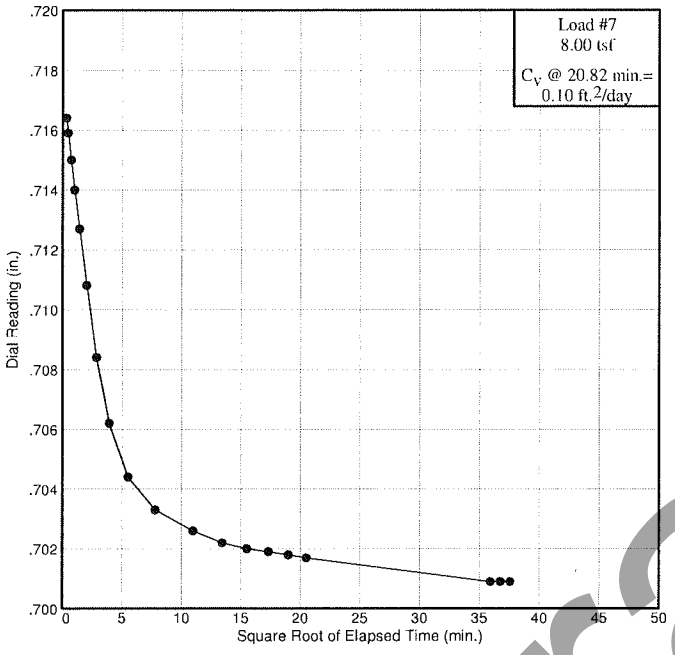
Madison, Wisconsin

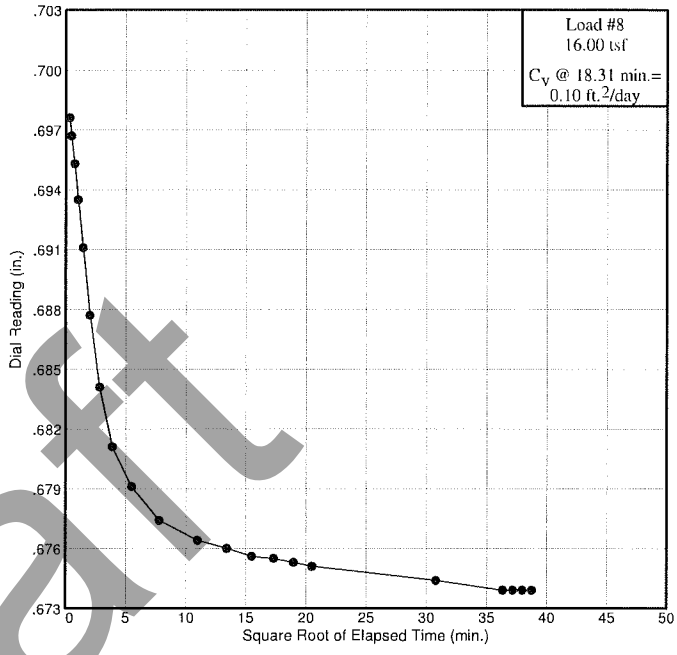
Figure

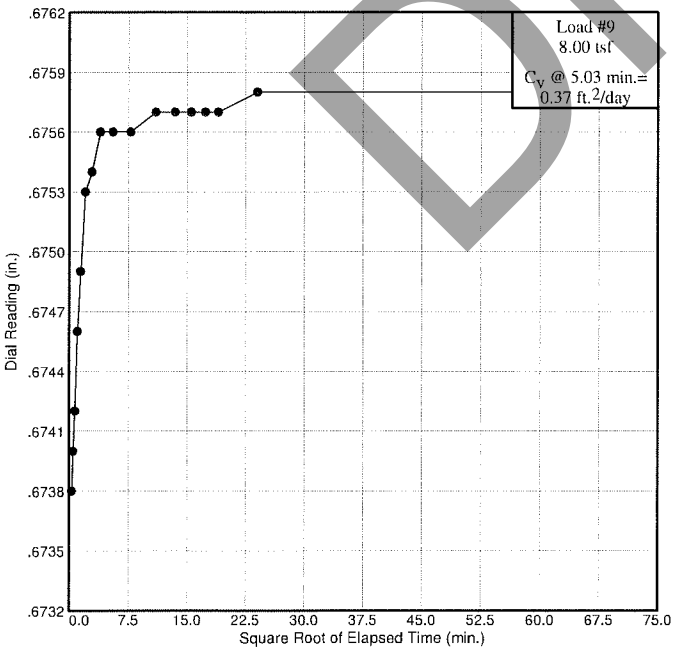
Dial Reading vs. Time

Project No.: C16033-1
Project: ECI - E. Chicago, IN.

Source: SB-04 Sample No.: SB-04, 34.5-39.5'







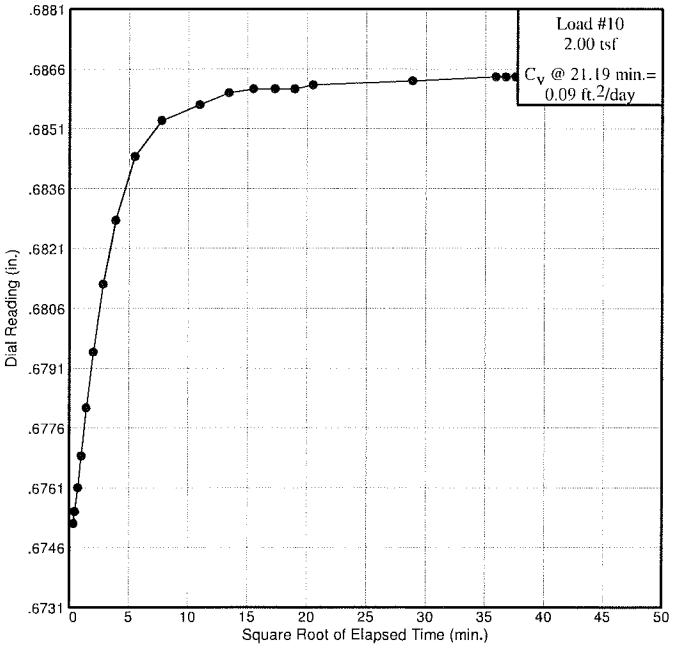


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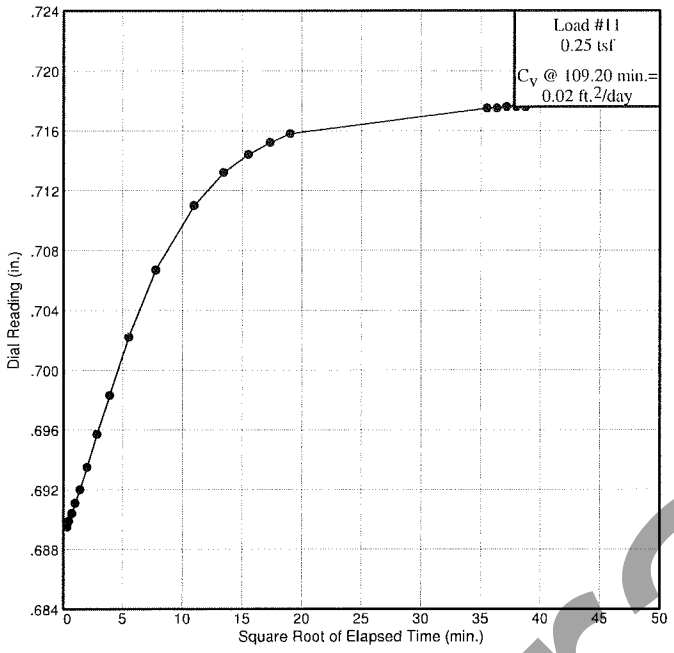
Figure

Dial Reading vs. Time

Project No.: C16033-1
Project: ECI - E. Chicago, IN.

Source: SB-04 Sample No.: SB-04, 34.5-39.5'



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TRC Environmental Corp.
Madison, Wisconsin

Figure

SWELL/CONSOLIDATION TEST DATA

Client:
Project: ECI - E. Chicago, IN.
Project Number: C16033-1

Sample Data

Source: SB-04
Liquid Limit: **Plasticity Index:**
USCS: CL **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE	BEFORE TEST	AFTER TEST
Wet w+t = 416.01 g.	**Consolidometer #** = 2	**Wet w+t** = 259.85 g.
Dry w+t = 362.64 g.		**Dry w+t** = 231.17 g.
Tare Wt. = 91.39 g.	**Spec. Gravity** = 2.71	**Tare Wt.** = 89.25 g.
Height = 1.00 in.	**Height** = 1.00 in.	
Diameter = 2.50 in.	**Diameter** = 2.50 in.	
Weight = 170.84 g.	**Defl. Table** = 2	
Moisture = 19.7 %	**Ht. Solids** = 0.6510 in.	**Moisture** = 20.2 %
Wet Den. = 132.6 pcf	**Dry Wt.** = 142.75 g.	**Dry Wt.** = 141.92 g.*
Dry Den. = 110.8 pcf	**Void Ratio** = 0.536	**Void Ratio** = 0.505
	Saturation = 99.5 %	

*** Final dry weight used in calculations**

End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.73800				0.536	
0.13	0.73920	0.00150			0.540	0.3 Swell
0.25	0.74020	0.00190			0.542	0.4 Swell
0.50	0.73830	0.00250	0.80		0.540	0.3 Swell
1.00	0.73340	0.00330	0.10		0.534	0.1 Comprs.
2.00	0.72230	0.00530	0.09		0.520	1.0 Comprs.
4.00	0.70710	0.00990	0.09		0.504	2.1 Comprs.
8.00	0.68720	0.01370	0.10		0.479	3.7 Comprs.
16.00	0.65470	0.01920	0.10		0.438	6.4 Comprs.
8.00	0.66210	0.01370	0.37		0.440	6.2 Comprs.
2.00	0.68110	0.00530	0.09		0.457	5.2 Comprs.
0.25	0.71570	0.00190	0.02		0.505	2.0 Comprs.

C_c = 0.14 P_c = 3.99 tsf C_r = 0.03

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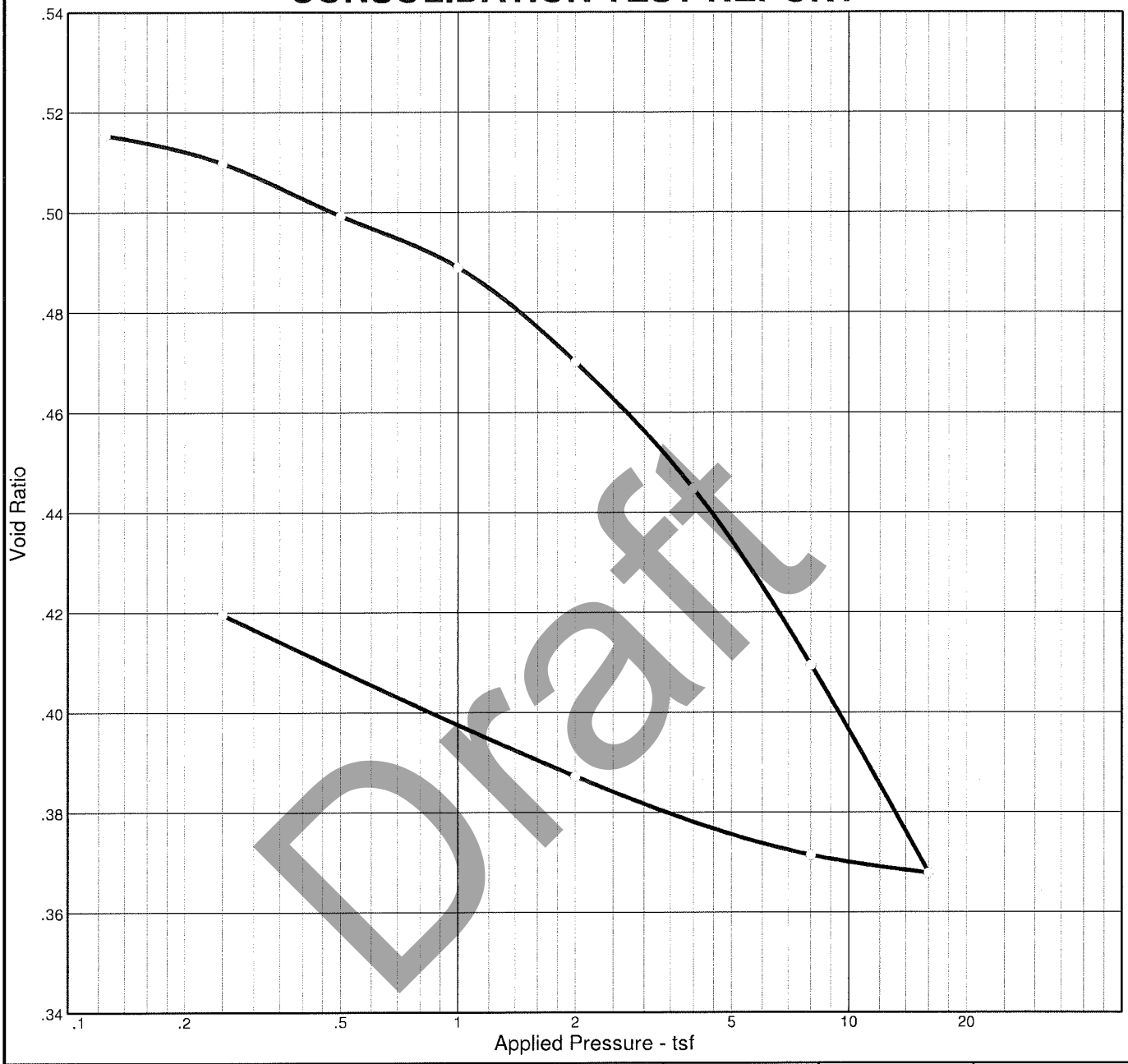
CONSOLIDATION TEST REPORT



Draft

Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
96.9 %	20.2 %	109.1			2.70	CL		0.563

MATERIAL DESCRIPTION

Gray Lean Clay, Trace Sand

Project No. C16033-1 **Client:**

Project: ECI - E. Chicago, IN.

Source: SB-06 **Sample No.:** SB-06, 34.5-39.5'

TRC Environmental Corp.

Madison, Wisconsin

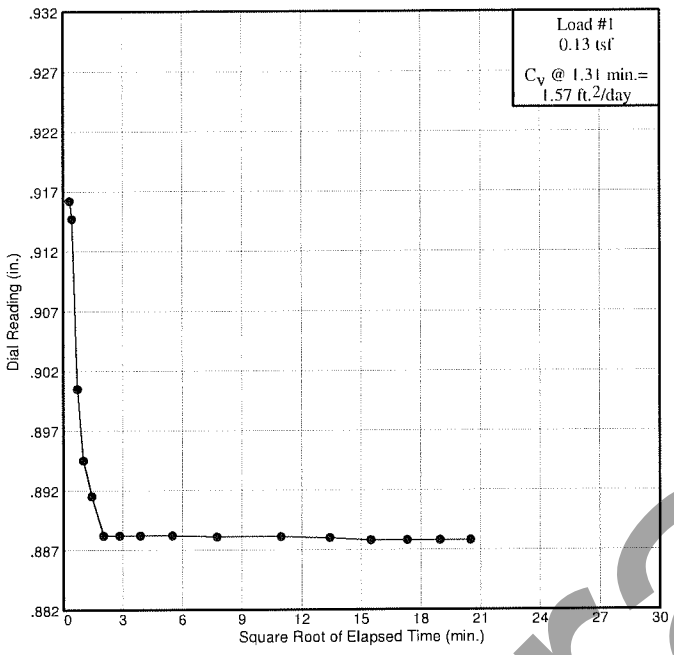
Remarks:

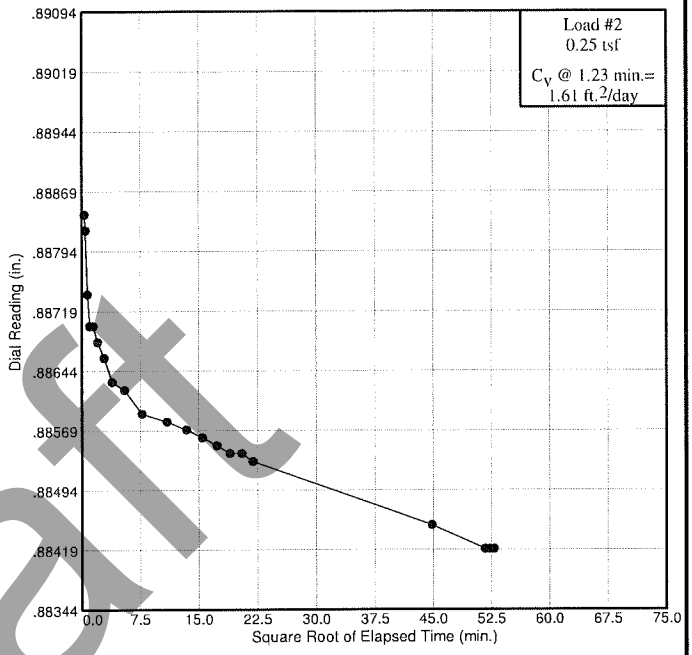
Figure

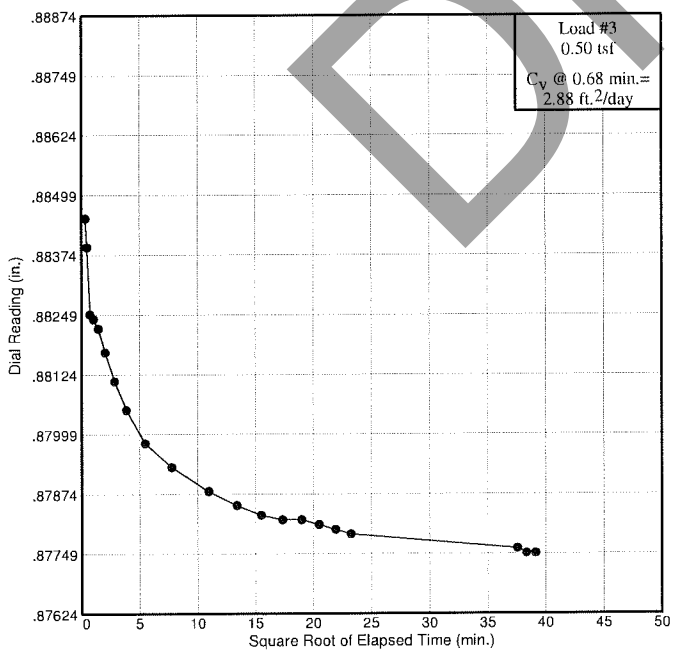
Dial Reading vs. Time

Project No.: C16033-1
Project: ECI - E. Chicago, IN.

Source: SB-06 Sample No.: SB-06, 34.5-39.5'







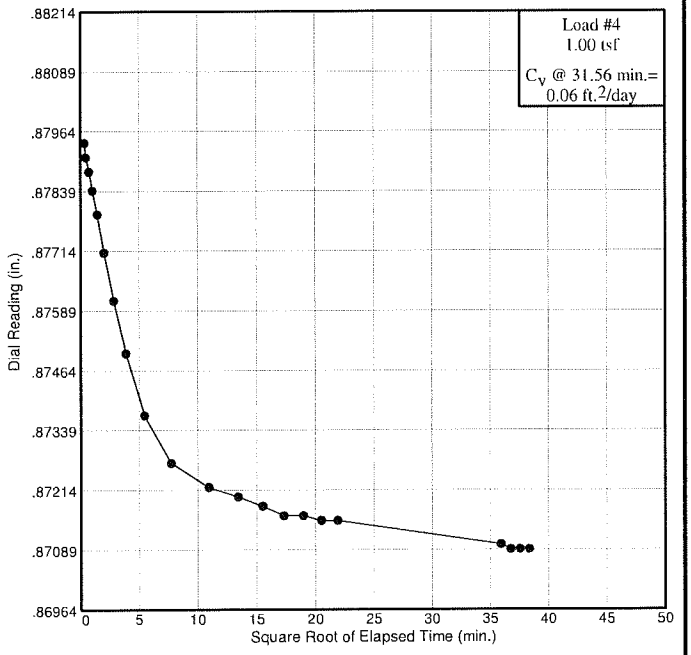


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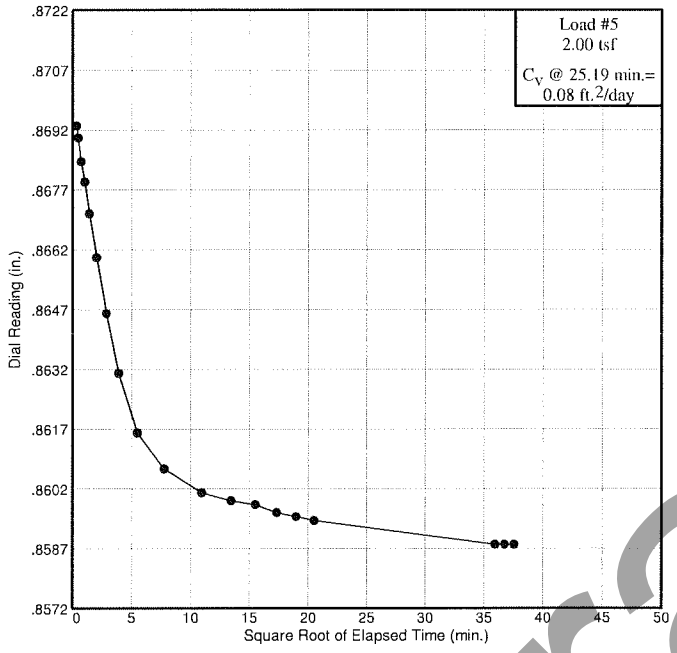
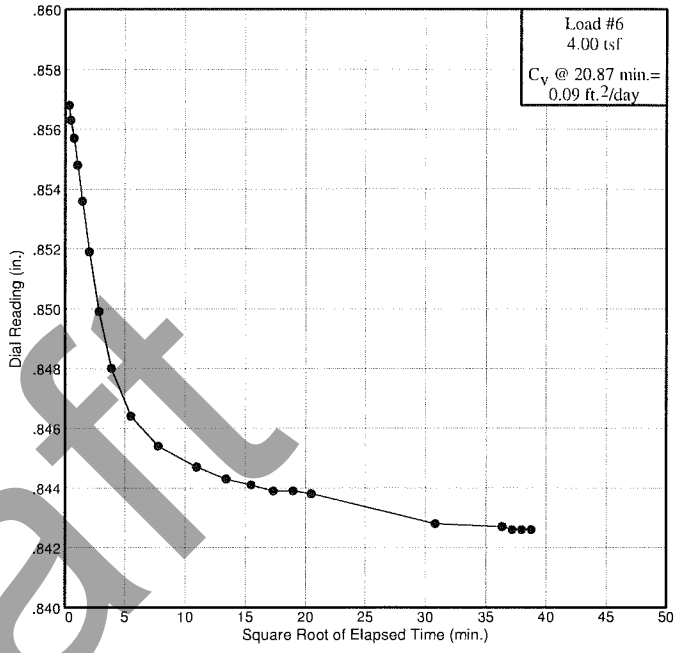
Figure

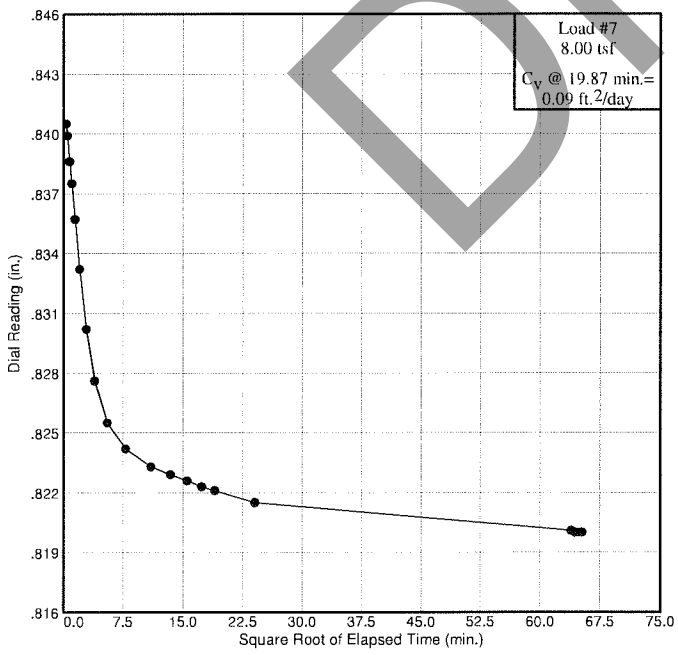
Dial Reading vs. Time

Project No.: C16033-1
Project: ECI - E. Chicago, IN.

Source: SB-06 Sample No.: SB-06, 34.5-39.5'







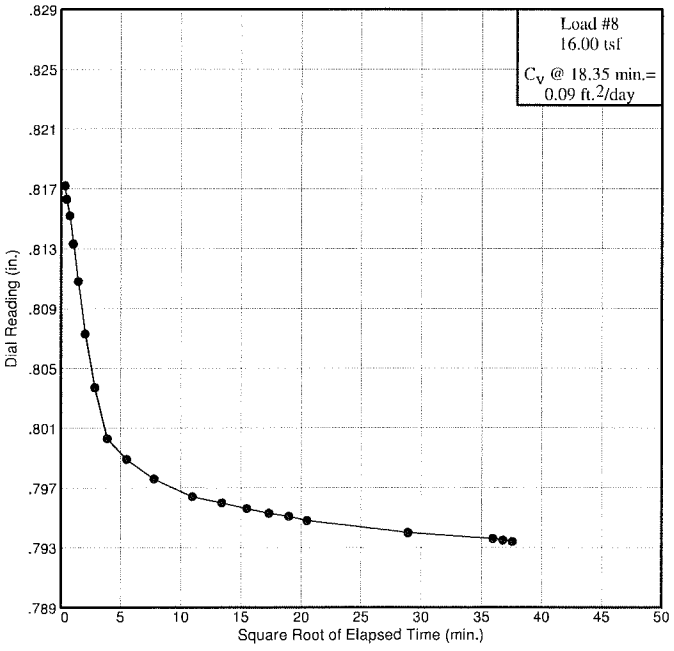


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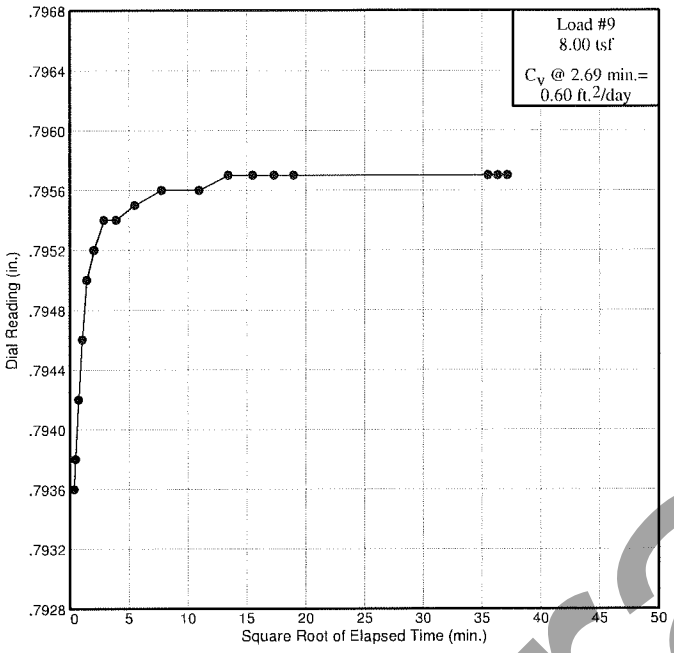
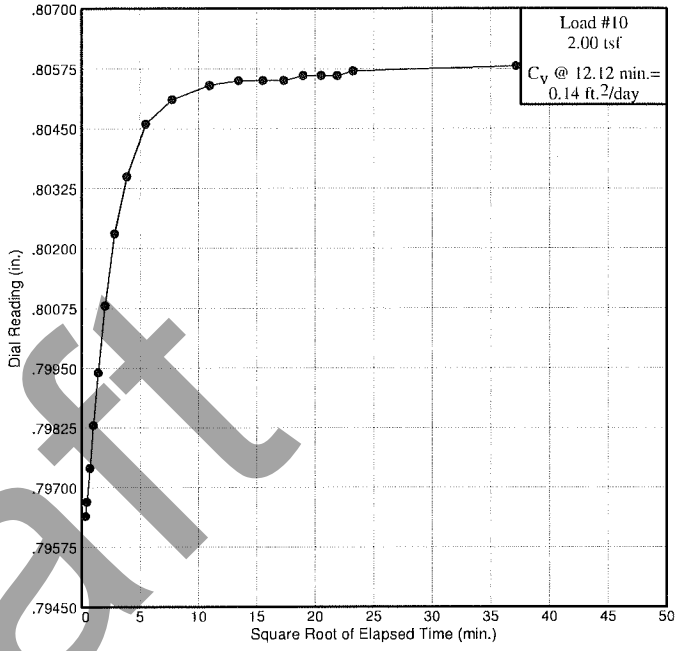
Figure

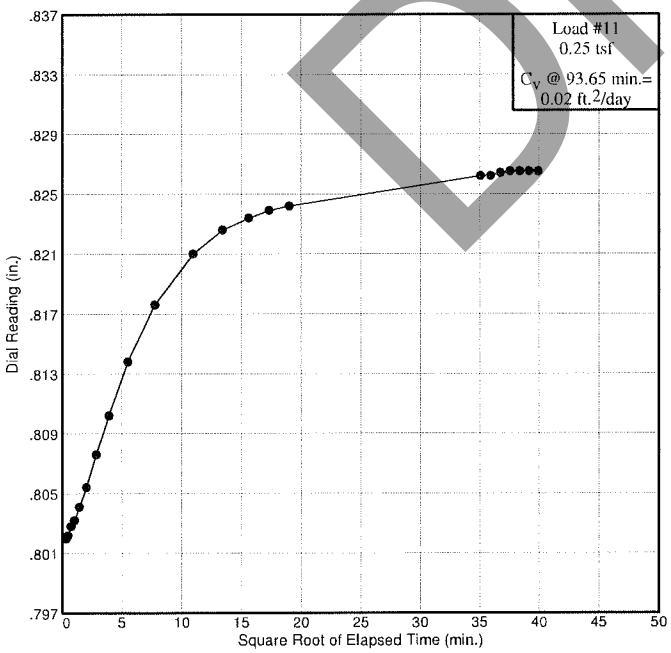
Dial Reading vs. Time

Project No.: C16033-1
Project: ECI - E. Chicago, IN.

Source: SB-06 Sample No.: SB-06, 34.5-39.5'







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Madison, Wisconsin

Figure

CONSOLIDATION TEST DATA

Client:
Project: ECI - E. Chicago, IN.
Project Number: C16033-1

Sample Data

Source: SB-06
Liquid Limit: **Plasticity Index:**
USCS: CL **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE	BEFORE TEST	AFTER TEST
Wet w+t = 417.81 g.	**Consolidometer #** = 3	**Wet w+t** = 261.10 g.
Dry w+t = 362.05 g.		**Dry w+t** = 233.90 g.
Tare Wt. = 86.20 g.	**Spec. Gravity** = 2.70	**Tare Wt.** = 94.95 g.
Height = 1.00 in.	**Height** = 1.00 in.	
Diameter = 2.50 in.	**Diameter** = 2.50 in.	
Weight = 168.97 g.	**Defl. Table** = 3	
Moisture = 20.2 %	**Ht. Solids** = 0.6398 in.	**Moisture** = 19.6 %
Wet Den. = 131.1 pcf	**Dry Wt.** = 140.56 g.	**Dry Wt.** = 138.95 g.*
Dry Den. = 109.1 pcf	**Void Ratio** = 0.563	**Void Ratio** = 0.420
	Saturation = 96.9 %	

*** Final dry weight used in calculations**

End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.91830				0.563	
0.13	0.88680	0.00100	1.57		0.515	3.1 Comprs.
0.25	0.88240	0.00180	1.61		0.510	3.4 Comprs.
0.50	0.87450	0.00300	2.88		0.499	4.1 Comprs.
1.00	0.86330	0.00760	0.06		0.489	4.7 Comprs.
2.00	0.85010	0.00870	0.08		0.470	5.9 Comprs.
4.00	0.83230	0.01030	0.09		0.445	7.6 Comprs.
8.00	0.80660	0.01340	0.09		0.409	9.8 Comprs.
16.00	0.77410	0.01930	0.09		0.368	12.5 Comprs.
8.00	0.78230	0.01340	0.60		0.371	12.3 Comprs.
2.00	0.79710	0.00870	0.14		0.387	11.3 Comprs.
0.25	0.82470	0.00180	0.02		0.420	9.2 Comprs.

C_c = 0.14 P_c = 2.52 tsf C_r = 0.02

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CONSOLIDATION TEST REPORT

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Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
99.6 %	22.2 %	103.7			2.54	CL		0.567

MATERIAL DESCRIPTION

Gray Lean Clay, Little Sand, Trace Gravel

Project No. C16033-1 **Client:**

Project: ECI - E. Chicago, IN.

Source: SB-08 **Sample No.:** SB-08, 33-38'

TRC Environmental Corp.

Madison, Wisconsin

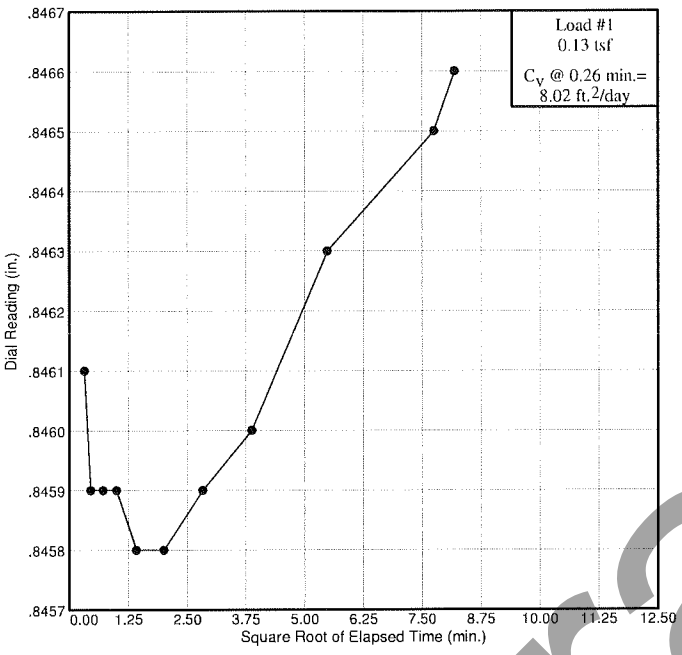
Remarks:

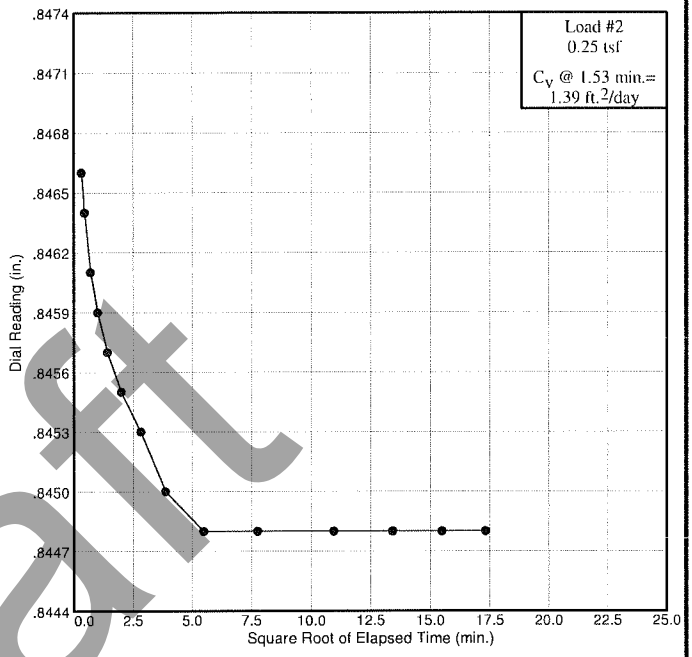
Figure

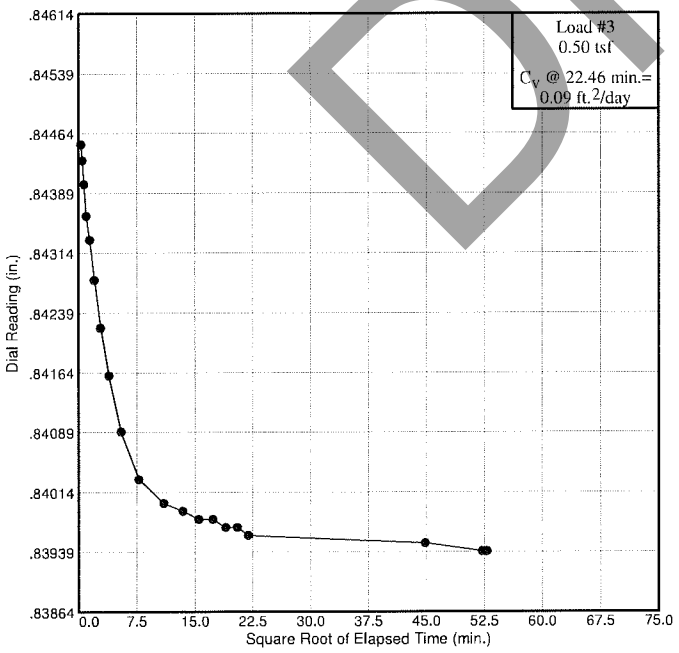
Dial Reading vs. Time

Project No.: C16033-1
Project: ECI - E. Chicago, IN.

Source: SB-08 Sample No.: SB-08, 33-38'







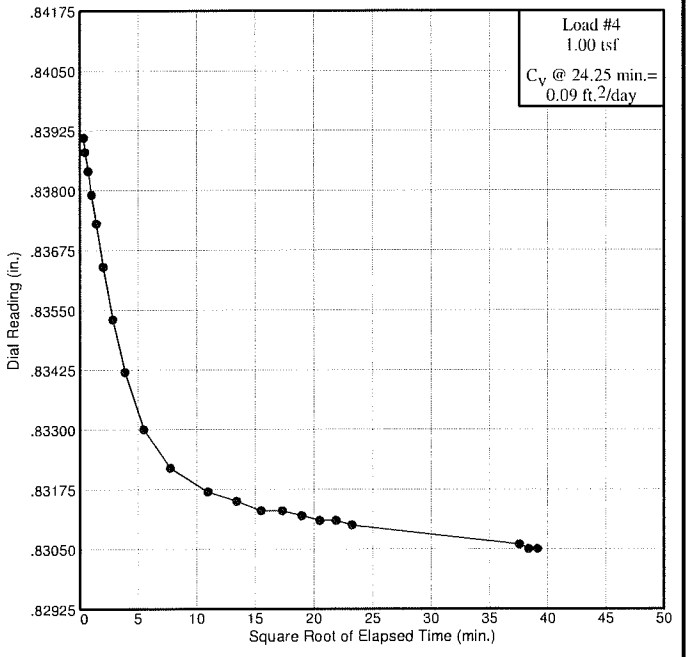


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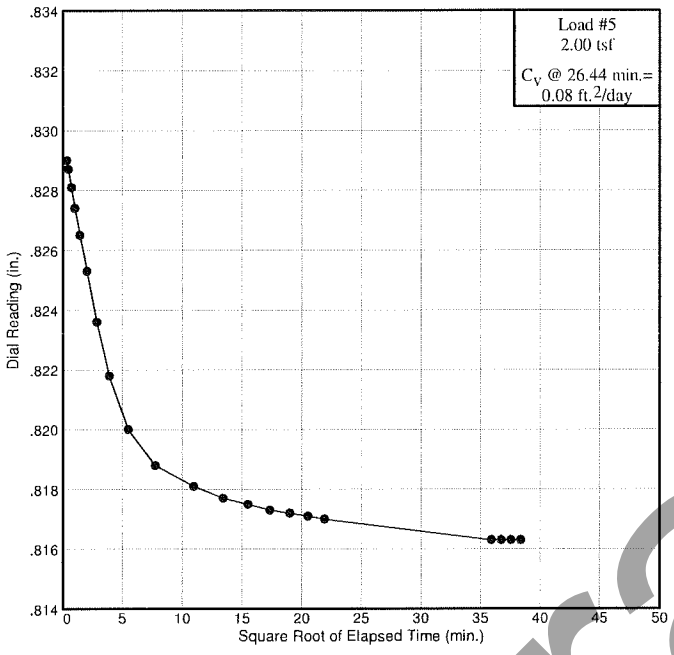
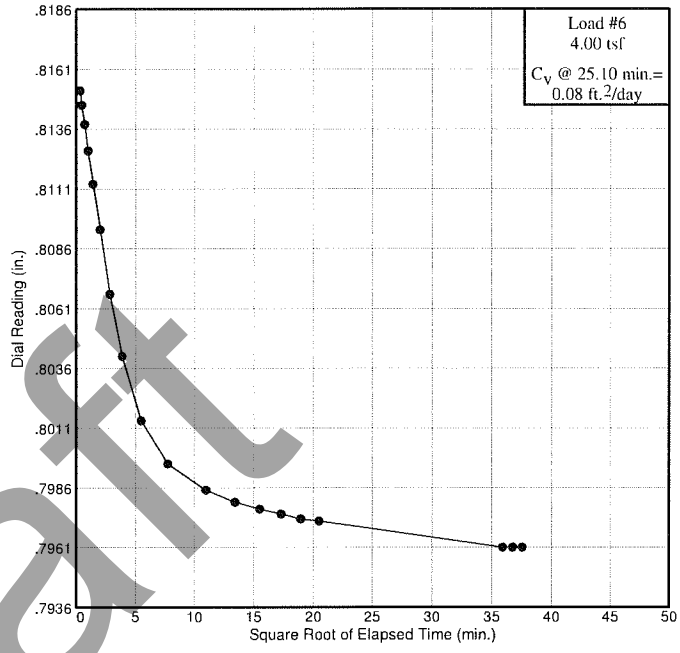
Figure

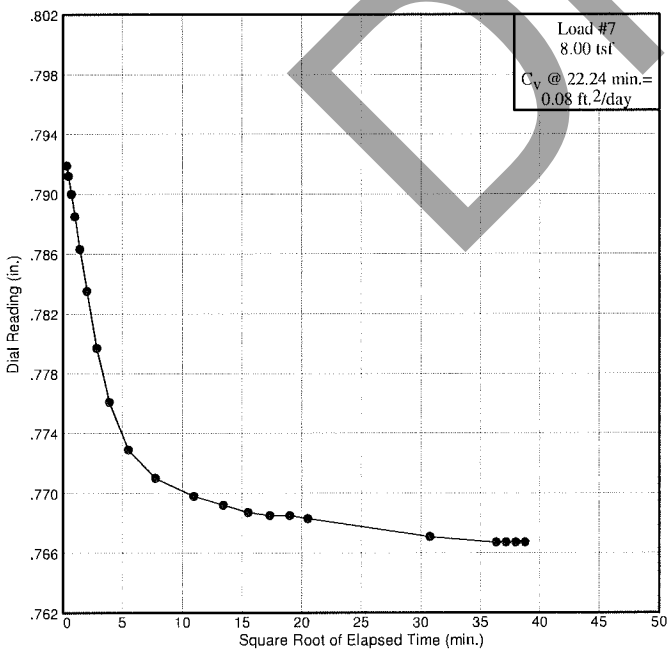
Dial Reading vs. Time

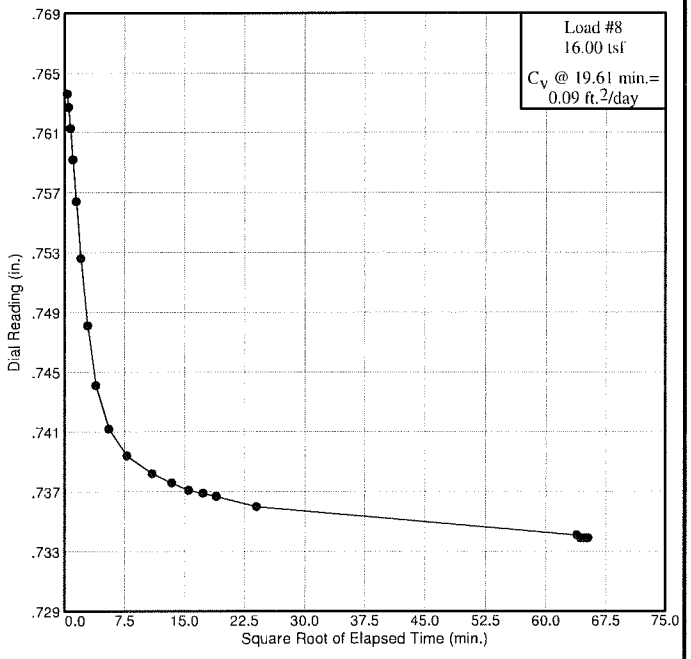
Project No.: C16033-1
Project: ECI - E. Chicago, IN.

Source: SB-08 Sample No.: SB-08, 33-38'









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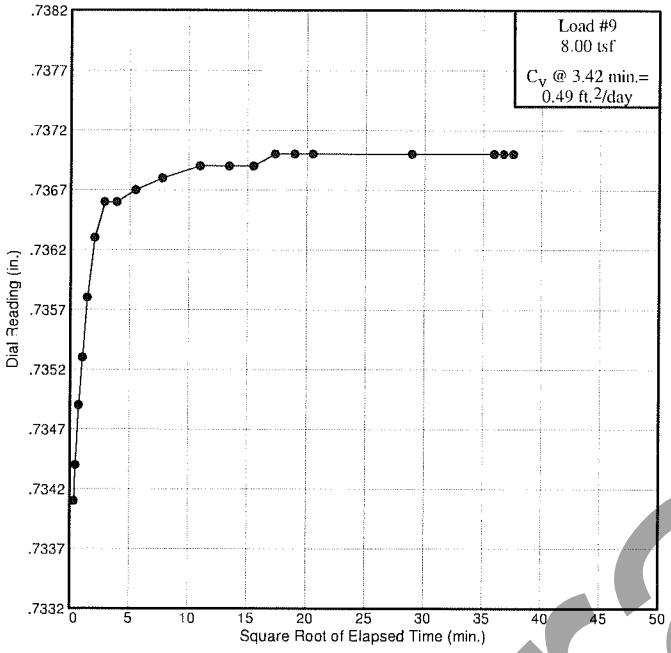
Madison, Wisconsin

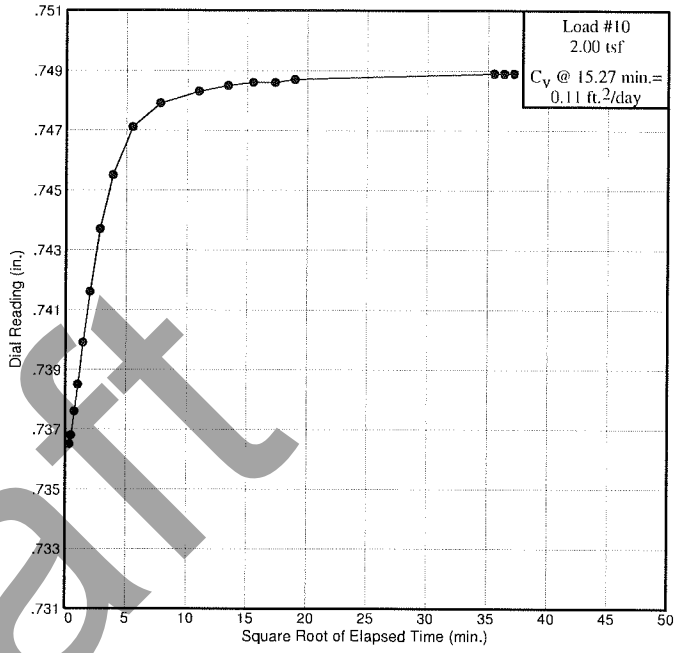
Figure

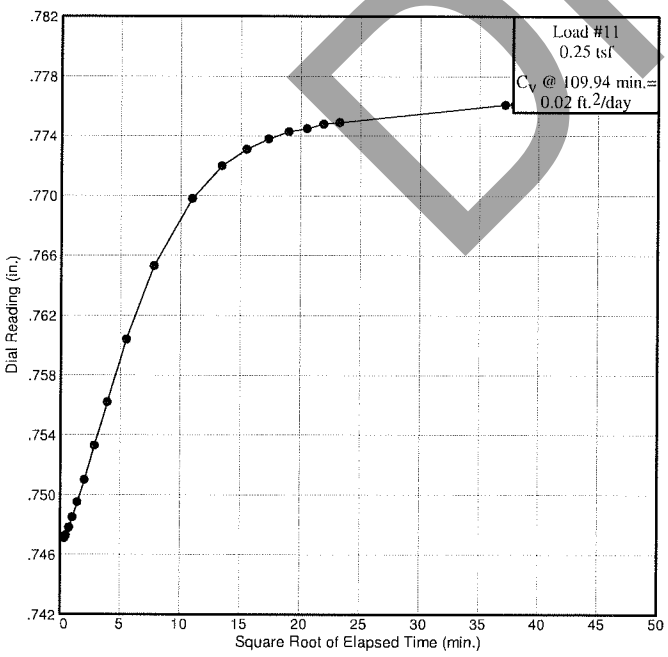
Dial Reading vs. Time

Project No.: C16033-1
Project: ECI - E. Chicago, IN.

Source: SB-08 Sample No.: SB-08, 33-38'







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Madison, Wisconsin

Figure

CONSOLIDATION TEST DATA

Client:
Project: ECI - E. Chicago, IN.
Project Number: C16033-1

Sample Data

Source: SB-08
Liquid Limit: **Plasticity Index:**
USCS: CL **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE	BEFORE TEST	AFTER TEST
Wet w+t = 268.29 g.	**Consolidometer #** = 4	**Wet w+t** = 247.74 g.
Dry w+t = 235.54 g.		**Dry w+t** = 219.55 g.
Tare Wt. = 88.21 g.	**Spec. Gravity** = 2.54	**Tare Wt.** = 89.15 g.
Height = 1.00 in.	**Height** = 1.00 in.	
Diameter = 2.50 in.	**Diameter** = 2.50 in.	
Weight = 163.34 g.	**Defl. Table** = 4	
Moisture = 22.2 %	**Ht. Solids** = 0.6382 in.	**Moisture** = 21.6 %
Wet Den. = 126.8 pcf	**Dry Wt.** = 133.63 g.	**Dry Wt.** = 130.40 g.*
Dry Den. = 103.7 pcf	**Void Ratio** = 0.567	**Void Ratio** = 0.457
	Saturation = 99.6 %	

*** Final dry weight used in calculations**

End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v (ft.^{2}/day)	C_α	Void Ratio	% Compression /Swell
start	0.84660				0.567	
0.13	0.84570	0.00090	8.02		0.567	0.0 Comprs.
0.25	0.84320	0.00160	1.39		0.564	0.2 Comprs.
0.50	0.83680	0.00260	0.09		0.556	0.7 Comprs.
1.00	0.82650	0.00400	0.09		0.542	1.6 Comprs.
2.00	0.81080	0.00550	0.08		0.519	3.0 Comprs.
4.00	0.78800	0.00810	0.08		0.488	5.0 Comprs.
8.00	0.75580	0.01090	0.08		0.442	8.0 Comprs.
16.00	0.71860	0.01530	0.09		0.390	11.3 Comprs.
8.00	0.72610	0.01090	0.49		0.395	11.0 Comprs.
2.00	0.74340	0.00550	0.11		0.414	9.8 Comprs.
0.25	0.77470	0.00160	0.02		0.457	7.0 Comprs.

C_c = 0.17 P_c = 4.53 tsf C_r = 0.03

Draft

CONSOLIDATION TEST REPORT

Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
97.5 %	21.5 %	106.8			2.70	CL		0.594

MATERIAL DESCRIPTION

Gray Lean Clay, Little Sand

Project No. C16033-1 **Client:**

Project: ECI - E. Chicago, IN.

Source: SB-11 **Sample No.:** SB-11, 32-37'

TRC Environmental Corp.

Madison, Wisconsin

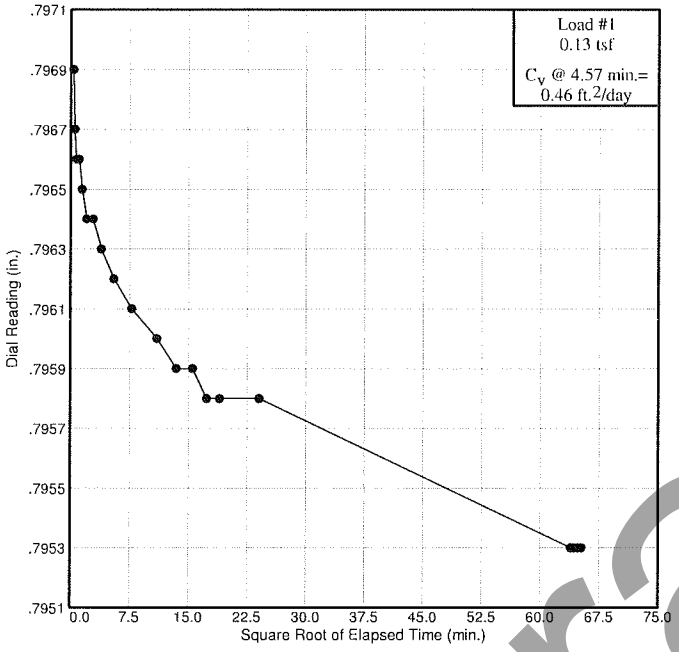
Remarks:

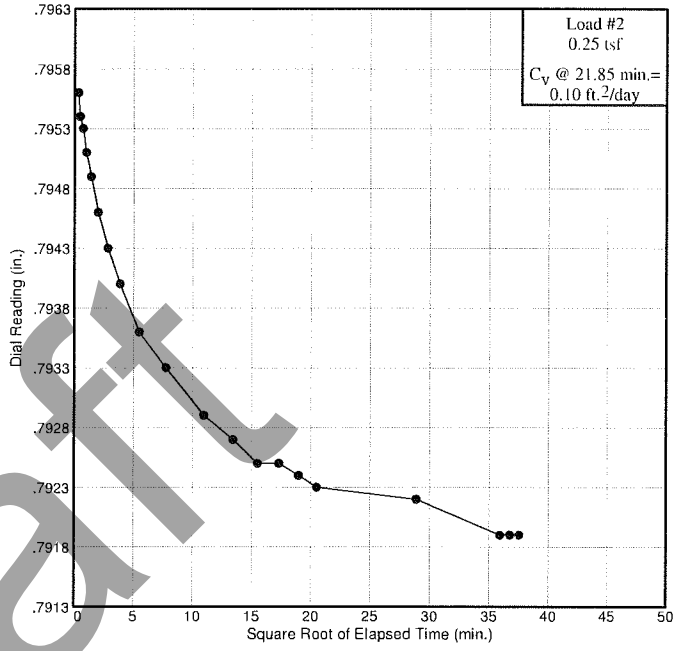
Figure

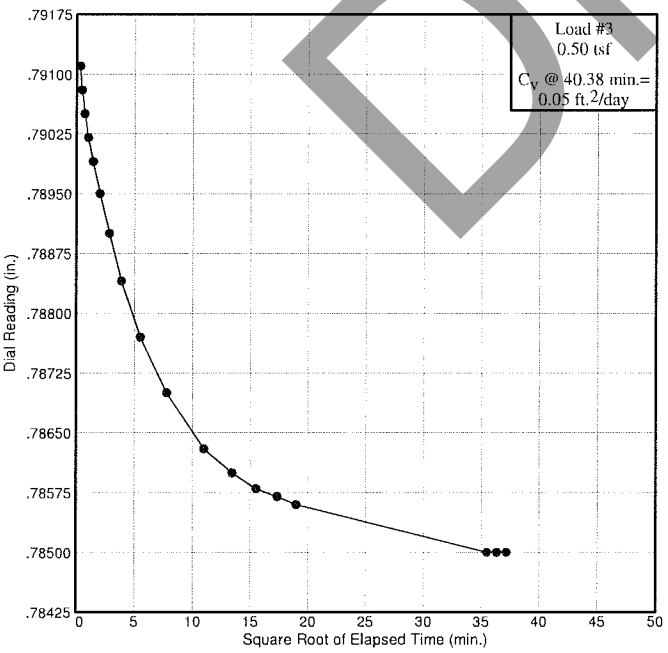
Dial Reading vs. Time

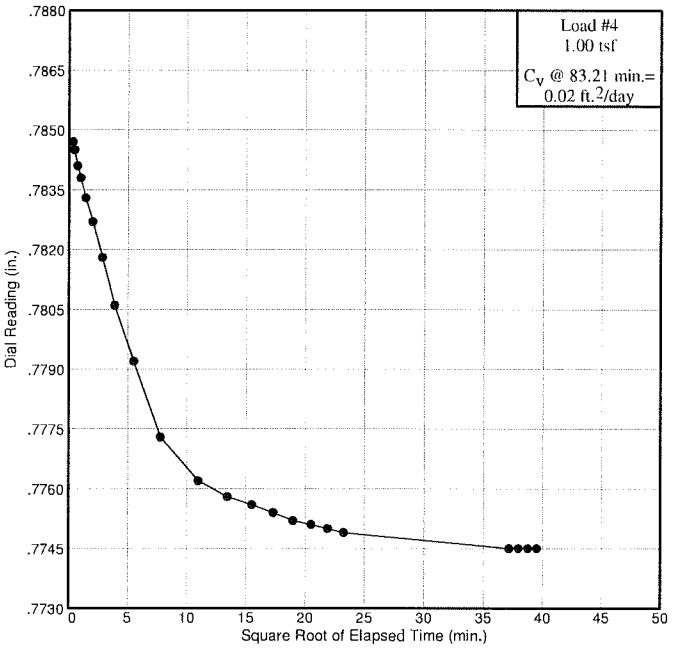
Project No.: C16033-1
Project: ECI - E. Chicago, IN.

Source: SB-11 Sample No.: SB-11, 32-37'









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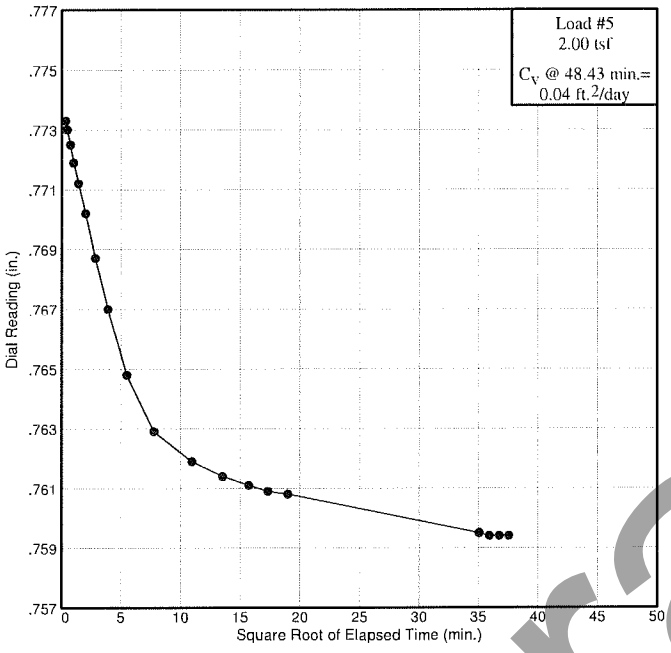
Madison, Wisconsin

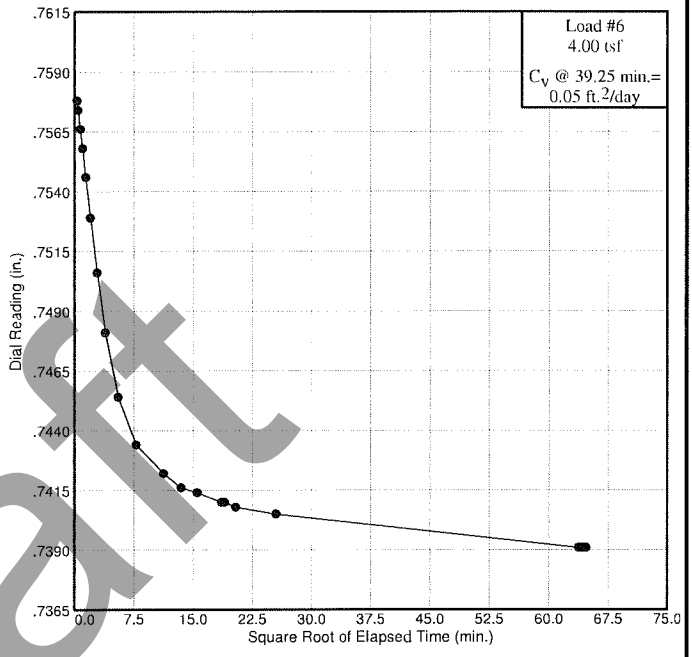
Figure

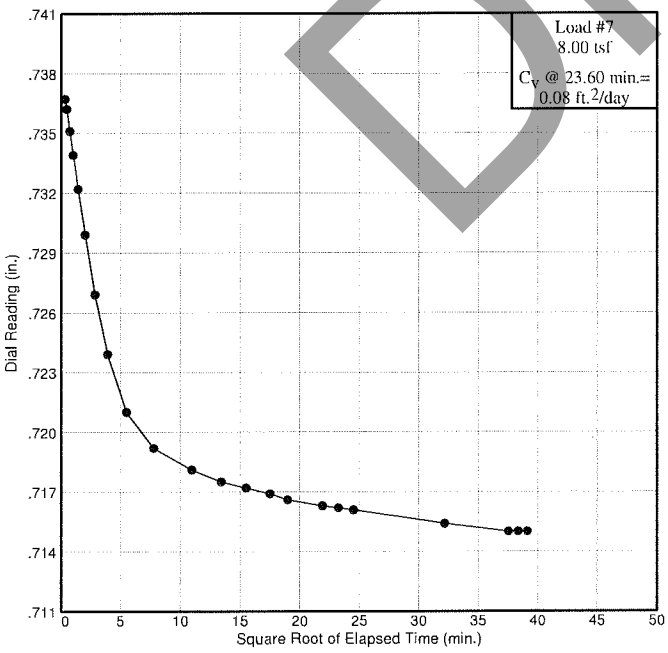
Dial Reading vs. Time

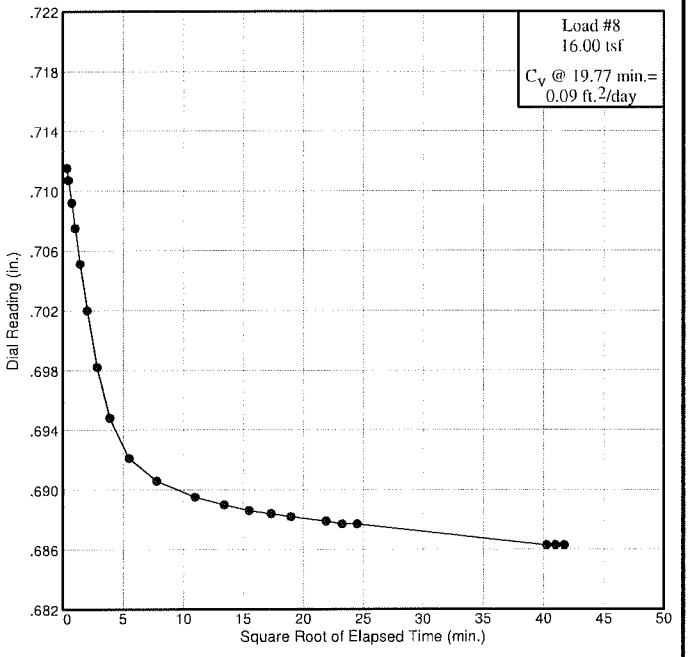
Project No.: C16033-1
Project: ECI - E. Chicago, IN.

Source: SB-11 Sample No.: SB-11, 32-37'









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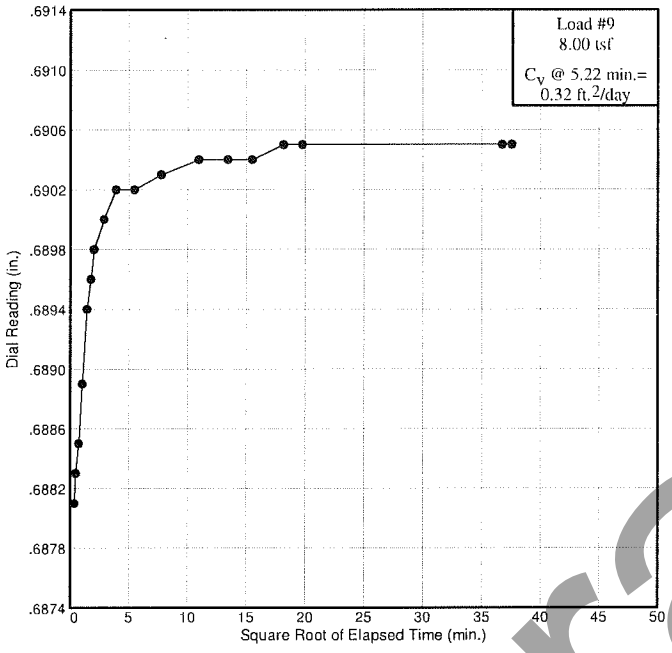
Madison, Wisconsin

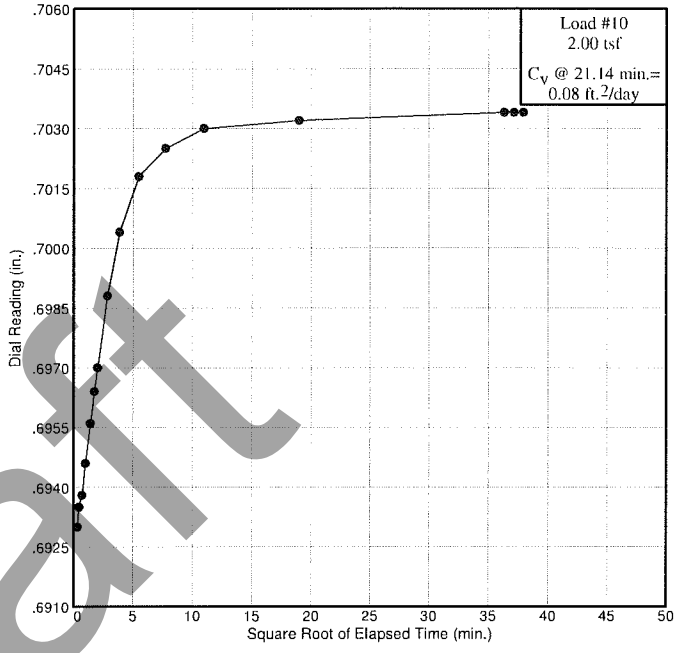
Figure

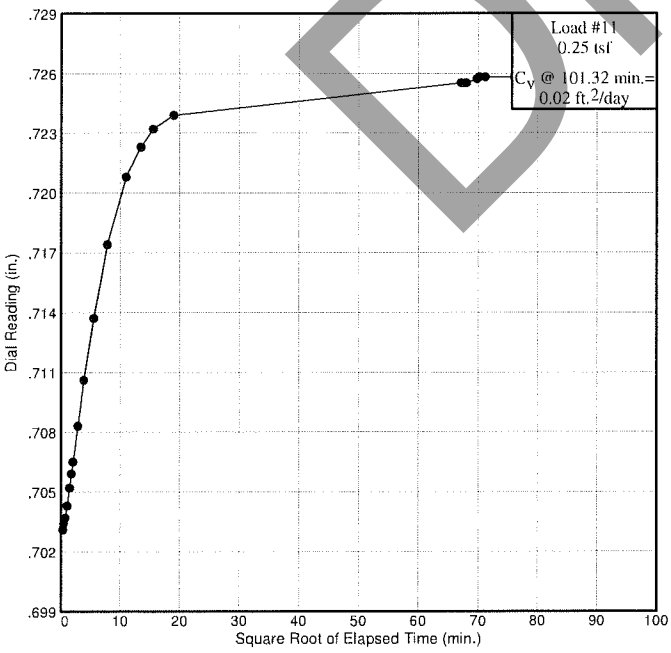
Dial Reading vs. Time

Project No.: C16033-1
Project: ECI - E. Chicago, IN.

Source: SB-11 Sample No.: SB-11, 32-37'







Draft

TRC Environmental Corp.
Madison, Wisconsin

Figure

CONSOLIDATION TEST DATA

Client:
Project: ECI - E. Chicago, IN.
Project Number: C16033-1

Sample Data

Source: SB-11
Liquid Limit: **Plasticity Index:**
USCS: CL **AASHTO:** **Figure No.:**
Testing Remarks:

Test Specimen Data

TOTAL SAMPLE		BEFORE TEST	AFTER TEST	
Wet w+t =	300.27 g.	Consolidometer # = 1	Wet w+t =	425.92 g.
Dry w+t =	263.06 g.		Dry w+t =	400.09 g.
Tare Wt. =	89.68 g.	Spec. Gravity = 2.70	Tare Wt. =	263.87 g.
Height =	1.00 in.	Height = 1.00 in.		
Diameter =	2.50 in.	Diameter = 2.50 in.		
Weight =	167.10 g.	Defl. Table = 1		
Moisture =	21.5 %	Ht. Solids = 0.6272 in.	Moisture =	19.0 %
Wet Den. =	129.7 pcf	Dry Wt. = 137.57 g.	Dry Wt. =	136.22 g.*
Dry Den. =	106.8 pcf	Void Ratio = 0.594	Void Ratio =	0.476
		Saturation = 97.5 %		

* Final dry weight used in calculations

End-of-Load Summary

Pressure (tsf)	Final Dial (in.)	Machine Defl. (in.)	C_v ($ft.^2$/day)	C_α	Void Ratio	% Compression /Swell
start	0.80000				0.594	
0.13	0.79360	0.00170	0.46		0.587	0.5 Comprs.
0.25	0.78920	0.00270	0.10		0.581	0.8 Comprs.
0.50	0.78110	0.00390	0.05		0.570	1.5 Comprs.
1.00	0.76910	0.00540	0.02		0.554	2.5 Comprs.
2.00	0.75230	0.00710	0.04		0.530	4.1 Comprs.
4.00	0.72910	0.01000	0.05		0.497	6.1 Comprs.
8.00	0.70140	0.01360	0.08		0.459	8.5 Comprs.
16.00	0.66680	0.01950	0.09		0.413	11.4 Comprs.
8.00	0.67690	0.01360	0.32		0.420	10.9 Comprs.
2.00	0.69630	0.00710	0.08		0.440	9.7 Comprs.
0.25	0.72310	0.00270	0.02		0.476	7.4 Comprs.

C_c = 0.15 P_c = 1.50 tsf C_r = 0.03

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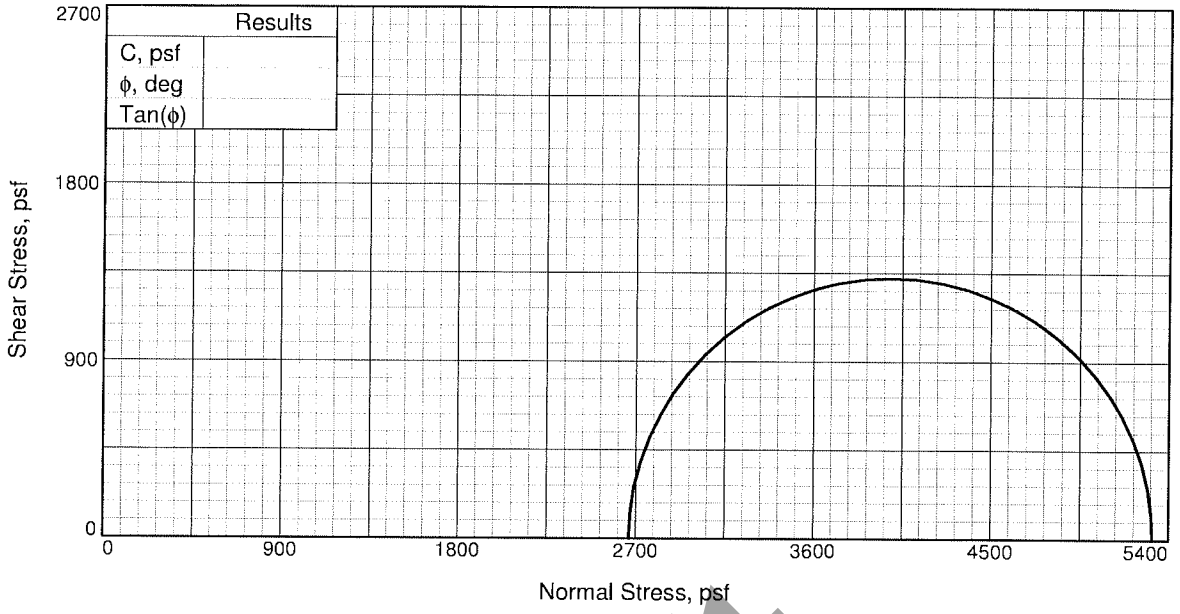

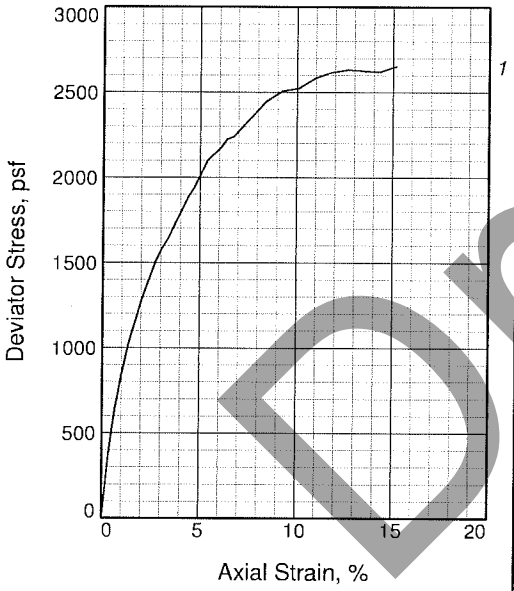

		Sample No.	1
Initial		Water Content, %	24.8
		Dry Density, pcf	100.8
		Saturation, %	99.7
		Void Ratio	0.6718
		Diameter, in.	2.85
		Height, in.	5.94
At Test		Water Content, %	24.8
		Dry Density, pcf	100.8
		Saturation, %	99.7
		Void Ratio	0.6718
		Diameter, in.	2.85
		Height, in.	5.94
Strain rate, %/min.			0.50
Back Pressure, psi			0.00
Cell Pressure, psi			18.50
Fail. Stress, psf			2652
Strain, %			15.2
Ult. Stress, psf			
Strain, %			
σ_1 Failure, psf			5316
σ_3 Failure, psf			2664

Type of Test: Unconsolidated Undrained

Sample Type: Undisturbed

Description: Gray Lean Clay, Trace Sand and Gravel

Assumed Specific Gravity= 2.70

Remarks:

Figure _____

Client:

Project: ECI - E. Chicago, IN.

Source of Sample: SB-02

Sample Number: SB-02, 34.5-39.5'

Proj. No.: C16033-1 **Date Sampled:** 01-20-16

TRIAXIAL SHEAR TEST REPORT
TRC Environmental Corp.
Madison, Wisconsin

Tested By: JPH **Checked By:** JPH

Samples are tested "as received". Initial graphs are best fit lines. Graphs do not represent engineering judgement by the lab.

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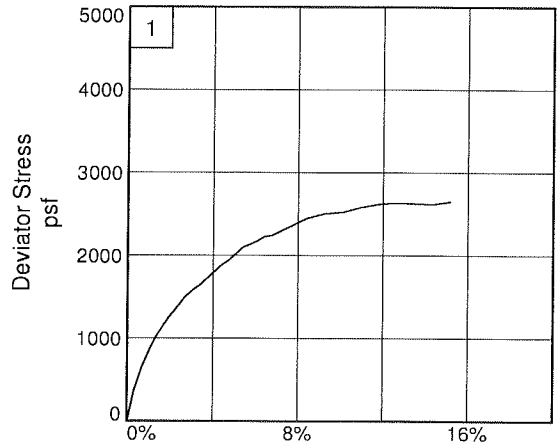
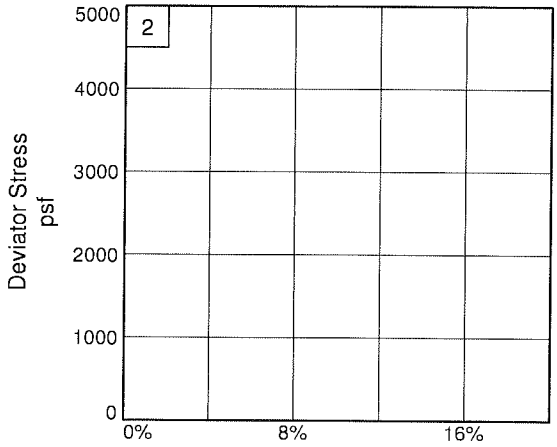
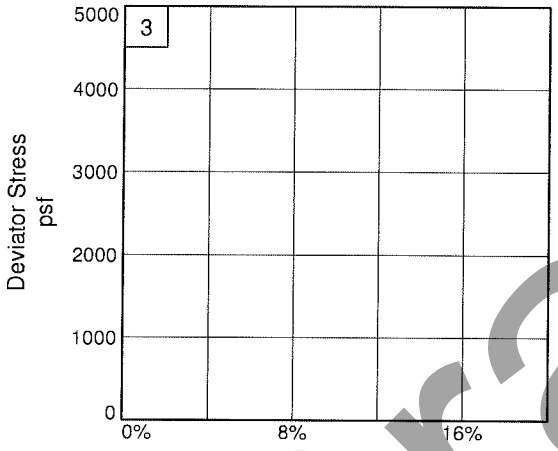
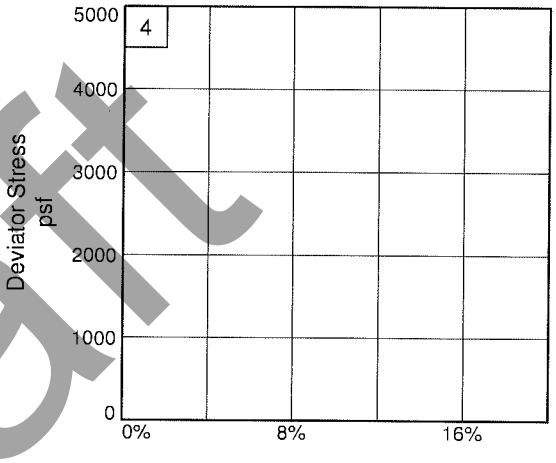
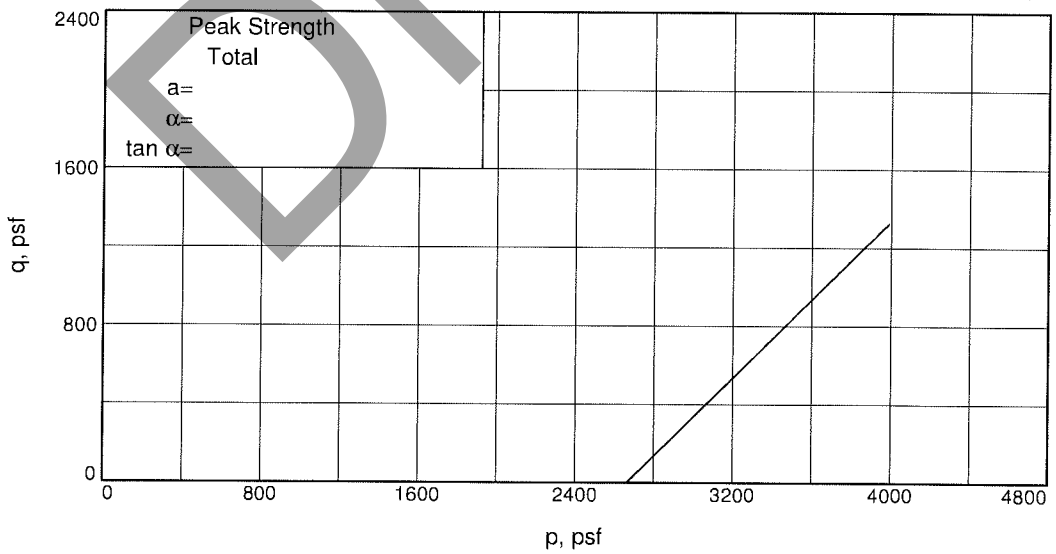










Draft

Samples are tested "as received". Initial graphs are best fit lines. Graphs do not represent engineering judgement by the lab.

Client:

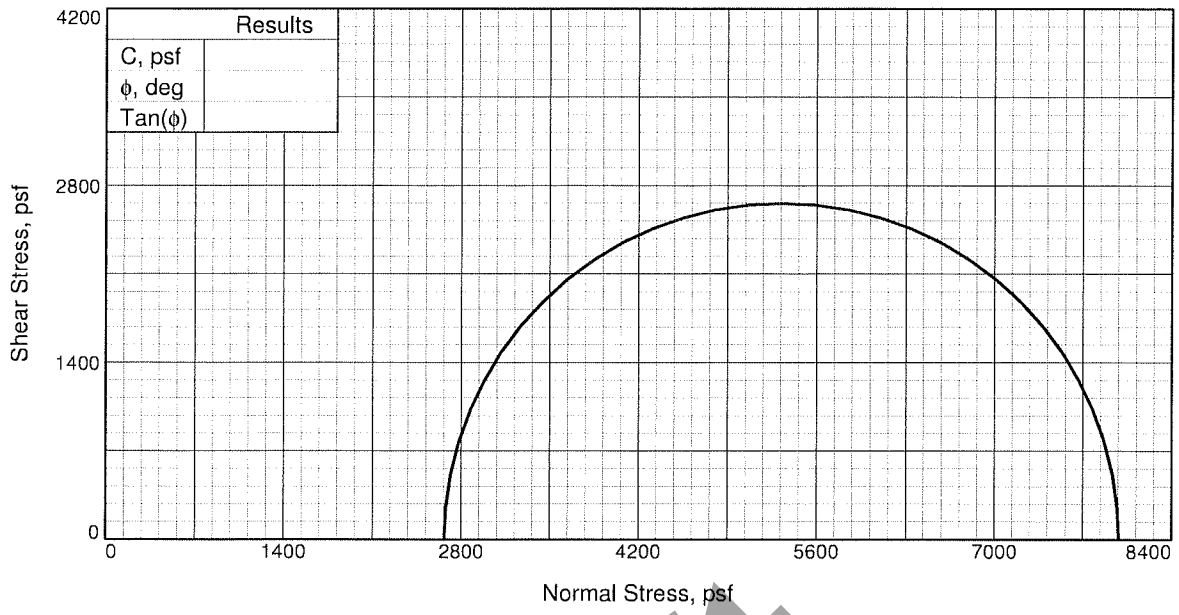
Project: ECI - E. Chicago, IN.

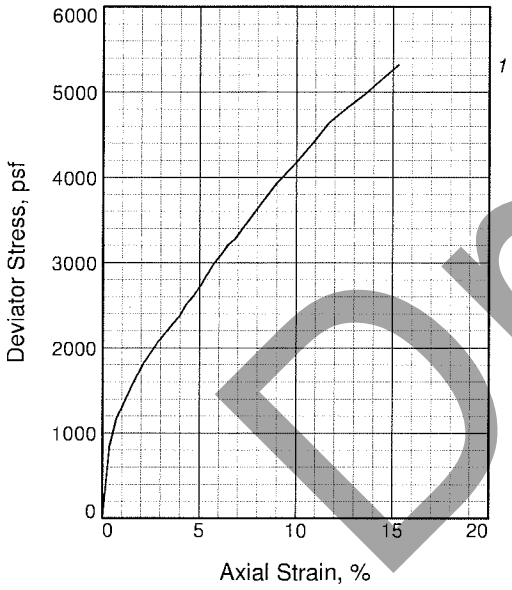
Source of Sample: SB-02 **Sample Number:** SB-02, 34.5-39.5'

Project No.: C16033-1 **Figure** _____

TRC Environmental Corp.

Tested By: JPH **Checked By:** JPH





Sample No.		1
Initial	Water Content, %	20.3
	Dry Density, pcf	110.1
	Saturation, %	99.9
	Void Ratio	0.5598
	Diameter, in.	2.87
	Height, in.	5.56
At Test	Water Content, %	20.3
	Dry Density, pcf	110.1
	Saturation, %	99.9
	Void Ratio	0.5598
	Diameter, in.	2.87
	Height, in.	5.56
Strain rate, %/min.		0.50
Back Pressure, psi		0.00
Cell Pressure, psi		18.50
Fail. Stress, psf		5318
Strain, %		15.3
Ult. Stress, psf		
Strain, %		
σ_1 Failure, psf		7982
σ_3 Failure, psf		2664

Type of Test: Unconsolidated Undrained

Sample Type: Undisturbed

Description: Gray Lean Clay, Trace Sand and Gravel

Assumed Specific Gravity= 2.75

Remarks:

Figure _____

Client:

Project: ECI - E. Chicago, IN.

Source of Sample: SB-04

Sample Number: SB-04, 34.5-39.5'

Proj. No.: C16033-1 **Date Sampled:** 01-21-16

TRIAXIAL SHEAR TEST REPORT
TRC Environmental Corp.
Madison, Wisconsin

Tested By: JPH **Checked By:** JPH

Samples are tested "as received". Initial graphs are best fit lines. Graphs do not represent engineering judgement by the lab.

Draft

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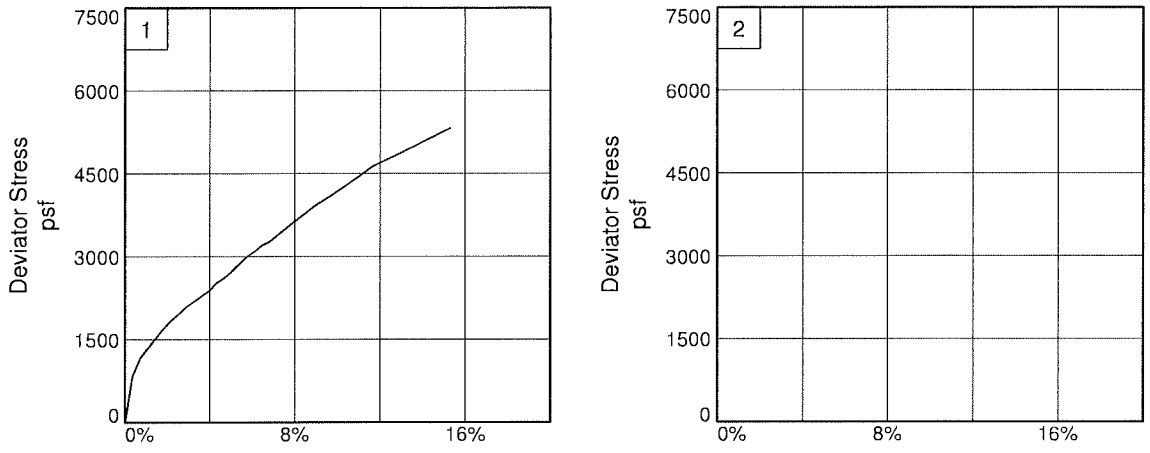
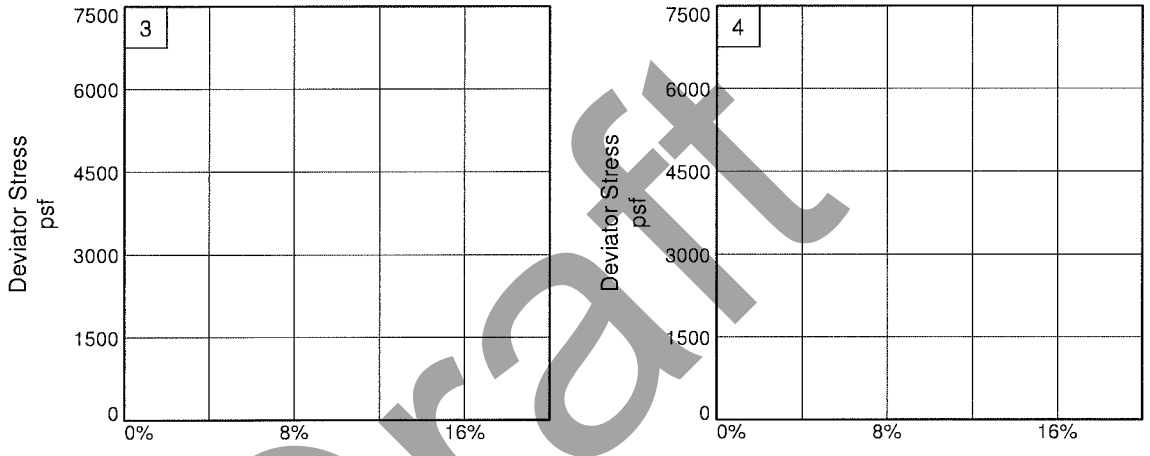
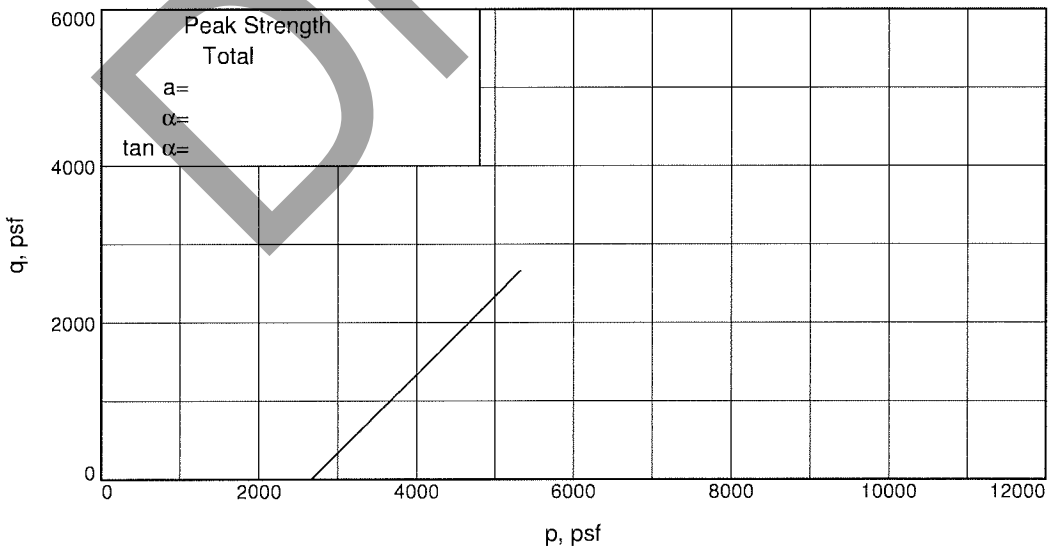






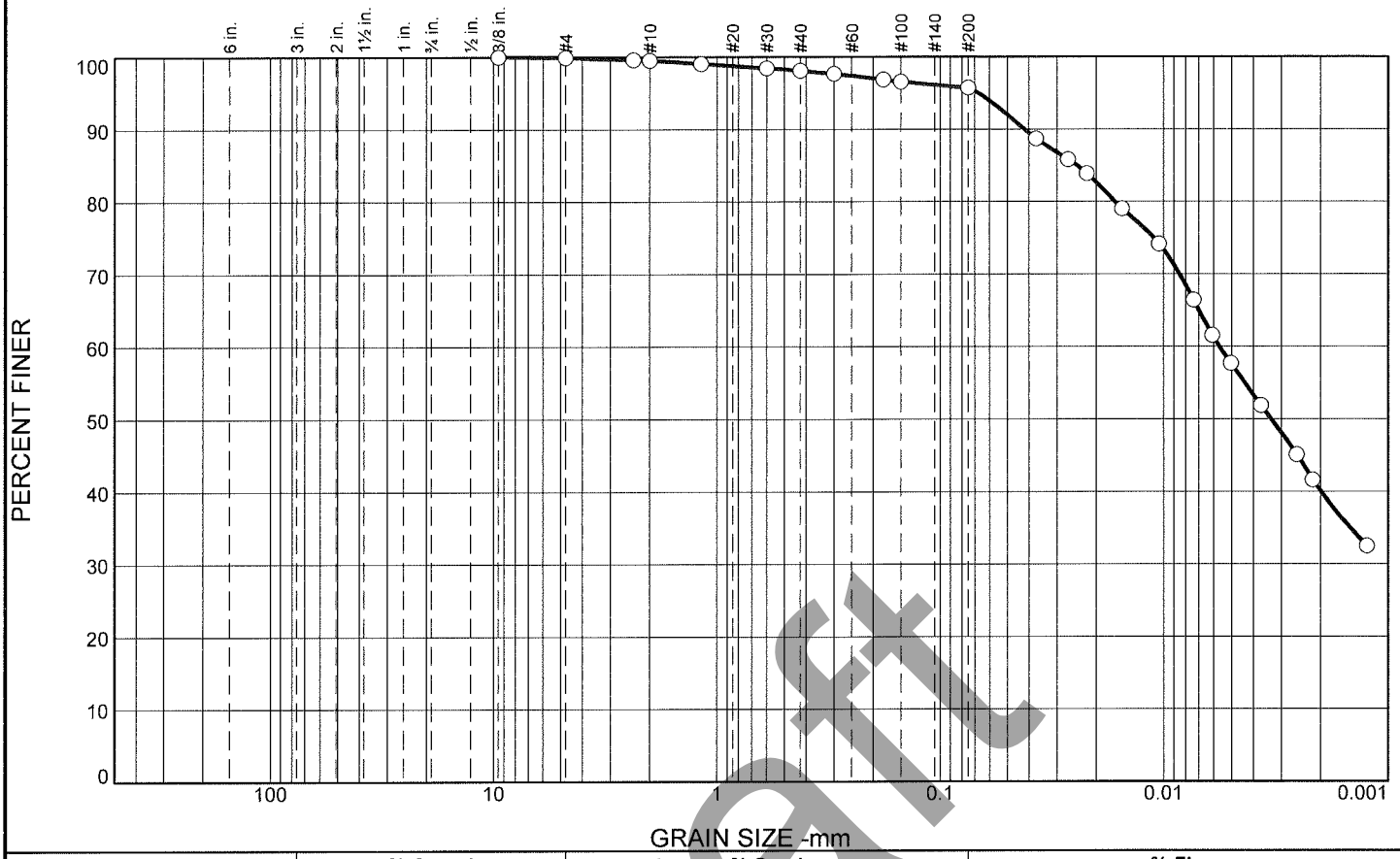
Draft

Client:
Project: ECI - E. Chicago, IN.
Source of Sample: SB-04 **Sample Number:** SB-04, 34.5-39.5'
Project No.: C16033-1 **Figure** _____

TRC Environmental Corp.

Tested By: JPH **Checked By:** JPH

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.1	0.4	1.4	2.3	38.2	57.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/8	100.0		
#4	99.9		
#8	99.6		
#10	99.5		
#16	99.1		
#30	98.5		
#40	98.1		
#50	97.7		
#80	96.9		
#100	96.6		
#200	95.8		

* (no specification provided)

Material Description

Gray Lean Clay, Trace Sand and Gravel

Atterberg Limits

PL= 19 LL= 39 PI= 20

Coefficients

D_{90}= 0.0420 D_{85}= 0.0245 D_{60}= 0.0057
D_{50}= 0.0033 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(20)

Remarks

Natural Moisture = 24.0% ; Organic Content = 1.7%;
Unit Weight (Dry) =103.4 pcf ; Specific Gravity = 2.77

Sample Number: SB-02 **Depth:** 34.5-39.5'

Date: 4/11/16

CGC, Inc.

Client: ARCADIS
Project: ECI/East Chicago, IN
ARCADIS# CI001067.1643
Project No: C16033-1 **Figure**

Tested By: DRW **Checked By:** DAS

Draft

Particle Size Distribution Report

% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.1	0.2	1.0	2.7	42.0	54.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/8	100.0		
#4	99.9		
#8	99.8		
#10	99.7		
#16	99.4		
#30	99.0		
#40	98.7		
#50	98.2		
#80	97.2		
#100	96.9		
#200	96.0		

* (no specification provided)

Material Description

Gray Lean Clay, Trace Sand and Gravel

Atterberg Limits

PL= 19 LL= 38 PI= 19

Coefficients

D_{90}= 0.0378 D_{85}= 0.0243 D_{60}= 0.0065
D_{50}= 0.0041 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(19)

Remarks

Natural Moisture = 19.7% ; Organic Content = 1.4%;
Unit Weight (Dry) = 110.8 pcf ; Specific Gravity = 2.78

Sample Number: SB-04 **Depth:** 34.5-39.5'

Date: 4/11/16

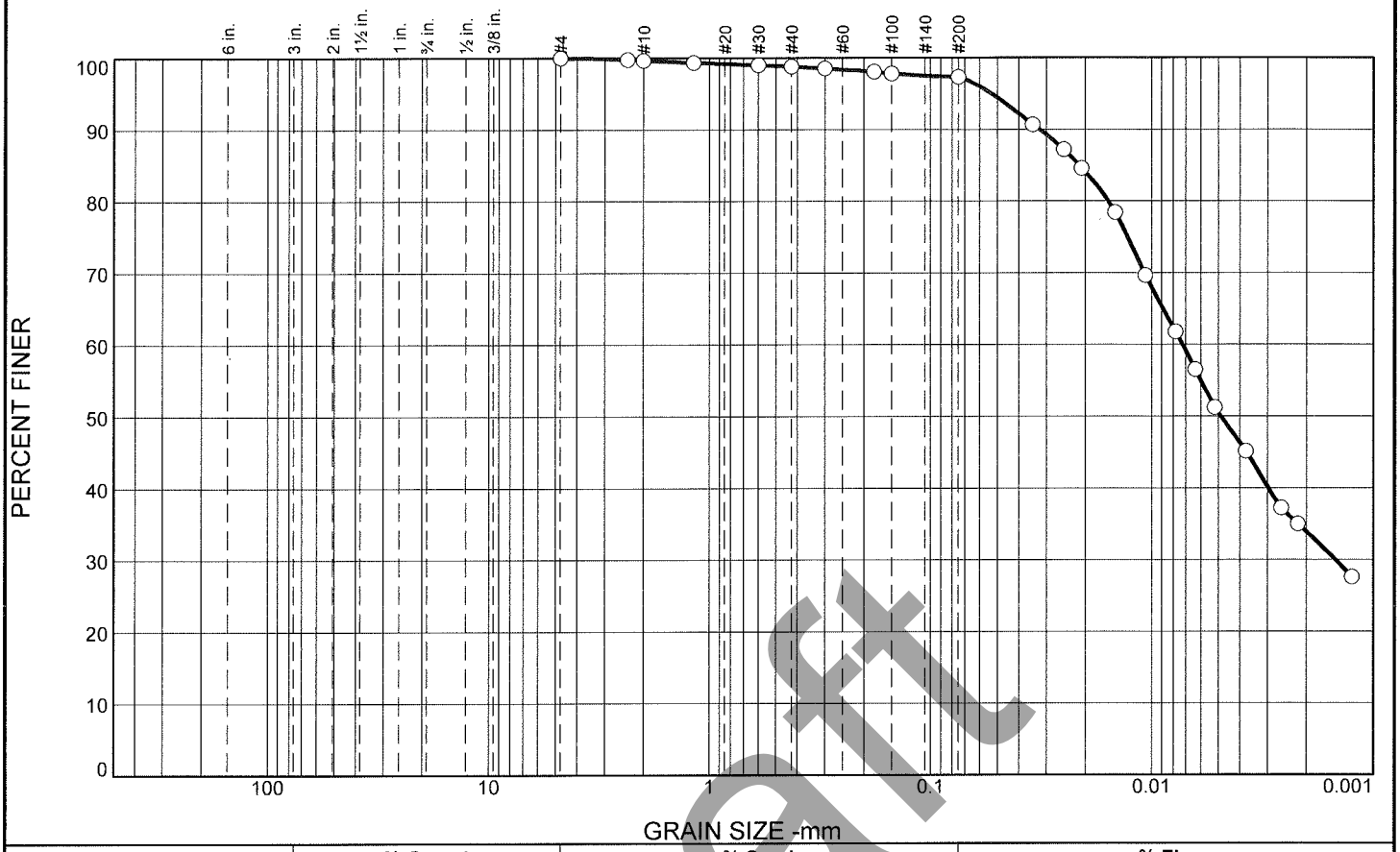
CGC, Inc.

Client: ARCADIS
Project: ECI/East Chicago, IN
ARCADIS# CI001067.1643
Project No: C16033-1 **Figure**

Tested By: DRW **Checked By:** DAS

Draft

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.3	0.9	1.4	46.9	50.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#8	99.8		
#10	99.7		
#16	99.4		
#30	99.0		
#40	98.8		
#50	98.5		
#80	98.1		
#100	97.8		
#200	97.4		

* (no specification provided)

Material Description

Gray Lean Clay, Trace Sand

Atterberg Limits

PL= 18 LL= 34 PI= 16

Coefficients

D_{90}= 0.0323 D_{85}= 0.0214 D_{60}= 0.0073
D_{50}= 0.0049 D_{30}= 0.0015 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(15)

Remarks

Natural Moisture = 20.2%; Organic Content = 1.5%
Unit Weight (Dry) = 109.1 pcf; Specific Gravity = 2.79

Sample Number: SB-06 **Depth:** 34.5-39.5'

Date: 4/11/16

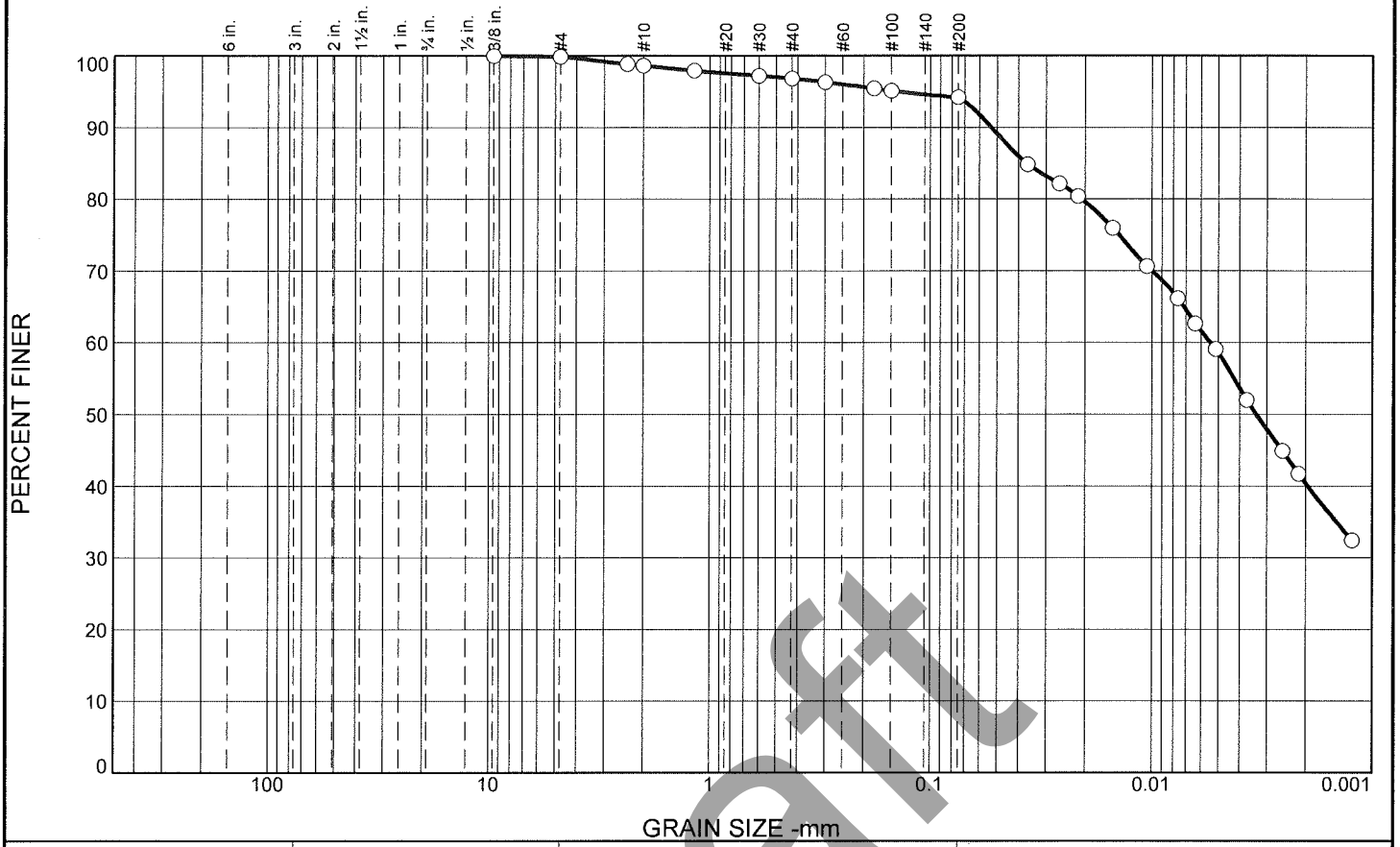
CGC, Inc.

Client: ARCADIS
Project: ECI/East Chicago, IN
ARCADIS# CI001067.1643
Project No: C16033-1 **Figure**

Tested By: DRW **Checked By:** DAS

Draft

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.1	1.3	1.8	2.6	35.7	58.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/8	100.0		
#4	99.9		
#8	98.9		
#10	98.6		
#16	97.9		
#30	97.2		
#40	96.8		
#50	96.3		
#80	95.4		
#100	95.1		
#200	94.2		

* (no specification provided)

Material Description

Gray Lean Clay, Little Sand, Trace Gravel

Atterberg Limits

PL= 20 LL= 39 PI= 19

Coefficients

D_{90}= 0.0531 D_{85}= 0.0369 D_{60}= 0.0054
D_{50}= 0.0034 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(19)

Remarks

Natural Moisture = 22.2%; Organic Content = 2.0%;
Unit Weight (Dry) = 103.7 pcf ; Specific Gravity = 2.77

Sample Number: SB-08 **Depth:** 33-38'

Date: 4/11/16

CGC, Inc.

Client: ARCADIS
Project: ECI/East Chicago, IN
ARCADIS# CI001067.1643
Project No: C16033-1 **Figure**

Tested By: DRW **Checked By:** DAS

Draft

Particle Size Distribution Report

% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	2.0	3.9	35.6	58.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#8	100.0		
#10	100.0		
#16	99.6		
#30	98.5		
#40	98.0		
#50	97.3		
#80	96.0		
#100	95.6		
#200	94.1		

* (no specification provided)

Material Description

Gray Lean Clay, Little Sand

Atterberg Limits

PL= 20 LL= 39 PI= 19

Coefficients

D_{90}= 0.0496 D_{85}= 0.0305 D_{60}= 0.0054
D_{50}= 0.0034 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(19)

Remarks

Natural Moisture = 21.5% ; Organic Content = 2.0%;
Unit Weight (Dry) = 106.8 pcf ; Specific Gravity = 2.79

Sample Number: SB-11 **Depth:** 32-37'

Date: 4/11/16

CGC, Inc.

Client: ARCADIS
Project: ECI/East Chicago, IN
ARCADIS# CI001067.1643
Project No: C16033-1 **Figure**

Tested By: DRW **Checked By:** DAS

Draft

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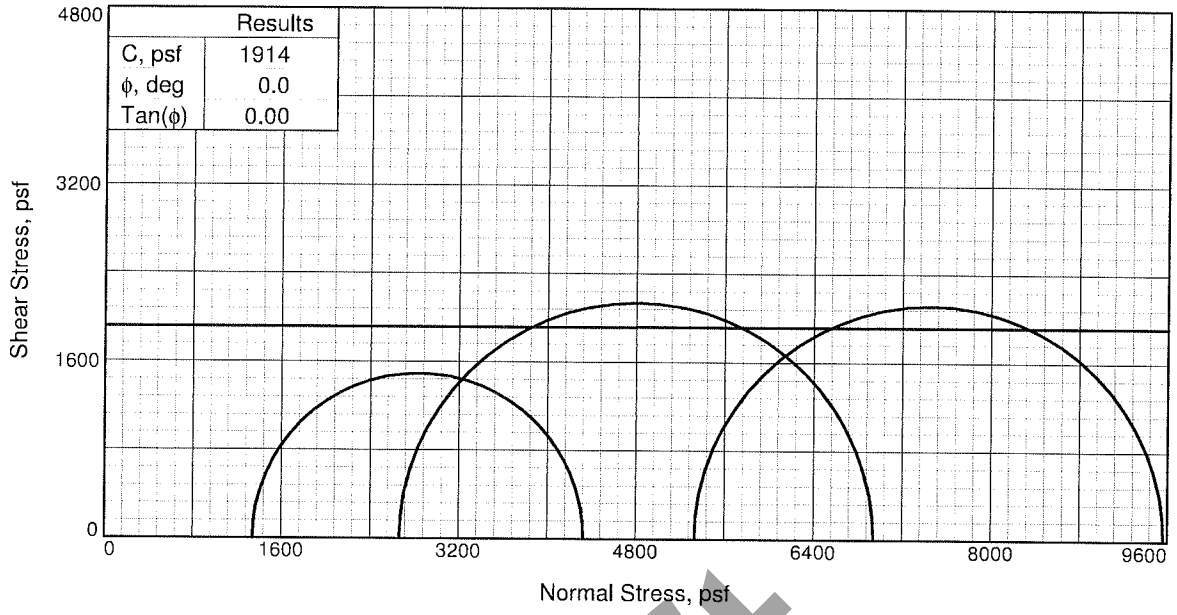

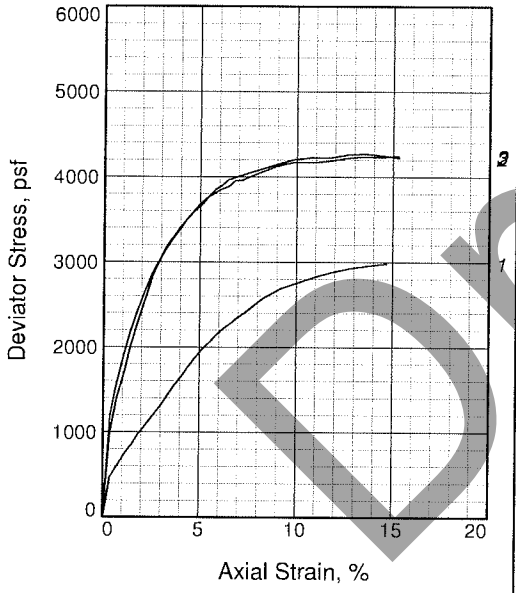

Sample No.		1	2	3
Initial	Water Content, %	25.7	25.5	25.3
	Dry Density, pcf	100.2	100.8	101.2
	Saturation, %	99.3	99.6	99.9
	Void Ratio	0.7127	0.7035	0.6962
	Diameter, in.	2.85	2.85	2.85
	Height, in.	5.45	5.55	5.57
At Test	Water Content, %	25.7	25.5	25.3
	Dry Density, pcf	100.2	100.8	101.2
	Saturation, %	99.3	99.6	99.9
	Void Ratio	0.7127	0.7035	0.6962
	Diameter, in.	2.85	2.85	2.85
	Height, in.	5.45	5.55	5.57
Strain rate, %/min.		0.50	0.50	0.50
Back Pressure, psi		0.00	0.00	0.00
Cell Pressure, psi		9.30	18.50	37.00
Fail. Stress, psf		2985	4275	4233
Strain, %		14.7	13.5	14.4
Ult. Stress, psf				
Strain, %				
σ_1 Failure, psf		4324	6939	9561
σ_3 Failure, psf		1339	2664	5328

Type of Test: Unconsolidated Undrained

Sample Type: Undisturbed

Description: Gray Lean Clay, Little Sand, Trace Gravel

Assumed Specific Gravity= 2.75

Remarks:

Figure _____

Client:

Project: ECI - E. Chicago, IN.

Source of Sample: SB-08

Sample Number: SB-08, 33-38'

Proj. No.: C16033-1 **Date Sampled:** 01-21-16

TRIAXIAL SHEAR TEST REPORT
TRC Environmental Corp.
Madison, Wisconsin

Draft

Tested By: JPH **Checked By:** JPH

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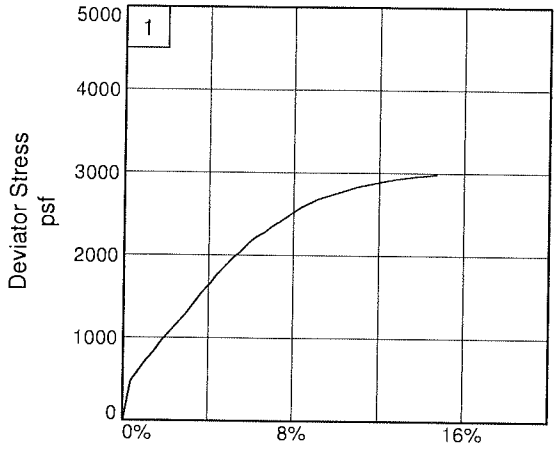
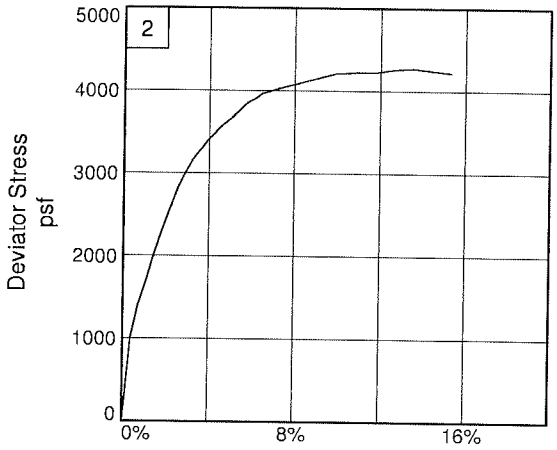
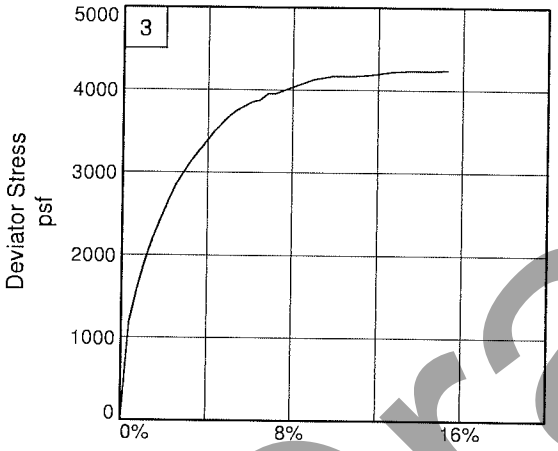
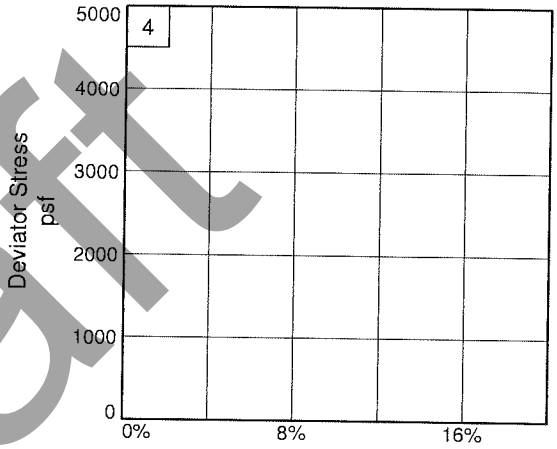
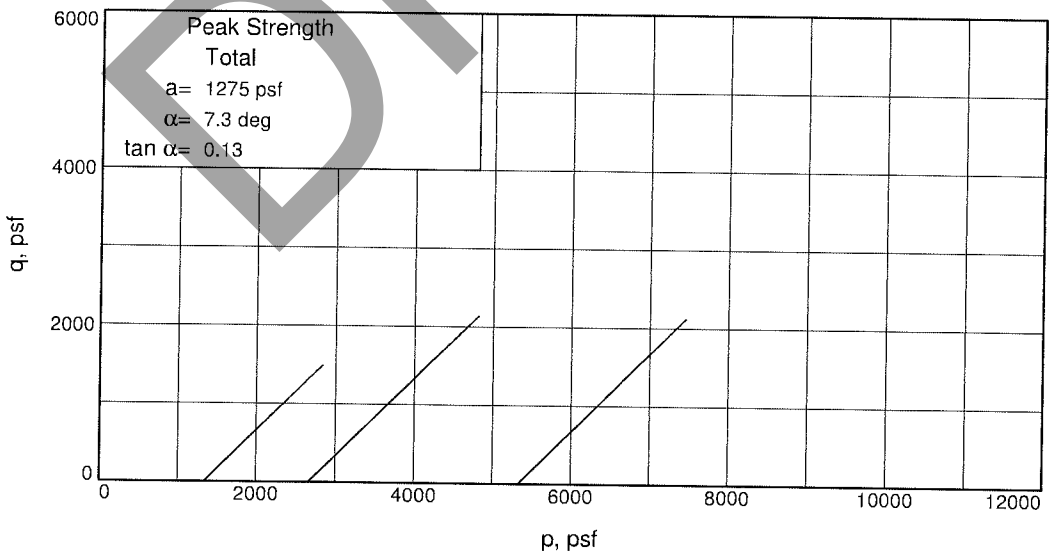










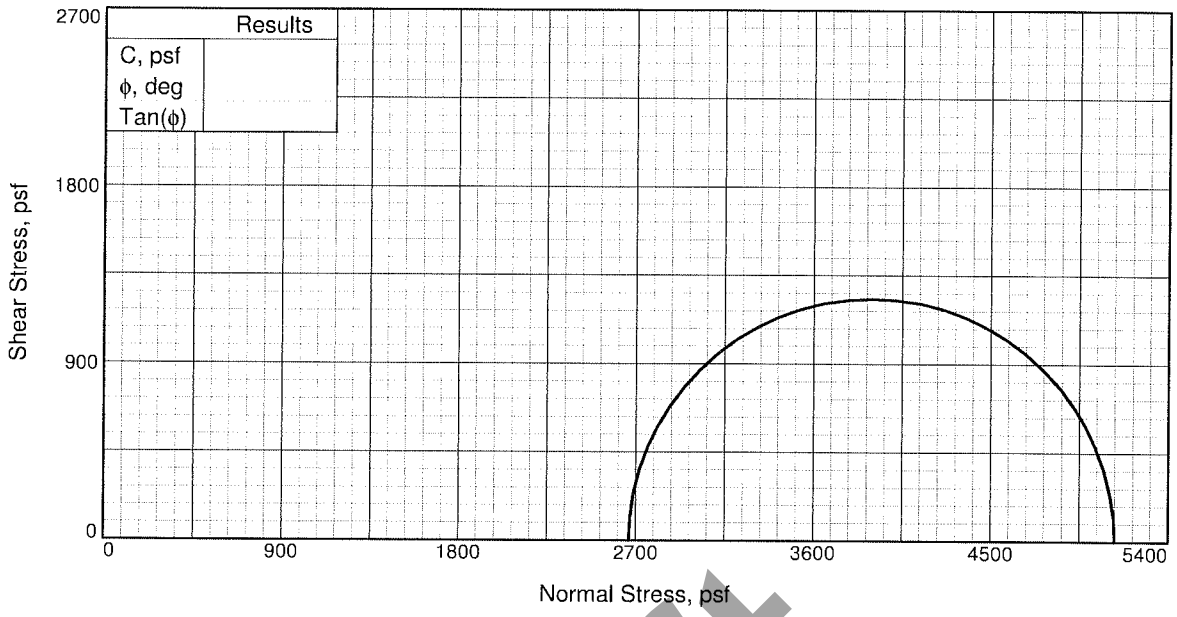
Draft

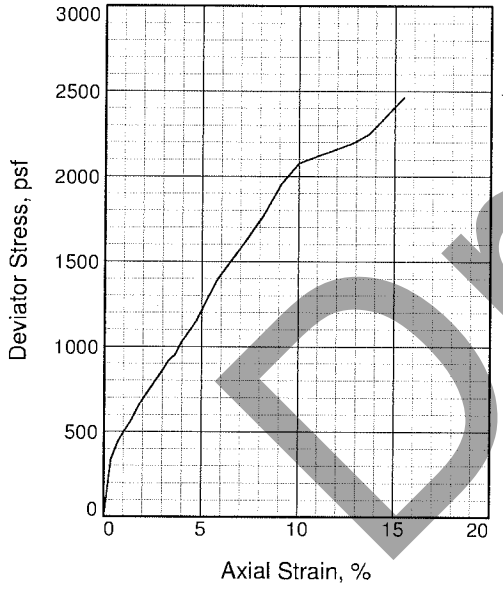
Client:
Project: ECI - E. Chicago, IN.
Source of Sample: SB-08 **Sample Number:** SB-08, 33-38'
Project No.: C16033-1 **Figure** _____

TRC Environmental Corp.

Tested By: JPH **Checked By:** JPH

Samples are tested "as received". Initial graphs are best fit lines. Graphs do not represent engineering judgement by the lab.





Sample No.		1
Initial	Water Content, %	20.7
	Dry Density, pcf	107.7
	Saturation, %	99.1
	Void Ratio	0.5649
	Diameter, in.	2.86
	Height, in.	5.50
At Test	Water Content, %	20.7
	Dry Density, pcf	107.7
	Saturation, %	99.1
	Void Ratio	0.5649
	Diameter, in.	2.86
	Height, in.	5.50
Strain rate, %/min.		0.50
Back Pressure, psi		0.00
Cell Pressure, psi		18.50
Fail. Stress, psf		2464
Strain, %		15.5
Ult. Stress, psf		
Strain, %		
σ_1 Failure, psf		5128
σ_3 Failure, psf		2664

Type of Test:
Unconsolidated Undrained
Sample Type: Undisturbed
Description: Gray Lean Clay, Little Sand

Assumed Specific Gravity= 2.70
Remarks:

Figure _____

Client:

Project: ECI - E. Chicago, IN.

Source of Sample: SB-11
Sample Number: SB-11, 32-37'
Proj. No.: C16033-1 **Date Sampled:** 01-22-16

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TRC Environmental Corp.
Madison, Wisconsin

Tested By: JPH **Checked By:** JPH

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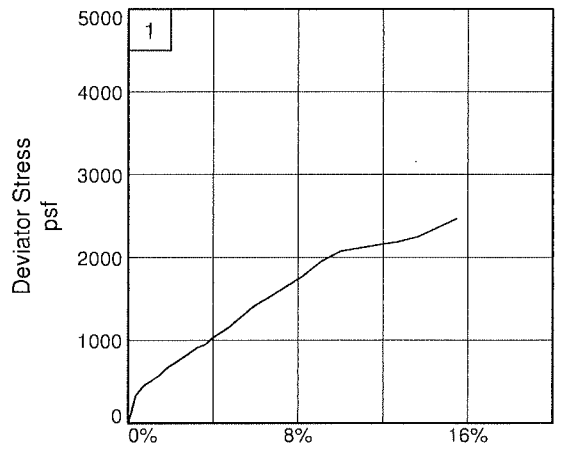
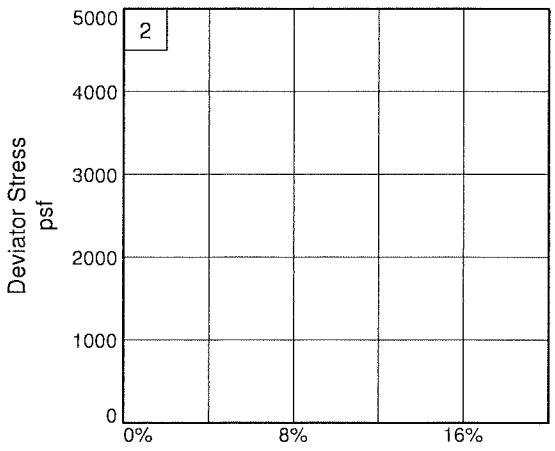
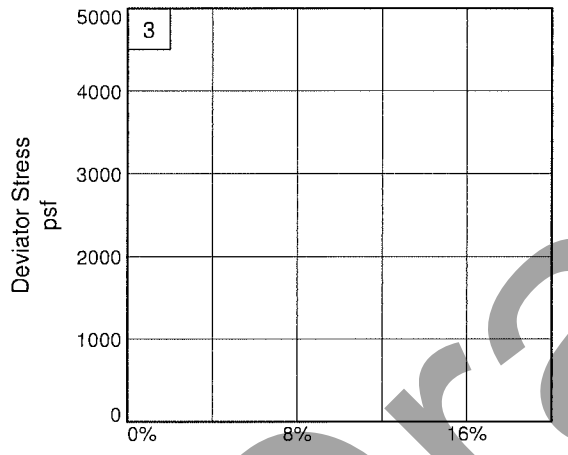
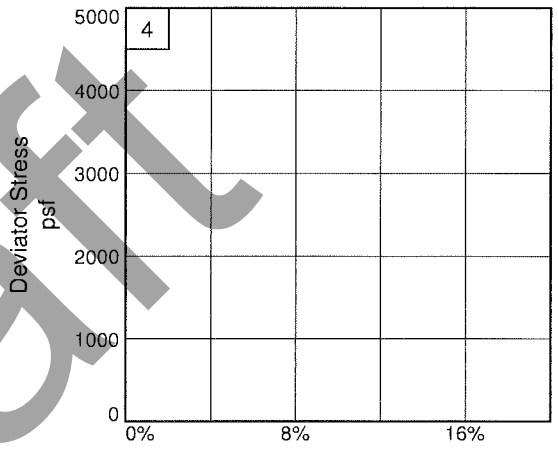
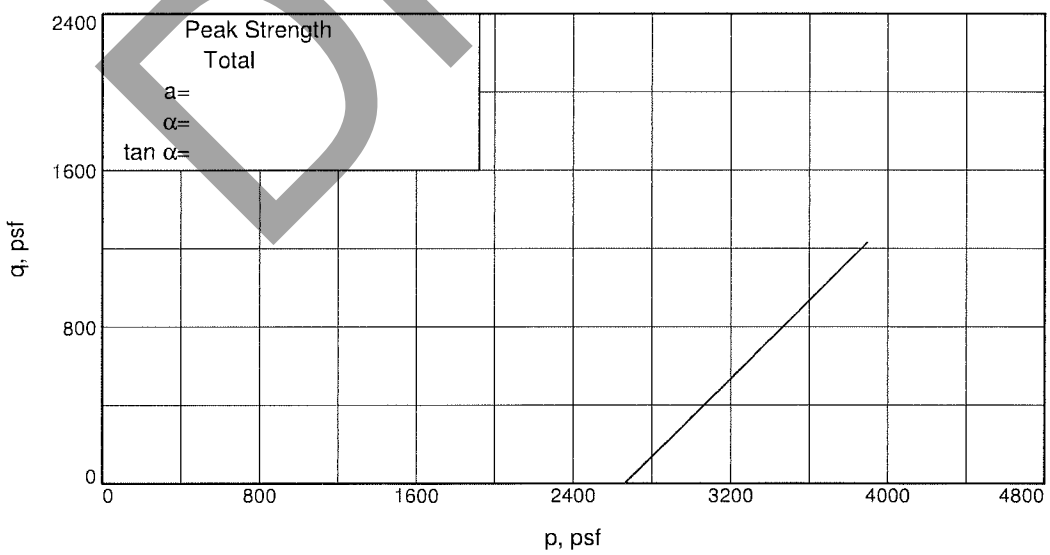










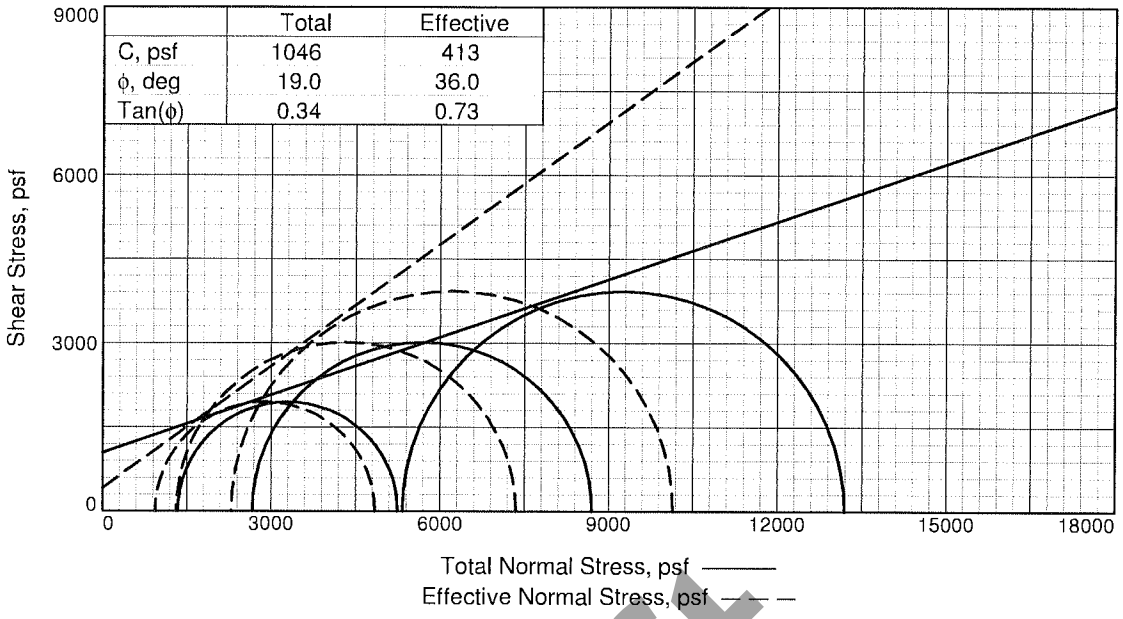
Draft

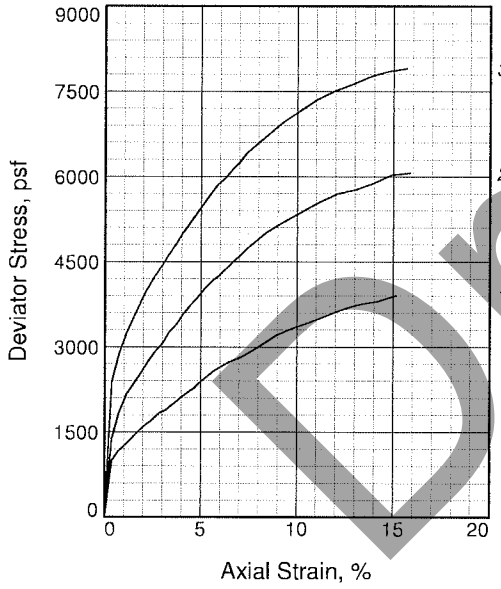
Client:
Project: ECI - E. Chicago, IN.
Source of Sample: SB-11 **Sample Number:** SB-11, 32-37'
Project No.: C16033-1 **Figure** _____

TRC Environmental Corp.

Tested By: JPH **Checked By:** JPH

Samples are tested "as received". Initial graphs are best fit lines. Graphs do not represent engineering judgement by the lab.





Sample No.		1	2	3
Initial	Water Content, %	20.8	20.1	20.2
	Dry Density, pcf	107.5	108.6	108.8
	Saturation, %	98.9	98.3	99.3
	Void Ratio	0.5682	0.5522	0.5490
	Diameter, in.	2.87	2.87	2.86
	Height, in.	5.63	5.38	5.50
At Test	Water Content, %	21.1	19.7	18.7
	Dry Density, pcf	107.4	110.0	111.9
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.5688	0.5323	0.5062
	Diameter, in.	2.87	2.85	2.84
	Height, in.	5.62	5.37	5.43
Strain rate, %/min.		0.50	0.50	0.50
Eff. Cell Pressure, psi		9.30	18.50	37.00
Fail. Stress, psf		3905	6034	7858
Excess Pore Pr., psf		403	1354	3038
Strain, %		15.1	14.9	14.7
Ult. Stress, psf				
Excess Pore Pr., psf				
Strain, %				
$\bar{\sigma}_1$ Failure, psf		4841	7344	10147
$\bar{\sigma}_3$ Failure, psf		936	1310	2290

Type of Test: CU with Pore Pressures

Sample Type: Undisturbed

Description: Gray Lean Clay, Trace Sand

Assumed Specific Gravity= 2.70

Remarks:

Figure _____

Client:

Project: ECI - E. Chicago, IN.

Source of Sample: SB-06

Sample Number: SB-06, 34.5-39.5'

Proj. No.: C16033-1 **Date Sampled:** 01-21-16

TRIAXIAL SHEAR TEST REPORT
TRC Environmental Corp.
Madison, Wisconsin

Draft

Tested By: JPH **Checked By:** JPH

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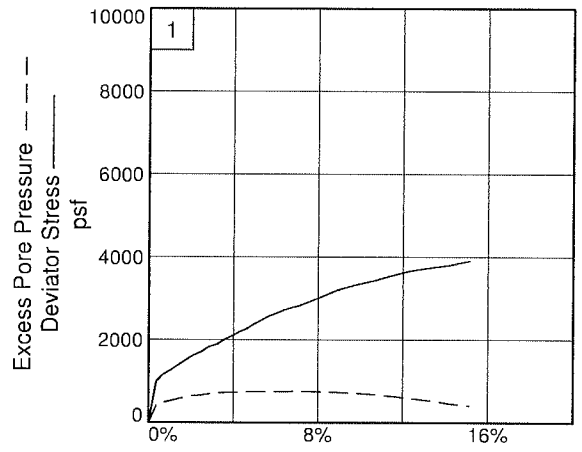

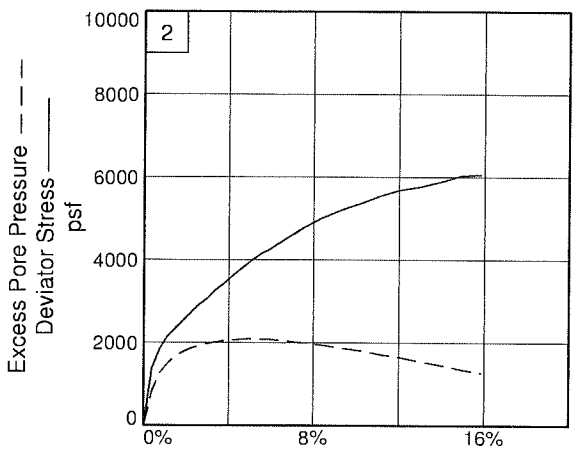

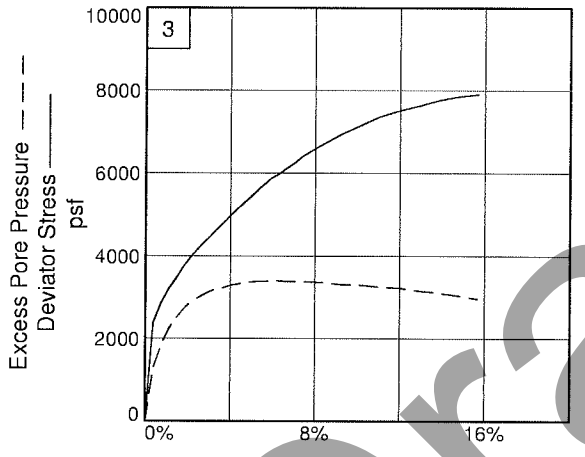

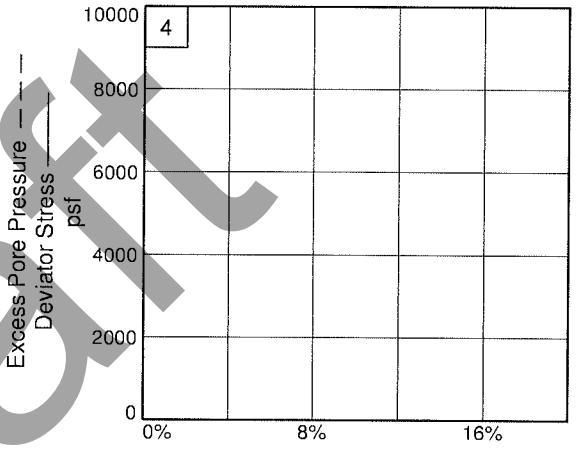

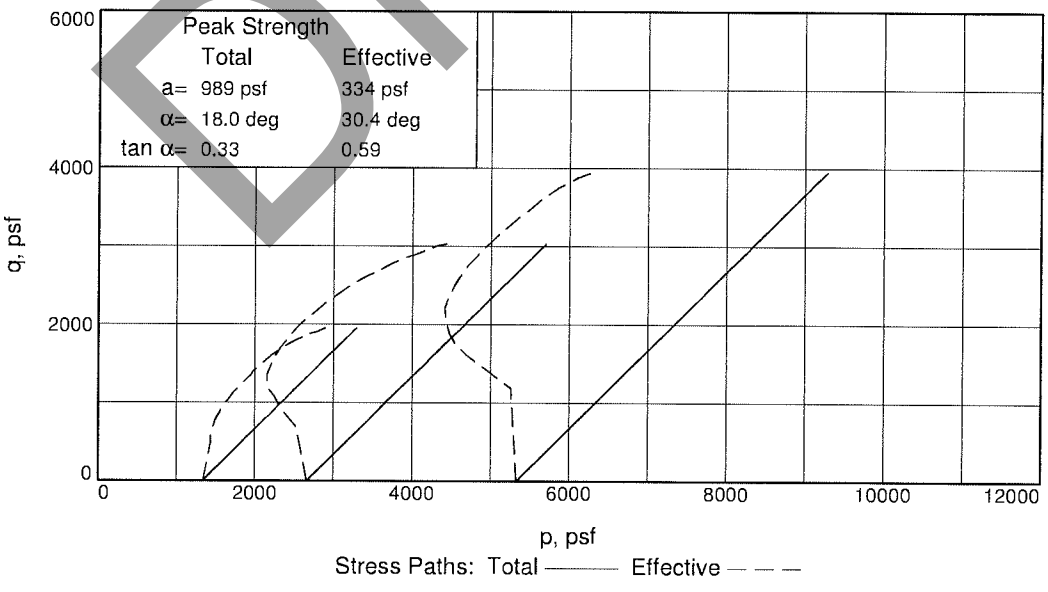

Draft

Client:

Project: ECI - E. Chicago, IN.

Source of Sample: SB-06 **Sample Number:** SB-06, 34.5-39.5'

Project No.: C16033-1 **Figure** _____

TRC Environmental Corp.

Tested By: JPH **Checked By:** JPH

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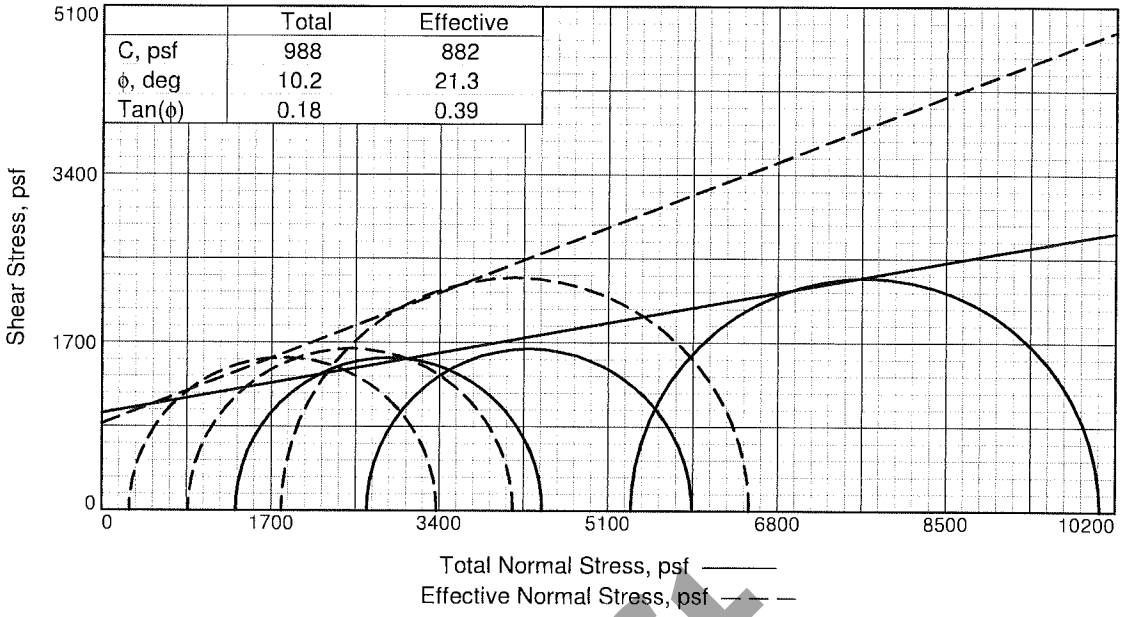

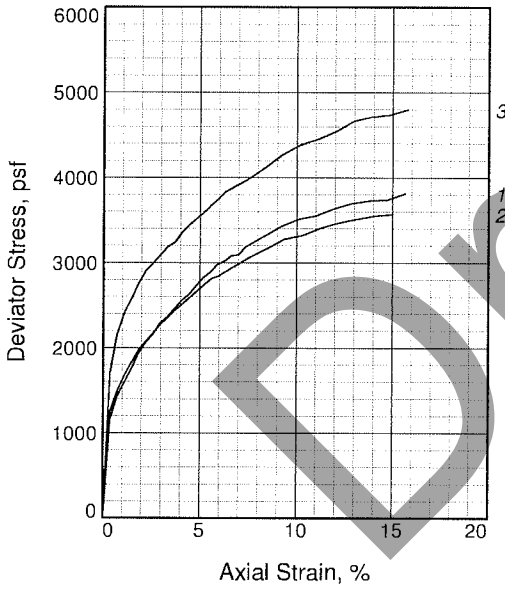

Sample No.		1	2	3
Initial	Water Content, %	24.9	25.3	25.7
	Dry Density, pcf	100.8	99.9	99.4
	Saturation, %	99.9	99.3	99.5
	Void Ratio	0.6730	0.6868	0.6963
	Diameter, in.	2.85	2.87	2.87
	Height, in.	5.44	5.38	5.50
At Test	Water Content, %	13.3	24.4	25.4
	Dry Density, pcf	124.0	101.7	100.0
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.3598	0.6582	0.6855
	Diameter, in.	2.57	2.86	2.89
	Height, in.	5.43	5.33	5.40
Strain rate, %/min.		0.50	0.50	0.50
Eff. Cell Pressure, psi		9.30	18.50	37.00
Fail. Stress, psf		3096	3276	4713
Excess Pore Pr., psf		1066	1800	3528
Strain, %		7.0	9.4	13.9
Ult. Stress, psf				
Excess Pore Pr., psf				
Strain, %				
$\bar{\sigma}_1$ Failure, psf		3370	4140	6513
$\bar{\sigma}_3$ Failure, psf		274	864	1800

Type of Test: CU with Pore Pressures

Sample Type: Undisturbed

Description: Gray Lean Clay, Little Sand, Trace Gravel

Assumed Specific Gravity= 2.70

Remarks: Used peak 1:3 ratio.

Figure _____

Client:

Project: ECI - E. Chicago, IN.

Source of Sample: SB-08

Sample Number: SB-08, 33-38'

Proj. No.: C16033-1 **Date Sampled:** 01-21-16

TRIAXIAL SHEAR TEST REPORT
TRC Environmental Corp.
Madison, Wisconsin

Tested By: JPH **Checked By:** JPH

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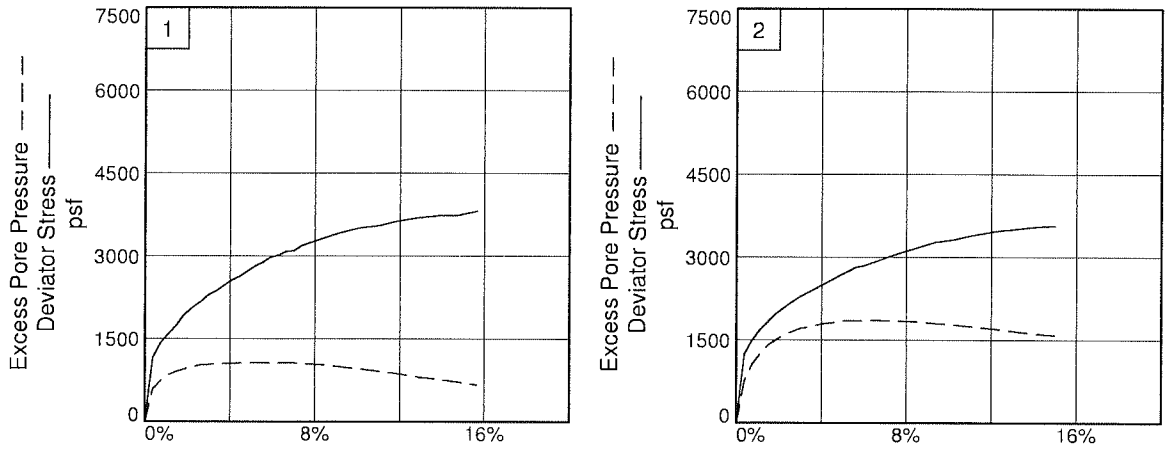

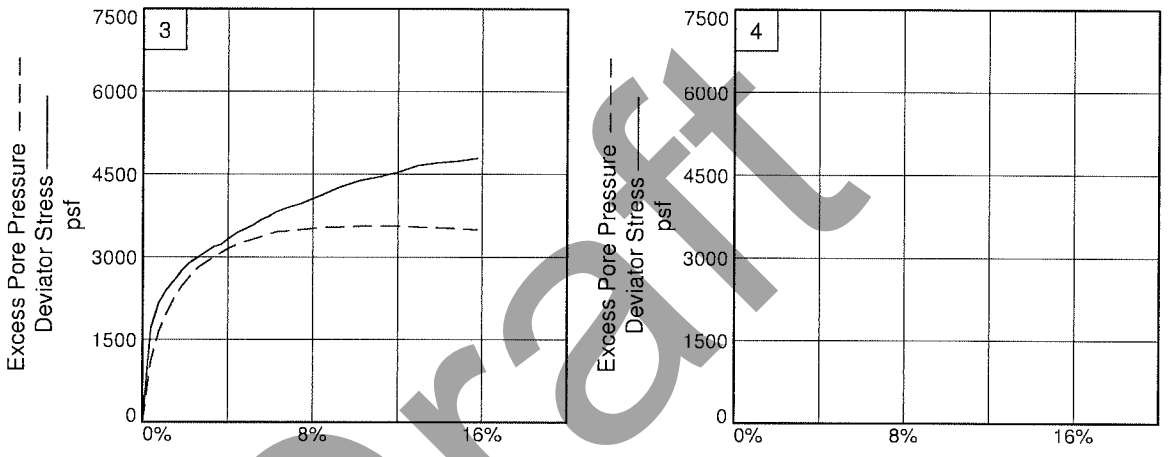

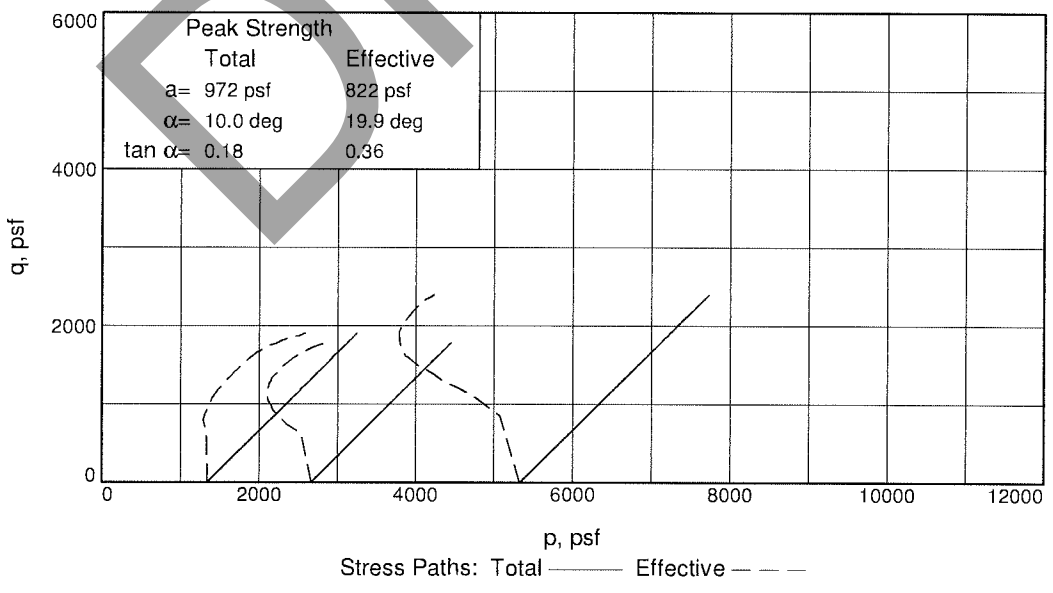

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Client:
Project: ECI - E. Chicago, IN.
Source of Sample: SB-08 **Sample Number:** SB-08, 33-38'
Project No.: C16033-1 **Figure** _____

TRC Environmental Corp.

Tested By: JPH **Checked By:** JPH

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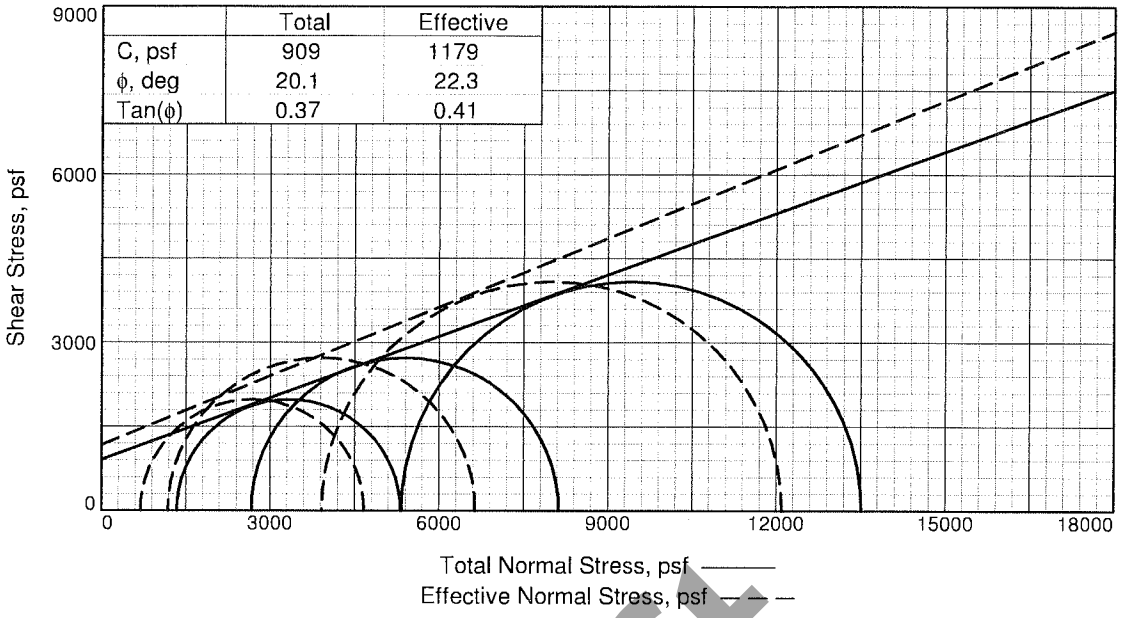

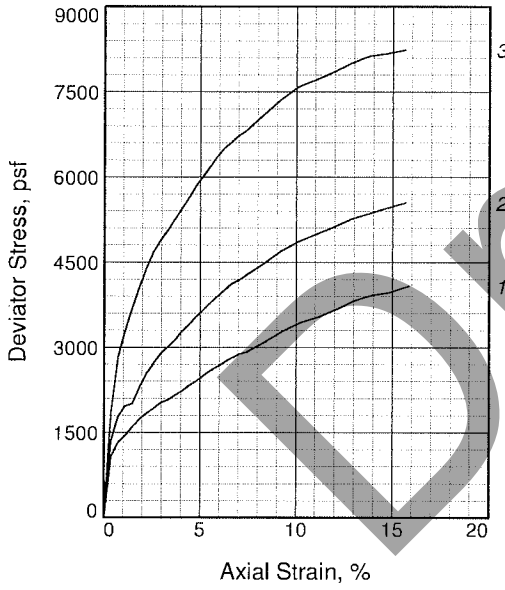

Sample No.		1	2	3
Initial	Water Content, %	21.6	21.8	21.1
	Dry Density, pcf	107.1	106.4	107.9
	Saturation, %	99.8	99.1	99.4
	Void Ratio	0.5918	0.6013	0.5800
	Diameter, in.	2.85	2.85	2.85
	Height, in.	5.38	5.50	5.58
At Test	Water Content, %	22.6	21.8	20.1
	Dry Density, pcf	105.5	106.8	110.0
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.6159	0.5954	0.5493
	Diameter, in.	2.87	2.86	2.86
	Height, in.	5.37	5.43	5.44
Strain rate, %/min.		0.50	0.50	0.50
Eff. Cell Pressure, psi		9.30	18.50	37.00
Fail. Stress, psf		3973	5457	8181
Excess Pore Pr., psf		648	1483	1411
Strain, %		14.9	14.7	14.7
Ult. Stress, psf				
Excess Pore Pr., psf				
Strain, %				
$\bar{\sigma}_1$ Failure, psf		4664	6638	12097
$\bar{\sigma}_3$ Failure, psf		691	1181	3917

Type of Test:
CU with Pore Pressures
Sample Type: Undisturbed
Description: Gray Lean Clay, Little Sand

Assumed Specific Gravity= 2.73
Remarks:

Figure _____

Client:

Project: ECI - E. Chicago, IN.

Source of Sample: SB-11
Sample Number: SB-11, 32-37'
Proj. No.: C16033-1 **Date Sampled:** 01-21-16

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TRC Environmental Corp.
Madison, Wisconsin

Tested By: JPH **Checked By:** JPH

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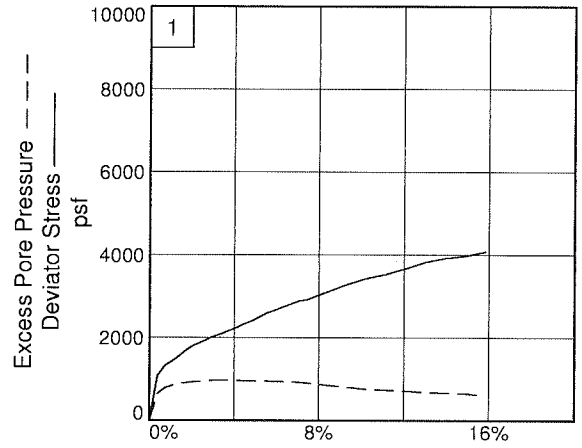

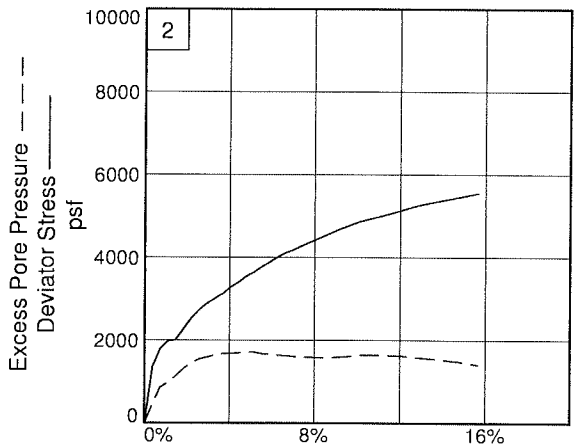

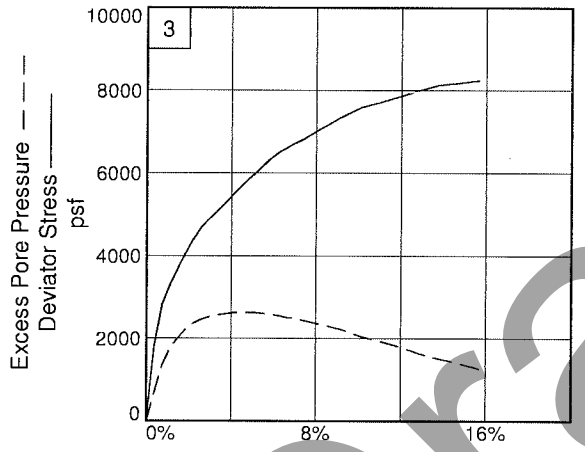

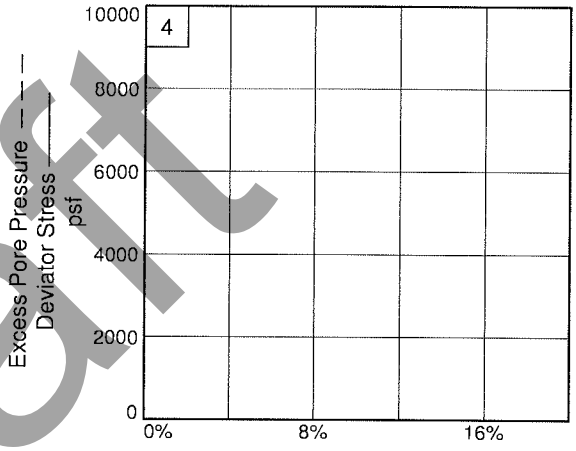

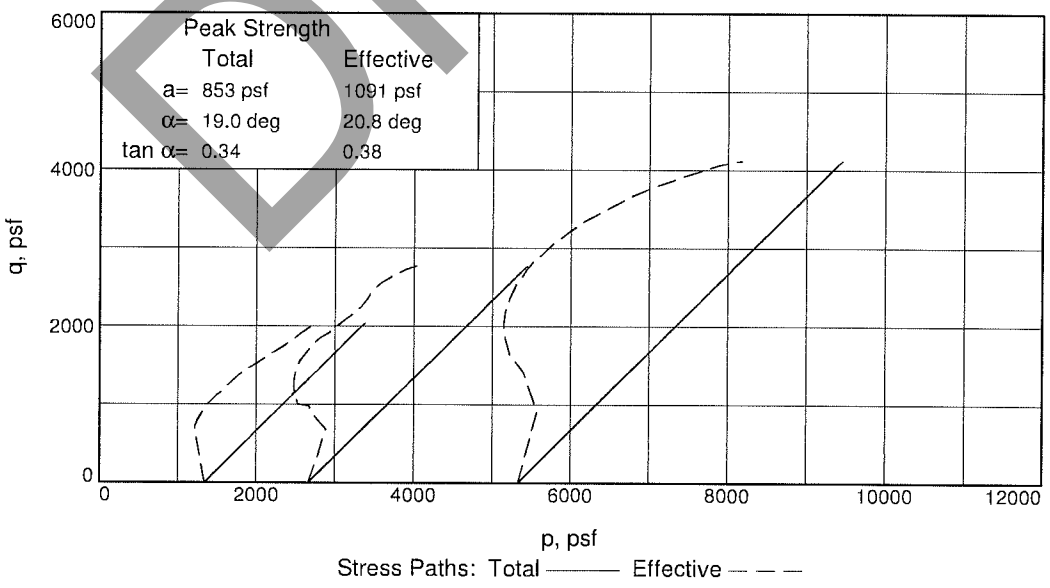

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Client:

Project: ECI - E. Chicago, IN.

Source of Sample: SB-11 **Sample Number:** SB-11, 32-37'

Project No.: C16033-1 **Figure** _____

TRC Environmental Corp.

Tested By: JPH **Checked By:** JPH

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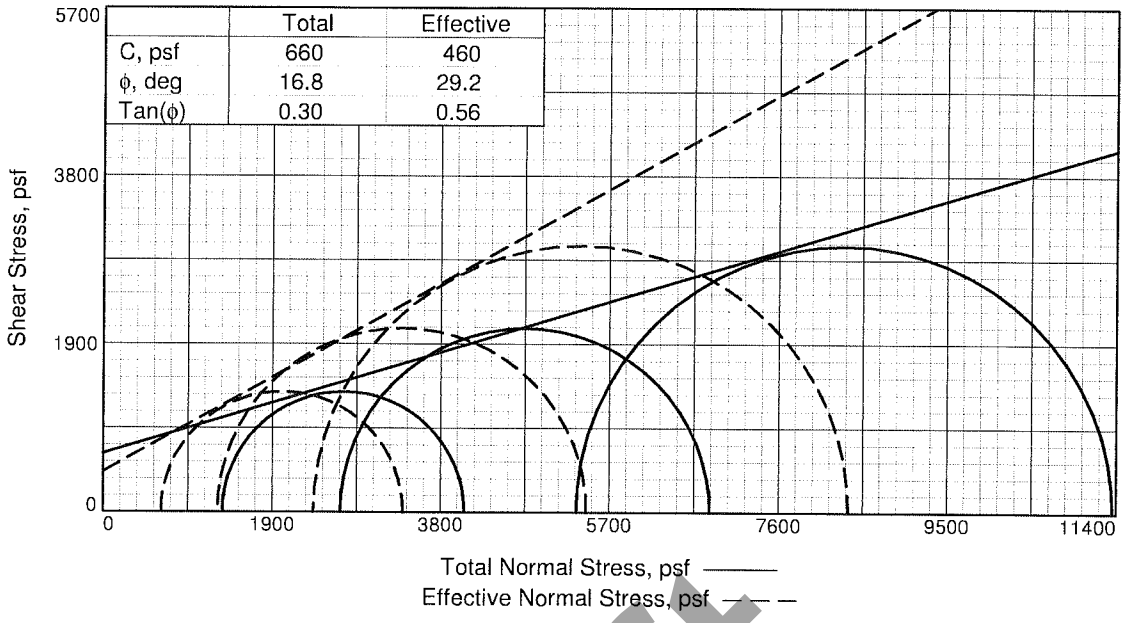

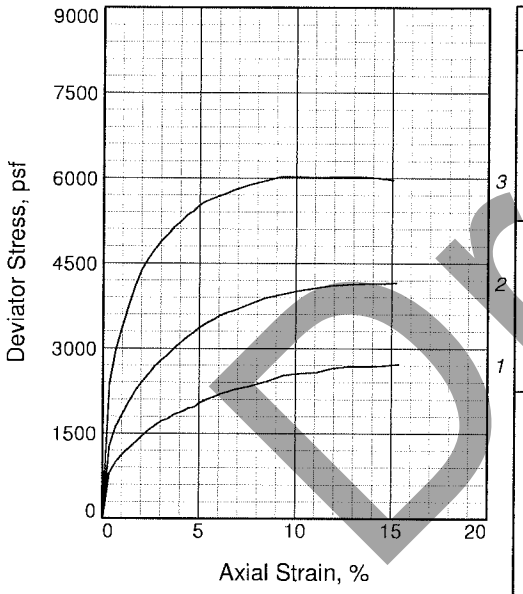

Sample No.		1	2	3
Initial	Water Content, %	24.3	24.3	24.3
	Dry Density, pcf	101.1	101.1	101.6
	Saturation, %	98.4	98.4	99.6
	Void Ratio	0.6678	0.6680	0.6598
	Diameter, in.	2.84	2.86	2.85
	Height, in.	5.88	5.95	6.05
At Test	Water Content, %	24.3	23.5	22.4
	Dry Density, pcf	101.7	103.1	105.1
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.6567	0.6345	0.6035
	Diameter, in.	2.83	2.84	2.82
	Height, in.	5.86	5.91	5.98
Strain rate, %/min.		0.50	0.50	0.50
Eff. Cell Pressure, psi		9.30	18.50	37.00
Fail. Stress, psf		2725	4160	6027
Excess Pore Pr., psf		691	1382	2966
Strain, %		15.4	15.2	10.0
Ult. Stress, psf				
Excess Pore Pr., psf				
Strain, %				
$\bar{\sigma}_1$ Failure, psf		3373	5442	8388
$\bar{\sigma}_3$ Failure, psf		648	1282	2362

Type of Test: CU with Pore Pressures

Sample Type: Undisturbed

Description: Gray Lean Clay, Trace Sand and Gravel

Assumed Specific Gravity= 2.70

Remarks:

Figure _____

Client:

Project: ECI - E. Chicago, IN.

Source of Sample: SB-02

Sample Number: SB-02, 34.5-39.5'

Proj. No.: C16033-1 **Date Sampled:** 01-20-16

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TRC Environmental Corp.
Madison, Wisconsin

Tested By: JPH **Checked By:** JPH

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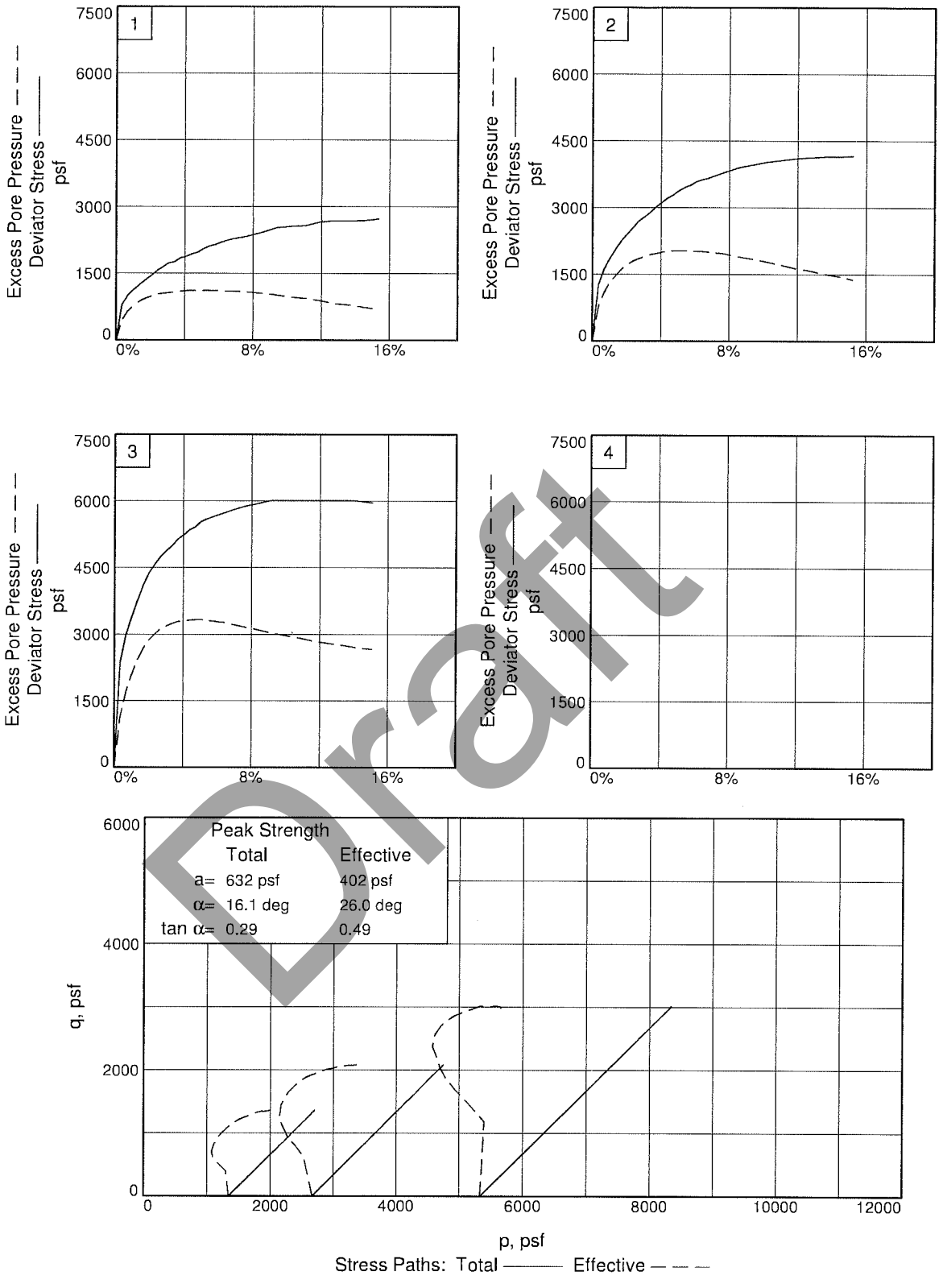

Draft

Client:

Project: ECI - E. Chicago, IN.

Source of Sample: SB-02 **Sample Number:** SB-02, 34.5-39.5'

Project No.: C16033-1 **Figure** _____

TRC Environmental Corp.

Tested By: JPH **Checked By:** JPH

Draft

ATTACHMENT D-2: BARGE LOADING REFERENCE

Design of Marine Facilities
for the Berthing, Mooring, and Repair of Vessels

JOHN W. GAYTHWAITE, P.E.
Consulting Engineer

Draft

VAN NOSTRAND REINHOLD
New York

6

Mooring Loads and Design Principles

Mooring loads usually govern the required lateral load capacity of a pier or berth structure. They are induced by the action of wind, current, and waves on the moored vessel and are transmitted to the structure via direct breasting or through the pull of mooring lines. Within protected harbors, wind and current loads usually are estimated for some assumed limiting wind and current velocities, and the effects of waves and harbor motions are neglected. Today with marine terminals in more exposed locations, wave loads cannot be neglected and, in fact, may govern design. With larger vessels transiting more crowded harbors, the effects of passing vessels on vessels already moored must be considered. Even in protected harbors, vessel movements in response to long period waves and harbor oscillations known as seiches may cause damage to vessel and pier alike, even when winds and currents are calm.

This chapter introduces some fundamental concepts of moored vessel behavior and the layout of mooring lines and hardware for vessels moored at fixed structures. Evaluations of wind, current, standoff forces, and wave loads are treated separately. Because of the complexities of calculating wave loads and other dynamic effects, mathematical and physical scale models are often used, and this subject is introduced at the end of the chapter. This discussion is oriented to vessels moored at fixed structures. The subject of freely moored vessels at single point moorings is addressed later, in Section 9.7.

6.1 MOORING SYSTEM PRINCIPLES

Mooring forces acting on a ship at berth arise from the following sources:

- Wind
- Current
- Passing vessel effects
- Hydrodynamic standoff forces
- Wave action
- Seiche and long period wave effects
- Tidal variations and vessel draft changes
- Vessel movements at berth
- Ice

In addition to staying secured in its berth, a moored vessel must remain as motionless as possible within a limited range of acceptable motions. At most harbor and near-shore locations it is usually sufficient to design the mooring system components for the maximum expected or prescribed limiting wind plus current loads. Mooring systems adequately designed for appropriate combined wind and current loads usually will possess sufficient capacity to cope with minor wave and water level changes, wind gust effects, and so on. Along river banks with strong currents or narrow channels, however, significant off-berth standoff forces may arise due to locally increased water velocities and resulting negative pressures caused by passing vessels or strong currents. At offshore berths and exposed near-shore sites, wave action also must be considered. Certain harbors are affected by long period wave action such as surging motions, sometimes referred to as range action or seiching, which can result in very large mooring line forces. In areas of large tidal range, especially when combined with rapid cargo transfer operations, mooring lines may be subject to rapidly changing lengths and angles, resulting in increased line loads. Large vertical forces may result from friction between the vessel and the fender facing. Warping and shifting of the vessel within its berth may impose longitudinal rubbing forces. Ice is seldom a factor in mooring design loads, but it should be considered in areas subject to moving ice floes.

The general approach to calculating mooring loads on piers, wharves, and berthing structures depends somewhat upon the vessel size and type, site exposure and environmental conditions, and amount of information available describing those factors. For example, for smaller vessels, and for general and bulk cargo ships up to around 20,000 tons displacement at protected harbor locations, it may be adequate to provide mooring bollards or bitts of specified capacity at suitable locations, usually between 30- to-60-foot centers along the wharf face. A similar approach may be taken for even larger vessels when little is known about the specific vessels to be berthed. The capacity of the mooring hardware can be presumed from some guideline standard such as references (1) through (4) or other accepted practice. British (1, 2) and German (3) code recommendations for bollard capacities are summarized in Table 6.1. Another method is to size the mooring hardware to exceed the breaking strength of the vessel's docking lines if this information can be reasonably attained.

The mooring point loads are distributed into the overall pier structure as described in Section 7.3. Equivalent distributed mooring loads for oceangoing vessels usually range from 1000 to 2500 pounds per lineal foot (plf) of pier face applied horizontally at deck level for vessels from 2000 to 20,000 tons displacement (DT), to over 3000 plf for the largest vessels. Longitudinal mooring forces are usually on the order of 25% to 75% of the lateral forces. Vertical uplift on bollards also must be considered.

In general, for vessels around and exceeding 20,000 DT, for special vessels

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Table 6.1. Mooring point (bollard) loads for general and bulk cargo ships (after BSI, 1984, and EAU, 1980).

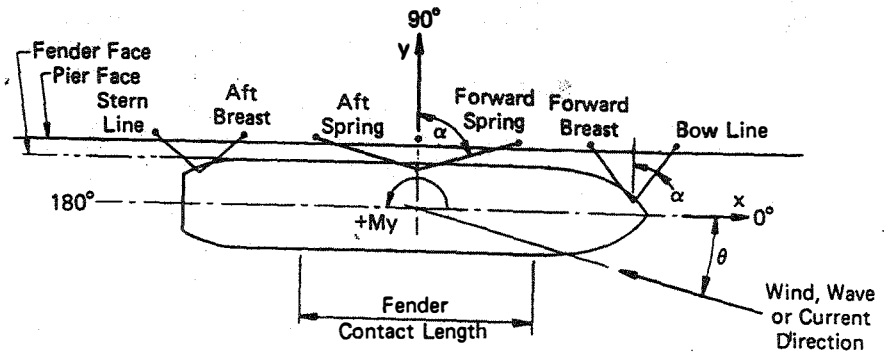
Vessel displacement (tons)	Bollard load (kn)*
Up to and incl. 2,000	100
10,000	300
20,000	600
50,000	800
100,000	1,000
200,000	1,500
> 200,000	2,000

*For exceptional wind, current, or other adverse effects, increase the above values by 25%. Per EAU (3), provide corner bollards of 2500 kN capacity for vessels > 100,000 T. Assumed bollard spacings of 15 m to 30 m. *Note:* 1 kN = 224.8 lb.; 1 m = 3.28 ft.

such as those with high superstructures, and/or where severe site conditions exist, the maximum probable loads should be calculated for each mooring point for the entire range of vessel sizes and types expected. This involves calculating the combined forces and moments produced by the design level wind plus current plus equivalent static wave force and/or standoff forces, as applicable and with regard to the elasticity and geometry of the mooring lines. The calculations may be simplified in some instances by assuming that only bow/stern and/or breast lines take the lateral loads, and spring lines take the longitudinal loads. Refer to Figure 6.1 for mooring line and layout definitions.

Another approach is to assume an unequal distribution of the total mooring force among the mooring points. According to BSI (2), when the vessel is moored at six points, one-third of the total force should be assumed at any one point; and where the vessel is moored at four points, one-half of the total force should be assumed to act at any single point. Calculation of line loads is discussed at the end of this section. In cases where wave loadings may be severe or long period waves or range action is present, a more rigorous analytical treatment and/or the use of physical models may be required, as described in Section 6.7.

A freely floating vessel possesses six degrees of freedom of motion—three translational and three rotational, as illustrated in Figure 6.2. These possible motions are defined as follows with respect to a cartesian coordinate system centered at the vessel's center of gravity (c.g.): *surge*, *sway*, and *heave* represent longitudinal, transverse, and vertical displacements in the x, y, and z directions, respectively, and *roll*, *pitch*, and *yaw* represent rotations about the x, y, and z axis, designated by ψ, ϕ, and θ, respectively. Heave, roll, and pitch motions are acted upon by the restoring force of gravity; so, a free floating vessel will possess natural periods of roll, heave, and pitch as described in



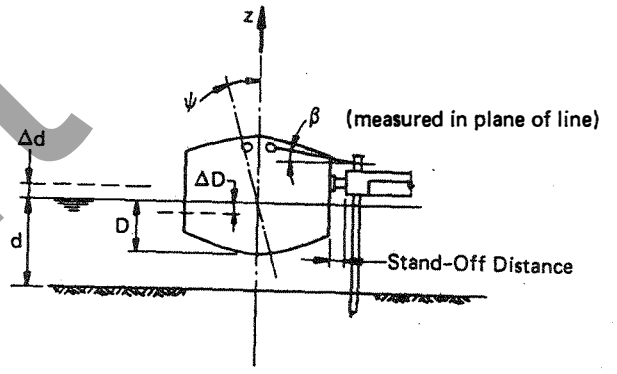


Figure 6.1. Vessel mooring lines and berth layout definitions.

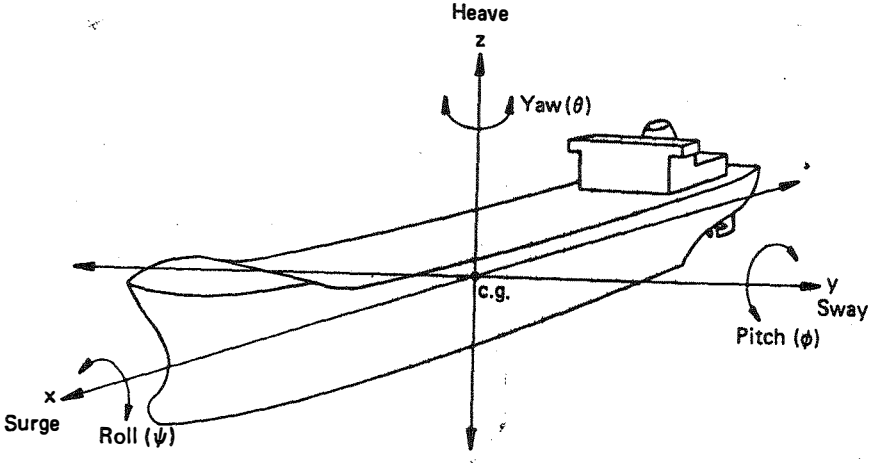


Figure 6.2. Vessel motions definition sketch.

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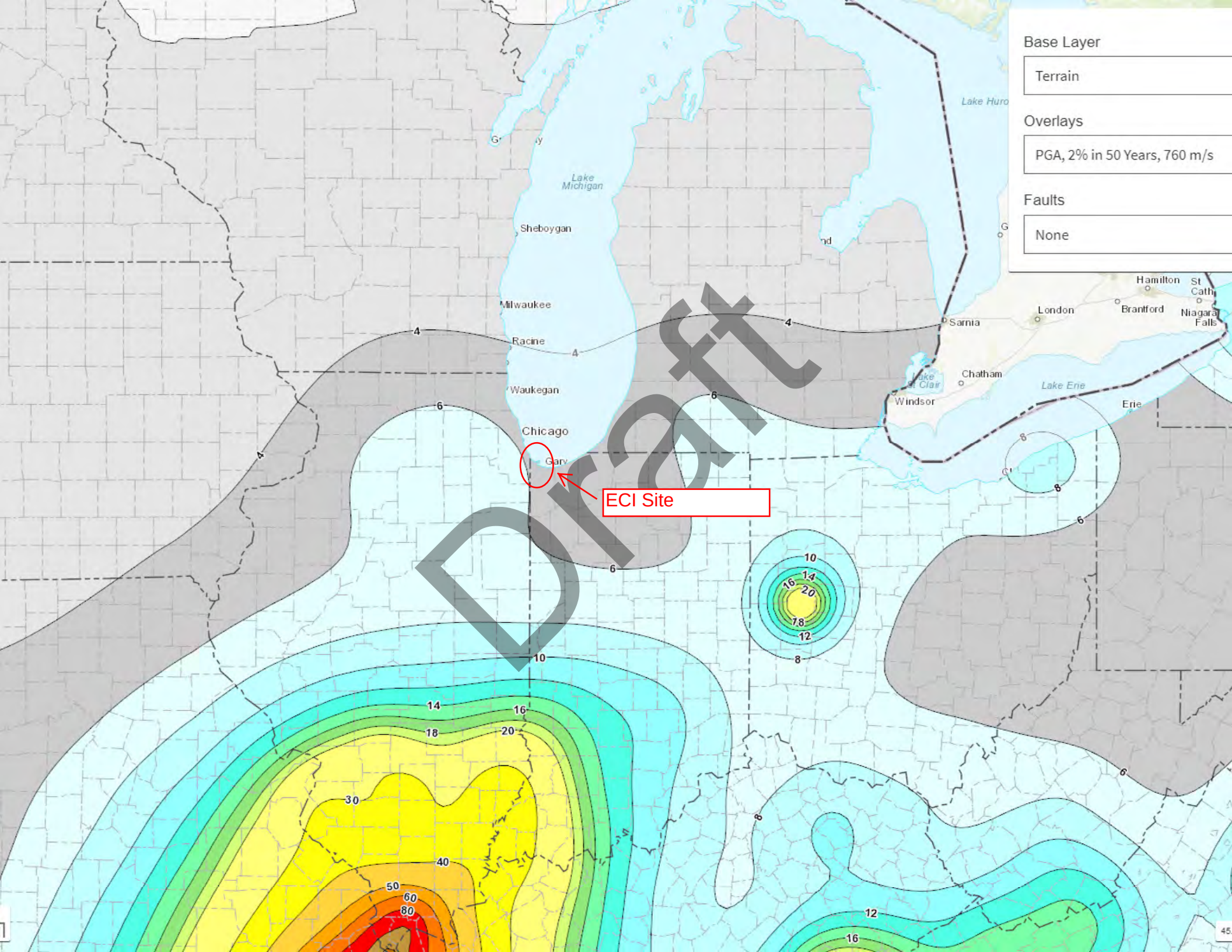
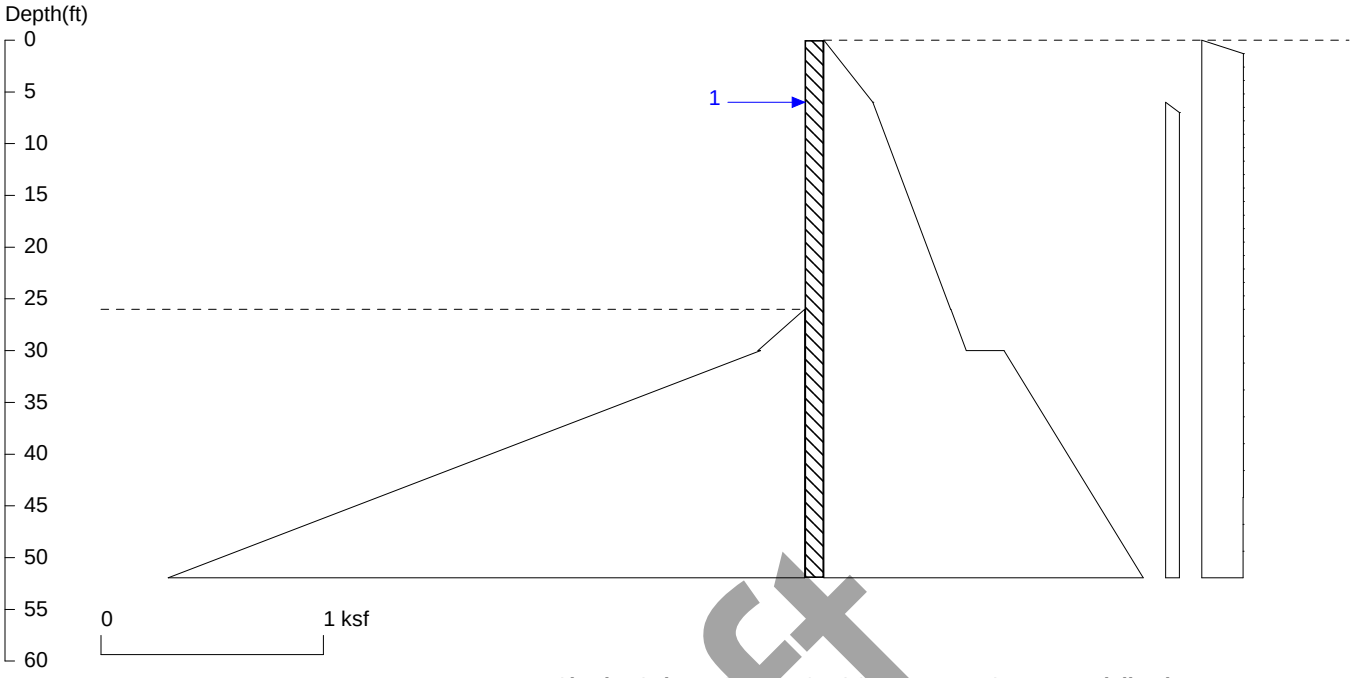
ATTACHMENT D-3: USGS 2014 SEISMIC HAZARD MAPPING DATA


Base Layer
Terrain
Overlays
PGA, 2% in 50 Years, 760 m/s
Faults
None
Lake Michigan
Sheboygan
Milwaukee
Racine
Waukegan
Chicago
Gary
Sarnia
London
Hamilton
Brantford
Niagara Falls
Chatham
Windsor
Lake Erie
Erie
ECI Site
Draft

Draft

ATTACHMENT D-4: SHORING SUITE OUTPUT FILES

BP ECI 30%
Usual - Long-Term



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File: P:\Projects\BP-ECI\3.0 Design\3.8 Geotechnical\02_30% Barrier Analyses\01_Bulkhead\00_Usual_LT.sh8

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MOMENT IN PILE: Max. Moment=127.73 per Pile Spacing=1.0 at Depth=25.43

BRACE FORCE: Strut, Tieback, Plate Anchor, and Deadman

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	6.0	0.0	1.0	14.1	14.1	0.0	0.0	0.0

UNITS: Width,Diameter,Spacing,Length,Depth,and Height - ft; Force - kip; Bond Strength and Pressure - ksf

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	6.000	0.220	0.036667
6.000	0.220	26.00	0.571	0.017533
*	Below	Base		
26.00	0.571	30.00	0.641	0.017533
30.00	0.810	260.0	7.368	0.028515
*	Water	Pres.		
6.000	0.000	7.000	0.062	0.062400
7.000	0.062	260.0	0.062	0.000000
*	Sur-	charg		
0.000	0.000	1.300	0.187	0.144207
1.300	0.187	2.600	0.187	-0.00002
2.600	0.187	3.900	0.187	-0.00002
3.900	0.187	5.200	0.187	-0.00002
5.200	0.187	6.500	0.187	-0.00002
6.500	0.187	7.800	0.187	-0.00002
7.800	0.187	9.100	0.187	-0.00002
9.100	0.187	10.40	0.187	-0.00002

Draft

10.40	0.187	11.70	0.187	-0.00002
11.70	0.187	13.00	0.187	-0.00002
13.00	0.187	14.30	0.187	-0.00002
14.30	0.187	15.60	0.187	-0.00002
15.60	0.187	16.90	0.187	-0.00002
16.90	0.187	18.20	0.187	-0.00002
18.20	0.187	19.50	0.187	-0.00002
19.50	0.187	20.80	0.187	-0.00002
20.80	0.187	22.10	0.187	-0.00002
22.10	0.187	23.40	0.187	-0.00002
23.40	0.187	24.70	0.187	-0.00002
24.70	0.187	26.00	0.187	-0.00002
26.00	0.187	28.60	0.187	-0.00002
28.60	0.187	31.20	0.187	-0.00002
31.20	0.187	33.80	0.187	-0.00002
33.80	0.187	36.40	0.187	-0.00002
36.40	0.187	39.00	0.187	-0.00002
39.00	0.187	41.60	0.187	-0.00002
41.60	0.187	44.20	0.186	-0.00002
44.20	0.186	46.80	0.186	-0.00002
46.80	0.186	49.40	0.186	-0.00002
49.40	0.186	52.00	0.186	-0.00002

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
26.00	0.000	30.00	0.209	0.052286
30.00	0.198	260.0	28.08	0.121234

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	26.00	1.00

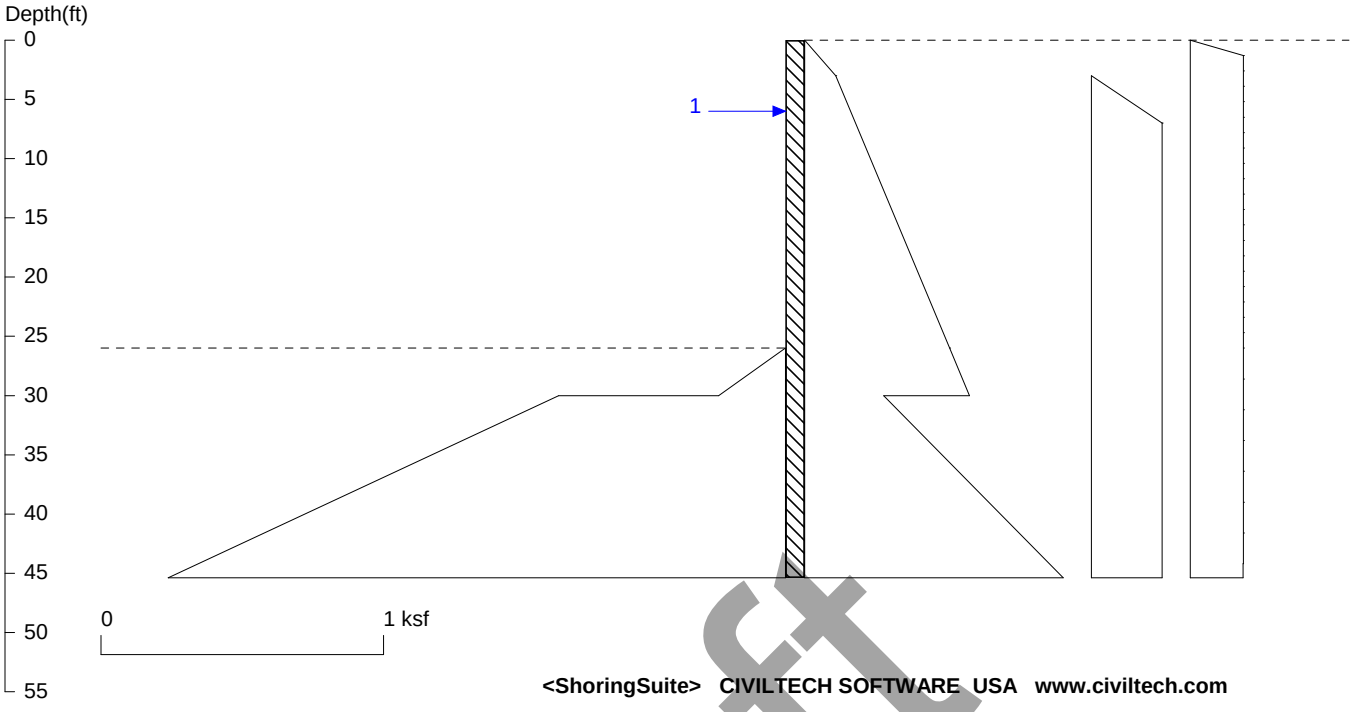
PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Draft

BP ECI 30%
Unusual 1a - High GW - phi-c



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File: P:\Projects\BP-ECI\3.0 Design\3.8 Geotechnical\02_30% Barrier Analyses\01_Bulkhead\01a_Unusual 1a_High GW_ph

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MOMENT IN PILE: Max. Moment=97.54 per Pile Spacing=1.0 at Depth=22.10

BRACE FORCE: Strut, Tieback, Plate Anchor, and Deadman

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	6.0	0.0	1.0	13.7	13.7	0.0	0.0	0.0

UNITS: Width,Diameter,Spacing,Length,Depth,and Height - ft; Force - kip; Bond Strength and Pressure - ksf

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	3.000	0.110	0.036667
3.000	0.110	26.00	0.513	0.017533
*	Below	Base		
26.00	0.513	30.00	0.583	0.017533
30.00	0.280	260.0	9.780	0.041302
*	Water	Pres.		
3.000	0.000	7.000	0.250	0.062400
7.000	0.250	260.0	0.250	0.000000
*	Sur-	charg		
0.000	0.000	1.300	0.187	0.144207
1.300	0.187	2.600	0.187	-0.00002
2.600	0.187	3.900	0.187	-0.00002
3.900	0.187	5.200	0.187	-0.00002
5.200	0.187	6.500	0.187	-0.00002
6.500	0.187	7.800	0.187	-0.00002
7.800	0.187	9.100	0.187	-0.00002
9.100	0.187	10.40	0.187	-0.00002

Draft

10.40	0.187	11.70	0.187	-0.00002
11.70	0.187	13.00	0.187	-0.00002
13.00	0.187	14.30	0.187	-0.00002
14.30	0.187	15.60	0.187	-0.00002
15.60	0.187	16.90	0.187	-0.00002
16.90	0.187	18.20	0.187	-0.00002
18.20	0.187	19.50	0.187	-0.00002
19.50	0.187	20.80	0.187	-0.00002
20.80	0.187	22.10	0.187	-0.00002
22.10	0.187	23.40	0.187	-0.00002
23.40	0.187	24.70	0.187	-0.00002
24.70	0.187	26.00	0.187	-0.00002
26.00	0.187	28.60	0.187	-0.00002
28.60	0.187	31.20	0.187	-0.00002
31.20	0.187	33.80	0.187	-0.00002
33.80	0.187	36.40	0.187	-0.00002
36.40	0.187	39.00	0.187	-0.00002
39.00	0.187	41.60	0.187	-0.00002
41.60	0.187	44.20	0.186	-0.00002
44.20	0.186	46.80	0.186	-0.00002

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
26.00	0.000	30.00	0.236	0.059094
30.00	0.803	260.0	21.45	0.089779

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	26.00	1.00

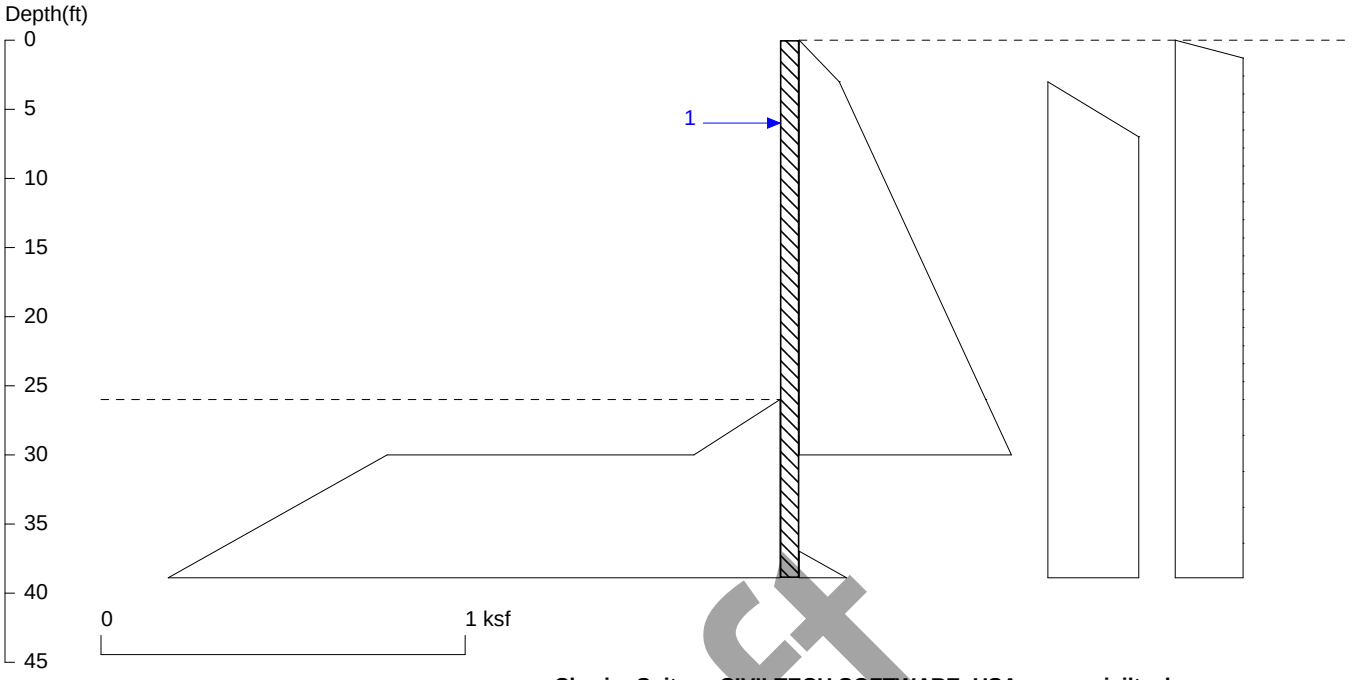
PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Draft

BP ECI 30%
Unusual 1b - High GW - su



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File: P:\Projects\BP-ECI\3.0 Design\3.8 Geotechnical\02_30% Barrier Analyses\01_Bulkhead\01b_Unusual 1b_High GW_su

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MOMENT IN PILE: Max. Moment=79.07 per Pile Spacing=1.0 at Depth=20.69

BRACE FORCE: Strut, Tieback, Plate Anchor, and Deadman

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	6.0	0.0	1.0	12.5	12.5	0.0	0.0	0.0

UNITS: Width,Diameter,Spacing,Length,Depth,and Height - ft; Force - kip; Bond Strength and Pressure - ksf

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	3.000	0.110	0.036667
3.000	0.110	26.00	0.513	0.017533
*	Below	Base		
26.00	0.513	30.00	0.583	0.017533
36.97	0.000	260.0	15.10	0.067726
*	Water	Pres.		
3.000	0.000	7.000	0.250	0.062400
7.000	0.250	260.0	0.250	0.000000
*	Sur-	charg		
0.000	0.000	1.300	0.187	0.144207
1.300	0.187	2.600	0.187	-0.00002
2.600	0.187	3.900	0.187	-0.00002
3.900	0.187	5.200	0.187	-0.00002
5.200	0.187	6.500	0.187	-0.00002
6.500	0.187	7.800	0.187	-0.00002
7.800	0.187	9.100	0.187	-0.00002
9.100	0.187	10.40	0.187	-0.00002

Draft

10.40	0.187	11.70	0.187	-0.00002
11.70	0.187	13.00	0.187	-0.00002
13.00	0.187	14.30	0.187	-0.00002
14.30	0.187	15.60	0.187	-0.00002
15.60	0.187	16.90	0.187	-0.00002
16.90	0.187	18.20	0.187	-0.00002
18.20	0.187	19.50	0.187	-0.00002
19.50	0.187	20.80	0.187	-0.00002
20.80	0.187	22.10	0.187	-0.00002
22.10	0.187	23.40	0.187	-0.00002
23.40	0.187	24.70	0.187	-0.00002
24.70	0.187	26.00	0.187	-0.00002
26.00	0.187	28.60	0.187	-0.00002
28.60	0.187	31.20	0.187	-0.00002
31.20	0.187	33.80	0.187	-0.00002
33.80	0.187	36.40	0.187	-0.00002
36.40	0.187	39.00	0.187	-0.00002

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
26.00	0.000	30.00	0.236	0.059094
30.00	1.079	260.0	16.62	0.067610

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	26.00	1.00

PASSIVE SPACING:

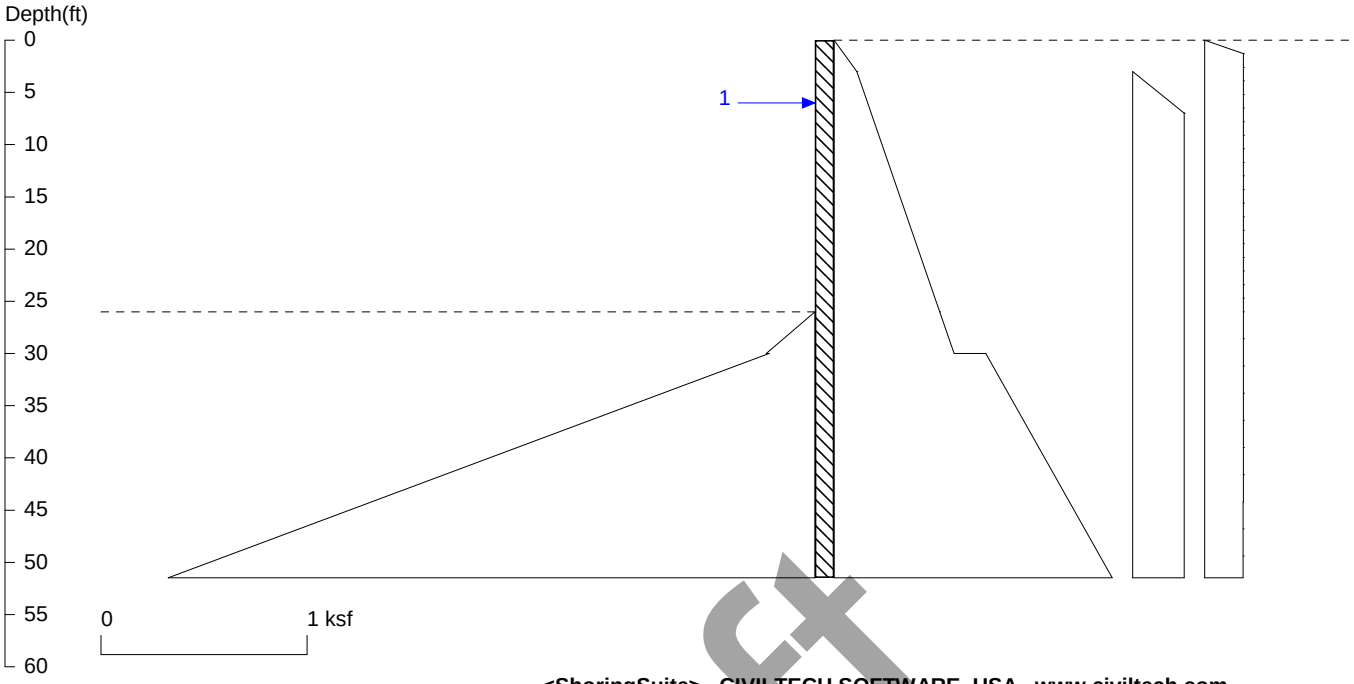
No.	Z depth	Spacing
1	0.00	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Draft

BP ECI 30%

Unusual 1c - High GW - phi'



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MOMENT IN PILE: Max. Moment=145.89 per Pile Spacing=1.0 at Depth=25.13

BRACE FORCE: Strut, Tieback, Plate Anchor, and Deadman

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	6.0	0.0	1.0	16.5	16.5	0.0	0.0	0.0

UNITS: Width,Diameter,Spacing,Length,Depth,and Height - ft; Force - kip; Bond Strength and Pressure - ksf

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	3.000	0.110	0.036667
3.000	0.110	26.00	0.513	0.017533
*	Below	Base		
26.00	0.513	30.00	0.583	0.017533
30.00	0.737	260.0	7.295	0.028514
*	Water	Pres.		
3.000	0.000	7.000	0.250	0.062400
7.000	0.250	260.0	0.250	0.000000
*	Sur-	charg		
0.000	0.000	1.300	0.187	0.144207
1.300	0.187	2.600	0.187	-0.00002
2.600	0.187	3.900	0.187	-0.00002
3.900	0.187	5.200	0.187	-0.00002
5.200	0.187	6.500	0.187	-0.00002
6.500	0.187	7.800	0.187	-0.00002
7.800	0.187	9.100	0.187	-0.00002
9.100	0.187	10.40	0.187	-0.00002

Draft

10.40	0.187	11.70	0.187	-0.00002
11.70	0.187	13.00	0.187	-0.00002
13.00	0.187	14.30	0.187	-0.00002
14.30	0.187	15.60	0.187	-0.00002
15.60	0.187	16.90	0.187	-0.00002
16.90	0.187	18.20	0.187	-0.00002
18.20	0.187	19.50	0.187	-0.00002
19.50	0.187	20.80	0.187	-0.00002
20.80	0.187	22.10	0.187	-0.00002
22.10	0.187	23.40	0.187	-0.00002
23.40	0.187	24.70	0.187	-0.00002
24.70	0.187	26.00	0.187	-0.00002
26.00	0.187	28.60	0.187	-0.00002
28.60	0.187	31.20	0.187	-0.00002
31.20	0.187	33.80	0.187	-0.00002
33.80	0.187	36.40	0.187	-0.00002
36.40	0.187	39.00	0.187	-0.00002
39.00	0.187	41.60	0.187	-0.00002
41.60	0.187	44.20	0.186	-0.00002
44.20	0.186	46.80	0.186	-0.00002
46.80	0.186	49.40	0.186	-0.00002
49.40	0.186	52.00	0.186	-0.00002

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
26.00	0.000	30.00	0.236	0.059094
30.00	0.222	260.0	31.46	0.135849

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	26.00	1.00

PASSIVE SPACING:

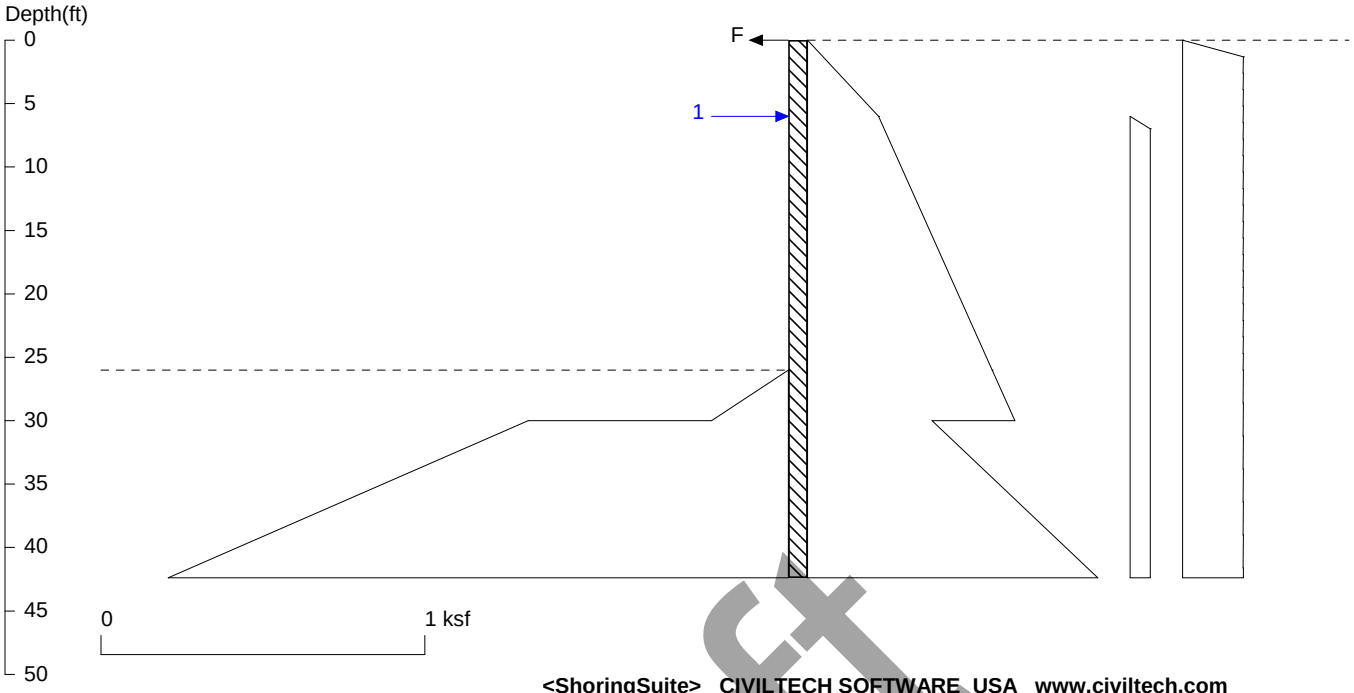
No.	Z depth	Spacing
1	0.00	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Draft

BP ECI 30%

Unusual 2a - Barge Mooring - phi-c



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File: P:\Projects\BP-ECI\3.0 Design\3.8 Geotechnical\02_30% Barrier Analyses\01_Bulkhead\02a_Unusual 2a_Barge_phi-c

Wall Height=26.0 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=16.39 Min. Pile Length=42.39 (in graphics and analysis)
MOMENT IN PILE: Max. Moment=66.38 per Pile Spacing=1.0 at Depth=22.39

BRACE FORCE: Strut, Tieback, Plate Anchor, and Deadman

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	6.0	0.0	1.0	14.7	14.7	0.0	0.0	0.0

UNITS: Width,Diameter,Spacing,Length,Depth,and Height - ft; Force - kip; Bond Strength and Pressure - ksf

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	6.000	0.220	0.036667
6.000	0.220	26.00	0.571	0.017533
*	Below	Base		
26.00	0.571	30.00	0.641	0.017533
30.00	0.385	260.0	9.885	0.041308
*	Water	Pres.		
6.000	0.000	7.000	0.062	0.062400
7.000	0.062	260.0	0.062	0.000000
*	Sur-	charg		
0.000	0.000	1.300	0.187	0.144207
1.300	0.187	2.600	0.187	-0.00002
2.600	0.187	3.900	0.187	-0.00002
3.900	0.187	5.200	0.187	-0.00002
5.200	0.187	6.500	0.187	-0.00002
6.500	0.187	7.800	0.187	-0.00002
7.800	0.187	9.100	0.187	-0.00002
9.100	0.187	10.40	0.187	-0.00002

Draft

10.40	0.187	11.70	0.187	-0.00002
11.70	0.187	13.00	0.187	-0.00002
13.00	0.187	14.30	0.187	-0.00002
14.30	0.187	15.60	0.187	-0.00002
15.60	0.187	16.90	0.187	-0.00002
16.90	0.187	18.20	0.187	-0.00002
18.20	0.187	19.50	0.187	-0.00002
19.50	0.187	20.80	0.187	-0.00002
20.80	0.187	22.10	0.187	-0.00002
22.10	0.187	23.40	0.187	-0.00002
23.40	0.187	24.70	0.187	-0.00002
24.70	0.187	26.00	0.187	-0.00002
26.00	0.187	28.60	0.187	-0.00002
28.60	0.187	31.20	0.187	-0.00002
31.20	0.187	33.80	0.187	-0.00002
33.80	0.187	36.40	0.187	-0.00002
36.40	0.187	39.00	0.187	-0.00002
39.00	0.187	41.60	0.187	-0.00002
41.60	0.187	44.20	0.186	-0.00002

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
26.00	0.000	30.00	0.236	0.059094
30.00	0.803	260.0	21.45	0.089779

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	26.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

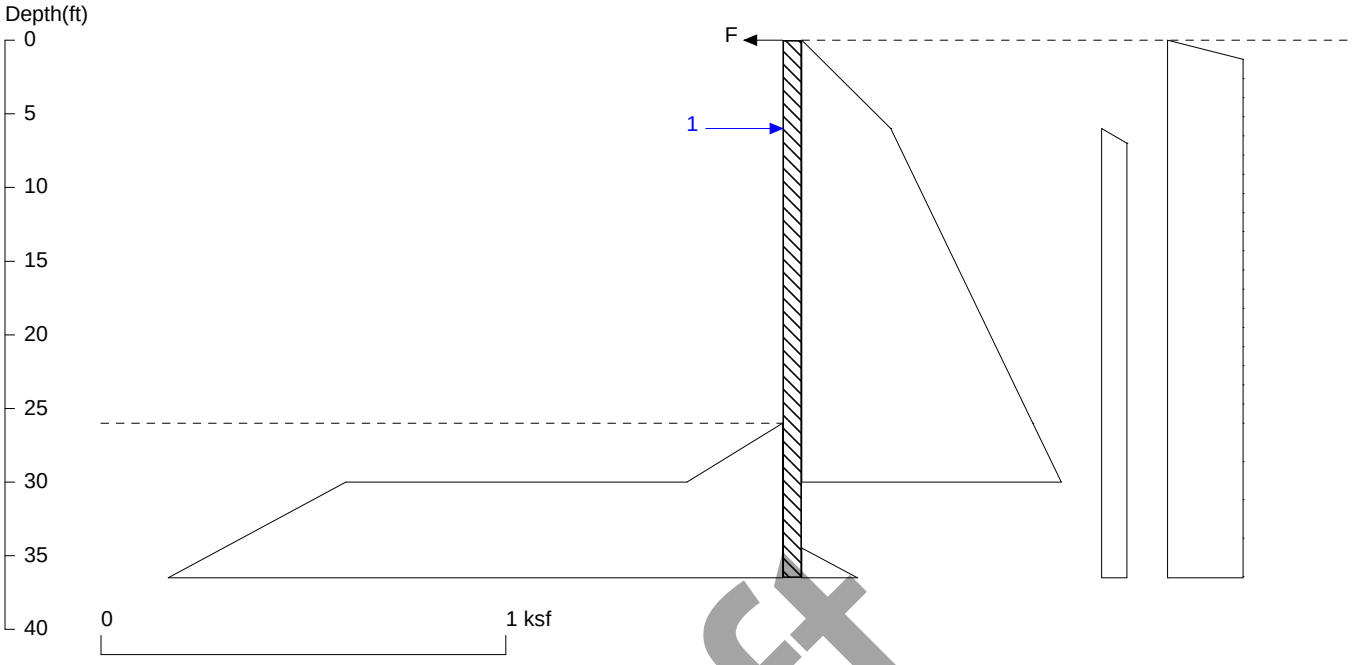
EXTERNAL FORCE ACTING ON WALL (Pusing on Wall - Positive; Against Wall - Negative)

No.	Z force	Force	Angle	Spacing
1	0.00	3.00	0.0	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Draft

BP ECI 30%
Unusual 2b - Barge Mooring - su



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Wall Height=26.0 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=10.50 Min. Pile Length=36.50 (in graphics and analysis)
MOMENT IN PILE: Max. Moment=52.70 per Pile Spacing=1.0 at Depth=21.20

BRACE FORCE: Strut, Tieback, Plate Anchor, and Deadman

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	6.0	0.0	1.0	13.8	13.8	0.0	0.0	0.0

UNITS: Width,Diameter,Spacing,Length,Depth,and Height - ft; Force - kip; Bond Strength and Pressure - ksf

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	6.000	0.220	0.036667
6.000	0.220	26.00	0.571	0.017533
*	Below	Base		
26.00	0.571	30.00	0.641	0.017533
34.47	0.000	260.0	15.27	0.067742
*	Water	Pres.		
6.000	0.000	7.000	0.062	0.062400
7.000	0.062	260.0	0.062	0.000000
*	Sur-	charg		
0.000	0.000	1.300	0.187	0.144207
1.300	0.187	2.600	0.187	-0.00002
2.600	0.187	3.900	0.187	-0.00002
3.900	0.187	5.200	0.187	-0.00002
5.200	0.187	6.500	0.187	-0.00002
6.500	0.187	7.800	0.187	-0.00002
7.800	0.187	9.100	0.187	-0.00002
9.100	0.187	10.40	0.187	-0.00002

Draft

10.40	0.187	11.70	0.187	-0.00002
11.70	0.187	13.00	0.187	-0.00002
13.00	0.187	14.30	0.187	-0.00002
14.30	0.187	15.60	0.187	-0.00002
15.60	0.187	16.90	0.187	-0.00002
16.90	0.187	18.20	0.187	-0.00002
18.20	0.187	19.50	0.187	-0.00002
19.50	0.187	20.80	0.187	-0.00002
20.80	0.187	22.10	0.187	-0.00002
22.10	0.187	23.40	0.187	-0.00002
23.40	0.187	24.70	0.187	-0.00002
24.70	0.187	26.00	0.187	-0.00002
26.00	0.187	28.60	0.187	-0.00002
28.60	0.187	31.20	0.187	-0.00002
31.20	0.187	33.80	0.187	-0.00002
33.80	0.187	36.40	0.187	-0.00002
36.40	0.187	39.00	0.187	-0.00002

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
26.00	0.000	30.00	0.236	0.059094
30.00	1.079	260.0	16.62	0.067610

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	26.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

EXTERNAL FORCE ACTING ON WALL (Pusing on Wall - Positive; Against Wall - Negative)

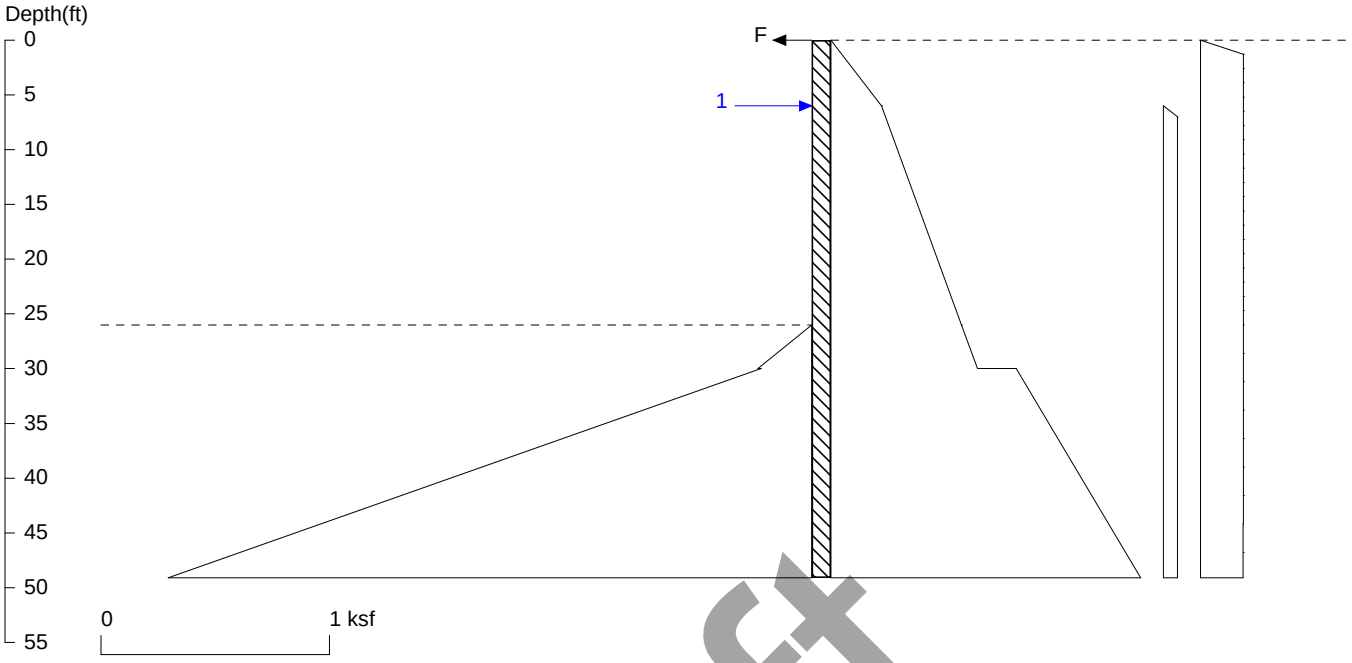
No.	Z force	Force	Angle	Spacing
1	0.00	3.00	0.0	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Draft

BP ECI 30%

Unusual 2c - Barge Mooring - phi'



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Wall Height=26.0 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=23.10 Min. Pile Length=49.10 (in graphics and analysis)
MOMENT IN PILE: Max. Moment=105.75 per Pile Spacing=1.0 at Depth=25.20

BRACE FORCE: Strut, Tieback, Plate Anchor, and Deadman

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	6.0	0.0	1.0	16.9	16.9	0.0	0.0	0.0

UNITS: Width,Diameter,Spacing,Length,Depth,and Height - ft; Force - kip; Bond Strength and Pressure - ksf

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	6.000	0.220	0.036667
6.000	0.220	26.00	0.571	0.017533
*	Below	Base		
26.00	0.571	30.00	0.641	0.017533
30.00	0.810	260.0	7.368	0.028515
*	Water	Pres.		
6.000	0.000	7.000	0.062	0.062400
7.000	0.062	260.0	0.062	0.000000
*	Sur-	charg		
0.000	0.000	1.300	0.187	0.144207
1.300	0.187	2.600	0.187	-0.00002
2.600	0.187	3.900	0.187	-0.00002
3.900	0.187	5.200	0.187	-0.00002
5.200	0.187	6.500	0.187	-0.00002
6.500	0.187	7.800	0.187	-0.00002
7.800	0.187	9.100	0.187	-0.00002
9.100	0.187	10.40	0.187	-0.00002

Draft

10.40	0.187	11.70	0.187	-0.00002
11.70	0.187	13.00	0.187	-0.00002
13.00	0.187	14.30	0.187	-0.00002
14.30	0.187	15.60	0.187	-0.00002
15.60	0.187	16.90	0.187	-0.00002
16.90	0.187	18.20	0.187	-0.00002
18.20	0.187	19.50	0.187	-0.00002
19.50	0.187	20.80	0.187	-0.00002
20.80	0.187	22.10	0.187	-0.00002
22.10	0.187	23.40	0.187	-0.00002
23.40	0.187	24.70	0.187	-0.00002
24.70	0.187	26.00	0.187	-0.00002
26.00	0.187	28.60	0.187	-0.00002
28.60	0.187	31.20	0.187	-0.00002
31.20	0.187	33.80	0.187	-0.00002
33.80	0.187	36.40	0.187	-0.00002
36.40	0.187	39.00	0.187	-0.00002
39.00	0.187	41.60	0.187	-0.00002
41.60	0.187	44.20	0.186	-0.00002
44.20	0.186	46.80	0.186	-0.00002
46.80	0.186	49.40	0.186	-0.00002

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
26.00	0.000	30.00	0.236	0.059094
30.00	0.222	260.0	31.46	0.135849

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	26.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

EXTERNAL FORCE ACTING ON WALL (Pusing on Wall - Positive; Against Wall - Negative)

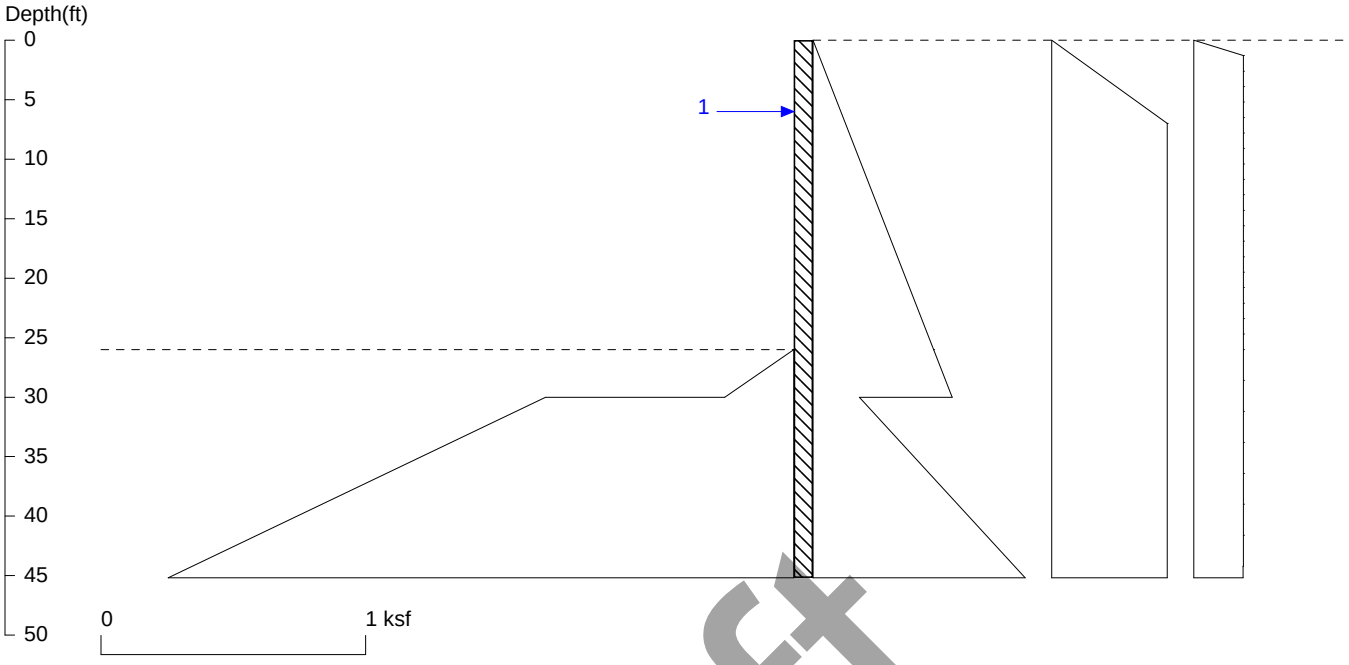
No.	Z force	Force	Angle	Spacing
1	0.00	3.00	0.0	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Draft

BP ECI 30%

Extreme 1a - Flood GW - phi-c



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Wall Height=26.0 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=19.18 Min. Pile Length=45.18 (in graphics and analysis)
MOMENT IN PILE: Max. Moment=110.89 per Pile Spacing=1.0 at Depth=21.94

BRACE FORCE: Strut, Tieback, Plate Anchor, and Deadman

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	6.0	0.0	1.0	16.3	16.3	0.0	0.0	0.0

UNITS: Width,Diameter,Spacing,Length,Depth,and Height - ft; Force - kip; Bond Strength and Pressure - ksf

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	26.00	0.456	0.017533
*	Below	Base		
26.00	0.456	30.00	0.526	0.017533
30.00	0.176	260.0	9.674	0.041295
*	Water	Pres.		
0.000	0.000	7.000	0.437	0.062400
7.000	0.437	260.0	0.437	0.000000
*	Sur-	charg		
0.000	0.000	1.300	0.187	0.144207
1.300	0.187	2.600	0.187	-0.00002
2.600	0.187	3.900	0.187	-0.00002
3.900	0.187	5.200	0.187	-0.00002
5.200	0.187	6.500	0.187	-0.00002
6.500	0.187	7.800	0.187	-0.00002
7.800	0.187	9.100	0.187	-0.00002
9.100	0.187	10.40	0.187	-0.00002
10.40	0.187	11.70	0.187	-0.00002

Draft

11.70	0.187	13.00	0.187	-0.00002
13.00	0.187	14.30	0.187	-0.00002
14.30	0.187	15.60	0.187	-0.00002
15.60	0.187	16.90	0.187	-0.00002
16.90	0.187	18.20	0.187	-0.00002
18.20	0.187	19.50	0.187	-0.00002
19.50	0.187	20.80	0.187	-0.00002
20.80	0.187	22.10	0.187	-0.00002
22.10	0.187	23.40	0.187	-0.00002
23.40	0.187	24.70	0.187	-0.00002
24.70	0.187	26.00	0.187	-0.00002
26.00	0.187	28.60	0.187	-0.00002
28.60	0.187	31.20	0.187	-0.00002
31.20	0.187	33.80	0.187	-0.00002
33.80	0.187	36.40	0.187	-0.00002
36.40	0.187	39.00	0.187	-0.00002
39.00	0.187	41.60	0.187	-0.00002
41.60	0.187	44.20	0.186	-0.00002
44.20	0.186	46.80	0.186	-0.00002

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
26.00	0.000	30.00	0.261	0.065195
30.00	0.938	260.0	22.55	0.094000

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	26.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

EXTERNAL FORCE ACTING ON WALL (Pusing on Wall - Positive; Against Wall - Negative)

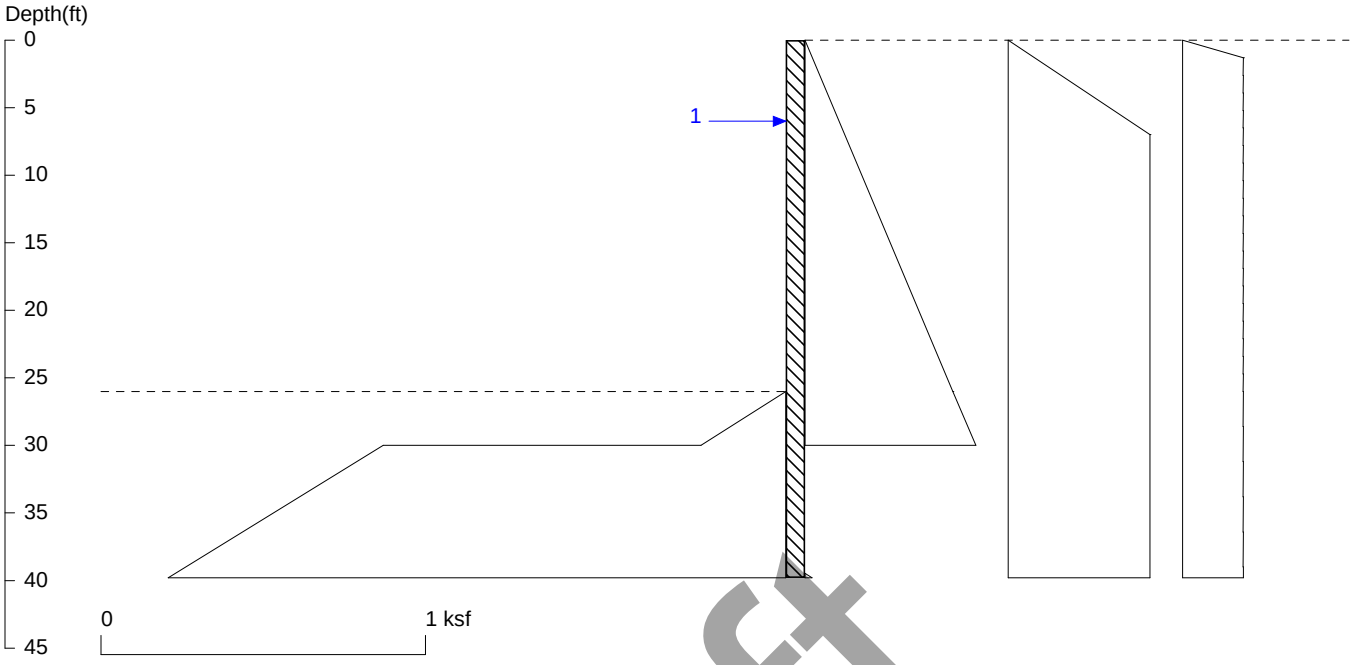
No.	Z force	Force	Angle	Spacing
1	0.00	0.00	0.0	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Draft

BP ECI 30%

Extreme 1b - Flood GW - su



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Wall Height=26.0 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=13.80 Min. Pile Length=39.80 (in graphics and analysis)
MOMENT IN PILE: Max. Moment=93.80 per Pile Spacing=1.0 at Depth=20.82

BRACE FORCE: Strut, Tieback, Plate Anchor, and Deadman

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	6.0	0.0	1.0	15.2	15.2	0.0	0.0	0.0

UNITS: Width,Diameter,Spacing,Length,Depth,and Height - ft; Force - kip; Bond Strength and Pressure - ksf

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	26.00	0.456	0.017533
*	Below	Base		
26.00	0.456	30.00	0.526	0.017533
39.47	0.000	260.0	14.93	0.067708
*	Water	Pres.		
0.000	0.000	7.000	0.437	0.062400
7.000	0.437	260.0	0.437	0.000000
*	Sur-	charg		
0.000	0.000	1.300	0.187	0.144207
1.300	0.187	2.600	0.187	-0.00002
2.600	0.187	3.900	0.187	-0.00002
3.900	0.187	5.200	0.187	-0.00002
5.200	0.187	6.500	0.187	-0.00002
6.500	0.187	7.800	0.187	-0.00002
7.800	0.187	9.100	0.187	-0.00002
9.100	0.187	10.40	0.187	-0.00002
10.40	0.187	11.70	0.187	-0.00002

Draft

11.70	0.187	13.00	0.187	-0.00002
13.00	0.187	14.30	0.187	-0.00002
14.30	0.187	15.60	0.187	-0.00002
15.60	0.187	16.90	0.187	-0.00002
16.90	0.187	18.20	0.187	-0.00002
18.20	0.187	19.50	0.187	-0.00002
19.50	0.187	20.80	0.187	-0.00002
20.80	0.187	22.10	0.187	-0.00002
22.10	0.187	23.40	0.187	-0.00002
23.40	0.187	24.70	0.187	-0.00002
24.70	0.187	26.00	0.187	-0.00002
26.00	0.187	28.60	0.187	-0.00002
28.60	0.187	31.20	0.187	-0.00002
31.20	0.187	33.80	0.187	-0.00002
33.80	0.187	36.40	0.187	-0.00002
36.40	0.187	39.00	0.187	-0.00002
39.00	0.187	41.60	0.187	-0.00002

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
26.00	0.000	30.00	0.261	0.065195
30.00	1.240	260.0	16.79	0.067612

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	26.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

EXTERNAL FORCE ACTING ON WALL (Pusing on Wall - Positive; Against Wall - Negative)

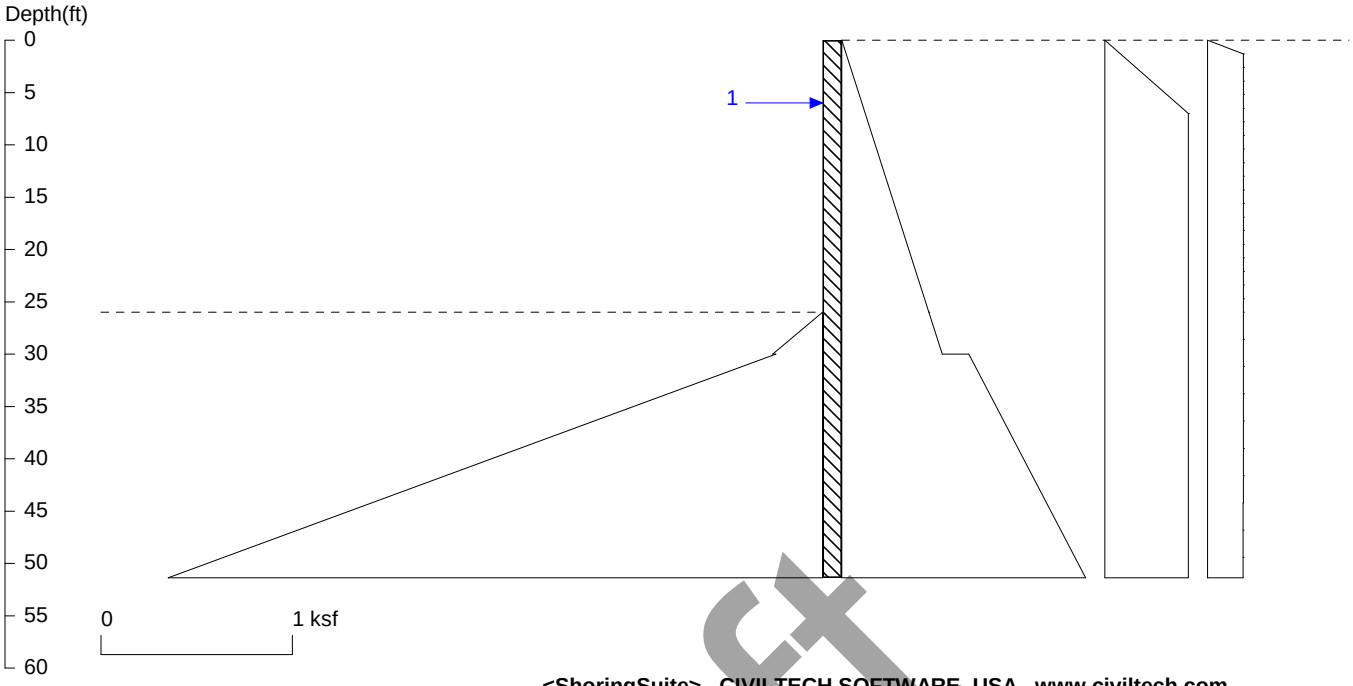
No.	Z force	Force	Angle	Spacing
1	0.00	0.00	0.0	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Draft

BP ECI 30%

Extreme 1c - Flood GW - phi'



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File: P:\Projects\BP-ECI\3.0 Design\3.8 Geotechnical\02_30% Barrier Analyses\01_Bulkhead\03c_Extreme 1c_Flood GW_p

Wall Height=26.0 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=25.37 Min. Pile Length=51.37 (in graphics and analysis)
MOMENT IN PILE: Max. Moment=165.04 per Pile Spacing=1.0 at Depth=24.95

BRACE FORCE: Strut, Tieback, Plate Anchor, and Deadman

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	6.0	0.0	1.0	19.4	19.4	0.0	0.0	0.0

UNITS: Width,Diameter,Spacing,Length,Depth,and Height - ft; Force - kip; Bond Strength and Pressure - ksf

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	26.00	0.456	0.017533
*	Below	Base		
26.00	0.456	30.00	0.526	0.017533
30.00	0.665	260.0	7.223	0.028513
*	Water	Pres.		
0.000	0.000	7.000	0.437	0.062400
7.000	0.437	260.0	0.437	0.000000
*	Sur-	charg		
0.000	0.000	1.300	0.187	0.144207
1.300	0.187	2.600	0.187	-0.00002
2.600	0.187	3.900	0.187	-0.00002
3.900	0.187	5.200	0.187	-0.00002
5.200	0.187	6.500	0.187	-0.00002
6.500	0.187	7.800	0.187	-0.00002
7.800	0.187	9.100	0.187	-0.00002
9.100	0.187	10.40	0.187	-0.00002
10.40	0.187	11.70	0.187	-0.00002

Draft

11.70	0.187	13.00	0.187	-0.00002
13.00	0.187	14.30	0.187	-0.00002
14.30	0.187	15.60	0.187	-0.00002
15.60	0.187	16.90	0.187	-0.00002
16.90	0.187	18.20	0.187	-0.00002
18.20	0.187	19.50	0.187	-0.00002
19.50	0.187	20.80	0.187	-0.00002
20.80	0.187	22.10	0.187	-0.00002
22.10	0.187	23.40	0.187	-0.00002
23.40	0.187	24.70	0.187	-0.00002
24.70	0.187	26.00	0.187	-0.00002
26.00	0.187	28.60	0.187	-0.00002
28.60	0.187	31.20	0.187	-0.00002
31.20	0.187	33.80	0.187	-0.00002
33.80	0.187	36.40	0.187	-0.00002
36.40	0.187	39.00	0.187	-0.00002
39.00	0.187	41.60	0.187	-0.00002
41.60	0.187	44.20	0.186	-0.00002
44.20	0.186	46.80	0.186	-0.00002
46.80	0.186	49.40	0.186	-0.00002
49.40	0.186	52.00	0.186	-0.00002

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
26.00	0.000	30.00	0.261	0.065195
30.00	0.243	260.0	34.41	0.148584

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	26.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

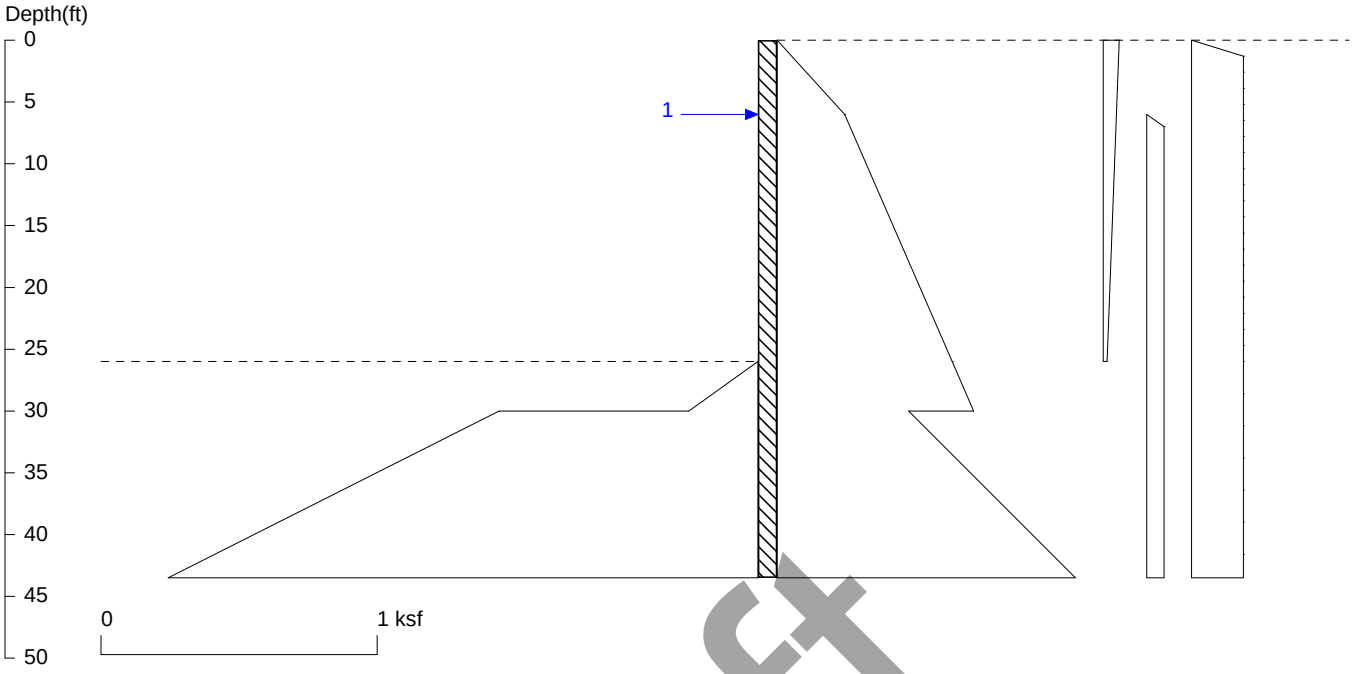
EXTERNAL FORCE ACTING ON WALL (Pusing on Wall - Positive; Against Wall - Negative)

No.	Z force	Force	Angle	Spacing
1	0.00	0.00	0.0	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Draft

BP ECI 30%
Extreme 2a - EQ - phi-c



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File: P:\Projects\BP-ECI\3.0 Design\3.8 Geotechnical\02_30% Barrier Analyses\01_Bulkhead\04a_Extreme 2a_EQ_phi-c.sh

Wall Height=26.0 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=17.49 Min. Pile Length=43.49 (in graphics and analysis)
MOMENT IN PILE: Max. Moment=84.54 per Pile Spacing=1.0 at Depth=21.72

BRACE FORCE: Strut, Tieback, Plate Anchor, and Deadman

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	6.0	0.0	1.0	12.7	12.7	0.0	0.0	0.0

UNITS: Width,Diameter,Spacing,Length,Depth,and Height - ft; Force - kip; Bond Strength and Pressure - ksf

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	6.000	0.244	0.040684
6.000	0.244	26.00	0.633	0.019454
*	Below	Base		
26.00	0.633	30.00	0.711	0.019454
30.00	0.476	260.0	10.76	0.044746
*	Earth	Queck		
0.000	0.058	26.00	0.014	-0.00166
*	Water	Pres.		
6.000	0.000	7.000	0.062	0.062400
7.000	0.062	260.0	0.062	0.000000
*	Sur-	charg		
0.000	0.000	1.300	0.187	0.144207
1.300	0.187	2.600	0.187	-0.00002
2.600	0.187	3.900	0.187	-0.00002
3.900	0.187	5.200	0.187	-0.00002
5.200	0.187	6.500	0.187	-0.00002
6.500	0.187	7.800	0.187	-0.00002

Draft

7.800	0.187	9.100	0.187	-0.00002
9.100	0.187	10.40	0.187	-0.00002
10.40	0.187	11.70	0.187	-0.00002
11.70	0.187	13.00	0.187	-0.00002
13.00	0.187	14.30	0.187	-0.00002
14.30	0.187	15.60	0.187	-0.00002
15.60	0.187	16.90	0.187	-0.00002
16.90	0.187	18.20	0.187	-0.00002
18.20	0.187	19.50	0.187	-0.00002
19.50	0.187	20.80	0.187	-0.00002
20.80	0.187	22.10	0.187	-0.00002
22.10	0.187	23.40	0.187	-0.00002
23.40	0.187	24.70	0.187	-0.00002
24.70	0.187	26.00	0.187	-0.00002
26.00	0.187	28.60	0.187	-0.00002
28.60	0.187	31.20	0.187	-0.00002
31.20	0.187	33.80	0.187	-0.00002
33.80	0.187	36.40	0.187	-0.00002
36.40	0.187	39.00	0.187	-0.00002
39.00	0.187	41.60	0.187	-0.00002
41.60	0.187	44.20	0.186	-0.00002

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
26.00	0.000	30.00	0.250	0.062588
30.00	0.937	260.0	21.36	0.088799

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	26.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

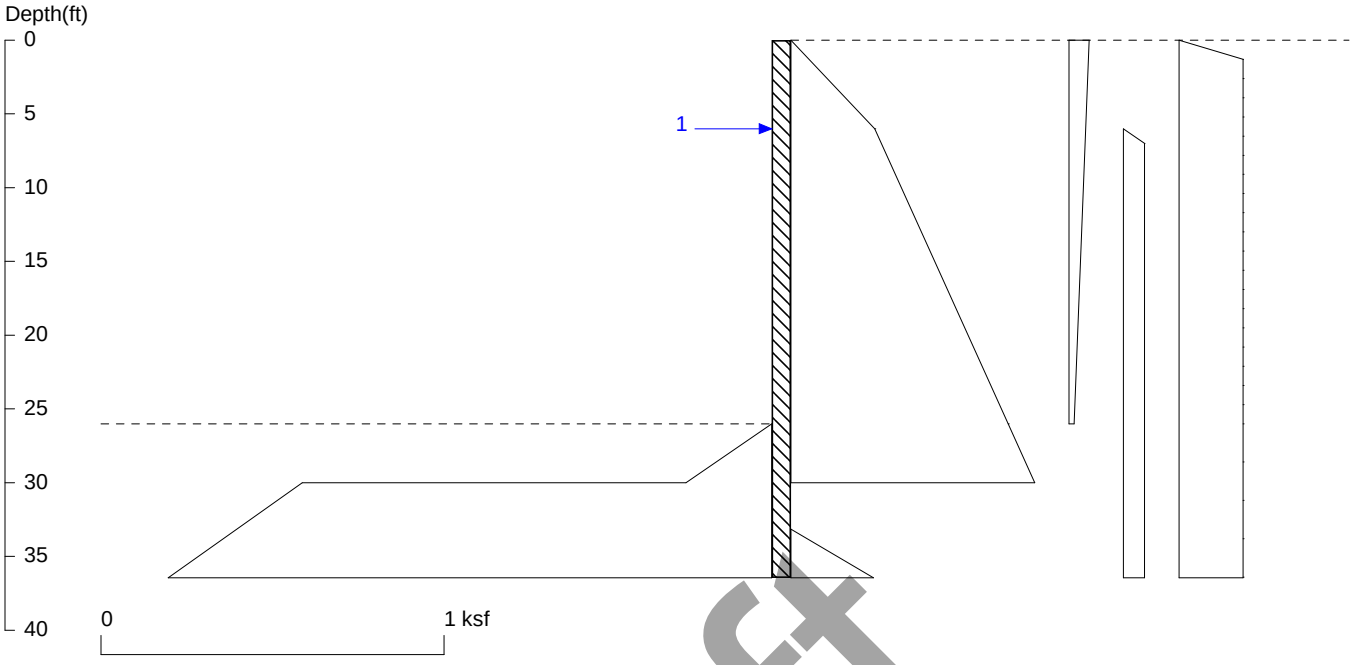
EXTERNAL FORCE ACTING ON WALL (Pusing on Wall - Positive; Against Wall - Negative)

No.	Z force	Force	Angle	Spacing
1	0.00	0.00	0.0	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Draft

BP ECI 30%
Extreme 2b - EQ - su



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File: P:\Projects\BP-ECI\3.0 Design\3.8 Geotechnical\02_30% Barrier Analyses\01_Bulkhead\04b_Extreme 2b_EQ_su.sh8

Wall Height=26.0 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=10.44 Min. Pile Length=36.44 (in graphics and analysis)
MOMENT IN PILE: Max. Moment=66.55 per Pile Spacing=1.0 at Depth=20.21

BRACE FORCE: Strut, Tieback, Plate Anchor, and Deadman

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	6.0	0.0	1.0	11.5	11.5	0.0	0.0	0.0

UNITS: Width,Diameter,Spacing,Length,Depth,and Height - ft; Force - kip; Bond Strength and Pressure - ksf

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	6.000	0.244	0.040684
6.000	0.244	26.00	0.633	0.019454
*	Below	Base		
26.00	0.633	30.00	0.711	0.019454
33.15	0.000	260.0	16.55	0.072989
*	Earth	Queck		
0.000	0.058	26.00	0.014	-0.00166
*	Water	Pres.		
6.000	0.000	7.000	0.062	0.062400
7.000	0.062	260.0	0.062	0.000000
*	Sur-	charg		
0.000	0.000	1.300	0.187	0.144207
1.300	0.187	2.600	0.187	-0.00002
2.600	0.187	3.900	0.187	-0.00002
3.900	0.187	5.200	0.187	-0.00002
5.200	0.187	6.500	0.187	-0.00002
6.500	0.187	7.800	0.187	-0.00002

Draft

7.800	0.187	9.100	0.187	-0.00002
9.100	0.187	10.40	0.187	-0.00002
10.40	0.187	11.70	0.187	-0.00002
11.70	0.187	13.00	0.187	-0.00002
13.00	0.187	14.30	0.187	-0.00002
14.30	0.187	15.60	0.187	-0.00002
15.60	0.187	16.90	0.187	-0.00002
16.90	0.187	18.20	0.187	-0.00002
18.20	0.187	19.50	0.187	-0.00002
19.50	0.187	20.80	0.187	-0.00002
20.80	0.187	22.10	0.187	-0.00002
22.10	0.187	23.40	0.187	-0.00002
23.40	0.187	24.70	0.187	-0.00002
24.70	0.187	26.00	0.187	-0.00002
26.00	0.187	28.60	0.187	-0.00002
28.60	0.187	31.20	0.187	-0.00002
31.20	0.187	33.80	0.187	-0.00002
33.80	0.187	36.40	0.187	-0.00002
36.40	0.187	39.00	0.187	-0.00002

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
26.00	0.000	30.00	0.250	0.062588
30.00	1.368	260.0	15.31	0.060649

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	26.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

EXTERNAL FORCE ACTING ON WALL (Pusing on Wall - Positive; Against Wall - Negative)

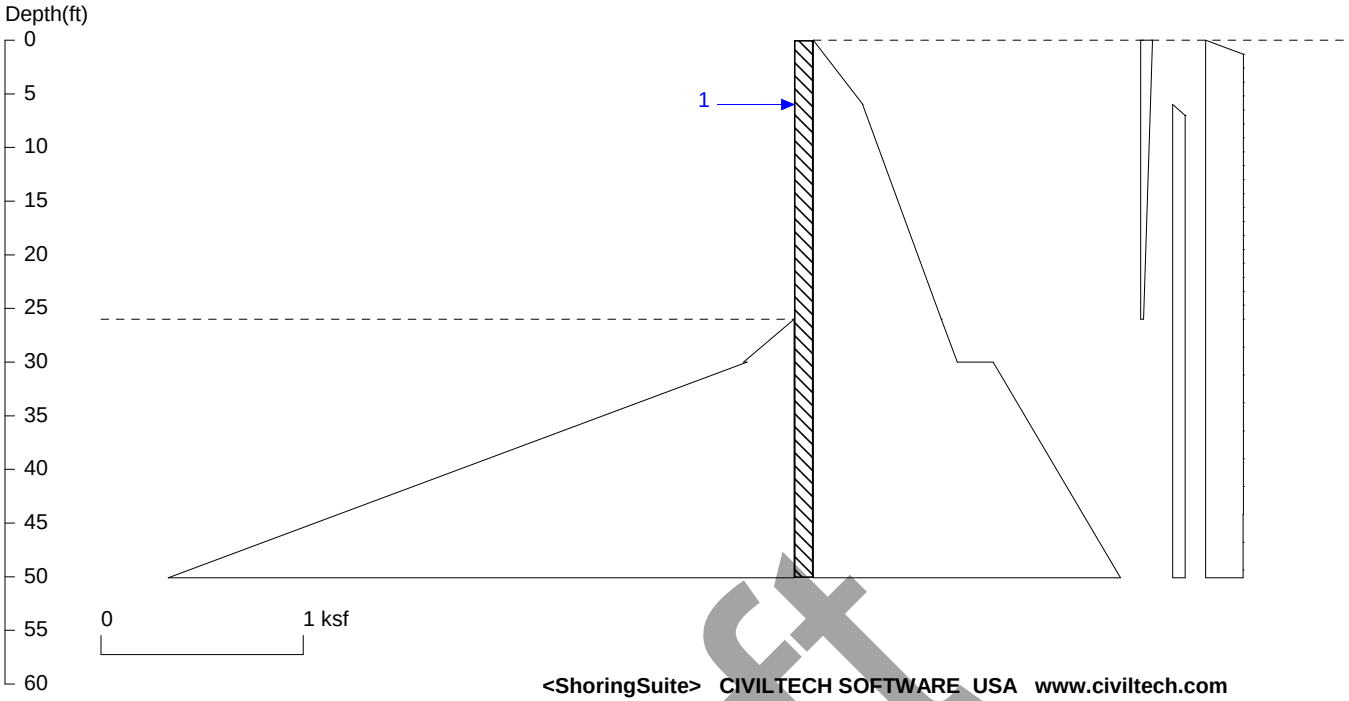
No.	Z force	Force	Angle	Spacing
1	0.00	0.00	0.0	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Draft

BP ECI 30%

Extreme 2c - EQ - phi'



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Wall Height=26.0 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=24.10 Min. Pile Length=50.10 (in graphics and analysis)
MOMENT IN PILE: Max. Moment=129.61 per Pile Spacing=1.0 at Depth=24.77

BRACE FORCE: Strut, Tieback, Plate Anchor, and Deadman

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	6.0	0.0	1.0	15.3	15.3	0.0	0.0	0.0

UNITS: Width,Diameter,Spacing,Length,Depth,and Height - ft; Force - kip; Bond Strength and Pressure - ksf

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	6.000	0.244	0.040684
6.000	0.244	26.00	0.633	0.019454
*	Below	Base		
26.00	0.633	30.00	0.711	0.019454
30.00	0.889	260.0	8.090	0.031310
*	Earth	Queck		
0.000	0.058	26.00	0.014	-0.00166
*	Water	Pres.		
6.000	0.000	7.000	0.062	0.062400
7.000	0.062	260.0	0.062	0.000000
*	Sur-	charg		
0.000	0.000	1.300	0.187	0.144207
1.300	0.187	2.600	0.187	-0.00002
2.600	0.187	3.900	0.187	-0.00002
3.900	0.187	5.200	0.187	-0.00002
5.200	0.187	6.500	0.187	-0.00002
6.500	0.187	7.800	0.187	-0.00002

Draft

7.800	0.187	9.100	0.187	-0.00002
9.100	0.187	10.40	0.187	-0.00002
10.40	0.187	11.70	0.187	-0.00002
11.70	0.187	13.00	0.187	-0.00002
13.00	0.187	14.30	0.187	-0.00002
14.30	0.187	15.60	0.187	-0.00002
15.60	0.187	16.90	0.187	-0.00002
16.90	0.187	18.20	0.187	-0.00002
18.20	0.187	19.50	0.187	-0.00002
19.50	0.187	20.80	0.187	-0.00002
20.80	0.187	22.10	0.187	-0.00002
22.10	0.187	23.40	0.187	-0.00002
23.40	0.187	24.70	0.187	-0.00002
24.70	0.187	26.00	0.187	-0.00002
26.00	0.187	28.60	0.187	-0.00002
28.60	0.187	31.20	0.187	-0.00002
31.20	0.187	33.80	0.187	-0.00002
33.80	0.187	36.40	0.187	-0.00002
36.40	0.187	39.00	0.187	-0.00002
39.00	0.187	41.60	0.187	-0.00002
41.60	0.187	44.20	0.186	-0.00002
44.20	0.186	46.80	0.186	-0.00002
46.80	0.186	49.40	0.186	-0.00002
49.40	0.186	52.00	0.186	-0.00002

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
26.00	0.000	30.00	0.250	0.062588
30.00	0.233	260.0	32.98	0.142410

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	26.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

EXTERNAL FORCE ACTING ON WALL (Pusing on Wall - Positive; Against Wall - Negative)

No.	Z force	Force	Angle	Spacing
1	0.00	0.00	0.0	1.00

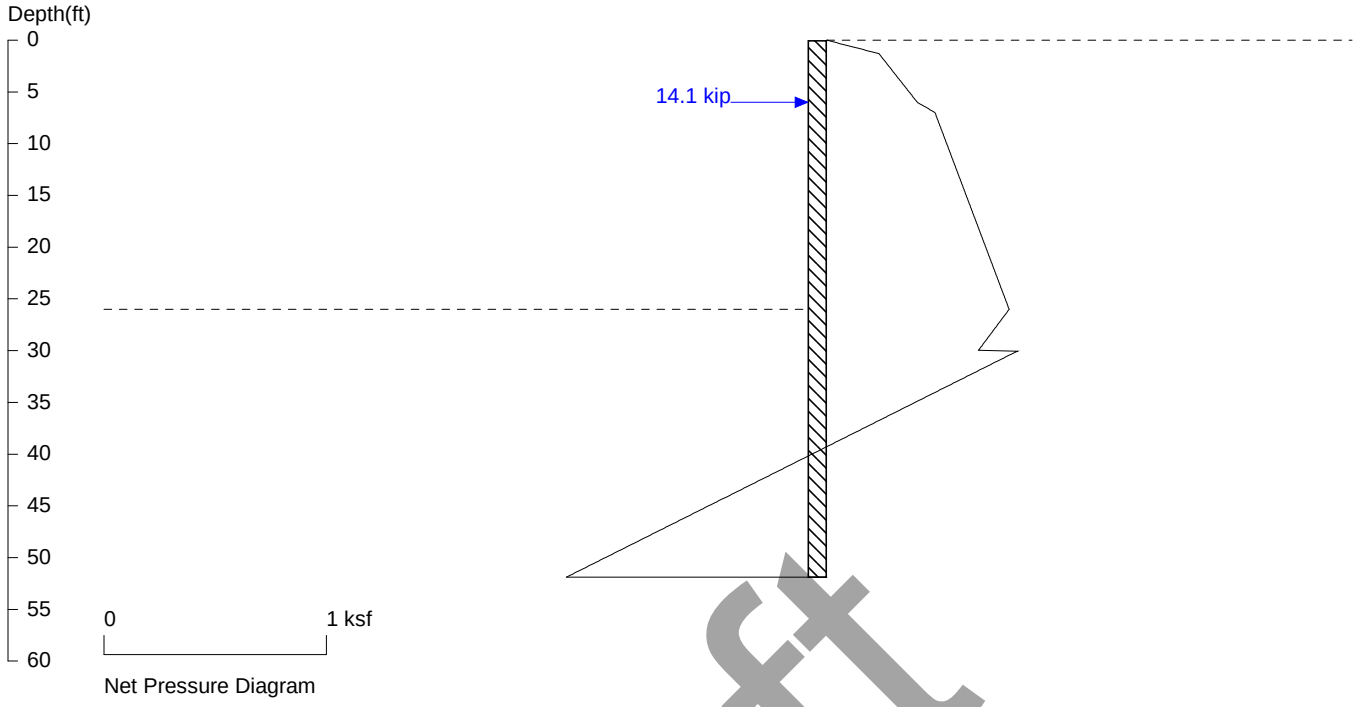
UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

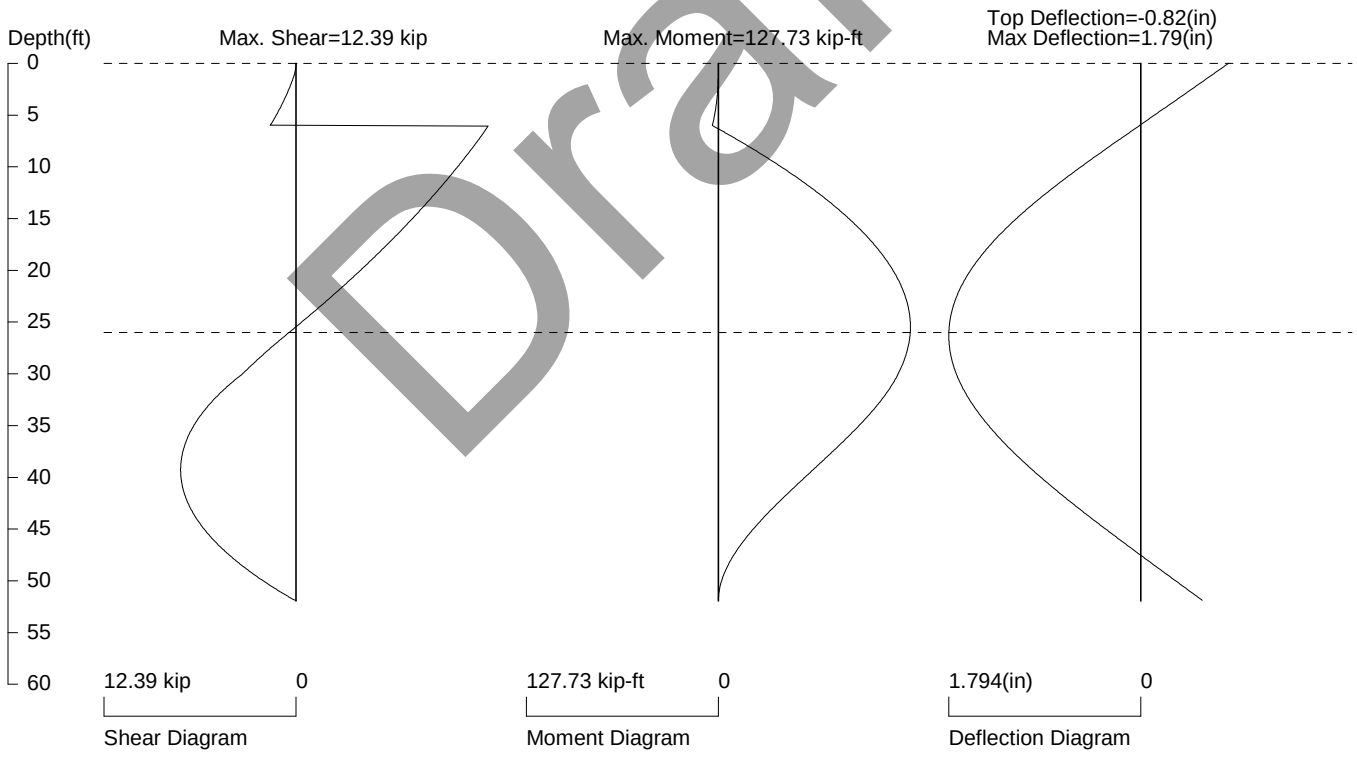
Draft

Draft

ATTACHMENT D-5: DEFLECTION OUTPUT FILES

BP ECI 30%
Usual - Long-Term





Draft

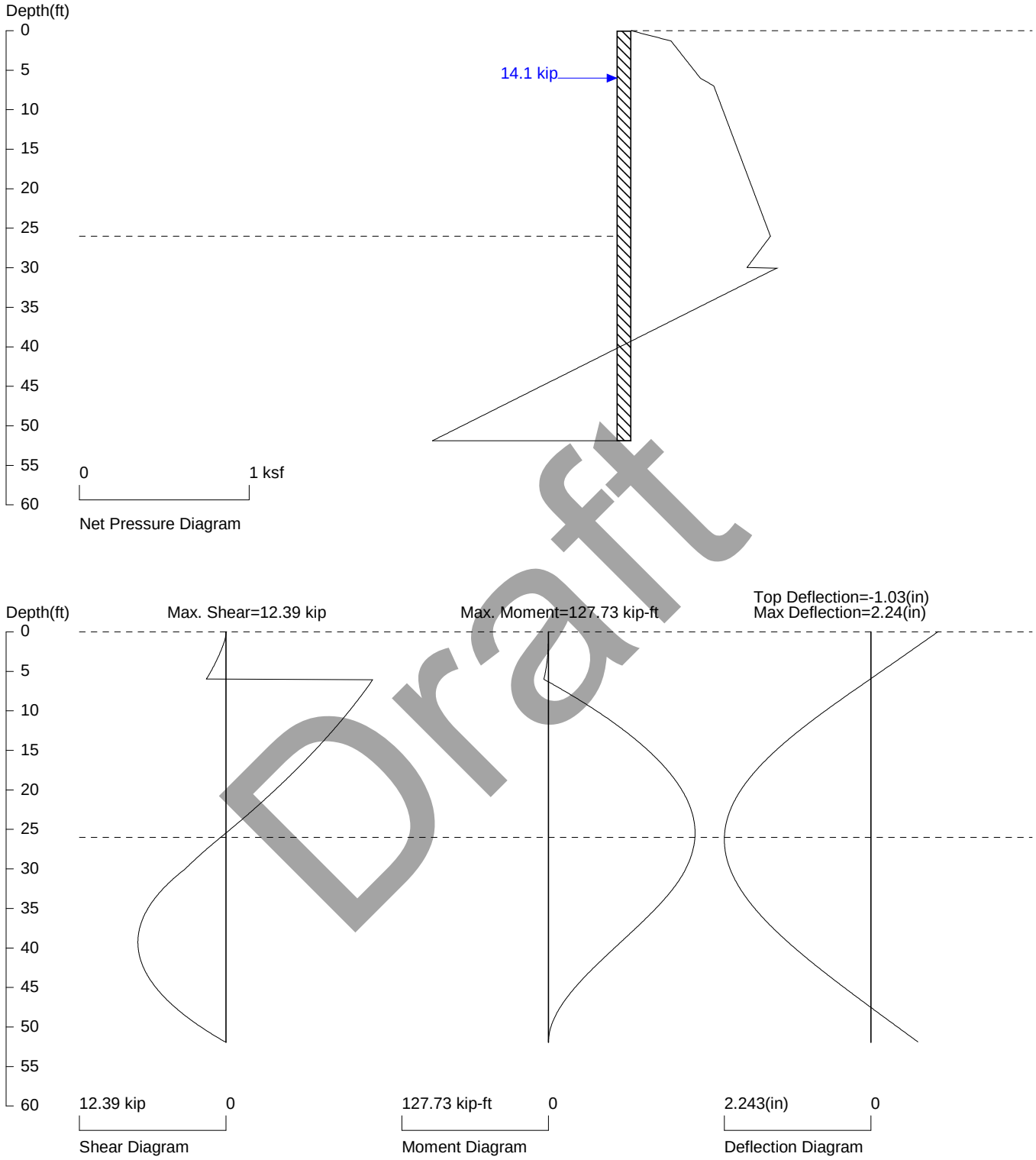
PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 1.0 foot or meter

User Input Pile, AZ40-700N: E (ksi)=29000.0, I (in4)/foot=732.9

File: P:\Projects\BP-ECI\3.0 Design\3.8 Geotechnical\02_30% Barrier Analyses\01_Bulkhead\00_Usual_LT.sh8

BP ECI 30%
Usual - Long-Term



Draft

PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

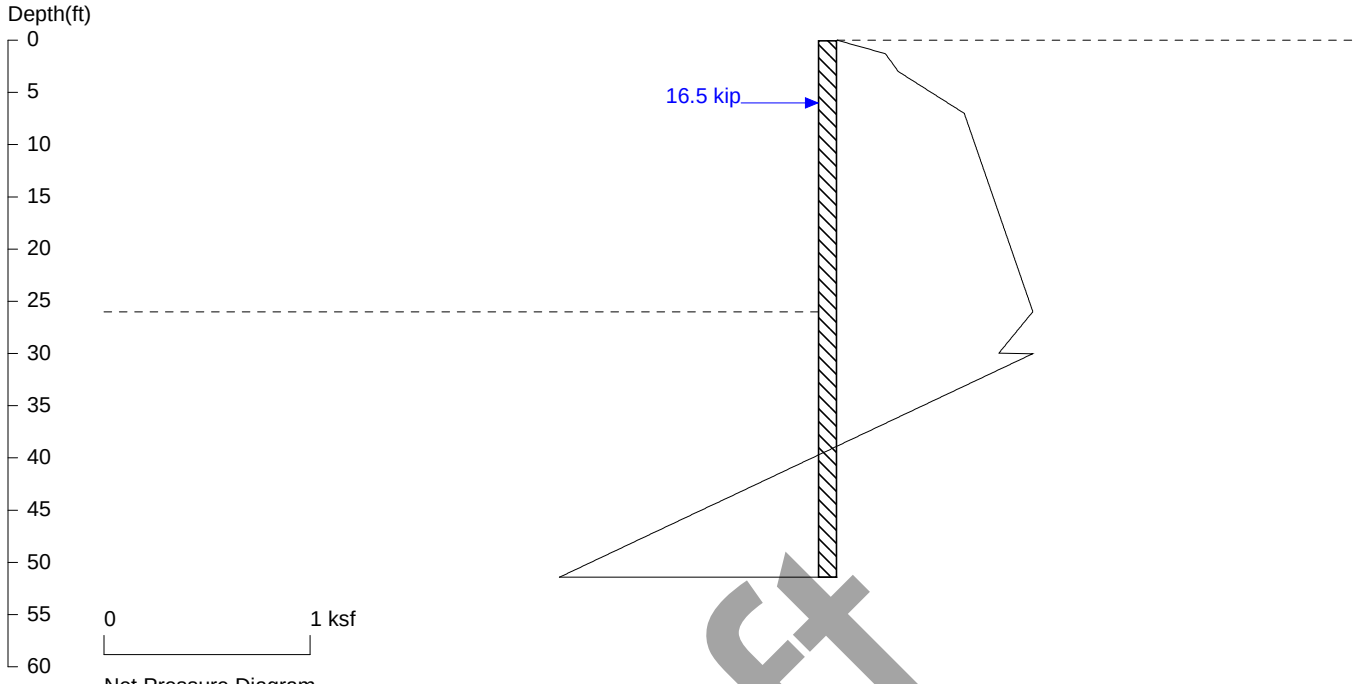
Based on pile spacing: 1.0 foot or meter

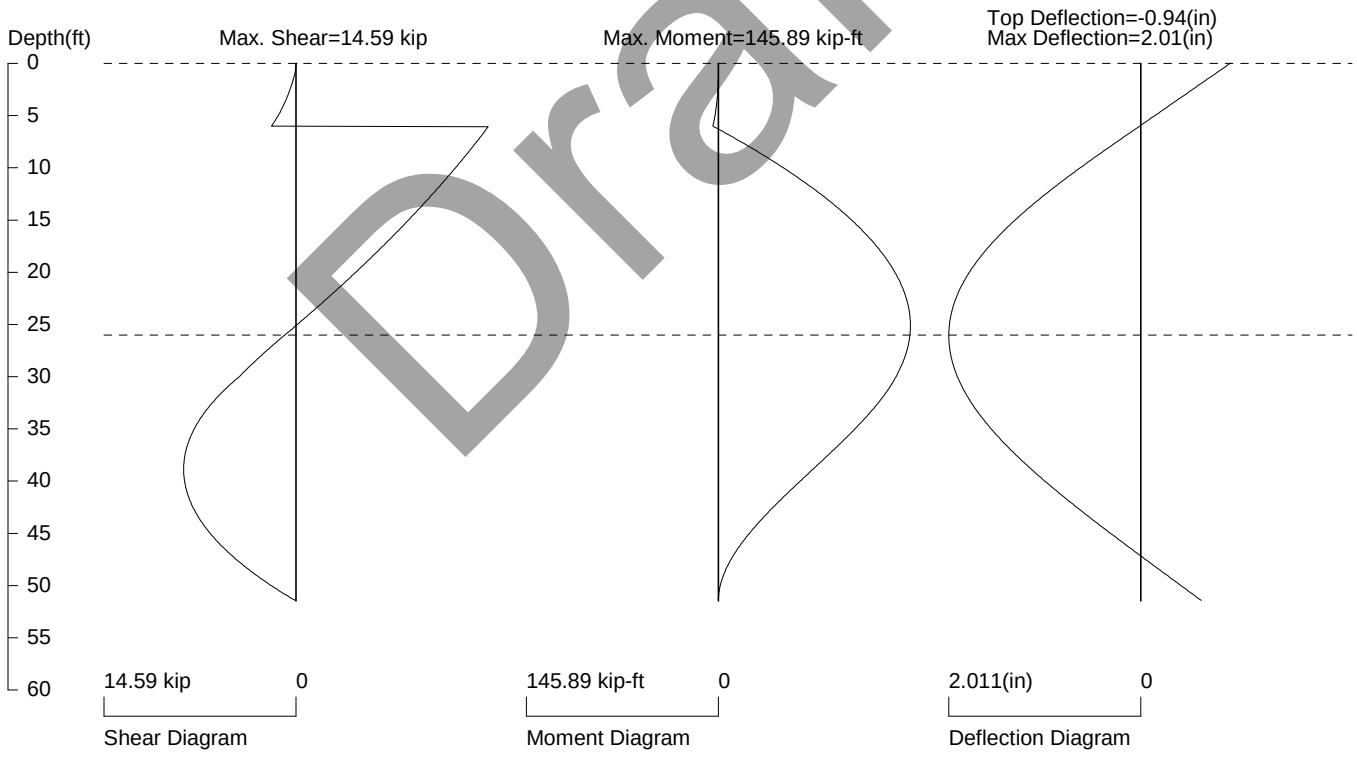
User Input Pile, AZ40-700NR: E (ksi)=29000.0, I (in4)/foot=586.3

File: P:\Projects\BP-ECI\3.0 Design\3.8 Geotechnical\02_30% Barrier Analyses\01_Bulkhead\00_Usual_LT.sh8

BP ECI 30%

Unusual 1c - High GW - phi'





Draft

PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

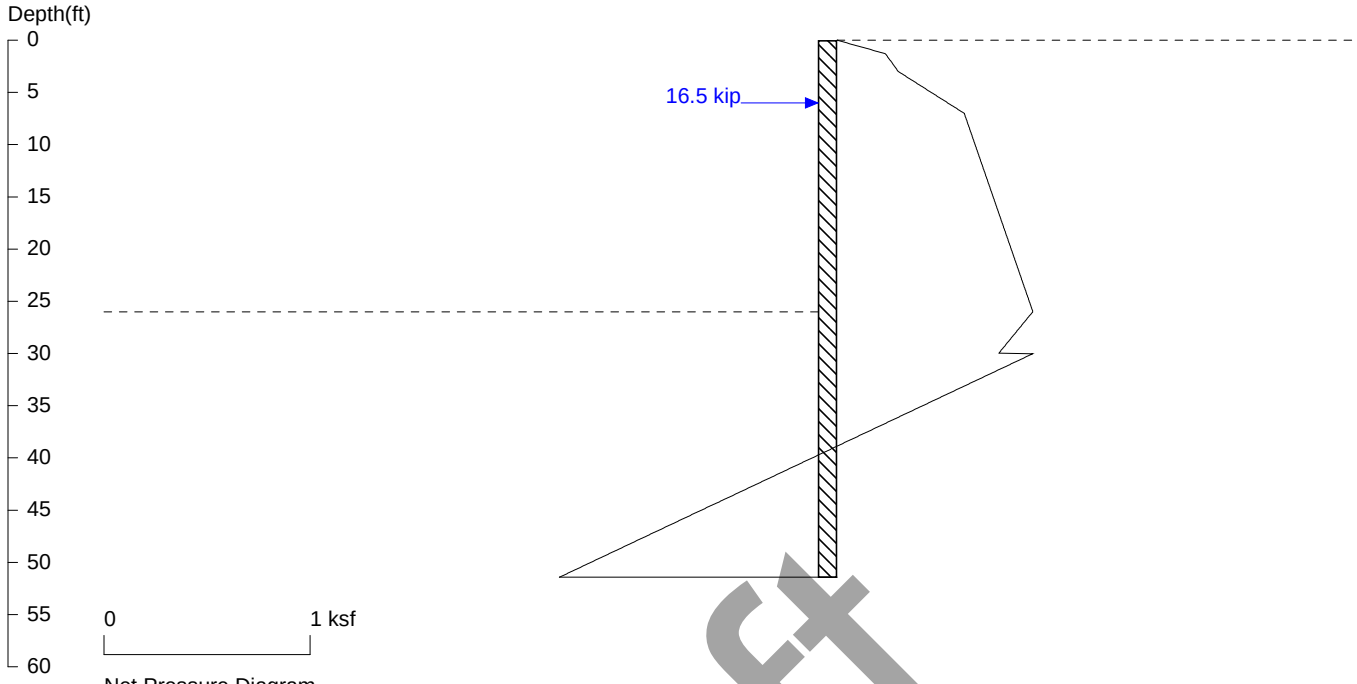
Based on pile spacing: 1.0 foot or meter

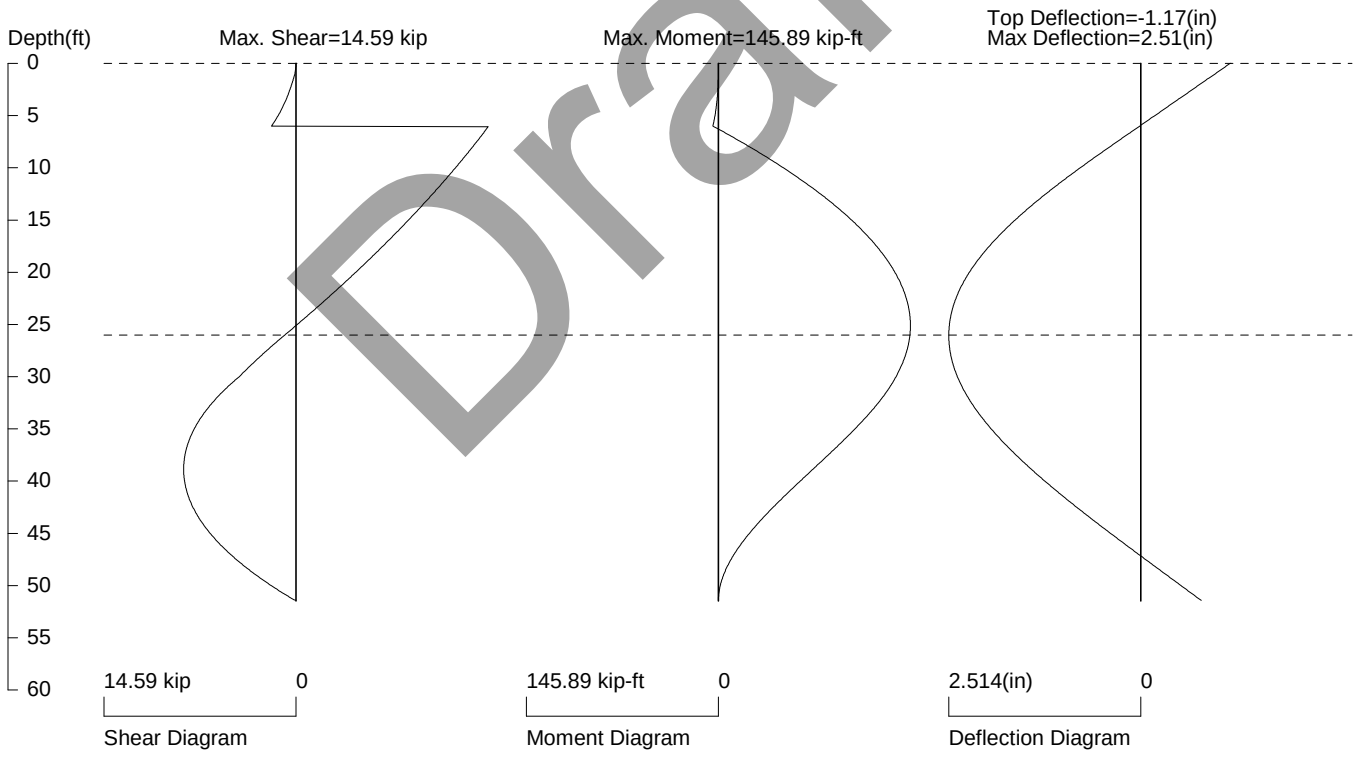
User Input Pile, AZ40-700N: E (ksi)=29000.0, I (in4)/foot=732.9

File: P:\Projects\BP-ECI\3.0 Design\3.8 Geotechnical\02_30% Barrier Analyses\01_Bulkhead\01c_Unusual 1c_High GW_phi'.sh8

BP ECI 30%

Unusual 1c - High GW - phi'





Draft

PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

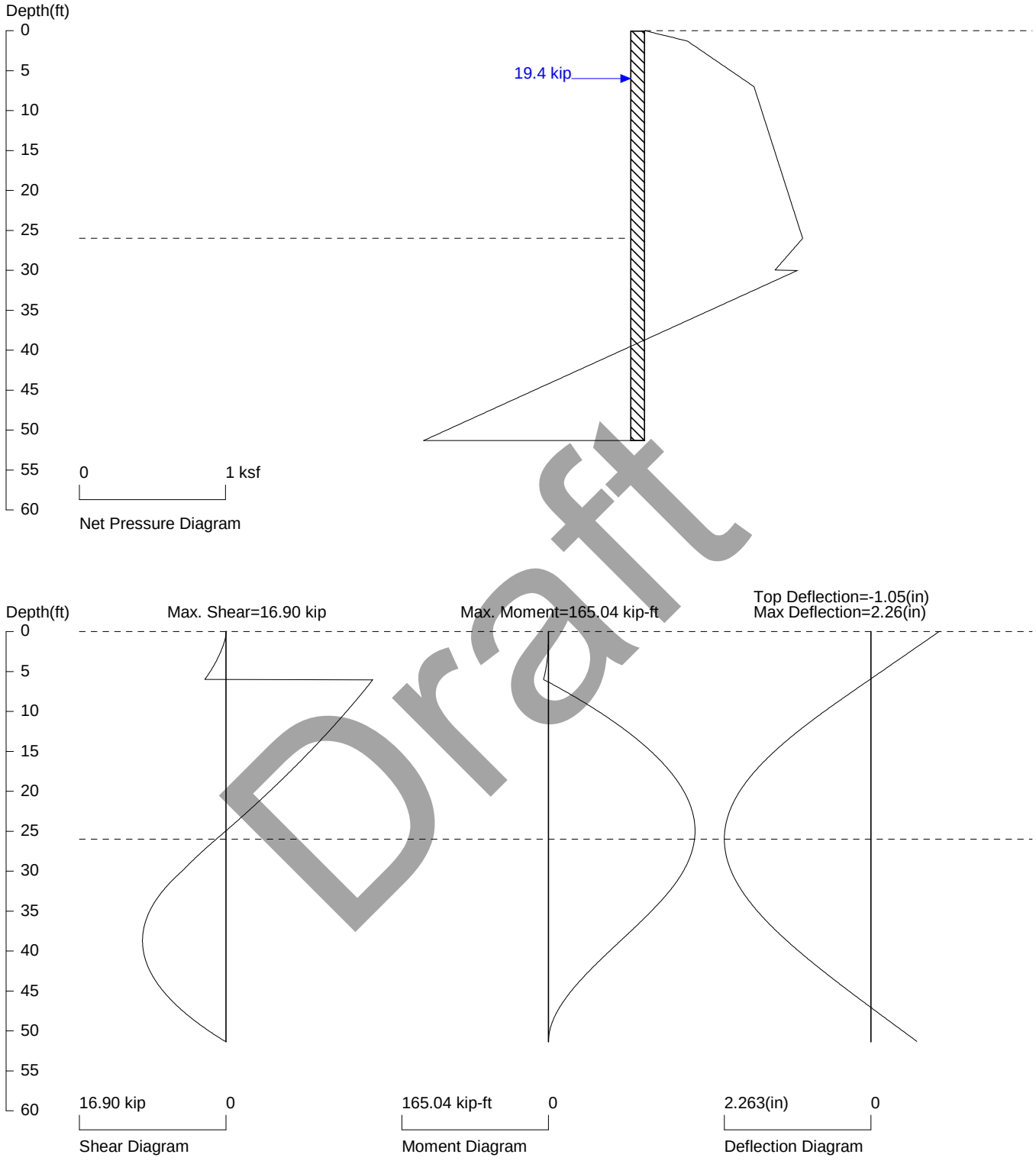
Based on pile spacing: 1.0 foot or meter

User Input Pile, AZ40-700NR: E (ksi)=29000.0, I (in4)/foot=586.3

File: P:\Projects\BP-ECI\3.0 Design\3.8 Geotechnical\02_30% Barrier Analyses\01_Bulkhead\01c_Unusual 1c_High GW_phi'.sh8

BP ECI 30%

Extreme 1c - Flood GW - phi'



Draft

PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

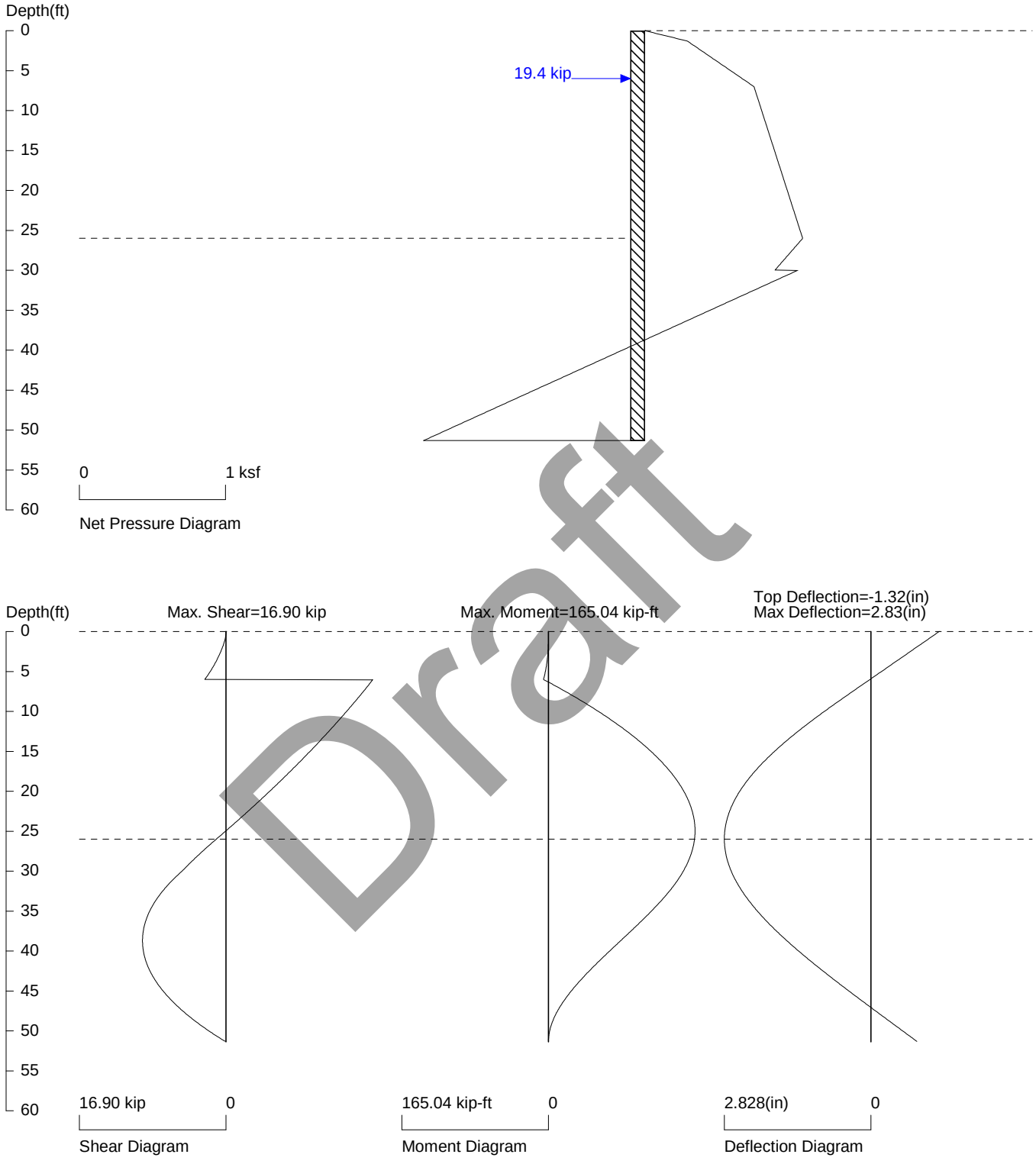
Based on pile spacing: 1.0 foot or meter

User Input Pile, AZ40-700N: E (ksi)=29000.0, I (in4)/foot=732.9

File: P:\Projects\BP-ECI\3.0 Design\3.8 Geotechnical\02_30% Barrier Analyses\01_Bulkhead\03c_Extreme 1c_Flood GW_phi'.sh8

BP ECI 30%

Extreme 1c - Flood GW - phi'



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PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 1.0 foot or meter

User Input Pile, AZ40-700NR: E (ksi)=29000.0, I (in4)/foot=586.3

File: P:\Projects\BP-ECI\3.0 Design\3.8 Geotechnical\02_30% Barrier Analyses\01_Bulkhead\03c_Extreme 1c_Flood GW_phi'.sh8

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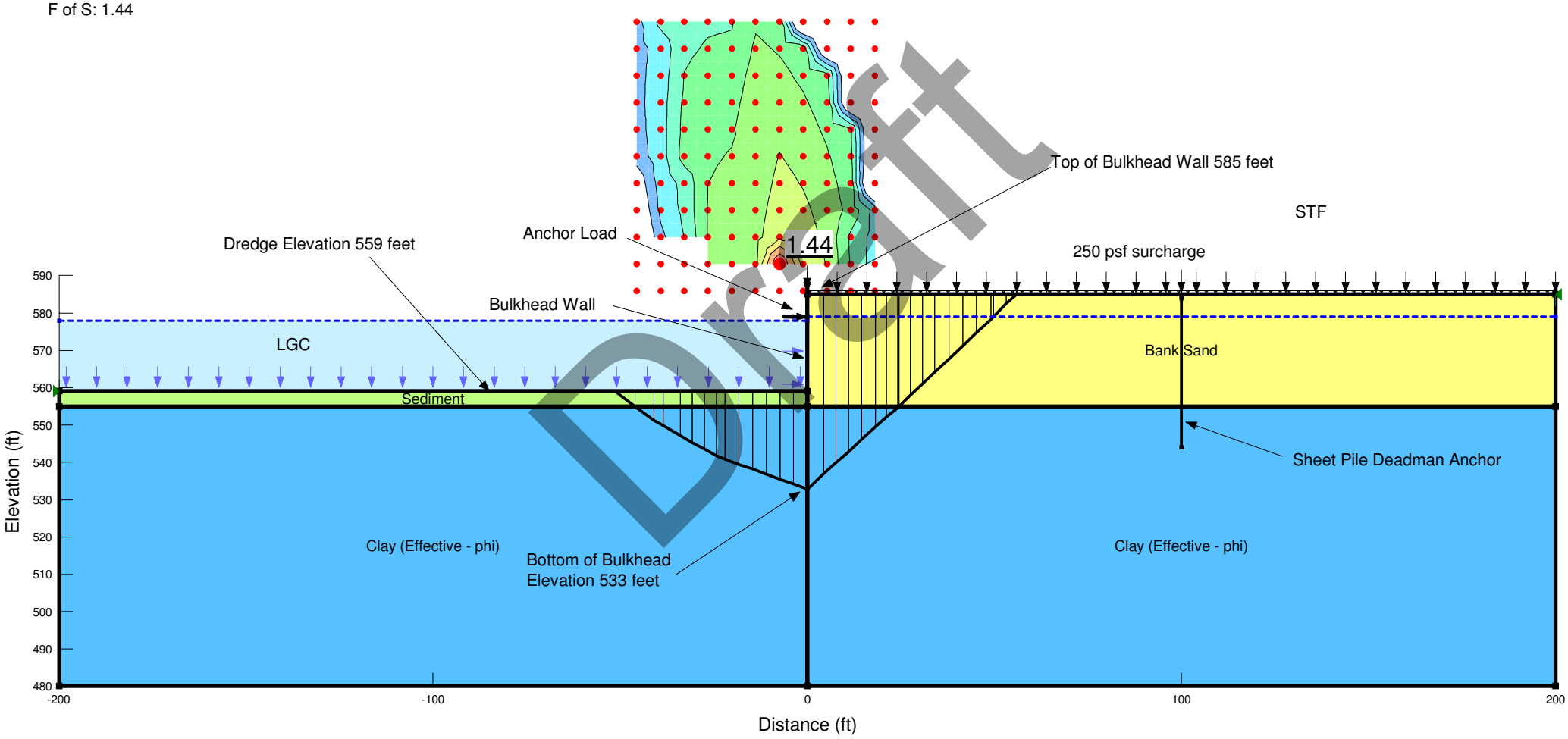
ATTACHMENT D-6: SLOPE/W OUTPUT FILES

File Name: BP-ECI_30%.gsz
Name: 00a_Usual_Bottom 533
Date: 11/7/2019

Method: Spencer
F of S: 1.44

Name: Bank Sand Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 30 ° Constant Unit Wt. Above Water Table: 110 pcf
Name: Sediment Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion': 0 psf Phi': 26 °
Name: Clay (Effective - phi) Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 0 psf Phi': 24 °

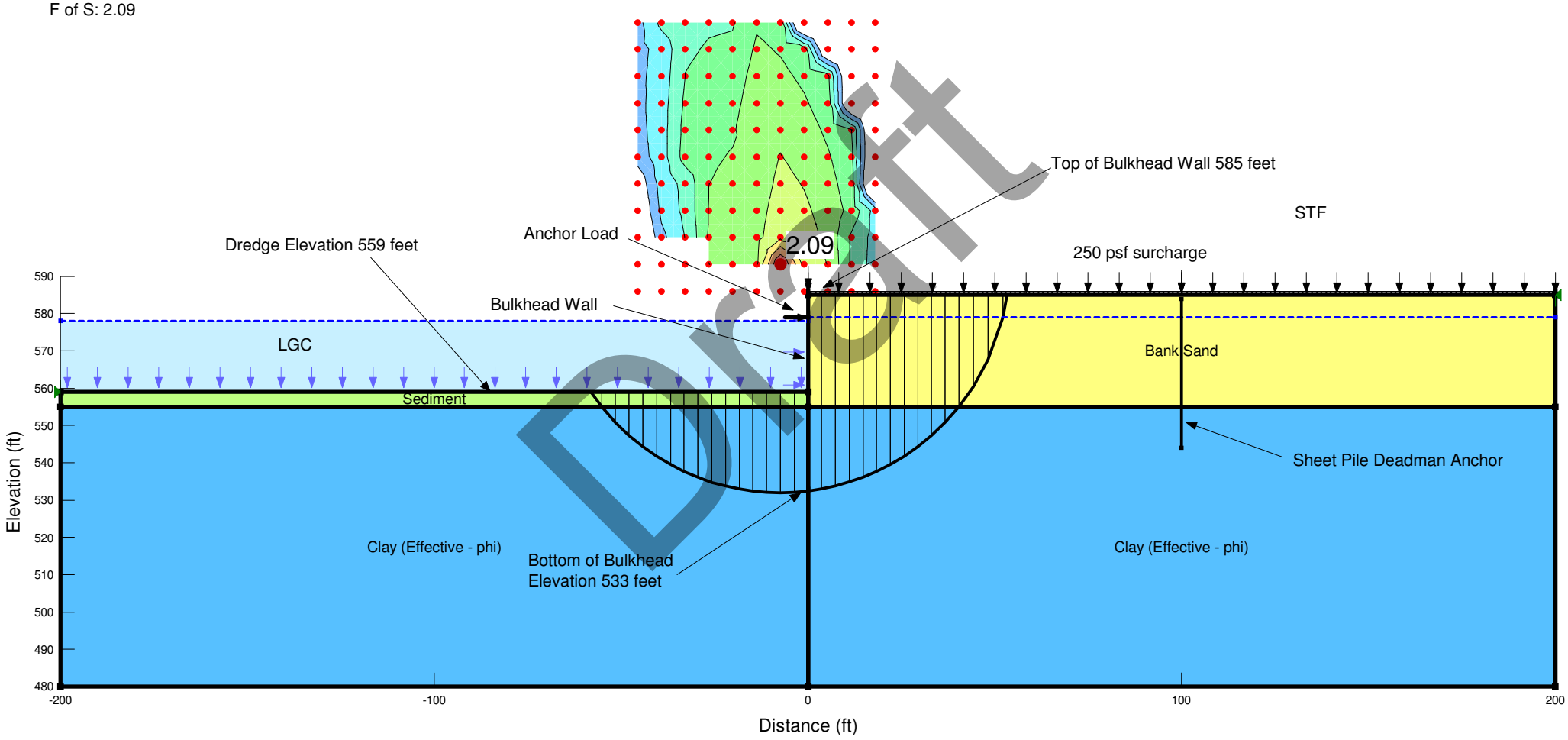


Draft

File Name: BP-ECI_30%.gsz
Name: 00a_Usual_Bottom 533
Date: 11/7/2019

Method: Spencer
F of S: 2.09

Name: Bank Sand Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 30 ° Constant Unit Wt. Above Water Table: 110 pcf
Name: Sediment Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion': 0 psf Phi': 26 °
Name: Clay (Effective - phi) Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 0 psf Phi': 24 °

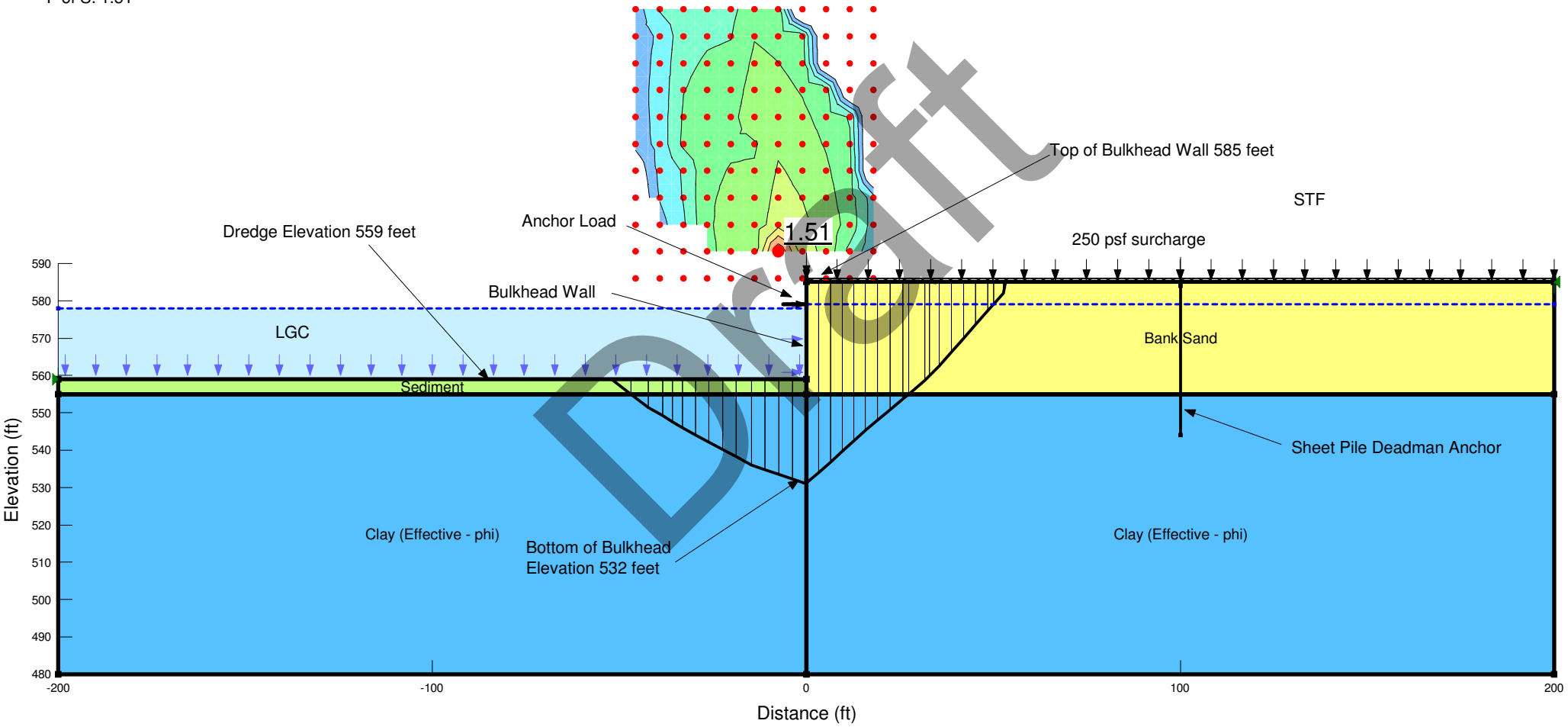


Draft

File Name: BP-ECI_30%.gsz
Name: 00b_Usual_Bottom 532
Date: 11/7/2019

Method: Spencer
F of S: 1.51

Name: Bank Sand Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 30 ° Constant Unit Wt. Above Water Table: 110 pcf
Name: Sediment Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion': 0 psf Phi': 26 °
Name: Clay (Effective - phi) Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 0 psf Phi': 24 °

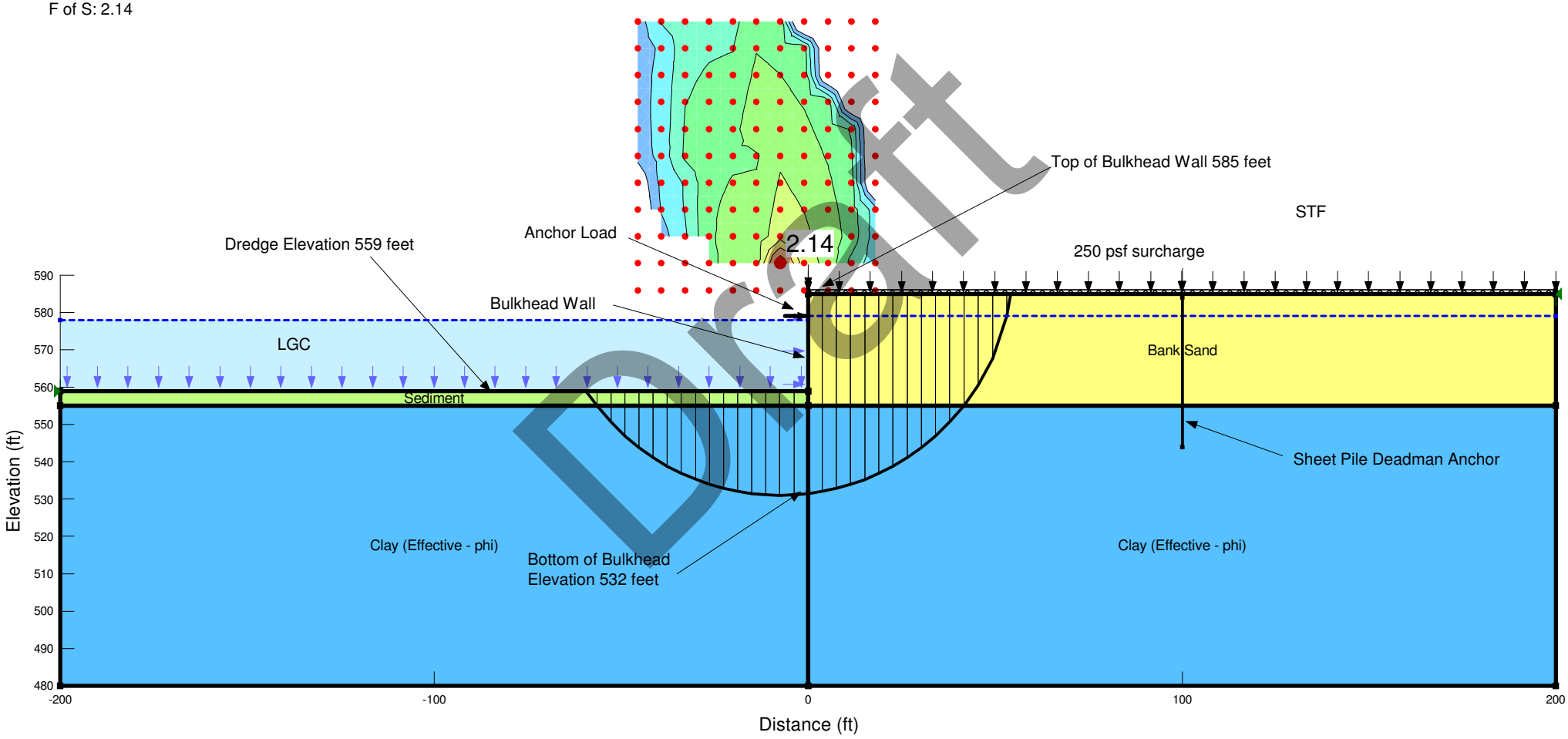


Draft

File Name: BP-ECI_30%.gsz
Name: 00b_Usual_Bottom 532
Date: 11/7/2019

Method: Spencer
F of S: 2.14

Name: Bank Sand Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 30 ° Constant Unit Wt. Above Water Table: 110 pcf
Name: Sediment Model: Mohr-Coulomb Unit Weight: 90 pcf Cohesion': 0 psf Phi': 26 °
Name: Clay (Effective - phi) Model: Mohr-Coulomb Unit Weight: 130 pcf Cohesion': 0 psf Phi': 24 °



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APPENDIX E BANK CONTROL SYSTEM EVALUATION

TECHNICAL MEMORANDUM

DATE: December 2019

TO: Project File

FROM: Divya Kamath

REVIEWED BY: Jeshua Hansen, Brian B. Johnson

SUBJECT: West Tank Farm Bank Control Calculations

PROJECT: 3205191698

Draft

PURPOSE

The purpose of these calculations is to determine the thickness of reactive mats that that are likely to provide bank control at the West Tank Farm (WTF) of the ECI Site in East Chicago, Indiana. The bank control is designed to mitigate the impacts of residual sheen on the banks of WTF from migrating into the Canal.

ASSUMPTIONS

No information is available from prior reports that quantifies the flux of sheen into the canal. The sheen flux is a key parameter to design bank control through reactive mats as the flux determines the rate of depletion of the reactive mat's absorption capabilities. As such, the following assumptions are made in support of the 30% design submission:

1. The entire width of approximately 300 ft at the WTF bank is to be covered using reactive mats.
2. Sheen observed in canal has bands of rainbow colors, which is associated with a thickness of 0.5 microns. The assumed density of LNAPL is 0.77 g/cc (Western States Petroleum Association, 2011). Based on these parameters, volume of 0.01 gallons of oil is assumed during a sheen observance. The assumed area of sheen in the assessment is approximately 1,000ft^2. These parameters are defined in the Oil Spill Response Field Manual (ExxonMobil, 2008).
3. LNAPL observations were reported to be between 6-8 ft below ground surface (Arcadis, 2016). Based on these numbers, and the approximate top of bank at 582', the residual LNAPL is assumed to be present from 576' to 574'.
4. The WTF bank is divided into cells, each having dimensions 20'×10' for simplified analysis. The mass flux into the canal is calculated per cell of the WTF bank. This calculated value is a mass flux every day for the entire year.

5. Mass flux from the bank is uniform across each of the cells that comprise the area to receive bank controls.
6. LNAPL sorption of a reactive mat containing organoclay is reported by the manufacturer, Huesker, to absorb 0.5 pounds of NAPL per pound of organoclay with the mat containing a minimum of 0.8 pounds of organoclay per square foot of the mat, and an assumed oil absorption capacity of 100% of the organoclay mass.
7. LNAPL sorption of a reactive mat containing oil absorbing polymer is reported to be 0.15 gal/ft^2 as per Huesker's product sheet included in **Attachment E-1**.

METHODOLOGY

Investigation data that quantifies the sheen flux into the canal or residual sheen observed is not available. As such, some assumptions are made about the sheen mass flux into the canal, that the bank control is to isolate from the canal. The two key parameters that drive the design of the reactive mat are:

(1) Sheen flux into the canal

(2) Life expectancy of the reactive media in the reactive mat

The reactive layer can be a combination of media.

Organophilic Clay

Organoclay (OC) is an engineered product consisting of clay (typically bentonite) that has been organically modified to improve its oleophilic sorption capacity that is sandwiched between two geotextiles. In this instance, the organoclay would be used to isolate and sorb LNAPL and/or sheen-bearing residuals, thereby mitigating the potential for sheen generation in the canal from the WTF. Two products (RCM™ with Organoclay® and Tektoseal Active OC by Huesker Inc.) that contain OC as an active layer are being considered. The encapsulating geotextiles add mechanical stability to the OC layer and achieve a stable, constant layer thickness over the installed area.

Oil Absorbing Polymers

Geofabrics containing oil-adsorbent melt-blown polymers are similar to the OC mats in that they are mechanically reinforced by non-woven geotextile. These polymers have a structure and surface properties that are suitable to separate oil from water in oil/water mixtures such as LNAPL in groundwater. Further, some of these polymers are appropriate for reliably binding petrochemical products like gasoline & diesel. The product being considered is Tektoseal® Active AS (AS) supplied by Huesker Inc. Tektoseal® Active AS has been developed as an environmental geocomposite used for contaminated runoff, contaminant capping and seep mitigation.

The combination of these two types of reactive mats for bank control has previously been implemented using the Active OC and Active AS supplied by Huesker on a different site to prevent oil migration into a canal. This case study along with product specification sheets are included as **Attachment E-1.**
The following describes the design methodology:

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1) An install area is determined based on the assumed width at WTF and the vertical extent of known and suspected LNAPL in the WTF proximal to the Canal. Install area and number of layers determine the number of rolls of reactive mats required. At a minimum, 1 layer of Tektoseal Active OC is expected to be installed throughout the WTF but the final number and combination of reactive mats will be dependent on the site-specific sheen flux and project requirements.
2) The entire area is divided into a grid containing cells, each having dimensions of 20 feet (ft) x 10 ft to estimate mat life. Cells of these dimensions are used to simplify evaluation of sheen location and the potential for sheen mass flux across the bank at the WTF. For the purposes of the 30% design submission, it is assumed that the sheen mass flux is evenly distributed across all cells. The expected reactive media density needed to achieve the required design life is determined per cell.
3) A mass flux is estimated using standard sheen characteristics such as type and area of sheen in the canal (ExxonMobil, 2008) and the desired design life of 30 years. This sheen flux is the maximum flux per cell that the bank control can isolate from the canal with 1 layer of OC reactive mat. The life is then calculated per cell of OC as shown in **Attachment E-2**. The life is calculated using equation **E1** below.

Life of geofabric containing 1 layer of OC = $\frac{Site\ LNAPL\ Absorption}{J}$ -------- (**E1**)

Site LNAPL Absorption = $\eta \times OC_{sorp} \times OC_{avail} \times A$

A= Design Area where the fabric is installed, ft^2

η = Efficiency of LNAPL capture by OC, % (vendor-reported from previous case studies)

OC_{sorp} = oil sorption capacity measured as lb LNAPL/lb OC

OC_{avail} = available OC in the product measured as lb OC/ft^2

J = Mass flux, measured as lb LNAPL/yr

BASIS OF CALCULATIONS

This section provides the details and basis of calculations performed to design the number of reactive mats to be used in the design based on mat characteristics. The following parameters were used in the calculations performed for the current assessment.

1) **Install Area**: Per the assumption, the entire width of 300 ft of the WTF is to be isolated from the canal. Based on the sediment cap proposed in the canal section adjacent to WTF (**Figure 2-2 of the 30% BODR**), the bank length varies throughout the install area but is approximately 45 ft. on average. The expected install area is estimated at approximately 15,800 ft^2, based on the shaded area shown in **Drawing C-111 of the 30% BODR**.

Draft

2) **LNAPL/Sheen Flux**: Information regarding the sheen flux into the canal is not available. Therefore, assumptions are made about the sheen flux that the bank control is to isolate from the canal. For the purposes of the 30 PD, the sheen flux assumption is made for a grid of 20' x 10' based on the required design life of 30 years and an assumed minimum 1 layer of Active OC. Calculations made using these assumptions result in a bank control that can isolate a sheen flux of ~2.5 lb NAPL/year from a single cell of 20' x 10'. This NAPL flux may be verified/validated on-site during the pre-design investigations. If the flux is greater than 2.5 lb NAPL/year, then additional layers of reactive mat may be added and bundled to meet the required design life.

3) **Life of the Reactive Mat per cell**: With 1 Layer of Active OC at a minimum that is expected to be used for bank control, and the assumptions listed in (2) regarding sheen flux, the design life of the reactive mat comes out to be ~32 years. Details on calculations are provided as **Attachment E-2**

Table 1 summarizes the assumed design parameters in addition to those identified in Section 1.1 and preliminary results.

Table 1. Summary of Assumed Parameters and Preliminary Results

Design Parameter	Value	Units
Install Area	15,800	ft^2
Sheen Type	Barely Discernible	-
Assumed Volume of LNAPL from each cell of 20 ftx10 ft	<0.01	gal
Flux of sheen per cell (calculated based on reactive mat layer assumptions)	2.5	lb NAPL/yr
RESULTS		
Estimated Life of reactive mat with 1 layer of Active OC	32	yr

Pre-design investigations may be conducted to verify the sheen flux and modifications may be made to the design. For example, if the sheen flux is greater than the assumed 2.5 lb NAPL/yr/cell, one or more additional layers of Active OC and/or Active AS may be recommended.

Detailed calculations are shown in **Attachment E-2**.

Draft

REFERENCES

1. *Light Non-Aqueous Phase Liquids (LNAPL) Literature Review*. The Los Angeles LNAPL Working Group. Western States Petroleum Association. October 27, 2011.
2. *AOC Site Investigation Report Version 3*. Former ECI Refinery. Arcadis. August 25, 2016.
3. *Oil Spill Response Field Manual*. ExxonMobil. Revised 2008.

Draft

Draft

ATTACHMENT E-1: HUESKER PRODUCT DATA

TECHNICAL DATA

REACTIVE CORE MAT™

with ORGANOCLAY®

DESCRIPTION

Organoclay® Reactive Core Mat™ is a permeable composite of geotextiles and granular Organoclay that reliably adsorbs NAPL and low solubility organics from water. Batch isotherm testing by a university determined the following partition coefficients:

- Naphthalene, Kd = 3280 L/kg
- Phenanthrene, Kd = 117,000 L/kg
- Pyrene, Kd - 286,000 L/kg

Reactive Core Mat™ is designed to provide a simple method of placing active materials into subaqueous sediment caps.

APPLICATION

Organoclay® Reactive Core Mat™ is designed for use in the following applications:

- In situ subaqueous cap for contaminated sediments or post-dredge residual sediments
- Embankment seepage control
- Groundwater remediation

BENEFITS

- Organoclay® Reactive Core Mat™ provides a reactive material that treats contaminants carried by advective/diffusive flow
- Reactive cap allows for thinner cap thickness than a traditional sand cap
- Geotextiles provide stability and physical isolation of contaminants

PACKAGING

15' by 100' rolls, packaged on 4" PVC core tubes wrapped with polyethylene plastic packaging.

AVAILABILITY

Organoclay® Reactive Core Mat™ is available from the following CETCO plant locations:

- 92 Highway 37, Lovell, WY

TESTING DATA

PHYSICAL PROPERTIES		
PROPERTY	**TEST METHOD**	**RESULT**
ORGANOCLAY[1]		
Bulk Density Range	ASTM D 7481	44 – 56 lbs/ft^3
Oil Adsorption Capacity	CETCO Test Method	0.5 lb of oil per lb of organoclay, min
Quaternary Amine Content	ASTM D 7626	25 – 33% quaternary amine loading
FINISHED RCM PRODUCT		
Organoclay Mass per Area	CETCO Test Method	0.8 lb/ft^2
Mat Grab Strength[2]	ASTM D4632	90 lbs. MARV
Hydraulic Conductivity[3]	ASTM D4491	1 x 10^{-3} cm/sec minimum

NOTES:
[1] Organoclay properties performed periodically on material prior to incorporation into the RCM
[2] All tensile testing is performed in the machine direction
[3] Permittivity at constant head of 2 inches and converted to hydraulic conductivity using Darcy's Law and RCM thickness per ASTM D5199 for geotextiles

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2870 Forbs Avenue, Hoffman Estates, IL 60192
800.527.9948 | www.cetco.com

IMPORTANT: The information contained herein supersedes all previous printed versions, and is believed to be accurate and reliable. For the most up-to-date information, please visit remediation.cetco.com. CETCO accepts no responsibility for the results obtained through application of this product. CETCO reserves the right to update information without notice.
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REV: 7/13

Tektoseal® Active OC

Data Sheet

Environmental Engineering

Tektoseal® Active OC is an engineered geocomposite comprised of multiple layers of nonwoven geotextiles with an inner layer of organophilic clay which are bonded together by a needlepunch process. Tektoseal® Active OC has been developed for use in capping contaminated sediments and contaminated groundwater remediation. Tektoseal® Active OC has the following properties:

Properties of Tektoseal® Active OC

PROPERTY[1]	TEST	ENGLISH units[1]	SI units[1]
Mass/Area Organophilic clay	HUESKER test method	0.8 lb/ft^2 (min)	3.9 kg/m^2 (min)
Organophilic clay Properties			
Quaternary Amine Loading	ASTM D-7626	25% (min)	25% (min)
Oil Sorption Capacity	ASTM D-8106	0.5 lb oil/lb OC (min)	0.5 g oil/g OC (min)
Grab Tensile Strength (MD)	ASTM D-4632	90 lb (MARV)	400 N (MARV)
Hydraulic Conductivity (water)	Modified ASTM D-4491	NA	1 x 10^{-3} cm/s (min)

[1] MARV - Minimum average roll values are based on a 97.5% confidence level. MD - Machine Direction. min – minimum. Permittivity converted to hydraulic conductivity using Darcy's Law and Tektoseal® Active mat thickness. Mat deaired prior to test by placing in flexible wall permeameter and applying vacuum for 1 hour.

Draft

Standard Roll Size: 15 ft (4.6 m) wide
100 ft (30.5 m) long
Typical Weight (w/ core): 1,500 lbs. (680 kg)

Each roll of Tektoseal® delivered to the project site is labeled by HUESKER with information containing the manufacturer's name, product identification, lot number, roll number and roll dimensions. All rolls of Tektoseal® are encased in a sturdy polyethylene wrap to shield the product from rain, dirt, dust and UV exposure. Contact HUESKER for information on our material warranty.

Revision: April 30, 2019

Tektoseal® Active AS

Data Sheet

Environmental Engineering

Tektoseal® Active AS is an engineered geocomposite comprised of two nonwoven geotextiles with an inner layer of oil-adsorbent melt-blown polymer which are bonded together by a needlepunch process. Tektoseal® Active AS has been developed as a strong and durable environmental geocomposite to be used for contaminated runoff, contaminant capping and turbidity curtain applications. Tektoseal® Active AS is inert to biological degradation and typical chemicals, alkalis and acids. Tektoseal® Active AS has the following nominal values.

Draft

Physical and Chemical Properties of Tektoseal® Active AS

PROPERTY[1]	TEST METHOD	ENGLISH units	SI units
Total Mass/Unit Area	ASTM D-5261	27 oz/yd^2	910 g/m^2
Oil Sorption Capacity	ASTM F-726	0.15 US gal/ft^2	6 l/m^2
Grab Tensile Strength (MD)	ASTM D-4632	240 lb-f	1.1 kN
Puncture Strength	ASTM D-4833	150 lb-f	0.67 kN
Hydraulic Conductivity	Modified ASTM D-4491		1 x 10^{-3} cm/sec min

[1]MD = machine direction
Oil sorption capacity run with medium viscosity canola oil.
Hydraulic conductivity converted from permittivity using mat thickness per ASTM D5199. Mat deaired prior to test by placing in flexible wall permeameter and applying vacuum for 1 hour.

Standard Roll Size: 15 ft (4.6 m) wide
150 ft (45.7 m) long
Typical Weight (w/ core): 500 lbs (230 kg)

Each roll of Tektoseal® Active geocomposite delivered to the project site is labeled by HUESKER with information that indicates manufacturer's name, product identification, lot number, roll number and roll dimensions. All rolls of Tektoseal® are encased in a sturdy polyethylene wrap to shield the product from rain, dirt, dust and UV exposure. Contact HUESKER for information on our material warranty.

Revised: 5/25/2018

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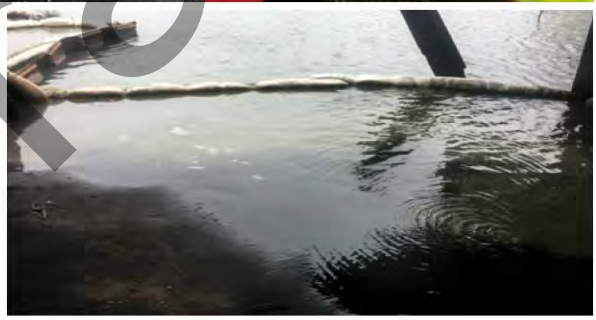
Contaminated Sites

Environmental Engineering

Active cap stops LNAPL sheen on canal

Tektoseal Active installed with anchor trench at sheet pile wall



Petroleum sheen prior to installation

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Situation

A major oil company operated a tank farm in the Midwest adjacent to a canal. A leak developed resulting in a petroleum plume at the air-water interface of the groundwater. The plume migrated toward the canal and daylighted on the bank resulting in sheen on the waterway. Arcadis US was contracted to design a remediation plan. A boom was deployed to contain the sheen. Assessment and design began to remediate the main source zone of the LNAPL plume. LNAPL was still expected to continue to migrate into the canal until the full remedy was complete.

Solution

As an interim LNAPL barrier, an active cap was designed for the canal bank. Based upon estimated LNAPL mass over the life of the interim barrier, the active cap consisted of four layers; three layers of Tektoseal® Active OC overlain by one layer of Tektoseal Active AS. Both the organo-clay in Tektoseal Active OC and the melt-blown polymer in Tektoseal Active AS adsorb LNAPL. Both are initially highly permeable to water, and decrease in permeability in the areas where they adsorb LNAPL. The Tektoseal Active AS layer LNAPL interaction is quicker than the organo-clay interaction. So addition of the Tektoseal Active AS layer increases the contact time between the organo-clay and LNAPL and precludes short circuiting.

Work was done in winter when a frostline existed near the surface which temporarily stopped the seep. There was existing armor stone and debris along the shoreline which was first removed to the extent possible. Where debris and other protrusions could be feasibly removed, a sand levelling layer was placed. The Tektoseal Active panels were deployed perpendicular to the shoreline and anchored in a trench at top of the slope. Adjacent panels were overlapped a minimum of 1 foot. Panels were cut, as needed, to fit around pipelines and bridge structures. Since the canal

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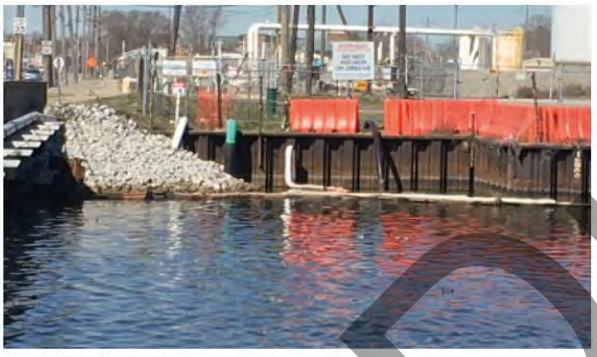
Contaminated Sites

Environmental Engineering

Tektoseal Active installation prior to cover placement



15 months after installation – view across canal

15 months after installation – no sheen

was freshwater, sodium bentonite could be used to seal around details and structures. Cover consisted of ¾" stone and rip rap.
A visit to the site was conducted 15 months after the construction of the project, The boom has been kept in place as a precaution, but there is no petroleum sheen observed in the waterway.

Advantages

Tektoseal Active geocomposites provided an active cap that allows groundwater to flow through, but adsorb LNAPL in areas of where the seep emanates along the shoreline. Tektoseal Active geocomposites were readily deployed in harsh winter conditions. Tektoseal Active geocomposites were easily cut and fit around pipe penetrations and structures. Tektoseal Active AS and OC have been effective in eliminating sheen on the waterway over the interim action period.

Project:	Canal Active Cap.
Location:	Midwest US.
Client:	Major Oil Company.
Design:	Arcadis US.
Construction:	Environmental Restoration LLC.
Construction period:	January 2018
HUESKER Product(s):	Tektoseal Active AS and Tektoseal Active OC

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HUESKER Synthetic is certified to ISO 9001 and ISO 50001.

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ATTACHMENT E-2: REACTIVE MAT CALCULATIONS

Attachment E-2. Sample Calculations

Install Area		
Install Area, ft^2	15800	Based on Drawing C-111

LNAPL Flux/Qty		
Type of NAPL		
Sheen Type	Barely Discernible	Assumed
Area of sheen in the canal, ft^2	1000	Assumed
Thickness, µm	0.05	Assumed
Volume of NAPL, gal	0.001066	Assumed
Density, g/cc	0.77	**Ref**: *LNAPL Literature Review.* The LA LNAPL Working Group, October 2011.
Mass of LNAPL, lb	0.006835	
Duration		
Duration of sheen loading into the canal, day	365	Assumed
Flux		
Flux of sheen, lb NAPL/yr	2.494763	

Fabric Life		
(+) Assumptions List		
1 layer of Active OC		
Fabric Properties		
NAPL Sorption, lb/NAPL/lb OC	0.5	Manufacturer Spec
OC Availability, lb OC/ft^2	0.8	Manufacturer Spec
Area of each cell, ft^2	200	Assuming dimensions/cell= 20' x 10'
Absorption Capacity, %	100	Assumed
Life of Fabric, yr	32.06717	$\frac{\text{lb NAPL/ lb OC} * \text{lb OC/ft}^2 \text{ material} * \text{Efficiency} * \text{ft}^2 \text{ of cell}}{\text{Sheen Flux} * 365 \text{ days/yr}}$
1 layer of Active AS		
Fabric Properties		
NAPL Sorption, gal/ft^2 of material	0.15	Manufacturer Spec
Density of material, oz/yd^2	27	Manufacturer Spec
Area of each cell, ft^2	200	
NAPL Sorption, lb/ft^2	0.96	Manufacturer Spec
Absorption Capacity, %	100	Assumed
Life of Fabric, yr	77.10298	$\frac{\text{lb NAPL/ ft}^2 \text{ material} * \text{Efficiency} * \text{ft}^2 \text{ of cell}}{\text{Sheen Flux} * 365 \text{ days/yr}}$

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APPENDIX F PERMITTING INFORMATION (TO BE PROVIDED IN 90% SUBMISSION)

Draft

APPENDIX G PROJECT CONTROLS

Draft

G.1 – HEALTH AND SAFETY PLAN (OUTLINE IN 30% SUBMISSION)

Appendix G.1_

Project Health and Safety Plan Outline (30% Submission)

SECTION TITLE

0.0 EMERGENCY RESPONSE INFORMATION

- 0.1 GENERAL EMERGENCY RESPONSE PROCEDURES
- 0.2 EMERGENCY EVACUATION PROCEDURES
- 0.3 EMERGENCY MEDICAL CARE
  - 0.3.1 Life Threatening Medical Emergency
  - 0.3.2 Non-Life Threatening Medical Care
    - 0.3.2.1 TBD Hospital
    - 0.3.2.2 Alternate Hospital TBD
  - 0.3.3 First Aid/CPR Trained Personnel
- 0.4 SEVERE WEATHER RESPONSE PLAN
  - 0.4.1 Electrical Storms Response
  - 0.4.2 High Winds Response
  - 0.4.3 Heavy Rain or Hail Response
  - 0.4.4 Tornadoes Response
  - 0.4.5 Flood Response
  - 0.4.6 Hurricane Response
- 0.5 FIRE RESPONSE PLAN
  - 0.5.1 Fire Prevention
- 0.6 EXPLOSION RESPONSE PLAN
- 0.7 RESPONSE TO A CHEMICAL RELEASE FROM AN OFF-SITE SOURCE
- 0.8 MATERIAL RELEASE RESPONSE PLAN
  - 0.8.1 Initial Spill Response
  - 0.8.2 Spill Site Decontamination
  - 0.8.3 Cleanup Materials and Used Personal Protective Equipment Disposal
  - 0.8.4 Spill Prevention

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0.9 SECURITY EVENT RESPONSE
0.10 REPORTING AND INVESTIGATION OF HSSE AND OPERATIONAL INCIDENTS
0.10.1 Near Miss/HSSE Observation Form (HEART)
0.11 WOOD WORKPLACE INJURY CASE MANAGEMENT
0.11.1 For a non-emergency incident:
0.11.2 For an emergency incident:
0.12 EMERGENCY RESPONSE EQUIPMENT
0.12.1 Inspection and Maintenance of Project HSSE Equipment
0.13 EMERGENCY PREPAREDNESS
1.0 INTRODUCTION & BACKGROUND INFORMATION
1.1 SITE LOCATION AND HISTORY
1.2 CONTRACTED SCOPE OF WORK
1.3 DOCUMENT CONTROL AND DOCUMENT AUTHORITIES
1.3.1 FIELD CHANGES TO THE HASP
1.3.2 AUTHORIZATION OF HASP SIGNATURES
1.4 COMPLIANCE AGREEMENT 3
2.0 STATEMENT OF WOOD SAFETY AND HEALTH POLICY
2.1 WOOD'S SAFETY SHIELD
2.2. WOOD LIFE SAVING RULES & SAFETY ESSENTIALS
2.3 Safety Leadership and Commitment
3.0 RISK MANAGEMENT PROCESS (Wood)
3.1 HSSE Risk Registers
3.2 BPRM Functional Disciplines
3.3 Conflict Resolution
3.4 Regular Health & Safety Inspections
3.5 HEART Observation System
3.6 Accident Reporting
3.7 Noncompliance with Safety Requirements

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4.0 AUTHORITIES – ROLES & RESPONSIBILITIES

4.1 PLAN OBJECTIVES

4.2 PROJECT AUTHORITIES AND RESPONSIBILITIES

4.2.1 Wood Project Manager / Single Point of Accountability (SPA)

4.2.2 Wood Construction Manager

4.2.3 Wood HSSE Lead & PROJECT Representative

4.2.4 Wood Advisor for BPRM HSSE & Assurance Programs

4.2.5 Wood Workforce

4.2.6 Wood Subcontractors

4.2.7 Vendors and Visitors

5.0 GENERAL SITE HAZARDS

5.1 CONTAMINANTS/CHEMICALS OF CONCERN

5.2 PHYSICAL HAZARDS (ROUTINE)

5.2.1 Driving

5.2.2 Use of Site Access Roads

5.2.3 Work near Heavy Equipment

5.2.4 Demolition Debris

5.2.5 Soil Contaminants

5.2.6 Noise

5.2.7 Heat Stress

5.2.8 Cold Stress

5.2.9 Musculoskeletal Injuries from Lifting

5.2.10 Energized Equipment / Systems

5.2.11 Work from Heights or on Slopes Greater than 40 Degrees

5.2.12 Working on Uneven Ground

5.2.13 Petroleum Contaminated Ground Water

5.2.14 Simultaneous Operations

5.2.15 Fuels and Oils

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5.2.16 Power and Hand Tools
5.2.16.1 Power Tools
5.2.16.2 Hand Tools
5.2.16.3 Safe Work Practices
5.2.16.4 Pneumatic Tools and Air Compressors
5.2.17 Work Adjacent to Roadways
5.2.18 Work Around Water
5.2.19 Fatigue Hazards
5.2.20 Sampling Related Hazards
5.2.21 Ground Disturbance
5.2.22 Petroleum Containing Piping
5.2.23 Active Railroad
5.2.24 UST & AST Removals
5.2.24.1 Line Breaking Procedure
5.2.25 Removal of Asbestos Containing Materials
5.2.26 Use of Metal Cutting Tools
5.3 BIOLOGICAL AND WILDLIFE HAZARDS
5.3.1 Hazardous Plants
5.3.2 Poisonous Snakes
5.3.3 Ticks
5.3.4 Bees, Wasp and Yellow Jackets
5.3.5 Mosquitoes
5.3.6 Spiders
5.3.7 Rodent Droppings
5.3.8 Chiggers
5.3.9 Coyotes, Racoons and Stray Animals
5.3.10 Bloodborne Pathogens
5.4 RISK ASSESSMENT AND CONTROL MEASURES OF (ROUTINE) PROJECT HAZARDS

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6.0 CONTROL OF WORK
6.1 BPRM COMMITMENT, GOALS, AND STANDARDS
6.1.1 Commitment Statement and Goals
6.1.2 Required Project HSSE Procedures
6.1.3 Golden Rules of Safety
6.2 TRAs
6.3 FIELD AUTHORIZATION FORM (FAF)
6.4 PERMITS
6.4.1 Energy Isolation
6.4.2 Ground Disturbance
6.4.3 Confined Space Entry
6.4.4 Working at Heights
6.4.5 Lifting Operations
6.4.6 Hot Work
6.4.7 Overhead Utilities
6.5 MANAGEMENT OF CHANGE
6.6 DAILY SAFETY MEETINGS
6.7 COMPETENCY ASSURANCE
7.0 TRAINING AND MEDICAL MONITORING REQUIREMENTS
7.1 WOOD TRAINING REQUIREMENTS
7.1.1 Project Safety Orientation Training
7.1.2 Hazard Communication Training
7.1.3 PPE Training
7.1.4 First Aid/CPR Training
7.1.5 Defensive Driver Training
7.1.6 Fatigue Awareness Training
7.1.7 Control of Work / HITRA Basics Training
7.1.8 HAZWOPER Training

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7.1.8.1 40- and 24-Hour HAZWOPER Training
7.1.8.2 HAZWOPER Supervisor Training
7.1.8.3 Personnel Working on Clean Construction Jobs
7.2 ADDITIONAL TRAINING
7.3 KICK-OFF MEETING
7.4 MEDICAL MONITORING REQUIREMENTS
7.5 DRUG AND ALCOHOL TESTING
8.0 PERSONAL PROTECTIVE EQUIPMENT
9.0 AIR MONITORING
9.1 PERIODIC MONITORING
9.2 INSTRUMENT CALIBRATION
9.3 UNKNOWN SITUATIONS
10.0 PROJECT-SPECIFIC PROCEDURES
10.1 SAFETY MEETINGS
10.1.1 Project Kick off Safety Meeting
10.2 BUDDY SYSTEM
10.3 EQUIPMENT AND PERSONNEL DECONTAMINATION
10.4 WASTE MANAGEMENT
11.0 SUBCONTRACTOR SPECIFIC HEALTH AND SAFETY PLANS
11.1 REQUIRED MATERIAL

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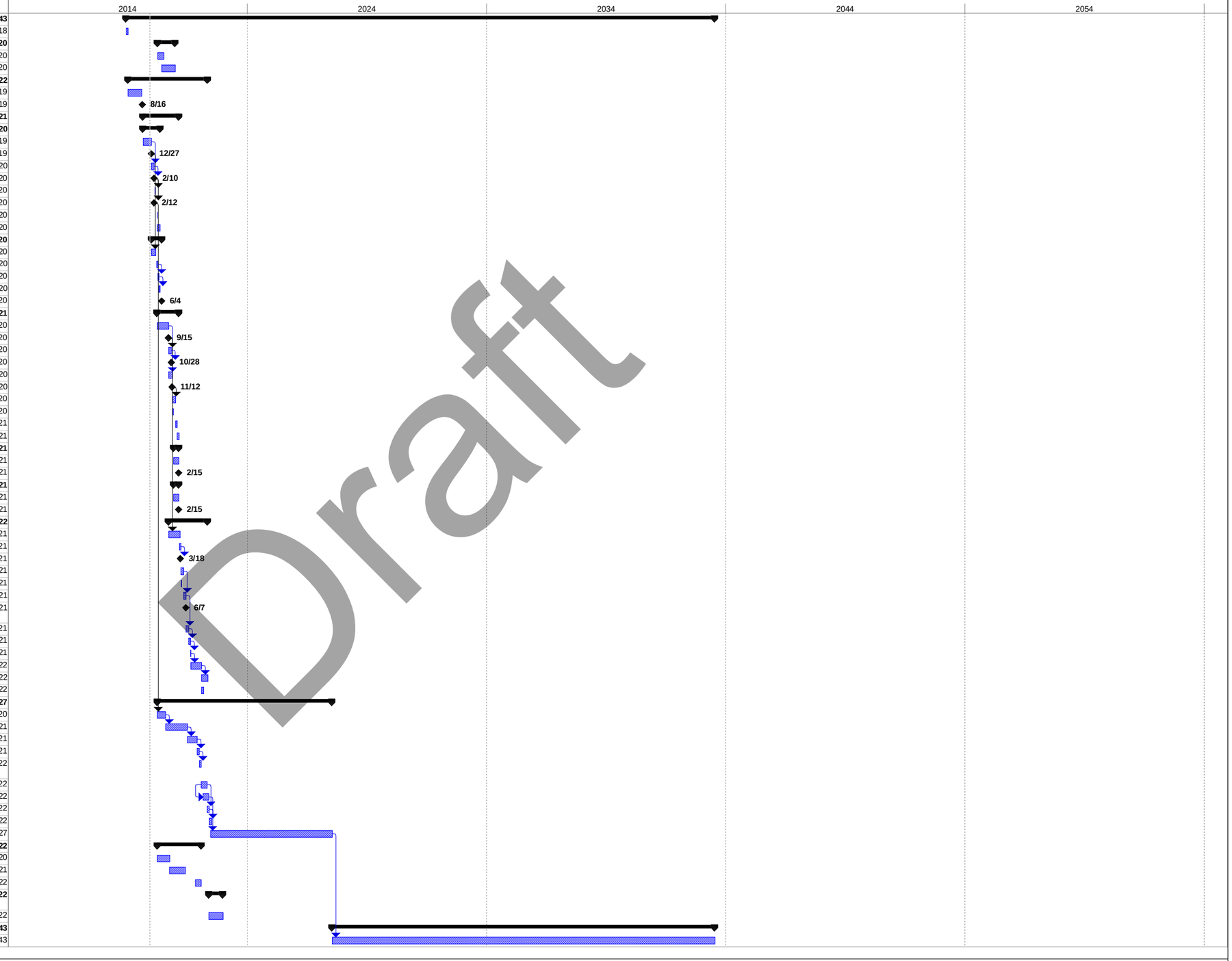
G.2 – DRAFT ECI GLLA PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**DRAFT ECI GLLA Project Schedule**	**6422 days**	**Mon 12/3/18**	**Tue 7/14/43**
2	**Execute Project Agreement (NFS/USEPA)**	21 days	Mon 12/3/18	Mon 12/31/18
3	**Pipe Decomissioning (ARC/BP)**	**189 days**	**Wed 4/1/20**	**Mon 12/21/20**
4	Construction of West Tank Farm (WTF)	65 days	Wed 4/1/20	Tue 6/30/20
5	Construction of South Tank Farm (STF)	144 days	Wed 6/3/20	Mon 12/21/20
6	**Sheet Pile Wall (ARC/BP)**	**870 days**	**Tue 1/1/19**	**Mon 5/2/22**
7	Design Contractor Procurement	153 days	Tue 1/1/19	Thu 8/1/19
8	EPA Contractor Approval	0 days	Fri 8/16/19	Fri 8/16/19
9	**Design**	**393 days**	**Mon 8/19/19**	**Wed 2/17/21**
10	**30% Basis of Design Report (BODR)**	**187 days**	**Mon 8/19/19**	**Tue 5/5/20**
11	AOC Duration to 30% BODR Due to USEPA	95 days	Mon 8/19/19	Fri 12/27/19
12	Issue DRAFT 30% BODR to USEPA	0 days	Fri 12/27/19	Fri 12/27/19
13	USEPA Review of 30% BODR	30 days	Mon 12/30/19	Fri 2/7/20
14	USEPA Issue Draft 30% Comments	0 days	Mon 2/10/20	Mon 2/10/20
15	Meet with USEPA to Discuss Comments	1 day	Thu 2/20/20	Thu 2/20/20
16	Issue FINAL 30% BODR to USEPA	30 days	Wed 2/12/20	Tue 3/24/20
17	Present 30% Design to ECWMD Board Meeting	1 day	Wed 3/25/20	Wed 3/25/20
18	Public Comment Period for 30% BODR	30 days	Wed 3/25/20	Tue 5/5/20
19	**Additional Field Data**	**113 days**	**Mon 12/30/19**	**Thu 6/4/20**
20	Develop Investigation Scopes	43 days	Mon 12/30/19	Wed 2/26/20
21	Field Work	15 days	Thu 3/12/20	Wed 4/1/20
22	Lab Work	15 days	Thu 4/2/20	Wed 4/22/20
23	Draft Report	10 days	Thu 4/23/20	Wed 5/6/20
24	Issue Additional Field Data Deliverable to USEPA	0 days	Thu 6/4/20	Thu 6/4/20
25	**90% Design**	**236 days**	**Wed 3/25/20**	**Wed 2/17/21**
26	Prepare DRAFT 90% Design	125 days	Wed 3/25/20	Tue 9/15/20
27	Issue 90% Design to USEPA	0 days	Tue 9/15/20	Tue 9/15/20
28	USEPA Review of 90% Design (Assumed Durati	31 days	Tue 9/15/20	Tue 10/27/20
29	USEPA Issue Comments on 90% Design	0 days	Wed 10/28/20	Wed 10/28/20
30	Prepare DRAFT IFC	42 days	Wed 9/16/20	Thu 11/12/20
31	Issue DRAFT IFC to USEPA	0 days	Thu 11/12/20	Thu 11/12/20
32	USEPA Review of DRAFT IFC Design	32 days	Fri 11/13/20	Mon 12/28/20
33	Present 90% Design to ECWMD Board Meeting	1 day	Wed 11/18/20	Wed 11/18/20
34	USEPA Issue Comments on DRAFT IFC Design	16 days	Tue 12/29/20	Tue 1/19/21
35	Issue FINAL IFC to USEPA	21 days	Wed 1/20/21	Wed 2/17/21
36	**Health and Safety Plan (HASP)**	**56 days**	**Mon 11/30/20**	**Mon 2/15/21**
37	Prepare HASP	56 days	Mon 11/30/20	Mon 2/15/21
38	Issue FINAL HASP to USEPA	0 days	Mon 2/15/21	Mon 2/15/21
39	**Quality Assurance Project Plan (QAPP)**	**56 days**	**Mon 11/30/20**	**Mon 2/15/21**
40	Prepare QAPP	56 days	Mon 11/30/20	Mon 2/15/21
41	Issue FINAL QAPP to USEPA	0 days	Mon 2/15/21	Mon 2/15/21
42	**Procurement for Barrier Wall Implementation**	**424 days**	**Wed 9/16/20**	**Mon 5/2/22**
43	Obtain Permits	122 days	Wed 9/16/20	Thu 3/4/21
44	Prepare RFP	19 days	Mon 2/22/21	Thu 3/18/21
45	Issue RFP to Bidders	0 days	Thu 3/18/21	Thu 3/18/21
46	Bid Preparation by Bidders	30 days	Thu 3/18/21	Wed 4/28/21
47	Site Walk	1 day	Fri 3/26/21	Fri 3/26/21
48	Review of Bids	28 days	Thu 4/29/21	Mon 6/7/21
49	ECWMD Board Meeting/ Approval of Construction Contractor	0 days	Mon 6/7/21	Mon 6/7/21
50	Contracting with the Contractor	28 days	Tue 6/8/21	Thu 7/15/21
51	ECWMD Review of the Contract	21 days	Fri 7/16/21	Fri 8/13/21
52	Contract Executed	1 day	Mon 8/16/21	Mon 8/16/21
53	Order of Steel	120 days	Tue 8/17/21	Mon 1/31/22
54	Construction	65 days	Tue 2/1/22	Mon 5/2/22
55	**Interim Accounting (USEPA)**	21 days	Mon 1/31/22	Mon 2/28/22
56	**Cap/Dredge (USEPA (USACE))**	**1905 days**	**Thu 3/26/20**	**Wed 7/14/27**
57	Interagency Agreement	89 days	Thu 3/26/20	Tue 7/28/20
58	Design Cap / Dredge	238 days	Wed 7/29/20	Fri 6/25/21
59	Procurement	108 days	Mon 6/28/21	Wed 11/24/21
60	Design O&M Plan	22 days	Thu 11/25/21	Fri 12/24/21
61	Construction Dewatering Pad (if necessary)	22 days	Mon 12/27/21	Tue 1/25/22
62	Construction (Dredge)	66 days	Tue 1/25/22	Tue 4/26/22
63	Construction (Cap)	65 days	Tue 2/22/22	Mon 5/23/22
64	Dispose Sediments (if necessary)	22 days	Wed 4/27/22	Thu 5/26/22
65	Staging Restoration	22 days	Fri 5/27/22	Mon 6/27/22
66	Cap Warranty	1327 days	Tue 6/14/22	Wed 7/14/27
67	**WTF Bank Stabilization (ARC/BP)**	**478 days**	**Thu 3/26/20**	**Mon 1/24/22**
68	Design	133 days	Thu 3/26/20	Mon 9/28/20
69	Procurement	171 days	Mon 9/28/20	Mon 5/24/21
70	Construction	65 days	Tue 10/26/21	Mon 1/24/22
71	**Habitat Restoration (If Necessary) (ARC/BP)**	**153 days**	**Mon 5/23/22**	**Wed 12/21/22**
72	Planning, design and Construction	153 days	Mon 5/23/22	Wed 12/21/22
73	**Cap O&M (ARC/BP)**	**4174 days**	**Thu 7/15/27**	**Tue 7/14/43**
74	Inspection & Maintenance	4174 days	Thu 7/15/27	Tue 7/14/43



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ECI GLLA Project Schedule
Date: 10/03//2019

Task Milestone Summary Deadline

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APPENDIX H – DRAFT TECHNICAL SPECIFICATIONS (30% SUBMISSION)

30% DRAFT
TECHNICAL SPECIFICATIONS
Oil Control Barrier and Bank Seep Controls

Former ECI Refinery STF & WTF
East Chicago, Indiana

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Prepared for: **December 2019**

Atlantic Richfield Company

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SECTION 01 10 00

SUMMARY OF WORK

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Procurement and Construction Agreement (the Agreement) and Division 01 Technical Specifications, apply to this Technical Specification.

B. Remediation Management Policy, Control of Work, Latest Revision, BPRM, (BPRM Control of Work).

C. Oil Control Barrier and Bank Control, Basis of Design Report, Former ECI Refinery, East Chicago, Indiana, TBD (Date of IFC version).

1.2 DEFINITIONS

A. **Site**: The Former Energy Cooperative, Inc (ECI) East Chicago, Indiana oil refinery facility, located west of Indianapolis Boulevard extending north and south of the Lake George Canal (Canal), which includes the STF and WTF where the Work shall be completed.

B. **STF**: South Tank Farm is a parcel within the Site, located south of the Canal and US Army Corps of Engineers Confined Disposal Facility (CDF), west of Indianapolis Boulevard, north of McShane Avenue Extension and southwest of the WTF, where an anchored bulkhead wall system shall be installed as part of the Work.

C. **WTF**: West Tank Farm is a parcel within the Site, located north of the Canal, west of the CDF and Northwest of the STF, where a bank control system shall be installed as part of the Work.

D. **Contractor**: The entity designated as the “Contractor” in the opening paragraph of the Agreement signed between the Owner and the Contractor. An individual under contractual relationship to Remediation Management Services Company (RMSC).

E. **Daily Toolbox Meeting**: A meeting held at the start of each work day, shift or task change that is designed for field work crews to discuss potential risks and hazards of assigned tasks. This meeting could also be conducted if a work stoppage is put in to affect or site hazards or risk change during a shift.

F. **Permit**: A formal and detailed document containing location, time, equipment to be worked on, hazard identification, mitigation or precaution measure used and the names of those authorizing the work and performing the work.

G. **Design Engineer**: The Engineer shall mean Wood Environment and Infrastructure Solutions, Inc. (Wood).

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H. **Owner**: The Owner shall mean Atlantic Richfield Company.

I. **Owner's Designated Representative**: The third-party entity that is designated by the Owner to represent them during construction.

J. **Procurement and Construction Agreement**: The contractual agreement (hereinafter referred to as "the Agreement") between the Owner and the Contractor for the performance of the Work on this Project.

K. **Procurement and Construction Agreement Documents**: The documents expressly incorporated through the Agreement including, but not limited to the Agreement, Conditions, Bid Schedule, Drawings, and Technical Specifications.

L. **Work:** The services performed under this Agreement including, but not limited to, furnishing labor, materials, and equipment for implementation of the barrier wall system and bank controls to isolate oil on the STF and WTF, respectively such that it does not cause sheen on the Canal. The Work also includes the entire completed construction/installation or the various separately identifiable parts thereof, required to be furnished under the Agreement Documents.

M. **Work Plan**: A plan to enable work to be carried out in a safe and reliable manner. It may include project execution plans (PEPs), Health and Safety Plans (HASPs), work risk assessments (RAs) and work risk mitigations.

1.3 EXISTING CONDITIONS

A. The ECI Site was previously used as an oil refinery that during its operating life the refinery produced motor fuels, light distillates, medium distillates, residual fuels and one type of pesticide (pyrethrin). The refinery was demolished between 1985 and 1989 under a federal court order. Today, the East Chicago Waterway Management District (ECWMD) owns the Site.

B. The STF and WTF, comprise of approximately 53.5 and 18.3 acres, respectively with surface elevations generally between 590 to 580 feet (NAVD88, which is the Site datum for the Work). The center of the STF is located at approximately 41° 38' 41"N and 87° 29' 7"W and the WTF is at approximately 41° 39' 5"N and 87° 29' 23W".

C. Existing conditions known to exist at the WTF and STF are shown on the Existing Conditions Plans (Sheets C-101 through C-105) including topography (before pipeline removal work began in 2019 at the STF), underground and above-ground utilities, existing wells, relevant historic subsurface explorations, infrastructure, site surface features and adjacent areas. The Contractor shall verify existing conditions prior to intrusive work. The Site has a USEPA ID of IND082547803 and complies with the 2018 AOC.

D. The ECI is a former refinery and petroleum storage facility. The refinery was dismantled and demolished between 1985 and 1990. The main refinery portion of the Site was converted into a United States Army Corps of Engineers (USACE) Confined Disposal Facility (CDF) in 2009. The STF and WTF formerly stored bulk

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petroleum products. Light non-aqueous phase liquid (LNAPL) (i.e., oil) has been identified on the STF and WTF parcels. An LNAPL recovery well systems exists at the STF and WFT, with less than about 10 gallons per year recovered over the past few years at the STF and none at the WTF.

E. Investigations and interim actions have been taken on the Site, including but not limited to: the installation in 1992 and continuing operation of an LNAPL recovery well system to recover free product from atop groundwater at the WTF and STF; maintenance of booms across the Canal to contain and remove petroleum found on the Canal's surface; removal of petroleum found in surface soils on site; investigation and sampling work; and development of proposed final remedy options. Stating in August 2019, approximately 70,000 linear feet (LF) of relic abandoned pipeline removal, flushing and capping began, to prevent the release of petroleum products that may be present in underground pipelines, with work scheduled to be completed by _2020_____(BP – please provide a date).

F. The remedial action objective (RAO), is to isolate oil in upland areas of the STF from the Canal and to control seepage at the WTF. The proposed remedy will be protective of human health and the environment, and consistent with the redevelopment goals for the ECI Site. The Canal is anticipated to be dredged and capped with sediments disposed of in the CDF; therefore, the STF barrier wall system is to be completed prior to __(date of site closure)__ so materials can be placed in the CDF before it is closed.

G. The barrier wall system at the STF shall be an anchored sheetpile bulkhead wall with sheetpile deadman anchors and includes the bulkhead wall, tiebacks and deadmen. Betterments to the wall system include features to mitigate the effects of groundwater mounding behind the wall and flow around the ends of the wall using a passive system which can be efficiently upgraded to an active system with minimal added infrastructure.

H. The bank control system at the WTF shall consist of installation of reactive mats, which are geotextile sheets that encapsulate an active media are proposed to control sheens in the canal and will be compatible with future sediment capping adjacent to the WTF.

I. All contractor and subcontractor Work shall comply with the requirements of these technical specifications and Drawings and be in accordance with the requirements of BPRM Control of Work.

1.4 SUBMITTALS

A. Identification of Submittals

1. Completely identify each submittal and resubmittal by showing at least the following information:

   a. Name and address of submitter, plus name and telephone number of the individual to contact for further information.

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b. Name of Project as the Project name appears in these Technical Specifications.

c. Drawing number and/or Technical Specification section number to which the submittal applies.

d. Whether this is an original submittal or resubmittal.

B. Coordination of Submittals

1. Prior to submittal to the Owner's Designated Representative, use all means necessary to fully coordinate all material, including the following procedures:

a. Determine and verify all field dimensions and conditions, materials, catalog numbers, and similar data.

b. Coordinate as required with the Owner, Owner's Designated Representative, all trades, and with all public agencies involved.

c. Secure all necessary approval(s) from public agencies and others and signify by stamp, or other means, that the approval(s) have been secured.

d. Clearly indicate all deviations from the Agreement documents.

C. Grouping of Submittals

1. Unless otherwise specifically permitted by the Owner's Designated Representative, make all submittals in groups containing all associated items; the Owner's Designated Representative can reject partial submittals as not complying with the provisions of the Agreement documents.

D. Timing of Submittals

1. Make all submittals in a timely fashion to meet Project schedules and required allowance time for Owner's Designated Representative and/or Owner reviews in accordance with Section 01 33 00 – Submittal Procedures and the Agreement.

E. Submit each submittal in accordance with the specific Technical Specification requirements, conditions of the Agreement, and Technical Specification 01 33 00 - Submittal Procedures.

F. The Contractor shall submit a Project Execution Plan (PEP) prior to commencing construction for review and acceptance by the Owner's Designated Representative and Owner, which contains, at a minimum:

1. Name, statement of qualifications (in resume format), duties, responsibilities, and authorities of key personnel (Project Manager, Superintendent, CQC Manager, Health and Safety Officer, and SAC Liaison) proposed for the Work.

2. Proposed list of Contractor personnel or subcontractors and their qualifications

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to be used for the Work, including installers/maintainers of survey control, potential turbidity curtains and oil booms, the bulkhead wall system, bank controls and excavation, stormwater controls, and utility work for review and approval by the Owner. Refer to Section 01 45 16 Contractor Quality Control for required qualifications for installers/maintainers.

3. Proposed sequence, phasing, equipment, and methods for the performance of Site preparation (e.g., temporary facilities and controls including health and safety, utilities, soil erosion and sediment control requirements, decontamination procedures, etc.).

4. Topographic survey procedures as outlined in Section 02 21 00 – Survey and Grade Controls.

5. A Contaminated Materials Handling Plan as outlined in Section 02 61 13 Excavation and Handling of Contaminated Materials.

6. A Construction Water Management Plan (CWMP) including proposed methods of handling, managing, transporting, treating, and disposing of construction water as required in Section 31 21 40 – Dewatering - Upland.

7. A Site Demolition Plan including demolition and sequencing for designated structures to be demolished as required in Section 02 41 19 – Selective Site Demolition.

8. Procedures for scheduling, delivery, staging, and storage of construction materials, including geosynthetic materials and soil and rock materials.

9. Contractor and subcontractor documentation showing compliance with SAC requirements for safety, security, and sustainability via prequalification in the Avetta/PICS system.

10. Proposed sequence, equipment, and methods for the excavation, removal and consolidation of contaminated soil/fill (e.g., required shoring for excavation support/protection, cofferdam construction, construction dewatering, stormwater management).

11. A Dust Control Plan including proposed means, methods, and equipment for control of dust as required in Section 31 20 00 - Earthwork.

12. A Debris Management Plan including proposed means, methods, procedures, and equipment for preventing the generation of FOD and for securing/anchoring equipment, materials, supplies and work in progress to mitigate impacts to flight field or other facility operations, as required in Section 31 20 00 – Earthwork. The Debris Management Plan applies to all materials used in the execution of the Work.

13. A Waste Management Plan identifying proposed method(s) of handling, managing, transporting, of all identified waste materials as outlined in Section 01 74 19 – Construction Waste Management and Disposal.

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14. A Contaminated Materials Handling Work Plan as outlined in Section 02 61 13 – Excavation and Handling of Contaminated Materials.

15. Proposed method(s) of handling, stockpiling, placing and compacting backfill material.

16. Proposed method(s) of Site restoration including establishment of vegetative cover, establishment and stabilization of drainage channels, and restoration.

17. Proposed Work schedule.

G. During construction, the Contractor shall prepare and submit electronically to the Owner's Designated Representative and Owner, Daily Activity Reports that document activities conducted on a daily basis including:

1. On-going work and completed work.

2. Materials or equipment delivered to the Site.

3. Visitors to the Site and any interaction with regulators, municipal representatives, abutters, or the general public.

4. Any issues or problems encountered, and steps or procedures undertaken or proposed for resolve them.

5. A summary of any inspections, testing, or maintenance activities conducted.

6. Changed conditions from those in the Agreement.

1.5 TECHNICAL SPECIFICATION FORMATS AND CONVENTIONS

A. Technical Specification Format: The Technical Specifications may be organized into divisions and sections using the 50-division format and CSI/CSC's "MasterFormat® April 2016" numbering system.

1. Section Identification: The Technical Specifications use section numbers and titles to help cross-referencing in the Agreement documents. Sections are in numeric sequence; however, the sequence is incomplete because all available section numbers are not used. Consult the table of contents to determine numbers and names of sections in the Agreement documents.

2. Division 01: Sections in Division 01 govern the execution of the Work of all sections in the Technical Specifications.

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PART 2 DESCRIPTION OF WORK

2.1 GENERAL

A. Furnish labor, supervision, field surveying, tools, materials, material testing, equipment, fuel, temporary field office(s), sanitary facilities, Foreign Objects and Debris (FOD) control, potable water, health and safety equipment and training and appropriate storage facilities and pay expenses and permit fees required for the successful performance of the Work.

B. The Technical Specifications and Drawings are intended to be fully explanatory and supplementary. Where Work is shown on one and not on the other, perform the Work the same as if shown, indicated or specified in both. The means and methods used by the Contractor to accomplish all Work are the responsibility of the Contractor. If an assumed method of construction/installation is not successful, the Contractor is responsible for making changes to the Contractor's Work Plan to meet the Technical Specifications without delay or additional cost to the Owner.

C. Utilize Contractor-supplied soil and material for the Work as approved by the Owner's Designated Representative. Any changes to the soil material source(s) used by the Contractor during performance of the Work are as directed and/or approved by the Owner's Designated Representative. All materials delivered to the Site shall be pre-approved by the Owner's Designated Representative.

2.2 PROJECT WORK

A. The BODR, which includes these Technical Specifications and Drawings, describes the design assumptions and the Work, including materials, testing and documentation requirements for the complete construction/installation of the Work. This 30% Submission Summary of Work is an overview of the Work and is subject to the more detailed Technical Specifications and Drawings. Implementation includes, but is not limited to, the following:

1. **Mobilization, Site Preparation, Demobilization, Permits and Temporary Facilities:** Includes mobilization of equipment and materials for construction of the Work. Also includes construction of temporary facilities (temporary office trailer(s) and set up, temporary utility connections, temporary sanitary facilities, health and safety controls, and stockpile areas), as necessary.

2. **General Conditions:** Includes all project management and administrative costs, which includes, but is not limited to: preparation of a preliminary construction schedule, schedule of submittals and Schedule of Values; coordination of a pre-construction meeting; maintaining Record Documents during construction activities; prepare pre-construction submittals and obtain approval; maintenance of a Health and Safety Program on Site, which includes Daily Toolbox Meetings and issuance of Permits (as needed) and testing and inspections. Coordination with the Owner, Owner's Designated Representative and other contractors and subcontractors.

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3. **Stormwater Management:** Complete the substantive requirements of the applicable permit requirements. Develop and submit, for approval by the Owner, a Storm Water Pollution Prevention Plan (SWPPP)/Best Management Practices (BMPs) Plan specific to the Project and the Contractor's planned sequence and phasing of operation. Installation/maintenance of erosion and sedimentation controls, including, but not limited to: temporary construction silt fence, vehicle/equipment decontamination facilities, in Canal water quality monitoring and control measures, oil boom maintenance, temporary straw bales and temporary filter socks.

4. **Selective Demolition**

5. **Dewatering:** Perform control, collection, treatment, testing, documentation and discharge of dewatering fluids (stormwater and groundwater) required to complete the Work.

6. **Bulkhead Wall**: Complete the installation of the proposed barrier wall system, including; bulkhead installation, deadman installation, waler installation, tieback installation, tieback tensioning and wingwall installation.

7. **STF Earthworks**: Complete earthworks in support of proposed barrier wall installation, including: bulkhead and deadman pre-installation probing, obstruction removal, excavation for tie-backs, and backfilling of tiebacks, backfilling behind the bulkhead wall, (exclusive of wall backfill).

8. **STF Enhancements**: Complete the installation of water treatment and discharge systems and prove-out.

9. **WTF Earthworks**: Complete the installation of bank controls, including: excavation/dredging to accommodate the controls, importing of borrow, construction of the bank control system.

10. **Field Surveying:** Establish existing conditions, survey control, construction layout/staking, volume estimates, progress payments, and as-built records.

11. **Selective Demolition, Site Clearing and Grubbing:** Complete selective site demolition of the existing dilapidated wooden bulkhead, underground utilities, product recovery system and appurtenances, and wells/piezometers. Structures include but are not limited to monitoring wells, electrical conduits and risers, storage containers, pavement, and fencing. The timing and sequence of demolition of infrastructure shall be coordinated with the Owner. Demolition includes proper offsite disposal at a licensed disposal facility. Remove all woody vegetation and grubbings from the Site to facilitate the Work. Document all material disposal at Owner approved off-site facilities.

9. **Additive Work:** Including: management, loading, transportation and disposal of hazardous solid waste, non-hazardous solid waste, non-hazardous liquid waste; soft digging around utilities; vapor and odor control, perimeter air monitoring, and TBD bonds, if required.

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10. **Site Restoration:** Includes Work required to restore the Site to the Owners satisfaction and clean up, including: grading; stormwater infrastructure; topsoil, seed, fertilizer, lime and seed; .

11. **Project Record Documents:** Provide project record documents (Technical Specifications, Drawings, and photographs) indicating the locations, depths and grades of the Work performed to implement the Oil Control Barrier and Bank Controls at the STF and WTF, respectively.

PART 3 GENERAL SITE REQUIREMENTS

3.1 PROJECT MEETINGS

A. General: Project meetings shall be in accordance with Owner and Owner's Designated Representative Requirements.

3.2 DUST AND DEBRIS CONTROL

A. Perform dust and debris control on the Job Site, access road and any adjacent affected areas throughout the performance of the Work.

B. The Contractor understands and acknowledges that controlling dust and debris is of critical importance. In that regard, perform the Work as follows:

1. In compliance with all Applicable Laws (including, without limitation, Federal, state and local statutes, ordinances, regulations, etc.) and with the Contractor's dust control plan(s) and permit(s) as such plans and permits are in effect, modified, amended, supplemented, or otherwise modified from time to time.

2. Such that no visible dust/debris leaves the area(s) where the Work is performed or materials are stockpiled (either while the Work is being performed or thereafter). Immediately remove dust/debris.

3. The foregoing requirements are cumulative, and compliance with one of the requirements does not relieve the Contractor of the Contractor's obligation to comply with all the other requirements.

4. If the Contractor believes any of the requirements are in conflict (i.e., the Contractor cannot comply with one requirement without violating another), immediately notify the Owner's Designated Representative and thereafter comply with the Owner's directives on complying with the requirements.

C. Adhere to other dust control requirements specified in the individual Technical Specifications.

3.3 STORM WATER CONTROL

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A. Within the construction limits of the Job Site, the Contractor is responsible for control of all sedimentation and erosion from the Project Work. Erosion control shall include all necessary ditching, silt fences, turbidity curtains, mulching, maintenance, or additional items to prevent deposition of materials in downstream, wetland and tidal areas as needed. Erosion control shall meet the minimum design established in the Technical Specifications and Drawings.

3.4 PROPERTY PROTECTION

A. Protect and preserve from damage by the Contractor all property along the line of Work or which is in the vicinity of, or is any way affected by the Work. Do not move fences, water or gas pipelines, sewers, drains, conduits, poles, or wires for electrical purposes, or other structures without consent of persons owning or controlling them; and in crossing or working near them, they are sustained securely in place and are so treated as to render their condition as efficient and permanent as before.

B. Immediately repair and restore damaged property or, if required, make the necessary repairs.

1. The locations of known utilities (either aboveground or underground) shown on the Drawings are plotted from available records and are considered approximate only. Determining the location of each utility within the area of the Work shown on the Drawings, or not, is the responsibility of the Contractor. Exercise care during such location Work to avoid damaging and/or disrupting the affected utility. Repairing damage to utilities caused by the Contractor is the Contractor's responsibility.

2. When excavating in close proximity of a utility or structure, notify the Owner thereof sufficiently in advance so that the Owner can accomplish any special protective measure(s) the Contractor or the Owner deem necessary.

3.5 MAINTENANCE OF ACCESS ROADS

A. Maintenance of construction access roads is incidental to the Work. Maintain, by the Contractor, onsite roadways and keep the onsite roadways free of dust/debris and open for the Owner's access. The Contractor ingress/egress point for the STF shall be the southeast corner of the STF, off Indianapolis Boulevard; and the WTF shall be accessed through the BP WBU via a gravel road west of the WTF.

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3.6 CONTRACTOR USE OF PREMISES

A. The Contractor shall use only designated areas of the Site for staging and storage. Staging and storage area uses are to be agreed upon and accepted by the Owner's Designated Representative and Owner.

B. The Contractor shall assume full responsibility for the protection and safe keeping of products and equipment under this Contract that are stored on-site and off-site during the Work.

3.7 Canal Water Quality Monitoring and Mitigation (TBD based on permitting)

A. As described in the 2016 SI (Arcadis, 2016), the groundwater at the Site is presently not being used for a drinking water nor will it be used as a source of potable water in future. Dissolved groundwater concentrations at the STF and WTF do not pose a threat to surface water quality.

B. A. Subcontractor shall perform the Work minimizing environmental pollution or damage as the result of construction operations. Environmental pollution or damage is the presence of chemical, physical, or biological elements or agents which adversely affect human health or welfare; unfavorably alter ecological balances of importance to human life; affect other species of importance to humankind; or degrade the utility of the environment for aesthetic, cultural and/or historical purposes.

C. Subcontractor shall remove all soil and debris from equipment and if necessary, decontaminate all equipment prior to mobilizing to site and prior to demobilizing from site. Waste haulers and imported soil transporters shall not distribute material (e.g. soil tracks from truck tires) offsite or onsite during transportation.

D. Canal water quality monitoring and mitigation is outlined in Section 35 20 25 Water Quality Monitoring and in Section 35 42 00 Water Bank Protection.

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PART 4 SPECIFICATIONS AND DRAWINGS

4.1 Contract Documents include Technical Specifications and Drawings

A. The Contractor is obligated to perform the Work in full compliance with the Project Requirements including these Technical Specifications and Drawings. The provisions of these Technical Specifications and Drawings are not intended to be a substitute for or in any way diminish the Project Requirements. If the Project Requirements require more or different Work than set forth in these Technical Specifications and Drawings, perform such Work. If any of the provisions of these Technical Specifications and Drawings is inconsistent with (i.e., not permitted under) any of the Project Requirements, notify the Owner's Designated Representative to that effect and the Owner's Designated R02 61 13epresentative will amend the Technical Specifications and Drawings to eliminate the inconsistency.

4.2 Specifications:

Number	Summary of Section	30%	90%	IFC
	Cover Sheet	X		
	Signature Sheet			X
00 01 00	Table of Contents		X	
01 10 00	Summary of Work	X		
01 31 00	Project Management and Coordination		X	
01 32 00	Construction Progress Documentation		X	
01 33 00	Submittal Procedures		X	
01 35 29	Health, Safety, and Emergency Response		X	
01 35 43	Environmental Procedures	X		
01 35 63.13	Sustainability Requirements	X		
01 41 00	Regulatory Requirements	X		
01 45 16	Quality Control	X		
01 50 00	Temporary Facilities and Controls		X	
01 70 00	Execution and Closeout Requirements		X	
01 74 19	Construction Waste Management and Disposal	X		
01 81 16	Facility Environmental Requirements		X	
02 21 00	Survey and Grade Control		X	
02 41 19	Selective Site Demolition		X	
02 61 13	Excavation and Handling of Contaminated Materials	X		

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02 72 00	Water Treatment	X		
13 50 00	Special Instrumentation		TBD	
31 10 00	Clearing and Grubbing		X	
31 20 00	Earthwork		X	
31 21 40	Dewatering- Upland	X		
31 23 23	Subaqueous Capping		X	
31 25 00	Erosion and Sedimentation Control		X	
31 41 16	Steel Sheet Piling and Sealing	X		
32 92 19	Seeding		X	
35 20 23	Environmental Dredging		X	
35 20 25	Water Quality Monitoring		X	
35 42 00	Waterway Bank Control		X	
35 51 13	Marine Signaling and Control Equipment	X		
46 01 07	Operations and Maintenance of packaged Treatment Equipment		TBD	
46 07 13	Packaged water Treatment Equipment		TBD	

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4.3 Drawings:

INCLUDED THIS 30% SUBMITTAL	SHEET NUMBER	DRAWING ID	DRAWING TITLE
X	1	G-001	COVER SHEET
X	2	G-002	LEGEND AND ABBREVIATIONS
X	3	G-003	GENERAL CONDITIONS
X	4	C-101	EXISTING CONDITIONS - STF OVERVIEW
X	5	C-102	EXISTING CONDITIONS - STF (NW)
X	6	C-103	EXISTING CONDITIONS - STF (NE)
X	7	C-104	EXISTING CONDITIONS - WTF OVERVIEW
X	8	C-105	EXISTING CONDITIONS - WTF (S)
	9	C-106	FINAL GRADING PLAN - STF (NE)
	10	C-107	FINAL GRADING PLAN - STF (NW)
	11	C-108	FINAL GRADING PLAN - WTF (S)
	12	C-109	BARRIER WALL BACKFILL PLAN - STF (NW)
	13	C-110	BARRIER WALL BACKFILL PLAN - STF (NE)
X	14	C-111	BANK CONTROL PLAN - WTF (S)
X	15	C-301	SOIL EROSION AND SEDIMENT CONTROL NOTES
	16	C-302	SOIL EROSION AND SEDIMENT CONTROL PLAN - STF
	17	C-303	SOIL EROSION AND SEDIMENT CONTROL PLAN – WTF
X	18	C-304	SOIL EROSION AND SEDIMENT CONTROL DETAILS
X	19	C-401	STF BARRIER WALL CROSS-SECTIONS STA 0+00 TO 5+00

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INCLUDED THIS 30% SUBMITTAL	SHEET NUMBER	DRAWING ID	DRAWING TITLE
X	20	C-402	STF BARRIER WALL CROSS-SECTIONS STA 6+00 TO 11+00
X	21	C-403	STF BARRIER WALL CROSS-SECTIONS STA 12+00 TO 17+00
X	22	C-404	STF BARRIER WALL CROSS-SECTIONS STA 18+00 TO 20+39
X	23	C-405	WTF BANK CONTROL CROSS-SECTIONS STA 300+00 to 303+17
X	24	C-501	CIVIL DETAILS
	25	S-001	STRUCTURAL NOTES
X	26	S-101	BARRIER WALL PLAN AND PROFILE - STF (NW)
X	27	S-102	BARRIER WALL PLAN AND PROFILE - STF (NE)
X	28	S-201	BARRIER WALL DETAILS I
	29	S-202	BARRIER WALL DETAILS II

X indicates included in this submission.

END OF SECTION

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SECTION 01 35 43

ENVIRONMENTAL PROCEDURES

PART 1 GENERAL

1.1 DESCRIPTION

Contractor shall perform the Work minimizing environmental pollution or damage as the result of construction operations. Environmental pollution or damage results from the presence of chemical, physical, or biological elements or agents which adversely affect human health or welfare; the unfavorable altering of ecological balances of importance to human life; affecting other species of importance to humankind; or degrading the utility of the environment for aesthetic, cultural and/or historical purposes. The control of environmental pollution or damage requires consideration of land, water, and air, and includes management of visual aesthetics, noise, solid waste, odor, and dust, as well as other pollutants. The environmental resources within the project Limit of Work and those affected beyond shall be protected during the entire duration of this Contract.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01 50 00 – Temporary Facilities and Controls

B. Section 01 74 19 – Construction Waste Management and Disposal

C. Section 01 81 16 – Facility Environmental Requirements

D. Section 02 61 13 – Excavation and Handling of Contaminated Materials

E. Section 31 25 00 – Erosion and Sedimentation Control

1.3 DEFINITIONS

A. Sediment - soil and other debris that has eroded and has been transported by runoff water or wind.

B. Heavy Duty Vehicle - on road and off-road vehicles powered by a diesel engine with a gross vehicle weight greater than 8,500 pounds.

C. On Road Vehicle - a motor vehicle powered by a diesel engine that has a gross vehicle weight rating greater than 8,500 pounds and is designed primarily for transporting persons or properties on a street or a highway.

D. Off Road Vehicle - a motor vehicle, other than an on-road vehicle, powered by a diesel engine with a gross vehicle weight greater than 8,500 pounds or having an engine of 50 horsepower or greater.

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E. Gross Vehicle Weight Rating - the value specified by the vehicle manufacturer as the maximum loaded weight of a single or combination vehicle.

F. Ultra-Low Sulfur Diesel - diesel fuel having sulfur content of 0.0015 percent (15 ppm) of sulfur or less.

G. Best Available Retrofit Technology (BART) – technology verified by the Environmental Protection Agency or California Air Resources Board for reducing the emissions of pollutants that achieves reductions in particulate matter emissions at the highest classification level for diesel emission control strategies that is applicable to the particular engine and application. Such technology shall also, at a reasonable cost, achieve the greatest reduction in emissions of nitrogen oxides at such particulate matter reduction level and shall in no event result in a net increase in the emissions of either particulate matter or nitrogen oxides.

H. Classification level for diesel emission control strategies – particulate matter reduction classification levels and corresponding particulate matter percent reductions as follows:

1. Particulate matter reduction less than 25%: not verified.

2. Particulate matter reduction greater than or equal 25%: Classification Level 1.

3. Particulate matter reduction greater than or equal 50%: Classification Level 2.

4. Particulate matter reduction greater than or equal 85%: Classification Level 3.

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PART 2 - PRODUCTS

Not Applicable

PART 3- EXECUTION

3.1 PROTECTION OF NATURAL RESOURCES

A. General: During the Work, the Contractor shall comply with appropriate requirements of Owner obtained environmental permits.

B. Preserve the natural resources within the Limit of Work and outside the project Limit of Work. Restore to an equivalent or improved condition upon completion of Work. Confine construction activities to within the Limit of Work indicated on the Construction Contract Drawings.

C. The Contractor shall provide means, methods, and facilities to prevent contamination of soil, water, and atmosphere from waste discharges due to spills and releases as a result of the Contractor's operation.

D. Land Resources:

1. Except in areas to be cleared, do not remove, cut, deface, injure, or destroy trees or shrubs without the Owner's permission. Do not fasten or attach ropes, cables, or guys to existing trees for anchorages unless authorized by the Owner. Where such use of attached ropes, cables, or guys is authorized, the Contractor shall be responsible for any resultant damage.

2. Protect existing trees and shrubs which are to remain and which may be injured, bruised, defaced, or otherwise damaged by construction operations. Cut off vegetation to be cleared flush with or as close as practical to the original ground surface in areas to be cleared, except for trees and vegetation indicated or directed to be left standing.

3. Remove traces of temporary construction facilities such as haul roads, work areas, stockpiles of excess or waste materials, and other signs of construction. Grade temporary roads and similar temporary areas to blend with surrounding conditions.

E. Water Resources:

1. Wastes - Prevent waste substances from entering the ground, drainage areas, or local bodies of water outside of excavation limits.

2. Sediments - Prevent sediment migration outside the Limit of Work.

F. Fish and Wildlife Resources - Do not disturb fish and wildlife. Do not alter water flows or otherwise significantly disturb the native habitat adjacent to the project and critical to the survival of fish and wildlife, except as indicated or specified as part of the work. Coordinate work with state regulated spawning periods to minimize disturbances to fisheries.

3.2 HISTORICAL AND ARCHAEOLOGICAL RESOURCES

A. Carefully protect in-place any historical and archaeological items or human skeletal remains discovered in the course of work and report immediately to the Owner.

B. Stop work in the immediate area of the discovery until directed by the Owner to resume work.

3.3 EROSION AND SEDIMENT CONTROL MEASURES

A. Refer to the Construction Contract Drawings and Section 31 25 00 - Erosion and Sedimentation Control for additional requirements.

B. Burnoff of the ground cover is not permitted.

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C. Protection of Erodible Soils

Immediately finish the earthwork brought to a final grade, as indicated or specified. Immediately protect the side slopes and back slopes upon completion of rough grading. Plan and conduct earthwork to minimize the duration of exposure of unprotected soils.

D. Temporary Protection of Erodible Soils

Use the methods prescribed in Section 31 25 00 – Erosion and Sedimentation Control to prevent erosion and control sediment.

3.4 CONTROL AND DISPOSAL OF WASTES

A. Liquid waste generated and captured during the course of the project shall be managed in accordance with the requirements of Section 01 74 19 – Construction Waste Management and Disposal and Section 31 21 40 – Dewatering-Upland.

B. Pick up Site trash, and place in containers which are regularly emptied. Do not prepare, cook, or dispose of food on the project Site. Prevent contamination of the Site or other areas when handling and disposing of wastes. Upon project completion, leave the Site clean. Control and properly handle and dispose of waste in accordance with Section 01 74 19 – Construction Waste Management and Disposal.

C. Temporary sanitary facilities shall be managed in accordance with Section 01 50 00 - Temporary Facilities and Controls. Include provisions for pest control and elimination of odors. Upon completion of the work, the facilities shall be removed by the Contractor from the premises, leaving the premises clean and free from nuisance.

3.5 DUST AND ODOR CONTROL

A. Provisions shall be taken during all construction activities to keep airborne dust and nuisance odors levels low, including during non-working periods. Dust and control measures shall be implemented in accordance with the State of Connecticut Best Management Practices (BMPs).

B Implement controls when visible air-borne dust becomes noticeable and is carried out of immediate work/disturbed areas.

3.6 NOISE

A. Make the maximum use of low-noise emission equipment according to USEPA regulations.

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3.7 DIESEL EMISSIONS REDUCTION

A. The Contractor shall comply with the Indiana Management IDEM Clean Air Act, Indiana Vehicle Emissions Testing Program. and EPA Regulations and Standards regarding emission standards and clean diesel technologies.

END OF SECTION

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SECTION 01 35 63 .13

SUSTAINABILITY REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes general requirements and procedures for achieving the most environmentally conscious Work possible within the limits of the Construction Schedule, Contract Sum, and available materials, equipment, and products.

1.2 OBJECTIVES

A. To minimize the environmental impacts of the construction and operation, the Contractor during the construction phase of this project shall implement the following procedures singly or in combination:

1. Select products that minimize consumption of non-renewable resources, consume reduced amounts of energy and minimize amounts of pollution to produce, and employ recycled and/or recyclable materials. To help government purchasers incorporate environmental considerations into purchasing decisions, it is the intent of this project to conform with EPA's Five Guiding Principles on environmentally preferable purchasing. The five principles are:

    a. Include environmental considerations as part of the normal purchasing process.

    b. Emphasize pollution prevention early in the purchasing process.

    c. Examine multiple environmental attributes throughout a product's or service's life cycle.

    d. Compare relevant environmental impacts when selecting products and services.

    e. Collect and base purchasing decisions on accurate and meaningful information about environmental performance.

2. Products and processes that achieve the above objective to the extent currently possible and practical have been selected and included in these Construction Documents. The Contractor is responsible to maintain and support these objectives in developing means and methods for performing the work of this Contract and in proposing product substitutions and/or

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changes to specified processes.

1.3 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Conditions and other Division 1 Specification Sections, apply to this Section.

B. Related Sections include the following:

1. 01 35 43 Environmental Procedures
2. 01 74 19 Construction Waste Management and Disposal
3. 35 20 23 Environmental Dredging

1.4 DEFINITIONS

A. Construction and Demolition Waste: Includes solid wastes, such as building materials, packaging, rubbish, debris, and rubble resulting from construction, remodeling, repair and demolition operations. A construction waste management plan is to be provided by the Contractor as defined in Section 01 74 19.

B. Recycled Content Materials: Products that contain pre-consumer or post-consumer materials as all or part of their feedstock

C. Post-Consumer Recycled Content: The percentage by weight of constituent materials that have been recovered or otherwise diverted from the solid-waste stream after consumer use

D. Pre-Consumer Recycled Content: Materials that have been recovered or otherwise diverted from the solid-waste stream during the manufacturing process. Pre-consumer content must be material that would not have otherwise entered the waste stream as per Section 5 of the FTC Act, Part 260 “Guidelines for the Use of Environmental Marketing Claims”: www.ftc.gov/bcp/grnrule/guides980427

E. Salvaged or Reused Materials: Materials extracted from existing buildings in order to be reused in other buildings without being manufactured

F. Sealant: Any material that fills and seals gaps between other materials

G. Type 1 Finishes: Materials and finishes which have a potential for short- term levels of off gassing from chemicals inherent in their manufacturing process, or which are applied in a form requiring vehicles or carriers for spreading which release a high level of particulate matter in the process of installation and/or curing.

H. Type 2 Finishes: “Fuzzy" materials and finishes which are woven, fibrous, or

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porous in nature and tend to adsorb chemicals off gassed by Type 1 finishes or may be adversely affected by particulates. These materials become "sinks" for deleterious substances which may be released much later, or collectors of contaminants that may promote subsequent bacterial growth.

I. Volatile Organic Compounds (VOCs): Any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions. Compounds that have negligible photochemical reactivity, listed in EPA 40 CFR 51.100(s), are also excluded from this regulatory definition.

1.5 SUBMITTALS

A. General: Additional Sustainable Design submittal requirements are included in other sections of the Specifications.

B. Sustainable Design Submittals:

1. Salvaged or Reused Materials: Provide documentation that lists each salvaged or reused material, the source or vendor of the material, the purchase price, and the replacement cost if greater than the purchase price.

2. Recycled Content: Submittals for all materials with recycled content (excluding MEP systems equipment and components) must include the following documentation:

   a. Cost of each material or product, excluding cost of labor and equipment for installation

   b. Manufacturer's product data, product literature, or a letter from the manufacturer verifying the percentage of post-consumer and pre-consumer recycled content (by weight) of each material or product

   c. An electronic spreadsheet that tabulates the Project's total materials cost and combined recycled content value (defined as the sum of the post-consumer recycled content value plus one- half of the pre-consumer recycled content value) expressed as a percentage of total materials cost. This spreadsheet shall be submitted every third month with the Contractor's Certificate and Application for Payment. It should indicate, on an ongoing basis, line items for each material, including cost, pre-consumer recycled content, post-consumer recycled content, and combined recycled content value.

C. Construction Waste Management: See Section 01 74 19 "Construction Waste Management and Disposal" for submittal requirements.

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D. Commissioning: See Section 01 33 00 “Submittal Procedures” for submittal requirements.

E. Sustainable Design Progress Reports: Concurrent with each Application for Payment, submit reports for the following:

1. Construction Waste Management: Waste reduction progress reports and logs complying with the requirements of Section 01 74 19 “Construction Waste Management and Disposal.”

1.6 QUALITY ASSURANCE

A. General: Perform the work of this Section as a supplement and in accordance with applicable requirements of Division 1 “Contractor Quality Control Program.”

B. Preconstruction Meeting: After award of Contract and prior to the commencement of the Work, schedule and conduct meeting with Owner, Architect, and all Subcontractors to discuss the Construction Waste Management Plan and all other Sustainable Design Requirements. The purpose of this meeting is to develop a mutual understanding of the Project’s Sustainable Design Requirements and coordination of the Contractor’s management of these requirements with the Contracting Officer and the Construction Quality Manager.

PART 2 - PRODUCTS

2.1 PRODUCT ENVIRONMENTAL REQUIREMENTS

PART 3 - EXECUTION

3.1 CONSTRUCTION WASTE MANAGEMENT

A. Develop and implement a Construction Waste Management Plan (CWMP), as defined in Section 01 74 19 “Construction Waste Management and Disposal,” .

B. Clean materials which are contaminated prior to placing in collection containers. Deliver materials free of dirt, adhesives, solvents, petroleum contamination, and other substances deleterious to the recycling process.

C. Arrange for materials collection by or materials delivery to the appropriate recycling or reuse facility.

D. Tax credits and other savings obtained, or revenue generated for recycled or reused materials accrue to the Contractor.

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E. Discuss CWMP procedures and measures as an agenda item at all regular job meetings conducted during the course of work at the site, and record progress in meeting minutes.

END OF SECTION

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SECTION 01 41 00

REGULATORY REQUIREMENTS

PART 1 GENERAL

1.1 DESCRIPTION

A. Comply with local, state, and federal regulations appropriate or applicable to the proposed work.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01 35 43: Environment Procedures

B. Section 01 74 19: Construction Waste Management and Disposal

C. Section 02 61 13: Excavation and Handling of Contaminated Materials

D. Section 02 72 00: Water Treatment

E. Section 31 20 00: Earthwork

1.3 REMEDIAL WORK

A. Regulations applicable to work activities will include but not necessarily be limited to the following governing authorities:

1. East Chicago Waterways Management District
2. Atlantic Richfield Company
3. BP Products North America Inc
4. City of East Chicago
5. Great Lakes Legacy Act
6. Occupational Safety and Health Act (OSHA)
7. U.S. Environmental Protection Agency (USEPA)
8. U.S. Army Corps of Engineers (USACE)
9. Indiana Management IDEM Clean Air Act (CAA)
10. Clean Water Act (CWA)

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11. Indiana Department of Transportation (IDOT)
12. Great Lakes Water Authority (GLWA)
13. Indiana Vehicle Emissions Testing Program
14. Indiana Department of Environmental Management (IDEM)
15. TBD others identified through permitting process

PART 2 PRODUCTS

Not Applicable.

PART 3 EXECUTION

Not Applicable.

END OF SECTION

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SECTION 01 45 16

QUALITY CONTROL

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Agreement and Division 01 Technical Specifications apply to this Technical Specification.

B. Remediation Management Policy, Control of Work, Latest Revision, BPRM, (BPRM Control of Work).

C. Oil Control Barrier and Bank Control, Basis of Design Report, Former ECI Refinery, East Chicago, Indiana, TBD (Date of IFC version).

D. City of East Chicago Storm Water Quality Management (letter - TBD)

E. TBD relevant Owner documents with QC requirements

1.2 SUMMARY

A. This Technical Specification covers the requirements where the Contractor warrants that the Work will be performed to the highest standards and quality. The Contractor further warrants that defects in the Work that are the result of the Contractor's or the Contractor's Subcontractor's methods, workmanship, and/or materials are corrected, removed, and/or replaced at no additional cost to the Owner.

B. Included in this Technical Specification are discussions of the following as related to quality control:

1. Quality Control Plan.
2. Quality control organization.
3. Quality control.
4. Coordination meeting.
5. Project completion inspection.
6. Documentation.
7. Notification of Noncompliance.

1.3 RELATED WORK SPECIFIED ELSEWHERE

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A. Section 01 31 00 – Project Management and Coordination

B. Section 01 33 00 – Submittal Procedures

C. Section 01 50 00 – Temporary Facilities and Controls

D. Section 31 10 00 – Clearing and Grubbing

E. Section 31 20 00 – Earthwork

F. Section 31 41 16 – Steel Sheet Piling and Sealing

G. Section 35 20 25 – Water Quality Monitoring

1.4 REFERENCES

Comply with all relevant codes and/or agency requirements, regardless of whether the codes and/or agency requirements are listed in the Technical Specifications.

1.5 SUBMITTALS

A. General: Submit each item in this Technical Specification in accordance with the conditions of the Agreement and Technical Specification 01 33 00 - Submittal Procedures.

B. Submit the following at the Pre-Construction Meeting (refer to Section 01 31 00 - Project Management and Coordination):

1. Quality Control (QC) Plan

    a. Includes any forms or reports generated by the procedures in the QC plan such as inspection and testing reports.

C. The Contractor QC organization is responsible for certifying that all submittals and deliverables comply with the Agreement.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

A. Establish and maintain an effective quality control (QC) system to demonstrate effective control of the Work. QC consists of plans, procedures, and organization necessary to produce a product which complies with the relevant requirements and Project objectives. Cover all operations, both onsite and offsite, and be keyed to the proposed sequence.

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B. The Contractor's Project Foreman/Superintendent:

1. Held responsible for the quality of Work and is subject to removal by the Owner and/or Owner's Designated Representative for non-compliance with the Contractor's approved QC Plan.

2. The highest-level manager responsible for the overall activities at the Job Site, including quality and production, is the Contractor's Project foreman/ superintendent.

3. The Contractor's Project foreman/superintendent or designee must maintain a physical presence at the Job Site at all times while Work is performed and is responsible for all activities at the Job Site, except as otherwise acceptable to the Owner and Owner's Designated Representative.

3.2 QUALITY CONTROL PLAN

A. Submit the QC Plan proposed to implement the requirements needed to achieve the Project objectives.

B. Job Site activities are permitted to begin only after acceptance of the QC Plan or acceptance of an interim plan applicable to the phase or feature of the Work to be started.

C. Work outside of the accepted interim plan is not be permitted to begin until acceptance of a QC Plan or another interim plan containing the additional Work.

D. Content of the QC Plan: Include, as a minimum, the following to cover all operations, including Work by Subcontractors, fabricators, suppliers, and purchasing agents, designers of record, consultants:

1. A description of the QC organization including a chart showing lines of authority and acknowledgment that the QC staff implements the control system for all aspects of the Work specified.

2. Include a QC manager who reports to the Contractor's foreman/project superintendent.

3. The name, qualifications (in resume format), duties, responsibilities, and authorities of each person assigned a QC function.

4. Procedures for scheduling, reviewing, certifying, and managing submittals, including those of Subcontractors, offsite fabricators, suppliers, and purchasing agents, designers of record, consultants, architects, and engineers. Submittal procedures must be in accordance with Technical Specification Section 01 33 00 - Submittal Procedures.

5. Reporting procedures, including proposed reporting formats.

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E. Acceptance of the QC Plan: Acceptance of the Contractor's QC Plan is required prior to the start of the Work. The Owner and Owner's Designated Representative reserve the right to require the Contractor to make changes to the Contractor's QC Plan and operations including removal of personnel, as necessary, to obtain the quality specified.

F. Notification of Changes: After acceptance of the QC Plan, notify the Owner and Owner's Designated Representative in writing of any proposed change(s). Proposed changes are subject to acceptance by the Owner and Owner's Designated Representative.

3.3 QUALITY CONTROL ORGANIZATION

A. Personnel Requirements:

1. The requirements for the QC organization are at the discretion of the Contractor as long as the Contractor demonstrates enough manpower is dedicated to the QC process and that a single point of contact at the Job Site is designated as having the responsibility as the QC manager.

2. The Contractor's QC staff must maintain a presence at the Job Site during progress of the Work and have complete authority and responsibility to take any action necessary to ensure compliance with the Agreement.

3. The QC staff is subject to acceptance by the Owner and Owner's Designated Representative.

4. Provide adequate office space, filing systems and other resources as necessary to maintain an effective and fully functional QC staff.

5. Promptly complete and furnish all letters, material submittals, schedules and all other project documentation to the QC staff.

6. Maintenance of documents and records at the Job Site is the responsibility of the QC staff, except as otherwise acceptable to the Owner and Owner's Designated Representative.

B. QC Manager:

1. Identify, as the QC manager, an individual within the onsite Work organization who is responsible for overall management of QC and has the authority to act in all QC matters for the Contractor.

2. The QC manager must be a construction person with a minimum of 10 (ten) years in related Work.

3. The QC manager must be on the Job Site during construction and be employed by the Contractor.

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4. The QC manager can have duties as Project foreman/superintendent in addition to quality control.

5. Identify in the QC Plan an alternate to serve in the event of the QC manager's absence.

    a. The requirements for the alternate are the same as the QC manager.

C. QC Personnel:

1. In addition to QC personnel specified elsewhere in the Agreement, provide as part of the QC staff, specialized personnel to assist the QC manager for the following areas: civil and environmental.

    a. These individuals are employees of either the Contractor or a Subcontractor.

    b. Are responsible to the QC manager.

    c. Are physically present at the Job Site during performance of Work on their areas of responsibility.

    d. Have the necessary education and/or experience in accordance with the experience matrix presented herein.

2. These individuals can perform other duties but must be allowed sufficient time to perform their assigned QC duties, as described in the QC Plan.

3. A single person can cover more than one area provided the person is qualified to perform QC activities in each designated area and that workload allows.

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Experience Matrix

Area	Qualifications
Civil	Construction manager with a minimum of two (2) years of experience in the type of Work being performed on this project or a technician with five (5) years related experience.
Environmental	Environmental Technician with a minimum of five (5) years of experience in the type of Work being performed on this project.
Steel Fabrication	Steel foreman with a minimum of five (5) years of experience in the type of Work being performed on this project.

D. QC Organizational Changes:

1. Maintain the QC staff at full strength throughout the performance of Work on the Project. If changes to the QC staff becomes necessary, revise the QC Plan to reflect the changes and submit the changes to the Owner and Owner's Designated Representative for acceptance.

3.4 QUALITY CONTROL

A. Quality Control (QC) is the means the Contractor ensures that the scope of Work, including that of Subcontractors, complies with the requirements of the Agreement. At least three phases of control must be conducted by the QC manager for each definable Work phase as follows:

1. Preparatory Phase: This phase is performed prior to beginning Work on each definable phase; after all the required plans/documents/materials are approved/ accepted, and after copies of the plans/documents/materials are at the Job Site.

2. Initial Phase: This phase is accomplished at the beginning of a Work phase. Establish that all necessary permits, equipment, materials and trained staff are prepared for the coming Work phase.

3. Follow-up Phase: Perform daily checks to assure control activities, including control testing, are providing continued compliance with the Agreement requirements, until completion of the Work phase. Record the checks in the field reports and/or QC documentation.

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3.5 COORDINATION MEETING

A. Prior to the start of the Work, and prior to acceptance by the Owner and Owner's Designated Representative of the QC Plan, meet with the Owner and Owner's Designated Representative and discuss the Contractor's quality control system.

B. Schedule additional meetings by either the Owner or the Contractor to reconfirm mutual understandings and/or address deficiencies in the QC system or procedures which may require corrective action by the Contractor.

3.6 PROJECT COMPLETION INSPECTION

A. Final Acceptance Inspection:

1. Attendees: The Owner, the Owner's Designated Representative, the Contractor, the Contractor's foreman/ superintendent, the Contractor's QC manager and inspection personnel, and other primary management personnel deemed appropriate by either the Owner or the Contractor.

2. Additional Owner personnel can also be in attendance.

3. The final acceptance inspection is formally scheduled by the Owner and Owner's Designated Representative.

3.7 DOCUMENTATION

A. Maintain current records providing factual evidence that required QC activities and/or tests have been performed. Include in the documentation Work of Subcontractor(s) on an acceptable form that includes, as a minimum, the following information:

1. Contractor/Subcontractor and their area of responsibility.

2. Work performed each day, giving location, description, and by whom.

3. Test and/or control activities performed with results. List of deficiencies noted, along with corrective action(s) taken.

4. Quantity of materials received at the Job Site with a statement as to acceptability, storage, and reference to Technical Specification(s)/drawing(s) requirements.

5. Submittals and deliverables reviewed and action taken.

6. Job safety evaluations stating what was checked, results, and instructions or corrective actions.

7. Instructions given/received and conflicts in the Technical Specifications.

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3.8 NOTIFICATION OF NONCOMPLIANCE

A. Any detected noncompliance with the foregoing requirements provided to the Contractor by the Owner and/or Owner's Designated Representative. Take immediate corrective action after receipt of such notice. Such notice, when delivered to the Contractor at the Job Site, is deemed sufficient for notification. If the Contractor fails or refuses to comply promptly, the Owner and/or Owner's Designated Representative can issue an order stopping all or part of the Work until satisfactory corrective action has been taken.

END OF SECTION

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SECTION 01 74 19

CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Procurement and Construction Agreement (the Agreement) and Division 01 Technical Specifications, apply to this Technical Specification.

1.2 SUMMARY

A. This Section includes administrative and procedural requirements for the following:

1. Scope of Work.
2. Definitions.
3. Quality Assurance.
4. Project Conditions.
5. Submittals.
6. Debris Management Plan.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01 10 00– Summary of Work.

B. Section 01 35 63.13 – Sustainability Requirements.

C. Section 01 50 00 – Temporary Facilities and Controls.

D. Section 02 41 19 – Selective Site Demolition.

E. Section 31 10 00 – Clearing and Grubbing.

F. Section 31 20 00 – Earthwork.

G. Section 31 21 40 – Dewatering- Upland.

H. Section 31 23 23 – Subaqueous Capping.

I. Section 31 25 00 – Erosion and Sedimentation Control.

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J. Section 31 41 16 – Steel Sheet Piling and Sealing.

K. Section 32 92 19 – Seeding.

1.4 SCOPE OF WORK

A. Work includes the following:

1. Management, characterization, processing, transportation, and off-site disposal of construction waste including, but not limited to, contaminated and non-contaminated unused/excess materials/scrap/waste, demolition debris and, if encountered during the performance of the subgrade preparation work, drums and drum contents, piping, or other materials identified by the Owner's Designated Representative.

1.5 DEFINITIONS

A. Construction Waste: Materials resulting from the selective site demolition operations and the performance of remedial construction, that will not be incorporated into the Work and requires off-site disposal.

B. Disposal: Off-site removal and disposal at a licensed facility permitted to accept the construction waste, acceptable to the Owner.

C. Bulky Waste: Material resulting from waste consolidation and relocation that is larger than one-foot in least dimension and unsuitable for use in the consolidation area as determined by the Owner's Designated Representative. Drums, containers, tires, metal debris, equipment, etc. shall be classified as Bulky Wastes, as approved by the Engineer.

D. Hazardous Waste: Hazardous materials, as defined by current applicable regulations. The ECI Facility is identified as a Large Quantity Generator and operates under the USEPA Identification Number IND082547803 and complies with the 2018 AOC. All storage, shipments and disposal will in accordance with Atlantic Richfield Company requirements.

E. Non-Hazardous Waste: Non-hazardous materials, as defined by current applicable regulations. All storage, shipments and disposal will in accordance with Atlantic Richfield Company requirements.

1.6 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with transportation and disposal regulations of authorities having jurisdiction and Atlantic Richfield Company.

B. Pre-Construction Conference: Conduct conference at the Site to comply with requirements in Technical Specification 01 10 00 – Summary of Work. Review methods and procedures related to construction waste management.

C. PROJECT CONDITIONS

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A. Minimize interference with adjoining roads and other adjacent occupied or used facilities during performance of earthwork activities associated with Technical Specifications.

B. Do not close or obstruct streets or other adjacent occupied or used facilities without advanced permission from the Owner, Atlantic Richfield and authorities having jurisdiction.

C. Provide alternate routes around closed or obstructed traffic ways, if required by Owner and authorities having jurisdiction.

D. Do not commence demolition or earth disturbing activities until erosion and sedimentation control measures are in place and site clearing activities for the designated selective site demolition area(s) have been completed.

1.7 SUBMITTALS

A. General: Submit each item in this Section according to the Conditions of the Contract and Technical Specification 01 33 00 - Submittal Procedures.

B. If necessary, submit Construction/Bulky Waste Management Plan.

C. For offsite disposal, submit copies of the following to the Owner and Owner's Designated Representative at least ten (10) Business Days prior to initiating off site transportation and disposal of debris:

1. Transporting Company:

   a. Name, address, and telephone number

   b. State of Indiana Transporter I.D. No.

   c. EPA Transporter I.D. No.

2. Disposal Facility:

   a. Name, address, and telephone number

   b. Current IDEM Operating Permit No.

D. For offsite waste disposal, obtain the required waste classification analytical test results, permits and/or authorizations for transportation and disposal of waste in accordance with all local, municipal, state, and federal rules and regulations.

E. For offsite waste disposal, prepare and sign all profiles, manifests, and disposal applications prior to transportation of waste to the off-site disposal facility. Obtain Owner's Agent signature on all manifests.

1. Submit copies of detailed and legible delivery tickets, weigh tickets, receipts, invoices, and/or manifests signed by the off-site disposal facility, acknowledging

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the Contractor's deliveries of the waste to the Owner and Owner's Designated Representative within three (3) days of the date of off-site disposal. Include the volume, method of disposal, and final location of waste materials on all disposal documentation.

1.8 CONSTRUCTION/BULKY WASTE MANAGEMENT PLAN

A. General: Develop a plan for the proper handling, management and off-site disposal of construction/bulky waste materials resulting from the performance of Work.

B. Waste Identification: Indicate anticipated types and quantities of waste generated by the Work. Include estimated quantities and assumptions for estimates.

C. List each type of waste. Include points of waste generation, total quantity of each type of waste, and handling, management, containerization, and transportation procedures.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION

3.1 PLAN IMPLEMENTATION

A. General: Implement the Construction/Bulky Waste Management Plan as approved by the Owner and Owner's Designated Representative.

B. Comply with Technical Specification 01 10 00 – Summary of Work.

C. Job Site Access and Temporary Controls: Conduct waste management operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.

3.2 TRANSPORTATION OF WASTE

A. Use or subcontract the use of trucks and/or roll-off boxes that can be covered during transit. Trucks and/or roll-off boxes remain covered and secured at all times in accordance with all federal, state and local regulations while traveling between the Job Site and the off-site disposal/recycling facility.

B. Loading the trucks and/or roll-off boxes in such a manner that the weight does not exceed State and local weight limits and restrictions is the responsibility of the Contractor.

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C. Providing the proper paperwork for the material being disposed is the responsibility of the Contractor. Making sure the truck drivers have the proper paperwork for each load before the truck leaves the Site is the responsibility of the Contractor.

D. Take measures required to prevent all trucks transporting waste for off-site disposal from tracking soil, dirt, mud, trash, debris, waste, etc. on the tires or undercarriage of the vehicle from the Site.

3.3 DISPOSAL OF CONSTRUCTION WASTE

A. General: Remove construction waste materials from the Job Site and legally dispose the waste in an off-site disposal facility licensed and permitted to accept the waste and approved by the Owner.

1. Except as otherwise specified, do not allow waste materials that are to be disposed or accumulate on the Site.

B. For off-site disposal facilities, provide a full description of the off-site disposal facility, licenses, permits, and compliance status prior to completing final off-site disposal arrangements. Upon request, provide all appropriate permits and licenses for review by the Owner and Owner's Designated Representative. If necessary, on-site observations may be requested to verify adequacy and compliance status. Base final selection of an off-site disposal facility on environmental compliance status, transportation/treatment/disposal and availability and Owner approval.

C. For offsite disposal, prepare and submit profiles, transportation and disposal manifests, bills of lading, land ban notices and all other documents required for debris shipment to the Owner and Owner's Designated Representative for approval prior to transportation and off-site disposal of each load of waste material.

D. For offsite disposal, provide an acceptance letter from the receiving off-site disposal facility prior to the transportation of the waste material. Provide copies of the letter to the Owner and Owner's Designated Representative for review and inclusion in the Project records.

E. For offsite disposal, provide to the Owner and Owner's Designated Representative a weigh ticket or other form of documentation of the amount of waste material accepted by the off-site disposal facility for each load of waste material removed from the Job Site.

F. For offsite disposal, the Contractor is responsible for the handling, management, and processing of debris to meet the disposal facility's waste acceptance criteria.

END OF SECTION

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SECTION 02 61 13

EXCAVATION AND HANDLING OF CONTAMINATED MATERIALS

PART 1 GENERAL

1.1 DESCRIPTION

A. The ECI is a former refinery and petroleum storage facility. The refinery was dismantled and demolished between 1985 and 1990. The main refinery portion of the Site was converted into a United States Army Corps of Engineers (USACE) Confined Disposal Facility (CDF) in 2009. Remedial measures implemented at the CDF have mitigated potential oil migration from the CDF into the adjacent Lake George Canal (Canal). The STF and WTF formerly stored bulk petroleum products. Light non-aqueous phase liquid (LNAPL) has been identified on the STF and WTF parcels. An LNAPL recovery well system exists at the STF and WTF, with less than about 10 gallons per year recovered over the past few years at the STF and none at the WTF. Remedial action objective is to prevent LNAPL/sheen migration from hydrocarbon- impacted zone (elevation of approximately 583 feet to 575 feet) in the upland area across the canal/upland area boundary. Additional characterization data is presented in the ECI Site Investigation Report from 2002 prepared by Arcadis and can be provided upon request.

1. Work will include excavating for sheet pile pre-trenching, tie-back installation and bank control installation by relocating, with minimal disposal.

2. Items will be added as design develops.

B. During performance of the Work, contaminated soils and debris will likely be encountered. Contaminated groundwater may also be encountered.

C. The Contractor shall furnish all labor, materials, equipment, services, and incidentals required to properly remove, handle, manage and consolidate onsite any contaminated soils and sediments within the limits of work. A Construction Water Management Plan (CWMP) including proposed methods of handling, managing, transporting, treating, and disposing of construction water as required in Section 31 21 40 – Dewatering – Upland.

D. All aspects of the Work shall be conducted in accordance with the requirements of the Contractor prepared Health and Safety Plan (HASP).

E. The Contractor shall develop, implement, maintain, supervise, and be responsible for a Spill and Discharge Control Plan. This plan shall be submitted to the Owner and Owner's Designated Representative for approval prior to mobilization to the Site and shall provide contingency measures for potential spills and discharges from all activities.

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F. The Contractor shall provide equipment and personnel to perform emergency measures required to contain any spills or waste discharges as outlined in the Spill and Discharge Control Plan.

G. The Contractor shall provide equipment and personnel to perform decontamination measures that may be required to remove residues on equipment or material used to exhume, handle, and consolidate contaminated materials. Decontamination residues shall be properly disposed of.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01 10 00 - Summary of Work

B. Section 01 33 00 - Submittal Procedures

C. Section 01 74 19 – Construction Waste Management and Disposal

D. Section 31 20 00 - Earthwork

E. Section 31 21 40 – Dewatering – Upland

1.3 REFERENCES

A. The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1. Occupational Safety and Health Administration (OSHA)

   29 CFR 1910 - Occupational Safety and Health Standards

   29 CFR 1926 - Safety & Health Regulations for Construction

2. U.S. Environmental Protection Agency

   40 CFR 261 -Identification and Listing of Hazardous Wastes

3. Remediation Management Policy, Control of Work, Latest Revision, BPRM Control of Work

1.4 SUBMITTALS

A. Prior to mobilization to the Site, the Contractor shall develop and submit for approval a Contaminated Materials Handling Plan and include as a component of the Construction Work Plan described in Section 01 10 00 - Summary of Work. As a minimum, this plan shall include the following provisions.

1. Description of work teams and the function of members of work teams involved in contaminated waste excavation and consolidation.

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2. Air monitoring during handling (excavation, relocation and disturbance) of Site soils and sediments, as directed by the Owner's Designated Representative.

3. Equipment used during handling of Site soils/sediments, with particular reference to how the equipment will limit damage to surrounding areas.

4. Spill and Discharge Control Plan to describe procedures to control and contain spilled liquids if encountered.

5. Procedures for turbidity controls; as needed.

6 Procedures for water handling and management.

B. Submit to the Owner's Designated Representative for approval the following manufacturer's data for products in accordance with Section 01 33 00 - Submittal Procedures:

1. Materials such as repack drums, overpack drums, and bulk containers, if necessary, and as selected by Contractor for the purpose intended and subject to Owner's Designated Representative's approval prior to use.

C. Prepare and submit a Traffic Control Plan, an Off-Site Transportation Plan, and an On-Site Transportation Plan as necessary

E. Provide copies of RCRA and/or permitting DOT training certifications for all waste haulers, if necessary.

F. Submit technical data for the proposed truck liner material and installation procedures; if necessary.

G. Shipping and Disposal Documents, including the following:

1. Complete copies of waste profiles

2. Completed copies of shipping and disposal documents, including a copy of each waste manifest or bill of lading form signed by the transporter prior to leaving Site and copy of each form signed by Disposal Facility accepting the shipment.

H. All Weight Scale Documents .

1.5 DEFINITIONS

A. Contaminated material: Contaminated material shall be defined as material which may contain USEPA Hazardous Substance List (HSL) compounds. All materials may be considered potentially contaminated, unless otherwise determined to be non-contaminated through analytical testing, as approved by the Owner's Designated Representative.

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PART 2 - PRODUCTS

2.1 MATERIALS

A. The Contractor shall provide for removal and consolidation of contaminated materials and control of any spills or discharges through provision of the following minimum equipment and materials to be kept on-site at all times during Site work activities.

1. Clean fill or other noncombustible absorbent.

2. Appropriate handling equipment.

3. Hand tools.

PART 3 - EXECUTION

3.1 GENERAL

A. Transportation and Disposal Coordinator (TDC). Subcontractor shall designate, by position and title, one person to act as the Transportation and Disposal Coordinator for this contract; as necessary.

B. Notify Engineer of TDC examination of waste transportation vehicles and containers sufficiently in advance on transportation activities.

C. Engineer shall perform sampling and / or analysis to confirm waste profile sampling and analysis as needed.

D. ECI approved bulk industrial non-hazardous waste landfill (TBD):

E. ECI approved hazardous waste Disposal Facility (TBD):

3.1.2 HAUL ROADS

A. Subcontractor shall construct and maintain temporary haul roads on site from the site entrance to the locations of excavation and potential stockpiles. Haul roads shall be maintained to permit efficient travel of fully loaded trucks. Subcontractor shall provide traffic control.

3.1.3 COORDINATING WASTE SHIPMENTS

A. ECI will obtain letters of commitment from the Disposal Facility agreeing to handle and dispose wastes.

3.1.4 SHIPPING DOCUMENTS AND PACKAGING CERTIFICATION

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A. Subcontractor shall be responsible for obtaining all permits and shipping documents (from the Disposal Facility or regulatory authorities) to ship wastes off site, either within the USA or outside of the USA.

B. Subcontractor shall use manifests for transporting wastes as required by 40 CFR 263. Transportation shall comply with all requirements in the Department of Transportation referenced regulations in the 49 CFR series. Subcontractor shall prepare manifests in accordance with the hierarchy established in 40 CFR 262, Section 21.

C. Subcontractor shall prepare waste manifests for each shipment of waste shipped off site; as necessary. Manifests shall be completed using instructions in 40 CFR 262, Subpart B and any applicable state or local law or regulation. Manifests and waste profiles shall be submitted to ARC for review and approval. Subcontractor shall prepare land disposal restriction notifications as required by 40 CFR 268 or any applicable state or local law or regulation for each shipment of waste. Notifications shall be submitted with the manifest to ARC for review and approval.

D. Subcontractor shall verify that each truck and-or container complies with applicable permitting.

3.1.5 LOADING TRUCKS

A. Waste shall be loaded into trucks or containers within the exclusion area. Where required, trucks shall be supplied with liners.

D. Each truck shall have a proper manifest and placard prior to leaving the site.

E. Each truck entering and exiting the site shall be recorded.

3.1.7 HAULING BY TRUCK

3.2 CONTAMINANTS REMOVAL

A. Contaminated soils will be encountered at the Site. All work shall be performed in the presence of both the Owner's Designated Representative and the Contractor's Health and Safety Officer and in accordance with Section 31 20 00 - Earthwork.

B. Contaminated soils/debris/waste will be identified prior/during excavation and consolidated at the Site. All work shall be performed in the presence of both the Owner's Designated Representative and the Contractor's Health and Safety Officer and in accordance with Section 31 20 00 - Earthwork.

C. The Contractor will properly manage, handle, prepare for shipment, test and transport and dispose of in accordance with all applicable regulations and disposal facility requirements all drums containers and remnants of hazardous waste encountered during the Work.

3.3 DEWATERING

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A. The Contractor shall construct temporary berms, swales and other facilities required to prevent surface water, groundwater, surface waters and liquids from entering or leaving the area of excavation where waste can contact such liquids in accordance with Section 31 21 40 – Dewatering - Upland.

B. The Contractor shall provide and maintain proper and satisfactory means and devices for the removal of water, which may enter the excavation in accordance with Section 31 21 40 – Dewatering - Upland.

C. The Contractor shall handle all liquids encountered during excavation in accordance with the requirements of Section 31 21 40 – Dewatering - Upland.

3.4 STAGING AND WASTE CONSOLIDATION

A. The project shall adhere to the following procedures.

1. Staging Area - The Contractor shall establish an on-site staging area to accommodate clean and contaminated soil storage areas as required. Storage of contaminated material outside the approved staging areas is prohibited.

2. Waste Materials - As waste materials are excavated, the Contractor shall transport, place, and consolidate the waste onsite.

3. Handling and Transport Equipment

4. All handling, moving, and transport of contaminated soils shall only be by use of mechanical equipment. All equipment shall be Site dedicated until the completion of the Work unless approval is received from the Owner's Designated Representative for removal from the project Site.

3.5 ON-SITE STORAGE

A. The Contractor shall maintain the on-site staging area for the duration of the work and shall protect and maintain soil and material storage from the elements, surface runoff, damage, or any related conditions in order to prevent spills or discharges.

3.6 OFF-SITE TRANSPORTION AND DISPOSAL

A. Subcontractor shall supply, operate, and maintain transport vehicles and containers used to transport and/or contain all waste generated during the execution of the work.

B. Subcontractor shall be responsible for coordinating waste transportation with the Owner's disposal facilities that are under separate contract to ECI. Coordination tasks include scheduling waste deliveries with Disposal Facility to ensure the arrival and departure of trucks.

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C. Subcontractor shall prepare transport vehicles and containers for off-site transportation. Transportation preparation includes, but is not limited to the following:

1. Load and secure waste materials in transport vehicles/containers

2. Prepare shipping documents including waste profiles, manifests, and bill of lading.

3. Ensure all waste generated during the work is properly characterized, has an approved profile with Disposal Facility, and is approved by Disposal Facility prior to transporting waste offsite.

4. Provide temporary on-site haul roads for trucks as necessary.

5. Control and coordinate traffic on site.

D. Transport the following materials from Site to approved Disposal Facility:

1. Non-hazardous soils and debris

E. Maintain transportation records and obtain Disposal Facility documentation for all waste transported off site.

F. Spill Prevention and Response: The Contractor shall conduct handling and transport of waste in a controlled and safe manner which will minimize damage to the environment.

END OF SECTION

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SECTION 02 72 00

WATER TREATMENT

PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. Subcontractor may procure, setup, operate, and maintain a temporary water treatment system to treat and discharge water collected/generated during the performance of contract work; if deemed necessary and will be determined in future design documents. Water that may be treated includes, but is not limited to the following:

1. Water that accumulates in open excavations, including:

    a. Groundwater infiltration into fill areas behind the bulkhead on the STF dredge/excavation.

    b. Groundwater infiltration into deadman pile alignment during obstruction removal and into tieback excavations.

    c. Storm water runoff or surface water entering into excavations.

2. Storm water or surface water that that comes in contact with disturbed or non-vegetated native site soils. Water used to decontaminate equipment that is accumulated throughout the project (no volume estimate).

3. Water used for dust control that contacts exposed native soil.

END OF SECTION

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SECTION 31 21 40

DEWATERING - UPLAND

PART 1 GENERAL

1.1 DESCRIPTION

A. As required, furnish, operate, and maintain dewatering measures and/or equipment for the control, collection, and disposal of ground, canal surge and surface water entering trenches, excavations, and proposed fill/backfill areas. The objective is to maintain water levels at a level that allows for placement and compaction of the backfill in adequately stable conditions.

B. TBD: Water from dewatering activities shall be classified as construction dewatering waste water. Water may not be discharged without treatment to any surface draining ways/water bodies. Discharge may also not occur to any storm drain system. Discharge may be allowed proximal to the dewatering location, provided no grossly impacted fluids (i.e., containing visible free-product) are observed, as approved by the Owner's Designated Representative.

C. The Contractor shall furnish all labor, equipment, and materials necessary for the control and collection of ground, tidal and surface water. Work includes, but is not limited to, the following:

1. Design dewatering sump and pumping system required to perform the work;

2. Furnishing, operating, and maintaining dewatering, storage and treatment equipment; and

3. Removal of temporary works.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01 10 00 – Summary of Work

B. Section 01 33 00 - Submittal Procedures

C. Section 01 74 19 – Construction Waste Management and Disposal

D. Section 02 61 13 – Excavation and Handling of Contaminated Materials

E. Section 31 20 00 - Earthwork

F. Section 31 25 00 - Erosion and Sedimentation Control

1.3 SUBMITTALS

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A. Submit a description of the proposed dewatering, containment and treatment method(s) which are to be utilized in a Construction Water Management Plan (CWMP) as part of the Project Execution Plan (PEP) specified in Section 01 10 00 – Summary of Work, to the Owner's Designated Representative for review.

PART 2 PRODUCTS

2.1 GENERAL

A. Provide, operate, and maintain a dewatering system to remove water from excavations, trenches, and sumps, using pumps, drains, well points, piping, and any other facilities necessary to keep the excavations and trenches free of water, as required by these Specifications (TBD) and the Owner's Designated Representative. Have spare units available for immediate use in the event of equipment breakdowns.

PART 3 - EXECUTION

3.1 PERFORMANCE

A. Perform dewatering work when necessary to keep excavations dry and/or to provide for stability of excavations, including but not limited to the stability of excavation sidewalls and tiebacks; the stability of excavation sheeting, shoring, and/or bracing; the stability of the excavation bottom relative to pumping, heaving, boiling, and/or rutting; and the stability of embankment slopes including surface water. For excavation of deadman, works needs to maintain stable conditions that subgrade is not softened, and the use of stone as backfill can be implemented, rather than compaction.

B. Perform excavations for during low water level conditions to minimize inflow. Contractor needs to accommodate the expected changes in canal water levels similar to and potentially greater than historical data indicates (USGS Gaging Station #04092750).

C. Limit the size and rate at which excavations progress to prevent quick conditions, sloughing or subgrade degradation.

D. Excavations shall be dewatered as backfill is placed, to prevent overtopping and discharge to wetlands and/or surface water bodies.

E. Open inactive excavations may be allowed to temporarily collect water if given the type of soils and groundwater and canal water level condition, the excavation sidewalls and base remain stable.

F. Open and inactive excavations that are deemed unstable due to groundwater or surface water inflow shall be stabilized prior to backfilling. Additional dewatering effort or re-work associated with temporary backfill shall be considered incidental work.

Draft

G. Mechanically retard and control the rate of run-on to and/or runoff from excavations. This includes construction of diversion ditches, benches, and berms to retard and divert run-on away from the area of work and runoff to protected drainage courses. Stormwater from the site shall be diverted, to the extent practicable, to minimize infiltration into open excavations and to avoid contact with contaminated materials.

H. Discharge of Water:

1. Water shall be discharged to the ground surface of a topographical depression for infiltration within the limits of ECI, proximal to the dewatering location and shall conform to the requirements of the applicable permits. The Owner may obtain the permit for discharge of dewatering water from IDEM; if necessary - TBD.

2. The Contractor shall be responsible for complying with the discharge permit.

I. Damage:

1. All damage resulting from the dewatering operations or the failure of the Contractor to maintain the Work in a suitably stable condition shall be repaired by the Contractor, at no additional cost to the Owner.

2. Take all necessary precautions to protect new work from damage due to flooding or from other causes.

J. Diversion Berms:

1. Design, construct, maintain, and remove diversion berms where necessary for diverting runoff away from open excavations and trenches to minimize the generation of liquid wastes.

2. Design and construct diversion berms to withstand all imposed loads to prevent injury to adjacent structures or property.

K. Temporary Under Drains:

1. When necessary, lay temporary under drains in the excavation.

2. Excavate trenches to suitable dimensions to provide space for the under drains and surrounding gravel.

L. Cofferdams:

1. When necessary, design, construct, maintain, and remove cofferdams where necessary for the dewatering, control, and diversion of water to keep excavations and trenches free of water.

2. Construct cofferdams to depths to permit a reasonable change in depths of the work, of sufficient height to prevent flooding, and of such dimensions to give sufficient clearance for construction and inspection.

Draft

3. As necessary, remove cofferdams after the completion of permanent construction.

M. Well Points:

1. When necessary to prevent softening of subgrade, dewater the excavations via a well point system.

2. Use well points designed for dewatering work.

3. Use pumping units designed to be used with well points, capable of maintaining high vacuums, and capable of handling large volumes of air and water at the same time.

3.2 DEWATERING THE CONSTRUCTION SITE

A. Dewater trenches and other parts of the construction Site and keep free of standing water or excessively muddy conditions as needed for proper execution of the construction Work.

B. Furnish, install, operate, and maintain all drains, sumps, pumps, and other equipment needed to perform the dewatering as required.

C. Dewatering methods that cause softening of subgrade will not be permitted.

D. Discharge of water pumped from excavations shall be limited to the ground surface and infiltration within the ECI footprint. Direct discharge, without proper analysis and/or treatment, to storm drain systems, sewer systems is not allowed.

3.3 REMOVAL OF TEMPORARY WORKS

A. After the temporary works have served their purposes, remove them or level and grade them to the extent required to present a slightly appearance and to prevent any obstruction of the flow of water or any other interference with the operation of or access to the permanent works.

B. Except as otherwise specified, remove any temporary under drain pipes.

END OF SECTION

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SECTION 31 41 16

STEEL SHEET PILING AND SEALING

PART 1 GENERAL

1.1 DESCRIPTION

A. A fully penetrating steel sheet pile wall with welded/sealed joints will be installed along the Lake George Canal at the South Tank Farm (STF) and will be further discussed in subsequent design documents. The permanent sheet pile is planned to be installed to provide permanent riverbank stabilization to prevent oil migration; and support sediment excavation and dredging (not in this contract).

B. Based on available information, the permanent sheet pile wall will be continuous along the canal front at the STF and will include hydrophilic joint seal to be applied from elevation 578 ft (above ground surface) to approximately 5 feet below the top of clay (approximately El. 550 ft.) - TBD. Wing walls will be included at the terminal ends of the walls.

C. Purchase, fabrication, delivery of the sheet piles for the permanent sheet pile, angle and base plate for future grouting of interlocks, fabricated corners, and sheet pile stiffener plates will be provided by TBD.

D. The permanent sheet pile wall shall be installed to the plan limits and depths depicted on the Drawings.

E. Work for this item includes but is not limited to the following items:

1. Coordination with the Engineer for sheet pile deliveries.
2. Unloading and proper storage of sheet pile as specified.
3. Installation of permanent steel sheet pile wall.
4. Non-destructive testing of all welds.
5. Protection of portions of sheeting to be left extended above grade.
6. Performing specified quality control.
7. Surveying completed sheet wall alignment and elevation.
8. Non-destructive testing of all welds in accordance with ASTM E 1742 (12) - TBD.

1.2 PERFORMANCE REQUIREMENTS

A. The permanent sheet pile wall shall be extended to the depths indicated on the Drawings and to the tolerances indicated in Part 3 of this section.

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B. The sheet pile deadmen shall be extended to the depths indicated on the Drawings and to the tolerances indicated in Part 3 of this section.

C. The steel angles shall be extended to the elevations indicated on the Drawings and as indicated in Paragraph 1.01.E of this section.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01 10 00: Summary of Work

B. Section 01 33 00: Submittal Procedures

C. Section 01 50 00: Temporary Facilities and Controls

D. Section 01 74 19: Construction Waste Management and Disposal

E. Section 02 41 19: Selective Site Demolition

F. Section 02 61 13 Excavation and Handling of Contaminated Materials

G. Section 31 20 00: Earthwork

H. Section 31 21 40: Dewatering - Upland

I. Section 31 25 00: Erosion and Sedimentation Control

1.4 SUBMITTALS

Submit the following in accordance with Section 01 33 00, "Submittal Procedures".

A. Construction Work Plan

1. The Subcontractor shall submit a construction work plan for approval by the Engineer after receipt of Notice of Award. The work plan shall include at a minimum the following items:

    a. Methods of permanent sheet pile wall and deadman construction.

    b. Equipment:

        1) A list of major equipment by type and capacity.

    c. The plan shall include description of the following:

        1) Quality control testing and sampling equipment.

        2) Quality control testing and sampling methods.

        3) The plan shall include minimum standards with which to gauge the quality of the work during construction.

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d. The plan shall address the physical properties and manufacturer's stated properties for all permanent materials, including manufacturer's certifications of quality, mill certificates, and gradation test data (if required).

e. The plan shall state the correction procedures which will be employed in the case of substandard results.

B. Vibration Monitoring Plan

1.If necessary the Subcontractor shall submit a Vibration Monitoring Plan for approval by the Engineer after receipt of Notice of Award. The plan shall include at a minimum the following items:

a. Methods of permanent sheet pile wall and deadman construction.

b. Equipment:

1) A list of major equipment by type and capacity.

c. The plan shall include description of the following:

1) Method and locations of vertical settlement and deflection monitoring of structures adjacent to the pile driving work.

2) Method and locations of vibration monitors to characterize peak particle velocities, frequencies, and amplitudes to mitigate damage to structures.

d. The plan shall state the correction procedures which will be employed in the case of impacts from driving of sheets.

C. Product Data: For each type of product indicated.

D. Shop Drawings

1. Show fabrication of structural-steel components. Include details of cuts, connections, splices, camber, holes, and other pertinent data. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld. Indicate type, size, and length of bolts, distinguishing between shop and field bolts. Identify pre-tensioned and slip-critical high-strength bolted connections.

E. Mill Test Reports: Signed by manufacturers certifying that the following products comply with requirements:

1. Structural steel, including all plates, and shall include chemical and physical properties.

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2. Tieback anchors, bolts, nuts, and washers including mechanical properties and chemical analysis.

3. Direct-tension indicators.

4. Tension-control, high-strength bolt-nut-washer assemblies.

5. Shop primers.

F. Qualifications

1. The installation of the permanent sheet pile wall shall be carried out by a qualified Subcontractor experienced in sheet pile wall installation. A qualified Subcontractor is defined as having at least 15 years direct experience. A qualified Subcontractor shall have self-performed not less than five projects of similar scope. The Subcontractor will be required to submit evidence that competent personnel are available to carry out the operations specified, that such personnel will be assigned to this project, and that such personnel will have previous experience with sheet pile installation. Documentation of work experience shall be provided by the Subcontractor with the bid.

2. Welding (Shop and Field): Qualification for welding procedures, welders, and operators shall comply with requirements of AWS D1.1. Subcontractor shall keep records of test results of welding procedures and submit copies of each qualified welding operator to Engineer for approval before starting welding.

G. A construction specialist provided by the Subcontractor, and approved by the Engineer, having experience with sheet pile wall construction shall be used to supervise construction and quality control. The specialist shall be at the site of operation at all times that the installation is in process. The knowledge and experience of the specialist should include, but not necessarily be limited to:

1. Construction equipment, materials, testing, and quality control as required for sheet pile wall construction.

I. Driving Records:

1. Submit copies of the driving records, including the results of the on-board/real-time rate of penetration monitoring system, of each sheet pile to the Engineer. Include the project name and number, name of Subcontractor, pile location and number, type and size of hammer used, type of pile driving cap used, rate of operation of sheet pile driving equipment, sheet pile dimensions, elevation of point, elevation of butt before and after cutoff, ground elevation, continuous record of number of blows, or rate of penetration, for each foot of penetration if appropriate, verticality measurements or pile deviation, adjacent sheet pile uplift and reaction, and any unusual occurrences during sheet pile driving.

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J. Non-destructive weld test results.

K. Post-construction report.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Steel Sheet pile. Steel sheet piles may include the following and will be further defined in subsequent design documents:

1. JD Fields ZZ36-700, ASTM A 572 Gr. 60 (permanent sheet pile wall).

2. JD Fields ZZ50-700, ASTM A 572 Gr. 65 (permanent sheet pile wall).

3. JD Fields ZZ19-700, ASTM A 572 Gr. 60 (deadmen).

4. JD Fields ZZ38-700, ASTM A 572 Gr. 60 (deadmen).

5. JD Fields ZZ36-700, ASTM A 572 Gr. 60 (sheet pile deadmen).

6. JD Fields ZZ40-700, ASTM A 572 Gr. 60 (deadman).

7. Steel sheet piles for permanent sheet pile wall shall be provided in full length welded pairs. Sheet pile for deadmen shall not be provided in welded pairs.

8. All manufactured materials shall be new.

B. Sheet piles along the Lake George Canal waterfront shall be welded pairs with steel angles attached as shown on the drawings at interlocks that are not welded pairs.

C. Steel Angles and Bottom Plates: Steel angles shall be provided at the ends of each welded pair for the permanent sheet pile wall on the ECI site for future sealing/grouting (under separate contract). The steel angles shall include a full welded, tapered base plate “plug” at the base of the angle to prevent migration of soil into the angle during driving. Angles and bottom plugs shall be as detailed in Section 3.7.

D. Driving Equipment

1. Provide vibratory sheet pile driving equipment of a type generally used in standard sheet pile driving practice, operated at Manufacturer’s specified rate, to develop the required installation energy while not overstressing the sheet pile.

2. Provide pile driving hammer(s) of a size and type able to deliver consistently effective driving energy, suitable to the piles to be driven and to the subgrade material into which they are to be driven.

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3. Equip hammer with a cast steel or structural steel driving cap, with a grooved base conforming to the pile shape. Keep bearing surfaces of grooves true and smooth.

4. Use fixed or rigid type pile driver leads that will hold the pile firmly in position and alignment, and in axial alignment with the hammer. Free-swinging leads will not be permitted. Extend leads to within 2 feet of the elevation at which the pile enters the ground.

PART 3 - EXECUTION

3.1 QUALITY CONTROL

A. The Subcontractor will submit QC Plans for the installation of the sheet pile wall and deadmen.

1. Materials to be used in construction.

2. Methods for installation.

3. Testing and checks to be performed during installation.

B. The Subcontractor shall perform non-destructive testing of all field welds in accordance with ASTM E 1742 (12).

3.2 SITE PREPRATION

A. Pre-trenching (or alternate method approved by the Engineer) along the permanent sheet pile wall and deadman alignments shall be performed prior to installation of sheeting. Requirements for pre-trenching work are specified in Section 31 20 00 “Earthwork.”

B. Obstructions encountered during pre-trenching, if any, shall be handled as specified in Section 02 41 19, “Selective Site Demolition.”

C. Store materials to permit easy access for inspection and identification. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from erosion and deterioration.

1. Store fasteners in a protected place. Clean and re-lubricate bolts and nuts that become dry or rusty before use.

2. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials or structures as directed.

3.3 PREPARATION

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A. Mark each pile's length by painting a horizontal line at 1-foot intervals, and the number of feet from the pile point at 5-foot intervals.

B. Perform all manual arc-welding using the shielded metal arc or the submerged arc method, complying with AWS Standards.

C. Use oxygen-gas or oxygen arc methods for field cutting of steel, complying with AWS Standards.

D. Clean surfaces to be welded of all rust, scale, oil, paint, and foreign material. Use only pile members with identical cross-sections for splicing. Only one splice per pile will be permitted, unless otherwise authorized by the Engineer. Make splices before starting driving operations wherever possible. If a welded splice is required during the driving operation, make the splice when the top of the driven pile portion is at least 3-feet above the ground to permit inspection of the welded connection during welding and during subsequent driving. Splices shall be 100% butt welded, producing a straight pile alignment through the splices and developing the full strength of the pile in both bearing and bending.

E. Verify elevations of bearing surfaces and locations of bearing plates, stiffener plates, and other embedments, with steel erector present, for compliance with requirements.

F. Provide temporary shores, guys, braces, and other supports during erection to keep structural steel secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural steel, connections, and bracing are in place, unless otherwise indicated.

G. Subcontractor shall coordinate installation of all non-structural steel items which will load the non-self-supporting structural steel frame. The structural steel frame temporary supports shall resist all loads from these non-structural steel items.

H. Field Modification: Obtain written acceptance from the Engineer before the use of flame cutting for field modification or refabrication of structural steel. The Subcontractor shall be responsible for errors in fabrication and for correct fit in the field.

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3.4 DEWATERING

A. Water encountered during the work shall be handled as specified in Section 31 21 40, "Dewatering-Upland."

3.5 TURBIDITY CONTROL

A. Water encountered during the work shall be handled as specified in Section 31 25 00, "Erosion and Sedimentation Control."

3.6 WASTE MANAGEMENT

A. Wastes generated during the performance of the work shall be managed and transported and disposed as specified in Section 02 61 13, "Excavation and Handling of Contaminated Materials" and Section 01 74 19, "Construction Waste Management and Disposal."

3.7 INSTALLATION

A. Continuously drive each pile at the locations indicated on the Drawings to the required point elevation and driving resistance established by driving.

B. Carefully plumb the leads and the pile before driving. Take care during driving to prevent and to correct any tendency of piles to twist, rotate, or walk.

C. Drive piles within 1-inch of the location indicated for the center of gravity for each pile.

D. Sheet piles shall be installed vertically, and batter angle shall not be more than 1-inch in 20-feet, measured when pile is above ground, in the leads.

E. Each pile shall be driven to full penetration without interruption other than by underground obstruction. Any interruption in driving the final 15% of penetration because of malfunctioning of the equipment or lack of attention to the driving shall be a basis of rejection by the Engineer.

F. If an underground obstruction preventing the proper installation without damage is encountered within 20 feet of the surface of the ground, the pile shall be withdrawn.

G. No jetting will be allowed.

H. Provide recorded instrument observations made during the pile driving to determine whether a driven pile has lifted from its original seat during the driving of adjacent piles. If uplift occurs, redrive the affected piles to a point elevation at least as deep as the original point elevation with a driving resistance at least as great as the original driving resistance.

I. Damaged piles and piles driven outside the required driving tolerances will not be accepted. Withdraw piles rejected after driving and replace with new plies. With the approval of the Engineer, piles rejected after driving may be abandoned and cut off, and

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additional piles driven to replace the rejected units at the newly designated locations. Solidly fill spaces that are left by withdrawn piles that will not be filled by new piles using Structural Fill.

J. Cut off the tops of driven piles square with the pile axis and at the elevation indicated. Cut-off sections may be used for splicing.

K. After pile is cut off and a sufficient number of sheets have been installed, weld top plates in place, square and level on top of pile.

L. Withdraw selected driven piles when directed by the Engineer to determine the condition of piles after driving.

M. Redrive piles withdrawn for test and inspection, unless damaged or found not meeting specification requirements. Replace rejected piles with new piles as specified.

3.8 DOCUMENTATION

A. The Subcontractor is responsible for the preparation of record drawings following construction indicating at a minimum the horizontal location of the wall and the top of wall and bottom of wall elevations.

B. The Subcontractor shall submit a post-construction report. The report shall include the following items at a minimum:

1. Record drawings as per above.

2. Summary of construction equipment, means/methods, and materials.

3. Driving records.

4. QC data.

END OF SECTION

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SECTION 35 51 13

MARINE SIGNALING AND CONTROL EQUIPMENT

PART 1 GENERAL

1.1 DESCRIPTION

A. The Subcontractor shall maintain vessels and provide safety equipment per USCG regulations and to the satisfaction of the Owner, in accordance with the Remediation Management Project Marine Assurance Plan (PMAP).

B. The Subcontractor shall comply with all PATON regulations and permit requirements in accordance with the Technical Specifications regarding navigation, lighting, signage, and marine notifications to the satisfaction of the Owner.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01 10 00: Summary of Work

B. Section 01 33 00: Submittal Procedures

C. Section 02 41 19: Selective Site Demolition

D. Section 31 20 00: Earthwork

E. Section 31 25 00: Erosion and Sedimentation Control

F. Section 31 41 16: Steel Sheet Piling and Sealing

1.3 REFERENCES

A. United States Coast Guard (USCG) Code of Federal Regulations (CFR), Title 33, Chapter 1, Parts 64 and 66 – Private Aids to Navigation (PATON).

B. American National Standards Institute (ANSI) 535.1 Standard for Safety Colors.

C. Remediation Management Project Marine Assurance Plan (PMAP)

1.4 SUBMITTALS

A. If necessary, prepare and submit an Anchoring Plan for review and approval for any work involving water or barge related work. At a minimum, the Anchoring Plan shall include:

1. The locations, methods, procedures, and protocols that will be used to secure the Work-related vessels including dredges, barges, and other Work vessels during the project, including during both active Work and non-Work periods.

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2. If necessary, A description of how the Subcontractor's anchoring system will work when a temporary movement is required for navigation or other purposes.

3. If necessary, proposed locations and methods for securing, mooring, and anchoring Work-related vessels, including dredges, barges, and other vessels. Such locations shall provide sufficient water depth to accommodate Work-related vessels, provide safe distance and clearance from infrastructure, provide safe distance and clearance from ongoing neighboring property operations, and provide and comply with all requirements provided herein.

4. If necessary, the methods, procedures, and protocols that will be used to reduce the number of times vessels spud and/or anchor to reduce stirring sediments and to avoid spudding after a dredging unit is capped, backfilled, or has received a Residual Cover.

5. If necessary, the locations and procedures for securing all vessels during storm conditions and extreme wave conditions.

PART 2 MATERIALS

Not Applicable.

PART 3 – EXECUTION

3.1 VESSEL REQUIREMENTS

A. The Subcontractor shall meet all USCG requirements for the vessels being operated and requirements will be documented and summarized in PMAP.

3.2 PRE-INSTALLATION PROBING AND OBSTRUCTION REMOVAL OPERATIONS

A. Pre-installation probing and obstruction removal inspection and documentation will be documented and summarized in work plans for the Site.

3.3 NAVIGATION

A. The Subcontractor shall obey all navigational regulations and conduct operations so as to interfere as little as possible with the use of channels, fairways, and passages. The Subcontractor shall install and maintain any and all protection to navigation as may be required by a properly constituted authority of the waterway.

B. Marine Work shall be planned and conducted so as to minimize interference with other vessel traffic activities and operations.

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3.4 LIGHTING AND SIGNAGE

A. Vessels, barges, containment booms, silt curtains, and other equipment must be able to display navigation and marker lights required by USCG and will be documented in PMAP.

3.5 LOCAL NOTICE TO MARINERS

A. The Subcontractor shall submit a Local Notice to Mariners form to the USCG prior to the start of in-water Work or installation of temporary in-water structures that may pose hazards to navigation or to the public.

3.6 COORDINATION WITH USCG

A. The Subcontractor shall contact the USCG District 9 office in Chicago, Illinois, by e-mail. Contact information is as follows:

USCG District 9 Calumet Harbor, Chicago

Phone: (773) 768 – 4093

Address: 4001 East 98th Street

Chicago, Illinois 60617

E-mail: D09-DG-STACalumetHarbor-Staff@esucleveland.uscg.mil

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B. The Subcontractor shall provide the following information to the USCG by e-mail at least 30 days prior to the start of Work:

1. The Subcontractor's contact information.
2. Project location.
3. Start/end dates of the Work.
4. Hours of operation.
5. Required duration for the Subcontractor to move in-water equipment if another vessel needs to pass.

C. Upon receipt of the information provided in Paragraph 3.7.B., the USCG will provide to the Subcontractor an "authorization to be in the way" letter, which may include conditions (e.g., bridge clearances) that the Subcontractor shall follow.

END OF SECTION

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APPENDIX I – DRAWINGS

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ATLANTIC RICHFIELD CORPORATION- EAST CHICAGO INDIANA SITE - SOUTH AND WEST TANK FARMS

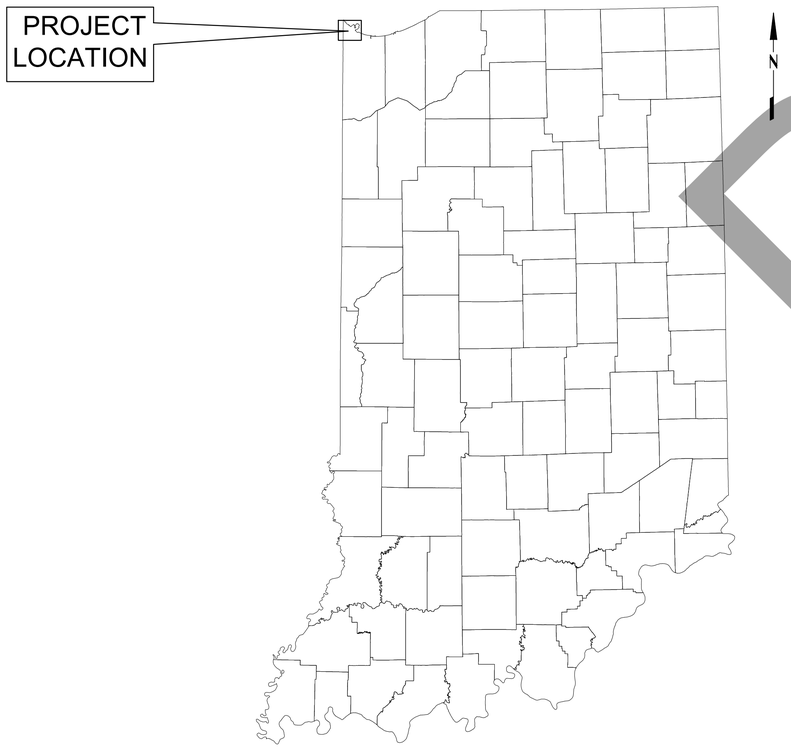
BASIS OF DESIGN

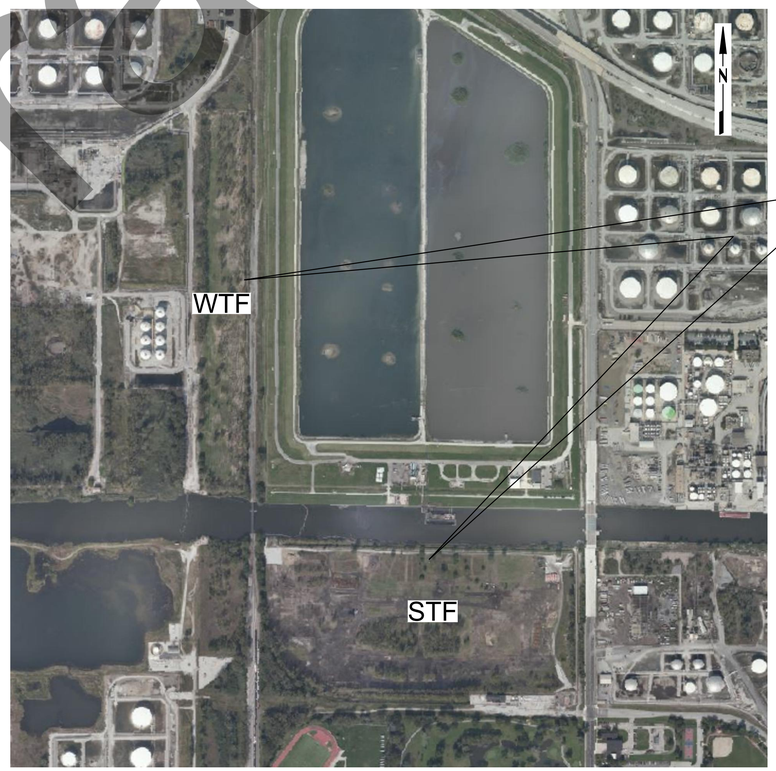
SOUTH END OF LAKE MICHIGAN

EAST CHICAGO, INDIANA

LAKE COUNTY

APPROXIMATE PARCEL AREA: WTF - 18.3 ACRES AND STF- 53.5ACRES
APPROXIMATE SITE LOCATION CENTER: LATITUDE: 41°38'42.31"N, LONGITUDE 87°29'7.68"W





WTF: WEST TANK FARM
STF: SOUTH TANK FARM

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CLIENT: ATLANTIC RICHFIELD (ECI)

CURRENT ISSUE STATUS: 30% BASIS OF DESIGN REPORT

PROJECT: OIL CONTROL BARRIER AND BANK CONTROL DESIGN (ARCO - EGI SITE)
EAST CHICAGO, IN

P:\Projects\EAST\ECI\1 Drawings\1 Civil\SHEETS\G-001

REV	REVISION ISSUE DESCRIPTION	DATE
B	30% DRAFT - USEPA REVIEW	12-20-19
A	30% DRAFT - CLIENT REVIEW	11-18-19

PROJECT NUMBER:	3205191698
PROJECT MANAGER:	DT
A/E OF RECORD:	BBJ
DRAWN BY:	BRT
CAD FILE:	G-001

TITLE: COVER SHEET

DRAWING NO: G-001

NOT FOR CONSTRUCTION

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LEGEND

EXISTING

PROPOSED

	PROPERTY BOUNDARY
	INTERIOR BOUNDARY LINES
	EXISTING BUILDING
	EXISTING TANK FOUNDATION
585	MAJOR CONTOUR
587	MINOR CONTOUR
586.5	SPOT GRADE
W? W? W? W?	POSSIBLE WATER LINE (TBD)
W W W	WATER LINE
	PAVED ROAD
	EXISTING GRAVEL ROADS
	EDGE OF WATER ELEV. 578'
X X	FENCE
OHU OHU	OVERHEAD UTILITY
EC EC	ELECTRIC CONDUIT
GAS GAS	GAS LINE
	RAILROAD TRACKS
	TREE LINE
	SINGLE TREE
	BOLLARD
	HYDRANT
	ELECTRIC UTILITY
TP-1601	TEST PIT
PZ-10	PIEZOMETER
OWS-102	MONITORING WELL
ROST-129	RAPID OPTICAL SCREENING TOOL
LIF-21	LASER INDUCED FLUORESCENCE
SB-2016-02	SOIL BORING
STP-TP2	SOUTH TANK FARM-TEST PIT
PRW-7	PRODUCT RECOVERY WELL
LB-8/LGC-9	LAKE BORING/LAKE GEORGE CANAL
	SAND CAP
	TYPE I BANK CONTROL
	TYPE II BANK CONTROL
	CONTRACTOR LAYDOWN AREA
10+00	BULKHEAD ALIGNMENT

ABBREVIATIONS

AASHTO	AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
ASTM	AMERICAN SOCIETY FOR TESTING AND MATERIALS
BGS	BELOW GROUND SURFACE
℄	CENTER LINE
CAD	CONFINED AQUATIC DISPOSAL
CON	CONCRETE
INDOT	INDIANA DEPARTMENT OF TRANSPORTATION
ELEV	ELEVATION
EX	EXISTING
F	FILTER
FT	FEET
GW	GROUND WATER
HP	HIGH POINT
INV	INVERT
LLDPE	LINEAR LOW DENSITY POLYETHYLENE
LP	LOW POINT
MIN	MINIMUM
MAX	MAXIMUM
NGVD 88	NATIONAL GEODETIC VERTICAL DATUM, 1988
NTS	NOT TO SCALE
OC	ON CENTER
OD	OUTSIDE DIAMETER
P	PUMP
PSI	POUNDS PER SQUARE INCH
PVC	POLYVINYL CHLORIDE
RCP	REINFORCE CONCRETE PIPE
R.O.W.	RIGHT OF WAY
STA	STATION
TC	TURBIDITY CURTAIN
TOS	TOP OF STEEL
TYP	TYPICAL
W	WATER
Ø	DIAMETER

SHEET INDEX

INCLUDED THIS SUBMITTAL	SHEET NUMBER	DRAWING ID	SHEET TITLE
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●	2	G-002	LEGEND AND ABBREVIATIONS
●	3	G-003	GENERAL CONDITIONS
●	4	C-101	EXISTING CONDITION - STF OVERVIEW
●	5	C-102	EXISTING CONDITION - STF (NW)
●	6	C-103	EXISTING CONDITION - STF (NE)
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○	9	C-106	FINAL GRADING PLAN - STF (NW)
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●	14	C-111	BANK CONTORL PLAN - WTF (S)
●	15	C-301	SOIL EROSION AND SEDIMENT CONTROL NOTES
○	16	C-302	SOIL EROSION AND SEDIMENT CONTROL PLAN (STF)
○	17	C-303	SOIL EROSION AND SEDIMENT CONTROL PLAN (WTF)
●	18	C-304	SOIL EROSION AND SEDIMENT CONTROL DETAILS
●	19	C-401	STF BARRIER WALL CROSS-SECTIONS STA 0+00 TO 5+00
●	20	C-402	STF BARRIER WALL CROSS-SECTIONS STA 6+00 TO 11+00
●	21	C-403	STF BARRIER WALL CROSS-SECTIONS STA 12+00 TO 17+00
●	22	C-404	STF BARRIER WALL CROSS-SECTIONS STA 18+00 TO 20+39
●	23	C-405	WTF BANK CONTROL CROSS-SECTIONS STA 300+00 TO 303+17
●	24	C-501	CIVIL DETAILS
○	25	S-001	STRUCTURAL NOTES
●	26	S-101	BARRIER WALL PLAN AND PROFILE - STF (NW)
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●	28	S-201	BARRIER WALL DETAILS I
○	29	S-202	BARRIER WALL DETAILS II

REFERENCE LEGEND:

A
C-501

DETAIL LETTER
WHERE DETAIL TAKEN

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CLIENT: ATLANTIC RICHFIELD (ECI)

CURRENT ISSUE STATUS: 30% BASIS OF DESIGN REPORT

PROJECT: OIL CONTROL BARRIER AND BANK CONTROL DESIGN (ARCO - ECI SITE)
EAST CHICAGO, IN

REV	REVISION/ISSUE DESCRIPTION	DATE
B	~~30%~~ DRAFT - USEPA REVIEW	~~12-20-18~~
A	30% DRAFT - CLIENT REVIEW	11-18-19

PROJECT NUMBER:	3205191698
PROJECT MANAGER:	DT
A/E OF RECORD:	BBJ
DRAWN BY:	BRT
CAD FILE:	G-002

TITLE: LEGEND AND ABBREVIATIONS

DRAWING NO: G-002

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P:\Projects\BF-ECI\3 Design\3.5 Civil\SHEETS\G-002

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GENERAL NOTES:

REFERENCES:

- SOIL BORINGS AND LIF LOCATIONS FROM ARCADIS U.S., INC., 2016a.
- CANAL BORINGS AND STF-TP LOCATIONS ARE TAKEN FROM TETRA TECH, 2015a.
- UPLAND CONTOURS 1FT SEPTEMBER 11, 2019 - INDIANA GEOGRAPHIC INFORMATION OFFICE.
- BATHYMETRY CONTOURS FROM TETRA TECH, 2019.
- BASE MAP FROM STANTEC CONSULTING SERVICES, 2019.
- EXISTING 8" WATER LINE LOCATION FROM ARCADIS, 2013.
- SAND CAP FOOTPRINT FROM TETRA TECH, 2015d.
- BULKHEAD AND EXPOSED PIPELINES LOCATIONS FROM WESTON, 2002.

GENERAL:

1. ALL CONSTRUCTION METHODS AND MATERIALS MUST CONFORM TO CURRENT STANDARDS AND SPECIFICATION OF THE FEDERAL, STATE, COUNTY, CITY OR LOCAL REQUIREMENTS, WHICHEVER HAS JURISDICTION.

2. THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS IN THE FIELD PRIOR TO STARTING CONSTRUCTION. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ALL FIELD DIMENSION. IF ANY DISCREPANCIES ARE FOUND IN THESE PLANS FROM THE ACTUAL FIELD CONDITION, THE CONTRACTOR SHALL NOTIFY ENGINEER IMMEDIATELY.

3. THE EXCAVATING CONTRACTOR MUST TAKE PARTICULAR CARE WHEN EXCAVATING IN AND AROUND EXISTING UTILITY LINES AND EQUIPMENT. VERIFY COVER REQUIREMENTS BY UTILITY CONTRACTORS AND/OR UTILITY COMPANIES SO AS NOT CAUSE DAMAGE.

4. THE CONTRACTOR SHALL NOTIFY ALL UTILITY COMPANIES 72 HOURS BEFORE CONSTRUCTIONS IS TO START, TO VERIFY IF ANY UTILITIES ARE PRESENT ON SITE. ALL VERIFICATIONS (LOCATION, SIZE AND DEPTH) SHALL BE MADE BY THE APPROPRIATE UTILITY COMPANIES. WHEN EXCAVATION IS AROUND OR OVER EXISTING UTILITIES, THE CONTRACTOR MUST NOTIFY THE UTILITY COMPANY SO A REPRESENTATIVE OF THAT UTILITY COMPANY CAN BE PRESENT TO INSTRUCT AND OBSERVE DURING WORK.

5. PROVIDE POSITIVE DRAINAGE WITHOUT PONDING, TO THE EXTENT POSSIBLE, AFTER INSTALLATION, CONTRACTOR TO TEST FOR, AND CORRECT, IF ANY "BIRD BATH" CONDITIONS.

6. ALL PROPOSED SPOT ELEVATIONS ARE THE FINAL GRADE ELEVATIONS.

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CLIENT:
ATLANTIC RICHFIELD (ECI)

CURRENT ISSUE STATUS:
30% BASIS OF DESIGN REPORT

PROJECT:
OIL CONTROL BARRIER AND BANK CONTROL DESIGN (ARCO - ECI SITE)
EAST CHICAGO, IN

P:\Projects\ECI\13 Design\13 Cad\BEET\NG\003

REV	REVISION ISSUE DESCRIPTION	DATE
A	30% DRAFT - CLIENT REVIEW	11-18-19
B	30% DRAFT - USEPA REVIEW	12-20-19

PROJECT NUMBER:	3205191698
PROJECT MANAGER:	DT
A/E OF RECORD:	BBJ
DRAWN BY:	BRT
CAD FILE:	G-003

TITLE:
GENERAL CONDITIONS

DRAWING NO:
G-003

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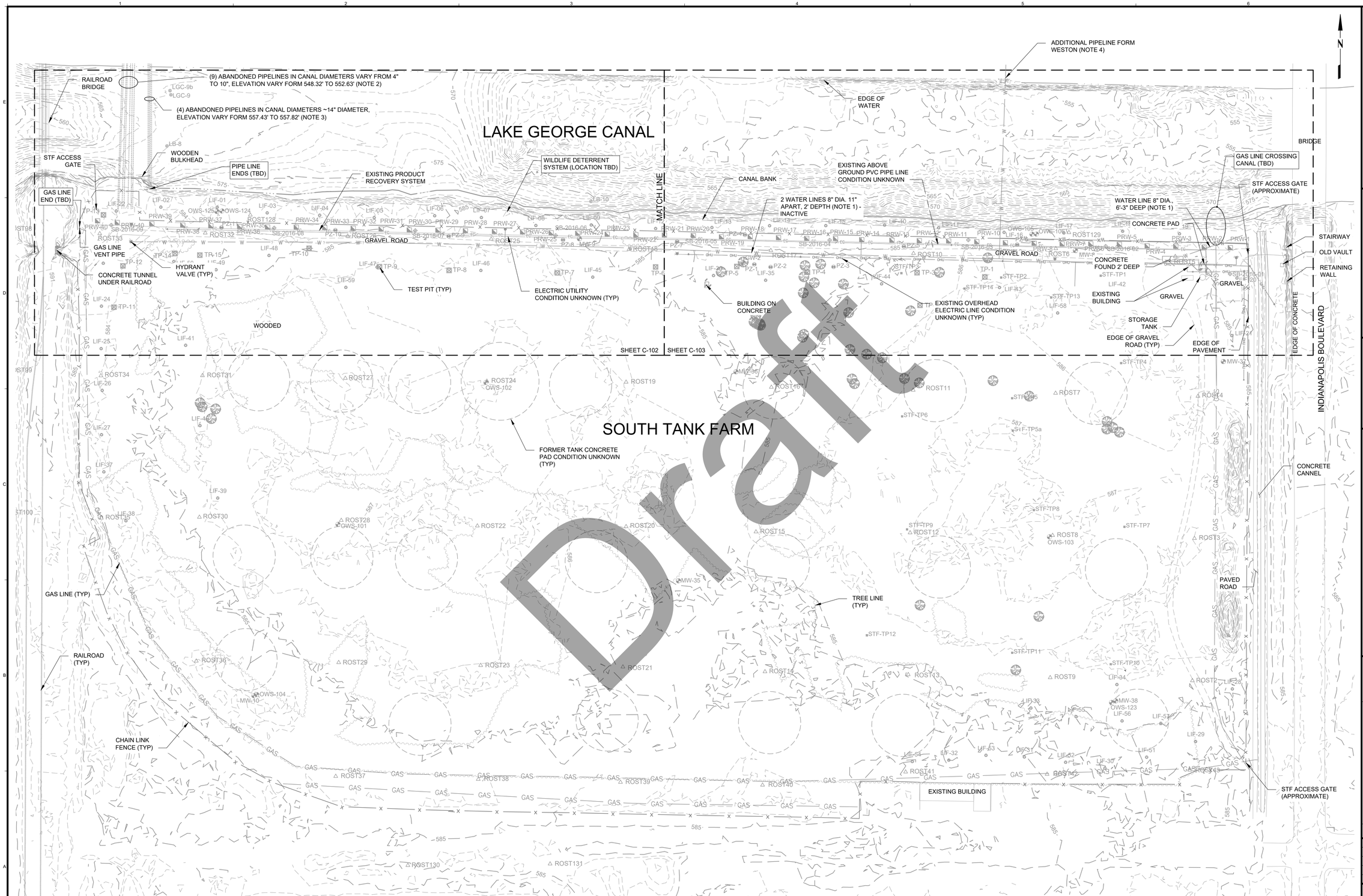

NOTES:

1. EXISTING 8" WATER LINE LOCATION FROM (ARCADIS, 2013).
2. NINE PIPES DIAMETERS VARY FROM 4" TO 11". PIPE HAVE BEEN GROUTED (WESTON, 2002).
3. FOUR PIPES DIAMETER 14" (WESTON, 2002).
4. 8" DIAMETER WATER PIPE REMAINING FROM 2002 PIPELINE REMOVAL (APPROXIMATE LOCATION), WESTON 2002.

0 40 80 160
HORIZONTAL SCALE IN FEET

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CLIENT: ATLANTIC RICHFIELD (ECI)

CURRENT ISSUE STATUS: 30% BASIS OF DESIGN REPORT

PROJECT: OIL CONTROL BARRIER AND BANK CONTROL DESIGN (ARCO - ECI SITE)
EAST CHICAGO, IN

P:\Projects\EC03 Design\1 Cont\REETSC-101

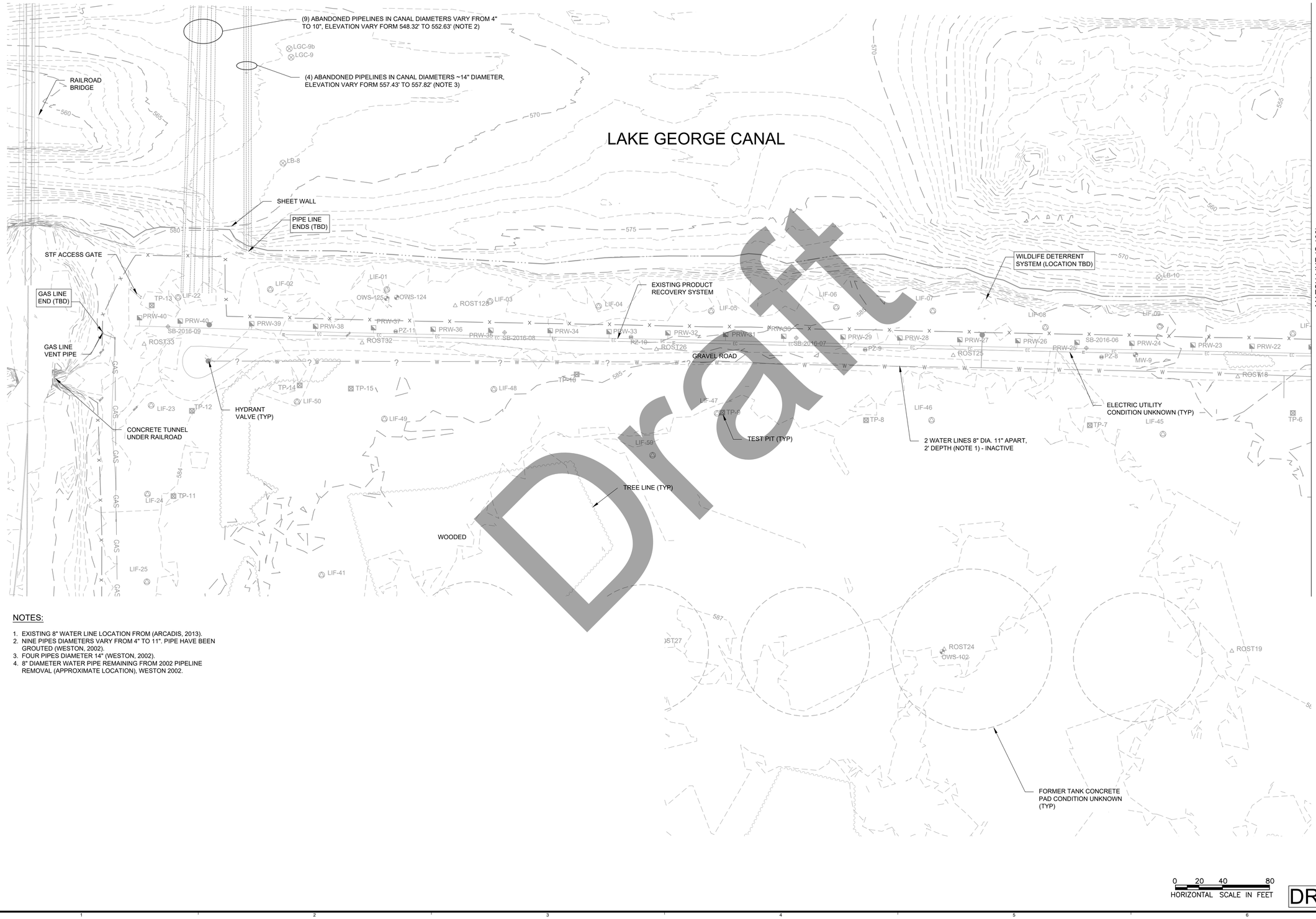
REV	REVISION ISSUE DESCRIPTION	DATE
B	30% DRAFT - USEPA REVIEW	12-20-19
A	30% DRAFT - CLIENT REVIEW	11-18-19

PROJECT NUMBER:	3205191698
PROJECT MANAGER:	DT
A/E OF RECORD:	BBJ
DRAWN BY:	BRT
CAD FILE:	C-101

TITLE: EXISTING CONDITIONS - STF OVERVIEW

DRAWING NO: C-101

NOT FOR CONSTRUCTION



NOTES:

1. EXISTING 8" WATER LINE LOCATION FROM (ARCADIS, 2013).
2. NINE PIPES DIAMETERS VARY FROM 4" TO 11". PIPE HAVE BEEN GROUTED (WESTON, 2002).
3. FOUR PIPES DIAMETER 14" (WESTON, 2002).
4. 8" DIAMETER WATER PIPE REMAINING FROM 2002 PIPELINE REMOVAL (APPROXIMATE LOCATION), WESTON 2002.

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CLIENT: ATLANTIC RICHFIELD (ECI)

CURRENT ISSUE STATUS: 30% BASIS OF DESIGN REPORT

PROJECT: OIL CONTROL BARRIER AND BANK CONTROL DESIGN (ARCO - ECI SITE) EAST CHICAGO, IN

P:\Projects\EC03 Design\1 Cont\REETPC-102

REV	REVISION ISSUE DESCRIPTION	DATE
A	30% DRAFT - CLIENT REVIEW	11-18-19
B	30% DRAFT - USEPA REVIEW	12-20-19

PROJECT NUMBER:	3205191698
PROJECT MANAGER:	DT
A/E OF RECORD:	BBJ
DRAWN BY:	BRT
CAD FILE:	C-102

TITLE: EXISTING CONDITIONS - STF (NW)

DRAWING NO: C-102

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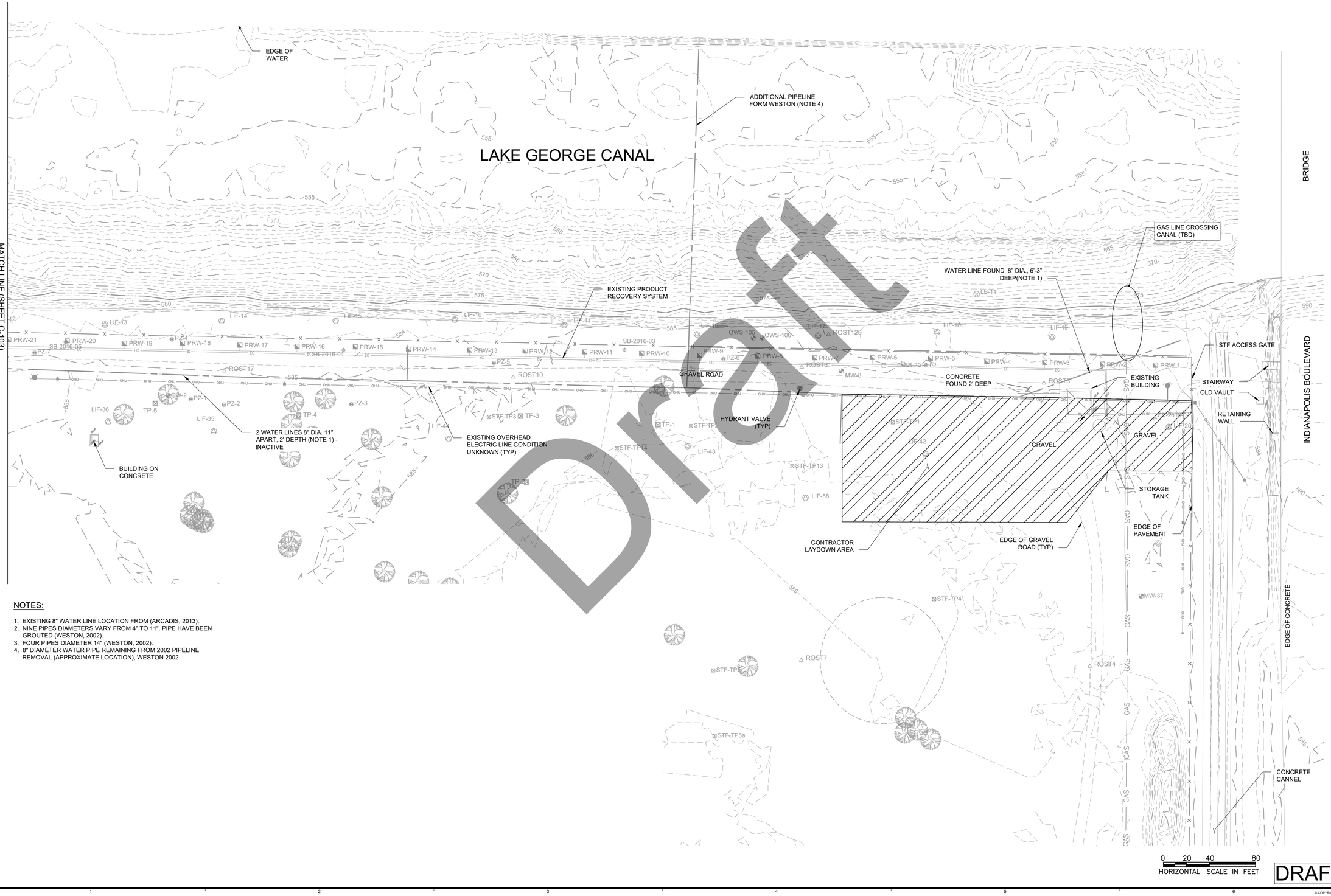
LAKE GEORGE CANAL
EDGE OF WATER
ADDITIONAL PIPELINE FORM WESTON (NOTE 4)
BRIDGE
INDIANAPOLIS BOULEVARD
MATCH LINE (SHEET C-103)
EXISTING PRODUCT RECOVERY SYSTEM
GRAVEL ROAD
WATER LINE FOUND 8" DIA., 6'-3" DEEP(NOTE 1)
GAS LINE CROSSING CANAL (TBD)
CONCRETE FOUND 2' DEEP
EXISTING BUILDING
STF ACCESS GATE
STAIRWAY
OLD VAULT
RETAINING WALL
GRAVEL
STORAGE TANK
EDGE OF PAVEMENT
EDGE OF GRAVEL ROAD (TYP)
CONTRACTOR LAYDOWN AREA
EDGE OF CONCRETE
CONCRETE CANNEL
HYDRANT VALVE (TYP)
2 WATER LINES 8" DIA. 11" APART, 2' DEPTH (NOTE 1) - INACTIVE
EXISTING OVERHEAD ELECTRIC LINE CONDITION UNKNOWN (TYP)
BUILDING ON CONCRETE
PRW-1
PRW-2
PRW-3
PRW-4
PRW-5
PRW-6
PRW-7
PRW-8
PRW-9
PRW-10
PRW-11
PRW-12
PRW-13
PRW-14
PRW-15
PRW-16
PRW-17
PRW-18
PRW-19
PRW-20
PRW-21
PZ-1
PZ-2
PZ-3
PZ-5
PZ-6
PZ-7
SB-2016-01
SB-2016-02
SB-2016-03
SB-2016-04
SB-2016-05
SB-2016-06
SB-2016-07
SB-2016-08
SB-2016-09
SB-2016-10
SB-2016-11
SB-2016-12
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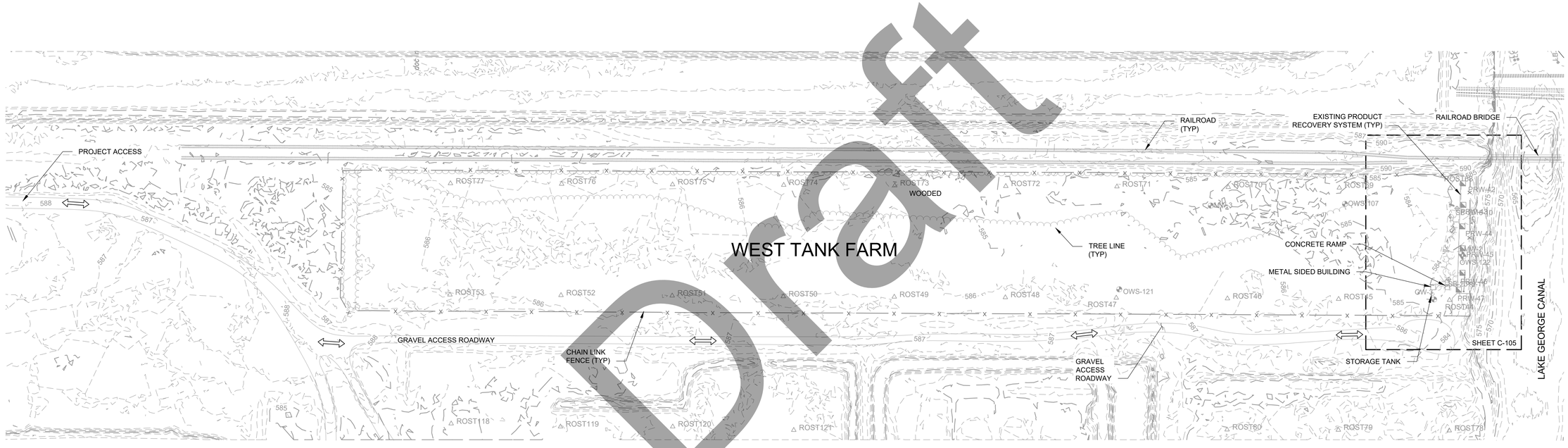
SB-2016-40



0 60 120 240
HORIZONTAL SCALE IN FEET

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CLIENT:
ATLANTIC RICHFIELD (ECI)

CURRENT ISSUE STATUS:
30% BASIS OF DESIGN REPORT

PROJECT:
OIL CONTROL BARRIER AND BANK CONTROL DESIGN
(ARCO - ECI SITE)
EAST CHICAGO, IN

P:\Projects\P425\3\Design\3.4\Cad\SETS\C104

REV	DATE	REVISION ISSUE DESCRIPTION
B	12-20-19	30% DRAFT - USEPA REVIEW
A	11-18-19	30% DRAFT - CLIENT REVIEW

PROJECT NUMBER: 320519168
PROJECT MANAGER: DT
A/E OF RECORD: BBJ
DRAWN BY: BRT
CAD FILE: C-104

TITLE:
EXISTING CONDITIONS - WTF OVERVIEW

DRAWING NO:
C-104

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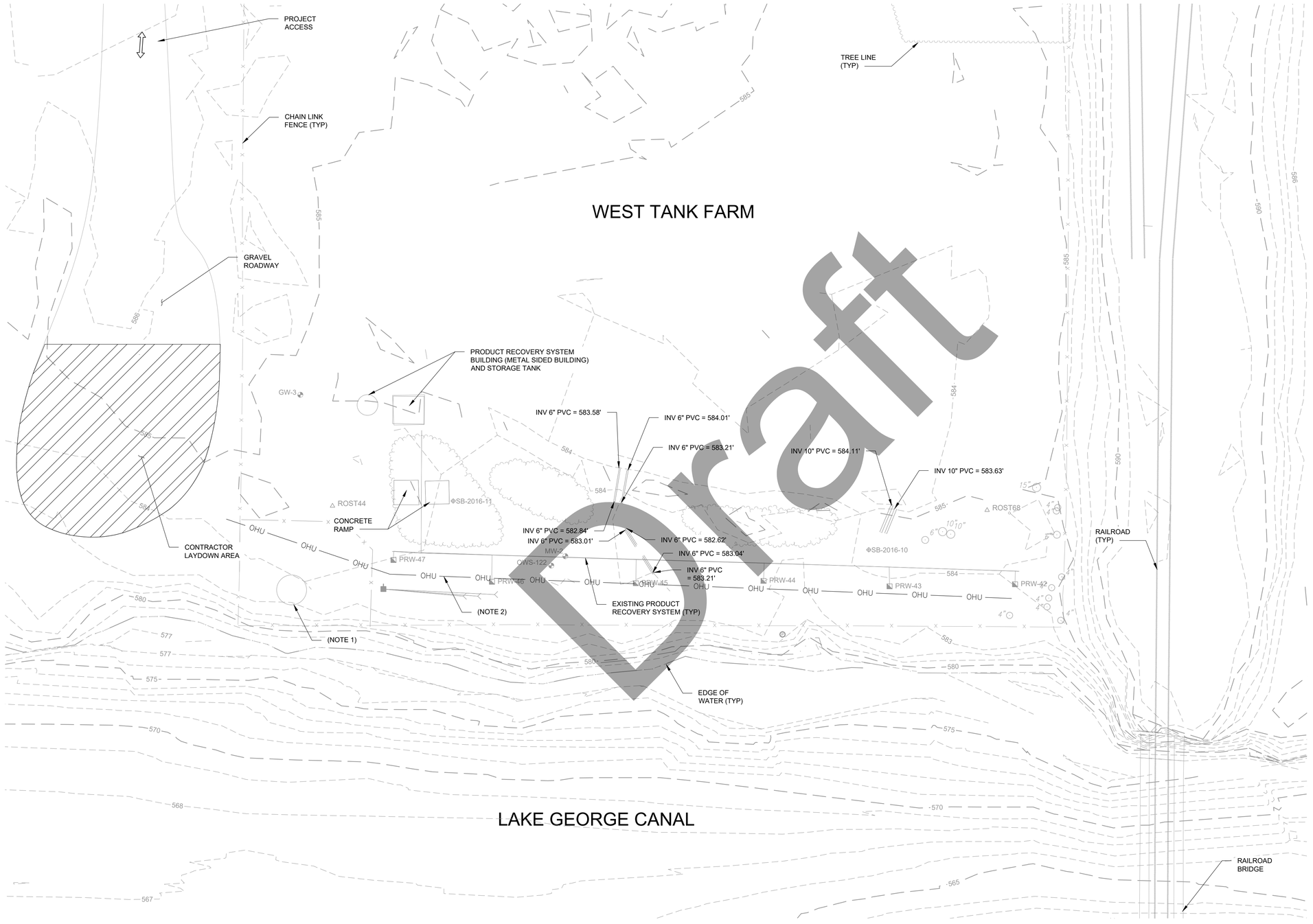

NOTES:

1. ABOVE GROUND STRUCTURE WHICH PROVIDES ACCESS TO THE OLD PIPLINE TUNES UNDER THE CANAL, OWNED BY BP PIPELINES. DETAILS TBD.
2. OHU IS APPROXIMATE. EXACT LOCATION IS TBD.

0 10 20 40
HORIZONTAL SCALE IN FEET

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CLIENT:
ATLANTIC RICHFIELD (ECI)

CURRENT ISSUE STATUS:
30% BASIS OF DESIGN REPORT

PROJECT:
OIL CONTROL BARRIER AND BANK CONTROL DESIGN (ARCO - ECI SITE)
EAST CHICAGO, IN

P:\Projects\PACKS\Design\14-Cell\EXISTCN.dwg

REV	REVISION ISSUE DESCRIPTION	DATE
A	30% DRAFT - CLIENT REVIEW	11-18-19
B	30% DRAFT - USEPA REVIEW	12-20-19

PROJECT NUMBER:	3205191698
PROJECT MANAGER:	DT
A/E OF RECORD:	BBJ
DRAWN BY:	BRT
CAD FILE:	C-105

TITLE:
EXISTING CONDITIONS - WTF (S)

DRAWING NO:
C-105

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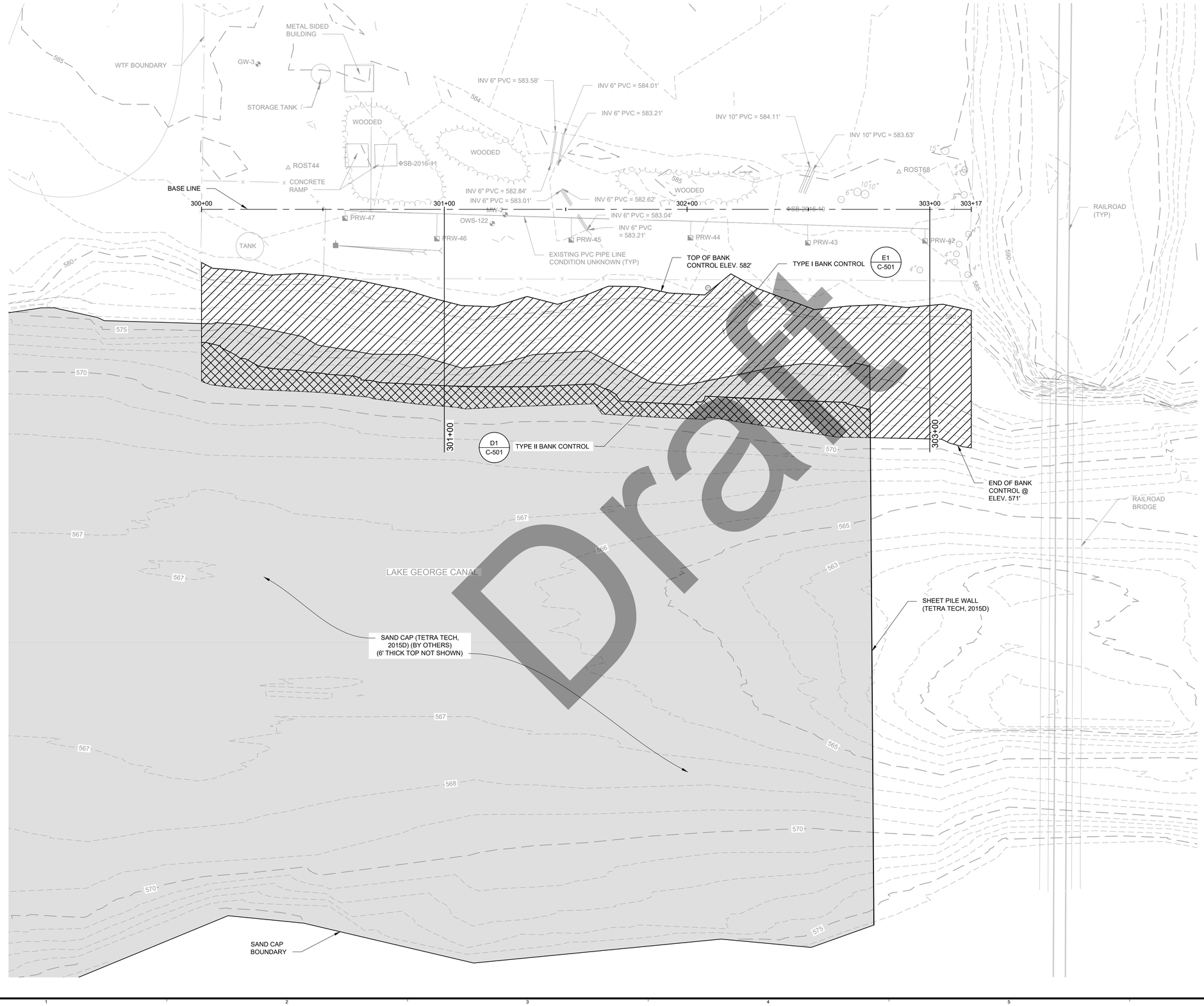

NOTE:

1. GLLA PLANNED BATHYMETRY AND DREDGING PLAN SHOWS EXISTING ANA PLANNED DREDGING CONDITIONS AND CONFIGURATIONS (TETRA TECH, 2015D).

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CLIENT:
ATLANTIC RICHFIELD (ECI)

CURRENT ISSUE STATUS:
30% BASIS OF DESIGN REPORT

PROJECT:
OIL CONTROL BARRIER AND BANK CONTROL DESIGN (ARCO - ECI SITE)
EAST CHICAGO, IN

P:\Projects\PCADs\Design\Civil\BRET\C-111

REV	REVISION ISSUE DESCRIPTION	DATE
B	30% DRAFT - USEPA REVIEW	12-20-19
A	30% DRAFT - CLIENT REVIEW	11-18-19

PROJECT NUMBER:	3205191698
PROJECT MANAGER:	DT
A/E OF RECORD:	BBJ
DRAWN BY:	BRT
CAD FILE:	C-111

TITLE:
BANK CONTROL PLAN
WTF (S)

DRAWING NO:
C-111

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EROSION CONTROL NOTES:

1. ALL CONSTRUCTION METHODS AND MATERIALS MUST CONFORM TO CURRENT STANDARDS AND SPECIFICATIONS OF THE FEDERAL, STATE, COUNTY, CITY OR LOCAL REQUIREMENTS, WHICHEVER HAS JURISDICTION.

2. LAND ALTERATION WHICH STRIPS THE LAND OF VEGETATION, INCLUDING REGRADING, SHALL BE DONE IN A WAY THAT WILL MINIMIZE EROSION.

3. THIS PLAN SHALL NOT BE CONSIDERED ALL INCLUSIVE AS THE CONTRACTOR SHALL TAKE ALL NECESSARY PRECAUTIONS TO PREVENT SOIL SEDIMENT FROM LEAVING THE SITE. ADDITIONAL EROSION AND SEDIMENT CONTROL MEASURES WILL BE INSTALLED IF DEEMED NECESSARY BY ON-SITE INSPECTION.

4. SEDIMENT LADEN WATER SHALL BE DETAINED BY EROSION CONTROL PRACTICES AS NEED TO MINIMIZE SEDIMENTATION IN THE RECEIVING STREAM. NO STORM WATER SHALL BE DISCHARGE FROM THE SITE IN A MANNER THAT CAUSES EROSION AT THE POINT OF DISCHARGE.

5. WASTES AND UNUSED BUILDING MATERIAL SHALL NOT BE ALLOWED TO BE CARRIED FROM THE SITE BY STORMWATER RUNOFF. PROPER DISPOSAL OF ALL WASTES AND UNUSED BUILDING MATERIALS IS REQUIRED.

6. SEDIMENT BEING TRACKED ONTO PUBLIC OR PRIVATE ROADWAYS SHALL BE MINIMIZED. CLEARING OF ACCUMULATED SEDIMENT SHALL NOT INCLUDE FLUSHING WITH WATER. CLEARED SEDIMENT SHALL BE RETURNED TO THE SITE FOR DISPOSAL.

7. SOIL WHICH HAS ACCUMULATED NEXT TO EROSION CONTROL DEVICES SHALL BE COLLECTED AND REDISTRIBUTED ON SITE AFTER EACH RAINFALL EVENT, AND AT LEAST ONCE A WEEK.

8. IF INSTALLATION OF STORM DRAINAGE SYSTEM SHOULD BE INTERRUPTED BY WATER OF NIGHTFALL, THE PIPE ENDS SHALL BE COVERED WITH FILTER FABRIC.

9. ALL EXISTING STRUCTURES, FENCING, TREES AND ETC., WITH CONSTRUCTION AREA SHALL BE REMOVED AND DISPOSED OF OFF SITE. BURNING IS NOT ALLOWED ON-SITE.

10. SCHEDULE OF EARTHWORK ACTIVITIES:
    a) THE DURATION OF TIME WHICH AN AREA REMAINS EXPOSED SHALL BE KEPT TO PRACTICAL MINIMUM. THE AREA SHALL BE STABILIZED SOON AS POSSIBLE. TEMPORARY VEGETATION OR MULCHING SHALL BE USED TO PROTECT EXPOSED AREAS IF PERMANENT VEGETATION CANNOT BE SEEDED WITH 14 DAYS OR ACTIVITY CEASES FOR MORE THAN 14 DAYS OR AS DIRECTED BY ENGINEER.

    b) TOPSOIL REPLACEMENT SHALL TAKE PLACE FORM MARCH 1 TO OCTOBER 31. STOCKPILE TOPSOIL AT ALL OTHER TIME OF THE YEAR. PERMANENT AND FINAL VEGETATION AND STRUCTURAL EROSION CONTROL DEVICES SHALL BE INSTALLED WITHIN SEVEN (7) DAYS AFTER FINAL GRADING OR AS SOON AS POSSIBLE.

11. ALL POND SLOPES SHALL BE HYDROSEEDED. MULCH BLANKET INSTALLED WHERE SPECIFIED.

SILT FENCE

LOCATION
1. INSTALLED PARALLEL TO THE SLOPE CONTOUR.
2. MINIMUM OF 10 FEET BEYOND THE TOE OF SLOPE TO PROVIDE A BROAD, SHALLOW SEDIMENT POOL.
3. ACCESSIBLE FOR MAINTENANCE (REMOVAL OF SEDIMENT AND SILT FENCE REPAIR).

INSTALLATION
1. LAY OUR THE LOCATION OF THE FENCE SO THAT IT IS PARALLEL TO THE CONTOUR OF THE SLOPE AND AT LEAST 10 FEET BEYOND THE TOE OF SLOPE TO PROVIDE A SEDIMENT STORAGE AREA. TURN THE ENDS OF THE FENCE UP SLOPE SUCH THAT THE POINT OF CONTACT BETWEEN THE GROUND AND THE BOTTOM OF THE FENCE END TERMINATES AT A HIGHER ELEVATION THAT THE TOP OF THE FENCE AT ITS LOWEST POINT.
2. EXCAVATE AN EIGHT -INCH DEEP BY FOUR INCH WIDE TRENCH ALONG THE ENTIRE LENGTH OF THE FENCE LINE. INSTALLATION BY PLOWING IS ALSO ACCEPTABLE.
3. INSTALL THE SILT FENCE WITH FILTER FABRIC LOCATED ON THE UP-SIDE OF THE EXCAVATED TRENCH AND THE SUPPORT POSTS ON THE DOWN-SLOPE SIDE OF THE TRENCH.
4. DRIVE THE SUPPORT POSTS AT LEAST 18 INCHES INTO THE GROUND, TIGHTLY STRETCHING THE FABRIC BETWEEN THE POSTS AS EACH IS DRIVEN INTO THE SOIL. A MINIMUM OF 12 INCHES OF THE FILTER FABRIC SHOULD EXTEND INTO THE TRENCH. (IF IT IS NECESSARY TO JOIN THE ENDS OF TWO FENCES, USE THE WRAP JOINT METHOD SHOWN).
5. LAY THE LOWER FOUR INCHES OF FILTER FABRIC ON THE BOTTOM OF THE TRENCH AND EXTEND IT TOWARD THE UP-SLOPE SIDE OF THE TRENCH.
6. BACKFILL THE TRENCH WITH SOIL MATERIAL AND COMPACT IT IN PLACE.

MAINTENANCE
1. INSPECT WITH 24 HOURS OF A RAIN EVENT AND AT LEAST ONCE EVERY SEVEN CALENDAR DAYS.
2. IF FENCE FABRIC TEARS, STARTS TO DECOMPOSE, PR IN WAY BECOMES INEFFECTIVE, REPLACE THE AFFECTED PORTION IMMEDIATELY. NOTE: ALL REPAIRS SHOULD MEET SPECIFICATION AS OUTLINE WITHIN THIS MEASURE.
3. REMOVE DEPOSITED SEDIMENT WHEN IT IS CAUSING THE FILTER FABRIC TO BULGE OR WHEN IT REACHES ONE-HALF THE HEIGHT OF THE FENCE AT ITS LOWEST POINT. WHEN CONTRIBUTION DRAINAGE AREA HAS BEEN STABILIZED, REMOVE THE FENCE AND SEDIMENT DEPOSITS, GRADE THE SITE TO BLEND WITH THE SURROUNDING ARE, AND STABILIZE.

TEMPORARY CONSTRUCTION ENTRENCE

DIMENSIONS
1. WIDTH - 20 FEET MINIMUM OR FULL WIDTH OF ENTRANCE/EXIT ROADWAY, WHICHEVER IS GREATER.
2. LENGTH - 150 FEET MINIMUM (LENGTH CAN BE SHORTER FOR SMALL SITES).
3. THICKNESS - EIGHT INCHES MINIMUM.
   WASTING FACILITY (OPTIONAL)
4. LEVEL AREA WITH THREE INCH, OR LARGER, WASHED AGGREGATE OR INSTALL A COMMERCIAL WASH RACK.
5. DIVER WASTE WATER TO A SEDIMENT TRAP OR BASIN.

INSTALLATION
1. REMOVE ALL VEGETATION AND OTHER OBJECTIONABLE MATERIAL FROM THE FOUNDATION AREA.
2. GRADE FOUNDATION AND CROWN FOR POSITIVE DRAINAGE. IF THE SLOPE OF THE CONSTRUCTION ENTRANCE IS TOWARD A PUBLIC ROAD AND EXCEED TWO PERCENT, CONSTRUCT AN EIGHT INCH HIGH DIVERSION RIDGE WITH A RATIO OF 3-TO-1 SIDE SLOPES ACROSS THE FOUNDATION AREA ABOUT 15 FEET FORM THE ENTRANCE TO DIVERT RUNOFF AWAY FROM THE ROAD.
3. INSTALL A CULVERT PIPE UNDER THE PAD IF NEEDED TO MAINTAIN PROPER PUBLIC ROAD DRAINAGE.
4. IF WET CONDITIONS ARE ANTICIPATED, PLACE GEOTEXTILE FABRIC ON THE GRADE FOUNDATION TO IMPROVE STABILITY.
5. PLACE AGGREGATE (INDOT CA No. 2) TO THE DIMENSIONS AND GRADE SHOWN IN THE CONSTRUCTION PLANS, LEAVING THE SURFACE SMOOTH AND SLOPE FOR DRAINAGE.
6. TOP-DRESS THE FIRST 50 FEET ADJACENT TO THE PUBLIC ROADWAY WITH TWO TO THREE INCHES OF WASHED AGGREGATE (INDOT CA No. 53) [OPTIONAL, USED PRIMARILY WHERE THE PURPOSE OF THE PAD IS TO KEEP SOIL FROM ADHERING TO VEHICLE TIRES].
7. WHERE POSSIBLE, DIVERT ALL STORM WATER RUNOFF AND DRAINAGE FROM THE INGRESS/EGRESS PAD TO A SEDIMENT TRAP OR BASIN.

MAINTENANCE
1. INSPECT DAILY.
2. RESHAPE PAD AS NEEDED FOR DRAINAGE AND RUNOFF CONTROL.
3. TOP DRESS WITH CLEAN AGGREGATE AS NEEDED.
4. IMMEDIATELY REMOVE MUD AND SEDIMENT TRACKED OR WASHED ONTO PUBLIC ROADS.
5. FLUSHING SHOULD ONLY BE USED IF THE WATER CAN BE CONVEYED INTO A SEDIMENT TRAP OR BASIN.

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CLIENT: ATLANTIC RICHFIELD (ECI)

CURRENT ISSUE STATUS: 30% BASIS OF DESIGN REPORT

PROJECT: OIL CONTROL BARRIER AND BANK CONTROL DESIGN (ARCO - ECI SITE)
EAST CHICAGO, IN

P:\Projects\BP ECSI\1 Design\3 Civil\SHEETS\C-301

REV	REVISION ISSUE DESCRIPTION	DATE
B	30% DRAFT - USEPA REVIEW	12-20-19
A	30% DRAFT - CLIENT REVIEW	11-18-19

PROJECT NUMBER:	3205191698
PROJECT MANAGER:	DT
A/E OF RECORD:	BBJ
DRAWN BY:	BRT
CAD FILE:	C-301

TITLE: SOIL EROSION AND SEDIMENT CONTROL NOTES

DRAWING NO: C-301

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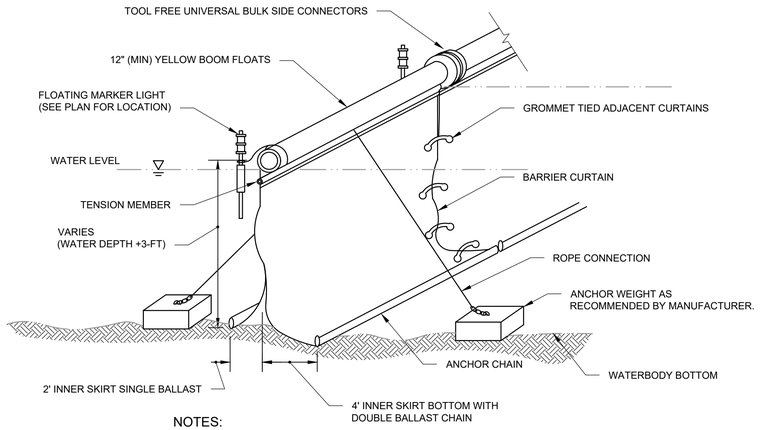
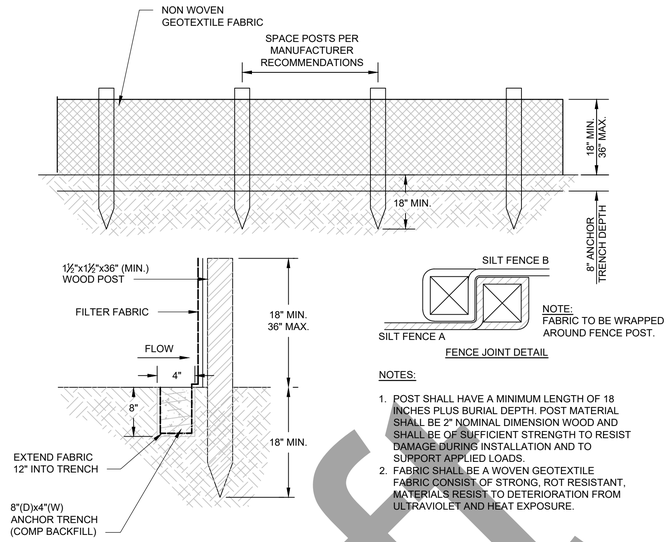


NOTES:

1. PLACE TURBIDITY BARRIER IMMEDIATELY DOWNSTREAM OF BYPASS DISCHARGE.
2. TURBIDITY BARRIER SHALL BE DEPLOYED PRIOR TO DREDGING OR DISTURBING UPLAND SOILS.

D1 TURBIDITY BARRIER

NOT TO SCALE



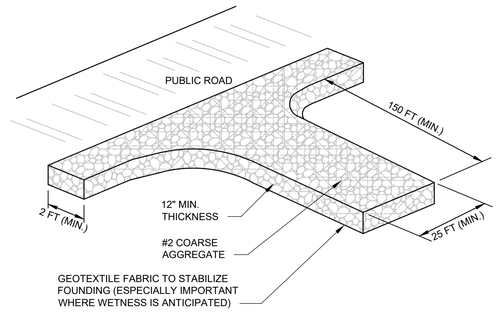
FENCE JOINT DETAIL

NOTES:

1. POST SHALL HAVE A MINIMUM LENGTH OF 18 INCHES PLUS BURIAL DEPTH. POST MATERIAL SHALL BE 2" NOMINAL DIMENSION WOOD AND SHALL BE OF SUFFICIENT STRENGTH TO RESIST DAMAGE DURING INSTALLATION AND TO SUPPORT APPLIED LOADS.
2. FABRIC SHALL BE A WOVEN GEOTEXTILE FABRIC CONSIST OF STRONG, ROT RESISTANT, MATERIALS RESIST TO DETERIORATION FROM ULTRAVIOLET AND HEAT EXPOSURE.

C3 SILT FENCE CONSTRUCTION

NOT TO SCALE



D5 TEMPORARY CONSTRUCTION ENTRANCE

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CLIENT: ATLANTIC RICHFIELD (ECI)

CURRENT ISSUE STATUS: 30% BASIS OF DESIGN REPORT

PROJECT: OIL CONTROL BARRIER AND BANK CONTROL DESIGN (ARCO - ECI SITE)
EAST CHICAGO, IN

P:\Projects\ECI\13 Design\13 Cad\SHEETS\C-304

REV	REVISION ISSUE DESCRIPTION	DATE
B	30% DRAFT - USEPA REVIEW	12-20-19
A	30% DRAFT - CLIENT REVIEW	11-18-19

PROJECT NUMBER:	3205191698
PROJECT MANAGER:	DT
A/E OF RECORD:	BBJ
DRAWN BY:	BRT
CAD FILE:	C-304

TITLE: SOIL EROSION AND SEDIMENT CONTROL DETAILS

DRAWING NO: C-304

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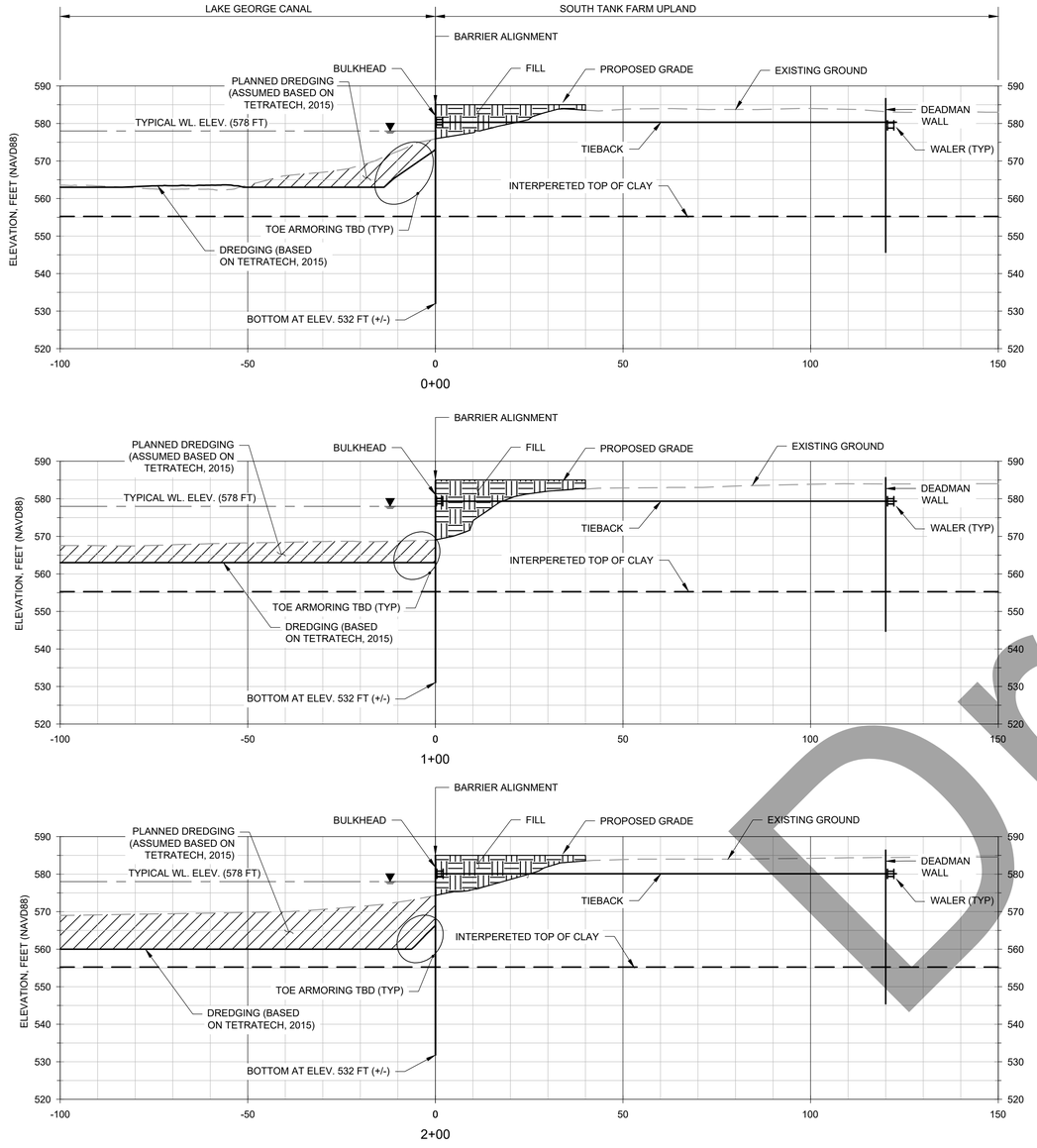

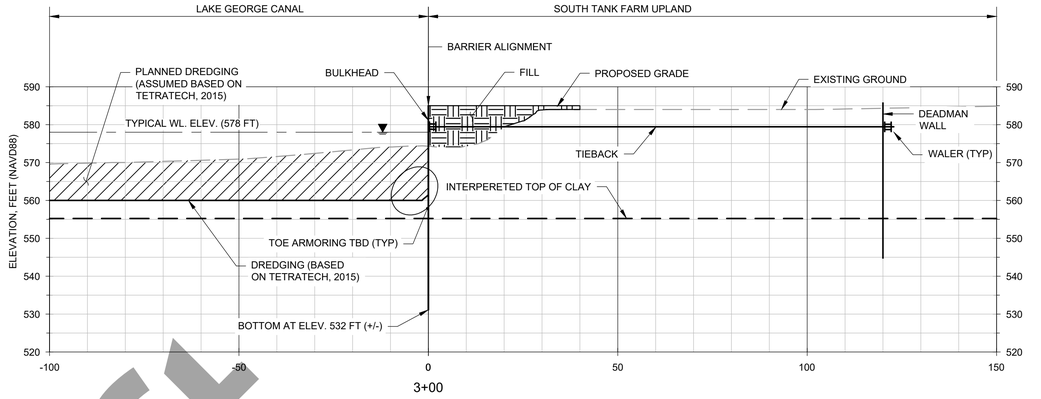

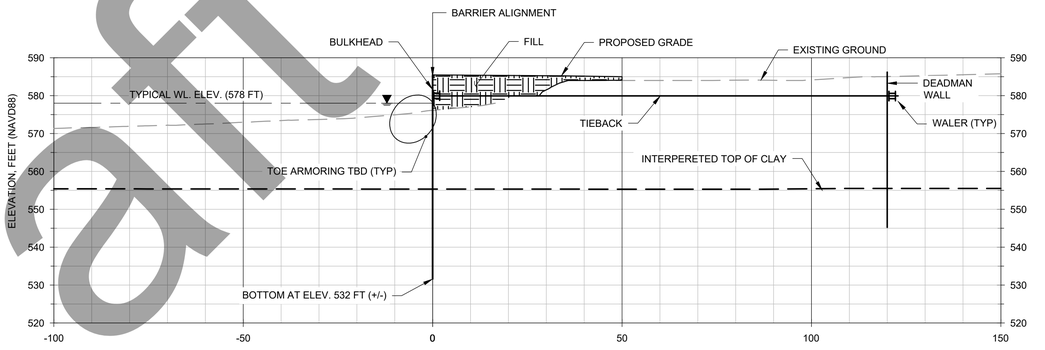

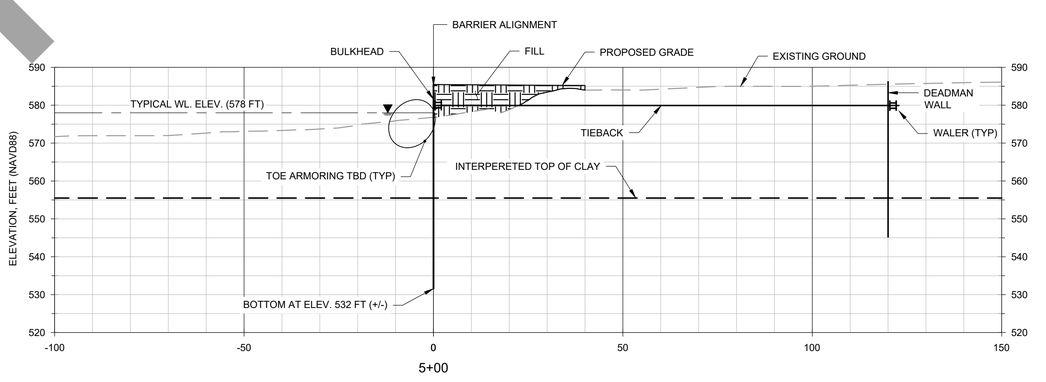

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VERTICAL SCALE IN FEET

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CLIENT:
ATLANTIC RICHFIELD (ECI)

CURRENT ISSUE STATUS:
30% BASIS OF DESIGN REPORT

PROJECT:
OIL CONTROL BARRIER AND BANK CONTROL DESIGN (ARCO - ECI SITE)
EAST CHICAGO, IN

P:\Projects\ECI\13 Design\13 Cont\REITSC-401

REV	REVISION/ISSUE DESCRIPTION	DATE
B	30% DRAFT - USEPA REVIEW	12/20/2019
A	30% DRAFT - CLIENT REVIEW	11-18-19

PROJECT NUMBER:	3205191698
PROJECT MANAGER:	DT
A/E OF RECORD:	BBJ
DRAWN BY:	BRT
CAD FILE:	C-401

TITLE:
STF BARRIER WALL CROSS-SECTION STA 0+00 TO 5+00

DRAWING NO:
C-401

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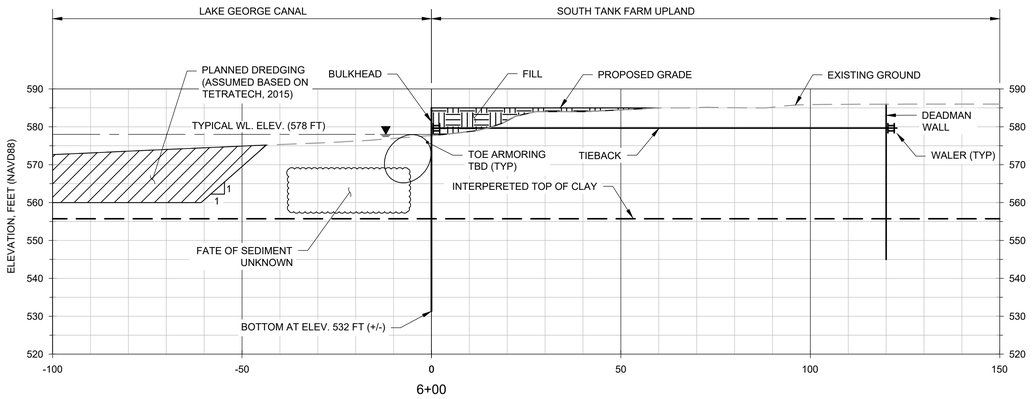

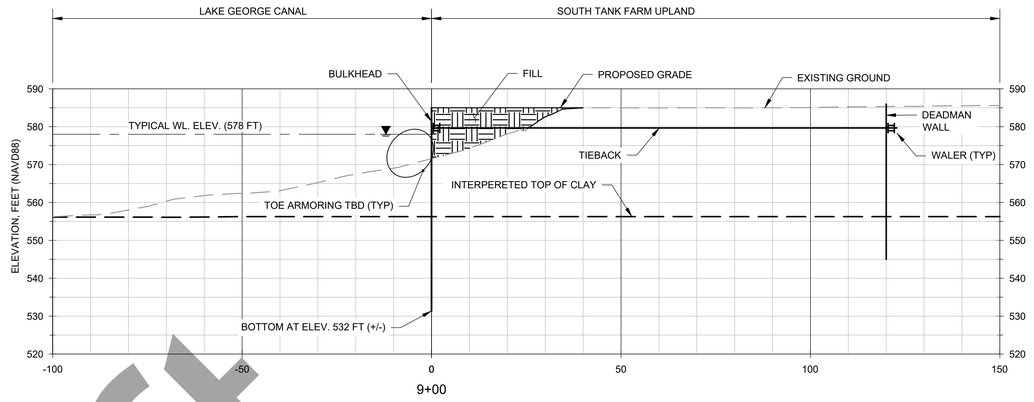

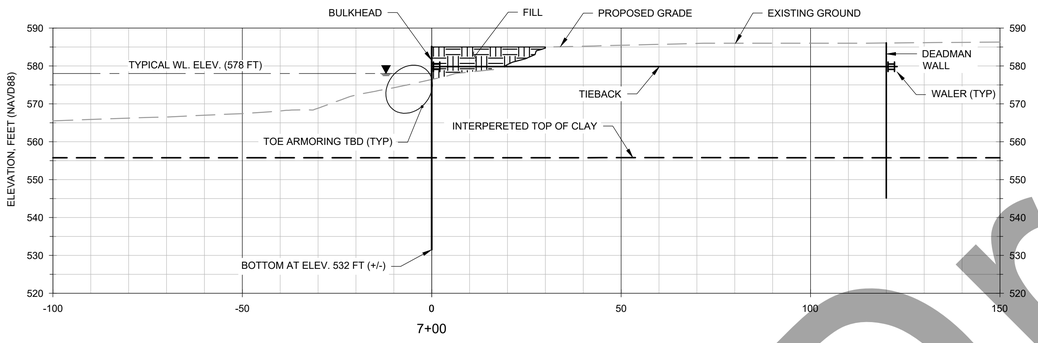

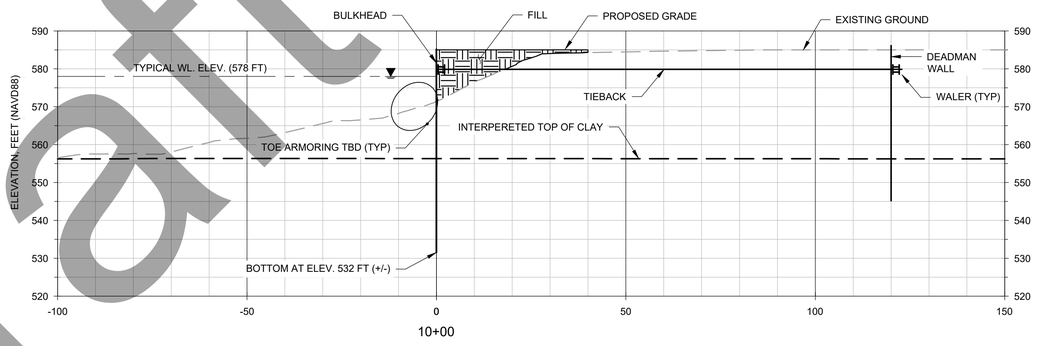

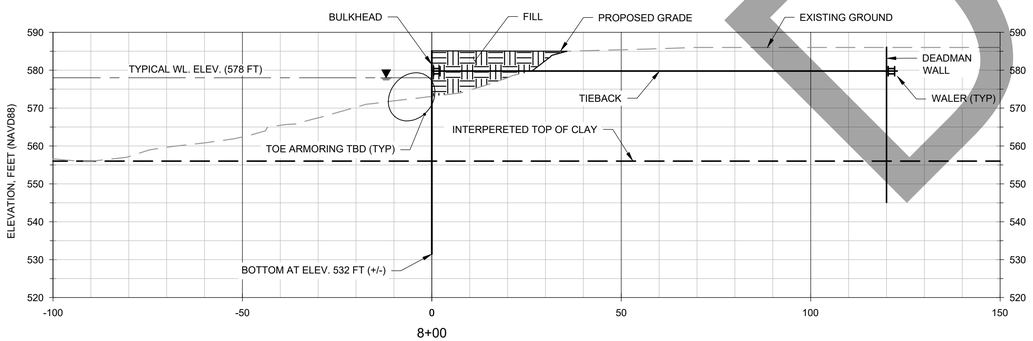

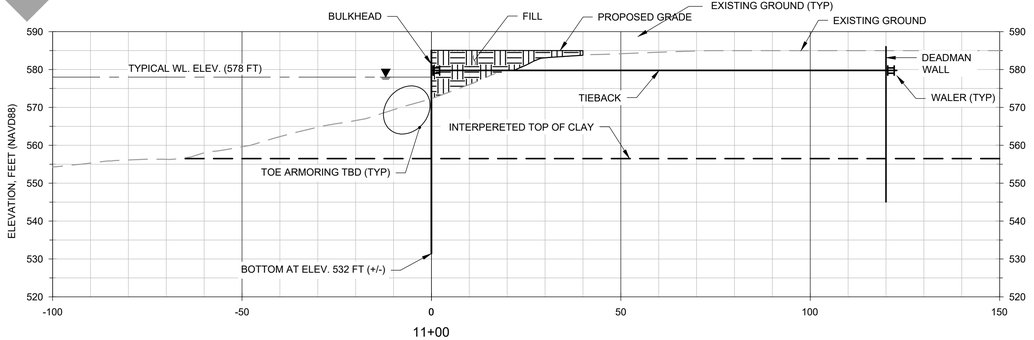

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CLIENT:
ATLANTIC RICHFIELD (ECI)

CURRENT ISSUE STATUS:
30% BASIS OF DESIGN REPORT

PROJECT:
OIL CONTROL BARRIER AND BANK CONTROL DESIGN (ARCO - ECI SITE)
EAST CHICAGO, IN

P:\Projects\ECI\13 Design\13 Cont\REITSC-402

REV	DATE
B	12-20-19
A	11-18-19

30% DRAFT - USEPA REVIEW
30% DRAFT - CLIENT REVIW
REVISION/ISSUE DESCRIPTION

PROJECT NUMBER:	3205191698
PROJECT MANAGER:	DT
A/E OF RECORD:	BBJ
DRAWN BY:	BRT
CAD FILE:	C-402

TITLE:
STF BARRIER WALL CROSS-SECTION STA 6+00 TO 11+00

DRAWING NO:
C-402

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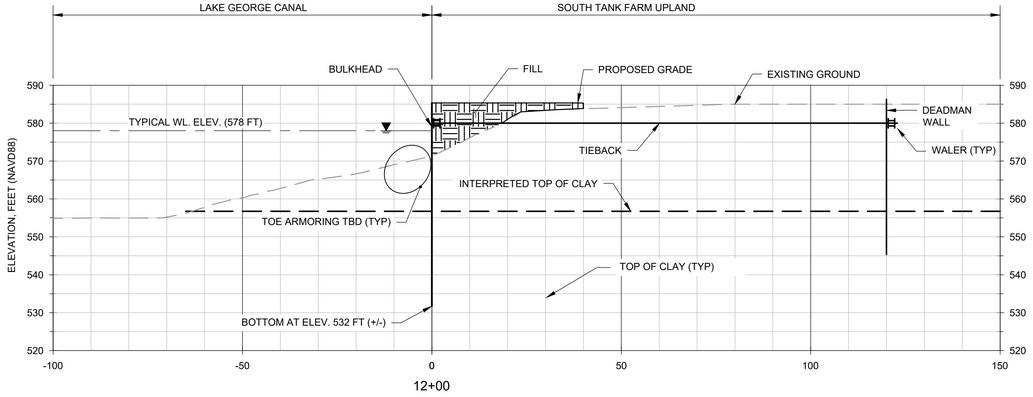

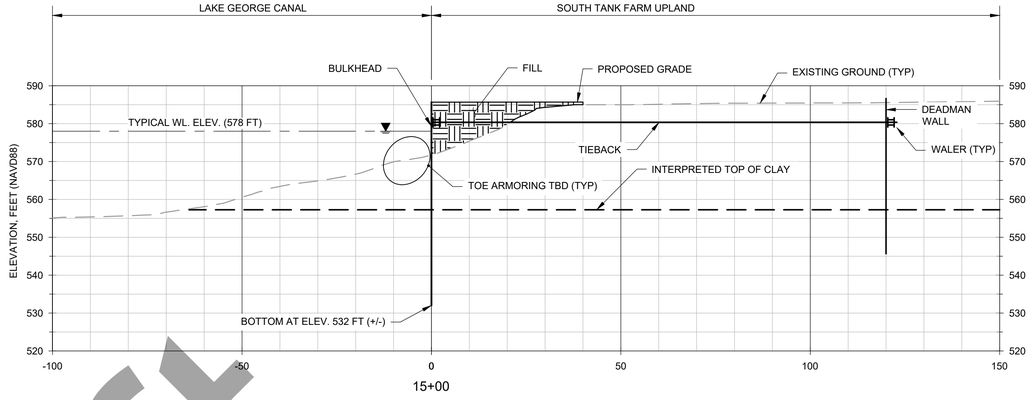

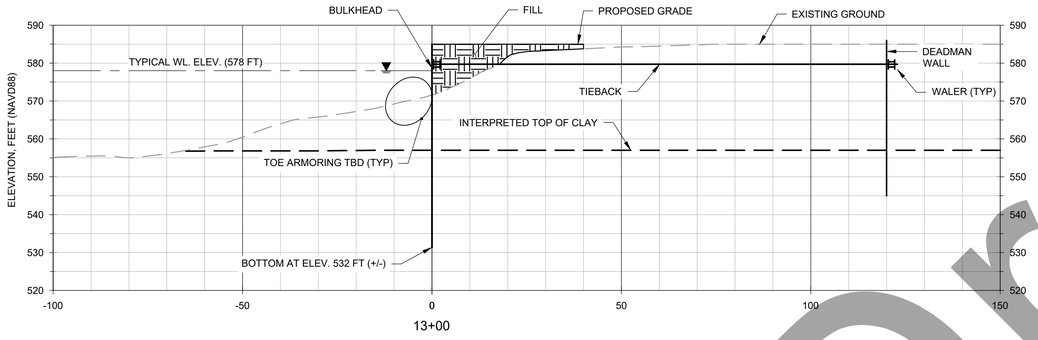

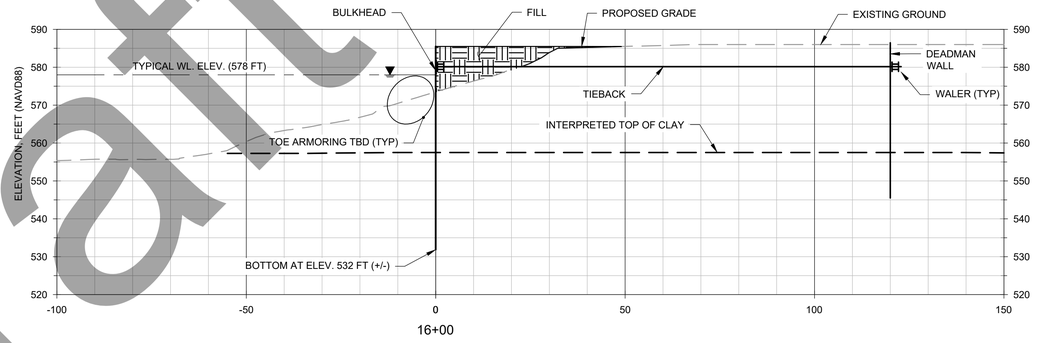

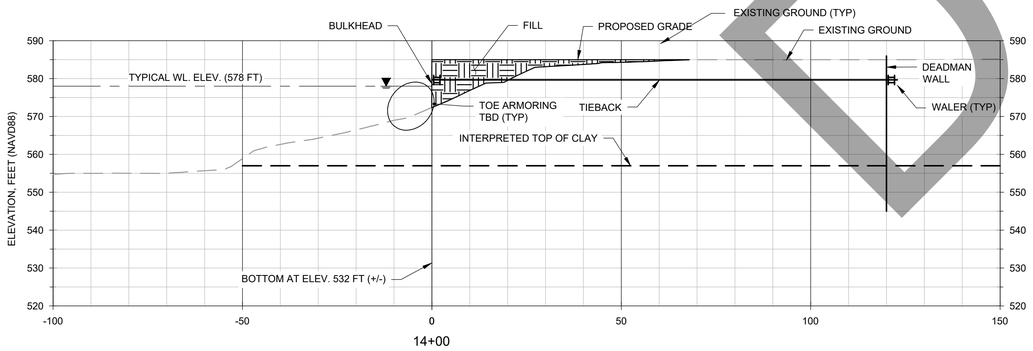

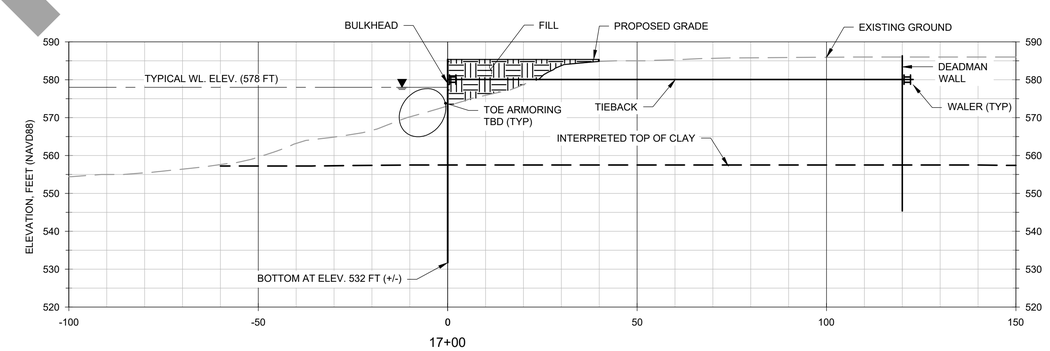

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CLIENT:
ATLANTIC RICHFIELD (ECI)

CURRENT ISSUE STATUS:
30% BASIS OF DESIGN REPORT

PROJECT:
OIL CONTROL BARRIER AND BANK CONTROL DESIGN (ARCO - ECI SITE)
EAST CHICAGO, IN

P:\Projects\ECI\13 Design\14 Cont\REITEC-403

REV	DATE
B	12-20-19
A	11-18-19
	REVISION/ISSUE DESCRIPTION
	30% DRAFT - USEPA REVIEW
	30% DRAFT - CLIENT REVIEW

PROJECT NUMBER:	3205191698
PROJECT MANAGER:	DT
A/E OF RECORD:	BBJ
DRAWN BY:	BRT
CAD FILE:	C-403

TITLE:
STF BARRIER WALL CROSS-SECTION STA 12+00 TO 17+00

DRAWING NO:
C-403

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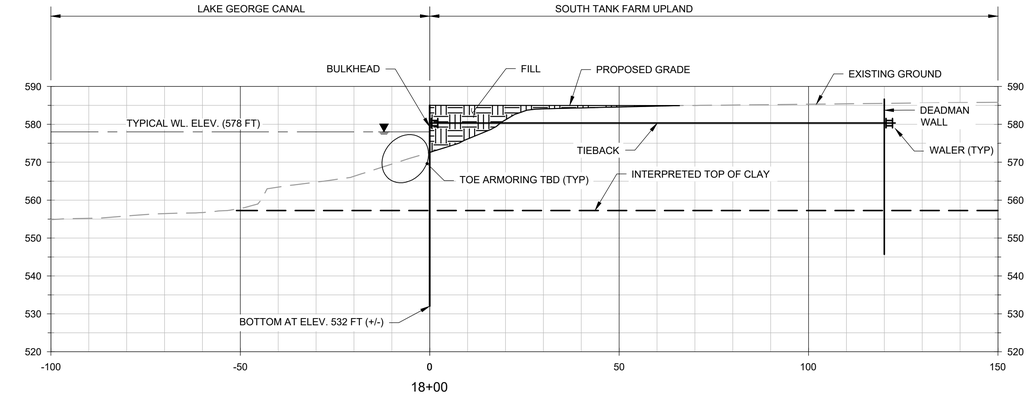

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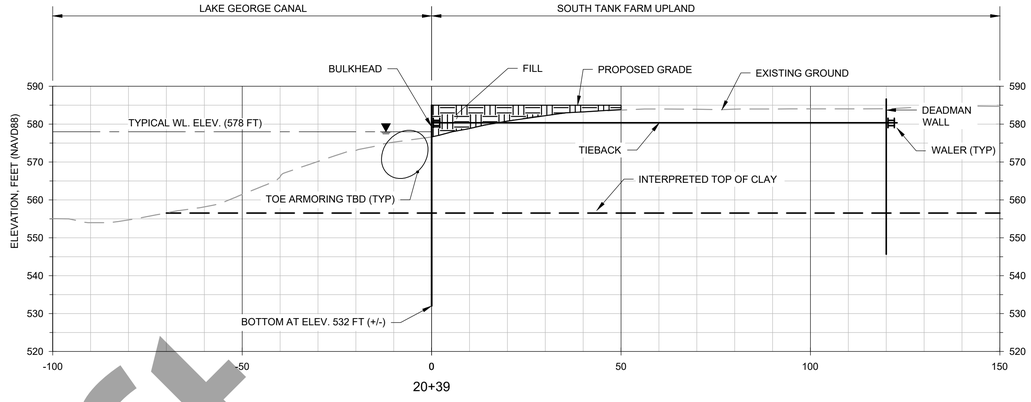
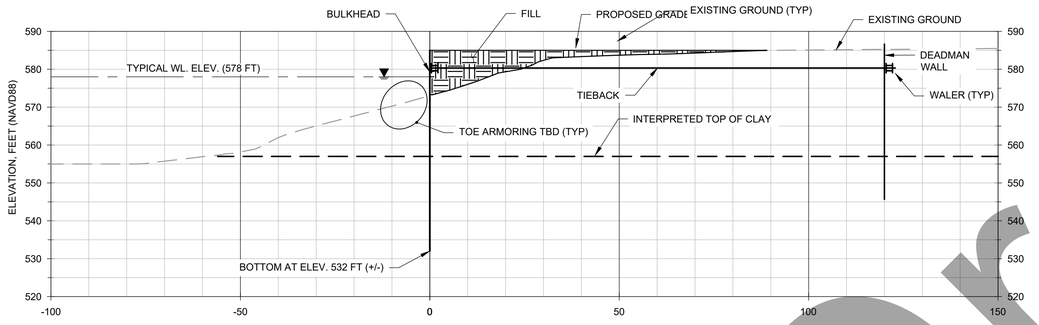


20+39



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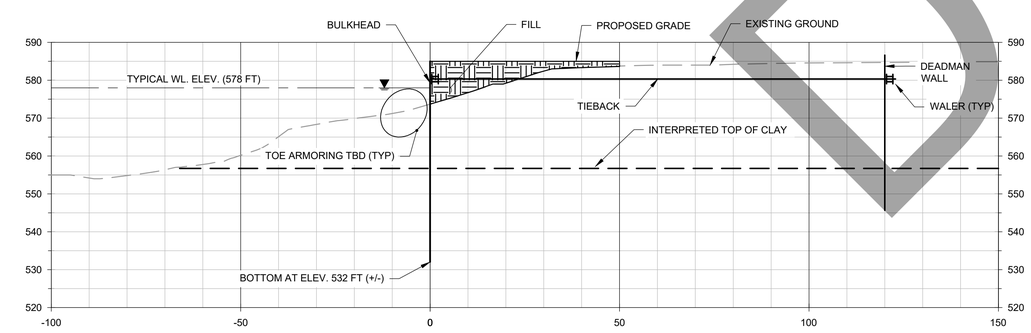

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CLIENT:
ATLANTIC RICHFIELD (ECI)

CURRENT ISSUE STATUS:
30% BASIS OF DESIGN REPORT

PROJECT:
OIL CONTROL BARRIER AND BANK CONTROL DESIGN
(ARCO - ECI SITE)
EAST CHICAGO, IN

P:\Projects\EC014 Design\14 Cad\Sheets\TSC-404

REV	REVISION/ISSUE DESCRIPTION	DATE
B	30% DRAFT - USEPA REVIEW	12-20-19
A	30% DRAFT - CLIENT REVIEW	11-18-19

PROJECT NUMBER: 3205191698
PROJECT MANAGER: DT
A/E OF RECORD: BBJ
DRAWN BY: BRT
CAD FILE: C-404

TITLE:
STF BARRIER WALL
CROSS-SECTION STA
18+00 TO 20+39

DRAWING NO:
C-404

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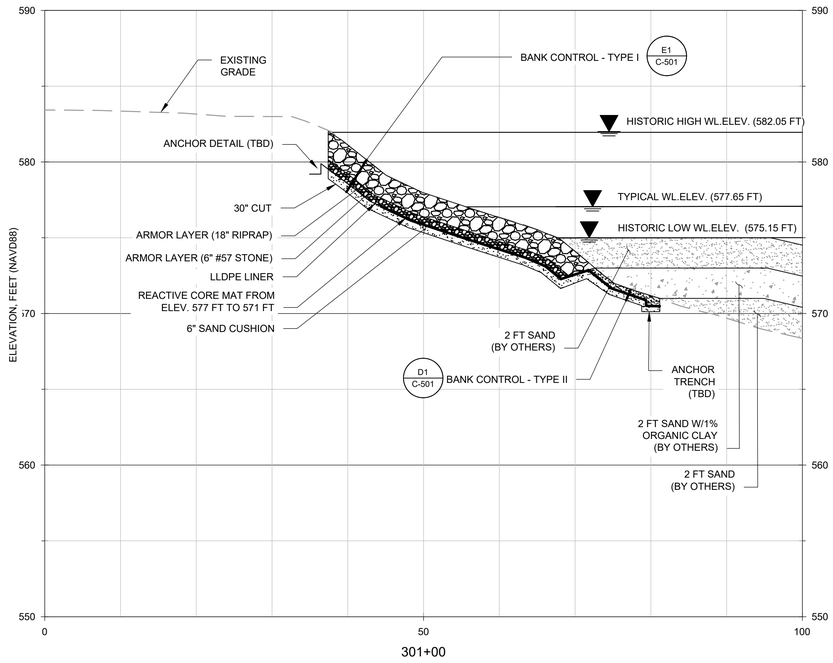

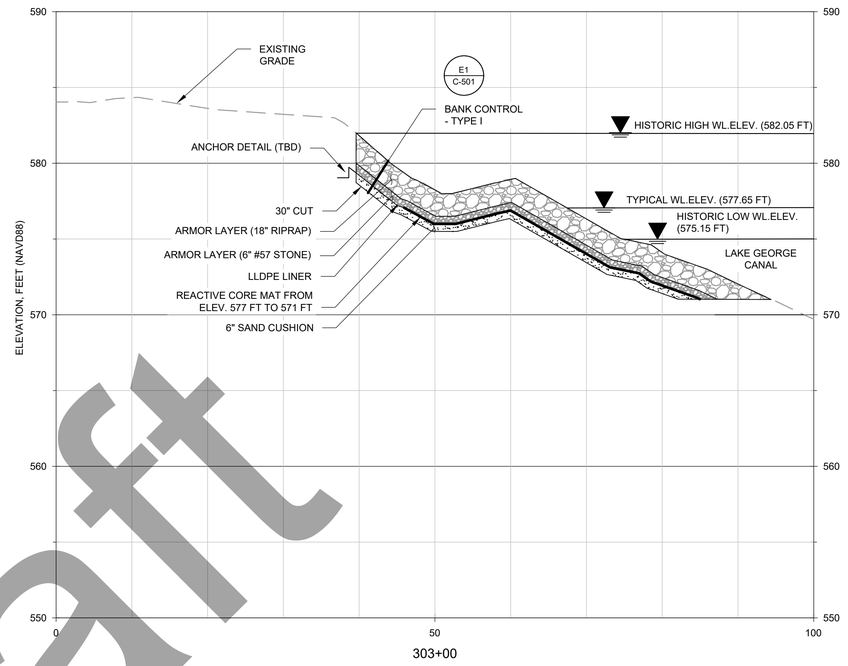

ADDITIONAL CROSS-SECTIONS WILL BE INCLUDED IN THE 60% SUBMISSION

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CLIENT:
ATLANTIC RICHFIELD (ECI)

CURRENT ISSUE STATUS:
30% BASIS OF DESIGN REPORT

PROJECT:
OIL CONTROL BARRIER AND BANK CONTROL DESIGN
(ARCO - ECI SITE)
EAST CHICAGO, IN

P:\Projects\PCOU\Design\14 Civil\SHEETS\C405

REV	DATE
B	12-20-19
A	11-18-19

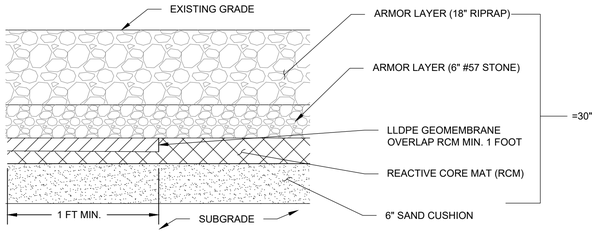
REVISION ISSUE DESCRIPTION
30% DRAFT - USEPA REVIEW
30% DRAFT - CLIENT REVIEW

PROJECT NUMBER: 3205191698
PROJECT MANAGER: DT
A/E OF RECORD: BBJ
DRAWN BY: BRT
CAD FILE: C-405

TITLE:
WTF BANK CONTROL CROSS-SECTION

DRAWING NO:
C-405

NOT FOR CONSTRUCTION



E1 TYPE I BANK CONTROL

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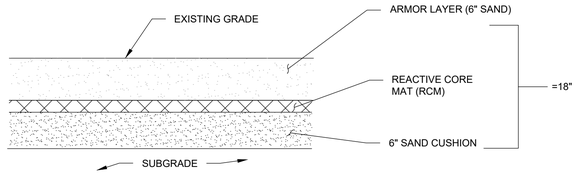

D1 TYPE II BANK CONTROL

NOT TO SCALE

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CLIENT: ATLANTIC RICHFIELD (ECI)

CURRENT ISSUE STATUS: 30% BASIS OF DESIGN REPORT

PROJECT: OIL CONTROL BARRIER AND BANK CONTROL DESIGN (ARCO - ECI SITE)
EAST CHICAGO, IN

P:\Projects\ECI\13 Design\13 Cad\SHEETS\C501

REV	REVISION ISSUE DESCRIPTION	DATE
B	30% DRAFT - USEPA REVIEW	12-20-19
A	30% DRAFT - CLIENT REVIEW	11-18-19

PROJECT NUMBER:	3205191698
PROJECT MANAGER:	DT
A/E OF RECORD:	BBJ
DRAWN BY:	BRT
CAD FILE:	C-501

TITLE: CIVIL DETAILS

DRAWING NO: C-501

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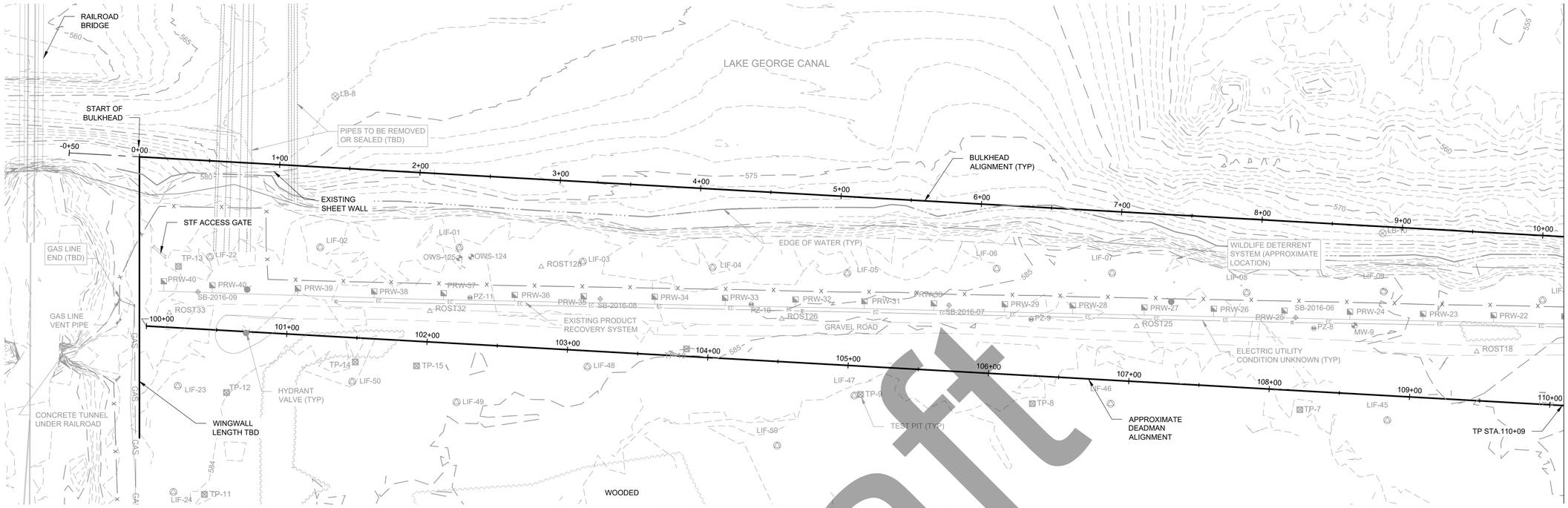
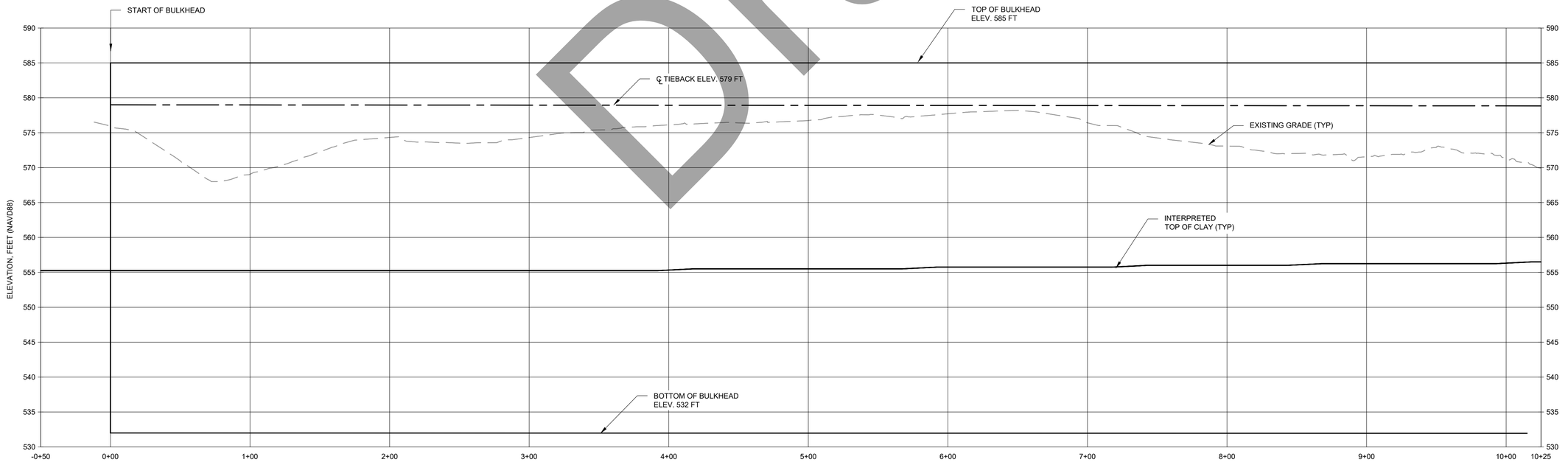


1 PLAN VIEW OF BARRIER WALL STF (NW)

0 20 40 80
HORIZONTAL SCALE IN FEET



2 PROFILE VIEW OF BARRIER WALL STF (NW)

0 20 40 80
HORIZONTAL SCALE IN FEET

0 4 8 16
VERTICAL SCALE IN FEET

NOTE:

INTERPRETED TOP OF CLAY BASED ON SB-2016 BORINGS BY ARCADIS (2016).

DRAFT

Draft

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CLIENT: ATLANTIC RICHFIELD (ECI)

CURRENT ISSUE STATUS: 30% BASIS OF DESIGN REPORT

PROJECT: OIL CONTROL BARRIER AND BANK CONTROL DESIGN (ARCO - ECI SITE) EAST CHICAGO, IN

P:\Projects\EC01\Design\14 Cad\BRETB\S-101

REV	DATE
B	12-20-19
A	11-18-19

30% DRAFT - USEPA REVIEW
30% DRAFT - CLIENT REVIEW
REVISION/ISSUE DESCRIPTION

PROJECT NUMBER:	3205191698
PROJECT MANAGER:	DT
A/E OF RECORD:	BBJ
DRAWN BY:	BRT
CAD FILE:	S-101

TITLE: BARRIER WALL PLAN AND PROFILE - STF (NW)

DRAWING NO: S-101

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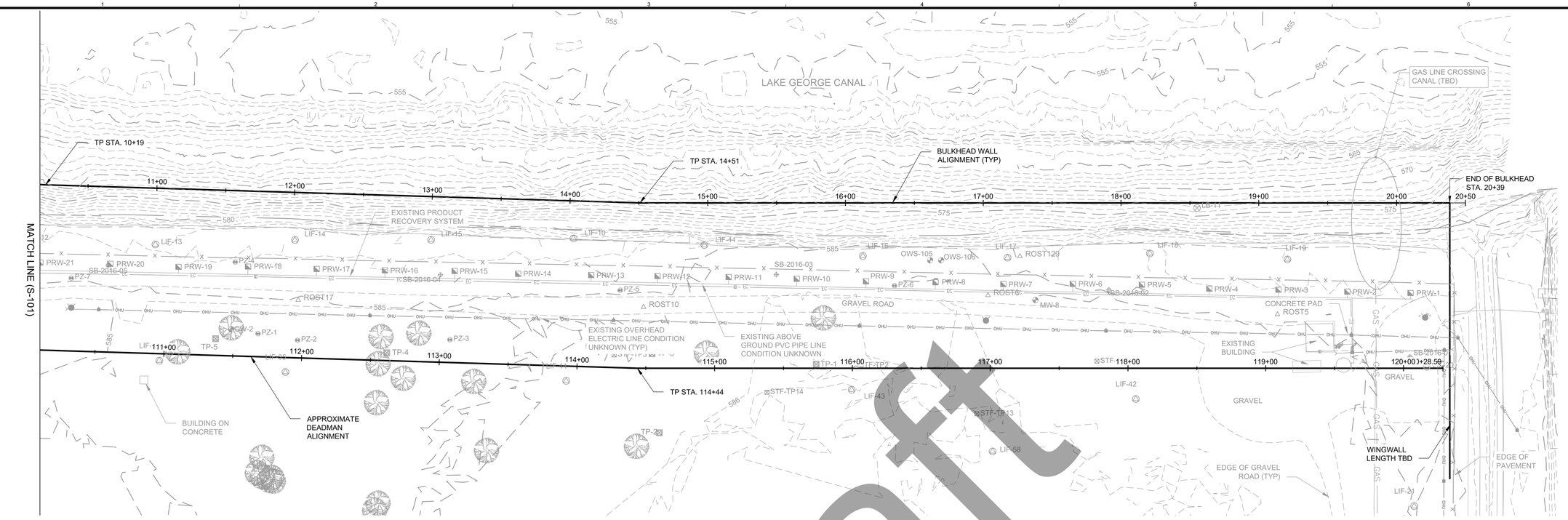
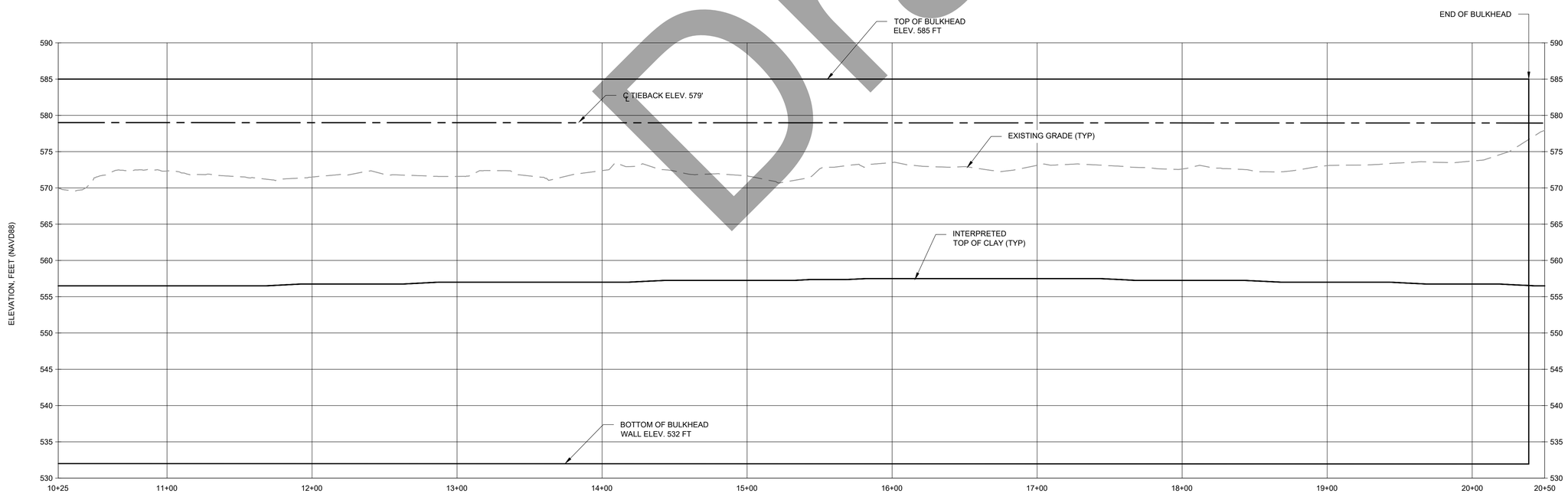


1 PLAN VIEW OF BARRIER WALL STF (NE)

0 20 40 80
HORIZONTAL SCALE IN FEET



2 PROFILE VIEW OF BARRIER WALL STF (NE)

0 20 40 80
HORIZONTAL SCALE IN FEET
0 4 8 16
VERTICAL SCALE IN FEET

NOTE:

INTERPRETED TOP OF CLAY BASED ON SB-2016 BORINGS BY ARCADIS (2016).

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CLIENT: ATLANTIC RICHFIELD (ECI)

CURRENT ISSUE STATUS: 30% BASIS OF DESIGN REPORT

PROJECT: OIL CONTROL BARRIER AND BANK CONTROL DESIGN (ARCO - ECI SITE) EAST CHICAGO, IN

P:\Projects\EC\S1\Design\1 Cad\BRET\S-102.dwg

REV	REVISION/ISSUE DESCRIPTION	DATE
B	30% DRAFT - USEPA REVIEW	12-20-19
A	30% DRAFT - CLIENT REVIEW	11-18-19

PROJECT NUMBER:	3205191698
PROJECT MANAGER:	DT
A/E OF RECORD:	BBJ
DRAWN BY:	BRT
CAD FILE:	S-102

TITLE: BARRIER WALL PLAN AND PROFILE STF (NE)

DRAWING NO: S-102

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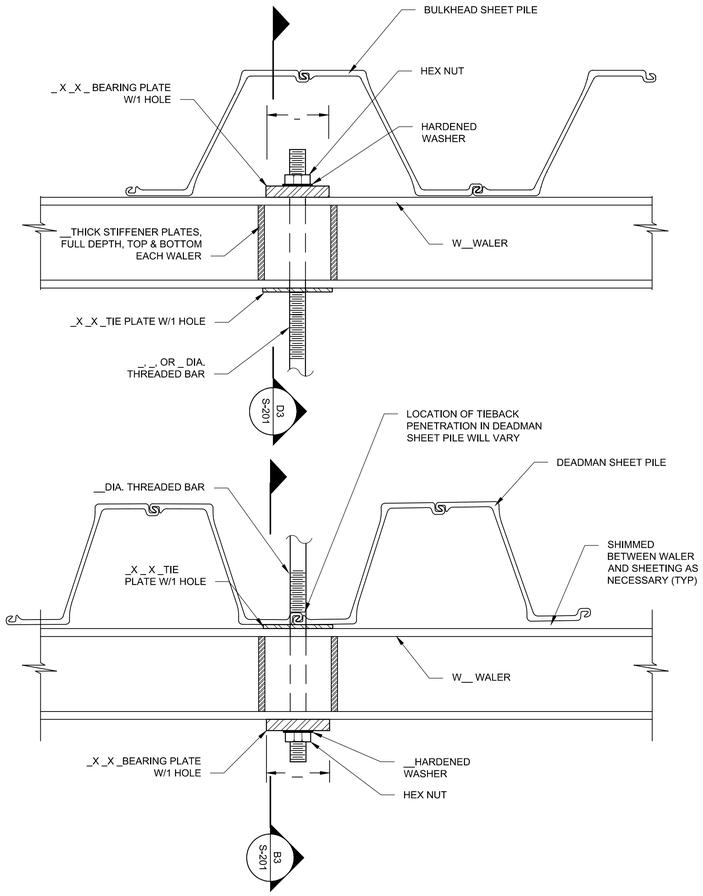
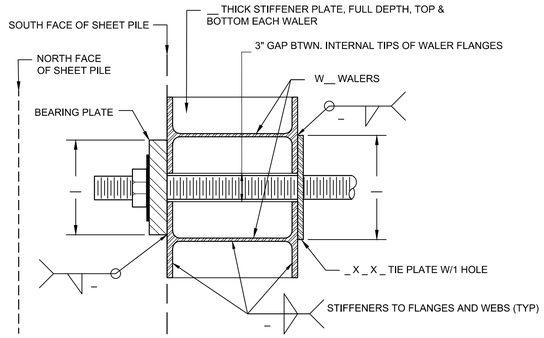
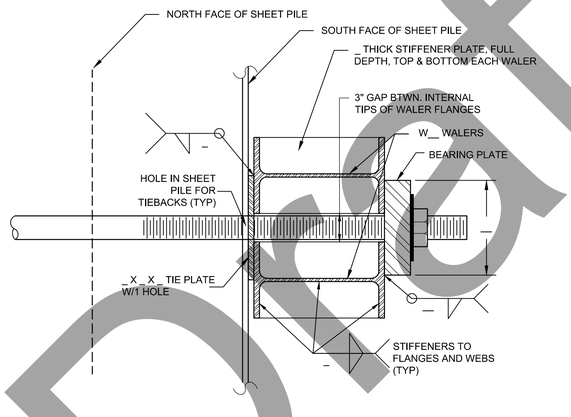




D3 SECTION

1 1/2" = 1' - 0"

0 6" 1"



B1 TIEBACK CONNECTIONS

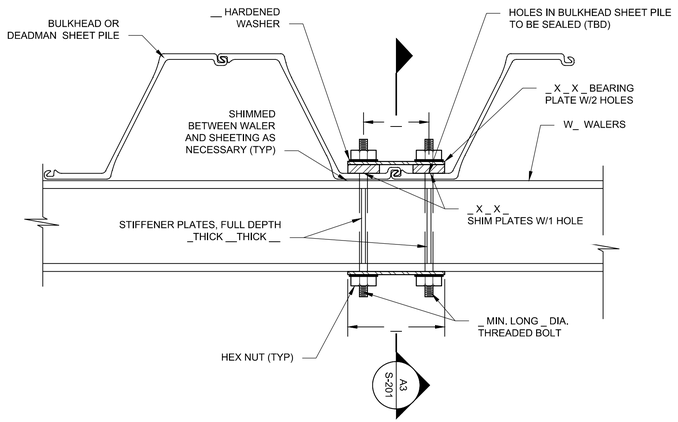
1" = 1' - 0"

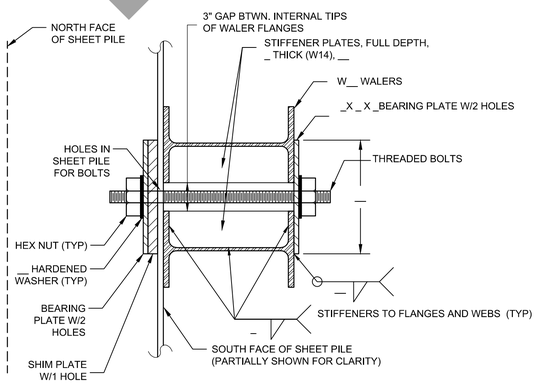
0 6" 1' 2'

B3 SECTION

1 1/2" = 1' - 0"

0 6" 1"





A1 SHEET PILE TO WALER CONNECTION

1" = 1' - 0"

0 6" 1' 2'

A3 SECTION

1 1/2" = 1' - 0"

0 6" 1"

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CLIENT: ATLANTIC RICHFIELD (ECI)

CURRENT ISSUE STATUS: 30% BASIS OF DESIGN REPORT

PROJECT: OIL CONTROL BARRIER AND BANK CONTROL DESIGN (ARCO - ECI SITE) EAST CHICAGO, IN

P:\Projects\ECO\1\Design\1 Cad\Bid\[Title]s201

REV	REVISION/ISSUE DESCRIPTION	DATE
B	30% DRAFT - USEPA REVIEW	12-20-19
A	30% DRAFT - CLIENT REVIEW	11-18-19

PROJECT NUMBER:	3205191698
PROJECT MANAGER:	DT
A/E OF RECORD:	BBJ
DRAWN BY:	BRT
CAD FILE:	S-201

TITLE: BARRIER WALL DETAILS I

DRAWING NO: S-201

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