GSI Engineering

4503 E. 47th St. S.
Wichita, KS 67210
(316) 554-0725 tel
(316) 554-0744 fax
www.gsinetwork.com

March 29, 2016

Mr. Mark Buckingham, P.E.
MKEC
411 North Webb Road
Wichita, KS 67206

SUBJECT: Geotechnical Exploration
WWTP #2 Waterline Crossing
Wichita, Kansas
GSI Job No. 167073B

Dear Mr. Buckingham:

This letter presents the results of the geotechnical exploration and testing services performed by GSI Engineering, LLC (GSI) at the above referenced site.

The project addressed in this report comprises the installation of a re-use water supply line extending from an existing wastewater treatment plant to Spirit Aerosystems in Wichita, Kansas. The proposed water line will be installed beneath a levee along the Arkansas River at the existing Wichita wastewater treatment plant (WWTP) No. 2. The purpose of our exploration is to evaluate the subsurface conditions as they relate to maintaining the integrity of the existing levee during the advancement of the proposed horizontal directional drill (HDD) borehole.

Field Exploration
We drilled one boring for this geotechnical exploration on March 15, 2016 with a CME 55 track-mounted drilling rig using 3.25-inch inside diameter hollow stem augers. We drilled the boring on the west side of the levee, north of the wastewater treatment plant, to a depth of approximately 30 feet below the site grade at the time of our exploration. The location of the boring in relation to existing features is indicated on theboring location plan included with this letter.

Our drill crew obtained soil samples at the intervals shown on the boring log included with this letter. Recovered samples were sealed in plastic containers, labeled, and protected for transportation to the laboratory for further examination, testing, and classification.

We obtained split-barrel samples (designated “Split Spoon” or “S” samples) while performing Standard Penetration Tests (SPT) with a 1-3/8 inch I.D. thick-walled sampler, driven using an automatic hammer in general accordance with ASTM D1586, “*Penetration Test and Split-Barrel Sampling of Soils*.” The “N” value, reported in blows per foot (bpf), equals the number of blows required to drive the sampler through the last 12 inches of the 18-inch sample interval using a 140-pound hammer falling 30 inches.

Our drilling personnel prepared a field boring log during drilling operations. This field log reports drilling and sampling methods, sampling intervals, groundwater measurements and the subsurface conditions we encountered. At the conclusion of drilling, our drill crew made groundwater measurements and backfilled the boring in accordance with Kansas state regulations.

Laboratory Classification

Our engineering staff reviewed the field boring log to outline the depth, thickness and extent of the soil strata. The samples taken from the boring were examined in our laboratory and visually classified in general accordance with ASTM D2488, "*Description and Identification of Soils (Visual-Manual Procedure)*." We established a testing program to evaluate the engineering properties of the recovered samples. A GSI technician performed laboratory testing in general accordance with the following current ASTM test methods:

- Moisture Content (ASTM D2216, "*Laboratory Determination of Water (Moisture) Content of Soil and Rock*")
- Minus No. 200 Sieve Wash (ASTM D1140, *"Amount of Material in Soils Finer Than the No. 200 (75-µm) Sieve")*

Moisture content tests were used to evaluate the existing moisture condition of the soils. The Minus No. 200 sieve tests were used to help classify the soils under the Unified Soils Classification System. Laboratory test results are presented on the boring log included with this letter.

Based on the results of the laboratory classification and testing program, we reviewed and supplemented the field log to arrive at the final log as presented with this report. The final log represents our interpretation of the field log and reflects the additional information obtained from the laboratory classification. Stratification boundaries indicated on the boring log were based on observations made during drilling, an extrapolation of information obtained by evaluating samples from the boring, and comparisons of similar engineering characteristics. Locations of these boundaries are approximate and the transitions between soil types may be gradual rather than clearly defined.

Subsurface Conditions

Although we observed some variability, the subsurface materials we encountered within the depths of exploration generally comprised clayey sand, poorly graded sand with clay and poorly graded sand. General descriptions of the strata we encountered are presented below, while more detailed subsurface information is presented on the boring log located in Appendix B. Please note that the indicated depths are relative to the site grade at the boring location at the time of our exploration.

Stratum 1

We encountered clayey sand and poorly graded sand with clay in our boring underlying a 6-inch topsoil layer and extending to a depth of 11 feet. This material was generally described as dark brown or yellowish brown and moist. We measured Standard Penetration Test (SPT) N-values between 11 and 15 blows per foot (bpf), indicating the clayey sand and poorly graded sand with clay soils are in a medium dense condition.

Stratum 2

We encountered poorly graded sand in our boring from a depth of 11 feet and extending to a depth of 25 feet. This material was generally described as yellowish brown to dark yellowish brown or very

dark gray and moist to wet. We measured SPT N-values between 7 and 22 bpf, indicating the poorly graded sand is in a loose to medium dense condition.

Stratum 3
We encountered sandy lean clay transitioning into shale bedrock in our boring underlying the sandy soils described above and extending to the termination of the boring at 30 feet. This material was generally described as very dark gray and wet. We measured an SPT N-values 19 bpf, indicating the cohesive soils are in a very stiff condition. The shale bedrock was generally described as decomposed, very soft rock.

Groundwater Conditions
Our drill crew made ground water observations during drilling to evaluate ground water conditions. We observed groundwater as indicated on the boring log at a depth of approximately 15 feet below current site grade. Please note that the addition of water during drilling obscured the post-drilling groundwater level. However, a review of nearby water well records indicates that the groundwater level we observed is representative of the typical water table depth.

The groundwater conditions we observed during our exploration program should not be construed to represent an absolute or permanent condition. Uncertainty is involved with short-term water level observations in boreholes. The groundwater level and the amount and level of any perched water on the site may be expected to fluctuate with variations in precipitation, site grading, drainage and adjacent land use.

Entry and Exit Pit Excavations
Vertical cuts and excavations may stand for short periods of time, but should not be considered stable in any case. All excavations should be sloped back, shored, or shielded for the protection of workers. As a minimum, trenching and excavation activities should conform to federal and local regulations.

The sandy soils we encountered in our test boring generally classify as a type “C” soil according to OSHA’s Construction Standards for Excavations. In general, the maximum allowable slope for shallow excavations of less than 20 feet in a type “C” soil is 1.5H:1V, although other provisions and restrictions may apply. If different soil types are encountered, the maximum allowable slope may be different.

The Contractor is responsible for designing any excavation slopes or temporary shoring. The Contractor must also be aware that slope height, slope inclination, and excavation depths (including utility trench excavations) should in no case exceed those specified in federal, state, or local safety regulations, such as OSHA Health and Safety Standards for Excavations, 29 CFR Part 1926, or successor regulations.

The information presented in this section is solely for our client’s reference. **GSI assumes no responsibility for site safety or the implementation of proper excavation techniques.**

Allowable Drilling Fluid Pressures
We evaluated the maximum allowable drilling fluid pressures for the HDD bore based on the method developed by the US Army Corps of Engineers and presented in Appendix A of CPAR-GL-98-1, *“Installation of Pipelines Beneath Levees Using Horizontal Directional Drilling,”* using the following input parameters:

- Wet Density ..... 105 lb/ft^3
- Cohesion .....0.0 kips/ft^2
- Friction Angle ..... 35 degrees
- Shear Modulus, G .....200 kips/ft^2
- Groundwater Table ..... 15 feet
- Borehole Radius ..... 10 inches

The maximum allowable drilling fluid pressure in relation to HDD bore depth for a 20 inch HDD bore is presented in a chart attached to this report and are based on a factor of safety of 1.5 against hydrofracture extending to the ground surface. The depths indicated on the chart are measured from the ground surface at the boring location.

Setback Distances and Riverbed Clearance

A detailed seepage analysis was not included in the scope of work for this exploration. We recommend contacting the US Army Corps of Engineers regarding setback distances from the existing levee.

In our experience with similar projects, the HDD bore should maintain a depth of approximately 20 feet below the riverbed to reduce the risk of scour on the installed pipe. However, the required pipe alignment and other factors may dictate the design depth of the bore.

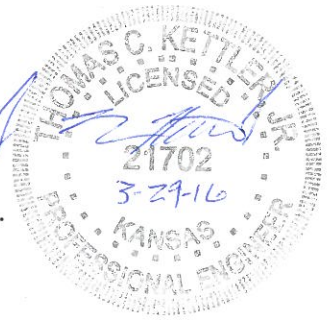
Closure

We appreciate this opportunity to be of service in the geotechnical exploration phase of this project and are prepared to assist you as the project progresses. Please contact us if you have any questions concerning this report or any of our other consulting or testing services.

Respectfully submitted,
GSI Engineering, LLC

Matthew N. Tye, I.E.
Staff Engineer

Thomas C. Kettler, Jr., P.E.
Senior Engineer



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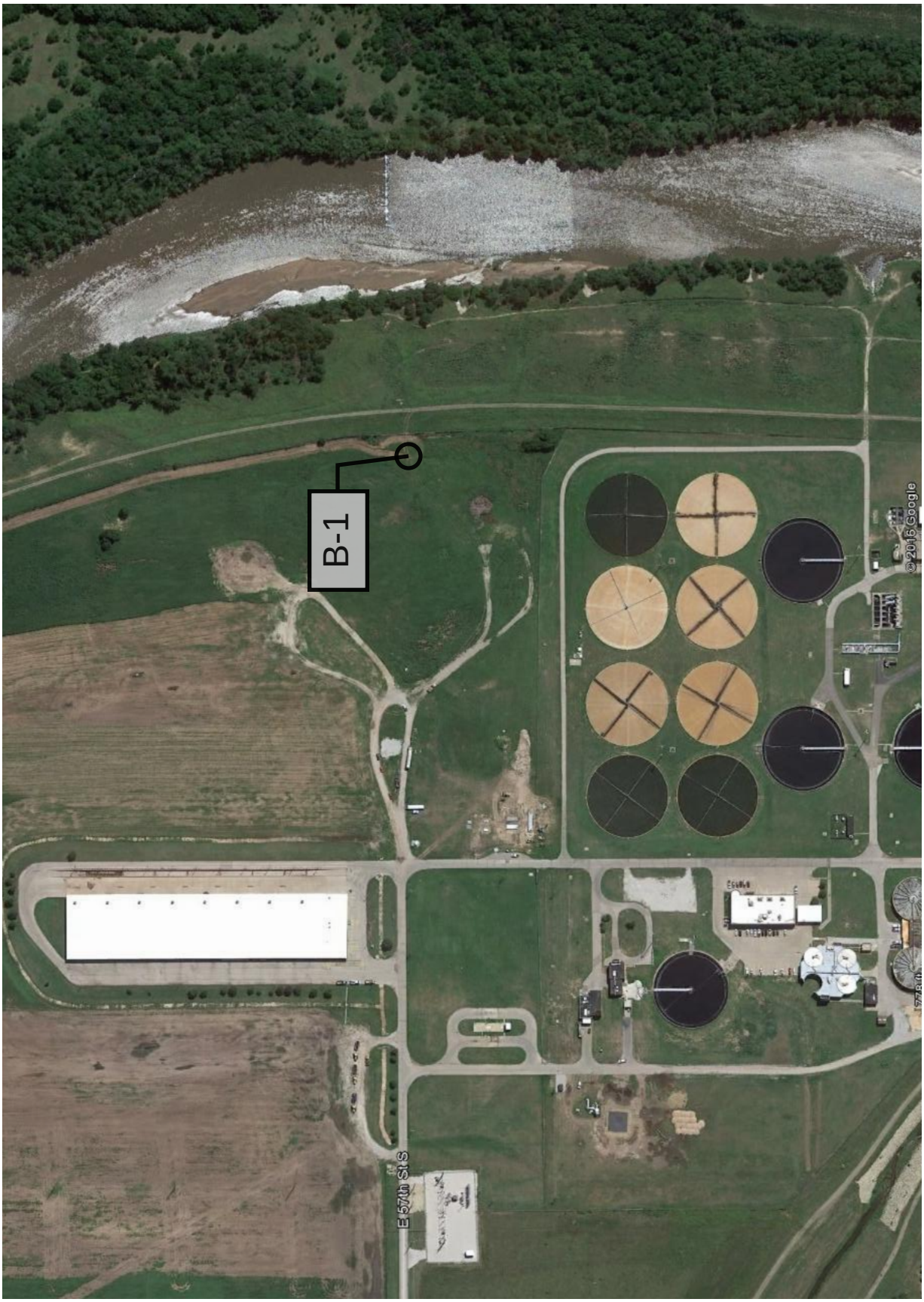

FIG #:	PROJ. #:
1	167073B
DATE:	SCALE:
3/21/16	NTS
DRAWN BY:	PROJECT MANAGER:
MNT	TCK

GSI Engineering

BORING LOCATION PLAN
WWTP #2 WATERLINE HDD
WICHITA, KANSAS

BORING LOG No. B-1

BORING NO.	LOCATION OF BORING	ELEVATION	DATUM	DRILLER	LOGGER
B-1	See Boring Location Plan			A. Thornburg	M. Schell

WATER LEVEL OBSERVATIONS				TYPE OF SURFACE	DRILL RIG
WHILE DRILLING	END OF DRILLING	24 HOURS AFTER DRILLING	AFTER DRILLING	Grass	CME 55 Track
				DRILLING METHOD	TOTAL DEPTH
15.0 ft.	N.D.	Boring Plugged After Drilling		3.25" Hollow Stem Augers	30.0 ft.

DEP. FT.	SAMPLE DATA: SAMPLE NO. & TYPE	"N" BLOWS (FT)	% REC.	SOIL DESCRIPTION: COLOR, CONSISTENCY, MOISTURE / GEOLOGIC DESCRIPTION & OTHER REMARKS	USCS CLASS.	LABORATORY DATA: MC %	Dry Dens. pcf	q_u ksf	ELEV. FT.
				6" TOPSOIL (0.5')					
	S-1	15		CLAYEY SAND- dark brown, moist, medium dense, fine grained (2.5')	SC	10.2			
	S-2	13		POORLY GRADED SAND w/ CLAY- yellowish brown, moist, medium dense, fine grained		12.2			
5	S-3	11		- as above	SP-SC	8.9			
10	S-4	14		- as above % Pass #200: 8.5		7.0			
	S-5	22		POORLY GRADED SAND- yellowish brown, moist, medium dense, medium grained with trace gravel (11.0')		2.6			
15	S-6	7		- wet, loose, medium to coarse grained, else as above					▽
20	S-7	7		- dark yellowish brown, coarse grained, else as above	SP				
25	S-8	10		- very dark gray, medium dense, else as above					
				SANDY LEAN CLAY- very dark gray, wet, stiff (25.0')	CL				
30	S-9	19		SHALE- very dark gray, decomposed, very soft rock (28.5')					
				Bottom of Boring @ 30' (30.0')					
35									
40									

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PROJECT: WWTP #2 Waterline HDD
LOCATION: Wichita, Kansas
JOB NO.: 167073B
DATE: March 15, 2016

KEY TO SYMBOLS

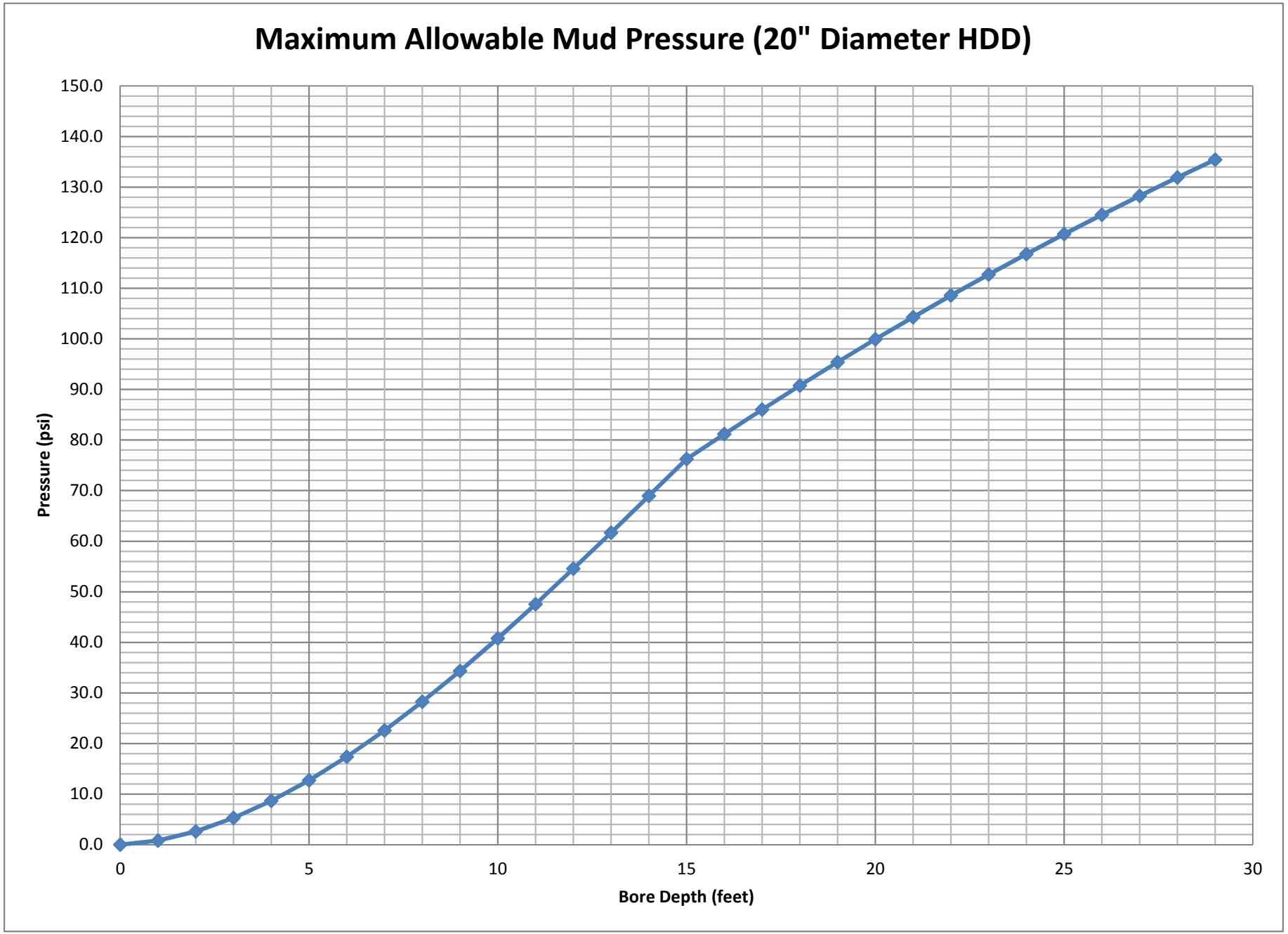
Symbol	Description
Strata symbols	
	Topsoil
	Clayey sand/ Low plasticity clay
	Poorly graded sand with clay
	Poorly graded sand
	Lean clay w/sand or sandy lean clay
	Shale
Misc. Symbols	
	Water table during drilling

Notes:

1. The exploratory boring was drilled on March 15, 2016 using 3.25-inch diameter hollow stem augers.

2. This log is subject to the limitations, conclusions, and recommendations in this report.

3. Results of tests conducted on samples recovered are reported on the log.


Maximum Allowable Mud Pressure (20" Diameter HDD)
Pressure (psi)
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
5
10
15
20
25
30
Bore Depth (feet)