SLOPE STABILITY ANALYSIS AND REMEDIATION RECOMMENDATIONS

HILLSBOROUGH COUNTY SHERIFF'S SHOOTING RANGE

Hillsborough County, Florida

PREPARED FOR:

LANDMARK ENGINEERING & SURVEYING CORPORATION

8515 Palm River Road
Tampa, Florida 33619

FES PROJECT NO.: 18-3712 (Rev. 1)

March 21, 2018
(Revised June 8, 2018)

EXHIBIT A (REVISED)

PREPARED BY:

FAULKNER
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FAULKNER
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GEOTECHNICAL ENGINEERING
& CONSTRUCTION
MATERIALS TESTING

March 21, 2018

(Revised on June 8, 2018)

Mr. E. Everett Morrow, P.E.
Landmark Engineering & Surveying Corporation
8515 Palm River Road
Tampa, Florida 33619

RE: Slope Stability Analysis and Remediation Recommendations
Hillsborough County Sheriff's Shooting Range
Hillsborough County, Florida
FES Project No.: 18-3712 (Rev.1)

Dear Mr. Morrow:

Faulkner Engineering Service, Inc. (FES) has completed a slope stability analysis for the referenced project. We provided our services in general accordance with our proposal number P17-5621, dated December 8, 2017. The purpose of the investigation was to evaluate the failed portion of the existing shooting backdrop berm and provide recommendations for stabilizing the slopes.

Based on the review of the information provided to us and a site visit, we understand that a shallow sloughing failure had occurred along approximately half of a shooting backdrop berm located at the Hillsborough County Sheriff's Shooting Range located on the west side of County Line Road 39 in Lithia, Hillsborough County, Florida (**Figure 1**). It was reported that the berm was originally built by the US Army Corps of Engineers (USACOE) about 30 years ago. The reported slope failure had occurred during/after hurricane Irma in September 2017.

FES was retained to perform slope stability analysis for the berm and provide remedial recommendations. Landmark Engineering & Surveying Corporation (Landmark) performed a topographic survey of the berm and provided cross-sections to FES.

Existing Site Conditions

The berm appears to have been constructed with side slopes of 2 horizontal to 1 vertical (2H:1V). The natural ground surface elevation near the base of the berm (both north and south sides) was approximately elevation 117 feet, North American Vertical Datum of 1988 (NAVD88) on both sides. The slopes meet near the crest of the berm at approximately elevation 147 feet (NAVD88). The backside of the berm had a bench approximately 10 to 15 feet wide near the area of the slope failure. Beyond the bench, the ground surface drops approximately 10 feet to a wetland area. The berm slopes were covered with thick grass. In addition, saturated conditions and indications of seepage (possibly from recent rains and/or irrigation) was observed within the slope failure area. We have also observed an irrigation system near the berm crest.

Field Investigation

During our field investigation, FES performed two (2) standard penetration test (SPT) borings advanced to depths of about 40 to 45 feet below ground surface (bgs) and six (6) hand auger borings within the berm slope near and within the failure area were advanced to depths of about 4 to 7 feet existing grade. The SPT borings were extended deeper than the previously proposed depths of 25 feet (bgs) to verify the depth and thickness of the very loose soils encountered. The fieldwork was performed on February 5, 2018. The procedures used by FES for field sampling and testing were in general accordance with ASTM procedures, industry standards of care and established geotechnical engineering practice.

A senior geotechnical engineering technician from FES, experienced in soil sampling and classifications, was onsite during the fieldwork to monitor the drilling and also perform a brief cursory site reconnaissance, noting pertinent site and topographic features as well as surface indicators of soil conditions. FES staff personnel located the SPT borings (B-1 and B-2) and hand auger borings (HA-1 to HA-6) in the field near and within the slope failure area and marked the borings with flags. Landmark performed topographic elevation survey of the berm and provided ground elevations near the boring locations. The boring locations are shown on the attached boring location plan (**Figure 2**) should be considered approximate.

The SPT borings were performed using an all-terrain vehicle mounted CME-45 drill rig, operated by J&R Precision Drilling, Inc. The SPT borings were performed utilizing continuous sampling methods within the first 10 feet and every 5 feet thereafter until the termination depths of the borings, employing wet rotary drilling techniques to keep the holes from collapsing. The drillers collected soil samples using a 1.4-inch I.D. split barrel sampler driven by an automatic hammer system with a 140-pound hammer falling a distance of 30 inches, in general accordance with standard penetration test procedures (ASTM D1586). Upon completion, each borehole was backfilled with cuttings and bentonite chips to the surface.

Hand auger borings were advanced by manually rotating a small diameter bucket auger into the subsurface soils. Cuttings brought to the surface were logged in the field and representative samples were obtained at each change in soil stratigraphy. Upon completion, each borehole was backfilled with soil cuttings to the ground surface.

Detailed descriptions of the soils encountered during the field exploration are presented on the attached boring logs and profiles in **Appendix A**.

Soil Sample Handling, Classification, and Laboratory Testing

FES field personnel classified the soils obtained from the field sampling techniques using standard visual manual methods in accordance with ASTM D2488. The samples recovered from both the SPT and auger borings were placed in sealed containers to retain moisture and transported to the FES soils laboratory accredited by Construction Materials Engineering Council, Inc., (CMEC) for further evaluation and testing. To further aid in classification and evaluation of geotechnical engineering properties, laboratory testing was performed on representative soil samples collected during the field sampling. The laboratory testing was performed in general accordance with appropriate sections of ASTM D1140, material finer than the No. 200 sieve, ASTM D6913, particle-size distribution (gradation) of soils using sieve analysis and ASTM D2434, permeability of granular soils. The laboratory test results and the soil classifications were reviewed by a professional geotechnical engineer. The results of the laboratory testing are presented in **Appendix A** and **B**.

Laboratory hydraulic conductivity testing was performed on four (4) soil samples collected from the berm fill. The laboratory hydraulic conductivity testing was performed in accordance with constant head test method (ASTM D2434). Measured values of saturated vertical hydraulic conductivity are provided below:

Location	Depth Below Ground Surface (feet, bgs)	Laboratory Saturated Vertical Hydraulic Conductivity, k_v (feet/day)
HA-1	0 - 2	16
HA-2	0 - 3	17
HA-5	0 - 3	14
HA-6	0 - 2	13

Subsurface Conditions

General Soil Profile

The subsurface stratigraphy at the project site is illustrated in the soil boring logs and profiles shown in **Appendix B**. The logs and profiles were developed using field and laboratory data from the SPT and auger borings. The computer generated boring logs and profiles should not imply increased accuracy. Based on this data, four subsurface units, or strata, were identified at the site as described below.

Stratum 1	FILL (SAND, SAND with clay, SAND with silt, CLAYEY SAND); very loose to medium dense, fine grained quartz, variable amounts of clay, silt, with shell and clay/clayey sand nodules USCS classification = SP, SP-SC, SP-SM, SC
Stratum 2	SAND, SAND with clay, SAND with silt; very loose to medium-dense, fine grained quartz with variable amounts of clay, silt, occasional cementation USCS classification = SP, SP-SC, SP-SM
Stratum 3	CLAYEY SAND, SILTY SAND; very loose to medium dense, fine grained quartz, variably clayey, silty USCS classification = SC, SM
Stratum 4	SILT; medium, SILT USCS classification = ML

Stratum 1 is the fill material previously used to construct the berm. This stratum was encountered only in the hand auger borings HA-1 to HA-6. The fill material consisted of sand, sand with silt, sand with clay, and clayey sand with occasional clayey sand/clay nodules. The results of laboratory testing performed on the representative samples of this stratum indicated fine contents ranging from 1.4 to 19.6 percent. The berm fill appears to be suitable for use as structural fill.

Stratum 2 occurred as the surficial stratum in the two SPT borings and extended with varying thicknesses to depths ranging from about 8 feet to boring termination at about 40 feet (bgs). This stratum consisted of sand, sand with clay and sand with silt. The SPT "N" values within this stratum ranged from 0 to 22 blows per foot indicating very loose to medium dense relative density.

Stratum 3 occurred in both SPT borings interbedded with Stratum 1 at depths ranging from about 8 to 43 feet (bgs). This stratum consisted of clayey sand and silty sand. The SPT "N" values within this stratum ranged from 2 to 11 blows per foot indicating very loose to medium dense relative density. The result of laboratory testing performed on one of the representative sample B-2 (8-10 feet, bgs) indicated fine contents of 22.3 percent.

Stratum 4 occurred only in boring B-1 at a depth of about 43.5 feet (bgs) extending to the boring termination depth of about 45 feet (bgs). This stratum consisted of silt with only SPT "N" value of 8 blows per foot indicating medium consistency.

The conditions presented above highlight the major subsurface stratifications encountered during our field investigation of the site. More detailed descriptions of the materials encountered are provided in **Appendix A**. A soil classification key sheet is included as **Appendix C**. Subsurface conditions will vary across this site and between boring locations. Changes in subsurface strata may be more gradual than indicated on the logs and profiles.

Groundwater

Groundwater was not encountered within the first 10 feet in the two SPT borings after which drilling fluid was used to keep the boreholes from collapsing. Based on the visual inspection and the topography contours provided by Landmark, it appears that the groundwater will be approximately at 12 feet (bgs) at elevation approximately 105 feet (NAVD88). In addition, water levels were not measured in the hand auger borings performed within the berm slope failure area. However, we observed saturated soil conditions within the berm fill and indications of seepage (possibly from recent rains and/or irrigation) along the failure surface.

Engineering Analyses

Design Cross-Section

The typical design cross-section of the shooting backdrop berm was analyzed based on the topographic survey and cross-sections provided by Landmark.

Typical Features

Based on the topographic survey information provided by Landmark, it appears that the berm was constructed with 2H:1V berm slopes to a crest elevation approximately 30 feet above ground surface. The berm fill consisted of sand (SP), sand with clay (SP-SC), sand with silt (SP-SM), and clayey sand (SC). The foundation soils consisted of sand (SP), sand with clay (SP-SC), sand with silt (SP-SM), clayey sand (SC), silty sand (SM), and silt (ML). Based on the SPT borings performed at the site, medium-dense sandy soils were encountered immediately below the berm foundation followed by very loose to loose sands underlain by medium silt. The groundwater table was not encountered within the first 10 feet in both the borings. Based on the inspection of the wetland area on the north side of the berm, groundwater is expected to be about 12 feet below the base of the berm.

Soil Strata Engineering Properties

The engineering properties for the foundation soil strata used for the design cross-section were estimated based on the data obtained from the SPT and hand auger borings using established geotechnical correlations. The properties for the berm fill were estimated based on the results of the laboratory data.

1. Berm Fill

This material is the fill used to construct the berm. We assumed the unit weight (γ) of the stratum to be 115 pounds per cubic feet (pcf), the effective stress angle of internal friction (ϕ') to be 34°, and the effective stress cohesion (c') was assumed to be 0 pounds per square foot (psf).

2. Foundation Sandy Soils - 1

This stratum is the soil unit occurring at the natural ground surface at the site immediately below the berm bottom and extending to about 10 to 15 feet below the berm bottom. The soil consisted of sand (SP), sand with clay (SP-SC), sand with silt (SP-SM), and clayey sand (SC). The following strength properties are assumed based on the results of the SPT borings performed at the site and established geotechnical correlations. The unit weight (γ) of this soil unit was assumed to be 115 pcf, ϕ' was assigned as 34°, and c' was assumed to be 0 psf.

3. Foundation Sandy Soils - 2

This stratum is the soil unit occurring at about 10 to 15 feet below the berm bottom extending to about 40 feet below berm bottom. The soil consisted of sand (SP), sand with clay (SP-SC), sand with silt (SP-SM), clayey sand (SC), and silty sand (SM). The following strength properties are assumed based on the results of the SPT borings performed at the site and established geotechnical correlations. The unit weight (γ) of this soil unit was assumed to be 105 pcf, ϕ' was assigned as 30°, and c' was assumed to be 0 psf.

4. Silt

This stratum is the soil unit that occurred below the sandy soils in our SPT boring at about 43.5 feet extending to boring termination at about 45 feet (bgs). This stratum consisted of silt. The following strength properties are assigned based on the results of the encountered SPT "N" value. The unit weight (γ) was assumed to be 120 pcf, ϕ' was assigned to be 0°, and c' was assigned to be 500 psf.

Slope Stability Analysis

Slope stability analyses were performed for the typical design section assuming well compacted fill material. Slope stability analyses were performed using the computer program SLOPE/W (Slope Stability Modeling with SLOPE/W, An Engineering Methodology, GEO-SLOPE International, Ltd., Krahn, John, 2004), of the GeoStudio 2012 (Version 8.14.1.10087) software package. SLOPE/W performs a limit-equilibrium analysis using a method-of-slices search routine to look for the critical failure surface, which is the surface with the minimum factor of safety.

SLOPE/W can use pore water pressures calculated from a phreatic surface that is defined by the user. The phreatic surface was drawn at approximately elevation 105 feet (NAVD88).

The cross-section geometry from the provided topographic survey was used for the berm in order to determine the minimum calculated factor of safety (FS) against slope failure. Factors of safety were checked for both shallow and deep seated failures.

The results of our field investigation indicated saturated conditions within the berm soils and the berm fill consisted of clean sandy soils and clayey sands interlayered within the failure area. It appears that the infiltration of water from heavy and prolonged rains probably caused water to temporarily perch over the clayey sand layers within the berm failure area, creating saturated conditions within the berm.

Slope stability analyses were performed for "as-constructed" geometry assuming dry fill (no phreatic surface within the berm), as the natural groundwater table is more than 10 feet below the base of the berm. Another iteration of the stability analysis was performed for "as-constructed" geometry assuming saturated berm fill conditions to simulate the effect of perched water condition within the berm as observed during our field investigation.

Results of the Stability Analysis

The results of the slope stability analyses (**Appendix D**) indicated an acceptable critical factor of safety of 1.5 for the "as-constructed" geometry and dry backfill conditions. The factor of safety for deep seated global failure that extended through the berm foundation was 1.6. However, the critical factor of safety reduced to less than 1.0 (unstable; indicates likely slope failure) when the berm fill was saturated.

Conclusions and Recommendations

Based on the results of the slope stability analyses and the field and laboratory data obtained, it appears that the berm has an adequate factory of safety against a slope failure for the "as-constructed" geometry and dry backfill conditions. However, the results of the hand auger borings performed within the slope failure area indicated that the fill material consisted of interlayered highly permeable sandy soils and low permeable clayey sands, causing saturated and possibly perched water conditions within the berm. The results of the slope stability analysis performed for the saturated berm soil conditions yielded a factor of safety of less than 1.0 indicating slope failure.

The remediation of the slope should include rebuilding the entire length of the slope failure (Sta. 1+50 to 5+00) as shown in **Figure 2**. Once the slope is re-built, we recommend installing a 30-mil PVC liner over the berm slope to reduce future infiltration due to precipitation. We also recommend placing a geotextile and 6-inch geoweb filled with soil over the PVC liner. Sod should be placed over the geoweb. The berm reconstruction and slope protection details are provided in **Figures 3** to **5**.

The existing south slope should be cut at a slope of 3H:1V in 3-foot wide and 1-foot high steps as shown in **Figure 5**. The previously sloughed fill material and the newly cut berm fill should be properly blended to prepare a homogeneous fill material. The blending process must include screening/removal of all vegetation. This properly blended fill material should be placed in maximum 1-foot thick loose lifts and compacted to a minimum of 95 percent of modified Proctor maximum dry density as determined by ASTM D1557. The moisture content of the fill material during placement and compaction should be within +3 and -2 percent of the optimum moisture content (ASTM D1557).

Once the berm slope is re-built to original slope (2H:1V) we recommend installing a 30 mil PVC liner (Colorado Lining International PVC 30 or equivalent) over the slopes (**Figure 5**). In addition, a geotextile (Mirafi 180 N or equivalent) overlain by a 6-inch geoweb (Presto Geosystems GW40V or equivalent) should be installed over the PVC liner. The geoweb cells can be filled with soil fill to facilitate vegetation growth. Sod can be placed over the geoweb. The PVC liner, geotextile and geoweb should be installed in accordance with manufacturer's recommendations. The product details of the geosynthetic slope protection are provided in **Appendix E**.

General Earthwork Recommendations

Site Preparation

Site Stripping/Undercutting

Before earthwork and construction activities begin, existing topsoil, vegetation surface debris, large roots down to finger-size, and any other deleterious material should be removed from the slopes within the construction limits. Site stripping should extend at least 10 feet beyond the construction area. Any pockets of organics, organic-laden soils and/or deleterious material should be undercut to competent soil.

This process should be observed by a representative of FES to check that organics, organic-laden soils and/or deleterious material has been removed.

Proof-Rolling / In-Place Densification

Following site stripping and prior to any fill placement, proof-rolling / in-place densification should be performed on the exposed construction surface using appropriate compaction equipment.

Compaction within the construction area should continue until the soils appear relatively firm and unyielding and have achieved a relative compaction of at least 95 percent of the modified Proctor maximum dry density (ASTM D1557). The water content of the soils during placement and compaction should be maintained within 2 percent of the optimum water content as determined by ASTM D1557.

An FES engineering technician should closely monitor proof-rolling and densification efforts to check for any unusual or excessive deflection of the soils beneath the compacting equipment used. If unusual or excessive deflection is observed, then the areas should be undercut to firm soil and backfilled with compacted structural fill placed in maximum one-foot thick loose lifts.

Borrow Areas

Structural Fill Suitability

Definition

The preferred soil for use as structural fill and backfill is clean or relatively clean fine sand containing less than 12 percent material by weight finer than a number 200 sieve (material conforming to SP to SP-SM or SP-SC in the Unified Soil Classification System).

Fill materials containing up to 25 percent fines (materials conforming to SC or SM in the Unified Soil Classification System) may also be utilized as structural fill, provided their plasticity index is less than 10, and the working subgrade is above the existing groundwater level. However, we recommend that the berm fill that was cut and previously sloughed near the toe of the berm should be properly blended to prepare a homogeneous material prior to construction.

Any muck or organic soil if encountered on site will not be suitable for use as structural fill and should be disposed of offsite or placed in landscape areas and used for planting purposes. In addition, soils containing organics, as determined by ASTM D2974, of more than 5 percent should not be used as structural fill. Because of the variability of the subsurface soils encountered, laboratory testing should be performed on the excavated material during grading and earthwork activities to evaluate suitability for use as fill material.

Placement

Structural fill with less than 12 percent fines should be placed in lifts not to exceed one foot thick. Materials with fines content greater than 12 percent should be placed in maximum 6-inch loose lifts.

Fill material should be compacted to at least 95 percent of its modified Proctor maximum dry density and the water content should be maintained within +3 to -2 percent of the optimum water content (ASTM D1557). Confined areas, such as anchor trenches, should be compacted with manually operated portable vibratory compaction equipment.

Field density testing should be performed as the fill is being placed. A minimum of 3 tests or one test in every 150 feet on each completed lift. Prior to beginning construction, samples of the blended homogeneous fill material should be collected for modified Proctor testing.

Testing and Monitoring

Construction testing and monitoring are essential to proper site construction and performance. Observation and testing of site preparation and earthwork activities is an integral part of the engineering recommendations contained in this report. Having FES provide the construction materials testing and inspection services provides continuity and increases the potential that our recommendations will be properly implemented.

Limitations

This report has been prepared for the exclusive use of **Landmark Engineering & Surveying Corporation** for the specific application to the project previously discussed. Our conclusions and recommendations have been rendered using generally accepted standards of geotechnical engineering and geology practice in the state of Florida. No other warranty is expressed or implied.

Our conclusions and recommendations are based on the design information furnished to us and the stated assumptions, and professional judgment. If changes are made in the overall design or the configuration of the slopes from those previously discussed in this report, the recommendations presented in this report must not be considered valid unless the changes are reviewed by our firm and recommendations modified or verified in writing.

Closing

Faulkner Engineering Services, Inc. appreciates the opportunity to be of service to **Landmark Engineering & Surveying Corporation,** by providing these geotechnical consulting services and we look forward to assisting you through project completion. If you have any questions concerning this report, please do not hesitate to contact the undersigned.

Sincerely,
Faulkner Engineering Services, Inc.

Khagendra Kandel, E.I.
Staff Geotechnical Engineer

Pavan K. Kolukula, P.E.
Senior Geotechnical Engineer
Florida License No. 83670

5/8/2018
PAVAN K. KOLUKULA
No. 83670

Figure 1: Site Location Map
Figure 2: Boring Location Plan
Figure 3: Proposed Berm Remediation
Figure 4: Proposed Slope Protection
Figure 5: Typical Berm Repair Details

Appendix A: SPT Boring Logs and Auger Boring Profiles

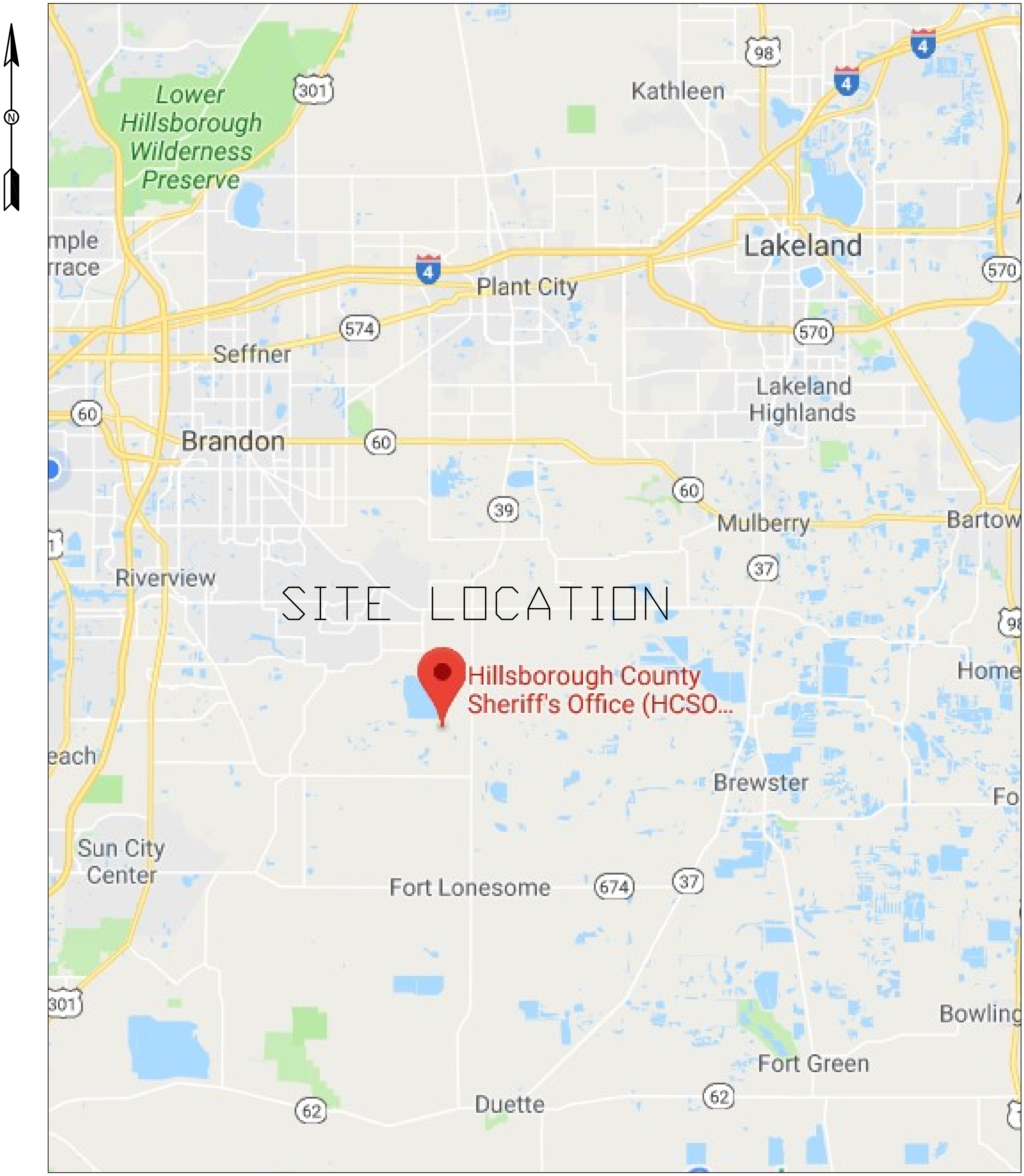
Appendix B: Laboratory Test Results

Appendix C: Key to Soil Classification

Appendix D: Slope Stability Analysis Results

Appendix E: Geosynthetic Slope Protection Product Details

SITE LOCATION MAP



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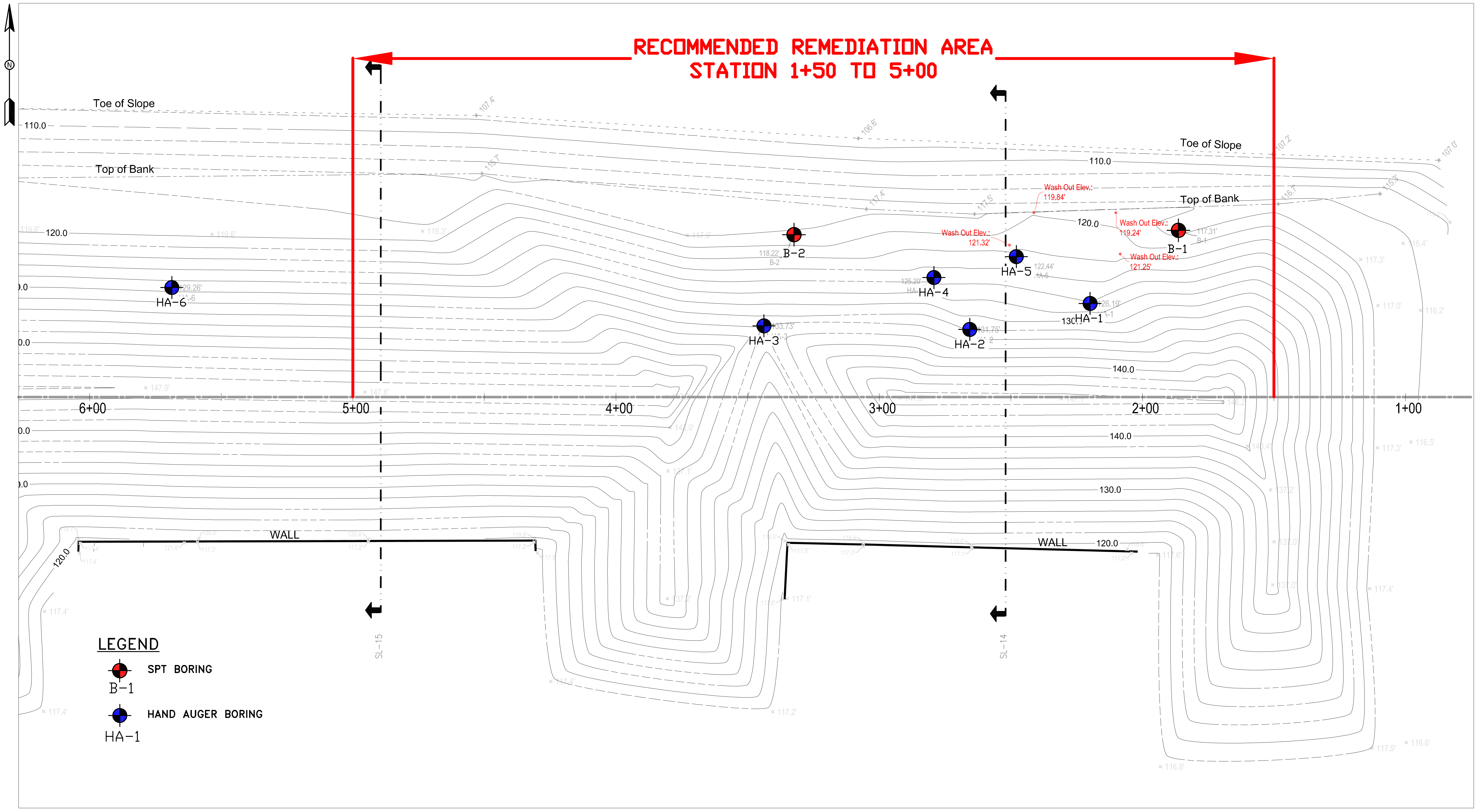
Hillsborough County
Sheriff's Shooting Range

N.T.S.	DATE 03.20.18	JOB NO. 18-3712
DRAWN: KK CHKD: PK	FIGURE 1	

BORING LOCATION PLAN



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DRAWN: KK
CHKD: PK
DATE 03.20.18
JOB NO. 18-3712
FIGURE 2

PROPOSED BERM REMEDIATION

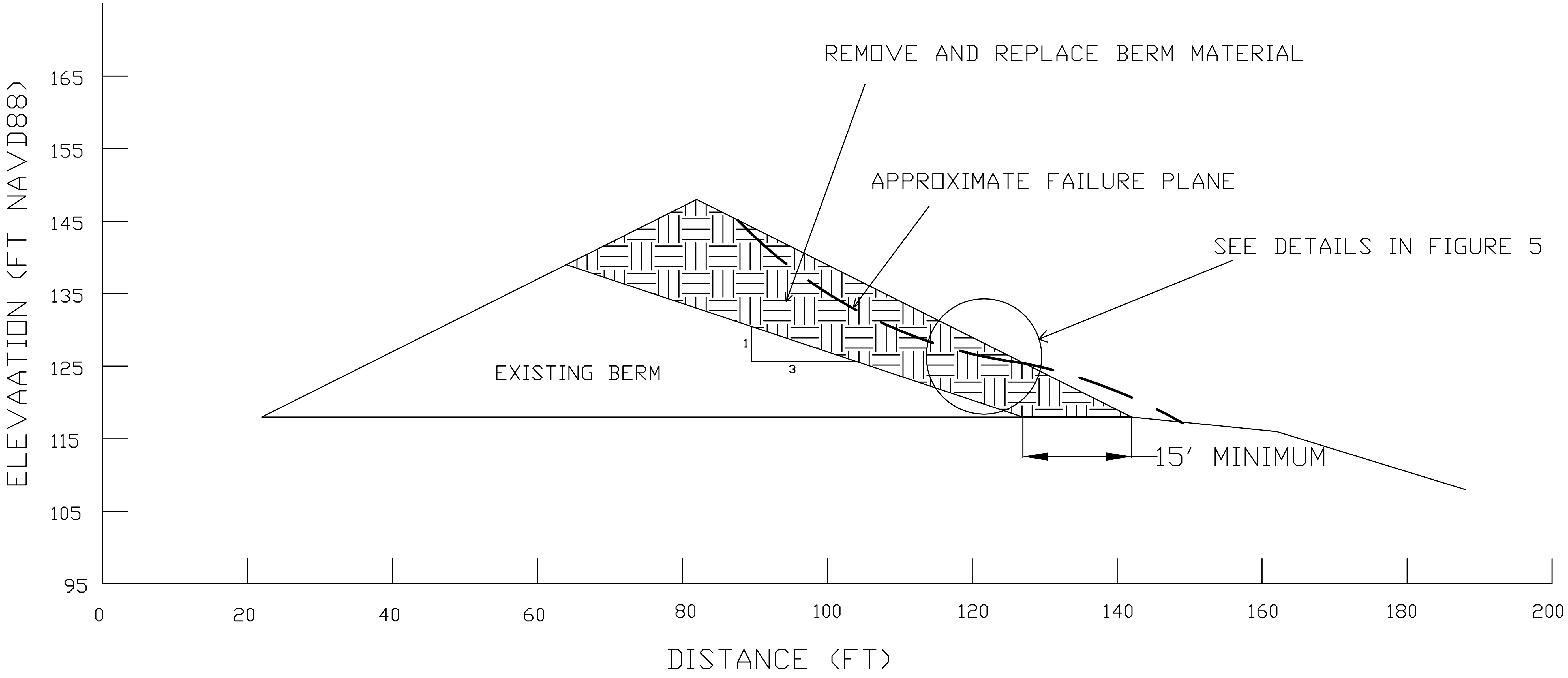

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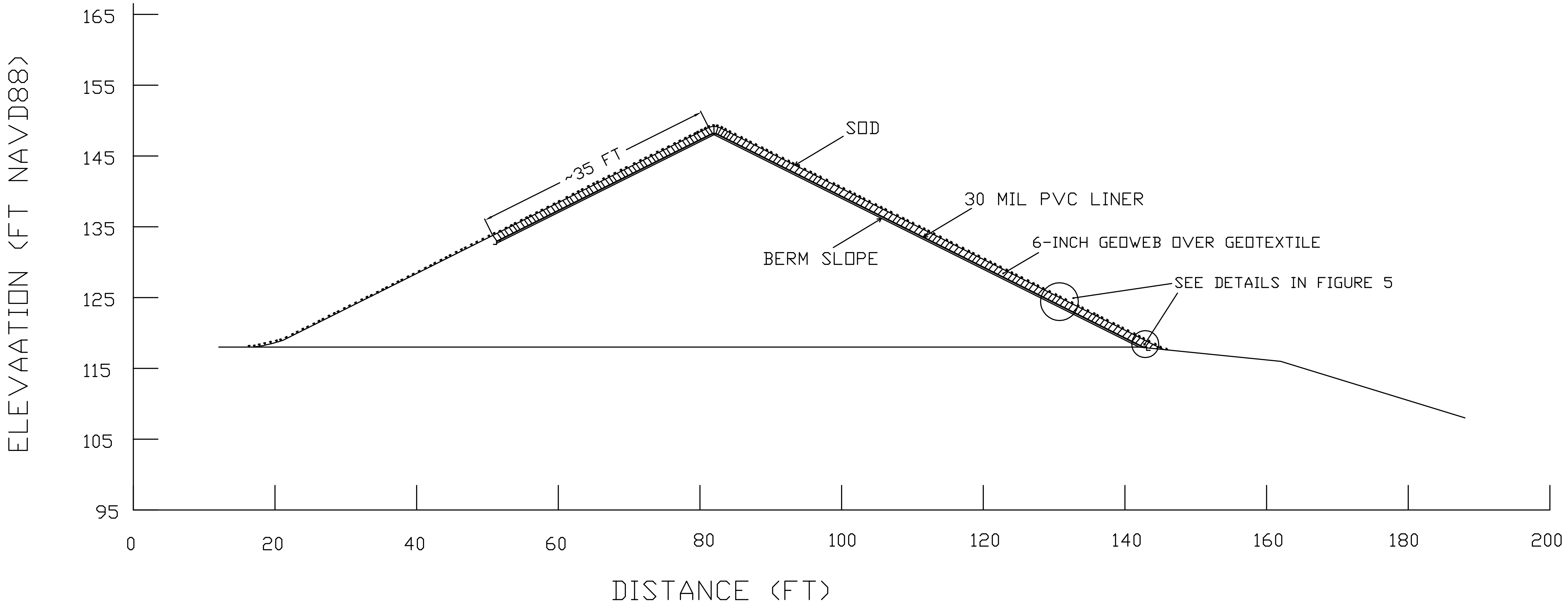
FIGURE 3

PROPOSED SLOPE PROTECTION



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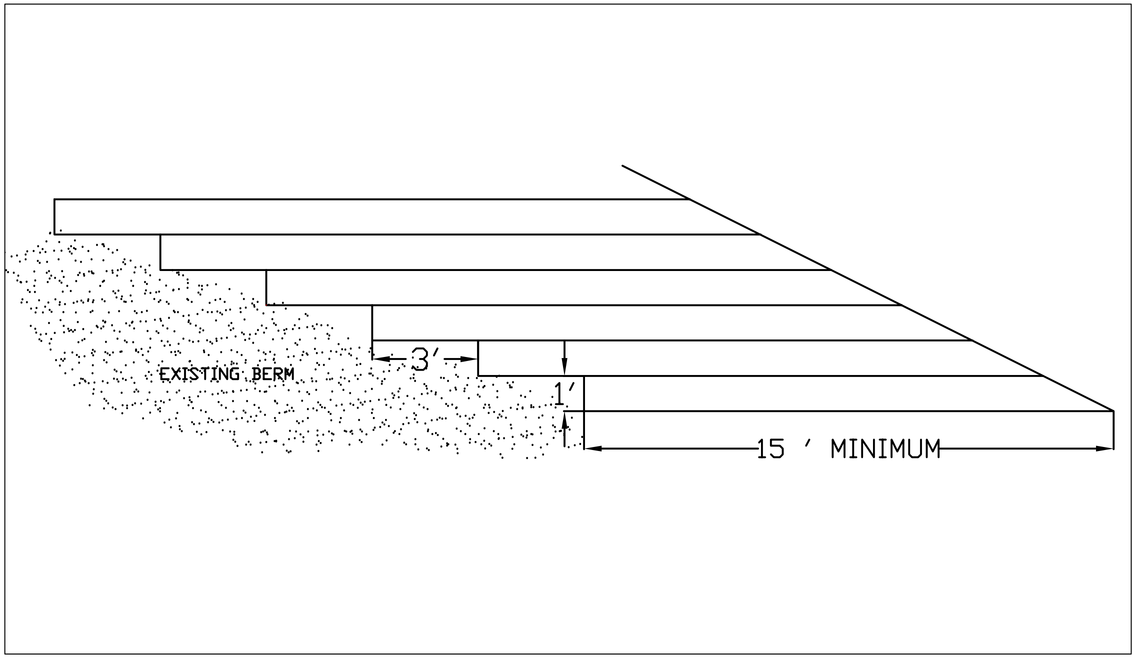
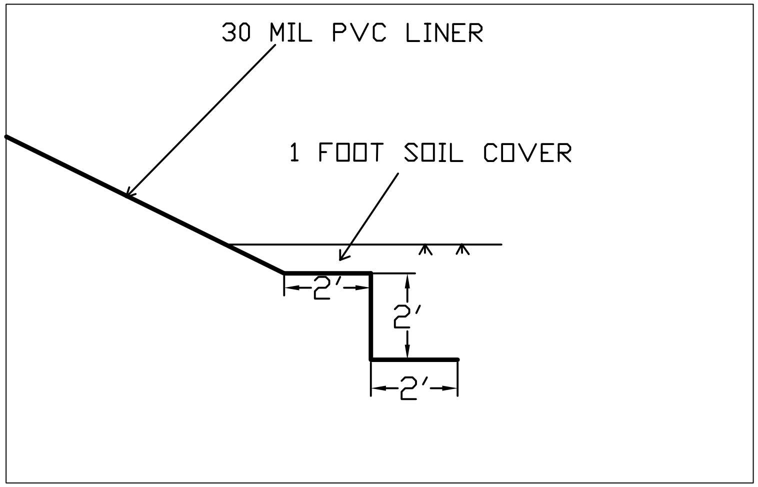
DRAWN: KK
CHKD: PK
DATE 06.07.18
JOB NO. 18-3712
FIGURE 4

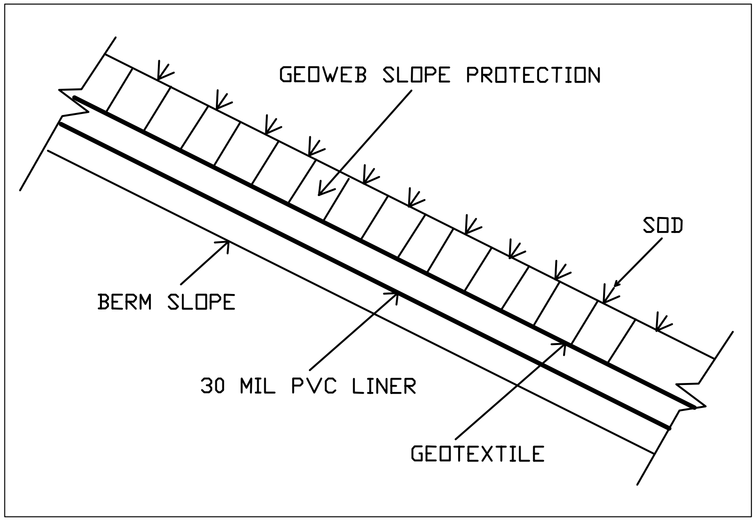
TYPICAL BERM REPAIR DETAILS



BERM RECONSTRUCTION DETAILS



LINER KEY-IN DETAIL



SLOPE PROTECTION DETAIL

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DATE 03.20.18
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DRAWN: KK
CHKD: PK
FIGURE 5

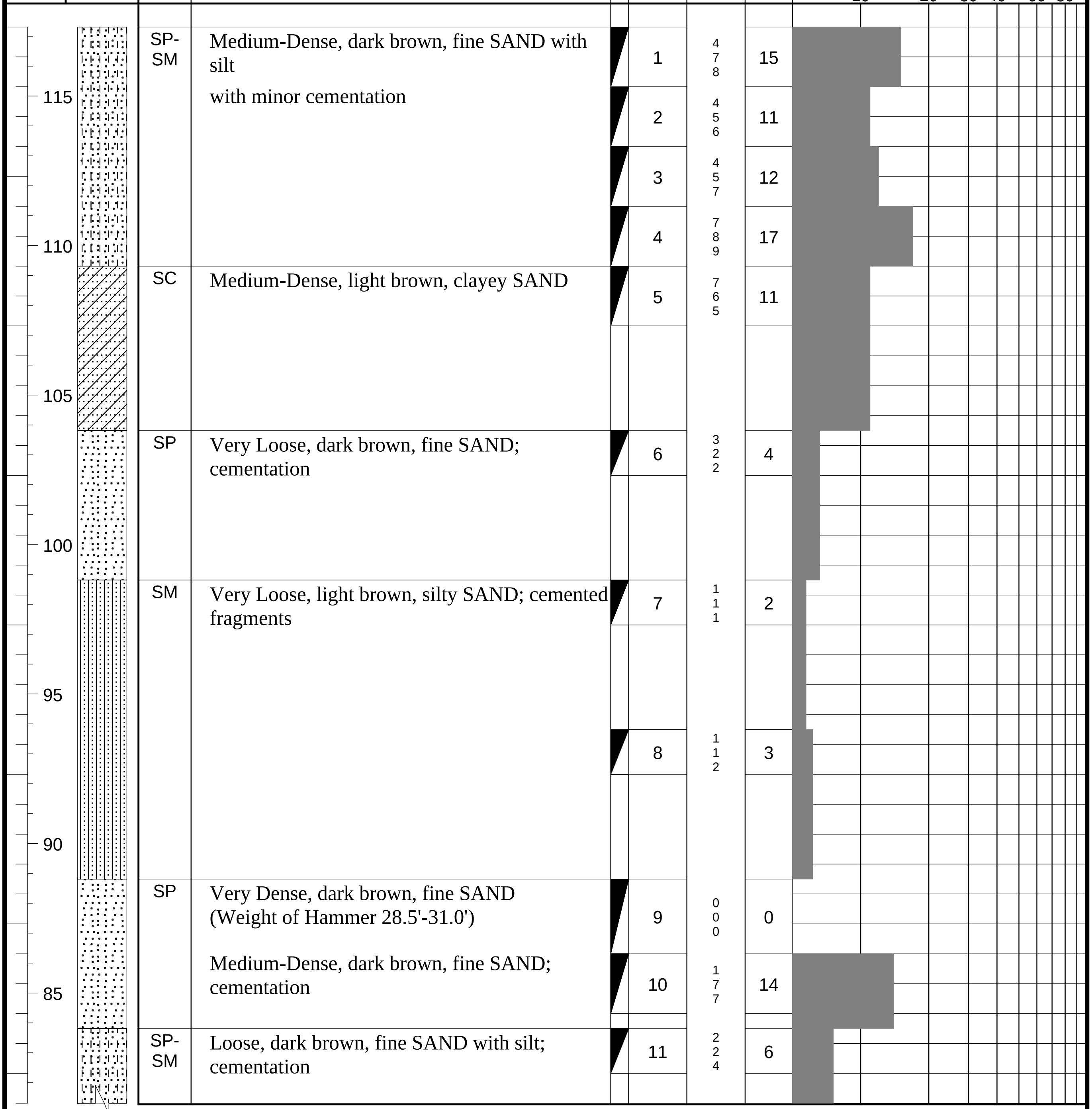
APPENDIX A

SPT Boring Logs and Auger Boring Profiles

DRILL HOLE LOG
BORING NO.: B-1

Project No.: 18-3712
Date: 2-5-2018

Project: Hillsborough County Sheriff's Shooting Range
Client: Landmark Engineering & Surveying Corporation
Location: Hillsborough County, Florida
Elevation: 117.31' NAVD 1988
Driller: J & R Precision Drilling
Logged By: KK
Drill Rig: CME-45
Depth to Water> **Initial** ▽ :
At Completion ▼ : NE in 10'

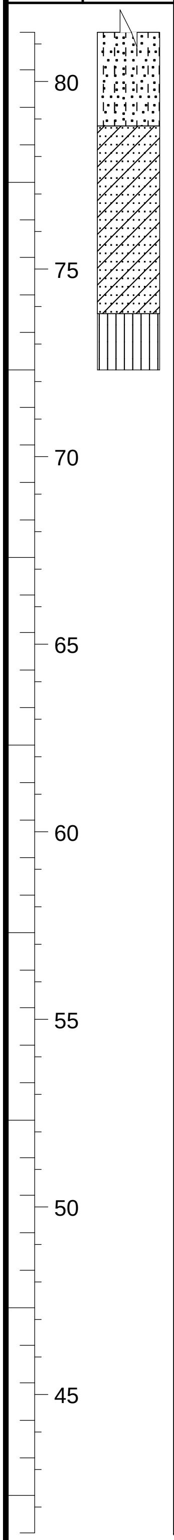


USCS	Description	No.	Blows	N
SP-SM	Medium-Dense, dark brown, fine SAND with silt	1	4 7 8	15
	with minor cementation	2	4 5 6	11
		3	4 5 7	12
		4	7 8 9	17
SC	Medium-Dense, light brown, clayey SAND	5	7 6 5	11
SP	Very Loose, dark brown, fine SAND; cementation	6	3 2 2	4
SM	Very Loose, light brown, silty SAND; cemented fragments	7	1 1 1	2
		8	1 1 2	3
SP	Very Dense, dark brown, fine SAND (Weight of Hammer 28.5'-31.0')	9	0 0 0	0
	Medium-Dense, dark brown, fine SAND; cementation	10	1 7 7	14
SP-SM	Loose, dark brown, fine SAND with silt; cementation	11	2 2 4	6

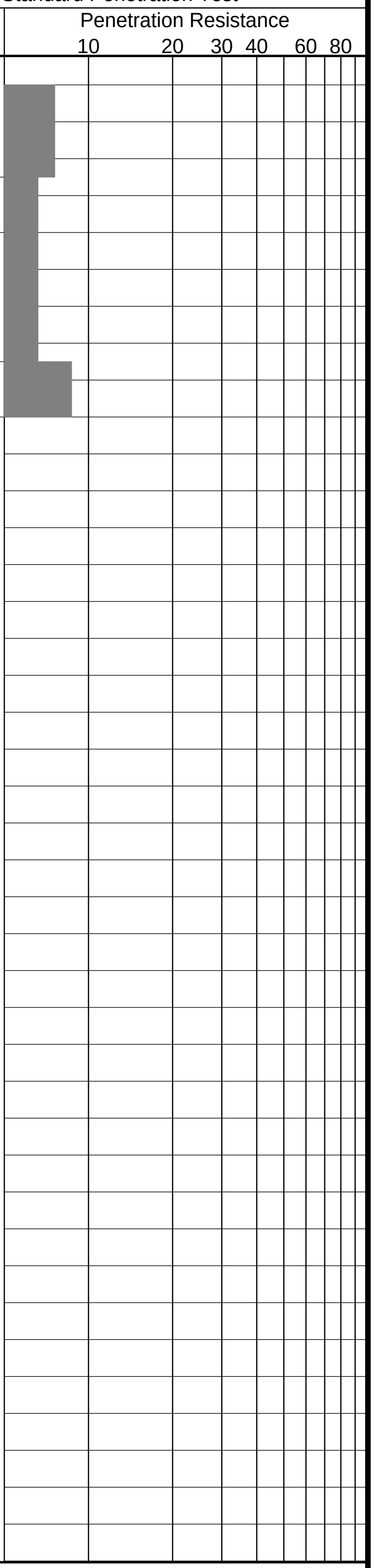
This information pertains only to this boring and should not be interpreted as being indicative of the site.

DRILL HOLE LOG
BORING NO.: B-1

PROJECT: Hillsborough County Sheriff's Shooting Range **PROJECT NO.:** 18-3712



USCS	Description	Sample Type	Sample No.	Blows	N
SC	Very Loose, light brown, clayey SAND	◢	12	2 2 2	4
ML	Medium, gray to brown SILT	◢	13	3 3 5	8
	End of Boring				

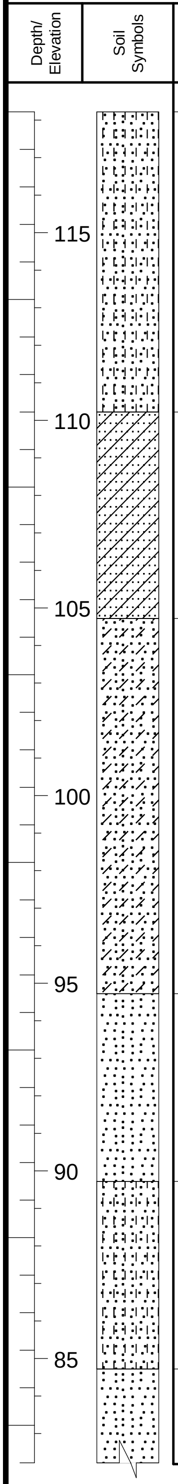


FAULKNER ENGINEERING SERVICES, Inc.

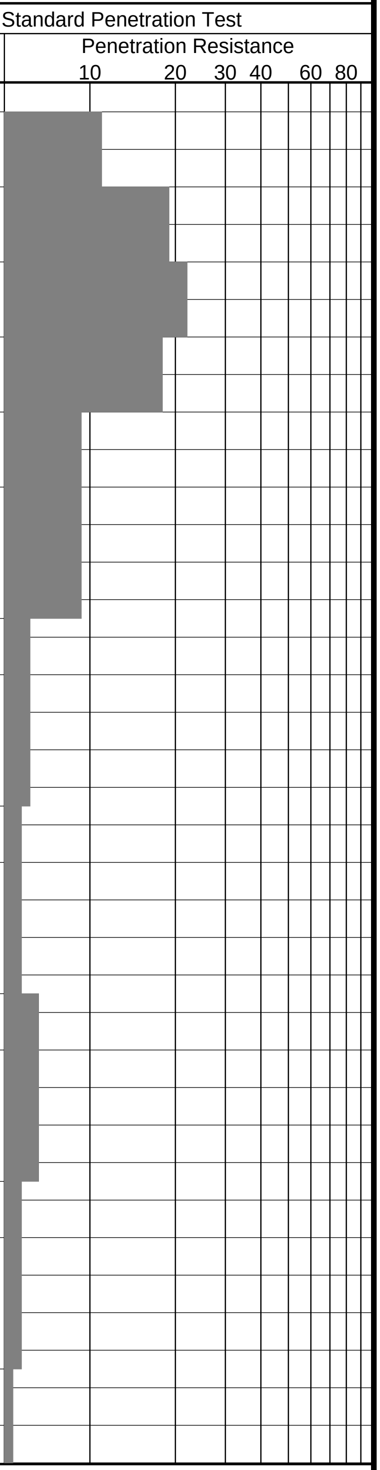
DRILL HOLE LOG
BORING NO.: B-2

Project No.: 18-3712
Date: 2-5-2018

Project: Hillsborough County Sheriff's Shooting Range
Client: Landmark Engineering & Surveying Corporation
Location: Hillsborough County, Florida
Elevation: 118.22' NAVD 1988
Driller: J & R Precision Drilling
Logged By: KK
Drill Rig: CME-45
Depth to Water> **Initial** ▽ **:**
At Completion ▼ **:** NE in 10'



USCS	Description	Sample No.	Blows	N
SP-SM	Medium-Dense, dark brown, fine SAND with silt; cementation; minor roots	1	3 5 6	11
		2	8 8 11	19
		3	8 10 12	22
		4	10 10 8	18
SC	Loose, light brown, clayey SAND (-200 = 22.3%)	5	5 5 4	9
SP-SC	Very Loose, light brown, fine SAND with clay; cementation	6	1 1 2	3
		7	1 1 1	2
SP	Very Loose, dark brown, fine SAND; cementation	8	1 2 2	4
SP-SM	Very Loose, dark brown, fine SAND with silt; cementation	9	1 1 1	2
SP	Very Loose, dark brown, fine SAND; cementation (1 blow/12 inches)	10		1/12"



This information pertains only to this boring and should not be interpreted as being indicative of the site.

DRILL HOLE LOG

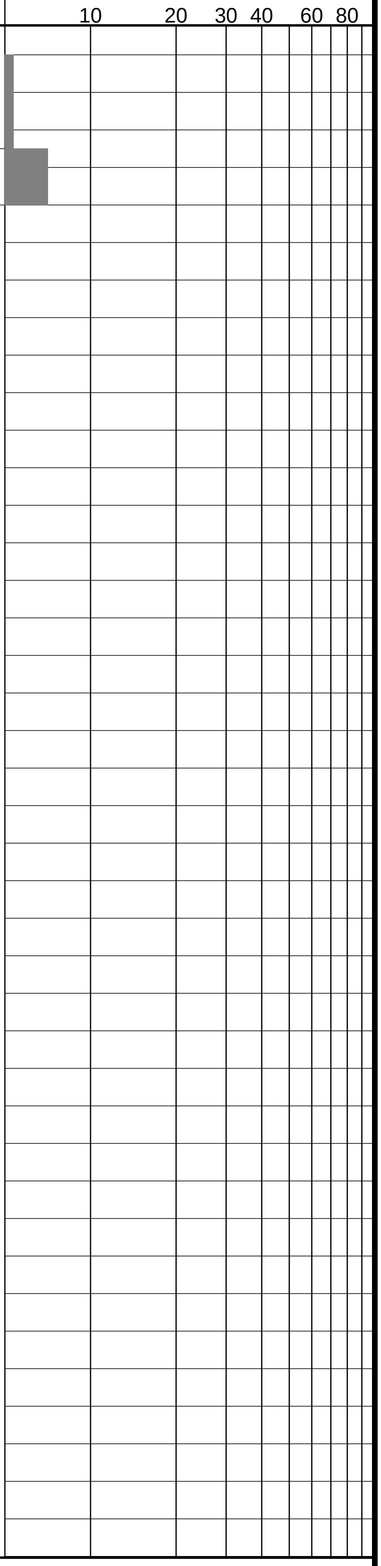
BORING NO.: B-2

PROJECT: Hillsborough County Sheriff's Shooting Range **PROJECT NO.:** 18-3712

Depth/ Elevation	Soil Symbols	USCS	Description	Sample Type	Sample No.	Standard Penetration Test Blows	N
80	⁙		Loose, light brown	◤	11	2 2 3	5
40			End of Boring				

Depth: 40, 45, 50, 55, 60, 65, 70, 75

Elevation: 80, 75, 70, 65, 60, 55, 50, 45



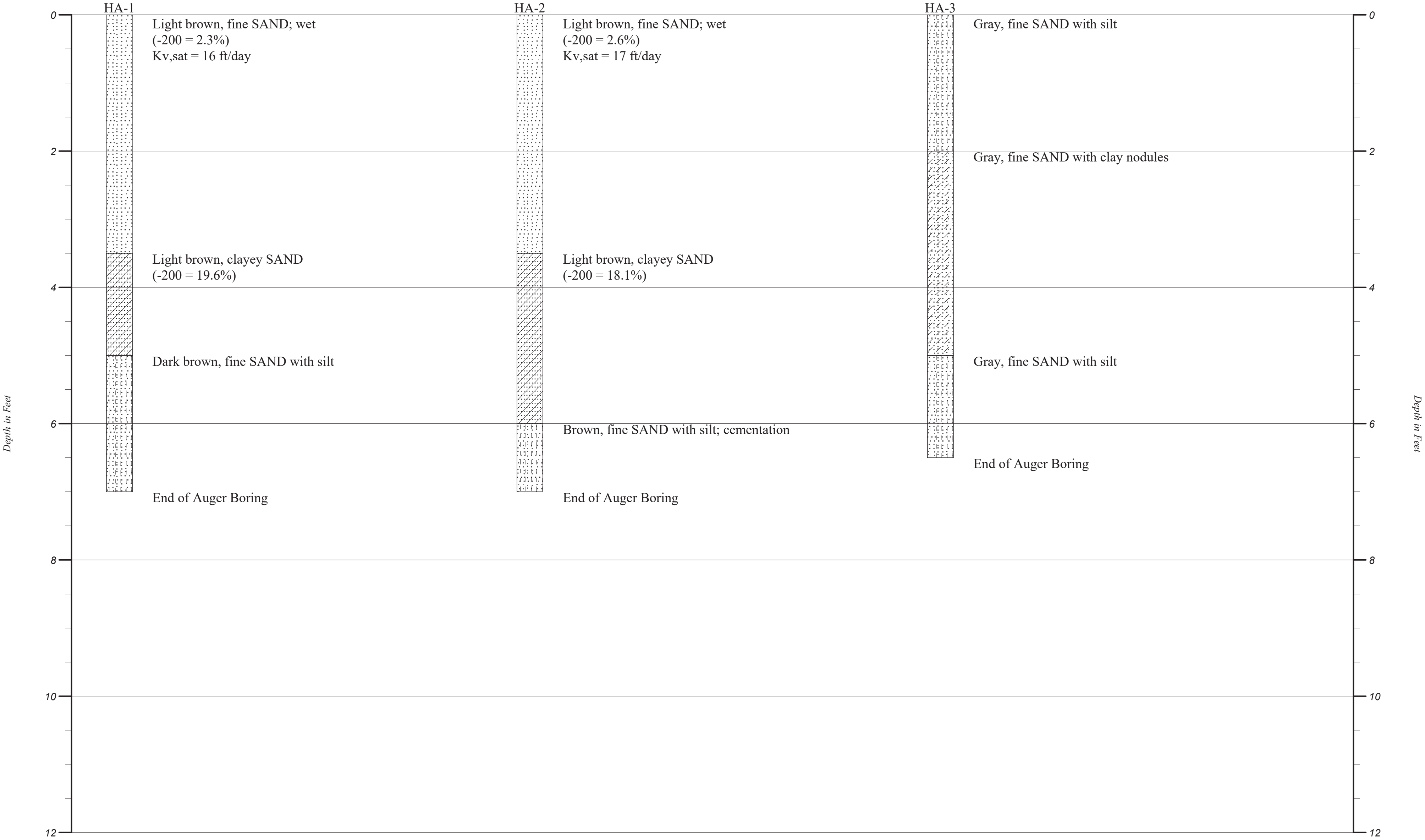
KEY TO SYMBOLS

Symbol	Description
Strata symbols	
▦	Poorly graded sand with silt
▨	Clayey sand
⁙	Poorly graded sand
▥	Silty sand
▥	Silt
▩	Poorly graded sand with clay
Misc. Symbols	
⌁	Boring continues
Soil Samplers	
◩	Standard penetration test

Notes:

1. Exploratory boring were performed using a 2-inch diameter split barrel sampler driven by a 140 lbs hammer (In accordance with ASTM D1586)

2. These logs are subject to the limitations, conclusions, and recommendations in this report.



Plan View

Strata symbols

- ░ Poorly graded sand
- ▨ Clayey sand
- ░ Poorly graded sand with silt
- ▨ Poorly graded sand with clay

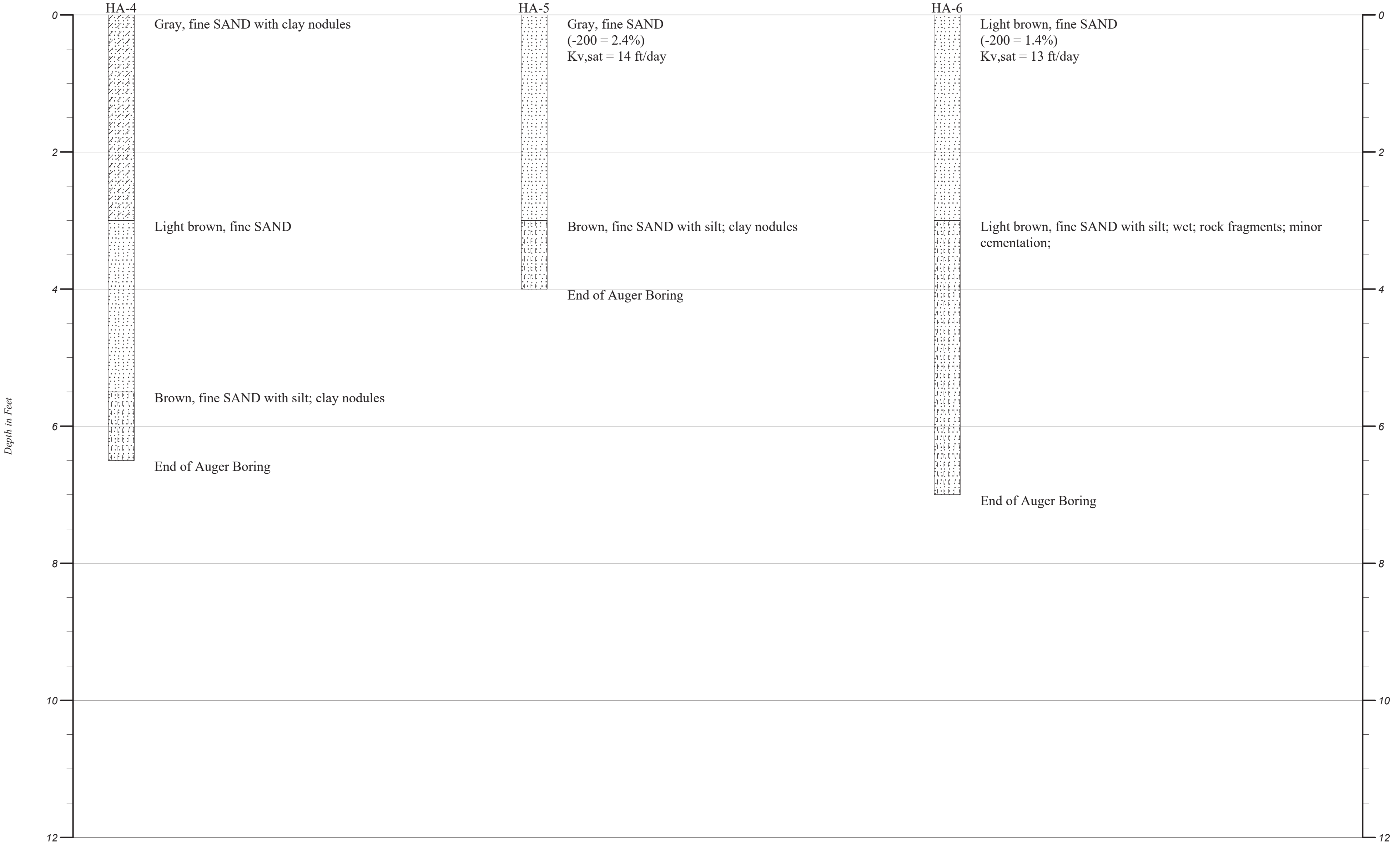
Faulkner Engineering Services, Inc.

GENERALIZED SOIL PROFILE

HORIZONTAL SCALE: VERTICAL SCALE: 1"=2'	DRAWN BY/APPROVED BY KK/PK	DATE PERFORMED 2-5-2018

Hillsborough County Sheriff's Shooting Range

PROJECT NO. 18-3712



Plan View

Strata symbols

⁘	Poorly graded sand
▨	Clayey sand
⁘	Poorly graded sand with silt
▨	Poorly graded sand with clay

Faulkner Engineering Services, Inc.

GENERALIZED SOIL PROFILE

HORIZONTAL SCALE:	DRAWN BY/APPROVED BY	DATE PERFORMED
VERTICAL SCALE: 1"=2'	KK/PK	2-5-2018

Hillsborough County Sheriff's Shooting Range

PROJECT NO. 18-3712

APPENDIX B

Laboratory Test Results

GRAIN SIZE DISTRIBUTION TEST REPORT

FAULKNER ENGINEERING SERVICES, INC.

Project No.: 18-3712

Date: 3/20/18

Project: Hillsborough County Sheriff's Shooting Range

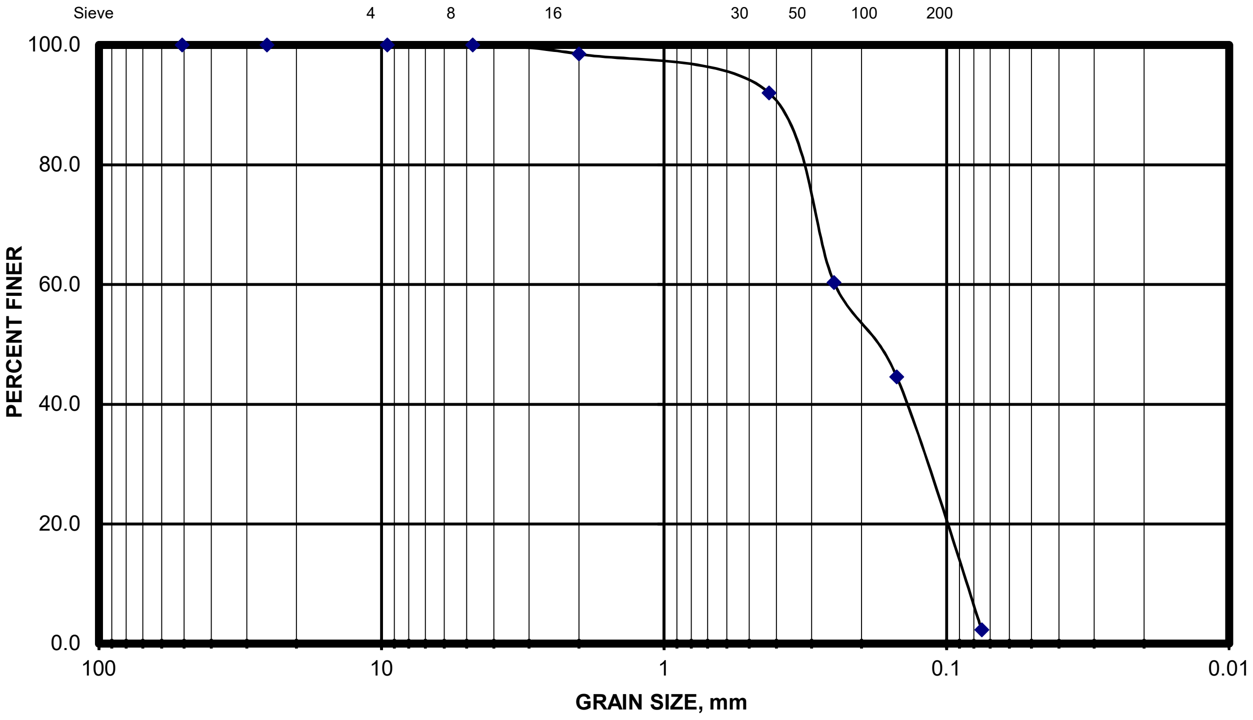
Sample Location: HA-1 (0-2')

Soil Description: Light Brown fine SAND

Soil Classification: SP LL ____ PI ____

*NP = Non-Plastic

GRAIN SIZE DISTRIBUTION



% Gravel	% Sand	%-200
0.0	97.7	2.3

D60	D30	D10	CC	CU
0.25	0.12	0.089	0.70	2.80

GRAIN SIZE DISTRIBUTION TEST REPORT

FAULKNER ENGINEERING SERVICES, INC.

Project No.: 18-3712 Date: 3/20/18

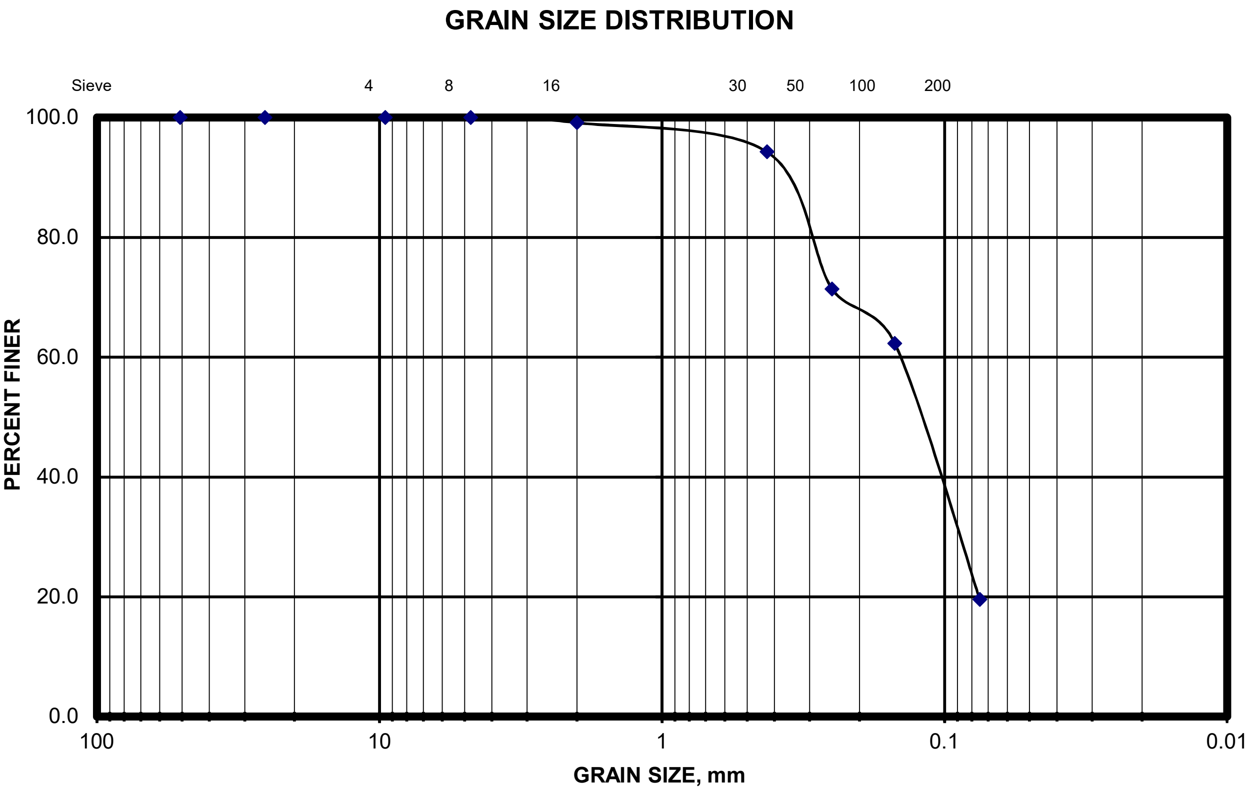
Project: Hillsborough County Sheriff's Shooting Range

Sample Location: HA-1 (4')

Soil Description: Reddish Brown, clayey SAND

Soil Classification: SC LL ______ PI ______

*NP = Non-Plastic



% Gravel		% Sand		%-200
0.0		80.4		19.6
D60	D30	D10	CC	CU
0.15	0.09			

GRAIN SIZE DISTRIBUTION TEST REPORT

FAULKNER ENGINEERING SERVICES, INC.

Project No.: 18-3712 Date: 3/20/18

Project: Hillsborough County Sheriff's Shooting Range

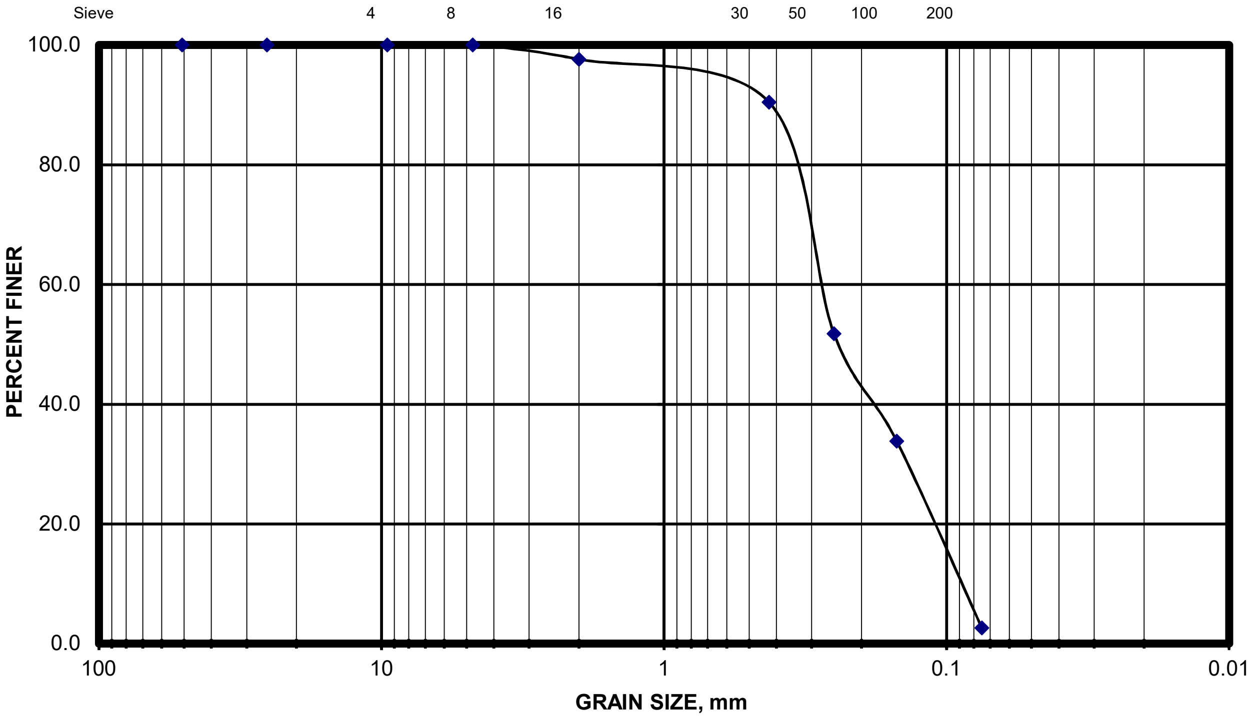
Sample Location: HA-2 (0-3.5')

Soil Description: Light Brown fine SAND

Soil Classification: SP LL _______ PI _________

*NP = Non-Plastic

GRAIN SIZE DISTRIBUTION



% Gravel	% Sand	%-200
0.0	97.4	2.6

D60	D30	D10	CC	CU
0.30	0.14	0.093	0.72	3.19

GRAIN SIZE DISTRIBUTION TEST REPORT

FAULKNER ENGINEERING SERVICES, INC.

Project No.: 18-3712 Date: 3/20/18

Project: Hillsborough County Sheriff's Shooting Range

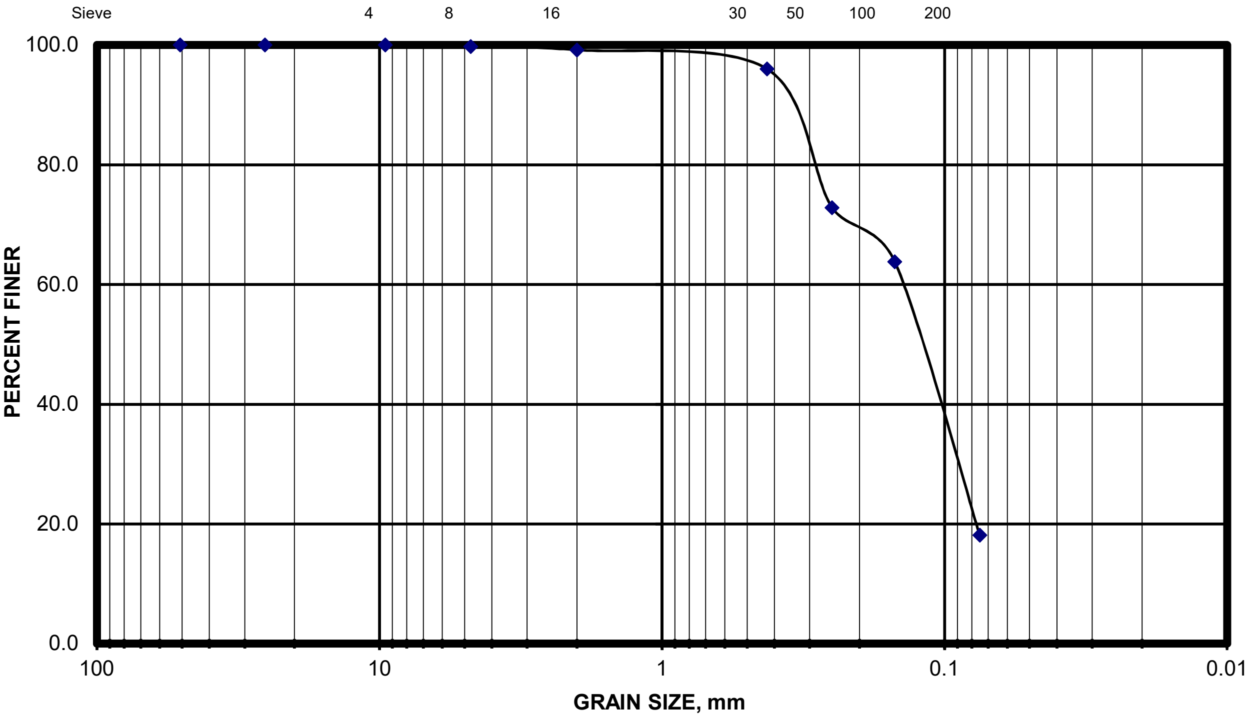
Sample Location: HA-2 (4-6')

Soil Description: Light Brown Clayey SAND

Soil Classification: SC LL ______ PI ______

*NP = Non-Plastic

GRAIN SIZE DISTRIBUTION



% Gravel		% Sand		%-200
0.3		81.6		18.1
D60	D30	D10	CC	CU
0.14	0.09			

GRAIN SIZE DISTRIBUTION TEST REPORT

FAULKNER ENGINEERING SERVICES, INC.

Project No.: 18-3712 Date: 3/20/18

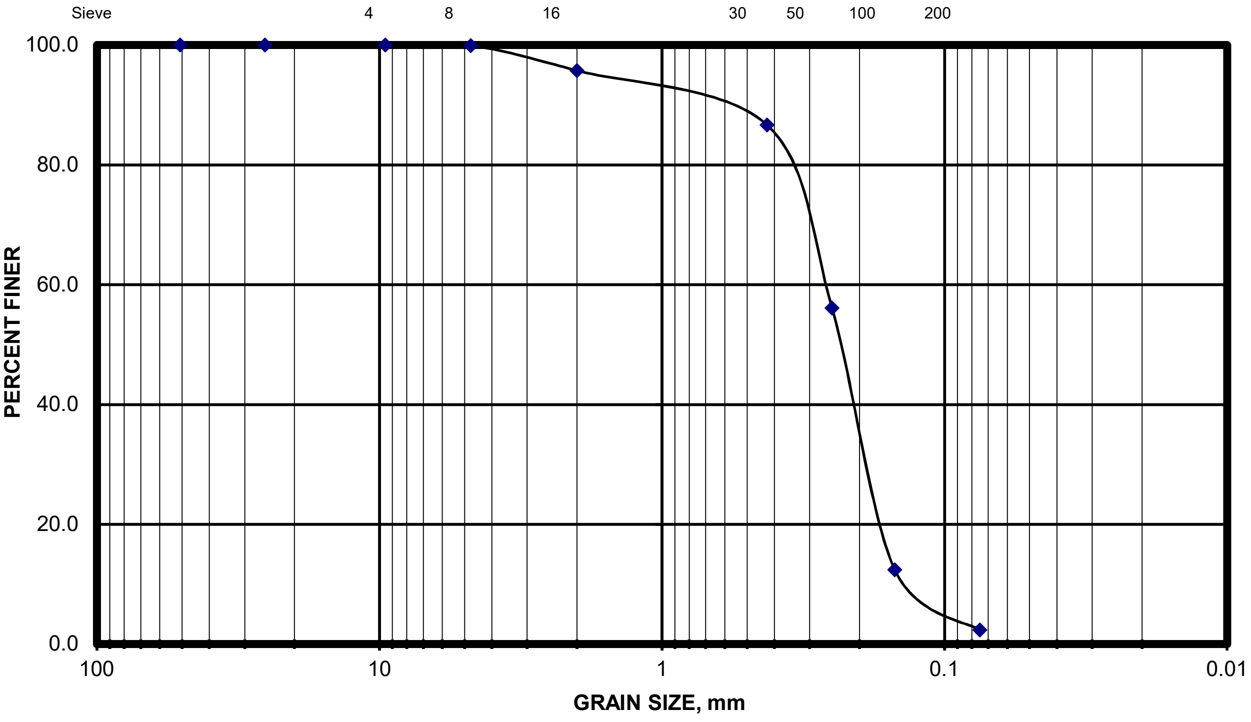
Project: Hillsborough County Sheriff's Shooting Range

Sample Location: HA-5 (0-4')

Soil Description: Light Brown fine SAND

Soil Classification: SP LL ____ PI ____

*NP = Non-Plastic



GRAIN SIZE DISTRIBUTION

% Gravel	% Sand	%-200
0.1	97.6	2.4

D60	D30	D10	CC	CU
0.26	0.19	0.132	1.06	1.96

GRAIN SIZE DISTRIBUTION TEST REPORT

FAULKNER ENGINEERING SERVICES, INC.

Project No.: 18-3712 Date: 3/20/18

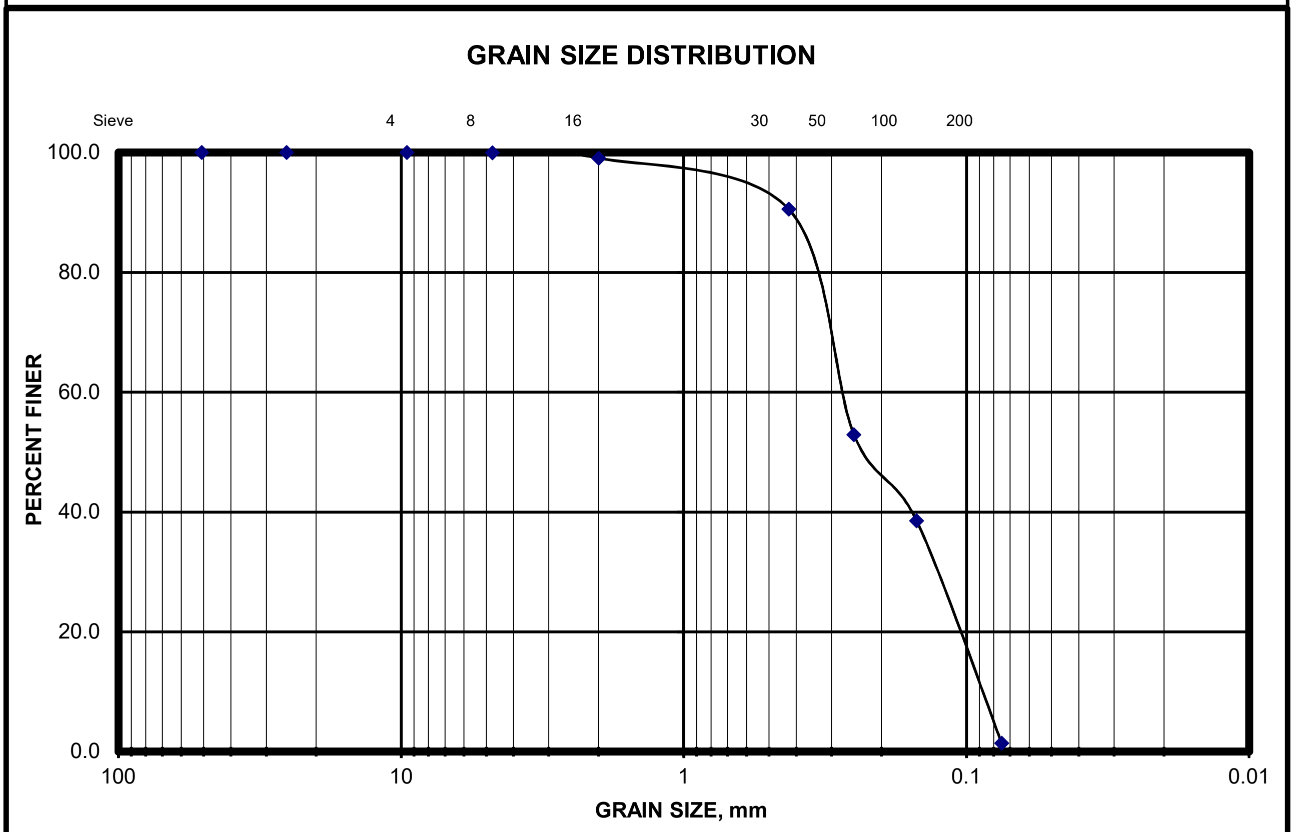
Project: Hillsborough County Sheriff's Shooting Range

Sample Location: HA-6 (0-2')

Soil Description: Light Brown fine SAND

Soil Classification: SP LL ______ PI ______

*NP = Non-Plastic



% Gravel	% Sand	%-200
0.0	98.6	1.4

D60	D30	D10	CC	CU
0.30	0.13	0.092	0.64	3.24

APPENDIX C

Key to Soil Classification

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)

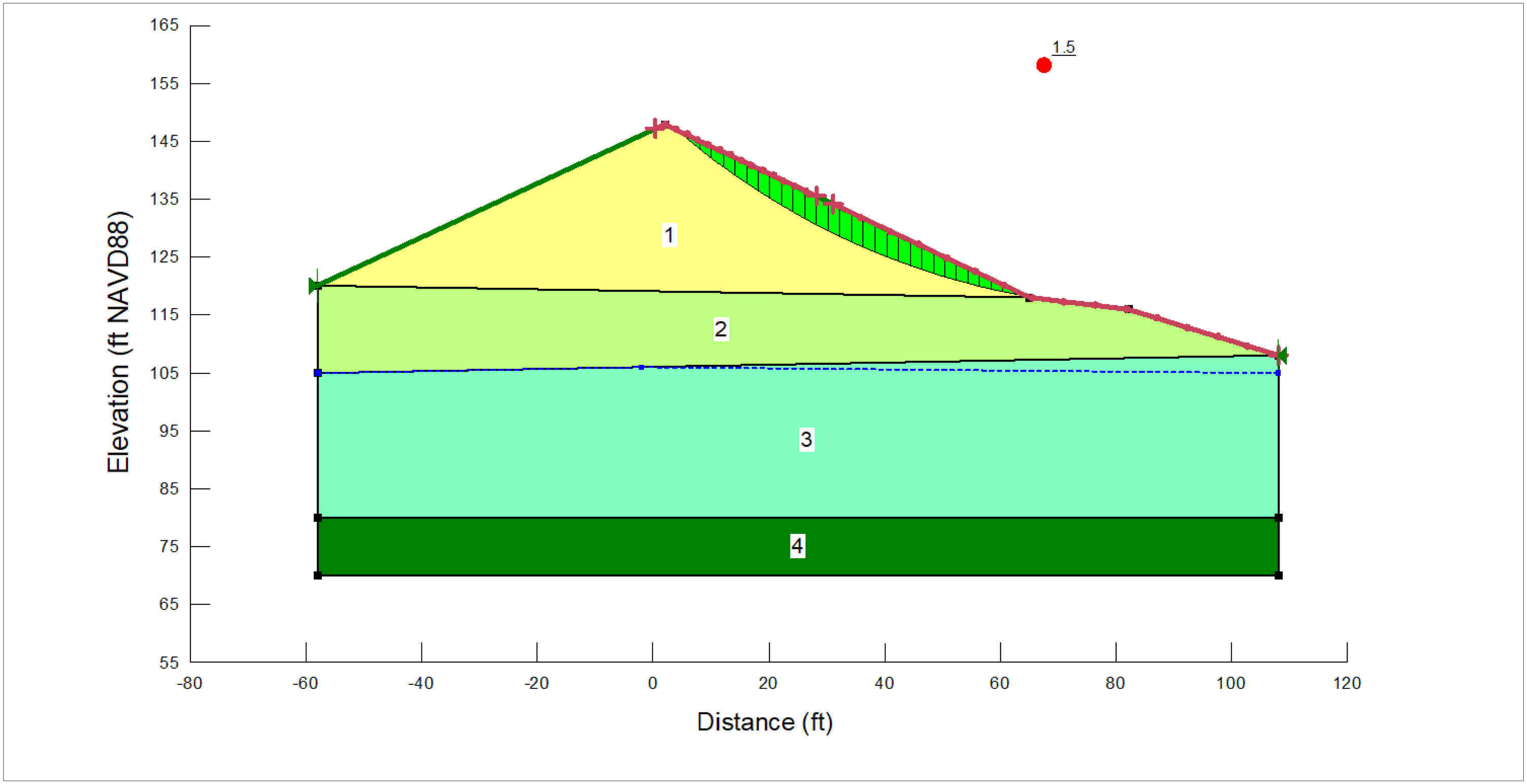
Major Division		Group Symbol	Laboratory Classification Data		Soil Description
			Finer than No. 200 Sieve %	Supplementary Requirements	
Coarse-Grained	Gravelly Soils	GW	0 - 5*	$C_u \geq 4$ and $1 \leq C_c \leq 3$	Well-Graded Gravels, Sandy Gravels
	(Over Half of Coarse Fraction Larger than No. 4 Sieve)	GP	0 - 5*	$C_u < 4$ and / or $1 > C_c > 3$	Gap-Graded or Uniform Gravels, Sandy Gravels
		GM	12 or More*	PI < 4 or Below A-Line	Silty Gravels, Silty Sandy Gravels
		GC	12 of More*	PI ≥ 7 and On or Above A-Line	Clayey Gravels, Clayey Sandy Gravels
(Over 50% by Weight Coarser than No. 200 Sieve)	Sandy Soils	SW	0 - 5*	$C_u \geq 6$ and $1 \leq C_c \leq 3$	Well-Graded Sands, Gravelly Sands
	(Over Half of Coarse Fraction Larger than No. 4 Sieve)	SP	0 - 5*	$C_u < 6$ and / or $1 > C_c > 3$	Gap-Graded or Uniform Sands, Gravelly Sands
		SM	12 or More*	PI < 4 or Below A-Line	Silty Sands, Silty Gravelly Sands
		SC	12 of More*	PI ≥ 7 and On or Above A-Line	Clayey Sands, Clayey Gravelly Sands
Fine-Grained	LOW Compressibility (Liquid Limit Less Than 50)	ML	Plasticity Chart		Silts, Very Fine Sands, Silty or Clayey Fine Sands, Micaceous Silts
		CL	Plasticity Chart		Low Plasticity Clays, Sandy or Silty Clays
		OL	Plasticity Chart, Organic Odor or Color		Organic Silts and Clays of Low Plasticity
(Over 50% by Weight Finer than No. 200 Sieve)	HIGH Compressibility (Liquid Limit Greater Than 50)	MH	Plasticity Chart		Micaceous Silts, Diatomaceous Silts, Volcanic Ash
		CH	Plasticity Chart		Highly Plastic Clays and Sandy Clays
		OH	Plasticity Chart, Organic Odor or Color		Organic Silts and Clays of High Plasticity
Soils with Fibrous Organic Matter		PT	Fibrous Organic Matter, Will Char, Burn, or Glow		Peat, Sandy Peats, and Clayey Peat

*For Soils having 5 to 12 percent passing the No. 200 Sieve, use a dual symbol such as GW-GC.

APPENDIX D

Slope Stability Analysis Results

TYPICAL CROSS SEDCTION "AS-CONSTRUCTED" GEOMETRY - DRY FILL



LEGEND

🟨 1. BERM FILL

🟩 2. FOUNDATION SANDY SOILS 1

🟩 3. FOUNDATION SANDY SOILS 2

🟩 4. SILT

FAULKNER
ENGINEERING SERVICES, Inc.

Geotechnical Engineers
Construction Material Testing

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PHONE: 813.621.8168
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www.faulknereng.com

Hillsborough County
Sheriff's Shooting Range

N.T.S.

DATE 03.20.18

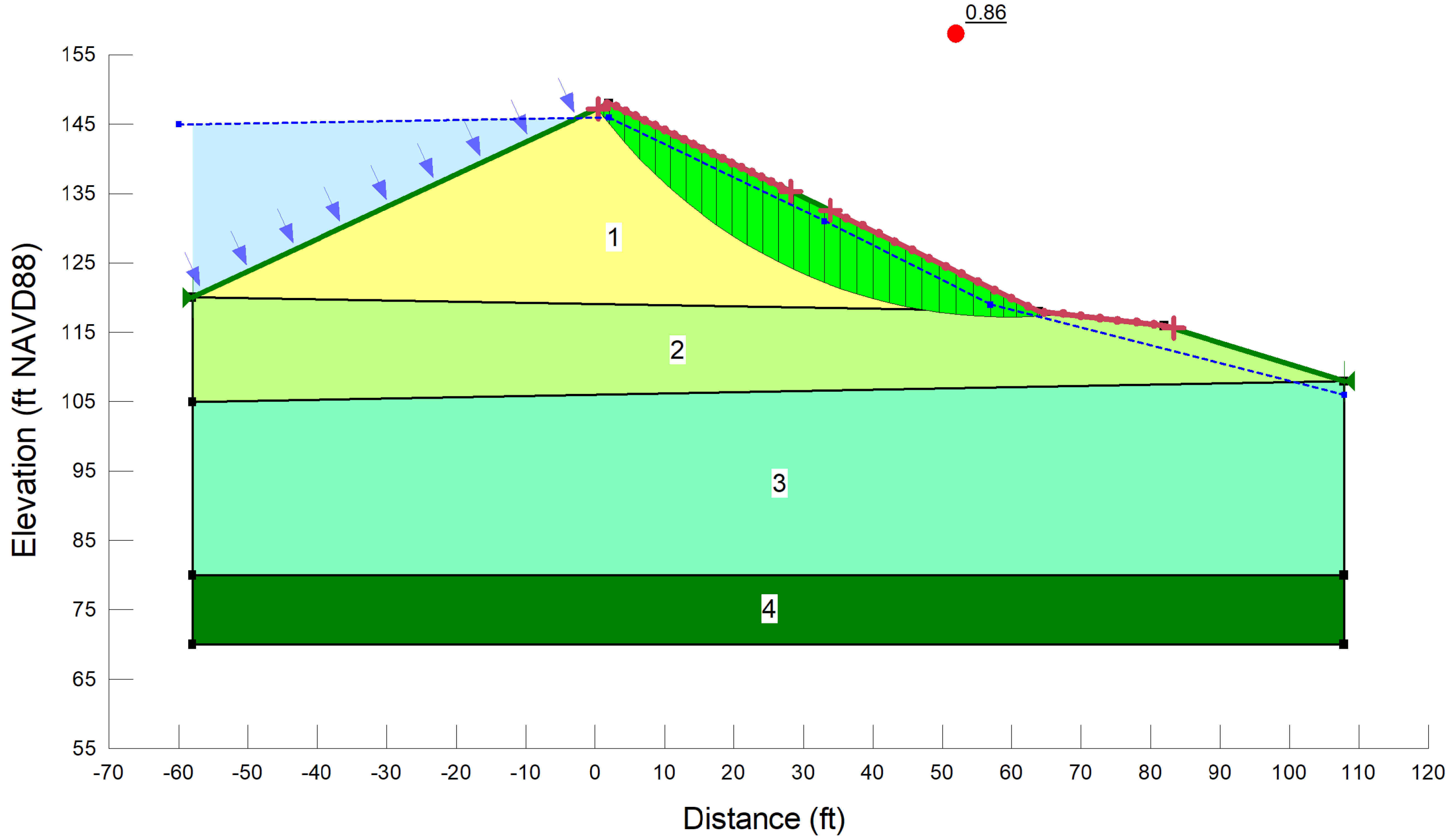
JOB NO. 18-3712

DRAWN: PK

CHKD: KK

Appendix D

TYPICAL CROSS SEDCTION "AS-CONSTRUCTED" GEOMETRY – SATURATED FILL; SIMULATED PERCHED WATER CONDITION



LEGEND

🟨 1. BERM FILL

🟩 2. FOUNDATION SANDY SOILS 1

🟩 3. FOUNDATION SANDY SOILS 2

🟩 4. SILT

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Hillsborough County
Sheriff's Shooting Range

N.T.S.

DATE 03.20.18

JOB NO. 18-3712

DRAWN: PK
CHKD: KK

Appendix D

APPENDIX E

Geosynthetic Slope Protection Product Details

PRESTO GEOSYSTEMS

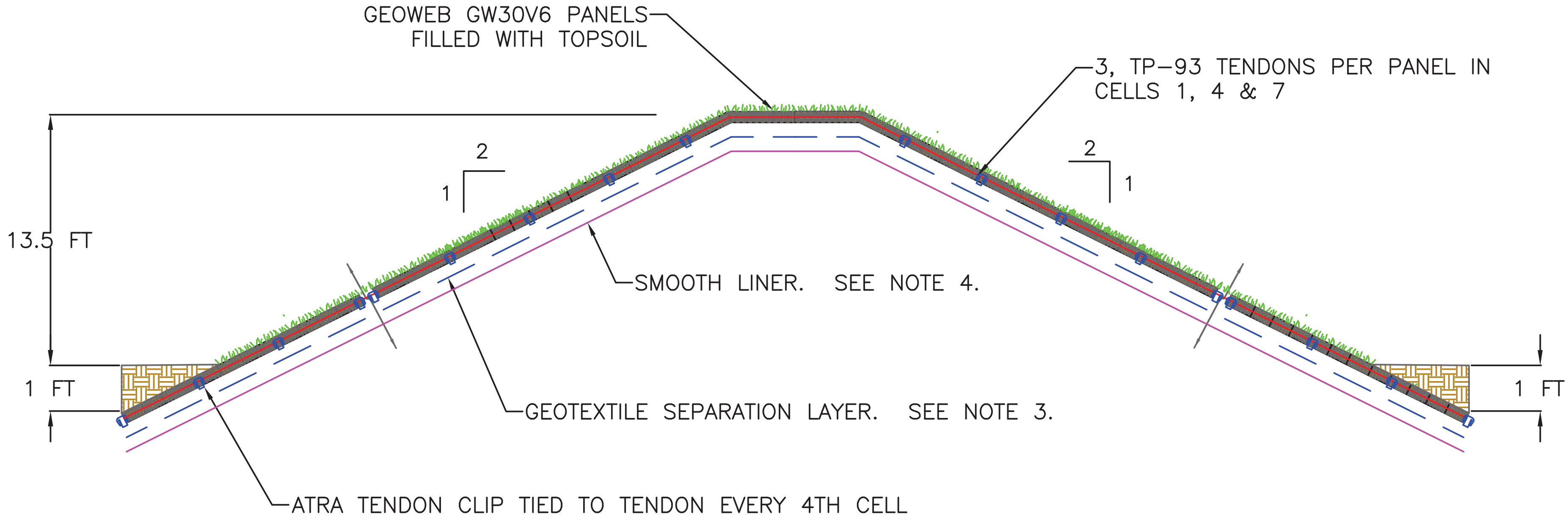
GEOWEB® SLOPE PROTECTION SYSTEM COMPONENTS GUIDELINES

Geoweb® System		PERMANENT PROTECTION OF EARTH-FILL SLOPES	
		Recommended Material Types	**Applications, Functions, Benefits and Design Considerations**
The Geoweb® Section	Section Length	Six section lengths (covering a range of 12 to 58 ft lengths)	Range of section lengths minimizes field cutting of sections, loss of area and installation effort.
	Cell Size	Mid (GW30V), Small (GW20V) or Large (GW40V)	Cell size is governed by slope geometry and design cover thickness. Generally, the GW30V cell is applicable for most conditions, theGW20V cell is applicable for very severe conditions, and the GW40V cell is applicable for mild conditions.
	Cell Depth	3, 4, 6, 8 in (75, 100, 150, 200 mm)	Depth is a function of slope geometry.
	Cell Type	Textured Perforated	Maximized interaction between infill and cellular structure. Perforated cells provide in-plane drainage and inter-cell root development where necessary.
	Cell Color	Standard Black	Material is primarily buried – standard stabilization is incorporated
The Infill	Topsoil & Vegetation	Local soils and vegetation	Structural restraint of topsoil cover on steep slopes. Cellular system confines and protects the upper soil layer and root zone when subjected to concentrated hydraulic flow. The development of rills and gullies is prevented. The cellular structure enhances moisture retention and vegetative development in arid climates.
	Aggregate	Gravels and uniform processed rock	Loose infills can be supported at slope angles greater than their normal angle of repose. Resistance to concentrated surface flows is increased.
	Concrete	Ready-mix	The Geoweb system functions as a flexible formwork and anchorage system. The hard protective cover is flexible, free-draining, and can be rapidly installed or precast in panels.
Other Components (as required)	Geotextiles	Non-woven	Light-weight non-woven underlayer acts as a drainage medium, soil filter and root-anchorage element.
	Geomembranes	Polymeric or GCL's	Can be employed selectively as infiltration control elements.
	Erosion Control Blankets	Temporary bio-degradable	Protects topsoil and seed immediately following installation and provides protection from washout potential prior to vegetation establishment.
	Turf Reinforcement Mats	Various	More permanent protection of topsoil and seed following installation, and provides protection from washout potential prior to vegetation establishment and longer-term surface flows.
	Tendons	Kevlar® and PE	Polymer type and design tensile strength depends on geometry, anchorage design and chemical environment.
	Anchor Component	ATRA® Stake Clip	Attached to steel rods to form ATRA® Anchors
	ATRA® Accessories for Anchoring and Load Transfer	ATRA® Tendon Clip	Attached to cell wall and tendons, provides positive transfer of sliding loads to the tendon system.
		ATRA® Anchor	Attached to steel rods, provides positive shear connection and uplift resistance. Anchors resist high hydraulic shear stresses. Project-specific assessment is recommended.
		ATRA® GFRP Anchor	Attached to glass fiber-reinforced polymer stakes, provides positive shear connection and uplift resistance for corrosive environments. Anchors resist high hydraulic shear stresses. Project-specific assessment is recommended.
	Surface Treatments	Various	Application specific including: hydro seeding, emulsion coating, cement grouts, etc.

Geoweb® System		PROTECTION OF GEOMEMBRANE COVERED SLOPES	
		Recommended Material Types	Applications, Functions, Benefits and Design Considerations
The Geoweb® Section	Section Length	Six section lengths (covering a range of 12 to 58 ft lengths)	Range of section lengths minimizes field cutting of sections, loss of area and installation effort.
	Cell Size	Mid (GW30V) or Large (GW40V)	Cell size is governed by slope geometry and design cover thickness.
	Cell Depth	3, 4, 6, 8 in (75, 100, 150, 200 mm)	Depth is a function of slope geometry.
	Cell Type	Textured Perforated	Maximized interaction between infill and cellular structure. Perforated cells provide in-plane drainage and inter-cell root development where necessary.
	Cell Color	Standard Black	Material is primarily buried – standard stabilization is incorporated.
The Infill	Topsoil & Vegetation	Local soils and vegetation	Structural restraint of topsoil cover on steep slopes. Cellular system confines and protects the root zone when subjected to concentrated hydraulic flow. The development of rills and gullies is prevented. The cellular structure enhances moisture retention and vegetative development in arid climates.
	Aggregate	Gravels and uniform processed rock	Loose infills can be supported at slope angles greater than their normal angle of repose. Resistance to concentrated surface flows is increased.
	Concrete	Ready-mix	The Geoweb system functions as a flexible formwork and anchorage system. The hard protective cover is flexible, free-draining, and can be rapidly installed or precast in panels.
Other Components (as required)	Geotextiles	Non-woven	Light-weight non-woven underlayer acts as a drainage medium, soil filter and root-anchorage element. Some applications may require a geotextile layer above and below the geomembrane.
	Geomembranes	HDPE, GCL or per design	Primary system underlayer.
	Erosion Control Blankets	Temporary bio-degradable	Protects topsoil and seed immediately following installation and provides protection from washout potential prior to vegetation establishment.
	Turf Reinforcement Mats	Various	More permanent protection of topsoil and seed following installation, and provides protection from washout potential prior to vegetation establishment and longer-term surface flows.
	Tendons	Kevlar® and PE	Polymer type and design tensile strength depends on geometry, anchorage design and chemical environment. Long-term creep performance is important.
	Tendon Load Transfer	ATRA® Tendon Clip	Attached to tendons, provides positive transfer of sliding loads to the tendon system.
	Tendon Anchor Systems	Various	Tendon anchor type depends on geometry, environment, site conditions, and infill type. Dead-man crest anchors or earth anchors are generally recommended.
	Surface Treatments	Various	Application specific including: hydro seeding, emulsion coating, cement grouts, etc.

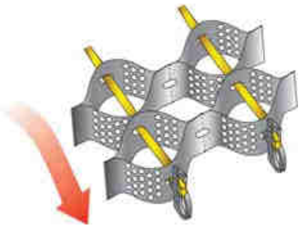
Notes:

1. This evaluation is copyrighted and is based on the use of products manufactured by Presto Products Company. All rights reserved. Any use of this evaluation for any product other than that manufactured by Presto makes this evaluation invalid.
2. The evaluation assumes that the slope is globally stable.
3. Provide a non–woven geotextile separation layer and install in accordance with Manufacturer instructions including overlaps.
4. Provide 30MIL PVC Smooth Liner and install in accordance with Manufacturer instructions including welds.
5. The Geoweb panels shall be connected with ATRA keys at each interleaf and end to end connection.
6. Infill must be placed at the crest first. The sides must be filled in equal increments.
7. Limit the drop of infill to prevent distortion of the cell walls.
8. Provide surface protection (hydroseed, ECB or TRM) sized for hydraulic conditions to prevent cell wash–out prior to establishment of vegetation.



ATRA KEY

ATRA TENDON CLIP



INSTALLATION

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APPLETON, WI 54914
920–738–1342
WWW.PRESTOGEO.COM

PR18241 – SHOOTING RANGE
GEOWEB SLOPE PROTECTION

PRESTO,® GEOWEB,® AND ATRA® ARE REGISTERED TRADEMARKS OF PRESTO PRODUCTS COMPANY.

DATE	APRIL 13, 2018	FILE NAME	SHEET 1
SCALE	NTS	SHEET	1 OF 2

Notes:

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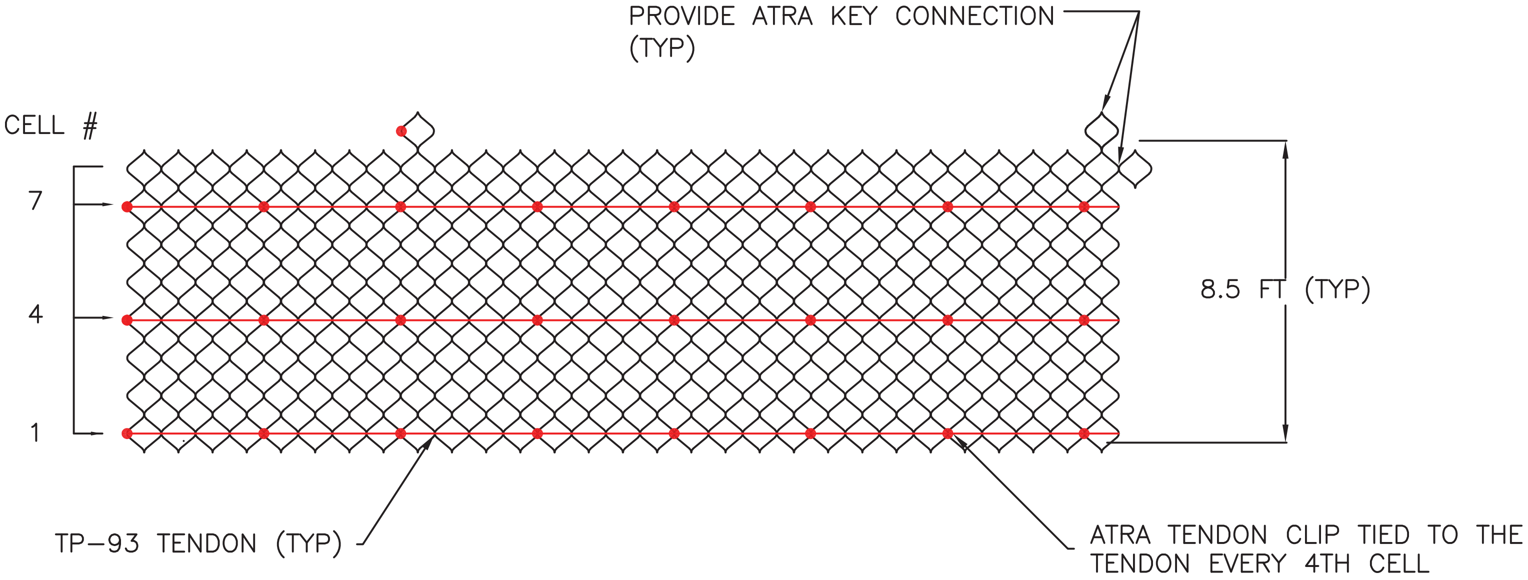
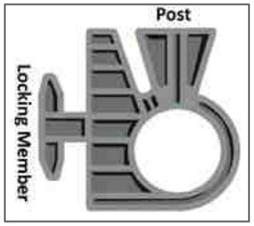
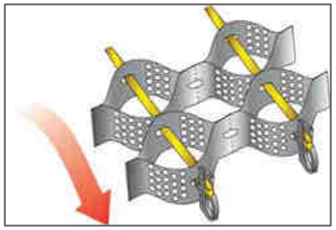


ATRA KEY



ATRA TENDON CLIP



INSTALLATION

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WWW.PRESTOGEO.COM

PR18241 – SHOOTING RANGE
GEOWEB SLOPE PROTECTION

PRESTO,® GEOWEB,® AND ATRA® ARE REGISTERED TRADEMARKS OF PRESTO PRODUCTS.

DATE	APRIL 13, 2018	FILE NAME	SHEET 2
SCALE	NTS	SHEET	2 OF 2

PVC
Product Data Sheet

Certified Properties	ASTM	PVC 10	PVC 20	PVC 30	PVC 40	PVC 50	PVC 60
Thickness	D-5199	10 +/- 0.5 mil 0.25 +/- .013mm	20 +/- 1 mil 0.51 +/- .03 mm	30 +/- 1.5 mil 0.76 +/- .04 mm	40 +/- 2 mil 1.02 +/- .05 mm	50 +/- 2.5 mil 1.27 +/- .06 mm	60 +/- 3 mil 1.52 +/- .08 mm
Tensile Properties[3]	D-882[4] Min						
Strength at Break		24 lbs/in 4.2 kN/m	48 lbs/in 8.4 kN/m	73 lbs/in 12.8 kN/m	97 lbs/in 17.0 kN/m	116 lbs/in 20.3 kN/m	137 lbs/in 24.0 kN/m
Elongation		250%	360%	380%	430%	430%	450%
Modulus at 100%		10 lbs/in 1.8 kN/m	21 lbs/in 3.7 kN/m	32 lbs/in 5.6 kN/m	40 lbs/in 7.0 kN/m	50 lbs/in 8.8 kN/m	60 lbs/in 10.5 kN/m
Tear Strength	D-1004[4] Min	2.5 lbs 11 N	6 lbs 27 N	8 lbs 35 N	10 lbs 44 N	13 lbs 58 N	15 lbs 67 N
Dimensional Stability	D-1204[4] Max Chg	4%	4%	3%	3%	3%	3%
Low Temperature Impact	D-1790[4] Pass	-10° F -23° C	-15° F -26° C	-20° F -29° C	-20° F -29° C	-20° F -29° C	-20° F -29° C

Index Properties	ASTM	PVC 10	PVC 20	PVC 30	PVC 40	PVC 50	PVC 60
Specific Gravity	D-792 Typical	1.2 g/cc	1.2 g/cc	1.2 g/cc	1.2 g/cc	1.2 g/cc	1.2 g/cc
Water Extraction Percent Loss (max)	D-1239[4] Max Loss	0.15%	0.15%	0.15%	0.20%	0.20%	0.20%
Average Plasticizer Molecular Weight	D-2124[4,5]	400	400	400	400	400	400
Volatile Loss Percent Loss (max)	D-1203[4] Max Loss	1.5%	0.9%	0.7%	0.5%	0.5%	0.5%
Soil Burial	G160[4] Max Chg						
Break Strength		5%	5%	5%	5%	5%	5%
Elongation		20%	20%	20%	20%	20%	20%
Modulus at 100%		20%	20%	20%	20%	20%	20%
Hydrostatic Resistance	D-751[4] Min	42 psi 290 kPa	68 psi 470 kPa	100 psi 690 kPa	120 psi 830 kPa	150 psi 1030 kPa	180 psi 1240 kPa

Seam Strengths	ASTM	PVC 10	PVC 20	PVC 30	PVC 40	PVC 50	PVC 60
Shear Strength[3]	D-882[4] Min	20 lbs/in 3.47 kN/m	38.4 lbs/in 6.7 kN/m	58.4 lbs/in 10 kN/m	77.6 lbs/in 14 kN/m	96 lbs/in 17 kN/m	116 lbs/in 20kN/m
Peel Strength[3]	D-882[4] Min	10 lbs/in 1.8 kN/m	12.5 lbs/in 2.2 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m	15 lbs/in 2.6 kN/m

Notes:

1. PGI 1104 replaces PGI 1103 Specification effective 1/1/04.
2. Certified properties are tested by lot as specified in PGI 1104 Appendix A.
3. Metric values are converted from US values and are rounded to the available significant digits.
4. Modifications or further details of test are described in PGI 1104 Appendix B.
5. Index properties are tested once per formulation as specified in PGI 1104 Appendix A.

TENCATE GEOSYNTHETICS
Americas

Mirafi® 180N

DRAINAGE EROSION PROTECTION FILTRATION SEPARATION

Mirafi® 180N is a needlepunched nonwoven geotextile composed of polypropylene fibers, which are formed into a stable network such that the fibers retain their relative position. Mirafi® 180N is inert to biological degradation and resists naturally encountered chemicals, alkalis, and acids. Mirafi® 180N meets AASHTO M288 Class 1 for Elongation > 50%.

TenCate Geosynthetics Americas Laboratories are accredited by Geosynthetic Accreditation Institute – Laboratory Accreditation Program (GAI-LAP). NTPEP Listed

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value	
			MD	CD
Grab Tensile Strength	ASTM D4632	lbs (N)	205 (912)	205 (912)
Grab Tensile Elongation	ASTM D4632	%	50	50
Trapezoid Tear Strength	ASTM D4533	lbs (N)	80 (356)	80 (356)
CBR Puncture Strength	ASTM D6241	lbs (N)	500 (2224)	
			Maximum Opening Size	
Apparent Opening Size (AOS)	ASTM D4751	U.S. Sieve (mm)	80 (0.18)	
			Minimum Roll Value	
Permittivity	ASTM D4491	sec^{-1}	1.4	
Flow Rate	ASTM D4491	gal/min/ft^2 (l/min/m^2)	95 (3870)	
			Minimum Test Value	
UV Resistance (at 500 hours)	ASTM D4355	% strength retained	70	

Physical Properties	Unit	Roll Sizes	
Roll Dimensions (width x length)	ft (m)	12.5 x 360 (3.8 x 110)	15 x 300 (4.57 x 91.4)
Roll Area	yd^2 (m^2)	500 (418)	

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