Mr. Richard Collumbine, P.Eng
ISL Engineering and Land Services
#101 621 – 10th Street
Canmore, AB T1W 2A2

June 5, 2024

Project Number: 2024-055

RE: Geotechnical Services for Construction Phase of Retaining Wall Replacement
Prospect Heights, Canmore, AB

Dear Mr. Collumbine,

As requested by ISL Engineering and Land Services (ISL), Taylor Geotechnical Ltd. (TGL) has conducted a review of the construction phase associated with the retaining wall replacement project at Prospect Heights in Canmore, AB (hereafter referred to as the "site"). The purpose of the review was to provide comments and recommendations pertaining to the construction phase of the retaining wall replacement project.

The scope of work for this project was provided in the proposal (quote number 1506), dated February 5, 2024. Authorization to proceed was given by Mr. Monson on April 15, 2024 via email correspondence.

It should be noted that the scope of this report is limited to the geotechnical assessment of the proposed development. It does not include any investigation, analytical testing, or assessment of possible groundwater contamination, archeological or biological considerations, or sediment control measures. This report should be read in conjunction with the Disclaimer and Limitations which are appended following the text of this letter. The reader's attention is specifically drawn to this information as it is essential for the proper use and interpretation of this report.

1.0 PROJECT UNDERSTANDING

It is understood that a boulder retaining wall along the access/egress road below Prospects Heights Road in Canmore, AB is experiencing distress, with notable areas of failure. The wall is located on the downhill side of Prospects Heights Road, with sloping terrain, an existing boulder wall, and existing residential structures existing above the retaining wall location. Canmore Creek exists below the retaining wall location.

ISL has designed a new retaining wall system to replace the existing failing system. Please refer to the drawing package *Town of Canmore Prospect Heights Retaining Wall,* dated April 27, 2024 for Draft Print for retaining wall details. ISL requires a global stability analysis of the construction phase of the retaining wall replacement project, to determine safe working slope angles for the new proposed retaining wall and ensure construction does not impact the overlying slope and infrastructure. Additionally, a preliminary global stability analysis of the proposed retaining wall design was required.

Please note, a retaining wall analysis inclusive of internal and external failure modes was not completed as part of this scope of work.

2.0 DOCUMENT REVIEW

The following section summarizes the pertinent information obtained from the document review. Documents were provided by the ISL upon initiation of this study.

The following summarizes information from the supplied drawing set, 62061_PropspectHtsWall_90P_230825 (July 2023) which documents retaining wall design:

- Approximately 65 metres of gabion wall designed for replacement.
- Gabion baskets are to be designed by others.
- Gabion baskets are to be battered at 6 degrees from vertical.
- No minimum embedment criterion is given.
- Native material compacted to 95% SPMDD used as backfill behind clean well graded material.
- Backfill parallel to gabion black to consist of clean, well graded crushed granular material compacted to a minimum of 98% SPMDD.
- Non-Woven geotextile fabric recommendations are given.
- The tallest wall section is 4 m high.

The report completed by Clifton titled "*Canmore Bow River Pathway Geotechnical Investigation, File CG3608*" dated June 24, 2022, summarizes results of a geotechnical investigation at site and provides commentary to evaluate the possible cause of retaining wall failure. Pertinent details of the subsurface investigation are summarized below.

- The investigation included advancing various boreholes and hand auger holes across site. BH22-05, HA22-02 and HA22-03 were advanced proximal to the retaining wall location.
- BH22-05 was drilled above the existing retaining wall to 6.2 mbgs, while HA22-02 and HA22-03 were hand excavated at the retaining wall base to 0.5 mbgs.
- The subsurface conditions are summarized, as follows:
    - Brown, compact sandy gravel, containing trace to some silt and trace clay, was encountered from ground surface to 3.4 mbgs.
    - Black coal was encountered beneath the sandy gravel to 3.6 mbgs.
    - Dark brown, dense to very dense gravel, containing trace clay, was encountered beneath the coal to 4.9 mbgs.

  - Very dense coal was encountered from 4.9 to the termination of the borehole at 6.2 mbgs.
  - Groundwater was not encountered at the time of the investigation.

- The report suggests that failure of the boulder wall was attributed to the use of rock, and its noncontinuous mechanical connection between the bearing surface and geogrid. Additionally, it mentions inadequate subgrade and base prep leading to the settlement of foundation soils.
- No evidence of significant instability below the retaining wall was noted.
- The report also suggests that possible undermining of the rock retaining wall could be attributed to underground seepage and loss of fines.
- Proposed remedial measures included replacing the existing failed gabions with a structural retaining wall at the failure locations.

A search of TGL's database for pre-existing subsurface investigations proximal to the site was also conducted. No pre-existing investigations relevant to the project site were found.

3.0 FIELD WORK AND OBSERVATIONS

A field review was carried out by TGL personnel on April 25, 2024. The assessment included a review of the existing retaining wall and the surrounding terrain, including the overlying pathway and the underlying sloping terrain to Canmore Creek. An additional subsurface investigation was not completed as part of this scope of work.

Key observations are summarized below.

- The boulder retaining wall was noted to be approximately 115 m in length.
- The terrain at the toe of the wall was noted to be moderate to moderately steep. Signs of ground instability were not noticed during investigation.
- Soils consisted of gravel and sands at the surficial level.
- No tension cracks were observed in the slope or in the overlying pathway.
- Ravelling of surficial materials was observed, with evidence of surface water runoff.
- Utilities were noted in the access/egress right of way by way of 200 mm sanitary. Depth and location to line is to be confirmed prior to construction.
- Groundwater seepage was not observed at the time of the review. Please note, groundwater levels are subject to seasonal variation with the highest water levels likely to occur during the late-spring and summer months.

4.0 SLOPE STABILITY ANALYSIS

A global stability analysis of the construction case and the design case (e.g., following construction of the retaining wall) was undertaken for the proposed retaining wall replacement. The analysis was completed using 2D numerical modelling techniques with limit equilibrium methods. Slide2 propriety software by Rocscience Inc was used. Three sections were reviewed, as provided in the ISL drawing package. The sections were confirmed using TGL's field observations.

The stratigraphy was selected based on the Clifton subsurface investigation. The Clifton investigation was deemed suitable for use considering the proximity of the investigation to the retaining wall, as well as considering no notable changes have been made to the area since the investigation occurred.

The material parameters used in the analysis were selected based on the subsurface investigation findings as summarized in Table 1 below. Additionally, a high groundwater level was selected based on the 100 year flood-level, as provided in the ISL drawing package.

Table 1: Material Properties

Material	Unit Weight (kN/m^3)	Angle of Internal Friction (°)	Apparent Cohesion (kPa)
Sandy Gravel	21.5	38	0
Coal	19.5	44	0
Gravel	21.0	45	0
Vegetation	19.5	35	3

A distributed load of 50 kPa was included at the existing Prospect Heights condominium location for both cases. Please note, a retaining wall analysis inclusive of internal and external failure modes was not completed as part of this scope of work.

4.1 CONSTRUCTION CASE

Section 3, located at Station 30+024, was deemed the critical section for the construction case as the retaining wall is tallest in this location. It is understood that a construction cut of 1 horizontal to 1 vertical (1H:1V) is to be used, which was assessed in this analysis. It was assumed that the overlying pathway will remain closed throughout the duration of construction and therefore no loading was considered at the pathway location.

For the slope to be considered stable in terms of short-term stability (e.g., for construction purposes), a minimum Factor of Safety (FOS) of 1.1 to 1.2 is required. FOS describes the ratio of culmination of resisting forces (or moments) compared to the culmination of driving forces (or moments). Table 2 below summarizes the FOS results for the critical sections. Please refer to Appendix A for graphical results.

Table 2: Summary of Retaining Wall Analysis Results

Section	Local FOS	Global FOS
3 (Sta 30+024)	1.16	2.35

Based on the slope stability analysis, a construction cut slope of 1H:1V is considered stable in terms of short-term performance and is therefore appropriate for construction. The cut slope does not influence the overall global stability of the slope, and the overlying infrastructure, inclusive of the condominium, is unaffected.

4.2 DESIGN CASE

For the design case, both Section 1, located at Station 30+005, and Section 3 were assessed. For the design case, the critical loading considered the weight of a firetruck on the pathway, with a distributed load of 20 kPa as provided by ISL.

For the slope to be considered stable in terms of long-term performance (e.g., following construction), a minimum FOS of 1.5 is required. The analysis considered the local global stability surrounding the retaining wall, as well as the overall global stability of the entire slope. Table 3 below summarizes the FOS results for the critical sections. Please refer to Appendix A for graphical results.

Table 3: Summary of Retaining Wall Analysis Results

Section	Local FOS	Global FOS
3 (Sta 30+024)	1.57	2.44
1 (Sta 30+005)	1.37	2.35

Based on the slope stability analysis, the retaining wall at Station 30+024 is stable in terms of long-term performance. Additionally, the entire slope remains stable in terms of global stability at both section locations. However, the local FOS at Station 30+005 does not meet the minimum FOS criteria, with a FOS less than 1.5.

5.0 GEOTECHNICAL COMMENTS AND RECOMMENDATIONS

Based on the results of the slope stability analysis, comments and recommendations pertaining to the construction phase of the retaining wall replacement project, as well as the retaining wall design, are provided below.

- A construction cut slope of 1H:1V is permitted. The pathway should remain closed throughout the duration of construction.
    - If steeper temporary excavation side slopes are required, additional geotechnical review is required.
    - Should sloughing soils or shallow groundwater be encountered during construction, excavations will need to be flattened. Additional geotechnical review is required to provide specific input on these requirements.
    - If excavations extend below the groundwater table, dewatering should be in place immediately after excavation. Dewatering should work continuously while constructing below the groundwater level. Dewatering is typically the responsibility of the contractor.

- The proposed retaining wall design located at Station 30+024 is considered acceptable in terms of local global stability.

- The proposed retaining wall design located at Station 30+005 does not meet the FOS criteria, with local global FOS less than 1.5. It is anticipated that the low FOS in this area can be attributed to the over-steepened slope located beneath the retaining wall.

- TGL recommends adjusting the retaining wall design at Station 30+005 to allow for greater embedment.

    - A revised design should consider a deeper embedment vertically into the ground surface, and/or horizontally into the sloping terrain.

    - An additional slope stability analysis should be undertaken to determine the revised design. TGL can complete this upon request.

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6.0 CLOSURE

It is trusted that this letter report meets your present requirements. Should you have any questions or need additional information, please do not hesitate to contact Heather Taylor at 403-707-5082 to discuss.

Kind Regards,

TAYLOR GEOTECHNICAL LTD.

Prepared By:

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Geotechnical Engineer in Training

Reviewed By:

PROFESSIONAL ENGINEER ALBERTA
HEATHER TAYLOR

2024-06-05

Heather Taylor, MSc, PEng
Geotechnical Engineer

APEGA Permit to Practice #:

PERMIT TO PRACTICE
TAYLOR GEOTECHNICAL LTD.
RM SIGNATURE:
RM APEGA ID #: 169143
DATE: 2024-06-05
PERMIT NUMBER: P014061
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

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This report was prepared for the Client for the purpose of providing geotechnical investigation for the specific site, development, and design described to Taylor Geotechnical by the Client.

The findings, opinions and recommendations in this report are only valid to the extent that the report addresses these specifics and remain subject to the limits described herein.

The opinions and recommendations in this report are based on geotechnical investigation work carried out on site in accordance with the Standard of practice described herein.

The report does not include any investigation, analytical testing or assessment of possible soil and groundwater contamination, archeological or biological considerations or sediment control measures.

The Client should provide Taylor Geotechnical with notice any material changes to the site, development, design and objectives, and provide Taylor Geotechnical with opportunity to revise the report accordingly. Any special concerns or circumstances not contemplated at the time of the report should be communicated so that Taylor Geotechnical may conduct further investigations not otherwise within the scope of services provided.

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In preparing this report, Taylor Geotechnical has relied in good faith on information from the Client and further persons. Taylor Geotechnical is entitled to rely on such information and is not required to independently verify the truth of information provided. Taylor Geotechnical accepts no responsibility for any misstatements in the report

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INTERPRETATION OF SITE CONDITIONS

The interpretations of site conditions in this report are based on the conditions at sample locations on a specific site at one point in time, and the opinions and recommendations provided are only valid to that extent.

The interpretation of site conditions involves inherent and unavoidable risks. The identification and classification of soils, rocks, geological units, materials and quantities of the same is inherently judgemental in nature. The investigative practice means that some conditions may not be detected or that actual conditions may vary from sample points. Comprehensive investigations conducted according to the applicable standards by experienced personnel with appropriate equipment can still fail to locate some site conditions.

As conditions may change over time, this report is intended for immediate use. The Client should provide Taylor Geotechnical with any changes to site conditions or new information that becomes available after the date of this report and have Taylor Geotechnical re-consider its opinions and recommendations prior to the Client or Third Parties making decisions based on this report.

REGULATORY CONTEXT

This report was prepared in the context of government regulations and policies in effect and generally promulgated at the time and, unless specifically noted, does not consider any government regulations or policies that were not in effect and generally promulgated at the time it was prepared. Unless specifically stated, this report provides no advice on regulatory issues associated with the site or project.

INDEPENDENT JUDGEMENT OF CLIENT

Opinions and recommendations in this report are based on Taylor Geotechnical's interpretations of information obtained through a limited investigation within a defined scope of services. Taylor Geotechnical is not liable for the independent conclusions, interpretations and decisions of the Client or any Third Parties based on this report. This limitation includes any decisions to purchase, sell, develop, lease or rent land or buildings.

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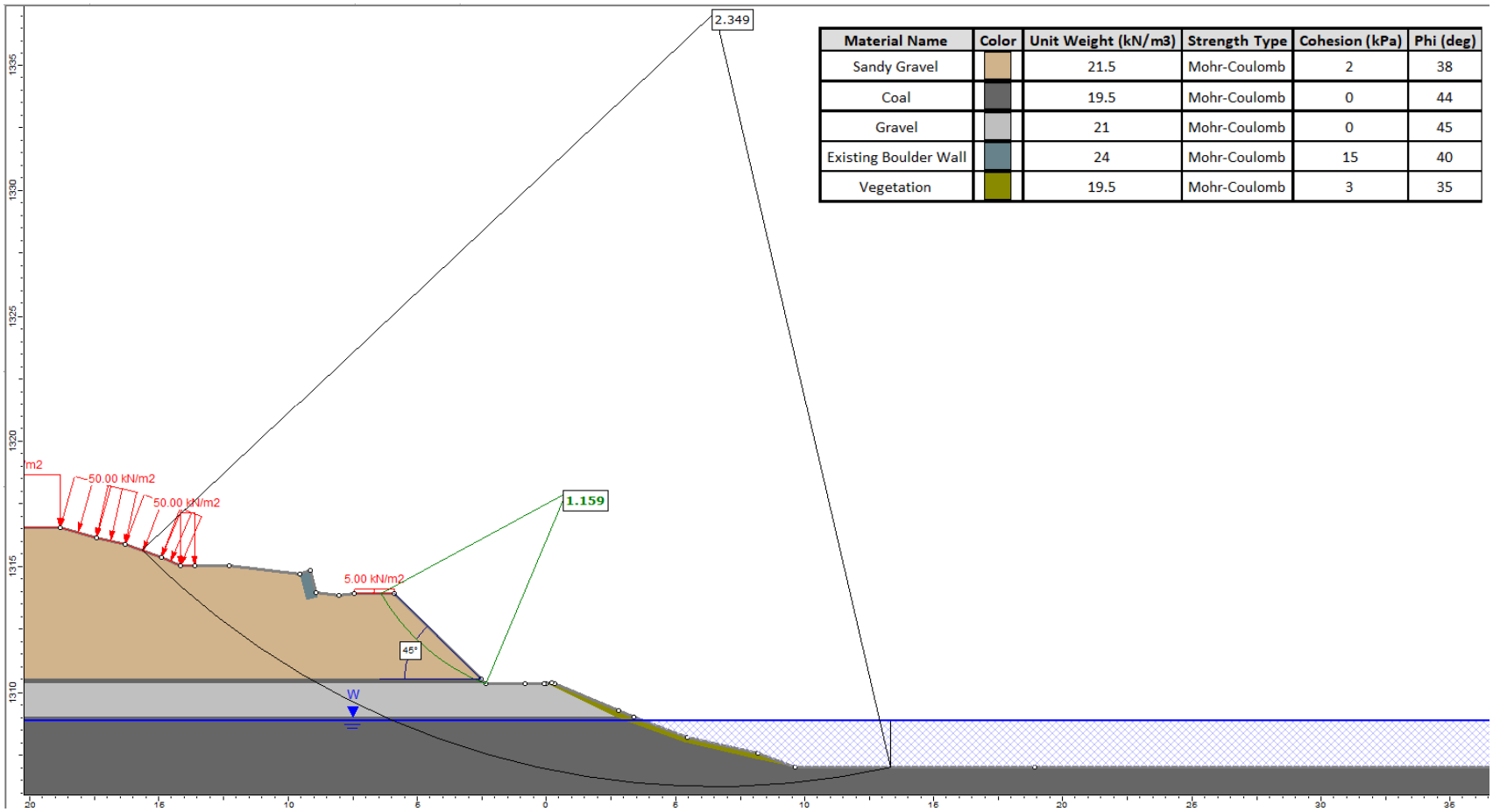
Geotechnical engineering and environmental consulting work involves risks of encountering and causing the release of pollutants or hazardous substances. Taylor Geotechnical shall have no liability to the Client or Third Parties for such releases unless the substance is specifically identified by the Client prior to the performance of services.

DESIGN AND CONSTRUCTION SERVICES

Where consented to by Taylor Geotechnical, this report may form part of design and construction documents for information purposes even though issued prior to final design. Any differences between the recommendations in this report and the final design should be reported to Taylor Geotechnical, and Taylor Geotechnical to review the final design for consistency with the recommendations prior to proceeding to construction. All recommendations remain subject to field review by Taylor Geotechnical during the construction phase, and Taylor Geotechnical should be retained to conduct such field review to confirm that the site conditions do not materially differ from the interpreted conditions at the time the report was prepared.

These further services may be necessary for Taylor Geotechnical to provide letters of assurance as required by regulatory bodies in some jurisdictions.

APPENDIX A: SLOPE STABILITY ANALYSIS



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Sandy Gravel		21.5	Mohr-Coulomb	2	38
Coal		19.5	Mohr-Coulomb	0	44
Gravel		21	Mohr-Coulomb	0	45
Existing Boulder Wall		24	Mohr-Coulomb	15	40
Vegetation		19.5	Mohr-Coulomb	3	35

Reference: Slide2

DATE:	2024-05-24
DRAWN:	RM
DESIGNED:	RM
CHECKED:	HT
APPROVED:	HT

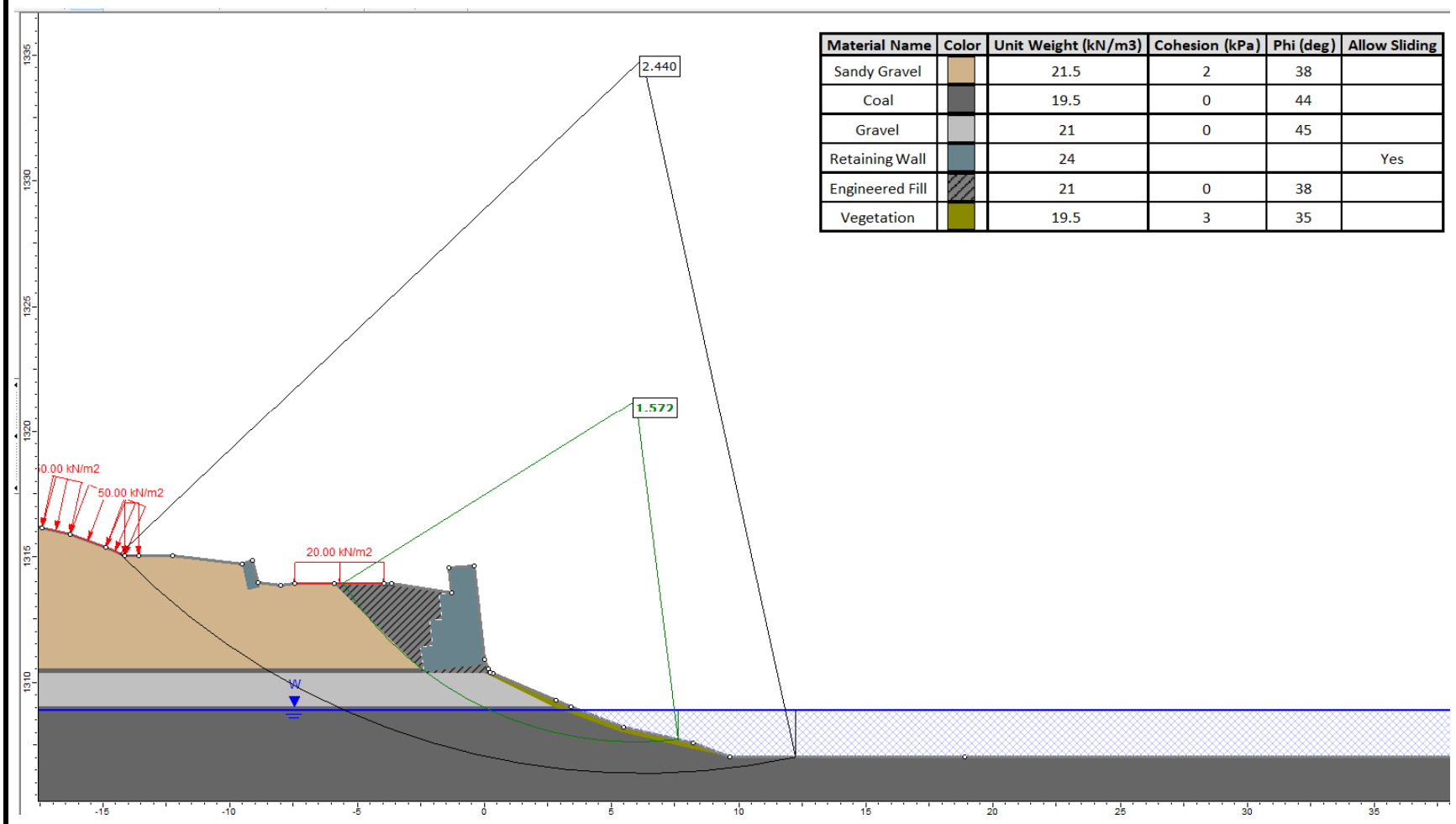
TAYLOR GEOTECHNICAL

CLIENT: **ISL**

PROJECT: **Prospect Heights Retaining Wall Global Stability Analysis**

TITLE: **Construction Case at Sta 30+024**

PROJECT #: 2024-055 | FIGURE: A1 | REV.: 0



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)	Allow Sliding
Sandy Gravel		21.5	2	38	
Coal		19.5	0	44	
Gravel		21	0	45	
Retaining Wall		24			Yes
Engineered Fill		21	0	38	
Vegetation		19.5	3	35	

Reference: Slide2

DATE:	2024-05-24
DRAWN:	RM
DESIGNED:	RM
CHECKED:	HT
APPROVED:	HT

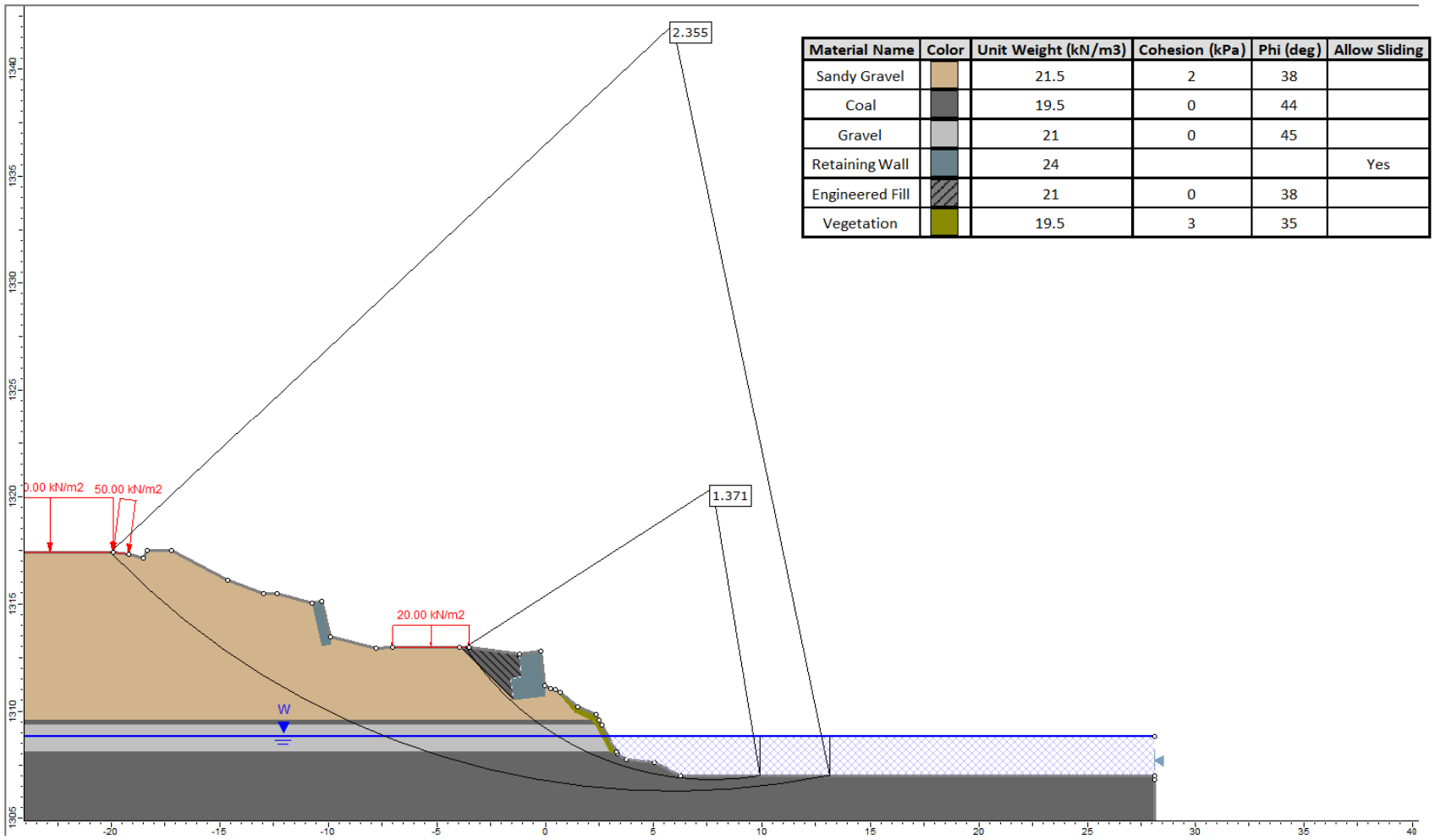
TAYLOR GEOTECHNICAL

CLIENT: **ISL**

PROJECT: **Prospect Heights Retaining Wall Global Stability Analysis**

TITLE: **Design Case at Sta 30+024**

PROJECT #: 2024-055 | FIGURE: A2 | REV.: 0



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)	Allow Sliding
Sandy Gravel		21.5	2	38	
Coal		19.5	0	44	
Gravel		21	0	45	
Retaining Wall		24			Yes
Engineered Fill		21	0	38	
Vegetation		19.5	3	35	

Reference: Slide2	DATE: 2024-05-24	TAYLOR GEOTECHNICAL	PROJECT: **Prospect Heights Retaining Wall Global Stability Analysis**
	DRAWN: RM		
	DESIGNED: RM		TITLE: **Design Case at Sta 30+005**
	CHECKED: HT	CLIENT: **ISL**	
	APPROVED: HT		PROJECT #: 2024-055 / FIGURE: A3 / REV.: 0