Town Common Park - Bulkhead and Esplanade

Geotechnical Engineering Report

May 16, 2024 | Terracon Project No. 72245005

Prepared for:

Moffatt & Nichol
4700 Falls of Neuse Road Suite 300
Raleigh NC, 27609

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May 16, 2024

Moffatt & Nichol
4700 Falls of Neuse Road Suite 300
Raleigh NC, 27609

Attn: Mr. Mark Pirrello / Managing Principal
P: 919-334-7984
E: mpirrello@moffatnichol.com

Re: Geotechnical Engineering Report
Town Common Park - Bulkhead and Esplanade
105 E 1st Street
Greenville, North Carolina
Terracon Project No. 72245005

Dear Mr. Pirrello:

We have completed the scope of Geotechnical Engineering services for the above referenced project in general accordance with Terracon Proposal No. P72245005 dated January 17, 2024. This report presents geotechnical recommendations concerning the bulkhead and pile design parameters for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,

Terracon

05/16/2024

NORTH CAROLINA PROFESSIONAL SEAL 042183 ENGINEER ANDREW J. GLINIAK

Andrew J Gliniak, P.E.
Project Engineer
Registered, NC 042183

Tom Schipporeit, PE, BC.GE
Senior Geotechnical Engineer

Table of Contents

Attachments

Site Location and Stability Plans
Supporting Information

Note: This report was originally delivered in a web-based format. **Blue Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the Terracon logo will bring you back to this page. For more interactive features, please view your project online at **client.terracon.com**.

Refer to each individual Attachment for a listing of contents.

Introduction

This report presents the results of our Geotechnical Engineering services performed for the proposed bulkhead replacement and esplanade to be located along 105 E 1st Street in Greenville, North Carolina. The purpose of these services was to provide information and geotechnical engineering recommendations relative to:

- Slope stability of the planned bulkhead and retaining walls
- Soil bond values of soil anchors for the new bulkhead
- Pile axial capacity for the planned boardwalk

Soil information gathered from our completed report to The East Group, P.A. for the Town Common Civic Center and Bulkhead Geotechnical Report, Terracon Project No. 72215104, dated February 11, 2022, was used to provide the requested parameters.

Project Description

A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Bulkhead: The bulkhead will be approximately 20 feet high with a mudline (including scour depth) of approximately -5 feet NAVD88. Stone fill will be used to fill the void between the new wall and old wall. The bulkhead will be completed prior to construction of the planned boardwalk and additional retaining walls. Soil anchors are planned for the sheet pile bulkhead along the river, typically 25 feet bonded and 25 feet unbonded based on client experience. The existing wall consists of sheet piling with tie rods to deadmen.

Site Retaining Walls: We understand retaining walls up to 8 feet high are planned. The walls will be cast-in-place reinforced concrete cantilever walls. Global stability runs were requested for the planned walls.

Boardwalk and Overlooks: Timber piles with up to a 10-inch butt diameter are planned for the anchors to the dock and overlook. Pipe piles with a 12-inch diameter are also being considered. Compressive loads along the bents of the boardwalks are anticipated to be approximately 5 kips.

Terracon should be notified if any of the above information is inconsistent with the planned construction, especially the grading information or wall construction, as modifications to our recommendations may be necessary.

Soil Anchors

The soil anchors should be designed and constructed by a specialty contractor experienced in this type of work. Preliminary pressure-grouted anchor ultimate bond stresses are presented in the following tables:

B-1 Preliminary Pressure-Grouted Anchor Ultimate Bond Stress		
Depth (feet)	**Elevation (feet, MSL)**	**Ultimate Bond Stress (psi)**
0 to 3	19 to 16	15
3 to 5	16 to 14	5
5 to 18	14 to 1	12
18 to 23	1 to -4	10
23 to 28	-4 to -9	20
28 to 38	-9 to -19	15
38 to 43	-19 to -29	59
43 to 68	-29 to -49	12
68 to 75	-49 to -56	20

B-2 Preliminary Pressure-Grouted Anchor Ultimate Bond Stress		
Depth (feet)	**Elevation (feet, MSL)**	**Ultimate Bond Stress (psi)**
0 to 13	19 to 6	10
13 to 18	6 to 1	10
18 to 28	1 to -9	25
28 to 43	-9 to -24	59
43 to 68	-24 to -49	12
68 to 75	-49 to -56	12

B-3 Preliminary Pressure-Grouted Anchor Ultimate Bond Stress		
Depth (feet)	**Elevation (feet, MSL)**	**Ultimate Bond Stress (psi)**
0 to 18	19 to 1	10
18 to 28	1 to -9	17
28 to 43	-9 to -24	59
43 to 48	-24 to -29	17
48 to 68	-29 to -49	10
68 to 75	-49 to -56	20

B-4 Preliminary Pressure-Grouted Anchor Ultimate Bond Stress		
Depth (feet)	**Elevation (feet, MSL)**	**Ultimate Bond Stress (psi)**
0 to 13	18 to 5	10
13 to 18	5 to 0	7
18 to 23	0 to -5	4
23 to 33	-5 to -15	17
33 to 53	-15 to -35	59
53 to 73	-35 to -55	11
73 to 75	-55 to -57	20

We recommend a factor of safety of at least 2.0 be used for design. For a more detailed discussion of soil anchors, reference should be made to: Ground Anchors and Anchored Systems - Publication No. FHWA-IF-99-015.

Construction Considerations

The soil anchor installation process should be performed under the direction of the Geotechnical Engineer. The Geotechnical Engineer should document the anchor installation process including soil and groundwater conditions encountered, consistency with expected conditions, and details of the installed anchors.

Global Slope Stability

Mechanics of Stability

Slope stability analyses take into consideration material strength, water (piezometric) pressures, river stage, surcharge loads, and the slope geometry. Mathematical computations are performed using computer-assisted simulations to calculate a Factor of Safety (FS). Minor changes to slope geometry, surface water flow and/or groundwater levels could result in slope instability. Reasonable FS values are dependent upon the confidence in the parameters utilized in the analyses performed, among other factors related to the project itself.

Drained and undrained soil parameters were selected based on the boring logs and our experience with soils in the area. These parameters were modeled by assuming the river stage returned to typical river elevation (Approximately 1 ft NAVD88) and groundwater at elevation 25 feet after flooding occurs.

Unstable or Potentially Unstable Slopes

The stability of the slopes at the cross-section locations shown on the **Stability Plan** were analyzed based on the provided topography, proposed grading, soil properties derived from our prior geotechnical exploration and our experience with similar soil conditions.

Based on the analyses, the calculated FS for the critical surface identified in each section is shown below. The typically accepted minimum FS for long-term slope stability supporting improvements is 1.5. The slope stability results are included in the Appendix of this report. The minimum factor-of-safety for global stability at the cross sections analyzed is greater than 1.5 as shown in the following table:

Cross-Section	Structure	Minimum Calculated Factor-of-Safety for Slopes	
		Drained	Undrained
B-302	Sheet pile Bulkhead	5.5	3.0
B-303	Sheet pile Bulkhead	6.0	3.9
	Site Retaining Wall	2.7	3.8
B-304	Sheet pile Bulkhead	5.9	3.8
	Site Retaining Wall	3.1	5.6

Surficial Slope Stability

Surficial slope instability typically effects the upper 3 to 5 feet of the subsurface profile, predominantly during extended wet periods. Regular maintenance should be anticipated to identify and address changes in natural drainage creating potential for soil creep or erosion near improvements. The maintenance program should include replacing or replanting trees and grasses, as necessary, and grading the slope to reduce soil creep and erosion. If future surficial slope erosion occurs near the crest of slopes, we recommend the slope face be restored as soon as practical.

Fill slopes should be re-vegetated as soon as possible after grading and protected from erosion until vegetation is established. Slope planting should consist of ground cover, shrubs, and trees possessing deep, dense root structures that require minimum irrigation. It is the responsibility of the owner to maintain such planting.

Deep Foundations – Driven Piles

We recommend supporting the boardwalks and overlook on driven piles embedded approximately 10 feet below the existing ground surface to reach the required compressive capacity (5 kips) for 10-inch butt timber piles or 12-inch pipe piles planned for the project. Additional pile capacities for uplift and lateral can be provided upon request. However, additional pile embedment should be anticipated for greater design loads.

Static pile analyses were used to estimate axial compressive and uplift load capacities of single vertical piles based on a factor of safety of 2 for compression. The compressive capacity is developed primarily from skin friction but includes a contribution of end bearing. Timber piles should be Southern Yellow Pine and CCA pressure treated in accordance with the requirements of AWPA C3. Pipe piles should include design for potential corrosion.

The piles should be spaced on-center no closer than the three times the pile butt diameter; a center-to-center spacing of approximately 3 feet. The minimum spacing should be maintained to prevent the pile group compression load capacity from being significantly less than the summation of individual pile capacities. This spacing restriction also serves to limit surface heave and to reduce the possibility of damaging previously installed piles

Deep Foundation Construction Considerations

It is the opinion of Terracon that field monitoring of the pile installation is a direct extension of the design process. Pile installation techniques must be observed, weighed against the pile installation criteria and driving resistance recorded and evaluated to determine the acceptance of each pile.

At least two indicator piles should be installed at the site prior to ordering production piles. The results of the indicator pile installation can be used to evaluate installation methods, driving resistance, develop appropriate termination criteria, and determine pile length. The indicator pile should be installed at a design pile location and expected to be part of the final pile layout. We recommend that a 15-foot-long indicator pile be used. Production piles should not be ordered until their length has been determined by driving the indicator pile. Installation of the indicator piles should be observed by a qualified Geotechnical Engineer or technician.

The piles should be driven with a hammer with a minimum energy rating of 19,000 foot-pounds. We recommend dynamic driving criteria required for the recommended design capacity be developed once the rated energy of the hammer is known. The driving resistance may be determined by the Engineering News Record Formula or a wave equation driving analysis (WEAP) performed by the Geotechnical Engineer. If vibrated pile driving is selected, vibrated pile capacity could be determined with a series of load tests.

Driving should be terminated immediately if refusal (i.e., 4 blows per inch for timber) is reached to prevent damaging the piles. In the event the driving criteria are not achieved during the installation of an individual pile, we recommend the pile be left 2 to 3 feet high to allow a "re-strike" the following day. The development of the pile skin friction may be delayed by the build-up of pore water pressures in the soil during driving.

The installation of a pile foundation system should be in accordance with the local and state building code requirements. In addition, pile installation should be monitored by the Geotechnical Engineer's representative. In general, the representative should:

1. Prepare criteria for final driving.
2. Be present continuously during installation.
3. Record the dimensions of each pile, locate, and report obvious defects.
4. Count and record the blows for each foot of driving, and the final 6 inches.
5. Record energy rating of hammer.
6. Have knowledge of soil conditions at the site and the minimum required penetration of each pile.
7. Be cognizant of intended support mechanisms of piles on which to base acceptance or rejection, the need to pre-drill, or evaluating the presence of obstructions.
8. Have authority to suspend driving when unanticipated difficulties or conditions are encountered.

Excavations for foundations (pile caps) should be observed by the Geotechnical Engineer prior to placing concrete. The excavations should be free of loose soil and water. Water that should be removed is anticipated in deeper pile cap excavations.

General Comments

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly effect excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety and cost estimating including excavation support and dewatering requirements/design are the responsibility of others. Construction and site development have the potential to affect adjacent properties. Such impacts can include damages due to vibration, modification of groundwater/surface water flow during construction, foundation movement due to undermining or subsidence from excavation, as well as noise or air quality concerns. Evaluation of these items on nearby properties are commonly associated with contractor means and methods and are not addressed in this report. The owner and contractor should consider a preconstruction/precondition survey of surrounding development. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

Attachments

Site Location and Stability Plans

Contents:

Note: All attachments are one page unless noted above.

Site Location

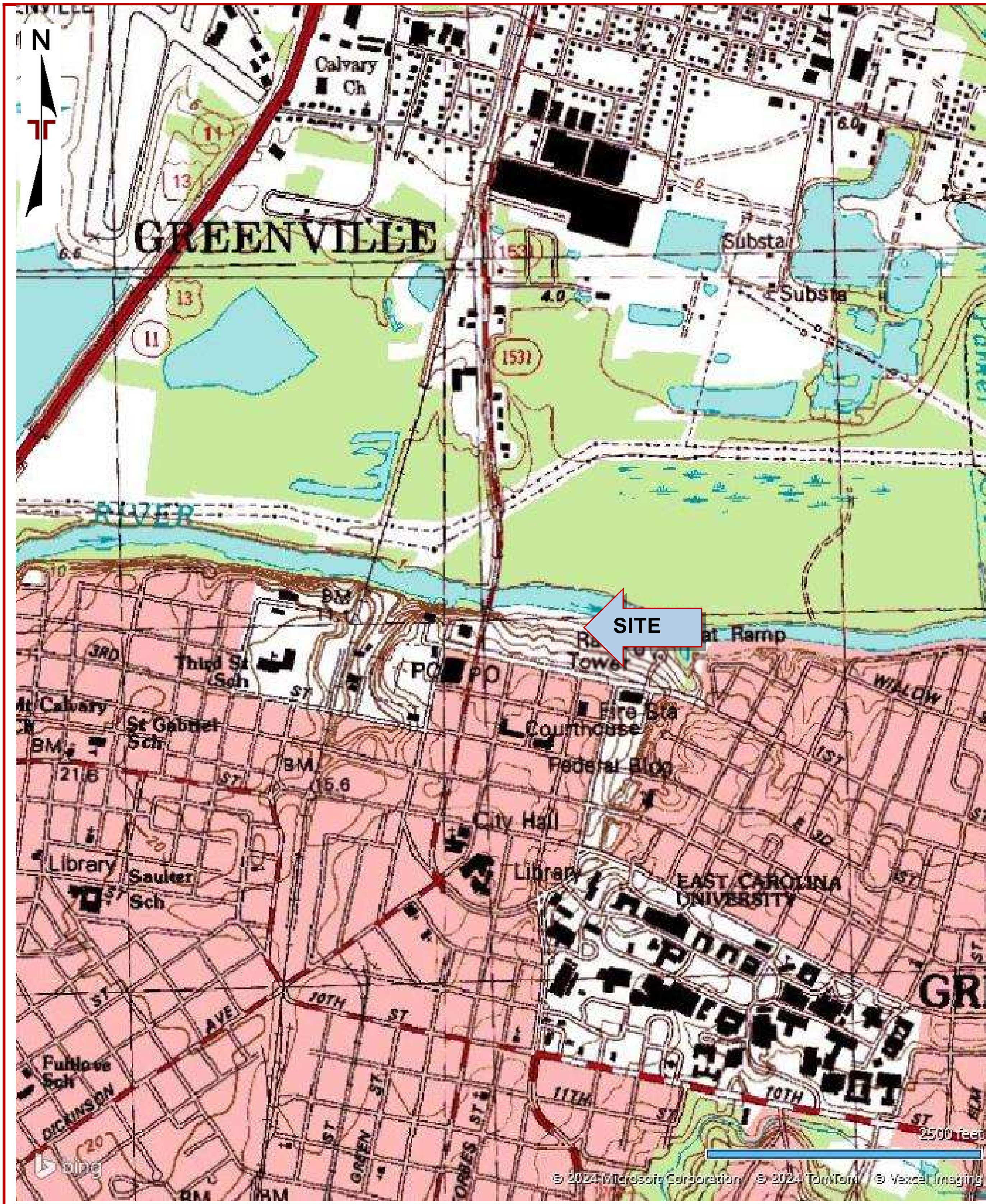


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES
MAP PROVIDED BY USGS; GREENVILLE, NC: SW, SE, NW, NE (1/1/1998)

Stability Plan

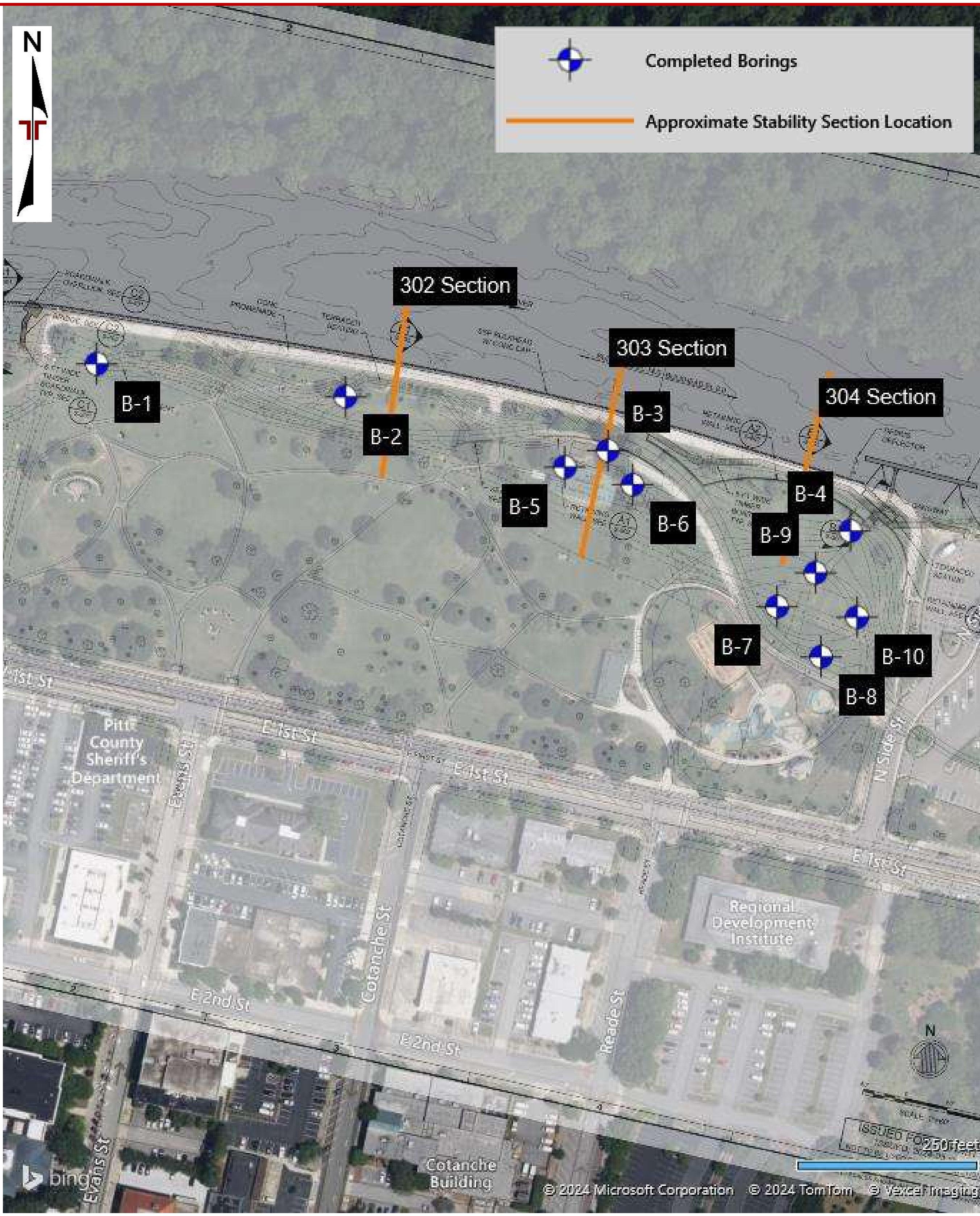


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

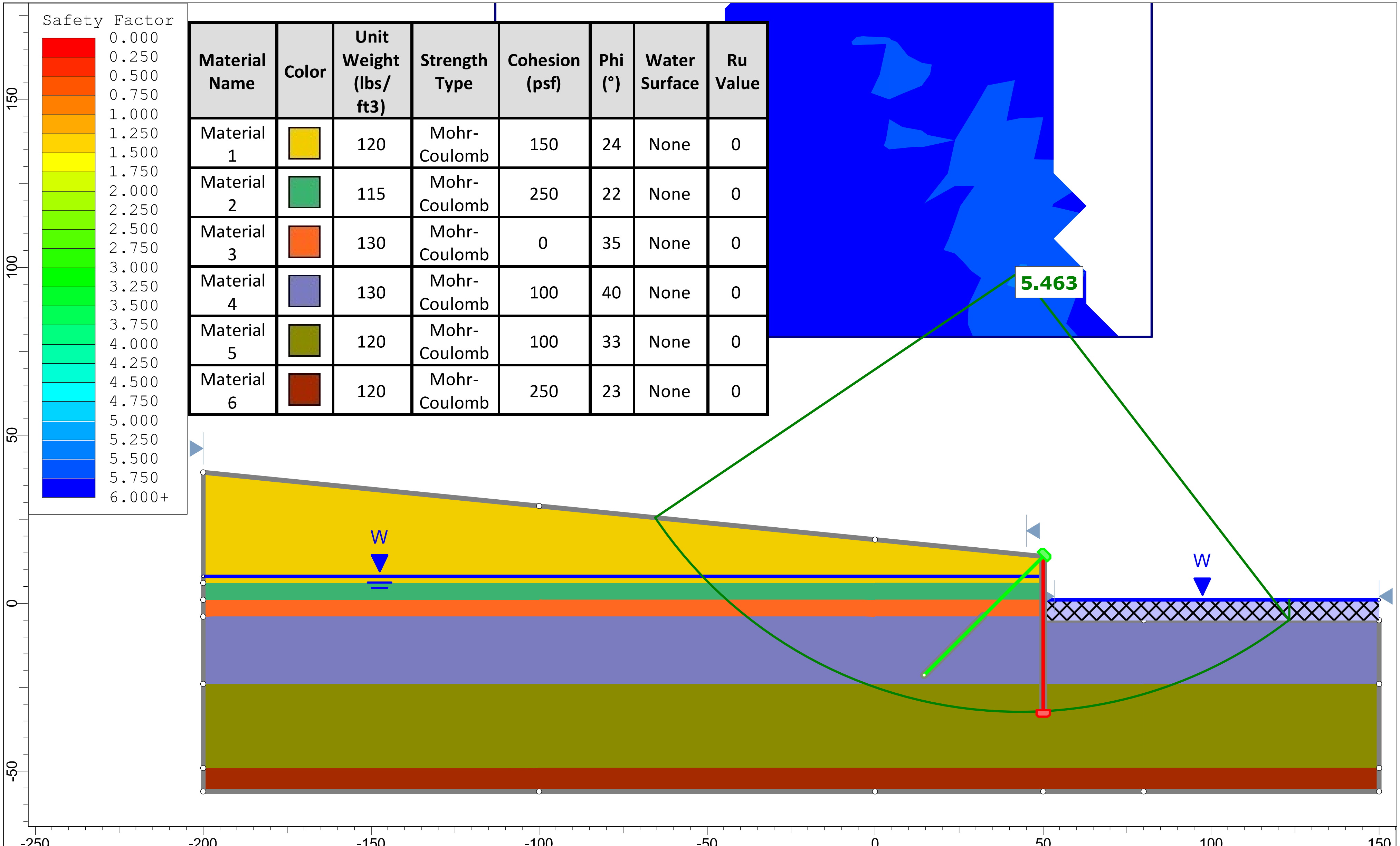
MAP PROVIDED BY BING MAPS
SITE PLAN PROVIDED BY CLIENT

Supporting Information

Contents:

Slope Stability Bulkhead Section Runs (six pages)
Slope Stability Site Retaining Wall Section Runs (four pages)

Note: All attachments are one page unless noted above.



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Material 1		120	Mohr-Coulomb	150	24	None	0
Material 2		115	Mohr-Coulomb	250	22	None	0
Material 3		130	Mohr-Coulomb	0	35	None	0
Material 4		130	Mohr-Coulomb	100	40	None	0
Material 5		120	Mohr-Coulomb	100	33	None	0
Material 6		120	Mohr-Coulomb	250	23	None	0

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Project	Slide2 - An Interactive Slope Stability Program		
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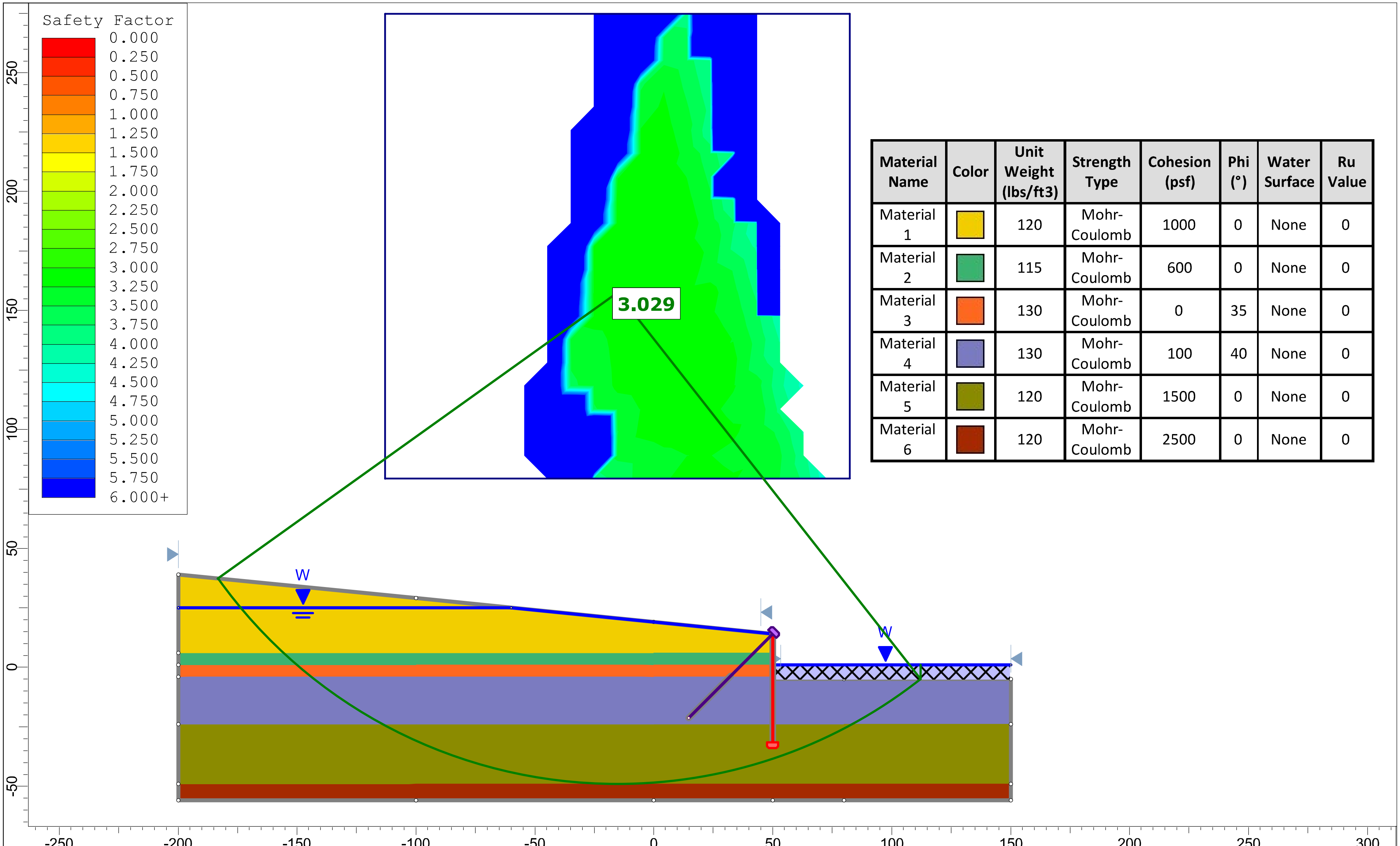
SLIDEINTERPRET 9.031



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Material 2		115	Mohr-Coulomb	600	0	None	0
Material 3		130	Mohr-Coulomb	0	35	None	0
Material 4		130	Mohr-Coulomb	100	40	None	0
Material 5		120	Mohr-Coulomb	1500	0	None	0
Material 6		120	Mohr-Coulomb	2500	0	None	0

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SLIDEINTERPRET 9.031

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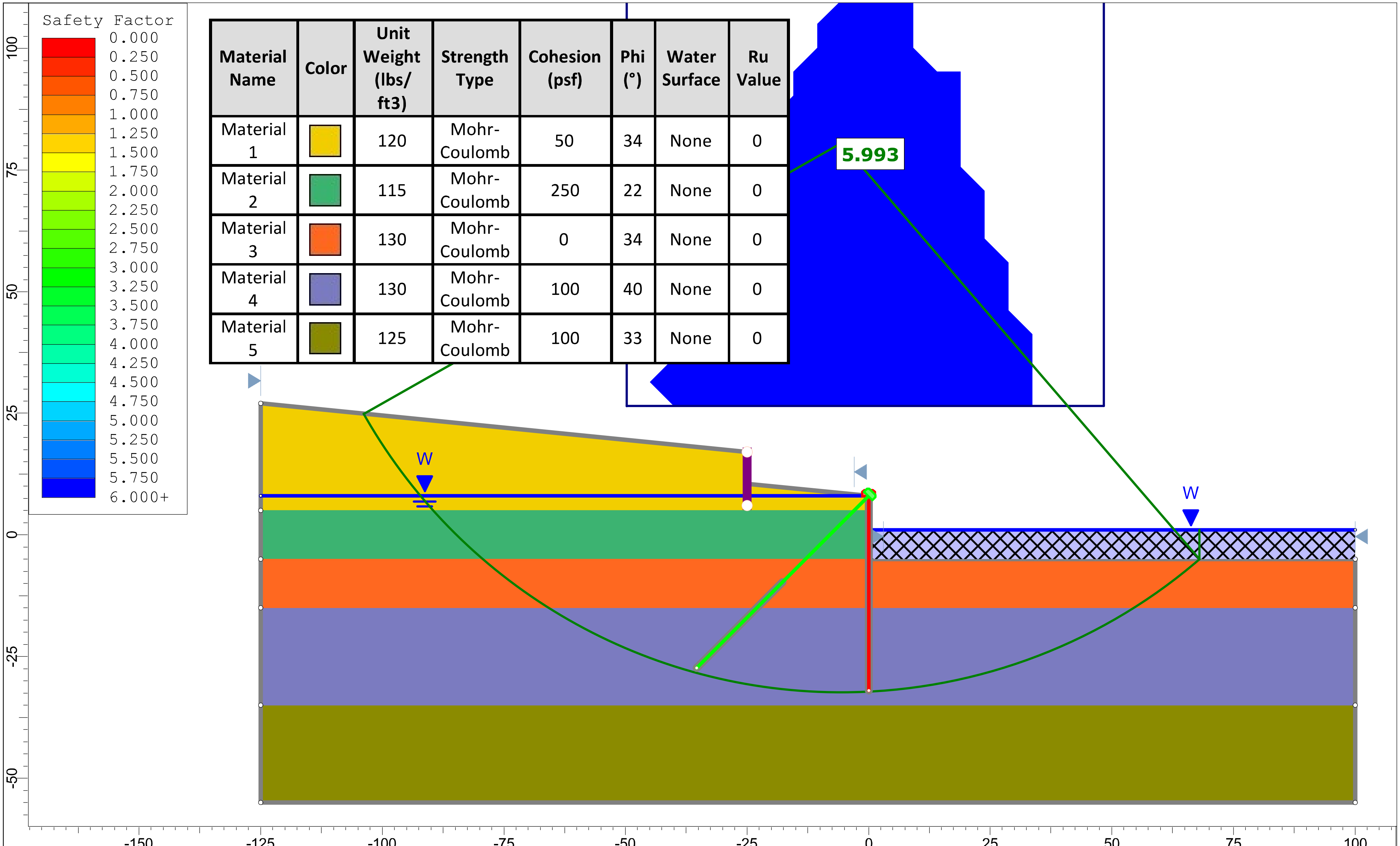

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Material 3		130	Mohr-Coulomb	0	34	None	0
Material 4		130	Mohr-Coulomb	100	40	None	0
Material 5		125	Mohr-Coulomb	100	33	None	0

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Project	Slide2 - An Interactive Slope Stability Program
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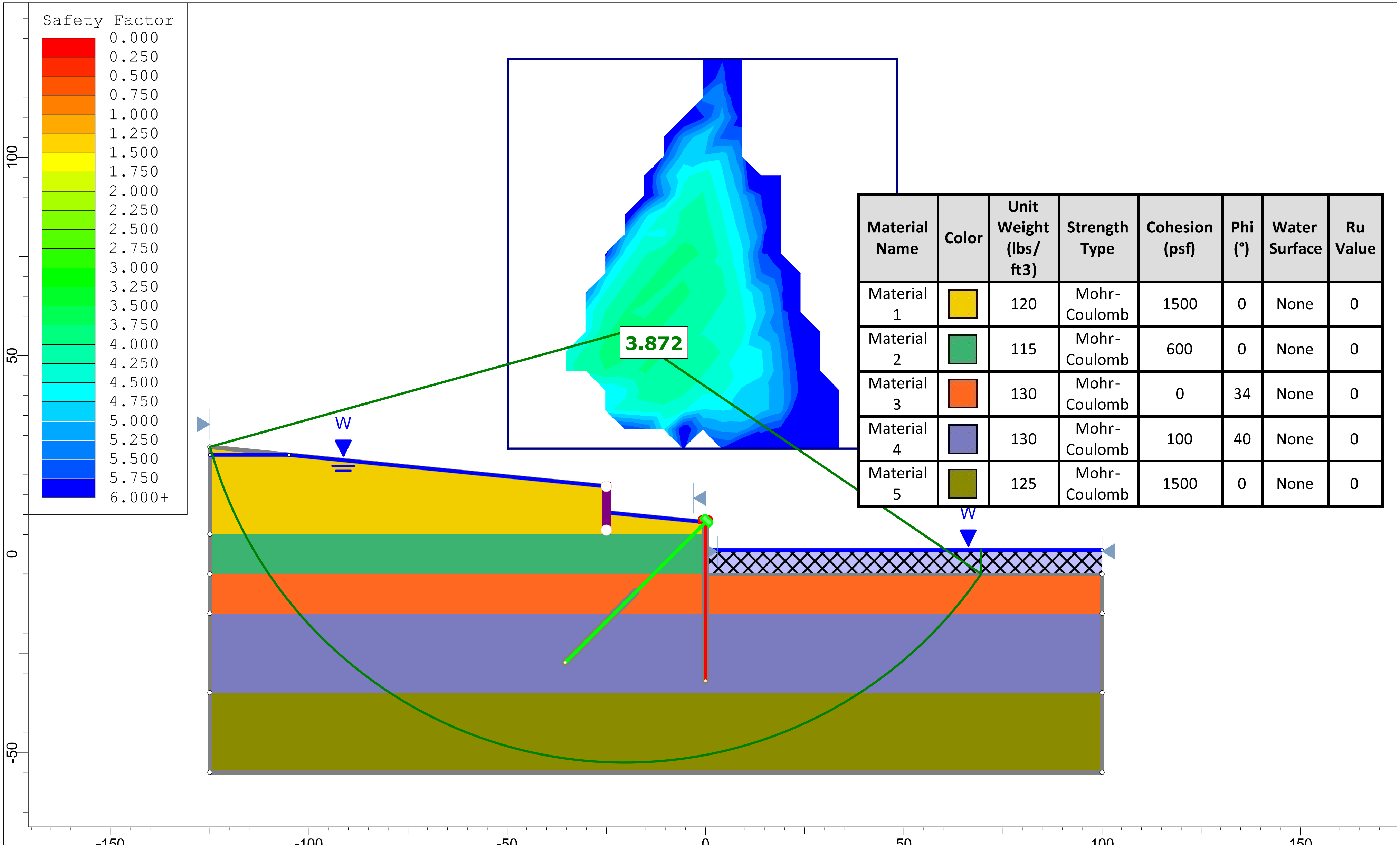
SLIDEINTERPRET 9.031



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Material 3		130	Mohr-Coulomb	0	34	None	0
Material 4		130	Mohr-Coulomb	100	40	None	0
Material 5		125	Mohr-Coulomb	1500	0	None	0

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SLIDEINTERPRET 9.031

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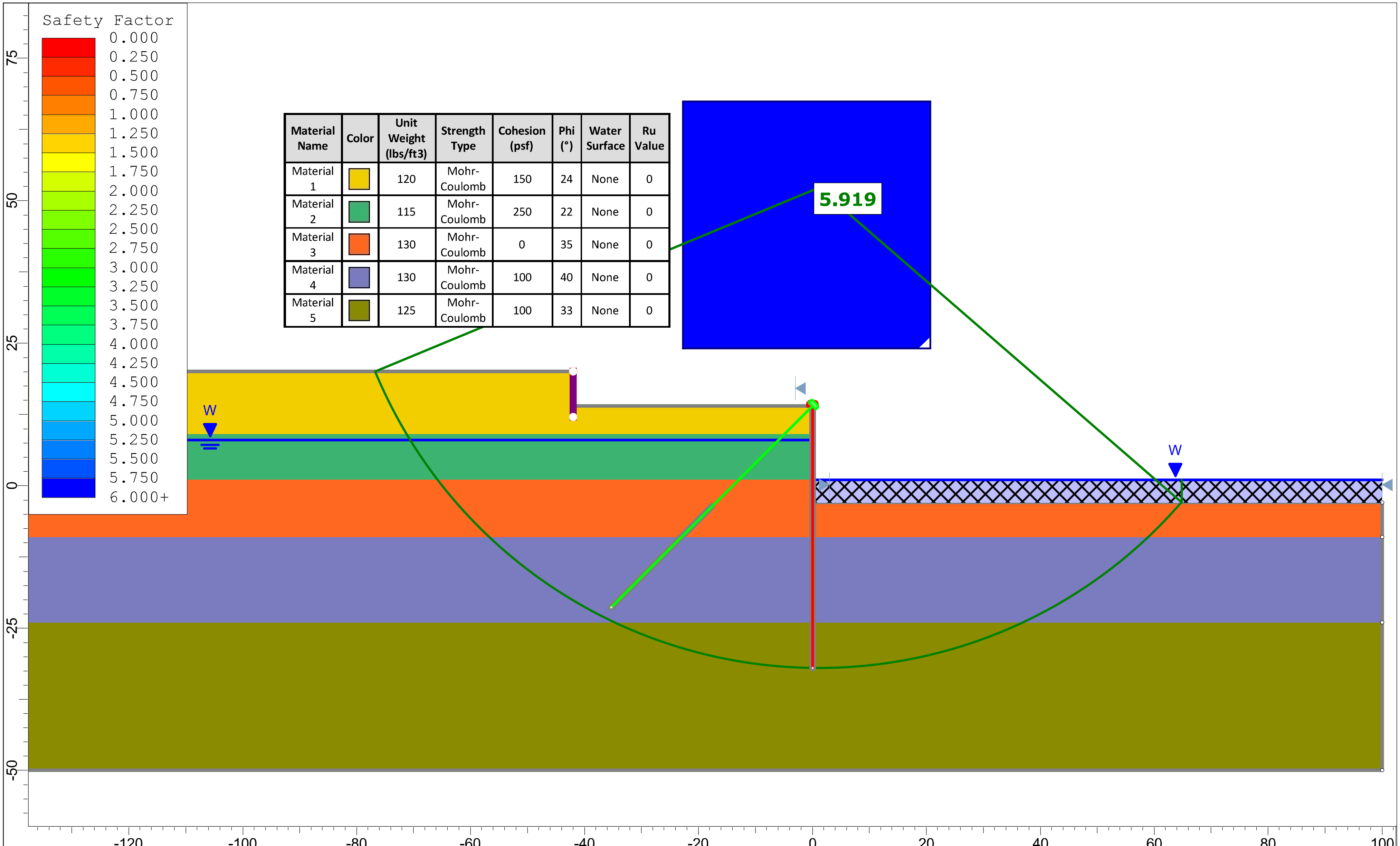

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Material 3		130	Mohr-Coulomb	0	35	None	0
Material 4		130	Mohr-Coulomb	100	40	None	0
Material 5		125	Mohr-Coulomb	100	33	None	0

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SLIDEINTERPRET 9.031

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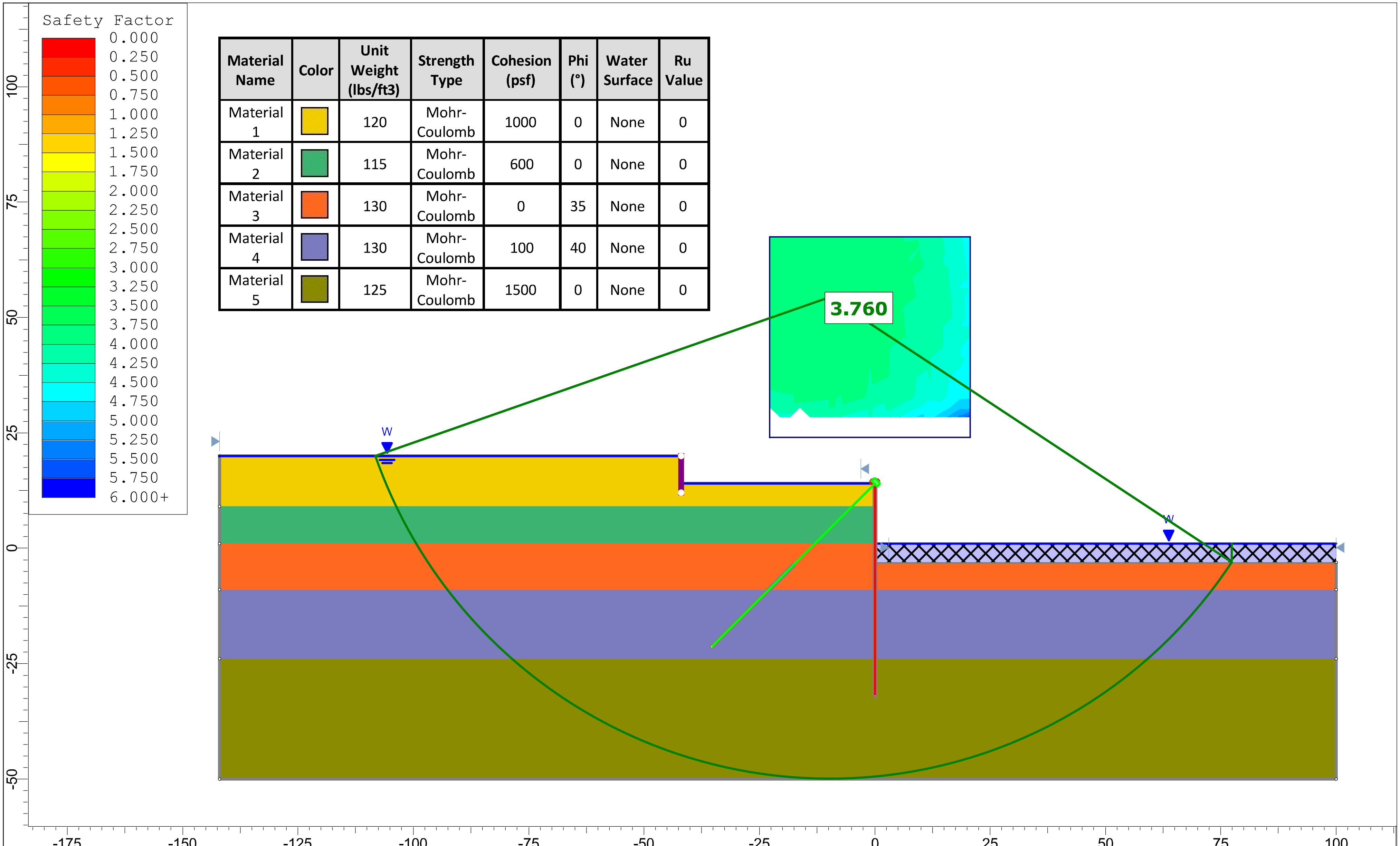

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Material 4		130	Mohr-Coulomb	100	40	None	0
Material 5		125	Mohr-Coulomb	1500	0	None	0

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SLIDEINTERPRET 9.031

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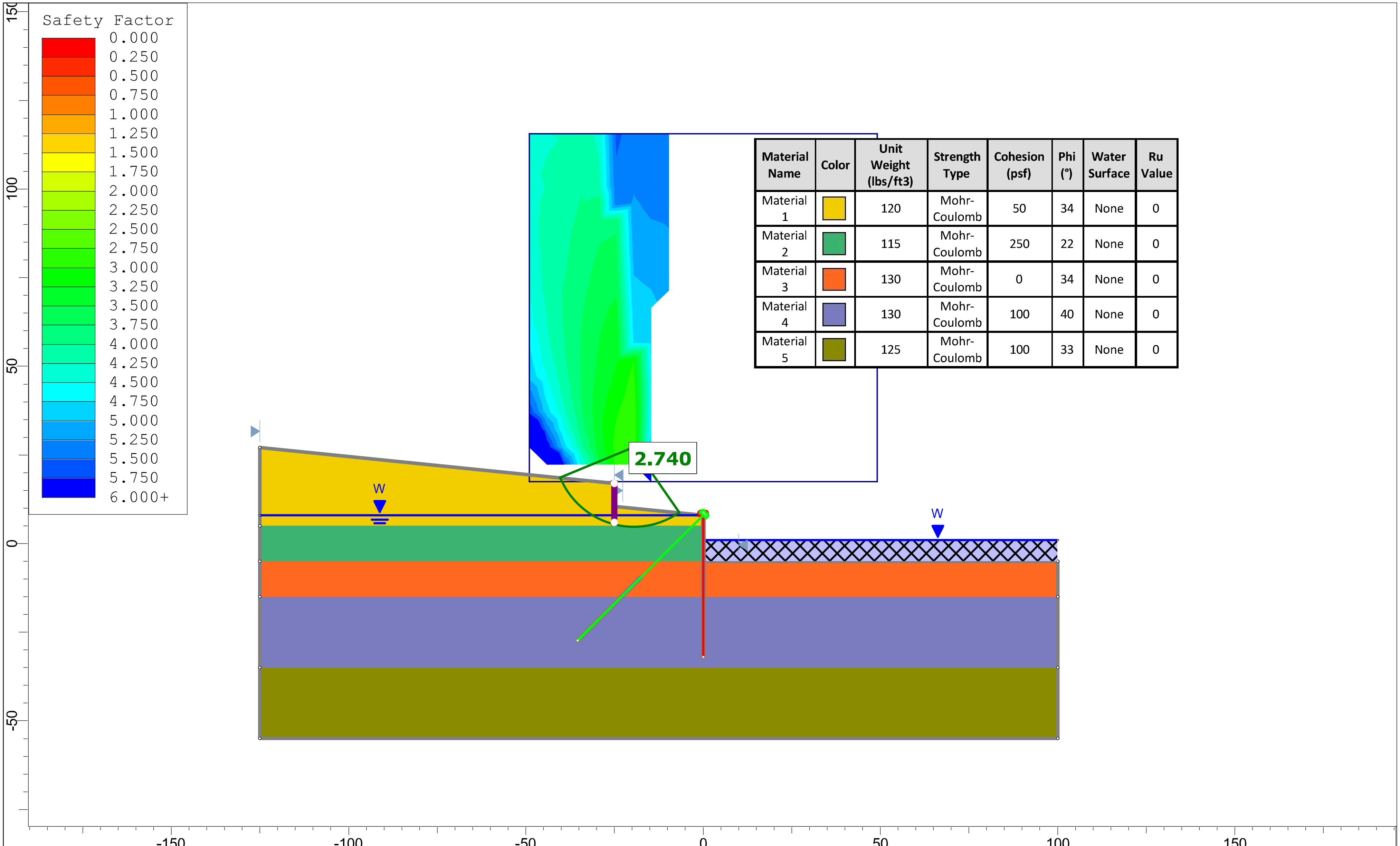

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Material 3		130	Mohr-Coulomb	0	34	None	0
Material 4		130	Mohr-Coulomb	100	40	None	0
Material 5		125	Mohr-Coulomb	100	33	None	0

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SLIDEINTERPRET 9.031

Project	Slide2 - An Interactive Slope Stability Program		
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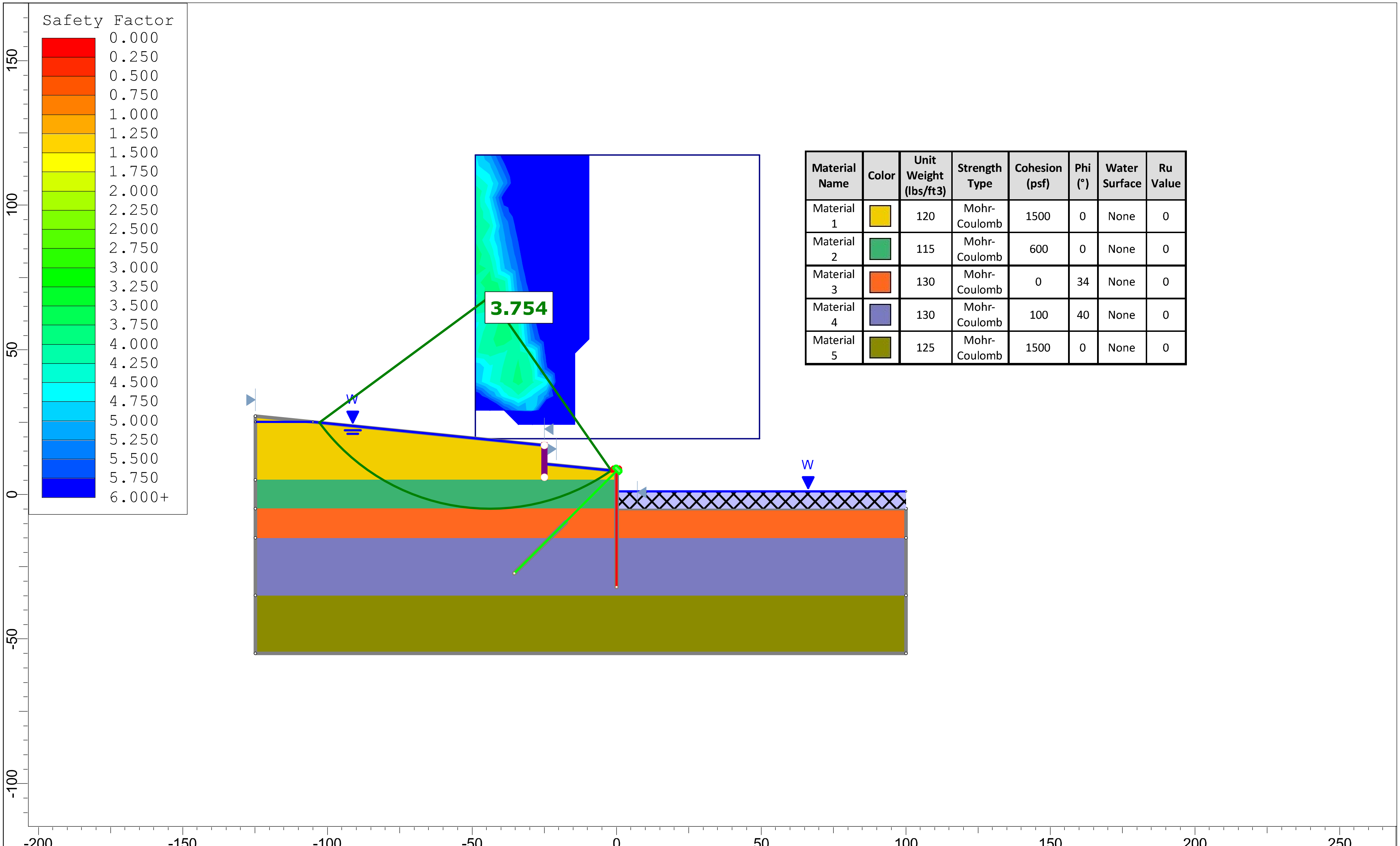

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Material 4		130	Mohr-Coulomb	100	40	None	0
Material 5		125	Mohr-Coulomb	1500	0	None	0

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SLIDEINTERPRET 9.031

Project	Slide2 - An Interactive Slope Stability Program		
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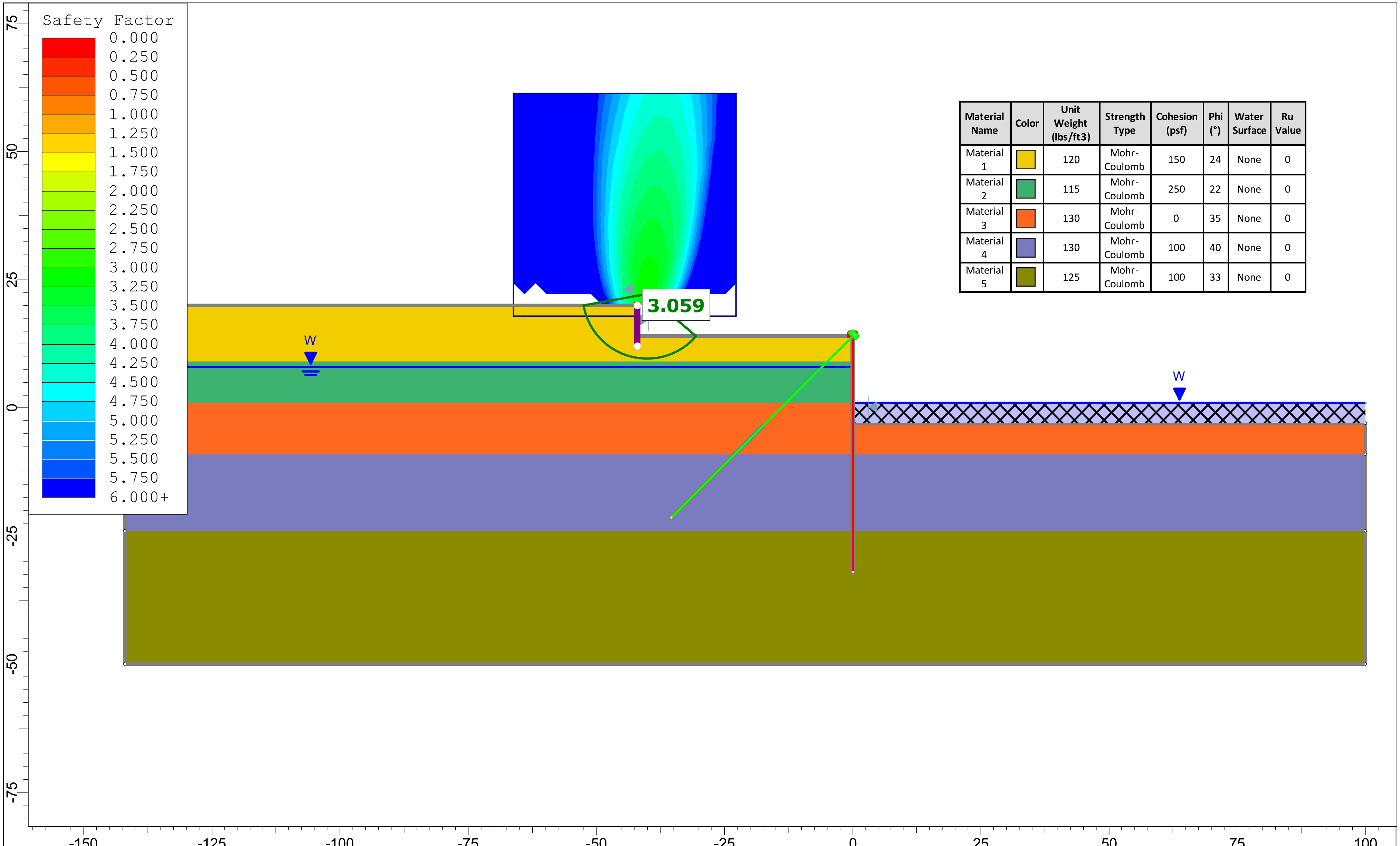

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Material 3		130	Mohr-Coulomb	0	35	None	0
Material 4		130	Mohr-Coulomb	100	40	None	0
Material 5		125	Mohr-Coulomb	100	33	None	0

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Project	Slide2 - An Interactive Slope Stability Program		
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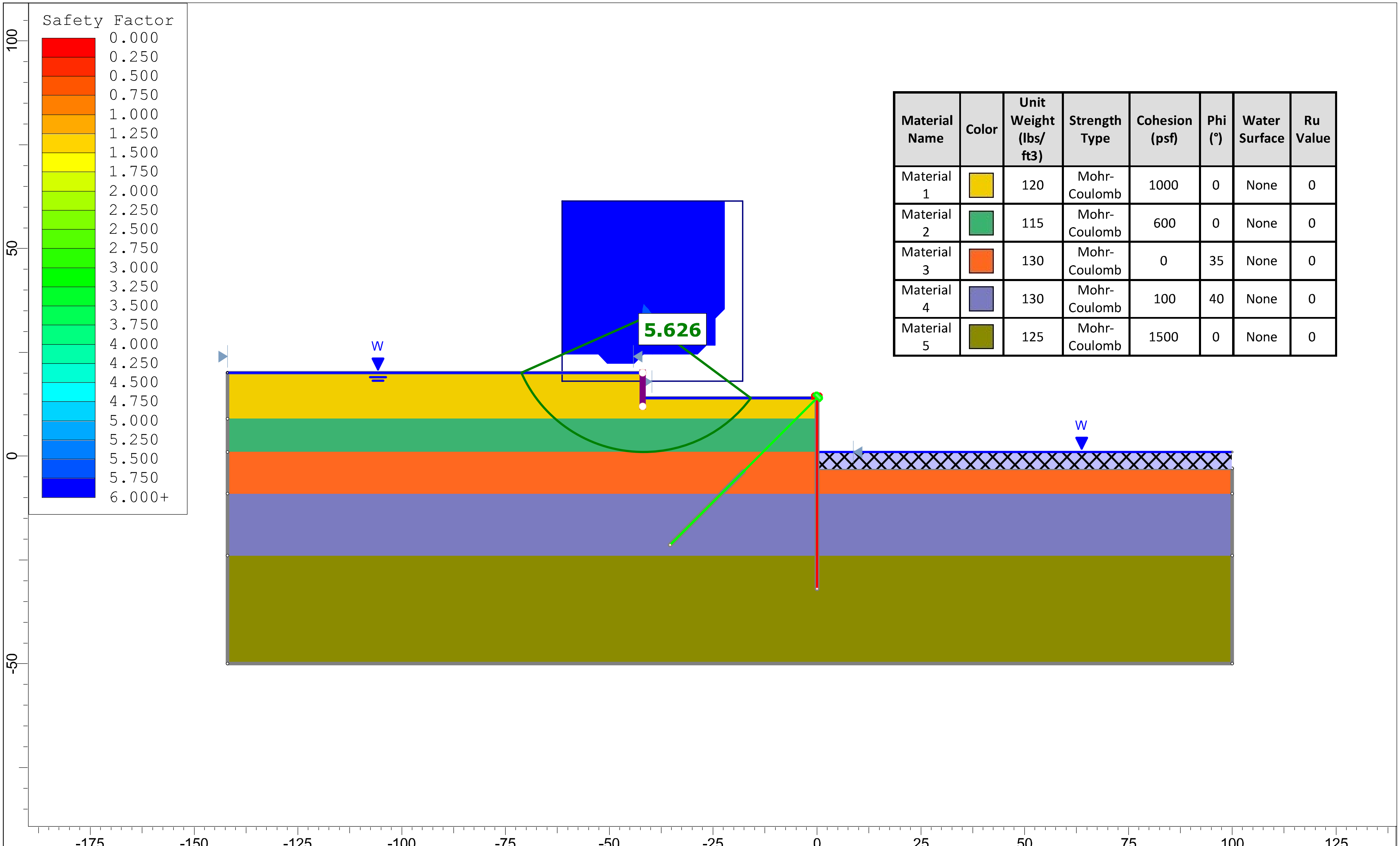
SLIDEINTERPRET 9.031



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Material 3		130	Mohr-Coulomb	0	35	None	0
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Material 5		125	Mohr-Coulomb	1500	0	None	0

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Project	Slide2 - An Interactive Slope Stability Program		
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SLIDEINTERPRET 9.031