June 15, 2022

Mr. Chris Jones
Hillsborough County Division Director
Field Maintenance Services
Water Resources Department
334 N. Falkenburg Road
Tampa, FL 33619

Re: Ground Stability Assessment
Symmes Road Lift Station
10837 Symmes Road, Riverview, FL 33534

Dear Mr. Jones

Further to your recent request, Integrity Drilling & Geophysical Services, LLC (IDGS) is pleased to present you with this brief report detailing the findings of our Ground Stability Assessment for the lift station structure located close to 10837 Symmes Road in Riverview, Hillsborough County, Florida.

PROJECT UNDERSTANDING

The wet well slab at the Symmes Road Lift Station has subsided by about 4 inches and requires repair. The well is around 8-feet in diameter and extends to a depth of 30-feet below surface. Options for permanent stabilization of the structure using deep polymer grouting are under consideration. The current study has been commissioned to establish ground conditions to assist in stabilization design.

FIELDWORK

IDGS carried out a non-intrusive and intrusive ground investigation around the lift station on Tuesday June 14, 2022. An Advanced Continuous Surface Wave (ACSW) seismic technique was used to determine the shear wave velocity characteristics of the in-situ soils around the structure. Two (2) Standard Penetration Test (SPT) soil borings were advanced to depths of 60-feet below surface.

Illustrative photographs of the ACSW and SPT testing procedures are presented below:

Plate 1 – SPT boring B-1 and Subsided Slab

Plate 2 – CSW05 testing on South Side of Lift Station

SPT borings B-1 and B-2 were completed to a depth of 60-feet below surface in general accordance with the procedures of ASTMD-1586. Hand auger excavation was carried out in the upper four feet as a precaution against utilities not marked by the utility locate company. Continuous sampling was performed to a depth of 10 feet, to detect variations in the soil profile at shallow depths, followed by sampling at 5-feet-on-center to the boring termination depths.

The basic procedure for the Standard Penetration Test is as follows: A standard split-barrel sampler is driven into the soil by a 140-pound hammer falling 30 inches. The number of blows required to drive the sampler 1-foot, after seating 6 inches, is designated the penetration resistance, or N-value; this value is an index to soil strength and consistency.

Soil samples were collected and transported in sealed glass jars to our laboratory for further classification and testing. The soil samples were visually classified in general accordance with ASTM D 2488. Samples will remain in our custody for 60 days after original exploration, after which, the samples will be discarded. Longer storage periods can be accommodated at your request. The boring logs are presented in Attachment B.

A total of seven (7) ACSW tests were completed, giving a layered profile of shear wave velocity to a depth of up to around 35-feet below surface. The test locations are indicated on the Site Plan in Attachment A to this report, which also indicates the locations of SPT borings B-1 and B-2.

ACSW testing carried out by IDGS is a proprietary engineering testing system developed by Ground Stiffness Surveys LLC (GSS) based on the general methodology for Continuous Surface Wave testing set out in Heymann, 2007[1]. Surface Rayleigh wave velocities over a range of frequencies are accurately measured using a short array of geophones to produce a *dispersion curve* plot of Rayleigh wave velocity (V_r) against frequency. These data can then be used to generate a reliable shear wave velocity (V_s) with depth profile, which in turn can be converted to a stiffness profile using standard relationships.

For a layered deposit with increasing stiffness with depth (a '*normally dispersive'* profile), the form of the dispersion curve should be an even polynomial curve with a single inflection point within the lower frequencies. Changes from this form can indicate, for example, where significantly stiffer or softer layers are present (an '*inversely dispersive*' profile). Very rapid oscillations or breaks in the profile can indicate the presence of sharp stiffness contrast boundaries, which cannot be addressed by the available advanced inversion analysis methods but are reported when assessing the quality of data.

Advanced inversion of the ACSW data involves the generation of a layered stiffness profile from the dispersion curve data. Published algorithms, selected depending on the extent of *multimodal* data, are used to generate a *synthetic dispersion curve* from an assumed ground profile, which is then compared with the *field dispersion curve* using standard model constraints in line with guidance given in Foti *et al*

[1] Heymann, G. (2007) Ground stiffness measurement by the continuous surface wave test. *Journal of the South African Institution of Civil Engineering*. Vol.49, No.1, p25-31.

2017[2]. An appropriate automatic iterative search methodology is then selected, which refines the model until the minimum statistical misfit between the field and synthetic dispersion curve is achieved. Checks are made in the modelling process against the *simple inversion* profile, adjacent test locations and, where available, any information on known ground profiles.

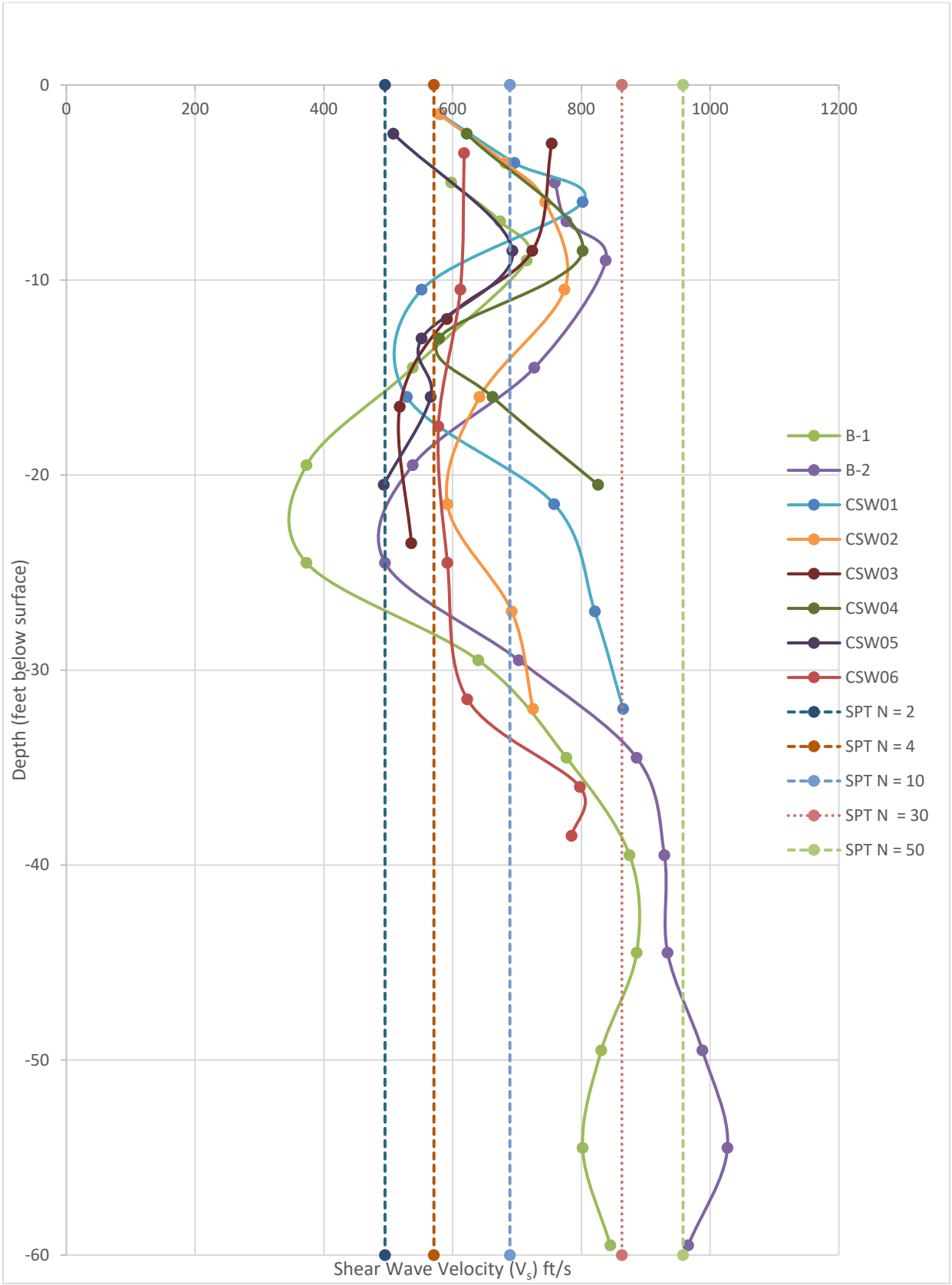
Spreadsheets summarizing the advanced inversion of the data collected at the Symmes Road Lift Station are included in Attachment B.

FINDINGS

Figure 1 below illustrates a graphical representation of V_s values measured during ACSW testing plotted against depth below surface. The graph includes vertical marker bars showing V_s derived equivalent SPT N_{60} values (using the Hasancebi & Ulusay[3] correlation) together with V_s values derived from SPT borings B-1 and B-2 using the same correlation, allowing a relative soil density against depth profile to be visualized for both techniques:

[2] Foti, S. *et al.* (2017) Guidelines for the good practice of surface wave analysis: a product of the InterPACIFIC project *Bull Earthquake Eng* DOI 10.1007/s10518-017-0206-7

[3] Hasancebi, N. and R. Ulusay, 2007. Empirical correlations between shear wave velocity and penetration resistance for ground shaking assessments. Bull. Eng. Geology and the Environment, **66**: 203 - 213.

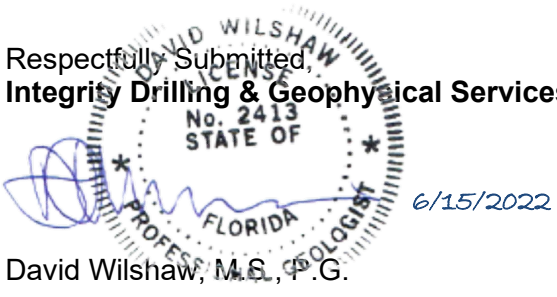

0
-10
-20
-30
-40
-50
-60
0
200
400
600
800
1000
1200
Depth (feet below surface)
Shear Wave Velocity (Vs) ft/s
B-1
B-2
CSW01
CSW02
CSW03
CSW04
CSW05
CSW06
SPT N = 2
SPT N = 4
SPT N = 10
SPT N = 30
SPT N = 50

The upper 10-feet of the soil profile consists of loose to medium dense clean sands. Below about 13.5-feet depth, the soils become looser, and boring B-1 found very loose (Weight of Rod strength) sandy soils between 18.5 and 28.5-feet depth (rod drop and loss of circulation indicative of subterranean void space). The soils in B-2 and in the ACSW tests outside of the lift station were also looser between 18.5 and 28.5-feet depth, but no void space was indicated.

Soils below the base of the wet well were medium dense to very dense fine sands with silt. There was no evidence of loosening of these deeper soils through karst activity. The void space found in boring B-1 appears to be a result of soil scour from structural leakage.

Please do not hesitate to contact us with any questions you may have, or if IDGS can be of additional service.

Respectfully Submitted,
Integrity Drilling & Geophysical Services, LLC



6/15/2022

David Wilshaw, M.S., P.G.
Principal Engineering Geologist
Florida License No. 2413

ATTACHMENT A

ACSW Test & SPT Boring Locations


Symmes Rd. Lift Station
Ground Exploration
Legend
CSW07
B-1
CSW06
CSW01
CSW02
CSW04
CSW03
CSW05
B-2
N
30 ft
Google Earth

ATTACHMENT B

SPT Boring Logs

ACSW Advanced Inversion Results

I.D.G.S.
1506 Max Hooks Road, Suite: C
Groveland, FL 34736
Telephone: 866-670-6066

BORING NUMBER B-1

CLIENT Hillsborough County
PROJECT NAME Symmes Road Lift Station
PROJECT NUMBER 7493
PROJECT LOCATION 10837 Symmes Road, Riverview, FL
DATE STARTED 6/14/22 **COMPLETED** 6/14/22
GROUND ELEVATION _____ **HOLE SIZE** 3 inches
DRILLING CONTRACTOR Integrity Drilling & Geophysical Services, LLC
GROUND WATER LEVELS:
DRILLING METHOD Rotary Wash / Standard Penetration Test
AT TIME OF DRILLING ---
LOGGED BY David Wilshaw MS, PG **CHECKED BY** _____
NOTES Groundwater not encountered in top 10-feet

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	BLOW COUNTS	▲ SPT *N* VALUE ▲ (20 40 60 80)	REMARKS
0	Concrete slab cored and patched.				
	Brown and dark brown fine SAND (SP)	AU-1			
		AU-2			
5	Loose brown fine SAND (SP)	SPT-3	4-2-3-3	5	
		SPT-4	6-4-5-7	9	
10	...medium dense	SPT-5	5-7-5-6	12	
15	Very loose brown and dark brown fine SAND (SP)	SPT-6	0-1-2	3	WH in seating drive
20					
25		SPT-7	0-0-0-0	0	WR from 18.5 to 28.5 feet. Pull spoon and drill out to 28.5-ft sample. LOC at 18.5-feet
30	Loose dark brown and brown fine SAND with silt (SP-SM).	SPT-8	2-3-4	7	
35	...medium dense	SPT-9	5-5-13	18	
40	...dense	SPT-10	16-14-18	32	Run steel casing to 42-feet depth. Intermittent LOC after casing.
45		SPT-11	14-15-19	34	
50	...medium dense	SPT-12	9-11-14	25	
55		SPT-13	10-10-11	21	
60		SPT-14	11-12-15	27	

Bottom of borehole at 60.0 feet.

LEGEND: Auger Cuttings; Standard Penetration Test

✳ Equivalent N or Q_u Value from Cone Penetrometer Test

WH= Weight of Hammer
WR= Weight of Rods

I.D.G.S.
1506 Max Hooks Road, Suite: C
Groveland, FL 34736
Telephone: 866-670-6066

BORING NUMBER B-2

CLIENT Hillsborough County
PROJECT NAME Symmes Road Lift Station
PROJECT NUMBER 7493
PROJECT LOCATION 10837 Symmes Road, Riverview, FL
DATE STARTED 6/14/22 **COMPLETED** 6/14/22
GROUND ELEVATION _____ **HOLE SIZE** 3 inches
DRILLING CONTRACTOR Integrity Drilling & Geophysical Services, LLC
GROUND WATER LEVELS:
DRILLING METHOD Rotary Wash / Standard Penetration Test
AT TIME OF DRILLING ---
LOGGED BY David Wilshaw MS, PG **CHECKED BY** _____
NOTES Groundwater not encountered in top 10-feet

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	BLOW COUNTS	▲ SPT *N* VALUE ▲ (20 40 60 80)	REMARKS
0	Dark brown fine SAND (SP)	AU-1			
		AU-2			
5	Medium dense dark brown and brown fine SAND (SP)	SPT-3	10-10-6-13	▲16	
		SPT-4	11-9-9-12	▲18	
10		SPT-5	12-12-14-13	▲26	
15	Medium dense dark brown and brown fine SAND (SP)	SPT-6	8-6-7	▲13	
20	...very loose	SPT-7	1-1-2	▲3	
25		SPT-8	1-1-1	▲2	
30	...medium dense	SPT-9	6-4-7	▲11	
35	Dense dark brown and brown fine SAND with silt (SP-SM)	SPT-10	5-16-18	▲34	
40		SPT-11	14-17-26	▲43	
45		SPT-12	17-20-24	▲44	
50	...very dense (hardpan)	SPT-13	19-26-32	▲58	
55		SPT-14	21-36-34	▲70	
60		SPT-15	22-25-27	▲52	

Bottom of borehole at 60.0 feet.

LEGEND: Auger Cuttings; Standard Penetration Test

✳ Equivalent N or Q_u Value from Cone Penetrometer Test

WH= Weight of Hammer
WR= Weight of Rods

Project:	Symmes Road Lift Station	**Report:**	
Shift:	6/14/2022	**Client:**	Hillsborough County
Test:	CSW01	**Date:**	6/14/2022

Test notes: CSW01 on NE corner of hedge S to N array. Advanced Inversion Model fit is "good".

Default values of density and Poisson's Ratio in the highlighted columns may be adjusted to known values
Strain level of softened value of Young's Modulus using the Rollins equation can be adjusted in the cell below.
See the GSS report ref for conditions of use of data

Eastings ***Northings*** ***Level (m)*** 0 Strain level softened to: 0.1 %

Vs (ft/s)	Thickness (ft)	Depth (ft)	Unit weight (lb/ft^3)	Go (tsf)	v	Eo (tsf)	E at x% strain (tsf)
581	3	0.0	112	524	0.26	1321.4	450.1
696	2	2.6	112	753	0.26	1896.7	646.0
802	6	4.3	112	998	0.26	2516.2	857.0
552	5	9.8	112	474	0.26	1193.6	406.5
529	7	14.7	112	435	0.26	1096.0	373.3
758	6	21.3	112	894	0.26	2252.4	767.2
821	4	26.8	112	1047	0.26	2638.5	898.7
865	6	31.1	112	1164	0.26	2932.1	998.7

Notes:

1 Vs values have been determined from advanced inversion of field dispersion data. Vs values derived by inversion rely on assumptions of soil density and Poisson's Ratio. Where no project specific data is provided then default values of γ=112 lb/ft^3 and ν=0.26 are assumed. *Refer to above GSS report conditions for further information.*

2 Density = $\rho = Y_t / g$ (where Y_t = unit weight in lb/ft^3)

3 Stiffness is provided in units of short tons/ft^2 or tsf where 1 short ton = 2,000lbs

4 Shear modulus = $G = \rho . v_s^2$

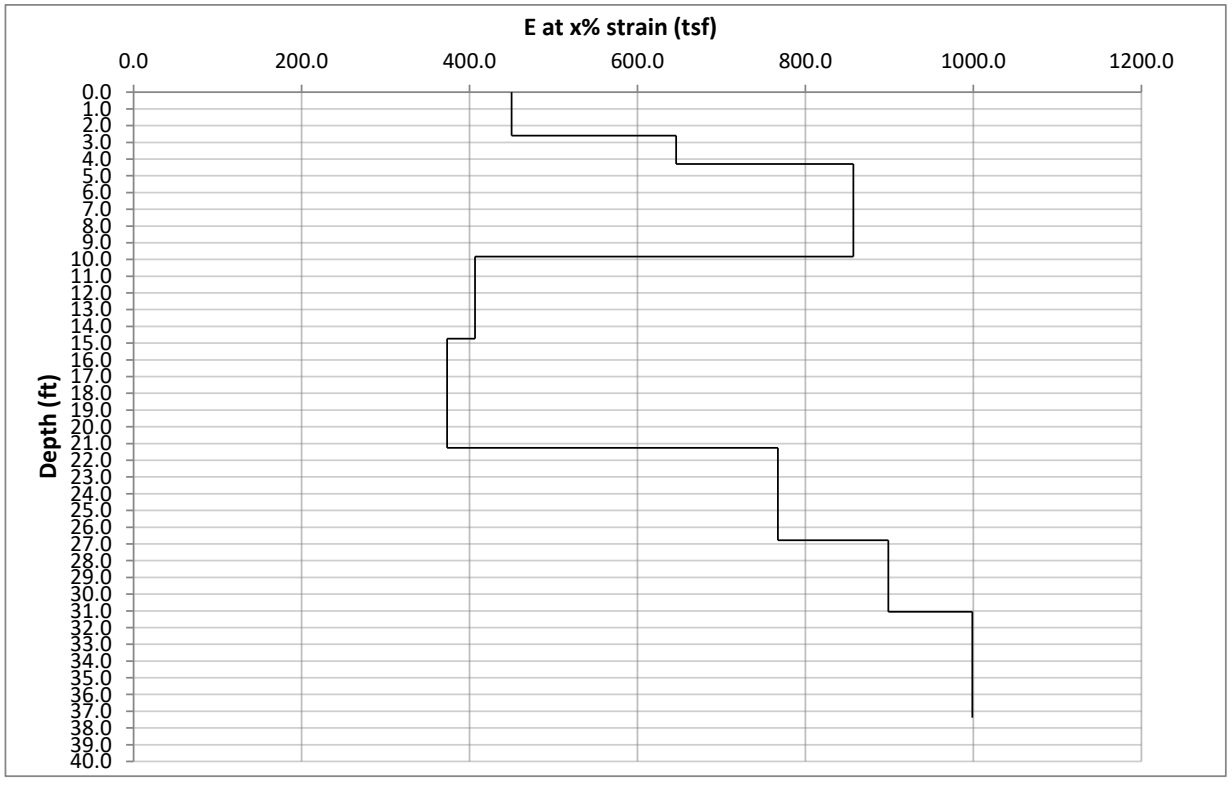
5 Youngs modulus = E=G.(2.(1+v))

6 Softened values of stiffness are calculated using Rollins equation:

$$\frac{G}{G_o} = \frac{1}{\left[1 + 16\gamma\left(1.2 + 10^{-20\gamma}\right)\right]}$$

where γ is shear strain

Rollins et al. (1998)



Project:	Symmes Road Lift Station	**Report:**	
Shift:	6/14/2022	**Client:**	Hillsborough County
Test:	CSW02	**Date:**	6/14/2022

Test notes: CSW02 on SE corner of hedge, N to S array. Advanced Inversion Model fit is "good".

Default values of density and Poisson's Ratio in the highlighted columns may be adjusted to known values
Strain level of softened value of Young's Modulus using the Rollins equation can be adjusted in the cell below.
See the GSS report ref for conditions of use of data

Eastings ***Northings*** ***Level (m)*** 0 Strain level softened to: 0.1 %

Vs (ft/s)	Thickness (ft)	Depth (ft)	Unit weight (lb/ft^3)	Go (tsf)	v	Eo (tsf)	E at x% strain (tsf)
579	3	0.0	112	522	0.26	1314.4	447.7
682	2	3.5	112	722	0.26	1819.1	619.6
744	2	5.2	112	861	0.26	2170.3	739.2
774	7	7.1	112	930	0.26	2344.0	798.4
642	4	13.7	112	641	0.26	1615.7	550.3
592	7	17.5	112	544	0.26	1370.5	466.8
692	4	24.0	112	745	0.26	1878.0	639.6
725	6	27.6	112	816	0.26	2057.5	700.8

Notes:

1 Vs values have been determined from advanced inversion of field dispersion data. Vs values derived by inversion rely on assumptions of soil density and Poisson's Ratio. Where no project specific data is provided then default values of γ=112 lb/ft^3 and v=0.26 are assumed. *Refer to above GSS report conditions for further information.*

2 Density = $\rho = Y_t / g$ (where Y_t = unit weight in lb/ft^3)

3 Stiffness is provided in units of short tons/ft^2 or tsf where 1 short ton = 2,000lbs

4 Shear modulus = $G = \rho . v_s^2$

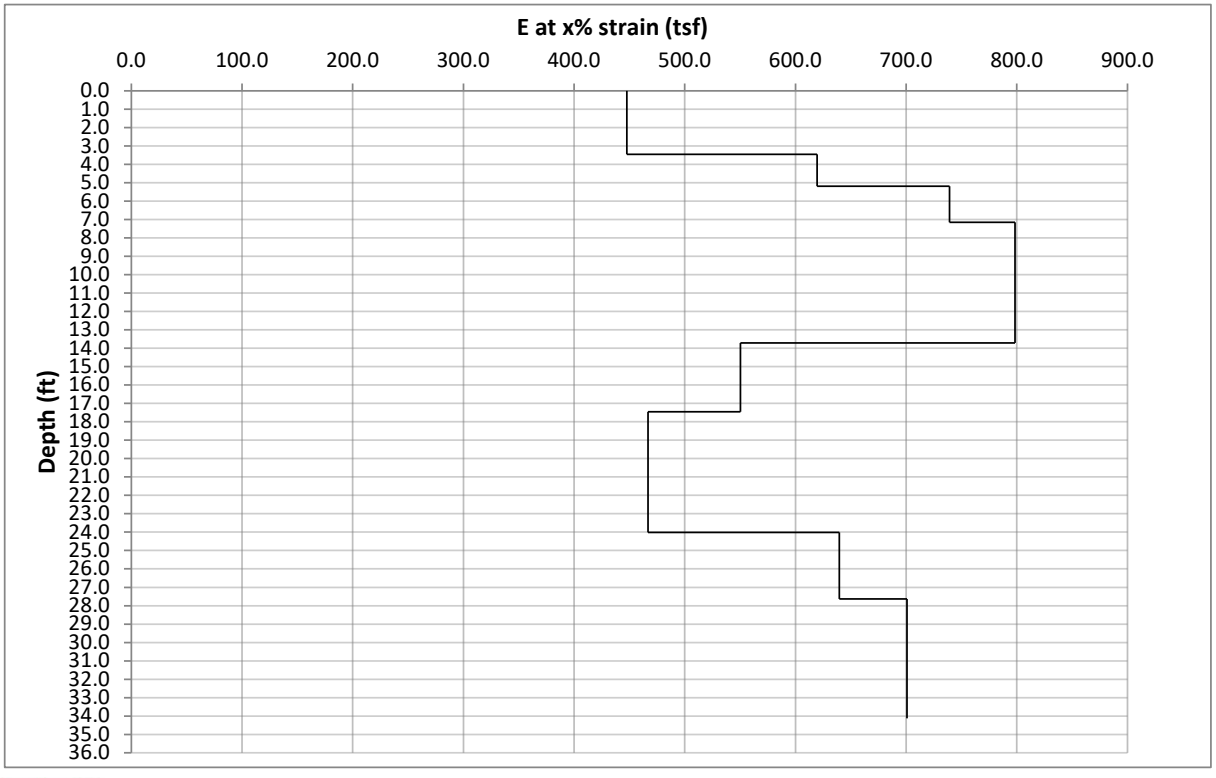
5 Youngs modulus = E=G.(2.(1+v))

6 Softened values of stiffness are calculated using Rollins equation:

$$\frac{G}{G_o} = \frac{1}{\left[1 + 16\gamma\left(1.2 + 10^{-20\gamma}\right)\right]}$$

where γ is shear strain

Rollins et al. (1998)



Project:	Symmes Road Lift Station	**Report:**	
Shift:	6/14/2022	**Client:**	Hillsborough County
Test:	CSW03	**Date:**	6/14/2022

Test notes: CSW03 at SE corner of station W to E array. Advanced Inversion Model fit is "fair".

Default values of density and Poisson's Ratio in the highlighted columns may be adjusted to known values
Strain level of softened value of Young's Modulus using the Rollins equation can be adjusted in the cell below.
See the GSS report ref for conditions of use of data

Eastings ***Northings*** ***Level (m)*** 0 Strain level softened to: 0.1 %

Vs (ft/s)	Thickness (ft)	Depth (ft)	Unit weight (lb/ft^3)	Go (tsf)	v	Eo (tsf)	E at x% strain (tsf)
754	6	0.0	112	882	0.26	2223.7	757.4
724	5	5.9	112	815	0.26	2053.7	699.5
591	2	11.2	112	542	0.26	1365.7	465.2
518	7	13.1	112	417	0.26	1050.4	357.8
536	7	19.7	112	447	0.26	1125.2	383.2

Notes:

1 Vs values have been determined from advanced inversion of field dispersion data. Vs values derived by inversion rely on assumptions of soil density and Poisson's Ratio. Where no project specific data is provided then default values of Υ=112 lb/ft^3 and ν=0.26 are assumed. *Refer to above GSS report conditions for further information.*

2 Density = $\rho = Y_t / g$ (where Y_t = unit weight in lb/ft^3)

3 Stiffness is provided in units of short tons/ft^2 or tsf where 1 short ton = 2,000lbs

4 Shear modulus = $G = \rho . v_s^2$

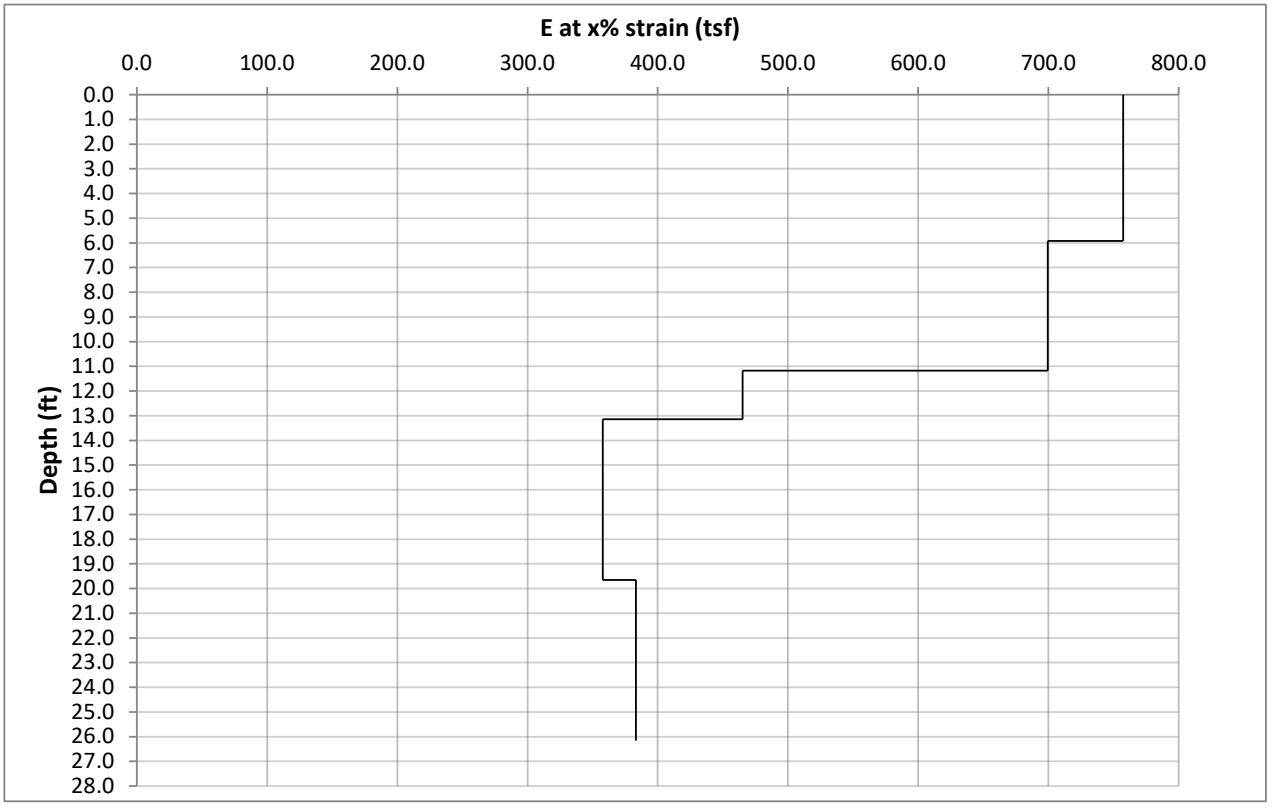
5 Youngs modulus = $E = G.(2.(1+\nu))$

6 Softened values of stiffness are calculated using Rollins equation:

$$\frac{G}{G_o} = \frac{1}{\left[1 + 16\gamma\left(1.2 + 10^{-20\gamma}\right)\right]}$$

where Υ is shear strain

Rollins et al. (1998)



Project:	Symmes Road Lift Station	**Report:**	
Shift:	6/14/2022	**Client:**	Hillsborough County
Test:	CSW04	**Date:**	6/14/2022

Test notes: CSW04 midway along south side of station, E to W array. Advanced Inversion Model fit is "fair".

Default values of density and Poisson's Ratio in the highlighted columns may be adjusted to known values
Strain level of softened value of Young's Modulus using the Rollins equation can be adjusted in the cell below.
See the GSS report ref for conditions of use of data

Eastings ***Northings*** ***Level (m)*** 0 Strain level softened to: 0.1 %

Vs (ft/s)	Thickness (ft)	Depth (ft)	Unit weight (lb/ft^3)	Go (tsf)	v	Eo (tsf)	E at x% strain (tsf)
622	6	0.0	112	602	0.26	1517.5	516.9
802	5	5.7	112	1000	0.26	2518.8	857.9
579	2	11.2	112	522	0.26	1315.0	447.9
662	5	13.1	112	680	0.26	1714.6	584.0
826	4	17.7	112	1059	0.26	2669.8	909.3

Notes:

1 Vs values have been determined from advanced inversion of field dispersion data. Vs values derived by inversion rely on assumptions of soil density and Poisson's Ratio. Where no project specific data is provided then default values of Υ=112 lb/ft^3 and ν=0.26 are assumed. *Refer to above GSS report conditions for further information.*

2 Density = $\rho = Y_t / g$ (where Y_t = unit weight in lb/ft^3)

3 Stiffness is provided in units of short tons/ft^2 or tsf where 1 short ton = 2,000lbs

4 Shear modulus = $G = \rho . v_s^2$

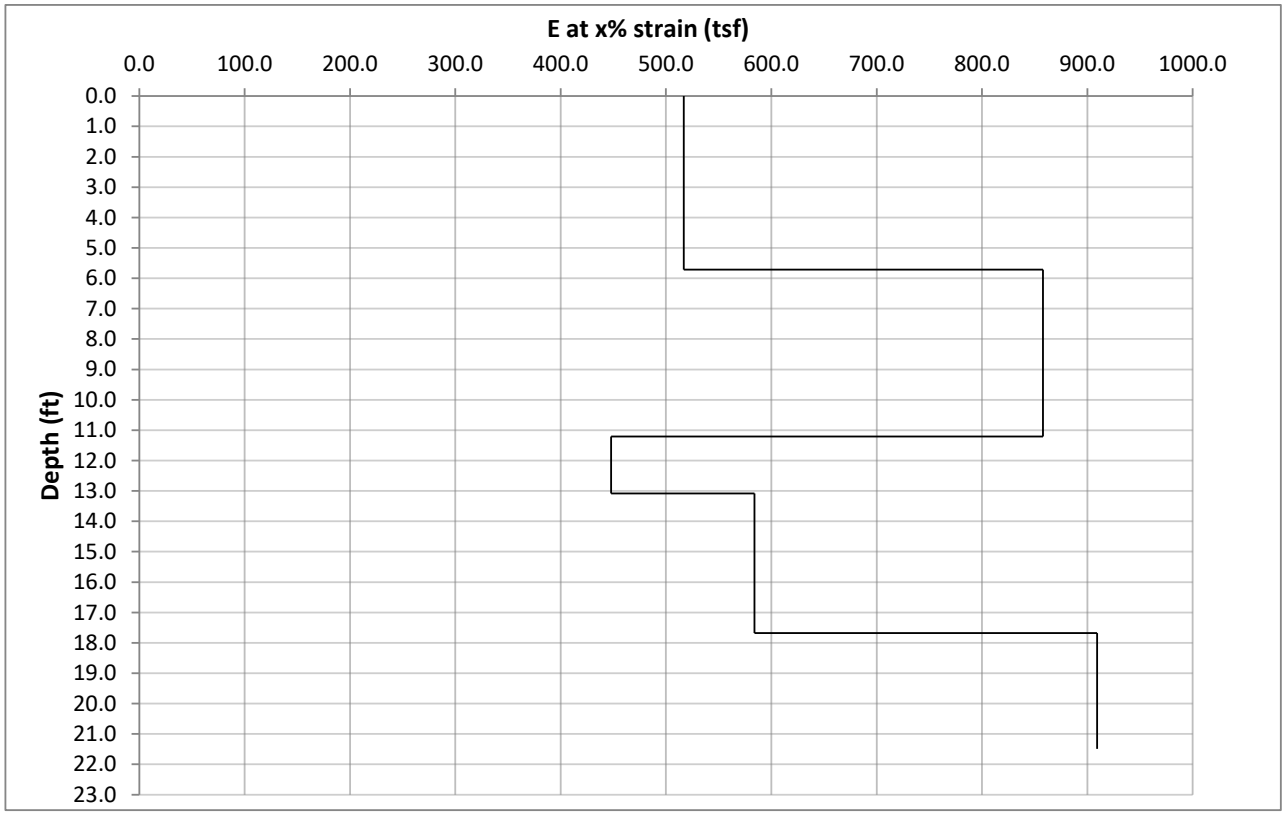
5 Youngs modulus = E=G.(2.(1+v))

6 Softened values of stiffness are calculated using Rollins equation:

$$\frac{G}{G_o} = \frac{1}{\left[1 + 16\gamma\left(1.2 + 10^{-20\gamma}\right)\right]}$$

where Υ is shear strain

Rollins et al. (1998)



Project:	Symmes Road Lift Station	**Report:**	
Shift:	6/14/2022	**Client:**	Hillsborough County
Test:	CSW05	**Date:**	6/14/2022

Test notes: CSW05 on SW corner of Station with E to W array. Advanced Inversion Model fit is "fair".

Default values of density and Poisson's Ratio in the highlighted columns may be adjusted to known values
Strain level of softened value of Young's Modulus using the Rollins equation can be adjusted in the cell below.
See the GSS report ref for conditions of use of data

Eastings ***Northings*** ***Level (m)*** 0 Strain level softened to: 0.1 %

Vs (ft/s)	Thickness (ft)	Depth (ft)	Unit weight (lb/ft^3)	Go (tsf)	v	Eo (tsf)	E at x% strain (tsf)
508	5	0.0	112	402	0.26	1012.5	344.8
693	7	4.9	112	746	0.26	1880.0	640.3
552	2	11.4	112	474	0.26	1194.1	406.7
566	4	13.1	112	497	0.26	1252.7	426.7
493	5	16.9	112	377	0.26	950.2	323.6

Notes:

1 Vs values have been determined from advanced inversion of field dispersion data. Vs values derived by inversion rely on assumptions of soil density and Poisson's Ratio. Where no project specific data is provided then default values of γ=112 lb/ft^3 and ν=0.26 are assumed. *Refer to above GSS report conditions for further information.*

2 Density = $\rho = Y_t / g$ (where Y_t = unit weight in lb/ft^3)

3 Stiffness is provided in units of short tons/ft^2 or tsf where 1 short ton = 2,000lbs

4 Shear modulus = $G = \rho . v_s^2$

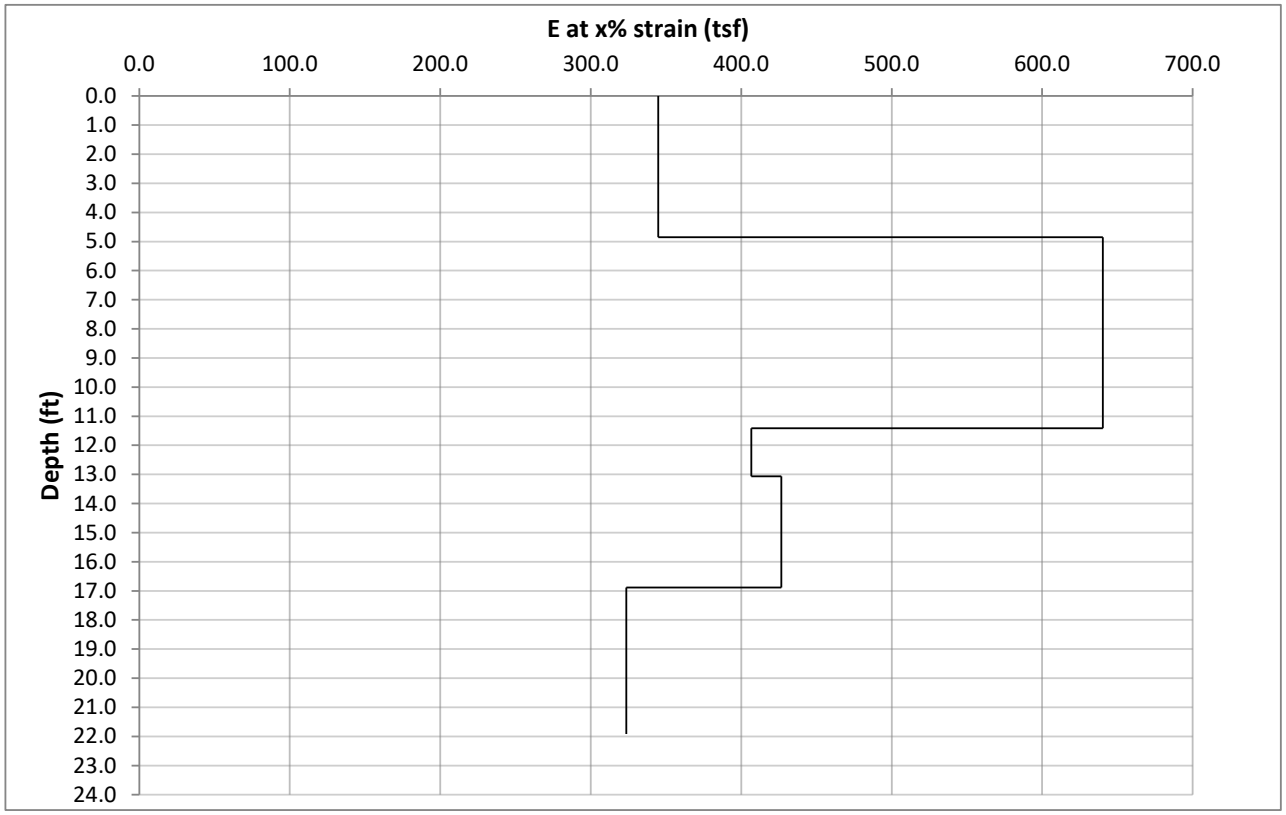
5 Youngs modulus = E=G.(2.(1+v))

6 Softened values of stiffness are calculated using Rollins equation:

$$\frac{G}{G_o} = \frac{1}{\left[1 + 16\gamma\left(1.2 + 10^{-20\gamma}\right)\right]}$$

where γ is shear strain

Rollins et al. (1998)



Project:	Symmes Road Lift Station	**Report:**	
Shift:	6/14/2022	**Client:**	Hillsborough County
Test:	CSW06	**Date:**	6/14/2022

Test notes: CSW06 inside lift station along eastern edge with N to S geophone array. Numerous concrete slabs and close to 8-ft well. Advanced Inversion Model fit is "fair".

Default values of density and Poisson's Ratio in the highlighted columns may be adjusted to known values
Strain level of softened value of Young's Modulus using the Rollins equation can be adjusted in the cell below.
See the GSS report ref for conditions of use of data

Eastings						
Northings			***Level (m)***	0	Strain level softened to:	0.1 %

Vs (ft/s)	Thickness (ft)	Depth (ft)	Unit weight (lb/ft^3)	Go (tsf)	v	Eo (tsf)	E at x% strain (tsf)
618	7	0.0	112	593	0.26	1494.7	509.1
612	7	6.9	112	581	0.26	1464.7	498.9
578	7	13.4	112	519	0.26	1308.1	445.5
592	7	19.9	112	545	0.26	1372.3	467.4
623	7	26.5	112	604	0.26	1521.6	518.3
798	2	33.0	112	991	0.26	2496.7	850.4
785	3	34.8	112	958	0.26	2413.9	822.2

Notes:

1 Vs values have been determined from advanced inversion of field dispersion data. Vs values derived by inversion rely on assumptions of soil density and Poisson's Ratio. Where no project specific data is provided then default values of γ=112 lb/ft^3 and ν=0.26 are assumed. *Refer to above GSS report conditions for further information.*

2 Density = $\rho = Y_t / g$ (where Y_t = unit weight in lb/ft^3)

3 Stiffness is provided in units of short tons/ft^2 or tsf where 1 short ton = 2,000lbs

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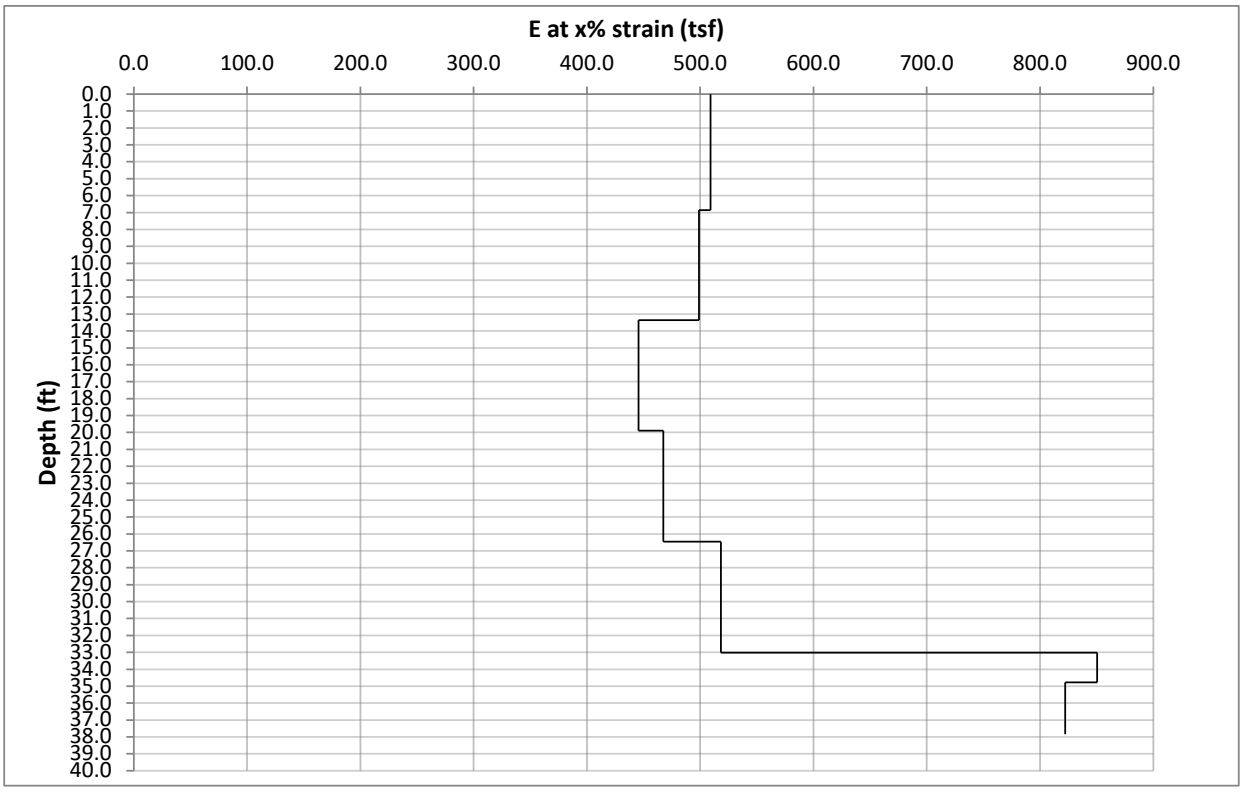
where γ is shear strain

Rollins et al. (1998)



Project:	Symmes Road Lift Station	**Report:**	
Shift:	6/14/2022	**Client:**	Hillsborough County
Test:	CSW07	**Date:**	6/14/2022

Test notes: CSW07 across boring B-1 in NE to SW direction. Poor model fit (10-ft WR in SPT).

Default values of density and Poisson's Ratio in the highlighted columns may be adjusted to known values
Strain level of softened value of Young's Modulus using the Rollins equation can be adjusted in the cell below.
See the GSS report ref for conditions of use of data

Eastings ***Northings*** ***Level (m)*** 0 Strain level softened to: 0.1 %

Vs (ft/s)	Thickness (ft)	Depth (ft)	Unit weight (lb/ft^3)	Go (tsf)	v	Eo (tsf)	E at x% strain (tsf)
859	6	0.0	112	1146	0.26	2888.9	983.9
269	4	5.5	112	112	0.26	283.2	96.4

Notes:

1 Vs values have been determined from advanced inversion of field dispersion data. Vs values derived by inversion rely on assumptions of soil density and Poisson's Ratio. Where no project specific data is provided then default values of γ=112 lb/ft^3 and ν=0.26 are assumed. *Refer to above GSS report conditions for further information.*

2 Density = $\rho = Y_t / g$ (where Y_t = unit weight in lb/ft^3)

3 Stiffness is provided in units of short tons/ft^2 or tsf where 1 short ton = 2,000lbs

4 Shear modulus = $G = \rho . v_s^2$

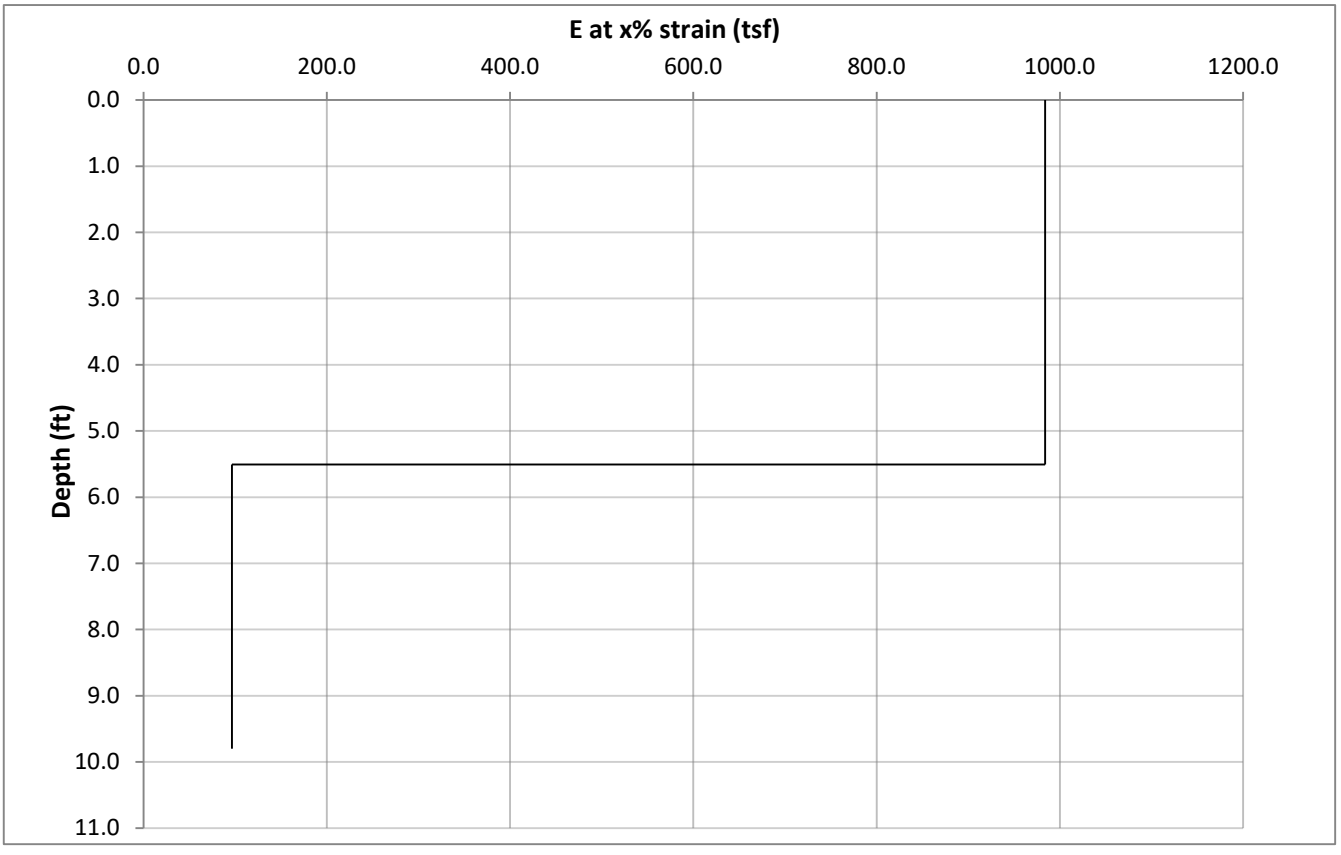
5 Youngs modulus = E=G.(2.(1+v))

6 Softened values of stiffness are calculated using Rollins equation:

$$\frac{G}{G_o} = \frac{1}{\left[1 + 16\gamma\left(1.2 + 10^{-20\gamma}\right)\right]}$$

where γ is shear strain

Rollins et al. (1998)



ATTACHMENT C

GBA Guidelines

Standard Terms and Conditions

INTEGRITY DRILLING & GEOPHYSICAL SERVICES, LLC - STANDARD TERMS AND CONDITIONS

1) ENTIRE AGREEMENT. Upon authorization by the CLIENT and commencement of performance hereunder, these terms and Integrity Drilling & Geophysical Services, LLC's (IDGSL's) Proposal constitute the entire agreement between the parties concerning its subject matter. Any changes or additional conditions proposed by CLIENT are hereby rejected, unless expressly stated in this Agreement or incorporated by a change order.

2) CHANGES. Upon receipt of notice from CLIENT of a change in the scope of the work hereunder, IDGSL will promptly notify the CLIENT if there is an impact on the schedule, price or terms of the Agreement. Thereafter, an estimate of any impact on the Agreement will be prepared and submitted to the CLIENT. The parties agree to promptly negotiate and implement changes to the Agreement. CLIENT acknowledges and agrees that its use of any purchase order or other form to procure services is solely for administrative purposes and in no event shall IDGSL be bound to any terms and conditions on such form regardless of reference to or signature. CLIENT shall endeavor to reference this Agreement on any purchase order (or any other form), but CLIENT's failure to do so shall not operate to modify this Agreement.

3) SITE INFORMATION AND ACCESS. The CLIENT shall make available to IDGSL all relevant information and documents under his control regarding past, present and proposed conditions of the site. The information shall include, but not be limited to, plot plans, topographic surveys, hydrologic data and previous soil and geologic data including borings, field or laboratory tests and written reports. The CLIENT shall immediately transmit to IDGSL any new information that becomes available or any change in plans. The CLIENT shall also ensure uninterrupted site access for IDGSL throughout performance of this Agreement.

4) PERMITS AND UTILITIES. Unless otherwise stated in the Proposal, the CLIENT shall apply for and obtain all required permits and licenses and shall make all necessary arrangements for right of entry to provide IDGSL access to the site for all equipment and personnel at no charge to IDGSL. The CLIENT shall also provide IDGSL with the location of all underground utilities and structures in the exploration area. IDGSL is not responsible for location or identification of utilities.

5) PAYMENT AND SUSPENSION. Unless otherwise stated in the Proposal, invoices will be submitted by IDGSL either at the completion of the work or on a monthly basis and will be due and payable on the invoice date. Invoices not paid within thirty (30) days of the invoice date shall be subject to a late fee of one and one-half percent (1.5%) per month computed at 31 days from the date of invoice. In addition, any collection fees, legal fees, court costs, and other related expenses incurred by IDGSL in the collection of delinquent invoice amounts shall be paid by CLIENT. **IN THE EVENT CLIENT DISPUTES ALL OR PART OF AN INVOICE, CLIENT MUST ADVISE IDGSL IN WRITING WITHIN FIFTEEN (15) DAYS FROM INVOICE DATE**. **UNDISPUTED PORTIONS ARE SUBJECT TO PAYMENT WITHIN THIRTY (30) DAYS.** IDGSL may suspend performance of services under this Agreement if: 1) CLIENT fails to make payment in accordance with the terms hereof, 2) CLIENT becomes insolvent, enters bankruptcy, receivership, or other like proceeding (voluntary or involuntary) or makes an assignment for the benefit of creditors, or 3) IDGSL reasonably believes that CLIENT will be unable to pay IDGSL in accordance with the terms hereof and notifies CLIENT in writing prior to such suspension of services. If any such suspension causes an increase in the time required for IDGSL's performance, the performance schedule and/or period for performance shall be extended for a period of time equal to the suspension period.

6) OWNERSHIP RIGHTS. Any documents produced by IDGSL shall be the sole property of IDGSL. At the request and expense of the CLIENT, IDGSL shall provide the CLIENT with copies of any or all drawings, specifications and other documents prepared by IDGSL.

7) STANDARD OF CARE. In the performance of professional services, IDGSL will use that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession practicing in the same or similar localities. No warranty, either express or implied, is made or intended by this Agreement or by furnishing oral or written reports of the findings. IDGSL is to be liable only for damage proximately caused by the negligence of IDGSL. The CLIENT recognizes that subsurface conditions may vary from those encountered at the location where borings, surveys or explorations are made by IDGSL and that the data, interpretations and recommendation of IDGSL are based solely on the information available to him. IDGSL will not be responsible for the interpretation by others of the information developed.

8) INSURANCE. IDGSL will maintain insurance for this Agreement in the following types: 1) Comprehensive General Liability (CGL) insurance; 2) Professional Liability Coverage; and 3) Contractors Pollution Liability.

9) ENVIRONMENTAL LIABILITY. Because CLIENT owns and/or operates the site where work is being performed, CLIENT has and shall retain all responsibility and liability associated with the environmental conditions at the site. Unless specifically identified in IDGSL's Proposal, CLIENT'S responsibility and liability includes the handling and disposal of any samples or hazardous materials generated on the site as a result of IDGSL's performance hereunder.

10) CONSEQUENTIAL DAMAGES. IDGSL shall NOT be responsible for any consequential, incidental or indirect damages.

11) LIMITATION OF LIABILITY. ***Notwithstanding any other provision of this Agreement, the total liability of IDGSL, its officers, directors and employees for liabilities, claims, judgments, demands and causes of action arising under or related to this Agreement, whether based in contract or tort, shall be limited to the total compensation actually paid to IDGSL for the services hereunder or $50,000, whichever is less. All claims by CLIENT shall be deemed relinquished unless filed within one (1) year after substantial completion of the services hereunder.***

12) DISPUTES. Any dispute arising hereunder shall first be resolved by taking the following steps, where a successive step is taken if the issue is not resolved at the preceding step: 1) by the technical and contractual personnel for each party performing this Agreement, 2) by executive management of each party, 3) by mediation or 4) through the court system of the jurisdiction of the IDGSL office that entered into this Agreement. CLIENT hereby waives the right to trial by jury for any disputes arising out of this Agreement. Except as otherwise provided herein, each party shall be responsible for its own legal costs and attorneys' fees.

13) AUTHORIZATION TO SIGN. The person signing this Agreement warrants that he has authority to sign as, or on behalf of, the CLIENT for whom or for whose benefit IDGSL's services are rendered. If such a person does not have such authority, he agrees that he is personally liable for all breaches of this Agreement, and that in any such action against him for breach of such warranty, reasonable attorneys'

fees and legal costs shall be included in a judgment rendered.

14) ASSIGNMENT. Neither party may delegate, assign, sublet or transfer his duties or interest in this Agreement without the written consent of the other party.

15) CHOICE OF LAWS. This Agreement shall be governed by the laws of the state of Florida.

16) FORCE MAJEURE. Should performance of services by IDGSL be affected by causes beyond its reasonable control, including but not limited to: acts of God; acts of a legislative, administrative or judicial entity; acts of contractors other than contractors engaged by IDGSL; fires; floods; labor disturbances; unusually severe weather and/or an epidemic; then CLIENT will grant IDGSL a time extension and the parties will negotiate an equitable adjustment to the price of any affected services, where appropriate.

17) FIELD REPRESENTATION. Unless otherwise expressly agreed in writing, IDGSL shall not be responsible for the safety or direction of the means and methods at the CLIENT's site of contractors or their employees or agents that are not hired by IDGSL, and the presence of IDGSL at the CLIENT's site will not relieve the contractor of its responsibilities for performing the work in accordance with applicable regulations, or in accordance with project plans and specifications. If necessary, CLIENT will advise any contractors that IDGSL's services are so limited. IDGSL will not assume the role of "prime contractor", "principal contractor", "constructor", "controlling employer", or their equivalents unless the scope of such services are expressly agreed in writing.

18) TERMINATION. This Agreement may be terminated by either party upon ten (10) days written notice to the other. In the event of a termination, Client shall pay for all reasonable charges for work performed and demobilization by IDGSL to date of notice of termination. The limitation of liability and indemnity obligations of this Agreement shall be binding notwithstanding any termination of this Agreement.

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, you can benefit from a lowered exposure to problems associated with subsurface conditions at project sites and development of them that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed herein, contact your GBA-member geotechnical engineer. Active engagement in GBA exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Understand the Geotechnical-Engineering Services Provided for this Report

Geotechnical-engineering services typically include the planning, collection, interpretation, and analysis of exploratory data from widely spaced borings and/or test pits. Field data are combined with results from laboratory tests of soil and rock samples obtained from field exploration (if applicable), observations made during site reconnaissance, and historical information to form one or more models of the expected subsurface conditions beneath the site. Local geology and alterations of the site surface and subsurface by previous and proposed construction are also important considerations. Geotechnical engineers apply their engineering training, experience, and judgment to adapt the requirements of the prospective project to the subsurface model(s). Estimates are made of the subsurface conditions that will likely be exposed during construction as well as the expected performance of foundations and other structures being planned and/or affected by construction activities.

The culmination of these geotechnical-engineering services is typically a geotechnical-engineering report providing the data obtained, a discussion of the subsurface model(s), the engineering and geologic engineering assessments and analyses made, and the recommendations developed to satisfy the given requirements of the project. These reports may be titled investigations, explorations, studies, assessments, or evaluations. Regardless of the title used, the geotechnical-engineering report is an engineering interpretation of the subsurface conditions within the context of the project and does not represent a close examination, systematic inquiry, or thorough investigation of all site and subsurface conditions.

Geotechnical-Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client.

Likewise, geotechnical-engineering services are performed for a specific project and purpose. For example, it is unlikely that a geotechnical-engineering study for a refrigerated warehouse will be the same as one prepared for a parking garage; and a few borings drilled during a preliminary study to evaluate site feasibility will not be adequate to develop geotechnical design recommendations for the project.

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project or purpose;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, the reliability of a geotechnical-engineering report can be affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying the recommendations in it. A minor amount of additional testing or analysis after the passage of time – if any is required at all – could prevent major problems.

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read the report in its entirety. Do not rely on an executive summary. Do not read selective elements only. *Read and refer to the report in full.*

You Need to Inform Your Geotechnical Engineer About Change

Your geotechnical engineer considered unique, project-specific factors when developing the scope of study behind this report and developing the confirmation-dependent recommendations the report conveys. Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the elevation, configuration, location, orientation, function or weight of the proposed structure and the desired performance criteria;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept*

responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface using various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing is performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgement to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team through project completion to obtain informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are not final, because the geotechnical engineer who developed them relied heavily on judgement and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* exposed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a continuing member of the design team, to:

- confer with other design-team members;
- help develop specifications;
- review pertinent elements of other design professionals' plans and specifications; and
- be available whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction-phase observations.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for information purposes only.* To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. This happens in part because soil and rock on project sites are typically heterogeneous and not manufactured materials with well-defined engineering properties like steel and concrete. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually provide environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures.* If you have not obtained your own environmental information about the project site, ask your geotechnical consultant for a recommendation on how to find environmental risk-management guidance.

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, the engineer's services were not designed, conducted, or intended to prevent migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration. Confront the risk of moisture infiltration*** by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

GEOPROFESSIONAL BUSINESS ASSOCIATION

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