Structural Geotechnical Report
Retaining Wall Project

Chicago to St. Louis High Speed Rail
Hoff Road, Mile Post 46.64
Elwood, Illinois
Will County

IDOT PTB 890-172
DOT# 290492F

Project Design Engineer
AECOM
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1.0 INTRODUCTION

GSG Consultants, Inc. (GSG) completed a geotechnical investigation for the design retaining walls at north and south of Illinois 53 and Hoff Road intersection, in Elwood, Illinois. The proposed improvement is part of the Chicago to St. Louis High Speed Rail project. The purpose of the investigation was to explore and characterize the subsurface soil and groundwater conditions to determine engineering properties of the subsurface soil, and develop design and construction recommendations for the retaining wall project. Figure 1 shows the project location map.

Figure 1: Project Location Map, From USGS Topography Quadrangle of Elwood IL

1.1 Proposed Retaining Wall Information

Based on the design plans were provided by AECOM, the overall project will include the widening of Hoff Road and IL Rte. 53 to include new culverts, additional traffic lanes and shoulders, which will require re-grading of the existing slopes. Two retaining walls will be constructed north and south of Hoff Road and east of IL Rte. 53. The following table presents a summary of the proposed retaining wall at this location.

Table 1 –Wall information

Structure Designation	Wall Location	Approximate Length (ft)	Maximum Exposed Wall Height (ft)	Back Slope / Front Slope
NA	South of Hoff Road	168	7.3	Level
NA	North of Hoff Road	72	6.4	Level

1.2 Regional Geology

GSG reviewed several published documents in an effort to determine the regional geological setting in the area of the Site. The subject area is located in the southwest portion of Will County, Illinois. The surficial geologic deposits in this area are typically glacial drift deposited during the Wisconsin Glacial Age. This project is located geographically in the Rockdale Moraine, part of the Valparaiso Morainic System of the Yorkville Member of the Wedron Group. This moraine is primarily silty, sandy, or gravelly till with local areas of silty clayey till, many lenses of poorly sorted gravel, and abundant small kames. This formation overlies the Silurian Elwood Bedrock Formation which consists of interbedded layers of dolomite with depths ranging from 50 to 80 feet.

The project area is approximately 5 miles south of the Sandwich Fault Zone. The Sandwich fault zone is one of the longest fault zones in Illinois and extends northwesterly approximately 85 miles between Manhattan in Will County to Oregon in Ogle County. The fault zone has a maximum displacement of approximately 800 feet at its midpoint in southeastern DeKalb County and is approximately ½ to 2 miles in width.

2.0 SUBSURFACE EXPLORATION

This section describes the subsurface exploration program and laboratory testing program completed as part of this project. The locations of the soil borings were provided by AECOM, and were completed based on field conditions and accessibility. The locations of all the soil borings completed for the improvements at the intersection of Hoff road and IL-53 are shown on the **Appendix A - Boring Location Plan & Subsurface Profile**. The subsurface exploration program was performed in accordance with applicable IDOT geotechnical manuals and procedures. Soil Borings were advanced to a depth of 40 feet below the existing ground surface at each location.

2.1 Subsurface Site Investigation

The subsurface investigation was conducted on September 8th, 2015, and included advancing a total of two (2) standard penetration test (SPT) borings within the vicinity of the proposed retaining walls to 40 feet per IDOT geotechnical manual requirements. **Table 1** below presents a list of the borings completed for the new retaining walls.

Table 2 – Summary of Subsurface Exploration Borings

Location	Illinois Route 53 Station	Soil Boring	Depth (ft)	Existing Ground Elevation
East side of IL Rte. 53 south of Hoff Road	76+80	FB-4	40	631.01
East side of IL Rte. 53 North of Hoff Road	78+10	FB-5	40	632.68

The soil borings were drilled using a Diedrich D-50 truck mounted drill rig. All of the borings were drilled using 3¼-inch I.D. hollow stem augers. Soil sampling was performed according to AASHTO T 206, "Penetration Test and Split Barrel Sampling of Soils." Soil samples were obtained with the use of a split spoon sampler, at intervals of 2.5 feet to a depth of 30 feet, and then at 5 foot intervals thereafter. GSG's field representative inspected, visually classified and logged the soil samples during the subsurface exploration activities, and performed unconfined compressive strength tests on cohesive soil samples using a calibrated Rimac compression tester and a calibrated hand penetrometer in accordance with IDOT procedures and requirements. Representative soil samples were collected from each sample interval, and were placed in jars and returned to the laboratory for further testing and evaluation. The existing ground surface elevations shown in the soil boring logs are based on field survey completed by GSG field crew using a bench mark CP 166 with an elevation of 632.86 feet MSL.

2.2 Laboratory Testing Program

All samples were inspected in the laboratory to verify the field classifications. A laboratory testing program was undertaken to characterize and determine engineering properties of the subsurface soils encountered in the area of the proposed culvert. The lab testing program included Moisture Content (AASHTO T-265), Atterberg Limits (AASHTO T-89/90), and Dry Unit Weight. The laboratory tests were performed in accordance with test procedures outlined in the IDOT Geotechnical Manual (1999), and per ASTM and AASHTO requirements. Based on the laboratory test results, the soils encountered were classified according to the AASHTO and the Illinois Division of Highways (IDH) classification systems. The results of the laboratory testing program are shown along with the field test results in the **Soil Boring Logs (Appendix B).**

2.3 Subsurface Soil Conditions

The subsurface soil conditions were developed based on the results of both the site investigation and laboratory results. Detailed descriptions of the subsurface soils, as well as the surface elevations, are provided in the soil boring logs. The soil boring logs provide specific soil conditions encountered at each soil boring location, including: soil descriptions, stratifications, penetration resistance, elevations, location of the samples, water levels (when encountered), and laboratory test data. Variations in the general subsurface soil profile were noted during the drilling activities. The stratifications shown on the boring logs represent the conditions only at the actual boring locations, and represent the approximate boundary between subsurface materials; however, the actual transition may be gradual.

The soil profile at the boring locations consisted of approximately 2 feet of crush aggregate fill at the surface underlain by cohesive fill materials consisting of clay to a depth of 5 feet below the grade. With the exception of a thin layer of sand noted in boring FB-4 at 17.5 to 18.5 feet below the surface, the soils below the fill materials generally consisted of native cohesive materials through the boring termination depth of 40 feet below the ground surface,. The native cohesive soils were composed of layers of silty clay, clay and silt soils. The representative soil samples collected from the borings were tested and had unconfined compressive strengths ranging from 1to 5 tsf.

2.4 Groundwater Conditions

Water levels were checked in each boring to determine the general groundwater conditions present at the site, and were measured while drilling. None of the borings were left open after leaving the site due to safety reasons. Water was encountered in both of the borings while drilling, at elevations between 626 and 613.5 feet. Based on the above average rainfall encountered in the months leading to the subsurface investigation and the low permeability of cohesive soils it appears that the water level reading made during the investigation may represent a perched water table condition. It is anticipated that the seasonal ground water level may be closer to elevation 617 and 614 due to the color transition from brown and gray to gray in the soils. The brown color of the soil is typically caused by oxidation that occurs above the long term water level. This color transition did not occur at a consistent elevation in all of the borings, which may indicate seasonal fluctuations from the above average rainfall and climatic conditions or impacts from the drainage of the surrounding area.

3.0 GEOTECHNICAL ANALYSES

This section provides GSG's geotechnical analysis and recommendations for the design of the proposed retaining wall based on the results of the initial field exploration, laboratory testing, and geotechnical analysis. Subsurface conditions in unexplored locations may vary from those encountered at the boring locations.

3.1 Derivation of Soil Parameters for Design

GSG determined the geotechnical parameters to be used for the project design based on the results of field and laboratory test data on individual boring logs as well as our experience. Unit weights, friction angles and shear strength parameters were estimated using corrected standard penetration test (SPT) results using published correlations for N values for the fill and cohesionless soils and in-situ and laboratory test results for cohesive soils. The SPT values were corrected for hammer efficiency. The hammer efficiency correction factor considers the use of a safety hammer/rope/cat-head system, generally estimated to be 60% efficient. Thus, correlations should be based upon what is currently termed as N60 data. The efficiency of the automatic hammer used for this exploration was estimated to be approximately 80% based on previous efficiency testing of the drill rigs equipped with such equipment. The correction for hammer efficiency is a direct ratio of relative efficiencies as follows:

$$N60 = N * (80/60)$$

* Where the N value is the field recorded blow counts

Table 3 presents generalized soil parameters to be used for design based on the laboratory and in-situ testing data:

Table 3 – Summary of On-site Soil Parameters

Depth/Elevation (feet)	Soil Description	In situ Unit Weight γ (pcf)	Undrained		Drained	
			Cohesion c (psf)	Friction Angle ϕ (Degrees)	Cohesion c (psf)	Friction Angle ϕ (Degrees)
	Proposed Granular Fill	120	0	30	0	30
(632-630) 0 to 2	Existing Granular Fill	120	0	30	0	30
(630-627) 2 to 5	Black and Gray Clay Fill	120	1,000	0	0	26
(627-621) 5 to 11	Stiff Clay	130	1,500	0	0	28
(621-592) 11 to 40	Very Stiff to Hard Silty Clay	135	3,500	0	100	30
(603-592) *29 to 35	Glacial Till – Silt	140	1,750	10	100	28

*Layer noted in boring FB-4 only

3.2 Seismic Parameters

The seismic hazard for the site was analyzed per the IDOT Geotechnical Manual, IDOT Bridge Design Manual, and AASHTO LRFD Bridge Design Specifications.

The Seismic Soil Site Class was determined per the requirements of All Geotechnical Manual Users (AGMU) Memo 9.1, Design Guide for Seismic Site Class Determination, and the "Seismic Site Class Determination" Excel spreadsheet provided by IDOT. A global Site Class Definition was determined for this project, and was found to be Soil Site Class C. The Seismic Performance Zone (SPZ) was determined using Figure 2.3.10-3 in the IDOT Bridge Manual, and was found to be Seismic Performance Zone 1. The AASHTO Seismic Design Parameters program was used to determine the peak ground acceleration coefficient (PGA), and the short (S_{DS}) and long (S_{D1}) period design spectral acceleration coefficients for each of the proposed structures. For this section of the project, the S_{DS} and the S_{D1} were determined using 2014 AASHTO Guide Specifications as shown in Table 4. Given the site location and materials encountered, the potential for liquefaction is minimal.

Table 4– Seismic Parameters

Building Code Reference	PGA	S_{DS}	S_{D1}
2014 AASHTO Guide for LRFD Seismic Bridge Design	0.049g	0.127g	0.069g

3.3 Wall and Embankment Settlement

The anticipated maximum height of the fill is 3 feet above existing grade. The estimated settlement due to the placement of fill materials for the construction of the proposed retaining walls is considered to be negligible.

3.4 Slope Stability Analyses

GSG evaluated the global stability of the proposed wall using the following design information for the wall.

Table 5– Wall Description

Maximum total exposed height of the retaining wall (H)*	7.4 feet
Minimum embedment required for frost protection	4 feet
Estimated embedment depth for global stability analysis (based on preliminary exposed height of wall)	9 feet

*Based on preliminary design and cross section drawings provided by AECOM

The actual embedment depth and total height of the wall should be based on structural analysis performed by a Licensed Structural Engineer in the State of Illinois.

Slide 6.0 is a comprehensive slope stability analysis software that performs finite element analysis and was used to evaluate the proposed retaining wall geometry for the project. The proposed designs were analyzed based on the preliminary grading and the soils encountered while drilling. Based on the geometry, and the soil borings, global stability analyses were performed for both circular and block failure analysis using the simplified Bishop and Janbu analyses methods. The analyses were performed using the soil parameters in Table 5 above.

3.4.1 Slope Stability Results

Circular and block failure analyses were evaluated using Bishop and Janbu analyses methods for a short term (undrained) condition and long term (drained) condition for the proposed retaining wall geometry. The analyses were performed at Hoff Road Station 57+75, which represents the highest fill elevation of the proposed wall. Table 6 provides a summary of the stability analyses for both cases applicable only at the location analyzed.

Table 6– Stability Analyses Results

Analysis Exhibit	Station	Failure Type	Factor of Safety	Required Minimum Factor of Safety
Exhibit 1	57+75	Circular – Short Term	11.5	1.5
Exhibit 2		Circular – Long Term	3.5	1.5
Exhibit 3		Block (Sliding) – Short Term	8.5	1.5
Exhibit 4		Block (Sliding) – Long Term	2.4	1.5

Based on the assumptions in Table 5, the existing subsurface conditions and the analyses results, the proposed retaining wall meets the minimum factor of safety of 1.5. **Appendix E** presents copies of the slope stability analyses.

4.0 GEOTECHNICAL RECOMMENDATIONS

This section provides recommendation regarding foundation and design parameters for the proposed retaining wall. The recommendations were developed based on the project information provided by AECOM and the results of the site investigation. If there are any significant changes to the project characteristics or if significantly different subsurface conditions are encountered during construction, GSG should be consulted so that the recommendations of this report can be reviewed. The foundation design recommendations were completed per the AASHTO LRFD 7th Edition (2014).

4.1 Retaining Wall Type Recommendations

There are several types of retaining walls that could be utilized for retaining earth embankments in fill areas or excavation slopes in cut areas. This section discusses several earth retaining structures that could be used for the proposed project. Possible wall types include cast-in-place concrete cantilever wall, soldier-pile wall, and steel sheet pile wall with concrete facing. Wall type should be selected based on the IDOT manual, site condition, soil conditions, and construction cost. The following sections present a brief description of each type of wall.

A. CIP Concrete Cantilever Walls

Cast-in-place concrete cantilever retaining walls are typically used in fill areas. They are constructed with a footing that extends laterally both in front of and behind the wall. They can be designed to resist the horizontal loading with or without tie-backs by changing the geometry of the foundation. They require that the area behind the wall be excavated to facilitate construction. Wall heights can range from 5 to 25-feet, but usually, above 20-feet the wall heights become uneconomical.

Advantages of the CIP wall include a conventional wall system with well-established design procedures and performance characteristics, durability, ability to easily be formed, textured, or colored to meet aesthetic requirements. Disadvantages include a relatively long construction period due to undercutting, excavation, form work, steel placement, and curing. The rigid wall system is sensitive to total and differential settlements and sequence of construction.

B. Sheet Pile Walls

Sheet pile walls are typically used in cut areas when continuous support must be provided to maintain existing structures or other adjacent facilities. Sheet pile walls are typically used in cut areas when continuous support must be provided to maintain existing structures or other adjacent facilities. Sheet piles are also used in wide trench excavations when the use of trench boxes becomes impractical. This type of wall can also be covered with precast panels for aesthetics. The installation of sheet pile walls requires the use of specialty equipment to drive the piles into the ground. To provide lateral resistance against the retained soil, the walls can be designed to act as a cantilever or can use tie back behind the wall. The walls maintain the existing site conditions with minimal disturbance to existing structures, and can be installed relatively quickly. Sheet pile walls are considered as feasible option for this project. However, due to the presence of very stiff to hard clay, we recommend using a heavier pile section with a minimum thickness of 0.4 inch to alleviate any damage to the pile section during driving.

C. Soldier Pile and Lagging Walls

Soldier pile and lagging walls are very similar to sheet pile walls, and include most of the benefits and costs of that type of retention wall. Solider pile and lagging walls are also typically used in cut areas where the existing ground surface needed to be maintained during construction or when a near vertical excavation is needed. However it could also be used for a fill condition. The major difference is that with the sheet pile wall, the entire wall section is installed vertically, one section at a time, with the use of the machinery. The pile and lagging wall is installed by installing a series of H-piles into predrilled holes, then installing the lagging by between the piles. The lagging should be designed to 100% of the earth pressure.

4.2 Recommended Wall Type

Based on the wall height and site conditions, soldier pile and lagging or sheet pile walls are suitable options for the project. AECOM shall complete engineering analysis and select either wall type for this project.

4.3 Retaining Wall Design Recommendations

This section provides design recommendations for the selected wall types based on the site condition and project information provided by AECOM.

4.3.1 Soldier Pile and Lagging

Soldier pile can be either driven or drilled into the soil. Driven soldier pile can be installed in dense or stiff soils where sheet pile walls may not be feasible. Drilled soldier pile walls can be installed in any soil type and even into bedrock. Drilled soldier pile walls are generally constructed by drilling 24-inch diameter holes at 6-8 foot centers along the retaining wall alignment into the bearing stratum. Then, a HP pile will be placed into the hole and centered, and the annular space around each HP section will be filled with flowable grout. As the excavation progresses from the top down, the grout will be removed from the flanges and lagging will be constructed between the flanges of the HP sections. The lagging should be designed based on structural analysis. Resistance to lateral movement or overturning of the soldier piles is furnished by passive resistance of the soil below the depth of excavation. The passive pressure between piles should act over an effective width equal to three times the width of the soldier piles for the stiff to very stiff clay at the Site. The total width for drilled soldier piles should be taken as the diameter of the concrete encasement, and the width for driven soldier piles should be taken as the width of the flange. A Geocomposite Wall Drain should be placed behind the wall for drainage, and connected to 4 inch perforated drain pipe.

4.3.2 Sheet Pile

The proposed sheet pile wall should be designed for a 75 year design life because it will carry traffic in accordance with the IDOT Bridge Manual. Grade 50 steel should be used for the sheet pile. The interlocks could be partially clogged during driving and after installation due to fine soil particle migration. The backfill behind the wall for a width of 2 feet should be free draining granular material. Water drainage through interlocks should not be considered for a permanent condition. We recommend that weep holes be provided or hydrostatic pressure be considered in the design. A Geocomposite Wall Drain should be placed over the interlocks and area of the weep holes. In place of weep holes, a Geocomposite Wall Drain could be connected to the 4-inch diameter perforated drain pipe.

4.3.3 Walls Design

Engineering analyses and design of the proposed wall shall be performed using the current AASHTO Load and Resistance Factor Design (LRFD) Methodology as required by the IDOT. LRFD methodology incorporates the use of load factors and resistance factors to account for uncertainty in applied loads and load resistance of structure elements separately. The AASHTO LRFD Bridge Design Specifications outline load factors and combinations for various strength, extreme event, service, and fatigue limit states. Section 11, which outlines geotechnical criteria for retaining walls, of the AASHTO Specifications requires the evaluation of bearing resistance failure, lateral sliding, and overturning at the strength limit state and excessive vertical displacement, excessive lateral displacement, and overall stability at the service limit state.

Table 7 provides the load factors to be used in the design of the retaining wall in accordance with AASHTO Table 3.4.1-1, Load Combinations and Load Factors, and Table 3.4.1-2, load Factors for Permanent Loads.

Table 7 - LRFD Load Factors for Retaining Wall Design

	Type of Load	Bearing Resistance Strength IA	Sliding and Eccentricity Strength IB	Settlement Service I
Load Factors for Vertical Loads	Dead Load of Structural Components (DC)	1.25	0.90	1.00
	Vertical Earth Pressure Load (EV)	1.35	1.00	1.00
	Earth Surcharge Load (ES)	1.50		1.00
	Live Load Surcharge (LS)	1.75		1.00
Load Factors for Horizontal Loads	Horizontal Earth Pressure Load (EH)		1.00	1.00
	Active	1.50		
	At-Rest	1.35		
	AEP for anchored walls	1.35		
	Earth Surcharge (ES)	1.50		
	Live Load Surcharge (LS)	1.75	1.00	1.00

4.3.4 Lateral Earth Pressures and Loadings

The wall shall be designed to withstand earth and live lateral earth pressures. The lateral earth pressures on retaining walls depend on the type of wall (i.e. restrained or unrestrained), the type of backfill and the method of placement against the wall, and the magnitude of surcharge weight on the ground surface adjacent to the wall. Soldier pile and sheet pile walls are considered flexible and such the earth loads may be calculated using active earth pressure for load above the design grade, and both active and passive earth pressures below the design grade. The active earth pressure coefficient (Ka), and the passive earth pressure coefficient (Kp) were determined in accordance with AASHTO Section 3.11.5.3 and 3.11.5.4, respectively. The simplified earth pressure distributions shown in the AASHTO Standard Specifications for Highway Bridges should be used. Table 8 also provides recommended lateral soil modulus and soil strain parameters that can be used for laterally loaded pile analysis via the p-y curve method based on the encountered subsurface conditions. The passive resistance in front of the soldier pile or sheet pile walls should be ignored for the upper 3.5 feet due to excavation required for installation of concrete facing, drainage system, and frost-heave condition. Since the wall is permanent, the soil strength parameters shown in Table 3 for drained conditions should be used.

Table 8- Geotechnical Lateral Design Parameters

Elev. Depth (feet)	Soil Description	Active Earth Pressure Coefficient (K_a)	Passive Earth Pressure Coefficient (K_p)	At Rest Earth Pressure Coefficient (K_o)	Lateral Modulus of Subgrade Reaction (pci)	Soil Strain (ε_{50})	Adhesion (C_a) psf	Friction Angle between steel and soils noted (Degrees)
	Proposed Granular Fill	0.33	3.00	0.50	90	NA	NA	17
(632-630) 0 to 2	Existing Granular Fill	0.33	3.00	0.50	90	NA	NA	17
(630-627) 2 to 5	Black and Gray Clay	0.39	2.56	0.80	500	0.007	750	14
(627-621) 5 to 11	Stiff Clay	0.36	2.77	1.00^{+}	750	0.007	975	15
(621-592) 11 to 40	Very Stiff to Hard Silty Clay	0.33	3.00	1.00^{+}	1,750	0.005	1200	16
(603-592) *29 to 35	Glacial Till - Silt	0.36	2.75	1.00^{+}	1,000	0.005	1000	11

*noted only in boring FB-4
+ Over Consolidation Ratio (OCR) for these soil layers ranged between 4 and 6

We recommend using granular backfill behind the soldier-pile and sheet pile walls. Hydrostatic pressure should be added to the earth pressure if drainage behind the wall is not provided as recommended.

Traffic and other surcharge loads should be included in the retaining wall design. A live load surcharge shall be applied where vehicular load is expected to act on the surface of the backfill within a distance equal to one-half the wall height behind the back face of the wall in accordance with Article 3.11.6.4 of AASHTO LRFD Bridge Design Specifications. The live load surcharge may be estimated as a uniform horizontal earth pressure due to an equivalent height (Heq) of soil. Table 9 provides the equivalent heights of soils for vehicular loadings on retaining walls.

Table 9 - Equivalent Height of Soil for Vehicular Loading on Retaining Walls Parallel to Traffic (AASHTO LRFD Manual - Table 3.11.6.4-2)

Retaining Wall Height (ft)	H_{eq} Distance from Wall Back face to Edge of Traffic	
	0 feet	1.0 feet or Further
5	5.0 feet	2.0 feet
10	3.5 feet	2.0 feet
≥20	2.0 feet	2.0 feet

5.0 CONSTRUCTION CONSIDERATIONS

All work performed for the proposed project should conform to the requirements in the IDOT SSRBC (2012). Any deviation from the requirements in the manuals above should be approved by the design engineer.

5.1 Existing Utilities

Before proceeding with construction, any existing underground utility lines that will interfere with construction should be completely rerouted or removed from beneath the proposed construction areas. Existing utility lines that are to be abandoned in place should be removed and/or plugged with a minimum of 2 feet of cement grout. All excavations resulting from underground utilities removal activities should be cleaned of loose and disturbed materials, including all previously-placed backfill, and backfilled with suitable fill materials in accordance with the requirements of this section. During the clearing and stripping operations, positive surface drainage should be maintained to prevent the accumulation of water.

5.2 Excavations

The contractor will be responsible to provide a safe excavation during the construction activities of the project. All excavations should be conducted in accordance with applicable federal, state, and local safety regulations, including, but not limited to the Occupational Safety and Health administration (OSHA) excavation safety standards. Excavation stability and soil pressures on temporary shoring are dependent on soil conditions, depth of excavations, installation procedures, and the magnitude of any surcharge loads on the ground surface adjacent to the excavation. Excavation near existing structures and underground utilities should be performed with extreme care to avoid undermining existing structures. Excavations should not extend below the level of adjacent existing foundations or utilities unless underpinning or other support is installed. It is the responsibility of the contractor for field determinations of applicable conditions and providing adequate shoring for all excavation activities.

5.3 Groundwater Management

It is anticipated that the long term water table is greater than 10 feet below the existing ground surface. GSG does not anticipate groundwater related issues during construction activity; however, water may become perched in the existing fill material encountered at the surface. If rainwater run-off or perched water is accumulated at the base of excavation, the contractor should remove accumulated water using conventional sump pit and pump procedures, and maintain a dry and stable excavation. The location of the sump should be determined by the contractor based on field conditions. During earthmoving activities at the site, grading should be performed to ensure that drainage is maintained throughout the construction period. Water should not be allowed to accumulate in the foundation area either during or after construction. Undercut and excavated areas should be sloped toward one corner to facilitate removal of any collected rainwater or surface run-off. Grades should be sloped away from the excavations to minimize runoff from entering the areas.

If water seepage occurs during footing excavations or where wet conditions are encountered such that the water cannot be removed with conventional sumping, we recommend placing open grade stone similar to IDOT CA-7 to stabilize the bottom of the excavation below the water table. The CA-7 stone should be placed to 12 inches above the water table, in 12-inch lifts, and should be compacted with the use of a heavy smooth drum roller or heavy vibratory plate compactor until stable. The remaining portion of the excavation beneath the footings should be backfilled using approved structural fill.

5.4 Wall Construction

The wall should be constructed as per IDOT Standard Specifications. Sheet piles and soldier pile and lagging walls should be constructed in accordance with IDOT Guide Bridge Special Provisions (GBSP). Soldier pile walls could be constructed by either drilling shafts or driving steel piles at required centers along the retaining wall alignment into the bearing stratum. Drilled soldier piles should be installed in accordance with the Guide Bridge Special Provisions (GBSP) No. 42, and the driven soldier piles should be installed in accordance with the GBSP No. 43. The sheet piles could be installed by driving to the required penetration using a vibratory hammer. If hard driving condition is encountered and the vibratory hammer cause damage to the interlocks, an impact hammer should be utilized on those cases.

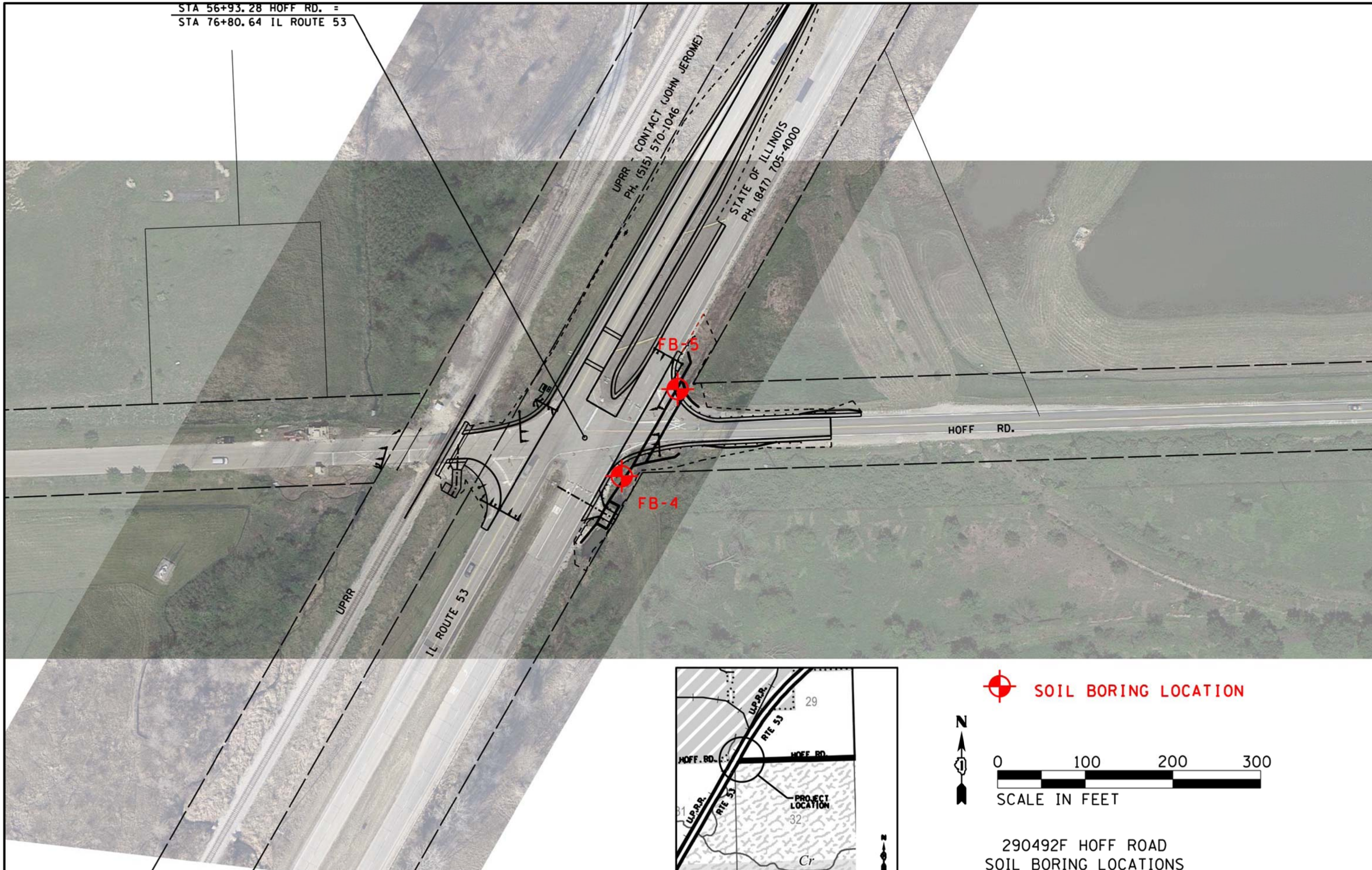
The backfill behind the wall should placed and compacted in accordance with the IDOT 2012 Bridge Manual. Heavy compaction equipment should not be used on the high side of the wall within a horizontal distance equal to the height of backfilling, as this may result in over-stressing of the wall and excessive deflection.

6.0 LIMITATIONS

This report has been prepared for the exclusive use of the Illinois Department of Transportation and its structural consultant. The recommendations provided in the report are specific to the project described herein, and are based on the information obtained at the soil boring locations within the proposed retaining wall area. The analyses performed and the recommendations provided in this report are based on subsurface conditions determined at the location of the borings. This report may not reflect all variations that may occur between boring locations or at some other time, the nature and extent of which may not become evident until during the time of construction. If variations in subsurface conditions become evident after submission of this report, it will be necessary to evaluate their nature and review the recommendations presented herein.

APPENDIX A

SOIL BORING LOCATION PLAN
AND SUBSURFACE PROFILE



290492F HOFF ROAD
SOIL BORING LOCATIONS

GSG CONSULTANTS, INC. 855 West Adams, Suite 200 Chicago, Illinois 60607 tel: 312.733.6262 • fax: 312.733.5612	USER NAME = $USER$	DESIGNED - NE	REVISED -
		DRAWN -	REVISED -
	PLOT SCALE = $SCALE$	CHECKED - DE	REVISED -
	PLOT DATE = $DATE$	DATE - 9/18/15	REVISED -

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

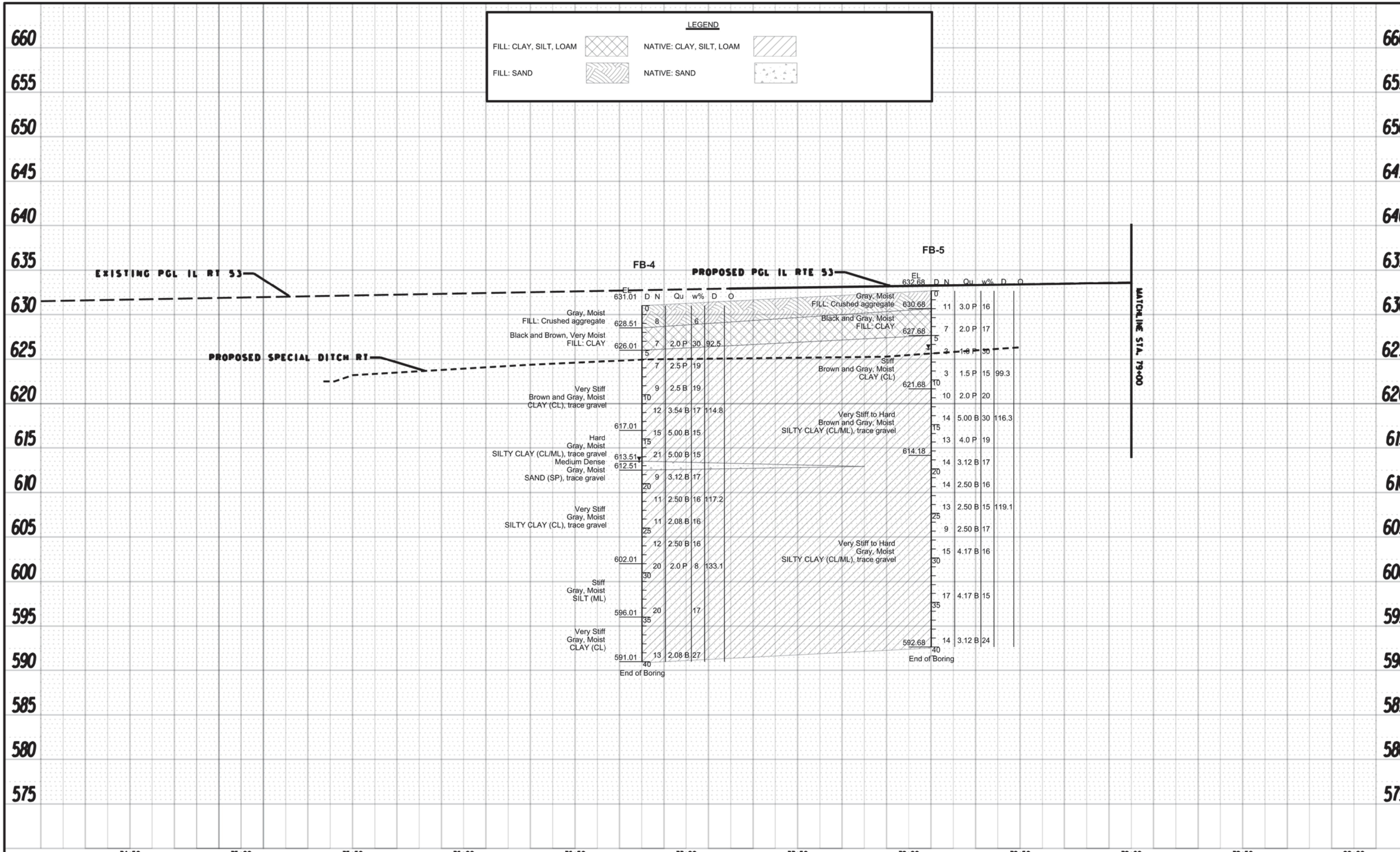
290492F HOFF ROAD
SOIL BORING LOCATIONS

SCALE: NTS | SHEET 1 OF 1 SHEETS | STA. | TO STA.

F.A. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
846	DDI HSR 2016-01	WILL	1	1

CONTRACT NO. 890-172

ILLINOIS | FED. AID PROJECT



GSG CONSULTANTS, INC. 855 West Adams, Suite 200 Chicago, Illinois 60607 tel: 312.733.6262 • fax: 312.733.5612	USER NAME = $USER$	DESIGNED - NE	REVISED -	STATE OF ILLINOIS DEPARTMENT OF TRANSPORTATION
		DRAWN -	REVISED -	
	PLOT SCALE = $SCALE$	CHECKED - DE	REVISED -	
	PLOT DATE = $DATE$	DATE - 9/8/15	REVISED -	

IL RTE. 53
SUBSURFACE PROFILE

SCALE: NTS | SHEET 2 OF 2 SHEETS | STA. 74+50 TO STA. 79+00

F.A. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
846	DDI HSRR 2016-01	WILL	1	1

CONTRACT NO. 890-172

ILLINOIS FED. AID PROJECT

APPENDIX B

SOIL BORING LOGS

GSG CONSULTANTS, INC.
855 West Adams, Suite 200
Chicago, Illinois 60607
tel: 312.733.6262 • fax: 312.733.5612

SOIL BORING LOG

Date 9/8/15

ROUTE IL Rte. 53 & Hoff Rd. **DESCRIPTION** High Speed Rail from Chicago to St. Louis **LOGGED BY** JR

SECTION Mile Post 46.64 **LOCATION** Hoff Road **Northing** 1721472.7763 **Easting** 1043839.3169

COUNTY Will **DRILLING METHOD** HSA **HAMMER TYPE** AUTO

STRUCT. NO. NA
Station NA

BORING NO. FB-4
Station 57+33
Offset 46.00ft RT
Ground Surface Elev. 631.01 ft

Surface Water Elev. NA ft
Stream Bed Elev. NA ft
Groundwater Elev.:
First Encounter 613.5 ft ▼
Upon Completion None ft
After NA **Hrs.** NA ft

NOTES:

Description	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)	DRY DENSITY (pcf)	ORGANIC (%)
Gray, Moist FILL: Crushed aggregate			8 6 2		6		
	628.51						
Black and Brown, Very Moist FILL: CLAY			3 3 4	2.0	30	92.5	
	626.01	-5					
Very Stiff Brown and Gray, Moist CLAY, trace gravel, A-7-6			2 3 4	2.5	19		
			6 4 5	2.5 B	19		
		-10					
			3 5 7	3.5 B	17	114.8	
	617.01		3				
Hard Gray, Moist SILTY CLAY, trace gravel, A-6			7 8	5.0 B	15		
		-15					
			5 7 14	5.0 B	15		
	613.51 ▼						
Medium Dense Gray, Moist SAND, A-3	612.51						
Very Stiff Gray, Moist CLAY, trace gravel A-7-6			2 4 5	3.1 B	17		
		-20					

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

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SOIL BORING LOG

Date 9/8/15

ROUTE IL Rte. 53 & Hoff Rd. **DESCRIPTION** High Speed Rail from Chicago to St. Louis **LOGGED BY** JR

SECTION Mile Post 46.64 **LOCATION** Hoff Road **Northing** 1721472.7763 **Easting** 1043839.3169

COUNTY Will **DRILLING METHOD** HSA **HAMMER TYPE** AUTO

STRUCT. NO. NA
Station NA

BORING NO. FB-4
Station 57+33
Offset 46.00ft RT
Ground Surface Elev. 631.01 ft

Surface Water Elev. NA ft
Stream Bed Elev. NA ft
Groundwater Elev.:
First Encounter 613.5 ft ▼
Upon Completion None ft
After NA **Hrs.** NA ft

Description	DEPTH (ft)	GRAPHIC LOG	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)	DRY DENSITY (pcf)	ORGANIC (%)	NOTES:
Very Stiff Gray, Moist CLAY, trace gravel A-7-6 *(continued)*			3 4 7	2.5 B	16	117.2		
			3 4 7	2.1 B	16			
	-25		3 5 7	2.5 B	16			
602.01			4 9 11	2.0	8	133.1		
Very Stiff Gray, Moist SILT, A-4	-30							
596.01	-35		4 9 11		17			
Very Stiff Gray, Very Moist CLAY, A-7-6								
591.01	-40		5 6 7	2.1 B	27			

End of Boring

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

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SOIL BORING LOG

Date 9/8/15

ROUTE IL Rte. 53 & Hoff Rd. **DESCRIPTION** High Speed Rail from Chicago to St. Louis **LOGGED BY** JR

SECTION Mile Post 46.64 **LOCATION** Hoff Road **Northing** 1721572.1243 **Easting** 1043903.3096

COUNTY Will **DRILLING METHOD** HSA **HAMMER TYPE** AUTO

STRUCT. NO. NA
Station NA

BORING NO. FB-5
Station 58+02
Offset 50.00ft LT
Ground Surface Elev. 632.68 ft

Surface Water Elev. NA ft
Stream Bed Elev. NA ft
Groundwater Elev.:
First Encounter 626.2 ft ▼
Upon Completion None ft
After NA **Hrs.** NA ft

NOTES:

Description	Elev.	DEPTH (ft)	GRAPHIC LOG	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)	DRY DENSITY (pcf)	ORGANIC (%)
Gray, Moist FILL: Crushed aggregate				4 5 6	3.0	16		
	630.68							
Black and Gray, Moist FILL: CLAY				4 3 4	2.0	17		
	627.68	-5						
Stiff Dark Gray to Brown, Very Moist CLAY, A-7-6		▼		2 1 2	1.0	30		
				1 1 2	1.5	15	99.3	
		-10						
	621.68							
Very Stiff to Hard Brown and Gray, Very Moist SILTY CLAY, A-6				3 5 5	2.0	20		
				4 6 8	5.0 B	30	116.3	
		-15						
				4 6 7	4.0	19		
	614.18							
Very Stiff to Hard Gray, Moist SILTY CLAY, A-6				4 7 7	3.1 B	17		
		-20						

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

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SOIL BORING LOG

Date 9/8/15

ROUTE IL Rte. 53 & Hoff Rd. **DESCRIPTION** High Speed Rail from Chicago to St. Louis **LOGGED BY** JR

SECTION Mile Post 46.64 **LOCATION** Hoff Road **Northing** 1721572.1243 **Easting** 1043903.3096

COUNTY Will **DRILLING METHOD** HSA **HAMMER TYPE** AUTO

STRUCT. NO. NA
Station NA

BORING NO. FB-5
Station 58+02
Offset 50.00ft LT
Ground Surface Elev. 632.68 ft

Surface Water Elev. NA ft
Stream Bed Elev. NA ft
Groundwater Elev.:
First Encounter 626.2 ft ▼
Upon Completion None ft
After NA **Hrs.** NA ft

NOTES:

Description	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)	DRY DENSITY (pcf)	ORGANIC (%)
Very Stiff to Hard Gray, Moist SILTY CLAY, A-6 *(continued)*		3 6 8	2.5 B	16		
	-25	3 5 8	2.5 B	15	119.1	
		3 4 5	2.5 B	17		
	-30	4 6 9	4.2 B	16		
	-35	5 6 11	4.2 B	15		
592.68	-40	4 6 8	3.1 B	24		

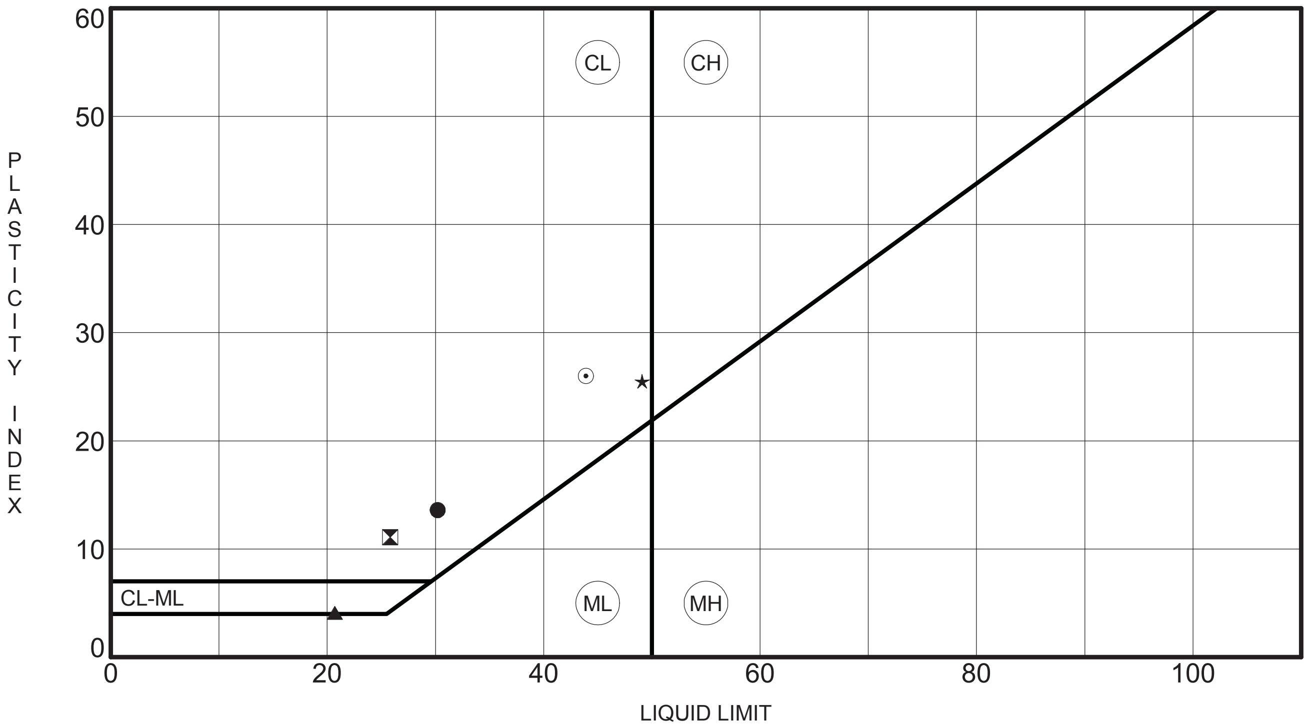
End of Boring

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

APPENDIX C

LABORATORY TEST RESULTS

Atterberg Limit Results							
Boring ID	**Sample Number**	**Sample Depth (Below Existing Grade)**		**Liquid Limit**	**Plastic Limit**	**Plasticity Index**
		Top (ft.)	Bottom (ft.)			
FB-4	SS-4	8.50	10.00	30.2	16.6	13.6
FB-4	SS-9	21.00	22.50	25.8	14.7	11.1
FB-4	SS-13	33.50	35.00	20.7	16.6	4.1
FB-5	SS-4	8.50	10.00	43.9	17.9	26.0



Symbol	Specimen Identification		LL	PL	PI	Fines	Classification
●	**FB-4**	**8.50**	**30.2**	**16.6**	**13.6**		
⧗	**FB-4**	**21.00**	**25.8**	**14.7**	**11.1**		
▲	**FB-4**	**33.50**	**20.7**	**16.6**	**4.1**		
★	**FB-5**	**3.50**	**49.1**	**23.6**	**25.5**		
⊙	**FB-5**	**8.50**	**43.9**	**17.9**	**26.0**		

GSG Consultants, Inc
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ATTERBERG LIMITS RESULTS

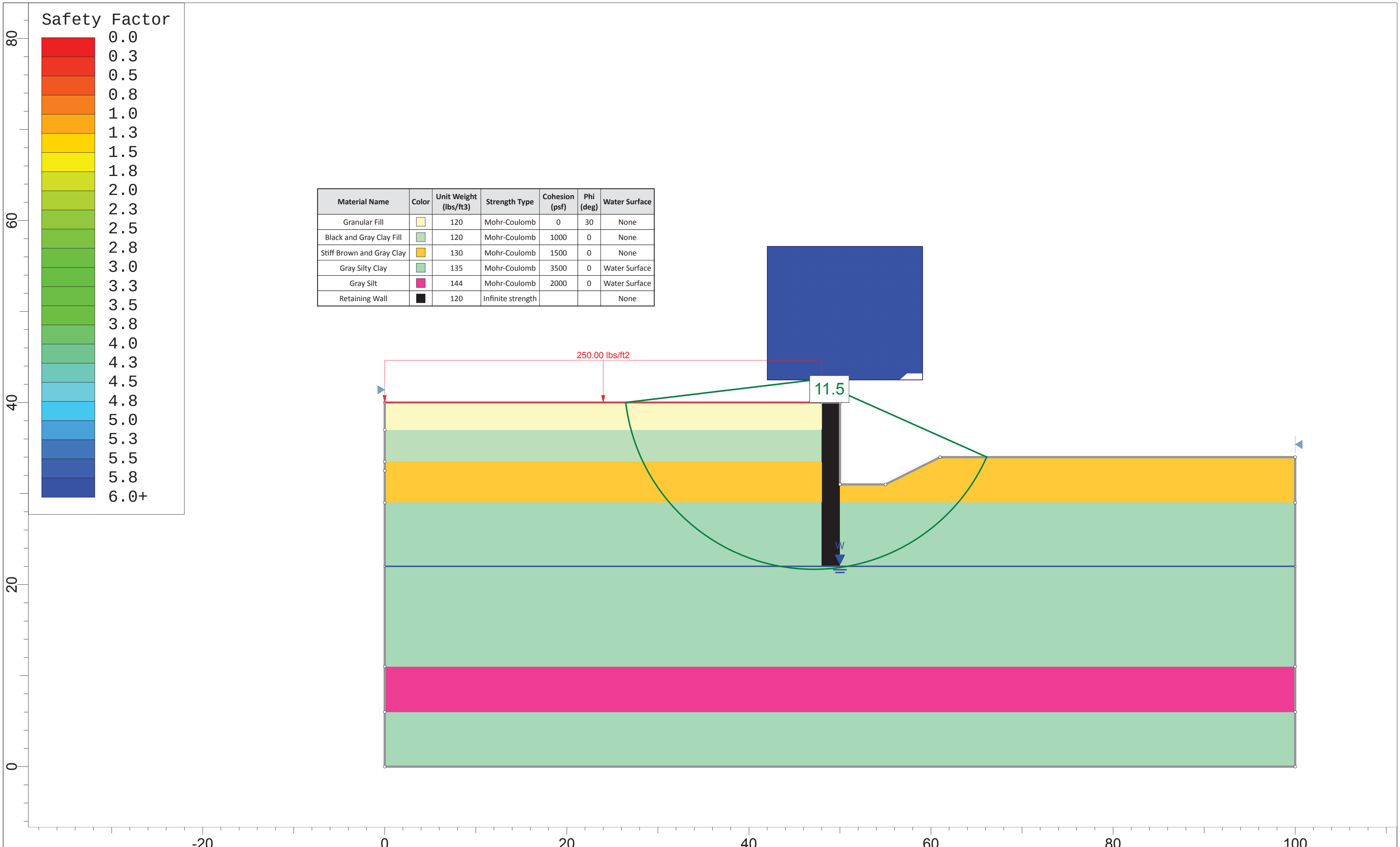
Route: IL Rte. 53 & Hoff Rd.

Section: Mile Post 46.64

County: Will

APPENDIX D

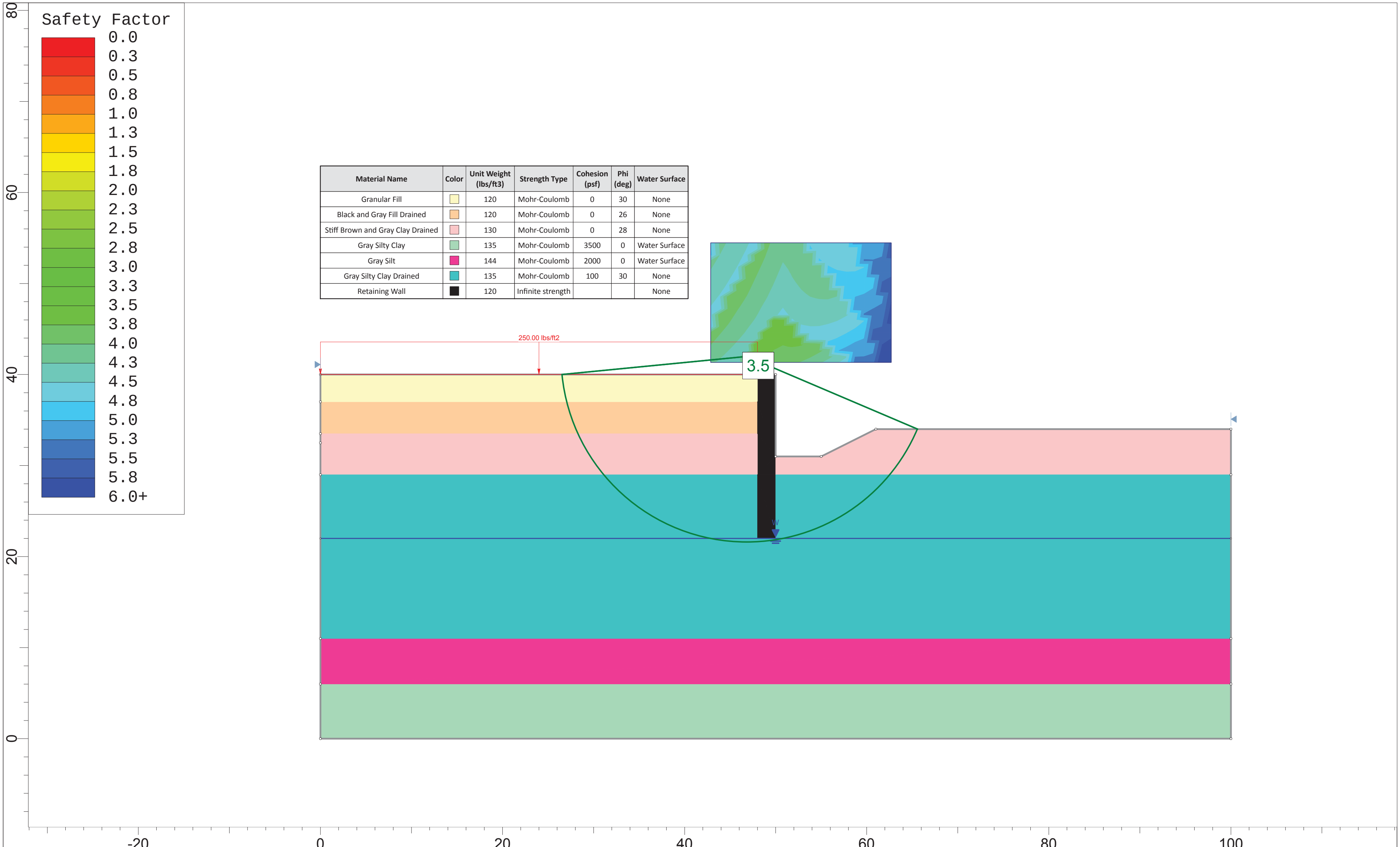
SLOPE STABILITY ANALYSES EXHIBITS



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Granular Fill		120	Mohr-Coulomb	0	30	None
Black and Gray Clay Fill		120	Mohr-Coulomb	1000	0	None
Stiff Brown and Gray Clay		130	Mohr-Coulomb	1500	0	None
Gray Silty Clay		135	Mohr-Coulomb	3500	0	Water Surface
Gray Silt		144	Mohr-Coulomb	2000	0	Water Surface
Retaining Wall		120	Infinite strength			None

SLIDEINTERPRET 6.034

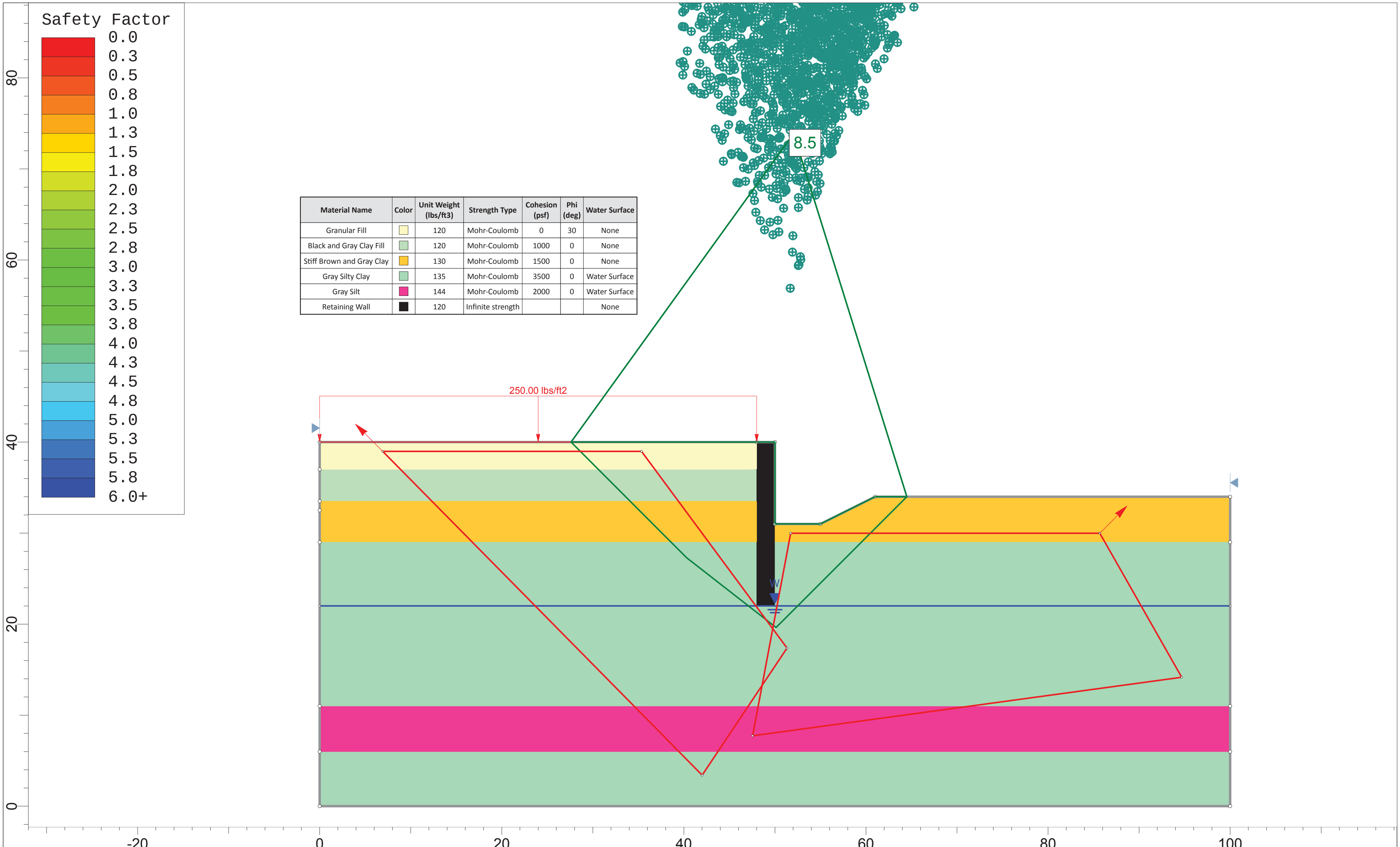
Project	Proposed Retaining Wall along Hoff Road
Analysis Description	Exhibit 1 - Circular Failure Short Term
Drawn By	KSC
Scale	1:175
Company	GSG Consultants, Inc.
Date	9/14/2015, 1:49:29 PM
File Name	Soldier Pile Circular Short Term.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Granular Fill		120	Mohr-Coulomb	0	30	None
Black and Gray Fill Drained		120	Mohr-Coulomb	0	26	None
Stiff Brown and Gray Clay Drained		130	Mohr-Coulomb	0	28	None
Gray Silty Clay		135	Mohr-Coulomb	3500	0	Water Surface
Gray Silt		144	Mohr-Coulomb	2000	0	Water Surface
Gray Silty Clay Drained		135	Mohr-Coulomb	100	30	None
Retaining Wall		120	Infinite strength			None

Project	Proposed Retaining Wall along Hoff Road		
Analysis Description	Exhibit 2 - Circular Failure Long Term		
Drawn By KSC	*Scale* 1:175	*Company*	GSG Consultants, Inc.
Date 9/14/2015, 1:49:29 PM		*File Name*	Soldier Pile Circular Long Term.slim

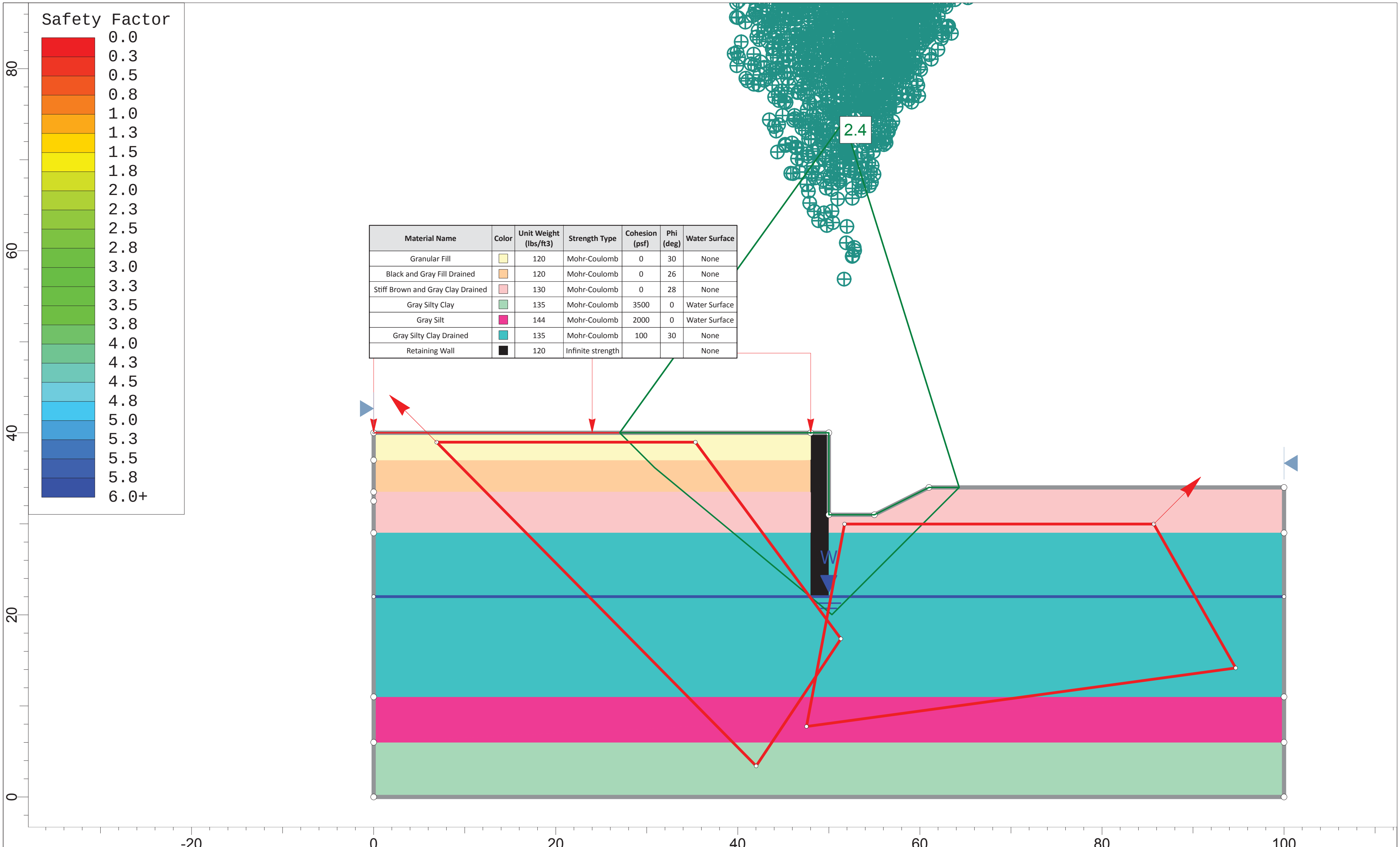
SLIDEINTERPRET 6.034



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Granular Fill		120	Mohr-Coulomb	0	30	None
Black and Gray Clay Fill		120	Mohr-Coulomb	1000	0	None
Stiff Brown and Gray Clay		130	Mohr-Coulomb	1500	0	None
Gray Silty Clay		135	Mohr-Coulomb	3500	0	Water Surface
Gray Silt		144	Mohr-Coulomb	2000	0	Water Surface
Retaining Wall		120	Infinite strength			None

Project	Proposed Retaining Wall along Hoff Road		
Analysis Description	Exhibit 3 - Block Failure Short Term		
Drawn By KSC	*Scale* 1:175	*Company*	GSG Consultants, Inc.
Date	9/14/2015, 1:49:29 PM	*File Name*	Soldier Pile Block Short Term.slim

SLIDEINTERPRET 6.034



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Granular Fill		120	Mohr-Coulomb	0	30	None
Black and Gray Fill Drained		120	Mohr-Coulomb	0	26	None
Stiff Brown and Gray Clay Drained		130	Mohr-Coulomb	0	28	None
Gray Silty Clay		135	Mohr-Coulomb	3500	0	Water Surface
Gray Silt		144	Mohr-Coulomb	2000	0	Water Surface
Gray Silty Clay Drained		135	Mohr-Coulomb	100	30	None
Retaining Wall		120	Infinite strength			None

Project	Proposed Retaining Wall along Hoff Road
Analysis Description	Exhibit 4 - Block Failure Long Term
Drawn By	KSC
Scale	1:175
Company	GSG Consultants, Inc.
Date	9/14/2015, 1:49:29 PM
File Name	Soldier Pile Block Long Term.slim

SLIDEINTERPRET 6.034