



US Army Corps
Of Engineers
Norfolk District

YORK RIVER SHORELINE STABILIZATION – COLONIAL PARKWAY YORKTOWN, VIRGINIA

Geotechnical Report

June 2013

PREPARED BY:
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GEOTECHNICAL REPORT

York River Shoreline Stabilization – Colonial Parkway
York Town, Virginia

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1. PURPOSE

The purpose of this report is to present the results of a subsurface exploration and to provide geotechnical recommendations for use in preparation of the final design of the York River Shoreline Stabilization project along the Colonial Parkway, Colonial National Historic Park, Virginia. The recommendations and evaluations provided are based on the 50% design concept and other information provided by the Hydraulics and Hydrology Section, Norfolk District.

The report summarizes the results of the subsurface exploration and laboratory testing performed by the Norfolk District U.S. Army Corps of Engineers (Corps). The report presents our understanding of the project, reviews the exploration procedures, and presents our observations, evaluations, and recommendations. The report does not address the archeological or environmental concerns related to this project; therefore appropriate references should be used to specifically address those concerns.

2. PROJECT INFORMATION

2.1. Scope of Work: The U.S. Army Corps of Engineers, Norfolk District, Geo-Environmental Section, Engineering Branch had responsibilities to provide Geotechnical recommendations for the proposed project. As part of our services a subsurface geotechnical exploration and laboratory testing program was performed. This report discusses the subsurface conditions encountered and provides foundation and earthwork recommendations for the York River shoreline stabilization project along the Colonial Parkway.

2.2. Site Description: The proposed project is located along the shore of the York River that parallels the Colonial Parkway in Yorktown, Virginia. The Colonial Parkway is within the Colonial National Historic Park, Virginia. The parkway is owned by the National Park Service. The location of the site is shown in the Site Vicinity Map included in Appendix A. The project has been divided into four reaches. Reach 1 extends from Felgates Creek eastward to Indian Field Creek, a distance of about 1.7 miles. Reach 2 extends from the mouth of Indian Field Creek eastward for about 1.4 miles to the west Pier of the Yorktown Naval Weapons Station. Reach 3 extends from the east pier at the Yorktown Naval Weapons Station downriver about 1.3 miles to Yorktown Creek. Reach 4 begins at the picnic area just downriver of Yorktown Beach and extends downriver about 1.4 miles to the U.S. Coast Guard Station. The picnic area is a low bank coast protected by a stone revetment built in 1983. Many of the banks along river are vertically exposed and incurred significant scarping. Many areas of the river banks had rock placed to prevent erosion; however, the rock has been overtopped causing erosion of the bluffs. Larger coastal storms will continue to overtop the lower existing revetments and erode the scarp face. The existing revetments will be raised to protect the shoreline bluffs. Some slope re-alignment through filling may be part of this component.

The Colonial Parkway ends near the Yorktown Battlefield Visitors Center. Reach 4 is generally within the Yorktown Battlefield grounds. The extent of work to be performed along Reach 4 was not known at the time the subsurface exploration was initiated and therefore no borings were made at this location.

2.3. Proposed Construction: This project will repair and stabilize approximately 6 miles of the York River Shoreline that have been severely eroding over the last 50 years. In order to protect the existing shoreline a combination of shoreline stabilization structures and marsh protection are proposed along the James River.

The shoreline stabilization structures will include the raising and reconstruction of existing rock revetments, constructing of new breakwaters, and construction of new sills and rehabilitation of existing rock sills. The raising and reconstruction of existing revetments is expected to include the placement of Class III armor stone/riprap that will have a crest elevation of either 9.0 feet or 10.0 feet, and a crest width of 4.0 feet. The side slope will meet the MLLW elevation at a slope of 2:1 (H:V). A rock toe will be constructed at the outboard side of the revetment generally 6 feet wide by 3 feet high. In order to facilitate the raising and reconstruction of the existing revetments along the bluffs, a 15' to 20' wide construction access is proposed along the shoreline over the existing rock revetments and into the existing bluff. The required excavation into the bluffs is expected to be on the order of five to ten feet resulting in a near vertical excavation ranging between four and six feet in height. The breakwaters are expected to have a crest elevation of 5 feet, and a crest width of 6 feet with a side slope of 1.5:1 (H:V). The rock sills for marsh protection are expected to consist of either a 3 or 5 foot crest elevation and 4 or 5 foot width with side slope of 1.5:1 (H:V). A description of what will be constructed in each reach is summarized below.

Reach 1: Adding between 2 to 4 feet of rock to increase the height of the existing rock revetment to elevation +5 (upper end of the reach) to elevation +9, and the construction of new rock sills at the upper end of the reach that will be installed along the low sand/marsh strand to stabilize the shore and enhance beach and marsh fringe habitat.

Reach 2: Adding between 2 to 4 feet of rock to the increase the height of the existing rock revetment to elevation +9 at the upper end of the reach to +10 at the lower end of the reach, and construction of new rock sills and rehabilitation of existing sills to elevation +3.

Reach 3: This phase will include raising the existing revetments 2 to 4 feet in height. A new breakwater system will be installed at the unprotected banks down river of the Navy pier to bring the beach movement to equilibrium.

Reach 4: The existing revetments will be raised to protect the bluffs. Some slope re-alignment through filling may be part of this component. The existing rock sills will also be rehabilitated.

3. DATA COLLECTION

3.1. General: A subsurface exploration consisting of sixteen (16) soil borings and in-situ testing consisting of eight (8) cone penetration tests were performed to further identify the subsurface material properties and define the subsurface stratigraphy. The subsurface exploration and laboratory testing was performed by Terracon Consulting LLC under contract to the Norfolk District.

3.2. Location: The test locations were marked in the field utilizing a tape and measuring from existing onsite features noted on the topographical information which was provided by the National Park Service (NPS) and a hand held global positioning device at selected locations. The locations of the in-situ testing (CPTs) performed over water were determined from the vessel global positioning equipment. Locations of the subsurface exploration tests are shown on the Subsurface Exploration Plan included in Appendix A. Ground surface elevations at each boring location were interpolated from the topographic map contours. The locations and elevations are only accurate to the degree implied by the method used in their determination.

3.3. Soil Test Borings: Sixteen (16) soil borings were advanced to depths ranging between 8 and 60 feet below the ground surface (bgs) which have been designated as 12DH-36 through 12DH-51. The soil borings were performed between February 22nd and 23rd 2012. The test borings were performed with truck mounted drill rig utilizing hollow stem auger (HSA) drilling procedures. Soils samples were obtained with a standard 1.4" I.D., 2" O.D., and 30 inch long split-spoon sampler driven with a 140-lb automatic hammer freely falling 30 inches. The number of blows required to drive the sampler for each 6 inch penetration increment was recorded. The recovered soil samples were visually classified in the field in general accordance with ASTM D 2488 by representatives of the Norfolk District. A portion of the recovered soil from the SPT test was obtained and placed in a sealed glass jar and returned to the Norfolk District Office for review and laboratory testing assignment. The soil boring logs are included in Appendix B.

3.4. Cone Penetration Test: The subsurface exploration program also consisted of eleven (11) Cone Penetration Tests (CPT) designated as CPT-1 through CPT-11. The CPT tests were performed by Terracon in accordance with ASTM D 5778. The tests were performed to a depth generally between 10 and 60 feet bgs. Cone resistance, friction resistance, and pore pressure were recorded at approximate 5cm intervals. The field test data was reduced by Terracon using established correlations and the results are provided in Appendix B. Five (5) of the CPT soundings (CPTs 4, 5, 6, 9 and 10) were obtained overwater. The Norfolk Districts, US Army Corps of Engineers work vessel was used as a floating platform to support the CPT testing rig.

3.5. Laboratory Testing: Laboratory soil index tests were performed on selected samples recovered from the site which consisted of 20 soil classification tests (ASTM D2216, D4318, D422 w/o hydrometer, and D1140). The results of these tests were used to aid in our classifications shown on the soil boring logs. The laboratory test results are provided in Appendix C.

4. SUBSURFACE CONDITIONS

4.1. Regional Geology: The project area which abuts York River and some of its small tributaries is located within the Coastal Plain Physiographic Province. The Coastal Plain consists of marine and fluvial deposits of the tertiary and cretaceous age in a series of major, glacially driven, marine transgressions. Through these transgressions older sediments have been eroded and deposited near the shore. This has resulted in a terrace-and-scarp geologic profile where each scarp essentially marks the landward limit of a marine transgression. The northern portion of the site between Felgates Creek and Yorktown Naval Weapons Station (YNWS) pier primarily consists of the Shirley Formation. The bluffs at Yorktown to the YNSW primarily consist of the Chuckatuck Formation. The Shirley and Chuckatuck Formation overly the underlying Yorktown Formation.

4.2. Subsurface Conditions: The subsurface conditions encountered are varied due to the changing topography over the approximate 5 miles of shore line. The major geologic formations encountered were the Shirley, Chuckatuck, and Yorktown Formations which are discussed in further depth below. The general descriptions, below, should not be considered as a substitute for the borings logs. Generalized subsurface profiles are included in Appendix B of this report.

Shirley Formation: Light to dark-gray, bluish gray and brown sand, gravel, silt, clay and peat. Constitutes surficial deposits of riverine terraces and relict baymouth barriers and bay-floor plains inset below depositional surfaces of the Chuckatuck Formation. Upper part of unit is truncated on the east by the Suffolk and Harpersville scarps; locally, lower part occurs east and west of scarps. Fluvial-estuarine comprises (1) lower pebble to boulder sand overlain by (2) fine to coarse sand interbedded with clayey silt rich in organic material which grade upward to (3) medium- to thick-bedded clayey and sandy silt and silty clay.

Chuckatuck Formation: Light- to medium-gray, yellowish-orange, and reddish-brown sand, silt and clay and minor amounts of dark-brown. Comprises surface deposits of mid-level coast-parallel plains and equivalent riverine terraces. Eastward, unit is truncated by the Suffolk scarp; westward along major stream drainages, unit is separated from the younger topographically lower Shirley Formation. Fluvial-estuarine facies included from bottom to top, (1) channel-fill deposits of poorly sorted, cross bedded, pebbly and cobbly sand interbedded, locally with sandy silt rich in organic matter, (2) moderately well-sorted, cross bedded to planar bedded, fine to medium grained sand grading upward into (3) clayey silt and sandy and silty clay.

Yorktown Formation: Bluish-gray and brownish-yellow sand, fine- to coarse-grained, in part glauconitic and phosphatic, commonly very shelly, interbedded with sandy and silty blue-gray clay. In lower York and James River basins, unit includes cross-bedded shell hash.

4.3 Groundwater Conditions: Groundwater, as noted at the time of drilling operations, was typically encountered between the depth of approximately 20 and 30.5 feet bgs along the bluffs and 1.5 and 6 feet bgs near the shore. The large variance in groundwater depth is likely due to the elevation change of the ground surface along the shoreline and bluffs.

Groundwater may become perched at relatively shallow depths by the underlying clay soils during wet weather conditions. Groundwater will also fluctuate with tidal changes, seasonal changes, periods of heavy or little rainfall and other factors. Our field measurements do not reveal the actual year-round groundwater conditions.

5. GEOTECHNICAL EVALUATION

5.1.General: The following findings and recommendations are based on our observations at the site, interpretation of the field and laboratory data obtained during our subsurface exploration, our experience with similar subsurface conditions and projects, and the project information available at the time this report was prepared.

5.2. Anticipated Settlements: revetments and breakwaters are expected to experience immediate settlement of the order of 1 inch during construction. Within the first year to year and a half, the structure is expected to experience an additional 1 to 2 inches of settlement due to consolidation after construction. The borings do not show considerable difference along the shore line; therefore, differential settlement is not expected to be significant within 1,000 foot increments of the shoreline.

5.3.Slope Stability: Due to the proposed excavation at the base of the bluffs to construct the rock revetments, it was deemed important to evaluate the stability of the slope once the slope is excavated and prior to placing the rock revetment at the toe. A slope stability analysis was performed at several locations along Reach 1 and Reach 3. The locations of these sections correspond to the soil borings and cone penetration tests as shown on the Subsurface Exploration Plan included in Appendix A.

Each cross-section was divided into several zones or strata based on material and strength properties as identified in the borings or CPT soundings. Groundwater levels were based on the water levels encountered during drilling. Material properties and shear strength for soil layers were estimated based on established empirical correlations and the results of the CPT soundings and SPT values. Tables 5.3-1 to 5.3-7 show the shear strength values and other parameters used in the slope stability analysis for the various soil layers. It is important to note that the material described at CPT locations is based on material behavior not physical observations.

Table 5.3-1: Summary of Engineering Properties for Slope Stability for 12DH-036

Zone/Material	Depth (ft)	Moist Unit Weight(pcf)	Undrained Shear Strength, psf	Effective Angle of Internal Friction, ϕ'
I/ (Drk. Gray to Brown Silty/Clayey Sand)	0 - 8	115	0	30°
II/ (Gray Sandy Clay)	8 - 21	100	1000	NA
III/ (Gray Silty Sand)	21 - 27	115	0	30°
IV/ (Gray Silty Sand)	27 - 40	120	0	32°

Table 5.3-2: Summary of Engineering Properties for Slope Stability for 12DH-037

Zone/Material	Depth (ft)	Moist Unit Weight(pcf)	Undrained Shear Strength, psf	Effective Angle of Internal Friction, ϕ'
I/ (Org-Brown sandy Clay)	0 - 5	110	950	NA
II/ (Gray Sand)	5 - 11	120	0	30°
IIA/ (Gray Sand w/clay)	21-Nov	120	500	32°
III/ (Brown/Gray Clayey Sand)	21 - 28.5	100	0	26°
IV/ (Gray Silty Sand)	28.5 - 33	120	0	32°
V/ (Gray Silty Sand)	33 - 40	120	0	35°

Table 5.3-3: Summary of Engineering Properties for Slope Stability for CPT-01

Zone/Material	Depth (ft)	Moist Unit Weight(pcf)	Undrained Shear Strength, psf	Effective Angle of Internal Friction, ϕ'
I/ (Clays)	0 - 1.5	120	1000	NA
II/(Sands)	1.5 - 2.5	125	0	32°
III/ (Silty Clays)	2.5 - 3.5	120	1500	NA
IV/ (Silty Sands)	3.5 - 6.5	125	0	33
V/ (Silty Clays)	6.5 - 8.5	115	1500	NA
VI/ (Sands)	8.5 - 10.5	120	0	35°
VII/ (Silty Clays)	10.5 - 18.5	115	1500	NA
VIII/ (Silty Clays)	18.5 - 32.5	118	3000	NA
IX/ (Silty Sands)	32.5 - 40	130	0	36°

Table 5.3-4: Summary of Engineering Properties for Slope Stability for CPT-02

Zone/Material	Depth (ft)	Moist Unit Weight(pcf)	Undrained Shear Strength, psf	Effective Angle of Internal Friction, ϕ'
I/ (Silty/Sandy Clays)	0 - 6	110	1500	NA
II/(Sands)	6 - 12	115	0	33°
III/ (Silty/Clayey Sands)	12 - 17	120	0	35°
IV/ (Clay to Silty Clays)	17 - 26	95	1000	NA
V/ (Silty Sands)	26 - 33	120	0	33°
VI/ (Silty Sands)	33 - 40	120	0	35°

Table 5.3-5: Summary of Engineering Properties for Slope Stability for CPT-03

Zone/Material	Depth (ft)	Moist Unit Weight(pcf)	Undrained Shear Strength, psf	Effective Angle of Internal Friction, ϕ'
I/ (Sands)	0 - 2	115	0	28°
II/(Clays)	2 - 4	100	1000	NA
III/ (Silty Sands)	4 - 13	120	0	30°
IV/ (Sandy Clays)	13 - 16	100	1000	NA
V/ (Sands)	16 - 20	120	0	32°
VI/(Clays)	20 - 26.5	100	3000	NA
VII/ (Silty Clay)	26.5 - 30	90	500	NA
VIII/ (Silty Sands)	30 - 32	125	0	32°
IX/ (Silty Sands)	32 - 40	125	0	35°

Table 5.3-6: Summary of Engineering Properties for Slope Stability for CPT-07

Zone/Material	Depth (ft)	Moist Unit Weight(pcf)	Undrained Shear Strength, psf	Effective Angle of Internal Friction, ϕ'
I/ (Sands)	0 - 9	120	0	32°
II/(Clays)	9 - 22	100	3000	NA
III/ (Silty Sands)	22 - 25	115	0	30°
IV/ (Sandy Clays)	25 - 36	98	2000	NA
V/ (Clays)	36-64	90	1000	NA
VI/(Silty Sands)	64 - 68	120	0	35°

Table 5.3-7: Summary of Engineering Properties for Slope Stability for CPT-08

Zone/Material	Depth (ft)	Moist Unit Weight(pcf)	Undrained Shear Strength, psf	Effective Angle of Internal Friction, ϕ'
I/ (Sands)	0 - 5	125	0	34°
II/(Silty Sands)	5 - 12	115	0	30°
III/ (Silty Clays)	12 - 16	105	2000	NA
IV/ (Clays)	16 - 21	110	3000	NA
V/ (Clays)	21 - 25	105	2000	NA
VI/(Clays)	25 - 28	98	1000	NA
VII/ (Organic Soils)	28 - 31	105	0	28°
VIII/ (Silty Clays)	31 - 56	95	1000	NA
IX/ (Silty Sands)	56 - 60	120	0	35°

Global stability was evaluated on the existing slope condition and anticipated slopes during construction to include the excavation of the bluff for the construction access. The slope stability program Slide, developed by Rock Science, was used to analyze stability of the existing and proposed grading of the project site. Block and circular failure surfaces were analyzed using, Bishops, Janbu, Corps, and Spencer's procedures. Individual and automatic searching failure planes were performed to determine the critical slip surface for a given slope. Stability results, along with sections of the soil profiles developed for the analysis, are included in Appendix D. A summary of the global minimum factor of safety is presented in Table 5.3-8. Based on a comparison of the existing conditions and conditions during construction, very little change in the factor of safety was found. Therefore, there should be no change in the stability between the existing condition and conditions during construction. Once the rock revetments are in place the factor of safety for the bluff should be similar or better than before the excavation. It should be noted that it is generally recommended to have factors of safety equal or greater than 1.5 for slopes. The section taken along CPT-8 was found to be less than 1.5 for the existing condition and the bluff overall bluff stability would not meet recommended standards. It should also be noted that slip surfaces with a factor of safety

below 1.0 were noted in some stability outputs but these were shallow surficial slide planes along the existing slopes which may occur regardless of the excavation and construction. These slip surfaces are shown in the outputs included in Appendix D

Table 5.3-8: Global Minimum Factors of Safety

Section	Global Minimum FS	
	Existing	After Construction
12DH-036	1.493	1.484
12DH-037	1.778	1.775
CPT-1	3.884	3.825
CPT-2	1.563	1.499
CPT-3	1.963	1.863
CPT-7	1.483	1.497
CPT-8	1.264	1.248

6. CONSTRUCTION RECOMMENDATIONS

6.1. Suitability of On-site Material for Reuse: The onsite soils may be reused on site for general grading. The natural fine subgrade soils are highly moisture sensitive and may lose stability when wet or subjected to loading from construction equipment. Based on experience, the in-situ moisture content is expected to be greater than three percent higher than the optimum moisture needed for compaction. As a result the contractor should expect that the onsite soil will require drying by aerating or disking before being reused in suitable areas and to develop a suitable subgrade for areas to receive compacted controlled fill, pavement, or concrete slabs-on-grade. It is important to stress that the subgrade needs to be properly prepared and protected during construction to minimize the degradation of these soils.

6.2. Compaction Requirements: The contractor shall provide proper compaction equipment to meet compaction requirements based on a modified Proctor (ASTM D 1557). Due to the higher energy from the modified Proctor, the optimum moisture content of the material will be lower than a standard Proctor. The in-situ moisture content of the subsurface material is expected to be higher than the optimum moisture content from a modified Proctor. The contractor should be prepared to adequately dry the in-situ soils prior to placement as backfill. The minimum compaction requirements for this project are listed on the following page.

Green Areas: Compact to 85 percent of ASTM 1557.

Proper compaction equipment should be utilized by the contractor to achieve the required compaction. For areas which do not permit the use of heavy compaction equipment (utility trenches and near retaining structures) lift thickness may need to be reduced to achieve the required compaction. During fill operations, positive surface drainage should be maintained to prevent the accumulation of water. Each lift of fill should be tested in order to confirm that the degree of compaction is attained. Field density tests to verify fill compaction should be as required by the earthwork specification.

The moisture of backfill material should be maintained within three percentage points of the optimum moisture content as determined from the modified Proctor. Compaction requirements may be reduced by 5 percent for cohesive material, defined as material containing more than 40 percent fines (material passing the No. 200 sieve) with a PI greater than 12 in accordance with ASTM D 4318 except in Green Areas.

6.3. Temporary Excavation Support System: It is recommended that prior to the excavation, the contractor have a geotechnical engineer observe the slope conditions of the bluffs to ensure there is no signs of instability such as tension cracks indicating potential conditions for a slope failure. These areas shall be carefully and continuously monitored during construction. All work shall be performed by heavy construction equipment which has enclosed safety cab. No personnel shall be allowed to work at the bottom of the bluff without proper protection such as a trench box or similar equipment. If space and site constraints permit, excavations in the onsite soils should be sloped back

at a grade of 2 horizontal to 1 vertical (2H:1V) or properly benched and should meet all the requirements of OSHA regulations. Sloped surfaces shall be covered with an erosion control mat to prevent sloughing or raveling the surface. Alternative methods for excavation support may be needed where space limitations and site constraints prevent the soil from being sloped back. Such alternatives may consist of soldier pile and wood lagging walls, with anchors and wales. All excavation support systems shall be designed by a registered professional engineer working for the Contractor. Alternative methods may be required to prevent sloughing of the bluff in the construction access excavation to maintain access. The Contractor shall minimize the duration the excavation will be left open to prevent sloughing of the bluff. As a result the Contractor shall phase his construction so that each section of the revetment is completed and bluff slope repaired prior to moving onto another portion of the revetment repair.

6.4. Dewatering: The alternating layers of clays and sands which compose the soil profile of the bluffs are susceptible to transmitting perched seepage water. Excavation along the base of the bluffs can expect to encounter groundwater and dewatering methods such as sumps with open pumping or well points may be required to allow construction under dry conditions.

Appendix A - Site Vicinity Map & Subsurface Exploration Plan

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Channel Framework
 Federal Navigation Projects
 Boundary or Other
 Placement Cell



Developed By: Geospatial Services
 Section, USACE Norfolk District
 via CorpsMap:
<https://corpsmap.usace.army.mil/nao>
 Email: geospatial@usace.army.mil

Site Vicinity

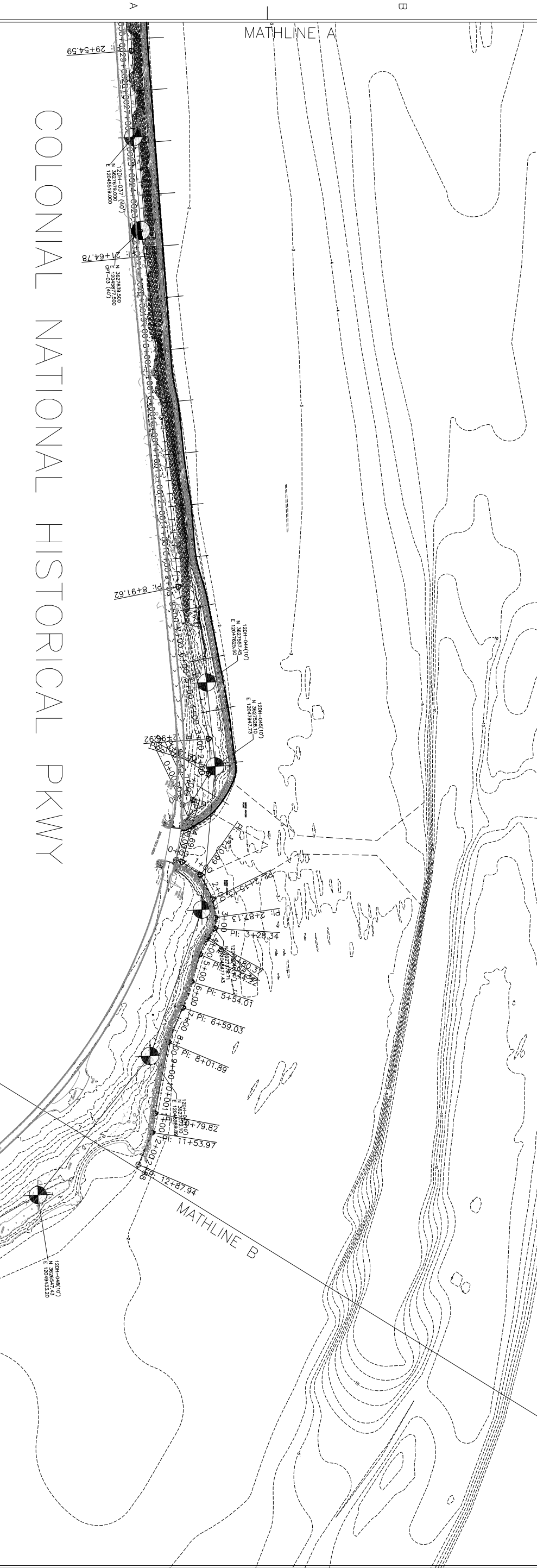
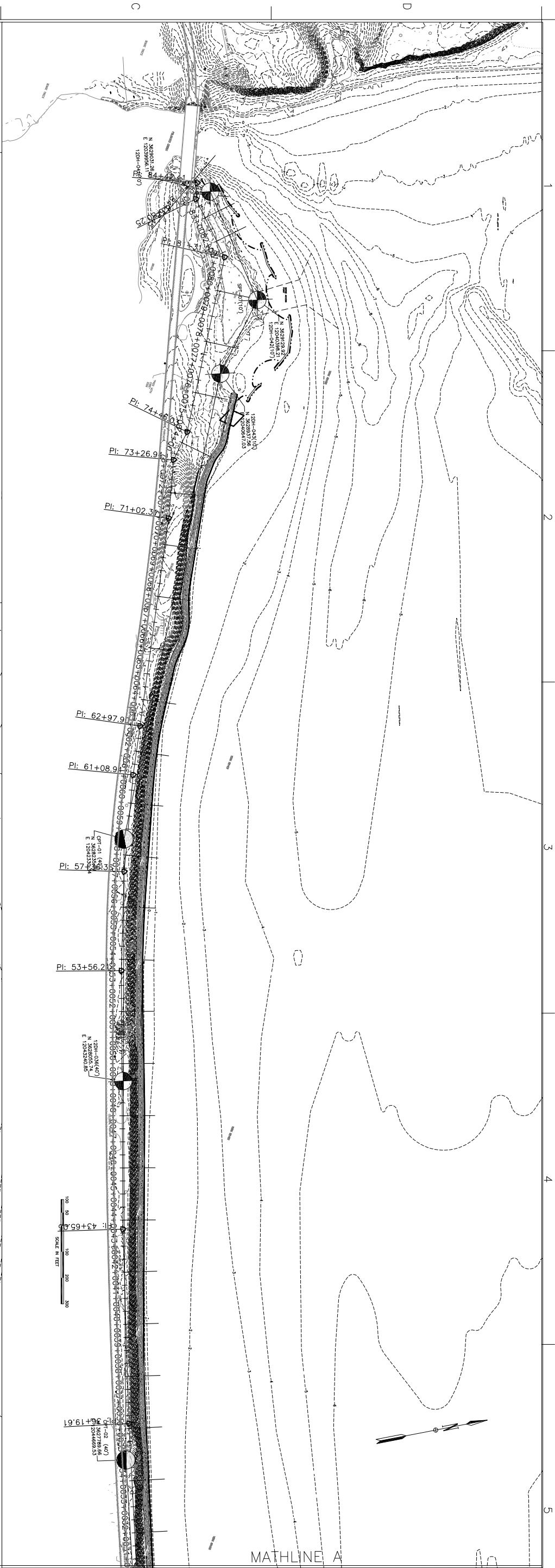
0 1 2 3km



Date Printed: 06.07.2013

Map Scale: 1:108336

Map data ©2013 Google Imagery ©2013 TerraMetrics



COLONIAL NATIONAL HISTORICAL PKWY

SHEET
REFERENCE
NUMBER
B-101
SHEET 2 OF 3

NATIONAL PARK SERVICE
COLONIAL NATIONAL HISTORIC PARK
SHORELINE STABILIZATION YORK RIVER

EXPLORATION PLAN

NORFOLK DISTRICT
CORPS OF ENGINEERS
NORFOLK, VIRGINIA

SUBMITTAL
MAY 2013

DESIGNED: RLH	CHECKED: RLH	DATE: 31-MAY-13
DRAWN: JAP	SUBMITTED: RLH	SCALE: AS SHOWN
PROJECT NO. XXXXXX	NORFOLK DISTRICT FILE NO. XXXXXXXXXX-	
DRAWING NO. XXX-XX-XX	SPECIFICATION NO. XXXXXXXXXXXX	
Last worked on: File name: FILE_NAME		Plot scale: XX

REV.	DATE	DESCRIPTION	BY	APP.

U.S. Army Corps
of Engineers
NORFOLK DISTRICT



Appendix B - Soil Boring and CPT Logs

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DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 1 OF 2 SHEETS	
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA			
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,043,240.9 E 3,628,055.7				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW			
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T			
4. HOLE NO. (As shown on drawing title and file number) 12DH-036				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 11 UNDISTURBED 0	
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES --			
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER NA			
7. THICKNESS OF OVERBURDEN -				16. DATE HOLE STARTED 2/23/2012		COMPLETED 2/23/2012	
8. DEPTH DRILLED INTO ROCK --				17. ELEVATION TOP OF HOLE +29.5 ±			
9. TOTAL DEPTH OF HOLE 40.0				18. TOTAL CORE RECOVERY FOR BORING -- %			
				19. GEOLOGIST R.L. Huntoon			
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g	
29	0.5		Dark Brown, silty fine SAND with little organics (moist) [Surficial Soil]	S1 0' to 2'	2-1-2-3 N=3	MC = 15.1% - #200 = 24% LL = 25 PI = 7	
27.5	2.0		Light Gray to Tan Mottled Light Gray, silty fine SAND (moist) [SM]	S2 2' to 4'	2-3-3-4 N=6		
25.5	4.0		Light Gray to Tan Mottled Light Gray, silty/clayey fine SAND (moist) [SM-SC]	S3 4' to 6'	3-4-4-4 N=8		
22.5	7.0		Brown to Tan clayey fine SAND (moist) [SC]	S4 6' to 8'	1-2-3-4 N=5	MC = 22% - #200 = 66% LL = 44 PI = 30 **H = weight of hammer	
21.5	8.0		Tan Mottled Light Gray fine SAND with little silt (moist) [SP-SM]	S5 8' to 10'	H-2-3-6 N=5		
17.5	12.0		Tan Mottled Light Gray, fine sandy CLAY (moist) [CL]	S6 13' to 15'	4-4-5-6 N=9		
			Tan Mottled Gray fine sandy CLAY with lenses of shell fragments (moist) [CL]	S7 18' to 20'	2-1-2-4 N=3		
8.5	21.0		Tan Mottled Gray fine sandy CLAY with lenses of shell fragments (moist to wet) [CL]	S8 23' to 25'	3-3-2-7 N=5		
			Gray to Tan silty fine SAND with some shell fragments and little clay (wet) [SM]	S9 28' to 30'	4-3-4-9 N=7		
			Gray to Tan silty fine SAND with some shell fragments and little clay (wet) [SM]				

DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 2 OF 2 SHEETS	
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA			
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,043,240.9 E 3,628,055.7				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW			
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T			
4. HOLE NO. (As shown on drawing title and file number) 12DH-036				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 11 UNDISTURBED 0	
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES --			
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER		NA	
7. THICKNESS OF OVERBURDEN -				16. DATE HOLE		STARTED 2/23/2012 COMPLETED 2/23/2012	
8. DEPTH DRILLED INTO ROCK --				17. ELEVATION TOP OF HOLE		+29.5 ±	
9. TOTAL DEPTH OF HOLE 40.0				18. TOTAL CORE RECOVERY FOR BORING		-- %	
				19. GEOLOGIST R.L. Huntoon			
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g	
			Gray to Tan silty fine SAND with some shell fragments and little clay (wet) [SM]	S10 33' to 35'	7-10-12-15 N=22	MC = 22.9% - #200 = 14% LL = NP PI = NP	
				S11 38' to 40'	8-12-9-19 N=21		
-10.5	40.0		Boring terminated at a depth of 40 feet				

DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 1 OF 2 SHEETS		
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA				
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,045,519.2 E 3,627,678.1				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW				
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T				
4. HOLE NO. (As shown on drawing title and file number) 12DH-037				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 11 UNDISTURBED 0		
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES --				
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER NA				
7. THICKNESS OF OVERBURDEN -				16. DATE HOLE		STARTED 2/23/2012 COMPLETED 2/23/2012		
8. DEPTH DRILLED INTO ROCK --				17. ELEVATION TOP OF HOLE +29.0 ±				
9. TOTAL DEPTH OF HOLE 40.0				18. TOTAL CORE RECOVERY FOR BORING -- %				
				19. GEOLOGIST R.L. Huntoon				
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g		
28.5	0.5		Dark Brown silty fine SAND with some organics [Surficial Soil]	S1 0' to 2'	3-1-1-2 N=2	MC = 9.2% - #200 = 11% LL = NP PI = NP		
27	2.0		Tan silty fine SAND (moist) [SM]	S2 2' to 4'	3-2-2-4 N=4			
24	5.0		Light Brown fine sandy CLAY (moist) [CL]	S3 4' to 6'	3-4-5-4 N=9			
			Tan Mottled Gray fine SAND with little silt (moist) [SP-SM]	S4 6' to 8'	1-2-2-2 N=4			
			Tan Mottled Gray fine SAND with little silt (moist) [SP-SM]	S5 8' to 10'	1-2-2-3 N=4	Cave-In depth at 18' MC = 8.5% - #200 = 7% LL = NP PI = NP		
			Tan Mottled Gray fine SAND with little silt (moist) [SP-SM]	S6 13' to 15'	1-2-3-4 N=5			
			Tan Mottled Gray fine SAND with little silt (moist) [SP-SM]	S7 18' to 20'	2-4-5-9 N=9			
8	21.0		Brown to Gray fine clayey SAND (moist) [SC]	S8 23' to 25'	1-H-1-H N=1	MC = 22.8% - #200 = 47% LL = 29 PI = 15 **H = weight of hammer		
0.5	28.5			S9 28' to 30'	H-H-1-1 N=1			
								**H = weight of hammer

DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 2 OF 2 SHEETS	
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA			
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,045,519.2 E 3,627,678.1				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW			
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T			
4. HOLE NO. (As shown on drawing title and file number) 12DH-037				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 11 UNDISTURBED 0	
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES --			
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER		NA	
7. THICKNESS OF OVERBURDEN -				16. DATE HOLE		STARTED 2/23/2012 COMPLETED 2/23/2012	
8. DEPTH DRILLED INTO ROCK --				17. ELEVATION TOP OF HOLE		+29.0 ±	
9. TOTAL DEPTH OF HOLE 40.0				18. TOTAL CORE RECOVERY FOR BORING		-- %	
				19. GEOLOGIST R.L. Huntoon			
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g	
			Gray silty fine SAND with some shell fragments (wet) [SM]	S10 33' to 35'	2-4-6-9 N=10		
			Gray silty fine SAND with some shell fragments (wet) [SM]	S11 38' to 40'	1-3-8-15 N=11		
-11	40.0		Boring terminated at a depth of 40 feet				

DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 1 OF 2 SHEETS	
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA			
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,052,200.5 E 3,623,467.6				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW			
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T			
4. HOLE NO. (As shown on drawing title and file number) 12DH-038				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 11 UNDISTURBED 0	
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES --			
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER NA		16. DATE HOLE STARTED 2/22/2012 COMPLETED 2/22/2012	
7. THICKNESS OF OVERBURDEN -				17. ELEVATION TOP OF HOLE +19.0 ±			
8. DEPTH DRILLED INTO ROCK --				18. TOTAL CORE RECOVERY FOR BORING -- %			
9. TOTAL DEPTH OF HOLE 40.0				19. GEOLOGIST P. Wunderly			
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g	
17	2.0		Orange-Brown silty fine SAND with trace organics [SM]	S1 0' to 2'	H-3-4-3 N=7	**H = weight of hammer	
			Orange-Brown fine sandy CLAY [CH]	S2 2' to 4'	3-4-5-8 N=9		
			Orange-Brown fine sandy CLAY (moist) [CH]	S3 4' to 6'	4-5-8-10 N=13	MC = 31.9% - #200 = 88% LL = 66 PI = 47	
			Orange-Brown CLAY with some fine sand (moist) [CH]	S4 6' to 8'	3-3-3-3 N=6		
			Orange-Brown fine sandy CLAY (moist) [CH]	S5 8' to 10'	H-H-2-4 N=2	**H = weight of hammer	
7.5	11.5		Brown silty fine SAND [SM]	S6 13' to 15'	1-2-3-3 N=5		
			Brown silty fine SAND with some shell fragments [SM]	S7 18' to 20'	1-2-8-9 N=10	MC = 27.2% - #200 = 22% LL = NP PI = NP	
						Cave-In at 21' bgs	
			Brown silty fine SAND [SM]	S8 23' to 25'	2-2-3-3 N=5		
			Brown silty fine SAND [SM]	S9 28' to 30'	2-2-5-7 N=7		

DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 2 OF 2 SHEETS	
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA			
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,052,200.5 E 3,623,467.6				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW			
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T			
4. HOLE NO. (As shown on drawing title and file number) 12DH-038				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 11 UNDISTURBED 0	
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES --			
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER		NA	
7. THICKNESS OF OVERBURDEN -				16. DATE HOLE		STARTED 2/22/2012 COMPLETED 2/22/2012	
8. DEPTH DRILLED INTO ROCK --				17. ELEVATION TOP OF HOLE		+19.0 ±	
9. TOTAL DEPTH OF HOLE 40.0				18. TOTAL CORE RECOVERY FOR BORING		-- %	
				19. GEOLOGIST P. Wunderly			
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g	
-12.5	31.5		Tan fine SAND with little silt and shell fragments [SP-SM]	S10 33' to 35'	3-16-16-18 N=32	Lense of dark gray sandy SILT	
			Tan fine SAND with little silt and shell fragments [SP-SM]	S11 38' to 40'	5-10-13-18 N=23	MC = 20.8% - #200 = 12% LL = NP PI = NP	
-21	40.0		Boring terminated at a depth of 40 feet				

DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 1 OF 3 SHEETS	
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA			
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,059,463.4 E 3,617,181.1				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW			
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T			
4. HOLE NO. (As shown on drawing title and file number) 12DH-039				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 15 UNDISTURBED 0	
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES --			
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER		NA	
7. THICKNESS OF OVERBURDEN -				16. DATE HOLE		STARTED 2/22/2012 COMPLETED 2/22/2012	
8. DEPTH DRILLED INTO ROCK --				17. ELEVATION TOP OF HOLE +44.0 ±			
9. TOTAL DEPTH OF HOLE 60.0				18. TOTAL CORE RECOVERY FOR BORING -- %			
				19. GEOLOGIST P. Wunderly			
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g	
42	2.0		Orange-Brown silty fine SAND with trace organics [Surficial Soil]	S1 0' to 2'	1-1-2-3 N=3	MC = 7.7% - #200 = 4% LL = NP PI = NP	
			Orange-Brown silty fine SAND [SM]	S2 2' to 4'	1-2-2-4 N=4		
40	4.0		Orange-Brown fine SAND with trace silt [SM-SP]	S3 4' to 6'	2-4-6-8 N=10		
38	6.0		Orange-Brown to Tan silty SAND with trace organics [SM]	S4 6' to 8'	3-4-4-5 N=8		
36	8.0		Tan silty fine SAND [SM]	S5 8' to 10'	4-4-6-5 N=10		
31	13.0		Gray silty fine SAND [SM]	S6 13' to 15'	1-2-4-7 N=6	MC = 20.3% - #200 = 43% LL = 28 PI = 5	
			Orange-Brown fine sandy CLAY [CH]	S7 18' to 20'	1-5-8-11 N=13		
26	18.0		Orange-Brown fine sandy CLAY [CH]	S7 18' to 20'	1-5-8-11 N=13	**H = weight of hammer No Sample Recovery	
22.5	21.5		Brown clayey SILT with shell fragments [ML]	S8 23' to 25'	2-2-2-7 N=4		
				S9 28' to 30'	H/24"--- N=0		

DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 2 OF 3 SHEETS	
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA			
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,059,463.4 E 3,617,181.1				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW			
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T			
4. HOLE NO. (As shown on drawing title and file number) 12DH-039				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 15 UNDISTURBED 0	
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES --			
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER NA		16. DATE HOLE STARTED 2/22/2012 COMPLETED 2/22/2012	
7. THICKNESS OF OVERBURDEN -				17. ELEVATION TOP OF HOLE +44.0 ±			
8. DEPTH DRILLED INTO ROCK --				18. TOTAL CORE RECOVERY FOR BORING -- %			
9. TOTAL DEPTH OF HOLE 60.0				19. GEOLOGIST P. Wunderly			
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g	
			Gray fine sandy SILT with shell fragments [ML]	S10 33' to 35'	H-H-2-4 N=2	MC = 37.4% - #200 = 60% LL = 34 PI = 9 **H = weight of hammer	
			Gray fine sandy SILT with shell fragments [ML]	S11 40' to 42'	2-3-4-11 N=7		
			Gray fine sandy SILT with shell fragments [ML]	S12 43' to 45'	3-3-5-5 N=8		
-4	48.0		Gray sandy CLAY with shell fragments [CL]	S13 48' to 50'	2-3-5-8 N=8	MC = 34.1 - #200 = 68% LL = 39 PI = 22 Cave-In at depth 49' bgs	
			Gray sandy CLAY with shell fragments [CL]	S14 53' to 55'	2-3-7-7 N=10		
-13	57.0		Gray silty fine SAND (moist) [SM]	S15 58' to 60'	3-6-6-8 N=12		

DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 3 OF 3 SHEETS	
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA			
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,059,463.4 E 3,617,181.1				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW			
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T			
4. HOLE NO. (As shown on drawing title and file number) 12DH-039				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 15 UNDISTURBED 0	
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES		--	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER		NA	
7. THICKNESS OF OVERBURDEN -				16. DATE HOLE		STARTED 2/22/2012 COMPLETED 2/22/2012	
8. DEPTH DRILLED INTO ROCK --				17. ELEVATION TOP OF HOLE		+44.0 ±	
9. TOTAL DEPTH OF HOLE 60.0				18. TOTAL CORE RECOVERY FOR BORING		-- %	
				19. GEOLOGIST		P. Wunderly	
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g	
-16	60.0		Boring terminated a a depth of 60 feet				

DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 1 OF 3 SHEETS	
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA			
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,060,334.4 E 3,617,015.6				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW			
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T			
4. HOLE NO. (As shown on drawing title and file number) 12DH-040				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 15 UNDISTURBED 0	
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES --			
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER NA			
7. THICKNESS OF OVERBURDEN -				16. DATE HOLE STARTED 2/22/2012		COMPLETED 2/22/2012	
8. DEPTH DRILLED INTO ROCK --				17. ELEVATION TOP OF HOLE +44.0 ±			
9. TOTAL DEPTH OF HOLE 60.0				18. TOTAL CORE RECOVERY FOR BORING -- %			
				19. GEOLOGIST P. Wunderly			
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g	
40	4.0		Dark brown silty clayey fine SAND with little organics [Surficial Soil]	S1 0' to 2'	H-2-2-1 N=4	**H = weight of hammer	
				S2 2' to 4'	1-2-1-1 N=3		
38	6.0		Orange-Brown silty fine SAND [SW-SM]	S3 4' to 6'	2-2-3-3 N=5	MC = 7% - #200 = 10% LL = NP PI = NP	
				S4 6' to 8'	4-5-5-4 N=10		
36	8.0		Orange-Brown silty SAND [SM]	S5 8' to 10'	3-4-4-3 N=8	MC = 4.5% - #200 = 1% LL = NP PI = NP	
32	12.0		Tan fine SAND with trace silt [SP]	S6 13' to 15'	1-3-4-4 N=7	MC = 13.8% - #200 = 43% LL = 25 PI = 13	
27	17.0		Gray clayey fine SAND [SC]	S7 18' to 20'	3-6-7-7 N=13		
			Orange Brown sandy SILT [ML]	S8 23' to 25'	0-2-3-4 N=5		
16	28.0		Orange Brown sandy SILT [ML]	S9 28' to 30'	H-H-H-H N=0	MC = 31% - #200 = 79% LL = 45 PI = 29 **H = weight of hammer	
			Orange Brown Mottled CLAY with some fine sand [CL]				

DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 2 OF 3 SHEETS	
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA			
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,060,334.4 E 3,617,015.6				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW			
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T			
4. HOLE NO. (As shown on drawing title and file number) 12DH-040				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 15 UNDISTURBED 0	
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES --			
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER NA		16. DATE HOLE STARTED 2/22/2012 COMPLETED 2/22/2012	
7. THICKNESS OF OVERBURDEN -				17. ELEVATION TOP OF HOLE +44.0 ±			
8. DEPTH DRILLED INTO ROCK --				18. TOTAL CORE RECOVERY FOR BORING -- %			
9. TOTAL DEPTH OF HOLE 60.0				19. GEOLOGIST P. Wunderly			
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g	
11	33.0		Orange Brown Mottled sandy SILT [ML]	S10 33' to 35'	H-H-H-H N=0	**H = weight of hammer	
				S11 38' to 40'	H-H-H-H N=0	No Sample Recovery	
2	42.0		Orange Brown silty fine SAND with shell fragments [SM]	S12 43' to 45'	2-3-4-4 N=7		
			Orange Brown silty fine SAND with shell fragments [SM]	S13 48' to 50'	4-6-6-6 N=12		
			Orange Brown silty fine SAND with shell fragments [SM]	S14 53' to 55'	3-4-5-9 N=9		
			Tan-White silty fine SAND with shell fragments [SM]	S15 58' to 60'	5-8-7-9 N=15		

DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 3 OF 3 SHEETS	
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA			
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,060,334.4 E 3,617,015.6				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW			
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T			
4. HOLE NO. (As shown on drawing title and file number) 12DH-040				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 15 UNDISTURBED 0	
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES		--	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER		NA	
7. THICKNESS OF OVERBURDEN -				16. DATE HOLE		STARTED 2/22/2012 COMPLETED 2/22/2012	
8. DEPTH DRILLED INTO ROCK --				17. ELEVATION TOP OF HOLE		+44.0 ±	
9. TOTAL DEPTH OF HOLE 60.0				18. TOTAL CORE RECOVERY FOR BORING		-- %	
				19. GEOLOGIST		P. Wunderly	
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g	
-16	60.0		Boring terminated at a depth of 60 feet				

DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 1 OF 1 SHEETS	
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA			
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,039,956.1 E 3,629,031.3				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW			
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T			
4. HOLE NO. (As shown on drawing title and file number) 12DH-041				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 5 UNDISTURBED 0	
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES --			
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER NA			
7. THICKNESS OF OVERBURDEN -				16. DATE HOLE STARTED 2/23/2012		COMPLETED 2/23/2012	
8. DEPTH DRILLED INTO ROCK --				17. ELEVATION TOP OF HOLE +3.0 ±			
9. TOTAL DEPTH OF HOLE 10.0				18. TOTAL CORE RECOVERY FOR BORING -- %			
				19. GEOLOGIST R.L. Huntoon			
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g	
2.6	0.4		Dark Gray to Brown silty fine SAND with little organics (moist) [Surficial Soil]	S1 0' to 2'	8-7-7-8 N=14	MC = 19.6% - #200 = 4% LL = NP PI = NP **H = weight of hammer	
1	2.0		Brown-Reddish Brown fine sandy CLAY (moist) [CL] [FILL]	S2 2' to 4'	6-7-8-3 N=15		
			Tan fine SAND with little silt and shell fragments (moist to wet) [SP]	S3 4' to 6'	5-5-7-2 N=12		
				S4 6' to 8'	H-3-3-2 N=6		
				S5 8' to 10'	H-3-3-4 N=6		
-7	10.0		Boring terminated at a depth of 10 feet				

DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 1 OF 1 SHEETS	
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA			
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,040,398.2 E 3,629,129.9				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW			
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T			
4. HOLE NO. (As shown on drawing title and file number) 12DH-042				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 4 UNDISTURBED 0	
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES --			
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER NA			
7. THICKNESS OF OVERBURDEN -				16. DATE HOLE STARTED 2/23/2012		COMPLETED 2/23/2012	
8. DEPTH DRILLED INTO ROCK --				17. ELEVATION TOP OF HOLE +3.0 ±			
9. TOTAL DEPTH OF HOLE 8.0				18. TOTAL CORE RECOVERY FOR BORING -- %			
				19. GEOLOGIST R.L. Huntoon			
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g	
2.5	0.5		Dark Brown silty fine SAND with little organics (moist) [Surficial Soil]	S1 0' to 2'	2-3-5-6 N=8		
1	2.0		Tan-Brown fine SAND with little shells and silt (moist) [SP-SM]	S2 2' to 4'	3-5-2-2 N=7		
			Gray silty fine SAND with little to some shell fragments (wet) [SM]	S3 4' to 6'	1-1-1-1 N=2		
				S4 6' to 8'	H/24"--- N=		
-5	8.0		Boring terminated at a depth of 8 feet				**H = weight of hammer

DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 1 OF 1 SHEETS	
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA			
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,040,648.8 E 3,628,936.8				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW			
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T			
4. HOLE NO. (As shown on drawing title and file number) 12DH-043				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 5 UNDISTURBED 0	
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES --			
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER		NA	
7. THICKNESS OF OVERBURDEN -				16. DATE HOLE		STARTED 2/23/2012 COMPLETED 2/23/2012	
8. DEPTH DRILLED INTO ROCK --				17. ELEVATION TOP OF HOLE		+3.0 ±	
9. TOTAL DEPTH OF HOLE 10.0				18. TOTAL CORE RECOVERY FOR BORING		-- %	
				19. GEOLOGIST R.L. Huntoon			
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g	
2.9	0.1		Shell Fragments (1")	S1 0' to 2'	1-1-2-8 N=3		
1	2.0		Brown-Tan silty fine SAND with some shell fragments [SM]	S2 2' to 4'	7-7-5-3 N=12		
-1	4.0		Gray silty fine SAND with some shell fragments (wet to moist) [SM]	S3 4' to 6'	6-6-9-5 N=15		
				S4 6' to 8'	2-2-3-2 N=5		
				S5 8' to 10'	1-1-1-H N=2		
-7	10.0		Boring terminated at a depth of 10 feet			**H = weight of hammer	

DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 1 OF 1 SHEETS	
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA			
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,047,625.5 E 3,627,557.4				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW			
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T			
4. HOLE NO. (As shown on drawing title and file number) 12DH-044				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 5 UNDISTURBED 0	
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES --			
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER NA			
7. THICKNESS OF OVERBURDEN -				16. DATE HOLE		STARTED 2/23/2012 COMPLETED 2/23/2012	
8. DEPTH DRILLED INTO ROCK --				17. ELEVATION TOP OF HOLE +6.5 ±			
9. TOTAL DEPTH OF HOLE 10.0				18. TOTAL CORE RECOVERY FOR BORING -- %			
				19. GEOLOGIST R.L. Huntoon			
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g	
6.2	0.3		Dark Brown silty fine SAND with trace organics [Surficial Soil]	S1 0' to 2'	1-2-4-5 N=6		
			Light Brown fine SAND with trace to little silt (moist) [SP]	S2 2' to 4'	3-5-5-5 N=10		
				S3 4' to 6'	3-5-5-4 N=10		
-0.5	7.0		Gray fine SAND with little silt (wet) [SP-SM]	S4 6' to 8'	1-1-2-2 N=3		
-2.5	9.0		Yellowish Brown silty fine SAND with little shell fragments (wet) [SM]	S5 8' to 10'	1-3-4-5 N=7		
-3.5	10.0		Boring terminated at a depth of 10 feet				

DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 1 OF 1 SHEETS	
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA			
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,047,947.7 E 3,627,528.1				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW			
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T			
4. HOLE NO. (As shown on drawing title and file number) 12DH-045				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 5 UNDISTURBED 0	
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES --			
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER NA			
7. THICKNESS OF OVERBURDEN -				16. DATE HOLE		STARTED 2/23/2012 COMPLETED 2/23/2012	
8. DEPTH DRILLED INTO ROCK --				17. ELEVATION TOP OF HOLE +7.5 ±			
9. TOTAL DEPTH OF HOLE 10.0				18. TOTAL CORE RECOVERY FOR BORING -- %			
				19. GEOLOGIST R.L. Huntoon			
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g	
			Tan fine SAND with trace silt (moist to wet) [SP]	S1 0' to 2'	H-2-4-5 N=6	**H = weight of hammer	
				S2 2' to 4'	3-3-3-4 N=6		
				S3 4' to 6'	3-3-4-4 N=7	Cave-In at 5' after drilling	
				S4 6' to 8'	2-2-1-2 N=3		
-1.5	9.0		Dark Gray silty fine SAND (wet) [SM]	S5 8' to 10'	1-H-1-1 N=0	**H = weight of hammer	
-2.5	10.0		Boring terminated at a depth of 10 feet				

DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 1 OF 1 SHEETS	
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA			
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,048,477.4 E 3,627,373.7				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW			
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T			
4. HOLE NO. (As shown on drawing title and file number) 12DH-046				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 5 UNDISTURBED 0	
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES --			
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER NA			
7. THICKNESS OF OVERBURDEN -				16. DATE HOLE		STARTED 2/23/2012 COMPLETED 2/23/2012	
8. DEPTH DRILLED INTO ROCK --				17. ELEVATION TOP OF HOLE +7.3 ±			
9. TOTAL DEPTH OF HOLE 10.0				18. TOTAL CORE RECOVERY FOR BORING -- %			
				19. GEOLOGIST R.L. Huntoon			
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g	
6.95	0.3		Dark-Brown silty fine SAND with little organics [Surficial Soil]	S1 0' to 2'	H-2-4-5 N=6	**H = weight of hammer	
5.25	2.0		Tan fine to medium SAND with little silt and shell fragments (moist) [SP-SM] Tan fine SAND with trace silt and shell fragments (moist-wet) [SP]	S2 2' to 4'	3-4-5-4 N=9		
				S3 4' to 6'	3-3-4-4 N=7	Cave-In at 5'2" after drilling	
				S4 6' to 8'	1-1-1-2 N=2		
-0.75	8.0		Dark-Brown silty fine SAND with little organics [Surficial Soil]	S5 8' to 10'	2-1-1-1 N=2		
-1.25	8.5		Gray silty fine SAND with little shell fragments (wet) [SM]				
-2.75	10.0		Boring terminated at a depth of 10 feet				

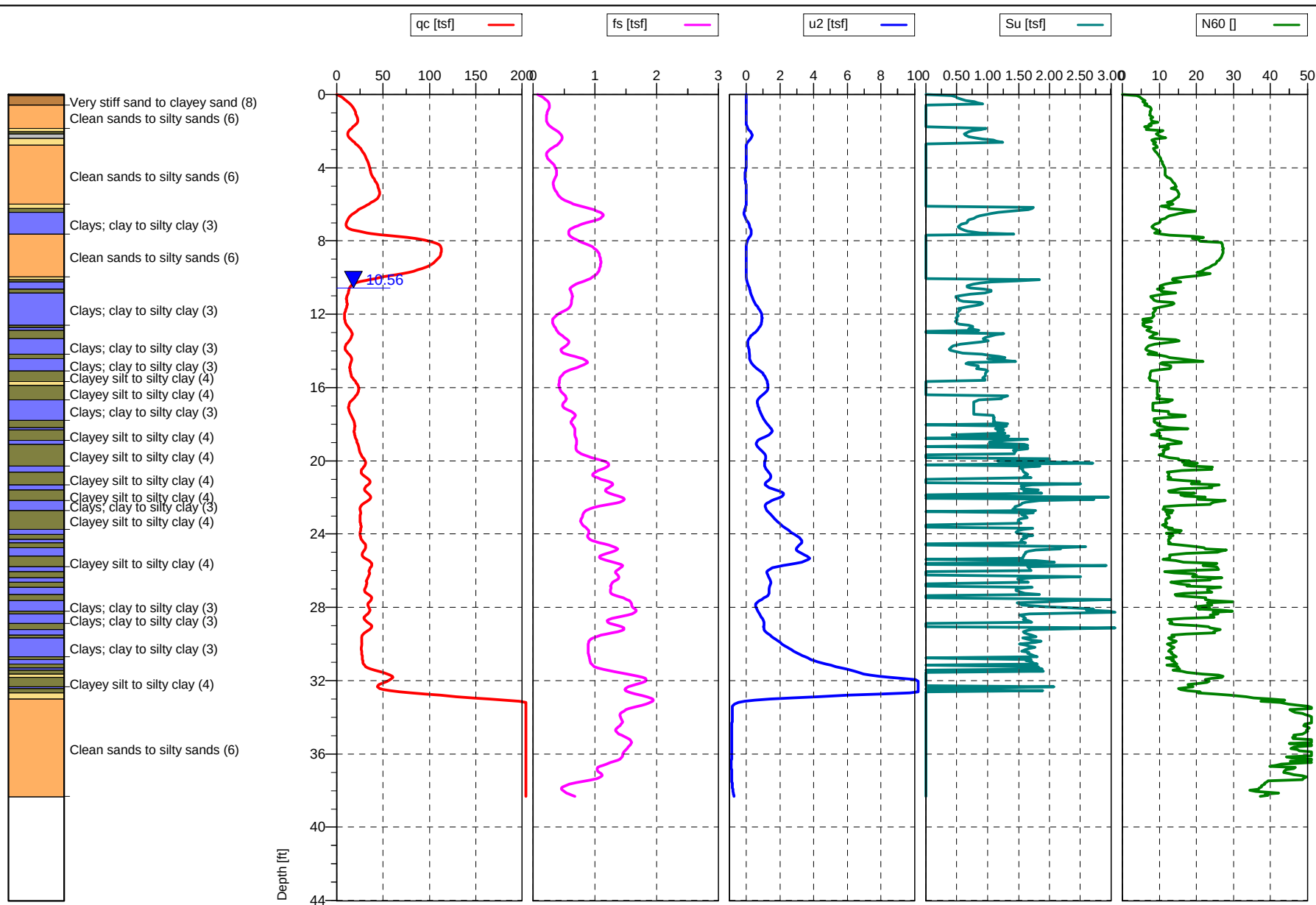
DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 1 OF 1 SHEETS	
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA			
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,048,991.3 E 3,627,071.3				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW			
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T			
4. HOLE NO. (As shown on drawing title and file number) 12DH-047				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 5 UNDISTURBED 0	
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES		--	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER		NA	
7. THICKNESS OF OVERBURDEN -				16. DATE HOLE STARTED 2/23/2012 COMPLETED 2/23/2012			
8. DEPTH DRILLED INTO ROCK --				17. ELEVATION TOP OF HOLE +7.0 ±			
9. TOTAL DEPTH OF HOLE 10.0				18. TOTAL CORE RECOVERY FOR BORING -- %			
				19. GEOLOGIST R.L. Huntoon			
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g	
6.7	0.3		Dark Gray silty fine SAND with little organics (moist) [Surficial Soil]	S1 0' to 2'	H-2-4-5 N=6	**H = weight of hammer	
			Tan fine SAND with trace silt and shell fragments (moist to wet) [SP]	S2 2' to 4'	5-4-6-7 N=10		
				S3 4' to 6'	5-6-7-5 N=13		
				S4 6' to 8'	2-2-2-1 N=4		
-1	8.0		Gray fine SAND with trace silt (wet) [SP]	S5 8' to 10'	H-H-H-H N=0	**H = weight of hammer	
-2	9.0		Gray silty CLAY with little organics (wet) [CH]				
-2.2	9.2		Gray silty CLAY with little fine sand (wet) [CH]				
-3	10.0		Boring terminated at a depth of 10 feet				

DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 1 OF 1 SHEETS	
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA			
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,049,432.4 E 3,626,548.4				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW			
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T			
4. HOLE NO. (As shown on drawing title and file number) 12DH-048				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 5 UNDISTURBED 0	
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES --			
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER NA			
7. THICKNESS OF OVERBURDEN -				16. DATE HOLE		STARTED 2/23/2012 COMPLETED 2/23/2012	
8. DEPTH DRILLED INTO ROCK --				17. ELEVATION TOP OF HOLE +4.5 ±			
9. TOTAL DEPTH OF HOLE 10.0				18. TOTAL CORE RECOVERY FOR BORING -- %			
				19. GEOLOGIST R.L. Huntoon			
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g	
4.1	0.4		Dark Brown silty fine SAND with little organics [Surficial Soil]	S1 0' to 2'	3-3-5-5 N=8	Cave-in at depth 1.5'	
			Gray SAND with trace silt and shell fragments (moist to wet) [SP]	S2 2' to 4'	2-2-3-2 N=5		
0.5	4.0		Gray fine SAND with little silt and shell fragments (wet) [SP-SM]	S3 4' to 6'	1-1-H-1 N=0	**H = weight of hammer	
-1.5	6.0		Gray sandy CLAY with trace shell fragments (wet) [CH]	S4 6' to 8'	H-H-H-H N=0	No Sample Recovery **H = weight of hammer	
-5	9.5		Gray silty fine SAND with little organics (wet) [SM]	S5 8' to 10'	H-H-1-1 N=0	**H = weight of hammer	
-5.5	10.0		Boring terminated at a depth of 10 feet				

DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 1 OF 1 SHEETS	
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA			
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,049,629.4 E 3,625,979.4				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW			
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T			
4. HOLE NO. (As shown on drawing title and file number) 12DH-049				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 5 UNDISTURBED 0	
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES --			
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER		NA	
7. THICKNESS OF OVERBURDEN -				16. DATE HOLE		STARTED 2/23/2012 COMPLETED 2/23/2012	
8. DEPTH DRILLED INTO ROCK --				17. ELEVATION TOP OF HOLE		+6.0 ±	
9. TOTAL DEPTH OF HOLE 10.0				18. TOTAL CORE RECOVERY FOR BORING		-- %	
				19. GEOLOGIST R.L. Huntoon			
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g	
4	2.0		Tan/Light Brown, fine SAND with trace silt and shell fragments (moist) [SP]	SS-1 0' to 2'	2-5-9-7 N=14		
	Light Gray, fine SAND with little silt and shell fragments (wet) [SP-SM]		SS-2 2' to 4'	7-7-6-6 N=13			
			SS-3 4' to 6'	2-4-3-3 N=7			
			SS-4 6' to 8'	2-2-2-1 N=4			
			SS-5 8' to 10'	H/24"--- N=			
-4	10.0		Boring terminated at a depth of 10 feet			**H = weight of hammer	

DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 1 OF 1 SHEETS	
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA			
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,050,062.9 E 3,625,441.5				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW			
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T			
4. HOLE NO. (As shown on drawing title and file number) 12DH-050				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 5 UNDISTURBED 0	
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES		--	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER		NA	
7. THICKNESS OF OVERBURDEN -				16. DATE HOLE STARTED 2/23/2012 COMPLETED 2/23/2012			
8. DEPTH DRILLED INTO ROCK --				17. ELEVATION TOP OF HOLE +7.5 ±			
9. TOTAL DEPTH OF HOLE 10.0				18. TOTAL CORE RECOVERY FOR BORING -- %			
				19. GEOLOGIST R.L. Huntoon			
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g	
7.333	0.2		Dark Brown fine SAND with some silt and organics (moist) [Surficial Soil]	SS-1 0' to 2'	2-4-6-8 N=10		
			Tan, fine SAND with trace silt and shell fragments (moist) [SP]	SS-2 2' to 4'	7-8-8-9 N=16		
3.5	4.0		Gray, silty fine SAND with little shell fragments (wet) [SM]	SS-3 4' to 6'	4-6-6-7 N=12		
				SS-4 6' to 8'	1-2-1-1 N=3		
				SS-5 8' to 10'	3-1-1-1 N=2		
-2.5	10.0		Boring terminated at a depth of 10 feet				

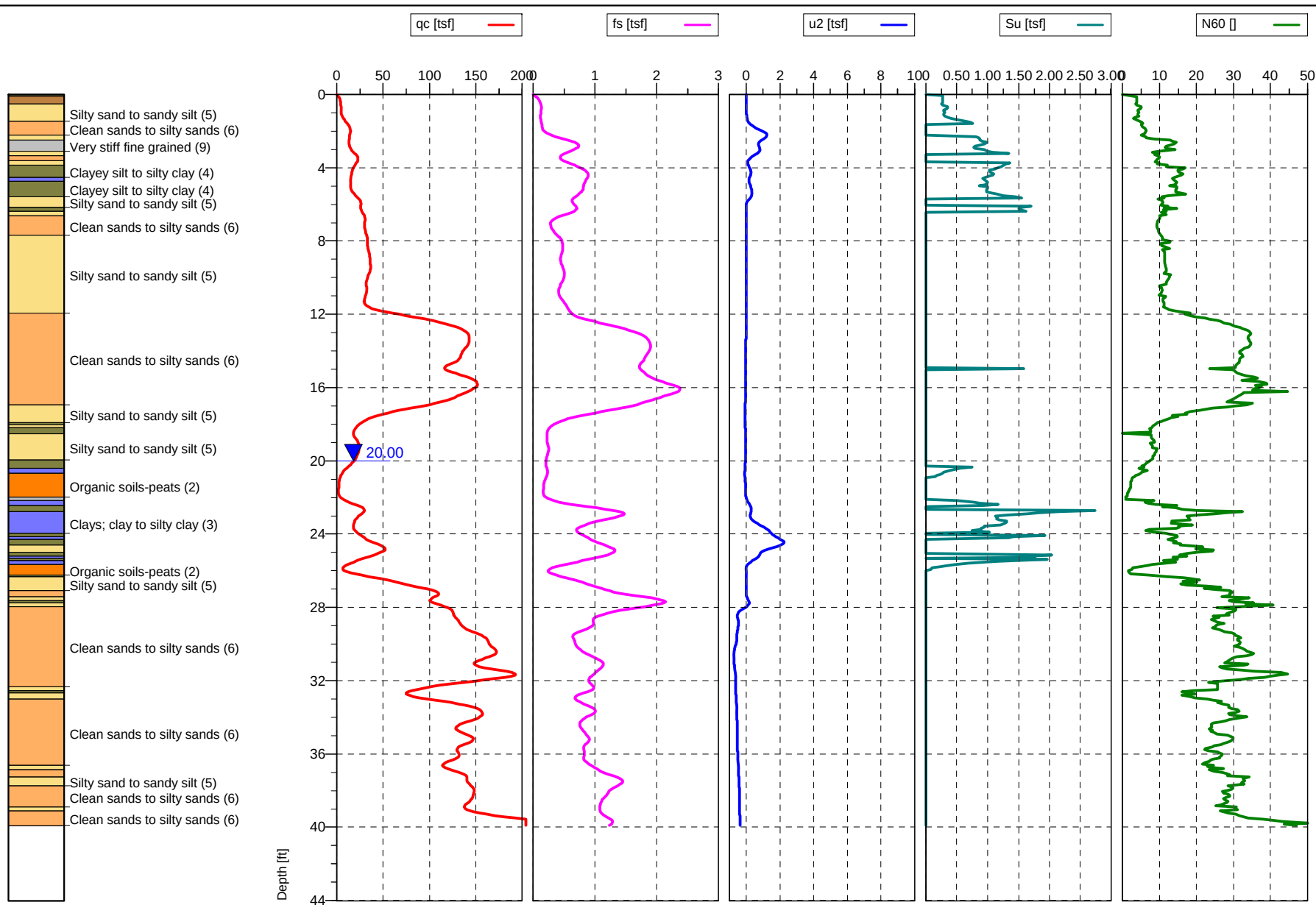
DRILLING LOG		DIVISION Norfolk District		INSTALLATION National Park Service		SHEET 1 OF 1 SHEETS	
1. PROJECT Colonial Parkway Shoreline Stabilization				10. SIZE AND TYPE OF BIT 3 1/4 HSA			
2. LOCATION (Coordinates or Station) Yorktown, VA N 12,050,647.0 E 3,624,843.5				11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW			
3. DRILLING AGENCY Terracon				12. MANUFACTURER'S DESIGNATION OF DRILL D-50T			
4. HOLE NO. (As shown on drawing title and file number) 12DH-051				13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN		DISTURBED 5 UNDISTURBED 0	
5. NAME OF DRILLER W. Duggins				14. TOTAL NUMBER CORE BOXES		--	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.				15. ELEVATION GROUND WATER		NA	
7. THICKNESS OF OVERBURDEN -				16. DATE HOLE		STARTED 2/22/2012 COMPLETED 2/22/2012	
8. DEPTH DRILLED INTO ROCK --				17. ELEVATION TOP OF HOLE		+5.0 ±	
9. TOTAL DEPTH OF HOLE 10.0				18. TOTAL CORE RECOVERY FOR BORING		-- %	
				19. GEOLOGIST		P. Wunderly	
ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g	
3	2.0		Gray to White silty fine SAND with shell fragments [SM]	S1 0' to 2'	2-4-6-7 N=10	Cave-In at depth 1.5'	
1	4.0		Gray to White fine SAND with little silt shell fragments [SP-SM]	S2 2' to 4'	5-5-6-6 N=11		
-1	6.0		Gray fine SAND with shell fragments and trace silt [SP]	S3 4' to 6'	1-1-2-2 N=3		
-4	9.0		Gray silty SAND [SM]	S4 6' to 8'	1-1-1-1 N=2		
-5	10.0		Gray to White silty fine SAND with shell fragments [SM] Mottled Orange-Brown silty fine SAND with trace shell fragments (moist) [SM] Boring terminated at a depth of 10 feet	S5 8' to 10'	2-3-4-5 N=7		



Terracon

Cone No: 0
Tip area [cm2]: 10
Sleeve area [cm2]: 150

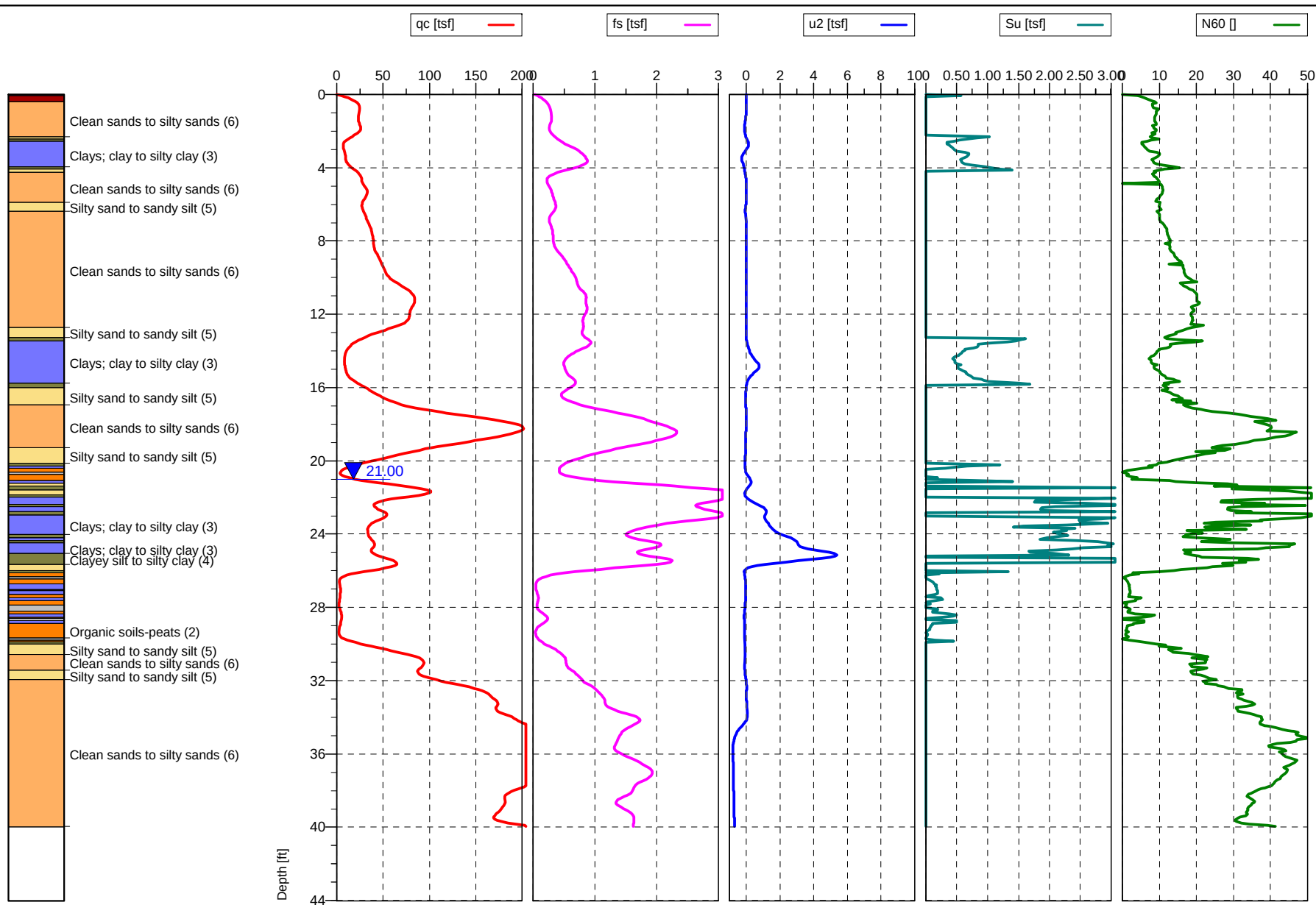
Location:	YORKTOWN, VIRGINIA	Position:		Ground level:	Test no:
Project ID:	70115065	Client:	U.S. ARMY CORPS OF ENGINEER	Date:	Scale:
Project:	PROPOSED SHORE LINE PROTECTION			Page:	Fig:
	NATIONAL PARK SERVICE COLONIAL PARKWAY			File:	C1.cpt



Terracon

Cone No: 0
Tip area [cm2]: 10
Sleeve area [cm2]: 150

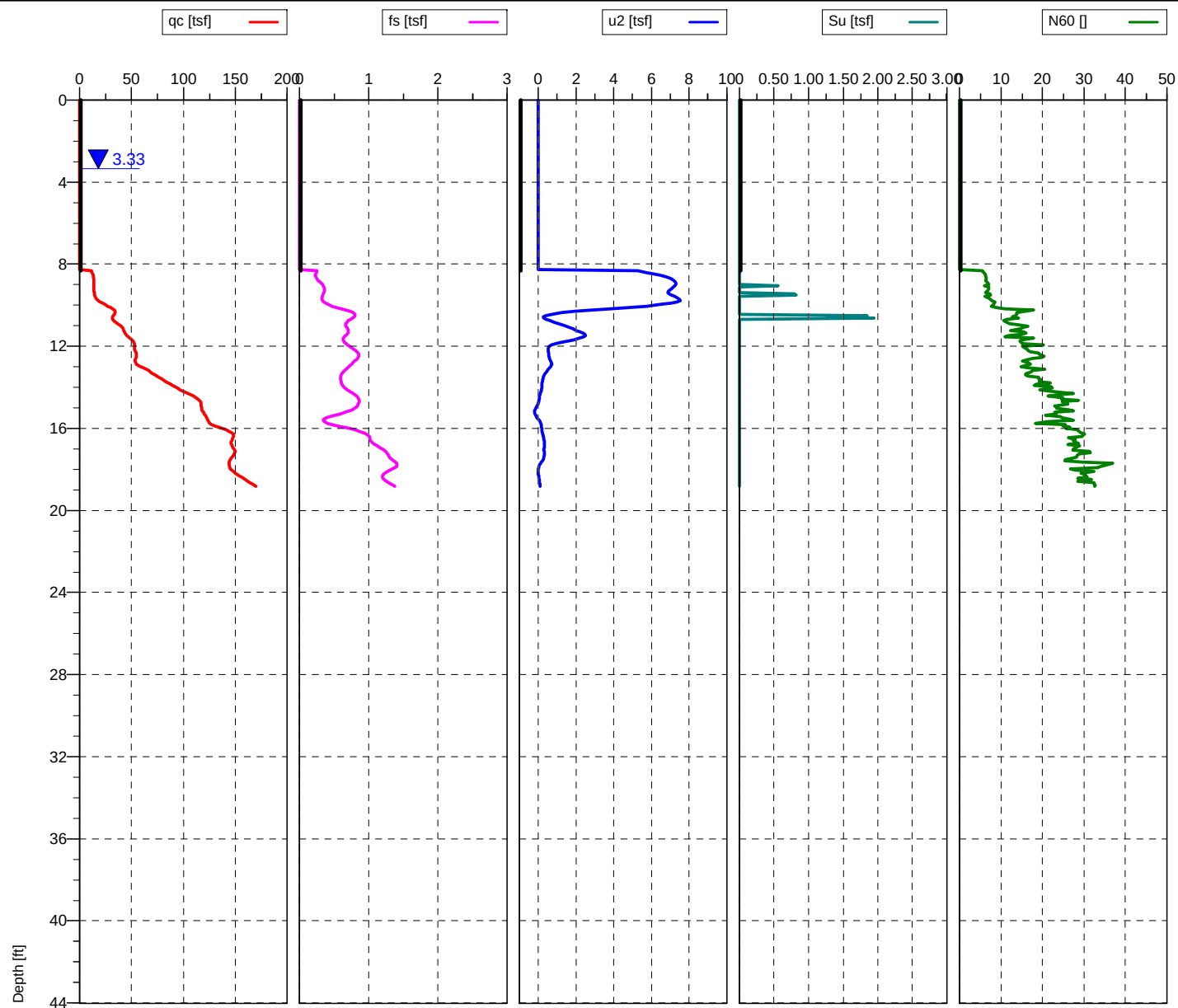
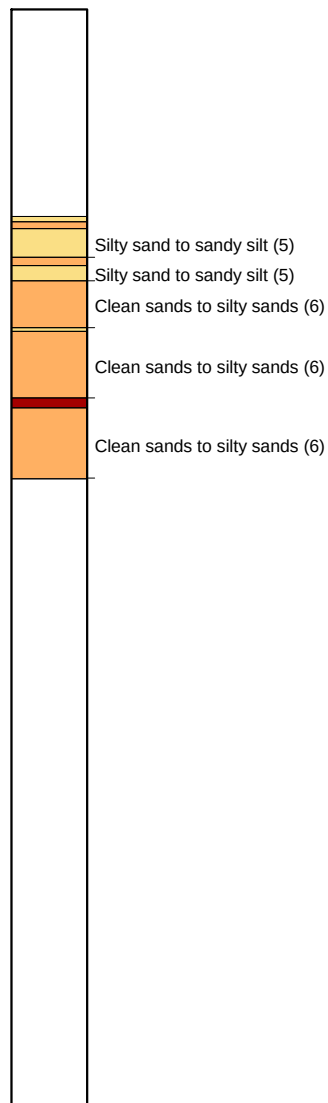
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Project:	PROPOSED SHORE LINE PROTECTION			Page:	Fig:
	NATIONAL PARK SERVICE COLONIAL PARKWAY			File:	C2.cpt



Terracon

Cone No: 0
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location:	YORKTOWN, VIRGINIA	Position:		Ground level:	Test no:
Project ID:	70115065	Client:	U.S. ARMY CORPS OF ENGINEER	Date:	Scale:
Project:	PROPOSED SHORE LINE PROTECTION			Page:	Fig:
	NATIONAL PARK SERVICE COLONIAL PARKWAY			File:	C3.cpt



Cone No: 0
Tip area [cm2]: 10
Sleeve area [cm2]: 150

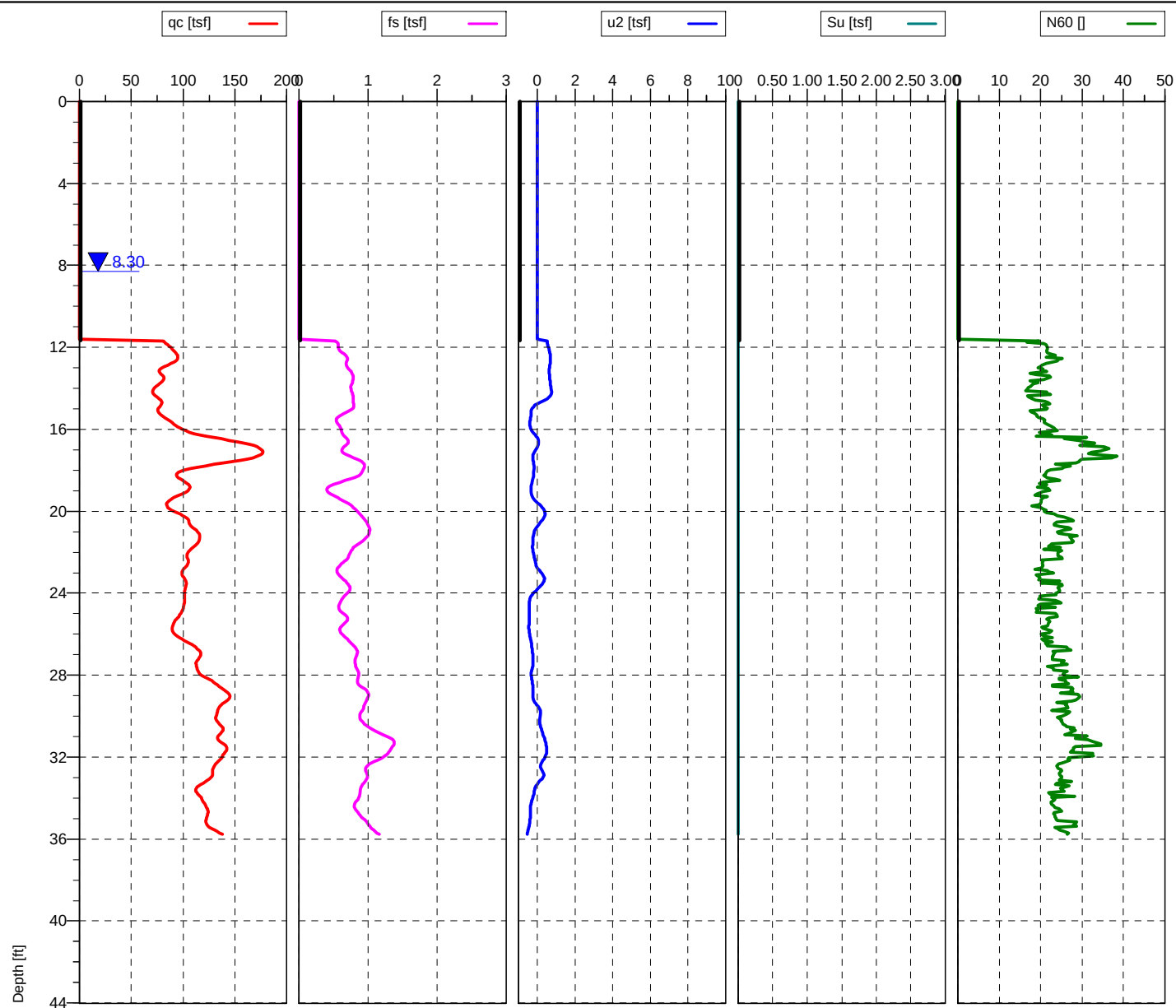
Terracon

Location:	YORKTOWN, VIRGINIA	Position:	X: 0.00 m, Y: 0.00 m	Ground level:	0.00	Test no:	C5
Project ID:	70115065	Client:	U.S. ARMY CORPS OF ENGINEER	Date:	2/22/2012	Scale:	
Project:	PROPOSED SHORE LINE PROTECTION			Page:	1/1	Fig:	
	NATIONAL PARK SERVICE COLONIAL PARKWAY			File:	C5.cpt		



Clean sands to silty sands (6)

Clean sands to silty sands (6)



Depth [ft]



Cone No: 0
Tip area [cm²]: 10
Sleeve area [cm²]: 150

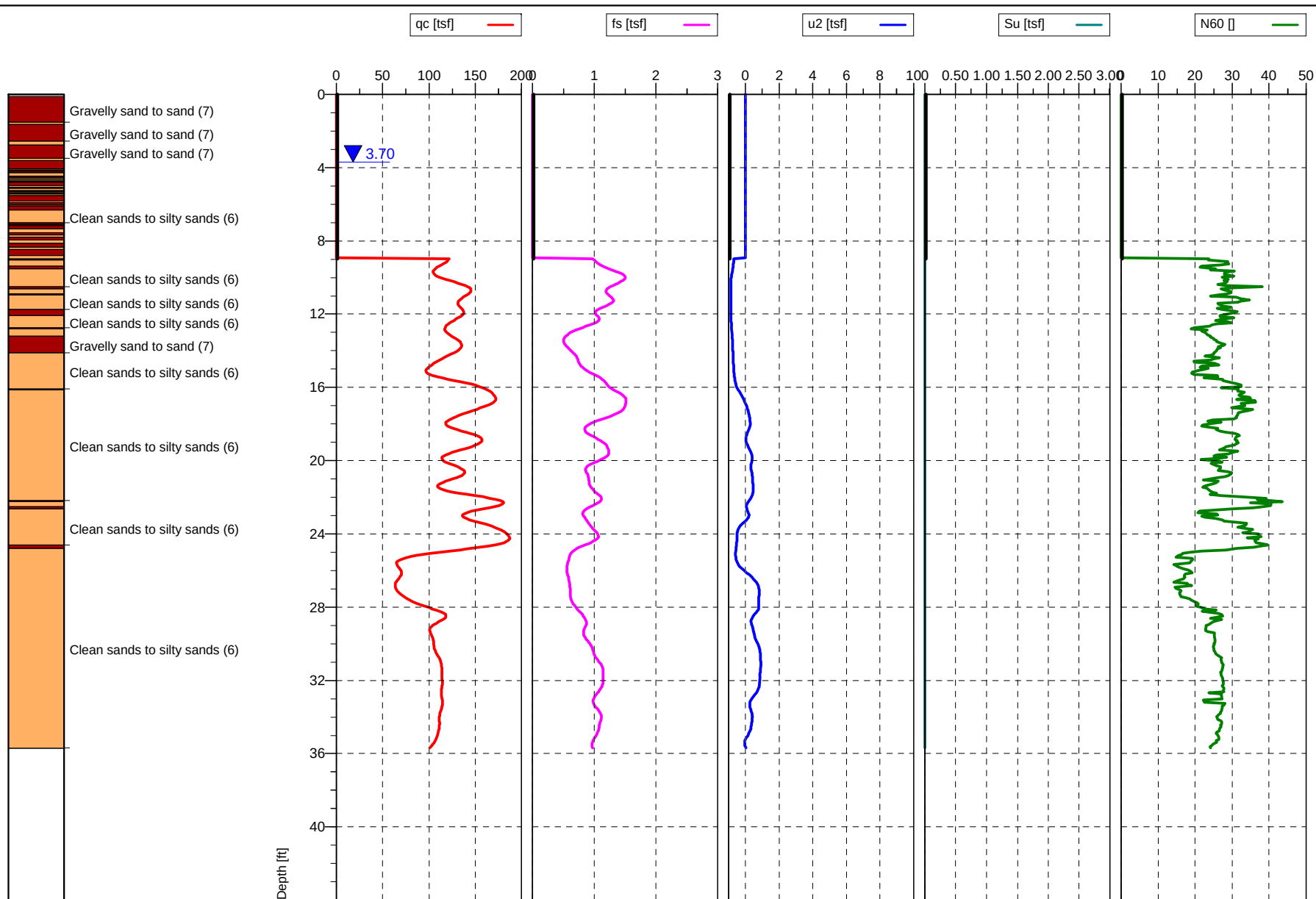
Terracon

Location:	YORKTOWN, VIRGINIA	Position:	X: 0.00 m, Y: 0.00 m	Ground level:	0.00	Test no:	C6
Project ID:	70115065	Client:	U.S. ARMY CORPS OF ENGINEER	Date:	2/22/2012	Scale:	
Project:	PROPOSED SHORE LINE PROTECTION			Page:	1/1	Fig:	
NATIONAL PARK SERVICE COLONIAL PARKWAY				File:	C6.cpt		



Cone No: 0
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location:	YORKTOWN, VIRGINIA	Position:		Ground level:	Test no:
Project ID:	70115065	Client:	U.S. ARMY CORPS OF ENGINEER	Date:	Scale:
Project:	PROPOSED SHORE LINE PROTECTION			Page:	Fig:
NATIONAL PARK SERVICE COLONIAL PARKWAY				File:	C7.cpt



Cone No: 0
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Terracon

Location:	YORKTOWN, VIRGINIA	Position:		Ground level:	0	Test no:	C10
Project ID:	70115065	Client:	U.S. ARMY CORPS OF ENGINEER	Date:	2/22/2012	Scale:	
Project:	PROPOSED SHORE LINE PROTECTION			Page:	1/1	Fig:	
	NATIONAL PARK SERVICE COLONIAL PARKWAY			File:	C10.cpt		



Cone No: 0
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location:	YORKTOWN, VIRGINIA	Position:		Ground level:	Test no:
Project ID:	70115065	Client:	U.S. ARMY CORPS OF ENGINEER	Date:	Scale:
Project:	PROPOSED SHORE LINE PROTECTION			Page:	Fig:
NATIONAL PARK SERVICE COLONIAL PARKWAY				File:	C11.cpt

Appendix C - Geotechnical Laboratory Testing Results

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MOISTURE CONTENT - ASTM D2216

BORING ID	DEPTH (FT.)	MOISTURE CONTENT (%)
SPT-01	2-4	15.1
SPT-01	8-10	22.0
SPT-01	33-35	22.9
SPT-02	6-8	9.2
SPT-02	18-20	8.5
SPT-02	23-25	22.8
SPT-03	4-6	31.9
SPT-03	18-20	27.2
SPT-03	38-40	20.8
SPT-04	4-6	7.7
SPT-04	13-15	20.3
SPT-04	33-35	37.4
SPT-04	48-50	34.1
SPT-05	2-4	7.0
SPT-05	8-10	4.5
SPT-05	13-15	13.8
SPT-05	28-30	31.0
SPT-06	2-4	19.6
SPT-07	0-2	22.2
SPT-08	2-4	16.0
SPT-09	2-4	8.5
SPT-10	6-8	22.3
SPT-11	4-6	23.6
SPT-12	4-6	22.6
SPT-12	8-10	60.8
SPT-13	4-6	24.5
SPT-14	2-4	18.7
SPT-15	8-10	26.4
SPT-16	2-4	17.5



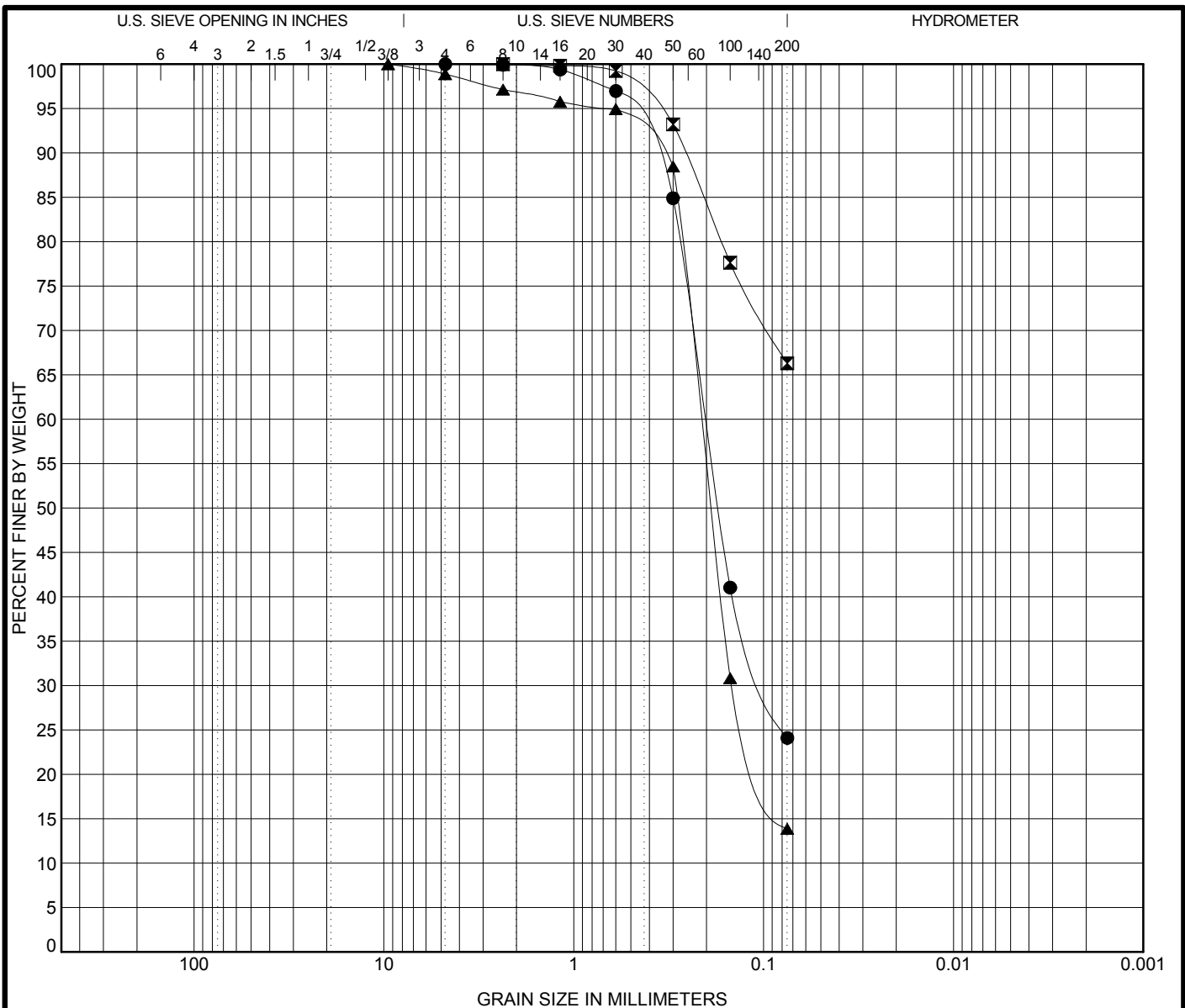
MOISTURE CONTENT ANALYSIS

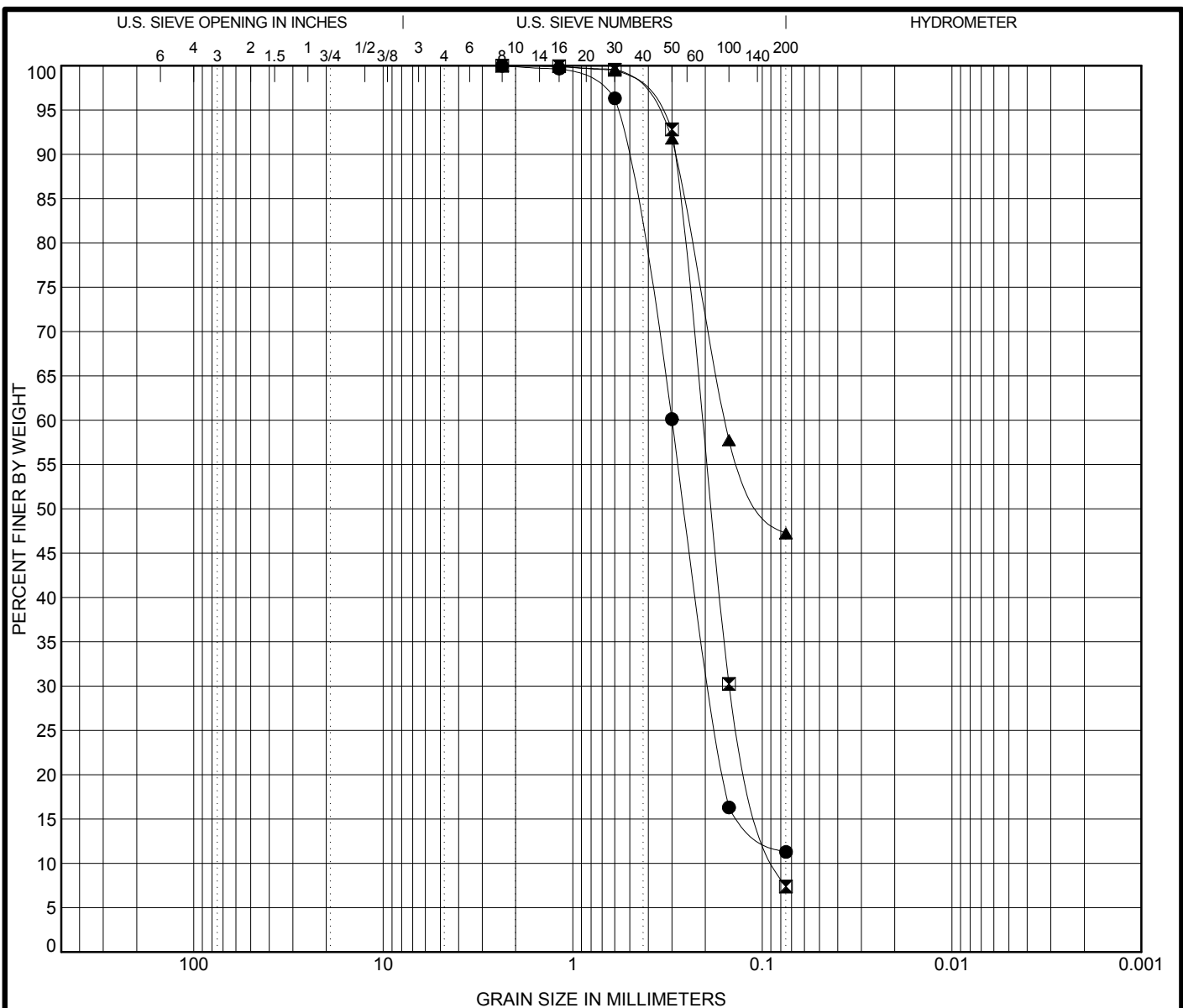
Project: NPS - Colonial Parkway Shoreline Stabilization

Site: Yorktown, Virginia

Job #: 70115065

Date: 3-13-2012





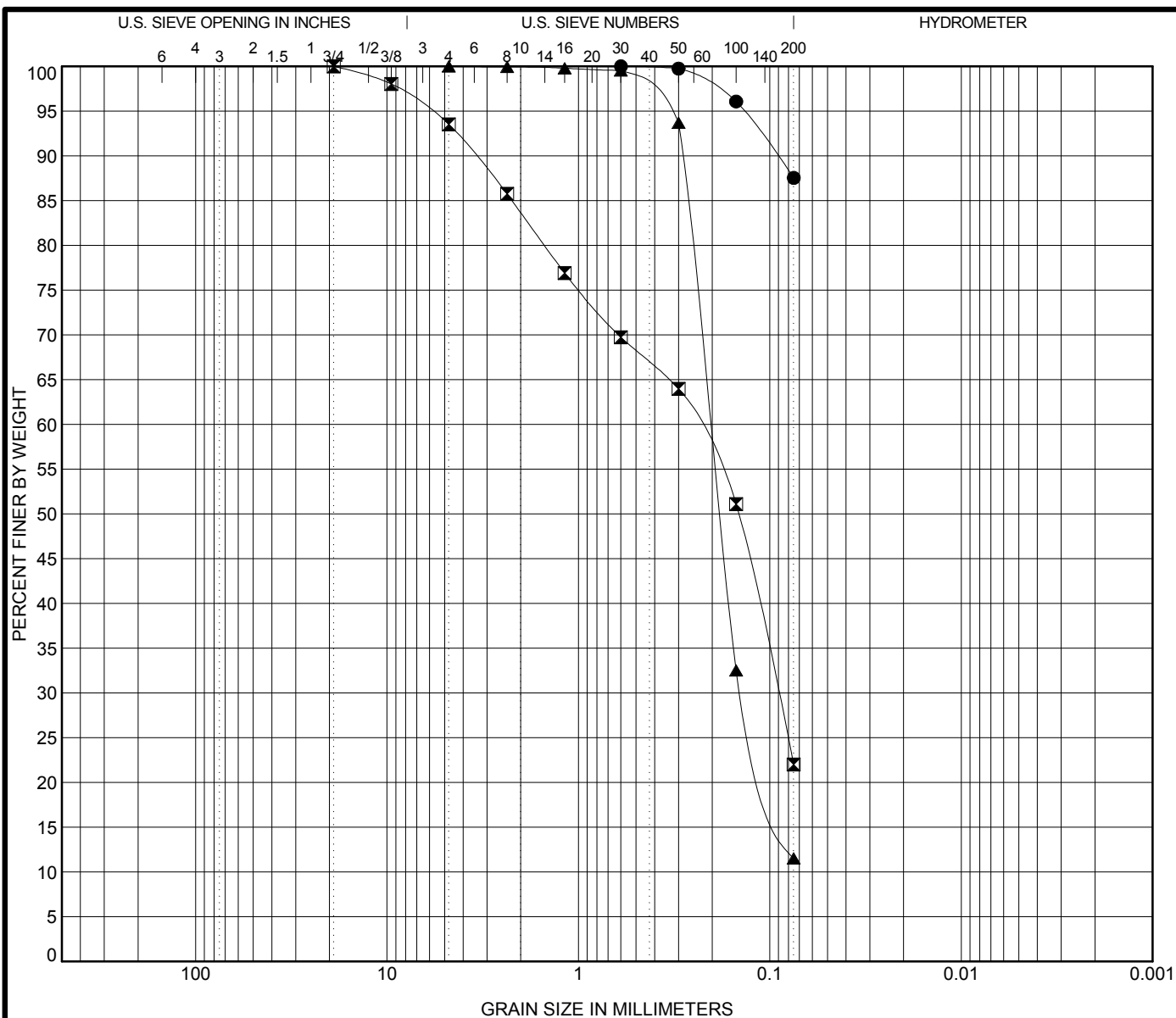
COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification			Classification			LL	PL	PI	Cc	Cu
●	SPT-02	6.0ft	POORLY GRADED SAND with SILT(SP-SM)			NP	NP	NP	1.85	4.77
☒	SPT-02	18.0ft	POORLY GRADED SAND with SILT(SP-SM)			NP	NP	NP	1.31	2.57
▲	SPT-02	23.0ft	CLAYEY SAND(SC)			29	14	15		
Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	SPT-02	6.0ft	2.36	0.299	0.186		-	-	11	
☒	SPT-02	18.0ft	2.36	0.209	0.149	0.081	-	-	7	
▲	SPT-02	23.0ft	2.36	0.157			-	-	47	
							-	-		
							-	-		

GRAIN SIZE DISTRIBUTION

Terracon

Project: NPS - Colonial Parkway Shoreline Stabilization
 Site: Yorktown, Virginia
 Job #: 70115065
 Date: 3-21-12



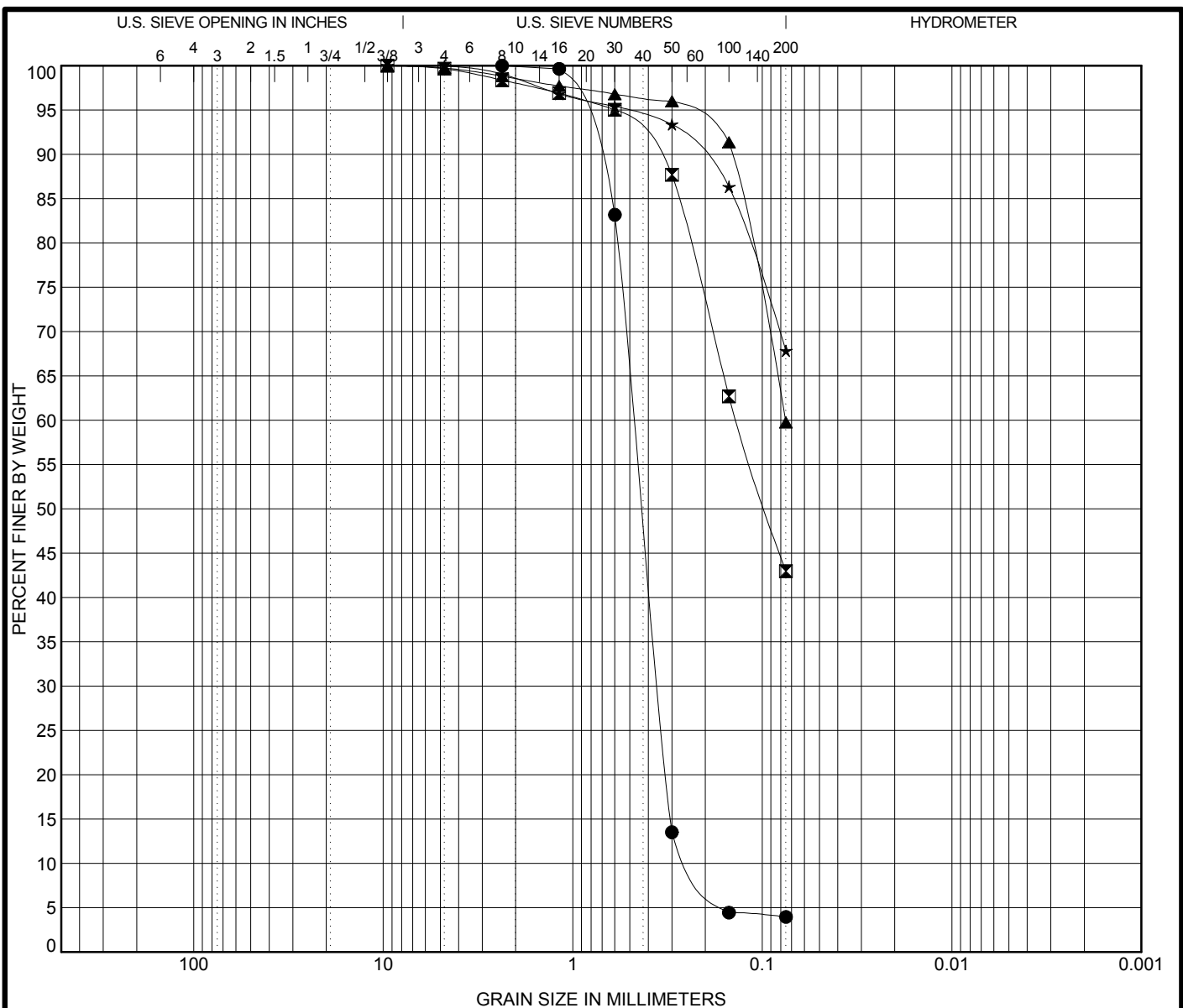
COBBLES	GRAVEL		SAND			SILT OR CLAY
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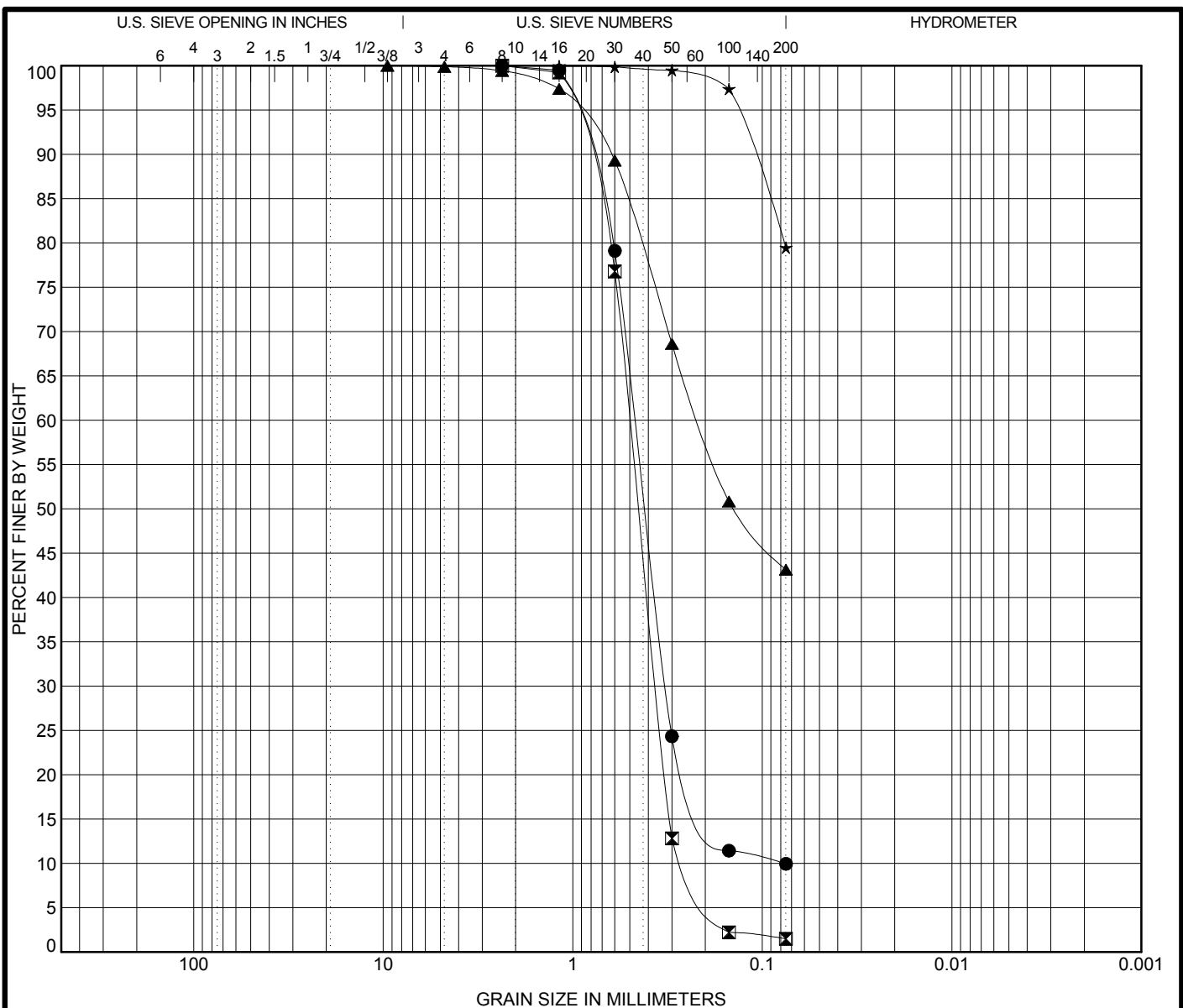
Specimen Identification			Classification			LL	PL	PI	Cc	Cu
●	SPT-03	4.0ft	FAT CLAY(CH)			66	19	47		
☒	SPT-03	18.0ft	SILTY SAND(SM)			NP	NP	NP		
▲	SPT-03	38.0ft	POORLY GRADED SAND with SILT(SP-SM)			NP	NP	NP	1.30	2.87
Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	SPT-03	4.0ft	0.6				-	-	88	
☒	SPT-03	18.0ft	19	0.242	0.091		-	-	22	
▲	SPT-03	38.0ft	4.75	0.205	0.138		-	-	12	
							-	-		
							-	-		

GRAIN SIZE DISTRIBUTION

Terracon

Project: NPS - Colonial Parkway Shoreline Stabilization
 Site: Yorktown, Virginia
 Job #: 70115065
 Date: 3-21-12





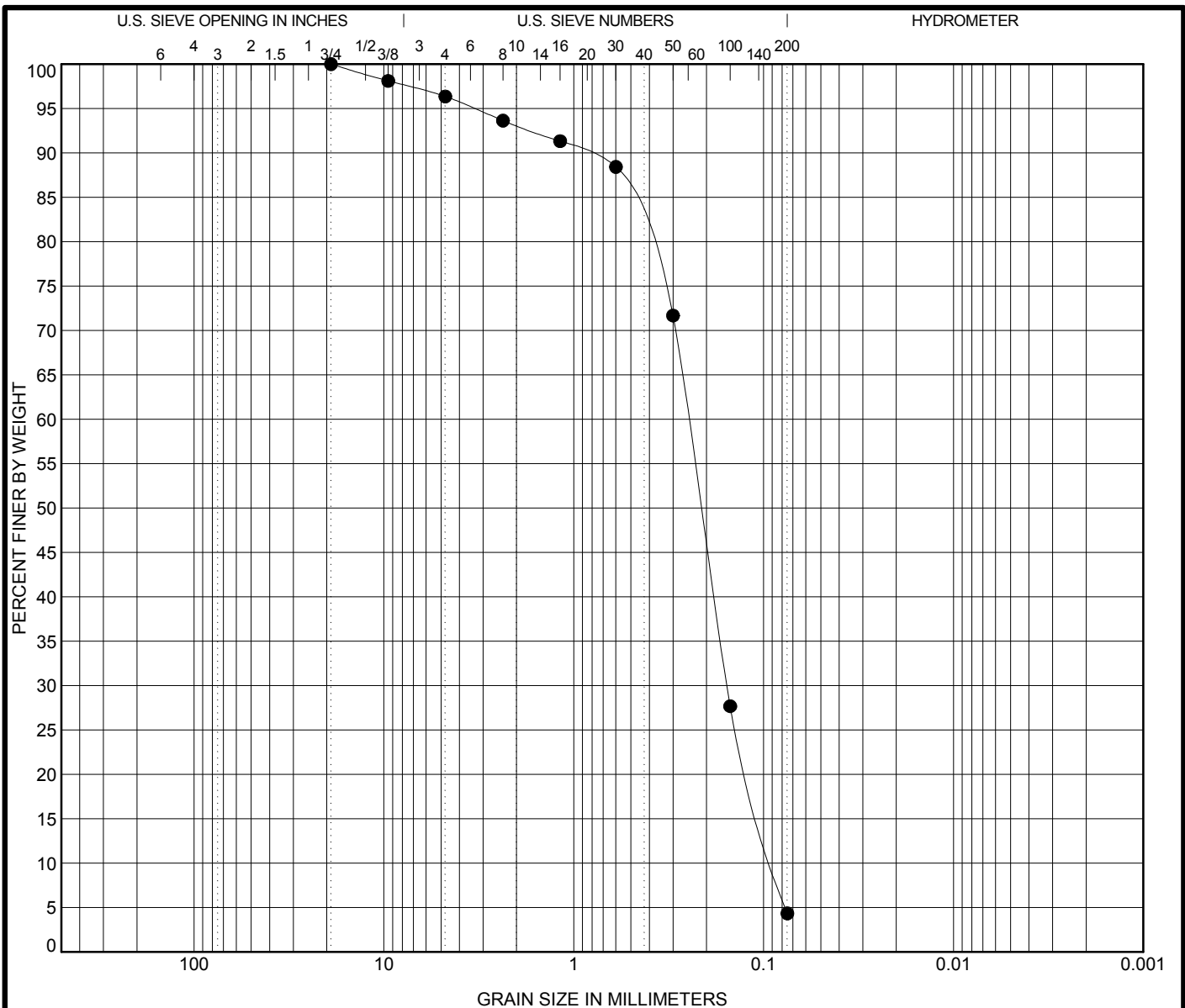
COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification			Classification			LL	PL	PI	Cc	Cu
●	SPT-05	2.0ft	WELL-GRADED SAND with SILT(SW-SM)			NP	NP	NP	2.87	6.13
☒	SPT-05	8.0ft	POORLY GRADED SAND(SP)			NP	NP	NP	1.05	2.00
▲	SPT-05	13.0ft	CLAYEY SAND(SC)			25	12	13		
★	SPT-05	28.0ft	LEAN CLAY with SAND(CL)			45	16	29		
Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	SPT-05	2.0ft	2.36	0.471	0.322	0.077	-	-	10	
☒	SPT-05	8.0ft	2.36	0.5	0.361	0.25	-	-	1	
▲	SPT-05	13.0ft	9.5	0.214			-	-	43	
★	SPT-05	28.0ft	2.36				-	-	79	

GRAIN SIZE DISTRIBUTION

Terracon

Project: NPS - Colonial Parkway Shoreline Stabilization
 Site: Yorktown, Virginia
 Job #: 70115065
 Date: 3-21-12



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

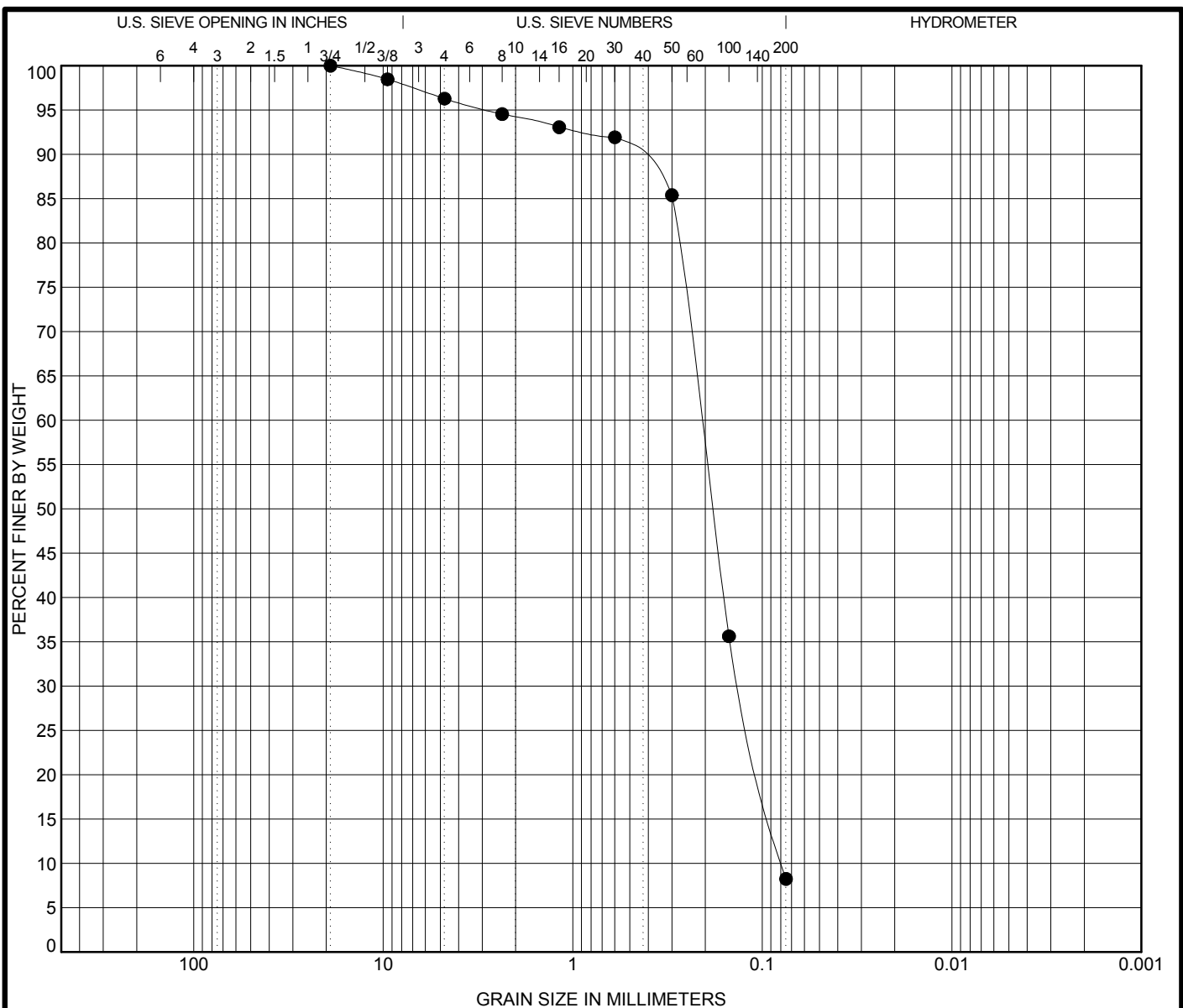
Specimen Identification			Classification			LL	PL	PI	Cc	Cu
●	SPT-06	2.0ft	POORLY GRADED SAND(SP)			NP	NP	NP	1.09	2.81

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	SPT-06	2.0ft	19	0.25	0.156	0.089	-	-	4	
							-	-		
							-	-		
							-	-		
							-	-		

GRAIN SIZE DISTRIBUTION

Terracon

Project: NPS - Colonial Parkway Shoreline Stabilization
 Site: Yorktown, Virginia
 Job #: 70115065
 Date: 3-21-12



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

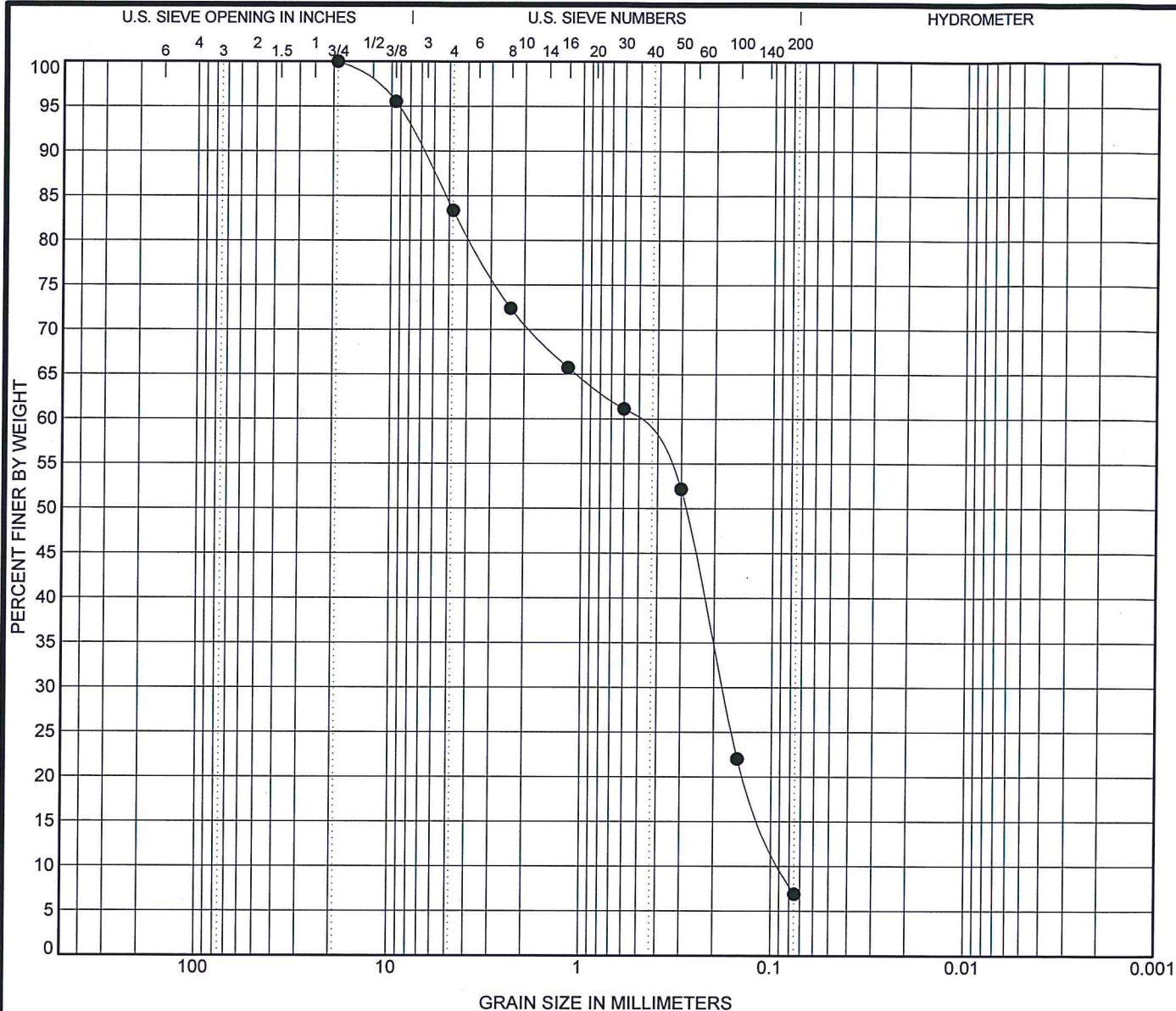
Specimen Identification			Classification			LL	PL	PI	Cc	Cu
●	SPT-07	0.0ft	POORLY GRADED SAND with SILT(SP-SM)			NP	NP	NP	1.02	2.69

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	SPT-07	0.0ft	19	0.211	0.13	0.078	-	-	8	
							-	-		
							-	-		
							-	-		

GRAIN SIZE DISTRIBUTION

Terracon

Project: NPS - Colonial Parkway Shoreline Stabilization
 Site: Yorktown, Virginia
 Job #: 70115065
 Date: 3-21-12



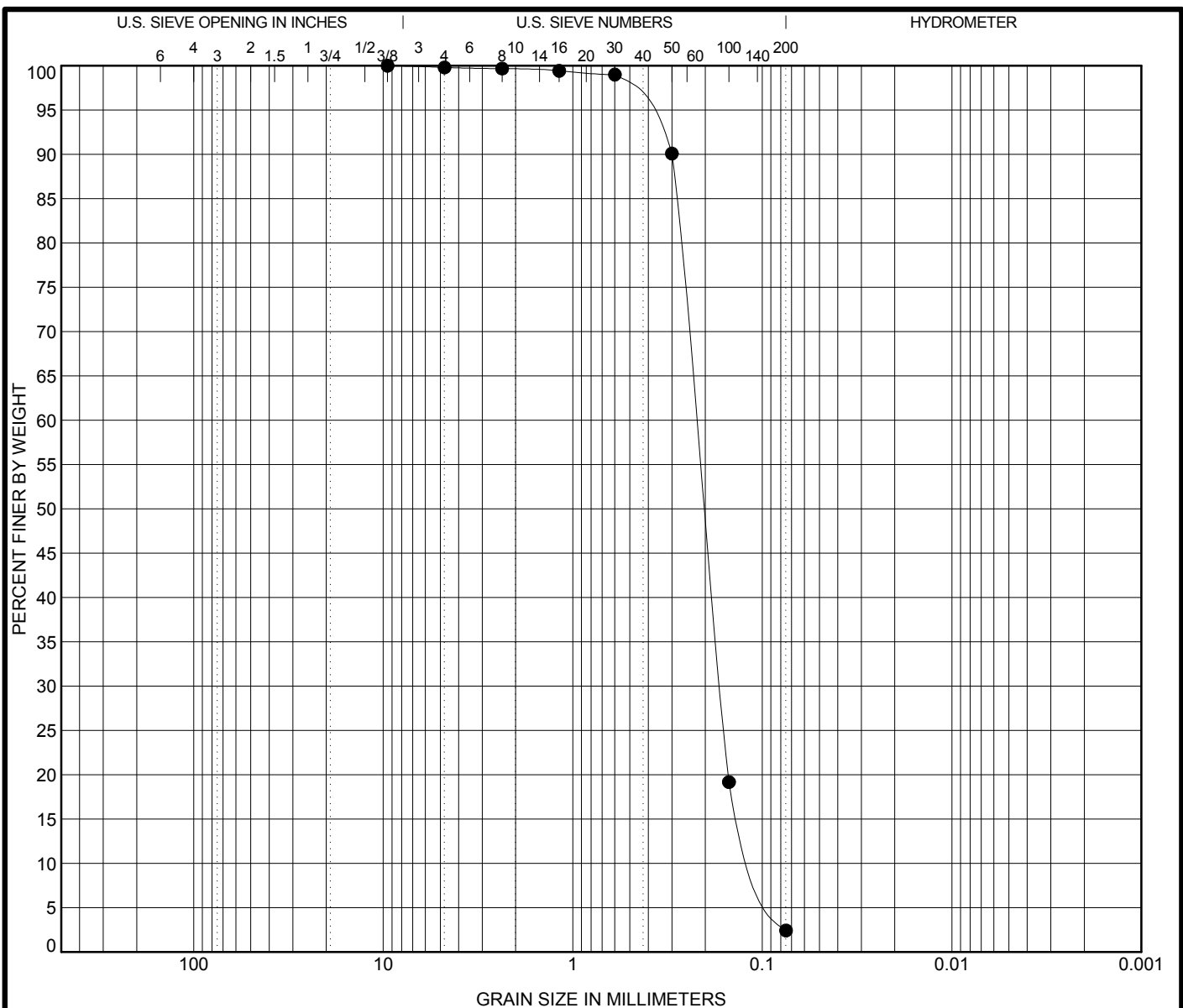
COBBLES	GRAVEL		SAND			SILT OR CLAY
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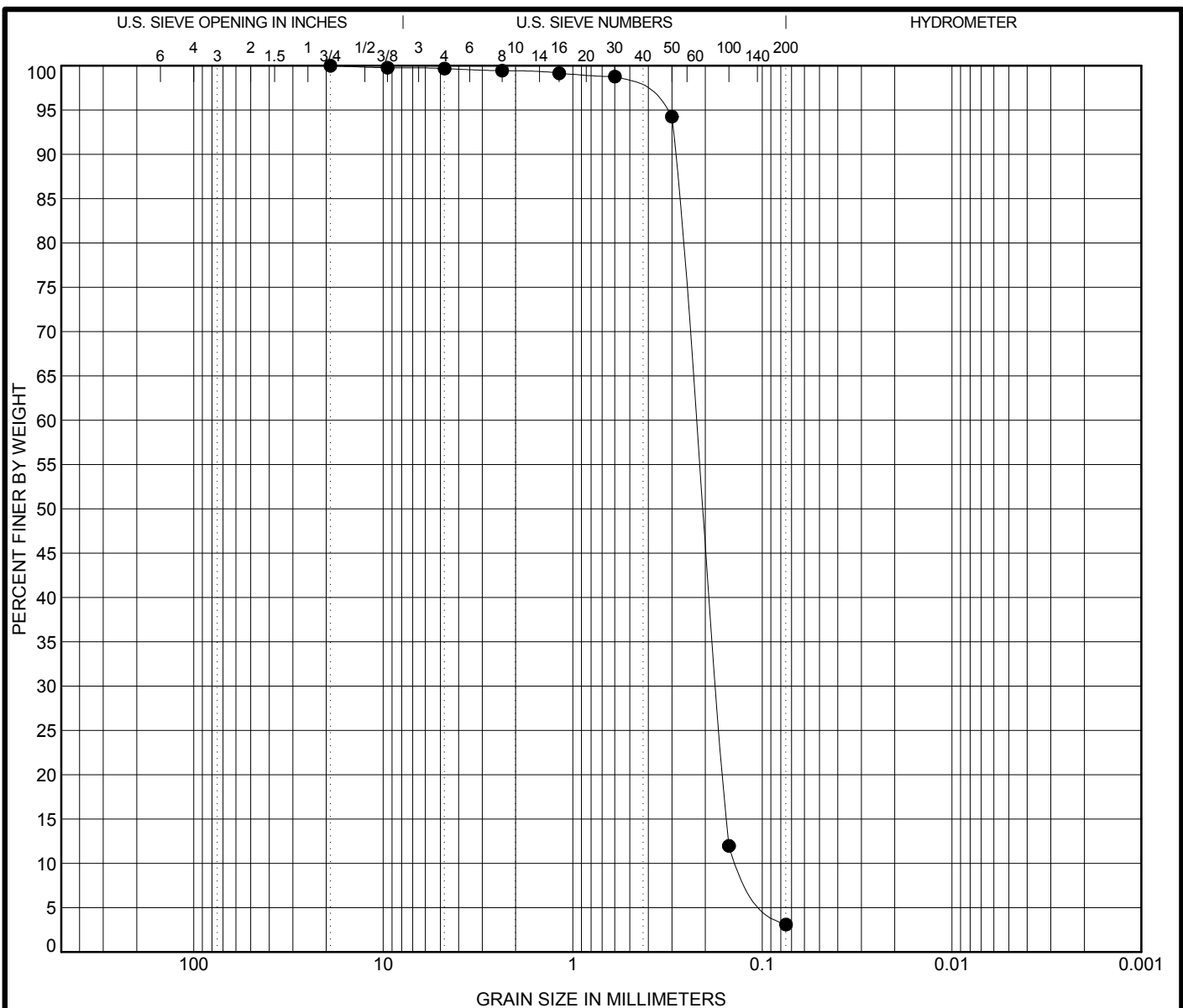
Specimen Identification			Classification				LL	PL	PI	Cc	Cu
●	SPT-08	2.0ft	POORLY GRADED SAND w/ SILT & GRAVEL(SP-SM)				NP	NP	NP	0.68	6.35
Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay	
●	SPT-08	2.0ft	19	0.549	0.18	0.086	-	-	7		
							-	-			
							-	-			
							-	-			
							-	-			

GRAIN SIZE DISTRIBUTION

Project: NPS - Colonial Parkway Shoreline Stabilization
 Site: Yorktown, Virginia
 Job #: 70115065
 Date: 3-21-12

Terracon





COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

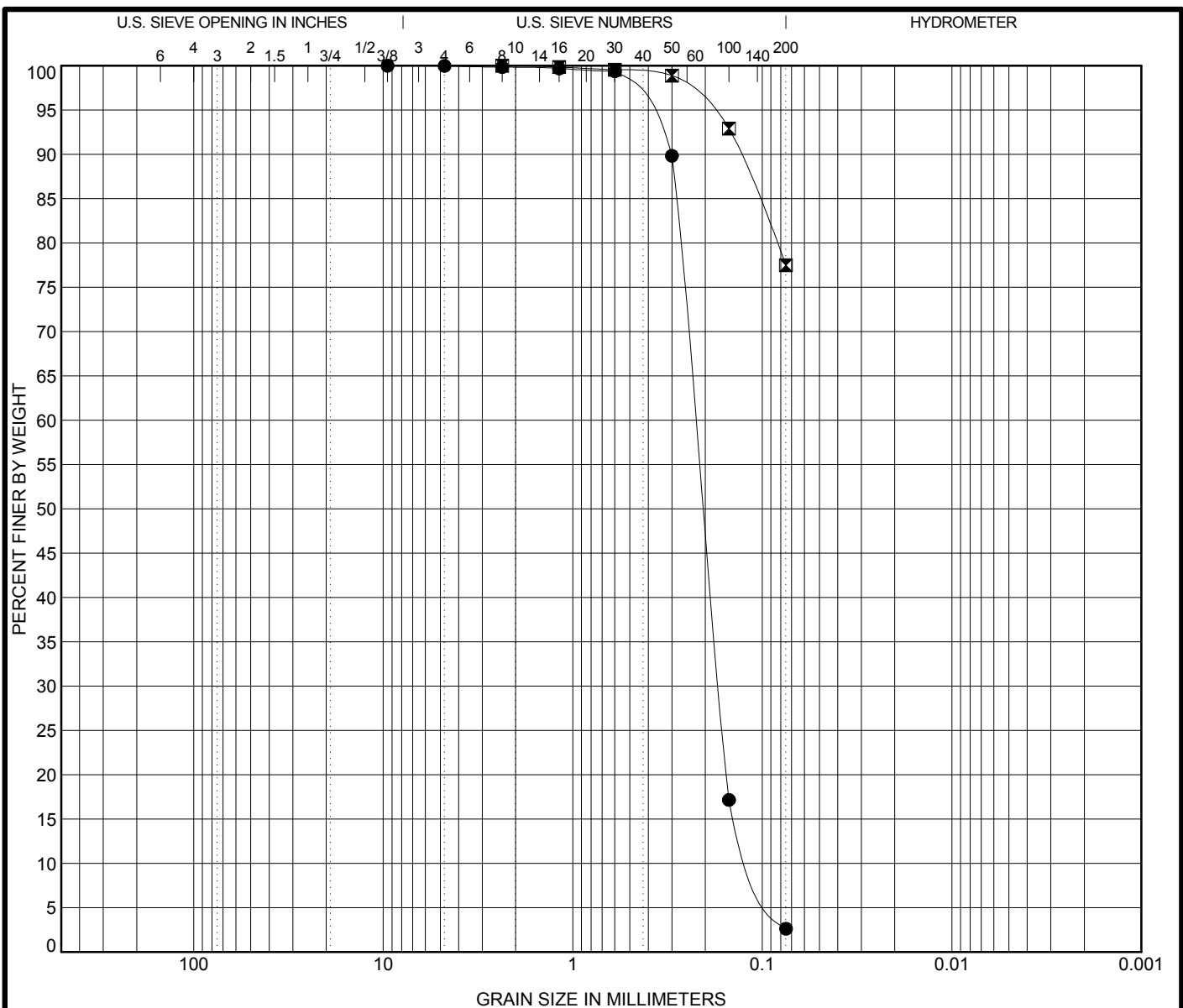
Specimen Identification			Classification				LL	PL	PI	Cc	Cu
●	SPT-10	6.0ft	POORLY GRADED SAND(SP)				NP	NP	NP	1.05	1.75
Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay	
●	SPT-10	6.0ft	19	0.225	0.175	0.129	-	-	3		
							-	-			
							-	-			
							-	-			
							-	-			

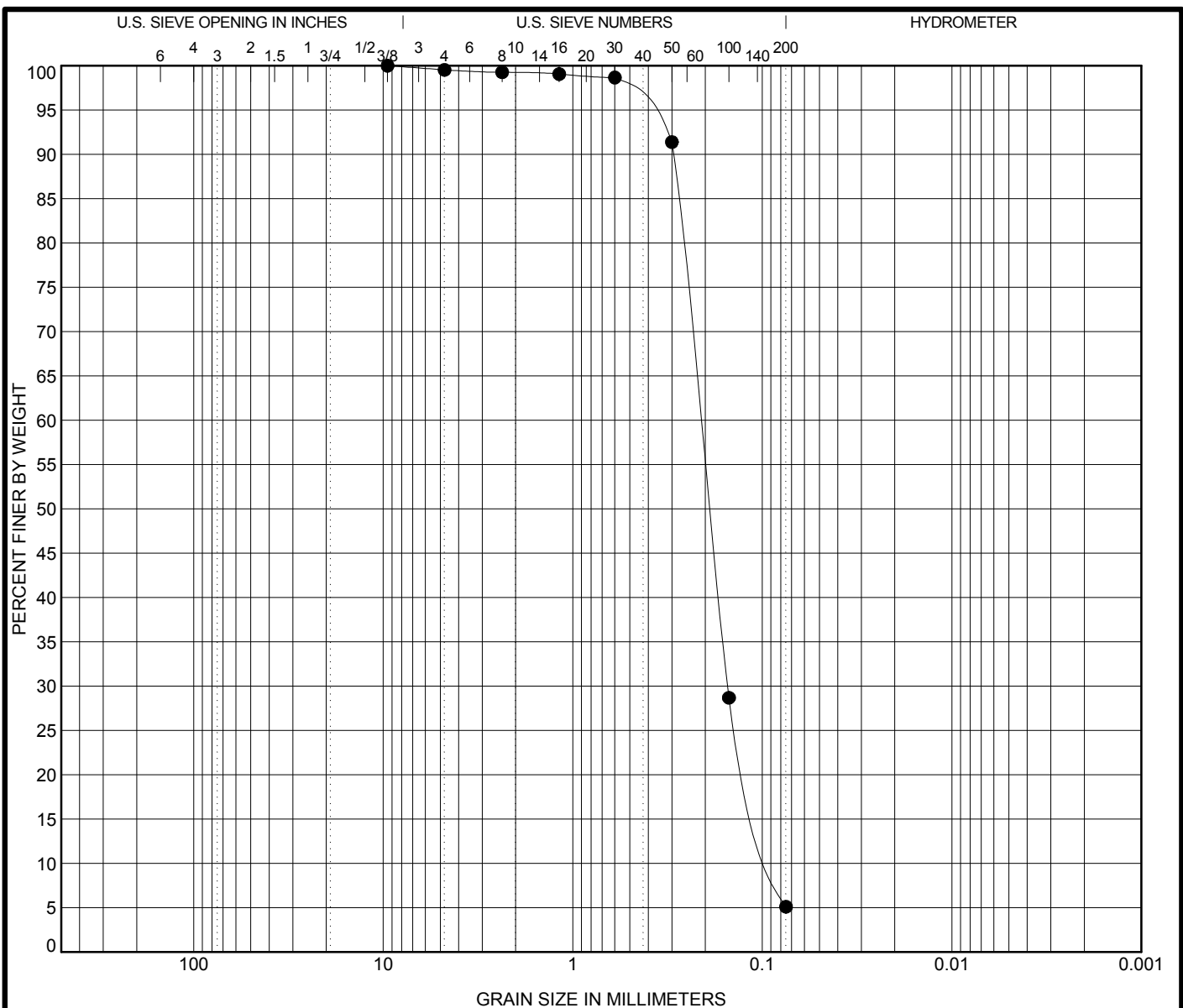
GRAIN SIZE DISTRIBUTION

Terracon

Project: NPS - Colonial Parkway Shoreline Stabilization
 Site: Yorktown, Virginia
 Job #: 70115065
 Date: 3-21-12

TC: GRAIN SIZE LOGS.GPJ GAGE TERRACON.GDT 3/21/12





COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

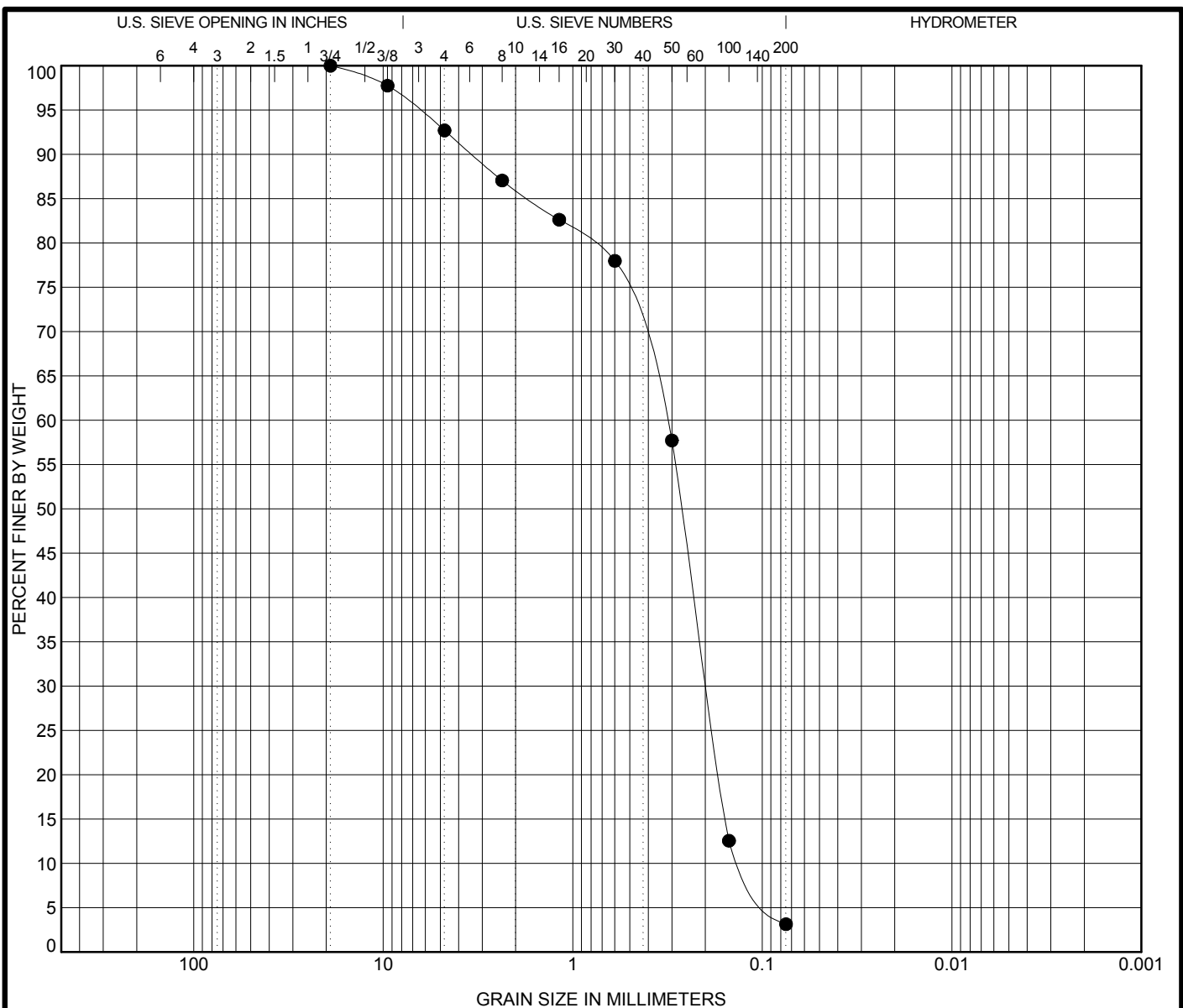
Specimen Identification			Classification			LL	PL	PI	Cc	Cu
●	SPT-13	4.0ft	POORLY GRADED SAND with SILT(SP-SM)			NP	NP	NP	1.26	2.45

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	SPT-13 4.0ft	9.5	0.212	0.152	0.087	-	-	5	
						-	-		
						-	-		
						-	-		
						-	-		

GRAIN SIZE DISTRIBUTION

Terracon

Project: NPS - Colonial Parkway Shoreline Stabilization
 Site: Yorktown, Virginia
 Job #: 70115065
 Date: 3-21-12



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

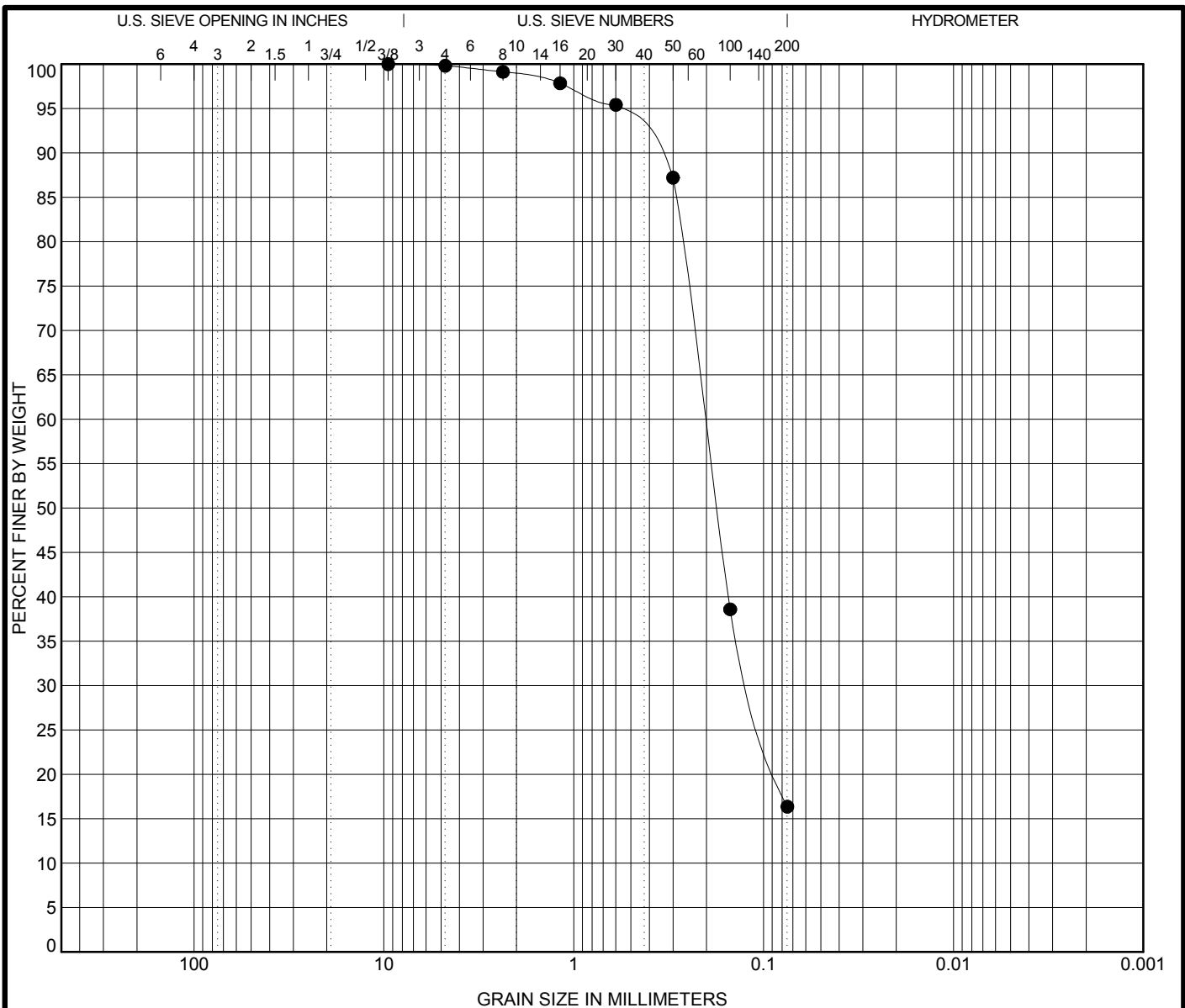
Specimen Identification			Classification			LL	PL	PI	Cc	Cu
●	SPT-14	2.0ft	POORLY GRADED SAND(SP)			NP	NP	NP	0.95	2.61

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	SPT-14	2.0ft	19	0.324	0.196	0.124	-	-	3	
							-	-		
							-	-		
							-	-		

GRAIN SIZE DISTRIBUTION

Terracon

Project: NPS - Colonial Parkway Shoreline Stabilization
 Site: Yorktown, Virginia
 Job #: 70115065
 Date: 3-21-12



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

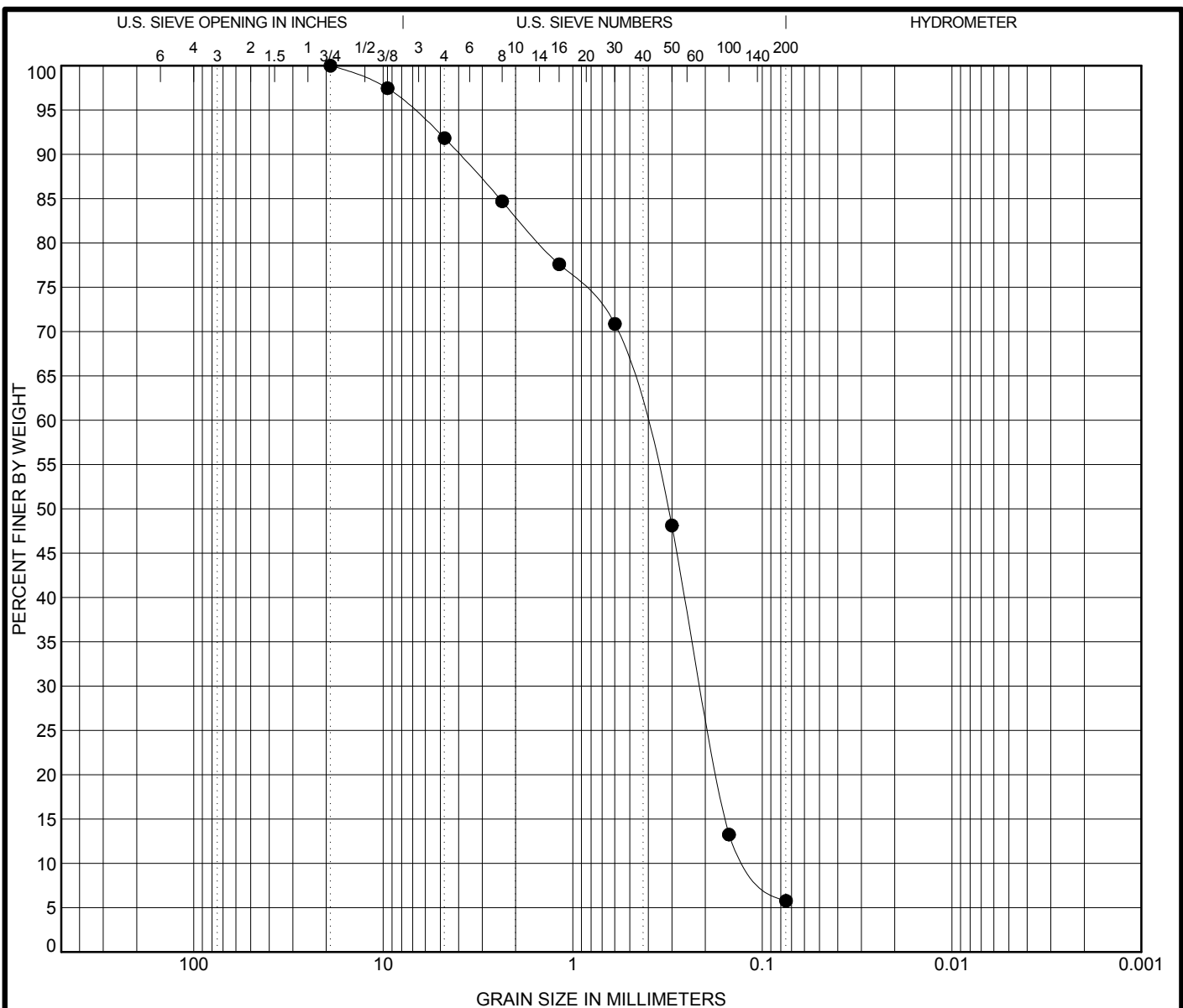
Specimen Identification			Classification			LL	PL	PI	Cc	Cu
●	SPT-15	8.0ft	SILTY SAND(SM)			NP	NP	NP		

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	SPT-15 8.0ft	9.5	0.204	0.115		-	-	16	
						-	-		
						-	-		
						-	-		

GRAIN SIZE DISTRIBUTION

Terracon

Project: NPS - Colonial Parkway Shoreline Stabilization
 Site: Yorktown, Virginia
 Job #: 70115065
 Date: 3-21-12



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification			Classification			LL	PL	PI	Cc	Cu
●	SPT-16	2.0ft	POORLY GRADED SAND with SILT(SP-SM)			NP	NP	NP	0.92	3.88

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	SPT-16	2.0ft	19	0.431	0.209	0.111	-	-	6	
							-	-		
							-	-		
							-	-		

GRAIN SIZE DISTRIBUTION

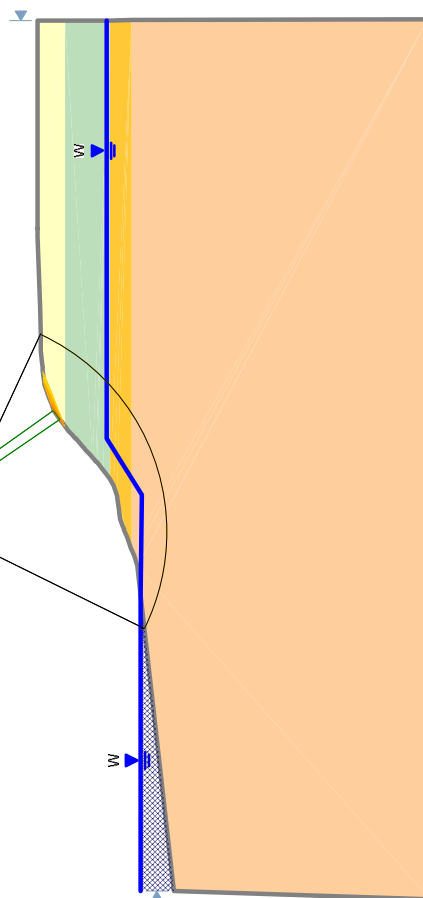
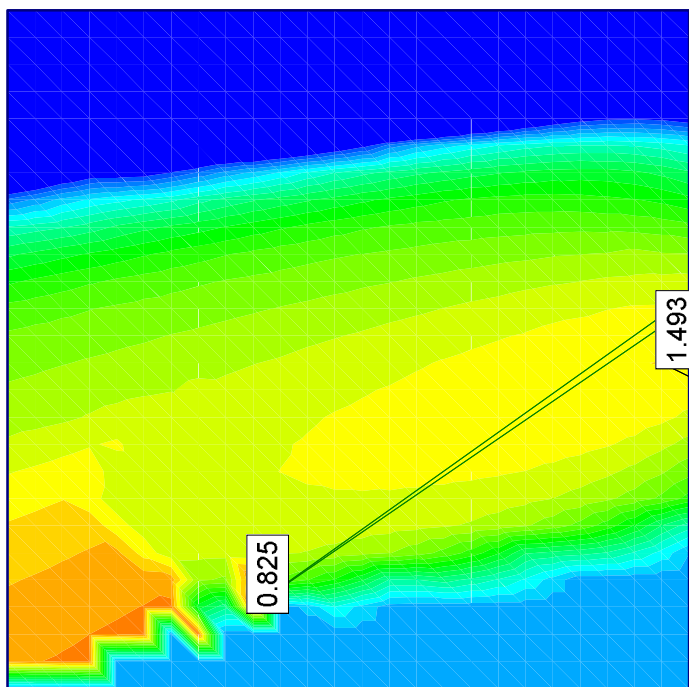
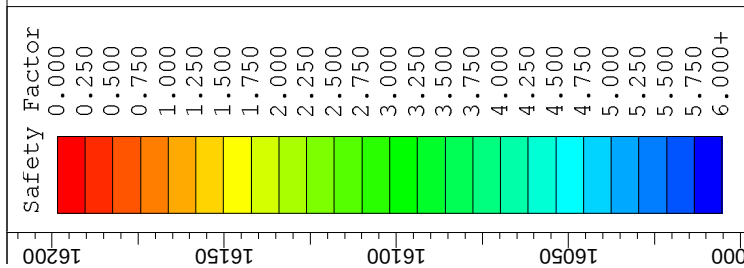
Terracon

Project: NPS - Colonial Parkway Shoreline Stabilization
 Site: Yorktown, Virginia
 Job #: 70115065
 Date: 3-21-12

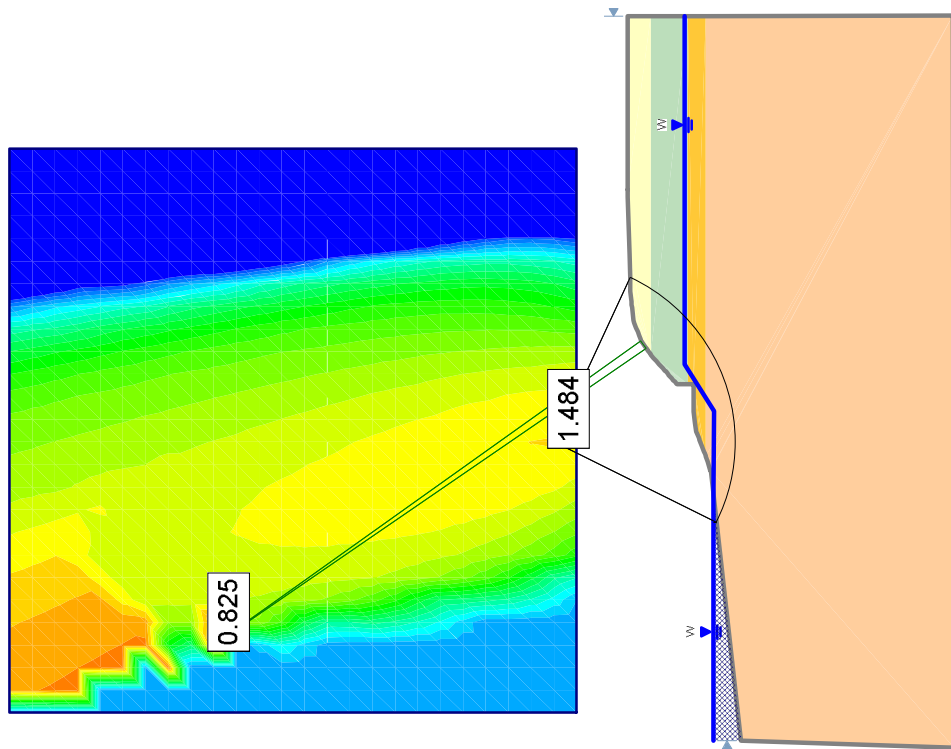
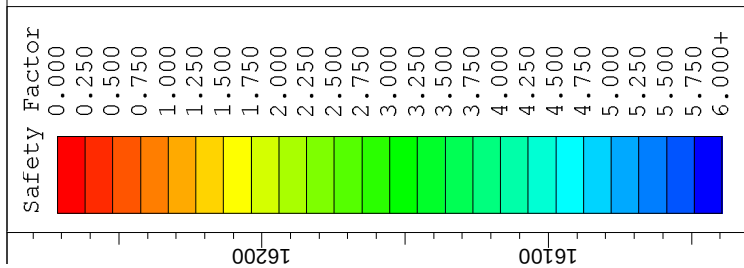
Appendix D - Global Stability Critical Surfaces

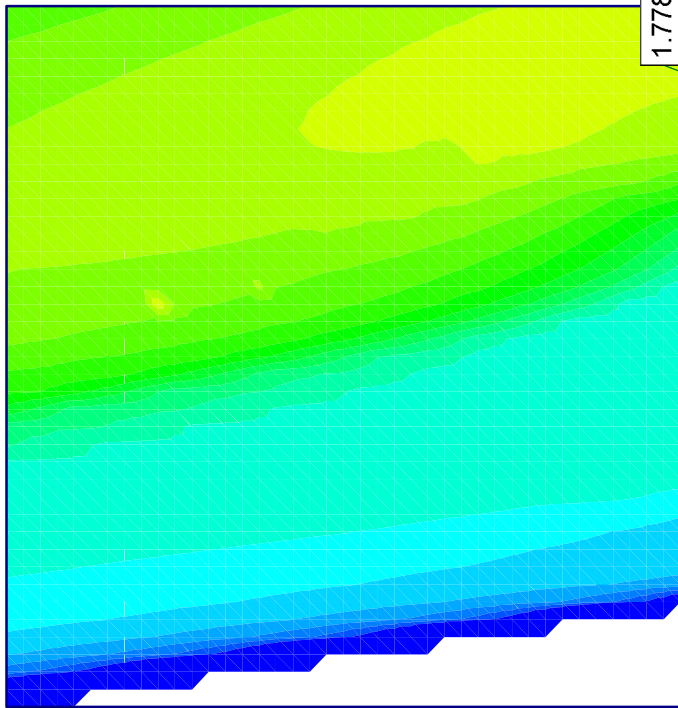
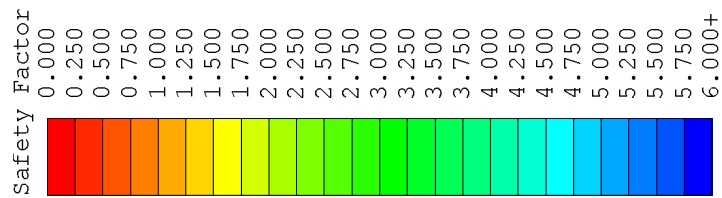
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12DH-036 Initial

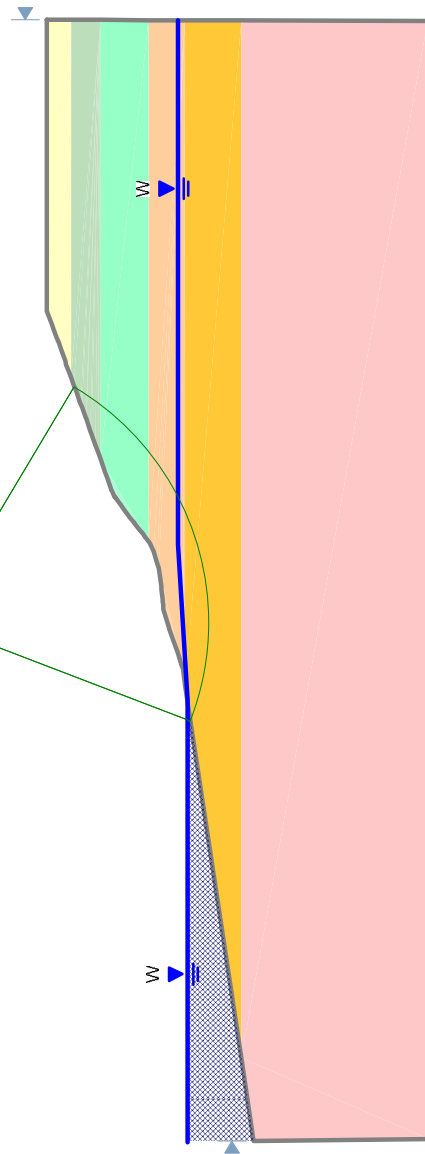


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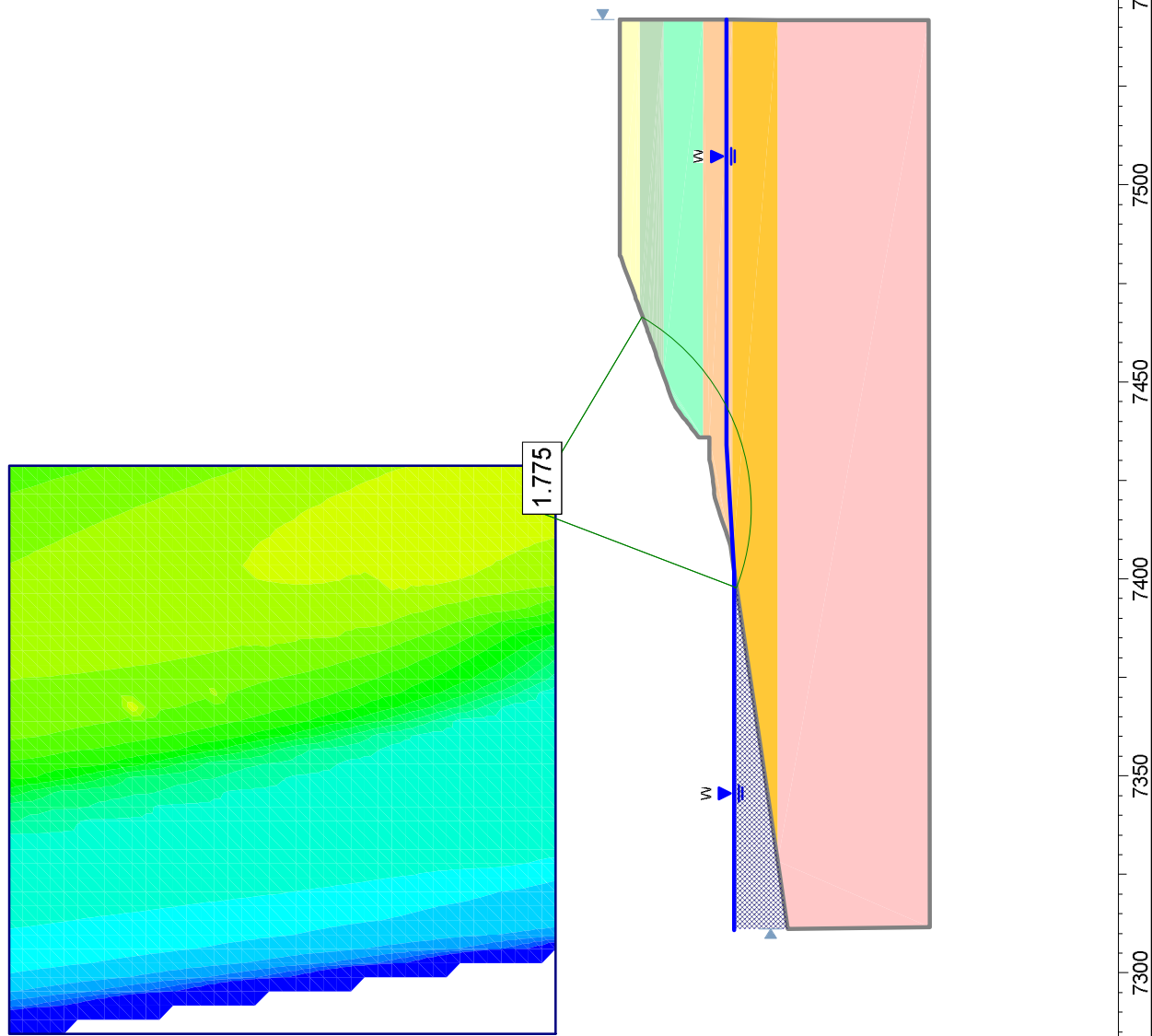
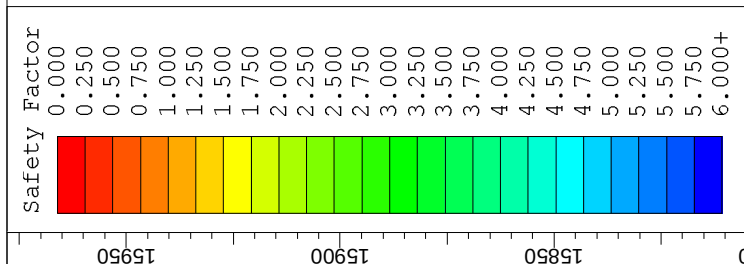




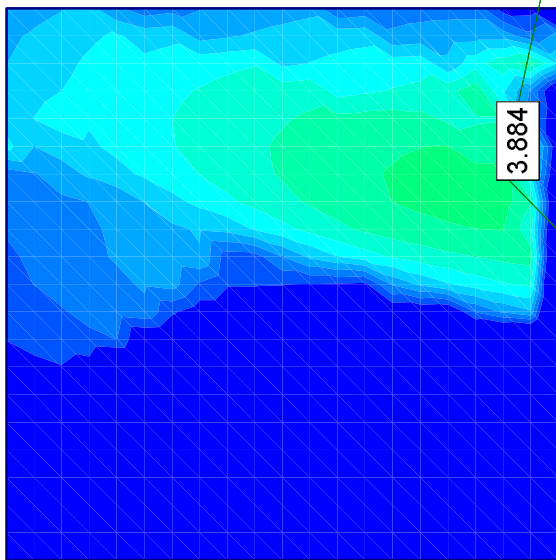
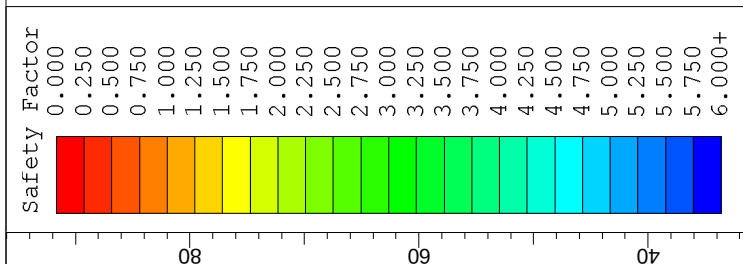
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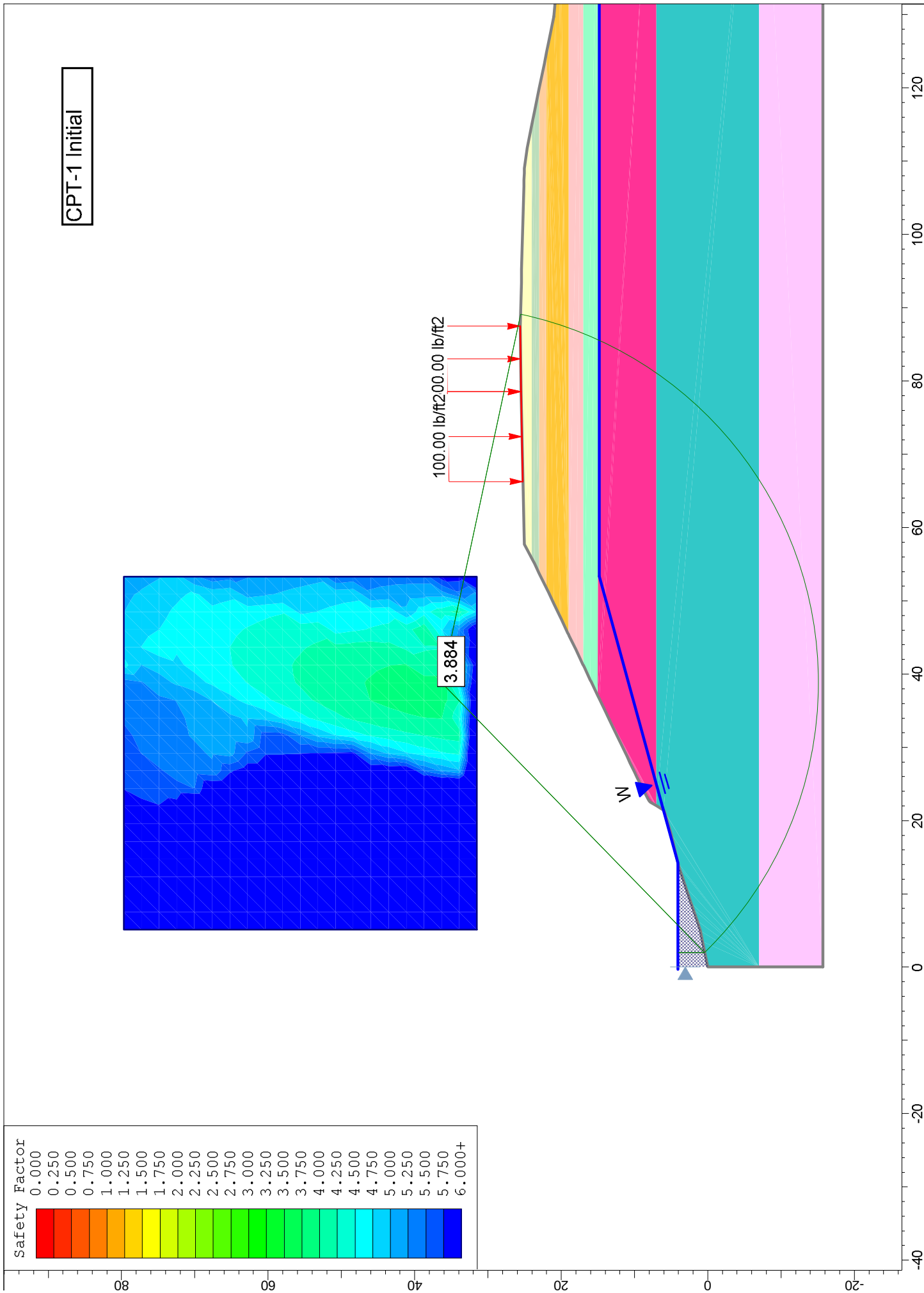
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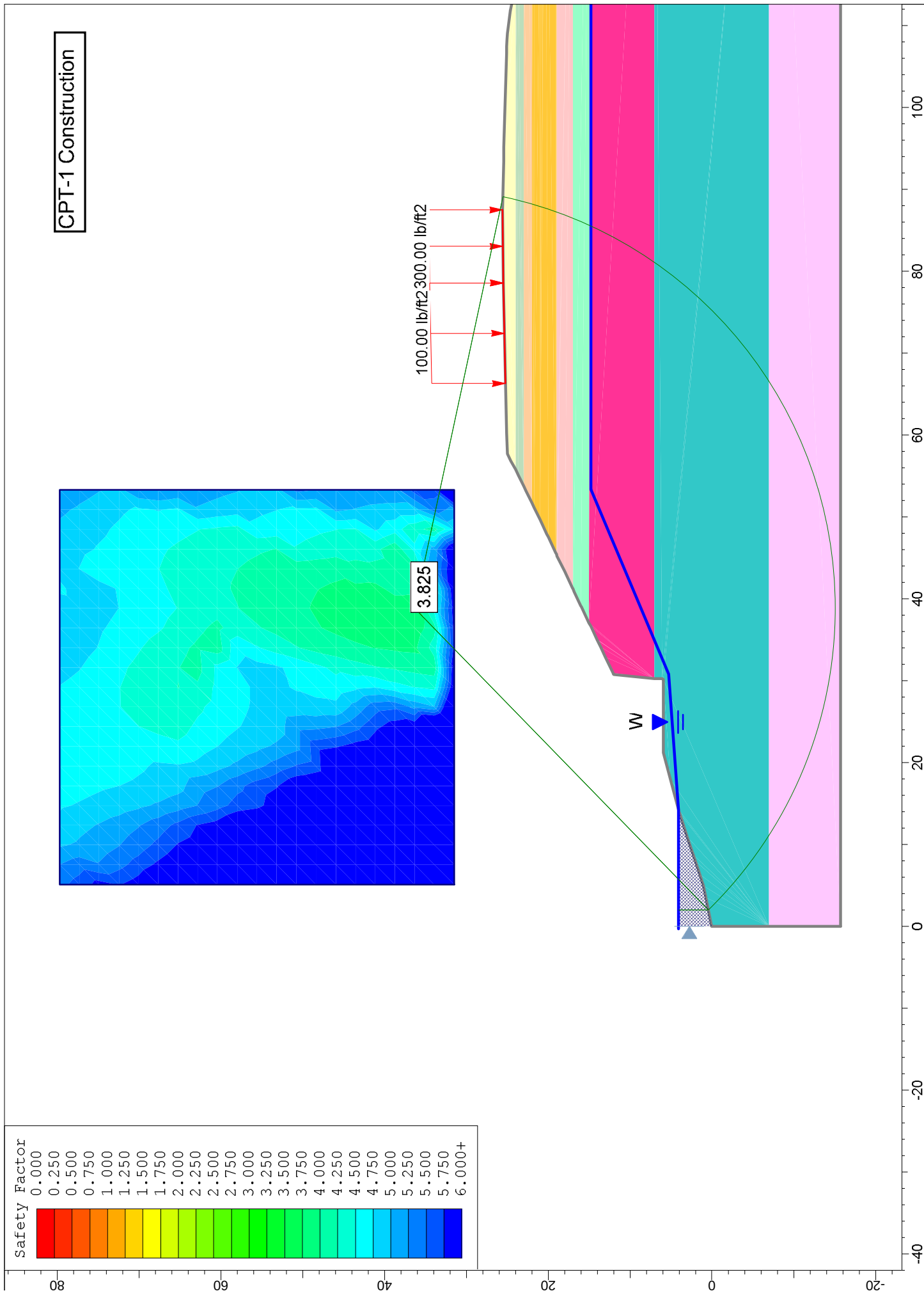
CPT-1 Initial

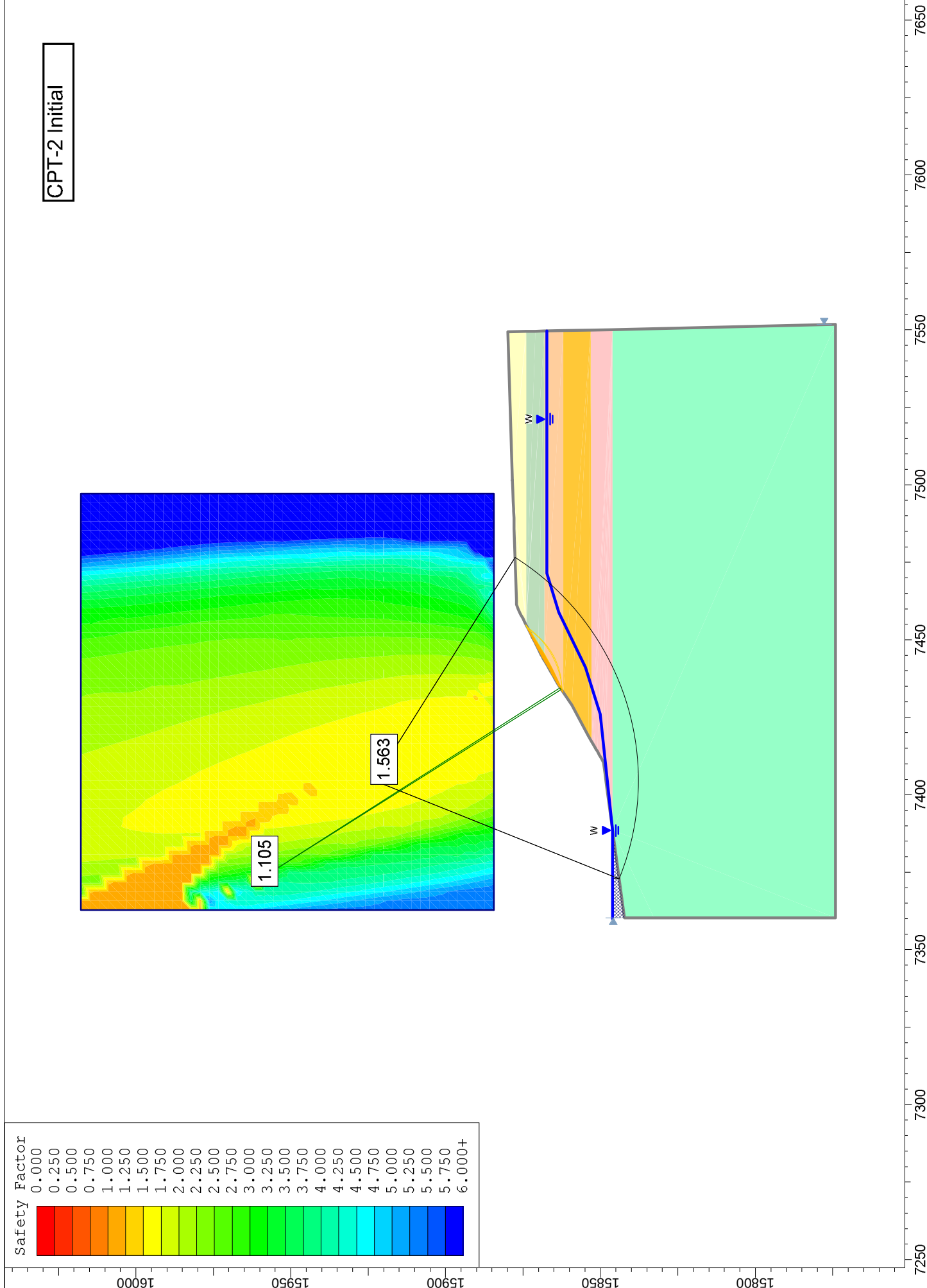


100.00 lb/ft200.00 lb/ft2

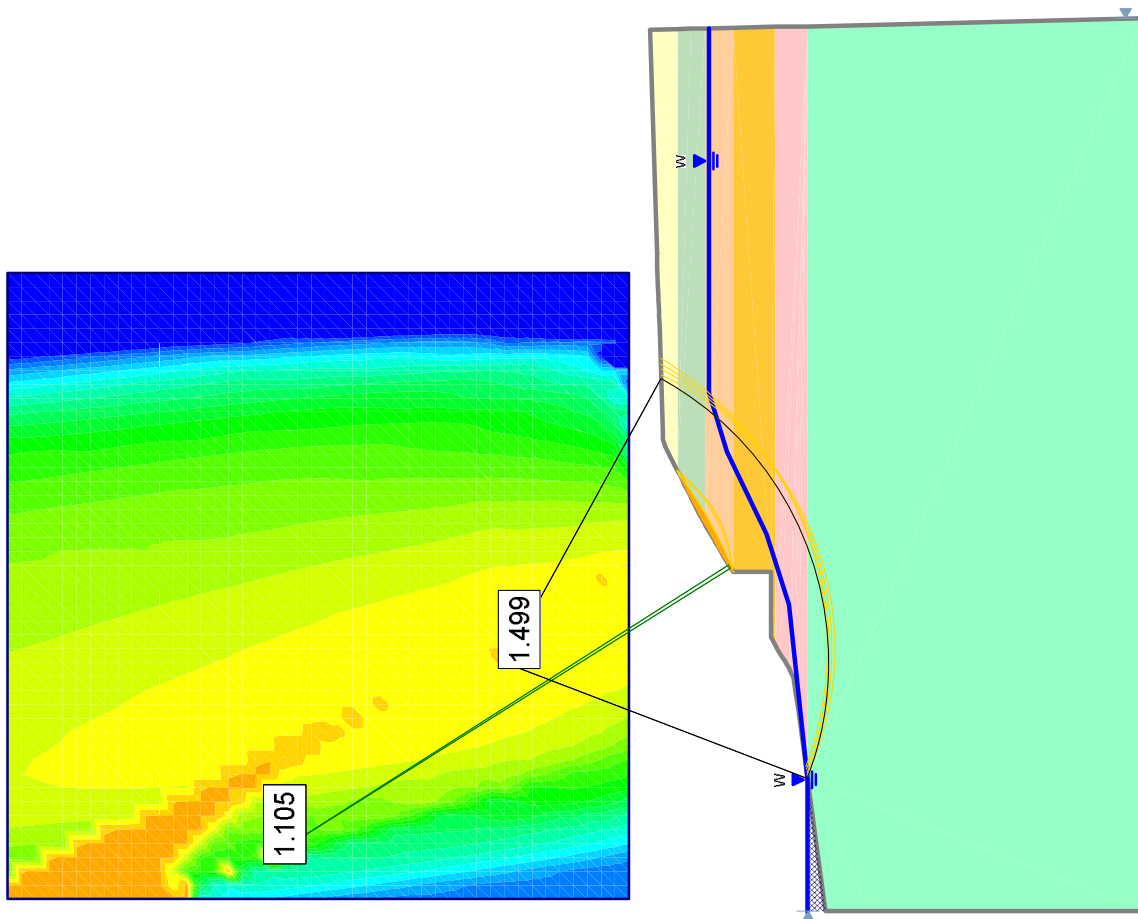
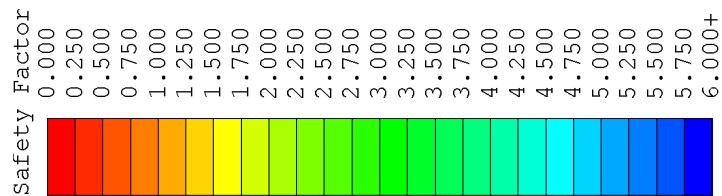


CPT-1 Construction

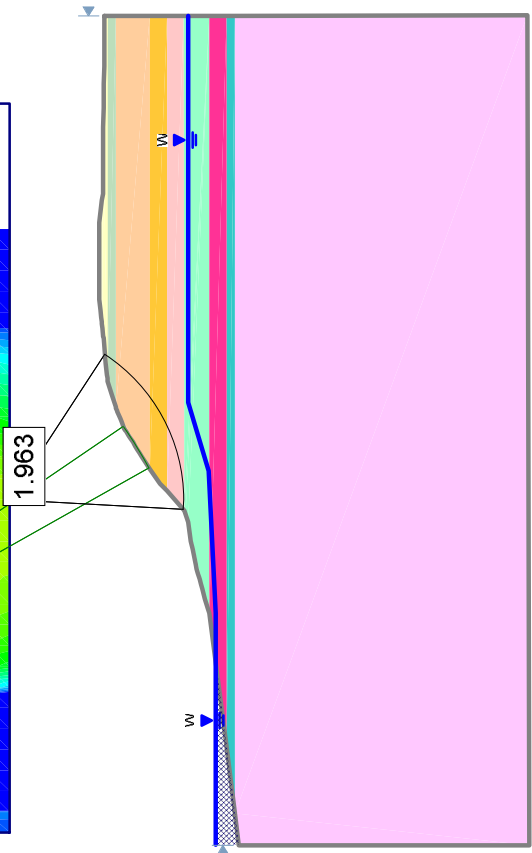
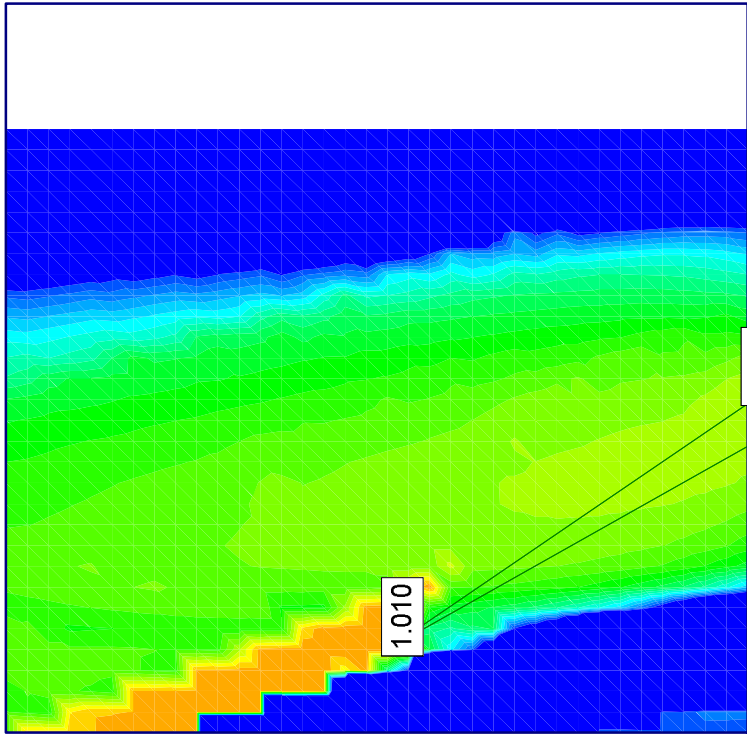
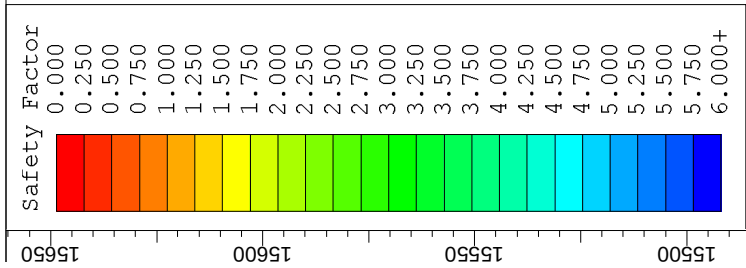




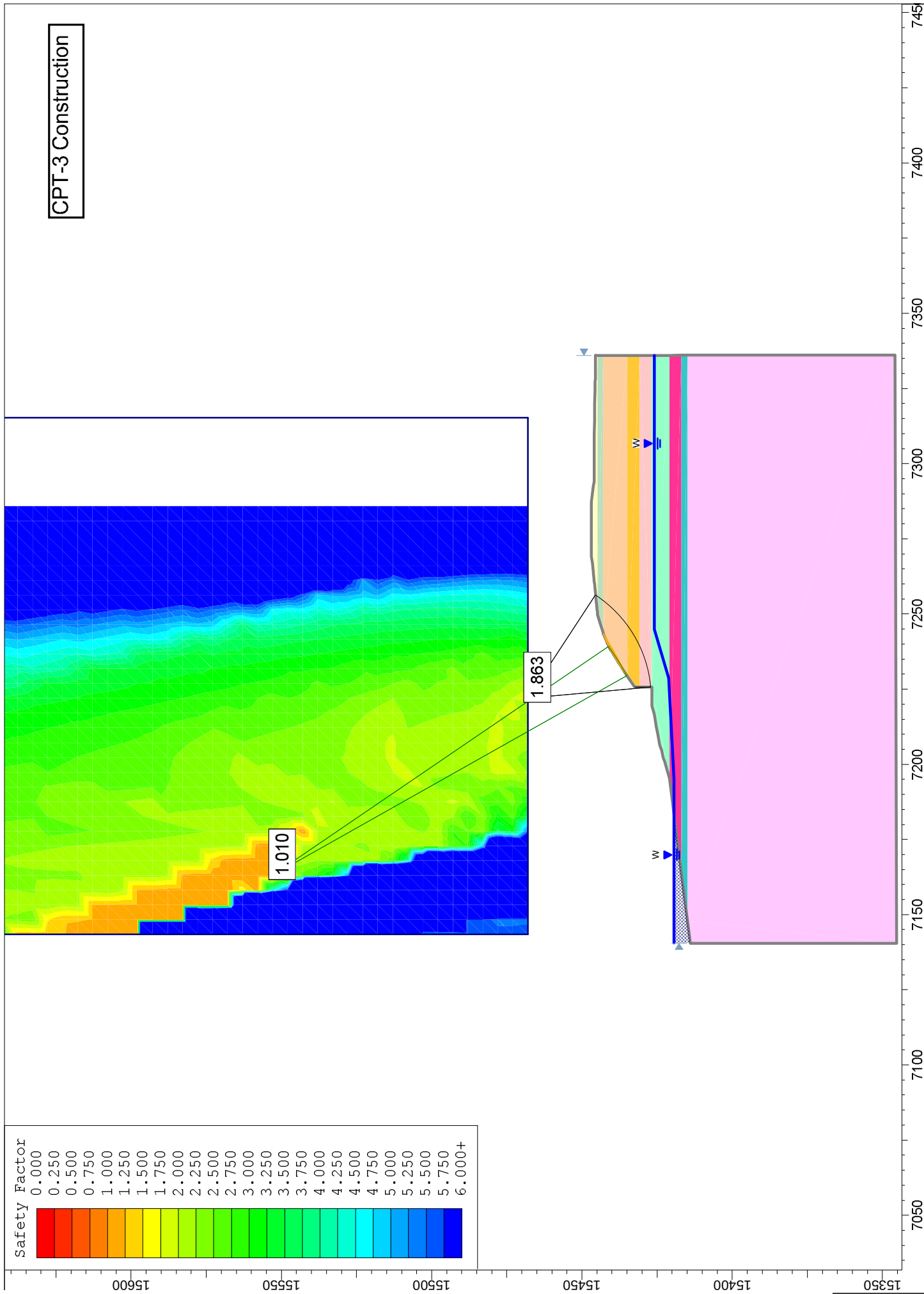
CPT-2 Construction



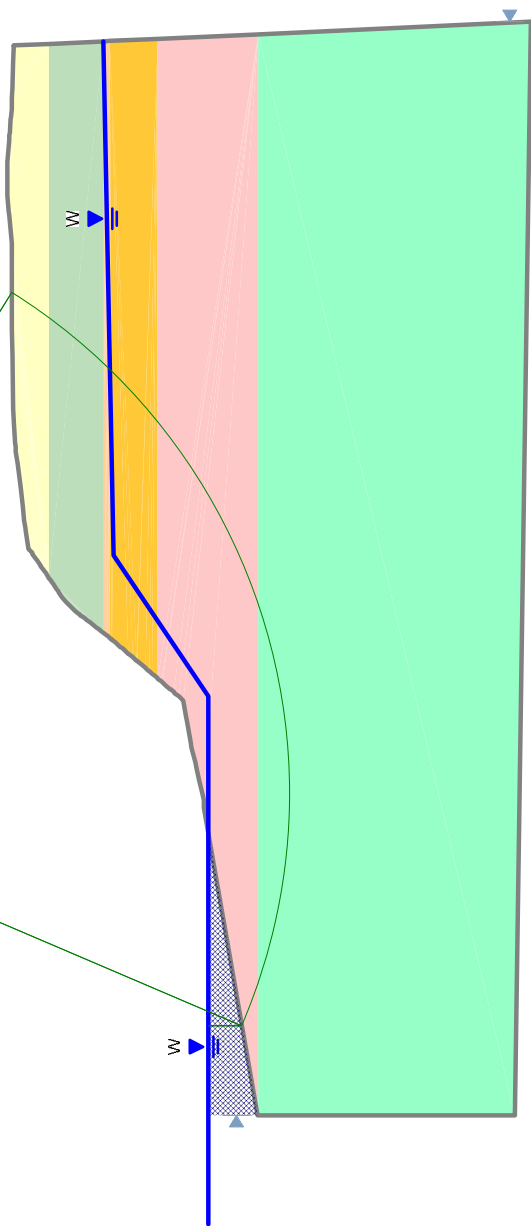
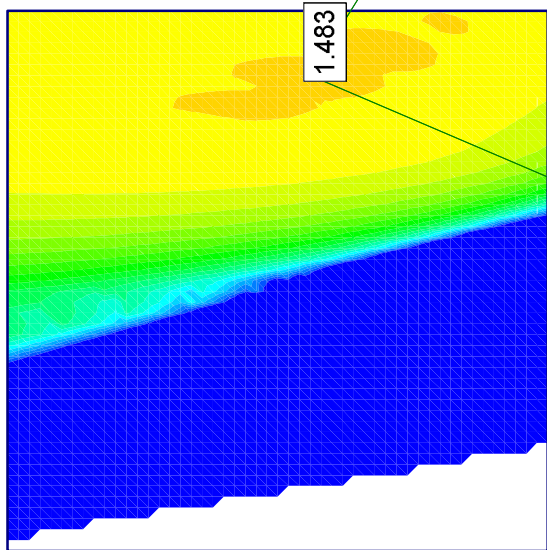
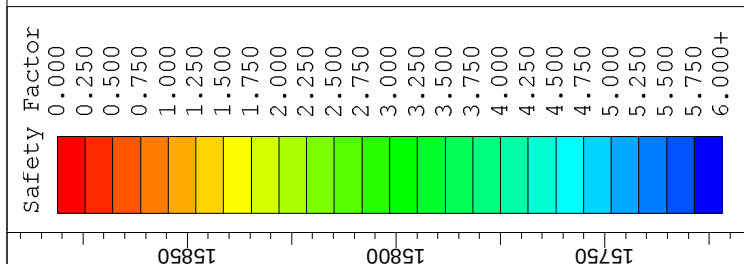
CPT-3 Initial



CPT-3 Construction

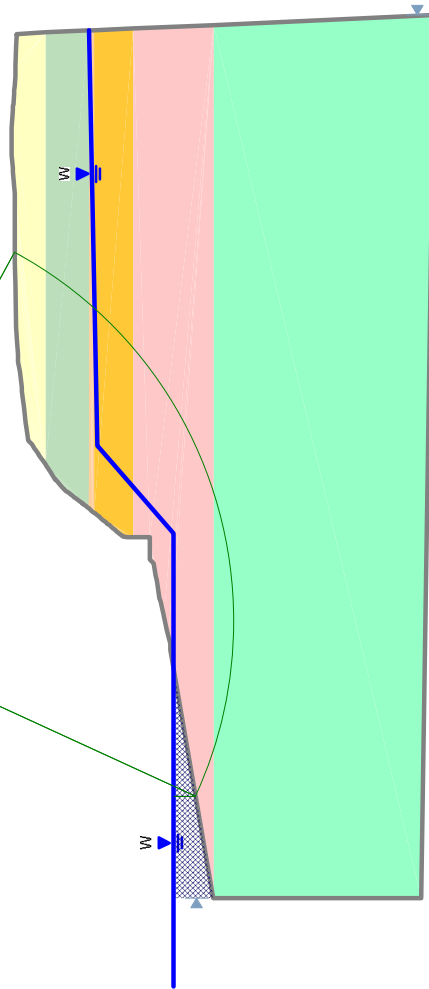
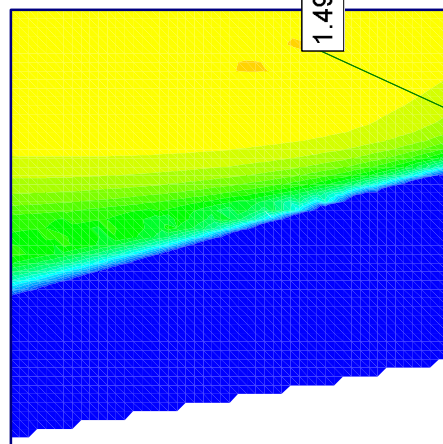
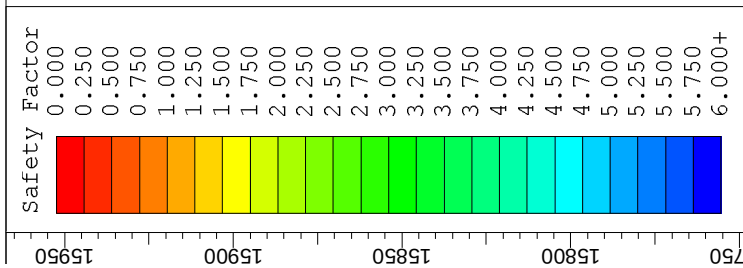


CPT-7 Initial



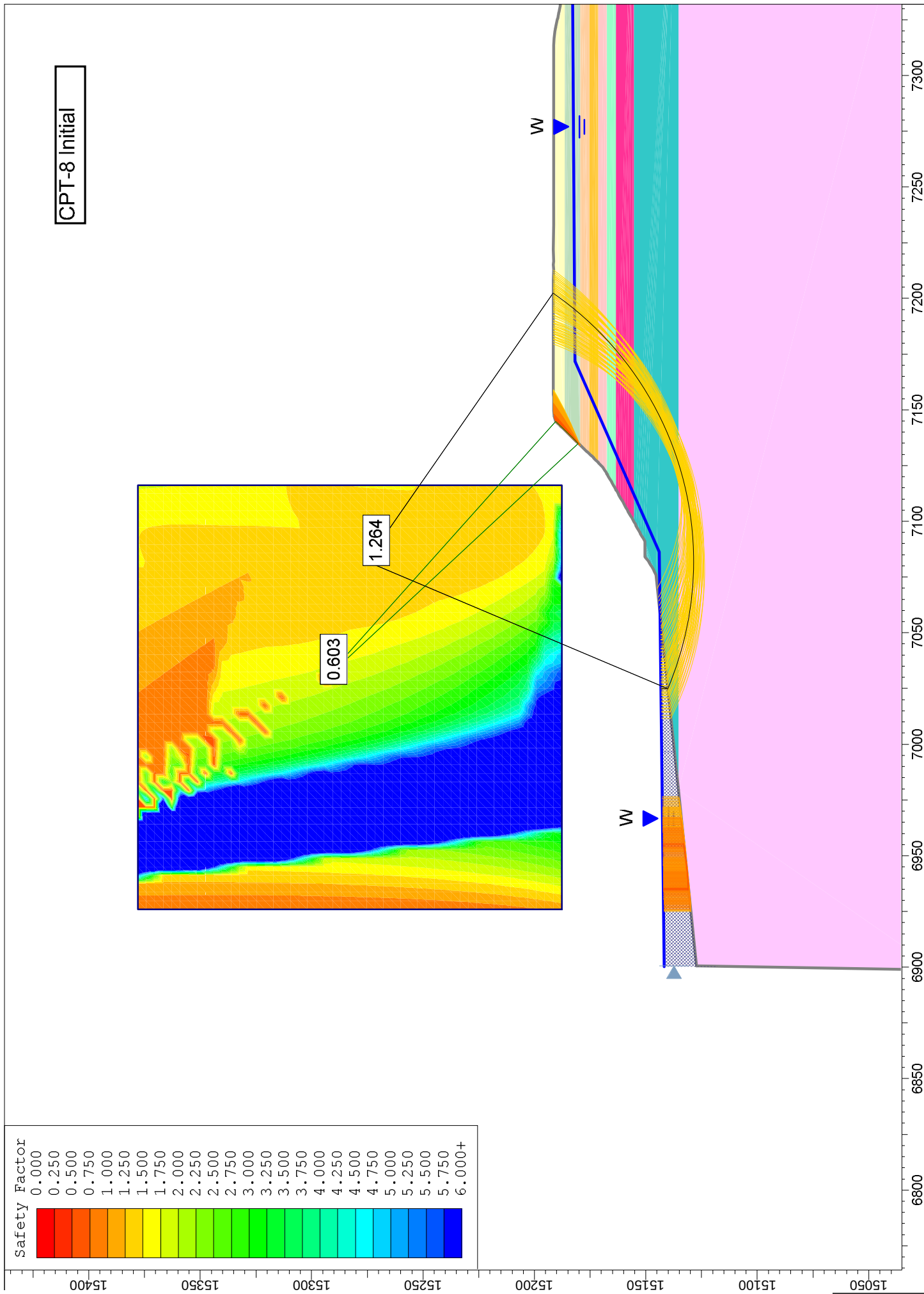
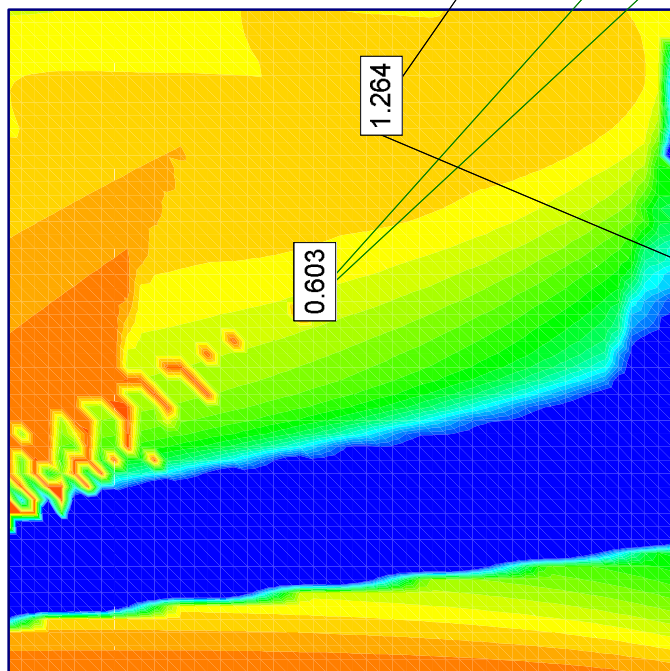
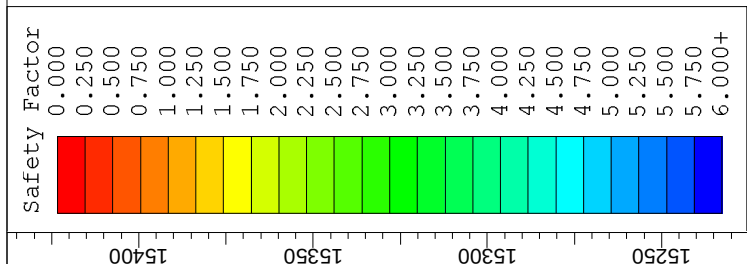
7150 7200 7250 7300 7350 7400 7450 7500 7550 7600

CPT-7 Construction



7100 7150 7200 7250 7300 7350 7400 7450 7500 7550 7600 7650

CPT-8 Initial



CPT-8 Construction

