24 June 2016

René McKibbin
Environment Canada – Canadian Wildlife Service
5241 Robertson Road
RR #1
Delta, BC V4K 3N2

Project No.: 219.05112
Client Reference No.: DFRP # 16096, ARMS # 00394, FCSI # 16096079

Dear Ms. McKibbin,

RE: CONCEPTUAL APPROACH -PROPOSED REMEDIATION PROGRAM UPLANDS TRAIL AREA, HISTORIC DUMP SITE, WILMER MARSH UNIT COLUMBIA NATIONAL WILDLIFE AREA, NEAR WILMER, BC

SLR Consulting (Canada) Ltd. (SLR) is submitting this letter to provide an overview of the conceptual approach for the proposed remediation program for the historic dump site at the Wilmer Marsh Unit of the Columbia National Wildlife Area (NWA), near Wilmer, BC (the Site). Specifically, SLR is providing this information in order to obtain approval from Canadian Wildlife Service (CWS) for the conceptual excavation and restoration approach and to identify probable conditions on the permit which would be issued for the remediation project by CWS. This information would then be included in the tender specification documents for the remediation project to ensure that potential contractors are aware of project constraints prior to submitting a bid for the project.

1.0 BACKGROUND

In early 2015, a remedial excavation was conducted at the Site to remove 3500 tonnes of contaminated soil and debris from a steep slope between the uplands bench and marsh. Historical dumping of automobiles, building debris, scrap metal, batteries and other refuse along the slope, with subsequent burial under soil, resulted in contamination of soils in the trail area. The buried debris has become exposed over time, particularly following high-intensity precipitation events which have occurred at the Site in the past 5 years. The observed exposure of contaminant source materials which have the potential for migration via erosion processes, coupled with the presence of sensitive habitat at the Site and the non-degrading nature of many of the contaminants (i.e. metals), resulted in the selection of a remedial excavation approach to reduce risks to ecological receptors. Not all of the debris and associated soil within the slope could be removed in 2015 due to geotechnical considerations and project constraints (budget and schedule) and a considerable amount of debris and associated contaminated soil remains embedded in the slope wall.

The soils at the Site are comprised of fine-textured glaciolacustrine materials that are susceptible to surface erosion and instability once disturbed. Consequently, restoration works were implemented in 2015 by the remediation contractor, and reviewed by the project geotechnical and environmental monitors, to mitigate these hazards and involved seeding of the disturbed areas with a native grass seed mix and installing a fully biodegradable erosion control blanket over the disturbed slope surfaces. Post-remedial site inspections by the project geotechnical and environmental monitors confirmed the efficacy of the sediment and erosion control measures to prevent loss of the fine-textured soils at the Site.

VAST Resource Solutions Inc. (VRSI) completed an excavation feasibility study and slope stability assessment at the Site in February 2016. As part of the study, VRSI made the following recommendations regarding future debris removal at the Site:

- *Excavation and removal of all of the estimated remaining debris and contaminated soil (estimated at 1500 m^3) can commence under the supervision of a Professional Engineer or Geoscientist. The excavation plan must employ a "Top Down" approach;*
- *The final excavation and reclamation plans must be approved by a Professional Engineer or Geoscientist prior to the commencement of debris removal;*
- *Machines and workers on the ground must not work below slopes containing debris and unconsolidated soil material (non-native) overlying native soils that are greater than 85% or 40 degrees (1H:1.17V). These slopes must be assessed by the supervising Professional during excavation;*
- *Based on the slope stability analyses and provided all recommendations within the VRSI report are adhered to, full bench trail construction can occur. Reclamation plans should consider recontouring by either pulling down the cut slope to reduce the slope or by hauling non-contaminated material back onto the trail to increase toe support. Reclamation will increase the Factors of Safety and overall long term stability. Final reclamation techniques may incorporate a series of small terraces and benches across the project site to achieve a final overall design ground slope of approximately 80% (1.25H:1V) or less. Full bench cut slopes should not exceed 200% (0.5H:1V). Small cut slope slumping and surface erosion is expected on cut slopes that are constructed at the 200% grade and not reclaimed/recontoured;*
- *If significant rain (or snowmelt) occurs during the excavation process, excavation must stop until a Professional Engineer or Geoscientist has assessed the Site and deemed the conditions safe to proceed* (NB: the role of the contractor's Professional Engineer or Geoscientist is discussed further in subsequent sections of this letter)*;*
- *Post-excavation monitoring to assess the slope stability should be conducted for several years after completion (i.e. annually for 5 years or until the slope is confirmed stable) and;*
- *All newly exposed soil will require erosion control measures to minimize erosion from wind and/or surface run-off and must be completed (where practicable) immediately after construction.*

A copy of the VRSI report has been appended to this letter. The VRSI report was reviewed by Clarke Geoscience Ltd. (CGL), the project geotechnical monitor during the original 2015 remediation activities. A copy of the CGL post-remediation monitoring report has been appended to this letter.

2.0 PROPOSED REMEDIATION PROGRAM

Remediation of the remaining debris/refuse and associated contaminated soil is scheduled for Winter 2016-2017. As part of the contracting process for the remediation project, National Master Specification (NMS) tender documents will be prepared and released on Buy and Sell, the federal government's procurement website. The NMS documents will detail the scope of work for the project and the associated constraints and regulatory requirements so that interested parties have sufficient information to submit a bid.

As part of the scope of work for the remediation project, which will be detailed in the NMS documents, the successful bidder will prepare and submit a detailed excavation design and restoration plan approved by a Professional Engineer or Geoscientist prior to conducting any excavation works. A Professional Engineer or Geoscientist will also be retained by the contractor to confirm implementation of the detailed excavation design and restoration plan and a qualified on-site Geotechnical Monitor will also be retained and supplied by the contractor to review excavation activities, as required by the detailed excavation design and restoration plan and the tender specification documents.

To ensure that the final remediation program design is approved and permitted by CWS, a conceptual excavation and restoration plan, indicating the required approach to the remediation project and potential permit conditions, must be incorporated into the tender specifications for the project.

To that end, SLR is providing the following information on the conceptual remediation approach for CWS review and approval. The conceptual excavation and restoration approach is based on the VRSI feasibility study and identifies potential geotechnical and environmental conditions of importance to CWS in the execution of the remediation project which must be incorporated into the project tender specifications. It is noted that specifying a particular conceptual approach will reduce the opportunity for the successful bidder to provide innovative approaches for the debris and contaminated soil removal. However, to limit uncertainty regarding the approach adopted by the successful bidder, as well as to reduce conflicts during the contracting process and to ensure implementation of an approach which will meet CWS' approval, it is SLR's opinion that the conceptual approach should be specified in the tender documents.

2.1 Excavation Approach

As recommended by VRSI, it is expected that a "Top Down" excavation approach will be employed. This approach has been recommended to facilitate the removal of unconsolidated debris and disturbed soils on the upper slope prior to removal of debris/refuse and contaminated soils at lower slope elevations. This is due to the potential for shallow slope failures of this unconsolidated material and the resulting risks to worker health and safety at lower elevations. It is also expected that this approach will minimize disturbance of the native vegetation areas on the upper bluff. Any alternate approach would require approval by the Public Works and Government Services Canada Departmental Representative and by CWS and would need to be approved by a Professional Engineer or Geoscientist.

The excavation will proceed sequentially as follows (please also refer to attached Drawings 1 and 3 and Section 5.2 of the attached VRSI report):

- The excavator will sit at the top of the upper bluff on level ground adjacent to the crest of the slope and reach down the slope and remove the thin (~0.5 m) veneer of debris and disturbed soil from the upper slope to the extent practical based on the reach of the equipment. Equipment access would be limited to the areas along the crest of the slope (some of which will be permanently lost as the excavation activities proceed).
- A full bench trail (4 m width, although this may vary depending on size of equipment and the final excavation design) would be constructed into the native soil across the slope. The first trail would be constructed along the elevation to which excavation of shallow

soil occurred in the previous bullet. The full bench cut slope shall be 200% / 0.5H:1V or less.

- The excavator will sit on the first bench and reach down the slope and remove soil and debris to the extent practical based on the reach of the equipment.
- A second full bench trail (4 m width) would be constructed into the native soil across the slope at the elevation to which excavation occurred in the previous bullet.
- The excavator will sit on the second bench and reach down the slope and remove soil and debris to the extent practical based on the reach of the equipment.
- If necessary, a third full bench trail (4 m width) would be constructed to facilitate the removal of any remaining soil and debris.
- The above will involve a balance of minimizing the footprint of the constructed bench trails, the number of constructed bench trails, the amount of native soil to be removed and the size of equipment appropriate to complete the work according to the final design.
- Two excavators may be required depending on the operational constraints associated with the grade of the lower trail. One to excavate material and bail it to a second excavator sitting at a higher elevation, which can then place the material into a transport vehicle. It should be noted that the transport vehicle must be able to operate on relatively steep grades comprised of loose silty soils and should be a rubber-tracked haul truck with 360˚ revolving upper structure given the space limitations on the access routes, such as a Morooka hauler. Rubber-tracked haulers with 360˚ revolving upper structures were utilized during previous excavation activities and are considered by SLR to be the preferred equipment for transporting materials on-site based on our experience and observations. Based on previous discussions with CWS personnel, it is SLR's understanding that surfacing the access trail with imported materials (such as crushed gravel) is not permitted.

The above-listed excavation approach is anticipated to result in the removal of approximately 1000 m^3 of native soil in order to access and remove approximately 1500 m^3 of debris/refuse and contaminated soil. The above approach is intended to minimize disturbance of native vegetation on the upper bluff other than in areas where native soils are being removed for the construction of full bench trails (i.e. loss of material along the crest of the slope). The above approach will also limit equipment traffic to previously disturbed areas in order to minimize disturbance of native vegetation at the Site.

Drawing 2 has been attached to conceptually illustrate the construction of the benches in the slope cross-section.

2.2 Restoration Approach

Because there is limited room along Westside Road for the stockpiling of excavated native soils (refer to Drawing 1), and because native soils are very susceptible to erosion once disturbed, it is expected that the excavated, non-contaminated native soils would be transported off-site for disposal at a permitted facility unless an alternate location could be identified within the NWA by CWS. Some limited re-use of excavated, non-contaminated native soils may occur where necessary to facilitate site restoration and/or to provide additional slope stability (i.e. placement of additional weight at toe of cut slopes - although this would require more extensive restoration and erosion and sediment control measures).

Following excavation, the full bench trails will have cut slopes of 200% / 0.5H:1V or less and the remaining excavated sections between are expected to have slopes of 80% / 1.25H:1V or less.

There are various options for the final physical appearance of the work area which vary in terms of cost and level of effort involved in implementation. SLR has presented the options below but it is expected that further discussion with CWS will be necessary to define the approved conceptual restoration approach:

- Option 1: Leave post-excavation state as is with areas of over-steepened slopes of native soil. Since application of erosion control blanket on slopes exceeding 1H:1V is not recommended, these exposed surfaces will likely be subject to surface erosion over time. Erosion control blankets and other measures (such as cross-ditches and waddles) could be installed on less steep slopes and it is anticipated that eroded sediments from the steeper sections would accumulate within these mitigative features and gradually soften the slope naturally over time. It is noted that undisturbed silt bluffs in the surrounding area (i.e. natural analogs) are comprised of oversteepened upper slopes which gradually become more shallow due to erosion processes. Photographs of natural analogs in the area of the Site are attached as Photos 1 and 2. It is noted that large-scale (i.e. deep-seated) failure of oversteepened native soils in the trail area is not expected due to the lack of observed features that may result in catastrophic slope weakness and slumping (e.g. groundwater) and based on the results of the VRSI slope stability assessment. Although large failures have been observed in the surrounding area, these have generally only been observed where groundwater is acting as a failure plane (e.g. slopes immediately adjacent to the marsh) or significant overland surface runoff has contributed to undercutting of slopes and removal of toe supports (e.g. at stormwater ditch outfalls).
- Option 2: Reclaim and regrade/recontour the full bench trails by pulling down the cutslope to an approximate 80% / 1.25H:1V slope and placing the material on the trail surface as toe support. As the material placed as toe support will be more susceptible to erosion, erosion control and mitigation will need to be applied over the entire extent of the excavated slope. As the recontoured slopes will be more amenable to the installation of erosion control blanket, this represents a significant surface area. Such an approach was implemented during the previous remediation activities and photographs have been attached to provide a visual indication of what the post-remediation condition could look like under such an approach.

There may also be the opportunity to incorporate the construction of narrow terraces for wildlife movement within the above options. Following the previous remediation activities, narrow terraces were created in select locations to facilitate installation of the erosion control blanket and to serve as access trails for wildlife. Subsequent site visits by SLR's Environmental Monitor confirmed the use of these terraces/trails by wildlife (e.g. deer). It is noted that the construction of these features may or may not be achievable based on observed site conditions at the time of construction.

Based on observed slope conditions following the previous remediation project in 2015, it is expected that vegetation growth will occur in areas where erosion control blanket has been installed on moderate slopes and where it provides moisture and protection from surface erosion processes. Hand-seeding of slopes with a native grass seed mix (60% Bluebunch Wheatgrass, 15% Sandberg's Bluegrass, 15% Idaho Fescue and 10% Indian Ricegrass) prior to installation of erosion control blanket would be completed. On oversteepened native soils where erosion control blanket cannot be applied, it is expected that the soils would remain exposed over time, similar to what is observed in natural analogs in the surrounding area. Hand-seeding would not be performed on oversteepened native soils. Given the timing of the project, it is not expected that planting of native plant plugs could occur within the remediation project contract.

Finally, the installation of erosion and sediment control measures within the gully at the base of the slope (installation of waddles, construction of cross ditches) is recommended to mitigate overland flow of sediments into the marsh. It is noted that these are conservative precautions given that the distance from the base of the slope where work will be occurring and the marsh is 200 m and the gully is relatively flat-lying and well vegetated. A photo of the gully between the work area and the marsh has been included for reference.

2.3 Potential Permit Conditions

During the previous remediation project, the following project-specific conditions were included on the permit and are considered applicable to the proposed 2016-2017 remediation project:

- Temporary construction access mats are to be placed from the fence adjacent to Westside Road to the top of trail leading to the work area to mitigate impacts from vehicle and equipment traffic on the upland bench. All vehicles and equipment will be required to travel on the access mats in the area. It is noted that placement of mats would also be recommended for the proposed remediation project between the fence on Westside Road to the crest of the slope above the proposed work area. The placement of mats is also dependent on observed climatic conditions and safety considerations.
- Equipment to be used on site will be limited to that equipment listed within the permit (contractor must provide details within final permit application). Equipment listed for the previous remediation project which may also be used for the 2016-2017 remediation project includes:
    - Spider excavator
    - 200 Class Excavator with thumb (or similar)
    - 160 Class Excavator with thumb (or similar)
    - 85 Class Excavator with thumb (or similar)
    - Tandem dump truck for transportation of materials on the flat-lying upper bluff
    - Rubber-Tracked Dumper with Revolving Upper Structure (Morooka-type hauler or similar) for transportation of materials on steeper grades
    - 650 Class Dozer with winch
    - Any other equipment prescribed by the Professional Engineer/Geoscientist approving the Detailed Excavation and Restoration Design which meets conditions/constraints listed in the permit and/or tender specifications for the project and which has been approved by the Departmental Representative in accordance with the tender specifications.
- Soil and debris from the trail work area would be transported to a staging area situated along Westside Road.
- The staging area alongside Westside Road is to be located outside of the NWA fencing, is to be lined with an impermeable liner, and is to be located immediately adjacent to Westside Road as done during past remediation projects.

Other standard terms and conditions included on the permit for the previous remediation project, and considered appropriate for the future works, include the following:

- Permit must be signed to be valid.
- This permit allows for work around migration in the area.

- The issuance of this permit does not supersede the necessity to meet other legal requirements to acquire any federal, provincial or municipal licenses, permits or other authorizations required by law.
- This permit is not transferrable to any other person(s) or organization(s).
- Upon completion, notify Courtney Albert (or alternate CWS representative) so an inspection of the Site may be conducted.
- Only qualified personnel, experienced in the identification and life cycle of Species at Risk and familiar with the specific locations, will monitor and oversee the timing of the activities.
- All reasonable alternatives to this activity have been considered, all feasible measures will be taken to minimize the impact of the activity on the species, and the activity will not jeopardize the survival or recovery of the species.
- These Terms and Conditions are only valid for the activities described above. They (or a copy) must be carried by the applicant or a member of the field crew and be made available to a Wildlife Enforcement Officer upon request.

Due to the nature of the proposed 2016-2017 remediation project, the following additional project-specific conditions are anticipated:

- Movement and operation of equipment in the vegetation exclusion zones identified in the tender specification documents is prohibited. Foot traffic is allowed along access paths identified in advance by the Environmental Monitor.
- Disturbance of wildlife trees is prohibited except where approved specifically by CWS.
- Erosion and sediment control materials must be comprised of natural materials, be fully biodegradable and be installed in accordance with the tender specification documents (and/or manufacturer specifications).
- Native grass seed used during the restoration process must be obtained from a supplier approved by CWS (e.g. Sagebrush Nursery in Oliver, BC or Interior Seed and Fertilizer in Cranbrook, BC). The seed mix composition must be as follows: 60% Bluebunch Wheatgrass, 15% Sandberg's Bluegrass, 15% Idaho Fescue and 10% Indian Ricegrass.
- Native, non-contaminated soil generated during the excavation of the full bench trails or from the physical restoration of oversteepened cut slopes is to be re-used on-site only where required for site restoration purposes (and appropriately mitigated for potential erosion) and/or slope stability purposes as approved by the Professional Engineer/Geoscientist approving the Detailed Excavation and Restoration Design and by the Departmental Representative. All other materials excavated during the project are to be transported off-site for disposal in accordance with the tender specifications.
- The Detailed Excavation and Restoration Design submitted for approval by the Departmental Representative and submitted to CWS as part of the remediation project permit application must be completed in consideration of the recommendations outlined in the VRSI excavation feasibility study which include the following:
    - The final excavation and restoration design must be approved by a Professional Engineer or Geoscientist.
    - The excavation plan must employ a "Top Down" approach.
    - Full bench cut slopes should not exceed 200% / 0.5H:1V.
    - The restoration design may consider re-contouring by either pulling down the cut slope to reduce the slope or by hauling non-contaminated native soil back onto the trail to increase toe support and/or may consider incorporating a series of small terraces and benches across the trail work area.

- o The final overall design ground slope should be approximately 80% 1.25H:1V or less.
- o Erosion and sediment control measures are to be implemented on newly exposed soil surfaces as part of the final restoration design immediately following completion of the excavation (where practicable).
- o Excavation and removal of all the estimated remaining debris and contaminated soil is to be conducted under the supervision of a Professional Engineer or Geoscientist.
- o Equipment and workers on the ground must not work below slopes containing debris and unconsolidated soil material (non-native) overlying native soils that are greater than 85%/40 degrees/1H:1.17V. These slopes must be assessed by the supervising Professional Engineer/Geoscientist during excavation.
- o If significant rain (or snowmelt) occurs during the excavation process, excavation must stop until a Professional Engineer or Geoscientist has assessed the Site and deemed the conditions safe to proceed;

3.0 PROJECT TIMELINES

In order to complete the remediation project within fiscal 2016-2017 and migratory bird windows, the following project timelines and milestone dates will be necessary:

- Receipt of documented approval of conceptual excavation and restoration design from CWS and identification of all potential permit conditions on July 25, 2016.
- Submission of draft tender specifications to PWGSC, EC and CWS on August 5, 2016 to allow review and edits prior to finalization.
- Submission of final tender specifications to PWSGC Contracting on August 19, 2016 in preparation for release on Buy and Sell.
- Release of tender opportunity on Buy and Sell on September 6, 2016. This will allow the bid to close on September 30, 2016.
- Award of contract to successful bidder on October 7, 2016 to allow three weeks for completion of Detailed Excavation and Restoration Design by Professional Engineer/Scientist retained by the bidder by October 28, 2016.
- Submission of permit application for the remediation project, including submission of Detailed Excavation and Restoration Design, to CWS by November 4, 2016.
- Receipt of permit for the remediation project from CWS by December 5, 2016.
- Completion of remediation and restoration between December 12, 2016 and March 3, 2017.

As noted above, in order to complete the remediation and restoration at the Site by March 3, 2017, approval from CWS for the enclosed conceptual excavation and restoration design and confirmation of anticipated permit conditions must be obtained **by July 25, 2016**.

4.0 CLOSING

This report has been prepared for specific application to this site and site conditions existing at the time work for the report was completed. Any conclusions or recommendations made in this report reflect SLR's professional opinion based on limited investigations including: visual observation of the site, surface and subsurface investigation at discrete locations and depths, and laboratory analysis of specific chemical parameters. The results cannot be extended to previous or future site conditions, portions of the site that were unavailable for direct investigation, subsurface locations which were not investigated directly, or chemical parameters and materials that were not addressed. Substances other than those addressed by the investigation may exist within the site; and substances addressed by the investigation may exist in areas of the site not investigated in concentrations that differ from those reported. SLR does not warranty information from third party sources used in the development of investigations and subsequent reporting.

Nothing in this report is intended to constitute or provide a legal opinion. SLR expresses no warranty to the accuracy of laboratory methodologies and analytical results. SLR makes no representation as to the requirements of compliance with environmental laws, rules, regulations or policies established by federal, provincial or local government bodies. Revisions to the regulatory standards referred to in this report may be expected over time. As a result, modifications to the findings, conclusions and recommendations in this report may be necessary.

If you have any questions or concerns, please do not hesitate to contact the undersigned. It may be beneficial to arrange a conference call with yourself, Environment Canada and PWGSC to discuss the information in this letter and I will be in contact with you to arrange this.

Yours sincerely,
SLR Consulting (Canada) Ltd.

Lindsay Paterson, MSc, PAg
Soil Scientist

Encl: Drawings 1 and 2
Photographs 1 through 5
VRSI Report, dated March 2016
Clarke Geoscience Ltd. Reports, dated October 23, 2015 and March 31, 2016

LP/lp

2016 June 24 Wilmer Conceptual Excavation Design.docx

NOTES:
DRAWING COMPILED FROM SURVEY PLAN FROM FOCUS 010047749-MCS101-R02.DWG AND (ACAD2004)030400548-102-TP1-R1, DATE MARCH 28,

LEGEND:

- PROVINCIAL - FEDERAL BOUNDARY
- FENCE
- SOIL AND/OR DEBRIS REMOVAL AREAS

0 25 50 100 m

SCALE 1:1,500
WHEN PLOTTED CORRECTLY ON A 17 x 11 PAGE LAYOUT
NAD 1983 UTM Zone 11 U

THIS DRAWING IS FOR CONCEPTUAL PURPOSES ONLY. ACTUAL LOCATIONS MAY VARY AND NOT ALL STRUCTURES ARE SHOWN.

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
WILMER MARSH UNIT COLUMBIA NWA
WILMER, BC

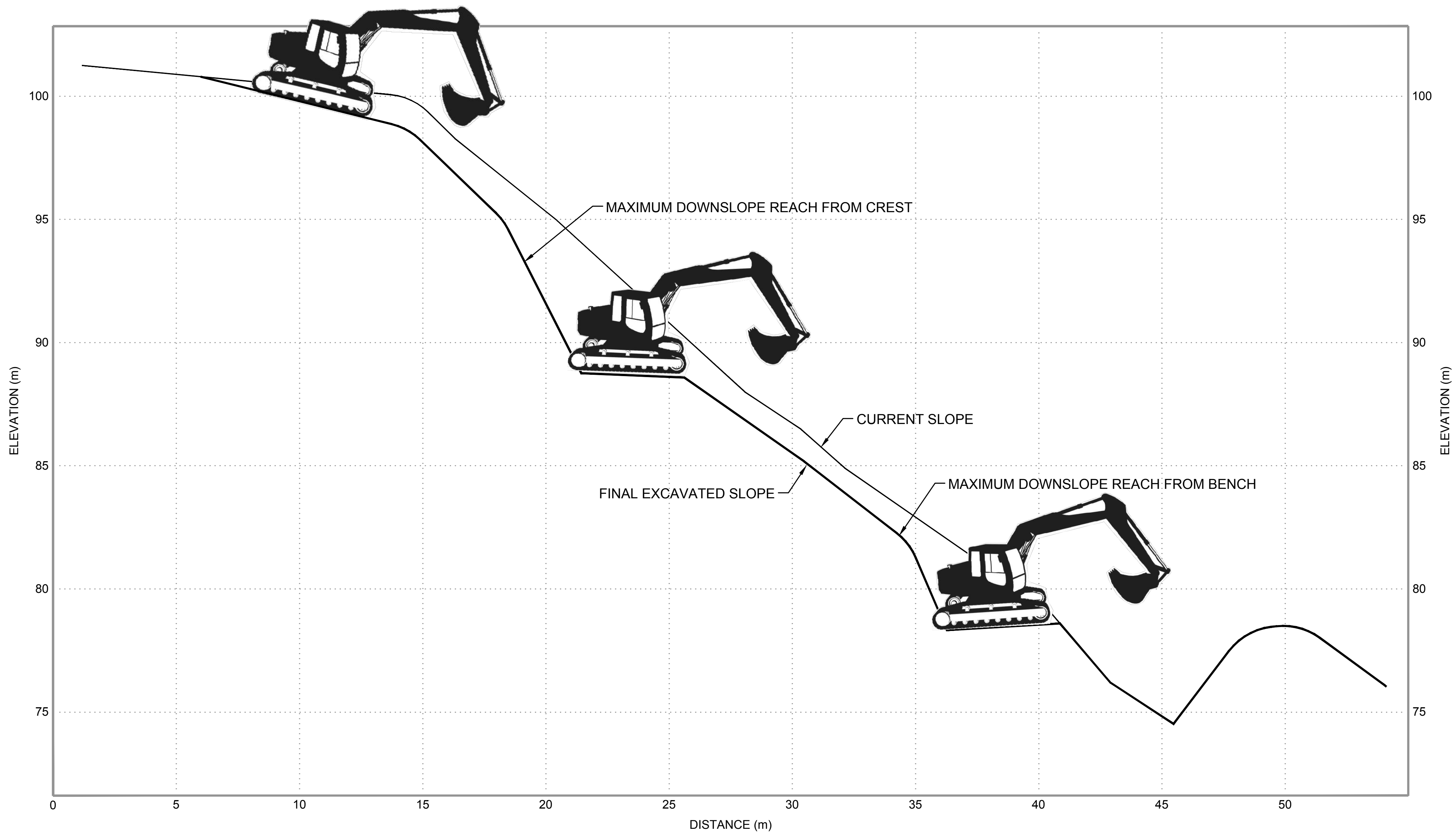
CONCEPTUAL REMEDIATION APPROACH

SITE PLAN

Date: June 24, 2016	Drawing No. 1
Project No. 219.05112.00013	

SLR
global environmental solutions

Cadfile name: S_219-05112-00013-A1.dwg



0 2 4 8 12 m

SCALE 1:200
WHEN PLOTTED CORRECTLY ON A 11 x 17 PAGE LAYOUT

THIS DRAWING IS FOR CONCEPTUAL PURPOSES ONLY. ACTUAL LOCATIONS MAY VARY AND NOT ALL STRUCTURES ARE SHOWN.

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
WILMER MARSH UNIT COLUMBIA NWA
WILMER, BC

CONCEPTUAL REMEDIATION APPROACH

EXAMPLE CROSS SECTION A

Date: June 24, 2016	Drawing No. 2
Project No. 219.05112.00012	

SLR
global environmental solutions

Cadfile name: S_219-05112-00013-A2.dwg

Photo 1: View of natural analogs next to marsh north of the site.

Photo 2: View of natural analog to southeast of proposed work area.

Photo 3: View of extensive erosion control blanket installation in March 2015.

Photo 4: View of narrow wildlife path within blanketed areas in March 2015.

Photo 5: View of gully below remediation work area looking toward marsh.

Excavation Feasibility and Slope Stability Assessment
Wilmer Marsh Unit, Columbia National Wildlife Refuge
Wilmer, BC

Prepared For: SLR Consulting (Canada) Ltd
1475 Ellis Street, Suite 200
Kelowna, BC V1Y 2A3

Prepared By: VAST Resource Solutions Inc.
PO Box 538
Cranbrook, BC
V1C 4J1

March, 2016

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March 30, 2016 VAST File: 16.0019.00

SLR Consulting (Canada) Ltd
1475 Ellis Street, Suite 200
Kelowna, BC V1Y 2A3

Attn: Lindsay Paterson, Project Manager, SLR Consulting (Canada) Ltd.

Re: Excavation Feasibility and Slope Stability Assessment, Wilmer Marsh Unit, Columbia National Wildlife Refuge - Wilmer, BC

Dear Ms Paterson:

This report presents the findings of a subsurface investigation, an excavation feasibility assessment, a slope stability assessment, and recommendations for the historic dump site located within the Wilmer Marsh Unit of the Columbia National Wildlife Refuge in Wilmer, BC.

This assessment was completed as waste debris (fill) was not completely removed from the site after the 2015 excavation program due to slope stability concerns. It was determined that removing additional material required further analysis to ensure the stability of the slope was not compromised.

The objectives of this assessment were:

- To describe and classify the soil and estimate the strength parameters to be used in slope stability analyses;
- To analyze the current slope stability and determine the effects of additional excavation and debris removal on slope stability based on a conceptual excavation approach;
- To estimate the volume of debris and disturbed soil that remains on top of native in situ soil; and
- To provide a conceptual excavation approach required to remove the remaining debris and soil based on the slope stability analyses and estimated depths of remaining debris.

This project was approved in January, 2015 by Ms. Lindsay Paterson, Project Manager, SLR Consulting (Canada) Ltd (SLR).

1.0 STUDY AREA

The former dump site is situated within the Wilmer Marsh Unit of the Columbia National Wildlife Refuge, located approximately one (1) kilometer north of Wilmer, BC. The study area is accessed from West Side Road (Figure 1).

The study area is uninhabited with no residential dwellings or utility/transportation corridors.

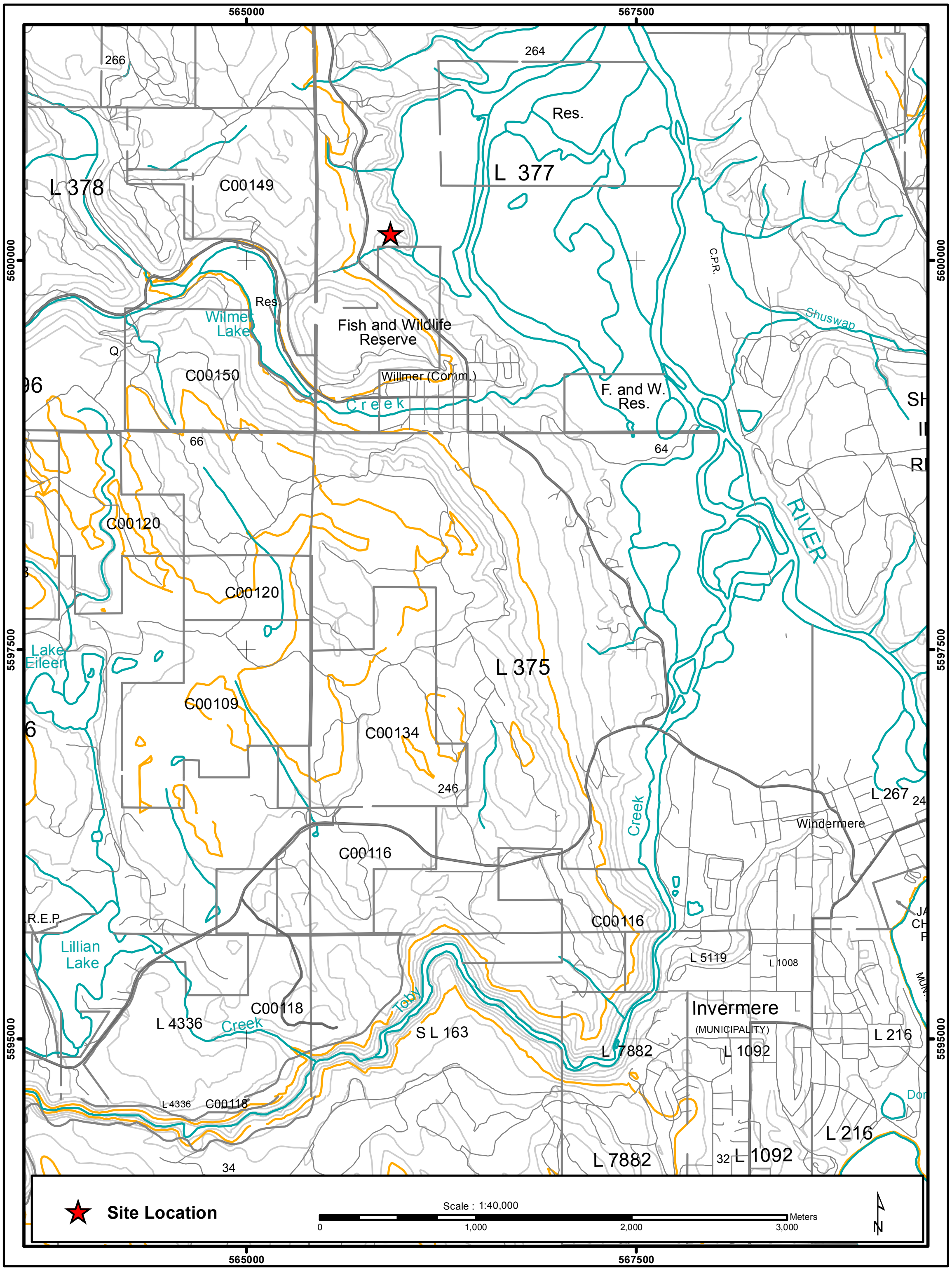


Figure 1: Location Map

2.0 BACKGROUND AND CURRENT SITE CONDITIONS

An estimated 3500 tonnes of debris and associated contaminated soil was removed from the former waste site between January and March 2015. Upon completion, test pitting was conducted by SLR to estimate the remaining depth of debris above the native soil (Appendix E).

Due to the potential for slope instability and other project constraints, all debris and soil within the Main Debris Zone (MDZ) could not be removed during the 2015 project period (Clarke Geoscience Ltd., 2015). The site was recontoured and hand seeded with a native grass seed blend. Following seeding, an erosion control blanket (coconut-straw mat; Nilex SC32BD) was laid out across all exposed soil surfaces. The main access trail was reclaimed (decompacted and recontoured) with organics (i.e. coarse woody debris) laid on top to assist with surface runoff and erosion control. Cross ditches were constructed to drain surface water off the reclaimed trail.

3.0 METHODOLOGY

3.1 References

This assessment was conducted by field examination of areas of interest within and adjacent to the former waste dump site. Reference was made to soils maps, geology maps, geotechnical design manuals, soil laboratory analyses, published soil strength parameters, figures provided by SLR, and reports prepared by Clarke Geoscience Ltd. (CGL). Aerial images from Google Earth©™ were used for reconnaissance level evaluation of the project site.

The soil was classified using the Unified Soil Classification System.

3.2 Field Assessment

The site assessment was completed on February 25, 2015 by Evan Kleindienst, P.Eng./R.P.F. of VAST Resource Solutions Inc (VAST) in the company of Ms. Jennifer Clarke, M.Sc., P.Geo. of Clarke Geoscience Ltd., Ms. Kalina Noel, R.P.Bio. of SLR, and Mr. Rick Hardy, Construction and Excavation Contractor.

The site investigation comprised of a sub-surface evaluation by test drilling at one site located on the upper terrace above the Main Debris Zone. One borehole was advanced to a depth of 25.0m (82.5ft).

Drilling was conducted with a hollow stem auger mounted on a Fraste tracked drill rig. Standard Penetration Tests (SPT) were conducted at 0.75m (2.5ft) intervals every 1.5m (5ft) or more. Drilling and Standard Penetration Tests were completed by Owen's Drilling. The borehole was backfilled with cuttings and topped with Bentonite chips. The borehole log is in Appendix B.

A Simmons Edeco Pilcon Hand Vane Tester was used to estimate the in situ shear strength.

A total station was used to survey eleven (11) cross sections within the area that contained remaining debris. These cross sections were used to analyse the slope stability. A topographic survey was also completed within and adjacent to the project site.

Soil samples were visually classified and hand textured. Select samples were submitted to Artech Consulting Ltd. for analysis of grain size distributions (sieve analysis) and Atterberg Limits. Laboratory results are in Appendix C.

3.3 Slope Stability

Slope stability analyses were completed throughout the area of remaining debris. Stability analyses were conducted using Limit Equilibrium software (Slope/W) by Geostudio 2012. Analyses were completed using the Bishop Method.

Slope geometry is based on 11 surveyed slope profile lines, labelled A to K, but only 7 were used to examine the conceptual excavation effects on slope stability. These 7 profiles, labelled E to K, were surveyed where the estimated debris remained. These slope profile lines were overlaid onto SLR's estimates of debris areas and corresponding depths to generate the cross sections used during the analyses. Profiles A to D were assumed have been surveyed where debris did not exist or had been removed in 2015. These profiles are illustrated in Appendix D.

A deep ground water table, well below the base of the debris has been assumed.

The natural ground slope of the area of concern was estimated to range from 75-80% or less, based on field observations using a clinometer, a surveyed natural slope profile line, and engineering judgement.

Assigned material properties were determined by visual examination, laboratory analysis, hand texturing, SPT data from drilling, engineering judgment, and published values of similar soils. A range of soil strength parameters were examined during the analysis. Circular failure surfaces and specific slip surface geometry were evaluated. Drained vs undrained analyses were examined and compared and used to evaluate short term stability (during excavation) vs long term stability.

4.0 PHYSIOGRAPHY

4.1 Geomorphic Process

Natural geomorphic processes observed within and adjacent to the study area consist of gullying, debris slides, and natural weathering of in-situ soil.

Post glacial gullying has occurring within the glaciolacustrine deposits. These gullies are dry and contain no running surface water. Gullies have steep sidewalls (70-90%) and extend downslope towards the wetland/valley bottom.

Evidence of surficial debris slides was observed within the study area at locations where a veneer of soil and debris covers the native ground slopes, creating oversteepened slopes (>80-100%). These debris slides exist upslope of the area that was previous excavated (Appendix A). These shallow debris slides are approximately 1.0-4.0 m wide, 10-15 long, and 0.5 m deep. The slide material settled downslope where ground slopes are slightly less than the natural slope (~80%).

The natural weathering of in-situ soil was observed as rills.

4.2 Topography

The study area is located on the western edge of the Purcell Mountain Range, within the Rocky Mountain Trench, upslope of the Columbia River and its wetlands. The upper elevations of the study area consist of a flat glaciolacustrine terrace with slopes that range from 0-3%. The mid to lower elevations consist of slopes that range from as little as 5-25% to as steep as 25-100% or more that descend towards the south, east, and north directions. Gullies, formed during glacial downwasting, initiate from this terrace and adjacent similar terraces to the south and north. The elevation ranges from 864 m on the terrace to 826 m at the lowest extent of the project site.

The study area contains a larger dry gully that trends in a west to east direction towards the wetland. The existing dump site was interpreted to be one of these gullies that initiated on the terrace, but was filled with debris. The 2015 excavation revealed this gully, but the natural shape can only be extrapolated from adjacent undisturbed gullies.

This old dump site is located on a southern aspect.

4.3 Bedrock Geology

Bedrock was not encountered within the depth of drill borehole (25.0m/82ft).

4.4 Surficial Soils

The following describes the soils encountered during the assessment and during drilling. See Appendix B for borehole log.

4.4.1 Native Soil Stratigraphy

Surficial soils are described below and soil properties are summarized in Table 1.

Very Low Plastic Silt Topsoil

The surficial soil consists of approximately 0.2 m /8 inch of topsoil, consisting of soft to firm, tan, dry, fine grained silt with little clay and fine sand. This material is comprised of organics, roots, and waste debris such as glass, metal, and plastic.

Very Low Plastic Silt with some Clay and little Sand

Surficial soil below the topsoil material, from approximately 0.2 m (8 inch) to 25.0 m (82 ft) consists of very low plastic, tan, stiff to very stiff, varved, dry silt with little clay and sand. This material is classified as ML.

Selected samples were submitted for laboratory analysis of Atterberg limits and grain size distribution (hydrometer) to assist with the classification. Soil laboratory results are in Appendix C.

This very low plastic silt material is inferred as glacio-lacustrine in origin.

4.4.2 Summary of Native Soil Properties

Table 1 below summarizes the properties of the native soil described above.

Table 1: Summary of Native Soil Properties

Material	Angle of Internal Friction	Estimated Cohesion *	Estimated Dry Unit Weight
Very Low plastic Silt with little Clay and Sand (ML)	30°	25 kPa	20 kN/m^3

*Estimated cohesion based on field vane shear test.

4.4.3 Native Soil Intermixed with Debris (Fill)

The depth of the remaining debris intermixed with native soil fill varies across the study area has been estimated by SLR (Appendix E) and ranges from 0.5 m to 3.0 m. The soil consists of unconsolidated very low plastic silt as described in 4.4.1. intermixed with glass, plastic, and metal. The consistency ranged from Very Soft to Firm. The Very Soft unconsolidated material was assumed to have been free dumped from the upper terrace and settled on the steeper slopes below as a sliver fill with depths ranging from 0.5 m to 1.0 m. Where debris depths were greater than 1.0 m, material was more consolidated (firm). This consolidation was assumed, but not confirmed, to be a result of historic machine traffic pushing debris and soil to lower elevations.

Two small surficial debris slides have occurred within the thin sliver fill that was free dumped from the upper terrace (Appendix A). These slides were approximately 10.0 – 15.0 m long, 1.0-4.0 m wide and 0.5 m deep. Material settled downslope where the ground slope decreased enough to hold the material (~80% or less).

Table 2 below summarizes the properties of the fill soil described above.

Table 2: Summary of Fill Soil Properties

Material	Angle of Internal Friction	Estimated Cohesion *	Estimated Dry Unit Weight
Very Low plastic Silt with little Clay and Sand (ML) intermixed with debris	0°	5 kPa	18 kN/m^3

*Estimated cohesion based on field vane shear test and engineering judgement.

4.5 Groundwater

The ground water table was not observed in the test borehole. No seeps or creeks were observed downslope of the study area. The Columbia Wetland is approximately 60 m below the top of the test borehole.

5.0 DISCUSSION

The following sections describe several options for excavating and removing the remaining debris (fill) from the site and the effects of this excavation on slope stability. This report is not an excavation plan. It is assumed that the actual excavation plan will be determined by the selected contractor and approved by a Professional Engineer or Geoscientist prior to the commencement of excavation and debris removal.

Additional options using different machines may be determined during the excavation planning phase. However, the stability must be analysed prior to the commencement of excavation. The depth of the remaining debris over native soil has been estimated by SLR. These estimated depths have been used within the slope stability analyses.

5.1 Slope Stability

The Global Stability Analyses examined the current stability of the slope within the area where debris remained after the 2015 excavation program and compared results with a conceptual excavation plan where skid trails were constructed to remove the remaining debris. Stability analysis results are summarized in Table 3 below and illustrated in Appendix D.

The depth of debris (fill) above native soil was assumed to range from approximately 0.5 m (1 ft 7 inches) to 3.0 m (9 ft 8 inches) below the existing ground surface. The area above the SLR estimated region containing 0.0-0.5 m depth was expanded to the top of the terrace by the undersigned based on ocular estimates taken during the field visit. The deepest estimated depths were used during the stability analyses. An additional 1.0 m depth of fill was added to cross sections I and J where the debris was estimated to be clean. Based on visual observations and judgment, the undersigned assumed a deeper depth compared to SLR's estimates.

The recommended range of Factors of Safety (FOS) for Global Stability for this site, considering the geotechnical engineering practise requirements against landslide, is 1.3 to 1.5. The FOS is the ratio between the resisting forces to the driving forces for the evaluated slope profile. A FOS of less than or equal to 1 would represent an unstable slope. FOS greater than 1 indicates an increasing confidence of a stable slope. In this instance, where the existing slope is a natural slope overlain by disturbed soil and debris, and no dwelling or infrastructure exist downslope, the less stringent objective of maintaining or creating conditions for a modest improvement, or absence of adverse effects on Global Stability, is judged appropriate.

By applying the range of soil strength parameters described in Table 1 and 2 above to the conceptual final post excavation slope and not reclaiming/recontouring the full bench constructed trails , the Factor of Safety was calculated to be 1.3 or higher and the Global Stability of the site is judged to be acceptable and considered stable. Applying the same parameters to the existing slope, given the estimated depths of remaining debris, the Factor of Safety for the slope was calculated to be 1.4 and higher with failure slip surfaces within the depth of remaining fill deposit and within the native in situ soil. If the debris is not removed, small surficial debris slides can be expected to occur over time, similar to the ones identified during the field assessment and described in Section 4.1, especially if the actual depths are greater than the estimated depths.

Table 3: Summary of Global Stability

Slope Profile	Factor of Safety – Leaving Debris	Factor of Safety Removing Debris	Comments
E	1.4	1.4	Critical slip surface for post excavation is outside the excavation zone.
F	1.3	1.4	Critical slip surface for post excavation is outside the excavation zone.
G	1.4	1.4	Critical slip surface for post excavation is outside the excavation zone.
H	1.5	1.4	Critical slip surface for post excavation is outside the excavation zone.
I	1.7	1.6	Critical slip surface for post excavation is outside the excavation zone.
J	1.4	1.7	Critical for pre excavation is within the fill deposit. Critical slip surface for post excavation starts at the toe of the cut slope.
K	1.7	2.1	Critical slip surface for pre excavation is below the excavation zone. Critical slip surface for post excavation starts at the toe of the cut slope.

5.2 Option 1 – Remove all Remaining Debris

The following section describes a conceptual excavation approach and the resulting influence on slope stability assuming all of the estimated volume of debris was excavated and removed from the site. For the purposes of this analysis, a Volvo EC160D excavator with a maximum reach of 8.9 m/ 29.5 ft, a cleanup bucket, and a full bench constructed trail width of 4.0 m / 13.1 ft was used.

A top down approach will be required to ensure that unconsolidated debris and soil material is removed from the upper elevations before removing material at lower elevations. This will ensure that material at the toe of the slope is not removed, potentially compromising the stability while machines are working below.

The final reclaimed ground slope used in the analyses after all the debris has been removed was estimated to be approximately 80%, or 1.25H:1V or less.

Based on the above excavator specifications, trail width, and final design ground slope, the following conceptual excavation scenario was used to model the final design slope and analyze the slope stability based on these steps. All excavated debris will be removed off site with either a dump truck (on the upper flat terrace) or a tracked marooka (on the steeper grades).

1. Starting at the top, the excavator will sit on the upper crest/terrace and reach down the slope and remove the 0.5 m veneer of debris and soil from the upper 8-9 metres of the slope;
2. Full bench (4.0 m wide) trails would be constructed across the slope at the downslope extent of debris removal (point 1 above), at approximately 90.0 m relative elevation, which is approximately 8-9 m downslope from the crest of the hill. The second lower trail was modeled at approximately 80.0 m relative elevation, at the downslope extent of the debris removal from the upper constructed trail;
3. A third trail could be constructed as required at lower elevations to facilitate the excavation and removal of debris. Full bench construction into native in situ soil was used in the slope stability model and would represent a conservative (i.e. the most unstable) approach because over steepened cut slopes would be generated. Full bench cut slopes used during stability analyses were 200% / 0.5H:1V.

Separating and stock piling native uncontaminated soil removed during full bench construction will require onsite supervision, a stockpile location, and a reclamation plan for replacing the material. Additional soil handling will be required, will increase the cost, and therefore, may not be desired.

An alternate option would be to remove all the excavated full bench native material from the site and reclaim the trails by pulling down the cutslope to approximately 80%/1.25H:1V and placing this material on the trail surface as toe support and recontouring. This approach would result in higher Factors of Safety and overall increased stability. Reclamation plans must be discussed prior to the excavation phase and approved by a Professional Engineer or Geoscientist.

Depending on the grade of the final lower trail, two excavators might be required. The lower one would bail the material to the second located at a higher elevation, which would place into the marooka (or similar haul truck).

Removing all the debris and disturbing the entire slope will result in a large area of exposed soil that will be susceptible to surface erosion. Erosion control and mitigation must be implemented after excavation is completed.

Based on the above approach that includes full excavation and full bench trail construction for one or more trails, no trail reclamation and/or recontouring, a conservative approach is provided and deep seated long term and short term slope failures are not expected to occur. Even though this conceptual excavation approach has been used to model the slope stability, minimizing full bench construction by using a combination of balanced cut and fill and partial bench construction where practical would add additional factors of safety to the long term and short term stability of the slope.

5.3 Option 2 – Leave the Remaining Debris

Based on the estimated depth of the remaining debris sitting on top of native soil and using a range of soil strength parameters, the current condition of the study area is considered stable on a global scale. The 7 slope profiles had a global factor of safety greater than 1.4.

Leaving the remaining debris could result in future small debris slides within the unconsolidated debris material, but catastrophic global failures are not expected.

5.4 Estimate of Excavated Soil and Debris (Fill)

The amount of debris and soil remaining as a veneer to blanket deposit over native soil is estimated to be approximately 1,500 m^3. This estimate is based on depths provided by SLR the added area by the undersigned containing 0.5 m of debris, combined with the topographic and slope profile surveys completed by VAST.

An estimate of 1,000 m^3 of native soil will be removed if full bench trail construction is implemented. This volume is based on two 50 m long trails, 4.0 m wide, 0.5H:1V /200% cutslopes, and an 80% ground slope.

6.0 RECOMMENDATIONS

The following recommendations for future debris removal at the Wilmer site are provided:

- Excavation and removal of all the estimated remaining debris and contaminated soil (estimated at 1,500 m^3) can commence under the supervision of a Professional Engineer or Geoscientist. The excavation plan must employ a "Top Down" approach;
- The final excavation and reclamation plans must be approved by a Professional Engineer or Geoscientist prior to the commencement debris removal;
- Machines and workers on the ground must not work below slopes containing debris and unconsolidated soil material (non-native) overlying native soils that are greater than 85%/40 degrees/1H:1.17V. These slopes must assessed by the supervising Professional during excavation;
- Based on the slope stability analyses and provided all recommendations within this report are adhered to, full bench trail construction can occur. Reclamation plans should consider recontouring by either pulling down the cut slope to reduce the slope or by hauling non contaminated material back onto the trail to increase the toe support. Reclamation will add increase the Factors of Safety and overall long term stability. Final reclamation techniques may incorporate a series of small terraces and benches across the project site and a final overall design ground slope of approximately 80% 1.25H:1V or less. Full bench cut slopes should not exceed 200% / 0.5:1 (H:V). Small cut slope slumping and surface erosion could occur over time on cut slopes that are constructed at the 200% and not reclaimed/recontoured;
- If significant rain (or snow melt) occurs during the excavation process, excavation must stop until a Professional Engineer or Geoscientist has assessed the site and deemed the conditions safe to proceed;
- Post excavation monitoring to assess the slope stability should be conducted for several years after completion (i.e. annually for 5 years or until the slope is confirmed stable); and
- All newly exposed soil will require erosion control measures to minimize erosion from wind and/or surface run off and must be completed immediately after construction;

7.0 CLOSURE

This report has been prepared in accordance with generally accepted engineering practices in British Columbia. No other warranty, express or implied is made.

Services provided by VAST Resource Solutions Inc. for this report have been conducted in a manner consistent with the level of skill, care and competence ordinarily exercised by members of the profession currently practicing under similar conditions and like circumstances in the same jurisdiction in which the services were provided. Professional judgment has been applied in developing the recommendations in this report.

The conclusions and/or recommendations provided in this report do not relieve the client or their agents or representatives of the responsibility to comply with applicable Acts, regulations, bylaws and/or decisions of any authorities that have jurisdiction under an enactment.

Assessments of soils and rock characteristics are based on interpretation of one drill borehole and hand dug test pits. Variability (even over short distances) is inherent in geological features, and actual ground conditions encountered may vary from those identified.

In order to properly understand the suggestions, recommendations and opinions expressed within this report, reference must be made to the whole report. We cannot be responsible for the use of portions of the report by any party without reference to the whole report.

This report is prepared for the specific site assessed, whether it is a development, a building, or a design objective that was described to us by the client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed within the report are only valid to the extent that there has been no material alteration to, or variation from any of the said descriptions provided to us, unless we have been specifically requested by the client to review and revise the report in light of such alteration or variation.

The information and opinions expressed in the report, or any document forming part of the report, are for the sole benefit of the client. No other party may use or rely upon the report or any portion thereof without our written consent. We will consent to any reasonable request by the client to approve the use of this report by other parties as “approved users”. The contents of the report remain our copyright property and we authorize the client and approved users to make copies of the report only in such quantities as are reasonably necessary for the use of the report by those parties. The client and approved users may not give, lend, sell or otherwise make the report, or any portion thereof, available to any party without our written permission. Any use which a third party makes of the report, or any portion thereof, is the sole responsibility of such third parties. We accept no responsibility for damages suffered by any third party resulting for the unauthorized use of the report.

In the event that conditions vary from those interpreted for this assessment, we reserve the right to re-inspect the foundation conditions and amend our recommendations accordingly. The author reserves the right to amend this report if additional information becomes available.

The report is based on, and limited by, circumstances, conditions and information available at the time the work was completed. The recommendations of this report are based in part on information provided by others. VAST Resource Solutions Inc. believes this information is accurate but cannot guarantee or warrant its accuracy or completeness.

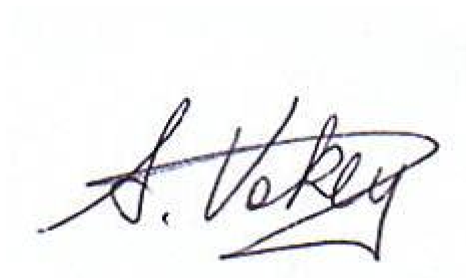
The information presented in this report was acquired, compiled and interpreted exclusively for SLR Consulting (Canada) Ltd. and Government of Canada Public Works for the purposes described in this report. VAST Resource Solutions Inc. does not accept any responsibility for the use of this report, in whole or in part, for any purpose other than intended or to any third party for use whatsoever.

This document has been digitally signed and sealed and certified by the author. Hard copies of the report can be produced upon request.

Yours truly,

Prepared By

Review By:



Evan Kleindienst, P.Eng., RPF
Project Engineer (Principal)

Shawn Vokey, P.Eng.
Senior Engineer (Principal)

P:\16.0019.00\Wilmer Marsh Feasibility Study\Report\Excavation_Feasibility_wilmer_final.doc

REFERENCES

"Canadian Foundation Engineering Manual" November, 2008. Canadian Geotechnical Society 2006. 4th Edition.

Clarke Geoscience Ltd. . February 18, 2014. "Geotechnical Implications of Remedial Excavaiton Work, Wilmer Marsh Unit, Columbia National Wildlife Refuge, Wilmer BC:

Clarke Geoscience Ltd.. October 23, 2015. "Site Inspection and Future Geotechnical Considerations Wilmer Marsh Unit, Columbia National Wildlife Refuge, Wilmer, BC".

Geological Survey Branch, Geoscience Map 1995-1, Purcell Supergroup Geological Compilation Map

Google Earth© Image. May 2013. Version 5.0.11337.1968 (beta).

Lacelle, L.E.H. March, 1990. "Biophysical Resources of the East Kootenays Area: Soils". Report No. 20. British Columbia Soil Survey. Wildlife Branch, Habitat Inventory Section. Victoria, BC.

Unified Soil Classification System.

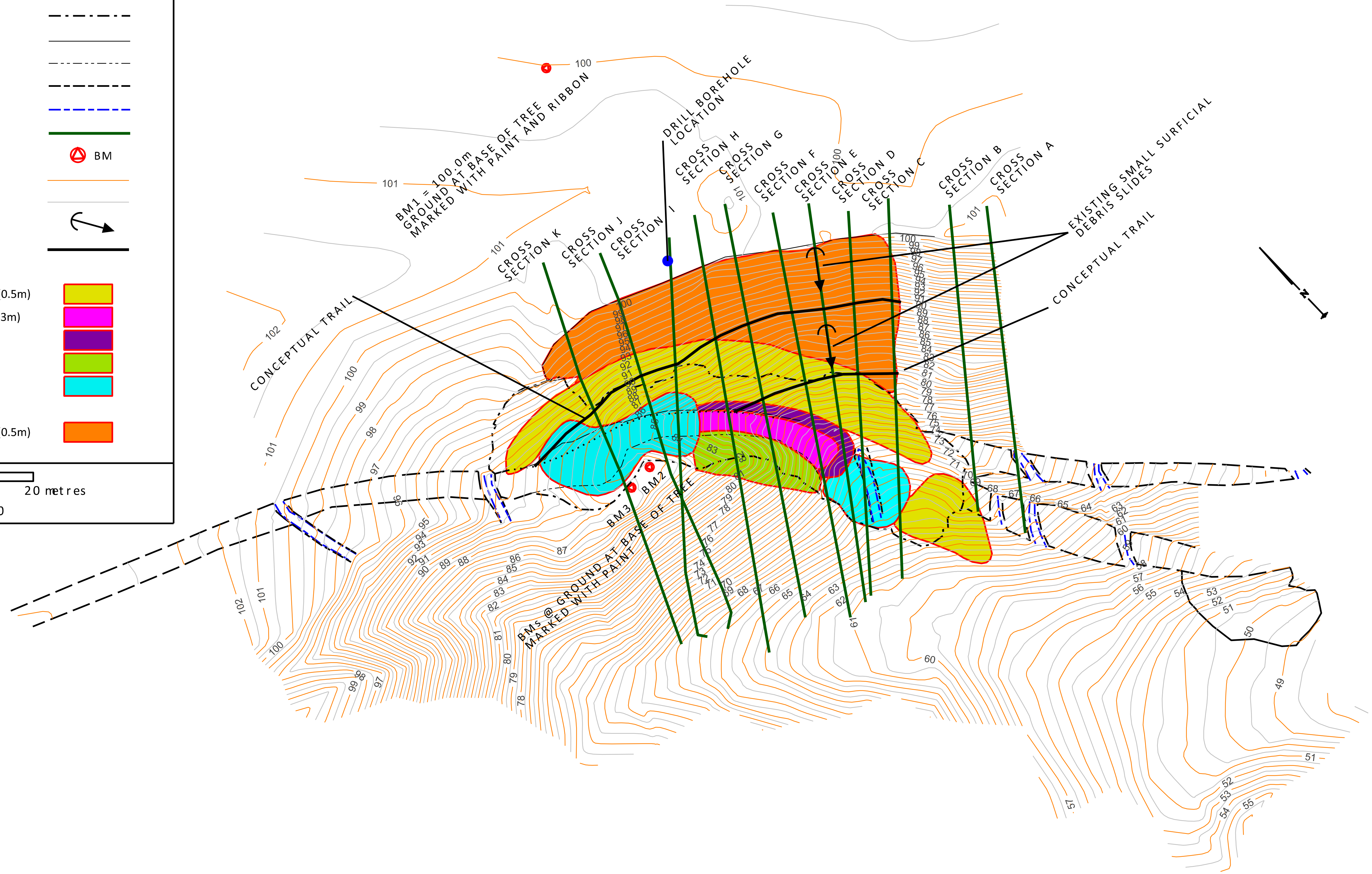
APPENDIX A: PROJECT SITE MAP

LEGEND:

ROAD EDGE	
ROAD EDGE (EXCAVATED)	
EDGE OF 2015 EXCAVATION	
TOP OF BANK	
TOE OF CUT	
TOP OF CROSS DITCH	
BOTTOM OF CROSS DITCH	
CROSS SECTION	
BENCHMARK	BM
1.0m INTERVAL CONTOUR	
0.5m INTERVAL CONTOUR	
DEBRIS SLIDE	
CONCEPTUAL TRAIL LOCATION	
BASED ON SLR ESTIMATES:	
MINIMAL SURFACE DEBRIS (0.5m)	
LARGE METALLIC DEBRIS (1-3m)	
DEBRIS (1-2m)	
DEBRIS (SMALL 0.5-1.0m)	
CLEAN	
BASED ON VAST ESTIMATE:	
MINIMAL SURFACE DEBRIS (0.5m)	

0 10 20 metres

SCALE 1 : 750



PLAN SKETCH

SCALE 1:750

SLR

VAST RESOURCE SOLUTIONS

FILE:16.0019.00_TOPO_SURVEY.S01

ISSUED FOR CONSTRUCTION:	DATE:	N/A
REVISION:		
ISSUED FOR APPROVAL:	DATE:	N/A
REVIEW:	DATE:	N/A
DRAWING: DM	DATE:	MAR 06/15
DESIGN:	DATE:	N/A
FIELD DATA: CR/DM	DATE:	MAR 05/15

PROJECT SITE MAP

SHEET 1/1

16.0019.00

WILMER MARSH

2016 TOPO SURVEY

Public Works and Government Services Canada

Travaux publics et Services gouvernementaux Canada

APPENDIX B: DRILL LOG

BORING NUMBER Wilmer-VAST-BH1

Vast Resource Solutions

CLIENT SLR Consulting (Canada) Ltd
PROJECT NAME Wilmer Marsh Unit - Excavation Feasibility and Slope Stability Ass
PROJECT NUMBER 16.0019.00
PROJECT LOCATION Wilmer, BC
DATE STARTED 25-2-16 **COMPLETED** 25-2-06
GROUND ELEVATION 2833 ft 2833 **HOLE SIZE** 4 inches
DRILLING CONTRACTOR Owen's Drilling
GROUND WATER LEVELS:
DRILLING METHOD Odex Drill and SPT
AT TIME OF DRILLING --- No Free Water
LOGGED BY Darin Lindsay **CHECKED BY** Evan Kleindienst
AT END OF DRILLING --- No Free Water
NOTES Borehole sealed with cuttings and Bentonite Chips
AFTER DRILLING --- No Free Water

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS AND REMARKS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0	AU			Top soil mixed with waste debris such as glass, plastic, and metal	ML		0.2 SILT, (ML) tan, fine grained, dry, soft to firm, homogeneous, very low plasticity 2832.8
					ML		SILT, (ML) tan, fine grained, dry, stiff to very stiff, homogeneous, very low plasticity
5							
	SPT	94	4-4-6 (10)				
10				Fines = 23%			
	SPT	94	3-5-6 (11)	Fines = 41%			
15							
				Fines = 23%			
	SPT	83	10-13-18 (31)				
20							
	SPT	94	13-10-12 (22)				
25							
	SPT	100	8-9-11 (20)				
30							
	SPT	89	10-12-15 (27)				
35							

(Continued Next Page)

CLIENT SLR Consulting (Canada) Ltd

PROJECT NAME Wilmer Marsh Unit - Excavation Feasibility and Slope Stability Ass

PROJECT NUMBER 16.0019.00

PROJECT LOCATION Wilmer, BC

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS AND REMARKS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
35					ML		SILT, (ML) tan, fine grained, dry, stiff to very stiff, homogeneous, very low plasticity *(continued)*
	SPT	106	7-8-11 (19)				
40							
	SPT	89	6-7-8 (15)				
45							
	SPT	100	7-7-10 (17)				
50							
55							
	SPT	100	8-10-12 (22)				
60							
65							
	SPT	100	8-11-14 (25)				
70							
75							

(Continued Next Page)

CLIENT SLR Consulting (Canada) Ltd

PROJECT NAME Wilmer Marsh Unit - Excavation Feasibility and Slope Stability Ass

PROJECT NUMBER 16.0019.00

PROJECT LOCATION Wilmer, BC

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	TESTS AND REMARKS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
75					ML		SILT, (ML) tan, fine grained, dry, stiff to very stiff, homogeneous, very low plasticity *(continued)*
80							
	SPT	100	10-13-18 (31)	Water Table was not encountered within the depth of drilling			83.5 / 2749.5

Bottom of borehole at 83.5 feet.

APPENDIX C: SOIL LAB ANALYSIS

ARTECH CONSULTING LTD

MATERIALS TESTING AND INSPECTION SERVICES
229 Industrial Road F, Cranbrook, BC V1C 6N4
Ph: 250/489-1940; Fax: 250/489-1667;
Email: info@artechconsulting.ca

ATTERBERG LIMITS REPORT

Lab No: **S16-096**

Project: Wilmer

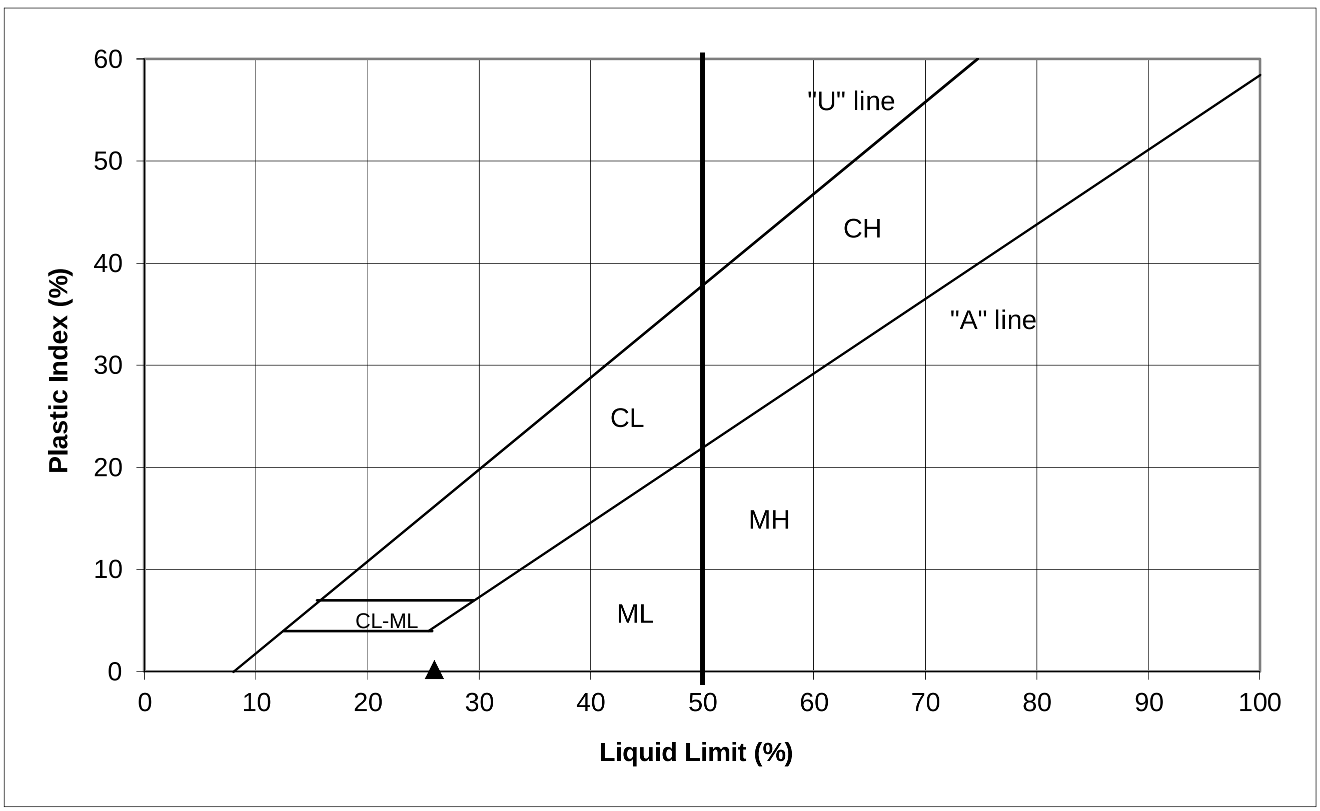
Date: March 16, 2016

Region: Invermere, BC

File: 2016-06

Sampling Details: Sample provided by VAST March 10, 2016

Sample	Soil Classification (USCS)	Sample Moisture %	Liquid Limit %	Plastic Limit %	Plasticity Index %
DH1 - S5 (27' - 28'6")	ML	4.9	26	26	0



Tested in accordance with ASTM D4318-00 Methods for the determination of liquid limits, plastic limits and plasticity indices of soils

Reports: VAST Resource Solutions

Report Date: March 16, 2016

c.c:

Per:

ARTECH CONSULTING LTD

MATERIALS TESTING AND INSPECTION SERVICES
229 Industrial Road F, Cranbrook, BC V1C 6N4
Ph: 250/489-1940; Fax: 250/489-1667;
Email: info@artechconsulting.ca

GRADATION REPORT

Lab No: **S16-097**

Project: Wilmer

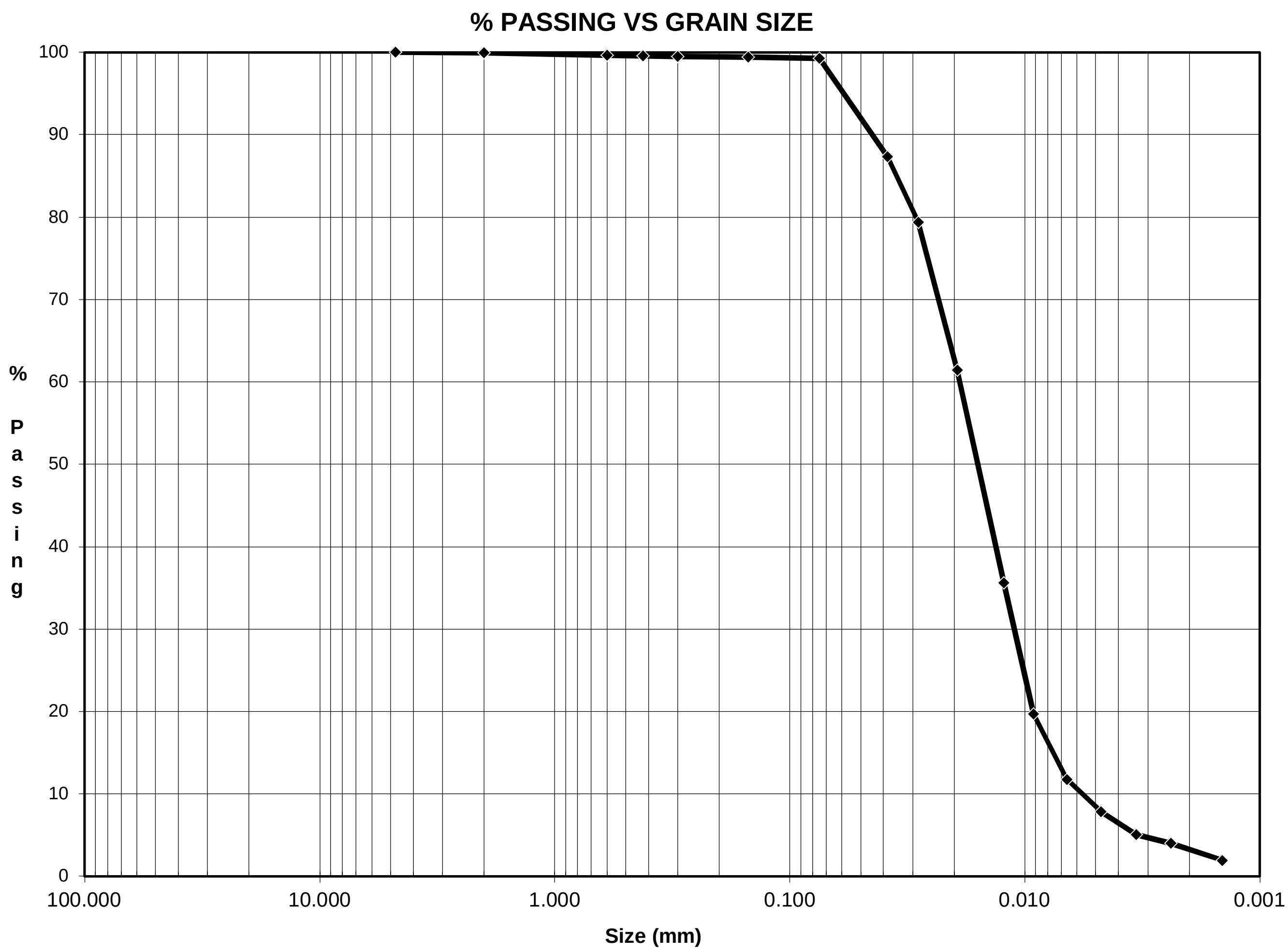
Our File: 2016-06

Sampling details: DH1-S12

Region: Invermere, BC

Material type: Silt with a trace of clay

Sieve Size	% Passing	Classification	Sieve Size	% Passing	Classification
37.5		Gravel	0.0123	35.6	Silt
19.0		Gravel	0.0092	19.7	Silt
4.75	100.0	Coarse Sand	0.0066	11.7	Silt
2.00	99.9	Medium Sand	0.0047	7.8	Silt/Clay
0.420	99.6	Fine Sand	0.0034	5.1	Silt/Clay
0.075	99.3	Silt	0.0024	4.0	Clay
0.0283	79.4	Silt	0.0014	1.9	Clay



Tested in accordance with ASTM C136, C117, D422 (washed gradation and hydrometer)

Moisture Content of Sample(%): 3.5

Reports: VAST Resource Solution - Evan Kleindienst

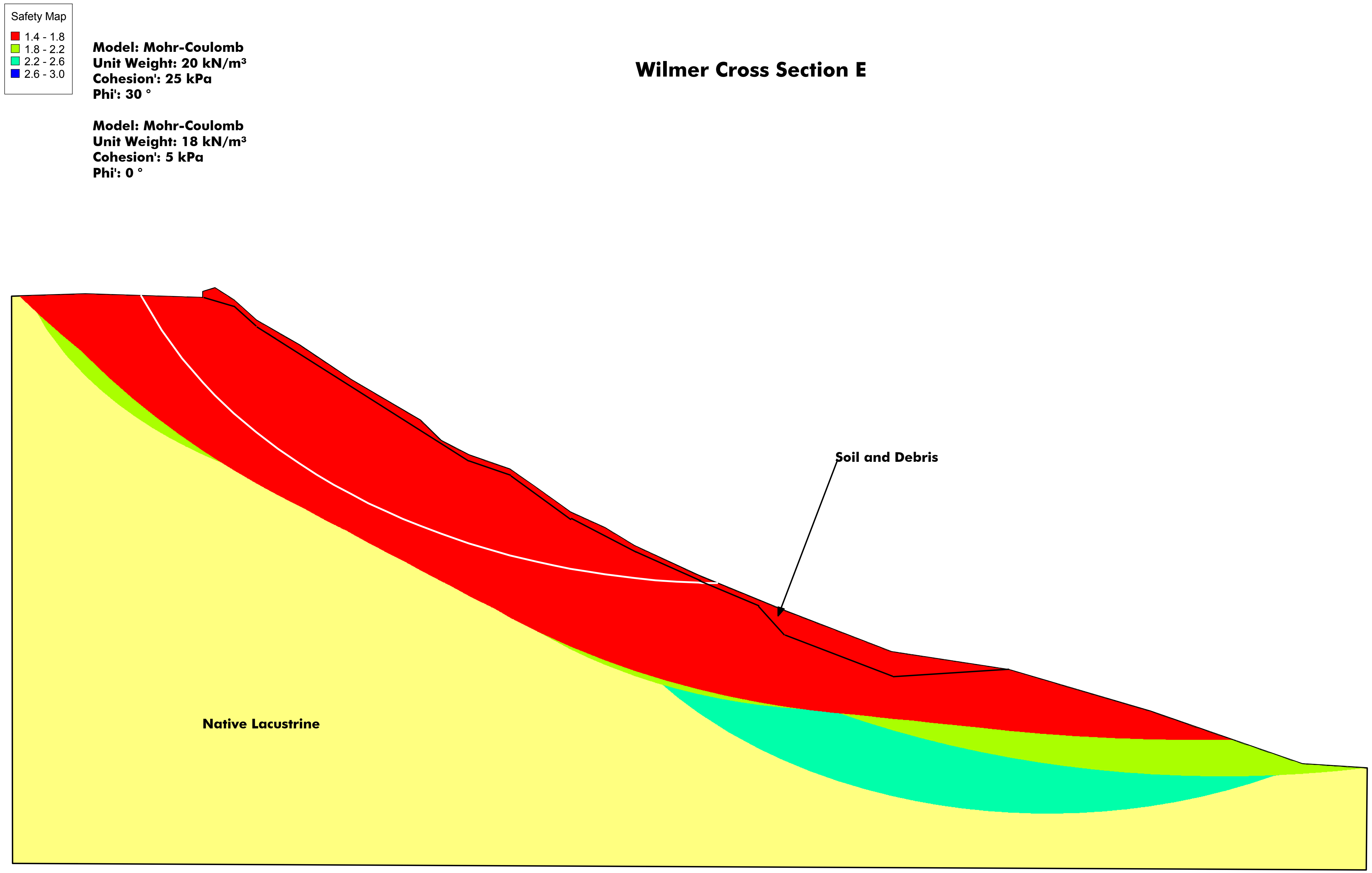
c.c:

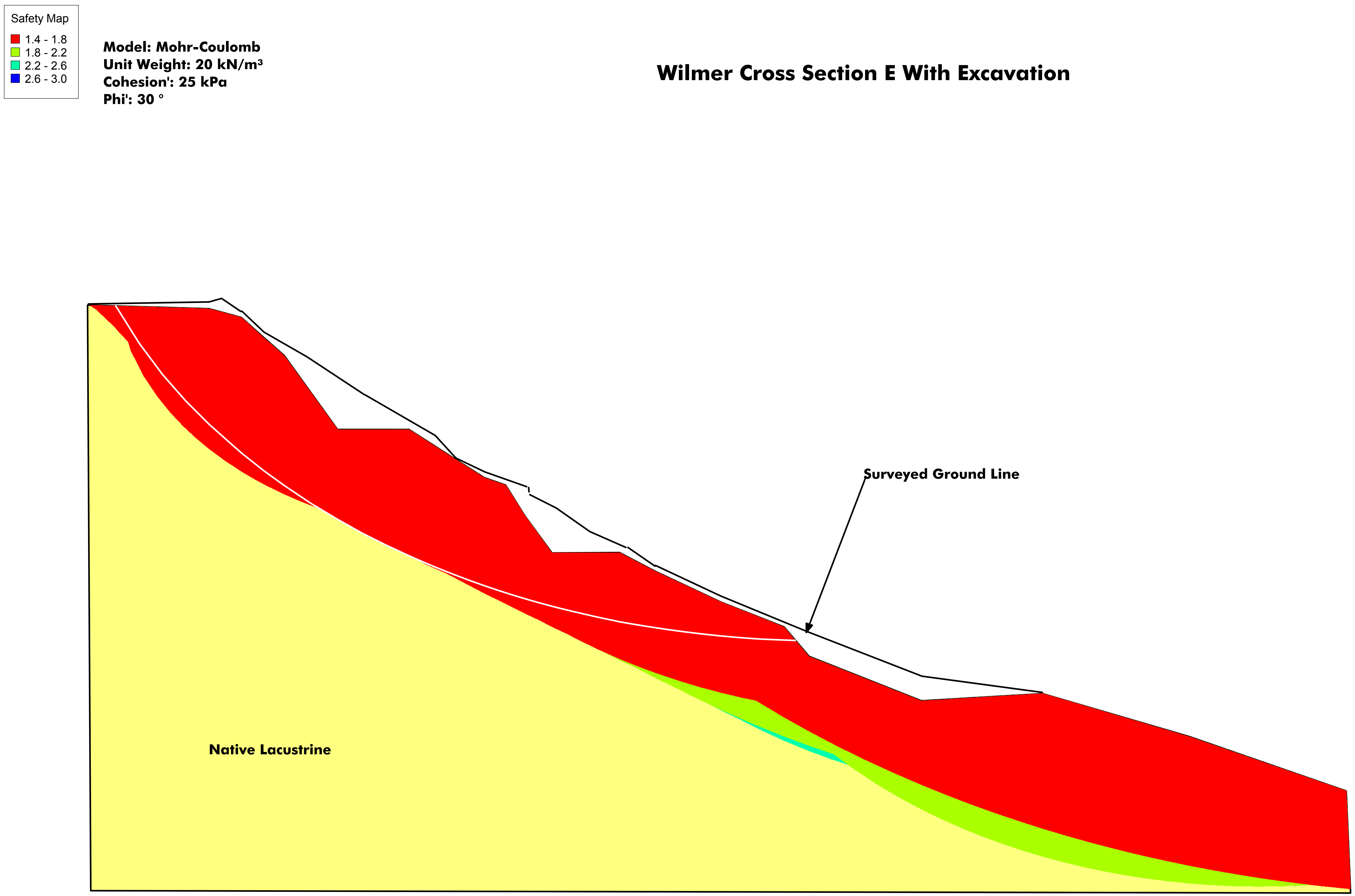
Report Date: March 16, 2016

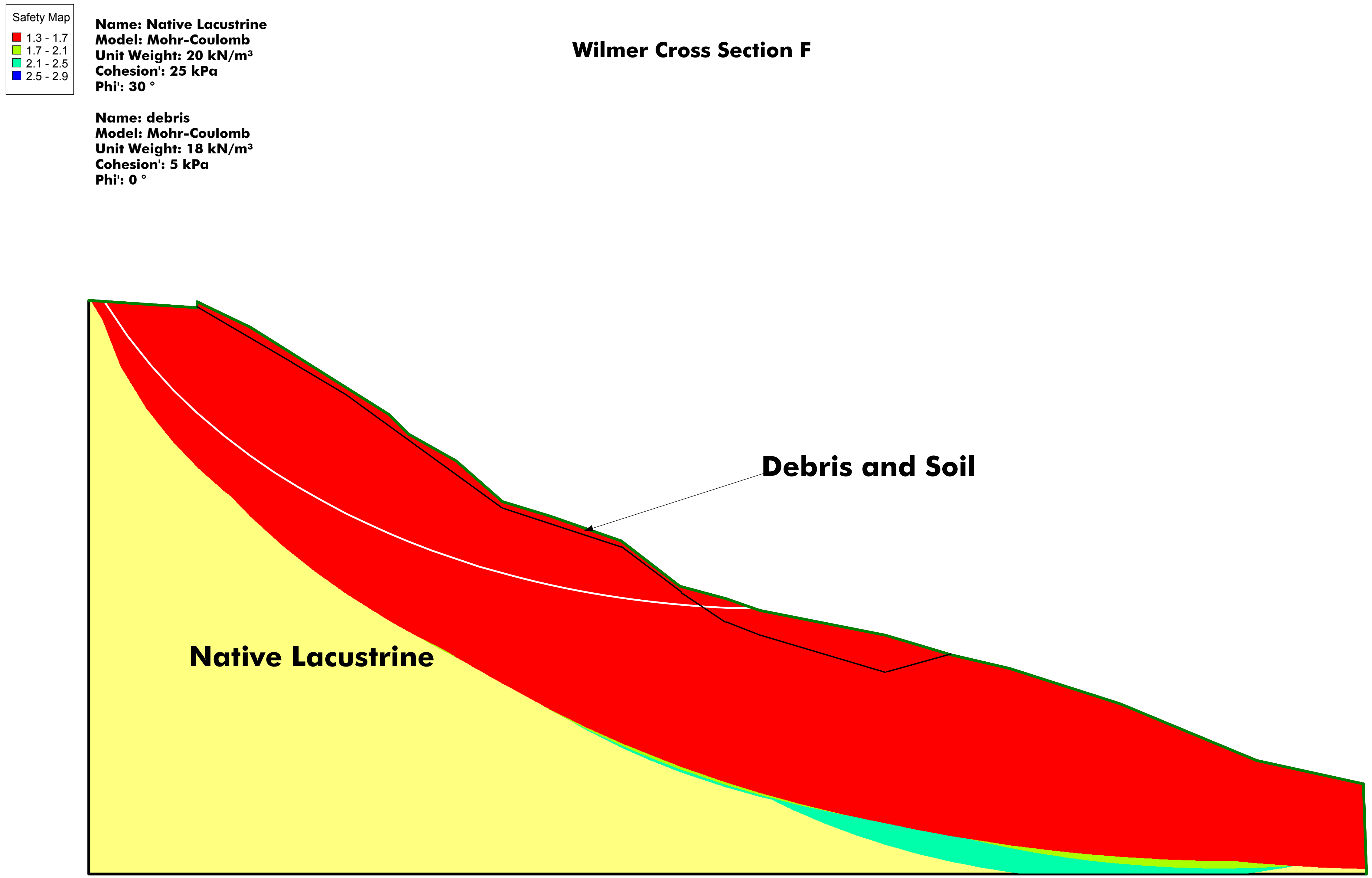
Per:

APPENDIX D: SLOPE STABILITY ANALYSES

Wilmer Cross Section E




Safety Map
1.4 - 1.8
1.8 - 2.2
2.2 - 2.6
2.6 - 3.0
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion': 25 kPa
Phi': 30 °
Wilmer Cross Section E With Excavation
Surveyed Ground Line
Native Lacustrine


Safety Map
1.3 - 1.7
1.7 - 2.1
2.1 - 2.5
2.5 - 2.9
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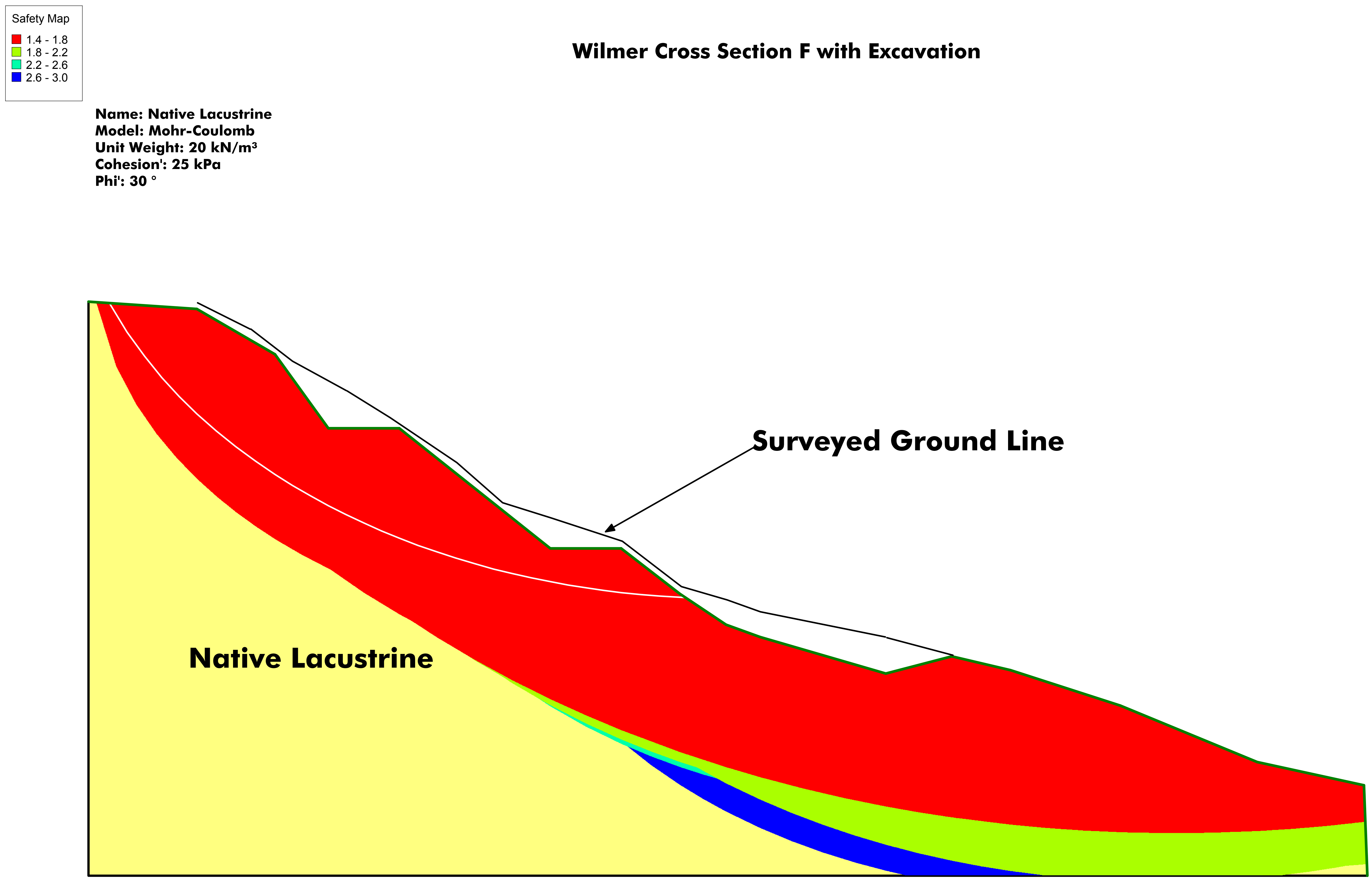
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion': 25 kPa
Phi': 30 °
Name: debris
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 5 kPa
Phi': 0 °
Wilmer Cross Section F
Debris and Soil
Native Lacustrine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1.4 - 1.8
1.8 - 2.2
2.2 - 2.6
2.6 - 3.0
Wilmer Cross Section F with Excavation
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Unit Weight: 20 kN/m³
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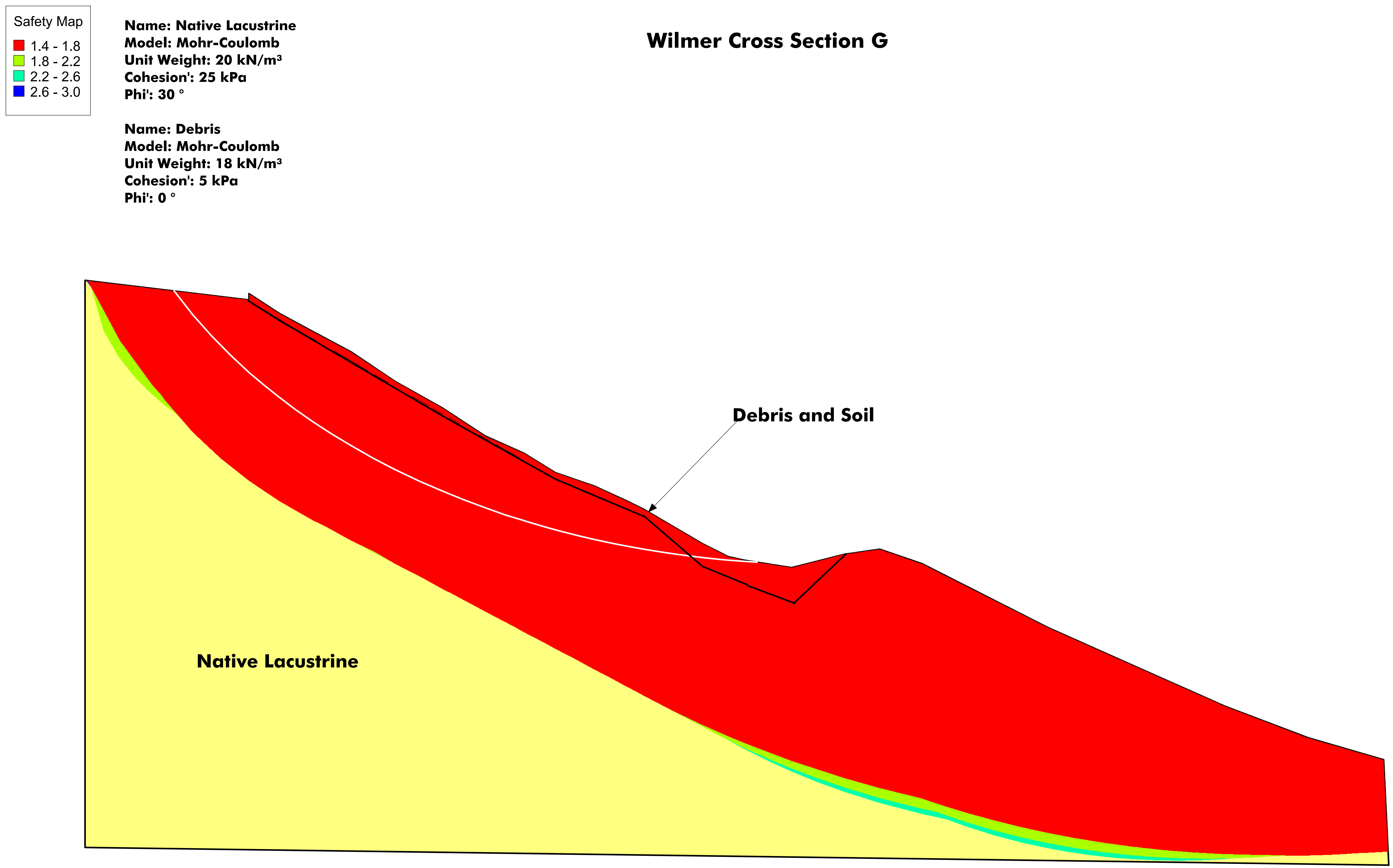
Phi': 30 °
Surveyed Ground Line
Native Lacustrine


Safety Map
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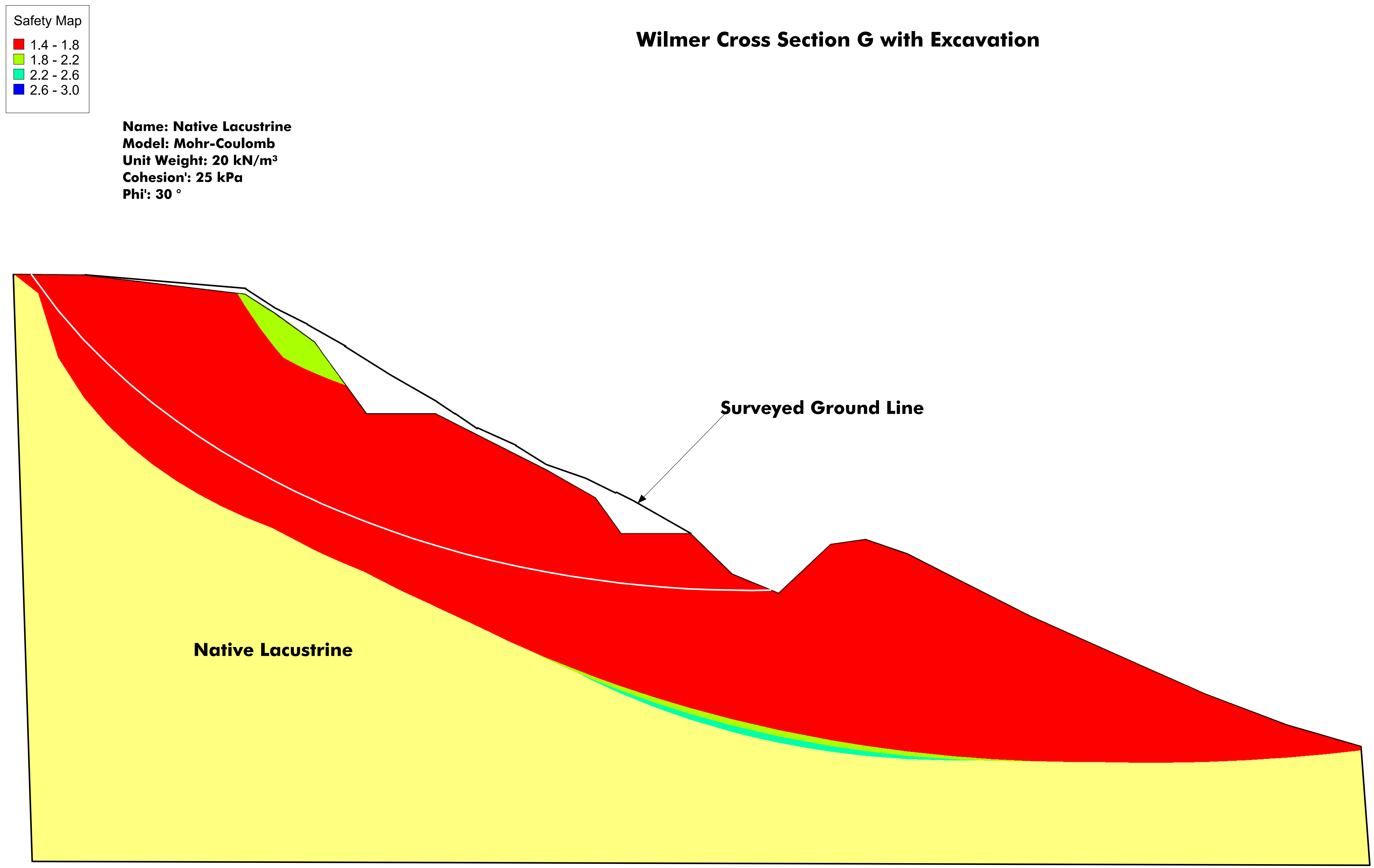
1.8 - 2.2
2.2 - 2.6
2.6 - 3.0
Name: Native Lacustrine
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion': 25 kPa
Phi': 30 °
Name: Debris
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 5 kPa
Phi': 0 °
Wilmer Cross Section G
Debris and Soil
Native Lacustrine


Safety Map
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2.2 - 2.6
2.6 - 3.0
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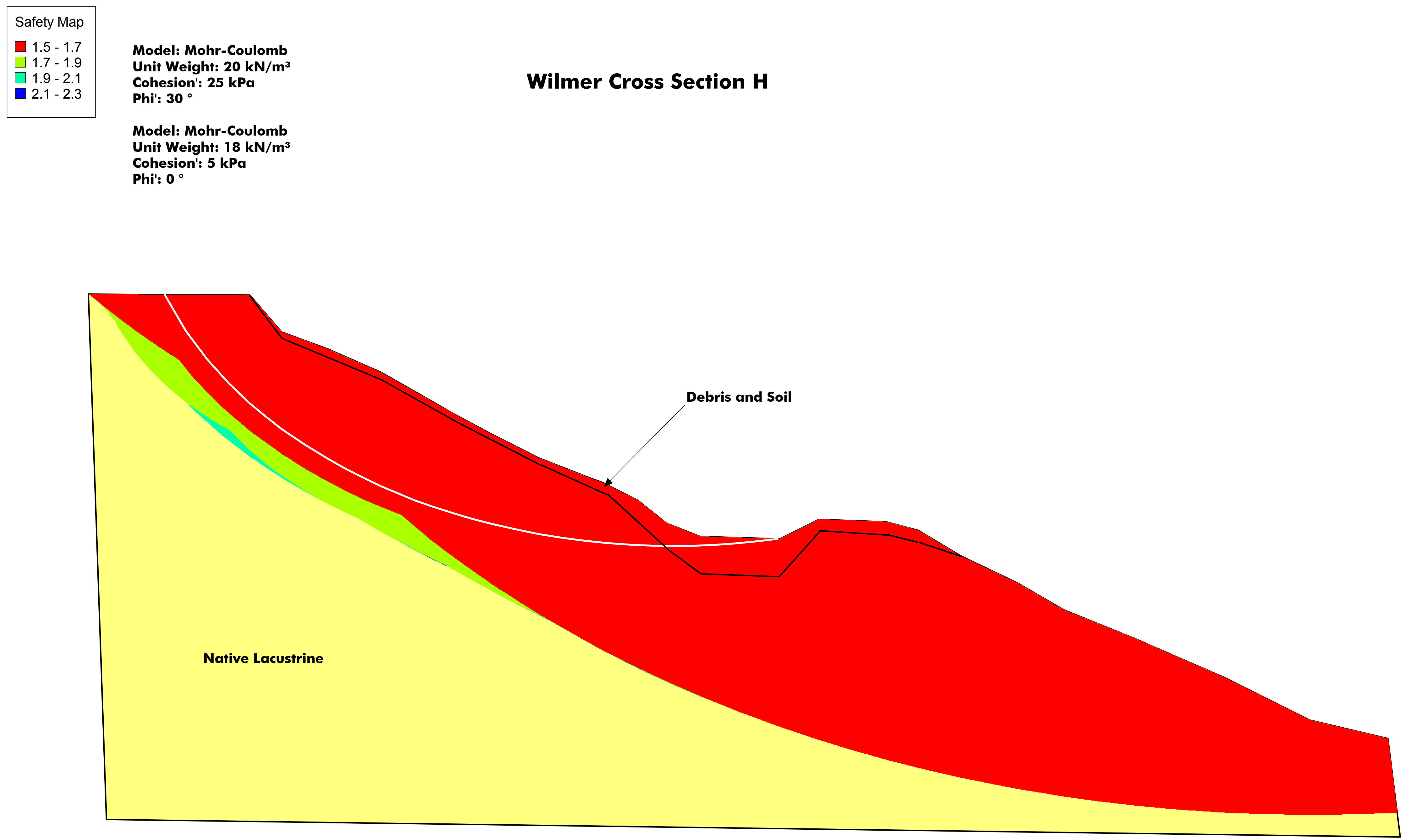
Surveyed Ground Line
Native Lacustrine


Safety Map
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1.7 - 1.9
1.9 - 2.1
2.1 - 2.3
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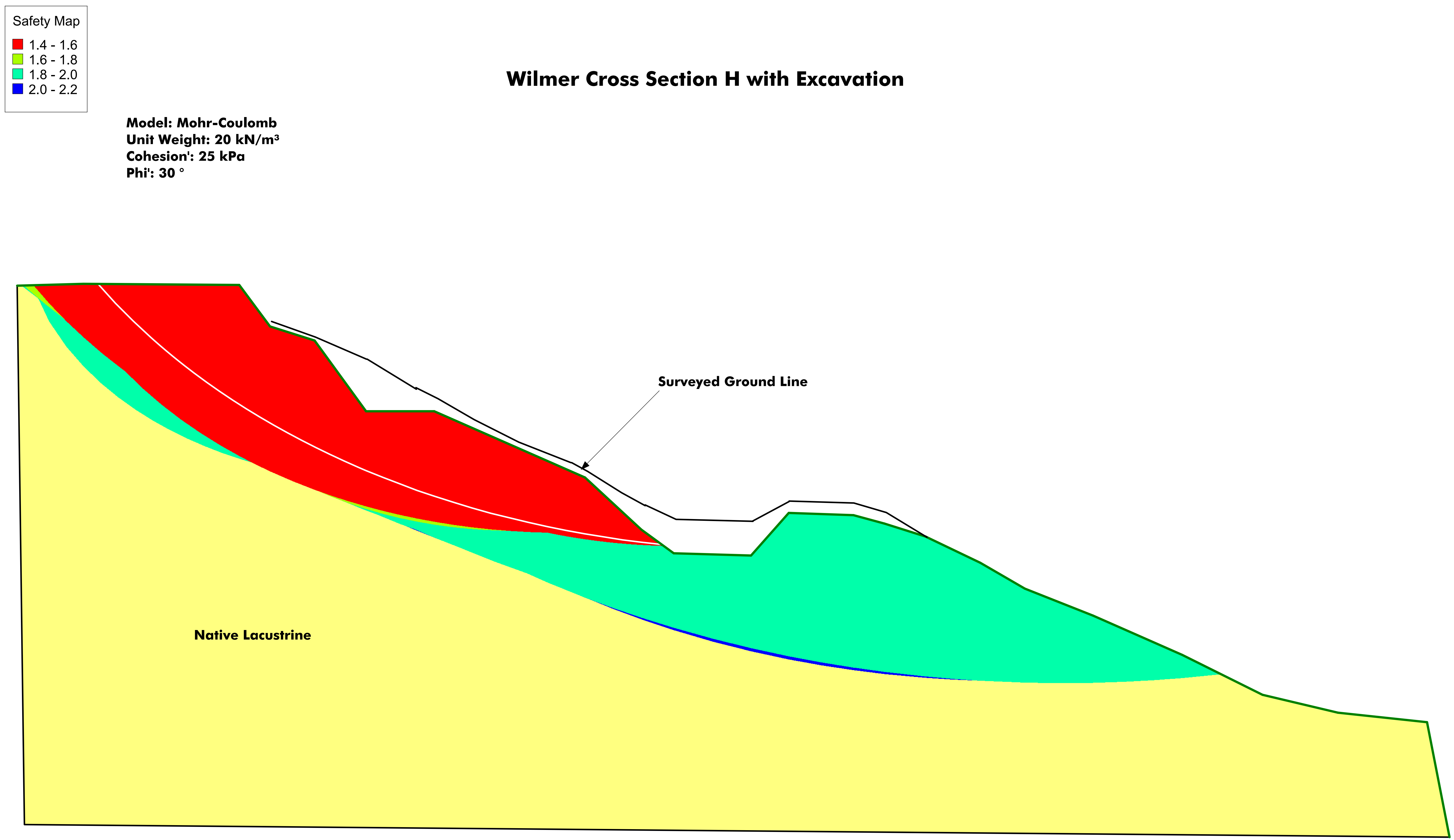
Cohesion': 25 kPa
Phi': 30 °
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 5 kPa
Phi': 0 °
Wilmer Cross Section H
Debris and Soil
Native Lacustrine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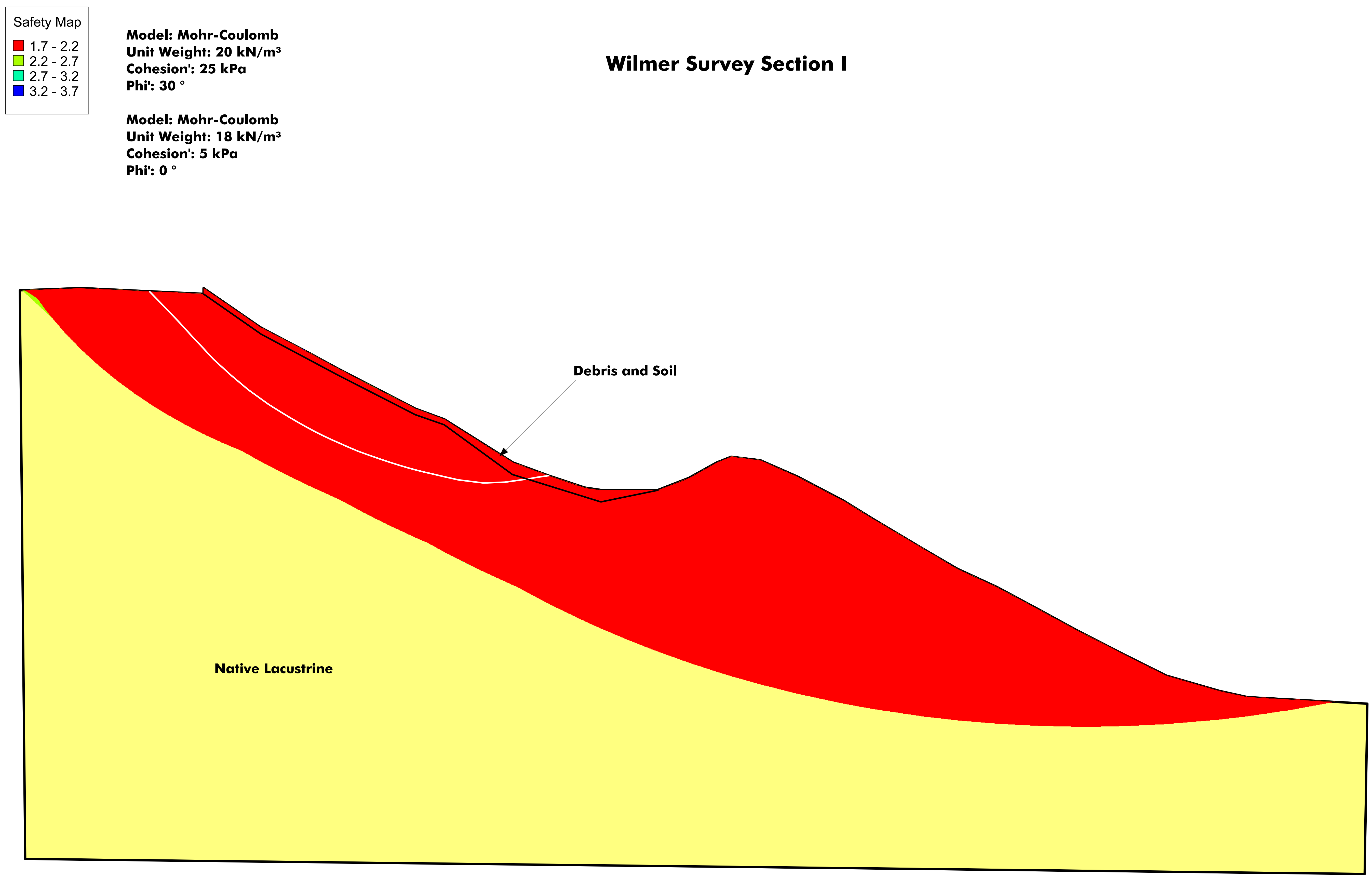
Phi': 30 °
Surveyed Ground Line
Native Lacustrine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2.7 - 3.2
3.2 - 3.7
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Model: Mohr-Coulomb
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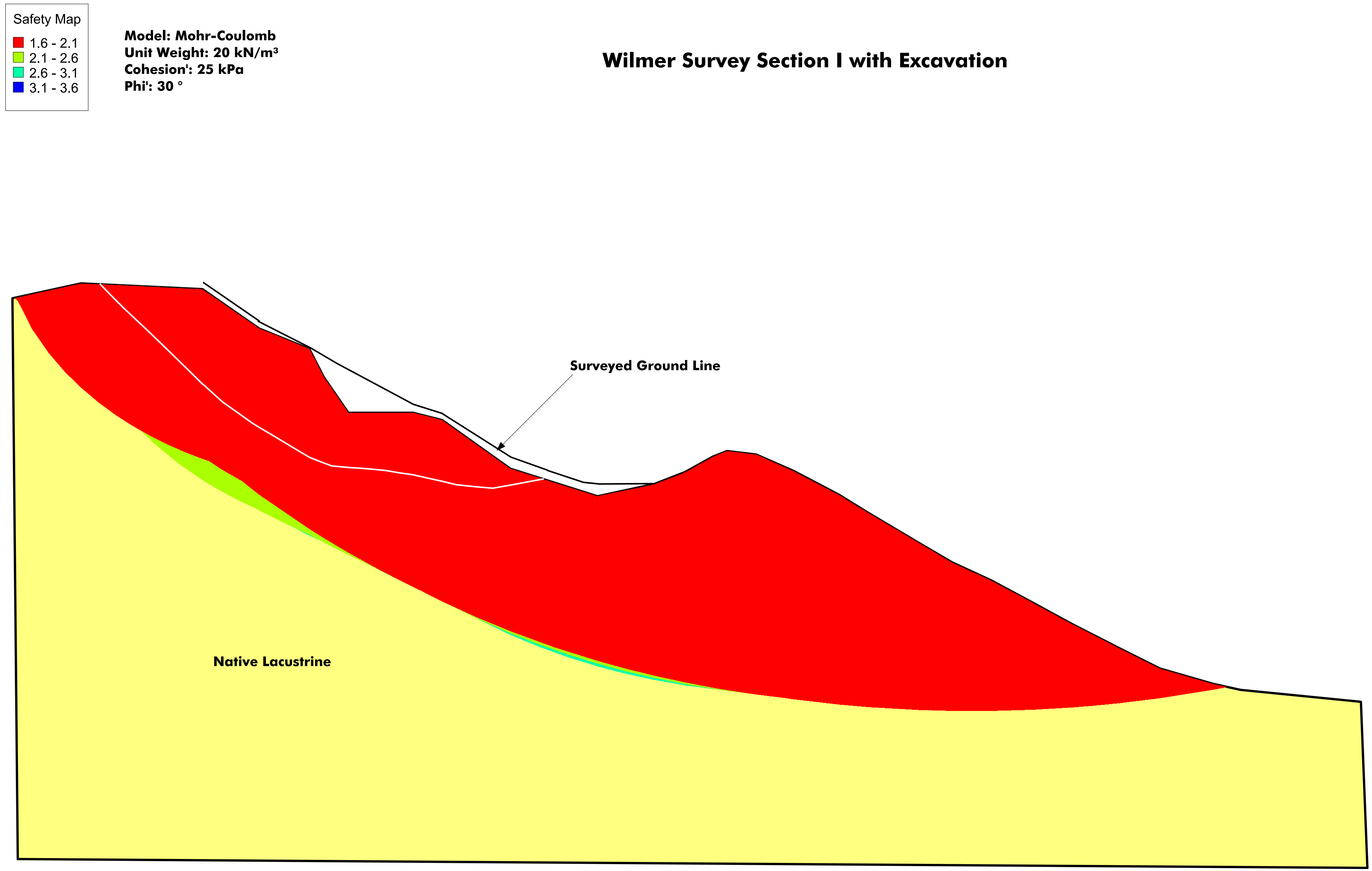
Phi': 0 °
Wilmer Survey Section I
Debris and Soil
Native Lacustrine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2.1 - 2.6
2.6 - 3.1
3.1 - 3.6
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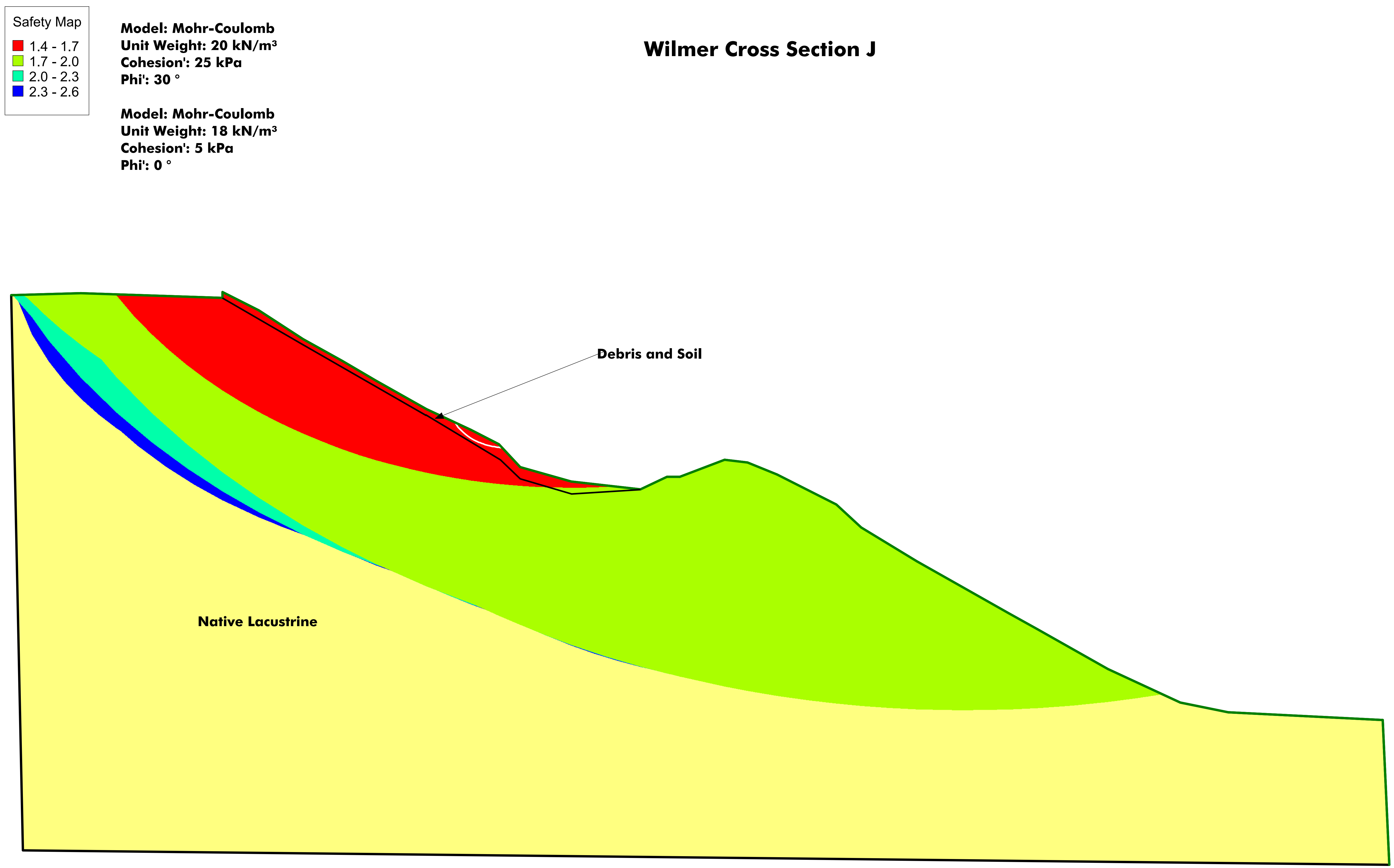
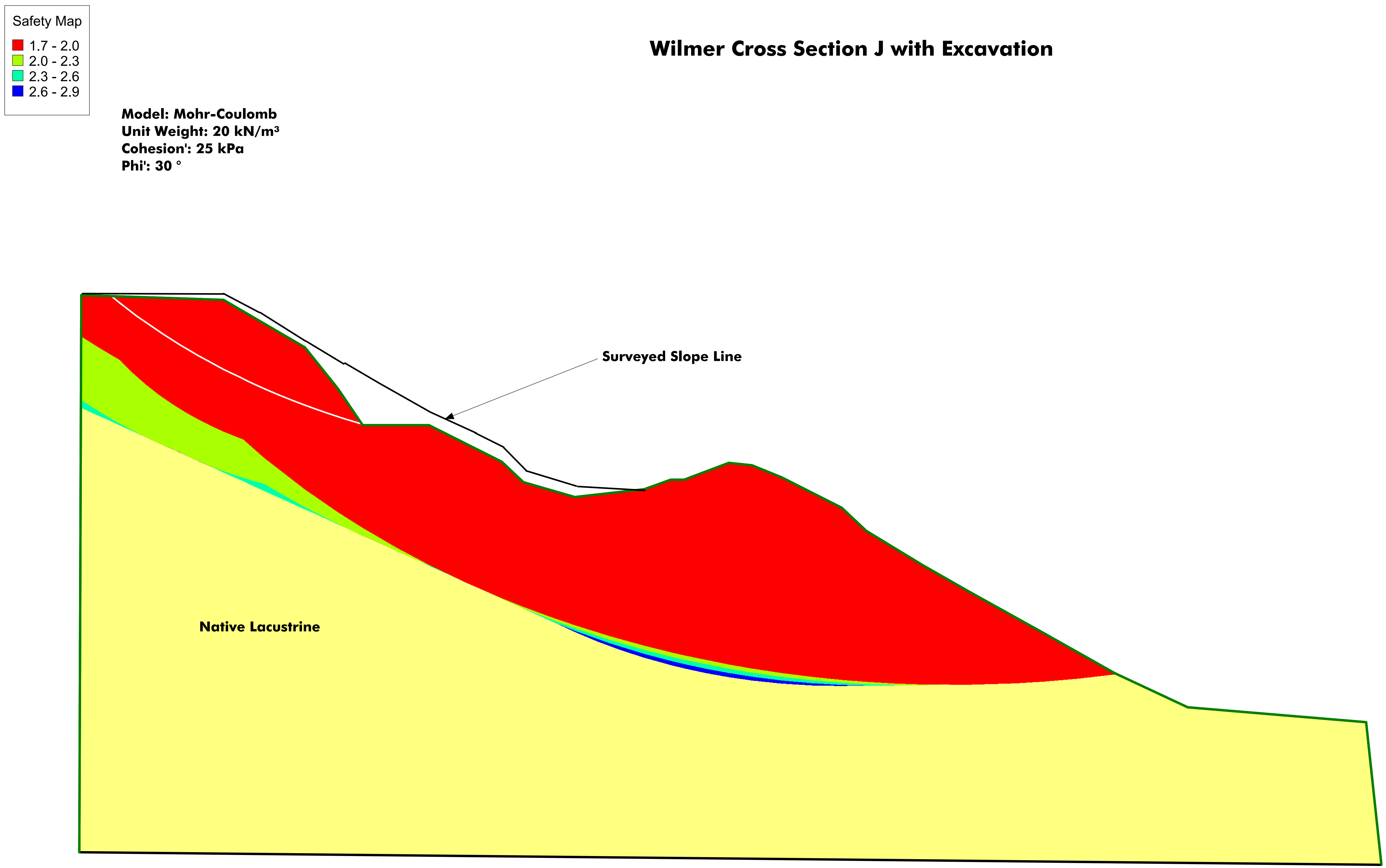
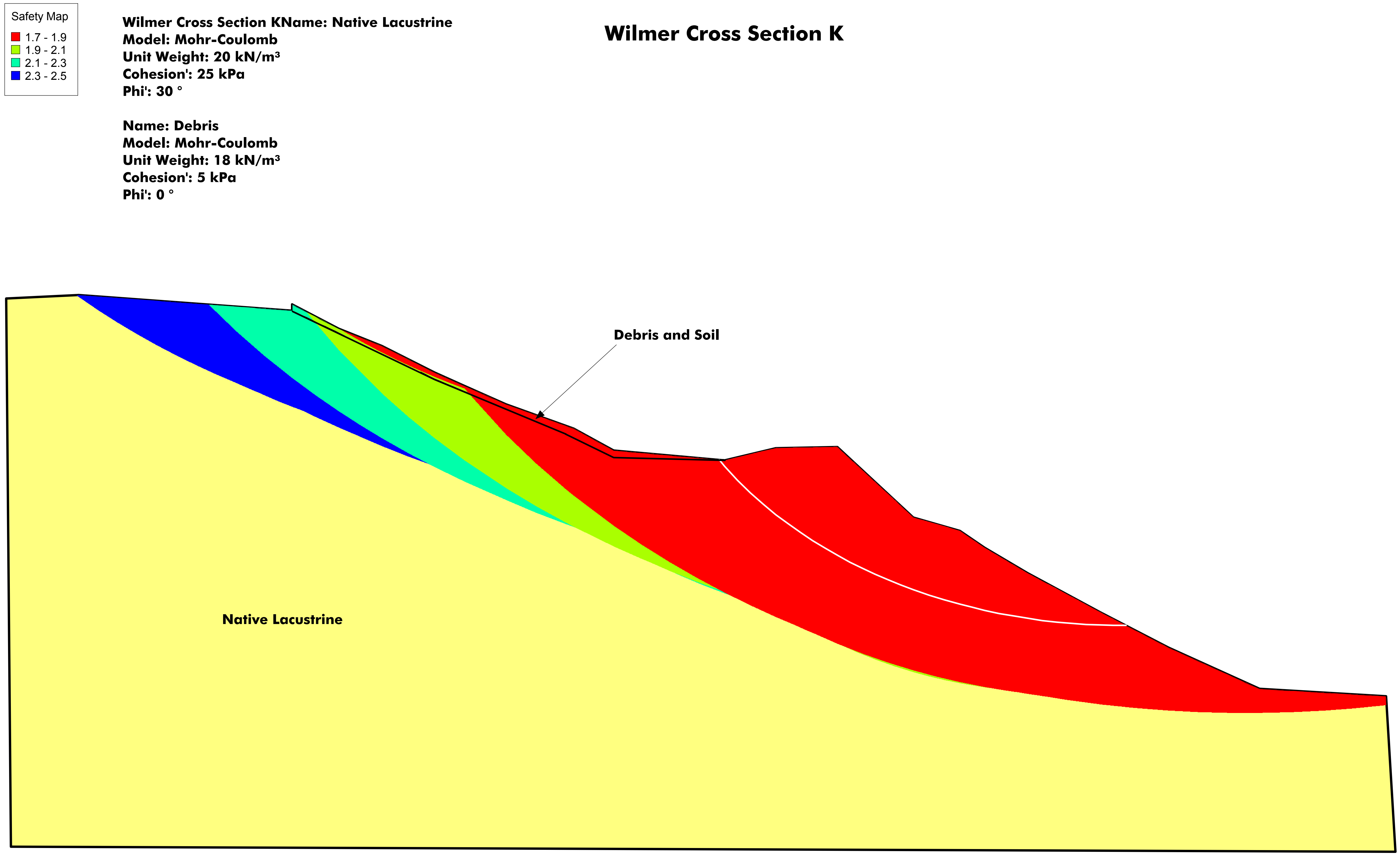
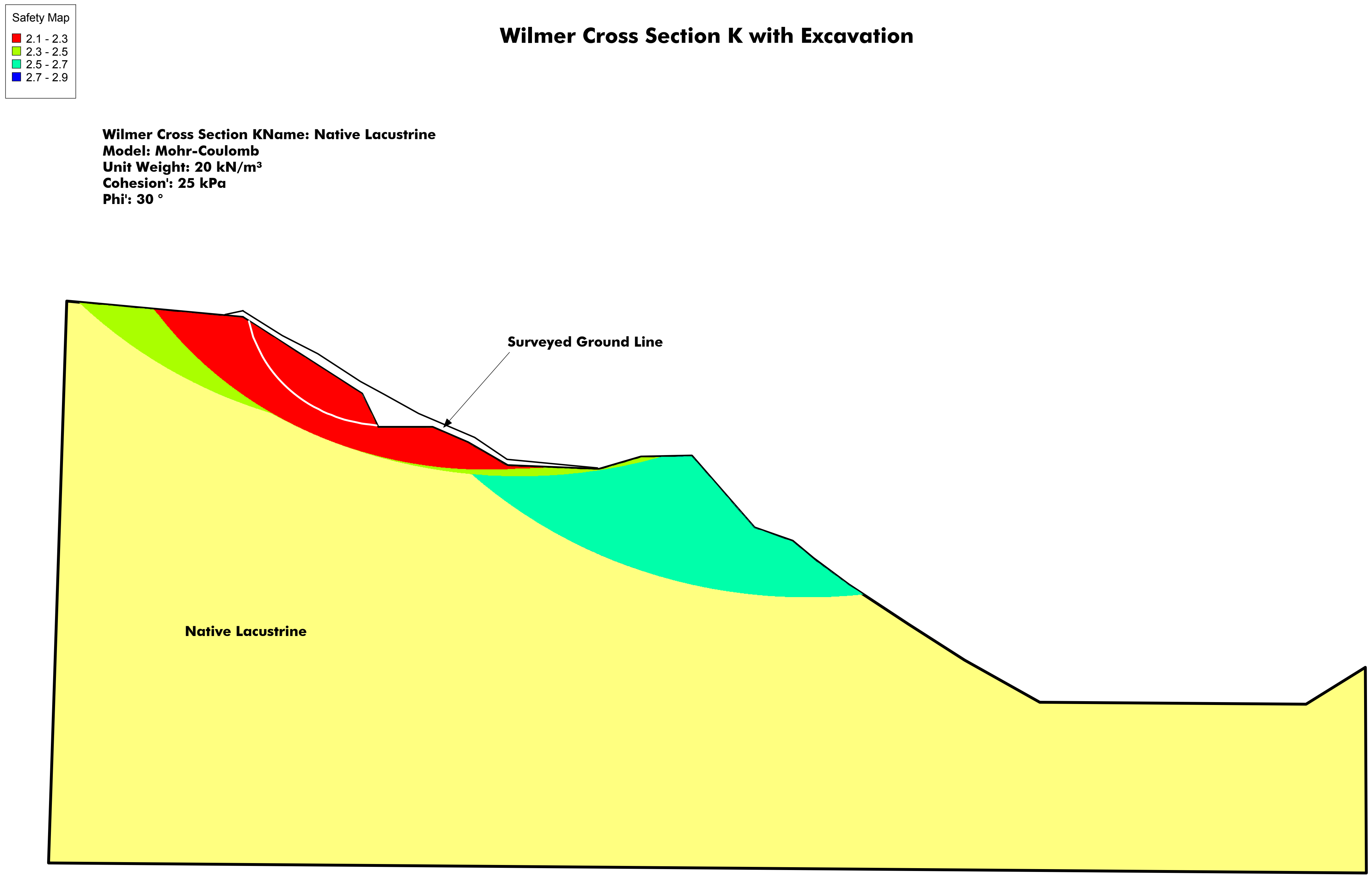
Phi': 30 °
Wilmer Survey Section I with Excavation
Surveyed Ground Line
Native Lacustrine


Safety Map
1.4 - 1.7
1.7 - 2.0
2.0 - 2.3
2.3 - 2.6
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion': 25 kPa
Phi': 30 °
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 5 kPa
Phi': 0 °
Wilmer Cross Section J
Debris and Soil
Native Lacustrine


Safety Map
1.7 - 2.0
2.0 - 2.3
2.3 - 2.6
2.6 - 2.9
Wilmer Cross Section J with Excavation
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion': 25 kPa
Phi': 30 °
Surveyed Slope Line
Native Lacustrine


Wilmer Cross Section K
Safety Map
1.7 - 1.9
1.9 - 2.1
2.1 - 2.3
2.3 - 2.5
Wilmer Cross Section KName: Native Lacustrine
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion': 25 kPa
Phi': 30 °
Name: Debris
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 5 kPa
Phi': 0 °
Debris and Soil
Native Lacustrine


Safety Map
2.1 - 2.3
2.3 - 2.5
2.5 - 2.7
2.7 - 2.9
Wilmer Cross Section K with Excavation
Wilmer Cross Section KName: Native Lacustrine
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion': 25 kPa
Phi': 30 °
Surveyed Ground Line
Native Lacustrine

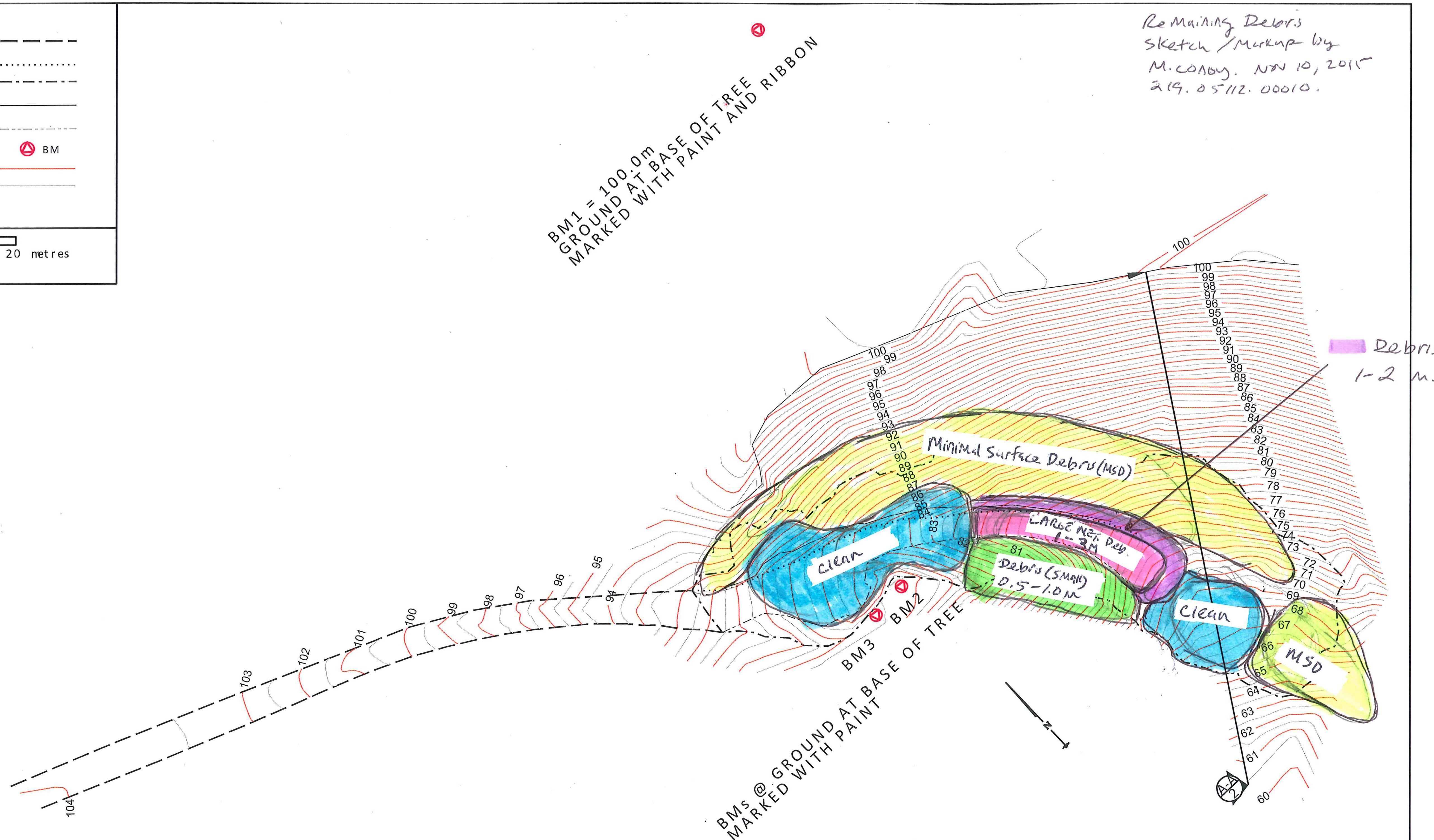
APPENDIX E: SLR MAP SHOWING AREA AND DEPTH OF REMAINING DEBRIS

LEGEND:

ROAD EDGE	— — — —
ROAD EDGE (EXCAVATED)	··············
EDGE OF EXCAVATION	—·—·—·—
TOP OF BANK	————
TOE OF CUT	- - - -
BENCHMARK	BM
1.0m INTERVAL CONTOUR	————
0.5m INTERVAL CONTOUR	————

0 10 20 metres

SCALE 1 : 500



PLAN SKETCH

SCALE 1:500

ISSUED FOR CONSTRUCTION:	DATE: N/ A	TOPO SURVEY	SHEET 1/2
REVISION:		15. 0026. 00	
ISSUED FOR APPROVAL:	DATE: N/ A		
REVIEW:	DATE: N/ A	WILMER MARSH	
DRAWING: DM	DATE: MAR 06/15		
DESIGN:	DATE: N/ A		
FIELD DATA: CR/DM	DATE: MAR 05/15	PRE-BACKFILL SURVEY	

VAST RESOURCE SOLUTIONS

FILE:15.0026.00_TOPO_SURVEY.S01

BRAUN GEOTECHNICAL LTD.

Public Works and Government Services Canada / Travaux publics et Services gouvernementaux Canada

October 23, 2015

CGL Project No. 14-0107

SLR Consulting (Canada) Ltd.
1475 Ellis Street, Suite 200
Kelowna, B.C.
V1Y 2A3

Attention: Lindsay Paterson, Project Manager

Dear Ms. Paterson,

RE: Site Inspection and Future Geotechnical Considerations
Wilmer Marsh Unit, Columbia National Wildlife Refuge, Wilmer, BC
(SLR Project No. 219.05112.00010, Task 0005)

On September 21, 2015, Clarke Geoscience Ltd. (CGL) was retained by SLR Consulting (Canada) Ltd. (SLR) to attend a site meeting at the Wilmer Marsh site, located near Invermere, BC. The purpose of the site meeting was to conduct a site inspection and to participate in a video teleconference call to discuss plans for future remediation work at the site.

Site observations are noted below and geotechnical aspects to be considered for planning future excavation work are provided.

Background

A remediation and restoration program was conducted at the former waste site between January and March 2015. During this period, over 3500 tonnes of debris and associated contaminated soil were removed from the site. Due to the slope steepness and the fine-textured glaciolacustrine silts, a geotechnical assessment was conducted prior to undertaking the excavation and on-site geotechnical monitoring was undertaken during the excavation activities.

Due to the potential for slope instability and other project constraints, all debris and soil within the Main Debris Zone could not be removed during the 2015 project period. Further excavation is required to access remaining debris located at the base of the steep silt bluff. Geotechnical considerations for future excavation and recommendations for excavation planning are presented here.

Site Observations

A site inspection was completed on September 21, 2015 by Jennifer Clarke (CGL), together with Lindsay Paterson (SLR) and Kalina Noel (SLR). Site observations are summarized as follows and photographs are attached:

- Following site recontouring, the site was hand-seeded with a native grass seed blend. Grasses (both native and non-native) have germinated across a large part (approx. 50%) of the site, with greater success on north aspects versus south aspects;

- Following seeding, an erosion control blanket (coconut-straw mat; Nilex SC32BD) was installed across exposed soil surfaces. In general, the fabric appears to have functioned well over the first 6 month period;

- It was observed that several panels of erosion control fabric were wind blown, exposing small areas of bare soil. Additional staking on the affected panels, and on panels that appear vulnerable to wind exposure, is recommended to provide additional support; and,

- There was no evidence of erosion occurring underneath the installed fabric. However, there are some areas where the fabric is not in direct contact with the underlying soil due to draping effects on some of the steeper slope sections. For future work, it is noted that the fabric functions best when installed on slopes less than 1H:1V in steepness. Additional staking to improve contact with underlying soils is recommended for the panels that are draping.

Geotechnical Considerations for Future Excavation

Based on observations made during the 2015 excavation program, SLR estimates that approximately 1,230 m^3 of debris and associated soil remains buried. Before the site was regraded and backfilled, the approximate depth and horizontal extent of remaining debris was estimated by SLR. Much of the remaining debris remains embedded into the toe of the north wall and south wall area near the wildlife tree.

To excavate the remaining material, some geotechnical aspects to consider include:

- Based on observed slope instability (tension cracks in north wall of excavation) there is a concern that additional excavation will destabilize the slope;

- To access buried debris along, and at the toe of, the north slope the excavation would likely entail working from the top-down in benches. To access material at the toe, the benches would extend into the top of the slope, resulting in a partial loss of the upper plateau. Detailed excavation planning will be required to ensure site safety and long-term geotechnical stability;

- Excavation along the north slope would disturb existing grass vegetation and, depending on the strategy, it is unclear whether the slope could be revegetated. It is possible that the slope would evolve into a near vertical silt bluff. Restoration planning should include requirements for regrading and/or backfilling.

Recommendations for an Excavation Feasibility Assessment

It is recommended that an excavation feasibility assessment be completed as part of the future works plan. The results of the feasibility assessment would be a useful first step in planning future excavation activity and could be incorporated into the contractor tender specifications.

An excavation feasibility assessment should include:

- A detailed topographic survey of the site (1 m contour interval) and cross-sections across the slope (at least 3) through the proposed excavation section. Surveying may be done using a total station approach, or may be suited to airborne photogrammetry or LiDAR.

- Collect soil samples (at least 5) by hand auger and conduct material testing to obtain parameters for stability analysis (including, but not necessarily limited to, grain size, density, specific weight).

- Complete a slope stability analysis for different excavation scenarios to determine the feasibility and approach for accessing and removing buried debris.

Results from the feasibility assessment would be used in the preparation of a detailed engineered excavation plan, which could be a specified contract requirement. It is recommended that, prior to undertaking the excavation work, an excavation plan be prepared, reviewed, and surveyed prior to any work moving forward. The plan should provide details regarding methodology and approach and should provide limits for safety and for slope stability.

If you have any questions or comments, please do not hesitate to contact the undersigned at 250-826-4367.

Respectfully submitted,

CLARKE GEOSCIENCE LTD.

PROFESSIONAL GEOSCIENTIST PROVINCE OF BRITISH COLUMBIA J.A. CLARKE 25319 10/23/15

Jennifer Clarke, M.Sc., P.Geo.
Geotechnical Consultant

Attachments:
Photographs 1 to 2

Photo 1: View of Main Debris Zone to the west from the top of the slope (Sept. 21, 2015)

Photo 2: View of the Main Debris Zone to the west from the bottom of the slope. Note panels of fabric on the south side of the slope that have been wind blown (Sept. 21, 2015)

March 31, 2016

CGL Project No. 15-0105

SLR Consulting (Canada) Ltd.
1475 Ellis Street, Suite 200
Kelowna, B.C.
V1Y 2A3

Attention: Lindsay Paterson, Project Manager

RE: Geotechnical Review Summary
Excavation Feasibility and Slope Stability Assessment
Wilmer Marsh Unit, Columbia National Wildlife Refuge, Wilmer, BC
(SLR Project No. 219.05112.00010, Task 0005)

Dear Ms. Paterson,

Clarke Geoscience Ltd. (CGL) was retained by SLR Consulting (Canada) Ltd. (SLR) to attend a site meeting at the Wilmer Marsh site, located near Invermere, BC. The purpose of the site meeting was to consult with and observe the geotechnical drilling investigation being conducted by VAST Resource Solutions Inc. (VAST), based out of Cranbrook, BC.

CGL provided an on-site presence during the investigation and completed a peer review of the geotechnical analysis and report. A summary of work completed is provided for documentation purposes.

Site Visit

A site visit was completed on February 25, 2016 by Jennifer Clarke (CGL), together with Kalina Noel (SLR), and Evan Kleindienst (VAST). Three other personnel from VAST were present on-site to provide drilling supervision and to conduct topographic surveying. In addition, construction contractor Rick Hardy was on-site to provide opinions regarding excavation approach considerations.

A single borehole was advanced 25 m (82.5 ft) from the top of the terrace near the slope crest. Standard penetration tests were done at intervals and soil samples were collected for lab analysis to assist in determining strength parameters. Groundwater was not encountered during the drilling program.

Summary of Excavation Feasibility and Slope Stability Assessment

Using surveyed topography, borehole data, and analyzed soil strength parameters, VAST completed slope stability analyses for seven (7) cross-sections of the study slope. Post-excavation scenarios used SLR estimates of the extent and depth of remaining debris. With respect to those estimates, an additional area of shallow (0.5 m) debris was extended to the crest of the slope, and 1.0 m depth was added to an area adjacent to the trees, to provide contingency to the post-excavation stability analysis completed by VAST.

The slope stability analysis concludes the following:
- In its existing state, and on a large scale, the slope is considered stable;
- The stability analyses for the existing slope finds that large-scale catastrophic failures are not expected. However, small, shallow debris slides within the remaining unconsolidated debris material are expected to occur in the future;
- Slope stability was analyzed for a post-excavation scenario, where all remaining debris (est. 1,500 m^3) is removed using an approach that assumes the construction of several full-bench trails to access buried debris. This excavation approach will generate an additional estimated 1,000 m^3 of soil for handling and management.
- The post-excavation slope is considered stable. The results indicate that the excavation will not compromise the stability of the slope and that the slope will remain stable on a large-scale.
- By removing the surficial debris, the likelihood of future shallow debris slides is reduced.

Recommendations for future debris removal are provided in the VAST report and include the following main points:
- To access buried debris, excavation should proceed in a top-down approach under the supervision of a Professional Engineer or Geoscientist;
- Detailed engineered excavation plans and site reclamation plans should be prepared for future work;
- Operational safety guidelines for working on or below the steep slopes are provided; and,
- Post-excavation site monitoring and erosion control measures are recommended.

Conclusion

The excavation feasibility and slope stability assessment forms a useful first step in future excavation planning and may be incorporated into contractor tender specification documents.

Once a decision has been made whether to proceed or not, it is recommended that a full excavation plan, approved by a Professional Engineer or Geoscientist, be requested of the selected contractor. Full-bench cuts into the slope were assumed for the feasibility assessment. However, the chosen excavation approach may vary based on the contractors innovation, use of specialized equipment, or ability to manage large volumes of soil. Excavation plans should allow for contingency based on the current uncertainty regarding the volume and extent of debris remaining on site.

Respectfully submitted,

CLARKE GEOSCIENCE LTD.

Jennifer Clarke, M.Sc., P.Geo.
Director

cc. Evan Kleindienst, P.Eng./RPF, VAST Resource Solutions Inc.

Environment and Climate Change Canada
Canadian Wildlife Service
5421 Robertson Rd.
Delta, BC.
V4K 3N2

August 17, 2016

SLR Consulting (Canada) Ltd.
200 – 1475 Ellis Street
Kelowna, BC V1Y 2A3
Fax (250) 763-7303

Dear Ms. Paterson,

Re: Regarding Conceptual Approach – Proposed Remediation Program Uplands Trail area, Wilmer marsh unit, Columbia National Wildlife Area

The Canadian Wildlife Service (CWS) has reviewed your Conceptual Approach document from 24 June 2016. CWS was requested to: 1) identify probable conditions on the permit which would be issued for the remediation project; and 2) provide approval for the conceptual excavation and restoration approach.

CWS has considered the potential permit conditions outlined under section 2.3. The stated standard terms and conditions are likely to be included on future permits for a proposed remediation program. Project-specific conditions will vary based on the proposed works and mitigation measures submitted by the successful contractor in the permit application. If the proposed works are to be consistent with previous remediation programs and the excavation and restoration methods outlined in this conceptual approach document then the described project-specific conditions are appropriate. We recommend adding the line, "SARA Species at Risk conditions contained in previous permits for this project are applicable." Otherwise, these standard and project-specific terms and conditions overall are acceptable, although the advice and actual prescribed permit conditions may change based upon our review of the final accepted proposal and permit application.

CWS has also reviewed the two options for the restoration approach as outlined in section 2.2. CWS considers option 2 as the better approach to restoration since it is likely to provide increased wildlife habitat more quickly and has been used for previous remediation activities at this site. Therefore, option 2 will be the preferred option for CWS.

CWS has considered the Conceptual Approach document and it appears well thought-out and reasonable. However, CWS is limited to biological expertise and it is appropriate for the Environment and Climate Change Canada Technical Lead, Mark Konecny, to ensure that the required geotechnical review is conducted.

Thank you.

Regards

René McKibbin
Protected Areas Coordinator
Canadian Wildlife Service
Pacific Wildlife Research Centre
5421 Robertson Road, RR1
Delta, BC
V4K 3N2
604-350-1994
Rene.mckibbin@canada.ca

cc Ian Parnell, Head Protected Areas