Hazard Potential Classification, Structural Stability, and Safety Factor Assessments, Revision 1

Drains Pond System CCR Surface Impoundment, Coal Creek Station

Submitted to:

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1.0 INTRODUCTION

Golder Associates Inc. (Golder) has prepared this hazard potential classification, structural stability, and safety factor assessment for the Drains Pond System CCR Surface Impoundment (Drains Pond System) at Great River Energy's (GRE's) Coal Creek Station (CCS). The United States Environmental Protection Agency's (USEPA's) Coal Combustion Residual (CCR) Rule, 40 Code of Federal Regulations (CFR) Part 257 (USEPA 2015) requires a hazard potential classification, structural stability, and safety factor assessment be completed as specified in 40 CFR 257.73(a)(2), 40 CFR 257.73(d), and 40 CFR 257.73(e) for all existing CCR surface impoundments. Per 40 CFR 257.73(f), the hazard potential classification, structural stability, and safety factor assessment must be revisited every five years. This document serves as the current version of the hazard potential classification, structural stability, and safety factor assessment.

The Drains Pond System is also regulated by the North Dakota Department of Environmental Quality (NDDEQ) under Permit 0033. The NDDEQ requires a hazard potential classification assessment, structural stability assessment, and safety factor assessment as part of the application for a permit as described in Section 33.1-20-08-04.3.f.1 of the North Dakota Administrative Code (NDAC 2020). This report satisfies the state-specific requirement.

1.1 Site Background

CCS is located in McLean County, approximately 10 miles northwest of Washburn, North Dakota. The Drains Pond System has approximately 17.5 acres of lined surface impoundment, of which approximately 7 acres was composite lined in 1993. The remainder of the Drains Pond System was composite lined in 2015. The Drains Pond System is used as a dewatering/storage facility for CCRs including bottom ash, pulverizer rejects, and economizer ash. The Drains Pond System is also part of the plant process water storage inventory, acting as a clarifier for process water conveyed with CCRs and plant drains that enter the impoundment. Water and CCRs enter the Drains Pond System through 12-inch ash lines, cross-tie pipes with Upstream Raise 91, and through a 30-inch pipeline that conveys the plant drains inflow.

The east cell of the Drains Pond System was closed by removal of CCR in the winter of 2019/2020 by removing sediment containing CCR material above the composite liner and protective cover system. A Notification of Closure (Golder 2020) of the east cell of the Drains Pond System was submitted in March 2020. After closure, the east cell was returned to operation as a non-CCR surface impoundment for the management of site process water. The east cell is not used to treat, store, or dispose of CCR.

Although the east cell of the Drains Pond System is no longer a CCR Surface Impoundment, the operation of this cell is critical to the overall operation of the Drains Pond System and the management of CCR materials and site process water. Therefore, the east cell is considered in the hazard potential classification assessment, structural stability assessment, and safety factor assessment associated with the Drains Pond System.

1.2 Geological Conditions

The Drains Pond System is generally constructed over a glacial till layer consisting of sandy and silty-clay soils. Glacial till varies in thickness from 20 feet to several hundred feet in the area of Coal Creek Station. Silty sand and sand lenses are present throughout the glacial till formation, which is underlain by poorly consolidated siltstone/sandstone bedrock (Barr 1982; CPA and UPA 1989).

1.3 Dam Oversight/Permits

The North Dakota State Engineer regulates, controls, and supervises the construction and operation of dams within the state of North Dakota. All dams and impoundments that contain more than 50 acre-feet of water require a construction permit (NDCC 2003). The Drains Pond System was issued Construction Permit 789 in 1994 and Construction Permit 2471 in 2015.

The NDDEQ Division of Waste Management is the environmental regulatory body for the CCR facilities at CCS. The Drains Pond System is currently permitted with the NDDEQ under Permit Number 0033.

1.4 Previous Evaluations

The following evaluations were previously performed on the Drains Pond System at CCS:

- Golder Associates Inc., Evaluation of the Plant Drains Pond Stability Report, Great River Energy Coal Creek Station, Revision 1, dated April 23, 2010
- Golder Associates Inc., Hazard Potential Classification, Structural Stability, and Safety Factor Assessments, Drains Pond System CCR Surface Impoundment, Great River Energy – Coal Creek Station, Underwood, North Dakota, dated October 13, 2016

In this study, we reviewed the previous analyses, modified the analyses as deemed appropriate, and added suitable cases to evaluate whether the impoundment meets the required safety factors in 40 CFR 257.73(e)(1)(i)-(iv) and NDAC Section 33.1-20-08-04.3.e.1.

2.0 HAZARD POTENTIAL CLASSIFICATION ASSESSMENT – 40 CFR 257.73(A)(2) AND NDAC SECTION 33.1-20-08-04.3.A.2

Both the federal CCR rules and North Dakota specific rules require conducting initial and periodic hazard potential classification assessments with certification by a qualified professional engineer to document the hazard potential classification of CCR surface impoundments and the basis for the classifications. Hazard classifications for CCR surface impoundments are divided in 40 CFR 257.73(a)(2) and NDAC Section 33.1-20-08-04.3.a.2 as follows:

- high hazard potential CCR surface impoundment
- significant hazard potential CCR surface impoundment
- low hazard potential CCR surface impoundment

The hazard classifications are defined under 40 CFR 257.53 and NDAC Section 33.1-20-08-01 as:

1) *High hazard potential CCR surface impoundment* means a diked surface impoundment where failure or mis-operation will probably cause loss of human life.

2) *Low hazard potential CCR surface impoundment* means a diked surface impoundment where failure or mis-operation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the surface impoundment owner’s property.

3) *Significant hazard potential CCR surface impoundment* means a diked surface impoundment where failure or mis-operation results in no probable loss of human life, but can cause economic loss, environmental damage, disruption of lifeline facilities, or impact other concerns.

2.1 Hazard Potential Classification Assessment

Based on the hazard classification definitions and review of the site and surroundings, Golder recommends the Drains Pond System be categorized as a Low Hazard Potential CCR Surface Impoundment. This recommended designation is based on the following:

- The impoundment volume is relatively small.
- There are no residences or occupied structures directly adjacent to the facility and loss of human life is not probable.
- Discharge of water or other materials contained within the impoundment cells is unlikely to have a significant environmental impact and is not likely to leave the owner's property. Samuelson Slough has significant volume to contain discharge from the impoundment and has a controlled discharge that can be closed in the event of a release.
- The economic impacts associated with a failure will primarily be to the owner's property.

2.2 Emergency Action Plan – 40 CFR 257.73(a)(3) and NDAC Section 33.1-20-08-04.3.a.3

The federal CCR rules and North Dakota-specific rules require the development of an Emergency Action Plan (EAP) for a CCR unit determined to be either a high hazard potential CCR surface impoundment or a significant hazard potential CCR surface impoundment. The Drains Pond System has been categorized as low hazard potential CCR surface impoundment and no EAP is required.

3.0 STRUCTURAL STABILITY ASSESSMENT – 40 CFR 257.73(D)(1)(I)-(VII) AND NDAC SECTION 33.1-20-08-04.3.D.1.A-G

The federal CCR rules (40 CFR 257.73(d)(1)) and North Dakota-specific CCR rules (NDAC Section 33.1-20-08-04.3.d.1) require conducting initial and periodic structural stability assessments by a qualified professional engineer to "document whether the design, construction, operation, and maintenance of the CCR unit is consistent with recognized and generally accepted good engineering practices for the maximum volume of CCR and CCR wastewater that can be impounded therein."

To support this structural stability assessment, annual inspections by a qualified professional engineer have been performed since 2015. These inspections have evaluated the current condition of constructed elements, operations and maintenance activities, and a review of weekly inspection reports to assist in identifying any signs of structural instability at the site. The most recent evaluation was conducted on September 1, 2021 by the authors and was used to inform this assessment.

3.1 Foundation – 40 CFR 257.73(d)(1)(i) and NDAC Section 33.1-20-08-04.3.d.1.a

The location of the Drains Pond System was originally characterized by Burns & McDonnel in 1973. A geotechnical investigation was completed by Black & Veatch in 1978, and a hydrogeologic study was performed for CCS by Barr Engineering in 1982. The foundation soils of the Drains Pond System consist of native soils (lean clay, fat clay, and sandy clay) and embankment fill materials sourced from nearby native soils (lean clay, fat clay, and sandy clay). The area was disturbed during original plant construction in the late 1970's, which resulted in the presence of fill materials near the surface.

Four piezometers and one monitoring well were installed near the Drains Pond System in June 2014. The geotechnical investigation report summarizing these borings is included in the 2015 permit modification for the facility (Golder 2015a) and is summarized below. In general, borings directly under the proposed area for the Drains Pond System (DP-A and DP-D) show approximately 15 feet of “fill” material underlain by lean clay and/or fat clay consistent with the native soils (see Appendix A).

Geotechnical testing was performed on samples collected during the 2014 field investigations. Atterberg Limits tests on grab samples showed soils between depths of 5 feet and 15 feet in DP-A and DP-D (borings directly under the proposed Drains Pond expansion) had plasticity indices ranging from 30 to 51. Moisture/Density testing was also evaluated for grab samples from DP-A and DP-D. Maximum dry densities ranged from 68 pounds per cubic foot (pcf) to 104 pcf with optimum moisture contents between 18% and 40%.

Based on historic site information of native materials, observations, and geotechnical testing, the Drains Pond System is not built over wet ash or other unsuitable materials, and foundation soils are stable.

3.2 Slope Protection – 40 CFR 257.73(d)(1)(ii) and NDAC Section 33.1-20-08-04.3.d.1.b

The downstream slopes of the Drains Pond System soil embankments are protected from erosion and deterioration by the establishment of a vegetative cover consisting of native grasses. The vegetative cover is inspected weekly for erosion, signs of seepage, animal burrows, sloughing, and woody vegetation that could affect the performance of the embankments. The upstream slopes of the soil embankments (composite liner slopes) are protected by either a 2-foot-thick layer of hardened fly ash or rip rap (approximately 6-inch to 24-inch diameter) placed on a 1-foot-thick hardened fly ash protective cover. Based on site experience and observations, the fly ash and/or rip rap provides sufficient protection from deterioration due to wave action.

3.3 Dikes (Embankment) – 40 CFR 257.73(d)(1)(iii) and NDAC Section 33.1-20-08-04.3.d.1.c

Soil embankments surrounding the west end of the Drains Pond System and the west interior separation embankment were constructed in 2015. Quality assurance included 135 nuclear density tests on embankment fill materials. Based on the construction quality assurance testing during the 2015 construction of the embankments, dry unit weight values ranged from 68 pcf to 122 pcf depending on the amount of coal inclusions in the soil. Comparison of the embankment fill compacted in the field to laboratory testing confirms that the materials were compacted to 95% standard Proctor density per the Specifications (Golder 2016a).

Of the four piezometers and one monitoring well installed near the Drains Pond System in 2014, two of the piezometers (DP-B and DP-C) were drilled into the historic Drains Pond embankments on the east side of the Drains Pond System. In general, the borings associated with these two piezometers show embankment fill materials typical of native soils sourced from the site (lean clay and fat clay). In addition, subgrade acceptance forms prior to placement of geomembrane on the east side of the Drains Pond System approved the condition of the subgrade materials (Golder Construction Services 1993). Based on historic site information of native materials, observations, and geotechnical drilling and testing, the embankment soils are stable.

3.4 Vegetated Slopes – 40 CFR 257.73(d)(1)(iv) and NDAC Section 33.1-20-08-04.3.d.1.d

The Drains Pond System is inspected weekly. As part of these inspections, unusual vegetative and woody growth is documented. Vegetated slopes of the Drains Pond System are re-seeded and mowed as required to maintain good vegetative growth and to limit woody vegetation from growing on the side slopes or near the toe.

3.5 Spillways – 40 CFR 257.73(d)(1)(v) and NDAC Section 33.1-20-08-04.3.d.1.e

There are no spillways associated with the Drains Pond System. Existing controls are in place to monitor water levels in the Drains Pond System and limit potential overtopping of the impoundment. The operational inflow to the facility (besides precipitation) includes hydraulically conveyed bottom ash, pulverizer rejects, and economizer ash material into the west cell, plant drains water into the center cell, and process water and run-off from the Upstream Raise 91 CCR Surface Impoundment and Upstream Raise 92 CCR Surface Impoundment into the east cell. Water from the west cell decants through pipelines to the center cell. These pipes are designed to maintain the west cell of the Drains Pond System at a constant elevation approximately two feet below the top elevation of the geomembrane liner when the bottom ash conveyance system is operating at capacity. The center cell and east cell of the Drains Pond System are connected via three 24-inch cross-over pipelines, which are designed to maintain these cells at approximately the same elevation during maximum expected flow conditions (i.e., when the bottom ash conveyance system is active).

Existing controls in place to monitor the water levels in the Drains Pond System include monthly observations of water levels by CCR laboratory personnel and daily observations by CCS operations personnel. Additional observations are noted by GRE employees familiar with site ash conveyance and handling equipment and operations of the hydraulic ash conveyance systems. After large storm events, CCS personnel evaluate site conditions, including water levels, and adjust operations to maintain water levels below design maximum elevations. Should water levels within the Drains Pond System reach the maximum design elevation, GRE has operating procedures to pump water from the Drains Pond System.

Outflow of water from the center and east cells of the Drains Pond System is controlled via actively pumping these cells from a dedicated pumphouse. Plant personnel manage the water contained in the center and east cells of the Drains Pond System for reuse at the plant, conveyance to the four site Evaporation Ponds, or injection into the permitted underground injection well.

The center and east cells of the Drains Pond System that receive runoff and/or contact water operate with between 4 and 6 feet of freeboard (to the top of the surrounding embankments). A run-on analysis was performed as part of the inflow design flood control system plan (Golder 2021) indicating that the Drains Pond System is operated with adequate freeboard to contain the 24-hour, 100-year storm event.

3.6 Hydraulic Structures – 40 CFR 257.73(d)(1)(vi) and NDAC Section 33.1-20-08-04.3.d.1.f

Hydraulic structures in the Drains Pond System include:

- Hydraulically conveyed bottom ash enters the west cell of the Drains Pond System via two above-grade 12-inch bottom ash conveyance pipelines.
- The west cell and center cell of the Drains Pond System are connected via two buried 24-inch high density polyethylene (HDPE) pipelines.
- The center cell and east cell of the Drains Pond System are connected via three buried 24-inch polyvinyl chloride (PVC) pipes.
- The east cell is connected to Upstream Raise 91 via three buried 24-inch PVC pipelines and two buried 18-inch pipelines.
- The east cell is connected to an external pumphouse via a buried 24-inch PVC pipeline.
- The center cell is connected to an external pumphouse via a buried 30-inch PVC pipeline.

No significant deterioration, deformation, distortion, bedding deficiencies, sedimentation, or debris were observed that may negatively affect the operation of the facility.

3.7 Downstream Slopes Adjacent to Water Body – 40 CFR 257.73(d)(1)(vii) and NDAC Section 33.1-20-08-04.3.d.1.g

Samuelson Slough lies downstream of the Drains Pond System (approximately 400 feet away); however, the outlet elevation of Samuelson Slough is controlled, and water cannot inundate the downstream toe or slopes of the Drains Pond System.

3.8 Structural Stability Deficiencies – 40 CFR 257.73(d)(2) and NDAC Section 33.1-20-08-04.3.d.2

No structural stability deficiencies were identified during this assessment.

4.0 SAFETY FACTOR ASSESSMENT – 40 CFR 257.73(E) AND NDAC SECTION 33.1-20-08-04.3.E

The federal CCR rules and North Dakota-specific rules require safety factors to be evaluated for the critical cross-section of each CCR facility under static and seismic loading for long-term maximum storage pool loading conditions and maximum surcharge pool loading conditions. Liquefaction potential analysis is only necessary when soil sampling, construction documentation, or anecdotal evidence from personnel with knowledge about the facility indicates that soils of the embankment are susceptible to liquefaction.

Slope stability analyses were performed using a limit-equilibrium-based commercial computer program, SLIDE v. 7.0 (Rocscience 2016). Factors of safety were computed for circular failure surface using Spencer's method for force and moment equilibrium (Spencer 1967). Global stability was analyzed, which evaluates the overall stability of a cross section through the entire facility.

4.1 Model Scenarios

Two types of loading conditions for the stability analyses were performed: static and seismic (pseudostatic analyses). For each of the two loading conditions, the critical cross section was modeled. Two impoundment pool loading scenarios were considered to evaluate the slope: long-term maximum storage pool loading condition and maximum surcharge pool loading condition. Four stability scenarios were analyzed (two static loading scenarios and two pseudostatic loading scenarios).

4.2 Slope Geometries and Critical Slope

A critical cross section for the Drains Pond System was identified and used for the stability analyses. The critical cross section is anticipated to be the most susceptible to structural failure and was selected based on loading conditions, geometry of the slopes, and the soil profile.

The critical cross section for the Drains Pond System is located across the east embankment (Figure 1). The cross section has a 25-foot wide crest and 2.5H:1V downstream slopes from 1922 feet to 1893 feet (Figure 2). As noted earlier, the east cell of the Drains Pond System is not a CCR surface impoundment but is critical to the overall management of CCR materials and site process water by the Drains Pond System. Since the slope associated with the east cell represents the tallest impoundment slope and narrowest crest width, this slope was deemed the most critical slope associated with the Drains Pond System.

4.3 Material Properties

Material properties (Table 1) were developed through Golder's site experience with onsite material, laboratory tests completed on Coal Creek Station CCRs and onsite soils, reviews of technical literature, and Golder's professional judgement and experience with similar materials used for this slope stability analysis. Additional static material properties information is included in Appendix B.

Table 1: Material Properties

Material	Wet Unit Weight (pcf)	Shear Strength Static Analysis		Shear Strength Pseudostatic Analysis		
		Effective Cohesion (psf)	Effective Friction Angle (degrees)	Undrained Cohesion (psf)	Undrained Friction Angle (degrees)	Undrained Shear Strength (psf)
Existing Natural Soil and Embankment Fill	127	500	19	165	14	NA*
Clay Liner	122	500	19	NA	NA	1,600
Sand Layer	125	0	37	0	37	NA
Bottom Ash	83	50	40	50	40	NA
Fly Ash	107	1,610	32	1,610	32	NA
Smooth Geomembrane – Clay Liner Interface	NA	200	7.5	200	7.5	NA
Geocomposite – Sand Interface	NA	0	33	0	33	NA

* NA – Not applicable

4.3.1 Pseudostatic Material Properties

The material properties for each soil type included in the pseudostatic stability analysis of the Drains Pond System are provided in Table 1 and were developed following the recommendations contained within Section 6.1 of RCRA Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities (USEPA 1995). Fine-grained soils (existing natural soil, embankment fill, clay liner, and fly ash) were assigned strength parameters corresponding to 80% of the total stress (undrained) strength parameters.

- The existing natural soil and embankment fill were assigned strength parameters based on laboratory testing of those materials. The reduction of the strength parameters of 80% of the total stress strength parameters resulted in cohesion intercept of 165 pounds per square foot (psf) and a friction angle of 14 degrees.
- The clay liner was assigned an undrained shear strength of 1,600 psf based on literature values for CH material (NAVFAC 1996).
- The geosynthetic interface strength parameters were not modified (from the static stability material properties for the pseudostatic stability analyses based on recommendations contained within Section 6.1.2. of RCRA Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities (USEPA 1995).
- Fly ash is a cemented material and is modeled with static shear strengths with no seismic reductions.

Coarse-grained materials (i.e., sand and bottom ash) are modeled with static shear strengths with no seismic reduction because they are not prone to developing excess pore pressure from the cyclic loading caused during seismic conditions. These materials are well compacted within the facility and are not likely to be saturated in the critical section evaluated.

4.4 Impoundment Pool Loading Conditions

Two different impoundment pool loading conditions were considered in these stability analyses:

- long-term maximum storage pool loading condition
- maximum surcharge pool loading condition

For the Drains Pond System at CCS, the impoundment pool elevation for the long-term maximum storage pool loading condition has been defined as the design maximum pool elevation for the east cell (location of the critical section), which is 1918 feet (2 feet of freeboard to the top of the composite liner system). The east cell's composite liner extends up to 1920 feet and the embankment crest is at elevation 1922 feet. The impoundment pool elevation for the maximum surcharge pool loading condition has been defined as the maximum pool elevation for the facility, which is 1922 feet (zero feet freeboard to the crest of the east cell). The likelihood of the Drains Pond System east cell pool elevation reaching an elevation of 1922 feet or overtopping the embankment is very low, based on the following reasoning:

- Primary inflows to the Drains Pond System are via pipelines from the plant, which include two bottom ash pipelines, the plant drains pipeline, and crossover pipelines form Upstream Raise 91. The bottom ash and plant drains inflows are actively managed per the operations plan and can be shut off at any time.

- Additional inflow may come from precipitation events, including contact water from Upstream Raise 91. However, the inflow design flood control system plan (Golder 2021) estimated a water elevation of 1920 feet due to run-on from the 24-hour, 100-year storm event.
- Outflow from each of the cells occurs via the Drains Pond Transfer Pumphouse. If necessary, pumps can be used to convey water to the plant, evaporation ponds, or the underground injection well.

The site operations plan discusses the operation and contingency plans associated with the Drains Pond System (Golder 2015b).

4.5 Subsurface Water Conditions

All three cells of the Drains Pond System are lined with composite geomembrane/clay liners. The composite liners are all covered with a minimum of two feet of protective cover material consisting of hardened fly ash, rip rap, or bottom ash.

Readings form the piezometers and monitoring wells installed near the Drains Pond System demonstrate that groundwater generally flows northeast to east under the facility toward Samuelson Slough. Groundwater elevations vary from approximately 1885 feet in the northeast corner of the Drains Pond System to 1915 feet in the southwest corner of the Drains Pond System. Based on these data and the location of the critical section (east cell), the stability analyses were performed with the groundwater elevations varying from approximately 1893 feet under the floor at the west end of the critical section to approximately 1886 feet under the east end of the critical section at the embankment of the Drains Pond System east cell.

4.6 Seismic Loading Conditions

Coal Creek Station, located in central North Dakota, is in an area with low historic seismic activity. No earthquakes of Magnitude V (i.e., Moderate-Strong) or greater (Mercalli intensity scale) have occurred in North Dakota during historical times (USGS 2021).

4.6.1 Peak Ground Acceleration Determination

For the site location, the peak (bedrock) ground acceleration (PGA) with a 2% probability of exceedance in 50 years is between 0.02g (1 gram [g] equals 32.2 feet per second squared [ft/sec^2]) and 0.04g using the United States Seismic Hazard 2018 Map (Rukstales and Petersen 2019); for purposes of this analysis, the bedrock PGA was estimated to be 0.03g (Appendix C). The peak ground acceleration at Coal Creek Station was estimated to be 0.05g using the simplified analysis guidelines presented in Section 4.1.1 of the RCRA Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities (USEPA 1995, see Appendix C).

4.6.2 Horizontal Seismic Coefficient Determination

The horizontal seismic load coefficient (k_s), for use in the pseudostatic slope stability analysis, was determined using the procedures recommended in Section 6.2 of the RCRA Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities (USEPA 1995). Based on Step 2 of the Seismic Stability and Deformation and Analysis section of the guidance (Section 6.2) the maximum value of the horizontal seismic load coefficient may be safely determined as one-half of the peak ground acceleration (determined in Section 4.6.1). As a result, a horizontal seismic load coefficient of 0.025g (0.5 * 0.05g = 0.025g) was used in the pseudostatic analysis.

4.7 Liquefaction Potential

Soil liquefaction describes a phenomenon in which a saturated or partially saturated soil substantially loses strength and stiffness in response to an applied stress, usually earthquake shaking or other sudden change in stress condition, causing the soil to behave like a liquid. The phenomenon is most often observed in saturated, loose (low density or uncompacted), sandy soils. The existing natural soils, embankment fill, and clay liner soils of the Drains Pond System are classified as either low or high plasticity clay. Based on these observations, the onsite soils are not anticipated to be susceptible to liquefaction.

4.8 Stability Analysis Results

Slope stability analyses were performed under static and pseudostatic conditions for the critical section (Figure 3 and Figure 4). The results of the slope stability analyses are presented in Table 2. The results indicated that the Drains Pond System slopes comply with the required safety factors per 40 CFR 257.73(e) and NDAC Section 33.1-20-08-04.3.e.

Table 2: Slope Stability Analyses Results

Loading Condition	Water Level	Required Factor of Safety	Calculated Factor of Safety	Figure for Stability Analysis Results
Static	Max Storage (el. 1918 ft)	1.50	2.27	3
	Max Surcharge (el. 1922 ft)	1.40	2.27	3
Pseudostatic	Max Storage (el. 1918 ft)	1.00	1.11	4
	Max Surcharge (el. 1922 ft)	1.00	1.11	4

5.0 REVISION HISTORY

A history of revisions to this document include:

Revision 0 – Published October 13, 2015.

Revision 1 – 5-Year Update: Published October 13, 2021

1) Reflect that the east cell of the Drains Pond System was closed by removal of CCR.

6.0 CERTIFICATION

Based on the review of the information provided by GRE and onsite observations, we have classified the Coal Creek Station Drains Pond System as a Low Hazard Potential CCR Surface Impoundment. Additionally, no structural stability deficiencies were identified during this assessment. Calculated factors of safety through the critical cross sections in the surface impoundment embankments exceed the values listed in 40 CFR 257.73(e)(1)(i)-(iv) and NDAC Section 33.1-20-08-04.3.e.1.

The undersigned attest to the completeness and accuracy of this hazard potential classification, structural stability assessment, and safety factor assessment, and certify that the assessments meet the requirements of 40 CFR 257.73(a)(2), 257.73(a)(3), 257.73(d), and 257.73(e) and NDAC Sections 33.1-20-08-04.3.a.2, 33.1-20-08-04.3.a.3, 33.1-20-08-04.3.d, and 33.1-20-08-04.3.e.

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https://golderassociates.sharepoint.com/sites/140044/project files/6 deliverables/21451024/reports/12-r-dps_stability_rev1/12-r-0/21451024-12-r-0-dps_stability_rev1_13oct21.docx

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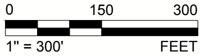
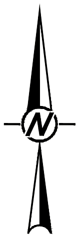
Figures

NOTE(S)

1. AERIAL IMAGERY OBTAINED FROM UNITED STATES DEPARTMENT OF AGRICULTURE NATIONAL AGRICULTURE IMAGERY PROGRAM 2020 AND DRONE PHOTOGRAPH PROVIDED BY GREAT RIVER ENERGY IN 2021.
2. MONITORING WELL GROUNDWATER ELEVATIONS FROM MAY 2021 SAMPLING EVENT.





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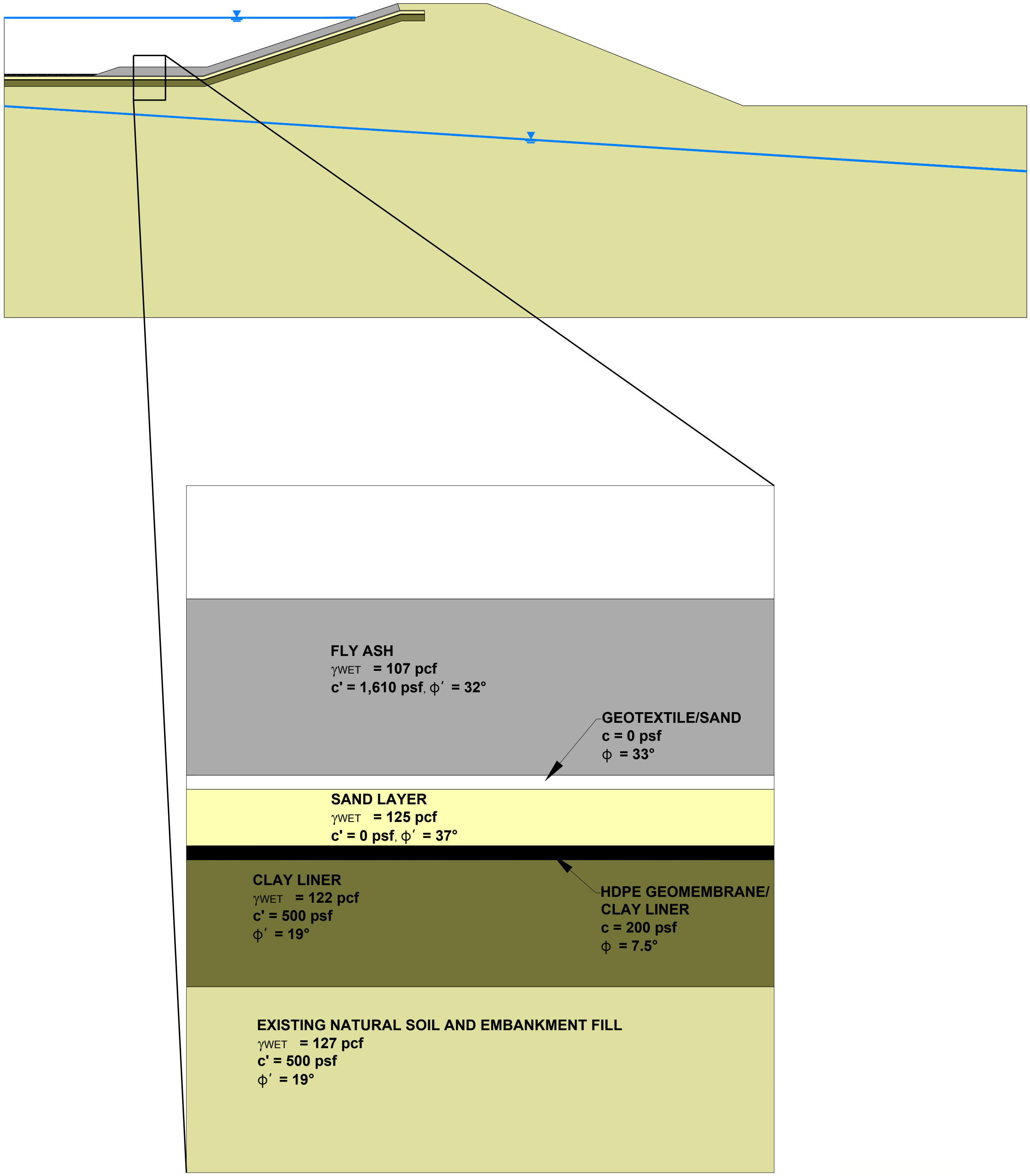
GOLDER
MEMBER OF WSP

GREAT RIVER ENERGY
COAL CREEK STATION - DRAINS POND SYSTEM
SITE OVERVIEW

FIGURE 1



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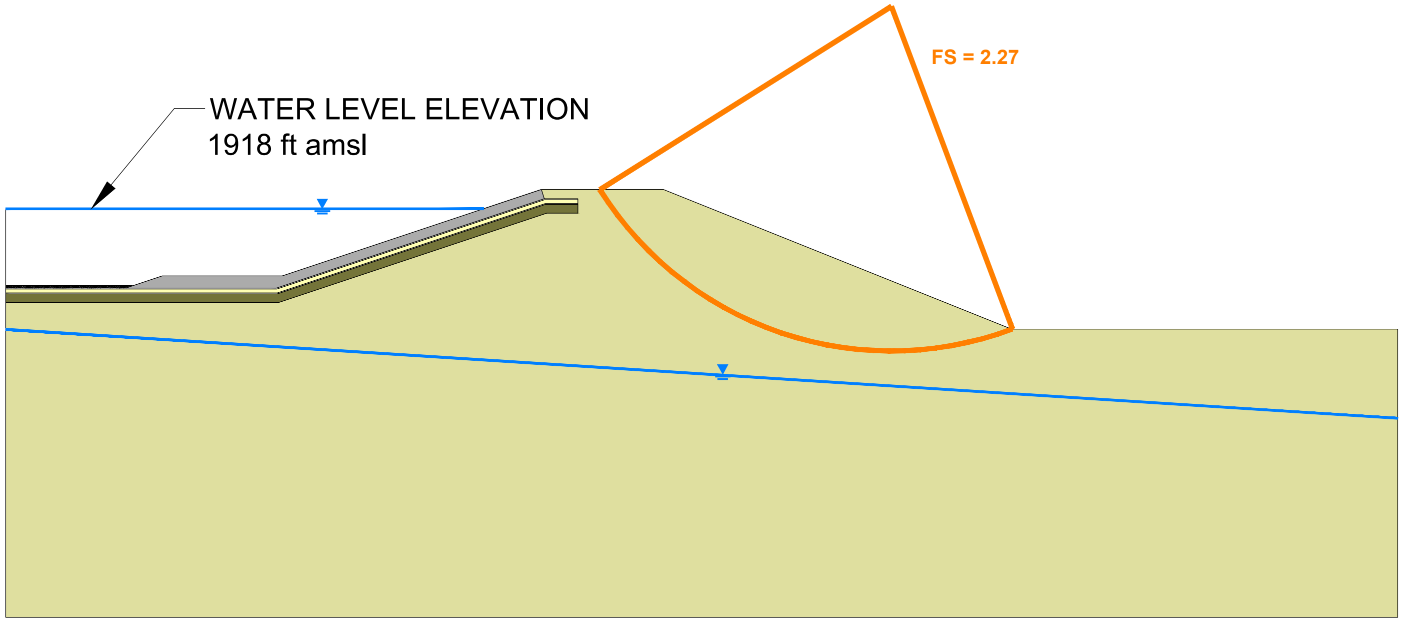
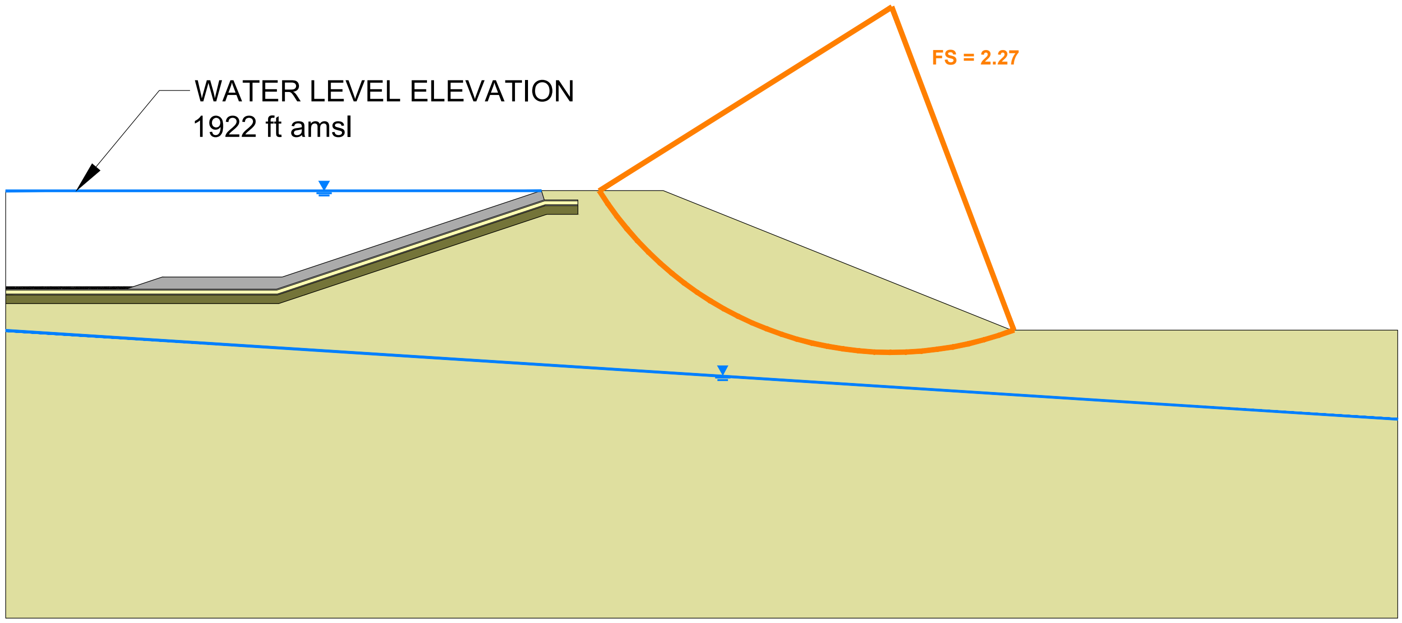
GOLDER
MEMBER OF WSP

GREAT RIVER ENERGY
COAL CREEK STATION - DRAINS POND SYSTEM
CRITICAL SECTION

FIGURE 2



STATIC ANALYSIS
MAXIMUM STORAGE POOL



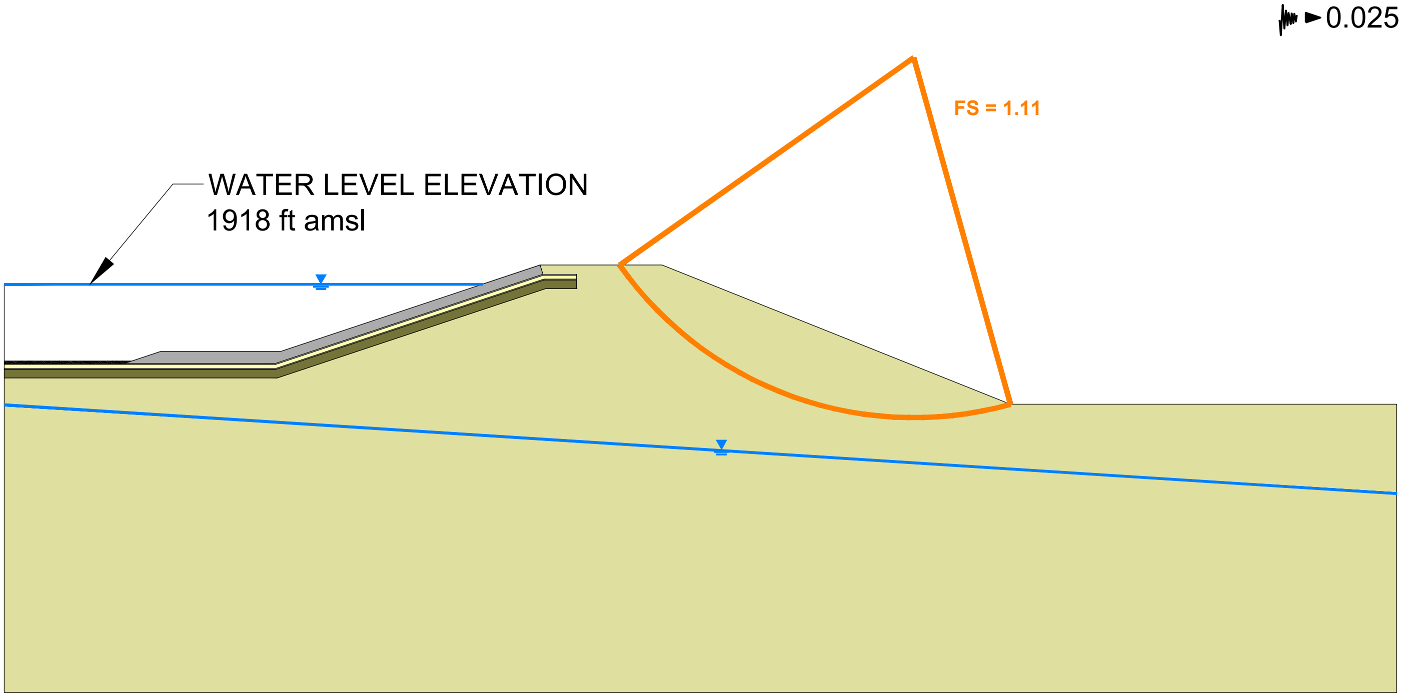
STATIC ANALYSIS
MAXIMUM SURCHARGE POOL

GREAT RIVER ENERGY
COAL CREEK STATION - DRAINS POND SYSTEM
STATIC STABILITY RESULTS

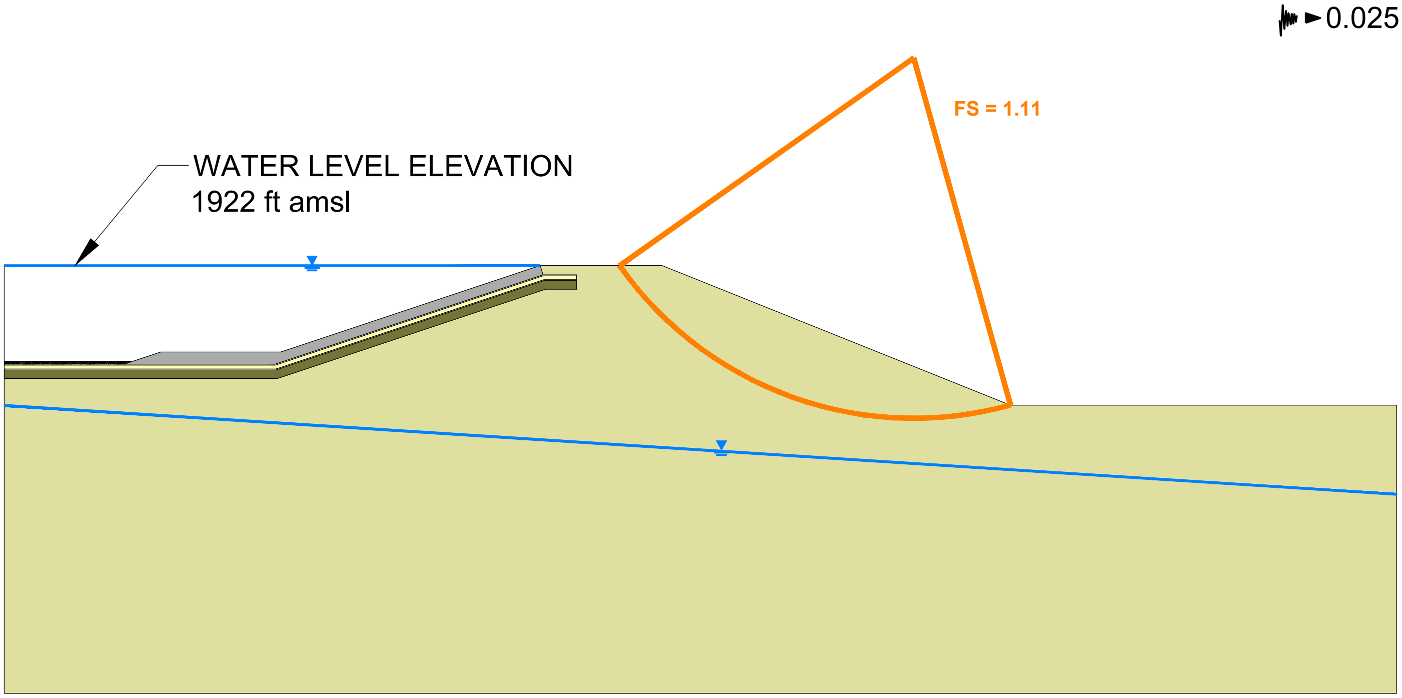
FIGURE 3

GOLDER
MEMBER OF WSP

Path: \\Denver\acad\GREAT RIVER ENERGY\COAL CREEK\99_PROJECTS\21451024\21451024\StabilityFigures\DPS_Stability_Figure_2021\ | File Name: DPS_Stability_Figures_2021.dwg



PSUEDOSTATIC ANALYSIS
MAXIMUM STORAGE POOL



PSEUDOSTATIC ANALYSIS
MAXIMUM SURCHARGE POOL

GREAT RIVER ENERGY
COAL CREEK STATION - DRAINS POND SYSTEM
SEISMIC (PSUEDOSTATIC) STABILITY RESULTS

FIGURE 4

GOLDER
MEMBER OF WSP

Path: \\Denver\acad\GREAT RIVER ENERGY\COAL CREEK\99_PROJECTS\21451024\21451024\StabilityFigures\DPS_Stability_Figure_2021\ | File Name: DPS_Stability_Figures_2021.dwg

APPENDIX A

Geotechnical Exploration Report – Midwest Testing Laboratory/Terracon

Geotechnical Exploration Report

Piezometers/Monitoring Well Installations
GRE – Coal Creek Station
McLean County, North Dakota
June 19, 2014
MTL/Terracon Project No. M2145058

Prepared for:
Golder Associates, Inc
Lakewood, Colorado

Prepared by:
Midwest Testing Laboratory/Terracon
Bismarck, North Dakota

Midwest Testing LABORATORY, INC. A Terracon COMPANY

Midwest Testing
LABORATORY, INC.
A Terracon COMPANY

June 19, 2014

Golder Associates, Inc
44 Union Boulevard, Suite 300
Lakewood, CO 80228

Attn: Craig Schuettpelz
P: (303) 980 0540
F: (303) 985 2080
E: schuettpelz@golder.com

Re: Geotechnical Exploration Report
Piezometers/Monitoring Well Installations
GRE – Coal Creek Station
Underwood, North Dakota
MTL/Terracon Project No. M2145058

Dear Craig:

Midwest Testing Laboratory, Inc. (A Terracon Co) has completed the geotechnical exploration services for the above referenced project. This study was performed in general accordance with our proposal number PM2140147 dated May 29, 2014. This report presents the findings of the subsurface exploration and the piezometers/monitoring well installations.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,

Midwest Testing Laboratory (A Terracon Company)

Steven S. Smith

Steven S. Smith, P.E.
Geotechnical Dept Manager

STEVEN S. SMITH
PE 2863

Chad A Cowley

Chad A. Cowley, P.E.
Project Geotechnical Engineer I

SSS/cb

cc: Client & pdf

TABLE OF CONTENTS

GEOTECHNICAL EXPLORATION REPORT
PIEZOMETERS/MONITORING WELL INSTALLATIONS
GRE – COAL CREEK STATION
MCLEAN COUNTY, NORTH DAKOTA

MTL/Terracon Project No. M2145058

June 19, 2014

1.0 INTRODUCTION

This report presents the results of our geotechnical exploration services performed for the piezometers/monitoring well installations at Great River Energy's Coal Creek Station in McLean County, North Dakota. The purpose of these services is to provide information relative to:

- subsurface soil conditions
- groundwater conditions

Our geotechnical exploration scope of work for this project included the advancement of five borings to depths ranging from 35.5 to 51 feet below existing grades and laboratory testing for soil engineering properties. Additionally, each test boring was converted to a piezometer or monitoring well installation.

Logs of the borings along with a Boring Location Plan are included in Appendix A of this report. The results of the laboratory testing performed on the soil samples obtained from the site during field exploration are found in Appendix B of this report.

2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Site layout	Refer to the Boring Location Plan, Appendix A, Exhibit A-2.
Piezometers	Four piezometers were installed to depths ranging from 34.5 to 49 feet. Piezometers consist of 2" diameter Schedule 40 PVC pipe and include a 20 foot sand packed screen section. The screen features a #10 slot. The top of the piezometers extend approximately 2.5 to 3 feet above the current existing ground surface.

Item	Description
Monitoring well	One monitoring well was installed to a depth of approximately 45 feet. The monitoring well consists of 2" diameter Schedule 40 PVC pipe and features a sand packed 20 foot screen section. The screen features a #10 slot. The top of the monitoring well extends approximately 2 feet above the current existing ground elevation. The monitoring well includes a concrete apron at the surface and a locking steel cover.

2.2 Site Location and Description

Item	Description
Location	Great River Energy-Coal Creek Station. Piezometers and monitoring wells will be installed along existing haul roads near the Drains Pond and in a grass field to the west of the Drains Pond. See Appendix A, Exhibit A-1, Site Location Plan.
Existing improvements	Coal fired power generation plant and ethanol plant.
Current ground cover	Bare earth and native grasses.
Existing topography	Gently rolling terrain.

3.0 SUBSURFACE CONDITIONS

3.1 Typical Subsurface Profile

Variable soil conditions were encountered within our borings. Fill was initially encountered to depths ranging from approximately 13 to 23 feet. This fill was variable consisting primarily of medium to high plasticity clays; however, in borings DP-A and DP-D, a significant amount of coal was found mixed with the clays.

Underlying the fill, natural soils were also variable consisting of both cohesive and cohesionless soils. The cohesive soils consisted of lean clays and fat clays of various shades of brown. Field consistencies ranged from soft to very stiff.

The cohesionless soils consisted of both clayey sands and silty sands. These soils were of a fine to medium-grained texture with field conditions ranging from loose to very dense. Colorations of the sands varied from brown to gray.

Specific conditions encountered at each boring location are indicated on the individual boring logs included in Appendix A of this report. Stratification boundaries on the boring logs represent the approximate location of changes in soil types; insitu, the transition between materials may be gradual. A discussion of field sampling procedures is included in Appendix A and laboratory test procedures and test results are presented in Appendix B.

3.2 Groundwater

The boreholes were observed while drilling and after completion for the presence and level of groundwater. Groundwater was not observed within any boring. Due to the cohesive nature of the soils encountered across the site, piezometers and a monitoring well were installed to assist in evaluating groundwater conditions.

4.0 GENERAL COMMENTS

The information presented in this exploration summary report is based upon the data obtained from the boring performed at the indicated location and from other information discussed in this report. This exploration summary report does not reflect variations that may occur between borings, across the site or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that the need for further exploration and testing can be evaluated. MTL/Terracon was not asked to provide geotechnical engineering recommendations for this project. Any interpretation or design performed by others based on this data is done at their risk.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This exploration summary report has been prepared for the exclusive use of our client and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Analysis, design, and associated recommendations as well as site safety, excavation support, and dewatering requirements are the responsibility of others.

APPENDIX A

FIELD EXPLORATION

Project Manager:	SS	**Project No.**	M2145058
Drawn by:	SS	**Scale:**	AS SHOWN
Checked by:	CC		
Approved by:	CC	**Date:**	6/17/2014

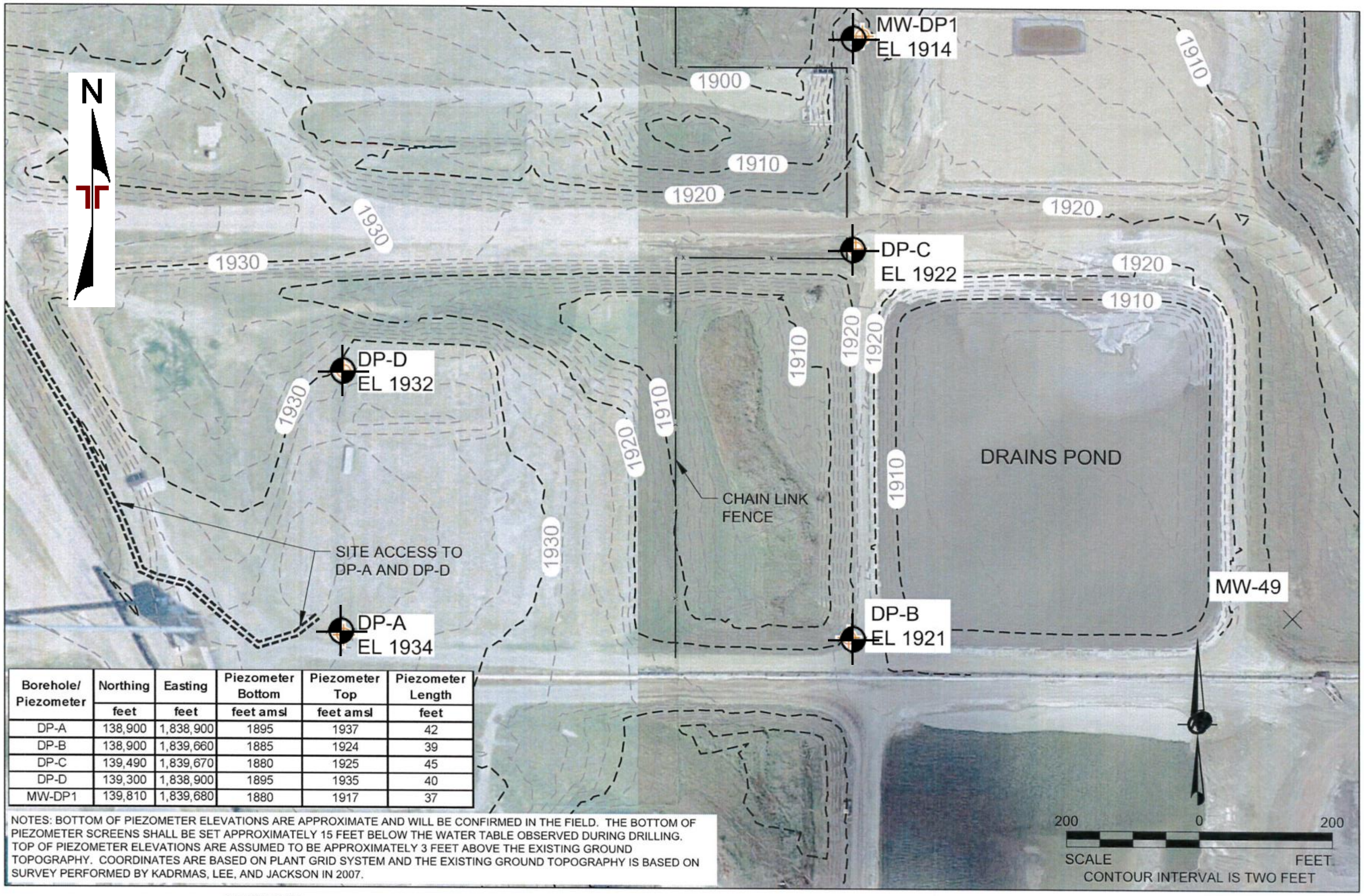
Midwest Testing
LABORATORY, INC.
A Terracon COMPANY
1805 Hancock Drive PO Box 2084 Bismarck, North Dakota 58502
PH. (701) 258-2833 FAX. (701) 258-2857

SITE LOCATION PLAN

Piezometers/Well Installations

GRE – Coal Creek Station
McLean County, North Dakota

EXHIBIT
A-1



Borehole/ Piezometer	Northing	Easting	Piezometer Bottom	Piezometer Top	Piezometer Length
	feet	feet	feet amsl	feet amsl	feet
DP-A	138,900	1,838,900	1895	1937	42
DP-B	138,900	1,839,660	1885	1924	39
DP-C	139,490	1,839,670	1880	1925	45
DP-D	139,300	1,838,900	1895	1935	40
MW-DP1	139,810	1,839,680	1880	1917	37

NOTES: BOTTOM OF PIEZOMETER ELEVATIONS ARE APPROXIMATE AND WILL BE CONFIRMED IN THE FIELD. THE BOTTOM OF PIEZOMETER SCREENS SHALL BE SET APPROXIMATELY 15 FEET BELOW THE WATER TABLE OBSERVED DURING DRILLING. TOP OF PIEZOMETER ELEVATIONS ARE ASSUMED TO BE APPROXIMATELY 3 FEET ABOVE THE EXISTING GROUND TOPOGRAPHY. COORDINATES ARE BASED ON PLANT GRID SYSTEM AND THE EXISTING GROUND TOPOGRAPHY IS BASED ON SURVEY PERFORMED BY KADRMAS, LEE, AND JACKSON IN 2007.

LEGEND

⌖ DP-A EL 1934	PROPOSED PIEZOMETER OR MONITORING WELL (APPROXIMATE ELEVATION OF GROUND SURFACE)
× MW-49	EXISTING MONITORING WELL

Golder Associates

PROPOSED PIEZOMETER AND MONITORING WELL LOCATIONS
DRAINS POND LATERAL EXPANSION

Base drawing provided by Golder Associates – May 19, 2014

Project Manager:	SS	**Project No.**	M2145058
Drawn by:	SS	**Scale:**	AS SHOWN
Checked by:	CC		
Approved by:	CC	**Date:**	6/17/2014

Midwest Testing Laboratory, Inc.
A Terracon COMPANY
1805 Hancock Drive PO Box 2084 Bismarck, North Dakota 58502
PH. (701) 258-2833 FAX. (701) 258-2857

BORING LOCATION PLAN
Piezometers/Well Installations
GRE – Coal Creek Station
McLean County,, North Dakota

EXHIBIT
A-2

Field Exploration Description

Five test borings were drilled at the site on June 9-10, 2014. The borings were drilled to depths ranging from 35 to 51 feet below the ground surface at the approximate locations shown on the attached Boring Location Plan, Exhibit A-2. Each boring was converted to a piezometer/monitoring well installation.

The boring locations were staked in the field by Great River Energy. Ground surface elevations indicated on the boring logs were provided by Golder Associates, Inc. The elevations on the boring logs have been rounded to the nearest one-half of one foot. The locations and elevations of the borings should be considered accurate only to the degree implied by the means and methods used to define them.

A track-mounted, rotary drill rig using hollow stem augers was used to advance the boreholes. Samples of the soils encountered in the borings were obtained using the split barrel sampling procedure.

In the split-barrel sampling procedure, the number of blows required to advance a standard 2-inch O.D. split-barrel sampler the last 12 inches of the typical total 18-inch penetration by means of a 140-pound hammer with a free fall of 30 inches, is the standard penetration resistance value (SPT-N). This value is used to estimate the in situ relative density of cohesionless soils and consistency of cohesive soils.

An automatic SPT hammer was used to advance the split-barrel sampler in the borings performed on this site. A significantly greater efficiency is achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. This higher efficiency has an appreciable effect on the SPT-N value. The effect of the automatic hammer's efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification. Information provided on the boring logs attached to this report includes soil descriptions, consistency evaluations, boring depths, sampling intervals, and groundwater conditions. The borings were backfilled with auger cuttings prior to the drill crew leaving the site.

Field logs of the borings were prepared by the drill crew. These logs included visual classifications of the materials encountered during drilling as well as the driller's interpretation of the subsurface conditions between samples. The final boring logs included with this report represent the engineer's interpretation of the field logs and include modifications based on laboratory observation and tests of the samples.

BORING LOG NO. DP-A

PROJECT: Piezometers/Well Installations

CLIENT: Golder Associates
Lakewood, Colorado

SITE: GRE - Coal Creek Station
McLean County, North Dakota

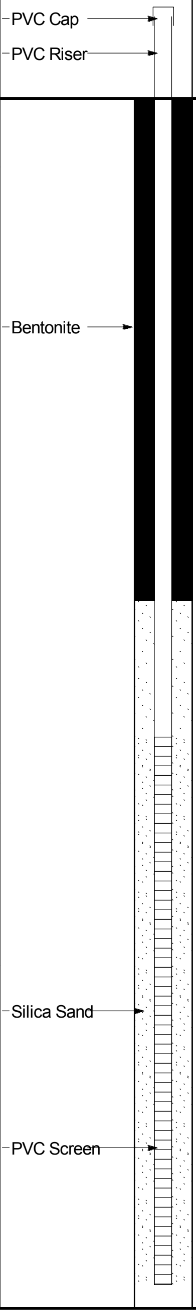
LOCATION: See Exhibit A-2

Northing: 138900 Easting: 1838900

Surface Elev.: 1934 (Ft.)

DEPTH		ELEVATION (Ft.)
	FILL - FAT CLAY (CH), gray	
1.5		1932.5
	FILL - COAL and CLAY MIXTURE , black	
15.0		1919
	SANDY FAT CLAY (CH), trace gravel, brown, stiff	
19.0		1915
	FAT CLAY (CH), brown, very stiff, silt laminations, waterbearing sand seams	

INSTALLATION DETAILS



DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		☒	3-4-5 N=9			
		☒	3-4-5 N=9			
5		☒	5-8-7 N=15			
		☒	5-14-10 N=24			
10		☒	4-7-11 N=18			
		☒				
15		☒	4-6-7 N=13			
20		☒	5-7-12 N=19			
25	▽	■				

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3¼" ID HSA 0-34½'

Abandonment Method:
Boring converted to piezometer installation.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

Shelby tube sample (24 to 26 feet) shipped to Golder Associates.

WATER LEVEL OBSERVATIONS

▽ *Initially Encountered*

Midwest Testing LABORATORY, INC.
a Terracon COMPANY
1805 Hancock Drive
Bismarck, North Dakota

Boring Started: 6/9/2014	Boring Completed: 6/10/2014
Drill Rig: D-50	Driller: MR
Project No.: M2145058	Exhibit: A-4

BORING LOG NO. DP-A

PROJECT: Piezometers/Well Installations

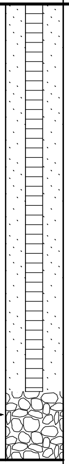
CLIENT: Golder Associates
Lakewood, Colorado

SITE: GRE - Coal Creek Station
McLean County, North Dakota

LOCATION: See Exhibit A-2

Northing: 138900 Easting: 1838900

Surface Elev.: 1934 (Ft.)



GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
▨		**FAT CLAY (CH)**, brown, very stiff, silt laminations, waterbearing sand seams *(continued)*				■				
▨	30.0		1904	30		☒	7-16-23 N=39			
▨		**CLAYEY SAND (SC)**, fine grained, light brown, dense to very dense, waterbearing								
▨	36.0		1898	35		☒	13-18-34 N=52			
		Boring Terminated at 36 Feet								

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3¼" ID HSA 0-34½'

Abandonment Method:
Boring converted to piezometer installation.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Initially Encountered*

Midwest Testing Laboratory, Inc.
A Terracon Company
1805 Hancock Drive
Bismarck, North Dakota

Boring Started: 6/9/2014	Boring Completed: 6/10/2014
Drill Rig: D-50	Driller: MR
Project No.: M2145058	Exhibit: A-4

BORING LOG NO. DP-B

PROJECT: Piezometers/Well Installations

CLIENT: Golder Associates
Lakewood, Colorado

SITE: GRE - Coal Creek Station
McLean County, North Dakota

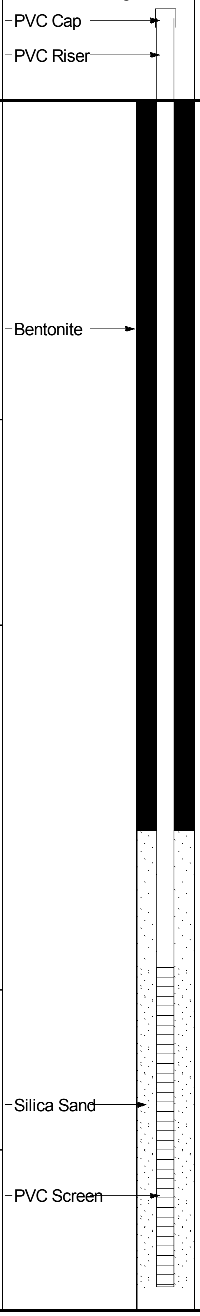
LOCATION: See Exhibit A-2

Northing: 138900 Easting: 1839660

Surface Elev.: 1921 (Ft.)

GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)
▨		**FILL - FAT CLAY (CH)**, grayish-brown	
▨	7.0	**FILL - SANDY LEAN CLAY (CL)**, brown	1914
▨	11.5	**FILL - SANDY LEAN CLAY (CL)**, grayish-brown	1909.5
▨	19.5	**FILL - LEAN CLAY WITH SAND (CL)**, grayish-brown	1901.5
▥	23.0	**SANDY SILT (ML)**, light brown, loose, waterbearing sand seams	1898

INSTALLATION DETAILS



DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		☒	2-2-2 N=4			
		☒	2-3-6 N=9			
5		☒	5-9-9 N=18			
		☒	7-6-10 N=16			
10		☒	4-5-8 N=13			
		☒	3-5-8 N=13			
15		■				
20		☒	5-7-8 N=15			
	▽					
25		☒	1-1-3 N=4			

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3¼" ID HSA 0-39½'

Abandonment Method:
Boring converted to piezometer installation.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

Shelby tube sample (14 to 16 feet) shipped to Golder Associates.

WATER LEVEL OBSERVATIONS

▽ *Initially Encountered*

Midwest Testing Laboratory, Inc.
a Terracon company
1805 Hancock Drive
Bismarck, North Dakota

Boring Started: 6/9/2014	Boring Completed: 6/9/2014
Drill Rig: D-50	Driller: MR
Project No.: M2145058	Exhibit: A-5

BORING LOG NO. DP-B

PROJECT: Piezometers/Well Installations

CLIENT: Golder Associates
Lakewood, Colorado

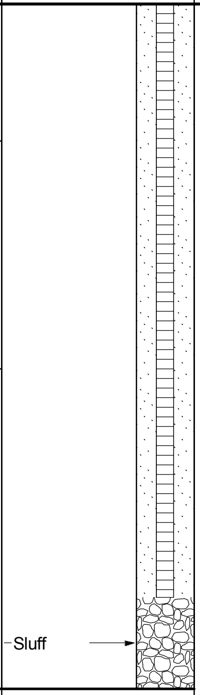
SITE: GRE - Coal Creek Station
McLean County, North Dakota

LOCATION: See Exhibit A-2

Northing: 138900 Easting: 1839660

Surface Elev.: 1921 (Ft.)

GRAPHIC LOG	DEPTH	Description	ELEVATION (Ft.)
▥		**SANDY SILT (ML)**, light brown, loose, waterbearing sand seams *(continued)*	
	29.0		1892
▨		**FAT CLAY (CH)**, gray, soft, roots, waterbearing sand seams	
	34.0		1887
▨		**SANDY LEAN CLAY (CL)**, trace gravel, dark gray, stiff	
	41.0		1880
		Boring Terminated at 41 Feet	



DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
30		☒	1-1-2 N=3			
35		☒	1-3-7 N=10			
40		☒	2-3-5 N=8			

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3¼" ID HSA 0-39½'

Abandonment Method:
Boring converted to piezometer installation.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Initially Encountered*

Midwest Testing Laboratory, Inc.
a Terracon company
1805 Hancock Drive
Bismarck, North Dakota

Boring Started: 6/9/2014	Boring Completed: 6/9/2014
Drill Rig: D-50	Driller: MR
Project No.: M2145058	Exhibit: A-5

BORING LOG NO. DP-C

PROJECT: Piezometers/Well Installations

CLIENT: Golder Associates
Lakewood, Colorado

SITE: GRE - Coal Creek Station
McLean County, North Dakota

LOCATION: See Exhibit A-2

Northing: 139490 Easting: 1839670

Surface Elev.: 1922 (Ft.)

INSTALLATION DETAILS: PVC Cap, PVC RISER, Bentonite

DEPTH	Description	ELEVATION (Ft.)
	FILL - SANDY LEAN CLAY (CL), brown	
2.0		1920
	FILL - FAT CLAY (CH), dark brown, coal inclusions	
11.0		1911
	FILL - FAT CLAY (CH), browish gray	
14.5		1907.5
	FILL - LEAN CLAY WITH SAND (CL), trace gravel, grayish-brown	
19.0		1903
	CLAYEY SAND (SC), fine grained, light brown, medium dense to very dense	

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		☒	5-3-4 N=7			
		☒	5-5-8 N=13			
5		☒	5-8-9 N=17			
		☒	4-6-10 N=16			
10		☒	2-4-3 N=7			
		☒	2-2-3 N=5			
15		☒	2-4-7 N=11			
20		☒	26-11-9 N=20			
25		■				

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3¼" ID HSA 0-49½'

Abandonment Method:
Boring converted to piezometer installation.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

Shelby tube sample (24 to 26 feet) shipped to Golder Associates.

WATER LEVEL OBSERVATIONS

▽ *Initially Encountered*

Midwest Testing LABORATORY, INC.
A Terracon COMPANY
1805 Hancock Drive
Bismarck, North Dakota

Boring Started: 6/9/2014	Boring Completed: 6/9/2014
Drill Rig: D-50	Driller: MR
Project No.: M2145058	Exhibit: A-6

BORING LOG NO. DP-C

Page 2 of 2

PROJECT: Piezometers/Well Installations

CLIENT: Golder Associates
Lakewood, Colorado

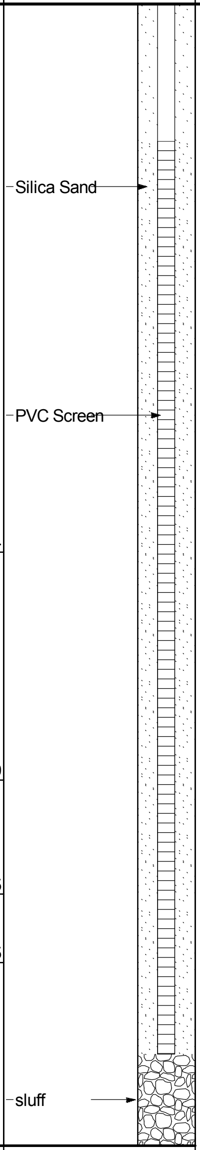
SITE: GRE - Coal Creek Station
McLean County, North Dakota

LOCATION: See Exhibit A-2

Northing: 139490 Easting: 1839670

Surface Elev.: 1922 (Ft.)

GRAPHIC LOG	DEPTH	Description	ELEVATION (Ft.)
▨		**CLAYEY SAND (SC)**, fine grained, light brown, medium dense to very dense *(continued)*	
	38.0		1884
		SILTY SAND (SM), gray, dense, fine to medium-grained	
	43.0		1879
		POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM), fine to coarse grained, brown, very dense	
	45.5		1876.5
		SANDY LEAN CLAY (CL), trace gravel, brownish gray, hard	
	47.0		1875
		SILTY SAND (SM), fine grained, dark gray, hard, waterbearing	
	51.0		1871
		Boring Terminated at 51 Feet	



DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
30		☒	10-14-17 N=31			
35		☒	18-28-47 N=75			
40		☒	10-15-17 N=32			
45		☒	15-22-31 N=53			
	▽					
50		☒	10-16-23 N=39			

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3¼" ID HSA 0-49½'

Abandonment Method:
Boring converted to piezometer installation.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Initially Encountered*

Midwest Testing Laboratory, Inc.
a Terracon company
1805 Hancock Drive
Bismarck, North Dakota

Boring Started: 6/9/2014	Boring Completed: 6/9/2014
Drill Rig: D-50	Driller: MR
Project No.: M2145058	Exhibit: A-6

BORING LOG NO. DP-D

Page 1 of 2

PROJECT: **Piezometers/Well Installations**

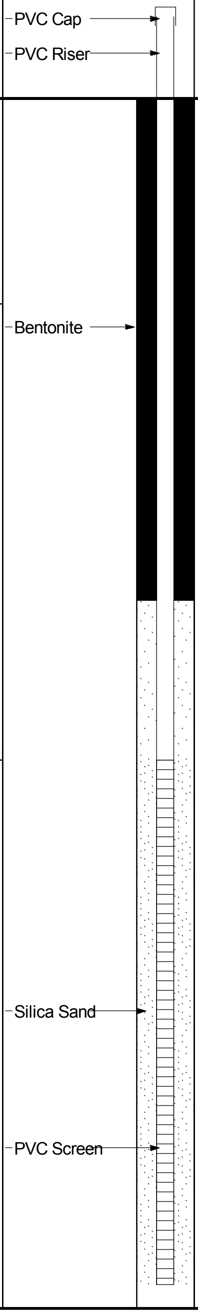
CLIENT: **Golder Associates**
Lakewood, Colorado

SITE: **GRE - Coal Creek Station**
McLean County, North Dakota

LOCATION: See Exhibit A-2

Northing: 139300 Easting: 1838900

Surface Elev.: 1932 (Ft.)



GRAPHIC LOG	DEPTH		ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		FILL - SANDY LEAN CLAY, gray				☒	2-1-2 N=3			
	4.5		1927.5							
		FILL - COAL and CLAY MIXTURE, black		5		☒	8-7-7 N=14			
				10		☒	4-7-10 N=17			
	14.5		1917.5							
		LEAN CLAY WITH SAND (CL), trace gravel, brown, very stiff to stiff		15		☒	5-8-10 N=18			
				20		■				
				25		☒	3-3-5 N=8			

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3¼" ID HSA 0-36'

Abandonment Method:
Boring converted to piezometer installation.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

Shelby tube sample (19 to 21 feet) shipped to Golder Associates.

WATER LEVEL OBSERVATIONS

▽ *Initially Encountered*

Midwest Testing Laboratory, Inc.
a Terracon company
1805 Hancock Drive
Bismarck, North Dakota

Boring Started: 6/10/2014	Boring Completed: 6/10/2014
Drill Rig: D-50	Driller: MR
Project No.: M2145058	Exhibit: A-7

BORING LOG NO. DP-D

Page 2 of 2

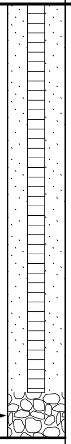
PROJECT: **Piezometers/Well Installations**

CLIENT: **Golder Associates**
Lakewood, Colorado

SITE: **GRE - Coal Creek Station**
McLean County, North Dakota

GRAPHIC LOG	LOCATION: See Exhibit A-2 Northing: 139300 Easting: 1838900 DEPTH	Surface Elev.: 1932 (Ft.) ELEVATION (Ft.)		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
▨	**LEAN CLAY WITH SAND (CL)**, trace gravel, brown, very stiff to stiff *(continued)*				▽					
	30.5	1901.5		30		☒	2-3-5 N=8			
▨	**SANDY LEAN CLAY (CL)**, trace gravel, grayish-brown, stiff									
	34.0	1898								
●	**BOULDER**									
	35.5	1896.5	Sluff	35			100/1"			

Sampler and Auger Refusal at 35.5 Feet



Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3¼" ID HSA 0-36'

Abandonment Method:
Boring converted to piezometer installation.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Initially Encountered*

Midwest Testing LABORATORY, INC. A Terracon COMPANY
1805 Hancock Drive
Bismarck, North Dakota

Boring Started: 6/10/2014	Boring Completed: 6/10/2014
Drill Rig: D-50	Driller: MR
Project No.: M2145058	Exhibit: A-7

BORING LOG NO. MW-DP1

PROJECT: Piezometers/Well Installations

CLIENT: Golder Associates
Lakewood, Colorado

SITE: GRE - Coal Creek Station
McLean County, North Dakota

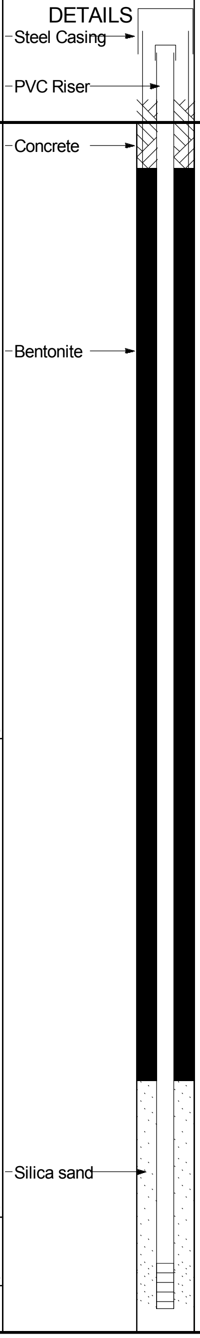
LOCATION: See Exhibit A-2

Northing: 139810 Easting: 1839680

Surface Elev.: 1914 (Ft.)

DEPTH		ELEVATION (Ft.)
	FILL - LEAN CLAY WITH SAND (CL), brown	
13.5		1900.5
	LEAN CLAY WITH SAND (CL), dark brown to brown, very stiff to stiff	
24.0		1890
	SILT WITH SAND (ML), light brown	
25.5		1888.5

INSTALLATION DETAILS



DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		☒	2-2-2 N=4			
		☒	3-3-5 N=8			
5		☒	5-7-11 N=18			
		☒	5-7-9 N=16			
10		☒	3-4-6 N=10			
		☒	3-6-12 N=18			
15		☒	5-6-10 N=16			
20		☒	4-5-8 N=13			
25	▽	☒	3-4-5 N=9			

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3¼" ID HSA 0-44½'

Abandonment Method:
Boring converted to monitoring well installation.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Initially Encountered*

Midwest Testing LABORATORY, INC.
A Terracon COMPANY
1805 Hancock Drive
Bismarck, North Dakota

Boring Started: 6/10/2014	Boring Completed: 6/10/2014
Drill Rig: D-50	Driller: MR
Project No.: M2145058	Exhibit: A-8

BORING LOG NO. MW-DP1

PROJECT: Piezometers/Well Installations

CLIENT: Golder Associates
Lakewood, Colorado

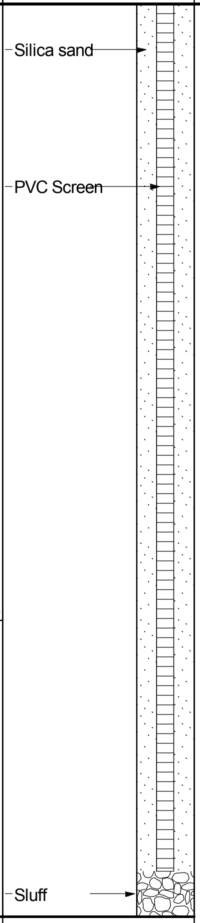
SITE: GRE - Coal Creek Station
McLean County, North Dakota

LOCATION: See Exhibit A-2

Northing: 139810 Easting: 1839680

Surface Elev.: 1914 (Ft.)

GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		SILTY SAND (SM), light brown, dense, fine to medium-grained, waterbearing *(continued)*		30		☒	11-16-21 N=37			
				35		☒	10-16-21 N=37			
	39.5		1874.5							
		SILTY SAND (SM), gray, dense, fine to medium-grained, waterbearing		40		☒	12-16-31 N=47			
				45		☒	12-16-21 N=37			
	46.0		1868							
		Boring Terminated at 46 Feet								



Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3¼" ID HSA 0-44½'

Abandonment Method:
Boring converted to monitoring well installation.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Initially Encountered*

Midwest Testing Laboratory, Inc.
a Terracon company
1805 Hancock Drive
Bismarck, North Dakota

Boring Started: 6/10/2014	Boring Completed: 6/10/2014
Drill Rig: D-50	Driller: MR
Project No.: M2145058	Exhibit: A-8

APPENDIX B

LABORATORY TESTING

Laboratory Testing

Samples retrieved during the field exploration were taken to the laboratory for further observation by the project geotechnical engineer and are classified in accordance with the Unified Soil Classification System (USCS) described in Appendix C. At that time, the field descriptions were confirmed or modified as necessary and an applicable laboratory testing program was formulated to determine the engineering properties of the subsurface materials.

The following bag samples were obtained during the field exploration:

- Bag 1: Boring DP-A, depth 0-5 feet (composite)
- Bag 2: Boring DP-A, depth 5-10 feet (composite)
- Bag 3: Boring DP-A, depth 10-15 feet (composite)
- Bag 4: Boring DP-A, depth 15-20 feet (composite)
- Bag 5: Boring DP-D, depth 0-5 feet (composite)
- Bag 6: Boring DP-D, depth 5-10 feet (composite)
- Bag 7: Boring DP-D, depth 10-15 feet (composite)
- Bag 8: Boring DP-D, depth 15-20 feet (composite)

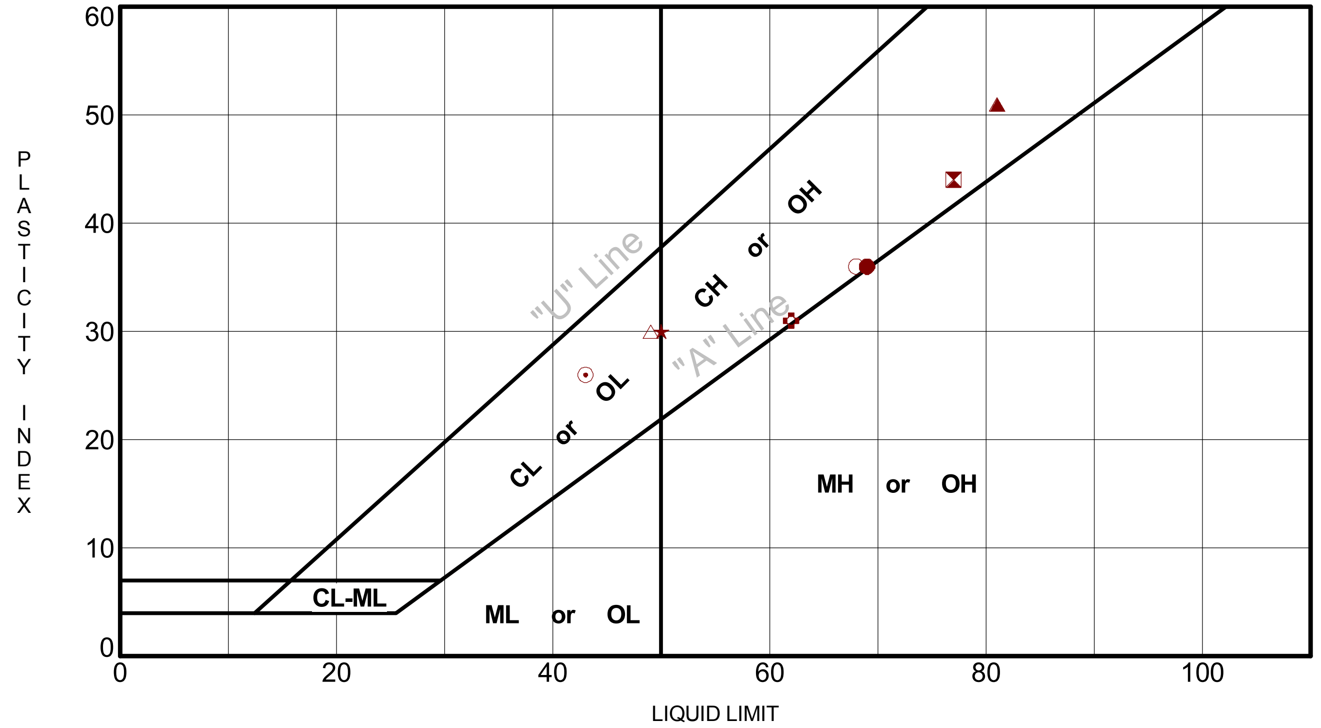
These samples were tested for the following engineering properties:

- Atterberg limits
- Grain-size distribution
- Moisture-density relationship

The laboratory tests were used for the geotechnical engineering analysis. Laboratory tests were performed in general accordance with the applicable ASTM, local, or other accepted standards. Laboratory test results are presented in Appendix B.

ATTERBERG LIMITS RESULTS

ASTM D4318



	Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
●	**DP-A (Bag)**	**0.0**	**69**	**33**	**36**	**87**	**CH**	**FAT CLAY**
⧗	**DP-A (Bag)**	**5.0**	**77**	**33**	**44**	**87**	**CH**	**FAT CLAY**
▲	**DP-A (Bag)**	**10.0**	**81**	**30**	**51**	**79**	**CH**	**FAT CLAY with SAND**
★	**DP-A (Bag)**	**15.0**	**50**	**20**	**30**	**60**	**CH**	**SANDY FAT CLAY**
⊙	**DP-D (Bag)**	**0.0**	**43**	**17**	**26**	**69**	**CL**	**SANDY LEAN CLAY**
✿	**DP-D (Bag)**	**5.0**	**62**	**31**	**31**	**81**	**CH**	**FAT CLAY with SAND**
○	**DP-D (Bag)**	**10.0**	**68**	**32**	**36**	**80**	**CH**	**FAT CLAY with SAND**
△	**DP-D (Bag)**	**15.0**	**49**	**19**	**30**	**74**	**CL**	**LEAN CLAY with SAND**

PROJECT: Piezometers/Well Installations

SITE: GRE - Coal Creek Station
McLean County, North Dakota

Midwest Testing LABORATORY, INC.
A Terracon COMPANY

1805 Hancock Drive
Bismarck, North Dakota

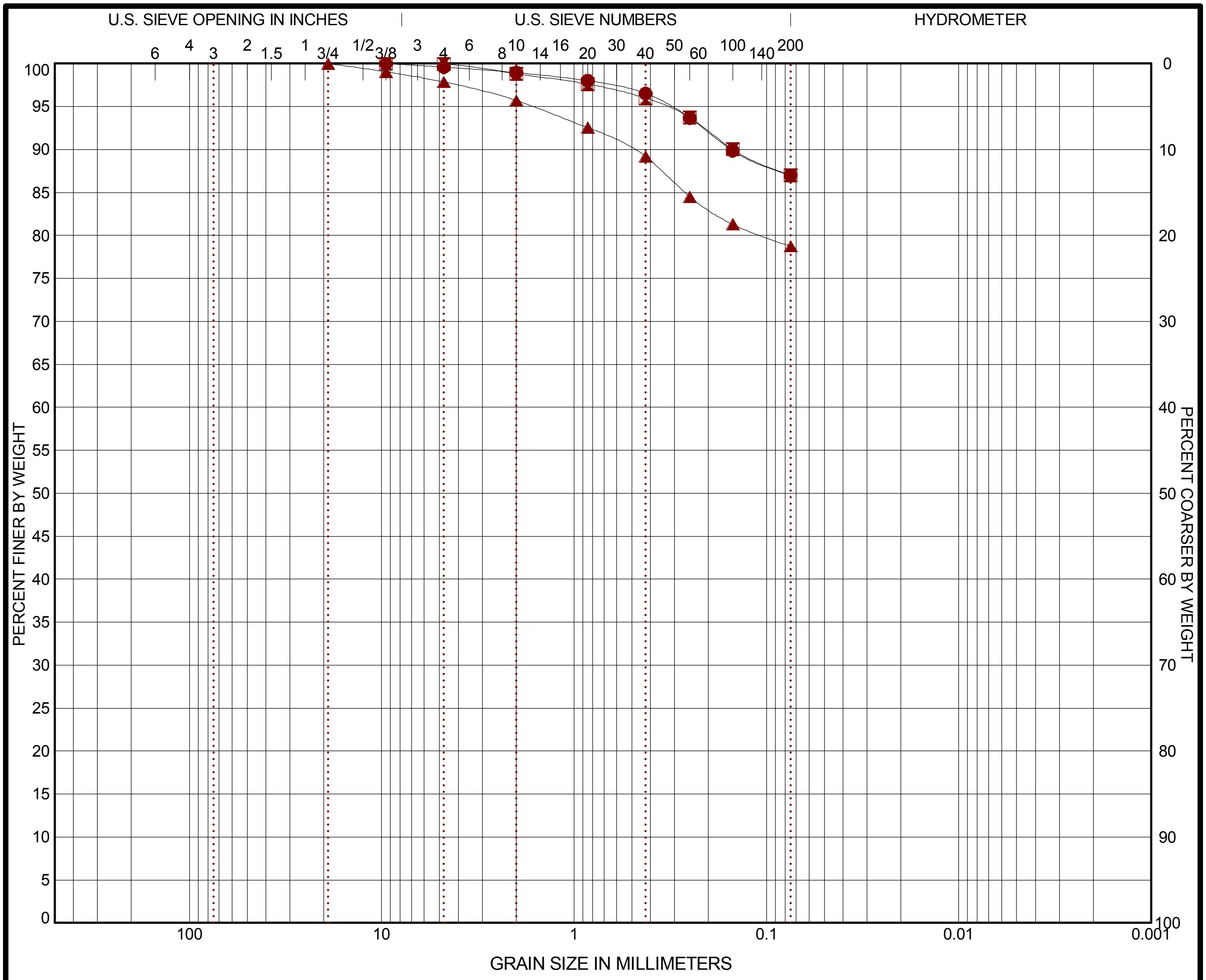
PROJECT NUMBER: M2145058

CLIENT: Golder Associates
Lakewood, Colorado

EXHIBIT: B-2

GRAIN SIZE DISTRIBUTION

ASTM D422



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	**DP-A (Bag)**	**0 - 5**	**0.0**	**0.4**	**12.6**		**87.0**		**CH**
☒	**DP-A (Bag)**	**5 - 10**	**0.0**	**0.0**	**12.9**		**87.0**		**CH**
▲	**DP-A (Bag)**	**10 - 15**	**0.0**	**2.1**	**19.1**		**78.8**		**CH**

	GRAIN SIZE		
	●	☒	▲
D_{60}			
D_{30}			
D_{10}			
	COEFFICIENTS		
C_C			
C_U			

SIEVE (size)	PERCENT FINER ●	☒	▲
1 1/2"			
1"			
3/4"			**100.0**
1/2"			
3/8"	**100.0**	**100.0**	**99.06**
#4	**99.6**	**99.97**	**97.87**
#10	**98.96**	**98.83**	**95.71**
#20	**98.02**	**97.62**	**92.55**
#40	**96.53**	**96.0**	**89.2**
#60	**93.69**	**93.73**	**84.51**
#100	**89.88**	**90.04**	**81.31**
#200	**86.99**	**87.04**	**78.76**

SOIL DESCRIPTION

- ● FAT CLAY(CH)
- ☒ FAT CLAY(CH)
- ▲ FAT CLAY with SAND(CH)

REMARKS

- ● COAL and CLAY Mixture
- ☒ COAL and CLAY Mixture
- ▲ COAL and CLAY Mixture

PROJECT: Piezometers/Well Installations

SITE: GRE - Coal Creek Station
McLean County, North Dakota

Midwest Testing
LABORATORY, INC.
A Terracon COMPANY

1805 Hancock Drive
Bismarck, North Dakota

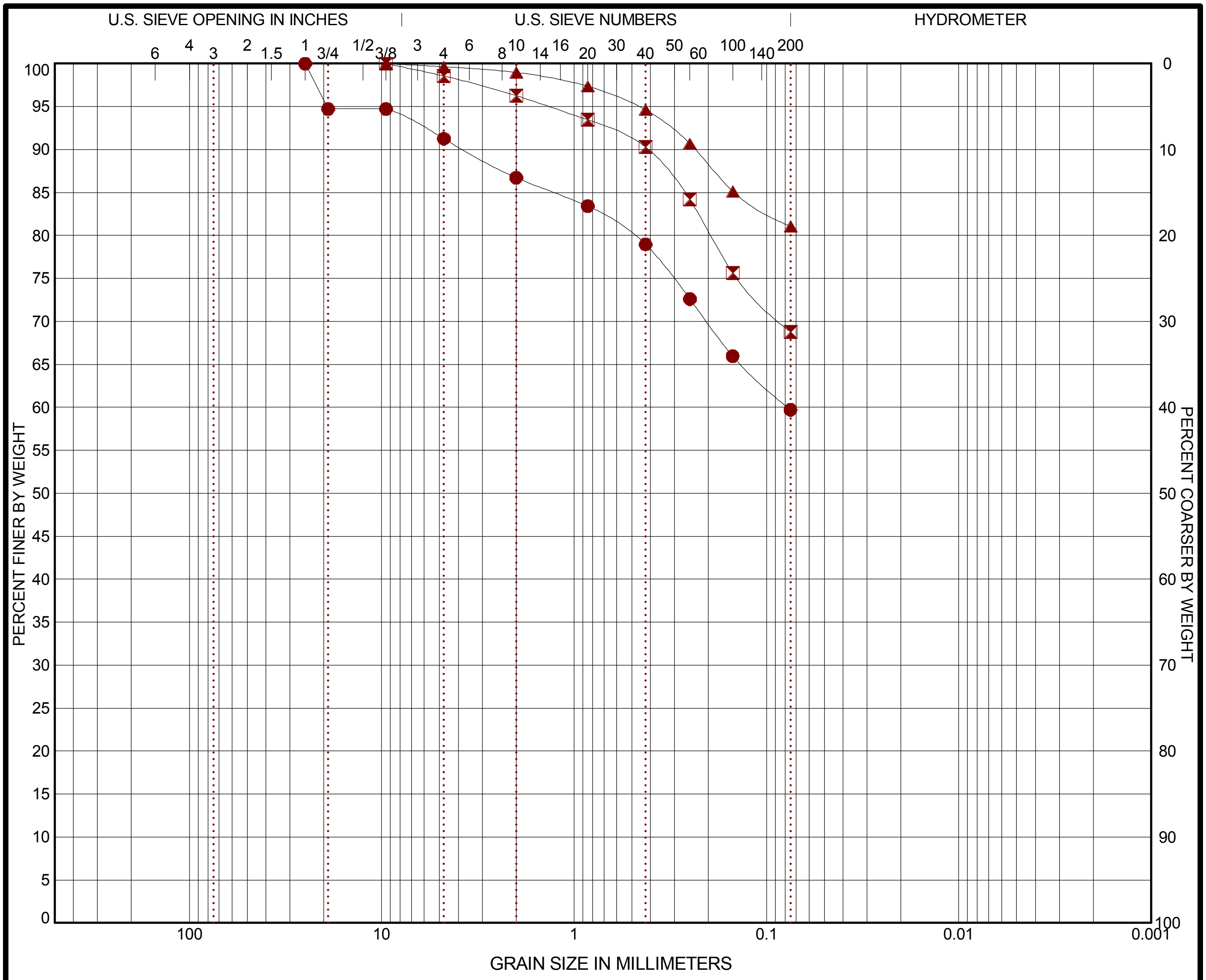
PROJECT NUMBER: M2145058

CLIENT: Golder Associates
Lakewood, Colorado

EXHIBIT: B-3

GRAIN SIZE DISTRIBUTION

ASTM D422



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	**DP-A (Bag)**	**15 - 20**	**0.0**	**8.7**	**31.5**		**59.7**		**CH**
⧗	**DP-D (Bag)**	**0 - 5**	**0.0**	**1.4**	**29.8**		**68.8**		**CL**
▲	**DP-D (Bag)**	**5 - 10**	**0.0**	**0.4**	**18.6**		**81.1**		**CH**

	GRAIN SIZE		
	●	⧗	▲
D_{60}	**0.077**		
D_{30}			
D_{10}			
	COEFFICIENTS		
C_C			
C_U			

SIEVE (size)	PERCENT FINER		
	●	⧗	▲
1 1/2"			
1"	**100.0**		
3/4"	**94.73**		
1/2"			
3/8"	**94.73**	**100.0**	**100.0**
#4	**91.27**	**98.56**	**99.64**
#10	**86.73**	**96.28**	**98.97**
#20	**83.43**	**93.48**	**97.37**
#40	**78.97**	**90.29**	**94.63**
#60	**72.62**	**84.21**	**90.7**
#100	**65.98**	**75.66**	**85.16**
#200	**59.73**	**68.79**	**81.08**

SOIL DESCRIPTION

- ● SANDY FAT CLAY(CH)
- ⧗ SANDY LEAN CLAY(CL)
- ▲ FAT CLAY with SAND(CH)

REMARKS

- ●
- ⧗
- ▲ COAL and CLAY Mixture

PROJECT: Piezometers/Well Installations

SITE: GRE - Coal Creek Station
McLean County, North Dakota

Midwest Testing Laboratory, Inc.
A Terracon Company
1805 Hancock Drive
Bismarck, North Dakota

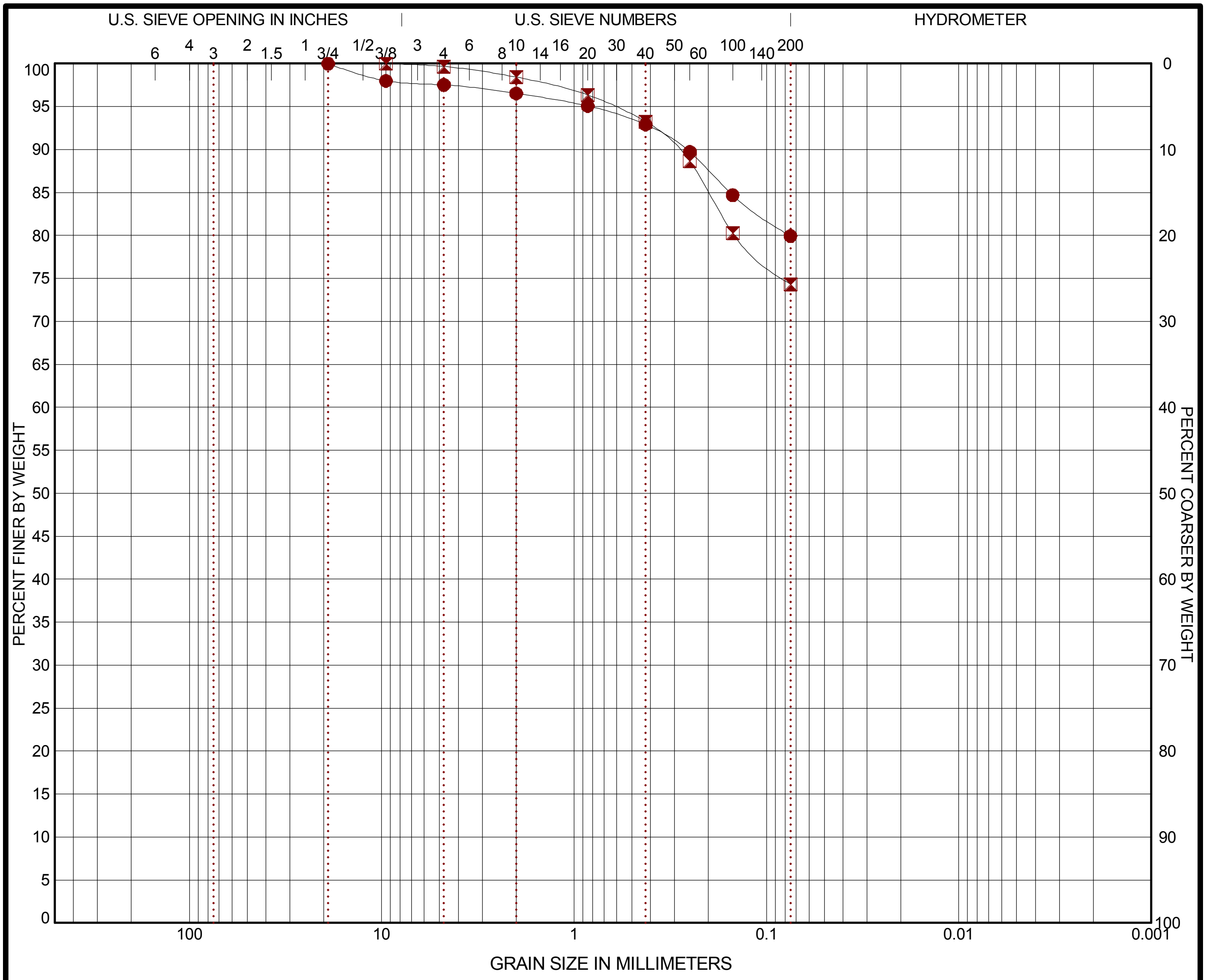
PROJECT NUMBER: M2145058

CLIENT: Golder Associates
Lakewood, Colorado

EXHIBIT: B-4

GRAIN SIZE DISTRIBUTION

ASTM D422



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	**DP-D (Bag)**	**10 - 15**	**0.0**	**2.5**	**17.6**		**79.9**		**CH**
⧗	**DP-D (Bag)**	**15 - 20**	**0.0**	**0.3**	**25.3**		**74.3**		**CL**

	GRAIN SIZE		
	●	⧗	
D_{60}			
D_{30}			
D_{10}			
	COEFFICIENTS		
C_C			
C_U			

SIEVE (size)	PERCENT FINER		
	●	⧗	
1 1/2"			
1"			
3/4"	**100.0**		
1/2"			
3/8"	**98.0**	**100.0**	
#4	**97.54**	**99.67**	
#10	**96.54**	**98.43**	
#20	**95.08**	**96.36**	
#40	**92.93**	**93.26**	
#60	**89.74**	**88.67**	
#100	**84.71**	**80.29**	
#200	**79.95**	**74.34**	

SOIL DESCRIPTION

● FAT CLAY with SAND(CH)

⧗ LEAN CLAY with SAND(CL)

REMARKS

● COAL and CLAY Mixture

⧗

PROJECT: Piezometers/Well Installations

SITE: GRE - Coal Creek Station
McLean County, North Dakota

Midwest Testing
LABORATORY, INC.
A Terracon COMPANY

1805 Hancock Drive
Bismarck, North Dakota

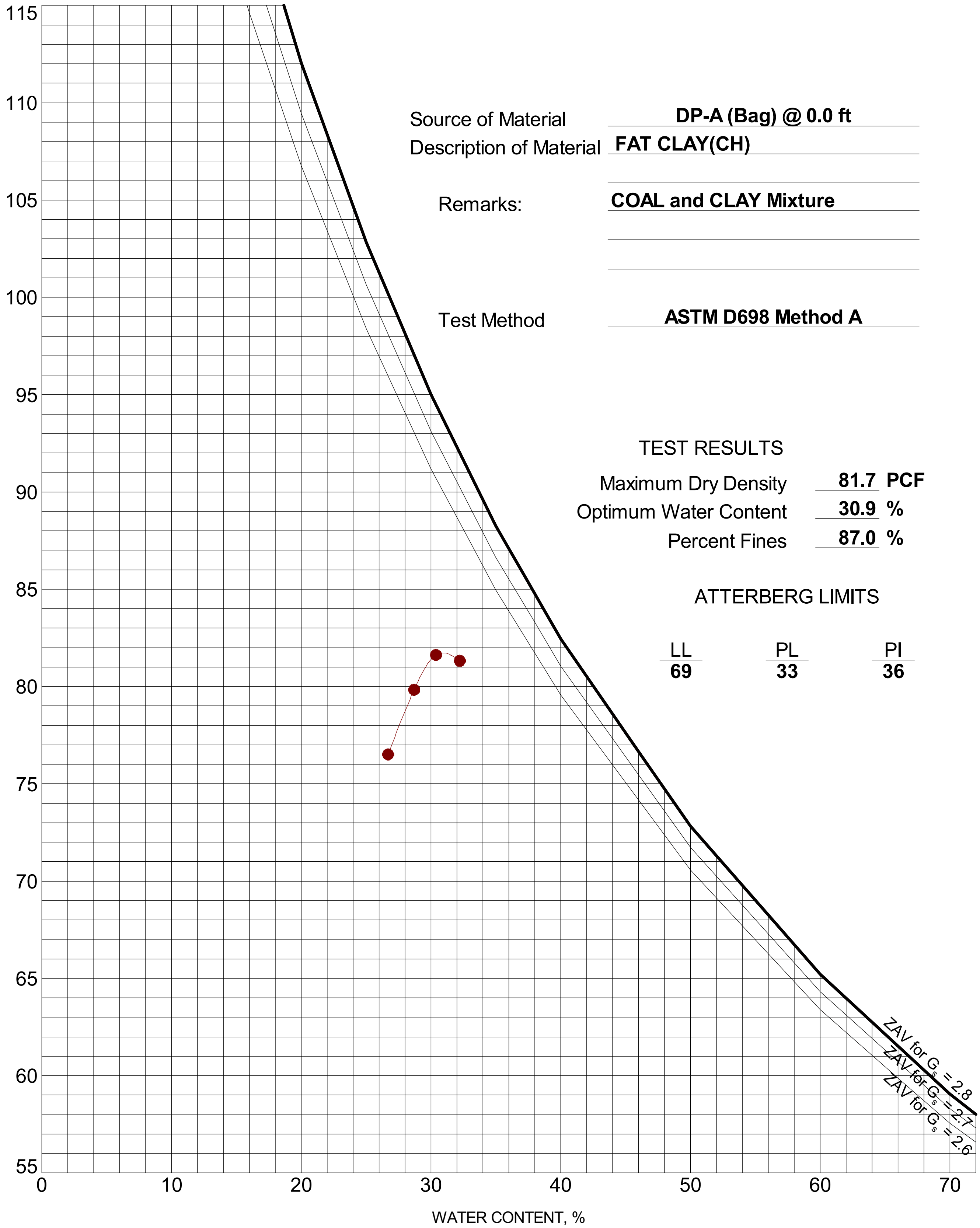
PROJECT NUMBER: M2145058

CLIENT: Golder Associates
Lakewood, Colorado

EXHIBIT: B-5

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material	**DP-A (Bag) @ 0.0 ft**
Description of Material	**FAT CLAY(CH)**
Remarks:	**COAL and CLAY Mixture**
Test Method	**ASTM D698 Method A**

TEST RESULTS

Maximum Dry Density	**81.7**	**PCF**
Optimum Water Content	**30.9**	**%**
Percent Fines	**87.0**	**%**

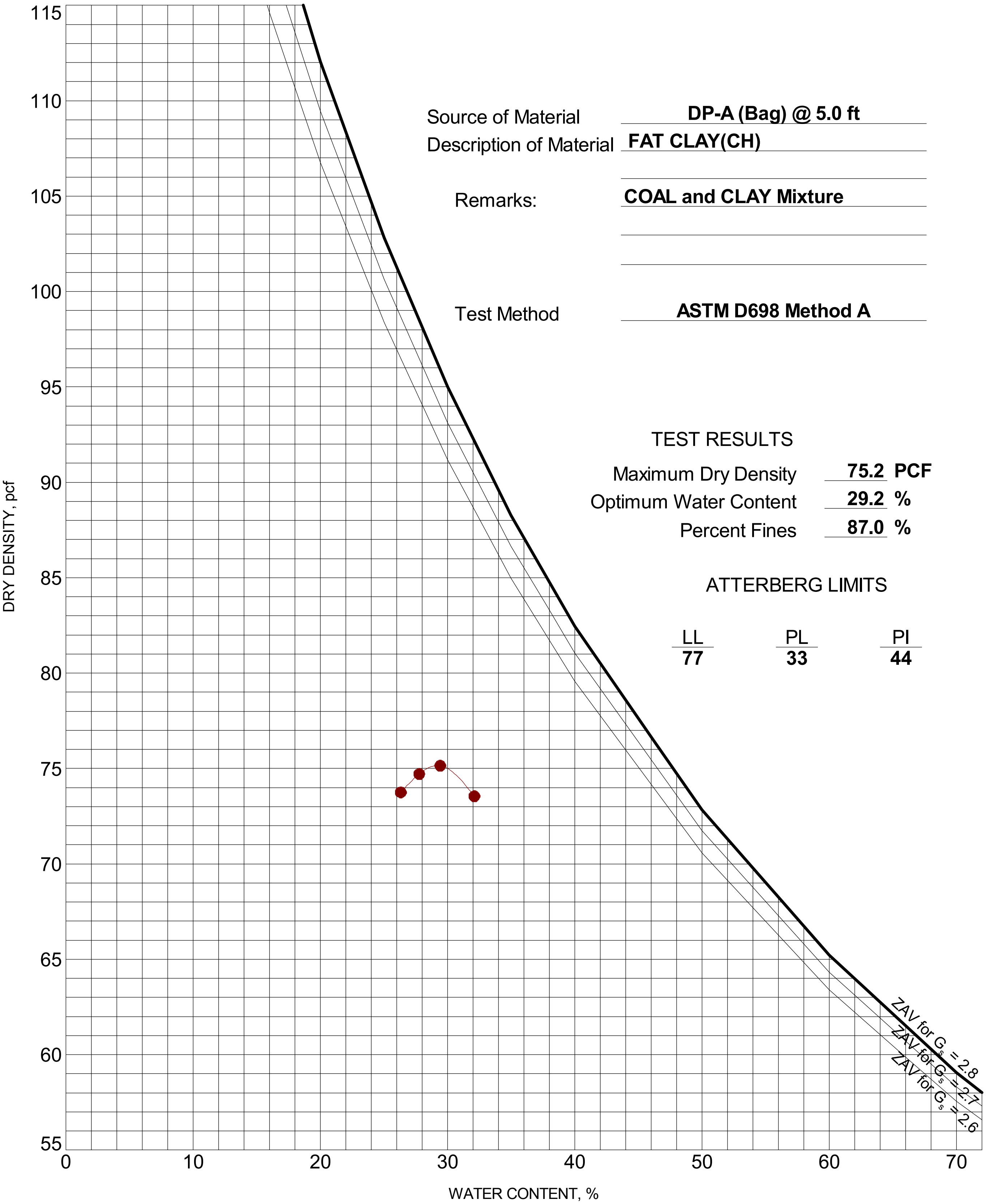
ATTERBERG LIMITS

LL	PL	PI
69	**33**	**36**

PROJECT: Piezometers/Well Installations	Midwest Testing Laboratory, Inc. A Terracon Company	PROJECT NUMBER: M2145058
SITE: GRE - Coal Creek Station McLean County, North Dakota		CLIENT: Golder Associates Lakewood, Colorado
	1805 Hancock Drive Bismarck, North Dakota	EXHIBIT: B-6

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material **DP-A (Bag) @ 5.0 ft**

Description of Material **FAT CLAY(CH)**

Remarks: **COAL and CLAY Mixture**

Test Method **ASTM D698 Method A**

TEST RESULTS

Maximum Dry Density	**75.2**	**PCF**
Optimum Water Content	**29.2**	**%**
Percent Fines	**87.0**	**%**

ATTERBERG LIMITS

LL	PL	PI
77	**33**	**44**

PROJECT: Piezometers/Well Installations

SITE: GRE - Coal Creek Station
McLean County, North Dakota

Midwest Testing
LABORATORY, INC.
A Terracon COMPANY

1805 Hancock Drive
Bismarck, North Dakota

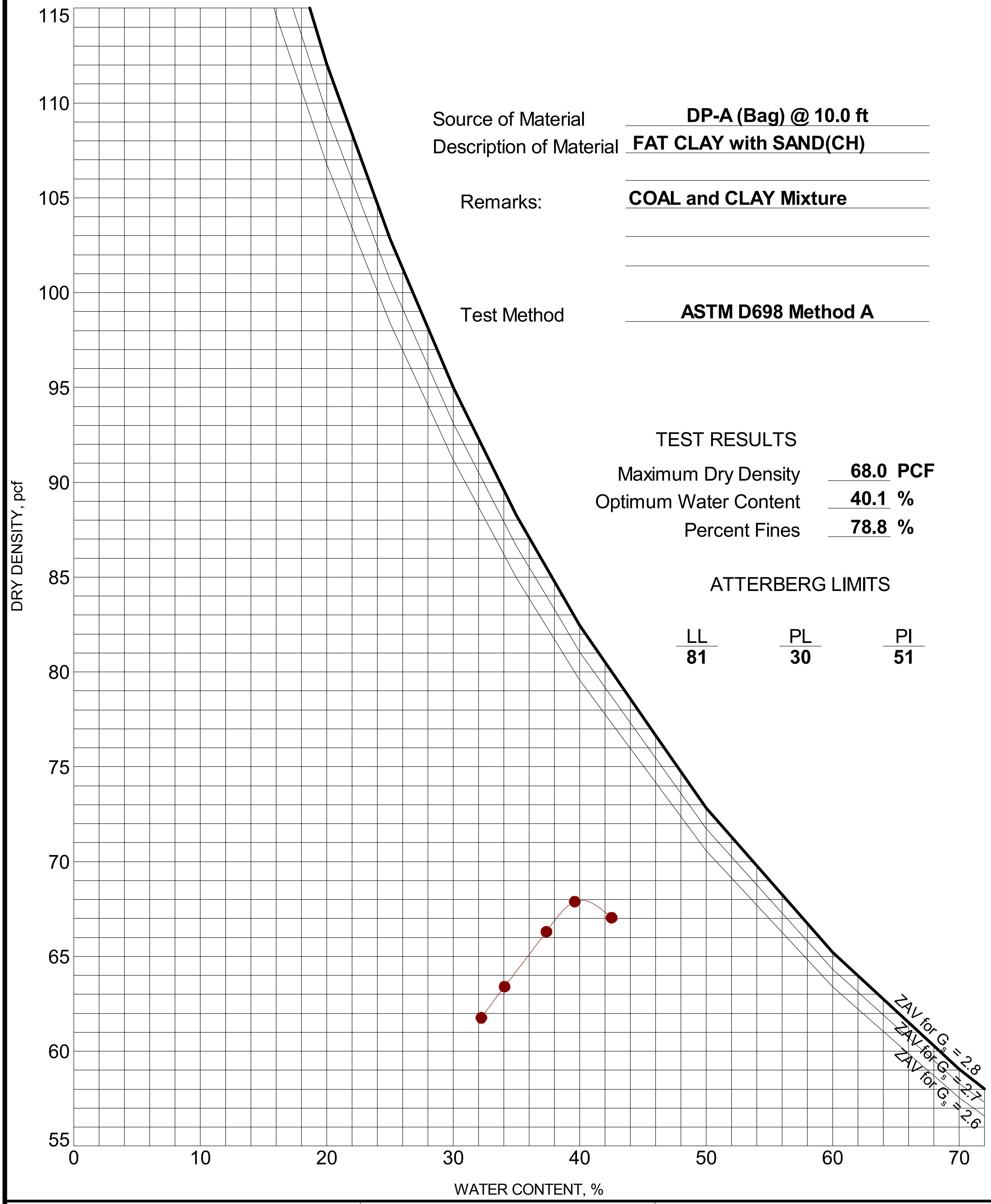
PROJECT NUMBER: M2145058

CLIENT: Golder Associates
Lakewood, Colorado

EXHIBIT: B-7

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material **DP-A (Bag) @ 10.0 ft**

Description of Material **FAT CLAY with SAND(CH)**

Remarks: **COAL and CLAY Mixture**

Test Method **ASTM D698 Method A**

TEST RESULTS

Maximum Dry Density	**68.0**	**PCF**
Optimum Water Content	**40.1**	**%**
Percent Fines	**78.8**	**%**

ATTERBERG LIMITS

LL	PL	PI
81	**30**	**51**

PROJECT: Piezometers/Well Installations

SITE: GRE - Coal Creek Station
McLean County, North Dakota

Midwest Testing
LABORATORY, INC.
A Terracon COMPANY

1805 Hancock Drive
Bismarck, North Dakota

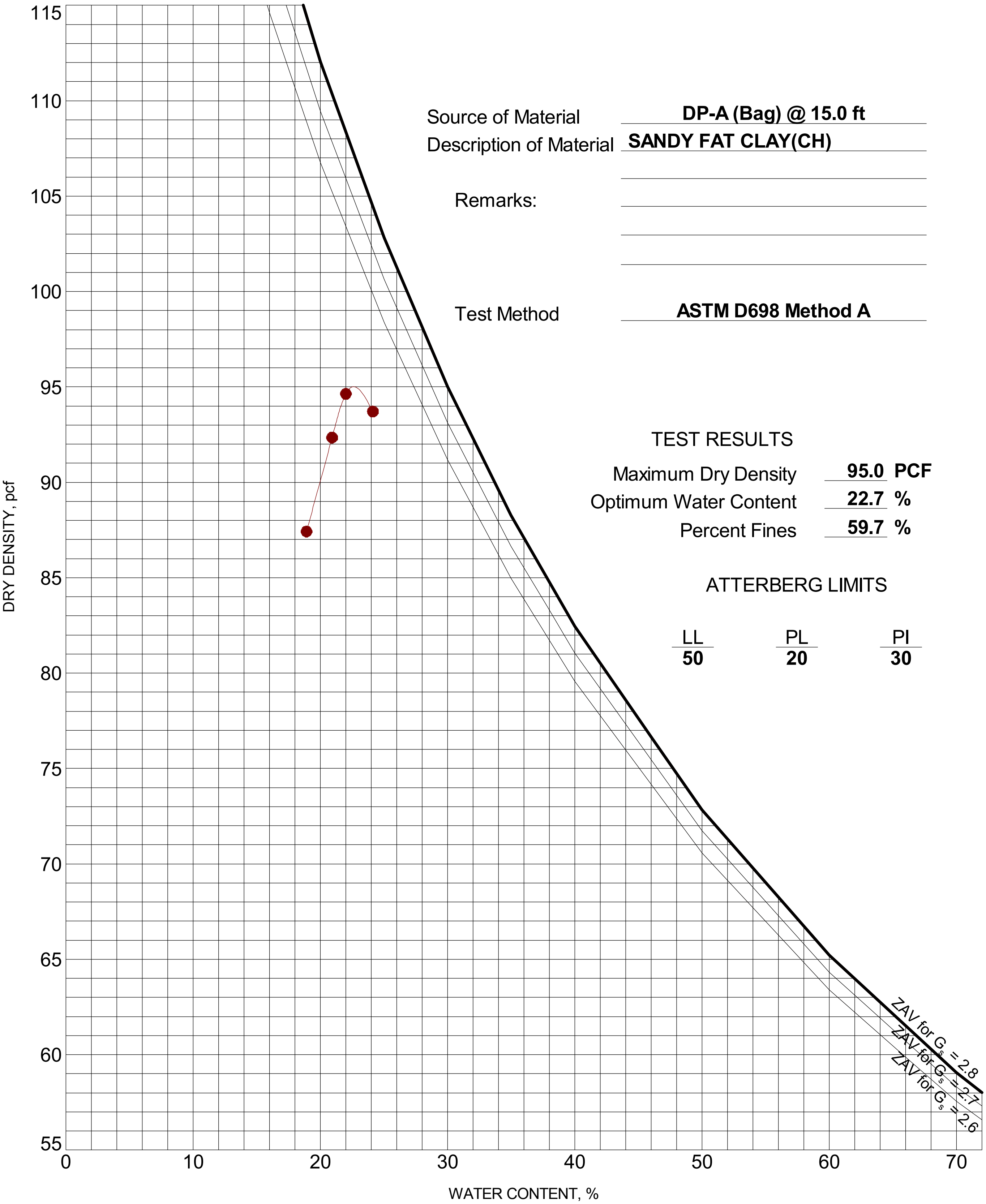
PROJECT NUMBER: M2145058

CLIENT: Golder Associates
Lakewood, Colorado

EXHIBIT: B-8

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material	**DP-A (Bag) @ 15.0 ft**
Description of Material	**SANDY FAT CLAY(CH)**
Remarks:	
Test Method	**ASTM D698 Method A**

TEST RESULTS

Maximum Dry Density	**95.0**	**PCF**
Optimum Water Content	**22.7**	**%**
Percent Fines	**59.7**	**%**

ATTERBERG LIMITS

LL	PL	PI
50	**20**	**30**

PROJECT: Piezometers/Well Installations

SITE: GRE - Coal Creek Station
McLean County, North Dakota

Midwest Testing LABORATORY, INC.
A Terracon COMPANY

1805 Hancock Drive
Bismarck, North Dakota

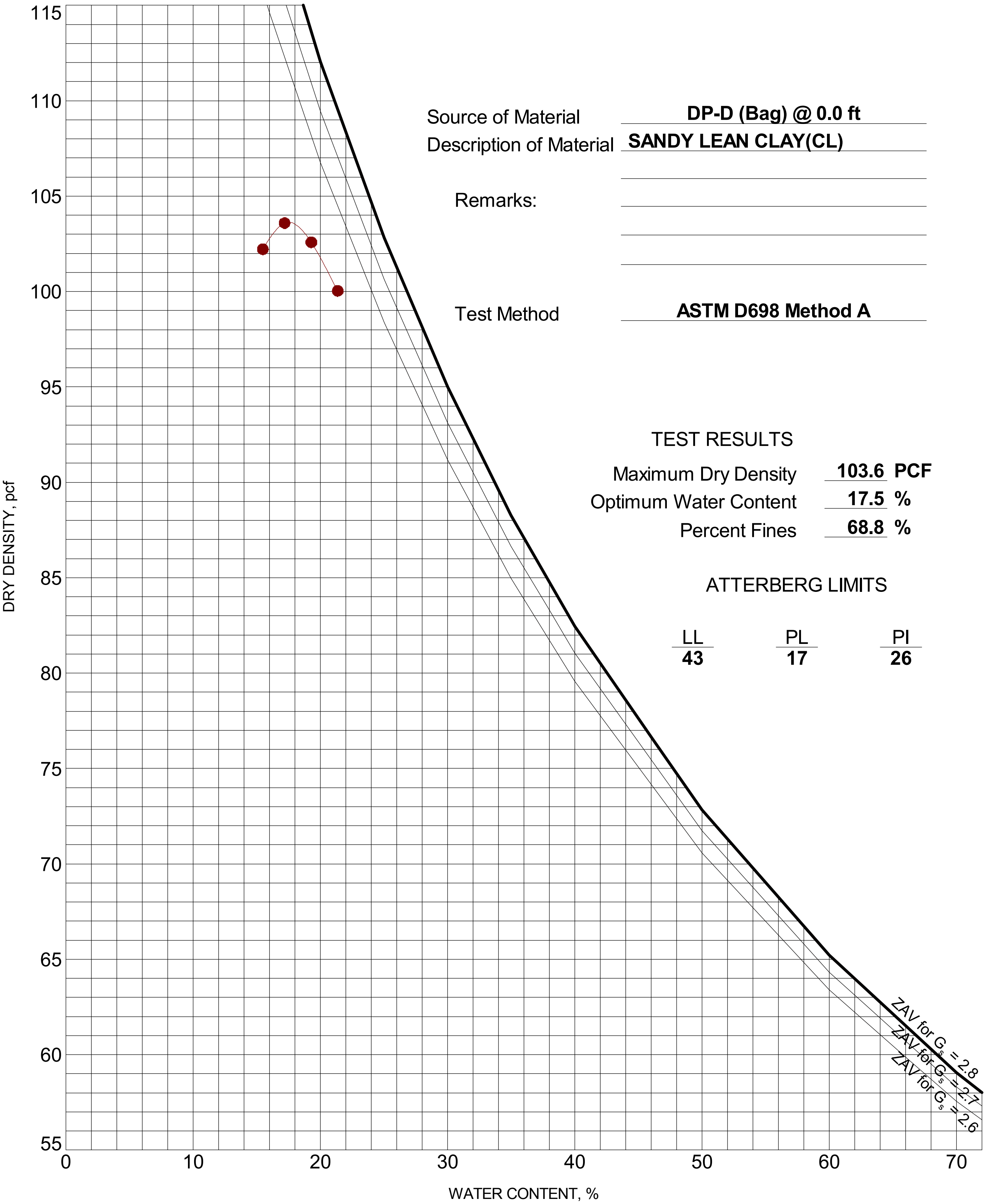
PROJECT NUMBER: M2145058

CLIENT: Golder Associates
Lakewood, Colorado

EXHIBIT: B-9

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material **DP-D (Bag) @ 0.0 ft**

Description of Material **SANDY LEAN CLAY(CL)**

Remarks:

Test Method **ASTM D698 Method A**

TEST RESULTS

Maximum Dry Density	**103.6**	**PCF**
Optimum Water Content	**17.5**	**%**
Percent Fines	**68.8**	**%**

ATTERBERG LIMITS

LL	PL	PI
43	**17**	**26**

PROJECT: Piezometers/Well Installations

SITE: GRE - Coal Creek Station
McLean County, North Dakota

Midwest Testing
LABORATORY, INC.
A Terracon COMPANY

1805 Hancock Drive
Bismarck, North Dakota

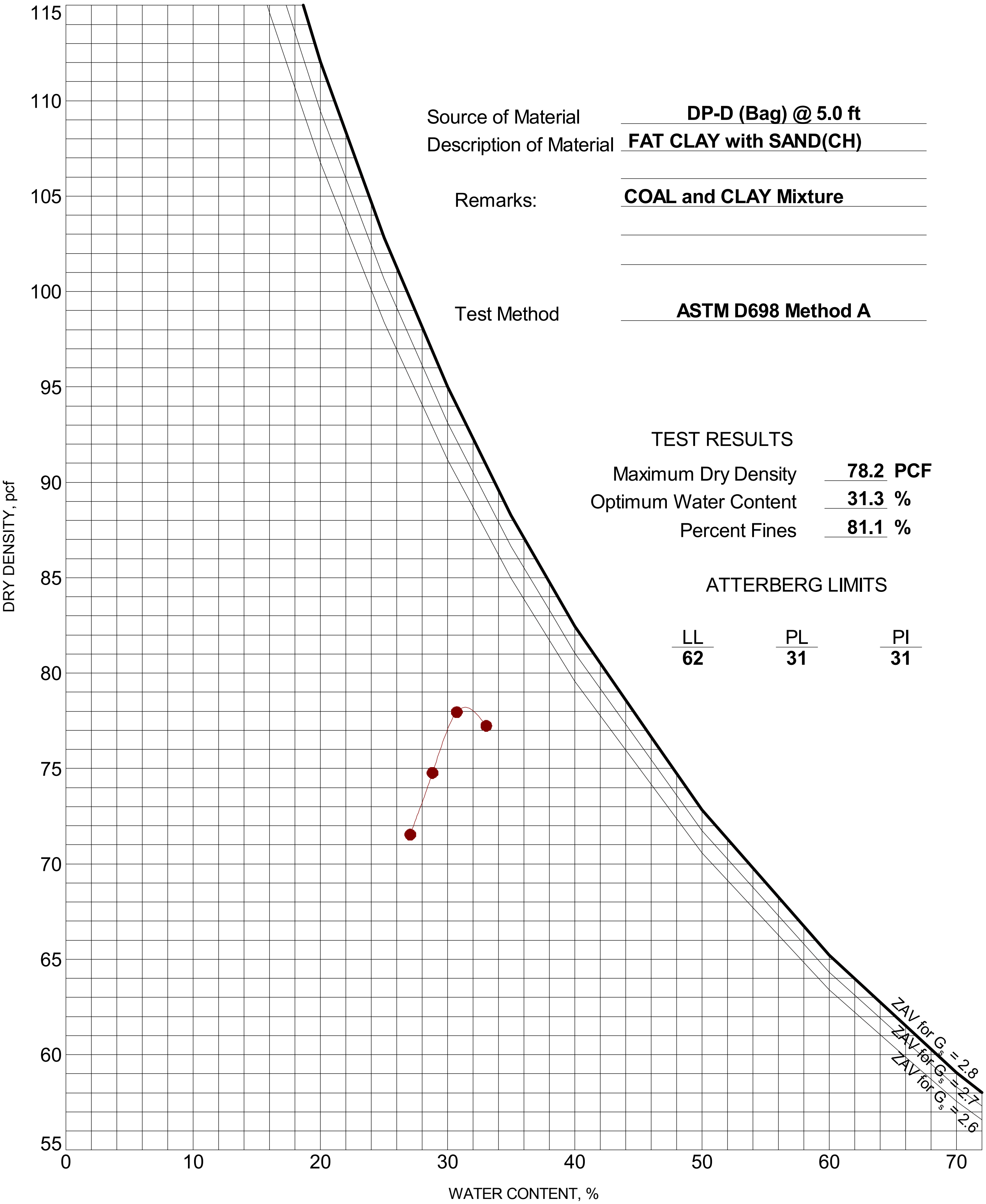
PROJECT NUMBER: M2145058

CLIENT: Golder Associates
Lakewood, Colorado

EXHIBIT: B-10

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material **DP-D (Bag) @ 5.0 ft**

Description of Material **FAT CLAY with SAND(CH)**

Remarks: **COAL and CLAY Mixture**

Test Method **ASTM D698 Method A**

TEST RESULTS

Maximum Dry Density	**78.2**	**PCF**
Optimum Water Content	**31.3**	**%**
Percent Fines	**81.1**	**%**

ATTERBERG LIMITS

LL	PL	PI
62	**31**	**31**

PROJECT: Piezometers/Well Installations

SITE: GRE - Coal Creek Station
McLean County, North Dakota

Midwest Testing
LABORATORY, INC.
A Terracon COMPANY

1805 Hancock Drive
Bismarck, North Dakota

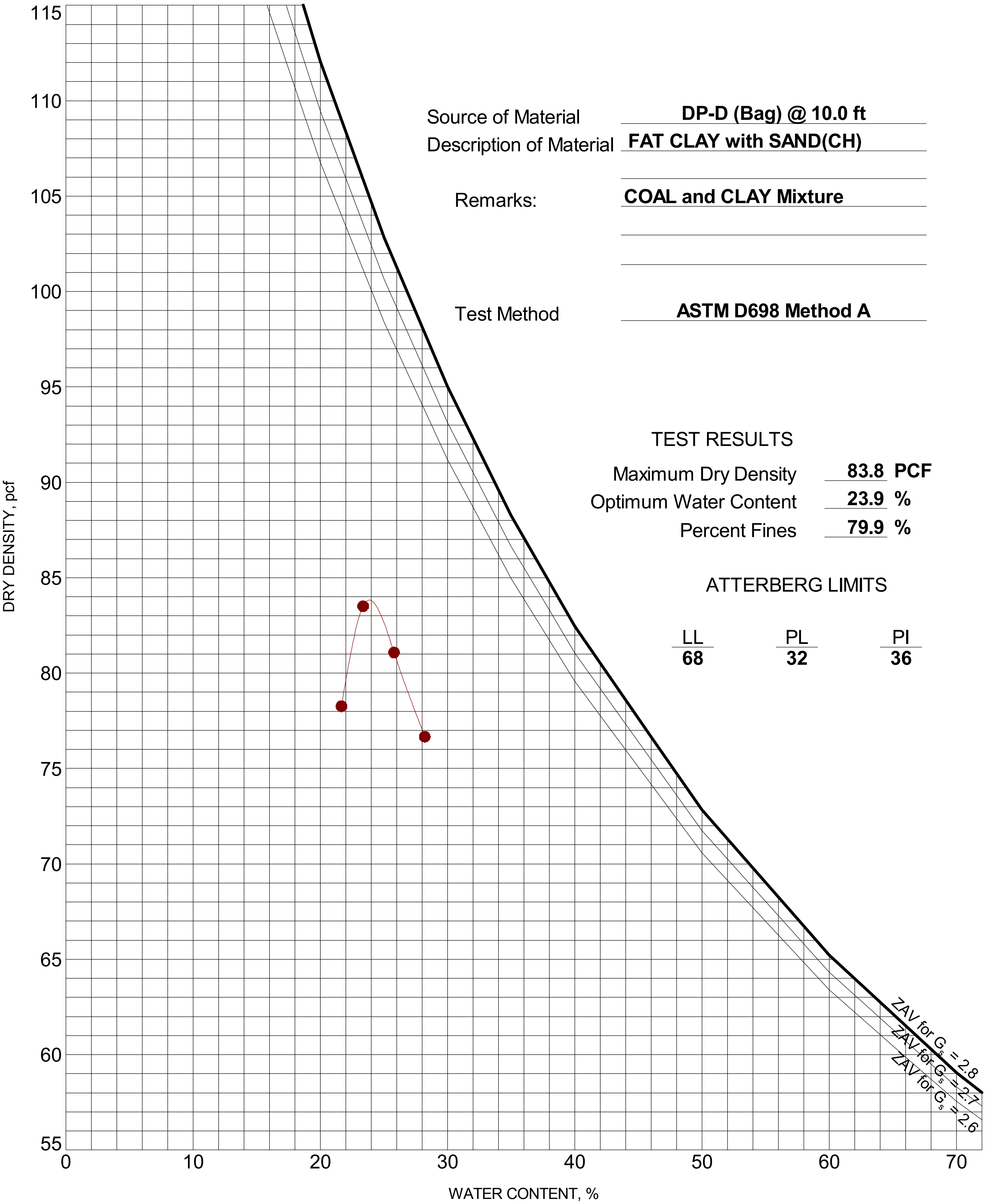
PROJECT NUMBER: M2145058

CLIENT: Golder Associates
Lakewood, Colorado

EXHIBIT: B-11

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material	**DP-D (Bag) @ 10.0 ft**
Description of Material	**FAT CLAY with SAND(CH)**
Remarks:	**COAL and CLAY Mixture**
Test Method	**ASTM D698 Method A**

TEST RESULTS

Maximum Dry Density	**83.8**	**PCF**
Optimum Water Content	**23.9**	**%**
Percent Fines	**79.9**	**%**

ATTERBERG LIMITS

LL	PL	PI
68	**32**	**36**

PROJECT: Piezometers/Well Installations

SITE: GRE - Coal Creek Station
McLean County, North Dakota

Midwest Testing
LABORATORY, INC.
A Terracon COMPANY

1805 Hancock Drive
Bismarck, North Dakota

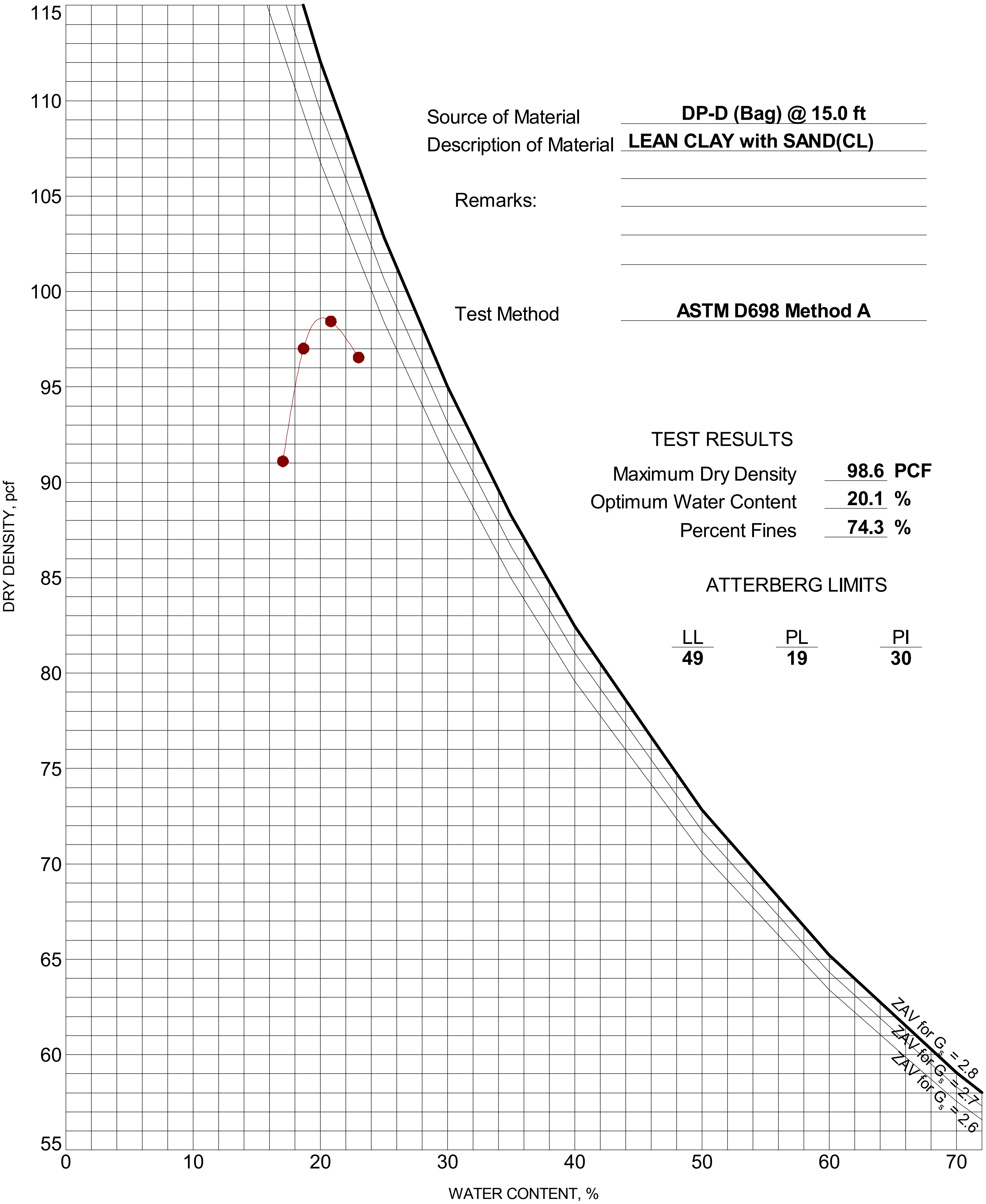
PROJECT NUMBER: M2145058

CLIENT: Golder Associates
Lakewood, Colorado

EXHIBIT: B-12

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material: **DP-D (Bag) @ 15.0 ft**

Description of Material: **LEAN CLAY with SAND(CL)**

Remarks:

Test Method: **ASTM D698 Method A**

TEST RESULTS

Maximum Dry Density	**98.6**	**PCF**
Optimum Water Content	**20.1**	**%**
Percent Fines	**74.3**	**%**

ATTERBERG LIMITS

LL	PL	PI
49	**19**	**30**

PROJECT: Piezometers/Well Installations

SITE: GRE - Coal Creek Station
McLean County, North Dakota

Midwest Testing Laboratory, Inc.
A Terracon Company

1805 Hancock Drive
Bismarck, North Dakota

PROJECT NUMBER: M2145058

CLIENT: Golder Associates
Lakewood, Colorado

EXHIBIT: B-13

APPENDIX C

SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Auger	**Split Spoon**
Shelby Tube	**Macro Core**
Ring Sampler	**Rock Core**
Grab Sample	**No Recovery**

WATER LEVEL

▽	**Water Initially Encountered**
▽	**Water Level After a Specified Period of Time**
▼	**Water Level After a Specified Period of Time**

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

(HP)	**Hand Penetrometer**
(T)	**Torvane**
(b/f)	**Standard Penetration Test (blows per foot)**
(PID)	**Photo-Ionization Detector**
(OVA)	**Organic Vapor Analyzer**

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			**CONSISTENCY OF FINE-GRAINED SOILS** (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength, Qu, psf**	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**
Very Loose	0 - 3	0 - 6	Very Soft	less than 500	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	500 to 1,000	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	1,000 to 2,000	5 - 7	5 - 9
Dense	30 - 50	59 - 98	Stiff	2,000 to 4,000	8 - 14	10 - 18
Very Dense	> 50	≥ 99	Very Stiff	4,000 to 8,000	15 - 30	19 - 42
			Hard	> 8,000	> 30	> 42

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

Midwest Testing
LABORATORY, INC.
A Terracon COMPANY

Exhibit C-1

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]					Soil Classification	
					Group Symbol	Group Name[B]
Coarse Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]		GW	Well-graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$[E]		GP	Poorly graded gravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH		GM	Silty gravel[F,G, H]
			Fines classify as CL or CH		GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]		SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3$[E]		SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH		SM	Silty sand[G,H,I]
			Fines Classify as CL or CH		SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	PI > 7 and plots on or above “A” line[J]		CL	Lean clay[K,L,M]
			PI < 4 or plots below “A” line[J]		ML	Silt[K,L,M]
		organic	Liquid limit - oven dried	< 0.75	OL	Organic clay[K,L,M,N]
			Liquid limit - not dried			Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above “A” line		CH	Fat clay[K,L,M]
			PI plots below “A” line		MH	Elastic Silt[K,L,M]
		organic	Liquid limit - oven dried	< 0.75	OH	Organic clay[K,L,M,P]
			Liquid limit - not dried			Organic silt[K,L,M,Q]
Highly organic soils		Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add “with cobbles or boulders, or both” to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10} \quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains $\geq$ 15% sand, add “with sand” to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add “with organic fines” to group name.

[I] If soil contains $\geq$ 15% gravel, add “with gravel” to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add “with sand” or “with gravel,” whichever is predominant.

[L] If soil contains $\geq$ 30% plus No. 200 predominantly sand, add “sandy” to group name.

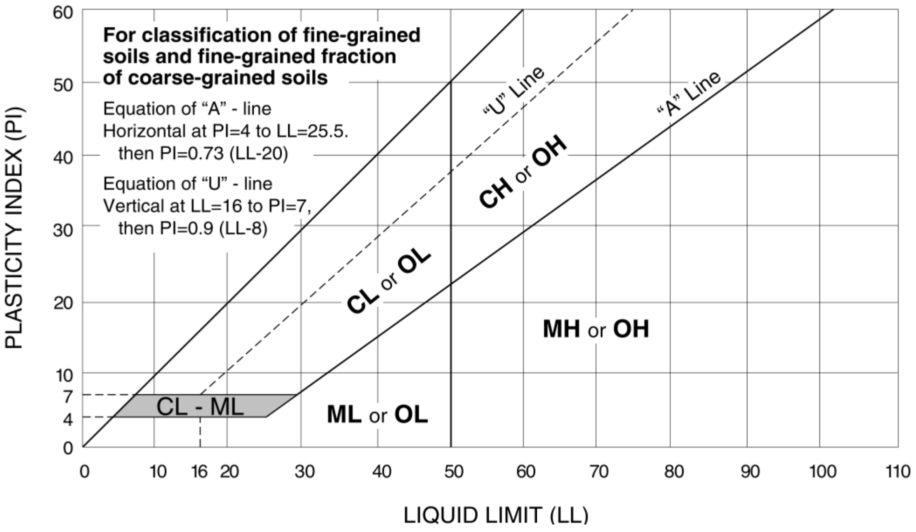
[M] If soil contains $\geq$ 30% plus No. 200, predominantly gravel, add “gravelly” to group name.

[N] $PI \geq 4$ and plots on or above “A” line.

[O] $PI < 4$ or plots below “A” line.

[P] PI plots on or above “A” line.

[Q] PI plots below “A” line.



Rev 03/11

Exhibit C-2

APPENDIX B

Material Properties

Subject GRE – Coal Creek Station	Made by CCS	Job No. 1649586
Drains Pond System	Checked by TJS	Date 10/13/2016
Material Properties		Sheet No. 1 of 5

1.0 OBJECTIVE

Compile a list of material properties used in the engineering evaluation and indicate sources for all inputs.

2.0 MATERIALS

2.1 Existing Natural Soil and Embankment Fill

Existing natural soil and embankment fill properties were based on lab work performed by Golder on samples taken from the SW Section 16 area in 2001, 2008, and 2011. Soils on site are generally low plasticity clay (CL), but high plasticity clays (CH) are also present. Samples yielded an average dry unit weight of 105.1 pcf and an average moisture content of 20.7%. Values of 105 pcf for the dry unit weight and 21% for the moisture content were chosen resulting in a moist unit weight of approximately 127 pcf.

Two triaxial shear strength tests were performed from the SW Section 16 Shelby tube samples in 2001 (BH3 and BH6). Three additional triaxial tests were performed on existing natural soil near the River Water Holding Basin in 1981 (boreholes BR-1 and BR-2) and two triaxial tests were performed on existing natural soil near the cooling towers in 2008 (Tower 91 and Tower 92). Based on triaxial test information, a conservative strength envelope was developed for existing natural soil. The strength envelope is shown in Figure 1 and is defined by an effective cohesion of 500 psf and an effective friction angle of 19 degrees.

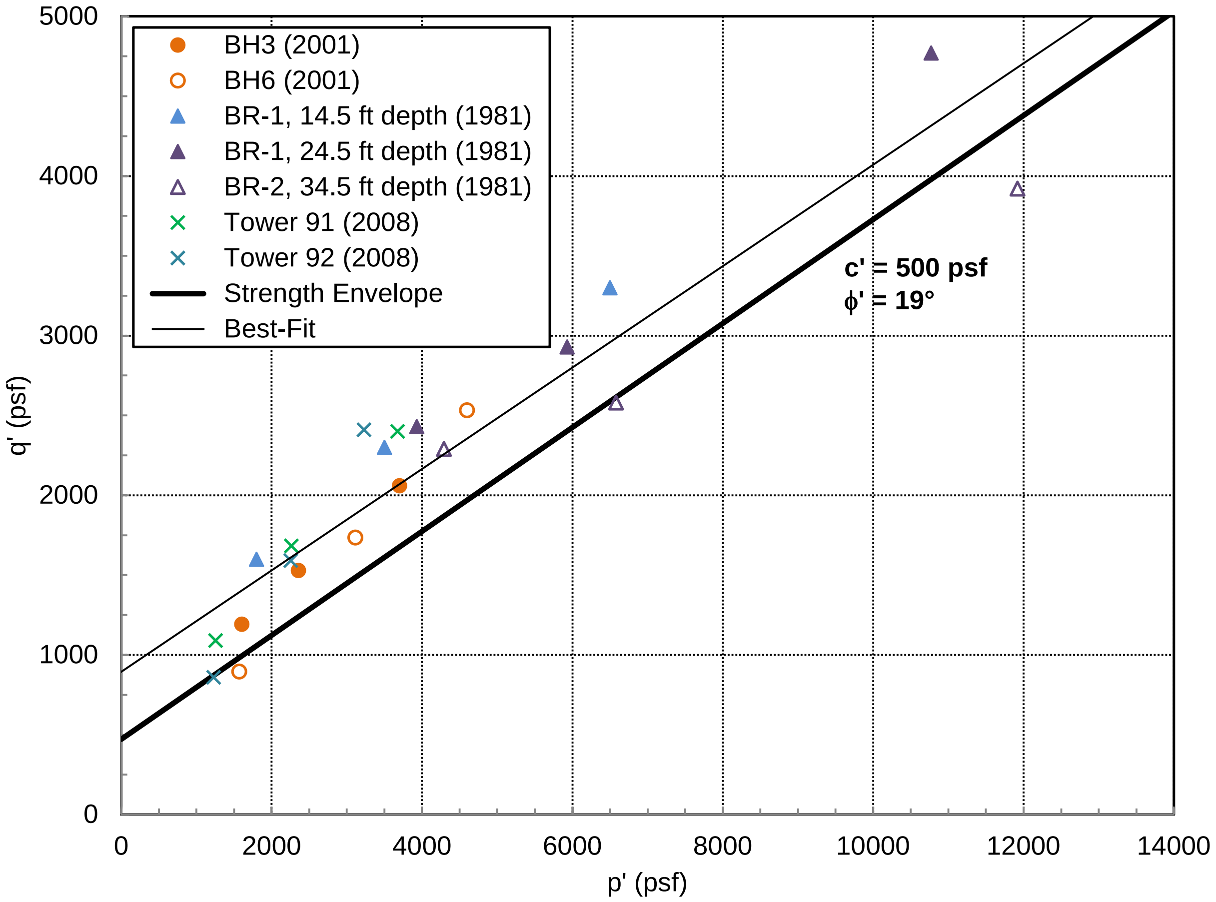


Figure 1: Strength Envelope for Existing Natural Soil Based on Triaxial Test Information

2.2 Clay Liner

Clay liner inputs are based on field experience and laboratory testing of materials at CCS. Dry unit weight and moisture content have been evaluated based on Shelby tube samples of other clay liners at CCS. Results yielded a dry unit weight ranging between 91.9 and 103.8 pcf (99.5 pcf average) and moisture content ranging between 18.6% and 27.7% (22.8% average). Using a dry unit weight of 99.5 pcf and a moisture content of 23 %, a moist unit weight of 122 pcf was calculated and used for these stability analyses. Clay liner materials used at CCS come from existing natural clays onsite. Therefore, shear strength properties of the clay liner are the same as the existing natural soils: the effective cohesion is 500 psf and the effective friction angle is 19 degrees.

2.3 Sand Layer

Sand layer inputs were based on published values for SW and SP type material (NAVFAC 7.02).

Published maximum dry unit weight values range between 100 and 130 pcf (115 pcf average) with optimum moisture contents between 9% and 21% (15% average). Assuming a construction specification of 95% maximum dry density and optimum moisture, the dry unit weight chosen is 109 pcf with a moisture content of 15 %. This results in a moist unit weight value of approximately 125 pcf.

Published values for effective cohesion of SW and SP material suggest a value of 0 psf. Published values for effective friction angle of SW material suggest a value of 38 degrees. Published values for effective friction angle of SP material suggest a value of 37 degrees. For conservatism, the lower effective friction angle of the SP material was chosen for analyses.

2.4 Bottom Ash

Bottom Ash input parameters are based on lab and field work performed by Golder.

The dry unit weight for compacted bottom ash is based on 95 % standard Proctor densities from lab testing which gives a value of approximately 81 pcf. The dry unit weight of sluiced bottom ash is 60 pcf. An average value of 70 pcf was chosen for analysis based on a combination of compacted material and loosely placed material. The moisture content from field sampling of drained and saturated bottom ash ranged between 12% and 6 %. For unsaturated conditions, a moisture content of 19 % was assumed. Using the lab measured specific gravity of bottom ash (2.60); the moisture content of bottom ash for saturated conditions was determined to be between 40% and 65% (average 53%). Bottom ash was assigned an average moist unit weight of 83 pcf and an average saturated unit weight of 107 pcf.

Lab direct shear strength testing of bottom ash indicated a residual effective cohesion of 463 psf and a residual friction angle of 40.3 degrees. Visual observations of the bottom ash material indicates little cohesion, therefore the effective cohesion was chosen as 50 psf and an effective friction angle of 40 degrees was chosen for analysis.

2.5 Fly Ash

Fly Ash input parameters are based on triaxial tests performed by Golder for a 75% solids paste mix and unconfined compression tests performed on fly ash samples prepared using standard Proctor compaction techniques.

Dry unit weights from triaxial tests ranged between 87.8 pcf and 94.5 pcf with an average value of 91.9 pcf; a value of 92 pcf was chosen. Moisture contents from the same testing ranged between 6.3% and 27.7% with an average value of 16%; a value of 16% was chosen. These values result in a moist unit weight of 107 pcf.

Triaxial tests were performed on the fly ash to evaluate the shear strength. Samples were allowed to "cure" for between 28 and 56 days prior to testing to evaluate long-term behavior. The results of the test provided an average cohesion of 1610 psf with a friction angle of 32 degrees. These properties were used in the stability analyses.

2.6 Geosynthetic Interfaces

Geomembrane Interface inputs are based on lab work performed by Golder and published values (GRI 2005). The interfaces of interest are:

- Smooth HDPE against clay liner.
- Nonwoven, Needle Punched Geotextile against sand.

Geosynthetic interface shear strengths are based on interface shear test results and consider both peak and residual shear strengths. Two large-scale direct shear interface friction tests were performed between a 40-mil smooth high density polyethylene (HDPE) liner and site specific clays representative of those used in liner construction. The HDPE liner used in testing was excavated from site facilities and is similar to what was used during construction of Ash Pond 91. Results of the two tests indicate a friction angle of about 7.5 degrees and a residual adhesion intercept of approximately 200 psf for smooth HDPE against clay liner (Figure 2).

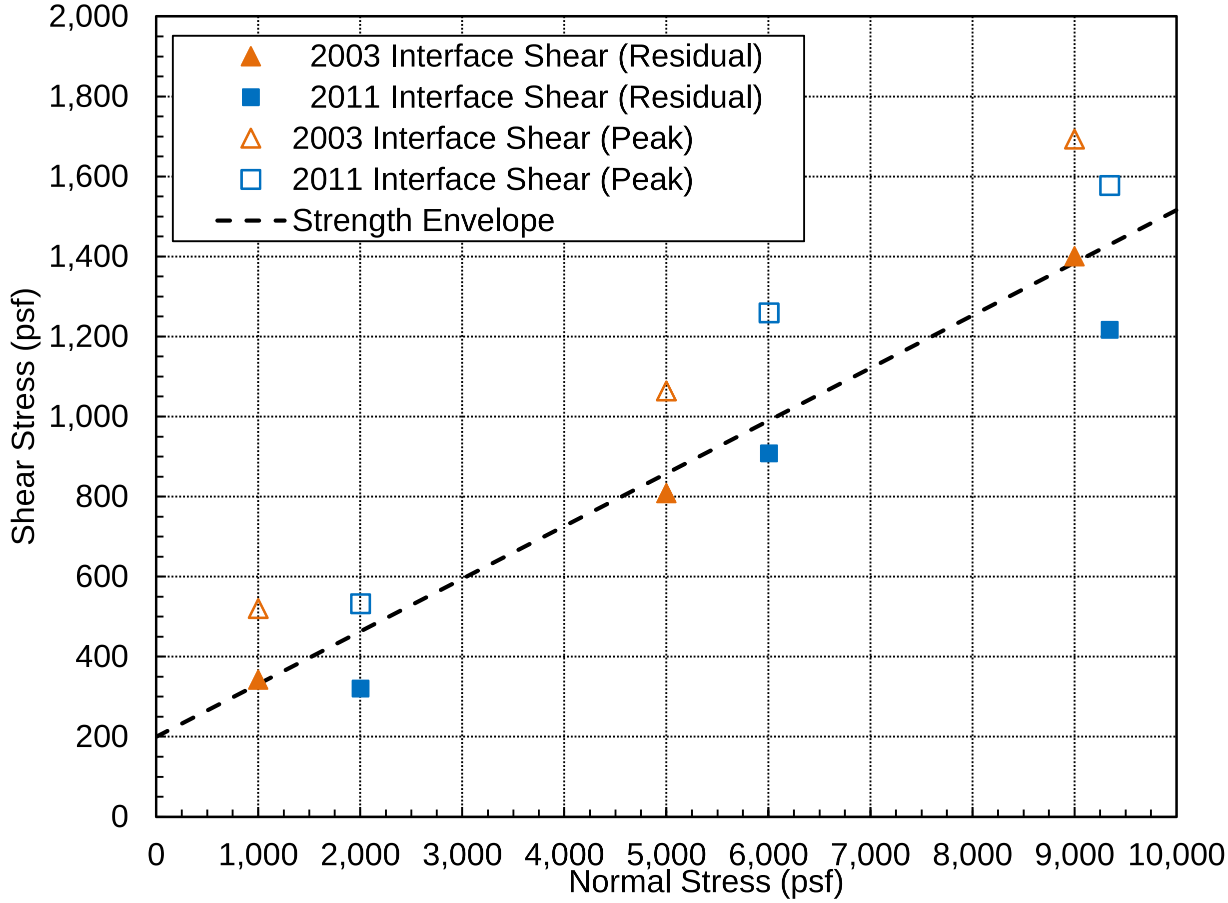


Figure 2: Interface Shear Tests for Smooth HDPE against Site-Specific Clay

Shear strength properties for the nonwoven, needle punched geotextile and sand/bottom ash are based on residual strength information for 117 tests published by GRI (2005) for interfaces between granular soil and nonwoven, needle punched geotextile. A friction angle of 33 degrees with no adhesion intercept was chosen for use in engineering analysis.

3.0 REFERENCES

NAVFAC 7.02. 1996. *Foundations and Earth Structures, Design Manual 7.02*, Naval Facilities Engineering Command. September.

Koerner, G.R. and Narejo, D. 2005. *Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces, Geosynthetic Research Institute Report #30.* June.

APPENDIX C

Seismic Loading Conditions

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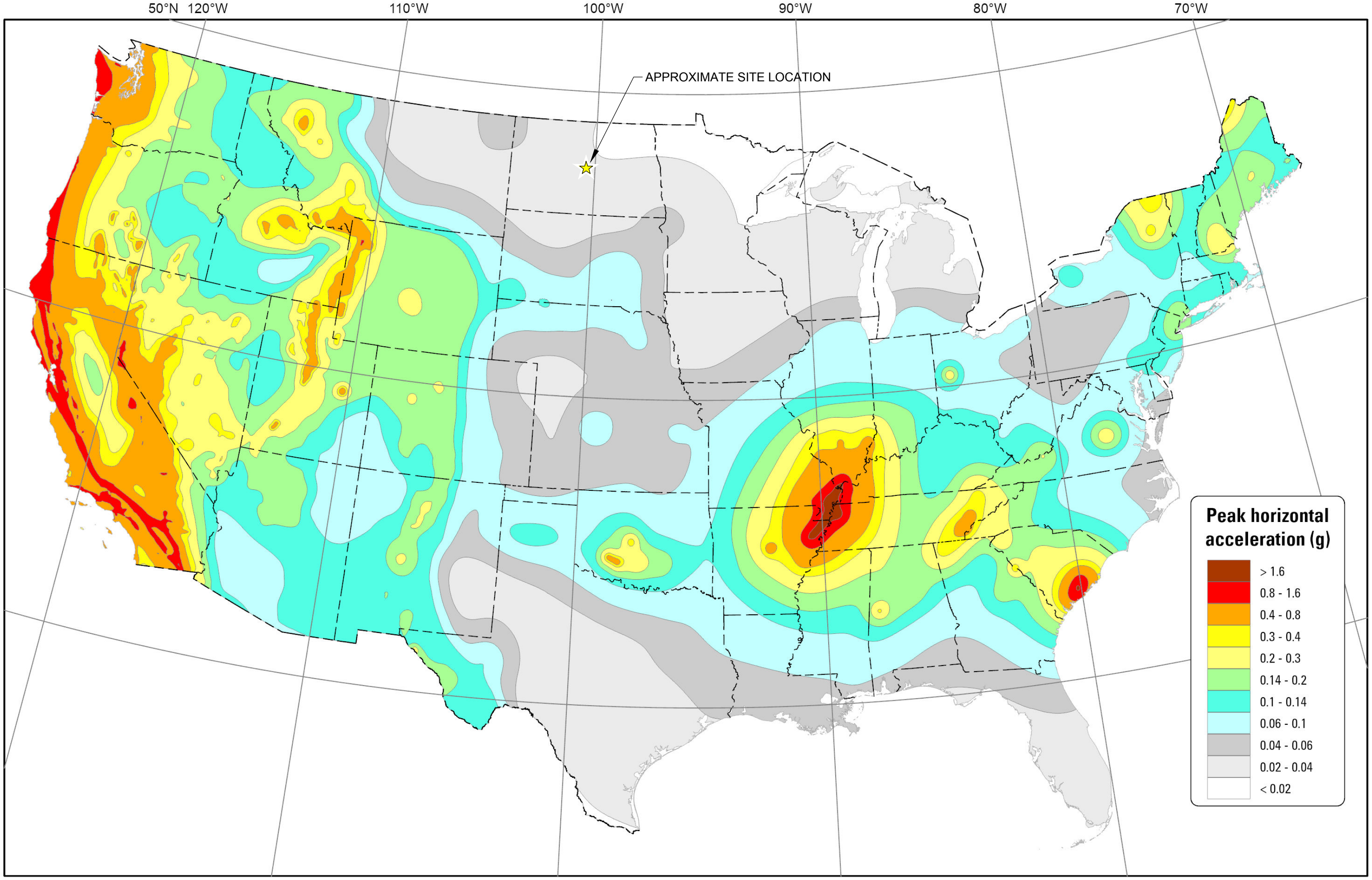

2018 National Seismic Hazard Model for the conterminous United States

Peak horizontal acceleration

with a 2% probability of exceedance in 50 years

NEHRP site class B/C (V_{s30} = 760 m/s)

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2% PROBABILITY OF EXCEEDANCE IN 50 YEARS MAP OF PEAK GROUND ACCELERATION
USGS SEISMIC HAZARD MAP (2018)

FIGURE C-1

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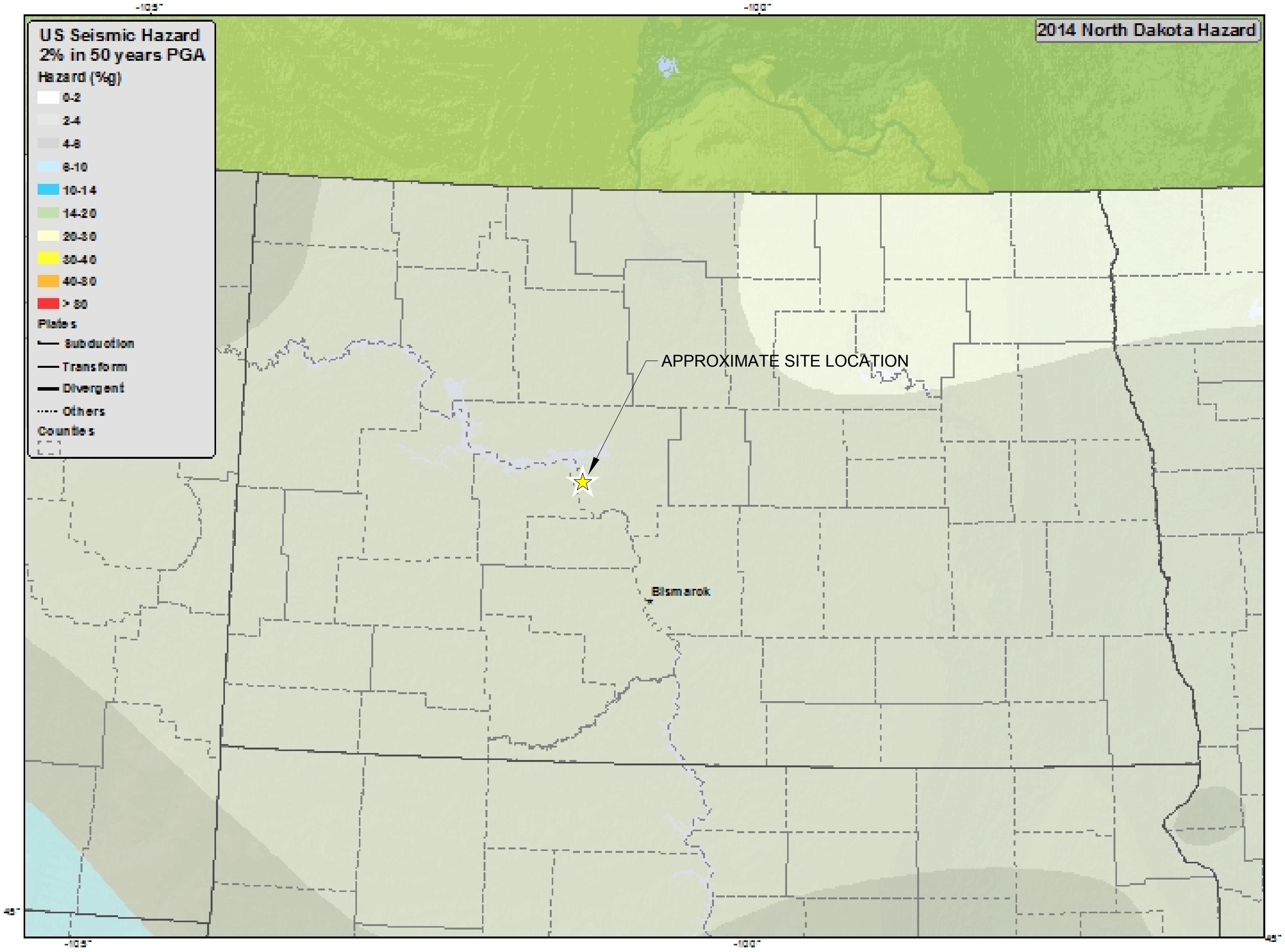

GOLDER
MEMBER OF WSP

2% PROBABILITY OF EXCEEDANCE IN 50 YEARS MAP OF PEAK GROUND ACCELERATION
USGS SEISMIC HAZARD MAP (2014)

FIGURE C-2

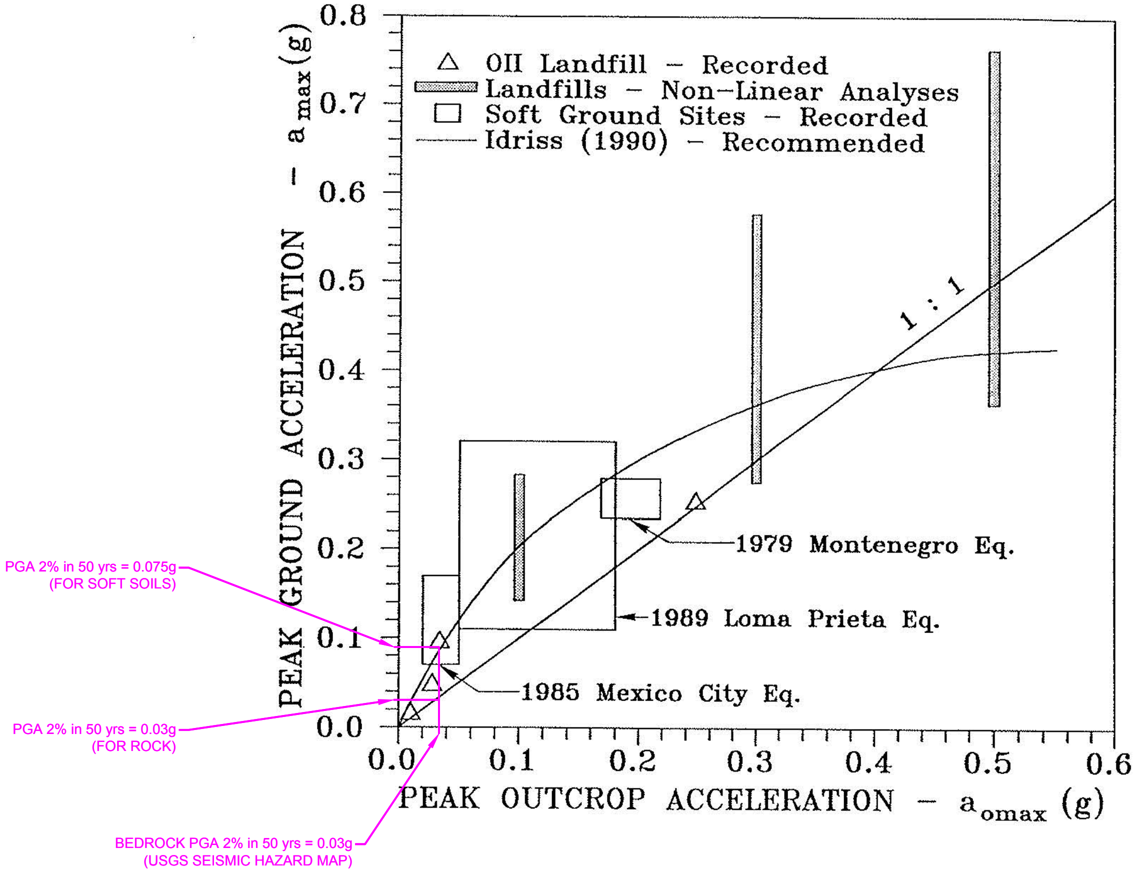

Figure 4.5 Observed Variations of Peak Horizontal Accelerations on Soft Soil and MSW Sites in Comparison to Rock Sites (Kavazanjian and Matasović, 1994).

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COMPARISON OF PEAK GROUND ACCELERATION AND PEAK OUTCROP ACCELERATION

FIGURE C-3

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