REPORT OF
SUBSURFACE EXPLORATION AND GEOTECHNICAL ENGINEERING DESIGN
PROPOSED ROANOKE REGIONAL STORMWATER SYSTEM DAM
SOUTH COUNTY HIGH SCHOOL (WOODS END SITE)
ROANOKE COUNTY, VIRGINIA

FOR

MR. GEORGE SIMPSON
ROANOKE COUNTY PLANNING/ENGINEERING
COMMUNITY DEVELOPMENT DEPARTMENT
5204 BERNARD DRIVE
ROANOKE, VIRGINIA 24018

MAY 22, 2000

ENGINEERING CONSULTING SERVICES, LTD.
Geotechnical • Construction Materials • Environmental

May 22, 2000

Mr. George Simpson
Roanoke County Planning/Engineering
Community Development Department
5204 Bernard Drive
Roanoke, Virginia 24018

ECS Project No. 1565

Re: Report of Subsurface Exploration and Geotechnical Engineering Design
Proposed Roanoke Regional Stormwater System Dam
South County High School (Woods End Site)
Roanoke County, Virginia

Dear Mr. Simpson:

Engineering Consulting Services, Ltd. (ECS, Ltd.) is pleased to submit this report of Subsurface Exploration and Geotechnical Engineering Design for the proposed Roanoke Regional Stormwater System Dam. The project will include construction of a retention basin with an estimated 32-foot-high earth dam. The embankment crest will be utilized as an entrance roadway to the proposed South County High School. Our services have been provided in accordance with ECS Proposal No. 1702-P, dated April 12, 2000, which was authorized by the County of Roanoke, Community Development Department.

This report includes the results of the soil borings, analysis of the proposed slopes, evaluation of on-site soils for use in the embankment, and construction specifications as they relate to the geotechnical aspects of this project. Engineering Concepts, Inc. (ECI) will provide specific design requirements for the hydraulic structures.

As you are aware, ECS, Ltd. has performed the geotechnical exploration, "Final Subsurface Exploration, Proposed South County High School, Woods End Site, ECS Project No. 1045A," dated November 16, 1998. We also performed a supplementary geotechnical exploration for the revised building location, "Addendum to Report of Final Subsurface Exploration, Woods End Site, ECS Project No. 1045B, dated January 25, 2000. The information from these explorations was incorporated into this report.

As part of this exploration, we have also prepared a site plan and project specifications for construction of the dam embankment with consideration for seepage control measures and other geotechnical aspects of this project. The site plan is included in the Appendix to this report.

Scope of Work

Our scope for this exploration consisted of a site visit by the Geotechnical Engineer and eight additional soil test borings (SB-1 through SB-8) drilled to depths of 20 to 30 feet below the existing ground surface. Three offset borings (SB-3A, SB-4A and SB-8A) were also drilled where auger refusal occurred above the scheduled depth of the boring. No rock coring was performed. We have also incorporate three soil test borings (B-15 through B-17) performed during the previous subsurface exploration (ECS Project No. 1045A) located within the area of the proposed dam embankment.

Laboratory testing performed on several representative samples obtained during the field exploration aided in the evaluation of the field data. The borings were located in the field by ECS, Ltd. personnel by measuring distances and estimating right angles from existing site features. The boring locations shown on the plan provided in the Appendix should be considered approximate.

The recommendations contained herein were developed from our interpretation of the subsurface data obtained from the soil test borings. The borings indicate subsurface conditions at specific locations at the time of the exploration. If, during the course of construction, variations appear evident, the Geotechnical Engineer should be informed so that the conditions can be addressed. Design recommendations were developed based on design criteria considered typical for this type of structure. Should design characteristics differ from those discussed herein, ECS, Ltd. should be contacted for review of these conditions and possible revisions to the recommendations of this report.

The ground surface elevations shown on the boring logs were estimated from the topographic survey information provided on the site plan and should be considered as approximate. Based on the plan and our site observations, we anticipate that these values are accurate to within approximately two feet.

PROJECT CHARACTERISTICS

The project will include construction of a retention basin with an estimated 32-foot-high earth dam with a minimum crest elevation of 1,124 feet. The embankment crest will be utilized as an entrance roadway to the proposed South County High School. The earth dam will have a downstream slope of 3H:1V and an upstream slope of 2H:1V.

Based on the information provided by Engineering Concepts, Inc., the retention basin will incorporate a multiple-stage spillway with a base flow pipe at the base of the earth dam with an invert elevation of 1095.5 feet. The 100-year flood level has been estimated to be 1121.5 feet. An overflow spillway will be constructed above the base flow pipe at an invert elevation of 1115.0 feet. We understand that the earth dam is designed to manage storm events with a 30-hour drawdown period. Concrete facing with baffles will be constructed along the downstream slope below the overflow spillway to prevent erosion and to dissipate hydraulic energy.

EXPLORATION PROCEDURES

Subsurface Exploration Procedures

In order to characterize the subsurface conditions for proposed dam embankment, eight additional soil test borings (SB-1 through SB-8) and three offset borings (SB-3A, SB-4A and SB-8A) were performed for our addendum study. The borings for the exploration were performed with track-mounted drilling equipment utilizing continuous-flight, hollow stem augers to advance the boreholes. Drilling fluid was not used in this process.

Representative samples were obtained by means of the split-barrel sampling procedure in accordance with ASTM Specification D-1586. In this procedure, a 2-inch O.D., split-barrel sampler is driven into the soil a distance of up to 18 inches by a 140-pound hammer falling 30 inches. The number of blows required to drive the sampler through a 12-inch interval is termed the Standard Penetration Test (SPT) N-value and is indicated for each sample on the boring logs. This value can be used as a qualitative indication of the in-place relative density of cohesionless soils. In a less reliable way, it also indicates the consistency of cohesive soils. This indication is qualitative, since many factors can significantly affect the Standard Penetration resistance value and prevent a direct correlation between drill crews, drill rigs, drilling procedures, and hammer-rod sampler assemblies. Samples were obtained at 2.5-foot intervals in the upper 10 feet of each boring, and at 5-foot intervals thereafter.

After recovery, representative portions of each sample were removed from the sampler and sealed in glass jars. The samples were taken to our laboratory in Roanoke, Virginia for visual classification and laboratory testing.

Laboratory Testing Program

Representative soil samples were selected and tested in our laboratory to substantiate visual classifications and to aid in the determination of pertinent engineering properties. The laboratory testing program included visual classifications, natural moisture content tests, Atterberg Limits and grain-size analysis tests. The results of all laboratory testing conducted are included in the Appendix of this report.

An experienced geotechnical engineer visually classified each soil sample on the basis of texture and plasticity in accordance with the Unified Soil Classification System. The group symbols for each soil type are indicated in parentheses following the soil descriptions on the boring logs. A brief explanation of the Unified System is included with this report. The engineer grouped the various soil types into the major strata noted on the boring logs. The stratification lines designating the interfaces between earth materials on the boring logs and profiles are approximate; in-situ, the transitions may be gradual.

The soil samples will be retained in our laboratory for a period of 60 days, after which, they will be discarded unless other instructions are received as to their disposition.

SUBSURFACE CONDITIONS

General

Site and geologic conditions for the project are discussed in our original report. Our current submittal describes only the conditions encountered in the additional soil test borings performed. Information for other site areas can be found in our previous report.

Soil Conditions

Based on the additional soil borings, the proposed dam embankment area is currently covered by topsoil ranging in thickness from 4 to 6 inches. Below the topsoil, the subsurface conditions for this exploration predominately consist of alluvial deposits along Mudlick Creek including fine to medium SAND (SM) with gravel with lenses of sandy CLAY (CL). In the low-lying areas, the alluvial deposits extend to maximum depths of up to 9 feet below existing grades. These soils are generally loose to medium dense with Standard Penetration Test (SPT) N-values ranged from 5 to 24 blows per foot (bpf). Generally, the alluvium is very moist and becomes saturated with depth below the current groundwater level. Along the side slopes, the alluvial deposits transition to fine-grained sandy CLAY (CL), gradually tapering to less than 3 feet in depth along the abutment locations.

Residual soils were encountered beneath the alluvial deposits and consist of clayey SILT (ML) with sand to depths ranging from 12 to 22 feet below existing grades. SPT N-values in the residual soils ranged from 6 to 17 blows per foot (bpf), demonstrating a medium stiff to very stiff consistency. In Boring SB-7, a loose zone of Sandy SILT (ML) was encountered from 9 to 19 feet with SPT N-values ranging from 2 to 3 bpf, and exhibited wet soil conditions.

In several of the soil borings, weathered SHALE was encountered at depths ranging from 9 to 20 feet. SPT N-values within the weathered SHALE ranged from 26 to 78 bpf, and up to 50 blows per 4 inches of penetration on less weathered rock. Auger refusal was encountered in several of the borings at depths ranging from 8 to 17 feet below existing grades.

In Boring SB-2, existing fill was encountered to approximately 8 feet below existing grades and consists of silty fine SAND (SM). Due to the proximity to the existing sewer line, the fill is believed to be backfill within the sewer line easement. The depth of the sewer pipe is estimated to be approximately 8 feet below existing grades. SPT N-values ranged from 5 to 6 bpf, indicating that these soils are relatively loose.

Boring logs describing the soil conditions encountered in the soil borings are included in the Appendix of this report.

Groundwater Observations

The boreholes were checked for the presence of water at the termination of drilling. Groundwater was encountered in several of the borings as indicated below:

Groundwater Levels

Boring No.	Surface Elevation	Groundwater Depth (ft)	Groundwater Elevation (ft)
SB-1	1110.0	17.0	1093.0
SB-2	1098.0	4.5	1093.5
SB-3	1096.0	3.0	1093.0
SB-4A	1112.0	21.0	1091.0
SB-5	1096.0	6.0	1090.0
SB-6	1100.0	5.0	1095.0
SB-7	1102.0	9.0	1093.0
SB-8	1100.0	6.0	1094.0
B-15	1125.0	29.0	1096.0
B-16	1097.0	4.0	1093.0
B-17	1115.0	Dry	N/A

The groundwater is believed to be flowing through the sandy alluvial soils above the less permeable residual soils and/or weathered shale. Based on grain-size analyses, the sandy alluvial deposits are very permeable with an estimated coefficient of permeability (k) of 1×10^{-3} cm/sec.

Given the shallow groundwater levels, extensive dewatering operations will be necessary to maintain a dry working environment during construction. Groundwater control and dewatering operations should be left to the discretion of the contractor.

ANALYSIS AND RECOMMENDATIONS

Seepage Analysis

To evaluate the seepage, we estimated the phreatic (water) level within the embankment based on the 100-year flood level with a water surface at 1,121.5 feet. Considering the high permeable sandy alluvial soils beneath the embankment, we have estimated seepage losses on the order of 100,000 gallons per day (gpd). To control seepage and to prevent piping (erosion within the embankment), we recommend that the dam design incorporate a clay cutoff trench and a drainage blanket. Seepage along the base flow pipe can be controlled with construction of a concrete cradle and graded filter.

Another source of seepage loss may occur along the existing sanitary sewer line. We understand that the sewer will be relocated; however, we recommend that the existing pipe and associated backfill be removed from beneath the embankment and replaced with compacted clay fill. We understand that the pipe is approximately 8 feet below existing grades.

The on-site clays and silts should also provide a relatively impervious barrier to reduce seepage losses through the embankment and suitable cutoff through the alluvial soils. Based on an estimated coefficient of permeability (k) of 1×10^{-5} cm/sec, we estimate the seepage losses to be on the order of 5,000 gpd provided the cutoff trench and embankment fill is properly placed and compacted.

The cutoff trench should be constructed through the sandy alluvial deposits and extend a minimum of 2 feet into the residual soils and/or weathered shale to reduce seepage losses beneath the embankment. The average depth of the cutoff trench is estimated to be 10 feet below existing grades based on the soil borings. A minimum cutoff trench depth of 2 feet into residual soils will be required along the abutment side slopes up to elevation 1,122 feet. Based on the site grades, we estimate approximately 465 linear feet of cutoff trench to be constructed. (See Profile View, Sheet 2 of 7).

A drainage blanket, consisting of VDOT Grading G, Fine Aggregate or equivalent, should be placed along the prepared subgrade behind the downstream end wall and continue up each abutment to elevation 1,110 feet. The drainage blanket should be at least 18 inches in thickness and a minimum of 30 feet in width. Filter fabric, conforming to Mirafi 140N or equivalent, should be placed along the top and bottom of the drainage blanket to prevent fines from migrating into the sand. A 4-inch diameter slotted PVC pipe should be placed at the downstream end of the blanket, and sloped toward the end wall. The drainage pipe should daylight at the end wall at about elevation 1092.5 feet. The length of the drainage blanket is estimated to be 325 feet. (See Profile View, Sheet 2 of 7 and Drainage Blanket Detail, Sheet 7 of 7).

Typically, compaction cannot be properly controlled below the mid-height of the base flow pipe. To prevent seepage losses this pipe, we recommend a concrete cradle be incorporated into the design. The concrete cradle should have a minimum thickness of 4 inches below the pipe invert and extend at least 8 inches laterally up the mid-height of the pipe. The cradle, beneath the base flow pipe, should begin at the upstream end wall and continue 100 linear feet. Compacted soil fill can then be placed above the mid-height of the pipe. (See Detail D-D, Sheet 6 of 7).

We also recommend that a graded filter extend 50 linear feet from the downstream end of the concrete cradle. The graded filter should consist of VDOT No. 78 stone, completely encapsulated with filter fabric, and extend a minimum lateral distance equal to the base flow pipe diameter. The graded filter should transition to a partially graded filter, approximately 60 linear feet to the end wall, with a minimum bedding of 6 inches up to the mid-height of the base flow pipe. Two 4-inch-diameter slotted PVC pipes should be placed on either side of the base flow pipe. The pipes should be hydraulically connected with the drainage blanket pipes and daylighted through the end wall at the pipe invert elevation of 1,092.5 feet. (See Details E-E and F-F).

Slope Stability Analyses

To evaluate the proposed dam embankment, we analyzed both the upstream and downstream slopes with maximum slope inclinations of 2H:1V and 3H:1V. The proposed slope profile represented by typical cross-sections were selected for the slope stability analysis based on site topography, soil test borings and estimated soil stratigraphy.

The slope stability analysis was performed using a two-dimensional computerized program called STABL6H. With this program, the analysis was performed using the Modified Bishop Method for circular failure analysis. The factor of safety against slope instability calculated using the program is defined as the sum of the moments resisting failure divided by the sum of the moments causing failure along a potential failure surface. Hence, a factor of safety less than 1.0 indicates a potentially unstable slope. Because of the margin of uncertainty regarding soil parameters in-situ, a factor of safety of 1.5 or greater is considered to be a minimum adequate factor of safety. Circular failure surfaces were generated and analyzed using the STABL6H program to compute the factor of safety of each potential failure surface.

The strength parameters used in the slope stability analyses were based on soil types encountered during this exploration, the previous soil borings, the anticipated condition of available materials, and engineering judgment. The soil strength parameters used in the analyses are summarized as follows:

Material Type	Unit Weight (pcf)	Cohesion (psf)	Angle of Internal Friction (∅)
Clayey SILT (Embankment Fill)	118	50	26
Weathered Shale (Shell Fill)	135	50	38
Silty SAND (Alluvium)	120	0	28
Clayey SILT (Residuum)	130	500	26

The results of the stability analyses for the representative cross-sections yield a factor of safety of 1.57 for the upstream slope and 1.53 for the downstream slope.

Embankment Construction

The embankment fill should consist of materials with USCS designations of CL, ML, CH or MH, with minimum Liquid Limit of 40 and minimum Plasticity Index of 15, and minimum percentage of fines of 60 percent. Maximum particle size should not exceed 2 inches.

To improve stability of the upstream slope and to reduce sloughing from rapid drawdown conditions along the saturated slope surface, we recommend the upstream portion of the slope (shell) should be granular material with USCS designations of SM, SC, GM, or GC. The on-site shale can be utilized provided this material is approved by the Geotechnical Engineer. Shale fragments should be mechanically pulverized with heavy construction equipment such that the maximum particle size does not exceed 12 inches after placement. The approximate limits of the upstream shell are illustrated on the attached cross sections (Sections A-A, B-B and C-C).

Fill placement for the embankment fill and shell fill should be performed together in an effort to maintain adequate compaction and proper bonding at the interfaces. Benching should also be performed at the interface between the existing grade and the new fill. The embankment fill should be placed in maximum 8-inch loose lifts and compacted to 95 percent of maximum dry density as determined by ASTM D-698, Standard Proctor method. Fill materials should be moisture conditioned at 2 to 4 percentage points wet of the optimum moisture content. Each compacted lift should be scarified slightly prior to proceeding with the next lift.

Maintenance of upstream and downstream slopes may be required if localized sloughing occurs. All slopes should be protected against erosion and scour by positive means of erosion control by hydroseeding, pre-seeded matting, or rip-rap as required. We do not recommend trees be planted along the slopes of the embankment because of the potential for seepage around established root systems.

At this time, the overflow spillway has not been designed; however, it is understood that the structure will include a series of culverts with an invert elevation of 1,115 feet. We recommend consideration be given to a box culvert as opposed to a circular pipe culvert. The primary advantage of the box culvert would be better compaction control and reduced seepage losses. In contrast, compaction below the mid-height of the pipe culvert, similar to the base flow pipe, cannot be properly achieved such that a concrete cradle may be required. Realizing that 4 to 6 overflow spillway culverts may be required, a multiple box culvert may be more economical.

The downstream slope will be protected with a concrete slab, approximately 8 inches in thickness, to prevent erosion. We recommend that a drainage layer be place between the soil and concrete to reduce hydrostatic pressures on the slab. It may be possible to extend the drainage layer to the drainage blanket with relief through the end wall as indicated on Section A-A.

Subgrade Preparation and Earthwork Operations

Prior to proceeding with construction, topsoil, tree stumps and other organic matter should be removed from the construction areas. The subgrade should be proofrolled with a loaded dump truck having a tandem-axle weight of at least 10 tons to aid in identifying localized soft of unsuitable material. Any soft or unsuitable materials encountered during the proofrolling should be removed and replaced with engineered fill. The excavation and backfilling should be observed by the Geotechnical Engineer so that excessive or inadequate removal of material can be avoided.

The alluvial deposits and residual soils can be excavated with conventional grading equipment; however, heavy construction equipment, such as a track loader or trackhoe, should be considered for excavation of the underlying weathered shale. In general, the weathered rock, which is defined as rock that can be drilled with conventional drilling equipment above the depth of auger refusal, is likely rippable with significant grading equipment. Hard rock, which is defined as rock below the depth of auger refusal, will likely require blasting or use of a pneumatic hoe ram to facilitate removal.

Relocation of the existing sanitary sewer pipe will be required. The existing pipe, bedding stone and associated loose backfill should be removed from beneath the embankment area and backfilled with engineered fill or flowable fill.

Drainage

Current surface drainage generally flows from the slopes toward Mudlick Creek. Diversion of surface drainage should be incorporated into the grading plan to prevent unnecessary saturation of the exposed subgrade soils and new fills. Wet alluvial soils are likely to be encountered during site grading, particularly along the sides of the stream channel.

Due to the shallow groundwater level encountered in the proposed dam embankment area and the steady creek flow, some difficulty should be anticipated during excavation for the cutoff trench and throughout embankment construction. Groundwater control and dewatering operations should be left to the discretion of the contractor.

Water from the creek should be temporarily retained and mechanical pumped beyond the downstream toe of the proposed embankment. In addition, a series of sump pumps or well points may be necessary to intercept hydrostatic groundwater beneath the embankment area and to maintain a dry working environment during fill placement.

CLOSING

The soil test borings performed for this project, as monitored by ECS, Ltd., were extended to the depths indicated on the boring logs provided. To the best of our knowledge, the descriptions and visual classifications of the soils are true reflections of the samples recovered at the levels indicated. We anticipate that they are reasonably representative of the subsurface conditions present at the locations and depths from which the samples were obtained.

We recommend that the construction activities be monitored by a qualified geotechnical engineering firm to provide the necessary construction quality control and to verify the seepage control measures are properly implemented. We would be most pleased to provide these services.

We appreciate this opportunity to be of service to the County of Roanoke during the design phase of this project. If you have any questions with regard to the information and recommendations presented in this report, or if we can be of further assistance to you in any way during the final design or construction of this project, please do not hesitate to contact us.

If you have any questions, please feel free to contact us.

Respectfully Submitted,

ENGINEERING CONSULTING SERVICES, LTD.

Michael R. Circeo, P.E.
Senior Geotechnical Engineer

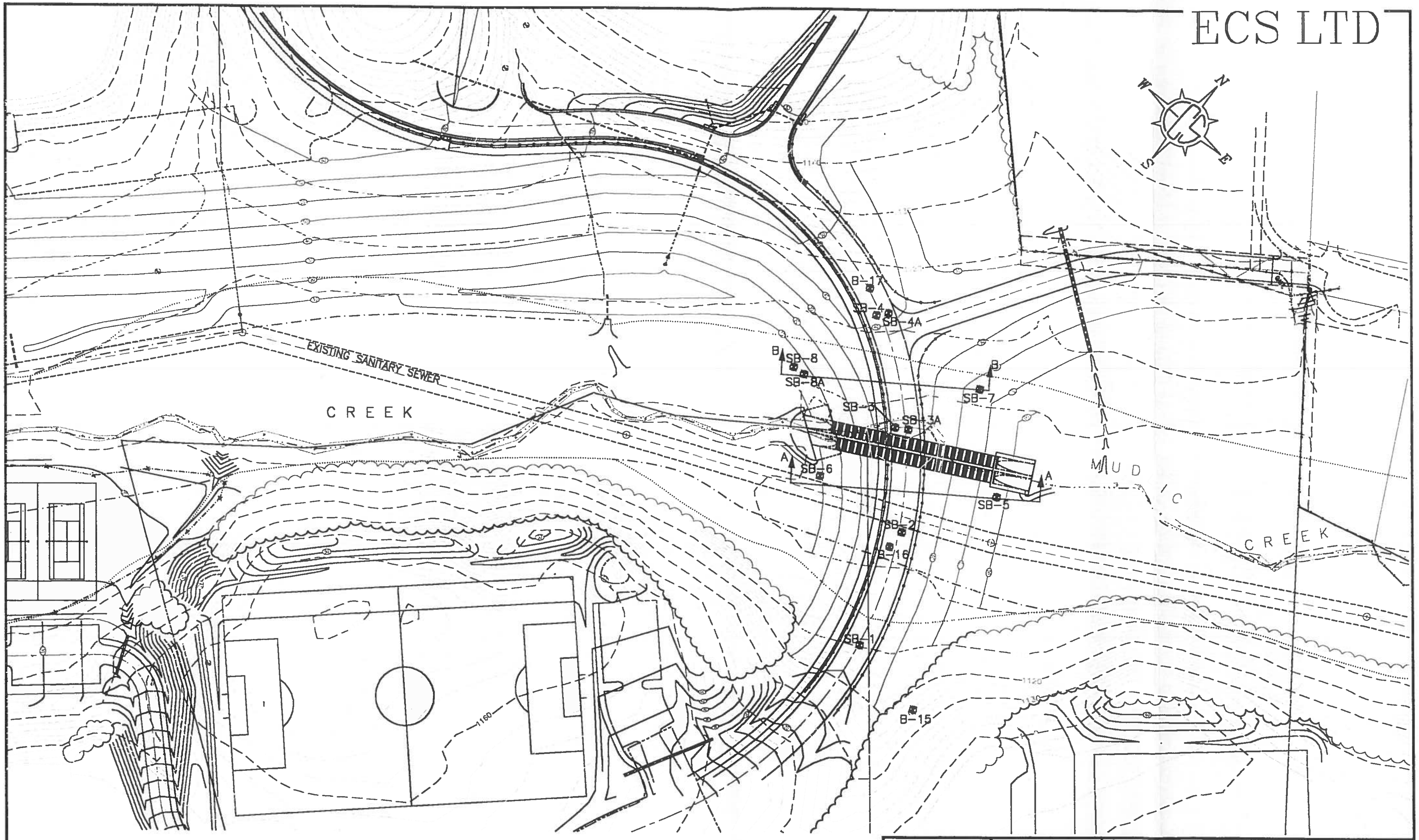
for Grant E. Walker, P.E.
Roanoke Branch Manager – V.P.
Senior Geotechnical Engineer

COMMONWEALTH OF VIRGINIA
MICHAEL R. CIRCEO
No. 021245
5/22/00
PROFESSIONAL ENGINEER

CC: Jack Ellinwood, Jr., Engineering Concepts, Inc.

APPENDIX I

Boring Location Plan
And
Soil Boring Logs



⊕ – Approximate Boring Location

REVISIONS	ECS LTD ENGINEERING CONSULTING SERVICES, LTD	BORING LOCATION DIAGRAM ROANOKE REGIONAL STORMWATER SYSTEM DAM				
		COUNTY OF ROANOKE				
		–	MRC	6-3-00	1"=100'	1565	1 OF 1

OWNER
COUNTY OF ROANOKE

JOB # 1565

BORING # SB-1

SHEET 1 OF 1

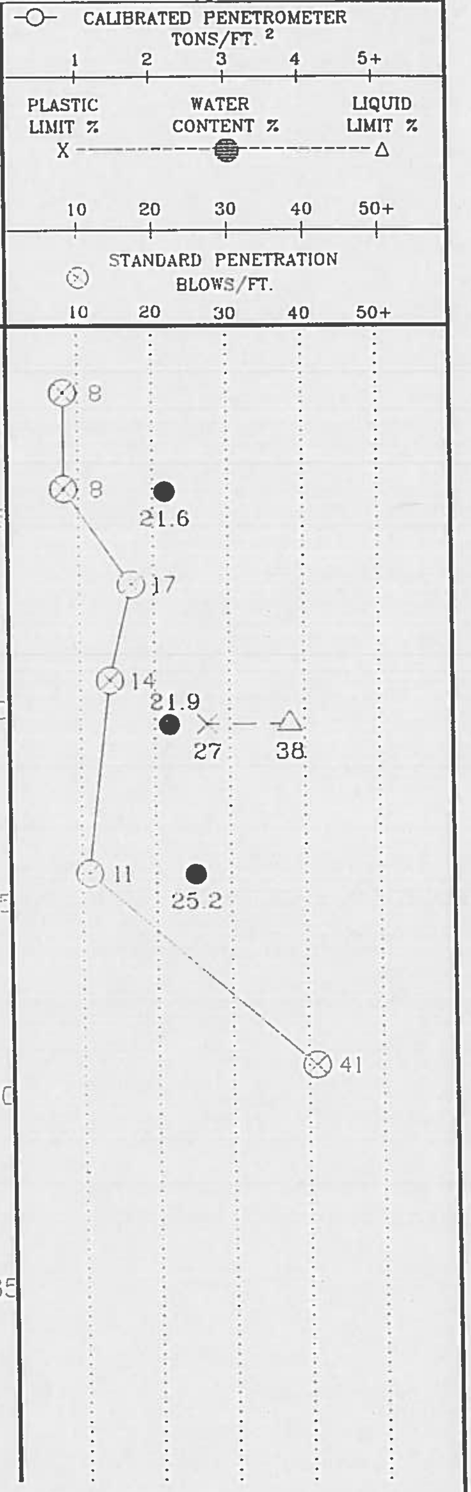
PROJECT NAME
ROANOKE REGIONAL STORMWATER SYSTEM DAM

ARCHITECT-ENGINEER
ENGINEERING CONCEPTS, INC.

SITE LOCATION
SOUTH CO. H.S., ROANOKE COUNTY, VIRGINIA

SURFACE ELEVATION 1110.00

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	ELEVATION (FT)
0					Sandy CLAY, Light Brown, Moist, Stiff, (CL) [Alluvium]	
	1	SS	18	18		
	2	SS	18	18	Clayey SILT With shale Fragments, Yellowish Brown, Moist, Stiff to Very Stiff, (ML) [Residuum]	
5						1105
	3	SS	18	18		
	4	SS	18	18		
10						1100
	5	SS	18	18		
15						1095
					Weathered SHALE With Fine Sand, Tannish Brown to Light Gray, Wet, Very Stiff [Residuurn]	
	6	SS	18	18		
20					END OF BORING @ 20.0'	1090
25						1085
30						



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES IN-SITU THE TRANSITION MAY BE GRADUAL

WL 17.0' WS OR [✓ WD]	BORING STARTED 4-17-00	TOPSOIL DEPTH: 4"
WL BCR ACR	BORING COMPLETED 4-17-00	CAVE IN DEPTH @ N/A
WL	RIG ATV FOREMAN HURDIS	DRILLING METHOD HOLLOW STEM AUGER

OWNER	JOB #	BORING #	SHEET
COUNTY OF ROANOKE	1565	SB-2	1 OF 1

ECS LTD

PROJECT NAME
ROANOKE REGIONAL STORMWATER SYSTEM DAM

ARCHITECT-ENGINEER
ENGINEERING CONCEPTS, INC.

SITE LOCATION
SOUTH CO. H.S., ROANOKE COUNTY, VIRGINIA

DESCRIPTION OF MATERIAL

SURFACE ELEVATION 1098.00

SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE (IN)	RECOVERY (IN)
1	SS	18	18
2	SS	18	18
3	SS	18	18
4	SS	18	18
5	SS	18	18
6	SS	18	18
7	SS	18	18
8	SS	18	18

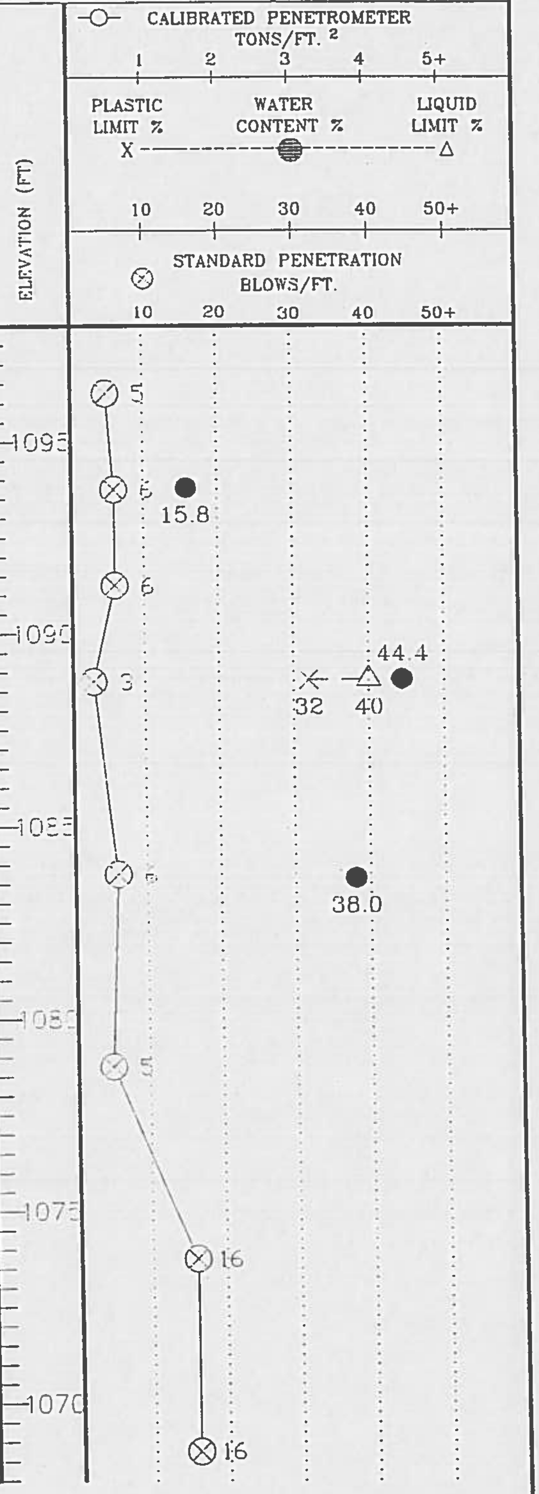
DEPTH (FT): 0, 5, 10, 15, 20, 25, 30

Silty Fine SAND, Light Brown, Moist, Loose, (SM) [Backfill]

Fine to Medium SAND, Some Gravel, Medium Brown, Saturated, Loose, (SM) [Possible Backfill-Sanitary Sewer Trench]

Clayey SILT With Fine Sand, Tannish Brown, Wet, Soft to Medium Stiff, (ML) [Residuum]

Weathered SHALE With Fine Sand, Tannish Brown to Light Gray, Wet, Stiff, [Residuum]



END OF BORING @ 30.0'

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES IN-SITU THE TRANSITION MAY BE GRADUAL

WL 4.5' WS OR [✓ WD]	BORING STARTED 4-17-00	TOPSOIL DEPTH: 6"
WL BCR ACR	BORING COMPLETED 4-17-00	CAVE IN DEPTH @ N/A
WL	RIG ATV FOREMAN HURDIS	DRILLING METHOD HOLLOW STEM AUGER

OWNER
COUNTY OF ROANOKE

JOB #
1565

BORING #
SB-3

SHEET
1 OF 1

ECS LTD

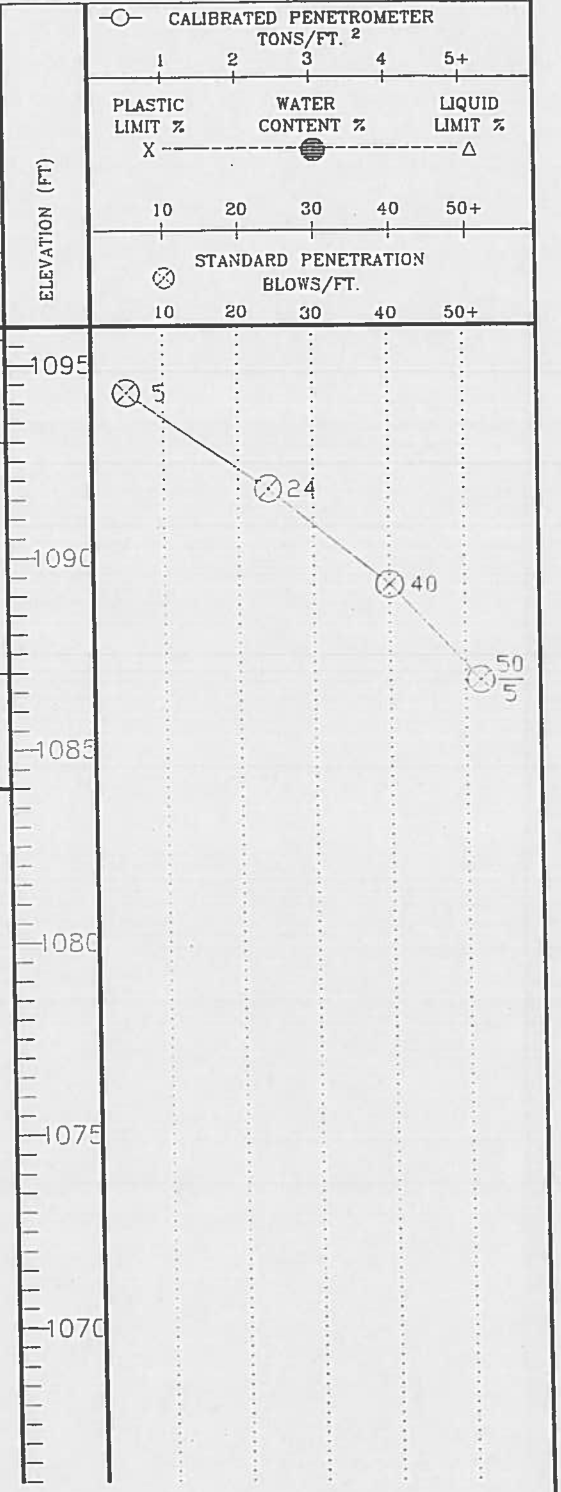
PROJECT NAME
ROANOKE REGIONAL STORMWATER SYSTEM DAM

ARCHITECT-ENGINEER
ENGINEERING CONCEPTS, INC.

SITE LOCATION
SOUTH CO. H.S., ROANOKE COUNTY, VIRGINIA

SURFACE ELEVATION 1096.00

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL
0					
	1	SS	18	18	Silty Fine SAND, Light Brown, Moist, Loose, (SM) [Alluvium]
	2	SS	18	18	Fine to Medium SAND, Some Gravel, Medium Brown, Saturated, Medium Dense, (SM) [Alluvium]
5					
	3	SS	18	18	
	4	SS	18	5	Weathered SHALE, Medium Gray to Tan, Wet, Hard, [Residuum]
10					
					AUGER PEFUSAL @ 12.0'
15					
20					
25					
30					



THE STRATIFICATION LINES REPRESENT THE APPPOXIMATE BOUNDARY LINES BETWEEN SOIL TYPES IN-SITU THE TRANSITION MAY BE GRADUAL

WL 3.0'	WS OR [✓ WD]	BORING STARTED 4-20-00	TOPSOIL DEPTH: 4"
WL BCR	ACR	BORING COMPLETED 4-20-00	CAVE IN DEPTH @ N/A
WL		RIG ATV FOREMAN HURDIS	DRILLING METHOD HOLLOW STEM AUGER

OWNER COUNTY OF ROANOKE	JOB # 1565	BORING # SB-3A	SHEET 1 OF 1	ECS LTD
PROJECT NAME ROANOKE REGIONAL STORMWATER SYSTEM DAM	ARCHITECT-ENGINEER ENGINEERING CONCEPTS, INC.			

SITE LOCATION
.SOUTH CO. H.S., ROANOKE COUNTY, VIRGINIA

-○- CALIBRATED PENETROMETER TONS/FT. ^{2}
1 2 3 4 5+

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT %
X ----------- ● ----------- △
10 20 30 40 50+

⊗ STANDARD PENETRATION BLOWS/FT.
10 20 30 40 50+

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	ELEVATION (FT)
					SURFACE ELEVATION 1096.00	
0					Silty Fine SAND, Light Brown, Moist, Loose, (SM) [Alluvium]	1095
5					Fine to Medium SAND, Some Gravel, Medium Brown, Saturated, Medium Dense, (SM) [Alluvium]	1090
10					Weathered SHALE, Bluish Gray, Wet, Hard, [Residuum]	1085
15					AUGER REFUSAL @ 13.0'	1080
20						1075
25						1070
30						

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES IN-SITU THE TRANSITION MAY BE GRADUAL

WL 3.0' WS OR [✓ WD]	BORING STARTED 4-20-00	TOPSOIL DEPTH: 4"
WL BCR ACR	BORING COMPLETED 4-20-00	CAVE IN DEPTH @ N/A
WL	RIG ATV FOREMAN HURDIS	DRILLING METHOD HOLLOW STEM AUGER

OWNER COUNTY OF ROANOKE	JOB # 1565	BORING # SB-4	SHEET 1 OF 1	ECS LTD
PROJECT NAME ROANOKE REGIONAL STORMWATER SYSTEM DAM	ARCHITECT-ENGINEER ENGINEERING CONCEPTS, INC.			
SITE LOCATION SOUTH CO. H.S., ROANOKE COUNTY, VIRGINIA				

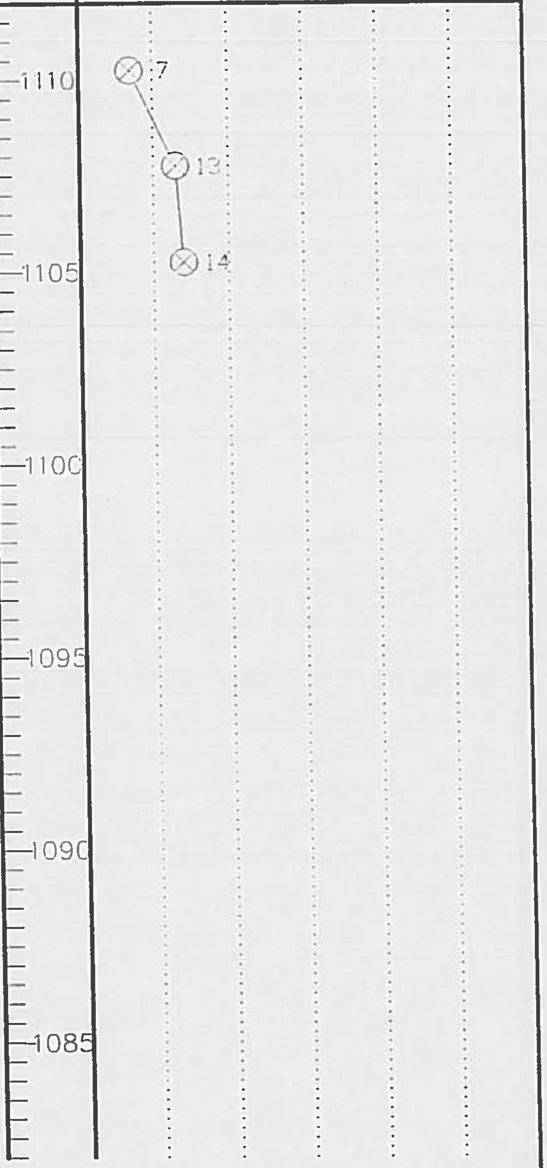
CALIBRATED PENETROMETER TONS/FT ^{2}: 1, 2, 3, 4, 5+

PLASTIC LIMIT % X — WATER CONTENT % ● — LIQUID LIMIT % Δ: 10, 20, 30, 40, 50+

STANDARD PENETRATION BLOWS/FT ⊗: 10, 20, 30, 40, 50+

SURFACE ELEVATION 1112.00

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL
0					Sandy CLAY, Light Brown, Moist, Stiff, (CL)
	1	SS	18	18	
	2	SS	18	18	
5					
	3	SS	18	18	[Possible boulder]
8.0					AUGER REFUSAL @ 8.0'



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES IN-SITU THE TRANSITION MAY BE GRADUAL

WL DRY WS OR [✓ WD]	BORING STARTED 4-20-00	TOPSOIL DEPTH: 6"
WL BCR ACR	BORING COMPLETED 4-20-00	CAVE IN DEPTH @ N/A
WL	RIG ATV FOREMAN HURDIS	DRILLING METHOD HOLLOW STEM AUGER

OWNER COUNTY OF ROANOKE	JOB # 1565	BORING # SB-4A	SHEET 1 OF 1
PROJECT NAME ROANOKE REGIONAL STORMWATER SYSTEM DAM	ARCHITECT-ENGINEER ENGINEERING CONCEPTS, INC.		
SITE LOCATION SOUTH CO. H.S., ROANOKE COUNTY, VIRGINIA			

ECS LTD

DESCRIPTION OF MATERIAL

SURFACE ELEVATION 1112.00

SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE (IN)	RECOVERY (IN)
1	SS	18	18
2	SS	18	18
3	SS	18	18
4	SS	18	18
5	SS	18	5
6	SS	18	18
7	SS	18	18
8	SS	18	18

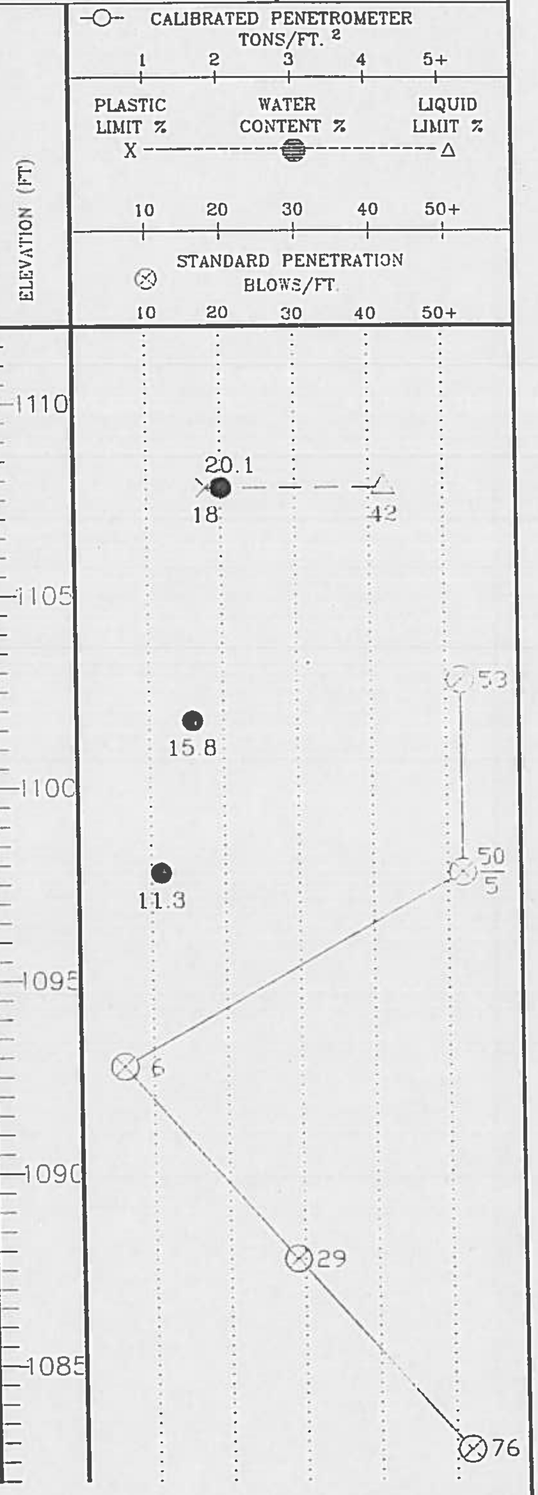
DEPTH (FT): 0, 5, 10, 15, 20, 25, 30

Sandy CLAY, Light Brown, Moist, Stiff, (CL) [Alluvium]

Weathered SHALE With Fine Sand, Yellowish Brown, Moist, Very Stiff to Hard, [Residuum]

Clayey SILT With Shale Fragments, Yellowish Brown, Wet, Medium Stiff, (ML) [Residuum]

Weathered SHALE, Tannish Brown to Light Gray, Moist, Very Stiff to Hard [Residuum]



END OF BORING @ 30.0'

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES IN-SITU THE TRANSITION MAY BE GRADUAL

WL 21.0' WS OR [✓ WD]	BORING STARTED 4-20-00	TOPSOIL DEPTH: 6"
WL BCR ACR	BORING COMPLETED 4-20-00	CAVE IN DEPTH @ N/A
WL	RIG ATV FOREMAN HURDIS	DRILLING METHOD HOLLOW STEM AUGER

OWNER
COUNTY OF ROANOKE

JOB # 1565

BORING # SB-5

SHEET 1 OF 1

ECS LTD

PROJECT NAME
ROANOKE REGIONAL STORMWATER SYSTEM DAM

ARCHITECT-ENGINEER
ENGINEERING CONCEPTS, INC.

SITE LOCATION
SOUTH CO. H.S., ROANOKE COUNTY, VIRGINIA

-○- CALIBRATED PENETROMETER TONS/FT.^{2}
1 2 3 4 5+

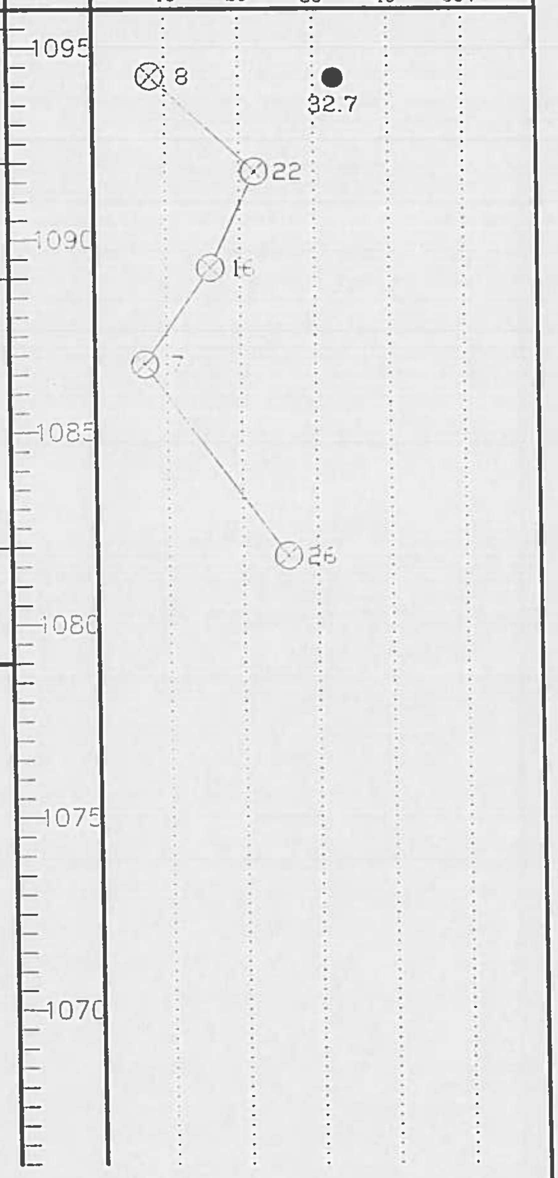
PLASTIC LIMIT % X ---- WATER CONTENT % ● ---- LIQUID LIMIT % △
10 20 30 40 50+

⊗ STANDARD PENETRATION BLOWS/FT.
10 20 30 40 50+

DESCRIPTION OF MATERIAL

SURFACE ELEVATION 1096.00

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL
0	1	SS	18	18	Silty Fine SAND, Light Brown, Moist, Loose, (SM) [Alluvium]
5	2	SS	18	18	Fine to Medium SAND, Some Gravel, Brown, Saturated, Medium Dense, (SM) [Alluvium]
	3	SS	18	18	Clayey SILT With Shale Fragments, Tannish Brown to Light Gray, Moist, Medium Stiff, (ML) [Residuum]
10	4	SS	18	18	
15	5	SS	18	18	Weathered SHALE, Medium Gray to Tan, Moist, Very Stiff to Hard
20					AUGER REFUSAL @ 17.0'
25					
30					



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES IN-SITU THE TRANSITION MAY BE GRADUAL

WL 6.0'	WS OR [✓ WD]	BORING STARTED 4-20-00	TOPSOIL DEPTH: 6"
WL BCR	ACR	BORING COMPLETED 4-20-00	CAVE IN DEPTH @ N/A
WL		RIG ATV FOREMAN HURDIS	DRILLING METHOD HOLLOW STEM AUGER

OWNER
COUNTY OF ROANOKE

JOB #
1565

BORING #
SB-6

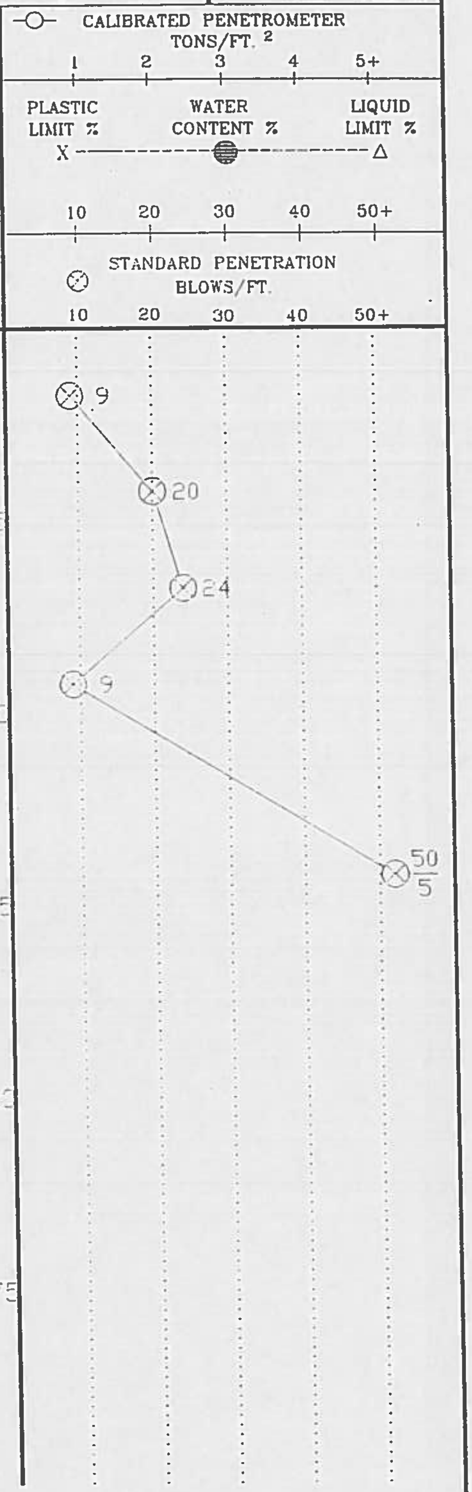
SHEET
1 OF 1

PROJECT NAME
ROANOKE REGIONAL STORMWATER SYSTEM DAM

ARCHITECT-ENGINEER
ENGINEERING CONCEPTS, INC.

SITE LOCATION
SOUTH CO. H.S., ROANOKE COUNTY, VIRGINIA

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	ELEVATION (FT)
					SURFACE ELEVATION 1100.00	
0						
	1	SS	18	18	Silty Fine SAND, Light Brown, Moist, Loose, (SM) [Alluvium]	
	2	SS	18	18	Fine to Medium SAND, Some Gravel, Medium Brown, Saturated, Medium (SM) [Alluvium]	
5						1095
	3	SS	18	18		
					Weathered SHALE, Reddish Brown, Moist, Very Stiff, [Residuum]	
	4	SS	18	18		
10					Clayey SILT With Shale Fragments, Yellowish Brown, Wet, Medium Stiff, [Residuum]	1090
					Weathered SHALE, Medium Gray to Tan, Moist, Hard, [Residuum]	
	5	SS	18	5		
15					AUGER REFUSAL @ 15.0'	1085
20						1080
25						1075
30						



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES IN-SITU THE TRANSITION MAY BE GRADUAL

WL 5.0' WS OR WD

BORING STARTED 4-20-00

TOPSOIL DEPTH: 6"

WL BCR ACR

BORING COMPLETED 4-20-00

CAVE IN DEPTH ● N/A

WL

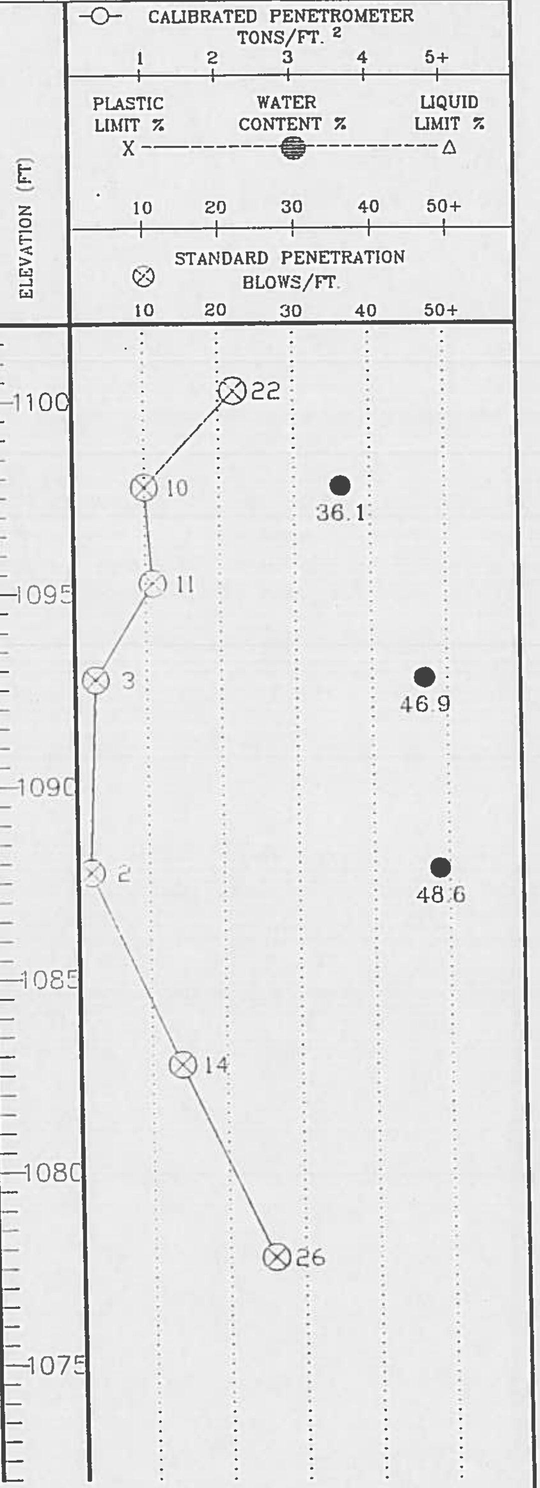
RIG ATV FOREMAN HURDIS

DRILLING METHOD HOLLOW STEM AUGER

OWNER COUNTY OF ROANOKE	JOB # 1565	BORING # SB-7	SHEET 1 OF 1
PROJECT NAME ROANOKE REGIONAL STORMWATER SYSTEM DAM	ARCHITECT-ENGINEER ENGINEERING CONCEPTS, INC.		

SITE LOCATION
SOUTH CO. H.S., ROANOKE COUNTY, VIRGINIA

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL
					SURFACE ELEVATION 1102.00
0					
	1	SS	18	18	Clayey SILT With Fine Sand, Tannish Brown, Moist, Stiff to Very Stiff, (ML) [Residuum]
	2	SS	18	18	
5					
	3	SS	18	18	
	4	SS	18	18	Fine Sandy SILT With Shale Fragments, Brown, Saturated, Loose, (ML) [Residuum]
10					
	5	SS	18	18	
15					
	6	SS	18	18	Weathered SHALE, Tannish Brown, Saturated, Stiff to Very Stiff
20					
	7	SS	18	18	
25					END OF BORING @ 25.0'
30					



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES IN-SITU THE TRANSITION MAY BE GRADUAL

WL 9.0' WS OR [✓ WD]	BORING STARTED 4-20-00	TOPSOIL DEPTH: 6"
WL BCR ACR	BORING COMPLETED 4-20-00	CAVE IN DEPTH @ N/A
WL	RIG ATV FOREMAN HURDIS	DRILLING METHOD HOLLOW STEM AUGER

OWNER
COUNTY OF ROANOKE

JOB # 1565

BORING # SB-8

SHEET 1 OF 1

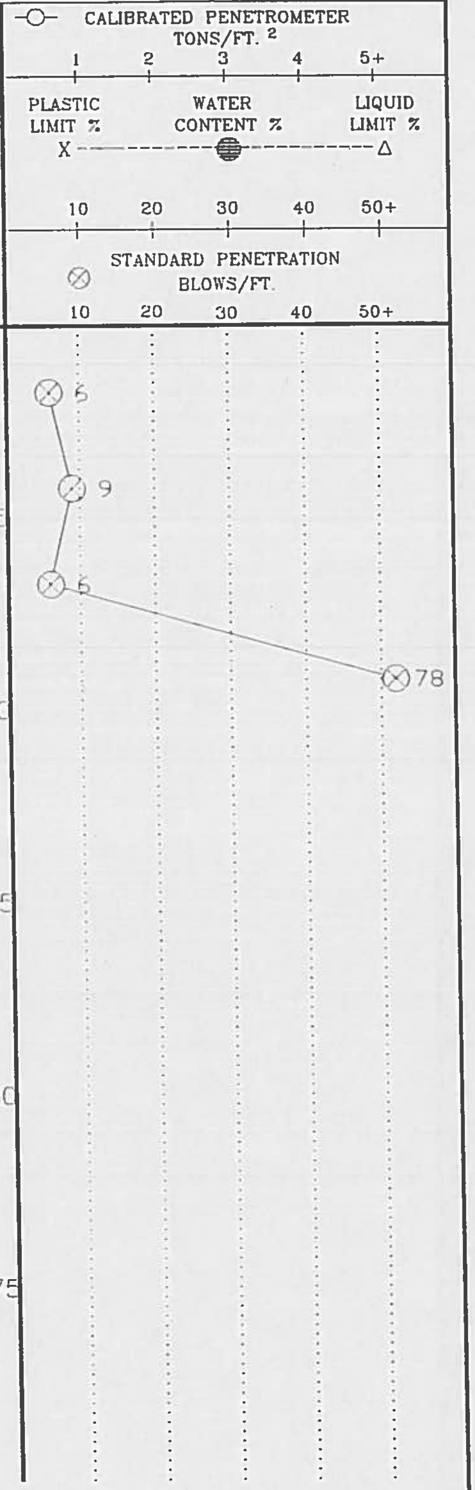
PROJECT NAME
ROANOKE REGIONAL STORMWATER SYSTEM DAM

ARCHITECT-ENGINEER
ENGINEERING CONCEPTS, INC.

SITE LOCATION
SOUTH CO. H.S., ROANOKE COUNTY, VIRGINIA

SURFACE ELEVATION 1100.00

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	ELEVATION (FT)
0						
	1	SS	18	18	Silty Fine SAND, Medium Brown, Moist, Loose, (SM) [Alluvium]	
	2	SS	18	18		
5					Fine to Medium SAND, Some Gravel, Dark Gray, Saturated, Loose, (SM) [Alluvium]	1095
	3	SS	18	18		
	4	SS	18	18	Weathered SHALE, Medium Gray to Tan, Moist, Hard, [Residuum]	
10						1090
					AUGER REFUSAL @ 10.5'	
15						1085
20						1080
25						1075
30						



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES IN-SITU THE TRANSITION MAY BE GRADUAL

WL 6.0' WS OR [✓ WD]

WL BCR ACR

WL

BORING STARTED 4-20-00

BORING COMPLETED 4-20-00

RIG ATV FOREMAN HURDIS

TOPSOIL DEPTH: 6"

CAVE IN DEPTH @ N/A

DRILLING METHOD HOLLOW STEM AUGER

OWNER COUNTY OF ROANOKE	JOB # 1565	BORING # SB-8A	SHEET 1 OF 1	ECS LTD
PROJECT NAME ROANOKE REGIONAL STORMWATER SYSTEM DAM	ARCHITECT–ENGINEER ENGINEERING CONCEPTS, INC.			

SITE LOCATION
SOUTH CO. H.S., ROANOKE COUNTY, VIRGINIA

—○— CALIBRATED PENETROMETER TONS/FT. ^{2}
1 2 3 4 5+

PLASTIC LIMIT % X ——— WATER CONTENT % ● ——— LIQUID LIMIT % △
10 20 30 40 50+

⊗ STANDARD PENETRATION BLOWS/FT.
10 20 30 40 50+

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	ELEVATION (FT)
					SURFACE ELEVATION 1100.00	
0					Silty Fine SAND, Medium Brown, Moist, Loose, (SM) [Alluvium]	
5					Silty Fine to Medium SAND, Trace Fine Gravel, Dark Gray, Saturated, Loose, (SM) [Alluvium]	1095
10					Weathered SHALE, Medium Gray, Moist, Hard, [Residuum]	1090
					AUGER REFUSAL @ 9.0'	
15						1085
20						1080
25						1075
30						

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES IN-SITU THE TRANSITION MAY BE GRADUAL

WL 6.0' WS OR [✓ WD]	BORING STARTED 4-20-00	TOPSOIL DEPTH: 6"
WL BCR ACR	BORING COMPLETED 4-20-00	CAVE IN DEPTH ● N/A
WL	RIG ATV FOREMAN HURDIS	DRILLING METHOD HOLLOW STEM AUGER

CLIENT	JOB #	BORING #	SHEET
ROANOKE COUNTY SCHOOLS	1045A	B-15	1 OF 2

PROJECT NAME: SOUTH COUNTY HIGH SCHOOL

ARCHITECT-ENGINEER: SFCS

SITE LOCATION: WOODS END SITE-ROANOKE COUNTY, VIRGINIA

DESCRIPTION OF MATERIAL

ENGLISH UNITS

SURFACE ELEVATION 1125.00

DEPTH (FT): 0, 5, 10, 15, 20, 25, 30

ELEVATION (FT): 1120, 1115, 1110, 1105, 1100

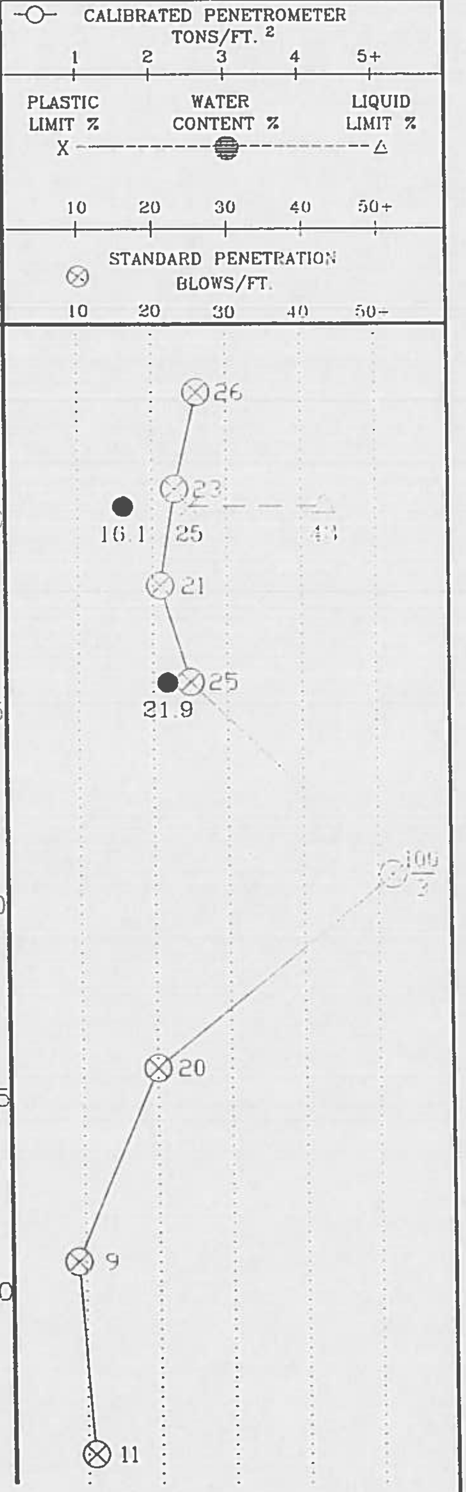
SAMPLE NO	SAMPLE TYPE	SAMPLE DISTANCE (IN)	RECOVERY (IN)
1	SS	18	18
2	SS	18	18
3	SS	18	18
4	SS	18	18
5	SS	18	3
6	SS	18	18
7	SS	18	18
8	SS	18	18

Silty CLAY With Shale Fragments, Yellowish Tan, Slightly Moist, Very Stiff, (CL)

Silty Weathered SHALE, Light Brown, Slightly Moist, Hard

Clayey SILT With Shale Fragments, Yellowish Tan, Moist, Very Stiff, (ML)

Fine Sandy SILT, Medium Brown to Light Gray, Moist to Wet, Loose, (ML)



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES IN-SITU THE TRANSITION MAY BE GRADUAL

WL 29.0' WS OR [✓ WD]	BORING STARTED 10-25-98	TOPSOIL DEPTH: 3"
WL BCR ACR	BORING COMPLETED 10-25-98	CAVE IN DEPTH @ N/A
WL	RIG ATV FOREMAN HURDIS	DRILLING METHOD HOLLOW STEM AUGER

CLIENT ROANOKE COUNTY SCHOOLS	JOB # 1045A	BORING # B-15	SHEET 2 OF 2
PROJECT NAME SOUTH COUNTY HIGH SCHOOL	ARCHITECT-ENGINEER SFCS		

ECS LTD

SITE LOCATION
WOODS END SITE-ROANOKE COUNTY, VIRGINIA

-○- CALIBRATED PENETROMETER TONS/FT.^{2}
1 2 3 4 5+

PLASTIC LIMIT % X ------ WATER CONTENT % ● ------ LIQUID LIMIT % △
10 20 30 40 50+

⊘ STANDARD PENETRATION BLOWS/FT.
10 20 30 40 50+

DEPTH (FT) | SAMPLE NO | SAMPLE TYPE | SAMPLE DISTANCE (IN) | RECOVERY (IN) | DESCRIPTION OF MATERIAL | ELEVATION (FT)

ENGLISH UNITS

SURFACE ELEVATION 1125.00

DEPTH (FT)	DESCRIPTION OF MATERIAL	ELEVATION (FT)
30	Weathered SHALE, Brown, Hard, [Auger Grinding at 32 ft]	
	AUGER REFUSAL @ 32.0'	
35		1090
40		1085
45		1080
50		1075
55		1070
60		

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES IN-SITU THE TRANSITION MAY BE GRADUAL

WL 29.0' WS OR [✓ WD]	BORING STARTED	10-25-98	TOPSOIL DEPTH: 3"
WL BCR ACR	BORING COMPLETED	10-25-98	CAVE IN DEPTH @ N/A
WL	RIG ATV	FOREMAN HURDIS	DRILLING METHOD HOLLOW STEM AUGER

CLIENT	JOB #	BORING #	SHEET
ROANOKE COUNTY SCHOOLS	1045A	B-16	1 OF 1

ECS LTD

PROJECT NAME: SOUTH COUNTY HIGH SCHOOL

ARCHITECT-ENGINEER: SFCS

SITE LOCATION: WOODS END SITE-ROANOKE COUNTY, VIRGINIA

-○- CALIBRATED PENETROMETER TONS/FT. ^{2}

1 2 3 4 5+

PLASTIC LIMIT % X ---- WATER CONTENT % ● ---- LIQUID LIMIT % △

10 20 30 40 50+

⊗ STANDARD PENETRATION BLOWS/FT

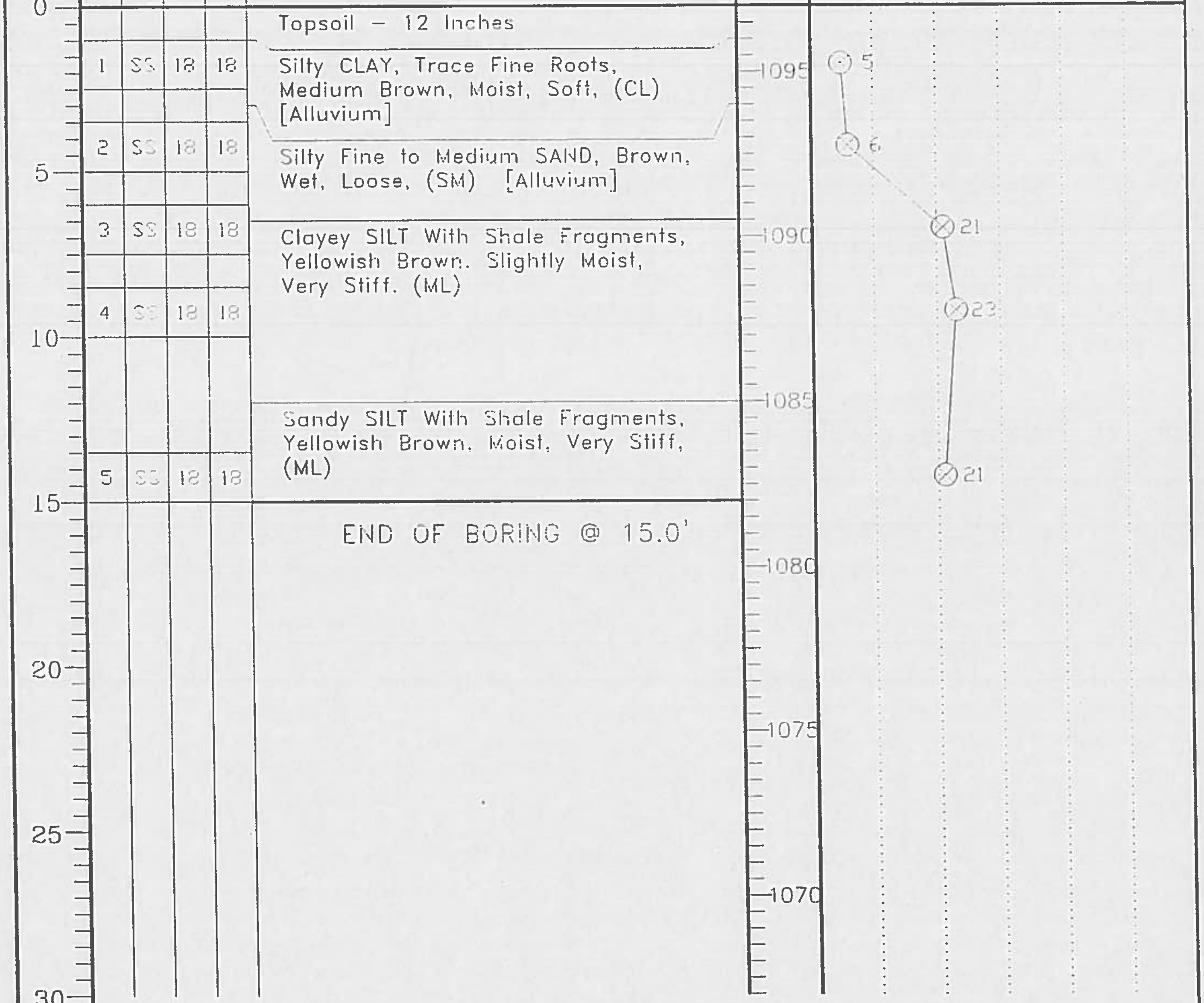
10 20 30 40 50+

DESCRIPTION OF MATERIAL — ENGLISH UNITS

SURFACE ELEVATION 1097.00

SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL
				Topsoil – 12 Inches
1	SS	18	18	Silty CLAY, Trace Fine Roots, Medium Brown, Moist, Soft, (CL) [Alluvium]
2	SS	18	18	Silty Fine to Medium SAND, Brown, Wet, Loose, (SM) [Alluvium]
3	SS	18	18	Clayey SILT With Shale Fragments, Yellowish Brown. Slightly Moist, Very Stiff. (ML)
4	SS	18	18	
				Sandy SILT With Shale Fragments, Yellowish Brown. Moist, Very Stiff, (ML)
5	SS	18	18	

END OF BORING @ 15.0'



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES IN-SITU THE TRANSITION MAY BE GRADUAL

WL 4.0' WS OR [✓ WD]	BORING STARTED 10-29-98	TOPSOIL DEPTH: 12"
WL BCR ACR	BORING COMPLETED 10-29-98	CAVE IN DEPTH ● N/A
WL	RIG ATV FOREMAN HURDIS	DRILLING METHOD HOLLOW STEM AUGER

CLIENT ROANOKE COUNTY SCHOOLS	JOB # 1045A	BORING # B-17	SHEET 1 OF 1
PROJECT NAME SOUTH COUNTY HIGH SCHOOL	ARCHITECT-ENGINEER SFCS		

ECS LTD

SITE LOCATION
WOODS END SITE-ROANOKE COUNTY, VIRGINIA

DESCRIPTION OF MATERIAL

ENGLISH UNITS

SURFACE ELEVATION 1115.00

SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE (IN)	RECOVERY (IN)
1	SS	18	18
2	SS	18	18
3	SS	18	18
4	SS	18	18
5	SS	18	18
6	SS	18	18
7	SS	18	11

DEPTH (FT): 0, 5, 10, 15, 20, 25, 30

ELEVATION (FT): 1110, 1105, 1100, 1095, 1090

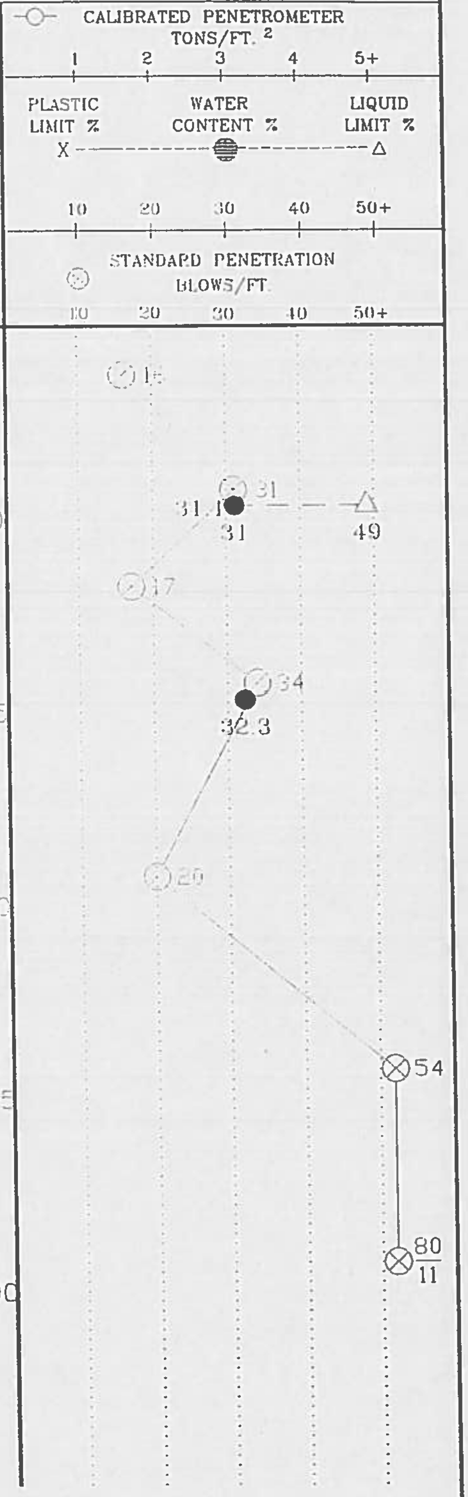
Clayey SILT With Shale Fragments, Yellowish Brown, Moist, Very Stiff, (ML)

Silty Weathered SHALE, Medium Brown, Slightly Moist, Stiff

Clayey SILT, Medium Brown, Moist, Very Stiff, (ML)

Sandy Weathered SHALE, Grayish Brown, Slightly, Moist, Hard

END OF BORING @ 25.0'



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES IN-SITU THE TRANSITION MAY BE GRADUAL

WL DRY	WS OR WD	BORING STARTED 10-25-98	TOPSOIL DEPTH: 8"
WL	BCR ACR	BORING COMPLETED 10-25-98	CAVE IN DEPTH ® N/A
WL		RIG ATV FOREMAN HURDIS	DRILLING METHOD HOLLOW STEM AUGER

REFERENCE NOTES FOR BORING LOGS

I. Drilling and Sampling Symbols:

SS - Split Spoon Sampler
ST - Shelby Tube Sampler
RC - Rock Core; NX, BX, AX
PM - Pressuremeter
DC - Dutch Cone Penetrometer
RB - Rock Bit Drilling
BS - Bulk Sample of Cuttings
PA - Power Auger (no sample)
HAS - Hollow Stem Auger
WS - Wash Sample

Standard Penetration Test (SPT) resistance refers to the blows per foot (bpf) of a 140 lb hammer falling 30 inches on a 2 in. O.D. split-spoon sampler as specified in ASTM D-1586. The blow count is commonly referred to as the N-value.

II. Correlation of Penetration Resistances to Soil Properties:

Relative Density-Sands, Silts

SPT-N (bpf)	Relative Density
0 – 5	Very Loose
6 – 10	Loose
11 – 30	Medium Dense
31 – 50	Dense
51+	Very Dense

Consistency of Cohesive Soils

SPT-N (bpf)	Consistency	Unconfined Compressive Strength, Qp, tsf
0 – 3	Very Soft	Under 0.25
4 – 5	Soft	0.25 - 0.49
6 – 10	Medium Stiff	0.50 - 0.99
11 – 15	Stiff	1.00 - 1.99
16 – 30	Very Stiff	2.00 - 3.99
31 – 50	Hard	4.00 - 8.00
51+	Very Hard	Over 8.00

Partially Weathered Rock (PWR) may be defined as SPT-N values exceeding 60 to 100 bpf depending on site specific conditions. Refer carefully to boring logs.

Rock Fragments, gravel, cobbles, boulders, or debris may produce N-values that are not representative of actual soil properties.

III. Unified Soil Classification Symbols:

GP – Poorly Graded Gravel
GW – Well Graded Gravel
GM – Silty Gravel
GC – Clayey Gravels
SP – Poorly Graded Sands
SW – Well Graded Sands
SM – Silty Sands
SC – Clayey Sands
ML – Low Plasticity Silts
MH – High Plasticity Silts
CL – Low Plasticity Clays
CH – High Plasticity Clays
OL – Low Plasticity Organics
OH – High Plasticity Organics
CL-ML – Dual Classification (Typical)

IV. Water Level Measurement Symbols:

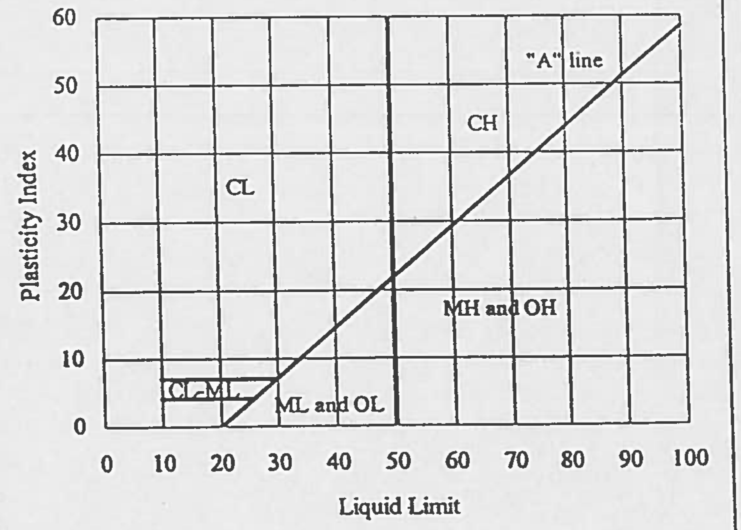
WL - Water Level
WS - While Sampling
WD - While Drilling
BCR – Before Casing Removal
ACR – After Casing Removal
WCI – Wet Cave In
DCI – Dry Cave In

The water levels are those water levels actually measured in the bore hole at the times indicated by the symbol. The measurements are relatively reliable when augering, without adding fluids, in a granular soil. In clays and plastic silts, the accurate determination of water levels may require several days for the water level to stabilize. In such cases, additional methods of measurement are generally required.

Unified Soil Classification System (ASTM D-2487)

Major Divisions			Group Symbols		Typical Names	Laboratory Classification Criteria		
Coarse-grained soils (More than half of material is larger than No. 200 Sieve size)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW		Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentage of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows: Less than 5 percent GW, GP, SW, SP More than 12 percent GM, GC, SM, SC 5 to 12 percent Border 4 line cases requiring dual symbols [b]	$C_u = D_{60}/D_{10}$ greater than 4 $C_c = (D_{30})^2/(D_{10}xD_{60})$ between 1 and 3	
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravels with fines (Appreciable amount of fines)	GM[a]	d u	Silty gravels, gravel-sand mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
			GC		Clayey gravels, gravel-sand-clay mixtures		Atterberg limits below "A" line or P.I. less than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW		Well-graded sands, gravelly sands, little or no fines		$C_u = D_{60}/D_{10}$ greater than 6 $C_c = (D_{30})^2/(D_{10}xD_{60})$ between 1 and 3	
			SP		Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount o fines)	SM[a]	d u	Silty sands, sand-silt mixtures		Atterberg limits above "A" line or P.I. less than 4	Limits plotting in CL-ML zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
			SC		Clayey sands, sand-clay mixtures		Atterberg limits above "A" line with P.I. greater than 7	
Fine-grained soils (More than half material is smaller than No. 200 Sieve)	Silts and clays (Liquid limit less than 50)		ML		Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity			
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays			
			OL		Organic silts and organic silty clays of low plasticity			
	Silts and clays (Liquid limit greater than 50)		MH		Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts			
			CH		Inorganic clays of high plasticity, fat clays			
			OH		Organic clays of medium to high plasticity, organic silts			
	Highly Organic soils		Pt		Peat and other highly organic soils			

Plasticity Chart



---

[a] Division of GM and SM groups into subdivisions of d and u are for roads and airfields only. Subdivision is based on Atterberg limits; suffix d used when L.L. is 28 or less and the P.I. is 6 or less; the suffix u used when L.L. is greater than 28.

[b] Borderline classifications, used for soils possessing characteristics of two groups, are designated by combinations of group symbols. For example: GW-GC, well-graded gravel-sand mixture with clay binder.

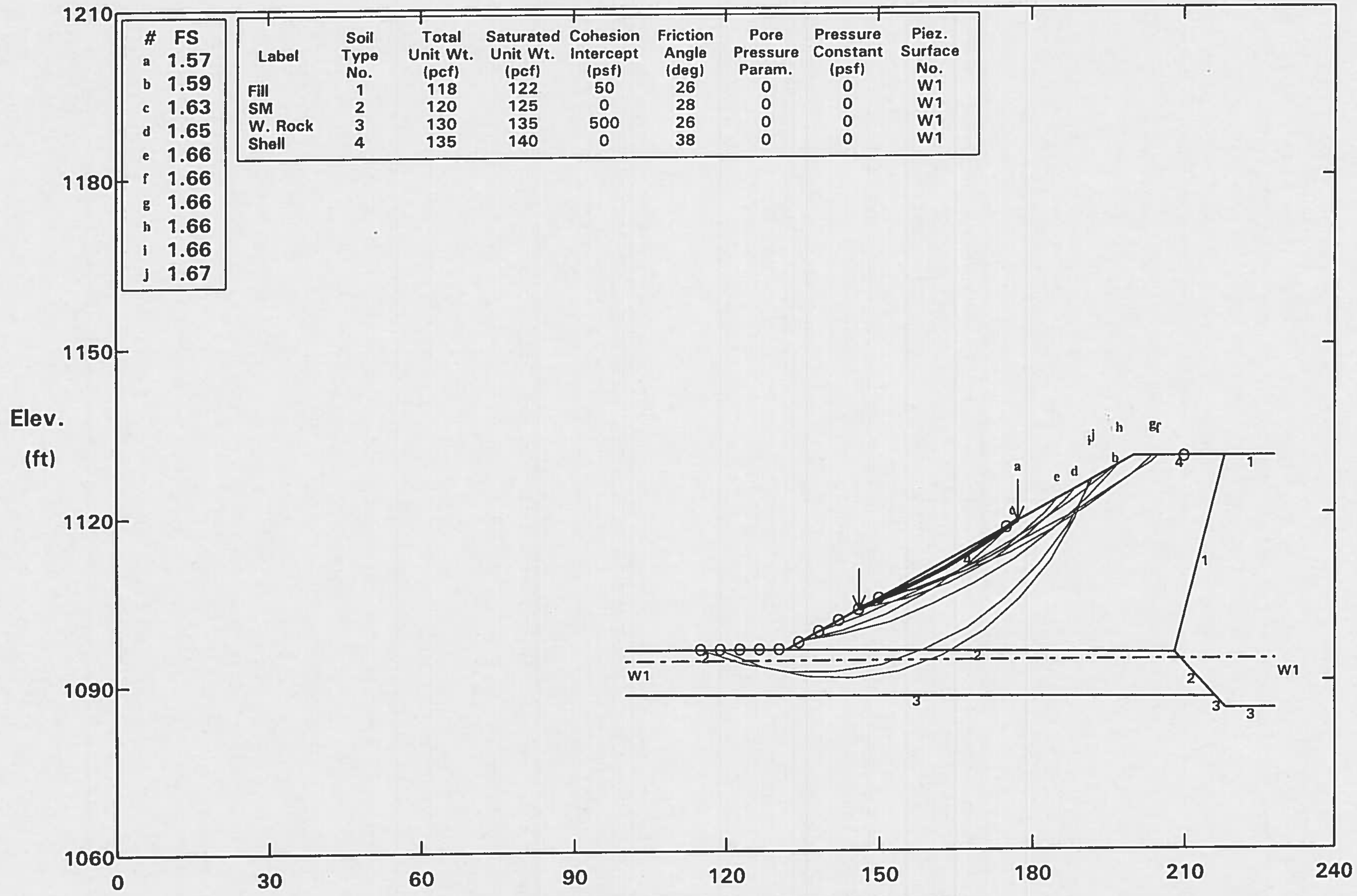
From Winterkorn and Fang. 1975.

APPENDIX II

Slope Stability Analyses

South County High School (ECS #1565) Upstream Slope (Rapid Drawdown)

Ten Most Critical. C:1565-US.PLT By: mrc 05-22-00 3:34pm



#	FS
a	1.57
b	1.59
c	1.63
d	1.65
e	1.66
f	1.66
g	1.66
h	1.66
i	1.66
j	1.67

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Fill	1	118	122	50	26	0	0	W1
SM	2	120	125	0	28	0	0	W1
W. Rock	3	130	135	500	26	0	0	W1
Shell	4	135	140	0	38	0	0	W1

PCSTABL5M/SI FSmin=1.57 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

```
                            ** PCSTABL5M **

                                   by
                            Purdue University
--------------------------------------------------------------------------------

                     --Slope Stability Analysis--
                  Simplified Janbu, Simplified Bishop
                     or Spencer's Method of Slices


          Run Date:                    05-22-00
          Time of Run:                 3:34pm
          Run By:                      mrc
          Input Data Filename:         C:1565-US.IN
          Output Filename:             C:1565-US.OUT
          Unit:                        ENGLISH
          Plotted Output Filename:     C:1565-US.PLT



          PROBLEM DESCRIPTION   South County High School (ECS #1565)
                                Upstream Slope (Rapid Drawdown)



          BOUNDARY COORDINATES
               NOTE:  User defined origin was specified.
               Add 00.00 to X values and 1060.00 to Y values listed.

             4 Top   Boundaries
            10 Total Boundaries

          Boundary     X-Left     Y-Left     X-Right    Y-Right    Soil Type
             No.        (ft)       (ft)        (ft)       (ft)     Below Bnd

              1        100.00      36.00      132.00      36.00         2
              2        132.00      36.00      200.00      70.00         4
              3        200.00      70.00      218.00      70.00         4
              4        218.00      70.00      228.00      70.00         1
              5        132.00      36.00      208.00      35.00         2
              6        208.00      35.00      218.00      70.00         1
              7        208.00      35.00      216.00      27.00         2
              8        216.00      27.00      218.00      25.00         3
              9        218.00      25.00      228.00      25.00         3
             10        100.00      28.00      216.00      27.00         3
--------------------------------------------------------------------------------

          ISOTROPIC SOIL PARAMETERS


            4 Type(s) of Soil
```

```
 Soil  Total  Saturated  Cohesion Friction   Pore    Pressure   Piez.
 Type Unit Wt. Unit Wt. Intercept   Angle  Pressure Constant  Surface
  No.  (pcf)    (pcf)     (psf)     (deg)   Param.    (psf)     No.

   1   118.0    122.0      50.0      26.0     .00        .0       1
   2   120.0    125.0        .0      28.0     .00        .0       1
   3   130.0    135.0     500.0      26.0     .00        .0       1
   4   135.0    140.0        .0      38.0     .00        .0       1
--------------------------------------------------------------------------------


 1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED


 Unit Weight of Water =  62.40


 Piezometric Surface No.  1 Specified by  2 Coordinate Points

   Point       X-Water     Y-Water
    No.          (ft)        (ft)

     1         100.00       34.00
     2         228.00       34.00
--------------------------------------------------------------------------------


 A Critical Failure Surface Searching Method, Using A Random
 Technique For Generating Circular Surfaces, Has Been Specified.


 200 Trial Surfaces Have Been Generated.


  20 Surfaces Initiate From Each Of 10 Points Equally Spaced
 Along The Ground Surface Between  X = 115.00 ft.
                              and  X = 150.00 ft.


 Each Surface Terminates Between   X = 175.00 ft.
                             and   X = 210.00 ft.


 Unless Further Limitations Were Imposed, The Minimum Elevation
 At Which A Surface Extends Is  Y =    .00 ft.


  9.00 ft. Line Segments Define Each Trial Failure Surface.


--------------------------------------------------------------------------------

 Following Are Displayed The Ten Most Critical Of The Trial
 Failure Surfaces Examined.  They Are Ordered - Most Critical
 First.
```

```
      * * Safety Factors Are Calculated By The Modified Bishop Method * *


      Failure Surface Specified By  5 Coordinate Points

        Point       X-Surf      Y-Surf
         No.         (ft)        (ft)

          1         146.11       43.06
          2         154.49       46.35
          3         162.65       50.15
          4         170.56       54.44
          5         177.31       58.66

      Circle Center At X =   96.6 ; Y =  181.3  and Radius,  146.8

              ***     1.574   ***


             Individual data on the      4  slices

                           Water   Water     Tie      Tie      Earthquake
                           Force   Force    Force    Force       Force    Surcharge
 Slice  Width    Weight     Top     Bot     Norm      Tan     Hor     Ver     Load
  No.    (ft)    (lbs)     (lbs)   (lbs)    (lbs)    (lbs)   (lbs)   (lbs)   (lbs)
   1      8.4    507.0       .0      .0       .0       .0      .0      .0      .0
   2      8.2   1142.4       .0      .0       .0       .0      .0      .0      .0
   3      7.9   1078.3       .0      .0       .0       .0      .0      .0      .0
   4      6.8    383.8       .0      .0       .0       .0      .0      .0      .0
      Failure Surface Specified By  9 Coordinate Points

        Point       X-Surf      Y-Surf
         No.         (ft)        (ft)

          1         138.33       39.17
          2         146.88       41.98
          3         155.29       45.19
          4         163.54       48.79
          5         171.62       52.76
          6         179.50       57.10
          7         187.17       61.81
          8         194.62       66.86
          9         196.42       68.21

      Circle Center At X =   81.8 ; Y =  225.1  and Radius,  194.3

              ***     1.585   ***
```

```
------------------------------------------------------------------------------------------

      Failure Surface Specified By  7 Coordinate Points

        Point      X-Surf      Y-Surf
         No.        (ft)        (ft)

          1        134.44       37.22
          2        143.21       39.28
          3        151.69       42.27
          4        159.81       46.17
          5        167.45       50.93
          6        174.52       56.49
          7        176.15       58.07

      Circle Center At X =  120.0 ; Y =  118.7  and Radius,   82.7

            ***     1.629   ***


      Failure Surface Specified By  7 Coordinate Points

        Point      X-Surf      Y-Surf
         No.        (ft)        (ft)

          1        146.11       43.06
          2        154.94       44.79
          3        163.50       47.59
          4        171.64       51.42
          5        179.26       56.21
          6        186.23       61.90
          7        188.47       64.24

      Circle Center At X =  136.4 ; Y =  115.9  and Radius,   73.5

            ***     1.652   ***

------------------------------------------------------------------------------------------

      Failure Surface Specified By  6 Coordinate Points

        Point      X-Surf      Y-Surf
         No.        (ft)        (ft)

          1        150.00       45.00
          2        158.81       46.82
          3        167.26       49.93
```

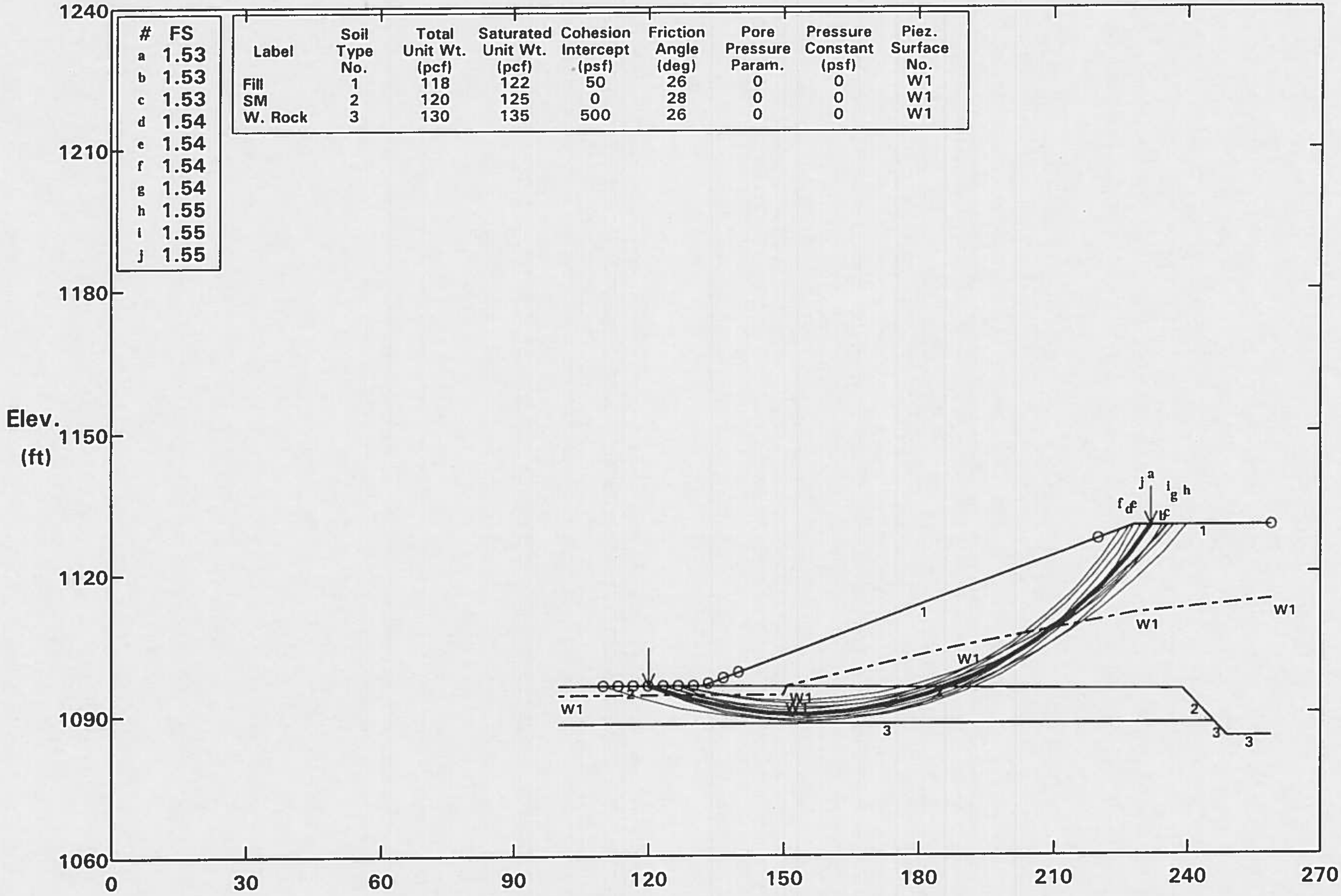
```
          4        175.15       54.26
          5        182.31       59.71
          6        185.05       62.52

   Circle Center At X =  142.6 ; Y =  103.7  and Radius,   59.1

        ***     1.655   ***


   Failure Surface Specified By  9 Coordinate Points

      Point        X-Surf       Y-Surf
       No.          (ft)         (ft)

        1         146.11        43.06
        2         154.68        45.79
        3         163.15        48.86
        4         171.49        52.25
        5         179.69        55.95
        6         187.74        59.97
        7         195.64        64.29
        8         203.36        68.91
        9         205.03        70.00

   Circle Center At X =   79.0 ; Y =  268.0  and Radius,  234.7

        ***     1.658   ***

--------------------------------------------------------------------------------

   Failure Surface Specified By  8 Coordinate Points

      Point        X-Surf       Y-Surf
       No.          (ft)         (ft)

        1         150.00        45.00
        2         158.75        47.10
        3         167.33        49.81
        4         175.71        53.12
        5         183.83        57.00
        6         191.66        61.43
        7         199.16        66.40
        8         203.84        70.00

   Circle Center At X =  124.6 ; Y =  170.1  and Radius,  127.7

        ***     1.660   ***
```

```
   Failure Surface Specified By  9 Coordinate Points

     Point        X-Surf         Y-Surf
      No.          (ft)           (ft)

       1          134.44          37.22
       2          143.33          38.65
       3          152.06          40.85
       4          160.56          43.80
       5          168.77          47.49
       6          176.62          51.88
       7          184.07          56.95
       8          191.03          62.64
       9          197.09          68.54

   Circle Center At X =  122.6 ; Y =  139.2  and Radius,  102.7

         ***     1.660   ***

--------------------------------------------------------------------------------

   Failure Surface Specified By 11 Coordinate Points


     Point        X-Surf         Y-Surf
      No.          (ft)           (ft)

       1          118.89          36.00
       2          127.28          32.73
       3          136.10          30.95
       4          145.09          30.71
       5          154.00          32.02
       6          162.55          34.83
       7          170.49          39.07
       8          177.58          44.61
       9          183.62          51.28
      10          188.43          58.89
      11          191.19          65.60

   Circle Center At X =  142.0 ; Y =   82.9  and Radius,   52.3

         ***     1.660   ***


   Failure Surface Specified By 12 Coordinate Points


     Point        X-Surf         Y-Surf
      No.          (ft)           (ft)
```

```
        1          115.00         36.00
        2          123.59         33.33
        3          132.49         31.95
        4          141.49         31.90
        5          150.40         33.19
        6          159.02         35.78
        7          167.16         39.61
        8          174.65         44.61
        9          181.31         50.65
       10          187.01         57.62
       11          191.62         65.35
       12          191.85         65.93

 Circle Center At X =  137.3 ; Y =   92.4  and Radius,   60.6

           ***     1.667   ***
```

South County High School (ECS #1565) Downstream Slope (Steady Seepage)

Ten Most Critical. C:1565-DS.PLT By: mrc 05-22-00 3:36pm



#	FS
a	1.53
b	1.53
c	1.53
d	1.54
e	1.54
f	1.54
g	1.54
h	1.55
i	1.55
j	1.55

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Fill	1	118	122	50	26	0	0	W1
SM	2	120	125	0	28	0	0	W1
W. Rock	3	130	135	500	26	0	0	W1

PCSTABL5M/SI FSmin = 1.53 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

```
                        ** PCSTABL5M **

                              by
                        Purdue University
--------------------------------------------------------------------------
   .

                  --Slope Stability Analysis--
               Simplified Janbu, Simplified Bishop
                  or Spencer`s Method of Slices


        Run Date:                  05-22-00
        Time of Run:               3:36pm
        Run By:                    mrc
        Input Data Filename:       C:1565-DS.IN
        Output Filename:           C:1565-DS.OUT
        Unit:                      ENGLISH
        Plotted Output Filename:   C:1565-DS.PLT



        PROBLEM DESCRIPTION   South County High School (ECS #1565)
                              Downstream Slope (Steady Seepage)



        BOUNDARY COORDINATES
             NOTE:  User defined origin was specified.
             Add 00.00 to X values and 1060.00 to Y values listed.

            3 Top   Boundaries
            8 Total Boundaries

        Boundary     X-Left     Y-Left     X-Right     Y-Right    Soil Type
           No.        (ft)       (ft)        (ft)        (ft)     Below Bnd

            1        100.00      36.00      132.00       36.00        2
            2        132.00      36.00      228.00       70.00        1
            3        228.00      70.00      259.00       70.00        1
            4        132.00      36.00      239.00       35.00        2
            5        239.00      35.00      246.00       28.00        2
            6        246.00      28.00      249.00       25.00        3
            7        249.00      25.00      259.00       25.00        3
            8        100.00      28.00      246.00       28.00        3
--------------------------------------------------------------------------

        ISOTROPIC SOIL PARAMETERS


          3 Type(s) of Soil


          Soil  Total  Saturated  Cohesion Friction   Pore   Pressure   Piez.
          Type Unit Wt. Unit Wt. Intercept   Angle  Pressure Constant Surface
```

```
          No.  (pcf)    (pcf)     (psf)     (deg)   Param.    (psf)    No.

           1   118.0    122.0      50.0      26.0     .00        .0      1
           2   120.0    125.0        .0      28.0     .00        .0      1
           3   130.0    135.0     500.0      26.0     .00        .0      1
--------------------------------------------------------------------------------


      1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED


      Unit Weight of Water =  62.40


      Piezometric Surface No.  1 Specified by  6 Coordinate Points

        Point      X-Water     Y-Water
         No.        (ft)        (ft)

          1        100.00       34.00
          2        150.00       34.00
          3        151.00       36.00
          4        188.00       44.00
          5        228.00       51.00
          6        259.00       54.00
--------------------------------------------------------------------------------


      A Critical Failure Surface Searching Method, Using A Random
      Technique For Generating Circular Surfaces, Has Been Specified.


      200 Trial Surfaces Have Been Generated.


       20 Surfaces Initiate From Each Of 10 Points Equally Spaced
      Along The Ground Surface Between  X = 110.00 ft.
                                  and  X = 140.00 ft.


      Each Surface Terminates Between   X = 220.00 ft.
                                 and   X = 259.00 ft.


      Unless Further Limitations Were Imposed, The Minimum Elevation
      At Which A Surface Extends Is  Y =   .00 ft.


       9.00 ft. Line Segments Define Each Trial Failure Surface.


--------------------------------------------------------------------------------

      Following Are Displayed The Ten Most Critical Of The Trial
      Failure Surfaces Examined.  They Are Ordered - Most Critical
      First.
```

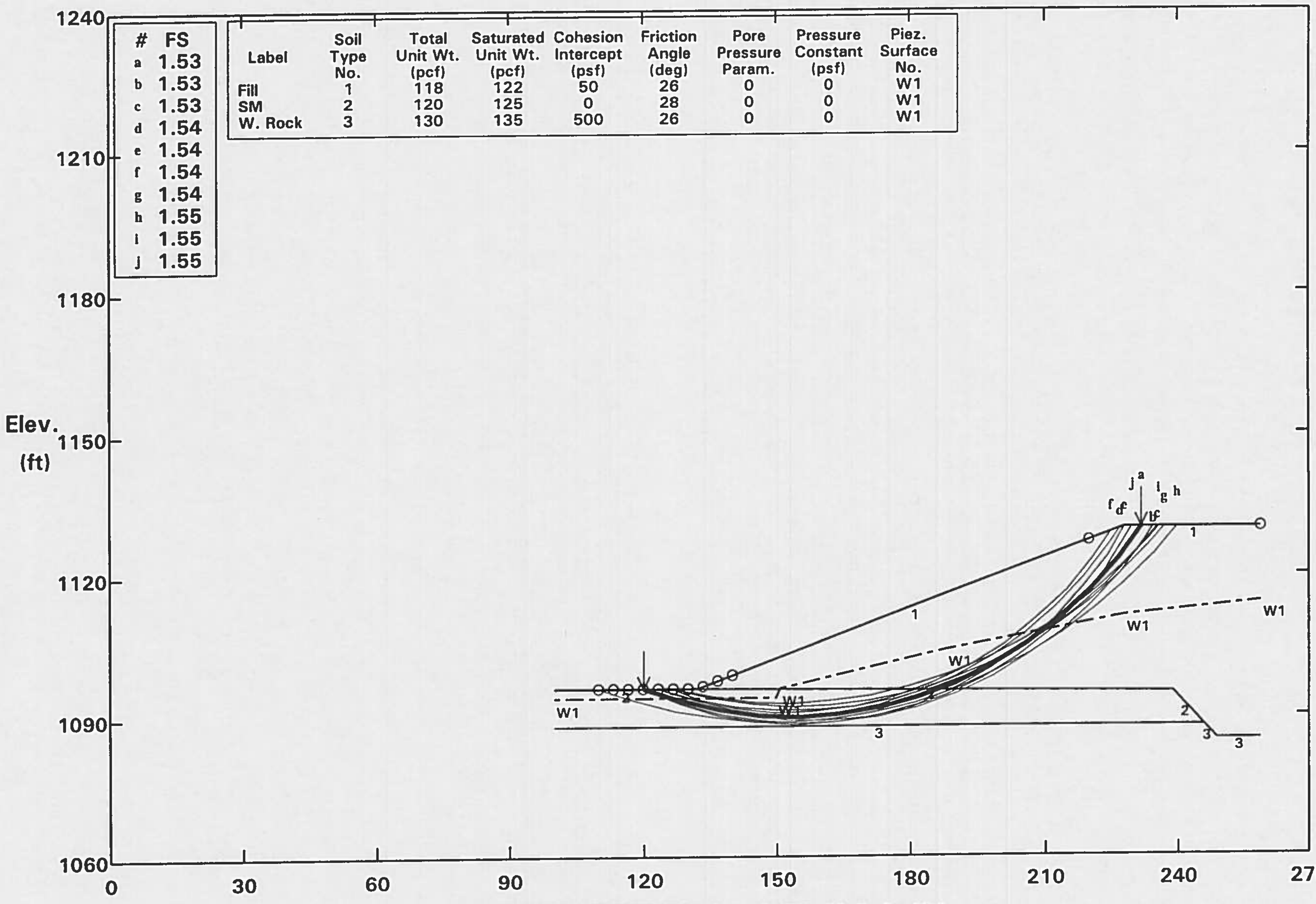
```
 16     8.2  18627.6      .0  3412.5      .0      .0      .0      .0      .0
 17     7.8  16398.7      .0  1870.0      .0      .0      .0      .0      .0
 18     3.3   6291.9      .0   220.6      .0      .0      .0      .0      .0
 19     4.0   7118.5      .0      .0      .0      .0      .0      .0      .0
 20     6.8   9959.0      .0      .0      .0      .0      .0      .0      .0
 21     6.2   6229.6      .0      .0      .0      .0      .0      .0      .0
 22     1.5    982.6      .0      .0      .0      .0      .0      .0      .0
 23     3.9   1160.2      .0      .0      .0      .0      .0      .0      .0

        Failure Surface Specified By 16 Coordinate Points


          Point      X-Surf      Y-Surf
           No.        (ft)        (ft)

            1        120.00       36.00
            2        128.43       32.85
            3        137.12       30.52
            4        146.00       29.04
            5        154.98       28.42
            6        163.98       28.68
            7        172.91       29.79
            8        181.69       31.77
            9        190.24       34.57
           10        198.48       38.19
           11        206.33       42.59
           12        213.72       47.72
           13        220.59       53.55
           14        226.86       60.00
           15        232.48       67.03
           16        234.41       70.00

        Circle Center At X =  156.9 ; Y =  121.5  and Radius,   93.1


              ***     1.529   ***


--------------------------------------------------------------------------------

        Failure Surface Specified By 15 Coordinate Points


          Point      X-Surf      Y-Surf
           No.        (ft)        (ft)

            1        123.33       36.00
            2        132.03       33.66
            3        140.89       32.09
            4        149.85       31.30
            5        158.85       31.28
            6        167.82       32.05
            7        176.69       33.59
            8        185.39       35.90
            9        193.85       38.95
           10        202.02       42.73
           11        209.83       47.20
```

```
      12         217.22         52.33
      13         224.14         58.09
      14         230.53         64.43
      15         235.25         70.00

  Circle Center At X =  154.5 ; Y =  134.7  and Radius,  103.5

         ***      1.531    ***



  Failure Surface Specified By 15 Coordinate Points

    Point       X-Surf       Y-Surf
     No.         (ft)         (ft)

       1         120.00        36.00
       2         128.54        33.17
       3         137.33        31.20
       4         146.26        30.13
       5         155.26        29.95
       6         164.23        30.68
       7         173.08        32.30
       8         181.73        34.80
       9         190.08        38.16
      10         198.05        42.33
      11         205.57        47.29
      12         212.55        52.97
      13         218.92        59.32
      14         224.63        66.28
      15         226.83        69.59

  Circle Center At X =  152.5 ; Y =  119.6  and Radius,   89.7

         ***      1.537    ***


--------------------------------------------------------------------------------

  Failure Surface Specified By 15 Coordinate Points

    Point       X-Surf       Y-Surf
     No.         (ft)         (ft)

       1         120.00        36.00
       2         128.36        32.67
       3         137.03        30.25
       4         145.91        28.77
       5         154.89        28.24
       6         163.88        28.67
       7         172.77        30.06
       8         181.47        32.39
```

```
       9          189.86          35.63
      10          197.87          39.75
      11          205.38          44.70
      12          212.33          50.42
      13          218.63          56.85
      14          224.21          63.91
      15          228.04          70.00

 Circle Center At X =   155.3 ; Y =   112.5  and Radius,    84.3


           ***      1.540    ***


 Failure Surface Specified By 14 Coordinate Points


     Point        X-Surf        Y-Surf
      No.          (ft)          (ft)

       1          123.33          36.00
       2          131.94          33.36
       3          140.77          31.63
       4          149.73          30.82
       5          158.73          30.93
       6          167.67          31.98
       7          176.46          33.94
       8          184.99          36.80
       9          193.18          40.53
      10          200.95          45.08
      11          208.20          50.41
      12          214.86          56.45
      13          220.87          63.16
      14          225.07          68.96

 Circle Center At X =   153.1 ; Y =   117.6  and Radius,    86.9


           ***      1.544    ***


-----------------------------------------------------------------------------

 Failure Surface Specified By 15 Coordinate Points


     Point        X-Surf        Y-Surf
      No.          (ft)          (ft)

       1          126.67          36.00
       2          135.44          33.98
       3          144.35          32.71
       4          153.33          32.18
       5          162.33          32.41
       6          171.28          33.39
```

South County High School (ECS #1565) Downstream Slope (Steady Seepage)

Ten Most Critical. C:1565-DS.PLT By: mrc 05-12-00 9:45am



#	FS
a	1.53
b	1.53
c	1.53
d	1.54
e	1.54
f	1.54
g	1.54
h	1.55
i	1.55
j	1.55

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Fill	1	118	122	50	26	0	0	W1
SM	2	120	125	0	28	0	0	W1
W. Rock	3	130	135	500	26	0	0	W1

PCSTABL5M/SI FSmin = 1.53 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

```
                          ** PCSTABL5M **

                               by
                        Purdue University
--------------------------------------------------------------------------------

                   --Slope Stability Analysis--
                Simplified Janbu, Simplified Bishop
                   or Spencer's Method of Slices


         Run Date:                 05-12-00
         Time of Run:              9:45am
         Run By:                   mrc
         Input Data Filename:      C:1565-DS.IN
         Output Filename:          C:1565-DS.OUT
         Unit:                     ENGLISH
         Plotted Output Filename:  C:1565-DS.PLT



         PROBLEM DESCRIPTION   South County High School (ECS #1565)
                               Downstream Slope (Steady Seepage)



         BOUNDARY COORDINATES
              NOTE:  User defined origin was specified.
              Add 00.00 to X values and 1060.00 to Y values listed.

             3 Top   Boundaries
             8 Total Boundaries

         Boundary     X-Left     Y-Left     X-Right     Y-Right     Soil Type
            No.        (ft)       (ft)        (ft)        (ft)      Below Bnd

             1        100.00      36.00      132.00       36.00         2
             2        132.00      36.00      228.00       70.00         1
             3        228.00      70.00      259.00       70.00         1
             4        132.00      36.00      239.00       35.00         2
             5        239.00      35.00      246.00       28.00         2
             6        246.00      28.00      249.00       25.00         3
             7        249.00      25.00      259.00       25.00         3
             8        100.00      28.00      246.00       28.00         3
--------------------------------------------------------------------------------

        ISOTROPIC SOIL PARAMETERS


          3 Type(s) of Soil


         Soil  Total  Saturated  Cohesion Friction   Pore    Pressure   Piez.
         Type Unit Wt. Unit Wt. Intercept   Angle  Pressure Constant Surface
```

```
 No.  (pcf)    (pcf)     (psf)     (deg)   Param.    (psf)    No.

  1   118.0    122.0      50.0      26.0     .00        .0      1
  2   120.0    125.0        .0      28.0     .00        .0      1
  3   130.0    135.0     500.0      26.0     .00        .0      1
-------------------------------------------------------------------------------


 1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED


 Unit Weight of Water =  62.40


 Piezometric Surface No.  1 Specified by  6 Coordinate Points

   Point      X-Water     Y-Water
    No.         (ft)        (ft)

     1       100.00       34.00
     2       150.00       34.00
     3       151.00       36.00
     4       188.00       44.00
     5       228.00       51.00
     6       259.00       54.00
-------------------------------------------------------------------------------


 A Critical Failure Surface Searching Method, Using A Random
 Technique For Generating Circular Surfaces, Has Been Specified.


 200 Trial Surfaces Have Been Generated.


  20 Surfaces Initiate From Each Of 10 Points Equally Spaced
 Along The Ground Surface Between  X = 110.00 ft.
                              and  X = 140.00 ft.


 Each Surface Terminates Between   X = 220.00 ft.
                             and   X = 259.00 ft.


 Unless Further Limitations Were Imposed, The Minimum Elevation
 At Which A Surface Extends Is  Y =   .00 ft.


  9.00 ft. Line Segments Define Each Trial Failure Surface.


-------------------------------------------------------------------------------

 Following Are Displayed The Ten Most Critical Of The Trial
 Failure Surfaces Examined.  They Are Ordered - Most Critical
 First.
```

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        * * Safety Factors Are Calculated By The Modified Bishop Method * *


        Failure Surface Specified By 15 Coordinate Points

          Point      X-Surf      Y-Surf
           No.        (ft)        (ft)

            1        120.00       36.00
            2        128.56       33.23
            3        137.35       31.27
            4        146.28       30.14
            5        155.27       29.85
            6        164.25       30.41
            7        173.15       31.80
            8        181.87       34.02
            9        190.34       37.05
           10        198.50       40.86
           11        206.26       45.41
           12        213.56       50.67
           13        220.34       56.60
           14        226.53       63.13
           15        231.93       70.00

        Circle Center At X =  153.8 ; Y =  125.9  and Radius,   96.0

              ***    1.525   ***


              Individual data on the    23  slices

                           Water  Water    Tie     Tie      Earthquake
                           Force  Force   Force   Force       Force    Surcharge
 Slice  Width   Weight      Top    Bot     Norm    Tan     Hor     Ver     Load
  No.    (ft)   (lbs)     (lbs)  (lbs)    (lbs)   (lbs)   (lbs)   (lbs)   (lbs)
   1      6.2    741.1      .0      .0      .0      .0      .0      .0      .0
   2      2.4    687.9      .0    60.5      .0      .0      .0      .0      .0
   3      3.4   1321.6      .0   254.0      .0      .0      .0      .0      .0
   4      5.3   3307.7      .0   730.0      .0      .0      .0      .0      .0
   5      8.9   9480.9      .0  1850.8      .0      .0      .0      .0      .0
   6      3.7   5228.6      .0   911.2      .0      .0      .0      .0      .0
   7       .9   1371.9      .0   167.5      .0      .0      .0      .0      .0
   8       .1    135.3      .0    19.6      .0      .0      .0      .0      .0
   9      4.3   7021.4      .0  1705.2      .0      .0      .0      .0      .0
  10      9.0  17067.1      .0  4262.7      .0      .0      .0      .0      .0
  11      8.9  19195.9      .0  4788.1      .0      .0      .0      .0      .0
  12      8.7  20133.3      .0  4841.1      .0      .0      .0      .0      .0
  13      4.1   9684.6      .0  2230.4      .0      .0      .0      .0      .0
  14      2.0   4725.7      .0  1034.3      .0      .0      .0      .0      .0
  15      2.3   5492.4      .0  1157.9      .0      .0      .0      .0      .0
```

```
  16       8.2  18627.6        .0  3412.5        .0      .0      .0      .0      .0
  17       7.8  16398.7        .0  1870.0        .0      .0      .0      .0      .0
  18       3.3   6291.9        .0   220.6        .0      .0      .0      .0      .0
  19       4.0   7118.5        .0      .0        .0      .0      .0      .0      .0
  20       6.8   9959.0        .0      .0        .0      .0      .0      .0      .0
  21       6.2   6229.6        .0      .0        .0      .0      .0      .0      .0
  22       1.5    982.6        .0      .0        .0      .0      .0      .0      .0
  23       3.9   1160.2        .0      .0        .0      .0      .0      .0      .0

        Failure Surface Specified By 16 Coordinate Points

          Point        X-Surf        Y-Surf
           No.          (ft)          (ft)

            1          120.00         36.00
            2          128.43         32.85
            3          137.12         30.52
            4          146.00         29.04
            5          154.98         28.42
            6          163.98         28.68
            7          172.91         29.79
            8          181.69         31.77
            9          190.24         34.57
           10          198.48         38.19
           11          206.33         42.59
           12          213.72         47.72
           13          220.59         53.55
           14          226.86         60.00
           15          232.48         67.03
           16          234.41         70.00

        Circle Center At X =  156.9 ; Y =  121.5  and Radius,   93.1

              ***     1.529   ***


---------------------------------------------------------------------------------

        Failure Surface Specified By 15 Coordinate Points

          Point        X-Surf        Y-Surf
           No.          (ft)          (ft)

            1          123.33         36.00
            2          132.03         33.66
            3          140.89         32.09
            4          149.85         31.30
            5          158.85         31.28
            6          167.82         32.05
            7          176.69         33.59
            8          185.39         35.90
            9          193.85         38.95
           10          202.02         42.73
           11          209.83         47.20
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```
       12         217.22         52.33
       13         224.14         58.09
       14         230.53         64.43
       15         235.25         70.00

  Circle Center At X =  154.5 ; Y =  134.7  and Radius,  103.5


          ***     1.531   ***



  Failure Surface Specified By 15 Coordinate Points

     Point        X-Surf        Y-Surf
      No.          (ft)          (ft)

        1         120.00         36.00
        2         128.54         33.17
        3         137.33         31.20
        4         146.26         30.13
        5         155.26         29.95
        6         164.23         30.68
        7         173.08         32.30
        8         181.73         34.80
        9         190.08         38.16
       10         198.05         42.33
       11         205.57         47.29
       12         212.55         52.97
       13         218.92         59.32
       14         224.63         66.28
       15         226.83         69.59

  Circle Center At X =  152.5 ; Y =  119.6  and Radius,   89.7


          ***     1.537   ***


----------------------------------------------------------------------------------

  Failure Surface Specified By 15 Coordinate Points

     Point        X-Surf        Y-Surf
      No.          (ft)          (ft)

        1         120.00         36.00
        2         128.36         32.67
        3         137.03         30.25
        4         145.91         28.77
        5         154.89         28.24
        6         163.88         28.67
        7         172.77         30.06
        8         181.47         32.39
```

```
         9         189.86        35.63
        10         197.87        39.75
        11         205.38        44.70
        12         212.33        50.42
        13         218.63        56.85
        14         224.21        63.91
        15         228.04        70.00

    Circle Center At X =  155.3 ; Y =  112.5  and Radius,   84.3


          ***     1.540   ***



    Failure Surface Specified By 14 Coordinate Points


       Point       X-Surf       Y-Surf
        No.         (ft)         (ft)

         1         123.33        36.00
         2         131.94        33.36
         3         140.77        31.63
         4         149.73        30.82
         5         158.73        30.93
         6         167.67        31.98
         7         176.46        33.94
         8         184.99        36.80
         9         193.18        40.53
        10         200.95        45.08
        11         208.20        50.41
        12         214.86        56.45
        13         220.87        63.16
        14         225.07        68.96

    Circle Center At X =  153.1 ; Y =  117.6  and Radius,   86.9


          ***     1.544   ***



--------------------------------------------------------------------------------

    Failure Surface Specified By 15 Coordinate Points


       Point       X-Surf       Y-Surf
        No.         (ft)         (ft)

         1         126.67        36.00
         2         135.44        33.98
         3         144.35        32.71
         4         153.33        32.18
         5         162.33        32.41
         6         171.28        33.39
```

```
      7          180.11          35.11
      8          188.77          37.57
      9          197.19          40.74
     10          205.32          44.61
     11          213.09          49.14
     12          220.46          54.31
     13          227.37          60.07
     14          233.78          66.39
     15          236.87          70.00
 Circle Center At X =  155.1 ; Y =  139.7  and Radius,  107.5

       ***     1.544   ***


 Failure Surface Specified By 17 Coordinate Points

   Point         X-Surf         Y-Surf
    No.           (ft)           (ft)

      1          110.00          36.00
      2          118.56          33.22
      3          127.31          31.11
      4          136.19          29.67
      5          145.16          28.92
      6          154.16          28.85
      7          163.14          29.48
      8          172.04          30.79
      9          180.82          32.78
     10          189.42          35.44
     11          197.79          38.74
     12          205.88          42.68
     13          213.65          47.23
     14          221.05          52.35
     15          228.03          58.03
     16          234.56          64.23
     17          239.77          70.00
 Circle Center At X =  150.5 ; Y =  146.2  and Radius,  117.4

       ***     1.545   ***

---------------------------------------------------------------------------

 Failure Surface Specified By 15 Coordinate Points

   Point         X-Surf         Y-Surf
    No.           (ft)           (ft)

      1          126.67          36.00
```

```
      2         135.49         34.21
      3         144.42         33.14
      4         153.42         32.80
      5         162.41         33.19
      6         171.34         34.32
      7         180.15         36.17
      8         188.77         38.73
      9         197.16         41.98
     10         205.26         45.91
     11         213.02         50.48
     12         220.37         55.67
     13         227.28         61.44
     14         233.69         67.75
     15         235.63         70.00

 Circle Center At X =  153.1 ; Y =  143.3  and Radius,  110.5

         ***      1.547    ***


 Failure Surface Specified By 15 Coordinate Points

    Point       X-Surf        Y-Surf
     No.         (ft)          (ft)

      1         126.67         36.00
      2         135.07         32.79
      3         143.79         30.54
      4         152.70         29.27
      5         161.70         29.01
      6         170.66         29.76
      7         179.49         31.51
      8         188.07         34.23
      9         196.29         37.89
     10         204.05         42.45
     11         211.25         47.85
     12         217.80         54.02
     13         223.63         60.89
     14         228.64         68.36
     15         229.50         70.00

 Circle Center At X =  159.5 ; Y =  109.4  and Radius,   80.4

         ***      1.550    ***
```

APPENDIX III

Laboratory Test Results

Engineering Consulting Services, Ltd.

Roanoke, Virginia

Laboratory Testing Summary

Date: 5/23/00

Project Number: 1565

Project Name: Roanoke Regional Stormwater System

Project Engineer: MRC

Principal Engineer: GEW

Summary By:

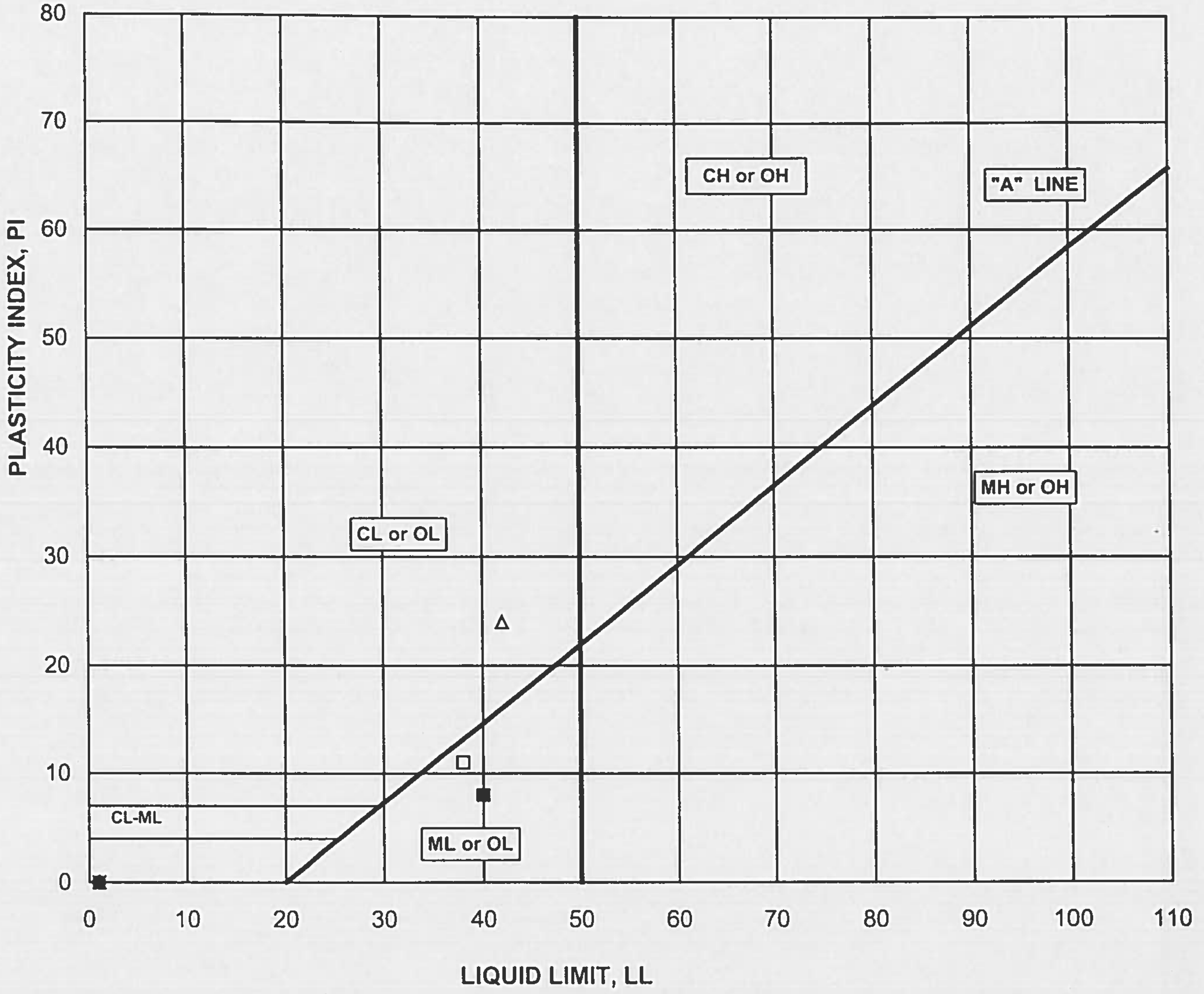
Boring Number	Sample Number	Depth (feet)	Moisture Content (%)	USCS	Liquid Limit	Plastic Limit	Plasticity Index	Percent Passing No. 200 Sieve	Compaction Maximum Density (pcf)	Compaction Optimum Moisture (%)	CBR Value	Other
B-2,3,5 &	Composite	4'-8'	14.2	SM				15.8				
SB-3 & 5	Composite	1'-4'	15.8	SM				32.7				
SB-1	2	3.5-5	21.6									
SB-1	4	8.5-10	21.9	ML	38	27	11					
SB-1	5	13.5-15	25.2									
SB-2	4	8.5-10	44.4	ML	40	32	8					
SB-2	5	13.5-15	38.0									
SB-4	Composite	1'-7.5'	20.1	CL	42	18	24	68.8				
SB-4A	4	8.5-10	15.8									
SB-4A	5	13.5-15	11.3									
SB-7	2	3.5-5	36.1									
SB-7	4	8.5-10	46.9									
SB-7	5	13.5-15	48.6									

Summary Key:

SA = See Attached
S = Standard Proctor
M= Modified Proctor
V = Virginia Test Method

Hyd = Hydrometer
Con = Consolidation
DS = Direct Shear
GS = Specific Gravity

UCS = Unconfined Compression Soil
UCR = Unconfined Compression Rock
LS = Lime Stabilization
CS = Cement Staibilization



BORING/ SAMPLE No.	DEPTH (feet)	TEST SYMBOL	DESCRIPTION	WATER CONTENT (%)	LL	PL	PI
SB-1 / 4	8.5-10	□	Yellowish Brown Clayey SILT (ML) w/ sh	21.9	38	27	11
SB-2 / 4	8.5-10	■	Tannish Brown Clayey SILT (ML)w/f.sand	44.4	40	32	8
SB-4 / Composit	1'-7.5'	△	Light Brown Sandy CLAY (CL)	20.1	42	18	24
/		▲			-	-	-
/		X			-	-	-
/		○			-	-	-
/		●			-	-	-
/		◇			-	-	-
/		◆			-	-	-
/		+			-	-	-
		X					

Project: Roanoke Regional Stormwater System

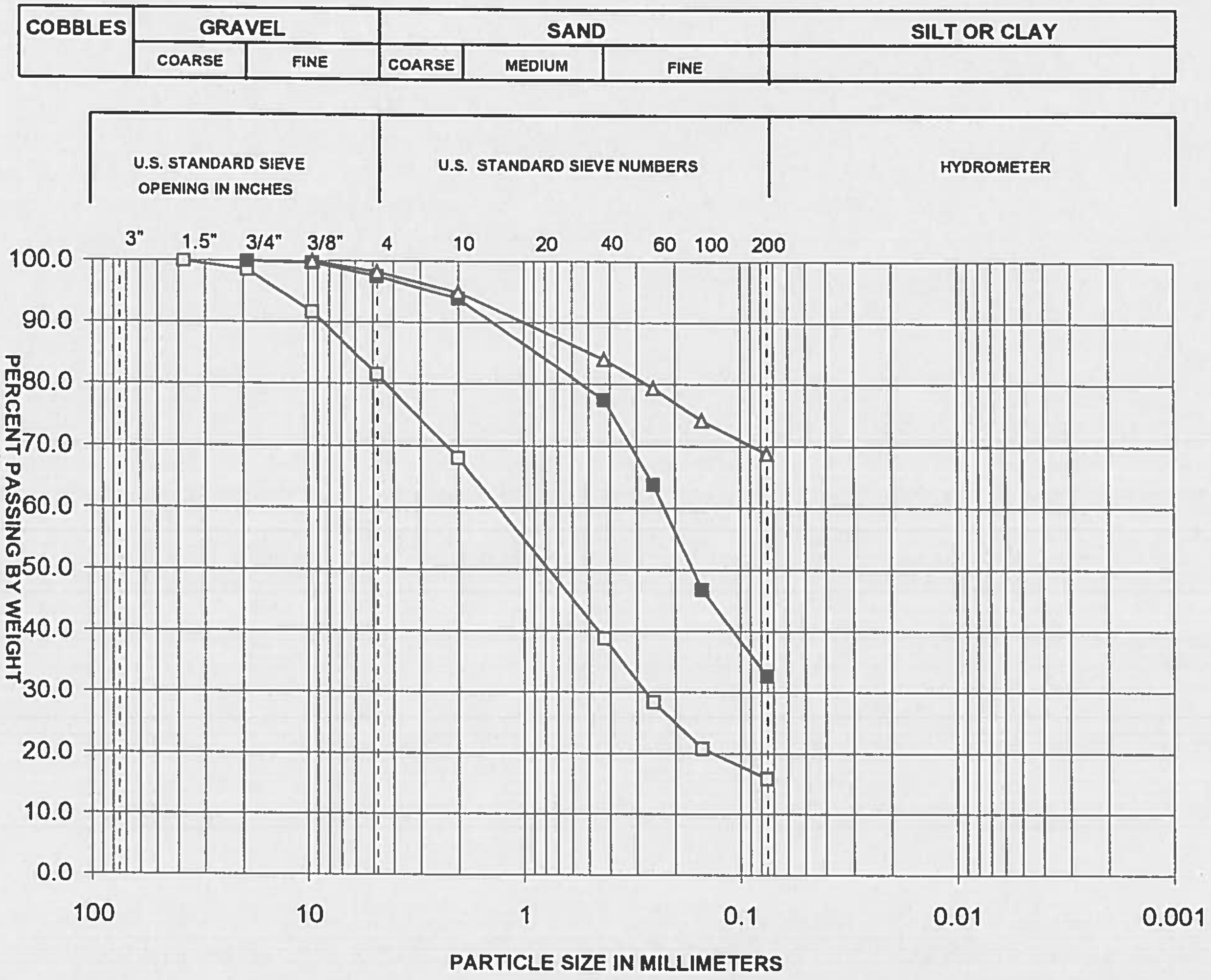
Project No.: 1565

Date: Apr 24,2000

Engineering Consulting Services Ltd.

Roanoke, Virginia

Plasticity Chart



Boring/ Sample No.	Depth (feet)	Symbol	LL	PI	Description
SB-2,3, 5/	4'-8'	□	NP	NP	Med. Brown Fine to Med. SAND (SM), some gravel
SB-3/ SB-	1'-4'	■	NP	NP	Med. Brown Silty Fine SAND (SM)
SB-4 / Co	1'-7.5'	△	42	27	Light Brown Sandy CLAY (CL)
/		▲			

Project: Roanoke Regional Stormwater System

Project No.: 1565

Date: 4/28/00

Engineering Consulting Services, Ltd

Roanoke, Virginia

Grain Size Analysis

APPENDIX IV

Project Specifications
Site Plan
Details

South County High School
Roanoke Regional Stormwater System Dam

Project Description

Project will include construction of a retention basin with an estimated 32-foot-high earth dam with a minimum crest elevation of 1,124 feet. The embankment crest will be utilized as an entrance roadway to the proposed South County High School. The earth dam will have a downstream slope of 3H:1V and an upstream slope of 2H:1V. On-site residual clays and silts are suitable for construction of the majority of the embankment, while granular soils or weathered shale will be required along the upstream portion of the embankment for stability. Refer to the typical cross-sections for approximate limits of upstream shell fill.

Hydraulic structures are represented on the plan for illustration purposes only. Engineering Concepts, Inc. will provide design of these structures. The retention basin will incorporate a multiple-stage spillway with a base flow pipe at the base of the earth dam with an invert elevation of 1095.5 feet and an overflow spillway above the base flow pipe at an invert elevation of 1115.0 feet. We understand that the earth dam is designed to manage storm events with a 30-hour drawdown period. Concrete facing with baffles will be constructed along the downstream slope below the overflow spillway to prevent erosion and to dissipate hydraulic energy.

A clay cutoff trench will be constructed through the sandy alluvial deposits and extended a minimum of 2 feet into the residual soils and/or weathered shale to reduce seepage losses beneath the embankment. The average depth of the cutoff trench is estimated to be 10 feet below existing grades based on the soil borings. A minimum cutoff trench depth of 2 feet into residual soils will be required along the abutment side slopes up to about elevation 1,122 feet. The groundwater level is expected to vary between elevation 1,096 and 1,092 feet; therefore, dewatering will be necessary during excavation. A 30-foot-wide drainage (sand) blanket will be installed beneath the downstream toe to control seepage through the embankment.

Seepage control along the base flow pipe will require a concrete cradle beginning at the upstream end wall and continuing for 100 linear feet, followed by a graded filter (50 linear feet) and a partially graded filter (60 linear feet) to the downstream end wall. A debris rack will be required at the upstream end of the base flow pipe to prevent branches, leaves and other debris from entering the pipe. Periodic maintenance of the debris rack will be required to remove any obstructions during operation.

Subgrade Preparation

All topsoil, tree stumps and other organic matter shall be removed from the construction limits and at least 5 feet beyond the toe of fill embankment.

Subgrade shall be proofrolled with a loaded dump truck having a tandem-axle weight of at least 10 tons to aid in identifying localized soft or unsuitable material.

Any soft or unsuitable materials encountered during proofrolling shall be removed and replaced with engineered fill.

The excavation and backfilling shall be observed by the Geotechnical Engineer to avoid excessive or inadequate removal of unsuitable material.

Relocation of the existing sanitary sewer pipe will be required. The existing pipe, bedding stone and associated loose backfill shall be removed from beneath the embankment and backfilled with engineered fill or flowable fill.

The drainage blanket shall consist of VDOT Grading G, Fine Aggregate, or equivalent with the following gradation:

Sieve Size	% Passing
3/8"	100
No. 50	Max 26
No. 100	Max 10
No. 200	Max 5

The drainage blanket shall have a minimum thickness of 18 inches and a minimum width of 30 feet.

Filter fabric, conforming to Mirafi 140N or equivalent, shall be placed along the top and bottom of the drainage blanket to prevent fines from migrating into the sand.

A 4-inch-diameter, slotted PVC pipe shall be placed within the drainage blanket approximately 3 feet from the downstream end. The pipe shall be hydraulically connected with the drainage pipe along each side of the base flow pipe. Daylight through the end wall at the pipe invert elevation (1,092.5 feet).

Concrete Cradle

The concrete cradle shall be cast-in-place Portland cement concrete with a minimum 28-day compressive strength of 4,000 psi.

The concrete cradle shall have a minimum thickness of 4 inches beneath the base flow pipe and extend 8 inches laterally up the mid-height of the pipe.

All loose materials shall be removed from the bottom and sides of the trench excavation prior to concrete placement.

The base flow pipe shall be raised using chairs or bricks and properly secured prior to concrete placement.

Graded Filter

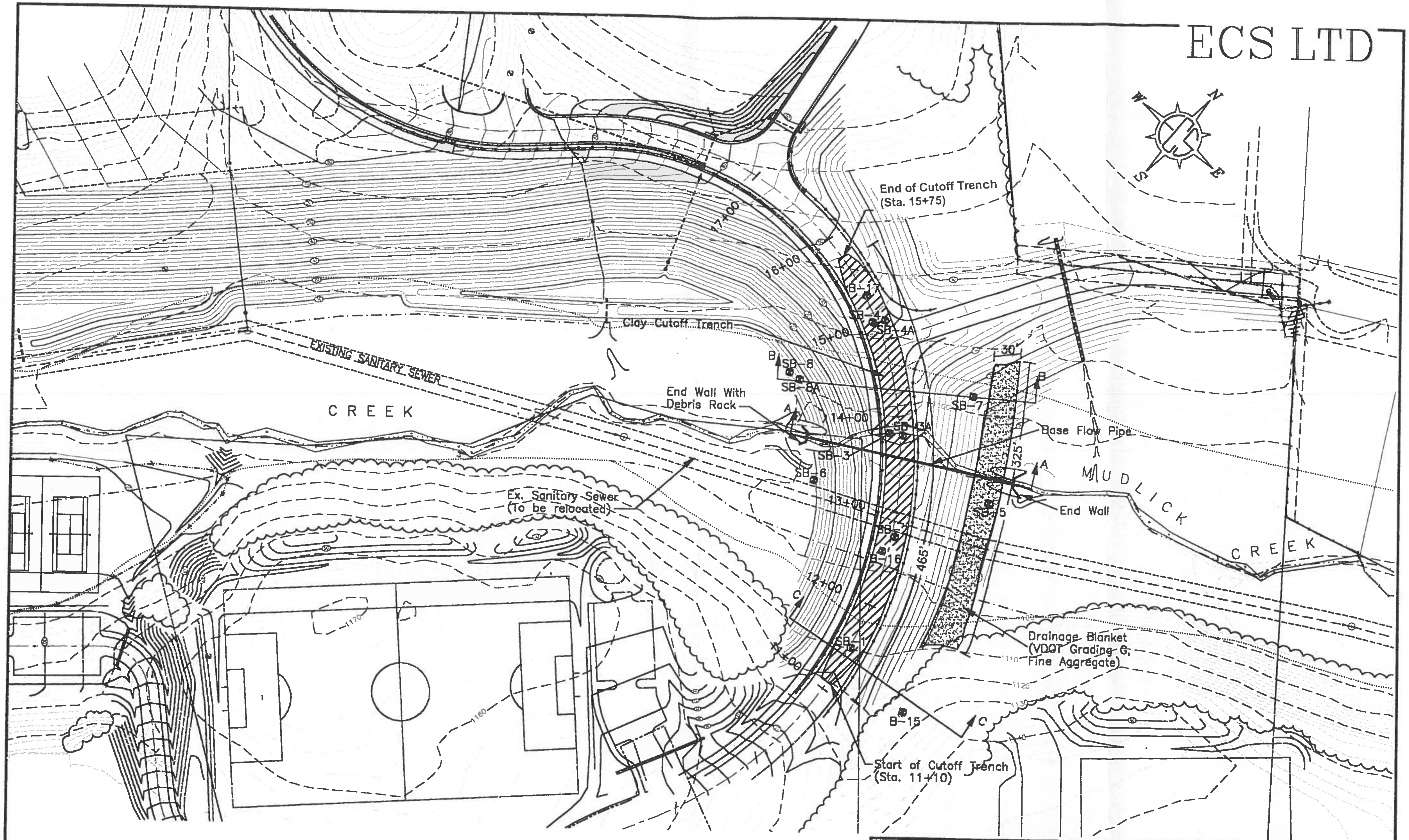
The graded filter shall consist of stone, completely encapsulated with filter fabric (Mirafi 140N or equivalent), and extend a minimum lateral distance equal to the base flow pipe diameter (D).

The graded filter shall transition to a partial graded filter with a minimum bedding of 6 inches up to the mid-height of the base flow pipe. Two 4-inch-diameter slotted PVC pipes shall be placed on either side of the base flow pipe. The pipes shall be hydraulically connected with the drainage blanket pipes. Daylight through the end wall at the pipe invert elevation (1,092 feet).

The graded filter shall consist of VDOT No. 78 Stone, Open-Graded Coarse Aggregate, or equivalent with the following gradation:

Sieve Size	% Passing
3/4"	100
½"	95 ± 5
3/8"	60 ± 20
No. 4	Max 20
No. 8	Max 8
No. 16	Max 5

ECS LTD



⊕ – Approximate Boring Location

REVISIONS

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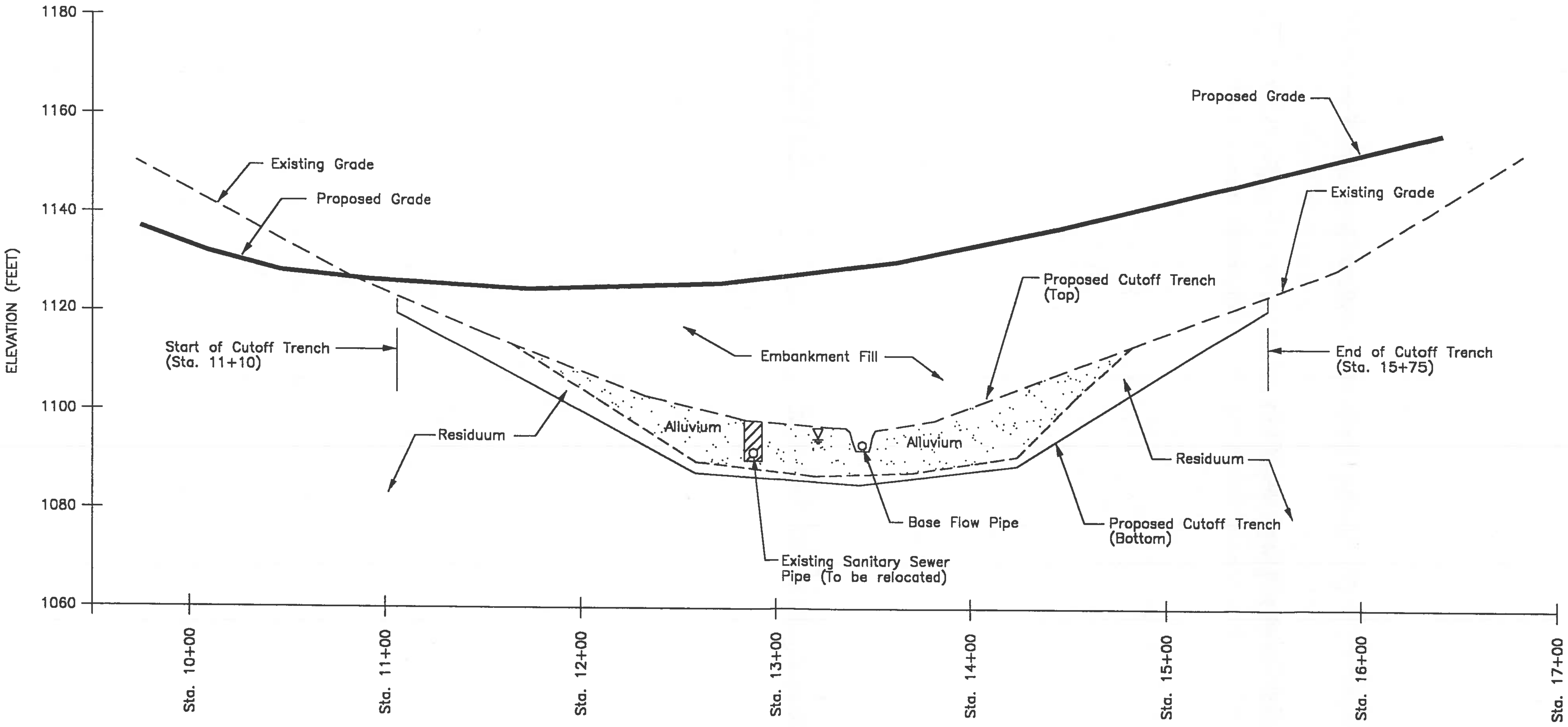
ENGINEERING
CONSULTING
SERVICES,LTD

SITE PLAN
ROANOKE REGIONAL STORMWATER SYSTEM DAM

SOUTH COUNTY HIGH SCHOOL

–	MRC	5-19-00	1"=100'	1566	1 OF 7

ECS LTD



SCALE
HORIZONTAL – 1"=60'
VERTICAL – NONE

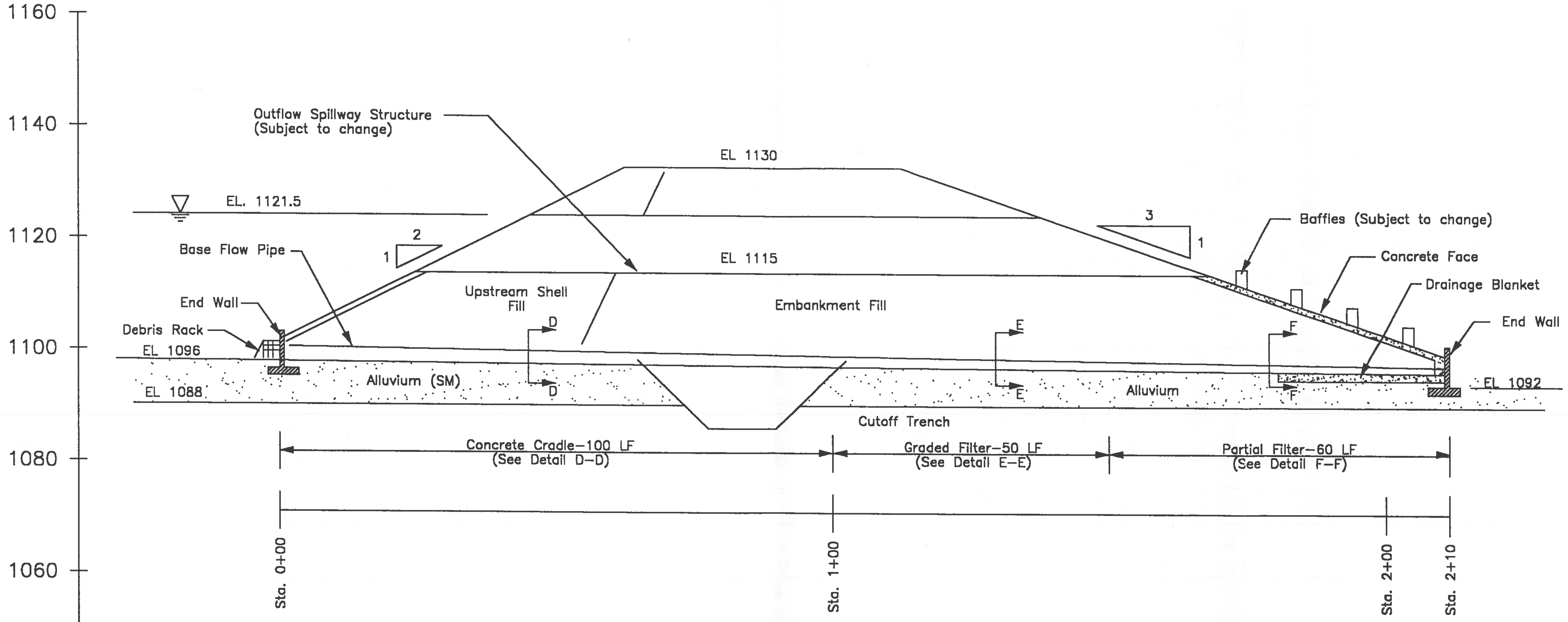
REVISIONS

ENGINEERING CONSULTING SERVICES,LTD

PROFILE VIEW
ROANOKE REGIONAL STORMWATER SYSTEM DAM
SOUTH COUNTY HIGH SCHOOL

KLG	MRC	5-19-00	-	1565	2 OF 7

ECS LTD

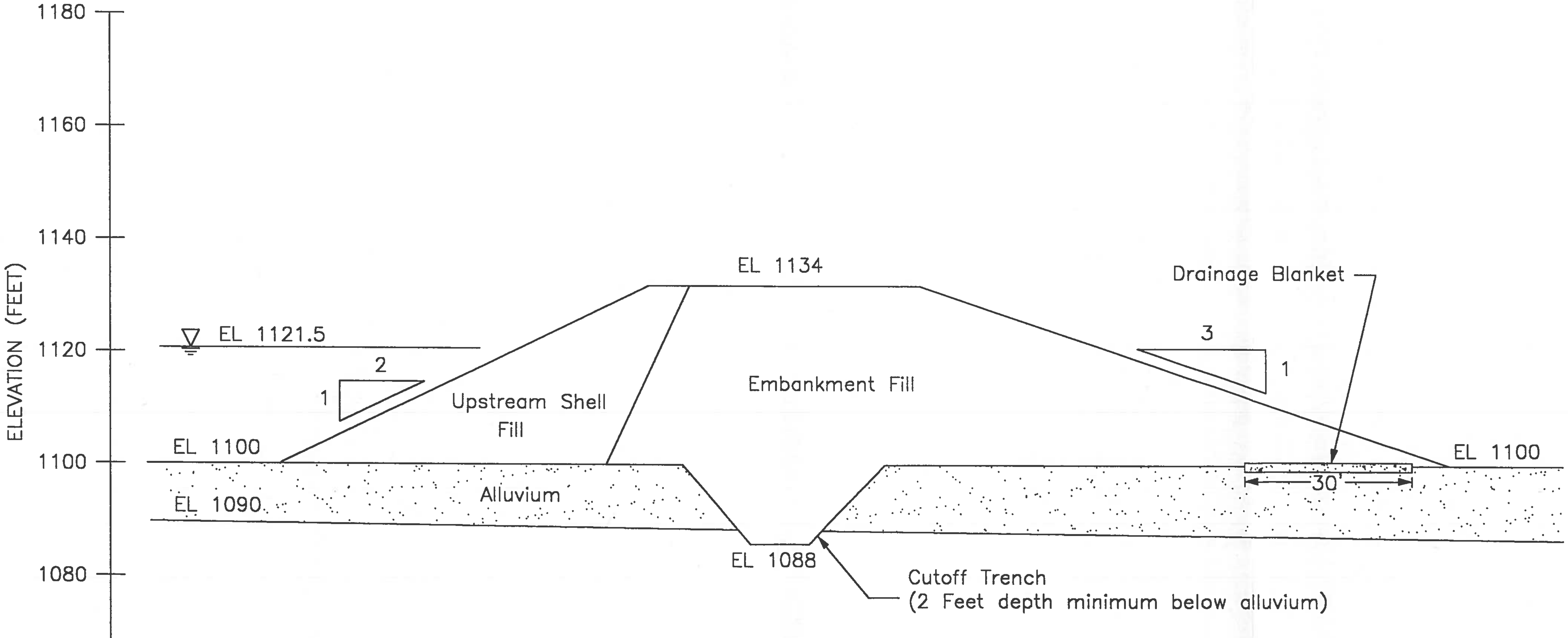


SECTION A–A

Scale: 1"=20'

REVISIONS	ENGINEERING CONSULTING SERVICES, LTD	SECTION A–A ROANOKE REGIONAL STORMWATER SYSTEM DAM			
		SOUTH COUNTY HIGH SCHOOL			
KLG	MRC	6-19-00	1"=20'	1565	3 OF 7

ECS LTD

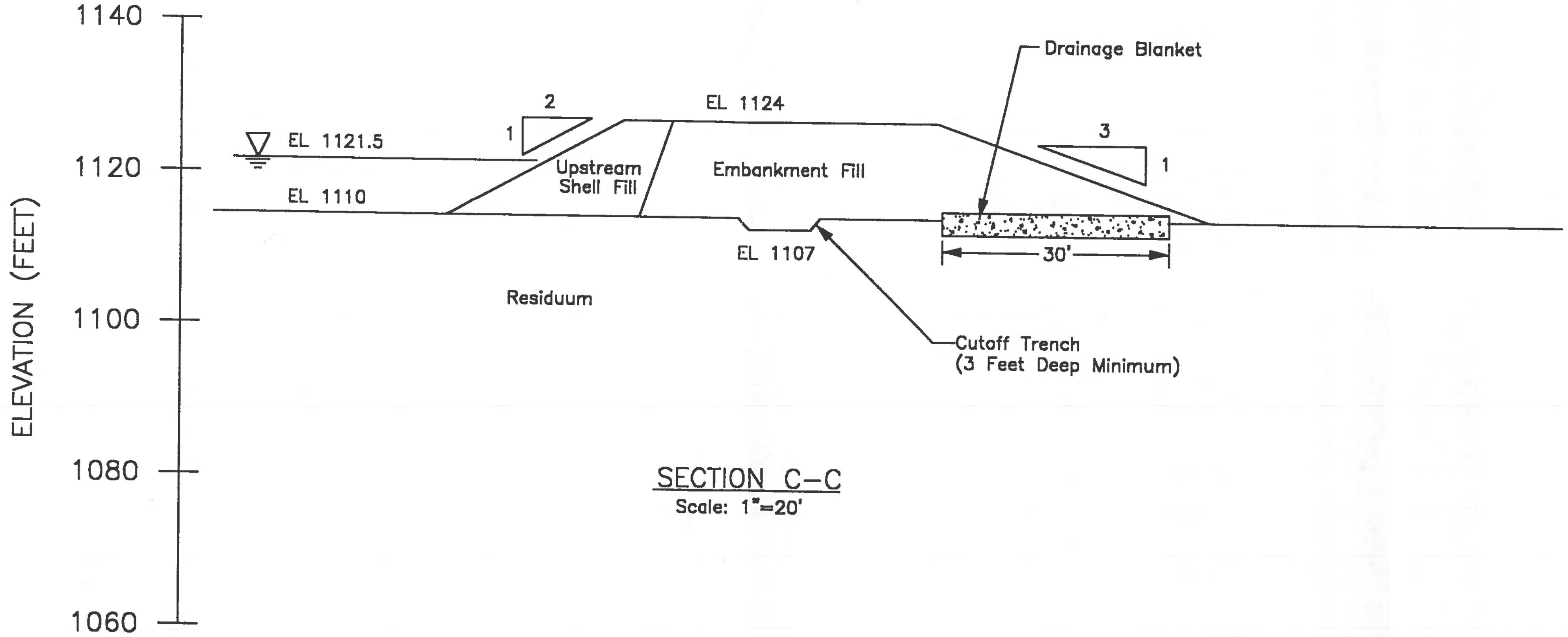


SECTION B–B
Scale: 1"=20'

REVISIONS	ENGINEERING CONSULTING SERVICES, LTD	SECTION B–B ROANOKE REGIONAL STORMWATER SYSTEM DAM
		SOUTH COUNTY HIGH SCHOOL

KLG	MRC	5–19–00	1"=20'	1565	4 OF 7

ECS LTD



SECTION C–C
Scale: 1"=20'

REVISIONS

ENGINEERING CONSULTING SERVICES, LTD

SECTION C–C
ROANOKE REGIONAL STORMWATER SYSTEM DAM
SOUTH COUNTY HIGH SCHOOL

KLG	MRC	6–19–00	1"=20'	1566	5 OF 7

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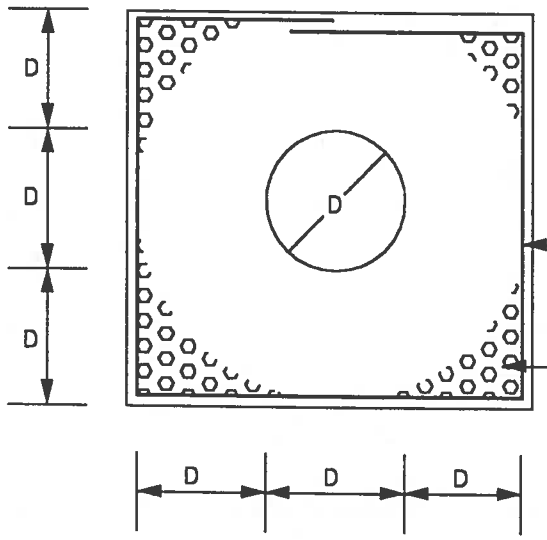
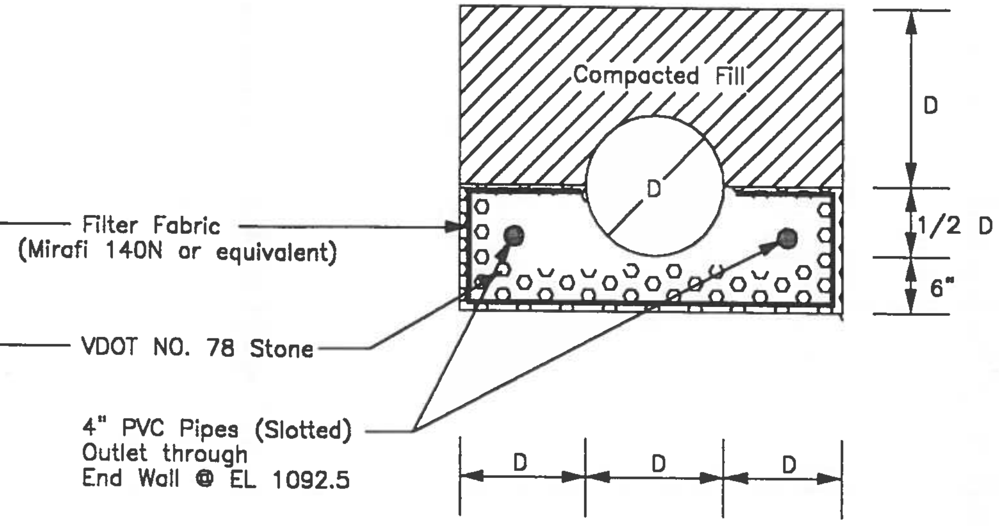
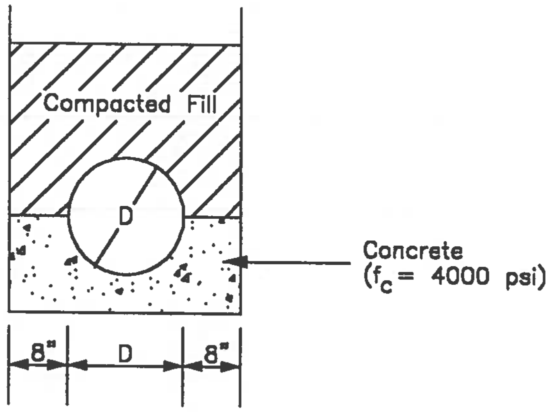


GRADED FILTER
(STA. 1+00 to STA. 1+50)
DETAIL E–E



PARTIALLY GRADED FILTER
(STA. 1+50 to END WALL)
DETAIL F–F



CONCRETE CRADLE
(STA. 0+00 TO STA. 1+00)
DETAIL D–D

REVISIONS

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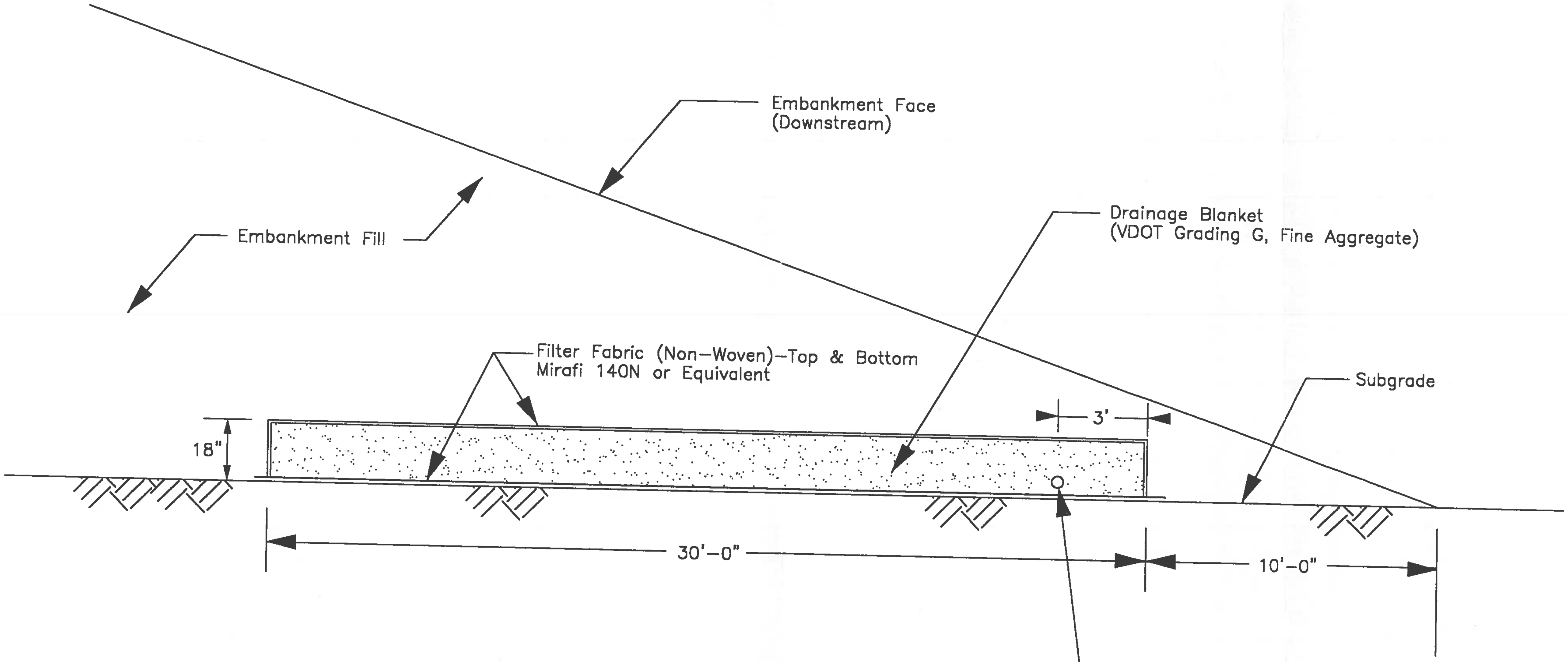
CONSULTING
SERVICES, LTD

BASE FLOW PIPE DETAILS
ROANOKE REGIONAL STORMWATER SYSTEM DAM
SOUTH COUNTY HIGH SCHOOL

KLG	MRC	5-19-00	NTS	1565	6 OF 7

ECS LTD



4" Diameter PVC (Slotted)–Positive Gradient
Daylight at Endwall–Each Side (EL 1092.5±)

DRAINAGE BLANKET
Scale: None

REVISIONS

ECS LTD
ENGINEERING
CONSULTING
SERVICES,LTD

DRAINAGE BLANKET DETAIL
ROANOKE REGIONAL STORMWATER SYSTEM DAM
SOUTH COUNTY HIGH SCHOOL

KLG	MRC	5-19-00	NTS	1565	7 OF 7