ENGINEERING REPORT (rev. 1)

ASH MANAGEMENT AREA (AMA)
PLANT YATES
COWETA COUNTY, GEORGIA

FOR

Georgia Power

JULY 2021

ATLANTIC COAST CONSULTING, INC.

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1. INTRODUCTION

The Ash Management Area (AMA) is the proposed unit where the excavated CCR from ponds AP-1, AP-2, AP-A and AP-B, which have been or are being closed by removal, is being consolidated. The AMA will be closed by leaving CCR in place. The CCR will be placed and graded to a maximum four to one side slope and a minimum three percent slope on the top. The AMA will be capped with a ClosureTurf® final cover system over a prepared subgrade. The ClosureTurf® system consists of a structured geomembrane covered with an engineered turf component and a sand infill. ClosureTurf® is specifically designed for long-term slope stability in the event of severe weather conditions.

The AMA will be closed in a manner that:

- controls post-closure infiltration of liquids into the waste and releases of CCR or contaminated run-off to the ground or surface waters;
- precludes the probability of future impoundment of water, sediment, or slurry;
- includes measures that provide for major slope stability to prevent the sloughing or movement of the final cover system during the closure and post-closure care period;
- minimizes the need for further maintenance of the CCR unit; and
- can be completed in the shortest amount of time consistent with recognized and generally accepted good engineering practices.

The AMA will be consolidated in a way that removes liquid wastes and solidifies the remaining wastes and waste residues to support the final cover system.

The proposed final cover system will minimize infiltration and erosion as well as:

- have a permeability no greater than 1×10^{-5} cm/sec;
- have an erosion layer that provides equivalent protection from wind or water erosion as six inches of earthen material with native plant growth;
- the integrity of the final cover system will accommodate settling and subsidence; and
- will have a written certification from a qualified professional engineer that the design of the final cover system meets the requirements of this permit.

The following report addresses the above mentioned requirements of the final configuration of the AMA including surface water management, stability analysis, final cover analysis, static and dynamic load evaluations, and erosion resistance.

Additional analyses and calculations concerning site hydrology and the primary stormwater drainage ditch (non-contact water ditch) provided by Schnabel Engineering are included as part of the appendix in section 7.1.

2. FINAL COVER SURFACE WATER MANAGEMENT

2.1 PERIMETER DITCH CAPACITY

Open channels are constructed to provide adequate capacity for flood water, drainage, other water management practices, or any combination thereof. The capacity of the AMA inside and outside perimeter ditches were evaluated. Each ditch was divided into sections based on slope and the location of outgoing storm drains. The Manning's Equation was used to calculate the overall capacity for each section of ditch. Then, using the Rational Method, each basin leading to each section of the ditch was analyzed using data from the NOAA Precipitation Frequency Data Server for both 25 year and 100 year storm events with a time of concentration of five minutes for inside ditches and 10 for outside ditches specific to Plant Yates and a runoff coefficient of 0.95 for ClosureTurf©. The Perimeter Ditch Capacity Calculations in section 2.6 show that both of the AMA perimeter ditches are more than sufficient to carry surface flows of both the 25 year and 100 year storm events. NOAA Precipitation Frequency Estimates for Newnan, GA are included in section 7.2. Ditch summary tables are provided below.

Inside Perimeter Ditch Design

Ditch #	Drainage area(acres)	Tc (min)	I (25) (in/yr)	I (100) (in/yr)	Capacity (cfs)	Q (25) (cfs)	Q (100) (cfs)	Ditch Lining Material
A	9.70	5.00	9.24	11.70	2279.12	85.15	107.82	ClosureTurf w/ ArmorFill
B	16.20	5.00	9.24	11.70	4324.33	142.20	180.06	ClosureTurf w/ ArmorFill
C	10.60	5.00	9.24	11.70	4324.33	93.05	117.82	ClosureTurf w/ ArmorFill
D	8.10	5.00	9.24	11.70	4324.33	71.10	90.03	ClosureTurf w/ ArmorFill
E	36.80	5.00	9.24	11.70	2279.12	323.03	409.03	ClosureTurf w/ ArmorFill
F	40.80	5.00	9.24	11.70	2324.26	358.14	453.49	ClosureTurf w/ ArmorFill
G	8.40	5.00	9.24	11.70	2734.95	73.74	93.37	ClosureTurf w/ ArmorFill
H	20.80	5.00	9.24	11.70	9229.75	182.58	231.19	ClosureTurf w/ ArmorFill
I	7.60	5.00	9.24	11.70	4077.02	66.71	84.47	ClosureTurf w/ ArmorFill

Outside Perimeter Ditch Design

Ditch #	Drainage area(acres)	Tc (min)	I (25) (in/yr)	I (100) (in/yr)	Capacity (cfs)	Q (25) (cfs)	Q (100) (cfs)	Ditch Lining Material
A	3.38	10.00	6.76	8.56	4843.01	13.71	17.36	Curlex II Matting
B	11.62	10.00	6.76	8.56	1789.85	47.13	59.68	Curlex II Matting
C	33.61	10.00	6.76	8.56	1789.85	136.32	172.62	Curlex II Matting
D	34.06	10.00	6.76	8.56	3705.35	138.15	174.93	Curlex II Matting
E	49.37	10.00	6.76	8.56	3314.16	200.24	253.56	Curlex II Matting
F	1.37	10.00	6.76	8.56	2233.53	5.56	7.04	Curlex II Matting

2.2 PERIMETER DITCH STABILITY

Open channels are constructed to be non-erosive, with no sediment deposition. The velocity of each section of the inside and outside perimeter ditches surrounding AMA was analyzed using the Hydraflow Express Extension for Autodesk AutoCAD Civil 3D. Using the 25 and 100 year flow rates calculated during the capacity evaluation, and the dimensions of each section of ditch, ditch liner material was determined given the resulting velocities in order to minimize any such deterioration of channel stability. For outside perimeter ditches, Curlex II matting was selected due to maximum 25-year storm velocities staying below 5 fps. Inside perimeter ditches will be lined with a ClosureTurf® with ArmorFill® combination, which is capable of withstanding flows greater than the maximum 25 year storm velocity of 10.37 fps. The Perimeter Ditch Stability Calculations are listed in section 2.7. Summary tables of the results are below.

Inside Perimeter Ditch Stability Summary

Inside Perimeter Ditch	Slope (%)	Depth 25 (ft)	Depth 100 (ft)	Vt 25 (ft/s)	Vt 100 (ft/s)	Shear Stress 25 (lb/sf)	Shear Stress 100 (lb/sf)
A	0.25	1.78	2.01	3.36	3.57	0.28	0.31
B	0.90	1.67	1.88	6.15	6.57	0.94	1.06
C	0.90	1.34	1.52	5.47	5.82	0.75	0.85
D	0.90	1.17	1.32	5.02	5.40	0.66	0.74
E	0.25	3.39	3.78	4.80	5.10	0.53	0.59
F	0.26	3.52	3.92	5.01	5.33	0.57	0.64
G	0.36	1.51	1.70	3.68	3.94	0.34	0.38
H	4.10	1.29	1.45	11.31	12.19	3.30	3.71
I	0.80	1.16	1.32	4.77	5.07	0.58	0.66

Outside Perimeter Ditch Stability Summary

Outside Perimeter Ditch	Slope (%)	Depth 25 (ft)	Depth 100 (ft)	Vt 25 (ft/s)	Vt 100 (ft/s)	Shear Stress 25 (lb/sf)	Shear Stress 100 (lb/sf)
A	2.05	0.37	0.42	2.83	3.12	0.47	0.54
B	0.28	1.31	1.49	2.26	2.43	0.23	0.26
C	0.28	2.31	2.61	3.12	3.34	0.40	0.46
D	1.20	1.58	1.79	5.22	5.63	1.18	1.34
E	0.96	2.05	2.32	5.38	5.76	1.23	1.39
F	0.70	0.43	0.49	1.77	1.92	0.19	0.21

2.3 STORM DRAIN CAPACITY

The capacity of the storm drains interconnecting the inside and outside perimeter ditches were evaluated for maximum capacity. That value was then compared to the flow expected to travel through each storm drain given the occurrence of a 100 year storm event. The Storm drain Capacity Calculations in section 2.9 show that the AMA storm drains are more than sufficient to carry surface flows for 100 year storm events. A summary of results is provided below.

Storm Drain Design

Structure	Drainage Area (acres)	I(100) (in/hr)	Q=C*I*A (cfs)	Slope (%)	Inv In (ft)	Inv Out (ft)	Pipe Length (ft)	No. of Pipes	Diam. (in)	Headwater (ft)	Type*	n
SD-1	16.20	11.70	180.06	3.73%	764.89	761.63	87.30	1	48	1.00	HDPE	0.01
SD-2	10.60	11.70	117.82	0.93%	756.91	756.00	98.00	1	48	1.00	HDPE	0.01
SD-3	48.40	11.70	537.97	1.53%	743.00	741.41	104.00	2	48	1.00	HDPE	0.01
SD-4	20.80	11.70	231.19	6.85%	746.98	740.11	100.25	1	48	1.00	HDPE	0.01

2.4 STORM DRAIN OUTLET PROTECTION

In order to reduce velocity of flow before entering receiving channels, rip-rap aprons will be placed below storm drain outlets. Rip-rap aprons have been designed in accordance with the 2016 edition of the "Manual for Erosion and Sediment Control in Georgia" (Green Book). Figures 6-34.1 and 6-34.2 from the Green Book were used as design guides and are included in section 7.4 and 7.5 respectively. Storm Drain Outlet Protection results are listed below.

Storm Drain	Max Flow (cfs)	Apron Length min (ft)	Apron Width min (ft)	RipRap D 50 min (ft)
SD-1	180.06	38.00	42.00	1.10
SD-2	117.82	26.00	30.00	0.90
SD-3[1]	537.97	48.00	52.00	1.80
SD-4[2]	231.19	60.00	28.00	0.60

[1]Flow divided by two pipes
[2]Tailwater > 0.5 diameter

2.5 FIGURE 2.1 – PERIMETER DITCHES

PERIMETER DITCHES

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FOR

GEORGIA POWER
PLANT YATES - ASH MANAGEMENT AREA
COWETA COUNTY, GEORGIA

Georgia Power

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FIGURE 2.1

2.6 PERIMETER DITCH CAPACITY CALCULATIONS

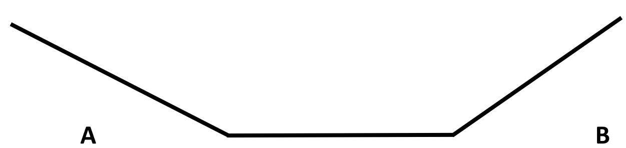
PERIMETER DITCH CAPACITY CALCULATIONS - 25 YEAR STORM EVENT

Project #:	I054-107				
Project Name:	Plant Yates - Ash Management Area	By:	MMT	Date	06/24/20
Subject: Perimeter Ditch Calculations		Checked:	JEH	Date	06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

<u>Inside Perimeter Ditch A</u>

Typical Cross Section
NTS



Inside Perimeter Ditch Capacity Calculation

Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	4.0	8.0	8.00	0.0025	0.025	288.00	4.35	**2279.12**

<u>Maximum possible flow calculation</u>

Maximum drainage area leading to ditch A 9.70 Acres

Q(max) = C*I*A

Assume:

C = 0.95 (ClosureTurf™)

Tc = 5 minutes (assuming developed conditions)

I = 9.24 in/hr (25 yr storm using Tc = 5 min),

Q(max) = 85.15 cfs

Therefore, ClosureTurf® lined perimeter ditch can handle flow from 25 year storm event.

85.15 cfs << 2279.12 cfs

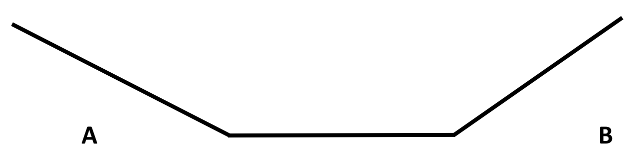
PERIMETER DITCH CAPACITY CALCULATIONS - 100 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area — By: MMT — Date 06/24/20
Subject: Perimeter Ditch Calculations — Checked: JEH — Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

Inside Perimeter Ditch A

Typical Cross Section
NTS



Inside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	4.0	8.0	8.00	0.0025	0.025	288.00	4.35	**2279.12**

Maximum possible flow calculation

Maximum drainage area leading to ditch A 9.70 Acres

Q(max) = C*I*A

Assume:
C = 0.95 (ClosureTurf™)
Tc = 5 minutes (assuming developed conditions)
I = 11.7 in/hr (100 yr storm using Tc = 5 min),

Q(max) = 107.82 cfs

Therefore, ClosureTurf® lined perimeter ditch can handle flow from 100 year storm event.
107.82 cfs << 2279.12 cfs

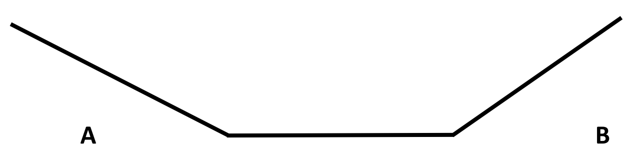
PERIMETER DITCH CAPACITY CALCULATIONS - 25 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area By: MMT Date 06/24/20
Subject: Perimeter Ditch Calculations Checked: JEH Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

Inside Perimeter Ditch B

Typical Cross Section
NTS



Inside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	4.0	8.0	8.00	0.0090	0.025	288.00	4.35	**4324.33**

Maximum possible flow calculation

Maximum drainage area leading to ditch B 16.20 Acres

Q(max) = C*I*A

Assume:
C = 0.95 (ClosureTurf™)
Tc = 5 minutes (assuming developed conditions)
I = 9.24 in/hr (25 yr storm using Tc = 5 min),

Q(max) = 142.20 cfs

Therefore, ClosureTurf® lined perimeter ditch can handle flow from 25 year storm event.
142.20 cfs << 4324.33 cfs

PERIMETER DITCH CAPACITY CALCULATIONS - 100 YEAR STORM EVENT

Project #:	I054-107				
Project Name:	Plant Yates - Ash Management Area	By:	MMT	Date	06/24/20
Subject: Perimeter Ditch Calculations		Checked:	JEH	Date	06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

Inside Perimeter Ditch B

Typical Cross Section
NTS

Inside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	4.0	8.0	8.00	0.0090	0.025	288.00	4.35	**4324.33**

Maximum possible flow calculation

Maximum drainage area leading to ditch B 16.20 Acres

Q(max) = C*I*A

Assume:

C = 0.95 (ClosureTurf™)

Tc = 5 minutes (assuming developed conditions)

I = 11.7 in/hr (100 yr storm using Tc = 5 min),

Q(max) = 180.06 cfs

Therefore, ClosureTurf® lined perimeter ditch can handle flow from 100 year storm event.

180.06 cfs << 4324.33 cfs

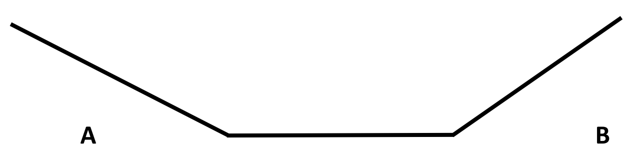
PERIMETER DITCH CAPACITY CALCULATIONS - 25 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area | By: MMT | Date 06/24/20
Subject: Perimeter Ditch Calculations | Checked: JEH | Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

Inside Perimeter Ditch C

Typical Cross Section
NTS



Inside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	4.0	8.0	8.00	0.0090	0.025	288.00	4.35	**4324.33**

Maximum possible flow calculation

Maximum drainage area leading to ditch C 10.60 Acres

Q(max) = C*I*A

Assume:

C = 0.95 (ClosureTurf™)

Tc = 5 minutes (assuming developed conditions)

I = 9.24 in/hr (25 yr storm using Tc = 5 min),

Q(max) = 93.05 cfs

Therefore, ClosureTurf® lined perimeter ditch can handle flow from 25 year storm event.
93.05 cfs << 4324.33 cfs

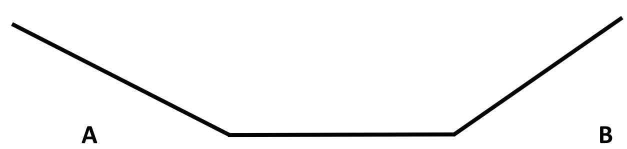
PERIMETER DITCH CAPACITY CALCULATIONS - 100 YEAR STORM EVENT

Project #:	I054-107				
Project Name:	Plant Yates - Ash Management Area	By:	MMT	Date	06/24/20
Subject: Perimeter Ditch Calculations		Checked:	JEH	Date	06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

Inside Perimeter Ditch C

Typical Cross Section
NTS



Inside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	4.0	8.0	8.00	0.0090	0.025	288.00	4.35	**4324.33**

Maximum possible flow calculation

Maximum drainage area leading to ditch C 10.60 Acres

Q(max) = C*I*A

Assume:

C = 0.95 (ClosureTurf^{TM})

Tc = 5 minutes (assuming developed conditions)

I = 11.7 in/hr (100 yr storm using Tc = 5 min),

Q(max) = 117.82 cfs

Therefore, ClosureTurf® lined perimeter ditch can handle flow from 100 year storm event.

117.82 cfs << 4324.33 cfs

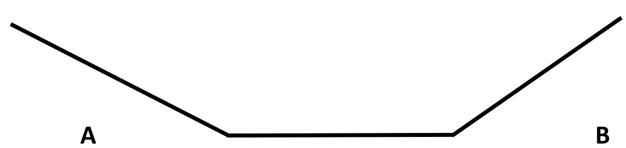
PERIMETER DITCH CAPACITY CALCULATIONS - 25 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area By: MMT Date 06/24/20
Subject: Perimeter Ditch Calculations Checked: JEH Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

<u>Inside Perimeter Ditch D</u>

Typical Cross Section
NTS



Inside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	4.0	8.0	8.00	0.0090	0.025	288.00	4.35	**4324.33**

<u>Maximum possible flow calculation</u>

Maximum drainage area leading to ditch D 8.10 Acres

Q(max) = C*I*A

Assume:

C = 0.95 (ClosureTurf™)
Tc = 5 minutes (assuming developed conditions)
I = 9.24 in/hr (25 yr storm using Tc = 5 min),

Q(max) = 71.10 cfs

Therefore, ClosureTurf® lined perimeter ditch can handle flow from 25 year storm event.
71.10 cfs << 4324.33 cfs

PERIMETER DITCH CAPACITY CALCULATIONS - 100 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area   By: MMT   Date 06/24/20
Subject: Perimeter Ditch Calculations   Checked: JEH   Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

Inside Perimeter Ditch D

Typical Cross Section
NTS

Inside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	4.0	8.0	8.00	0.0090	0.025	288.00	4.35	**4324.33**

Maximum possible flow calculation

Maximum drainage area leading to ditch D   8.10 Acres

Q(max) = C*I*A

Assume:

C = 0.95 (ClosureTurf™)
Tc = 5 minutes (assuming developed conditions)
I = 11.7 in/hr (100 yr storm using Tc = 5 min),

Q(max) = 90.03 cfs

Therefore, ClosureTurf® lined perimeter ditch can handle flow from 100 year storm event.
90.03 cfs << 4324.33 cfs

PERIMETER DITCH CAPACITY CALCULATIONS - 25 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area   By: MMT   Date 06/24/20
Subject: Perimeter Ditch Calculations   Checked: JEH   Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

Inside Perimeter Ditch E

Typical Cross Section
NTS

Inside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	4.0	8.0	8.00	0.0025	0.025	288.00	4.35	**2279.12**

Maximum possible flow calculation

Maximum drainage area leading to ditch E   36.80 Acres

Q(max) = C*I*A

Assume:

C = 0.95 (ClosureTurf™)
Tc = 5 minutes (assuming developed conditions)
I = 9.24 in/hr (25 yr storm using Tc = 5 min),

Q(max) = 323.03 cfs

Therefore, ClosureTurf® lined perimeter ditch can handle flow from 25 year storm event.
323.03 cfs << 2279.12 cfs

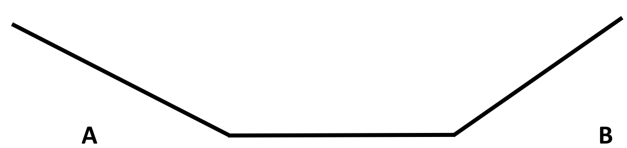
PERIMETER DITCH CAPACITY CALCULATIONS - 100 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area — By: MMT — Date 06/24/20
Subject: Perimeter Ditch Calculations — Checked: JEH — Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

<u>Inside Perimeter Ditch E</u>

Typical Cross Section
NTS



Inside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	4.0	8.0	8.00	0.0025	0.025	288.00	4.35	**2279.12**

<u>Maximum possible flow calculation</u>

Maximum drainage area leading to ditch E 36.80 Acres

Q(max) = C*I*A

Assume:

C = 0.95 (ClosureTurf™)
Tc = 5 minutes (assuming developed conditions)
I = 11.7 in/hr (100 yr storm using Tc = 5 min),

Q(max) = 409.03 cfs

Therefore, ClosureTurf® lined perimeter ditch can handle flow from 100 year storm event.
409.03 cfs << 2279.12 cfs

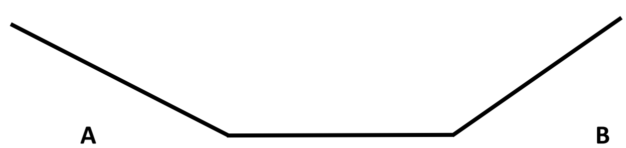
PERIMETER DITCH CAPACITY CALCULATIONS - 25 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area — By: MMT — Date 06/24/20
Subject: Perimeter Ditch Calculations — Checked: JEH — Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

<u>Inside Perimeter Ditch F</u>

Typical Cross Section
NTS



Inside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	4.0	8.0	8.00	0.0026	0.025	288.00	4.35	**2324.26**

<u>Maximum possible flow calculation</u>

Maximum drainage area leading to ditch F 40.80 Acres

Q(max) = C*I*A

Assume:

C = 0.95 (ClosureTurf^{TM})
Tc = 5 minutes (assuming developed conditions)
I = 9.24 in/hr (25 yr storm using Tc = 5 min),

Q(max) = 358.14 cfs

Therefore, ClosureTurf® lined perimeter ditch can handle flow from 25 year storm event.
358.14 cfs << 2324.26 cfs

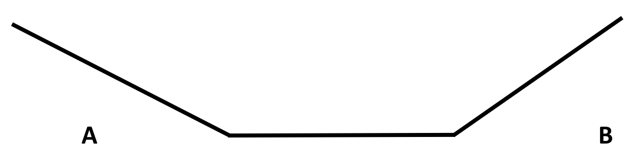
PERIMETER DITCH CAPACITY CALCULATIONS - 100 YEAR STORM EVENT

Project #:	I054-107				
Project Name:	Plant Yates - Ash Management Area	By:	MMT	Date	06/24/20
Subject: Perimeter Ditch Calculations		Checked:	JEH	Date	06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

<u>Inside Perimeter Ditch F</u>

Typical Cross Section
NTS



Inside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	4.0	8.0	8.00	0.0026	0.025	288.00	4.35	**2324.26**

<u>Maximum possible flow calculation</u>

Maximum drainage area leading to ditch F 40.80 Acres

Q(max) = C*I*A

Assume:

C = 0.95 (ClosureTurf™)

Tc = 5 minutes (assuming developed conditions)

I = 11.7 in/hr (100 yr storm using Tc = 5 min),

Q(max) = 453.49 cfs

Therefore, ClosureTurf® lined perimeter ditch can handle flow from 100 year storm event.

453.49 cfs << 2324.26 cfs

PERIMETER DITCH CAPACITY CALCULATIONS - 25 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area By: MMT Date 06/24/20
Subject: Perimeter Ditch Calculations Checked: JEH Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

<u>Inside Perimeter Ditch G</u>

Typical Cross Section
NTS

Inside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	4.0	8.0	8.00	0.0036	0.025	288.00	4.35	**2734.95**

<u>Maximum possible flow calculation</u>

Maximum drainage area leading to ditch G 8.40 Acres

Q(max) = C*I*A

Assume:

C = 0.95 (ClosureTurf™)
Tc = 5 minutes (assuming developed conditions)
I = 9.24 in/hr (25 yr storm using Tc = 5 min),

Q(max) = 73.74 cfs

Therefore, ClosureTurf® lined perimeter ditch can handle flow from 25 year storm event.
73.74 cfs << 2734.95 cfs

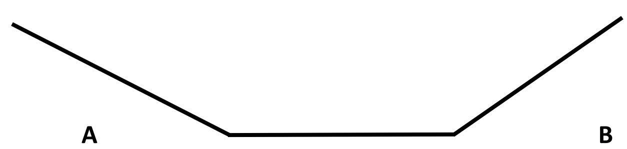
PERIMETER DITCH CAPACITY CALCULATIONS - 100 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area — By: MMT — Date 06/24/20
Subject: Perimeter Ditch Calculations — Checked: JEH — Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

Inside Perimeter Ditch G

Typical Cross Section
NTS



Inside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	4.0	8.0	8.00	0.0036	0.025	288.00	4.35	**2734.95**

Maximum possible flow calculation

Maximum drainage area leading to ditch G 8.40 Acres

Q(max) = C*I*A

Assume:

C = 0.95 (ClosureTurf™)

Tc = 5 minutes (assuming developed conditions)

I = 11.7 in/hr (100 yr storm using Tc = 5 min),

Q(max) = 93.37 cfs

Therefore, ClosureTurf® lined perimeter ditch can handle flow from 100 year storm event.
93.37 cfs << 2734.95 cfs

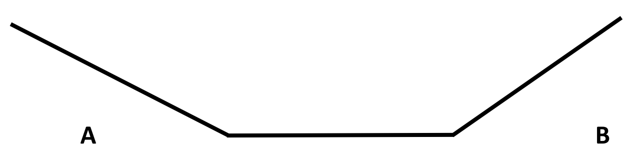
PERIMETER DITCH CAPACITY CALCULATIONS - 25 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area — By: MMT — Date 06/24/20
Subject: Perimeter Ditch Calculations — Checked: JEH — Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

<u>**Inside Perimeter Ditch H**</u>

Typical Cross Section
NTS



Inside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	4.0	8.0	8.00	0.0410	0.025	288.00	4.35	**9229.75**

<u>Maximum possible flow calculation</u>

Maximum drainage area leading to ditch H 20.80 Acres

Q(max) = C*I*A

Assume:
C = 0.95 (ClosureTurf™)
Tc = 5 minutes (assuming developed conditions)
I = 9.24 in/hr (25 yr storm using Tc = 5 min),

Q(max) = 182.58 cfs

Therefore, ClosureTurf® lined perimeter ditch can handle flow from 25 year storm event.
182.58 cfs << 9229.75 cfs

PERIMETER DITCH CAPACITY CALCULATIONS - 100 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area By: MMT Date 06/24/20
Subject: Perimeter Ditch Calculations Checked: JEH Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

<u>Inside Perimeter Ditch H</u>

Typical Cross Section
NTS

Inside Perimeter Ditch Capacity Calculation									
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	4.0	8.0	8.00	0.0410	0.025	288.00	4.35	**9229.75**

<u>Maximum possible flow calculation</u>

Maximum drainage area leading to ditch H 20.80 Acres

Q(max) = C*I*A

Assume:

C = 0.95 (ClosureTurf™)
Tc = 5 minutes (assuming developed conditions)
I = 11.7 in/hr (100 yr storm using Tc = 5 min),

Q(max) = 231.19 cfs

Therefore, ClosureTurf® lined perimeter ditch can handle flow from 100 year storm event.
231.19 cfs << 9229.75 cfs

PERIMETER DITCH CAPACITY CALCULATIONS - 25 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area By: MMT Date 06/24/20
Subject: Perimeter Ditch Calculations Checked: JEH Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

Inside Perimeter Ditch I

Typical Cross Section
NTS

Inside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	4.0	8.0	8.00	0.0080	0.025	288.00	4.35	**4077.02**

Maximum possible flow calculation

Maximum drainage area leading to ditch I 7.60 Acres

Q(max) = C*I*A

Assume:

C = 0.95 (ClosureTurf™)

Tc = 5 minutes (assuming developed conditions)

I = 9.24 in/hr (25 yr storm using Tc = 5 min),

Q(max) = 66.71 cfs

Therefore, ClosureTurf® lined perimeter ditch can handle flow from 25 year storm event.
66.71 cfs << 4077.02 cfs

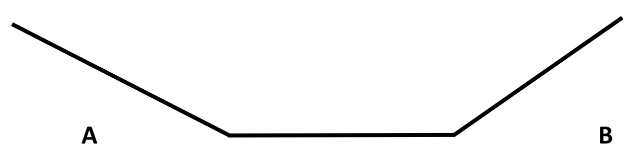
PERIMETER DITCH CAPACITY CALCULATIONS - 100 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area — By: MMT — Date 06/24/20
Subject: Perimeter Ditch Calculations — Checked: JEH — Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

<u>Inside Perimeter Ditch I</u>

Typical Cross Section
NTS



Inside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	4.0	8.0	8.00	0.0080	0.025	288.00	4.35	**4077.02**

<u>Maximum possible flow calculation</u>

Maximum drainage area leading to ditch I 7.60 Acres

Q(max) = C*I*A

Assume:

C = 0.95 (ClosureTurf™)
Tc = 5 minutes (assuming developed conditions)
I = 11.7 in/hr (100 yr storm using Tc = 5 min),

Q(max) = 84.47 cfs

Therefore, ClosureTurf® lined perimeter ditch can handle flow from 100 year storm event.
84.47 cfs << 4077.02 cfs

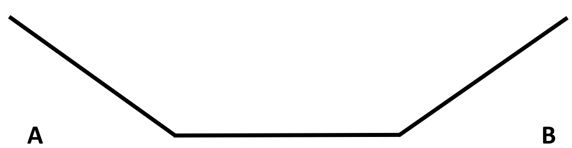
PERIMETER DITCH CAPACITY CALCULATIONS - 25 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area | By: MMT | Date 06/24/20
Subject: Perimeter Ditch Calculations | Checked: JEH | Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

Outside Perimeter Ditch A

Typical Cross Section
NTS



Outside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	3.0	12.0	8.00	0.0205	0.035	288.00	4.60	**4843.01**

Maximum possible flow calculation

Maximum drainage area leading to ditch A 3.38 Acres

Q(max) = C*I*A

Assume:
C = 0.6 (rolling, loamy, commercial)
Tc = 10 minutes (assuming developed conditions)
I = 6.76 in/hr (25 yr storm using Tc = 10 min),

Q(max) = 13.71 cfs

Therefore, grass lined perimeter ditch can handle flow from 25 year storm event.
13.71 cfs << 4843.01 cfs

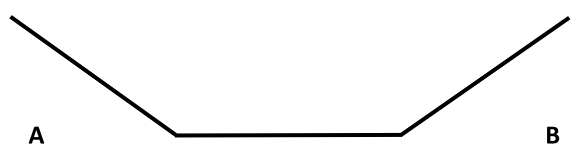
PERIMETER DITCH CAPACITY CALCULATIONS - 100 YEAR STORM EVENT

Project #:	I054-107				
Project Name:	Plant Yates - Ash Management Area	By:	MMT	Date	06/24/20
Subject: Perimeter Ditch Calculations		Checked:	JEH	Date	06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

Outside Perimeter Ditch A

Typical Cross Section
NTS



Outside Perimeter Ditch Capacity Calculation									
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**	
3.0	3.0	12.0	8.00	0.0205	0.035	288.00	4.60	**4843.01**	

Maximum possible flow calculation

Maximum drainage area leading to ditch A 3.38 Acres

Q(max) = C*I*A

Assume:

C = 0.6 (rolling, loamy, commercial),

Tc = 10 minutes (assuming developed conditions)

I = 8.56 in/hr (100 yr storm using Tc = 10 min),

Q(max) = 17.36 cfs

Therefore, grass lined perimeter ditch can handle flow from 100 year storm event.

17.36 cfs << 4843.01 cfs

PERIMETER DITCH CAPACITY CALCULATIONS - 25 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area By: MMT Date 06/24/20
Subject: Perimeter Ditch Calculations Checked: JEH Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

Outside Perimeter Ditch B

Typical Cross Section
NTS

Outside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	3.0	12.0	8.00	0.0028	0.035	288.00	4.60	**1789.85**

Maximum possible flow calculation

Maximum drainage area leading to ditch B 11.62 Acres

Q(max) = C*I*A

Assume:
C = 0.6 (rolling, loamy, commercial)
Tc = 10 minutes (assuming developed conditions)
I = 6.76 in/hr (25 yr storm using Tc = 10 min),

Q(max) = 47.13 cfs

Therefore, grass lined perimeter ditch can handle flow from 25 year storm event.
47.13 cfs << 1789.85 cfs

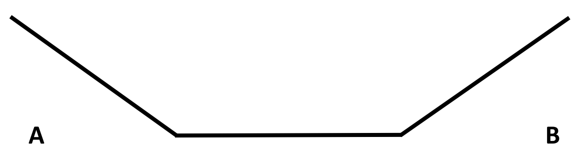
PERIMETER DITCH CAPACITY CALCULATIONS - 100 YEAR STORM EVENT

Project #:	I054-107				
Project Name:	Plant Yates - Ash Management Area	By:	MMT	Date	06/24/20
Subject: Perimeter Ditch Calculations		Checked:	JEH	Date	06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

<u>**Outside Perimeter Ditch B**</u>

Typical Cross Section
NTS



Outside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	3.0	12.0	8.00	0.0028	0.035	288.00	4.60	**1789.85**

<u>Maximum possible flow calculation</u>

Maximum drainage area leading to ditch B 11.62 Acres

Q(max) = C*I*A

Assume:

C = 0.6 (rolling, loamy, commercial),

Tc = 10 minutes (assuming developed conditions)

I = 8.56 in/hr (100 yr storm using Tc = 10 min),

Q(max) = 59.68 cfs

Therefore, grass lined perimeter ditch can handle flow from 100 year storm event.

59.68 cfs << 1789.85 cfs

PERIMETER DITCH CAPACITY CALCULATIONS - 25 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area By: MMT Date 06/24/20
Subject: Perimeter Ditch Calculations Checked: JEH Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

Outside Perimeter Ditch C

Typical Cross Section
NTS

Outside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	3.0	12.0	8.00	0.0028	0.035	288.00	4.60	**1789.85**

Maximum possible flow calculation

Maximum drainage area leading to ditch C 33.61 Acres

Q(max) = C*I*A

Assume:

C = 0.6 (rolling, loamy, commercial)
Tc = 10 minutes (assuming developed conditions)
I = 6.76 in/hr (25 yr storm using Tc = 10 min),

Q(max) = 136.32 cfs

Therefore, grass lined perimeter ditch can handle flow from 25 year storm event.
136.32 cfs << 1789.85 cfs

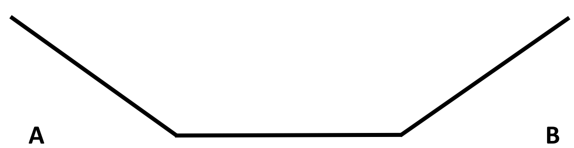
PERIMETER DITCH CAPACITY CALCULATIONS - 100 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area — By: MMT — Date 06/24/20
Subject: Perimeter Ditch Calculations — Checked: JEH — Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

<u>Outside Perimeter Ditch C</u>

Typical Cross Section
NTS



Outside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	3.0	12.0	8.00	0.0028	0.035	288.00	4.60	**1789.85**

<u>Maximum possible flow calculation</u>

Maximum drainage area leading to ditch C 33.61 Acres

Q(max) = C*I*A

Assume:

C = 0.6 (rolling, loamy, commercial),
Tc = 10 minutes (assuming developed conditions)
I = 8.56 in/hr (100 yr storm using Tc = 10 min),

Q(max) = 172.62 cfs

Therefore, grass lined perimeter ditch can handle flow from 100 year storm event.
172.62 cfs << 1789.85 cfs

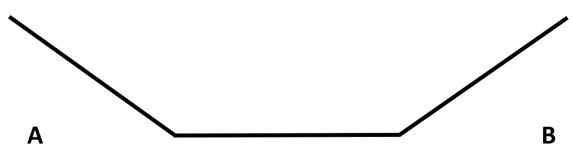
PERIMETER DITCH CAPACITY CALCULATIONS - 25 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area — By: MMT — Date 06/24/20
Subject: Perimeter Ditch Calculations — Checked: JEH — Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

Outside Perimeter Ditch D

Typical Cross Section
NTS



Outside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	3.0	12.0	8.00	0.0120	0.035	288.00	4.60	**3705.35**

Maximum possible flow calculation

Maximum drainage area leading to ditch D 34.06 Acres

Q(max) = C*I*A

Assume:

C = 0.6 (rolling, loamy, commercial)
Tc = 10 minutes (assuming developed conditions)
I = 6.76 in/hr (25 yr storm using Tc = 10 min),

Q(max) = 138.15 cfs

Therefore, grass lined perimeter ditch can handle flow from 25 year storm event.
138.15 cfs << 3705.35 cfs

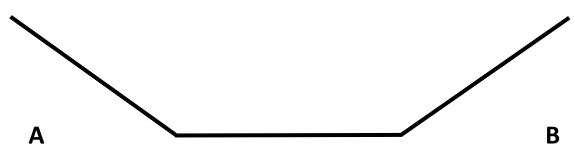
PERIMETER DITCH CAPACITY CALCULATIONS - 100 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area | By: MMT | Date 06/24/20
Subject: Perimeter Ditch Calculations | Checked: JEH | Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

<u>Outside Perimeter Ditch D</u>

Typical Cross Section
NTS



Outside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	3.0	12.0	8.00	0.0120	0.035	288.00	4.60	**3705.35**

<u>Maximum possible flow calculation</u>

Maximum drainage area leading to ditch D 34.06 Acres

Q(max) = C*I*A

Assume:

C = 0.6 (rolling, loamy, commercial),
Tc = 10 minutes (assuming developed conditions)
I = 8.56 in/hr (100 yr storm using Tc = 10 min),

Q(max) = 174.93 cfs

Therefore, grass lined perimeter ditch can handle flow from 100 year storm event.
174.93 cfs << 3705.35 cfs

PERIMETER DITCH CAPACITY CALCULATIONS - 25 YEAR STORM EVENT

Project #:	I054-107				
Project Name:	Plant Yates - Ash Management Area	By:	MMT	Date	06/24/20
Subject: Perimeter Ditch Calculations		Checked:	JEH	Date	06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

<u>**Outside Perimeter Ditch E**</u>

Typical Cross Section
NTS

Outside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	3.0	12.0	8.00	0.0096	0.035	288.00	4.60	**3314.16**

<u>Maximum possible flow calculation</u>

Maximum drainage area leading to ditch E 49.37 Acres

Q(max) = C*I*A

Assume:

C = 0.6 (rolling, loamy, commercial)

Tc = 10 minutes (assuming developed conditions)

I = 6.76 in/hr (25 yr storm using Tc = 10 min),

Q(max) = 200.24 cfs

Therefore, grass lined perimeter ditch can handle flow from 25 year storm event.

200.24 cfs << 3314.16 cfs

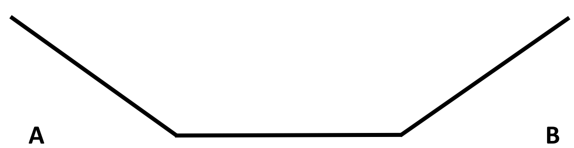
PERIMETER DITCH CAPACITY CALCULATIONS - 100 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area — By: MMT — Date 06/24/20
Subject: Perimeter Ditch Calculations — Checked: JEH — Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

Outside Perimeter Ditch E

Typical Cross Section
NTS



Outside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	3.0	12.0	8.00	0.0096	0.035	288.00	4.60	**3314.16**

Maximum possible flow calculation

Maximum drainage area leading to ditch E 49.37 Acres

Q(max) = C*I*A

Assume:

C = 0.6 (rolling, loamy, commercial),
Tc = 10 minutes (assuming developed conditions)
I = 8.56 in/hr (100 yr storm using Tc = 10 min),

Q(max) = 253.56 cfs

Therefore, grass lined perimeter ditch can handle flow from 100 year storm event.
253.56 cfs << 3314.16 cfs

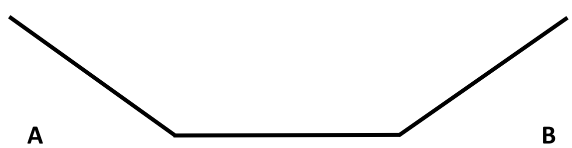
PERIMETER DITCH CAPACITY CALCULATIONS - 25 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area | By: MMT | Date 06/24/20
Subject: Perimeter Ditch Calculations | Checked: JEH | Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

Outside Perimeter Ditch F

Typical Cross Section
NTS



Outside Perimeter Ditch Capacity Calculation								
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**
3.0	3.0	6.0	8.00	0.0070	0.035	240.00	4.24	**2233.53**

Maximum possible flow calculation

Maximum drainage area leading to ditch F 1.37 Acres

Q(max) = C*I*A

Assume:

C = 0.6 (rolling, loamy, commercial)
Tc = 5 minutes (assuming developed conditions)
I = 6.76 in/hr (25 yr storm using Tc = 10 min),

Q(max) = 5.56 cfs

Therefore,ClosureTurf® lined perimeter ditch can handle flow from 25 year storm event.
5.56 cfs << 2233.53 cfs

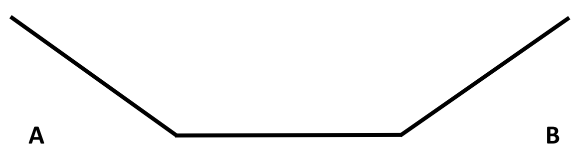
PERIMETER DITCH CAPACITY CALCULATIONS - 100 YEAR STORM EVENT

Project #: I054-107
Project Name: Plant Yates - Ash Management Area   By: MMT   Date 06/24/20
Subject: Perimeter Ditch Calculations   Checked: JEH   Date 06/25/20

Calculate the maximum flow in ditches, and check capacity to carry these flows.

<u>Outside Perimeter Ditch F</u>

Typical Cross Section
NTS



Outside Perimeter Ditch Capacity Calculation									
Side Slope A (x:1)	Side Slope B (x:1)	Bottom Width (ft)	Depth (ft)	Minimum Slope (ft/ft)	Manning 's Number	Area (s.f.)	Hydraulic Radius (ft)	**Maximum Flow (cfs)**	
3.0	3.0	6.0	8.00	0.0070	0.035	240.00	4.24	**2233.53**	

<u>Maximum possible flow calculation</u>

Maximum drainage area leading to ditch F   1.37 Acres

Q(max) = C*I*A

Assume:

C = 0.6 (rolling, loamy, commercial),
Tc = 10 minutes (assuming developed conditions)
I = 8.56 in/hr (100 yr storm using Tc = 10 min),

Q(max) = 7.04 cfs

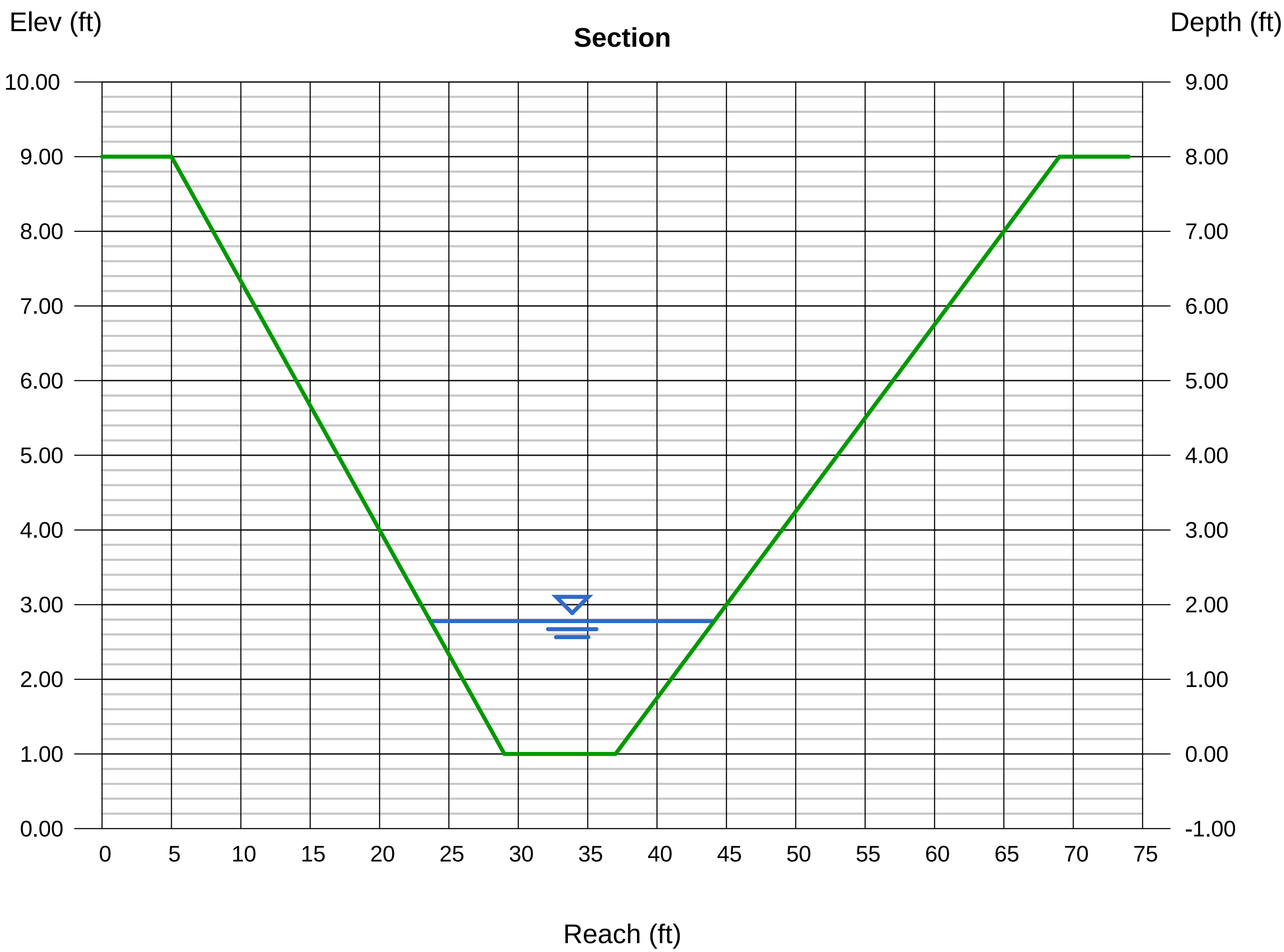
Therefore, grass lined terrace ditch can handle flow from 25 year storm event.
7.04 cfs << 2233.53 cfs

2.7 PERIMETER DITCH STABILITY CALCULATIONS

Channel Report

25 Yr - Inside Perimeter Ditch A

Trapezoidal		**Highlighted**	
Bottom Width (ft)	= 8.00	Depth (ft)	= 1.78
Side Slopes (z:1)	= 3.00, 4.00	Q (cfs)	= 85.15
Total Depth (ft)	= 8.00	Area (sqft)	= 25.33
Invert Elev (ft)	= 1.00	Velocity (ft/s)	= 3.36
Slope (%)	= 0.25	Wetted Perim (ft)	= 20.97
N-Value	= 0.025	Crit Depth, Yc (ft)	= 1.26
		Top Width (ft)	= 20.46
Calculations		EGL (ft)	= 1.96
Compute by:	Known Q		
Known Q (cfs)	= 85.15		

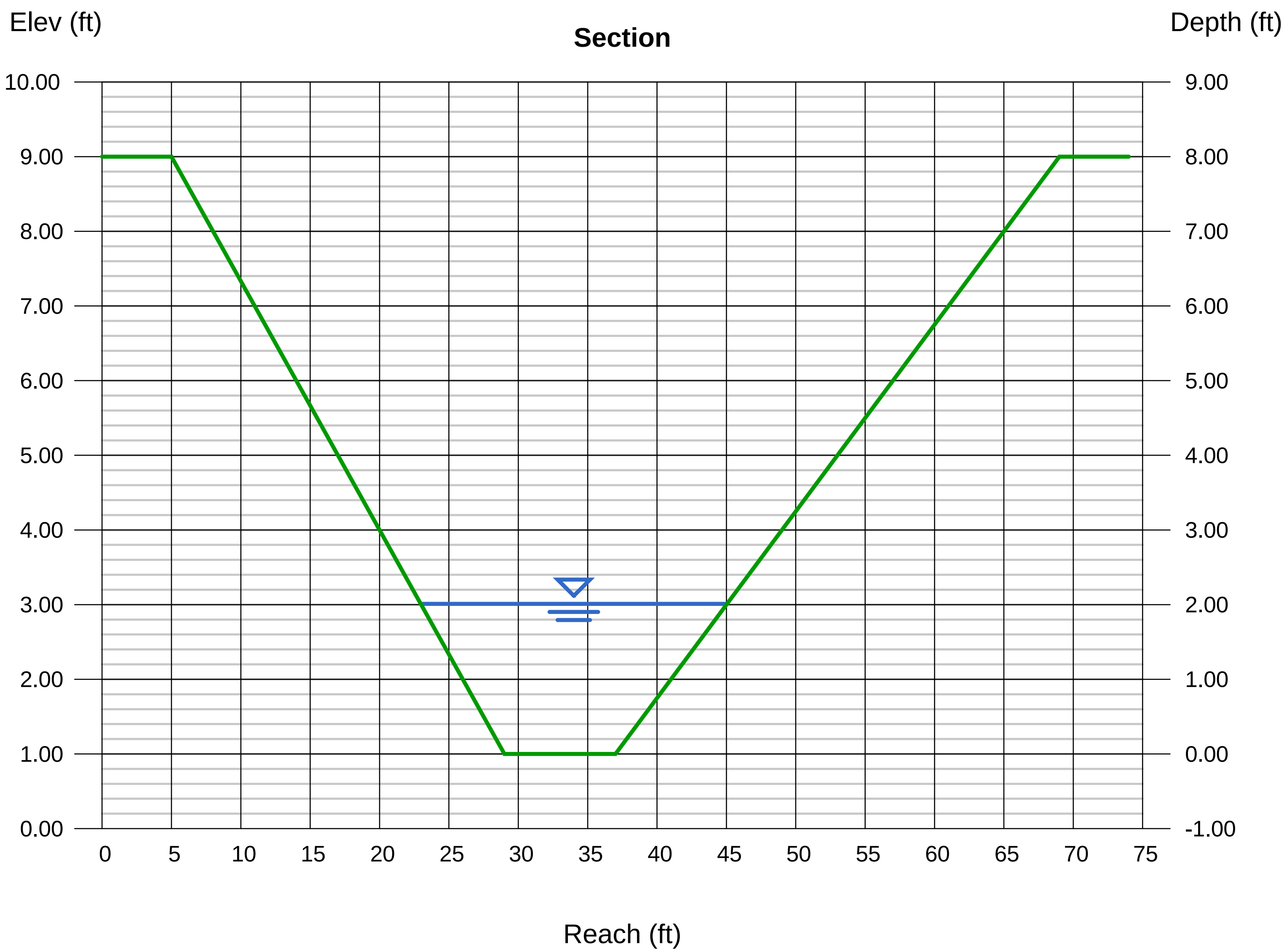


Channel Report

100 Yr - Inside Perimeter Ditch A

Trapezoidal	
Bottom Width (ft)	= 8.00
Side Slopes (z:1)	= 3.00, 4.00
Total Depth (ft)	= 8.00
Invert Elev (ft)	= 1.00
Slope (%)	= 0.25
N-Value	= 0.025
Calculations	
Compute by:	Known Q
Known Q (cfs)	= 107.82

Highlighted	
Depth (ft)	= 2.01
Q (cfs)	= 107.82
Area (sqft)	= 30.22
Velocity (ft/s)	= 3.57
Wetted Perim (ft)	= 22.64
Crit Depth, Yc (ft)	= 1.44
Top Width (ft)	= 22.07
EGL (ft)	= 2.21



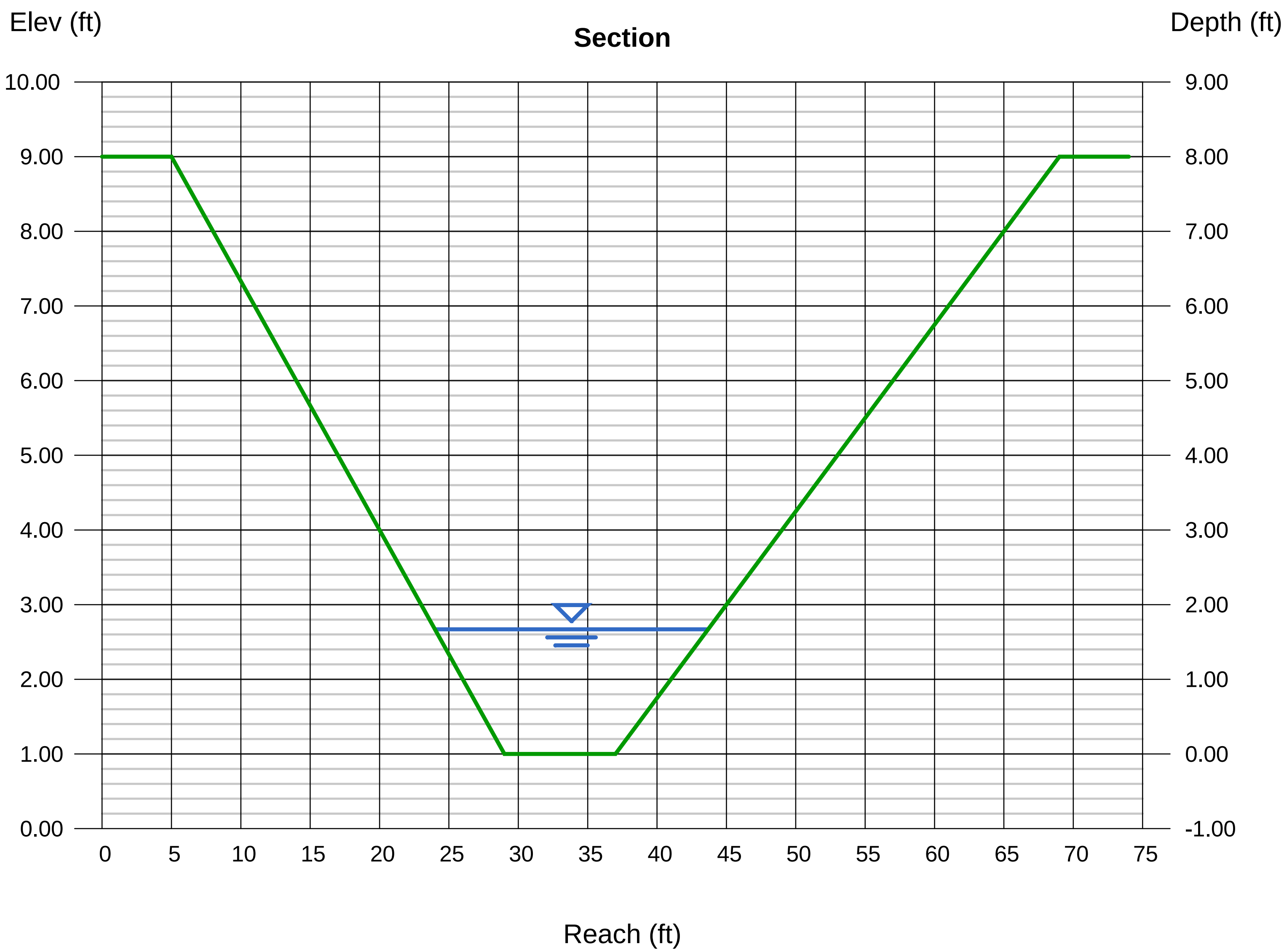
Channel Report

25 Yr - Inside Perimeter Ditch B

Trapezoidal	
Bottom Width (ft)	= 8.00
Side Slopes (z:1)	= 3.00, 4.00
Total Depth (ft)	= 8.00
Invert Elev (ft)	= 1.00
Slope (%)	= 0.90
N-Value	= 0.025

Calculations	
Compute by:	Known Q
Known Q (cfs)	= 142.20

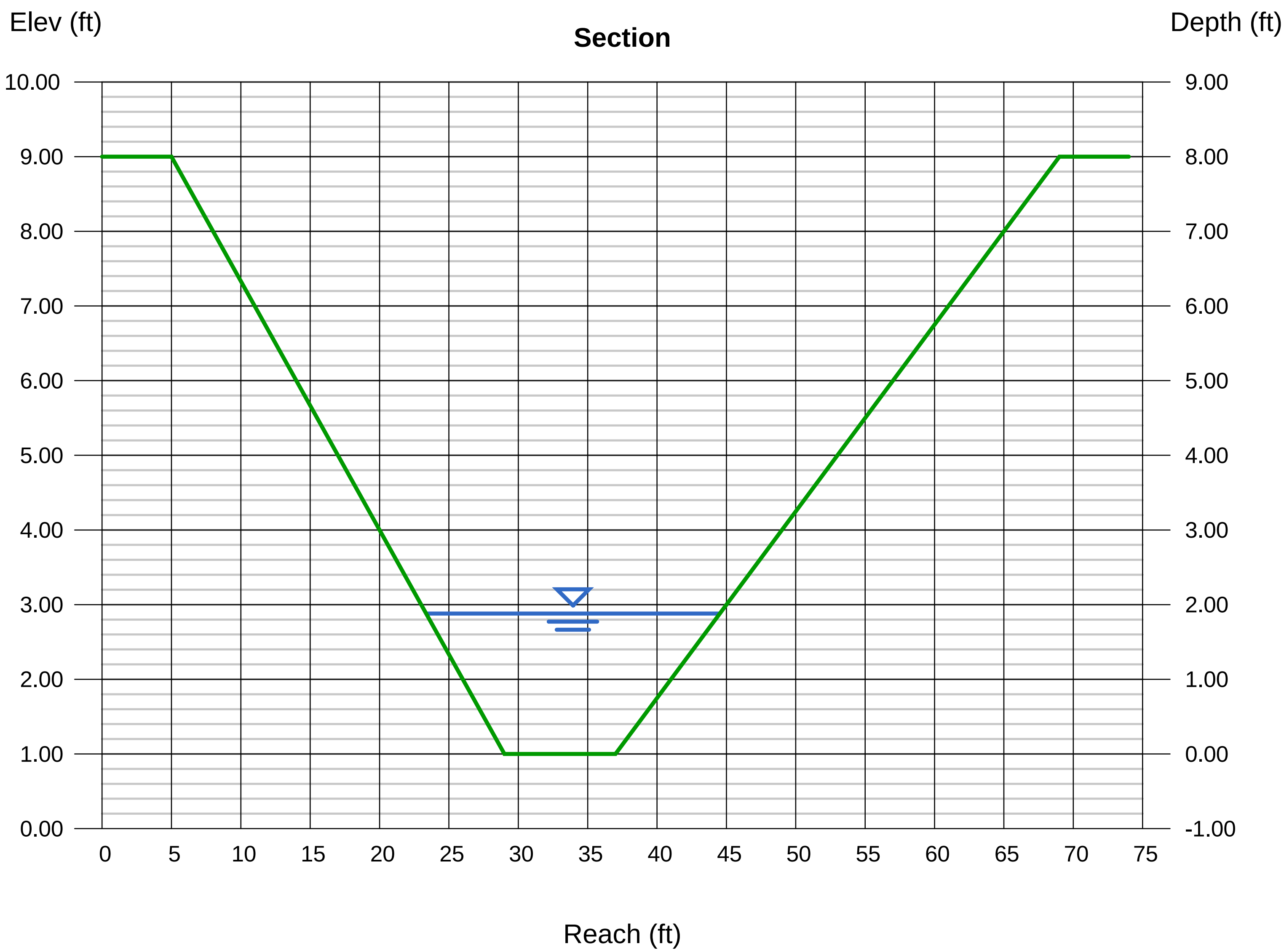
Highlighted	
Depth (ft)	= 1.67
Q (cfs)	= 142.20
Area (sqft)	= 23.12
Velocity (ft/s)	= 6.15
Wetted Perim (ft)	= 20.17
Crit Depth, Yc (ft)	= 1.68
Top Width (ft)	= 19.69
EGL (ft)	= 2.26



Channel Report

100 Yr - Inside Perimeter Ditch B

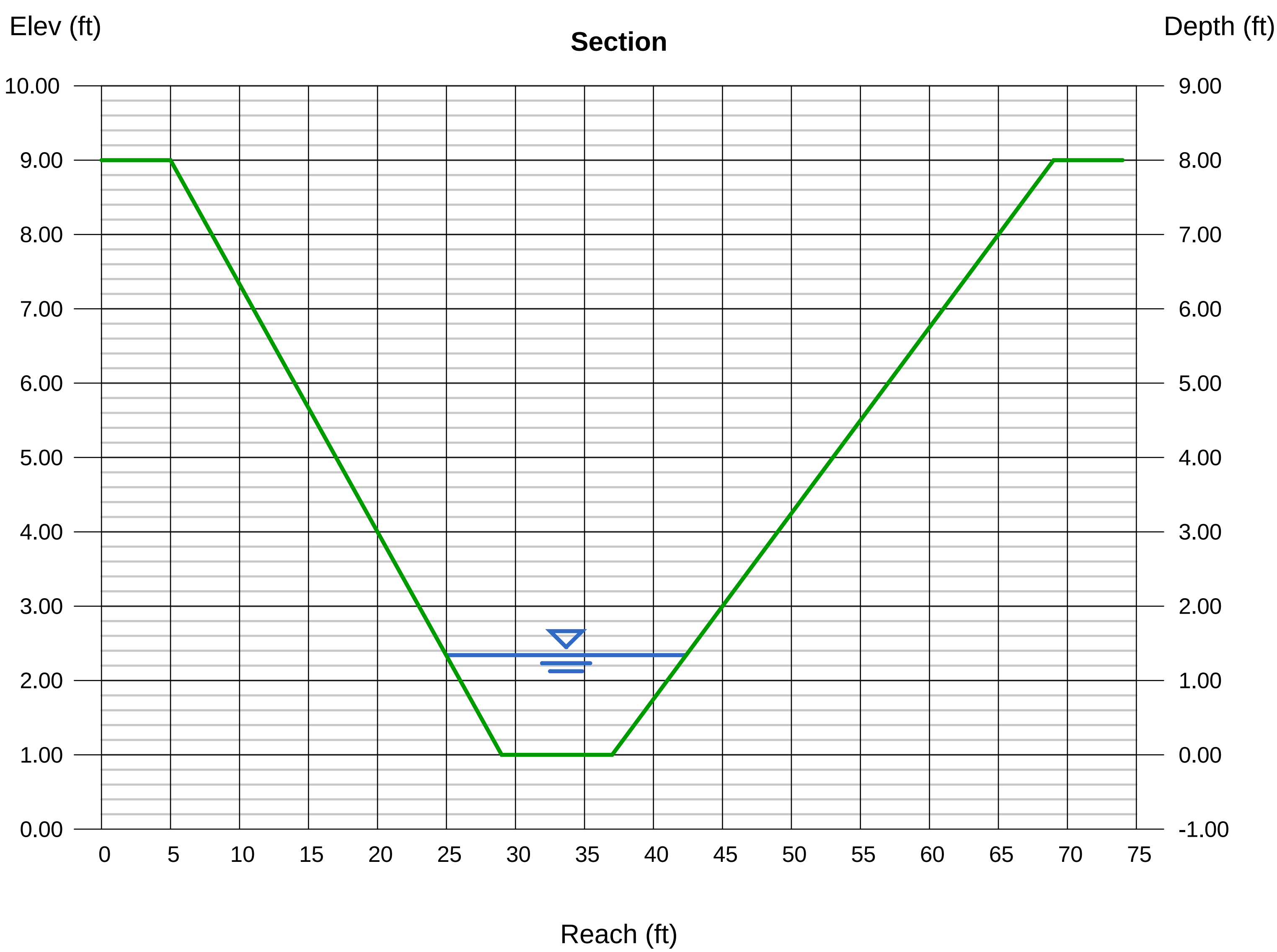
Trapezoidal		**Highlighted**	
Bottom Width (ft)	= 8.00	Depth (ft)	= 1.88
Side Slopes (z:1)	= 3.00, 4.00	Q (cfs)	= 180.06
Total Depth (ft)	= 8.00	Area (sqft)	= 27.41
Invert Elev (ft)	= 1.00	Velocity (ft/s)	= 6.57
Slope (%)	= 0.90	Wetted Perim (ft)	= 21.70
N-Value	= 0.025	Crit Depth, Yc (ft)	= 1.90
		Top Width (ft)	= 21.16
Calculations		EGL (ft)	= 2.55
Compute by:	Known Q		
Known Q (cfs)	= 180.06		



Channel Report

25 Yr - Inside Perimeter Ditch C

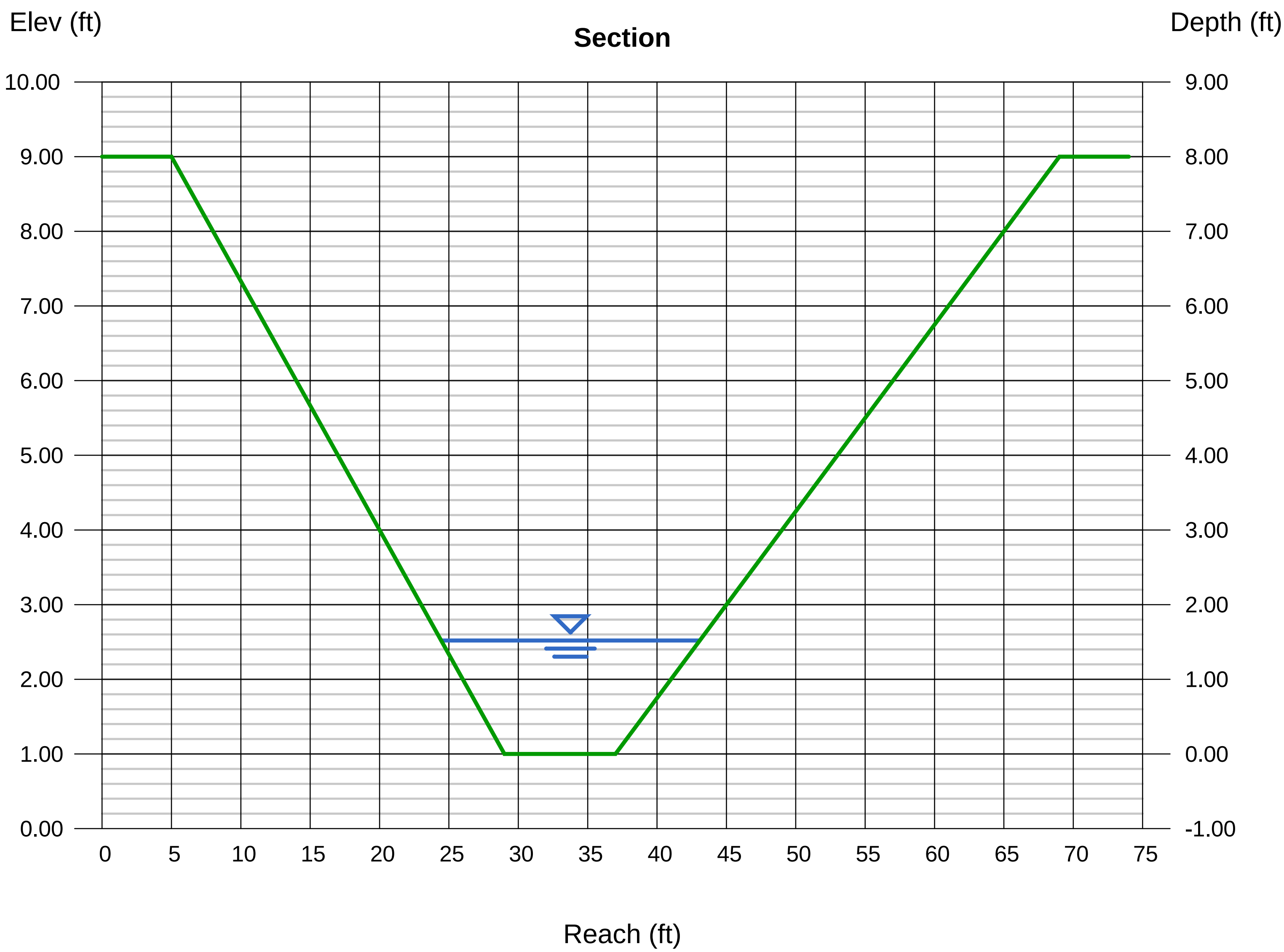
Trapezoidal		**Highlighted**	
Bottom Width (ft)	= 8.00	Depth (ft)	= 1.34
Side Slopes (z:1)	= 3.00, 4.00	Q (cfs)	= 93.05
Total Depth (ft)	= 8.00	Area (sqft)	= 17.00
Invert Elev (ft)	= 1.00	Velocity (ft/s)	= 5.47
Slope (%)	= 0.90	Wetted Perim (ft)	= 17.76
N-Value	= 0.025	Crit Depth, Yc (ft)	= 1.33
		Top Width (ft)	= 17.38
Calculations		EGL (ft)	= 1.81
Compute by:	Known Q		
Known Q (cfs)	= 93.05		



Channel Report

100 Yr - Inside Perimeter Ditch C

Trapezoidal		**Highlighted**	
Bottom Width (ft)	= 8.00	Depth (ft)	= 1.52
Side Slopes (z:1)	= 3.00, 4.00	Q (cfs)	= 117.82
Total Depth (ft)	= 8.00	Area (sqft)	= 20.25
Invert Elev (ft)	= 1.00	Velocity (ft/s)	= 5.82
Slope (%)	= 0.90	Wetted Perim (ft)	= 19.07
N-Value	= 0.025	Crit Depth, Yc (ft)	= 1.51
		Top Width (ft)	= 18.64
Calculations		EGL (ft)	= 2.05
Compute by:	Known Q		
Known Q (cfs)	= 117.82		

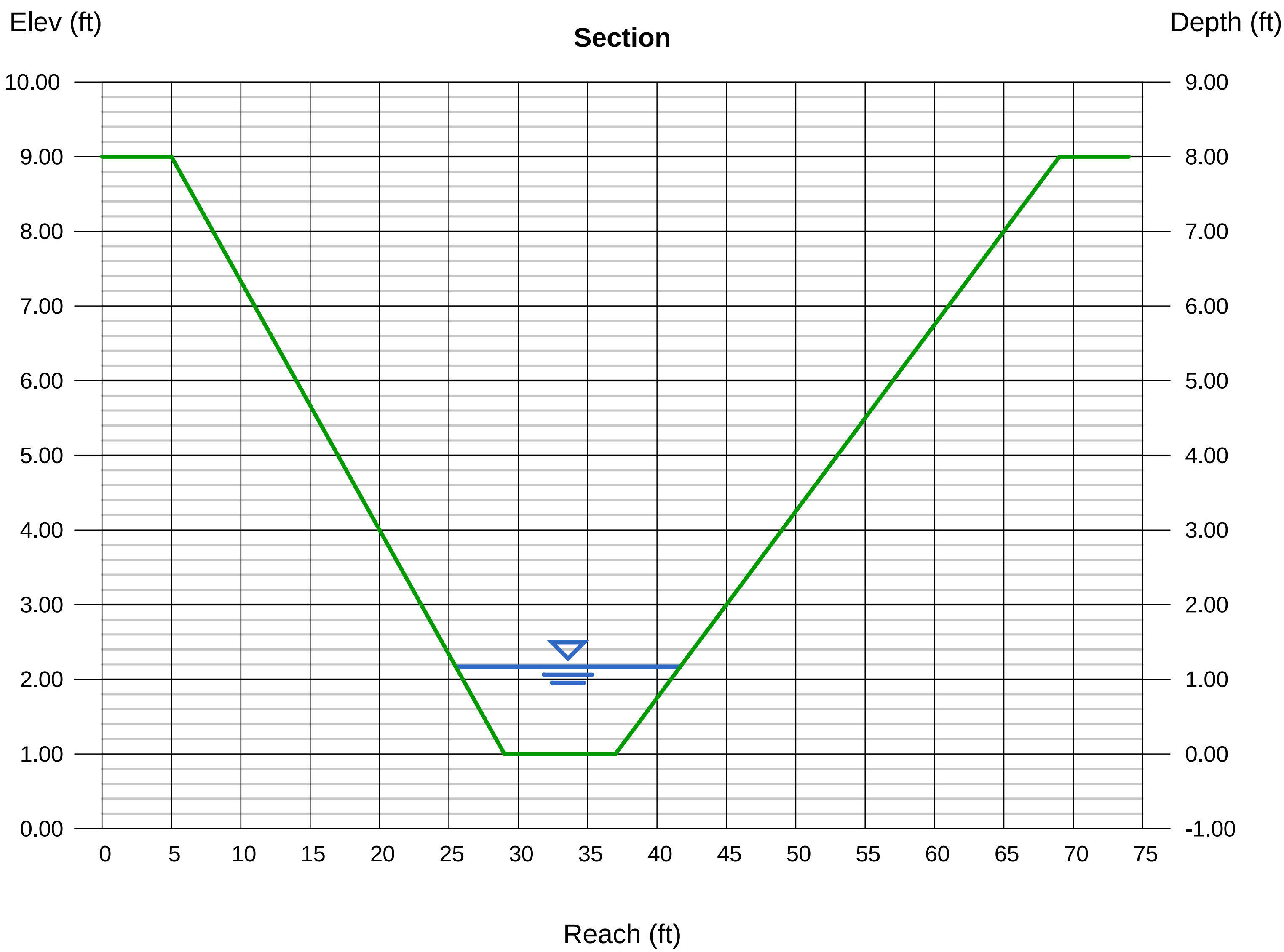


Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Friday, Jun 26 2020

25 Yr - Inside Perimeter Ditch D

Trapezoidal		**Highlighted**	
Bottom Width (ft)	= 8.00	Depth (ft)	= 1.17
Side Slopes (z:1)	= 3.00, 4.00	Q (cfs)	= 71.10
Total Depth (ft)	= 8.00	Area (sqft)	= 14.15
Invert Elev (ft)	= 1.00	Velocity (ft/s)	= 5.02
Slope (%)	= 0.90	Wetted Perim (ft)	= 16.52
N-Value	= 0.025	Crit Depth, Yc (ft)	= 1.14
		Top Width (ft)	= 16.19
Calculations		EGL (ft)	= 1.56
Compute by:	Known Q		
Known Q (cfs)	= 71.10		



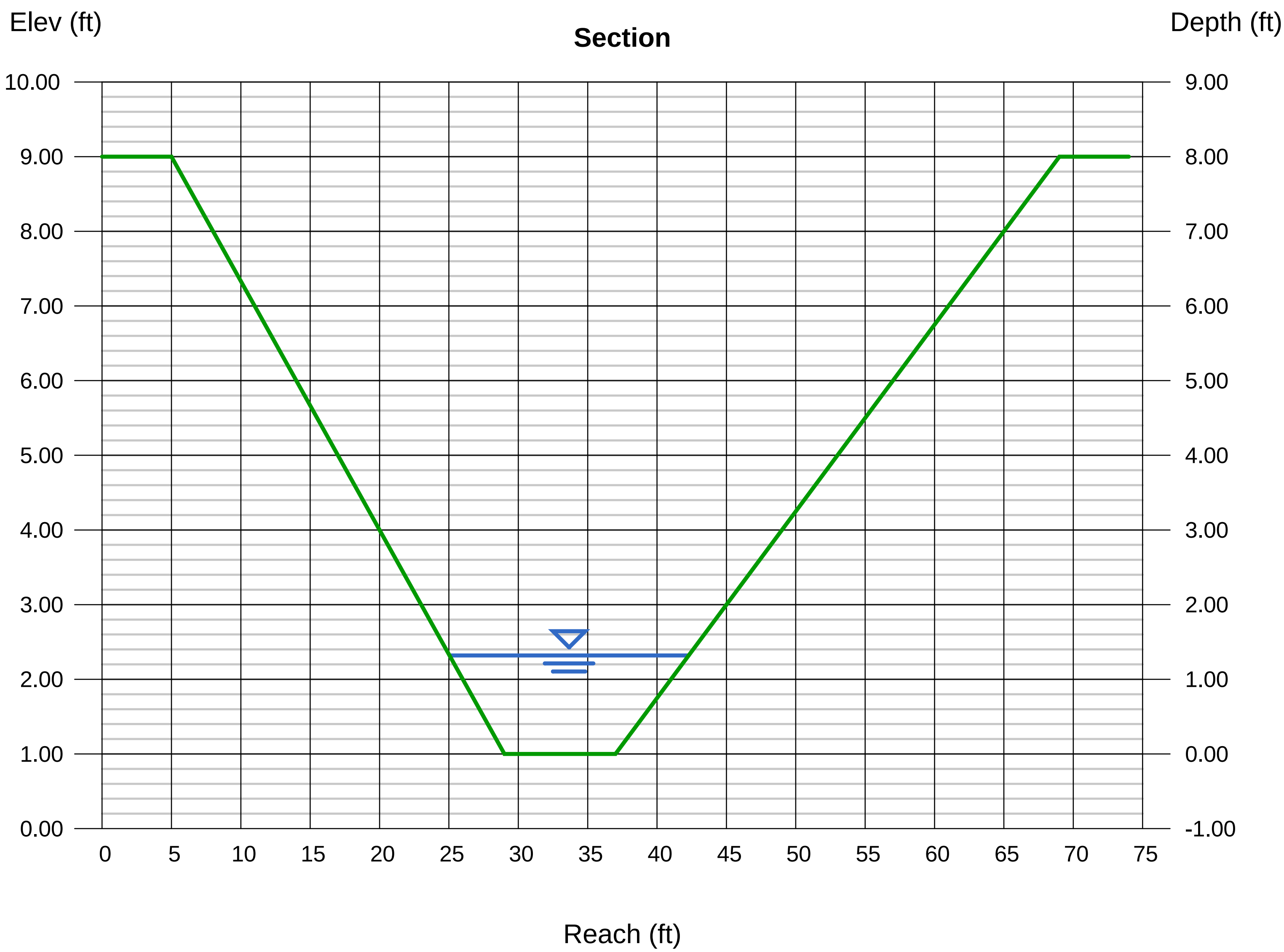
Channel Report

100 Yr - Inside Perimeter Ditch D

Trapezoidal	
Bottom Width (ft)	= 8.00
Side Slopes (z:1)	= 3.00, 4.00
Total Depth (ft)	= 8.00
Invert Elev (ft)	= 1.00
Slope (%)	= 0.90
N-Value	= 0.025

Calculations	
Compute by:	Known Q
Known Q (cfs)	= 90.03

Highlighted	
Depth (ft)	= 1.32
Q (cfs)	= 90.03
Area (sqft)	= 16.66
Velocity (ft/s)	= 5.40
Wetted Perim (ft)	= 17.62
Crit Depth, Yc (ft)	= 1.30
Top Width (ft)	= 17.24
EGL (ft)	= 1.77



Channel Report

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25 Yr - Inside Perimeter Ditch E

Trapezoidal

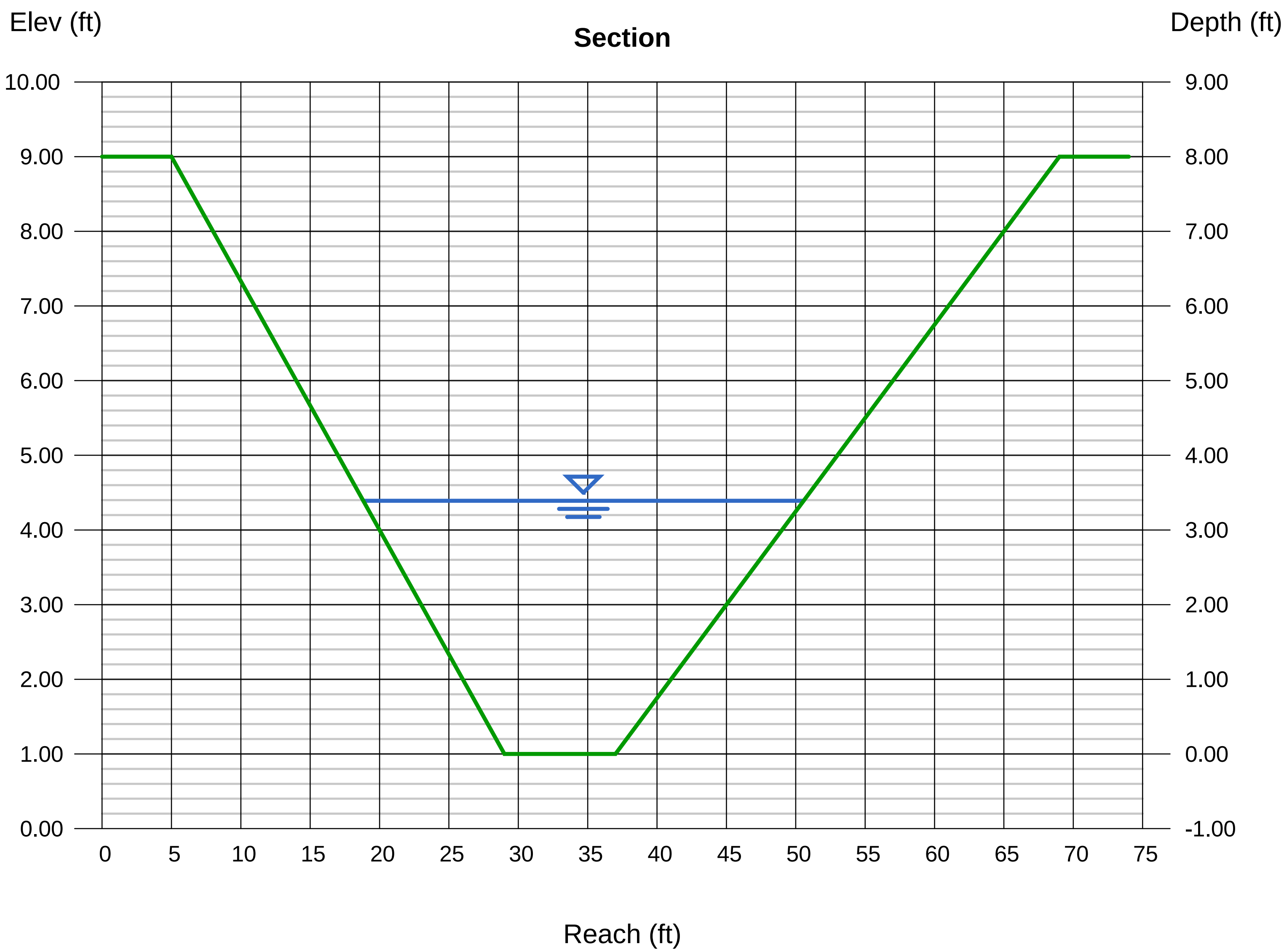
Bottom Width (ft)	= 8.00
Side Slopes (z:1)	= 3.00, 4.00
Total Depth (ft)	= 8.00
Invert Elev (ft)	= 1.00
Slope (%)	= 0.25
N-Value	= 0.025

Calculations

Compute by:	Known Q
Known Q (cfs)	= 323.03

Highlighted

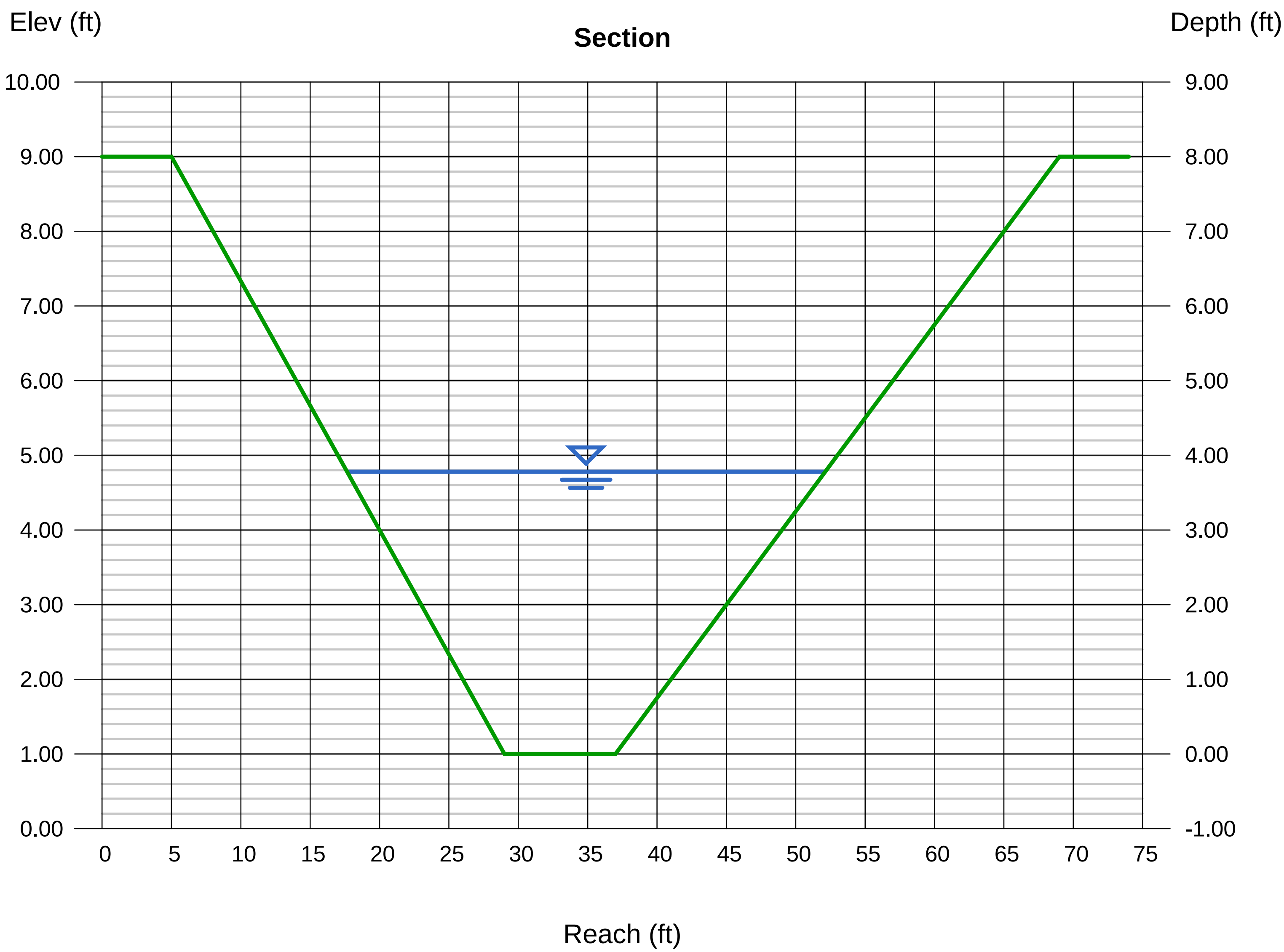
Depth (ft)	= 3.39
Q (cfs)	= 323.03
Area (sqft)	= 67.34
Velocity (ft/s)	= 4.80
Wetted Perim (ft)	= 32.70
Crit Depth, Yc (ft)	= 2.58
Top Width (ft)	= 31.73
EGL (ft)	= 3.75



Channel Report

100 Yr - Inside Perimeter Ditch E

Trapezoidal		**Highlighted**	
Bottom Width (ft)	= 8.00	Depth (ft)	= 3.78
Side Slopes (z:1)	= 3.00, 4.00	Q (cfs)	= 409.03
Total Depth (ft)	= 8.00	Area (sqft)	= 80.25
Invert Elev (ft)	= 1.00	Velocity (ft/s)	= 5.10
Slope (%)	= 0.25	Wetted Perim (ft)	= 35.54
N-Value	= 0.025	Crit Depth, Yc (ft)	= 2.91
		Top Width (ft)	= 34.46
Calculations		EGL (ft)	= 4.18
Compute by:	Known Q		
Known Q (cfs)	= 409.03		



Channel Report

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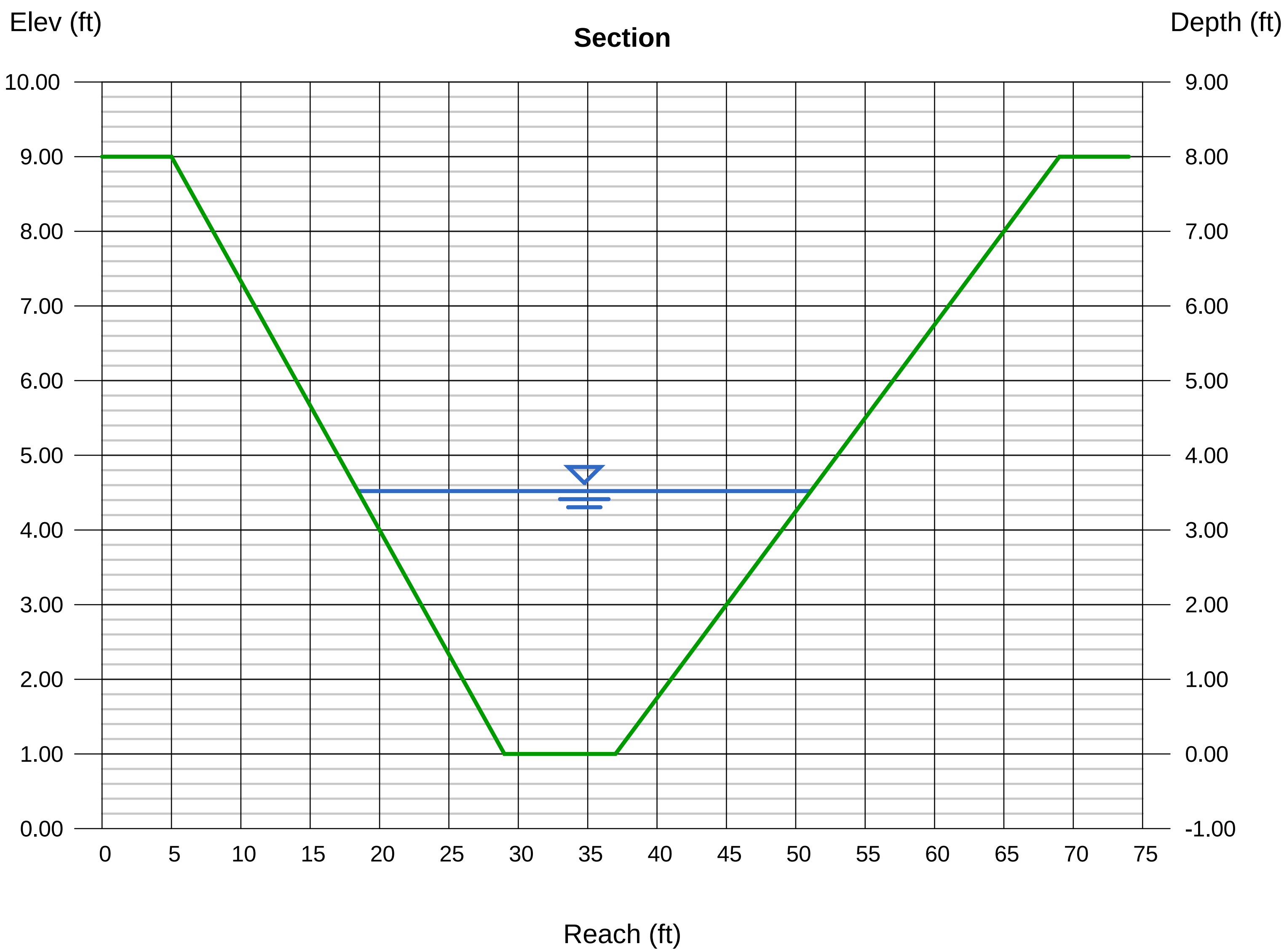
25 Yr - Inside Perimeter Ditch F

Trapezoidal	
Bottom Width (ft)	= 8.00
Side Slopes (z:1)	= 3.00, 4.00
Total Depth (ft)	= 8.00
Invert Elev (ft)	= 1.00
Slope (%)	= 0.26
N-Value	= 0.025

Calculations	
Compute by:	Known Q
Known Q (cfs)	= 358.14

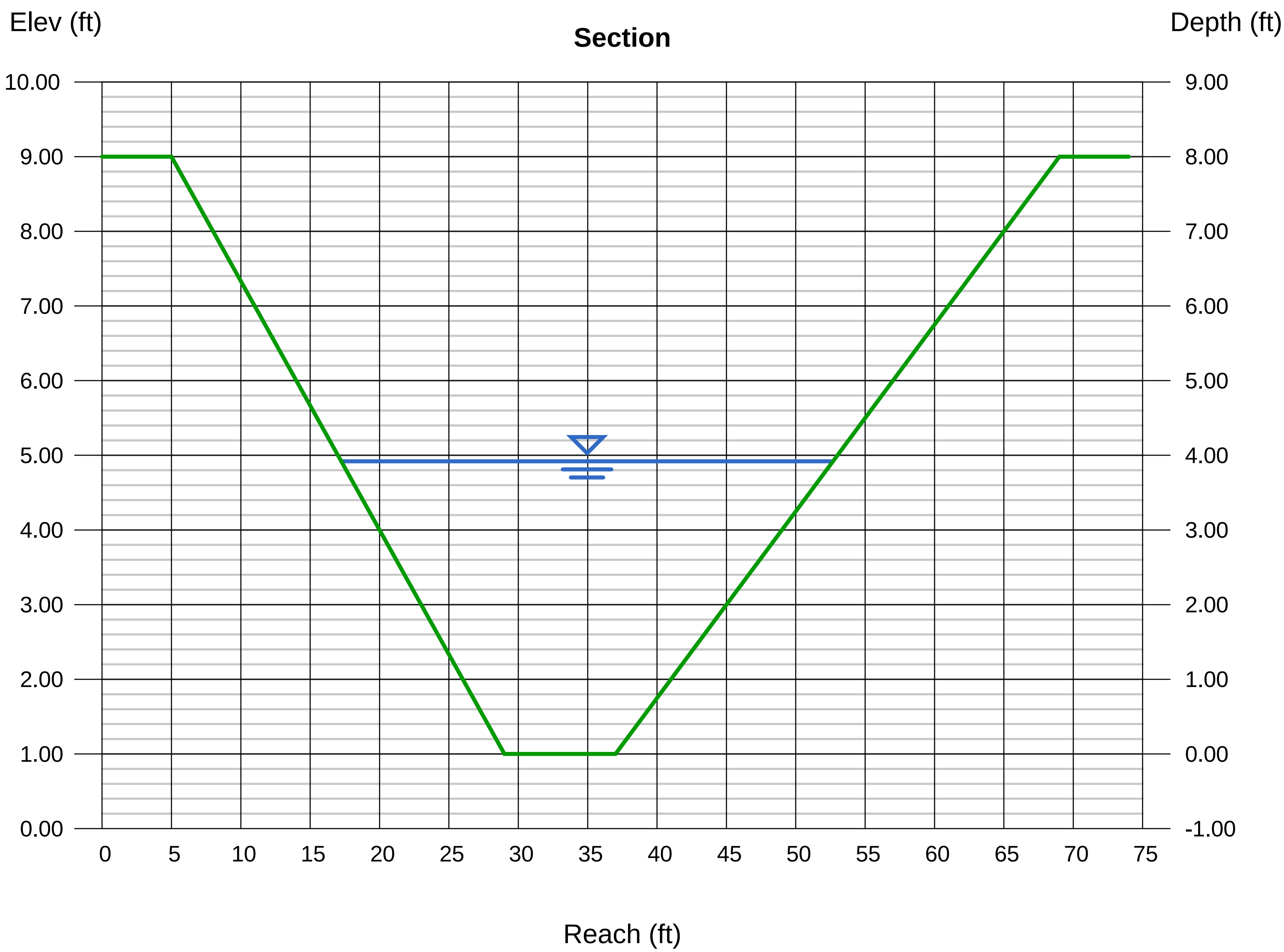
Highlighted	
Depth (ft)	= 3.52
Q (cfs)	= 358.14
Area (sqft)	= 71.53
Velocity (ft/s)	= 5.01
Wetted Perim (ft)	= 33.64
Crit Depth, Yc (ft)	= 2.72
Top Width (ft)	= 32.64
EGL (ft)	= 3.91



Channel Report

100 Yr - Inside Perimeter Ditch F

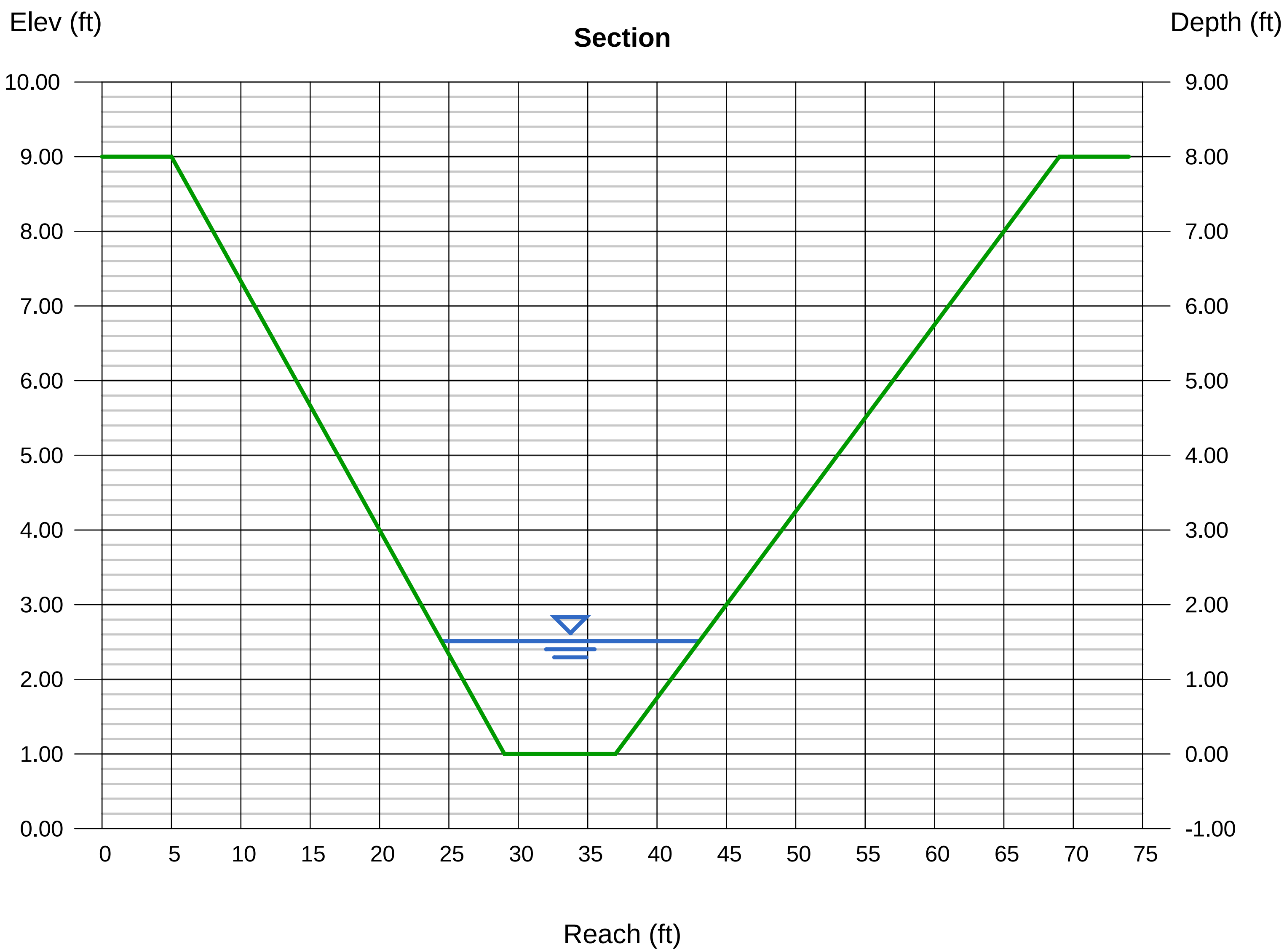
Trapezoidal		**Highlighted**	
Bottom Width (ft)	= 8.00	Depth (ft)	= 3.92
Side Slopes (z:1)	= 3.00, 4.00	Q (cfs)	= 453.49
Total Depth (ft)	= 8.00	Area (sqft)	= 85.14
Invert Elev (ft)	= 1.00	Velocity (ft/s)	= 5.33
Slope (%)	= 0.26	Wetted Perim (ft)	= 36.56
N-Value	= 0.025	Crit Depth, Yc (ft)	= 3.07
		Top Width (ft)	= 35.44
Calculations		EGL (ft)	= 4.36
Compute by:	Known Q		
Known Q (cfs)	= 453.49		



Channel Report

25 Yr - Inside Perimeter Ditch G

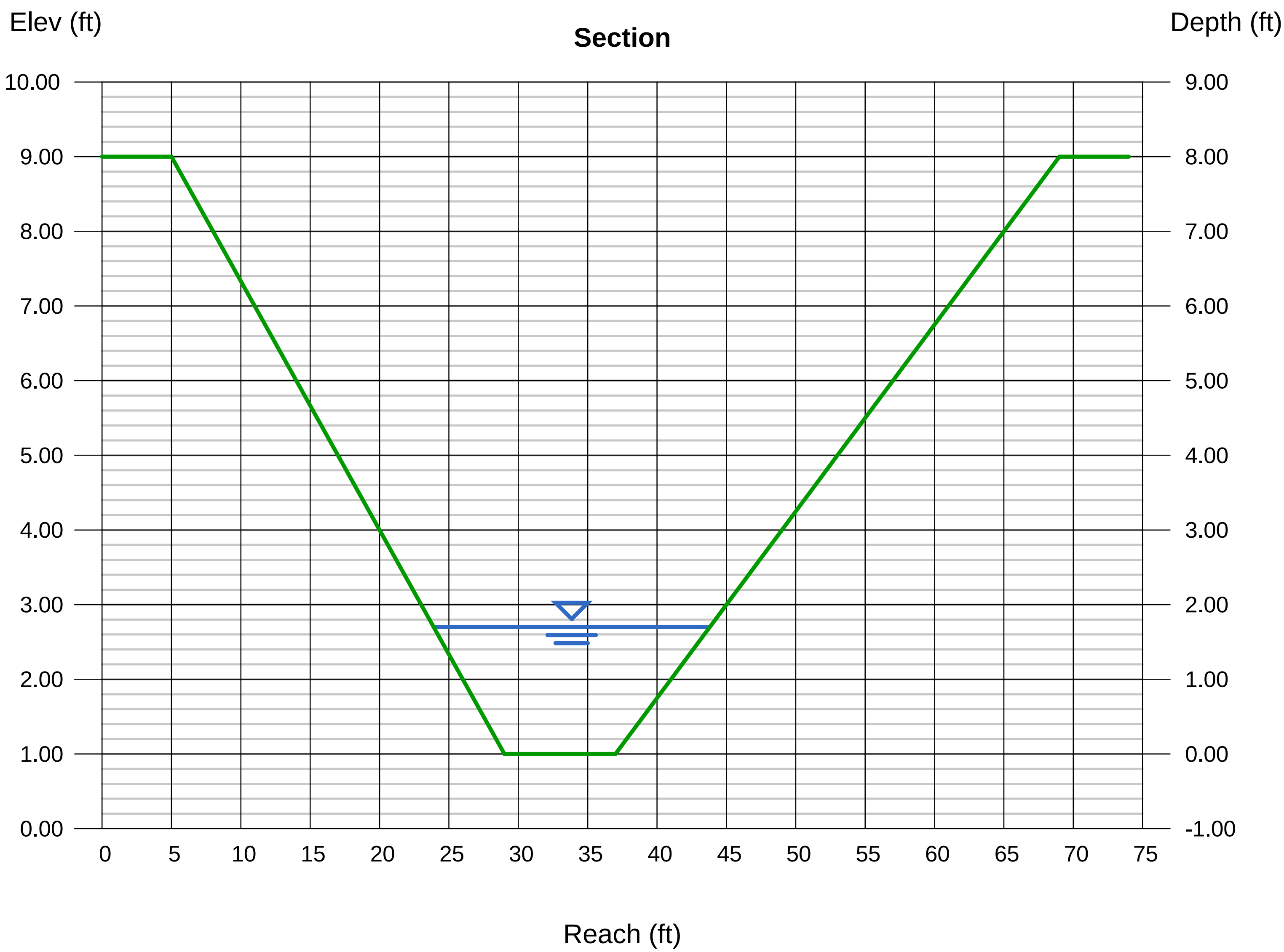
Trapezoidal		**Highlighted**	
Bottom Width (ft)	= 8.00	Depth (ft)	= 1.51
Side Slopes (z:1)	= 3.00, 4.00	Q (cfs)	= 73.74
Total Depth (ft)	= 8.00	Area (sqft)	= 20.06
Invert Elev (ft)	= 1.00	Velocity (ft/s)	= 3.68
Slope (%)	= 0.36	Wetted Perim (ft)	= 19.00
N-Value	= 0.025	Crit Depth, Yc (ft)	= 1.16
		Top Width (ft)	= 18.57
Calculations		EGL (ft)	= 1.72
Compute by:	Known Q		
Known Q (cfs)	= 73.74		



Channel Report

100 Yr - Inside Perimeter Ditch G

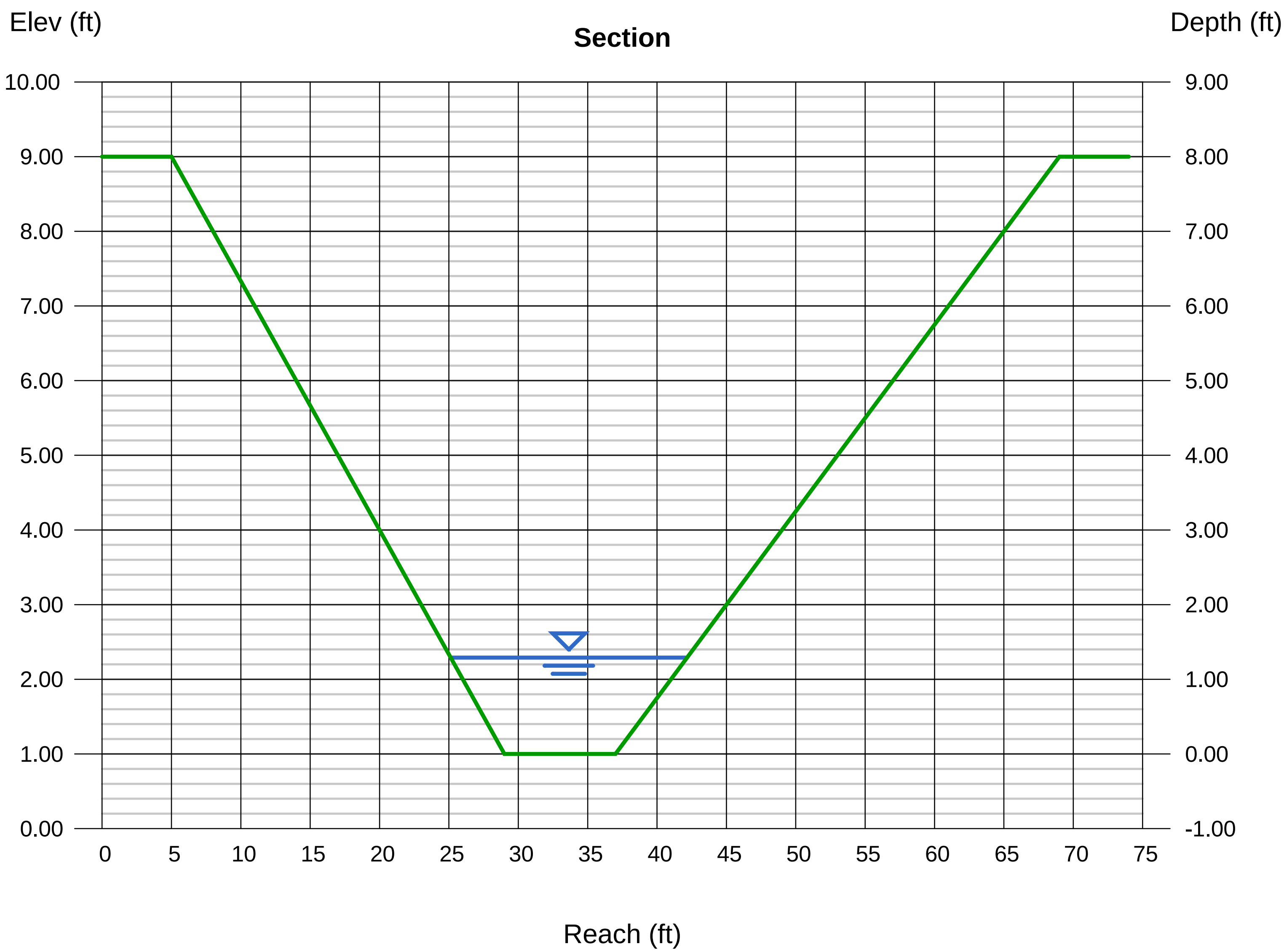
Trapezoidal		**Highlighted**	
Bottom Width (ft)	= 8.00	Depth (ft)	= 1.70
Side Slopes (z:1)	= 3.00, 4.00	Q (cfs)	= 93.37
Total Depth (ft)	= 8.00	Area (sqft)	= 23.71
Invert Elev (ft)	= 1.00	Velocity (ft/s)	= 3.94
Slope (%)	= 0.36	Wetted Perim (ft)	= 20.39
N-Value	= 0.025	Crit Depth, Yc (ft)	= 1.33
		Top Width (ft)	= 19.90
Calculations		EGL (ft)	= 1.94
Compute by:	Known Q		
Known Q (cfs)	= 93.37		



Channel Report

25 Yr - Inside Perimeter Ditch H

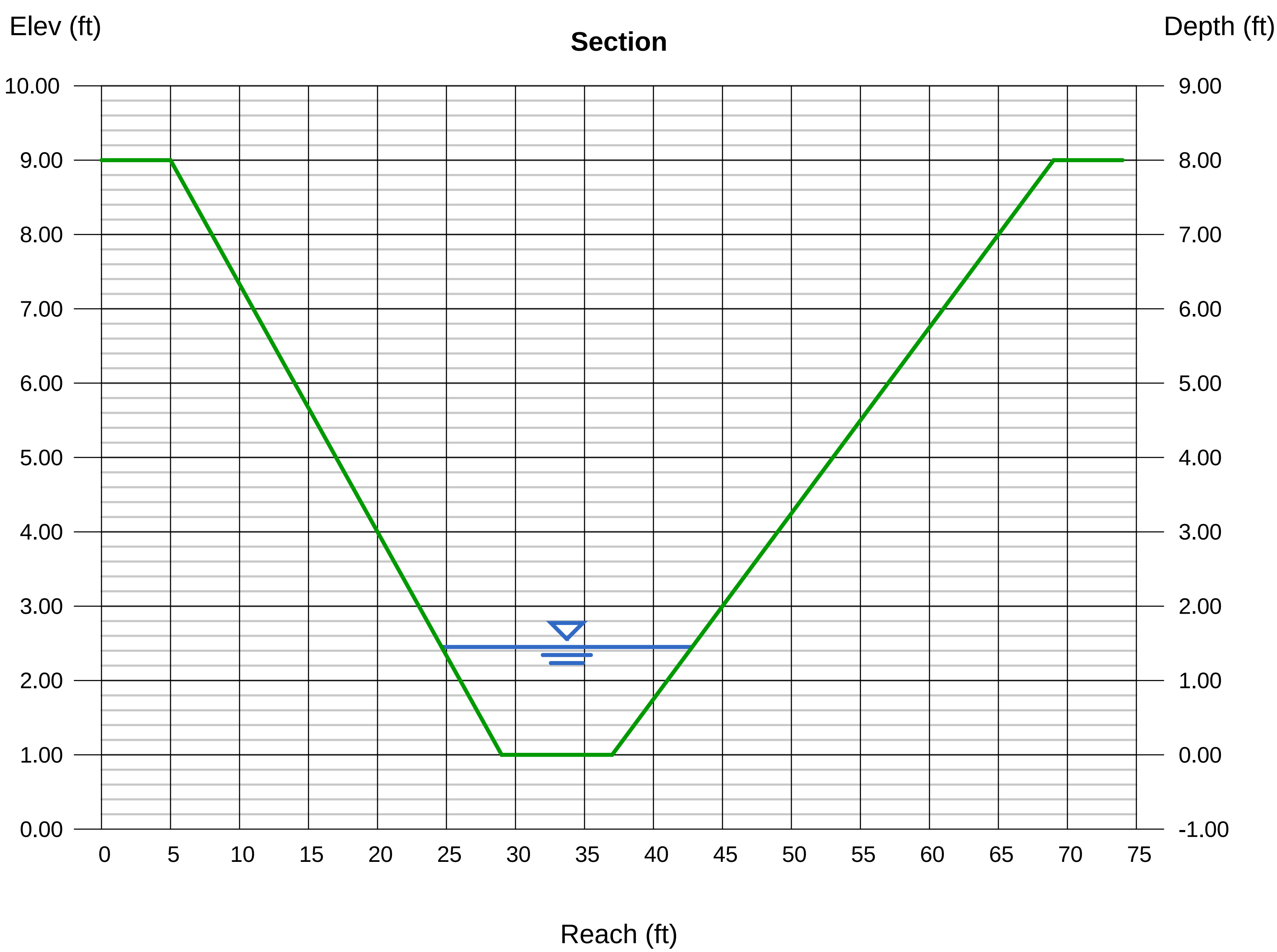
Trapezoidal		**Highlighted**	
Bottom Width (ft)	= 8.00	Depth (ft)	= 1.29
Side Slopes (z:1)	= 3.00, 4.00	Q (cfs)	= 182.58
Total Depth (ft)	= 8.00	Area (sqft)	= 16.14
Invert Elev (ft)	= 1.00	Velocity (ft/s)	= 11.31
Slope (%)	= 4.10	Wetted Perim (ft)	= 17.40
N-Value	= 0.025	Crit Depth, Yc (ft)	= 1.92
		Top Width (ft)	= 17.03
Calculations		EGL (ft)	= 3.28
Compute by:	Known Q		
Known Q (cfs)	= 182.58		



Channel Report

100 Yr - Inside Perimeter Ditch H

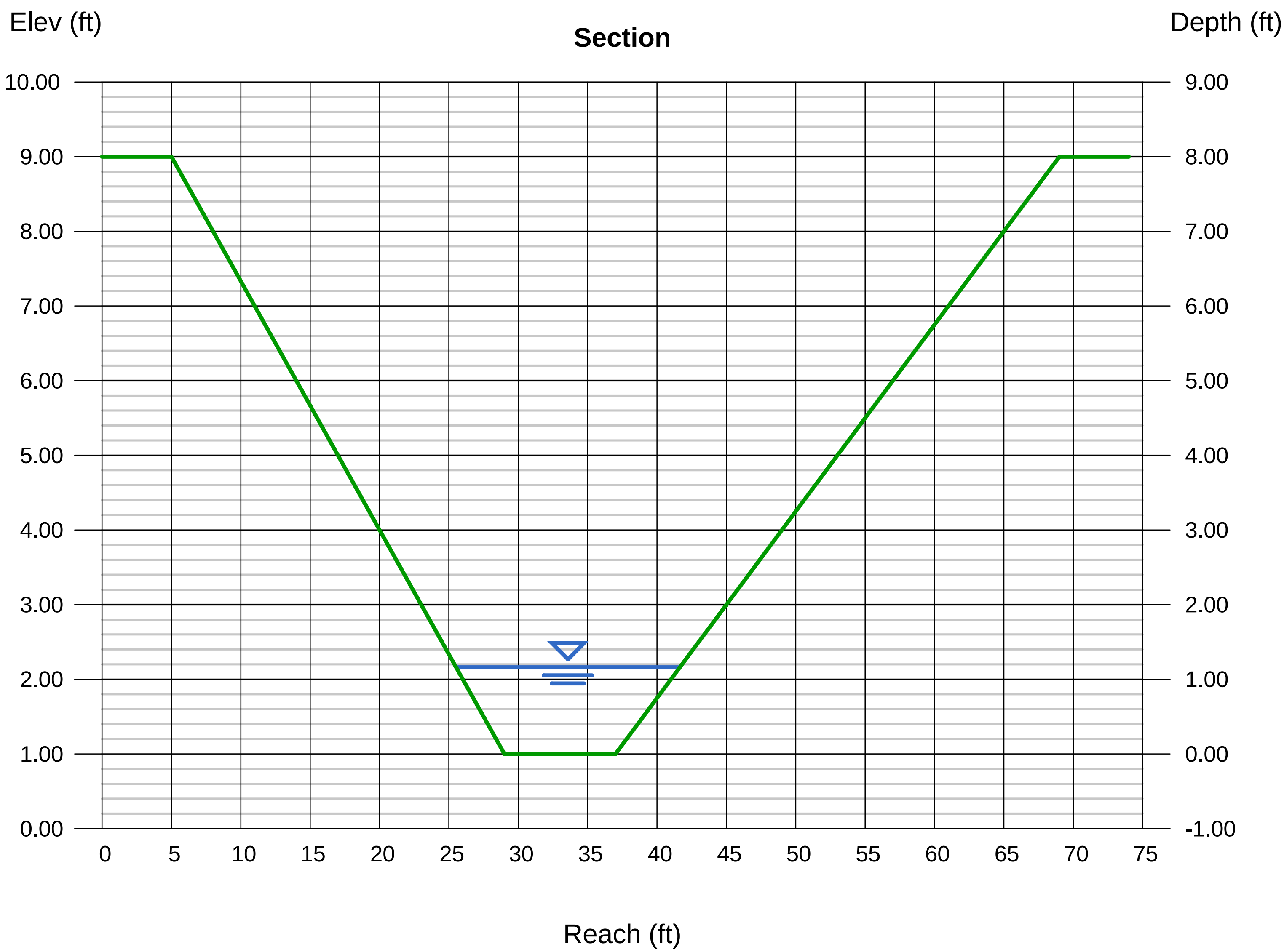
Trapezoidal		**Highlighted**	
Bottom Width (ft)	= 8.00	Depth (ft)	= 1.45
Side Slopes (z:1)	= 3.00, 4.00	Q (cfs)	= 231.19
Total Depth (ft)	= 8.00	Area (sqft)	= 18.96
Invert Elev (ft)	= 1.00	Velocity (ft/s)	= 12.19
Slope (%)	= 4.10	Wetted Perim (ft)	= 18.56
N-Value	= 0.025	Crit Depth, Yc (ft)	= 2.17
		Top Width (ft)	= 18.15
Calculations		EGL (ft)	= 3.76
Compute by:	Known Q		
Known Q (cfs)	= 231.19		



Channel Report

25 Yr - Inside Perimeter Ditch I

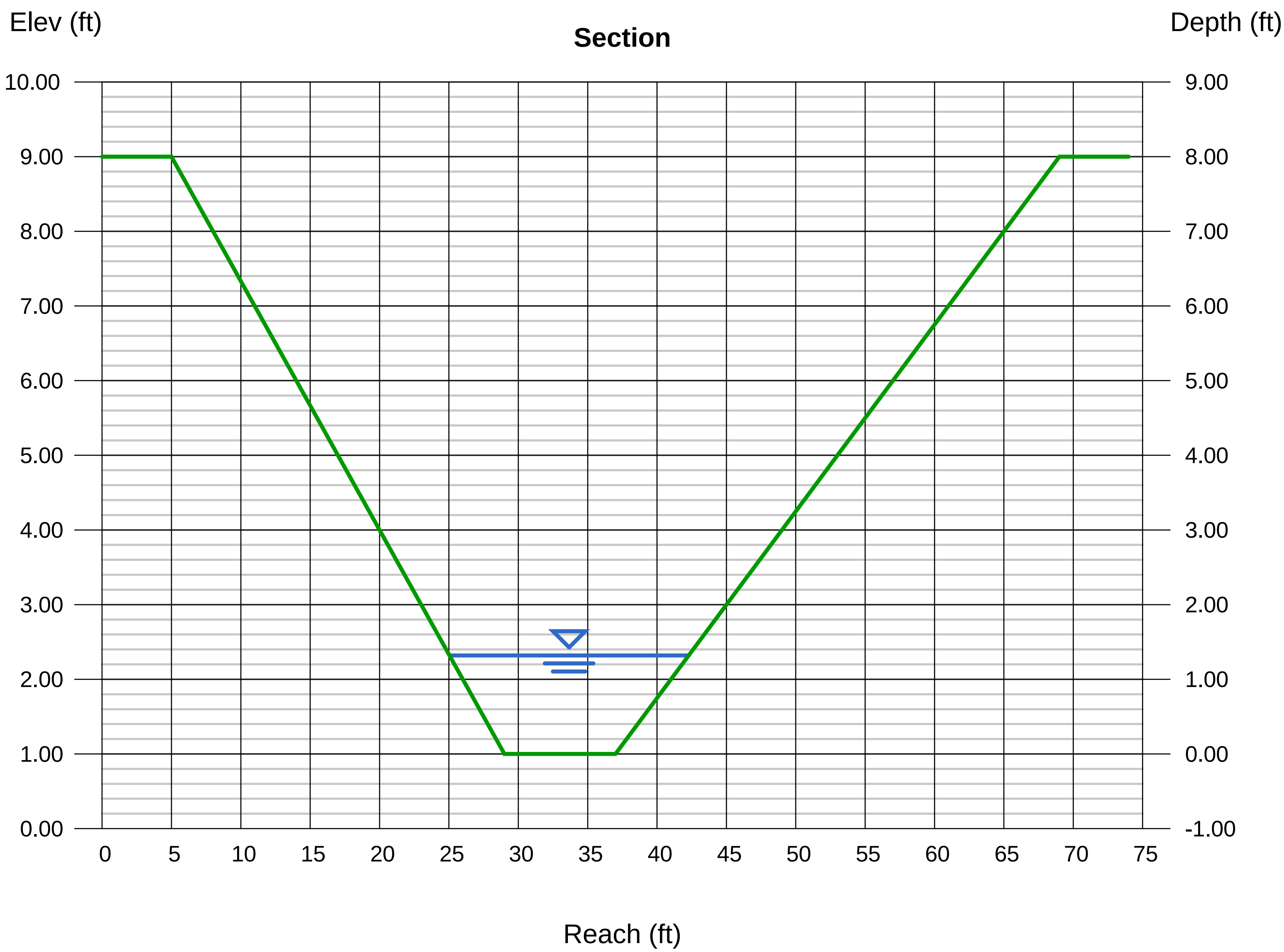
Trapezoidal		**Highlighted**	
Bottom Width (ft)	= 8.00	Depth (ft)	= 1.16
Side Slopes (z:1)	= 3.00, 4.00	Q (cfs)	= 66.71
Total Depth (ft)	= 8.00	Area (sqft)	= 13.99
Invert Elev (ft)	= 1.00	Velocity (ft/s)	= 4.77
Slope (%)	= 0.80	Wetted Perim (ft)	= 16.45
N-Value	= 0.025	Crit Depth, Yc (ft)	= 1.10
		Top Width (ft)	= 16.12
Calculations		EGL (ft)	= 1.51
Compute by:	Known Q		
Known Q (cfs)	= 66.71		



Channel Report

100 Yr - Inside Perimeter Ditch I

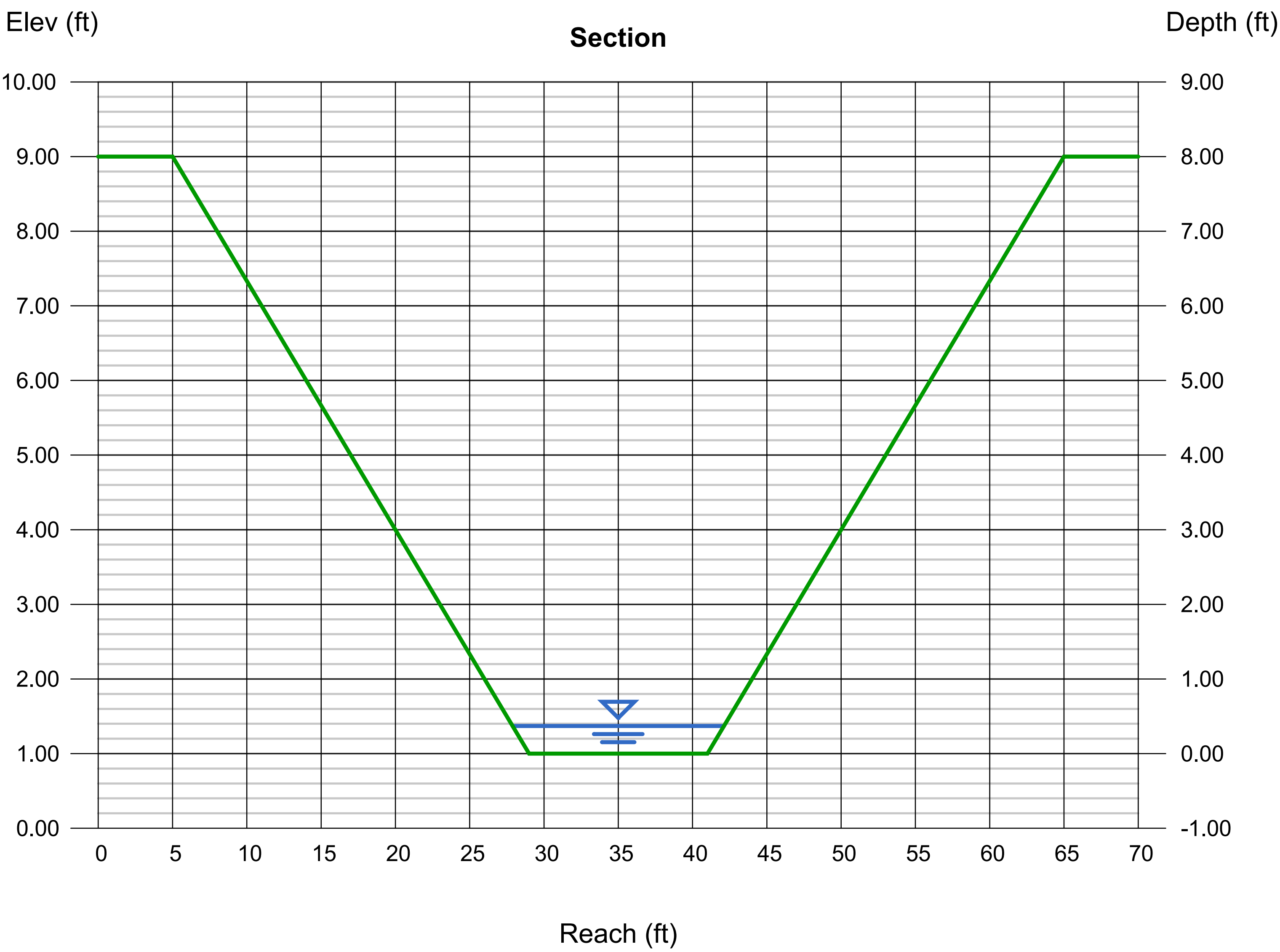
Trapezoidal			**Highlighted**	
Bottom Width (ft)	= 8.00		Depth (ft)	= 1.32
Side Slopes (z:1)	= 3.00, 4.00		Q (cfs)	= 84.47
Total Depth (ft)	= 8.00		Area (sqft)	= 16.66
Invert Elev (ft)	= 1.00		Velocity (ft/s)	= 5.07
Slope (%)	= 0.80		Wetted Perim (ft)	= 17.62
N-Value	= 0.025		Crit Depth, Yc (ft)	= 1.26
			Top Width (ft)	= 17.24
Calculations			EGL (ft)	= 1.72
Compute by:	Known Q			
Known Q (cfs)	= 84.47			



Channel Report

25 Yr - Outside Perimeter Ditch A

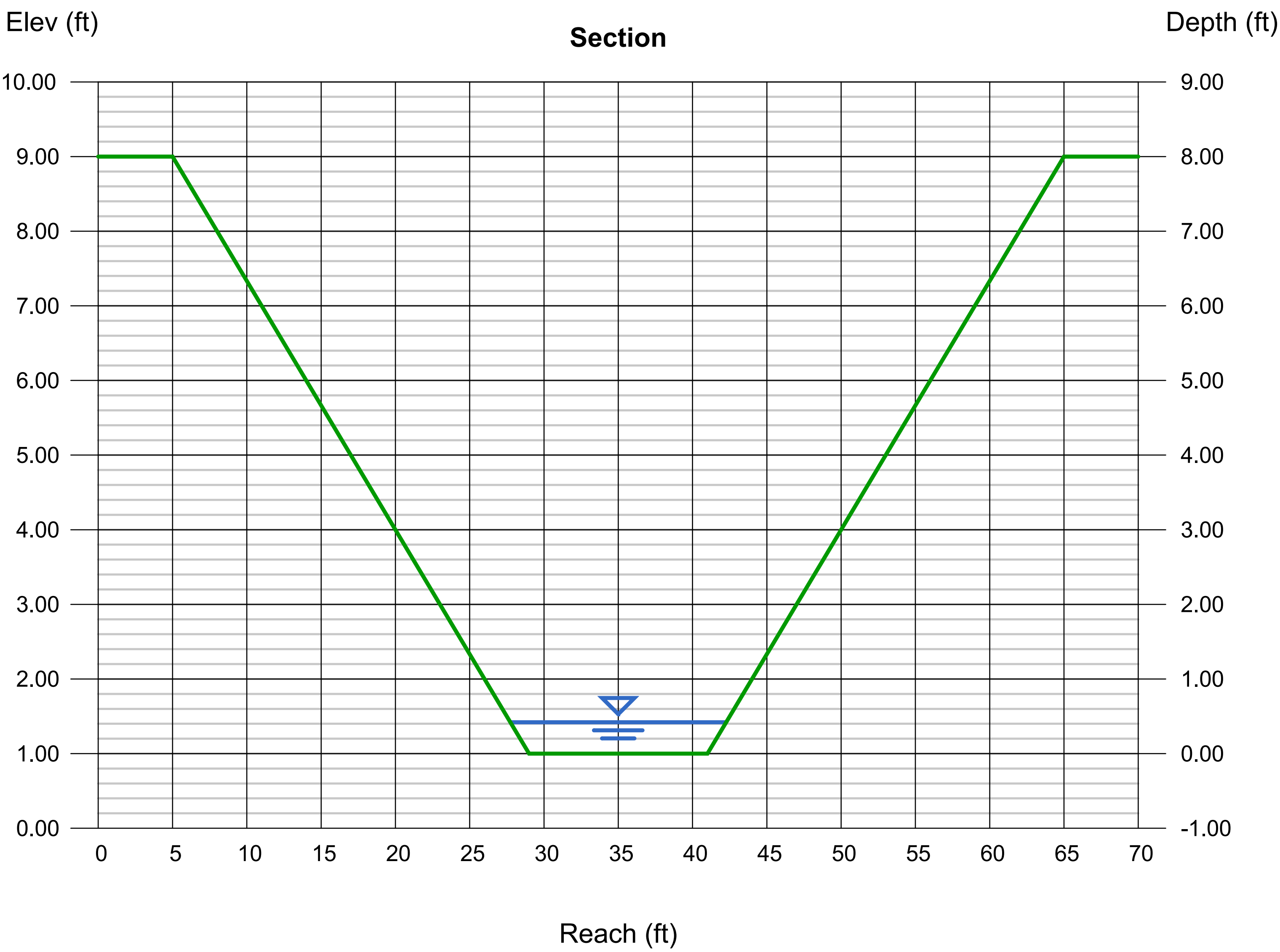
Trapezoidal		**Highlighted**	
Bottom Width (ft)	= 12.00	Depth (ft)	= 0.37
Side Slopes (z:1)	= 3.00, 3.00	Q (cfs)	= 13.71
Total Depth (ft)	= 8.00	Area (sqft)	= 4.85
Invert Elev (ft)	= 1.00	Velocity (ft/s)	= 2.83
Slope (%)	= 2.05	Wetted Perim (ft)	= 14.34
N-Value	= 0.035	Crit Depth, Yc (ft)	= 0.34
		Top Width (ft)	= 14.22
Calculations		EGL (ft)	= 0.49
Compute by:	Known Q		
Known Q (cfs)	= 13.71		



Channel Report

100 Yr - Outside Perimeter Ditch A

Trapezoidal		**Highlighted**	
Bottom Width (ft)	= 12.00	Depth (ft)	= 0.42
Side Slopes (z:1)	= 3.00, 3.00	Q (cfs)	= 17.36
Total Depth (ft)	= 8.00	Area (sqft)	= 5.57
Invert Elev (ft)	= 1.00	Velocity (ft/s)	= 3.12
Slope (%)	= 2.05	Wetted Perim (ft)	= 14.66
N-Value	= 0.035	Crit Depth, Yc (ft)	= 0.39
		Top Width (ft)	= 14.52
Calculations		EGL (ft)	= 0.57
Compute by:	Known Q		
Known Q (cfs)	= 17.36		



Channel Report

25 Yr - Outside Perimeter Ditch B

Trapezoidal

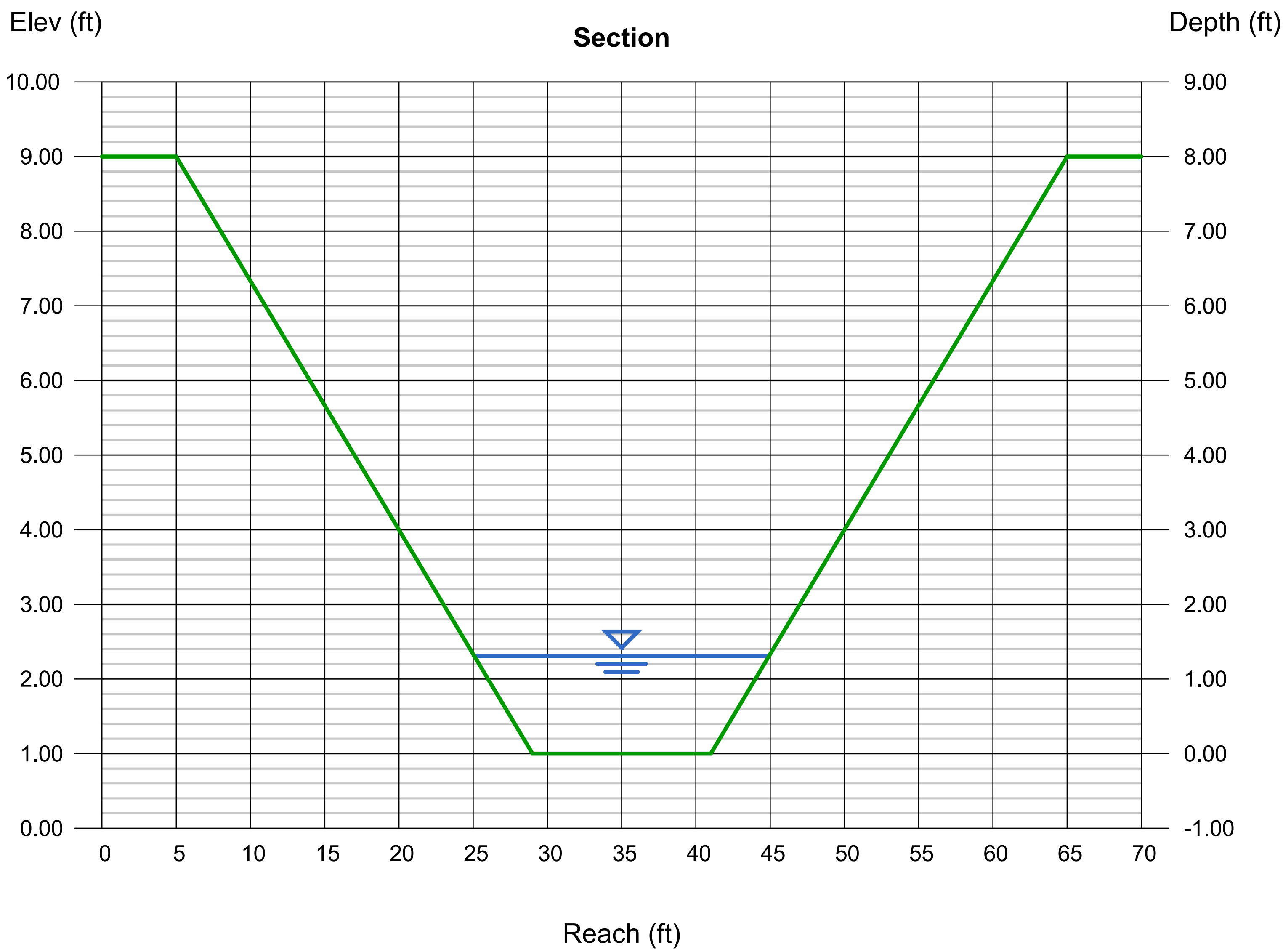
Bottom Width (ft)	=	12.00
Side Slopes (z:1)	=	3.00, 3.00
Total Depth (ft)	=	8.00
Invert Elev (ft)	=	1.00
Slope (%)	=	0.28
N-Value	=	0.035

Calculations

Compute by:		Known Q
Known Q (cfs)	=	47.13

Highlighted

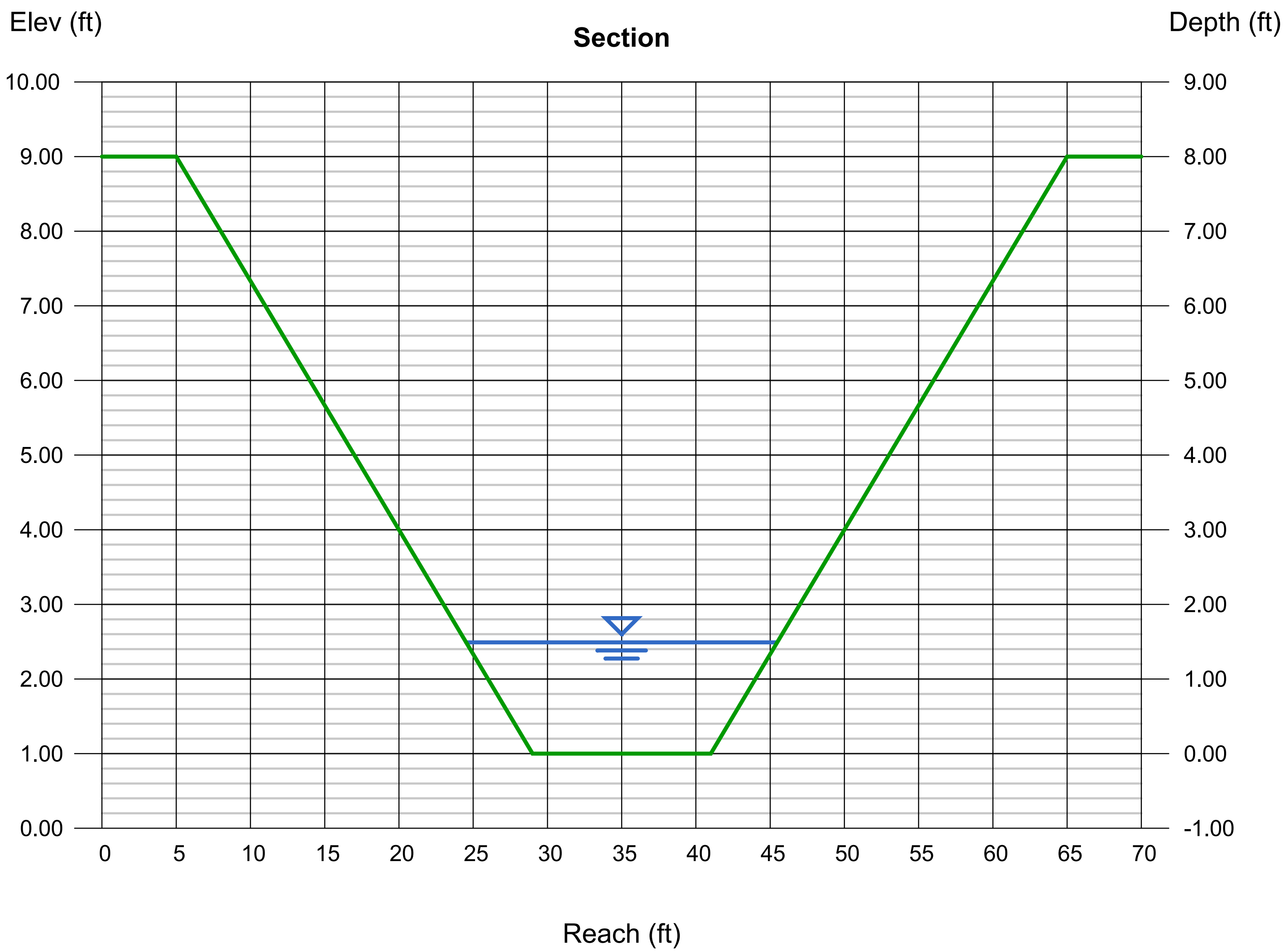
Depth (ft)	=	1.31
Q (cfs)	=	47.13
Area (sqft)	=	20.87
Velocity (ft/s)	=	2.26
Wetted Perim (ft)	=	20.29
Crit Depth, Yc (ft)	=	0.74
Top Width (ft)	=	19.86
EGL (ft)	=	1.39



Channel Report

100 Yr - Outside Perimeter Ditch B

Trapezoidal		**Highlighted**	
Bottom Width (ft)	= 12.00	Depth (ft)	= 1.49
Side Slopes (z:1)	= 3.00, 3.00	Q (cfs)	= 59.68
Total Depth (ft)	= 8.00	Area (sqft)	= 24.54
Invert Elev (ft)	= 1.00	Velocity (ft/s)	= 2.43
Slope (%)	= 0.28	Wetted Perim (ft)	= 21.42
N-Value	= 0.035	Crit Depth, Yc (ft)	= 0.86
		Top Width (ft)	= 20.94
Calculations		EGL (ft)	= 1.58
Compute by:	Known Q		
Known Q (cfs)	= 59.68		



Channel Report

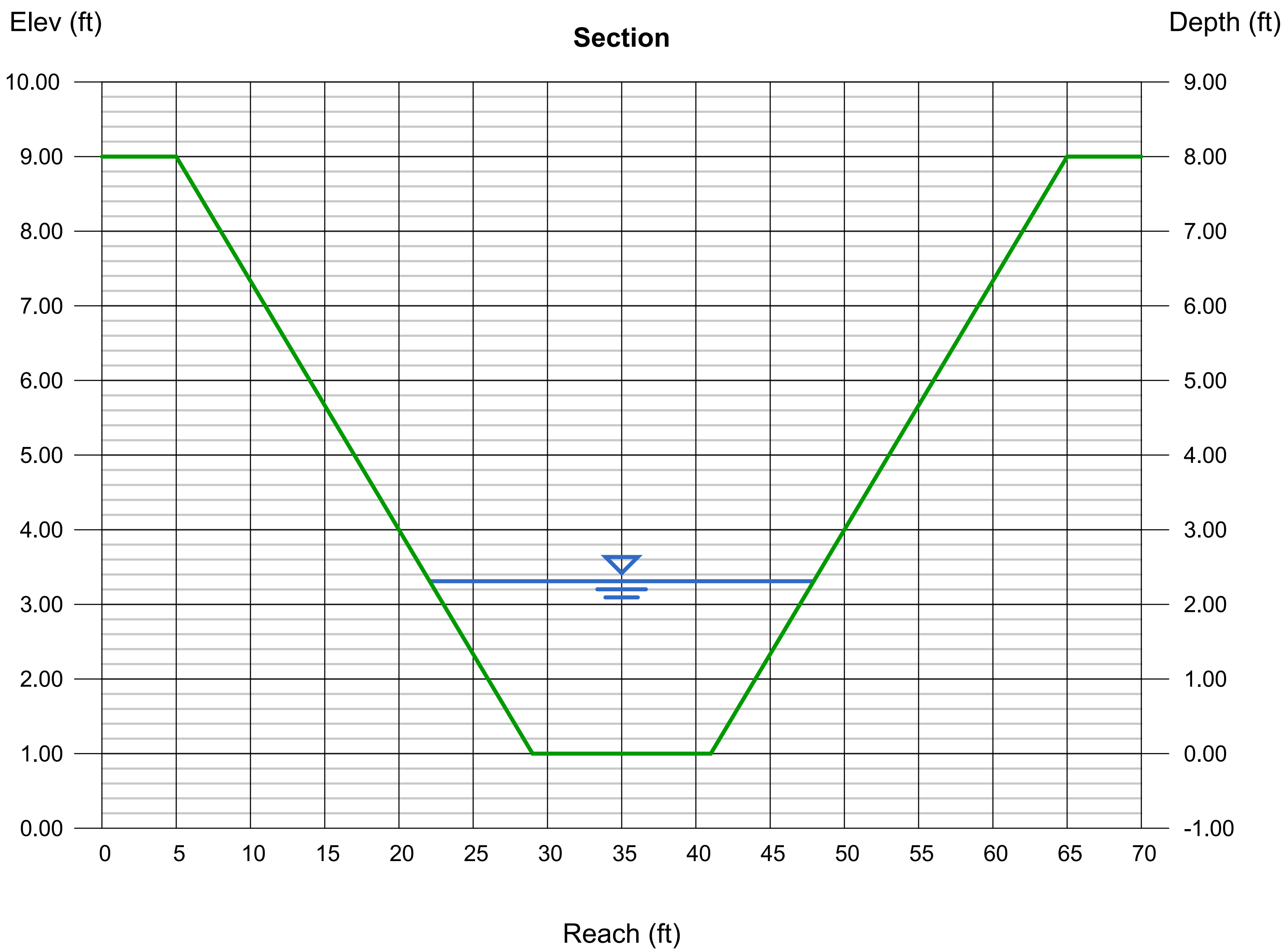
Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. — Friday, Oct 26 2018

25 Yr - Outside Perimeter Ditch C

Trapezoidal
Bottom Width (ft) = 12.00
Side Slopes (z:1) = 3.00, 3.00
Total Depth (ft) = 8.00
Invert Elev (ft) = 1.00
Slope (%) = 0.28
N-Value = 0.035

Calculations
Compute by: Known Q
Known Q (cfs) = 136.32

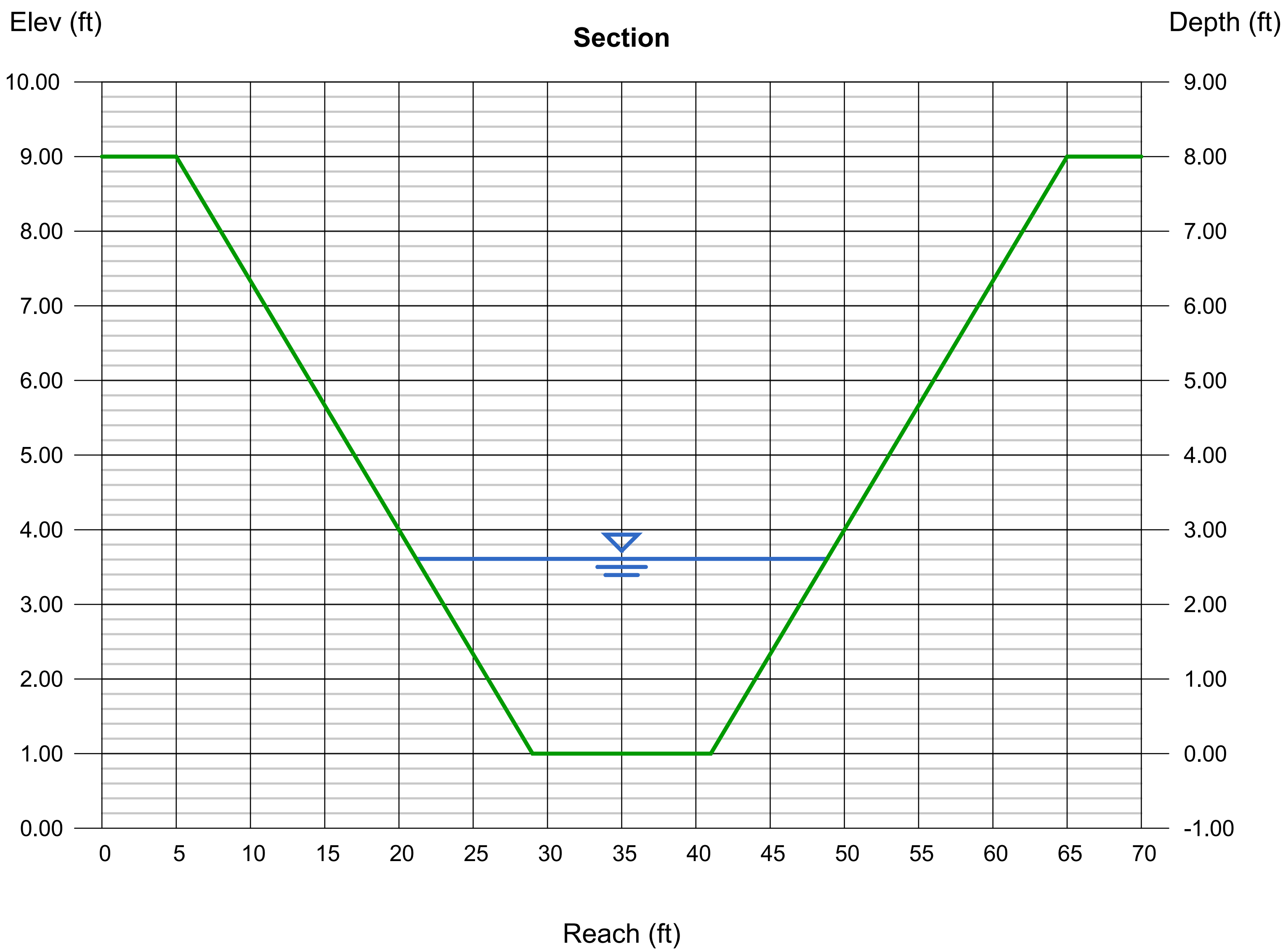
Highlighted
Depth (ft) = 2.31
Q (cfs) = 136.32
Area (sqft) = 43.73
Velocity (ft/s) = 3.12
Wetted Perim (ft) = 26.61
Crit Depth, Yc (ft) = 1.41
Top Width (ft) = 25.86
EGL (ft) = 2.46



Channel Report

100 Yr - Outside Perimeter Ditch C

Trapezoidal		**Highlighted**	
Bottom Width (ft)	= 12.00	Depth (ft)	= 2.61
Side Slopes (z:1)	= 3.00, 3.00	Q (cfs)	= 172.62
Total Depth (ft)	= 8.00	Area (sqft)	= 51.76
Invert Elev (ft)	= 1.00	Velocity (ft/s)	= 3.34
Slope (%)	= 0.28	Wetted Perim (ft)	= 28.51
N-Value	= 0.035	Crit Depth, Yc (ft)	= 1.62
		Top Width (ft)	= 27.66
Calculations		EGL (ft)	= 2.78
Compute by:	Known Q		
Known Q (cfs)	= 172.62		



Channel Report

25 Yr - Outside Perimeter Ditch D

Trapezoidal

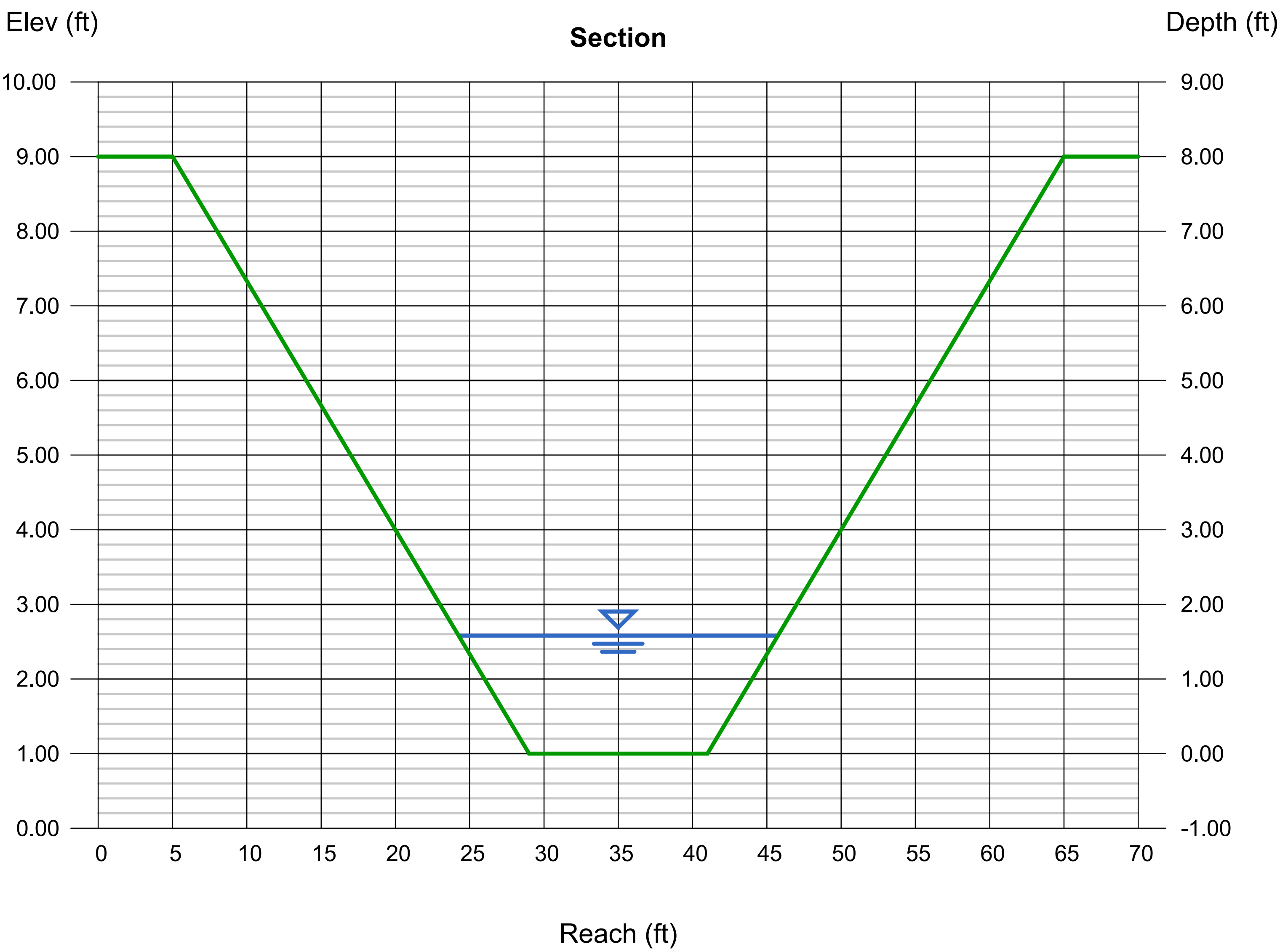
Bottom Width (ft)	= 12.00
Side Slopes (z:1)	= 3.00, 3.00
Total Depth (ft)	= 8.00
Invert Elev (ft)	= 1.00
Slope (%)	= 1.20
N-Value	= 0.035

Calculations

Compute by:	Known Q
Known Q (cfs)	= 138.15

Highlighted

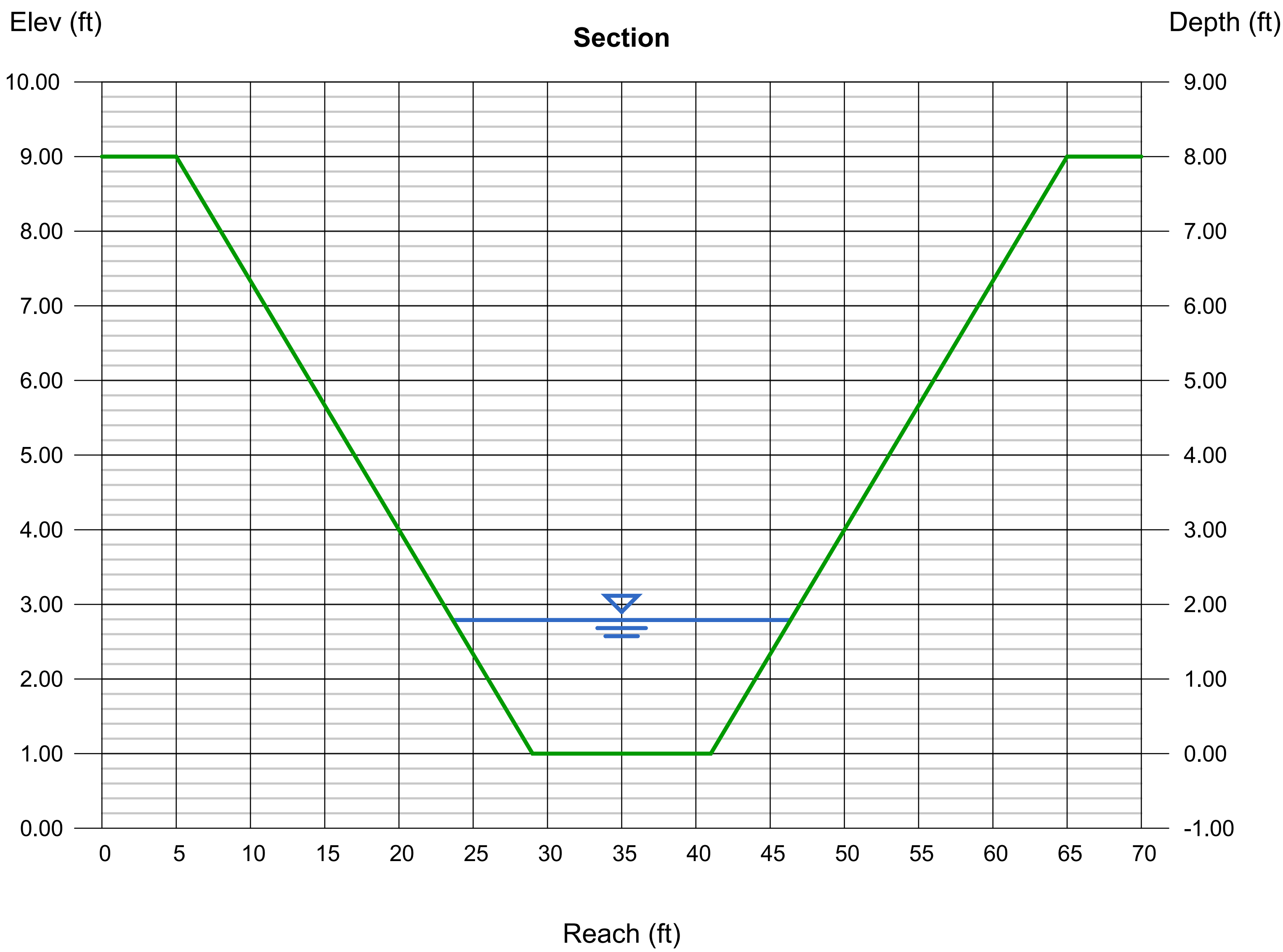
Depth (ft)	= 1.58
Q (cfs)	= 138.15
Area (sqft)	= 26.45
Velocity (ft/s)	= 5.22
Wetted Perim (ft)	= 21.99
Crit Depth, Yc (ft)	= 1.42
Top Width (ft)	= 21.48
EGL (ft)	= 2.00



Channel Report

100 Yr - Outside Perimeter Ditch D

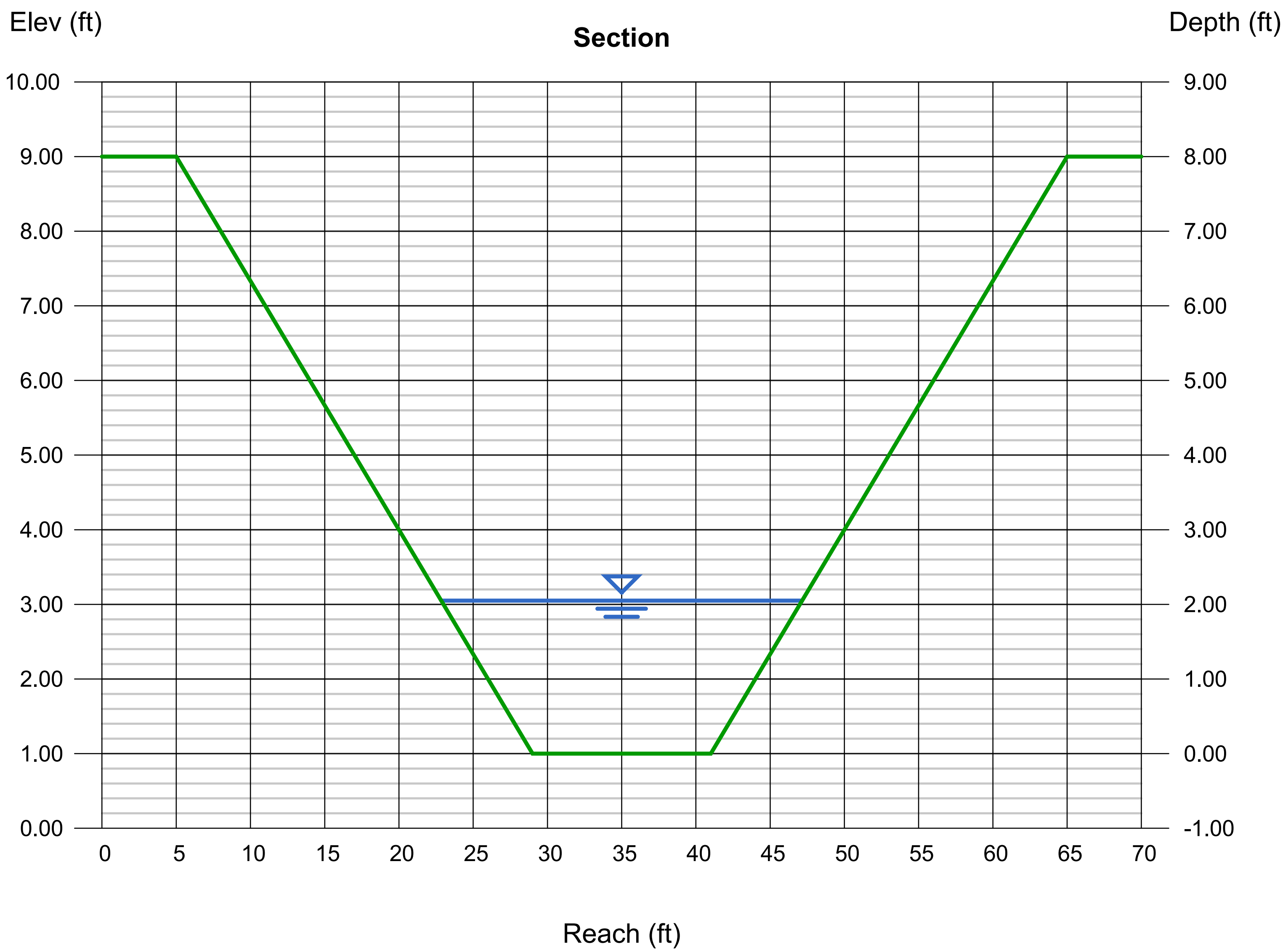
Trapezoidal		**Highlighted**	
Bottom Width (ft)	= 12.00	Depth (ft)	= 1.79
Side Slopes (z:1)	= 3.00, 3.00	Q (cfs)	= 174.93
Total Depth (ft)	= 8.00	Area (sqft)	= 31.09
Invert Elev (ft)	= 1.00	Velocity (ft/s)	= 5.63
Slope (%)	= 1.20	Wetted Perim (ft)	= 23.32
N-Value	= 0.035	Crit Depth, Yc (ft)	= 1.63
		Top Width (ft)	= 22.74
Calculations		EGL (ft)	= 2.28
Compute by:	Known Q		
Known Q (cfs)	= 174.93		



Channel Report

25 Yr - Outside Perimeter Ditch E

Trapezoidal		**Highlighted**	
Bottom Width (ft)	= 12.00	Depth (ft)	= 2.05
Side Slopes (z:1)	= 3.00, 3.00	Q (cfs)	= 200.24
Total Depth (ft)	= 8.00	Area (sqft)	= 37.21
Invert Elev (ft)	= 1.00	Velocity (ft/s)	= 5.38
Slope (%)	= 0.96	Wetted Perim (ft)	= 24.97
N-Value	= 0.035	Crit Depth, Yc (ft)	= 1.76
		Top Width (ft)	= 24.30
Calculations		EGL (ft)	= 2.50
Compute by:	Known Q		
Known Q (cfs)	= 200.24		



Channel Report

100 Yr - Outside Perimeter Ditch E

Trapezoidal

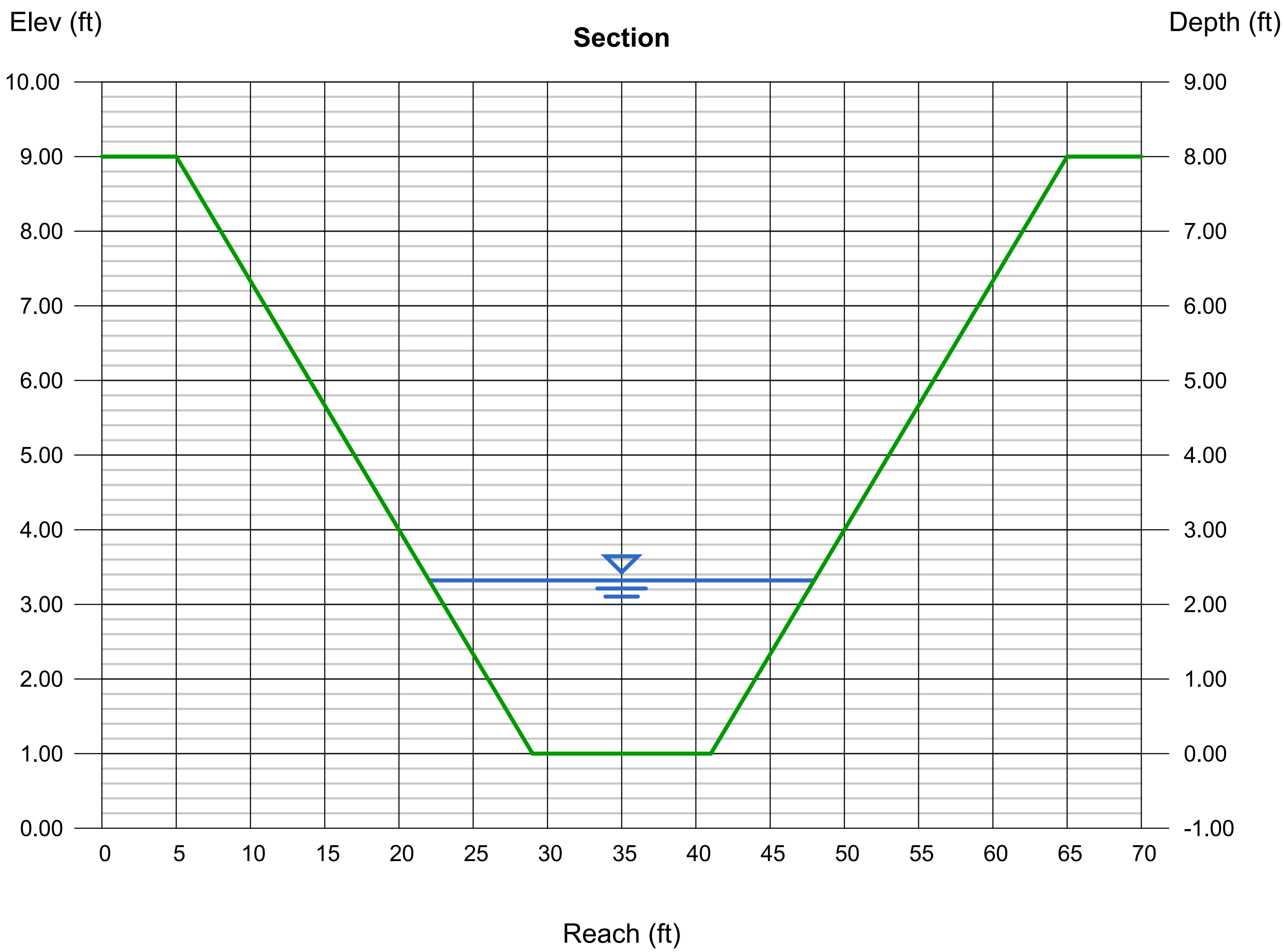
Bottom Width (ft)	=	12.00
Side Slopes (z:1)	=	3.00, 3.00
Total Depth (ft)	=	8.00
Invert Elev (ft)	=	1.00
Slope (%)	=	0.96
N-Value	=	0.035

Calculations

Compute by:		Known Q
Known Q (cfs)	=	253.56

Highlighted

Depth (ft)	=	2.32
Q (cfs)	=	253.56
Area (sqft)	=	43.99
Velocity (ft/s)	=	5.76
Wetted Perim (ft)	=	26.67
Crit Depth, Yc (ft)	=	2.02
Top Width (ft)	=	25.92
EGL (ft)	=	2.84



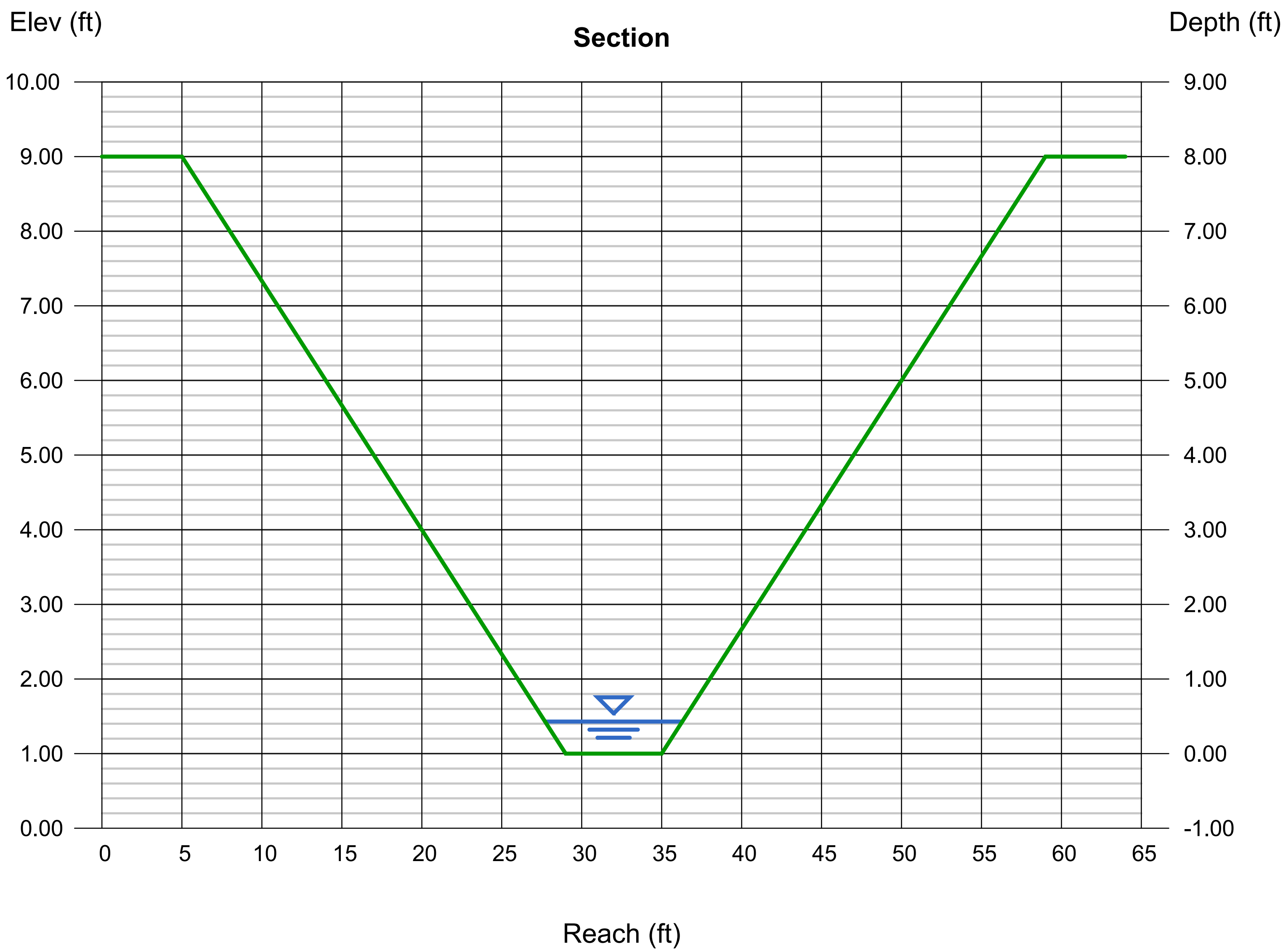
Channel Report

25 Yr - Outside Perimeter Ditch F

Trapezoidal	
Bottom Width (ft)	= 6.00
Side Slopes (z:1)	= 3.00, 3.00
Total Depth (ft)	= 8.00
Invert Elev (ft)	= 1.00
Slope (%)	= 0.70
N-Value	= 0.035

Calculations	
Compute by:	Known Q
Known Q (cfs)	= 5.56

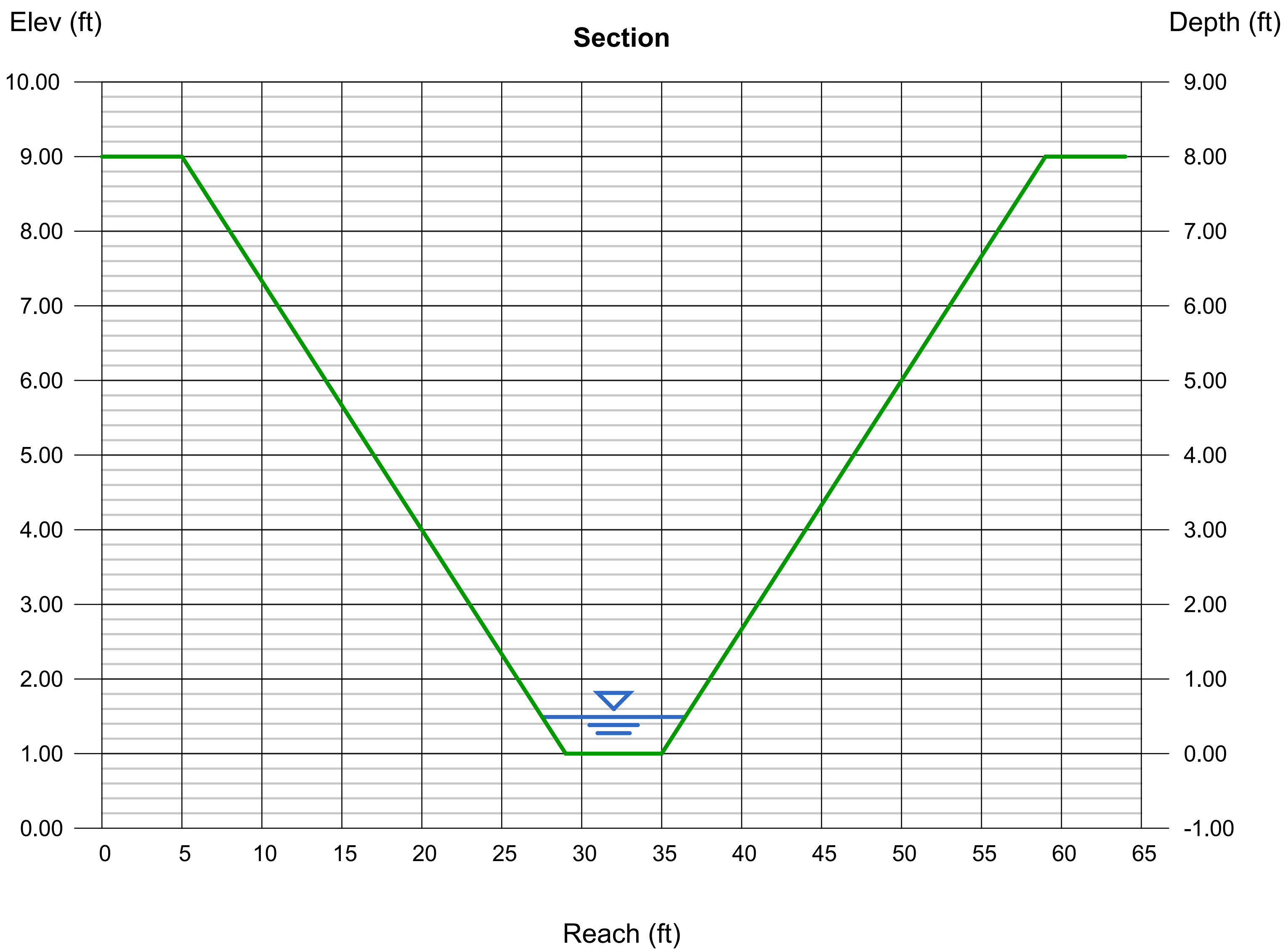
Highlighted	
Depth (ft)	= 0.43
Q (cfs)	= 5.560
Area (sqft)	= 3.13
Velocity (ft/s)	= 1.77
Wetted Perim (ft)	= 8.72
Crit Depth, Yc (ft)	= 0.29
Top Width (ft)	= 8.58
EGL (ft)	= 0.48



Channel Report

100 Yr - Outside Perimeter Ditch F

Trapezoidal		**Highlighted**	
Bottom Width (ft)	= 6.00	Depth (ft)	= 0.49
Side Slopes (z:1)	= 3.00, 3.00	Q (cfs)	= 7.040
Total Depth (ft)	= 8.00	Area (sqft)	= 3.66
Invert Elev (ft)	= 1.00	Velocity (ft/s)	= 1.92
Slope (%)	= 0.70	Wetted Perim (ft)	= 9.10
N-Value	= 0.035	Crit Depth, Yc (ft)	= 0.34
		Top Width (ft)	= 8.94
Calculations		EGL (ft)	= 0.55
Compute by:	Known Q		
Known Q (cfs)	= 7.04		



2.8 FIGURE 2.2 – STORM DRAINS

STORM DRAINS

ENGINEERING REPORT
FOR
GEORGIA POWER
PLANT YATES - ASH MANAGEMENT AREA
COWETA COUNTY, GEORGIA

Georgia Power

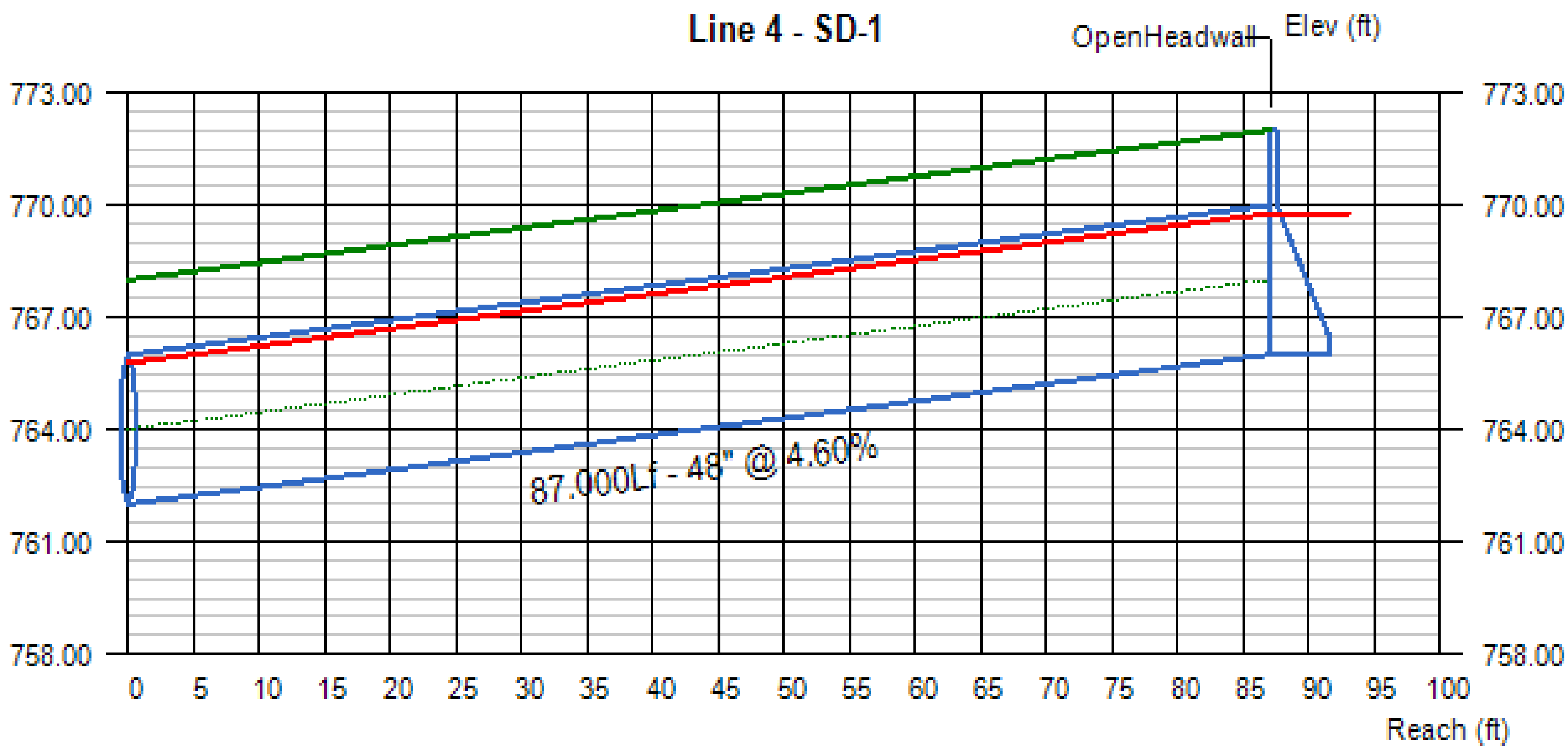
Atlantic Coast Consulting, Inc.
770-594-5998
www.atlcc.net

1150 Northmeadow Pkwy.
Suite 100
Roswell, GA 30076

FIGURE 2.2

2.9 STORM DRAIN CAPACITY CALCULATIONS

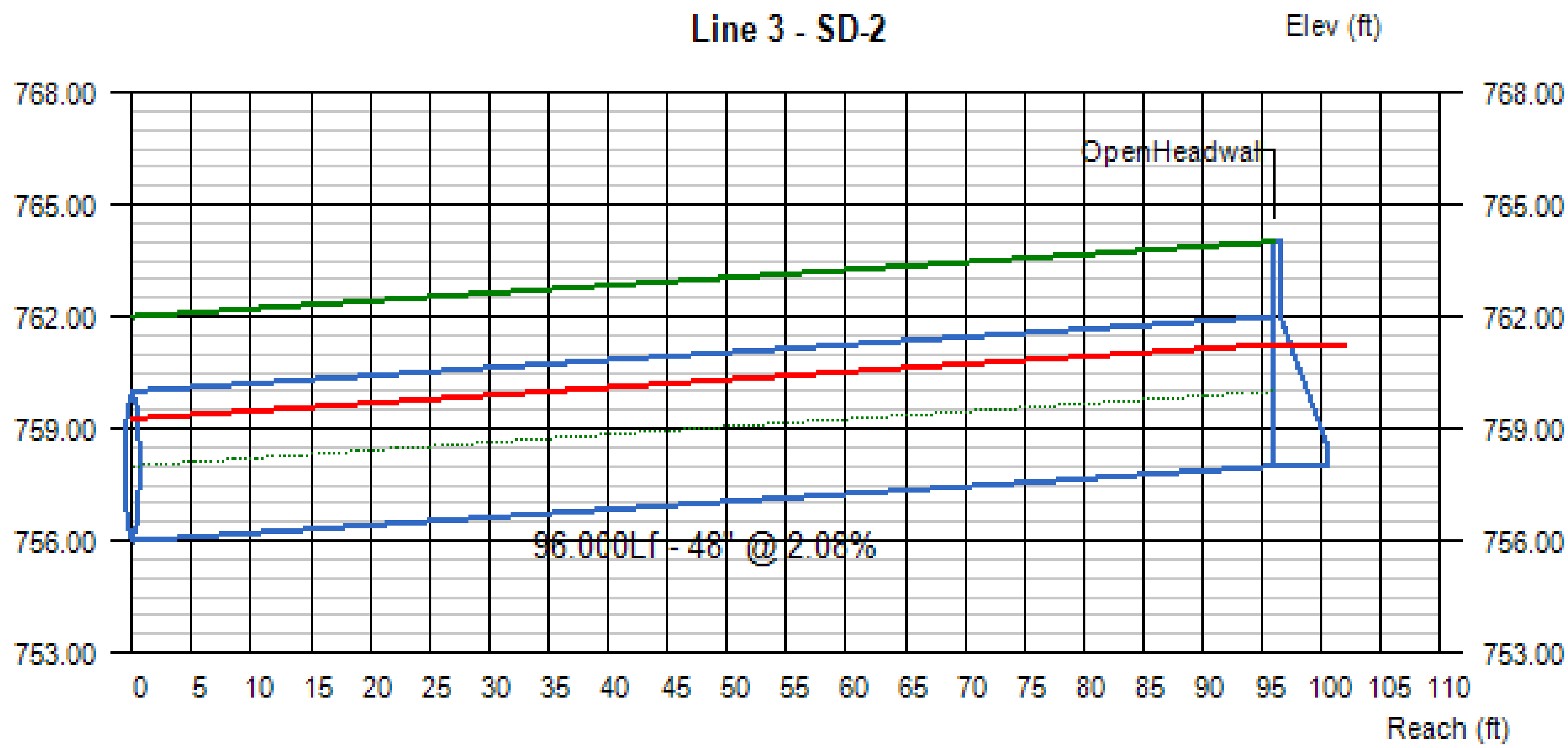
Line Profile (Line 4) - SD-1



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
4	180.06	762.00	766.00	3.77	3.77	3.77	765.77	769.77	769.77	14.66	14.66	2.00	2.00

Project File:	No. Lines: 4	Run Date: 6/26/2020

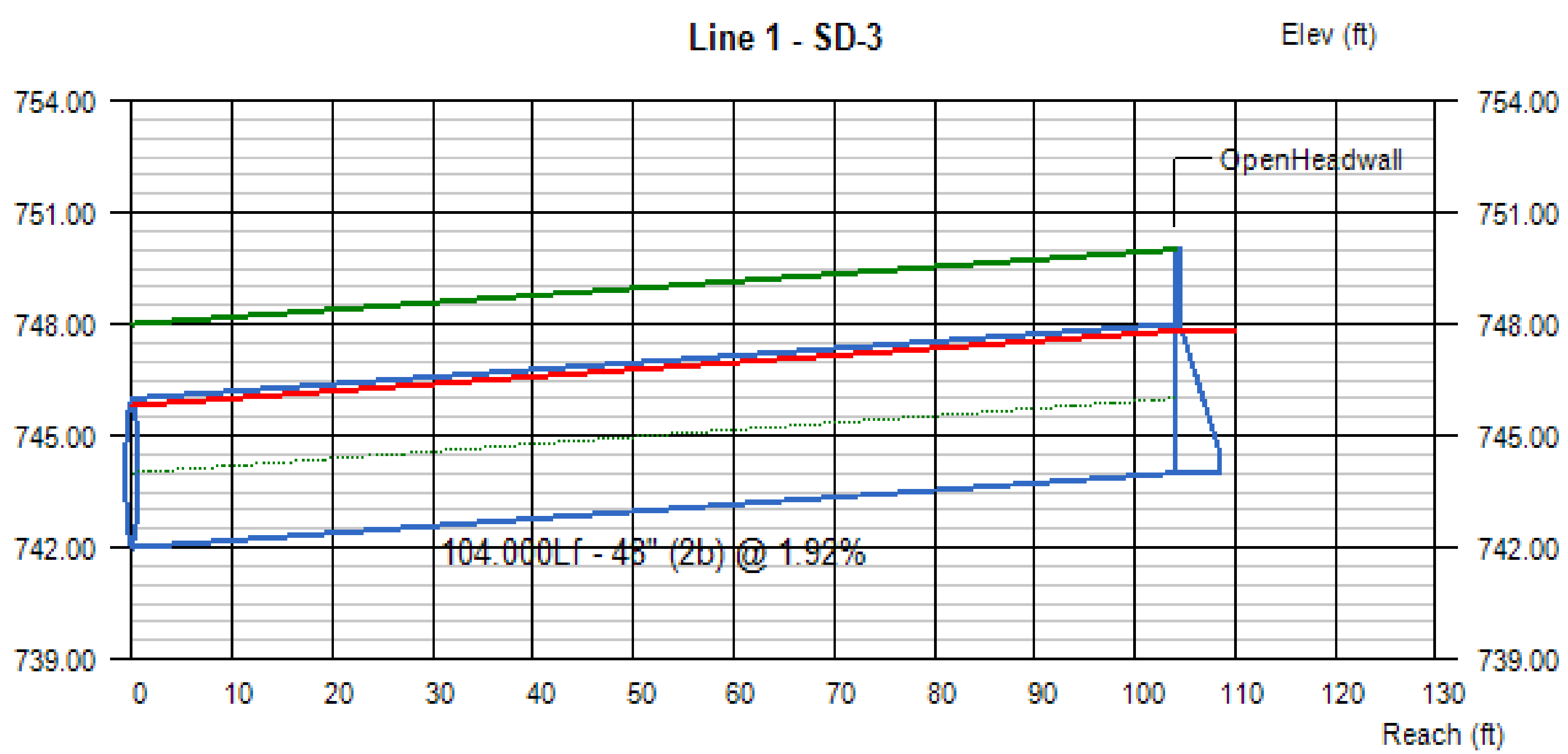
Line Profile (Line 3) - SD-2



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
3	117.82	756.00	758.00	3.27	3.27	3.27	759.27	761.27	761.27	10.72	10.72	2.00	2.00

Project File: | No. Lines: 4 | Run Date: 6/26/2020

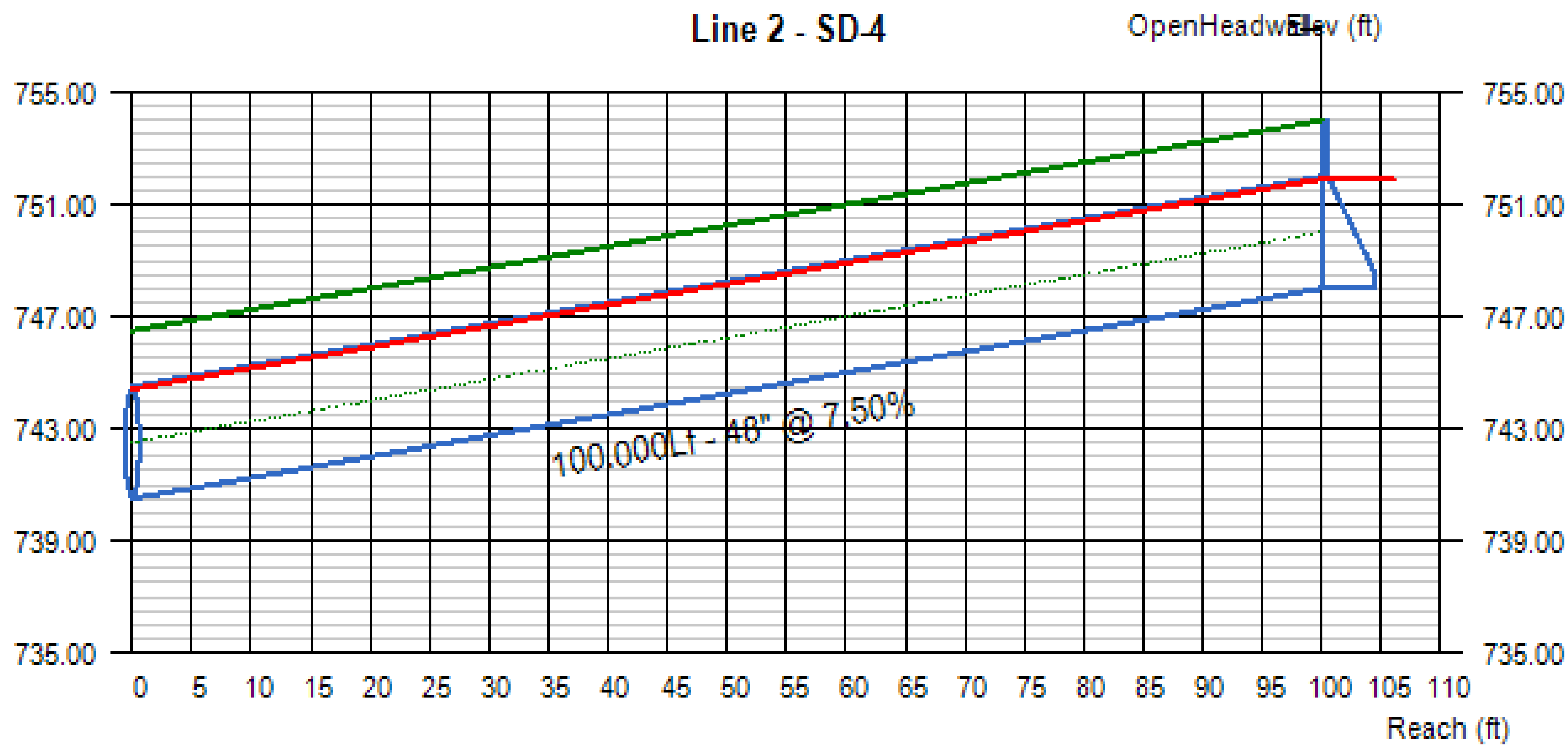
Line Profile (Line 1) - SD-3



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	537.97	742.00	744.00	3.81	3.81	3.81	745.81	747.81	747.81	21.77	21.77	2.00	2.00

Project File: | No. Lines: 4 | Run Date: 6/26/2020

Line Profile (Line 2) - SD-4



Line #	Q (cfs)	Invert Elevation Dn (ft)	Invert Elevation Up (ft)	Depth of Flow Dn (ft)	Depth of Flow Up (ft)	Depth of Flow Hw (ft)	Hydraulic Grade Line Dn (ft)	Hydraulic Grade Line Up (ft)	Hydraulic Grade Line Jnct (ft)	Velocity Dn (ft/s)	Velocity Up (ft/s)	Cover Dn (ft)	Cover Up (ft)
2	231.19	740.50	748.00	3.91	3.91	3.91	744.41	751.91	751.91	18.50	18.50	2.00	2.00

Project File:	No. Lines: 4	Run Date: 6/26/2020

3. STABILITY ANALYSIS

3.1 GLOBAL SLOPE STABILITY

OBJECTIVE:
Evaluate the slope stability for the Plant Yates Ash Management Area (AMA). Specifically, analyses were performed to evaluate long-term, steady-state slope stability of the closed AMA.

DESIGN CRITERIA:
The design of the proposed AMA is performed in accordance with the Georgia Department of Natural Resources, Environmental Protection Division (GA EPD) CCR regulations, Rule 391-3-4-10 (GA EPD CCR Rule) [GA EPD, 2016], which adopts most provisions of the United States Environmental Protection Agency's (USEPA's) federal CCR Rule contained in 40 CFR §257 (and 40 CFR §261 by reference), as amended [USEPA, 2015; USEPA, 2016]. The stability of the proposed final configuration of AMA was evaluated using relevant design criteria and recommendations in technical literature that represent the state of practice for geotechnical design of slopes. The GA EPD CCR Rule [GA EPD 391-3-4-.10(4)] states that the CCR surface impoundment should meet the structural integrity criteria in 40 CFR 257.73, which are:

- The calculated static Factor of Safety (FS) under the long-term condition must equal or exceed 1.50 per the United States Environmental Protection Agency (USEPA).

- The USEPA defines a "seismic impact zone" as an area having a 2 percent or greater probability that the maximum expected horizontal acceleration, expressed as a percentage of the earth's gravitational pull will exceed 0.10g in 50 years (40 CFR 257.53). Based on the United States Geological Survey (USGS) Unified Hazard Tool for the U.S.(2014)(v4.1.1) the site has a 2 percent probability of exceeding a maximum horizontal acceleration of 0.08g in 50 years, less than 0.10g, therefore, the site is not located in a seismic impact zone and no seismic analysis is necessary.

- Furthermore, the seismic site response was previously determined for Ash Pond 3 which is incorporated into the AMA. The "Plant Yates Ash Pond 3 Slope Stability Analyses of Ash Pond 3 Dam" states that the Seismic site repose was determined using a one-dimensional equivalent linear site response analysis. The analysis was performed using Strata and utilizing random vibration theory. The input motion consisted of the USGS published 2008 Uniform Hazard Response Spectrum (UHRS) for Site Class B/C at a 2% Probability of Exceedance in 50 years. The UHRS was converted to a Fourier Amplitude Spectrum and propagated through a representative one-dimensional soil column using linear wave propagation with strain-dependent dynamic soil properties. The input soil properties and layer thickness were randomized based on defined statistical distributions to perform Monte Carlo simulations for 100 realizations, which were used to generate a median estimate of the surface ground motions. The median surface ground motions were then used to calculate a pseudostatic seismic coefficient using the approach suggested by Bray and Tavasarou (2009). The procedure calculates the seismic coefficient for an allowable seismic displacement and a probability exceedance of the displacement. For the analysis, an allowable displacement of 0.5 ft, and a probability of exceedance of 16% were conservatively selected, providing a seismic coefficient of 0.048g. Again, less than 0.10g, therefore, the site is not located in a seismic impact zone and no seismic analysis is necessary

METHOD:
Slope stability analyses were performed using Spencer's method [Spencer, 1973] and GLE/Morgenstern-Price' method [Morgenstern, N.R., and Price, V.E. 1965, 1967], as implemented in the computer program Slide2, version 9.006 [Rocscience, 2020]. The Slide2 program generates potential slip surfaces, calculates the FS for each of the surfaces, and identifies the slip surface with the lowest calculated FS (i.e., the critical slip surface). Circular (Global) slip surfaces were analyzed in Slide2 to identify the lowest calculated FS for the critical cross section and cases analyzed.

DATA:
The following input parameters were used for the stability analysis:

Subsurface Stratigraphy

The data used to develop the subsurface stratigraphy properties were obtained from the Hydrogeological Assessment Report (HAR), historic boring logs, field investigation and laboratory test that included soil classification and consolidated undrained triaxial shear test (Appendix 7.3). Based on the data, the subsurface stratigraphy primarily consists of compacted CCR, native soil, and bedrock.

Below is a summary of the geotechnical parameters used in the analysis for the different materials represented.

Material	Unit Weight	Shear Strength Parameters (effective)	
	γ(pcf)	ϕ' (degree)	c' (psf)
Compacted Coal Combustion Residuals (CCR)	124	33	28
Structural Fill	126	32	170
Residuum/Saprolite	128	35	288
Bedrock	160	-	-

Water Table Elevations

The HAR shows the water table elevation in the vicinity of AMA ranges from 740 to 750 feet mean sea level. Advanced Engineering Methods were used to design a subsurface drain along the eastern portion of the AMA. The subsurface drain is expected to lower the water table going forward. However, for a conservative approach this analysis will utilize the water table elevation represented in the HAR, Figure 9, depicting the October 2017 water table contour map.

Cross Section Analyzed

Cross sections A & B, Shown in Figure 3.1, were selected as the critical cross sections for the slope stability analyses. This cross section was selected because it is located along the steepest and longest slope while also passes through the peak elevation of the AMA.

Results:

The Slide2 program outputs for the critical analysis show the geometry of the critical cross sections evaluated for failure, the location of the critical failure surfaces, and the associated factor of safety. The minimum factor of safety against failure for each condition is as follows:

Section **A** Static:

Spencer:
Factor of Safety (Spencer) = **2.927**

GLE/Morgenstern – Price:
Factor of Safety (Spencer) = **2.927**

Section **B** Static:

Spencer:
Factor of Safety (Spencer) = **3.068**

GLE/Morgenstern – Price:
Factor of Safety (Spencer) = **3.069**

Conclusion:

The results of the stability analyses are provided on the following pages. The proposed configuration of the AMA will exceed the target factors of safety of 1.5 for long term stability and exceeding the required design criteria.

3.2 FIGURE 3.1 – GLOBAL SLOPE STABILITY SECTION LAYOUT

200 0 100 200 400 800

SCALE (IN FEET)

GLOBAL SLOPE STABILITY

ENGINEERING REPORT

FOR

GEORGIA POWER

PLANT YATES - ASH MANAGEMENT AREA

COWETA COUNTY, GEORGIA

Georgia Power

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www.atlcc.net

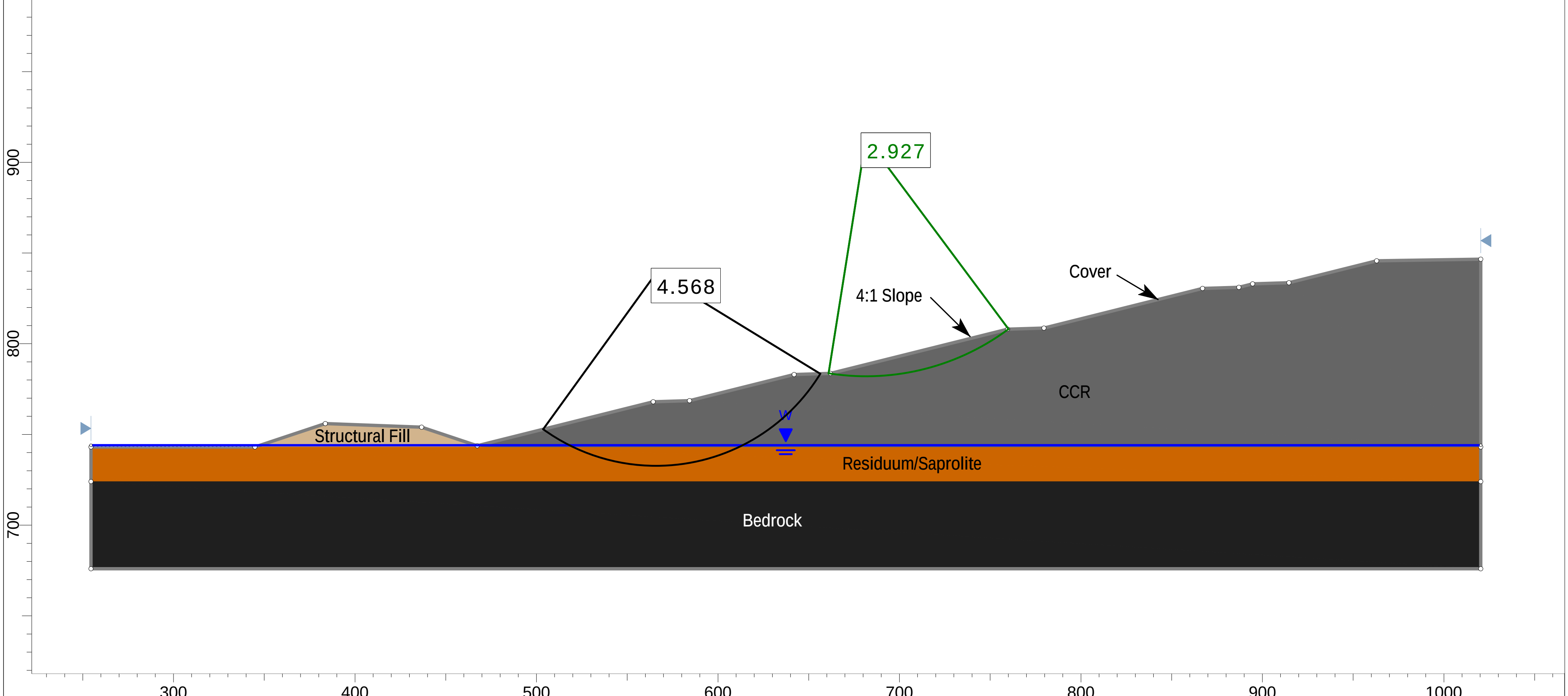
1150 Northmeadow Pkwy.
Suite 100
Roswell, GA 30076

FIGURE 3.1

3.3 GLOBAL SLOPE STABILITY CALCULATIONS

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Structural Fill		126	Mohr-Coulomb	170	32
CCR		124	Mohr-Coulomb	28	33
Residuum/ Saprolite		128	Mohr-Coulomb	288	35
Bedrock		160	Infinite strength		

Method Name	Min FS
Spencer	2.927
GLE / Morgenstern-Price	2.927



Project	Plant Yates AMA - Section A Static Global Slope Stability		
Group	Group 1	*Scenario*	Master Scenario
Drawn By	Mathieu Trunnell	*Company*	Atlantic Coast Consulting, Inc.
Date	6/23/2020, 3:37:15 PM	*File Name*	AMA Section A Global.slmd

rocscience

SLIDEINTERPRET 9.006

rocscience

AMA Section A Global
Plant Yates AMA - Section A Static Global Slope Stability
Atlantic Coast Consulting, Inc.
Date Created: 6/23/2020, 3:37:15 PM
Software Version: 9.006

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Slide Analysis Information

AMA Section A Global

Project Summary

File Name:	AMA Section A Global.slmd
Slide Modeler Version:	9.006
Compute Time:	00h:00m:01.489s
Project Title:	Plant Yates AMA - Section A Static Global Slope Stability
Analysis:	Global
Author:	Mathieu Trunnell
Company:	Atlantic Coast Consulting, Inc.
Date Created:	5/18/2020, 3:37:15 PM

General Settings

Units of Measurement:	Imperial Units
Time Units:	days
Permeability Units:	feet/second
Data Output:	Standard
Failure Direction:	Right to Left

Analysis Options

Slices Type:	Vertical
Analysis Methods Used	
	GLE/Morgenstern-Price with interslice force function (Half Sine)
	Spencer
Number of slices:	50
Tolerance:	0.005
Maximum number of iterations:	75
Check malpha < 0.2:	Yes
Create Interslice boundaries at intersections with water tables and piezos:	Yes
Initial trial value of FS:	1
Steffensen Iteration:	Yes

Groundwater Analysis

Groundwater Method:	Water Surfaces
Pore Fluid Unit Weight [lbs/ft3]:	62.4
Use negative pore pressure cutoff:	Yes
Maximum negative pore pressure [psf]:	0
Advanced Groundwater Method:	None

Random Numbers

Pseudo-random Seed:	10116
Random Number Generation Method:	Park and Miller v.3

Surface Options

Surface Type:	Circular
Search Method:	Auto Refine Search
Divisions along slope:	20
Circles per division:	10
Number of iterations:	10
Divisions to use in next iteration:	50%
Composite Surfaces:	Enabled
Minimum Elevation:	Not Defined
Minimum Depth [ft]:	10
Minimum Area:	Not Defined
Minimum Weight:	Not Defined

Materials

Structural Fill	
Color	
Strength Type	Mohr-Coulomb
Unit Weight [lbs/ft3]	126
Cohesion [psf]	170
Friction Angle [deg]	32
Water Surface	Water Table
Hu Value	Automatically Calculated
CCR	
Color	
Strength Type	Mohr-Coulomb
Unit Weight [lbs/ft3]	124
Cohesion [psf]	28
Friction Angle [deg]	33
Water Surface	Water Table
Hu Value	Automatically Calculated
Residuum / Saprolite	
Color	
Strength Type	Mohr-Coulomb
Unit Weight [lbs/ft3]	128
Cohesion [psf]	288
Friction Angle [deg]	35
Water Surface	Water Table
Hu Value	Automatically Calculated
Bedrock	
Color	
Strength Type	Infinite strength
Unit Weight [lbs/ft3]	160
Allow Sliding Along Boundary	Yes
Water Surface	Water Table
Hu Value	Automatically Calculated

Global Minimums

Method: spencer

FS	2.926520
Center:	681.549, 913.523
Radius:	131.574
Left Slip Surface Endpoint:	660.958, 783.570
Right Slip Surface Endpoint:	760.163, 808.016
Resisting Moment:	7.76142e+06 lb-ft
Driving Moment:	2.6521e+06 lb-ft
Resisting Horizontal Force:	56502 lb
Driving Horizontal Force:	19306.9 lb
Total Slice Area:	703.59 ft2
Surface Horizontal Width:	99.2052 ft
Surface Average Height:	7.09227 ft

Method: gle/morgenstern-price

FS	2.926950
Center:	681.549, 913.523
Radius:	131.574
Left Slip Surface Endpoint:	660.958, 783.570
Right Slip Surface Endpoint:	760.163, 808.016
Resisting Moment:	7.76256e+06 lb-ft
Driving Moment:	2.6521e+06 lb-ft
Resisting Horizontal Force:	56502.5 lb
Driving Horizontal Force:	19304.2 lb
Total Slice Area:	703.59 ft2
Surface Horizontal Width:	99.2052 ft
Surface Average Height:	7.09227 ft

Global Minimum Support Data

No Supports Present

Slice Data

Global Minimum Query (spencer) - Safety Factor: 2.92652

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [deg]	Base Material	Base Cohesion [psf]	Base Friction Angle [deg]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	1.9841	56.993	-8.56671	CCR	28	33	17.7626	51.9825	36.9298	0	36.9298	34.254	34.254
2	1.9841	234.776	-7.69389	CCR	28	33	40.1181	117.406	137.674	0	137.674	132.254	132.254
3	1.9841	418.934	-6.82288	CCR	28	33	62.9201	184.137	240.429	0	240.429	232.901	232.901
4	1.9841	595.571	-5.95344	CCR	28	33	84.4324	247.093	337.374	0	337.374	328.569	328.569
5	1.9841	764.725	-5.08537	CCR	28	33	104.692	306.382	428.671	0	428.671	419.355	419.355
6	1.9841	926.43	-4.21848	CCR	28	33	123.732	362.103	514.473	0	514.473	505.346	505.346
7	1.9841	1080.71	-3.35255	CCR	28	33	141.584	414.349	594.927	0	594.927	586.633	586.633
8	1.9841	1227.59	-2.48739	CCR	28	33	158.279	463.207	670.16	0	670.16	663.284	663.284
9	1.9841	1367.09	-1.6228	CCR	28	33	173.844	508.757	740.299	0	740.299	735.374	735.374
10	1.9841	1499.22	-0.758572	CCR	28	33	188.304	551.076	805.467	0	805.467	802.974	802.974
11	1.9841	1623.98	0.10548	CCR	28	33	201.685	590.234	865.765	0	865.765	866.136	866.136
12	1.9841	1741.39	0.969556	CCR	28	33	214.008	626.298	921.297	0	921.297	924.919	924.919
13	1.9841	1851.42	1.83385	CCR	28	33	225.295	659.331	972.163	0	972.163	979.376	979.376
14	1.9841	1954.09	2.69857	CCR	28	33	235.567	689.391	1018.45	0	1018.45	1029.56	1029.56
15	1.9841	2049.36	3.5639	CCR	28	33	244.841	716.531	1060.24	0	1060.24	1075.49	1075.49
16	1.9841	2137.23	4.43004	CCR	28	33	253.135	740.804	1097.62	0	1097.62	1117.23	1117.23
17	1.9841	2217.67	5.2972	CCR	28	33	260.466	762.258	1130.66	0	1130.66	1154.81	1154.81
18	1.9841	2290.66	6.16558	CCR	28	33	266.848	780.935	1159.42	0	1159.42	1188.25	1188.25
19	1.9841	2356.15	7.03539	CCR	28	33	272.296	796.88	1183.97	0	1183.97	1217.57	1217.57
20	1.9841	2414.12	7.90682	CCR	28	33	276.823	810.129	1204.37	0	1204.37	1242.82	1242.82
21	1.9841	2464.5	8.78011	CCR	28	33	280.443	820.721	1220.68	0	1220.68	1264	1264
22	1.9841	2507.26	9.65545	CCR	28	33	283.165	828.688	1232.95	0	1232.95	1281.13	1281.13
23	1.9841	2542.34	10.5331	CCR	28	33	285.002	834.063	1241.23	0	1241.23	1294.22	1294.22
24	1.9841	2569.66	11.4132	CCR	28	33	285.962	836.874	1245.56	0	1245.56	1303.29	1303.29
25	1.9841	2589.17	12.2961	CCR	28	33	286.056	837.148	1245.98	0	1245.98	1308.33	1308.33
26	1.9841	2600.79	13.1819	CCR	28	33	285.291	834.91	1242.53	0	1242.53	1309.35	1309.35
27	1.9841	2604.43	14.071	CCR	28	33	283.676	830.184	1235.26	0	1235.26	1306.36	1306.36
28	1.9841	2600	14.9635	CCR	28	33	281.218	822.991	1224.18	0	1224.18	1299.34	1299.34
29	1.9841	2587.41	15.8598	CCR	28	33	277.924	813.349	1209.33	0	1209.33	1288.29	1288.29
30	1.9841	2566.55	16.7601	CCR	28	33	273.799	801.277	1190.74	0	1190.74	1273.2	1273.2
31	1.9841	2537.3	17.6646	CCR	28	33	268.848	786.789	1168.43	0	1168.43	1254.05	1254.05
32	1.9841	2499.53	18.5738	CCR	28	33	263.077	769.901	1142.43	0	1142.43	1230.83	1230.83
33	1.9841	2453.13	19.4878	CCR	28	33	256.491	750.625	1112.75	0	1112.75	1203.51	1203.51
34	1.9841	2397.93	20.407	CCR	28	33	249.092	728.972	1079.4	0	1079.4	1172.07	1172.07
35	1.9841	2333.79	21.3317	CCR	28	33	240.884	704.951	1042.41	0	1042.41	1136.48	1136.48
36	1.9841	2260.55	22.2623	CCR	28	33	231.87	678.571	1001.79	0	1001.79	1096.71	1096.71
37	1.9841	2178.01	23.1991	CCR	28	33	222.052	649.839	957.548	0	957.548	1052.72	1052.72
38	1.9841	2085.99	24.1425	CCR	28	33	211.432	618.759	909.692	0	909.692	1004.46	1004.46
39	1.9841	1984.28	25.093	CCR	28	33	200.011	585.337	858.223	0	858.223	951.885	951.885
40	1.9841	1872.65	26.0509	CCR	28	33	187.791	549.574	803.156	0	803.156	894.954	894.954
41	1.9841	1750.87	27.0166	CCR	28	33	174.772	511.474	744.484	0	744.484	833.598	833.598
42	1.9841	1618.68	27.9908	CCR	28	33	160.954	471.035	682.215	0	682.215	767.763	767.763
43	1.9841	1475.79	28.9739	CCR	28	33	146.337	428.259	616.343	0	616.343	697.371	697.371
44	1.9841	1321.9	29.9663	CCR	28	33	130.921	383.143	546.87	0	546.87	622.355	622.355
45	1.9841	1156.68	30.9688	CCR	28	33	114.704	335.685	473.793	0	473.793	542.629	542.629
46	1.9841	979.78	31.982	CCR	28	33	97.6867	285.882	397.104	0	397.104	458.102	458.102
47	1.9841	790.813	33.0064	CCR	28	33	79.8662	233.73	316.797	0	316.797	368.675	368.675
48	1.9841	589.356	34.043	CCR	28	33	61.242	179.226	232.867	0	232.867	274.242	274.242
49	1.9841	374.953	35.0923	CCR	28	33	41.8117	122.363	145.306	0	145.306	174.683	174.683
50	1.9841	142.98	36.1553	CCR	28	33	21.7811	63.7427	55.0389	0	55.0389	70.9541	70.9541

Query 1 (spencer) - Safety Factor: 2.92652

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [deg]	Base Material	Base Cohesion [psf]	Base Friction Angle [deg]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	1.9841	56.993	-8.56671	CCR	28	33	17.7626	51.9825	36.9298	0	36.9298	34.254	34.254
2	1.9841	234.776	-7.69389	CCR	28	33	40.1181	117.406	137.674	0	137.674	132.254	132.254
3	1.9841	418.934	-6.82288	CCR	28	33	62.9201	184.137	240.429	0	240.429	232.901	232.901
4	1.9841	595.571	-5.95344	CCR	28	33	84.4324	247.093	337.374	0	337.374	328.569	328.569
5	1.9841	764.725	-5.08537	CCR	28	33	104.692	306.382	428.671	0	428.671	419.355	419.355
6	1.9841	926.43	-4.21848	CCR	28	33	123.732	362.103	514.473	0	514.473	505.346	505.346
7	1.9841	1080.71	-3.35255	CCR	28	33	141.584	414.349	594.927	0	594.927	586.633	586.633
8	1.9841	1227.59	-2.48739	CCR	28	33	158.279	463.207	670.16	0	670.16	663.284	663.284
9	1.9841	1367.09	-1.6228	CCR	28	33	173.844	508.757	740.299	0	740.299	735.374	735.374
10	1.9841	1499.22	-0.758572	CCR	28	33	188.304	551.076	805.467	0	805.467	802.974	802.974
11	1.9841	1623.98	0.10548	CCR	28	33	201.685	590.234	865.765	0	865.765	866.136	866.136
12	1.9841	1741.39	0.969556	CCR	28	33	214.008	626.298	921.297	0	921.297	924.919	924.919
13	1.9841	1851.42	1.83385	CCR	28	33	225.295	659.331	972.163	0	972.163	979.376	979.376
14	1.9841	1954.09	2.69857	CCR	28	33	235.567	689.391	1018.45	0	1018.45	1029.56	1029.56
15	1.9841	2049.36	3.5639	CCR	28	33	244.841	716.531	1060.24	0	1060.24	1075.49	1075.49
16	1.9841	2137.23	4.43004	CCR	28	33	253.135	740.804	1097.62	0	1097.62	1117.23	1117.23
17	1.9841	2217.67	5.2972	CCR	28	33	260.466	762.258	1130.66	0	1130.66	1154.81	1154.81
18	1.9841	2290.66	6.16558	CCR	28	33	266.848	780.935	1159.42	0	1159.42	1188.25	1188.25
19	1.9841	2356.15	7.03539	CCR	28	33	272.296	796.88	1183.97	0	1183.97	1217.57	1217.57
20	1.9841	2414.12	7.90682	CCR	28	33	276.823	810.129	1204.37	0	1204.37	1242.82	1242.82
21	1.9841	2464.5	8.78011	CCR	28	33	280.443	820.721	1220.68	0	1220.68	1264	1264
22	1.9841	2507.26	9.65545	CCR	28	33	283.165	828.688	1232.95	0	1232.95	1281.13	1281.13
23	1.9841	2542.34	10.5331	CCR	28	33	285.002	834.063	1241.23	0	1241.23	1294.22	1294.22
24	1.9841	2569.66	11.4132	CCR	28	33	285.962	836.874	1245.56	0	1245.56	1303.29	1303.29
25	1.9841	2589.17	12.2961	CCR	28	33	286.056	837.148	1245.98	0	1245.98	1308.33	1308.33
26	1.9841	2600.79	13.1819	CCR	28	33	285.291	834.91	1242.53	0	1242.53	1309.35	1309.35
27	1.9841	2604.43	14.071	CCR	28	33	283.676	830.184	1235.26	0	1235.26	1306.36	1306.36
28	1.9841	2600	14.9635	CCR	28	33	281.218	822.991	1224.18	0	1224.18	1299.34	1299.34
29	1.9841	2587.41	15.8598	CCR	28	33	277.924	813.349	1209.33	0	1209.33	1288.29	1288.29
30	1.9841	2566.55	16.7601	CCR	28	33	273.799	801.277	1190.74	0	1190.74	1273.2	1273.2
31	1.9841	2537.3	17.6646	CCR	28	33	268.848	786.789	1168.43	0	1168.43	1254.05	1254.05
32	1.9841	2499.53	18.5738	CCR	28	33	263.077	769.901	1142.43	0	1142.43	1230.83	1230.83
33	1.9841	2453.13	19.4878	CCR	28	33	256.491	750.625	1112.75	0	1112.75	1203.51	1203.51
34	1.9841	2397.93	20.407	CCR	28	33	249.092	728.972	1079.4	0	1079.4	1172.07	1172.07
35	1.9841	2333.79	21.3317	CCR	28	33	240.884	704.951	1042.41	0	1042.41	1136.48	1136.48
36	1.9841	2260.55	22.2623	CCR	28	33	231.87	678.571	1001.79	0	1001.79	1096.71	1096.71
37	1.9841	2178.01	23.1991	CCR	28	33	222.052	649.839	957.548	0	957.548	1052.72	1052.72
38	1.9841	2085.99	24.1425	CCR	28	33	211.432	618.759	909.692	0	909.692	1004.46	1004.46
39	1.9841	1984.28	25.093	CCR	28	33	200.011	585.337	858.223	0	858.223	951.885	951.885
40	1.9841	1872.65	26.0509	CCR	28	33	187.791	549.574	803.156	0	803.156	894.954	894.954
41	1.9841	1750.87	27.0166	CCR	28	33	174.772	511.474	744.484	0	744.484	833.598	833.598
42	1.9841	1618.68	27.9908	CCR	28	33	160.954	471.035	682.215	0	682.215	767.763	767.763
43	1.9841	1475.79	28.9739	CCR	28	33	146.337	428.259	616.343	0	616.343	697.371	697.371
44	1.9841	1321.9	29.9663	CCR	28	33	130.921	383.143	546.87	0	546.87	622.355	622.355
45	1.9841	1156.68	30.9688	CCR	28	33	114.704	335.685	473.793	0	473.793	542.629	542.629
46	1.9841	979.78	31.982	CCR	28	33	97.6867	285.882	397.104	0	397.104	458.102	458.102
47	1.9841	790.813	33.0064	CCR	28	33	79.8662	233.73	316.797	0	316.797	368.675	368.675
48	1.9841	589.356	34.043	CCR	28	33	61.242	179.226	232.867	0	232.867	274.242	274.242
49	1.9841	374.953	35.0923	CCR	28	33	41.8117	122.363	145.306	0	145.306	174.683	174.683
50	1.9841	142.98	36.1553	CCR	28	33	21.7811	63.7427	55.0389	0	55.0389	70.9541	70.9541

Global Minimum Query (gle / morgenstern-price) - Safety Factor: 2.92695

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [deg]	Base Material	Base Cohesion [psf]	Base Friction Angle [deg]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	1.9841	56.993	-8.56671	CCR	28	33	16.5796	48.5276	31.6097	0	31.6097	29.1122	29.1122
2	1.9841	234.776	-7.69389	CCR	28	33	37.4668	109.663	125.751	0	125.751	120.689	120.689
3	1.9841	418.934	-6.82288	CCR	28	33	59.3266	173.646	224.275	0	224.275	217.177	217.177
4	1.9841	595.571	-5.95344	CCR	28	33	80.4821	235.567	319.624	0	319.624	311.232	311.232
5	1.9841	764.725	-5.08537	CCR	28	33	100.867	295.232	411.502	0	411.502	402.526	402.526
6	1.9841	926.43	-4.21848	CCR	28	33	120.416	352.452	499.612	0	499.612	490.73	490.73
7	1.9841	1080.71	-3.35255	CCR	28	33	139.065	407.037	583.666	0	583.666	575.52	575.52
8	1.9841	1227.59	-2.48739	CCR	28	33	156.755	458.814	663.397	0	663.397	656.588	656.588
9	1.9841	1367.09	-1.6228	CCR	28	33	173.43	507.62	738.551	0	738.551	733.638	733.638
10	1.9841	1499.22	-0.758572	CCR	28	33	189.04	553.312	808.909	0	808.909	806.406	806.406
11	1.9841	1623.98	0.10548	CCR	28	33	203.546	595.769	874.288	0	874.288	874.662	874.662
12	1.9841	1741.39	0.969556	CCR	28	33	216.912	634.89	934.53	0	934.53	938.201	938.201
13	1.9841	1851.42	1.83385	CCR	28	33	229.113	670.602	989.522	0	989.522	996.858	996.858
14	1.9841	1954.09	2.69857	CCR	28	33	240.133	702.857	1039.19	0	1039.19	1050.51	1050.51
15	1.9841	2049.36	3.5639	CCR	28	33	249.964	731.632	1083.5	0	1083.5	1099.07	1099.07
16	1.9841	2137.23	4.43004	CCR	28	33	258.607	756.93	1122.45	0	1122.45	1142.49	1142.49
17	1.9841	2217.67	5.2972	CCR	28	33	266.071	778.777	1156.09	0	1156.09	1180.76	1180.76
18	1.9841	2290.66	6.16558	CCR	28	33	272.373	797.222	1184.5	0	1184.5	1213.92	1213.92
19	1.9841	2356.15	7.03539	CCR	28	33	277.536	812.335	1207.77	0	1207.77	1242.02	1242.02
20	1.9841	2414.12	7.90682	CCR	28	33	281.591	824.203	1226.05	0	1226.05	1265.15	1265.15
21	1.9841	2464.5	8.78011	CCR	28	33	284.571	832.926	1239.48	0	1239.48	1283.43	1283.43
22	1.9841	2507.26	9.65545	CCR	28	33	286.516	838.619	1248.24	0	1248.24	1296.99	1296.99
23	1.9841	2542.34	10.5331	CCR	28	33	287.467	841.402	1252.53	0	1252.53	1305.98	1305.98
24	1.9841	2569.66	11.4132	CCR	28	33	287.467	841.401	1252.53	0	1252.53	1310.56	1310.56
25	1.9841	2589.17	12.2961	CCR	28	33	286.56	838.747	1248.44	0	1248.44	1310.9	1310.9
26	1.9841	2600.79	13.1819	CCR	28	33	284.79	833.566	1240.46	0	1240.46	1307.16	1307.16
27	1.9841	2604.43	14.071	CCR	28	33	282.199	825.981	1228.78	0	1228.78	1299.52	1299.52
28	1.9841	2600	14.9635	CCR	28	33	278.826	816.11	1213.58	0	1213.58	1288.1	1288.1
29	1.9841	2587.41	15.8598	CCR	28	33	274.709	804.06	1195.03	0	1195.03	1273.07	1273.07
30	1.9841	2566.55	16.7601	CCR	28	33	269.881	789.928	1173.27	0	1173.27	1254.55	1254.55
31	1.9841	2537.3	17.6646	CCR	28	33	264.37	773.798	1148.43	0	1148.43	1232.62	1232.62
32	1.9841	2499.53	18.5738	CCR	28	33	258.199	755.737	1120.62	0	1120.62	1207.38	1207.38
33	1.9841	2453.13	19.4878	CCR	28	33	251.388	735.799	1089.92	0	1089.92	1178.88	1178.88
34	1.9841	2397.93	20.407	CCR	28	33	243.946	714.019	1056.38	0	1056.38	1147.13	1147.13
35	1.9841	2333.79	21.3317	CCR	28	33	235.882	690.416	1020.03	0	1020.03	1112.15	1112.15
36	1.9841	2260.55	22.2623	CCR	28	33	227.195	664.987	980.875	0	980.875	1073.88	1073.88
37	1.9841	2178.01	23.1991	CCR	28	33	217.876	637.713	938.875	0	938.875	1032.25	1032.25
38	1.9841	2085.99	24.1425	CCR	28	33	207.914	608.553	893.972	0	893.972	987.161	987.161
39	1.9841	1984.28	25.093	CCR	28	33	197.286	577.445	846.072	0	846.072	938.458	938.458
40	1.9841	1872.65	26.0509	CCR	28	33	185.964	544.307	795.042	0	795.042	885.947	885.947
41	1.9841	1750.87	27.0166	CCR	28	33	173.912	509.033	740.725	0	740.725	829.402	829.402
42	1.9841	1618.68	27.9908	CCR	28	33	161.087	471.495	682.923	0	682.923	768.542	768.542
43	1.9841	1475.79	28.9739	CCR	28	33	147.436	431.539	621.396	0	621.396	703.033	703.033
44	1.9841	1321.9	29.9663	CCR	28	33	132.898	388.987	555.869	0	555.869	632.494	632.494
45	1.9841	1156.68	30.9688	CCR	28	33	117.403	343.632	486.031	0	486.031	556.487	556.487
46	1.9841	979.78	31.982	CCR	28	33	100.869	295.239	411.511	0	411.511	474.497	474.497
47	1.9841	790.813	33.0064	CCR	28	33	83.2064	243.541	331.904	0	331.904	385.952	385.952
48	1.9841	589.356	34.043	CCR	28	33	64.3127	188.24	246.749	0	246.749	290.198	290.198
49	1.9841	374.953	35.0923	CCR	28	33	44.0742	129.003	155.532	0	155.532	186.499	186.499
50	1.9841	142.98	36.1553	CCR	28	33	21.9679	64.299	55.8955	0	55.8955	71.9473	71.9473

Query 1 (gle/morgenstern-price) - Safety Factor: 2.92695

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [deg]	Base Material	Base Cohesion [psf]	Base Friction Angle [deg]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	1.9841	56.993	-8.56671	CCR	28	33	16.5796	48.5276	31.6097	0	31.6097	29.1122	29.1122
2	1.9841	234.776	-7.69389	CCR	28	33	37.4668	109.663	125.751	0	125.751	120.689	120.689
3	1.9841	418.934	-6.82288	CCR	28	33	59.3266	173.646	224.275	0	224.275	217.177	217.177
4	1.9841	595.571	-5.95344	CCR	28	33	80.4821	235.567	319.624	0	319.624	311.232	311.232
5	1.9841	764.725	-5.08537	CCR	28	33	100.867	295.232	411.502	0	411.502	402.526	402.526
6	1.9841	926.43	-4.21848	CCR	28	33	120.416	352.452	499.612	0	499.612	490.73	490.73
7	1.9841	1080.71	-3.35255	CCR	28	33	139.065	407.037	583.666	0	583.666	575.52	575.52
8	1.9841	1227.59	-2.48739	CCR	28	33	156.755	458.814	663.397	0	663.397	656.588	656.588
9	1.9841	1367.09	-1.6228	CCR	28	33	173.43	507.62	738.551	0	738.551	733.638	733.638
10	1.9841	1499.22	-0.758572	CCR	28	33	189.04	553.312	808.909	0	808.909	806.406	806.406
11	1.9841	1623.98	0.10548	CCR	28	33	203.546	595.769	874.288	0	874.288	874.662	874.662
12	1.9841	1741.39	0.969556	CCR	28	33	216.912	634.89	934.53	0	934.53	938.201	938.201
13	1.9841	1851.42	1.83385	CCR	28	33	229.113	670.602	989.522	0	989.522	996.858	996.858
14	1.9841	1954.09	2.69857	CCR	28	33	240.133	702.857	1039.19	0	1039.19	1050.51	1050.51
15	1.9841	2049.36	3.5639	CCR	28	33	249.964	731.632	1083.5	0	1083.5	1099.07	1099.07
16	1.9841	2137.23	4.43004	CCR	28	33	258.607	756.93	1122.45	0	1122.45	1142.49	1142.49
17	1.9841	2217.67	5.2972	CCR	28	33	266.071	778.777	1156.09	0	1156.09	1180.76	1180.76
18	1.9841	2290.66	6.16558	CCR	28	33	272.373	797.222	1184.5	0	1184.5	1213.92	1213.92
19	1.9841	2356.15	7.03539	CCR	28	33	277.536	812.335	1207.77	0	1207.77	1242.02	1242.02
20	1.9841	2414.12	7.90682	CCR	28	33	281.591	824.203	1226.05	0	1226.05	1265.15	1265.15
21	1.9841	2464.5	8.78011	CCR	28	33	284.571	832.926	1239.48	0	1239.48	1283.43	1283.43
22	1.9841	2507.26	9.65545	CCR	28	33	286.516	838.619	1248.24	0	1248.24	1296.99	1296.99
23	1.9841	2542.34	10.5331	CCR	28	33	287.467	841.402	1252.53	0	1252.53	1305.98	1305.98
24	1.9841	2569.66	11.4132	CCR	28	33	287.467	841.401	1252.53	0	1252.53	1310.56	1310.56
25	1.9841	2589.17	12.2961	CCR	28	33	286.56	838.747	1248.44	0	1248.44	1310.9	1310.9
26	1.9841	2600.79	13.1819	CCR	28	33	284.79	833.566	1240.46	0	1240.46	1307.16	1307.16
27	1.9841	2604.43	14.071	CCR	28	33	282.199	825.981	1228.78	0	1228.78	1299.52	1299.52
28	1.9841	2600	14.9635	CCR	28	33	278.826	816.11	1213.58	0	1213.58	1288.1	1288.1
29	1.9841	2587.41	15.8598	CCR	28	33	274.709	804.06	1195.03	0	1195.03	1273.07	1273.07
30	1.9841	2566.55	16.7601	CCR	28	33	269.881	789.928	1173.27	0	1173.27	1254.55	1254.55
31	1.9841	2537.3	17.6646	CCR	28	33	264.37	773.798	1148.43	0	1148.43	1232.62	1232.62
32	1.9841	2499.53	18.5738	CCR	28	33	258.199	755.737	1120.62	0	1120.62	1207.38	1207.38
33	1.9841	2453.13	19.4878	CCR	28	33	251.388	735.799	1089.92	0	1089.92	1178.88	1178.88
34	1.9841	2397.93	20.407	CCR	28	33	243.946	714.019	1056.38	0	1056.38	1147.13	1147.13
35	1.9841	2333.79	21.3317	CCR	28	33	235.882	690.416	1020.03	0	1020.03	1112.15	1112.15
36	1.9841	2260.55	22.2623	CCR	28	33	227.195	664.987	980.875	0	980.875	1073.88	1073.88
37	1.9841	2178.01	23.1991	CCR	28	33	217.876	637.713	938.875	0	938.875	1032.25	1032.25
38	1.9841	2085.99	24.1425	CCR	28	33	207.914	608.553	893.972	0	893.972	987.161	987.161
39	1.9841	1984.28	25.093	CCR	28	33	197.286	577.445	846.072	0	846.072	938.458	938.458
40	1.9841	1872.65	26.0509	CCR	28	33	185.964	544.307	795.042	0	795.042	885.947	885.947
41	1.9841	1750.87	27.0166	CCR	28	33	173.912	509.033	740.725	0	740.725	829.402	829.402
42	1.9841	1618.68	27.9908	CCR	28	33	161.087	471.495	682.923	0	682.923	768.542	768.542
43	1.9841	1475.79	28.9739	CCR	28	33	147.436	431.539	621.396	0	621.396	703.033	703.033
44	1.9841	1321.9	29.9663	CCR	28	33	132.898	388.987	555.869	0	555.869	632.494	632.494
45	1.9841	1156.68	30.9688	CCR	28	33	117.403	343.632	486.031	0	486.031	556.487	556.487
46	1.9841	979.78	31.982	CCR	28	33	100.869	295.239	411.511	0	411.511	474.497	474.497
47	1.9841	790.813	33.0064	CCR	28	33	83.2064	243.541	331.904	0	331.904	385.952	385.952
48	1.9841	589.356	34.043	CCR	28	33	64.3127	188.24	246.749	0	246.749	290.198	290.198
49	1.9841	374.953	35.0923	CCR	28	33	44.0742	129.003	155.532	0	155.532	186.499	186.499
50	1.9841	142.98	36.1553	CCR	28	33	21.9679	64.299	55.8955	0	55.8955	71.9473	71.9473

Interslice Data

Global Minimum Query (spencer) - Safety Factor: 2.92652

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [deg]
1	660.958	783.57	0	0	0
2	662.942	783.271	46.272	11.0436	13.4235
3	664.926	783.003	162.753	38.8439	13.4235
4	666.91	782.765	344.639	82.254	13.4235
5	668.895	782.558	581.925	138.887	13.4236
6	670.879	782.382	865.282	206.515	13.4235
7	672.863	782.236	1186.01	283.062	13.4235
8	674.847	782.119	1536.01	366.594	13.4235
9	676.831	782.033	1907.73	455.313	13.4235
10	678.815	781.977	2294.18	547.547	13.4235
11	680.799	781.951	2688.87	641.744	13.4235
12	682.783	781.954	3085.77	736.472	13.4235
13	684.767	781.988	3479.34	830.405	13.4235
14	686.752	782.051	3864.48	922.325	13.4235
15	688.736	782.145	4236.51	1011.12	13.4236
16	690.72	782.268	4591.16	1095.76	13.4235
17	692.704	782.422	4924.56	1175.33	13.4235
18	694.688	782.606	5233.23	1249	13.4235
19	696.672	782.82	5514.04	1316.02	13.4235
20	698.656	783.065	5764.26	1375.74	13.4235
21	700.64	783.341	5981.5	1427.59	13.4235
22	702.624	783.647	6163.71	1471.08	13.4235
23	704.608	783.985	6309.2	1505.8	13.4235
24	706.593	784.354	6416.63	1531.44	13.4235
25	708.577	784.754	6484.97	1547.75	13.4235
26	710.561	785.187	6513.55	1554.57	13.4235
27	712.545	785.652	6502.05	1551.83	13.4235
28	714.529	786.149	6450.45	1539.51	13.4235
29	716.513	786.679	6359.12	1517.71	13.4235
30	718.497	787.243	6228.73	1486.59	13.4235
31	720.481	787.84	6060.34	1446.4	13.4235
32	722.465	788.472	5855.34	1397.48	13.4235
33	724.449	789.139	5615.52	1340.24	13.4235
34	726.434	789.841	5343	1275.2	13.4235
35	728.418	790.579	5040.33	1202.96	13.4235
36	730.402	791.354	4710.46	1124.23	13.4235
37	732.386	792.166	4356.73	1039.81	13.4235
38	734.37	793.017	3982.94	950.598	13.4235
39	736.354	793.906	3593.35	857.616	13.4235
40	738.338	794.835	3192.7	761.993	13.4235
41	740.322	795.805	2786.23	664.982	13.4235
42	742.306	796.817	2379.73	567.965	13.4235
43	744.291	797.871	1979.57	472.459	13.4235
44	746.275	798.97	1592.72	380.129	13.4235
45	748.259	800.114	1226.81	292.799	13.4235
46	750.243	801.304	890.19	212.459	13.4235
47	752.227	802.543	591.976	141.285	13.4235
48	754.211	803.832	342.109	81.6501	13.4235
49	756.195	805.173	151.44	36.1438	13.4235
50	758.179	806.567	31.8137	7.5929	13.4235
51	760.163	808.016	0	0	0

Query 1 (spencer) - Safety Factor: 2.92652

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [deg]
1	660.958	783.57	0	0	0
2	662.942	783.271	46.272	11.0436	13.4235
3	664.926	783.003	162.753	38.8439	13.4235
4	666.91	782.765	344.639	82.254	13.4235
5	668.895	782.558	581.925	138.887	13.4236
6	670.879	782.382	865.282	206.515	13.4235
7	672.863	782.236	1186.01	283.062	13.4235
8	674.847	782.119	1536.01	366.594	13.4235
9	676.831	782.033	1907.73	455.313	13.4235
10	678.815	781.977	2294.18	547.547	13.4235
11	680.799	781.951	2688.87	641.744	13.4235
12	682.783	781.954	3085.77	736.472	13.4235
13	684.767	781.988	3479.34	830.405	13.4235
14	686.752	782.051	3864.48	922.325	13.4235
15	688.736	782.145	4236.51	1011.12	13.4236
16	690.72	782.268	4591.16	1095.76	13.4235
17	692.704	782.422	4924.56	1175.33	13.4235
18	694.688	782.606	5233.23	1249	13.4235
19	696.672	782.82	5514.04	1316.02	13.4235
20	698.656	783.065	5764.26	1375.74	13.4235
21	700.64	783.341	5981.5	1427.59	13.4235
22	702.624	783.647	6163.71	1471.08	13.4235
23	704.608	783.985	6309.2	1505.8	13.4235
24	706.593	784.354	6416.63	1531.44	13.4235
25	708.577	784.754	6484.97	1547.75	13.4235
26	710.561	785.187	6513.55	1554.57	13.4235
27	712.545	785.652	6502.05	1551.83	13.4235
28	714.529	786.149	6450.45	1539.51	13.4235
29	716.513	786.679	6359.12	1517.71	13.4235
30	718.497	787.243	6228.73	1486.59	13.4235
31	720.481	787.84	6060.34	1446.4	13.4235
32	722.465	788.472	5855.34	1397.48	13.4235
33	724.449	789.139	5615.52	1340.24	13.4235
34	726.434	789.841	5343	1275.2	13.4235
35	728.418	790.579	5040.33	1202.96	13.4235
36	730.402	791.354	4710.46	1124.23	13.4235
37	732.386	792.166	4356.73	1039.81	13.4235
38	734.37	793.017	3982.94	950.598	13.4235
39	736.354	793.906	3593.35	857.616	13.4235
40	738.338	794.835	3192.7	761.993	13.4235
41	740.322	795.805	2786.23	664.982	13.4235
42	742.306	796.817	2379.73	567.965	13.4235
43	744.291	797.871	1979.57	472.459	13.4235
44	746.275	798.97	1592.72	380.129	13.4235
45	748.259	800.114	1226.81	292.799	13.4235
46	750.243	801.304	890.19	212.459	13.4235
47	752.227	802.543	591.976	141.285	13.4235
48	754.211	803.832	342.109	81.6501	13.4235
49	756.195	805.173	151.44	36.1438	13.4235
50	758.179	806.567	31.8137	7.5929	13.4235
51	760.163	808.016	0	0	0

Global Minimum Query (gle / morgenstern-price) - Safety Factor: 2.92695

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [deg]
1	660.958	783.57	0	0	0
2	662.942	783.271	42.3386	0.769967	1.04186
3	664.926	783.003	150.373	5.45855	2.07893
4	666.91	782.765	321.308	17.4377	3.10645
5	668.895	782.558	547.102	39.4064	4.11976
6	670.879	782.382	819.861	73.3776	5.11435
7	672.863	782.236	1131.86	120.678	6.08584
8	674.847	782.119	1475.58	181.965	7.03009
9	676.831	782.033	1843.73	257.255	7.94318
10	678.815	781.977	2229.3	345.966	8.82139
11	680.799	781.951	2625.57	446.975	9.66137
12	682.783	781.954	3026.18	558.68	10.4599
13	684.767	781.988	3425.11	679.076	11.2143
14	686.752	782.051	3816.77	805.834	11.9218
15	688.736	782.145	4195.96	936.381	12.5801
16	690.72	782.268	4557.95	1067.99	13.1873
17	692.704	782.422	4898.45	1197.87	13.7415
18	694.688	782.606	5213.6	1323.23	14.2412
19	696.672	782.82	5500.06	1441.37	14.685
20	698.656	783.065	5754.91	1549.74	15.0717
21	700.64	783.341	5975.68	1646.02	15.4004
22	702.624	783.647	6160.38	1728.17	15.6704
23	704.608	783.985	6307.42	1794.45	15.881
24	706.593	784.354	6415.63	1843.49	16.0317
25	708.577	784.754	6484.22	1874.31	16.1223
26	710.561	785.187	6512.8	1886.29	16.1525
27	712.545	785.652	6501.32	1879.25	16.1223
28	714.529	786.149	6450.07	1853.39	16.0317
29	716.513	786.679	6359.66	1809.31	15.8809
30	718.497	787.243	6231.02	1747.98	15.6703
31	720.481	787.84	6065.35	1670.72	15.4004
32	722.465	788.472	5864.17	1579.16	15.0716
33	724.449	789.139	5629.26	1475.22	14.6849
34	726.434	789.841	5362.7	1361.07	14.2411
35	728.418	790.579	5066.88	1239.06	13.7415
36	730.402	791.354	4744.47	1111.7	13.1873
37	732.386	792.166	4398.5	981.58	12.5801
38	734.37	793.017	4032.36	851.351	11.9218
39	736.354	793.906	3649.81	723.626	11.2143
40	738.338	794.835	3255.08	600.94	10.4599
41	740.322	795.805	2852.89	485.674	9.66137
42	742.306	796.817	2448.53	379.988	8.82138
43	744.291	797.871	2047.91	285.744	7.94317
44	746.275	798.97	1657.72	204.426	7.03008
45	748.259	800.114	1285.47	137.056	6.08585
46	750.243	801.304	939.657	84.0994	5.11435
47	752.227	802.543	629.926	45.3721	4.11977
48	754.211	803.832	367.231	19.93	3.10645
49	756.195	805.173	164.059	5.95536	2.07893
50	758.179	806.567	34.6754	0.630604	1.04186
51	760.163	808.016	0	0	0

Query 1 (gle / morgenstern-price) - Safety Factor: 2.92695

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [deg]
1	660.958	783.57	0	0	0
2	662.942	783.271	42.3386	0.769967	1.04186
3	664.926	783.003	150.373	5.45855	2.07893
4	666.91	782.765	321.308	17.4377	3.10645
5	668.895	782.558	547.102	39.4064	4.11976
6	670.879	782.382	819.861	73.3776	5.11435
7	672.863	782.236	1131.86	120.678	6.08584
8	674.847	782.119	1475.58	181.965	7.03009
9	676.831	782.033	1843.73	257.255	7.94318
10	678.815	781.977	2229.3	345.966	8.82139
11	680.799	781.951	2625.57	446.975	9.66137
12	682.783	781.954	3026.18	558.68	10.4599
13	684.767	781.988	3425.11	679.076	11.2143
14	686.752	782.051	3816.77	805.834	11.9218
15	688.736	782.145	4195.96	936.381	12.5801
16	690.72	782.268	4557.95	1067.99	13.1873
17	692.704	782.422	4898.45	1197.87	13.7415
18	694.688	782.606	5213.6	1323.23	14.2412
19	696.672	782.82	5500.06	1441.37	14.685
20	698.656	783.065	5754.91	1549.74	15.0717
21	700.64	783.341	5975.68	1646.02	15.4004
22	702.624	783.647	6160.38	1728.17	15.6704
23	704.608	783.985	6307.42	1794.45	15.881
24	706.593	784.354	6415.63	1843.49	16.0317
25	708.577	784.754	6484.22	1874.31	16.1223
26	710.561	785.187	6512.8	1886.29	16.1525
27	712.545	785.652	6501.32	1879.25	16.1223
28	714.529	786.149	6450.07	1853.39	16.0317
29	716.513	786.679	6359.66	1809.31	15.8809
30	718.497	787.243	6231.02	1747.98	15.6703
31	720.481	787.84	6065.35	1670.72	15.4004
32	722.465	788.472	5864.17	1579.16	15.0716
33	724.449	789.139	5629.26	1475.22	14.6849
34	726.434	789.841	5362.7	1361.07	14.2411
35	728.418	790.579	5066.88	1239.06	13.7415
36	730.402	791.354	4744.47	1111.7	13.1873
37	732.386	792.166	4398.5	981.58	12.5801
38	734.37	793.017	4032.36	851.351	11.9218
39	736.354	793.906	3649.81	723.626	11.2143
40	738.338	794.835	3255.08	600.94	10.4599
41	740.322	795.805	2852.89	485.674	9.66137
42	742.306	796.817	2448.53	379.988	8.82138
43	744.291	797.871	2047.91	285.744	7.94317
44	746.275	798.97	1657.72	204.426	7.03008
45	748.259	800.114	1285.47	137.056	6.08585
46	750.243	801.304	939.657	84.0994	5.11435
47	752.227	802.543	629.926	45.3721	4.11977
48	754.211	803.832	367.231	19.93	3.10645
49	756.195	805.173	164.059	5.95536	2.07893
50	758.179	806.567	34.6754	0.630604	1.04186
51	760.163	808.016	0	0	0

Entity Information

Group 1

Shared Entities

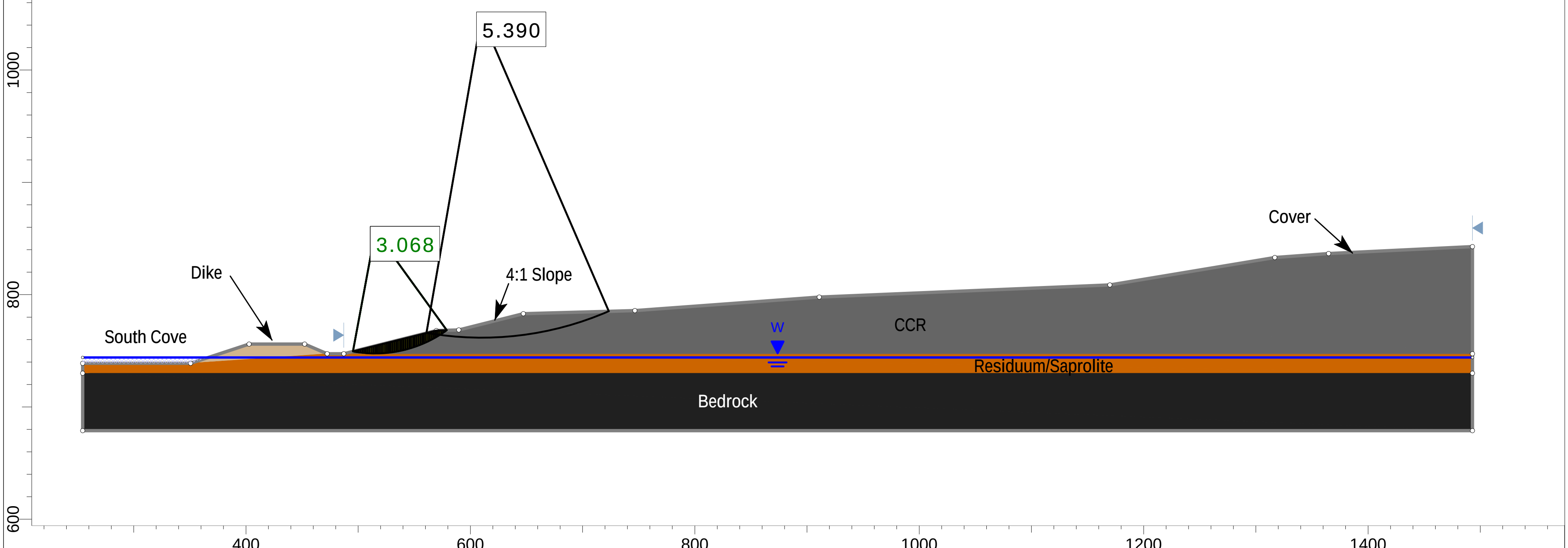
Type	Coordinates (x,y)
External Boundary	1020.29, 743.056 1020.29, 846.575 962.906, 845.676 914.602, 833.6 894.574, 832.995 887.032, 831.098 866.986, 830.459 779.622, 808.6 759.613, 808 661.969, 783.6 641.96, 783 584.334, 768.6 564.325, 768 467.369, 743.77 436.676, 754 383.672, 756 344.836, 743.056 254.484, 743.056 254.484, 724 254.484, 675.965 1020.29, 675.965 1020.29, 724
Material Boundary	467.369, 743.77 469.511, 743.056
Material Boundary	344.836, 743.056 469.511, 743.056
Material Boundary	469.511, 743.056 1020.29, 743.056
Material Boundary	254.484, 724 1020.29, 724

Scenario-based Entities

Type	Coordinates (x,y)	Master Scenario
Water Table	254.484, 744 1020.29, 744	Assigned to: Structural Fill CCR Residuum/Saprolite Bedrock

Material Name	Color	Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Structural Fill		126	Mohr-Coulomb	170	32
CCR		124	Mohr-Coulomb	28	33
Residuum/ Saprolite		128	Mohr-Coulomb	288	35
Bedrock		160	Infinite strength		

Method Name	Min FS
Spencer	3.068
GLE / Morgenstern-Price	3.069



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SLIDEINTERPRET 9.006

Project	Plant Yates AMA - Section B Static Global Slope Stability		
Group	Group 1	*Scenario*	Master Scenario
Drawn By	Mathieu Trunnell	*Company*	Atlantic Coast Consulting, Inc.
Date	6/23/2020, 3:31:36 PM	*File Name*	AMA Section B Global.slmd

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AMA Section B Global

Plant Yates AMA - Section B Static Global Slope Stability

Atlantic Coast Consulting, Inc.

Date Created: 6/23/2020, 3:31:36 PM

Software Version: 9.006

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Slide Analysis Information

AMA Section B Global

Project Summary

File Name:	AMA Section B Global.slmd
Slide Modeler Version:	9.006
Compute Time:	00h:00m:01.558s
Project Title:	Plant Yates AMA - Section B Global Slope Stability
Analysis:	Global Slope Stability
Author:	Mathieu Trunnell
Company:	Atlantic Coast Consulting, Inc.
Date Created:	5/18/2020, 3:31:36 PM

General Settings

Units of Measurement:	Imperial Units
Time Units:	days
Permeability Units:	feet/second
Data Output:	Standard
Failure Direction:	Right to Left

Analysis Options

Slices Type:	Vertical
Analysis Methods Used	
	GLE/Morgenstern-Price with interslice force function (Half Sine)
	Spencer
Number of slices:	50
Tolerance:	0.005
Maximum number of iterations:	75
Check malpha < 0.2:	Yes
Create Interslice boundaries at intersections with water tables and piezos:	Yes
Initial trial value of FS:	1
Steffensen Iteration:	Yes

Groundwater Analysis

Groundwater Method:	Water Surfaces
Pore Fluid Unit Weight [lbs/ft3]:	62.4
Use negative pore pressure cutoff:	Yes
Maximum negative pore pressure [psf]:	0
Advanced Groundwater Method:	None

Random Numbers

Pseudo-random Seed:	10116
Random Number Generation Method:	Park and Miller v.3

Surface Options

Surface Type:	Circular
Search Method:	Auto Refine Search
Divisions along slope:	20
Circles per division:	10
Number of iterations:	10
Divisions to use in next iteration:	50%
Composite Surfaces:	Disabled
Minimum Elevation:	Not Defined
Minimum Depth [ft]:	10
Minimum Area:	Not Defined
Minimum Weight:	Not Defined

Materials

Structural Fill	
Color	
Strength Type	Mohr-Coulomb
Unit Weight [lbs/ft3]	126
Cohesion [psf]	170
Friction Angle [deg]	32
Water Surface	Water Table
Hu Value	Automatically Calculated
CCR	
Color	
Strength Type	Mohr-Coulomb
Unit Weight [lbs/ft3]	124
Cohesion [psf]	28
Friction Angle [deg]	33
Water Surface	Water Table
Hu Value	Automatically Calculated
Residuum/Saprolite	
Color	
Strength Type	Mohr-Coulomb
Unit Weight [lbs/ft3]	128
Cohesion [psf]	288
Friction Angle [deg]	35
Water Surface	Water Table
Hu Value	Automatically Calculated
Bedrock	
Color	
Strength Type	Infinite strength
Unit Weight [lbs/ft3]	160
Allow Sliding Along Boundary	Yes
Water Surface	Water Table
Hu Value	Automatically Calculated

Global Minimums

Method: spencer

FS	3.068330
Center:	515.169, 856.384
Radius:	108.751
Left Slip Surface Endpoint:	495.368, 749.451
Right Slip Surface Endpoint:	578.921, 768.280
Resisting Moment:	5.32634e+06 lb-ft
Driving Moment:	1.73591e+06 lb-ft
Resisting Horizontal Force:	46972.3 lb
Driving Horizontal Force:	15308.7 lb
Total Slice Area:	581.772 ft2
Surface Horizontal Width:	83.5533 ft
Surface Average Height:	6.96288 ft

Method: gle/morgenstern-price

FS	3.068930
Center:	515.169, 856.384
Radius:	108.751
Left Slip Surface Endpoint:	495.368, 749.451
Right Slip Surface Endpoint:	578.921, 768.280
Resisting Moment:	5.32737e+06 lb-ft
Driving Moment:	1.73591e+06 lb-ft
Resisting Horizontal Force:	46972.8 lb
Driving Horizontal Force:	15305.9 lb
Total Slice Area:	581.772 ft2
Surface Horizontal Width:	83.5533 ft
Surface Average Height:	6.96288 ft

Global Minimum Support Data

No Supports Present

Slice Data

Global Minimum Query (spencer) - Safety Factor: 3.06833

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [deg]	Base Material	Base Cohesion [psf]	Base Friction Angle [deg]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	1.67107	73.9262	-10.0437	CCR	28	33	20.6908	63.4863	54.6441	0	54.6441	50.9794	50.9794
2	1.67107	219.003	-9.15075	CCR	28	33	41.3716	126.942	152.357	0	152.357	145.692	145.692
3	1.67107	358.55	-8.26004	CCR	28	33	60.9475	187.007	244.85	0	244.85	236.002	236.002
4	1.67107	492.606	-7.37134	CCR	28	33	79.452	243.785	332.28	0	332.28	322.001	322.001
5	1.67107	621.207	-6.48442	CCR	28	33	96.9166	297.372	414.796	0	414.796	403.78	403.78
6	1.67107	744.382	-5.59905	CCR	28	33	113.369	347.855	492.534	0	492.534	481.42	481.42
7	1.67107	862.159	-4.71503	CCR	28	33	128.838	395.318	565.621	0	565.621	554.994	554.994
8	1.67107	974.561	-3.83213	CCR	28	33	143.348	439.838	634.173	0	634.173	624.571	624.571
9	1.67107	1081.6	-2.95014	CCR	28	33	156.922	481.488	698.309	0	698.309	690.222	690.222
10	1.67107	1183.31	-2.06885	CCR	28	33	169.582	520.333	758.129	0	758.129	752.003	752.003
11	1.67107	1279.67	-1.18805	CCR	28	33	181.349	556.438	813.724	0	813.724	809.964	809.964
12	1.67107	1370.72	-0.307535	CCR	28	33	192.241	589.86	865.19	0	865.19	864.158	864.158
13	1.67107	1456.44	0.572912	CCR	28	33	202.278	620.655	912.611	0	912.611	914.634	914.634
14	1.67107	1536.84	1.45349	CCR	28	33	211.475	648.874	956.064	0	956.064	961.429	961.429
15	1.67107	1611.91	2.33442	CCR	28	33	219.848	674.565	995.621	0	995.621	1004.58	1004.58
16	1.67107	1681.65	3.2159	CCR	28	33	227.411	697.772	1031.36	0	1031.36	1044.14	1044.14
17	1.67107	1746.04	4.09814	CCR	28	33	234.178	718.536	1063.33	0	1063.33	1080.11	1080.11
18	1.67107	1805.07	4.98135	CCR	28	33	240.163	736.898	1091.6	0	1091.6	1112.54	1112.54
19	1.67107	1858.72	5.86576	CCR	28	33	245.375	752.892	1116.23	0	1116.23	1141.44	1141.44
20	1.67107	1906.96	6.75157	CCR	28	33	249.827	766.553	1137.27	0	1137.27	1166.85	1166.85
21	1.67107	1949.77	7.639	CCR	28	33	253.529	777.912	1154.76	0	1154.76	1188.76	1188.76
22	1.67107	1987.11	8.52828	CCR	28	33	256.49	786.997	1168.75	0	1168.75	1207.21	1207.21
23	1.67107	2018.95	9.41964	CCR	28	33	258.72	793.837	1179.29	0	1179.29	1222.21	1222.21
24	1.67107	2045.25	10.3133	CCR	28	33	260.225	798.456	1186.4	0	1186.4	1233.75	1233.75
25	1.67107	2065.95	11.2095	CCR	28	33	261.014	800.876	1190.13	0	1190.13	1241.85	1241.85
26	1.67107	2081.02	12.1085	CCR	28	33	261.093	801.119	1190.5	0	1190.5	1246.51	1246.51
27	1.67107	2090.4	13.0105	CCR	28	33	260.469	799.204	1187.55	0	1187.55	1247.73	1247.73
28	1.67107	2094.02	13.9159	CCR	28	33	259.147	795.149	1181.31	0	1181.31	1245.51	1245.51
29	1.67107	2091.83	14.8248	CCR	28	33	257.133	788.968	1171.79	0	1171.79	1239.84	1239.84
30	1.67107	2083.74	15.7375	CCR	28	33	254.431	780.678	1159.02	0	1159.02	1230.72	1230.72
31	1.67107	2069.68	16.6543	CCR	28	33	251.045	770.289	1143.02	0	1143.02	1218.12	1218.12
32	1.67107	2049.58	17.5756	CCR	28	33	246.979	757.814	1123.82	0	1123.82	1202.05	1202.05
33	1.67107	2023.33	18.5015	CCR	28	33	242.237	743.262	1101.41	0	1101.41	1182.47	1182.47
34	1.67107	1990.84	19.4325	CCR	28	33	236.82	726.642	1075.81	0	1075.81	1159.36	1159.36
35	1.67107	1952	20.3689	CCR	28	33	230.731	707.959	1047.05	0	1047.05	1132.71	1132.71
36	1.67107	1906.7	21.311	CCR	28	33	223.972	687.221	1015.11	0	1015.11	1102.48	1102.48
37	1.67107	1854.83	22.2592	CCR	28	33	216.545	664.431	980.017	0	980.017	1068.65	1068.65
38	1.67107	1796.23	23.2138	CCR	28	33	208.449	639.591	941.767	0	941.767	1031.17	1031.17
39	1.67107	1730.78	24.1753	CCR	28	33	199.686	612.704	900.364	0	900.364	990.004	990.004
40	1.67107	1658.32	25.1442	CCR	28	33	190.257	583.771	855.812	0	855.812	945.114	945.114
41	1.67107	1578.69	26.1207	CCR	28	33	180.16	552.789	808.103	0	808.103	896.443	896.443
42	1.67107	1491.7	27.1055	CCR	28	33	169.394	519.758	757.242	0	757.242	843.946	843.946
43	1.67107	1397.17	28.0991	CCR	28	33	157.961	484.675	703.219	0	703.219	787.559	787.559
44	1.67107	1294.88	29.1019	CCR	28	33	145.856	447.534	646.026	0	646.026	727.214	727.214
45	1.67107	1171.9	30.1146	CCR	28	33	131.744	404.233	579.346	0	579.346	655.76	655.76
46	1.67107	984.057	31.1379	CCR	28	33	111.077	340.82	481.701	0	481.701	548.806	548.806
47	1.67107	780.937	32.1722	CCR	28	33	89.1596	273.571	378.146	0	378.146	434.232	434.232
48	1.67107	569.038	33.2185	CCR	28	33	66.706	204.676	272.056	0	272.056	315.738	315.738
49	1.67107	348.046	34.2774	CCR	28	33	43.7166	134.137	163.437	0	163.437	193.233	193.233
50	1.67107	117.618	35.3499	CCR	28	33	20.7304	63.6076	54.8308	0	54.8308	69.5358	69.5358

Query 1 (spencer) - Safety Factor: 3.06833

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [deg]	Base Material	Base Cohesion [psf]	Base Friction Angle [deg]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	1.67107	73.9262	-10.0437	CCR	28	33	20.6908	63.4863	54.6441	0	54.6441	50.9794	50.9794
2	1.67107	219.003	-9.15075	CCR	28	33	41.3716	126.942	152.357	0	152.357	145.692	145.692
3	1.67107	358.55	-8.26004	CCR	28	33	60.9475	187.007	244.85	0	244.85	236.002	236.002
4	1.67107	492.606	-7.37134	CCR	28	33	79.452	243.785	332.28	0	332.28	322.001	322.001
5	1.67107	621.207	-6.48442	CCR	28	33	96.9166	297.372	414.796	0	414.796	403.78	403.78
6	1.67107	744.382	-5.59905	CCR	28	33	113.369	347.855	492.534	0	492.534	481.42	481.42
7	1.67107	862.159	-4.71503	CCR	28	33	128.838	395.318	565.621	0	565.621	554.994	554.994
8	1.67107	974.561	-3.83213	CCR	28	33	143.348	439.838	634.173	0	634.173	624.571	624.571
9	1.67107	1081.6	-2.95014	CCR	28	33	156.922	481.488	698.309	0	698.309	690.222	690.222
10	1.67107	1183.31	-2.06885	CCR	28	33	169.582	520.333	758.129	0	758.129	752.003	752.003
11	1.67107	1279.67	-1.18805	CCR	28	33	181.349	556.438	813.724	0	813.724	809.964	809.964
12	1.67107	1370.72	-0.307535	CCR	28	33	192.241	589.86	865.19	0	865.19	864.158	864.158
13	1.67107	1456.44	0.572912	CCR	28	33	202.278	620.655	912.611	0	912.611	914.634	914.634
14	1.67107	1536.84	1.45349	CCR	28	33	211.475	648.874	956.064	0	956.064	961.429	961.429
15	1.67107	1611.91	2.33442	CCR	28	33	219.848	674.565	995.621	0	995.621	1004.58	1004.58
16	1.67107	1681.65	3.2159	CCR	28	33	227.411	697.772	1031.36	0	1031.36	1044.14	1044.14
17	1.67107	1746.04	4.09814	CCR	28	33	234.178	718.536	1063.33	0	1063.33	1080.11	1080.11
18	1.67107	1805.07	4.98135	CCR	28	33	240.163	736.898	1091.6	0	1091.6	1112.54	1112.54
19	1.67107	1858.72	5.86576	CCR	28	33	245.375	752.892	1116.23	0	1116.23	1141.44	1141.44
20	1.67107	1906.96	6.75157	CCR	28	33	249.827	766.553	1137.27	0	1137.27	1166.85	1166.85
21	1.67107	1949.77	7.639	CCR	28	33	253.529	777.912	1154.76	0	1154.76	1188.76	1188.76
22	1.67107	1987.11	8.52828	CCR	28	33	256.49	786.997	1168.75	0	1168.75	1207.21	1207.21
23	1.67107	2018.95	9.41964	CCR	28	33	258.72	793.837	1179.29	0	1179.29	1222.21	1222.21
24	1.67107	2045.25	10.3133	CCR	28	33	260.225	798.456	1186.4	0	1186.4	1233.75	1233.75
25	1.67107	2065.95	11.2095	CCR	28	33	261.014	800.876	1190.13	0	1190.13	1241.85	1241.85
26	1.67107	2081.02	12.1085	CCR	28	33	261.093	801.119	1190.5	0	1190.5	1246.51	1246.51
27	1.67107	2090.4	13.0105	CCR	28	33	260.469	799.204	1187.55	0	1187.55	1247.73	1247.73
28	1.67107	2094.02	13.9159	CCR	28	33	259.147	795.149	1181.31	0	1181.31	1245.51	1245.51
29	1.67107	2091.83	14.8248	CCR	28	33	257.133	788.968	1171.79	0	1171.79	1239.84	1239.84
30	1.67107	2083.74	15.7375	CCR	28	33	254.431	780.678	1159.02	0	1159.02	1230.72	1230.72
31	1.67107	2069.68	16.6543	CCR	28	33	251.045	770.289	1143.02	0	1143.02	1218.12	1218.12
32	1.67107	2049.58	17.5756	CCR	28	33	246.979	757.814	1123.82	0	1123.82	1202.05	1202.05
33	1.67107	2023.33	18.5015	CCR	28	33	242.237	743.262	1101.41	0	1101.41	1182.47	1182.47
34	1.67107	1990.84	19.4325	CCR	28	33	236.82	726.642	1075.81	0	1075.81	1159.36	1159.36
35	1.67107	1952	20.3689	CCR	28	33	230.731	707.959	1047.05	0	1047.05	1132.71	1132.71
36	1.67107	1906.7	21.311	CCR	28	33	223.972	687.221	1015.11	0	1015.11	1102.48	1102.48
37	1.67107	1854.83	22.2592	CCR	28	33	216.545	664.431	980.017	0	980.017	1068.65	1068.65
38	1.67107	1796.23	23.2138	CCR	28	33	208.449	639.591	941.767	0	941.767	1031.17	1031.17
39	1.67107	1730.78	24.1753	CCR	28	33	199.686	612.704	900.364	0	900.364	990.004	990.004
40	1.67107	1658.32	25.1442	CCR	28	33	190.257	583.771	855.812	0	855.812	945.114	945.114
41	1.67107	1578.69	26.1207	CCR	28	33	180.16	552.789	808.103	0	808.103	896.443	896.443
42	1.67107	1491.7	27.1055	CCR	28	33	169.394	519.758	757.242	0	757.242	843.946	843.946
43	1.67107	1397.17	28.0991	CCR	28	33	157.961	484.675	703.219	0	703.219	787.559	787.559
44	1.67107	1294.88	29.1019	CCR	28	33	145.856	447.534	646.026	0	646.026	727.214	727.214
45	1.67107	1171.9	30.1146	CCR	28	33	131.744	404.233	579.346	0	579.346	655.76	655.76
46	1.67107	984.057	31.1379	CCR	28	33	111.077	340.82	481.701	0	481.701	548.806	548.806
47	1.67107	780.937	32.1722	CCR	28	33	89.1596	273.571	378.146	0	378.146	434.232	434.232
48	1.67107	569.038	33.2185	CCR	28	33	66.706	204.676	272.056	0	272.056	315.738	315.738
49	1.67107	348.046	34.2774	CCR	28	33	43.7166	134.137	163.437	0	163.437	193.233	193.233
50	1.67107	117.618	35.3499	CCR	28	33	20.7304	63.6076	54.8308	0	54.8308	69.5358	69.5358

Global Minimum Query (gle / morgenstern-price) - Safety Factor: 3.06893

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [deg]	Base Material	Base Cohesion [psf]	Base Friction Angle [deg]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	1.67107	73.9262	-10.0437	CCR	28	33	19.3095	59.2595	48.1353	0	48.1353	44.7154	44.7154
2	1.67107	219.003	-9.15075	CCR	28	33	38.7193	118.827	139.861	0	139.861	133.624	133.624
3	1.67107	358.55	-8.26004	CCR	28	33	57.5976	176.763	229.074	0	229.074	220.713	220.713
4	1.67107	492.606	-7.37134	CCR	28	33	75.8909	232.904	315.524	0	315.524	305.706	305.706
5	1.67107	621.207	-6.48442	CCR	28	33	93.5447	287.082	398.952	0	398.952	388.319	388.319
6	1.67107	744.382	-5.59905	CCR	28	33	110.504	339.13	479.099	0	479.099	468.266	468.266
7	1.67107	862.159	-4.71503	CCR	28	33	126.717	388.886	555.715	0	555.715	545.263	545.263
8	1.67107	974.561	-3.83213	CCR	28	33	142.132	436.194	628.56	0	628.56	619.04	619.04
9	1.67107	1081.6	-2.95014	CCR	28	33	156.704	480.913	697.425	0	697.425	689.349	689.349
10	1.67107	1183.31	-2.06885	CCR	28	33	170.391	522.917	762.106	0	762.106	755.951	755.951
11	1.67107	1279.67	-1.18805	CCR	28	33	183.157	562.097	822.436	0	822.436	818.637	818.637
12	1.67107	1370.72	-0.307535	CCR	28	33	194.975	598.365	878.283	0	878.283	877.236	877.236
13	1.67107	1456.44	0.572912	CCR	28	33	205.822	631.654	929.546	0	929.546	931.604	931.604
14	1.67107	1536.84	1.45349	CCR	28	33	215.684	661.919	976.152	0	976.152	981.625	981.625
15	1.67107	1611.91	2.33442	CCR	28	33	224.554	689.139	1018.07	0	1018.07	1027.22	1027.22
16	1.67107	1681.65	3.2159	CCR	28	33	232.43	713.312	1055.29	0	1055.29	1068.35	1068.35
17	1.67107	1746.04	4.09814	CCR	28	33	239.321	734.459	1087.85	0	1087.85	1105	1105
18	1.67107	1805.07	4.98135	CCR	28	33	245.239	752.621	1115.82	0	1115.82	1137.2	1137.2
19	1.67107	1858.72	5.86576	CCR	28	33	250.203	767.857	1139.28	0	1139.28	1164.98	1164.98
20	1.67107	1906.96	6.75157	CCR	28	33	254.238	780.24	1158.35	0	1158.35	1188.44	1188.44
21	1.67107	1949.77	7.639	CCR	28	33	257.373	789.859	1173.16	0	1173.16	1207.68	1207.68
22	1.67107	1987.11	8.52828	CCR	28	33	259.638	796.811	1183.87	0	1183.87	1222.8	1222.8
23	1.67107	2018.95	9.41964	CCR	28	33	261.069	801.204	1190.63	0	1190.63	1233.94	1233.94
24	1.67107	2045.25	10.3133	CCR	28	33	261.704	803.15	1193.62	0	1193.62	1241.25	1241.25
25	1.67107	2065.95	11.2095	CCR	28	33	261.577	802.763	1193.03	0	1193.03	1244.87	1244.87
26	1.67107	2081.02	12.1085	CCR	28	33	260.729	800.158	1189.02	0	1189.02	1244.95	1244.95
27	1.67107	2090.4	13.0105	CCR	28	33	259.194	795.447	1181.77	0	1181.77	1241.66	1241.66
28	1.67107	2094.02	13.9159	CCR	28	33	257.007	788.738	1171.44	0	1171.44	1235.12	1235.12
29	1.67107	2091.83	14.8248	CCR	28	33	254.203	780.131	1158.18	0	1158.18	1225.46	1225.46
30	1.67107	2083.74	15.7375	CCR	28	33	250.809	769.716	1142.14	0	1142.14	1212.82	1212.82
31	1.67107	2069.68	16.6543	CCR	28	33	246.853	757.576	1123.45	0	1123.45	1197.29	1197.29
32	1.67107	2049.58	17.5756	CCR	28	33	242.358	743.779	1102.2	0	1102.2	1178.97	1178.97
33	1.67107	2023.33	18.5015	CCR	28	33	237.34	728.381	1078.49	0	1078.49	1157.91	1157.91
34	1.67107	1990.84	19.4325	CCR	28	33	231.815	711.424	1052.38	0	1052.38	1134.16	1134.16
35	1.67107	1952	20.3689	CCR	28	33	225.79	692.934	1023.91	0	1023.91	1107.74	1107.74
36	1.67107	1906.7	21.311	CCR	28	33	219.269	672.922	993.094	0	993.094	1078.63	1078.63
37	1.67107	1854.83	22.2592	CCR	28	33	212.251	651.384	959.924	0	959.924	1046.8	1046.8
38	1.67107	1796.23	23.2138	CCR	28	33	204.728	628.296	924.377	0	924.377	1012.18	1012.18
39	1.67107	1730.78	24.1753	CCR	28	33	196.688	603.621	886.377	0	886.377	974.671	974.671
40	1.67107	1658.32	25.1442	CCR	28	33	188.111	577.299	845.845	0	845.845	934.139	934.139
41	1.67107	1578.69	26.1207	CCR	28	33	178.973	549.256	802.666	0	802.666	890.424	890.424
42	1.67107	1491.7	27.1055	CCR	28	33	169.243	519.396	756.683	0	756.683	843.309	843.309
43	1.67107	1397.17	28.0991	CCR	28	33	158.884	487.604	707.728	0	707.728	792.561	792.561
44	1.67107	1294.88	29.1019	CCR	28	33	147.851	453.743	655.584	0	655.584	737.883	737.883
45	1.67107	1171.9	30.1146	CCR	28	33	134.696	413.372	593.421	0	593.421	671.547	671.547
46	1.67107	984.057	31.1379	CCR	28	33	114.537	351.506	498.156	0	498.156	567.352	567.352
47	1.67107	780.937	32.1722	CCR	28	33	92.7349	284.597	395.125	0	395.125	453.461	453.461
48	1.67107	569.038	33.2185	CCR	28	33	69.9306	214.612	287.357	0	287.357	333.15	333.15
49	1.67107	348.046	34.2774	CCR	28	33	46.0138	141.213	174.333	0	174.333	205.695	205.695
50	1.67107	117.618	35.3499	CCR	28	33	20.8659	64.036	55.4907	0	55.4907	70.2919	70.2919

Query 1 (gle / morgenstern-price) - Safety Factor: 3.06893

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [deg]	Base Material	Base Cohesion [psf]	Base Friction Angle [deg]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	1.67107	73.9262	-10.0437	CCR	28	33	19.3095	59.2595	48.1353	0	48.1353	44.7154	44.7154
2	1.67107	219.003	-9.15075	CCR	28	33	38.7193	118.827	139.861	0	139.861	133.624	133.624
3	1.67107	358.55	-8.26004	CCR	28	33	57.5976	176.763	229.074	0	229.074	220.713	220.713
4	1.67107	492.606	-7.37134	CCR	28	33	75.8909	232.904	315.524	0	315.524	305.706	305.706
5	1.67107	621.207	-6.48442	CCR	28	33	93.5447	287.082	398.952	0	398.952	388.319	388.319
6	1.67107	744.382	-5.59905	CCR	28	33	110.504	339.13	479.099	0	479.099	468.266	468.266
7	1.67107	862.159	-4.71503	CCR	28	33	126.717	388.886	555.715	0	555.715	545.263	545.263
8	1.67107	974.561	-3.83213	CCR	28	33	142.132	436.194	628.56	0	628.56	619.04	619.04
9	1.67107	1081.6	-2.95014	CCR	28	33	156.704	480.913	697.425	0	697.425	689.349	689.349
10	1.67107	1183.31	-2.06885	CCR	28	33	170.391	522.917	762.106	0	762.106	755.951	755.951
11	1.67107	1279.67	-1.18805	CCR	28	33	183.157	562.097	822.436	0	822.436	818.637	818.637
12	1.67107	1370.72	-0.307535	CCR	28	33	194.975	598.365	878.283	0	878.283	877.236	877.236
13	1.67107	1456.44	0.572912	CCR	28	33	205.822	631.654	929.546	0	929.546	931.604	931.604
14	1.67107	1536.84	1.45349	CCR	28	33	215.684	661.919	976.152	0	976.152	981.625	981.625
15	1.67107	1611.91	2.33442	CCR	28	33	224.554	689.139	1018.07	0	1018.07	1027.22	1027.22
16	1.67107	1681.65	3.2159	CCR	28	33	232.43	713.312	1055.29	0	1055.29	1068.35	1068.35
17	1.67107	1746.04	4.09814	CCR	28	33	239.321	734.459	1087.85	0	1087.85	1105	1105
18	1.67107	1805.07	4.98135	CCR	28	33	245.239	752.621	1115.82	0	1115.82	1137.2	1137.2
19	1.67107	1858.72	5.86576	CCR	28	33	250.203	767.857	1139.28	0	1139.28	1164.98	1164.98
20	1.67107	1906.96	6.75157	CCR	28	33	254.238	780.24	1158.35	0	1158.35	1188.44	1188.44
21	1.67107	1949.77	7.639	CCR	28	33	257.373	789.859	1173.16	0	1173.16	1207.68	1207.68
22	1.67107	1987.11	8.52828	CCR	28	33	259.638	796.811	1183.87	0	1183.87	1222.8	1222.8
23	1.67107	2018.95	9.41964	CCR	28	33	261.069	801.204	1190.63	0	1190.63	1233.94	1233.94
24	1.67107	2045.25	10.3133	CCR	28	33	261.704	803.15	1193.62	0	1193.62	1241.25	1241.25
25	1.67107	2065.95	11.2095	CCR	28	33	261.577	802.763	1193.03	0	1193.03	1244.87	1244.87
26	1.67107	2081.02	12.1085	CCR	28	33	260.729	800.158	1189.02	0	1189.02	1244.95	1244.95
27	1.67107	2090.4	13.0105	CCR	28	33	259.194	795.447	1181.77	0	1181.77	1241.66	1241.66
28	1.67107	2094.02	13.9159	CCR	28	33	257.007	788.738	1171.44	0	1171.44	1235.12	1235.12
29	1.67107	2091.83	14.8248	CCR	28	33	254.203	780.131	1158.18	0	1158.18	1225.46	1225.46
30	1.67107	2083.74	15.7375	CCR	28	33	250.809	769.716	1142.14	0	1142.14	1212.82	1212.82
31	1.67107	2069.68	16.6543	CCR	28	33	246.853	757.576	1123.45	0	1123.45	1197.29	1197.29
32	1.67107	2049.58	17.5756	CCR	28	33	242.358	743.779	1102.2	0	1102.2	1178.97	1178.97
33	1.67107	2023.33	18.5015	CCR	28	33	237.34	728.381	1078.49	0	1078.49	1157.91	1157.91
34	1.67107	1990.84	19.4325	CCR	28	33	231.815	711.424	1052.38	0	1052.38	1134.16	1134.16
35	1.67107	1952	20.3689	CCR	28	33	225.79	692.934	1023.91	0	1023.91	1107.74	1107.74
36	1.67107	1906.7	21.311	CCR	28	33	219.269	672.922	993.094	0	993.094	1078.63	1078.63
37	1.67107	1854.83	22.2592	CCR	28	33	212.251	651.384	959.924	0	959.924	1046.8	1046.8
38	1.67107	1796.23	23.2138	CCR	28	33	204.728	628.296	924.377	0	924.377	1012.18	1012.18
39	1.67107	1730.78	24.1753	CCR	28	33	196.688	603.621	886.377	0	886.377	974.671	974.671
40	1.67107	1658.32	25.1442	CCR	28	33	188.111	577.299	845.845	0	845.845	934.139	934.139
41	1.67107	1578.69	26.1207	CCR	28	33	178.973	549.256	802.666	0	802.666	890.424	890.424
42	1.67107	1491.7	27.1055	CCR	28	33	169.243	519.396	756.683	0	756.683	843.309	843.309
43	1.67107	1397.17	28.0991	CCR	28	33	158.884	487.604	707.728	0	707.728	792.561	792.561
44	1.67107	1294.88	29.1019	CCR	28	33	147.851	453.743	655.584	0	655.584	737.883	737.883
45	1.67107	1171.9	30.1146	CCR	28	33	134.696	413.372	593.421	0	593.421	671.547	671.547
46	1.67107	984.057	31.1379	CCR	28	33	114.537	351.506	498.156	0	498.156	567.352	567.352
47	1.67107	780.937	32.1722	CCR	28	33	92.7349	284.597	395.125	0	395.125	453.461	453.461
48	1.67107	569.038	33.2185	CCR	28	33	69.9306	214.612	287.357	0	287.357	333.15	333.15
49	1.67107	348.046	34.2774	CCR	28	33	46.0138	141.213	174.333	0	174.333	205.695	205.695
50	1.67107	117.618	35.3499	CCR	28	33	20.8659	64.036	55.4907	0	55.4907	70.2919	70.2919

Interslice Data

Global Minimum Query (spencer) - Safety Factor: 3.06833

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [deg]
1	495.368	749.451	0	0	0
2	497.039	749.155	50.7426	11.3369	12.5942
3	498.71	748.886	160.876	35.9431	12.5943
4	500.381	748.643	322.104	71.9648	12.5942
5	502.052	748.427	526.684	117.672	12.5942
6	503.723	748.237	767.394	171.452	12.5942
7	505.394	748.073	1037.5	231.798	12.5942
8	507.065	747.935	1330.71	297.309	12.5943
9	508.736	747.823	1641.2	366.678	12.5942
10	510.407	747.737	1963.52	438.691	12.5942
11	512.078	747.677	2292.62	512.218	12.5942
12	513.749	747.642	2623.81	586.214	12.5942
13	515.42	747.633	2952.76	659.709	12.5943
14	517.091	747.65	3275.47	731.809	12.5942
15	518.762	747.692	3588.26	801.692	12.5942
16	520.434	747.761	3887.75	868.605	12.5942
17	522.105	747.854	4170.87	931.859	12.5942
18	523.776	747.974	4434.82	990.83	12.5942
19	525.447	748.12	4677.08	1044.96	12.5943
20	527.118	748.292	4895.41	1093.74	12.5943
21	528.789	748.489	5087.83	1136.73	12.5943
22	530.46	748.714	5252.61	1173.54	12.5942
23	532.131	748.964	5388.27	1203.85	12.5942
24	533.802	749.241	5493.6	1227.38	12.5942
25	535.473	749.545	5567.61	1243.92	12.5942
26	537.144	749.877	5609.57	1253.3	12.5943
27	538.815	750.235	5619	1255.4	12.5942
28	540.486	750.621	5595.65	1250.18	12.5942
29	542.157	751.035	5539.52	1237.64	12.5942
30	543.828	751.478	5450.86	1217.84	12.5943
31	545.5	751.948	5330.18	1190.87	12.5942
32	547.171	752.448	5178.23	1156.92	12.5942
33	548.842	752.978	4996.03	1116.22	12.5943
34	550.513	753.537	4784.87	1069.04	12.5942
35	552.184	754.126	4546.3	1015.74	12.5943
36	553.855	754.747	4282.18	956.729	12.5942
37	555.526	755.399	3994.65	892.488	12.5942
38	557.197	756.083	3686.15	823.562	12.5942
39	558.868	756.799	3359.46	750.573	12.5942
40	560.539	757.549	3017.69	674.214	12.5942
41	562.21	758.334	2664.3	595.261	12.5943
42	563.881	759.153	2303.15	514.572	12.5942
43	565.552	760.009	1938.48	433.096	12.5942
44	567.223	760.901	1574.96	351.879	12.5942
45	568.894	761.831	1217.73	272.067	12.5943
46	570.566	762.8	876.313	195.787	12.5943
47	572.237	763.81	575.592	128.599	12.5942
48	573.908	764.861	327.052	73.0703	12.5942
49	575.579	765.955	140.795	31.4565	12.5942
50	577.25	767.094	27.6875	6.18596	12.5942
51	578.921	768.28	0	0	0

Query 1 (spencer) - Safety Factor: 3.06833

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [deg]
1	495.368	749.451	0	0	0
2	497.039	749.155	50.7426	11.3369	12.5942
3	498.71	748.886	160.876	35.9431	12.5943
4	500.381	748.643	322.104	71.9648	12.5942
5	502.052	748.427	526.684	117.672	12.5942
6	503.723	748.237	767.394	171.452	12.5942
7	505.394	748.073	1037.5	231.798	12.5942
8	507.065	747.935	1330.71	297.309	12.5943
9	508.736	747.823	1641.2	366.678	12.5942
10	510.407	747.737	1963.52	438.691	12.5942
11	512.078	747.677	2292.62	512.218	12.5942
12	513.749	747.642	2623.81	586.214	12.5942
13	515.42	747.633	2952.76	659.709	12.5943
14	517.091	747.65	3275.47	731.809	12.5942
15	518.762	747.692	3588.26	801.692	12.5942
16	520.434	747.761	3887.75	868.605	12.5942
17	522.105	747.854	4170.87	931.859	12.5942
18	523.776	747.974	4434.82	990.83	12.5942
19	525.447	748.12	4677.08	1044.96	12.5943
20	527.118	748.292	4895.41	1093.74	12.5943
21	528.789	748.489	5087.83	1136.73	12.5943
22	530.46	748.714	5252.61	1173.54	12.5942
23	532.131	748.964	5388.27	1203.85	12.5942
24	533.802	749.241	5493.6	1227.38	12.5942
25	535.473	749.545	5567.61	1243.92	12.5942
26	537.144	749.877	5609.57	1253.3	12.5943
27	538.815	750.235	5619	1255.4	12.5942
28	540.486	750.621	5595.65	1250.18	12.5942
29	542.157	751.035	5539.52	1237.64	12.5942
30	543.828	751.478	5450.86	1217.84	12.5943
31	545.5	751.948	5330.18	1190.87	12.5942
32	547.171	752.448	5178.23	1156.92	12.5942
33	548.842	752.978	4996.03	1116.22	12.5943
34	550.513	753.537	4784.87	1069.04	12.5942
35	552.184	754.126	4546.3	1015.74	12.5943
36	553.855	754.747	4282.18	956.729	12.5942
37	555.526	755.399	3994.65	892.488	12.5942
38	557.197	756.083	3686.15	823.562	12.5942
39	558.868	756.799	3359.46	750.573	12.5942
40	560.539	757.549	3017.69	674.214	12.5942
41	562.21	758.334	2664.3	595.261	12.5943
42	563.881	759.153	2303.15	514.572	12.5942
43	565.552	760.009	1938.48	433.096	12.5942
44	567.223	760.901	1574.96	351.879	12.5942
45	568.894	761.831	1217.73	272.067	12.5943
46	570.566	762.8	876.313	195.787	12.5943
47	572.237	763.81	575.592	128.599	12.5942
48	573.908	764.861	327.052	73.0703	12.5942
49	575.579	765.955	140.795	31.4565	12.5942
50	577.25	767.094	27.6875	6.18596	12.5942
51	578.921	768.28	0	0	0

Global Minimum Query (gle / morgenstern-price) - Safety Factor: 3.06893

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [deg]
1	495.368	749.451	0	0	0
2	497.039	749.155	46.5124	0.797104	0.981808
3	498.71	748.886	148.859	5.09208	1.95918
4	500.381	748.643	300.676	15.3772	2.92768
5	502.052	748.427	495.699	33.6456	3.883
6	503.723	748.237	727.785	61.3816	4.82093
7	505.394	748.073	990.923	99.5605	5.7374
8	507.065	747.935	1279.26	148.66	6.62849
9	508.736	747.823	1587.12	208.683	7.49059
10	510.407	747.737	1909.03	279.183	8.32015
11	512.078	747.677	2239.75	359.312	9.11402
12	513.749	747.642	2574.31	447.859	9.86911
13	515.42	747.633	2907.99	543.31	10.5828
14	517.091	747.65	3236.38	643.903	11.2525
15	518.762	747.692	3555.39	747.688	11.8761
16	520.434	747.761	3861.27	852.589	12.4514
17	522.105	747.854	4150.57	956.47	12.9769
18	523.776	747.974	4420.23	1057.19	13.4508
19	525.447	748.12	4667.5	1152.66	13.8719
20	527.118	748.292	4889.99	1240.91	14.2391
21	528.789	748.489	5085.67	1320.1	14.5513
22	530.46	748.714	5252.8	1388.61	14.8078
23	532.131	748.964	5389.99	1445.04	15.0079
24	533.802	749.241	5496.15	1488.24	15.1511
25	535.473	749.545	5570.49	1517.36	15.2373
26	537.144	749.877	5612.49	1531.82	15.266
27	538.815	750.235	5621.89	1531.36	15.2373
28	540.486	750.621	5598.7	1516.01	15.1512
29	542.157	751.035	5543.14	1486.09	15.0078
30	543.828	751.478	5455.66	1442.24	14.8078
31	545.5	751.948	5336.93	1385.32	14.5513
32	547.171	752.448	5187.81	1316.48	14.239
33	548.842	752.978	5009.38	1237.09	13.8719
34	550.513	753.537	4802.9	1148.72	13.4509
35	552.184	754.126	4569.84	1053.09	12.9769
36	553.855	754.747	4311.87	952.084	12.4514
37	555.526	755.399	4030.87	847.68	11.8761
38	557.197	756.083	3728.99	741.912	11.2525
39	558.868	756.799	3408.59	636.84	10.5828
40	560.539	757.549	3072.34	534.503	9.86912
41	562.21	758.334	2723.23	436.873	9.11399
42	563.881	759.153	2364.59	345.806	8.32016
43	565.552	760.009	2000.18	262.994	7.49058
44	567.223	760.901	1634.21	189.909	6.62852
45	568.894	761.831	1271.46	127.746	5.73736
46	570.566	762.8	921.355	77.7073	4.82093
47	572.237	763.81	609.828	41.3921	3.883
48	573.908	764.861	349.433	17.8707	2.92767
49	575.579	765.955	151.835	5.19387	1.95917
50	577.25	767.094	30.1653	0.516956	0.981807
51	578.921	768.28	0	0	0

Query 1 (gle/morgenstern-price) - Safety Factor: 3.06893

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [deg]
1	495.368	749.451	0	0	0
2	497.039	749.155	46.5124	0.797104	0.981808
3	498.71	748.886	148.859	5.09208	1.95918
4	500.381	748.643	300.676	15.3772	2.92768
5	502.052	748.427	495.699	33.6456	3.883
6	503.723	748.237	727.785	61.3816	4.82093
7	505.394	748.073	990.923	99.5605	5.7374
8	507.065	747.935	1279.26	148.66	6.62849
9	508.736	747.823	1587.12	208.683	7.49059
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11	512.078	747.677	2239.75	359.312	9.11402
12	513.749	747.642	2574.31	447.859	9.86911
13	515.42	747.633	2907.99	543.31	10.5828
14	517.091	747.65	3236.38	643.903	11.2525
15	518.762	747.692	3555.39	747.688	11.8761
16	520.434	747.761	3861.27	852.589	12.4514
17	522.105	747.854	4150.57	956.47	12.9769
18	523.776	747.974	4420.23	1057.19	13.4508
19	525.447	748.12	4667.5	1152.66	13.8719
20	527.118	748.292	4889.99	1240.91	14.2391
21	528.789	748.489	5085.67	1320.1	14.5513
22	530.46	748.714	5252.8	1388.61	14.8078
23	532.131	748.964	5389.99	1445.04	15.0079
24	533.802	749.241	5496.15	1488.24	15.1511
25	535.473	749.545	5570.49	1517.36	15.2373
26	537.144	749.877	5612.49	1531.82	15.266
27	538.815	750.235	5621.89	1531.36	15.2373
28	540.486	750.621	5598.7	1516.01	15.1512
29	542.157	751.035	5543.14	1486.09	15.0078
30	543.828	751.478	5455.66	1442.24	14.8078
31	545.5	751.948	5336.93	1385.32	14.5513
32	547.171	752.448	5187.81	1316.48	14.239
33	548.842	752.978	5009.38	1237.09	13.8719
34	550.513	753.537	4802.9	1148.72	13.4509
35	552.184	754.126	4569.84	1053.09	12.9769
36	553.855	754.747	4311.87	952.084	12.4514
37	555.526	755.399	4030.87	847.68	11.8761
38	557.197	756.083	3728.99	741.912	11.2525
39	558.868	756.799	3408.59	636.84	10.5828
40	560.539	757.549	3072.34	534.503	9.86912
41	562.21	758.334	2723.23	436.873	9.11399
42	563.881	759.153	2364.59	345.806	8.32016
43	565.552	760.009	2000.18	262.994	7.49058
44	567.223	760.901	1634.21	189.909	6.62852
45	568.894	761.831	1271.46	127.746	5.73736
46	570.566	762.8	921.355	77.7073	4.82093
47	572.237	763.81	609.828	41.3921	3.883
48	573.908	764.861	349.433	17.8707	2.92767
49	575.579	765.955	151.835	5.19387	1.95917
50	577.25	767.094	30.1653	0.516956	0.981807
51	578.921	768.28	0	0	0

Entity Information

Group 1

Shared Entities

Type	Coordinates (x,y)
External Boundary	487.133, 747.393 472.407, 747.393 452.314, 756 402.755, 756 350.679, 738.799 254.484, 738.799 254.484, 730 254.484, 678.833 1493.01, 678.833 1493.01, 730 1493.01, 747.393 1493.01, 842.71 1364.78, 836.571 1316.77, 833 1169.84, 808.6 910.904, 797.788 746.552, 785.749 647.23, 783 589.603, 768.6 569.6, 768
Material Boundary	350.679, 738.799 472.407, 747.393
Material Boundary	487.133, 747.393 1493.01, 747.393
Material Boundary	254.484, 730 1493.01, 730

Scenario-based Entities

Type	Coordinates (x,y)	Master Scenario
Water Table	254.484, 744 1493.01, 744	Assigned to: Structural Fill CCR Residuum/Saprolite Bedrock

3.4 FINAL COVER VENEER STABILITY

OBJECTIVE:
Evaluate the stability of the final cover system in a veneer failure mode for the Plant Yates Ash Management Area (AMA). The analysis applies to the condition when the *ClosureTurf® Cover System* is placed along the final side slope of the landfill. The stability of the final cover system was evaluated under static, and seepage conditions. The Analysis presents calculations to estimate the minimum required interface shear strengths for the final cover system design.

METHOD:
Slope stability of the final cover liner system was analyzed using finite slope analysis per Koerner and Soong (1998). (Koerner, RM and Soong, T-Y., 1998, "Analysis and Design of Veneer Cover Soils", Sixth International Conference on Geosynthetics, Atlanta, GA). A copy of the referenced paper is included as 7.5 in the Appendix. The governing equations were coded into a spreadsheet to analyze the slope stability.

DATA:
The following input parameters were used for the stability analysis:

ClosureTurf® Cover System
The proposed *ClosureTurf®* cover system consists of the following components, from bottom to top:

- A 50-mil LLDPE MicroDrain geomembrane with studs side up and Microspike side down against compacted Coal Combustion Residuals (CCR);
- Synthetic turf with base geotextile; and
- 0.5-in (minimum) thick sand infill.

The 0.5-in thick sand infill and the geotextile component of the engineered turf is considered the most critical interface for the *ClosureTurf®* cover system. The sand infill was modeled with a total unit weight of 120 pcf, an internal friction angle of 30 degrees, and cohesion of 0 psf.

Water Head Buildup
The water depth above the vertical interface is the maximum head on top of the liner for the proposed final cover system per the HELP model design in Section 4.1 of the Engineering Report. The peak maximum head on top of the final cover liner is 0.114-inches or 9.5×10^{-3} feet, which was used in the seepage stability analysis.

Geosynthetic Tension

The reinforcing effect provided by allowable tension in the geosynthetics was conservatively neglected for this analysis.

Interface Friction Angles and Shear Strength

The minimum interface friction angle used in the calculations is the minimum within the final cover system. The apparent interface adhesion (i.e., a) was assumed to be zero for this analysis.

Slope Inclination

The proposed final cover configuration has a maximum slope inclination of 4H:1V (i.e., 14 degrees).

Slope Height and Length

The proposed final cover configuration has a maximum uninterrupted slope of 99 feet along the 4:1 slope as shown on Figure 3.2.

Target Factor of Safety

For static analysis, a factor of safety of 1.5 or greater was considered acceptable based on Tables 2 and 3 (page 22) of Koerner's paper.

RESULTS:

The results of the stability analyses are provided on the following pages. The proposed configuration of the final cover system will meet the target factors of safety with a minimum peak interface friction angle of **24** degrees or greater. Initial laboratory testing with the final cover components show a minimum interface fiction angel of 32 degrees which exceeds the minimum (Appendix 7.4). Laboratory test shall be conducted with final cover components to confirm a peak interface friction angle of **24** degrees or greater.

3.5 FIGURE 3.2 – VENEER STABILITY SECTION LAYOUT

VENEER STABILITY

ENGINEERING REPORT

FOR

GEORGIA POWER
PLANT YATES - ASH MANAGEMENT AREA
COWETA COUNTY, GEORGIA

Georgia Power

Atlantic Coast Consulting, Inc.
770-594-5998
www.atlcc.net

1150 Northmeadow Pkwy.
Suite 100
Roswell, GA 30075

FIGURE 3.2

P:\Industrial\054-Southern Company\107-Plant Yates CCR Permitting\5 - CCR Permit AMA\2-Design Calcs\3. Final Cover Analysis\2. Veneer Stability\AMA Veneer Figure.dwg 5/25/21 MATHIEU TRUNNELL

3.6 FINAL COVER VENEER STABILITY CALCULATIONS

Gravitational Slope Analysis - Static

W_A	total weight of the active wedge				
W_P	total weight of the passive wedge				
N_A	effective force normal to the failure plane of the active wedge				
γ	Cover Soil Unit Weight	=	120 pcf		
h	Cover soil thickness	=	0.042 ft		
H	Vertical height of uninterupted slope	=	24 ft		
L	length of the slope measured along geomembrane	=	99 ft		
β	Slope Inclination	=	14.04 degrees or	0.25 radians	
	Soil Internal Friction Angle	=	30 degrees or	0.52 radians	
δ	Minimum interface friction angle in the final cover system	=	24 degrees or	0.42 radians	
C_a	adhesive force between cover soil of active wedge and geomembrane				
c_a	adhesion between cover soil of active wedge and geomembrane	=	0		
C	cohesive force along the failure plane of passive wedge				
c	cohesion of cover soil				
FS	Factor of Safety				

$$W_A = \gamma h^2 (\frac{L}{h} - \frac{1}{sin\beta} - \frac{tan\beta}{2})$$ W_A 497.7 pcf

$$N_A = W_A cos\beta$$ N_A 482.8 pcf

$$C_a = c_a(L - \frac{h}{sin\beta})$$ C_a 0.0 pcf

$$W_P = \frac{\gamma h^2}{sin2\beta}$$ W_P 0.4 pcf

Gravitational Slope Analysis - Static

$a = (W_A - NA\cos\beta)\cos\beta$	a	28.4
$b = -[(W_A - NA\cos\beta)\sin\beta\tan\varphi + (N_A \tan\delta + Ca)\sin\beta\cos\beta + \sin\beta(C + WP\tan\varphi)]$	b	-54.8
$c = (N_A \tan\delta + Ca)\sin^2\beta\tan\phi$	c	7.3

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

Factor of Safety, FS = 1.8

Seepage Parallel to Slope Analysis - Static

W_A	total weight of the active wedge			
W_P	total weight of the passive wedge			
N_A	effective force normal to the failure plane of the active wedge			
γ_t	Cover Soil Unit Weight (moist)	=	120 pcf	
γ_{sat}	Saturated Soil Unit Weight	=	120 pcf	
γ_w	Water Unit Weight	=	62.4 pcf	
h	Cover soil thickness	=	0.042 ft	
h_w	Water Depth Above Critical Interface	=	0.0095 ft	
H	Vertical height of uninterupted slope	=	24 ft	
L	length of the slope measured along geomembrane	=	99 ft	
β	Slope Inclination	=	14.04 degrees or	0.25 radians
	Soil Internal Friction Angle	=	30 degrees or	0.52 radians
δ	Minimum interface friction angle in the final cover system	=	24 degrees or	0.42 radians
C_a	adhesive force between cover soil of active wedge and geomembrane			
c_a	adhesion between cover soil of active wedge and geomembrane	=	0	
C	cohesive force along the failure plane of passive wedge			
c	cohesion of cover soil			
U_h	resultant of pore pressures acting on interwedge surfaces			
U_n	resultant of pore pressures acting perpendicular to the slope			
U_v	resultant of vertical pore pressures acting on the passive wedge			
FS	Factor of Safety			

$$W_A = \frac{\gamma_t(h-hw)(2Hcos\beta-(h+hw))}{sin2\beta} + \frac{\gamma_{sat}(hw)(2Hcos\beta - w)}{sin2\beta}$$

W_A 374.1 pcf

$$U_n = \frac{\gamma_w h_w cos\beta(2Hcos\beta - hw)}{sin2\beta}$$

U_n 55.2 pcf

$$U_h = \frac{\gamma_w (h_w)^2}{2}$$

U_h 0.0 pcf

$$N_A = W_A cos\beta + Uh\, sin\beta\ - Un$$

N_A 307.7

Seepage Parallel to Slope Analysis - Static

$W_P = \dfrac{\gamma_t(h^2 - hw^2) + \gamma_{sat}(hw^2)}{sin2\beta}$	W_P	0.4	pcf
$U_V = U_h\, cot\beta$	U_v	0.01	
$a = WAsin\beta cos\beta\ - Uhcos^2\beta + Ul$	a	88.0	
$b = -WAsin^2\beta tan\varphi + Uhsin\beta\ cos\beta\ tan\phi$ $- N_A\, cos\beta\ tan\delta\ - (W_P\ - UV)tan\phi$	b	-145.9	
$c = NAsin\beta\ tan\delta\ tan\phi$	c	19.2	

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

Factor of Safety, FS = **1.5**

4. FINAL COVER ANALYSIS

4.1 FINAL COVER EQUIVALENCY

OBJECTIVE:
Evaluate the hydraulic performance of the proposed ClosureTurf® final cover systems using the Hydrologic Evaluation of Landfill Performance (HELP) Model Version 3.07.

METHODOLOGY:
Using the HELP Model, evaluate the infiltration through the proposed ClosureTurf® final cover system and compare it with the infiltration through the prescriptive minimum final cover system.

The Georgia Solid Waste Management Rule §391-3-4-.11(1) references 40 CFR 258, Subpart F, §258.60 regarding closure criteria, which states:

> *(a) Owners or operators of all MSWLF units must install a final cover system that is designed to minimize infiltration and erosion. The final cover system must be designed and constructed to:*
> *(1) Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present, or a permeability no greater than $1x10^{-5}$ cm/sec, whichever is less, and*
> *(2) Minimize infiltration through the closed MSWLF by the use of an infiltration layer that contains a minimum 18-inches of earthen material, and*
> *(3) Minimize erosion of the final cover by the use of an erosion layer that contains a minimum 6-inches of earthen material that is capable of sustaining native plant growth.*
> *(b) The Director of an approved State may approve an alternative final cover design that includes:*
> *(1) An infiltration layer that achieves an equivalent reduction in infiltration as the infiltration layer specified in paragraphs (a)(1) and (a)(2) of this section, and*
> *(2) An erosion layer that provides equivalent protection from wind and water erosion as the erosion layer specified in paragraph (a)(3) of this section.*

INPUT DATA:

- The daily precipitation, temperature, and solar radiation data was synthetically generated in HELP using the coefficients for Atlanta, Georgia, the mean monthly precipitation for Atlanta, GA and temperature for Atlanta, Georgia.
- The peak daily rainfall from the synthetically generated record was adjusted to match the 25-year 24-hour storm event precipitation for the site as published on the National Weather Service Precipitation Frequency Data Server, (i.e., 6.4 inches) for the simulation (Appendix 7.2).
- The final/closed condition was modeled using a 100 year simulation.
- All calculations were performed for a unit acre area.
- The final cover slope was modeled along the top at 3% with a maximum drainage length of 680. (Figure 4.1)
- The material properties of each layer used in the analysis were based on the anticipated and/or the required material properties. Table 4 of the HELP User's manual provides default values used. Default values were utilized for all layers except for the following conditions:

    - The effective saturated hydraulic conductivity for layer 2 in the prescriptive minimum final cover system was adjusted to the required value.
    - Parameters for layer 2 in the Final Cover System – ClosureTurf® were based on published product specifications and test data. A very conservative effective saturated hydraulic conductivity of 25 cm/sec was chosen for the model.

- The SCS curve numbers was specified to be 98 for each scenario with 100 percent of the area allowing runoff.
- Geomembrane installation within the final cover was assumed to be good with a pinhole density and defect density of 3 holes per acre. These assumptions will result in a conservative scenario for percolation/leakage through the ClosureTurf® final cover systems.

The liner systems are described as follows from top to bottom:

Prescriptive Minimum Final Cover System:
6-inch vegetative/erosion layer
18-inch thick soil barrier layer (maximum $1x10^{-5}$ cm/sec)

Final Cover System – ClosureTurf®:
0.5-in (minimum) thick sand infill
Synthetic turf with base geotextile
50-Mil LLDPE MicroDrain geomembrane
12-inches of prepared subgrade

RESULTS:

The results for each scenario is summarized below:

Scenario No.	Description	Head on Peak Day (Inches)	Annual Average Infiltration (CF/Ac/year)
1	Prescriptive Minimum Cover	3.15	10,034
2	ClosureTurf® Final Cover	0.070	7.149

CONCLUSION:

The ClosureTurf® final cover system exceeds the design guidelines. Therefore, it is a suitable cover system.

4.2 FINAL COVER EQUIVALENCY CALCULATIONS – PRESCRIPTIVE MINIMUM FINAL COVER SYSTEM

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************
```

```
PRECIPITATION DATA FILE:    C:\help\Y4.D4
TEMPERATURE DATA FILE:      C:\help\Y7.D7
SOLAR RADIATION DATA FILE:  C:\help\Y13.D13
EVAPOTRANSPIRATION DATA:    C:\help\Y11.D11
SOIL AND DESIGN DATA FILE:  C:\help\YFC3A.D10
OUTPUT DATA FILE:           C:\help\yfc3A.OUT
```

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TIME:   2:45     DATE:   8/ 3/2018
```

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******************************************************************************

     TITLE:  Min Final Cover

******************************************************************************
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```
     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   6
           THICKNESS                    =      6.00   INCHES
           POROSITY                     =      0.4530 VOL/VOL
           FIELD CAPACITY               =      0.1900 VOL/VOL
           WILTING POINT                =      0.0850 VOL/VOL
           INITIAL SOIL WATER CONTENT   =      0.1444 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.720000011000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.20
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	18.00	INCHES
POROSITY	=	0.4750	VOL/VOL
FIELD CAPACITY	=	0.3780	VOL/VOL
WILTING POINT	=	0.2650	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4750	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-05	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM A USER-SPECIFIED CURVE NUMBER OF 98.0, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 680. FEET.

SCS RUNOFF CURVE NUMBER	=	98.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	6.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	0.866	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	2.718	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.510	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	9.416	INCHES
TOTAL INITIAL WATER	=	9.416	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
ATLANTA GEORGIA

STATION LATITUDE	=	33.65	DEGREES
MAXIMUM LEAF AREA INDEX	=	3.00	
START OF GROWING SEASON (JULIAN DATE)	=	77	
END OF GROWING SEASON (JULIAN DATE)	=	316	
EVAPORATIVE ZONE DEPTH	=	6.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	65.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	76.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	69.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ATLANTA GEORGIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.91	4.43	5.91	4.43	4.02	3.41
4.73	3.41	3.17	2.53	3.43	4.23

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ATLANTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
41.90	44.90	52.50	61.80	69.30	75.80
78.60	78.20	73.00	62.20	52.00	44.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ATLANTA GEORGIA
AND STATION LATITUDE = 33.65 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.72	4.57	5.60	4.70	4.24	3.58
	4.94	3.47	3.49	2.35	3.21	4.12
STD. DEVIATIONS	2.41	2.05	2.43	2.39	2.20	1.65
	2.28	1.92	2.10	1.50	1.65	2.29
RUNOFF						
TOTALS	2.402	2.448	3.206	2.566	2.335	1.542
	2.378	1.721	1.809	1.112	1.690	2.037
STD. DEVIATIONS	1.680	1.595	1.833	1.667	1.555	1.017
	1.579	1.282	1.411	0.930	1.208	1.610
EVAPOTRANSPIRATION						
TOTALS	1.547	1.799	2.220	2.076	1.986	2.038
	2.525	1.788	1.593	1.036	1.079	1.295
STD. DEVIATIONS	0.328	0.390	0.660	0.747	0.742	0.716
	0.827	0.708	0.790	0.545	0.368	0.289

PERCOLATION/LEAKAGE THROUGH LAYER 2

TOTALS	0.7252	0.5395	0.2457	0.1194	0.0448	0.0038
	0.0036	0.0005	0.0168	0.0934	0.2999	0.6716
STD. DEVIATIONS	0.5889	0.6249	0.2823	0.1537	0.1041	0.0221
	0.0192	0.0043	0.0526	0.1687	0.3543	0.6621

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	0.0154	0.0159	0.0049	0.0023	0.0009	0.0001
	0.0001	0.0000	0.0003	0.0016	0.0063	0.0139
STD. DEVIATIONS	0.0140	0.0321	0.0062	0.0031	0.0022	0.0006
	0.0004	0.0001	0.0010	0.0033	0.0082	0.0141

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	48.99	(7.588)	177848.6	100.00
RUNOFF	25.246	(5.4649)	91643.18	51.529
EVAPOTRANSPIRATION	20.982	(2.2566)	76164.86	42.826
PERCOLATION/LEAKAGE THROUGH LAYER 2	2.76420	(1.15369)	**10034.058**	5.64191
AVERAGE HEAD ON TOP OF LAYER 2	0.005	(0.003)		
CHANGE IN WATER STORAGE	0.002	(0.4568)	6.46	0.004

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	6.37	23195.699
RUNOFF	5.827	21152.7539
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.391710	1421.90588
AVERAGE HEAD ON TOP OF LAYER 2	**3.151**	
SNOW WATER	5.40	19602.5937
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3794	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0850	

****

****

FINAL WATER STORAGE AT END OF YEAR 100

LAYER	(INCHES)	(VOL/VOL)
1	1.0442	0.1740
2	8.5500	0.4750
SNOW WATER	0.000	

****
****

4.3 FINAL COVER EQUIVALENCY CALCULATIONS - CLOSURETURF® FINAL COVER SYSTEM

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    C:\help\Y4.D4
TEMPERATURE DATA FILE:      C:\help\Y7.D7
SOLAR RADIATION DATA FILE:  C:\help\Y13.D13
EVAPOTRANSPIRATION DATA:    C:\help\Y11.D11
SOIL AND DESIGN DATA FILE:  C:\help\YFC2a.D10
OUTPUT DATA FILE:           C:\help\yfc2a.OUT


TIME:   1:30     DATE:   8/ 2/2018


******************************************************************************

     TITLE:  Closed Turf Cover

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   1
           THICKNESS                   =      0.50   INCHES
           POROSITY                    =      0.4170 VOL/VOL
           FIELD CAPACITY              =      0.0450 VOL/VOL
           WILTING POINT               =      0.0180 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.0175 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.20
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

```
THICKNESS                  =     0.13   INCHES
POROSITY                   =     0.8500 VOL/VOL
FIELD CAPACITY             =     0.0100 VOL/VOL
WILTING POINT              =     0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT =     0.0069 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  25.0000000000     CM/SEC
SLOPE                      =     3.00   PERCENT
DRAINAGE LENGTH            =   680.0    FEET
```

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

```
THICKNESS                  =     0.05   INCHES
POROSITY                   =     0.0000 VOL/VOL
FIELD CAPACITY             =     0.0000 VOL/VOL
WILTING POINT              =     0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT =     0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.  = 0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY        =     1.00   HOLES/ACRE
FML INSTALLATION DEFECTS   =     1.00   HOLES/ACRE
FML PLACEMENT QUALITY      = 3 - GOOD
```

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 6

```
THICKNESS                  =    12.00   INCHES
POROSITY                   =     0.4530 VOL/VOL
FIELD CAPACITY             =     0.1900 VOL/VOL
WILTING POINT              =     0.0850 VOL/VOL
INITIAL SOIL WATER CONTENT =     0.4530 VOL/VOL
EFFECTIVE SAT. HYD. COND.  = 0.720000011000E-03 CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM A USER-SPECIFIED CURVE NUMBER OF 98.0, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 680. FEET.

```
SCS RUNOFF CURVE NUMBER           =    98.00
FRACTION OF AREA ALLOWING RUNOFF  =   100.0    PERCENT
```

```
AREA PROJECTED ON HORIZONTAL PLANE  =      1.000  ACRES
EVAPORATIVE ZONE DEPTH              =      0.6    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      0.010  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      0.319  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      0.010  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =      5.446  INCHES
TOTAL INITIAL WATER                 =      5.446  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

```
NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         ATLANTA              GEORGIA

     STATION LATITUDE                          =  33.65 DEGREES
     MAXIMUM LEAF AREA INDEX                   =   3.00
     START OF GROWING SEASON (JULIAN DATE)     =     77
     END OF GROWING SEASON (JULIAN DATE)       =    316
     EVAPORATIVE ZONE DEPTH                    =   0.6  INCHES
     AVERAGE ANNUAL WIND SPEED                 =   9.10 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY     =  65.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY     =  67.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY     =  76.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY     =  69.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR   ATLANTA   GEORGIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.91	4.43	5.91	4.43	4.02	3.41
4.73	3.41	3.17	2.53	3.43	4.23

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR   ATLANTA   GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
41.90	44.90	52.50	61.80	69.30	75.80
78.60	78.20	73.00	62.20	52.00	44.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR   ATLANTA   GEORGIA
AND STATION LATITUDE = 33.65 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.72	4.57	5.60	4.70	4.24	3.58
	4.94	3.47	3.49	2.35	3.21	4.12
STD. DEVIATIONS	2.41	2.05	2.43	2.39	2.20	1.65
	2.28	1.92	2.10	1.50	1.65	2.29
RUNOFF						
TOTALS	2.490	2.567	3.307	2.658	2.460	1.670
	2.535	1.797	1.899	1.179	1.723	2.103
STD. DEVIATIONS	1.734	1.650	1.888	1.721	1.612	1.077
	1.643	1.328	1.469	0.975	1.225	1.655
EVAPOTRANSPIRATION						
TOTALS	0.647	0.706	0.817	0.757	0.715	0.898
	1.431	1.056	0.787	0.403	0.380	0.571
STD. DEVIATIONS	0.237	0.245	0.362	0.409	0.413	0.424
	0.551	0.455	0.415	0.273	0.178	0.210
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	1.4613	1.4444	1.4805	1.2933	1.0704	1.0050
	0.9810	0.6222	0.8071	0.7698	1.0906	1.4097
STD. DEVIATIONS	0.5293	0.4861	0.4173	0.4151	0.3841	0.3444
	0.3579	0.2920	0.3975	0.3950	0.3944	0.5869
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001
	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002
STD. DEVIATIONS	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0076	0.0082	0.0077	0.0070	0.0056	0.0054
	0.0051	0.0033	0.0043	0.0040	0.0058	0.0073
STD. DEVIATIONS	0.0028	0.0028	0.0022	0.0022	0.0020	0.0019
	0.0019	0.0015	0.0021	0.0020	0.0021	0.0030

****

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	48.99	(7.588)	177848.6	100.00
RUNOFF	26.387	(5.6175)	95786.04	53.858
EVAPOTRANSPIRATION	9.169	(1.4895)	33284.69	18.715
LATERAL DRAINAGE COLLECTED FROM LAYER 2	13.43545	(1.37610)	48770.668	27.42258
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00197	(0.00020)	**7.149**	0.00402
AVERAGE HEAD ON TOP OF LAYER 3	0.006	(0.001)		
CHANGE IN WATER STORAGE	0.000	(0.3406)	0.04	0.000

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	6.37	23195.699
RUNOFF	5.827	21152.7539
DRAINAGE COLLECTED FROM LAYER 2	0.35627	1293.24756
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000054	0.19576
AVERAGE HEAD ON TOP OF LAYER 3	**0.070**	
MAXIMUM HEAD ON TOP OF LAYER 3	**0.114**	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	5.40	19602.5937
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4135	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0153	

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

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FINAL WATER STORAGE AT END OF YEAR 100

LAYER	(INCHES)	(VOL/VOL)
1	0.0094	0.0188
2	0.0012	0.0094
3	0.0000	0.0000
4	5.4360	0.4530
SNOW WATER	0.000	

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4.4 FINAL COVER SETTLEMENT

ATLANTIC COAST CONSULTING, INC.

Project Number: I054-107
Project Name: AMA Permit Application — By: JEH — Date: 6/23/2020
Subject: Final Cover Settlement — Chkd: RBB — Date: 6/25/2020

OBJECTIVE:

Evaluate the settlement of the native soil and consolidated CCR material as a result of the change in stress due to the placement of consolidated CCR and construction of a final cover system as part of the proposed Plant Yates Ash Management Area (AMA) closure. Determine effects of the estimated settlement (overall and differential) on the final cover system along a typical cross section.

METHOD:

Settlement of the consolidated CCR and native soil was calculated using equations for one-dimensional consolidation theory. The overall settlement is a sum of the primary and secondary settlements of the CCR and native soil. The first step in the evaluation was to review the geometry, soils and waste mass and the physical properties of the soils and CCR at discrete points along a selected cross section and perform a one-dimensional settlement analysis at critical analysis locations. This allows for an estimation of post settlement grades and the resulting tensile stresses in the liner system.

Settlement:

Immediate settlement occurs during construction and is typically uniform thus is was not calculated for the consolidated CCR and native soil. The primary consolidation settlement (S_c) is related to the increase in the vertical effective stress in the subsurface and consolidated CCR materials due to the loads imposed by the consolidated CCR. The CCR and native soil were conservatively considered to be in normally consolidated state (i.e., the initial vertical effective stress is approximately equal to the pre-consolidation pressure) The primary consolidation settlement was calculated using the equation below [Holtz and Kovacs, 1981]:

$$S_p = C_{c\varepsilon} H \log((\sigma'_{v0}+\Delta\sigma'_v)/\sigma'_{v0}) \text{ for } \sigma'_{v0} = \sigma'_p$$

where:

S_p = primary consolidation settlement (ft);

$C_{c\varepsilon}$ = modified compression index (dimensionless);

H = initial thickness of compressible layer (ft);

σ'_{v0} = initial vertical effective stress at the mid-point of each sublayer (psf); and

σ'_p = pre-consolidation pressure (psf).

The secondary settlement is related to the plastic realignment of the material structure and is the result of a sustained load. Secondary settlement can be calculated using the following equation [Holtz and Kovacs, 1981]:

$$S_s = C_{\alpha\varepsilon} H \log (t_2/t_1)$$

where:

S_s = secondary settlement (ft);

$C_{\alpha\varepsilon}$ = modified secondary compression index (dimensionless);

t_2 = time at which settlement is calculated (years) (30 years, corresponding to the end of a typical post closure care period); and

t_1 = time to complete primary consolidation (years) (presumed to be one year).

Tensile Strains:

The effects of settlement on the final cover system were evaluated using the following equation:

$$\varepsilon = L_0 - L_f / L_0$$

where:

ε = strain in the cover system

L_0 = time at which settlement is calculated (years) (30 years, corresponding to the end of a typical post closure care period); and

L_f = time to complete primary consolidation (years) (presumed to be one year).

The estimated tensile strains were compared to conservative allowable tensile strains of 5% for the cover system geomembrane. Grade changes induced by differential settlement were estimated by considering the magnitude of differential settlement and the horizontal distance between adjacent points. The estimated grade changes were then compared to the design grades of the final cover system to ensure that positive post-settlement surface water flow is maintained.

DATA:

Topography maps and design drawings of the final configuration of the AMA were used to identify a representative cross section for settlement analysis. The critical section was chosen along the top representing the flattest slope and through the thickest waste mass. The geometry of AMA along the analyzed cross section is shown in Figure 4.1 & 4.2.

Material Parameters:

The data used to develop the subsurface stratigraphy for the analyses were taking from the Hydrogeological Assessment Report as well as field and laboratory investigations form the site. The subsurface primarily consists of existing CCR, native soil consisting of residuum and saprolite, and bedrock. No compressible layers have been identified on site.

Consolidation tests were performed on CCR and native soil to estimate their stress history. The compression index was calculated from the consolidation test curves. The modified compression index was then derived from the compression index.

$C_{c\varepsilon} = C_c/(1+e)$

where:

C_c = Compression index

e = in-situ void ratio

The in-situ void ration was calculated from the equation below:

$$e = G_s W_0 / S$$

where:

G_s = specific gravity of the soil;

W_0 = moisture content of the soil measured in the lab; and

S = degree of saturation

The modified recompression index is approximately 0.05 to 0.1 times the modified compression index [Holtz and Kovacs, 1981]. The modified recompression was chosen to be 0.075 the modified compression index.

Unit weights for the CCR and native soils were computed based on dry unit weight

$$\gamma = \gamma_d\ (1 + W_0/100)$$

where:

γ_d = dry unit weight (pcf); and

W_0 = moisture content of the soil measured in the lab.

Material Properties used for the analysis are listed below:

Material	Unit Weight (pcf), γ	Modified Compression Index, $C_{c\varepsilon}$	Modified Secondary Compression Index, $C_{\alpha\varepsilon}$
CCR	120	0.09	0.00675
Native Soil	122	0.22	0.0165

RESULTS:

Settlement was calculated in a Microsoft Excel spreadsheet. The pre- settlement and post-settlement calculated elevation of the surface along the critical cross section are. The results of the analysis are summarized below.

CONCLUSION:

Final cover settlement for the AMA was evaluated along a critical cross section. The Settlements were calculated considering short-term primary compression and long-term secondary compression of the consolidated CCR and native soils. The 30-year final cover total settlement, along the critical points of the cross section, were subtracted from the initial top of the final cover to get the top of the final cover after settlement. The post settlement elevation of the final cover system confirmed that the final grades maintain positive drainage as shown in Figure 4.2. Settlement induced tensile strains in the geomembrane component of the final cover system were also evaluated and found to have a maximum strain of 0.82 percent well below the allowable tensile strain of 5 percent. Thus, the design criteria of the final cover system have been met. The results of the analysis are presented in the attached spreadsheet, Table 4.1.

4.5 FIGURE 4.1 – FINAL COVER SETTLEMENT SECTION LAYOUT

SETTLEMENT

ENGINEERING REPORT

FOR

GEORGIA POWER

PLANT YATES - ASH MANAGEMENT AREA

COWETA COUNTY, GEORGIA

Atlantic Coast Consulting, Inc.
770-594-5998
www.atlcc.net

1150 Northmeadow Pkwy.
Suite 100
Roswell, GA 30075

FIGURE 4.1

P:\Industrial\054-Southern Company\107-Plant Yates CCR Permitting\5 - CCR Permit AMA\2-Design Calcs\4. Settlement\AMA Settlement Figure.dwg 5/25/21 MATHIEU TRUNNELL

4.6 FIGURE 4.2 – FINAL COVER SETTLEMENT CROSS-SECTION

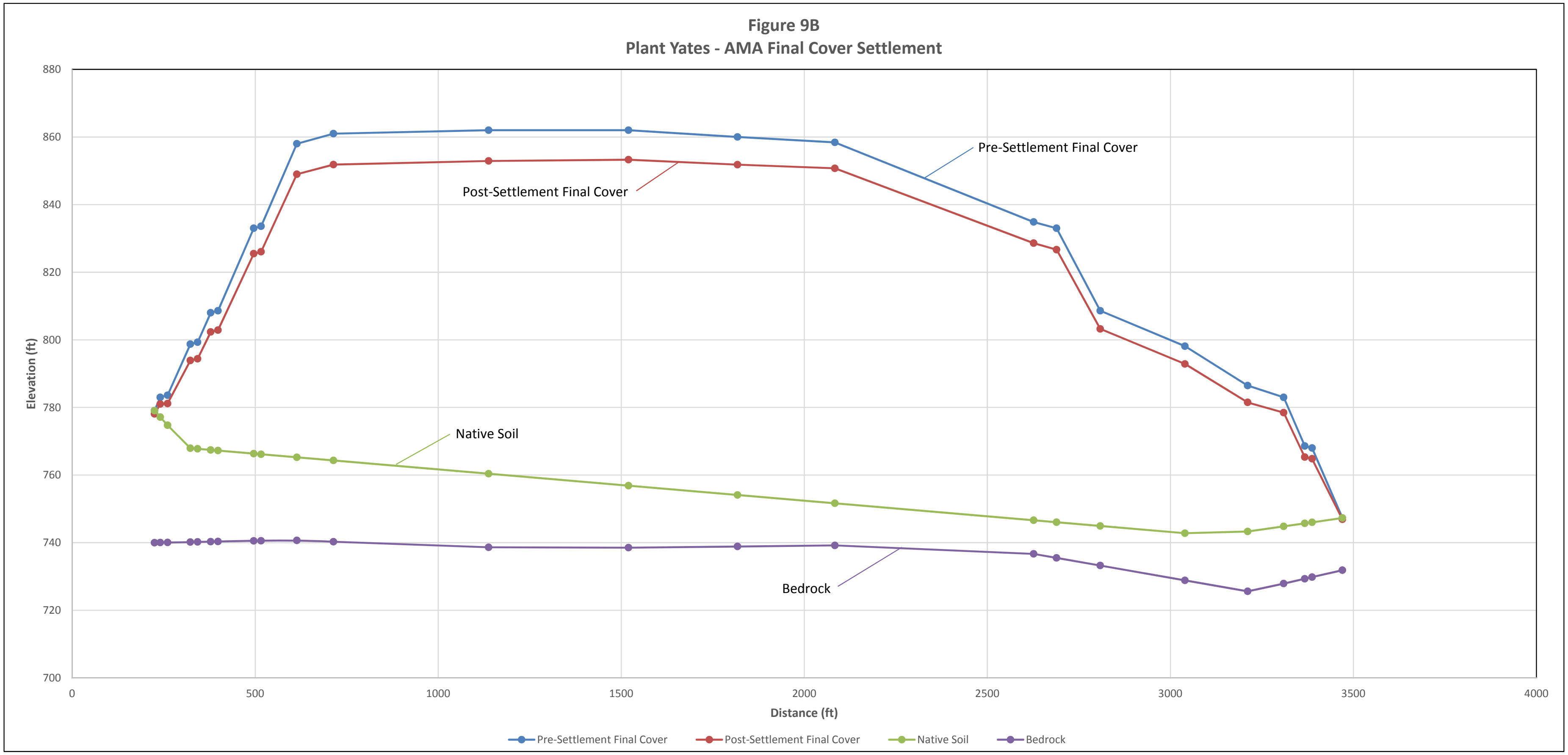


Figure 9B
Plant Yates - AMA Final Cover Settlement
Elevation (ft)
880
860
840
820
800
780
760
740
720
700
0
500
1000
1500
2000
2500
3000
3500
4000
Distance (ft)
Pre-Settlement Final Cover
Post-Settlement Final Cover
Native Soil
Bedrock

4.7 TABLE 4.1 – FINAL COVER SETTLEMENT CALCULATIONS BASED ON 1-D CONSOLIDATION THEORY

Point No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Horizontal Distance	224.98	240.77	260.79	322.88	342.73	378.46	398.48	496.14	516.16	613.82	713.88	1137.87	1519.72	1817.61	2083.57	2626.57	2689.19	2808.54	3039.88	3211.21	3309.54	3367.18	3387.19	3470.03
Top of Final Cover Elevation (ft MSL)	779.05	783.00	783.60	798.73	799.29	808.00	808.60	833.00	833.60	858.00	861.00	862.00	862.00	860.00	858.40	834.87	833.00	808.60	798.12	786.47	783.00	768.60	768.00	747.30
Top of Waste Elevation (ft MSL)	779.05	782.50	783.10	798.23	798.79	807.50	808.10	832.50	833.10	857.50	860.50	861.50	861.50	859.50	857.90	834.37	832.50	808.10	797.62	785.97	782.50	768.10	767.50	746.80
Top of Liner Elevation (ft MSL)	778.55	782.50	783.10	798.23	798.79	807.50	808.10	832.50	833.10	857.50	860.50	861.50	861.50	859.50	857.90	834.37	832.50	808.10	797.62	785.97	782.50	768.10	767.50	746.80
Subgrade Elevation (ft MSL)	779.05	777.15	774.73	767.94	767.76	767.43	767.24	766.34	766.15	765.25	764.32	760.40	756.87	754.11	751.65	746.63	746.05	744.94	742.80	743.30	744.82	745.71	746.02	747.30
Bedrock Elevation (ft MSL)	740.00	740.03	740.07	740.19	740.23	740.30	740.34	740.53	740.57	740.67	740.28	738.63	738.52	738.88	739.20	736.69	735.50	733.24	728.86	725.61	727.90	729.32	729.82	731.86
CCR Layer Thickness (ft)	0.00	5.35	8.37	30.29	31.03	40.07	40.86	66.16	66.95	92.25	96.18	101.10	104.63	105.39	106.25	87.74	86.45	63.16	54.82	42.67	37.68	22.39	21.48	0.00
CCR Density (pcf)	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00
CCR Primary Comression Index	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Effective Initial Stress before loading (psf)	0.00	321.00	502.20	1817.40	1861.80	2404.20	2451.60	3969.60	4017.00	5535.00	5770.80	6066.00	6277.80	6323.40	6375.00	5264.40	5187.00	3789.60	3289.20	2560.20	2260.80	1343.40	1288.80	0.00
Pre-consolidation pressure (psf)	0.00	321.00	502.20	1817.40	1861.80	2404.20	2451.60	3969.60	4017.00	5535.00	5770.80	6066.00	6277.80	6323.40	6375.00	5264.40	5187.00	3789.60	3289.20	2560.20	2260.80	1343.40	1288.80	0.00
Change in Stress (psf)	0.00	321.00	502.20	1817.40	1861.80	2404.20	2451.60	3969.60	4017.00	5535.00	5770.80	6066.00	6277.80	6323.40	6375.00	5264.40	5187.00	3789.60	3289.20	2560.20	2260.80	1343.40	1288.80	0.00
CCR Primary Settlement (ft)		**0.14**	**0.23**	**0.82**	**0.84**	**1.09**	**1.11**	**1.79**	**1.81**	**2.50**	**2.61**	**2.74**	**2.83**	**2.86**	**2.88**	**2.38**	**2.34**	**1.71**	**1.49**	**1.16**	**1.02**	**0.61**	**0.58**	
CCR Secondary Comression Index	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068
Start of Secondary Compression (years)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
End of Secondary Compression (years)	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
CCR Secondary Settlement (ft)	**0.00**	**0.05**	**0.08**	**0.30**	**0.31**	**0.40**	**0.41**	**0.66**	**0.67**	**0.92**	**0.96**	**1.01**	**1.04**	**1.05**	**1.06**	**0.87**	**0.86**	**0.63**	**0.55**	**0.43**	**0.38**	**0.22**	**0.21**	**0.00**
Subgrade Layer Thickness (ft)	39.05	37.12	34.66	27.75	27.53	27.13	26.90	25.81	25.58	24.58	24.04	21.77	18.35	15.23	12.45	9.94	10.55	11.70	13.94	17.69	16.92	16.39	16.20	15.44
Subgrade Soil Density (pcf)	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00
Subgrade Primary Comression Index	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Effective Initial Stress before loading (psf)	2382.05	2264.32	2114.26	1692.75	1679.33	1654.93	1640.90	1574.41	1560.38	1499.38	1466.44	1327.97	1119.35	929.03	759.45	606.34	643.55	713.70	850.34	1079.09	1032.12	999.79	988.20	941.84
Pre-consolidation pressure (psf)	2382.05	2264.32	2114.26	1692.75	1679.33	1654.93	1640.90	1574.41	1560.38	1499.38	1466.44	1327.97	1119.35	929.03	759.45	606.34	643.55	713.70	850.34	1079.09	1032.12	999.79	988.20	941.84
Change in Stress (psf)	0.0	642.0	1,004.4	3,634.8	3,723.6	4,808.4	4,903.2	7,939.2	8,034.0	11,070.0	11,541.6	12,132.0	12,555.6	12,646.8	12,750.0	10,528.8	10,374.0	7,579.2	6,578.4	5,120.4	4,521.6	2,686.8	2,577.6	0.0
Subgrade Primary Settlement (ft)	**0.00**	**0.89**	**1.29**	**3.04**	**3.07**	**3.53**	**3.56**	**4.44**	**4.44**	**4.99**	**5.01**	**4.82**	**4.39**	**3.90**	**3.42**	**2.76**	**2.86**	**2.74**	**2.89**	**2.96**	**2.72**	**2.04**	**1.99**	**0.00**
Subgrade Secondary Comression Index	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165
Start of Secondary Compression (years)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
End of Secondary Compression (years)	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Subgrade Secondary Settlement (ft)	**0.95**	**0.90**	**0.84**	**0.68**	**0.67**	**0.66**	**0.66**	**0.63**	**0.62**	**0.60**	**0.59**	**0.53**	**0.45**	**0.37**	**0.30**	**0.24**	**0.26**	**0.29**	**0.34**	**0.43**	**0.41**	**0.40**	**0.39**	**0.38**
30-year Final Cover Total Settlement (ft)	**0.95**	**1.99**	**2.44**	**4.84**	**4.89**	**5.68**	**5.73**	**7.52**	**7.54**	**9.01**	**9.16**	**9.10**	**8.71**	**8.18**	**7.67**	**6.26**	**6.32**	**5.37**	**5.26**	**4.97**	**4.53**	**3.27**	**3.18**	**0.38**
Top of final cover after settlement (ft)	778.10	781.01	781.16	793.89	794.40	802.32	802.87	825.48	826.06	848.99	851.84	852.90	853.29	851.82	850.73	828.61	826.68	803.23	792.86	781.50	778.47	765.33	764.82	746.92
Initial Slope of Final Cover (ft/ft)		0.25	0.03	0.24	0.03	0.24	0.03	0.25	0.03	0.25	0.03	0.00	0.00	-0.01	-0.01	-0.04	-0.03	-0.20	-0.05	-0.07	-0.04	-0.25	-0.03	-0.25
Final Slope of Final Cover (ft/ft)		0.18	0.01	0.21	0.03	0.22	0.03	0.23	0.03	0.23	0.03	0.00	0.00	0.00	0.00	-0.04	-0.03	-0.20	-0.04	-0.07	-0.03	-0.23	-0.03	-0.22
Horizontal Length (ft)		15.79	20.02	62.09	19.85	35.73	20.02	97.66	20.02	97.66	100.06	423.99	381.85	297.89	265.96	543.00	62.62	119.35	231.34	171.33	98.33	57.64	20.01	82.84
Initial Segment Length (ft)		16.28	20.03	63.91	19.86	36.78	20.03	100.66	20.03	100.66	100.10	423.99	381.85	297.90	265.96	543.51	62.65	121.82	231.58	171.73	98.39	59.41	20.02	85.39
Final Segment Length (ft)		16.06	20.02	63.38	19.86	36.60	20.03	100.24	20.03	100.32	100.10	423.99	381.85	297.89	265.96	543.45	62.65	121.63	231.57	171.71	98.38	59.12	20.02	84.75
Strain (%, Tensile Negative)			**0.04**	**0.82**	**0.01**	**0.48**	**0.01**	**0.42**	**0.00**	**0.34**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.15**	**0.00**	**0.01**	**0.01**	**0.49**	**0.01**	

5. STATIC AND DYNAMIC LOAD EVALUATIONS (CLOSURE TURF)

5.1 TRAFFIC LOADING EVALUATIONS

Rubber tire vehicles are allowed to drive on the ClosureTurf™ System. Typically, on steep slopes the manufacturer recommends limiting to vehicles with tire pressures less than 60 psi, and on flat decks (2% or less) and designed access roads, the manufacturer recommends limiting to vehicles with tire pressures less than 100 psi. Detailed calculations for puncture of the geomembrane from wheel loading and lateral movement due to vehicle breaking are included in the Appendix as 7.12 Evaluation of Drivability Light Weight Construction Equipment on Closure Turf™ System, By SGI Testing Services, dated July 8, 2010.

5.2 AERODYNAMIC EVALUATIONS

ClosureTurf™ has features that help mitigate the forces of wind. These include a porous surface to break the vacuum, and turf blades that will increase the aerodynamic boundary conditions and react against the wind causing a resistance to the uplift component.

The ClosureTurf™ System was evaluated in the wind tunnel at the Georgia Tech Research Institute (GTRI). It was tested up to 120 mph without uplift. Based on these results, the ClosureTurf™ System is projected to withstand 150+ mph winds when properly designed. The photo in Figure 5.1 shows the test at 170 fps (120 mph). The detailed aerodynamic evaluation report from GTRI is included in the Appendix as 7.13 Aerodynamic Evaluations of Closure Turf Ground Cover Materials, by Georgia Tech Research Institute (GTRI), dated July 8, 2010.

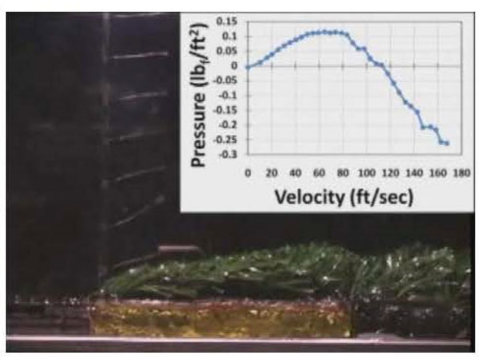


Figure 5.1 – Aerodynamic Evaluation of ClosureTurf™ at GTRI

5.3 INTERFACE SHEAR STRENGTH EVALUATIONS

Interface Direct Shear Testing was performed on the ClosureTurf™ System at SGI. Their test report is included in the Appendix of this Report as 7.14 Laboratory Results Transmittal Interface Direct Shear Testing ClosureTurf™ Cover System, by SGI Testing Services, dated June 27, 2010.

6. EROSION RESISTANCE (CLOSURE TURF)

6.1 EROSION RESISTANCE FROM RAINFALL

When water falls on the ClosureTurf™ during rainfall events, it penetrates through the geosynthetic erosion layer into the underlying drainage layer integrated with the structured geomembrane (MicroDrain® liner by AGRU America). The ClosureTurf™ technology was designed so that the surface water flows in the geomembrane drainage layer and not within or on the sand layer. The drainage layer resists the hydraulic forces of the flowing water. The sand infill is not subjected to those factors, and therefore, it stays in place. On designs where bench drains are not desired; the sand infill is bound ArmorFill™, See Section 6.3.

ClosureTurf™ has been tested in the rainfall simulator at TRI Environmental's Erosion Control Laboratory. TRI Environmental tested ClosureTurf™ in accordance with ASTM D6459-Standard Test Method for determination of Rolled Erosion Control Product (RECP) Performance in Protecting Hillslopes from Rainfall-Induced Erosion. Their full-scale rainfall simulator is 8-ft wide by 40-ft long with a slope of 3H:1V. The ClosureTurf™ was tested to a heavy rainfall intensity of over 6.5 in/hr which resulted in a loss of only 0.04% of the sand infill. This measured loss of sand infill is approximately 0.03 tons/acre. The results of the testing at TRI Environmental substantiate that the sand stays in place. Figure 6.1 shows the testing being performed, and the testing report is provided in the Appendix of this Report as 7.15 Large Scale Erosion Test ASTM.

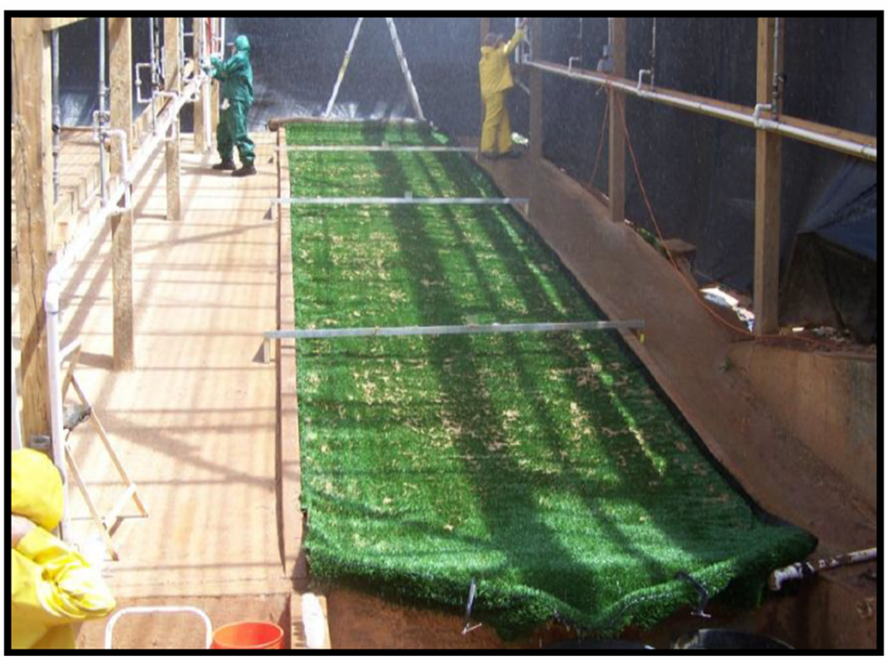


Figure 6.1 – Rainfall Erosion Resistance Testing on ClosureTurf® (3H:1V Slope)

In addition to the laboratory testing, the following real world data shows that not only does the system perform well in the laboratory, but it also performs well in real-world applications.

- ClosureTurf™ has been installed on over 17.9 million square feet (sf) of landfill closures. The first project was installed in 2009. Of the roughly 18 million square feet installed thus far, less than 1% of the sand infill has been displaced.
- In May 2013, ClosureTurf™ was installed as the final cover of the Saufley Landfill in Escambia County, Florida. In April 2014, it was recorded that the landfill was subjected to greater than 22-inches of rain over 2 days with the majority of the rain falling in a 24 hour period. The peak intensity for this storm event was 5.68 in/hr. this was estimated to be a 500-year storm intensity putting ClosureTurf™ to the ultimate test. The ClosureTurf™ suffered minimal sand displacement (less than 1%).
- ClosureTurf™ was also installed on the Tangipahoa Landfill located in Tangipahoa Parish, Louisiana in November 2013. The landfill is monitoring the stormwater quality from two distinct areas by collecting and analyzing run-off samples. One area is where the ClosureTurf™ system is installed, and the other area is where an interim soil cover was installed. Both of these areas are approximately 5 acres in size and have similar drainage characteristics. During a 24-hour one-inch rain event, stormwater was sampled from the separate areas. Photographs of each stormwater sample is shown in Figure 6.2, and analytical results of the samples are included in Table 6.1. the stormwater runoff from the ClosureTurf™ area was of significantly higher quality than from the soil cover area. For example, the turbidity of the stormwater from the ClosureTurf™ cover area was 11 NTU, and the turbidity from the soil cover area was 371 NTU.

Figure 6.2 – Stormwater Samples from Tangipahoa Landfill

Table 6.1 – Analytical Results from Stormwater Samples at Tangipahoa Landfill

Parameter	Area with Soil Cover	Area with ClosureTurf™
Turbidity (NTU)	371	11
TSS (mg/L)	349	< 4
pH	6.5	7.3
TOC (mg/L)	174	1
TRI (mg/L)	16	0.5

Sand displacement may occur if the untreated sand infill is subjected to shear stresses that exceed 1.5 psf. Flows that exceed 1.5 psf usually only occur in concentrated flow, (i.e. channel flow) conditions. On landfills, these types of higher flows typically only occur within downchutes, bench drains, and perimeter channels. For the ClosureTurf™ cover system where only sand infill is utilized, the locations and areas of sheet flow, shallow concentrated flow, and concentrated flow should be identified so the proper infill technique can be used to prevent sand displacement. This is performed by evaluating the critical slope length of overland flow where the sand infill of the ClosureTurf™ does not migrate due to excessive shear forces. The bench drains and channels can be spaced at distances that are less than the critical slope length so that the runoff is channelized prior to movement of the sand infill. Figure 6.3 shows the critical slope length for ClosureTurf™ based on differing rainfall intensities and slope angles. Note that as the slope angle is reduced to less than 6%, the shear force in any rain event becomes negligible and the drainage length can become significantly longer.

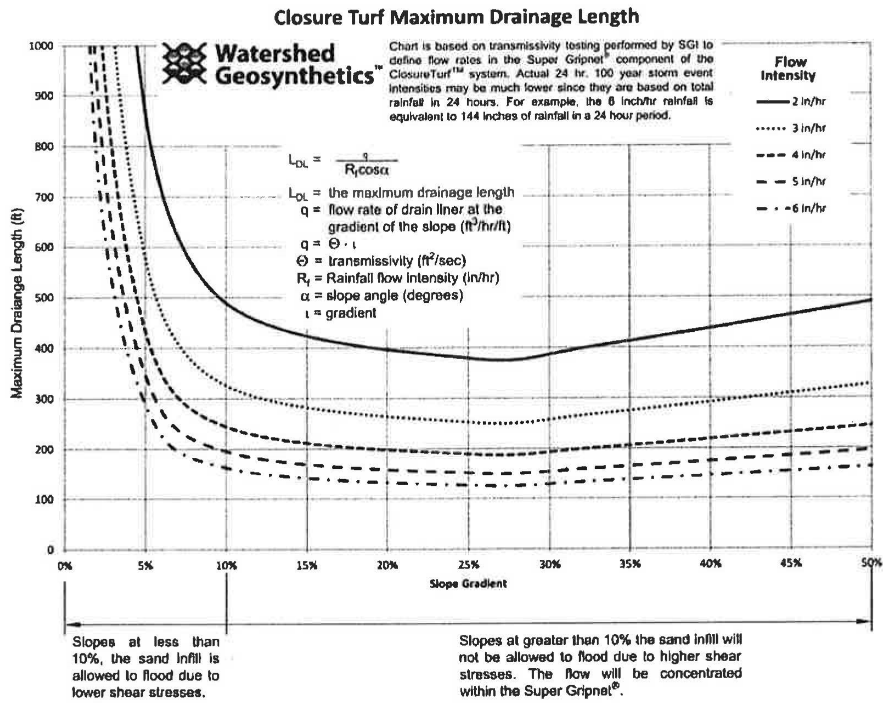


Figure 6.3 – ClosureTurf™ Critical Slope Length

In the areas of channelized runoff, a bound infill (HydroBinder®) should be incorporated into the engineered synthetic turf instead of the sand. The resulting product is called HydroTurf®. HydroTurf® is similar to the ClosureTurf™ system except that the sand infill is changed to a cementitious infill layer with approximately 5000 psi compressive strength.

The maximum flow length for AMA is approximately 400 feet in areas with a slope of 3%, and approximately 60 feet in areas of 4H:1V maximum slope.

According to Figure 6.3, these slope lengths are well within the critical slope lengths required for rainfall intensities up to and exceeding 6 in/hr.

6.2 EROSION CONTROL FROM CHANNELIZED FLOW

When longer drainage lengths beyond what is recommended in Figure 6.3 are required, ArmorFill™ is utilized to bind the sand within the turf blades while maintaining high permeability to the MicroDrain®. ArmorFill™ is a liquid cement infill product that is available also as an emulsion. ArmorFill™ was tested for erosion resistance in TRI's laboratory. The results are shown in Figure 6.4 below.

The results of the test show clearly that in sheet flow, shallow concentrated flow, and even in many channel flow conditions, the ArmorFill™ will bind the sand by increasing its shear strength many times.

Note that earlier testing at TRI's laboratory showed that the sand infill alone could withstand sheet flow/shallow concentrated flow conditions with shear stresses up to 1.5 psf with no sand loss. A shear stress of up to 1.5 psf does not cause the sand to migrate in any sheet flow conditions. Obviously, when ArmorFill™ is applied, a higher shear stress can be applied with no infill loss.

TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

Project: ClosureTurf with Sand-Cement Infill - Channel Lining
Client: Watershed Geo
Test Dates: 7/20/2015 7/31/2015
Shear Range: 2.0 - 10.0+ psf (target)
Flume Size & Slope: 2-ft wide x 40-ft long; 10% Bed (Shear Levels 1 - 4)
2-ft wide x 40-ft long; 20% Bed (Shear Levels 5 - 8)
Event: 30 minutes at each shear

Shear Level	Flow depth (in)	Flow velocity (fps)	Flow (cfs)	Manning's roughness, n	Max Bed Shear Stress (psf)	CSLI (in)	Cumm. CSLI, (in)
1	1.86	3.68	1.14	0.037	0.96	0.00	0.00
2	2.56	5.19	2.21	0.032	1.30	0.00	0.00
3	3.76	7.93	4.96	0.027	1.90	0.00	0.00
4	6.91	14.57	16.78	0.022	3.53	0.00	0.01
5	1.94	5.13	1.66	0.039	1.99	0.00	0.00
6	3.87	10.64	6.86	0.029	3.86	0.00	0.00
7	5.80	17.29	16.72	0.023	5.37	0.03	0.03
8	9.63	25.09	40.27	0.020	7.62	0.03	0.07

Observations:

Shears 1 - 3 & 5 - 7: The flow was laminar and uniform through the test reach. There was no observable loss or cracking of fill material. Shear events appeared to have no effect on the system.

Shears 4 & 8: Flow was turbulent entering the channel but became reasonably laminar by Section 6. Still, there was no observable loss or cracking of fill material. Even these highest shear events appeared to have no effect on the system.


Channel Prepared for Testing


Highest Shear = Maximum Flow in 20% Flume


After Highest Shear


Close-up After Highest Shear

The testing is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose

CJS 8/17/15
Quality Review / Date

9063 Bee Caves Road / Austin, Texas 78733 / ph: 512 263 2101 / fax: 512 263 2558 / www.GeosyntheticTesting.com

Figure 6.4 – ArmorFill™ Testing at TRI

To evaluate the AMA Closure for use of ClosureTurf™ with ArmorFill™ and no tack-on berms or downchutes, calculations were performed to determine flow depths for comparison to Figure 6.4.

From *Urban Storm Water Management*, Second Edition (Hormoz Pazwash), sheet flow depth can be solved by:

$d = 0.116(nI/\sqrt{S})^{0.6} \text{ X } L^{0.6}$

where:

L = sheet flow length, m

d = flow depth, mm

I = rainfall intensity, mm/h

S = surface slope, m/m

For the AMA Closure, top deck area has a minimum slope of 3 percent and maximum flow length of 400 feet, and the side slope area has a maximum slope of 25 percent and maximum flow length of 60 feet.

Assuming a 25-year, 60-minute storm, the rainfall intensity is 2.67 in/hr (66.75mm/h) From NOAA Atlas 14, Vol. 9, Version 2 for Newnan, Georgia, Point Precipitation Frequency Estimates).

The depths of sheet flow are calculated as:

Top Deck: $d = 0.116(nI/\sqrt{S})^{0.6} \text{ X } L^{0.6}$

$= 0.116(0.95*66.75/\sqrt{0.03})^{0.6} \text{ X } 133^{0.6}$

= 75.3 mm

= 2.96 in

Side Slope: $d = 0.116(nI/\sqrt{S})^{0.6} \text{ X } L^{0.6}$

$= 0.116(0.95*66.75/\sqrt{0.25})^{0.6} \text{ X } 20^{0.6}$

= 12.8 mm

= 0.5 in

According to Figure 6.3, these flow depths are well within the maximum bed shear stress for laminar and uniform flow, with no observable loss or cracking of infill material.

6.3 EROSION CONTROL USING CLOSURE TURF^{TM} WITH ARMORFILL

In areas of channelized flow (i.e., bench drains, downchutes, and perimeter channels), Watershed Geosynthetics recommends that the ClosureTurf^{TM} system be infilled with HydroBinder® (cementitious infill) instead of ASTM C-33 sand. We refer to the resulting product as HydroTurf®. HydroTurf has been tested at Colorado State University Engineering Research Center (CSU).

CSU tested HydroTurf in accordance with ASTM D 7277 – Standard Test Method for Performance Testing of Articulated Concrete Block (ACB) Revetment Systems for Hydraulic Stability in Open Channel Flow. The results of the testing were analyzed in accordance with ASTM D 7276 – Standard Guide for Analysis and Interpretation of Test Data for Articulating Concrete Block (ACB) Revetment Systems in Open Channel Flow. Testing was performed to the 5-ft overtop flume capacity which resulted in over 29 fps in velocity. The photos in Figure 6.5 show this steady state testing being performed.

Figure 6.5 – Steady State Hydraulic Testing of HydroTurf^{TM} at CSU

Full-scale Wave Overtopping Testing for Levee Landward Side Slope Protection was also performed on the HydroTurf System at CSU. CSU has the world's largest Wave Overtopping Simulator which they developed for the US Army Corps of Engineers. Testing was performed on HydroTurf for a total of 13 hours with 9 hours at the simulator maximum capacity of 4.0 cfs/ft, which represents a generic hurricane in New Orleans, LA with a 0.2 percent annual exceedance probability (i.e. 500 year event). The photos in Figure 6.6 show wave overtop testing on the HydroTurf.

Figure 6.6 – Wave Overtop Hydraulic Testing of HydroTurf® at CSU

A detailed technical note of the CSU testing is included in the Appendix of this Report as 7.16 Full Scale Hydraulic Testing of the HydroTurf™ Advanced Revetment Technology.

In conclusion, the erosion resistance of ClosureTurf significantly outperforms the traditional vegetative soil cover system. Also, ClosureTurf significantly improves water quality by reducing sediment loads and runoff turbidity.

7. APPENDIX

7.1 SCHNABEL ENGINEERING MEMORANDUM

6445 Shiloh Road, Suite A
Alpharetta, GA 30005
T/ 770-781-8008
F/ 770-781-8003

MEMORANDUM

TO:	Stacey Simpson, PE	**DATE:**	October 11, 2018
COMPANY:	Southern Company	**SUBJECT:**	Dyer Road Culvert Analysis
ADDRESS:	3535 Colonnade Parkway, Birmingham, AL 35246	**PROJECT NAME/NO.:**	Plant Yates Ash Pond 2/17C17013.00
FROM:	Schnabel Engineering	**CC:**	

Schnabel Engineering, LLC (Schnabel) has completed the authorized hydrologic and hydraulic (H&H) analysis associated with portions of property contained within the limits of Plant Yates. More specifically, the H&H analysis was performed to evaluate the capacity and resulting water surface elevations of three proposed sets of culverts. Two sets of culverts are being proposed beneath a relocated portion of Dyer Road. The third set of proposed culverts are located upstream of Dyer Road, within the proposed outside perimeter ditch beneath a proposed earthen crossing which provides access to the R6 stack. Figure 1 appended to this memo depicts the locations of the proposed culverts.

Based upon our understanding, the subject culverts are to be designed to pass inflows associated with the 100-year, 24-hour duration storm event. Additionally, the proposed culverts are to be sized such that the 100-year headwater elevation upstream of the culverts does not inundate ash covers associated with the R6 stack and the AMA. The following sections describe the analyses performed and the results obtained.

Watershed Hydrology

The watersheds contributing runoff to each of the three proposed culverts were analyzed based upon the methodologies contained in the NRCS National Engineering Handbook (NEH) Part 630, Hydrology. For the purpose of this report, the three watersheds are designated as follows:

- Dyer Road Culvert East
- Dyer Road Culvert West
- R6 Access Road

The watersheds were delineated utilizing topographic information provided by Southern Company. Table 1 below presents the areas associated with each of the three watersheds.

Table 1 – Watershed Areas

Watershed	Area (Acres)	Area (Square Miles)
Dyer Road Culvert East	30	0.05
Dyer Road Culvert West	37	0.06
R6 Access Road	127	0.2

Land cover types for each watershed were obtained from the National Land Cover Dataset 2011, Zone 14. Curve numbers presented in NEH Part 630, Chapter 6 were assigned to various land use categories. Soil types and data were determined utilizing the NRCS Web Soil Survey online application. Soil Types “B,” “C” and “D” were determined to be present within each watershed.

Utilizing NRCS Technical Release No. 55 (TR-55) and NEH Part 630, an NRCS Runoff Curve Number (CN) was computed for each watershed to provide the anticipated surface runoff conditions. Runoff CN’s were calculated for the “average” antecedent runoff condition, denoted ARC II, for use in routing the storm event. The computed curve numbers for each watershed are presented in Table 2 below.

Table 2 – Runoff Curve Numbers

Watershed	Curve Number
Dyer Road Culvert East	71
Dyer Road Culvert West	62
R6 Access Road	67

The lag time for each sub-basin was calculated utilizing methodologies contained in TR-55. The watershed lag method as well as the NRCS velocity method was utilized to estimate the lag times for each watershed. The lag times utilized for each watershed are presented below in Table 3.

Table 3 – Lag Time

Watershed	Lag Time (hours)
Dyer Road Culvert East	0.2
Dyer Road Culvert West	0.3
R6 Access Road	0.6

Precipitation data utilized in routing the 100-year, 24-hour storm event was obtained from the National Oceanic and Atmospheric Administration (NOAA) Precipitation Frequency Data Server. The 100-year, 24-hour rainfall depth was determined to be approximately eight (8) inches. The NRCS Type II rainfall distribution was utilized to develop the storm hyetograph.

Proposed Culverts – Dyer Road East

Based upon information provided to Schnabel by Southern Company, the proposed culvert set beneath the eastern portion of Dyer Road are planned to be four, 48-inch diameter HDPE pipes. Table 4 below presents details of the proposed Dyer Road East culvert set.

Table 4 – Dyer Road East Culvert Properties

Dyer Road East Culverts	
Number of Pipes	4
Diameter	48 inches
Length	~100 feet
Upstream Invert Elevation	~729.8 feet
Downstream Invert Elevation	~729.0 feet

Proposed Culverts – Dyer Road West

Based upon information provided to Schnabel by Southern Company, the proposed culvert set beneath the western portion of Dyer Road are planned to be four, 30-inch diameter HDPE pipes. Table 5 below presents details of the proposed Dyer Road West culvert set.

Table 5 – Dyer Road West Culvert Properties

Dyer Road West Culverts	
Number of Pipes	4
Diameter	30 inches
Length	~70 feet
Upstream Invert Elevation	~726.0 feet
Downstream Invert Elevation	~725.2 feet

Proposed Culverts – R6 Access Road

Based upon information provided to Schnabel by Southern Company, the proposed culvert set beneath the proposed R6 access road are planned to be four, 48-inch diameter HDPE pipes. Table 4 below presents details of the proposed R6 Access Road culvert set.

Table 5 – R6 Access Road Culvert Properties

R6 Access Road Culverts	
Number of Pipes	4
Diameter	48 inches
Length	~190 feet
Upstream Invert Elevation	~737.9 feet
Downstream Invert Elevation	~737.2 feet

Watershed Modeling

The computer software used to develop inflows into each of the culvert sets was the HEC-HMS version 4.2 program developed by the U.S. Army Corps of Engineers. Additionally, Schnabel utilized the U.S. Army Corps of Engineers computer program HEC-RAS for more refined evaluations of the stormwater impacts associated with the proposed culvert sets, with the exception of the Dyer Road West culverts. A depiction of the HEC-RAS modeled cross-sections is provided in Figure 2 appended to this memo. Given than no well-defined channel exists upstream of the Dyer Road West culverts, Schnabel utilized level pool routing methodologies within HEC-HMS to evaluate the culvert performance and resulting upstream headwater elevations. The results of the hydrologic and hydraulic analysis associated with the proposed culvert sets are presented below in Tables 6 and 7.

Table 6 – HEC-RAS Results for R6 Access Road Culverts and Dyer Road East Culverts

Station	Discharge (cfs)	Channel Invert El. (ft)	Peak Water Surface El. (ft)
4446.15	27.5	743.86	745.07
4271.11	27.5	743.42	744.64
4091.21	27.5	742.97	744.19
3951.42	27.5	742.62	743.84
3819.45	27.5	742.29	743.52
3644.54	27.5	741.85	743.13
3448.17	27.5	741.36	742.79
3269.87	27.5	740.91	742.54
3091.86	27.5	740.47	742.41
2937.99	27.5	740.08	742.35
2760.88	27.5	739.64	742.32
2583.98	27.5	739.2	742.3
2420	27.5	738.79	742.29
2293.53	27.5	738.29	742.28
2200.75	292.1	737.92	742.16
2105.67	**R6 Access Road Culverts**		
2008.26	292.1	737.16	741.16
1902	292.1	736.73	740.67
1769.4	292.1	736.18	740
1603.89	292.1	735.52	739.21
1439.72	292.1	734.86	738.65
1269.21	292.1	734.18	737.83
1110.44	292.1	733.34	736.97
972.11	292.1	732.3	736.22
819.19	292.1	731.06	735.81
746	292.1	730.34	735.71
684.88	455.5	729.74	735.63
644.6	**Dyer Road East Culverts**		
600.25	455.5	728.86	732.69
538	455.5	728.27	732.17
363.93	455.5	726.58	730.31

Table 7 – Dyer Road West Culverts

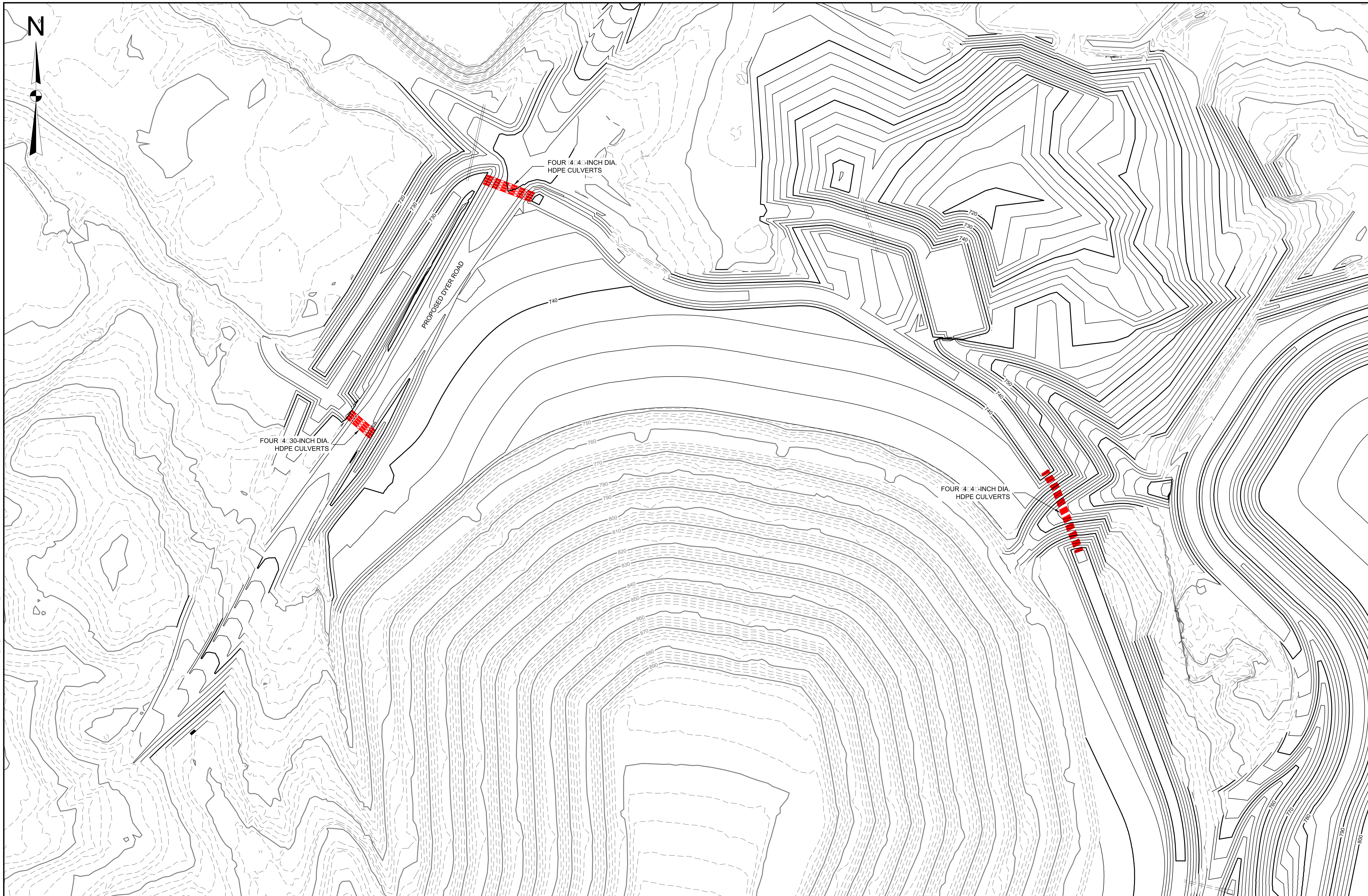
Dyer Road West Culverts	Discharge (cfs)	Peak Water Surface Elevation (ft)
	111	729.0

Figure 3 appended to this memo depicts the approximate 100-year water surface elevation limits of each of the three modeled culvert sets.

We caution that the results contained herein are based upon the information provided by Southern Company with regards to proposed site grading, alignment of the relocated portion of Dyer Road and culvert properties. Any modifications to these features will likely result in changes in the modeled results as presented herein.

SIGNED: ______________________________

Jonathan T. Dean, PE, Associate



PLANT YATES
ASH POND CLOSURE
COWETA COUNTY□GEORGIA

PROPOSED CULVERTS LOCATION E□HIBIT

Schnabel ENGINEERING
6445 Sh□loh Ro□d□S□□te A / Alph□rett□□GA 30005 /
Pho□e: □□0-□□1-□00□ / F□□: □□0-□□1-□003 /
sch□□□el-e□g.com

DESIGNED BY: BWD
DRAWN BY: BWD
CHECKED BY: □TD

REV	DESCRIPTION	DATE

PRO□ECT: 1□C1□013.00
DATE: 10/11/201□
FIGURE 1
1 OF 1

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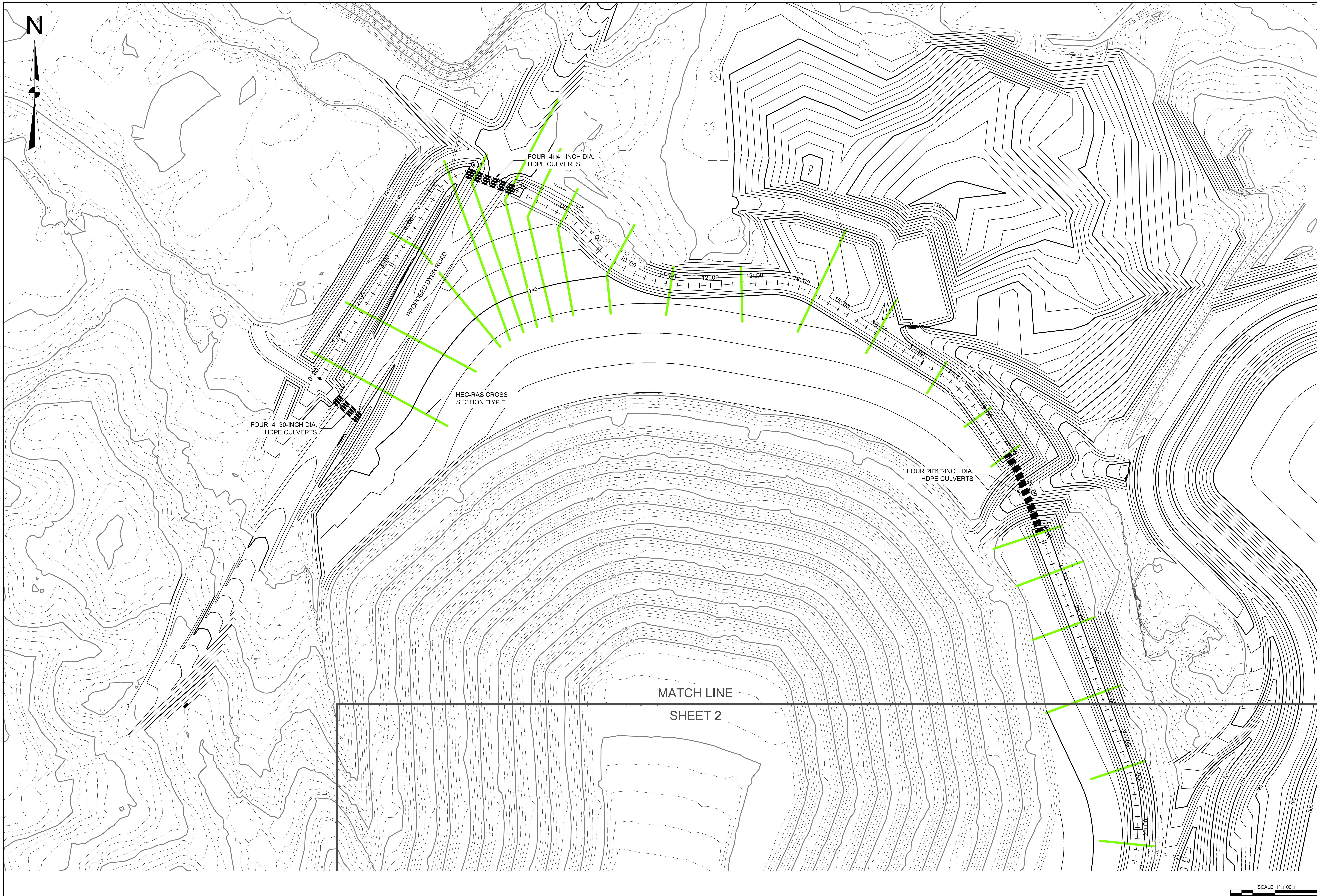

PLANT YATES
ASH POND CLOSURE
COWETA COUNTY□GEORGIA

PROPOSED CULVERTS HEC-RAS CROSS SECTIONS

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6445 Shiloh Ro□d□S□ite A / Alph□rett□□GA 30005 / Pho□e: □□0-□□1-□00□ / F□□: □□0-□□1-□003 / sch□□□el-e□g.com

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CHECKED BY: □TD

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FIGURE 2
1 OF 2

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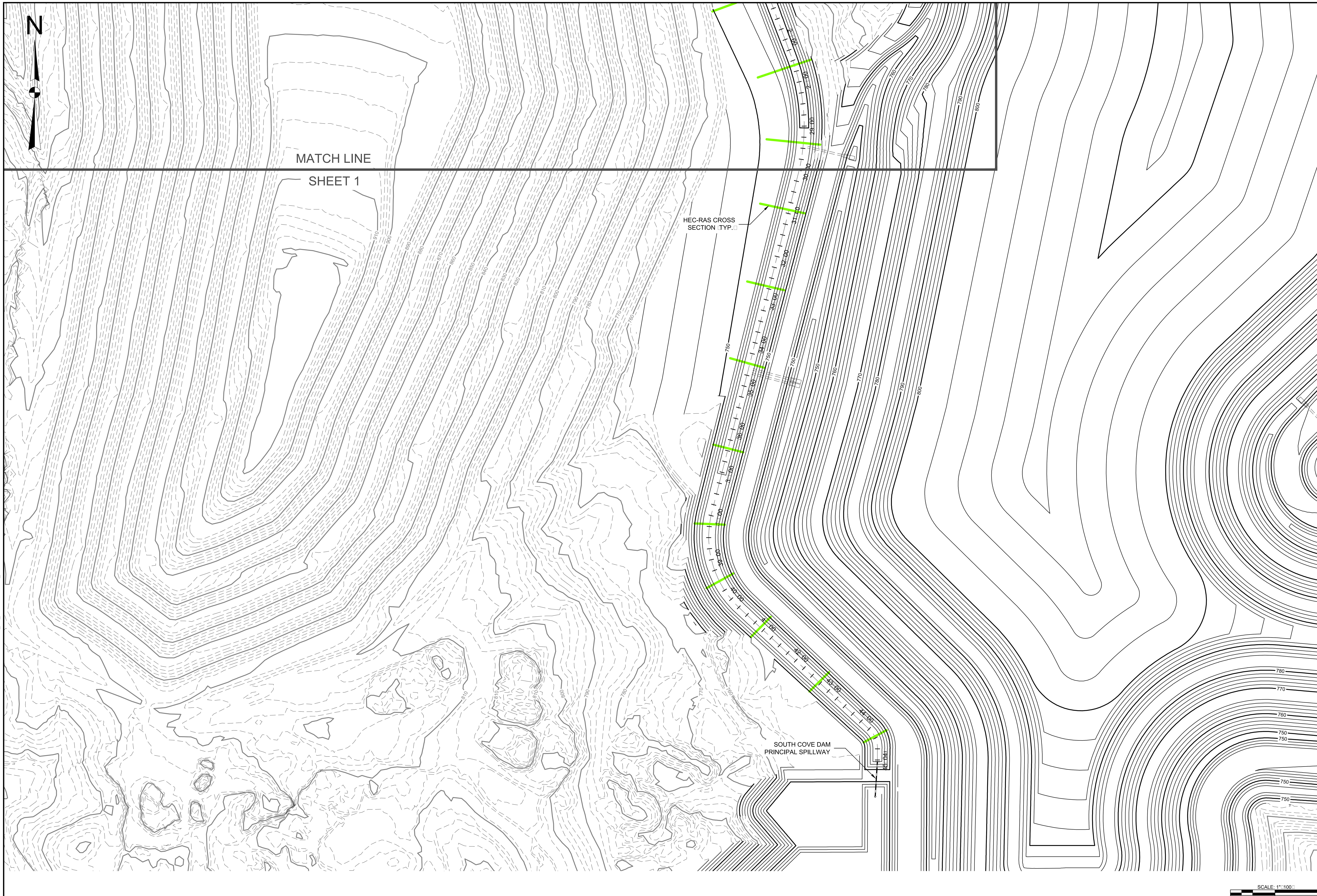

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Phone: / Fax: /
schnabel-eng.com

PLANT YATES
ASH POND CLOSURE
COWETA COUNTY, GEORGIA

PROPOSED CULVERTS HEC-RAS CROSS SECTIONS

PROJECT: 1_C1_013.00

DATE: 10/11/201_

FIGURE 2
2 OF 2

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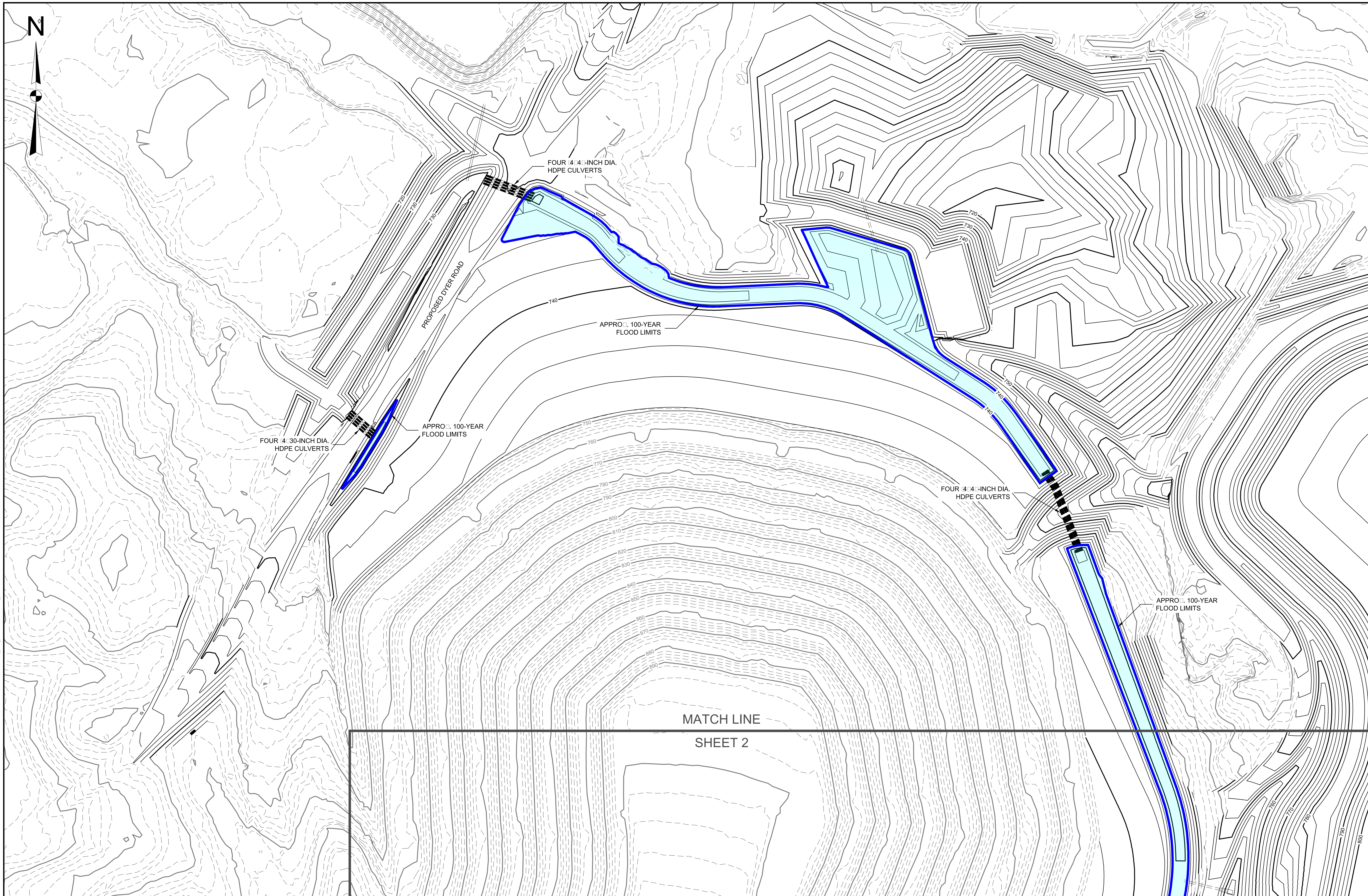

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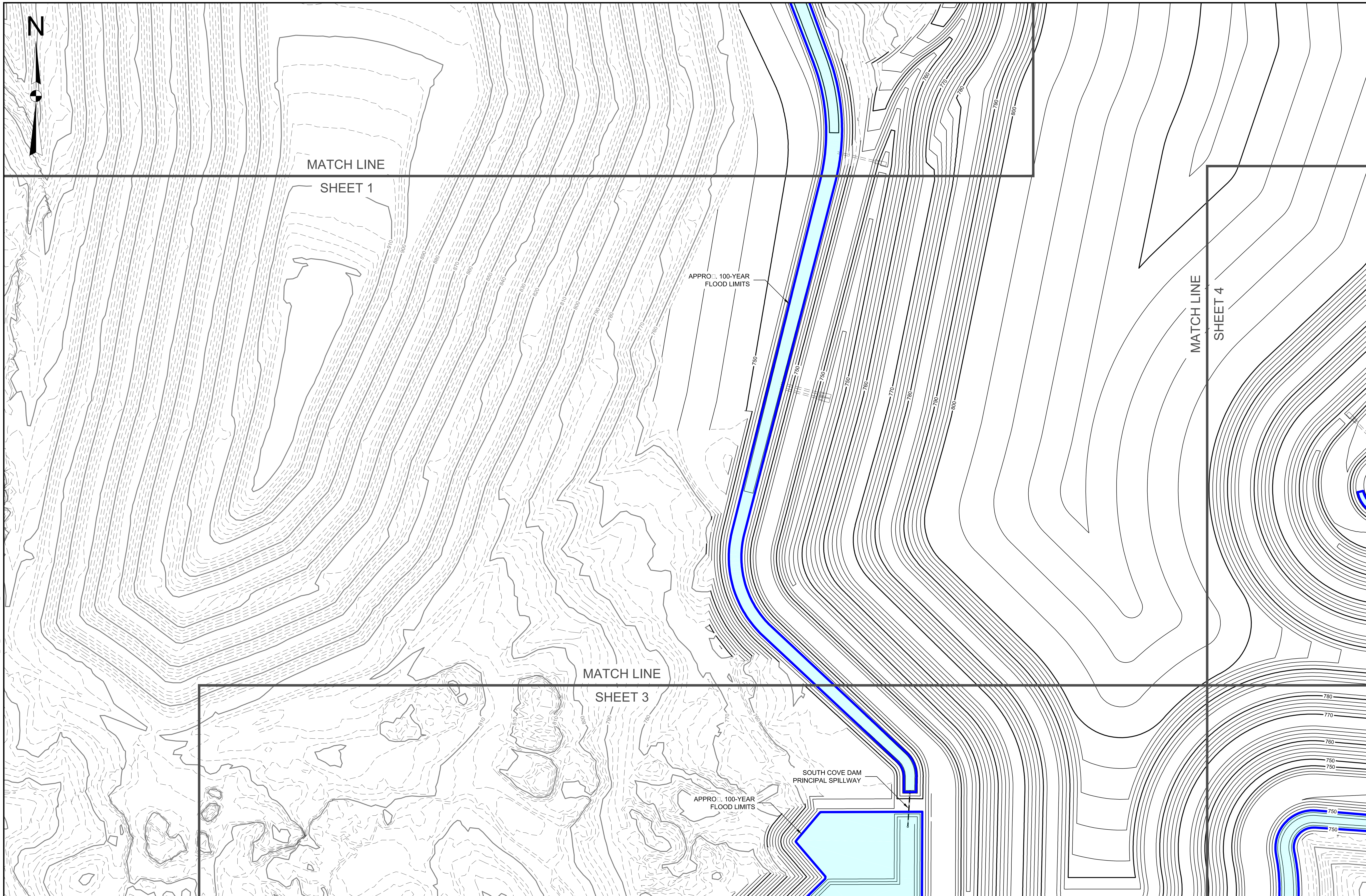
PLANT YATES
ASH POND CLOSURE
COWETA COUNTY□GEORGIA

PROPOSED CULVERTS
FLOOD E□HIBIT

PRO□ECT: 1□C1□013.00
DATE: 10/11/201□
FIGURE 3
1 OF 4



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PLANT YATES
ASH POND CLOSURE
COWETA COUNTY□GEORGIA

PROPOSED CULVERTS
FLOOD E□HIBIT

SCALE: 1"□100□
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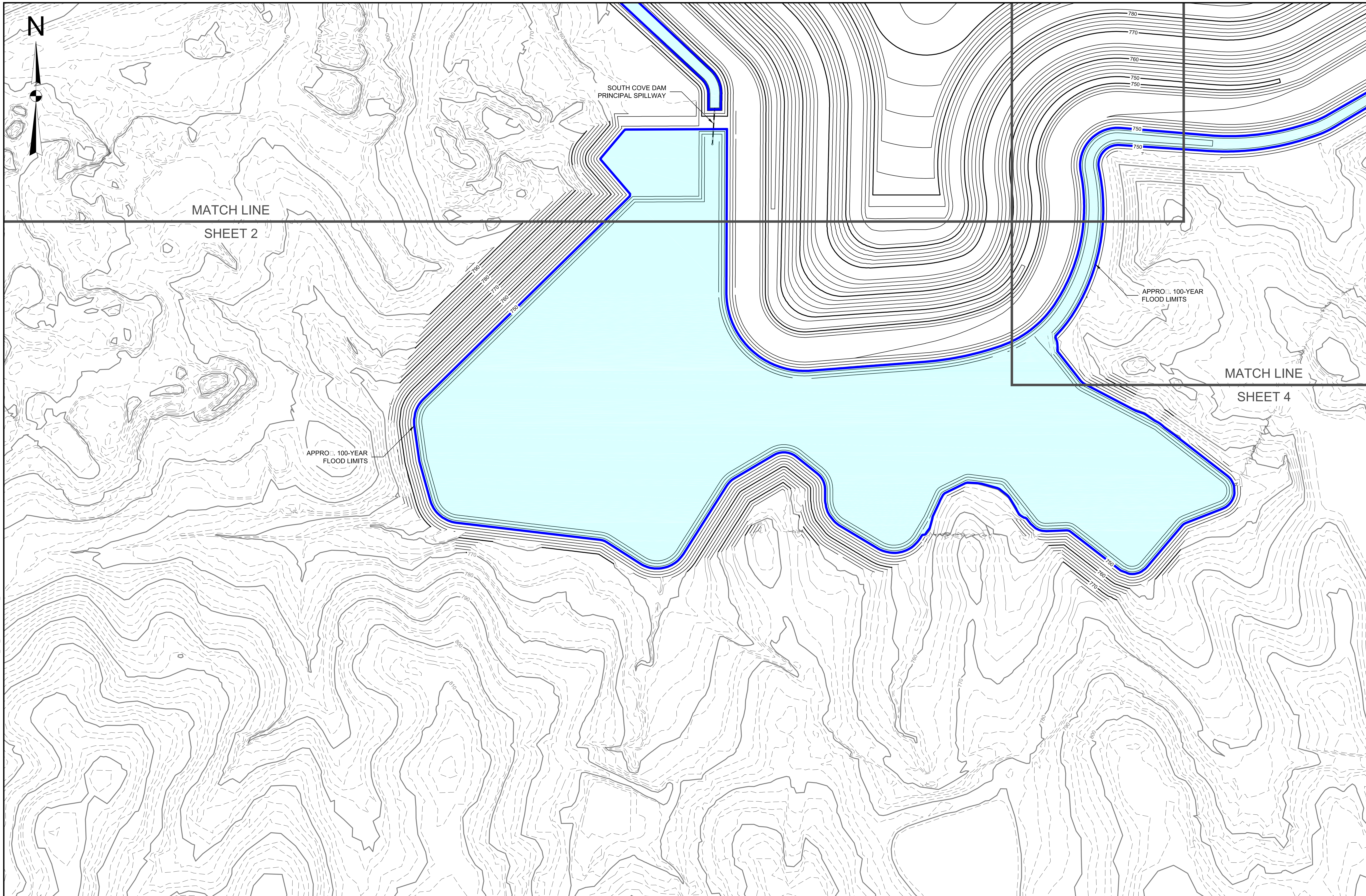
FIGURE 3
2 OF 4



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PLANT YATES
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COWETA COUNTY□GEORGIA

PROPOSED CULVERTS FLOOD E□HIBIT

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FIGURE 3
3 OF 4

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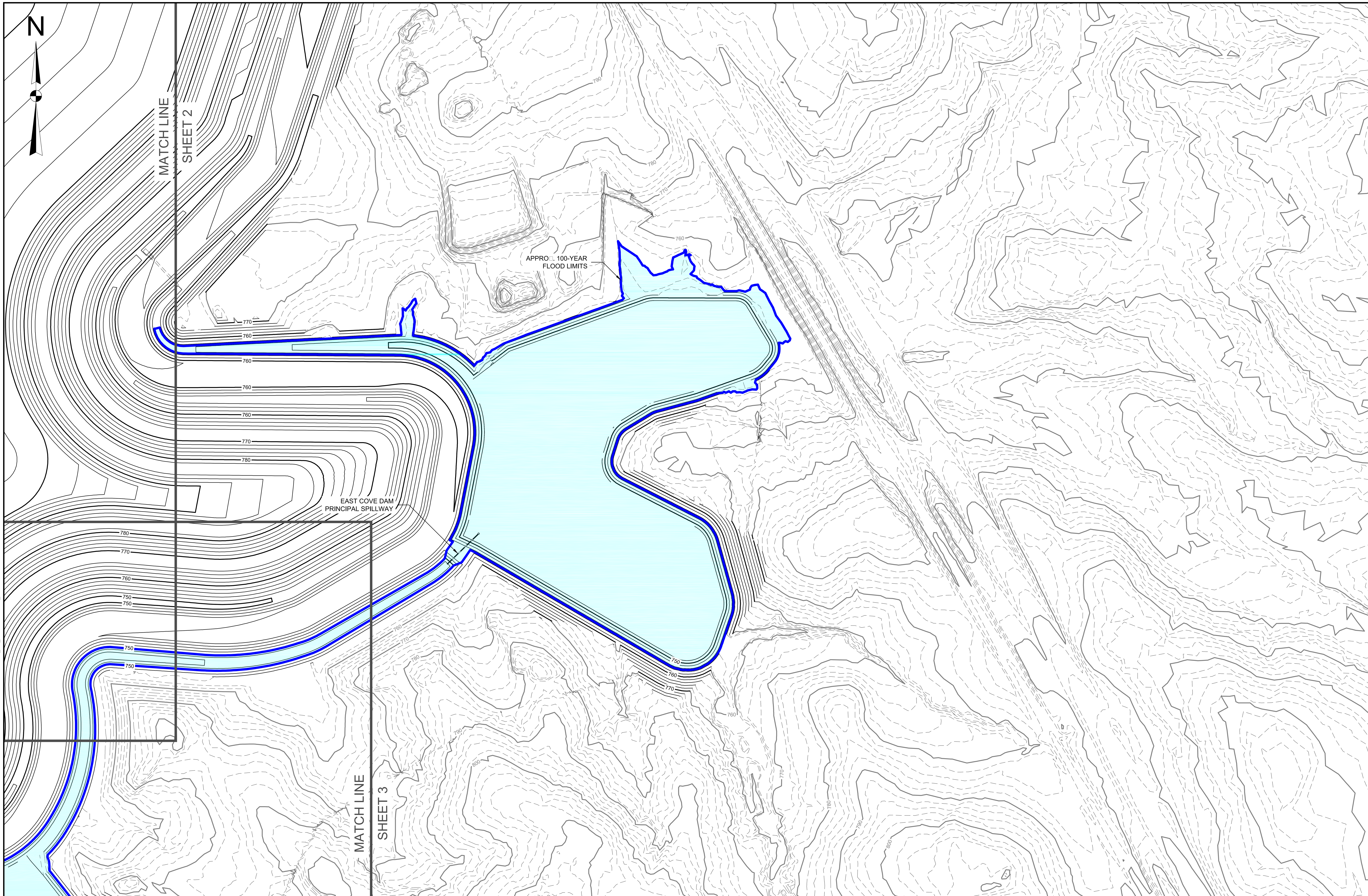

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PLANT YATES
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PROPOSED CULVERTS FLOOD E□HIBIT

PRO□ECT: 1□C1□013.00

DATE: 10/11/201□

FIGURE 3
4 OF 4

7.2 TABLE 1 – NOAA POINT PRECIPITATION FREQUENCY ESTIMATES (INTENSITY) – NEWNAN, GEORGIA

NOAA Atlas 14, Volume 9, Version 2
Location name: Newnan, Georgia, USA*
Latitude: 33.4565°, Longitude: -84.8983°
Elevation: 711.96 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	4.76 (3.90-5.99)	5.47 (4.48-6.88)	6.68 (5.45-8.41)	7.73 (6.26-9.76)	9.24 (7.26-12.0)	10.4 (8.03-13.6)	11.7 (8.69-15.5)	13.0 (9.28-17.6)	14.8 (10.2-20.4)	16.2 (10.8-22.6)
10-min	3.49 (2.86-4.38)	4.01 (3.28-5.03)	4.90 (3.98-6.16)	5.66 (4.58-7.14)	6.76 (5.32-8.77)	7.64 (5.87-9.99)	8.56 (6.36-11.4)	9.53 (6.80-12.9)	10.9 (7.45-15.0)	11.9 (7.94-16.5)
15-min	2.84 (2.32-3.56)	3.26 (2.66-4.10)	3.98 (3.24-5.01)	4.60 (3.73-5.81)	5.50 (4.32-7.12)	6.22 (4.78-8.12)	6.96 (5.17-9.25)	7.74 (5.52-10.5)	8.82 (6.06-12.2)	9.67 (6.46-13.4)
30-min	2.07 (1.69-2.59)	2.38 (1.94-2.99)	2.91 (2.37-3.66)	3.37 (2.73-4.25)	4.02 (3.16-5.21)	4.55 (3.49-5.94)	5.09 (3.78-6.76)	5.66 (4.03-7.65)	6.44 (4.42-8.87)	7.05 (4.71-9.80)
60-min	1.36 (1.11-1.71)	1.57 (1.28-1.97)	1.92 (1.56-2.41)	2.22 (1.80-2.80)	2.67 (2.11-3.48)	3.04 (2.34-3.98)	3.43 (2.55-4.56)	3.84 (2.74-5.20)	4.41 (3.03-6.09)	4.86 (3.25-6.76)
2-hr	0.846 (0.700-1.05)	0.970 (0.802-1.20)	1.19 (0.978-1.48)	1.38 (1.13-1.72)	1.67 (1.33-2.15)	1.91 (1.48-2.47)	2.16 (1.62-2.84)	2.42 (1.75-3.25)	2.80 (1.95-3.83)	3.10 (2.10-4.26)
3-hr	0.637 (0.530-0.784)	0.728 (0.605-0.895)	0.888 (0.736-1.10)	1.03 (0.852-1.28)	1.25 (1.01-1.60)	1.43 (1.13-1.85)	1.63 (1.24-2.13)	1.84 (1.34-2.45)	2.13 (1.50-2.90)	2.37 (1.62-3.24)
6-hr	0.394 (0.331-0.478)	0.446 (0.375-0.542)	0.539 (0.452-0.656)	0.625 (0.520-0.763)	0.754 (0.614-0.954)	0.862 (0.685-1.10)	0.979 (0.753-1.27)	1.11 (0.817-1.46)	1.29 (0.914-1.73)	1.43 (0.988-1.93)
12-hr	0.240 (0.204-0.288)	0.270 (0.230-0.324)	0.323 (0.274-0.389)	0.371 (0.313-0.448)	0.443 (0.365-0.552)	0.503 (0.404-0.631)	0.566 (0.440-0.723)	0.634 (0.474-0.826)	0.731 (0.526-0.970)	0.808 (0.565-1.08)
24-hr	0.143 (0.123-0.169)	0.162 (0.139-0.192)	0.195 (0.167-0.231)	0.224 (0.191-0.266)	0.265 (0.220-0.324)	0.299 (0.242-0.369)	0.333 (0.262-0.419)	0.370 (0.279-0.474)	0.420 (0.305-0.549)	0.459 (0.325-0.606)
2-day	0.082 (0.071-0.095)	0.094 (0.082-0.110)	0.115 (0.100-0.134)	0.132 (0.114-0.155)	0.157 (0.131-0.189)	0.176 (0.144-0.214)	0.196 (0.155-0.243)	0.216 (0.165-0.273)	0.244 (0.179-0.314)	0.265 (0.190-0.345)
3-day	0.060 (0.053-0.070)	0.068 (0.060-0.079)	0.082 (0.072-0.096)	0.094 (0.082-0.110)	0.112 (0.094-0.134)	0.126 (0.104-0.152)	0.140 (0.112-0.172)	0.155 (0.119-0.195)	0.175 (0.130-0.225)	0.191 (0.139-0.248)
4-day	0.049 (0.043-0.056)	0.055 (0.048-0.063)	0.065 (0.057-0.075)	0.075 (0.065-0.086)	0.088 (0.075-0.105)	0.099 (0.083-0.120)	0.111 (0.089-0.136)	0.123 (0.096-0.155)	0.141 (0.105-0.180)	0.154 (0.112-0.199)
7-day	0.033 (0.029-0.037)	0.037 (0.032-0.042)	0.043 (0.038-0.050)	0.050 (0.044-0.057)	0.059 (0.051-0.070)	0.066 (0.056-0.079)	0.075 (0.061-0.091)	0.083 (0.065-0.103)	0.095 (0.072-0.121)	0.105 (0.077-0.134)
10-day	0.026 (0.023-0.029)	0.029 (0.026-0.033)	0.034 (0.030-0.039)	0.039 (0.035-0.044)	0.046 (0.040-0.054)	0.052 (0.044-0.062)	0.058 (0.048-0.070)	0.065 (0.051-0.080)	0.074 (0.057-0.094)	0.082 (0.061-0.104)
20-day	0.017 (0.016-0.019)	0.019 (0.017-0.021)	0.022 (0.020-0.025)	0.025 (0.022-0.028)	0.029 (0.025-0.033)	0.032 (0.028-0.038)	0.036 (0.029-0.042)	0.039 (0.031-0.047)	0.044 (0.034-0.055)	0.048 (0.036-0.060)
30-day	0.014 (0.013-0.016)	0.016 (0.014-0.017)	0.018 (0.016-0.020)	0.020 (0.018-0.022)	0.023 (0.020-0.026)	0.025 (0.021-0.029)	0.027 (0.023-0.032)	0.030 (0.024-0.036)	0.033 (0.025-0.040)	0.035 (0.027-0.044)
45-day	0.012 (0.011-0.013)	0.013 (0.012-0.014)	0.015 (0.014-0.016)	0.016 (0.015-0.018)	0.018 (0.016-0.021)	0.020 (0.017-0.023)	0.022 (0.018-0.025)	0.023 (0.019-0.027)	0.025 (0.020-0.030)	0.026 (0.020-0.033)
60-day	0.010 (0.010-0.011)	0.011 (0.011-0.012)	0.013 (0.012-0.014)	0.014 (0.013-0.016)	0.016 (0.014-0.018)	0.017 (0.015-0.020)	0.019 (0.016-0.021)	0.020 (0.016-0.023)	0.021 (0.017-0.025)	0.022 (0.017-0.027)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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7.3 TABLE 2 – NOAA POINT PRECIPITATION FREQUENCY ESTIMATES (DEPTH) – NEWNAN, GEORGIA

NOAA Atlas 14, Volume 9, Version 2
Location name: Newnan, Georgia, USA*
Latitude: 33.3748°, Longitude: -84.8005°
Elevation: 990.43 ft**

* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	**2**	**5**	**10**	**25**	**50**	**100**	**200**	**500**	**1000**
5-min	**0.403** (0.327-0.510)	**0.464** (0.376-0.587)	**0.566** (0.457-0.717)	**0.653** (0.525-0.831)	**0.778** (0.607-1.01)	**0.877** (0.669-1.16)	**0.979** (0.723-1.31)	**1.09** (0.770-1.48)	**1.23** (0.842-1.71)	**1.34** (0.896-1.89)
10-min	**0.590** (0.479-0.747)	**0.679** (0.550-0.859)	**0.828** (0.669-1.05)	**0.957** (0.768-1.22)	**1.14** (0.889-1.49)	**1.28** (0.979-1.69)	**1.43** (1.06-1.92)	**1.59** (1.13-2.17)	**1.80** (1.23-2.51)	**1.97** (1.31-2.76)
15-min	**0.720** (0.584-0.910)	**0.828** (0.671-1.05)	**1.01** (0.816-1.28)	**1.17** (0.937-1.48)	**1.39** (1.08-1.81)	**1.57** (1.19-2.06)	**1.75** (1.29-2.34)	**1.94** (1.38-2.65)	**2.20** (1.50-3.06)	**2.40** (1.60-3.37)
30-min	**1.03** (0.840-1.31)	**1.20** (0.968-1.51)	**1.46** (1.18-1.86)	**1.69** (1.36-2.15)	**2.02** (1.57-2.63)	**2.27** (1.73-2.99)	**2.54** (1.87-3.40)	**2.81** (1.99-3.83)	**3.18** (2.17-4.43)	**3.47** (2.31-4.88)
60-min	**1.36** (1.10-1.72)	**1.57** (1.27-1.98)	**1.92** (1.55-2.43)	**2.22** (1.79-2.83)	**2.67** (2.09-3.50)	**3.03** (2.32-4.00)	**3.41** (2.52-4.58)	**3.81** (2.71-5.21)	**4.36** (2.99-6.08)	**4.80** (3.20-6.75)
2-hr	**1.69** (1.38-2.11)	**1.94** (1.59-2.42)	**2.37** (1.94-2.97)	**2.76** (2.24-3.46)	**3.32** (2.63-4.31)	**3.79** (2.93-4.95)	**4.28** (3.21-5.69)	**4.81** (3.46-6.51)	**5.55** (3.84-7.65)	**6.13** (4.13-8.52)
3-hr	**1.91** (1.57-2.36)	**2.18** (1.80-2.70)	**2.66** (2.19-3.30)	**3.09** (2.53-3.86)	**3.75** (2.99-4.83)	**4.29** (3.34-5.57)	**4.87** (3.67-6.43)	**5.49** (3.98-7.40)	**6.38** (4.46-8.75)	**7.09** (4.81-9.78)
6-hr	**2.35** (1.96-2.87)	**2.66** (2.22-3.25)	**3.22** (2.67-3.94)	**3.73** (3.08-4.59)	**4.51** (3.65-5.75)	**5.16** (4.08-6.63)	**5.87** (4.48-7.67)	**6.64** (4.87-8.84)	**7.73** (5.47-10.5)	**8.61** (5.91-11.7)
12-hr	**2.87** (2.42-3.46)	**3.23** (2.73-3.91)	**3.88** (3.26-4.70)	**4.47** (3.74-5.42)	**5.35** (4.37-6.72)	**6.09** (4.86-7.71)	**6.88** (5.31-8.86)	**7.73** (5.74-10.2)	**8.94** (6.39-12.0)	**9.91** (6.88-13.4)
24-hr	**3.39** (2.89-4.03)	**3.86** (3.29-4.59)	**4.66** (3.97-5.56)	**5.37** (4.54-6.43)	**6.40** (5.27-7.90)	**7.23** (5.82-9.01)	**8.11** (6.32-10.3)	**9.04** (6.77-11.7)	**10.3** (7.46-13.6)	**11.3** (7.98-15.1)
2-day	**3.89** (3.36-4.56)	**4.48** (3.87-5.26)	**5.49** (4.72-6.46)	**6.35** (5.43-7.50)	**7.58** (6.30-9.20)	**8.56** (6.96-10.5)	**9.57** (7.54-12.0)	**10.6** (8.05-13.5)	**12.1** (8.81-15.7)	**13.2** (9.39-17.4)
3-day	**4.29** (3.73-4.99)	**4.88** (4.24-5.68)	**5.90** (5.11-6.89)	**6.79** (5.85-7.96)	**8.09** (6.80-9.78)	**9.15** (7.51-11.2)	**10.3** (8.15-12.7)	**11.4** (8.74-14.5)	**13.1** (9.62-16.9)	**14.4** (10.3-18.7)
4-day	**4.63** (4.05-5.35)	**5.21** (4.55-6.04)	**6.25** (5.44-7.25)	**7.17** (6.21-8.35)	**8.54** (7.22-10.3)	**9.67** (7.99-11.8)	**10.9** (8.69-13.5)	**12.2** (9.35-15.4)	**14.0** (10.4-18.0)	**15.4** (11.1-20.0)
7-day	**5.44** (4.80-6.22)	**6.10** (5.38-6.99)	**7.28** (6.40-8.35)	**8.36** (7.31-9.62)	**9.97** (8.53-11.9)	**11.3** (9.46-13.6)	**12.8** (10.3-15.7)	**14.3** (11.2-18.0)	**16.6** (12.4-21.2)	**18.4** (13.4-23.6)
10-day	**6.15** (5.46-6.98)	**6.88** (6.11-7.82)	**8.18** (7.24-9.32)	**9.37** (8.24-10.7)	**11.1** (9.59-13.2)	**12.6** (10.6-15.1)	**14.2** (11.6-17.3)	**15.9** (12.5-19.8)	**18.4** (13.9-23.3)	**20.3** (14.9-26.0)
20-day	**8.27** (7.44-9.26)	**9.14** (8.21-10.2)	**10.6** (9.52-11.9)	**12.0** (10.7-13.5)	**13.9** (12.1-16.2)	**15.5** (13.2-18.2)	**17.2** (14.1-20.6)	**19.0** (15.0-23.3)	**21.5** (16.4-26.9)	**23.5** (17.5-29.7)
30-day	**10.2** (9.21-11.3)	**11.2** (10.1-12.4)	**12.9** (11.6-14.3)	**14.3** (12.8-16.0)	**16.4** (14.3-18.8)	**18.0** (15.4-20.9)	**19.7** (16.3-23.3)	**21.4** (17.1-26.0)	**23.8** (18.3-29.5)	**25.7** (19.2-32.2)
45-day	**12.7** (11.6-14.0)	**13.9** (12.7-15.4)	**16.0** (14.5-17.6)	**17.6** (15.9-19.5)	**19.9** (17.4-22.5)	**21.6** (18.5-24.7)	**23.3** (19.4-27.2)	**25.0** (20.0-29.9)	**27.2** (21.0-33.3)	**28.8** (21.7-35.9)
60-day	**14.9** (13.7-16.3)	**16.5** (15.1-18.0)	**18.9** (17.2-20.7)	**20.7** (18.9-22.8)	**23.2** (20.4-26.0)	**25.0** (21.6-28.4)	**26.8** (22.3-31.0)	**28.4** (22.8-33.7)	**30.5** (23.6-37.0)	**31.9** (24.2-39.5)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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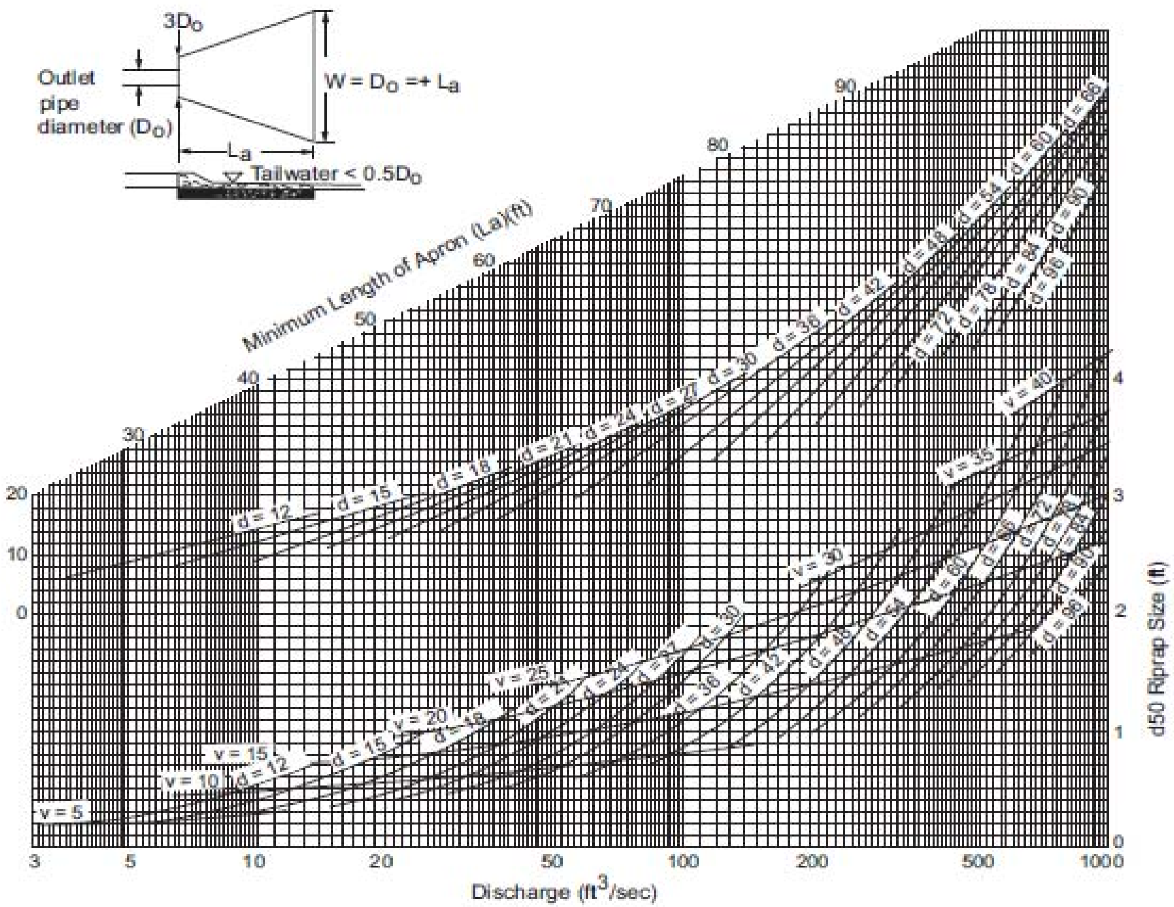
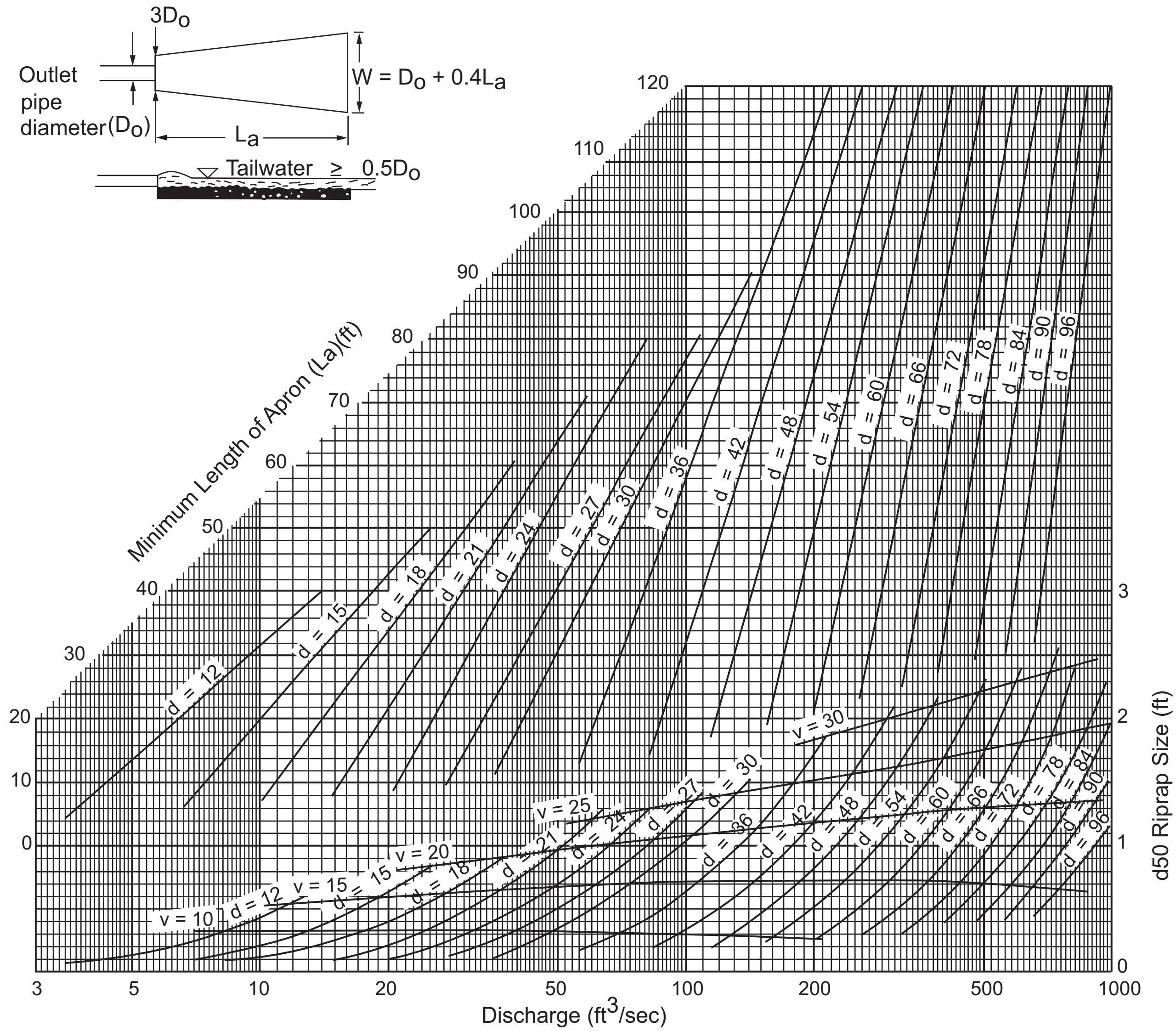
7.4 DESIGN OF OUTLET PROTECTION FROM A ROUND PIPE FLOWING FULL, MINIMUM TAILWATER CONDITION



Curves may not be extrapolated.

Figure 6-34.1 - Design of Outlet Protection From a Round Pipe Flowing Full, Minimum Tailwater Condition (Tw < 0.5 Diameter)

7.5 DESIGN OF OUTLET PROTECTION FROM A ROUND PIPE FLOWING FULL, MAXIMUM TAILWATER CONDITION



Curves may not be extrapolated.

Figure 6-34.2 - Design of Outlet Protection From a Round Pipe Flowing Full, Maximum Tailwater Condition (Tw > 0.5 Diameter)

7.6 PLANT YATES – AMA FIELD AND LABORATORY INVESTIGATIONS – STABILITY

Summary of Groundwater Elevations
Plant Yates
Ash Ponds 3, A, B/B`
October 2017 Sampling Event

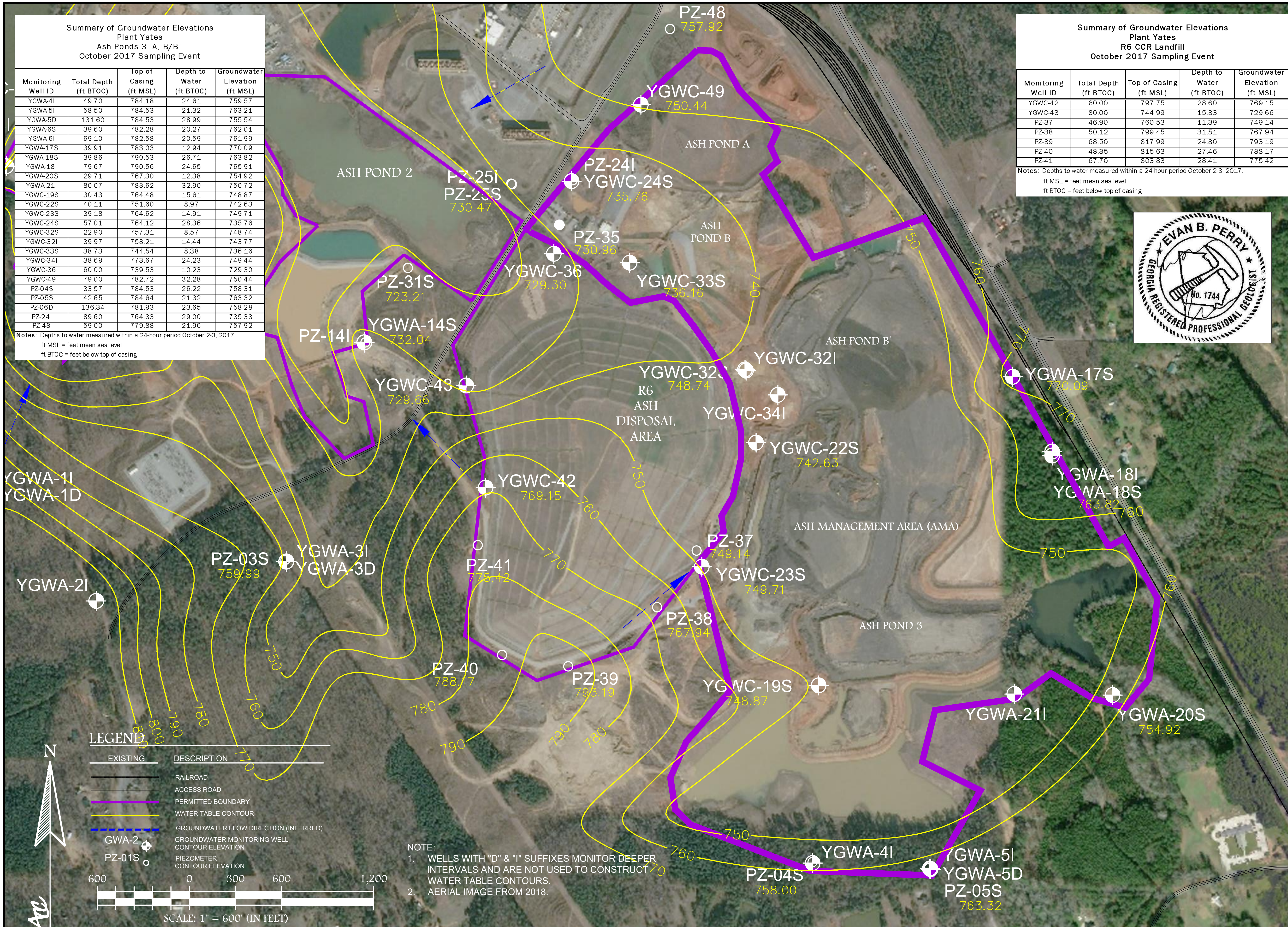
Monitoring Well ID	Total Depth (ft BTOC)	Top of Casing (ft MSL)	Depth to Water (ft BTOC)	Groundwater Elevation (ft MSL)
YGWA-4I	49.70	784.18	24.61	759.57
YGWA-5I	58.50	784.53	21.32	763.21
YGWA-5D	131.60	784.53	28.99	755.54
YGWA-6S	39.60	782.28	20.27	762.01
YGWA-6I	69.10	782.58	20.59	761.99
YGWA-17S	39.91	783.03	12.94	770.09
YGWA-18S	39.86	790.53	26.71	763.82
YGWA-18I	79.67	790.56	24.65	765.91
YGWA-20S	29.71	767.30	12.38	754.92
YGWA-21I	80.07	783.62	32.90	750.72
YGWC-19S	30.43	764.48	15.61	748.87
YGWC-22S	40.11	751.60	8.97	742.63
YGWC-23S	39.18	764.62	14.91	749.71
YGWC-24S	57.01	764.12	28.36	735.76
YGWC-32S	22.90	757.31	8.57	748.74
YGWC-32I	39.97	758.21	14.44	743.77
YGWC-33S	38.73	744.54	8.38	736.16
YGWC-34I	38.69	773.67	24.23	749.44
YGWC-36	60.00	739.53	10.23	729.30
YGWC-49	79.00	782.72	32.28	750.44
PZ-04S	33.57	784.53	26.22	758.31
PZ-05S	42.65	784.64	21.32	763.32
PZ-06D	136.34	781.93	23.65	758.28
PZ-24I	89.60	764.33	29.00	735.33
PZ-48	59.00	779.88	21.96	757.92

Notes: Depths to water measured within a 24-hour period October 2-3, 2017.
ft MSL = feet mean sea level
ft BTOC = feet below top of casing

Summary of Groundwater Elevations
Plant Yates
R6 CCR Landfill
October 2017 Sampling Event

Monitoring Well ID	Total Depth (ft BTOC)	Top of Casing (ft MSL)	Depth to Water (ft BTOC)	Groundwater Elevation (ft MSL)
YGWC-42	60.00	797.75	28.60	769.15
YGWC-43	80.00	744.99	15.33	729.66
PZ-37	46.90	760.53	11.39	749.14
PZ-38	50.12	799.45	31.51	767.94
PZ-39	68.50	817.99	24.80	793.19
PZ-40	48.35	815.63	27.46	788.17
PZ-41	67.70	803.83	28.41	775.42

Notes: Depths to water measured within a 24-hour period October 2-3, 2017.
ft MSL = feet mean sea level
ft BTOC = feet below top of casing



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PROJECT:

PLANT YATES

708 DYER ROAD
NEWNAN, GEORGIA

REVISIONS

Drawn by: MM | Checked by: EP

PROJECT NUMBER:
I054-110
March 2020

OCTOBER 2017 WATER TABLE CONTOUR MAP

FIGURE 9

TABLE 1
YATES R6-AMA
BORING LITHOLOGY LOG SUMMARY

Boring/Well No.	Total Boring (ft. bgs)	UR Depth Interval (ft. bgs)	UR Lithology - USCS	LR Depth Interval (ft. bgs)	LR Lithology - USCS	Saprolite Depth (ft. bgs)	Saprolite Lithology -	DEPTH TO BEDROCK (ft. bgs)
YGWA-4I	46.5	0-3	ML	3-15	SM	15-31	SM	31
YGWA-51	56.5	0-5	SM	5-10	SM-SP	10-40	SP	40
YGWA-6S	37.2	0-10	SM	10-15	SM	15 - 37	SM	37
YGWA-18I	77	0-5	SC	5-17	SM	17-50	SC-SM	50
YGWA-20S	27	0-17	SC-SM	17-23	SM	23-27	SC-SM	n/a
YGWA-21I	77	0-4	SC-SM	4-17	SP-SM	17-38	SP-SM-SW	38
YGWC-23S	36	0-6	SC	6-23	SM	23 - 36	SC-SM	n/a
YGWC-24S	54	0-11	SC	11-27	SM	27 - 54	SC-SM	n/a
YGWC-33S	40	0-15	ML	15-30	SC-SM	30 - 40	SC-SM	n/a
PZ-35	47	0-14	SM-CH	14-30	SP-SM	30 - 47	SM	n/a
YGWC-36	57	0-10	SM	10-18	SM	18 - 57	SM	57
PZ-37	47	0-3	CL-ML	3-5	SM	5-37	SM-PWR	37
YGWC-38	67	0-1	SM	1-27	SM	27-37	SM	37
YGWA-39	66	0-7	SP-SM	7-21	SM	21-33	SP-SM	33
YGWA-40	46	0-6	SM	6-17	SM	17-36	SM-SP	36
YGWC-41	64.5	0-4	ML	4-24	SM	24-39	SM-SP	39
YGWC-42	57	0-3	SM	3-19	SM	19-30	SM-SP	30
YGWC-43	77	0-5	SM	5-14	SM	14-28	SM-SP	28
YGWC-48	56	0-5	SM	5-16	SC-ML	16-36	SM-SP	36
YGWC-49	76	0-5	SM	5-16	SM	16-54	SP	54

Note: UR - upper residuum, LR - lower residuum,
NOTE: ML - sandy SILT, SM-silty SAND, SP - well sorted SAND, no fines, CL- silty CLAY, CH - CLAY
K values for Upper & Lower Residuum in Piedmont are typically 0.5 - 1 ft/day (10E-04 cm/sec)
K values for Saprolite are typically around 5- 10 ft/day (10E-03 cm/sec)

Table 2
Plant Yates - AMA
Laboratory Soil Testing Summary

						Sieve Analysis					Atterberg				Classification		Triaxial (CU)								Permeability				
Sample ID	from Depth (ft. bgs)	to Depth (ft. bgs)	Material Type	Lab Sample ID	Recovery (in.)	% Gravel	% Sand	% Fines	Moisture Content (%)	Specific Gravity	LL	PL	PI	LI	USCS Symbol	Description	Initial Moisture Content (%)	Initial Dry Density (pcf)	Confining Pressure (psi)	Max Deviator Stress (psi)	Total Friction Angle (ϕ)	Total Coeffient of Friction (psi)	Effective Friction Angle (ϕ)	Effective Coefficient of Friction (psi)	Unit Weight (pcf)	Dry Unit Weight (pcf)	Confining Pressure (psi)	Hydraulic Conductivity (cm/s)	Consolidation
Ash #1			CCR	33248		2	55	53	27	2.553	30	23	7	0.57	ML	Dark Gray Sandy Silt	17.63	100.3	10.0 20.0 40.0	19.7 22.6 35.0	11.7	5.5	33.9	0.2	124.4	101.9	-	-	x
Ash #2			CCR	33249		2	56	42	29	2.639	29	24	5	1.03	SM	Gray and Yellowish Brown Silty Sand	17.61	100.9	10.0 20.0 40.0	22.5 29.0 44.3	15.8	5.4	33.8	0.6	126	102.4	-	-	
Borrow Soil # 1			Structural Fill	33250		5	41	54	29	2.677	39	29	10	0.01	ML	Gray, Yellow and Red Sandy Silt	20.32	99.0	10.0 20.0 40.0	21.0 28.7 44.5	16.3	4.9	31.8	1.2	125	99.8	-	-	
Borrow Soil # 2			Structural Fill	33251		5	49	45	19	2.675	39	28	11	-0.8	SM	Yellowish Brown Silty Sand	18.87	108.3	10.0 20.0 40.0	22.2 29.4 46.8	17.7	4.7	32.2	1.8	129	106.4	-	-	
Borrow Soil # 3			Structural Fill	33252		12	53	36	20	2.680	33	26	7	-0.9	SM	Yellowish Brown and Dark Gray Silty Sand	18.66	106.4	10.0 20.0 40.0	24.6 37.9 56.8	20.0	5.5	33.6	1.7	128.7	105.7	-	-	
Borrow Soil # 4			Structural Fill	33253		1	60	38	20	2.665	35	27	8	-0.8	SM	Brownish Yellow Silty Sand	16.35	109.2	10.0 20.0 40.0	25.4 40.9 62.8	22.4	4.7	36.0	0.4	130.8	109.5	-	-	
YGWA-39-10-12	10	12	Residuum	33611		0	73	27.5	12	2.698	NP	NP	NP	-	SM	Olive Gray Silty Sand	12.41	97.9	10.0 20.0 40.0	21.1 38.7 73.1	27.5	1.2	35.3	2.0	126.3	101.5	-	-	x
YGWA-18I-12-14	12	14	Residuum	33612		0	77	23.4	25	2.7*	NP	NP	NP	-	SM	Olive Gray Silty Sand	24.64	86.1	10.0 20.0 40.0	28.2 42.7 60.3	20.2	6.6	35.8	2.8	120.3	91.9	-	-	
YGWA-18I-28-30	28	30	Residuum/ Saprolite	33613		0.1	76	24	24	2.7*	NP	NP	NP	-	SM	Olive Gray Silty Sand	23.93	101.2	10.0 20.0 40.0	27.7 55.2 111.8	35.7	0.1	43.2	0.4	128.9	105.6	-	-	
YGWA-20S-18-20	18	20	Residuum/ Saprolite	33614		0	67	33.2	22	2.7*	NP	NP	NP	-	SM	Olive Gray Silty Sand	22.02	101.6	10.0 20.0 40.0	23.3 47.4 80.8	29.4	1.3	42.1	0.5	130.2	107.6	-	-	

TIMELY **E**NGINEERING **S**OIL **T**ESTS, LLC

1874 Forge Street Tucker, GA 30084
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Tested By	EB/KP
Date	03/03/20
Checked By	[signature]

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33248/Ash #1	Depth/Elevation	-
Location	Yates	Additional Info	-

SPECIMEN PROPERTIES

		(initial)	(after consol.)
Height, in		6.000	5.977
Diameter, in		2.875	2.857
Height-to-Diameter Ratio		2.1	2.1
Area, in^2		6.49	6.41
Volume, cm^3		638.29	627.93
Mass of Wet Sample, g		1206.00	1251.70
Mass of Dry Sample, g		1025.26	1025.42
Wet Density, pcf		118.0	124.4
Dry Density, pcf		100.3	101.9
Specific Gravity	(assumed)	2.553	2.553
Volume of Solids, cm^3		401.59	401.65
Volume of Voids, cm^3		236.70	226.28
Void Ratio		0.59	0.56
% Saturation		76.4	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	401.20	1553.80
Mass of Dry Sample and Tare, g	356.30	1327.56
Mass of Tare, g	101.60	302.30
Moisture, %	17.63	22.07

TEST DATA PRIOR TO LOADING

Machine Speed, in / min	0.0100
Strain Rate, % / min	0.17
Chamber Pressure, psi	80.0
Back Pressure,psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	10.0
Change in Height, in	0.023
"B" Value	0.95

SHEAR DATA

Elapsed Time (min)	Deformation (inch)	Axial Load (lb)	Pore-Water Pressure,psi		Total Strain (%)	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$)	Major Principal Stress,psi		Eff.Stress Ratio	P' $(s'_1+s'_3)/2$ (psi)	Q $[(s_1-s_3)/2]$ (psi)	Eff. Minor Pr. Stress
			Total,U	Change,DU			(psi)	Total s_1	Eff. s'_1	s'_1/s'_3			s'_3 (psi)
0.0	0.000	17.8	70.0	0.0	0.00	6.41	0.0	10.0	10.0	1.00	10.0	0.0	10.0
1.1	0.011	63.1	71.8	1.8	0.18	6.42	7.1	17.1	15.2	1.86	11.7	3.5	8.2
2.1	0.021	83.2	72.6	2.6	0.35	6.43	10.2	20.2	17.5	2.38	12.4	5.1	7.4
3.1	0.031	98.1	72.9	2.9	0.52	6.44	12.5	22.5	19.5	2.76	13.3	6.2	7.1
4.1	0.041	110.9	73.0	3.0	0.69	6.46	14.4	24.4	21.5	3.05	14.2	7.2	7.0
5.1	0.051	120.4	72.9	2.9	0.86	6.47	15.9	25.9	23.0	3.24	15.0	7.9	7.1
7.2	0.072	133.6	72.7	2.7	1.20	6.49	17.8	27.8	25.2	3.43	16.3	8.9	7.3
10.2	0.102	143.7	72.3	2.3	1.71	6.52	19.3	29.3	27.0	3.50	17.4	9.6	7.7
12.3	0.123	146.6	72.1	2.1	2.05	6.55	19.7	29.7	27.6	3.50	17.7	9.8	7.9
15.3	0.153	149.2	72.0	2.0	2.56	6.58	20.0	30.0	28.0	3.49	18.0	10.0	8.0
17.4	0.174	149.8	71.9	1.9	2.91	6.60	20.0	30.0	28.1	3.47	18.1	10.0	8.1
20.4	0.204	150.2	71.9	1.9	3.42	6.64	19.9	29.9	28.1	3.45	18.1	10.0	8.1
24.5	0.245	150.8	71.9	1.9	4.10	6.69	19.9	29.9	28.0	3.45	18.1	9.9	8.1
29.6	0.296	151.6	71.9	1.9	4.95	6.75	19.8	29.8	27.9	3.45	18.0	9.9	8.1
35.7	0.357	152.5	71.9	1.9	5.97	6.82	19.8	29.8	27.8	3.45	17.9	9.9	8.1
40.8	0.408	153.8	72.1	2.1	6.83	6.88	19.8	29.8	27.7	3.50	17.8	9.9	7.9
45.9	0.459	154.9	72.2	2.2	7.68	6.94	19.7	29.7	27.6	3.52	17.7	9.9	7.8
50.0	0.500	155.9	72.1	2.1	8.36	7.00	19.7	29.7	27.6	3.51	17.7	9.9	7.9
60.2	0.602	158.7	72.1	2.1	10.07	7.13	19.8	29.8	27.7	3.50	17.8	9.9	7.9
70.4	0.704	161.7	72.0	2.0	11.77	7.27	19.8	29.8	27.8	3.48	17.9	9.9	8.0
80.6	0.806	165.4	71.9	1.9	13.48	7.41	19.9	29.9	28.0	3.46	18.1	10.0	8.1
85.6	0.856	166.9	71.8	1.8	14.33	7.48	19.9	29.9	28.1	3.43	18.2	10.0	8.2
90.0	0.900	168.5	71.8	1.8	15.06	7.55	20.0	30.0	28.2	3.43	18.2	10.0	8.2
Values @ Failure				2.2	7.68	6.94	19.7	29.7	27.6	3.52	17.7	9.9	7.8

Failure criteria used*: 3

*Note:"1"=Max Deviator Stress;"2"=Deviator Stress @ 15% Strain;"3"=Max Eff.Stress Ratio(s'_1/s'_3)

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Tested By	EB/KP
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ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33248/Ash #1	Depth/Elevation	-
Location	Yates	Additional Info	-

SPECIMEN PROPERTIES

	(initial)	(after consol.)
Height, in	6.000	5.975
Diameter, in	2.875	2.854
Height-to-Diameter Ratio	2.1	2.1
Area, in^2	6.49	6.40
Volume, cm^3	638.29	626.22
Mass of Wet Sample, g	1206.50	1250.20
Mass of Dry Sample, g	1025.69	1025.77
Wet Density, pcf	118.0	124.6
Dry Density, pcf	100.3	102.3
Specific Gravity (assumed)	2.553	2.553
Volume of Solids, cm^3	401.76	401.79
Volume of Voids, cm^3	236.53	224.43
Void Ratio	0.59	0.56
% Saturation	76.4	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	401.20	1512.10
Mass of Dry Sample and Tare, g	356.30	1287.69
Mass of Tare, g	101.60	262.00
Moisture, %	17.63	21.88

TEST DATA PRIOR TO LOADING

Machine Speed, in / min	0.0100
Strain Rate, % / min	0.17
Chamber Pressure, psi	90.0
Back Pressure,psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	20.0
Change in Height, in	0.025
"B" Value	0.95

SHEAR DATA

Elapsed Time (min)	Deformation (inch)	Axial Load (lb)	Pore-Water Pressure,psi Total,U	Pore-Water Pressure,psi Change,DU	Total Strain (%)	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$) (psi)	Major Principal Stress,psi Total s_1	Major Principal Stress,psi Eff. s'_1	Eff.Stress Ratio s'_1/s'_3	P' $(s'_1+s'_3)/2$ (psi)	Q $[(s_1-s_3)/2]$ (psi)	Eff. Minor Pr. Stress s'_3 (psi)
0.0	0.000	23.1	70.0	0.0	0.00	6.40	0.0	20.0	20.0	1.00	20.0	0.0	20.0
1.0	0.010	77.2	74.7	4.7	0.17	6.41	8.5	28.5	23.8	1.55	19.5	4.2	15.3
2.0	0.020	97.1	76.9	6.9	0.34	6.42	11.5	31.5	24.7	1.88	18.9	5.8	13.1
3.1	0.031	109.3	78.1	8.1	0.51	6.43	13.4	33.4	25.3	2.13	18.6	6.7	11.9
4.1	0.041	119.0	79.0	9.0	0.68	6.44	14.9	34.9	25.9	2.35	18.5	7.4	11.0
5.1	0.051	126.6	79.6	9.6	0.85	6.45	16.0	36.0	26.5	2.54	18.4	8.0	10.4
7.1	0.071	137.9	80.2	10.2	1.19	6.47	17.7	37.7	27.5	2.81	18.7	8.9	9.8
10.2	0.102	149.2	80.7	10.7	1.71	6.51	19.4	39.4	28.7	3.08	19.0	9.7	9.3
12.2	0.122	154.2	80.8	10.8	2.05	6.53	20.1	40.1	29.3	3.19	19.2	10.0	9.2
15.3	0.153	159.3	81.0	11.0	2.56	6.56	20.8	40.8	29.8	3.30	19.4	10.4	9.0
17.3	0.173	161.6	81.0	11.0	2.90	6.59	21.0	41.0	30.0	3.34	19.5	10.5	9.0
20.4	0.204	164.7	81.0	11.0	3.41	6.62	21.4	41.4	30.3	3.39	19.6	10.7	9.0
24.5	0.245	167.0	81.0	11.0	4.09	6.67	21.6	41.6	30.5	3.41	19.7	10.8	9.0
29.6	0.296	169.8	81.1	11.1	4.95	6.73	21.8	41.8	30.7	3.45	19.8	10.9	8.9
35.7	0.357	172.1	81.3	11.3	5.97	6.80	21.9	41.9	30.6	3.51	19.7	11.0	8.7
40.8	0.408	174.2	81.4	11.4	6.82	6.86	22.0	42.0	30.6	3.56	19.6	11.0	8.6
45.9	0.459	176.3	81.4	11.4	7.68	6.93	22.1	42.1	30.7	3.56	19.7	11.1	8.6
49.9	0.499	177.8	81.4	11.4	8.36	6.98	22.2	42.2	30.8	3.57	19.7	11.1	8.6
60.1	0.601	181.6	81.3	11.3	10.06	7.11	22.3	42.3	31.0	3.55	19.9	11.1	8.7
70.3	0.703	185.6	81.3	11.3	11.77	7.25	22.4	42.4	31.1	3.59	19.9	11.2	8.7
80.5	0.805	190.4	81.3	11.3	13.47	7.39	22.6	42.6	31.3	3.61	20.0	11.3	8.7
85.6	0.856	191.9	81.3	11.3	14.33	7.47	22.6	42.6	31.4	3.58	20.1	11.3	8.8
90.0	0.900	193.7	81.2	11.2	15.06	7.53	22.7	42.7	31.5	3.57	20.2	11.3	8.8
Values @ Failure				11.3	13.47	7.39	22.6	42.6	31.3	3.61	20.0	11.3	8.7
Failure criteria used*			3										

*Note:"1"=Max Deviator Stress;"2"=Deviator Stress @ 15% Strain;"3"=Max Eff.Stress Ratio(s'_1/s'_3)

TIMELY **E**NGINEERING **S**OIL **T**ESTS, LLC	1874 Forge Street Tucker, GA 30084 Phone: 770-938-8233 Fax: 770-923-8973 Web: www.test-llc.com	Tested By: EB/KP Date: 03/03/20 Checked By:

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33248/Ash #1	Depth/Elevation	-
Location	Yates	Additional Info	-

SPECIMEN PROPERTIES

	(initial)	(after consol.)
Height, in	6.000	5.941
Diameter, in	2.875	2.843
Height-to-Diameter Ratio	2.1	2.1
Area, in^2	6.49	6.35
Volume, cm^3	638.29	618.22
Mass of Wet Sample, g	1206.60	1242.20
Mass of Dry Sample, g	1025.77	1025.77
Wet Density, pcf	118.0	125.4
Dry Density, pcf	100.3	103.6
Specific Gravity (assumed)	2.553	2.553
Volume of Solids, cm^3	401.79	401.79
Volume of Voids, cm^3	236.50	216.43
Void Ratio	0.59	0.54
% Saturation	76.5	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	401.20	1578.60
Mass of Dry Sample and Tare, g	356.30	1362.17
Mass of Tare, g	101.60	336.40
Moisture, %	17.63	21.10

TEST DATA PRIOR TO LOADING

Machine Speed, in / min	0.0100
Strain Rate, % / min	0.17
Chamber Pressure, psi	110.0
Back Pressure,psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	40.0
Change in Height, in	0.059
"B" Value	0.95

SHEAR DATA

Elapsed Time (min)	Deformation (inch)	Axial Load (lb)	Pore-Water Pressure,psi		Total Strain (%)	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$)	Major Principal Stress,psi		Eff.Stress Ratio	P' $(s'_1+s'_3)/2$ (psi)	Q $[(s_1-s_3)/2]$ (psi)	Eff. Minor Pr. Stress
			Total,U	Change,DU			(psi)	Total s_1	Eff. s'_1	s'_1/s'_3			s'_3 (psi)
0.0	0.000	24.6	70.0	0.0	0.00	6.35	0.0	40.0	40.0	1.00	40.0	0.0	40.0
1.0	0.010	131.1	76.6	6.6	0.17	6.36	16.7	56.7	50.1	1.50	41.8	8.4	33.4
2.0	0.020	169.3	80.9	10.9	0.34	6.37	22.7	62.7	51.8	1.78	40.4	11.4	29.1
3.1	0.031	191.8	84.0	14.0	0.51	6.38	26.2	66.2	52.2	2.01	39.1	13.1	26.0
4.1	0.041	207.7	86.3	16.3	0.69	6.39	28.6	68.6	52.4	2.21	38.0	14.3	23.7
5.1	0.051	218.5	88.0	18.0	0.86	6.41	30.3	70.3	52.3	2.38	37.1	15.1	22.0
7.1	0.071	232.1	90.6	20.6	1.20	6.43	32.3	72.3	51.7	2.66	35.6	16.1	19.4
10.2	0.102	242.7	92.7	22.7	1.72	6.46	33.8	73.8	51.0	2.95	34.2	16.9	17.3
12.2	0.122	247.3	93.5	23.5	2.06	6.48	34.3	74.3	50.8	3.09	33.6	17.2	16.5
15.3	0.153	252.3	94.3	24.3	2.57	6.52	34.9	74.9	50.6	3.22	33.2	17.5	15.7
17.3	0.173	254.8	94.6	24.6	2.92	6.54	35.2	75.2	50.6	3.28	33.0	17.6	15.4
20.4	0.204	257.3	94.9	24.9	3.43	6.58	35.4	75.4	50.5	3.34	32.8	17.7	15.1
24.5	0.245	258.5	95.1	25.1	4.12	6.62	35.3	75.3	50.2	3.37	32.6	17.7	14.9
29.6	0.296	259.8	95.7	25.7	4.97	6.68	35.2	75.2	49.5	3.47	31.9	17.6	14.3
35.7	0.357	261.5	96.0	26.0	6.00	6.76	35.1	75.1	49.1	3.50	31.6	17.5	14.0
40.8	0.408	263.1	96.0	26.0	6.86	6.82	35.0	75.0	49.0	3.49	31.5	17.5	14.0
45.9	0.459	265.2	95.9	25.9	7.72	6.88	35.0	75.0	49.0	3.49	31.5	17.5	14.1
49.9	0.499	266.9	95.9	25.9	8.41	6.93	34.9	74.9	49.0	3.48	31.5	17.5	14.1
60.1	0.601	271.3	95.8	25.8	10.12	7.07	34.9	74.9	49.1	3.46	31.6	17.5	14.2
70.3	0.703	276.7	96.2	26.2	11.84	7.20	35.0	75.0	48.8	3.54	31.3	17.5	13.8
80.5	0.805	282.0	96.0	26.0	13.55	7.35	35.0	75.0	49.1	3.50	31.5	17.5	14.0
85.6	0.856	284.6	95.9	25.9	14.41	7.42	35.0	75.0	49.2	3.48	31.7	17.5	14.1
90.0	0.900	286.7	95.8	25.8	15.15	7.48	35.0	75.0	49.3	3.46	31.7	17.5	14.2
Values @ Failure				26.2	11.84	7.20	35.0	75.0	48.8	3.54	31.3	17.5	13.8
Failure criteria used*			3										

*Note:"1"=Max Deviator Stress;"2"=Deviator Stress @ 15% Strain;"3"=Max Eff.Stress Ratio(s'_1/s'_3)

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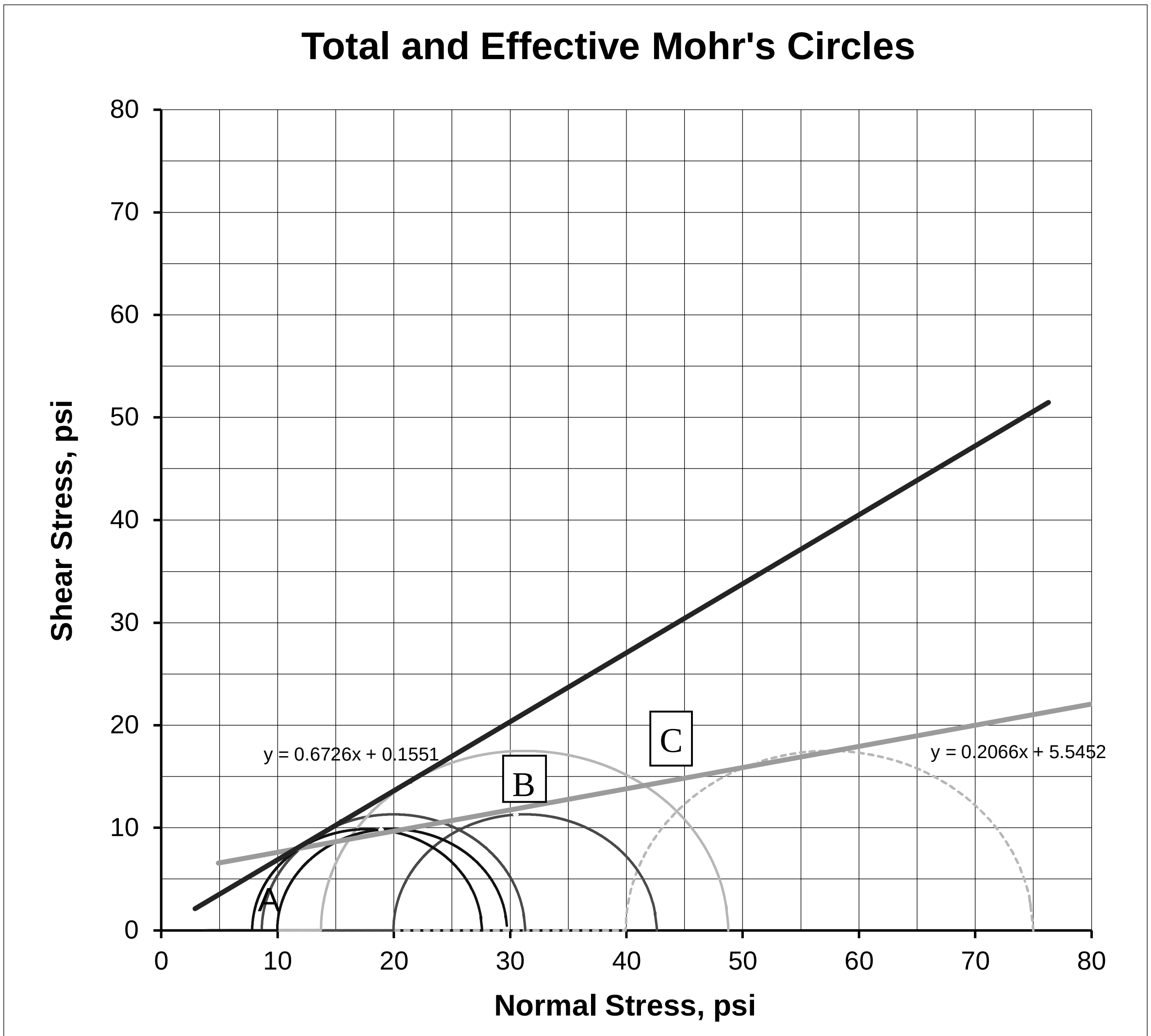
Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Project #	I054-107	Laboratory Project #	2008-08-1
Project Name	AMA	Sample Type	Remold
Sample ID	33248/Ash #1	Depth/Elevation	-
Location	Yates	Additional Info	-



Specimen	A	B	C
Effective Consolidation Stress, psi	10.0	20.0	40.0
Deviator Stress at Failure, psi	19.7	22.6	35.0
Effective Minor Principal Stress at Failure, psi	7.8	8.7	13.8
Effective Major Principal Stress at Failure, psi	27.6	31.3	48.8
Axial Strain at Failure, %	7.68	13.47	11.84

STRENGTH PARAMETERS*			
Total		Effective	
f °	11.7	f ' °	33.9
C, psi	5.5	C', psi	0.2

***Valid only for Received Material at Reported Densities and Moisture Contents. Please see remarks on page 6 of this report**

Triaxial CU.xls [Mohr's Circles], REV. 1; 10-10-05

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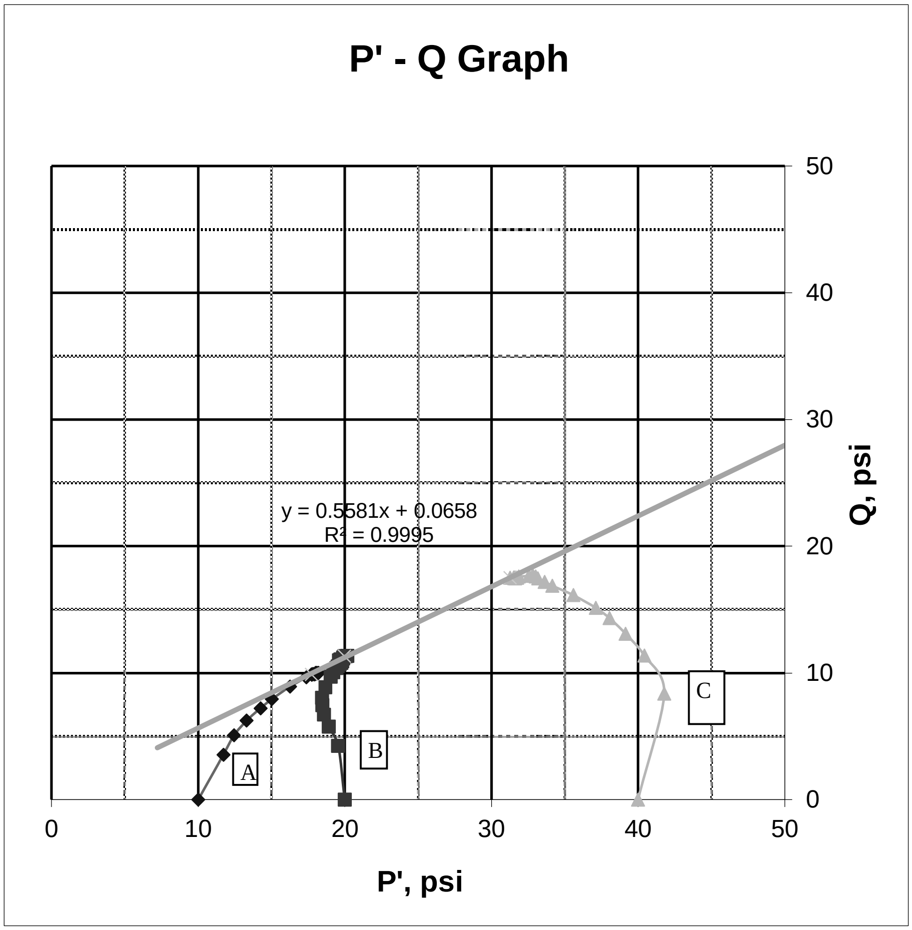
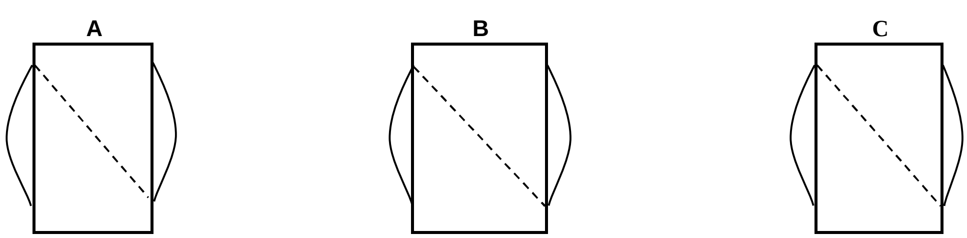
Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33248/Ash #1	Depth/Elevation	-
Location	Yates	Additional Info	-



a, psi	**0.1**
a, degree	**29.2**

FAILURE SKETCH



REMOLDING PROPERTIES

	A	B	C
% Compaction of Max Dry Density	95.0	95.0	95.0
% Difference from Optimum M.C.	2.1	2.1	2.1

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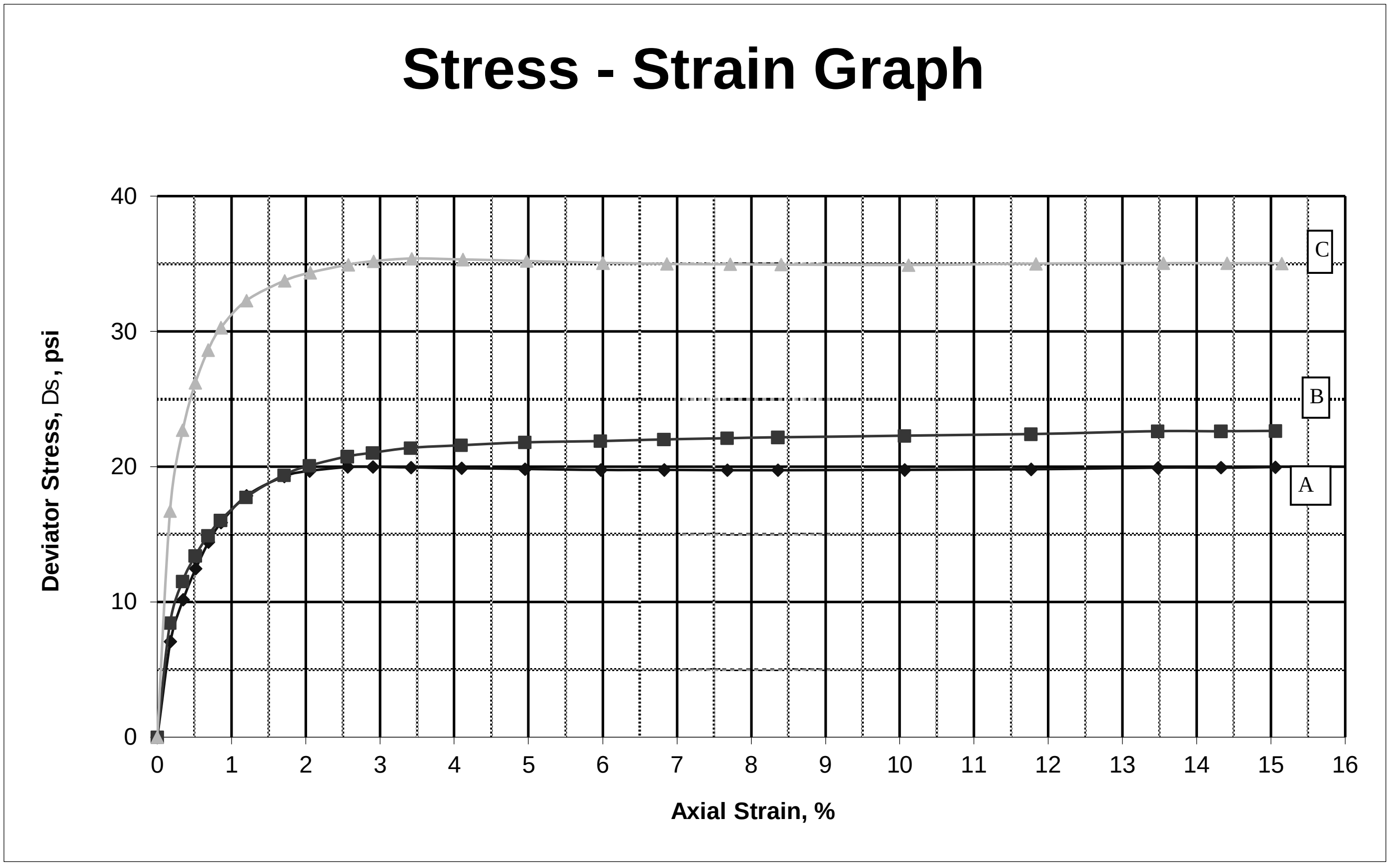
ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33248/Ash #1	Depth/Elevation	-
Location	Yates	Additional Info	-



Balance ID Number	563/700
Oven ID Number	496/610
Deformation Indicator ID #	178/349/689
Digital Caliper ID #	370/458
Load Cell ID #	347/692/815
Apparatus ID #	293/693/814

REMARKS

Samples (Material passing #4 Sieve) were remolded to specified % compaction and moisture content of Standard Proctor values

DESCRIPTION

Dark Gray Sandy Silt

NOTES:

1. Method for Saturation — WET
2. Method for determination of cross-sectional after consolidation — B
3. Initial specimen moisture content obtained from cuttings
4. Final specimen moisture content obtained from entire sample

LL	-
PL	-
PI	-
Gs	-

USCS (ASTM D2487: D2488): ML

Triaxial CU.xls [Stress-Strain GRAPH], REV. 1; 10-10-05

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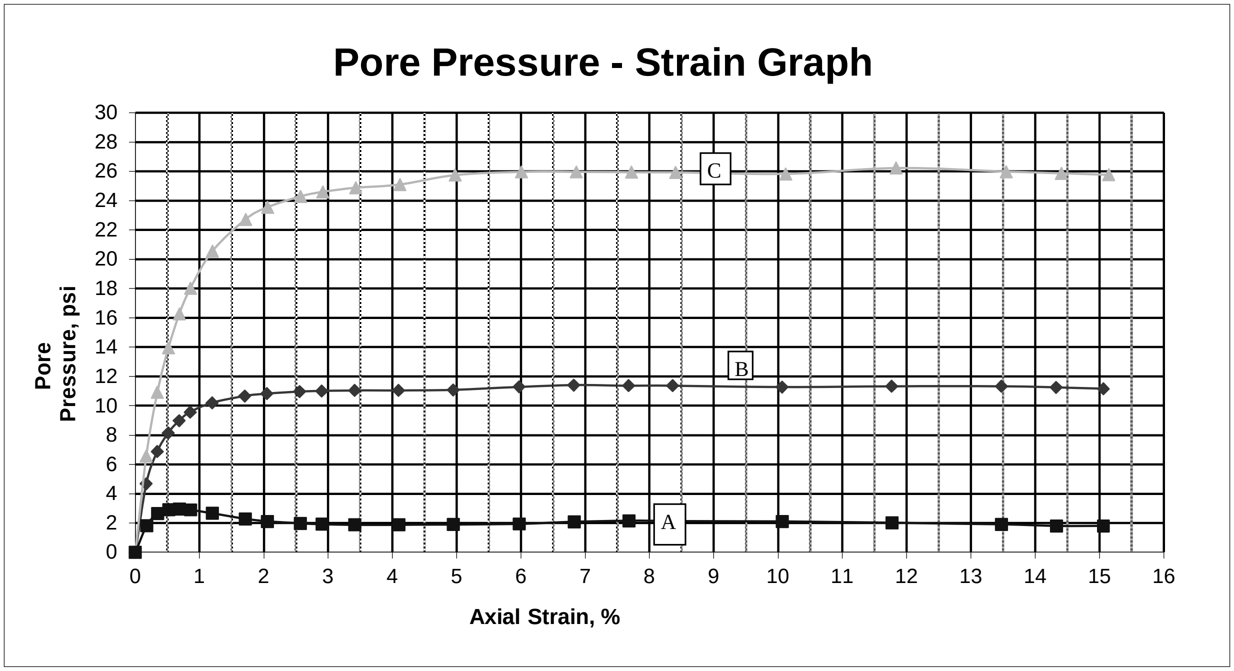
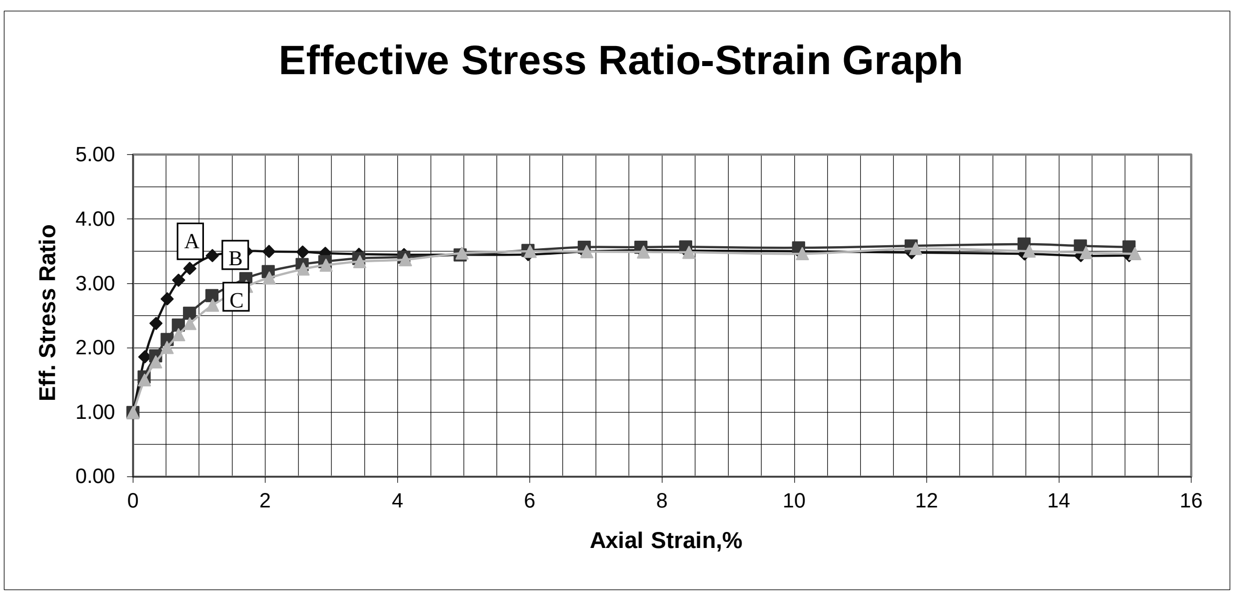
		Date	03/03/20
		Check	

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33248/Ash #1	Depth/Elevation	-
Location	Yates	Additional Info	-





Triaxial CU.xls [Stress Ratio & Pore Water Pr.-Strain GRAPH], REV. 1; 10-10-05

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Date	03/04/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Project Name	AMA	S. Type	Remold
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 2

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	0.0
2	0.10	0.32	8.5
3	0.30	0.55	9.0
4	0.50	0.71	9.5
5	0.80	0.89	10.0
6	1.50	1.22	10.0
7	2.25	1.50	10.5
8	3.00	1.73	10.5
9	3.75	1.94	10.5
10	5.00	2.24	11.0
11	6.50	2.55	11.0
12	8.5	2.92	11.0
13	11.0	3.32	11.0
14	16.0	4.00	11.5
15	22.0	4.69	11.5
16	32.0	5.66	11.5
17			
18			
19			
20			

Pressure* on Specimen, lbf/ft^2

250

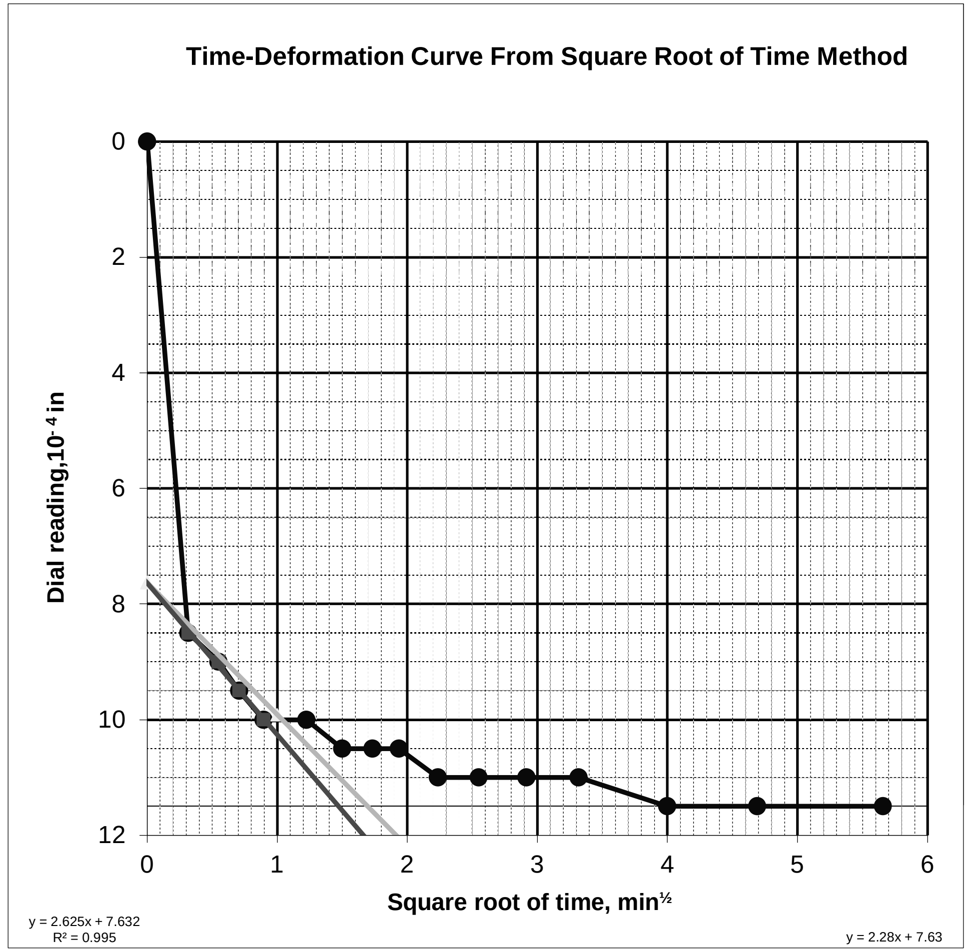
Selection	5
m_1	2.63
m_2	2.28

X	Y
0	7.63
1	9.91

d_0	7.6
d_{90}	10
d_{100}	10
d_{50}	9
sq.root t_{90}	1.05
t_{90}, min	1.10
sq.root t_{50}	0.51
t_{50}, min	0.26

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Date	03/04/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Project Name	AMA	S. Type	Remold
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 3

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	11.5
2	0.10	0.32	26.0
3	0.30	0.55	27.5
4	0.50	0.71	28.0
5	0.80	0.89	29.0
6	1.50	1.22	30.0
7	2.25	1.50	30.0
8	3.00	1.73	30.5
9	3.75	1.94	31.0
10	5.00	2.24	31.5
11	6.50	2.55	31.5
12	8.5	2.92	32.0
13	11.0	3.32	32.0
14	16.0	4.00	32.5
15	22.0	4.69	33.0
16	32.0	5.66	33.5
17			
18			
19			
20			

Pressure* on Specimen, lbf/ft^2

500

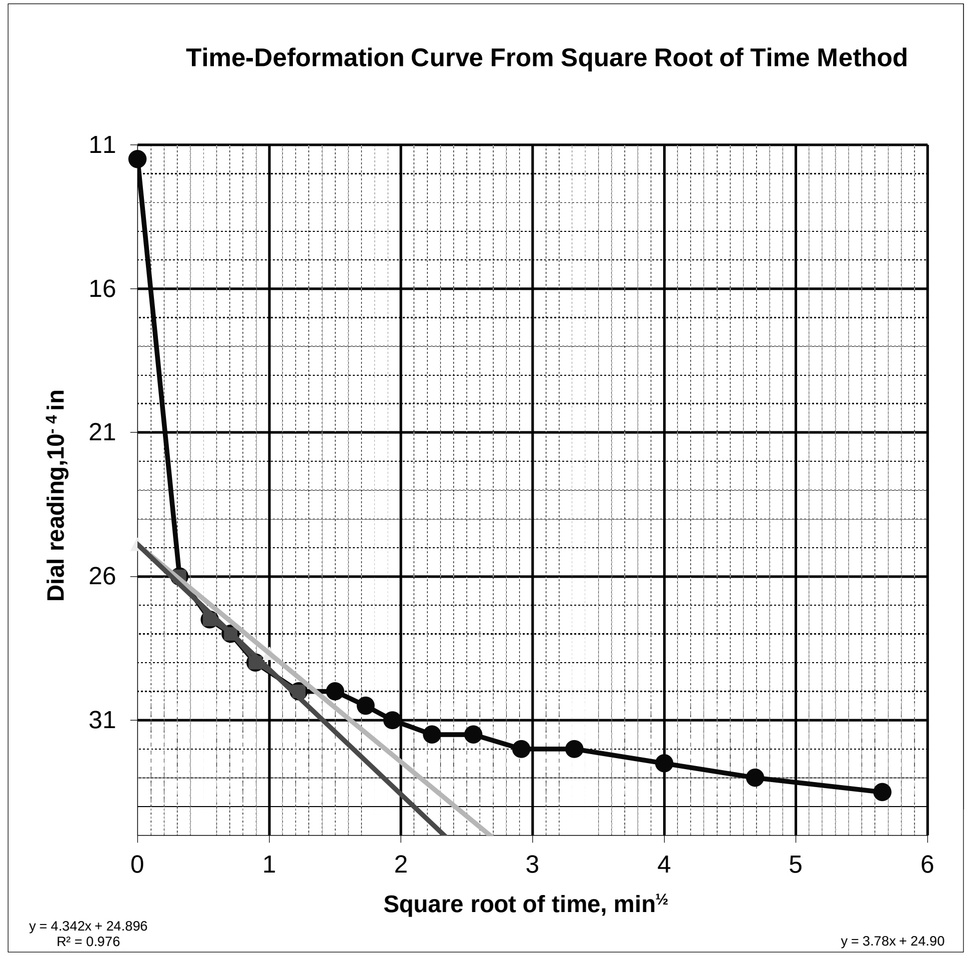
Selection	6
m_1	4.34
m_2	3.78

X	Y
0	24.90
1	28.67

d_0	24.9
d_{90}	30
d_{100}	31
d_{50}	28
$sq.root\ t_{90}$	1.35
t_{90}, min	1.82
$sq.root\ t_{50}$	0.65
t_{50}, min	0.43

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Tested By	KP
Date	03/04/20
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Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Project Name	AMA	S. Type	Remold
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	34.0
2	0.10	0.32	64.0
3	0.30	0.55	67.0
4	0.50	0.71	68.0
5	0.80	0.89	69.0
6	1.50	1.22	71.0
7	2.25	1.50	71.5
8	3.00	1.73	72.0
9	3.75	1.94	73.0
10	5.00	2.24	73.5
11	6.50	2.55	73.5
12	8.5	2.92	74.5
13	11.0	3.32	74.5
14	16.0	4.00	75.0
15	22.0	4.69	75.5
16	32.0	5.66	76.5
17			
18			
19			
20			

STEP # 4

Pressure* on Specimen, lbf/ft^2

1000

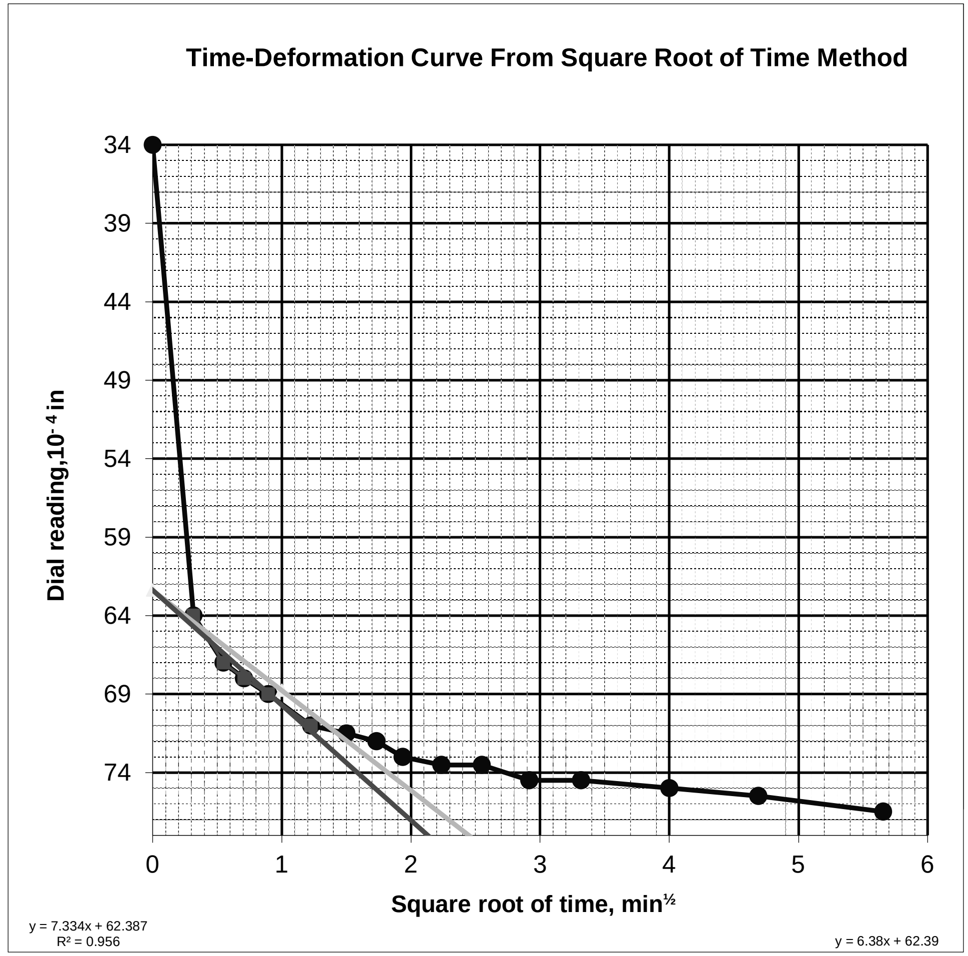
Selection	6
m_1	7.33
m_2	6.38

X	**Y**
0	62.39
1	68.76

d_0	62.4
d_{90}	71
d_{100}	72
d_{50}	67
$sq.root\ t_{90}$	1.4
t_{90}, min	1.96
$sq.root\ t_{50}$	0.68
t_{50}, min	0.46

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Date	03/05/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Project Name	AMA	S. Type	Remold
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 5

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	77.0
2	0.10	0.32	118.0
3	0.30	0.55	121.0
4	0.50	0.71	122.5
5	0.80	0.89	124.0
6	1.50	1.22	126.0
7	2.25	1.50	127.0
8	3.00	1.73	128.0
9	3.75	1.94	128.5
10	5.00	2.24	129.0
11	6.50	2.55	129.5
12	8.5	2.92	130.0
13	11.0	3.32	131.0
14	16.0	4.00	131.5
15	22.0	4.69	132.0
16	32.0	5.66	132.5
17	65.0	8.06	134.0
18	90.0	9.49	134.0
19	165.0	12.85	135.0
20	240.0	15.49	135.5
	390.0	19.75	136.0
	540.0	23.24	136.0
	690.0	26.27	136.5

Pressure* on Specimen, lbf/ft^2

2000

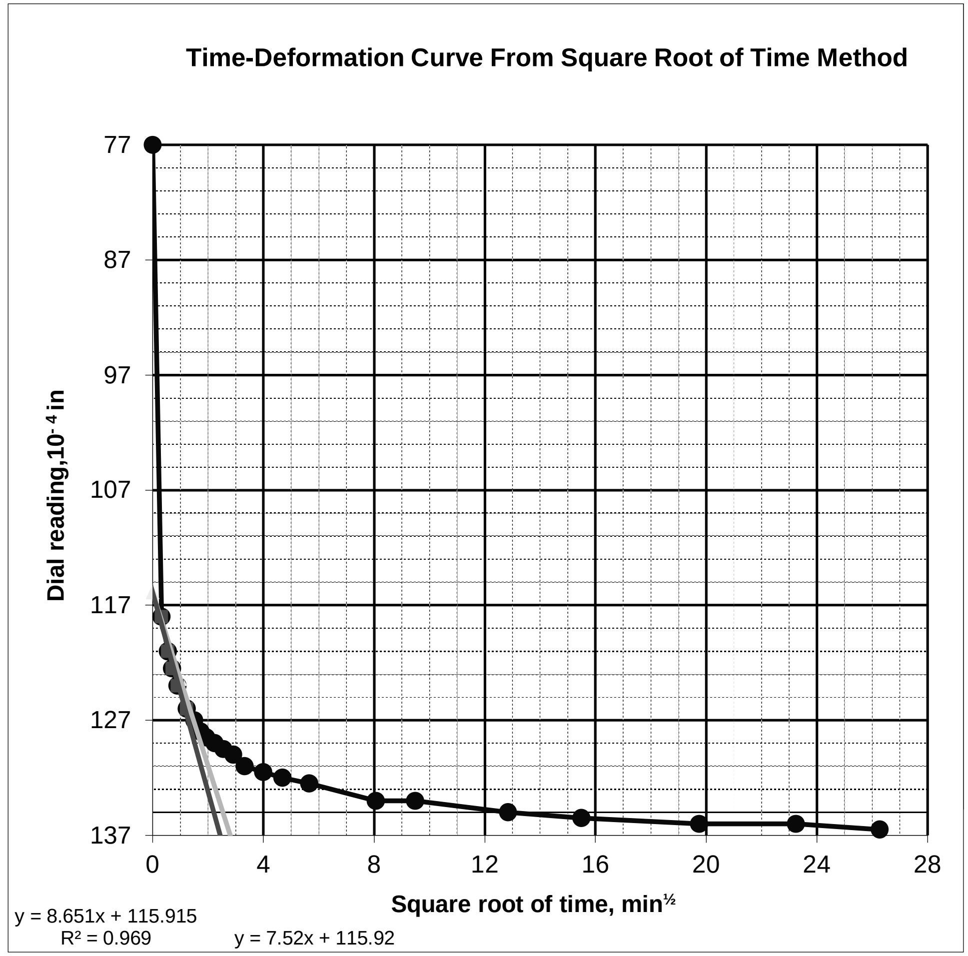
Selection	6
m_1	8.65
m_2	7.52

X	Y
0	115.92
1	123.44

d_0	115.9
d_{90}	127
d_{100}	128
d_{50}	122
sq.root t_{90}	1.45
t_{90}, min	2.10
sq.root t_{50}	0.70
t_{50}, min	0.49

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Tested By	KP
Date	03/05/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Project Name	AMA	S. Type	Remold
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 6

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	136.5
2	0.10	0.32	185.5
3	0.30	0.55	189.0
4	0.50	0.71	191.5
5	0.80	0.89	193.0
6	1.50	1.22	195.5
7	2.25	1.50	197.0
8	3.00	1.73	198.5
9	3.75	1.94	199.0
10	5.00	2.24	200.0
11	6.50	2.55	201.0
12	8.5	2.92	201.5
13	11.0	3.32	202.5
14	16.0	4.00	203.5
15	22.0	4.69	204.5
16	32.0	5.66	205.0
17	65.0	8.06	206.5
18	90.0	9.49	207.0
19	165.0	12.85	208.5
20			

Pressure* on Specimen, lbf/ft²

4000

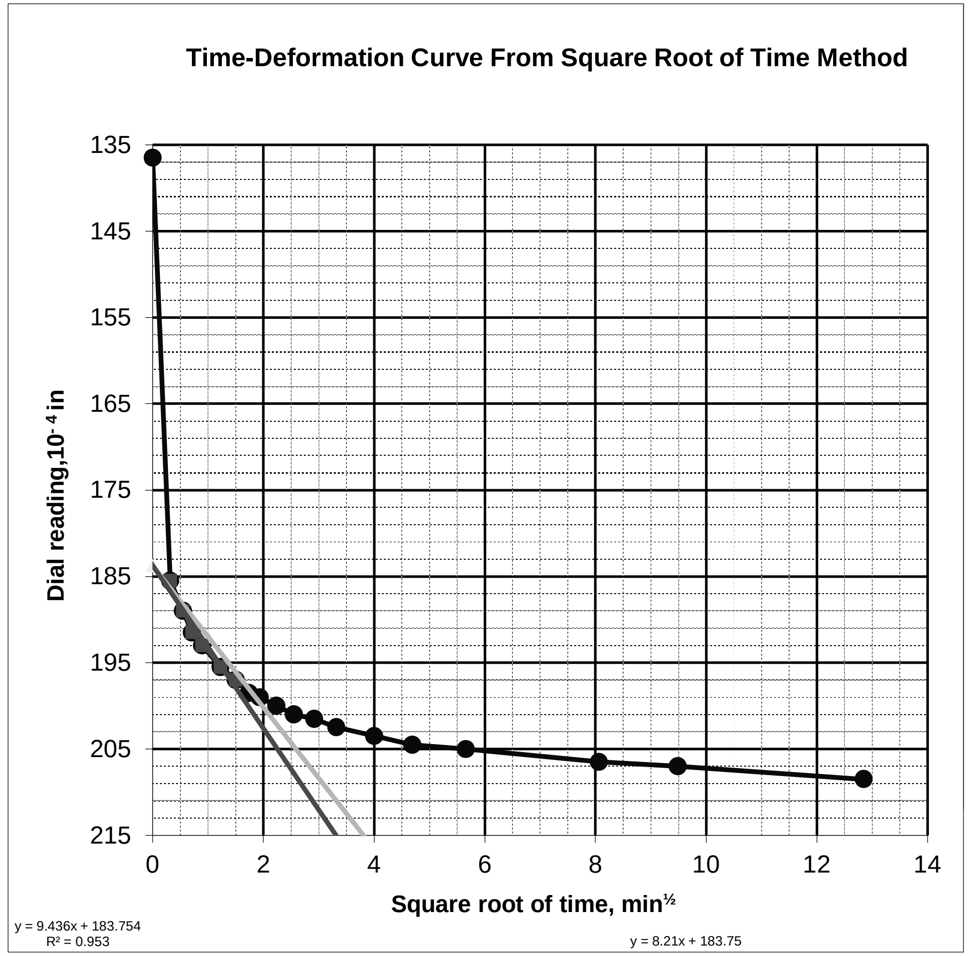
Selection	7
m_1	9.44
m_2	8.21

X	Y
0	183.75
1	191.96

d_0	183.8
d_{90}	199
d_{100}	200
d_{50}	192
sq.root t_{90}	1.8
t_{90}, min	3.24
sq.root t_{50}	0.87
t_{50}, min	0.76

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Date	03/05/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Project Name	AMA	S. Type	Remold
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 7

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	208.5
2	0.08	0.29	288.0
3	0.28	0.53	294.5
4	0.48	0.70	298.5
5	0.78	0.89	301.5
6	1.48	1.22	306.0
7	2.23	1.49	309.0
8	2.98	1.73	310.5
9	3.73	1.93	312.0
10	4.98	2.23	313.5
11	6.48	2.55	315.0
12	8.5	2.91	316.5
13	11.0	3.31	317.5
14	16.0	4.00	319.5
15	22.0	4.69	320.5
16	32.0	5.66	322.0
17	65.0	8.06	324.5
18	90.0	9.49	325.5
19	165.0	12.84	327.0
20			

Pressure* on Specimen, lbf/ft^2

8000

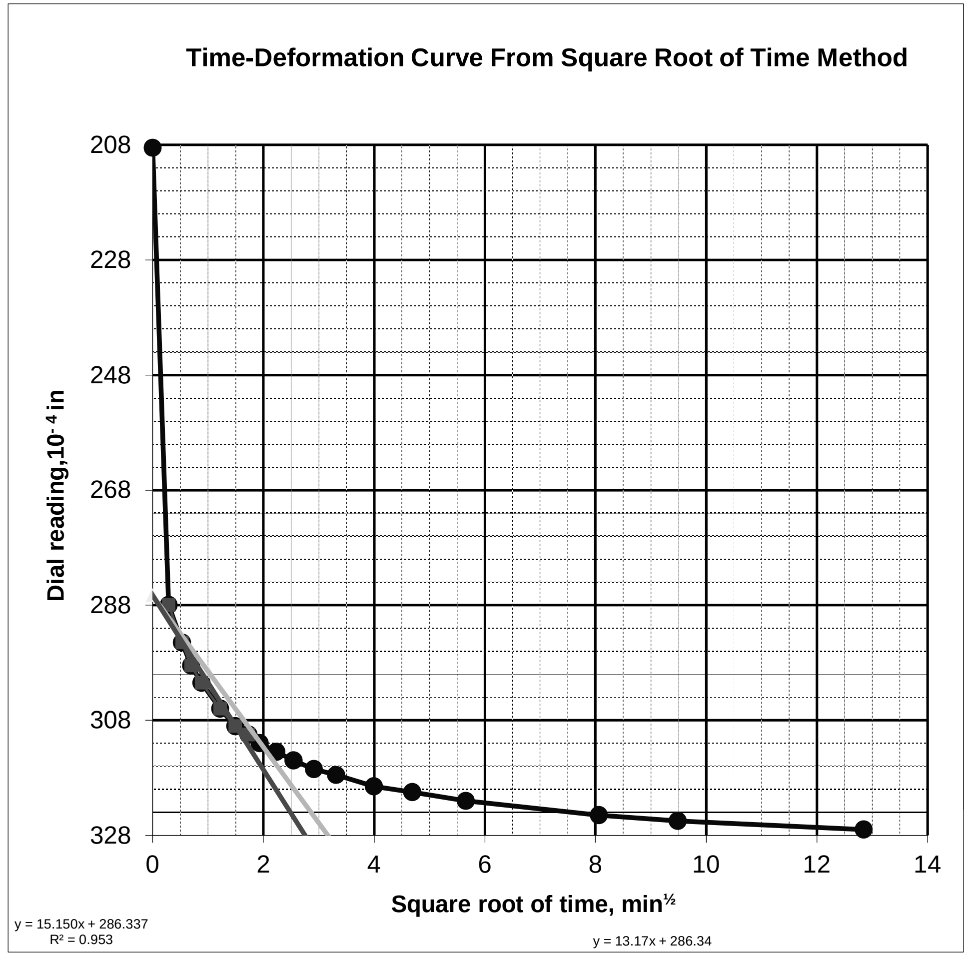
Selection	8
m_1	15.15
m_2	13.17

X	Y
0	286.34
1	299.51

d_0	286.3
d_{90}	311
d_{100}	314
d_{50}	300
sq.root t_{90}	1.9
t_{90}, min	3.61
sq.root t_{50}	0.92
t_{50}, min	0.84

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Tested By	KP
Date	03/05/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Project Name	AMA	S. Type	Remold
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	328.0
2	0.08	0.29	452.5
3	0.28	0.53	461.0
4	0.48	0.70	466.5
5	0.78	0.89	471.0
6	1.48	1.22	477.0
7	2.23	1.49	481.0
8	2.98	1.73	483.5
9	3.73	1.93	485.5
10	4.98	2.23	487.5
11	6.48	2.55	490.0
12	8.5	2.91	492.0
13	11.0	3.31	494.0
14	16.0	4.00	496.5
15	22.0	4.69	498.0
16	32.0	5.66	500.0
17	65.0	8.06	503.5
18	90.0	9.49	506.0
19	165.0	12.84	509.0
20	240.0	15.49	510.5

STEP # 8

Pressure* on Specimen, lbf/ft^2

16000

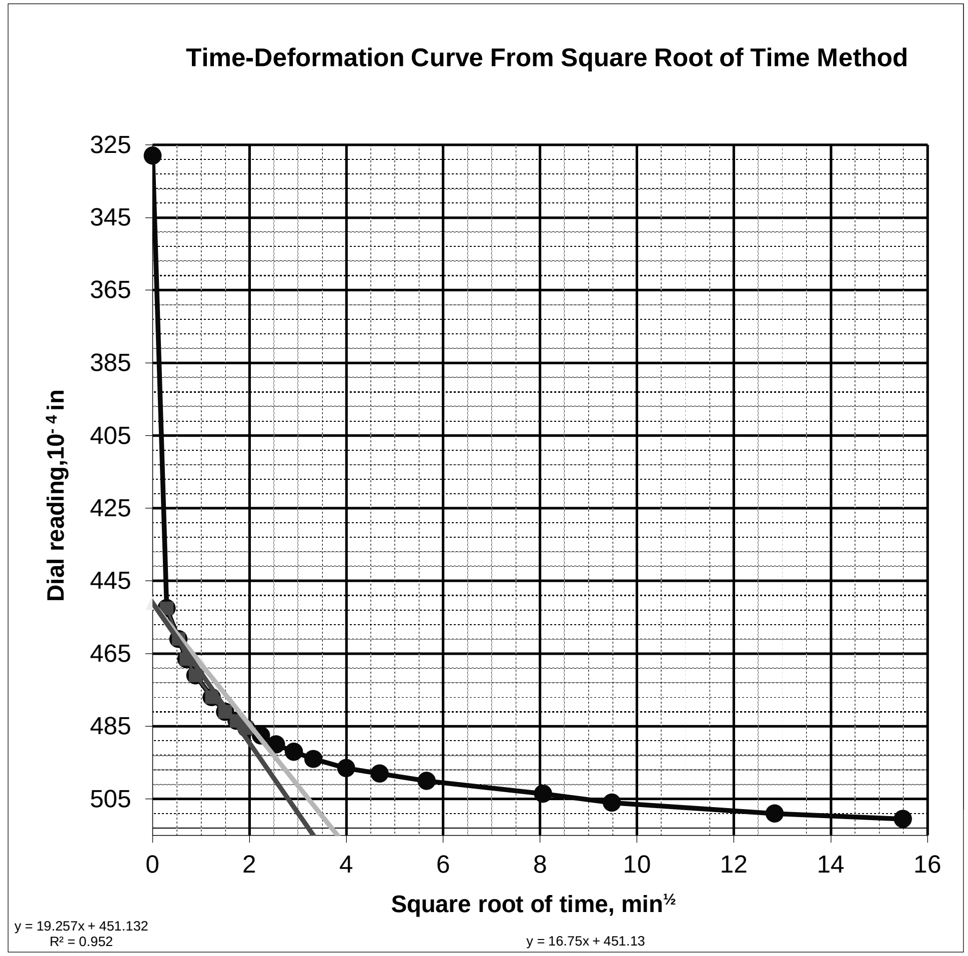
Selection	9
m_1	19.26
m_2	16.75

X	**Y**
0	451.13
1	467.88

d_0	451.1
d_{90}	487
d_{100}	491
d_{50}	471
sq.root t_{90}	2.15
t_{90}, min	4.62
sq.root t_{50}	1.04
t_{50}, min	1.08

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Tested By	RI
Date	03/04/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Project Name	AMA	S. Type	Remold
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D2435

Standard Test Method for One-Dimensional Consolidation Properties of Soils (Method B)

Sample Data

	Initial	Final
Mass of Ring, g	194.73	194.73
Mass of Wet Sample and Ring, g	346.60	347.03
Mass of Wet Sample, g	151.87	152.30
Mass of Dry Sample, g	129.89	129.89
Height of Sample, in	0.9970	0.9479
Diameter of Sample, in	2.501	2.501
Area of Sample, in^2	4.91	4.91
Volume of Sample, in^3	4.90	4.66
Specific Gravity (Assumed)	2.553	2.553
Wet Unit Weight, pcf	118.1	124.6
Dry Unit Weight, pcf	101.0	106.3
Height of Solids, in	0.6320	0.6320
Height of Voids, in	0.3650	0.3159
Height of Water, in	0.2730	0.2784
Void Ratio	0.578	0.500
Degree of Saturation, %	74.8	88.1

Initial Seating Pressure, lbf/ft^2	100
Additional Vertical Pressure, lbf/ft^2	0
Total Seating Pressure, lbf/ft^2	100
STATION #	1
Consolidometer Ring ID Number	1
Consolidometer ID Number	1
Frame ID Number	103
Dial Gage ID Number	676
Initial Dial Gauge Reading, 10^{-4} in	0
Final Dial Gauge Reading, 10^{-4} in	491

DESCRIPTION

Dark Gray Sandy Silt

Condition of Test:

1. Deionized water used for inundation of sample.
2. Saturated porous stones w/t filter paper used

USCS (ASTM D2487;2488)

ML

REMARKS

Material passed #4 sieve used for testing. Material was remolded to 95.2% of maximum dry density (standard proctor) at 2.1% above optimum moisture content.

Moisture Content

	Trimmings	Initial	Final
Mass of Wet Sample and Tare, g	401.20	346.60	406.44
Mass of Dry Sample and Tare, g	356.30	324.62	384.03
Mass of Tare, g	101.60	194.73	254.15
Moisture Content, %	17.6	16.9	17.3

LL	-
PL	-
PI	-

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Date	03/04/20
Checked By	[signature]

Client Pr. #	I054-107	Lab Pr. #	2008-08-1
Project Name	AMA	S. Type	Remold
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D2435

Standard Test Method for One-Dimensional Consolidation Properties of Soils (Method B)

Void Ratio, Strain Information and Coefficient of Consolidation Calculation

Pressure		Uncorrected Dial Reading, in		Apparatus Correction, in	Corrected Dial Reading, in		Change in specimen height, in		Sample Height, in		Height of Voids, in	Void Ratio		Strain, %		Fitting Time, min		Hd_{50}, in	Coefficient of Consolidation	
lbf/ft²	Ksf	d_{100}	d_{50}		d_{100}	d_{50}	$S D H_{100}$	$S D H_{50}$	H_{100}	H_{50}	Hv^{100},in	e_{100}	e_{50}	e_{100}	e_{50}	t_{90}	t_{50}		in²/min	ft²/day
100	0.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.9970	0.9970	0.3650	0.578	0.578	0.00	0.00	-	-	0.4985	-	-
250	0.25	0.0010	0.0009	0.0000	0.0010	0.0009	0.0010	0.0009	0.9960	0.9961	0.3640	0.576	0.576	0.10	0.09	1.10	0.26	0.4981	0.19	1.91
500	0.5	0.0031	0.0028	0.0000	0.0031	0.0028	0.0031	0.0028	0.9939	0.9942	0.3620	0.573	0.573	0.31	0.28	1.82	0.43	0.4971	0.11	1.15
1000	1	0.0072	0.0067	0.0000	0.0072	0.0067	0.0072	0.0067	0.9898	0.9903	0.3578	0.566	0.567	0.73	0.68	1.96	0.46	0.4951	0.11	1.06
2000	2	0.0128	0.0122	0.0000	0.0128	0.0122	0.0128	0.0122	0.9842	0.9848	0.3522	0.557	0.558	1.28	1.22	2.10	0.49	0.4924	0.10	0.98
4000	4	0.0200	0.0192	0.0000	0.0200	0.0192	0.0200	0.0192	0.9770	0.9778	0.3450	0.546	0.547	2.01	1.93	3.24	0.76	0.4889	0.06	0.63
8000	8	0.0314	0.0300	0.0000	0.0314	0.0300	0.0314	0.0300	0.9656	0.9670	0.3336	0.528	0.530	3.15	3.01	3.61	0.84	0.4835	0.05	0.55
16000	16	0.0491	0.0471	0.0000	0.0491	0.0471	0.0491	0.0471	0.9479	0.9499	0.3159	0.500	0.503	4.93	4.73	4.62	1.08	0.4749	0.04	0.41

Note:
d_{100} = Dial gauge reading at 100% primary consolidation, in
d_{50} = Dial gauge reading at 50% primary consolidation, in
H_{100} = Specimen height at 100% primary consolidation, in
H_{50} = Specimen height at 50% primary consolidation, in
Hd_{50} = Length of the drainage path at 50% consolidation, in
e_{100} = Void ratio at 100% primary consolidation
e_{50} = Void ratio at 50% primary consolidation

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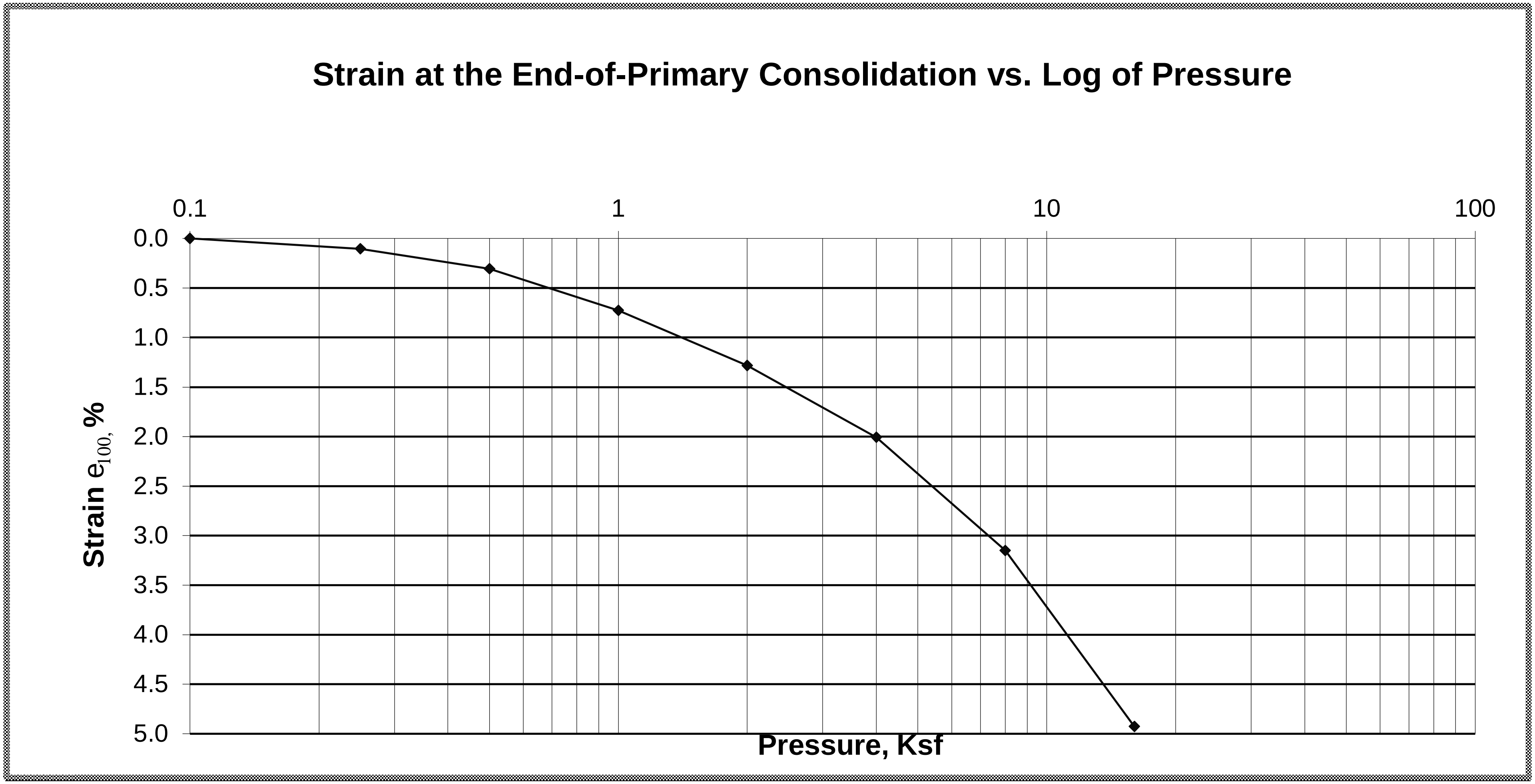
Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Project Name	AMA	S. Type	Remold
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 2435; Standard Test Method for One-Dimensional Consolidation Properties of Soils (Method B)



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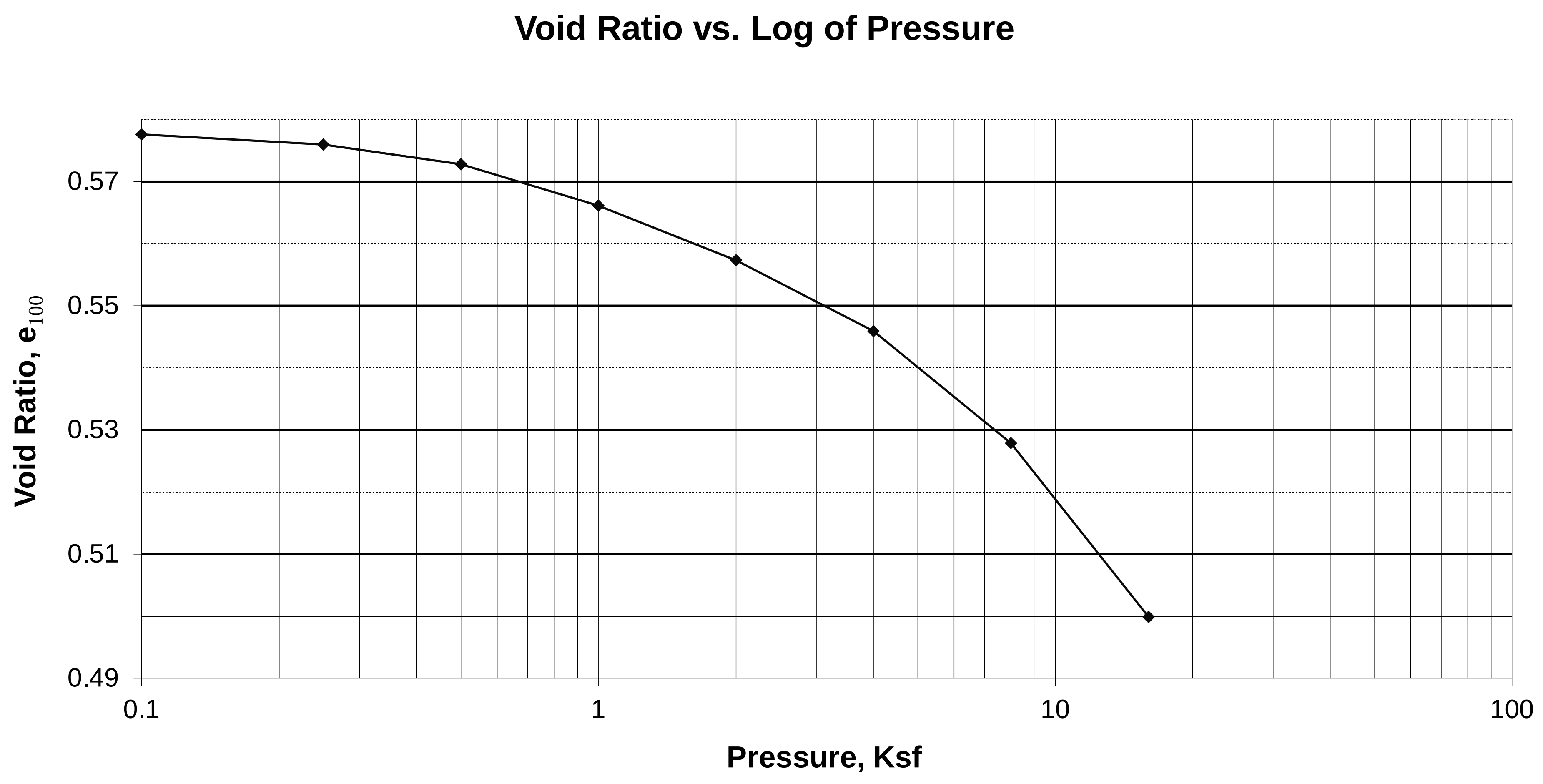
		Date	03/04/20
		Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Project Name	AMA	S. Type	Remold
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 2435; Standard Test Method for One-Dimensional Consolidation Properties of Soils (Method B)



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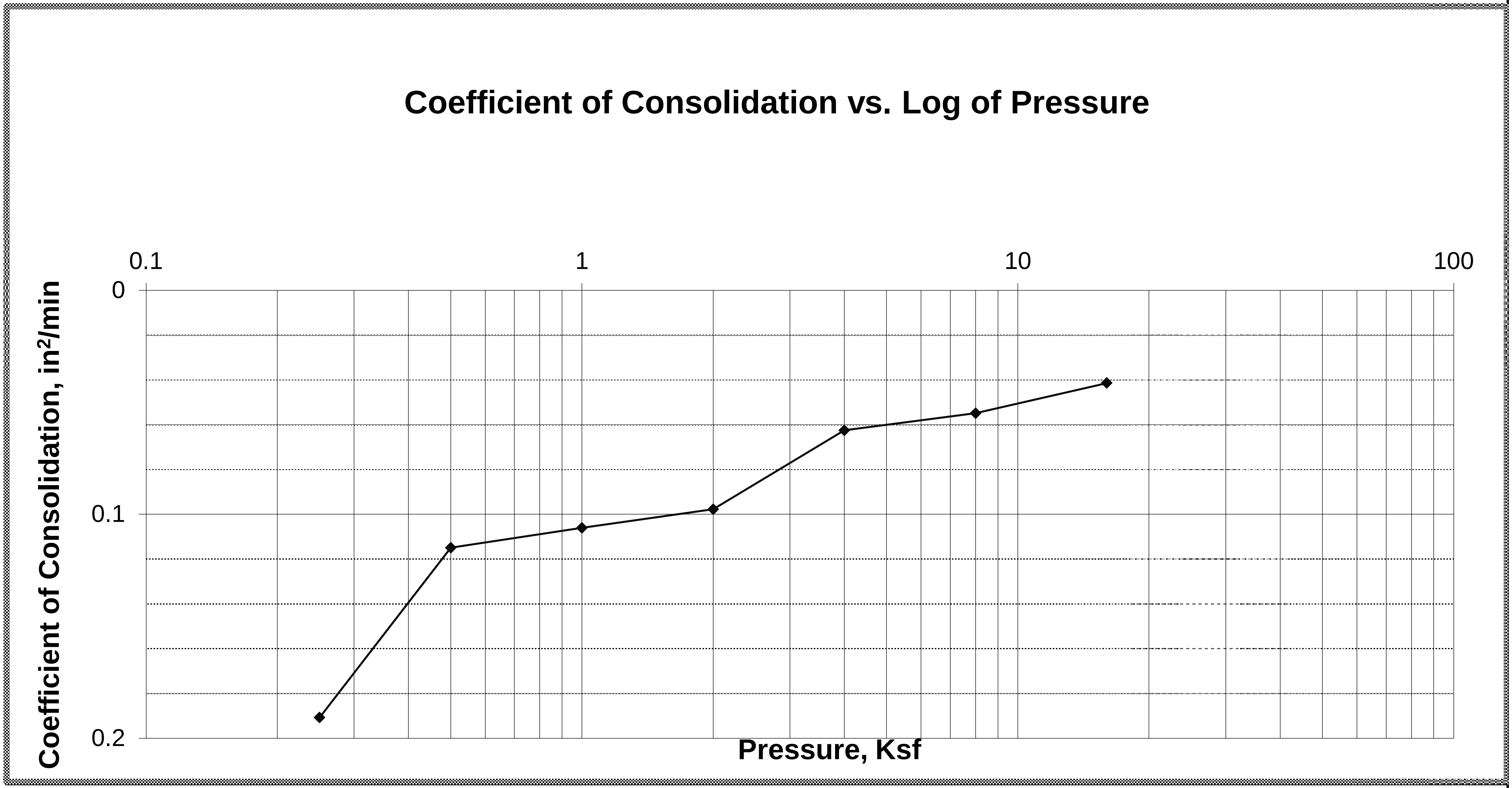
Tested By	RI
Date	03/04/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Project Name	AMA	S. Type	Remold
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 2435; Standard Test Method for One-Dimensional Consolidation Properties of Soils (Method B)



TIMELY ENGINEERING SOIL TESTS, LLC	1874 Forge Street Tucker, GA 30084 Phone: 770-938-8233 Fax: 770-923-8973 Web: www.test-llc.com AASHTO ACCREDITED	Tested By: IH Date: 03/04/20 Checked By: [illegible]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

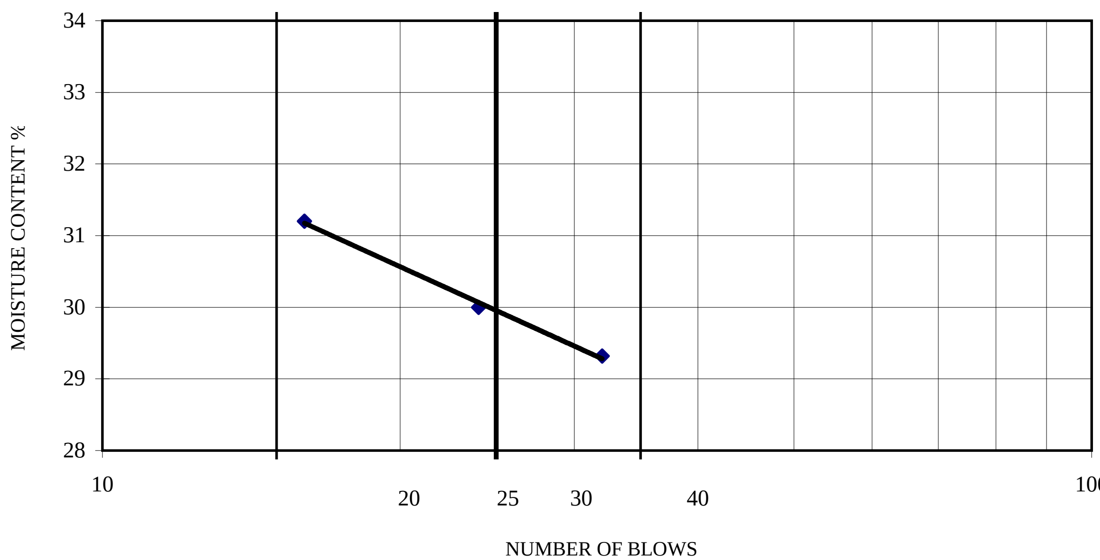
ASTM D 4318/AASHTO T 88, T 89

Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils (Atterberg Limits)

LIQUID LIMIT

Number of Blows	32	24	16
Mass of Wet Sample & Tare, g	39.20	37.03	38.83
Mass of Dry Sample & Tare, g	35.79	34.12	35.51
Mass of Tare, g	24.16	24.42	24.87
Moisture Content, %	29.32	30.00	31.20

Oven ID #	15/496/610
Balance ID #	139/563
Liquid Limit Device ID #	451/569



PLASTIC LIMIT

Mass of Wet Sample & Tare, g	35.62	38.50
Mass of Dry Sample & Tare, g	33.48	36.00
Mass of Tare, g	23.96	24.93
Moisture Content, %	22.48	22.58

NOTE: MATERIAL PASSING NO. 40 SIEVE WAS USED FOR TEST

NATURAL MOISTURE

Mass of Wet Sample & Tare, g	542.70
Mass of Dry Sample & Tare, g	453.60
Mass of Tare, g	123.40
Moisture Content, %	26.98

LIQUID LIMIT (LL)	30
PLASTIC LIMIT (PL)	23
PLASTICITY INDEX (PI)	7
LIQUIDITY INDEX (LI)	0.57

DESCRIPTION: Dark Gray Sandy Silt

USCS (ASTM D2487; D2488): ML

AASHTO (M 145): NA

TIMELY ENGINEERING SOIL TESTS, LLC (T.E.S.T.)

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AASHTO ACCREDITED

Tested By	RI
Date	02/28/20
Checked By	(signature)

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 422/AASHTO T 88

Standard Test Method for Particle-Size Analysis of Soils (with Double Separation per ASTM D6913 and Hydrometer Analysis)

As-Received Moisture Content (Total Sample)

Mass of Wet Sample & Tare, g	542.7
Mass of Dry Sample & Tare, g	453.6
Mass of Tare, g	123.4
Moisture Content, %	27.0

Moisture Content of FINER PORTION

	1st Subsample	*2nd Subsample*
Mass of Wet Sample & Tare, g	422.5	482.20
Mass of Dry Sample & Tare, g	419.6	478.10
Mass of Tare, g	126.4	95.00
Moisture Content, %	1.0	1.1

Mass of Total Sample before separation on 3/8" sieve & Tare, g	17700
Mass of Tare, g	0.0
Total Mass of Dry Sample, g	13939

	1st Subsample	*2nd Subsample*
Mass of Wet Finer Portion & Tare, g	1518.2	82.30
Mass of Tare	0.0	0.0
Dry Mass, g	1503.3	81.43
% of Total Sample passing Split Sieve	99.3	97.7

SIEVE ANALYSIS

COARSER PORTION OF SAMPLE (RETAINED ON 3/8" SIEVE)

Mass of Tare, g: 0.00

Sieve Size		Sample & Tare, g	% RETAINED	% PASSING (of Total)
12"	COBBLES		0	100
3"	COARSE GRAVEL		0	100
2.5"			0	100
2"			0	100
1.5"			0	100
1"			0	100
.75"	FINE GRAVEL	0.0	0	100
.5"		62.2	0	100
.375"		96.9	1	99
#4	COARSE SAND	24.2	2	98

#4 <First Subsample of Finer Portion<3/8"

2nd Subsample of FINER PORTION OF SAMPLE (PASSING #4 SIEVE:Hydrometer Backsieve)

Sieve Size		Cumulative Mass retained, g	% PASSING (of Total)
#10	MEDIUM SAND	1.53	96
#20		5.87	91
#40	FINE SAND	13.63	81
#60		21.73	72
#100		29.31	63
#200	FINES	37.23	53

Remarks

HYDROMETER ANALYSIS

Length of Dispersion Period	1 Minute
Mechanical Dispersion Device ID #	61
Amount of Dispersing Agent (ml)	125.0
Specific Gravity (assumed)	2.650
Specific Gravity (tested)	
Starting time	14:00

PARTICLE-SIZE ANALYSIS

% COBBLES	0	% MEDIUM SAND	15
% COARSE GRAVEL	0	% FINE SAND	28
% FINE GRAVEL	2	% FINES	53
% COARSE SAND	2	% TOTAL SAMPLE	100
% CLAY(<0.005mm)	20	% CLAY(<0.002mm)	15

Date	Time	Testing time (min)	Reading	Temp (^oC)	K	Composite Correction	Actual Reading	Effective Depth (cm)	a	Particle Diam. (mm)	Percent Passing
03/04/20	14:02	2	41.5	17.7	0.01399	6.5	35.0	10.6	1.00	0.0322	42.0
03/04/20	14:05	5	36.0	17.7	0.01399	6.5	29.5	11.5	1.00	0.0212	35.4
03/04/20	14:15	15	32.0	17.7	0.01399	6.5	25.5	12.1	1.00	0.0126	30.6
03/04/20	14:30	30	28.0	17.7	0.01399	6.5	21.5	12.8	1.00	0.0091	25.8
03/04/20	15:00	60	26.0	17.7	0.01399	6.5	19.5	13.1	1.00	0.0065	23.4
03/04/20	18:10	250	20.0	17.7	0.01399	6.5	13.5	14.1	1.00	0.0033	16.2
03/05/20	14:00	1440	18.0	17.7	0.01399	6.5	11.5	14.5	1.00	0.0014	13.8

Hydrometer 152H ID #	305527	Oven ID #	15/496/610
Sieve Shaker ID #	555	Balance ID#	139/142/700

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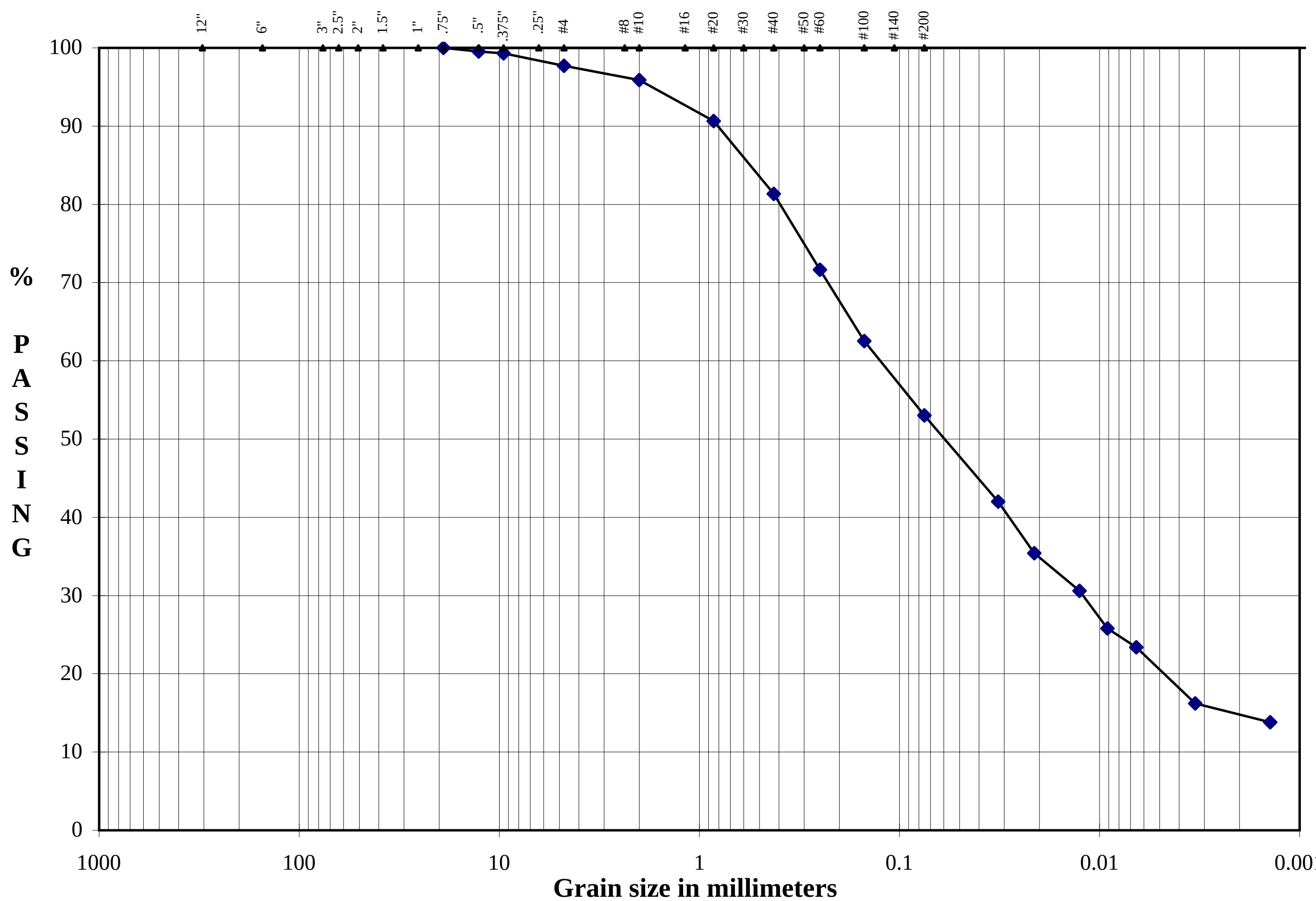
			Date	02/28/20
			Checked By	

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 422/AASHTO T 88

Standard Test Method for Particle-Size Analysis of Soils (with Double Separation per ASTM D6913 and Hydrometer Analysis)

Particle-Size Analysis



Boulders	Cobbles	Gravel		Sand			Fines
		Coarse	Fine	Coarse	Medium	Fine	Silt or Clay

D_{10}	NA	mm
D_{30}	NA	mm
D_{60}	NA	mm
Cu	NA	
Cc	NA	

DESCRIPTION: Dark Gray Sandy Silt

USCS (ASTM D2487; D2488): ML

Project's Specific % Passing	NA
Project's Specific Particle Size, mm	NA

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Tested By	IH
Date	02/28/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 698
Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600kN-m/m^3))

DETERMINATION OF TEST PROCEDURE

	wet	dry
Mass of Soil before sieving, g	17700.0	13938.8
Mass of Mat. Retained on No. 4 sieve, g		
Mass of Mat. Retained on 3/8" sieve, g	96.9	96.9
Mass of Mat. Retained on 3/4" sieve, g		

MOISTURE CONTENT

	Coarse + Fine Fraction	Coarse Fraction
Mass of Wet Sample & Tare, g	542.7	96.9
Mass of Dry Sample & Tare, g	453.6	96.9
Mass of Tare, g	123.4	0.0
Moisture Content, %	27.0	0.0

Material Retained on No. 4 Sieve, %	
Material Retained on 3/8" Sieve, %	0.7
Material Retained on 3/4" Sieve, %	
Total, % (oversized)	0.7

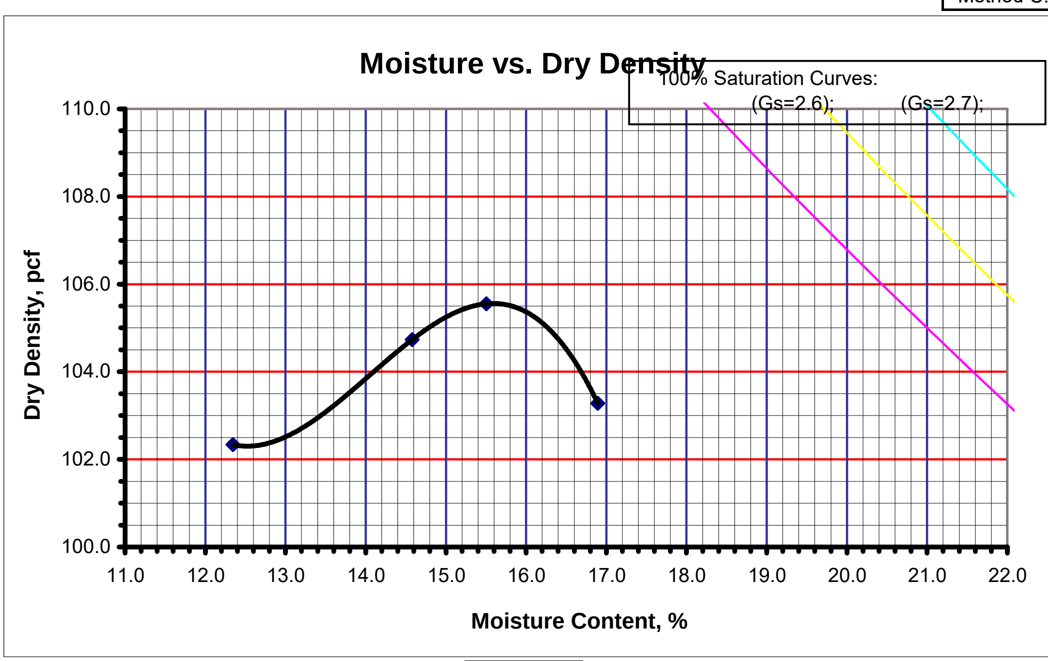
Procedure: B

TEST DATA

Points	1	2	3	4	5
Mass of Mold and Soil, g	5989.0	6065.0	6094.0	6076.0	
Mass of Wet Sample & Tare, g	508.0	513.9	504.6	467.7	
Mass of Dry Sample & Tare, g	472.4	470.5	460.5	419.0	
Mass of Tare, g	184.0	172.8	176.1	130.7	
Moisture Content, %	12.3	14.6	15.5	16.9	
Wet Density, pcf	115.0	120.0	121.9	120.7	
Dry Density, pcf	102.3	104.7	105.6	103.3	

Mold ID Number	798
Mass of Mold, g	4252.4
Volume of Mold, ft^3	0.0333
Hammer ID Number	318
Number of Blows per layer	25
Number of Layers	3
Mechanical Compactor ID Number	317

Method A: Material retained on No. 4 Sieve ≤ 25%
Method B: Material retained on 3/8" Sieve ≤ 25%
Method C: Material retained on 3/4" Sieve ≤ 30%



REMARKS

DESCRIPTION

Dark Gray Sandy Silt

USCS (ASTM D2487; D2488): ML

AASHTO M145: NA

Maximum Dry Density, pcf	105.6
Optimum Moisture Content, %	15.5
Corrected Maximum Dry Density, pcf	**NA**
Corrected Optimum Moisture Content, %	**NA**

TIMELY ENGINEERING SOIL TESTS, LLC

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AASHTO ACCREDITED

Tested By	RI
Date	03/03/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D854; Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

TEST METHOD	B

MOISTURE CONTENT

Mass of Wet Sample & Tare, g	-
Mass of Dry Sample & Tare, g	-
Mass of Tare, g	-
Moisture Content, %	NA*

TEST DATA

Pycnometer Number	3
Mass of Pycnometer, g	134.56
Mass of Sample & Pycnometer, g	214.62
Mass of Sample, Water & Pycnometer, g	681.60
Test Temperature, ^{o}C	19.2
Mass of Tare,g	360.48
Mass of Dry Sample & Tare, g	440.20
Mass of Dry Soil, g	79.72
Mass of Pycnometer (Calibrated), g	134.56
Density of Water @ Test Temperature, g/mL	0.99837
Mass of Pycnometer & Water @ Test Temp.	633.12
Temperature Coefficient	1.00016
Calibrated Volume of Pycnometer, mL	499.37
Specific Gravity @ Test Temperature	2.552

SPECIFIC GRAVITY @ 20 ^{o}C **2.553**

DESCRIPTION

Dark Gray Sandy Silt

USCS (ASTM D2487, D2488)

ML

Thermometer ID Number	72
Vacuum Pump ID Number	62
Deaerator ID Number	213
Specific Gravity Board ID Number	214
Balance ID Number	139
Oven ID Number	12

NOTES:

1.* Oven-Dry material passing #4 sieve used for test.
2. Air removed by vacuum method.
3. Deionized / Deaired water was used for test.

TIMELY **E**NGINEERING **S**OIL **T**ESTS, LLC

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AASHTO ACCREDITED

Tested By	EB/KP
Date	03/03/20
Checked By	

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33249/Ash #2	Depth/Elevation	-
Location	Yates	Additional Info	-

SPECIMEN PROPERTIES

	(initial)	(after consol.)
Height, in	6.000	5.966
Diameter, in	2.875	2.862
Height-to-Diameter Ratio	2.1	2.1
Area, in^2	6.49	6.43
Volume, cm^3	638.29	628.77
Mass of Wet Sample, g	1213.00	1269.50
Mass of Dry Sample, g	1031.42	1031.66
Wet Density, pcf	118.6	126.0
Dry Density, pcf	100.9	102.4
Specific Gravity (assumed)	2.639	2.639
Volume of Solids, cm^3	390.84	390.93
Volume of Voids, cm^3	247.45	237.84
Void Ratio	0.63	0.61
% Saturation	73.4	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	411.20	1529.40
Mass of Dry Sample and Tare, g	366.50	1291.62
Mass of Tare, g	112.60	260.20
Moisture, %	17.61	23.05

TEST DATA PRIOR TO LOADING

Machine Speed, in / min	0.0100
Strain Rate, % / min	0.17
Chamber Pressure, psi	80.0
Back Pressure,psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	10.0
Change in Height, in	0.034
"B" Value	0.95

SHEAR DATA

Elapsed Time (min)	Deformation (inch)	Axial Load (lb)	Pore-Water Pressure,psi		Total Strain (%)	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$)	Major Principal Stress,psi		Eff.Stress Ratio	P' $(s'_1+s'_3)/2$ (psi)	Q $[(s_1-s_3)/2]$ (psi)	Eff. Minor Pr. Stress
			Total,U	Change,DU			(psi)	Total s_1	Eff. s'_1	s'_1/s'_3			s'_3 (psi)
0.0	0.000	18.1	70.0	0.0	0.00	6.43	0.0	10.0	10.0	1.00	10.0	0.0	10.0
1.0	0.010	58.9	72.3	2.3	0.16	6.44	6.3	16.3	14.0	1.82	10.9	3.2	7.7
2.0	0.020	74.8	73.0	3.0	0.33	6.45	8.8	18.8	15.8	2.26	11.4	4.4	7.0
3.0	0.030	88.5	73.3	3.3	0.50	6.46	10.9	20.9	17.6	2.62	12.1	5.4	6.7
4.0	0.040	101.6	73.4	3.4	0.67	6.47	12.9	22.9	19.5	2.94	13.1	6.4	6.6
5.0	0.050	113.7	73.3	3.3	0.83	6.49	14.7	24.7	21.5	3.19	14.1	7.4	6.7
7.0	0.070	131.8	72.9	2.9	1.17	6.51	17.5	27.5	24.5	3.47	15.8	8.7	7.1
10.0	0.100	148.9	72.4	2.4	1.67	6.54	20.0	30.0	27.6	3.64	17.6	10.0	7.6
12.0	0.120	155.7	72.2	2.2	2.01	6.56	21.0	31.0	28.8	3.69	18.3	10.5	7.8
15.0	0.150	163.0	72.0	2.0	2.51	6.60	22.0	32.0	30.0	3.74	19.0	11.0	8.0
17.0	0.170	167.0	71.9	1.9	2.85	6.62	22.5	32.5	30.6	3.76	19.4	11.3	8.1
20.0	0.200	171.5	71.6	1.6	3.35	6.65	23.1	33.1	31.5	3.75	19.9	11.5	8.4
24.0	0.240	175.8	71.3	1.3	4.02	6.70	23.5	33.5	32.2	3.70	20.5	11.8	8.7
29.0	0.290	179.0	71.0	1.0	4.86	6.76	23.8	33.8	32.8	3.64	20.9	11.9	9.0
35.0	0.350	181.9	70.8	0.8	5.86	6.83	24.0	34.0	33.2	3.59	21.2	12.0	9.2
40.0	0.400	183.8	70.6	0.6	6.70	6.89	24.0	34.0	33.4	3.56	21.4	12.0	9.4
45.0	0.450	185.6	70.5	0.5	7.54	6.96	24.1	34.1	33.6	3.54	21.5	12.0	9.5
49.0	0.490	187.1	70.6	0.6	8.21	7.01	24.1	34.1	33.6	3.55	21.5	12.1	9.4
59.0	0.590	190.5	70.5	0.5	9.89	7.14	24.2	34.2	33.7	3.54	21.6	12.1	9.5
69.0	0.690	193.5	70.4	0.4	11.56	7.27	24.1	34.1	33.7	3.51	21.7	12.1	9.6
79.0	0.790	196.5	70.3	0.3	13.24	7.41	24.1	34.1	33.8	3.48	21.7	12.0	9.7
84.0	0.840	198.2	70.3	0.3	14.08	7.49	24.1	34.1	33.7	3.49	21.7	12.0	9.7
90.0	0.900	200.2	70.4	0.4	15.08	7.57	24.0	34.0	33.7	3.50	21.6	12.0	9.6
Values @ Failure				1.9	2.85	6.62	22.5	32.5	30.6	3.76	19.4	11.3	8.1

Failure criteria used*: 3

*Note:"1"=Max Deviator Stress;"2"=Deviator Stress @ 15% Strain;"3"=Max Eff.Stress Ratio(s'_1/s'_3)

TIMELY ENGINEERING SOIL TESTS, LLC

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Web: www.test-llc.com

Tested By	EB/KP
Date	03/03/20
Checked By	

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33249/Ash #2	Depth/Elevation	-
Location	Yates	Additional Info	-

SPECIMEN PROPERTIES

		(initial)	(after consol.)
Height, in		6.000	5.963
Diameter, in		2.875	2.845
Height-to-Diameter Ratio		2.1	2.1
Area, in^2		6.49	6.36
Volume, cm^3		638.29	621.21
Mass of Wet Sample, g		1213.30	1262.00
Mass of Dry Sample, g		1031.67	1031.75
Wet Density, pcf		118.7	126.8
Dry Density, pcf		100.9	103.7
Specific Gravity	(assumed)	2.639	2.639
Volume of Solids, cm^3		390.93	390.96
Volume of Voids, cm^3		247.36	230.25
Void Ratio		0.63	0.59
% Saturation		73.4	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	411.20	1520.10
Mass of Dry Sample and Tare, g	366.50	1289.87
Mass of Tare, g	112.60	258.20
Moisture, %	17.61	22.32

TEST DATA PRIOR TO LOADING

Machine Speed, in / min	0.0100
Strain Rate, % / min	0.17
Chamber Pressure, psi	90.0
Back Pressure,psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	20.0
Change in Height, in	0.037
"B" Value	0.95

SHEAR DATA

Elapsed Time (min)	Deformation (inch)	Axial Load (lb)	Pore-Water Pressure,psi		Total Strain (%)	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$)	Major Principal Stress,psi		Eff.Stress Ratio	P' $(s'_1+s'_3)/2$ (psi)	Q $[(s_1-s_3)/2]$ (psi)	Eff. Minor Pr. Stress
			Total,U	Change,DU			(psi)	Total s_1	Eff. s'_1	s'_1/s'_3			s'_3 (psi)
0.0	0.000	22.8	70.0	0.0	0.00	6.36	0.0	20.0	20.0	1.00	20.0	0.0	20.0
1.0	0.010	91.1	74.1	4.1	0.16	6.37	10.7	30.7	26.6	1.67	21.3	5.4	15.9
2.0	0.020	119.9	76.0	6.0	0.33	6.38	15.2	35.2	29.2	2.09	21.6	7.6	14.0
3.0	0.030	141.9	77.2	7.2	0.50	6.39	18.6	38.6	31.5	2.45	22.2	9.3	12.8
4.0	0.040	159.3	77.8	7.8	0.67	6.40	21.3	41.3	33.5	2.75	22.8	10.7	12.2
5.0	0.050	172.7	78.2	8.2	0.83	6.41	23.4	43.4	35.2	2.98	23.5	11.7	11.8
7.0	0.070	190.5	78.5	8.5	1.17	6.43	26.1	46.1	37.5	3.28	24.5	13.0	11.5
10.0	0.100	204.7	78.6	8.6	1.67	6.47	28.1	48.1	39.5	3.48	25.4	14.1	11.4
12.0	0.120	209.1	78.7	8.7	2.01	6.49	28.7	48.7	40.0	3.53	25.7	14.4	11.3
15.0	0.150	212.0	78.7	8.7	2.51	6.52	29.0	49.0	40.3	3.58	25.8	14.5	11.3
17.0	0.170	213.3	78.8	8.8	2.85	6.54	29.1	49.1	40.3	3.60	25.8	14.6	11.2
20.0	0.200	215.0	78.9	8.9	3.35	6.58	29.2	49.2	40.3	3.63	25.7	14.6	11.1
24.0	0.240	215.1	79.1	9.1	4.02	6.62	29.0	49.0	39.9	3.67	25.4	14.5	10.9
29.0	0.290	216.5	79.4	9.4	4.86	6.68	29.0	49.0	39.6	3.73	25.1	14.5	10.6
35.0	0.350	218.6	79.3	9.3	5.86	6.75	29.0	49.0	39.7	3.72	25.2	14.5	10.7
40.0	0.400	220.2	79.3	9.3	6.70	6.81	29.0	49.0	39.7	3.70	25.2	14.5	10.7
45.0	0.450	222.6	79.2	9.2	7.54	6.88	29.1	49.1	39.9	3.69	25.3	14.5	10.8
49.0	0.490	224.0	79.2	9.2	8.21	6.93	29.1	49.1	39.9	3.68	25.4	14.5	10.8
59.0	0.590	228.4	79.2	9.2	9.89	7.05	29.1	49.1	39.9	3.70	25.4	14.6	10.8
69.0	0.690	232.3	79.3	9.3	11.57	7.19	29.1	49.1	39.9	3.72	25.3	14.6	10.7
79.0	0.790	235.8	79.1	9.1	13.24	7.33	29.1	49.1	39.9	3.67	25.4	14.5	10.9
84.0	0.840	237.9	79.1	9.1	14.08	7.40	29.1	49.1	40.0	3.66	25.5	14.5	10.9
90.0	0.900	240.2	79.0	9.0	15.09	7.49	29.0	49.0	40.1	3.63	25.5	14.5	11.0
	Values @ Failure			9.4	4.86	6.68	29.0	49.0	39.6	3.73	25.1	14.5	10.6
	Failure criteria used*		3	*Note:"1"=Max Deviator Stress;"2"=Deviator Stress @ 15% Strain;"3"=Max Eff.Stress Ratio(s'_1/s'_3)									

TIMELY ENGINEERING SOIL TESTS, LLC

1874 Forge Street Tucker, GA 30084
Phone: 770-938-8233
Fax: 770-923-8973
Web: www.test-llc.com

Tested By	EB/KP
Date	03/03/20
Checked By	[signature]

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33249/Ash #2	Depth/Elevation	-
Location	Yates	Additional Info	-

SPECIMEN PROPERTIES

	(initial)	(after consol.)
Height, in	6.000	5.939
Diameter, in	2.875	2.837
Height-to-Diameter Ratio	2.1	2.1
Area, in^2	6.49	6.32
Volume, cm^3	638.29	615.26
Mass of Wet Sample, g	1213.40	1256.10
Mass of Dry Sample, g	1031.76	1031.84
Wet Density, pcf	118.7	127.4
Dry Density, pcf	100.9	104.7
Specific Gravity (assumed)	2.639	2.639
Volume of Solids, cm^3	390.96	391.00
Volume of Voids, cm^3	247.33	224.26
Void Ratio	0.63	0.57
% Saturation	73.4	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	411.20	1616.60
Mass of Dry Sample and Tare, g	366.50	1392.36
Mass of Tare, g	112.60	360.60
Moisture, %	17.61	21.73

TEST DATA PRIOR TO LOADING

Machine Speed, in / min	0.0100
Strain Rate, % / min	0.17
Chamber Pressure, psi	110.0
Back Pressure,psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	40.0
Change in Height, in	0.061
"B" Value	0.95

SHEAR DATA

Elapsed Time (min)	Deformation (inch)	Axial Load (lb)	Pore-Water Pressure,psi		Total Strain (%)	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$)	Major Principal Stress,psi		Eff.Stress Ratio	P' ($(s'_1+s'_3)/2$)	Q ($[(s_1-s_3)/2]$)	Eff. Minor Pr. Stress
			Total,U	Change,DU			(psi)	Total s_1	Eff. s'_1	s'_1/s'_3	(psi)	(psi)	s'_3 (psi)
0.0	0.000	25.6	70.0	0.0	0.00	6.32	0.0	40.0	40.0	1.00	40.0	0.0	40.0
1.0	0.010	159.9	75.3	5.3	0.17	6.33	21.2	61.2	56.0	1.61	45.4	10.6	34.7
2.0	0.020	202.1	78.9	8.9	0.34	6.34	27.8	67.8	58.9	1.89	45.0	13.9	31.1
3.0	0.030	229.7	81.5	11.5	0.50	6.35	32.1	72.1	60.6	2.13	44.5	16.1	28.5
4.0	0.040	250.3	83.5	13.5	0.67	6.36	35.3	75.3	61.8	2.33	44.1	17.7	26.5
5.0	0.050	265.9	85.0	15.0	0.84	6.38	37.7	77.7	62.6	2.51	43.8	18.8	25.0
7.0	0.070	286.8	87.2	17.2	1.18	6.40	40.8	80.8	63.6	2.79	43.2	20.4	22.8
10.0	0.100	303.1	89.0	19.0	1.68	6.43	43.2	83.2	64.1	3.06	42.5	21.6	21.0
12.0	0.120	309.6	90.1	20.1	2.02	6.45	44.0	84.0	63.9	3.22	41.9	22.0	19.9
15.0	0.150	315.0	91.2	21.2	2.53	6.49	44.6	84.6	63.4	3.37	41.1	22.3	18.8
17.0	0.170	316.7	91.7	21.7	2.86	6.51	44.7	84.7	63.0	3.45	40.7	22.4	18.3
20.0	0.200	318.5	92.1	22.1	3.37	6.54	44.8	84.8	62.7	3.50	40.3	22.4	17.9
24.0	0.240	320.2	92.4	22.4	4.04	6.59	44.7	84.7	62.3	3.54	40.0	22.4	17.6
29.0	0.290	322.1	92.6	22.6	4.88	6.65	44.6	84.6	62.0	3.56	39.7	22.3	17.4
35.0	0.350	325.1	92.7	22.7	5.89	6.72	44.6	84.6	61.9	3.58	39.6	22.3	17.3
40.0	0.400	327.1	92.7	22.7	6.73	6.78	44.5	84.5	61.8	3.57	39.5	22.2	17.3
45.0	0.450	329.3	92.7	22.7	7.58	6.84	44.4	84.4	61.7	3.56	39.5	22.2	17.3
49.0	0.490	331.6	92.9	22.9	8.25	6.89	44.4	84.4	61.5	3.60	39.3	22.2	17.1
59.0	0.590	336.5	93.2	23.2	9.93	7.02	44.3	84.3	61.1	3.63	39.0	22.1	16.8
69.0	0.690	340.8	93.0	23.0	11.62	7.15	44.1	84.1	61.1	3.59	39.0	22.0	17.0
79.0	0.790	345.1	92.8	22.8	13.30	7.29	43.8	83.8	61.0	3.54	39.1	21.9	17.2
84.0	0.840	347.2	92.6	22.6	14.14	7.36	43.7	83.7	61.1	3.51	39.2	21.8	17.4
90.0	0.900	351.2	92.5	22.5	15.15	7.45	43.7	83.7	61.2	3.50	39.3	21.8	17.5
Values @ Failure				23.2	9.93	7.02	44.3	84.3	61.1	3.63	39.0	22.1	16.8

Failure criteria used* 3

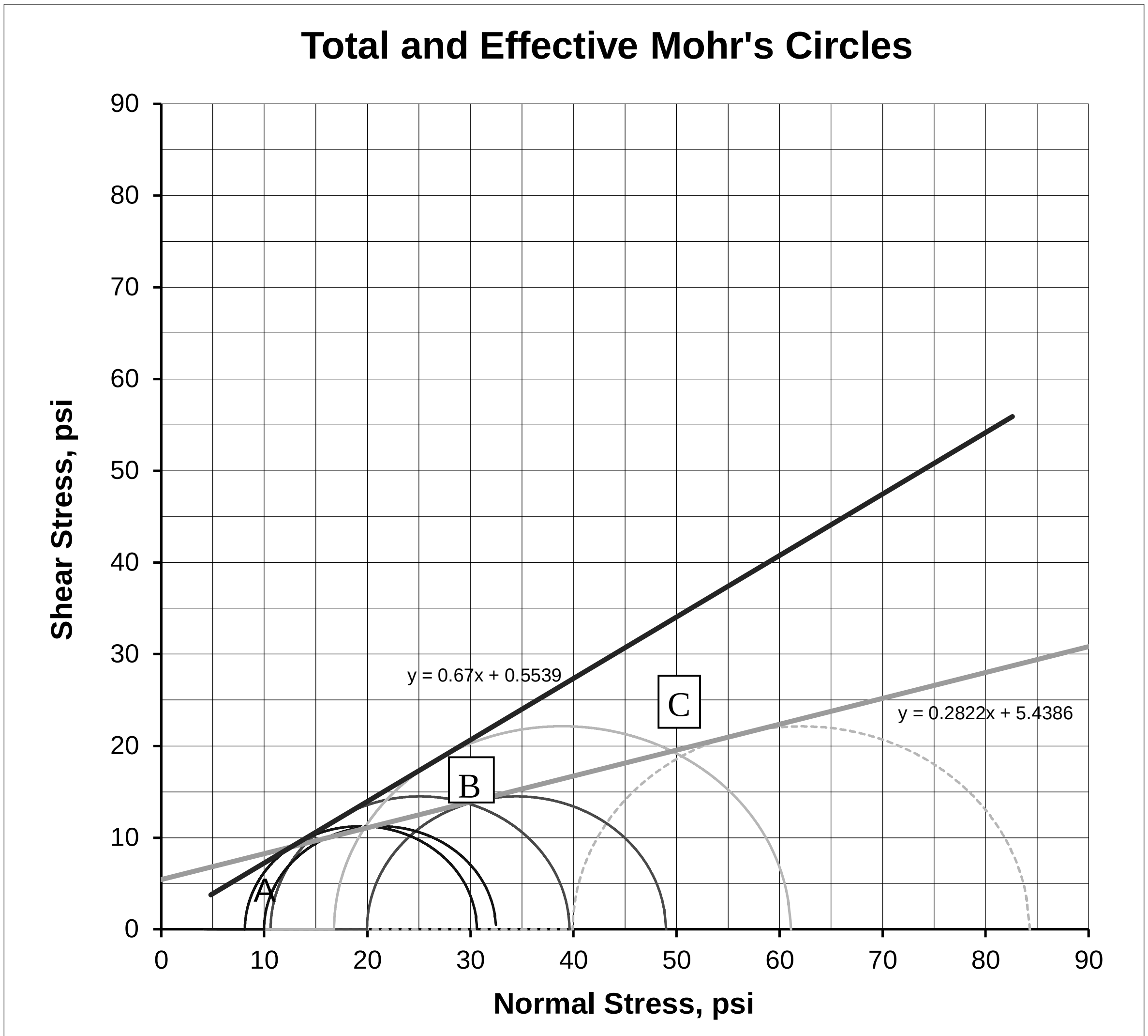
*Note:"1"=Max Deviator Stress;"2"=Deviator Stress @ 15% Strain;"3"=Max Eff.Stress Ratio(s'_1/s'_3)

TIMELY **E**NGINEERING **S**OIL **T**ESTS, LLC	1874 Forge Street Tucker, GA 30084 Phone: 770-938-8233 Fax: 770-923-8973 Web: www.test-llc.com	AASHTO ACCREDITED	Tested By: EB/KP Date: 03/03/20 Check: [signature]

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Project #	I054-107	Laboratory Project #	2008-08-1
Project Name	AMA	Sample Type	Remold
Sample ID	33249/Ash #2	Depth/Elevation	-
Location	Yates	Additional Info	-



Specimen	A	B	C
Effective Consolidation Stress, psi	10.0	20.0	40.0
Deviator Stress at Failure, psi	22.5	29.0	44.3
Effective Minor Principal Stress at Failure, psi	8.1	10.6	16.8
Effective Major Principal Stress at Failure, psi	30.6	39.6	61.1
Axial Strain at Failure, %	2.85	4.86	9.93

STRENGTH PARAMETERS*			
Total		Effective	
f °	15.8	f ' °	33.8
C, psi	5.4	C', psi	0.6

***Valid only for Received Material at Reported Densities and Moisture Contents. Please see remarks on page 6 of this report**

Triaxial CU.xls [Mohr's Circles], REV. 1; 10-10-05

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TESTS, LLC

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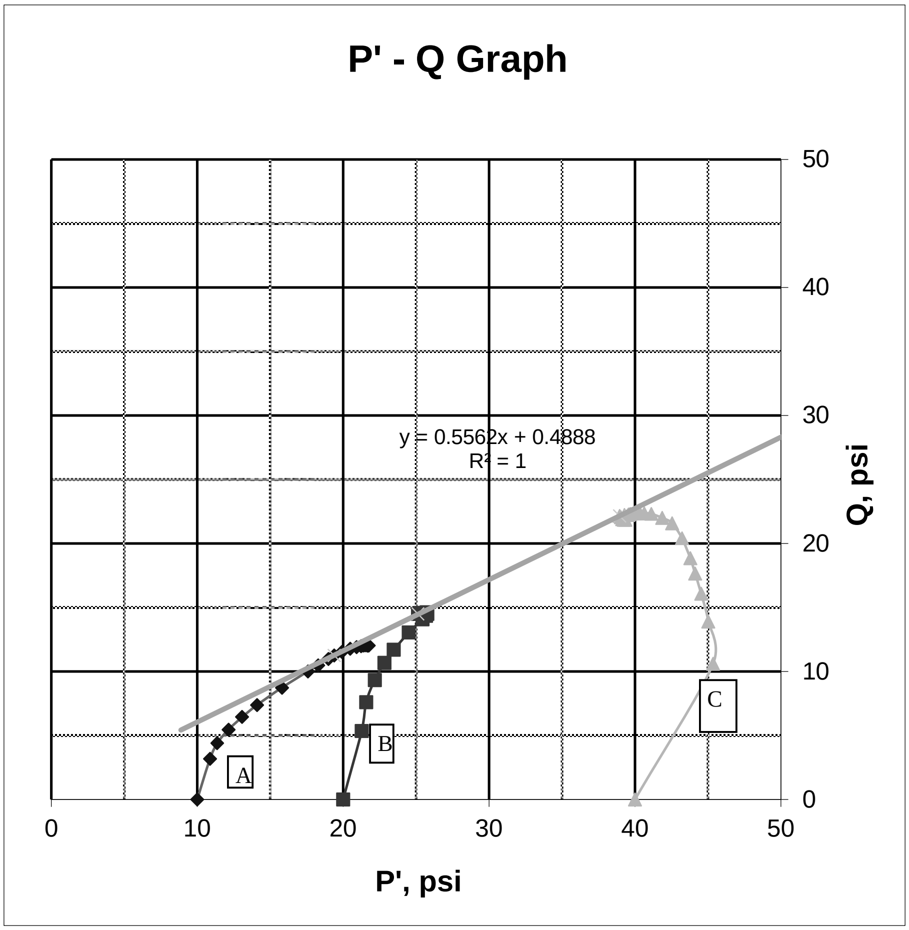
AASHTO ACCREDITED

Tested By	EB/KP
Date	03/03/20
Check	

ASTM D 4767 / AASHTO T 297

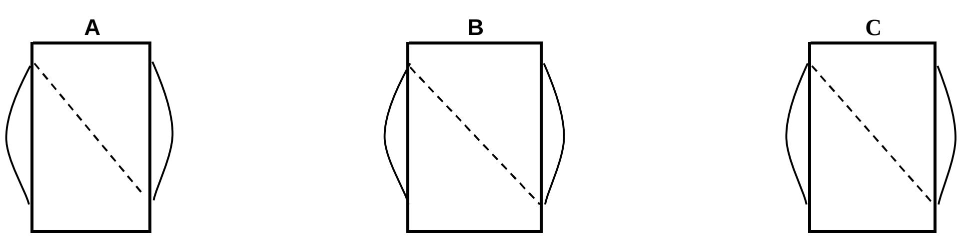
Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33249/Ash #2	Depth/Elevation	-
Location	Yates	Additional Info	-



a, psi	0.5
a, degree	29.1

FAILURE SKETCH



REMOLDING PROPERTIES

	A	B	C
% Compaction of Max Dry Density	95.0	95.0	95.0
% Difference from Optimum M.C.	2.1	2.1	2.1

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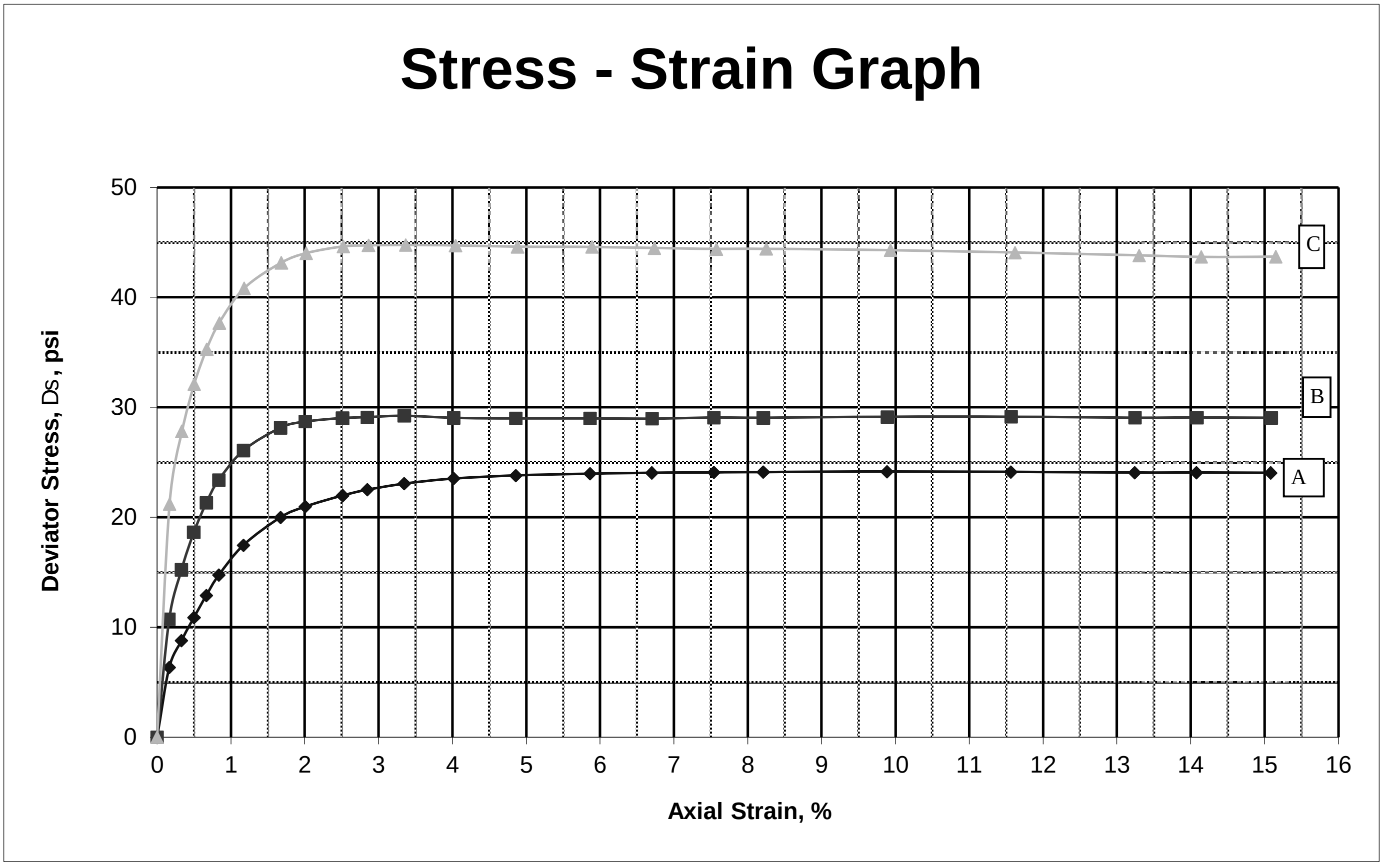
ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33249/Ash #2	Depth/Elevation	-
Location	Yates	Additional Info	-



Balance ID Number	563/700
Oven ID Number	496/610
Deformation Indicator ID #	178/349/689
Digital Caliper ID #	370/458
Load Cell ID #	347/692/815
Apparatus ID #	293/693/814

REMARKS

Samples (Material passing #4 Sieve) were remolded to specified % compaction and moisture content of Standard Proctor values

DESCRIPTION

Gray and Yellowish Brown Silty Sand

NOTES:

1. Method for Saturation — WET
2. Method for determination of cross-sectional after consolidation — B
3. Initial specimen moisture content obtained from cuttings
4. Final specimen moisture content obtained from entire sample

LL	-
PL	-
PI	-
Gs	-

USCS (ASTM D2487: D2488)

SM

Triaxial CU.xls [Stress-Strain GRAPH], REV. 1; 10-10-05

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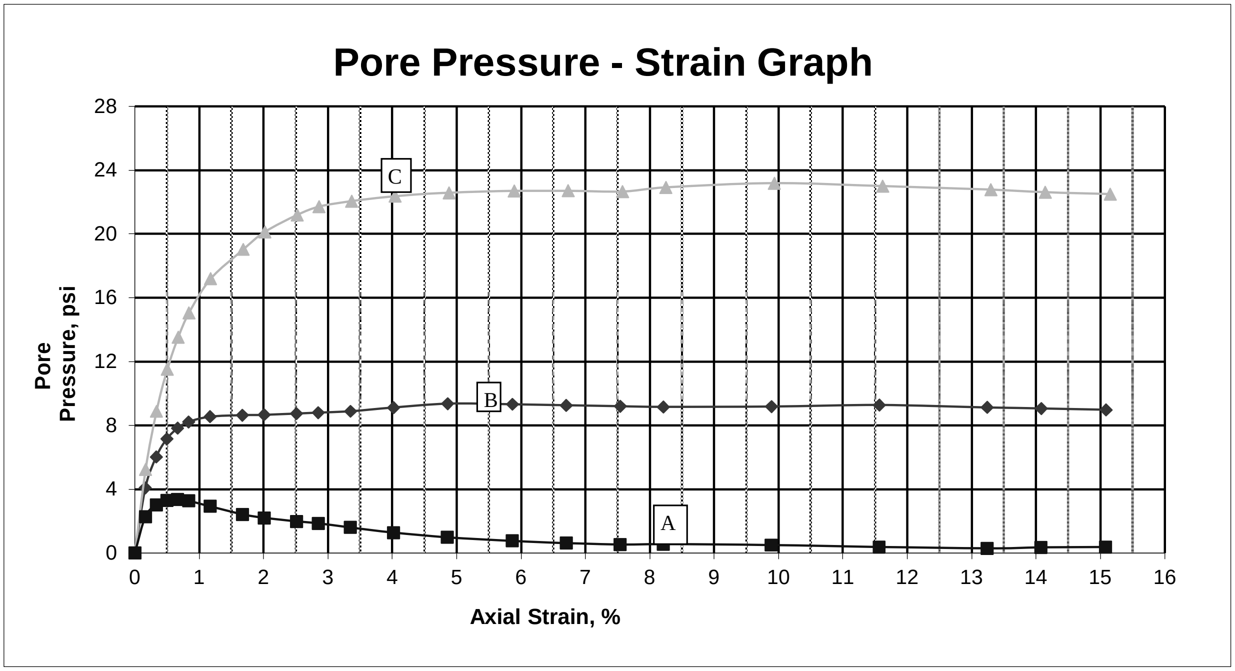
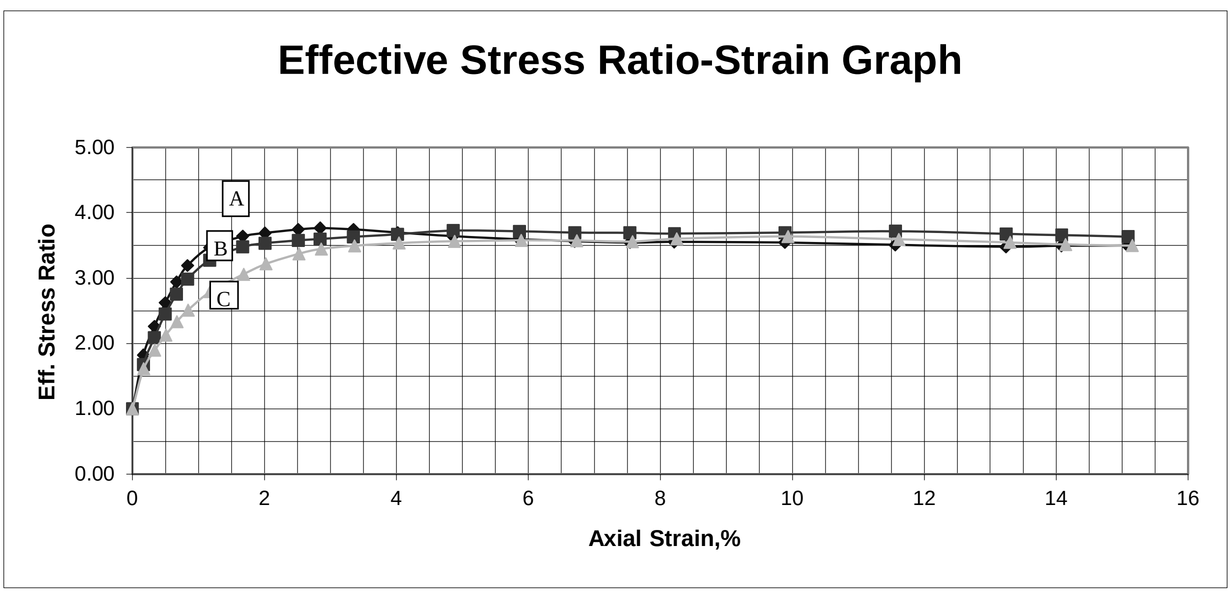
ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33249/Ash #2	Depth/Elevation	-
Location	Yates	Additional Info	-





Triaxial CU.xls [Stress Ratio & Pore Water Pr.-Strain GRAPH], REV. 1; 10-10-05

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			Tested By	IH
			Date	03/04/20
			Checked By	LB

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33249/Ash #2	Depth/Elev.	-
Location	Yates	Add. Info	-

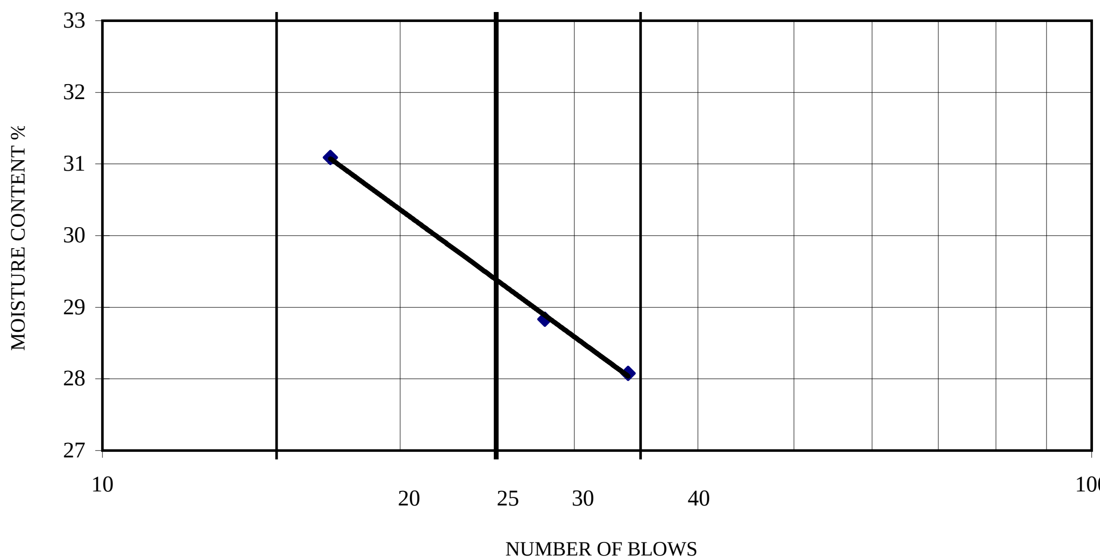
ASTM D 4318/AASHTO T 88, T 89

Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils (Atterberg Limits)

LIQUID LIMIT

Number of Blows	34	28	17
Mass of Wet Sample & Tare, g	36.91	40.29	36.82
Mass of Dry Sample & Tare, g	34.06	36.98	33.77
Mass of Tare, g	23.91	25.50	23.96
Moisture Content, %	28.08	28.83	31.09

Oven ID #	15/496/610
Balance ID #	139/563
Liquid Limit Device ID #	451/569



PLASTIC LIMIT

Mass of Wet Sample & Tare, g	38.92	37.79
Mass of Dry Sample & Tare, g	36.31	35.33
Mass of Tare, g	25.31	24.88
Moisture Content, %	23.73	23.54

NOTE: MATERIAL PASSING NO. 40 SIEVE WAS USED FOR TEST

NATURAL MOISTURE

Mass of Wet Sample & Tare, g	621.10
Mass of Dry Sample & Tare, g	520.60
Mass of Tare, g	175.70
Moisture Content, %	29.14

LIQUID LIMIT (LL)	29
PLASTIC LIMIT (PL)	24
PLASTICITY INDEX (PI)	5
LIQUIDITY INDEX (LI)	1.03

DESCRIPTION: Gray and Yellowish Brown Silty Sand

USCS (ASTM D2487; D2488): SM

AASHTO (M 145): NA

TIMELY ENGINEERING SOIL TESTS, LLC

1874 Forge Street Tucker, GA 30084
Phone: 770-938-8233
Fax: 770-923-8973
Web: www.test-llc.com

AASHTO ACCREDITED

Tested By	RI
Date	02/28/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33249/Ash #2	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 422/AASHTO T 88

Standard Test Method for Particle-Size Analysis of Soils (with Double Separation per ASTM D6913 and Hydrometer Analysis)

As-Received Moisture Content (Total Sample)

Mass of Wet Sample & Tare, g	621.1
Mass of Dry Sample & Tare, g	520.6
Mass of Tare, g	175.7
Moisture Content, %	29.1

Moisture Content of FINER PORTION

	1st Subsample	2nd Subsample
Mass of Wet Sample & Tare, g	462.2	483.70
Mass of Dry Sample & Tare, g	460.5	480.20
Mass of Tare, g	128.7	93.60
Moisture Content, %	0.5	0.9

Mass of Total Sample before separation on 3/8" sieve & Tare, g	21200
Mass of Tare, g	0.0
Total Mass of Dry Sample, g	16416

	1st Subsample	2nd Subsample
Mass of Wet Finer Portion & Tare, g	1501.3	82.70
Mass of Tare	0.0	0.0
Dry Mass, g	1493.6	81.96
% of Total Sample passing Split Sieve	99.0	97.4

SIEVE ANALYSIS

COARSER PORTION OF SAMPLE (RETAINED ON 3/8" SIEVE)

Mass of Tare, g: 0.00

Sieve Size		Sample & Tare, g	% RETAINED	% PASSING (of Total)
12"	COBBLES		0	100
3"	COARSE GRAVEL		0	100
2.5"			0	100
2"			0	100
1.5"			0	100
1"		0.0	0	100
.75"	FINE GRAVEL	74.4	0	100
.5"		130.1	1	99
.375"		165.0	1	99
#4	COARSE SAND	23.8	2	97

#4 <First Subsample of Finer Portion<3/8"

2nd Subsample of FINER PORTION OF SAMPLE (PASSING #4 SIEVE:Hydrometer Backsieve)

Sieve Size		Cumulative Mass retained, g	% PASSING (of Total)
#10	MEDIUM SAND	2.55	94
#20		7.39	89
#40	FINE SAND	16.69	78
#60		27.01	65
#100		37.17	53
#200	FINES	47.03	42

Remarks

HYDROMETER ANALYSIS

Length of Dispersion Period	1 Minute
Mechanical Dispersion Device ID #	61
Amount of Dispersing Agent (ml)	125.0
Specific Gravity (assumed)	2.650
Specific Gravity (tested)	
Starting time	14:02

PARTICLE-SIZE ANALYSIS

% COBBLES	0	% MEDIUM SAND	17
% COARSE GRAVEL	0	% FINE SAND	36
% FINE GRAVEL	2	% FINES	42
% COARSE SAND	3	% TOTAL SAMPLE	100
% CLAY(<0.005mm)	17	% CLAY(<0.002mm)	13

Date	Time	Testing time (min)	Reading	Temp (°C)	K	Composite Correction	Actual Reading	Effective Depth (cm)	a	Particle Diam. (mm)	Percent Passing
03/04/20	14:04	2	34.0	17.7	0.01399	6.5	27.5	11.8	1.00	0.0340	32.7
03/04/20	14:07	5	30.5	17.7	0.01399	6.5	24.0	12.4	1.00	0.0220	28.5
03/04/20	14:17	15	27.0	17.7	0.01399	6.5	20.5	13.0	1.00	0.0130	24.4
03/04/20	14:32	30	24.0	17.7	0.01399	6.5	17.5	13.5	1.00	0.0094	20.8
03/04/20	15:02	60	23.0	17.7	0.01399	6.5	16.5	13.6	1.00	0.0067	19.6
03/04/20	18:12	250	18.0	17.7	0.01399	6.5	11.5	14.5	1.00	0.0034	13.7
03/05/20	14:02	1440	17.0	17.7	0.01399	6.5	10.5	14.6	1.00	0.0014	12.5

Hydrometer 152H ID #	305527	Oven ID #	15/496/610
Sieve Shaker ID #	555	Balance ID#	139/142/700

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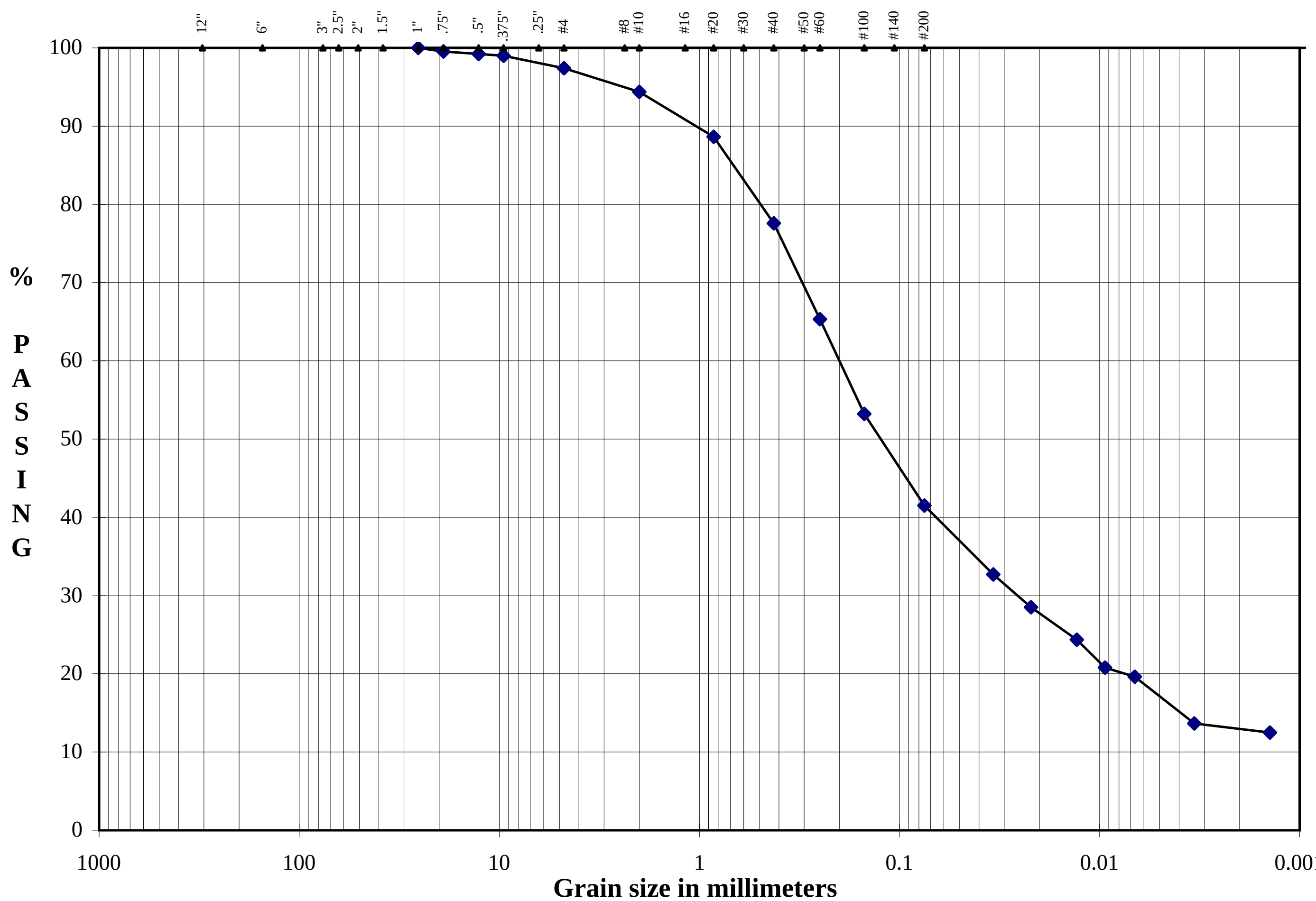
		Date	02/28/20
		Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33249/Ash #2	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 422/AASHTO T 88

Standard Test Method for Particle-Size Analysis of Soils (with Double Separation per ASTM D6913 and Hydrometer Analysis)

Particle-Size Analysis



Boulders	Cobbles	Gravel		Sand			Fines
		Coarse	Fine	Coarse	Medium	Fine	Silt or Clay

D_{10}	NA	mm
D_{30}	NA	mm
D_{60}	NA	mm
Cu	NA	
Cc	NA	

DESCRIPTION: Gray and Yellowish Brown Silty Sand

USCS (ASTM D2487; D2488): SM

Project's Specific % Passing	NA
Project's Specific Particle Size, mm	NA

TIMELY ENGINEERING SOIL TESTS, LLC	1874 Forge Street Tucker, GA 30084 Phone: 770-938-8233 Fax: 770-923-8973 Web: www.test-llc.com	Tested By	IH
		Date	02/28/20
		Checked By	[illegible]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33249/Ash #2	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 698
Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600kN-m/m^3))

DETERMINATION OF TEST PROCEDURE

	wet	dry
Mass of Soil before sieving, g	21200.0	16416.4
Mass of Mat. Retained on No. 4 sieve, g		
Mass of Mat. Retained on 3/8" sieve, g	165.0	165.0
Mass of Mat. Retained on 3/4" sieve, g		

MOISTURE CONTENT

	Coarse + Fine Fraction	Coarse Fraction
Mass of Wet Sample & Tare, g	621.1	165.0
Mass of Dry Sample & Tare, g	520.6	165.0
Mass of Tare, g	175.7	0.0
Moisture Content, %	29.1	0.0

Material Retained on No. 4 Sieve, %	
Material Retained on 3/8" Sieve, %	1.0
Material Retained on 3/4" Sieve, %	
Total, % (oversized)	1.0

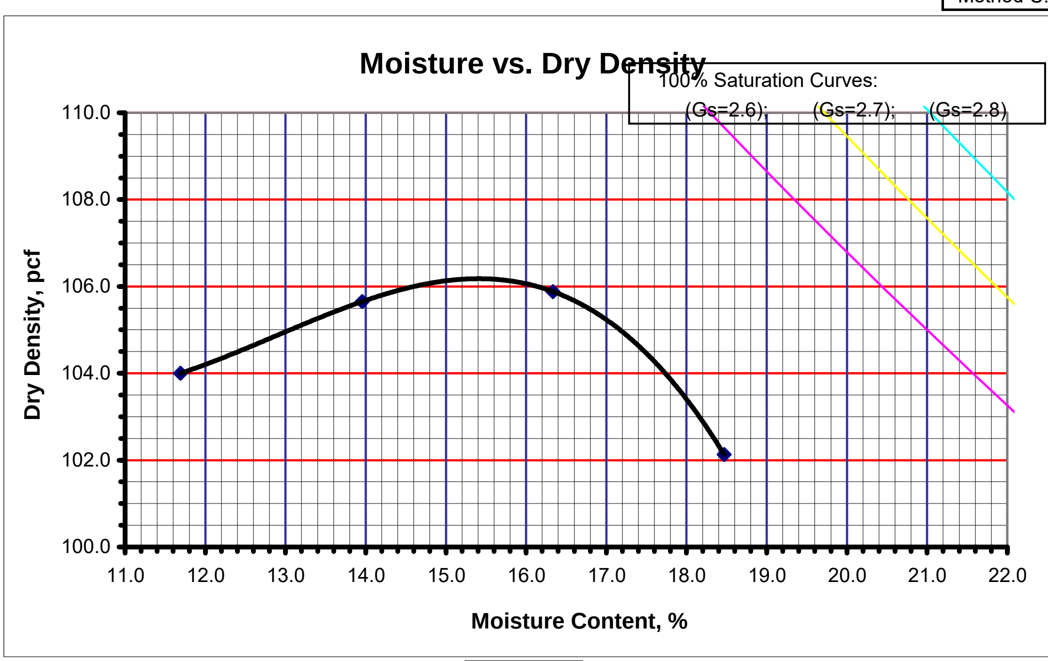
Procedure: B

TEST DATA

Points	1	2	3	4	5
Mass of Mold and Soil, g	6007.0	6071.0	6113.0	6080.0	
Mass of Wet Sample & Tare, g	552.3	519.5	465.8	478.6	
Mass of Dry Sample & Tare, g	512.9	478.3	425.6	423.4	
Mass of Tare, g	175.9	183.1	179.5	124.5	
Moisture Content, %	11.7	14.0	16.3	18.5	
Wet Density, pcf	116.2	120.4	123.2	121.0	
Dry Density, pcf	104.0	105.7	105.9	102.1	

Mold ID Number	798
Mass of Mold, g	4252.4
Volume of Mold, ft^3	0.0333
Hammer ID Number	318
Number of Blows per layer	25
Number of Layers	3
Mechanical Compactor ID Number	317

Method A: Material retained on No. 4 Sieve ≤ 25%
Method B: Material retained on 3/8" Sieve ≤ 25%
Method C: Material retained on 3/4" Sieve ≤ 30%



REMARKS

DESCRIPTION

Gray and Yellowish Brown Silty Sand

USCS (ASTM D2487; D2488): SM

AASHTO M145: NA

Maximum Dry Density, pcf	106.2	**Corrected Maximum Dry Density, pcf**	**NA**
Optimum Moisture Content, %	15.5	**Corrected Optimum Moisture Content, %**	**NA**

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Tested By	RI
Date	03/03/20
Checked By	[illegible]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33249/Ash #2	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D854; Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

TEST METHOD: B

MOISTURE CONTENT

Mass of Wet Sample & Tare, g	-
Mass of Dry Sample & Tare, g	-
Mass of Tare, g	-
Moisture Content, %	NA*

TEST DATA

Pycnometer Number	4
Mass of Pycnometer, g	139.31
Mass of Sample & Pycnometer, g	219.30
Mass of Sample, Water & Pycnometer, g	687.21
Test Temperature, ^oC	19.2
Mass of Tare,g	359.99
Mass of Dry Sample & Tare, g	439.60
Mass of Dry Soil, g	79.61
Mass of Pycnometer (Calibrated), g	139.31
Density of Water @ Test Temperature, g/mL	0.99837
Mass of Pycnometer & Water @ Test Temp.	637.78
Temperature Coefficient	1.00016
Calibrated Volume of Pycnometer, mL	499.28
Specific Gravity @ Test Temperature	2.638

SPECIFIC GRAVITY @ 20 ^oC: **2.639**

DESCRIPTION

Gray and Yellowish Brown Silty Sand

Thermometer ID Number	72
Vacuum Pump ID Number	62
Deaerator ID Number	213
Specific Gravity Board ID Number	214
Balance ID Number	139
Oven ID Number	12

USCS (ASTM D2487, D2488)

SM

NOTES:

1.* Oven-Dry material passing #4 sieve used for test.

2. Air removed by vacuum method.

3. Deionized / Deaired water was used for test.

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Tested By	EB/KP
Date	03/04/20
Checked By	(initials)

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33250/Borrow Soil #1	Depth/Elevation	-
Location	Yates	Additional Info	-

SPECIMEN PROPERTIES

	(initial)	(after consol.)
Height, in	6.000	5.983
Diameter, in	2.875	2.866
Height-to-Diameter Ratio	2.1	2.1
Area, in^2	6.49	6.45
Volume, cm^3	638.29	632.72
Mass of Wet Sample, g	1217.36	1266.60
Mass of Dry Sample, g	1011.79	1011.87
Wet Density, pcf	119.1	125.0
Dry Density, pcf	99.0	99.8
Specific Gravity (assumed)	2.677	2.677
Volume of Solids, cm^3	377.96	377.99
Volume of Voids, cm^3	260.33	254.73
Void Ratio	0.69	0.67
% Saturation	79.0	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	404.80	1626.60
Mass of Dry Sample and Tare, g	353.60	1371.89
Mass of Tare, g	101.60	360.10
Moisture, %	20.32	25.17

TEST DATA PRIOR TO LOADING

Machine Speed, in / min	0.0100
Strain Rate, % / min	0.17
Chamber Pressure, psi	80.0
Back Pressure,psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	10.0
Change in Height, in	0.017
"B" Value	0.95

SHEAR DATA

Elapsed Time (min)	Deformation (inch)	Axial Load (lb)	Pore-Water Pressure,psi Total,U	Pore-Water Pressure,psi Change,DU	Total Strain (%)	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$) (psi)	Major Principal Stress,psi Total s_1	Major Principal Stress,psi Eff. s'_1	Eff.Stress Ratio s'_1/s'_3	P' $(s'_1+s'_3)/2$ (psi)	Q $[(s_1-s_3)/2]$ (psi)	Eff. Minor Pr. Stress s'_3 (psi)
0.0	0.000	17.6	70.0	0.0	0.00	6.45	0.0	10.0	10.0	1.00	10.0	0.0	10.0
1.0	0.010	71.7	72.8	2.8	0.17	6.46	8.4	18.4	15.5	2.17	11.3	4.2	7.2
2.0	0.020	90.2	73.6	3.6	0.33	6.48	11.2	21.2	17.7	2.74	12.0	5.6	6.4
3.0	0.030	102.9	73.8	3.8	0.50	6.49	13.2	23.2	19.4	3.11	12.8	6.6	6.2
4.0	0.040	114.4	73.8	3.8	0.67	6.50	14.9	24.9	21.1	3.39	13.7	7.4	6.2
5.0	0.050	124.5	73.7	3.7	0.84	6.51	16.4	26.4	22.8	3.59	14.6	8.2	6.3
7.0	0.070	140.2	73.2	3.2	1.17	6.53	18.8	28.8	25.5	3.78	16.1	9.4	6.8
10.0	0.100	155.8	72.5	2.5	1.67	6.56	21.0	31.0	28.5	3.81	18.0	10.5	7.5
12.0	0.120	162.3	72.1	2.1	2.01	6.59	22.0	32.0	29.9	3.78	18.9	11.0	7.9
15.0	0.150	169.5	71.6	1.6	2.51	6.62	23.0	33.0	31.4	3.72	19.9	11.5	8.4
17.0	0.170	173.2	71.3	1.3	2.84	6.64	23.4	33.4	32.1	3.69	20.4	11.7	8.7
20.0	0.200	177.9	70.9	0.9	3.34	6.68	24.0	34.0	33.1	3.65	21.1	12.0	9.1
24.0	0.240	183.2	70.6	0.6	4.01	6.72	24.6	34.6	34.0	3.63	21.7	12.3	9.4
29.0	0.290	188.7	70.4	0.4	4.85	6.78	25.2	35.2	34.8	3.63	22.2	12.6	9.6
35.0	0.350	194.7	70.0	0.0	5.85	6.85	25.8	35.8	35.8	3.60	22.9	12.9	10.0
40.0	0.400	199.1	69.8	-0.2	6.69	6.92	26.2	36.2	36.5	3.57	23.3	13.1	10.2
45.0	0.450	203.5	69.6	-0.4	7.52	6.98	26.6	36.6	37.1	3.55	23.8	13.3	10.4
49.0	0.490	206.7	69.4	-0.6	8.19	7.03	26.9	36.9	37.5	3.53	24.1	13.5	10.6
59.0	0.590	215.1	69.0	-1.0	9.86	7.16	27.6	37.6	38.5	3.52	24.7	13.8	11.0
69.0	0.690	222.6	68.9	-1.1	11.53	7.29	28.1	38.1	39.2	3.52	25.2	14.0	11.1
79.0	0.790	230.0	68.5	-1.5	13.20	7.44	28.6	38.6	40.0	3.49	25.8	14.3	11.5
84.0	0.840	233.1	68.4	-1.6	14.04	7.51	28.7	38.7	40.3	3.47	26.0	14.4	11.6
90.0	0.900	237.5	68.2	-1.8	15.04	7.60	28.9	38.9	40.8	3.45	26.3	14.5	11.8
Values @ Failure				2.5	1.67	6.56	21.0	31.0	28.5	3.81	18.0	10.5	7.5

Failure criteria used*: 3

*Note:"1"=Max Deviator Stress;"2"=Deviator Stress @ 15% Strain;"3"=Max Eff.Stress Ratio(s'_1/s'_3)

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Tested By	EB/KP
Date	03/04/20
Checked By	

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33250/Borrow Soil #1	Depth/Elevation	-
Location	Yates	Additional Info	-

SPECIMEN PROPERTIES

		(initial)	(after consol.)
Height, in		6.000	5.971
Diameter, in		2.875	2.856
Height-to-Diameter Ratio		2.1	2.1
Area, in^2		6.49	6.41
Volume, cm^3		638.29	626.84
Mass of Wet Sample, g		1217.50	1260.80
Mass of Dry Sample, g		1011.91	1011.99
Wet Density, pcf		119.1	125.6
Dry Density, pcf		99.0	100.8
Specific Gravity	(assumed)	2.677	2.677
Volume of Solids, cm^3		378.00	378.03
Volume of Voids, cm^3		260.29	248.81
Void Ratio		0.69	0.66
% Saturation		79.0	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	404.80	1562.80
Mass of Dry Sample and Tare, g	353.60	1314.01
Mass of Tare, g	101.60	302.10
Moisture, %	20.32	24.59

TEST DATA PRIOR TO LOADING

Machine Speed, in / min	0.0100
Strain Rate, % / min	0.17
Chamber Pressure, psi	90.0
Back Pressure,psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	20.0
Change in Height, in	0.029
"B" Value	0.95

SHEAR DATA

Elapsed Time (min)	Deformation (inch)	Axial Load (lb)	Pore-Water Pressure,psi		Total Strain (%)	Corrected Area (in^2)	Dev.Stress ($D s=s_1-s_3$)	Major Principal Stress,psi		Eff.Stress Ratio	P' $(s'_1+s'_3)/2$ (psi)	Q $[(s_1-s_3)/2]$ (psi)	Eff. Minor Pr. Stress
			Total,U	Change,DU			(psi)	Total s_1	Eff. s'_1	s'_1/s'_3			s'_3 (psi)
0.0	0.000	23.6	70.0	0.0	0.00	6.41	0.0	20.0	20.0	1.00	20.0	0.0	20.0
1.0	0.010	95.3	74.0	4.0	0.17	6.42	11.2	31.2	27.1	1.70	21.5	5.6	16.0
2.0	0.020	119.1	75.9	5.9	0.33	6.43	14.9	34.9	28.9	2.06	21.5	7.4	14.1
3.0	0.030	132.0	76.9	6.9	0.50	6.44	16.8	36.8	29.9	2.29	21.5	8.4	13.1
4.0	0.040	142.5	77.5	7.5	0.67	6.45	18.4	38.4	30.9	2.48	21.7	9.2	12.5
5.0	0.050	151.4	78.0	8.0	0.84	6.46	19.8	39.8	31.8	2.64	21.9	9.9	12.0
7.0	0.070	165.3	78.5	8.5	1.17	6.48	21.9	41.9	33.4	2.90	22.5	10.9	11.5
10.0	0.100	179.5	78.8	8.8	1.67	6.52	23.9	43.9	35.2	3.13	23.2	12.0	11.2
12.0	0.120	187.2	78.8	8.8	2.01	6.54	25.0	45.0	36.2	3.23	23.7	12.5	11.2
15.0	0.150	195.6	78.7	8.7	2.51	6.57	26.2	46.2	37.4	3.33	24.3	13.1	11.3
17.0	0.170	201.3	78.7	8.7	2.85	6.59	26.9	46.9	38.2	3.39	24.7	13.5	11.3
20.0	0.200	207.9	78.7	8.7	3.35	6.63	27.8	47.8	39.1	3.47	25.2	13.9	11.3
24.0	0.240	215.0	78.6	8.6	4.02	6.67	28.7	48.7	40.1	3.52	25.7	14.3	11.4
29.0	0.290	222.1	78.2	8.2	4.86	6.73	29.5	49.5	41.3	3.50	26.5	14.7	11.8
35.0	0.350	230.5	77.8	7.8	5.86	6.81	30.4	50.4	42.6	3.48	27.4	15.2	12.2
40.0	0.400	235.0	77.4	7.4	6.70	6.87	30.8	50.8	43.3	3.45	28.0	15.4	12.6
45.0	0.450	240.8	77.1	7.1	7.54	6.93	31.3	51.3	44.2	3.44	28.5	15.7	12.9
49.0	0.490	244.4	76.9	6.9	8.21	6.98	31.6	51.6	44.7	3.42	28.9	15.8	13.1
59.0	0.590	253.8	76.8	6.8	9.88	7.11	32.4	52.4	45.6	3.46	29.4	16.2	13.2
69.0	0.690	261.6	76.3	6.3	11.56	7.24	32.9	52.9	46.6	3.39	30.2	16.4	13.7
79.0	0.790	269.2	75.8	5.8	13.23	7.38	33.3	53.3	47.4	3.35	30.8	16.6	14.2
84.0	0.840	272.7	75.6	5.6	14.07	7.46	33.4	53.4	47.8	3.33	31.1	16.7	14.4
90.0	0.900	276.6	75.6	5.6	15.07	7.54	33.5	53.5	47.9	3.33	31.2	16.8	14.4
Values @ Failure				8.6	4.02	6.67	28.7	48.7	40.1	3.52	25.7	14.3	11.4
Failure criteria used*			3										

*Note:"1"=Max Deviator Stress;"2"=Deviator Stress @ 15% Strain;"3"=Max Eff.Stress Ratio(s'_1/s'_3)

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AASHTO ACCREDITED

Tested By	EB/KP
Date	03/04/20
Checked By	[signature]

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33250/Borrow Soil #1	Depth/Elevation	-
Location	Yates	Additional Info	-

SPECIMEN PROPERTIES

		(initial)	(after consol.)
Height, in		6.000	5.923
Diameter, in		2.875	2.838
Height-to-Diameter Ratio		2.1	2.1
Area, in^2		6.49	6.33
Volume, cm^3		638.29	613.99
Mass of Wet Sample, g		1217.80	1248.00
Mass of Dry Sample, g		1012.16	1012.07
Wet Density, pcf		119.1	126.9
Dry Density, pcf		99.0	102.9
Specific Gravity	(assumed)	2.677	2.677
Volume of Solids, cm^3		378.09	378.06
Volume of Voids, cm^3		260.20	235.93
Void Ratio		0.69	0.62
% Saturation		79.0	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	404.80	1582.00
Mass of Dry Sample and Tare, g	353.60	1346.06
Mass of Tare, g	101.60	333.90
Moisture, %	20.32	23.31

TEST DATA PRIOR TO LOADING

Machine Speed, in / min	0.0100
Strain Rate, % / min	0.17
Chamber Pressure, psi	110.0
Back Pressure,psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	40.0
Change in Height, in	0.077
"B" Value	0.95

SHEAR DATA

Elapsed Time (min)	Deformation (inch)	Axial Load (lb)	Pore-Water Pressure,psi		Total Strain (%)	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$)	Major Principal Stress,psi		Eff.Stress Ratio	P' $(s'_1+s'_3)/2$ (psi)	Q $[(s_1-s_3)/2]$ (psi)	Eff. Minor Pr. Stress
			Total,U	Change,DU			(psi)	Total s_1	Eff. s'_1	s'_1/s'_3			s'_3 (psi)
0.0	0.000	25.6	70.0	0.0	0.00	6.33	0.0	40.0	40.0	1.00	40.0	0.0	40.0
1.0	0.010	120.1	77.1	7.1	0.17	6.34	14.9	54.9	47.8	1.45	40.4	7.5	32.9
2.0	0.020	156.8	81.0	11.0	0.34	6.35	20.7	60.7	49.7	1.71	39.4	10.3	29.0
3.0	0.030	181.7	83.6	13.6	0.51	6.36	24.6	64.6	51.0	1.93	38.7	12.3	26.4
4.0	0.040	200.9	85.5	15.5	0.67	6.37	27.5	67.5	52.1	2.12	38.3	13.8	24.5
5.0	0.050	215.9	86.8	16.8	0.84	6.38	29.8	69.8	53.0	2.29	38.1	14.9	23.2
7.0	0.070	237.4	88.6	18.6	1.18	6.40	33.1	73.1	54.4	2.55	37.9	16.5	21.4
10.0	0.100	259.3	90.2	20.2	1.69	6.43	36.3	76.3	56.1	2.84	37.9	18.2	19.8
12.0	0.120	269.6	90.9	20.9	2.03	6.46	37.8	77.8	56.9	2.97	38.0	18.9	19.1
15.0	0.150	281.1	91.4	21.4	2.53	6.49	39.4	79.4	58.0	3.12	38.3	19.7	18.6
17.0	0.170	287.2	91.6	21.6	2.87	6.51	40.2	80.2	58.5	3.19	38.5	20.1	18.4
20.0	0.200	295.0	91.8	21.8	3.38	6.55	41.1	81.1	59.3	3.26	38.8	20.6	18.2
24.0	0.240	303.4	91.9	21.9	4.05	6.59	42.1	82.1	60.3	3.32	39.2	21.1	18.1
29.0	0.290	312.3	91.7	21.7	4.90	6.65	43.1	83.1	61.4	3.36	39.8	21.6	18.3
35.0	0.350	321.3	91.9	21.9	5.91	6.72	44.0	84.0	62.1	3.43	40.1	22.0	18.1
40.0	0.400	327.7	91.9	21.9	6.75	6.78	44.5	84.5	62.6	3.46	40.3	22.3	18.1
45.0	0.450	333.9	91.6	21.6	7.60	6.85	45.0	85.0	63.4	3.45	40.9	22.5	18.4
49.0	0.490	338.3	91.4	21.4	8.27	6.90	45.3	85.3	63.9	3.44	41.3	22.7	18.6
59.0	0.590	348.9	90.9	20.9	9.96	7.03	46.0	86.0	65.2	3.41	42.1	23.0	19.1
69.0	0.690	358.8	90.6	20.6	11.65	7.16	46.5	86.5	65.9	3.40	42.7	23.3	19.4
79.0	0.790	368.2	90.4	20.4	13.34	7.30	46.9	86.9	66.5	3.40	43.1	23.5	19.6
84.0	0.840	372.7	90.1	20.1	14.18	7.37	47.1	87.1	67.0	3.37	43.4	23.5	19.9
90.0	0.900	377.5	89.8	19.8	15.19	7.46	47.2	87.2	67.3	3.34	43.8	23.6	20.2
Values @ Failure				21.9	6.75	6.78	44.5	84.5	62.6	3.46	40.3	22.3	18.1

Failure criteria used* 3

*Note:"1"=Max Deviator Stress;"2"=Deviator Stress @ 15% Strain;"3"=Max Eff.Stress Ratio(s'_1/s'_3)

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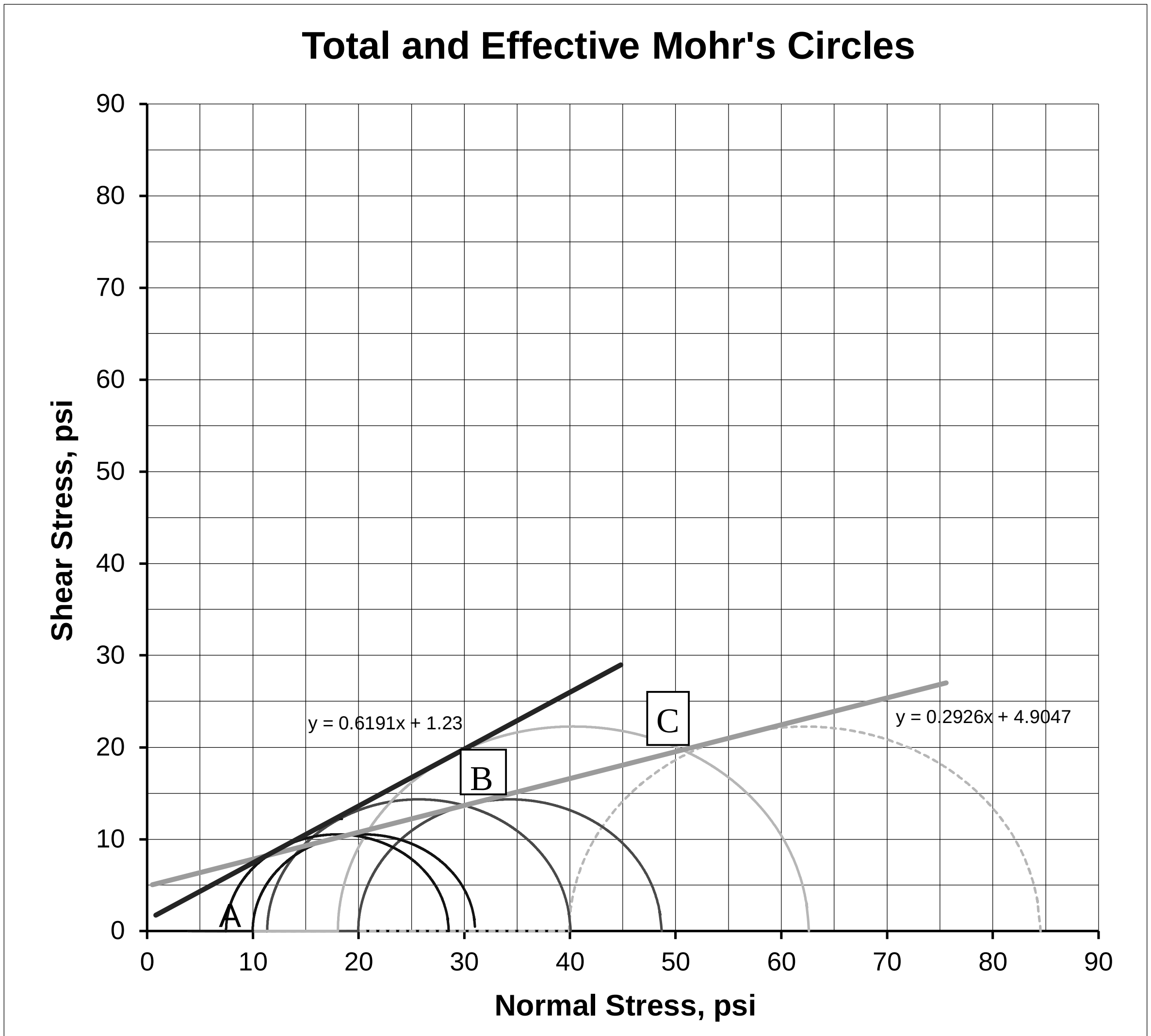
ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Project #	I054-107	Laboratory Project #	2008-08-1
Project Name	AMA	Sample Type	Remold
Sample ID	33250/Borrow Soil #1	Depth/Elevation	-
Location	Yates	Additional Info	-



Specimen	A	B	C
Effective Consolidation Stress, psi	10.0	20.0	40.0
Deviator Stress at Failure, psi	21.0	28.7	44.5
Effective Minor Principal Stress at Failure, psi	7.5	11.4	18.1
Effective Major Principal Stress at Failure, psi	28.5	40.1	62.6
Axial Strain at Failure, %	1.67	4.02	6.75

STRENGTH PARAMETERS*			
Total		Effective	
f °	16.3	f ' °	31.8
C, psi	4.9	C', psi	1.2

***Valid only for Received Material at Reported Densities and Moisture Contents. Please see remarks on page 6 of this report**

Triaxial CU.xls [Mohr's Circles], REV. 1; 10-10-05

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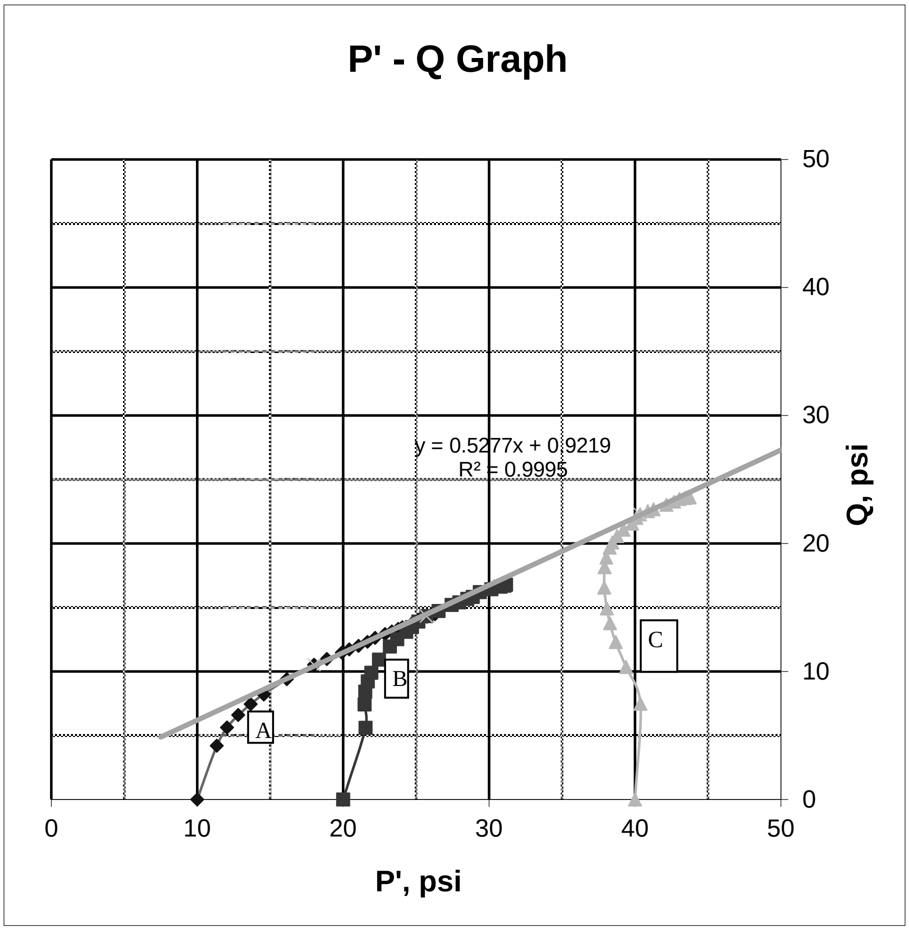
ASTM D 4767 / AASHTO T 297

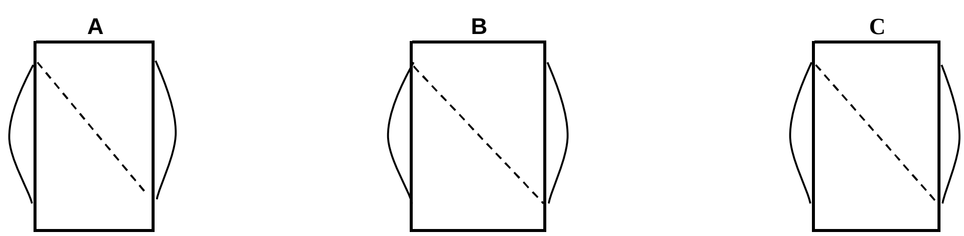
Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33250/Borrow Soil #1	Depth/Elevation	-
Location	Yates	Additional Info	-



a, psi	**0.9**
a, degree	**27.8**

FAILURE SKETCH



REMOLDING PROPERTIES

	A	B	C
% Compaction of Max Dry Density	95.0	95.0	95.0
% Difference from Optimum M.C.	3.1	3.1	3.1

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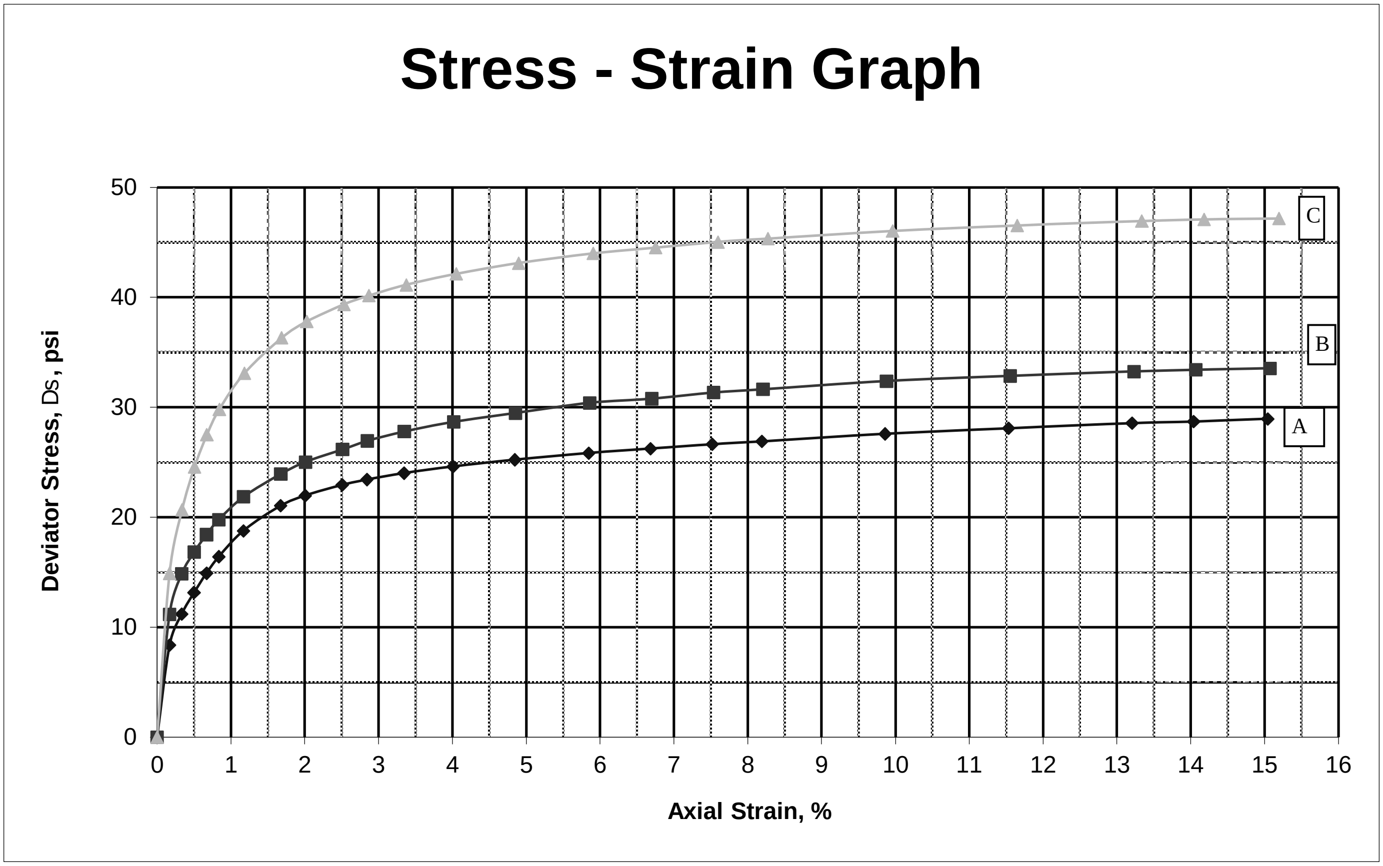
		Date	03/04/20
		Check	

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33250/Borrow Soil #1	Depth/Elevation	-
Location	Yates	Additional Info	-



		REMARKS	DESCRIPTION
Balance ID Number	563/700	Samples (Material passing #4 Sieve) were remolded to specified % compaction and moisture content of Standard Proctor values	Gray, Yellow and Red Sandy Silt
Oven ID Number	496/610		
Deformation Indicator ID #	178/349/689		
Digital Caliper ID #	370/458		
Load Cell ID #	347/692/815		
Apparatus ID #	293/693/814		

NOTES:

		LL	-	**USCS (ASTM D2487: D2488)**
1. Method for Saturation	WET	PL	-	ML
2. Method for determination of cross-sectional after consolidation	B	PI	-	
3. Initial specimen moisture content obtained from cuttings		Gs	-	
4. Final specimen moisture content obtained from entire sample				

Triaxial CU.xls [Stress-Strain GRAPH], REV. 1; 10-10-05

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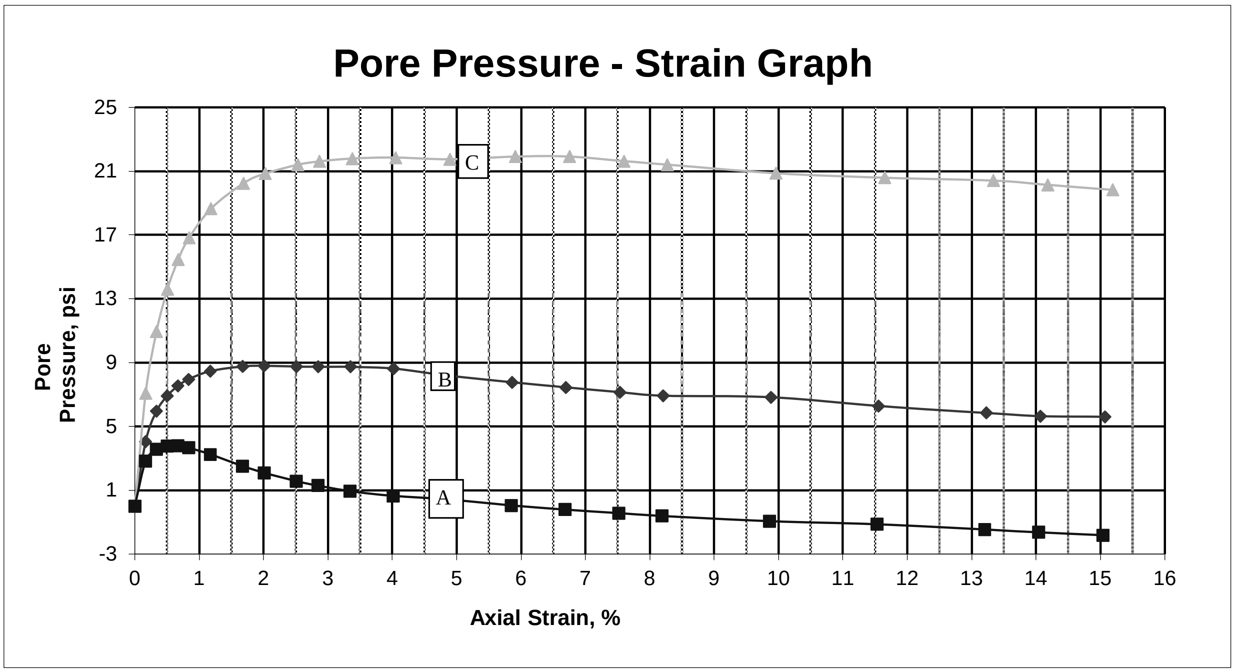
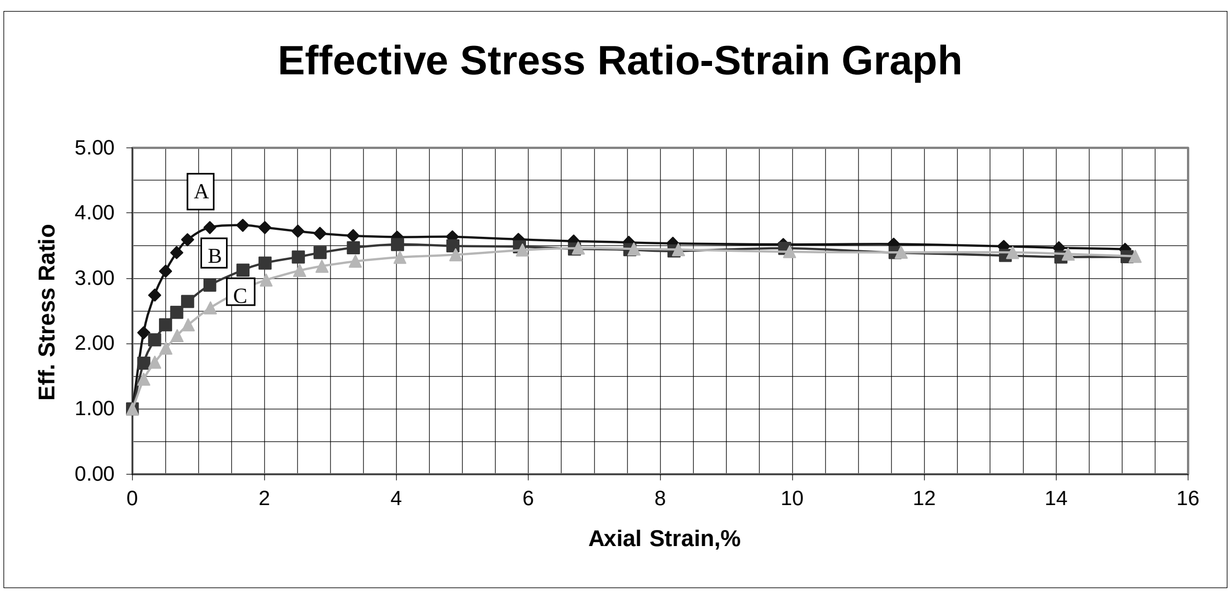
ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33250/Borrow Soil #1	Depth/Elevation	-
Location	Yates	Additional Info	-





Triaxial CU.xls [Stress Ratio & Pore Water Pr.-Strain GRAPH], REV. 1; 10-10-05

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Web: www.test-llc.com

AASHTO ACCREDITED

Tested By	IH
Date	03/04/20
Checked By	*(initials)*

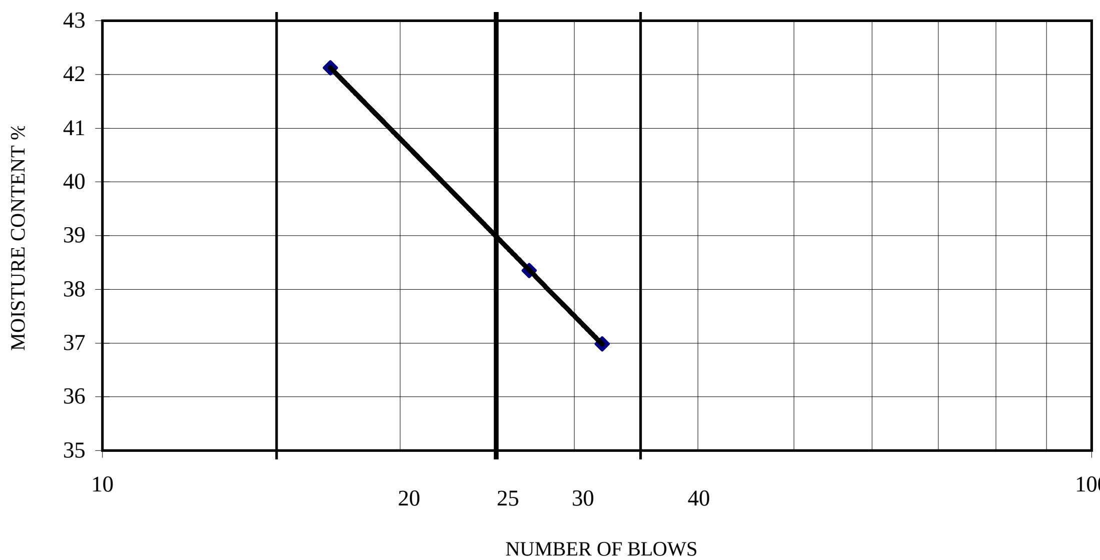
Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33250/Borrow Soil #1	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 4318/AASHTO T 88, T 89
Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils (Atterberg Limits)

LIQUID LIMIT

Number of Blows	32	27	17
Mass of Wet Sample & Tare, g	37.67	38.58	36.81
Mass of Dry Sample & Tare, g	33.72	35.32	32.45
Mass of Tare, g	23.04	26.82	22.10
Moisture Content, %	36.99	38.35	42.13

Oven ID #	15/496/610
Balance ID #	139/563
Liquid Limit Device ID #	451/569



PLASTIC LIMIT

Mass of Wet Sample & Tare, g	36.42	37.52
Mass of Dry Sample & Tare, g	33.43	34.52
Mass of Tare, g	23.34	24.23
Moisture Content, %	29.63	29.15

NOTE: MATERIAL PASSING NO. 40 SIEVE WAS USED FOR TEST

NATURAL MOISTURE

Mass of Wet Sample & Tare, g	556.70
Mass of Dry Sample & Tare, g	475.20
Mass of Tare, g	195.20
Moisture Content, %	29.11

LIQUID LIMIT (LL)	39
PLASTIC LIMIT (PL)	29
PLASTICITY INDEX (PI)	10
LIQUIDITY INDEX (LI)	0.01

DESCRIPTION: Gray, Yellow and Red Sandy Silt

USCS (ASTM D2487; D2488): ML

AASHTO (M 145): NA

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Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33250/Borrow Soil #1	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 422/AASHTO T 88

Standard Test Method for Particle-Size Analysis of Soils (with Double Separation per ASTM D6913 and Hydrometer Analysis)

As-Received Moisture Content (Total Sample)

Mass of Wet Sample & Tare, g	556.7
Mass of Dry Sample & Tare, g	475.2
Mass of Tare, g	195.2
Moisture Content, %	29.1

Moisture Content of FINER PORTION

	1st Subsample	2nd Subsample
Mass of Wet Sample & Tare, g	412.4	502.70
Mass of Dry Sample & Tare, g	364.9	442.10
Mass of Tare, g	89.1	101.70
Moisture Content, %	17.2	17.8

Mass of Total Sample before separation on 3/8" sieve & Tare, g	20300
Mass of Tare, g	0.0
Total Mass of Dry Sample, g	15723

	1st Subsample	2nd Subsample
Mass of Wet Finer Portion & Tare, g	1084.3	70.10
Mass of Tare	0.0	0.0
Dry Mass, g	925.0	59.51
% of Total Sample passing Split Sieve	96.2	95.0

SIEVE ANALYSIS

COARSER PORTION OF SAMPLE (RETAINED ON 3/8" SIEVE)

Mass of Tare, g: 0.00

Sieve Size		Sample & Tare, g	% RETAINED	% PASSING (of Total)
12"	COBBLES		0	100
3"	COARSE GRAVEL		0	100
2.5"			0	100
2"			0	100
1.5"		0.0	0	100
1"		131.2	1	99
.75"	FINE GRAVEL	381.8	2	98
.5"		507.7	3	97
.375"		600.3	4	96
#4	COARSE SAND	11.0	1	95

#4 <First Subsample of Finer Portion<3/8"

2nd Subsample of FINER PORTION OF SAMPLE (PASSING #4 SIEVE:Hydrometer Backsieve)

Sieve Size		Cumulative Mass retained, g	% PASSING (of Total)
#10	MEDIUM SAND	1.83	92
#20		4.31	88
#40	FINE SAND	7.70	83
#60		12.04	76
#100		17.77	67
#200	FINES	25.95	54

Remarks

HYDROMETER ANALYSIS

Length of Dispersion Period	1 Minute
Mechanical Dispersion Device ID #	61
Amount of Dispersing Agent (ml)	125.0
Specific Gravity (assumed)	2.650
Specific Gravity (tested)	
Starting time	14:04

PARTICLE-SIZE ANALYSIS

% COBBLES	0	% MEDIUM SAND	9
% COARSE GRAVEL	2	% FINE SAND	29
% FINE GRAVEL	3	% FINES	54
% COARSE SAND	3	% TOTAL SAMPLE	100
% CLAY(<0.005mm)	25	% CLAY(<0.002mm)	22

Date	Time	Testing time (min)	Reading	Temp (^oC)	K	Composite Correction	Actual Reading	Effective Depth (cm)	a	Particle Diam. (mm)	Percent Passing
03/04/20	14:06	2	33.0	17.7	0.01399	6.5	26.5	12.0	1.00	0.0342	42.3
03/04/20	14:09	5	30.0	17.7	0.01399	6.5	23.5	12.5	1.00	0.0221	37.5
03/04/20	14:19	15	27.0	17.7	0.01399	6.5	20.5	13.0	1.00	0.0130	32.7
03/04/20	14:34	30	24.0	17.7	0.01399	6.5	17.5	13.5	1.00	0.0094	27.9
03/04/20	15:04	60	23.5	17.7	0.01399	6.5	17.0	13.6	1.00	0.0067	27.2
03/04/20	18:14	250	21.0	17.7	0.01399	6.5	14.5	14.0	1.00	0.0033	23.2
03/05/20	14:04	1440	19.5	17.7	0.01399	6.5	13.0	14.2	1.00	0.0014	20.8

Hydrometer 152H ID #	305527	Oven ID #	15/496/610
Sieve Shaker ID #	555	Balance ID#	139/142/700

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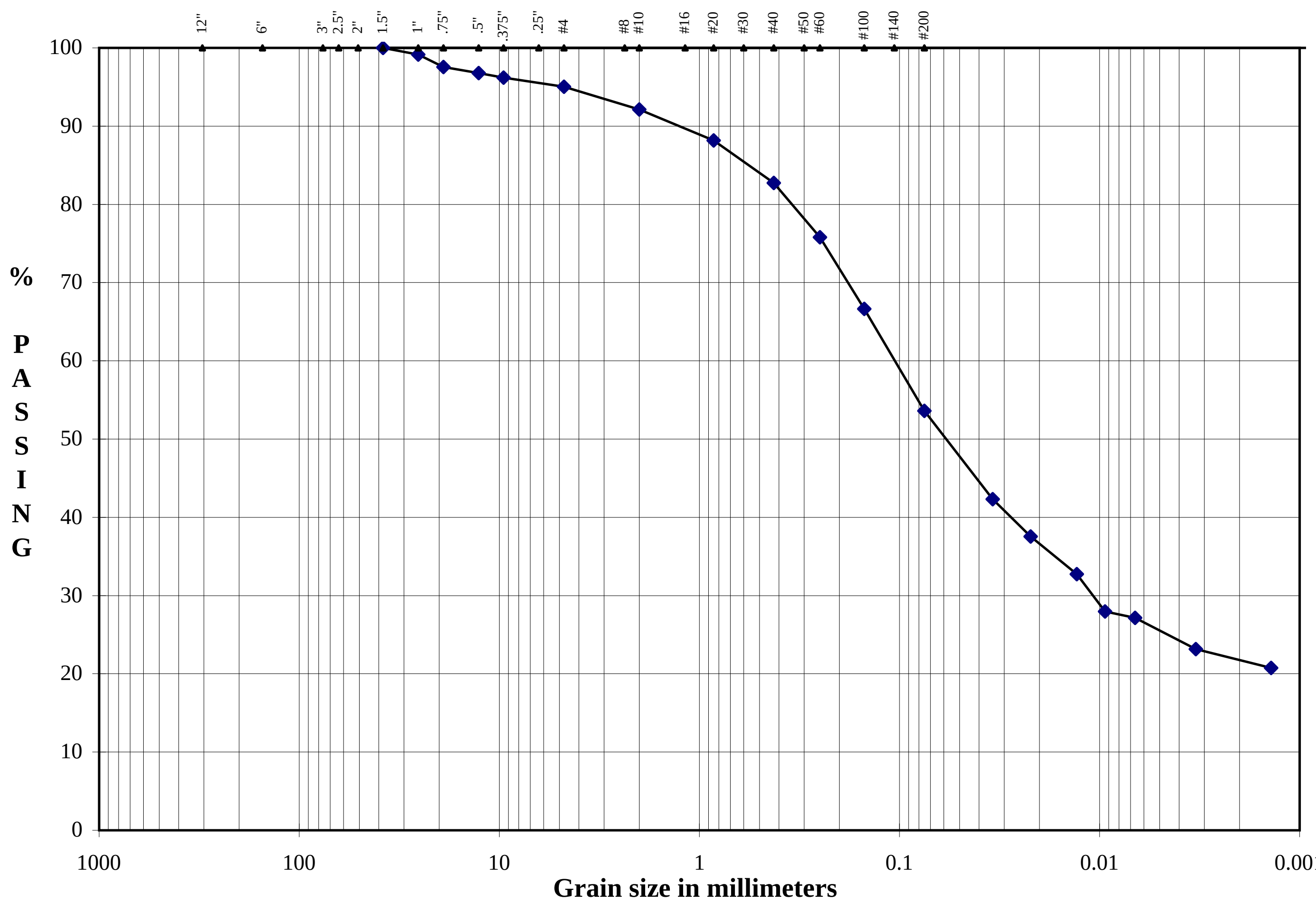
		Date	03/02/20
		Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33250/Borrow Soil #1	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 422/AASHTO T 88

Standard Test Method for Particle-Size Analysis of Soils (with Double Separation per ASTM D6913 and Hydrometer Analysis)

Particle-Size Analysis



Boulders	Cobbles	Gravel		Sand			Fines
		Coarse	Fine	Coarse	Medium	Fine	Silt or Clay

DESCRIPTION: Gray, Yellow and Red Sandy Silt

D_{10}	NA	mm
D_{30}	NA	mm
D_{60}	NA	mm
Cu	NA	
Cc	NA	

USCS (ASTM D2487; D2488): ML

Project's Specific % Passing	NA
Project's Specific Particle Size, mm	NA

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		Date	03/02/20
		Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33250/Borrow Soil #1	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 698
Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600kN-m/m^3))

DETERMINATION OF TEST PROCEDURE

	wet	dry
Mass of Soil before sieving, g	20300.0	15723.4
Mass of Mat. Retained on No. 4 sieve, g		
Mass of Mat. Retained on 3/8" sieve, g	600.3	600.3
Mass of Mat. Retained on 3/4" sieve, g		

MOISTURE CONTENT

	Coarse + Fine Fraction	Coarse Fraction
Mass of Wet Sample & Tare, g	556.7	600.3
Mass of Dry Sample & Tare, g	475.2	600.3
Mass of Tare, g	195.2	0.0
Moisture Content, %	29.1	0.0

Material Retained on No. 4 Sieve, %	
Material Retained on 3/8" Sieve, %	3.8
Material Retained on 3/4" Sieve, %	
Total, % (oversized)	3.8

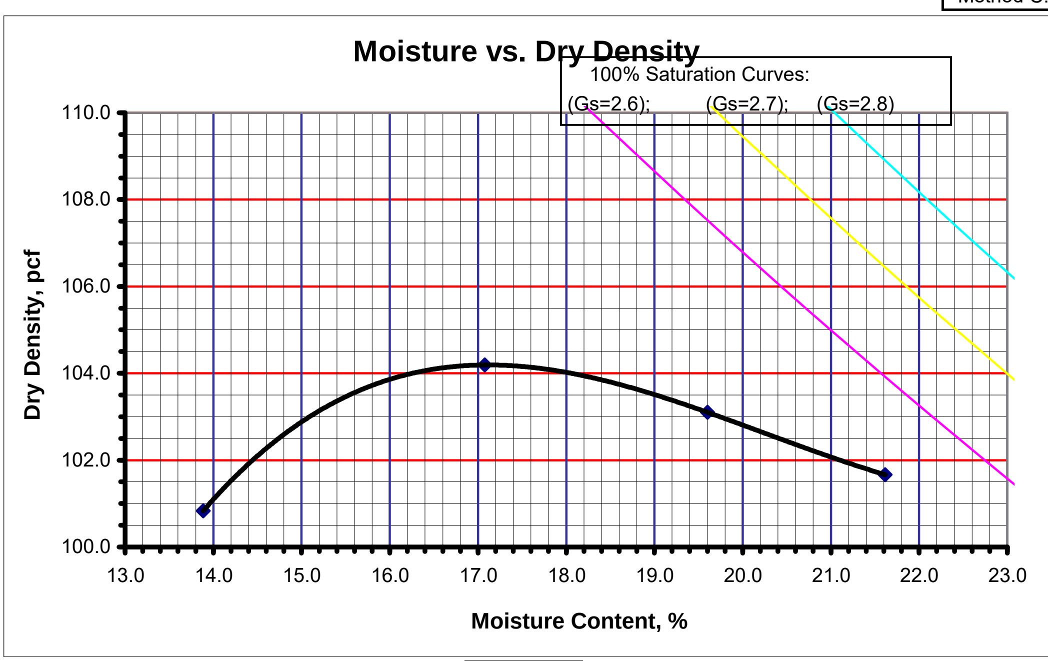
Procedure: B

TEST DATA

Points	1	2	3	4	5
Mass of Mold and Soil, g	5987.0	6095.0	6115.0	6120.0	
Mass of Wet Sample & Tare, g	516.3	557.8	499.8	515.3	
Mass of Dry Sample & Tare, g	475.6	494.9	438.6	456.1	
Mass of Tare, g	182.5	126.6	126.4	182.2	
Moisture Content, %	13.9	17.1	19.6	21.6	
Wet Density, pcf	114.8	122.0	123.3	123.6	
Dry Density, pcf	100.8	104.2	103.1	101.7	

Mold ID Number	798
Mass of Mold, g	4252.4
Volume of Mold, ft^3	0.0333
Hammer ID Number	318
Number of Blows per layer	25
Number of Layers	3
Mechanical Compactor ID Number	317

Method A: Material retained on No. 4 Sieve $\leq$ 25%
Method B: Material retained on 3/8" Sieve $\leq$ 25%
Method C: Material retained on 3/4" Sieve $\leq$ 30%



REMARKS

DESCRIPTION

Gray, Yellow and Red Sandy Silt

USCS (ASTM D2487; D2488): ML

AASHTO M145: NA

Maximum Dry Density, pcf	104.2	**Corrected Maximum Dry Density, pcf**	**NA**
Optimum Moisture Content, %	17.2	**Corrected Optimum Moisture Content, %**	**NA**

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AASHTO ACCREDITED

Tested By	RI
Date	03/03/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33250/Borrow Soil #1	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D854; Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

TEST METHOD: B

MOISTURE CONTENT

Mass of Wet Sample & Tare, g	-
Mass of Dry Sample & Tare, g	-
Mass of Tare, g	-
Moisture Content, %	NA*

TEST DATA

Pycnometer Number	6
Mass of Pycnometer, g	136.83
Mass of Sample & Pycnometer, g	216.82
Mass of Sample, Water & Pycnometer, g	685.32
Test Temperature, ^{o}C	19.2
Mass of Tare,g	419.71
Mass of Dry Sample & Tare, g	499.30
Mass of Dry Soil, g	79.59
Mass of Pycnometer (Calibrated), g	136.83
Density of Water @ Test Temperature, g/mL	0.99837
Mass of Pycnometer & Water @ Test Temp.	635.47
Temperature Coefficient	1.00016
Calibrated Volume of Pycnometer, mL	499.45
Specific Gravity @ Test Temperature	2.677

SPECIFIC GRAVITY @ 20 ^{o}C: 2.677

DESCRIPTION

Gray, Yellow and Red Sandy Silt

Thermometer ID Number	72
Vacuum Pump ID Number	62
Deaerator ID Number	213
Specific Gravity Board ID Number	214
Balance ID Number	139
Oven ID Number	12

USCS (ASTM D2487, D2488): ML

NOTES:

1.* Oven-Dry material passing #4 sieve used for test.
2. Air removed by vacuum method.
3. Deionized / Deaired water was used for test.

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Tested By	EB/KP
Date	03/04/20
Checked By	[signature]

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33251/Borrow Soil #2	Depth/Elevation	-
Location	Yates	Additional Info	-

SPECIMEN PROPERTIES

		(initial)	(after consol.)
Height, in		6.000	5.974
Diameter, in		2.875	2.907
Height-to-Diameter Ratio		2.1	2.1
Area, in^2		6.49	6.64
Volume, cm^3		638.29	649.78
Mass of Wet Sample, g		1316.20	1343.10
Mass of Dry Sample, g		1107.25	1107.25
Wet Density, pcf		128.7	129.0
Dry Density, pcf		108.3	106.4
Specific Gravity	(assumed)	2.675	2.675
Volume of Solids, cm^3		413.92	413.92
Volume of Voids, cm^3		224.37	235.85
Void Ratio		0.54	0.57
% Saturation		93.1	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	427.10	1674.70
Mass of Dry Sample and Tare, g	375.60	1438.85
Mass of Tare, g	102.70	331.60
Moisture, %	18.87	21.30

TEST DATA PRIOR TO LOADING

Machine Speed, in / min	0.0100
Strain Rate, % / min	0.17
Chamber Pressure, psi	80.0
Back Pressure,psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	10.0
Change in Height, in	0.026
"B" Value	0.95

SHEAR DATA

Elapsed Time (min)	Deformation (inch)	Axial Load (lb)	Pore-Water Pressure,psi		Total Strain (%)	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$) (psi)	Major Principal Stress,psi		Eff.Stress Ratio	P' $(s'_1+s'_3)/2$ (psi)	Q $[(s_1-s_3)/2]$ (psi)	Eff. Minor Pr. Stress
			Total,U	Change,DU				Total s_1	Eff. s'_1	s'_1/s'_3			s'_3 (psi)
0.0	0.000	17.7	70.0	0.0	0.00	6.64	0.0	10.0	10.0	1.00	10.0	0.0	10.0
1.0	0.010	60.4	73.0	3.0	0.17	6.65	6.4	16.4	13.4	1.92	10.2	3.2	7.0
2.0	0.020	74.3	73.9	3.9	0.34	6.66	8.5	18.5	14.6	2.39	10.4	4.2	6.1
3.1	0.031	85.5	74.3	4.3	0.51	6.67	10.2	20.2	15.9	2.78	10.8	5.1	5.7
4.1	0.041	95.0	74.5	4.5	0.68	6.68	11.6	21.6	17.1	3.10	11.3	5.8	5.5
5.1	0.051	103.1	74.6	4.6	0.85	6.69	12.8	22.8	18.2	3.34	11.8	6.4	5.4
7.1	0.071	117.0	74.4	4.4	1.19	6.72	14.8	24.8	20.3	3.66	13.0	7.4	5.6
10.2	0.102	133.1	74.0	4.0	1.71	6.75	17.1	27.1	23.1	3.86	14.5	8.5	6.0
12.2	0.122	141.3	73.8	3.8	2.05	6.78	18.2	28.2	24.5	3.92	15.4	9.1	6.3
15.3	0.153	150.6	73.4	3.4	2.56	6.81	19.5	29.5	26.1	3.95	16.4	9.8	6.6
17.3	0.173	155.7	73.2	3.2	2.90	6.84	20.2	30.2	27.0	3.96	16.9	10.1	6.8
20.4	0.204	162.8	72.9	2.9	3.41	6.87	21.1	31.1	28.2	3.97	17.7	10.6	7.1
24.5	0.245	171.2	72.7	2.7	4.09	6.92	22.2	32.2	29.5	4.04	18.4	11.1	7.3
29.6	0.296	181.3	72.2	2.2	4.95	6.98	23.4	33.4	31.3	3.99	19.6	11.7	7.8
35.7	0.357	192.4	71.7	1.7	5.97	7.06	24.7	34.7	33.0	3.99	20.6	12.4	8.3
40.8	0.408	201.1	71.4	1.4	6.82	7.12	25.7	35.7	34.3	3.99	21.5	12.9	8.6
45.9	0.459	209.5	71.0	1.0	7.68	7.19	26.7	36.7	35.7	3.97	22.3	13.3	9.0
49.9	0.499	215.7	70.7	0.7	8.36	7.24	27.3	37.3	36.7	3.93	23.0	13.7	9.3
60.1	0.601	231.1	69.7	-0.3	10.06	7.38	28.9	38.9	39.2	3.82	24.7	14.5	10.3
70.3	0.703	245.0	68.9	-1.1	11.77	7.52	30.2	40.2	41.4	3.71	26.3	15.1	11.1
80.5	0.805	258.2	68.2	-1.8	13.48	7.67	31.3	41.3	43.2	3.65	27.5	15.7	11.8
85.6	0.856	264.8	67.8	-2.2	14.33	7.75	31.9	41.9	44.1	3.61	28.2	15.9	12.2
90.0	0.900	269.3	67.4	-2.6	15.06	7.81	32.2	42.2	44.8	3.56	28.7	16.1	12.6
Values @ Failure				2.7	4.09	6.92	22.2	32.2	29.5	4.04	18.4	11.1	7.3

Failure criteria used*: 3

*Note:"1"=Max Deviator Stress;"2"=Deviator Stress @ 15% Strain;"3"=Max Eff.Stress Ratio(s'_1/s'_3)

Triaxial CU.xls [A], REV. 1; 10-10-05

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		Tested By	EB/KP
		Date	03/04/20
		Checked By	

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33251/Borrow Soil #2	Depth/Elevation	-
Location	Yates	Additional Info	-

SPECIMEN PROPERTIES

		(initial)	(after consol.)
Height, in		6.000	5.948
Diameter, in		2.875	2.895
Height-to-Diameter Ratio		2.1	2.1
Area, in^2		6.49	6.58
Volume, cm^3		638.29	641.72
Mass of Wet Sample, g		1316.30	1335.20
Mass of Dry Sample, g		1107.33	1107.50
Wet Density, pcf		128.7	129.9
Dry Density, pcf		108.3	107.7
Specific Gravity	(assumed)	2.675	2.675
Volume of Solids, cm^3		413.96	414.02
Volume of Voids, cm^3		224.33	227.70
Void Ratio		0.54	0.55
% Saturation		93.2	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	427.10	1595.20
Mass of Dry Sample and Tare, g	375.60	1367.53
Mass of Tare, g	102.70	260.20
Moisture, %	18.87	20.56

TEST DATA PRIOR TO LOADING

Machine Speed, in / min	0.0100
Strain Rate, % / min	0.17
Chamber Pressure, psi	90.0
Back Pressure,psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	20.0
Change in Height, in	0.052
"B" Value	0.95

SHEAR DATA

Elapsed Time (min)	Deformation (inch)	Axial Load (lb)	Pore-Water Pressure,psi		Total Strain (%)	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$)	Major Principal Stress,psi		Eff.Stress Ratio	P' $(s'_1+s'_3)/2$ (psi)	Q $[(s_1-s_3)/2]$ (psi)	Eff. Minor Pr. Stress
			Total,U	Change,DU			(psi)	Total s_1	Eff. s'_1	s'_1/s'_3			s'_3 (psi)
0.0	0.000	23.6	70.0	0.0	0.00	6.58	0.0	20.0	20.0	1.00	20.0	0.0	20.0
1.0	0.010	86.9	76.0	6.0	0.17	6.60	9.6	29.6	23.6	1.69	18.8	4.8	14.0
2.0	0.020	108.6	78.1	8.1	0.34	6.61	12.9	32.9	24.8	2.08	18.4	6.4	11.9
3.1	0.031	124.2	79.2	9.2	0.51	6.62	15.2	35.2	26.0	2.40	18.4	7.6	10.8
4.1	0.041	136.9	79.8	9.8	0.69	6.63	17.1	37.1	27.3	2.67	18.7	8.5	10.2
5.1	0.051	147.6	80.2	10.2	0.86	6.64	18.7	38.7	28.5	2.90	19.2	9.3	9.8
7.1	0.071	164.0	80.6	10.6	1.20	6.66	21.1	41.1	30.5	3.24	20.0	10.5	9.4
10.2	0.102	181.3	80.7	10.7	1.71	6.70	23.5	43.5	32.8	3.54	21.0	11.8	9.3
12.2	0.122	190.2	80.8	10.8	2.06	6.72	24.8	44.8	34.0	3.68	21.6	12.4	9.2
15.3	0.153	200.9	80.5	10.5	2.57	6.76	26.2	46.2	35.7	3.76	22.6	13.1	9.5
17.3	0.173	207.0	80.3	10.3	2.91	6.78	27.0	47.0	36.7	3.80	23.2	13.5	9.7
20.4	0.204	215.2	80.1	10.1	3.43	6.82	28.1	48.1	38.0	3.83	24.0	14.1	9.9
24.5	0.245	225.2	79.7	9.7	4.11	6.87	29.4	49.4	39.6	3.86	24.9	14.7	10.3
29.6	0.296	236.8	79.2	9.2	4.97	6.93	30.8	50.8	41.5	3.86	26.2	15.4	10.8
35.7	0.357	249.5	78.6	8.6	6.00	7.00	32.3	52.3	43.6	3.84	27.5	16.1	11.4
40.8	0.408	259.0	78.1	8.1	6.85	7.07	33.3	53.3	45.2	3.81	28.5	16.7	11.9
45.9	0.459	268.2	77.9	7.9	7.71	7.13	34.3	54.3	46.4	3.83	29.3	17.1	12.1
49.9	0.499	275.1	77.5	7.5	8.40	7.19	35.0	55.0	47.5	3.80	30.0	17.5	12.5
60.1	0.601	291.1	76.4	6.4	10.11	7.32	36.5	56.5	50.1	3.69	31.9	18.3	13.6
70.3	0.703	305.3	75.4	5.4	11.82	7.47	37.7	57.7	52.3	3.59	33.4	18.9	14.6
80.5	0.805	318.5	74.7	4.7	13.54	7.61	38.7	58.7	54.0	3.53	34.6	19.4	15.3
85.6	0.856	324.6	74.4	4.4	14.39	7.69	39.1	59.1	54.7	3.51	35.2	19.6	15.6
90.0	0.900	329.8	74.0	4.0	15.13	7.76	39.5	59.5	55.5	3.47	35.7	19.7	16.0
Values @ Failure				9.7	4.11	6.87	29.4	49.4	39.6	3.86	24.9	14.7	10.3
Failure criteria used*			3										

*Note:"1"=Max Deviator Stress;"2"=Deviator Stress @ 15% Strain;"3"=Max Eff.Stress Ratio(s'_1/s'_3)

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Tested By	EB/KP
Date	03/04/20
Checked By	[signature]

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33251/Borrow Soil #2	Depth/Elevation	-
Location	Yates	Additional Info	-

SPECIMEN PROPERTIES

		(initial)	(after consol.)
Height, in		6.000	5.926
Diameter, in		2.875	2.884
Height-to-Diameter Ratio		2.1	2.1
Area, in^2		6.49	6.53
Volume, cm^3		638.29	634.37
Mass of Wet Sample, g		1316.40	1327.80
Mass of Dry Sample, g		1107.42	1107.42
Wet Density, pcf		128.7	130.7
Dry Density, pcf		108.3	109.0
Specific Gravity	(assumed)	2.675	2.675
Volume of Solids, cm^3		413.99	413.99
Volume of Voids, cm^3		224.30	220.38
Void Ratio		0.54	0.53
% Saturation		93.2	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	427.10	1589.80
Mass of Dry Sample and Tare, g	375.60	1369.42
Mass of Tare, g	102.70	262.00
Moisture, %	18.87	19.90

TEST DATA PRIOR TO LOADING

Machine Speed, in / min	0.0100
Strain Rate, % / min	0.17
Chamber Pressure, psi	110.0
Back Pressure,psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	40.0
Change in Height, in	0.074
"B" Value	0.95

SHEAR DATA

Elapsed Time (min)	Deformation (inch)	Axial Load (lb)	Pore-Water Pressure,psi Total,U	Pore-Water Pressure,psi Change,DU	Total Strain (%)	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$) (psi)	Major Principal Stress,psi Total s_1	Major Principal Stress,psi Eff. s'_1	Eff.Stress Ratio s'_1/s'_3	P' $(s'_1+s'_3)/2$ (psi)	Q $[(s_1-s_3)/2]$ (psi)	Eff. Minor Pr. Stress s'_3 (psi)
0.0	0.000	26.4	70.0	0.0	0.00	6.53	0.0	40.0	40.0	1.00	40.0	0.0	40.0
1.1	0.011	123.1	78.0	8.0	0.18	6.54	14.8	54.8	46.8	1.46	39.4	7.4	32.0
2.1	0.021	165.5	83.2	13.2	0.35	6.56	21.2	61.2	48.0	1.79	37.4	10.6	26.8
3.1	0.031	190.7	86.2	16.2	0.52	6.57	25.0	65.0	48.8	2.05	36.3	12.5	23.8
4.1	0.041	208.9	88.1	18.1	0.70	6.58	27.7	67.7	49.6	2.27	35.7	13.9	21.9
5.1	0.051	222.8	89.4	19.4	0.87	6.59	29.8	69.8	50.4	2.45	35.5	14.9	20.6
7.2	0.072	243.2	91.2	21.2	1.21	6.61	32.8	72.8	51.6	2.74	35.2	16.4	18.8
10.2	0.102	263.6	92.6	22.6	1.73	6.65	35.7	75.7	53.1	3.05	35.3	17.8	17.4
12.3	0.123	273.4	93.1	23.1	2.07	6.67	37.0	77.0	53.9	3.19	35.4	18.5	16.9
15.3	0.153	285.7	93.3	23.3	2.59	6.71	38.7	78.7	55.4	3.31	36.0	19.3	16.7
17.4	0.174	292.6	93.3	23.3	2.93	6.73	39.6	79.6	56.2	3.37	36.5	19.8	16.7
20.4	0.204	302.3	93.3	23.3	3.45	6.77	40.8	80.8	57.5	3.44	37.1	20.4	16.7
24.5	0.245	313.3	93.1	23.1	4.13	6.81	42.1	82.1	59.0	3.49	38.0	21.1	16.9
29.6	0.296	325.5	92.7	22.7	4.99	6.88	43.5	83.5	60.8	3.51	39.0	21.7	17.3
35.7	0.357	338.4	92.2	22.2	6.03	6.95	44.9	84.9	62.7	3.52	40.3	22.4	17.8
40.8	0.408	348.0	91.7	21.7	6.89	7.02	45.8	85.8	64.2	3.50	41.3	22.9	18.3
45.9	0.459	357.8	91.9	21.9	7.75	7.08	46.8	86.8	64.9	3.58	41.5	23.4	18.1
50.0	0.500	364.8	91.6	21.6	8.43	7.13	47.4	87.4	65.9	3.57	42.1	23.7	18.4
60.2	0.602	381.1	90.6	20.6	10.15	7.27	48.8	88.8	68.2	3.51	43.8	24.4	19.4
70.4	0.704	396.0	89.7	19.7	11.87	7.41	49.9	89.9	70.2	3.45	45.2	24.9	20.3
80.6	0.806	409.8	89.4	19.4	13.59	7.56	50.7	90.7	71.3	3.46	46.0	25.4	20.6
85.6	0.856	416.6	89.1	19.1	14.45	7.64	51.1	91.1	72.0	3.45	46.4	25.6	20.9
90.0	0.900	422.2	88.8	18.8	15.18	7.70	51.4	91.4	72.6	3.42	46.9	25.7	21.2
Values @ Failure				21.9	7.75	7.08	46.8	86.8	64.9	3.58	41.5	23.4	18.1
Failure criteria used*			3										

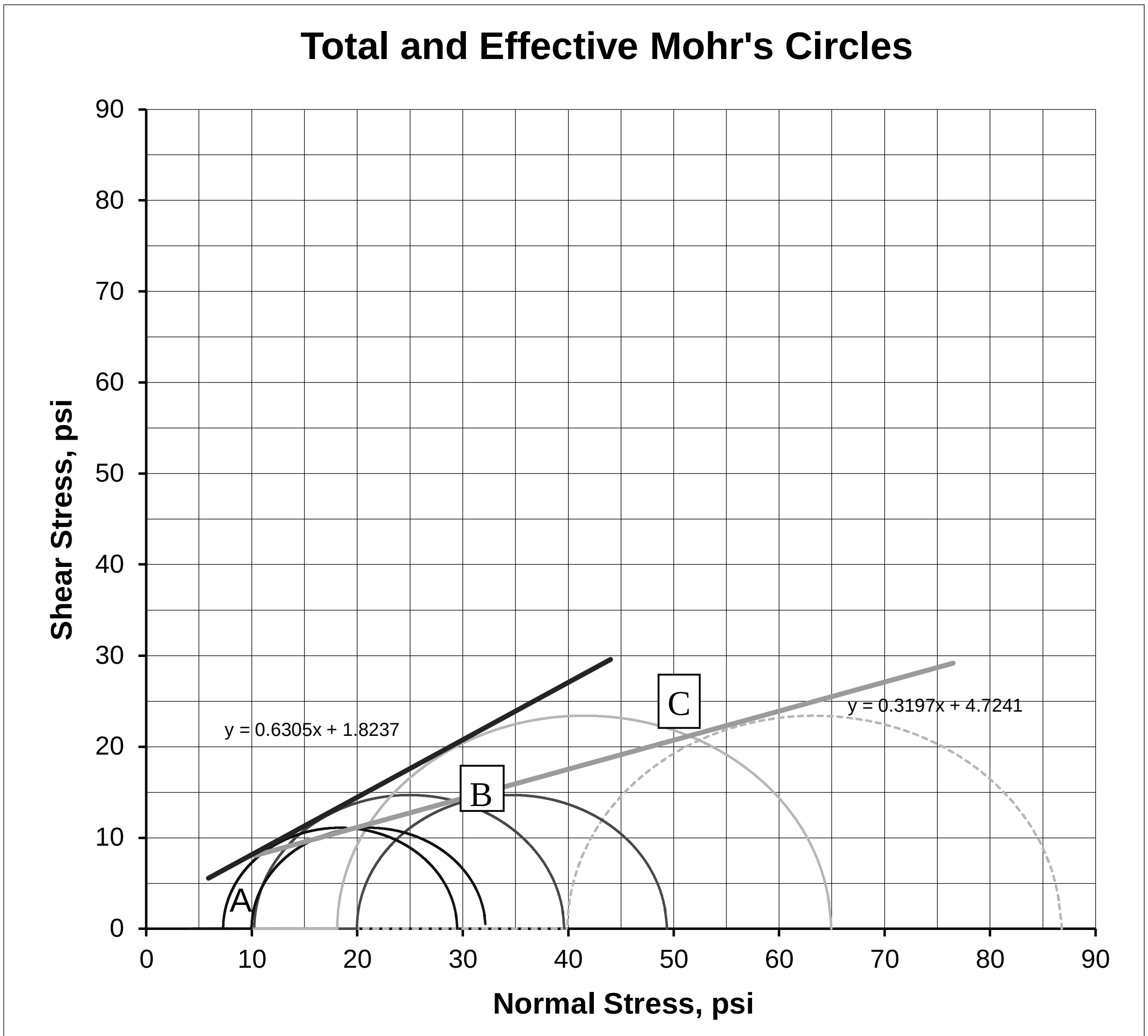
*Note:"1"=Max Deviator Stress;"2"=Deviator Stress @ 15% Strain;"3"=Max Eff.Stress Ratio(s'_1/s'_3)

TIMELY **E**NGINEERING **S**OIL **T**ESTS, LLC	1874 Forge Street Tucker, GA 30084 Phone: 770-938-8233 Fax: 770-923-8973 Web: www.test-llc.com	AASHTO ACCREDITED	Tested By: EB/KP Date: 03/04/20 Check: [signature]

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Project #	I054-107	Laboratory Project #	2008-08-1
Project Name	AMA	Sample Type	Remold
Sample ID	33251/Borrow Soil #2	Depth/Elevation	-
Location	Yates	Additional Info	-



Specimen	A	B	C
Effective Consolidation Stress, psi	10.0	20.0	40.0
Deviator Stress at Failure, psi	22.2	29.4	46.8
Effective Minor Principal Stress at Failure, psi	7.3	10.3	18.1
Effective Major Principal Stress at Failure, psi	29.5	39.6	64.9
Axial Strain at Failure, %	4.09	4.11	7.75

STRENGTH PARAMETERS*			
Total		Effective	
f °	17.7	f ' °	32.2
C, psi	4.7	C', psi	1.8

***Valid only for Received Material at Reported Densities and Moisture Contents. Please see remarks on page 6 of this report**

Triaxial CU.xls [Mohr's Circles], REV. 1; 10-10-05

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Date	03/04/20
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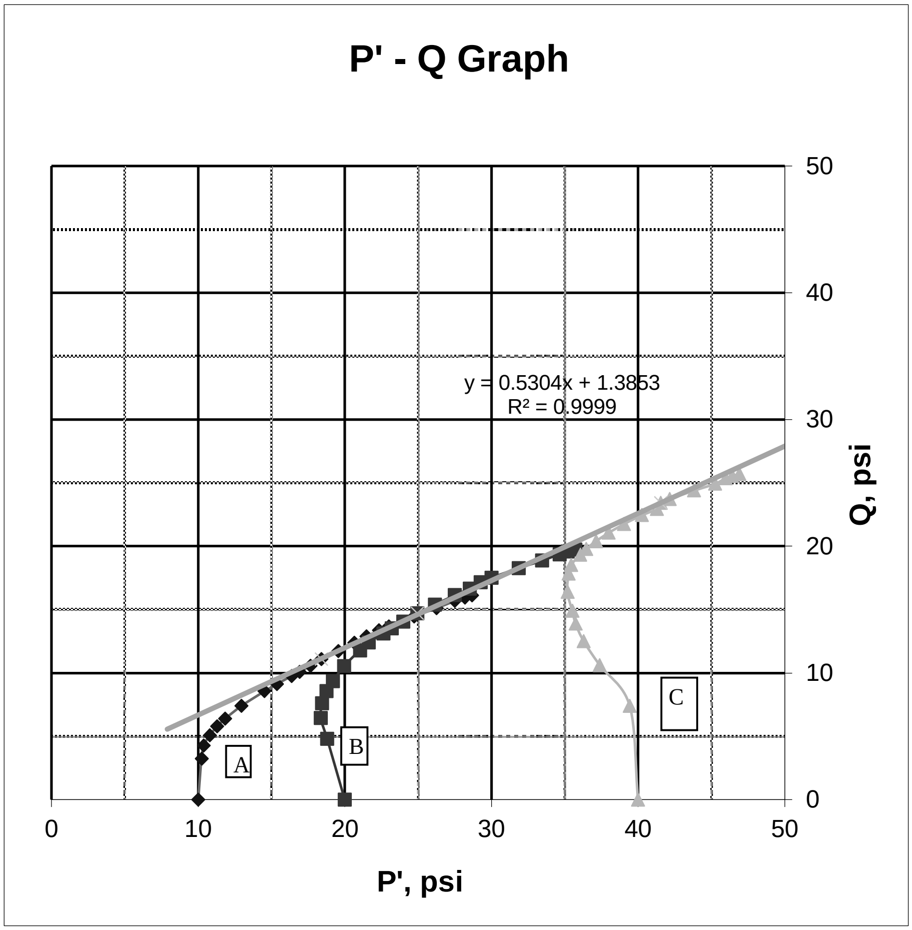
ASTM D 4767 / AASHTO T 297

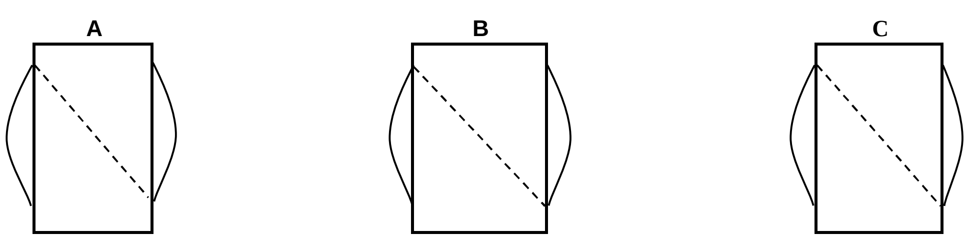
Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33251/Borrow Soil #2	Depth/Elevation	-
Location	Yates	Additional Info	-



a, psi	**1.4**
a, degree	**27.9**

FAILURE SKETCH



REMOLDING PROPERTIES

	A	B	C
% Compaction of Max Dry Density	94.9	94.9	94.9
% Difference from Optimum M.C.	3.2	3.2	3.2

Triaxial CU.xls [P'-Q GRAPH], REV. 1; 10-10-05

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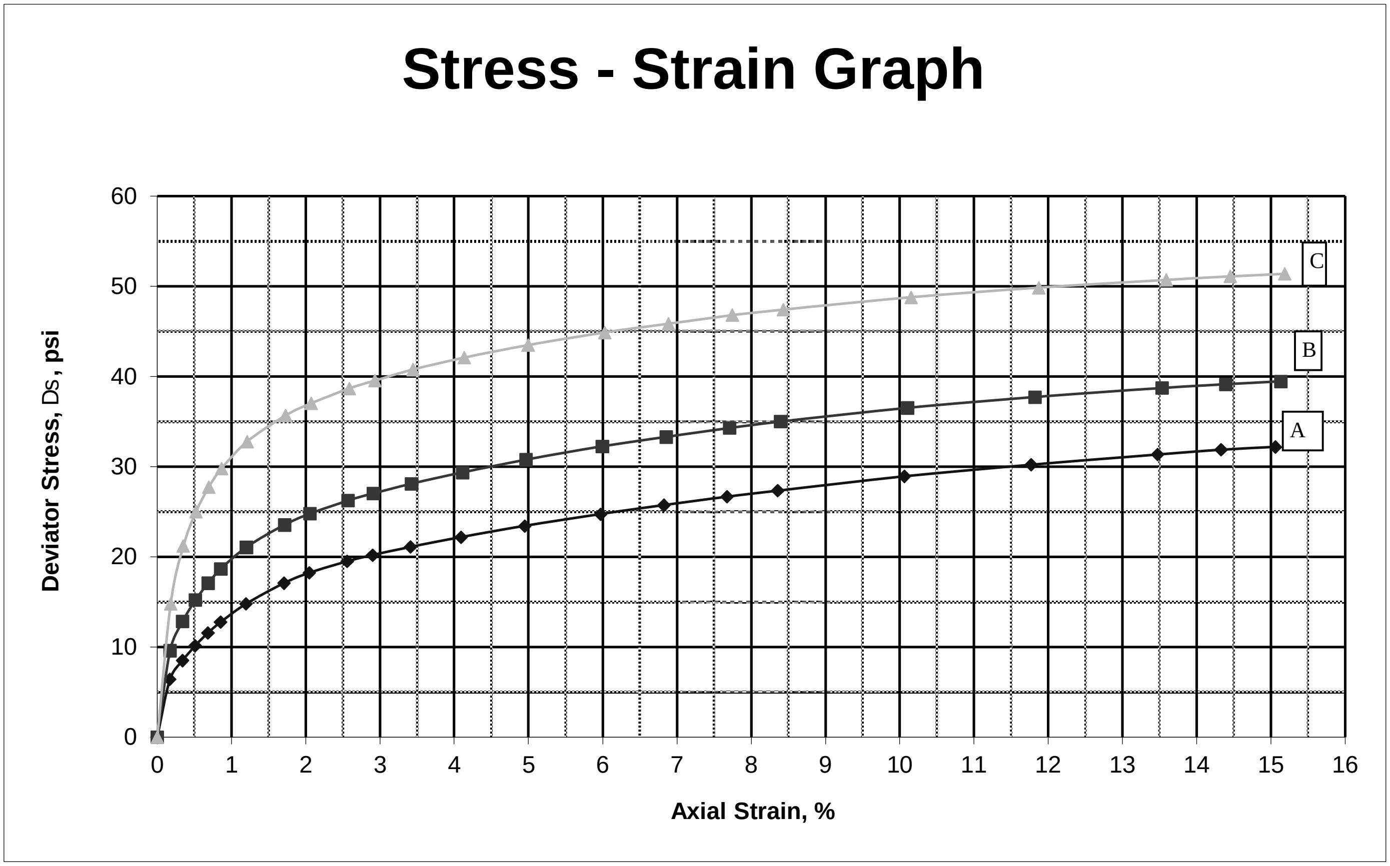
		Date	03/04/20
		Check	

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33251/Borrow Soil #2	Depth/Elevation	-
Location	Yates	Additional Info	-



		REMARKS	DESCRIPTION
Balance ID Number	563/700	Samples (Material passing #4 Sieve) were remolded to specified % compaction and moisture content of Standard Proctor values	Yellowish Brown Silty Sand
Oven ID Number	496/610		
Deformation Indicator ID #	178/349/689		
Digital Caliper ID #	370/458		
Load Cell ID #	347/692/815		
Apparatus ID #	293/693/814		

NOTES:

1. Method for Saturation — WET
2. Method for determination of cross-sectional after consolidation — B
3. Initial specimen moisture content obtained from cuttings
4. Final specimen moisture content obtained from entire sample

LL	-
PL	-
PI	-
Gs	-

USCS (ASTM D2487: D2488): SM

Triaxial CU.xls [Stress-Strain GRAPH], REV. 1; 10-10-05

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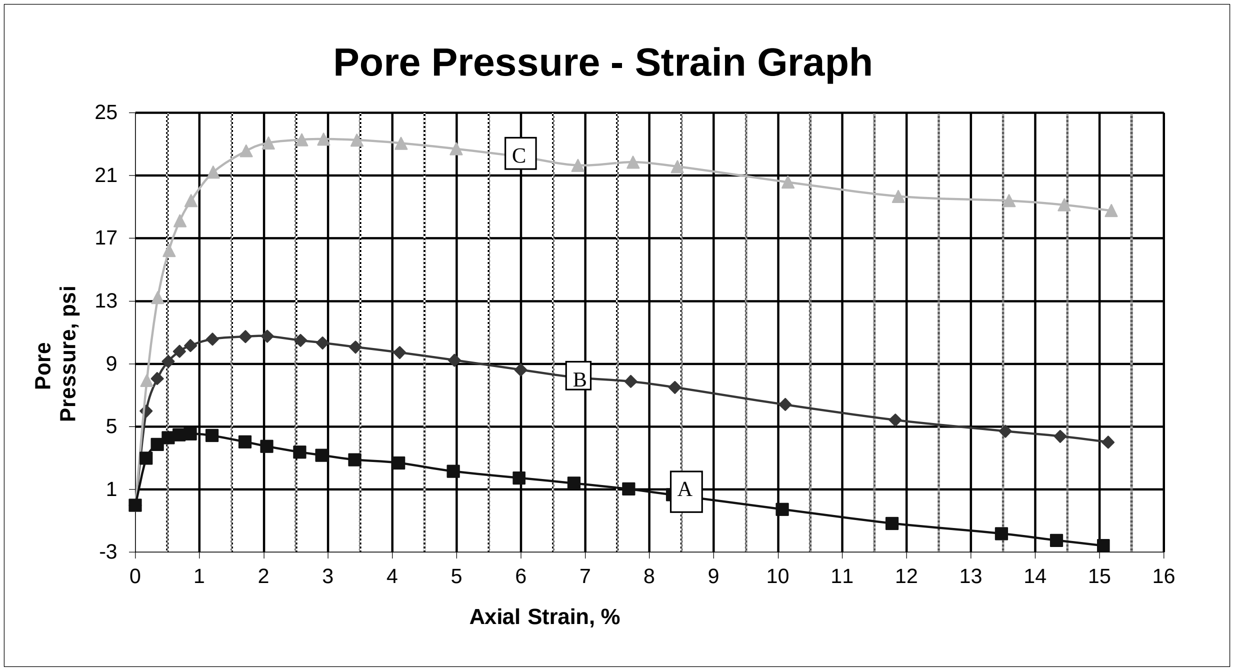
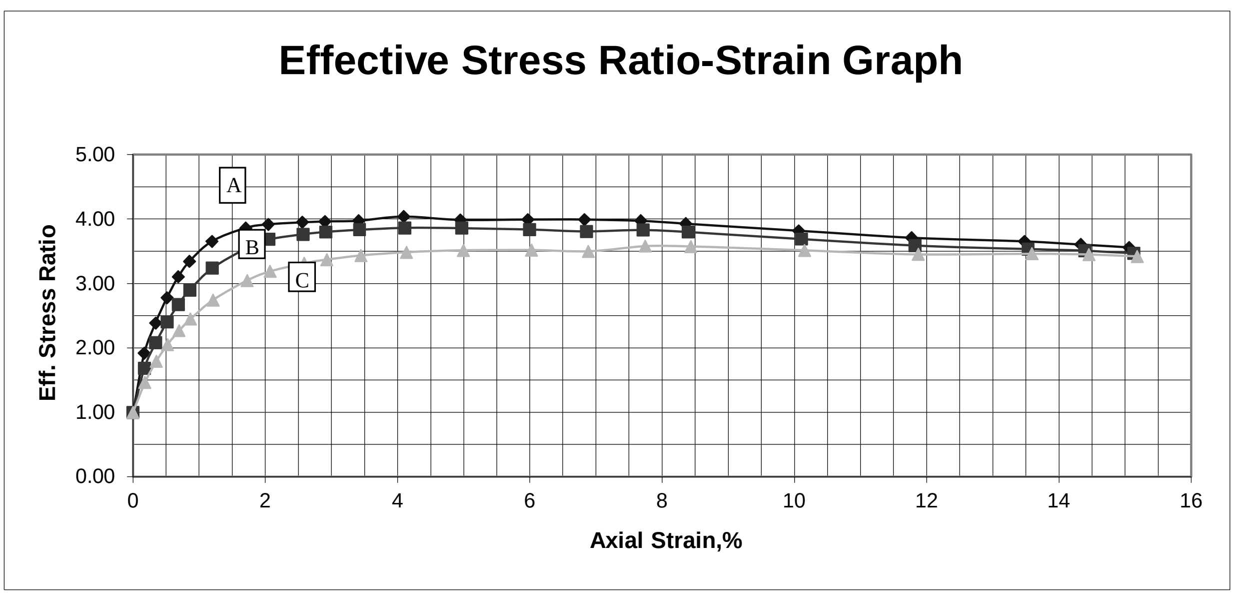
ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33251/Borrow Soil #2	Depth/Elevation	-
Location	Yates	Additional Info	-





Triaxial CU.xls [Stress Ratio & Pore Water Pr.-Strain GRAPH], REV. 1; 10-10-05

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AASHTO ACCREDITED

Tested By	IH
Date	03/04/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33251/Borrow Soil #2	Depth/Elev.	-
Location	Yates	Add. Info	-

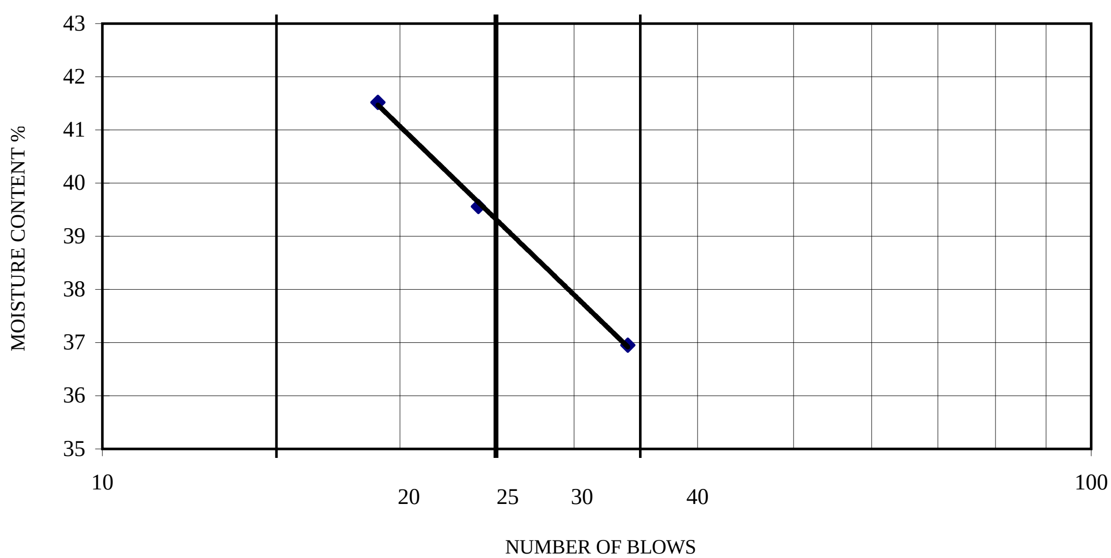
ASTM D 4318/AASHTO T 88, T 89

Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils (Atterberg Limits)

LIQUID LIMIT

Number of Blows	34	24	19
Mass of Wet Sample & Tare, g	37.30	39.37	38.09
Mass of Dry Sample & Tare, g	33.69	36.13	34.20
Mass of Tare, g	23.92	27.94	24.83
Moisture Content, %	36.95	39.56	41.52

Oven ID #	15/496/610
Balance ID #	139/563
Liquid Limit Device ID #	451/569



PLASTIC LIMIT

Mass of Wet Sample & Tare, g	41.60	36.71
Mass of Dry Sample & Tare, g	38.08	34.22
Mass of Tare, g	25.39	25.15
Moisture Content, %	27.74	27.45

NOTE: MATERIAL PASSING NO. 40 SIEVE WAS USED FOR TEST

NATURAL MOISTURE

Mass of Wet Sample & Tare, g	571.50
Mass of Dry Sample & Tare, g	508.60
Mass of Tare, g	184.00
Moisture Content, %	19.38

LIQUID LIMIT (LL)	39
PLASTIC LIMIT (PL)	28
PLASTICITY INDEX (PI)	11
LIQUIDITY INDEX (LI)	-0.78

DESCRIPTION: Yellowish Brown Silty Sand

USCS (ASTM D2487; D2488): SM

AASHTO (M 145): NA

T.E.S.T.
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Phone: 770-938-8233
Fax: 770-923-8973
Web: www.test-llc.com

AASHTO ACCREDITED

Tested By	RI
Date	03/02/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33251/Borrow Soil #2	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 422/AASHTO T 88

Standard Test Method for Particle-Size Analysis of Soils (with Double Separation per ASTM D6913 and Hydrometer Analysis)

As-Received Moisture Content (Total Sample)

Mass of Wet Sample & Tare, g	571.5
Mass of Dry Sample & Tare, g	508.6
Mass of Tare, g	184.0
Moisture Content, %	19.4

Moisture Content of FINER PORTION

	1st Subsample	2nd Subsample
Mass of Wet Sample & Tare, g	401.0	401.20
Mass of Dry Sample & Tare, g	366.7	369.80
Mass of Tare, g	90.1	108.30
Moisture Content, %	12.4	12.0

Mass of Total Sample before separation on 3/8" sieve & Tare, g	16800
Mass of Tare, g	0.0
Total Mass of Dry Sample, g	14073

	1st Subsample	2nd Subsample
Mass of Wet Finer Portion & Tare, g	1008.3	75.20
Mass of Tare	0.0	0.0
Dry Mass, g	897.1	67.14
% of Total Sample passing Split Sieve	97.2	95.0

SIEVE ANALYSIS

COARSER PORTION OF SAMPLE (RETAINED ON 3/8" SIEVE)

Mass of Tare, g: 0.00

Sieve Size		Sample & Tare, g	% RETAINED	% PASSING (of Total)
12"	COBBLES		0	100
3"	COARSE GRAVEL		0	100
2.5"			0	100
2"			0	100
1.5"		0.0	0	100
1"		151.7	1	99
.75"	FINE GRAVEL	241.3	2	98
.5"		326.8	2	98
.375"		397.1	3	97
#4	COARSE SAND	19.8	2	95

#4 <First Subsample of Finer Portion<3/8"

2nd Subsample of FINER PORTION OF SAMPLE (PASSING #4 SIEVE:Hydrometer Backsieve)

Sieve Size		Cumulative Mass retained, g	% PASSING (of Total)
#10	MEDIUM SAND	4.34	89
#20		10.68	80
#40	FINE SAND	17.37	70
#60		23.26	62
#100		28.80	54
#200	FINES	35.20	45

Remarks

HYDROMETER ANALYSIS

Length of Dispersion Period	1 Minute
Mechanical Dispersion Device ID #	61
Amount of Dispersing Agent (ml)	125.0
Specific Gravity (assumed)	2.650
Specific Gravity (tested)	
Starting time	14:06

PARTICLE-SIZE ANALYSIS

% COBBLES	0	% MEDIUM SAND	18
% COARSE GRAVEL	2	% FINE SAND	25
% FINE GRAVEL	3	% FINES	45
% COARSE SAND	6	% TOTAL SAMPLE	100
% CLAY(<0.005mm)	22	% CLAY(<0.002mm)	16

Date	Time	Testing time (min)	Reading	Temp (^oC)	K	Composite Correction	Actual Reading	Effective Depth (cm)	a	Particle Diam. (mm)	Percent Passing
03/04/20	14:08	2	33.0	17.7	0.01399	6.5	26.5	12.0	1.00	0.0342	37.5
03/04/20	14:11	5	30.0	17.7	0.01399	6.5	23.5	12.5	1.00	0.0221	33.3
03/04/20	14:21	15	27.5	17.7	0.01399	6.5	21.0	12.9	1.00	0.0130	29.7
03/04/20	14:36	30	25.5	17.7	0.01399	6.5	19.0	13.2	1.00	0.0093	26.9
03/04/20	15:06	60	24.5	17.7	0.01399	6.5	18.0	13.4	1.00	0.0066	25.5
03/04/20	18:16	250	20.0	17.7	0.01399	6.5	13.5	14.1	1.00	0.0033	19.1
03/05/20	14:06	1440	17.0	17.7	0.01399	6.5	10.5	14.6	1.00	0.0014	14.9

Hydrometer 152H ID #	305527	Oven ID #	15/496/610
Sieve Shaker ID #	555	Balance ID#	139/142/700

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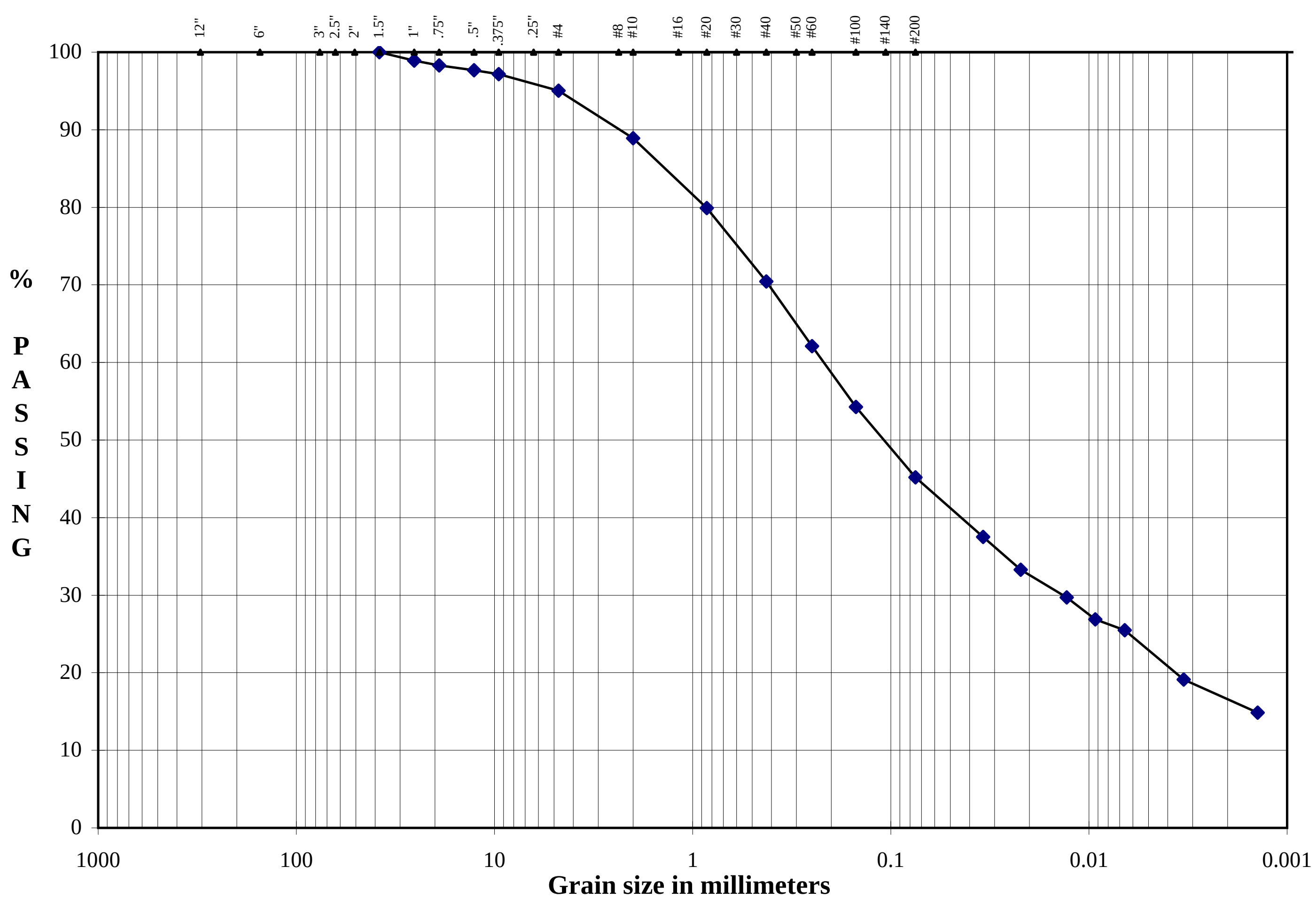
		Phone: 770-938-8233	Tested By	RI
		Fax: 770-923-8973	Date	03/02/20
		Web: www.test-llc.com	Checked By	

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33251/Borrow Soil #2	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 422/AASHTO T 88

Standard Test Method for Particle-Size Analysis of Soils (with Double Separation per ASTM D6913 and Hydrometer Analysis)

Particle-Size Analysis



Boulders	Cobbles	Gravel		Sand			Fines
		Coarse	Fine	Coarse	Medium	Fine	Silt or Clay

DESCRIPTION: Yellowish Brown Silty Sand

D_{10}	NA	mm
D_{30}	NA	mm
D_{60}	NA	mm
Cu	NA	
Cc	NA	

USCS (ASTM D2487; D2488): SM

Project's Specific % Passing	NA
Project's Specific Particle Size, mm	NA

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Tested By	RI
Date	03/02/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33251/Borrow Soil #2	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 698
Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600kN-m/m^3))

DETERMINATION OF TEST PROCEDURE

	wet	dry
Mass of Soil before sieving, g	16800.0	14073.0
Mass of Mat. Retained on No. 4 sieve, g		
Mass of Mat. Retained on 3/8" sieve, g	397.1	397.1
Mass of Mat. Retained on 3/4" sieve, g		

MOISTURE CONTENT

	Coarse + Fine Fraction	Coarse Fraction
Mass of Wet Sample & Tare, g	571.5	397.1
Mass of Dry Sample & Tare, g	508.6	397.1
Mass of Tare, g	184.0	0.0
Moisture Content, %	19.4	0.0

Material Retained on No. 4 Sieve, %	
Material Retained on 3/8" Sieve, %	2.8
Material Retained on 3/4" Sieve, %	
Total, % (oversized)	2.8

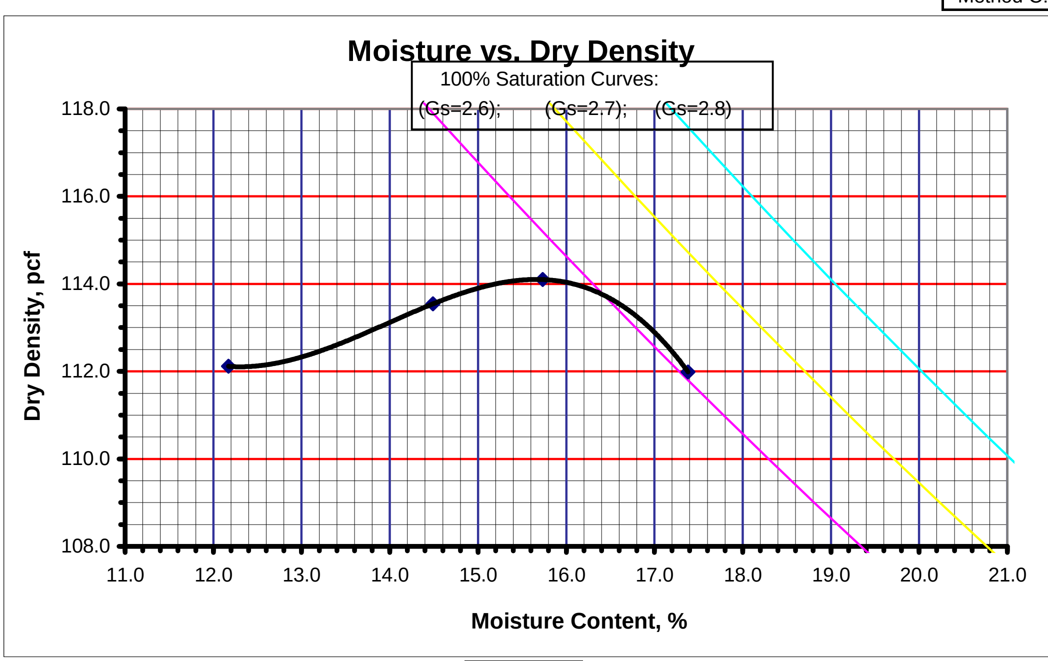
Procedure: B

TEST DATA

Points	1	2	3	4	5
Mass of Mold and Soil, g	6152.0	6216.0	6247.0	6238.0	
Mass of Wet Sample & Tare, g	472.5	582.8	501.6	589.5	
Mass of Dry Sample & Tare, g	440.6	525.2	450.5	528.7	
Mass of Tare, g	178.5	127.7	125.7	178.9	
Moisture Content, %	12.2	14.5	15.7	17.4	
Wet Density, pcf	125.8	130.0	132.1	131.5	
Dry Density, pcf	112.1	113.5	114.1	112.0	

Mold ID Number	798
Mass of Mold, g	4252.4
Volume of Mold, ft^3	0.0333
Hammer ID Number	318
Number of Blows per layer	25
Number of Layers	3
Mechanical Compactor ID Number	317

Method A: Material retained on No. 4 Sieve ≤ 25%
Method B: Material retained on 3/8" Sieve ≤ 25%
Method C: Material retained on 3/4" Sieve ≤ 30%



REMARKS

DESCRIPTION

Yellowish Brown Silty Sand

USCS (ASTM D2487; D2488)

SM

AASHTO M145

NA

Maximum Dry Density, pcf	114.1
Optimum Moisture Content, %	15.7
Corrected Maximum Dry Density, pcf	**NA**
Corrected Optimum Moisture Content, %	**NA**

T.E.S.T.
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		Tested By	RI
		Date	03/03/20
		Checked By	[signature]
Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33251/Borrow Soil #2	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D854; Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

TEST METHOD	B

MOISTURE CONTENT

Mass of Wet Sample & Tare, g	-
Mass of Dry Sample & Tare, g	-
Mass of Tare, g	-
Moisture Content, %	NA*

TEST DATA

Pycnometer Number	5
Mass of Pycnometer, g	174.35
Mass of Sample & Pycnometer, g	254.37
Mass of Sample, Water & Pycnometer, g	723.12
Test Temperature, ^{o}C	19.2
Mass of Tare,g	416.14
Mass of Dry Sample & Tare, g	496.78
Mass of Dry Soil, g	80.64
Mass of Pycnometer (Calibrated), g	174.35
Density of Water @ Test Temperature, g/mL	0.99837
Mass of Pycnometer & Water @ Test Temp.	672.63
Temperature Coefficient	1.00016
Calibrated Volume of Pycnometer, mL	499.09
Specific Gravity @ Test Temperature	2.675

SPECIFIC GRAVITY @ 20 ^{o}C **2.675**

DESCRIPTION

Yellowish Brown Silty Sand

USCS (ASTM D2487, D2488)

SM

Thermometer ID Number	72
Vacuum Pump ID Number	62
Deaerator ID Number	213
Specific Gravity Board ID Number	214
Balance ID Number	139
Oven ID Number	12

NOTES:

1.* Oven-Dry material passing #4 sieve used for test.
2. Air removed by vacuum method.
3. Deionized / Deaired water was used for test.

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Date	03/05/20
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ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33252/Borrow Soil #3	Depth/Elevation	-
Location	Yates	Additional Info	-

SPECIMEN PROPERTIES

		(initial)	(after consol.)
Height, in		6.000	5.968
Diameter, in		2.875	2.892
Height-to-Diameter Ratio		2.1	2.1
Area, in^2		6.49	6.57
Volume, cm^3		638.29	642.54
Mass of Wet Sample, g		1290.50	1324.30
Mass of Dry Sample, g		1087.56	1087.56
Wet Density, pcf		126.2	128.7
Dry Density, pcf		106.4	105.7
Specific Gravity	(assumed)	2.680	2.680
Volume of Solids, cm^3		405.81	405.81
Volume of Voids, cm^3		232.48	236.74
Void Ratio		0.57	0.58
% Saturation		87.3	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	550.30	1655.90
Mass of Dry Sample and Tare, g	502.40	1419.16
Mass of Tare, g	245.70	331.60
Moisture, %	18.66	21.77

TEST DATA PRIOR TO LOADING

Machine Speed, in / min	0.0100
Strain Rate, % / min	0.17
Chamber Pressure, psi	80.0
Back Pressure,psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	10.0
Change in Height, in	0.032
"B" Value	0.95

SHEAR DATA

Elapsed Time (min)	Deformation (inch)	Axial Load (lb)	Pore-Water Pressure,psi		Total Strain (%)	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$)	Major Principal Stress,psi		Eff.Stress Ratio	P' $(s'_1+s'_3)/2$ (psi)	Q $[(s_1-s_3)/2]$ (psi)	Eff. Minor Pr. Stress
			Total,U	Change,DU			(psi)	Total s_1	Eff. s'_1	s'_1/s'_3			s'_3 (psi)
0.0	0.000	17.6	70.0	0.0	0.00	6.57	0.0	10.0	10.0	1.00	10.0	0.0	10.0
1.7	0.017	60.7	73.5	3.5	0.28	6.59	6.5	16.5	13.0	2.01	9.8	3.3	6.5
2.7	0.027	76.3	74.4	4.4	0.45	6.60	8.9	18.9	14.5	2.58	10.1	4.4	5.6
3.7	0.037	90.3	74.7	4.7	0.62	6.61	11.0	21.0	16.3	3.08	10.8	5.5	5.3
4.7	0.047	103.0	74.8	4.8	0.79	6.62	12.9	22.9	18.1	3.47	11.7	6.4	5.2
5.7	0.057	115.3	74.7	4.7	0.95	6.63	14.7	24.7	20.0	3.78	12.7	7.4	5.3
7.7	0.077	138.6	74.2	4.2	1.29	6.66	18.2	28.2	23.9	4.16	14.8	9.1	5.8
10.7	0.107	166.9	73.3	3.3	1.79	6.69	22.3	32.3	29.0	4.33	17.9	11.2	6.7
12.7	0.127	182.5	72.7	2.7	2.13	6.71	24.6	34.6	31.9	4.36	19.6	12.3	7.3
15.7	0.157	201.4	71.8	1.8	2.63	6.75	27.2	37.2	35.4	4.33	21.8	13.6	8.2
17.7	0.177	212.3	71.3	1.3	2.96	6.77	28.8	38.8	37.5	4.30	23.1	14.4	8.7
20.7	0.207	225.6	70.5	0.5	3.47	6.81	30.6	40.6	40.1	4.21	24.8	15.3	9.5
24.7	0.247	240.8	69.5	-0.5	4.14	6.85	32.6	42.6	43.0	4.11	26.7	16.3	10.5
29.7	0.297	256.3	68.5	-1.5	4.97	6.91	34.5	44.5	46.0	4.01	28.7	17.3	11.5
35.7	0.357	271.4	67.5	-2.5	5.98	6.99	36.3	46.3	48.8	3.91	30.6	18.2	12.5
40.7	0.407	281.6	66.8	-3.2	6.82	7.05	37.4	47.4	50.6	3.84	31.9	18.7	13.2
45.7	0.457	290.5	66.2	-3.8	7.66	7.11	38.4	48.4	52.2	3.78	33.0	19.2	13.8
49.7	0.497	296.5	65.9	-4.1	8.33	7.17	38.9	48.9	53.0	3.76	33.6	19.5	14.1
59.7	0.597	309.6	65.1	-4.9	10.00	7.30	40.0	50.0	54.9	3.68	34.9	20.0	14.9
69.7	0.697	319.8	64.4	-5.6	11.68	7.44	40.6	50.6	56.2	3.60	35.9	20.3	15.6
79.7	0.797	328.7	63.9	-6.1	13.35	7.58	41.0	51.0	57.1	3.55	36.6	20.5	16.1
84.7	0.847	333.3	63.7	-6.3	14.19	7.66	41.2	51.2	57.5	3.53	36.9	20.6	16.3
90.0	0.900	338.1	63.6	-6.4	15.08	7.74	41.4	51.4	57.8	3.53	37.1	20.7	16.4
Values @ Failure				2.7	2.13	6.71	24.6	34.6	31.9	4.36	19.6	12.3	7.3

Failure criteria used*: 3

*Note:"1"=Max Deviator Stress;"2"=Deviator Stress @ 15% Strain;"3"=Max Eff.Stress Ratio(s'_1/s'_3)

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AASHTO ACCREDITED

Tested By	EB/KP
Date	03/05/20
Checked By	[signature]

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33252/Borrow Soil #3	Depth/Elevation	-
Location	Yates	Additional Info	-

SPECIMEN PROPERTIES

		(initial)	(after consol.)
Height, in		6.000	5.938
Diameter, in		2.875	2.893
Height-to-Diameter Ratio		2.1	2.1
Area, in^2		6.49	6.57
Volume, cm^3		638.29	639.66
Mass of Wet Sample, g		1290.10	1321.20
Mass of Dry Sample, g		1087.22	1087.22
Wet Density, pcf		126.2	128.9
Dry Density, pcf		106.3	106.1
Specific Gravity	(assumed)	2.680	2.680
Volume of Solids, cm^3		405.68	405.68
Volume of Voids, cm^3		232.61	233.98
Void Ratio		0.57	0.58
% Saturation		87.2	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	550.30	1628.50
Mass of Dry Sample and Tare, g	502.40	1394.52
Mass of Tare, g	245.70	307.30
Moisture, %	18.66	21.52

TEST DATA PRIOR TO LOADING

Machine Speed, in / min	0.0100
Strain Rate, % / min	0.17
Chamber Pressure, psi	90.0
Back Pressure,psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	20.0
Change in Height, in	0.062
"B" Value	0.95

SHEAR DATA

Elapsed Time (min)	Deformation (inch)	Axial Load (lb)	Pore-Water Pressure,psi Total,U	Pore-Water Pressure,psi Change,DU	Total Strain (%)	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$) (psi)	Major Principal Stress,psi Total s_1	Major Principal Stress,psi Eff. s'_1	Eff.Stress Ratio s'_1/s'_3	P' $(s'_1+s'_3)/2$ (psi)	Q $[(s_1-s_3)/2]$ (psi)	Eff. Minor Pr. Stress s'_3 (psi)
0.0	0.000	23.0	70.0	0.0	0.00	6.57	0.0	20.0	20.0	1.00	20.0	0.0	20.0
1.0	0.010	86.9	75.8	5.8	0.17	6.58	9.7	29.7	23.9	1.69	19.0	4.9	14.2
2.0	0.020	112.8	78.0	8.0	0.33	6.60	13.6	33.6	25.6	2.13	18.8	6.8	12.0
3.0	0.030	132.9	79.0	9.0	0.50	6.61	16.6	36.6	27.6	2.52	19.3	8.3	11.0
4.0	0.040	150.1	79.6	9.6	0.67	6.62	19.2	39.2	29.6	2.84	20.0	9.6	10.4
5.0	0.050	165.4	79.8	9.8	0.84	6.63	21.5	41.5	31.7	3.10	20.9	10.7	10.2
7.0	0.070	189.3	79.8	9.8	1.18	6.65	25.0	45.0	35.2	3.44	22.7	12.5	10.2
10.0	0.100	216.3	79.3	9.3	1.68	6.69	28.9	48.9	39.6	3.69	25.2	14.5	10.7
12.0	0.120	230.2	78.9	8.9	2.02	6.71	30.9	50.9	42.0	3.77	26.6	15.4	11.1
15.0	0.150	247.0	78.3	8.3	2.52	6.74	33.2	53.2	44.9	3.83	28.3	16.6	11.7
17.0	0.170	256.4	77.9	7.9	2.86	6.77	34.5	54.5	46.6	3.84	29.4	17.2	12.1
20.0	0.200	268.7	77.5	7.5	3.37	6.80	36.1	56.1	48.6	3.89	30.6	18.1	12.5
24.0	0.240	282.7	77.0	7.0	4.04	6.85	37.9	57.9	50.9	3.92	31.9	19.0	13.0
29.0	0.290	297.4	76.2	6.2	4.88	6.91	39.7	59.7	53.5	3.87	33.7	19.9	13.8
35.0	0.350	312.2	75.3	5.3	5.89	6.99	41.4	61.4	56.1	3.82	35.4	20.7	14.7
40.0	0.400	322.9	74.6	4.6	6.73	7.05	42.5	62.5	57.9	3.77	36.6	21.3	15.4
45.0	0.450	332.5	74.1	4.1	7.58	7.11	43.5	63.5	59.4	3.73	37.7	21.8	15.9
49.0	0.490	339.1	73.7	3.7	8.25	7.16	44.1	64.1	60.5	3.70	38.4	22.1	16.3
59.0	0.590	353.3	73.1	3.1	9.93	7.30	45.3	65.3	62.1	3.68	39.5	22.6	16.9
69.0	0.690	365.0	72.4	2.4	11.62	7.44	46.0	66.0	63.6	3.61	40.6	23.0	17.6
79.0	0.790	375.8	71.8	1.8	13.30	7.58	46.5	66.5	64.7	3.56	41.5	23.3	18.2
84.0	0.840	380.9	71.6	1.6	14.14	7.66	46.7	66.7	65.2	3.54	41.8	23.4	18.4
90.0	0.900	386.6	71.5	1.5	15.15	7.75	46.9	66.9	65.5	3.53	42.0	23.5	18.5
Values @ Failure				7.0	4.04	6.85	37.9	57.9	50.9	3.92	31.9	19.0	13.0

Failure criteria used*: 3

*Note:"1"=Max Deviator Stress;"2"=Deviator Stress @ 15% Strain;"3"=Max Eff.Stress Ratio(s'_1/s'_3)

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Tested By	EB/KP
Date	03/05/20
Checked By	

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33252/Borrow Soil #3	Depth/Elevation	-
Location	Yates	Additional Info	-

SPECIMEN PROPERTIES

		(initial)	(after consol.)
Height, in		6.000	5.924
Diameter, in		2.875	2.874
Height-to-Diameter Ratio		2.1	2.1
Area, in^2		6.49	6.49
Volume, cm^3		638.29	629.80
Mass of Wet Sample, g		1290.40	1311.50
Mass of Dry Sample, g		1087.48	1087.48
Wet Density, pcf		126.2	130.0
Dry Density, pcf		106.4	107.8
Specific Gravity	(assumed)	2.680	2.680
Volume of Solids, cm^3		405.78	405.78
Volume of Voids, cm^3		232.51	224.02
Void Ratio		0.57	0.55
% Saturation		87.3	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	550.30	1671.60
Mass of Dry Sample and Tare, g	502.40	1447.58
Mass of Tare, g	245.70	360.10
Moisture, %	18.66	20.60

TEST DATA PRIOR TO LOADING

Machine Speed, in / min	0.0100
Strain Rate, % / min	0.17
Chamber Pressure, psi	110.0
Back Pressure,psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	40.0
Change in Height, in	0.076
"B" Value	0.95

SHEAR DATA

Elapsed Time (min)	Deformation (inch)	Axial Load (lb)	Pore-Water Pressure,psi Total,U	Pore-Water Pressure,psi Change,DU	Total Strain (%)	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$) (psi)	Major Principal Stress,psi Total s_1	Major Principal Stress,psi Eff. s'_1	Eff.Stress Ratio s'_1/s'_3	P' $(s'_1+s'_3)/2$ (psi)	Q $[(s_1-s_3)/2]$ (psi)	Eff. Minor Pr. Stress s'_3 (psi)
0.0	0.000	26.2	70.0	0.0	0.00	6.49	0.0	40.0	40.0	1.00	40.0	0.0	40.0
1.0	0.010	116.8	77.7	7.7	0.17	6.50	13.9	53.9	46.2	1.43	39.2	7.0	32.3
2.0	0.020	167.6	83.3	13.3	0.34	6.51	21.7	61.7	48.4	1.81	37.5	10.9	26.7
3.0	0.030	200.0	86.6	16.6	0.50	6.52	26.7	66.7	50.0	2.14	36.7	13.3	23.4
4.0	0.040	224.7	88.8	18.8	0.67	6.53	30.4	70.4	51.6	2.43	36.4	15.2	21.2
5.0	0.050	243.7	90.1	20.1	0.84	6.54	33.2	73.2	53.1	2.67	36.5	16.6	19.9
7.0	0.070	272.3	91.7	21.7	1.18	6.57	37.5	77.5	55.8	3.05	37.1	18.7	18.3
10.0	0.100	302.6	92.6	22.6	1.69	6.60	41.9	81.9	59.3	3.40	38.4	20.9	17.4
12.0	0.120	317.6	92.7	22.7	2.02	6.62	44.0	84.0	61.4	3.54	39.3	22.0	17.3
15.0	0.150	335.5	92.5	22.5	2.53	6.66	46.5	86.5	63.9	3.66	40.7	23.2	17.5
17.0	0.170	345.8	92.4	22.4	2.87	6.68	47.9	87.9	65.5	3.71	41.6	23.9	17.6
20.0	0.200	358.9	92.0	22.0	3.37	6.71	49.5	89.5	67.5	3.76	42.7	24.8	18.0
24.0	0.240	373.5	91.6	21.6	4.05	6.76	51.4	91.4	69.8	3.79	44.1	25.7	18.4
29.0	0.290	388.7	90.9	20.9	4.89	6.82	53.1	93.1	72.2	3.79	45.6	26.6	19.1
35.0	0.350	404.3	90.2	20.2	5.91	6.89	54.8	94.8	74.7	3.76	47.3	27.4	19.8
40.0	0.400	415.8	89.9	19.9	6.75	6.96	56.0	96.0	76.1	3.79	48.1	28.0	20.1
45.0	0.450	425.3	89.6	19.6	7.60	7.02	56.8	96.8	77.2	3.79	48.8	28.4	20.4
49.0	0.490	432.3	89.2	19.2	8.27	7.07	57.4	97.4	78.2	3.76	49.5	28.7	20.8
59.0	0.590	447.8	88.3	18.3	9.96	7.21	58.5	98.5	80.2	3.69	51.0	29.3	21.7
69.0	0.690	459.6	87.5	17.5	11.65	7.34	59.0	99.0	81.5	3.62	52.0	29.5	22.5
79.0	0.790	470.8	87.5	17.5	13.33	7.49	59.4	99.4	81.9	3.63	52.2	29.7	22.5
84.0	0.840	475.5	87.1	17.1	14.18	7.56	59.4	99.4	82.3	3.59	52.6	29.7	22.9
90.0	0.900	481.0	86.7	16.7	15.19	7.65	59.5	99.5	82.7	3.56	53.0	29.7	23.3
Values @ Failure				19.6	7.60	7.02	56.8	96.8	77.2	3.79	48.8	28.4	20.4
Failure criteria used*			3										

*Note:"1"=Max Deviator Stress;"2"=Deviator Stress @ 15% Strain;"3"=Max Eff.Stress Ratio(s'_1/s'_3)

TIMELY ENGINEERING SOIL TESTS, LLC
1874 Forge Street Tucker, GA 30084
Phone: 770-938-8233
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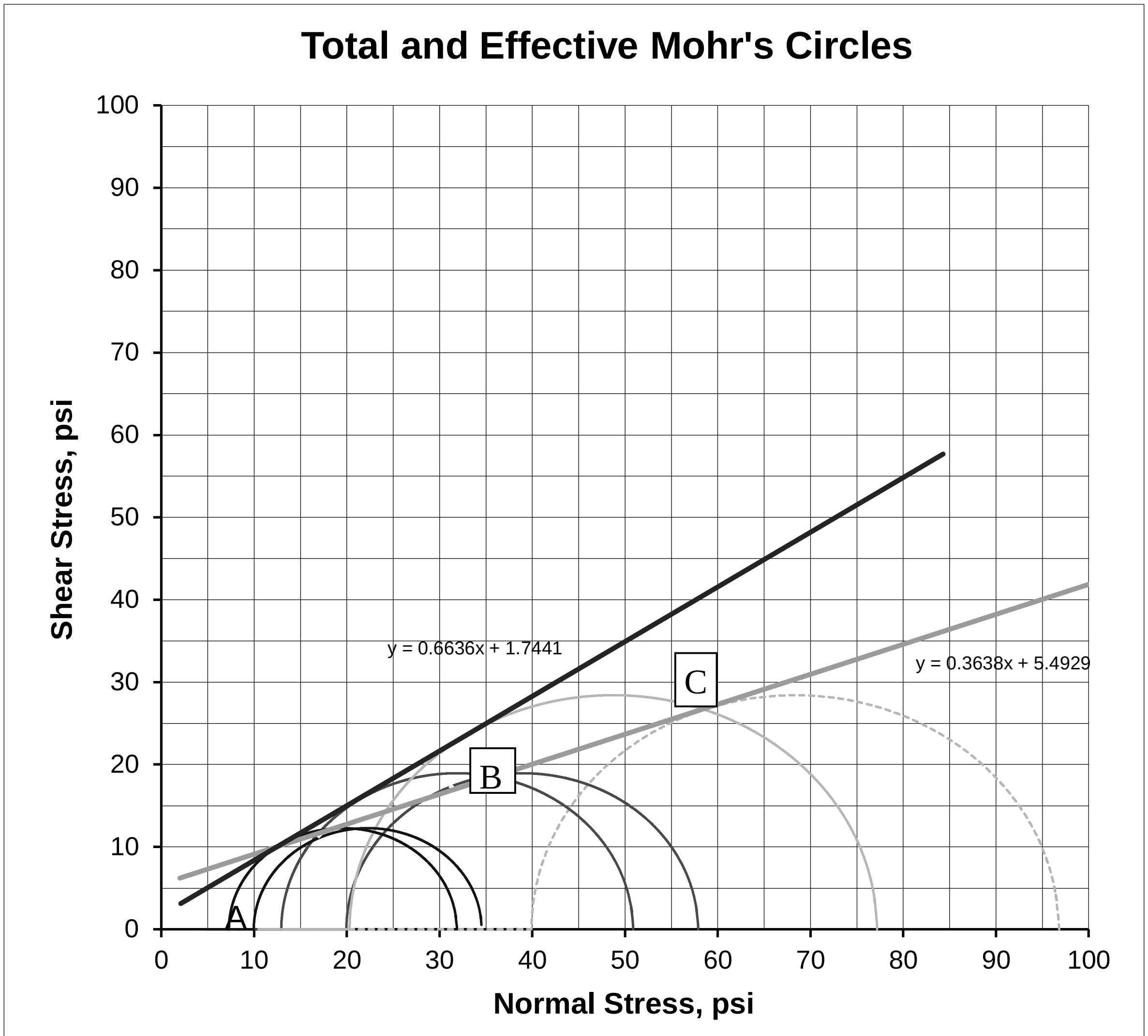
Web: www.test-llc.com

Tested By	EB/KP
Date	03/05/20
Check	

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Project #	I054-107	Laboratory Project #	2008-08-1
Project Name	AMA	Sample Type	Remold
Sample ID	33252/Borrow Soil #3	Depth/Elevation	-
Location	Yates	Additional Info	-



Specimen	A	B	C
Effective Consolidation Stress, psi	10.0	20.0	40.0
Deviator Stress at Failure, psi	24.6	37.9	56.8
Effective Minor Principal Stress at Failure, psi	7.3	13.0	20.4
Effective Major Principal Stress at Failure, psi	31.9	50.9	77.2
Axial Strain at Failure, %	2.13	4.04	7.60

STRENGTH PARAMETERS*			
Total		Effective	
f °	20.0	f ' °	33.6
C, psi	5.5	C', psi	1.7

***Valid only for Received Material at Reported Densities and Moisture Contents. Please see remarks on page 6 of this report**

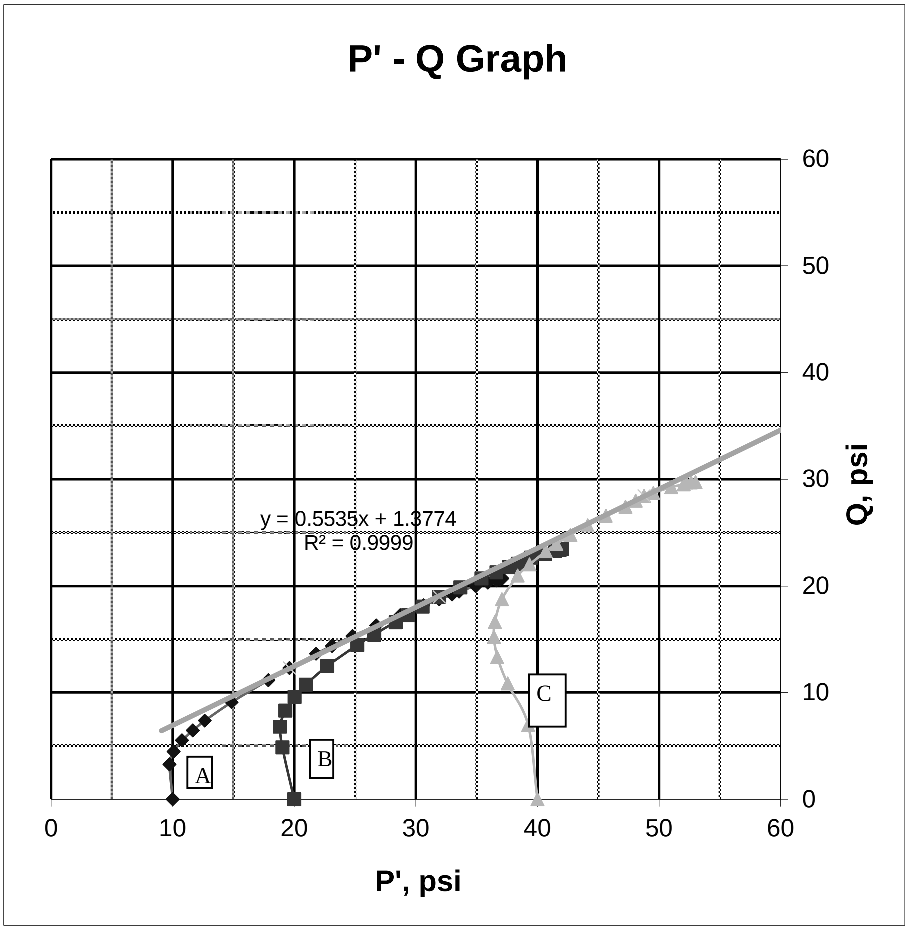
Triaxial CU.xls [Mohr's Circles], REV. 1; 10-10-05

TIMELY **E**NGINEERING **S**OIL **T**ESTS, LLC	1874 Forge Street Tucker, GA 30084 Phone: 770-938-8233 Fax: 770-923-8973 Web: www.test-llc.com	AASHTO ACCREDITED	Tested By: EB/KP Date: 03/05/20 Check: [signature]

ASTM D 4767 / AASHTO T 297

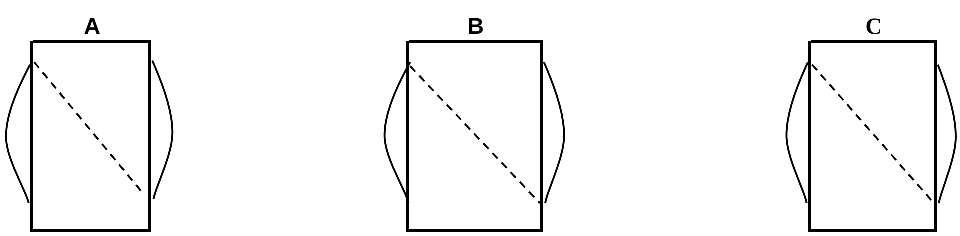
Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33252/Borrow Soil #3	Depth/Elevation	-
Location	Yates	Additional Info	-



a, psi	**1.4**
a, degree	**29.0**

FAILURE SKETCH



REMOLDING PROPERTIES

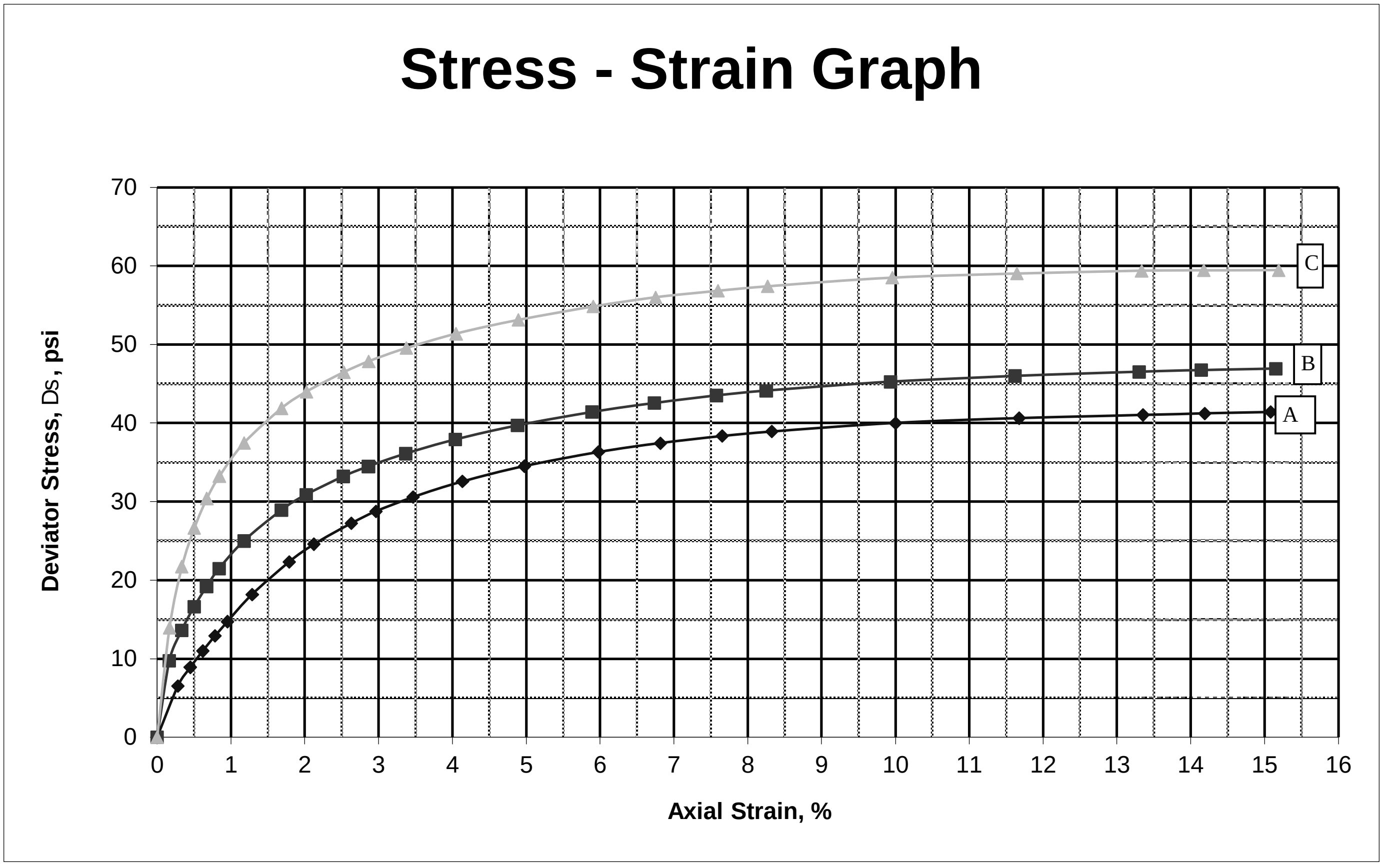
	A	B	C
% Compaction of Max Dry Density	95.1	95.0	95.0
% Difference from Optimum M.C.	3.1	3.1	3.1

T.E.S.T. **T**IMELY **E**NGINEERING **S**OIL **T**ESTS, LLC	1874 Forge Street Tucker, GA 30084 Phone: 770-938-8233 Fax: 770-923-8973 Web: www.test-llc.com	AASHTO ACCREDITED	Tested By: EB/KP Date: 03/05/20 Check:

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33252/Borrow Soil #3	Depth/Elevation	-
Location	Yates	Additional Info	-



Balance ID Number	563/700	
Oven ID Number	496/610	
Deformation Indicator ID #	178/349/689	
Digital Caliper ID #	370/458	
Load Cell ID #	347/692/815	
Apparatus ID #	293/693/814	

REMARKS

Samples (Material passing #4 Sieve) were remolded to specified % compaction and moisture content of Standard Proctor values

DESCRIPTION

Yellowish Brown and Dark Gray Silty Sand

NOTES:

1. Method for Saturation — WET
2. Method for determination of cross-sectional after consolidation — B
3. Initial specimen moisture content obtained from cuttings
4. Final specimen moisture content obtained from entire sample

LL	-
PL	-
PI	-
Gs	-

USCS (ASTM D2487: D2488): SM

Triaxial CU.xls [Stress-Strain GRAPH], REV. 1; 10-10-05

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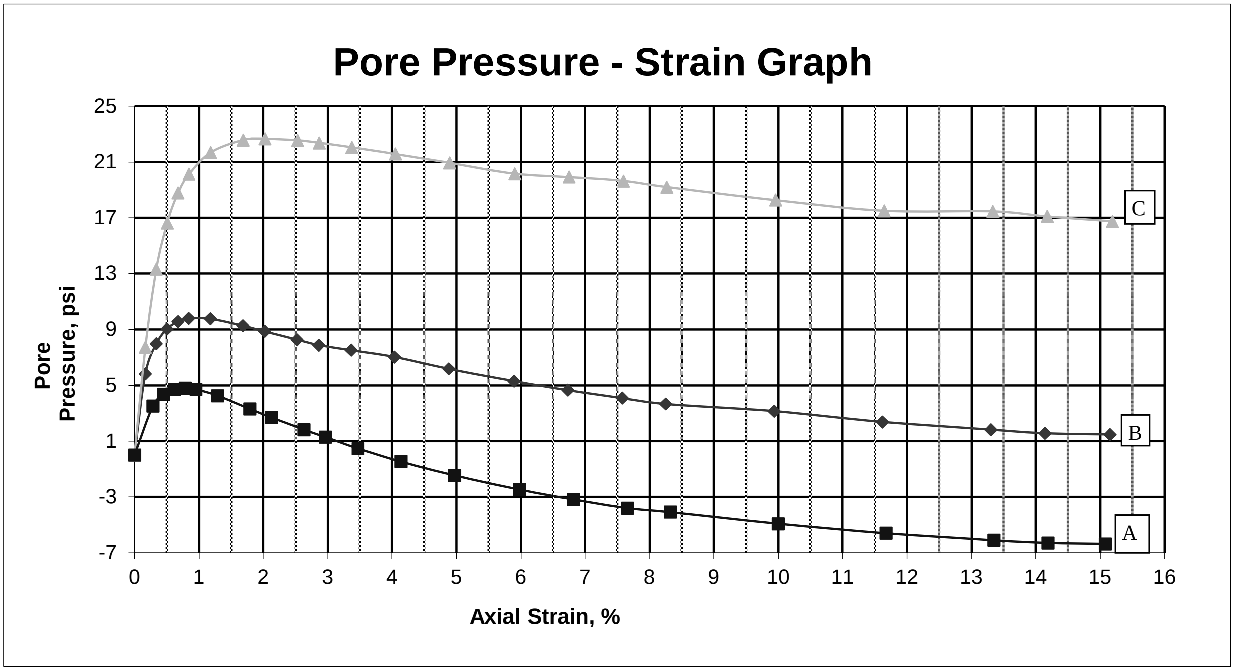
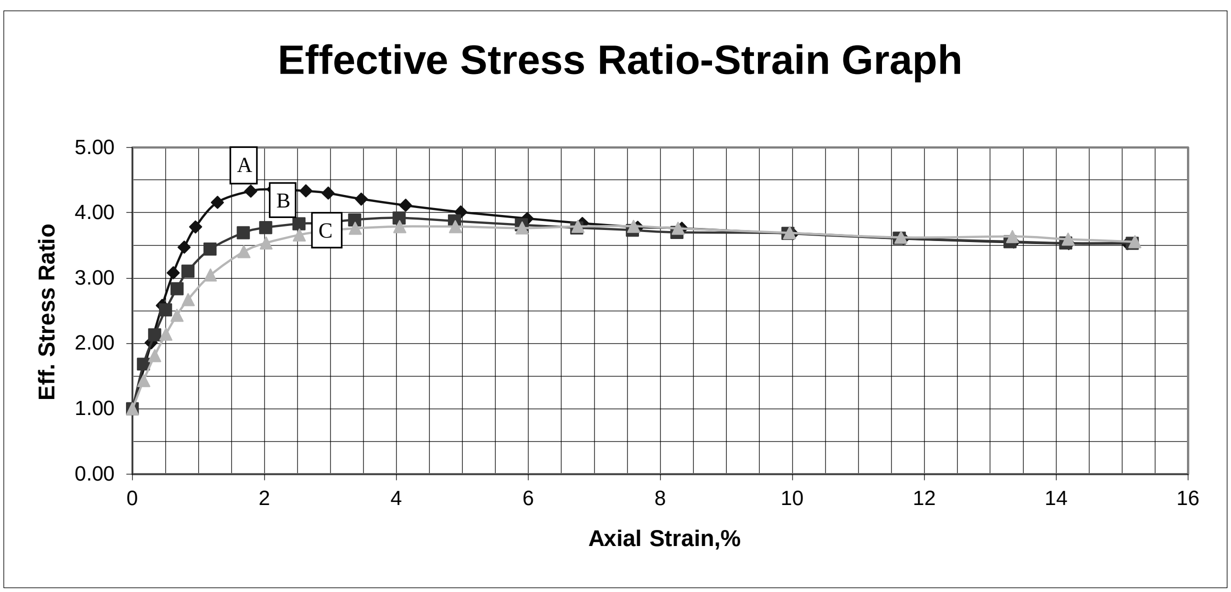
ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33252/Borrow Soil #3	Depth/Elevation	-
Location	Yates	Additional Info	-





Triaxial CU.xls [Stress Ratio & Pore Water Pr.-Strain GRAPH], REV. 1; 10-10-05

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Tested By	IH
Date	03/04/20
Checked By	LB

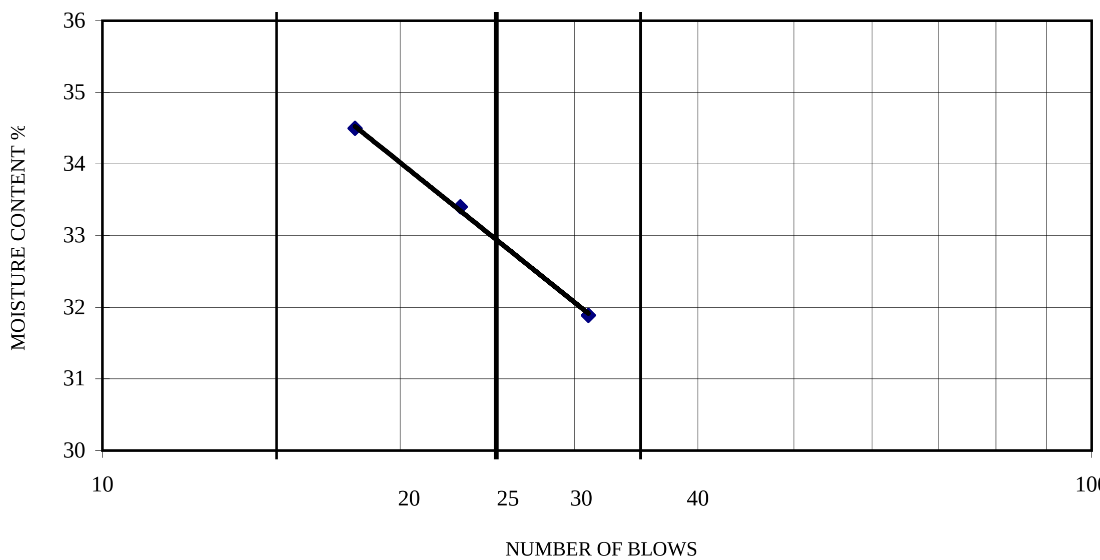
Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33252/Borrow Soil #3	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 4318/AASHTO T 88, T 89
Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils (Atterberg Limits)

LIQUID LIMIT

Number of Blows	31	23	18
Mass of Wet Sample & Tare, g	42.74	37.75	39.38
Mass of Dry Sample & Tare, g	38.99	34.44	35.72
Mass of Tare, g	27.23	24.53	25.11
Moisture Content, %	31.89	33.40	34.50

Oven ID #	15/496/610
Balance ID #	139/563
Liquid Limit Device ID #	451/569



PLASTIC LIMIT

Mass of Wet Sample & Tare, g	38.71	35.60
Mass of Dry Sample & Tare, g	35.67	33.20
Mass of Tare, g	23.95	23.84
Moisture Content, %	25.94	25.64

NOTE: MATERIAL PASSING NO. 40 SIEVE WAS USED FOR TEST

NATURAL MOISTURE

Mass of Wet Sample & Tare, g	564.80
Mass of Dry Sample & Tare, g	500.00
Mass of Tare, g	175.00
Moisture Content, %	19.94

LIQUID LIMIT (LL)	33
PLASTIC LIMIT (PL)	26
PLASTICITY INDEX (PI)	7
LIQUIDITY INDEX (LI)	-0.87

DESCRIPTION: Yellowish Brown and Dark Gray Silty Sand

USCS (ASTM D2487; D2488): SM

AASHTO (M 145): NA

TIMELY ENGINEERING SOIL TESTS, LLC

1874 Forge Street Tucker, GA 30084
Phone: 770-938-8233
Fax: 770-923-8973
Web: www.test-llc.com

AASHTO ACCREDITED

Tested By	RI
Date	03/02/20
Checked By	*(initials)*

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33252/Borrow Soil #3	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 422/AASHTO T 88

Standard Test Method for Particle-Size Analysis of Soils (with Double Separation per ASTM D6913 and Hydrometer Analysis)

As-Received Moisture Content (Total Sample)

Mass of Wet Sample & Tare, g	564.8
Mass of Dry Sample & Tare, g	500.0
Mass of Tare, g	175.0
Moisture Content, %	19.9

Moisture Content of FINER PORTION

	1st Subsample	*2nd Subsample*
Mass of Wet Sample & Tare, g	424.5	406.80
Mass of Dry Sample & Tare, g	393.7	375.30
Mass of Tare, g	107.3	101.10
Moisture Content, %	10.8	11.5

Mass of Total Sample before separation on 3/8" sieve & Tare, g	19800
Mass of Tare, g	0.0
Total Mass of Dry Sample, g	16508

	1st Subsample	*2nd Subsample*
Mass of Wet Finer Portion & Tare, g	1051.1	82.80
Mass of Tare	0.0	0.0
Dry Mass, g	949.0	74.27
% of Total Sample passing Split Sieve	90.8	88.0

SIEVE ANALYSIS

COARSER PORTION OF SAMPLE (RETAINED ON 3/8" SIEVE)

Mass of Tare, g: 0.00

Sieve Size		Sample & Tare, g	% RETAINED	% PASSING (of Total)
12"	COBBLES		0	100
3"	COARSE GRAVEL		0	100
2.5"			0	100
2"		0.0	0	100
1.5"		102.4	1	99
1"		466.1	3	97
.75"	FINE GRAVEL	819.0	5	95
.5"		1314.7	8	92
.375"		1518.2	9	91
#4	COARSE SAND	29.3	3	88

#4 <First Subsample of Finer Portion<3/8"

2nd Subsample of FINER PORTION OF SAMPLE (PASSING #4 SIEVE:Hydrometer Backsieve)

Sieve Size		Cumulative Mass retained, g	% PASSING (of Total)
#10	MEDIUM SAND	5.50	81
#20		12.86	73
#40	FINE SAND	20.50	64
#60		27.79	55
#100		35.31	46
#200	FINES	44.03	36

Remarks

HYDROMETER ANALYSIS

Length of Dispersion Period	1 Minute
Mechanical Dispersion Device ID #	61
Amount of Dispersing Agent (ml)	125.0
Specific Gravity (assumed)	2.650
Specific Gravity (tested)	
Starting time	14:08

PARTICLE-SIZE ANALYSIS

% COBBLES	0	% MEDIUM SAND	18
% COARSE GRAVEL	5	% FINE SAND	28
% FINE GRAVEL	7	% FINES	36
% COARSE SAND	7	% TOTAL SAMPLE	100
% CLAY(<0.005mm)	15	% CLAY(<0.002mm)	12

Date	Time	Testing time (min)	Reading	Temp (°C)	K	Composite Correction	Actual Reading	Effective Depth (cm)	a	Particle Diam. (mm)	Percent Passing
03/04/20	14:10	2	30.0	17.7	0.01399	6.5	23.5	12.5	1.00	0.0349	27.8
03/04/20	14:13	5	27.5	17.7	0.01399	6.5	21.0	12.9	1.00	0.0225	24.9
03/04/20	14:23	15	23.5	17.7	0.01399	6.5	17.0	13.6	1.00	0.0133	20.1
03/04/20	14:38	30	22.0	17.7	0.01399	6.5	15.5	13.8	1.00	0.0095	18.4
03/04/20	15:08	60	21.0	17.7	0.01399	6.5	14.5	14.0	1.00	0.0068	17.2
03/04/20	18:18	250	18.0	17.7	0.01399	6.5	11.5	14.5	1.00	0.0034	13.6
03/05/20	14:08	1440	16.0	17.7	0.01399	6.5	9.5	14.8	1.00	0.0014	11.3

Hydrometer 152H ID #	305527	Oven ID #	15/496/610
Sieve Shaker ID #	555	Balance ID#	139/142/700

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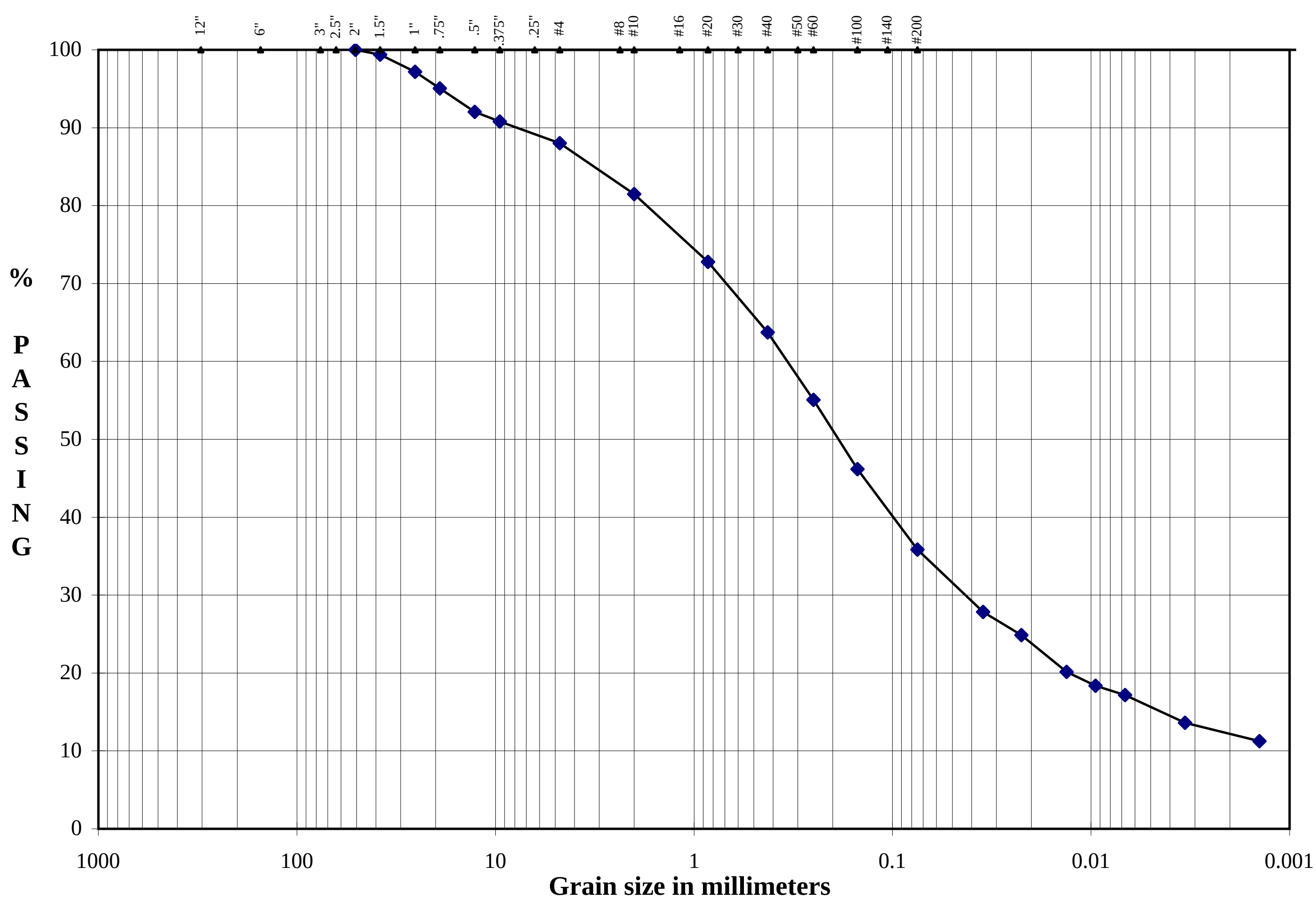
Tested By	RI
Date	03/02/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33252/Borrow Soil #3	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 422/AASHTO T 88

Standard Test Method for Particle-Size Analysis of Soils (with Double Separation per ASTM D6913 and Hydrometer Analysis)

Particle-Size Analysis



Boulders	Cobbles	Gravel		Sand			Fines
		Coarse	Fine	Coarse	Medium	Fine	Silt or Clay

D_{10}	NA	mm
D_{30}	NA	mm
D_{60}	NA	mm
Cu	NA	
Cc	NA	

DESCRIPTION: Yellowish Brown and Dark Gray Silty Sand

USCS (ASTM D2487; D2488): SM

Project's Specific % Passing	NA
Project's Specific Particle Size, mm	NA

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Tested By	RI
Date	03/02/20
Checked By	LB

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33252/Borrow Soil #3	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 698

Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600kN-m/m^3))

DETERMINATION OF TEST PROCEDURE

	wet	dry
Mass of Soil before sieving, g	19800.0	16508.5
Mass of Mat. Retained on No. 4 sieve, g		
Mass of Mat. Retained on 3/8" sieve, g	1518.2	1518.2
Mass of Mat. Retained on 3/4" sieve, g		

MOISTURE CONTENT

	Coarse + Fine Fraction	Coarse Fraction
Mass of Wet Sample & Tare, g	564.8	1518.2
Mass of Dry Sample & Tare, g	500.0	1518.2
Mass of Tare, g	175.0	0.0
Moisture Content, %	19.9	0.0

Material Retained on No. 4 Sieve, %	
Material Retained on 3/8" Sieve, %	9.2
Material Retained on 3/4" Sieve, %	
Total, % (oversized)	9.2

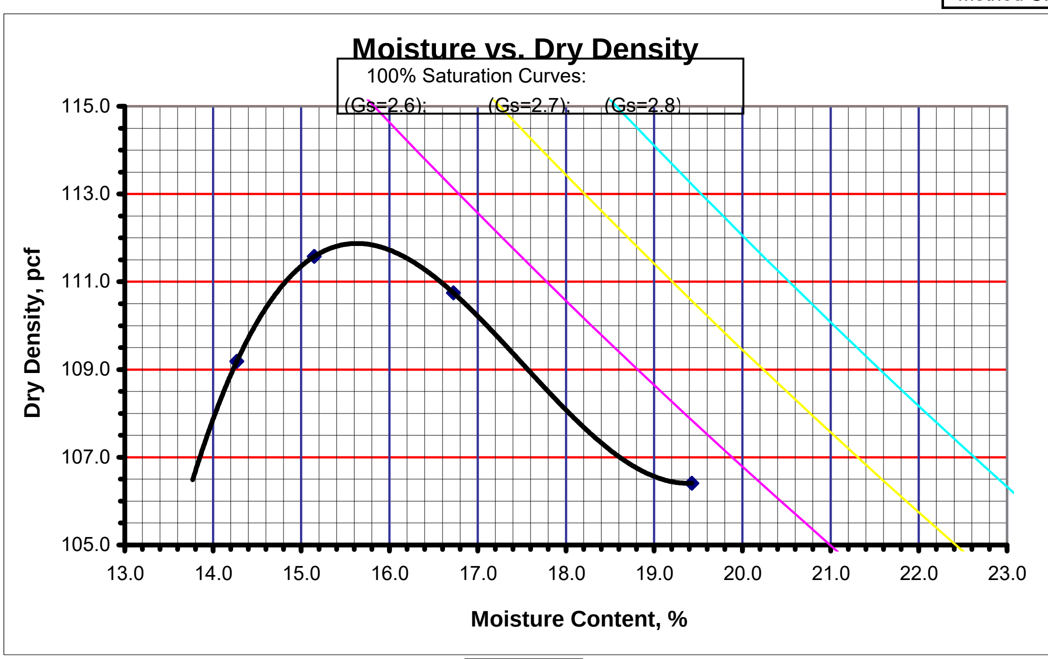
Procedure: B

TEST DATA

Points	1	2	3	4	5
Mass of Mold and Soil, g	6137.0	6193.0	6205.0	6172.0	
Mass of Wet Sample & Tare, g	601.4	508.7	615.4	467.6	
Mass of Dry Sample & Tare, g	549.2	458.9	553.5	411.9	
Mass of Tare, g	183.4	130.1	183.4	125.2	
Moisture Content, %	14.3	15.1	16.7	19.4	
Wet Density, pcf	124.8	128.5	129.3	127.1	
Dry Density, pcf	109.2	111.6	110.7	106.4	

Mold ID Number	798
Mass of Mold, g	4252.4
Volume of Mold, ft^3	0.0333
Hammer ID Number	318
Number of Blows per layer	25
Number of Layers	3
Mechanical Compactor ID Number	317

Method A: Material retained on No. 4 Sieve ≤ 25%
Method B: Material retained on 3/8" Sieve ≤ 25%
Method C: Material retained on 3/4" Sieve ≤ 30%



REMARKS

DESCRIPTION

Yellowish Brown and Dark Gray Silty Sand

USCS (ASTM D2487; D2488): SM

AASHTO M145: NA

Maximum Dry Density, pcf	111.9	**Corrected Maximum Dry Density, pcf**	**NA**
Optimum Moisture Content, %	15.6	**Corrected Optimum Moisture Content, %**	**NA**

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Web: www.test-llc.com

AASHTO ACCREDITED

Tested By	RI
Date	03/03/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33252/Borrow Soil #3	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D854; Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

TEST METHOD: B

MOISTURE CONTENT

Mass of Wet Sample & Tare, g	-
Mass of Dry Sample & Tare, g	-
Mass of Tare, g	-
Moisture Content, %	NA*

TEST DATA

Pycnometer Number	8
Mass of Pycnometer, g	172.10
Mass of Sample & Pycnometer, g	252.12
Mass of Sample, Water & Pycnometer, g	720.30
Test Temperature, ^{o}C	19.2
Mass of Tare,g	359.50
Mass of Dry Sample & Tare, g	439.20
Mass of Dry Soil, g	79.70
Mass of Pycnometer (Calibrated), g	172.10
Density of Water @ Test Temperature, g/mL	0.99837
Mass of Pycnometer & Water @ Test Temp.	670.35
Temperature Coefficient	1.00016
Calibrated Volume of Pycnometer, mL	499.06
Specific Gravity @ Test Temperature	2.679

SPECIFIC GRAVITY @ 20 ^{o}C **2.680**

DESCRIPTION

Yellowish Brown and Dark Gray Silty Sand

USCS (ASTM D2487, D2488)

SM

Thermometer ID Number	72
Vacuum Pump ID Number	62
Deaerator ID Number	213
Specific Gravity Board ID Number	214
Balance ID Number	139
Oven ID Number	12

NOTES:

1.* Oven-Dry material passing #4 sieve used for test.
2. Air removed by vacuum method.
3. Deionized / Deaired water was used for test.

TIMELY ENGINEERING SOIL TESTS, LLC	1874 Forge Street Tucker, GA 30084	Tested By	EB/KP
	Phone: 770-938-8233	Date	03/05/20
	Fax: 770-923-8973	Checked By	[signature]
	Web: www.test-llc.com		

AASHTO ACCREDITED

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33253/Borrow Soil #4	Depth/Elevation	-
Location	Yates	Additional Info	-

SPECIMEN PROPERTIES

	(initial)	(after consol.)
Height, in	6.000	5.974
Diameter, in	2.875	2.878
Height-to-Diameter Ratio	2.1	2.1
Area, in^2	6.49	6.51
Volume, cm^3	638.29	636.86
Mass of Wet Sample, g	1299.30	1334.60
Mass of Dry Sample, g	1116.71	1116.80
Wet Density, pcf	127.1	130.8
Dry Density, pcf	109.2	109.5
Specific Gravity (assumed)	2.665	2.665
Volume of Solids, cm^3	419.03	419.06
Volume of Voids, cm^3	219.26	217.80
Void Ratio	0.52	0.52
% Saturation	83.3	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	550.60	1668.50
Mass of Dry Sample and Tare, g	507.50	1450.71
Mass of Tare, g	243.90	334.00
Moisture, %	16.35	19.50

TEST DATA PRIOR TO LOADING

Machine Speed, in / min	0.0100
Strain Rate, % / min	0.17
Chamber Pressure, psi	80.0
Back Pressure,psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	10.0
Change in Height, in	0.026
"B" Value	0.95

SHEAR DATA

Elapsed Time (min)	Deformation (inch)	Axial Load (lb)	Pore-Water Pressure,psi Total,U	Pore-Water Pressure,psi Change,DU	Total Strain (%)	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$) (psi)	Major Principal Stress,psi Total s_1	Major Principal Stress,psi Eff. s'_1	Eff.Stress Ratio s'_1/s'_3	P' $(s'_1+s'_3)/2$ (psi)	Q $[(s_1-s_3)/2]$ (psi)	Eff. Minor Pr. Stress s'_3 (psi)
0.0	0.000	18.9	70.0	0.0	0.00	6.51	0.0	10.0	10.0	1.00	10.0	0.0	10.0
1.0	0.010	69.9	72.8	2.8	0.17	6.52	7.8	17.8	15.1	2.08	11.2	3.9	7.2
2.0	0.020	89.0	73.5	3.5	0.34	6.53	10.7	20.7	17.2	2.65	11.9	5.4	6.5
3.1	0.031	104.8	73.8	3.8	0.51	6.54	13.1	23.1	19.4	3.10	12.8	6.6	6.3
4.1	0.041	118.8	73.7	3.7	0.68	6.55	15.3	25.3	21.5	3.43	13.9	7.6	6.3
5.1	0.051	131.7	73.6	3.6	0.85	6.56	17.2	27.2	23.6	3.68	15.0	8.6	6.4
7.1	0.071	152.9	73.1	3.1	1.19	6.58	20.4	30.4	27.3	3.94	17.1	10.2	6.9
10.2	0.102	175.9	72.2	2.2	1.71	6.62	23.7	33.7	31.5	4.05	19.6	11.9	7.8
12.2	0.122	187.6	71.7	1.7	2.05	6.64	25.4	35.4	33.7	4.06	21.0	12.7	8.3
15.3	0.153	201.7	71.0	1.0	2.56	6.68	27.4	37.4	36.4	4.04	22.7	13.7	9.0
17.3	0.173	209.5	70.6	0.6	2.90	6.70	28.5	38.5	37.9	4.02	23.6	14.2	9.4
20.4	0.204	219.7	70.0	0.0	3.41	6.74	29.8	39.8	39.8	3.99	24.9	14.9	10.0
24.5	0.245	231.2	69.4	-0.6	4.09	6.78	31.3	41.3	41.9	3.95	26.3	15.6	10.6
29.6	0.296	243.8	68.7	-1.3	4.95	6.84	32.9	42.9	44.2	3.90	27.8	16.4	11.3
35.7	0.357	256.9	67.9	-2.1	5.97	6.92	34.4	44.4	46.5	3.85	29.3	17.2	12.1
40.8	0.408	267.2	67.5	-2.5	6.82	6.98	35.6	45.6	48.1	3.85	30.3	17.8	12.5
45.9	0.459	275.1	67.0	-3.0	7.68	7.05	36.4	46.4	49.3	3.81	31.1	18.2	13.0
49.9	0.499	281.3	66.7	-3.3	8.36	7.10	37.0	47.0	50.3	3.77	31.8	18.5	13.3
60.1	0.601	295.6	65.9	-4.1	10.06	7.23	38.2	48.2	52.4	3.71	33.3	19.1	14.1
70.3	0.703	307.7	65.2	-4.8	11.77	7.37	39.2	49.2	53.9	3.65	34.4	19.6	14.8
80.5	0.805	318.7	64.8	-5.2	13.48	7.52	39.9	49.9	55.0	3.63	35.1	19.9	15.2
85.6	0.856	323.8	64.6	-5.4	14.33	7.59	40.2	50.2	55.5	3.61	35.5	20.1	15.4
90.0	0.900	327.9	64.4	-5.6	15.06	7.66	40.3	50.3	56.0	3.58	35.8	20.2	15.6
Values @ Failure				1.7	2.05	6.64	25.4	35.4	33.7	4.06	21.0	12.7	8.3
Failure criteria used*			3										

*Note:"1"=Max Deviator Stress;"2"=Deviator Stress @ 15% Strain;"3"=Max Eff.Stress Ratio(s'_1/s'_3)

Triaxial CU.xls [A], REV. 1; 10-10-05

TIMELY **E**NGINEERING **S**OIL **T**ESTS, LLC	1874 Forge Street Tucker, GA 30084 Phone: 770-938-8233 Fax: 770-923-8973 Web: www.test-llc.com	Tested By: EB/KP Date: 03/05/20 Checked By: [signature]

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33253/Borrow Soil #4	Depth/Elevation	-
Location	Yates	Additional Info	-

SPECIMEN PROPERTIES

	(initial)	(after consol.)
Height, in	6.000	5.957
Diameter, in	2.875	2.865
Height-to-Diameter Ratio	2.1	2.1
Area, in^2	6.49	6.45
Volume, cm^3	638.29	629.21
Mass of Wet Sample, g	1299.40	1327.00
Mass of Dry Sample, g	1116.80	1116.88
Wet Density, pcf	127.1	131.7
Dry Density, pcf	109.2	110.8
Specific Gravity (assumed)	2.665	2.665
Volume of Solids, cm^3	419.06	419.09
Volume of Voids, cm^3	219.23	210.12
Void Ratio	0.52	0.50
% Saturation	83.3	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	550.60	1630.80
Mass of Dry Sample and Tare, g	507.50	1420.70
Mass of Tare, g	243.90	303.90
Moisture, %	16.35	18.81

TEST DATA PRIOR TO LOADING

Machine Speed, in / min	0.0100
Strain Rate, % / min	0.17
Chamber Pressure, psi	90.0
Back Pressure,psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	20.0
Change in Height, in	0.043
"B" Value	0.95

SHEAR DATA

Elapsed Time (min)	Deformation (inch)	Axial Load (lb)	Pore-Water Pressure,psi		Total Strain (%)	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$)	Major Principal Stress,psi		Eff.Stress Ratio	P' $(s'_1+s'_3)/2$	Q $[(s_1-s_3)/2]$	Eff. Minor Pr. Stress
			Total,U	Change,DU			(psi)	Total s_1	Eff. s'_1	s'_1/s'_3	(psi)	(psi)	s'_3 (psi)
0.0	0.000	23.0	70.0	0.0	0.00	6.45	0.0	20.0	20.0	1.00	20.0	0.0	20.0
1.0	0.010	97.9	75.7	5.7	0.17	6.46	11.6	31.6	25.9	1.81	20.1	5.8	14.3
2.0	0.020	128.6	77.4	7.4	0.34	6.47	16.3	36.3	29.0	2.29	20.8	8.2	12.6
3.1	0.031	149.9	78.1	8.1	0.51	6.48	19.6	39.6	31.5	2.65	21.7	9.8	11.9
4.1	0.041	166.7	78.4	8.4	0.68	6.49	22.1	42.1	33.7	2.92	22.6	11.1	11.6
5.1	0.051	180.0	78.6	8.6	0.86	6.50	24.2	44.2	35.6	3.11	23.5	12.1	11.4
7.1	0.071	200.3	78.6	8.6	1.20	6.52	27.2	47.2	38.6	3.38	25.0	13.6	11.4
10.2	0.102	220.1	78.3	8.3	1.71	6.56	30.1	50.1	41.7	3.58	26.7	15.0	11.7
12.2	0.122	229.6	78.1	8.1	2.05	6.58	31.4	51.4	43.2	3.65	27.6	15.7	11.9
15.3	0.153	242.6	77.8	7.8	2.57	6.62	33.2	53.2	45.3	3.73	28.8	16.6	12.2
17.3	0.173	249.9	77.6	7.6	2.91	6.64	34.2	54.2	46.6	3.76	29.5	17.1	12.4
20.4	0.204	260.8	77.2	7.2	3.42	6.67	35.6	55.6	48.4	3.79	30.6	17.8	12.8
24.5	0.245	272.8	76.7	6.7	4.11	6.72	37.2	57.2	50.4	3.80	31.9	18.6	13.3
29.6	0.296	286.9	76.2	6.2	4.96	6.78	38.9	58.9	52.7	3.81	33.3	19.5	13.8
35.7	0.357	303.1	75.7	5.7	5.99	6.86	40.9	60.9	55.2	3.85	34.8	20.4	14.3
40.8	0.408	313.3	75.0	5.0	6.84	6.92	42.0	62.0	56.9	3.80	36.0	21.0	15.0
45.9	0.459	324.2	74.5	4.5	7.70	6.98	43.1	63.1	58.7	3.78	37.1	21.6	15.5
49.9	0.499	332.2	74.0	4.0	8.38	7.04	43.9	63.9	59.9	3.75	38.0	22.0	16.0
60.1	0.601	348.9	73.0	3.0	10.09	7.17	45.5	65.5	62.5	3.67	39.7	22.7	17.0
70.3	0.703	364.0	72.5	2.5	11.80	7.31	46.7	66.7	64.2	3.66	40.9	23.3	17.5
80.5	0.805	376.7	71.6	1.6	13.52	7.45	47.5	67.5	65.8	3.58	42.1	23.7	18.4
85.6	0.856	382.7	71.3	1.3	14.37	7.53	47.8	67.8	66.5	3.55	42.6	23.9	18.8
90.0	0.900	388.0	70.9	0.9	15.10	7.59	48.1	68.1	67.1	3.52	43.1	24.0	19.1
Values @ Failure				5.7	5.99	6.86	40.9	60.9	55.2	3.85	34.8	20.4	14.3

Failure criteria used*: 3

*Note:"1"=Max Deviator Stress;"2"=Deviator Stress @ 15% Strain;"3"=Max Eff.Stress Ratio(s'_1/s'_3)

TIMELY ENGINEERING SOIL TESTS, LLC

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Tested By	EB/KP
Date	03/05/20
Checked By	[signature]

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33253/Borrow Soil #4	Depth/Elevation	-
Location	Yates	Additional Info	-

SPECIMEN PROPERTIES

	(initial)	(after consol.)
Height, in	6.000	5.928
Diameter, in	2.875	2.847
Height-to-Diameter Ratio	2.1	2.1
Area, in^2	6.49	6.36
Volume, cm^3	638.29	618.26
Mass of Wet Sample, g	1299.40	1316.00
Mass of Dry Sample, g	1116.80	1116.80
Wet Density, pcf	127.1	132.9
Dry Density, pcf	109.2	112.8
Specific Gravity (assumed)	2.665	2.665
Volume of Solids, cm^3	419.06	419.06
Volume of Voids, cm^3	219.23	199.20
Void Ratio	0.52	0.48
% Saturation	83.3	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	550.60	1615.90
Mass of Dry Sample and Tare, g	507.50	1416.70
Mass of Tare, g	243.90	299.90
Moisture, %	16.35	17.84

TEST DATA PRIOR TO LOADING

Machine Speed, in / min	0.0100
Strain Rate, % / min	0.17
Chamber Pressure, psi	110.0
Back Pressure,psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	40.0
Change in Height, in	0.072
"B" Value	0.95

SHEAR DATA

Elapsed Time (min)	Deformation (inch)	Axial Load (lb)	Pore-Water Pressure,psi		Total Strain (%)	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$)	Major Principal Stress,psi		Eff.Stress Ratio	P' $(s'_1+s'_3)/2$	Q $[(s_1-s_3)/2]$	Eff. Minor Pr. Stress
			Total,U	Change,DU			(psi)	Total s_1	Eff. s'_1	s'_1/s'_3	(psi)	(psi)	s'_3 (psi)
0.0	0.000	26.8	70.0	0.0	0.00	6.36	0.0	40.0	40.0	1.00	40.0	0.0	40.0
1.0	0.010	160.1	78.5	8.5	0.17	6.38	20.9	60.9	52.4	1.66	42.0	10.5	31.5
2.0	0.020	213.6	82.8	12.8	0.34	6.39	29.2	69.2	56.5	2.07	41.8	14.6	27.2
3.1	0.031	244.5	85.2	15.2	0.52	6.40	34.0	74.0	58.9	2.37	41.9	17.0	24.8
4.1	0.041	266.2	86.7	16.7	0.69	6.41	37.4	77.4	60.6	2.61	41.9	18.7	23.3
5.1	0.051	281.9	87.8	17.8	0.86	6.42	39.7	79.7	62.0	2.79	42.1	19.9	22.2
7.1	0.071	304.9	89.4	19.4	1.20	6.44	43.2	83.2	63.8	3.10	42.2	21.6	20.6
10.2	0.102	327.8	90.7	20.7	1.72	6.48	46.5	86.5	65.8	3.41	42.6	23.2	19.3
12.2	0.122	339.8	91.2	21.2	2.06	6.50	48.2	88.2	67.0	3.56	42.9	24.1	18.8
15.3	0.153	354.5	91.3	21.3	2.58	6.53	50.2	90.2	68.9	3.68	43.8	25.1	18.7
17.3	0.173	363.6	91.3	21.3	2.92	6.56	51.4	91.4	70.1	3.75	44.4	25.7	18.7
20.4	0.204	375.9	91.1	21.1	3.44	6.59	53.0	93.0	71.8	3.81	45.3	26.5	18.9
24.5	0.245	391.8	90.8	20.8	4.13	6.64	55.0	95.0	74.2	3.86	46.7	27.5	19.2
29.6	0.296	409.8	90.2	20.2	4.99	6.70	57.2	97.2	77.0	3.89	48.4	28.6	19.8
35.7	0.357	429.8	89.4	19.4	6.02	6.77	59.5	99.5	80.2	3.88	50.4	29.8	20.6
40.8	0.408	445.4	88.7	18.7	6.88	6.83	61.2	101.2	82.5	3.88	51.9	30.6	21.3
45.9	0.459	460.2	88.6	18.6	7.74	6.90	62.8	102.8	84.3	3.93	52.8	31.4	21.4
49.9	0.499	470.8	88.0	18.0	8.42	6.95	63.9	103.9	85.9	3.90	54.0	31.9	22.0
60.1	0.601	494.8	86.6	16.6	10.14	7.08	66.1	106.1	89.5	3.82	56.4	33.0	23.4
70.3	0.703	516.4	85.3	15.3	11.86	7.22	67.8	107.8	92.5	3.75	58.6	33.9	24.7
80.5	0.805	535.6	84.9	14.9	13.58	7.36	69.1	109.1	94.2	3.76	59.6	34.5	25.1
85.6	0.856	544.9	84.5	14.5	14.44	7.44	69.6	109.6	95.2	3.73	60.4	34.8	25.5
90.0	0.900	552.7	84.0	14.0	15.18	7.50	70.1	110.1	96.1	3.70	61.0	35.0	26.0
Values @ Failure				18.6	7.74	6.90	62.8	102.8	84.3	3.93	52.8	31.4	21.4

Failure criteria used*: 3

*Note:"1"=Max Deviator Stress;"2"=Deviator Stress @ 15% Strain;"3"=Max Eff.Stress Ratio(s'_1/s'_3)

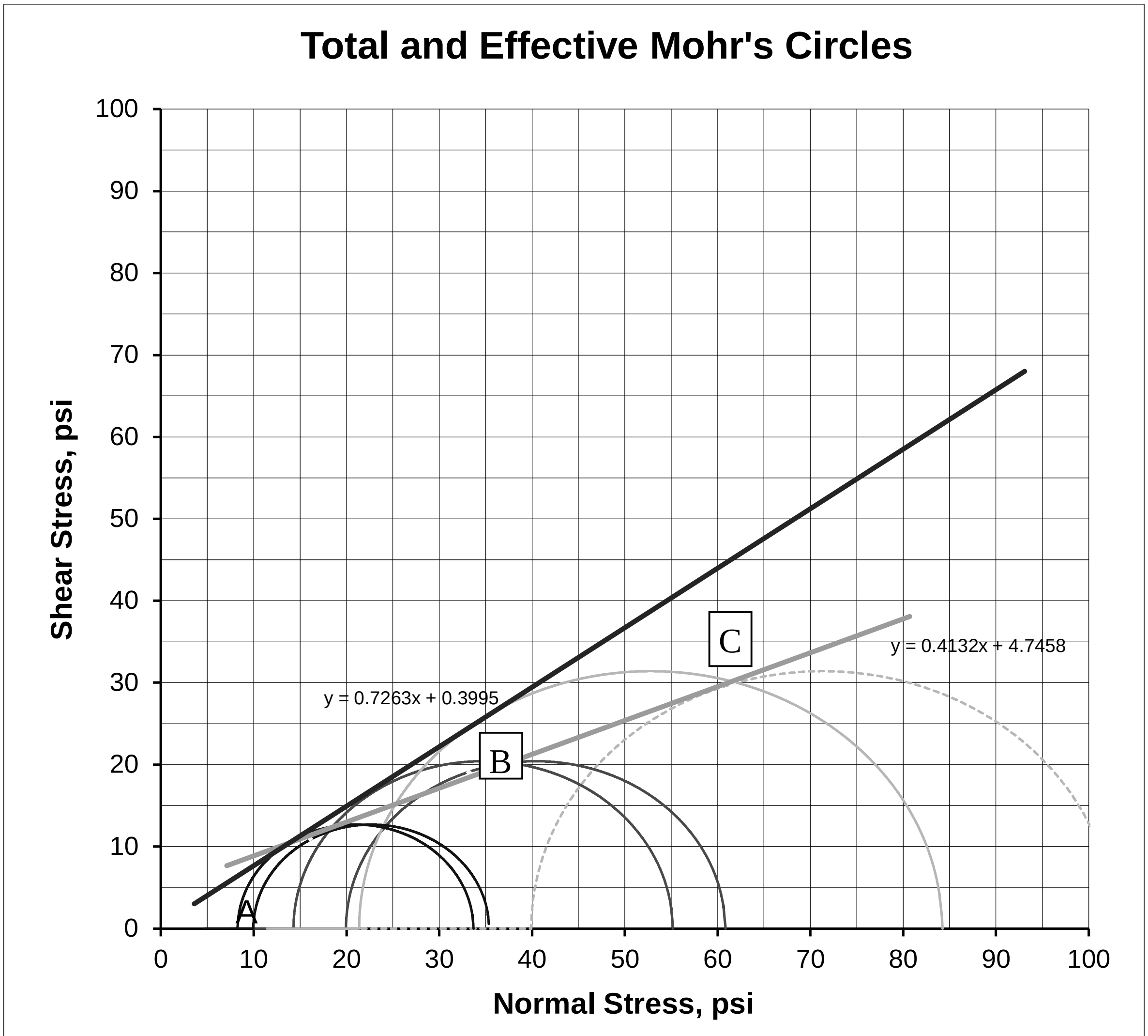
TIMELY ENGINEERING SOIL TESTS, LLC	1874 Forge Street Tucker, GA 30084 Phone: 770-938-8233 Fax: 770-923-8973 Web: www.test-llc.com	AASHTO ACCREDITED

Tested By	EB/KP
Date	03/05/20
Check	[signature]

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Project #	I054-107	Laboratory Project #	2008-08-1
Project Name	AMA	Sample Type	Remold
Sample ID	33253/Borrow Soil #4	Depth/Elevation	-
Location	Yates	Additional Info	-



Specimen	A	B	C
Effective Consolidation Stress, psi	10.0	20.0	40.0
Deviator Stress at Failure, psi	25.4	40.9	62.8
Effective Minor Principal Stress at Failure, psi	8.3	14.3	21.4
Effective Major Principal Stress at Failure, psi	33.7	55.2	84.3
Axial Strain at Failure, %	2.05	5.99	7.74

STRENGTH PARAMETERS*			
Total		Effective	
f °	22.4	f ' °	36.0
C, psi	4.7	C', psi	0.4

***Valid only for Received Material at Reported Densities and Moisture Contents. Please see remarks on page 6 of this report**

Triaxial CU.xls [Mohr's Circles], REV. 1; 10-10-05

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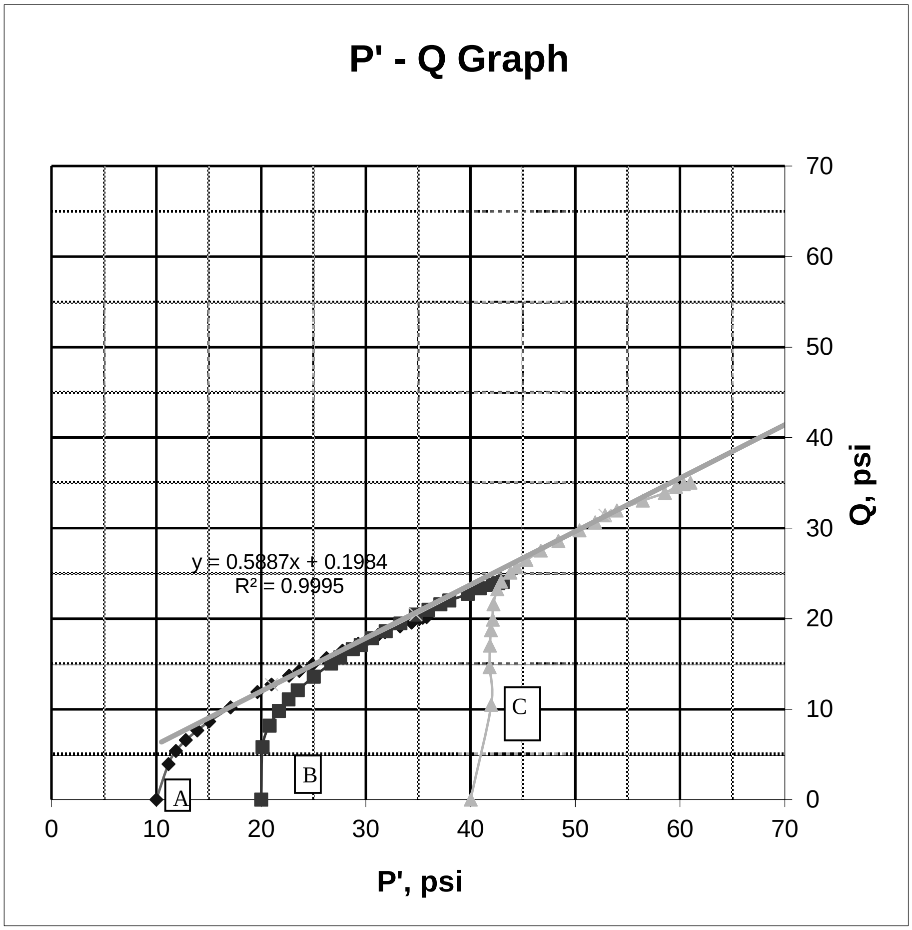
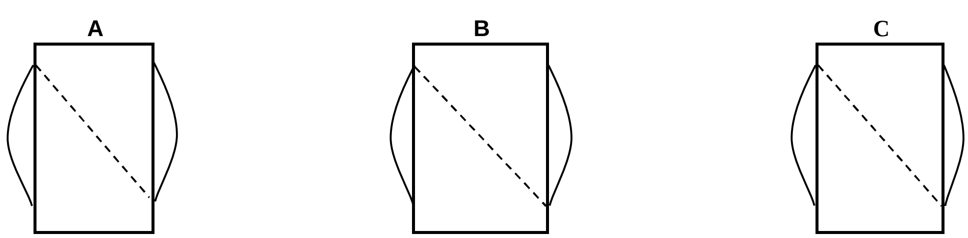
Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33253/Borrow Soil #4	Depth/Elevation	-
Location	Yates	Additional Info	-



a, psi	0.2
a, degree	30.5

FAILURE SKETCH



REMOLDING PROPERTIES

	A	B	C
% Compaction of Max Dry Density	95.1	95.1	95.1
% Difference from Optimum M.C.	3.1	3.1	3.1

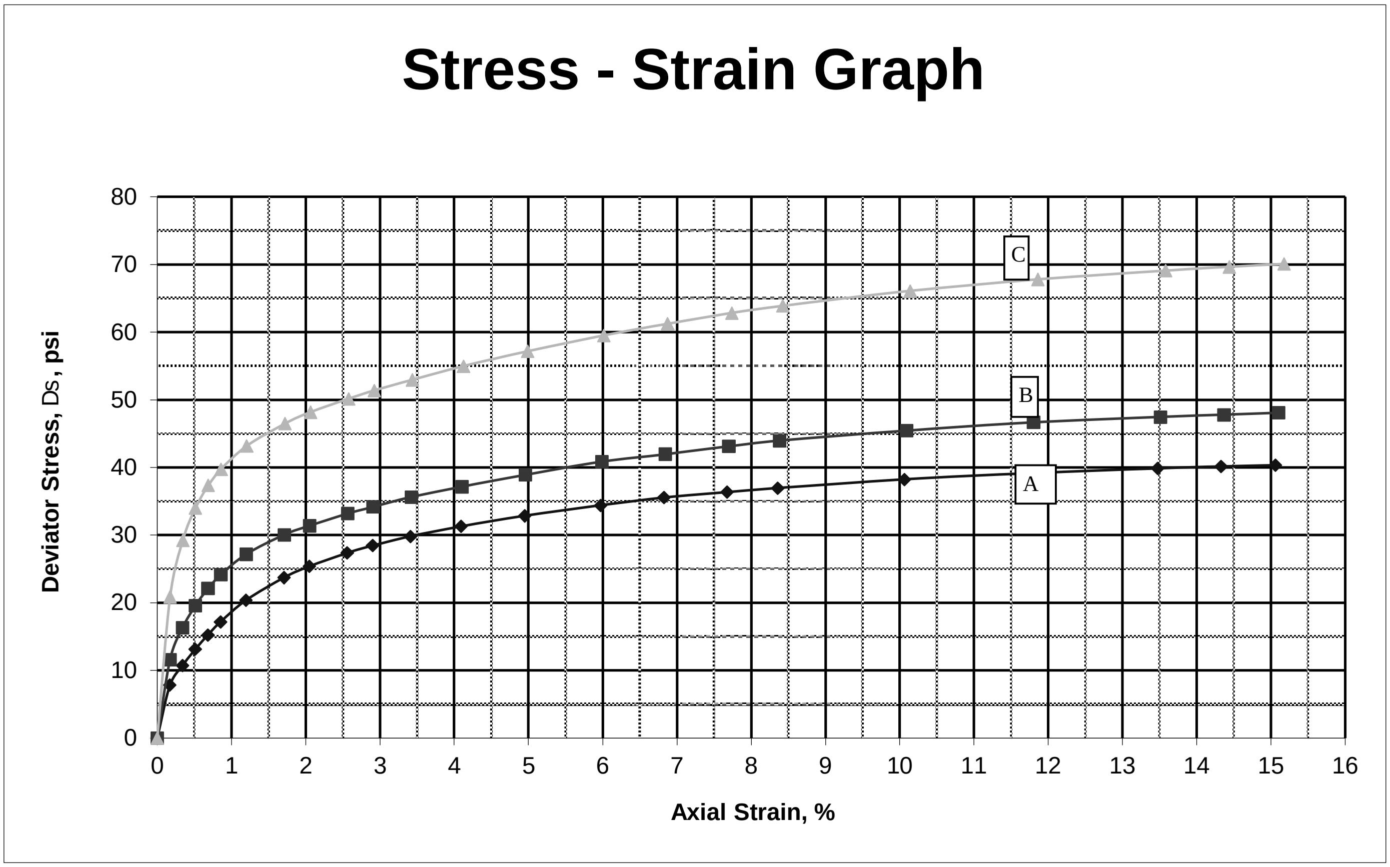
Triaxial CU.xls [P'-Q GRAPH], REV. 1; 10-10-05

T.E.ST.	**TIMELY ENGINEERING SOIL TESTS, LLC**	1874 Forge Street Tucker, GA 30084 Phone: 770-938-8233 Fax: 770-923-8973 Web: www.test-llc.com	Tested By: EB/KP Date: 03/05/20 Check:

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33253/Borrow Soil #4	Depth/Elevation	-
Location	Yates	Additional Info	-



Balance ID Number	563/700
Oven ID Number	496/610
Deformation Indicator ID #	178/349/689
Digital Caliper ID #	370/458
Load Cell ID #	347/692/815
Apparatus ID #	293/693/814

REMARKS

Samples (Material passing #4 Sieve) were remolded to specified % compaction and moisture content of Standard Proctor values

DESCRIPTION

Brownish Yellow Silty Sand

NOTES:

1. Method for Saturation — WET
2. Method for determination of cross-sectional after consolidation — B
3. Initial specimen moisture content obtained from cuttings
4. Final specimen moisture content obtained from entire sample

LL	-
PL	-
PI	-
Gs	-

USCS (ASTM D2487: D2488) SM

Triaxial CU.xls [Stress-Strain GRAPH], REV. 1; 10-10-05

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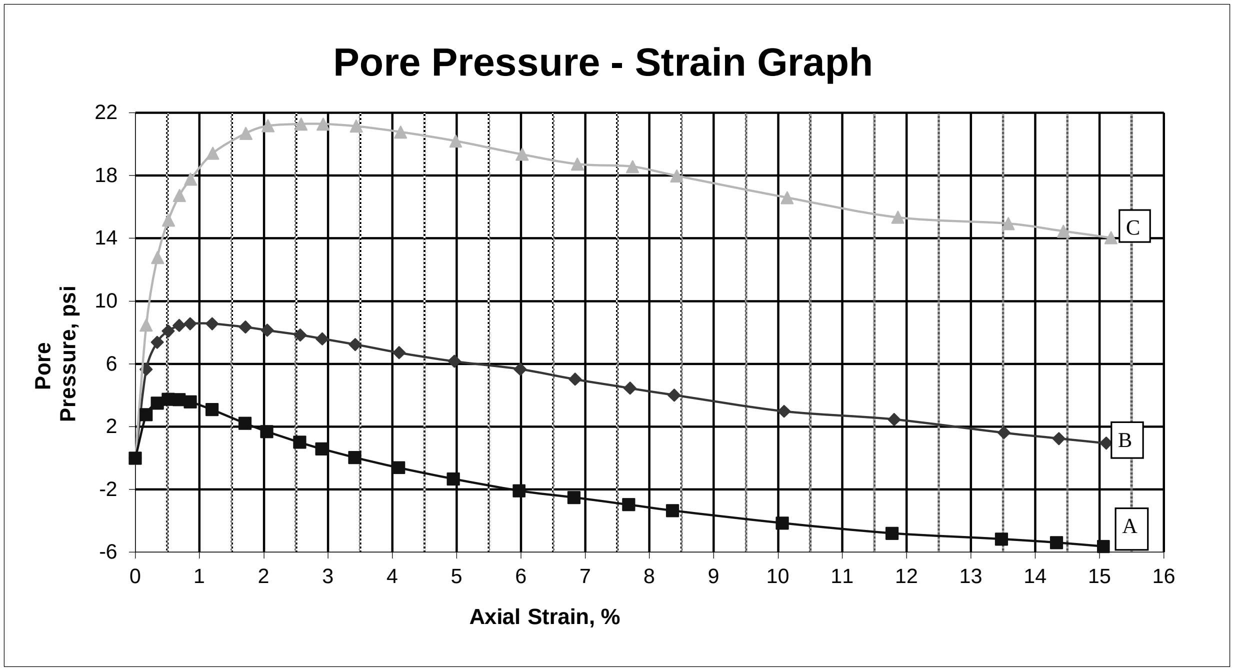
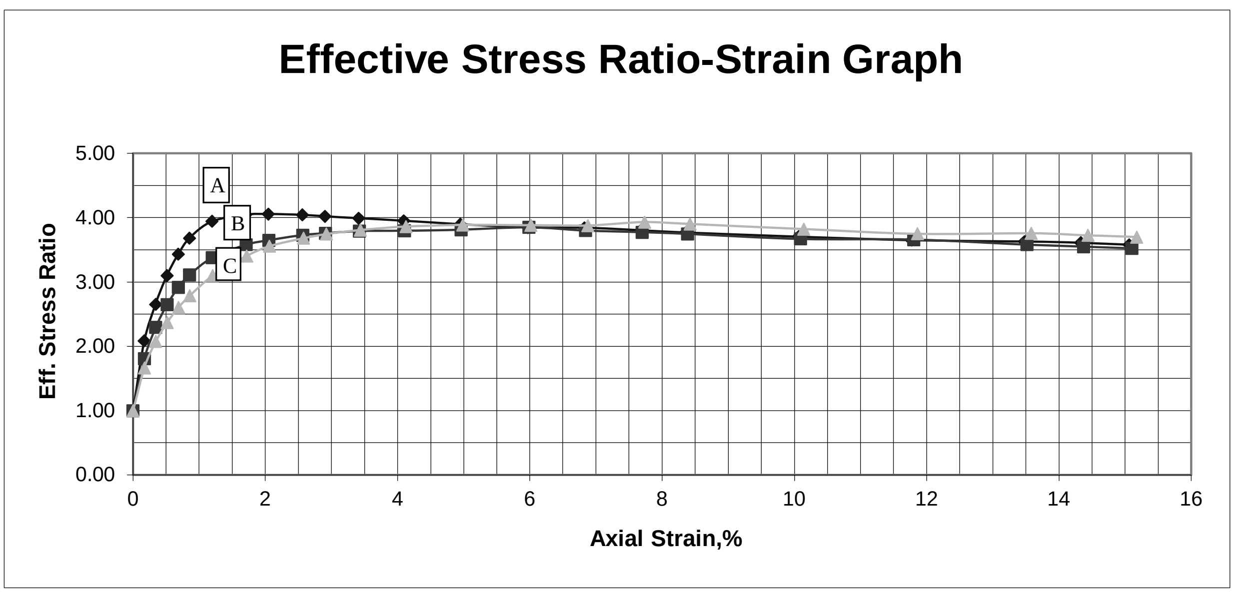
		Date	03/05/20
		Check	

ASTM D 4767 / AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

Client Pr. #	I054-107	Laboratory Project #	2008-08-1
Pr. Name	AMA	Sample Type	Remold
Sample ID	33253/Borrow Soil #4	Depth/Elevation	-
Location	Yates	Additional Info	-





Triaxial CU.xls [Stress Ratio & Pore Water Pr.-Strain GRAPH], REV. 1; 10-10-05

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Fax: 770-923-8973
Web: www.test-llc.com

AASHTO ACCREDITED

Tested By	IH
Date	03/04/20
Checked By	[illegible]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33253/Borrow Soil #4	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 4318/AASHTO T 88, T 89
Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils (Atterberg Limits)

LIQUID LIMIT

Number of Blows	35	26	18
Mass of Wet Sample & Tare, g	37.45	40.49	35.82
Mass of Dry Sample & Tare, g	34.10	36.74	32.02
Mass of Tare, g	23.92	26.04	21.98
Moisture Content, %	32.91	35.05	37.85

Oven ID #	15/496/610
Balance ID #	139/563
Liquid Limit Device ID #	451/569

PLASTIC LIMIT

Mass of Wet Sample & Tare, g	45.36	37.61
Mass of Dry Sample & Tare, g	41.99	35.16
Mass of Tare, g	29.34	25.88
Moisture Content, %	26.64	26.40

NOTE: MATERIAL PASSING NO. 40 SIEVE WAS USED FOR TEST

NATURAL MOISTURE

Mass of Wet Sample & Tare, g	476.50
Mass of Dry Sample & Tare, g	418.00
Mass of Tare, g	130.70
Moisture Content, %	20.36

LIQUID LIMIT (LL)	35
PLASTIC LIMIT (PL)	27
PLASTICITY INDEX (PI)	8
LIQUIDITY INDEX (LI)	-0.83

DESCRIPTION: Brownish Yellow Silty Sand

USCS (ASTM D2487; D2488): SM

AASHTO (M 145): NA

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	AASHTO ACCREDITED	Date	03/02/20
		Checked By	

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33253/Borrow Soil #4	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 422/AASHTO T 88

Standard Test Method for Particle-Size Analysis of Soils (with Double Separation per ASTM D6913 and Hydrometer Analysis)

As-Received Moisture Content (Total Sample)

Mass of Wet Sample & Tare, g	476.5
Mass of Dry Sample & Tare, g	418.0
Mass of Tare, g	130.7
Moisture Content, %	20.4

Moisture Content of FINER PORTION

	1st Subsample	*2nd Subsample*
Mass of Wet Sample & Tare, g	420.1	430.10
Mass of Dry Sample & Tare, g	391.0	399.70
Mass of Tare, g	100.4	90.20
Moisture Content, %	10.0	9.8

Mass of Total Sample before separation on 3/8" sieve & Tare, g	18000
Mass of Tare, g	0.0
Total Mass of Dry Sample, g	14955

	1st Subsample	*2nd Subsample*
Mass of Wet Finer Portion & Tare, g	1104.0	73.70
Mass of Tare	0.0	0.0
Dry Mass, g	1003.5	67.11
% of Total Sample passing Split Sieve	99.6	98.8

SIEVE ANALYSIS

COARSER PORTION OF SAMPLE (RETAINED ON 3/8" SIEVE)

Mass of Tare, g: 0.00

Sieve Size		Sample & Tare, g	% RETAINED	% PASSING (of Total)
12"	COBBLES		0	100
3"	COARSE GRAVEL		0	100
2.5"			0	100
2"			0	100
1.5"			0	100
1"			0	100
.75"	FINE GRAVEL	0.0	0	100
.5"		29.8	0	100
.375"		62.3	0	100
#4	COARSE SAND	8.2	1	99

#4 <First Subsample of Finer Portion<3/8"

2nd Subsample of FINER PORTION OF SAMPLE (PASSING #4 SIEVE:Hydrometer Backsieve)

Sieve Size		Cumulative Mass retained, g	% PASSING (of Total)
#10	MEDIUM SAND	1.44	97
#20		7.01	88
#40	FINE SAND	17.07	74
#60		26.36	60
#100		34.09	49
#200	FINES	41.18	38

Remarks

HYDROMETER ANALYSIS

Length of Dispersion Period	1 Minute
Mechanical Dispersion Device ID #	61
Amount of Dispersing Agent (ml)	125.0
Specific Gravity (assumed)	2.650
Specific Gravity (tested)	
Starting time	14:10

PARTICLE-SIZE ANALYSIS

% COBBLES	0	% MEDIUM SAND	23
% COARSE GRAVEL	0	% FINE SAND	35
% FINE GRAVEL	1	% FINES	38
% COARSE SAND	2	% TOTAL SAMPLE	100
% CLAY(<0.005mm)	20	% CLAY(<0.002mm)	16

Date	Time	Testing time (min)	Reading	Temp (°C)	K	Composite Correction	Actual Reading	Effective Depth (cm)	a	Particle Diam. (mm)	Percent Passing
03/04/20	14:12	2	29.0	17.7	0.01399	6.5	22.5	12.6	1.00	0.0352	33.1
03/04/20	14:15	5	27.0	17.7	0.01399	6.5	20.5	13.0	1.00	0.0225	30.2
03/04/20	14:25	15	25.0	17.7	0.01399	6.5	18.5	13.3	1.00	0.0132	27.2
03/04/20	14:40	30	23.0	17.7	0.01399	6.5	16.5	13.6	1.00	0.0094	24.3
03/04/20	15:10	60	21.0	17.7	0.01399	6.5	14.5	14.0	1.00	0.0068	21.3
03/04/20	18:20	250	19.0	17.7	0.01399	6.5	12.5	14.3	1.00	0.0033	18.4
03/05/20	14:10	1440	17.0	17.7	0.01399	6.5	10.5	14.6	1.00	0.0014	15.5

Hydrometer 152H ID #	305527	Oven ID #	15/496/610
Sieve Shaker ID #	555	Balance ID#	139/142/700

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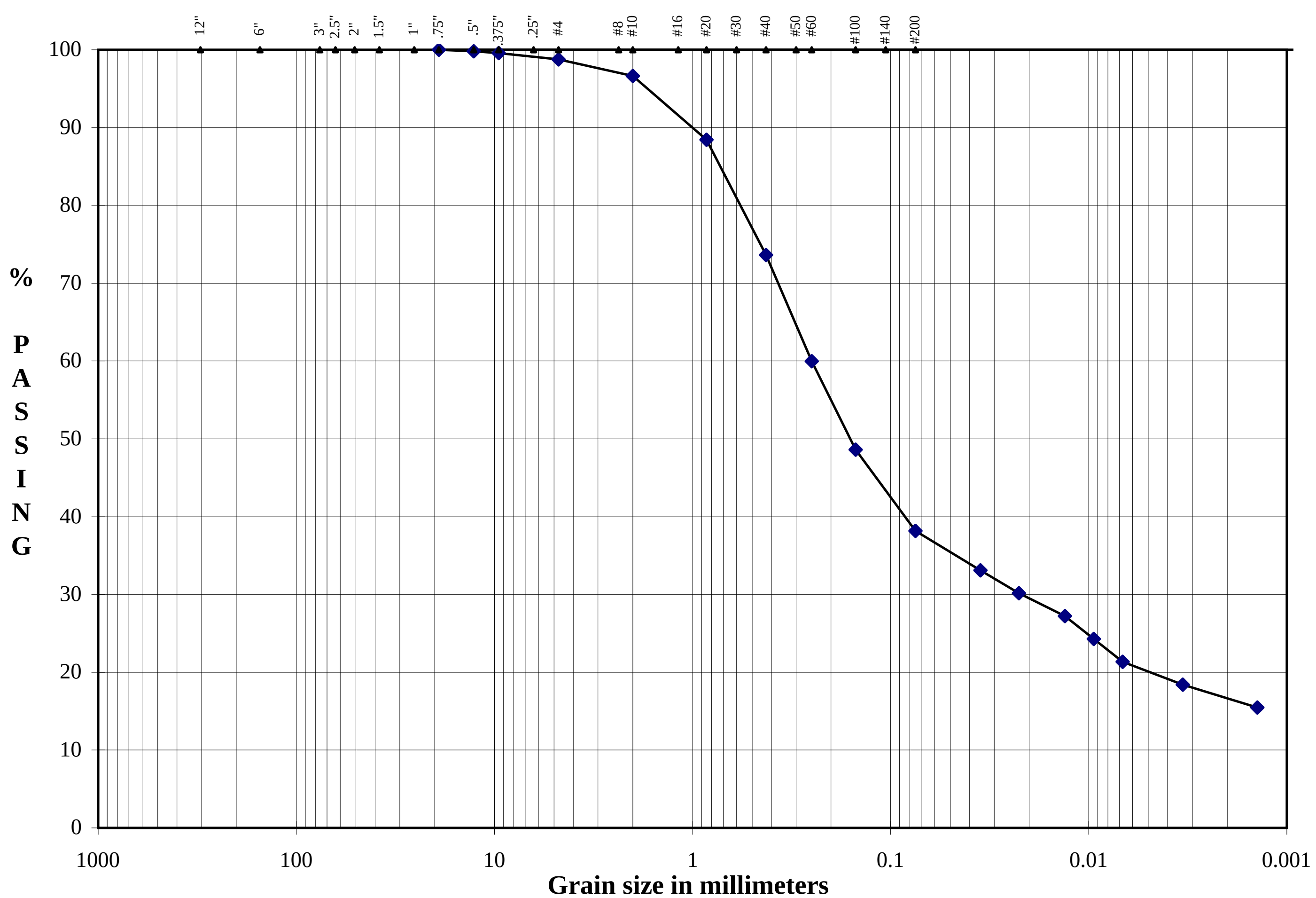
		Date	03/02/20
		Checked By	

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33253/Borrow Soil #4	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 422/AASHTO T 88

Standard Test Method for Particle-Size Analysis of Soils (with Double Separation per ASTM D6913 and Hydrometer Analysis)

Particle-Size Analysis



Boulders	Cobbles	Gravel		Sand			Fines
		Coarse	Fine	Coarse	Medium	Fine	Silt or Clay

DESCRIPTION: Brownish Yellow Silty Sand

D_{10}	NA	mm
D_{30}	NA	mm
D_{60}	NA	mm
Cu	NA	
Cc	NA	

USCS (ASTM D2487; D2488): SM

Project's Specific % Passing	NA
Project's Specific Particle Size, mm	NA

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Tested By	RI
Date	03/02/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33253/Borrow Soil #4	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 698
Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600kN-m/m^3))

DETERMINATION OF TEST PROCEDURE

	wet	dry
Mass of Soil before sieving, g	18000.0	14954.9
Mass of Mat. Retained on No. 4 sieve, g		
Mass of Mat. Retained on 3/8" sieve, g	62.3	62.3
Mass of Mat. Retained on 3/4" sieve, g		

MOISTURE CONTENT

	Coarse + Fine Fraction	Coarse Fraction
Mass of Wet Sample & Tare, g	476.5	62.3
Mass of Dry Sample & Tare, g	418.0	62.3
Mass of Tare, g	130.7	0.0
Moisture Content, %	20.4	0.0

Material Retained on No. 4 Sieve, %	
Material Retained on 3/8" Sieve, %	0.4
Material Retained on 3/4" Sieve, %	
Total, % (oversized)	0.4

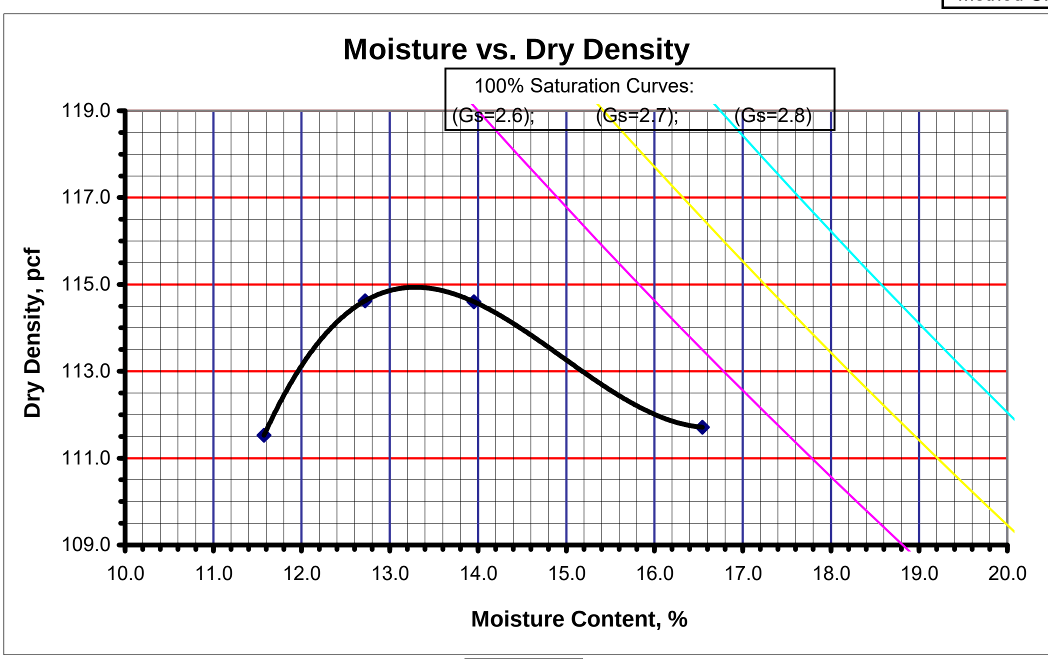
Procedure: B

TEST DATA

Points	1	2	3	4	5
Mass of Mold and Soil, g	6132.0	6204.0	6225.0	6219.0	
Mass of Wet Sample & Tare, g	519.8	452.1	473.9	384.9	
Mass of Dry Sample & Tare, g	484.9	415.2	431.1	348.7	
Mass of Tare, g	183.4	125.1	124.4	129.9	
Moisture Content, %	11.6	12.7	14.0	16.5	
Wet Density, pcf	124.4	129.2	130.6	130.2	
Dry Density, pcf	111.5	114.6	114.6	111.7	

Mold ID Number	798
Mass of Mold, g	4252.4
Volume of Mold, ft^3	0.0333
Hammer ID Number	318
Number of Blows per layer	25
Number of Layers	3
Mechanical Compactor ID Number	317

Method A: Material retained on No. 4 Sieve ≤ 25%
Method B: Material retained on 3/8" Sieve ≤ 25%
Method C: Material retained on 3/4" Sieve ≤ 30%



REMARKS

DESCRIPTION

Brownish Yellow Silty Sand

USCS (ASTM D2487; D2488): SM

AASHTO M145: NA

Maximum Dry Density, pcf	114.9
Optimum Moisture Content, %	13.3
Corrected Maximum Dry Density, pcf	**NA**
Corrected Optimum Moisture Content, %	**NA**

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AASHTO ACCREDITED

Tested By	RI
Date	03/03/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Pr. Name	AMA	S. Type	Bulk
Sample ID	33253/Borrow Soil #4	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D854; Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

TEST METHOD: B

MOISTURE CONTENT

Mass of Wet Sample & Tare, g	-
Mass of Dry Sample & Tare, g	-
Mass of Tare, g	-
Moisture Content, %	NA*

TEST DATA

Pycnometer Number	10
Mass of Pycnometer, g	171.57
Mass of Sample & Pycnometer, g	251.60
Mass of Sample, Water & Pycnometer, g	719.60
Test Temperature, ^{o}C	19.2
Mass of Tare,g	358.77
Mass of Dry Sample & Tare, g	438.40
Mass of Dry Soil, g	79.63
Mass of Pycnometer (Calibrated), g	171.57
Density of Water @ Test Temperature, g/mL	0.99837
Mass of Pycnometer & Water @ Test Temp.	669.86
Temperature Coefficient	1.00016
Calibrated Volume of Pycnometer, mL	499.10
Specific Gravity @ Test Temperature	2.664

SPECIFIC GRAVITY @ 20 ^{o}C **2.665**

DESCRIPTION

Brownish Yellow Silty Sand

Thermometer ID Number	72
Vacuum Pump ID Number	62
Deaerator ID Number	213
Specific Gravity Board ID Number	214
Balance ID Number	139
Oven ID Number	12

USCS (ASTM D2487, D2488): SM

NOTES:

1.* Oven-Dry material passing #4 sieve used for test.
2. Air removed by vacuum method.
3. Deionized / Deaired water was used for test.

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ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33611/YGWA-39-10-12	Depth/Elev.	-
Location	-	Additional Info	-

SPECIMEN PROPERTIES

	(initial)	(after consol.)
Height, in	5.730	5.640
Diameter, in	2.879	2.850
Height-to-Diameter Ratio	2.0	2.0
Area, in^2	6.51	6.38
Volume, cm^3	611.26	589.46
Mass of Wet Sample, g	1077.30	1192.60
Mass of Dry Sample, g	958.35	958.35
Wet Density, pcf	110.0	126.3
Dry Density, pcf	97.9	101.5
Specific Gravity (assumed)	2.698	2.698
Volume of Solids, cm^3	355.21	355.21
Volume of Voids, cm^3	256.06	234.25
Void Ratio	0.72	0.66
% Saturation	46.5	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	426.80	1192.60
Mass of Dry Sample and Tare, g	393.30	958.35
Mass of Tare, g	123.40	0.00
Moisture, %	12.41	24.44

TEST DATA PRIOR TO LOADING

Volume change (Consolidation), ml	115.3
Machine Speed, in / min	0.0100
Strain Rate, % / min	0.18
Chamber Pressure, psi	80.0
Back Pressure, psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	10.0
Change in Height, in	0.090
"B" Value	0.95

SHEAR DATA

Elapsed Time (min)	Deformation Stage 1 (inch)	Axial Load (lb)	Pore-Water Pressure, psi		Total Strain Stage 1 (%)	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$)	Major Principal Stress, psi		Eff.Stress Ratio	P' ($s'_1+s'_3$)/2 (psi)	Q (s_1-s_3)/2 (psi)	Eff. Minor Pr. Stress
			Total, U	Change,DU			(psi)	Total s_1	Eff. s'_1	s'_1/s'_3			s'_3 (psi)
0.0	0.000	18.1	70.00	0.0	0.00	6.38	0.0	10.0	10.0	1.00	10.0	0.0	10.0
0.5	0.005	31.9	71.15	1.2	0.09	6.38	2.2	12.2	11.0	1.24	9.9	1.1	8.8
1.0	0.010	42.2	72.07	2.1	0.18	6.39	3.8	13.8	11.7	1.48	9.8	1.9	7.9
1.5	0.015	49.6	72.77	2.8	0.27	6.39	4.9	14.9	12.2	1.68	9.7	2.5	7.2
2.0	0.020	54.8	73.22	3.2	0.35	6.40	5.7	15.7	12.5	1.85	9.6	2.9	6.8
2.5	0.025	59.3	73.61	3.6	0.44	6.41	6.4	16.4	12.8	2.01	9.6	3.2	6.4
3.0	0.030	63.6	73.94	3.9	0.53	6.41	7.1	17.1	13.2	2.17	9.6	3.5	6.1
3.5	0.035	67.9	74.23	4.2	0.62	6.42	7.8	17.8	13.5	2.34	9.6	3.9	5.8
4.0	0.040	71.0	74.43	4.4	0.71	6.42	8.2	18.2	13.8	2.48	9.7	4.1	5.6
5.0	0.050	77.8	74.77	4.8	0.89	6.43	9.3	19.3	14.5	2.77	9.9	4.6	5.2
6.0	0.060	83.8	75.02	5.0	1.06	6.45	10.2	20.2	15.2	3.05	10.1	5.1	5.0
7.0	0.070	89.2	75.19	5.2	1.24	6.46	11.0	21.0	15.8	3.29	10.3	5.5	4.8
8.0	0.080	94.8	75.33	5.3	1.42	6.47	11.9	21.9	16.5	3.54	10.6	5.9	4.7
9.0	0.090	100.1	75.42	5.4	1.60	6.48	12.7	22.7	17.2	3.76	10.9	6.3	4.6
10.0	0.100	105.2	75.50	5.5	1.77	6.49	13.4	23.4	17.9	3.98	11.2	6.7	4.5
11.0	0.110	110.2	75.56	5.6	1.95	6.50	14.2	24.2	18.6	4.19	11.5	7.1	4.4
12.0	0.120	114.6	75.59	5.6	2.13	6.52	14.8	24.8	19.2	4.36	11.8	7.4	4.4
15.0	0.150	127.4	75.58	5.6	2.66	6.55	16.7	26.7	21.1	4.77	12.8	8.3	4.4
20.0	0.200	145.6	75.35	5.3	3.55	6.61	19.3	29.3	23.9	5.15	14.3	9.6	4.7
23.0	0.230	155.7	75.12	5.1	4.08	6.65	20.7	30.7	25.6	5.24	15.2	10.3	4.9
24.0	0.240	158.9	75.04	5.0	4.26	6.66	21.1	31.1	26.1	5.26	15.5	10.6	5.0
25.0	0.250	162.1	74.93	4.9	4.43	6.67	21.6	31.6	26.6	5.26	15.9	10.8	5.1
25.5	0.255	163.8	74.87	4.9	4.52	6.68	21.8	31.8	26.9	5.25	16.0	10.9	5.1
Values @ Failure				5.0	4.26	6.66	21.1	31.1	26.1	**5.26**	15.5	10.6	5.0

Failure criteria used*: 3

*Note: "1" = Max Deviator Stress; "2" = Deviator Stress @ 15% Strain; "3" = Max Eff.Stress Ratio(s'_1/s'_3)

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Web: www.test-llc.com

AASHTO ACCREDITED

Tested By	EB/KP
Date	04/02/20
Checked By	[signature]

ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33611/YGWA-39-10-12	Depth/Elev.	-
Location	-	Additional Info	-

SPECIMEN PROPERTIES

		(initial)	(after consol.)
Height, in		5.385	5.444
Diameter, in		2.916	2.863
Height-to-Diameter Ratio		1.8	1.9
Area, in^2		6.68	6.44
Volume, cm^3		589.46	574.46
Mass of Wet Sample, g		1192.60	1177.60
Mass of Dry Sample, g		958.35	958.35
Wet Density, pcf		126.3	128.0
Dry Density, pcf		101.5	104.1
Specific Gravity	(assumed)	2.698	2.698
Volume of Solids, cm^3		355.21	355.21
Volume of Voids, cm^3		234.25	219.25
Void Ratio		0.66	0.62
% Saturation		100.0	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	1192.60	1177.60
Mass of Dry Sample and Tare, g	958.35	958.35
Mass of Tare, g	0.00	0.00
Moisture, %	24.44	22.88

TEST DATA PRIOR TO LOADING

Volume change (Consolidation), ml	-15.0
Machine Speed, in / min	0.0100
Strain Rate, % / min	0.18
Chamber Pressure, psi	90.0
Back Pressure, psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	20.0
Change in Height, in	-0.059
"B" Value	0.95

SHEAR DATA

Deformation Stage 2 (inch)	Total Deformation ST.1 + ST.2 (inch)	Axial Load (lb)	Pore-Water Pressure, psi		Strain Stage 2 %	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$)	Major Principal Stress, psi		Effective Stress Ratio	P' $(s'_1+s'_3)/2$ (psi)	Q $(s_1-s_3)/2$ (psi)	Eff. Minor Pr. Stress	Total Strain ST.1 + ST.2 %
			Total, U	Change,DU			(psi)	Total s_1	Eff. s'_1	s'_1/s'_3			s'_3 (psi)	
0.000	0.196	26.6	70.00	0.0	0.00	6.44	0.0	20.0	20.0	1.00	20.0	0.0	20.0	3.48
0.005	0.201	46.9	71.30	1.3	0.09	6.45	3.1	23.1	21.8	1.17	20.3	1.6	18.7	3.56
0.010	0.206	72.5	72.85	2.8	0.18	6.45	7.1	27.1	24.3	1.41	20.7	3.6	17.2	3.65
0.015	0.211	91.8	74.01	4.0	0.28	6.46	10.1	30.1	26.1	1.63	21.0	5.0	16.0	3.74
0.020	0.216	105.8	74.87	4.9	0.37	6.46	12.3	32.3	27.4	1.81	21.3	6.1	15.1	3.83
0.025	0.221	118.9	75.57	5.6	0.46	6.47	14.3	34.3	28.7	1.99	21.6	7.1	14.4	3.92
0.030	0.226	130.3	76.15	6.2	0.55	6.47	16.0	36.0	29.9	2.16	21.9	8.0	13.9	4.01
0.035	0.231	141.0	76.57	6.6	0.64	6.48	17.7	37.7	31.1	2.31	22.3	8.8	13.4	4.10
0.040	0.236	150.6	76.97	7.0	0.73	6.49	19.1	39.1	32.1	2.47	22.6	9.6	13.0	4.18
0.050	0.246	167.7	77.55	7.6	0.92	6.50	21.7	41.7	34.2	2.74	23.3	10.9	12.5	4.36
0.060	0.256	183.9	77.98	8.0	1.10	6.51	24.2	44.2	36.2	3.01	24.1	12.1	12.0	4.54
0.070	0.266	197.5	78.32	8.3	1.29	6.52	26.2	46.2	37.9	3.24	24.8	13.1	11.7	4.72
0.080	0.276	210.0	78.58	8.6	1.47	6.54	28.1	48.1	39.5	3.46	25.5	14.0	11.4	4.89
0.090	0.286	220.7	78.77	8.8	1.65	6.55	29.6	49.6	40.9	3.64	26.1	14.8	11.2	5.07
0.100	0.296	230.3	78.91	8.9	1.84	6.56	31.1	51.1	42.1	3.80	26.6	15.5	11.1	5.25
0.110	0.306	238.1	78.98	9.0	2.02	6.57	32.2	52.2	43.2	3.92	27.1	16.1	11.0	5.43
0.120	0.316	245.3	79.03	9.0	2.20	6.58	33.2	53.2	44.2	4.03	27.6	16.6	11.0	5.60
0.130	0.326	251.8	79.04	9.0	2.39	6.60	34.1	54.1	45.1	4.11	28.0	17.1	11.0	5.78
0.140	0.336	257.2	79.01	9.0	2.57	6.61	34.9	54.9	45.9	4.17	28.4	17.4	11.0	5.96
0.170	0.366	272.2	78.80	8.8	3.12	6.65	36.9	56.9	48.1	4.30	29.7	18.5	11.2	6.49
0.200	0.396	285.4	78.49	8.5	3.67	6.68	38.7	58.7	50.2	4.36	30.9	19.4	11.5	7.02
0.210	0.406	289.0	78.35	8.3	3.86	6.70	39.2	59.2	50.8	4.36	31.2	19.6	11.7	7.20
0.215	0.411	291.1	78.24	8.2	3.95	6.70	39.5	59.5	51.2	4.35	31.5	19.7	11.8	7.29
Values @ Failure				8.5	3.67	6.68	38.7	58.7	50.2	**4.36**	30.9	19.4	11.5	7.02

Failure criteria used* 3

*Note: "1" = Max Deviator Stress; "2" = Deviator Stress @ 15% Strain; "3" = Max Eff.Stress Ratio(s'_1/s'_3)

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Date	04/02/20
Checked By	[signature]

ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33611/YGWA-39-10-12	Depth/Elev.	-
Location	-	Additional Info	-

SPECIMEN PROPERTIES

	(initial)	(after consol.)
Height, in	5.229	5.306
Diameter, in	2.922	2.884
Height-to-Diameter Ratio	1.8	1.8
Area, in^2	6.70	6.53
Volume, cm^3	574.46	567.99
Mass of Wet Sample, g	1177.60	1166.70
Mass of Dry Sample, g	958.35	951.30
Wet Density, pcf	128.0	128.2
Dry Density, pcf	104.1	104.6
Specific Gravity (assumed)	2.698	2.698
Volume of Solids, cm^3	355.21	352.59
Volume of Voids, cm^3	219.25	215.40
Void Ratio	0.62	0.61
% Saturation	100.0	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	1177.60	1470.20
Mass of Dry Sample and Tare, g	958.35	1254.80
Mass of Tare, g	0.00	303.50
Moisture, %	22.88	22.64

TEST DATA PRIOR TO LOADING

Volume change (Consolidation), ml	-10.9
Machine Speed, in / min	0.01000
Strain Rate, % / min	0.19
Chamber Pressure, psi	110.0
Back Pressure, psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	40.0
Change in Height, in	-0.077
"B" Value	0.95

SHEAR DATA

Deformation Stage 3 (inch)	Total Deformation ST.1 + ST.2 + ST.3 (inch)	Axial Load (lb)	Pore-Water Pressure, psi		Strain Stage 3 %	Corrected Area (in^2)	Deviator Stress ($Ds=s_1-s_3$)	Major Principal Stress, psi		Effective Stress Ratio	P' $(s'_1+s'_3)/2$ (psi)	Q $(s_1-s_3)/2$ (psi)	Eff. Minor Pr. Stress	Total Strain ST.1 + ST.2 + ST.3, %
			Total, U	Change,DU			(psi)	Total s_1	Eff. s'_1	s'_1/s'_3			s'_3 (psi)	
0.000	0.334	24.5	70.00	0.0	0.00	6.53	0.0	40.0	40.0	1.00	40.0	0.0	40.0	5.92
0.011	0.345	48.4	70.65	0.6	0.20	6.55	3.7	43.7	43.0	1.09	41.2	1.8	39.4	6.11
0.072	0.406	143.1	74.76	4.8	1.35	6.62	17.9	57.9	53.1	1.51	44.2	9.0	35.2	7.19
0.092	0.426	241.4	80.16	10.2	1.74	6.65	32.6	72.6	62.5	2.09	46.2	16.3	29.8	7.56
0.113	0.447	305.1	83.29	13.3	2.12	6.67	42.0	82.0	68.8	2.57	47.7	21.0	26.7	7.92
0.133	0.467	351.4	85.32	15.3	2.50	6.70	48.8	88.8	73.5	2.98	49.1	24.4	24.7	8.28
0.153	0.487	385.2	86.77	16.8	2.89	6.73	53.6	93.6	76.8	3.31	50.0	26.8	23.2	8.64
0.174	0.508	409.3	87.72	17.7	3.27	6.75	57.0	97.0	79.3	3.56	50.8	28.5	22.3	9.00
0.204	0.538	434.4	88.43	18.4	3.85	6.79	60.3	100.3	81.9	3.80	51.7	30.2	21.6	9.54
0.235	0.569	451.8	88.59	18.6	4.43	6.83	62.5	102.5	83.9	3.92	52.7	31.3	21.4	10.09
0.265	0.599	467.7	88.53	18.5	5.00	6.88	64.5	104.5	85.9	4.00	53.7	32.2	21.5	10.63
0.286	0.620	476.8	88.39	18.4	5.39	6.90	65.5	105.5	87.1	4.03	54.4	32.8	21.6	10.99
0.306	0.640	485.6	88.21	18.2	5.77	6.93	66.5	106.5	88.3	4.05	55.0	33.3	21.8	11.35
0.316	0.650	489.0	88.10	18.1	5.96	6.95	66.9	106.9	88.8	4.05	55.3	33.4	21.9	11.53
0.347	0.681	500.1	87.76	17.8	6.54	6.99	68.0	108.0	90.3	4.06	56.3	34.0	22.2	12.07
0.367	0.701	508.2	87.50	17.5	6.92	7.02	68.9	108.9	91.4	4.06	57.0	34.5	22.5	12.43
0.388	0.722	516.0	87.22	17.2	7.31	7.05	69.7	109.7	92.5	4.06	57.7	34.9	22.8	12.80
0.408	0.742	523.9	86.90	16.9	7.69	7.08	70.6	110.6	93.7	4.05	58.4	35.3	23.1	13.16
0.428	0.762	530.8	86.61	16.6	8.07	7.11	71.2	111.2	94.6	4.05	59.0	35.6	23.4	13.52
0.439	0.773	535.5	86.51	16.5	8.27	7.12	71.8	111.8	95.2	4.05	59.4	35.9	23.5	13.70
0.469	0.803	548.2	86.17	16.2	8.84	7.17	73.1	113.1	96.9	4.07	60.4	36.5	23.8	14.24
0.500	0.834	559.1	85.65	15.6	9.42	7.21	74.1	114.1	98.5	4.04	61.4	37.1	24.4	14.78
0.525	0.859	567.0	85.16	15.2	9.90	7.25	74.8	114.8	99.7	4.01	62.3	37.4	24.8	15.24
Values @ Failure				16.2	8.84	7.17	73.1	113.1	96.9	**4.07**	60.4	36.5	23.8	14.24

Failure criteria used*: 3

*Note: "1" = Max Deviator Stress; "2" = Deviator Stress @ 15% Strain; "3" = Max Eff.Stress Ratio(s'_1/s'_3)

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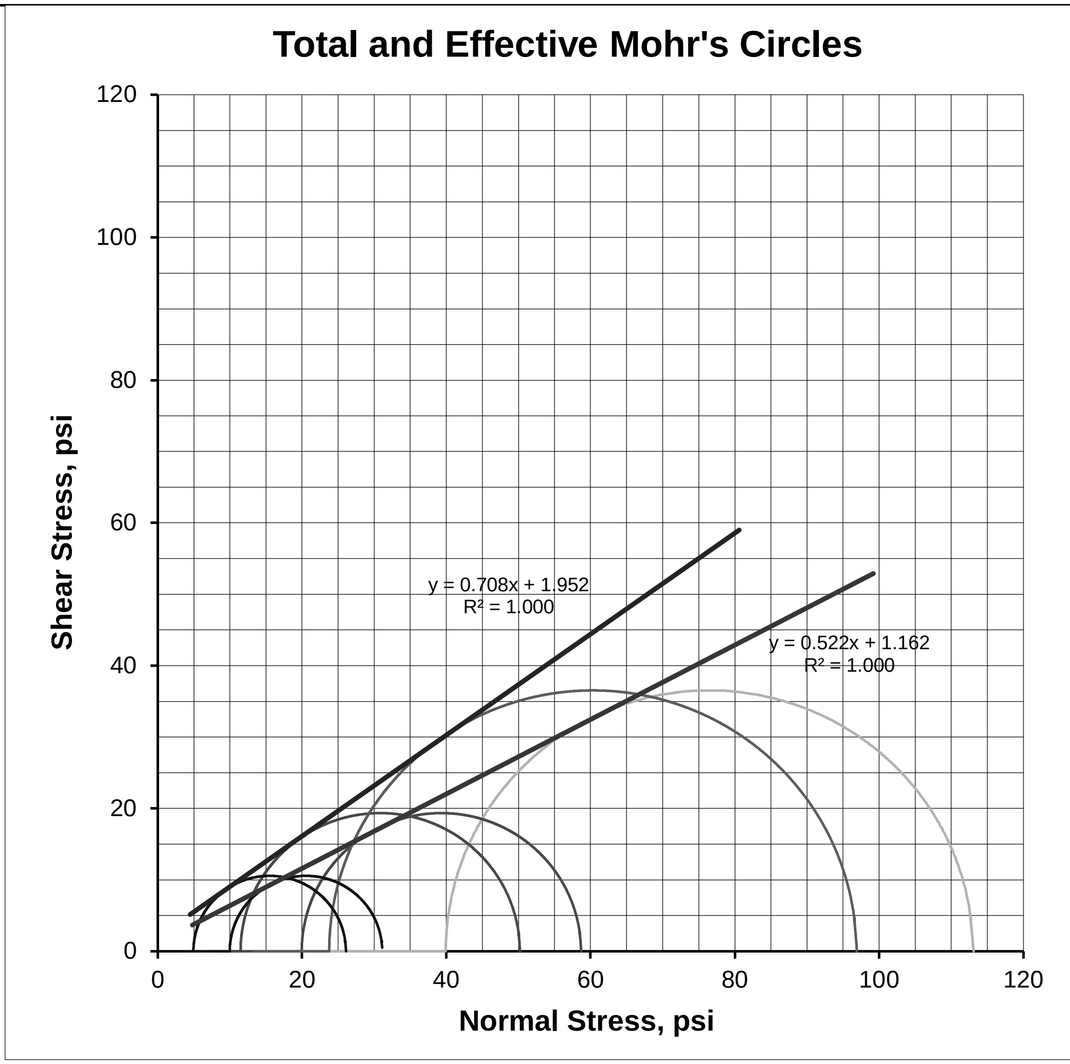
		Date	04/02/20
		Check	

ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33611/YGWA-39-10-12	Depth/Elev.	-
Location	-	Additional Info	-



	ST. 1	ST. 2	ST. 3
Effective Consolidation Stress, psi	10.0	20.0	40.0
Deviator Stress at Failure, psi	21.1	38.7	73.1
Effective Minor Principal Stress at Failure, psi	5.0	11.5	23.8
Effective Major Principal Stress at Failure, psi	26.1	50.2	96.9
Axial Strain at Failure, %	4.26	3.67	8.84

STRENGTH PARAMETERS*			
Total		Effective	
f °	27.5	f ' °	35.3
C, psi	1.2	C', psi	2.0

***Valid only for Received Material at Reported Densities and Moisture Contents. Please see remarks on page 6 of this report**

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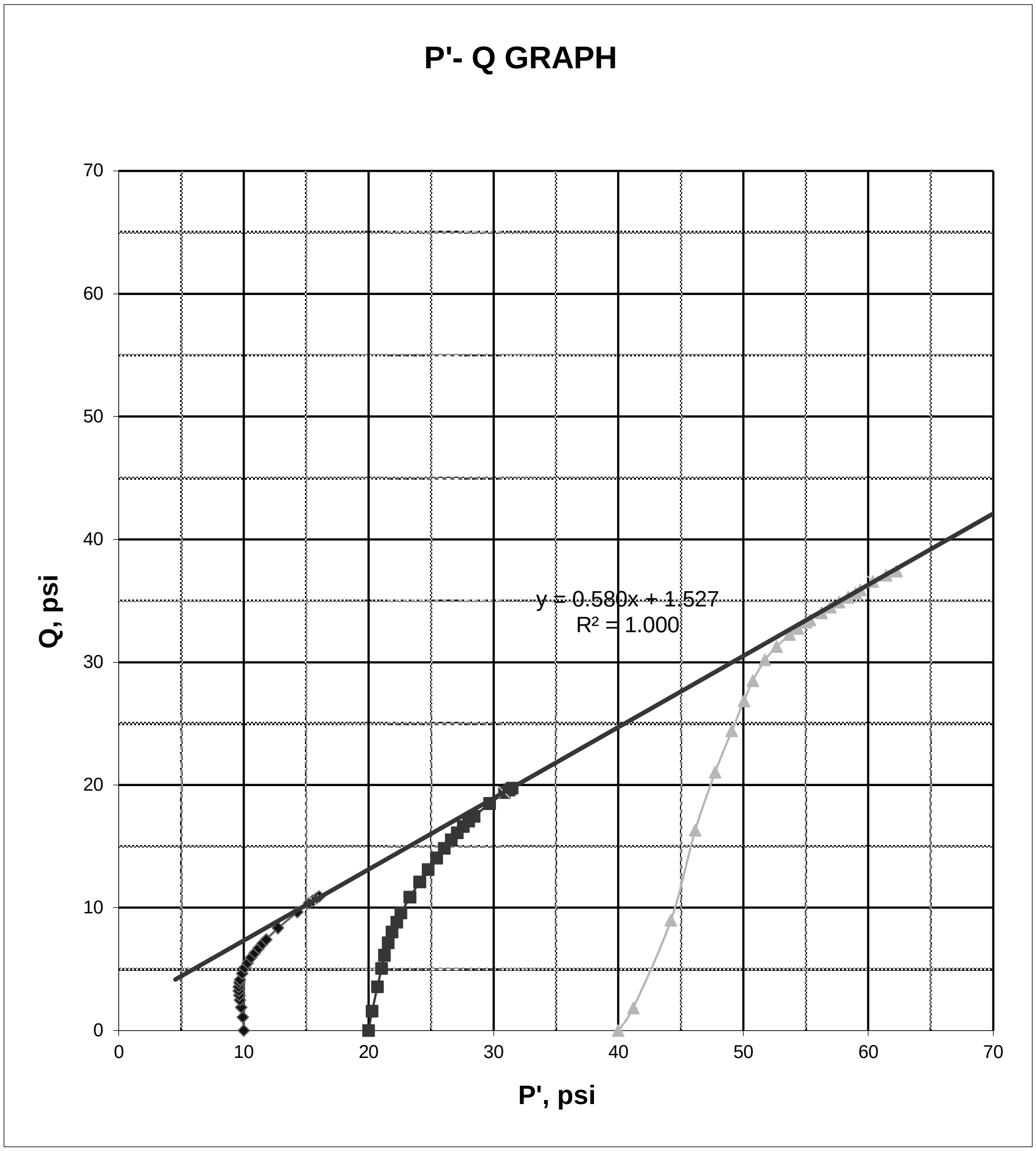
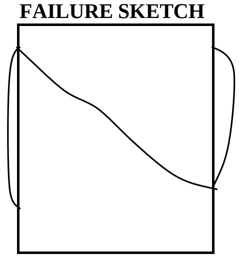


FAILURE SKETCH



a, psi	1.5
a, degree	30.1

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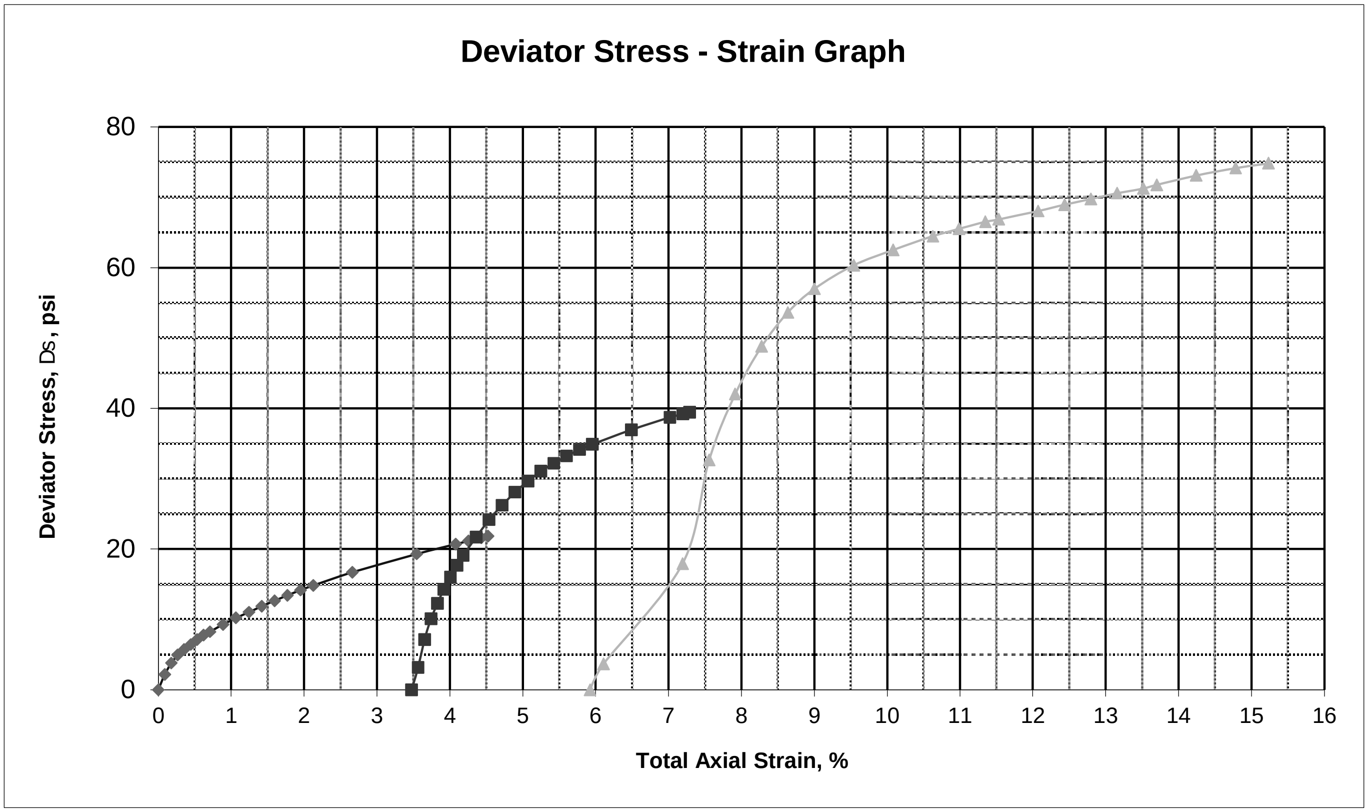
ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33611/YGWA-39-10-12	Depth/Elev.	-
Location	-	Additional Info	-



Balance ID Number	563/700
Oven ID Number	496/610
Deformation Indicator ID #	178/349/689
Digital Caliper ID #	370/458
Load Cell ID #	11/347/692
Apparatus ID #	10/293/693

REMARKS

Material from shelby tube was not homogeneous and/or not long enough to select 3 uniform specimens 6" long each. Most representative portion of sample (1" above the bottom of shelby tube) was selected for multi-stage triaxial testing (per ASTM STP 883).

DESCRIPTION

Olive Gray Silty Sand

NOTES:

1. Method for Saturation	WET	LL	-
2. Method for determination of cross-sectional area after consol.	B	PL	-
3. Final moisture content (Stage 3) obtained from entire sample		PI	-
		Gs	-

USCS (ASTM D2487: D2488)

SM

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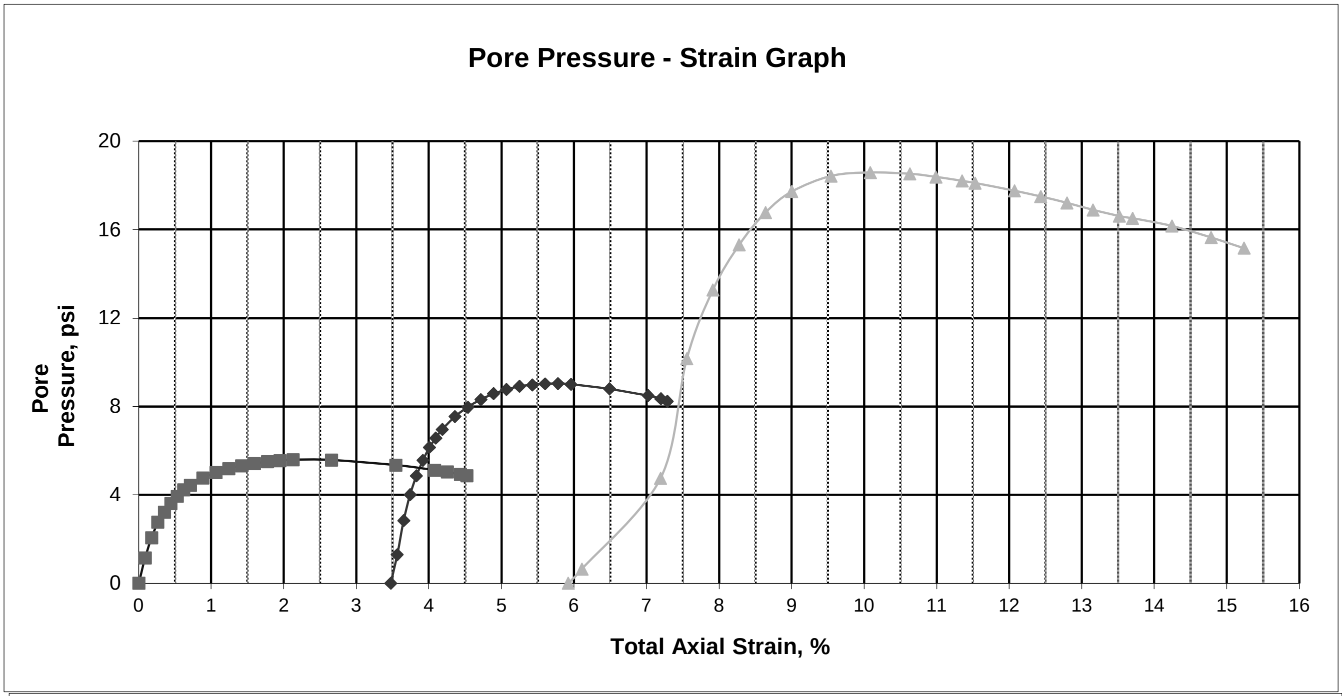
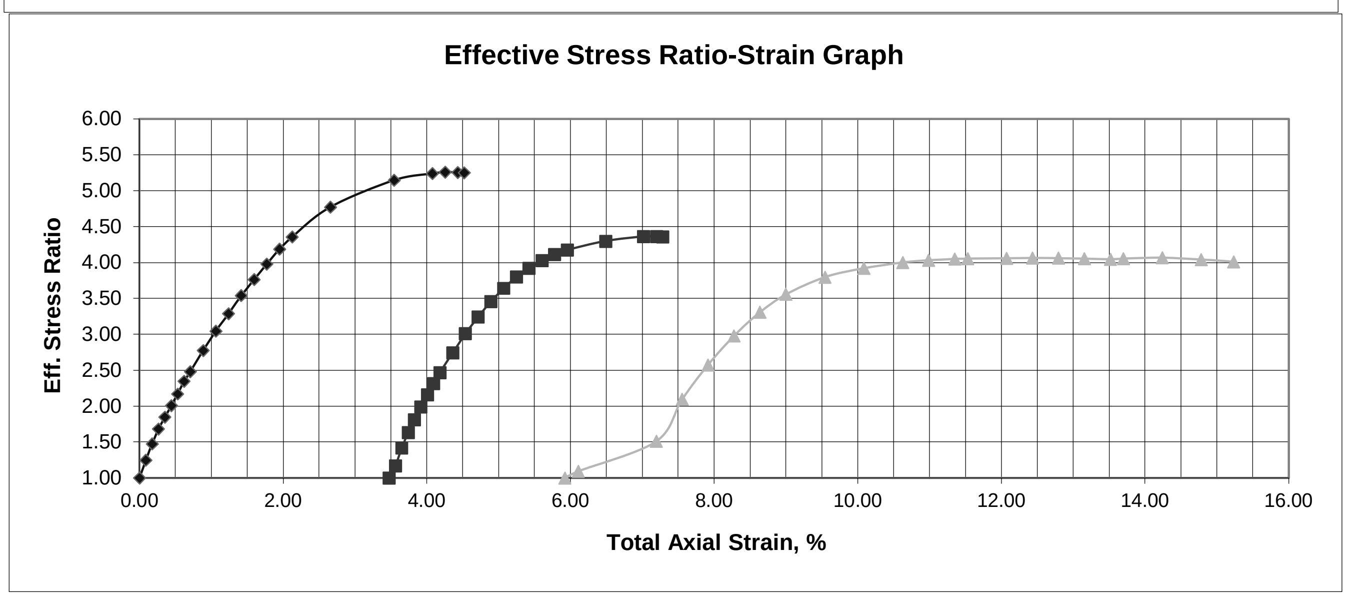
Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33611/YGWA-39-10-12	Depth/Elev.	-
Location	-	Additional Info	-





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Date	04/02/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Pr. Name	AMA	S. Type	UD
Sample ID	33611/YGWA-39-10-12	Depth/Elev.	-
Location	-	Add. Info	-

ASTM D 4318

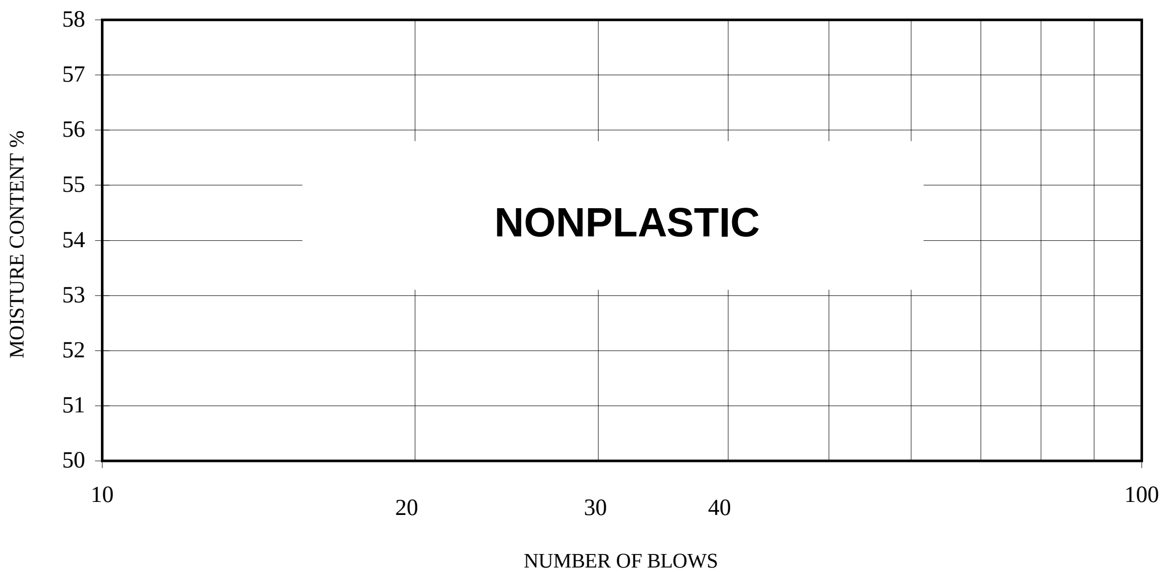
Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils (Atterberg Limits)

LIQUID LIMIT

Number of Blows	10	10
Weight of Wet Sample & Tare, g	41.01	36.34
Weight of Dry Soil & Tare, g	37.17	33.05
Weight of Tare, g	27.41	24.65
Moisture Content, %	39.34	39.17

Liquid Limit Device ID # 56

NOTES: 1. Material appears to be Nonplastic. (Liquid Limit or Plastic Limit test could not be performed.)
2. Material passing No. 40 sieve was used for test.



PLASTIC LIMIT

Weight of Wet Soil & Tare, g	36.22	36.36
Weight of Dry Soil & Tare, g	32.80	33.12
Weight of Tare, g	24.07	24.91
Moisture Content, %	39.18	39.46

Oven ID Number	15/496/610
Balance ID Number	139/563

NATURAL MOISTURE

Weight of Wet Soil & Tare, g	426.80
Weight of Dry Soil & Tare, g	393.30
Weight of Tare, g	123.40
Moisture Content, %	12.41

LIQUID LIMIT (LL)	NP
PLASTIC LIMIT (PL)	NP
PLASTICITY INDEX (PI)	NP
LIQUIDITY INDEX (LI)	-

DESCRIPTION: Olive Gray Silty Sand

USCS (ASTM D2487;2488): SM

AASHTO (M 145): NA

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Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Pr. Name	AMA	S. Type	UD
Sample ID	33611/YGWA-39-10-12	Depth/Elev.	-
Location	-	Add. Info	-

ASTM D 422/AASHTO T 88
Standard Test Method for Particle-Size Analysis of Soils (with Hydrometer Analysis)

As-Received Moisture Content

Mass of Wet Sample & Tare, g	426.80
Mass of Dry Sample & Tare, g	393.30
Mass of Tare, g	123.40
Moisture Content, %	12.4

Moisture Content of Material Used for Hydrometer Analysis

Mass of Wet Sample & Tare, g	426.80
Mass of Dry Sample & Tare, g	393.30
Mass of Tare, g	123.40
Moisture Content, %	12.4

Mass of Total Sample before separation on #4 sieve & Tare, g	651.70
Mass of Tare, g	0.00
Total Mass of Dry Sample, g	579.74

Mass of Sample used for hydrometer analysis, g	93.30
Dry Mass, g	83.00
% of Total Sample passing #4 sieve	100.0

SIEVE ANALYSIS

PORTION OF SAMPLE RETAINED ON #4 SIEVE

Mass of Tare, g: 0.00

Sieve Size		Sample & Tare, g	% RETAINED	%PASSING
12"	COBBLES		0.0	100.0
3"	COARSE GRAVEL		0.0	100.0
2.5"			0.0	100.0
2"			0.0	100.0
1.5"			0.0	100.0
1"			0.0	100.0
.75"	FINE GRAVEL		0.0	100.0
.5"			0.0	100.0
.375"			0.0	100.0
#4	COARSE SAND	0.00	0.0	100.0

PORTION OF SAMPLE PASSING #4 SIEVE (Hydrometer Backsieve)

Sieve Size		Cumulative Mass retained, g	% PASSING
#10	MEDIUM SAND	0.00	100.0
#20		0.48	99.4
#40	FINE SAND	9.25	88.9
#60		28.46	65.7
#100		45.58	45.1
#200	FINES	60.20	27.5

Remarks

HYDROMETER ANALYSIS

Length of Dispersion Period	1 Minute
Mechanical Dispersion Device ID #	61
Amount of Dispersing Agent (ml)	125.0
Specific Gravity (assumed)	2.700
Specific Gravity (tested)	
Starting time	13:45

PARTICLE-SIZE ANALYSIS

% COBBLES	0.0	% MEDIUM SAND	11.1
% COARSE GRAVEL	0.0	% FINE SAND	61.4
% FINE GRAVEL	0.0	% FINES	27.5
% COARSE SAND	0.0	% TOTAL SAMPLE	100.0
% CLAY(<0.005mm)	4.3	% CLAY(<0.002mm)	3.6

Date	Time	Testing time (min)	Reading	Temp (°C)	K	Composite Correction	Actual Reading	Effective Depth (cm)	a	Particle Diam. (mm)	Percent Passing
04/01/20	13:47	2	20.5	16.1	0.01414	6.5	14.0	14.1	0.99	0.0375	16.7
04/01/20	13:50	5	16.5	16.1	0.01414	6.5	10.0	14.7	0.99	0.0243	11.9
04/01/20	14:00	15	13.0	16.1	0.01414	6.5	6.5	15.3	0.99	0.0143	7.8
04/01/20	14:15	30	12.0	16.1	0.01414	6.5	5.5	15.5	0.99	0.0102	6.6
04/01/20	14:45	60	11.0	16.1	0.01414	6.5	4.5	15.6	0.99	0.0072	5.4
04/01/20	17:55	250	9.5	16.1	0.01414	6.5	3.0	15.9	0.99	0.0036	3.6
04/02/20	13:45	1440	9.5	16.1	0.01414	6.5	3.0	15.9	0.99	0.0015	3.6

Hydrometer 152H ID #	305527	Oven ID #	15/496/610
Sieve Shaker ID #	555	Balance ID#	139/142/700

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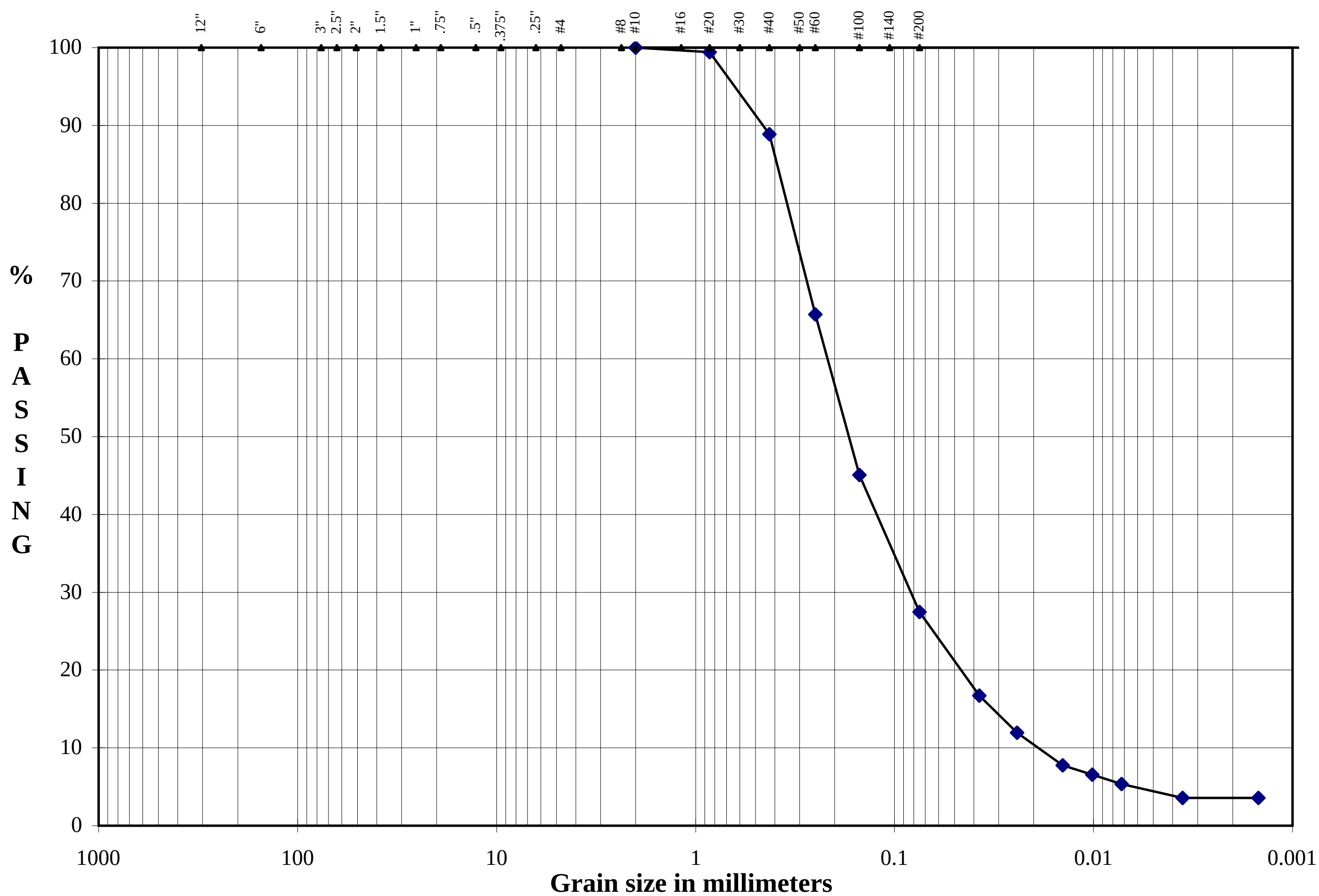
Date	03/31/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Pr. Name	AMA	S. Type	UD
Sample ID	33611/YGWA-39-10-12	Depth/Elev.	-
Location	-	Add. Info	-

ASTM D 422/AASHTO T 88

Standard Test Method for Particle-Size Analysis of Soils (with Hydrometer Analysis)

Particle-Size Analysis



Boulders	Cobbles	Gravel (Coarse)	Gravel (Fine)	Sand (Coarse)	Sand (Medium)	Sand (Fine)	Fines (Silt or Clay)

D_{10}	NA	mm
D_{30}	NA	mm
D_{60}	NA	mm
Cu	NA	
Cc	NA	

DESCRIPTION: Olive Gray Silty Sand

USCS (ASTM D2487; D2488): SM

Project's Specific % Passing	NA
Project's Specific Particle Size, mm	NA

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Phone: 770-938-8233
Fax: 770-923-8973
Web: www.test-llc.com
AASHTO ACCREDITED

Tested By	RI
Date	04/06/20
Checked By	LB

Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Pr. Name	AMA	S. Type	UD
Sample ID	33611/YGWA-39-10-12	Depth/Elev.	-
Location	-	Add. Info	-

ASTM D854; Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

TEST METHOD: B

MOISTURE CONTENT

Mass of Wet Sample & Tare, g	-
Mass of Dry Sample & Tare, g	-
Mass of Tare, g	-
Moisture Content, %	NA*

TEST DATA

Pycnometer Number	3
Mass of Pycnometer, g	134.56
Mass of Sample & Pycnometer, g	214.61
Mass of Sample, Water & Pycnometer, g	682.88
Test Temperature, ^{o}C	22.8
Mass of Tare,g	153.74
Mass of Dry Sample & Tare, g	233.40
Mass of Dry Soil, g	79.66
Mass of Pycnometer (Calibrated), g	134.56
Density of Water @ Test Temperature, g/mL	0.99759
Mass of Pycnometer & Water @ Test Temp.	632.73
Temperature Coefficient	0.99938
Calibrated Volume of Pycnometer, mL	499.37
Specific Gravity @ Test Temperature	2.700

SPECIFIC GRAVITY @ 20 ^{o}C **2.698**

DESCRIPTION

Olive Gray Silty Sand

USCS (ASTM D2487, D2488): SM

Thermometer ID Number	72
Vacuum Pump ID Number	62
Deaerator ID Number	213
Specific Gravity Board ID Number	214
Balance ID Number	139
Oven ID Number	12

NOTES:

1.* Oven-Dry material passing #4 sieve used for test.
2. Air removed by vacuum method.
3. Deionized / Deaired water was used for test.

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Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Project Name	AMA	S. Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 2

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	0.0
2	0.08	0.29	17.0
3	0.28	0.53	17.5
4	0.48	0.70	17.8
5	0.78	0.89	18.0
6	1.48	1.22	18.0
7	2.23	1.49	18.0
8	2.98	1.73	18.0
9	3.73	1.93	18.0
10	4.98	2.23	18.0
11	6.48	2.55	18.0
12	8.5	2.91	18.5
13	11.0	3.31	18.5
14	16.0	4.00	18.5
15	22.0	4.69	18.5
16	32.0	5.66	19.0
17	65.0	8.06	19.0
18	90.0	9.49	19.0
19	165.0	12.84	19.5
20	240.0	15.49	19.5
	390.0	19.75	19.5
	540.0	23.24	19.5
	690.0	26.27	19.5

Pressure* on Specimen, lbf/ft^2

250

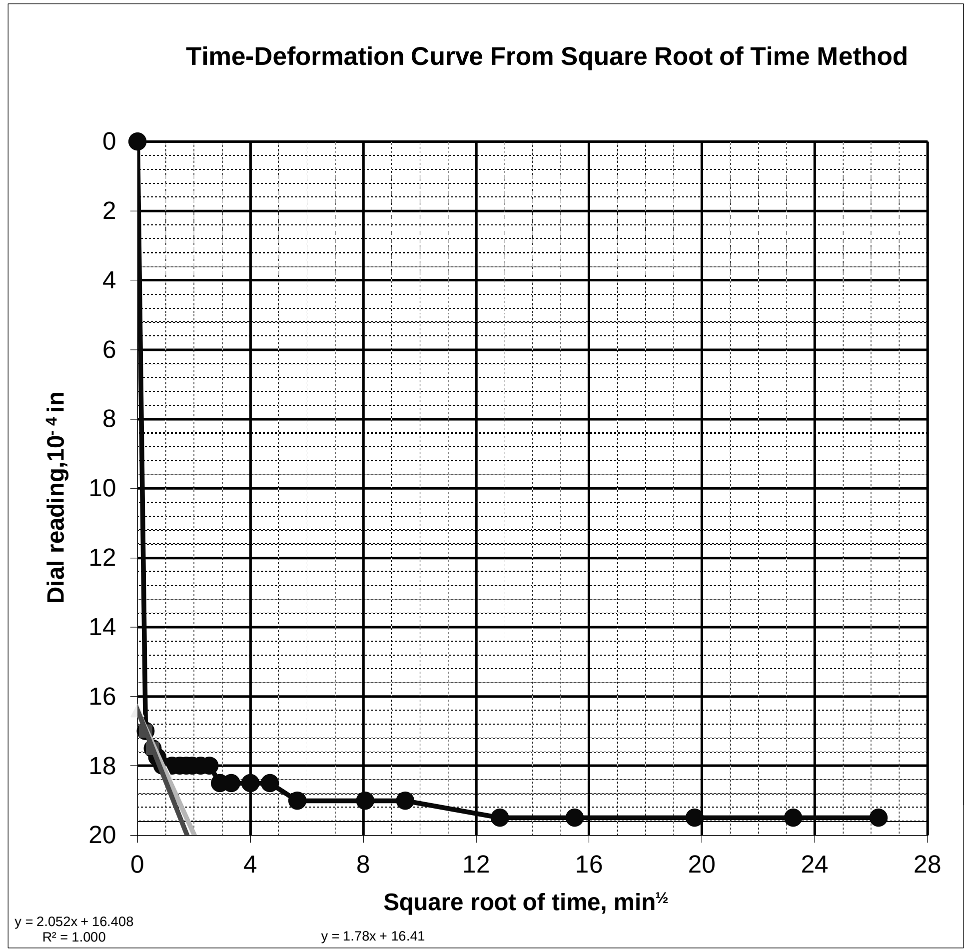
Selection	3
m_1	2.05
m_2	1.78

X	Y
0	16.41
1	18.19

d_0	16.4
d_{90}	18
d_{100}	18
d_{50}	17
sq.root t_{90}	0.9
t_{90}, min	0.81
sq.root t_{50}	0.43
t_{50}, min	0.19

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Date	04/06/20
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Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Project Name	AMA	S. Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 3

Point #	Time, min	Square Root of Time, min$^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	19.5
2	0.08	0.29	38.0
3	0.28	0.53	39.0
4	0.50	0.71	39.5
5	0.78	0.89	40.0
6	1.48	1.22	40.5
7	2.23	1.49	41.0
8	2.98	1.73	41.0
9	3.73	1.93	41.0
10	4.98	2.23	41.5
11	6.48	2.55	41.5
12	8.5	2.91	41.5
13	11.0	3.31	42.0
14	16.0	4.00	42.0
15	22.0	4.69	42.0
16	32.0	5.66	42.5
17			
18			
19			
20			

Pressure* on Specimen, lbf/ft^2

500

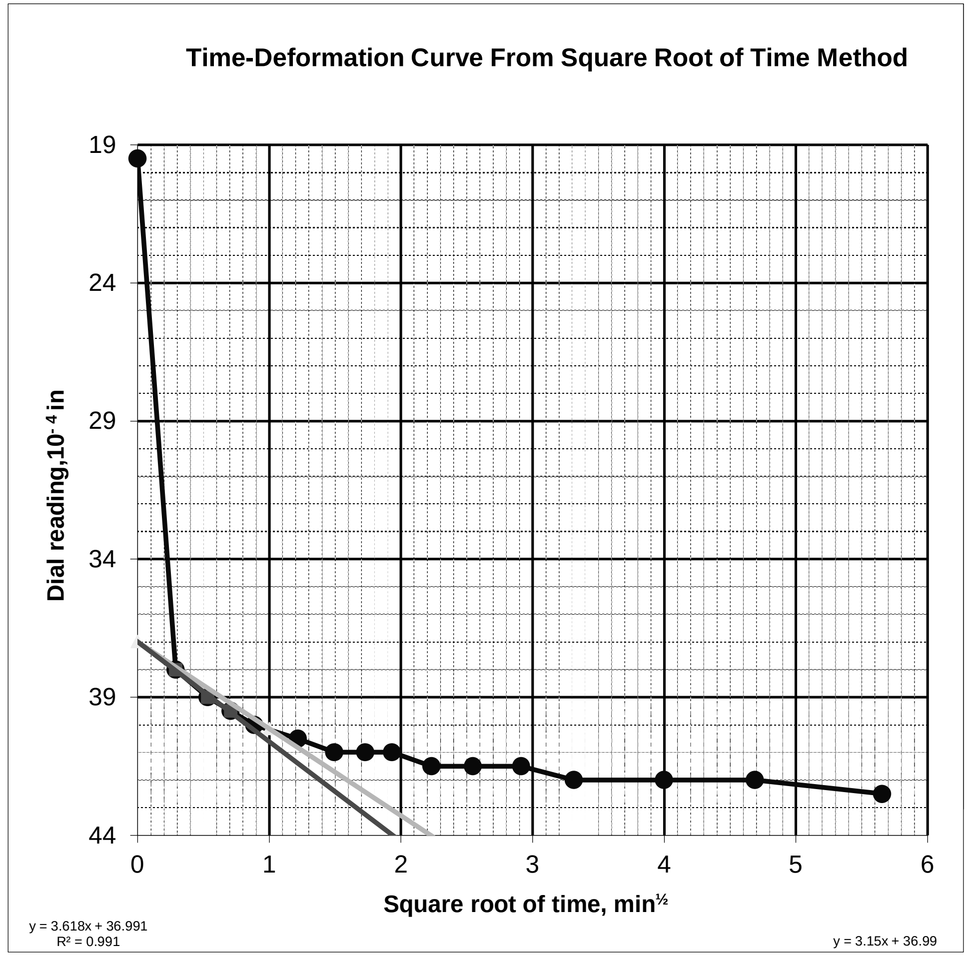
Selection	4
m_1	3.62
m_2	3.15

X	**Y**
0	36.99
1	40.14

d_0	37.0
d_{90}	40
d_{100}	40
d_{50}	39
sq.root t_{90}	1
t_{90}, min	1.00
sq.root t_{50}	0.48
t_{50}, min	0.23

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Project Name	AMA	S. Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 4

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	42.5
2	0.08	0.29	84.0
3	0.28	0.53	86.0
4	0.48	0.70	87.0
5	0.78	0.89	87.5
6	1.48	1.22	88.5
7	2.23	1.49	89.5
8	2.98	1.73	90.0
9	3.73	1.93	90.0
10	4.98	2.23	90.5
11	6.48	2.55	91.0
12	8.5	2.91	91.5
13	11.0	3.31	92.0
14	16.0	4.00	92.5
15	22.0	4.69	93.0
16	32.0	5.66	93.5
17			
18			
19			
20			

Pressure* on Specimen, lbf/ft²

1000

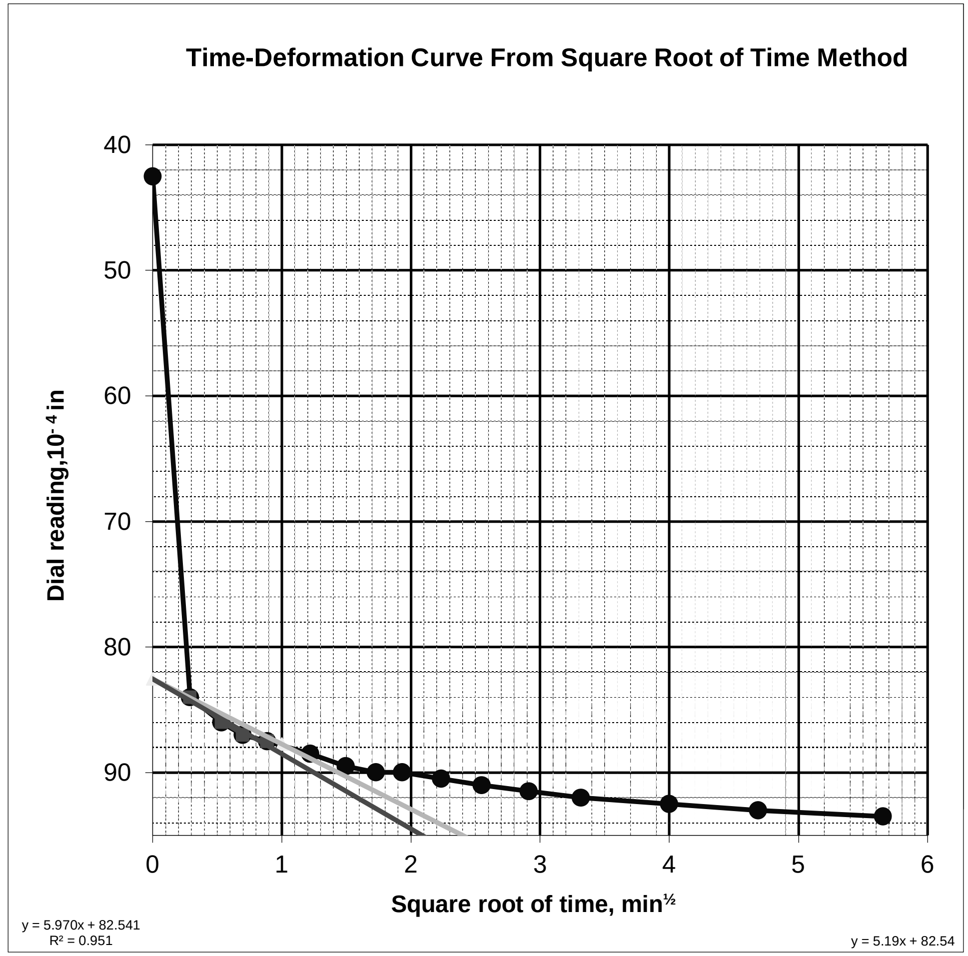
Selection	5
m_1	5.97
m_2	5.19

X	Y
0	82.54
1	87.73

d_0	82.5
d_{90}	88
d_{100}	89
d_{50}	86
$sq.root\ t_{90}$	1.05
t_{90}, min	1.10
$sq.root\ t_{50}$	0.51
t_{50}, min	0.26

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Tested By	KP
Date	04/06/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Project Name	AMA	S. Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	94.0
2	0.10	0.32	175.5
3	0.30	0.55	177.5
4	0.50	0.71	179.0
5	0.80	0.89	180.0
6	1.50	1.22	181.0
7	2.25	1.50	182.0
8	3.00	1.73	183.0
9	3.75	1.94	183.0
10	5.00	2.24	183.5
11	6.50	2.55	184.5
12	8.5	2.92	185.0
13	11.0	3.32	185.5
14	16.0	4.00	186.5
15	22.0	4.69	186.5
16	32.0	5.66	187.5
17			
18			
19			
20			

STEP # 5

Pressure* on Specimen, lbf/ft^2

2000

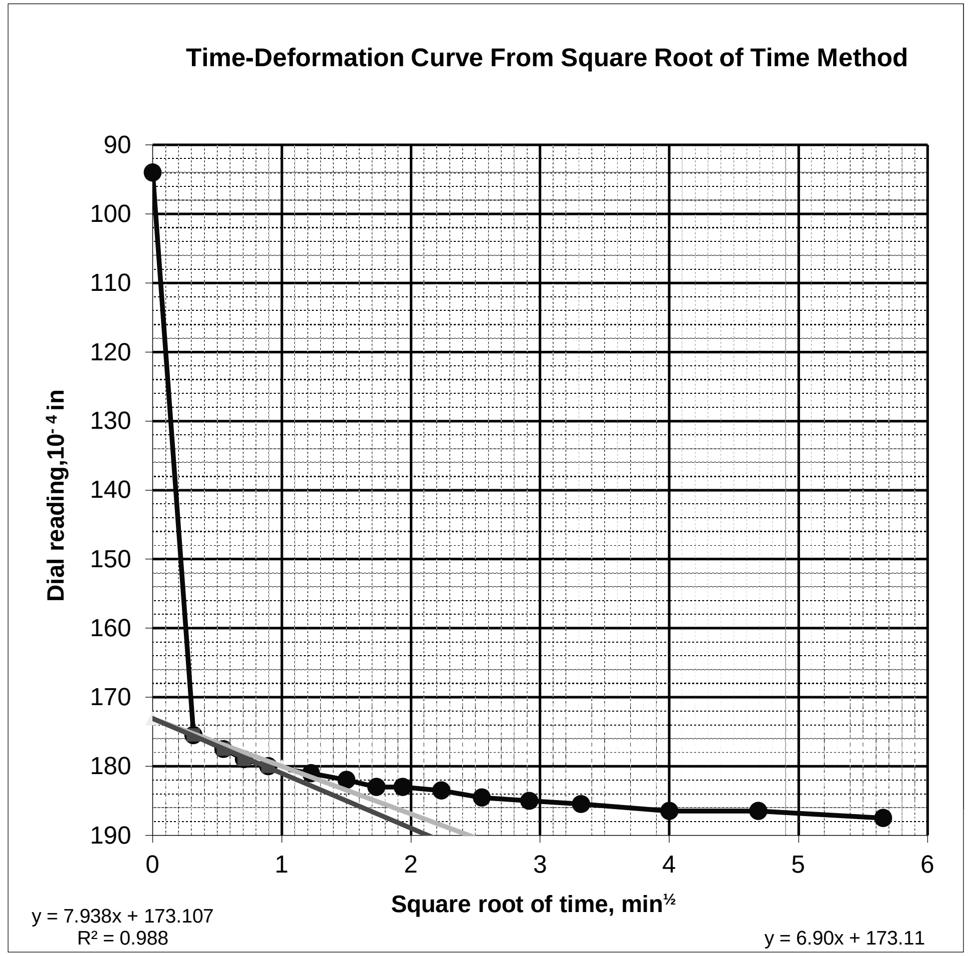
Selection	5
m_1	7.94
m_2	6.90

X	Y
0	173.11
1	180.01

d_0	173.1
d_{90}	181
d_{100}	182
d_{50}	177
sq.root t_{90}	1.1
t_{90}, min	1.21
sq.root t_{50}	0.53
t_{50}, min	0.28

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Tested By	KP
Date	04/06/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Project Name	AMA	S. Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 6

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	189.0
2	0.10	0.32	307.5
3	0.30	0.55	312.0
4	0.50	0.71	314.5
5	0.80	0.89	317.0
6	1.50	1.22	319.5
7	2.25	1.50	321.0
8	3.00	1.73	322.0
9	3.75	1.94	323.0
10	5.00	2.24	324.0
11	6.50	2.55	325.0
12	8.5	2.92	325.5
13	11.0	3.32	326.5
14	16.0	4.00	328.0
15	22.0	4.69	329.0
16	32.0	5.66	330.5
17	65.0	8.06	333.0
18	90.0	9.49	334.5
19	165.0	12.85	337.5
20			

Pressure* on Specimen, lbf/ft²

4000

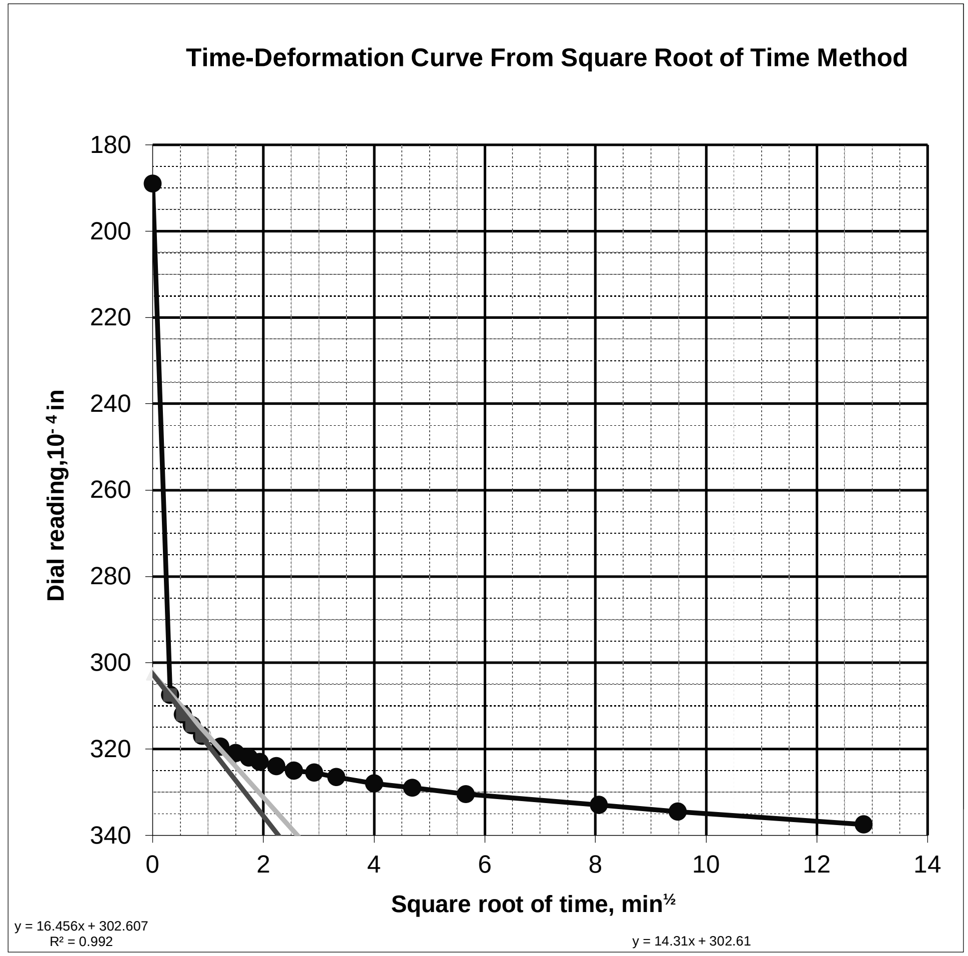
Selection	5
m_1	16.46
m_2	14.31

X	Y
0	302.61
1	316.92

d_0	302.6
d_{90}	319
d_{100}	321
d_{50}	312
sq.root t_{90}	1.15
t_{90}, min	1.32
sq.root t_{50}	0.56
t_{50}, min	0.31

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Tested By	KP
Date	04/06/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Project Name	AMA	S. Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 7

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	338.0
2	0.10	0.32	496.0
3	0.30	0.55	503.0
4	0.50	0.71	508.0
5	0.80	0.89	511.5
6	1.50	1.22	517.0
7	2.25	1.50	520.0
8	3.00	1.73	522.5
9	3.75	1.94	524.0
10	5.00	2.24	526.0
11	6.50	2.55	527.5
12	8.5	2.92	529.5
13	11.0	3.32	531.0
14	16.0	4.00	533.5
15	22.0	4.69	535.0
16	32.0	5.66	537.5
17	65.0	8.06	541.5
18	90.0	9.49	543.5
19			
20			

Pressure* on Specimen, lbf/ft^2

8000

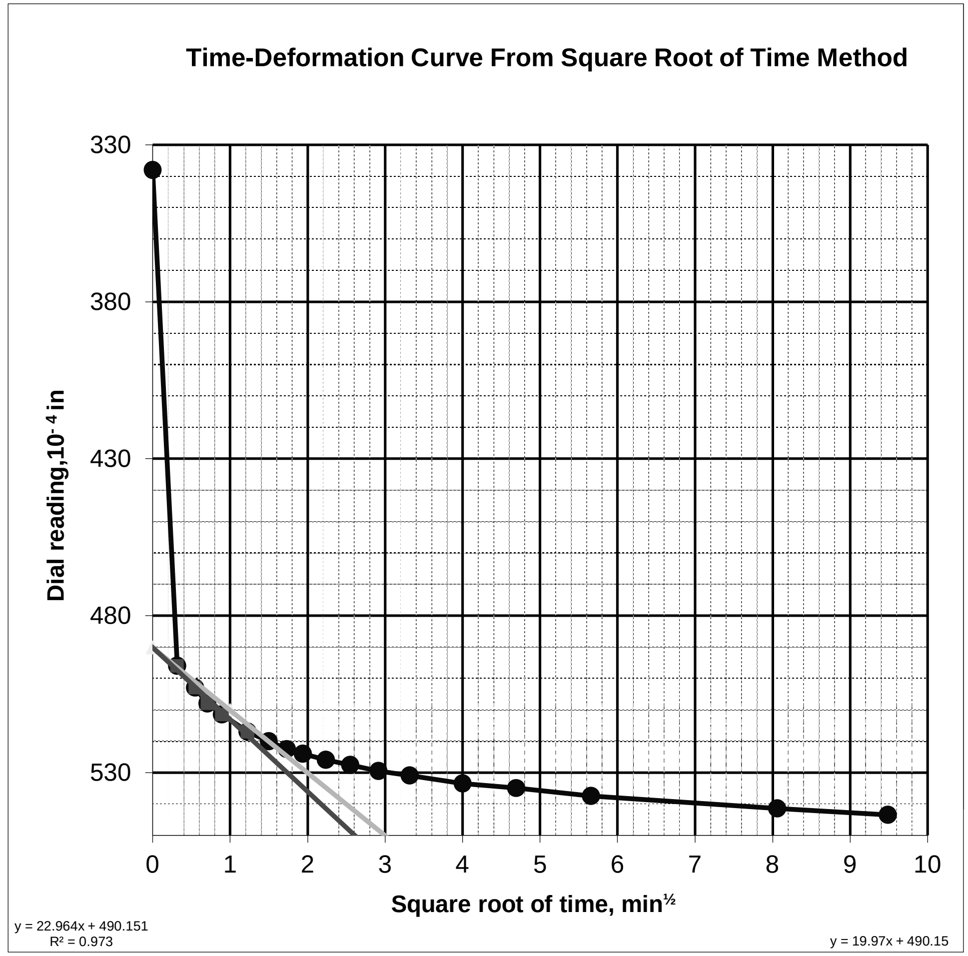
Selection	6
m_1	22.96
m_2	19.97

X	Y
0	490.15
1	510.12

d_0	490.2
d_{90}	519
d_{100}	522
d_{50}	506
sq.root t_{90}	1.45
t_{90}, min	2.10
sq.root t_{50}	0.70
t_{50}, min	0.49

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Project Name	AMA	S. Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 8

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	545.0
2	0.08	0.29	808.0
3	0.28	0.53	819.0
4	0.48	0.70	827.0
5	0.78	0.89	834.5
6	1.48	1.22	843.5
7	2.23	1.49	849.5
8	2.98	1.73	853.5
9	3.73	1.93	857.0
10	4.98	2.23	861.0
11	6.48	2.55	864.5
12	8.5	2.91	868.0
13	11.0	3.31	871.5
14	16.0	4.00	876.5
15	22.0	4.69	880.5
16	32.0	5.66	885.5
17	65.0	8.06	894.5
18	90.0	9.49	899.0
19			
20			

Pressure* on Specimen, lbf/ft^2

16000

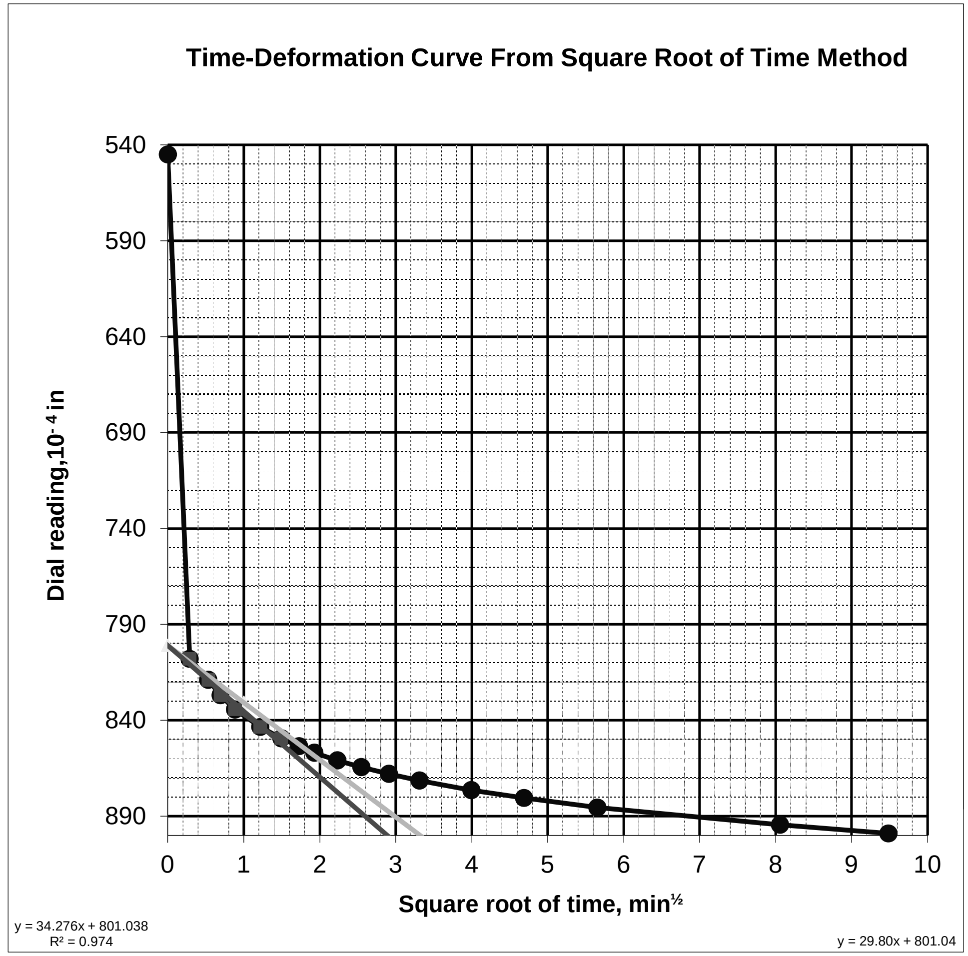
Selection	7
m_1	34.28
m_2	29.80

X	Y
0	801.04
1	830.84

d_0	801.0
d_{90}	858
d_{100}	864
d_{50}	832
sq.root t_{90}	1.9
t_{90}, min	3.61
sq.root t_{50}	0.92
t_{50}, min	0.84

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Project Name	AMA	S. Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

ASTM D2435

Standard Test Method for One-Dimensional Consolidation Properties of Soils (Method B)

Sample Data

	Initial	Final
Mass of Ring, g	194.73	194.73
Mass of Wet Sample and Ring, g	322.95	329.06
Mass of Wet Sample, g	128.22	134.33
Mass of Dry Sample, g	102.04	102.04
Height of Sample, in	0.9970	0.9106
Diameter of Sample, in	2.501	2.501
Area of Sample, in^2	4.91	4.91
Volume of Sample, in^3	4.90	4.47
Specific Gravity (Assumed)	2.700	2.700
Wet Unit Weight, pcf	99.7	114.4
Dry Unit Weight, pcf	79.4	86.9
Height of Solids, in	0.4694	0.4694
Height of Voids, in	0.5276	0.4412
Height of Water, in	0.3253	0.4011
Void Ratio	1.124	0.940
Degree of Saturation, %	61.7	90.9

Initial Seating Pressure, lbf/ft^2	100
Additional Vertical Pressure, lbf/ft^2	0
Total Seating Pressure, lbf/ft^2	100
STATION #	1
Consolidometer Ring ID Number	1
Consolidometer ID Number	1
Frame ID Number	103
Dial Gage ID Number	676
Initial Dial Gauge Reading, 10^{-4} in	0
Final Dial Gauge Reading, 10^{-4} in	864

DESCRIPTION

Olive Gray Silty Sand

Condition of Test:

1. Deionized water used for inundation of sample.
2. Saturated porous stones w/t filter paper used

USCS (ASTM D2487;2488)

SM

REMARKS

Portion of sample used for testing was located 13" above the bottom of the shelby tube.

Moisture Content

	Trimmings	Initial	Final
Mass of Wet Sample and Tare, g	428.30	322.95	413.57
Mass of Dry Sample and Tare, g	371.00	296.77	381.28
Mass of Tare, g	138.20	194.73	279.26
Moisture Content, %	24.6	25.7	31.7

LL	-
PL	-
PI	-

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Date	04/06/20
Checked By	

Client Pr. #	I054-107	Lab Pr. #	2008-08-2
Project Name	AMA	S. Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

ASTM D2435

Standard Test Method for One-Dimensional Consolidation Properties of Soils (Method B)

Void Ratio, Strain Information and Coefficient of Consolidation Calculation

Pressure		Uncorrected Dial Reading, in		Apparatus Correction, in	Corrected Dial Reading, in		Change in specimen height, in		Sample Height, in		Height of Voids, in	Void Ratio		Strain, %		Fitting Time, min		Hd_{50}, in	Coefficient of Consolidation	
lbf/ft^2	Ksf	d_{100}	d_{50}		d_{100}	d_{50}	$S\,D\,H_{100}$	$S\,D\,H_{50}$	H_{100}	H_{50}	Hv^{100},in	e_{100}	e_{50}	e_{100}	e_{50}	t_{90}	t_{50}		in^2/min	ft^2/day
100	0.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.9970	0.9970	0.5276	1.124	1.124	0.00	0.00	-	-	0.4985	-	-
250	0.25	0.0018	0.0017	0.0000	0.0018	0.0017	0.0018	0.0017	0.9952	0.9953	0.5258	1.120	1.120	0.18	0.17	0.81	0.19	0.4976	0.26	2.59
500	0.5	0.0040	0.0039	0.0000	0.0040	0.0039	0.0040	0.0039	0.9930	0.9931	0.5235	1.115	1.116	0.41	0.39	1.00	0.23	0.4966	0.21	2.09
1000	1	0.0089	0.0086	0.0000	0.0089	0.0086	0.0089	0.0086	0.9881	0.9884	0.5187	1.105	1.106	0.89	0.86	1.10	0.26	0.4942	0.19	1.88
2000	2	0.0182	0.0177	0.0000	0.0182	0.0177	0.0182	0.0177	0.9788	0.9793	0.5094	1.085	1.086	1.82	1.78	1.21	0.28	0.4896	0.17	1.68
4000	4	0.0321	0.0312	0.0000	0.0321	0.0312	0.0321	0.0312	0.9649	0.9658	0.4955	1.056	1.057	3.22	3.13	1.32	0.31	0.4829	0.15	1.50
8000	8	0.0522	0.0506	0.0000	0.0522	0.0506	0.0522	0.0506	0.9448	0.9464	0.4753	1.013	1.016	5.24	5.08	2.10	0.49	0.4732	0.09	0.90
16000	16	0.0864	0.0832	0.0000	0.0864	0.0832	0.0864	0.0832	0.9106	0.9138	0.4412	0.940	0.947	8.67	8.35	3.61	0.84	0.4569	0.05	0.49

Note:
- d_{100} = Dial gauge reading at 100% primary consolidation, in
- d_{50} = Dial gauge reading at 50% primary consolidation, in
- H_{100} = Specimen height at 100% primary consolidation, in
- H_{50} = Specimen height at 50% primary consolidation, in
- Hd_{50} = Length of the drainage path at 50% consolidation, in
- e_{100} = Void ratio at 100% primary consolidation
- e_{50} = Void ratio at 50% primary consolidation

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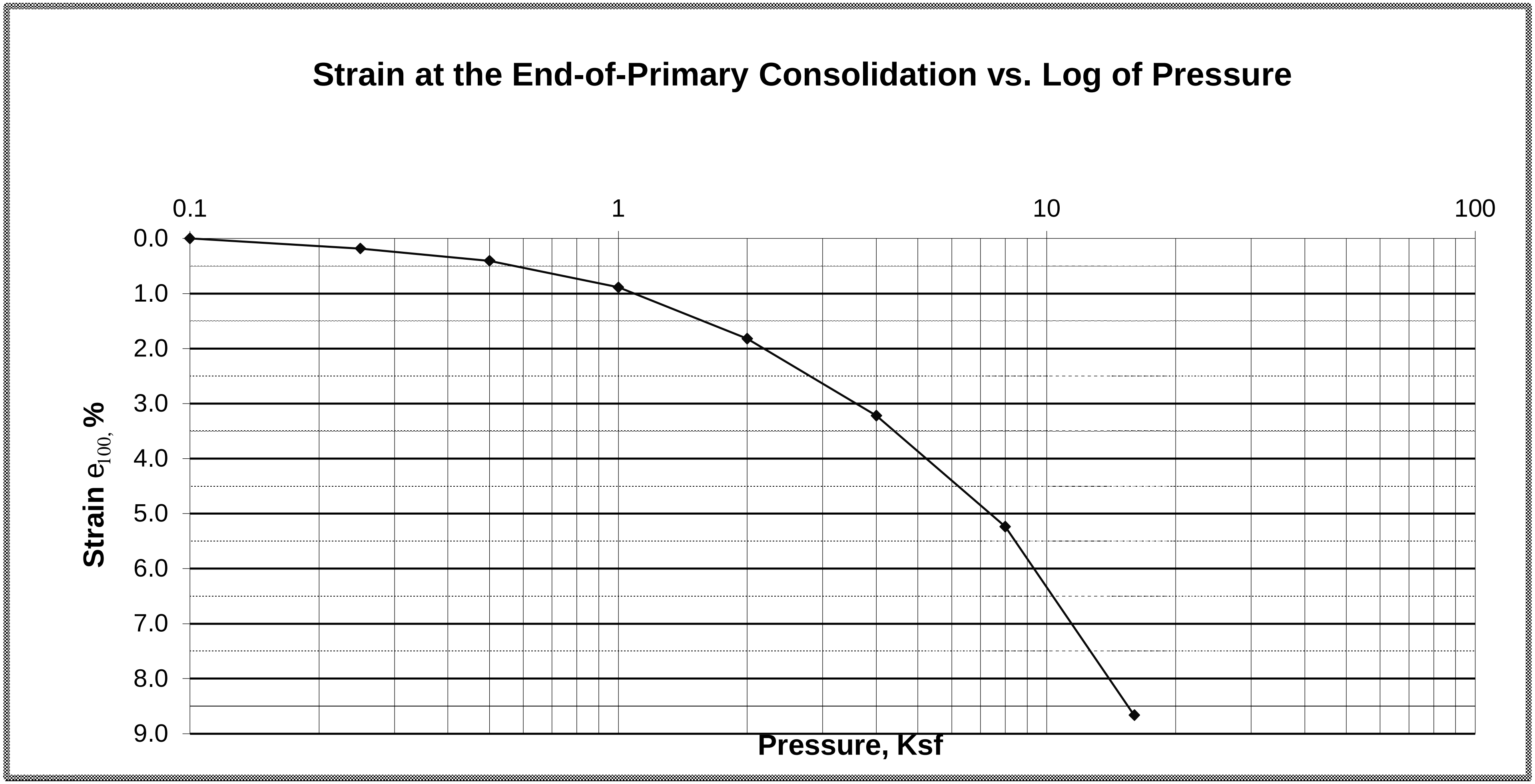
Tested By	RI
Date	04/06/20
Checked By	

Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Project Name	AMA	S. Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

ASTM D 2435; Standard Test Method for One-Dimensional Consolidation Properties of Soils (Method B)



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Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
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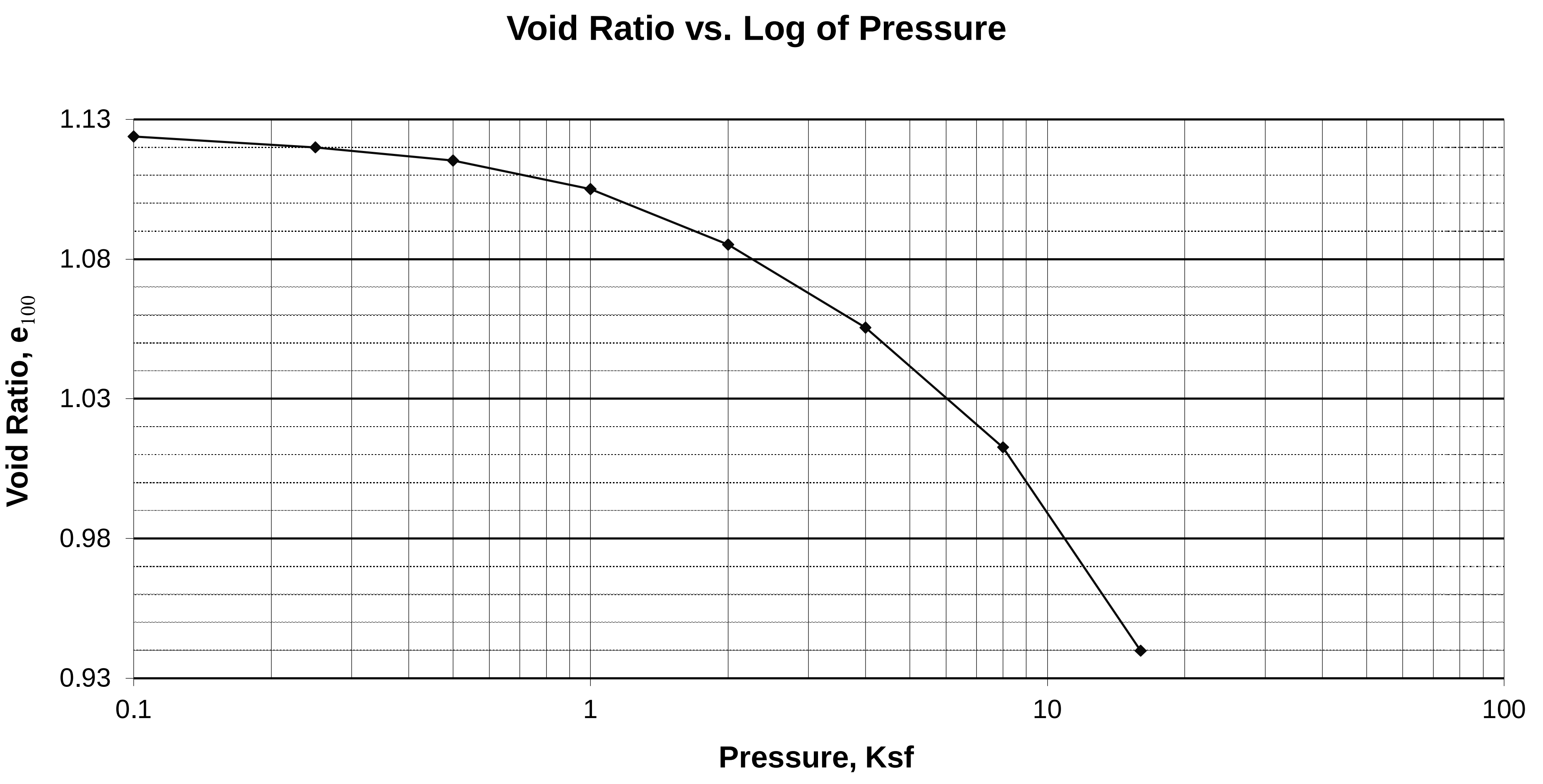

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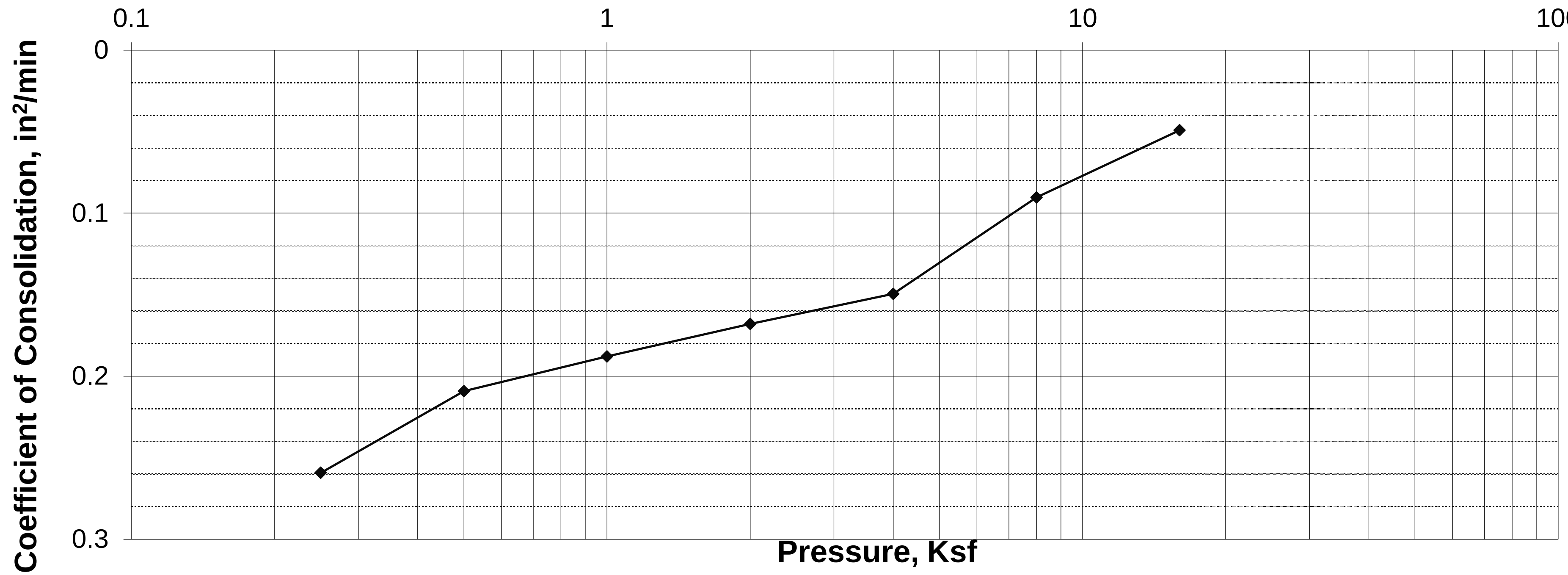
Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Project Name	AMA	S. Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

ASTM D 2435; Standard Test Method for One-Dimensional Consolidation Properties of Soils (Method B)

Coefficient of Consolidation vs. Log of Pressure



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Tested By	EB/KP
Date	04/01/20
Checked By	[signature]

ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Additional Info	-

SPECIMEN PROPERTIES

	(initial)	(after consol.)
Height, in	5.672	5.643
Diameter, in	2.869	2.784
Height-to-Diameter Ratio	2.0	2.0
Area, in^2	6.46	6.09
Volume, cm^3	600.88	562.87
Mass of Wet Sample, g	1033.00	1084.70
Mass of Dry Sample, g	828.79	828.79
Wet Density, pcf	107.3	120.3
Dry Density, pcf	86.1	91.9
Specific Gravity (assumed)	2.700	2.700
Volume of Solids, cm^3	306.96	306.96
Volume of Voids, cm^3	293.92	255.91
Void Ratio	0.96	0.83
% Saturation	69.5	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	429.50	1084.70
Mass of Dry Sample and Tare, g	369.60	828.79
Mass of Tare, g	126.50	0.00
Moisture, %	24.64	30.88

TEST DATA PRIOR TO LOADING

Volume change (Consolidation), ml	51.7
Machine Speed, in / min	0.0100
Strain Rate, % / min	0.18
Chamber Pressure, psi	80.0
Back Pressure, psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	10.0
Change in Height, in	0.029
"B" Value	0.95

SHEAR DATA

Elapsed Time (min)	Deformation Stage 1 (inch)	Axial Load (lb)	Pore-Water Pressure, psi		Total Strain Stage 1 (%)	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$)	Major Principal Stress, psi		Eff.Stress Ratio	P' $(s'_1+s'_3)/2$ (psi)	Q $(s_1-s_3)/2$ (psi)	Eff. Minor Pr. Stress
			Total, U	Change,DU			(psi)	Total s_1	Eff. s'_1	s'_1/s'_3			s'_3 (psi)
0.0	0.000	18.2	70.00	0.0	0.00	6.09	0.0	10.0	10.0	1.00	10.0	0.0	10.0
0.5	0.005	47.2	71.77	1.8	0.09	6.09	4.8	14.8	13.0	1.58	10.6	2.4	8.2
1.0	0.010	62.2	72.66	2.7	0.18	6.10	7.2	17.2	14.6	1.98	10.9	3.6	7.3
1.5	0.015	69.7	73.21	3.2	0.27	6.10	8.4	18.4	15.2	2.24	11.0	4.2	6.8
2.0	0.020	74.5	73.48	3.5	0.35	6.11	9.2	19.2	15.7	2.41	11.1	4.6	6.5
2.5	0.025	79.7	73.77	3.8	0.44	6.11	10.1	20.1	16.3	2.61	11.3	5.0	6.2
3.0	0.030	84.5	73.98	4.0	0.53	6.12	10.8	20.8	16.9	2.80	11.4	5.4	6.0
3.5	0.035	89.1	74.14	4.1	0.62	6.12	11.6	21.6	17.4	2.98	11.6	5.8	5.9
4.0	0.040	93.9	74.29	4.3	0.71	6.13	12.3	22.3	18.1	3.16	11.9	6.2	5.7
5.0	0.050	103.9	74.46	4.5	0.89	6.14	14.0	24.0	19.5	3.52	12.5	7.0	5.5
6.0	0.060	113.9	74.58	4.6	1.06	6.15	15.6	25.6	21.0	3.87	13.2	7.8	5.4
7.0	0.070	124.4	74.62	4.6	1.24	6.16	17.2	27.2	22.6	4.20	14.0	8.6	5.4
8.0	0.080	133.8	74.63	4.6	1.42	6.17	18.7	28.7	24.1	4.49	14.7	9.4	5.4
9.0	0.090	144.6	74.58	4.6	1.59	6.19	20.4	30.4	25.9	4.77	15.6	10.2	5.4
10.0	0.100	154.9	74.48	4.5	1.77	6.20	22.1	32.1	27.6	5.00	16.5	11.0	5.5
11.0	0.110	164.0	74.37	4.4	1.95	6.21	23.5	33.5	29.1	5.17	17.4	11.7	5.6
12.0	0.120	172.5	74.21	4.2	2.13	6.22	24.8	34.8	30.6	5.29	18.2	12.4	5.8
13.0	0.130	180.8	74.01	4.0	2.30	6.23	26.1	36.1	32.1	5.36	19.0	13.0	6.0
14.0	0.140	188.2	73.80	3.8	2.48	6.24	27.2	37.2	33.4	5.39	19.8	13.6	6.2
15.0	0.150	194.7	73.62	3.6	2.66	6.25	28.2	38.2	34.6	5.42	20.5	14.1	6.4
16.0	0.160	200.6	73.40	3.4	2.84	6.26	29.1	39.1	35.7	5.41	21.2	14.6	6.6
17.0	0.170	205.8	73.18	3.2	3.01	6.28	29.9	39.9	36.7	5.38	21.8	14.9	6.8
Values @ Failure				3.6	2.66	6.25	28.2	38.2	34.6	**5.42**	20.5	14.1	6.4

Failure criteria used*: 3

*Note: "1" = Max Deviator Stress; "2" = Deviator Stress @ 15% Strain; "3" = Max Eff.Stress Ratio(s'_1/s'_3)

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ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Additional Info	-

SPECIMEN PROPERTIES

		(initial)	(after consol.)
Height, in		5.473	5.518
Diameter, in		2.827	2.798
Height-to-Diameter Ratio		1.9	2.0
Area, in^2		6.28	6.15
Volume, cm^3		562.87	555.87
Mass of Wet Sample, g		1084.70	1077.70
Mass of Dry Sample, g		828.79	828.79
Wet Density, pcf		120.3	121.0
Dry Density, pcf		91.9	93.1
Specific Gravity	(assumed)	2.700	2.700
Volume of Solids, cm^3		306.96	306.96
Volume of Voids, cm^3		255.91	248.91
Void Ratio		0.83	0.81
% Saturation		100.0	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	1084.70	1077.70
Mass of Dry Sample and Tare, g	828.79	828.79
Mass of Tare, g	0.00	0.00
Moisture, %	30.88	30.03

TEST DATA PRIOR TO LOADING

Volume change (Consolidation), ml	-7.0
Machine Speed, in / min	0.0100
Strain Rate, % / min	0.18
Chamber Pressure, psi	90.0
Back Pressure, psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	20.0
Change in Height, in	-0.045
"B" Value	0.95

SHEAR DATA

Deformation Stage 2 (inch)	Total Deformation ST.1 + ST.2 (inch)	Axial Load (lb)	Pore-Water Pressure, psi		Strain Stage 2 %	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$)	Major Principal Stress, psi		Effective Stress Ratio	P' $(s'_1+s'_3)/2$ (psi)	Q $(s_1-s_3)/2$ (psi)	Eff. Minor Pr. Stress	Total Strain ST.1 + ST.2 %
			Total, U	Change,DU			(psi)	Total s_1	Eff. s'_1	s'_1/s'_3			s'_3 (psi)	
0.000	0.125	21.6	70.00	0.0	0.00	6.15	0.0	20.0	20.0	1.00	20.0	0.0	20.0	2.22
0.005	0.130	54.6	71.91	1.9	0.09	6.15	5.4	25.4	23.5	1.30	20.8	2.7	18.1	2.30
0.010	0.135	86.6	73.88	3.9	0.18	6.16	10.6	30.6	26.7	1.65	21.4	5.3	16.1	2.39
0.015	0.140	107.8	74.97	5.0	0.27	6.16	14.0	34.0	29.0	1.93	22.0	7.0	15.0	2.48
0.020	0.145	119.4	75.48	5.5	0.36	6.17	15.9	35.9	30.4	2.09	22.4	7.9	14.5	2.57
0.025	0.150	135.0	76.00	6.0	0.45	6.18	18.4	38.4	32.4	2.31	23.2	9.2	14.0	2.66
0.030	0.155	148.7	76.35	6.3	0.54	6.18	20.6	40.6	34.2	2.51	23.9	10.3	13.7	2.75
0.035	0.160	162.7	76.66	6.7	0.63	6.19	22.8	42.8	36.1	2.71	24.7	11.4	13.3	2.84
0.040	0.165	175.2	76.83	6.8	0.72	6.19	24.8	44.8	38.0	2.88	25.6	12.4	13.2	2.92
0.050	0.175	199.6	77.17	7.2	0.91	6.20	28.7	48.7	41.5	3.24	27.2	14.3	12.8	3.10
0.060	0.185	220.8	77.43	7.4	1.09	6.21	32.1	52.1	44.6	3.55	28.6	16.0	12.6	3.28
0.070	0.195	237.9	77.66	7.7	1.27	6.23	34.7	54.7	47.1	3.82	29.7	17.4	12.3	3.46
0.080	0.205	250.3	77.83	7.8	1.45	6.24	36.7	56.7	48.8	4.01	30.5	18.3	12.2	3.63
0.090	0.215	260.0	77.92	7.9	1.63	6.25	38.1	58.1	50.2	4.16	31.2	19.1	12.1	3.81
0.100	0.225	266.9	77.96	8.0	1.81	6.26	39.2	59.2	51.2	4.25	31.6	19.6	12.0	3.99
0.110	0.235	272.2	77.96	8.0	1.99	6.27	40.0	60.0	52.0	4.32	32.0	20.0	12.0	4.16
0.120	0.245	276.8	77.91	7.9	2.17	6.28	40.6	60.6	52.7	4.36	32.4	20.3	12.1	4.34
0.130	0.255	280.5	77.87	7.9	2.36	6.30	41.1	61.1	53.3	4.39	32.7	20.6	12.1	4.52
0.140	0.265	284.0	77.82	7.8	2.54	6.31	41.6	61.6	53.8	4.42	33.0	20.8	12.2	4.70
0.150	0.275	287.0	77.77	7.8	2.72	6.32	42.0	62.0	54.2	4.43	33.2	21.0	12.2	4.87
0.160	0.285	290.0	77.71	7.7	2.90	6.33	42.4	62.4	54.7	4.45	33.5	21.2	12.3	5.05
0.170	0.295	292.6	77.64	7.6	3.08	6.34	42.7	62.7	55.1	4.46	33.7	21.4	12.4	5.23
0.180	0.305	294.9	77.54	7.5	3.26	6.35	43.0	63.0	55.5	4.45	34.0	21.5	12.5	5.40
Values @ Failure				7.6	3.08	6.34	42.7	62.7	55.1	**4.46**	33.7	21.4	12.4	5.23

Failure criteria used*: 3

*Note: "1" = Max Deviator Stress; "2" = Deviator Stress @ 15% Strain; "3" = Max Eff.Stress Ratio(s'_1/s'_3)

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ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Additional Info	-

SPECIMEN PROPERTIES

	(initial)	(after consol.)
Height, in	5.338	5.389
Diameter, in	2.844	2.847
Height-to-Diameter Ratio	1.9	1.9
Area, in^2	6.35	6.37
Volume, cm^3	555.87	562.15
Mass of Wet Sample, g	1077.70	1075.50
Mass of Dry Sample, g	828.79	815.32
Wet Density, pcf	121.0	119.4
Dry Density, pcf	93.1	90.5
Specific Gravity (assumed)	2.700	2.700
Volume of Solids, cm^3	306.96	301.97
Volume of Voids, cm^3	248.91	260.18
Void Ratio	0.81	0.86
% Saturation	100.0	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	1077.70	1381.60
Mass of Dry Sample and Tare, g	828.79	1121.40
Mass of Tare, g	0.00	306.00
Moisture, %	30.03	31.91

TEST DATA PRIOR TO LOADING

Volume change (Consolidation), ml	-2.2
Machine Speed, in / min	0.01000
Strain Rate, % / min	0.19
Chamber Pressure, psi	110.0
Back Pressure, psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	40.0
Change in Height, in	-0.051
"B" Value	0.95

SHEAR DATA

Deformation Stage 3 (inch)	Total Deformation ST.1 + ST.2 + ST.3 (inch)	Axial Load (lb)	Pore-Water Pressure, psi		Strain Stage 3 %	Corrected Area (in^2)	Deviator Stress ($Ds=s_1-s_3$)	Major Principal Stress, psi		Effective Stress Ratio	P' $(s'_1+s'_3)/2$ (psi)	Q $(s_1-s_3)/2$ (psi)	Eff. Minor Pr. Stress	Total Strain ST.1 + ST.2 + ST.3, %
			Total, U	Change,DU			(psi)	Total s_1	Eff. s'_1	s'_1/s'_3			s'_3 (psi)	
0.000	0.254	28.2	70.00	0.0	0.00	6.37	0.0	40.0	40.0	1.00	40.0	0.0	40.0	4.50
0.010	0.264	148.7	76.68	6.7	0.19	6.38	18.9	58.9	52.2	1.57	42.8	9.4	33.3	4.68
0.020	0.274	208.1	80.82	10.8	0.37	6.39	28.1	68.1	57.3	1.96	43.3	14.1	29.2	4.86
0.030	0.284	251.3	83.45	13.5	0.56	6.40	34.9	74.9	61.4	2.31	44.0	17.4	26.5	5.03
0.040	0.294	285.0	85.22	15.2	0.74	6.41	40.0	80.0	64.8	2.62	44.8	20.0	24.8	5.21
0.050	0.304	311.8	86.51	16.5	0.93	6.43	44.1	84.1	67.6	2.88	45.6	22.1	23.5	5.39
0.070	0.324	351.9	88.46	18.5	1.30	6.45	50.2	90.2	71.7	3.33	46.6	25.1	21.5	5.74
0.100	0.354	382.3	90.18	20.2	1.86	6.49	54.6	94.6	74.4	3.75	47.1	27.3	19.8	6.27
0.120	0.374	392.6	90.82	20.8	2.23	6.51	56.0	96.0	75.2	3.92	47.2	28.0	19.2	6.63
0.150	0.404	402.2	91.34	21.3	2.78	6.55	57.1	97.1	75.8	4.06	47.2	28.6	18.7	7.16
0.170	0.424	407.1	91.60	21.6	3.15	6.57	57.7	97.7	76.0	4.13	47.2	28.8	18.4	7.51
0.200	0.454	412.8	92.10	22.1	3.71	6.61	58.2	98.2	76.1	4.25	47.0	29.1	17.9	8.04
0.230	0.484	417.6	92.31	22.3	4.27	6.65	58.6	98.6	76.3	4.31	47.0	29.3	17.7	8.58
0.260	0.514	422.1	92.29	22.3	4.82	6.69	58.9	98.9	76.6	4.32	47.2	29.4	17.7	9.11
0.280	0.534	424.9	92.26	22.3	5.20	6.71	59.1	99.1	76.8	4.33	47.3	29.5	17.7	9.46
0.310	0.564	429.0	92.21	22.2	5.75	6.75	59.3	99.3	77.1	4.33	47.5	29.7	17.8	9.99
0.360	0.614	435.4	92.07	22.1	6.68	6.82	59.7	99.7	77.6	4.33	47.8	29.8	17.9	10.88
0.410	0.664	441.0	91.91	21.9	7.61	6.89	59.9	99.9	78.0	4.31	48.0	30.0	18.1	11.77
0.470	0.724	447.8	91.80	21.8	8.72	6.97	60.2	100.2	78.4	4.31	48.3	30.1	18.2	12.83
0.510	0.764	452.4	92.06	22.1	9.46	7.03	60.3	100.3	78.3	4.36	48.1	30.2	17.9	13.54
0.540	0.794	455.5	91.92	21.9	10.02	7.07	60.4	100.4	78.5	4.34	48.3	30.2	18.1	14.07
0.570	0.824	457.5	91.76	21.8	10.58	7.12	60.3	100.3	78.6	4.31	48.4	30.2	18.2	14.60
0.600	0.854	460.9	91.60	21.6	11.13	7.16	60.4	100.4	78.8	4.28	48.6	30.2	18.4	15.13
Values @ Failure				22.1	9.46	7.03	60.3	100.3	78.3	**4.36**	48.1	30.2	17.9	13.54

Failure criteria used*: 3

*Note: "1" = Max Deviator Stress; "2" = Deviator Stress @ 15% Strain; "3" = Max Eff.Stress Ratio(s'_1/s'_3)

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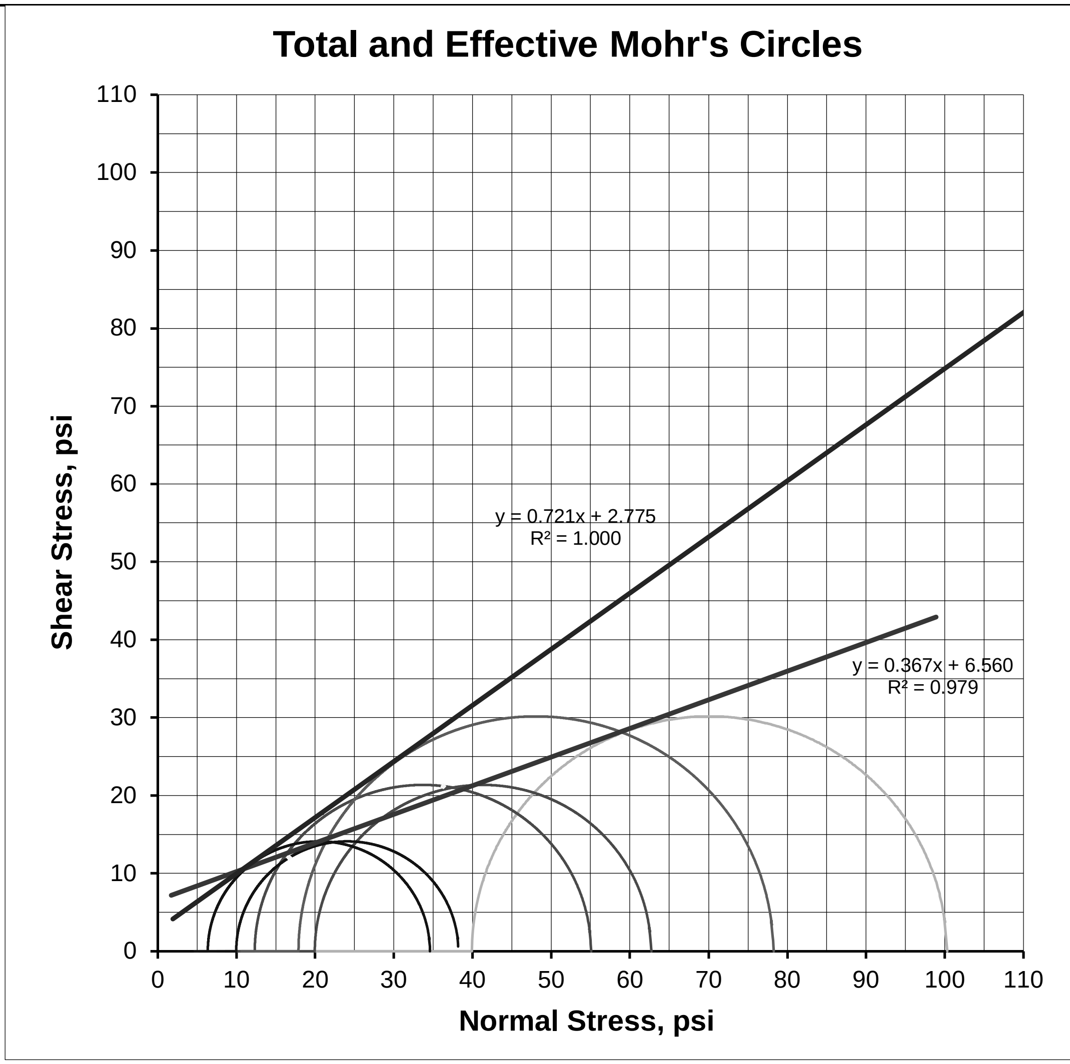
ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Additional Info	-



	ST. 1	ST. 2	ST. 3
Effective Consolidation Stress, psi	10.0	20.0	40.0
Deviator Stress at Failure, psi	28.2	42.7	60.3
Effective Minor Principal Stress at Failure, psi	6.4	12.4	17.9
Effective Major Principal Stress at Failure, psi	34.6	55.1	78.3
Axial Strain at Failure, %	2.66	3.08	9.46

STRENGTH PARAMETERS*			
Total		Effective	
f °	20.2	f ' °	35.8
C, psi	6.6	C', psi	2.8

***Valid only for Received Material at Reported Densities and Moisture Contents. Please see remarks on page 6 of this report**

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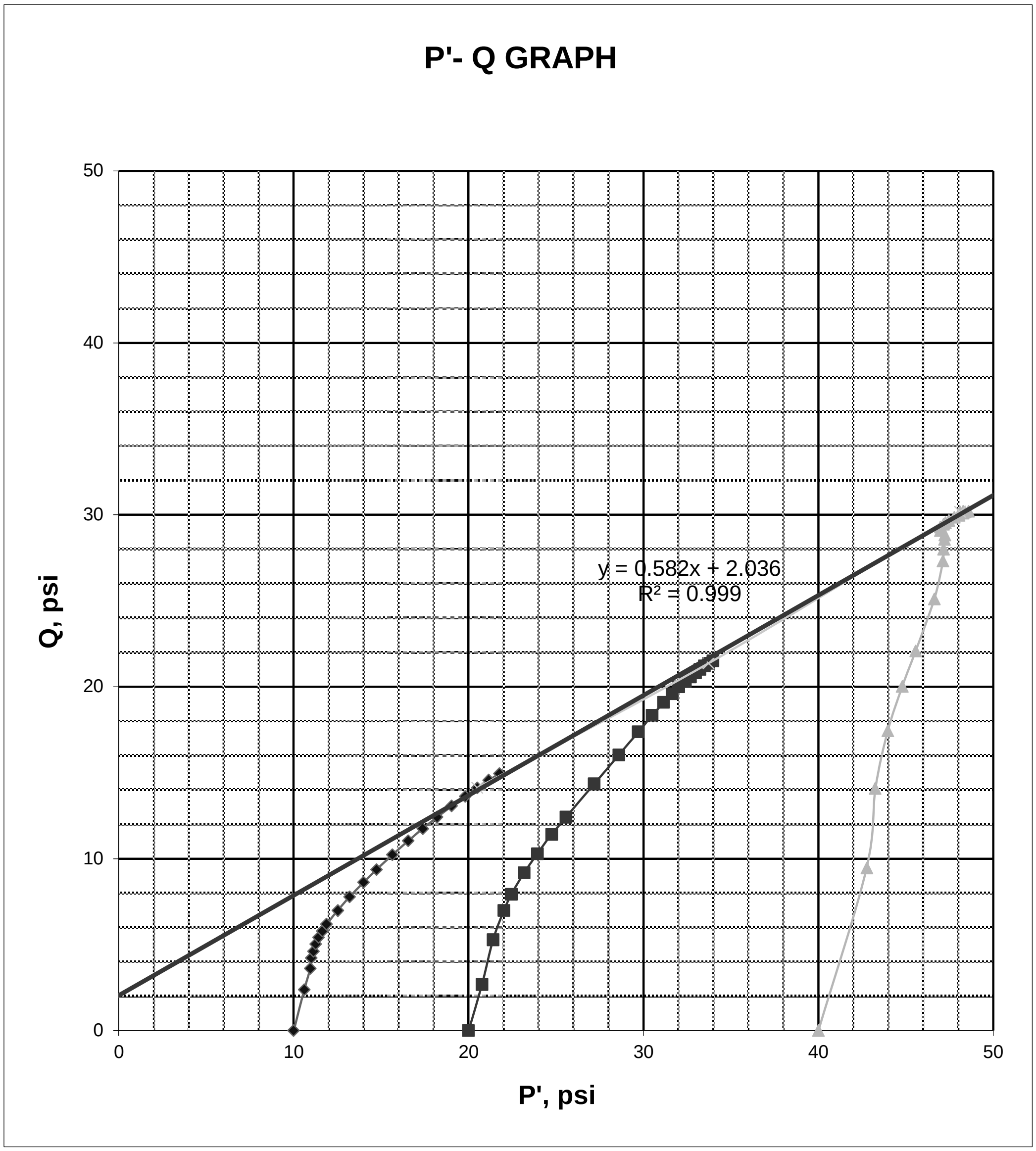
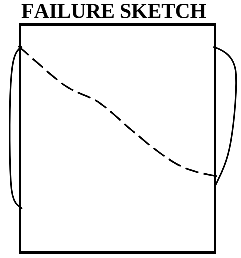
ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Additional Info	-



FAILURE SKETCH



a, psi	2.0
a, degree	30.2

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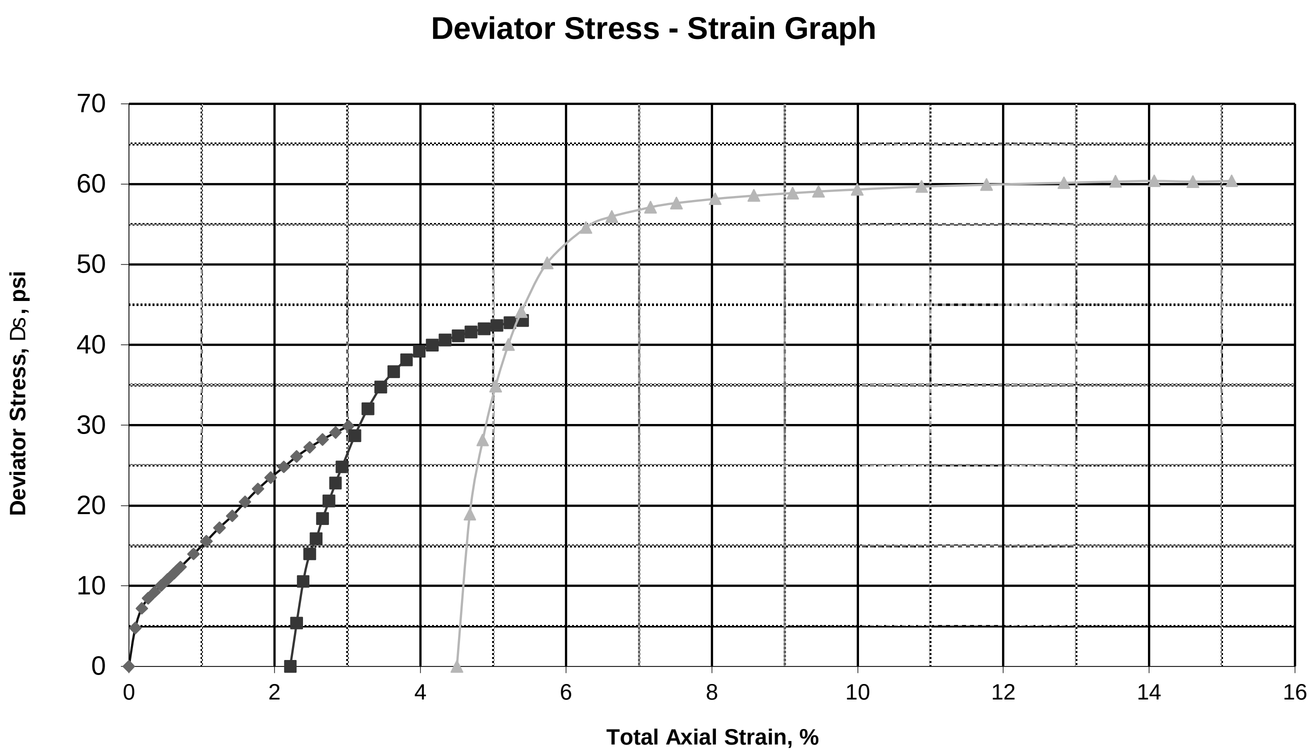
ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Additional Info	-



		REMARKS	DESCRIPTION
Balance ID Number	563/700	Material from shelby tube was not homogeneous and/or not long enough to select 3 uniform specimens 6" long each. Most representative portion of sample (4" above the bottom of shelby tube) was selected for multi-stage triaxial testing (per ASTM STP 883).	Olive Gray Silty Sand
Oven ID Number	496/610		
Deformation Indicator ID #	178/349/689		
Digital Caliper ID #	370/458		
Load Cell ID #	11/347/692		
Apparatus ID #	10/293/693		

NOTES:

				USCS (ASTM D2487: D2488)
1. Method for Saturation	WET	LL	-	SM
2. Method for determination of cross-sectional area after consol.	B	PL	-	
3. Final moisture content (Stage 3) obtained from entire sample		PI	-	
		Gs	-	

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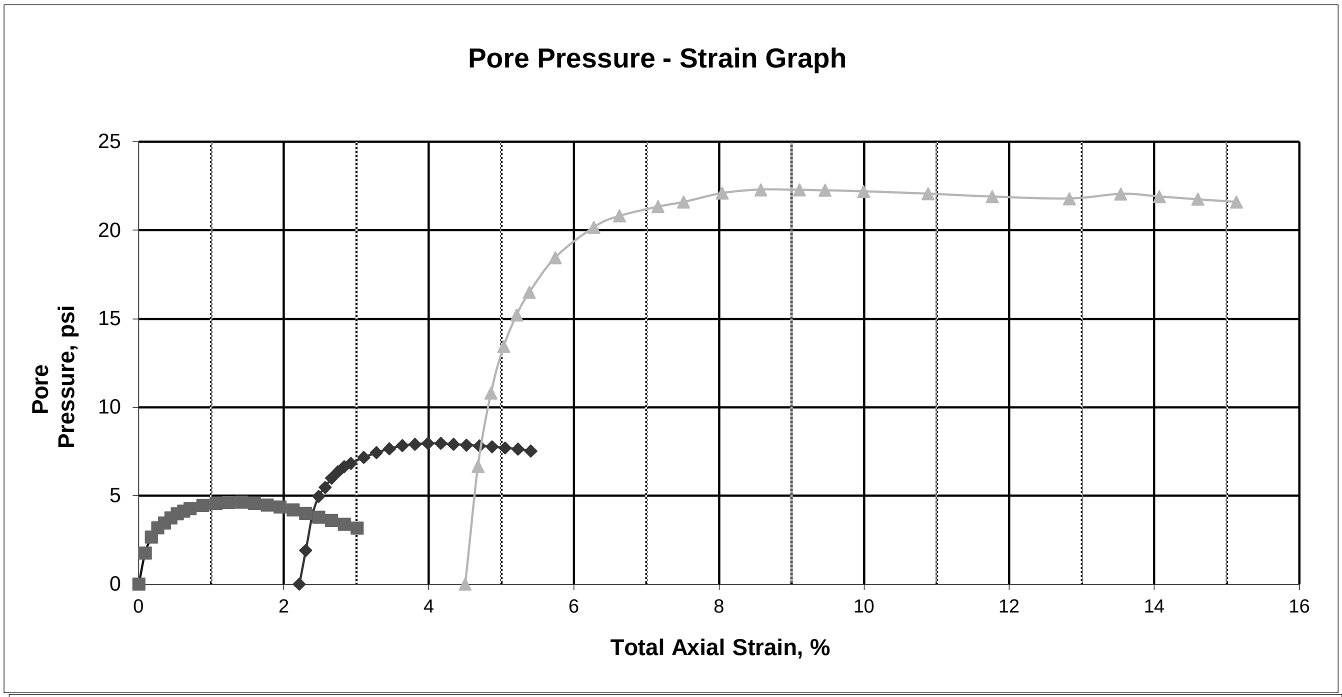
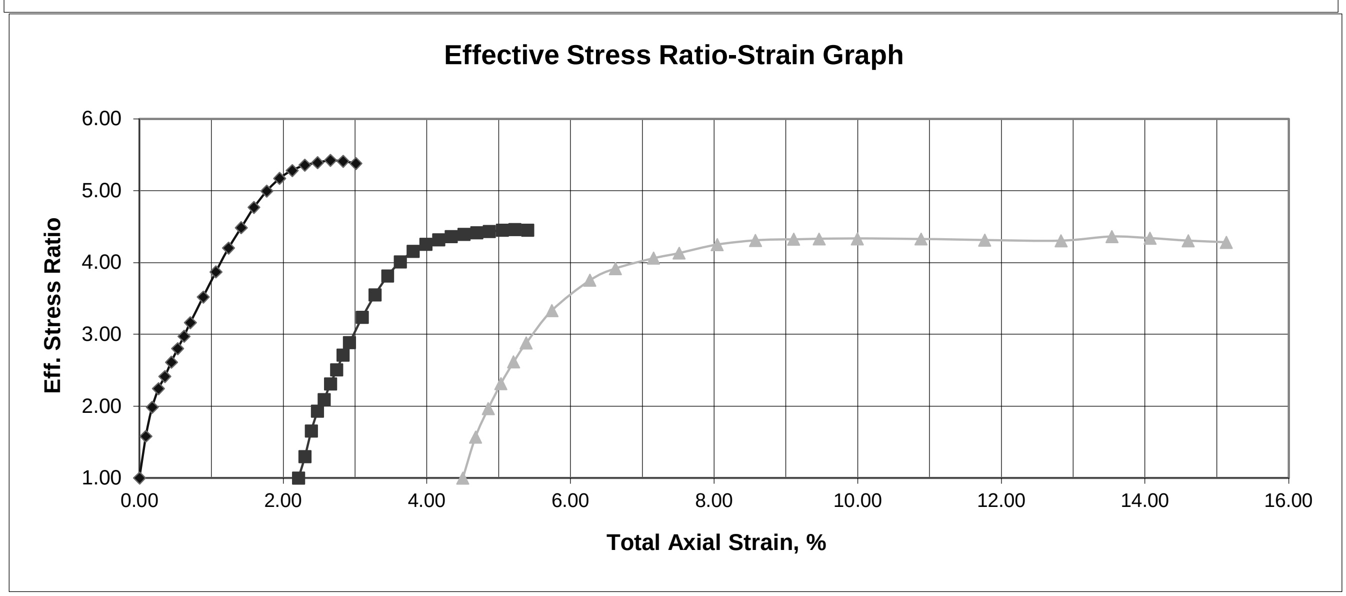
ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Additional Info	-





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Date	04/02/20
Checked By	[signature]

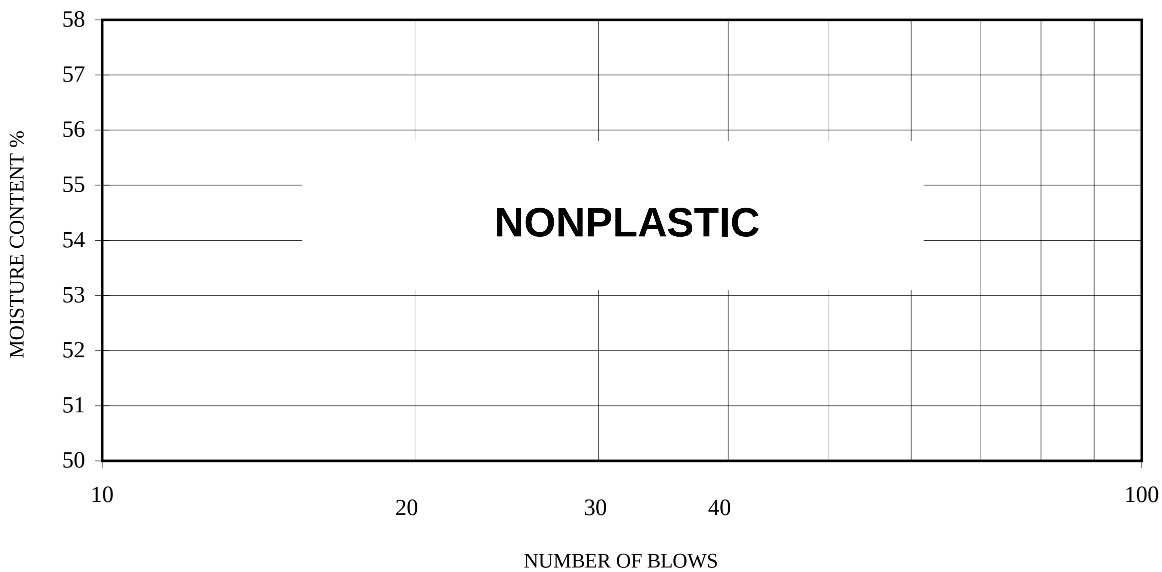
Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Pr. Name	AMA	S. Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

ASTM D 4318
Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils (Atterberg Limits)

Liquid Limit Device ID # 56

NOTES: 1. Material appears to be Nonplastic. (Liquid Limit or Plastic Limit test could not be performed.)
2. Material passing No. 40 sieve was used for test.

LIQUID LIMIT		
Number of Blows	8	8
Weight of Wet Sample & Tare, g	39.33	35.43
Weight of Dry Soil & Tare, g	35.08	31.92
Weight of Tare, g	25.29	23.78
Moisture Content, %	43.41	43.12



PLASTIC LIMIT		
Weight of Wet Soil & Tare, g	37.89	37.43
Weight of Dry Soil & Tare, g	34.01	33.82
Weight of Tare, g	25.07	25.46
Moisture Content, %	43.40	43.18

Oven ID Number	15/496/610
Balance ID Number	139/563

NATURAL MOISTURE	
Weight of Wet Soil & Tare, g	429.50
Weight of Dry Soil & Tare, g	369.60
Weight of Tare, g	126.50
Moisture Content, %	24.64

LIQUID LIMIT (LL)	NP
PLASTIC LIMIT (PL)	NP
PLASTICITY INDEX (PI)	NP
LIQUIDITY INDEX (LI)	-

DESCRIPTION: Olive Gray Silty Sand

USCS (ASTM D2487;2488): SM

AASHTO (M 145): NA

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Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Pr. Name	AMA	S. Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

ASTM D 422/AASHTO T 88
Standard Test Method for Particle-Size Analysis of Soils (with Hydrometer Analysis)

As-Received Moisture Content

Mass of Wet Sample & Tare, g	429.50
Mass of Dry Sample & Tare, g	369.60
Mass of Tare, g	126.50
Moisture Content, %	24.6

Moisture Content of Material Used for Hydrometer Analysis

Mass of Wet Sample & Tare, g	429.50
Mass of Dry Sample & Tare, g	369.60
Mass of Tare, g	126.50
Moisture Content, %	24.6

Mass of Total Sample before separation on #4 sieve & Tare, g	792.50
Mass of Tare, g	0.00
Total Mass of Dry Sample, g	635.83

Mass of Sample used for hydrometer analysis, g	90.20
Dry Mass, g	72.37
% of Total Sample passing #4 sieve	100.0

SIEVE ANALYSIS

PORTION OF SAMPLE RETAINED ON #4 SIEVE

Mass of Tare, g: 0.00

Sieve Size		Sample & Tare, g	% RETAINED	%PASSING
12"	COBBLES		0.0	100.0
3"	COARSE GRAVEL		0.0	100.0
2.5"			0.0	100.0
2"			0.0	100.0
1.5"			0.0	100.0
1"			0.0	100.0
.75"	FINE GRAVEL		0.0	100.0
.5"			0.0	100.0
.375"			0.0	100.0
#4	COARSE SAND	0.00	0.0	100.0

PORTION OF SAMPLE PASSING #4 SIEVE (Hydrometer Backsieve)

Sieve Size		Cumulative Mass retained, g	% PASSING
#10	MEDIUM SAND	0.76	98.9
#20		9.00	87.6
#40	FINE SAND	25.93	64.2
#60		38.66	46.6
#100		48.04	33.6
#200	FINES	55.43	23.4

Remarks

HYDROMETER ANALYSIS

Length of Dispersion Period	1 Minute
Mechanical Dispersion Device ID #	61
Amount of Dispersing Agent (ml)	125.0
Specific Gravity (assumed)	2.700
Specific Gravity (tested)	
Starting time	13:47

PARTICLE-SIZE ANALYSIS

% COBBLES	0.0	% MEDIUM SAND	34.8
% COARSE GRAVEL	0.0	% FINE SAND	40.8
% FINE GRAVEL	0.0	% FINES	23.4
% COARSE SAND	1.1	% TOTAL SAMPLE	100.0
% CLAY(<0.005mm)	4.9	% CLAY(<0.002mm)	4.1

Date	Time	Testing time (min)	Reading	Temp (°C)	K	Composite Correction	Actual Reading	Effective Depth (cm)	a	Particle Diam. (mm)	Percent Passing
04/01/20	13:49	2	18.0	16.1	0.01414	6.5	11.5	14.5	0.99	0.0380	15.7
04/01/20	13:52	5	16.5	16.1	0.01414	6.5	10.0	14.7	0.99	0.0243	13.7
04/01/20	14:02	15	13.5	16.1	0.01414	6.5	7.0	15.2	0.99	0.0142	9.6
04/01/20	14:17	30	12.0	16.1	0.01414	6.5	5.5	15.5	0.99	0.0102	7.5
04/01/20	14:47	60	11.0	16.1	0.01414	6.5	4.5	15.6	0.99	0.0072	6.2
04/01/20	17:57	250	9.5	16.1	0.01414	6.5	3.0	15.9	0.99	0.0036	4.1
04/02/20	13:47	1440	9.5	16.1	0.01414	6.5	3.0	15.9	0.99	0.0015	4.1

Hydrometer 152H ID #	305527	Oven ID #	15/496/610
Sieve Shaker ID #	555	Balance ID#	139/142/700

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Date	03/31/20
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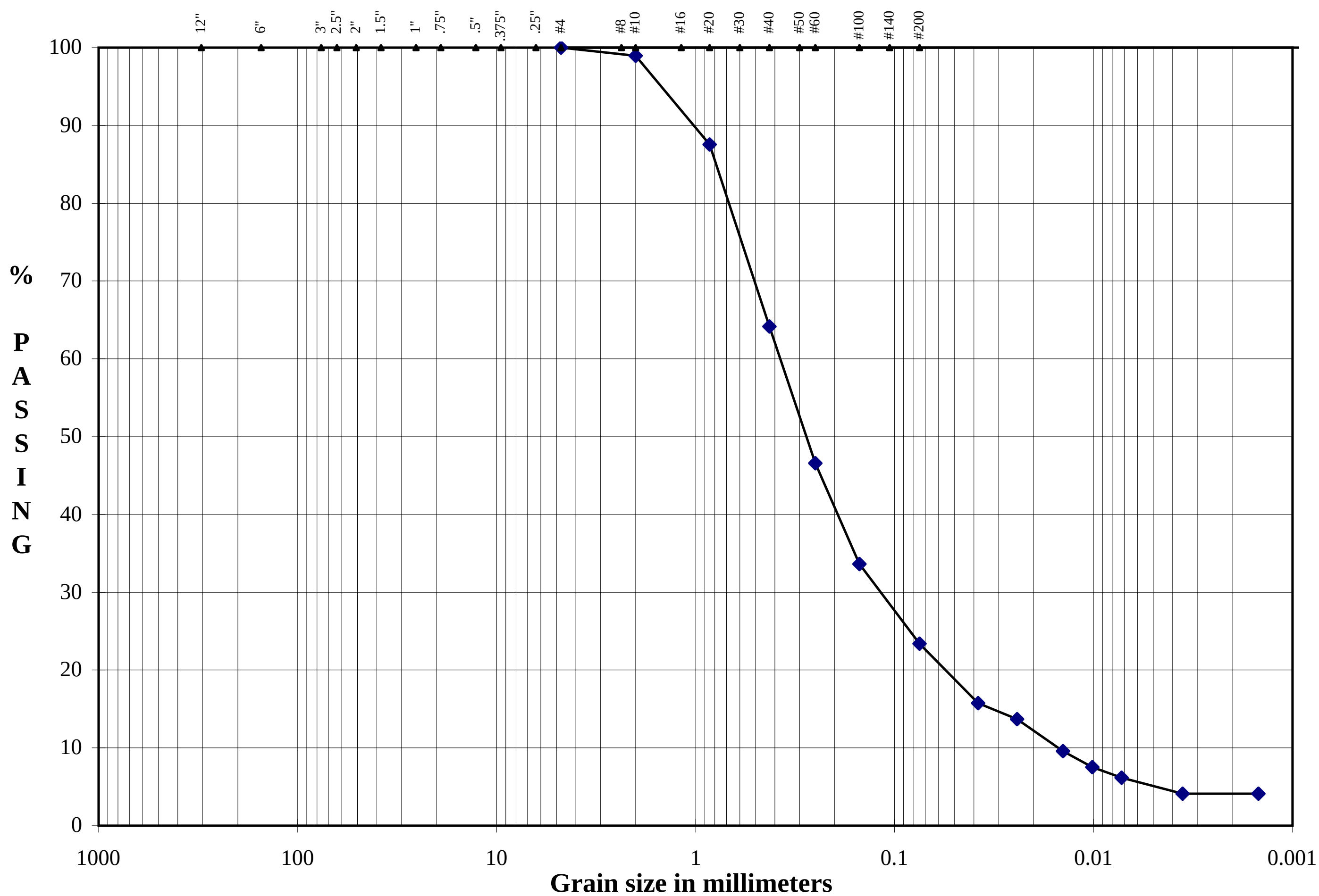
Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Pr. Name	AMA	S. Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

ASTM D 422/AASHTO T 88
Standard Test Method for Particle-Size Analysis of Soils (with Hydrometer Analysis)

Particle-Size Analysis



Boulders	Cobbles	Gravel: Coarse	Gravel: Fine	Sand: Coarse	Sand: Medium	Sand: Fine	Fines: Silt or Clay

DESCRIPTION: Olive Gray Silty Sand

USCS (ASTM D2487; D2488): SM

D_{10}	NA	mm
D_{30}	NA	mm
D_{60}	NA	mm
Cu	NA	
Cc	NA	
Project's Specific % Passing	NA	
Project's Specific Particle Size, mm	NA	

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ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33613/YGWA-181-28-30	Depth/Elev.	-
Location	-	Additional Info	-

SPECIMEN PROPERTIES

	(initial)	(after consol.)
Height, in	5.675	5.650
Diameter, in	2.847	2.793
Height-to-Diameter Ratio	2.0	2.0
Area, in^2	6.37	6.13
Volume, cm^3	592.01	567.18
Mass of Wet Sample, g	1189.30	1171.40
Mass of Dry Sample, g	959.65	959.65
Wet Density, pcf	125.4	128.9
Dry Density, pcf	101.2	105.6
Specific Gravity (assumed)	2.700	2.700
Volume of Solids, cm^3	355.43	355.43
Volume of Voids, cm^3	236.59	211.75
Void Ratio	0.67	0.60
% Saturation	97.1	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	477.10	1171.40
Mass of Dry Sample and Tare, g	418.90	959.65
Mass of Tare, g	175.70	0.00
Moisture, %	23.93	22.07

TEST DATA PRIOR TO LOADING

Volume change (Consolidation), ml	-17.9
Machine Speed, in / min	0.0100
Strain Rate, % / min	0.18
Chamber Pressure, psi	80.0
Back Pressure, psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	10.0
Change in Height, in	0.025
"B" Value	0.95

SHEAR DATA

Elapsed Time (min)	Deformation Stage 1 (inch)	Axial Load (lb)	Pore-Water Pressure, psi Total, U	Pore-Water Pressure, psi Change, DU	Total Strain Stage 1 (%)	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$) (psi)	Major Principal Stress, psi Total s_1	Major Principal Stress, psi Eff. s'_1	Eff.Stress Ratio s'_1/s'_3	P' $(s'_1+s'_3)/2$ (psi)	Q $(s_1-s_3)/2$ (psi)	Eff. Minor Pr. Stress s'_3 (psi)
0.0	0.000	17.8	70.00	0.0	0.00	6.13	0.0	10.0	10.0	1.00	10.0	0.0	10.0
0.5	0.005	43.7	72.34	2.3	0.09	6.13	4.2	14.2	11.9	1.55	9.8	2.1	7.7
1.0	0.010	54.1	73.42	3.4	0.18	6.14	5.9	15.9	12.5	1.90	9.5	3.0	6.6
1.5	0.015	62.1	74.22	4.2	0.27	6.14	7.2	17.2	13.0	2.25	9.4	3.6	5.8
2.0	0.020	67.4	74.76	4.8	0.35	6.15	8.1	18.1	13.3	2.54	9.3	4.0	5.2
2.5	0.025	73.1	75.10	5.1	0.44	6.15	9.0	19.0	13.9	2.83	9.4	4.5	4.9
3.0	0.030	77.1	75.34	5.3	0.53	6.16	9.6	19.6	14.3	3.07	9.5	4.8	4.7
3.5	0.035	81.3	75.57	5.6	0.62	6.16	10.3	20.3	14.7	3.33	9.6	5.2	4.4
4.0	0.040	84.7	75.71	5.7	0.71	6.17	10.8	20.8	15.1	3.53	9.7	5.4	4.3
5.0	0.050	90.9	75.89	5.9	0.88	6.18	11.8	21.8	15.9	3.88	10.0	5.9	4.1
6.0	0.060	97.0	75.99	6.0	1.06	6.19	12.8	22.8	16.8	4.19	10.4	6.4	4.0
7.0	0.070	102.0	76.04	6.0	1.24	6.20	13.6	23.6	17.5	4.43	10.7	6.8	4.0
8.0	0.080	107.1	76.02	6.0	1.42	6.21	14.4	24.4	18.4	4.61	11.2	7.2	4.0
9.0	0.090	111.8	75.98	6.0	1.59	6.23	15.1	25.1	19.1	4.76	11.6	7.6	4.0
10.0	0.100	116.6	75.91	5.9	1.77	6.24	15.8	25.8	19.9	4.87	12.0	7.9	4.1
11.0	0.110	120.9	75.84	5.8	1.95	6.25	16.5	26.5	20.7	4.97	12.4	8.3	4.2
12.0	0.120	125.5	75.76	5.8	2.12	6.26	17.2	27.2	21.4	5.06	12.8	8.6	4.2
13.0	0.130	129.6	75.66	5.7	2.30	6.27	17.8	27.8	22.2	5.11	13.3	8.9	4.3
21.0	0.210	164.8	74.74	4.7	3.72	6.36	23.1	33.1	28.4	5.39	16.8	11.6	5.3
27.0	0.270	191.7	73.95	4.0	4.78	6.43	27.0	37.0	33.1	5.47	19.6	13.5	6.1
28.0	0.280	196.3	73.81	3.8	4.96	6.45	27.7	37.7	33.9	5.47	20.0	13.8	6.2
29.0	0.290	201.3	73.62	3.6	5.13	6.46	28.4	38.4	34.8	5.45	20.6	14.2	6.4
Values @ Failure				3.8	4.96	6.45	27.7	37.7	33.9	**5.47**	20.0	13.8	6.2

Failure criteria used*: 3

*Note: "1" = Max Deviator Stress; "2" = Deviator Stress @ 15% Strain; "3" = Max Eff.Stress Ratio(s'_1/s'_3)

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Date	04/02/20
Checked By	

ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33613/YGWA-181-28-30	Depth/Elev.	-
Location	-	Additional Info	-

SPECIMEN PROPERTIES

		(initial)	(after consol.)
Height, in		5.360	5.413
Diameter, in		2.867	2.841
Height-to-Diameter Ratio		1.9	1.9
Area, in^2		6.46	6.34
Volume, cm^3		567.18	562.18
Mass of Wet Sample, g		1171.40	1166.40
Mass of Dry Sample, g		959.65	959.65
Wet Density, pcf		128.9	129.5
Dry Density, pcf		105.6	106.6
Specific Gravity	(assumed)	2.700	2.700
Volume of Solids, cm^3		355.43	355.43
Volume of Voids, cm^3		211.75	206.75
Void Ratio		0.60	0.58
% Saturation		100.0	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	1171.40	1166.40
Mass of Dry Sample and Tare, g	959.65	959.65
Mass of Tare, g	0.00	0.00
Moisture, %	22.07	21.54

TEST DATA PRIOR TO LOADING

Volume change (Consolidation), ml	-5.0
Machine Speed, in / min	0.0100
Strain Rate, % / min	0.18
Chamber Pressure, psi	90.0
Back Pressure, psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	20.0
Change in Height, in	-0.053
"B" Value	0.95

SHEAR DATA

Deformation Stage 2 (inch)	Total Deformation ST.1 + ST.2 (inch)	Axial Load (lb)	Pore-Water Pressure, psi		Strain Stage 2 %	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$)	Major Principal Stress, psi		Effective Stress Ratio	P' $(s'_1+s'_3)/2$ (psi)	Q $(s_1-s_3)/2$ (psi)	Eff. Minor Pr. Stress	Total Strain ST.1 + ST.2 %
			Total, U	Change,DU			(psi)	Total s_1	Eff. s'_1	s'_1/s'_3			s'_3 (psi)	
0.000	0.237	24.6	70.00	0.0	0.00	6.34	0.0	20.0	20.0	1.00	20.0	0.0	20.0	4.19
0.005	0.242	79.9	73.94	3.9	0.09	6.34	8.7	28.7	24.8	1.54	20.4	4.4	16.1	4.28
0.010	0.247	105.0	75.62	5.6	0.18	6.35	12.7	32.7	27.0	1.88	20.7	6.3	14.4	4.37
0.015	0.252	123.2	76.62	6.6	0.28	6.36	15.5	35.5	28.9	2.16	21.1	7.8	13.4	4.46
0.020	0.257	140.6	77.32	7.3	0.37	6.36	18.2	38.2	30.9	2.44	21.8	9.1	12.7	4.55
0.025	0.262	151.0	77.65	7.7	0.46	6.37	19.9	39.9	32.2	2.61	22.3	9.9	12.4	4.64
0.030	0.267	163.3	77.95	8.0	0.55	6.37	21.8	41.8	33.8	2.81	22.9	10.9	12.1	4.73
0.035	0.272	175.0	78.17	8.2	0.65	6.38	23.6	43.6	35.4	2.99	23.6	11.8	11.8	4.81
0.040	0.277	186.4	78.38	8.4	0.74	6.38	25.3	45.3	37.0	3.18	24.3	12.7	11.6	4.90
0.050	0.287	207.5	78.66	8.7	0.92	6.40	28.6	48.6	39.9	3.52	25.6	14.3	11.3	5.08
0.060	0.297	225.6	78.94	8.9	1.11	6.41	31.4	51.4	42.4	3.84	26.7	15.7	11.1	5.26
0.070	0.307	241.6	79.15	9.2	1.29	6.42	33.8	53.8	44.6	4.11	27.7	16.9	10.9	5.43
0.080	0.317	254.4	79.34	9.3	1.48	6.43	35.7	55.7	46.4	4.35	28.5	17.9	10.7	5.61
0.090	0.327	264.8	79.51	9.5	1.66	6.44	37.3	57.3	47.8	4.55	29.1	18.6	10.5	5.79
0.100	0.337	274.3	79.65	9.7	1.85	6.46	38.7	58.7	49.0	4.74	29.7	19.3	10.4	5.96
0.110	0.347	282.8	79.74	9.7	2.03	6.47	39.9	59.9	50.2	4.89	30.2	20.0	10.3	6.14
0.120	0.357	290.9	79.79	9.8	2.22	6.48	41.1	61.1	51.3	5.02	30.8	20.5	10.2	6.32
0.130	0.367	297.1	79.82	9.8	2.40	6.49	42.0	62.0	52.1	5.12	31.2	21.0	10.2	6.50
0.220	0.457	351.1	78.77	8.8	4.06	6.61	49.4	69.4	60.7	5.40	35.9	24.7	11.2	8.09
0.260	0.497	379.8	78.18	8.2	4.80	6.66	53.4	73.4	65.2	5.51	38.5	26.7	11.8	8.80
0.270	0.507	386.5	78.00	8.0	4.99	6.67	54.3	74.3	66.3	5.52	39.1	27.1	12.0	8.97
0.280	0.517	393.5	77.80	7.8	5.17	6.68	55.2	75.2	67.4	5.52	39.8	27.6	12.2	9.15
0.290	0.527	399.7	77.58	7.6	5.36	6.70	56.0	76.0	68.4	5.51	40.4	28.0	12.4	9.33
Values @ Failure				7.8	5.17	6.68	55.2	75.2	67.4	**5.52**	39.8	27.6	12.2	9.15
Failure criteria used*			3											

*Note: "1" = Max Deviator Stress; "2" = Deviator Stress @ 15% Strain; "3" = Max Eff.Stress Ratio(s'_1/s'_3)

TIMELY **E**NGINEERING **S**OIL **T**ESTS, LLC	1874 Forge Street Tucker, GA 30084 Phone: 770-938-8233 Fax: 770-923-8973 Web: www.test-llc.com	Tested By: EB/KP Date: 04/03/20 Checked By:

ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33613/YGWA-181-28-30	Depth/Elev.	-
Location	-	Additional Info	-

SPECIMEN PROPERTIES

	(initial)	(after consol.)
Height, in	5.123	5.183
Diameter, in	2.920	2.893
Height-to-Diameter Ratio	1.8	1.8
Area, in^2	6.70	6.57
Volume, cm^3	562.18	558.20
Mass of Wet Sample, g	1166.40	1159.30
Mass of Dry Sample, g	959.65	954.68
Wet Density, pcf	129.5	129.7
Dry Density, pcf	106.6	106.8
Specific Gravity (assumed)	2.700	2.700
Volume of Solids, cm^3	355.43	353.59
Volume of Voids, cm^3	206.75	204.62
Void Ratio	0.58	0.58
% Saturation	100.0	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	1166.40	1457.60
Mass of Dry Sample and Tare, g	959.65	1253.00
Mass of Tare, g	0.00	298.40
Moisture, %	21.54	21.43

TEST DATA PRIOR TO LOADING

Volume change (Consolidation), ml	-7.1
Machine Speed, in / min	0.01000
Strain Rate, % / min	0.19
Chamber Pressure, psi	110.0
Back Pressure, psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	40.0
Change in Height, in	-0.060
"B" Value	0.95

SHEAR DATA

Deformation Stage 3 (inch)	Total Deformation ST.1 + ST.2 + ST.3 (inch)	Axial Load (lb)	Pore-Water Pressure, psi		Strain Stage 3 %	Corrected Area (in^2)	Deviator Stress $(Ds=s_1-s_3)$	Major Principal Stress, psi		Effective Stress Ratio	P' $(s'_1+s'_3)/2$ (psi)	Q $(s_1-s_3)/2$ (psi)	Eff. Minor Pr. Stress	Total Strain ST.1 + ST.2 + ST.3, %
			Total, U	Change,DU			(psi)	Total s_1	Eff. s'_1	s'_1/s'_3			s'_3 (psi)	
0.000	0.467	20.9	70.00	0.0	0.00	6.57	0.0	40.0	40.0	1.00	40.0	0.0	40.0	8.27
0.010	0.477	178.0	80.75	10.7	0.20	6.59	23.9	63.9	53.1	1.82	41.2	11.9	29.3	8.45
0.020	0.487	243.9	84.31	14.3	0.39	6.60	33.8	73.8	59.5	2.32	42.6	16.9	25.7	8.63
0.031	0.498	292.8	85.91	15.9	0.59	6.61	41.1	81.1	65.2	2.71	44.7	20.6	24.1	8.81
0.041	0.508	336.8	86.81	16.8	0.79	6.62	47.7	87.7	70.9	3.06	47.0	23.8	23.2	8.99
0.051	0.518	376.5	87.44	17.4	0.98	6.64	53.6	93.6	76.1	3.37	49.3	26.8	22.6	9.17
0.071	0.538	442.6	88.45	18.4	1.38	6.66	63.3	103.3	84.8	3.94	53.2	31.6	21.6	9.53
0.092	0.559	488.9	89.21	19.2	1.77	6.69	69.9	109.9	90.7	4.37	55.8	35.0	20.8	9.89
0.112	0.579	520.2	89.78	19.8	2.16	6.72	74.3	114.3	94.5	4.68	57.4	37.2	20.2	10.25
0.132	0.599	545.3	90.04	20.0	2.56	6.74	77.8	117.8	97.7	4.90	58.8	38.9	20.0	10.61
0.153	0.620	567.6	90.10	20.1	2.95	6.77	80.7	120.7	100.6	5.06	60.3	40.4	19.9	10.97
0.173	0.640	588.0	89.80	19.8	3.34	6.80	83.4	123.4	103.6	5.13	61.9	41.7	20.2	11.33
0.194	0.661	607.8	89.48	19.5	3.74	6.83	86.0	126.0	106.5	5.19	63.5	43.0	20.5	11.69
0.214	0.681	627.3	89.11	19.1	4.13	6.86	88.5	128.5	109.3	5.24	65.1	44.2	20.9	12.05
0.234	0.701	647.1	88.71	18.7	4.52	6.88	91.0	131.0	112.3	5.27	66.8	45.5	21.3	12.41
0.255	0.722	667.1	88.27	18.3	4.92	6.91	93.5	133.5	115.2	5.30	68.5	46.7	21.7	12.77
0.275	0.742	688.4	87.78	17.8	5.31	6.94	96.2	136.2	118.4	5.33	70.3	48.1	22.2	13.14
0.296	0.763	709.5	87.26	17.3	5.70	6.97	98.8	138.8	121.5	5.34	72.1	49.4	22.7	13.50
0.316	0.783	731.8	86.75	16.8	6.10	7.00	101.6	141.6	124.8	5.37	74.0	50.8	23.2	13.86
0.336	0.803	754.5	86.19	16.2	6.49	7.03	104.4	144.4	128.2	5.38	76.0	52.2	23.8	14.22
0.357	0.824	776.6	85.58	15.6	6.88	7.06	107.1	147.1	131.5	5.39	78.0	53.5	24.4	14.58
0.377	0.844	799.9	84.96	15.0	7.28	7.09	109.9	149.9	134.9	5.39	80.0	55.0	25.0	14.94
0.390	0.857	815.4	84.54	14.5	7.53	7.11	111.8	151.8	137.3	5.39	81.4	55.9	25.5	15.17
Values @ Failure				14.5	7.53	7.11	111.8	151.8	137.3	**5.39**	81.4	55.9	25.5	0.00

Failure criteria used*: 3

*Note: "1" = Max Deviator Stress; "2" = Deviator Stress @ 15% Strain; "3" = Max Eff.Stress Ratio(s'_1/s'_3)

TIMELY ENGINEERING SOIL TESTS, LLC

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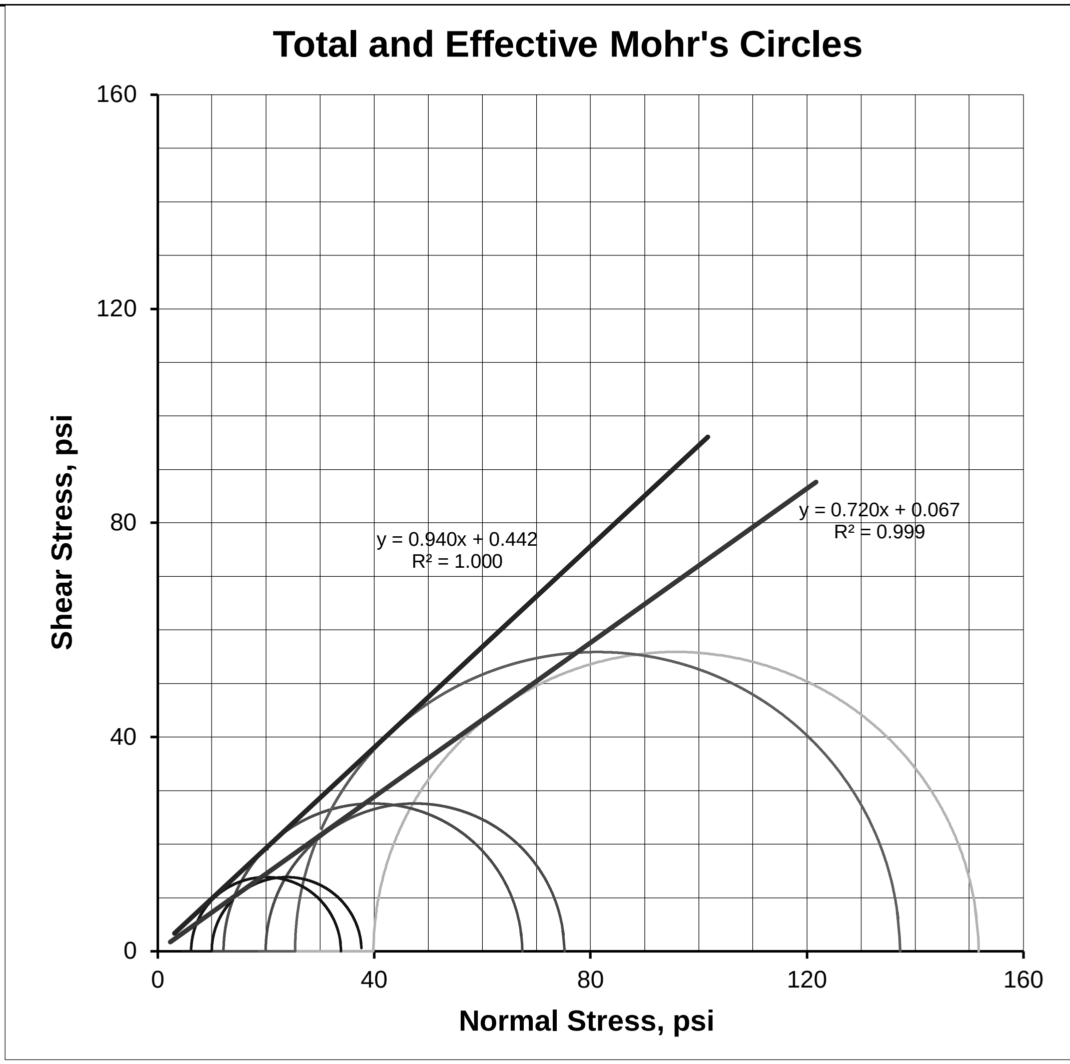
Tested By	EB/KP
Date	04/03/20
Check	

ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33613/YGWA-181-28-30	Depth/Elev.	-
Location	-	Additional Info	-



	ST. 1	ST. 2	ST. 3
Effective Consolidation Stress, psi	10.0	20.0	40.0
Deviator Stress at Failure, psi	27.7	55.2	111.8
Effective Minor Principal Stress at Failure, psi	6.2	12.2	25.5
Effective Major Principal Stress at Failure, psi	33.9	67.4	137.3
Axial Strain at Failure, %	4.96	5.17	7.53

STRENGTH PARAMETERS*			
Total		Effective	
f °	35.7	f ' °	43.2
C, psi	0.1	C', psi	0.4

***Valid only for Received Material at Reported Densities and Moisture Contents. Please see remarks on page 6 of this report**

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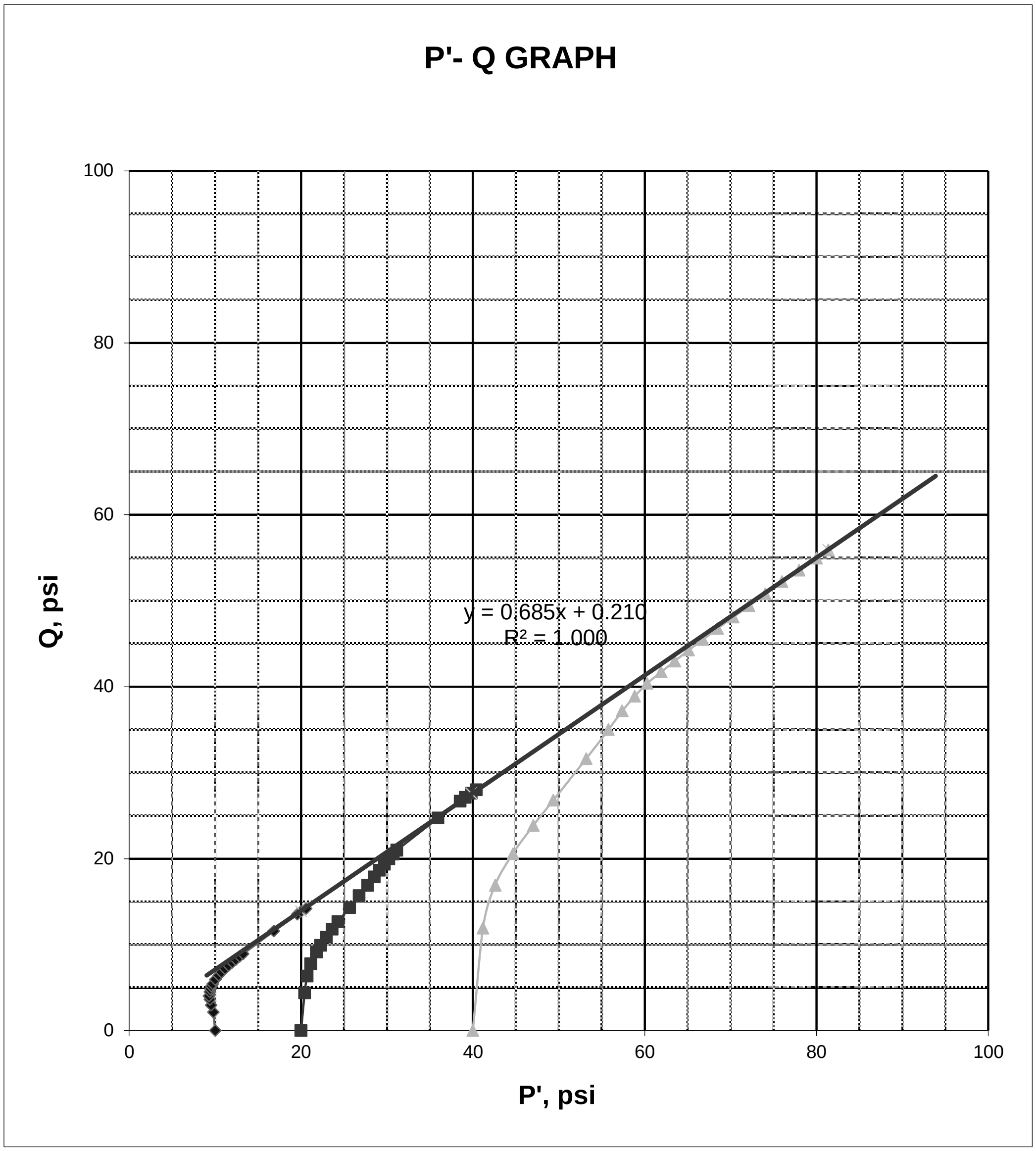
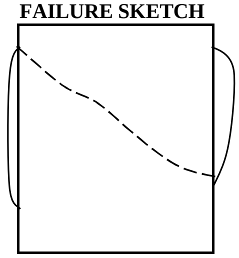
ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33613/YGWA-181-28-30	Depth/Elev.	-
Location	-	Additional Info	-



FAILURE SKETCH



a, psi	0.2
a, degree	34.4

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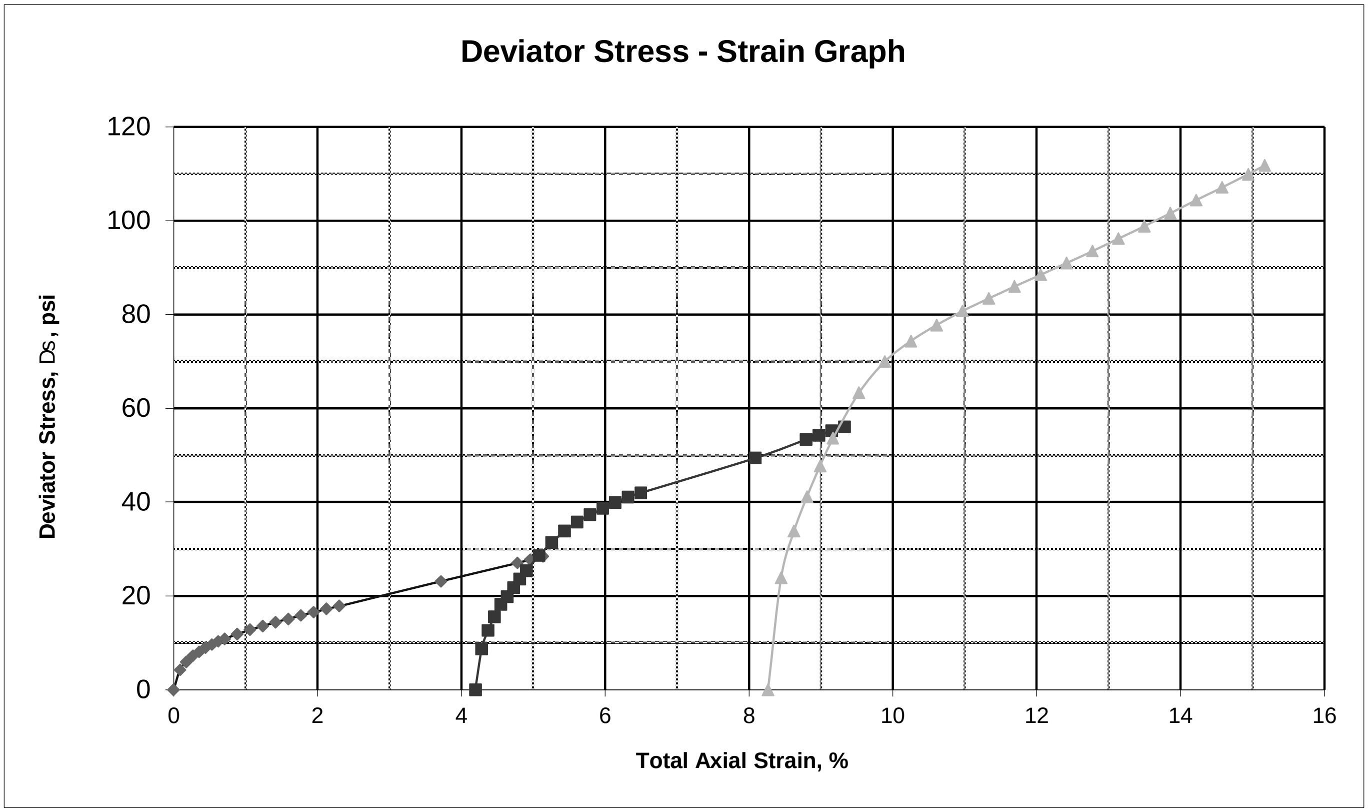
ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33613/YGWA-181-28-30	Depth/Elev.	-
Location	-	Additional Info	-



		REMARKS	DESCRIPTION
Balance ID Number	563/700	Material from shelby tube was not homogeneous and/or not long enough to select 3 uniform specimens 6" long each. Most representative portion of sample (13" above the bottom of shelby tube) was selected for multi-stage triaxial testing (per ASTM STP 883). Failure occurred along weak zone of partially weathered soft rock. Application of safety factors to results of this report is recommended due to not uniformity of material on site.	Olive Gray Silty Sand
Oven ID Number	496/610		
Deformation Indicator ID #	178/349/689		
Digital Caliper ID #	370/458		
Load Cell ID #	11/347/692		
Apparatus ID #	10/293/693		

NOTES:

1. Method for Saturation — WET
2. Method for determination of cross-sectional area after consol. — B
3. Final moisture content (Stage 3) obtained from entire sample

LL	-
PL	-
PI	-
Gs	-

USCS (ASTM D2487: D2488): SM

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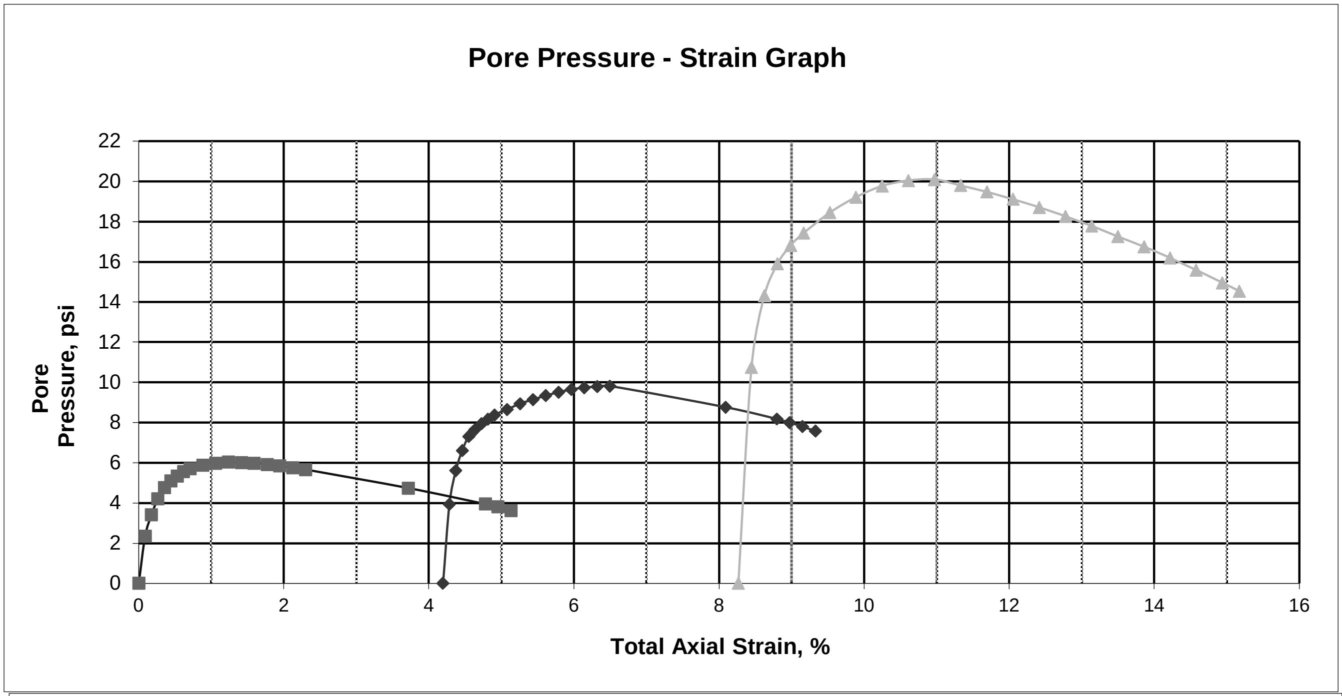
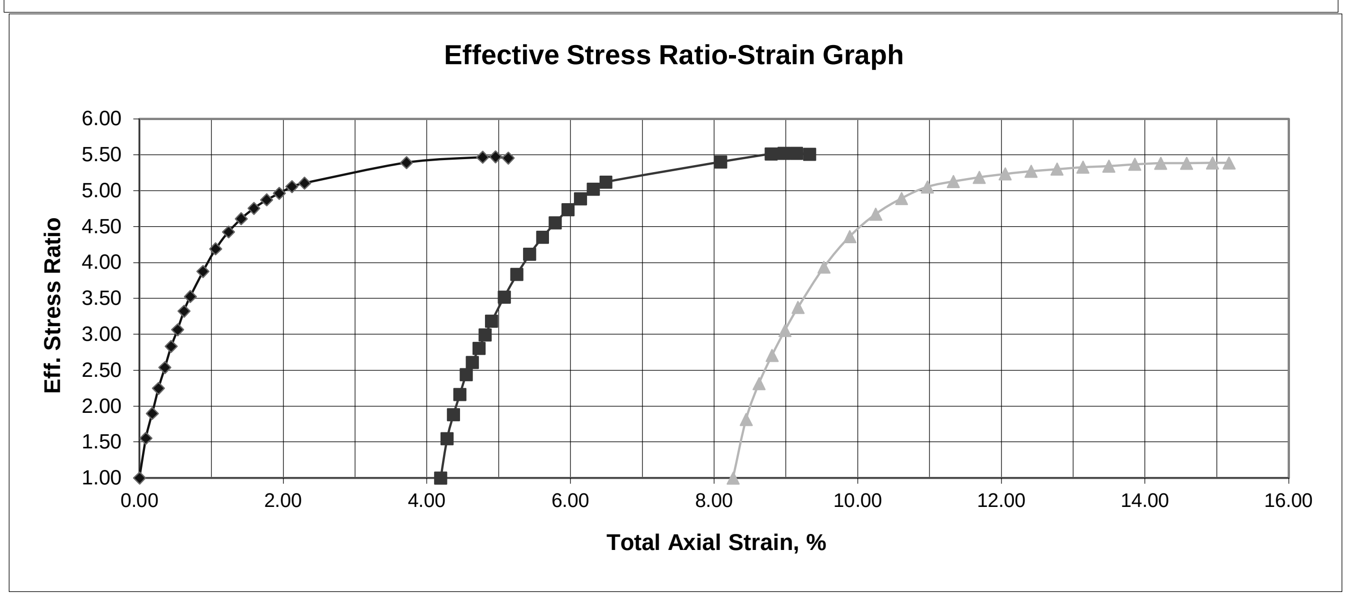
ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33613/YGWA-181-28-30	Depth/Elev.	-
Location	-	Additional Info	-





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Tested By	IH
Date	04/02/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Pr. Name	AMA	S. Type	UD
Sample ID	33613/YGWA-181-28-30	Depth/Elev.	-
Location	-	Add. Info	-

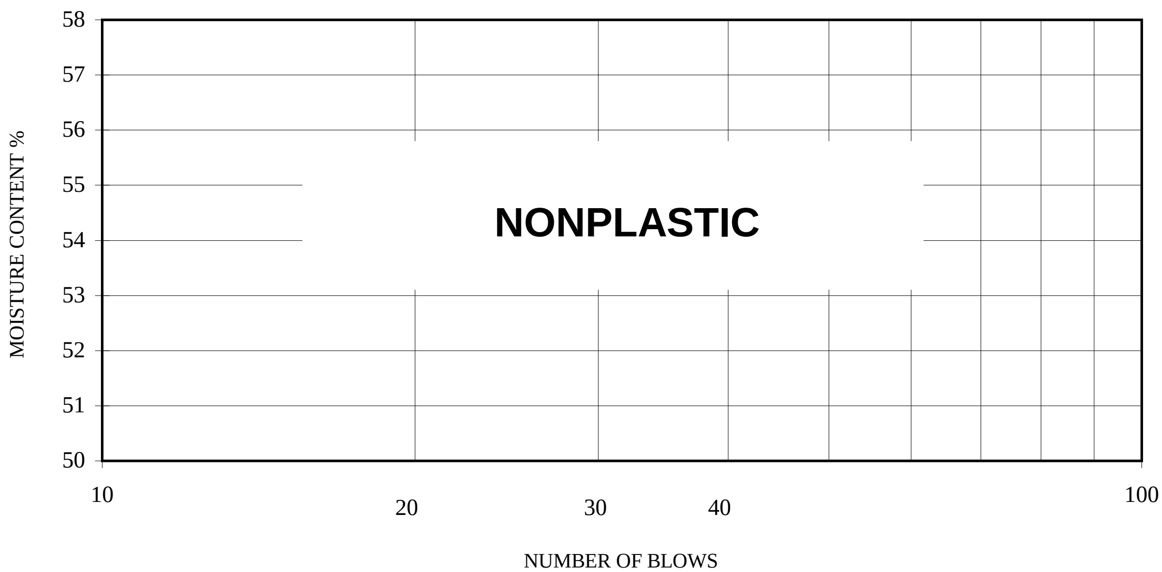
ASTM D 4318

Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils (Atterberg Limits)

Liquid Limit Device ID # 56

NOTES: 1. Material appears to be Nonplastic. (Liquid Limit or Plastic Limit test could not be performed.)
2. Material passing No. 40 sieve was used for test.

LIQUID LIMIT		
Number of Blows	10	10
Weight of Wet Sample & Tare, g	37.42	37.68
Weight of Dry Soil & Tare, g	33.87	34.19
Weight of Tare, g	23.95	24.33
Moisture Content, %	35.79	35.40



PLASTIC LIMIT		
Weight of Wet Soil & Tare, g	37.03	36.69
Weight of Dry Soil & Tare, g	33.82	33.72
Weight of Tare, g	24.80	25.34
Moisture Content, %	35.59	35.44

Oven ID Number	15/496/610
Balance ID Number	139/563

NATURAL MOISTURE	
Weight of Wet Soil & Tare, g	477.10
Weight of Dry Soil & Tare, g	418.90
Weight of Tare, g	175.70
Moisture Content, %	23.93

LIQUID LIMIT (LL)	NP
PLASTIC LIMIT (PL)	NP
PLASTICITY INDEX (PI)	NP
LIQUIDITY INDEX (LI)	-

DESCRIPTION: Olive Gray Silty Sand

USCS (ASTM D2487;2488): SM

AASHTO (M 145): NA

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Web: www.test-llc.com

Tested By	RI	Date	03/31/20
Checked By	[signature]		

Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Pr. Name	AMA	S. Type	UD
Sample ID	33613/YGWA-181-28-30	Depth/Elev.	-
Location	-	Add. Info	-

ASTM D 422/AASHTO T 88
Standard Test Method for Particle-Size Analysis of Soils (with Hydrometer Analysis)

As-Received Moisture Content

Mass of Wet Sample & Tare, g	477.10
Mass of Dry Sample & Tare, g	418.90
Mass of Tare, g	175.70
Moisture Content, %	23.9

Moisture Content of Material Used for Hydrometer Analysis

Mass of Wet Sample & Tare, g	477.10
Mass of Dry Sample & Tare, g	418.90
Mass of Tare, g	175.70
Moisture Content, %	23.9

Mass of Total Sample before separation on #4 sieve & Tare, g	902.30
Mass of Tare, g	0.00
Total Mass of Dry Sample, g	728.07

Mass of Sample used for hydrometer analysis, g	91.70
Dry Mass, g	73.99
% of Total Sample passing #4 sieve	99.9

SIEVE ANALYSIS

PORTION OF SAMPLE RETAINED ON #4 SIEVE

Mass of Tare, g: 0.00

Sieve Size		Sample & Tare, g	% RETAINED	%PASSING
12"	COBBLES		0.0	100.0
3"	COARSE GRAVEL		0.0	100.0
2.5"	COARSE GRAVEL		0.0	100.0
2"	COARSE GRAVEL		0.0	100.0
1.5"	COARSE GRAVEL		0.0	100.0
1"	COARSE GRAVEL		0.0	100.0
.75"	FINE GRAVEL		0.0	100.0
.5"	FINE GRAVEL		0.0	100.0
.375"	FINE GRAVEL	0.00	0.0	100.0
#4	COARSE SAND	0.50	0.1	99.9

PORTION OF SAMPLE PASSING #4 SIEVE (Hydrometer Backsieve)

Sieve Size		Cumulative Mass retained, g	% PASSING
#10	MEDIUM SAND	0.37	99.4
#20	MEDIUM SAND	8.46	88.5
#40	FINE SAND	25.64	65.3
#60	FINE SAND	38.25	48.3
#100	FINE SAND	47.96	35.2
#200	FINES	56.25	24.0

Remarks

HYDROMETER ANALYSIS

Length of Dispersion Period	1 Minute
Mechanical Dispersion Device ID #	61
Amount of Dispersing Agent (ml)	125.0
Specific Gravity (assumed)	2.700
Specific Gravity (tested)	
Starting time	13:49

PARTICLE-SIZE ANALYSIS

% COBBLES	0.0	% MEDIUM SAND	34.1
% COARSE GRAVEL	0.0	% FINE SAND	41.3
% FINE GRAVEL	0.1	% FINES	24.0
% COARSE SAND	0.5	% TOTAL SAMPLE	100.0
% CLAY(<0.005mm)	5.7	% CLAY(<0.002mm)	4.7

Date	Time	Testing time (min)	Reading	Temp (°C)	K	Composite Correction	Actual Reading	Effective Depth (cm)	a	Particle Diam. (mm)	Percent Passing
04/01/20	13:51	2	19.0	16.1	0.01414	6.5	12.5	14.3	0.99	0.0378	16.7
04/01/20	13:54	5	17.0	16.1	0.01414	6.5	10.5	14.6	0.99	0.0242	14.0
04/01/20	14:04	15	14.5	16.1	0.01414	6.5	8.0	15.1	0.99	0.0142	10.7
04/01/20	14:19	30	13.0	16.1	0.01414	6.5	6.5	15.3	0.99	0.0101	8.7
04/01/20	14:49	60	12.0	16.1	0.01414	6.5	5.5	15.5	0.99	0.0072	7.4
04/01/20	17:59	250	10.0	16.1	0.01414	6.5	3.5	15.8	0.99	0.0036	4.7
04/02/20	13:49	1440	10.0	16.1	0.01414	6.5	3.5	15.8	0.99	0.0015	4.7

Hydrometer 152H ID #	305527	Oven ID #	15/496/610
Sieve Shaker ID #	555	Balance ID#	139/142/700

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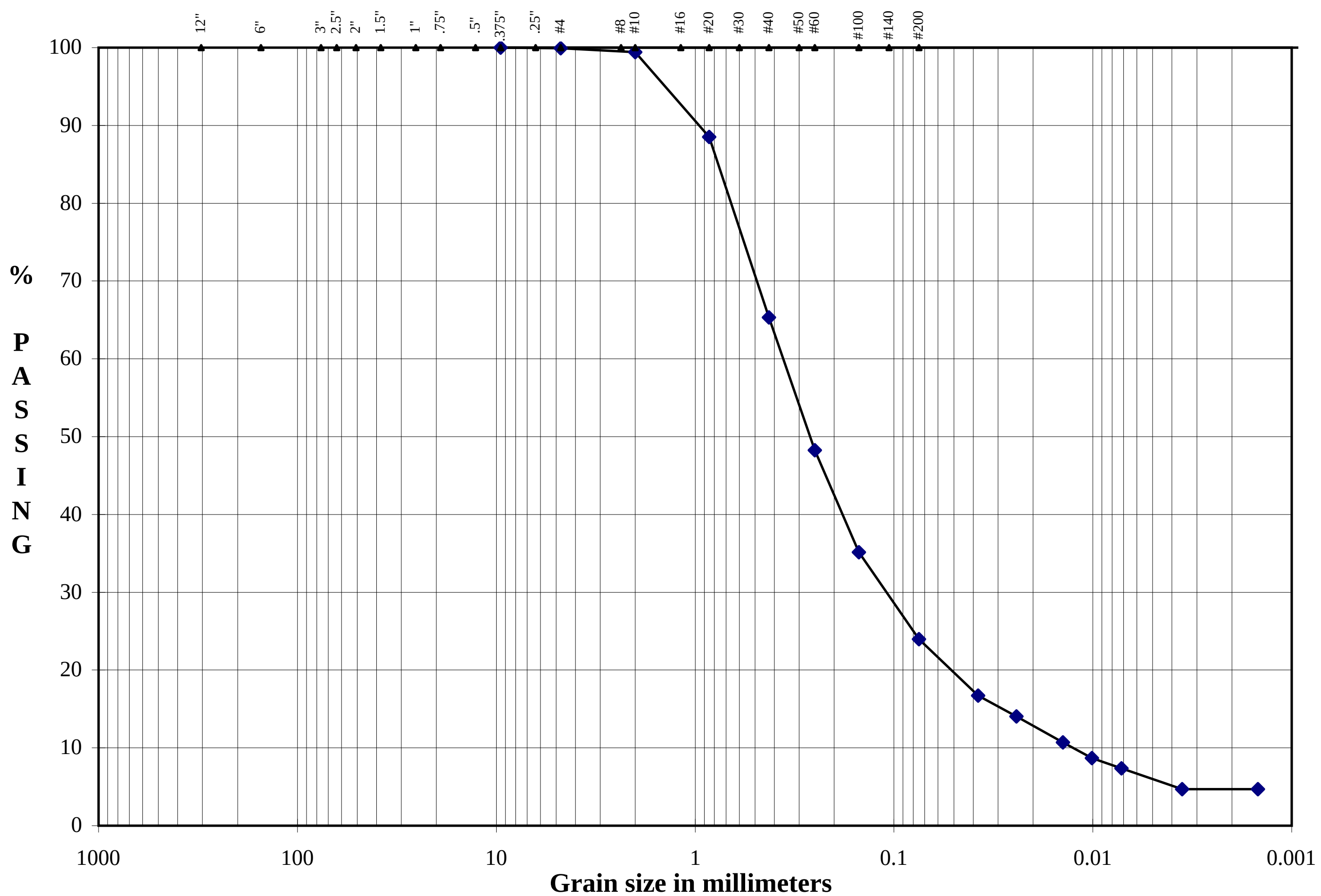
		Date	03/31/20
		Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Pr. Name	AMA	S. Type	UD
Sample ID	33613/YGWA-181-28-30	Depth/Elev.	-
Location	-	Add. Info	-

ASTM D 422/AASHTO T 88

Standard Test Method for Particle-Size Analysis of Soils (with Hydrometer Analysis)

Particle-Size Analysis



Boulders	Cobbles	Gravel		Sand			Fines
		Coarse	Fine	Coarse	Medium	Fine	Silt or Clay

DESCRIPTION: Olive Gray Silty Sand

D_{10}	NA	mm
D_{30}	NA	mm
D_{60}	NA	mm
Cu	NA	
Cc	NA	

USCS (ASTM D2487; D2488): SM

Project's Specific % Passing	NA
Project's Specific Particle Size, mm	NA

TIMELY ENGINEERING SOIL TESTS, LLC	1874 Forge Street Tucker, GA 30084 Phone: 770-938-8233 Fax: 770-923-8973 Web: www.test-llc.com	Tested By: EB/KP Date: 04/01/20 Checked By: [signature]

ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33614/YGWA-205-18-20	Depth/Elev.	-
Location	-	Additional Info	-

SPECIMEN PROPERTIES

	(initial)	(after consol.)
Height, in	5.713	5.674
Diameter, in	2.870	2.798
Height-to-Diameter Ratio	2.0	2.0
Area, in^2	6.47	6.15
Volume, cm^3	605.65	571.65
Mass of Wet Sample, g	1202.20	1192.00
Mass of Dry Sample, g	985.26	985.26
Wet Density, pcf	123.9	130.2
Dry Density, pcf	101.6	107.6
Specific Gravity (assumed)	2.700	2.700
Volume of Solids, cm^3	364.91	364.91
Volume of Voids, cm^3	240.74	206.74
Void Ratio	0.66	0.57
% Saturation	90.1	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	452.10	1192.00
Mass of Dry Sample and Tare, g	402.80	985.26
Mass of Tare, g	178.90	0.00
Moisture, %	22.02	20.98

TEST DATA PRIOR TO LOADING

Volume change (Consolidation), ml	-10.2
Machine Speed, in / min	0.0100
Strain Rate, % / min	0.18
Chamber Pressure, psi	80.0
Back Pressure, psi	70.0
Eff. Consol. Stress,(Minor pr. stress, σ_3),psi	10.0
Change in Height, in	0.039
"B" Value	0.95

SHEAR DATA

Elapsed Time (min)	Deformation Stage 1 (inch)	Axial Load (lb)	Pore-Water Pressure, psi		Total Strain Stage 1 (%)	Corrected Area (in^2)	Dev.Stress ($\Delta\sigma=\sigma_1-\sigma_3$)	Major Principal Stress, psi		Eff.Stress Ratio	P' $(\sigma'_1+\sigma'_3)/2$ (psi)	Q $(\sigma_1-\sigma_3)/2$ (psi)	Eff. Minor Pr. Stress
			Total, U	Change, ΔU			(psi)	Total σ_1	Eff. σ'_1	σ'_1/σ'_3			σ'_3 (psi)
0.0	0.000	19.1	70.00	0.0	0.00	6.15	0.0	10.0	10.0	1.00	10.0	0.0	10.0
0.5	0.005	40.7	72.22	2.2	0.09	6.15	3.5	13.5	11.3	1.45	9.5	1.8	7.8
1.0	0.010	49.5	73.31	3.3	0.18	6.16	4.9	14.9	11.6	1.74	9.2	2.5	6.7
1.5	0.015	55.7	73.97	4.0	0.26	6.16	5.9	15.9	12.0	1.98	9.0	3.0	6.0
2.0	0.020	61.5	74.54	4.5	0.35	6.17	6.9	16.9	12.3	2.26	8.9	3.4	5.5
2.5	0.025	66.6	74.98	5.0	0.44	6.18	7.7	17.7	12.7	2.53	8.9	3.8	5.0
3.0	0.030	70.0	75.20	5.2	0.53	6.18	8.2	18.2	13.0	2.72	8.9	4.1	4.8
3.5	0.035	72.7	75.36	5.4	0.62	6.19	8.7	18.7	13.3	2.87	9.0	4.3	4.6
4.0	0.040	75.7	75.51	5.5	0.70	6.19	9.1	19.1	13.6	3.04	9.1	4.6	4.5
5.0	0.050	82.0	75.77	5.8	0.88	6.20	10.1	20.1	14.4	3.40	9.3	5.1	4.2
6.0	0.060	87.5	75.89	5.9	1.06	6.21	11.0	21.0	15.1	3.68	9.6	5.5	4.1
7.0	0.070	93.0	75.96	6.0	1.23	6.22	11.9	21.9	15.9	3.94	10.0	5.9	4.0
8.0	0.080	97.7	76.02	6.0	1.41	6.24	12.6	22.6	16.6	4.17	10.3	6.3	4.0
9.0	0.090	102.8	76.00	6.0	1.59	6.25	13.4	23.4	17.4	4.35	10.7	6.7	4.0
10.0	0.100	106.7	75.96	6.0	1.76	6.26	14.0	24.0	18.0	4.46	11.0	7.0	4.0
11.0	0.110	110.8	75.92	5.9	1.94	6.27	14.6	24.6	18.7	4.58	11.4	7.3	4.1
12.0	0.120	115.0	75.86	5.9	2.11	6.28	15.3	25.3	19.4	4.69	11.8	7.6	4.1
15.0	0.150	127.4	75.64	5.6	2.64	6.32	17.1	27.1	21.5	4.93	12.9	8.6	4.4
22.0	0.220	153.9	74.98	5.0	3.88	6.40	21.1	31.1	26.1	5.20	15.6	10.5	5.0
26.0	0.260	169.5	74.54	4.5	4.58	6.44	23.3	33.3	28.8	5.28	17.1	11.7	5.5
27.0	0.270	173.2	74.41	4.4	4.76	6.46	23.9	33.9	29.5	5.27	17.5	11.9	5.6
27.5	0.275	175.1	74.31	4.3	4.85	6.46	24.1	34.1	29.8	5.24	17.8	12.1	5.7
Values @ Failure				4.5	4.58	6.44	23.3	33.3	28.8	**5.28**	17.1	11.7	5.5

Failure criteria used* 3

*Note: "1" = Max Deviator Stress; "2" = Deviator Stress @ 15% Strain; "3" = Max Eff.Stress Ratio(σ'_1/σ'_3)

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AASHTO ACCREDITED

Tested By	EB/KP
Date	04/02/20
Checked By	[signature]

ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33614/YGWA-205-18-20	Depth/Elev.	-
Location	-	Additional Info	-

SPECIMEN PROPERTIES

		(initial)	(after consol.)
Height, in		5.399	5.459
Diameter, in		2.868	2.839
Height-to-Diameter Ratio		1.9	1.9
Area, in^2		6.46	6.33
Volume, cm^3		571.65	566.25
Mass of Wet Sample, g		1192.00	1186.60
Mass of Dry Sample, g		985.26	985.26
Wet Density, pcf		130.2	130.8
Dry Density, pcf		107.6	108.6
Specific Gravity	(assumed)	2.700	2.700
Volume of Solids, cm^3		364.91	364.91
Volume of Voids, cm^3		206.74	201.34
Void Ratio		0.57	0.55
% Saturation		100.0	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	1192.00	1186.60
Mass of Dry Sample and Tare, g	985.26	985.26
Mass of Tare, g	0.00	0.00
Moisture, %	20.98	20.44

TEST DATA PRIOR TO LOADING

Volume change (Consolidation), ml	-5.4
Machine Speed, in / min	0.0100
Strain Rate, % / min	0.18
Chamber Pressure, psi	90.0
Back Pressure, psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	20.0
Change in Height, in	-0.060
"B" Value	0.95

SHEAR DATA

Deformation Stage 2 (inch)	Total Deformation ST.1 + ST.2 (inch)	Axial Load (lb)	Pore-Water Pressure, psi		Strain Stage 2 %	Corrected Area (in^2)	Dev.Stress ($Ds=s_1-s_3$)	Major Principal Stress, psi		Effective Stress Ratio	P' $(s'_1+s'_3)/2$ (psi)	Q $(s_1-s_3)/2$ (psi)	Eff. Minor Pr. Stress	Total Strain ST.1 + ST.2 %
			Total, U	Change,DU			(psi)	Total s_1	Eff. s'_1	s'_1/s'_3			s'_3 (psi)	
0.000	0.215	24.6	70.00	0.0	0.00	6.33	0.0	20.0	20.0	1.00	20.0	0.0	20.0	3.79
0.005	0.220	66.6	73.25	3.3	0.09	6.34	6.6	26.6	23.4	1.40	20.1	3.3	16.8	3.88
0.010	0.225	90.7	75.16	5.2	0.18	6.34	10.4	30.4	25.3	1.70	20.1	5.2	14.8	3.97
0.015	0.230	107.9	76.41	6.4	0.27	6.35	13.1	33.1	26.7	1.97	20.2	6.6	13.6	4.05
0.020	0.235	121.1	77.18	7.2	0.37	6.35	15.2	35.2	28.0	2.18	20.4	7.6	12.8	4.14
0.025	0.240	133.3	77.85	7.8	0.46	6.36	17.1	37.1	29.2	2.41	20.7	8.5	12.2	4.23
0.030	0.245	143.5	78.30	8.3	0.55	6.36	18.7	38.7	30.4	2.60	21.0	9.3	11.7	4.32
0.035	0.250	153.8	78.69	8.7	0.64	6.37	20.3	40.3	31.6	2.79	21.5	10.1	11.3	4.41
0.040	0.255	163.7	79.01	9.0	0.73	6.38	21.8	41.8	32.8	2.98	21.9	10.9	11.0	4.49
0.050	0.265	181.2	79.50	9.5	0.92	6.39	24.5	44.5	35.0	3.33	22.8	12.3	10.5	4.67
0.060	0.275	196.3	79.89	9.9	1.10	6.40	26.8	46.8	36.9	3.65	23.5	13.4	10.1	4.85
0.070	0.285	209.7	80.20	10.2	1.28	6.41	28.9	48.9	38.7	3.95	24.2	14.4	9.8	5.02
0.080	0.295	221.1	80.29	10.3	1.47	6.42	30.6	50.6	40.3	4.15	25.0	15.3	9.7	5.20
0.090	0.305	231.6	80.38	10.4	1.65	6.44	32.2	52.2	41.8	4.34	25.7	16.1	9.6	5.38
0.100	0.315	240.8	80.42	10.4	1.83	6.45	33.5	53.5	43.1	4.50	26.3	16.8	9.6	5.55
0.110	0.325	248.5	80.42	10.4	2.02	6.46	34.7	54.7	44.2	4.62	26.9	17.3	9.6	5.73
0.120	0.335	256.3	80.39	10.4	2.20	6.47	35.8	55.8	45.4	4.73	27.5	17.9	9.6	5.90
0.170	0.385	288.4	79.92	9.9	3.11	6.53	40.4	60.4	50.5	5.01	30.3	20.2	10.1	6.79
0.220	0.435	320.2	79.18	9.2	4.03	6.60	44.8	64.8	55.6	5.14	33.2	22.4	10.8	7.67
0.230	0.445	326.3	79.01	9.0	4.21	6.61	45.7	65.7	56.6	5.15	33.8	22.8	11.0	7.84
0.240	0.455	332.8	78.82	8.8	4.40	6.62	46.5	66.5	57.7	5.16	34.5	23.3	11.2	8.02
0.250	0.465	339.0	78.62	8.6	4.58	6.63	47.4	67.4	58.8	5.16	35.1	23.7	11.4	8.20
0.260	0.475	346.1	78.35	8.3	4.76	6.65	48.4	68.4	60.0	5.15	35.8	24.2	11.7	8.37
Values @ Failure				8.6	4.58	6.63	47.4	67.4	58.8	**5.16**	35.1	23.7	11.4	8.20
Failure criteria used*			3											

*Note: "1" = Max Deviator Stress; "2" = Deviator Stress @ 15% Strain; "3" = Max Eff.Stress Ratio(s'_1/s'_3)

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ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33614/YGWA-205-18-20	Depth/Elev.	-
Location	-	Additional Info	-

SPECIMEN PROPERTIES

	(initial)	(after consol.)
Height, in	5.199	5.259
Diameter, in	2.909	2.899
Height-to-Diameter Ratio	1.8	1.8
Area, in^2	6.65	6.60
Volume, cm^3	566.25	568.99
Mass of Wet Sample, g	1186.60	1179.10
Mass of Dry Sample, g	985.26	969.00
Wet Density, pcf	130.8	129.4
Dry Density, pcf	108.6	106.3
Specific Gravity (assumed)	2.700	2.700
Volume of Solids, cm^3	364.91	358.89
Volume of Voids, cm^3	201.34	210.10
Void Ratio	0.55	0.59
% Saturation	100.0	100.0

WATER CONTENT DETERMINATION

	(initial)	(final)
Mass of Wet Sample and Tare, g	1186.60	1486.10
Mass of Dry Sample and Tare, g	985.26	1276.00
Mass of Tare, g	0.00	307.00
Moisture, %	20.44	21.68

TEST DATA PRIOR TO LOADING

Volume change (Consolidation), ml	-7.5
Machine Speed, in / min	0.01000
Strain Rate, % / min	0.19
Chamber Pressure, psi	110.0
Back Pressure, psi	70.0
Eff. Consol. Stress,(Minor pr. stress, s_3),psi	40.0
Change in Height, in	-0.060
"B" Value	0.95

SHEAR DATA

Deformation Stage 3 (inch)	Total Deformation ST.1 + ST.2 + ST.3 (inch)	Axial Load (lb)	Pore-Water Pressure, psi		Strain Stage 3 %	Corrected Area (in^2)	Deviator Stress ($Ds=s_1-s_3$)	Major Principal Stress, psi		Effective Stress Ratio	P' ($s'_1+s'_3$)/2 (psi)	Q (s_1-s_3)/2 (psi)	Eff. Minor Pr. Stress	Total Strain ST.1 + ST.2 + ST.3, %
			Total, U	Change,DU			(psi)	Total s_1	Eff. s'_1	s'_1/s'_3			s'_3 (psi)	
0.000	0.415	25.6	70.00	0.0	0.00	6.60	0.0	40.0	40.0	1.00	40.0	0.0	40.0	7.31
0.010	0.425	158.1	80.73	10.7	0.19	6.62	20.0	60.0	49.3	1.68	39.3	10.0	29.3	7.49
0.020	0.435	218.6	84.98	15.0	0.38	6.63	29.1	69.1	54.1	2.16	39.6	14.6	25.0	7.67
0.030	0.445	263.1	87.17	17.2	0.57	6.64	35.8	75.8	58.6	2.57	40.7	17.9	22.8	7.84
0.040	0.455	300.5	88.51	18.5	0.76	6.65	41.3	81.3	62.8	2.92	42.2	20.7	21.5	8.02
0.050	0.465	335.1	89.50	19.5	0.95	6.67	46.4	86.4	66.9	3.27	43.7	23.2	20.5	8.20
0.070	0.485	388.4	90.84	20.8	1.33	6.69	54.2	94.2	73.4	3.83	46.3	27.1	19.2	8.55
0.100	0.515	440.2	91.91	21.9	1.90	6.73	61.6	101.6	79.7	4.41	48.9	30.8	18.1	9.08
0.120	0.535	463.9	92.12	22.1	2.28	6.76	64.9	104.9	82.7	4.63	50.3	32.4	17.9	9.43
0.150	0.565	492.8	92.02	22.0	2.85	6.80	68.7	108.7	86.7	4.82	52.4	34.4	18.0	9.96
0.170	0.585	510.9	91.87	21.9	3.23	6.82	71.1	111.1	89.3	4.92	53.7	35.6	18.1	10.31
0.200	0.615	536.4	91.68	21.7	3.80	6.86	74.4	114.4	92.7	5.06	55.5	37.2	18.3	10.84
0.230	0.645	561.6	91.13	21.1	4.37	6.90	77.6	117.6	96.5	5.11	57.7	38.8	18.9	11.37
0.260	0.675	587.0	90.40	20.4	4.95	6.95	80.8	120.8	100.4	5.12	60.0	40.4	19.6	11.90
0.280	0.695	603.9	89.88	19.9	5.33	6.97	82.9	122.9	103.0	5.12	61.6	41.5	20.1	12.25
0.310	0.725	629.6	89.07	19.1	5.90	7.02	86.1	126.1	107.0	5.11	64.0	43.0	20.9	12.78
0.330	0.745	646.4	88.48	18.5	6.28	7.04	88.1	128.1	109.6	5.10	65.6	44.1	21.5	13.13
0.350	0.765	663.1	87.89	17.9	6.66	7.07	90.1	130.1	112.2	5.08	67.2	45.1	22.1	13.48
0.370	0.785	681.2	87.25	17.2	7.04	7.10	92.3	132.3	115.1	5.06	68.9	46.2	22.8	13.84
0.390	0.805	698.3	86.61	16.6	7.42	7.13	94.3	134.3	117.7	5.03	70.6	47.2	23.4	14.19
0.410	0.825	716.3	85.89	15.9	7.80	7.16	96.5	136.5	120.6	5.00	72.3	48.2	24.1	14.54
0.430	0.845	733.9	85.16	15.2	8.18	7.19	98.5	138.5	123.3	4.97	74.1	49.3	24.8	14.89
0.450	0.865	752.5	84.38	14.4	8.56	7.22	100.7	140.7	126.3	4.93	76.0	50.3	25.6	15.25
Values @ Failure				20.4	4.95	6.95	80.8	120.8	100.4	**5.12**	60.0	40.4	19.6	11.90

Failure criteria used*: 3

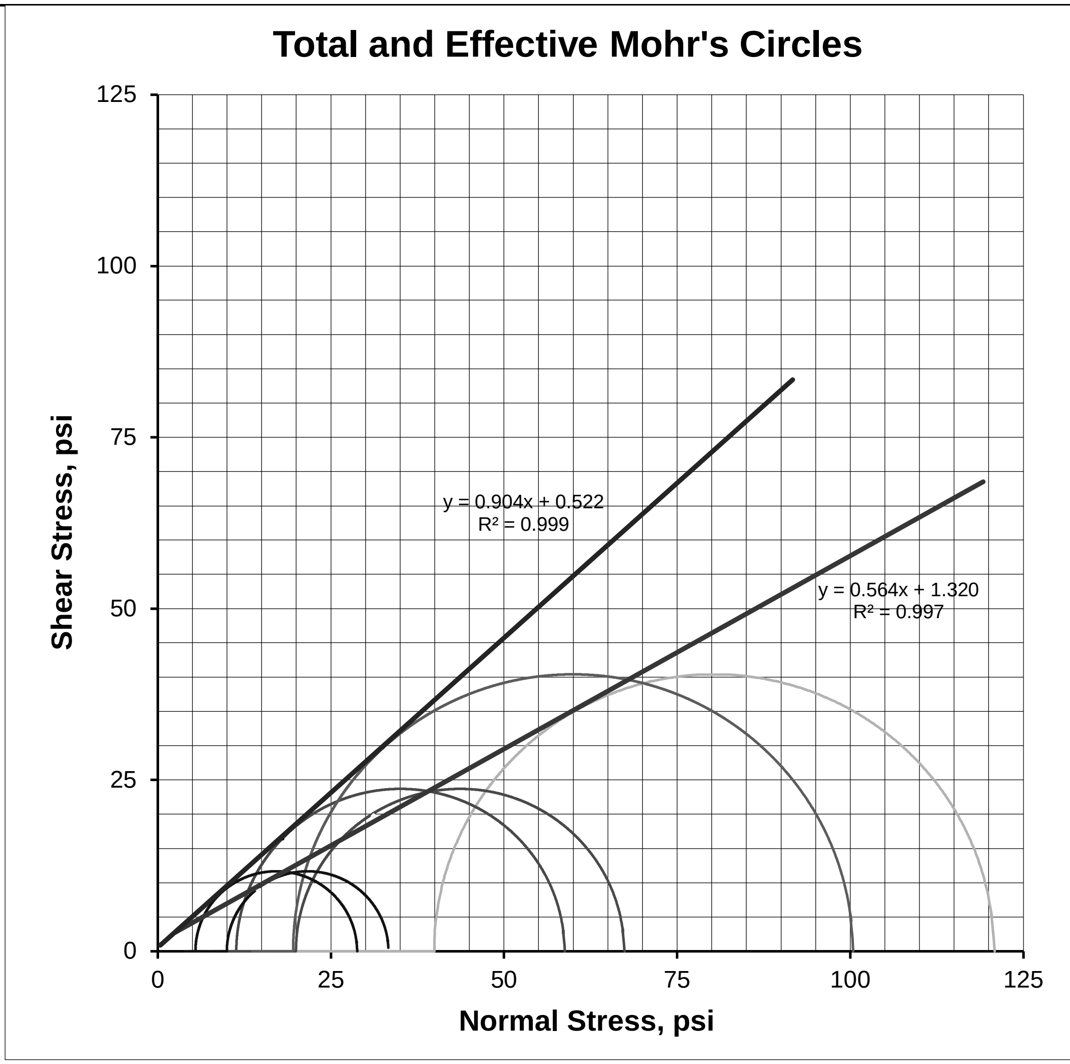
*Note: "1" = Max Deviator Stress; "2" = Deviator Stress @ 15% Strain; "3" = Max Eff.Stress Ratio(s'_1/s'_3)

TIMELY **E**NGINEERING **S**OIL **T**ESTS, LLC	1874 Forge Street Tucker, GA 30084 Phone: 770-938-8233 Fax: 770-923-8973 Web: www.test-llc.com	Tested By	EB/KP
		Date	04/02/20
		Check	

ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33614/YGWA-205-18-20	Depth/Elev.	-
Location	-	Additional Info	-



	ST. 1	ST. 2	ST. 3
Effective Consolidation Stress, psi	10.0	20.0	40.0
Deviator Stress at Failure, psi	23.3	47.4	80.8
Effective Minor Principal Stress at Failure, psi	5.5	11.4	19.6
Effective Major Principal Stress at Failure, psi	28.8	58.8	100.4
Axial Strain at Failure, %	4.58	4.58	4.95

STRENGTH PARAMETERS*			
Total		Effective	
f °	29.4	f ' °	42.1
C, psi	1.3	C', psi	0.5

***Valid only for Received Material at Reported Densities and Moisture Contents. Please see remarks on page 6 of this report**

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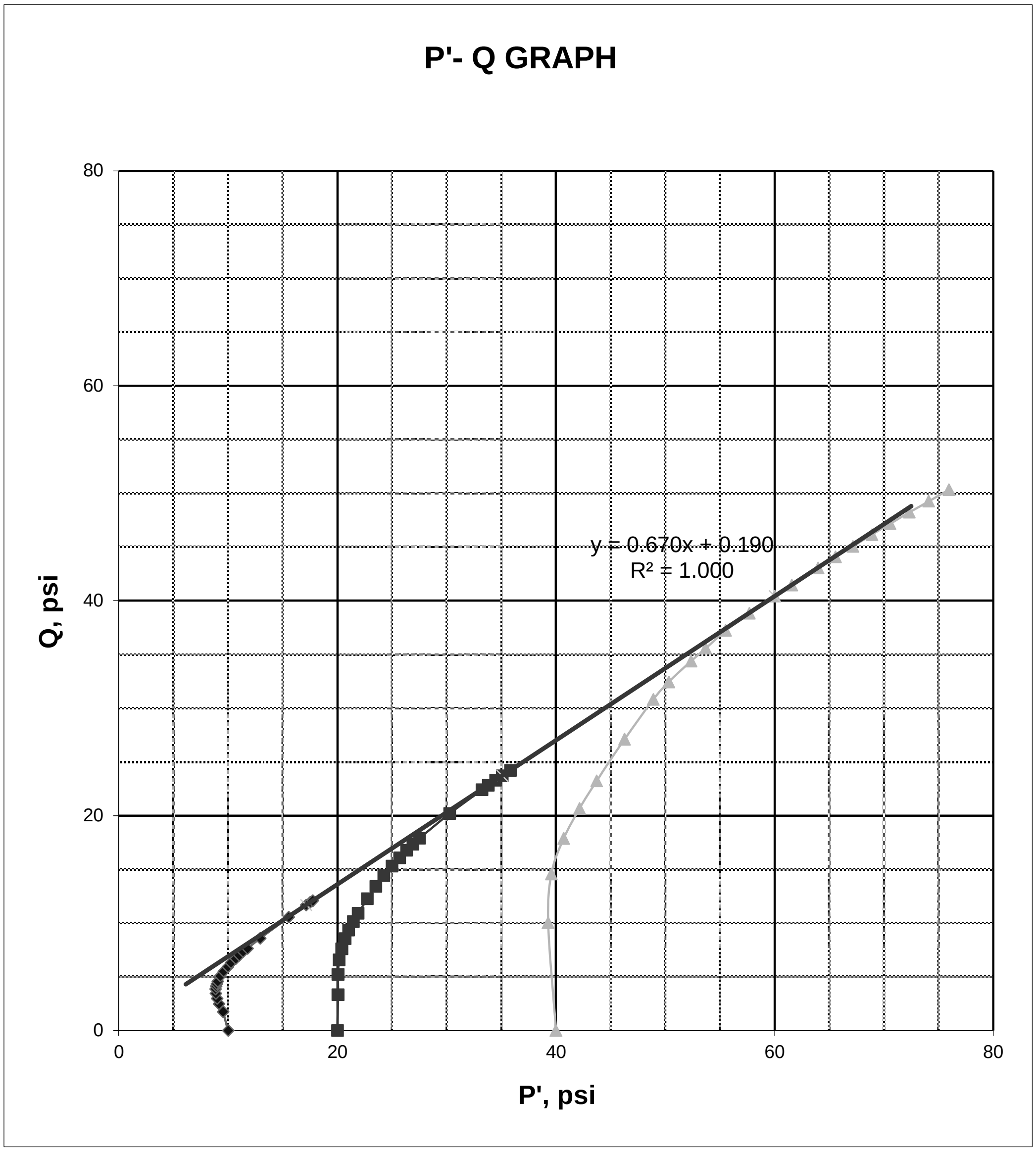
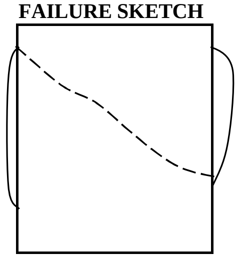
Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33614/YGWA-205-18-20	Depth/Elev.	-
Location	-	Additional Info	-



FAILURE SKETCH



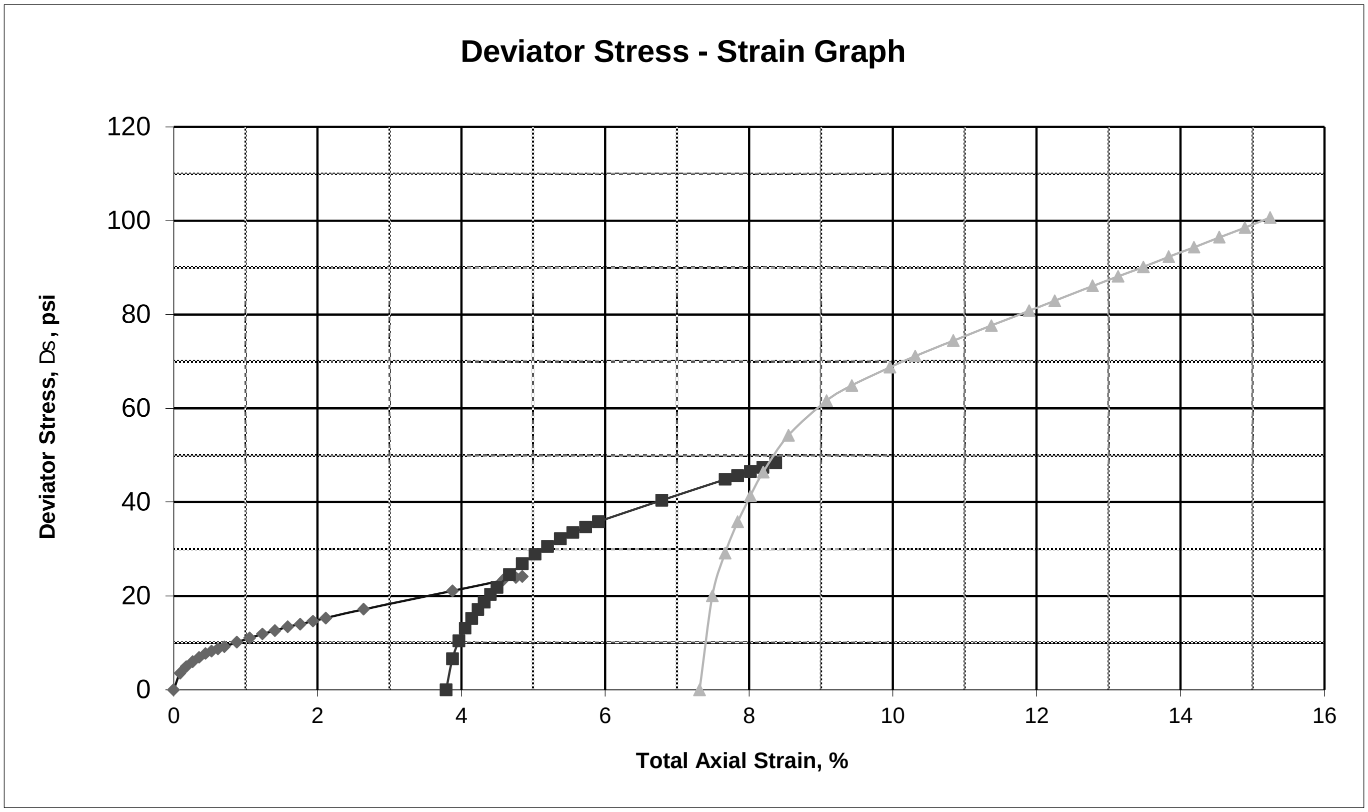
a, psi	0.2
a, degree	33.8

T.E.S.T.	**TIMELY ENGINEERING SOIL TESTS, LLC**	1874 Forge Street Tucker, GA 30084 Phone: 770-938-8233 Fax: 770-923-8973 Web: www.test-llc.com AASHTO ACCREDITED	Tested By: EB/KP Date: 04/02/20 Check: [signature]

ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33614/YGWA-205-18-20	Depth/Elev.	-
Location	-	Additional Info	-



Balance ID Number	563/700
Oven ID Number	496/610
Deformation Indicator ID #	178/349/689
Digital Caliper ID #	370/458
Load Cell ID #	11/347/692
Apparatus ID #	10/293/693

REMARKS

Material from shelby tube was not homogeneous and/or not long enough to select 3 uniform specimens 6" long each. Most representative portion of sample (3" above the bottom of shelby tube) was selected for multi-stage triaxial testing (per ASTM STP 883). Failure occurred along weak zone of partially weathered soft rock. Application of safety factors to results of this report is recommended due to not uniformity of material on site.

DESCRIPTION

Olive Gray Silty Sand

USCS (ASTM D2487: D2488)

SM

NOTES:

1. Method for Saturation — WET
2. Method for determination of cross-sectional area after consol. — B
3. Final moisture content (Stage 3) obtained from entire sample

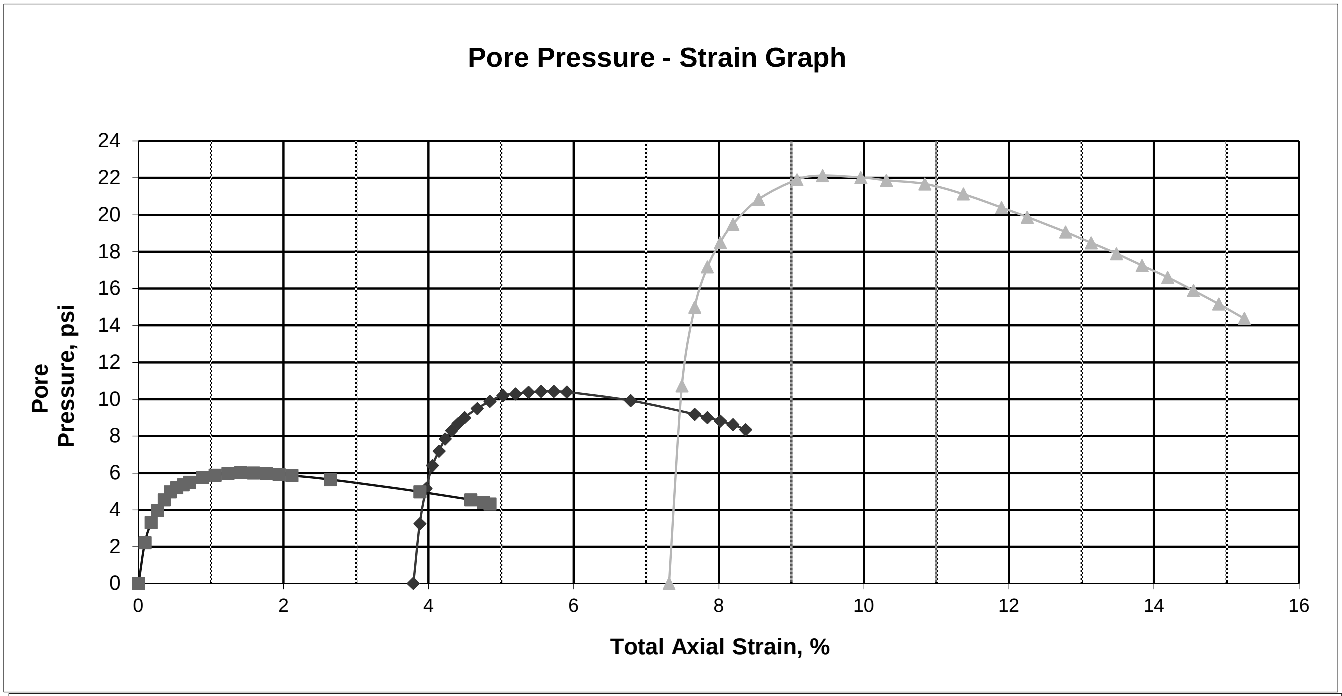
LL	-
PL	-
PI	-
Gs	-

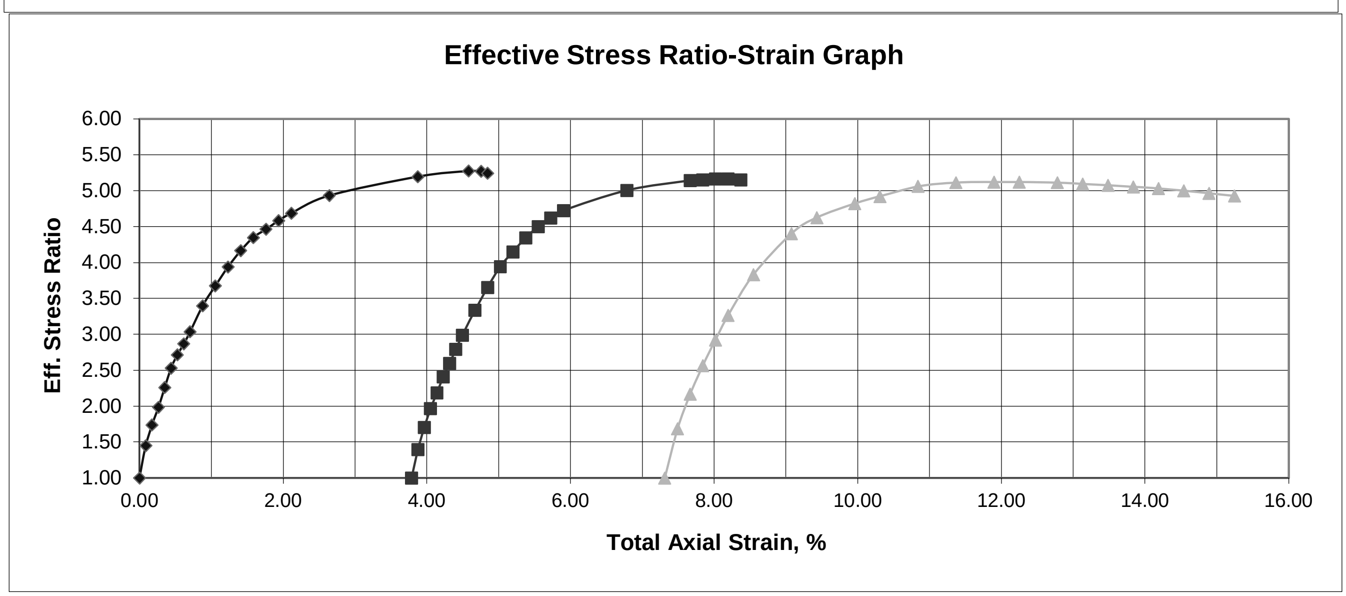
TIMELY **E**NGINEERING **S**OIL **T**ESTS, LLC	1874 Forge Street Tucker, GA 30084 Phone: 770-938-8233 Fax: 770-923-8973 Web: www.test-llc.com	Tested By	EB/KP
		Date	04/02/20
		Check	

ASTM D 4767/AASHTO T 297

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils (Multistage per ASTM STP 883)

Client Project #	I054-107	Laboratory Project #	2008-08-2
Project Name	AMA	Sample Type	UD
Sample ID	33614/YGWA-205-18-20	Depth/Elev.	-
Location	-	Additional Info	-





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1874 Forge Street Tucker, GA 30084
Phone: 770-938-8233
Fax: 770-923-8973
Web: www.test-llc.com

AASHTO ACCREDITED

Tested By	IH
Date	04/02/20
Checked By	[illegible]

Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Pr. Name	AMA	S. Type	UD
Sample ID	33614/YGWA-205-18-20	Depth/Elev.	-
Location	-	Add. Info	-

ASTM D 4318

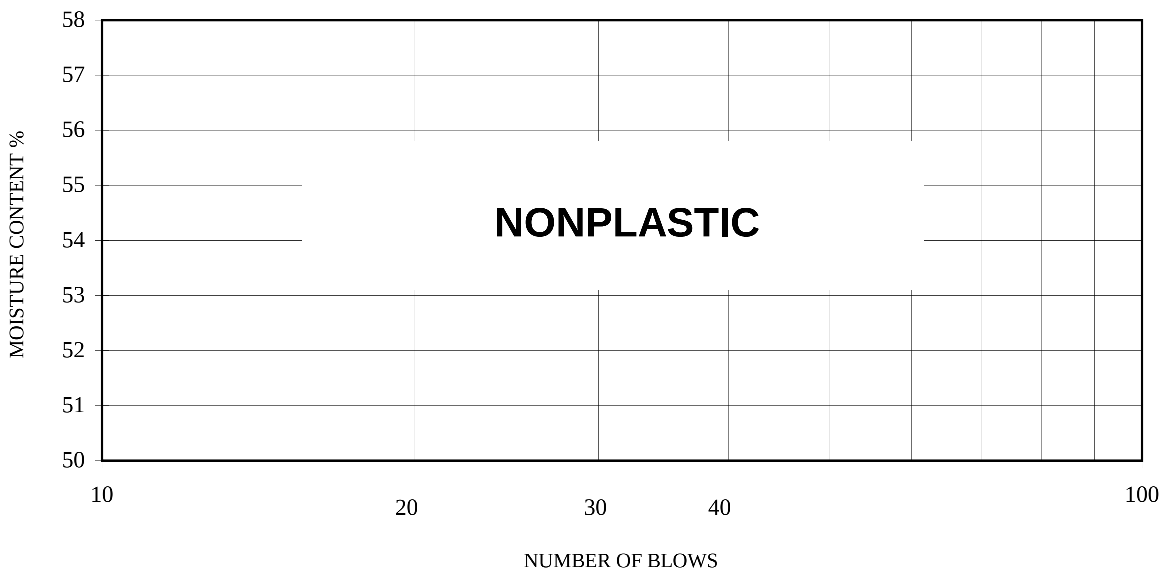
Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils (Atterberg Limits)

LIQUID LIMIT

Number of Blows	11	11
Weight of Wet Sample & Tare, g	37.17	35.09
Weight of Dry Soil & Tare, g	33.66	31.96
Weight of Tare, g	24.57	23.83
Moisture Content, %	38.61	38.50

Liquid Limit Device ID # 56

NOTES: 1. Material appears to be Nonplastic. (Liquid Limit or Plastic Limit test could not be performed.)
2. Material passing No. 40 sieve was used for test.



PLASTIC LIMIT

Weight of Wet Soil & Tare, g	34.10	37.78
Weight of Dry Soil & Tare, g	30.96	34.11
Weight of Tare, g	22.80	24.69
Moisture Content, %	38.48	38.96

Oven ID Number	15/496/610
Balance ID Number	139/563

NATURAL MOISTURE

Weight of Wet Soil & Tare, g	452.10
Weight of Dry Soil & Tare, g	402.80
Weight of Tare, g	178.90
Moisture Content, %	22.02

LIQUID LIMIT (LL)	NP
PLASTIC LIMIT (PL)	NP
PLASTICITY INDEX (PI)	NP
LIQUIDITY INDEX (LI)	-

DESCRIPTION: Olive Gray Silty Sand

USCS (ASTM D2487;2488): SM

AASHTO (M 145): NA

T.E.S.T.	TIMELY ENGINEERING SOIL TESTS, LLC	1874 Forge Street Tucker, GA 30084 Phone: 770-938-8233 Fax: 770-923-8973 Web: www.test-llc.com AASHTO ACCREDITED	Tested By: RI Date: 03/31/20 Checked By: [signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Pr. Name	AMA	S. Type	UD
Sample ID	33614/YGWA-205-18-20	Depth/Elev.	-
Location	-	Add. Info	-

ASTM D 422/AASHTO T 88

Standard Test Method for Particle-Size Analysis of Soils (with Hydrometer Analysis)

As-Received Moisture Content		*Moisture Content of Material Used for Hydrometer Analysis*	
Mass of Wet Sample & Tare, g	452.10	Mass of Wet Sample & Tare, g	452.10
Mass of Dry Sample & Tare, g	402.80	Mass of Dry Sample & Tare, g	402.80
Mass of Tare, g	178.90	Mass of Tare, g	178.90
Moisture Content, %	22.0	Moisture Content, %	22.0

Mass of Total Sample before separation on #4 sieve & Tare, g	1441.40	Mass of Sample used for hydrometer analysis, g	90.70
Mass of Tare, g	0.00	Dry Mass, g	74.33
Total Mass of Dry Sample, g	1181.29	% of Total Sample passing #4 sieve	100.0

SIEVE ANALYSIS

PORTION OF SAMPLE RETAINED ON #4 SIEVE

Mass of Tare, g: 0.00

Sieve Size		Sample & Tare, g	% RETAINED	%PASSING
12"	COBBLES		0.0	100.0
3"	COARSE GRAVEL		0.0	100.0
2.5"	COARSE GRAVEL		0.0	100.0
2"	COARSE GRAVEL		0.0	100.0
1.5"	COARSE GRAVEL		0.0	100.0
1"	COARSE GRAVEL		0.0	100.0
.75"	FINE GRAVEL		0.0	100.0
.5"	FINE GRAVEL		0.0	100.0
.375"	FINE GRAVEL		0.0	100.0
#4	COARSE SAND	0.00	0.0	100.0

PORTION OF SAMPLE PASSING #4 SIEVE (Hydrometer Backsieve)

Sieve Size		Cumulative Mass retained, g	% PASSING
#10	MEDIUM SAND	0.63	99.2
#20	MEDIUM SAND	10.02	86.5
#40	FINE SAND	23.68	68.1
#60	FINE SAND	33.43	55.0
#100	FINE SAND	41.58	44.1
#200	FINES	49.67	33.2

Remarks

HYDROMETER ANALYSIS

Length of Dispersion Period	1 Minute
Mechanical Dispersion Device ID #	61
Amount of Dispersing Agent (ml)	125.0
Specific Gravity (assumed)	2.700
Specific Gravity (tested)	
Starting time	13:51

PARTICLE-SIZE ANALYSIS

% COBBLES	0.0	% MEDIUM SAND	31.0
% COARSE GRAVEL	0.0	% FINE SAND	35.0
% FINE GRAVEL	0.0	% FINES	33.2
% COARSE SAND	0.8	% TOTAL SAMPLE	100.0
% CLAY(<0.005mm)	4.6	% CLAY(<0.002mm)	3.3

Date	Time	Testing time (min)	Reading	Temp (°C)	K	Composite Correction	Actual Reading	Effective Depth (cm)	a	Particle Diam. (mm)	Percent Passing
04/01/20	13:53	2	23.0	16.1	0.01414	6.5	16.5	13.6	0.99	0.0369	22.0
04/01/20	13:56	5	18.0	16.1	0.01414	6.5	11.5	14.5	0.99	0.0241	15.3
04/01/20	14:06	15	14.5	16.1	0.01414	6.5	8.0	15.1	0.99	0.0142	10.7
04/01/20	14:21	30	13.0	16.1	0.01414	6.5	6.5	15.3	0.99	0.0101	8.7
04/01/20	14:51	60	11.5	16.1	0.01414	6.5	5.0	15.6	0.99	0.0072	6.7
04/01/20	18:01	250	9.0	16.1	0.01414	6.5	2.5	16.0	0.99	0.0036	3.3
04/02/20	13:51	1440	9.0	16.1	0.01414	6.5	2.5	16.0	0.99	0.0015	3.3

Hydrometer 152H ID #	305527	Oven ID #	15/496/610
Sieve Shaker ID #	555	Balance ID#	139/142/700

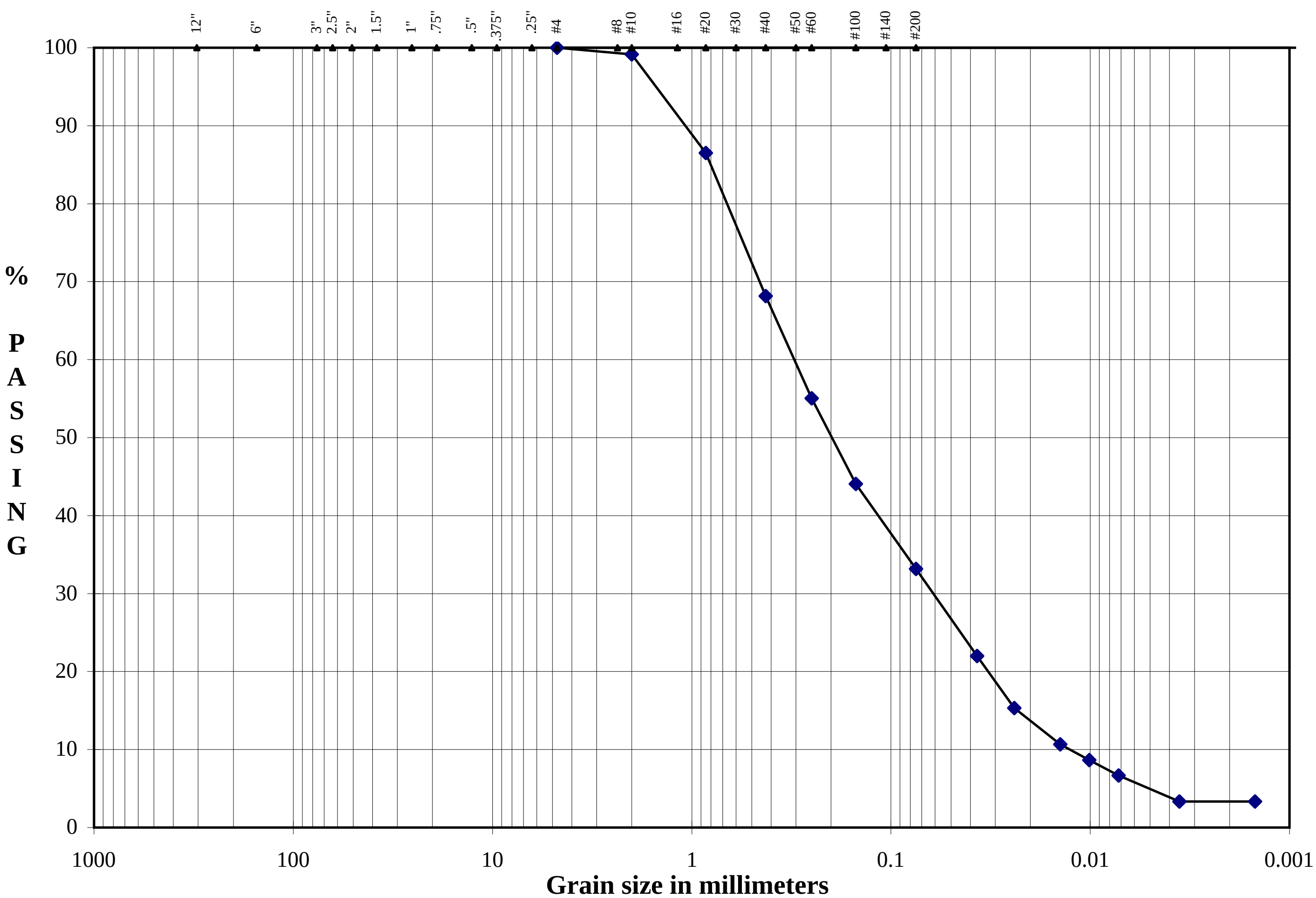
TIMELY ENGINEERING SOIL TESTS, LLC	1874 Forge Street Tucker, GA 30084 Phone: 770-938-8233 Fax: 770-923-8973 Web: www.test-llc.com	Tested By	RI
		Date	03/31/20
		Checked By	

Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Pr. Name	AMA	S. Type	UD
Sample ID	33614/YGWA-205-18-20	Depth/Elev.	-
Location	-	Add. Info	-

ASTM D 422/AASHTO T 88

Standard Test Method for Particle-Size Analysis of Soils (with Hydrometer Analysis)

Particle-Size Analysis



Boulders	Cobbles	Gravel (Coarse)	Gravel (Fine)	Sand (Coarse)	Sand (Medium)	Sand (Fine)	Fines (Silt or Clay)

DESCRIPTION	Olive Gray Silty Sand	D_{10}	NA mm
		D_{30}	NA mm
		D_{60}	NA mm
		Cu	NA
		Cc	NA

USCS (ASTM D2487; D2488)	SM
Project's Specific % Passing	NA
Project's Specific Particle Size, mm	NA

7.7 SGI TESTING SERVICES – INTERFACE DIRECT SHEAR TESTING LABORATORY RESULTS

7 April 2020

Beth Headrick, P.E.
Atlantic Coast Consulting, Inc.
212 S. Peters Road., Suite 201
Knoxville, Tennessee 37923

Subject: Laboratory Test Results Transmittal
Interface Direct Shear Testing
Southern Company - The Plant Yates Project

Dear Ms. Headrick,

SGI Testing Services, LLC (SGI) is pleased to present the attached test results for the above-mentioned project. The note section below addresses sample preparation, sample disposal and a disclosure statement.

SGI appreciates the opportunity to provide laboratory testing services to Atlantic Coast Consulting, Inc. Should you have any questions regarding the attached document(s), or if you require additional information, please do not hesitate to contact the undersigned.

Sincerely,

Zehong Yuan, Ph.D., P.E.
Laboratory Manager

Attachments

NOTES:
(1) Unless otherwise noted in the test results the sample(s)/specimen(s) were prepared in accordance with the applicable test standards or generally accepted sampling procedures.
(2) Contaminated/chemical samples and all related laboratory generated waste (i.e., test liquids, PPE, absorbents, etc.) will be returned to the client or designated representative(s), at the client's cost, within 60 days following the completion of the testing program, unless special arrangements for proper disposal are made with SGI.
(3) Materials that are not contaminated will be discarded after test specimens and archived specimens are obtained. Archived specimens will be discarded 30 days after the completion of the testing program, unless long-term storage arrangements are specifically made with SGI.
(4) The reported results apply only to the materials and test conditions used in the laboratory testing program. The results do not necessarily apply to other materials or test conditions. The test results should not be used in engineering analysis unless the test conditions model the anticipated field conditions. The testing was performed in accordance with general engineering testing standards and requirements. The reported results are submitted for the exclusive use of the client to whom they are addressed.

SGI20014.REPORT.2020.02

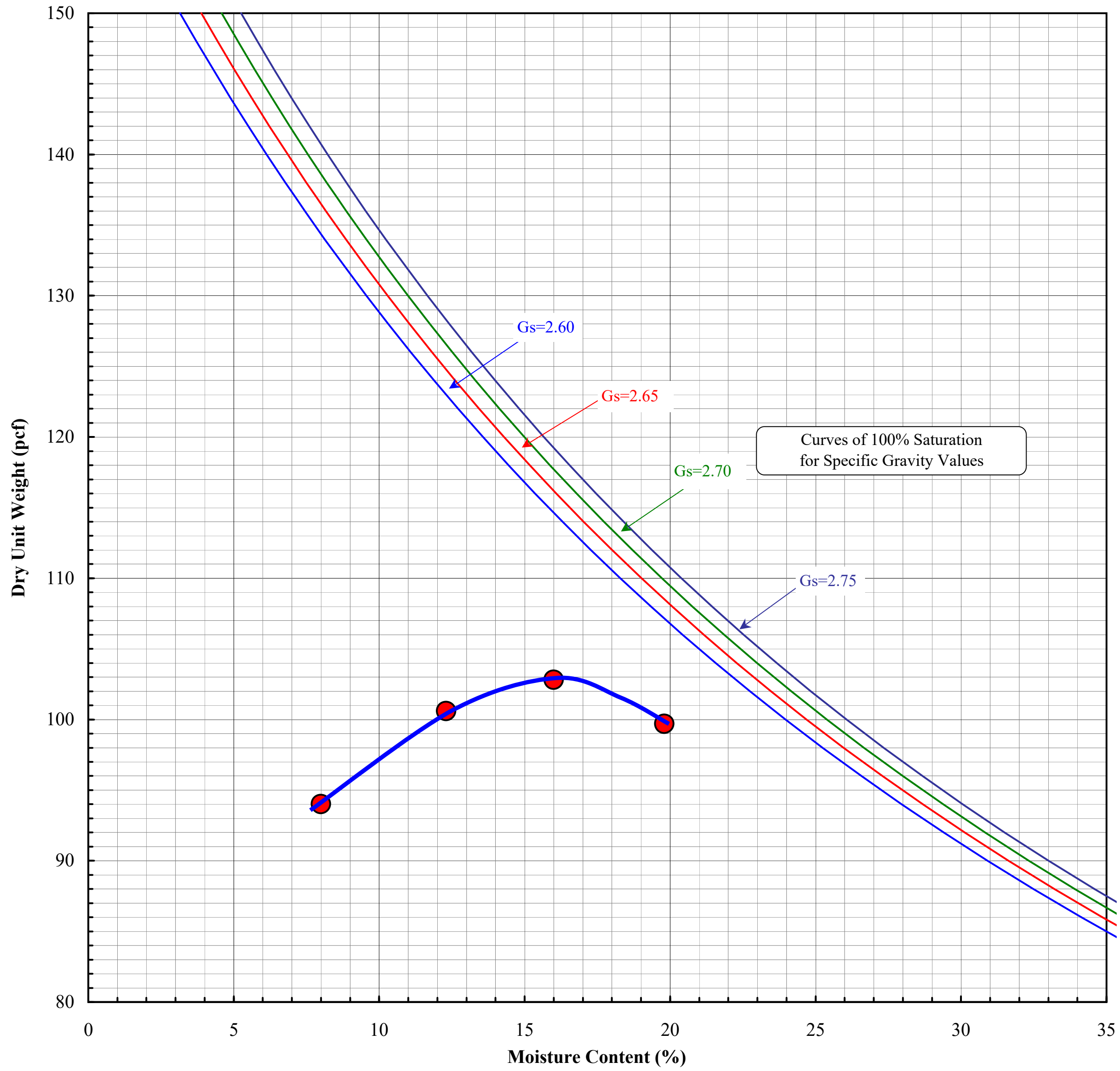
ATTACHMENT 1

SUMMARY OF TEST RESULTS

SGI Testing Services, LLC
4405 International Blvd., Suite B-117, Norcross, GA 30093
Ph: (770) 931 8222 Fax: (770) 931 8240

Project Name:	The Plant Yates
Project No:	SGI20014
Client Sample ID:	Subgrade soil
Lab Sample No:	S22469

ASTM D 698 — **COMPACTION MOISTURE-DENSITY RELATIONSHIP** — **Method A**

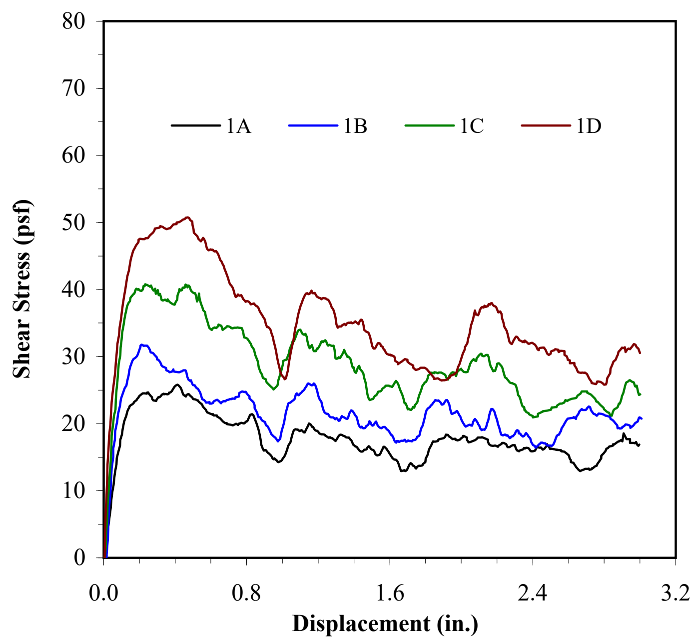


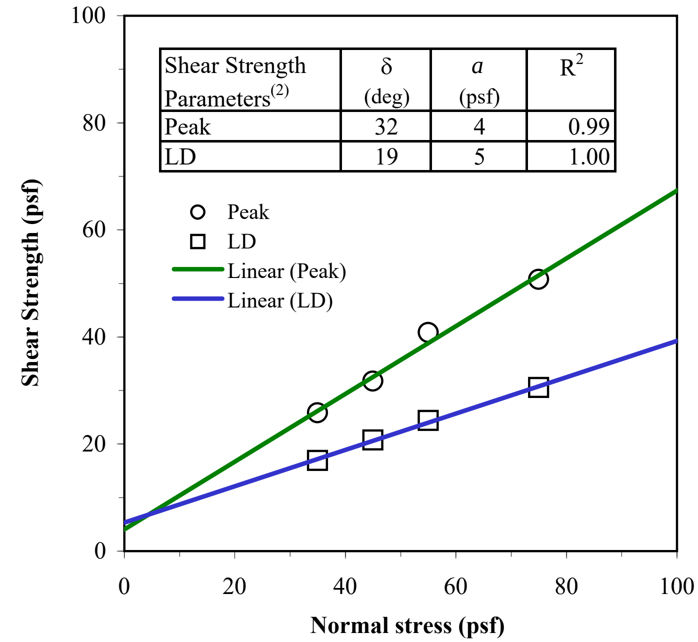
Client Sample ID NO/Description	SGI Sample ID NO.	Compaction Data		Maximum Dry Unit Weight and Optimum Moisture Content			
				Measured		Corrected	
		ω_i (%)	γ_d (pcf)	ω_{om} (%)	γ_{dmax} (pcf)	ω_{om} (%)	γ_{dmax} (pcf)
Subgrade soil	S22469	8.0	94.0	16.0	102.8		
		12.3	100.6				
		16.0	102.8				
		19.8	99.7				

% Retained on #4 Sieve: 2.2
% Retained on #3/8" Sieve:
% Retained on 3/4" Sieve:
% Retained on 2.0" Sieve:

ATLANTIC COAST CONSULTING, INC.
INTERFACE DIRECT SHEAR TESTING (ASTM D 5321)

Upper Shear Box: Concrete sand nominally compacted against
Synthetic turf with base geotextile side down against
Agru 50-mil LLDPE MicroDrain geomembrane #GTA0024550169 with studs side up and Microspike side down against
Lower Shear Box: Subgrade soil compacted to approximately 95% of max standard Proctor density at OMC + 2%





Test No.	Shear Box Size (in x in)	Normal Stress (psf)	Shear Rate (in/min)	Soaking Stress (psf)	Soaking Time (hour)	Consolidation Stress (psf)	Consolidation Time (hour)	Upper Soil γ_d (pcf)	Upper Soil ω_i (%)	Upper Soil ω_f (%)	Subgrade Soil γ_d (pcf)	Subgrade Soil ω_i (%)	Subgrade Soil ω_f (%)	GCL ω_i (%)	GCL ω_f (%)	Shear Strength(2) τ_P (psf)	Shear Strength(2) τ_{LD} (psf)	Secant Angle δ_P (deg)	Secant Angle δ_{LD} (deg)	Failure Mode
1A	12 x 12	35	0.04	35	24	-	-	-	-	-	97.2	18.6	-	-	-	25.8	16.9	36	26	(1)
1B	12 x 12	45	0.04	45	24	-	-	-	-	-			-	-	-	31.8	20.7	35	25	(1)
1C	12 x 12	55	0.04	55	24	-	-	-	-	-			-	-	-	40.8	24.4	37	24	(1)
1D	12 x 12	75	0.04	75	24	-	-	-	-	-			-	-	-	50.7	30.6	34	22	(1)

NOTES:
(1) Sliding (i.e., shear failure) occurred at the interface between the base fabric side of synthetic turf and stud side of MicroDrain.
(2) The reported total-stress parameters of friction angle and adhesion were determined from a best-fit line drawn through the test data. Caution should be exercised in using these strength parameters for applications involving normal stresses outside the range of the stresses covered by the test series. The large-displacement (LD) shear strength was calculated using the shear force measured at the end of the test .

DATE OF REPORT:	4/7/2020
FIGURE NO.	2
PROJECT NO.	SGI20014
DOCUMENT NO.	
FILE NO.	

SGI TESTING SERVICES, LLC

Figure 3. Test setup.

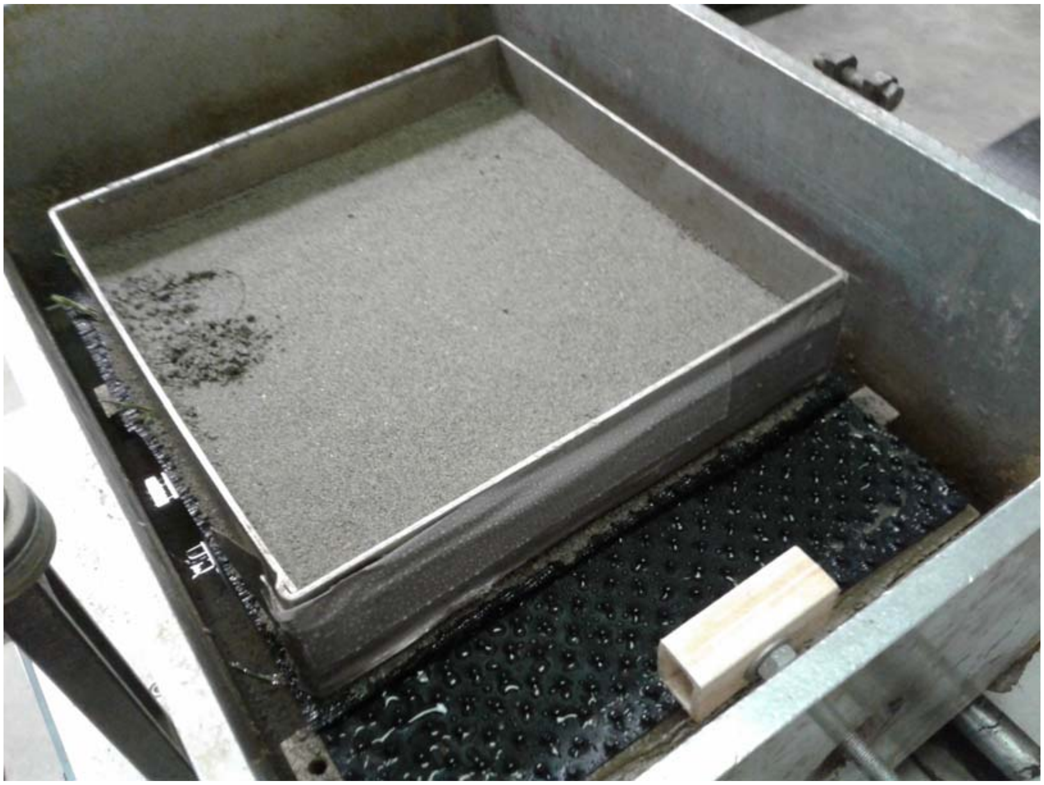


Figure 4. Failure mode: sliding occurred at the interface between the base geotextile of the synthetic turf and stud side of MicroDrain.

Figure 5. MicroDrain (Microspike side) and subgrade soil surfaces at the completion of test #1D at 75 psf.

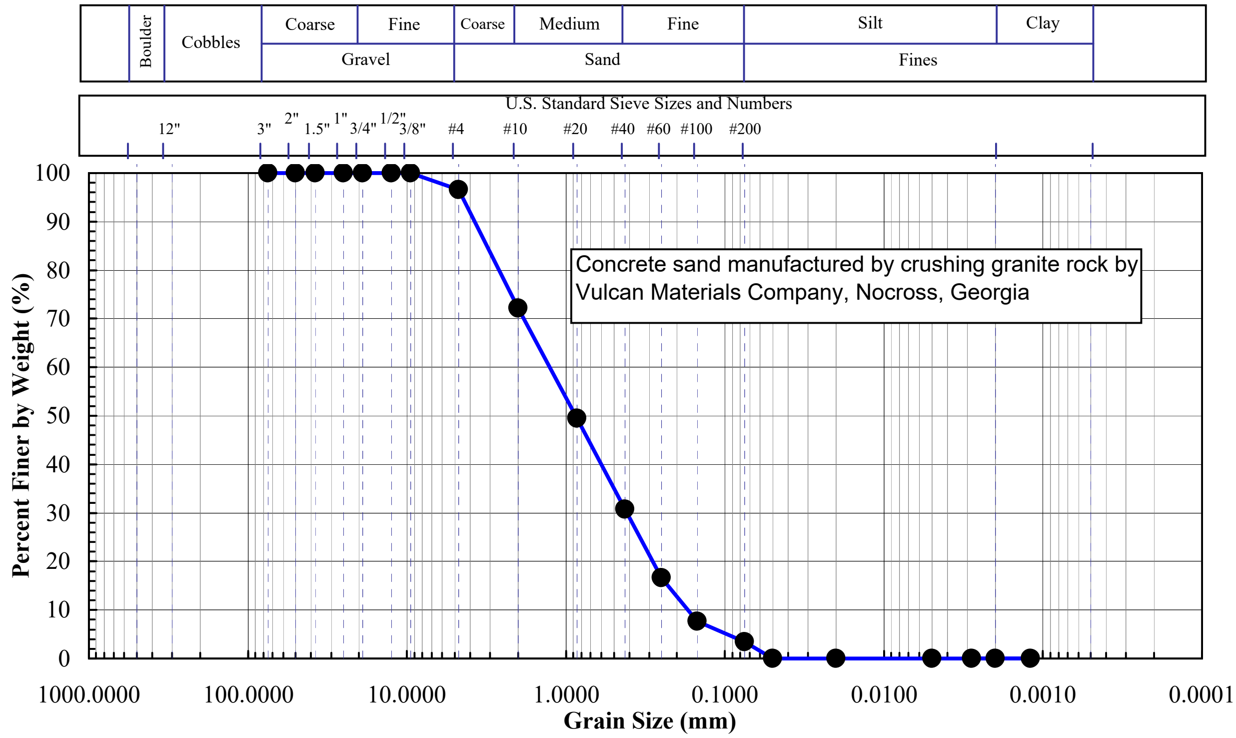
SGI Testing Services, LLC
4405 International Blvd., Suite B-117, Norcross, GA 30093
Ph: (770) 931 8222 Fax: (770) 931 8240

Project Name:	Pullout
Project No:	SGI2019
Client Sample ID:	Concrete Sand
Lab Sample No:	SGISP

ASTM D 2216, D 1140, D 422, C 136, D 4318, D 2487

SOIL INDEX PROPERTIES

Moisture Content, Grain Size, Atterberg Limits, Classification

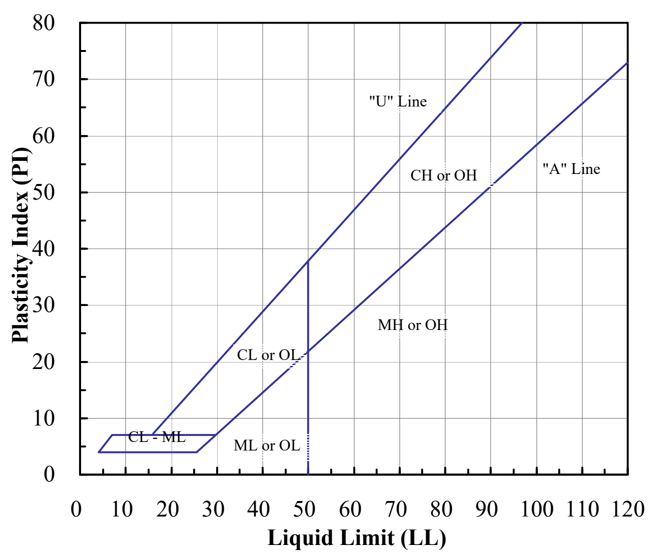


Sieve No.	Size (mm)	% Finer
3"	75	100.0
2"	50	100.0
1.5"	37.5	100.0
1"	25	100.0
3/4"	19	100.0
1/2"	12.5	100.0
3/8"	9.5	100.0
#4	4.75	96.6
#10	2.00	72.1
#20	0.850	49.5
#40	0.425	30.7
#60	0.250	16.6
#100	0.150	7.6
#200	0.075	3.4

Hydrometer Particle Diameter (mm)	% Finer
0.0500	
0.0200	
0.0050	
0.0020	
0.0012	

Gravel (%):	3.4
Sand (%):	93.2
Fines (%):	3.4
Silt (%):	
Clay (%):	

Coeff. Unif. (Cu):	7.4
Coeff. Curv. (Cc):	0.8



Client Sample ID.	Lab Sample No:	Moisture Content (%)	Fines Content < No. 200 (%)	Atterberg Limits LL (%)	PL (%)	PI (-)	Engineering Classification
Concrete Sand	SGISP	-	3.4				SP (Poorly-Graded Sand)

Note(s):

7.8 DESIGN REFERENCE – ANALYSIS AND DESIGN OF VENEER COVER SOILS

Analysis and Design of Veneer Cover Soils

Robert M. Koerner
Professor and Director, Geosynthetic Research Institute, Drexel University, Philadelphia, Pennsylvania, USA

Te-Yang Soong
Research Engineer, Geosynthetic Research Institute, Drexel University, Philadelphia, Pennsylvania, USA

ABSTRACT: The sliding of cover soils on slopes underlain by geosynthetics is obviously an unacceptable situation and, if the number of occurrences becomes excessive, will eventually reflect poorly on the entire technology. Steeply sloped leachate collection layers and final covers of landfills are situations where incidents of such sliding have occurred. Paradoxically, the analytic formulation of the situation is quite straightforward. This paper presents an analysis of the common problem of a veneer of cover soil (0.3 to 1.0 m thick) on a geosynthetic material at a given slope angle and length so as to arrive at a FS-value. The paper then presents different scenarios that create lower FS-values than the gravitational stresses of the above situation, e.g., equipment loads, seepage forces and seismic loads. As a counterpoint, different scenarios that create higher FS-values also are presented, e.g., toe berms, tapered thickness cover soils and veneer reinforcement. In this latter category, a subdivision is made between intentional reinforcement (using geogrids or high strength geotextiles) and nonintentional reinforcement (cases where geosynthetics overlay a weak interface within a multilayered slope). Hypothetical numeric examples are used in each of the above situations to illustrate the various influences on the resulting FS-value. In many cases, design curves are also generated. Suggested minimum FS-values are presented for final closures of landfills, waste piles, leach pads, etc., which are the situations where veneer slides of this type are the most troublesome. Hopefully, the paper will serve as a vehicle to bring a greater awareness to such situations so as to avert slides from occurring in the future.

KEYWORDS: Analysis, Design, Limit Equilibrium Methods, Steep Slopes, Veneer Stability.

1 INTRODUCTION

There have been numerous cover soil stability problems in the past resulting in slides that range from being relatively small (which can be easily repaired), to very large (involving litigation and financial judgments against the parties involved). Furthermore, the number of occurrences appears to have increased over the past few years. Soong and Koerner (1996) report on eight cover soil failures resulting from seepage induced stresses alone. While such slides can occur in transportation and geotechnical applications, it is in the environmental applications area where they are most frequent. Specifically, the sliding of relatively thin cover soil layers (called "veneer") above both geosynthetic and natural soil liners, i.e., geomembranes (GM), geosynthetic clay liners (GCL) and compacted clay liners (CCL) are the particular materials of concern. These situations represent a major challenge due (in part) to the following reasons:

(a) The underlying barrier materials generally represent a low interface shear strength boundary with respect to the soil placed above them.
(b) The liner system is oriented precisely in the direction of potential sliding.
(c) The potential shear planes are usually linear and are essentially uninterrupted along the slope.
(d) Liquid (water or leachate) cannot continue to percolate downward through the cross section due to the presence of the barrier material.

When such slopes are relatively steep, long and uninterrupted in their length (which is the design goal for landfills, waste piles and surface impoundments so as to maximize containment space and minimize land area), the situation is exacerbated.

There are two specific applications in which cover soil stability has been difficult to achieve in light of this discussion.

- Leachate collection soil placed above a GM, GCL and/or CCL along the sides of a landfill before waste is placed and stability achieved accordingly.
- Final cover soil placed above a GM, GCL and/or CCL in the cap or closure of a landfill or waste pile after the waste has been placed to its permitted height.

For the leachate collection soil situation, the time frame is generally short (from months to a few years) and the implications of a slide may be minor in that repairs can oftentimes be done by on-site personnel. For the final cover soil situation, the time frame is invariably long (from decades to centuries) and the implications of a slide can be serious in that repairs often call for a forensic analysis, engineering redesign, separately engaged contractors and quite high remediation costs. These latter cases sometime involve litigation, insurance carriers, and invariably technical experts, thus becoming quite contentious.

Since both situations (leachate collection and final covers) present the same technical issues, the paper will address them simultaneously. It should be realized, however, that the final cover situation is of significantly greater concern.

In the sections to follow, geotechnical engineering considerations will be presented leading to the goal of establishing a suitable factor of safety (FS) against slope instability. A number of common situations will then be analyzed, all of which have the tendency to decrease stability. As a counterpoint, a number of design options will follow, all of which have the objective of increasing stability. A summary and conclusions section will compare the various situations which tend to either create slope instability or aid in slope stability. It is hoped that an increased awareness in the analysis and design details offered herein, and elsewhere in the published literature which is referenced herein, leads to a significant decrease in the number of veneer cover soil slides that have occurred.

2 GEOTECHNICAL ENGINEERING CONSIDERATIONS

As just mentioned, the potential failure surface for veneer cover soils is usually linear with the cover soil sliding with respect to the lowest interface friction layer in the underlying cross section. The potential failure plane being linear allows for a straightforward stability calculation without the need foı trial center locations and different radii as with soil stability problems analyzed by rotational failure surfaces. Furthermore, full static equilibrium can be achieved without solving simultaneous equations or making simplified design assumptions.

2.1 Limit Equilibrium Concepts

The free body diagram of an *infinitely* long slope with uniformly thick cohesionless cover soil on an incipient planar shear surface, like the upper surface of a geomembrane, is shown in Figure 1. The situation can be treated quite simply.

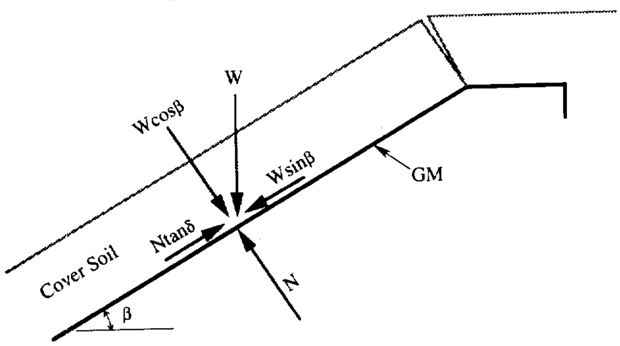


Figure 1. Limit equilibrium forces involved in an infinite slope analysis for a uniformly thick cohesionless cover soil.

By taking force summation parallel to the slope and comparing the resisting force to the driving or mobilizing force, a global factor of safety (FS) results;

$$FS = \frac{\sum \text{Resisting Forces}}{\sum \text{Driving Forces}} = \frac{N \tan\delta}{W \sin\beta} = \frac{W \cos\beta \tan\delta}{W \sin\beta}$$

hence:

$$FS = \frac{\tan\delta}{\tan\beta} \qquad (1)$$

Here it is seen that the FS-value is the ratio of tangents of the interface friction angle of the cover soil against the upper surface of the geomembrane (δ), and the slope angle of the soil beneath the geomembrane (β). As simple as this analysis is, its teachings are very significant, for example:

- To obtain an accurate FS-value, an accurately determined laboratory δ-value is absolutely critical. The accuracy of the final analysis is only as good as the accuracy of the laboratory obtained δ-value.
- For low δ-values, the resulting soil slope angle will be proportionately low. For example, for a δ-value of 20 deg., and a required FS-value of 1.5, the maximum slope angle is 14 deg. This is equivalent to a 4(H) on 1(V) slope which is relatively low. Furthermore, many geosynthetics have even lower δ-values than 20 deg.
- This simple formula has driven geosynthetic manufacturers to develop products with high δ-values, e.g., textured geomembranes, thermally bonded drainage geocomposites, internally reinforced GCLs, etc.

Unfortunately, the above analysis is too simplistic to use in most realistic situations. For example, the following situations cannot be accommodated:

- A finite length slope with the incorporation of a passive soil wedge at the toe of the slope
- The consideration of equipment loads on the slope
- Consideration of seepage forces within the cover soil
- Consideration of seismic forces acting on the cover soil
- The use of soil masses acting as toe berms
- The use of tapered covered soil thicknesses
- Reinforcement of the cover soil using geogrids or high strength geotextiles

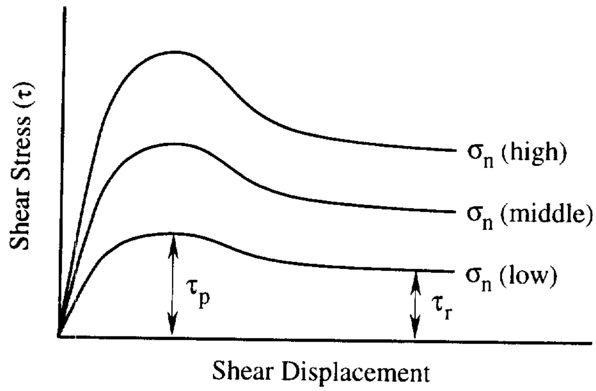
These specific situations will be treated in subsequent sections. For each situation, the essence of the theory will be presented, followed by the necessary design equations. This will be followed, in each case, with a design graph and a numeric example. First, however, the important issue of interface shear testing will be discussed.

2.2 Interface Shear Testing

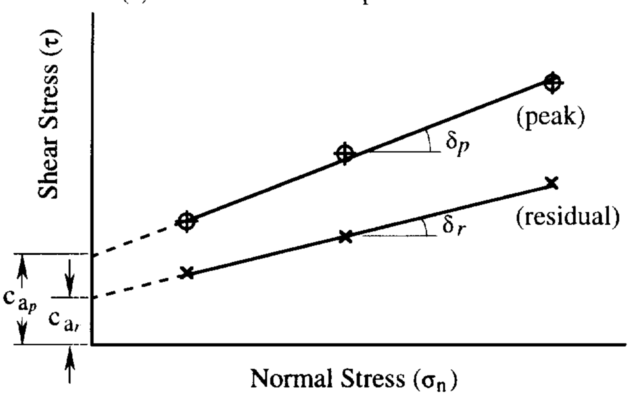
The interface shear strength of a cover soil with respect to the underlying material (often a geomembrane) is critical so as to properly analyze the stability of the cover soil. This value of interface shear strength is obtained by laboratory testing of the project specific materials at the site specific conditions. By project specific materials, we mean sampling of the candidate geosynthetics to be used at the site, as well as the cover soil at its targeted density and moisture conditions. By site specific conditions we mean normal stresses, strain rates, peak or residual shear strengths and temperature extremes (high and/or low). Note that it is completely inappropriate to use values of interface shear strengths from the literature for final design.

While the above list of items is formidable, at least the type of test is established. It is the direct shear test which has been utilized in geotechnical engineering testing for many years. The test has been adapted to evaluate geosynthetics in the USA as ASTM D5321 and in Germany as DIN 60500.

In conducting a direct shear test on a specific interface, one typically performs three replicate tests with the only variable being different values of normal stress. The middle value is usually targeted to the site specific condition, with a lower and higher value of normal stress covering the range of possible values. These three tests result in a set of shear displacement versus shear stress curves, see Figure 2a. From each curve, a peak shear strength (τ_p) and a residual shear strength (τ_r) are obtained. As a next step, these shear strength values, together with their respective normal stress values, are plotted on Mohr-Coulomb stress space to obtain the shear strength parameters of friction and adhesion, see Figure 2b.



(a) Direct shear test experimental data



(b) Resulting behavior on Mohr - Coulomb stress space

Figure 2. Direct shear test results and analysis procedure to obtain shear strength parameters.

The points are then connected (usually with a straight line), and the two fundamental shear strength parameters are obtained. These shear strength parameters are:

δ = the angle of shearing resistance, peak and/or residual, of the two opposing surfaces (often called the interface friction angle)

c_a = the adhesion of the two opposing surfaces, peak and/or residual (synonymous with cohesion when testing fine grained soils against one another)

Each set of parameters constitute the equation of a straight line which is the Mohr-Coulomb failure criterion common to geotechnical engineering. The concept is readily adaptable to geosynthetic materials in the following form:

$$\tau_p = c_{ap} + \sigma_n \tan \delta_p \quad (2a)$$

$$\tau_r = c_{ar} + \sigma_n \tan \delta_r \quad (2b)$$

The upper limit of "δ" when soil is involved as one of the interfaces is "ϕ", the angle of shearing resistance of the soil component. The upper limit of the "c_a" value is "c", the cohesion of the soil component. In the slope stability analyses to follow, the "c_a" term will be included for the sake of completeness, but then it will be neglected (as being a conservative assumption) in the design graphs and numeric examples. To utilize an adhesion value, there must be a clear physical justification for use of such values when geosynthetics are involved. Some unique situations such as textured geomembranes with physical interlocking of soils having cohesion, or the bentonite component of a GCL are valid reasons for including such a term.

Note that residual strengths are equal, or lower, than peak strengths. The amount of difference is very dependent on the material and no general guidelines can be given. Clearly, material specific and site specific direct shear tests must be performed to determine the appropriate values. Further, each direct shear test must be conducted to a relatively large displacement to determine the residual behavior, see Stark and Poeppel (1994). The decision as to the use of peak or residual strengths in the subsequent analysis is a very subjective one. It is both a materials specific and site specific issue which is left up to the designer and/or regulator. Even further, the use of peak values at the crest of a slope and residual values at the toe may be justified. As such, the analyses to follow will use an interface δ-value with no subscript thereby concentrating on the computational procedures rather than this particular detail. However, the importance of an appropriate and accurate δ-value should not be minimized.

Due to the physical structure of many geosynthetics, the size of the recommended shear box is quite large. It must be at least 300 mm by 300 mm unless it can be shown that data generated by a smaller device contains no scale or edge effects, i.e., that no bias exists with a smaller shear box. The implications of such a large shear box should not be taken lightly. Some issues which should receive particular attention are the following:

- Unless it can be justified otherwise, the interface will usually be tested in a saturated state. Thus complete and uniform saturation over the entire specimen area must be achieved. This is particularly necessary for CCLs and GCLs, Daniel, et al. (1993). Hydration takes relatively long in comparison to soils in conventional (smaller) testing shear boxes.
- Consolidation of soils (including CCLs and GCLs) in larger shear boxes is similarly affected.
- Uniformity of normal stress over the entire area must be maintained during consolidation and shearing so as to avoid stress concentrations from occurring.
- The application of relatively low normal stresses, e.g., 10, to 30 kPa simulating typical cover soil thicknesses, challenges the accuracy of some commercially available shear box setups and monitoring systems, particularly the accuracy of pressure gages.

- The issue of appropriate normal stress is greatly complicated if gas pressures are generated in the underlying waste. These gas pressures will counteract some (or all) of the gravitational stress of the cover soil. The resulting shear strength, and subsequent stability, can be significantly decreased. See Liu et al (1997) for insight into this possibility.
- Shear rates necessary to attain drained conditions (if this is the desired situation) are extremely slow, requiring long testing times.
- Deformations necessary to attain residual strengths require large relative movement of the two respective halves of the shear box. So as not to travel over the edges of the opposing shear box sections, devices should have the lower shear box significantly longer than 300 mm. However, with a lower shear box longer than the upper traveling section, new surface is constantly being added to the shearing plane. This influence is not clear in the material's response or in the subsequent behavior.
- The attainment of a true residual strength is difficult to achieve. ASTM D5321 states that one should "run the test until the applied shear force remains constant with increasing displacement". Many commercially available shear boxes have insufficient travel to reach this condition.
- The ring torsion shearing apparatus is an alternative device to determine true residual strength values, but is not without its own problems. Some outstanding issues are the small specimen size, nonuniform shear rates along the width of the specimen, anisotropic shearing with some geosynthetics and no standardized testing protocol. See Stark and Poeppel (1994) for information and data using this alternative test method.

2.3 Various Types of Loadings

There are a large variety of slope stability problems that may be encountered in analyzing and/or designing final covers of engineered landfills, abandoned dumps and remediation sites as well as leachate collection soils covering geomembranes beneath the waste. Perhaps the most common situation is a uniformly thick cover soil on a geomembrane placed over the soil subgrade at a given and constant slope angle. This "standard" problem will be analyzed in the next section. A variation of this problem will include equipment loads used during placement of cover soil on the geomembrane. This problem will be solved with equipment moving up the slope and then moving down the slope.

Unfortunately, cover soil slides have occurred and it is felt that the majority of the slides have been associated with seepage forces. Indeed, drainage above a geomembrane (or other barrier material) in the cover soil cross section must be accommodated to avoid the possibility of seepage forces. A section will be devoted to this class of slope stability problems.

Lastly, the possibility of seismic forces exists in earthquake prone locations. If an earthquake occurs in the vicinity of an engineered landfill, abandoned dump or remediation site, the seismic wave travels through the solid waste mass reaching the upper surface of the cover. It then decouples from the cover soil materials, producing a horizontal force which must be appropriately analyzed. A section will be devoted to the seismic aspects of cover soil slope analysis as well.

All of the above actions are destabilizing forces tending to cause slope instability. Fortunately, there are a number of actions that can be taken to increase the stability of slopes.

Other than geometrically redesigning the slope with a flatter slope angle or shorter slope length, a designer can add soil mass at the toe of the slope thereby enhancing stability. Both toe berms and tapered soil covers are available options and will be analyzed accordingly. Alternatively, the designer can always use geogrids or high strength geotextiles within the cover soil acting as reinforcement materials. This technique is usually referred to as veneer reinforcement. Cases of both intentional and nonintentional veneer reinforcement will be presented.

Thus it is seen that a number of strategies influence slope stability. Each will be described in the sections to follow. First, the basic gravitational problem will be presented followed by those additional loading situations which tend to decrease slope stability. Second, various actions that can be taken by the designer to increase slope stability will be presented. The summary will contrast the FS-values obtained in the similarly crafted numeric examples.

3 SITUATIONS CAUSING DESTABILIZATION OF SLOPES

This section treats the standard veneer slope stability problem and then superimposes upon it a number of situations, all of which tend to destabilize slopes. Included are gravitational, construction equipment, seepage and seismic forces. Each will be illustrated by a design graph and a numeric example.

3.1 Cover Soil (Gravitational) Forces

Figure 3 illustrates the common situation of a *finite* length, uniformly thick cover soil placed over a liner material at a slope angle "β". It includes a passive wedge at the toe and has a tension crack of the crest. The analysis that follows is after Koerner and Hwu (1991), but comparable analyses are available from Giroud and Beech (1989), McKelvey and Deutsch (1991), Ling and Leshchinsky (1997) and others.

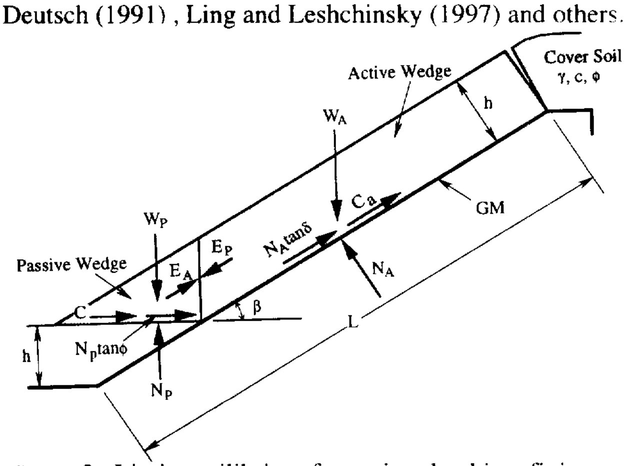


Figure 3. Limit equilibrium forces involved in a finite length slope analysis for a uniformly thick cover soil.

The symbols used in Figure 3 are defined below.

W_A = total weight of the active wedge
W_P = total weight of the passive wedge
N_A = effective force normal to the failure plane of the active wedge
N_P = effective force normal to the failure plane of the passive wedge
γ = unit weight of the cover soil
h = thickness of the cover soil
L = length of slope measured along the geomembrane
β = soil slope angle beneath the geomembrane
ϕ = friction angle of the cover soil
δ = interface friction angle between cover soil and geomembrane
C_a = adhesive force between cover soil of the active wedge and the geomembrane
c_a = adhesion between cover soil of the active wedge and the geomembrane
C = cohesive force along the failure plane of the passive wedge
c = cohesion of the cover soil
E_A = interwedge force acting on the active wedge from the passive wedge
E_P = interwedge force acting on the passive wedge from the active wedge
FS = factor of safety against cover soil sliding on the geomembrane

The expression for determining the factor of safety can be derived as follows:

Considering the active wedge,

$$W_A = \gamma h^2\left(\frac{L}{h} - \frac{1}{\sin\beta} - \frac{\tan\beta}{2}\right) \tag{3}$$

$$N_A = W_A \cos\beta \tag{4}$$

$$C_a = c_a\left(L - \frac{h}{\sin\beta}\right) \tag{5}$$

By balancing the forces in the vertical direction, the following formulation results:

$$E_A \sin\beta = W_A - N_A \cos\beta - \frac{N_A \tan\delta + C_a}{FS}\sin\beta \tag{6}$$

Hence the interwedge force acting on the active wedge is:

$$E_A = \frac{(FS)(W_A - N_A\cos\beta) - (N_A\tan\delta + C_a)\sin\beta}{\sin\beta(FS)} \tag{7}$$

The passive wedge can be considered in a similar manner:

$$W_P = \frac{\gamma h^2}{\sin 2\beta} \tag{8}$$

$$N_p = W_P + E_P \sin\beta \tag{9}$$

$$C = \frac{(c)(h)}{\sin\beta} \tag{10}$$

By balancing the forces in the horizontal direction, the following formulation results:

$$E_P \cos\beta = \frac{C + N_P \tan\phi}{FS} \tag{11}$$

Hence the interwedge force acting on the passive wedge is:

$$E_P = \frac{C + W_P\tan\phi}{\cos\beta(FS) - \sin\beta\tan\phi} \tag{12}$$

By setting $E_A = E_P$, the resulting equation can be arranged in the form of the quadratic equation $ax^2 + bx + c = 0$ which in our case, using FS-values, is:

$$a(FS)^2 + b(FS) + c = 0 \tag{13}$$

where

$$a = (W_A - N_A\cos\beta)\cos\beta$$
$$b = -\left[(W_A - N_A\cos\beta)\sin\beta\tan\phi + (N_A\tan\delta + C_a)\sin\beta\cos\beta + \sin\beta(C + W_P\tan\phi)\right]$$
$$c = (N_A\tan\delta + C_a)\sin^2\beta\tan\phi \tag{14}$$

The resulting FS-value is then obtained from the solution of the quadratic equation:

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a} \tag{15}$$

When the calculated FS-value falls below 1.0, sliding of the cover soil on the geomembrane is to be anticipated. Thus a value of greater than 1.0 must be targeted as being the minimum factor of safety. How much greater than 1.0 the FS-value should be, is a design and/or regulatory issue. The issue of minimum allowable FS-values under different conditions will be assessed at the end of the paper. In order to better illustrate the implications of Eqs. 13, 14 and 15, typical design curves for various FS-values as a function of slope angle and interface friction angle are given in Figure 4. Note that the curves are developed specifically for the variables stated in the legend of the figure. Example 1 illustrates the use of the curves in what will be the standard example to which other examples will be compared.

Example 1:
Given a 30 m long slope with a uniformly thick 300 mm cover soil at a unit weight of 18 kN/m^3. The soil has a friction angle of 30 deg. and zero cohesion, i.e., it is a sand. The cover soil is placed directly on a geomembrane as shown in Figure 3. Direct shear testing has resulted in a interface friction angle between the cover soil and geomembrane of 22 deg. with zero adhesion. What is the FS-value at a slope angle of 3(H)-to-1(V), i.e., 18.4 deg?

Solution:

Substituting Eq. 14 into Eq. 15 and solving for the FS-value results in the following which is seen to be in agreement with the curves of Figure 4.

$$\left.\begin{array}{l} a = 14.7\,\text{kN/m} \\ b = -21.3\,\text{kN/m} \\ c = 3.5\,\text{kN/m} \end{array}\right\} \quad FS = 1.25$$

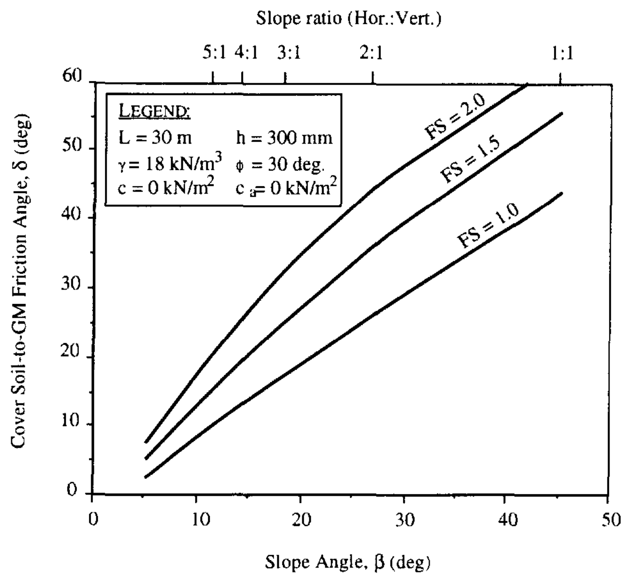


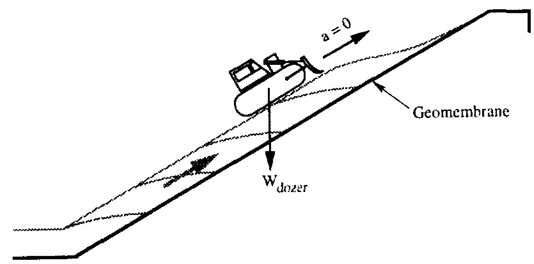
Figure 4. Design curves for stability of uniform thickness cohesionless cover soils on linear failure planes for various global factors-of-safety.

Comment:
In general, this is too low of a value for a final cover soil factor-of-safety and a redesign is necessary. While there are many possible options of changing the geometry of the situation, the example will be revisited later in this section using toe berms, tapered cover soil thickness and veneer reinforcement. Furthermore, this general problem will be used throughout the main body of this paper for comparison purposes to other cover soil slope stability situations.

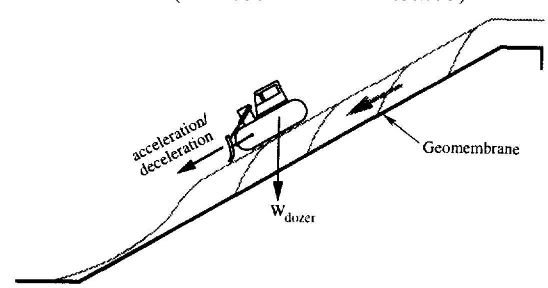
3.2 Tracked Construction Equipment Forces

The placement of cover soil on a slope with a relatively low shear strength inclusion (like a geomembrane) should always be from the toe upward to the crest. Figure 5a shows the recommended method. In so doing, the gravitational forces of the cover soil and live load of the construction equipment are compacting previously placed soil and working with an ever present passive wedge and stable lower-portion beneath the active wedge. While it is necessary to specify low ground pressure equipment to place the soil, the reduction of the FS-value for this situation of equipment working up the slope will be seen to be relatively small.

For soil placement down the slope, however, a stability analysis cannot rely on toe buttressing and also a dynamic stress should be included in the calculation. These conditions decrease the FS-value and in some cases to a great extent. Figure 5b shows this procedure. Unless absolutely necessary, it is not recommended to place cover soil on a slope in this manner. If it is necessary, the design must consider the unsupported soil mass and the dynamic force of the specific type of construction equipment and its manner of operation.



(a) Equipment backfilling up slope
(the recommended method)



(b) Equipment backfilling down slope
(method is not recommended)

Figure 5. Construction equipment placing cover soil on slopes containing geosynthetics.

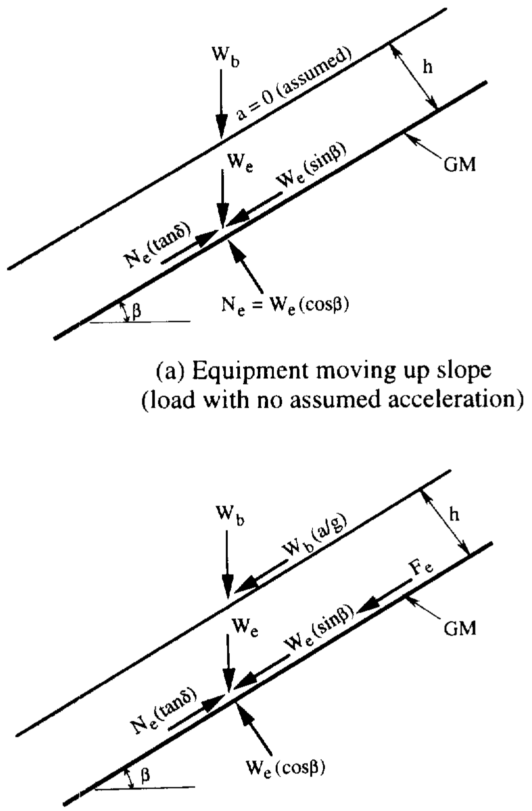
For the first case of a bulldozer pushing cover soil up from the toe of the slope to the crest, the analysis uses the free body diagram of Figure 6a. The analysis uses a specific piece of tracked construction equipment (like a bulldozer characterized by its ground contact pressure) and dissipates this force or stress through the cover soil thickness to the surface of the geomembrane. A Boussinesq analysis is used, see Poulos and Davis (1974). This results in an equipment force per unit width as follows:

$$W_e = q\,w\,I \qquad (16)$$

where

W_e = equivalent equipment force per unit width at the geomembrane interface
q = $W_b / (2 \times w \times b)$

W_b = actual weight of equipment (e.g., a bulldozer)
w = length of equipment track
b = width of equipment track
I = influence factor at the geomembrane interface see Figure 7



(a) Equipment moving up slope (load with no assumed acceleration)

(b) Equipment moving down slope (load plus acceleration or deceleration)

Figure 6. Additional (to gravitational forces) limit equilibrium forces due to construction equipment moving on cover soil (see Figure 3 for the gravitational soil force to which the above forces are added).

Upon determining the additional equipment force at the cover soil-to-geomembrane interface, the analysis proceeds as described in Section 3.1 for gravitational forces only. In essence, the equipment moving up the slope adds an additional term, W_e, to the W_A-force in Eq. 3. Note, however, that this involves the generation of a resisting force as well. Thus, the net effect of increasing the driving force as well as the resisting force is somewhat neutralized insofar as the resulting FS-value is concerned. It should also be noted that no acceleration/deceleration forces are included in this analysis which is somewhat optimistic. Using these concepts (the same equations used in Section 3.1 are used here), typical design curves for various FS-values as a function of equivalent ground contact equipment pressures and cover soil thicknesses are given in Figure 8. Note that the curves are developed specifically for the variables stated in the legend. Example 2a illustrates the use of the formulation.

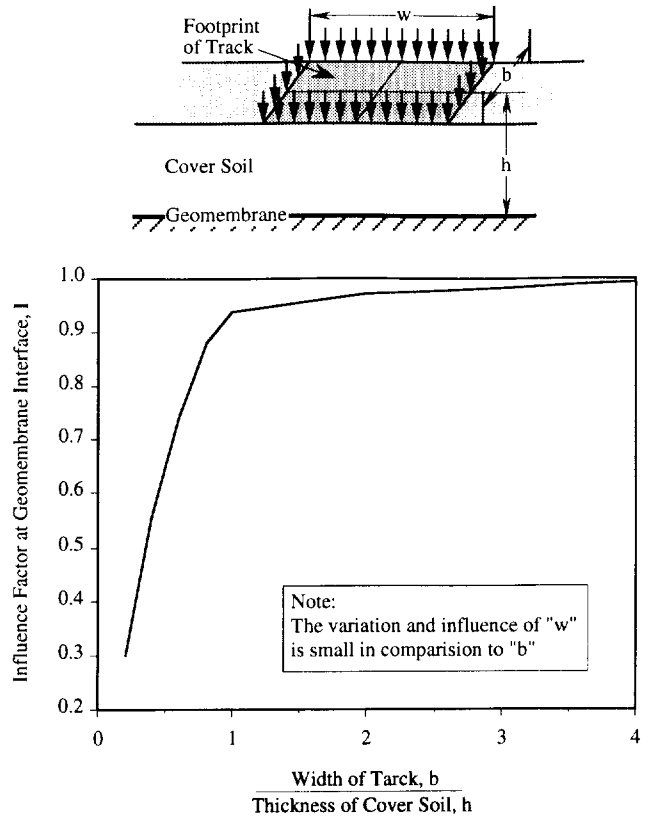


Figure 7. Values of influence factor, "I", for use in Eq. 16 to dissipate surface force of tracked equipment through the cover soil to the geomembrane interface, after Poulos and Davis (1974).

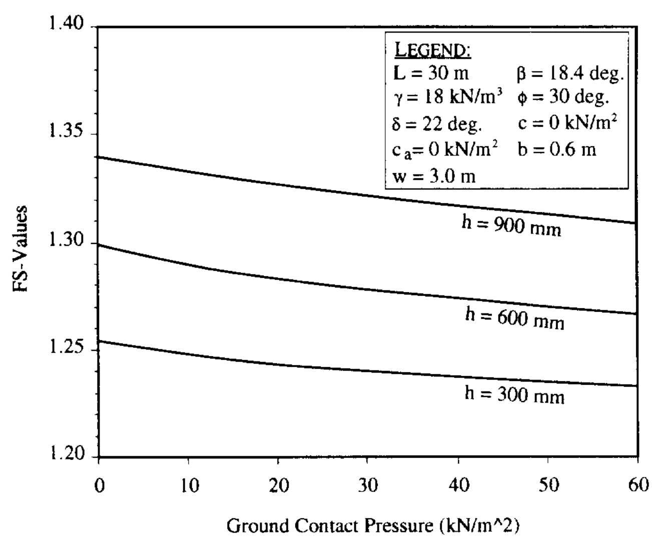


Figure 8. Design curves for stability of different thickness of cover soil for various values of tracked ground contact pressure construction equipment.

Example 2a:

Given 30 m long slope with uniform cover soil of 300 mm thickness at a unit weight of 18 kN/m³. The soil has a friction angle of 30 deg. and zero cohesion, i.e., it is a sand. It is placed on the slope using a bulldozer moving from the toe of the slope up to the crest. The bulldozer has a ground pressure of 30 kN/m² and tracks that are 3.0 m long and 0.6 m wide. The cover soil to geomembrane friction angle is 22 deg. with zero adhesion. What is the FS-value at a slope angle of 3(H)-to-1(V), i.e., 18.4 deg.

Solution:
This problem follows Example 1 exactly except for the addition of the bulldozer moving up the slope. Using the additional equipment load Eq. 16, substituted into Eqs. 14 and 15 results in the following.

$$\left.\begin{aligned} a &= 73.1\,\mathrm{kN/m} \\ b &= -104.3\,\mathrm{kN/m} \\ c &= 17.0\,\mathrm{kN/m} \end{aligned}\right\} \mathrm{FS} = 1.24$$

Comment:
While the resulting FS-value is low, the result is best assessed by comparing it to Example 1, i.e., the same problem except without the bulldozer. It is seen that the FS-value has only decreased from 1.25 to 1.24. Thus, in general, a low ground contact pressure bulldozer placing cover soil up the slope with negligible acceleration/ deceleration forces does not significantly decrease the factor-of-safety.

For the second case of a bulldozer pushing cover soil down from the crest of the slope to the toe as shown in Figure 5b, the analysis uses the force diagram of Figure 6b. While the weight of the equipment is treated as just described, the lack of a passive wedge along with an additional force due to acceleration (or deceleration) of the equipment significantly changes the resulting FS-values. This analysis again uses a specific piece of construction equipment operated in a specific manner. It produces a force parallel to the slope equivalent to W_b (a/g), where W_b = the weight of the bulldozer, a = acceleration of the bulldozer and g = acceleration due to gravity. Its magnitude is equipment operator dependent and related to both the equipment speed and time to reach such a speed, see Figure 9. A similar behavior will be seen for deceleration.

The acceleration of the bulldozer, coupled with an influence factor "I" from Figure 7, results in the dynamic force per unit width at the cover soil to geomembrane interface, "F_e". The relationship is as follows:

$$F_e = W_e\left(\frac{a}{g}\right) \tag{17}$$

where

F_e = dynamic force per unit width parallel to the slope at the geomembrane interface,

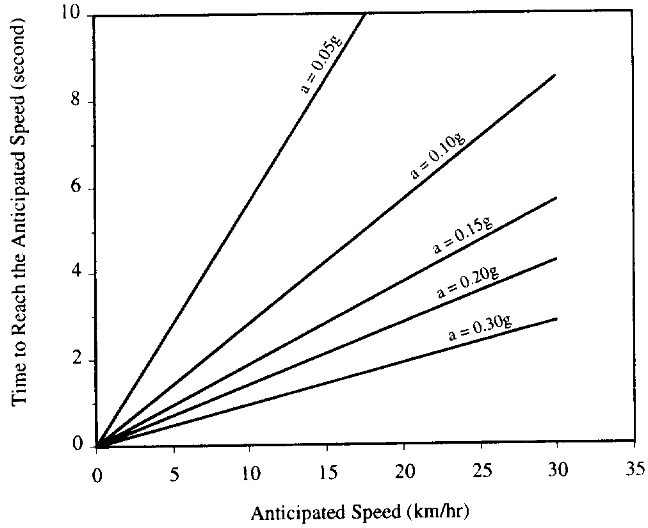


Figure 9. Graphic relationship of construction equipment speed and rise time to obtain equipment acceleration.

W_e = equivalent equipment (bulldozer) force per unit width at geomembrane interface, recall Eq. 16.
β = soil slope angle beneath geomembrane
a = acceleration of the bulldozer
g = acceleration due to gravity

Using these concepts, the new force parallel to the cover soil surface is dissipated through the thickness of the cover soil to the interface of the geomembrane. Again, a Boussinesq analysis is used, see Poulos and Davis (1974). The expression for determining the FS-value can now be derived as follows:

Considering the active wedge, and balancing the forces in the direction parallel to the slope, the following formulation results:

$$E_A + \frac{(N_e + N_A)\tan\delta + C_a}{FS} = (W_A + W_e)\sin\beta + F_e \tag{18}$$

where

N_e = effective equipment force normal to the failure plane of the active wedge

$$= W_e\cos\beta \tag{19}$$

Note that all the other symbols have been previously defined.

The interwedge force acting on the active wedge can down be expressed as:

$$E_A = \frac{(FS)\left[(W_A + W_e)\sin\beta + F_e\right]}{FS} - \frac{\left[(N_e + N_A)\tan\delta + C_a\right]}{FS} \tag{20}$$

The passive wedge can be treated in a similar manner. The following formulation of the interwedge force acting on the passive wedge results:

$$E_P = \frac{C + W_P \tan\phi}{\cos\beta(FS) - \sin\beta\tan\phi} \tag{21}$$

By setting $E_A = E_P$, the following equation can be arranged in the form of Eq. 13 in which the "a", "b" and "c" terms are as follows:

$$a = \left[(W_A + W_e)\sin\beta + F_e\right]\cos\beta$$

$$b = -\left\{\left[(N_e + N_A)\tan\delta + C_a\right]\cos\beta + \left[(W_A + W_e)\sin\beta + F_e\right]\sin\beta\tan\phi + (C + W_P\tan\phi)\right\}$$

$$c = \left[(N_e + N_A)\tan\delta + C_a\right]\sin\beta\tan\phi \tag{22}$$

Finally, the resulting FS-value can be obtained using Eq. 15. Using these concepts, typical design curves for various FS-values as a function of equipment ground contact pressure and equipment acceleration can be developed, see Figure 10. Note that the curves are developed specifically for the variables stated in the legend. Example 2b illustrates the use of the formulation.

Example 2b:

Given a 30 m long slope with uniform cover soil of 300 mm thickness at a unit weight of 18 kN/m^3. The soil has a friction angle of 30 deg. and zero cohesion, i.e., it is a sand. It is placed on the slope using a bulldozer moving from the crest of the slope down to the toe. The bulldozer has a ground contact pressure of 30 kN/m^2 and tracks that are 3.0 m long and 0.6 m wide. The estimated equipment speed is 20 km/hr and the time to reach this speed is 3.0 sec. The cover soil to geomembrane friction angle is 22 deg. with zero adhesion. What is the FS-value at a slope angle of 3(H)-to-1(V), i.e., 18.4 deg.

Solution:

Using the design curves of Figure 10 along with Eqs. 22 substituted into Eq. 15 the solution can be obtained:

- From Figure 9 at 20 km/hr and 3.0 sec. the bulldozer's acceleration is 0.19g.
- From Eq. 22 substituted into Eq. 15 we obtain

$$\left.\begin{array}{l} a = 88.8\,\text{kN/m} \\ b = -107.3\,\text{kN/m} \\ c = 17.0\,\text{kN/m} \end{array}\right\} \quad FS = 1.03$$

Comment:

This problem solution can now be compared to the previous two examples:

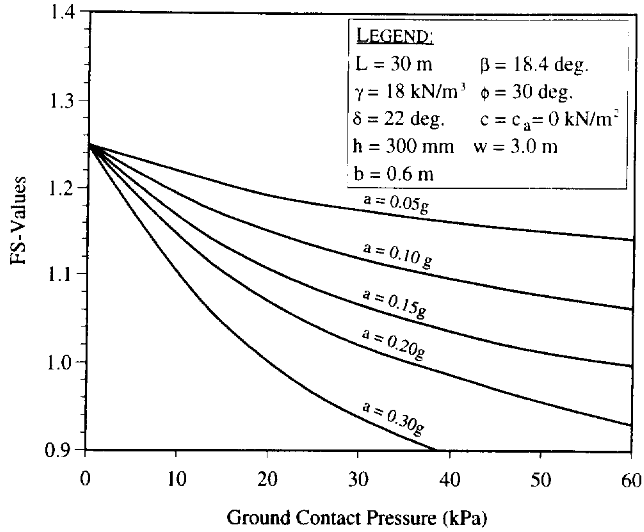


Figure 10. Design curves for stability of different construction equipment ground contact pressure for various equipment accelerations.

Ex. 1:	cover soil alone with no bulldozer loading	FS = 1.25
Ex. 2a:	cover soil plus bulldozer moving up slope	FS = 1.24
Ex. 2b:	cover soil plus bulldozer moving down slope	FS = 1.03

The inherent danger of a bulldozer moving down the slope is readily apparent. Note, that the same result comes about by the bulldozer decelerating instead of accelerating. The sharp breaking action of the bulldozer is arguable the more severe condition due to the extremely short times involved when stopping forward motion. Clearly, only in unavoidable situations should the cover soil placement equipment be allowed to work down the slope. If it is unavoidable, an analysis should be made of the specific stability situation and the construction specifications should reflect the exact conditions made in the design. The maximum allowable weight and ground contact pressure of the equipment should be stated along with suggested operator movement of the cover soil placement operations. Truck traffic on the slopes can also give as high, or even higher, stresses and should be avoided unless adequately designed. Additional detail is given in McKelvey (1994). The issue of access ramps is a unique subset of this example and one which deserves focused attention due to the high loads and decelerations that often occur.

3.3 Consideration of Seepage Forces

The previous sections presented the general problem of slope stability analysis of cover soils placed on slopes under different conditions. The tacit assumption throughout was that either permeable soil or a drainage layer was placed above the barrier layer with adequate flow capacity to efficiently remove permeating water safely way from the cross section. The amount of water to be removed is obviously a site specific situation. Note that in extremely arid areas, or with very low permeability cover soils drainage may not be required although this is generally the exception.

Unfortunately, adequate drainage of final covers has sometimes not been available and seepage induced slope stability problems have occurred. The following situations have resulted in seepage induced slides:

- Drainage soils with hydraulic conductivity (permeability) too low for site specific conditions.
- Inadequate drainage capacity at the toe of long slopes where seepage quantities accumulate and are at their maximum.
- Fines from quarried drainage stone either clogging the drainage layer or accumulating at the toe of the slope thereby decreasing the as-constructed permeability over time.
- Fine, cohesionless, cover soil particles migrating through the filter (if one is present) either clogging the drainage layer, or accumulating at the toe of the slope thereby decreasing the as-constructed outlet permeability over time.
- Freezing of the drainage layer at the toe of the slope, while the soil covered top of the slope thaws, thereby mobilizing seepage forces against the ice wedge at the toe.

If seepage forces of the types described occur, a variation in slope stability design methodology is required. Such an analysis is the focus of this subsection. Note that additional discussion is given in Cancelli and Rimoldi (1989), Thiel and Stewart (1993) and Soong and Koerner (1996).

Consider a cover soil of uniform thickness placed directly above a geomembrane at a slope angle of "β" as shown in Figure 11. Different from previous examples, however, is that within the cover soil exists a saturated soil zone for part or all of the thickness. The saturated boundary is shown as two possibly different phreatic surface orientations. This is because seepage can be built-up in the cover soil in two different ways: a horizontal buildup from the toe upward or a parallel-to-slope buildup outward. These two hypotheses are defined and quantified as a horizontal submergence ratio (HSR) and a parallel submergence ratio (PSR). The dimensional definitions of both ratios are given in Figure 11.

When analyzing the stability of slopes using the limit equilibrium method, free body diagrams of the passive and active wedges are taken with the appropriate forces (now including pore water pressures) being applied. The formulation for the resulting factor-of-safety, for horizontal seepage buildup and then for parallel-to-slope seepage buildup, follows.

<u>The Case of the Horizontal Seepage Buildup</u>. Figure 12 shows the free body diagram of both the active and passive wedge assuming horizontal seepage. Horizontal seepage buildup can occur when toe blockage occurs due to inadequate outlet capacity, contamination or physical blocking of outlets, or freezing conditions at the outlets.

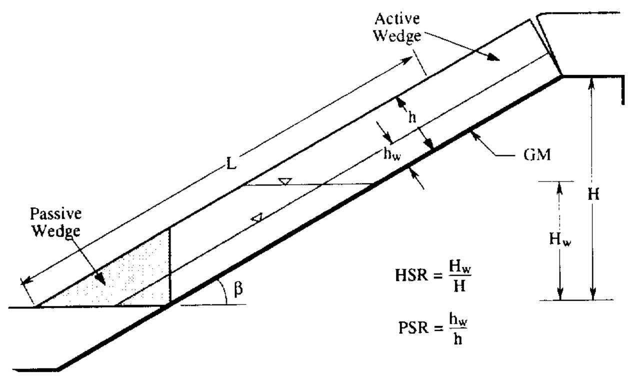


Figure 11. Cross section of a uniform thickness cover soil on a geomembrane illustrating different submergence assumptions and related definitions, Soong and Koerner (1996).

All symbols used in Figure 12 were previously defined except the following:

$\gamma_{sat'd}$ = saturated unit weight of the cover soil
γ_t = total (moist) unit weight of the cover soil
γ_w = unit weight of water
H = vertical height of the slope measured from the toe
H_w = vertical height of the free water surface measured from the toe
U_h = resultant of the pore pressures acting on the interwedge surfaces
U_n = resultant of the pore pressures acting perpendicular to the slope
U_v = resultant of the vertical pore pressures acting on the passive wedge

The expression for finding the factor-of-safety can be derived as follows:

Considering the active wedge,

$$W_A = \left(\frac{\gamma_{sat'd}(h)(2H_w \cos\beta - h)}{\sin 2\beta}\right) + \left(\frac{\gamma_t(h)(H - H_w)}{\sin\beta}\right) \quad (23)$$

$$U_n = \frac{\gamma_w(h)(\cos\beta)(2H_w \cos\beta - h)}{\sin 2\beta} \quad (24)$$

$$U_h = \frac{\gamma_w h^2}{2} \quad (25)$$

$$N_A = W_A(\cos\beta) + U_h(\sin\beta) - U_n \quad (26)$$

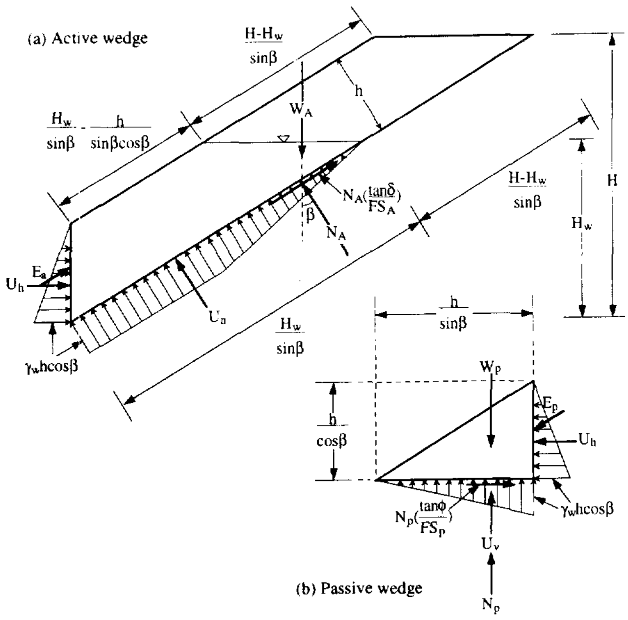


Figure 12. Limit equilibrium forces involved in a finite length slope of uniform cover soil with horizontal seepage buildup.

The interwedge force acting on the active wedge can then be expressed as:

$$E_A = W_A \sin\beta - U_h \cos\beta - \frac{N_A \tan\delta}{FS} \qquad (27)$$

The passive wedge can be considered in a similar manner and the following expressions result:

$$W_P = \frac{\gamma_{sat'd} h^2}{\sin 2\beta} \qquad (28)$$

$$U_V = U_h \cot\beta \qquad (29)$$

The interwedge force acting on the passive wedge can then be expressed as:

$$E_P = \frac{U_h(FS) - (W_P - U_V)\tan\phi}{\sin\beta\tan\phi - \cos\beta(FS)} \qquad (30)$$

By setting $E_A = E_P$, the following equation can be arranged in the form of $ax^2 + bx + c = 0$ which in this case is:

$$a(FS)^2 + b(FS) + c = 0 \qquad (13)$$

where

$$a = W_A \sin\beta\cos\beta - U_h \cos^2\beta + U_h$$

$$b = -W_A \sin^2\beta\tan\phi + U_h \sin\beta\cos\beta\tan\phi - N_A \cos\beta\tan\delta - (W_P - U_V)\tan\phi$$

$$c = N_A \sin\beta\tan\delta\tan\phi \qquad (31)$$

As with previous solution, the resulting FS-value is obtained using Eq. 15.

<u>The Case of Parallel-to-Slope Seepage Buildup</u>. Figure 13 shows the free body diagrams of both the active and passive wedges with seepage buildup in the direction parallel to the slope. Parallel seepage buildup can occur when soils placed above a geomembrane are initially too low in their hydraulic conductivity, or become too low due to long-term clogging from overlying soils which do not have a filter. Identical symbols as defined in the previous cases are used here with an additional definition of h_w equal to the height of free water surface measured in the direction perpendicular to the slope.

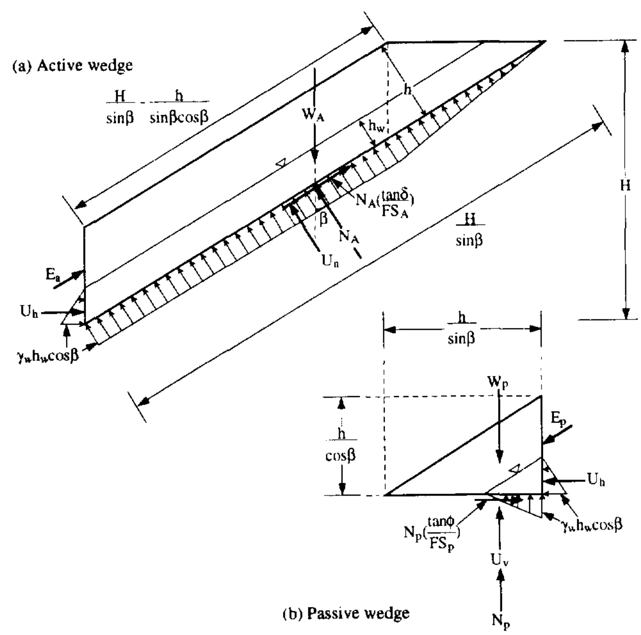


Figure 13. Limit equilibrium forces involved in a finite length slope of uniform cover soil with parallel-to-slope seepage buildup.

Note that the general expression of factor-of-safety shown in Eq. 15 is still valid. However, the a, b and c terms given in Eq. 31 have different definitions in this case owing to the new definitions of the following terms:

$$W_A = \frac{\gamma_t(h-h_w)(2H\cos\beta-(h+h_w))}{\sin 2\beta} + \frac{\gamma_{sat'd}(h_w)(2H\cos\beta - h_w)}{\sin 2\beta} \quad (32)$$

$$U_n = \frac{\gamma_w h_w \cos\beta(2H\cos\beta - h_w)}{\sin 2\beta} \quad (33)$$

$$U_h = \frac{\gamma_w (h_w)^2}{2} \quad (34)$$

$$W_P = \frac{\gamma_t(h^2 - h_w^2) + \gamma_{sat'd}(h_w^2)}{\sin 2\beta} \quad (35)$$

In order to illustrate the behavior of these equations, the design curves of Figure 14 have been developed. They show the decrease in FS-value with increasing submergence ratio for all values of interface friction. Furthermore, the differences in response curves for the parallel and horizontal submergence ratio assumptions are seen to be very small. Note that the curves are developed specifically for variables stated in the legend. Example 3 illustrates the use of the design curves.

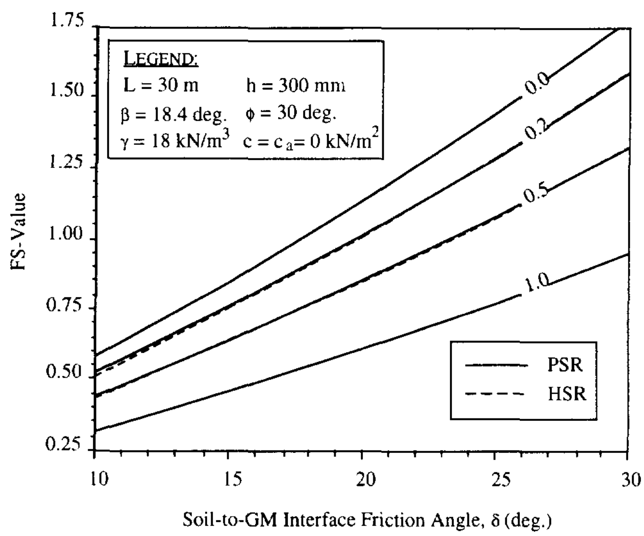


Figure 14. Design curves for stability of cohesionless, uniform thickness, cover soils for different submergence ratios.

Example 3:
Given a 30 m long slope with a uniform thickness cover soil of 300 mm at a dry unit weight of 18 kN/m^3. The soil has a friction angle of 30 deg. and zero cohesion, i.e., it is a sand. The soil becomes saturated through 50% of its thickness, i.e., it is a parallel seepage problem with PSR = 0.5, and its saturated unit weight increases to 21 kN/m^3. Direct shear testing has resulted in an interface friction angle of 22 deg. with zero adhesion. What is the factor-of-safety at a slope of 3(H)-to-1(V), i.e., 18.4 deg.

Solution:

Solving Eqs. 31 with the values of Eqs. 32 to 35 for the a, b and c terms and then substituting them into Eq. 15 results in the following.

$$\left.\begin{array}{l} a = 51.7\,kN/m \\ b = -57.8\,kN/m \\ c = 9.0\,kN/m \end{array}\right\} \quad FS = 0.93$$

Comment:
The seriousness of seepage forces in a slope of this type are immediately obvious. Had the saturation been 100% of the drainage layer thickness, the FS-value would have been even lower. Furthermore, the result using a horizontal assumption of saturated cover soil with the same saturation ratio will give identically low FS-values. Clearly, the teaching of this example problem is that adequate long-term drainage above the barrier layer in cover soil slopes must be provided to avoid seepage forces from occurring.

3.4 Consideration of Seismic Forces

In areas of anticipated earthquake activity, the slope stability analysis of a final cover soil over an engineered landfill, abandoned dump or remediated site must consider seismic forces. In the United States, the Environmental Protection Agency (EPA) regulations require such an analysis for sites that have a probability of ≥ 10% of experiencing a 0.10 g peak horizontal acceleration within the past 250 years. For the continental USA this includes not only the western states, but major sections of the midwest and northeast states, as well. If practiced worldwide, such a criterion would have huge implications.

The seismic analysis of cover soils of the type under consideration in this paper is a two-part process:

- The calculation of a FS-value using a pseudo-static analysis via the addition of a horizontal force acting at the centroid of the cover soil cross section.
- If the FS-value in the above calculation is less than 1.0, a permanent deformation analysis is required. The calculated deformation is then assessed in light of the potential damage to the cover soil section and is either accepted, or the slope requires an appropriate redesign. The redesign is then analyzed until the situation becomes acceptable.

The first part of the analysis is a pseudo-static approach which follows the previous examples except for the addition of a horizontal force at the centroid of the cover soil in proportion to the anticipated seismic activity. It is first necessary to obtain an average seismic coefficient (C_S). The bedrock acceleration can be estimated from a seismic zone map, e.g., Algermissen (1991), using the procedures embodied in Richardson, et al (1995). Such maps are available on a worldwide basis. The value of C_s is nondimensional and is a ratio of the bedrock acceleration to gravitational acceleration. This value of C_s is modified using available computer codes such as "SHAKE", see

Schnabel, et al. (1972), for propagation to the site and then to the landfill cover. The computational process within such programs is quite intricate. For detailed discussion see Seed and Idriss (1982) and Idriss (1990). The analysis is then typical to those previously presented.

Using Figure 15, the additional seismic force is seen to be $C_S W_A$ acting horizontally on the active wedge. All additional symbols used in Figure 15 have been previously defined and the expression for finding the FS-value can be derived as follows:

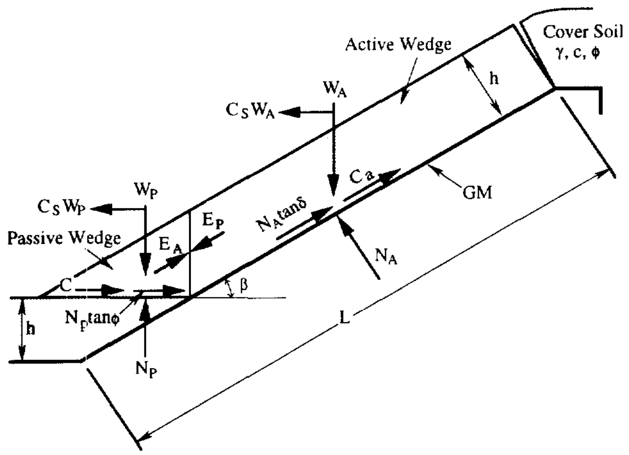


Figure 15. Limit equilibrium forces involved in pseudo-static analysis including use of an average seismic coefficient

Considering the active wedge, by balancing the forces in the horizontal direction, the following formulation results:

$$E_A \cos\beta + \frac{(N_A \tan\delta + C_a)\cos\beta}{FS} = C_S W_A + N_A \sin\beta \quad (36)$$

Hence the interwedge force acting on the active wedge results:

$$E_A = \frac{(FS)(C_S W_A + N_A \sin\beta)}{(FS)\cos\beta} - \frac{(N_A \tan\delta + C_a)\cos\beta}{(FS)\cos\beta} \quad (37)$$

The passive wedge can be considered in a similar manner and the following formulation results:

$$E_P \cos\beta + C_S W_P = \frac{C + N_P \tan\phi}{FS} \quad (38)$$

Hence the interwedge force acting on the passive wedge is:

$$E_P = \frac{C + W_P \tan\phi - C_S W_P (FS)}{(FS)\cos\beta - \sin\beta \tan\phi} \quad (39)$$

Again, by setting $E_A = E_P$, the following equation can be arranged in the form of $ax^2 + bx + c = 0$ which in this case is:

$$a(FS)^2 + b(FS) + c = 0 \quad (13)$$

where

$$\begin{aligned} a &= (C_S W_A + N_A \sin\beta)\cos\beta + C_S W_P \cos\beta \\ b &= -[(C_S W_A + N_A \sin\beta)\sin\beta \tan\phi \\ &\quad + (N_A \tan\delta + C_a)\cos^2\beta \\ &\quad + (C + W_P \tan\phi)\cos\beta] \\ c &= (N_A \tan\delta + C_a)\cos\beta \sin\beta \tan\phi \end{aligned} \quad (40)$$

The resulting FS-value is then obtained from the following equation:

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a} \quad (15)$$

Using these concepts, a design curve for the general problem under consideration as a function of seismic coefficient can be developed, see Figure 16. Note that the curve is developed specifically for the variables stated in the legend. Example 4a illustrates the use of the curve.

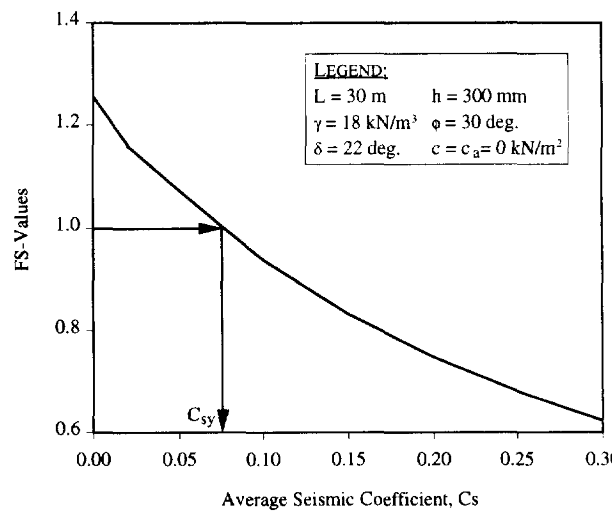


Figure 16. Design curve for a uniformly thick cover soil pseudo-static seismic analysis with varying average seismic coefficients.

Example 4a:

Given a 30 m long slope with uniform thickness cover soil of 300 mm at a unit weight of 18 kN/m^3. The soil has a friction angle of 30 deg. and zero cohesion, i.e., it is a sand. The cover soil is on a geomembrane as shown in Figure 15. Direct shear testing has resulted in an interface friction angle of 22 deg. with zero adhesion. The slope angle is 3(H)-to-1(V), i.e., 18.4 deg. A design earthquake appropriately transferred to the site's cover soil results in an average seismic coefficient of 0.10. What is the FS-value?

Solution:
Solving Eqs. 40 for the values given in the example and substituting into Eq. 15 results in the following FS-value.

$$\left.\begin{array}{l} a = 59.6\,\text{kN/m} \\ b = -66.9\,\text{kN/m} \\ c = 10.4\,\text{kN/m} \end{array}\right\} \quad FS = 0.94$$

Note that the value of FS = 0.94 agrees with the design curve of Figure 16 at a seismic coefficient of 0.10.

Comment:
Had the above FS-value been greater than 1.0, the analysis would be complete. The assumption being that cover soil stability can withstand the short-term excitation of an earthquake and still not slide. However, since the value in this example is less than 1.0, a second part of the analysis is required.

The second part of the analysis is directed toward calculating the estimated deformation of the lowest shear strength interface in the cross section under consideration. The deformation is then assessed in light of the potential damage that may be imposed on the system.

To begin the permanent deformation analysis, a yield acceleration, "C_{sy}", is obtained from a pseudo-static analysis under an assumed FS = 1.0. Figure 16 illustrates this procedure for the assumptions stated in the legend. It results in a value of C_{sy} = 0.075. Coupling this value with the time history response obtained for the actual site location and cross section, results in a comparison as shown in Figure 17a. If the earthquake time history response never exceeds the value of C_{sy}, there is no anticipated permanent deformation. However, whenever any part of the time history curve exceeds the value of C_{sy}, permanent deformation is expected. By double integration of the time history curve (which is acceleration), to velocity (Figure 17b) and then to displacement (Figure 17c), the anticipated value of deformation can be obtained. This value is considered to be permanent deformation and is then assessed based on the site-specific implications of damage to the final cover system. Empirical charts, e.g., Makdisi and Seed (1978) can also be used to estimate the permanent deformation. Example 4b continues the previous pseudo-static analysis into the deformation calculation.

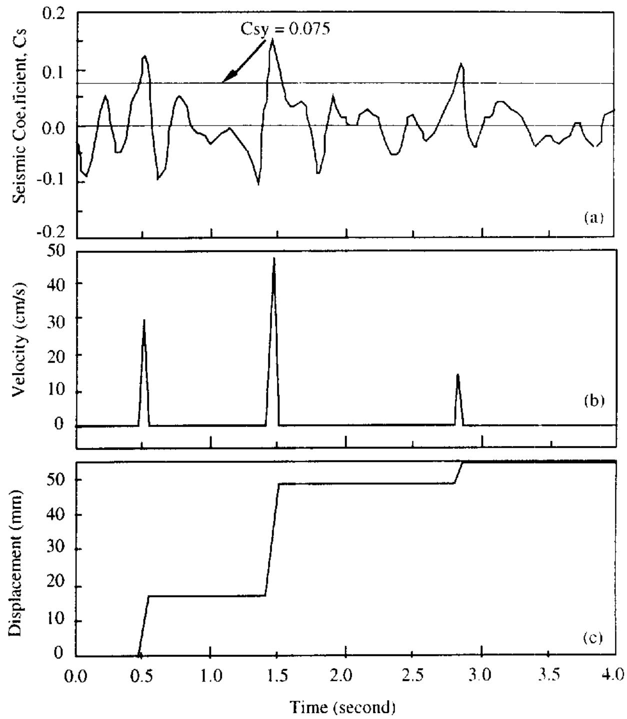


Figure 17. Hypothetical design curves to obtain permanent deformation utilizing (a) acceleration, (b) velocity and (c) displacement curves.

Example 4b:
Continue Example 4a and determine the anticipated permanent deformation of the weakest interface in the cover soil system. The site-specific seismic time-history diagram is given in Figure 17a.

Solution:
The interface of concern is the cover soil-to-geomembrane for this particular example. With a yield acceleration of 0.075 from Figure 16 and the site-specific (design) time history shown in Figures 17a, integration produces Figure 17b and then 17c. The three peaks exceeding the yield acceleration value of 0.075, produce a cumulative deformation of approximately 54 mm. This value is now viewed in light of the deformation capability of the cover soil above the particular interface used at the site. Note that current practice limits such deformation to either 100 or 300 mm depending on site-specific situations, see Richardson et al (1995).

Comments:
An assessment of the implications of deformation (in this example it is 54 mm) is very subjective. For example, this problem could easily have been framed to produce much higher permanent deformation. Such deformation can readily be envisioned in high seismic-prone areas. In addition to an assessment of cover soil stability, the concerns for appurtenances and ancillary piping must also be addressed.

4 SITUATIONS CAUSING THE ENHANCED STABILIZATION OF SLOPES

This section represents a counterpoint to the previous section on slope destabilization situations, in that all situations presented here tend to increase the stability of the slopes. Thus they represent methods to increase the cover soil FS-value. Included are toe berms, tapered cover soils and veneer reinforcement (both intentional and nonintentional). Not included, but very practical in site-specific situations, is to simply decrease the slope angle and/or decrease the slope length. These solutions, however, do not incorporate new design techniques and are therefore not illustrated. They are, however, very viable alternatives for the design engineer.

4.1 Toe (Buttress) Berm

A common method of stabilizing highway slopes and earth dams is to place a soil mass, i.e., a berm, at the toe of the slope. In so doing one provides a soil buttress, acting in a passive state thereby providing a stabilizing force. Figure 18 illustrates the two geometric cases necessary to provide the requisite equations. While the force equilibrium is performed as previously described, i.e., equilibrium along the slope with abutting interwedge forces aligned with the slope angle or horizontal, the equations are extremely long. Due to space limitations (and the resulting trends in FS-value improvement) they are not presented.

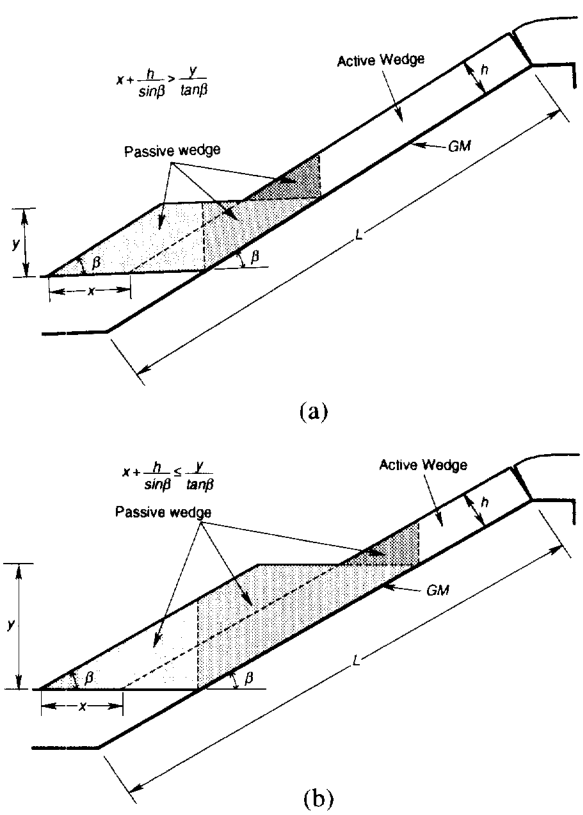


Figure 18. Dimensions of toe (buttress) berms acting as passive wedges to enhance stability.

Example 5:

Given a 30 m long slope with a uniform cover soil thickness of 300 mm and a unit weight of 18 kN/m^3. The soil has a friction angle of 30 deg. and zero cohesion, i.e., it is a sand. The cover soil is on a geomembrane as shown in Figure 18. Direct shear testing has resulted in a interface friction angle between the cover soil and geomembrane of 22 deg. and zero adhesion. The FS-value at a slope angle of 3(H)-to-1(V), i.e., 18.4 deg., was shown in Section 3.1 to be 1.25. What is the increase in FS-value using different sized toe berms with values of x = 1, 2 and 3 m, and gradually increasing y-values?

Solution:

The FS-value response to this type of toe berm stabilization is given in two parts, see Figure 19. Using thickness values of x = 1, 2 and 3 m, the lower berm section by itself is seen to have high FS-values initially, which decrease rapidly as the height of the toe berm increases. This is a predictable response for this passive wedge zone. Unfortunately, the upper layer of soil above the toe berm

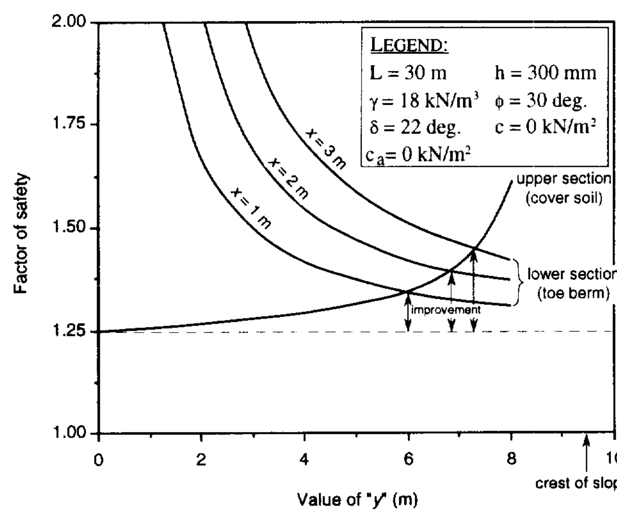


Figure 19. Design curves for FS-values using toe (buttress) berms of different dimensions.

(the active zone) is only nominally increasing in its FS-value. Note that at the crossover points of the upper and lower FS-values (which is the optimum solution for each set of conditions), the following occurs:

- For x = 1 m; y = 6.0 m (63% of the slope height) and FS = 1.35 (only an 8% improvement in stability)
- For x = 2 m; y = 6.8 m (72% of the slope height) and FS = 1.37 (only a 12% improvement in stability)
- For x = 3 m; y = 7.3 m (77% of the slope height) and FS = 1.40 (only a 16% improvement in stability)

Comment:

Readily seen is that construction of a toe berm is not a viable strategy to stabilize relatively thin layers of sloped cover soil of the type under investigation. Essentially what is happening is that the upper section of the cover soil (the active wedge) above the berm is sliding off of the top of the toe berm. While the upper slope length is becoming shorter (as evidenced by the slight improvement in FS-values), it is only doing so with the addition of a tremendous amount of soil fill. Thus this toe berm concept is a poor strategy for the stabilization of forces oriented in the slope's direction. Conversely, it is an excellent strategy for embankments and dams where the necessary resisting force for the toe berm is horizontal thereby counteracting a horizontal thrust by the potentially unstable soil and/or water mass.

4.2 Slopes with Tapered Thickness Cover Soil

An alternative method available to the designer to increase the FS-value of a given slope is to uniformly taper the cover soil thickness from thick at the toe, to thin at the crest, see Figure 20. The FS-value will increase in approximate proportion to the thickness of soil at the toe. The analysis for tapered cover soils includes the design assumptions of a tension crack at the top of the slope, the upper surface of the cover soil tapered at a constant angle "ω", and the earth pressure forces on the respective wedges oriented at the average of the surface and slope angles, i.e., the E-forces are at an angle of (ω + β)/2. The procedure follows that of the uniform cover soil thickness analysis. Again, the resulting equation is not an explicit solution for the FS, and must be solved indirectly.

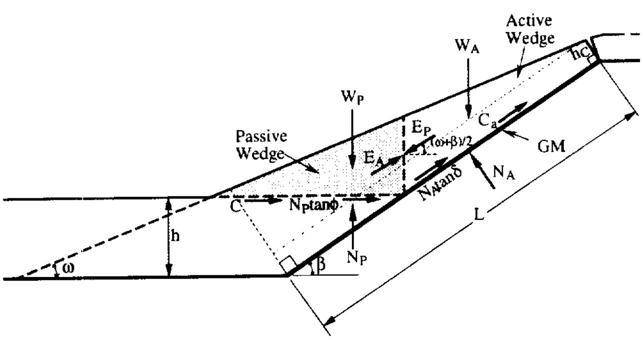


Figure 20. Limit equilibrium forces involved in a finite length slope analysis with tapered thickness cover soil from toe to crest.

All symbols used in Figure 20 were previously defined (see Section 3.1) except the following:

h = thickness of cover soil at bottom of the landfill, measured perpendicular to the base liner

h_C = thickness of cover soil at crest of the slope, measured perpendicular to the slope

y = see Figure 20

$$= \left(L - \frac{h}{\sin\beta} - h_c\tan\beta\right)(\sin\beta - \cos\beta\tan\omega)$$

ω = finished slope angle of cover soil, note that ω < β

The expression for determining the FS-value can be derived as follows:

Considering the active wedge,

$$W_A = \gamma\left[\left(L - \frac{h}{\sin\beta} - h_c\tan\beta\right)\left(\frac{y\cos\beta}{2} + h_c\right) + \frac{h_c^2\tan\beta}{2}\right] \tag{41}$$

$$N_A = W_A\cos\beta \tag{42}$$

$$C_a = c_a\left(L - \frac{h}{\sin\beta}\right) \tag{43}$$

By balancing the forces in the vertical direction, the following formulations result:

$$E_A\sin\left(\frac{\omega+\beta}{2}\right) = W_A - N_A\cos\beta - \frac{N_A\tan\delta + C_a}{FS}(\sin\beta) \tag{44}$$

Hence the interwedge force acting on the active wedge is:

$$E_A = \frac{(FS)(W_A - N_A\cos\beta) - (N_A\tan\delta + C_a)\sin\beta}{\sin\left(\frac{\omega+\beta}{2}\right)(FS)} \tag{45}$$

The passive wedge can be considered in a similar manner:

$$W_P = \frac{\gamma}{2\tan\omega}\left[\left(L - \frac{h}{\sin\beta} - h_c\tan\beta\right)(\sin\beta - \cos\beta\tan\omega) + \frac{h_c}{\cos\beta}\right]^2 \tag{46}$$

$$N_P = W_P + E_P\sin\left(\frac{\omega+\beta}{2}\right) \tag{47}$$

$$C = \frac{\gamma}{\tan\omega}\left[\left(L - \frac{h}{\sin\beta} - h_c\tan\beta\right)(\sin\beta - \cos\beta\tan\omega) + \frac{h_c}{\cos\beta}\right] \tag{48}$$

By balancing the forces in the horizontal direction, the following formulation results:

$$E_P\cos\left(\frac{\omega+\beta}{2}\right) = \frac{C + N_P\tan\phi}{FS} \tag{49}$$

Hence the interwedge force acting on the passive wedge is:

$$E_P = \frac{C + W_P \tan\phi}{\cos\left(\frac{\omega+\beta}{2}\right)(FS) - \sin\left(\frac{\omega+\beta}{2}\right)\tan\phi} \qquad (50)$$

By setting $E_A = E_P$, the following equation can be arranged in the form of $ax^2 + bx + c = 0$ which in our case is

$$a(FS)^2 + b(FS) + c = 0 \qquad (13)$$

where

$$a = (W_A - N_A\cos\beta)\cos\left(\frac{\omega+\beta}{2}\right)$$

$$b = -\left[(W_A - N_A\cos\beta)\sin\left(\frac{\omega+\beta}{2}\right)\tan\phi + (N_A\tan\delta + C_a)\sin\beta\cos\left(\frac{\omega+\beta}{2}\right) + \sin\left(\frac{\omega+\beta}{2}\right)(C + W_P\tan\phi)\right]$$

$$c = (N_A\tan\delta + C_a)\sin\beta\sin\left(\frac{\omega+\beta}{2}\right)\tan\phi \qquad (51)$$

As usual, the resulting FS-value can then be obtained using Eq. 15. To illustrate the use of the above developed equations, the design curves of Figure 21 are offered. They show that the FS-value increases in proportion to greater cover soil thicknesses at the toe of the slope with respect to the thickness at the crest. This is evidenced by a shallower surface slope angle than that of the slope of the geomembrane and the soil beneath, i.e., the value of "ω" being less than "β". Note that the curves are developed specifically for the variables stated in the legend. Example 6 illustrates the use of the curves.

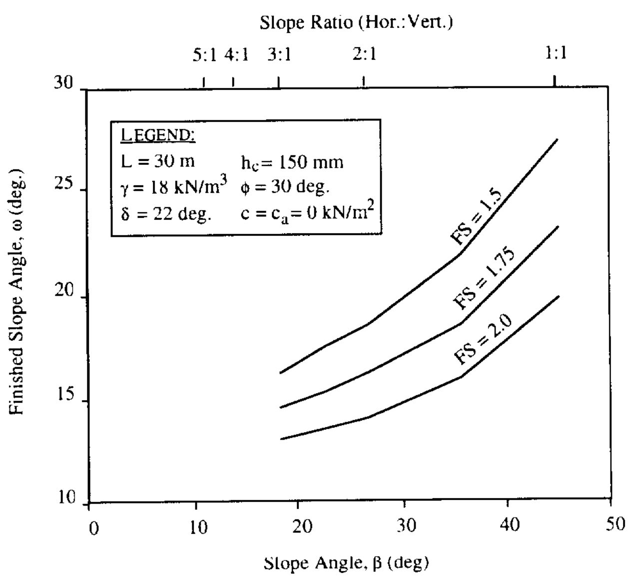


Figure 21. Design curves for FS-values of tapered cover soil thickness.

Example 6:
Given a 30 m long slope with a tapered thickness cover soil of 150 mm at the crest extending at an angle "ω" of 16 deg. to the intersection of the cover soil at the toe. The unit weight of the cover soil is 18 kN/m^3. The soil has a friction angle of 30 deg. and zero cohesion, i.e., it is a sand. The interface friction angle with the underlying geomembrane is 22 deg. with zero adhesion. What is the FS-value at an underlying soil slope angle "β" of 3(H)-to-1(V), i.e., 18.4 deg.?

Solution:
Using Eqs. 51, substituted into Eq. 15 yields the following:

$$\left.\begin{array}{l} a = 37.0\,kN/m \\ b = -63.6\,kN/m \\ c = 8.6\,kN/m \end{array}\right\} \quad FS = 1.57$$

Comment:
The result of this problem (with tapered thickness cover soil) is FS = 1.57, versus Example 1 (with a uniform thickness cover soil) which was FS = 1.25. Thus the increase in FS-value is 24%. Note, however, that at ω = 16 deg. the thickness of the cover soil normal to the slope at the toe is approximately 1.4 m. Thus the increase in cover soil volume used over Example 1 is from 8.9 to 24.1 m^3/m (≈170%) and the increase in necessary toe space distance is from 1.0 to 4.8 m (≈380%). The trade-offs between these issues should be considered when using the strategy of tapered cover soil thickness to increase the FS-value of a particular cover soil slope.

4.3 Veneer Reinforcement - Intentional

A fundamentally different way of increasing a given slope's factor of safety is to reinforce it with a geosynthetic material. Such reinforcement can be either intentional or non-intentional. By *intentional*, we mean to include a geogrid or high strength geotextile within the cover soil to purposely reinforce the system against instability, see Figure 22. Depending on the type and amount of reinforcement, the majority, or even all, of the driving, or mobilizing, stresses can be supported resulting in major increase in FS-value. By *non-intentional*, we refer to multi-component liner systems where a low shear strength interface is located beneath an overlying geosynthetic(s). In this case, the overlying geosynthetic(s) is inadvertently acting as veneer reinforcement to the composite system. In some cases, the designer may not realize that such geosynthetic(s) are being stressed in an identical manner as a geogrid or high strength geotextile, but they are. The situation where a relatively low strength protection geotextile is placed over a smooth geomembrane and beneath the cover soil is a case in point. Intentional, or non-intentional, the stability analysis is identical. The difference is that the geogrids and/or high strength geotextiles give a major increase in the FS-value, while a protection geotextile (or other lower strength geosynthetics) only nominally increases the FS-value.

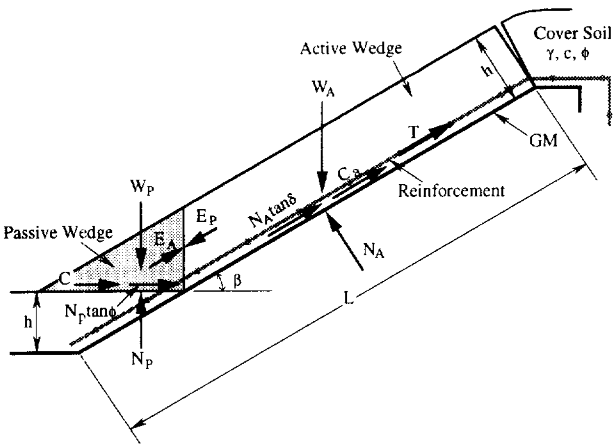


Figure 22. Limit equilibrium forces involved in a finite length slope analysis for a uniformly thick cover soil including the use of veneer reinforcement.

Seen in Figure 22 is that the analysis follows Section 3.1, but a force from the reinforcement "T", acting parallel to the slope, provides additional stability. This force "T", acts only within the active wedge. By taking free body force diagrams of the active and passive wedges, the following formulation for the factor of safety results. All symbols used in Figure 22 were previously defined (see Section 3.1) except the following:

T = T_{allow}, the allowable (long-term) strength of the geosynthetic reinforcement inclusion

Consider the active wedge and by balancing the forces in the vertical direction, the following formulation results:

$$E_A \sin\beta = W_A - N_A \cos\beta - \left(\frac{N_A \tan\delta + C_a}{FS} + T\right)\sin\beta \qquad (52)$$

Hence the interwedge force acting on the active wedge is:

$$E_A = \frac{(FS)(W_A - N_A \cos\beta - T\sin\beta)}{\sin\beta(FS)} - \frac{(N_A \tan\delta + C_a)\sin\beta}{\sin\beta(FS)} \qquad (53)$$

Again, by setting $E_A = E_P$ (see Eq. 12 for the expression of E_P), the following equation can be arranged in the usual form in which the "a", "b" and "c" terms are defined as follows:

$$a = (W_A - N_A \cos\beta - T\sin\beta)\cos\beta$$

$$b = -\left[(W_A - N_A \cos\beta - T\sin\beta)\sin\beta\tan\phi + (N_A \tan\delta + C_A)\sin\beta\cos\beta + \sin\beta(C + W_P \tan\phi)\right]$$

$$c = (N_A \tan\delta + C_a)\sin^2\beta\tan\phi \qquad (54)$$

Again, the resulting FS-value can be obtained using Eq. 15.

As noted, the value of T in the design formulation is T_{allow} which is invariably less than the as-manufactured strength of the geosynthetic reinforcement material. Considering the as-manufactured strength as being T_{ult}, the value should be reduced by such factors as installation damage, creep and long-term degradation. Note that if seams are involved in the reinforcement, a reduction factor should be added accordingly. See Koerner, 1998 (among others), for recommended numeric values.

$$T_{allow} = T_{ult}\left(\frac{1}{RF_{ID} \times RF_{CR} \times RF_{CBD}}\right) \qquad (55)$$

where

T_{allow} = allowable value of reinforcement strength
T_{ult} = ultimate (as-manufactured) value of reinforcement strength
RF_{ID} = reduction factor for installation damage
RF_{CR} = reduction factor for creep
RF_{CBD} = reduction factor for long term chemical/ biological degradation

To illustrate the use of the above developed equations, the design curves of Figure 23 have been developed. The reinforcement strength can come from either geogrids or high strength geotextiles. If geogrids are used, the friction angle is the cover soil to the underlying geomembrane, under the assumption that the apertures are large enough to allow for cover soil strike-through. If geotextiles are used, this is not the case and the friction angle is the geotextile to the geomembrane. Also note that this value under discussion is the required reinforcement strength which is essentially T_{allow} in Eq. 55. The curves of Figure 23 clearly show the improvement of FS-values with increasing strength of the reinforcement. Note that the curves are developed specifically for the variables stated in the legend. Example 7 illustrates the use of the design curves.

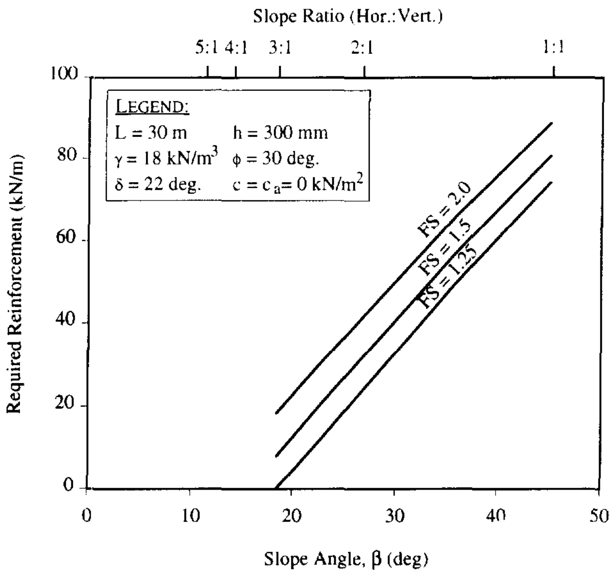


Figure 23. Design curves for FS-values for different slope angles and veneer reinforcement strengths for uniform thickness cohesionless cover soils.

Example 7:

Given a 30 m long slope with a uniform thickness cover soil of 300 mm and a unit weight of 18 kN/m^3. The soil has a friction angle of 30 deg. and zero cohesion, i.e., it is a sand. The proposed reinforcement is a geogrid with an allowable wide width tensile strength of 10 kN/m. Thus reduction factors in Eq. 55 have already been included. The geogrid apertures are large enough that the cover soil will strike-through and provide an interface friction angle with the underlying geomembrane of 22 deg. with zero adhesion. What is the FS-value at a slope angle of 3(H)-to-1(V), i.e., 18.4 deg.?

Solution:

Solving Eqs. 54 and substituting into Eq. 15 produces the following:

$$\left.\begin{aligned} a &= 11.8\,\text{kN/m} \\ b &= -20.7\,\text{kN/m} \\ c &= 3.5\,\text{kN/m} \end{aligned}\right\} \quad FS = 1.57$$

Comments:

Note that the use of T_{allow} = 10 kN/m in the analysis will require a significantly higher T_{ult} value of the geogrid per Eq. 55. For example, if the summation of the reduction factors in Eq. 55 were 4.0, the ultimate (as-manufactured) strength of the geogrid would have to be 40 kN/m. Also, note that this same type of analysis could also be used for high strength geotextile reinforcement. The analysis follows along the same general lines as presented here.

4.4 Veneer Reinforcement - Nonintentional

It should be emphasized that the preceding analysis is focused on intentionally improving the FS-value by the inclusion of geosynthetic reinforcement. This is provided by geogrids or high strength geotextiles being placed above the upper surface of the low strength interface material. The reinforcement is usually placed directly above the geomembrane or other geosynthetic material.

Interestingly, some amount of veneer reinforcement is often nonintentionally provided by a geosynthetic(s) material placed over an interface with a lower shear strength. Several situations are possible in this regard.

- Geotextile protection layer placed over a geomembrane
- Geomembrane placed over an underlying geotextile protection layer
- Geotextile/geomembrane placed over a compacted clay liner or geosynthetic clay liner
- Multilayered geosynthetics placed over a compacted clay liner or a geosynthetic clay liner

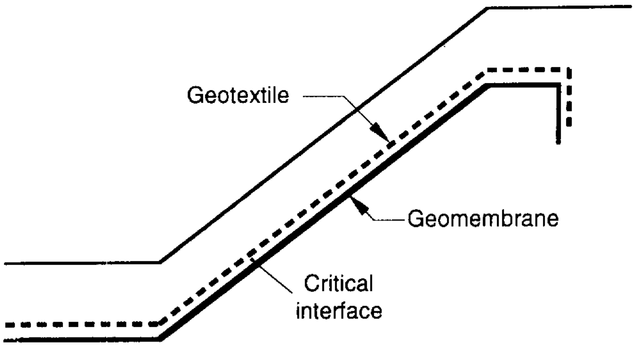
Each of these four situations are illustrated in Figure 24. They represent precisely the formulation of Section 4.3 which is based on Figure 22. On the condition that the geosynthetics above the weakest interface are held in their respective anchor trenches, the overlying geosynthetics provide veneer reinforcement, albeit of a nonintentional type. In the general case, such designs are not recommended although they can indeed provide increased resistance to slope instability of the weakest interface.

In performing calculations of the situations shown in Figure 24, the issue of strain compatibility must be considered. For the slopes shown in Figure 24 a and b, the issue is not important and the full wide width strength of the geotextile and geomembrane, respectively, can be used in the analysis. For the slopes shown in Figure 24 c and d, however, the complete stress vs. strain curves of each geosynthetic layer over the weak interface are necessary. The lowest value of failure strain of any one material dictates the strain at which the other geosynthetics will act. This will invariably be less than the full strength of the other geosynthetics. At this value of strain, however, the allowable strengths are additive and can be used in the analysis. Some detail on this issue is available in Corcoran and McKelvey (1995).

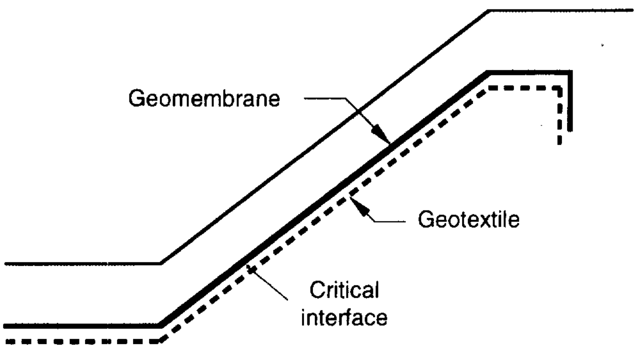
To illustrate the use of the above concepts, examples are given for the four situations shown in Figure 24.

Example 8:

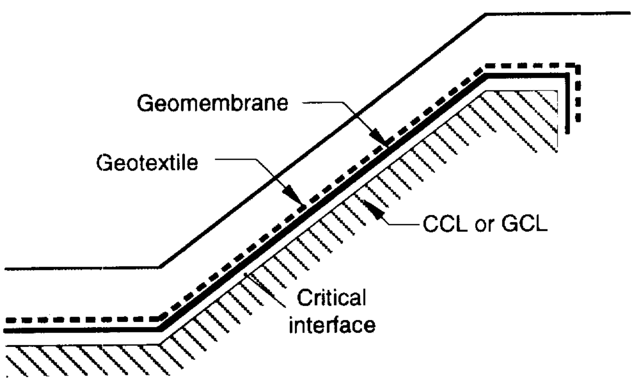
Given four 3(H)-to-1(V), i.e., 18.4 deg. slopes with cover soils as shown in Figures 24 a to d. In each case, the slope is 30 m long with 300 mm of uniformly thick cover soil at a unit weight of 18 kN/m^3. The soil has a friction angle of 30 deg. and zero cohesion, i.e., it is a sand. The friction angle of the critical interface is 10 deg. What are the FS-values using the geosynthetic tensile strength data provided in the following table?



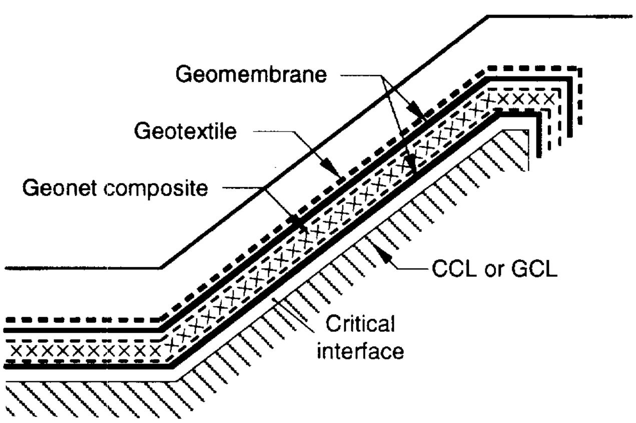
(a) Geotextile sliding on geomembrane



(b) Geomembrane sliding on geotextile



(c) Geotextile and geomembrane sliding on CCL or GCL



(d) Double liner system sliding on CCL or GCL

Figure 24. Various situations illustrating veneer reinforcement, albeit of an nonintentional type.

Values used for numeric examples of nonintentional veneer reinforcement.[1]

Slope type (figure)	GT strength[2] (kN/m)	GM strength[3] (kN/m)	GC strength[4] (kN/m)
24a	25	n/a	n/a
24b	n/a	15	n/a
24c	25	13	n/a
24d	25	13+13	36

Notes:

1. Strengths are product-specific and have been adjusted for strain compatibility.
2. Nonwoven needle punched geotextile of 540 g/m^2
3. Very flexible polyethylene geomembrane 1.0 mm thick
4. Biaxial geonet with two 200 g/m^2 nonwoven needle punched geotextiles thermally bonded to each side

Solution:

Substituting Eqs. 54 into Eq. 15 results in the following data and respective FS-values.

Slope type (figure)	a (kN/m)	b (kN/m)	c (kN/m)	FS-value
24a	7.3	-9.7	1.5	1.15
24b	10.3	-10.3	1.5	0.82
24c	3.4	-9.0	1.5	2.45
24d	-11.0	-6.2	1.5	>10.0

Comments:
While the practice illustrated in these examples of using the overlying geosynthetics as nonintentional veneer reinforcement is not recommended, it is seen to be quite effective when a number of geosynthetics overlying the weak interface are present. On a cumulative basis, they can represent a substantial force as shown in Figure 24d. If one were to rely on such strength, however, it would be prudent to apply suitable reduction factors to each material, and to inform the parties involved of the design situation.

5 SUMMARY

This paper has focused on the mechanics of analyzing slopes as part of final cover systems on engineered landfills, abandoned dumps and remediated waste piles. It also applies to drainage soils placed on geomembrane lined slopes beneath the waste, at least until solid waste is placed against the slope. Numeric examples in all of the sections have resulted in global FS-values. Each section was presented from a designer's perspective in transitioning from the simplest to the most advanced. It should be clearly recognized that there are other approaches to the analyses illustrated in the various examples. References available in the literature by Giroud and Beech (1989), McKelvey and Deutsch (1991), Koerner and Hwu (1991), Giroud et al (1995a), Giroud et al (1995b), Liu et al (1997), and Ling and Leshchinsky (1997) are relevant in this regard. All are based on the concept of limit equilibrium with different assumptions involving particular details, e.g.,

- Existence of a tension crack at the top of slope (filled or unfilled with water)
- Orientation of the failure plane beneath the passive wedge (horizontal or inclined)
- Specific details of construction equipment movement on the slopes in placing the cover soil, particularly the acceleration or deceleration, and the type of equipment itself (e.g., tracked versus wheel equipment)
- Specific details on seepage forces within the drainage layer, including the amount and its orientation
- Specific details on seismic forces, particularly the magnitude and the selection of interface strengths
- Specific details on the geometry of the toe berms or tapered cover soils
- Specific details on the strength and reduction factors used for intentional veneer reinforcement
- Specific details on the strain compatibility issues used with nonintentional veneer reinforcement.

When considering all of these site-specific details, it is readily seen that veneer cover soil analysis and design is a daunting, yet quite tractable, task. For example, one of the reviewers of this paper reanalyzed one of the examples presented herein and another reviewer reanalyzed all of the examples. Both used the analyses of Giroud et al (1995a) and (1995b). They found good agreement in all cases except the nonintentional veneer reinforcement with multiple geosynthetic layers, i.e., the last example presented. It is likely in this regard that different values of mobilized composite strength were being used.

Table 1 summarizes the FS-values of the similarly framed numeric examples presented herein so that insight can be gained from each of the conditions analyzed. Throughout the paper, however, the inherent danger of building a relatively steep slope on a potentially weak interface material, oriented in the exact direction of a potential slide, should have been apparent.

The standard example was purposely made to have a relatively low factor of safety, i.e., FS = 1.25. This FS-value was seen to moderately decrease for construction equipment moving up the slope, but seriously decrease with equipment moving down the slope, i.e., 1.24 to 1.03. It should be noted, however, that the example problems were hypothetical , particularly the equipment examples in the selection of acceleration /deceleration factors. There are an innumerable number of choices to select from, and we have selected values to make the point of proper construction practice. Also, drastically decreasing the FS-value were the influences of seepage and seismicity. The former is felt to be most serious in light of a number of slides occurring after heavy precipitation. The latter is known to be a concern at one landfill in an area of active seismicity.

The sequence of design situations shifted to scenarios where the FS-values were increased over the standard example. Adding soil either in the form of a toe berm or tapered cover soil both increase the FS-value depending on the mass of soil involved. The tapered situation was seen to be more efficient and preferred over the toe berm. Both

Table 1. Summary of numeric examples given in this paper for different slope stability scenarios.

Example No.	Situation or condition	Control FS-value	Scenarios decreasing FS-values	Scenarios increasing FS-values
1	standard example*	1.25		
2a	equipment up-slope		1.24	
2b	equipment down-slope		1.03	
3	seepage forces		0.93	
4	seismic forces		0.94	
5	toe (buttress) berm			1.35-1.40
6	tapered cover soil			1.57
7	veneer reinforcement (intentional)			1.57
8	veneer reinforcement (non intentional)			varies

* 30 m long slope at a slope angle of 18.4 deg. with sandy cover soil of 18.4 kN/m^3 dry unit weight with ϕ = 30 deg. and thickness 300 mm placed on an underlying geosynthetic with a friction angle δ =22 deg.

designs, however, require physical space at the toe of the slope which is often not available. Thus the use of geosynthetic reinforcement was illustrated. By intentional veneer reinforcement it is meant that geogrids or high strength geotextiles are included to resist some, or all, of the driving forces that are involved. The numeric example illustrated an increase in FS-value from 1.25 to 1.57, but this is completely dependent on the type and amount of reinforcement. It was also shown that whenever the weakest interface is located beneath overlying geosynthetics they also act as veneer reinforcement albeit nonintentionally in most cases. The overlying geosynthetic layers must physical fail (or pull out of their respective anchor trenches, see Hullings, 1996) in order for the slope to mobilize the weakest interface strength layer and slide. While this is not a recommended design situation, it does have the effect of increasing the FS-value. The extent of increase varies from a flexible geomembrane to a nonwoven needle punched protection geotextile (both with relatively low strengths) to a multilayered geosynthetic system with 2 to 8 layers of geosynthetics (with very high cumulative strengths).

6 CONCLUSION

We conclude with a discussion on factor of safety (FS) values for cover soil situations. Note that we are referring to the global FS-value, not reduction factors which necessarily must be placed on geosynthetic reinforcement materials when they are present. In general, one can consider global FS-values to vary in accordance with the site specific issue of required service time (i.e., the anticipated lifetime) and the implication of a slope failure (i.e., the concern). Table 2 gives the general concept in qualitative terms.

Table 2. Qualitative rankings for global factor-of-safety values in performing stability analysis of final cover systems, after Bonaparte and Berg (1987).

Duration→ ↓Concern	Temporary	Permanent
Noncritical	Low	Moderate
Critical	Moderate	High

Using the above as a conceptual guide, the authors recommend the use of the minimum global factor-of-safety values listed in Table 3, as a function of the type of underlying waste for *static* conditions.

Table 3. Recommended global factor-of-safety values for static conditions in performing stability analyses of final cover systems.

Type of Waste→ ↓Ranking	Hazard-ous waste	Non-hazardous waste	Aban-donded dumps	Waste piles and leach pads
Low	1.4	1.3	1.4	1.2
Moderate	1.5	1.4	1.5	1.3
High	1.6	1.5	1.6	1.4

It is hoped that the above values give reasonable guidance in final cover slope stability decisions, but it should be emphasized that engineering judgment and (oftentimes) regulatory agreement is needed in many, if not all, situations.

ACKNOWLEDGMENTS

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7.9 PLANT YATES – AMA FIELD AND LABORATORY INVESTIGATIONS - SETTLEMENT

TIMELY ENGINEERING SOIL TESTS, LLC

1874 Forge Street Tucker, GA 30084
Ph: 770-938-8233
Fax: 770-923-8973
Web: www.test-llc.com

AASHTO ACCREDITED

Tested By	KP
Date	03/04/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Project Name	AMA	S. Type	Remold
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 2

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	0.0
2	0.10	0.32	8.5
3	0.30	0.55	9.0
4	0.50	0.71	9.5
5	0.80	0.89	10.0
6	1.50	1.22	10.0
7	2.25	1.50	10.5
8	3.00	1.73	10.5
9	3.75	1.94	10.5
10	5.00	2.24	11.0
11	6.50	2.55	11.0
12	8.5	2.92	11.0
13	11.0	3.32	11.0
14	16.0	4.00	11.5
15	22.0	4.69	11.5
16	32.0	5.66	11.5
17			
18			
19			
20			

Pressure* on Specimen, lbf/ft^2

250

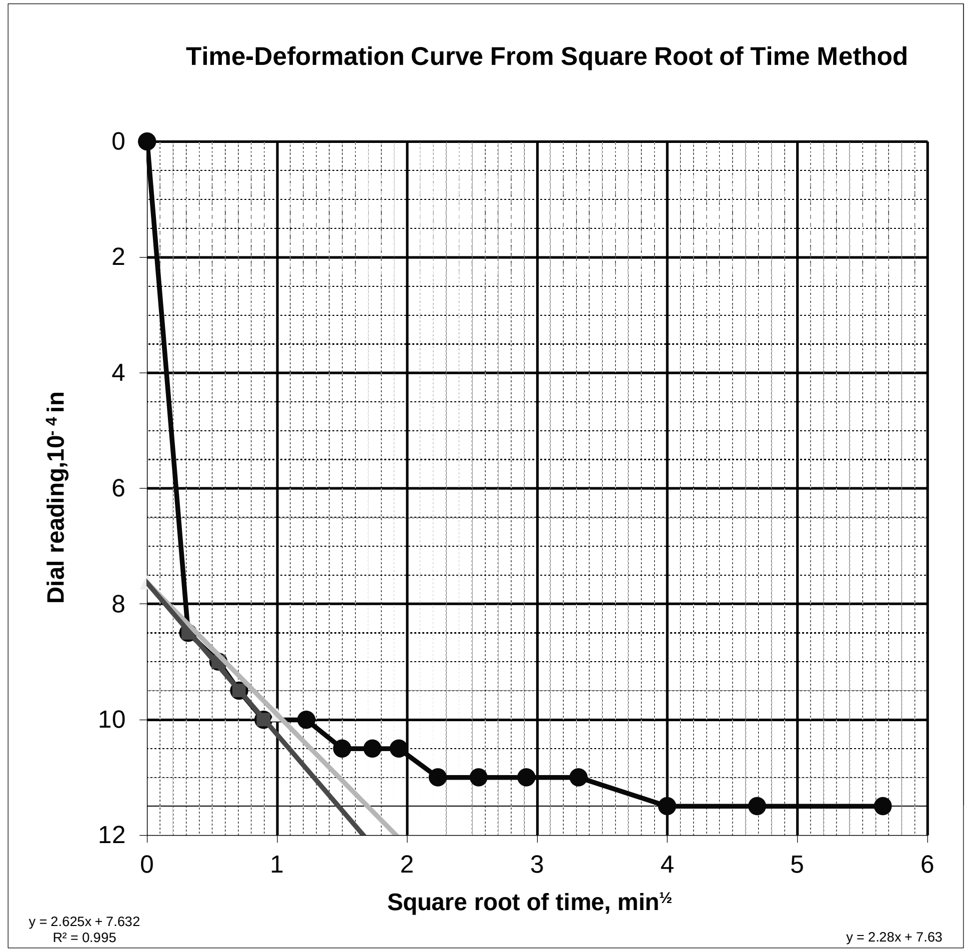
Selection	5
m_1	2.63
m_2	2.28

X	Y
0	7.63
1	9.91

d_0	7.6
d_{90}	10
d_{100}	10
d_{50}	9
$sq.root\ t_{90}$	1.05
t_{90}, min	1.10
$sq.root\ t_{50}$	0.51
t_{50}, min	0.26

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Fax: 770-923-8973
Web: www.test-llc.com

AASHTO ACCREDITED

Tested By	KP
Date	03/04/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Project Name	AMA	S. Type	Remold
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	11.5
2	0.10	0.32	26.0
3	0.30	0.55	27.5
4	0.50	0.71	28.0
5	0.80	0.89	29.0
6	1.50	1.22	30.0
7	2.25	1.50	30.0
8	3.00	1.73	30.5
9	3.75	1.94	31.0
10	5.00	2.24	31.5
11	6.50	2.55	31.5
12	8.5	2.92	32.0
13	11.0	3.32	32.0
14	16.0	4.00	32.5
15	22.0	4.69	33.0
16	32.0	5.66	33.5
17			
18			
19			
20			

STEP # 3

Pressure* on Specimen, lbf/ft²

500

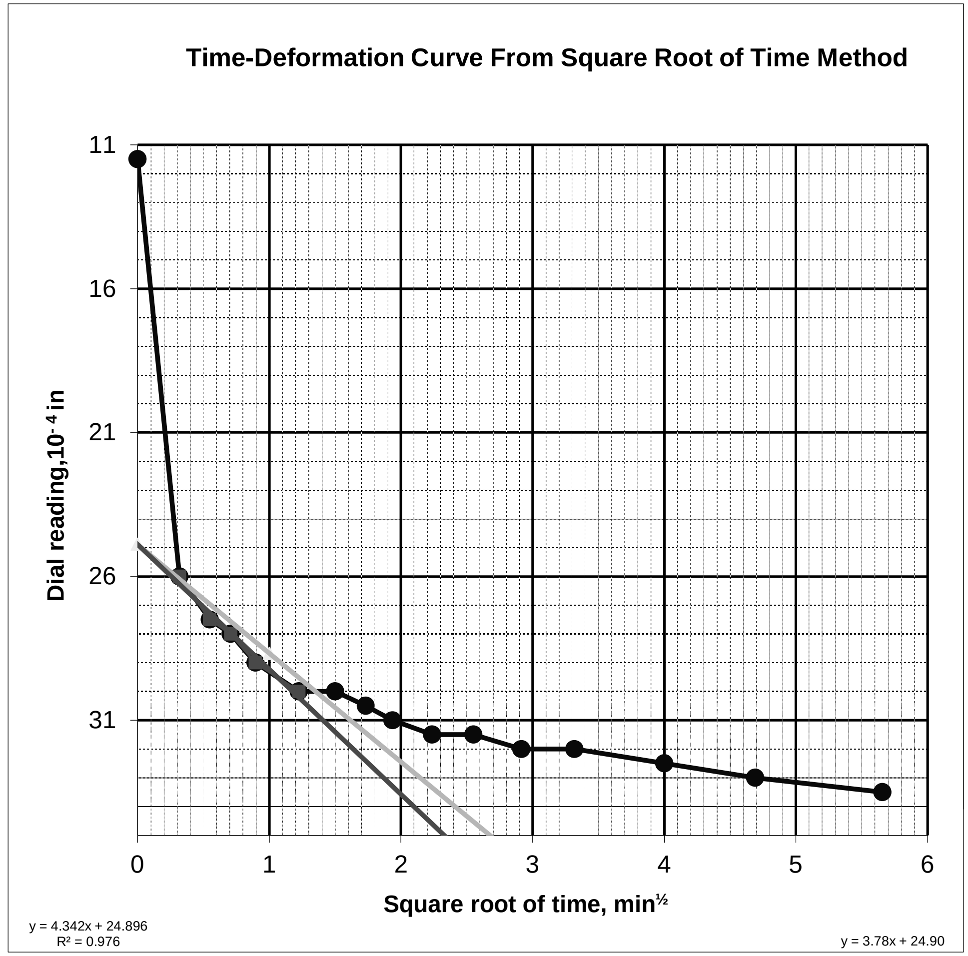
Selection	6
m_1	4.34
m_2	3.78

X	Y
0	24.90
1	28.67

d_0	24.9
d_{90}	30
d_{100}	31
d_{50}	28
$sq.root\ t_{90}$	1.35
t_{90}, min	1.82
$sq.root\ t_{50}$	0.65
t_{50}, min	0.43

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 4

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	34.0
2	0.10	0.32	64.0
3	0.30	0.55	67.0
4	0.50	0.71	68.0
5	0.80	0.89	69.0
6	1.50	1.22	71.0
7	2.25	1.50	71.5
8	3.00	1.73	72.0
9	3.75	1.94	73.0
10	5.00	2.24	73.5
11	6.50	2.55	73.5
12	8.5	2.92	74.5
13	11.0	3.32	74.5
14	16.0	4.00	75.0
15	22.0	4.69	75.5
16	32.0	5.66	76.5
17			
18			
19			
20			

Pressure* on Specimen, lbf/ft^2

1000

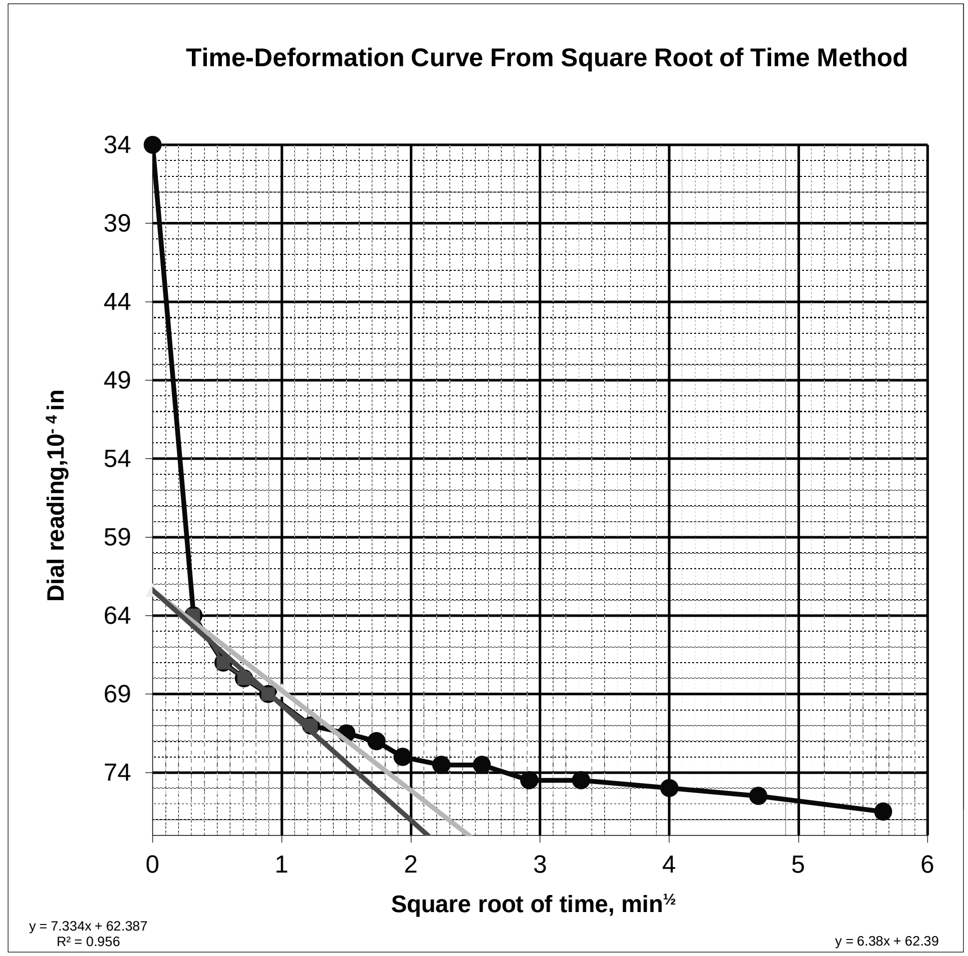
Selection	6
m_1	7.33
m_2	6.38

X	Y
0	62.39
1	68.76

d_0	62.4
d_{90}	71
d_{100}	72
d_{50}	67
sq.root t_{90}	1.4
t_{90}, min	1.96
sq.root t_{50}	0.68
t_{50}, min	0.46

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Project Name	AMA	S. Type	Remold
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 5

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	77.0
2	0.10	0.32	118.0
3	0.30	0.55	121.0
4	0.50	0.71	122.5
5	0.80	0.89	124.0
6	1.50	1.22	126.0
7	2.25	1.50	127.0
8	3.00	1.73	128.0
9	3.75	1.94	128.5
10	5.00	2.24	129.0
11	6.50	2.55	129.5
12	8.5	2.92	130.0
13	11.0	3.32	131.0
14	16.0	4.00	131.5
15	22.0	4.69	132.0
16	32.0	5.66	132.5
17	65.0	8.06	134.0
18	90.0	9.49	134.0
19	165.0	12.85	135.0
20	240.0	15.49	135.5
	390.0	19.75	136.0
	540.0	23.24	136.0
	690.0	26.27	136.5

Pressure* on Specimen, lbf/ft^2

2000

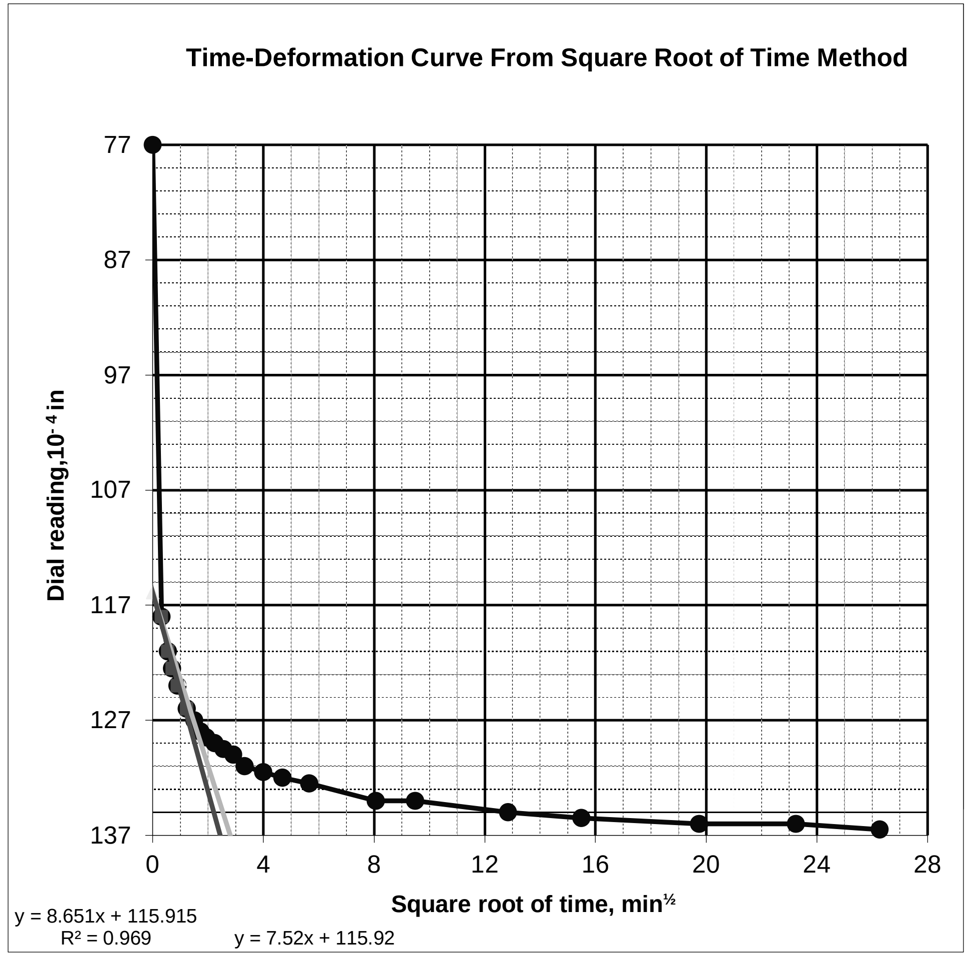
Selection	6
m_1	8.65
m_2	7.52

X	Y
0	115.92
1	123.44

d_0	115.9
d_{90}	127
d_{100}	128
d_{50}	122
sq.root t_{90}	1.45
t_{90}, min	2.10
sq.root t_{50}	0.70
t_{50}, min	0.49

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Project Name	AMA	S. Type	Remold
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	136.5
2	0.10	0.32	185.5
3	0.30	0.55	189.0
4	0.50	0.71	191.5
5	0.80	0.89	193.0
6	1.50	1.22	195.5
7	2.25	1.50	197.0
8	3.00	1.73	198.5
9	3.75	1.94	199.0
10	5.00	2.24	200.0
11	6.50	2.55	201.0
12	8.5	2.92	201.5
13	11.0	3.32	202.5
14	16.0	4.00	203.5
15	22.0	4.69	204.5
16	32.0	5.66	205.0
17	65.0	8.06	206.5
18	90.0	9.49	207.0
19	165.0	12.85	208.5
20			

STEP # 6

Pressure* on Specimen, lbf/ft^2

4000

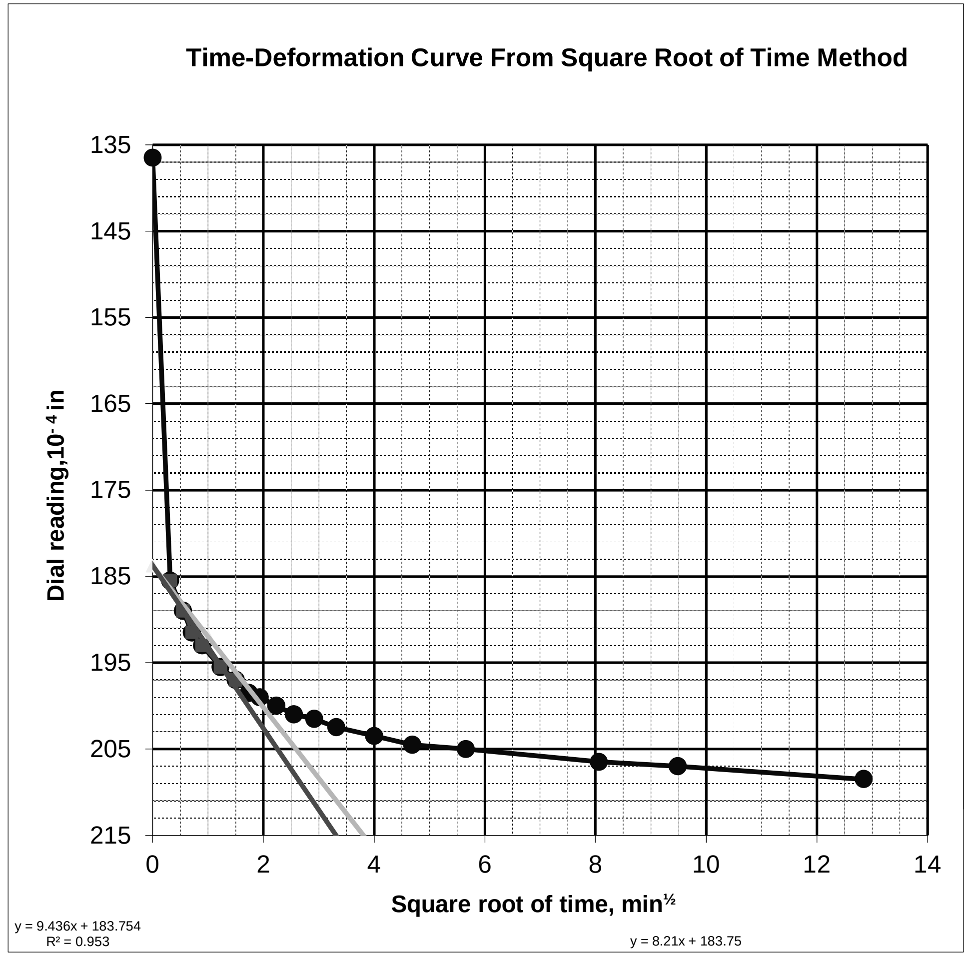
Selection	7
m_1	9.44
m_2	8.21

X	**Y**
0	183.75
1	191.96

d_0	183.8
d_{90}	199
d_{100}	200
d_{50}	192
$sq.root\ t_{90}$	1.8
t_{90}, min	3.24
$sq.root\ t_{50}$	0.87
t_{50}, min	0.76

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Project Name	AMA	S. Type	Remold
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 7

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	208.5
2	0.08	0.29	288.0
3	0.28	0.53	294.5
4	0.48	0.70	298.5
5	0.78	0.89	301.5
6	1.48	1.22	306.0
7	2.23	1.49	309.0
8	2.98	1.73	310.5
9	3.73	1.93	312.0
10	4.98	2.23	313.5
11	6.48	2.55	315.0
12	8.5	2.91	316.5
13	11.0	3.31	317.5
14	16.0	4.00	319.5
15	22.0	4.69	320.5
16	32.0	5.66	322.0
17	65.0	8.06	324.5
18	90.0	9.49	325.5
19	165.0	12.84	327.0
20			

Pressure* on Specimen, lbf/ft^2

8000

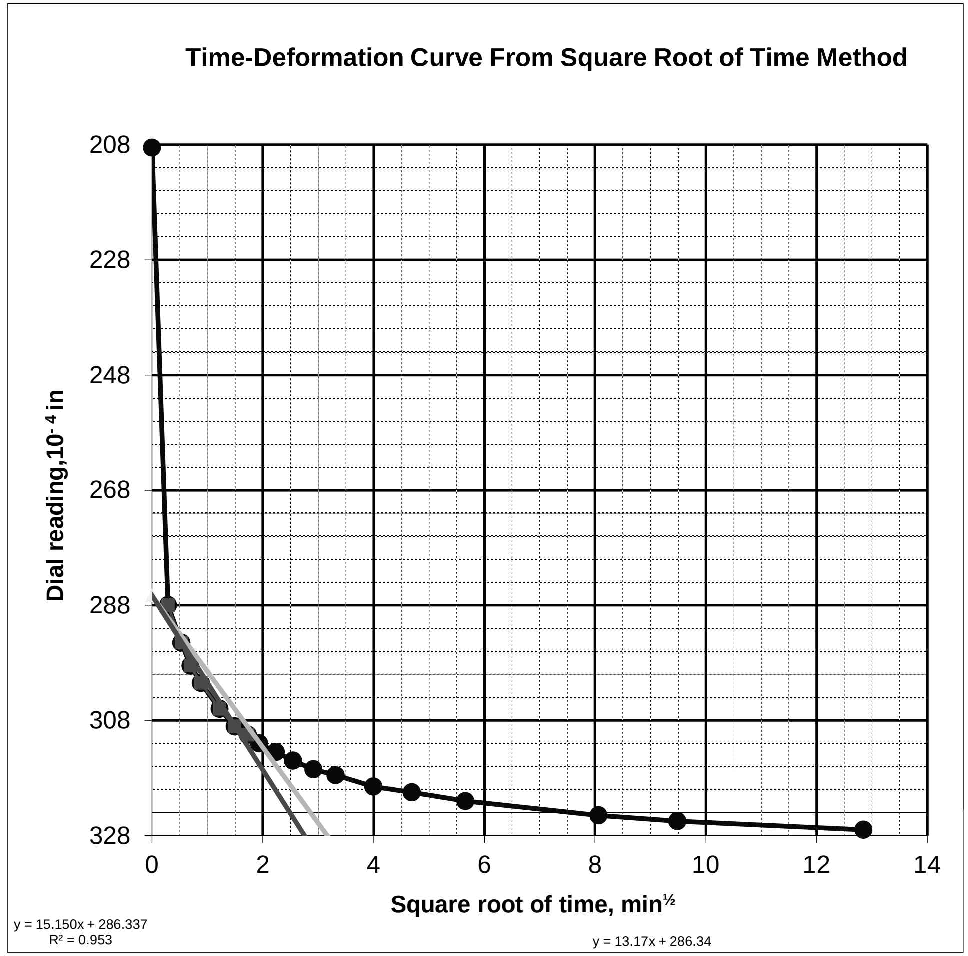
Selection	8
m_1	15.15
m_2	13.17

X	Y
0	286.34
1	299.51

d_0	286.3
d_{90}	311
d_{100}	314
d_{50}	300
sq.root t_{90}	1.9
t_{90}, min	3.61
sq.root t_{50}	0.92
t_{50}, min	0.84

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Project Name	AMA	S. Type	Remold
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 8

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	328.0
2	0.08	0.29	452.5
3	0.28	0.53	461.0
4	0.48	0.70	466.5
5	0.78	0.89	471.0
6	1.48	1.22	477.0
7	2.23	1.49	481.0
8	2.98	1.73	483.5
9	3.73	1.93	485.5
10	4.98	2.23	487.5
11	6.48	2.55	490.0
12	8.5	2.91	492.0
13	11.0	3.31	494.0
14	16.0	4.00	496.5
15	22.0	4.69	498.0
16	32.0	5.66	500.0
17	65.0	8.06	503.5
18	90.0	9.49	506.0
19	165.0	12.84	509.0
20	240.0	15.49	510.5

Pressure* on Specimen, lbf/ft^2

16000

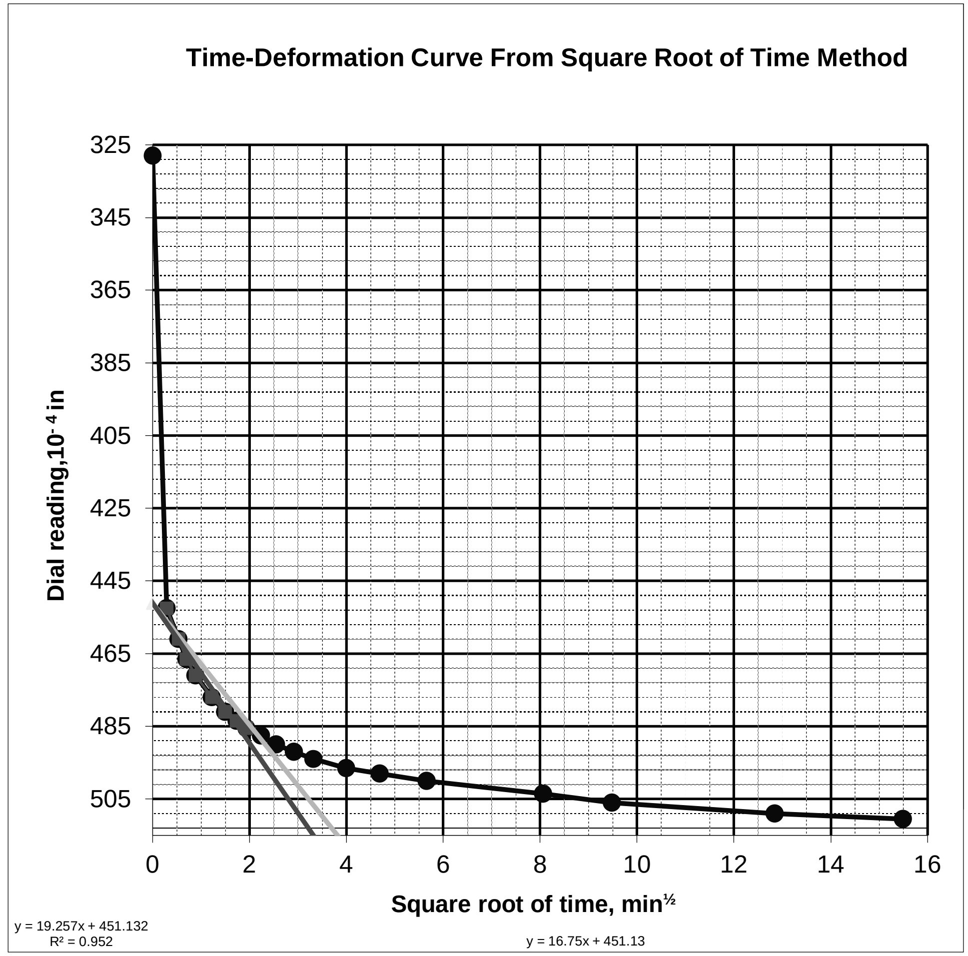
Selection	9
m_1	19.26
m_2	16.75

X	Y
0	451.13
1	467.88

d_0	451.1
d_{90}	487
d_{100}	491
d_{50}	471
$sq.root\ t_{90}$	2.15
t_{90}, min	4.62
$sq.root\ t_{50}$	1.04
t_{50}, min	1.08

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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		Date	03/04/20
		Checked By	

Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Project Name	AMA	S. Type	Remold
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D2435

Standard Test Method for One-Dimensional Consolidation Properties of Soils (Method B)

Sample Data

	Initial	Final
Mass of Ring, g	194.73	194.73
Mass of Wet Sample and Ring, g	346.60	347.03
Mass of Wet Sample, g	151.87	152.30
Mass of Dry Sample, g	129.89	129.89
Height of Sample, in	0.9970	0.9479
Diameter of Sample, in	2.501	2.501
Area of Sample, in^2	4.91	4.91
Volume of Sample, in^3	4.90	4.66
Specific Gravity (Assumed)	2.553	2.553
Wet Unit Weight, pcf	118.1	124.6
Dry Unit Weight, pcf	101.0	106.3
Height of Solids, in	0.6320	0.6320
Height of Voids, in	0.3650	0.3159
Height of Water, in	0.2730	0.2784
Void Ratio	0.578	0.500
Degree of Saturation, %	74.8	88.1

Initial Seating Pressure, lbf/ft^2	100
Additional Vertical Pressure, lbf/ft^2	0
Total Seating Pressure, lbf/ft^2	100
STATION #	1
Consolidometer Ring ID Number	1
Consolidometer ID Number	1
Frame ID Number	103
Dial Gage ID Number	676
Initial Dial Gauge Reading, 10^{-4} in	0
Final Dial Gauge Reading, 10^{-4} in	491

DESCRIPTION

Dark Gray Sandy Silt

Condition of Test:

1. Deionized water used for inundation of sample.
2. Saturated porous stones w/t filter paper used

USCS (ASTM D2487;2488)

ML

REMARKS

Material passed #4 sieve used for testing. Material was remolded to 95.2% of maximum dry density (standard proctor) at 2.1% above optimum moisture content.

Moisture Content

	Trimmings	Initial	Final
Mass of Wet Sample and Tare, g	401.20	346.60	406.44
Mass of Dry Sample and Tare, g	356.30	324.62	384.03
Mass of Tare, g	101.60	194.73	254.15
Moisture Content, %	17.6	16.9	17.3

LL	-
PL	-
PI	-

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Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D2435

Standard Test Method for One-Dimensional Consolidation Properties of Soils (Method B)

Void Ratio, Strain Information and Coefficient of Consolidation Calculation

Pressure		Uncorrected Dial Reading, in		Apparatus Correction, in	Corrected Dial Reading, in		Change in specimen height, in		Sample Height, in		Height of Voids, in	Void Ratio		Strain, %		Fitting Time, min		Hd_{50}, in	Coefficient of Consolidation	
lbf/ft^2	Ksf	d_{100}	d_{50}		d_{100}	d_{50}	S D H_{100}	S D H_{50}	H_{100}	H_{50}	Hv^{100},in	e_{100}	e_{50}	e_{100}	e_{50}	t_{90}	t_{50}		in^2/min	ft^2/day
100	0.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.9970	0.9970	0.3650	0.578	0.578	0.00	0.00	-	-	0.4985	-	-
250	0.25	0.0010	0.0009	0.0000	0.0010	0.0009	0.0010	0.0009	0.9960	0.9961	0.3640	0.576	0.576	0.10	0.09	1.10	0.26	0.4981	0.19	1.91
500	0.5	0.0031	0.0028	0.0000	0.0031	0.0028	0.0031	0.0028	0.9939	0.9942	0.3620	0.573	0.573	0.31	0.28	1.82	0.43	0.4971	0.11	1.15
1000	1	0.0072	0.0067	0.0000	0.0072	0.0067	0.0072	0.0067	0.9898	0.9903	0.3578	0.566	0.567	0.73	0.68	1.96	0.46	0.4951	0.11	1.06
2000	2	0.0128	0.0122	0.0000	0.0128	0.0122	0.0128	0.0122	0.9842	0.9848	0.3522	0.557	0.558	1.28	1.22	2.10	0.49	0.4924	0.10	0.98
4000	4	0.0200	0.0192	0.0000	0.0200	0.0192	0.0200	0.0192	0.9770	0.9778	0.3450	0.546	0.547	2.01	1.93	3.24	0.76	0.4889	0.06	0.63
8000	8	0.0314	0.0300	0.0000	0.0314	0.0300	0.0314	0.0300	0.9656	0.9670	0.3336	0.528	0.530	3.15	3.01	3.61	0.84	0.4835	0.05	0.55
16000	16	0.0491	0.0471	0.0000	0.0491	0.0471	0.0491	0.0471	0.9479	0.9499	0.3159	0.500	0.503	4.93	4.73	4.62	1.08	0.4749	0.04	0.41

Note:
d_{100} = Dial gauge reading at 100% primary consolidation, in
d_{50} = Dial gauge reading at 50% primary consolidation, in
H_{100} = Specimen height at 100% primary consolidation, in
H_{50} = Specimen height at 50% primary consolidation, in
Hd_{50} = Length of the drainage path at 50% consolidation, in
e_{100} = Void ratio at 100% primary consolidation
e_{50} = Void ratio at 50% primary consolidation

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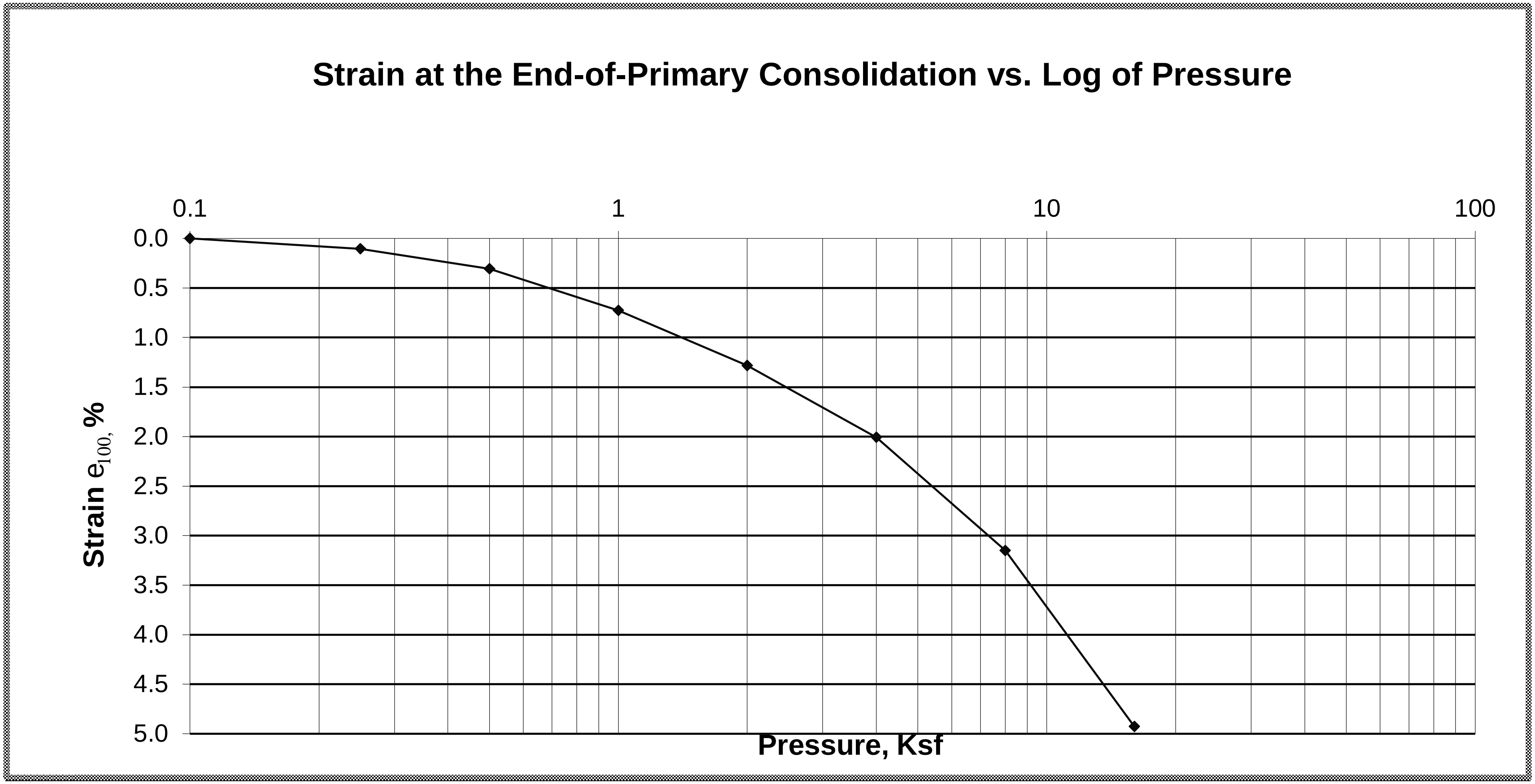
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 2435; Standard Test Method for One-Dimensional Consolidation Properties of Soils (Method B)



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		Date	03/04/20
		Checked By	[signature]

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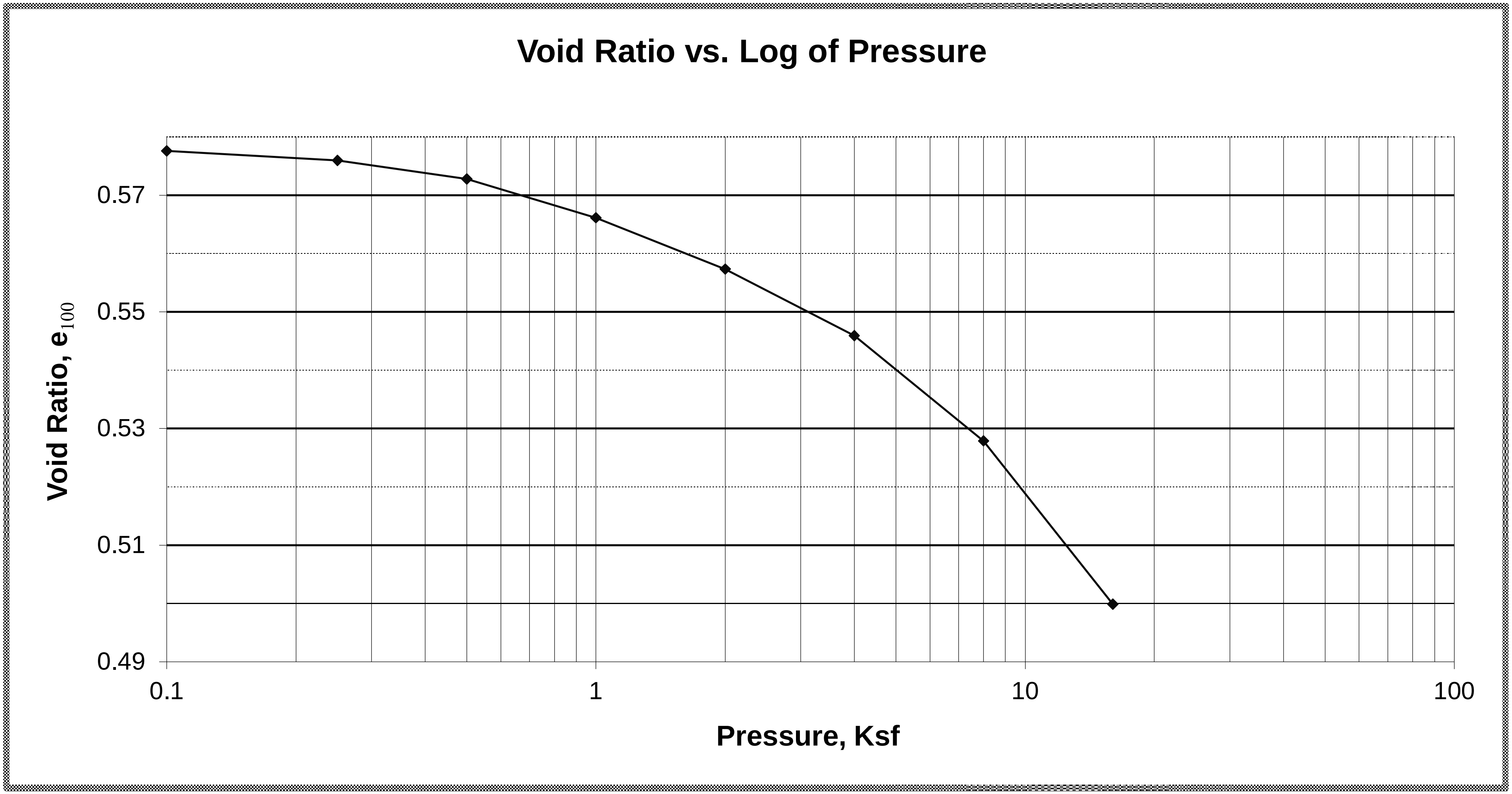
Project Name	AMA	S. Type	Remold
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 2435; Standard Test Method for One-Dimensional Consolidation Properties of Soils (Method B)



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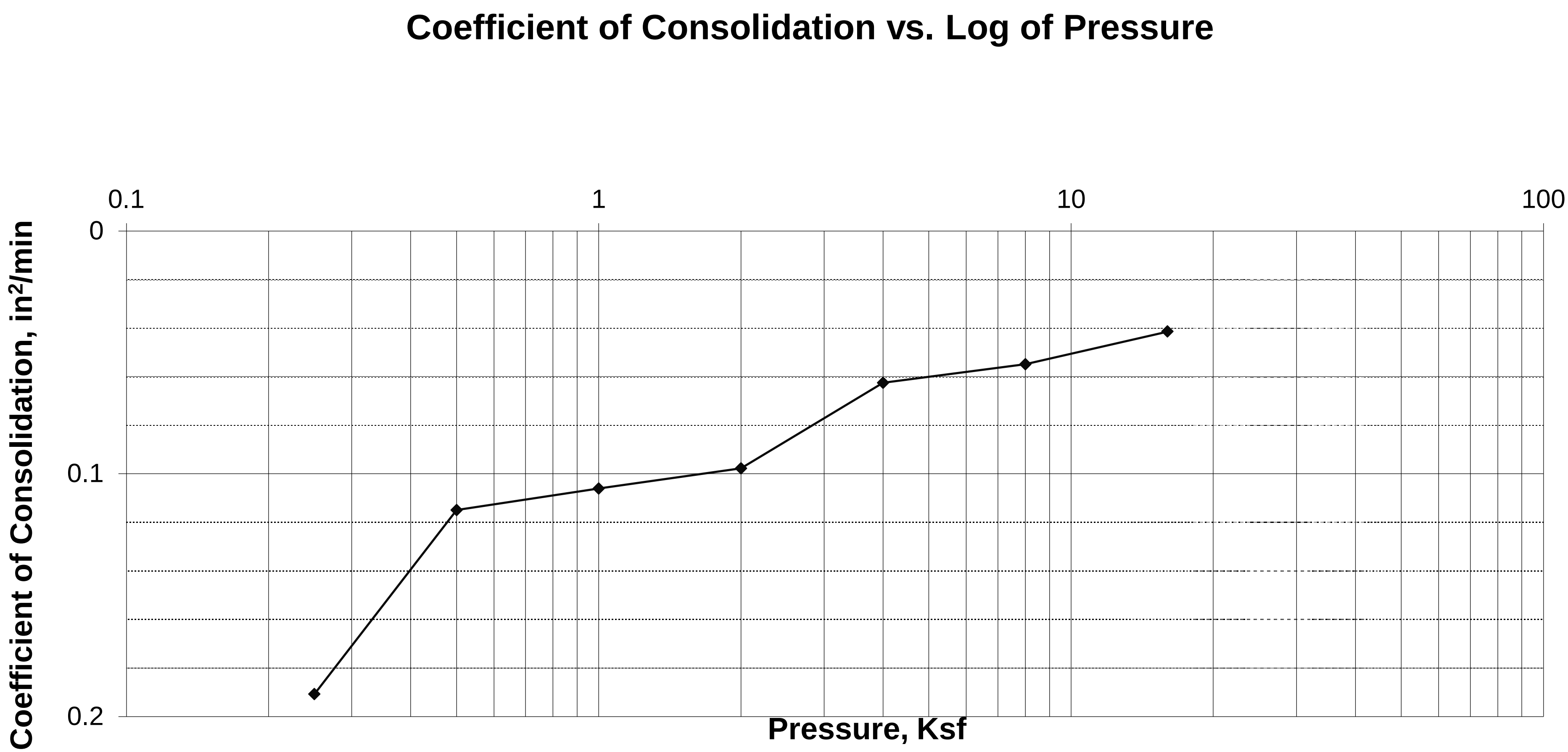
Client Pr. #	I054-107	Lab. PR. #	2008-08-1
Project Name	AMA	S. Type	Remold
Sample ID	33248/Ash #1	Depth/Elev.	-
Location	Yates	Add. Info	-

ASTM D 2435; Standard Test Method for One-Dimensional Consolidation Properties of Soils (Method B)



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Tested By	KP
Date	04/06/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Project Name	AMA	S. Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 2

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	0.0
2	0.08	0.29	17.0
3	0.28	0.53	17.5
4	0.48	0.70	17.8
5	0.78	0.89	18.0
6	1.48	1.22	18.0
7	2.23	1.49	18.0
8	2.98	1.73	18.0
9	3.73	1.93	18.0
10	4.98	2.23	18.0
11	6.48	2.55	18.0
12	8.5	2.91	18.5
13	11.0	3.31	18.5
14	16.0	4.00	18.5
15	22.0	4.69	18.5
16	32.0	5.66	19.0
17	65.0	8.06	19.0
18	90.0	9.49	19.0
19	165.0	12.84	19.5
20	240.0	15.49	19.5
	390.0	19.75	19.5
	540.0	23.24	19.5
	690.0	26.27	19.5

Pressure* on Specimen, lbf/ft^2

250

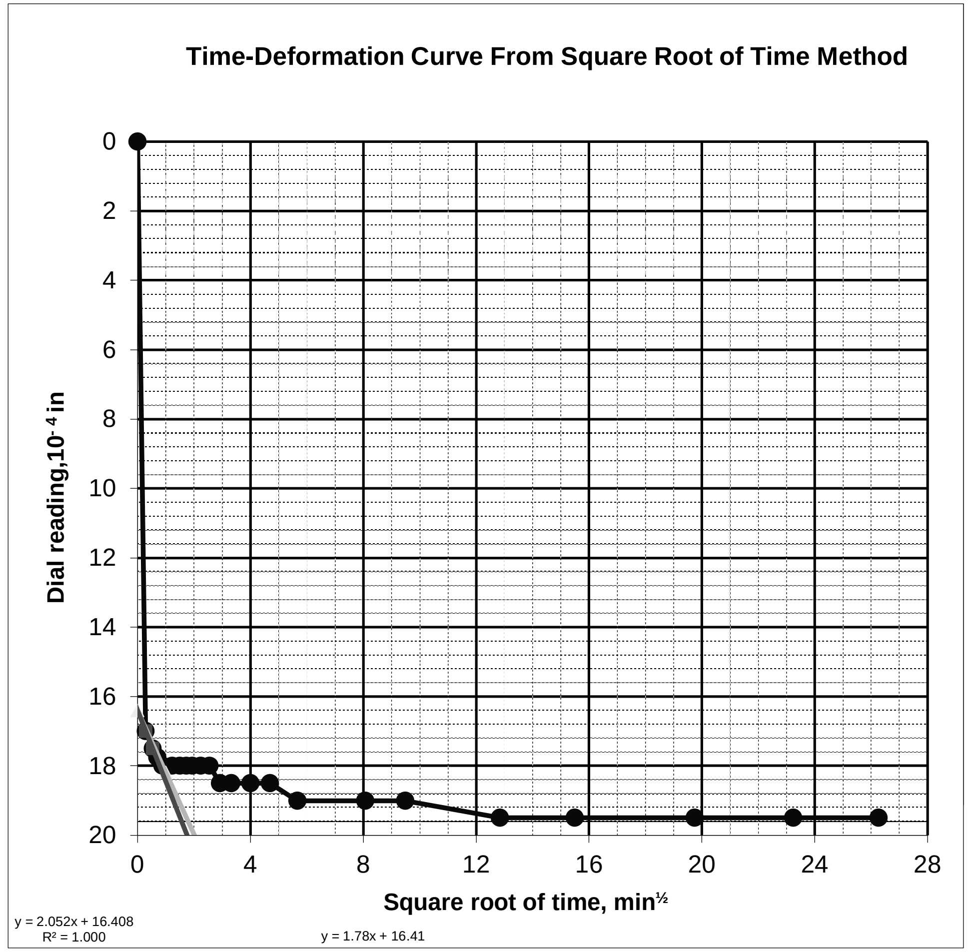
Selection	3
m_1	2.05
m_2	1.78

X	Y
0	16.41
1	18.19

d_0	16.4
d_{90}	18
d_{100}	18
d_{50}	17
sq.root t_{90}	0.9
t_{90}, min	0.81
sq.root t_{50}	0.43
t_{50}, min	0.19

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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AASHTO ACCREDITED

Tested By	KP
Date	04/06/20
Checked By	[signature]

Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Project Name	AMA	S. Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 3

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	19.5
2	0.08	0.29	38.0
3	0.28	0.53	39.0
4	0.50	0.71	39.5
5	0.78	0.89	40.0
6	1.48	1.22	40.5
7	2.23	1.49	41.0
8	2.98	1.73	41.0
9	3.73	1.93	41.0
10	4.98	2.23	41.5
11	6.48	2.55	41.5
12	8.5	2.91	41.5
13	11.0	3.31	42.0
14	16.0	4.00	42.0
15	22.0	4.69	42.0
16	32.0	5.66	42.5
17			
18			
19			
20			

Pressure* on Specimen, lbf/ft^2

500

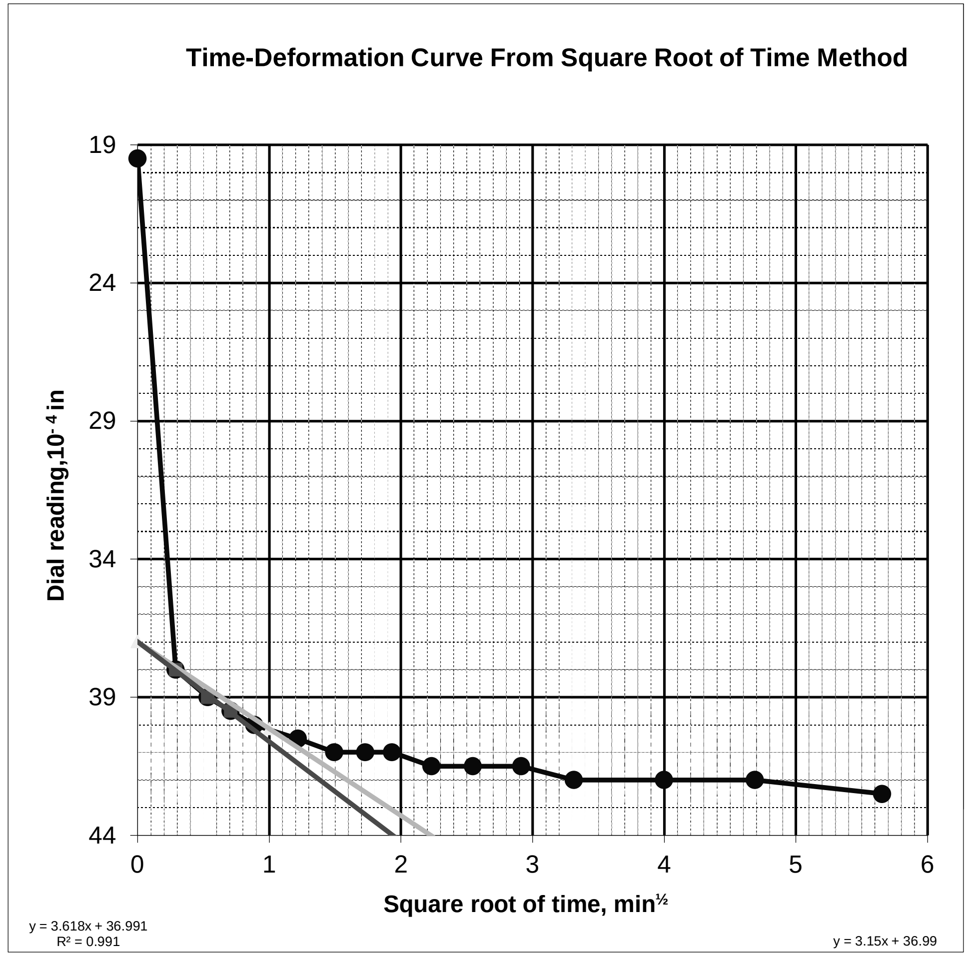
Selection	4
m_1	3.62
m_2	3.15

X	Y
0	36.99
1	40.14

d_0	37.0
d_{90}	40
d_{100}	40
d_{50}	39
sq.root t_{90}	1
t_{90}, min	1.00
sq.root t_{50}	0.48
t_{50}, min	0.23

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Project Name	AMA	S. Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 4

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	42.5
2	0.08	0.29	84.0
3	0.28	0.53	86.0
4	0.48	0.70	87.0
5	0.78	0.89	87.5
6	1.48	1.22	88.5
7	2.23	1.49	89.5
8	2.98	1.73	90.0
9	3.73	1.93	90.0
10	4.98	2.23	90.5
11	6.48	2.55	91.0
12	8.5	2.91	91.5
13	11.0	3.31	92.0
14	16.0	4.00	92.5
15	22.0	4.69	93.0
16	32.0	5.66	93.5
17			
18			
19			
20			

Pressure* on Specimen, lbf/ft^2

1000

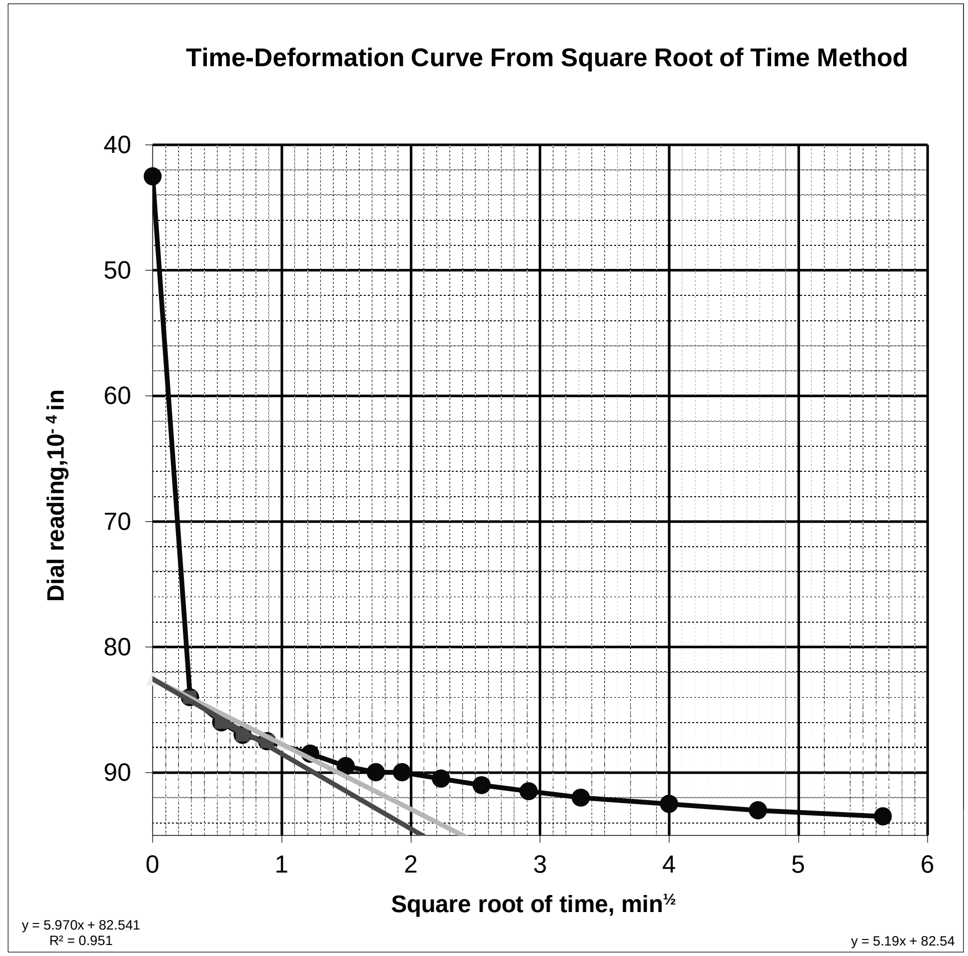
Selection	5
m_1	5.97
m_2	5.19

X	Y
0	82.54
1	87.73

d_0	82.5
d_{90}	88
d_{100}	89
d_{50}	86
$sq.root\ t_{90}$	1.05
t_{90}, min	1.10
$sq.root\ t_{50}$	0.51
t_{50}, min	0.26

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Project Name	AMA	S. Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 5

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	94.0
2	0.10	0.32	175.5
3	0.30	0.55	177.5
4	0.50	0.71	179.0
5	0.80	0.89	180.0
6	1.50	1.22	181.0
7	2.25	1.50	182.0
8	3.00	1.73	183.0
9	3.75	1.94	183.0
10	5.00	2.24	183.5
11	6.50	2.55	184.5
12	8.5	2.92	185.0
13	11.0	3.32	185.5
14	16.0	4.00	186.5
15	22.0	4.69	186.5
16	32.0	5.66	187.5
17			
18			
19			
20			

Pressure* on Specimen, lbf/ft^2

2000

Selection	5
m_1	7.94
m_2	6.90

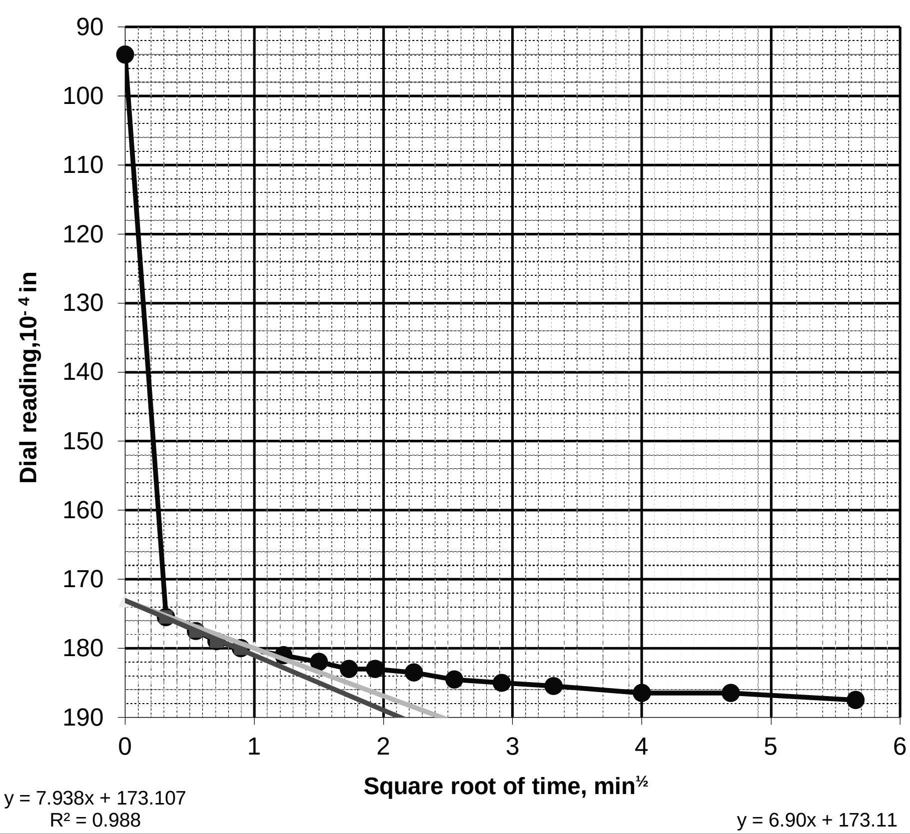
X	Y
0	173.11
1	180.01

d_0	173.1
d_{90}	181
d_{100}	182
d_{50}	177
sq.root t_{90}	1.1
t_{90}, min	1.21
sq.root t_{50}	0.53
t_{50}, min	0.28

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.

Time-Deformation Curve From Square Root of Time Method



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Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 6

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	189.0
2	0.10	0.32	307.5
3	0.30	0.55	312.0
4	0.50	0.71	314.5
5	0.80	0.89	317.0
6	1.50	1.22	319.5
7	2.25	1.50	321.0
8	3.00	1.73	322.0
9	3.75	1.94	323.0
10	5.00	2.24	324.0
11	6.50	2.55	325.0
12	8.5	2.92	325.5
13	11.0	3.32	326.5
14	16.0	4.00	328.0
15	22.0	4.69	329.0
16	32.0	5.66	330.5
17	65.0	8.06	333.0
18	90.0	9.49	334.5
19	165.0	12.85	337.5
20			

Pressure* on Specimen, lbf/ft^2

4000

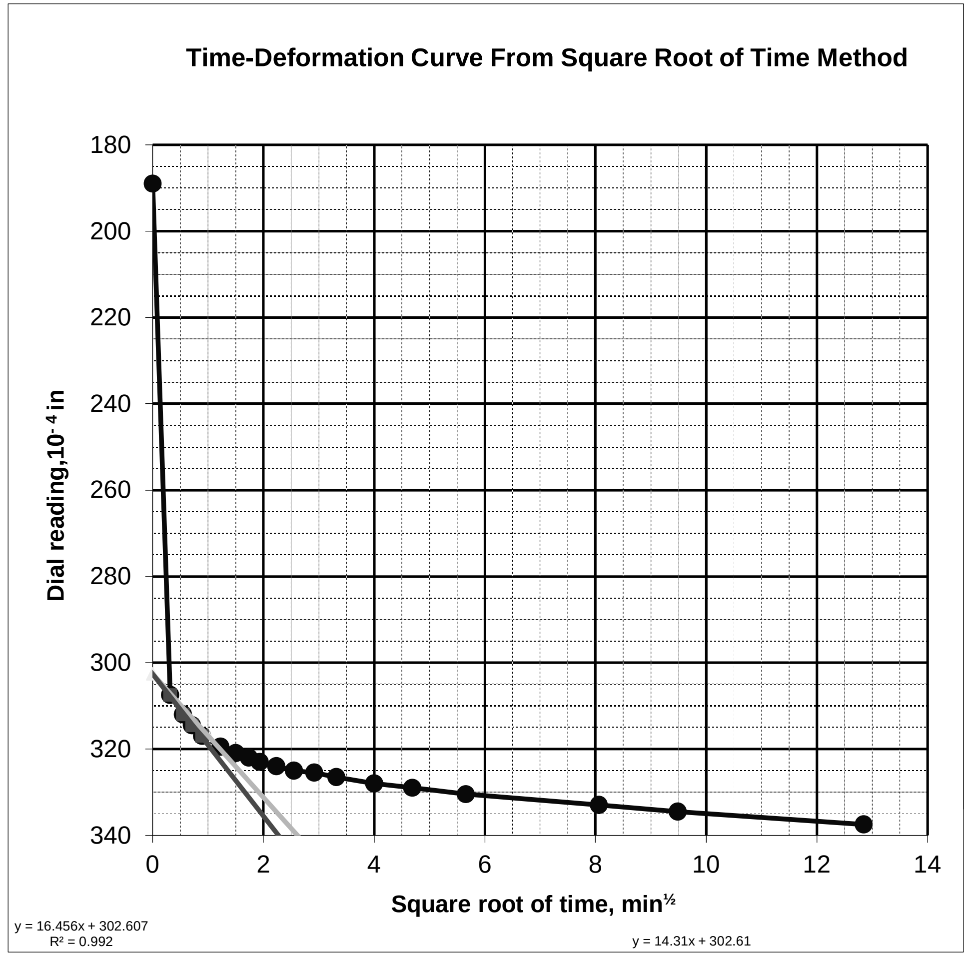
Selection	5
m_1	16.46
m_2	14.31

X	Y
0	302.61
1	316.92

d_0	302.6
d_{90}	319
d_{100}	321
d_{50}	312
sq.root t_{90}	1.15
t_{90}, min	1.32
sq.root t_{50}	0.56
t_{50}, min	0.31

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Checked By			
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Project Name	AMA	S. Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 7

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	338.0
2	0.10	0.32	496.0
3	0.30	0.55	503.0
4	0.50	0.71	508.0
5	0.80	0.89	511.5
6	1.50	1.22	517.0
7	2.25	1.50	520.0
8	3.00	1.73	522.5
9	3.75	1.94	524.0
10	5.00	2.24	526.0
11	6.50	2.55	527.5
12	8.5	2.92	529.5
13	11.0	3.32	531.0
14	16.0	4.00	533.5
15	22.0	4.69	535.0
16	32.0	5.66	537.5
17	65.0	8.06	541.5
18	90.0	9.49	543.5
19			
20			

Pressure* on Specimen, lbf/ft^2

8000

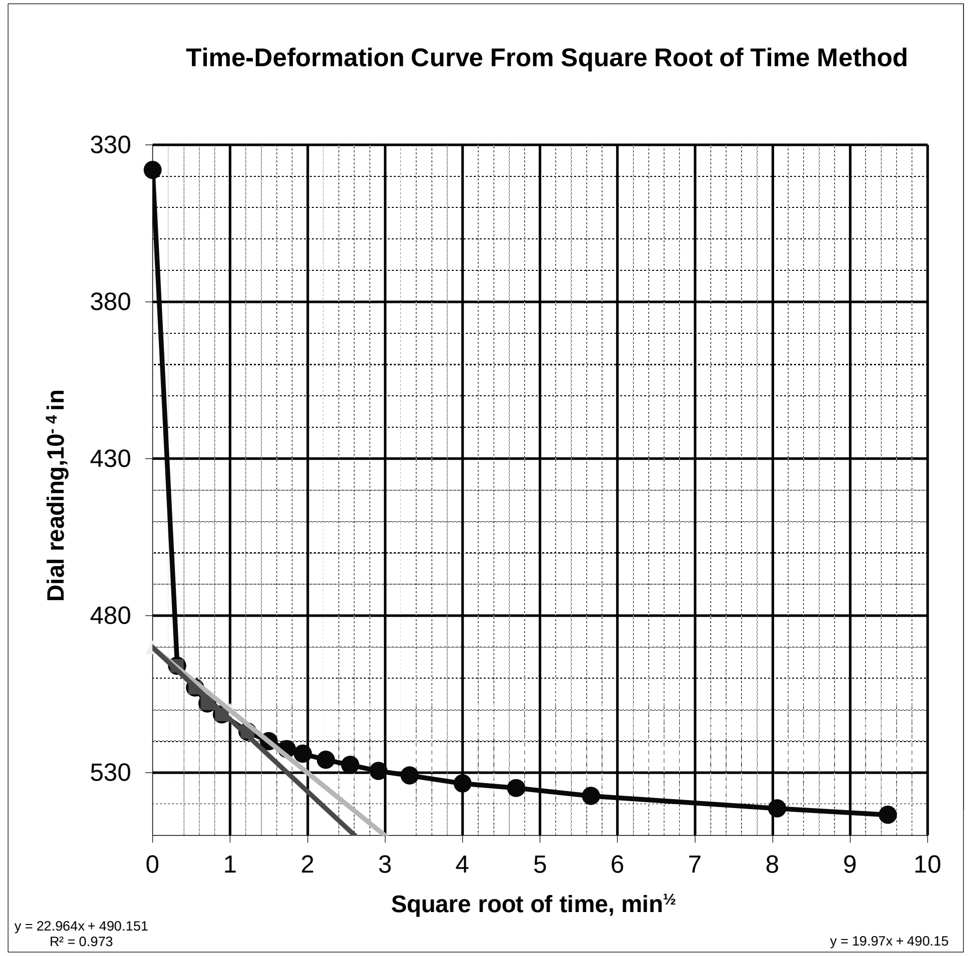
Selection	6
m_1	22.96
m_2	19.97

X	**Y**
0	490.15
1	510.12

d_0	490.2
d_{90}	519
d_{100}	522
d_{50}	506
$sq.root\ t_{90}$	1.45
t_{90}, min	2.10
$sq.root\ t_{50}$	0.70
t_{50}, min	0.49

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D2435 (Method B)/AASHTO T 216

STEP # 8

Point #	Time, min	Square Root of Time, $min^{1/2}$	Dial Gauge Reading, 10^{-4} in
1	0	0	545.0
2	0.08	0.29	808.0
3	0.28	0.53	819.0
4	0.48	0.70	827.0
5	0.78	0.89	834.5
6	1.48	1.22	843.5
7	2.23	1.49	849.5
8	2.98	1.73	853.5
9	3.73	1.93	857.0
10	4.98	2.23	861.0
11	6.48	2.55	864.5
12	8.5	2.91	868.0
13	11.0	3.31	871.5
14	16.0	4.00	876.5
15	22.0	4.69	880.5
16	32.0	5.66	885.5
17	65.0	8.06	894.5
18	90.0	9.49	899.0
19			
20			

Pressure* on Specimen, lbf/ft^2

16000

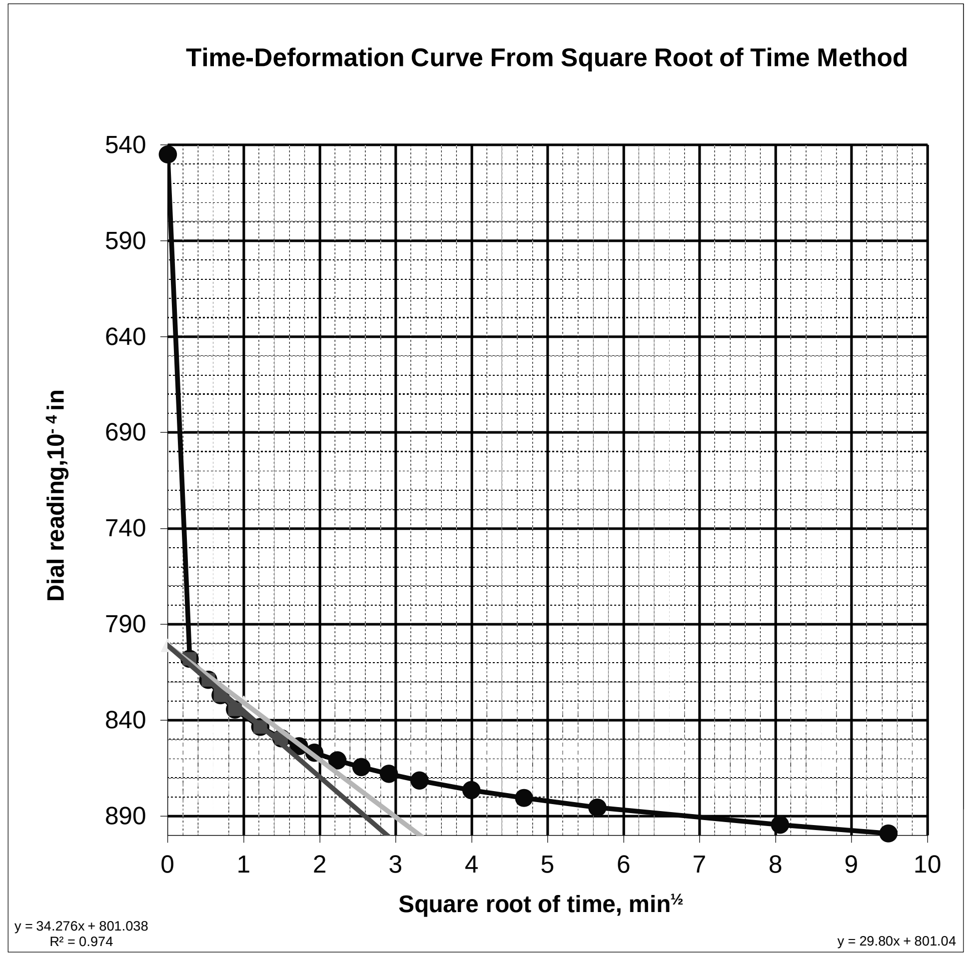
Selection	7
m_1	34.28
m_2	29.80

X	Y
0	801.04
1	830.84

d_0	801.0
d_{90}	858
d_{100}	864
d_{50}	832
sq.root t_{90}	1.9
t_{90}, min	3.61
sq.root t_{50}	0.92
t_{50}, min	0.84

d=dial gauge reading, 10^{-4} in

Note: * - Reported Pressure is not including seating pressure of 100 psf and possible additional vertical pressure applied to sample to prevent swell. If swell was observed additional vertical pressure is reported on page 1 of report.



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Client Pr. #	I054-107	Lab. PR. #	2008-08-2
Project Name	AMA	S. Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

ASTM D2435

Standard Test Method for One-Dimensional Consolidation Properties of Soils (Method B)

Sample Data

	Initial	Final
Mass of Ring, g	194.73	194.73
Mass of Wet Sample and Ring, g	322.95	329.06
Mass of Wet Sample, g	128.22	134.33
Mass of Dry Sample, g	102.04	102.04
Height of Sample, in	0.9970	0.9106
Diameter of Sample, in	2.501	2.501
Area of Sample, in^2	4.91	4.91
Volume of Sample, in^3	4.90	4.47
Specific Gravity (Assumed)	2.700	2.700
Wet Unit Weight, pcf	99.7	114.4
Dry Unit Weight, pcf	79.4	86.9
Height of Solids, in	0.4694	0.4694
Height of Voids, in	0.5276	0.4412
Height of Water, in	0.3253	0.4011
Void Ratio	1.124	0.940
Degree of Saturation, %	61.7	90.9

Initial Seating Pressure, lbf/ft^2	100
Additional Vertical Pressure, lbf/ft^2	0
Total Seating Pressure, lbf/ft^2	100
STATION #	1
Consolidometer Ring ID Number	1
Consolidometer ID Number	1
Frame ID Number	103
Dial Gage ID Number	676
Initial Dial Gauge Reading, 10^{-4} in	0
Final Dial Gauge Reading, 10^{-4} in	864

DESCRIPTION

Olive Gray Silty Sand

Condition of Test:

1. Deionized water used for inundation of sample.
2. Saturated porous stones w/t filter paper used

USCS (ASTM D2487;2488)

SM

REMARKS

Portion of sample used for testing was located 13" above the bottom of the shelby tube.

Moisture Content

	Trimmings	Initial	Final
Mass of Wet Sample and Tare, g	428.30	322.95	413.57
Mass of Dry Sample and Tare, g	371.00	296.77	381.28
Mass of Tare, g	138.20	194.73	279.26
Moisture Content, %	24.6	25.7	31.7

LL	-
PL	-
PI	-

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Location	-	Add. Info	-

ASTM D2435
Standard Test Method for One-Dimensional Consolidation Properties of Soils (Method B)

Void Ratio, Strain Information and Coefficient of Consolidation Calculation

Pressure		Uncorrected Dial Reading, in		Apparatus Correction, in	Corrected Dial Reading, in		Change in specimen height, in		Sample Height, in		Height of Voids, in	Void Ratio		Strain, %		Fitting Time, min		Hd_{50}, in	Coefficient of Consolidation	
lbf/ft^2	Ksf	d_{100}	d_{50}		d_{100}	d_{50}	SDH_{100}	SDH_{50}	H_{100}	H_{50}	Hv^{100},in	e_{100}	e_{50}	e_{100}	e_{50}	t_{90}	t_{50}		in^2/min	ft^2/day
100	0.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.9970	0.9970	0.5276	1.124	1.124	0.00	0.00	-	-	0.4985	-	-
250	0.25	0.0018	0.0017	0.0000	0.0018	0.0017	0.0018	0.0017	0.9952	0.9953	0.5258	1.120	1.120	0.18	0.17	0.81	0.19	0.4976	0.26	2.59
500	0.5	0.0040	0.0039	0.0000	0.0040	0.0039	0.0040	0.0039	0.9930	0.9931	0.5235	1.115	1.116	0.41	0.39	1.00	0.23	0.4966	0.21	2.09
1000	1	0.0089	0.0086	0.0000	0.0089	0.0086	0.0089	0.0086	0.9881	0.9884	0.5187	1.105	1.106	0.89	0.86	1.10	0.26	0.4942	0.19	1.88
2000	2	0.0182	0.0177	0.0000	0.0182	0.0177	0.0182	0.0177	0.9788	0.9793	0.5094	1.085	1.086	1.82	1.78	1.21	0.28	0.4896	0.17	1.68
4000	4	0.0321	0.0312	0.0000	0.0321	0.0312	0.0321	0.0312	0.9649	0.9658	0.4955	1.056	1.057	3.22	3.13	1.32	0.31	0.4829	0.15	1.50
8000	8	0.0522	0.0506	0.0000	0.0522	0.0506	0.0522	0.0506	0.9448	0.9464	0.4753	1.013	1.016	5.24	5.08	2.10	0.49	0.4732	0.09	0.90
16000	16	0.0864	0.0832	0.0000	0.0864	0.0832	0.0864	0.0832	0.9106	0.9138	0.4412	0.940	0.947	8.67	8.35	3.61	0.84	0.4569	0.05	0.49

Note:
- d_{100} = Dial gauge reading at 100% primary consolidation, in
- d_{50} = Dial gauge reading at 50% primary consolidation, in
- H_{100} = Specimen height at 100% primary consolidation, in
- H_{50} = Specimen height at 50% primary consolidation, in
- Hd_{50} = Length of the drainage path at 50% consolidation, in
- e_{100} = Void ratio at 100% primary consolidation
- e_{50} = Void ratio at 50% primary consolidation

T.E.S.T.
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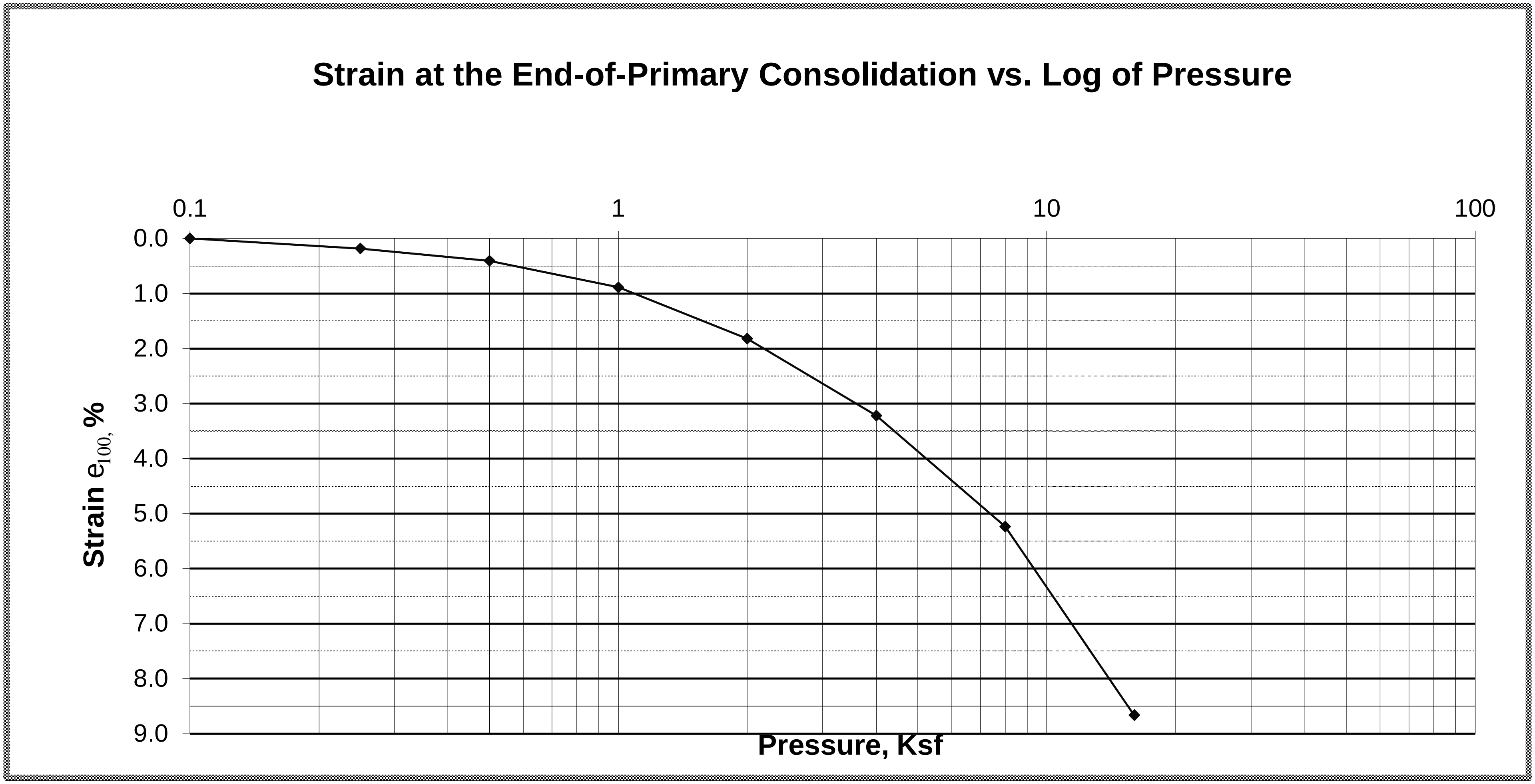
Project Name	AMA	S. Type	UD
Sample ID	33612/YGWA-181-12-14	Depth/Elev.	-
Location	-	Add. Info	-

ASTM D 2435; Standard Test Method for One-Dimensional Consolidation Properties of Soils (Method B)



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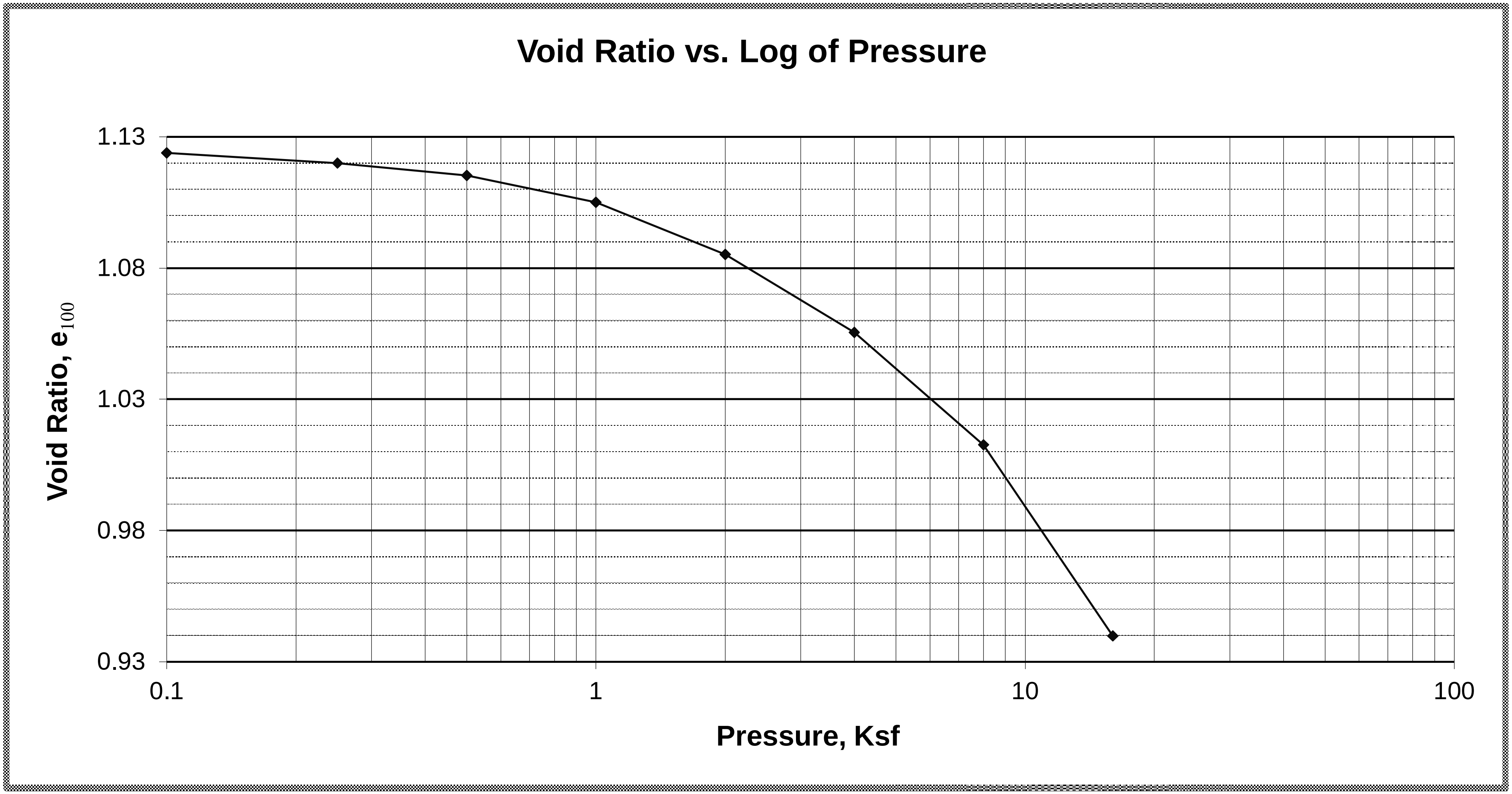
Location	-	Add. Info	-

ASTM D 2435; Standard Test Method for One-Dimensional Consolidation Properties of Soils (Method B)



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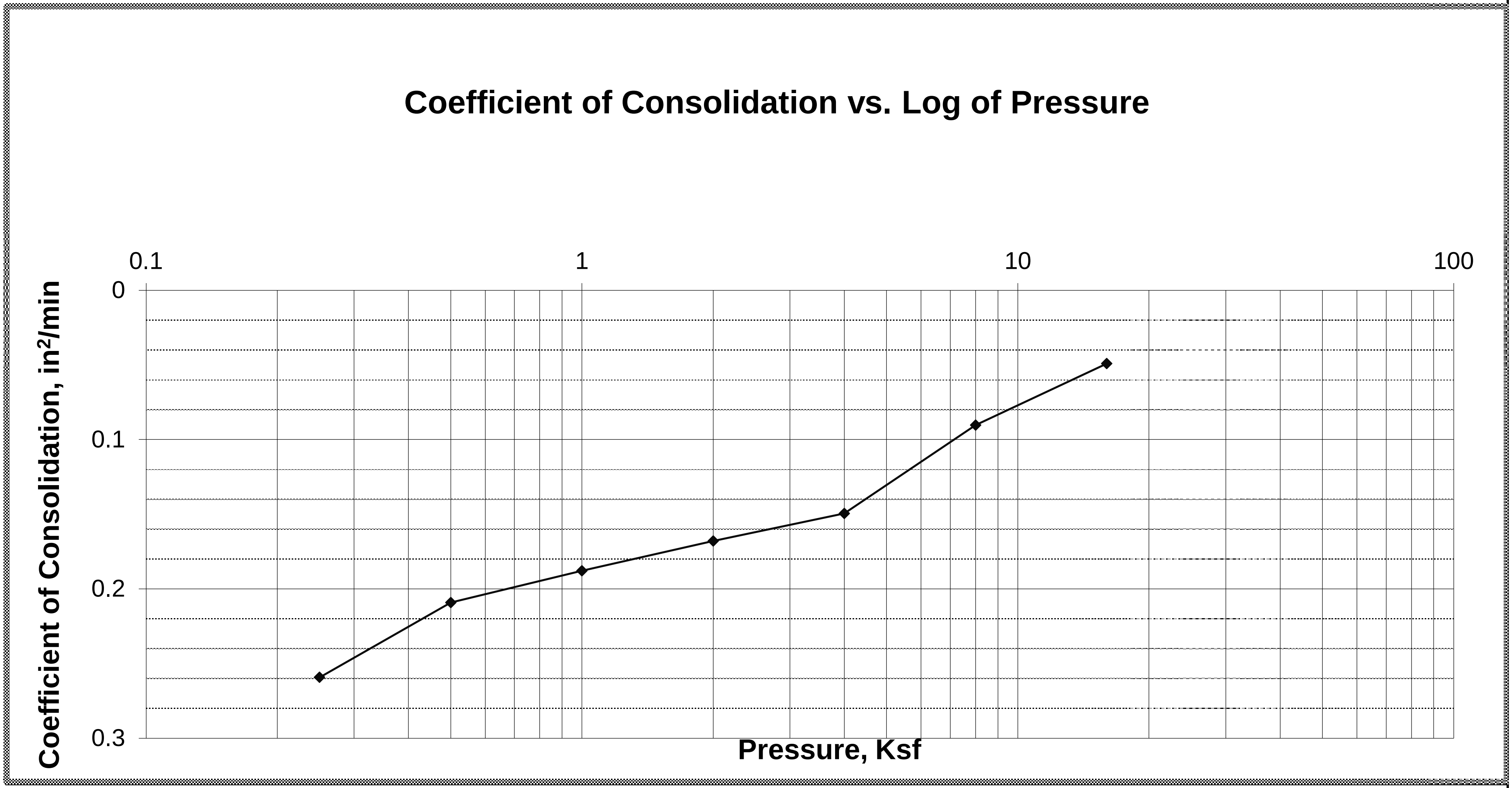
Location	-	Add. Info	-

ASTM D 2435; Standard Test Method for One-Dimensional Consolidation Properties of Soils (Method B)



7.10 CLOSURETURF WITH SAND-CEMENT INFILL – CHANNEL LINING – MANNING'S ROUGHNESS COEFFICIENTS

Project: ClosureTurf with Sand-Cement Infill - Channel Lining
Client: Watershed Geo
Test Dates: 7/20/2015 7/31/2015
Shear Range: 2.0 - 10.0+ psf (target)
Flume Size & Slope: 2-ft wide x 40-ft long; 10% Bed (Shear Levels 1 - 4)
2-ft wide x 40-ft long; 20% Bed (Shear Levels 5 - 8)
Event: 30 minutes at each shear

Shear Level	Flow depth (in)	Flow velocity (fps)	Flow (cfs)	Manning's roughness, n	Max Bed Shear Stress (psf)	CSLI (in)	Cumm. CSLI, (in)
1	1.86	3.68	1.14	0.037	0.96	0.00	0.00
2	2.56	5.19	2.21	0.032	1.30	0.00	0.00
3	3.76	7.93	4.96	0.027	1.90	0.00	0.00
4	6.91	14.57	16.78	0.022	3.53	0.00	0.01
5	1.94	5.13	1.66	0.039	1.99	0.00	0.00
6	3.87	10.64	6.86	0.029	3.86	0.00	0.00
7	5.80	17.29	16.72	0.023	5.37	0.03	0.03
8	9.63	25.09	40.27	0.020	7.62	0.03	0.07

Observations:

Shears 1 - 3 & 5 - 7: The flow was laminar and uniform through the test reach. There was no observable loss or cracking of fill material. Shear events appeared to have no effect on the system.

Shears 4 & 8: Flow was turbulent entering the channel but became reasonably laminar by Section 6. Still, there was no observable loss or cracking of fill material. Even these highest shear events appeared to have no effect on the system.


Channel Prepared for Testing


Highest Shear = Maximum Flow in 20% Flume


After Highest Shear


Close-up After Highest Shear

CJS 8/17/15
Quality Review / Date

7.11 TABLE 3 – SOIL CLASSIFICATION TABLE

Table 2					
		SOIL CLASSIFICATION			
SLOPE	LAND USE	SAND OR SANDY LOAM SOILS (Pervious)		HIGH CLAY SOILS (Impervious)	
		Min.	Max.	Min.	Max.
Flat (0% - 3%)	Woodlands	0.15	0.20	0.20	0.25
	Pasture	0.20	0.25	0.25	0.30
	Paved	0.95		0.95	
	Residential	0.35	0.60	0.50	0.60
	Commercial	0.60	0.95	0.60	0.95
Rolling (3% - 7%)	Woodlands	0.15	0.20	0.18	0.25
	Pasture	0.30	0.40	0.35	0.45
	Paved	0.95		0.95	
	Residential	0.50	0.60	0.50	0.60
	Commercial	0.60	0.95	0.60	0.95
Hilly (7% - 11%)	Woodlands	0.20	0.25	0.25	0.30
	Pasture	0.35	0.45	0.45	0.55
	Paved	0.95		0.95	
	Residential	0.50	0.60	0.50	0.60
	Commercial	0.60	0.95	0.60	0.95
Mountainous (11% +)	Woodlands			0.70	0.80
	Bare		0.80	0.80	0.95
Steep Grassed Slopes	Pasture	0.70		0.70	

Table 2: Soil Classification Table from the GSWCC Manual for Erosion and Sediment Control in Georgia 1995

7.12 EVALUATION OF DRIVABILITY LIGHT WEIGHT CONSTRUCTION EQUIPMENT ON CLOSURE TURF™ SYSTEM, BY SGI TESTING SERVICES

8 July 2010

Mr. Jose Urrutia
Closure Turf, LLC
3005 Breckinridge Blvd., Suite 240
Duluth, Georgia 3096

Subject: Evaluation of Drivability
Light Weight Construction Equipment on
Closure Turf™ System

Dear Mr. Urrutia,

DEFINITION OF CLOSURE TURF™ SYSTEM

As shown in Figure 1, the installed Closure Turf™ system from top to bottom consists of:

- A thin sand layer;
- Artificial grass with geotextile down;
- Agru 50-mil Super Gripnet with spike sides down; and
- Subgarde (foundation) soil.

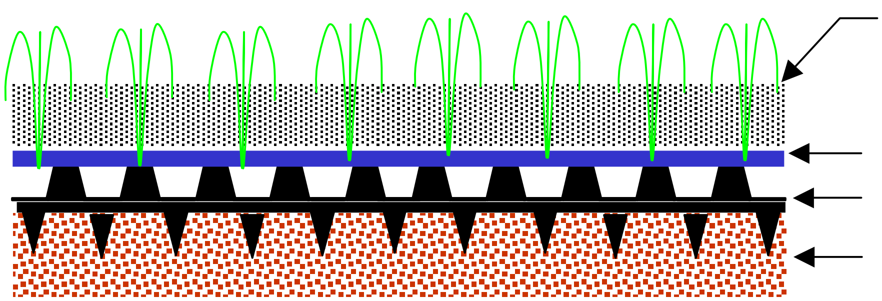


Figure 1. Cross-section of the Closure Turf system

MAIL TO: SGI TESTING SERVICES, LLC
P.O. BOX 2427
LILBURN, GA 30048-2427

FACILITY LOCATION
4405 INTERNATIONAL BLVD., SUITE B-117
NORCROSS, GA 30093

WEB SITE: WWW.INTERACTIONSPECIALISTS.COM
PHONE: 770.931.8222 FAX: 770.931.8240

DEFINITION OF POST-CONSTRUCTION DRIVABILITY

Drivability of rubber-tired construction equipment (RTCE) on the Closure Turf™ system is a rather broad subject including: (i) stability - potential sliding (shear failure) within the Turf Closure system; (ii) bearing capacity of the subgrade soil; (iii) localized settlement after construction due to waste decomposing and compression under gravity force; and (iv) rut depth. The purpose of this report is to evaluate the stability within the Turf Closure system and bearing capacity of the subgrade soil.

STABILITY

As shown in Figure 2, when a RTCE moves at a constant speed on the Closure Turf system, its gravity load is transferred to the Closure Turf system through the tire-soil contact.

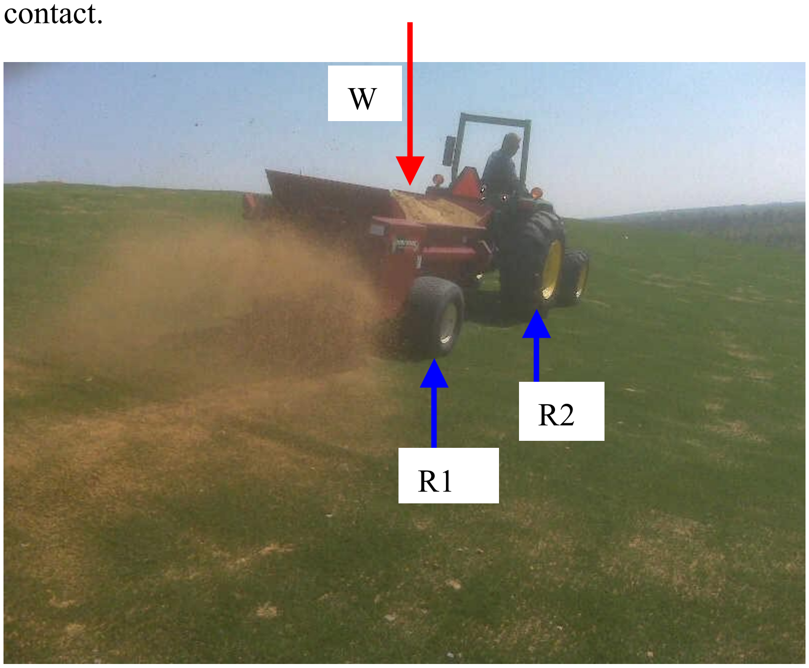


Figure 2. Rubber-tired construction equipment on the Closure Turf system.

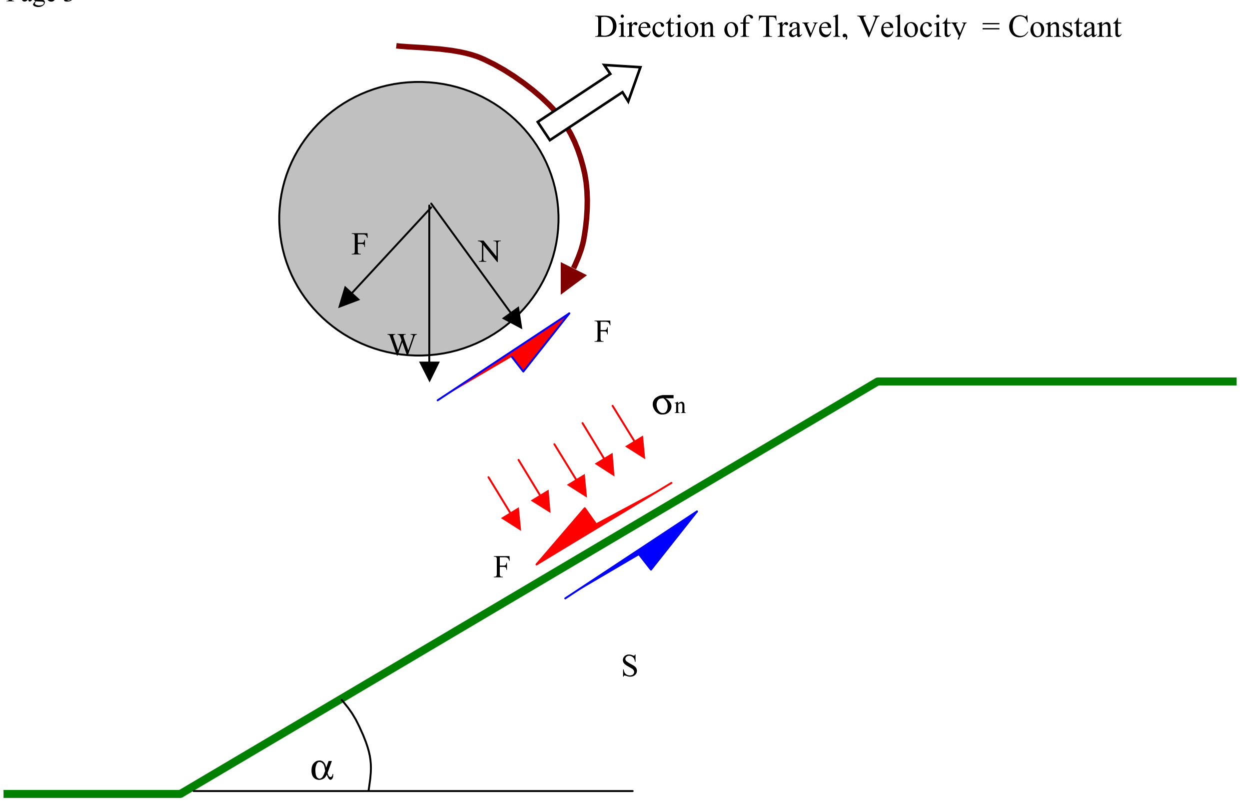


Figure 3. Tire-soil contact loading conditions on a slope. (NOTE: not to scale).

Assuming the gravity force of RTCE is evenly distributed to four tires, the contact normal stress at the tire-sand contact area as shown in Figure 3 can be estimated by the following equation:

$$\sigma_n = \frac{W \cos \alpha}{4A} \qquad (1)$$

where:

α = the slope angle;

σ_n = contact normal stress between the tire and sand;

W = total gravity force of equipment; and

A = contact area between a tire and sand layer.

Assuming: (i) the tire-soil contact area is approximately equivalent to a 10 inch diameter circular area and (ii) the total weight of a RTCE is 8000 lbs, then the contact normal stress in the unit of psi is:

$$\sigma_n = \frac{8000\cos\alpha}{4(3.14)(5^2)} = 25.5\cos\alpha \quad (2)$$

Equation (2) is also applicable to a level surface by setting $\alpha = 0$. This gives the maximum contact normal stress of 25.5 psi. It is noted that the tire-sand contact normal stress over a 10-inch diameter area is much higher than the overburden pressure of 1 inch thick cover sand. Therefore, it is necessary to evaluate the stability of the Closure Turf system in the tire-sand contact area under the high normal stress conditions. The shear strength parameters for this localized stability analysis should be determined from the interface direct shear tests at high normal stresses (2000 to 5000 psf). Based on the test results in Attachment 1, the peak friction angle and adhesion of the sand/artificial grass/Agru 50-mil Super Gripnet LLDPE geomemebrane system is 34 degree and 39 psf, respectively for the normal stress range of 2000 to 5000 psf. Under the drained conditions (i.e., no pore pressure induced by RTCE), neglecting the adhesion for the conservative reason, the safety factor (FS) against the localized shear failure within the tire-soil contact area is:

$$FS = \frac{A\sigma_n \tan\delta}{0.25(W)\sin\alpha} \quad (3)$$

where:

α = the slope angle;

σ_n = contact normal stress between the tire and sand;

δ = the peak friction angle of the Closure Turf system;

W = total gravity force of equipment; and

A = contact area between a tire and sand layer.

Substituting Equation (1) into (3), Equation (3) is reduced to:

$$FS = \frac{\tan\delta}{\tan\alpha} \tag{4}$$

For the given Closure Turf system, the peak friction angle is constant. It is obvious that FS decreases with increasing the slope angle. Based on the information provided by Closure Turf LLC, the maximum allowable slope angle is 18 degree (3:1 slope).

At $\alpha = 18.4$ degree,

$$FS = \frac{\tan 34}{\tan 18} = 2.0 \tag{5}$$

This indicates that there is sufficient shear resistance in the Closure Turf system against the localized shear failure within the tire-soil area. It is not expected the localized internal shear failure to occur within the tire-soil contact area of Closure Turf system when it subjected to the gravity force from a typical lightweight RTCE traveling at a constant velocity.

BEARING CAPACITY

For a given RTCE, W and A are constant, therefore the maximum contact normal stress occurs when the RTCE travels on the level surface (Equation 1). The contact normal stress is transferred to the subgade soil as shown in Figure 4.

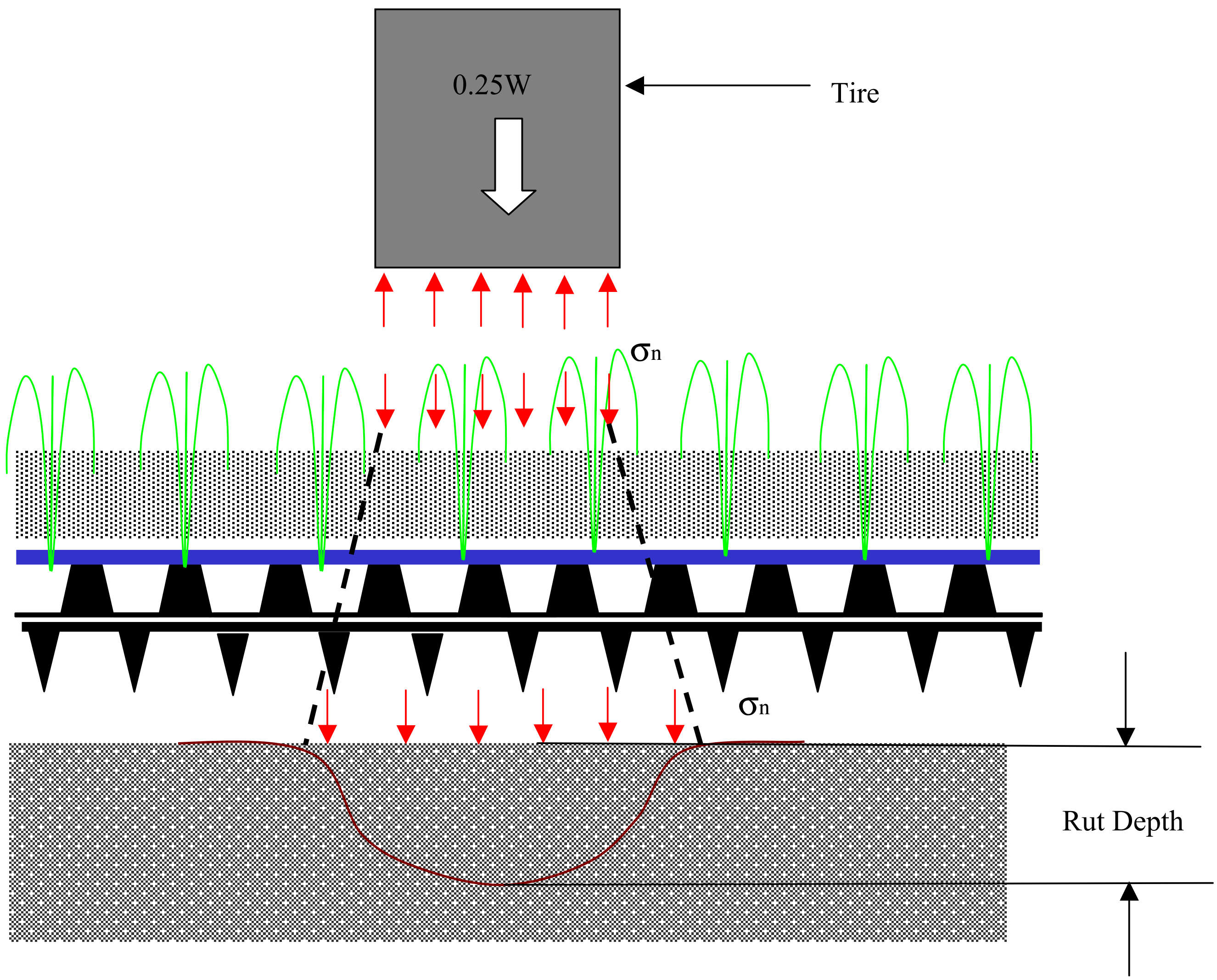


Figure 4. Normal stress acting on top of the subgrade (foundation) soil

Based on soil mechanics, the contact load (0.25W) distributes to a larger area as depth increases (depth starting from the top surface of the cover sand). However, due to the fact that the cover sand layer is only 1 inch thick, and the artificial grass and geomembrane are flexible, the load spreading angle (factor) is insignificant. The normal stress transferred to the top of subgrade soil is considered the same as the tire-sand contact stress for the conservative reason.

As shown previously (Equation 2), assuming (i) the tire-soil contact area is approximately a 10 inch diameter circular area and (ii) the total weight of a RTCE is 8000 lbs, then the maximum contact normal stress is:

$$\sigma_n = \frac{8000\cos\alpha}{4(3.14)(5^2)} = 25.5\,psi \qquad (6)$$

Under the action of tire-sand contact normal stress over the contact area (10 in diameter), there are two major concerns:

- Excessive rut depth, which is not defined for the Closure Turf system at the present time. Generally speaking, the subgrade soil settles and rut forms when it is subjected a normal stress. As number of vehicle passes increases, the rut depth increases. Eventually the surface may reach such a condition that driving is difficult if the accumulated pass is larger than some critical number. Therefore, for the given type of equipment (W and A are fixed), one way to reduce rut depth is to limit the number of passes. This may be achieved by not driving over the same area when a significant rut depth is already developed. The other way is to compact subgrade soil to high density to improve the stiffness for the subgrade soil.

- Bearing capacity failure because the contact normal stress is greater than the bearing capacity of the subgrade soil.

In the case of soft subgrade soil (worst case), the bearing capacity is estimated by the following equation:

$$q_u = c_u N_C \qquad (7)$$

where:

c_u = undrained shear strength of soft subgrade soil

N_c = bearing capacity factor (6.2 for a circular loading area)

$$q_u = 6.2 c_u \tag{8}$$

For the soft subgrade soil, the safety factor against bearing capacity failure is:

$$FS = \frac{6.2 c_u}{\sigma_n} \tag{9}$$

Typically, the acceptable bearing capacity safety factor is 2.0. The required undrained shear strength for the subgrade soil is,

$$c_u \geq \frac{2(25.5)}{6.2} = 8.2\, psi \tag{10}$$

The value of c_u can be estimated from the widely used CBR value for soft subgrade soil with CBR < 5 using the following equation (Giroud and Noiray 1981):

$$c_u = 4.3 CBR \tag{11}$$

Substituting Equation 11 into 10 gives the following equation:

$$CBR \geq 1.9 \tag{12}$$

Therefore, under the action of the gravity force from a typical RTCE (W = 8000 lbs, A = 79 square inch), the required minimum CBR value for the subgrade is 2. In reality, a well-compacted subgarde soil for the Closure Turf system should have a CBR value significantly higher than 2. It is expected that a well-compacted subgarde soil layer (SM or SC, typically used as subgarde soil for the landfill cover system) should have sufficient bearing capacity to support the lightweight RTCE.

CLOSURE

SGI appreciates the opportunity to provide technical services to Closure Turf, LLC. Should you have any questions regarding the attached document(s), or if you require additional information, please do not hesitate to contact the undersigned.

Sincerely,

Zehong Yuan, Ph.D., P.E.
Laboratory Manager

REFERENCES

Giroud, J.P., and Noiray, L. (1981) "Geotextile-reinforced unpaved road design." Journal of Geotechnical Engineering 107(9), 1233-1254.

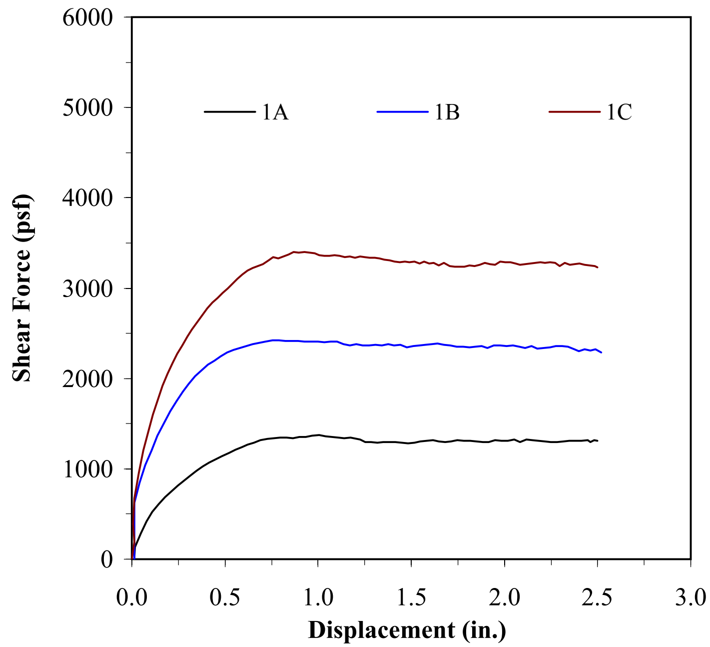
NOTES:
(1) Unless otherwise noted in the test results the sample(s)/specimen(s) were prepared in accordance with the applicable test standards or generally accepted sampling procedures.
(2) Contaminated/chemical samples and all related laboratory generated waste (i.e., test liquids, PPE, absorbents, etc.) will be returned to the client or designated representative(s), at the client's cost, within 60 days following the completion of the testing program, unless special arrangements for proper disposal are made with SGI.
(3) Materials that are not contaminated will be discarded after test specimens and archived specimens are obtained. Archived specimens will be discarded 30 days after the completion of the testing program, unless long-term storage arrangements are specifically made with SGI.
(4) The reported results apply only to the materials and test conditions used in the laboratory testing program. The results do not necessarily apply to other materials or test conditions. The test results should not be used in engineering analysis unless the test conditions model the anticipated field conditions. The testing was performed in accordance with general engineering testing standards and requirements. The reported results are submitted for the exclusive use of the client to whom they are addressed.

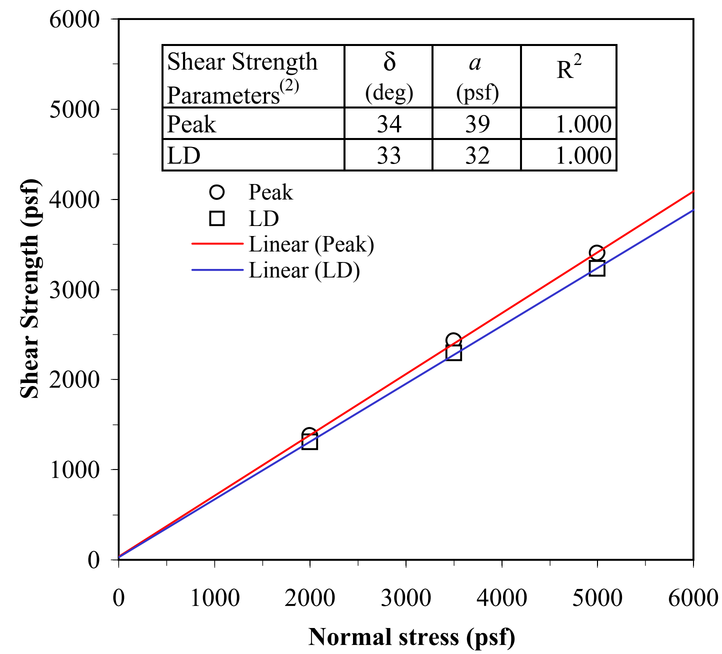
ATTACHMENT 1

INTERFACE DIRECT SHEAR TEST RESULTS

CLOSURETURF LLC -LANDFILL COVER SYSTEM
INTERFACE DIRECT SHEAR TESTING (ASTM D 5321)

Upper Shear Box: Concrete sand nominally compacted
Artificial grass with grass side (green yarns) up/
Agru 50 mil LLDPE Super Gripnet geomembrane with studs side up/
Lower Shear Box: Concrete sand





Test No.	Shear Box Size (in. x in.)	Normal Stress (psf)	Shear Rate (in./min)	Soaking		Consolidation		Lower Soil			Upper Soil			GCL		Shear Strengths		Failure Mode
				Stress (psf)	Time (hour)	Stress (psf)	Time (hour)	γ_d (pcf)	ω_i (%)	ω_f (%)	γ_d (pcf)	ω_i (%)	ω_f (%)	ω_i (%)	ω_f (%)	τ_P (psf)	τ_{LD} (psf)	
1A	12 x 12	2000	0.04	10	24	-	-	-	-	-	-	-	-	-	-	1376	1308	(1)
1B	12 x 12	3500	0.04	20	24	-	-	-	-	-	-	-	-	-	-	2425	2291	(1)
1C	12 x 12	5000	0.04	50	24	-	-	-	-	-	-	-	-	-	-	3400	3233	(1)

NOTES:
(1) Sliding (i.e., shear failure) occurred at the interface between the cover (upper) sand and artificial grass.
(2) The reported total-stress parameters of friction angle and adhesion were determined from a best-fit line drawn through the test data. Caution should be exercised in using these strength parameters for applications involving normal stresses outside the range of the stresses covered by the test series. The large-displacement (LD) shear strength was calculated using the shear force measured at the end of the test.

SGI TESTING SERVICES, LLC

DATE OF TEST:	6/21/2010
FIGURE NO.	C-1
PROJECT NO.	SGI10007
DOCUMENT NO.	
FILE NO.	

7.13 AERODYNAMIC EVALUATIONS OF CLOSURE TURF GROUND COVER MATERIALS, BY GEORGIA TECH RESEARCH INSTITUTE (GTRI)

July 8, 2010

Mr. Michael R. Ayres, P.E.
Closure Turf, LCC
3005 Breckinridge Blvd.
Duluth, GA 30096

Subject: **Aerodynamic Evaluations of Closure Turf Ground Cover Materials**

References: **1: Contract # AGR DTD 5/14/10**

Dear Mr. Ayres and Closure Turf LCC affiliates:

The Georgia Tech Research Institute is pleased to submit the attached Report, covering the period from May 14 to July 8, 2010, in fulfillment of Reference. This document details the tasks and analysis made on contracted work performed by the GTRI Aerospace, Transportation and Advanced Systems Laboratory and its team members on Phase I of the Project entitled "Aerodynamic Evaluations of Closure Turf Ground Cover Materials".

We look forward to continuation of this work for/with Closure Turf, LCC upon the adoption of Phase II activities related to aerodynamic investigation of Closure Turf Material or other desired evaluations.

Sincerely,

Graham M. Blaylock
Principal Investigator

Aerodynamic Evaluations of Closure Turf Ground Cover

Phase I REPORT

May 14 – July 8, 2010

Project Expires: August 14, 2010

Contract No. AGR DTD 5/14/10

Proposal No. ATASL-AATD-10-1119

GTRI Project No. D-6244

Prepared for:

Mr. Michael R. Ayres, P.E.
Closure Turf, LCC
3005 Breckinridge Blvd.
Duluth, GA 30096

Prepared by:
Graham M. Blaylock, Research Engineer II
Aerospace, Transportation and Advanced Systems Laboratory
Georgia Tech Research Institute
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Atlanta, GA 30332-0844
gb62@gtri.gatech.edu

Principal Investigator: Graham M. Blaylock, Research Engineer II
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Introduction

GTRI has been contracted by Closure Turf, LCC to **experimentally evaluate the aerodynamic properties and ballast requirements** of a novel synthetic ground-cover system under a range of wind speed conditions (V_{inf}). The Closure Turf Material was tested full-scale in **GTRI's subsonic Model Test Facility (MTF) wind tunnel** wherein the normal force loading (lb_f/ft^2) and the shear stress (lb_f/ft^2) were determined for a suitable section of the material. The turf material was tested in two configurations, one representing the perimeter of the turf installation (Fig 5) and the 2nd at a representative interior section (Fig 6). Both installations were evaluated on a **flat level surface**. The installation is shown in Figures 1a-d below.

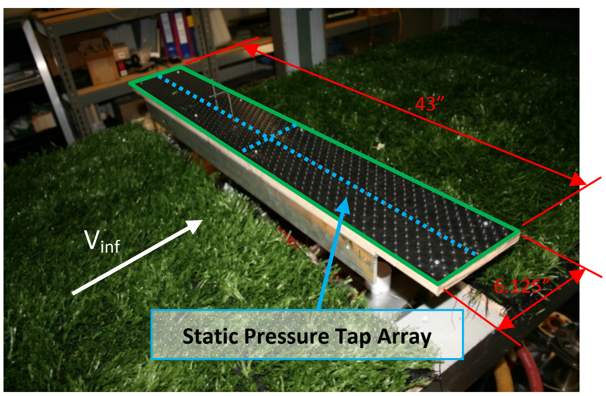


Figure 1a – Model Before Final Turf Layer

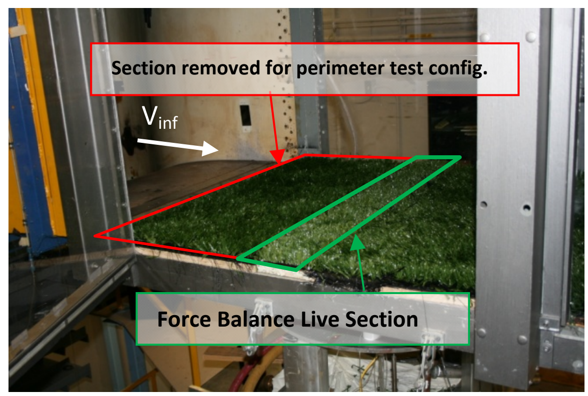


Figure 1b – Turf Installed & Model Lowered

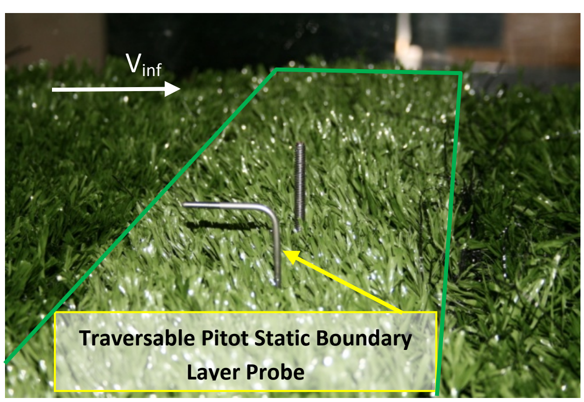


Figure 1c - Pitot Static Boundary Layer Probe

Figure 1d – Full Installation Looking Downstream

Program Description

Closure Turf system - The Closure Turf ground cover system consists of two independent layers. The first layer is a **geomembrane** to cap the upper soil layer. This is then covered with a **geotextile** turf layer (Fig 2a and 2b)

Geomembrane Layer -The impermeable geomembrane is made from Agru 50-mil LLDPE Super Gripnet® material and is used to cap the terrain being covered. It has an array of spikes to interface to the soil below and an array of studs to interface with the turf covering above. Throughout the testing and subsequent analysis of the Closure Turf system, **it was assumed that the geomembrane will be sufficiently installed to prevent movement of that layer.**

Geotextile Turf Layer – This component is designed to be installed on top of the geomembrane. The turf is intended to remain in place without an anchoring system linking it to the geomembrane below. It relies on the interface friction and sand ballast added on top of the turf to ensure that it remains immobile under all environmental conditions. It is constructed of two permeable sheets of woven HDPE mesh material which are linked together with synthetic blades of grass that are looped through the two HDPE substrates (Fig 2a).

Figure 2a – Closure Turf Synthetic Ground Cover System

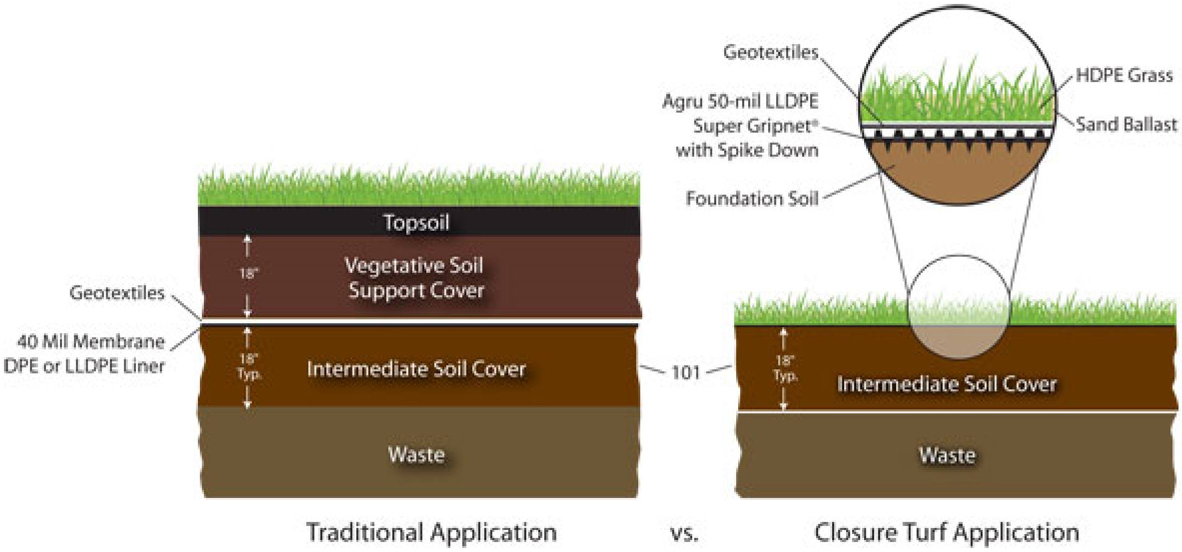


Figure 2b – Installation of Closure Turf

Purpose – The scope of this program was to conduct a full-scale wind tunnel test and experimentally isolate and measure the aerodynamic forces acting on a section of the permeable upper geotextile turf layer alone as installed above the impermeable geomembrane. The wind tunnel install configuration would simulate a wide range of wind speeds flowing over a **flat and level terrain installation** of the Closure Turf ground cover system (Fig 1a-d). The sand ballast requirements needed to counteract the resulting aerodynamic forces could then be determined. The purpose of the ballast is twofold. It serves to prevent both lift-off and tangential motion of the turf material along the geomembrane underlayment **resulting from aerodynamic lift and drag acting on the turf layer**.

Methodology

Model Design – The model represented a full-scale 2D section of the Closure Turf material with a 6.125" chord (stream-wise dimension) with a width of 43" that spanned the tunnel wall to wall. This area constituted the live balance section upon which the total sum of all aerodynamic forces could be measured by a 6 component force balance located under the test section. The model consisted of 4 layers listed below from the lower to uppermost turf layer

1) ¾" Furniture grade plywood support base – This incorporated several pressure taps on the underside in order to measure the ambient pressure (P_{amb}) to determine the vertical force (F_{amb}) due to pressure acting upward on the lower surface of the model.
2) Foam Filler Layer – This represented the soil layer surrounding the lower geomembrane spikes.
3) Impermeable Goemembrane Layer – This was fixed rigidly to the base. An array of static pressure taps was installed on the upper side of this layer, shown schematically in Fig. 1a. These

pressures were integrated numerically to determine the force (F_{geo}) due to pressure acting down on the membrane.

4) Geotextile Turf Layer – The turf was first mounted to a thin wire support frame to maintain the geometry and to provide a safety measure to prevent material from dislodging in the tunnel. The frame was then mounted rigidly on top of the lower construction flush with the top of the geomembrane upper surface studs.

Pitot Static Boundary Layer Probe – In general, pressure variation through the height of the boundary layer is due to viscous forces which cause deficits in the total pressure as the bounding flat and level surface is approached. The static pressure remains constant. However, the unique characteristics of the flexible and permeable turf layer warranted investigating the boundary layer formation on the Closure Turf system. To accomplish this, a traverse system was built into the model to actuate a Pitot static probe vertically through the boundary layer (Fig 1c). This allows the measurement of the total and static pressure as a function of the probe height, defined as h = 0" at the upper surface of the turf HDPE woven mesh. From these measurements the flow velocity distribution was determined. This characterizes the shape of the boundary layer which is by its nature a transition from the no slip condition at the surface ($V = 0$) to free stream conditions ($V = V_{inf}$). The characteristics of this boundary layer profile such as the BL thickness, the height required for the flow to reach free stream velocity, provide valuable insight into the observed results.

Force Balance – An under floor 6 component force balance was utilized to measure the aerodynamic lift (L) and the total drag (D) of the model. These forces were transmitted to the balance through a vertical strut which mounted to the underside of the model base. It should be noted that these forces represent the total sum of all pressure distributions acting on the model resolved vertically and tangentially. As such the isolated vertical force acting on just the turf layer (L_{turf}) is found by Equation 1.

$$L_{turf} = L - L_{amb} + L_{geo} \qquad \text{(Eq 1)}$$

Under the confines of this program, it was not feasible to separate the drag acting on just the turf from skin friction and pressure drag acting on the geomembrane. That being the case, the total drag as measured from the force balance was taken as the drag acting on the turf. This results in a conservative overestimation of the actual turf drag force present.

Installation Conditions – Two installation conditions were examined separately. To more accurately simulate the actual installation conditions, both geomembrane and turf layers were installed upstream and downstream of the balance live model (Fig 1b and 1d). This represents an **interior** condition and in this case the model was located approximately 18" inboard of the **perimeter**. It was also suspected that the perimeter, if unaccounted for, could lead to a worse case situation. To determine the nature of this the upstream turf was removed leaving just the geomembrane as a stand in for a typical surface soil roughness that could be expected at the edge of a real world installation. This left the model mounted turf exposed at the leading edge.

Results and Discussion

These results represent the required thickness of sand for the Closure Turf system as installed on **flat and level terrain**. The density of the sand was provided by Closure Turf. If a different material density is to be used as ballast, the results can be recalculated via Equation 2.

In all cases, **the driving parameter for the depth of the sand is tangential slip due to the aerodynamic formation of shear stress**. The sand ballast requirements have been illustrated in Figures 5 and 6 for several assumed representative interface coefficients of static friction (μ_s). The **minimum** required sand ballast height is found by Equation 2.

$$h_{sand}(in) = \frac{1}{\rho_{sand}}\left(\frac{\tau}{\mu_s} + P\right)\frac{12in}{ft} \quad \text{(Eq 2)}$$

Where:

$$\rho_{sand} = Weight\ Density\ of\ Ballast(sand) = 110\ \frac{lb_f}{ft^3}$$

$$\tau = \frac{D}{Area} = Shear\ Stress, \frac{lb_f}{ft^2}$$

$$P = \frac{L_{turf}}{Area} = Normal\ Force\ Loading, \frac{lb_f(+tve\ up)}{ft^2}$$

The measured data for determining the sand depth are shown in Table I and Table II and plotted in Figures 5 and 6 for the perimeter and interior configurations respectively. The last column of each table gives the resulting sand height requirement, based on Equation 2, for μ_s = 0.93. This value was determined independently from the efforts of this program by Closure Turf affiliates and supplied for use in this analysis.

Perimeter Condition (PC) – The ballast requirement resulting from this configuration are substantially greater than the interior condition. For the given μ_s =0.93 a **minimum** sand height of 0.4" or 3.6 lb_f/ft^2 is needed to provide the ballast based on the resulting shear at 175 ft/s. The lifting pressure will be satisfied by this loading as shown in Figure 4. It should be noted that the required ballast height due to uplift goes from positive to negative at around 115 ft/s. There are several factors contributing to these results.

PC Boundary Layer (BL) – The profile for the perimeter condition is shown in Figure 4 (Red Curve). One characteristic to note is that the boundary layer thickness reaches 99% of free stream velocity at a height of approximately 2". This subjects the turf to up to 89% of the total free stream based on a max vertical blade height of 1.25". This has several resulting effects which can be followed in Figures 3a to 3f. The cascade of effects proceeds as follows.

The blades are subject to higher velocities and thus higher increasing drag as the wind speed increases. The higher drag increases the bending of the blades back onto the mesh substrate. The effect of this has 2 **counteracting effects on the net lift**. At lower velocities (Fig3a-b) the blades are bent slightly with the flow being deflected and accelerated of over the perimeter as shown by the tufts. This flow acceleration increases the **local** velocity and lowers the local static pressure **below** that of free stream static which creates the pressure differential building up in 3a and b Additionally, in this installation, the perimeter exposes the gap between the turf and the geomembrane which allows for some uplift pressure recovery beneath the turf. However, as the free stream velocity increases, the drag is increased further by virtue of greater velocity exposure in the relatively thin boundary layer, the bending angle of the turf also increases (Fig 3b-c). This bending produces an increasing down force reaction which starts to counteract the suction created by the local flow acceleration. Simultaneously, the slightly reduced turf profile geometry (caused by the increased bending) shown in Figure 3c-d begins to reduce the relative local flow acceleration and thus also reduces the suction. This continues until the net vertical force becomes zero at about 110 ft/s (Fig 3d) and continues to decrease through Figure 3f.

Interior Condition (IC) – This condition owes its behavior to the formation of a drastically different boundary layer than the perimeter as shown by the blue profile in Figure 4. Compared to the Perimeter profile it is 25% thicker with no measurable velocity until the height is greater than 50% of the turf length (0.75”). The blades thusly experience a maximum velocity of 45% of free stream. This reduces the drag acting on the turf layer. Furthermore, the static pressure remains constant as a function of height through the BL which effectively prevents the formation of a pressure differential on the flat and level permeable turf membrane.

The cause for the deficient boundary layer is created by longer flow paths over a given surface and all boundaries grow in thickness and increase in turbulence with increasing distance. In the case of Closure Turf, the interaction of the flow with the flexible blades causes this growth to occur quite rapidly. The distance producing the profile in Fig 4 was 18” however, the effect of the growing boundary layer can be seen even in the perimeter condition development in Figures 3a –f. The Model section (highlighted in yellow) is 6.125” wide. It is clearly seen that little to no defection occurs in the turf at a distance just over 6 inches behind the perimeter edge. Thus the boundary layer at further distances than 18” and greater from the perimeter can be expected to have minimal interaction with the turf. Figure 6 shows these results by producing measurements requiring minimal ballast.

<u>Final Comments and Executive Summary</u>

GTRI was contracted by Closure Turf to determine the effective required ballast in terms of sand thickness needed to counteract the aerodynamic forces versus wind velocity acting on a permeable geotextile synthetic turf ground covering material that is to be overlaid onto an impermeable geomembrane underlayment. *It was found that in both perimeter and interior loading conditions, the shear acting on the material serves as the more demanding factor for determining the ballast.*

- **The resulting measurements represent the forces acting on the permeable Turf Layer *only*. The impermeable geomembrane layer was to be assumed immobile as a founding assumption of this program**

- **If it is determined that the static interface friction coefficient (μ_s) between the soil and the lower side of the membrane is lower than that occurring between the turf and the membrane upper surface studs, the lower μ_s should be used in Equation 2 to recalculate the sand depth required by shear. The same shear data given in Tables I & II will apply because, as discussed within the methodology section, the measured shear could not be feasibly separated between the two layers independently and thus represents their combined effect.**
- **The sand ballast depths represented in Figures 5 & 6 and Tables I & II are the Minimum depths required, the proper factor of safety has been left to be determined by Closure Turf, LCC and the authorized building permit issuing agencies.**
- **The perimeter of the turf installation is much more demanding than interior sections.**
- **All measurements were made on a rigidly constrained system. It was not within the scope of this investigation to determine what dynamic effects might occur, including gusts or erosion of sand ballast or any possible unstable perturbations.**
- **All configurations consisted of flat and level terrain installation.**
- **All calculations and measurements assume that the blade length is increased to account for any added ballast material. This is to ensure that the installation matches the conditions as tested.**

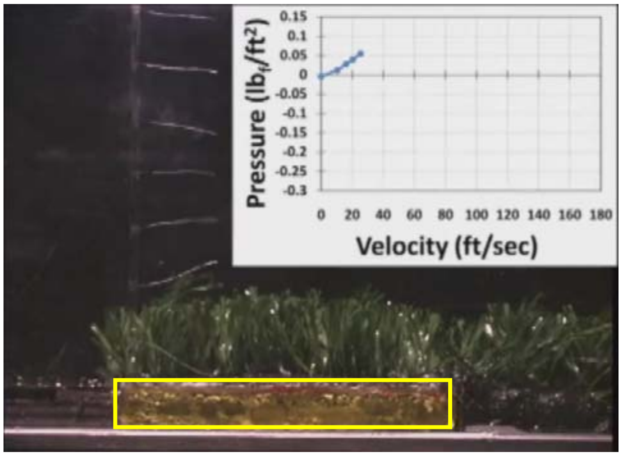


Figure 3a: Vinf = 25 ft/sec

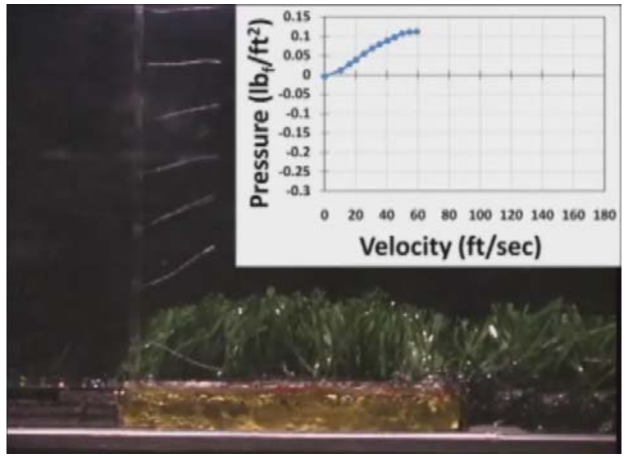


Figure 3b: Vinf = 60 ft/sec

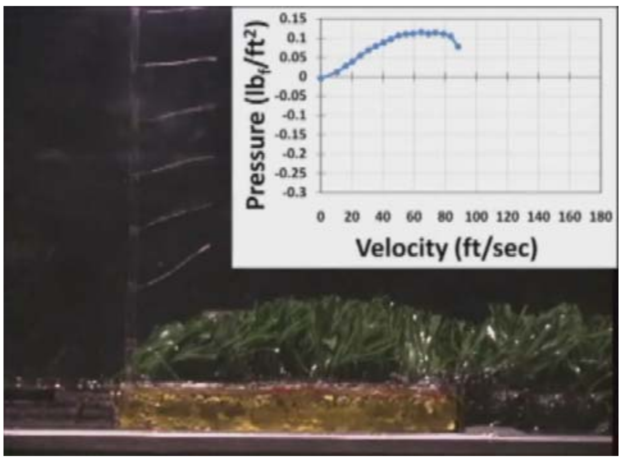


Figure 3c: Vinf = 90 ft/sec

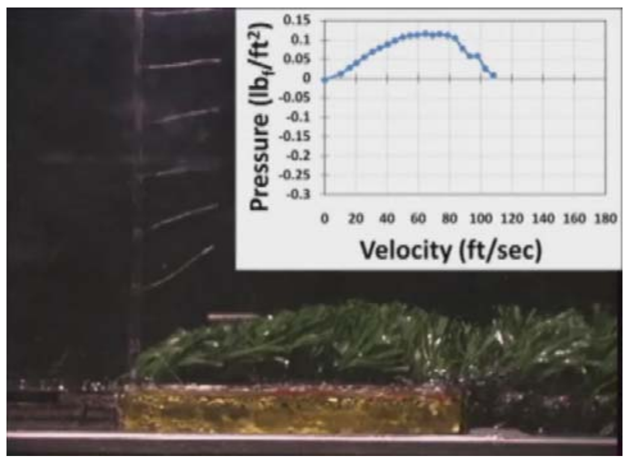


Figure 3d: Vinf = 110 ft/sec

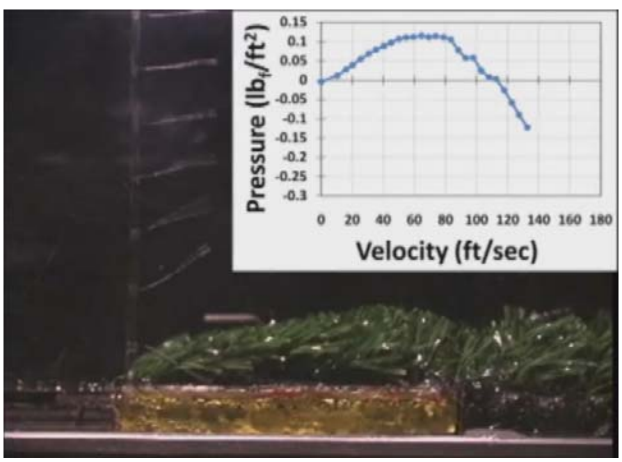


Figure 3e: Vinf = 135 ft/sec

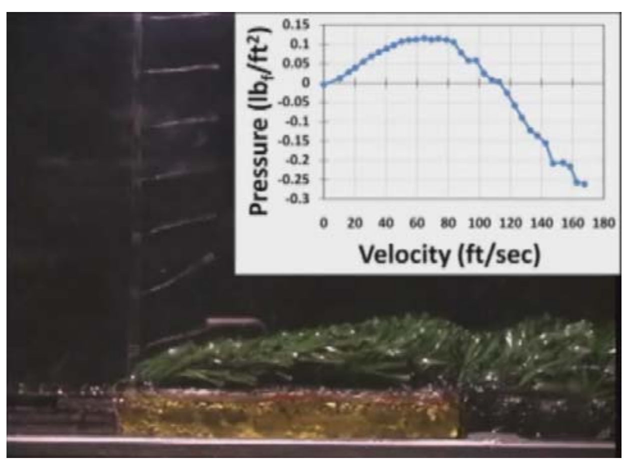


Figure 3f: Vinf = 170 ft/sec

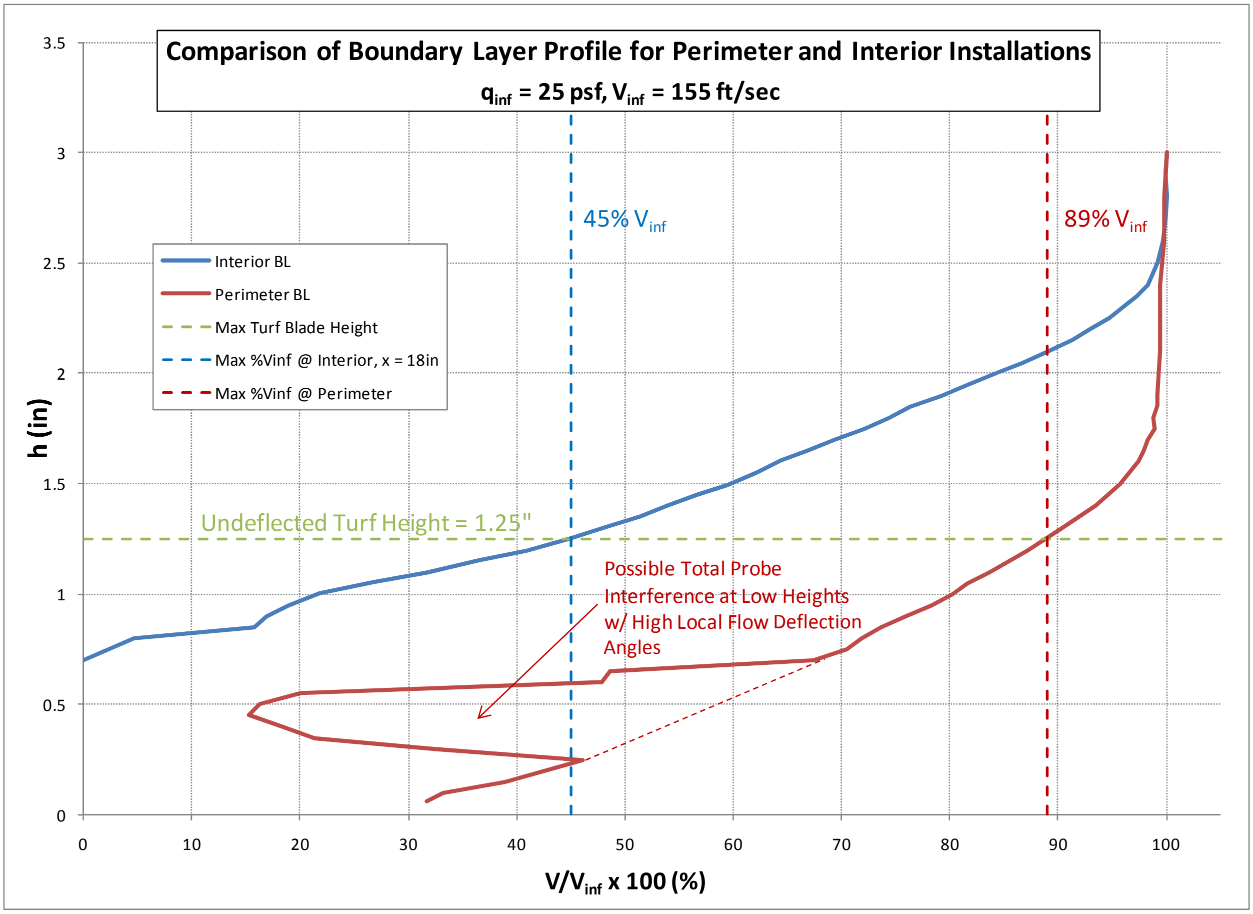


Figure 4 – Non-Dimensional Boundary Layer Profiles for Perimeter and Interior Installations

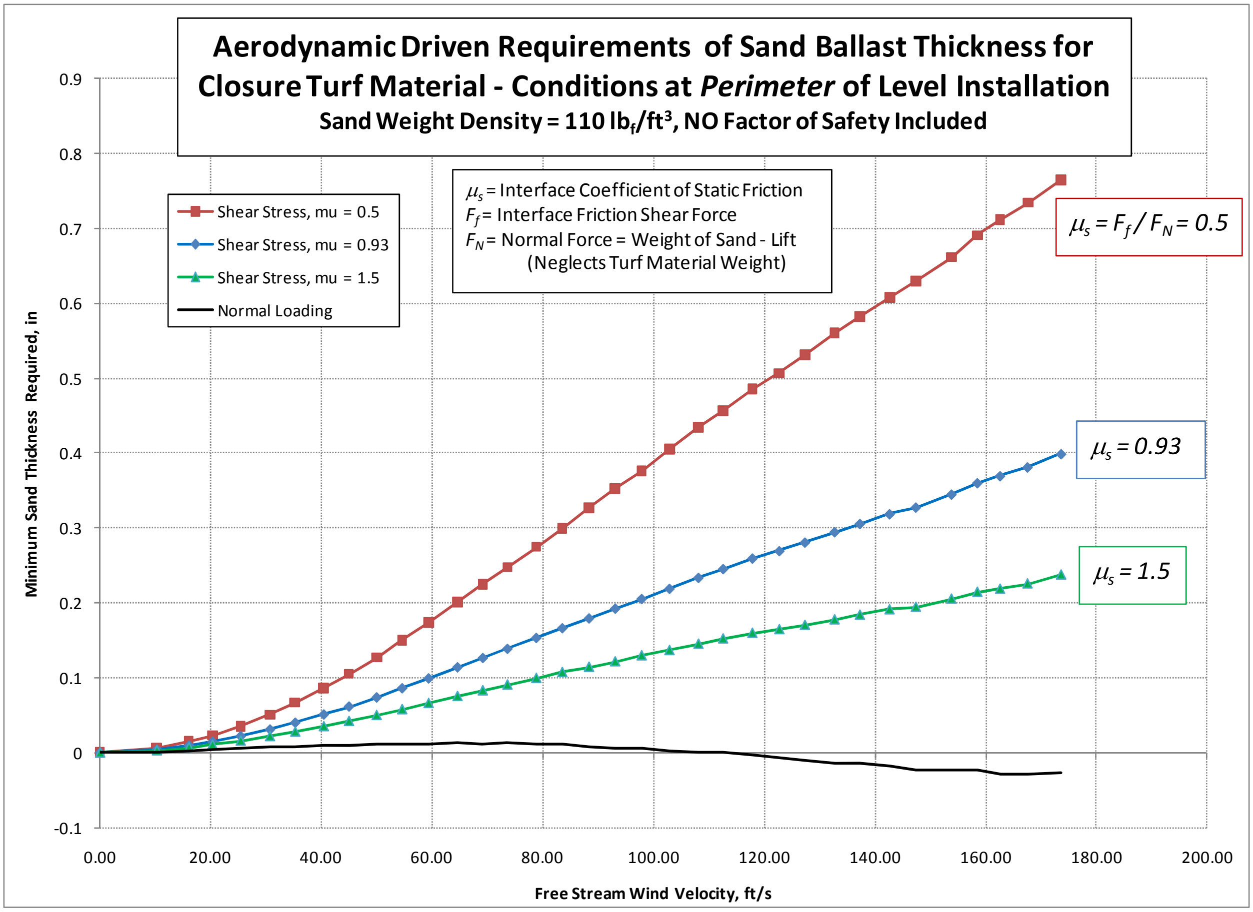


Figure 5 – Sand Ballast Minimum Requirement at the *Perimeter* of Turf Installation

Table I - Perimeter Installation

Wind Speed (*ft/s*)	Wind Speed (*mi/hr*)	Turf Normal Force Loading (lb_f/ft^2)	Turf Shear Stress (lb_f/ft^2)	Sand Height Due to Shear (*in*)
0.00	0.00	0	0	0
10.26	6.99	0.011689	0.023784	0.0040651
16.06	10.95	0.027798	0.053106	0.009262
20.31	13.84	0.039396	0.086922	0.0144939
25.40	17.32	0.054936	0.136103	0.0219582
30.70	20.93	0.06927	0.198423	0.0308322
35.26	24.04	0.078777	0.266915	0.0399035
40.42	27.56	0.088429	0.351918	0.0509275
44.97	30.66	0.096783	0.434606	0.0615383
49.97	34.07	0.10646	0.529776	0.0737576
54.57	37.21	0.110561	0.630469	0.0860165
59.36	40.47	0.111817	0.741903	0.099225
64.58	44.03	0.115373	0.865046	0.1140578
69.15	47.15	0.111526	0.975305	0.1265718
73.60	50.18	0.114496	1.076528	0.1387694
78.82	53.74	0.111457	1.204017	0.1533926
83.52	56.94	0.104976	1.320714	0.1663744
88.34	60.23	0.077354	1.458158	0.1794835
93.08	63.46	0.057303	1.588598	0.192597
97.86	66.72	0.058201	1.697814	0.2055063
102.89	70.15	0.024978	1.844449	0.2190825
108.12	73.72	0.007601	1.985703	0.2337562
112.58	76.76	0.002646	2.090641	0.2455251
117.87	80.37	-0.026041	2.237684	0.2596441
122.74	83.69	-0.058742	2.352732	0.2695721
127.36	86.84	-0.089852	2.479185	0.2810115
132.72	90.49	-0.122289	2.627843	0.2949108
137.29	93.61	-0.135769	2.734267	0.305924
142.65	97.26	-0.155489	2.863465	0.3189279
147.40	100.50	-0.208034	2.98848	0.3278602
153.84	104.89	-0.206002	3.134988	0.3452676
158.51	108.08	-0.21588	3.274285	0.3605298
162.63	110.88	-0.256805	3.392572	0.3699406
167.59	114.26	-0.261535	3.496667	0.3816351
173.66	118.41	-0.23928	3.626641	0.3993092

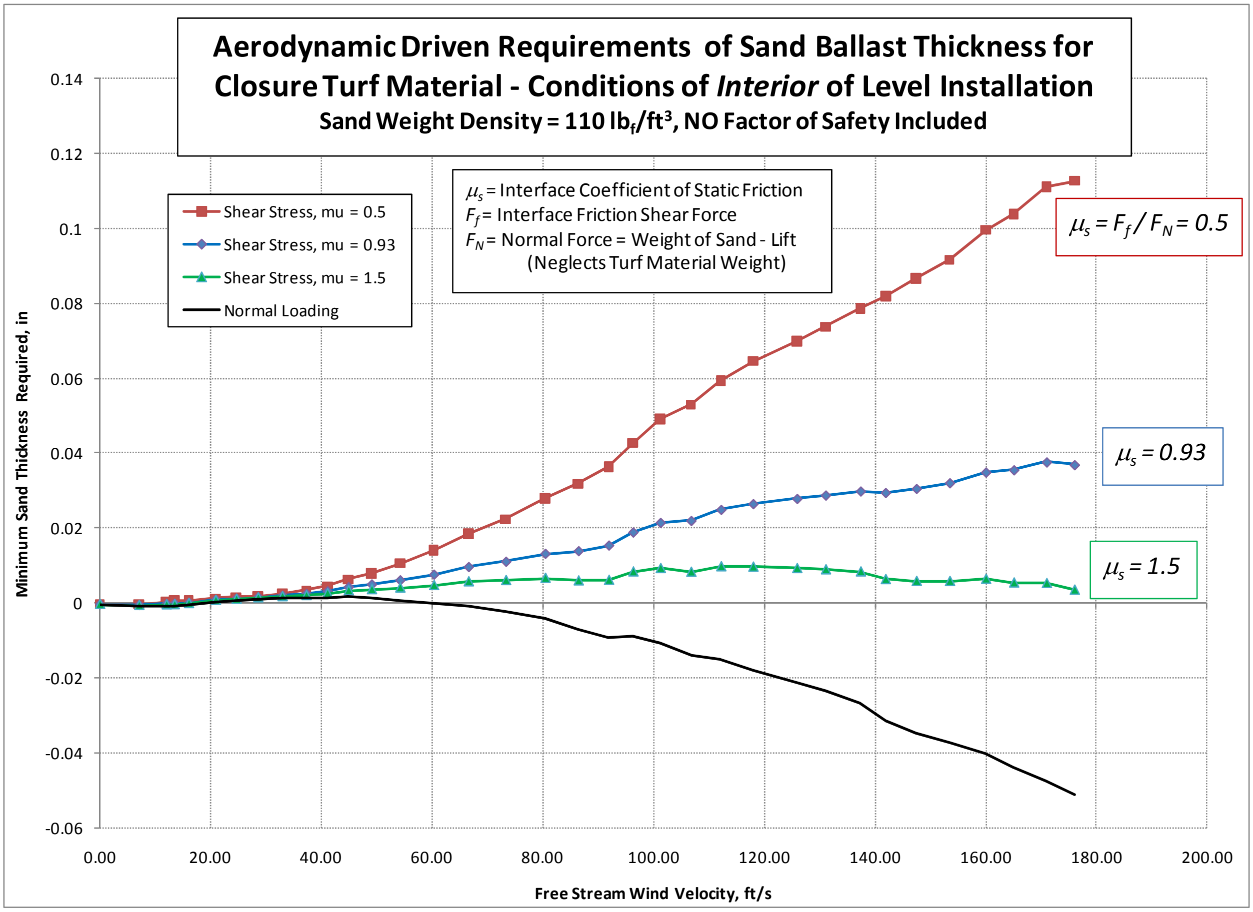


Figure 6 – Minimum Sand Ballast Requirement in the *Interior* of Turf Installation

Table I - Interior Installation				
Wind Speed (ft/s)	Wind Speed (mi/hr)	Turf Normal Force Loading (lb_f/ft^2)	Turf Sheer Stress (lb_f/ft^2)	Sand Height Due to Shear (*in*)
0.00	0.00	-0.00419	0.000471	0
7.07	4.82	-0.00858	0.002819	-0.000605326
12.02	8.20	-0.00858	0.005658	-0.000272305
13.47	9.18	-0.009201	0.006927	-0.000191194
16.05	10.94	-0.005314	0.005174	2.72117E-05
20.91	14.26	0.003753	0.0034	0.000808245
24.64	16.80	0.006062	0.004099	0.00114213
28.56	19.47	0.009925	0.003388	0.001480147
32.94	22.46	0.011669	0.005393	0.001905592
37.27	25.41	0.011221	0.009767	0.002369798
41.09	28.01	0.013608	0.013502	0.003068321
44.90	30.61	0.015886	0.02088	0.004182285
49.08	33.47	0.011842	0.03072	0.004895374
54.21	36.96	0.006407	0.045273	0.006009561
60.31	41.12	-0.000648	0.064883	0.007540218
66.57	45.39	-0.006394	0.087581	0.009575904
73.32	49.99	-0.019878	0.112271	0.01100111
80.43	54.84	-0.037311	0.146631	0.013129826
86.42	58.92	-0.06477	0.178237	0.013841748
91.90	62.66	-0.083261	0.208285	0.01534924
96.30	65.66	-0.081403	0.236369	0.018846242
101.24	69.02	-0.097454	0.273298	0.021427071
106.76	72.79	-0.129489	0.30751	0.021945482
112.17	76.48	-0.138401	0.341067	0.024909568
117.97	80.43	-0.163997	0.378085	0.026459565
125.89	85.83	-0.193612	0.417441	0.027845377
131.07	89.36	-0.215792	0.445855	0.028758761
137.38	93.67	-0.245542	0.482763	0.029842691
141.88	96.73	-0.289393	0.520185	0.029448623
147.46	100.54	-0.317409	0.555461	0.030530279
153.47	104.64	-0.340708	0.59023	0.032067045
159.99	109.08	-0.369093	0.641021	0.034928388
165.05	112.53	-0.4029	0.677722	0.035545455
170.96	116.56	-0.437374	0.727691	0.037646121
176.00	120.00	-0.469865	0.751682	0.036915842

7.14 LABORATORY RESULTS TRANSMITTAL INTERFACE DIRECT SHEAR TESTING CLOSURETURF™ COVER SYSTEM, BY SGI TESTING SERVICES

27 June 2010

Mr. Jose Urrutia
Closure Turf, LLC
3005 Breckinridge Blvd., Suite 240
Duluth, Georgia 3096

Subject: Laboratory Test Results Transmittal
Interface Direct Shear Testing
Closure Turf Cover System

Dear Mr. Urrutia,

SGI Testing Services, LLC (SGI) is pleased to present the attached test results for the above-mentioned project. The note section below addresses sample preparation, sample disposal and a disclosure statement.

SGI appreciates the opportunity to provide laboratory testing services to Closure Turf, LLC. Should you have any questions regarding the attached document(s), or if you require additional information, please do not hesitate to contact the undersigned.

Sincerely,

Zehong Yuan, Ph.D., P.E.
Laboratory Manager

Attachments

NOTES:
(1) Unless otherwise noted in the test results the sample(s)/specimen(s) were prepared in accordance with the applicable test standards or generally accepted sampling procedures.
(2) Contaminated/chemical samples and all related laboratory generated waste (i.e., test liquids, PPE, absorbents, etc.) will be returned to the client or designated representative(s), at the client's cost, within 60 days following the completion of the testing program, unless special arrangements for proper disposal are made with SGI.
(3) Materials that are not contaminated will be discarded after test specimens and archived specimens are obtained. Archived specimens will be discarded 30 days after the completion of the testing program, unless long-term storage arrangements are specifically made with SGI.
(4) The reported results apply only to the materials and test conditions used in the laboratory testing program. The results do not necessarily apply to other materials or test conditions. The test results should not be used in engineering analysis unless the test conditions model the anticipated field conditions. The testing was performed in accordance with general engineering testing standards and requirements. The reported results are submitted for the exclusive use of the client to whom they are addressed.

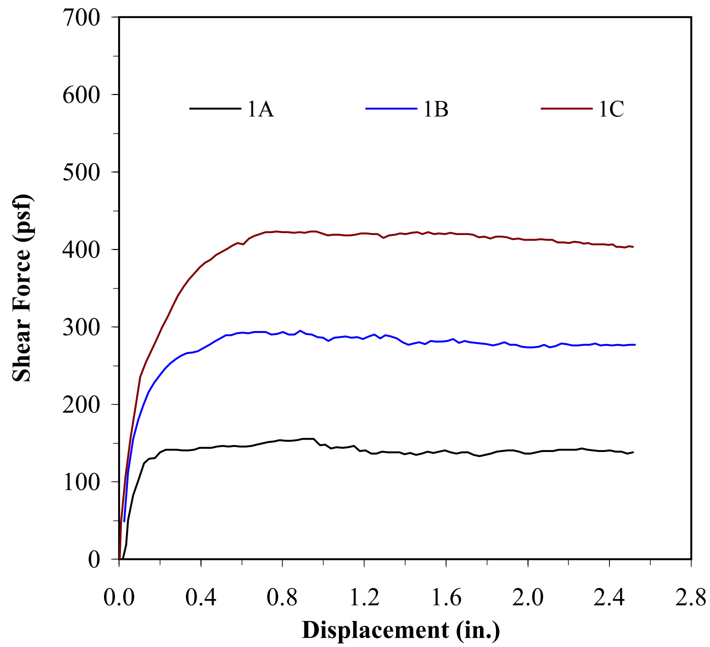
SGI10007.REPORT.2010.06

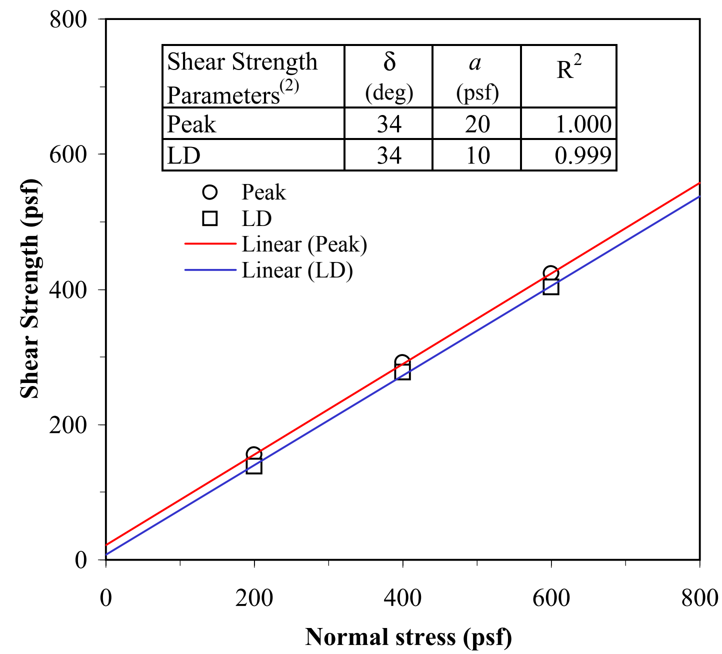
ATTACHMENT A

TEST RESULTS

CLOSURE TURF LLC -LANDFILL COVER SYSTEM
INTERFACE DIRECT SHEAR TESTING (ASTM D 5321)

Upper Shear Box: Concrete sand nominally compacted/
Artificial grass with grass side (green yarns) side up
Lower Shear Box: Concrete sand





Test No.	Shear Box Size (in. x in.)	Normal Stress (psf)	Shear Rate (in./min)	Soaking		Consolidation		Concrete Sand			Upper Soil			GCL		Shear Strengths		Failure Mode
				Stress (psf)	Time (hour)	Stress (psf)	Time (hour)	γ_d (pcf)	ω_i (%)	ω_f (%)	γ_d (pcf)	ω_i (%)	ω_f (%)	ω_i (%)	ω_f (%)	τ_P (psf)	τ_{LD} (psf)	
1A	12 x 12	200	0.04	200	24	-	-	-	-	-	-	-	-	-	-	155	138	(1)
1B	12 x 12	400	0.04	400	24	-	-	-	-	-	-	-	-	-	-	292	277	(1)
1C	12 x 12	600	0.04	600	24	-	-	-	-	-	-	-	-	-	-	423	403	(1)

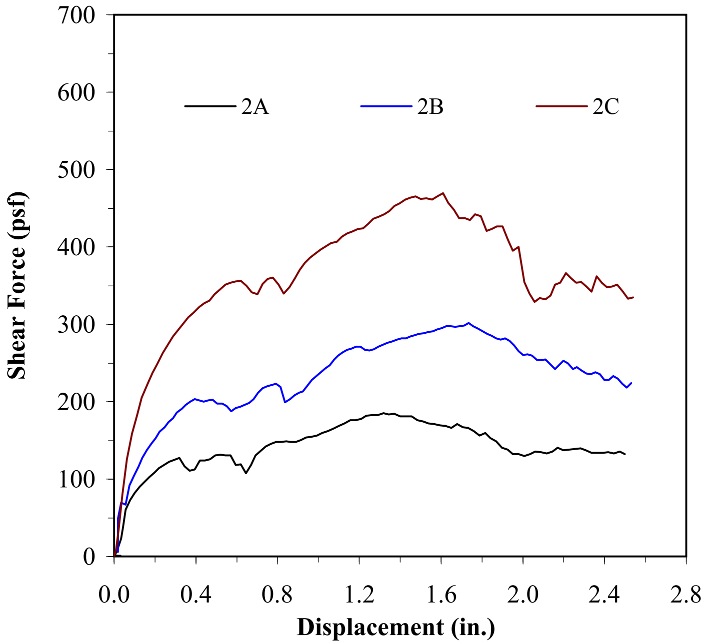
NOTES:
(1) Sliding (i.e., shear failure) occurred at the interface between the upper concrete sand and grass side of the artificial grass.
(2) The reported total-stress parameters of friction angle and adhesion were determined from a best-fit line drawn through the test data. Caution should be exercised in using these strength parameters for applications involving normal stresses outside the range of the stresses covered by the test series. The large-displacement (LD) shear strength was calculated using the shear fo measured at the end of the test.

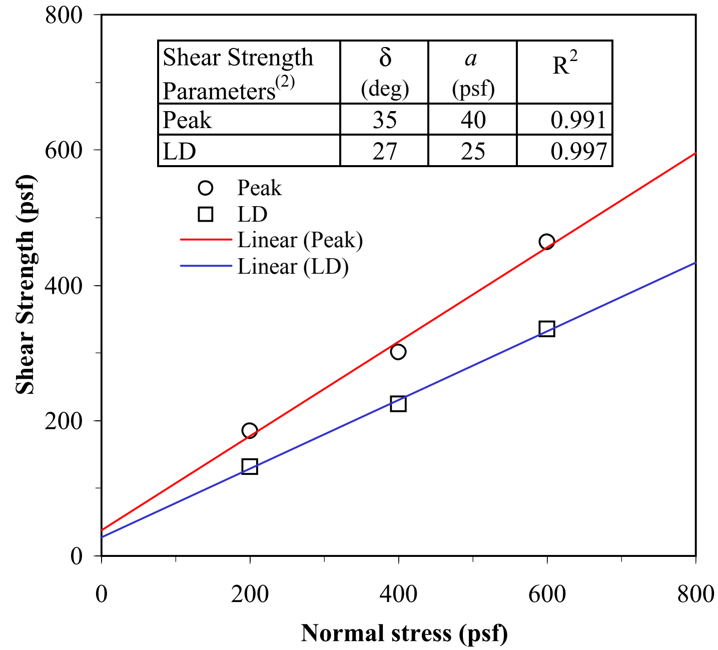
SGI TESTING SERVICES, LLC

DATE OF TEST:	4/27/2010
FIGURE NO.	C-1
PROJECT NO.	SGI10007
DOCUMENT NO.	
FILE NO.	

CLOSURE TURF LLC -LANDFILL COVER SYSTEM
INTERFACE DIRECT SHEAR TESTING (ASTM D 5321)

Upper Shear Box: Concrete sand nominally compacted
Artificial grass with grass side (green yarns) up/
Agru 50 mil LLDPE Super Gripnet geomembrane with studs side up/
Lower Shear Box: Concrete sand





Test No.	Shear Box Size (in. x in.)	Normal Stress (psf)	Shear Rate (in./min)	Soaking		Consolidation		Concrete Sand			Upper Soil			GCL		Shear Strengths		Failure Mode
				Stress (psf)	Time (hour)	Stress (psf)	Time (hour)	γ_d (pcf)	ω_i (%)	ω_f (%)	γ_d (pcf)	ω_i (%)	ω_f (%)	ω_i (%)	ω_f (%)	τ_P (psf)	τ_{LD} (psf)	
2A	12 x 12	200	0.04	200	24	-	-	-	-	-	-	-	-	-	-	185	132	(1)
2B	12 x 12	400	0.04	400	24	-	-	-	-	-	-	-	-	-	-	302	224	(1)
2C	12 x 12	600	0.04	600	24	-	-	-	-	-	-	-	-	-	-	464	335	(1)

NOTES:
(1) Sliding (i.e., shear failure) occurred at the interface between the geotextile of the artificial grass and studs side of the geomembrane.
(2) The reported total-stress parameters of friction angle and adhesion were determined from a best-fit line drawn through the test data. Caution should be exercised in using these strength parameters for applications involving normal stresses outside the range of the stresses covered by the test series. The large-displacement (LD) shear strength was calculated using the shear fo measured at the end of the test.

SGI TESTING SERVICES, LLC

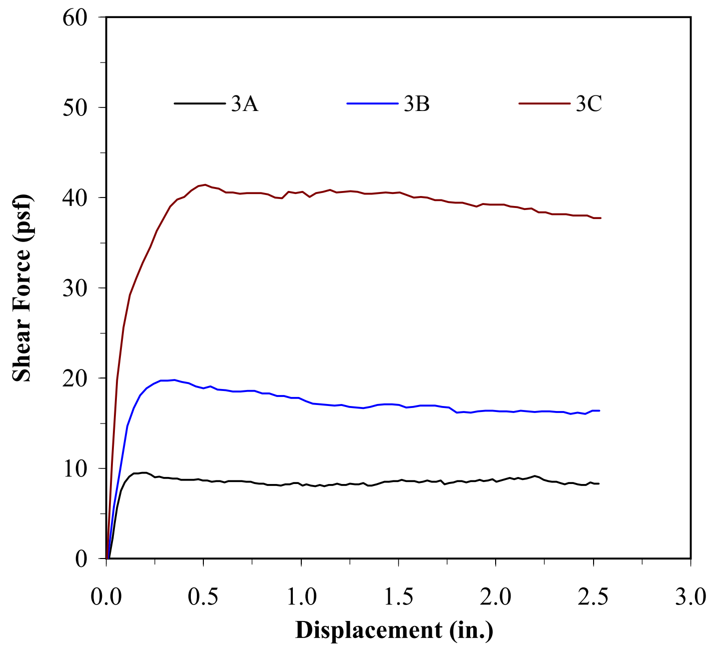
DATE OF TEST:	4/27/2010
FIGURE NO.	C-2
PROJECT NO.	SGI10007
DOCUMENT NO.	
FILE NO.	

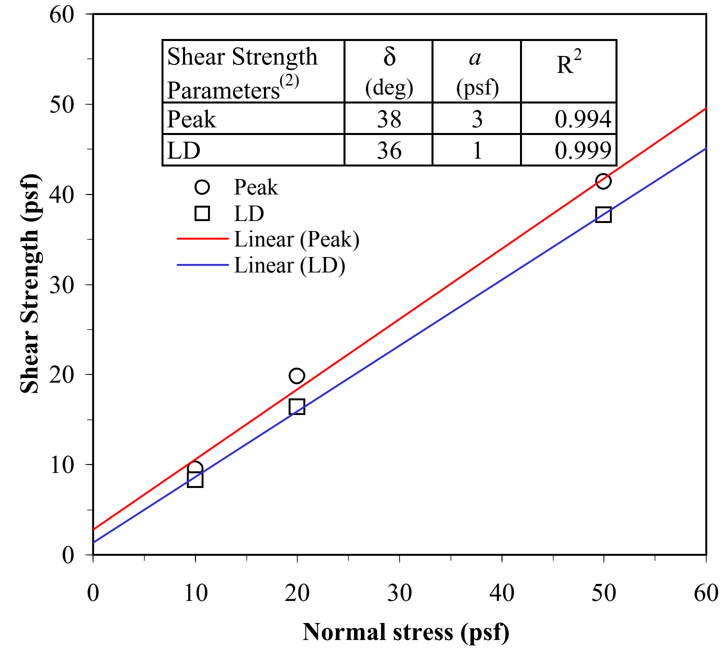
ATTACHMENT B

TEST RESULTS (LOW NORMAL STRESS)

CLOSURETURF LLC -LANDFILL COVER SYSTEM
INTERFACE DIRECT SHEAR TESTING (ASTM D 5321)

Upper Shear Box: Concrete sand nominally compacted/
Artificial grass with grass side (green yarns) side up
Lower Shear Box: Concrete sand





Test No.	Shear Box Size (in. x in.)	Normal Stress (psf)	Shear Rate (in./min)	Soaking Stress (psf)	Soaking Time (hour)	Consolidation Stress (psf)	Consolidation Time (hour)	Lower Soil γ_d (pcf)	Lower Soil ω_i (%)	Lower Soil ω_f (%)	Upper Soil γ_d (pcf)	Upper Soil ω_i (%)	Upper Soil ω_f (%)	GCL ω_i (%)	GCL ω_f (%)	Shear Strengths τ_P (psf)	Shear Strengths τ_{LD} (psf)	Failure Mode
3A	12 x 12	10	0.04	10	24	-	-	-	-	-	-	-	-	-	-	10	8	(1)
3B	12 x 12	20	0.04	20	24	-	-	-	-	-	-	-	-	-	-	20	16	(1)
3C	12 x 12	50	0.04	50	24	-	-	-	-	-	-	-	-	-	-	41	38	(1)

NOTES:

(1) Sliding (i.e., shear failure) occurred at the interface between the upper concrete sand and grass side of the artificial grass.

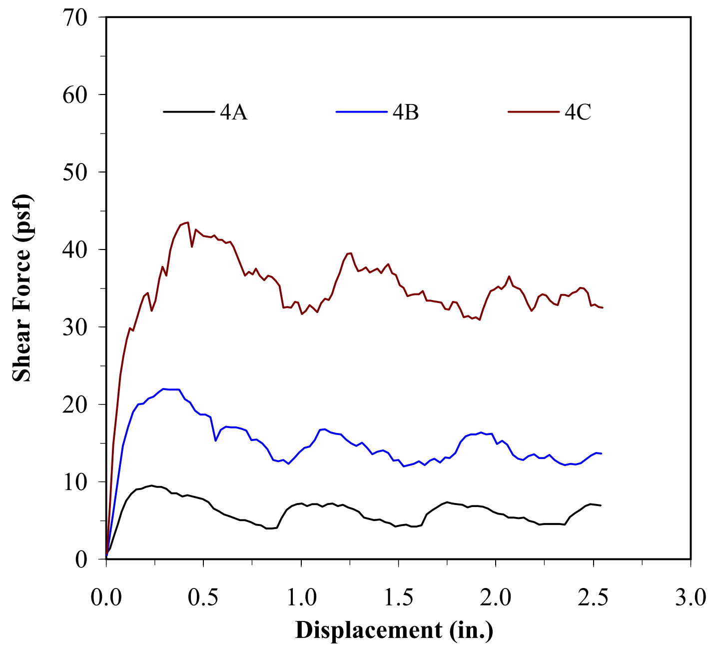
(2) The reported total-stress parameters of friction angle and adhesion were determined from a best-fit line drawn through the test data. Caution should be exercised in using these strength parameters for applications involving normal stresses outside the range of the stresses covered by the test series. The large-displacement (LD) shear strength was calculated using the shear force measured at the end of the test.

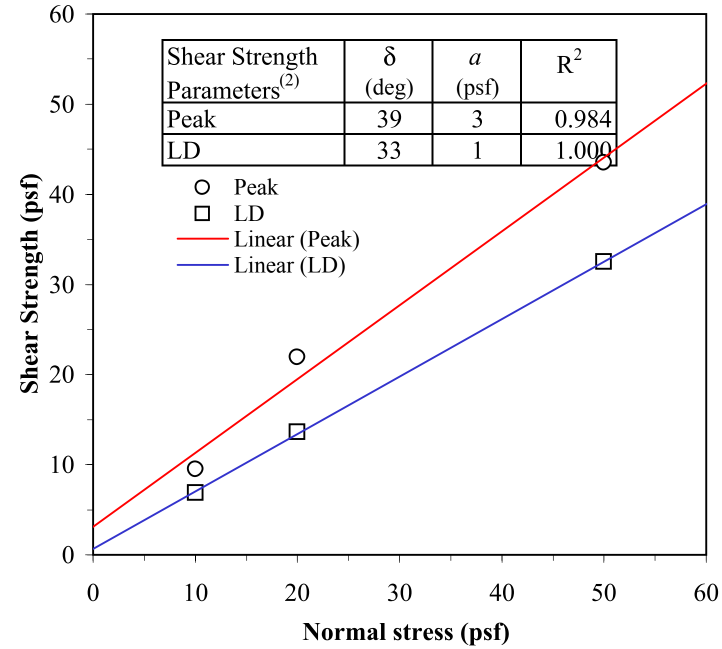
SGI TESTING SERVICES, LLC

DATE OF TEST:	5/15/2010
FIGURE NO.	C-3
PROJECT NO.	SGI10007
DOCUMENT NO.	
FILE NO.	

CLOSURETURF LLC -LANDFILL COVER SYSTEM
INTERFACE DIRECT SHEAR TESTING (ASTM D 5321)

Upper Shear Box: Concrete sand nominally compacted
Artificial grass with grass side (green yarns) up/
Agru 50 mil LLDPE Super Gripnet geomembrane with studs side up/
Lower Shear Box: Concrete sand





Test No.	Shear Box Size (in. x in.)	Normal Stress (psf)	Shear Rate (in./min)	Soaking		Consolidation		Lower Soil			Upper Soil			GCL		Shear Strengths		Failure Mode
				Stress (psf)	Time (hour)	Stress (psf)	Time (hour)	γ_d (pcf)	ω_i (%)	ω_f (%)	γ_d (pcf)	ω_i (%)	ω_f (%)	ω_i (%)	ω_f (%)	τ_P (psf)	τ_{LD} (psf)	
4A	12 x 12	10	0.04	10	24	-	-	-	-	-	-	-	-	-	-	10	7	(1)
4B	12 x 12	20	0.04	20	24	-	-	-	-	-	-	-	-	-	-	22	14	(1)
4C	12 x 12	50	0.04	50	24	-	-	-	-	-	-	-	-	-	-	44	33	(1)

NOTES:
(1) Sliding (i.e., shear failure) occurred at the interface between the geotextile of the artificial grass and studs side of the geomembrane.
(2) The reported total-stress parameters of friction angle and adhesion were determined from a best-fit line drawn through the test data. Caution should be exercised in using these strength parameters for applications involving normal stresses outside the range of the stresses covered by the test series. The large-displacement (LD) shear strength was calculated using the shear force measured at the end of the test.

SGI TESTING SERVICES, LLC

DATE OF TEST:	5/15/2010
FIGURE NO.	C-4
PROJECT NO.	SGI10007
DOCUMENT NO.	
FILE NO.	

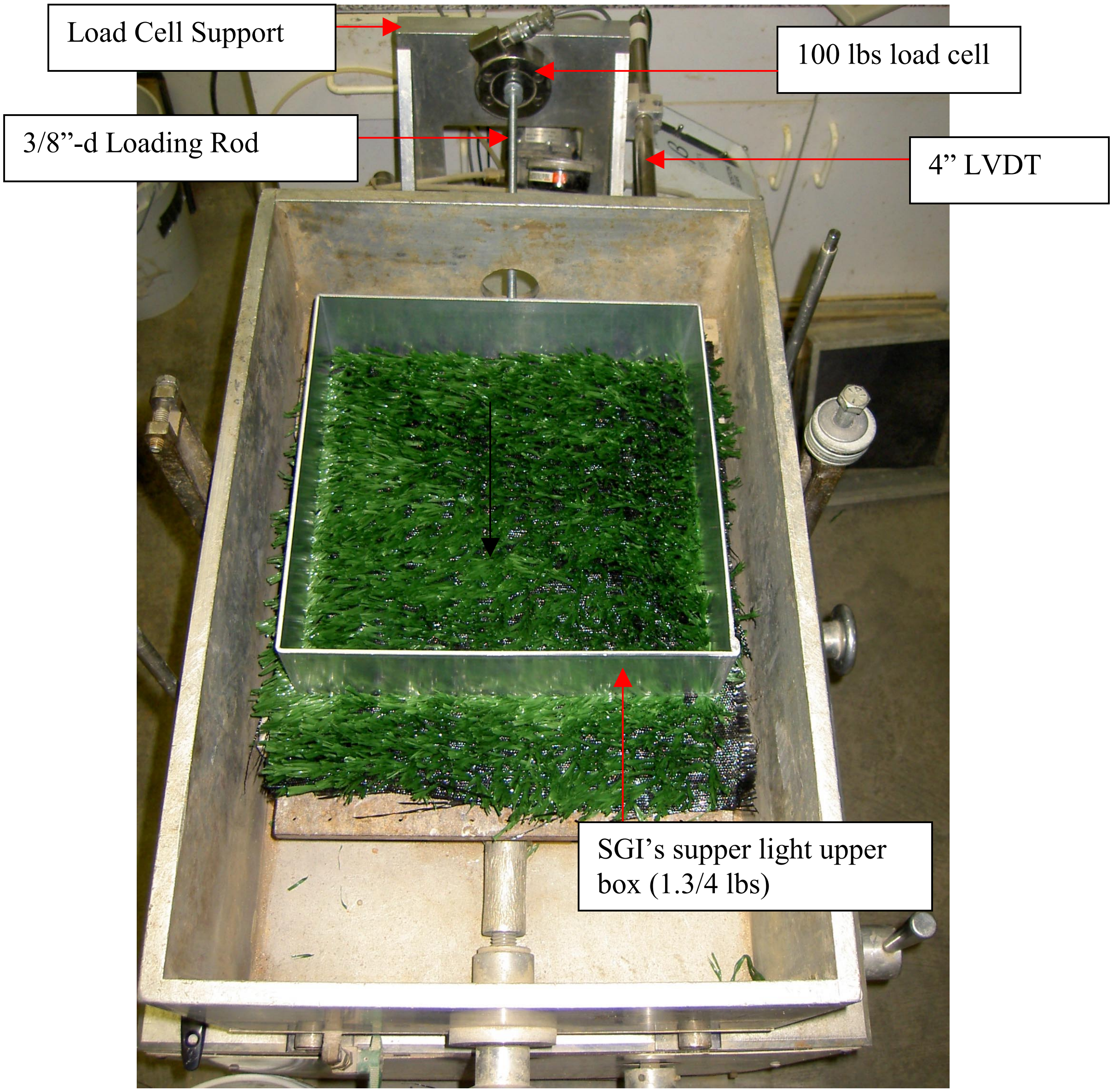


Figure 1. SGI's low pressure interface direct shear test setup.

Figure 2. Sand/grass interface test at a normal stress of 20 psf.

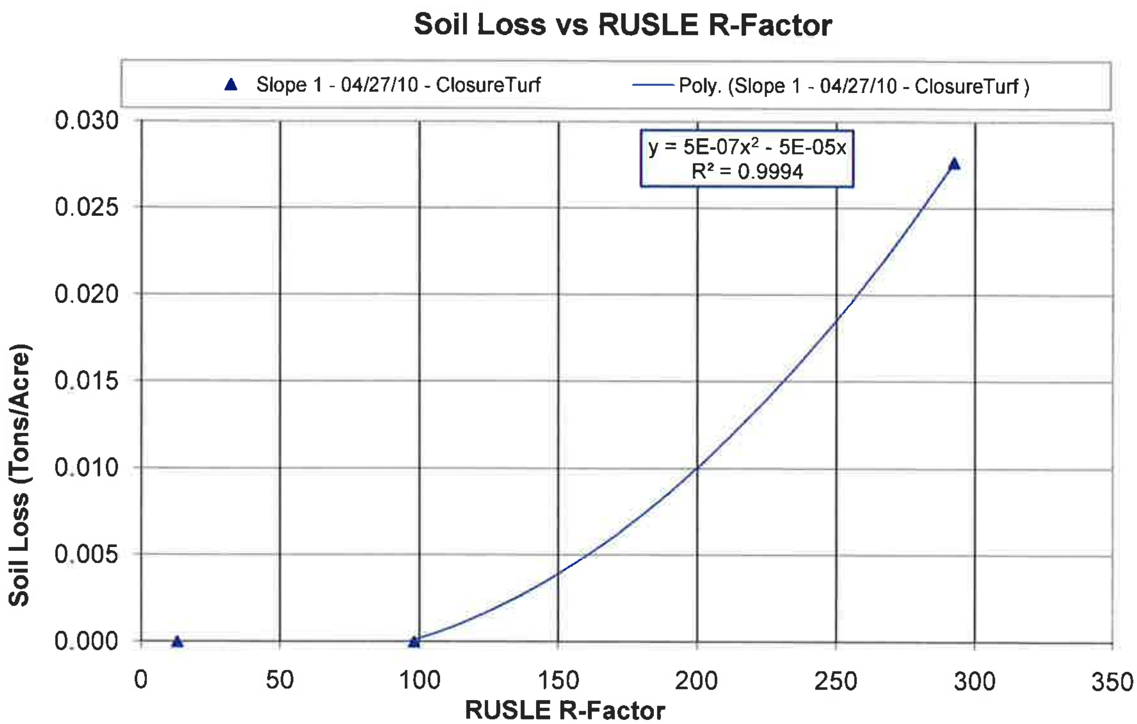
7.15 LARGE SCALE EROSION TEST ASTM

TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

Project: ASTM D 6459
Client: RPH
Test Date: 4/26/2010
Rainfall Rates: 2,4,6 in/hr (target); 20 minutes at each intensity (60 min. total)
Bed Size & Slope: 8-ft wide x 40-ft long; 3H:1V
Sand Ballast Layer, lbs: 1130 (approximately 1/2-inch thick, hand spread)

Plot	Intensity (in/hr)	Runoff (gallons)	Cumm. R-Factor	Soil Loss (lbs/slope)	Sediment Yield (tons/acre)	% of Ballast in Runoff/Seepage
ClosureTurf	2.36	93	13.13	0.00	0.00	0.04%
	4.65	258	97.99	0.00	0.00	
	6.57	360	292.43	0.41	0.03	

Time (min)	Cumm. Rainfall (in)	Cumm. Runoff (in)	Peak Runoff (cfs)	CN[1]	Rational "C"[2]
20	0.79	0.46	0.013	96.2	0.74
40	2.34	1.76	0.026	94.5	0.76
60	4.53	3.56	0.038	91.3	0.78



1. The effective runoff curve number was determined by solving for S in the equation Q = [(P-0.2S)2/(P+0.8S)] where Q is the depth of runoff (in) and P is the rainfall depth (in). Then, CN = 1000/(S+10).

2. The rational "C" coefficient was determined by solving for C in Q = C I A where Q is the peak discharge rate (cfs), I is the peak rainfall intensity (in/hr) and A is the drainage area (acre).

Note: The testing is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose

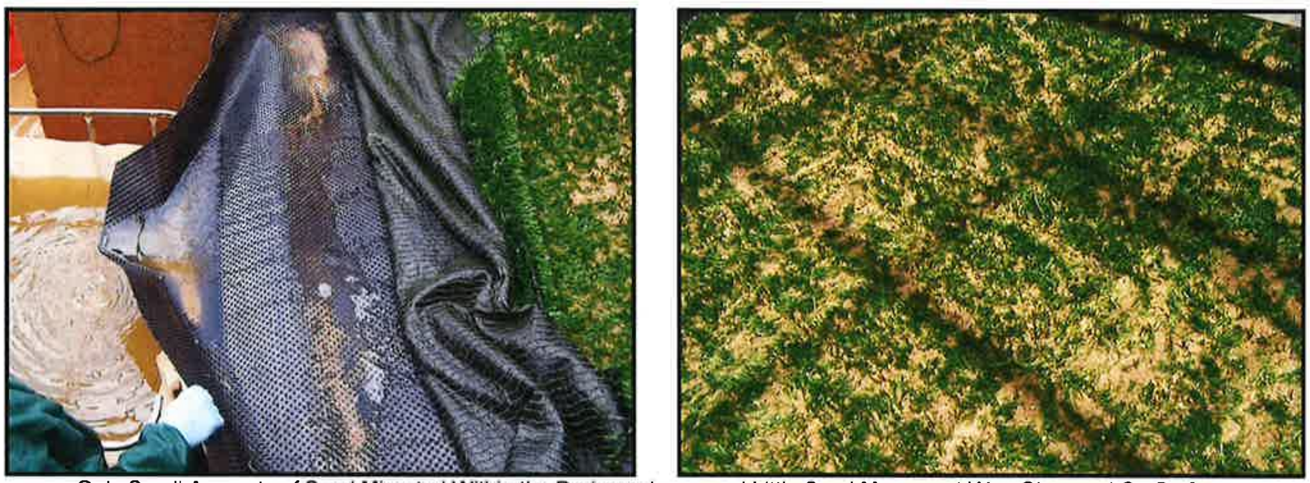
CJS 5/5/10
Quality Review / Date


Test Slope Prepared and Liner Installed


Synthetic Turf Deployed and Sand Ballast Layer Hand-Applied


2, 4, and 6 in/hr Rainfall Applied in Succession and Substantial In-Plane Drainage Observed

Bottle Grab Samples and Flow Rate Measurements Taken During Testing



Only Small Amounts of Sand Migrated Within the Drainage Layer and Little Sand Movement Was Observed On Surface

Typical Unprotected Slope Erosion from Testing Protocol (2 in/hr on left; 6 in/hr on right)

APPENDIX - DATA

DDRF Rainfall Testing

Slope #: 1 | **Target Rain: 2 in/hr**

Date:	4/26/2010	Start Rain:	12:25 PM	End Rain:	12:45 PM
		Sampling interval:	0:03	End Runoff:	12:47 PM
		Rain Time (min):	20.00	Test Time (min):	22.00
Product:	ClosureTurf	Descr.:	Membrane and Synthetic Turf Capping System		
Lot #:	n/a	Anchors:	Sand	Anchorage:	1/2-inch Thick

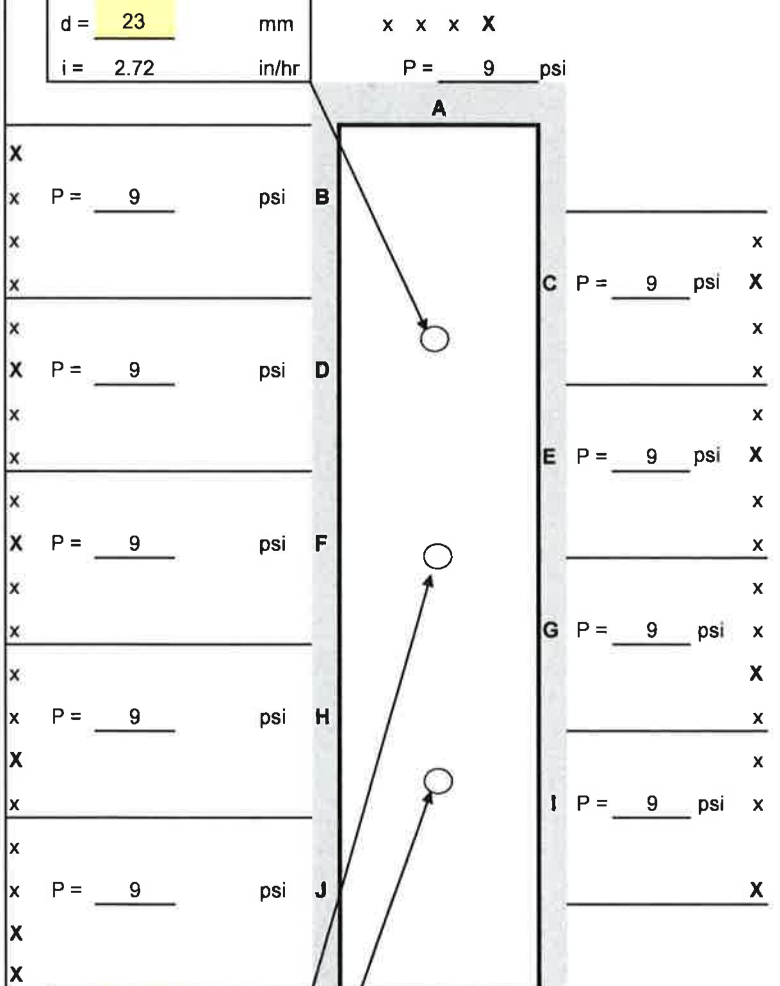
TOP OF SLOPE

(circle "x" for open valves)

Set valves to 9 psi.

w_{c1} = 17.7%

d = 23 mm
i = 2.72 in/hr



d = 18 mm
i = 2.13 in/hr

w_{c2} = 17.4%

d = 19 mm
i = 2.24 in/hr

w_{c3} = 18.6%

Temp. 78 deg
Hum. 78 %

Average Depth: **20.00** **mm**
Avg Rainfall Intensity: **2.36** **in/hr**

Notes:
0 mph breeze.
Approx 92 gal collected.

Sediment Concentration Grab Samples Followed by Runoff Rate Measurements

#	Time	
1	12:28	
2	12:31	
3	12:34	
4	12:37	
5	12:40	
6	12:43	
7		
8		
9		
10		
11		
12		
13		
14		
15		
12		
13		
14		
15		

Runoff Rate Measurements

#	Time	Time to Collect 1 Gallon, Seconds
1	2	180
2	6	31
3	10	15
4	14	10
5	18	10
6	20	9
7		
8		
9		
10		
11		
12		
13		
14		
15		
12		
13		
14		
15		

DDRF Rainfall Testing

Slope #: 1 | **Target Rain: 4 in/hr**

Date: 4/26/2010 | Start Rain: 12:53 PM | End Rain: 1:13 PM
Sampling interval: 0:02 | End Runoff: 1:17 PM
Rain Time (min): 20.00 | Test Time (min): 24.00

Product: ClosureTurf | Descr.: Membrane and Synthetic Turf Capping System
Lot #: n/a | Anchors: Sand | Anchorage: 1/2-inch Thick

TOP OF SLOPE | **Set valves to 9 psi.**

X X x x

w_{c1} = 17.7%

d = 42 mm
i = 4.96 in/hr

P = 9 psi

A

X
X P = 9 psi B
x
x

X
C P = 9 psi X
x
x

X
X P = 9 psi D
x
x

X
E P = 9 psi X
x
x

x
X P = 9 psi F
X
x

x
G P = 9 psi X
X
x

x
x P = 9 psi H
X
X

x
I P = 9 psi X
X
X

x
X P = 9 psi J
X
X

d = 39 mm
i = 4.61 in/hr

w_{c2} = 17.4%

d = 37 mm
i = 4.37 in/hr

w_{c3} = 18.6%

Temp. 77 deg
Hum. 86 %

Average Depth: **39.33** **mm**

Avg Rainfall Intensity: **4.65** **in/hr**

Sediment Concentration Grab Samples Followed by Runoff Rate Measurements

#	Time	
1	12:55	
2	12:57	
3	12:59	
4	13:01	
5	13:03	
6	13:05	
7	13:07	
8	13:09	
9	13:11	
10	13:13	
11		
12		
13		
14		
15		
12		
13		
14		
15		

Runoff Rate Measurements

#	Time	Time to Collect 1 Gallon, **Seconds**
1	2	8
2	4	6
3	6	6
4	8	6
5	10	6
6	12	6
7	14	5
8	16	5
9	18	5
10	20	5
11		
12		
13		
14		
15		
12		
13		
14		
15		

Notes:
0 mph breeze.
Approx 260 gal collected.

DDRF Rainfall Testing

Slope #: 1 | **Target Rain: 6 in/hr**

Date: 4/26/2010 | Start Rain: 12:53 PM | End Rain: 1:13 PM

Sampling interval: 0:02 | End Runoff: 1:17 PM

Rain Time (min): 20.00 | Test Time (min): 24.00

Product: ClosureTurf | Descr:. Membrane and Synthetic Turf Capping System

Lot #: n/a | Anchors: Sand | Anchorage: 1/2-inch Thick

TOP OF SLOPE

(circle "x" for open valves) **Set valves to 9 psi.**

w_{c1} = 17.7%

d = 57 mm
i = 6.73 in/hr

x X X X

P = 9 psi

A

X
X P = 9 psi B
X
x

X
X P = 9 psi D
X
x

X
X P = 9 psi F
X
x

x
X P = 9 psi H
X
X

X
X P = 9 psi J
X
X

X
C P = 9 psi X
X
x

X
E P = 9 psi X
X
x

x
G P = 9 psi X
X
X

X
I P = 9 psi X
X
X

d = 58 mm
i = 6.85 in/hr

w_{c2} = 17.4%

d = 52 mm
i = 6.14 in/hr

w_{c3} = 18.6%

Temp. 69 deg

Hum. 88 %

Average Depth: **55.67** **mm**

Avg Rainfall Intensity: **6.57** **in/hr**

Notes:

0 mph breeze.
Approx 360 gal collected.

Sediment Concentration Grab Samples Followed by Runoff Rate Measurements

#	Time	
1	12:55	
2	12:57	
3	12:59	
4	13:01	
5	13:03	
6	13:05	
7	13:07	
8	13:09	
9	13:11	
10	13:13	
11		
12		
13		
14		
15		
12		
13		
14		
15		

Runoff Rate Measurements

#	Time	Time to Collect 1 Gallon, Seconds
1	2	4
2	4	4
3	6	4
4	8	4
5	10	4
6	12	4
7	14	4
8	16	4
9	18	4
10	20	4
11		
12		
13		
14		
15		
12		
13		
14		
15		

0-Jan-00

Slope #1

Sample Number	Test Time, minutes	Time per Gallon, sec	Interval Time, min	Total Time, min	Collection Mid-Time, min	Runoff Rate, gal/min	Associated Runoff, gal	Cumulative Runoff, gal	
2.36 in/hr									
2	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	
2-1	2.00	180	5.00	5.00	3.50	0.33	1.67	1.67	
2-2	6.00	31	1.52	6.52	6.26	1.94	2.94	4.60	
2-3	10.00	15	3.73	10.25	10.13	4.00	14.93	19.54	
2-4	14.00	10	3.92	14.17	28.17	6.00	23.50	43.04	
2-5	18.00	10	4.00	18.17	36.17	6.00	24.00	67.04	
2-6	20.00	9	1.98	20.15	40.15	6.67	13.22	80.26	
2-end	22.00		1.85	22.00			12.33	**92.59**	**Total Collected Runoff (approx)**
4.65 in/hr									
4	0	0	0.00	0.00	0.00	0.00	0.00	0.00	
4-1	2	8	2.13	2.13	2.07	7.50	16.00	16.00	
4-2	4	6	1.97	4.10	4.05	10.00	19.67	35.67	
4-3	6	6	2.00	6.10	6.05	10.00	20.00	55.67	
4-4	8	6	2.00	8.10	8.05	10.00	20.00	75.67	
4-5	10	6	2.00	10.10	10.05	10.00	20.00	95.67	
4-6	12	6	2.00	12.10	12.05	10.00	20.00	115.67	
4-7	14	5	1.98	14.08	14.04	12.00	23.80	139.47	
4-8	16	5	2.00	16.08	16.04	12.00	24.00	163.47	
4-9	18	5	2.00	18.08	18.04	12.00	24.00	187.47	
4-10	20	5	2.00	20.08	20.04	12.00	24.00	211.47	
4-end	24.00		3.92	24.00			47.00	**258.47**	**Total Collected Runoff (approx)**
5.90 in/hr									
6	0	0	0.00	0.00	0.00	0.00	0.00	0.00	
6-1	2	4	2.07	2.07	2.03	15.00	31.00	31.00	
6-2	4	4	2.00	4.07	4.03	15.00	30.00	61.00	
6-3	6	4	2.00	6.07	6.03	15.00	30.00	91.00	
6-4	8	4	2.00	8.07	8.03	15.00	30.00	121.00	
6-5	10	4	2.00	10.07	10.03	15.00	30.00	151.00	
6-6	12	4	2.00	12.07	12.03	15.00	30.00	181.00	
6-7	14	4	2.00	14.07	14.03	15.00	30.00	211.00	
6-8	16	4	2.00	16.07	16.03	15.00	30.00	241.00	
6-9	18	4	2.00	18.07	18.03	15.00	30.00	271.00	
6-10	20	4	2.00	20.07	20.03	15.00	30.00	301.00	
6-end	24.00		3.93	24.00			59.00	**360.00**	**Total Collected Runoff (approx)**

Slope #1 - Sediment Concentration

	Sample Number	Test Time, minutes	Total Weight, g	Decanted Weight, g	Dry Weight, g	Bottle Weight, g	Dry Sediment Weight, mg	Total Collected Water Wt., g	Total Collected Volume of Water, l	Sediment Concentration, mg/l	Runoff Sampling Time	Time to Collect 1 gal	Associate d Runoff, gal	Associated Sediment Conc, mg/l	Associated Solids Loss, lbs
#DIV/0! in/hr	avg														
0-Jan-00	2-1	3.00	300.51	32.92	32.92	32.92	0.00	267.59	0.27	0.00	2.00	180	1.67	0.00	0.00
	2-2	6.00	310.76	32.92	32.92	32.92	0.00	277.84	0.28	0.00	6.00	31	2.94	0.00	0.00
	2-3	9.00	305.13	32.92	32.92	32.92	0.00	272.21	0.27	0.00	10.00	15	14.93	0.00	0.00
	2-4	12.00	311.56	32.92	32.92	32.92	0.00	278.64	0.28	0.00	14.00	10	23.50	0.00	0.00
	2-5	15.00	298.63	32.92	32.92	32.92	0.00	265.71	0.27	0.00	18.00	10	24.00	0.00	0.00
	2-6	18.00	304.77	32.92	32.92	32.92	0.00	271.85	0.27	0.00	20.00	9	13.22	0.00	0.00
									AVG =	**0.00**	22.00	0	12.33	0.00	0.00
4.24 in/hr	avg												**Total Solids Lost:**		**0.00**
11/5/2009	4-1	2.00	311.17	32.92	32.92	32.92	0.00	278.25	0.28	0.00	2.00	8	16.00	0.00	0.00
	4-2	4.00	308.34	32.92	32.92	32.92	0.00	275.42	0.28	0.00	4.00	6	19.67	0.00	0.00
	4-3	6.00	290.56	32.92	32.92	32.92	0.00	257.64	0.26	0.00	6.00	6	20.00	0.00	0.00
	4-4	8.00	313.40	32.92	32.92	32.92	0.00	280.48	0.28	0.00	8.00	6	20.00	0.00	0.00
	4-5	10.00	313.35	32.92	32.92	32.92	0.00	280.43	0.28	0.00	10.00	6	20.00	0.00	0.00
	4-6	12.00	310.89	32.92	32.92	32.92	0.00	277.97	0.28	0.00	12.00	6	20.00	0.00	0.00
	4-7	14.00	314.63	32.92	32.92	32.92	0.00	281.71	0.28	0.00	14.00	5	23.80	0.00	0.00
	4-8	16.00	317.22	32.92	32.92	32.92	0.00	284.30	0.28	0.00	16.00	5	24.00	0.00	0.00
	4-9	18.00	315.58	32.92	32.92	32.92	0.00	282.66	0.28	0.00	18.00	5	24.00	0.00	0.00
	4-10	20.00	313.87	32.92	32.92	32.92	0.00	280.95	0.28	0.00	20.00	5	24.00	0.00	0.00
									AVG =	**0.00**	24.00	0	47.00	0.00	0.00
5.90 in/hr	avg												**Total Solids Lost:**		**0.00**
6/11/2009	6-1	2.00	317.68	32.92	32.92	32.92	0.00	284.76	0.28	0.00	2.00	4.00	31.00	0.00	0.00
	6-2	4.00	315.42	32.92	32.92	32.92	0.00	282.50	0.28	0.00	4.00	4.00	30.00	0.00	0.00
	6-3	6.00	314.68	32.92	32.92	32.92	0.00	281.76	0.28	0.00	6.00	4.00	30.00	0.00	0.00
	6-4	8.00	312.89	32.92	32.92	32.92	0.00	279.97	0.28	0.00	8.00	4.00	30.00	0.00	0.00
	6-5	10.00	313.42	32.92	32.92	32.92	0.00	280.50	0.28	0.00	10.00	4.00	30.00	0.00	0.00
	6-6	12.00	309.16	32.92	32.92	32.92	0.00	276.24	0.28	0.00	12.00	4.00	30.00	0.00	0.00
	6-7	14.00	313.41	32.92	32.92	32.92	0.00	280.49	0.28	0.00	14.00	4.00	30.00	0.00	0.00
	6-8	16.00	315.77	32.92	32.92	32.92	0.00	282.85	0.28	0.00	16.00	4.00	30.00	0.00	0.00
	6-9	18.00	309.69	32.92	32.92	32.92	0.00	276.77	0.28	0.00	18.00	4.00	30.00	0.00	0.00
	6-10	20.00	310.70	32.92	32.92	32.92	0.00	277.78	0.28	0.00	20.00	4.00	30.00	0.00	0.00
									AVG =	**0.00**	24.00	0.00	59.00	0.00	0.00
													Total Solids Lost:		**0.00**

SLOPE #1 - Sediment Weights

Total Dry Sediments:	**0.00**	
2 in/hr	Collected	Typ. TSS in Decanted Collected Runoff, lb/gal
Wt. Of pan + wet soil, g	0	
Wt. Of pan + dry soil, g	0	
Wt. Of pan, g	0	
Wt. Of dry soil, g	0	0
Wt. Of water, g		Collected Runoff, gal
Water Content, w%		
Total Wet Sediments,g		
% dry solids		92.6
Dry Collected Sediments, g	0.00	0.00

Total Dry Sediments:	**0.00**	
4 in/hr	Collected	Typ. TSS in Decanted Collected Runoff, lb/gal
Wt. Of pan + wet soil, g	0	
Wt. Of pan + dry soil, g	0	
Wt. Of pan, g	0	
Wt. Of dry soil, g	0	0
Wt. Of water, g		Collected Runoff, gal
Water Content, w%		
Total Wet Sediments, g		
% dry solids		258.5
Dry Collected Sediments, g	0.00	0.00

Total Dry Sediments, lbs:	**0.41**	
6 in/hr	Collected	Typ. TSS in Decanted Collected Runoff, lb/gal
Wt. Of pan + wet soil, g	402.35	
Wt. Of pan + dry soil, g	400.76	
Wt. Of pan, g	216.31	
Wt. Of dry soil, g	184.45	0
Wt. Of water, g	1.59	Collected Runoff, gal
Water Content, w%	0.9	
Total Wet Sediments, g		
% dry solids		360.0
Dry Collected Sediments, g	184.45	0.00

7.16 FULL SCALE HYDRAULIC TESTING OF THE HYDROTURF™ ADVANCED REVETMENT TECHNOLOGY

WG WatershedGeo®
Unearthing Solutions

TECHNICAL NOTE

FULL-SCALE HYDRAULIC TESTING OF THE HYDROTURF® ADVANCED REVETMENT TECHNOLOGY

Extensive independent, 3rd party hydraulic testing has been performed at Colorado State University – Engineering Research Center (CSU) in Fort Collins, CO on the HydroTurf® Revetment System. This technical note describes the full-scale testing that was completed. The information presented in this technical note is as follows:

- Introduction to HydroTurf® Revetment System
- Benefits
- Steady State Hydraulic Testing
  - Steady State Overtopping
  - Hydraulic Jump
  - Heavy Debris Loads - Assessment of Resilience to Impact and Abrasion
  - Assessment of Performance in an Intentionally Damaged State – Hole Created Using a Pick Axe
- Wave Overtopping Hydraulic Testing for Levee Landward-Side Slope Protection
- Assessment of Performance in an Intentionally Damaged State (Wave Overtopping)
  - Pulverized HydroBinder® Infill
  - Simulated Bullet Hole
  - Hole Created Using a Pick Axe

Non-hydraulic testing and evaluations have also been performed on the HydroTurf® System. This information is included in a separate Technical Note. Please contact Watershed Geosynthetics for this document.

INTRODUCTION TO HYDROTURF® REVETMENT SYSTEM

HydroTurf® was developed as an engineered revetment solution for use in preventing erosion in the following applications:

- Protection from Wave Overwash / Overtopping on the Landward Side of Levees and Embankments;
- Lining of Channels, Swales, Canals, and Spillways;
- Shoreline Protection within Basins, Impoundments, and Reservoirs; and
- Facings for Slopes and Mechanically Stabilized Earth Walls.

HydroTurf® is a flexible, reinforced concrete erosion prevention solution consisting of a high-friction, impermeable geomembrane layer with an integrated drainage layer overlain by an engineered synthetic turf. The geomembrane is placed directly on the subgrade soil. It is covered with the engineered turf whose fibers provide reinforcement for the HydroBinder® cementitious infill. This infill is placed dry to a thickness of ¾-inch minimum. After placement, it is then hydrated with a light spray of water. A cross section of HydroTurf® is shown in Figure 1.

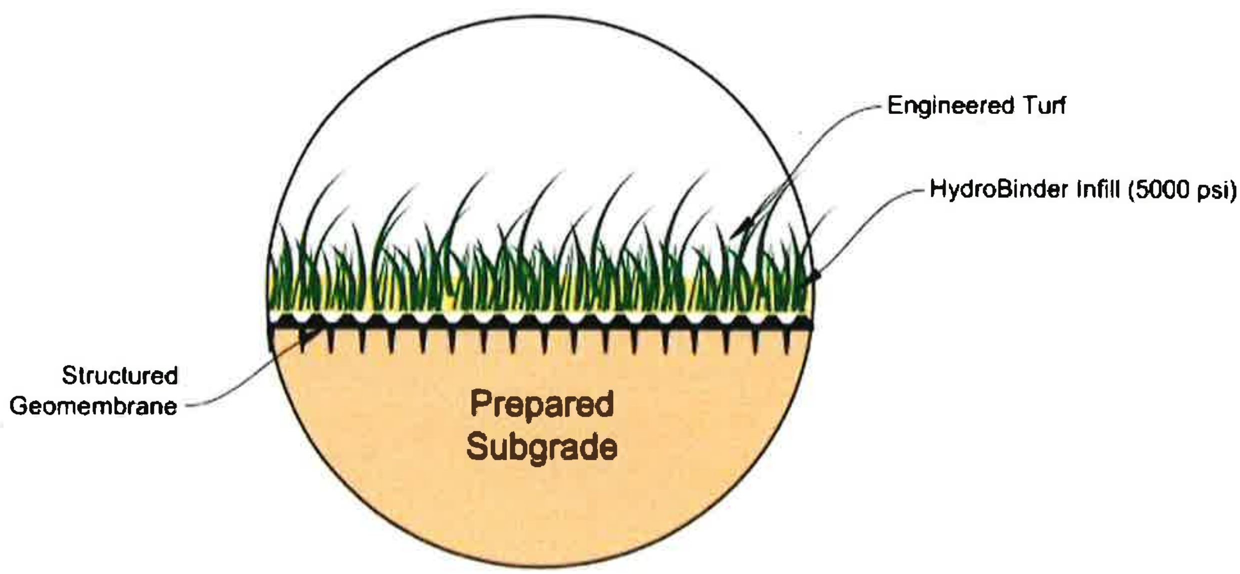


Figure 1 – Section of HydroTurf® Revetment System

BENEFITS

HydroTurf® has a number of benefits over other revetment solutions. These benefits include the following:

- ***Excellent Hydraulic Performance*** – HydroTurf® has been measured to have exceptional hydraulic performance over other hard armor revetment systems.
- ***50+ Year Functional Longevity*** – Through long term weathering tests, HydroTurf® is extrapolated to have a 50+ year functional longevity.
- ***Less Costly Construction*** – HydroTurf® is significantly less costly than hard armor revetment systems (i.e., concrete, rock riprap, and articulated concrete block (ACB)). The installed cost for HydroTurf® is typically up to 50% less than that for traditional hard armor systems.
- ***Rapid, Low Impact, and Scalable Construction*** – Construction and installation of the HydroTurf® System are rapid, low impact, and scalable. Only small, light construction equipment is needed to install the system. On large projects, one (1) experienced construction crew is able to install approximately 1 acre per day. Additional crews can be added to increase this rate. .
- ***Significant Long Term Maintenance Cost Savings*** – Vegetation management and erosion control are significant maintenance costs for Anchored Turf Reinforcement Mats (TRMs) products. Maintenance costs for these TRMs may be as high as $1500/acre/year. HydroTurf® has minimal maintenance and will drastically lower long term maintenance costs.
- ***Reduction in Carbon Footprint*** - HydroTurf® has a significantly lower carbon footprint (1/4 to 1/8) than that of the other revetment solutions.
- ***Aesthetics*** – HydroTurf® looks and feels like natural vegetation.

STEADY STATE OVERTOP TESTING

CSU tested HydroTurf® in accordance with ASTM D 7277 – Standard Test Method for Performance Testing of Articulated Concrete Block (ACB) Revetment Systems for Hydraulic Stability in Open Channel Flow. The results of the testing were analyzed in accordance with ASTM D 7276 - Standard Guide for Analysis and Interpretation of Test Data for Articulating Concrete Block (ACB) Revetment Systems in Open Channel Flow.

HydroTurf® was installed in the flume in general accordance with Watershed Geosynthetics' installation guidelines. The flume is at a 2H:1V slope. First, a sandy-loam subgrade was compacted in place in the flume (See Figure 2). Next, a continuous sheet of the 50-mil structured geomembrane was placed with the "spike" side down (See Figure 3). This geomembrane serves as the underlayer of the system. Then, the engineered synthetic turf was placed on the geomembrane. A horizontal seam was placed in the synthetic turf layer near the bottom of the flume. The purpose of the seam was to test its strength under high flow velocity and shear stress conditions. This seam consists of two (2) sections of the synthetic turf which were heat-bonded together using similar equipment used for field installations. The next step in sample preparation was applying approximately a ¾-inch thick layer of dry HydroBinder® into the fibers of the synthetic turf. The dry mixture was placed using a drop spreader. It was broomed against the grain of the turf in order to pull the fibers up through the infill. The HydroBinder® infill was then hydrated by applying a light spray of water until saturation. The completed installation of the HydroTurf® System is shown in Figure 4.

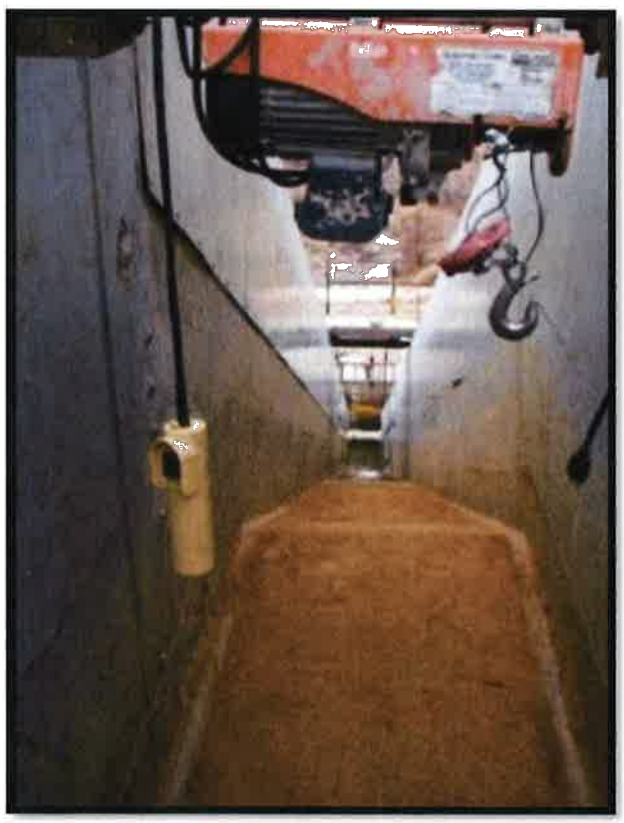


Figure 2 – Compacted Sandy-Loam Subgrade

Figure 3 – Installation of the Structured Geomembrane

Figure 4 – Completed Installation of the HydroTurf® System

The HydroTurf® was tested on a 30-ft embankment at 1.5, 3.0, and 5.0-ft steady-state overtop depths for a total of 12 hours in April 2013. Also, it was tested on a 60-ft embankment at 1.5, 5.0, and 5.5-ft steady-state overtop depths for an additional 12 hours in September 2015. After both tests, the embankment flume was inspected. The system and underlying soil were determined to be intact. CSU reported stable performance values of 40 fps for velocity. Since no instability, deformation, loss of intimate contact or damage to the system occurred, and since no erosion of the underlying subgrade occurred; this value of velocity is not a maximum performance threshold. A summary of these results is shown in Table 1. A profile of the testing section is shown in Figure 5, and photographs of the testing are shown in Figure 6.

Table 1 – Results of Steady State Hydraulic Testing of HydroTurf®

Overtop Depth (ft)	Q (cfs)	Embankment Length (ft)	Manning's "n" Value	Velocity (fps)
1.5	20	30	0.017	21.4
3.0	52	30	0.018	26.3
5.0	117	30	0.020	29.2
1.5	20	60	0.025	18
5.0	119	60	0.021	37
5.5	140	60	0.018	40

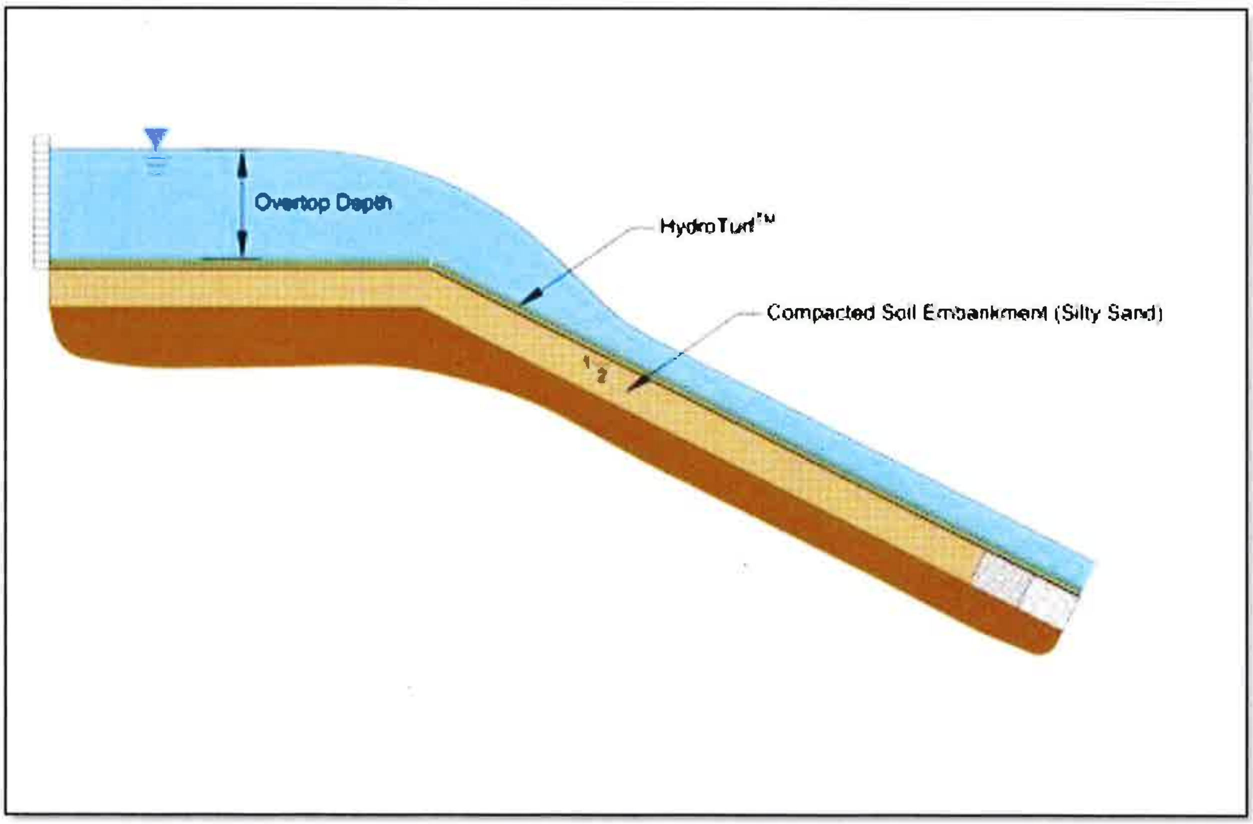


Figure 5 - Profile Section of the Installed HydroTurf® System in the Overtopping Flume

Figure 6 – Steady State Hydraulic Testing of HydroTurf® at CSU

The HydroTurf® performance value for velocity as measured in this steady state test is 40 fps at a 5.5-ft overtop depth. This value can be compared to the published maximum performance thresholds / permissible design values for various erosion and revetment technologies. This comparison shows that HydroTurf® outperforms these other systems (See Figure 7).

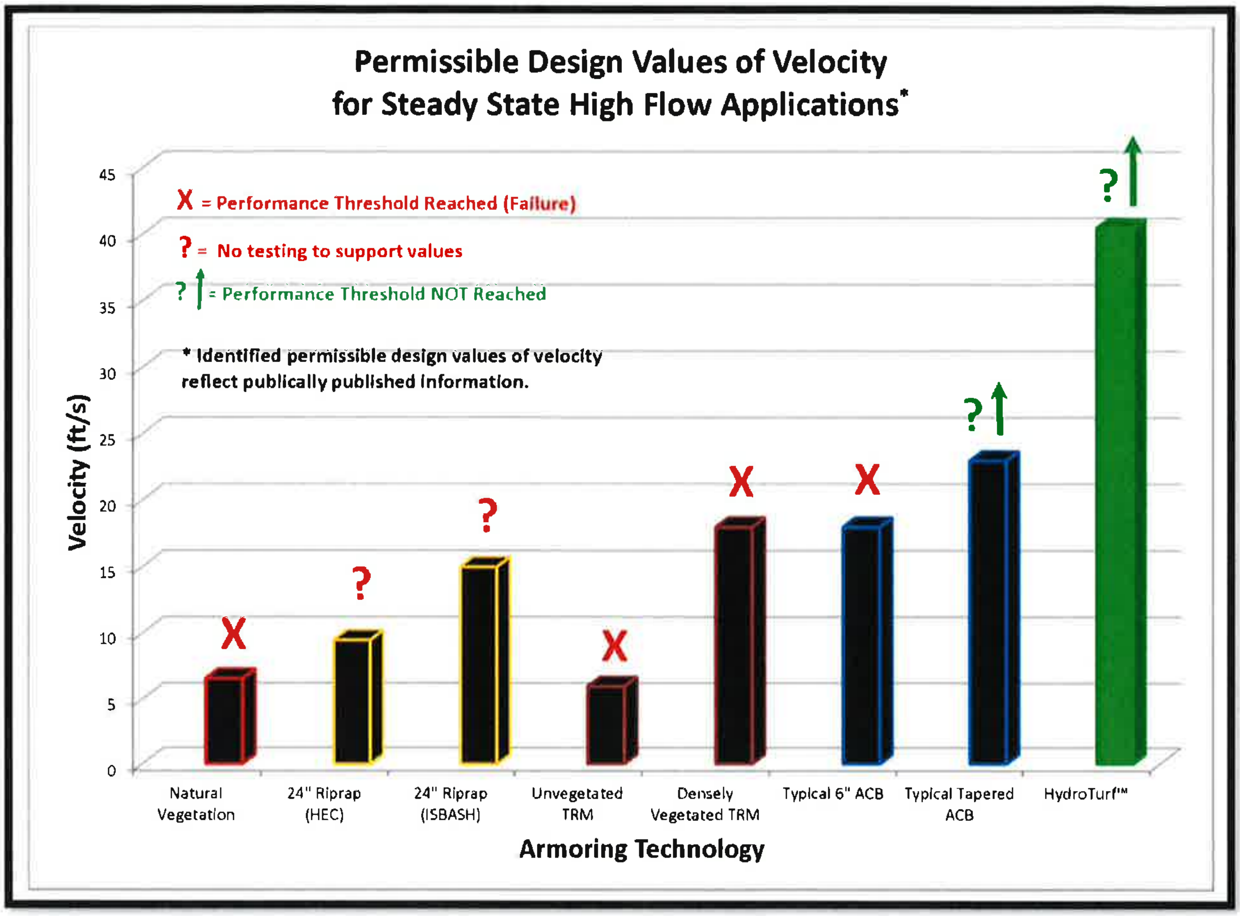


Figure 7 – Permissible Design Values of Velocity for Steady State High Flow Applications

Following completion of the three (3) steady state tests on the 30-ft embankment, additional testing was performed on the same installed HydroTurf® material in the flume. This testing evaluated the performance of HydroTurf® to Hydraulic Jumps, Large Debris, and Intentional Damage. It is described in the following sections of the Technical Note.

Hydraulic Jump Testing - Since there is no standard test method for measuring hydraulic jump, CSU developed a test program that would adequately quantify the performance of the HydroTurf® under a series of hydraulic jumps. A manually operated vertical sluice gate was installed approximately 22 feet from the top of the embankment in order to create a hydraulic jump on the HydroTurf®. Figure 8 shows a picture of this sluice gate installed in the channel. This gate was set so that it created the jump on the lower third of the material in the flume. A profile section of the Hydraulic Jump test is shown in Figure 9.

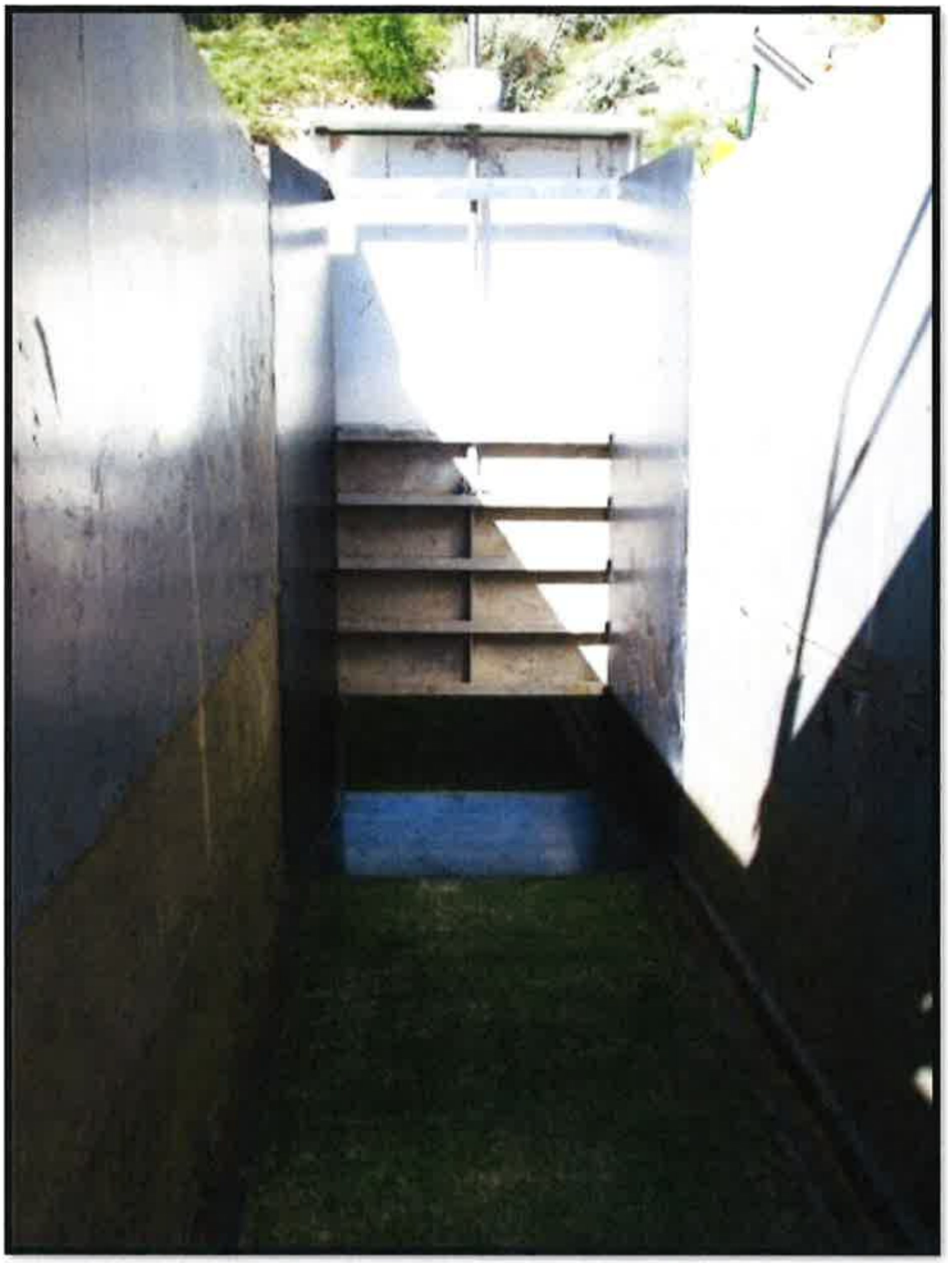


Figure 8 – Sluice Gate Installed in Overtop Flume for Hydraulic Jump Testing

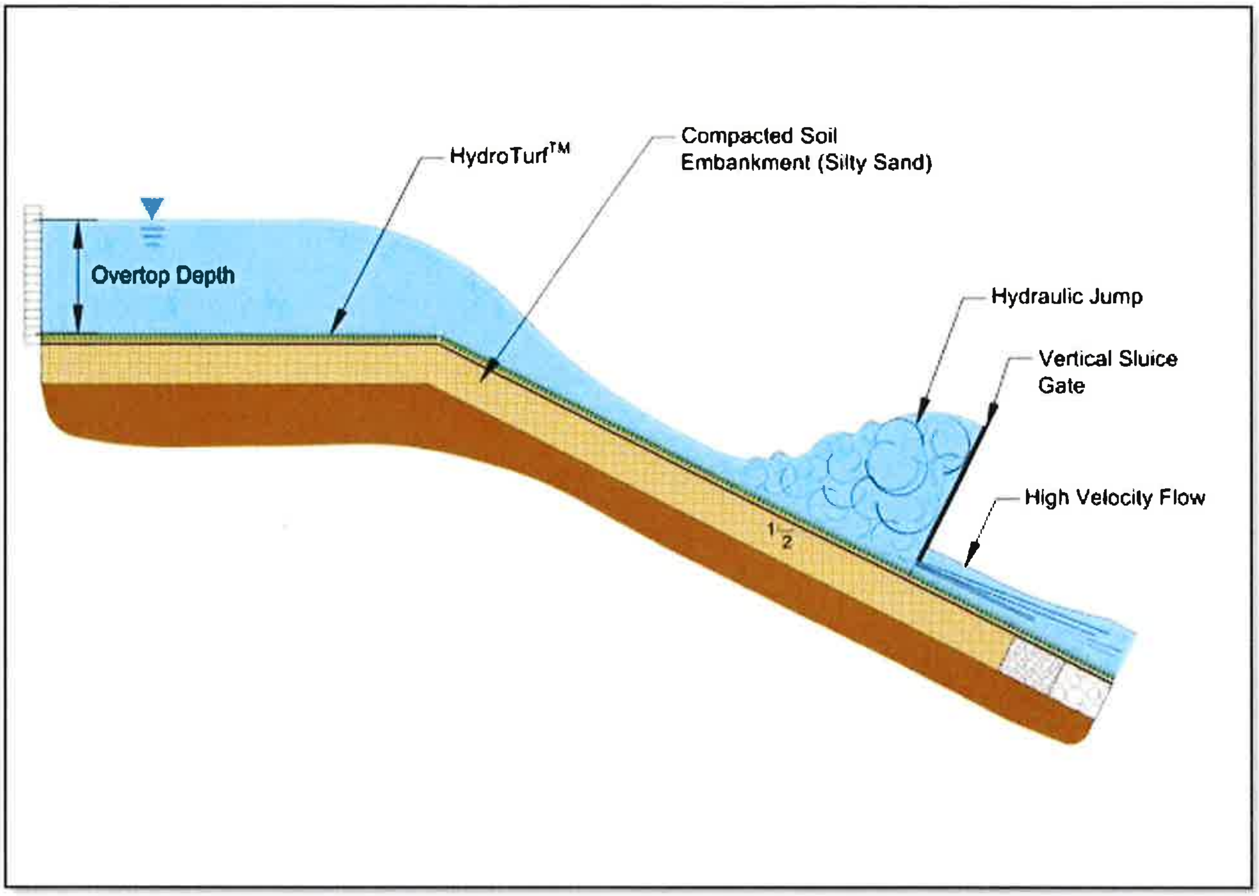


Figure 9 - Profile Section of the Installed HydroTurf® System in the Overtopping Flume for Hydraulic Jump Testing

A test consisted of at least 1.5 hours of continuous flow at each discharge interval (1.5, 3.0, and 5.0-ft overtop depths). Measurements of water surface were taken at the gate, at the beginning of the jump and at approximate 2-ft intervals upstream along the centerline of the slope. After at least 30 minutes of flow under a hydraulic jump, the sluice gate was adjusted to move the jump upstream. The procedure was repeated to collect data for three (3) hydraulic jumps at each overtop depth. Photographs of the Hydraulic Jump Testing are shown in Figure 10.

Figure 10 – Hydraulic Jump Testing of HydroTurf® at CSU

The objective of the hydraulic jump test program was to quantify the performance of HydroTurf® under the hydraulic loading caused by a range of hydraulic jumps at various overtopping depths. A performance threshold was not reached since there was no instability, deformation, loss of intimate contact, or damage of the HydroTurf® system, and since there was no erosion of the underlying subgrade. However, a relationship between the energy lost in the jump and the ratio of the upstream and downstream Froude numbers was developed. This relationship is shown in Figure 11. Also, power dissipation was calculated for each hydraulic jump interval. It was plotted as a function of specific energy upstream of the jump (See Figure 12). The HydroTurf® System demonstrated the ability to withstand hydraulic loads caused by hydraulic jumps dissipating as much as 30 horsepower per foot of width.

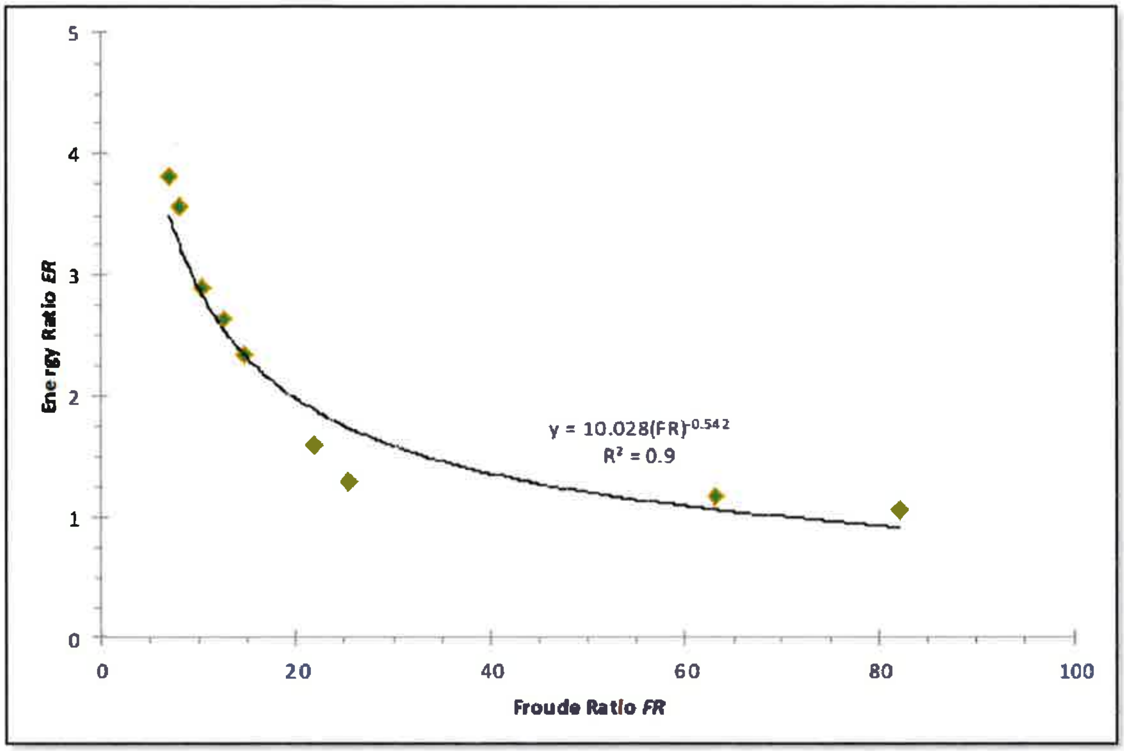


Figure 11 - Envelope Curve for Energy Ratio as a Function of Froude Ratio for HydroTurf®

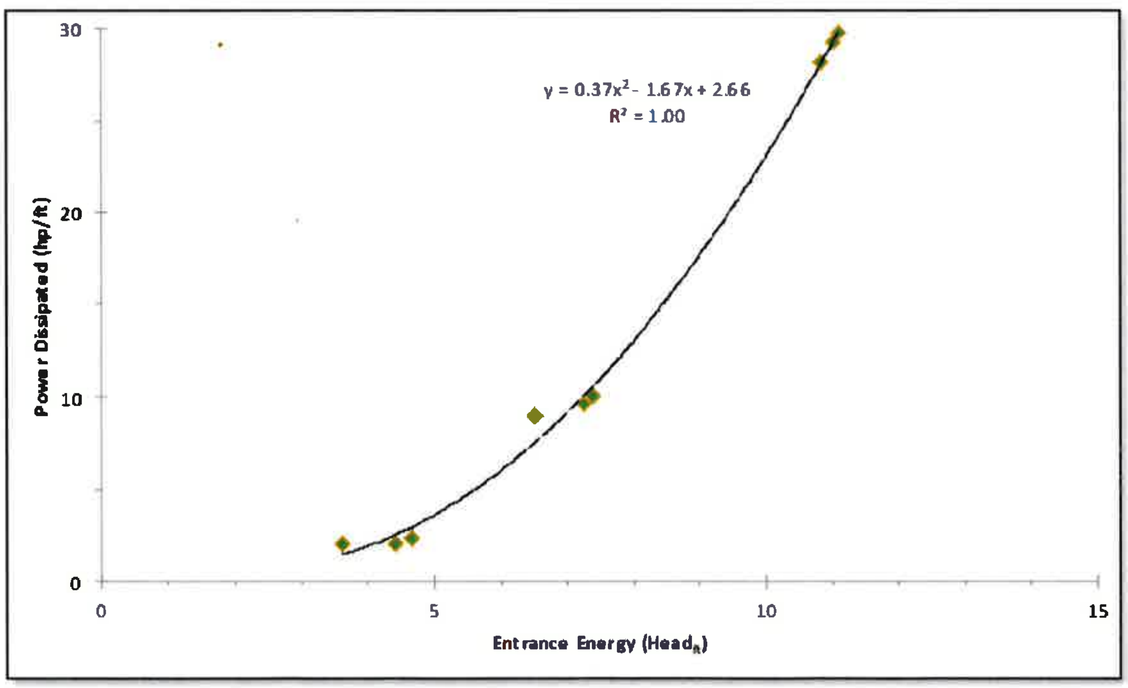


Figure 12 - Power Dissipation per Foot of Width as a Function of Specific Energy at the Entrance to the Hydraulic Jump for HydroTurf®

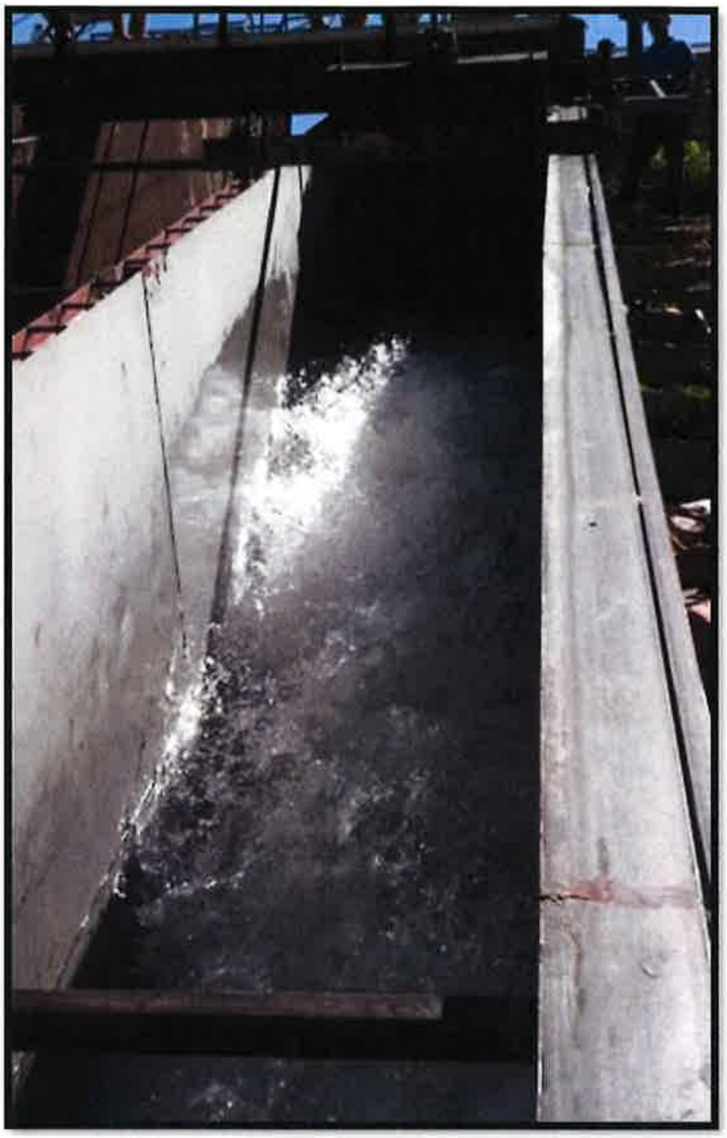


Figure 13 – Pressurized "Jet" from Under the Sluice Gate Surging onto the HydroTurf®

Since the sluice gate had a small opening at the base, the flow immediately downstream of it was a pressurized "jet" surging onto the HydroTurf® System. The extreme turbulence of the flow made it difficult to measure the velocity precisely, but the velocity of the jet of water exiting the hydraulic jump was approximately 35 fps. At the location of this jet, there was no instability, deformation, loss of intimate contact, or damage of the HydroTurf® system, and there was no erosion of the underlying highly-erodible subgrade. Figure 13 shows a photograph of the "jet" flow.

Heavy Debris Loads – After the hydraulic jump testing was complete, testing was performed to simulate heavy debris loads. The purpose of this test was to qualitatively assess the resilience of the HydroTurf® Revetment System to impact and abrasion from large debris.

The flow in the flume was brought to an overtopping depth of 5.0-ft. A Bobcat S850 front-end loader was filled with broken, angular concrete blocks ranging from approximately 3 to 15 inches in diameter (See Figure 14). The front-end loader dumped two (2) full buckets of concrete debris into the flume at the top of the embankment from a height of approximately 12 feet (See Figures 15 and 16). The concrete debris caused a few minor surface impressions at the location of the 12-ft drop. The integrity of the HydroTurf® System was not compromised. Also, there was no observed damage to the system downstream of the drop location. No instability, loss of intimate contact, or erosion was observed.

Figure 14 - Broken Concrete in Bobcat Bucket

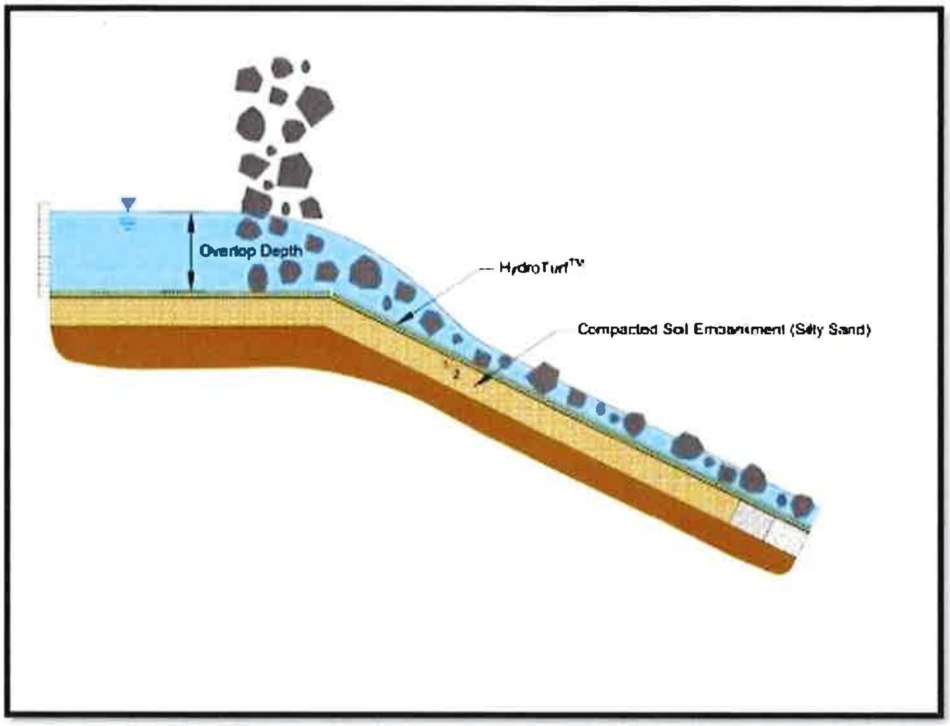


Figure 15 – Profile Section of Broken Concrete Being Dumped into the Flume

Figure 16 - Broken Concrete Being Dumped into the Flume

Intentionally Damaged State – The next test was designed to evaluate the performance of the HydroTurf® System in a damaged state. A pick axe was intentionally driven through the HydroTurf® system and approximately 6-in into the underlying sandy-loam subgrade. Figure 17 shows a photograph of this hole. Testing was performed at the 3-ft and 5-ft overtop depths for a duration of 1 hour at each overtop depth (total of 2 hours).

No instability or discernible erosion was observed. After removal of the HydroTurf® System, the subgrade was inspected. There was no erosion, and the initial hole closed. Also, the subgrade along the entire embankment showed no signs of erosion. Figure 18 shows a photograph of the intentional hole at the conclusion of testing and a photograph of the subgrade at the location of the hole after the system was removed.

Figure 17 - Intentional Damage: Hole from Pick Ax (Prior to Testing)

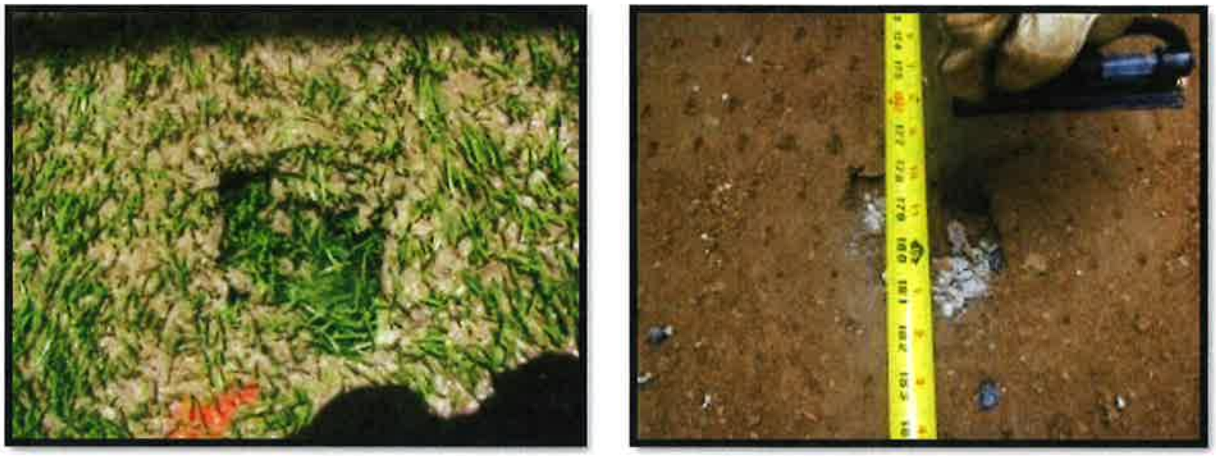


Figure 18 - Intentional Damage: Hole from Pick Ax (After Testing)

Full-scale hydraulic performance testing of the HydroTurf® Revetment Technology was completed at CSU in the steady state overtopping flume. Testing was conducted in accordance with standard procedures for ACB revetment system testing. HydroTurf® was tested in steady state flow conditions for a total of 20 hours under various events. HydroTurf® was able to withstand hydraulic loads resulting in a velocity exceeding 29.2 ft/s at a Manning's n value of 0.020. The test program has also demonstrated the ability of the system to withstand hydraulic loads caused by hydraulic jumps dissipating as much as 30 horsepower per foot of width. The qualitative tests demonstrated the ability for the HydroTurf® System to withstand impact and abrasion caused by large debris, as well as to withstand damage associated with puncture. Instability or failure of the system did not occur, and erosion of the subgrade did not happen. Therefore, the HydroTurf® Revetment System was not tested to its performance threshold. A photograph of the condition of the soil subgrade post-test is shown in Figure 19.

Figure 19 – Condition of the Soil Subgrade (After Testing and Removal of HydroTurf® System)

FULL-SCALE WAVE OVERTOPPING TESTS FOR LEVEE LANDWARD SIDE SLOPE PROTECTION

Full-scale Wave Overtopping Tests for Levee Landward Side Slope Protection were performed on HydroTurf® at CSU. Testing was performed in accordance with the methodology developed for the US Army Corps of Engineers. A schematic and a photograph of the wave overtopping simulator facility are shown in Figures 20 and 21, respectively.

Test Preparation

The testing tray set containing the HydroTurf® Revetment System was prepared at the CSU Wave Overtopping Test Facility. A 2-in thick layer of pea gravel was placed in the bottom of the trays and covered with filter geotextile that is manufactured using high tenacity polypropylene yarns, woven to form a dimensionally stable network. A highly-erodible soil (silty sand) was then placed into the trays in two (2) 5-in thick layers. Each layer was compacted to a minimum of 98% of the Standard Proctor (ASTM D698).

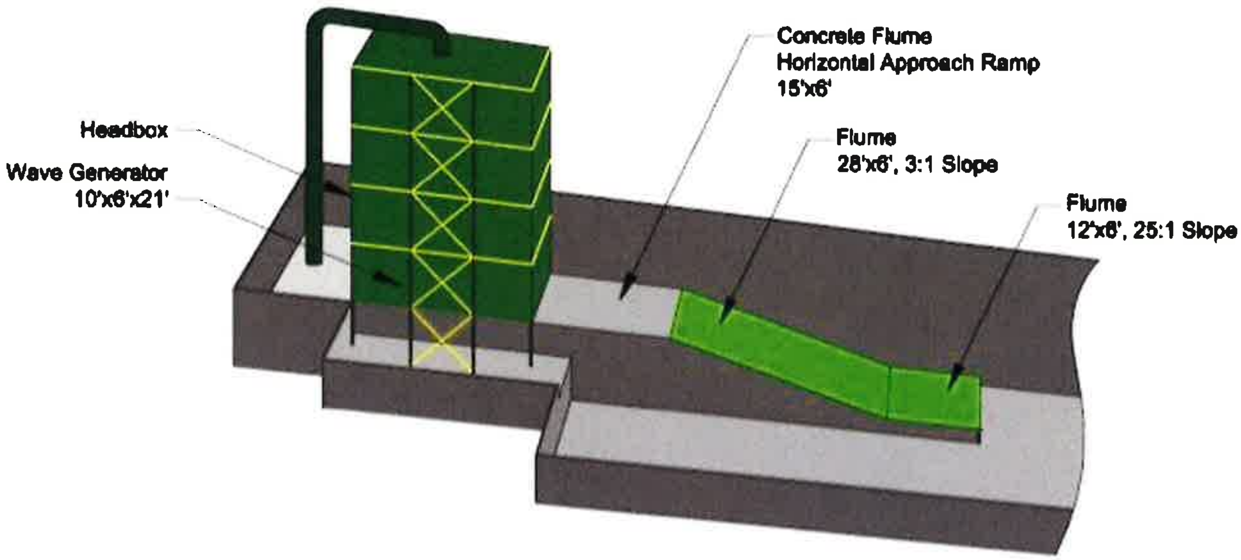


Figure 20 – Schematic of the CSU Wave Overtopping Test Facility

Figure 21 – CSU Wave Overtopping Test Facility

The HydroTurf® was installed on the soil in the trays. First, a continuous sheet of the 50-mil structured geomembrane was placed with the "spike" side down. This geomembrane serves as the underlayer of the system. Then, the engineered synthetic turf was placed on the geomembrane. One of the primary purposes of the experiment was to test the strength of the sewn seam between two adjacent pieces of the synthetic turf component. Two (2) sections of the synthetic turf were sewn together using a similar machine used for field installations. This joined piece was placed on the trays so the seam was situated along the down-slope centerline of the trays. The next step in tray preparation was applying approximately a ¾-inch thick layer of dry HydroBinder® infill into the fibers of the synthetic turf. The dry mixture was placed using a drop spreader, and then it was broomed against the grain of the turf in order to pull the fibers up through the infill. The HydroBinder® mix was then hydrated. Installation photos are shown in Figure 22.

Figure 22 – Installation of the HydroTurf® System

Testing

Testing of the HydroTurf® Revetment System was conducted in four (4) phases. The first phase tested the installed HydroTurf® up to the limits of the Wave Overtopping Simulator. At the completion of the first phase, the installed and tested HydroTurf® was intentionally damaged before continuing with further testing. The intentional damage (Phases 2 – 4) was to simulate conditions that might exist after a number of years of service without maintenance. This intentional damage consisted of the following:

- Phase 2 - Pulverization of the hardened HydroBinder® infill in order to simulate cracked mortar and portions of the surface that had been severely damaged. (See Figure 23)

Figure 23 – Intentional Damage: Pulverization of HydroBinder® Infill

- Phase 3 - A bullet hole was simulated by driving rebar through the HydroTurf® into the underlying subgrade. (See Figure 24)

Figure 24 – Intentional Damage: Simulated Bullet Hole through HydroTurf®

- Phase 4 - A larger hole was created using a pick axe to expand the simulated bullet hole. This larger hole was approximately 4-inch diameter and 7-inches deep. (See Figure 25)

Figure 25 – Intentional Damage: Large Hole through HydroTurf®

Photos of the testing are included in Figure 26.

Figure 26 – Wave Overtopping Testing of HydroTurf® at CSU

Results

The HydroTurf® Revetment System withstood the largest wave overtopping flows (4 cfs/ft) that could be applied by the CSU Wave Overtopping Simulator. These flows are the most energetic wave overtopping conditions that can be produced in any existing wave overtopping experimental facility. They represent a generic 500-year hurricane (0.2 percent annual exceedance probability) in New Orleans, LA. The testing continued for a total of 13 hours with HydroTurf® being subjected to 165,600 cf/ft of cumulative water volume.

Upon completion of the tests, the HydroTurf® was removed and the underlying soil condition was documented. The HydroTurf® Revetment System performed well in maintaining the underlying, highly-erodible soils during these severe conditions, even in an intentionally damaged state. Figure 27 is a photograph of the condition of the HydroTurf® System after the 13 hours of testing. Figure 28 is a photograph of the condition of the highly-erodible, silty sand subgrade which was underneath the HydroTurf®.

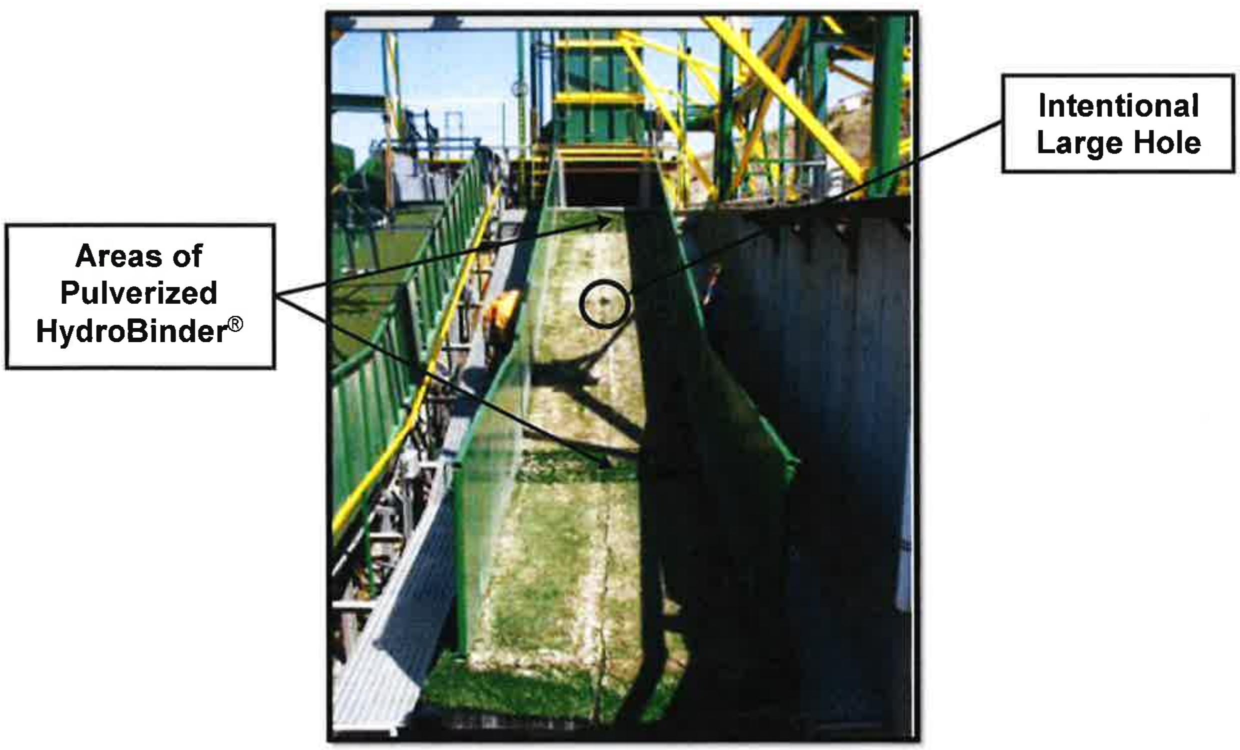


Figure 27 – Condition of HydroTurf® System after Completion of Wave Overtopping Testing

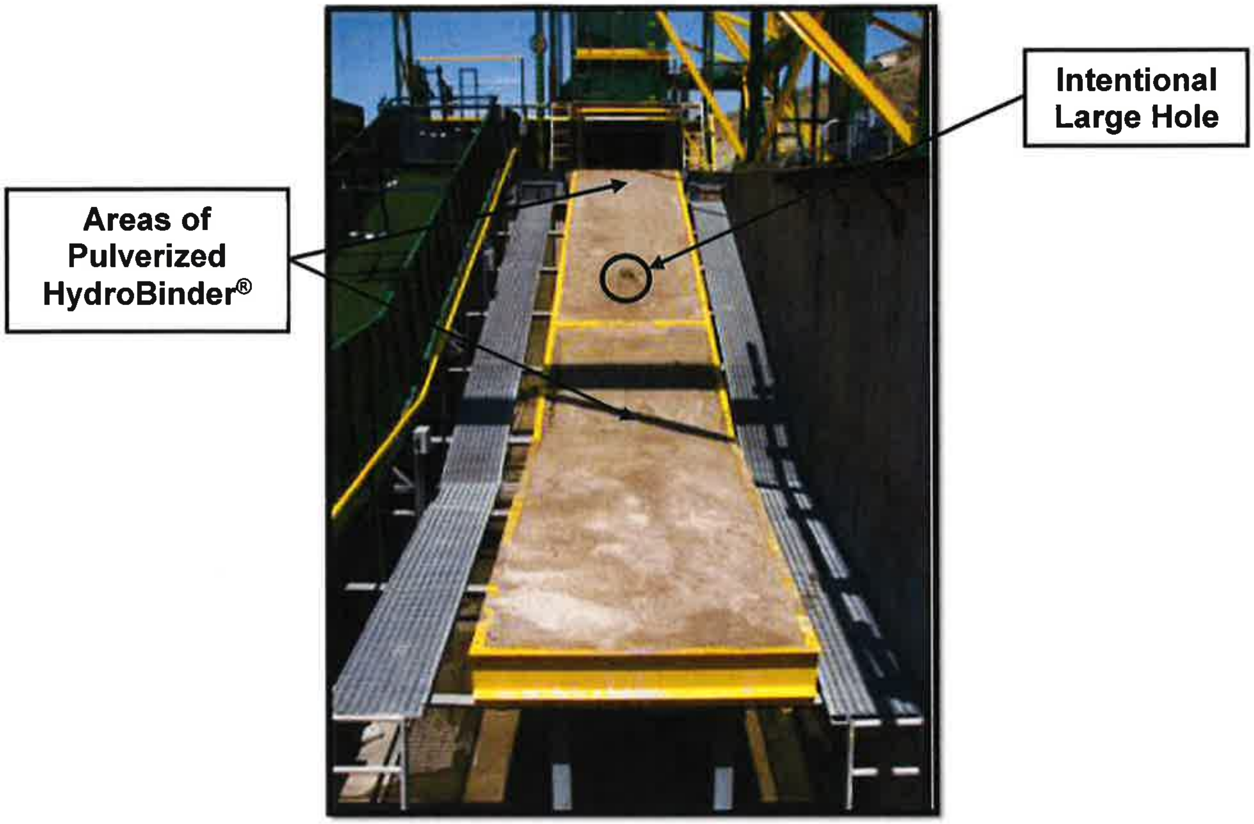


Figure 28 – Condition of Silty Sand Subgrade after Completion of Wave Overtopping Testing

Detailed results for each of the testing Phases are as follows:

- *Phase 1 – Intact HydroTurf®:* For the six (6) hours of testing with four (4) being at the maximum capacity of 4.0 cfs/ft, there was no observed erosion of the silty sand under the HydroTurf®.

- *Phase 2 – Pulverized HydroBinder® Infill:* For the additional five (5) hours of testing with three (3) being at 4.0 cfs/ft, there was no observed erosion of the silty sand under the damaged HydroTurf®.

- *Phase 3 – Pulverized HydroBinder® Infill and Simulated Bullet Hole:* For the additional one (1) hour of testing at 4.0 cfs/ft, there was no observed erosion of the silty sand under the damaged HydroTurf®. The simulated hole did not expand or cause localized erosion.

- *Phase 4 – Pulverized HydroBinder® Infill and Large Hole:* For the additional one (1) hour of testing at 4.0 cfs/ft, minimal erosion of the silty sand was observed in a localized area around and downstream of the large hole. No head-cutting was observed at the location of the hole.

- The field sewn seam adjoining the adjacent panels of engineered turf proved successful throughout the high stresses exerted during the 13 hours of testing.
- A graph of Cumulative Wave Overtopping Volume vs. Test Duration is shown in Figure 29.

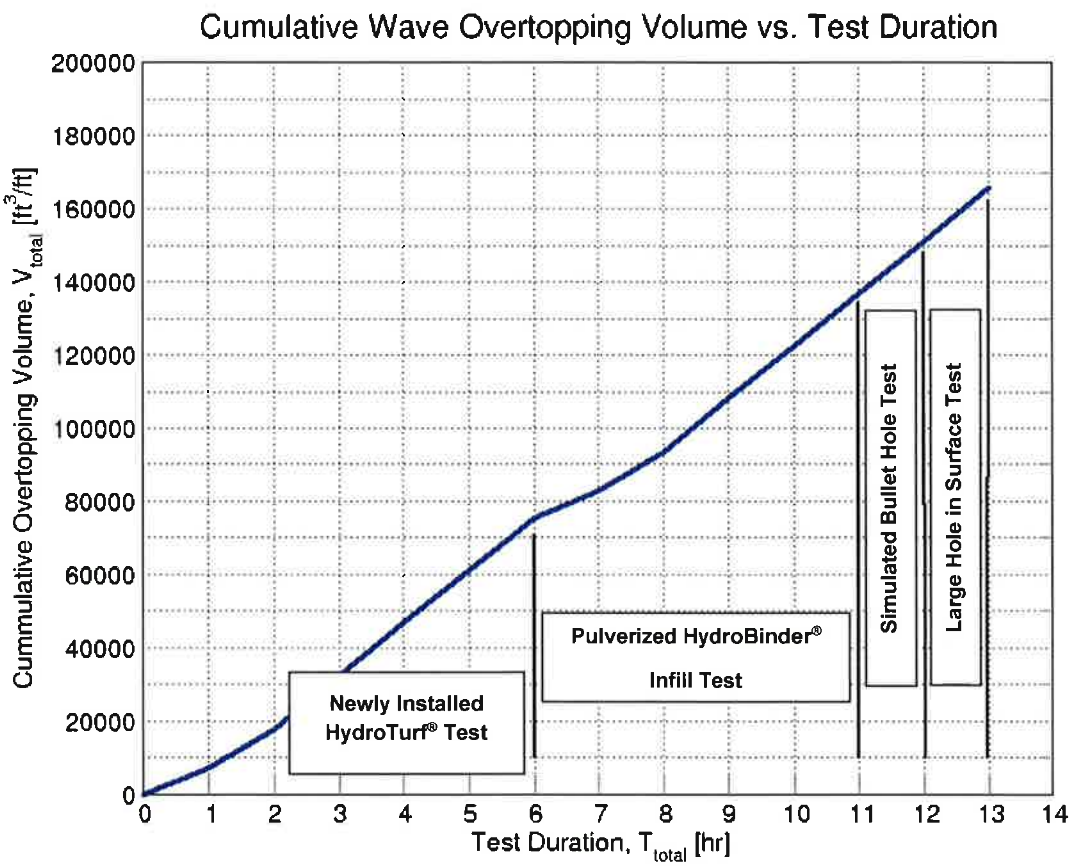


Figure 29 – Cumulative Wave Overtopping Volume vs. Test Duration for HydroTurf®

The performance of HydroTurf® in the wave overtopping simulator can be compared to the performance of other erosion control technologies. The graph in Figure 30 shows a comparison of armoring performance for levee landward-side protection for various technologies which have been tested in the CSU Wave Overtopping Simulator. HydroTurf® outperformed these other systems. Also, note that the subgrade for the other technologies was clay while the subgrade for the HydroTurf® was highly-erodible silty sand.

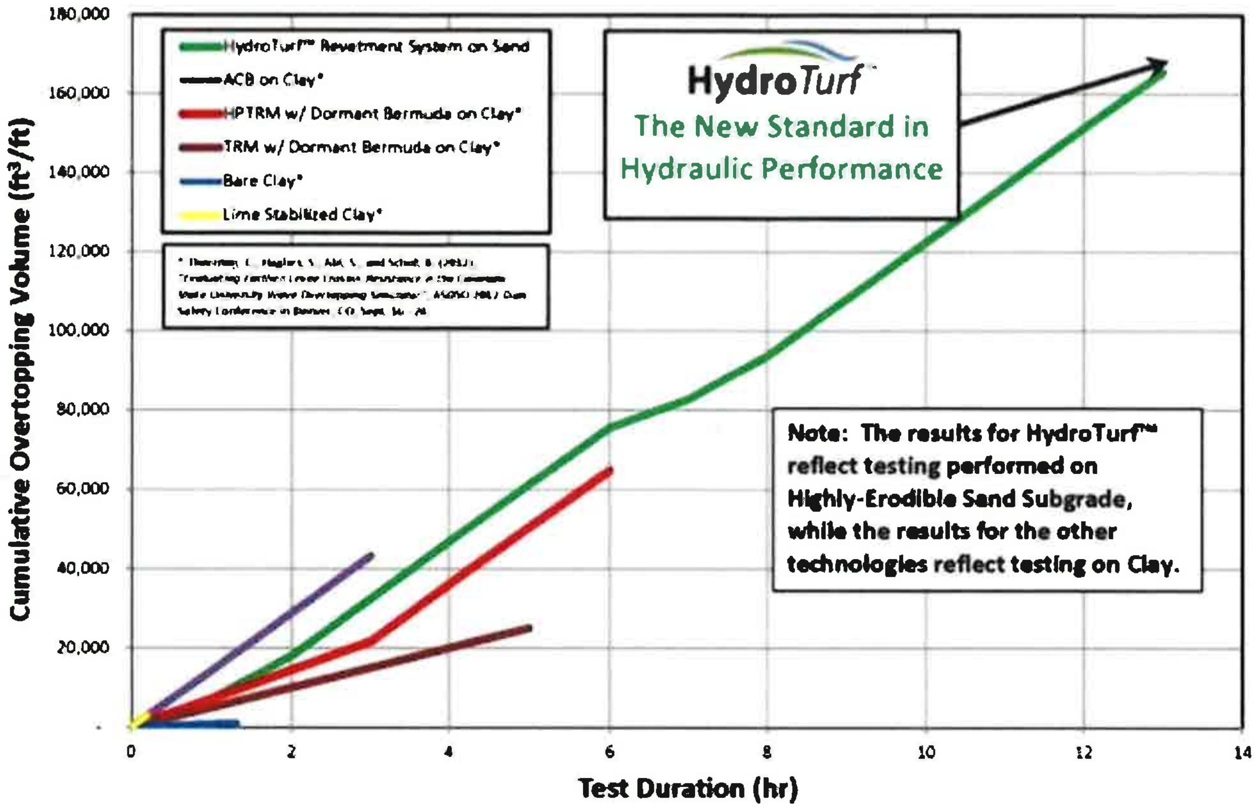


Figure 30 – Armoring Performance for Levee Landward-Side Protection from Wave Overtopping

LIMITATIONS

HydroTurf® product (US Patent Nos. 7,682,105; 8,585,322; and 9,163,375; Canadian Patent No. 2,663,170; and other Patents Pending) and registered trademark are the property of Watershed Geosynthetics LLC. All information, recommendations and suggestions appearing in this literature concerning the use of our products are based upon tests and data believed to be reliable; however, this information should not be used or relied upon for any specific application without independent professional examination and verification of its accuracy, suitability and applicability. Since the actual use by others is beyond our control, no guarantee or warranty of any kind, expressed or implied, is made by Watershed Geosynthetics LLC as to the effects of such use or the results to be obtained, nor does Watershed Geosynthetics LLC assume any liability in connection herewith. Any statement made herein may not be absolutely complete since additional information may be necessary or desirable when particular or exceptional conditions or circumstances exist or because of applicable laws or government regulations. Nothing herein is to be construed as permission or as a recommendation to infringe any patent.