Geotechnical Baseline Report for 30% Design

Mid Barataria Diversion (BA-153)
Plaquemines Parish, Louisiana

for

HDR Engineering, Inc.

February 7, 2014

GeoEngineers
Earth Science + Technology

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Mid Barataria Diversion Project (BA-153)
Plaquemines Parish, Louisiana

LDNR Contract No. 2503-13-59, Task No. 3

File No. 18274-001-00

February 7, 2014

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MLR:VT:DSE:CLE:lb

Table of Contents

INTRODUCTION

This report provides a geotechnical interpretation of data collected for the Mid Barataria Diversion (MBD) Project (BA-153) 30% design in accordance with the scope of services presented in the Office of Coastal Protection and Restoration Authority (CPRA) task order 0300 under the LADNR Contract No. 2503-13-59 and our proposal dated January 29, 2013 (Phase 1 scope of services only). GeoEngineers, Inc. (GeoEngineers) is subcontracted to HDR, Inc. (HDR) for the MBD project. The MBD is a large-scale, long-term Mississippi River diversion structure project recommended for implementation in Louisiana's Comprehensive Master Plan for a Sustainable Coast. The project is located near Myrtle Grove in Plaquemines Parish, Louisiana (Figure 1).

Previous work performed by GeoEngineers included a study and review of available geologic information. This work was completed in the early part of 2013 and helped establish the basis for our 30% design scope. Previous studies were presented in our "Report of Existing Geotechnical Data" dated May 22, 2013 (re-issued with additional information on January 17, 2014).

Information regarding the data obtained for this project and a description of the field activities is provided in our "Geotechnical Data Report for 30% Design" dated January 24, 2014.

This report contains a general geologic history section, site plans with soil boring locations, interpreted geologic subsurface profiles, geotechnical strength profiles, pump test results, vibrating wire piezometer data, and a summary of consolidation test curve reconstruction.

PROJECT AND SITE UNDERSTANDING

The MBD project is a large scale, engineered river diversion that will restore the natural over-land flooding cycle of the Mississippi River and Tributaries (MR&T). The MBD project will consist of the following elements as shown on Figure 2:

1. A diversion structure consisting of a channel into the Mississippi River and through the MR&T levee with levee tie-ins and gates to control flow.
2. A conveyance channel approximately 8,000 feet long with guide levees (conveyance complex) that extends west from the diversion structure to the existing back levee at the western edge of the agricultural land between the two levees. The existing back levee is currently being rebuilt to meet federal levee standards.
3. A storm surge protection structure at the back levee to prevent storm surges from entering the conveyance channel.
4. A new pump station located about 5,500 feet northwest of the diversion complex near the back levee.
5. An outfall area west of the back levee where sediment diverted from the Mississippi River will settle.
6. A new Louisiana Highway 23 (LA 23) bridge to span the conveyance complex.

7. A new railroad bridge to extend an existing railroad spur that will cross the conveyance complex.

All the site design features together are referred to as the diversion complex in this report.

As shown on Figure 2, the surficial geology of the site is complex and reflects the different subsurface soil conditions across the project site. The scope of work for the 30% design exploration program was developed based on design requirements for each structure (at the time of scoping) and expected geologic conditions shown on Figure 2. The intent of the 30% design geotechnical explorations was to evaluate subsurface soil conditions and provide design soil parameters. Figure 2 also presents the project stationing and the topography across the project area.

For the 30% design exploration program, the geotechnical investigation focused on soil conditions at the diversion structure, the conveyance complex, the storm surge protection structure and the Barataria Bay marsh. We did not investigate the LA 23 overpass, the rail overpass, or the pump station in the 30% geotechnical investigation. At the time of the investigation the location of these features had not yet been determined, and was likely to change based on the 30% design for the diversion complex. Figure 3 shows all the field investigation locations known to exist at the time of this report that are relevant to this project. Detailed information, including soil boring logs and test data, was provided in the Report of Existing Geotechnical Data previously issued.

SITE DESCRIPTION

The diversion complex is bounded on the east by the Mississippi River and on the west by the Barataria Bay marsh. Within these limits the diversion complex alignment crosses LA 23 at approximate Station (Sta.) 65+00. LA 23 is a 4-lane divided highway that extends south to Venice, Louisiana and is the primary evacuation route for Plaquemines Parish. East of LA 23 to the MR&T levee the site is forested. West of LA 23 to the back levee, the site is predominantly agricultural fields that are currently used for livestock grazing. A railroad spur runs along the protected toe (west side) of the MR&T levee.

The natural site grade gently slopes from the Mississippi River where the ground elevation is approximately +5 feet, based on the North American Vertical Datum of 1988 (NAVD 88), to the western edge of the agricultural fields, where the ground elevation is approximately -5 feet. All precipitation that falls between the MR&T and back levees is contained within this area and has to be removed by pumping. Drainage flows through man made shallow swales and ditches spaced at regular intervals throughout the fields to a drainage ditch that parallels the back levee along its eastern edge. A pump station located to the south of the project area pumps water from this ditch to Barataria Bay. The proposed diversion complex will block southward flow in this ditch to the existing pump station; therefore, a new pump station will be required north of the diversion complex to remove drainage water. Generally paralleling the back levee on the west (marsh) side there is a pipeline. This pipeline is shown on Figure 3.

The surficial soils become progressively softer and more difficult for equipment access towards the back levee. Below the shallow surface layer of grass and a thin crust of drier soil, the underlying saturated soils are soft. The lower ground elevations and subsurface soil conditions (described below) result in the very soft to soft clay and organic soil remaining saturated.

MBD SITE GEOLOGY

In the MBD project area, the USACE mapped the site into four major geomorphologic areas. A detailed description of the site geologic history and geologic formations is included in the January 24, 2014 Geotechnical Data Report for 30% Design. Given below are project station numbers for the approximate extent of the geomorphologic areas as noted along the centerline of the diversion complex (Figure 4):

1. Point Bar (Sta. 0+00 to Sta. 49+00)
2. Abandoned Distributary Channel (Sta. 52+00 to 60+00; Sta. 77+00 to Sta. 82+00)
3. Interdistributary/Intradelta (Sta. 49+00 to Sta. 52+00; Sta. 60+00 to Sta. 77+00; Sta. 82+00 to Sta. 93+00)
4. Marsh/backland area (Sta. 93+00 and west)

The following geologic and geomorphic descriptions are based on soil borings, laboratory testing and available information for the 30% design. Additional explorations are being planned for the 60% design phase to better delineate the limits of these deposits. The limits described are approximate and will be revisited as additional data becomes available during the 60% design phase. The paragraphs below discuss the MBD site geology as estimated along the centerline of the diversion complex based on the 30% design phase explorations and published literature. Descriptions of the individual soil units are provided in the subsequent report section.

Point Bar (Sta. 0+00 to Sta. 49+00)

The eastern portion of the MBD project site lies within an inside bend of the present Mississippi River (Figure 2). From the ground surface to an approximate elevation of -10 feet (EL -10 feet) natural levee deposits are present. Beneath the natural levee deposits, point bar deposits extend to approximately EL -132 feet. Underlying the point bar deposits are Pleistocene deposits to the extent explored. The MR&T levee is built over this point bar area at Sta. 28+00 and has a crown elevation of approximately +15.5 feet.

As shown on Figure 4, the soil between approximately EL -5 feet to EL -30 feet encountered in exploration NL-9A is not representative of typical point bar deposits. This exploration encountered more soft clay with interbedded silt and silty sand layers which are characteristic of deposits within the abandoned distributaries. Due to the apparent disparity between the USACE mapped geologic units and our explorations, additional investigation is recommended in this area for the 60% design.

Abandoned Distributary Channels (Sta. 52+00 to Sta. 60+00; Sta. 77+00 to Sta. 82+00)

The USACE surficial geology map indicates two abandoned distributary channels within the conveyance complex as shown on Figure 4. Soil borings advanced within the mapped abandoned channels encountered soil consistent with descriptions from previous studies. Specifically, the abandoned distributary deposits consist of zones of layered soft clay and loose silty sand, silt and clayey silt.

Natural levee deposits overlie the abandoned distributary channels. The abandoned distributary channels are underlain by (in stratigraphic order) interdistributary/intradelta deposits, prodelta deposits, and Pleistocene deposits. In the soil boring performed in the east channel, a thin layer of near shore gulf deposits was encountered directly over the Pleistocene deposits.

The east abandoned distributary channel has been mapped by the US Army Corps of Engineers (USACE) as being about 800 feet wide from Sta. 52+00 to Sta. 60+00, however exploration (NL-12C suggests that the channel may extend farther east. Explorations indicate the bottom of the abandoned distributary extends to approximately EL -43 feet. The western channel is mapped to be about 500 feet wide, and current explorations indicate it may extend to approximately EL -43 feet.

Since there is uncertainty regarding the limits of the abandoned distributary channels, both the lateral limits and depths of these channels should be investigated further in the 60% design phase exploration program.

Interdistributary/Intradelta (Sta. 49+00 to Sta. 52+00; Sta. 60+00 to Sta. 77+00; Sta. 82+00 to Sta. 93+00)

As shown on Figure 4, the USACE surficial geology map indicates that the interdistributary/intradelta deposits extend from approximately Sta. 49+00 to Sta. 52+00, Sta. 60+00 to Sta. 77+00 and Sta. 82+00 to Sta. 93+00 and are overlain by natural levee deposits. Based on our interpretation of explorations for the 30% design, interdistributary/intradelta deposits were observed in all explorations located west of Sta. 49+00. These deposits were overlain by natural levee and/or abandoned distributary deposits approximately between Sta. 49+00 and 93+00 and marsh deposits west of Sta. 93+00. In general, the interdistributary/intradelta deposits were found to exist typically between EL -5 feet to EL -40 feet west of Sta. 49+00.

Prodelta deposits were encountered below the interdistributary/intradelta deposits to approximately EL -110 feet. Approximately from Sta. 49+00 to Sta. 68+00 and Sta. 93+00 to Sta. 137+00, the prodelta deposits overlay a layer (less than 10 feet) of near shore gulf deposits which overlies Pleistocene deposits. Approximately from Sta. 68+00 to Sta. 93+00, prodelta deposits were directly overlaying the Pleistocene deposits.

Marsh/Backland (Sta. 93+00 and west)

Marsh deposits were observed in the western portion of the project area overlying the interdistributary/intradelta deposits. The thickness of the marsh deposits varied from 5 to 15 feet in the soil borings.

West of the back levee in the open marsh areas of Barataria Bay, the organic content increased with distinct layers of peat and organic clay identified in our soil boring logs.

SUBSURFACE SOIL CONDITIONS

The subsurface soil conditions described below are based on limited data within a complex geology. Certain areas, such as the point bar, are typically quite variable naturally, and with the limited investigation completed for the 30% design, there is uncertainty regarding the consistency and extent of the subsurface conditions described below. All descriptions should be considered preliminary and are based only on the limited soil borings and data available at this time.

Figures showing GeoEngineers interpretation of soil moisture content, strength, and density are included in Appendix A for every exploration location completed by GeoEngineers. Figures 4 and 5 are visual representations of the subsurface soil stratigraphy based on our investigation.

Point Bar (Sta. 0+00 to Sta. 49+00)

Our soil borings identified that there is variability in both the type and consistency of soil within the point bar area. Figure 4 is a soil section along the diversion complex project centerline, and Figure 5 is a soil section along the MR&T levee centerline. The eastern portion of Figure 4, from Sta. 0+00 to Sta. 49+00, and all of Figure 5 show soil conditions based on our soil borings within point bar deposits. As shown on these figures, there is tremendous variability within the point bar area. In general, sand is more prevalent towards the river, and contains less silt and clay towards the river, with the river soil borings encountering predominantly fine, poorly graded sand.

Starting at the ground surface and going down, natural levee deposits consisting predominantly of clay with layers of silty clay and silt are present from the ground surface (EL +2 feet to EL +6 feet) down to approximately EL -10 feet to EL -15 feet. Exceptions to this include fill placed for the levee over the natural levee soil and in the river where the natural levee this layer does not exist. In general, natural levee clay deposits have a thin (1 foot to 5 feet thick) "crust" layer of medium, to stiff, desiccated clay (greater than 500 pounds per square foot [psf] shear strength) at the ground surface, that becomes very soft, to soft, below the crust. The MR&T levee fill typically is medium consistency clay (approximately 600 psf shear strength). Natural clay beneath MR&T levees typically has a soft to medium consistency, which is slightly stronger than natural levee clay without the MR&T levee fill overburden.

Within the point bar area beneath natural levee deposits, interbedded silt, clay, and sand layers are present. Each different layer typically contains all three grain sizes (i.e. silt, clay and sand), and variations in content determine the predominant soil type. The point bar soil beneath the natural levee is predominantly silty or sandy; however, there are exceptions. Soil borings PZ-7, PZ-12, and IS-13A, and the upper portion of soil boring NL-9A encountered predominantly clay. Soil boring NL-9A may have been influenced by an abandoned distributary channel as will be discussed in the next section; however, it is not clear why the other borings have so little silt and sand even though they seem to be within the geologically mapped point bar, as verified by surrounding soil borings. Silt and sand higher in the point bar profile are typically very loose to loose, and the clay is soft, and the density and strength increase with depth.

As shown on Figure 4 the transition from point bar deposits to underlying prodelta or Pleistocene clay is not at a constant elevation. Towards the western point bar limits, the transition represents the western-most edge of the historic Mississippi River channel and has a geometry consistent with the river channel in this area thousands of years ago. In the lower elevation portion of the point bar, on top of the older Pleistocene deposits, poorly graded sand with little silt or clay is present. This sand, due both to minimal clay/silt content and the pressure of overburden soil, typically has a dense to very dense consistency.

The Pleistocene clay underlying the point bar deposits is overconsolidated with a stiff to hard consistency (shear strength typically in excess of 1,000 psf).

Abandoned Distributary Channels (Sta. 52+00 to Sta. 60+00; Sta. 77+00 to Sta. 82+00)

The abandoned distributary channels mapped by the USACE as shown on the plan view portion of Figure 4 in gray, appear to be consistent with the highly variable layered soil encountered beneath the natural levee clay deposits in soil borings NL-6A and NL8-A. Thin layers of sand, silt, and clay (1 foot to 5 feet thick) with variable soft to stiff consistency (250-1,000 psf shear strength) are typical with higher strengths in some instances. We interpret these interdistributary channel fills are present from approximately EL -9.0 feet to EL -42.0 feet in soil boring NL-6A, and from EL -12.5 feet to EL -33.0 feet in soil boring NL-8A. What has not been established at this 30% design level is the lateral extent of these channels.

The eastern-most abandoned distributary channel is shown on Figure 4 in the plan view as having a width of approximately 700 feet; however, the soil present above EL -28.6 feet in NL-8A isn't as silty/sandy as would be expected for point bar deposits, and the silt and sand layers above EL -45 feet in NL-12C are more than might be expected for interdistributary/intradelta deposits. One possible explanation is that the abandoned distributary channel may have influenced a broader area than shown on the plan view. From a geological time frame perspective this doesn't seem likely, but more investigation is warranted in this area of uncertainty as shown on the Figure 4 soil section to better define point bar and abandoned distributary channel limits.

Point Bar to Back Levee (Sta. 49+00 to Sta. 140+00)

The soil stratigraphy and strength consistency west of the point bar to the back levee, is similar, with the exception of the change in the top 10 to 15 feet of the soil profile from natural levee deposits to marsh deposits in the vicinity of Sta. 93+00. These surficial soil deposits transition gradually so that there is no sudden change in soil conditions.

Natural levee deposits consisting predominantly of clay with some silt and sand layers continue west of the point bar and gradually transition to marsh deposits. Natural levee and marsh deposits are similar from a consistency perspective in that they both typically have a thin (1 foot to 5 feet) desiccated crust of soil with medium (500 psf) or better shear strength, with underlying very soft to soft clay. The difference between the two deposits is that natural levee soils tend to be a bit stronger, have low organic content, and lower moisture content (typically less than 50%). West of Sta. 93+00 the marsh soil in the top 10 to 15 feet of the soil profile (shown as marsh on Figure 4) is typically weaker, has higher moisture content (greater than 50%), and organic clay and peat layers are more evident further west.

Beneath the top 10-15 feet of surface natural levee and marsh deposits, interdistributary/intradelta deposits are present to approximately El -35 feet to EL -45 feet. Intradelta deposits, as discussed in the data report are typically coarser deposits (silt and sand) deposited at the mouth of a distributary channel. Sand and silt layers, most likely formed as intradelta deposits are shown on Figure 4. Interdistributary deposits are finer clay deposits that settled between river and distributary channels. Typically, within this interdistributary/intradelta zone, between EL -20 feet and EL -30 feet the soil shear strength starts to gradually increase from the very soft to soft consistency below the surface crust. The increase is generally in proportion to the effective overburden stress, and usually closely approximates 22% of the effective stress, or normally consolidated clay strength.

Below the interdistributary/intradelta deposits, prodelta clay is present. This layer is typically 60 to 75 feet thick and extends down to the Pleistocene clay, or near shore sand over the Pleistocene clay, at approximately EL -115 feet. The shear strength of these deposits is generally normally consolidated and increases with depth as a function of effective overburden stress.

Near shore sand and Pleistocene deposits underlie the prodelta clay. Near shore sands are thin sand layers (less than 5 feet thick) that directly overlie the Pleistocene. Pleistocene deposits are over-consolidated and typically have a stiff to hard consistency with shear strength in excess of 1,000 psf.

Marsh (Sta. 140+00 and west)

West of the back levee, soil conditions are geologically very similar to those previously described from Sta. 93+00 to Sta. 140+00 (the back levee). The main geological difference is that the upper marsh deposits are thicker west of Sta. 140+00 and have more organic layers (peat and organic clay). The high moisture content clay, organic clay, and peat marsh layers typically end between EL -10 feet and EL -15 feet. Beneath the marsh deposits, a similar profile with underlying interdistributary/intradelta deposits followed by Pleistocene deposits is expected. The soil types encountered in the interdistributary/intradelta deposits below the marsh deposits varied significantly from predominantly silt and sand (M-1) to a mix of silt, sand and clay (M-2, M-3, M-4, M-5, M-8, M-12, M-13, M-14, M-15, and M-16), to all clay (M-6, M-7, M-9, M-10, and M-11).

An important difference from an engineering perspective is that the interdistributary/intradelta deposits underlying the marsh deposits appear to be underconsolidated. This is evident both from the shear strength profiles included in Appendix A, and consolidation test results indicating overconsolidation ratios (OCRs) less than one (Appendix B). Clay shear strengths of very soft to soft (less than 500 psf) should be expected as deep as EL -60 feet to EL -80 feet. Sand and silt layers tended to be a bit more variable and stronger with loose to medium dense consistency variations.

With regard to design implications, underconsolidated soil will be expected to settle more than normally consolidated soil, and soil boring locations with predominantly clay profiles are expected to settle slower than locations with silt and sand layers. With the exception of soil boring M-8, generally, more silt and sand was observed in soil borings in the southeastern portion of the marsh investigation area.

Pump Test Results

A detailed evaluation of the pump test results for both PT-1 and PT-2 wells and associated piezometers is included in Appendix C. A surprising finding was the variability in the ability of wells set in what were thought to be point bar deposits, to produce water. Within the closely spaced pumping and monitoring wells surrounding well PT-2, GeoEngineers pumped from four different wells in this cluster with widely varying results as documented in Appendix C. This unexpected variability is consistent with other soil borings in the USACE mapped point bar area and warrants additional investigation.

Water level data for piezometers PZ-13, PZ-14, and PZ-15 is included in Appendix D.

CONSIDERATIONS FOR THE 60% DESIGN PHASE

GeoEngineers offers the following considerations for the 60% design phase.

- There is no site specific information for LA 23 bridge, the railroad bridge, the storm surge protection structure or the pump station. We understand that for the 30% design phase, there was not sufficient information to effectively design an investigation program for these areas.
- There appears to be significant variability in the point bar deposits as evidenced by widely varying soil boring logs and pump test results for the PT-2 well cluster, and soil exploration log variability (for example NL-12C, NL-9A, and IS-13A). More investigation is recommended in this area to better define the;
    - transition from the abandoned distributary channel to the point bar,
    - point bar limits, and
    - lateral and vertical variability of soil type and hydraulic characteristics for the point bar deposits. More pump tests may be warranted depending on investigation findings.
- Currently there are only two CPT/soil boring pairings, and based on these locations there is inconsistency in the empirical relationships used to determine shear strength and soil behavior type. Additional CPT/soil boring pairings are recommended to better define empirical relationships for the geologic formations across the site.

LIMITATIONS

The information presented in this report is based on the soil borings and soil testing completed for this study, and judgments made by the engineers. This report is specific to this site and should not be used other than for the design of the Mid Barataria Diversion project (BA-153), located in Myrtle Grove, Louisiana. We have provided the requested information for the geotechnical investigation data report. A detailed engineering report for the marsh borings will be provided in a different report. HDR will be preparing a geotechnical engineering report for the overall project that will include the information presented in this data report.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of geotechnical engineering in this area at the time this report was prepared. No warranty or other conditions express or implied should be understood.

Please refer to “Report Limitations and Guidelines for Use” for additional information pertaining to use of this report.

TECHNICAL REFERENCES

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FIGURES

DRAFT

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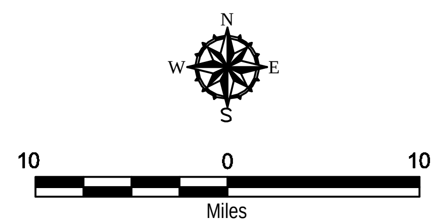


Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

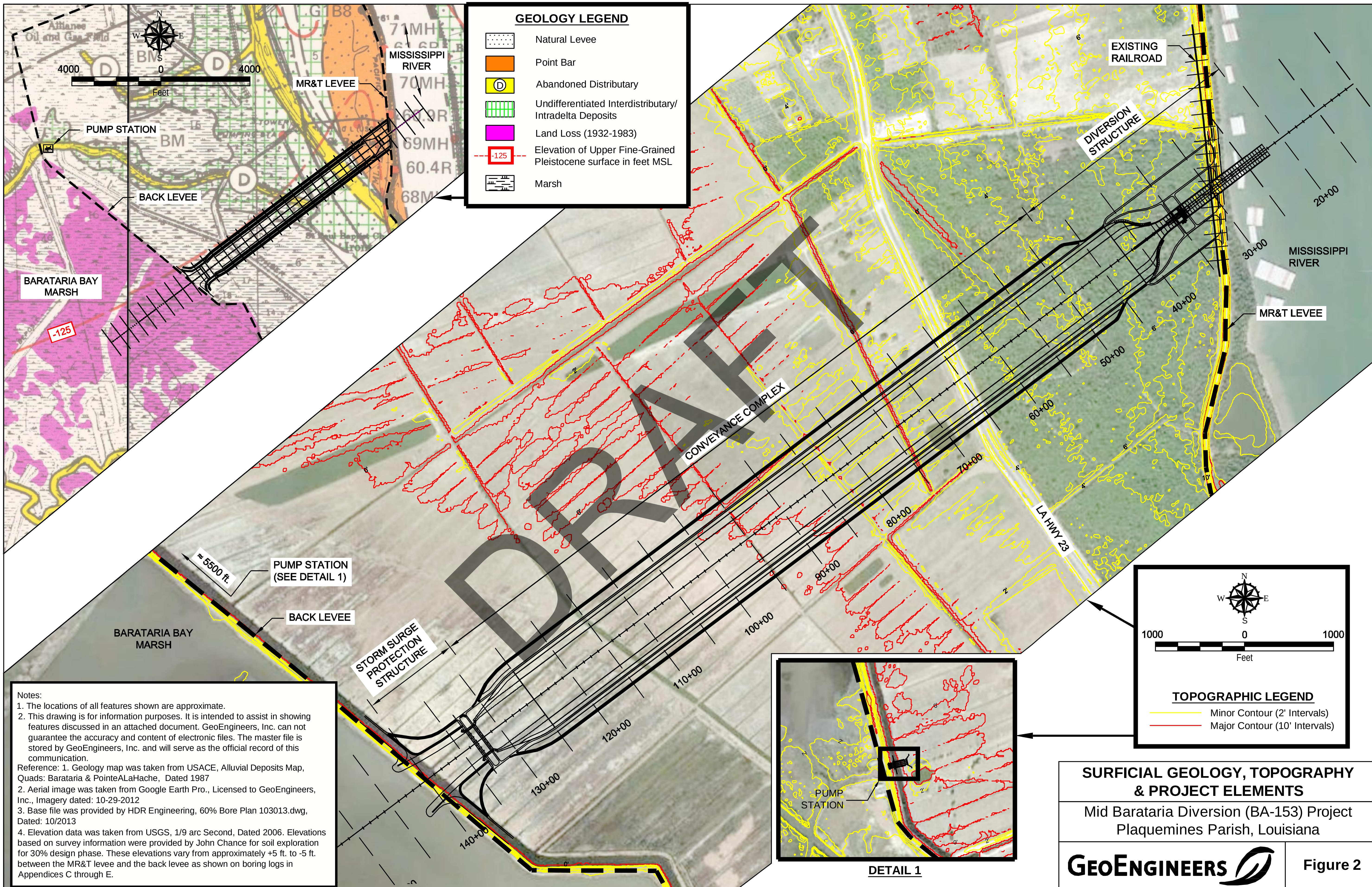
Reference: Aerial image was taken from Google Earth Pro., Licensed to GeoEngineers Inc., Imagery dated: 11/14/2012

VICINITY MAP

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure 1



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2. Aerial image was taken from Google Earth Pro., Licensed to GeoEngineers, Inc., Imagery dated: 10-29-2012
3. Base file was provided by HDR Engineering, 60% Bore Plan 103013.dwg, Dated: 10/2013
4. Elevation data was taken from USGS, 1/9 arc Second, Dated 2006. Elevations based on survey information were provided by John Chance for soil exploration for 30% design phase. These elevations vary from approximately +5 ft. to -5 ft. between the MR&T levee and the back levee as shown on boring logs in Appendices C through E.

SURFICIAL GEOLOGY, TOPOGRAPHY & PROJECT ELEMENTS

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure 2

DSE : KMC

P:\18\18274001\00\CAD\Site Location Plan 011414.dwg\TAB:Layout2 modified on Jan 17, 2014 - 7:06am

Notes:
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Reference:
1. Base file was provided by HDR Engineering, 60% Bore Plan 103013.dwg, Dated: 10/2013
2. Aerial image was taken from Google Earth Pro., Licensed to GeoEngineers, Inc., Imagery dated: 10-29-2012

LEGEND

M-12/PZ-1	3" Borehole Location/ Piezometer Location
R-60.4-R	USACE Boring Location
NL-1C	CPT Location
IS-1A	5" Borehole Location

600 0 600
FEET

FIELD INVESTIGATION LOCATIONS

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure 3

VT : KMC

P:\18\1827400100\CAD\Source\60% Bore Plan 1030131.dwg\TAB:Layout1 (2) modified on Feb 10, 2014 - 10:47am

Notes:
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Reference:
1. Base file was provided by HDR Engineering, MBSD_Data.dwg, Dated: 5/2013
2. Geology map was taken from USACE, Alluvial Deposits Map, Quads: Barataria & PointeALaHache, Dated 1987
3. Hydrographic Survey was taken from USACE, Hydrographic Survey 2004, Page 58
4. Elevation data was taken from USGS, 1/9 arc Second, Dated 2006. Elevations based on survey information were provided by John Chance for soil exploration for 30% design phase. These elevations vary from approximately +5 ft. to -5 ft. between the MR&T levee and the back levee as shown on boring logs in Appendices C through E.

BORING LEGEND

CL, CH, ML, SM, SP, SC, PT, CHOA

Interbedded layers of Silt, Clay and Sand

CPT LEGEND

1 - sensitive fine grained
2 - organic material
3 - clay
4 - silty clay to clay
5 - clayey silt to silty clay
6 - sandy silt to clayey silt
7 - silty sand to sandy silt
8 - sand to silty sand
9 - sand
10 - gravelly sand to sand
11 - very stiff fine grained (*)
12 - sand to clayey sand (*)
* Overconsolidated or cemented

LEGEND

Assumed boundaries for soil layer
Assumed boundaries for geologic deposits
Assumed upper boundary of Pleistocene deposits
Water

SCALE

500 0 500
FEET

SOIL SECTION - DIVERSION COMPLEX CENTERLINE

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure 4

VT : KMC

P:\18\1827400100\CAD\Plan and Profile.dwg\TAB:Layout1 modified on Feb 10, 2014 - 12:46pm

BORING LEGEND

CL, SP, CH, SC, ML, PT, SM, CHOA, Interbedded layers of Silt, Clay and Sand

CPT LEGEND

1 - sensitive fine grained
2 - organic material
3 - clay
4 - silty clay to clay
5 - clayey silt to silty clay
6 - sandy silt to clayey silt
7 - silty sand to sandy silt
8 - sand to silty sand
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* Overconsolidated or cemented

LEGEND

Assumed boundaries for soil layer
Assumed boundaries for geologic deposits
Assumed upper boundary of Pleistocene deposits

Notes:
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Reference: 1. Base file was provided by HDR Engineering, MBSD_Data.dwg, Dated: 5/2013
2. Geology map was taken from USACE, Alluvial Deposits Map, Quads: Barataria & PointeALaHache, Dated 1987
3. Hydrographic Survey was taken from USACE, Hydrographic Survey 2004, Page 58
4. Elevation data was taken from USGS, 1/9 arc Second, Dated 2006. Elevations based on survey information were provided by John Chance for soil exploration for 30% design phase. These elevations vary from approximately +2.2 ft. to +16.7 ft. between the MR&T levee and the batture levee as shown on boring logs in Appendices C through E.

200 0 200
FEET

SOIL SECTION - MR&T LEVEE CENTERLINE

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure 5

VT : KMC

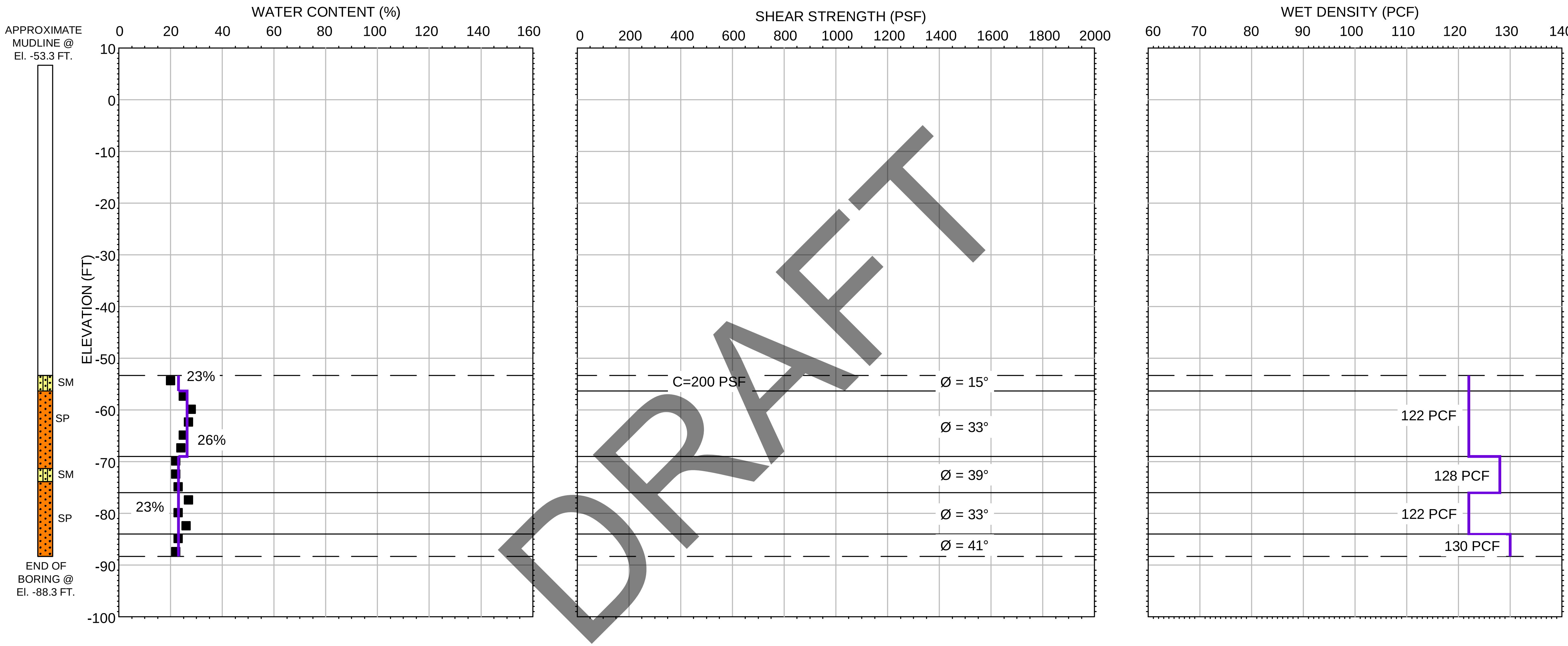
P:\18\18274001\00\CAD\Plan and Profile.dwg\TAB:Layout1 (2) modified on Feb 07, 2014 - 4:03pm

APPENDICES

DRAFT

GeoEngineers

APPENDIX A
Strength Profiles



LEGEND

- ■ R-1A
- DESIGN STRENGTH
- CL
- CH
- SM
- PT
- ML
- SP
- SC

Notes:
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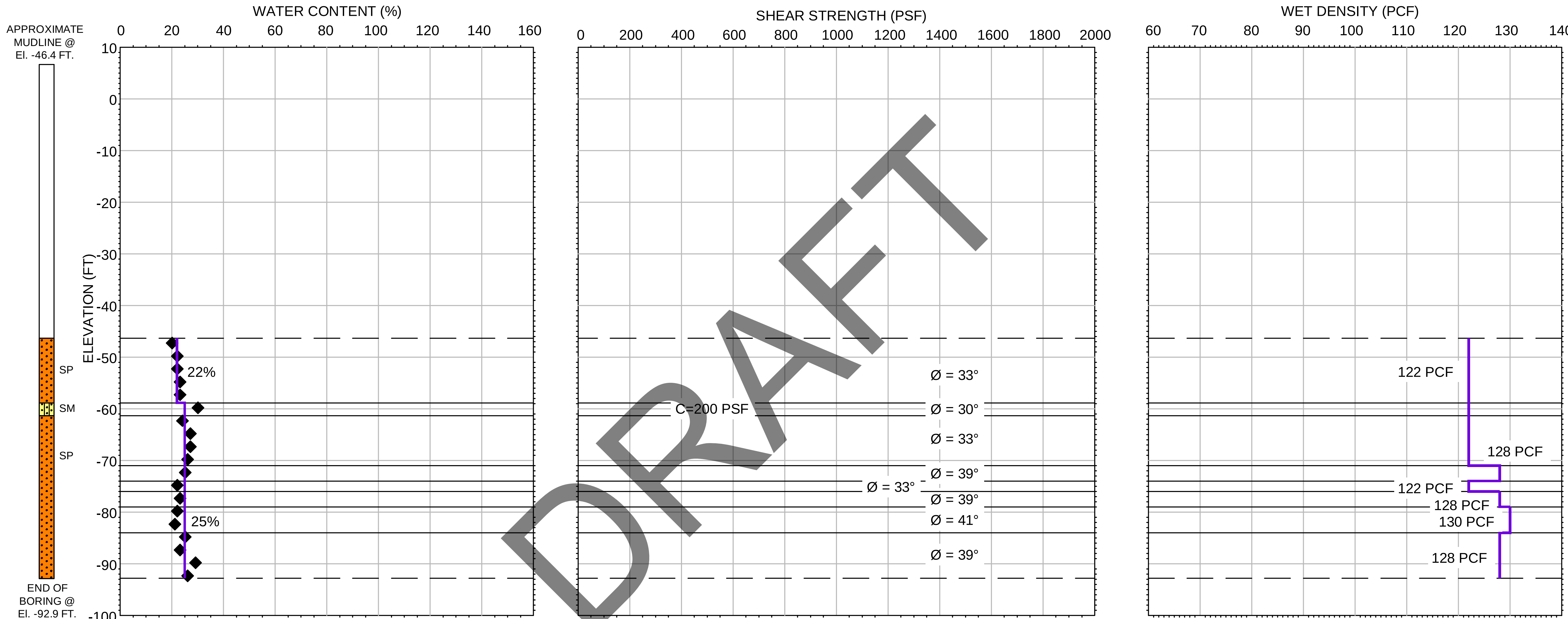
DESIGN CHARTS
R-1A

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-1a



LEGEND

◆ R-2A

DESIGN STRENGTH

CL, ML, CH, SP, SM, SC, PT

Notes:
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DESIGN CHARTS
R-2A

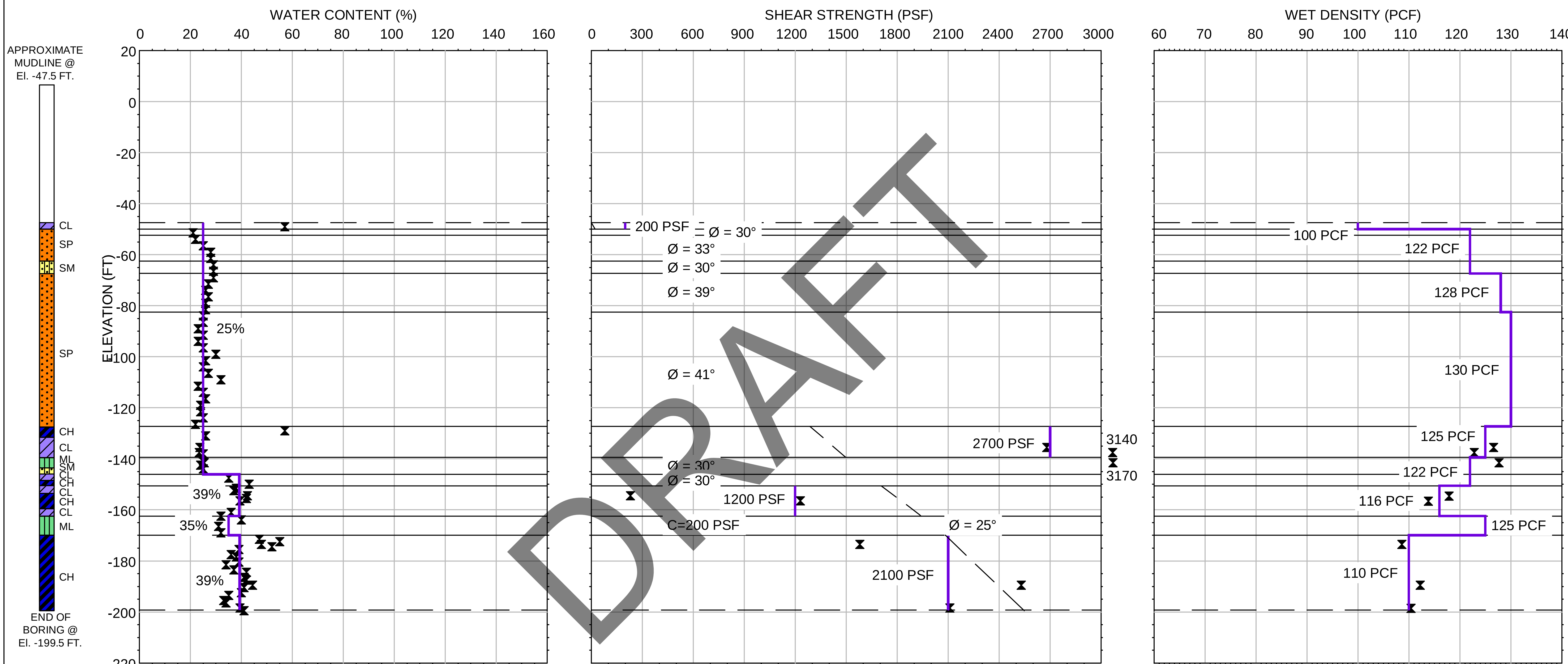
Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GeoEngineers

Figure A-1b

DPS : KMC

P:\18\18274001\00\CAD\GRAPH-MC.dwg\TAB:R-2A modified on Feb 07, 2014 - 11:27am



LEGEND

R-3A
DESIGN STRENGTH
C/P LINE = 0.22

CL ML
CH SP
SM SC
PT

Notes:

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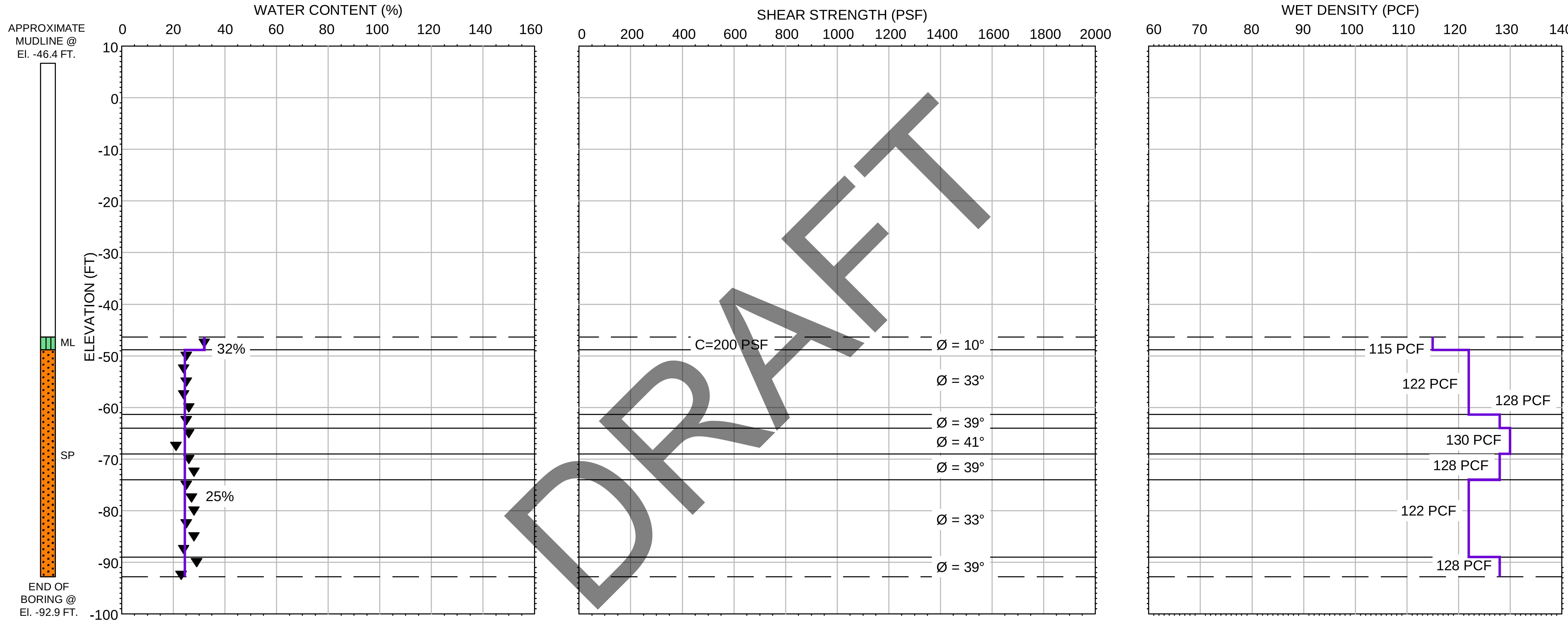
DESIGN CHARTS R-3A	
Mid Barataria Diversion (BA-153) Project Plaquemines Parish, Louisiana	
GEOENGINEERS	**Figure A-1c**

DPS : KMC

P:\18\18274001\00\CAD\GRAPH-MC.dwg\TAB:R-3A modified on Feb 10, 2014 - 2:08pm



LEGEND

- ▼ R-4A
- DESIGN STRENGTH
- CL
- ML
- CH
- SP
- SM
- SC
- PT

Notes:
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DESIGN CHARTS
R-4A

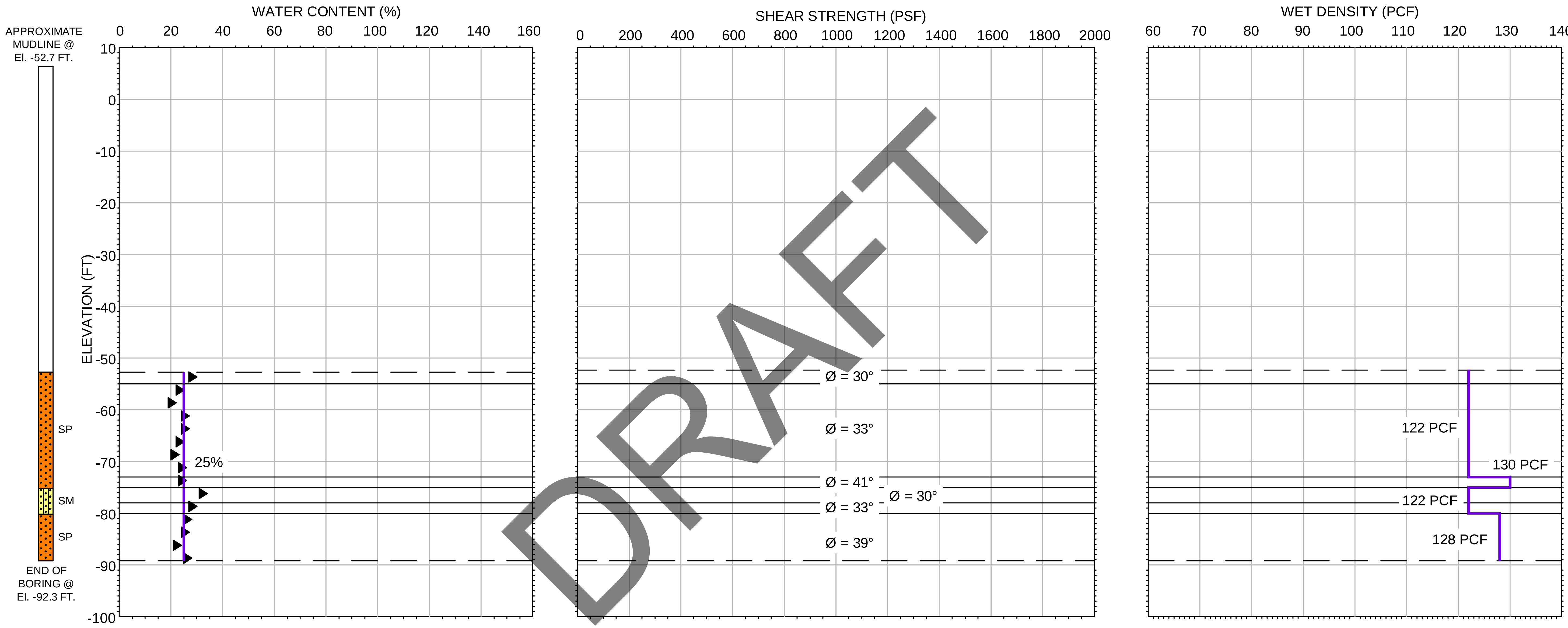
Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-1d

DPS : KMC

P:\18\18274001\00\CAD\GRAPH-MC.dwg\TAB:R-4A modified on Feb 07, 2014 - 11:27am



LEGEND

R-5A
DESIGN STRENGTH

CL
ML
CH
SP
SM
SC
PT

Notes:
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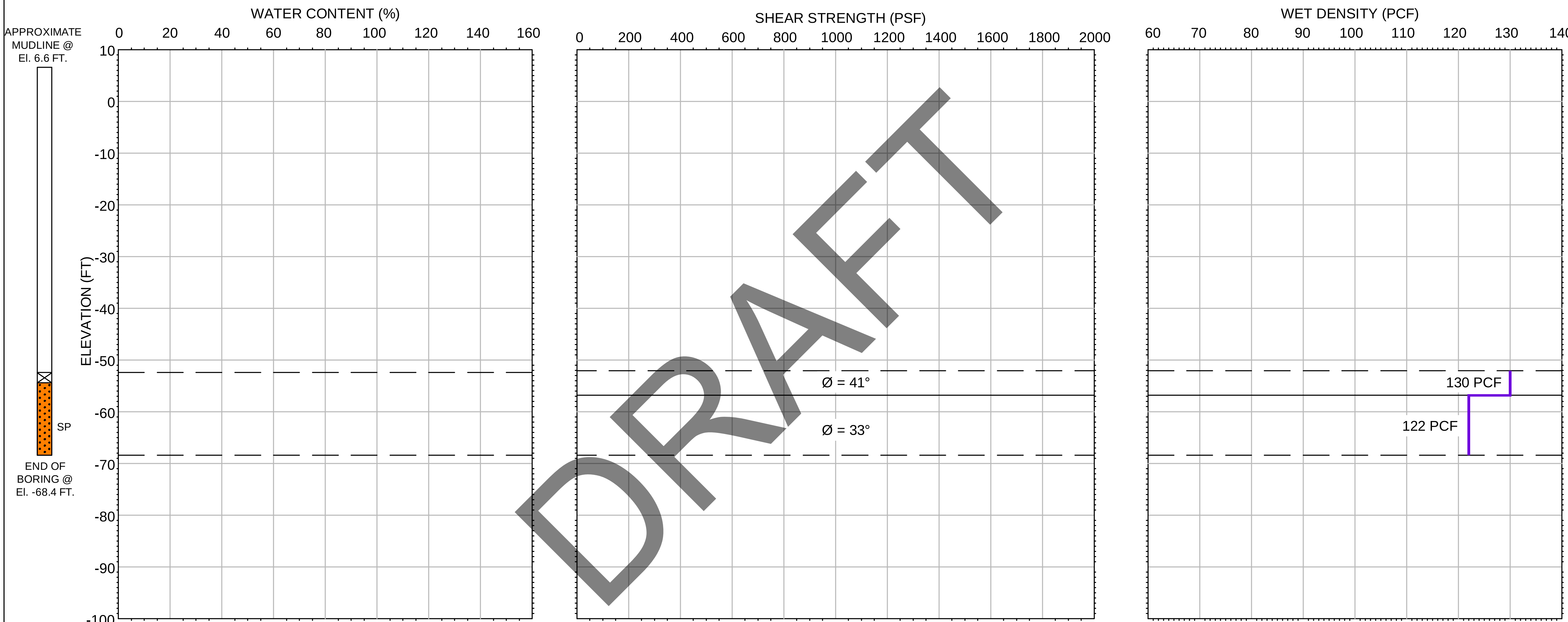
DESIGN CHARTS
R-5A

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-1e



LEGEND

DESIGN STRENGTH

CL | ML
CH | SP
SM | SC
PT

Notes:
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DESIGN CHARTS
R-6A

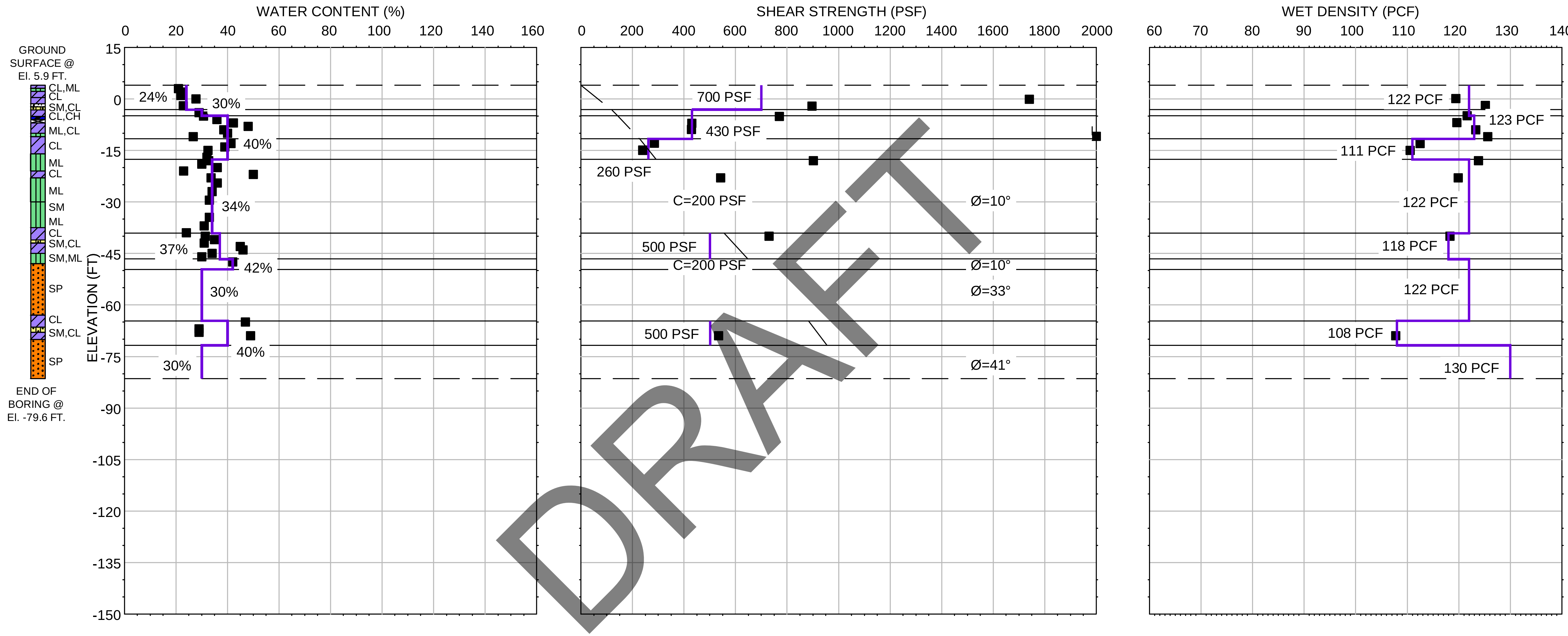
Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-1f

DPS : KMC

P:\18\1827400100\CAD\GRAPH-MC.dwg\TAB:R-6A modified on Feb 10, 2014 - 3:25pm



LEGEND

- B-1A
- DESIGN STRENGTH
- C/P = 0.22
- CL
- SP
- CH
- SC
- ML
- PT
- SM

Notes:

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DESIGN CHARTS
B-1A / B-1Aa

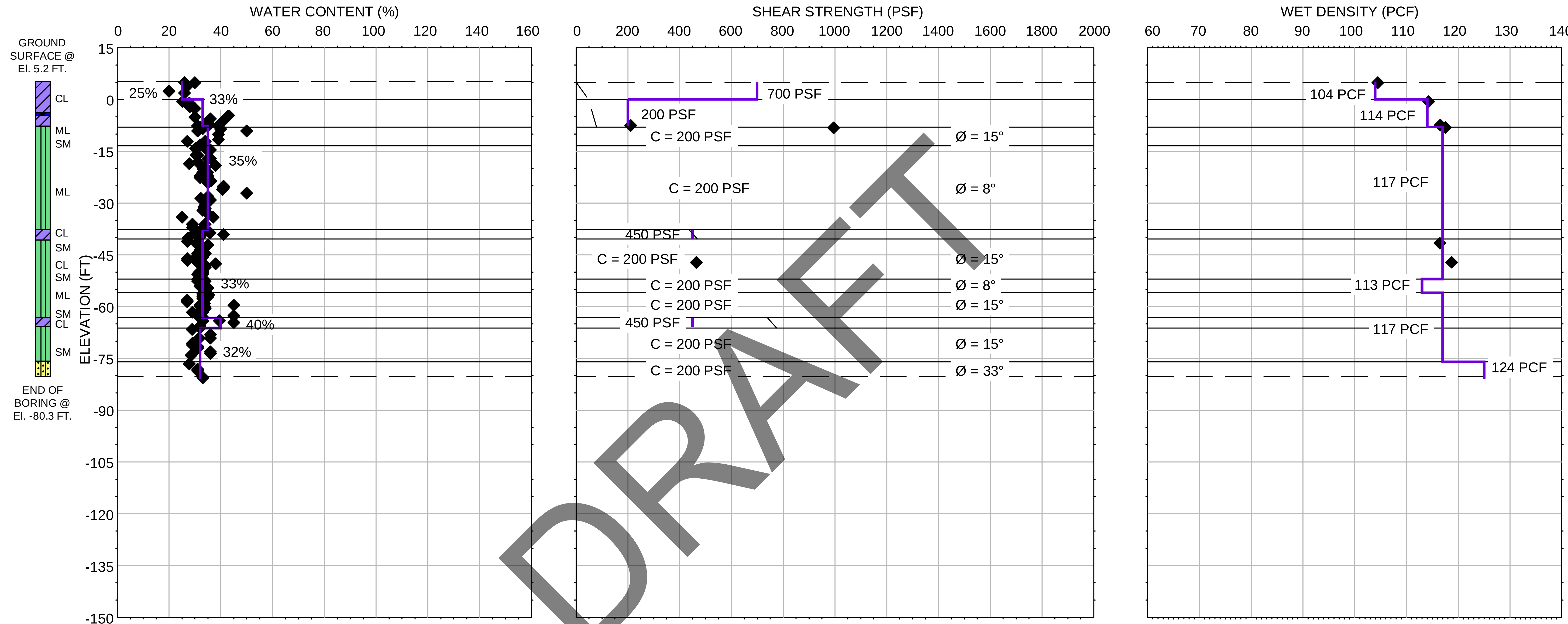
Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2a

DPS : KMC

P:\18\18274001\00\CAD\GRAPH-MC.dwg\TAB:B-1a modified on Feb 10, 2014 - 6:38am



LEGEND

- ◆ B-2A
- DESIGN STRENGTH
- — — C/P = 0.22
- CL
- SP
- CH
- SC
- ML
- PT
- SM

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DESIGN CHARTS
B-2A

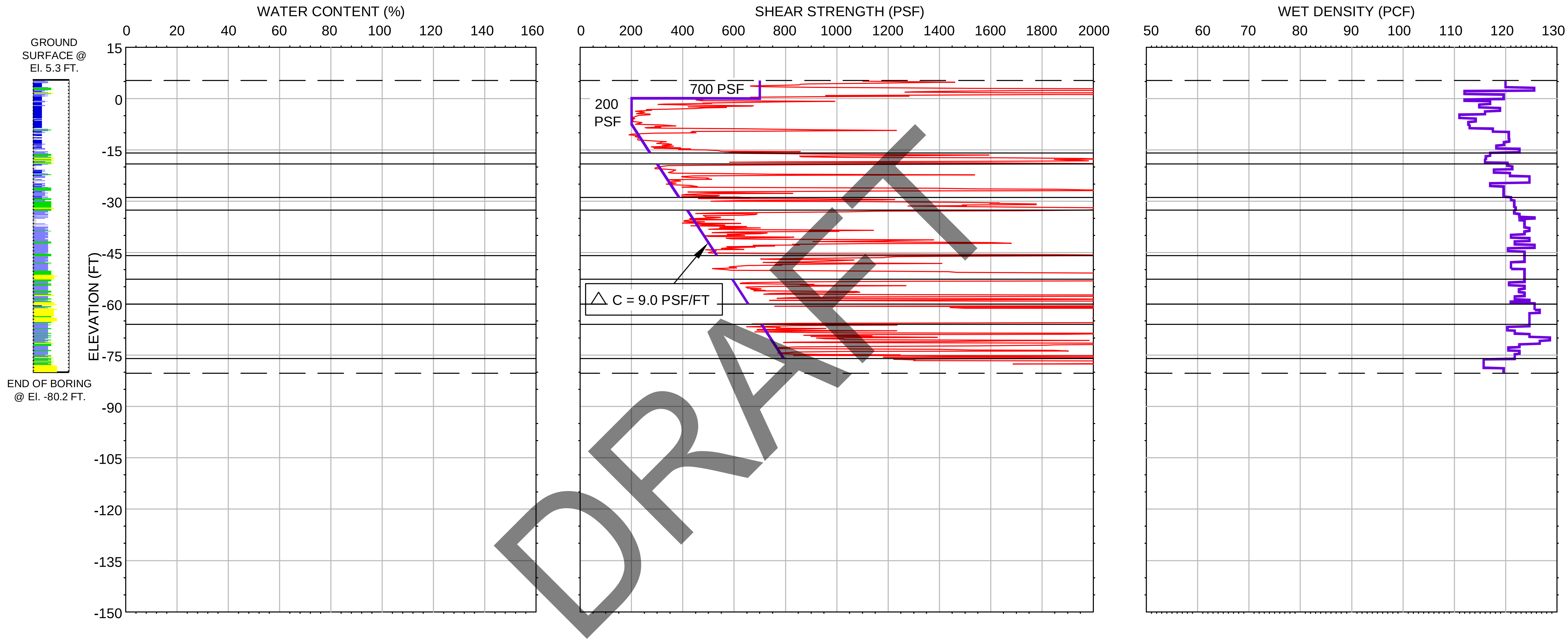
Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2b

DPS : KMC

P:\18\1827400100\CAD\GRAPH-MC.dwg\TAB:B-2a modified on Feb 10, 2014 - 6:42am



LEGEND

B-3C
Design Strength

1 - sensitive fine grained
2 - organic material
3 - clay
4 - silty clay to clay
5 - clayey silt to silty clay
6 - sandy silt to clayey silt
7 - silty sand to sandy silt
8 - sand to silty sand
9 - sand
10 - gravelly sand to sand
11 - very stiff fine grained (*)
12 - sand to clayey sand (*)

* Overconsolidated or cemented

Notes:
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DESIGN CHARTS
B-3C

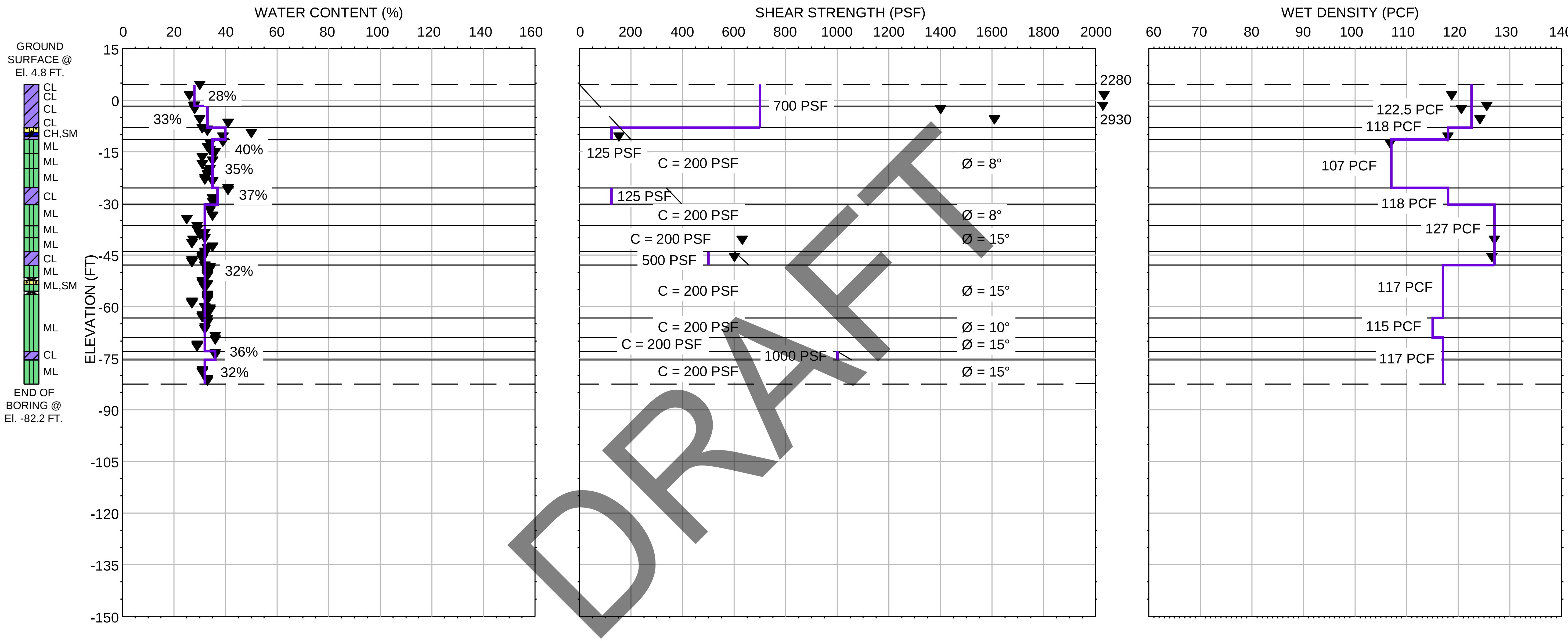
Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2c

DPS : KMC

P:\18\1827400100\CAD\GRAPH-MC.dwg\TAB:B-3c modified on Feb 10, 2014 - 2:16pm



LEGEND

DPS : KMC

P:\18\1827400100\CAD\GRAPH-MC.dwg\TAB:B-4a modified on Feb 10, 2014 - 2:16pm

Notes:
1. The locations of all features shown are approximate.
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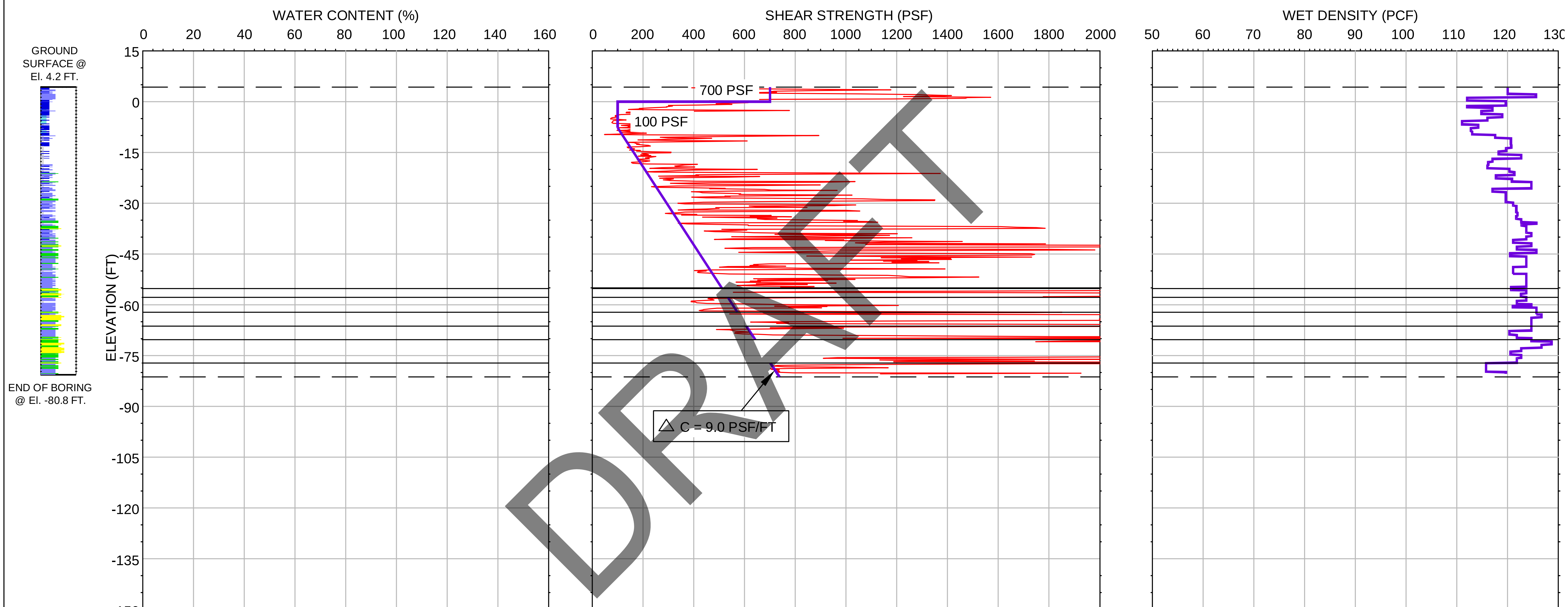
DESIGN CHARTS
B-4A

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2d



LEGEND

B-5C
Design Strength

1 - sensitive fine grained
2 - organic material
3 - clay
4 - silty clay to clay
5 - clayey silt to silty clay
6 - sandy silt to clayey silt
7 - silty sand to sandy silt
8 - sand to silty sand
9 - sand
10 - gravelly sand to sand
11 - very stiff fine grained (*)
12 - sand to clayey sand (*)

* Overconsolidated or cemented

Notes:
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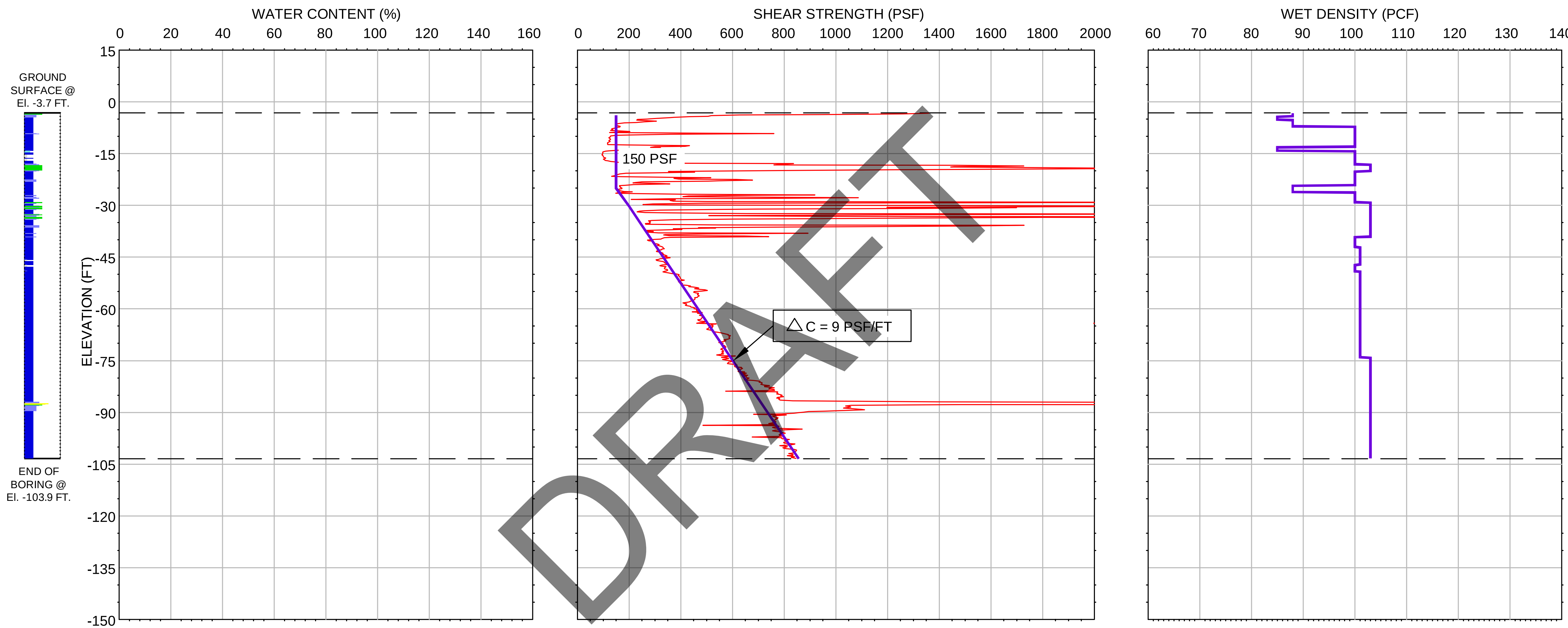
DESIGN CHARTS
B-5C

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2e



LEGEND

SL-1C

DESIGN STRENGTH

- 1 - sensitive fine grained
- 2 - organic material
- 3 - clay
- 4 - silty clay to clay
- 5 - clayey silt to silty clay
- 6 - sandy silt to clayey silt
- 7 - silty sand to sandy silt
- 8 - sand to silty sand
- 9 - sand
- 10 - gravelly sand to sand
- 11 - very stiff fine grained (*)
- 12 - sand to clayey sand (*)

* Overconsolidated or cemented

Notes:
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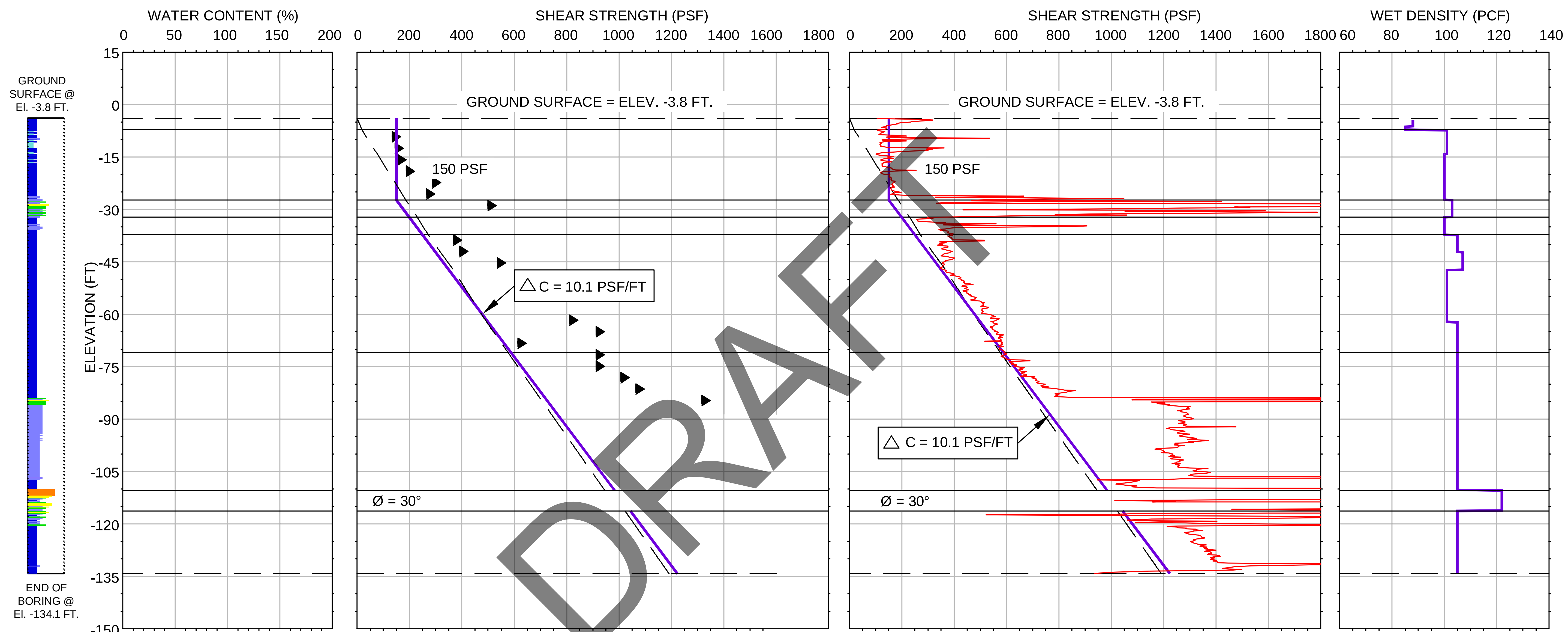
DESIGN CHARTS
SL-1C

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GeoEngineers

Figure A-2f



LEGEND

- ▶ FV-1
- NL-1C
- DESIGN STRENGTH
- C/P = 0.22

1 - sensitive fine grained	7 - silty sand to sandy silt
2 - organic material	8 - sand to silty sand
3 - clay	9 - sand
4 - silty clay to clay	10 - gravelly sand to sand
5 - clayey silt to silty clay	11 - very stiff fine grained (*)
6 - sandy silt to clayey silt	12 - sand to clayey sand (*)

* Overconsolidated or cemented

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DESIGN CHARTS
FV-1 & NL-1C

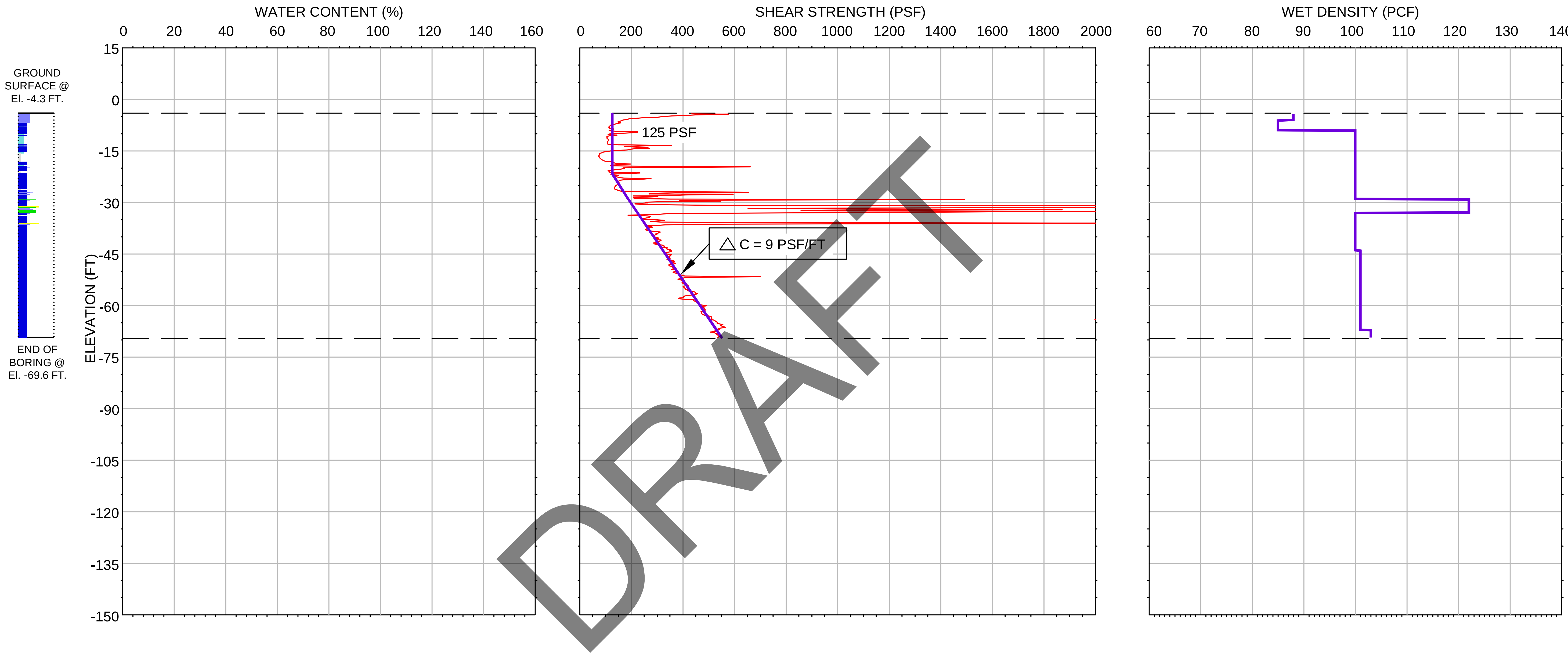
Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2g

DPS : KMC

P:\18\1827400100\CAD\GRAPH-MC.dwg\TAB:NL-1C modified on Feb 10, 2014 - 8:50am



LEGEND

NL-2C
Design Strength

1 - sensitive fine grained
2 - organic material
3 - clay
4 - silty clay to clay
5 - clayey silt to silty clay
6 - sandy silt to clayey silt
7 - silty sand to sandy silt
8 - sand to silty sand
9 - sand
10 - gravelly sand to sand
11 - very stiff fine grained (*)
12 - sand to clayey sand (*)

* Overconsolidated or cemented

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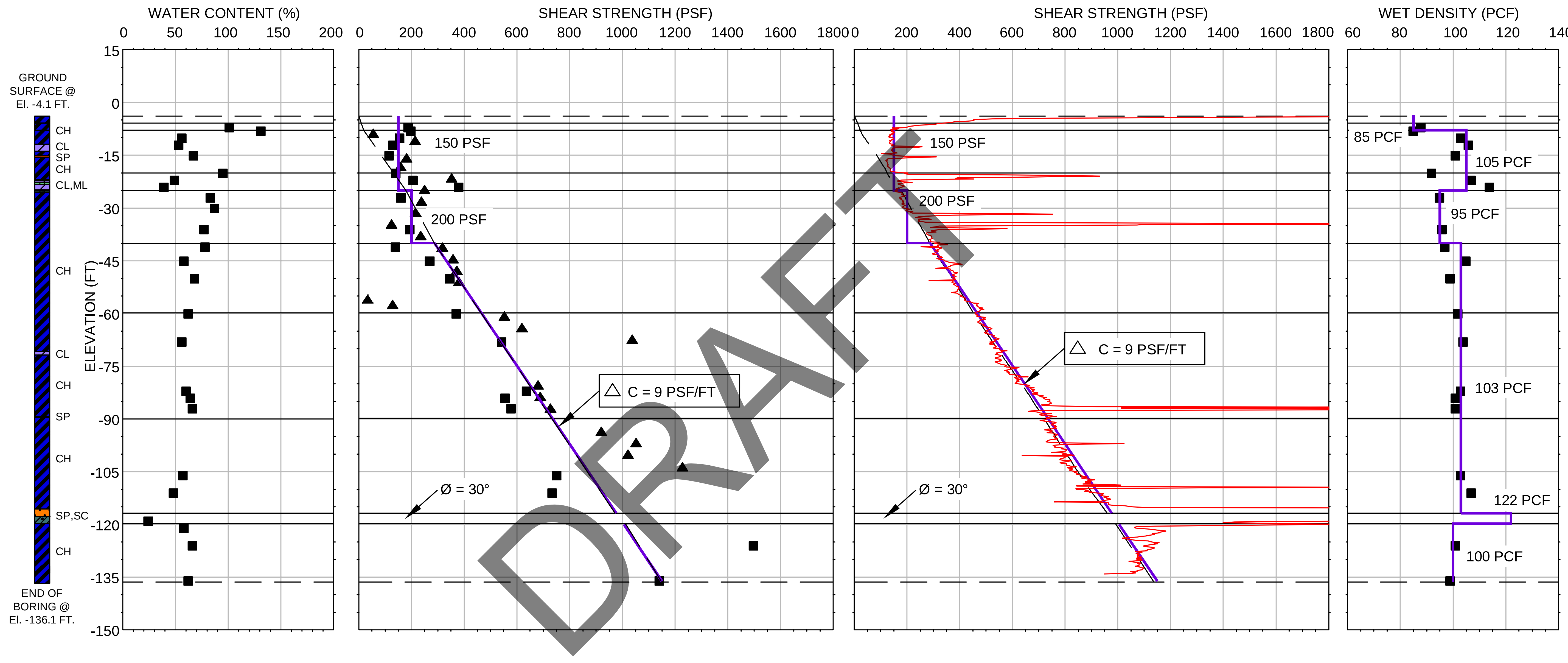
DESIGN CHARTS
NL-2C

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS **Figure A-2h**

DPS : KMC

P:\18\1827400100\CAD\GRAPH-MC.dwg\TAB:NL-2C modified on Feb 04, 2014 - 1:28pm



LEGEND

DESIGN CHARTS
FV2, NL-3A & NL-3C

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2i

Notes:
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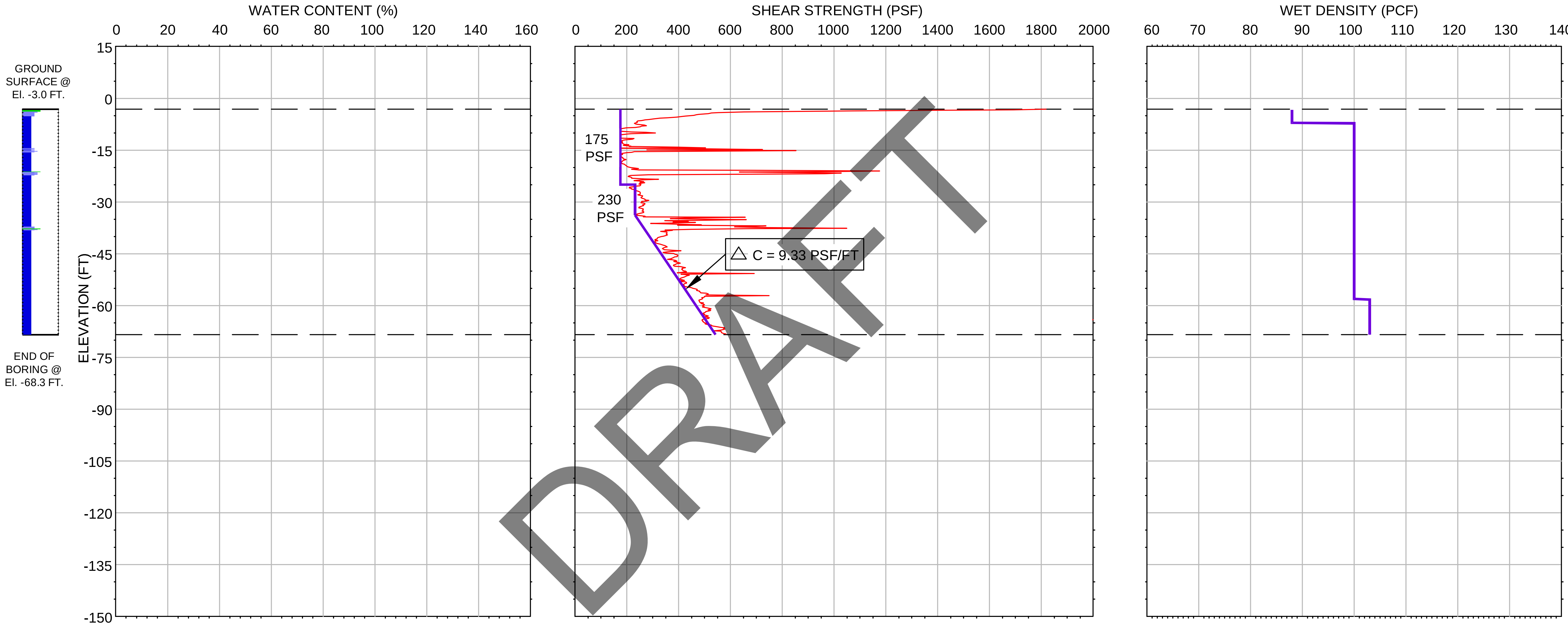

LEGEND

NL-4C
Design Strength

1 - sensitive fine grained
2 - organic material
3 - clay
4 - silty clay to clay
5 - clayey silt to silty clay
6 - sandy silt to clayey silt
7 - silty sand to sandy silt
8 - sand to silty sand
9 - sand
10 - gravelly sand to sand
11 - very stiff fine grained (*)
12 - sand to clayey sand (*)

* Overconsolidated or cemented

Notes:
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DESIGN CHARTS
NL-4C

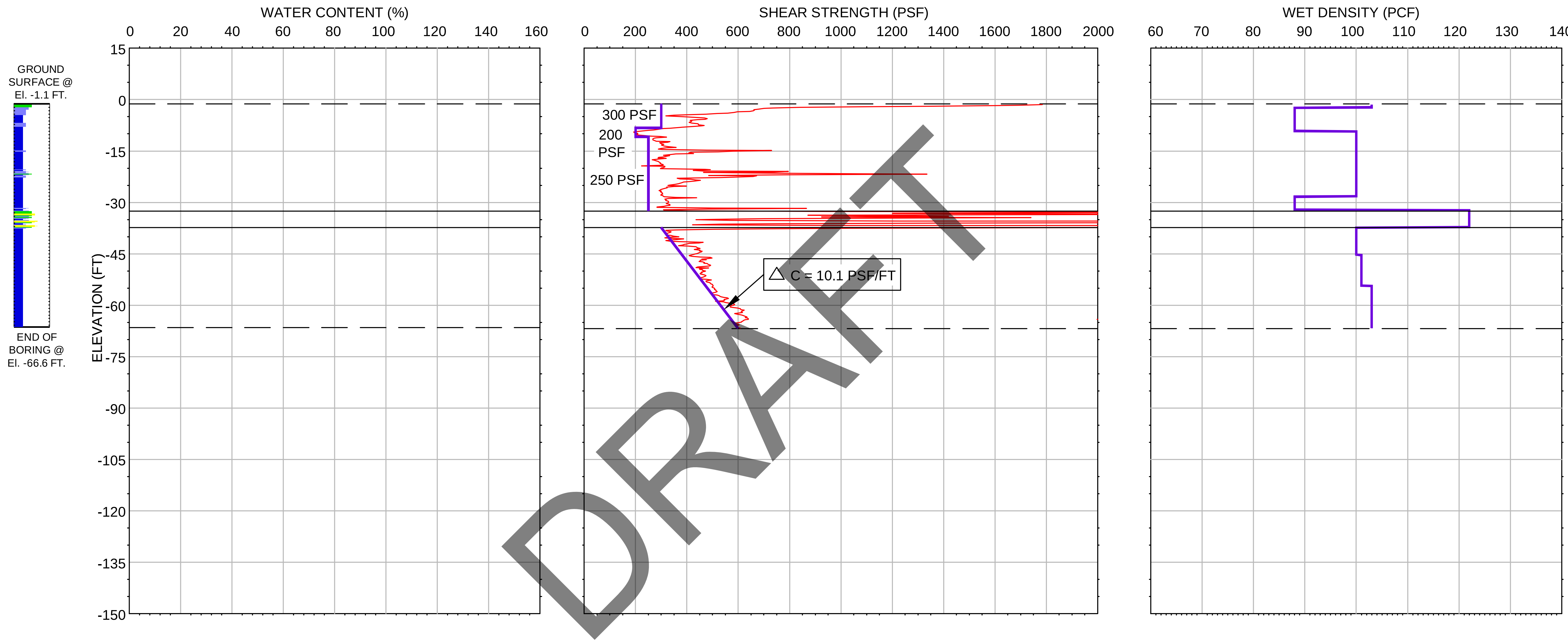
Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2j

DPS : KMC

P:\18\18274001\00\CAD\GRAPH-MC.dwg\TAB:NL-4C modified on Feb 04, 2014 - 1:33pm



DPS : KMC

LEGEND

NL-5C
Design Strength

1 - sensitive fine grained	7 - silty sand to sandy silt
2 - organic material	8 - sand to silty sand
3 - clay	9 - sand
4 - silty clay to clay	10 - gravelly sand to sand
5 - clayey silt to silty clay	11 - very stiff fine grained (*)
6 - sandy silt to clayey silt	12 - sand to clayey sand (*)

* Overconsolidated or cemented

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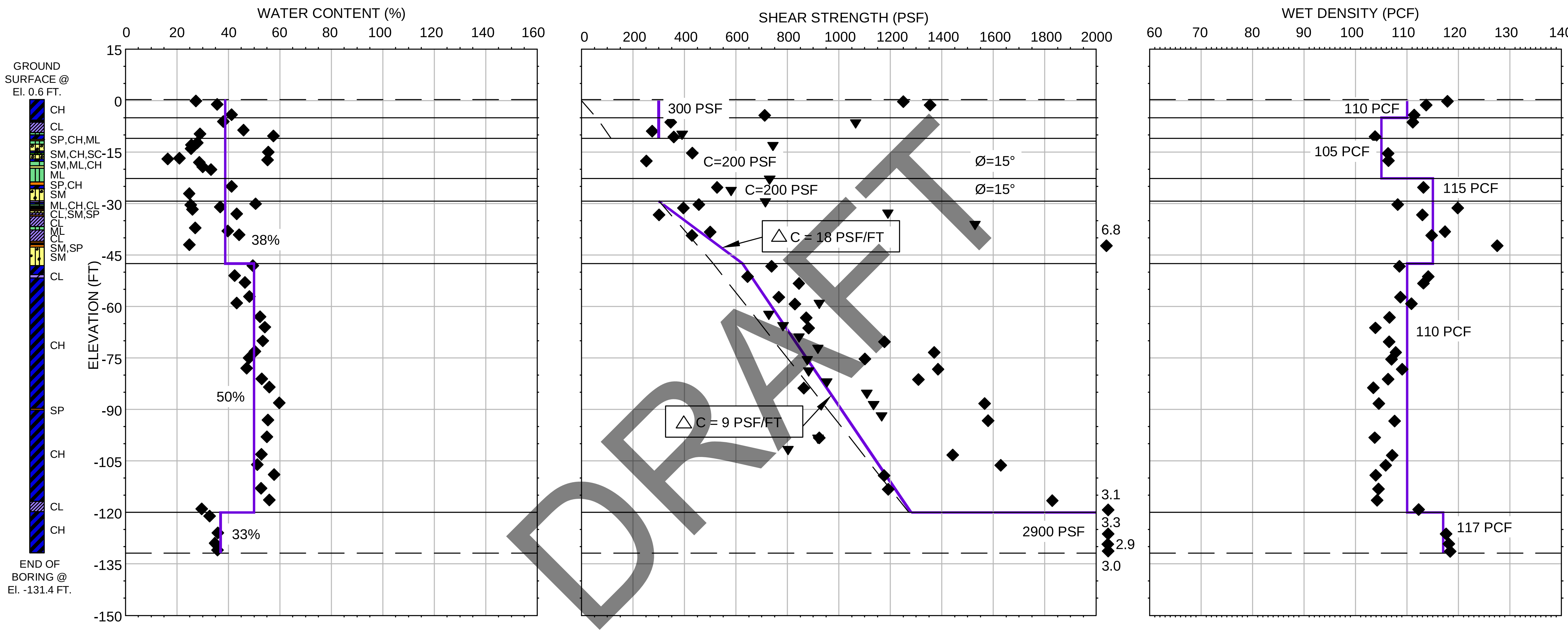
DESIGN CHARTS
NL-5C

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2k

P:\18\1827400100\CAD\GRAPH-MC.dwg\TAB:NL-5C modified on Feb 04, 2014 - 1:36pm



LEGEND

- NL-6A
- FV-3
- DESIGN STRENGTH
- C/P = 0.22
- CL
- CH
- ML
- SM
- SP
- SC
- PT

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DESIGN CHARTS
FV3 & NL-6A

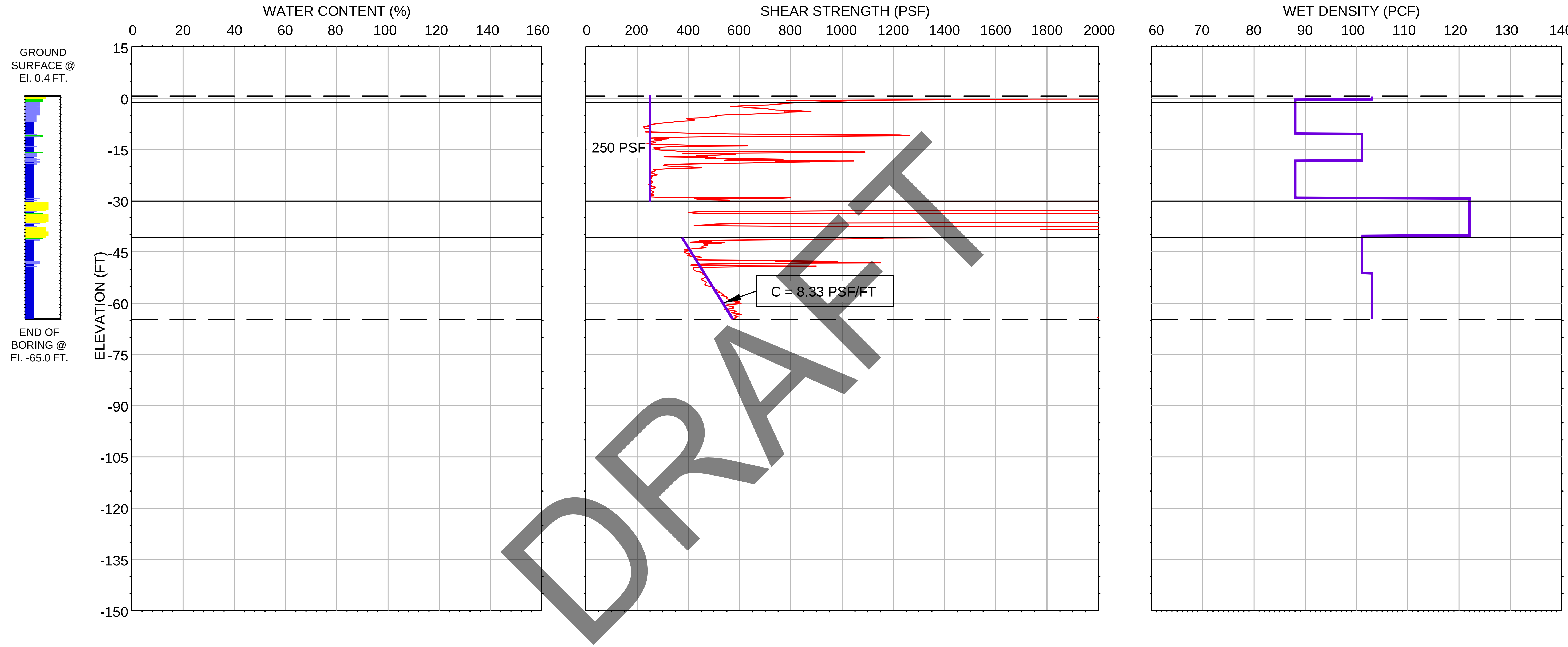
Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2I

DPS : KMC

P:\18\1827400100\CAD\GRAPH-MC.dwg\TAB:NL-6A modified on Feb 10, 2014 - 6:51am



LEGEND

NL-7C
Design Strength

1 - sensitive fine grained
2 - organic material
3 - clay
4 - silty clay to clay
5 - clayey silt to silty clay
6 - sandy silt to clayey silt
7 - silty sand to sandy silt
8 - sand to silty sand
9 - sand
10 - gravelly sand to sand
11 - very stiff fine grained (*)
12 - sand to clayey sand (*)

* Overconsolidated or cemented

Notes:
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DESIGN CHARTS
NL-7C

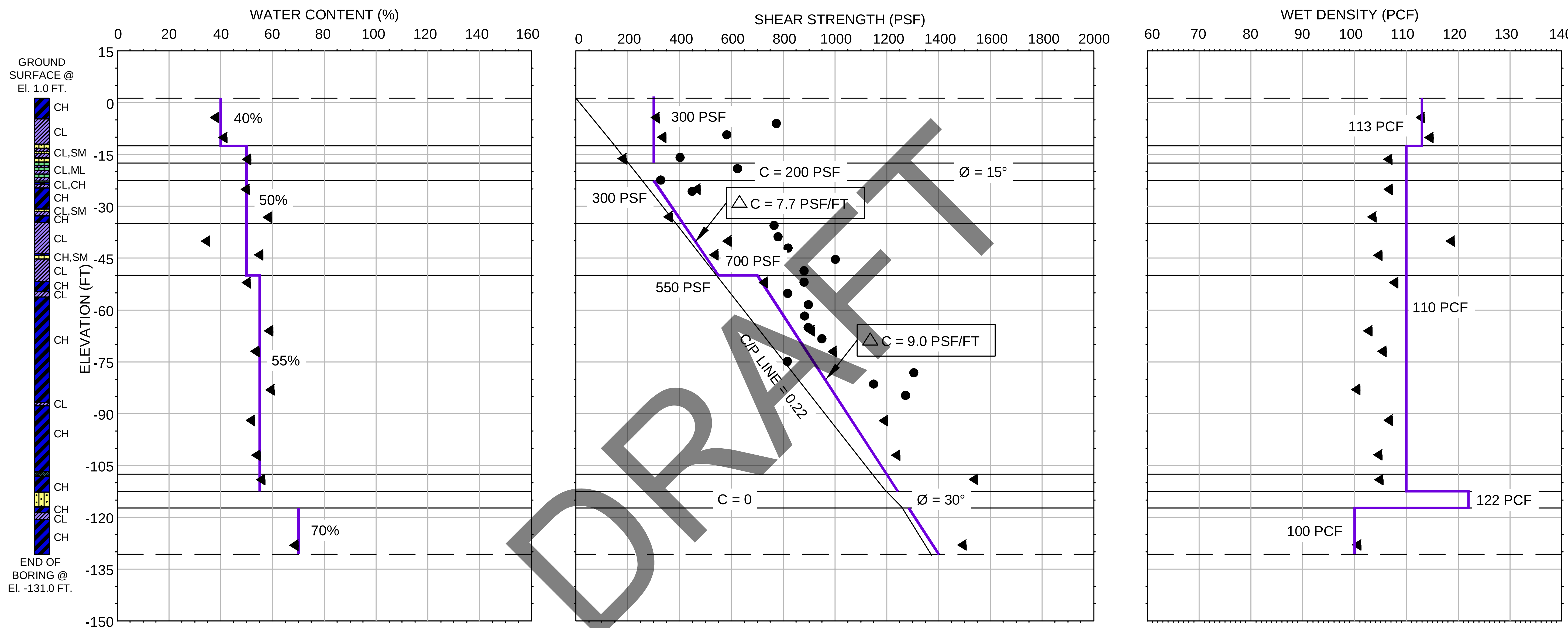
Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2m

DPS : KMC

P:\18\18274001\00\CAD\GRAPH-MC.dwg\TAB:NL-7C modified on Feb 10, 2014 - 8:50am



LEGEND

- NL-8A
- FV-4
- DESIGN STRENGTH
- C/P= 0.22

CL, CH, ML, SM, SP, SC, PT

Notes:
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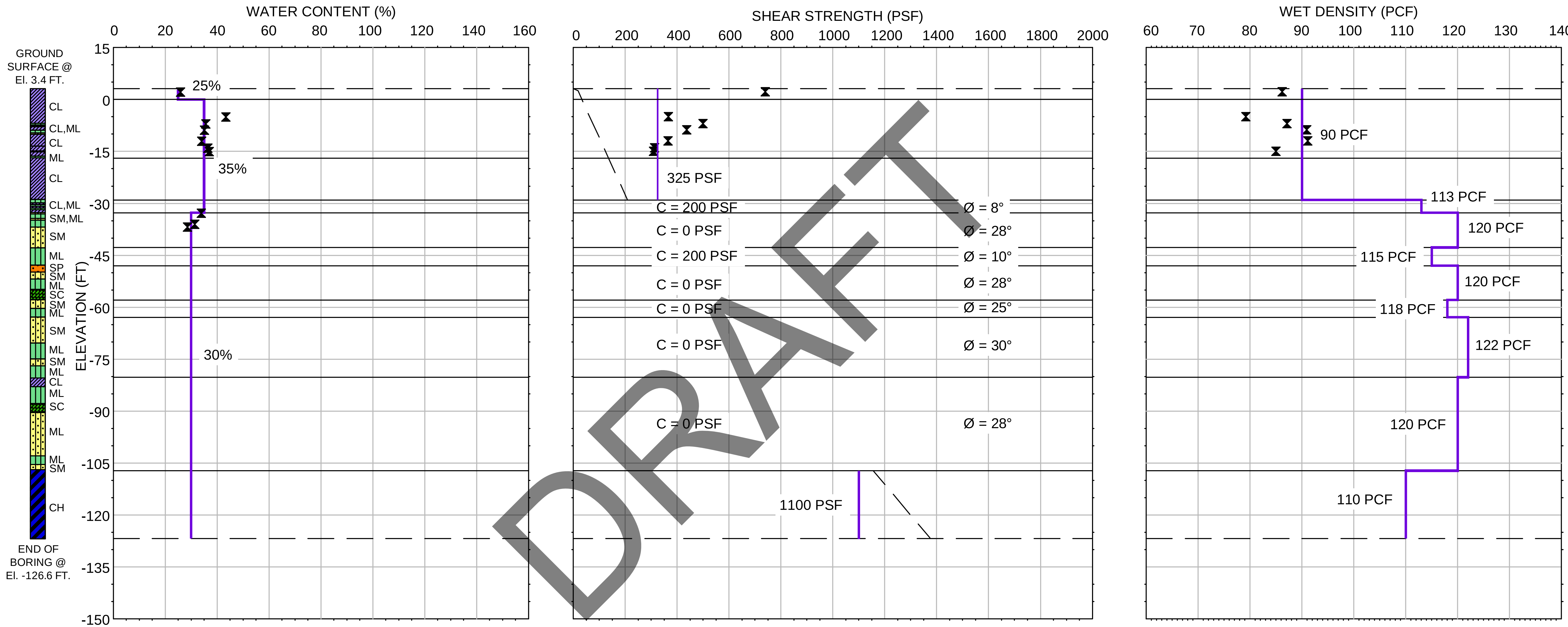
DESIGN CHARTS
NL-8A & FV-4

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2n



LEGEND

- NL-9A
- C/P = 0.22
- DESIGN STRENGTH
- CL
- SP
- CH
- SC
- ML
- PT
- SM

Notes:
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DESIGN CHARTS
NL-9A

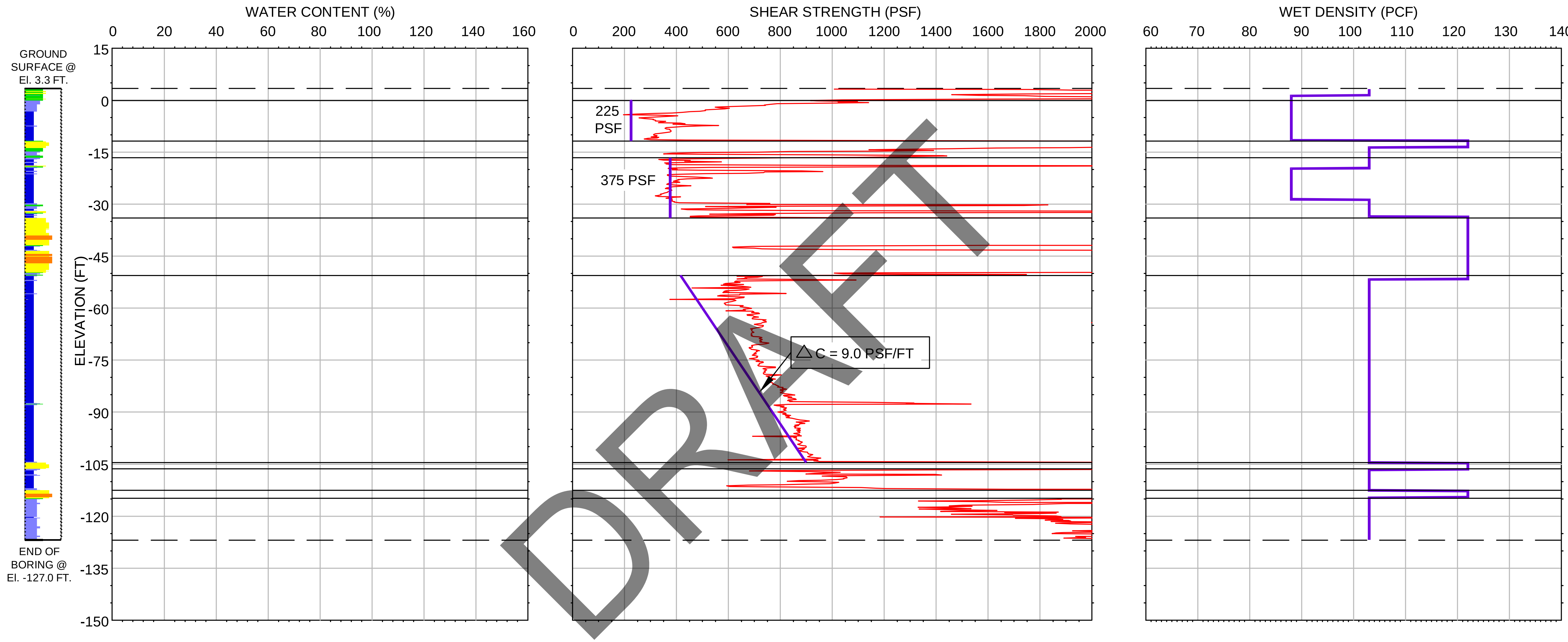
Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2o

DPS : KMC

P:\18\1827400100\CAD\GRAPH-MC.dwg\TAB:NL-9A modified on Feb 10, 2014 - 6:56am



LEGEND

NL-10C
Design Strength

1 - sensitive fine grained
2 - organic material
3 - clay
4 - silty clay to clay
5 - clayey silt to silty clay
6 - sandy silt to clayey silt
7 - silty sand to sandy silt
8 - sand to silty sand
9 - sand
10 - gravelly sand to sand
11 - very stiff fine grained (*)
12 - sand to clayey sand (*)

* Overconsolidated or cemented

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DESIGN CHARTS
NL-10C

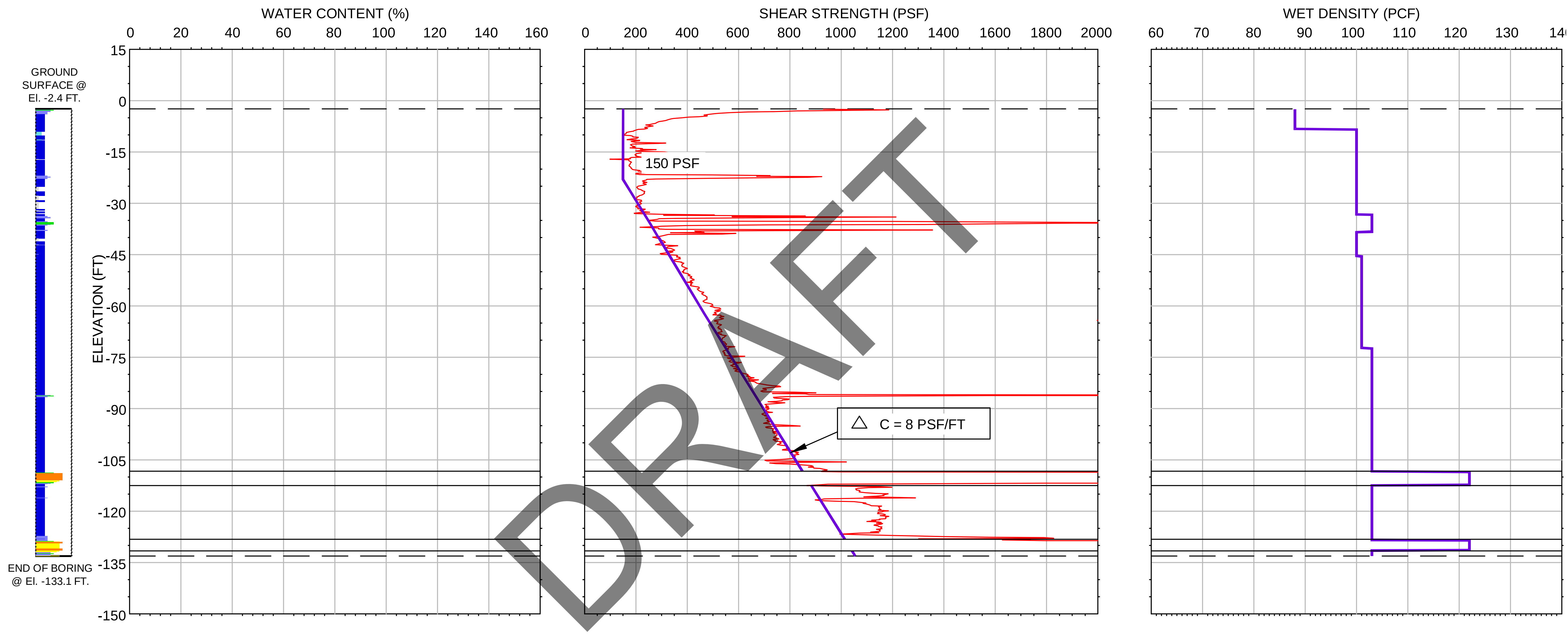
Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2p

DPS : KMC

P:\18\18274001\00\CAD\GRAPH-MC.dwg\TAB:NL-10C modified on Feb 04, 2014 - 2:00pm



LEGEND

NL-11C

DESIGN STRENGTH

1 - sensitive fine grained
2 - organic material
3 - clay
4 - silty clay to clay
5 - clayey silt to silty clay
6 - sandy silt to clayey silt
7 - silty sand to sandy silt
8 - sand to silty sand
9 - sand
10 - gravelly sand to sand
11 - very stiff fine grained (*)
12 - sand to clayey sand (*)

* Overconsolidated or cemented

Notes:
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DESIGN CHARTS
NL-11C

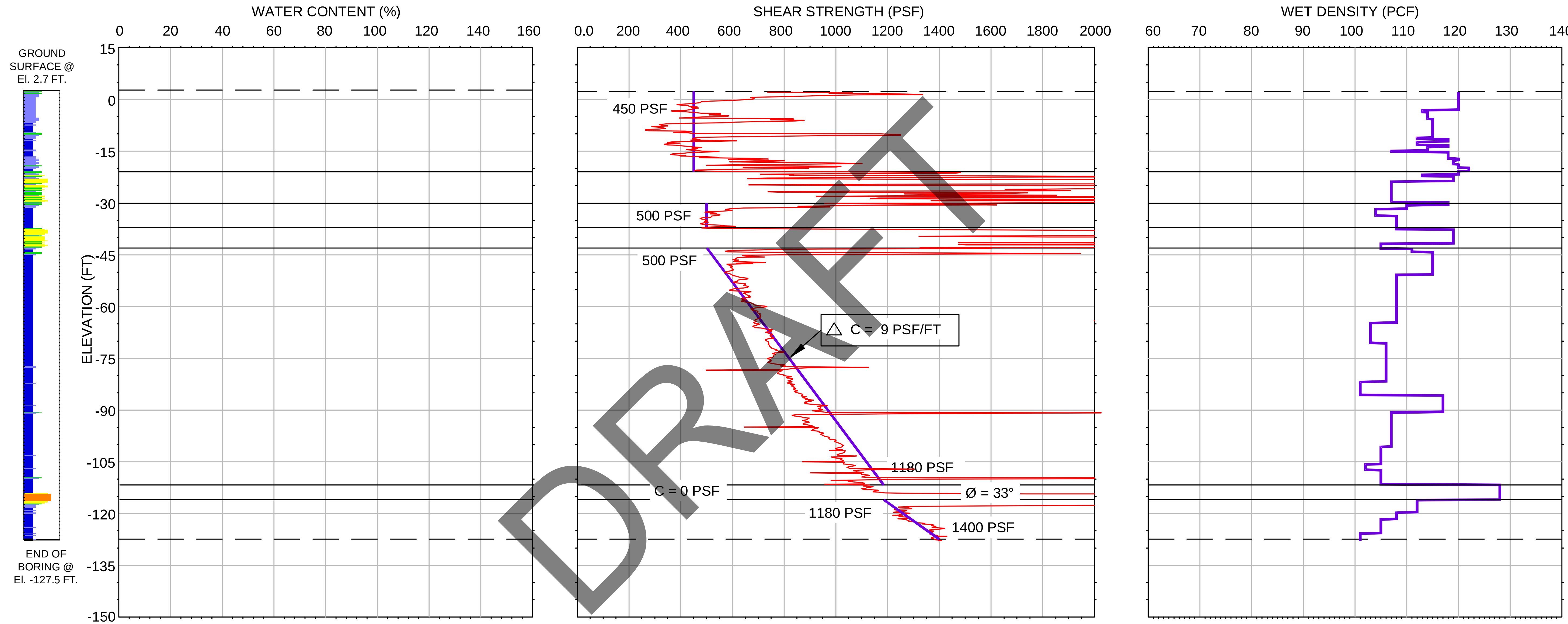
Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GeoEngineers

Figure A-2q

DPS : KMC

P:\18\1827400100\CAD\GRAPH-MC.dwg\TAB:NL-11C modified on Feb 04, 2014 - 2:05pm



LEGEND

NL-12C
DESIGN STRENGTH

1 - sensitive fine grained	7 - silty sand to sandy silt
2 - organic material	8 - sand to silty sand
3 - clay	9 - sand
4 - silty clay to clay	10 - gravelly sand to sand
5 - clayey silt to silty clay	11 - very stiff fine grained (*)
6 - sandy silt to clayey silt	12 - sand to clayey sand (*)

* Overconsolidated or cemented

Notes:
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2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

DESIGN CHARTS
NL-12C

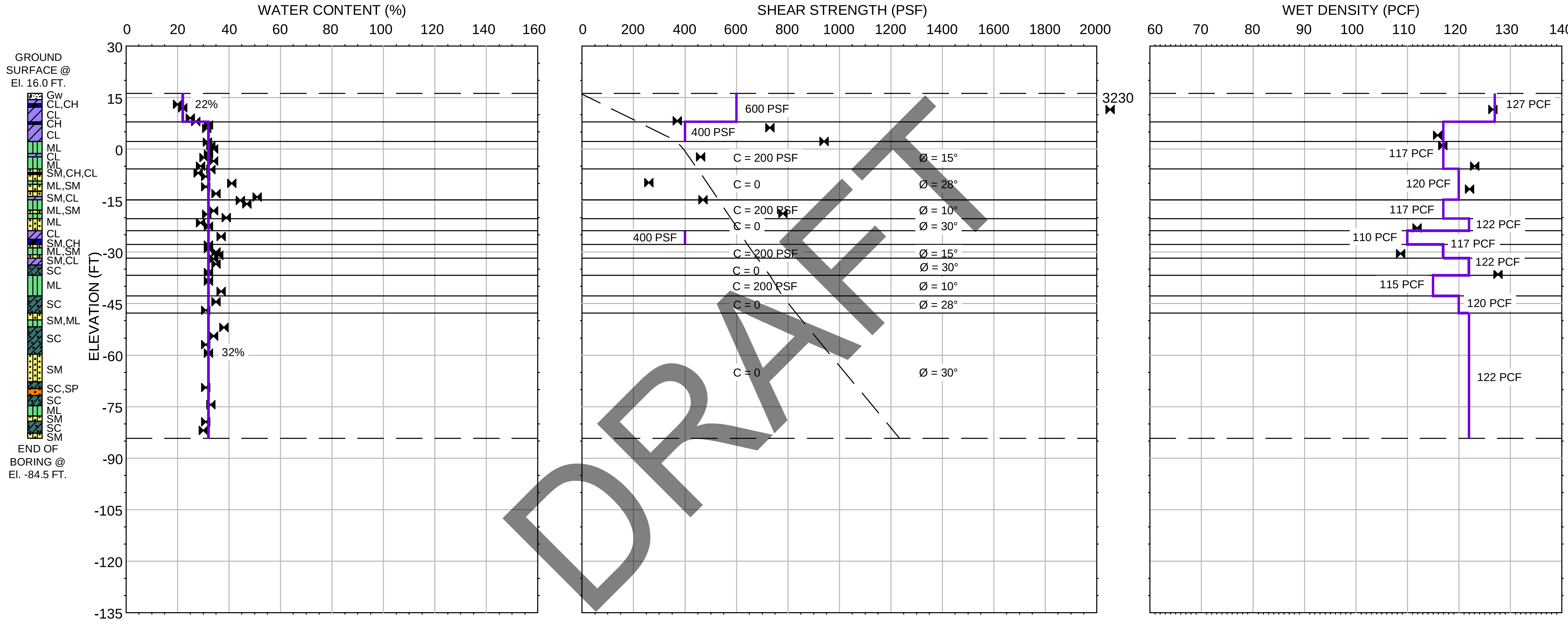
Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2r

DPS : KMC

P:\18\1827400100\CAD\GRAPH-MC.dwg\TAB:NL-12C modified on Feb 06, 2014 - 2:44pm



LEGEND

IS-1A
DESIGN STRENGTH
C/P LINE = 0.22

CL
CH
ML
SM
SP
SC
PT

Notes:
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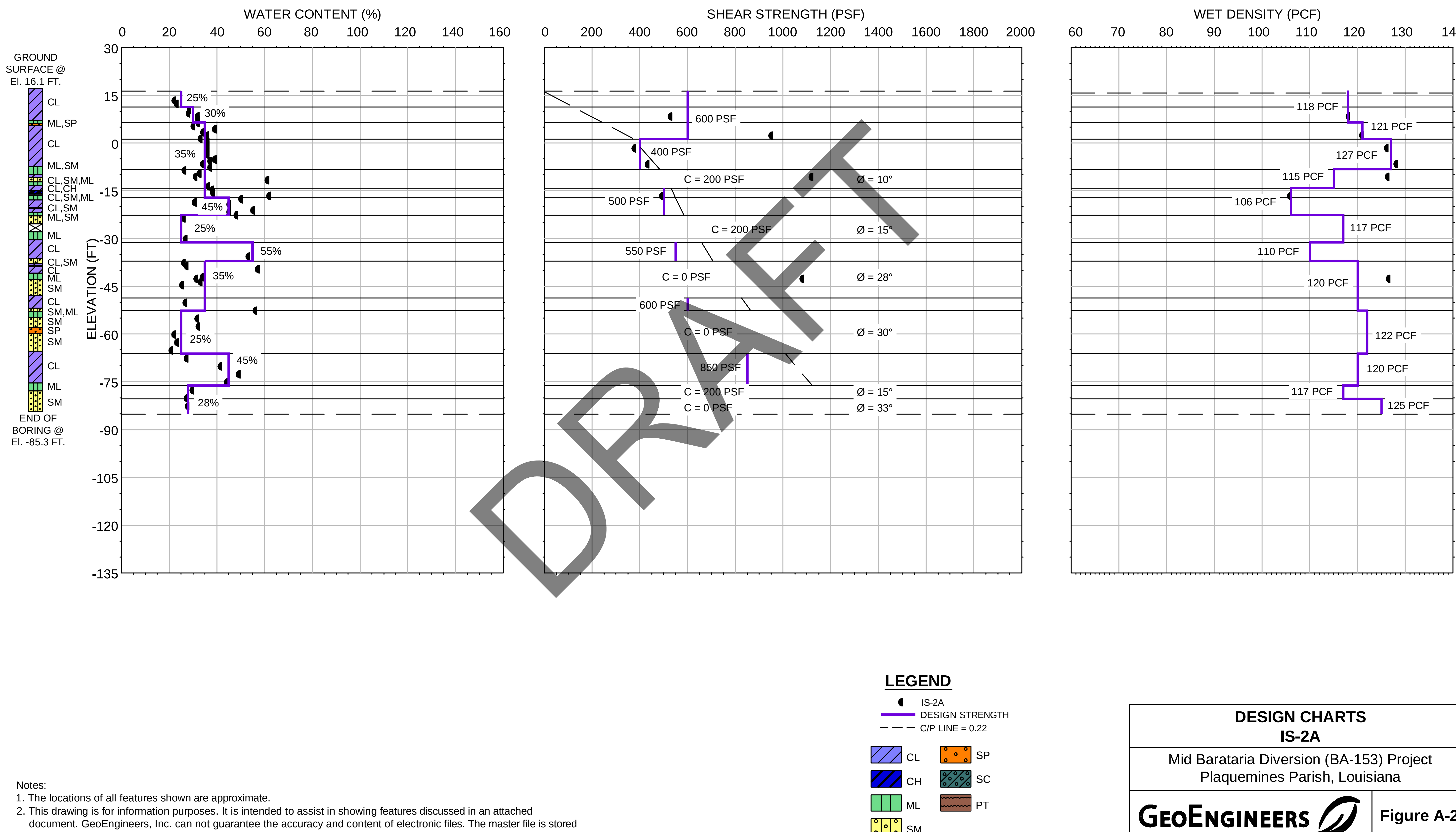
DESIGN CHARTS
IS-1A

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2s



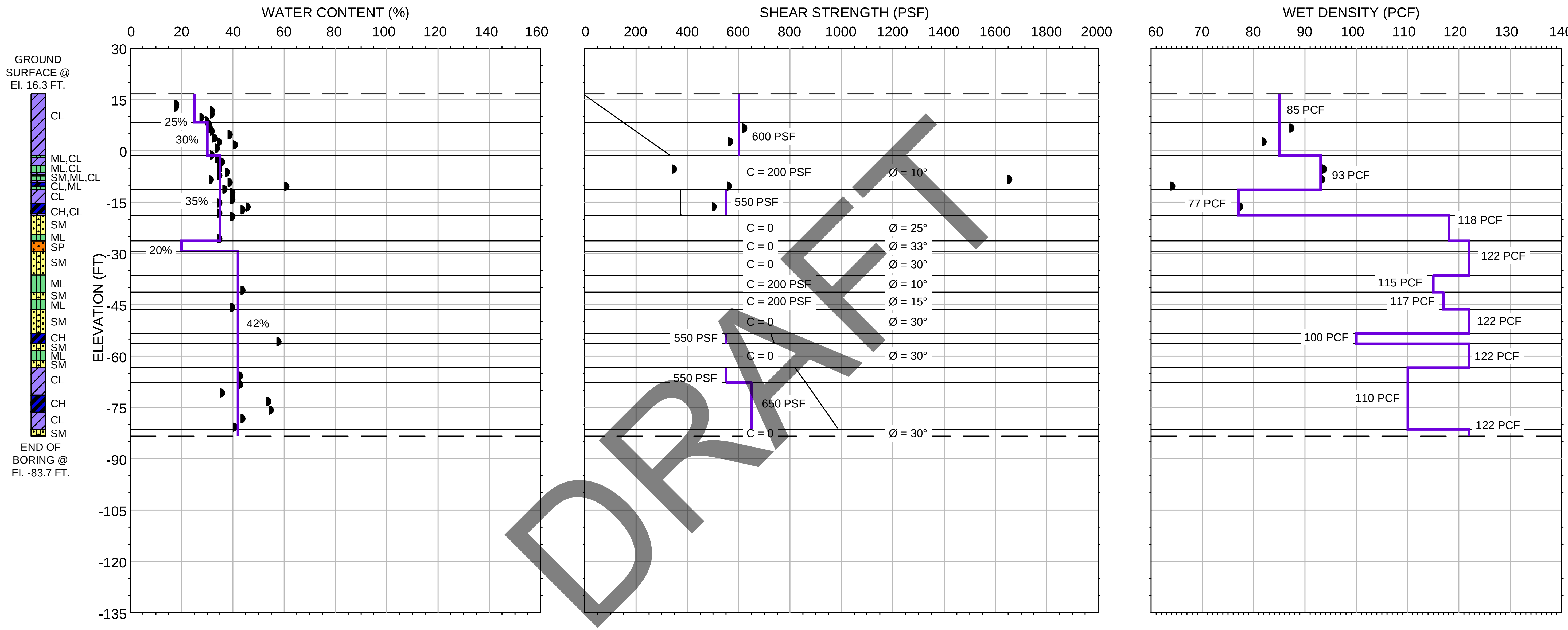
Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

DESIGN CHARTS
IS-2A

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2t



LEGEND

- IS-3A
- DESIGN STRENGTH
- C/P LINE = 0.22

CL
SP
CH
SC
ML
PT
SM

DESIGN CHARTS
IS-3A

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2u

Notes:
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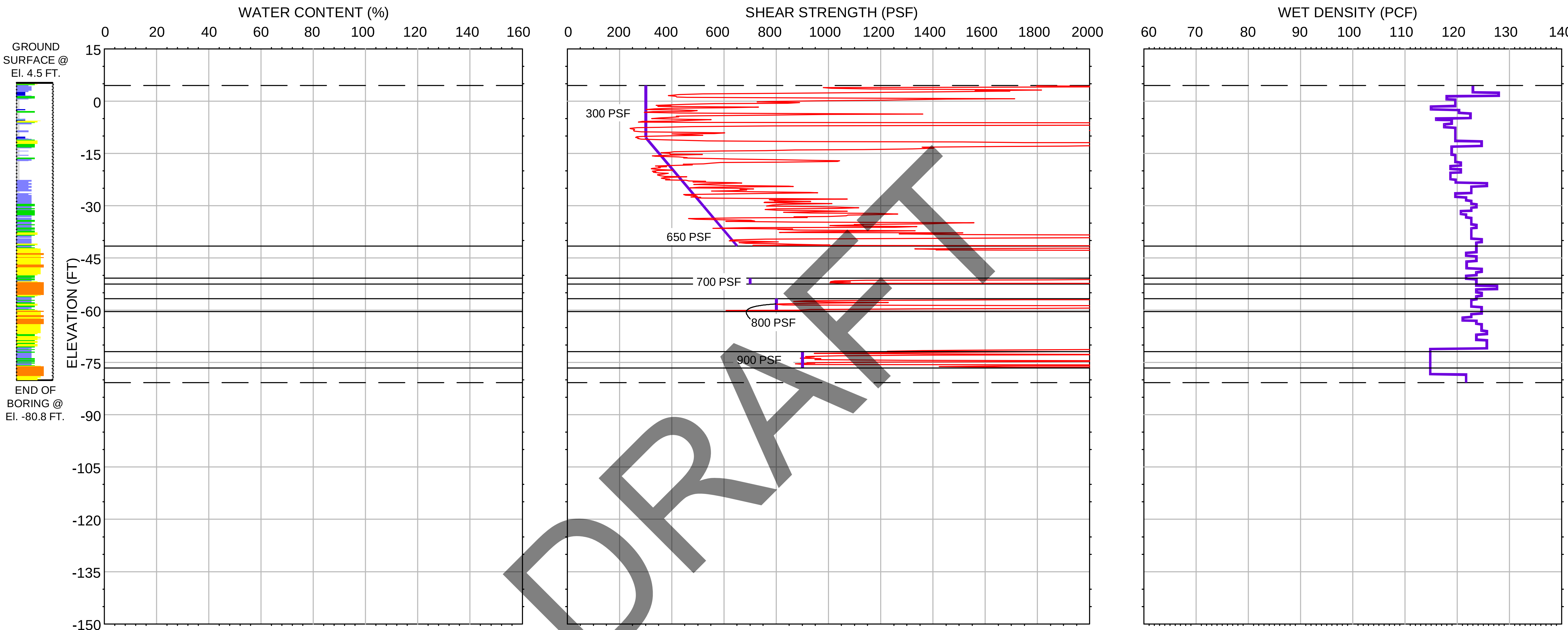
DPS : KMC

P:\18\18274001\00\CAD\GRAPH-MC.dwg\TAB:IS-3A modified on Feb 10, 2014 - 7:08am



LEGEND

IS-4C
DESIGN STRENGTH

1 - sensitive fine grained
2 - organic material
3 - clay
4 - silty clay to clay
5 - clayey silt to silty clay
6 - sandy silt to clayey silt
7 - silty sand to sandy silt
8 - sand to silty sand
9 - sand
10 - gravelly sand to sand
11 - very stiff fine grained (*)
12 - sand to clayey sand (*)

* Overconsolidated or cemented

Notes:
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DESIGN CHARTS
IS-4C

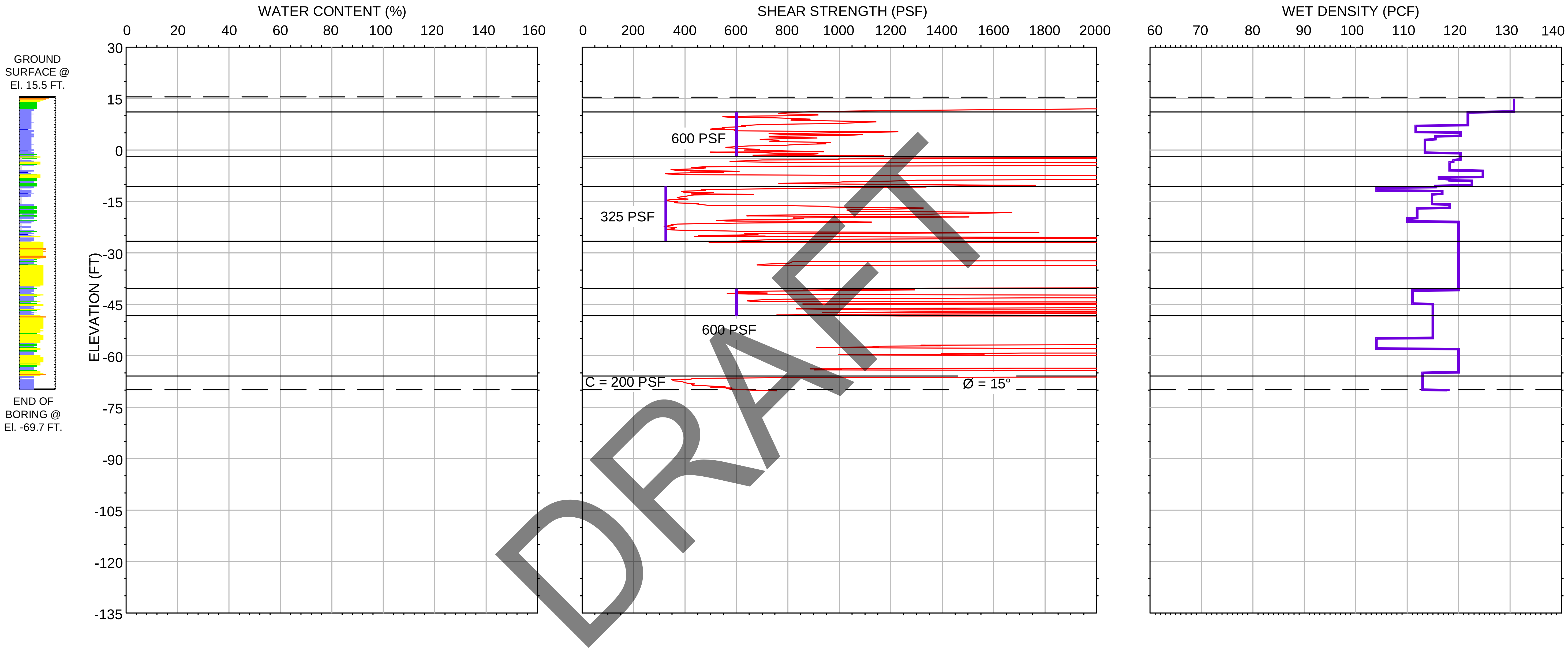
Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2v

DPS : KMC

P:\18\1827400100\CAD\GRAPH-MC.dwg\TAB:IS-4C modified on Feb 04, 2014 - 2:19pm



LEGEND

IS-5C
DESIGN STRENGTH

1 - sensitive fine grained
2 - organic material
3 - clay
4 - silty clay to clay
5 - clayey silt to silty clay
6 - sandy silt to clayey silt
7 - silty sand to sandy silt
8 - sand to silty sand
9 - sand
10 - gravelly sand to sand
11 - very stiff fine grained (*)
12 - sand to clayey sand (*)

* Overconsolidated or cemented

Notes:
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DESIGN CHARTS
IS-5C

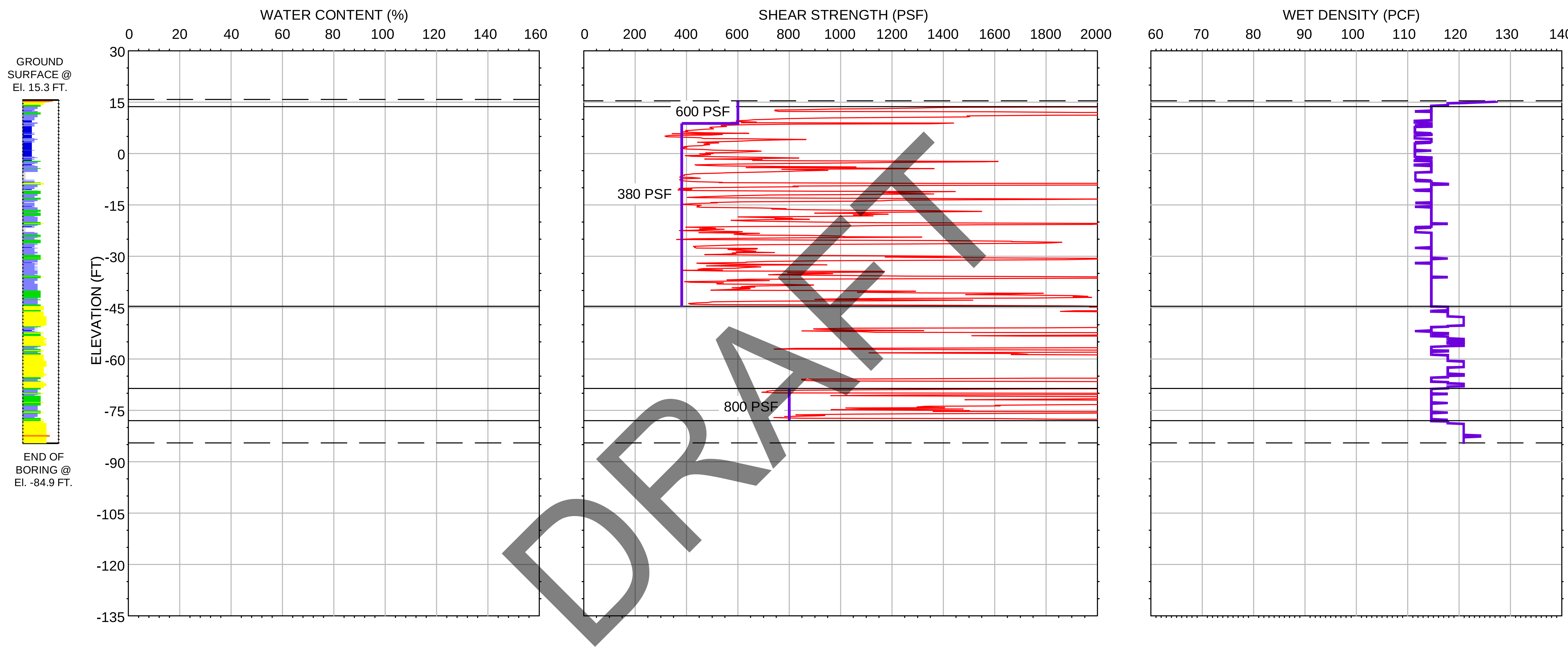
Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2w

DPS : KMC

P:\18\1827400100\CAD\GRAPH-MC.dwg\TAB:IS-5C modified on Feb 04, 2014 - 2:20pm



LEGEND

IS-6C
DESIGN STRENGTH

1 - sensitive fine grained
2 - organic material
3 - clay
4 - silty clay to clay
5 - clayey silt to silty clay
6 - sandy silt to clayey silt
7 - silty sand to sandy silt
8 - sand to silty sand
9 - sand
10 - gravelly sand to sand
11 - very stiff fine grained (*)
12 - sand to clayey sand (*)

* Overconsolidated or cemented

Notes:
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DESIGN CHARTS
IS-6C

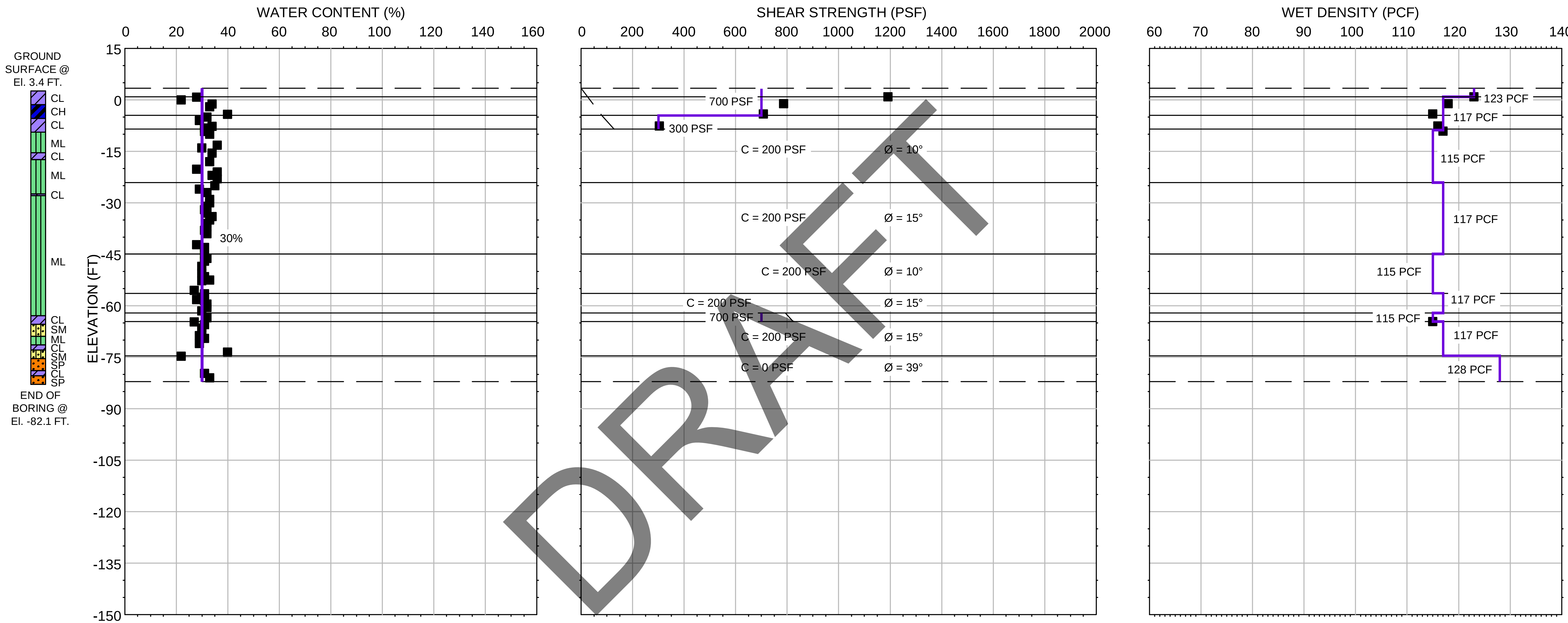
Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GeoEngineers

Figure A-2x

DPS : KMC

P:\18\18274001\00\CAD\GRAPH-MC.dwg\TAB:IS-6C modified on Feb 04, 2014 - 2:23pm



LEGEND

- IS-7A
- DESIGN STRENGTH
- C/P LINE = 0.22

CL, SP, CH, SC, ML, PT, SM

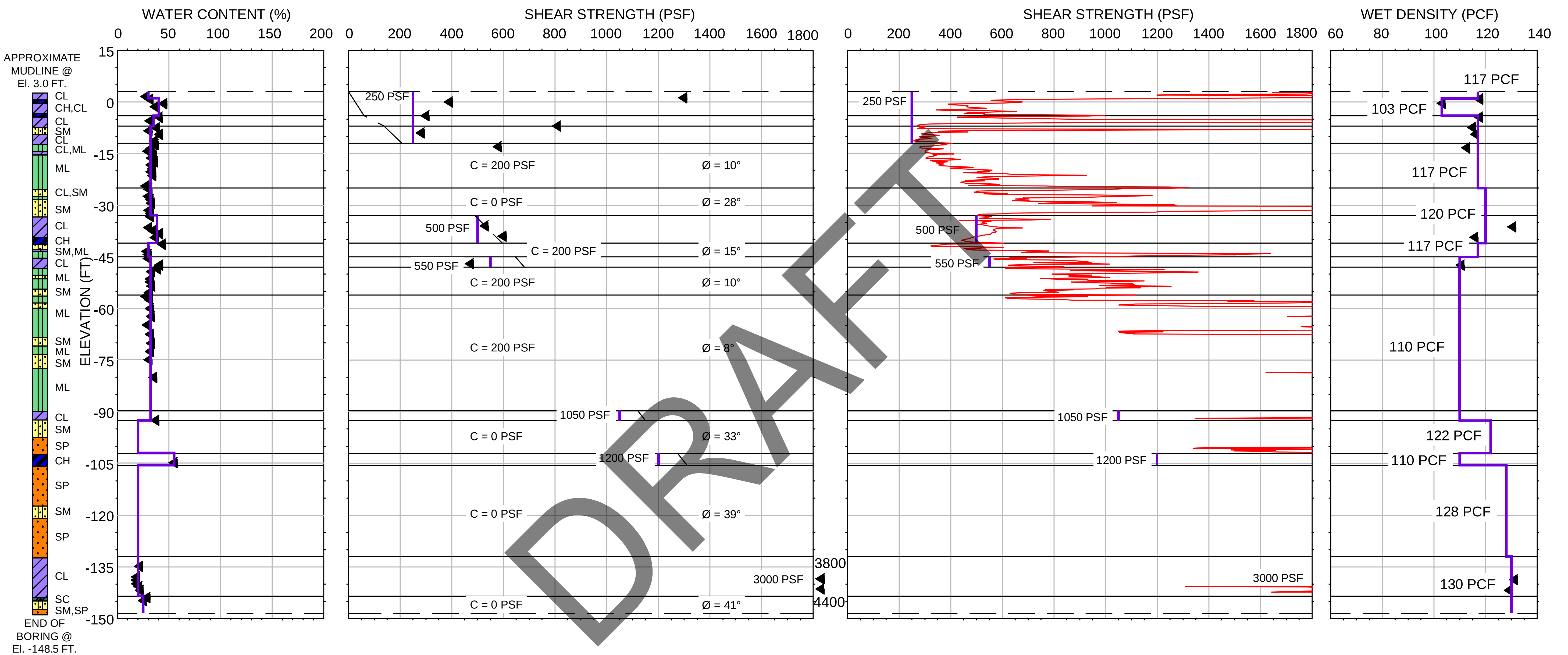
Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

DESIGN CHARTS
IS-7A

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2y



LEGEND

- IS-8A
- IS-10C
- DESIGN STRENGTH
- C/P LINE = 0.22
- CL
- CH
- ML
- SM
- SP
- SC
- PT

Notes:

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DESIGN CHARTS
IS-8A & IS-10C

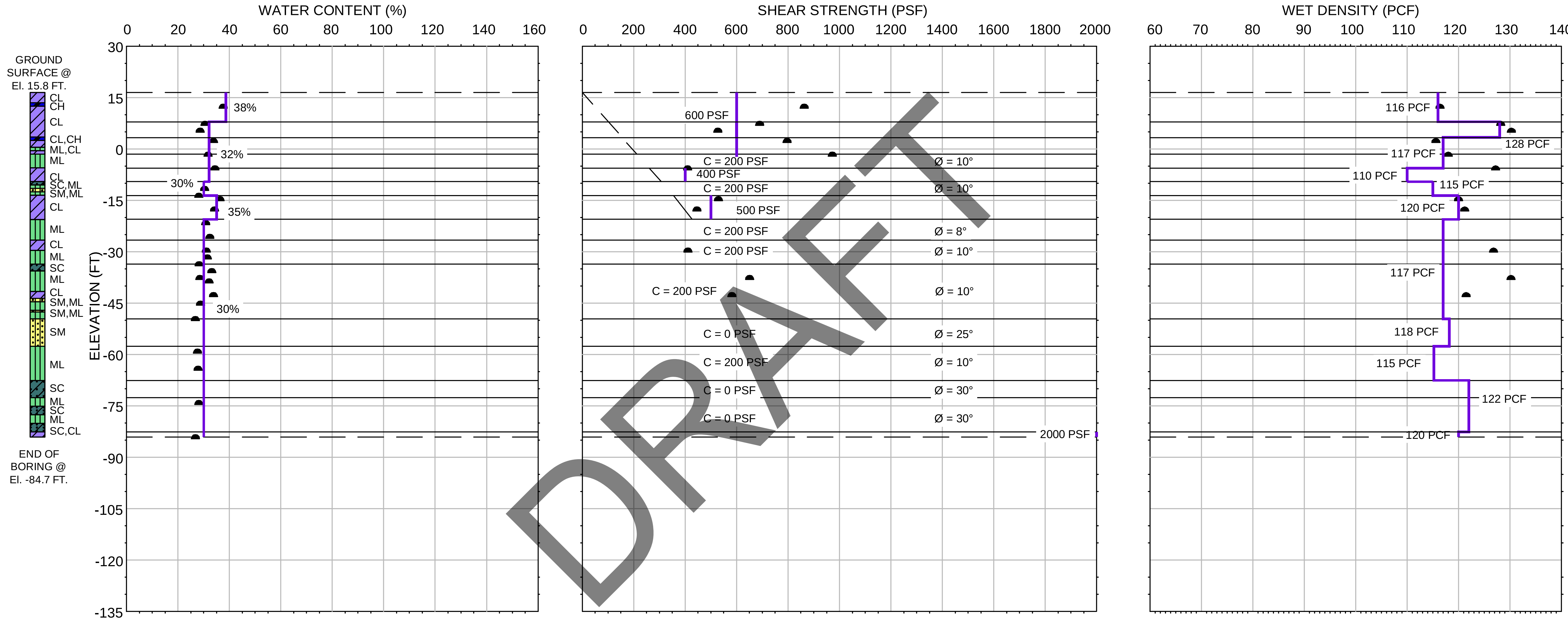
Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2z

DPS : KMC

P:\18\1827400100\CAD\GRAPH-MC.dwg\TAB:IS-8A 10C modified on Feb 10, 2014 - 2:03pm



LEGEND

- IS-9A
- DESIGN STRENGTH
- C/P LINE = 0.22
- CL
- SP
- CH
- SC
- ML
- PT
- SM

DESIGN CHARTS
IS-9A

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2aa

Notes:
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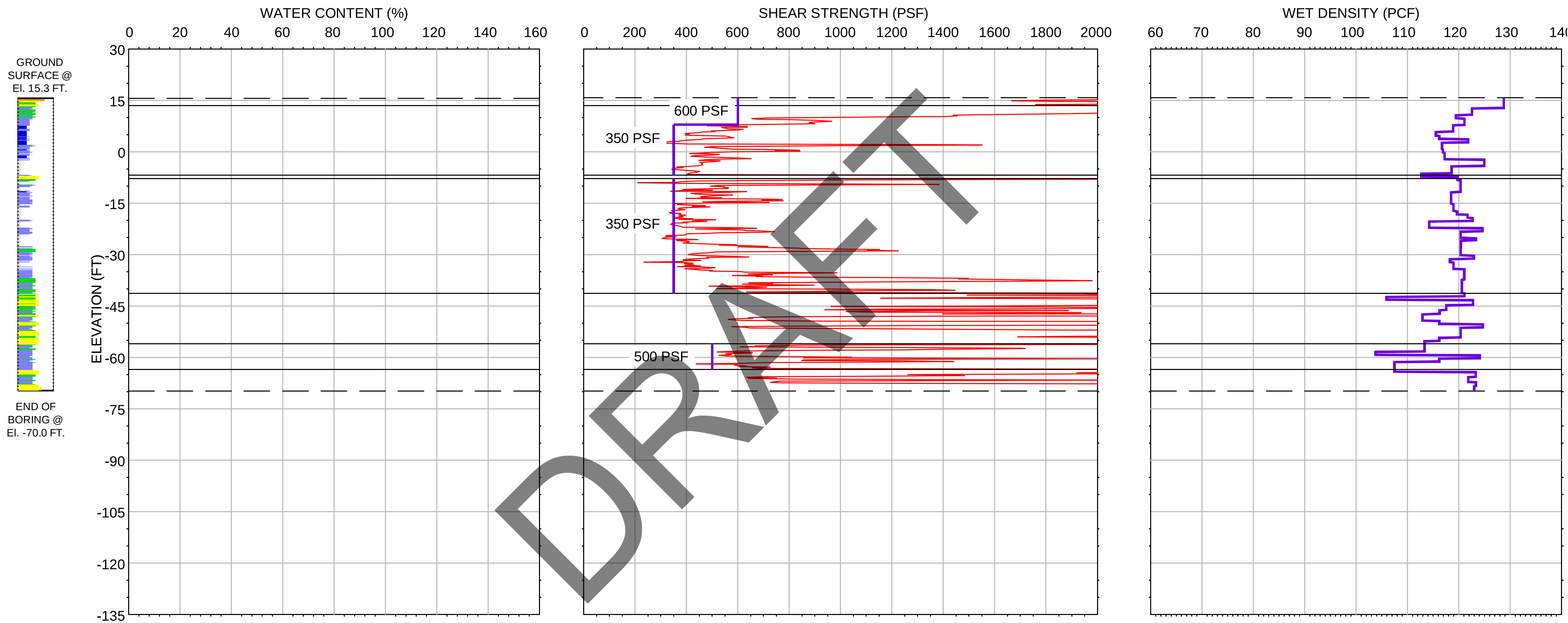
DPS : KMC

P:\18\1827400100\CAD\GRAPH-MC.dwg\TAB:IS-9A modified on Feb 10, 2014 - 7:23am



LEGEND

- IS-11C
- DESIGN STRENGTH

1 - sensitive fine grained	7 - silty sand to sandy silt
2 - organic material	8 - sand to silty sand
3 - clay	9 - sand
4 - silty clay to clay	10 - gravelly sand to sand
5 - clayey silt to silty clay	11 - very stiff fine grained (*)
6 - sandy silt to clayey silt	12 - sand to clayey sand (*)

* Overconsolidated or cemented

DPS : KMC

Notes:
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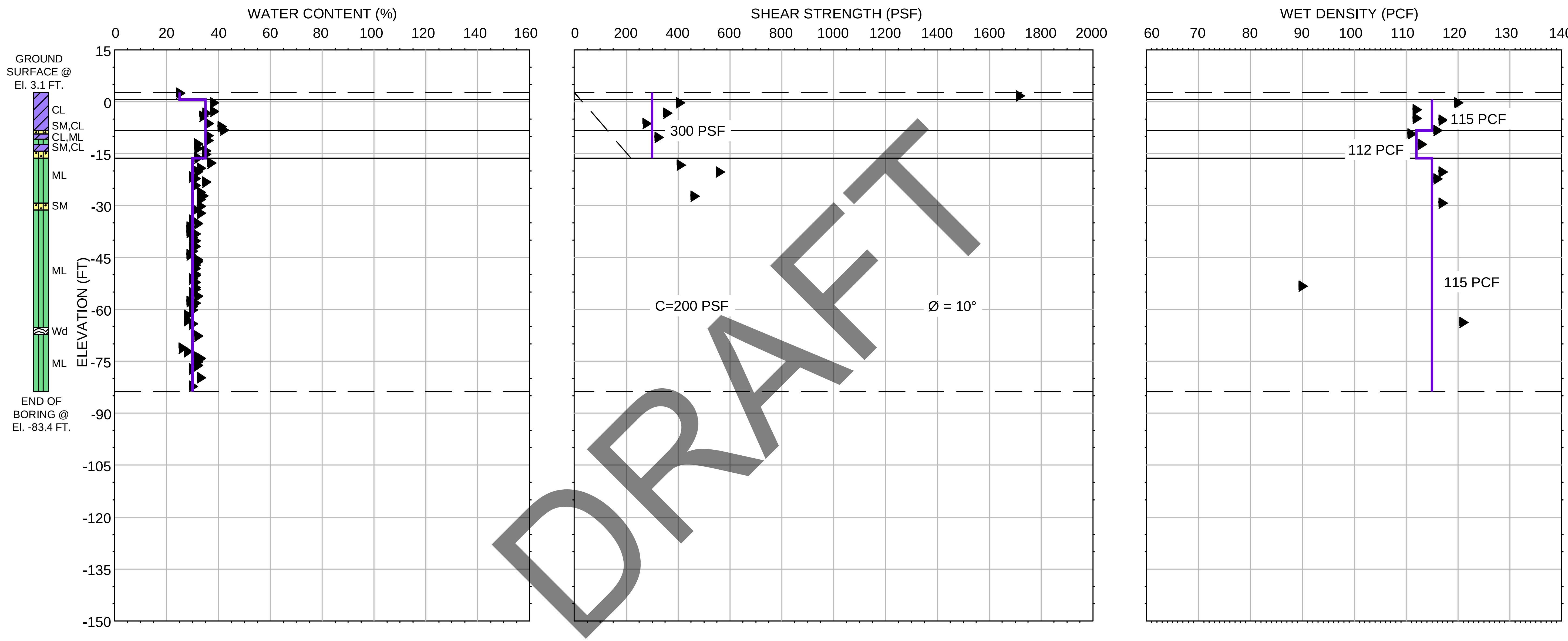
P:\18\1827400100\CAD\GRAPH-MC.dwg\TAB:IS-11C modified on Feb 04, 2014 - 2:34pm

DESIGN CHARTS
IS-11C

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2ab



LEGEND

- ▶ IS-12A
- DESIGN STRENGTH
- C/P LINE = 0.22

CL SP
CH SC
ML PT
SM

DESIGN CHARTS
IS-12A

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-2ac

Notes:
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DPS : KMC

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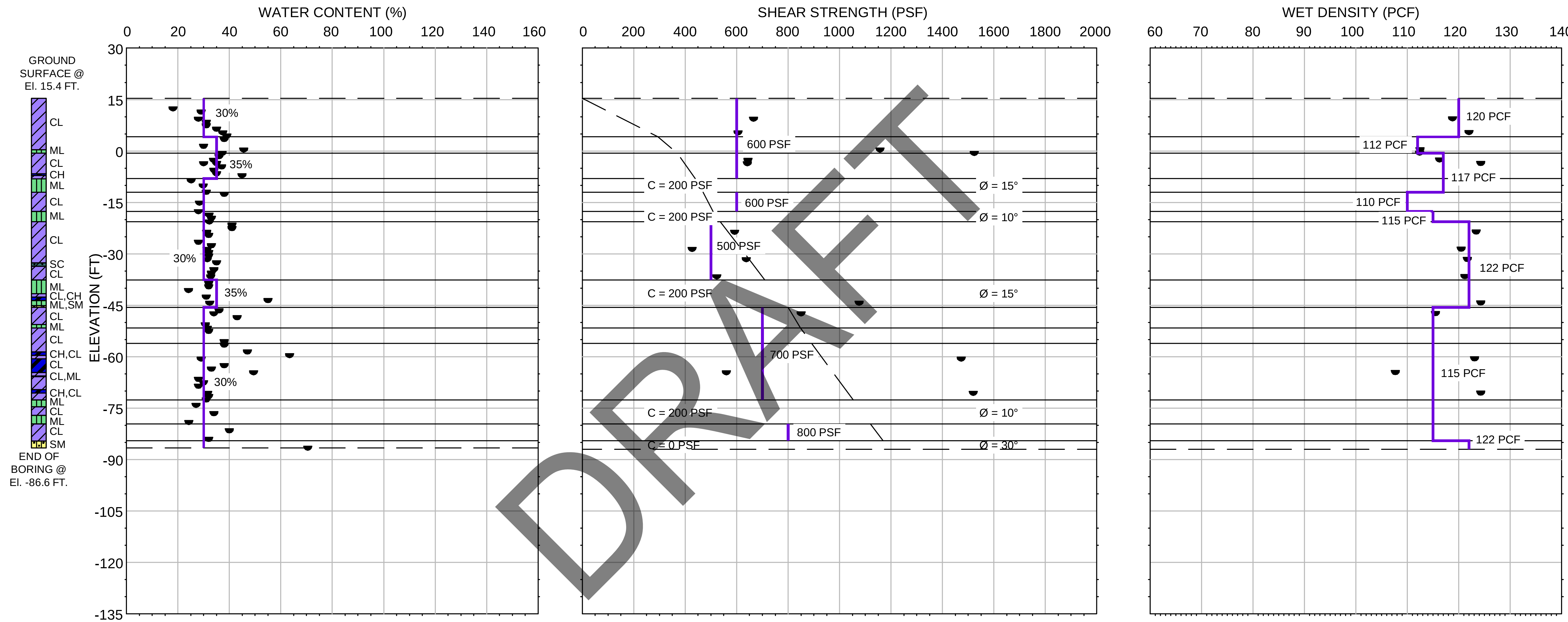

LEGEND

- IS-13A
- DESIGN STRENGTH
- C/P LINE = 0.22

CL, SP, CH, SC, ML, PT, SM

DESIGN CHARTS
IS-13A

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GeoEngineers | Figure K-2ad

Notes:
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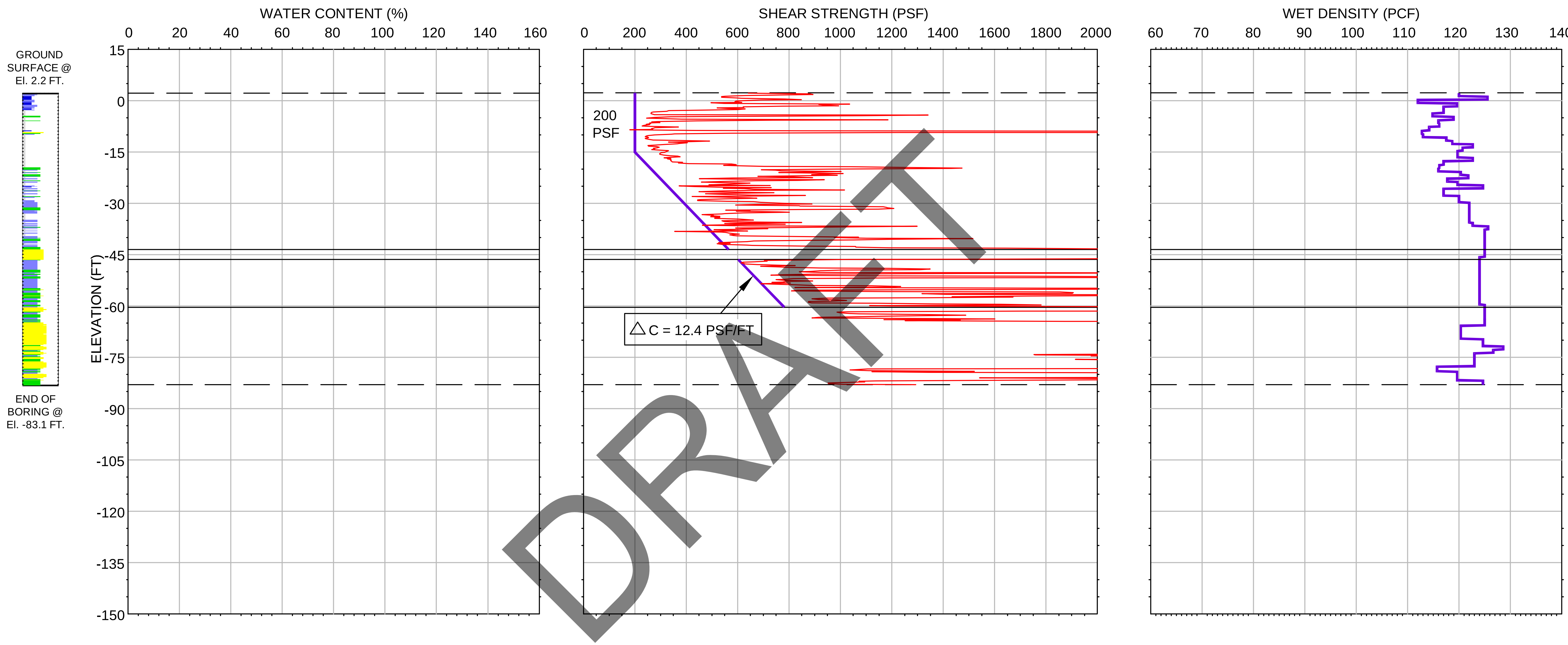
DPS : KMC

P:\18\1827400100\CAD\GRAPH-MC.dwg\TAB:IS-13A modified on Feb 10, 2014 - 7:30am



LEGEND

IS-14C
DESIGN STRENGTH

1 - sensitive fine grained
2 - organic material
3 - clay
4 - silty clay to clay
5 - clayey silt to silty clay
6 - sandy silt to clayey silt
7 - silty sand to sandy silt
8 - sand to silty sand
9 - sand
10 - gravelly sand to sand
11 - very stiff fine grained (*)
12 - sand to clayey sand (*)

* Overconsolidated or cemented

Notes:
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DESIGN CHARTS
IS-14C

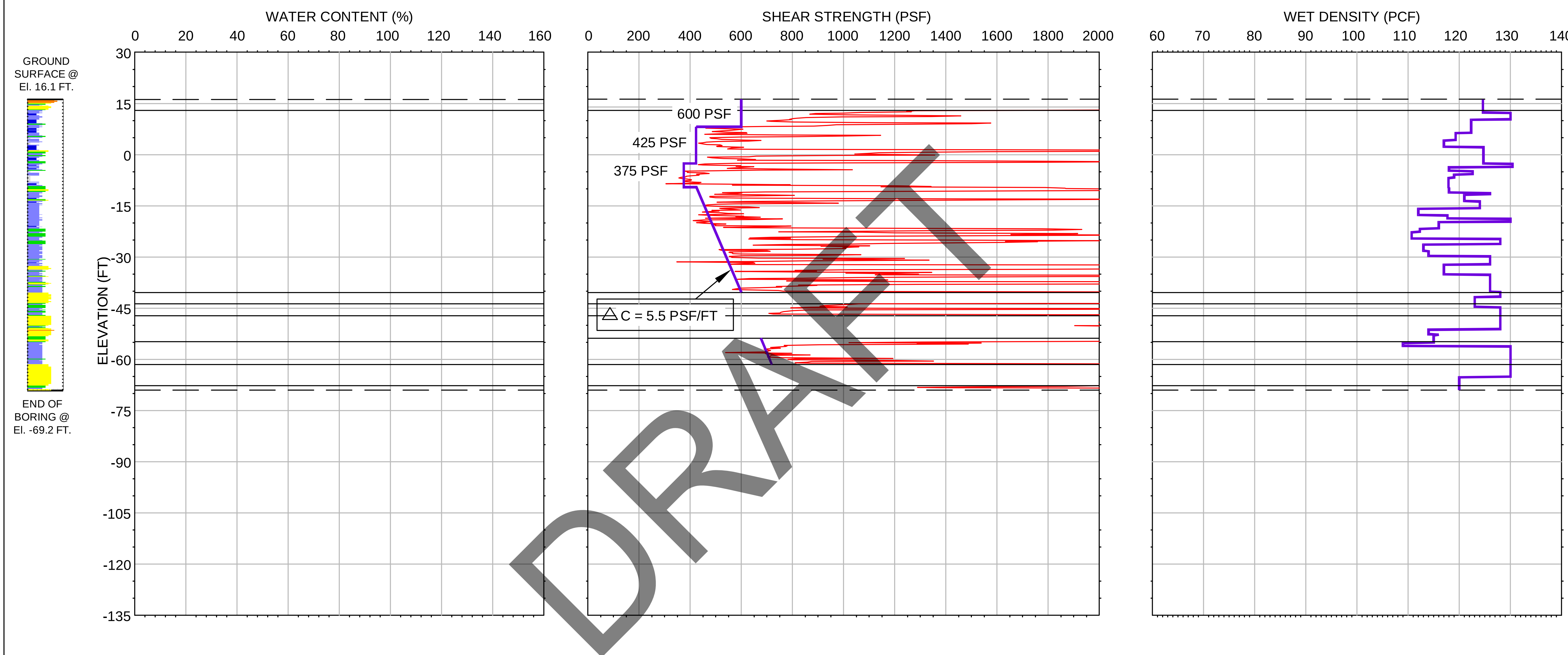
Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GeoEngineers

Figure A-2ae

DPS : KMC

P:\18\1827400100\CAD\GRAPH-MC.dwg\TAB:IS-14C modified on Feb 04, 2014 - 2:44pm



LEGEND

IS-15C

DESIGN STRENGTH

1 - sensitive fine grained

2 - organic material

3 - clay

4 - silty clay to clay

5 - clayey silt to silty clay

6 - sandy silt to clayey silt

7 - silty sand to sandy silt

8 - sand to silty sand

9 - sand

10 - gravelly sand to sand

11 - very stiff fine grained (*)

12 - sand to clayey sand (*)

* Overconsolidated or cemented

Notes:
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DESIGN CHARTS
IS-15C

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

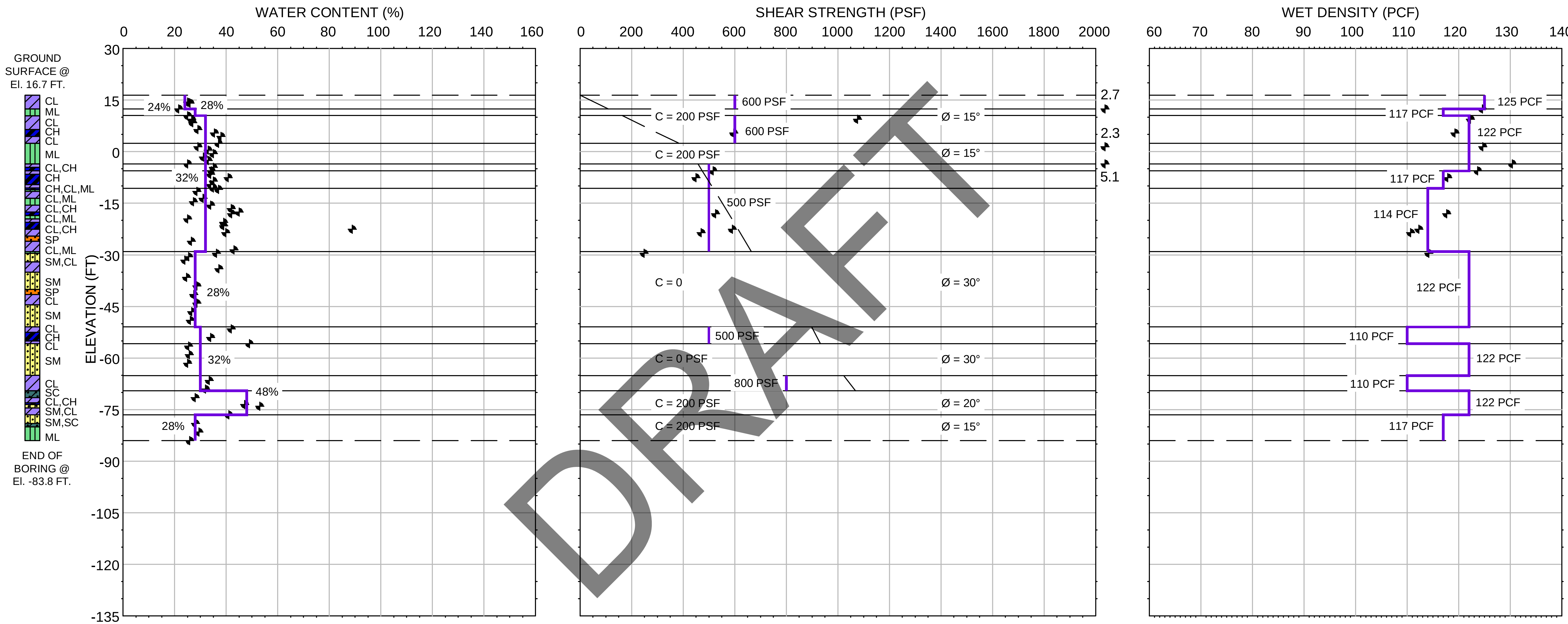
GEOENGINEERS

Figure A-2af

DPS : KMC

P:\18\1827400100\CAD\GRAPH-MC.dwg\TAB:IS-15C modified on Feb 06, 2014 - 3:51pm

DPS : KMC



LEGEND

- IS-16A
- DESIGN STRENGTH
- C/P LINE = 0.22

CL, CH, ML, SM, SP, SC, PT

Notes:
1. The locations of all features shown are approximate.
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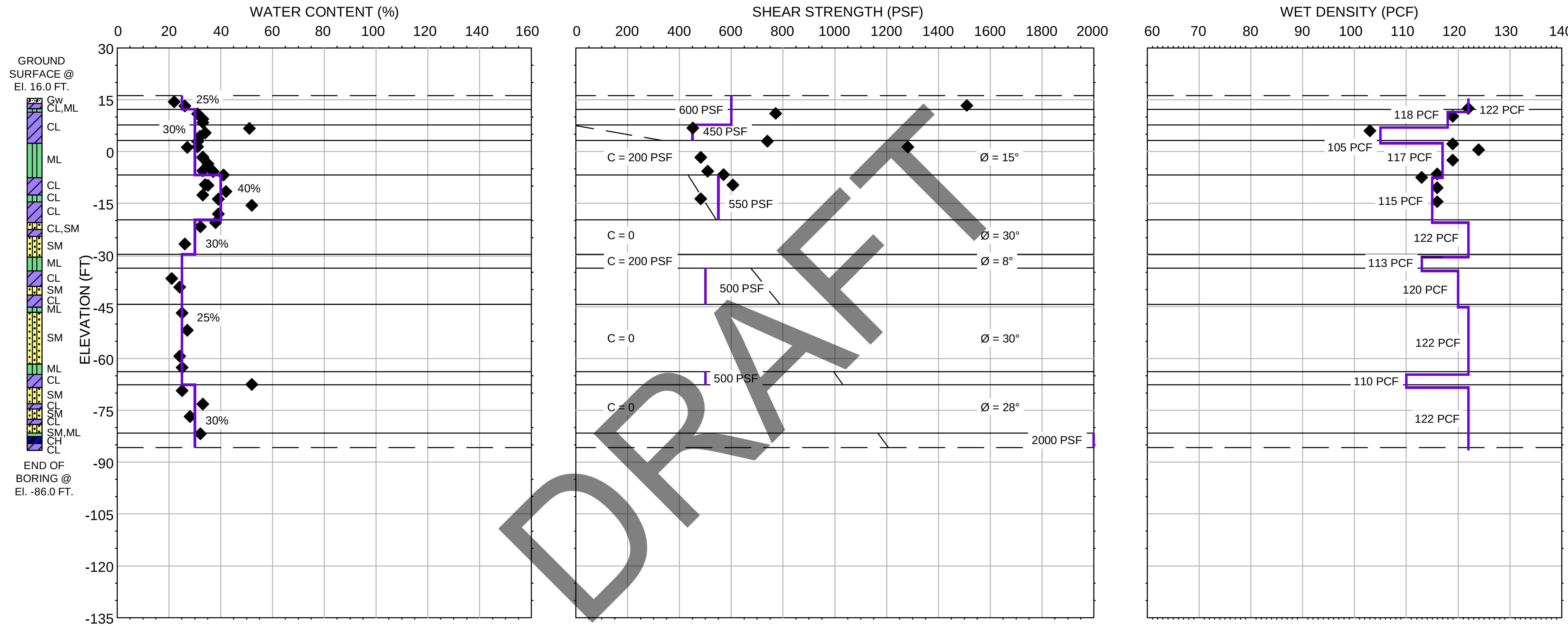
DESIGN CHARTS
IS-16A

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS **Figure A-2ag**

P:\18\18274001\00\CAD\GRAPH-MC.dwg\TAB:IS-16A modified on Feb 10, 2014 - 7:32am



LEGEND

- ◆ IS-17A
- DESIGN STRENGTH
- C/P LINE = 0.22

CL, CH, ML, SM, SP, SC, PT

Notes:
1. The locations of all features shown are approximate.
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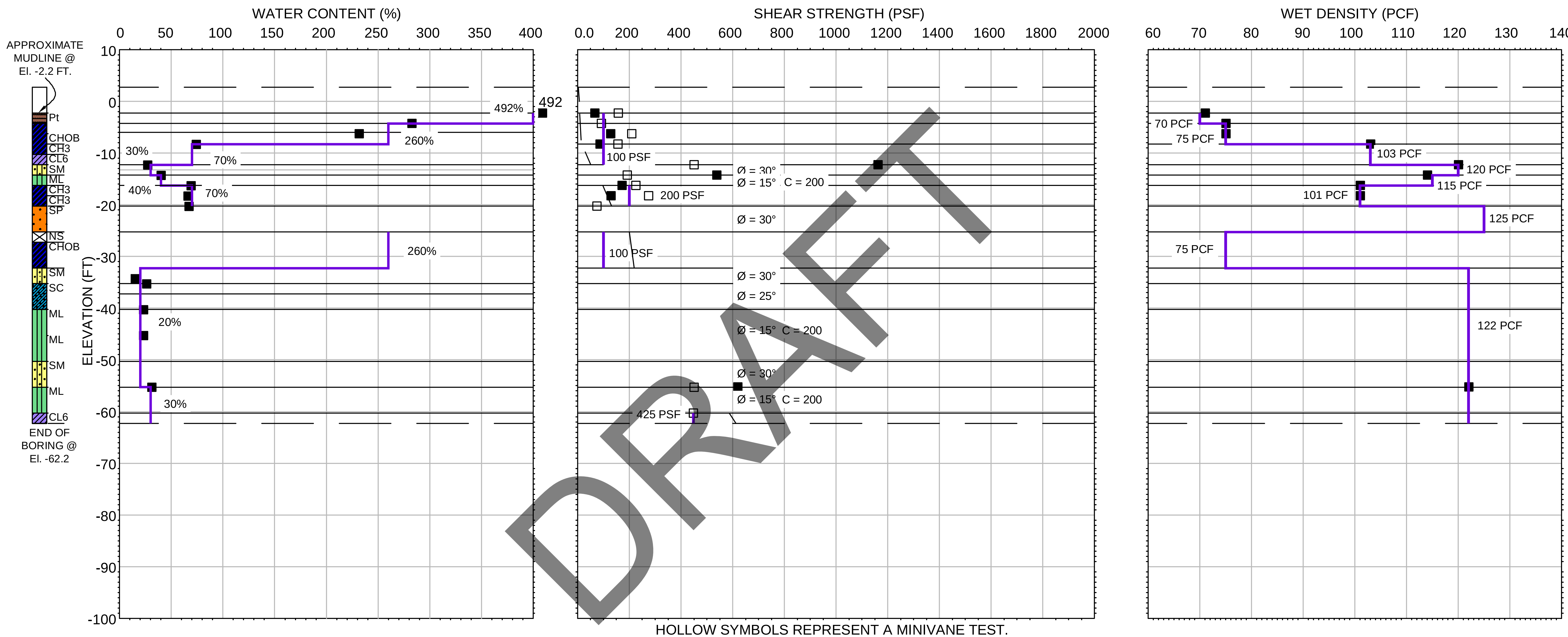
DESIGN CHARTS IS-17A	
Mid Barataria Diversion (BA-153) Project Plaquemines Parish, Louisiana	
GEOENGINEERS	**Figure A-2ah**

DPS : KMC

P:\18\18274001\00\CAD\GRAPH-MC.dwg\TAB:IS-17A modified on Feb 10, 2014 - 7:35am



LEGEND

DESIGN STRENGTH
C/P LINE = 0.22
M-1
CL
CH
ML
SM
SP
SC
PT

Notes:
1. The locations of all features shown are approximate.
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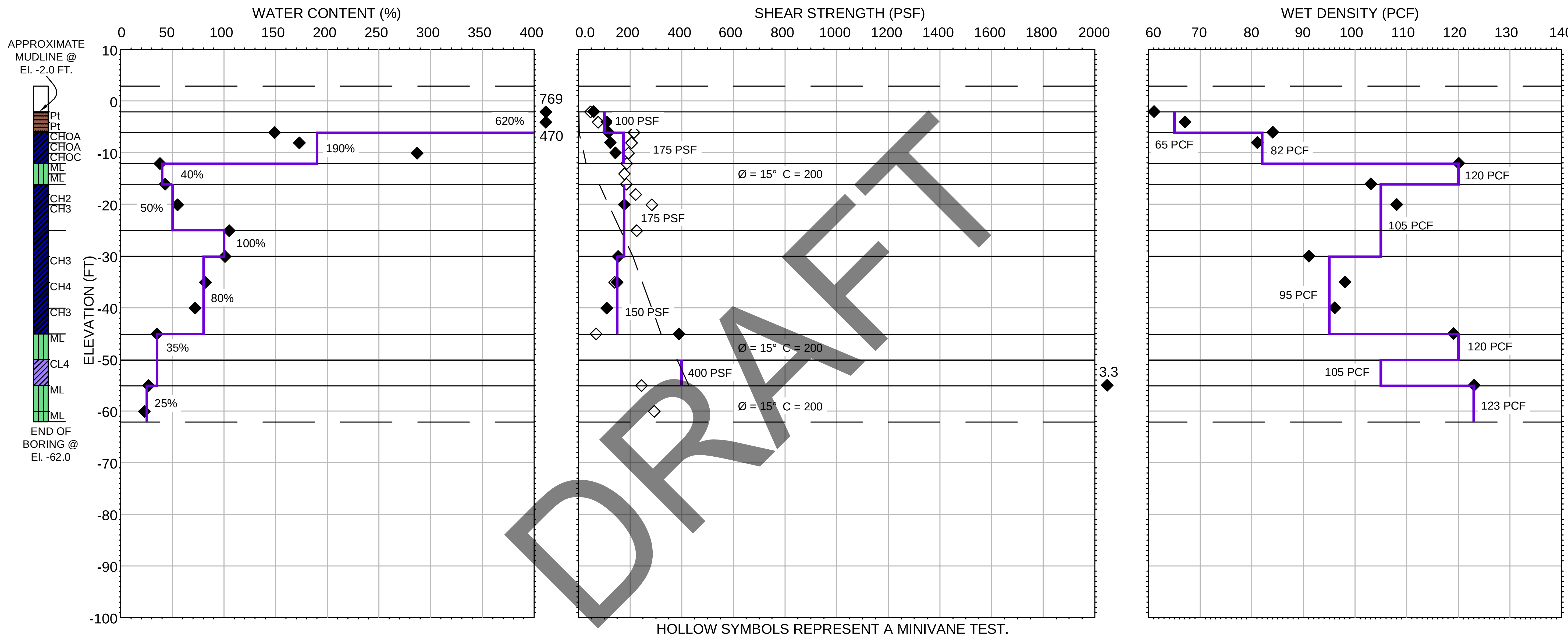
DESIGN CHARTS M-1	
Mid Barataria Diversion (BA-153) Project Plaquemines Parish, Louisiana	
GEOENGINEERS	Figure A-3a

DPS : KMC

P:\18\18274001\00\CAD\Graph-Marsh (2-4).dwg\TAB:M1 modified on Feb 10, 2014 - 7:53am



LEGEND

- DESIGN STRENGTH
- C/P LINE = 0.22
- M-2
- CL
- CH
- ML
- SM
- SP
- SC
- PT

Notes:
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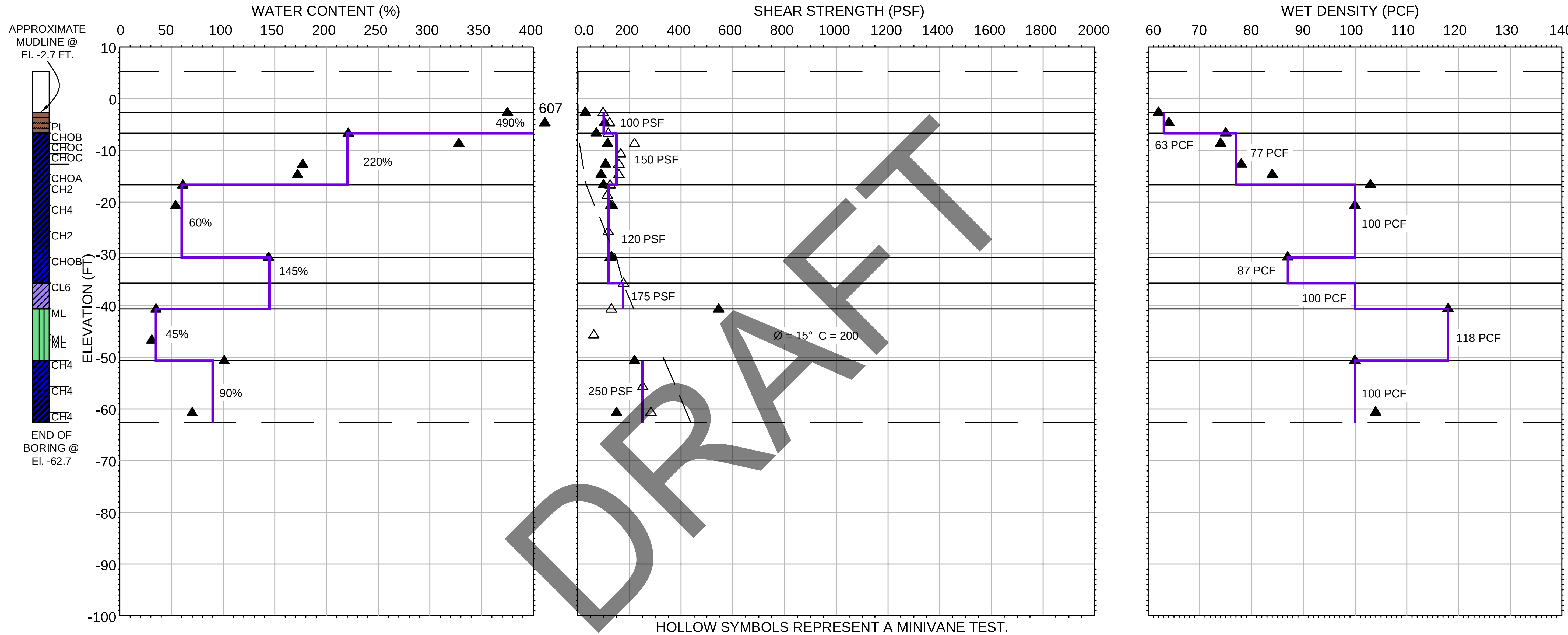
DESIGN CHARTS
M-2

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-3b



LEGEND

DESIGN STRENGTH
C/P LINE = 0.22
M-3

CL
SP
CH
SC
ML
PT
SM

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

DESIGN CHARTS
M-3

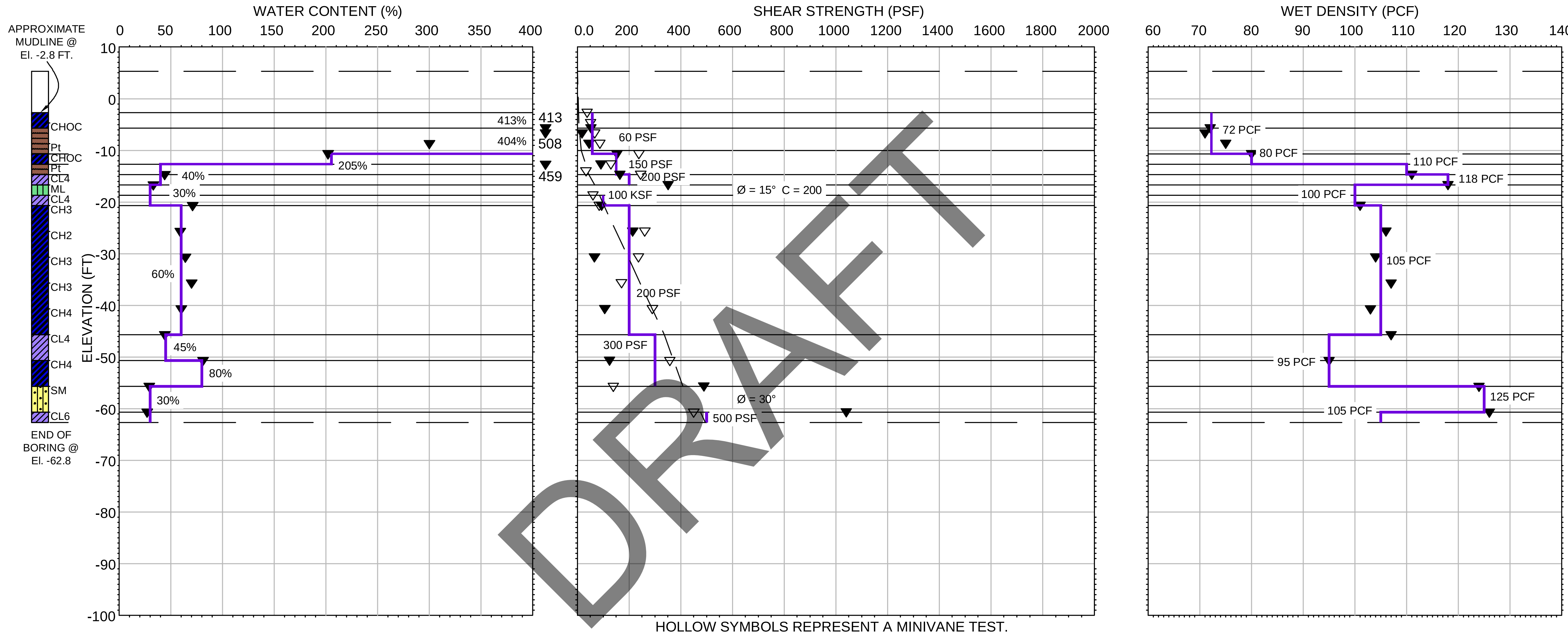
Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-3c

DPS : KMC

P:\18\1827400100\CAD\Graph-Marsh (2-4).dwg\TAB:M3 modified on Feb 10, 2014 - 8:08am



LEGEND

DESIGN STRENGTH
C/P LINE = 0.22
M-4
CL
SP
CH
SC
ML
PT
SM

Notes:
1. The locations of all features shown are approximate.
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DESIGN CHARTS
M-4

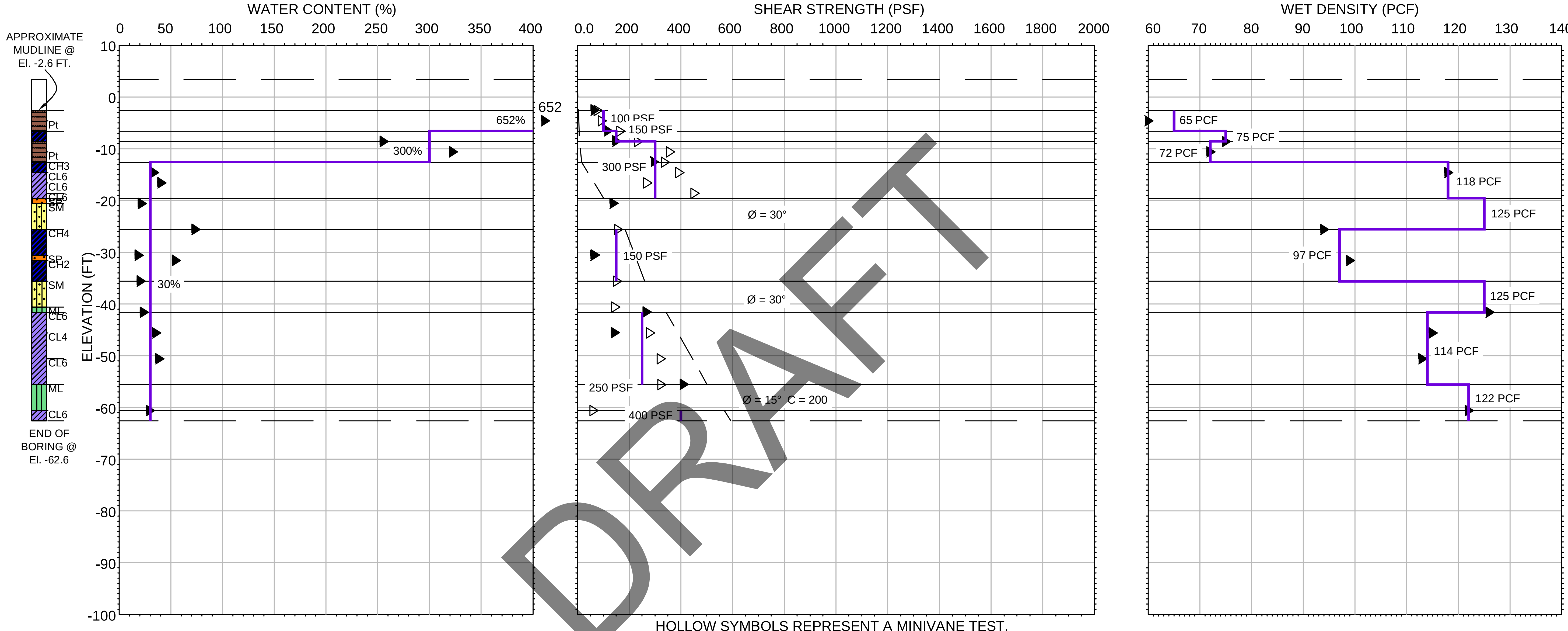
Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-3d

DPS : KMC

P:\18\1827400100\CAD\Graph-Marsh (2-4).dwg\TAB:M4 modified on Feb 10, 2014 - 8:11am



HOLLOW SYMBOLS REPRESENT A MINIVANE TEST.

LEGEND

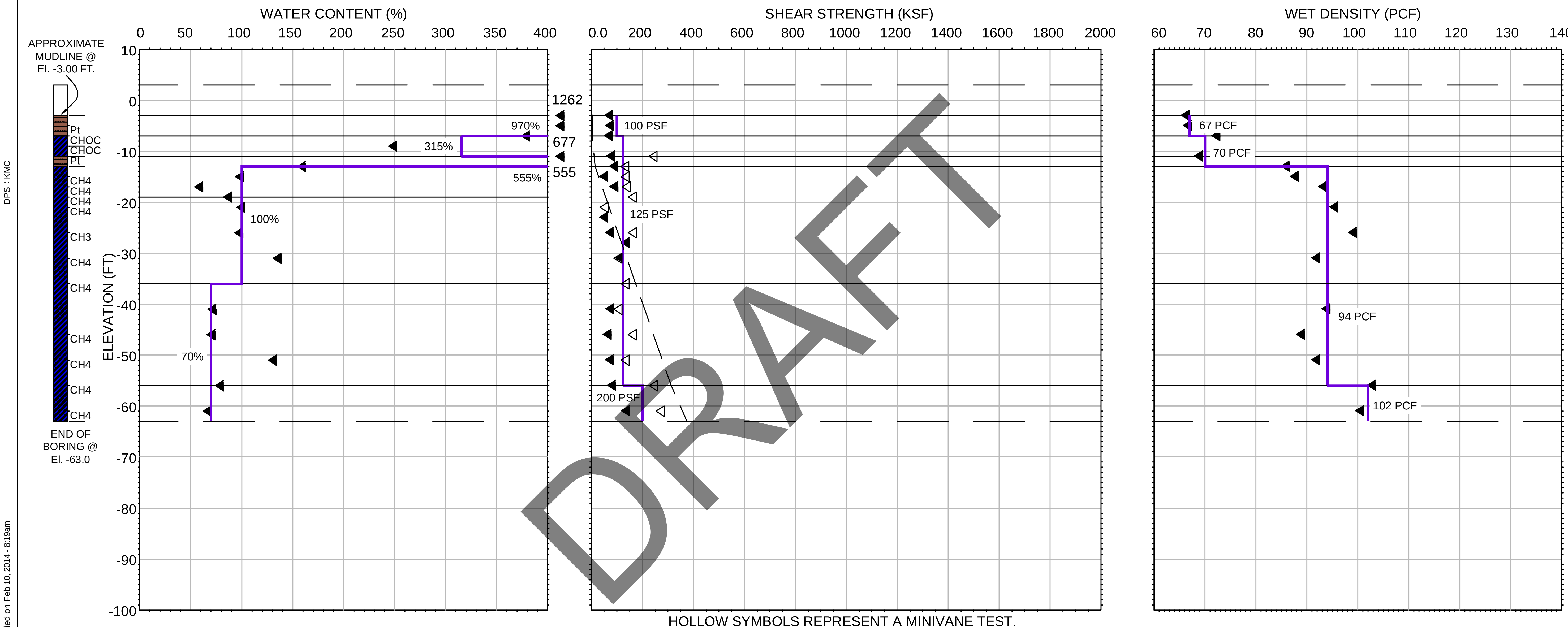
- DESIGN STRENGTH
- C/P LINE = 0.22
- M-5
- CL
- SP
- CH
- SC
- ML
- PT
- SM

DPS : KMC

P:\18\18274001\00\CAD\Graph-Marsh (2-4).dwg\TAB:M5 modified on Feb 10, 2014 - 8:14am

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

DESIGN CHARTS M-5	
Mid Barataria Diversion (BA-153) Project Plaquemines Parish, Louisiana	
GEOENGINEERS	Figure A-3e



LEGEND

- DESIGN STRENGTH
- C/P LINE = 0.22
- M-6
- CL
- CH
- ML
- SM
- SP
- SC
- PT

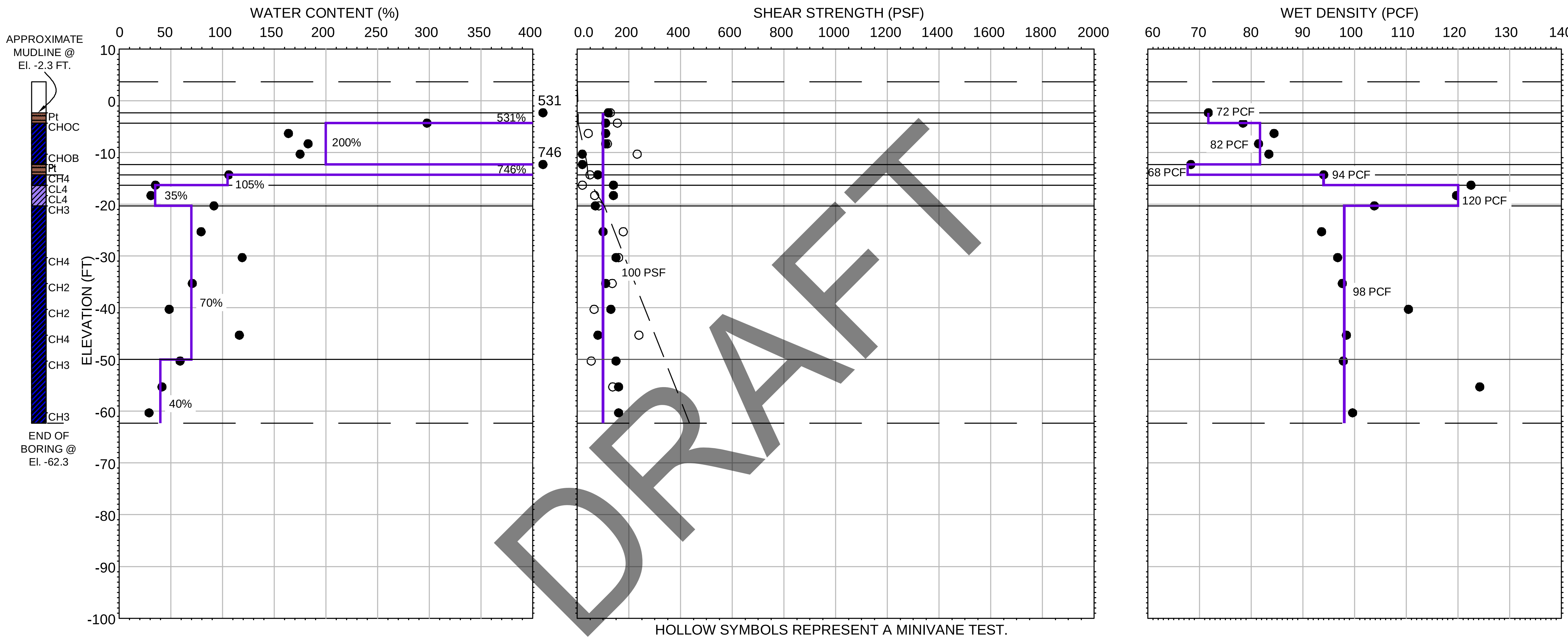
DESIGN CHARTS
M-6

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-3f

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.



DRAFT

LEGEND

- DESIGN STRENGTH
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- CH
- ML
- SM
- SP
- SC
- PT

DESIGN CHARTS
M-7

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-3g

Notes:
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2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

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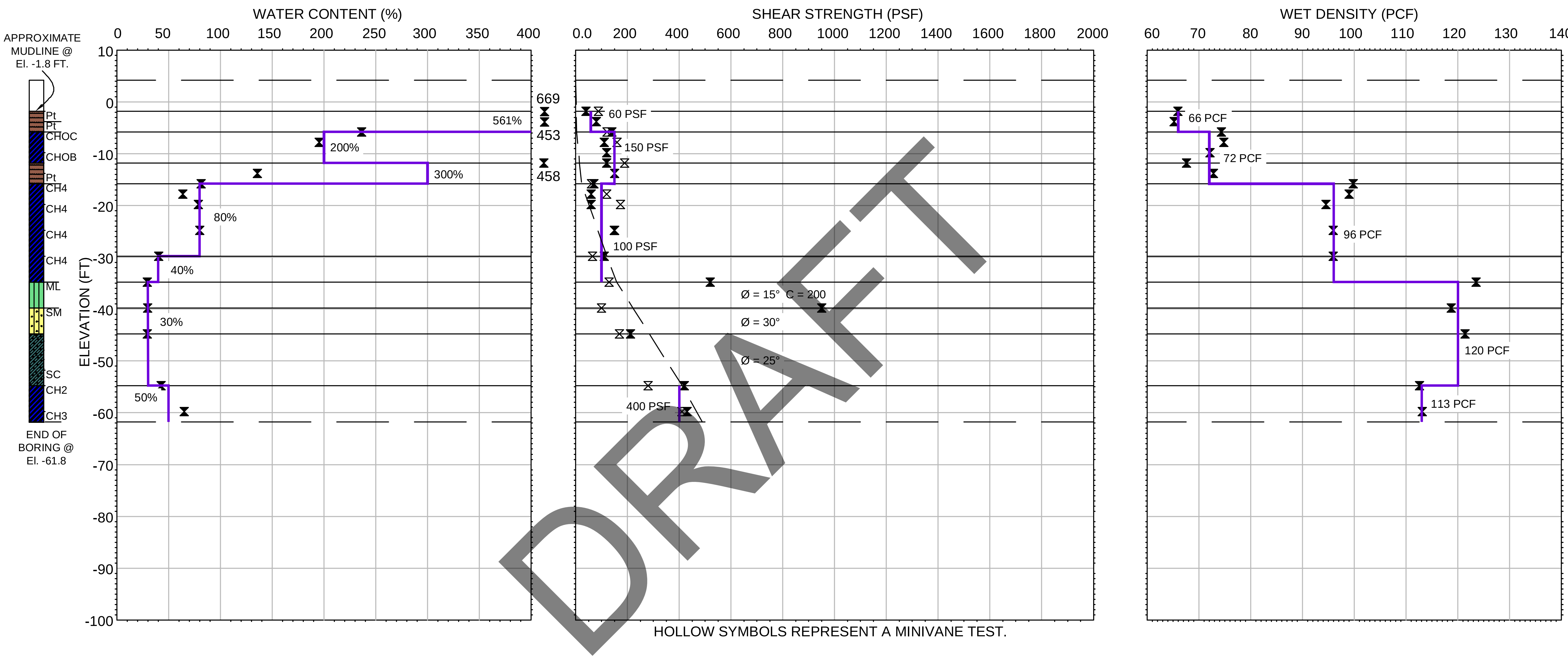

HOLLOW SYMBOLS REPRESENT A MINIVANE TEST.

DPS : KMC

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LEGEND

- DESIGN STRENGTH
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- M-8
- CL
- SP
- CH
- SC
- ML
- PT
- SM

Notes:
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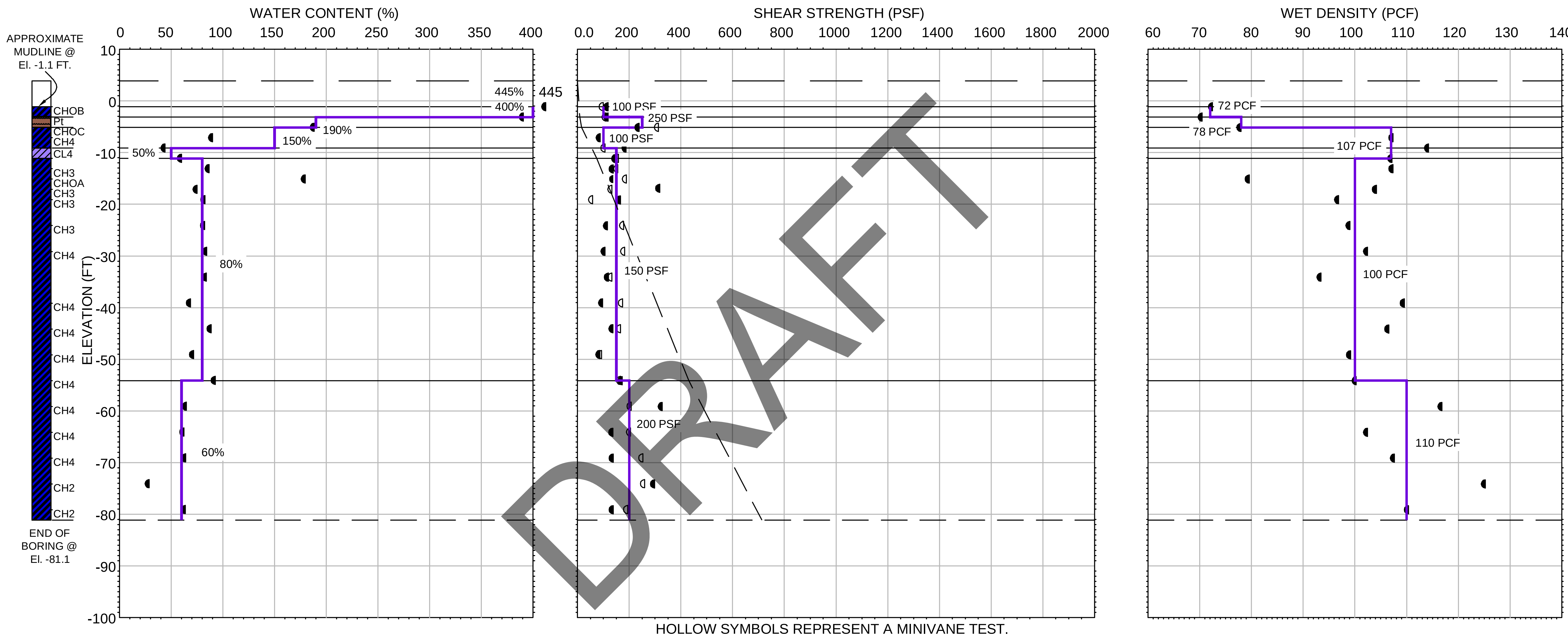
DESIGN CHARTS
M-8

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-3h



LEGEND

DESIGN STRENGTH
C/P LINE = 0.22
M-9
CL
SP
CH
SC
ML
PT
SM

DESIGN CHARTS
M-9

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-3i

Notes:
1. The locations of all features shown are approximate.
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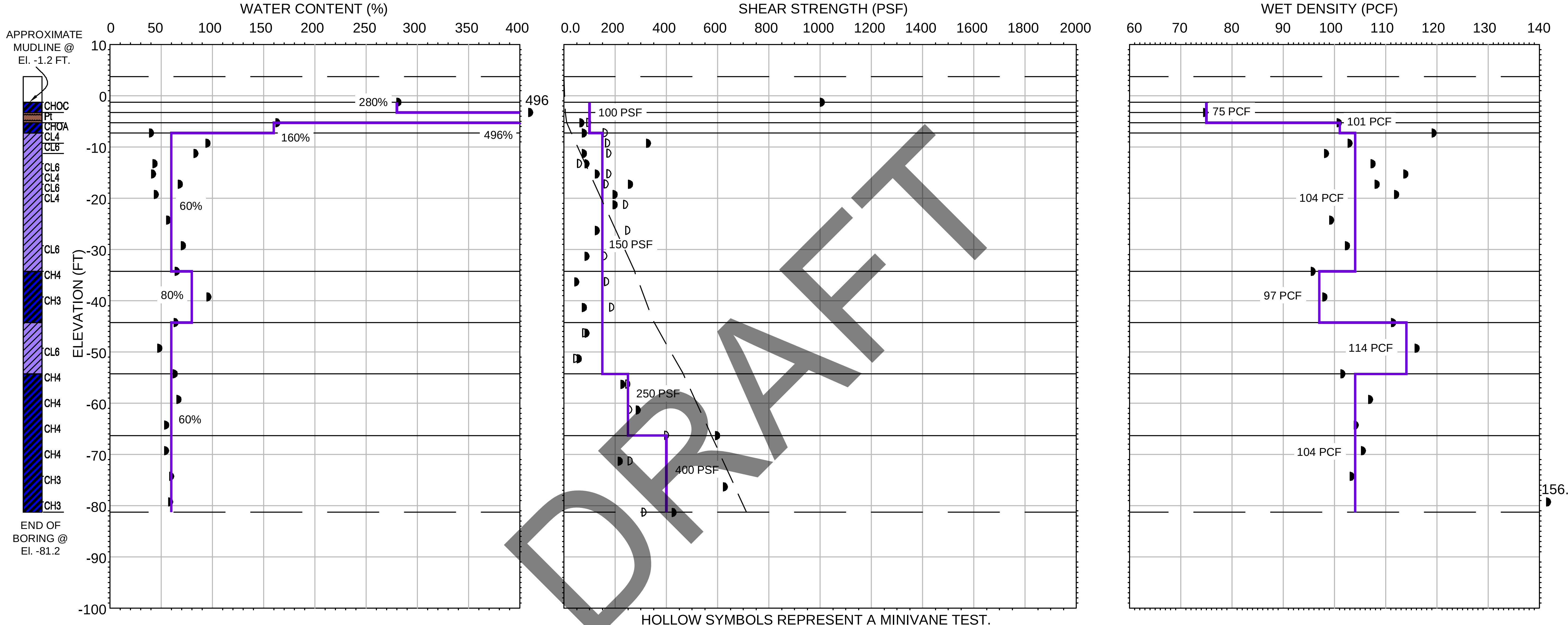

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- M10
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- CH
- ML
- SM
- SP
- SC
- PT

Notes:
1. The locations of all features shown are approximate.
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DESIGN CHARTS
M10

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-3j

DPS : KMC

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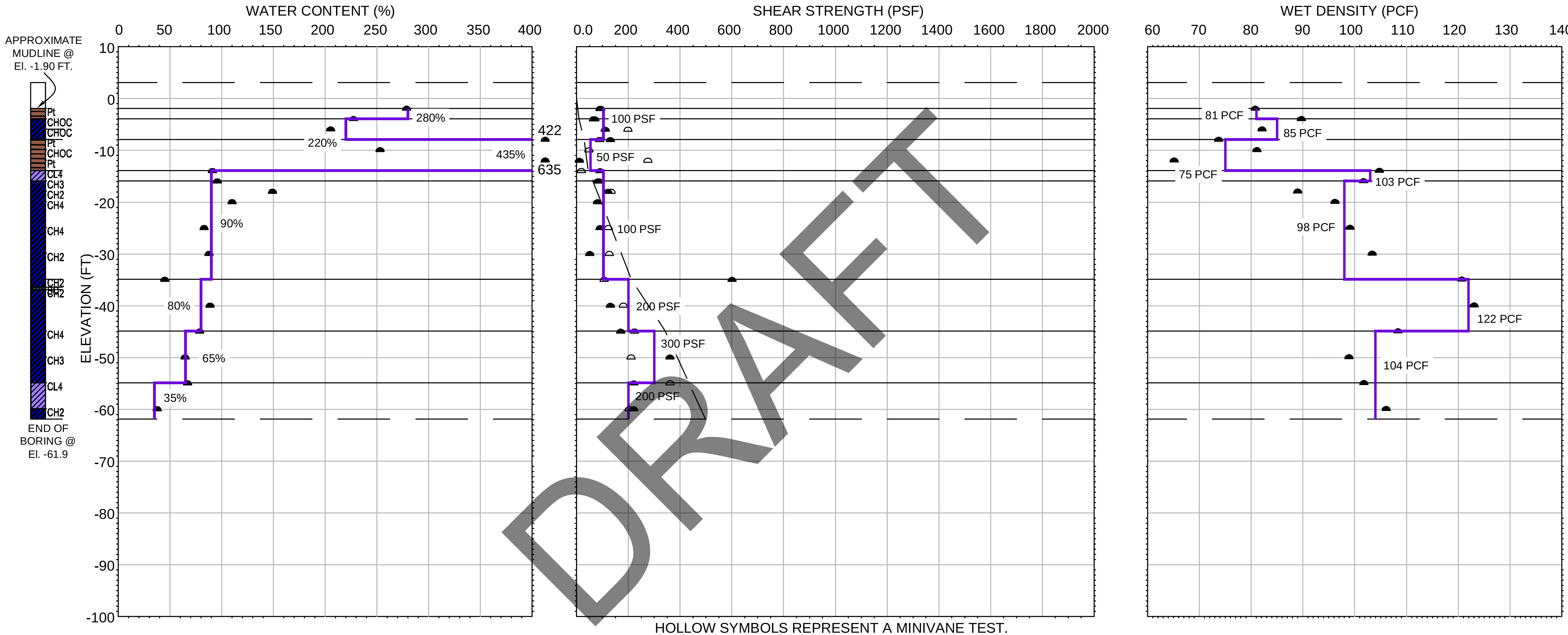

LEGEND

DESIGN STRENGTH
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M-11
CL
SP
CH
SC
ML
PT
SM

Notes:
1. The locations of all features shown are approximate.
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DESIGN CHARTS
M-11

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-3k

DPS : KMC

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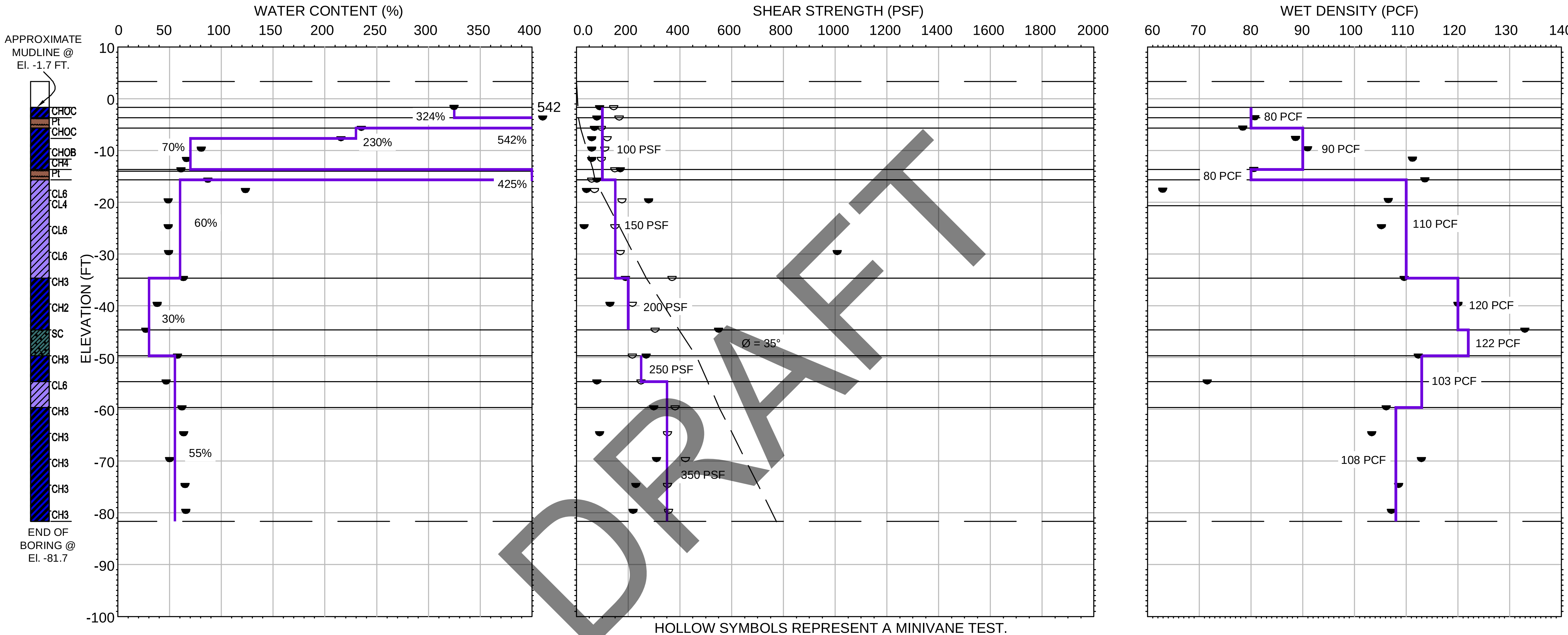

HOLLOW SYMBOLS REPRESENT A MINIVANE TEST.

LEGEND

DESIGN STRENGTH
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M-12
CL
CH
ML
SM
SP
SC
PT

Notes:
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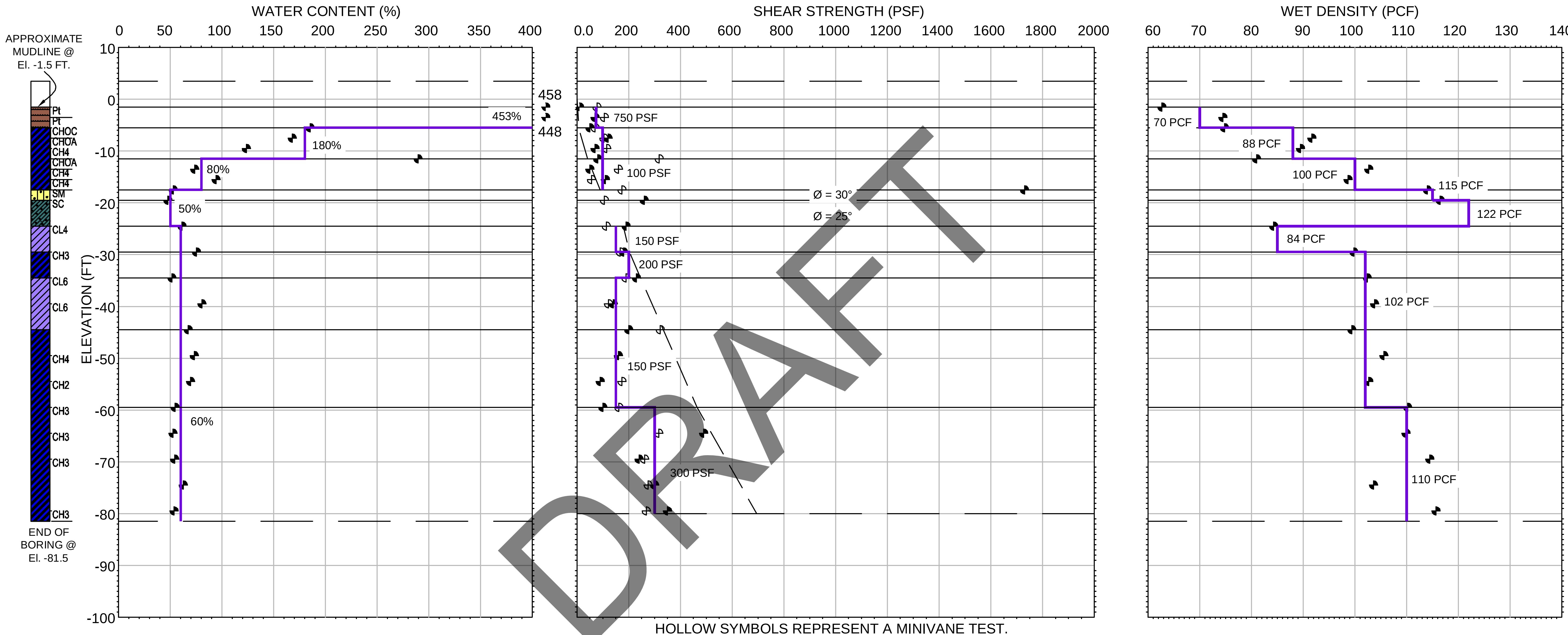
DESIGN CHARTS
M-12

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-3I



LEGEND

DESIGN STRENGTH
C/P LINE = 0.22
M-13

CL
SP
CH
SC
ML
PT
SM

DESIGN CHARTS
M-13

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-3m

Notes:
1. The locations of all features shown are approximate.
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DPS : KMC

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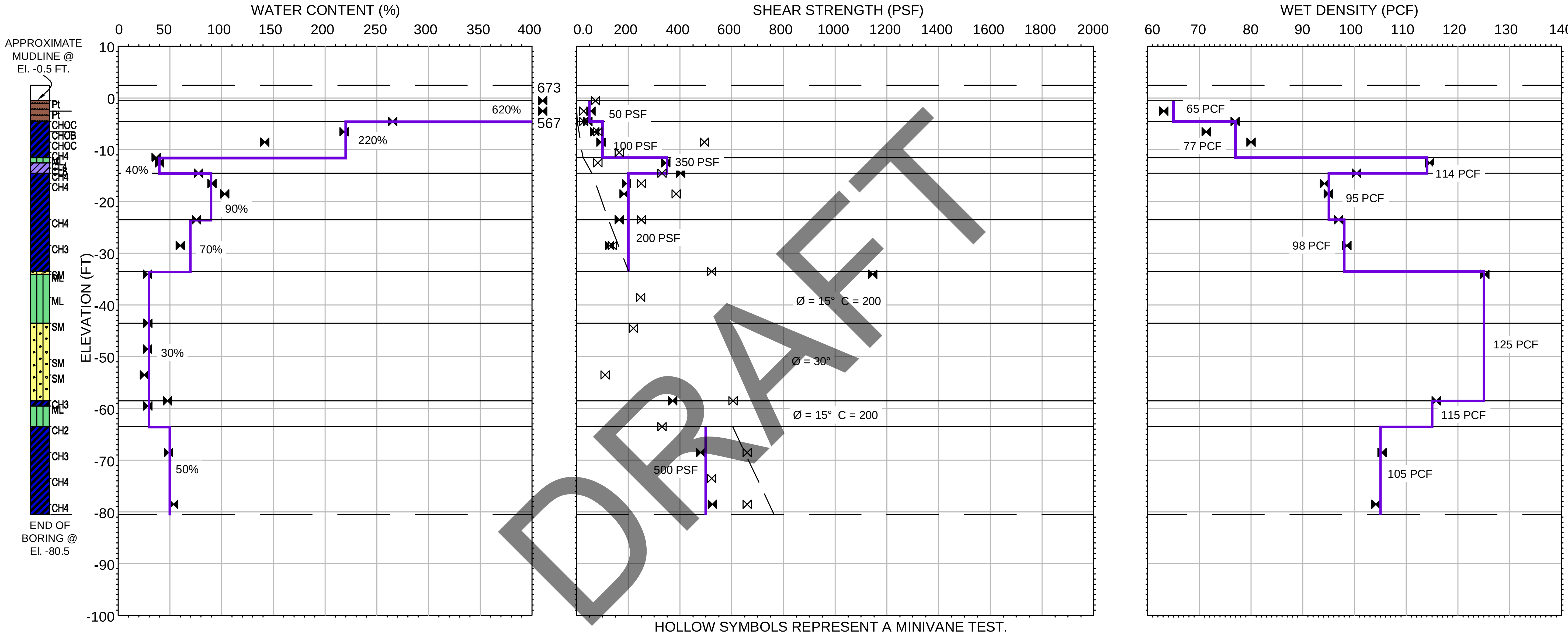

LEGEND

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- M-14
- CL
- CH
- ML
- SM
- SP
- SC
- PT

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

DESIGN CHARTS
M-14

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-3n

DPS : KMC

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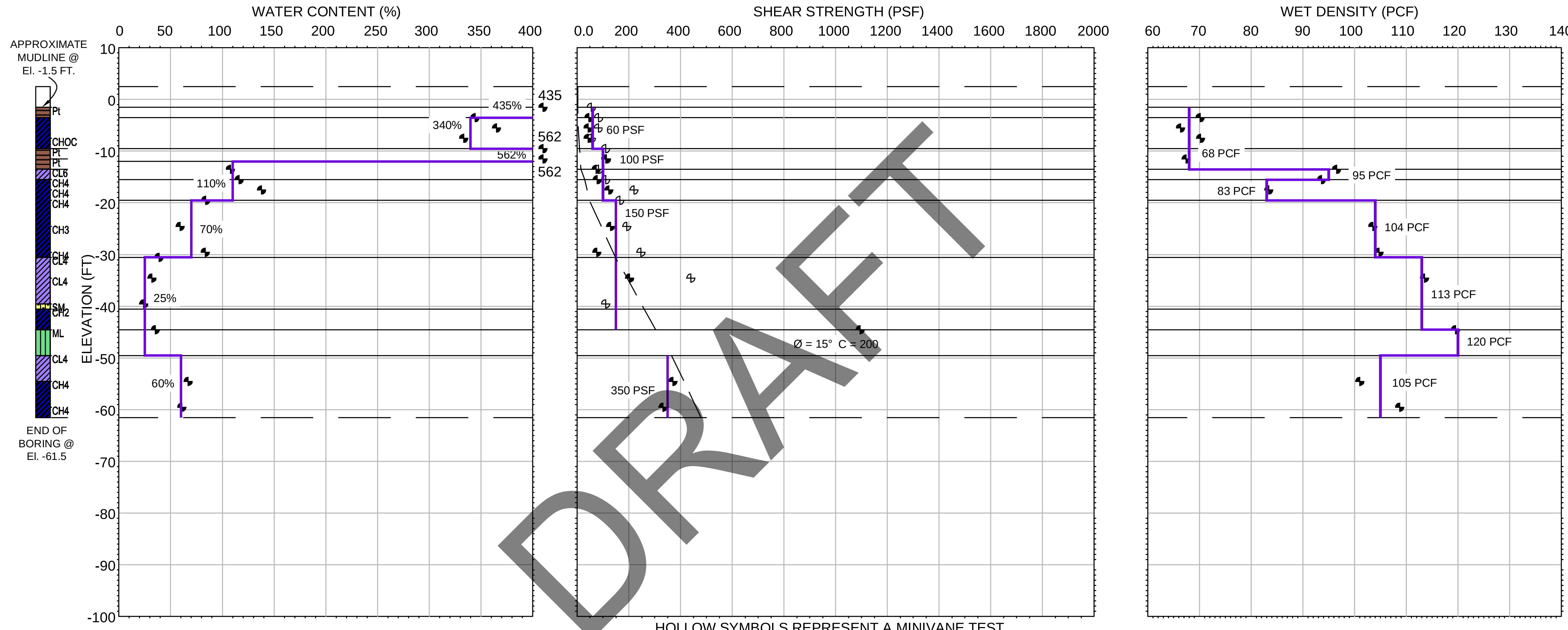

LEGEND

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- C/P LINE = 0.22
- M-15
- CL
- SP
- CH
- SC
- ML
- PT
- SM

DESIGN CHARTS
M-15

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-3o

Notes:
1. The locations of all features shown are approximate.
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DPS : KMC

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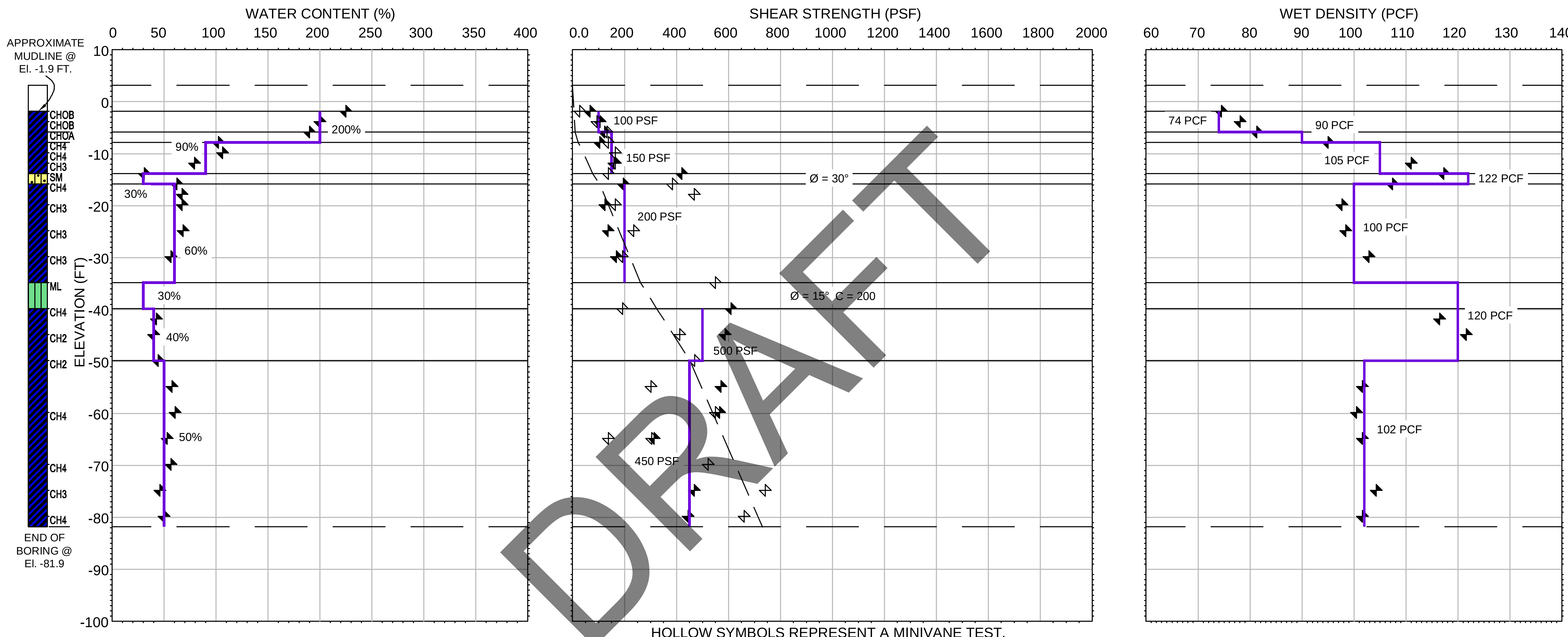

LEGEND

DESIGN STRENGTH

C/P LINE = 0.22

M-16

CL

CH

ML

SM

SP

SC

PT

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

P:\18\1827400100\CAD\Graph-Marsh (2-4).dwg\TAB:M16 modified on Feb 10, 2014 - 8:48am

DESIGN CHARTS
M-16

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

GEOENGINEERS

Figure A-3p

APPENDIX B
Consolidation Test Results

Project	Mid Barataria Diversion (BA-153)
Location	Plaquemines Parish, Louisiana
Subject	Summary of Consolidation Test Results - Reconstructed Curves

Boring	Sample depth (top)	Elevation	Description	MC	LL	PI	SG	e0	Dry Density	Wet Density	Cc	Cr	Pc	p'0	OCR	Cv
	feet	feet							pcf	pcf			tsf	tsf		ft2/day
IS-3A	21	-4.7	ML	38%	36	9	2.70	1.07	82	112	0.346	0.035	0.70	0.79	0.9	0.582
IS-8A	6	-3	CH-2	38%	51	29	2.65	0.95	85	117	0.389	0.056	1.20	0.12	10.0	0.062
IS-8A	38.1	-35.1	CL-4	32%	30	10	2.65	0.82	91	120	0.304	0.035	1.80	1.19	1.5	0.181
IS-9A	45	-29.2	CL-ML	30%	30	7	2.70	0.88	90	117	0.314	0.032	0.60	1.45	0.4	0.629
IS-13A	43	-27.6	CL-4	30%	34	10	2.65	0.84	90	117	0.148	0.008	1.10	1.38	0.8	0.780
IS-7A	11	-7.6	CL-4	31%	-	-	2.70	0.87	90	117	0.182	0.070	1.10	0.36	3.1	0.645
IS-17A	30	-14	CL-6	42%	42	23	2.68	1.31	73	103	0.425	0.040	0.70	1.12	0.6	0.129
B-1Aa	14	-8.2	ML	28%	26	5	2.65	0.74	95	122	0.090	0.009	0.42	0.42	1.0	0.106
B-1Aa	26	-20.2	CL-4	34%	34	13	2.65	0.85	89	119	0.202	0.018	0.88	0.75	1.2	0.187
NL-3A	7	-11.1	CH-2	56%	51	29	2.68	1.55	66	102	0.445	0.047	0.25	0.11	2.3	0.181
NL-3A	15	-19.1	CH-4	90%	94	66	2.71	2.73	45	86	1.083	0.170	0.20	0.28	0.7	0.075
NL-3A	25	-29.1	CH-4	87%	99	68	2.71	2.51	48	90	1.367	0.205	0.47	0.47	1.0	0.078
NL-3A	63	-67.1	CH-4	57%	77	49	2.71	1.68	63	99	0.698	-	1.15	1.20	1.0	0.029
NL-3A	121	-125.1	CH-4	62%	105	74	2.71	1.86	59	96	1.025	-	2.40	2.40	1.0	0.032
NL-6A	6	-5.4	CL	34%	47	26	2.70	1.05	82	110	0.254	0.023	0.68	0.14	4.9	0.198
NL-6A	39	-38.4	CL	40%	48	25	2.70	1.16	78	109	0.460	0.050	0.78	0.92	0.8	0.324
NL-8A	26	-25	CH-3	57%	62	43	2.70	1.64	64	101	0.550	0.083	1.18	0.64	1.8	0.048
NL-8A	41	-40	CL-6	42%	43	26	2.68	1.14	78	111	0.360	0.039	1.15	1.00	1.2	1.597
NL-8A	84	-83	CH-4	57%	-	-	2.71	1.75	62	97	0.691	0.157	1.15	2.02	0.6	0.015
NL-9A	14	-10.6	CL-4	35%	35	12	2.70	0.98	85	115	0.253	0.021	0.60	0.22	2.7	0.523
M-1	7	-4.2	CH-OB	283%	174	122	2.45	6.89	19	74	3.375	0.375	0.18	0.01	21.9	0.050
M-1	21	-18.2	CL4	70%	78	49	2.71	1.99	57	96	0.905	0.069	0.46	0.26	1.8	0.070
M-2	5	-2	PT	466%	576	344	2.10	9.93	12	68	5.830	0.200	0.11	0.0004	275.0	2.000
M-3	20	-14.7	CH-OA	155%	157	120	2.68	4.07	33	84	1.770	0.290	0.11	0.06	1.9	0.156
M-4	12	-6.8	PT	508%	379	244	2.15	11.09	11	67	11.250	0.521	0.25	0.02	11.4	1.000
M-4	41	-35.8	CH-3	68%	-	-	2.70	1.92	58	97	0.750	-	0.40	0.55	0.7	0.250
M-5	14	-10.6	PT	412%	344	221	2.12	8.02	15	75	4.372	0.378	0.16	0.03	5.3	1.950
M-5	45	-41.6	CL	23%	-	-	2.68	0.65	102	125	0.069	0.012	0.50	0.78	0.6	1.250
M-6	18	-15	CH-4	102%	95	66	2.80	2.97	44	89	1.150	0.200	0.08	0.06	1.3	0.007
M-7	18	-20.3	CH-4	125%	75	46	2.62	3.60	36	80	1.770	0.770	0.20	0.24	0.8	0.044
M-7	34	-36.3	CH-4	133%	108	77	2.46	3.34	35	83	1.750	0.344	0.17	0.53	0.3	0.010
M-7	59	-61.3	CH-3	63%	64	45	2.65	1.68	62	101	0.600	0.072	0.19	0.97	0.2	0.015
M-8	10	-11.8	CH-OC	181%	274	218	1.81	3.06	28	78	1.598	0.221	0.15	0.03	4.8	0.106
M-8	49	-50.8	SP	28%	23	0	2.65	0.79	92	118	0.272	0.024	3.47	0.82	4.2	0.416
M-9	7	-8.1	PT	504%	479	309	1.73	9.10	11	64	6.000	0.745	0.16	0.10	1.6	0.026
M-9	33	-34.1	CH-4	79%	79	52	2.65	1.97	56	99	0.880	0.144	0.30	0.49	0.6	0.048
M-10	11	-12	CL-4	52%	41	17	2.65	1.17	76	116	0.298	0.027	0.39	0.16	2.4	0.274
M-10	43	-44	CH-3	61%	67	39	2.65	1.76	60	96	0.740	0.117	0.17	0.79	0.2	0.020
M-10	73	-74	CH-4	64%	88	59	2.65	1.58	64	105	0.600	0.115	0.52	1.47	0.4	0.008

Project: Mid Barataria Diversion (BA-153)
Location: Plaquemines Parish, Louisiana
Subject: Summary of Consolidation Test Results - Reconstructed Curves

Boring	Sample depth (top)	Elevation	Description	MC	LL	PI	SG	e0	Dry Density	Wet Density	Cc	Cr	Pc	p'0	OCR	Cv
	feet	feet							pcf	pcf			tsf	tsf		ft2/day
M-11	5	-6.9	PT	277%	517	375	1.38	3.74	18	69	2.388	0.275	0.10	0.05	2.0	0.082
M-11	23	-24.9	CH-4	84%	84	58	2.65	2.29	50	92	1.250	0.150	0.18	0.30	0.6	0.040
M-12	7	-8.7	PT	428%	397	330	1.87	8.28	13	66	4.605	0.625	0.20	0.08	2.5	1.070
M-12	33	-34.7	CL-6	46%	42	22	2.65	1.20	75	110	0.650	0.030	0.18	0.62	0.3	0.008
M-13	17	-18.5	CH-4	56%	89	65	2.65	1.45	67	105	0.528	0.056	0.20	0.23	0.9	0.045
M-13	48	-49.5	CH-4	66%	82	59	2.65	1.67	62	103	0.660	0.105	0.50	0.86	0.6	0.044
M-14	5	-2.5	CH-OC	672%	Non Plastic		1.50	9.96	9	66	5.500	0.500	0.10	0.00	33.3	0.026
M-14	33	-30.5	CH-4	88%	74	47	2.80	2.63	48	90	1.000	0.138	0.12	0.41	0.3	0.006
M-15	20	-17.5	CH-4	116%	104	79	2.80	3.42	40	85	1.450	0.150	0.15	0.09	1.7	0.240
M-15	59	-56.5	CH-4	52%	90	64	2.80	1.50	70	107	0.822	0.116	0.78	0.98	0.8	0.060
M-16	9	-10.9	CHOA/CHOC	92%	158	122	2.90	2.86	47	90	1.053	0.150	0.11	0.11	1.0	0.018
M-16	28	-29.9	CH-3	61%	77	53	2.80	1.86	61	98	1.000	0.140	0.16	0.50	0.3	0.011

Notes

-	Not Available

APPENDIX C
Dewatering Pumping Test Analyses Report

Dewatering Pumping Tests Analyses

Mid-Barataria Diversion (BA-153)
Plaquemines Parish, Louisiana

for
HDR Engineering, Inc.

February 7, 2014

GeoEngineers

11955 Lakeland Park Boulevard, Suite 100
Baton Rouge, Louisiana 70809
225.293.2460

Dewatering Pumping Tests Analyses

Mid-Barataria Diversion (BA-153)
Plaquemines Parish, Louisiana

File No. 18274-001-00

February 7, 2014

Prepared for:

HDR Engineering, Inc.
2365 Iron Point Road, Suite 300
Folsom, California 95630

Attention: Mark Stanley, PE, GE
Senior Technical Advisor - Geotechnical

Prepared by:

GeoEngineers, Inc.
11955 Lakeland Park Boulevard, Suite 100
Baton Rouge, Louisiana 70809
225.293.2460

Joel W. Purdy, LG, LHG
Senior Hydrogeologist

Michael A.P. Kenrick, PE, LHG
Senior Principal Hydrogeologist

Charles L. Eustis, PE
Principal

JWP:CLE:MAPK:leh

Table of Contents

LIST OF FIGURES

INTRODUCTION AND PURPOSE

GeoEngineers, Inc. (GeoEngineers) is working with HDR, Inc. (HDR) on the Mid-Barataria Diversion (MBD) Project (BA-153) under LADNR Contract No. 2503-13-59, Task Order 0200. This report was prepared to provide a summary and evaluation of the aquifer pumping tests conducted in five wells at two separate sites as part of Phase 1B for the MBD Project in Plaquemines Parish, Louisiana. The intent of the pumping tests was to provide aquifer characteristics of the materials encountered at two sites to support the development of dewatering recommendations for the excavations involved with the MBD Project.

MBD PROJECT

The MBD Project is a large-scale, permanent river diversion complex that will restore the natural over-land flooding cycle of the Mississippi River and Tributaries (MR&T) as shown in Figure 1. The two sites, referred to as PT-1 and PT-2 sites after the test wells constructed at each site, are shown on Figure 2. They are located within the area between the MR&T levee and the Mid-Barataria marsh levee (back levee). As shown on Figure 2, this area is relatively flat and Louisiana Highway 23 (LA 23) runs approximately north-south through the project area. The PT-1 site is located in the area between LA 23 and the back levee. The PT-2 site is located in the area between the MR&T levee and LA 23.

SCOPE OF SERVICES

The hydrogeologic services performed were part of Phase 1B of the MBD Project. The services performed during Phase 1B described within this report are outlined below:

- Perform the explorations at two sites. One site is located approximately 1,000 feet west of the Mississippi River and the other site is located approximately 9,000 feet southwest of the first site, both within the proposed diversion complex.
- Construct a 6-inch-diameter test well and six 2-inch-diameter observation wells at each site.
- Perform an aquifer pumping test at each site.
- Perform in-field water quality testing.
- Analyze the pumping test data.
- Prepare a stand-alone report with test procedures and results.

The pumping test at PT-1 was performed successfully. At the PT-2 site, problems were encountered when attempting to pump from the PT-2 test well. Additional pumping tests were conducted on three of the observation wells (PZ-8, PZ-10 and PZ-11) at the PT-2 site. The most useful information was gathered from the PZ-10 testing.

SITE DESCRIPTIONS

PT-1 Site

The PT-1 site is located near the west-central extent of the proposed diversion complex and about 9,000 feet west of the Mississippi River. The site is currently used for cattle grazing and is generally flat. It is at approximately Elevation –4 feet relative to the North American Vertical Datum 1988 (NAVD 88), Epoch 2010 using Geoid 12A. The groundwater table was generally a few feet below the ground at the time of the testing and is reported to rise to near or above the ground surface during certain times of the year. A series of northwest-southeast-trending canals spaced approximately every 1,000 feet can be seen on Figure 2. These canals transmit water to the southeast. They are fed by ditches, oriented perpendicular to the canals and spaced approximately every 200 feet. PT-1 and the associated observation wells are located between two ditches. The site plan and well locations are shown on Figure 2.

The PT-1 site is generally underlain to the depths explored by a complex layered sequence of variable percentages of fine to very fine sand, silt and clay likely formed as intradelta deposits from Mississippi River distributary channels. Layers with higher percentage of sand were targeted for screened sections of well completions. These thin sand layers generally occurred more frequently at depths below 20 feet (Elevation –24 feet). The well logs for the wells drilled at PT-1 are included in our Geotechnical Data Report dated January 27, 2014, along with additional information regarding the data obtained for this project and a description of the field activities.

PT-2 Site

The PT-2 site is located near the east-central extent of the proposed diversion complex, and approximately 1,000 feet west of the Mississippi River. The site is vegetated with trees and shrubs and is generally flat, at approximately Elevation 4 feet (NAVD 88). The groundwater table was generally a few feet below the ground at the time of the testing and is reported to rise to near or above the ground surface during certain times of the year. The site plan and well locations are shown on Figure 2.

The PT-2 site is generally underlain to the depths explored by a complex layered sequence of variable percentages of fine to very fine sand, silt and clay likely formed as point bar deposits of the Mississippi River. Layers with higher percentage of sand were targeted for screened sections of well completions. Although the soil profile was predominantly silt, higher percentages of sand generally occurred more frequently at depths below 20 feet (Elevation –16 feet). The surface geologic map for the area and other explorations nearby suggested that point bar deposits may be present at the PT-2 site. The well logs for the wells drilled at PT-2 are also included in our Geotechnical Data Report dated January 27, 2014.

DRILLING AND WELL CONSTRUCTION

At each site, a test well and six observation wells were installed. The pumping test wells (PT designation) were drilled as 11.5-inch-diameter boreholes and completed with 6-inch-diameter polyvinyl chloride (PVC) casing and filter-packed well screens. The observation wells (PZ designation) were drilled as 6-inch-diameter boreholes and completed with 2-inch-diameter PVC casing and filter-packed well screens. Observation wells were installed within the expected cone of depression of each pumping test to provide drawdown and recovery data for the analysis of aquifer properties. Screens in all the wells were 0.010-inch machine-slotted PVC set within an annulus of 20 x 40 silica sand filter pack, extending from the bottom of each well to approximately 3 feet above the top of the screen.

Once constructed, the pumping test and observation wells were developed initially using a surge block to thoroughly flush drilling debris and fine particles from the filter pack placed around the well screen. Surging was accomplished over short vertical sections of the screen (typically 2 to 5 feet). The surging was followed by pumping using air-lift techniques. An air hose was place in the bottom of the wells and the water and sediment were blown out of the casing. Well development continued until sand/silt production was minimal and water pumped from each well was relatively clear and sand-free.

PT-1 Site

Well installation at the PT-1 site included one 6-inch diameter pumping well (PT-1) and six 2-inch-diameter observation wells (PZ-1 through PZ-6). PT-1 was drilled to 42 feet below ground surface (bgs) and constructed with flush-threaded 6-inch-diameter schedule-40 PVC casing, screened from 10 to 40 feet bgs. Observation wells (piezometers PZ-1 through PZ-6) were installed in two orthogonal directions at nominal distances of 25 to 100 feet from PT-1, as shown in Figure 2. Observation wells were each drilled to a depth of 45 feet and constructed with flush-threaded 2-inch-diameter casing and screen. The screened intervals and well construction details are presented in Table 1 below:

TABLE 1. WELL CONSTRUCTION DETAILS AT THE PT-1 SITE

Well	Ground Surface Elevation[1] (feet)	Total Depth Drilled (feet bgs)	Bottom of Well (feet bgs)	Screened Interval (feet bgs)	Filter-Packed Interval (feet bgs)	Groundwater Level[2] (feet bgs)	Groundwater Elevation[1] (feet)
PT-1	-3.47	42	42	10 to 40	7 to 42	1.26	-4.73
PZ-1	-4.07	45	31	20 to 30	17 to 31	0.54	-4.61
PZ-2	-3.98	45	31	15 to 30	12 to 31	0.69	-4.67
PZ-3	-3.83	45	26	15 to 25	12 to 26	0.90	-4.73
PZ-4	-3.60	45	39	32 to 37	29 to 39	1.16	-4.76
PZ-5	-3.86	45	31	10 to 30	7 to 31	0.99	-4.85
PZ-6	-4.01	45	31	20 to 30	17 to 31	0.63	-4.63

Notes:

[1] Elevations are surveyed relative to NAVD 88.

[2] Groundwater levels measured manually on July 13, 2013, prior to testing of PT-1.

PT-2 Site

Well installation at the PT-2 site included one 6-inch diameter pumping well (PT-2) and six 2-inch-diameter observation wells (PZ-7 through PZ-12). PT-2 was drilled to 80 feet bgs and constructed with flush-threaded 6-inch-diameter schedule-40 PVC casing, screened from 30 to 75 feet bgs. Observation wells (piezometers PZ-7 through PZ-12) were installed in two orthogonal directions at nominal distances of 25 to 200 feet from PT-2 as shown in Figure 2. Observation wells were drilled to depths ranging from 51 to 70 feet and constructed with flush-threaded 2-inch-diameter PVC casing and screened. The screened intervals and well construction details are presented in Table 2 below.

TABLE 2. WELL CONSTRUCTION DETAILS AT THE PT-2 SITE

Well	Ground Surface Elevation[1] (feet)	Total Depth Drilled (feet bgs)	Bottom of Well (feet bgs)	Screened Interval (feet bgs)	Filter-Packed Interval (feet bgs)	Groundwater Level[2] (feet bgs)	Groundwater Elevation[1] (feet)
PT-2	3.54	80	76	30 to 75	25 to 80	3.00	0.54
PZ-7	3.03	55	50	30 to 50	25 to 55	1.52	1.51
PZ-8	3.38	60	50	20 to 50	16 to 60	2.04	1.34
PZ-9	3.46	55	50	20 to 50	17 to 55	2.35	1.11
PZ-10	3.72	51	51	20 to 50	16 to 51	2.58	1.14
PZ-11	3.61	55	50	20 to 50	15 to 55	2.10	1.51
PZ-12	3.43	70	50	20 to 50	17 to 70	1.61	1.72

Notes:
1. Elevations are surveyed relative to NAVD 88.
2. Groundwater levels as manually measured on August 4, 2013, 1 day after the last pumping test.

Data Collection Equipment

The collection of water level and drawdown data in each well was accomplished using INW PT2X pressure sensors comprised of submersible solid-state piezoelectric pressure transducers and integrated programmable dataloggers. The sensors used in the observation wells were unvented (measuring absolute pressure) and the sensor used in the pumping wells was vented (measuring gage pressure). All sensors had a range of 0 to 30 pounds per square inch. The data from the unvented sensors were corrected to gage pressure by subtracting the barometric recorded on site using a separate barometric sensor. The manufacturer calibrated all sensors prior to shipment. The data readings were checked using manual depth-to-water measurements in each well throughout the testing period.

Data logging intervals were set at every minute for all sensors. Manual measurements were generally made at standard logarithmically expanding time intervals. Note that the sensor installed in PZ-1 during the testing of PT-1 apparently did not function properly. Manual measurements in PZ-1 were used for the analyses.

WATER QUALITY MONITORING

A Horriba multi-parameter field meter was used to measure water quality parameters in samples collected during pumping of the test wells. The meter measured dissolved oxygen, conductivity, salinity, turbidity and pH. The pH readings did not stabilize during the monitoring and were assumed to be in error. Downhole temperature was also recorded by the sensors installed to measure water levels. Temperatures ranged from 69 to 73 degrees Fahrenheit (20.5 to 22.8 Celsius). The color of the water sampled turned from clear to deep orange after about 15 to

30 minutes of standing within a bucket, suggesting oxidation of dissolved iron. The results for the water quality measurements are shown below in Table 3. The results indicate that groundwater at both sites is saline. The salinity of water from PT-1 was measured at 13,100 parts per million (or 1.3 percent salt), about three times the concentration in PT-2.

TABLE 3. IN-SITU WATER QUALITY RESULTS

Pumping Well	Date, Elapsed Pumping Time	Salinity (ppm)	Conductivity (µS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)
PT-1	7/13/13, 75 min	13,100	21,900	>1,000	3.77
PT-1	7/13/13, 275 min	11,900	19,900	122	3.63
PT-1	7/14/13, 960 min	12,700	21,000	145	3.42
PT-2	7/16/13, 205 min	4,400	8,260	432	5.30
PT-2	7/16/13, 310 min	4,300	7,800	207	5.30

Notes:
ppm = parts per million; µS/cm = microsiemens per centimeter; NTU = Nephelometric turbidity units;
mg/L = milligrams per liter.

PUMPING TESTS

A total of five wells were pumped at the two sites. Test well PT-1 was tested at the PT-1 site and test well PT-2 and observation wells PZ-10, PZ-8 and PZ-11 were pumped at the PT-2 site. The following is a description of the pumping tests.

PT-1 and PT-2 Tests

The pumping of the 6-inch-diameter PT-1 and PT-2 wells was conducted using a 3-inch-diameter electric submersible pump powered by a portable diesel-powered generator. The pump was installed with 2-inch-diameter PVC riser pipe such that the pump intake was approximately 2 feet above the bottom of the well. Two 1-inch-diameter PVC sounding tubes were installed, one for the down-hole transducer and one to facilitate manual measurement of water levels in the well as the test proceeded. A gate valve was installed in the discharge line to control and regulate the flow rate.

Water was generally discharged from the well through the PVC discharge pipe and a hose to a discharge point in a nearby ditch (located approximately 90 feet north of PT-1, and about 30 feet from PT-2). A 2-inch flow meter was installed on a horizontal section of the PVC discharge pipe. However, since the pumping rate was so small, the flow meter did not operate within the meter's specifications (it needs the pipe to be full of water with a flow of greater than 2 gallons per minute [gpm]). Thus, the pumping rates were measured periodically using a 5-gallon bucket and stop watch. Water quality samples were obtained at the discharge point at the end of the PVC pipe.

PZ-10, PZ-8 and PZ-11 Tests

The pumping of the 2-inch-diameter observation wells PZ-10, PZ-8 and PZ-11 was conducted using a 1½-inch-diameter electric submersible pump powered by a portable gasoline-powered generator. The vented transducer was installed at the bottom of the wells and the pump was installed such that the pump intake was approximately 1.5 feet above the bottom of the well. Water was pumped to the surface through ⅜-inch-diameter tubing. The flow rate could be controlled with a separate controller; however, the pump was run at its maximum rate at all times for these three wells.

PUMPING TEST DATA ANALYSIS

The analysis of pumping test data is presented in the following sections for each site. The pumping test conducted at the PT-1 site is first described and analyzed. The pumping tests of the four wells at the PT-2 site are then described and analyzed. A summary of the most relevant data from the two sites is provided at the end of the section.

PT-1 Site Pumping Test Description

After the pump was installed in PT-1, a pumping test was conducted. The valve that controlled flow was completely shut prior to the test. At 11:30 AM on July 13, 2013, the pump was turned on. Flow was gradually adjusted to 2.95 gpm within the first 30 seconds of pumping. When an excessive drawdown rate was observed in PT-1, the pumping rate was adjusted to approximately 1 gpm after 40 minutes. The valve was not adjusted thereafter during the pumping test. The pumping rate gradually fell to 0.9 gpm after 60 minutes of pumping (likely in response to the increased total pumping head) and was maintained at this rate until the end of the test.

The pump was turned off at 3:55 AM on July 14 because the water level in PT-1 had dropped to less than 2 feet above the pump intake. PT-1 was pumped for a total of 985 minutes (about 16.4 hours). The average pumping rate was 0.9 gpm. After the pump was turned off, recovering water levels were recorded manually for the first 30 minutes and periodically thereafter. The sensors continued to record water levels until about 8:00 AM on July 15, when the sensors were removed from all wells except PZ-3. A sensor remained in PZ-3 until 4:10 PM on July 15 when the sensor was removed and transferred to the PT-2 site.

Drawdown and recovery trends were analyzed using standard graphical and analytical software, AQTESOLV v. 4.50, to identify the overall character of the aquifer system and evaluate the corresponding hydrogeologic properties, including transmissivity and storativity.

For reference, the *transmissivity* of an aquifer is proportional to the rate at which water can move through the aquifer under a hydraulic gradient, and is a composite term wherein the average hydraulic conductivity of the aquifer, measured in feet per day (ft/d) is multiplied by the thickness of the aquifer. Transmissivity is therefore measured in units of square feet per day (ft^2/d). The hydraulic conductivity was previously known as the *coefficient of permeability*, and commonly measured in units of centimeters per second (cm/s).

Storativity is a measure of the amount of water that is released from storage within an aquifer under a unit decline in head or water level.

- In a *confined aquifer* where groundwater is held under pressure beneath a confining unit or aquitard, the storativity (previously called the *storage coefficient*) is related to the compressibility of the confined aquifer system (water, soil grains, and aquifer matrix or structure) and is expressed as the volume of water (ft^3) released from a unit-area column of the aquifer (ft^3).

- In an *unconfined aquifer* where a water table is present, creating a phreatic surface at atmospheric pressure and there is no confining unit or aquitard, the storativity (also called the *specific yield*) is dominated by drainage (or refilling) of water-filled pores above the water table as the groundwater level changes. It is also expressed as the volume of water (ft^3) released from a unit-area column of the aquifer (ft^3).

The storativity is defined in both cases as a ratio of volumes (ft^3/ft^3), and is dimensionless. Storativity values for confined aquifers are typically orders of magnitude smaller than for unconfined aquifers.

Drawdown Analysis

Pumping Well Data

Drawdown data from PT-1 are shown on a semi-logarithmic plot on Figure 3. Because the pumping rate was adjusted during the first hour of the test, and the drawdown appears to be significantly affected by wellbore storage without stabilizing, the drawdown trend could not be used reliably for analysis of aquifer transmissivity. The total drawdown is also substantial, and suggests that significant well losses or wellbore skin effects were limiting the hydraulic performance of the well. Wellbore skin effects can include smearing of sand layers with silt and clay during drilling that is not completely removed during well development, with the resultant 'skin' on the face of the wellbore causing additional hydraulic resistance to water entering the well.

Conventional Analysis of Observation Well Data

Despite the limited flow obtained from PT-1, it was sufficient to cause lowering of the water levels in all observation wells at the PT-1 site. Drawdown observed in observation wells PZ-1 through PZ-6 during pumping from PT-1 is shown on a semi-logarithmic plot on Figure 4.

The drawdown trend for each observation well approaches an asymptotic slope and each was initially analyzed using the Cooper-Jacob (1946) simplified method applied to selected portions of each drawdown trend that approximates to a straight-line on Figure 4. Although the pumping rate was adjusted during the first hour of the test, the drawdown plots of the observation wells do not appear to be adversely affected by this. The portions of the data that fit to straight-lines indicate an apparent aquifer transmissivity of 45 square feet per day (ft^2/d) for the closest observation well (PZ-3), increasing to almost 100 ft^2/d for the most distant observation well (PZ-6). This is a dramatically higher value than would obtained by fitting a straight line to parts of the drawdown trend measured in PT-1, confirming that a significant portion of the drawdown trend in PT-1 was adversely affected by wellbore storage and therefore is not representative of aquifer conditions.

The drawdown trend for PZ-4 shows an atypical change in slope after 40 minutes, with the later portion twice as steep as the early portion. This would normally be interpreted to indicate a vertical barrier present nearby within the aquifer, but the absence of this feature in any of the other drawdown trends suggests a different hydraulic explanation must be found for this behavior.

Each of the straight-line fits to the drawdown trends in Figure 4 can be further analyzed using the Copper-Jacob Method to yield estimates of the apparent aquifer storativity by determining the intercepts with the zero-drawdown axis. A range of storativity values from 1.9 x 10^{-3} to 6.6 x 10^{-3} was estimated from the observation well data. The full results of the conventional analyses are listed in Table 4.

TABLE 4. CONVENTIONAL PUMPING TEST DRAWDOWN ANALYSIS RESULTS FROM PT-1

Well Number	Distance, *r* (ft)	Drawdown Slope, *Δs* (ft)	Time Intercept, t_o (mins)	Transmissivity, *T* (ft^2/d)	Storativity, S (–)
PT-1	0.25	N/A	N/A	—	--
PZ-1	72.3	0.6	230	53	0.0036
PZ-2	49.3	0.68	85	47	0.0025
PZ-3	25.2	0.7	17	45	0.0019
PZ-4	26.8	0.7	37	46	0.0037
PZ-5	52.2	0.43	84	74	0.0035
PZ-6	100	0.33	440	96	0.0066

Composite Drawdown Analysis

The consistency of the observed drawdown trends among the observation wells can be compared by constructing a composite drawdown plot (Figure 5). In the composite plot, the drawdown in each observation well is plotted versus pumping time, ***t***, divided by the square of the distance from the pumping well, ***r²***. The intended result is to compensate for the different distances of the individual observation wells, on the basis that, in a perfectly confined aquifer with uniform radial flow to the pumped well that conforms to the basic Theis (1935) aquifer model, all the drawdown trends should overlie and conform to one single curve, with no scatter or spread.

The divergence of the drawdown trends reflects the variability of ground conditions at PT-1, which are inhomogeneous and non-uniform relative to the idealized aquifer conditions implied by the Theis or Cooper-Jacob models. Furthermore, as in this case, when there is a spread among the plotted trends over approximately one-half log cycle of time, this spread represents a deviation from the standard Theis aquifer model, and diagnostic analysis of the deviation can help to identify a more appropriate aquifer model for refining the analysis of the data.

The trend of flatter slope and larger transmissivity with increasing distance from PT-1 suggests some form of leaky aquifer conditions may apply. Aquitard leakage is the term given to generally vertical seepage that occurs through lower permeability layers (typically silts and clays) that are interbedded with more permeable sand layers, when water is pumped from the sand layers.

The difference in responses between observation wells at similar distances may indicate lateral variations in soil properties, especially hydraulic conductivity. These possibilities for modified aquifer models to provide better explanations of the observed drawdown responses were further explored later in this report.

Distance-Drawdown Analysis

A plot of the maximum drawdown within each well versus radial distance, ***r***, is shown on Figure 6 and depicts on a logarithmic scale the development of the cone of depression with increasing distance away from the pumping well at the end of pumping. Based on the analysis of this plot, the apparent aquifer transmissivity was calculated as 33 ft^2/d (250 gallons per day per foot [gpd/ft]) and a storativity of 3.6×10^{-3}. These values fall within the range of those calculated using the transient drawdown methods described above.

The total drawdown of 34.6 feet in PT-1 (nominal drilled radius of 0.5 feet) is not presented in Figure 6, but suggests that total well losses were on the order of 30 feet inside the well. By extrapolating the apparent trend of the cone of depression shown in Figure 6 back to the well radius, there is an implied drawdown of only 4.5 feet within the aquifer at the face of the pumping well. This significant difference confirms that the drawdown response in PT-2 is likely not representative of aquifer conditions.

RECOVERY ANALYSIS

Recovery of the water level in PT-1 after the pump was turned off is shown on a semi-logarithmic plot in Figure 7. The recovery data from PT-1 exhibit a distinct S-shaped curve that is characteristic of wellbore storage, which affects almost the entire recovery trend. When wellbore storage is significant, a large portion of the recovery period is taken up by the relatively small inflow from the aquifer (less than 1 gpm) refilling the evacuated drawdown volume within the pumped well. Under these conditions, only the very late-time recovery data can be analyzed using the Theis recovery method to give an estimate for the aquifer transmissivity, with the residual drawdown data plotted against the ratio of ***t/t'*** (time since pumping began/time since pumping stopped). A straight line is shown that runs through the origin, with a slope of 0.95 feet per log cycle. This represents an estimate of the late-time recovery data trend in PT-1 that would correspond to an aquifer transmissivity of 33 ft^2/d, comparable with the distance-drawdown analysis.

Recovery data observed in the observation wells are shown on semi-logarithmic plot on Figure 8. The line fit to the late-time recovery data for individual observation wells indicate an apparent aquifer transmissivity ranging from 21 to 44 ft^2/d. The recovery trends do not overlie each other, nor conform to a uniform slope, as would be expected for an ideal aquifer. Also it was noted that drawdowns continued to increase after the pump was turned off. This is consistent with the large drawdown and the wellbore storage effect in PT-1 creating a condition whereby the inflow from the aquifer into the well did not change appreciable when the pump was turned off, and through until about one hour after the end of the test, when the rising water level in PT-1 significantly reduced the residual head gradient driving flow from the aquifer into the well.

AQTESOLV ANALYSIS

The observation well data from the PT-1 test was further analyzed using AQTESOLV (v. 4.5) software that allows for the simultaneous analysis of the full testing sequence (drawdown and recovery data) measured in each observation well. Individual observation wells were analyzed separately and shown on Figures 9, 10 and 11. These analyses indicate a more consistent set of transmissivity values that are lower than the values estimated using conventional Cooper-Jacob drawdown methods, but are comparable to the values estimated using the distance-drawdown and Theis recovery methods. The storativity values derived from the AQTESOLV analyses are generally higher than estimated using conventional analyses. The results of the AQTESOLV analyses are shown on Table 5.

TABLE 5. PUMPING TEST AQTESOLV ANALYSIS RESULTS FROM PT-1

Well Number	Distance *r* (ft)	Transmissivity *T* (ft²/d)	Storativity *S* (–)
PT-1	0.25	N/A	N/A
PZ-1	72.3	29	0.0062
PZ-2	49.3	30	0.0049
PZ-3	25.2	25	0.0075
PZ-4	26.8	27	0.0091
PZ-5	52.2	36	0.0084
PZ-6	100	32	0.010

The AQTESOLV analyses are likely more accurate because the Cooper-Jacob method used in the conventional analysis is based on a simplification of the underlying well function describing observation well drawdown induced by pumping. The method can result in fitting a flatter slope to the semi-log drawdown trend, which provide overestimated values for the aquifer transmissivity.

The Theis solution used in the AQTESOLV analyses shown in Figures 9, 10 and 11 includes a more accurate representation of the transitional early drawdown response before the drawdown trend approaches a straight line with a steeper slope in these semi-logarithmic plots. The steeper slopes result in lower values calculated for aquifer transmissivity.

PT-2 Site Pumping Tests Descriptions

After problems were encountered when attempting to pump from the PT-2 test well, additional tests were conducted on three of the observation wells at the PT-2 site.

The first test was conducted on PT-2. However, the pumping rate that could be established for PT-2 was so low that the test had to be stopped due to excessive drawdown in PT-2. Additional testing was therefore proposed for observation well PZ-10. PZ-10 was pumped for 24 hours and induced drawdown in all but the most distant observation wells at the PT-2 site (PZ-7 and PZ-12). Further testing was conducted on PZ-8 and PZ-11. However, the testing of PZ-8 and PZ-11 resulted in limited useful data. In the end, the PZ-10 testing provided the best information for the PT-2 site. The following is a more detailed description of the pumping tests conducted at the PT-2 site.

PT-2 Pumping Test, July 16

After the same pump used for the testing of PT-1 was installed in PT-2, a pumping test was conducted. The valve that controlled flow was completely shut prior to the test. At 08:00 AM on

July 16, 2013, the pump was turned on. The initial flow rate was approximately 2.4 gpm. Because of the rapid drawdown rate in PT-2, the flow rate was adjusted to 0.9 gpm within the first 30 seconds of pumping. Rapid drawdown continued and the pumping rate fell to less than 0.25 gpm after about 2 hours when the water level reached the pump intake at about 56.5 feet bgs.

The pump was turned off at 01:10 PM on July 16 after 310 minutes of pumping. After the pump was turned off, manual recovery water levels were recorded for the first 20 minutes and periodically thereafter. The sensors continued to record water levels until about 8:00 AM on July 17, when the sensors were removed from all wells, the pump was removed from PT-2 and the test was abandoned with no appreciable drawdown observed in the observation wells.

PZ-10 Pumping Test, July 31 to August 1

After consultation with the project team members, it was decided that a least one additional pumping test would be conducted at the PT-2 site, but this could not be done using the PT-2 test well because of inadequate yield. Observation well PZ-10 was selected for the pumping test based on the flow rate observed during development. A smaller pump was selected for pumping the 2-inch-diameter well. At 11:05 AM on July 31, 2013, the pump was turned on. The initial flow rate was approximately 2 gpm. After 20 minutes, the pump stopped due to power failure. After about 15 seconds, the pump was restarted at approximately 1.9 gpm. At 12:18 PM, the pump again stopped due to power failure.

A more reliable gas-powered generator was obtained and the PZ-10 pumping test resumed at 03:00 PM on July 31. The flow rate started at about 2 gpm and was adjusted to 1.5 gpm after 5 minutes. Pumping continued at a rate of 1.4 gpm until 2:31 PM on August 1, when a severe rainstorm occurred at the site and apparently caused an electrical short. Attempts were made to restart the pump between 2:54 and 3:03 PM, but the pump failed to run for more than a few seconds. The well had been pumped continuously for 1,411 minutes (about 23.5 hours) at an average rate of 1.38 gpm.

After the pump shut down, recovering water levels were recorded manually for 60 minutes and periodically thereafter. The sensors continued to record water levels every minute.

PZ-8 Pumping Test, August 2

After consultation with the project team members, it was decided that additional pumping tests would be conducted at two more observation wells, one on each orthogonal "leg" of the observation well layout (Figure 2). Observation well PZ-8 was pumped using the same pump used for the PZ-10 test. At 2:50 PM on August 2, 2013, the pump was turned on at an initial flow rate of approximately 1.5 gpm. Excessive drawdown approaching 40 feet occurred and after 14 minutes, when the water level reached the pump intake, the pump was turned off.

After the pump shut down, manual recovery water levels were recorded for 94 minutes. The sensors continued to record water levels every minute. The excessive drawdown and extended recovery indicated well PZ-8 exhibited poor inflow characteristics, with no drawdown observed in the nearest observation well, and so testing of PZ-8 was abandoned.

PZ-11 Pumping Test, August 3

Observation well PZ-11 was pumped, starting at 08:20 AM on August 3. The pump was turned on at an initial flow rate of approximately 1.7 gpm. Excessive drawdown approaching 40 feet occurred and after 53 minutes, when the water level reached the pump intake, the pump was turned off. A total volume of 50 gallons was pumped from PZ-11 for an average flow rate of 0.9 gpm.

After the pump shut down, manual recovery water levels were recorded for 70 minutes. The sensors continued to record water levels every minute until 07:30 AM on August 4, when all sensors and the pump were removed from the wells. The excessive drawdown and extended recovery indicated well PZ-11 exhibited poor inflow characteristics with no drawdown observed in the nearest observation well, and so testing of PZ-11 was abandoned.

Drawdown Analysis

The PZ-10 testing was found to provide the best data for the PT-2 site, with sustained pumping for almost 24 hours and drawdown responses monitored in adjacent observation wells. Thus, we analyzed the PZ-10 test results in greater detail. Conventional graphical methods of analysis were applied, along with using the AQTESOLV software. The abandoned tests of PT-2, PZ-8 and P-11 are also discussed briefly in this section, but the results of those tests were compromised by limited well inflow and are not considered representative of aquifer conditions.

PUMPING WELL DATA

Drawdown data from PZ-10 are shown on a semi-logarithmic plot on Figure 12. The drawdown slope flattens after 5 minutes due to the adjustment of the flow rate from about 2 to 1.5 gpm. The drawdown data for the first 30 minutes is influenced by the borehole storage effect. Between 30 and 500 minutes, the slope appeared steady while pumping at an average rate of 1.38 gpm. This portion of the drawdown plot was used to fit a straight line using the Cooper-Jacob simplified method, which indicates an apparent aquifer transmissivity of 12 ft^2/d. However, the drawdown in PZ-10 is excessive compared with the observation wells and the transient slope used for the analysis is not considered to be representative of aquifer conditions.

CONVENTIONAL ANALYSIS OF OBSERVATION WELL DATA

Despite the limited flow obtained from PZ-10, it was sufficient to cause lowering of the water levels in all observation wells at the PT-2 site, except in the two most distant ones, PZ-7 (196 feet away) and PZ-12 (181 feet away). Drawdowns observed in observation wells PZ-7 through PZ-12, PT-2 and barometric pressure during the pumping from PZ-10 are shown on a semi-logarithmic plot on Figure 13. The data plots for PZ-7 and PZ-12 are nearly coincident and lie on top of each other in a similar pattern to the barometric pressure data plot, showing no discernible drawdown.

The drawdown trends from four of the observation wells approach an asymptotic slope and each of these was analyzed using the Cooper-Jacob method as shown on Figure 13. The first indication of drawdown appeared to occur in each well in proportion to its distance from the pumping well, except for PT-2 (r = 26.5 feet), where drawdown occurred after about 50 minutes of pumping compared to about 10 minutes for PZ-9 (r = 39.2 feet). This is another indication that PT-2 may have a wellbore skin that retards water inflow to the well. The portions of the drawdown trends that fit to straight lines on Figure 13 indicate an apparent aquifer transmissivity of 25 ft^2/d for the closest well (PT-2), increasing to 72 ft^2/d for the most distant observation well that showed interference drawdown (PZ-8; r = 97 feet). These are higher values than obtained by fitting a straight line to the drawdown trend measured in PZ-10.

Each of the straight-line fits to the drawdown trends in Figure 13 can be further analyzed using the Copper-Jacob method to yield estimates of the apparent aquifer storativity by determining the intercepts with the zero-drawdown axis. A range of storativity values from 1.2×10^{-3} to 9.5×10^{-3} was estimated from the observation data. The full results of the conventional analyses are listed in Table 6.

TABLE 6. CONVENTIONAL PUMPING TEST ANALYSIS RESULTS FROM PZ-10

Well Number	Distance, *r* (ft)	Drawdown Slope, *Δs* (ft)	Time Intercept, to (mins)	Transmissivity, T (ft²/d)	Storativity, S (–)
PT-2	26.5	1.95	210	25	0.0012
PZ-7	196	N/A	N/A	N/A	N/A
PZ-8	97	0.68	510	78	0.0061
PZ-9	39.2	1.46	50	33	0.0017
PZ-10	0.25	4	N/A	12	N/A
PZ-11	71.2	0.8	510	61	0.0095
PZ-12	181	N/A	N/A	N/A	N/A

COMPOSITE DRAWDOWN ANALYSIS

The consistency of the observed drawdown trends among the observation wells can be compared by constructing a composite drawdown plot (Figure 14). The divergence of the drawdown trends reflects the variability of ground conditions at PT-2, which are inhomogeneous and non-uniform relative to the idealized aquifer conditions implied by the Theis or Cooper-Jacob models. Furthermore, as in this case, when there is a spread among the plotted trends that approaches one log cycle on the time axis, this spread represents a significant deviation from the standard Theis aquifer model. Diagnostic analysis of the deviation can help to identify a more appropriate aquifer model for refining the analysis of the data.

The trend of flatter slope and larger transmissivity with increasing distance from PZ-10 suggests some form of leaky confined aquifer conditions may apply, but this may be compromised by the limited hydraulic response of PT-2, which is confirmed as being strongly delayed relative to PZ-9. The difference in responses between observation wells at similar distances may indicate areal anisotropy in the permeability tensor, with hydraulic conductivity differing by horizontal direction but results appear to be compromised by inconsistent hydraulic connections between the wells, which may be indicative of highly heterogeneous ground conditions at the scale of the pumping test.

DISTANCE-DRAWDOWN ANALYSIS

A plot of the maximum drawdown within each well versus radial distance, ***r***, is shown on Figure 15 and depicts development of the cone of depression with increasing distance away from the pumping well. Based on the analysis of this plot, the apparent aquifer transmissivity was calculated as 42 ft^2/d and a storativity of 5.5 x 10^{-3}. These values fall within the range of those calculated using the transient drawdown methods described above.

The total drawdown of 24 feet in PZ-10 (nominal radius 0.25 ft) is not presented in Figure 15, but suggests that total well losses were on the order of 17.5 feet inside the well. By extrapolating the apparent trend of the cone of depression shown in Figure 15 back to the drilled well radius, there is an implied drawdown of only 6.5 feet within the aquifer at the face of the pumped observation well. This significant difference confirms that the drawdown and recovery response in PZ-10 is likely not representative of aquifer conditions.

Recovery Analysis

The recovery data can be analyzed using the Theis recovery method to give an estimate for the aquifer transmissivity, with the residual drawdown data plotted against the ratio of ***t/t'***. Recovery of the water level in PZ-10 after the pump was turned off is shown on a semi-logarithmic plot on Figure 16. Unsuccessful attempts were made to restart the pump as indicated on Figure 16. However, the recovery data show that a short time after these attempts, the slope approaches a straight line. A straight line is shown that runs through the late-time data, with a slope of 3.5 feet per log cycle. This represents an estimate of the late-time recovery data trend in PZ-10 and corresponds to an aquifer transmissivity of 14 ft^2/d, comparable with the PZ-10 drawdown analysis.

Recovery data observed in the observation wells are shown on semi-logarithmic plot on Figure 17. The line fit to the late-time recovery data for individual wells indicate an apparent aquifer transmissivity ranging from 17 to 75 ft^2/d. The recovery trends do not overlie each other, nor conform to a uniform endpoint, as would be expected for an ideal aquifer. The water levels recover, or are projected to recover in the case of PT-2, above the pre-test static water levels in each observation well. This indicates that recharge occurred during the PZ-10 testing. A significant rainfall event of close to 1 inch was observed at the site near the end of the pumping, and appears to have affected the recovering water levels, and possibly affecting the values of transmissivity calculated by this method.

AQTESOLV Analysis

The observation well data from the PZ-10 test was further analyzed using AQTESOLV software that allows for the analysis of the full testing sequence (drawdown and recovery) data. Individual observation wells were analyzed separately and are shown on Figures 18 and 19. These analyses indicate variable transmissivity and storativity values. The transmissivity values are within the range of the values estimated using conventional Cooper-Jacob drawdown methods, but storativity values derived from the AQTESOLV analyses are generally lower than estimated using conventional analyses. The results of the AQTESOLV analyses are shown on Table 7.

TABLE 7. PUMPING TEST AQTESOLV ANALYSIS RESULTS FROM PZ-10

Well Number	Distance, *r* (ft)	Transmissivity, *T* (ft^2/d)	Storativity, *S* (–)
PT-2	26.5	19	0.024
PZ-7	196	N/A	N/A

Well Number	Distance, *r* (ft)	Transmissivity, *T* (ft^2/d)	Storativity, *S* (–)
PZ-8	97	104	0.012
PZ-9	39.2	47	0.0041
PZ-10	0.25	N/A	N/A
PZ-11	71.2	36	0.008
PZ-12	181	N/A	N/A

Notes:
N/A = Not applicable, PZ-10 because of wellbore storage effects; PZ-7 and PZ-12 because no drawdown was observed.

Data Analysis Summary

A constant-rate pumping test was conducted on PT-1 at an average pumping rate of 0.9 gpm. Drawdown reached within a few feet of the pump intake and the test was therefore terminated after 985 minutes. The pumping of PT-1 at this rate and duration did produce interference drawdown in all six observation wells oriented in two orthogonal directions at distances from PT-1 ranging from 25 to 100 feet.

The data were analyzed using several methods. The best results indicate an apparent aquifer transmissivity of 33 ft^2/d and a storativity of 3.6×10^{-3} for the PT-1 site. Overall, the testing at PT-1 was effective and provided adequate data, despite a shortened test at a relatively low pumping rate resulting from the low permeability of materials encountered. Assuming the effective thickness of the permeable formations tested at PT-1 is between 20 and 40 feet, the average hydraulic conductivity at the PT-1 site ranges from 0.83 to 1.65 ft/d (between 2.9×10^{-4} and 5.8×10^{-4} cm/s). Drawdown data from the relatively short pumping test appear to conform to a confined aquifer model with relatively low storativity, although the formation materials may be very heterogeneous.

Four pumping tests were conducted at the PT-2 site. The best results came from the 23.5-hour constant-rate test on PZ-10 at an average pumping rate of 1.38 gpm. An electrical failure caused the test to be terminated after 1,411 minutes. The pumping of PZ-10 at this rate and duration did produce interference drawdown in four of the six observation wells at the PT-2 site, ranging between 25 and 97 feet from PZ-10.

The data were analyzed using several methods. Analyses indicated that the pumping wells (PT-1 and PT-2) showed significant wellbore storage effects that rendered the drawdown and recovery data obtained from the pumped wells as unrepresentative of aquifer conditions, more distant wells showed only small responses suggesting high transmissivity values but these should be discounted in our opinion as the drawdown response was generally incomplete due to the limited duration of the pumping tests. The results from the closer observation wells appear to indicate a low but variable aquifer transmissivity of between 15 and 30 ft^2/d and a storativity of between1.0 x 10^{-2} and 1.0×10^{-3} for the PT-2 site. Additional testing of PT-2, PZ-8 and PZ-11 provided limited data due to the short test duration, low pumping rates and wellbore storage effects.

Overall, the testing of PZ-10 was effective and provided adequate data for characterizing the aquifer conditions and dewatering challenges of the site. Assuming the effective thickness of the permeable formations tested at the PT-2 site is between 20 and 40 feet, the average hydraulic conductivity at the PT-2 site ranges from 0.25 to 1.5 ft/d (between 2.9 and 5.8 x 10^{-4} cm/s). Drawdown data from the relatively short pumping test appear to conform to a confined aquifer model with relatively low storativity, although the formation materials may be very heterogeneous.

DEWATERING ASSESSMENT

The deposits at both the PT-1 and PT-2 sites appear to be highly stratified and contain a potentially confined aquifer that is amenable to dewatering by pumping from either active or passive dewatering systems. The low permeability of the aquifer suggests it could be feasible to use open ditches or trenches and sumps to dewater the area to facilitate construction of the MBD provided these do not compromise the stability of open cut slopes. However, there are several benefits to an active dewatering system, such as pumping from vacuum wellpoints or eductors which apply a vacuum to the ground that increases the efficiency and effectiveness of the dewatering effort. Conventional dewatering wells that do not utilize a vacuum effect are not considered appropriate for this site as the soils are not sufficiently permeable for adequate drainage by means of unassisted gravity flow to the wells.

Active removal of water from the area has the added benefit of reducing the potential for erosion and helping to keep the site dry (less muddy working conditions) because the water is piped away from the work area as opposed to collecting in ditches within the work area. In addition both these methods apply a partial vacuum to the soil formations being dewatered, and this can substantially improve the stability of the soils, and prevent them from sloughing or softening up.

To achieve active dewatering before excavation for the MBD to an assumed depth of elevation -40 feet, a system of eductor wells would need to be installed that penetrate to elevation –55 feet or lower, (greater installation depth may be required depending on the maximum planned construction depth in the final design) and completed with 5-feet-long well screens. We estimate that a row of eductor wells spaced 40 feet apart, and set back 50 feet from the base of unsupported open-cut excavations would achieve the required drawdown. It is presumed that groundwater inflow induced by pumping will flow radially toward the well from all directions, with recharge of the groundwater system provided by the waters of the Mississippi.

Alternatively, dewatering open cut excavations could be accomplished with the installation of vacuum wellpoints in two or more staged tiers. These should be installed on 10-feet spacing, and each to a depth of no more than 30 feet, so that the well screens of the wellpoints are located at elevation –30 and –55 feet respectively. Wellpoints should be constructed with sand packs placed around the screens and extending up to within 5 feet of the surface to encourage drainage of permeable layers through downward flow in the annulus of each wellpoint.

The upper 5 feet of each wellpoint should be completed with a bentonite seal that is fully hydrated before starting to operate the dewatering system. Effective surface seals can help to promote the retention of vacuum within the sand pack so that this propagate out into the formation, and helps to improve the stability of cut slopes in relatively weak soils.

Considerations for 60% Design

- Address pH variability and recommend additional testing to determine corrosivity of water on possible bridge piles.
- Recommend additional pump tests to address the variability of the soils based on better soils information and grain size results.
- Depth of excavation should be verified and dewatering results re-confirmed.

Construction Excavation

Monitoring

Monitoring of groundwater levels is recommended at the MBD excavation to assess the effectiveness of drawdown created by the vacuum wellpoint system and, thus, ensure dewatering objectives are being met:

- Existing monitoring wells at PT-1 and PT-2 sites should be preserved to the extent possible.
- Additional wellpoints can be installed as dedicated monitoring wells and left disconnected from the vacuum header.
- Individual operating wellpoints can be periodically disconnected from the vacuum header and used as temporary monitoring wells that are reconnected after measuring water levels.

The standpipe piezometers will allow direct measurement of the dewatering achieved.

LIMITATIONS

We have prepared this report for HDR and their authorized agents and regulatory agencies for the Mid-Barataria Diversion (BA-153) project in Plaquemines Parish, Louisiana.

Within the limitations of scope, schedule and budget, our services have been executed. All data presented have been provided to us by other agencies or companies to include in this report for the Mid-Barataria Diversion (BA-153) project. No warranty or other conditions express or implied should be understood.

Any electronic form, facsimile or hard copy of the original document (email, text, table and/or figure), if provided, and any attachments should be considered a copy of the original document. The original document is stored by GeoEngineers, Inc. and will serve as the official document of record.

Please refer to Appendix E titled “Report Limitations and Guidelines for Use” of the Geotechnical Baseline Report for 30% Design for additional information pertaining to use of this report.

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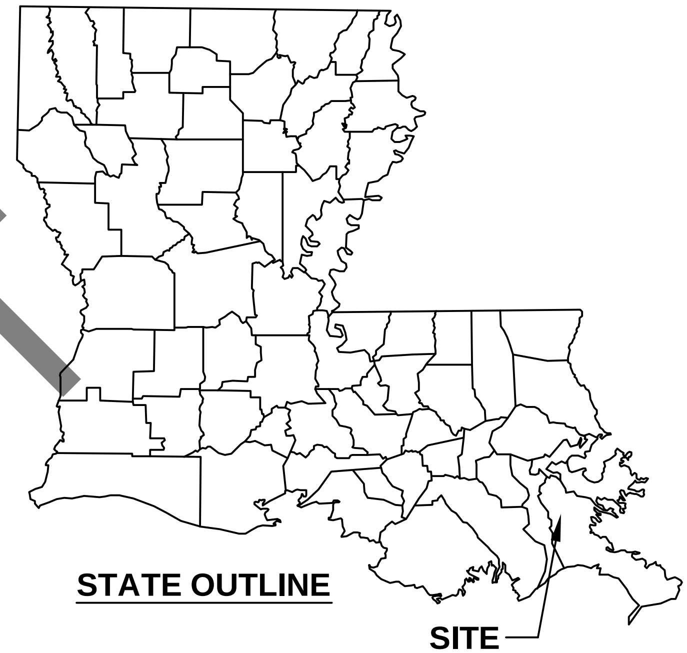

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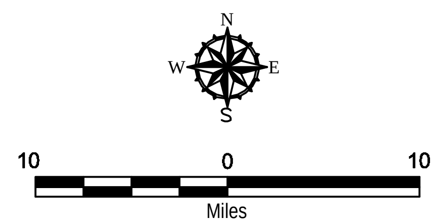

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Reference: Aerial image was taken from Google Earth Pro., Licensed to GeoEngineers Inc., Imagery dated: 11/14/2012

VICINITY MAP

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

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Figure 1

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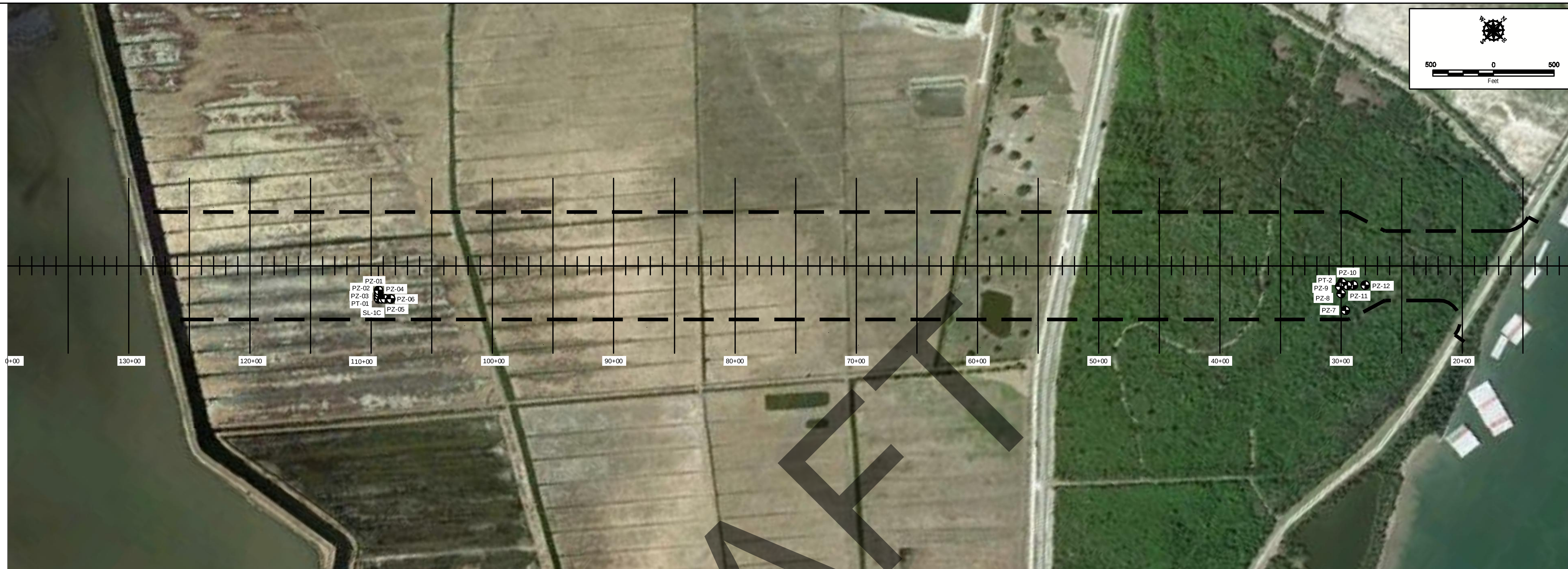
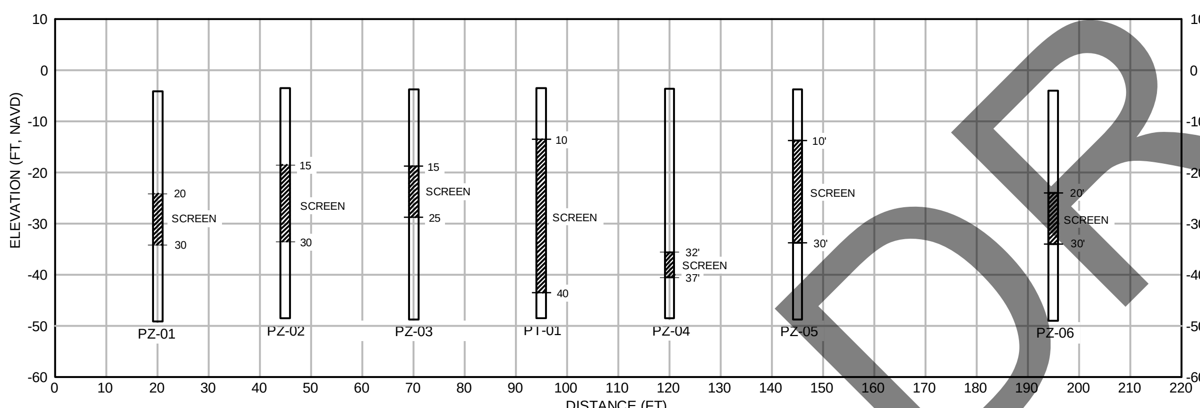
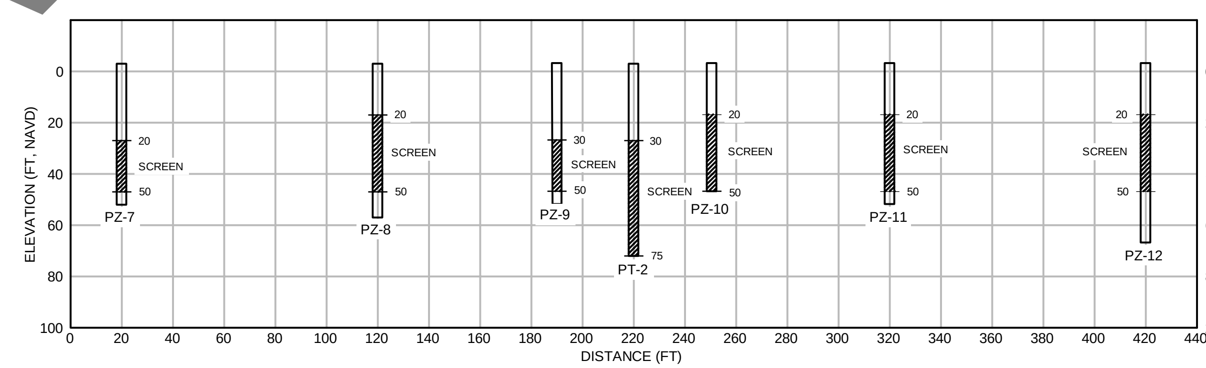




SECTION VIEW



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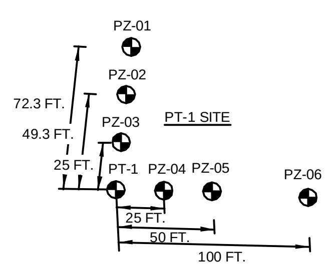
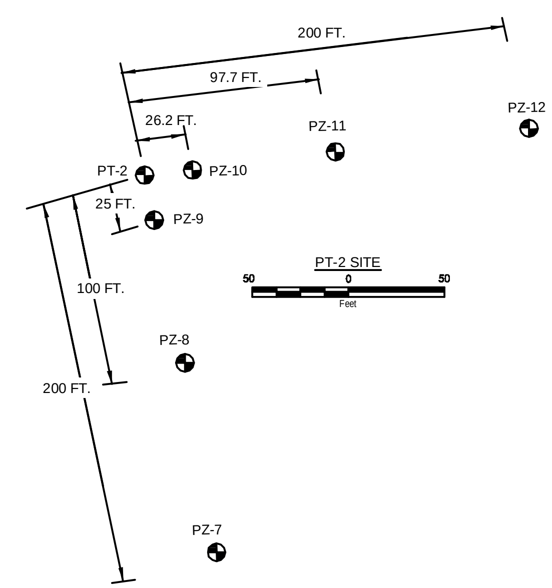


PT-1 SITE



PT-2 SITE

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Reference:
1. Base file was provided by HDR Engineering, MBSD_Data.dwg, Dated: 5/2013
2. Geology map was taken from USACE, Alluvial Deposits Map, Quads: Barataria & PointeALaHache, Dated 1987

MAP LEGEND

PZ-1	Test and Observation Wells
	Mid-Barataria Diversion Boundary

OVERALL SITE PLAN
PT-1 AND PT-2 SITES

Mid Barataria Diversion (BA-153) Project
Plaquemines Parish, Louisiana

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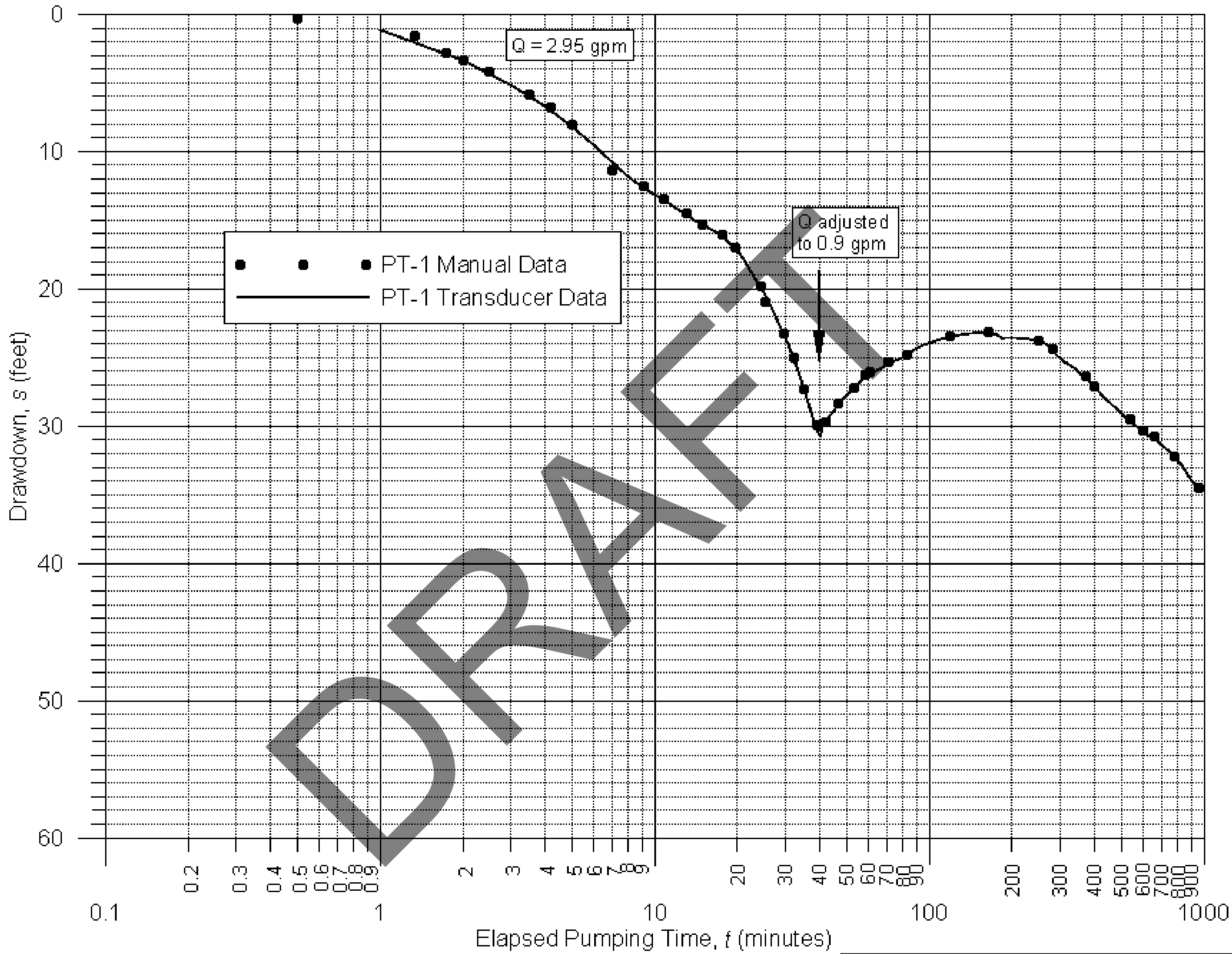
Figure 2



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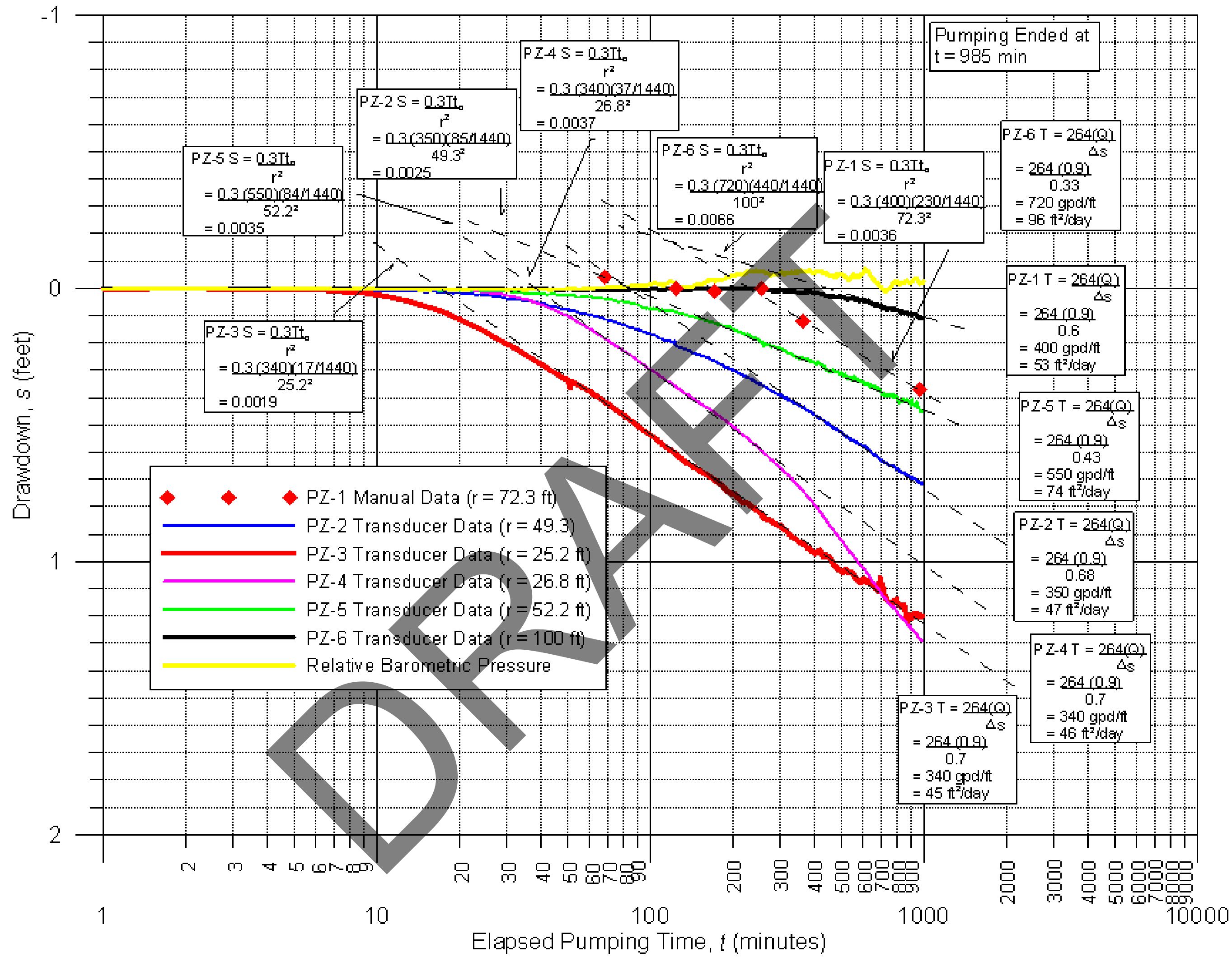
PT-1 Drawdown, PT-1 Test	
Mid-Barataria Diversion Plaquemines Parish, Louisiana	
GeoEngineers	Figure 3



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Observation Well Drawdown, PT-1 Test

Mid-Barataria Diversion
Plaquemines Parish, Louisiana

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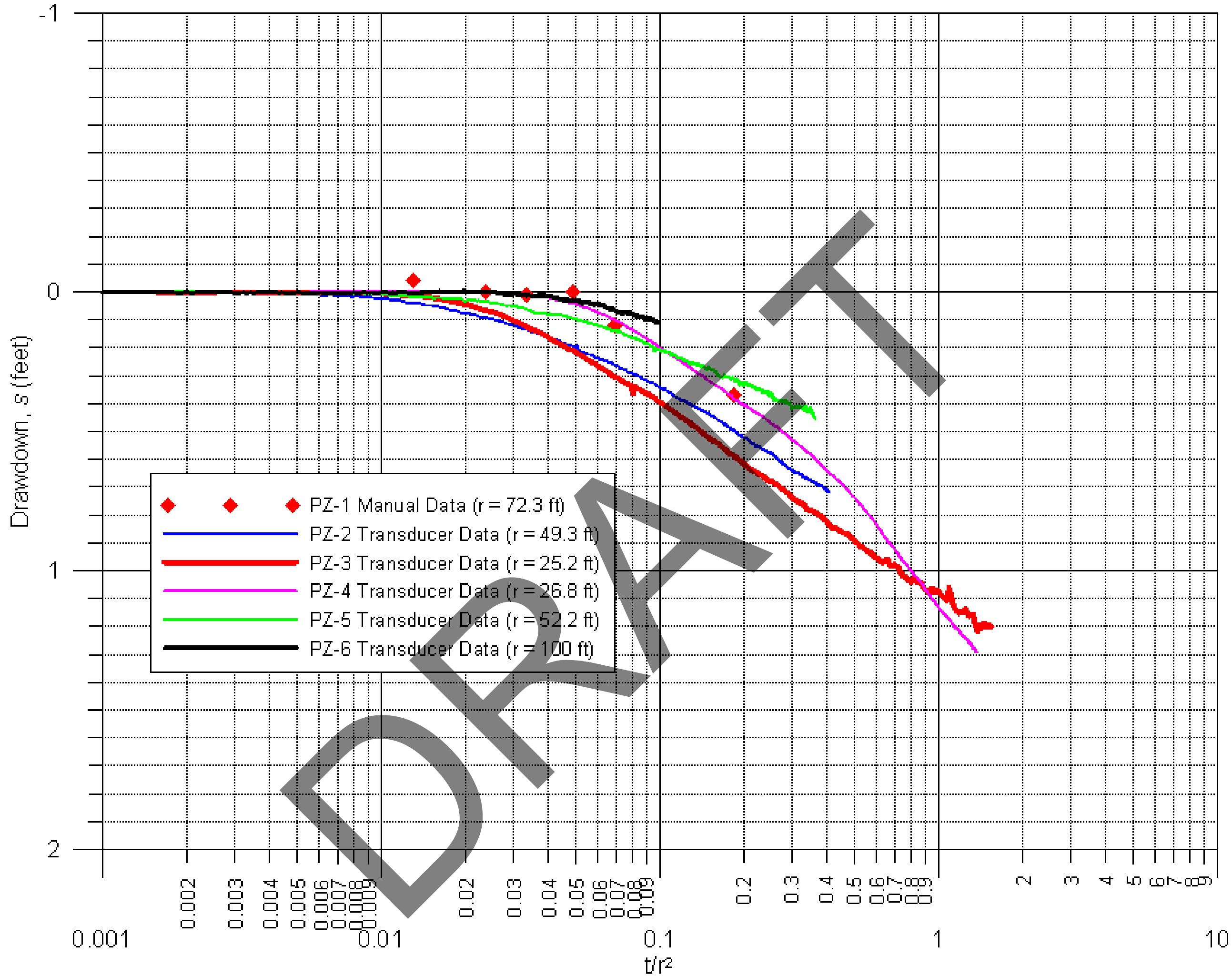
Figure 4



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Composite Drawdown Analysis, PT-1 Test

Mid-Barataria Diversion
Plaquemines Parish, Louisiana

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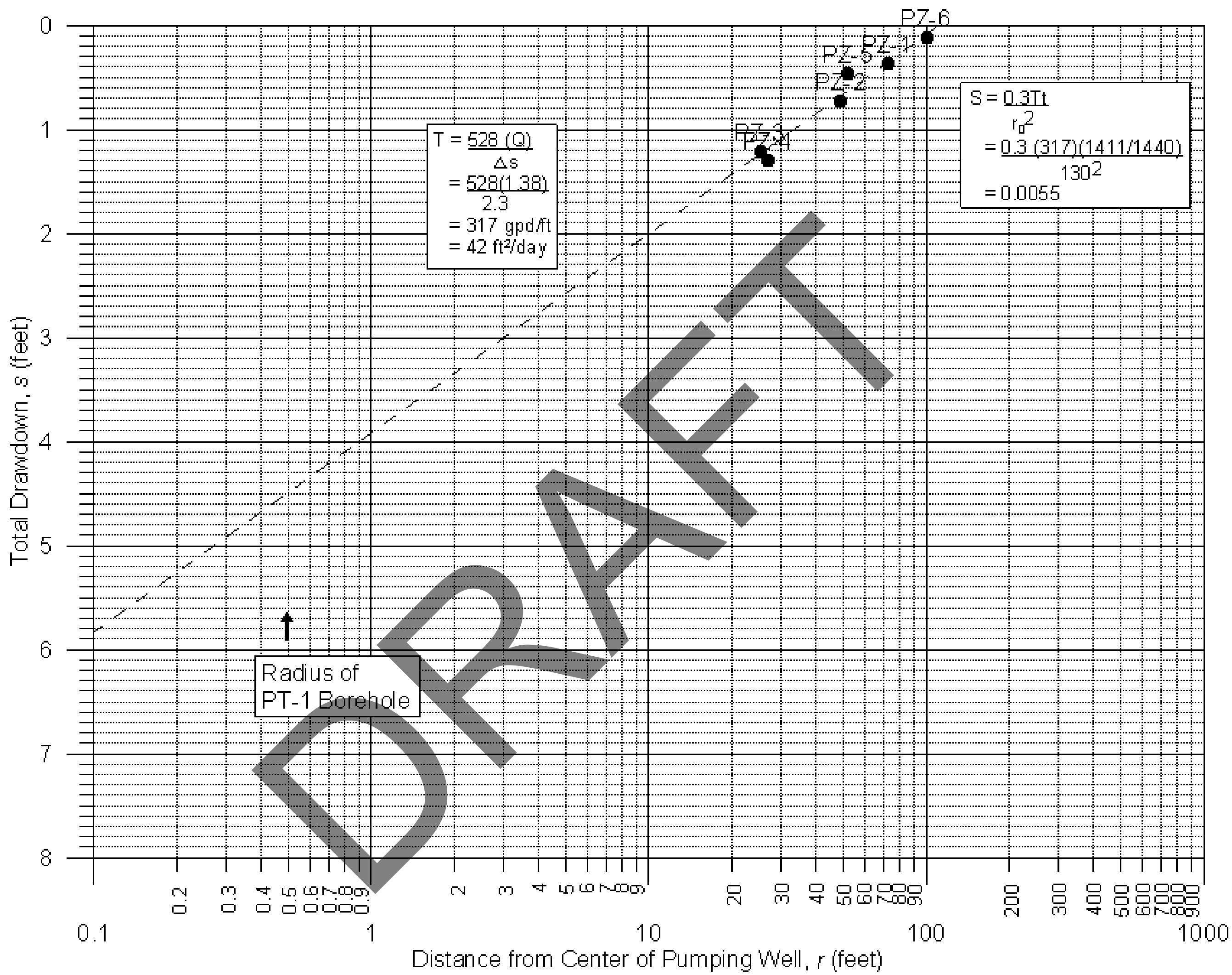
Figure 5



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Distance-Drawdown Analysis, PT-1 Test

Mid-Barataria Diversion
Plaquemines Parish, Louisiana

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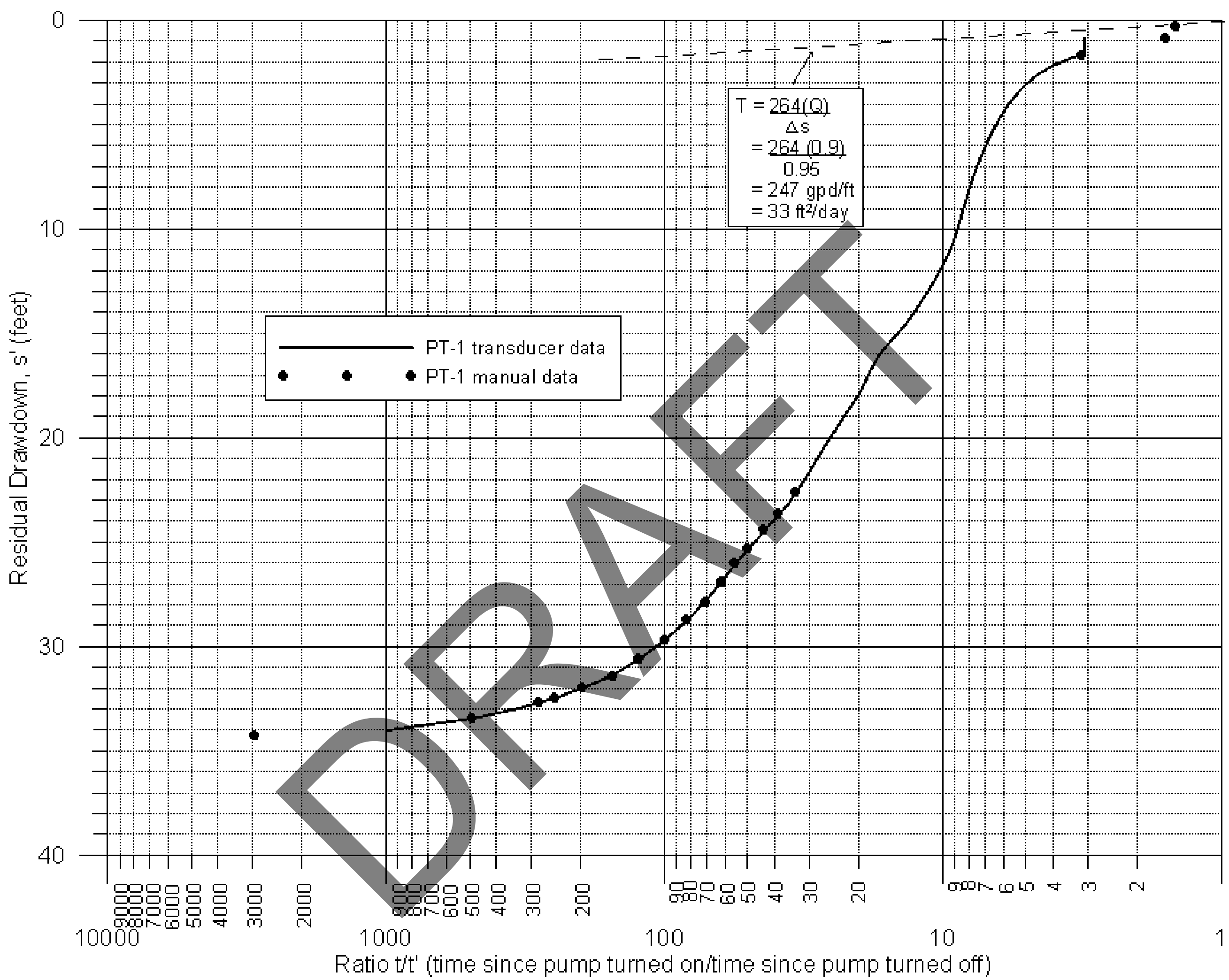
Figure 6



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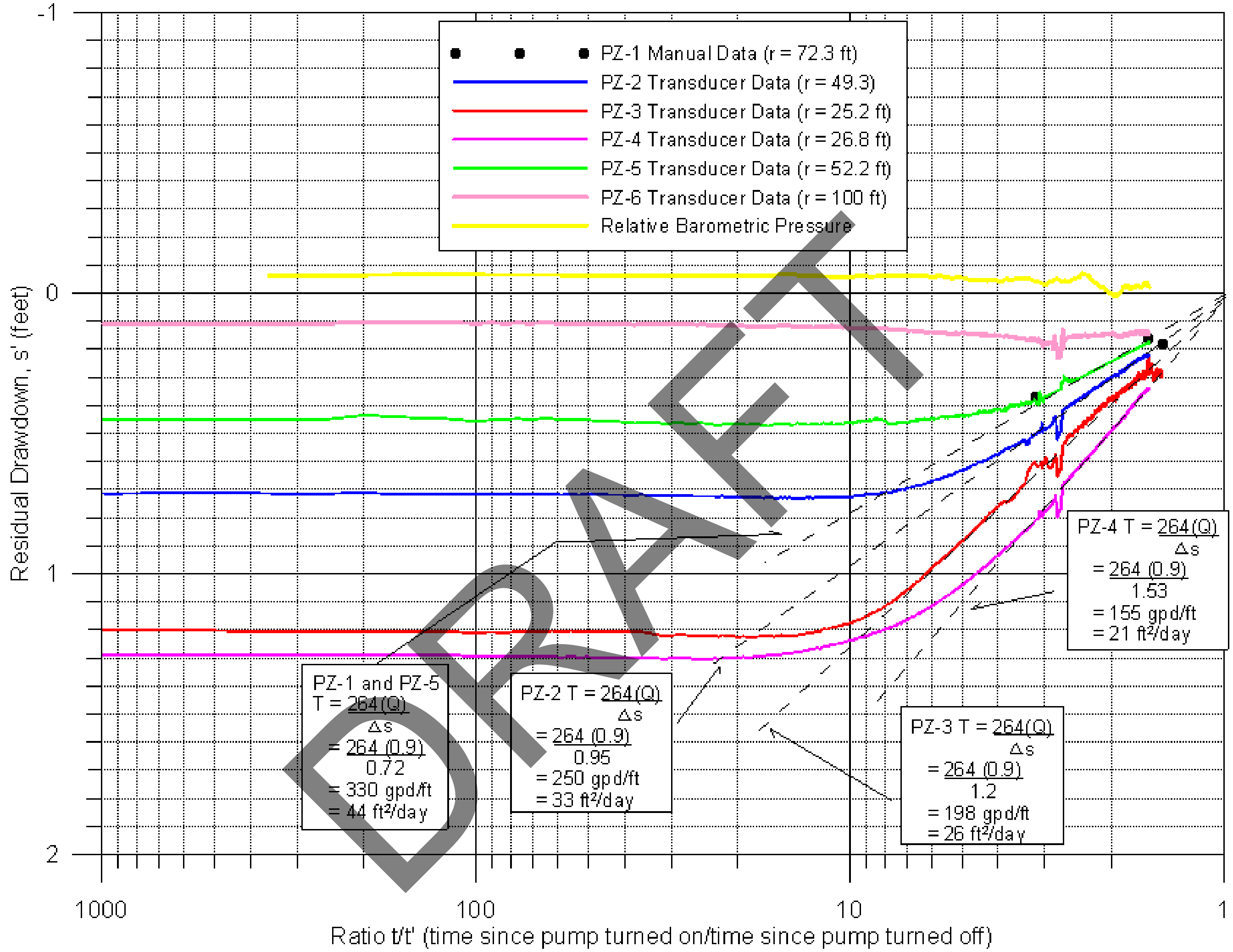
Theis Recovery Analysis, PT-1 Test	
Mid-Barataria Diversion Plaquemines Parish, Louisiana	
GeoEngineers	Figure 7



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Observation Well Recovery Analysis, PT-1 Test

Mid-Barataria Diversion
Plaquemines Parish, Louisiana

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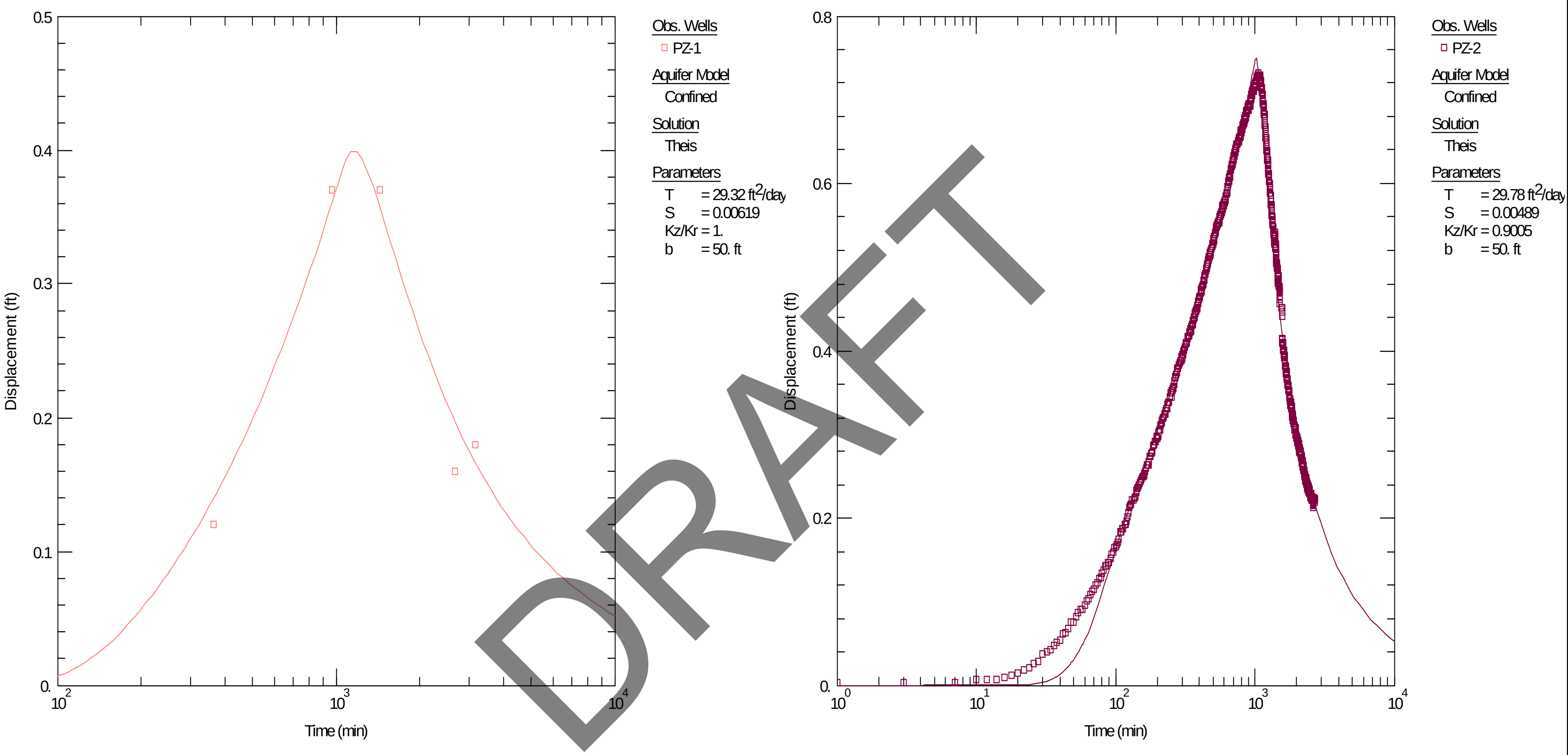
Figure 8



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AQTESOLV Analyses of PZ-1 and PZ-2, PT-1 Test

Mid-Barataria Diversion
Plaquemines Parish, Louisiana

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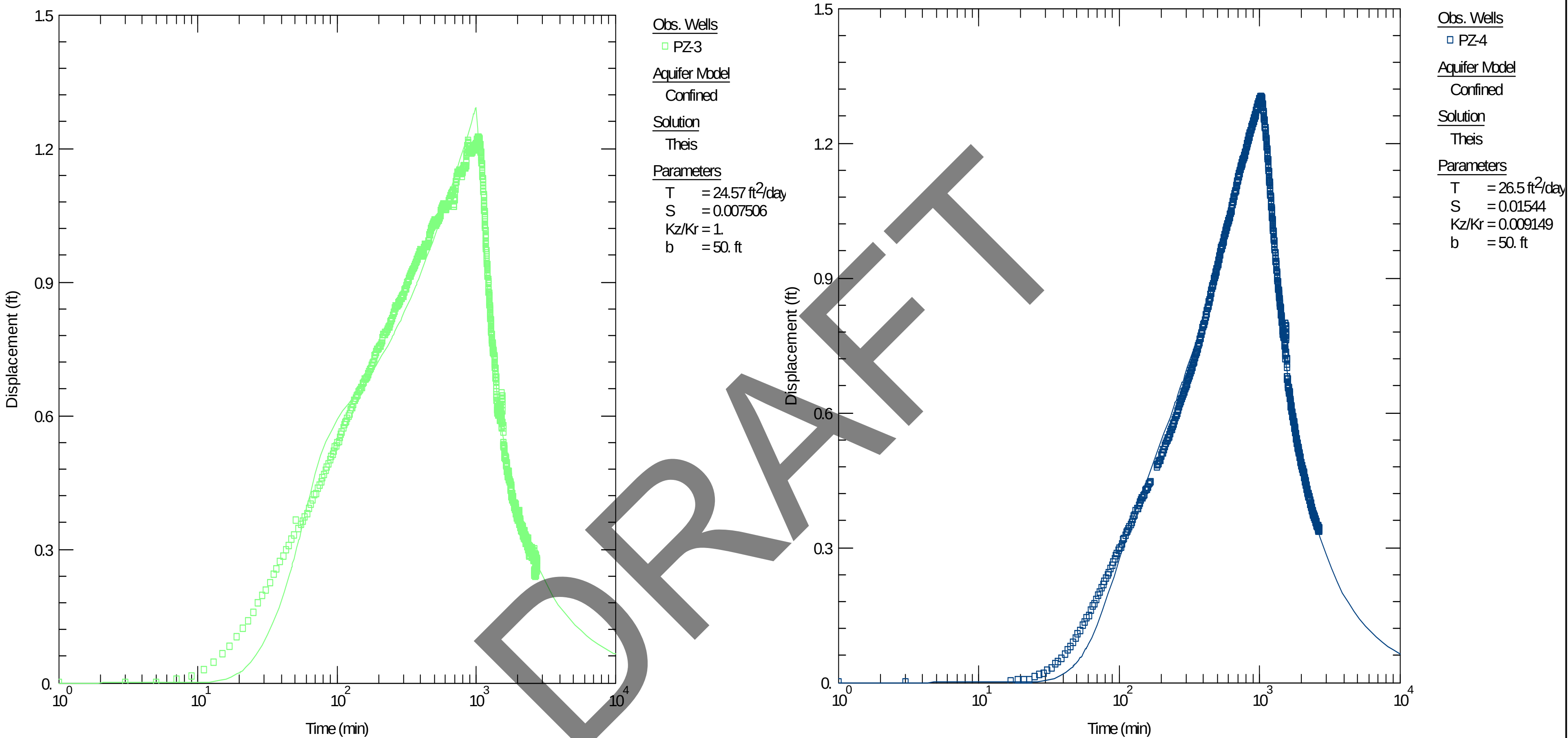
Figure 9



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AQTESOLV Analysis of PZ-3 and PZ-4, PT-1 Test

Mid-Barataria Diversion
Plaquemines Parish, Louisiana

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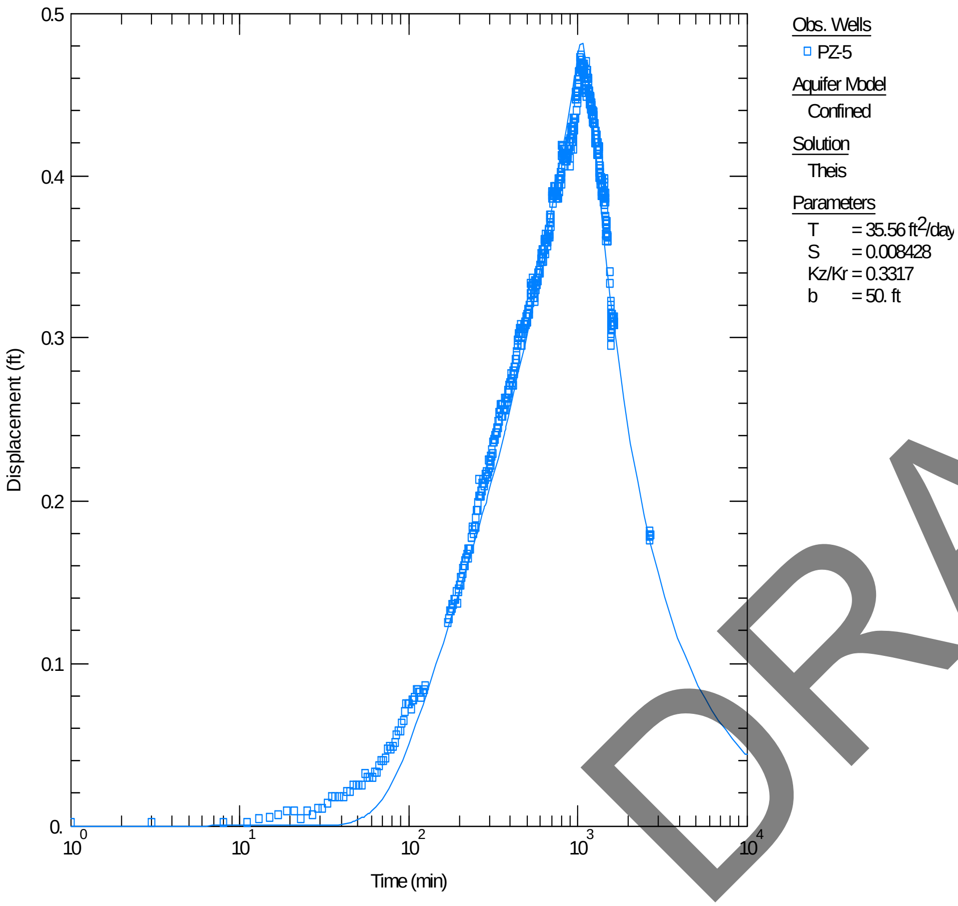
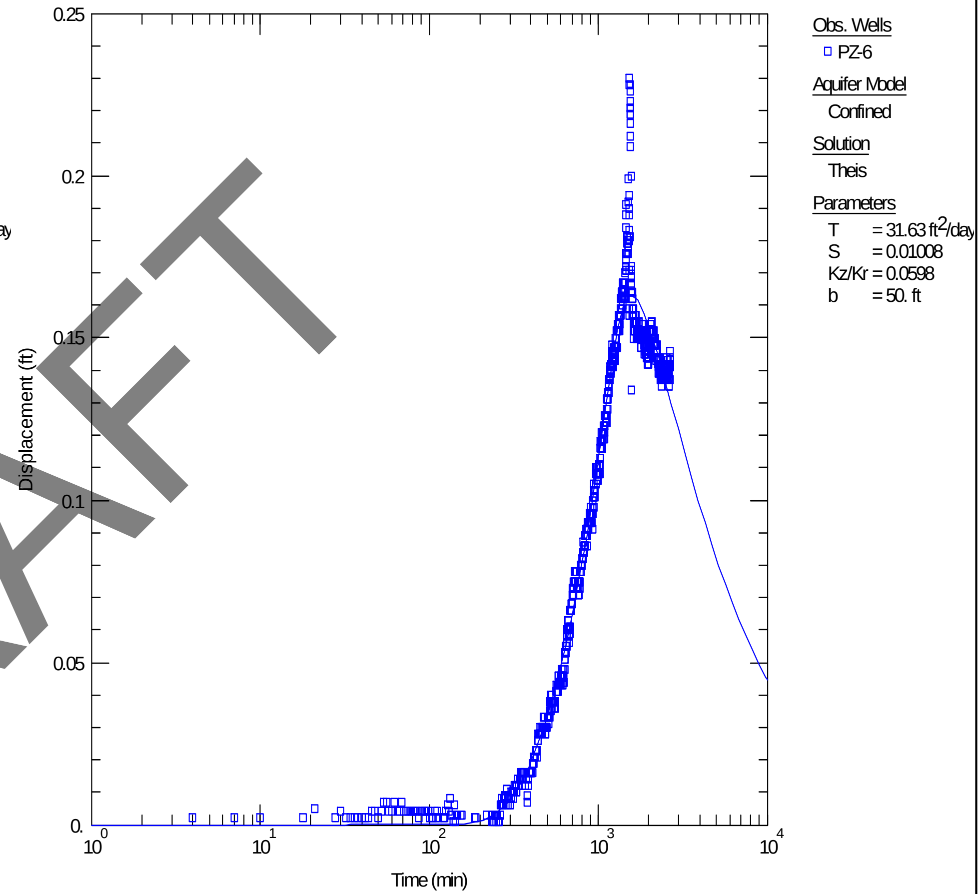
Figure 10





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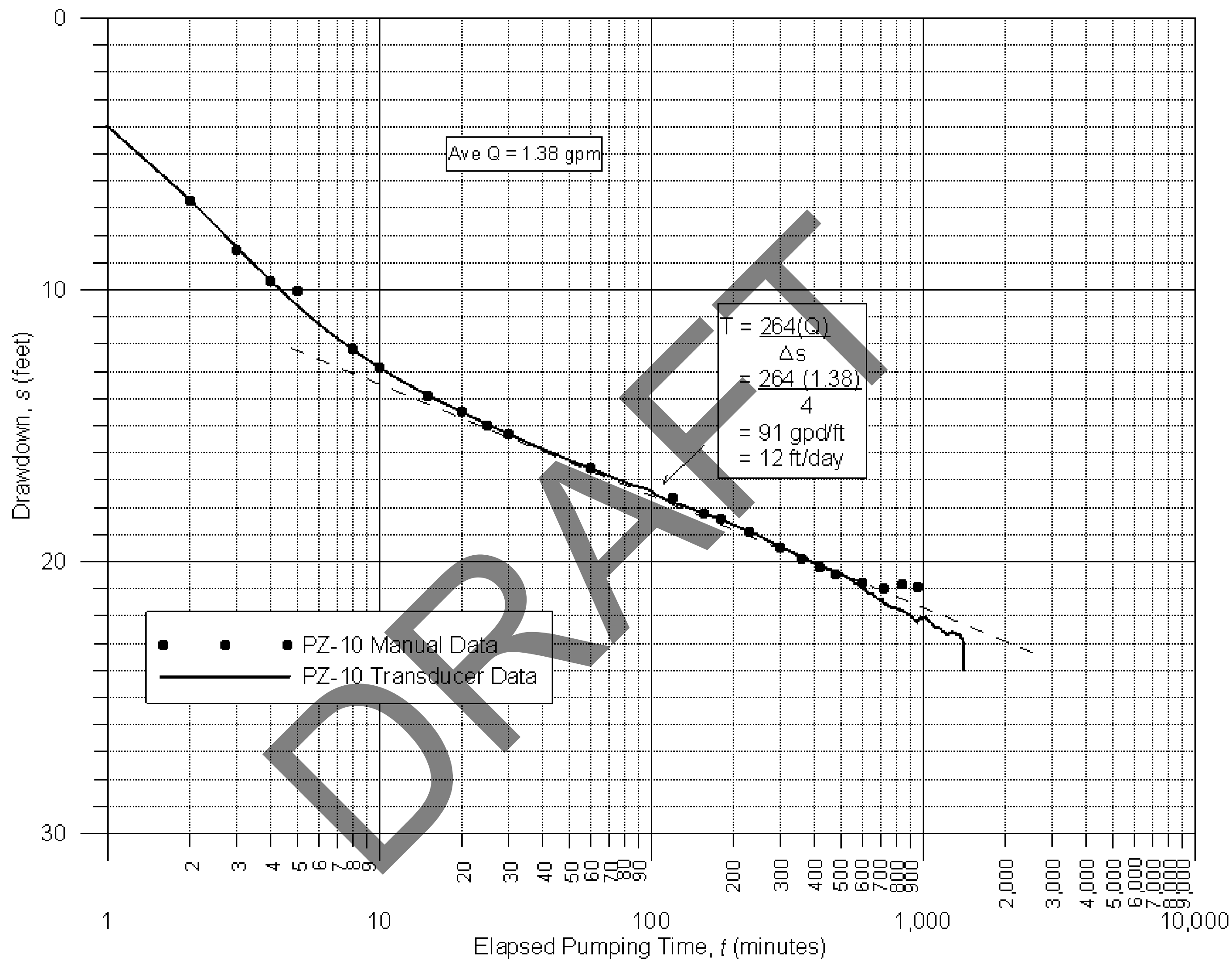
AQTESOLV Analysis of PZ-5 and PZ-6, PT-1 Test	
Mid-Barataria Diversion Plaquemines Parish, Louisiana	
GEOENGINEERS	**Figure 11**



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PZ-10 Drawdown, PZ-10 Test

Mid-Barataria Diversion
Plaquemines Parish, Louisiana

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Figure 12

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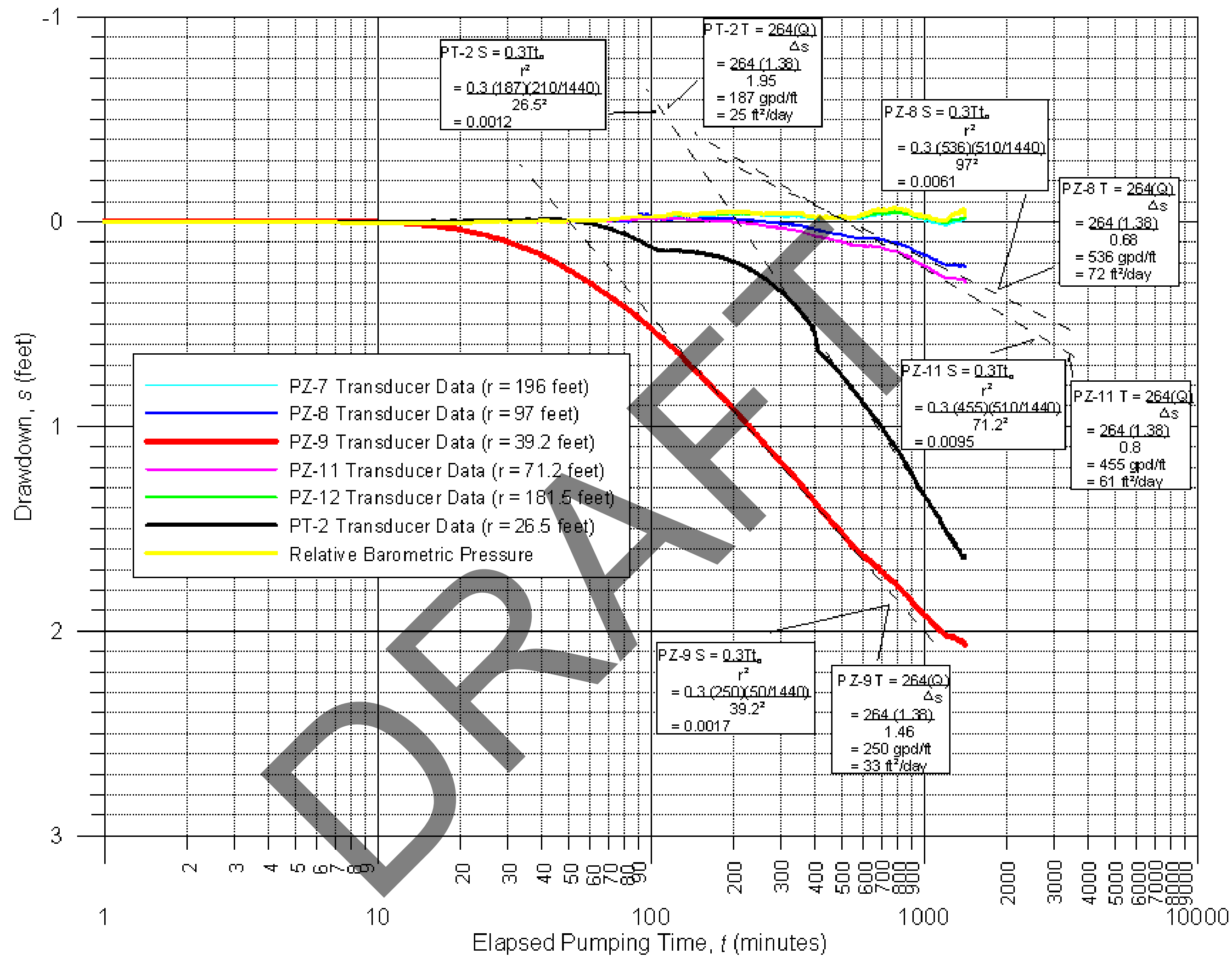

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Observation Well Drawdown, PZ-10 Test

Mid-Barataria Diversion
Plaquemines Parish, Louisiana

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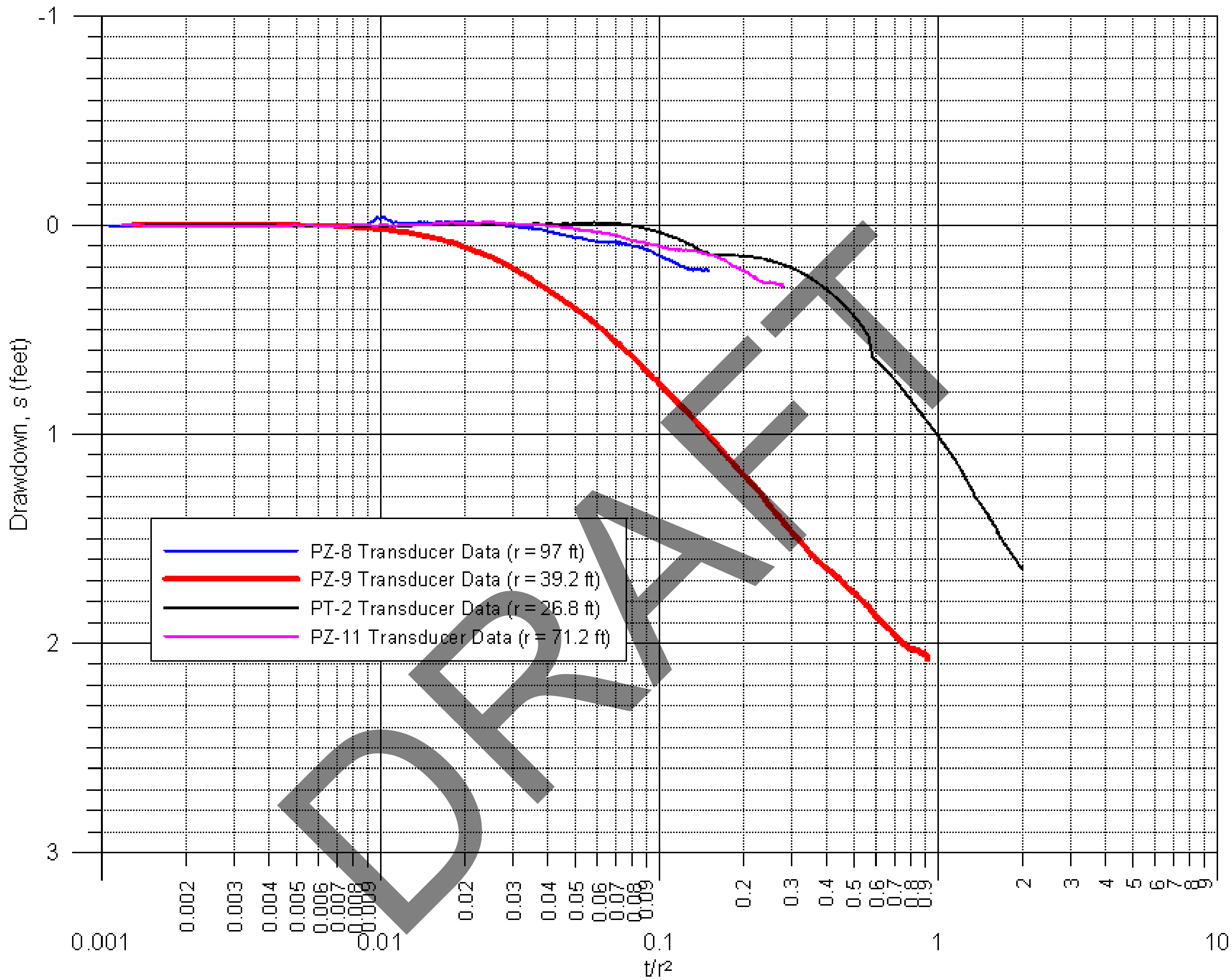
Figure 13



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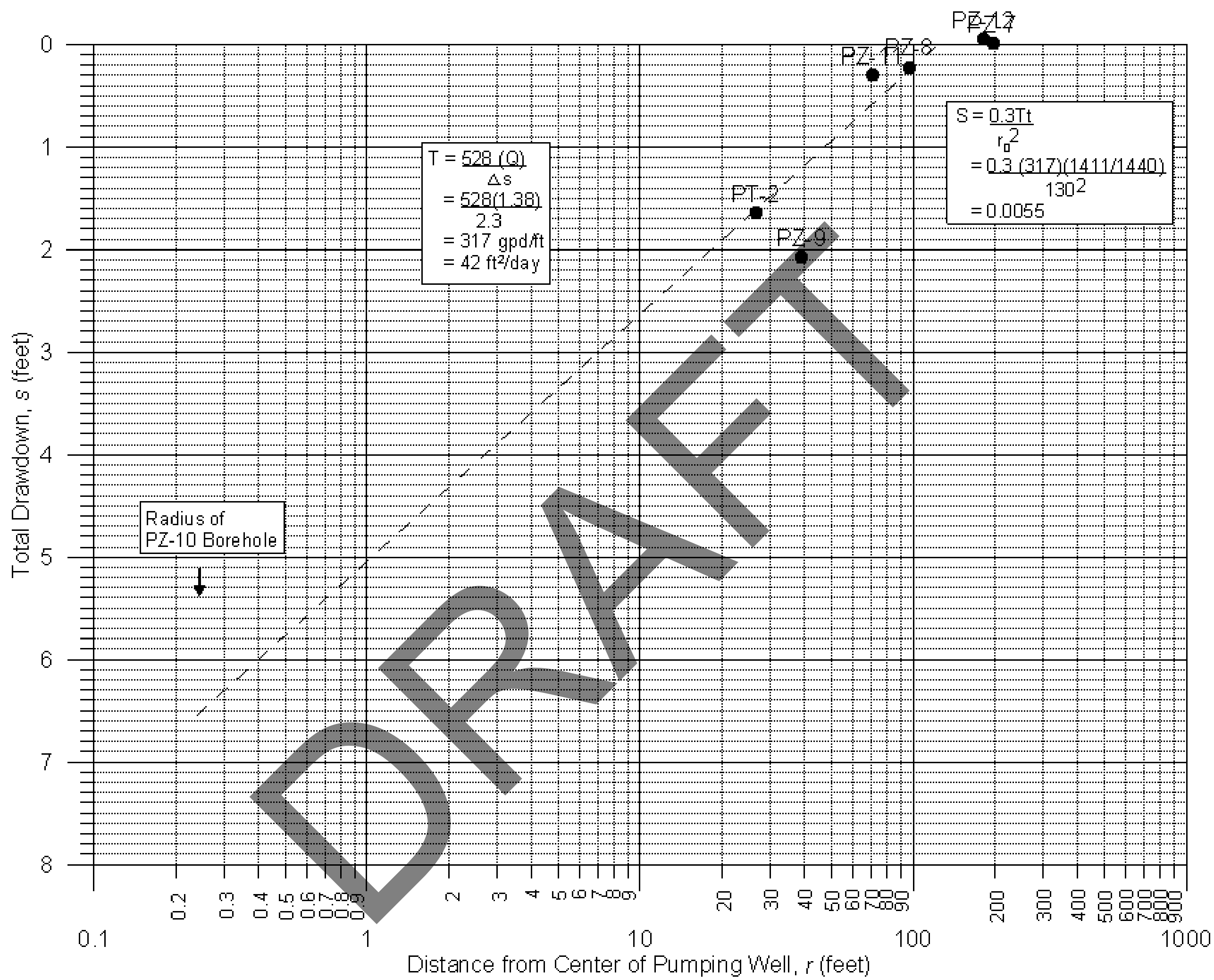
Composite Drawdown Analysis, PZ-10 Test	
Mid-Barataria Diversion Plaquemines Parish, Louisiana	
GEOENGINEERS	Figure 14



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Distance-Drawdown Analysis, PZ-10 Test

Mid-Barataria Diversion
Plaquemines Parish, Louisiana

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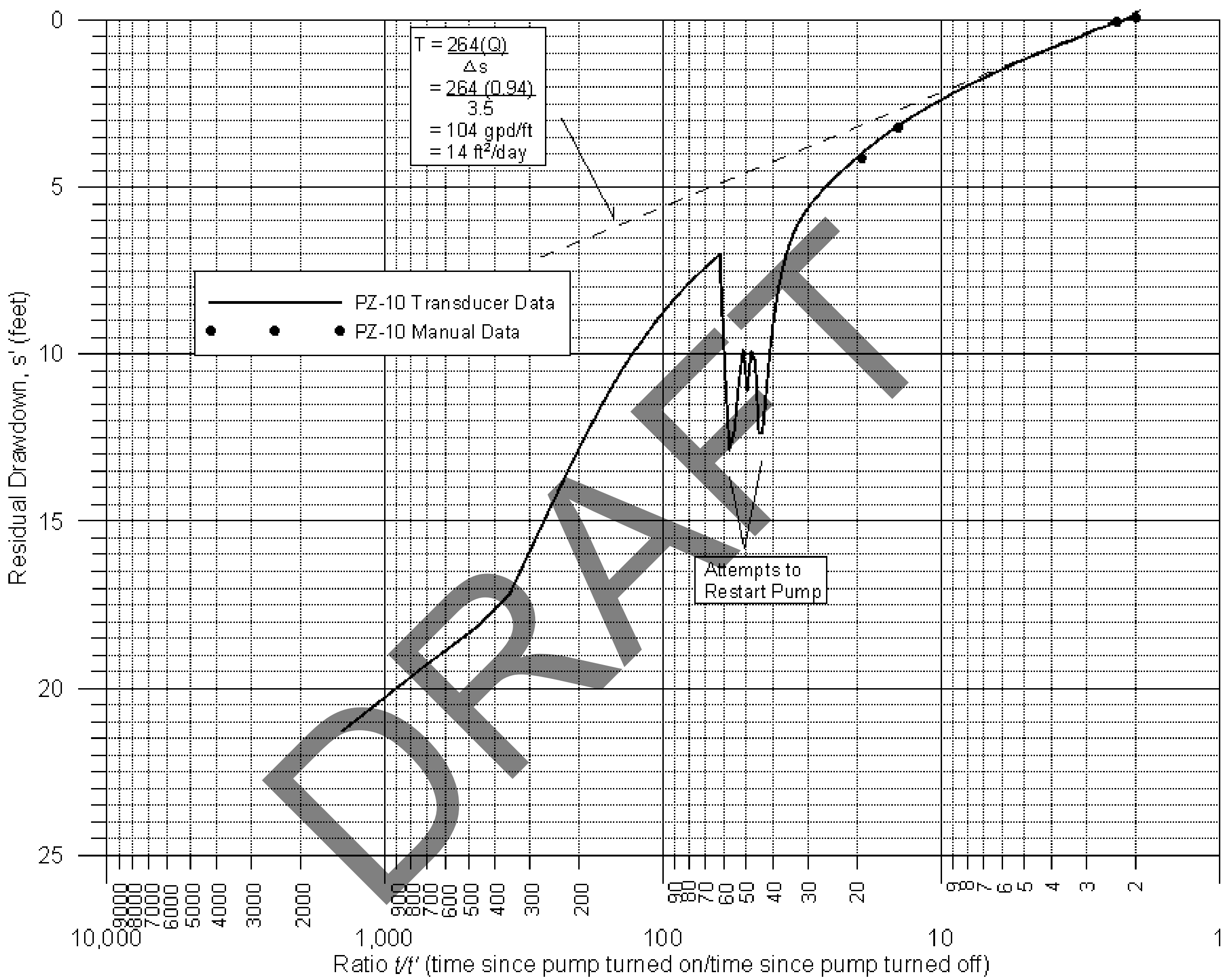
Figure 15



Notes:

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Theis Recovery Analysis, PZ-10 Test

Mid-Barataria Diversion
Plaquemines Parish, Louisiana

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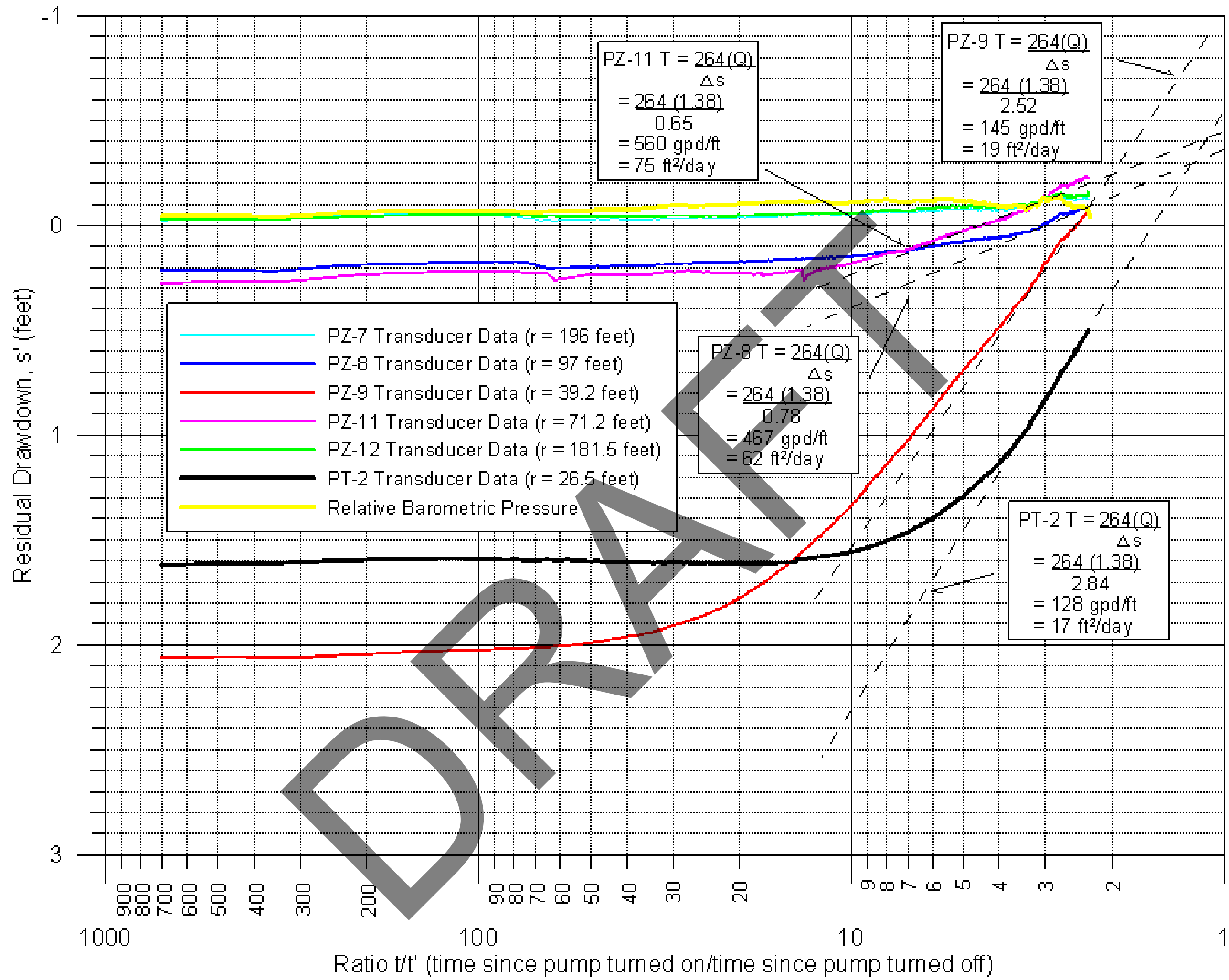
Figure 16



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Observation Well Recovery Analysis, PZ-10 Test

Mid-Barataria Diversion
Plaquemines Parish, Louisiana

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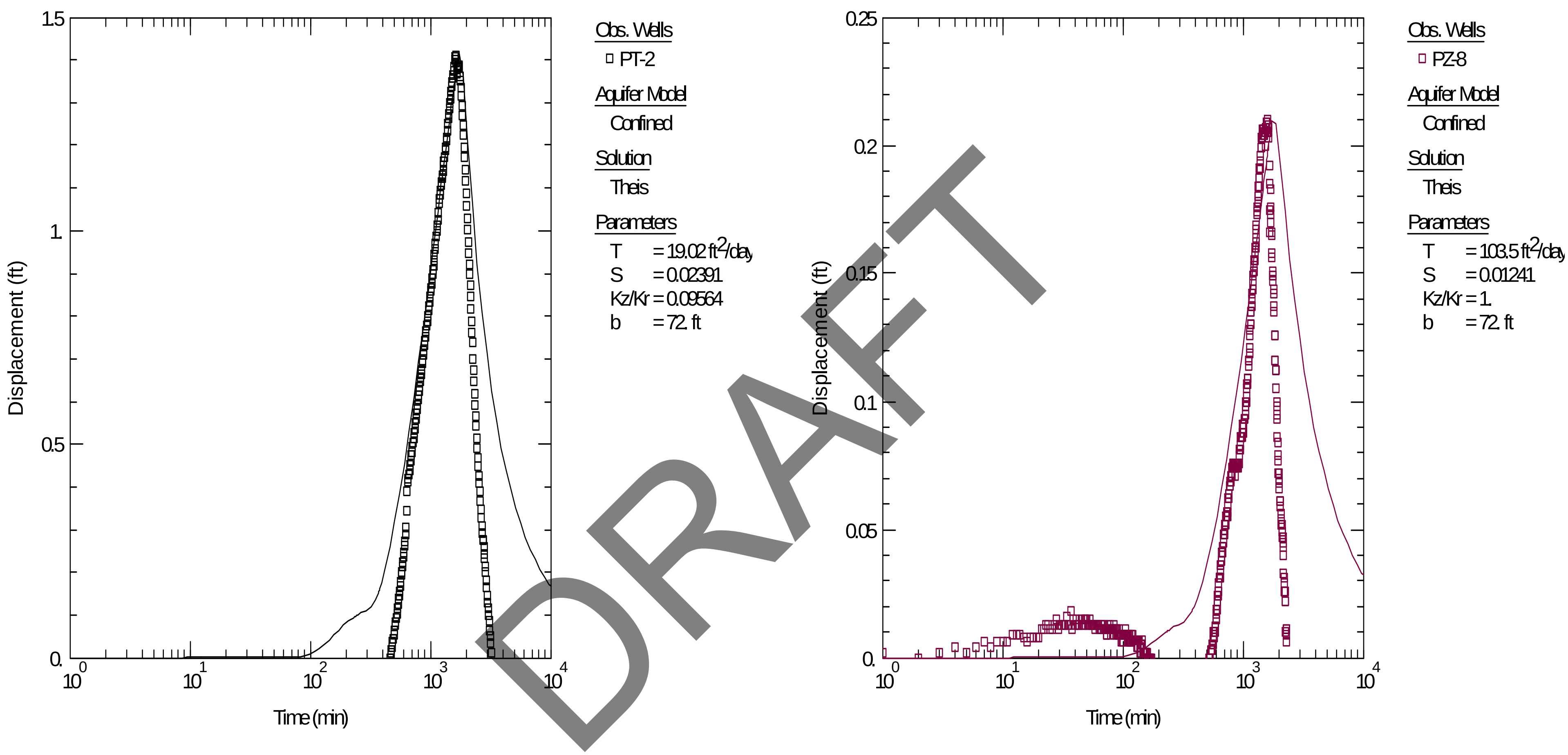
Figure 17



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AQTESOLV Analysis of PT-2 and PZ-8, PZ-10 Test

Mid-Barataria Diversion
Plaquemines Parish, Louisiana

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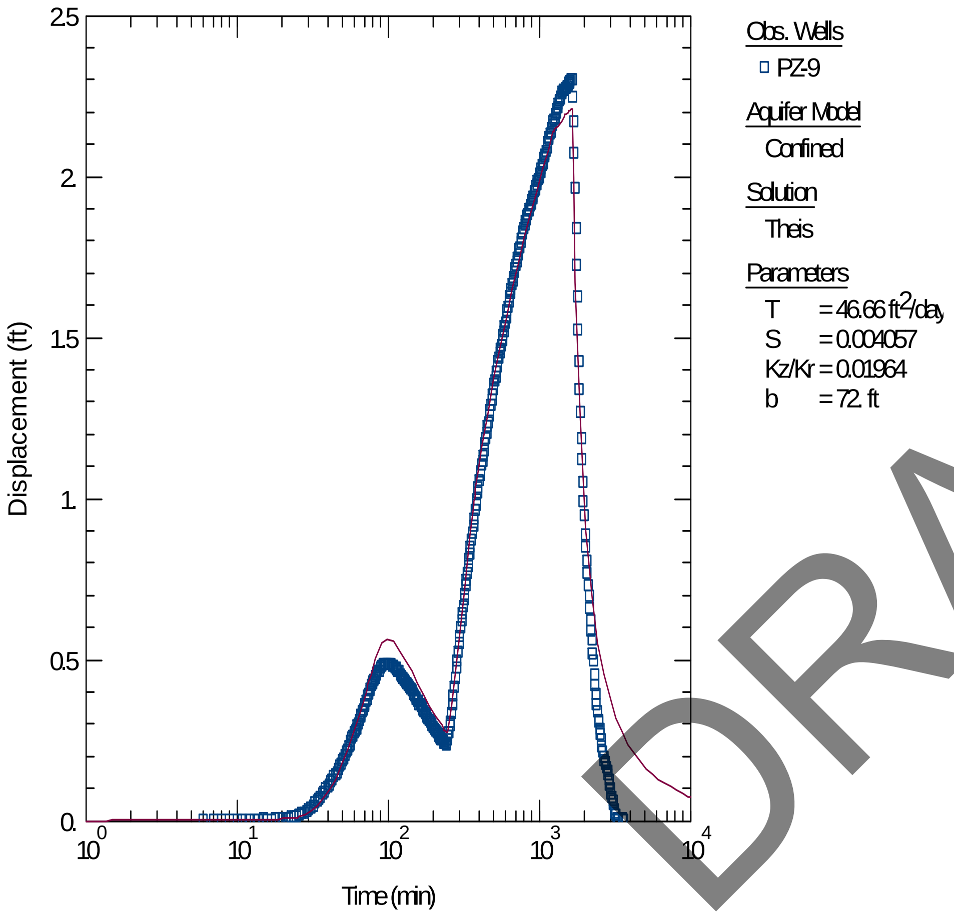
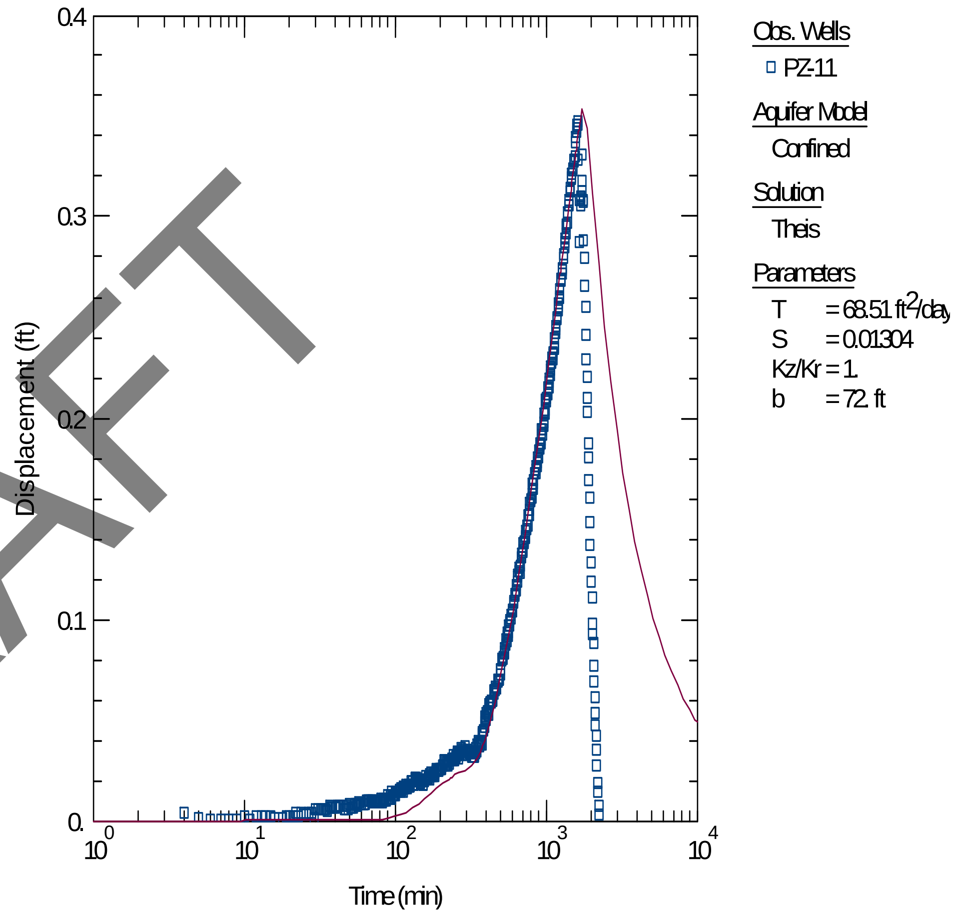
Figure 18





Notes:

1. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
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AQTESOLV Analysis of PT-9 and PZ-11, PZ-10 Test

Mid-Barataria Diversion
Plaquemines Parish, Louisiana

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Figure 19

APPENDIX D
Vibrating Wire Piezometer Data

18274-001-00 8/5/2013
Mid Barataria Sediment Diversion IAH

Piezometer Data and Pressure Adjustment Discussion

Piezometer Model: Geokon 4500 S, unvented, 0-50 psi range

Initial zero readings were established by submerging the piezometers into a bucket of water and allowing the temperature to stabilize for a minimum of 15 minutes. The zero reading was then collected once the sensor was removed from the water.

The second order polynomial was used once the calibration data was collected to program the data logger and reduce the potential for erroneous pressure results. The gage factors (A and B) were provided by the manufacturer. The zero reading (R_0) was used to calculated the polynomial gage factor, C, using the provided factors A and B and setting the pressure, P, equal to zero.

$$Zero\ Reading\ Pressure = P_0 = AR_0^2 + BR_0 + C$$

The data loggers were programmed to calculate the pressure using the polynomial fit. The current reading of the piezometer, R_1, is converted to kPa then stored by the data logger.

$$Pressure\ Reported\ by\ Data\ Logger = P_{DL} = AR_1^2 + BR_1 + C$$

The actual pressure experienced by the piezometer includes adjustments for the temperature, T, and the barometric pressure, S. T_0 was recorded at the same time as R_0. S_0 was determined from local weather station data. The manufacturer supplied the temperature correction factor, K.

$$Pressure\ adjusted\ for\ temperature\ variation = P_{(temp)} = P_{DL} + K(T_1 - T_0)$$

$$Pressure = P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$$

$$Pressure = P = P_{DL} + K(T_1 - T_0) - (S_1 - S_0) = P_{(temp)} - (S_1 - S_0)$$

The sensors are read every 3 hours (10800 seconds) beginning at 0600 on the date of installation. As a result, some 'blank' readings were recorded until the sensors were connected to the data loggers. These readings are ignored for all analyses.

The barometric pressure at the time of the zero reading is equal to the zero reading pressure. The hydraulic connectivity between the atmosphere and the piezometer influences the piezometer recording, and a lag time may be observed between the change in barometric pressure and the corresponding change in a piezometer at a certain distance below the ground surface. The piezometers were installed in 'collection zones' in the boreholes. The sensors were embedded in sand and a bentonite layer was placed between the sand layers. The borehole was capped with a bentonite/cement grout, which seals the installation. The seal results in the atmospheric barometric pressure having a minimal influence on the piezometers installed.

The influence of the barometric pressure and the temperature correction on the pressure readings was explored at PZ-13. The influence of the atmospheric barometric pressure on the pressure reported by the piezometer is initially assumed to be directly related. Maximum hydraulic conductivity between the atmosphere and the piezometer is expected at the shallowest piezometer, so the variations were considered for the piezometer installed at 20' below ground surface, ID #1223993.

$$Variation\ caused\ by\ Temperature\ and\ Pressure\ Correction = P - P_{DL}$$

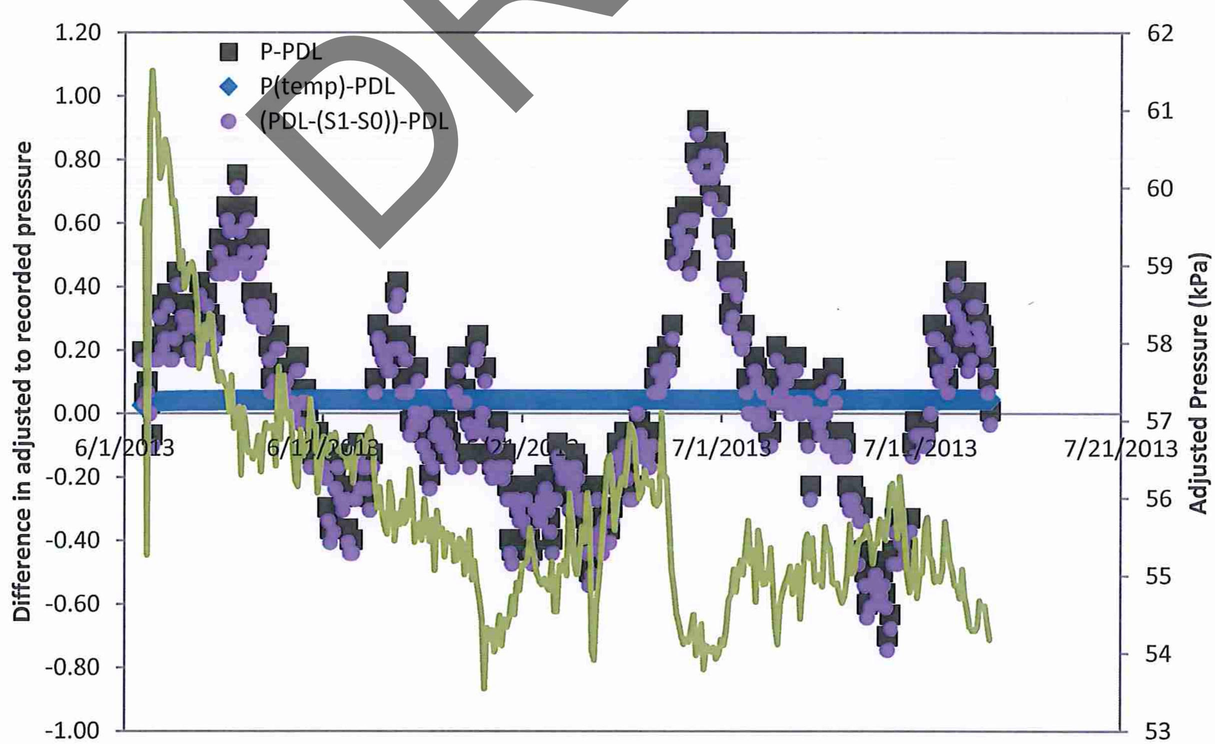
$$Variation\ caused\ by\ Temperature\ Correction = P_{(temp)} - P_{DL} = K(T_1 - T_0)$$

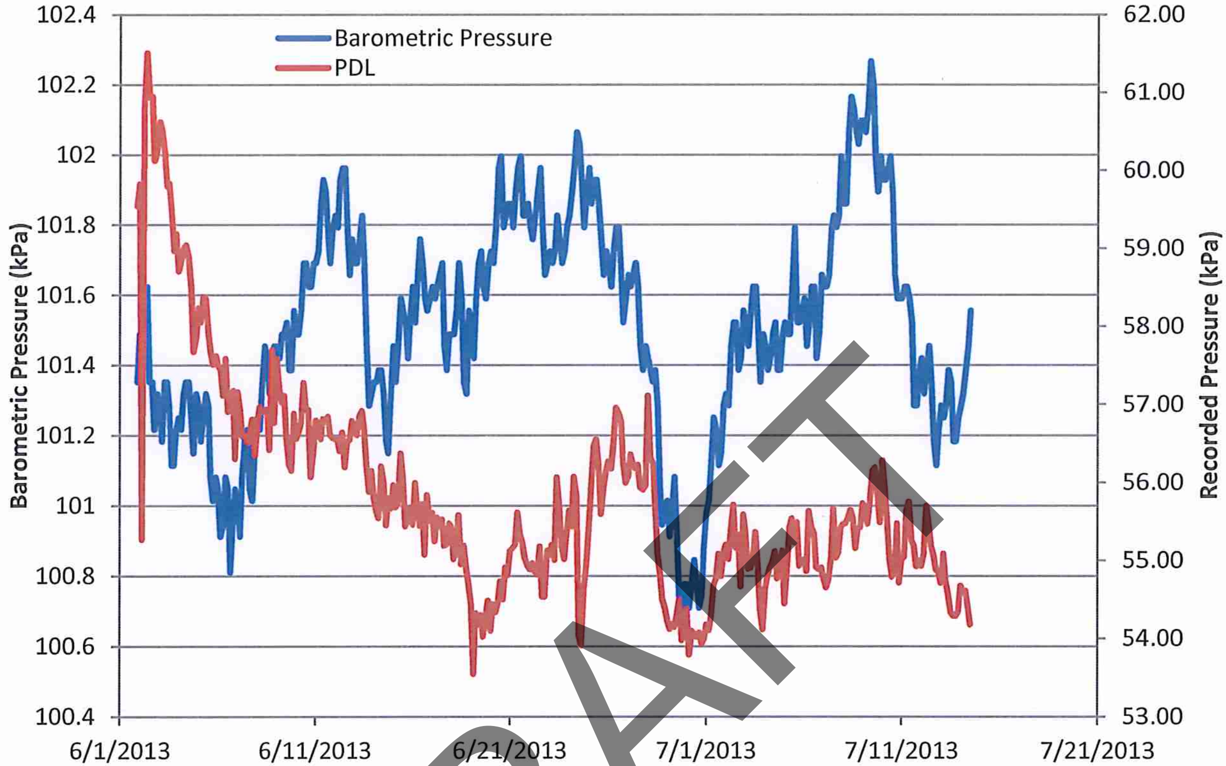
$$Variation\ caused\ by\ Pressure\ Correction = (P_{DL} - (S_1 - S_0)) - P_{DL} = -(S_1 - S_0)$$

The pressure correction induced far more variation in the calculated pressure than the temperature correction.

An additional comparison between the recorded barometric pressure and the pressure recorded by the Piezometer does not suggest any relationship between the two pressures.

	Variation caused by Temp and Pressure Adjustment	Variation caused by Temperature Adjustment	Variation Caused by Pressure Adjustment
	$P-P_{DL}$	$P_{(temp)}-P_{DL}$	$(P_{DL}-(S_1-S_0))-P_{DL}$
Variance	0.0973	0.0000	0.0975
Standard Deviation	0.3119	0.0018	0.3123
Average (Mean)	0.0564	0.0431	0.0133





Due to the significant influence the barometric pressure correction has on the adjusted pressure calculation and the lack of correlation between the original data and the barometric pressure, the adjusted pressure equation will not include the atmospheric pressure correction. The adjusted pressure of the piezometer will be calculated at $P = P_{(temp)}$.

APPENDIX E
Report Limitations and Guidelines for Use

APPENDIX E
REPORT LIMITATIONS AND GUIDELINES FOR USE[1]

This appendix provides information to help you manage your risks with respect to the use of this report.

Geotechnical Services Are Performed for Specific Purposes, Persons and Projects

This report has been prepared for HDR Engineering, Inc. (HDR) and their authorized agents and regulatory agencies. The information contained herein is not applicable to other sites.

GeoEngineers structures our services to meet the specific needs of our clients. No party other than HDR, may rely on the product of our services unless we agree to such reliance in advance and in writing. This is to provide our firm with reasonable protection against open-ended liability claims by third parties with whom there would otherwise be no contractual limits to their actions. Within the limitations of scope, schedule and budget, our services have been executed in accordance with our Agreement with the Client and generally accepted geotechnical practices in this area at the time this report was prepared. Use of this report is not recommended for any purpose or project except the one originally contemplated.

A Geotechnical Data Report is based on a Unique Set of Project-Specific Factors

This report has been prepared for Mid-Barataria Diversion (BA-153) project in Myrtle Grove, Louisiana. Geotechnical interpretation provided in this report is based on data provided in the “Geotechnical Data Report for 30% Design dated January 24, 2014 and the “Report of Existing Geotechnical Data” dated May 22, 2014. Unless GeoEngineers specifically indicates otherwise, it is important not to rely on this report if it was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

For example, changes that can affect the applicability of this report include those that affect:

- the function of the proposed structure;
- elevation, configuration, location, orientation or weight of the proposed structure;
- composition of the design team; or
- project ownership.

If important changes are made after the date of this report, we recommend that GeoEngineers be given the opportunity to review our interpretations and recommendations. Based on that review, we can provide written modifications or confirmation, as appropriate.

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1 Developed based on material provided by ASFE, Professional Firms Practicing in the Geosciences; www.asfe.org.

Subsurface Conditions Can Change

This geotechnical or geologic data report is based on information available at the time the study was performed. The findings and conclusions of this data report may be affected by the passage of time, by man-made events such as construction on or adjacent to the site, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. If more than a few months have passed since issuance of our report or work product, or if any of the described events may have occurred, please contact GeoEngineers before applying this report for its intended purpose so that we may evaluate whether changed conditions affect the continued reliability or applicability of our data report.

Geotechnical Engineering Data Report Is Not Final

The geotechnical data included in this report are those provided by others to GeoEngineers and should not be considered final. GeoEngineers is unable to assume responsibility for the data provided in this report.

A Geotechnical Data Report Could Be Subject to Misinterpretation

Misinterpretation of this data report by members of the design team or by contractors can result in costly problems. GeoEngineers can help reduce the risks of misinterpretation by conferring with appropriate members of the design team after submitting the data report.

Do Not Redraw the Exploration Logs

Geotechnical engineers and geologists compiled the boring and testing logs based upon information provided by other agencies/companies. The logs included in a geotechnical data report should never be redrawn for inclusion in architectural or other design drawings. Photographic or electronic reproduction is acceptable, but separating logs from the report can create a risk of misinterpretation.

Read These Provisions Closely

It is important to recognize that the geosciences practices (geotechnical engineering, geology and environmental science) are less exact that other engineering and natural science disciplines. Without this understanding, there may be expectations that could lead to disappointments, claims and disputes. GeoEngineers includes these explanatory “limitations” provisions in our reports to help reduce such risks. Please confer with GeoEngineers if you need to know more how these “Report Limitations and Guidelines for Use” apply to your project or site.

Biological Pollutants

GeoEngineers’ Scope of Work specifically excludes the investigation, detection, prevention or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants, and no conclusions or inferences should be drawn regarding Biological Pollutants as they may relate to this project. The term “Biological Pollutants” includes, but is not limited to, molds, fungi, spores, bacteria and viruses, and/or any of their byproducts.

A Client that desires these specialized services is advised to obtain them from a consultant who offers services in this specialized field.

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