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Mount Cooee Landfill Development Plan and Resource Recovery Centre

Geotechnical Interpretive Report

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Contents

List of Figures

List of Tables

List of Appendices

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This report ('**Report**') has been prepared by WSP exclusively for Clutha District Council ('**Client**') in relation to the geotechnical interpretation and preliminary assessments of the existing Mount Cooee landfill and the proposed expansion. The scope of this report is to present the findings from the preliminary geotechnical assessments to inform the resource consent renewal for the existing landfill and preliminary design of the proposed landfill ('**Purpose**'). The findings in this Report are based on and are subject to the assumptions specified in the Report and the Offer of Service dated 31 August 2022 and the subsequent Confirmation Briefing Notice (CBN) dated 19 September 2022. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

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1 Introduction

1.1 Objectives

WSP have been engaged by the Clutha District Council (CDC) to provide engineering services for the renewal and development of the Mt Cooee Landfill ('landfill') in Balclutha. The scope of services was presented in the WSP Offer of Service dated 6 August 2021.

As part of the project, WSP undertook deep ground Investigations in October and November 2022 to inform the variability of ground and groundwater conditions across the site. A summary of the factual data from the investigations was presented in the WSP report 'Mt Cooee Landfill Development Plan and Resource Recovery Centre – Geotechnical Factual Report – Rev 2' dated 31 March 2023 (WSP, March 2023).

This report provides a summary of a preliminary geotechnical assessment for the resource consent renewal for the existing landfill and the preliminary design of the proposed landfill expansion.

1.2 Relevant Reports

This report should be read in conjunction with the following reports:

- 'A Report of Site Investigations at the Mount Cooee Landfill', by Royds Consulting Limited, May 1994 (Royds Consulting Limited, 1994).
- 'Mt Cooee Landfill Development Plan and Resource Recovery Centre – Geotechnical Factual Report' by WSP dated 31 March 2023, Revision 2 (WSP, March 2023).
- 'Mt Cooee Landfill Development Plan – Sheet Pile Cut-off Review Report (Final Issue)' by WSP dated 5 April 2023 (WSP, April 2023).

2 Site Description

The Mt Cooee Landfill site (the 'site') is situated on the Kaitangata Highway in the outskirts of Balclutha. The site encompasses 2 lots on the property DP 12203 and has a total area of approximately 12.8 hectares. The approximate location of the site relative to Balclutha is shown on Figure 1 below.

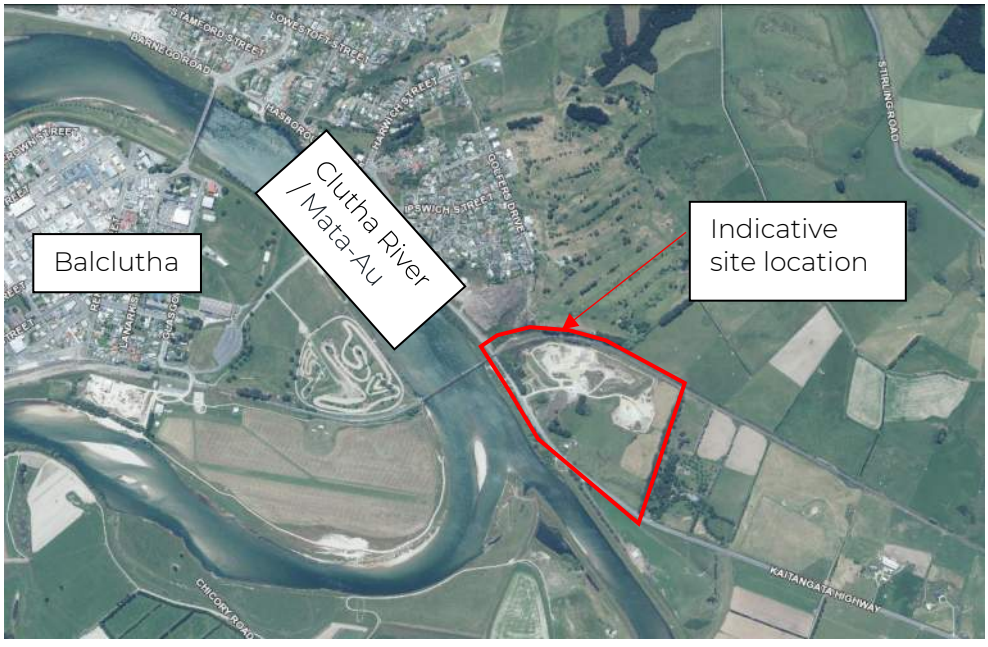


Figure 1: Indicative location of the Site (Image courtesy of DCC's Web Map)

The site is situated in a gently sloping valley that drops southwest towards the Clutha River/ Mata-Au. The site is bounded by the Dunedin – Invercargill Railway Line (the 'Railway Line') to the north and the Katitangata Highway to the south. The Highway runs adjacent to the Clutha River / Mata-Au. The site adjoins private farmland to the east, from which it is screened by a windbreak of large macrocarpa trees. Access to the site is via a driveway off the Kaitangata Highway.

The area to the east of the site is rural land, with the nearest dwelling roughly 250 m from the site boundary. The Balclutha Golf Course is situated across the Railway Line to the north of the site.

2.1 Site Features and Operations

The landfill has been operating since about 1985 and is currently operated under the classification of a "Class 1" landfill in accordance with WasteMINZ Technical Guidelines to Land 2022 (WasteMINZ, 2022). The landfill is currently the only municipal solid waste landfill in the Clutha District, servicing a district population of around 18,400, including approximately 4,000 in the immediate township of Balclutha. The landfill receives approximately 9,000 tonnes of waste per year, including waste received through Council's kerbside refuse collection service (servicing around 6,000 households) and ten public drop-off facilities/transfer stations, along with residential, commercial, and industrial customers.

Site operations are managed by a private contractor, with general waste deposited directly to the tip face and green waste and hardfill deposited on an area of capped landfill. Resource Recovery facilities are situated across the southern end of the landfill on hard stand areas.

The existing landfill is not lined but a low permeability cut off element was designed under the southern perimeter bund comprising a clay filled trench and an approximately 46m long section of sheet pile to bedrock. The indicative extents of the perimeter bund and the sheet pile wall are shown on the Site Plan – Appendix A. Based on the review of available information by Royds Consulting Limited (1995), the wall was constructed circa 1995 using a total of 115 sheet pile sections, each nominally 0.4m wide. The records indicate the wall was driven to refusal on top of weathered greywacke bedrock, with pile lengths ranging between 6 to 11 m along the wall. A typical cross section of the bund and the cut off wall is presented on
Figure 2 below. Further details of the cut off wall are presented in WSP (April 2023).

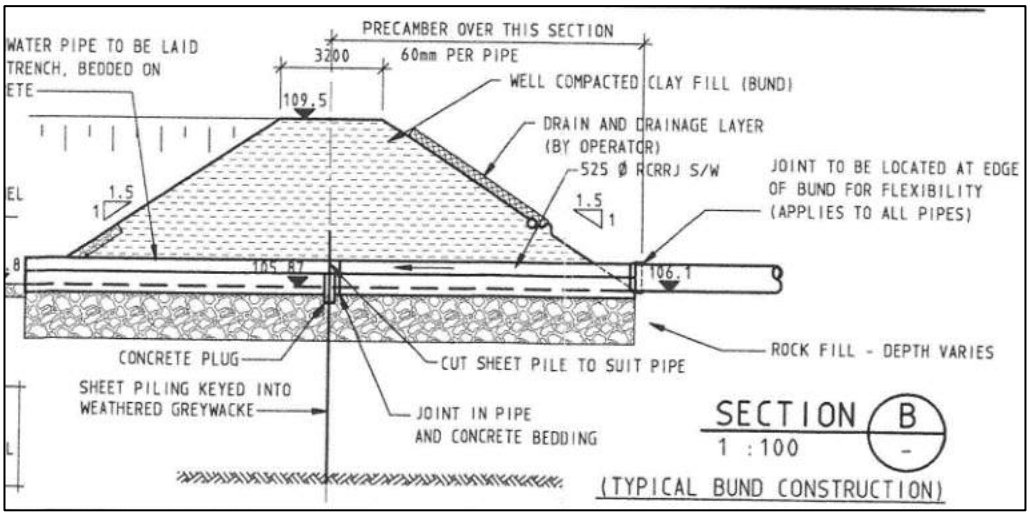


Figure 2: Typical bond construction and sheet pile detail (Courtesy of Royds Consulting Limited, 1995)

A historic drawing by Royds Consulting Limited (1995) suggests the sheet pile wall is situated along the central section of the clay bund, where the bedrock is deepest at the valley floor (in the order of 10m or so). Instead of the sheet pile wall, it appears that an approximately 1.0m wide low permeability clay barrier was constructed along the clay bund beyond the two ends of the sheet

pile wall, where bedrock becomes progressively shallower. An extract from the drawing is presented as Figures 3 and 4 below.

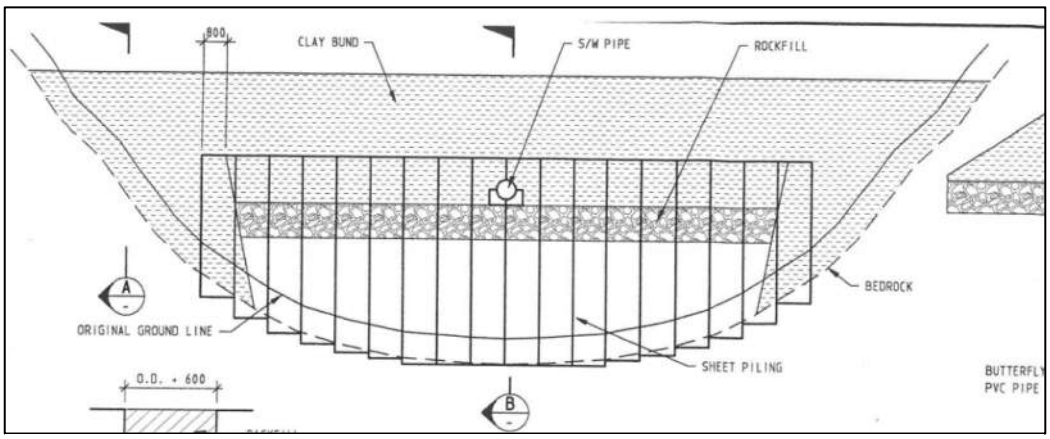


Figure 3: Schematic elevation of cut-off wall (image courtesy of Royds Consulting Limited (1995))

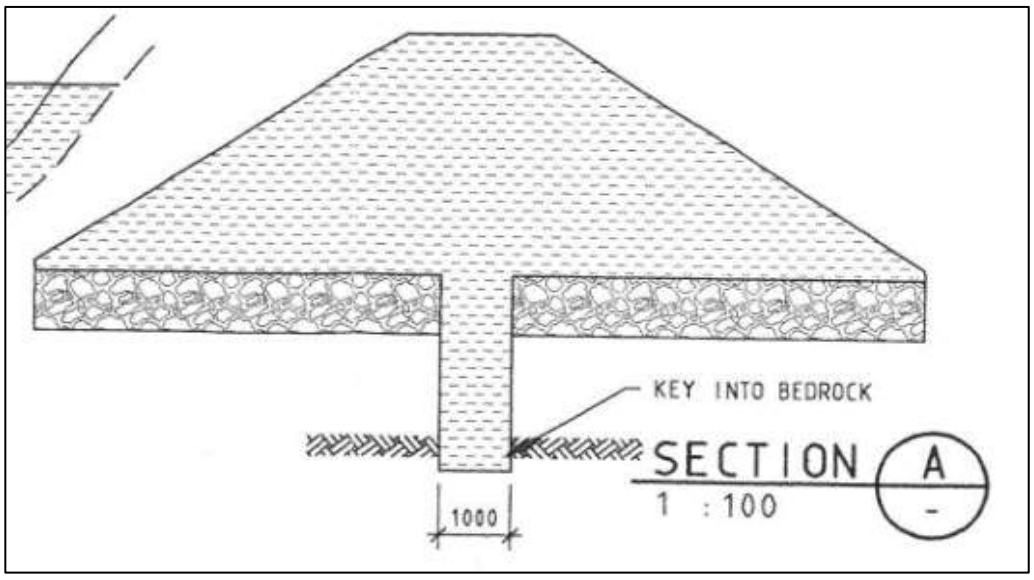


Figure 4: Sketch of the clay barrier beyond the two ends of the cut off wall (image courtesy of Royds Consulting Limited (1995))

3 Proposed Development

The existing landfill is now nearing the closure design level and therefore requires upgrading and reconsenting to continue operation as the main landfill in Balclutha. The proposed development to enhance the capacity of the existing landfill mainly includes the following:

- Improved public waste receival facilities including the development of a Resource Recovery Centre (RCC) and associated carparking space to the east of the existing access road and a Transfer Station and associated facilities towards the centre of the site (to the east of the existing weighbridge).
- Landfill expansion to the east and south of the existing landfill operation.
- A new road providing access to the site.

The new landfill will be fully lined and consistent with the WasteMINZ Technical Guidelines for Disposal to Land (WateMINZ, October 2022). The landfill is proposed to be constructed in 4 stages, with a clockwise staging sequence commencing with the cell at the north alongside the Railway Line.

A Preliminary Layout Plan showing the main features of the proposed development is presented in Appendix B. Further details of the proposed development are presented in the WSP Design Report titled 'Mount Cooee Landfill Expansion' dated 6 April 2023.

4 Site Geology

4.1 Published Geology

The Published Geology Web Map by GNS Science indicates that the site is underlain by two geological units: the Caples Terrane (Unit YTr) across the northern half of the site and the Pakihi Supergroup (Unit Q1a) across the southern half. An extract from the Web Map showing the indicative boundary between the two geological units is shown on

Figure 5 below.

The Caples Group is described as massive to well bedded grey, red and green sandstone with sub-ordinate mudstone and granular conglomerate. The Pakihi Supergroup consists of unconsolidated gravel, sand, and peats in modern stream beds as well as flood plains with minor riverbank swamps.

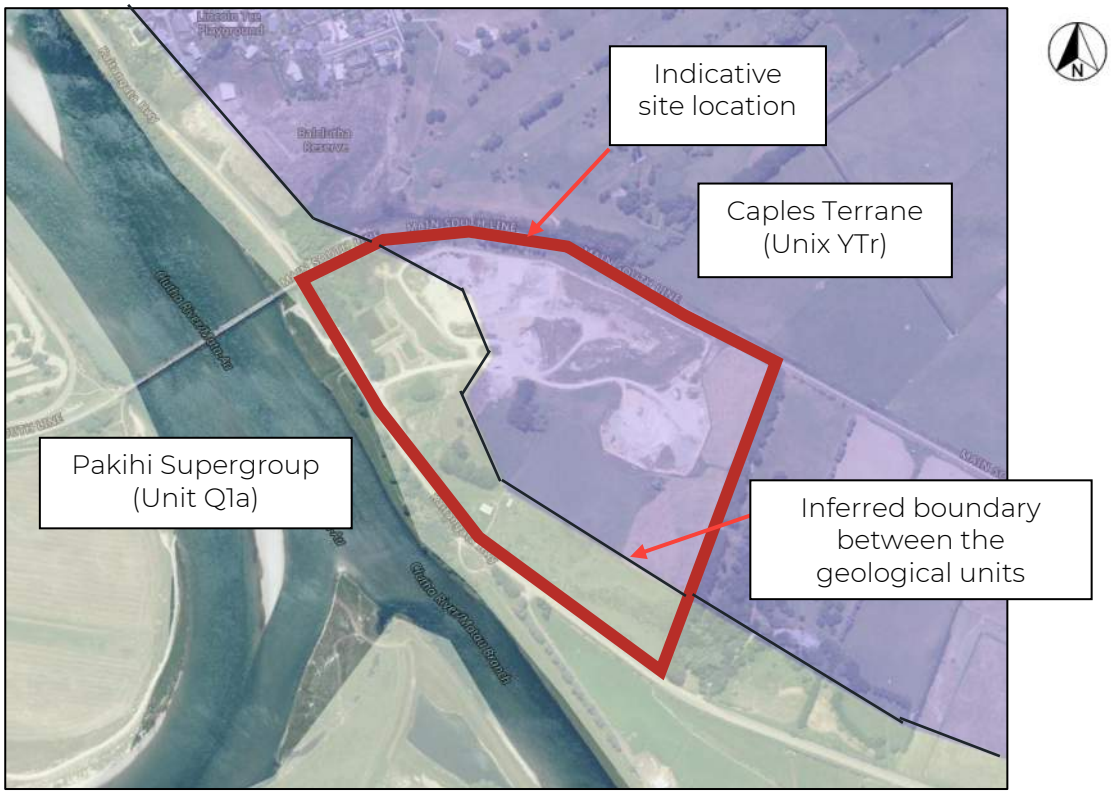


Figure 5: Published geology of the site (image courtesy of 1:250k GNS Science Web Map)

4.2 Regional Geology

The Balclutha region is situated in a region of complex arrangement of tectonic terranes. These tectonic terranes form the basement of New Zealand, originating from the sedimentary rocks of the accretionary wedge of Gondwana (Mortimer, 2004). The Clutha region, and specifically Balclutha, lies within a zone of regional metamorphism, where rocks are buried due to tectonic processes, heated and then brought back to the surface through faulting and folding over millennia.

The overall geology of the region typically consists of highly fractured and tectonically disturbed basement rocks overlain by alluvial deposits associated with the Clutha River / Mata-Au.

4.3 Geomorphology

The site occupies an ancient floodplain, overlain by alluvial gravels. The general topography of the site has been extensively modified by earthworks for the current landfill at the northern extent of the site, and preparation of the proposed landfill at the eastern section of the site. The south-eastern section of the site, where BH3 – BH6 are situated is a gently sloping grazing paddock for farmstock and has remained relatively unchanged since the establishment of the current landfill.

The presence of a paleo-valley inferred from reviewing available topographical maps was noted trending northeast to southwest through the site. A review of the report by Royds Consulting Limited (1994) and historic imagery confirmed the presence of an incised stream bed feature oriented in the northeast to southwest direction and inferred to be running under the current landfill site. Royds Consulting Limited (1994) identified this area as a swamp that was heavily vegetated at the time of their report. The indicative alignment of the historic stream is shown on Figure 6 below and overlain on survey imagery on Figure 7 on the next page.

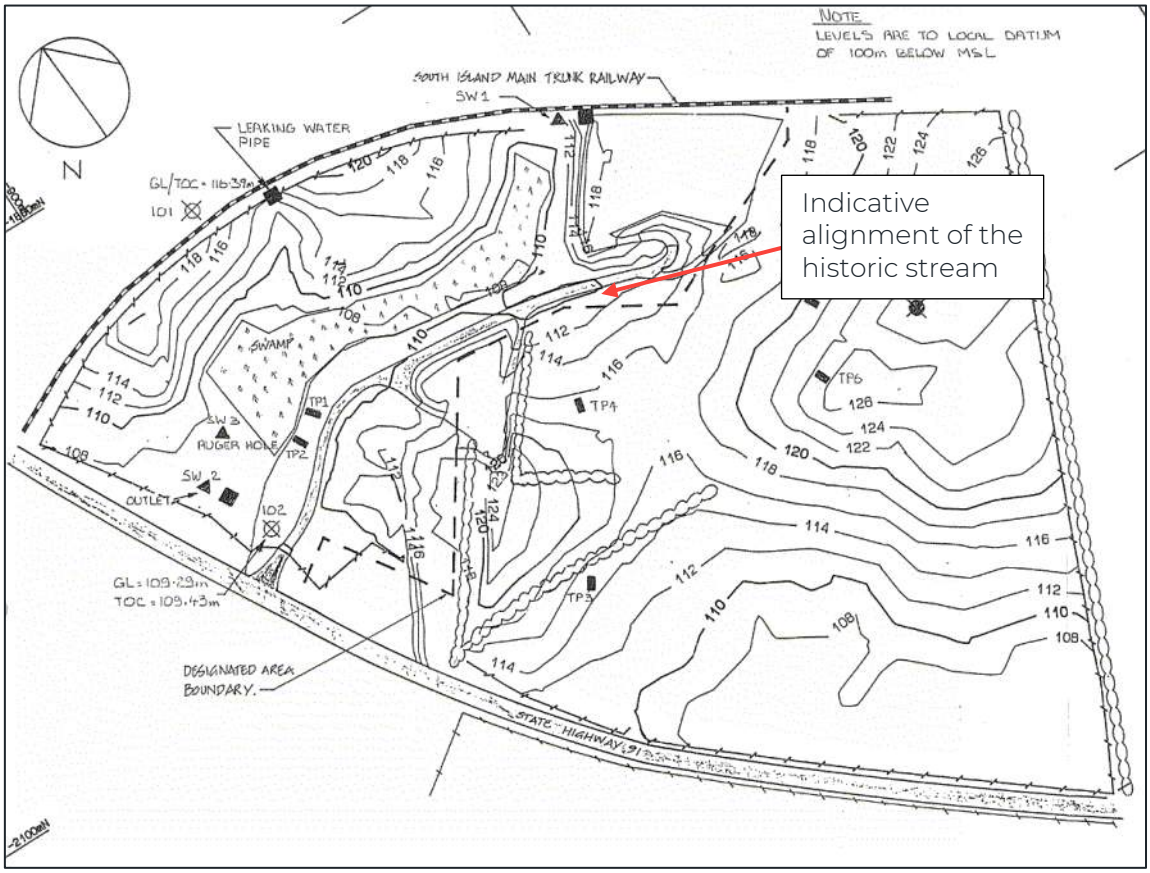


Figure 6: Indicative alignment of the historic stream through the site (image courtesy of Royds Consulting Limited (1994))

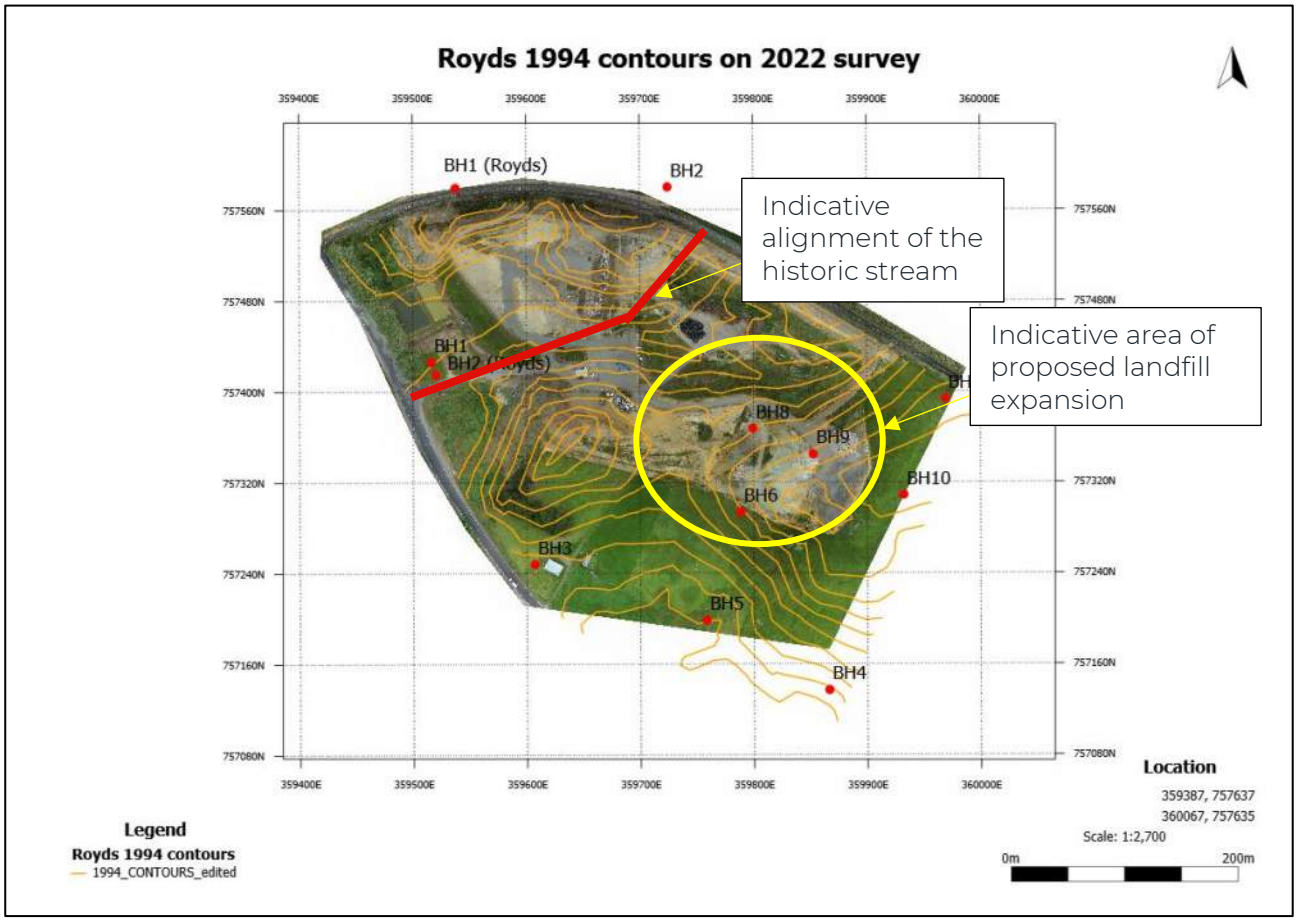


Figure 7: Excerpt from Leapfrog with Royds Consulting Limited (1994) contours overlain on December 2022 aerial image

4.4 Preliminary Geological Mapping

Preliminary geological mapping of the available exposures across the site were carried out by WSP Engineering Geologists in 2021 and 2023 to inform the assessments. The mapping was carried out across most of the site where access to outcrops was possible, with greater focus on the proposed landfill expansion area to the east of the site as well the area to the south of the existing landfill, where new landfill facilities are generally concentrated.

The mapping features were limited to exposed rock cuttings from the current earthworks operations on site. Measurements were obtained using a geologic compass to record the orientation of any bedding and jointing features within sites of interest.

Based on our field mapping observations, the alluvium is constrained to thin, isolated locations across the eastern section of the site, overlain by a thin layer of topsoil. The alluvium appears to be thicker and more consistent across the western section, with thickness of up to 6m encountered in BH1 at the south-western section of the site (south of the existing landfill).

The Caples Terrane bedrock underlying topsoil and alluvium across the entire site consists of interbedded sandstone and siltstone, which exhibits mm-scale sub-horizontal bedding features with localised shear zones ranging between a few mm's to ~0.5 m. The main findings from the preliminary mapping are presented below.

4.4.1 2021 Preliminary Mapping Findings

The preliminary mapping carried out in 2021 was constrained to three localised areas across the entire site, where rock exposures were observed. The indicative locations of the

mapping sites (referred to as sites 1 (2021) to site 3 (2021) hereafter) are shown in Appendix D.

A summary of the findings from the sites are presented below.

- The rock exposures consisted of interbedded sandstone and siltstone of Caples Terrane.
- The bedrock was found to be highly jointed, with defect spacings ranging between approximately 30 – 100 mm. The bedrock exhibited very close defect spacing (in the order of a few mm's).
- Slightly weathered to fresh rock was observed at sites 1 and 3. Site 3 consisted of a thin (<0.3m) layer of residual soils overlying bedrock, whilst rock was observed at surface at site 2 (refer
- Figure 8 below).

Figure 8: View of cut slope at Site 2

4.4.2 2023 Preliminary Mapping Findings

The preliminary mapping carried out in 2023 was mainly concentrated on the areas of proposed landfill expansion.

Mapping was also carried out in the southern section of the site where new facilities are proposed, and in particular the existing cut slope immediately to the south of the proposed building platforms. Excavation into this cut slope is currently proposed to form the building platforms and therefore a detailed inspection of this feature was carried out.

The main findings for the mapped areas are presented below and in Appendix D.

4.4.3 Existing Cut slope

Based on the visual inspection, the cut slope has been divided to three distinct sections (referred to as Sections 1 to 3 hereafter). A photograph showing the cut slope is presented on Figure 9 below, with further commentary in Appendix D.

Figure 9: Photograph showing various sections of the cut slope

A brief summary of the observations for each section is presented below.

Section 1

- This western section of the slope is typically 2m high, with its height increasing eastward towards Section 2. The slope is at typical angle of 1(V): 2(H).
- Based on discussions with the excavator operators on site, we understand this section of the cut slope is extremely difficult to excavate and many of their machines struggled to remove the top layer.
- The slope consists of interbedded sandstone and siltstone, light grey to dark grey where fresh. Some minor horizontal bedding was observed, though no obvious trend was established. Rip-up clasts were observed within localised areas of this section, typically associated with quartz veining and jointing (refer Figure 10). Rip-up clasts are typically clasts of muddy sediments of variable sizes found within sandstone.
- The slope face exhibits various jointing and fracturing throughout, with some veining in the order of a few mm's thick but in groups of up to ~0.5 m in thickness in localised areas (refer
- Figure 10).

Figure 10: Quartz veining and rip-up clasts in sandstone beds of section 1

No distinct boundary between Sections 1 and 2 was observed, with the change being gradational.

Section 2

- The middle section of the slope is the highest section, with the maximum height of up to 10m based on the site survey. The current slope is typically at a 1(V): 1.5 (H) angle.
- At the time of the site visit, this section exhibited marginal surficial stability, with evidence of surficial rock dislodgement along the joints.
- Horizontal jointing of oxidised, highly fractured interbedded sandstone and siltstone was apparent along this section. Measurements were limited on this section due to the marginal stability at the time of the site visit. General observations concluded orientation of bedding to be slightly dipping to the southwest.

Section 3

- The eastern section is in the order of 1m to 2m high, at a typical angle of 1(V): 1.5(H). This slope consists of bulbous, well rounded, and completely weathered sandstone and siltstone. The rock observed is generally light brown to light grey in colour and very friable. The quality of the rock mass is better (stronger/higher) in this area compared to sections 1 and 2.
- No distinct boundary between Sections 2 and 3 was apparent, although a gradational change from the completely weathered to highly weathered rock was observed.

4.4.4 Landfill Expansion Area

The proposed landfill expansion site has been excavated in some areas to expose fresh to slightly weathered interbedded rock (refer Appendix D for photographs). An approximately 1 m – 2 m thick layer of well-rounded alluvial deposits was observed at the north-eastern end of the site. These deposits were localised to only this section and are not considered to be continuous across the eastern section of the site.

Depositional bedding features were observed in the alluvium and flow direction was able to be determined by visually analysing the orientation of the quartz gravel in this layer. This paleo-flow direction suggests a south to southwestern trending flow. A photograph showing this section of the landfill is presented on

Figure 11 on the next page.

The remainder of the landfill expansion area was typically exposed to slightly weathered to moderately weathered interbedded sandstone and siltstone. No obvious bedding features were observed, and the outcrops were limited to machine excavated faces, which made geological interpretation difficult. Knowledge gathered from other locations across the site helped to confirm the general trend of bedding oriented south to southwest.

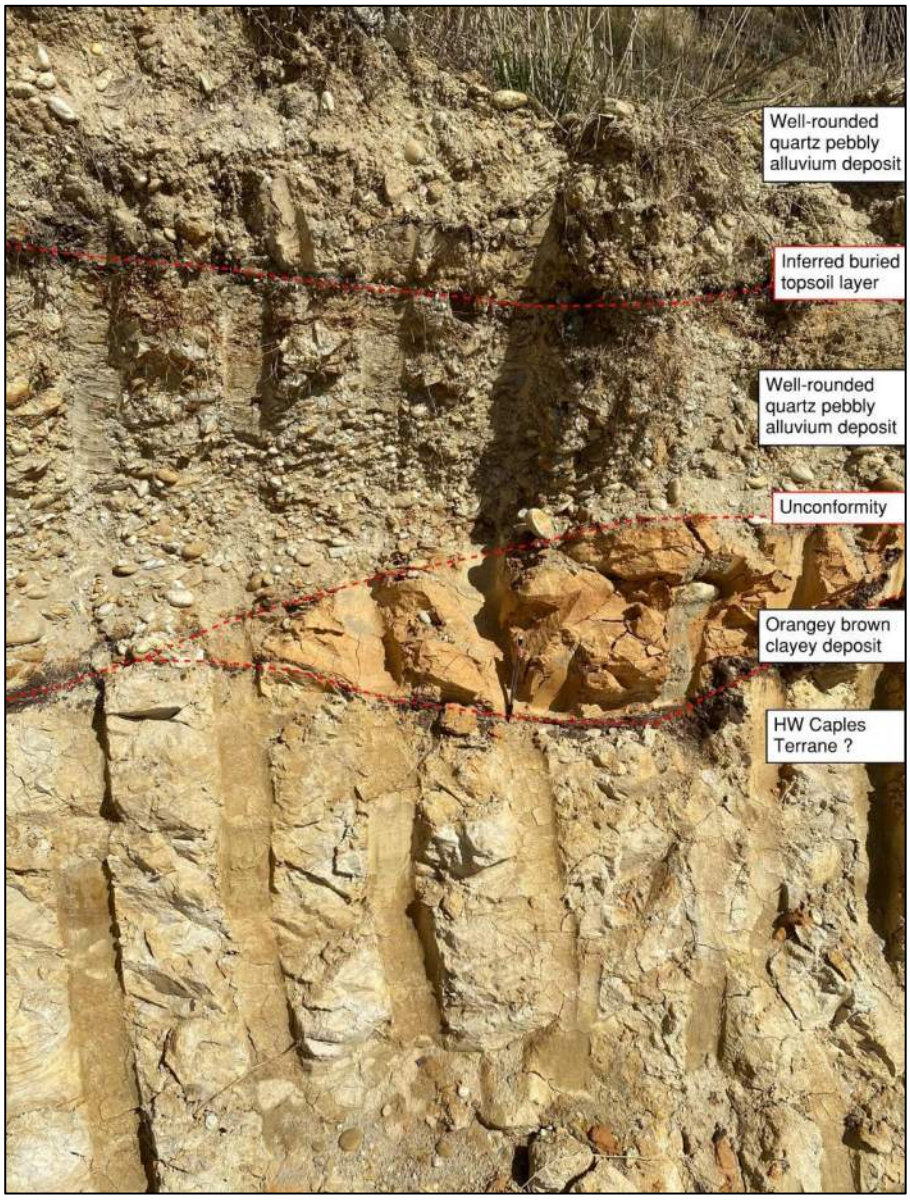


Figure 11: A photograph showing the localised alluvial deposits to the north of the proposed landfill expansion

4.4.5 Preliminary 3-Dimensional (3D) Geological Model

A preliminary 3D geological model of the entire site has been developed using the Leapfrog software by Seequent. The model is based on the historic and recent deep investigation data and utilises the preliminary mapping findings to extrapolate the ground conditions between the investigation points.

The current model has the following limitations:

- No investigations have been carried out within the existing landfill footprint at the north-western section of the site and therefore the ground conditions across this section are inferred based on the nearby boreholes, namely BH1, BH2, BH1 (Royds) and BH2 (Royds). It is anticipated that the alluvial deposits within the landfill footprint have been removed to date to create the landfill floor.
- No intrusive investigations were completed in the area to the east of the existing access road and the locations of the proposed RRC and Transfer Station. However, preliminary geological mapping has been utilised to inform the likely ground conditions.

The current model is considered adequate to inform the preliminary assessments.

4.4.6 Likely Slope Instability Mechanisms

Based on the site observations and preliminary mapping, the likelihood of deep-seated instability in the rock slopes across the site is considered to be low. The likely modes of failure are constrained to the surficial rock as blocky or wedge failure, expected along joint or sheared planes. Section 2 of the existing cut slope predominantly displayed this failure mechanism.

4.5 Active Faults

There are currently no active faults at the immediate site. However, the GNS Science Active Faults Database in 3 fault traces within the 100 km radius of the site. The faults and their characteristics are listed below.

- The Clifton Fault (#8677): This fault has a normal fault sense and a recurrence interval of IV (>5,000 to <= 10,000 years) and is approximately 11 km west of the landfill site.
- The Unknown Fault (#8994): There is currently no available information on the fault sense or recurrence interval of this fault, apart from the approximate location of the fault surface. This active fault is located within 5 km to the northeast of the site.
- The Titri Fault (#9954): This fault lies approximately 14 km to the northeast of the site and runs in the north-east/south-west direction. No recent rupture of this fault has been recorded, and it is estimated the last rupture has occurred in the late Quaternary (i.e. 0.5 – 1.0 million years ago) and GNS estimate a recurrence interval of 70,000 to 80,000 years.

The approximate locations of the faults relative to the site are shown on Figure 12 below.

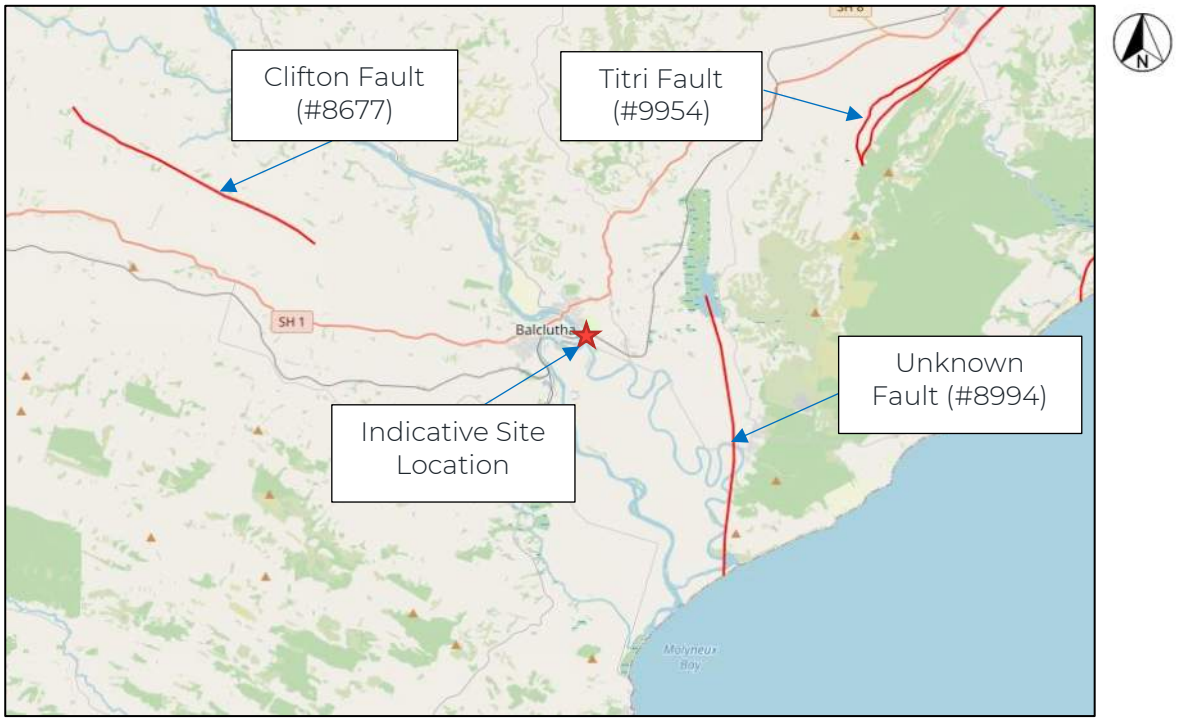


Figure 12: Nearest active faults to the site (image courtesy of the GNS Science Active Faults Database)

Given the distances from the active faults to the site and their associated recurrence intervals, the risk of fault rupture affecting the site is anticipated to be low.

4.6 Hydrogeology

The current understanding of the groundwater system at the Mt Cooee Landfill site is that of a groundwater system dominated by flow through the Caples Terrane bedrock of various permeabilities. Some flow is also likely to occur through the overlying alluvial deposits, particularly in the valley floor that runs through the southwest side of the site where the alluvial sediments are generally thicker.

Groundwater level measurements in the historic and recent wells to date have not shown clear differences in groundwater levels within the bedrock and overlying alluvium. Therefore, the groundwater system is conceptualised as effectively one connected system. Groundwater is largely recharged by rainfall in the catchment and flows from the topographic highs at the north towards the southwest. Groundwater level measurements at the landfill and riverbank elevations (obtained from LiDAR) indicate that groundwater is likely connected to the Clutha River / Mata-Au and the river gains groundwater from the site.

5 Geotechnical Investigations

A summary of the historic and recent investigations carried out across the site is presented below.

5.1 Historic Investigations

Royd Consulting Limited (1994) carried out limited geotechnical investigations across the site in 1994. The purpose of the investigations was to obtain a better understanding of ground and groundwater conditions across the site to inform the developments at the time. The investigations included the following:

- A total of two boreholes (labelled BH1 (Royds) and BH2 (Royds) hereafter) to target depths of 15m and 9.5m bgl. The boreholes were drilled using the rotary air flush techniques between 28 January and 7 February 1994.
- 5 machine-excavated test pits, (labelled as trial pits No. 1 to No. 5) carried out on 11 February 1994.
- A total of 7 groundwater wells (GW1 – GW7) across the site to inform groundwater levels. Please note that only limited logs are available for the groundwater wells.

Indicative locations of the above investigation points are shown on the Site Plan – refer Appendix A. Further details of the investigations are presented in Royds Consulting Limited (1994).

5.2 Recent Investigations

Site-specific ground investigations were undertaken by WSP across the site between October and November 2022. The investigation points were spread across the entire site to assess the nature and variability of the ground conditions and allow groundwater and gas monitoring through the installation of the piezometers.

The investigations included the following:

- A total of ten machine boreholes (BH1 to BH10) to target depths ranging between 3.0 m and 11.6 m bgl for geotechnical and hydrogeological purposes. Drilling was undertaken using the rotary coring method in both soils and in rock. Boreholes were terminated upon proving a sufficient thickness of bedrock or reaching the pre-determined target depths.
- Installation of standpipe piezometers in BH1 to BH6 to allow groundwater monitoring purposes.
- Installation of a standpipe piezometer in BH10 for ground gas monitoring.

- Laboratory testing on selected samples of soils and rock (refer Section 6.4 for details).

The approximate locations of the machine boreholes are presented on the Site Plan – Appendix A. The borehole logs and photographs are presented in Appendix C. Further details of the investigations are presented in WSP (March 2023).

6 Ground Conditions

6.1 Interpreted Ground Profile

The soils and rock encountered within the historic and recent geotechnical investigation points are generally consistent with the published geology and comprise Caples Terrane bedrock across the site, overlain by topsoil and alluvial deposits.

For preliminary assessments, we have divided the ground profile across the entire site to two distinct profiles, referred to as 'eastern' and 'western' sections hereafter. This is mainly due to the increased presence and thickness of alluvial deposits across the western section. The indicate boundary between the two sections is presented on Figure 13 below. The two profiles are further discussed below.

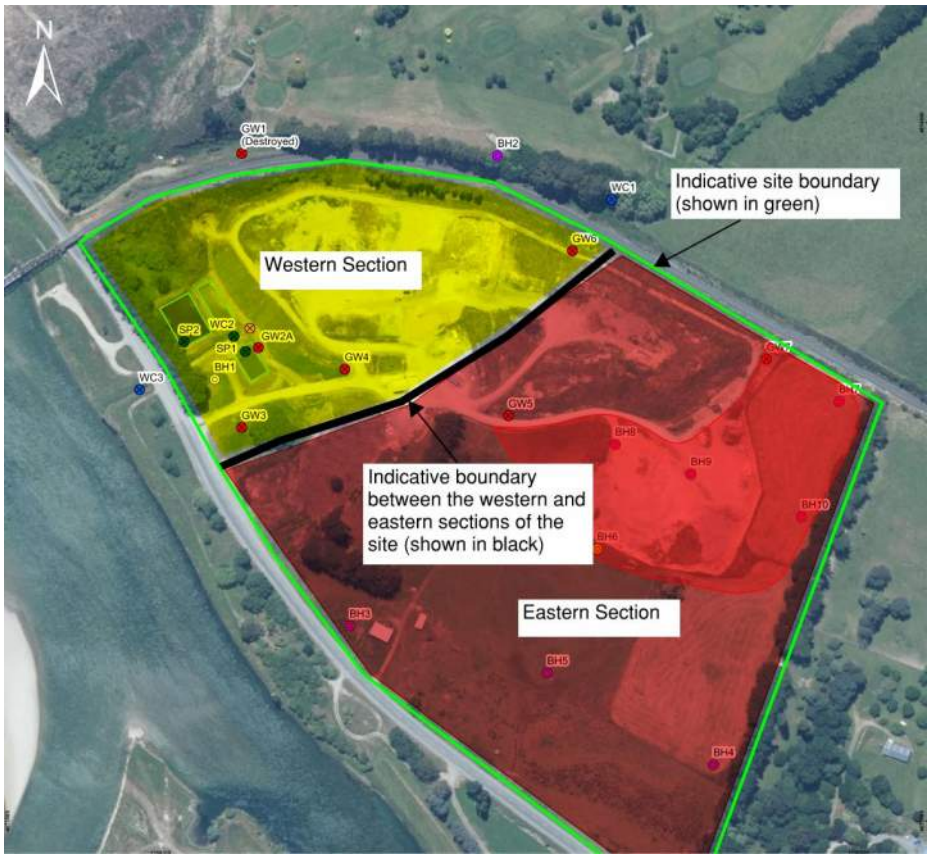


Figure 13: Indicative boundary between 'eastern' and 'western' Sections

6.1.1 Eastern Section Ground Profile

Based on the site investigation and preliminary geological mapping findings, the eastern section of the site is predominantly underlain by a typically less than 0.5m thick layers of topsoil **(Unit 1)** overlying Caples Terrane bedrock **(Unit 3)**.

The machine boreholes BH6 – BH10 drilled near the location of the proposed landfill expansion indicate that the upper layer of the Caples Terrane bedrock generally consists of several sequences of 'highly to moderately weathered, weak to moderately strong

SANDSTONE/SILTSTONE' **(Unit 3b)**, with a typical uncorrected SPT N value exceeding 50. This layer transitions to 'moderately to slightly weathered, moderately strong SANDSTONE/SILSTONE' **(Unit 3c)** at depths typically ranging between 3m to 5m bgl. A typically 1.0m thick layer of 'completely weathered SANDSTONE/SILSTONE' (Unit 3a) was encountered in some of the boreholes.

The bedrock was found to be highly fractured, with joints at very close spacing and a typical Rock Quality Designation (RQD) value of 0% in particular in weathered rock. Some variations in the strength and weathering of the rock were observed in the cores obtained from the boreholes. A thin layer (typically < 1m thick) of 'completely weathered, extremely weak SANDSTONE/SILTSTONE' **(Unit 3a)** was observed in some of the boreholes across the eastern section. This layer was generally recovered as 'stiff sandy/clayey SILT with low to moderate plasticity'.

As described under Section 4.3.4, an approximately 1m – 2 m thick layer of well-rounded alluvial deposits was observed to the north-east of the site. layers of alluvial deposits less than 1m in thickness were also encountered in BH5 and BH3 to the south-east of the site. Based on site observations, we anticipate the alluvial deposits to be present localised pockets only and not be laterally continuous across the eastern section of the site.

A representative ground profile for the eastern section of the site is presented in Table 1 below. Please note that variations in the ground conditions, in particular the thickness of weathered rock may be anticipated.

A geological section (Section B – B') showing the variations in the ground conditions across the entire site is presented in Appendix D.

Table 1: Summary ground profile for the eastern section of the site

Unit ID		Unit Name	Generalised Unit Description	Typical Depth Range (m RL) [1]	SPT N Value Range [2]
1		Topsoil	Topsoil.	11.0 – 10.5	Not tested
3	3(a)	Completely weathered, extremely weak SANDSTONE / SILTSTONE	Completely weathered, fine fabric SANDSTONE, extremely weak. Recovered as stiff to very stiff SILT with some sand and clay, low to moderate plasticity.	10.5 – 9.5	56 - 60+ (typ. 60+)
	3(b)	Highly to moderately weathered, very weak to weak SANDSTONE / SILTSTONE	Highly to moderately weathered, highly fractured, fine fabric SANDSTONE/SILTSTONE; very weak to weak. Closely spaced joints and white veins.	9.5 – 4.5	60+
	3(c)	Slightly weathered to fresh, moderately strong to strong SANDSTONE / SILTSTONE	Slightly weathered, highly fractured, fine fabric SANDSTONE/SILTSTONE; moderately strong to strong. Closely spaced joints and white veins.	< 4.5	60+

[1] The depth ranges (in m RL) are generally based on considering 11m RL (based on NZVD 2016 datum) as the existing ground level at BH3 location, considering BH10 at the eastern end of the site as the datum. Due to variations in site topography, the depth ranges vary across the site.

[2] The SPT N values are uncorrected and based on blows per 300mm. Typical values are presented in brackets.

6.1.2 Western Section Profile

The intrusive investigation results and preliminary mapping findings indicate the ground conditions across the western section of the site are generally similar to the eastern section,

with the exception of a layer of 'Alluvium' encountered in the recent and historic machine boreholes.

Based on the investigation results, the western section of the site is underlain by an approximately a thin layer (typically < 1m) of topsoil **(Unit 1)**, overlying alluvium **(Unit 2)**. The alluvium is approximately 5.5m thick in BH1 and 2.5m thick in BH2 to the south and north of the existing landfill, respectively. The nature of alluvium appears to be highly variable, with BH1 indicating the layer to consist of thin layers of cohesive 'soft to firm silty CLAY with high plasticity' interbedded with 'sandy SILT/silty SAND with low plasticity'. In addition to the recent boreholes, alluvial deposits are inferred to be present in the historic BH2 (Royds) and appears to be continuous with variable thicknesses across the western section of the site.

Unit 2 is underlain by Caples Terrane bedrock **(Unit 3)**, consisting of sequences of moderately to slightly weathered, highly fractured, fine fabric SANDSTONE and SILSTONE. An approximately 1m thick layer of 'completely weathered, extremely weak SANSTONE' was encountered in BH2. This layer was recovered as stiff to very stiff SILT.

A simplified ground profile for the western section of the site based on BH1 and BH2 is presented in Table 2 below. A geological section (Section A – A') showing the variations in the ground conditions across the western section of the site is presented in Appendix D.

Table 2: Summary ground profile for the western section of the site

Unit ID		Unit Name	Generalised Unit Description	Typical Depth Range (m RL) [1]	SPT N Value Range [2]
1		Topsoil	Topsoil with trace rootlets and trace fine quartz gravel.	9.0 – 8.5	Not tested
2		Alluvium	Soft to firm silty CLAY, moist, high plasticity interbedded with loose silty fine to coarse SAND, low to no plasticity.	8.5 – 3.0	1 – 7 (typ. 5)
3	3(a)	Completely weathered, extremely weak SANDSTONE / SILTSTONE	Completely weathered, fine fabric SANDSTONE, extremely weak. Recovered as stiff to very stiff SILT with some sand and clay, low to moderate plasticity.	3.0 – 2.0	56 - 60+ (typ. 60+)
	3(b)	Highly to moderately weathered, very weak to weak SANDSTONE / SILTSTONE	Highly to moderately weathered, highly fractured, fine fabric SANDSTONE/SILTSTONE; very weak to weak. Closely spaced joints and white veins.	2.0 – 0.0	60+
	3(c)	Slightly weathered to fresh, moderately strong to strong SANDSTONE / SILTSTONE	Slightly weathered, highly fractured, fine fabric SANDSTONE/SILTSTONE; moderately strong to strong. Closely spaced joints and white veins.	< 0.0	60+

[1] The depth ranges (in m RL) are generally based on considering 9m RL (based on NZVD 2016 datum) as the ground level, considering BH1 at south-western end of the site as the datum. Due to variations in site topography, the depth ranges vary across the site.
[2] The SPT N values are uncorrected and based on blows per 300mm. Typical values are presented in brackets.

6.2 Groundwater

Groundwater was recorded at depths ranging between approximately 1.2 m and 5.6 m bgl within the machine boreholes during the investigation.

Several rounds of monitoring of the piezometers installed in BH1 – BH6 and BH10 have been completed on typically monthly basis since the drilling. A summary of the readings to date is presented in the WSP (March 2023). A plot of groundwater levels (in m RL based on the NZ Vertical Datum 2016) carried out to date is presented as Figure 14 below. The existing ground levels (in m RL) at borehole locations are presented on the plot legend.

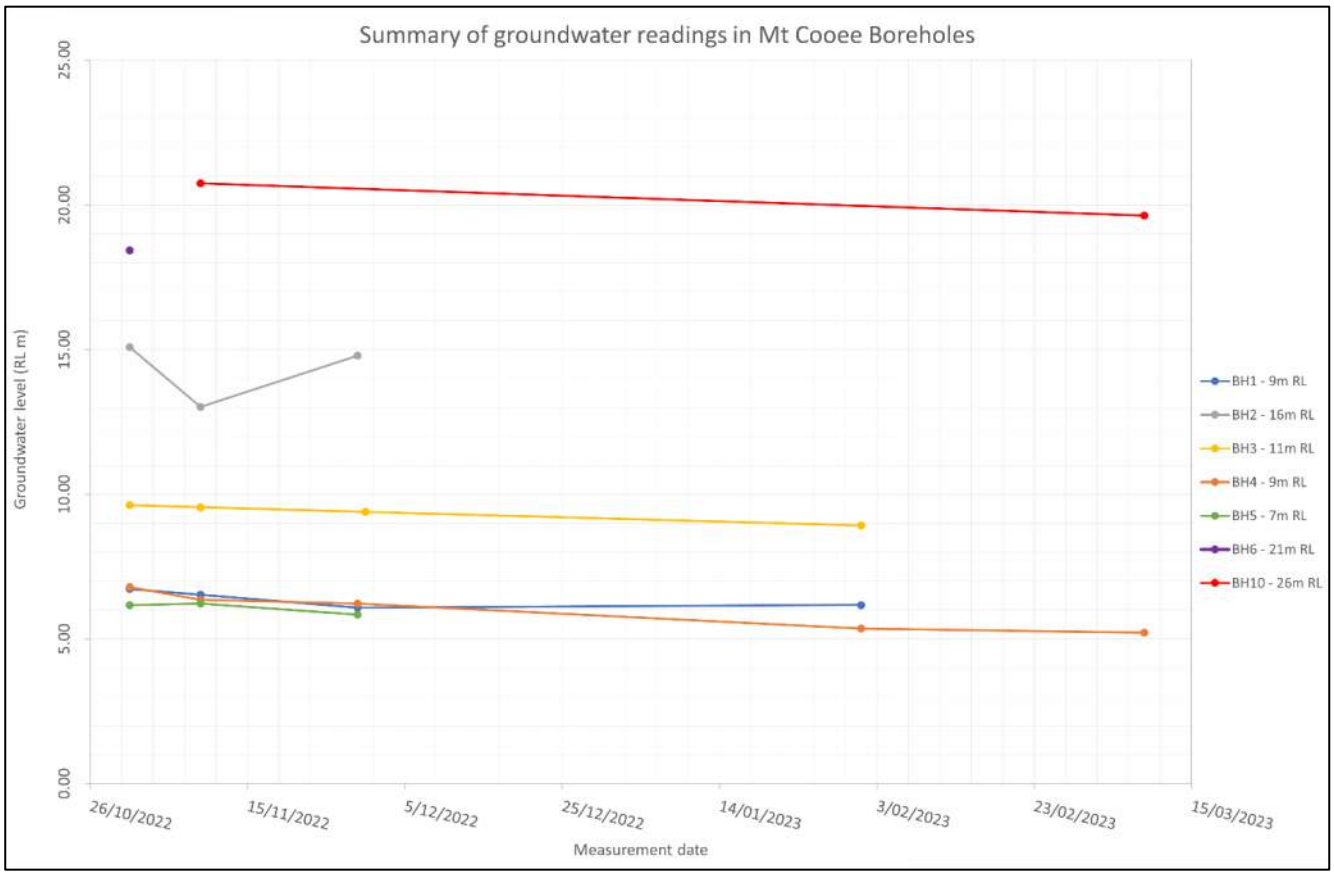


Figure 14: Plot of groundwater levels recorded within standpipe piezometers since October 2022

As indicated on Figure 14 above, the long-term groundwater level is anticipated at depths ranging between 6m to 20m RL (in the order of 1m to 4m below existing ground levels) across the site, with flow towards the Clutha River / Mata-Au in the south. Across the western section of the site, long-term groundwater is anticipated at lie approximately 2m bgl and within the alluvial deposits. The piezometer readings in the boreholes across the eastern section suggest groundwater typically lies within the fractured rock or close to the interface between rock and overlying soils. Except for a groundwater level of 2.3m bgl (~ 18.7m RL) measured in October 2022, the piezometer readings in BH6 at the proposed landfill site have indicated dry conditions.

Elevated groundwater levels may be anticipated during heavy rainfalls and have been considered in the preliminary geotechnical analyses.

6.3 Soil and Rock Permeability

Permeability testing (include reference) of geological units on site to date indicate the hydraulic conductivities are in the order of 10^{-7} m/s in slightly weathered to fresh rock (Unit 3(c)). The hydraulic conductivities within weathered rock (Unit 3(b)) are found to have a wide range of 10^{-9} to 10^{-4} m/s. The wide range observed is likely due to the presence of fractures in the sandstone/siltstone.

The overlying alluvium is shown to have a hydraulic conductivity of 10^{-6} m/s. This is based on limited information from one well only (BH1) and is likely to vary given the interbedded and variable nature of this layer.

6.4 Laboratory Testing

Laboratory testing was undertaken by the WSP Laboratory (based in Christchurch) on selected soil samples recovered from BH1, BH8, and BH10. Testing includes the following:

- Atterberg Limits in accordance with NZS 4402: 1986: Test 2.1 - Test 2.5.
- Particle Size Distribution (PSD) in accordance with NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)
- Uniaxial Compressive Strength (UCS) testing of intact rock core samples in accordance with ASTM D7012 – Test C (previously ASTM D2938).

A summary of the laboratory testing details and results is presented in WSP (March 2023).

Please note that due to the highly fractured nature of rock underlying the site, only limited suitable samples were available for laboratory testing.

6.5 Design Parameters

6.5.1 In-situ Soil and Rock Parameters

A set of preliminary design parameters has been derived for the in-situ soils and rock based on the ground investigation, limited laboratory testing results and our experience with local soils and rock.

The parameters are presented in Table 3 below, with typical parameters presented inside the brackets.

Table 3: Summary preliminary design parameters

Unit ID	Unit Name	Unit Weight Y, (kN/m^3)	Effective Cohesion c', (kPa)	Friction Angle Φ, (Deg)	Undrained Shear Strength, S_u (kPa)
1	Topsoil	16 - 17 **(16)**	0 – 1 **(1)**	24 - 26 **(25)**	N/A
2	Alluvium	17 - 18 **(17)**	1 - 2 **(1)**	26 - 30 **(28)**	30 – 50 **(30)**
3a	Completely weathered, extremely weak SANDSTONE / SILTSTONE	19 - 20 **(19)**	3 – 6 **(5)**	26 - 30 **(28)**	100 – 200 **(150)**
3b	Highly to moderately weathered, very weak to weak SANDSTONE / SILTSTONE	20 - 22 **(21)**	15 - 25 **(20)**	38 - 42 **(40)**	300 – 500 **(400)**
3c	Slightly weathered to fresh, moderately strong to strong SANDSTONE / SILTSTONE	22 - 24 **(23)**	20 - 40 **(30)**	40 - 45 **(44)**	500 – 1000 **(750)**

6.5.2 Refuse Parameters

The nature and strength of refuse material is highly variable and difficult to measure. Research carried out by Singh and Murphy (1990) suggests that municipal waste can exhibit significant apparent cohesion or friction angles. A plot of the likely parameters for solid waste based on a combination of laboratory testing, in-situ testing and back calculations is presented as Figure 15.

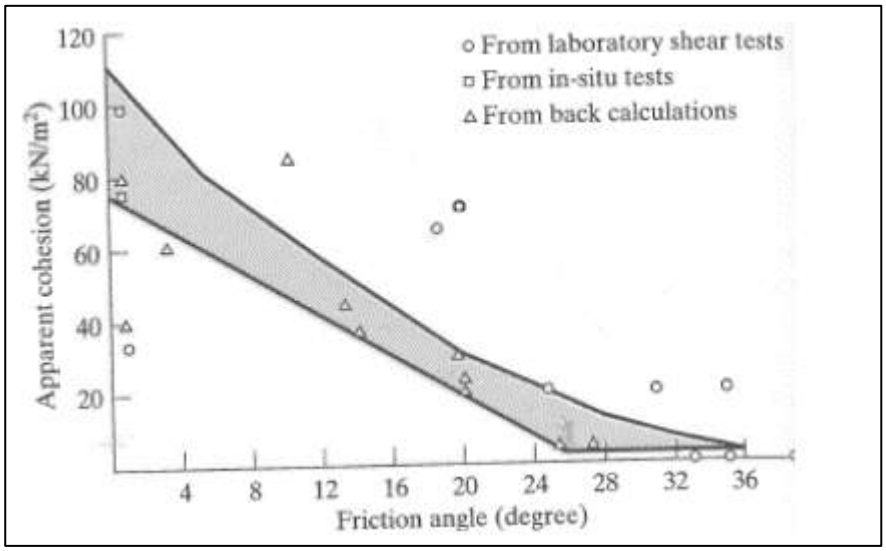


Figure 15: Published solid waste strength parameters (Singh and Murphy 1990) – (refer Qian et al 2002)

A suggested range of parameters for the refuse is presented in Table 4 below, with typical values inside brackets. The preliminary stability assessments for the landfill expansion have considered relatively conservative, lower bound refuse parameters to assess the sensitivity of results to the input parameters. The parameters are based on the consideration the refuse is placed in thin layers and compacted.

Table 4: Suggested refuse parameters

Material Type	Unit Weight Y, (kN/m³)	Effective Cohesion c', (kPa)	Friction Angle Φ, (Deg)
Municipal Solid Waste	12 - 14 (13)	3 – 8 (5)	22 - 28 (25)

7 Seismicity

7.1 Site Subsoil Class

Bedrock was encountered at shallow depths (typically < 1m bgl) in the machine boreholes across the eastern section of the site. On this basis, the site subsoil class is considered to be 'B – Rock' for this section of the site (in accordance with NZS1170.5).

Alluvial deposits with thickness of up to 6m (based on BH1) were encountered across the western section of the site. We recommend site subsoil class 'C – Shallow Soils' be adopted for this section of the site.

7.2 Seismic Design Criteria

New Zealand has no specific standard developed to assess design earthquakes for landfills, and landfills are not specifically mentioned within NZS1170.0:2002. We have assessed the importance level of the landfill facility based on the following assumptions as described within Table 3.1 of NZS 1170.0: 2002:

- Low consequence for loss of human life.
- Considerable economic and environmental consequence.

Based on Tables 3.1 and 3.2 in NZS1170.0:2002, we consider the landfill to be an Importance Level 2 structure (*i.e. Normal structures and structures not in other importance levels*).

The landfill will have an operative life of approximately 35 years, followed by anticipated 15 - 20 years of aftercare. Therefore, we have adopted a design working life of 50 years in order to derive the seismic loads for the landfill.

7.3 Seismic Loads

Peak ground accelerations (PGAs) have been derived for liquefaction and global stability assessments in accordance with Section 6.2 of the current Waka Kotahi Bridge Manual using Equation 1 below:

$$C_o g\ (or\ PGA) = C_{0,1000} \frac{R_u}{1.3} f g \qquad \text{(Equation 1)}$$

PGAs have been derived based on the following parameters and presented in Table 5 below.

- Importance Level 2 (IL2) structure with a 50-year design life.
- Site subsoil classes 'B - Rock' for the eastern section and 'C – Shallow Soils' for the western section of the site (in accordance with NZS1170.5).
- f, site subsoil class factor = 1.33 for site subsoil class 'C' and 1.0 for site subsoil class 'B'.
- $C_{0,1000}$, 1000-year return period PGA coefficient = 0.22 (Balclutha).

Table 5: Summary seismic loads for the site

Seismic Case	Annual Probability of Exceedance [1]	Return Period Factor (R) [2]	PGA (g)		Effective Magnitude
			Eastern Section	Western Section	
Serviceability Limit State (SLS)	1/25	0.25	0.04	0.06	6.0
Damage Control Limit State (DCLS)	1/500	1.0	0.17	0.23	

[1] Annual probabilities of exceedance (APE) are based on Table 3.3 NZS 1170.0, Table 3.5 NZS 1170.5 and Table 5.3 of the Bridge Manual.
[2] Return period factors are based on Table 3.5 of NZS1170.5 and Table 5.1 of the Bridge Manual

Please note the seismic loads presented in Table 5 for the western section are consistent with those provided by the current MBIE Module 1 (2021a) guideline.

7.4 Liquefaction and Cyclic Softening

Liquefaction is a phenomenon where saturated loose to medium-dense sands and low plasticity silts experience a rise in porewater pressures during strong shaking. This results in the loss of strength and stiffness of liquefied soils and consequent large deformations due to the development and subsequent dissipation of excess pore water pressures.

Cyclic softening can occur within cohesive materials under earthquake loading. This will cause the shear strength of cohesive soils to reduce under successive cyclic action.

7.4.1 Liquefaction Susceptibility

Based on the recommendations by Boulanger and Idriss (2014), soils are generally divided in two categories in terms of liquefaction susceptibility based on the plasticity index:

- Soils that behave in a 'sand-like' manner under seismic shaking and are susceptible to classic liquefaction. These soils generally exhibit a plasticity index (PI) of less than 7.

- Soils that behave in a 'clay-like' manner under seismic shaking and are susceptible to cyclic strain softening. These soils generally exhibit a plasticity index (PI) of great than 12.

A summary of the Atterberg Limits testing on two representative samples from the alluvium in BH1 is presented in Table 6 below.

Table 6: Summary Atterberg Limits test results in BH1

Sample Depth (m BGL)	Sample Description*	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Natural Water Content (%)
2.0 – 2.45	Sandy SILT with trace clay	40	NP**	NP**	29.8
5.0 – 5.45	SILT with some clay and minor sand	39	25	14	34.2

The testing suggests the 'sandy silt interbeds' (sample between 2.0m – 2.45m bgl) to be generally low in plasticity or non-plastic, consistent with the borehole log descriptions. However, the 'silty CLAY/clayey SILT' interbeds (sample between 5.0m – 5.45m bgl) tend to exhibit a high Plasticity Index value of 14 and therefore is not considered susceptible to liquefaction.

7.4.2 Assessment Methodology

A quantitative liquefaction assessment has been carried out using the CLiq software (Version 3.0.2.4) based on the methodology outlined by Idriss and Boulanger (2014) method. The assessment has utilised the SPT data within the alluvium in BH1. A SPT hammer efficiency of 91% was adopted based on the calibration information provided by the drillers.

The fine contents have been estimated based on the limited PSD testing on selected samples from BH1 as well as the proportion of fines in the borehole log descriptions in accordance with the NZGS (2005) guideline. The adopted fines contents are presented on the analysis outputs in Appendix E. A sensitivity assessment has been carried out by reducing the input fines contents by 20% to assess the sensitivity of results to input fines contents.

A groundwater level of 2m bgl has been adopted based on the piezometer monitoring results to date. A sensitivity check has also been carried out based on a higher groundwater level of 1m bgl.

7.4.3 Results

The assessment results suggest the following:

- Liquefaction or cyclic softening is not expected under a SLS shaking event (i.e. 1 in 25-year event).
- Liquefaction or cyclic softening is not anticipated under a ULS shaking event (i.e. 1 in 500-year event).

Selected liquefaction assessment outputs are presented in Appendix E.

The undrained shear strength adopted for the alluvium (Unit 2) in the stability assessments is reasonably conservative and allows for potentially cyclic softening in the deeper clay-like layers below groundwater table.

The sensitivity checks based on lower fine content values as well as the elevated groundwater level did not have an appreciate effect on the analyses results. Please note the analysis has been based on the SPT's within BH1. Given the highly interbedded nature of

the alluvial deposits, the SPTs may not capture the presence of thin liquefiable layers. The BH1 logs indicate the alluvium to consist of high plasticity silty CLAY (around 60% of the total layer thickness) and therefore any consequences of liquefaction of thin sand-like interbeds below groundwater table are going to be minor due to the presence of a cohesive crust.

8 Geotechnical Considerations

8.1 Global Stability

Preliminary global stability assessments have been carried out under static, seismic and high groundwater conditions using the GeoStudio software Slope/W (2022 Version). The analyses have been carried out for the proposed landfill expansion site, the proposed Transfer Station site and the existing landfill site. The assessment results are discussed below.

8.1.1 Landfill Expansion Stability

A preliminary global stability the proposed landfill expansion has been carried out under static, seismic and high groundwater conditions using the GeoStudio software Slope/W (2022 Version). The analyses have been based on two representative sections across the new landfill as described below. Indicative alignments of the sections are shown on the preliminary drawings in Appendix B.

- Section 1 in the 'east to west' direction.
- Section 2 in the 'north to south' direction.

The proposed landfill consists of 1(V): 4(H) side batters, with 1(V): 3(H) side slopes excavated into rock to form the landfill cell floor.

The minimum required Factors of Safety (FoS) in line with the industry practice are as follows:

- Minimum FoS of 1.5 and 1.25 under the 'static – long-term' and 'static – high groundwater level' conditions, respectively.
- Minimum FoS of 1.2 for the 'seismic' event, with allowance for seismically induced displacements if FoS < 1.2. These displacements have been estimated based on the methodologies by Jibson (2007), Bray & Travasarou (2007) and Ambraseys & Menu (1988), as recommended by the Bridge Manual.

A summary of the global stability assessment results is presented in Table 7 below. Selected Slope/W outputs are presented in Appendix F of this report.

There is a very low risk of global stability of the proposed landfill extension toward the south (Clutha River / Mata-Au) due to the presence of bedrock at very shallow depth below the ground between the landfill and the highway. Therefore, the assessment is focused on the stability of the landfill batters.

The assessments indicate the minimum factors of safety are achieved under the static case and the seismically induced slope movements are small and insignificant.

Table 7: Summary preliminary global stability assessment results

Analysed Section	Cases	Slope/W Factor of Safety	Minimum Target Factor of Safety	Yield Acceleration / Seismically-induced Displacements (mm)	Comments
Section 1 (east to west)	Static – Long Term	3.0	1.5	N/A	Long-term GWL of 2m bgl.
	Static – Short Term (High GWL)	3.0	1.25	N/A	Elevated GWL of 1m bgl.
	Seismic - SLS	2.5	1.0	None	Pseudo-static PGA of 0.04g.
	Seismic - DCLS	1.6	1.0	None	Pseudo-static PGA of 0.17g.
Section 2 (north to south)	Static – Long Term	2.8	1.5	N/A	Long-term GWL of 2m bgl.
	Static – Short Term (High GWL)	2.8	1.25	N/A	Elevated GWL of 1m bgl.
	Seismic - SLS	2.3	1.2	None	Pseudo-static PGA of 0.04g. Undrained parameters for Unit 2 govern.
	Seismic - DCLS	1.05	1.2	Negligible	Pseudo-static PGA of 0.17g. Undrained parameters for Unit 2 govern. Displacements are expected to be negligible of PGA of 0.23g is adopted (MBIE model 1)

8.1.2 Existing Landfill Stability

The stability of the existing landfill and the western section of the site has been analysed based on a typical cross section through the landfill and in the north-east / south-west direction (refer to Appendix B for the indicative alignment of the section). The assessment has been based on the extrapolated ground conditions and conservatively does not allow for any stabilising effect from the existing cut off wall. A summary of the assessment results is presented in Table 8 below.

Table 8: Summary of the stability assessment results for the existing landfill

Cases	Slope/W Factor of Safety	Minimum Target Factor of Safety	Yield Acceleration / Seismically-induced Displacements (mm)	Comments
Static – Long Term	2.1	1.5	N/A	Long-term GWL of 2m bgl at the base of landfill (i.e. pond locations)
Static – Short Term (High GWL)	1.7	1.25	N/A	Long-term GWL at ground level at the base of landfill also approximately 5m below landfill top.
Seismic - SLS	1.3	1.2	None	Pseudo-static PGA of 0.06g. Undrained parameters govern for Unit 2.
Seismic – DCLS	0.7	1.2 (Except where limited displacement is acceptable)	0.08 g / (10 – 90mm)	Pseudo-static PGA of 0.23g. Undrained parameters govern for Unit 2.

The preliminary assessment indicates the existing landfill site achieves the minimum required factors of safety under the static case. While the factor of safety under DCLS seismic is less than the 1.2 normally accepted the seismic displacements are small (<100mm) and may be acceptable. Under a DCLS event, displacements of the bund may occur with some associate cracking of the capping soils. However, these displacements are not expected to be sufficient to release contaminated landfill soils and may cause some cracking of the capping soils that may need to be reprofiled/topped up.

8.1.3 Transfer Station Cut Slope Stability

Excavations into an existing cut slope are proposed to allow the construction of the Transfer Station and associated facilities towards the centre of the site. A preliminary assessment has been carried out to assess the stability of the cut slope excavated at 1(V): 2(H) based on a representative cross section (refer Appendix B). A summary of the assessment results is presented in Table 9 below.

Table 9: Summary cut slope stability assessment results

Cases	Slope/W Factor of Safety	Minimum Target Factor of Safety	Yield Acceleration / Seismically-induced Displacements (mm)	Comments
Static – Long Term	2.9	1.5	N/A	Long-term GWL of 2m bgl at the toe of slope.
Static – Short Term (High GWL)	2.8	1.25	N/A	Elevated GWL of 1m bgl.
Seismic - SLS	2.6	1.2	None	Pseudo-static PGA of 0.04g. Drained parameters govern.
Seismic - DCLS	2.0	1.2	None	Pseudo-static PGA of 0.17g. Drained parameters govern.

The assessment indicates that 1(V): 2(H) cut slopes are stable under the static and seismic cases. This is generally supported by the inspection of existing cut slopes across the site. The seismic displacements are expected to be negligible even if the PGA of 0.23g is adopted under the DCLS case.

8.2 Long-Term Settlements

The surficial soils overlying bedrock generally consist of a thin layer of topsoil across the entire site and alluvial deposits across the western section of the site. Topsoil is typically less than 1m thick and the thickness of alluvium is expected to be variable, with a thickness of up to 6m proven in BH1.

The currently proposed landfill facilities, namely the RRC and Transfer Station, are mainly concentrated towards the landfill entrance at the southern end, where continuous alluvial deposits are not anticipated. There, any settlements affecting these light-weight structures are expected to be small (typically less than 20mm). The proposed landfill floor is also underlain by bedrock.

Please note that if encountered, any topsoil or localised alluvial deposits should be removed from the landfill floor or building footprints to minimise the risk of differential settlements.

If structures are considered on the existing landfill or in the proposed western landfill in the future, these may be subject to excessive settlement. Detailed settlement analyses should be carried out to assess the magnitude and rate of settlement. Additional investigations and/or laboratory testing may also be required to inform the assessment of appropriate settlement parameters.

8.3 Foundation Design Inputs

We understand that several light-weight structures are proposed near the landfill entrance at the southern end. Even though the actual forms of these structures are not certain at this stage of the project, these structures are expected to be single storey and light weight. Given the anticipated shallow depths to bedrock at the locations of the proposed buildings and there are no proposed buildings on the existing landfill, shallow foundations such as isolated pad footings or slabs are considered appropriate.

The forms of foundations should be confirmed during the Detailed Design stage of the project following the confirmation of locations and loading from the structures.

8.4 Existing Cut-off Wall Performance

As described in Section 2.1, an approximately 46m long sheet pile cut-off wall is currently employed to contain leachate from the existing landfill. Limited information about the cut-off wall is currently available. Due to difficulties with physically accessing the wall due to its depth below the bund, no materials testing has been carried out to date to determine the condition of the existing sheet pile sections.

Given the sheet pile has been in ground for almost 28 years, it is likely that a degree of corrosion loss of the steel sections has occurred to date. A preliminary assessment of the likely level of corrosion in the sheet pile and therefore the residual life of the structure has been carried out through discussions with a WSP Materials Expert. The assessment is based on the following considerations:

- Based on our discussions with the Materials Expert, the likely corrosion rates for the fully embedded driven piles in non-aggressive soils are typically less than 10 micron-m/year. The historic pH testing carried out by Royd Consulting Limited on three samples suggested pH values ranging between 6 – 8, suggesting the soils are non-corrosive. This is further supported by the visual inspection of the cores recovered from the boreholes (in particular BH1), which do not suggest the presence of organics or potentially aggressive soils.

- Pitting corrosion is likely to be the governing type of corrosion affecting the sheet piles. Pitting is a localised form of corrosion resulting in the formation of localised holes or cavities in the materials. Based on the review of available literature, the average rate of pitting corrosion is typically considered to be 5 times the average corrosion rate. On this basis, the pitting corrosion rate is 50 micron-m/year.

- Based on a conservative assumption that the pitting occurs at same locations on both sides of the sheet pile (i.e., total pitting corrosion loss of 0.1mm/year) and considering the wall has been in ground for around 28 years, the total section loss due to pitting is assessed to be up to 3mm.

- The sheet pile section type is not specified on the historic drawings, except for the suggested section width of 0.4m. Based on our knowledge of sheet pile products, the sheet pile section is likely an AZ-800 section. The various AZ-800 sections have thicknesses ranging between 8.5mm and 11mm. Assuming the section had the thickness of 8.5mm as the worst-case scenario, the expected residual thickness of the section is currently expected to be 5.5mm. This means the existing wall is expected to have a residual life of over 55 years.

Based on the conservative approach above, we consider the risk of pitting corrosion having resulted in holes in the existing wall is very low. Contamination testing on samples from the

groundwater wells downgradient of the cut-off wall also indicate a relatively high pH values in the samples (typically ranging between 6 – 8), resulting in low levels of corrosion.

The available drawings indicate the sheet piles were driven to refusal on the weathered or fresh bedrock. The assessments to date (section 6.3) have indicated a wide range of permeability of between 10^{-9} to 10^{-4} m/s in the weathered rock. This is thought to result from variability in jointing with the higher values likely to be in highly jointed rock and the lower values possibly in fresh rock.

No construction records of the low permeability clay barrier constructed at the two ends of the cut-off wall (beyond the sheet piles) is available. Based on above, the potential for leachate escaping through the bedrock below the cut-off wall or through the clay barrier at the two ends cannot be discounted. Based on discussions with the WSP Hydro-geologist, we understand that leachate has potentially been identified through groundwater monitoring of the historic wells and BH1 downgradient of the cut-off wall.

Given the consequences of leachate escaping through the landfill, it is recommended that monitoring the groundwater wells downgradient of the wall to be continued.

8.5 Suitability of site Soils for Reuse as a natural Soil Liner

The site is underlain by a thin layer of topsoil and alluvial deposits, overlying bedrock. The alluvial deposits encountered in BH1 are highly interbedded and mixed and are unlikely to have sufficiently low permeabilities to be suitable for use as liner based on the borehole descriptions. The extent of the alluvial deposits is also relatively limited to the south-west section of the site, and the use of these soils would require extensive excavations and sorting on site. The completely weathered bedrock (Unit 3a) may potentially be a suitable source to be used in the liner or capping system, however this layer is quite thin and localised and requires considerable testing and quality control.

Based on the above, low permeability clays to achieve the target permeability levels (in the order of 10^{-8} m/s) to be used in the liner or the capping layer systems need to be imported to site.

A suitable and adequate source of clay have not been identified from onsite but could be considered from an off-site location. We are not aware of a suitable location. Also, significant investigation and testing could be required to identify and prove an adequate source and then a reasonable extensive programme of quality control laboratory testing would need to be completed during construction to ensure the required permeability is achieved. The natural liner soils would be moisture sensitive, limiting construction to dry periods and tight dimension controls would be required during construction as well as *in-situ* permeability testing.

8.6 Proposed Liner for Landfill Expansion

Given that suitable site-won soils to be incorporated into the liner system are not available, a needle punched Geosynthetic Clay Liner (GCL) will be required to reduce the thickness of low permeability clays in the liner system. The proposed liner configuration has the following main components:

- Placement and compaction of suitable clays as part of the liner system. The compacted clay liner would have a nominal thickness of 600mm at the required permeability of around 1×10^{-8} m/s.
- A needle punched bentonite GCL liner.
- 300mm thick layer of compacted confining soil over the GCL.
- Leachate drainage system.
- The subgrade will need to be cut to a smooth profile and a protection layer (e.g. sand or other fine soils) is likely to be required under and possible over the liner.

8.7 Liner Settlements

The proposed liner will be placed over the existing bedrock across the eastern section of the proposed landfill. However, Stages 4 and 5 of the proposed landfill expansion (around the western and north-western sections) will involve the placement of fill and refuse over the existing landfill batters and top, with a liner between the new and existing waste. The additional fill on top of the existing landfill is in the order of 10m high based on the existing cross sections. This is likely to result in settlements of the existing fill and may cause damage to the liner system due to differential settlements. The risk of rupture of the liner resulting in leachate escaping towards the Clutha River / Mata-Au is considered low due to the following reasons:

- The site topography suggests that in the event of liner rupture, any leachate flow is expected to drain quickly to the base liner and the leachate collection system.
- Construction of Stages 4 and 5 are currently estimated to be 20 years away, which will give adequate time for the landfill to settle and provide an indication of the performance of the landfill.

A specific design of a suitable liner system will be required at that stage to address that the risk of rupture is minimised, and leachate is adequate collected and discharged in the event of localised rupture.

9 Earthworks Considerations

A summary of the earthworks considerations relevant to the landfill development is presented below.

9.1 Overview

The expected earthworks operations for the landfill expansion generally includes the following:

- Excavations in the area to the east and south of the existing landfill to create the proposed landfill floor. Some level of excavation has been completed to date in some areas.
- Cut and fill to form the access roads and proposed building platforms. Extensive excavations into an existing cut slope would be required to allow the construction of Transfer Station and associated structures.
- Liner protection layer placement, if required
- Liner construction.
- Landfill capping, including intermediate capping layers.
- Landscaping on completed landfill cells.

9.2 Cut and Fill Batters

Based on the investigation results and preliminary mapping, the following preliminary permanent cut batters are proposed for this stage of the project:

- 1(V): 2.5(H) cut slopes in Alluvium **(Unit 2)**.
- 1(V): 1.5(H) in Caples Terrane bedrock **(Unit 3)**, with 1(V): 2(H) cut slopes in more weathered rock encountered (such as Section 2 of the cut slope).

Minor filling would be required to form the access track and the building platforms. The fill should consist of granular free-draining aggregate (AP65 or similar approved by the Engineer), compacted in thin lifts.

Given the highly fractured nature of the rock, excavations into rock are anticipated to be generally easy as currently carried out on site. Rock breakers may be required in localised areas, where more fresh rock is encountered.

Any topsoil or soft alluvial deposits should be removed from the base of the slopes, subject to the approval of the Engineer.

9.3 Material Re-use

The recent investigations carried out across the site indicate the thin layer of topsoil as well as alluvial deposits across the western half of the site. Given the soft nature of topsoil as well high fines content and interbedded nature of the alluvial deposits, these soils are not considered suitable to be used as structural or bulk fill. The excavated soils may however be used for landscaping purposes across the site.

Excavated weathered rock may be used as bulk fill subject to approval of the Engineer and provided they can be well compacted in thin layers. Laboratory testing will be required to demonstrate the suitability of rock to be used as fill.

10 Conclusions

The main conclusions from the preliminary geotechnical assessments are summarised below;

- Based on the investigation results and our knowledge of site geology, the site is generally underlain by a thin layer of topsoil and alluvium, overlying Caples Terrane bedrock. The alluvium is thin to absent across the western section, but inferred to be continuous across the eastern section, with thickness of up to 6m proven in BH1.

  The recent investigations and preliminary geological mapping suggest the strength and weathering of the bedrock is relatively consistent across the site and is highly jointed. The rock typically consists of 'Highly to moderately weathered, very weak to weak sandstone/siltstone' overlying 'slightly weathered to fresh, moderately strong to strong sandstone/siltstone'.

- Monitoring of the standpipe piezometers installed in BH1 to BH6 and BH10 to date indicates the long-term groundwater levels generally lie within the alluvial deposits or weathered bedrock at depths ranging between 1m to 4m bgl (or 6m to 20m RL). The preliminary analyses have considered elevated groundwater levels during heavy rainfall events.

- Caples Terrane bedrock is expected at shallow depths (typically < 1m bgl) across the eastern section of the site, resulting in the subsoil class for this section is 'B – Rock' (in accordance with NZS1170.5). Due to the presence of alluvial deposits, bedrock is anticipated at greater depths across the western section of the site (up to approximately 7m bgl in BH1), resulting in the site subsoil class is 'C – Shallow Soils'.

- Due to the shallow depths to bedrock across the eastern section, liquefaction or cyclic softening is not anticipated. A quantitative liquefaction assessment based on the SPT data within BH1 indicates that liquefaction nor cyclic softening of the alluvial deposits below the groundwater table are not anticipated under seismic SLS or ULS shaking events.

- Preliminary global stability assessments using the Slope/W software indicate the proposed landfill faces at 1(V): 4(H) achieve the acceptable factors of safety under the static and seismic cases. A moderately conservative assessment of the stability of the existing landfill site ignoring any pinning effect from the existing cut off wall also indicates that the factors of safety under the static and seismic SLS cases are achieved and minor displacement of the landfill face of up to 100mm in a DCLS event but this is considered to be acceptable.

- A part of the construction of Stages 4 and 5, the new landfill will be constructed over the existing landfill, with the construction anticipated to be around 20 years away. The design of a suitable liner system for these sections should consider the potential settlements and ensure any leachate in the event of localised liner rupture is adequately collected and discharged.

- Given the shallow depth to bedrock and the limited thickness of the soil cover across the majority of the site, long term settlements under the loads from the proposed structures or fill slopes are anticipated to be small and occur immediately. The proposed landfill facilities are concentrated towards the existing landfill entrance to the south of the site, where thick

layers of alluvium are not anticipated. This assumes future buildings are not located on the existing landfill.

- The alluvial deposits across the site are highly variable and are not likely to achieve the low permeabilities required for use as liner. Therefore, suitable low permeability clays need be imported to site for use as liner and capping layers (including intermediate) of the proposed landfill. Excavated topsoil and alluvium may be used for landscaping purposes.
- The existing landfill is not lined and relies on an existing sheet pile cut off wall immediately to the south to contain leachate. An assessment of the likely corrosion of the existing sheet pile cut off wall indicates the sheet pile section is likely to have a residual life exceeding 50 years and the risk of holes or cavities being present due to pitting corrosion is considered to be low.
- Monitoring of the existing groundwater wells downgradient of the cut-off wall to date has detected leachate. Based on the existing data, the likelihood of leachate escaping through the highly fractured bedrock below the cut-off wall or through the low permeability clay barriers at the two ends cannot be discounted.
- Based on the ground conditions, preliminary safe cut batters of 1(V): 1.5(H) and 1(V): 2(H) are proposed for weathered bedrock and 1(V): 2.5(H) are proposed for alluvium.

  Any fill slopes should comprise well compacted granular fill (AP65 or similar approved) at slopes not exceeding 1(V): 2(H).

11 Recommendations for Next Stage

The main recommendations for the next stage of the project (subject to the final layout) are presented below.

1. Intrusive investigations and preliminary geological completed across the site to date provide a good overview of the variability of ground and groundwater profiles across the site. However, additional investigations or mapping, in particular in the area to the south-west of the site, may be required dependent on the final layout of the proposed development. If these investigations are warranted, these may take the form of boreholes or cone penetration tests, or detailed geological mapping.
2. We recommend the ongoing monitoring of the piezometers to be carried out to assess the variability of groundwater levels.
3. Given the condition of the sheet pile cut off wall cannot be visually confirmed on site, we recommend ongoing monitoring of the water bores downgradient of the cut off wall by an experienced hydrogeologist to identify trends of leachate escape.
4. The design of the new landfill for Stages 4 and 5 should consider the risk of settlements and potential damage to the liner. The design should allow for measures to capture and discharge leachate in the event of localised rupture.
5. Subject to the final locations and arrangement of the buildings, geotechnical inputs may be required for the design of foundations for such structures.

12 References

Ambraseys, N and J. M. Menu (1988). Earthquake-induced Ground Displacements.

ASTM, 2011. ASTM D1586-11, Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils. ASTM International, West Conshohocken, PA.

Bray, J. D., & Travasarou, T. (2007). Simplified procedure for estimating earthquake-induced deviatoric slope displacements. Journal of geotechnical and geoenvironmental engineering, 133(4), 381-392.

Idriss, I.M., & Boulanger R.W., (2014). Soil Liquefaction during Earthquakes: CPT and SPT based Liquefaction Triggering Procedures, University of California Davis, Report No. UCD/CGM 14/01.

Jibson, R. W. (2007). Regression models for estimating co-seismic landslide displacement. Engineering geology, 91(2-4), 209-218.

Ministry of Business, Innovation & Employment (MBIE), 2021a, *Earthquake geotechnical engineering practice – Module 1. Overview of the guidelines.*

Mortimer, N., (2004). New Zealand's Geological Foundations, Gondwana Research, Volume 7, Issue 1, Pages 261 – 272.

New Zealand Active Faults Database. Institute of Geological and Nuclear Sciences (GNS) Ltd. Accessed 28/03/2023.

New Zealand Geotechnical Society (NZGS), 2005, *Field Description of Soil and Rock.*

Qian X, Koerner R, Gray D (2002). Geotechnical Aspects of Landfill Design and Construction. Prentice-Hall Inc., New Jersey, USA.

Royd Consulting Limited (1994). 'A Report of Site Investigations at the Mount Cooee Landfill', dated May 1994.

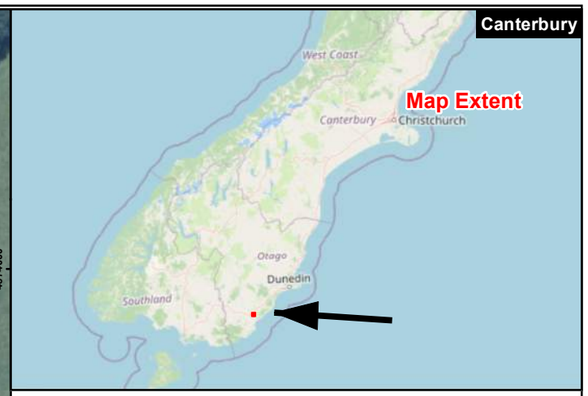
Waka Kotahi NZ transport Agency (2022). Bridge Manual (SP/M/022), Third Edition.

WasteMINZ, 2022. WasteMINZ Technical Guidelines to Land 2022.

WSP (March 2023). 'Mt Cooee Landfill Development Plan and Resource Recovery Centre – Geotechnical Factual Report' by WSP dated 31 March 2023, Revision 2.

WSP (April 2023). 'Mt Cooee Landfill Development Plan – Sheet Pile Cut-off Review Report' by WSP dated 5 April 2023.

Appendix A
Site Plan



LEGEND

- Proposed New Shallow Groundwater Well
- Proposed Shared Hydro/Geotech Borehole
- Proposed Geotechnical Boreholes
- Existing Groundwater Monitoring Well
- Sediment Pond Monitoring Site
- Surface Water Monitoring Site
- Oxidation Ponds
- Pump Station
- Royds Boreholes (1993)
- Proposed Fill Area Expansion

ISSUED FOR COMMENT

DRAFT

NOTES

1. Map image: © OpenStreetMap (and) contributors, CC-BY-SA Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors
2. Schematic only, not to be interpreted as an engineering design or construction drawing.

0 50 100
Meters

REFERENCE SCALE: 1:2,200 (at A3)

PROJECTION: NZGD 2000 New Zealand Transverse Mercator

CLIENT
CLUTHA DISTRICT COUNCIL

PROJECT
MT COOEE LANDFILL DEVELOPMENT PLAN

TITLE
MT COOEE PROPOSED DRILLING PLAN

CONSULTANT

YYYY-MM-DD	2022-07-06
PREPARED	KC

PROJECT NO.	REPORT	REV.	FIGURE
6-CO082.00	N/A	N/A	**01**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM A3
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Appendix B
Preliminary Layout Plan

NOTES

1. ALL SIGNS TO BE IN ACCORDANCE WITH THE TRAFFIC CONTROL DEVICES MANUAL. PAINT MARKINGS TO BE IN ACCORDANCE WITH THE LATEST VERSION OF THE NZTA MANUAL OF TRAFFIC SIGNS AND MARKINGS PART I AND PART II.
2. ALL EXISTING SERVICES ARE SHOWN INDICATIVELY ONLY.
3. COORDINATES IN TERMS OF NORTH TAIERI CIRCUIT 2000. LEVELS ARE IN TERMS OF BALCLUTHA FUNDAMENTAL.
4. REFER TO THE WSP GEOTECHNICAL FACTUAL REPORT FOR THE LOCATION OF GEOTECHNICAL INVESTIGATION POINTS.

Section through Existing Landfill

EXISTING LANDFILL

EXISTING CUT OFF WALL

EXISTING WEIGHBRIDGE

Transfer Station Cut Stability Section (indicative)

RESOURCE RECOVERY CENTRE

TRANSFER STATION

PROPOSED LANDFILL

PROPOSED SEDIMENT RETENTION POND

TO BALCLUTHA

KAITANGATA HIGHWAY

CLUTHA RIVER

TO KAITANGATA

N

LEGEND

- EXISTING EDGE OF SEAL
- NEW CENTERLINE
- NEW EDGE OF SEAL
- EXISTING FENCE
- NEW OR RELOCATED FENCE
- TOP OF CUT BATTER
- EXISTING LEACHATE DRAIN
- EXISTING FOUL SEWER LINE
- EXISTING OPEN DRAIN
- EXISTING WATER LINE
- EXISTING SUBSOIL DRAIN
- PROPOSED LEACHATE DRAIN
- PROPOSED FOUL SEWER LINE
- PROPOSED STORMWATER
- EXISTING CULVERT
- PROPOSED SUBSOIL
- CADASTRAL BOUNDARY
- PROPOSED LANDFILL
- NEW SEAL
- PROPOSED CONCRETE PAD
- OPERATIONS AREA
- PROPOSED LANDSCAPING
- PROPOSED RESOURCE CENTRE YARD
- POWER POLES
- PROPOSED SUMP
- PROPOSED MANHOLE

1:750@ A1
1:1500@ A3
0 10 20 30 40 50 60 70 m

NOTE:
THIS DRAWING IS TO BE REPRODUCED IN COLOUR

WORK IN PROGRESS

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REVISION	AMENDMENT	APPROVED	DATE

wsp
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Invercargill 9840
New Zealand

CIVIL

SCALES	ORIGINAL SIZE
1:750@ A1, 1:1500@A3	A1

DRAWN	DESIGNED	APPROVED
AUTHOR	DESIGNER	APPROVER

DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
VERIFIER	VERIFIER	YYYY-MM-DD

PRELIMINARY

PROJECT
CLUTHA DISTRICT COUNCIL
KAITANGATA HIGHWAY BALCLUTHA
MT COOEE LANDFILL DEVELOPMENT

TITLE
LANDFILL, TRANSFER STATION & RESOURCE RECOVERY CENTRE OVERALL SITE PLAN

WSP PROJECT NO. (SUB-PROJECT)	SHEET NO.	REVISION
6-CO082.00	C101	A

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REVISION	AMENDMENT	APPROVED	DATE
A	DRAFT FOR COMMENT		

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CIVIL

SCALES		ORIGINAL SIZE
N.T.S		A1
DRAWN	DESIGNED	APPROVED
R.GOLDSMITH	R.GOLDSMITH	APPROVER
DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
VERIFIER	VERIFIER	YYYY-MM-DD

PRELIMINARY

PROJECT
CLUTHA DISTRICT COUNCIL
KAITANGATA HIGHWAY BALCLUTHA
MT COOEE LANDFILL DEVELOPMENT

TITLE
LANDFILL EXPANSION
OVERALL LANDFILL FLOOR DESIGN

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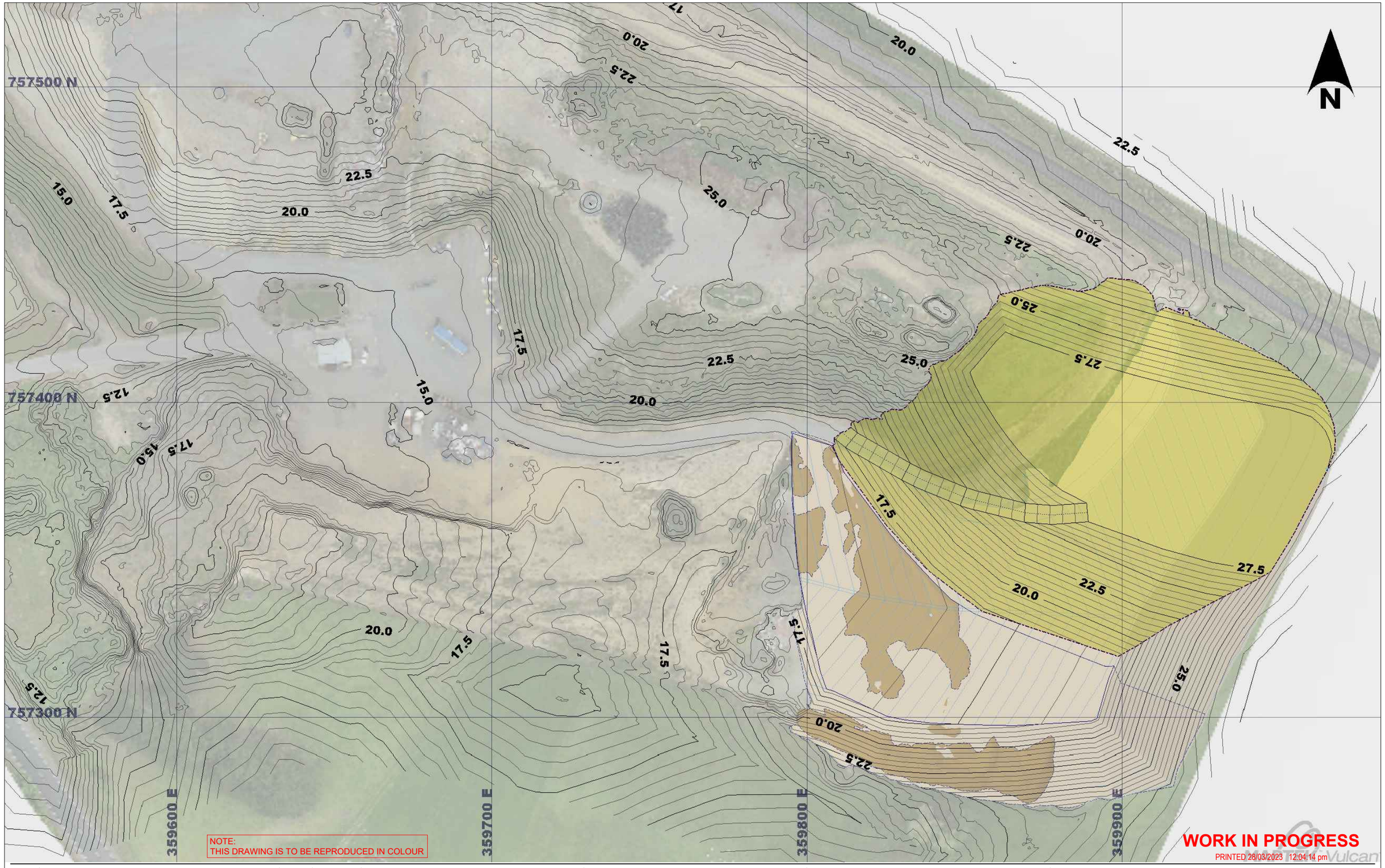

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DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
VERIFIER	VERIFIER	YYYY-MM-DD

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PROJECT
CLUTHA DISTRICT COUNCIL
KAITANGATA HIGHWAY BALCLUTHA
MT COOEE LANDFILL DEVELOPMENT

TITLE
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LANDFILL STAGE 01

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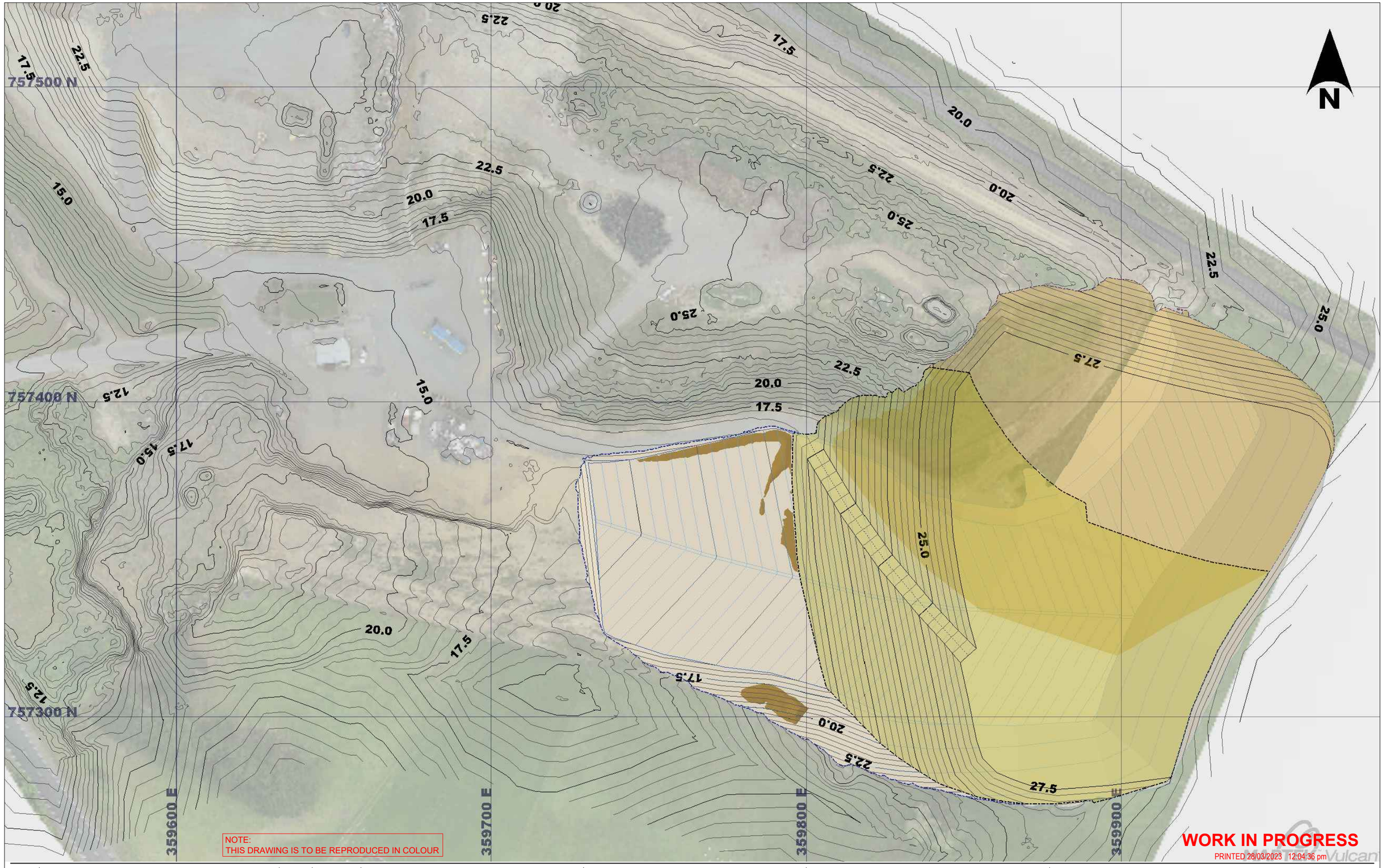

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ORIGINAL SIZE: A1

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VERIFIER	VERIFIER	YYYY-MM-DD

PRELIMINARY

PROJECT
CLUTHA DISTRICT COUNCIL
KAITANGATA HIGHWAY BALCLUTHA
MT COOEE LANDFILL DEVELOPMENT

TITLE
LANDFILL EXPANSION
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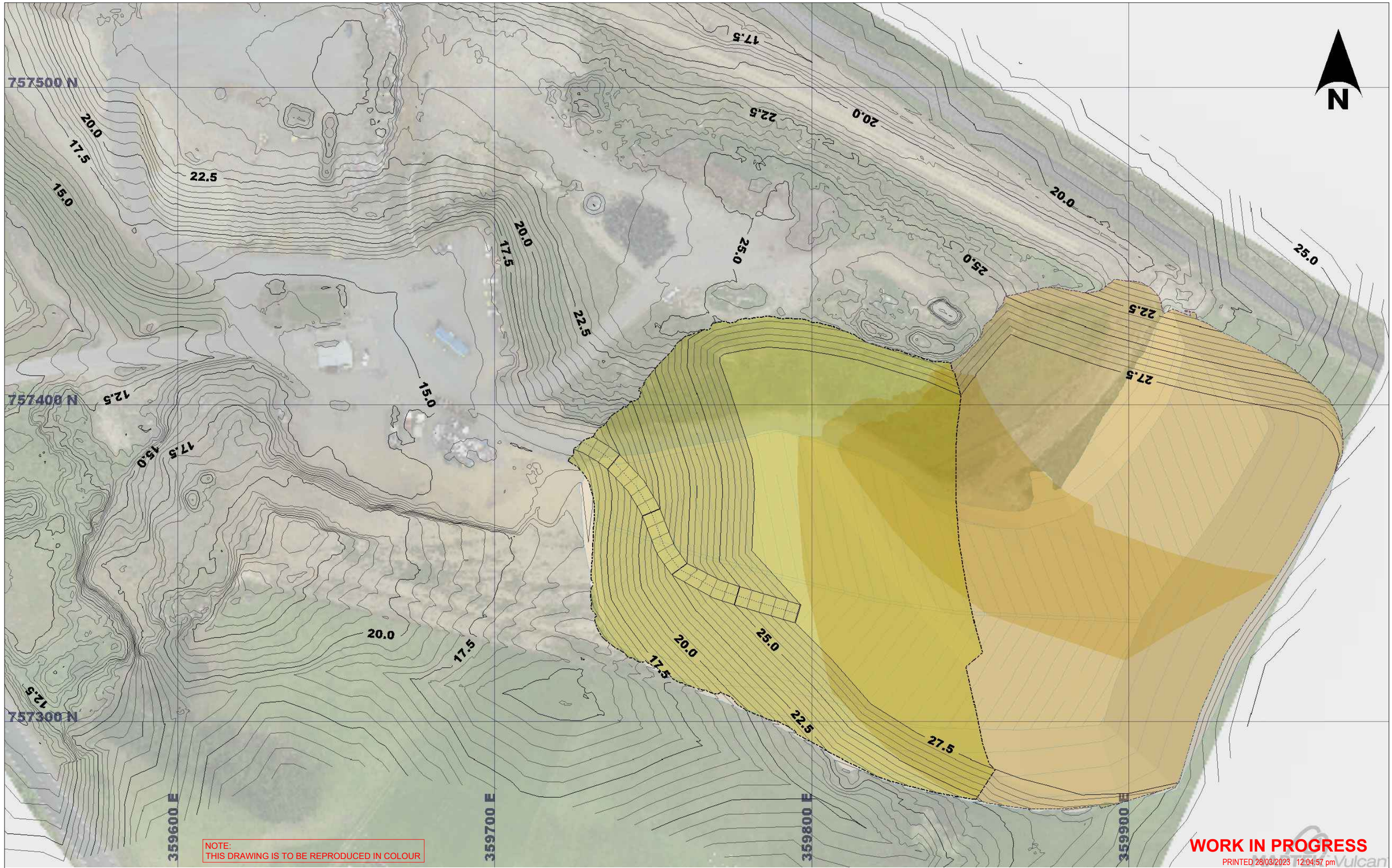

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PROJECT
CLUTHA DISTRICT COUNCIL
KAITANGATA HIGHWAY BALCLUTHA
MT COOEE LANDFILL DEVELOPMENT

TITLE
LANDFILL EXPANSION
LANDFILL STAGE 03

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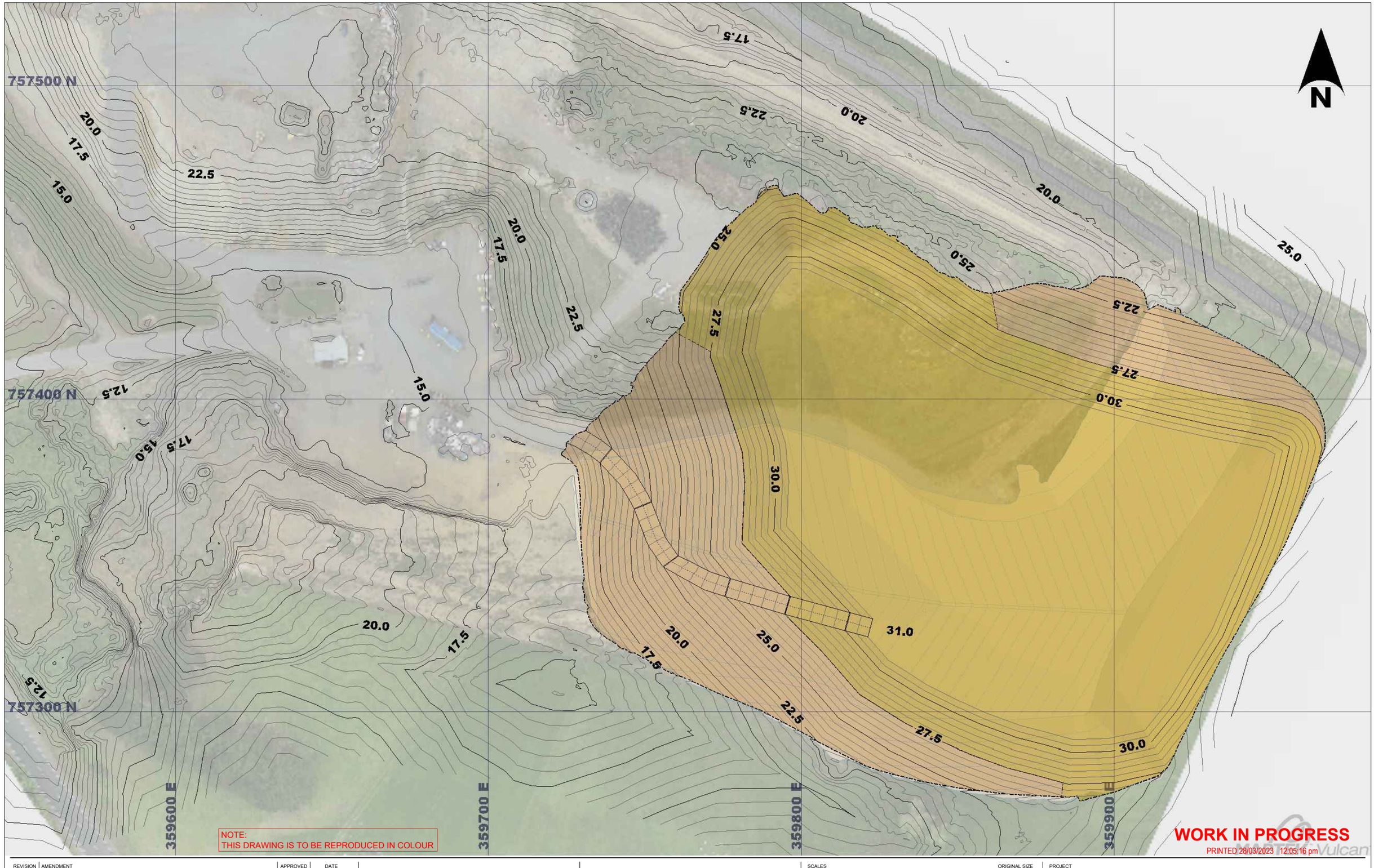

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ORIGINAL SIZE: A1

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VERIFIER	VERIFIER	YYYY-MM-DD

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PROJECT
CLUTHA DISTRICT COUNCIL
KAITANGATA HIGHWAY BALCLUTHA
MT COOEE LANDFILL DEVELOPMENT

TITLE
LANDFILL EXPANSION
LANDFILL STAGE 04

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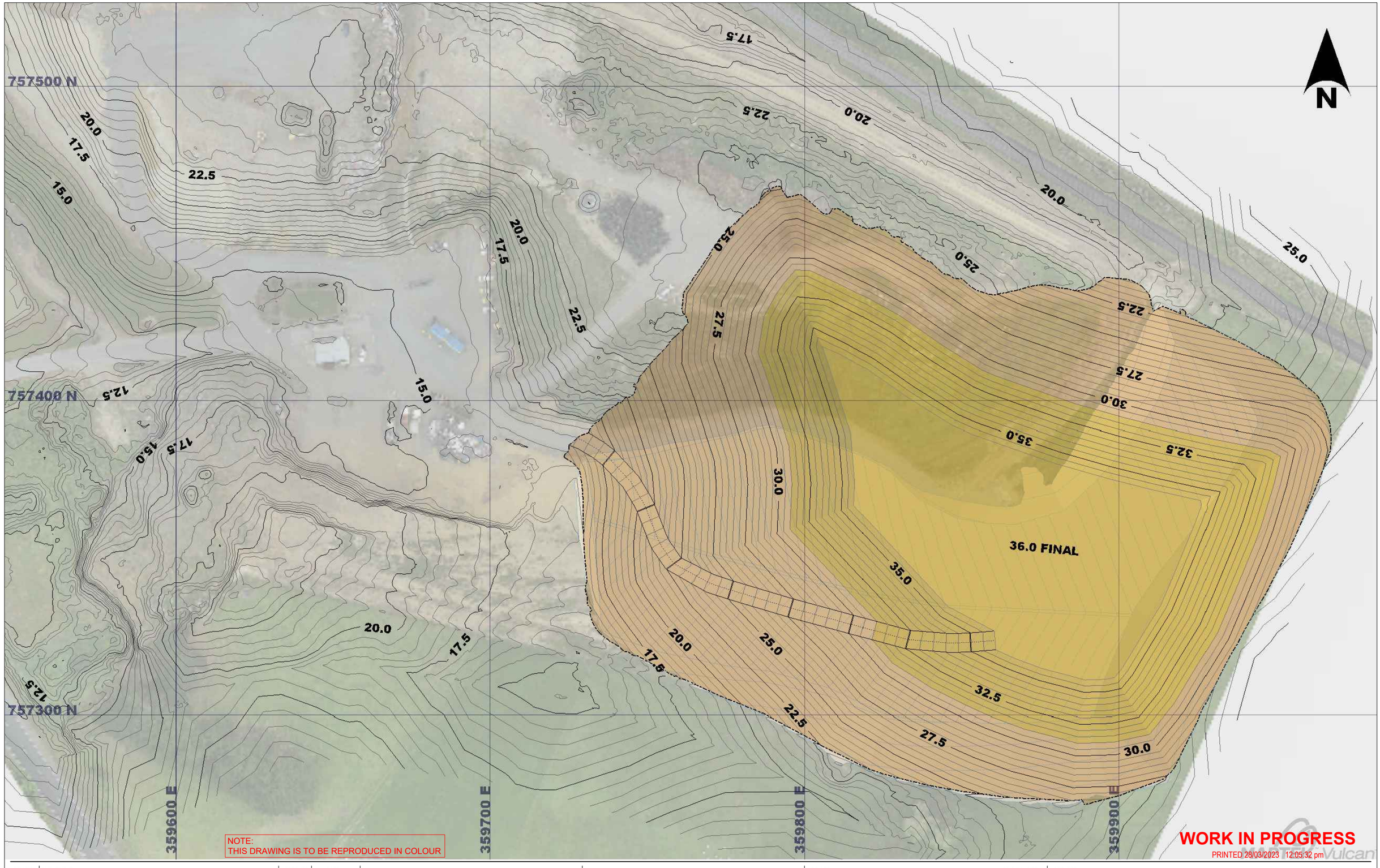

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SCALES		ORIGINAL SIZE
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DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
VERIFIER	VERIFIER	YYYY-MM-DD

PRELIMINARY

PROJECT
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KAITANGATA HIGHWAY BALCLUTHA
MT COOEE LANDFILL DEVELOPMENT

TITLE
LANDFILL EXPANSION
LANDFILL STAGE 05

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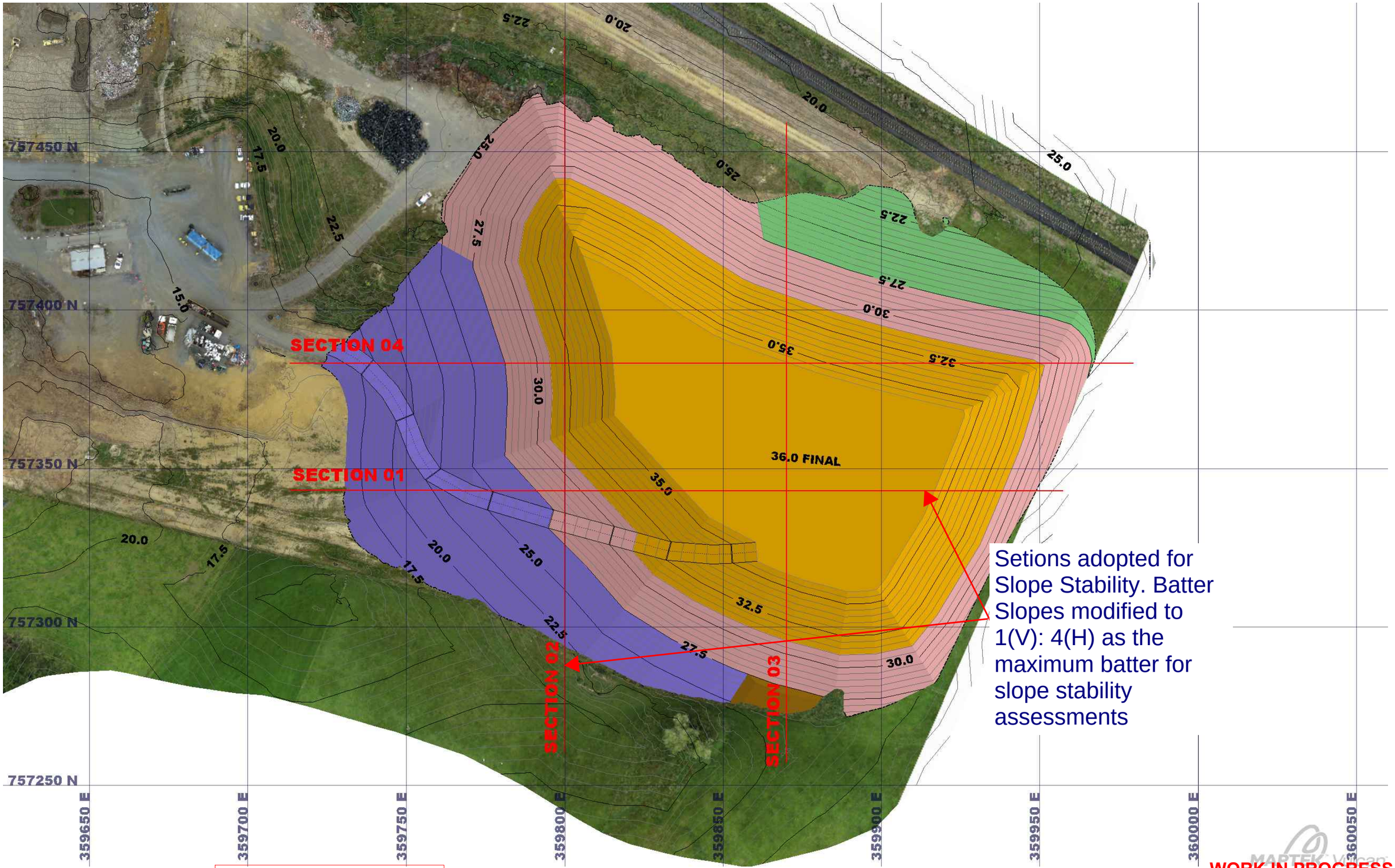

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DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
VERIFIER	VERIFIER	YYYY-MM-DD

PRELIMINARY

PROJECT
CLUTHA DISTRICT COUNCIL
KAITANGATA HIGHWAY BALCLUTHA
MT COOEE LANDFILL DEVELOPMENT

TITLE
LANDFILL EXPANSION
SECTION OVERALL

WSP PROJECT NO. (SUB-PROJECT)	SHEET NO.	REVISION
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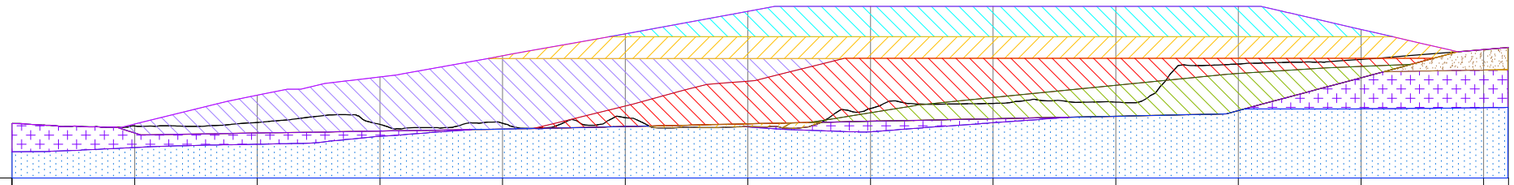
ONLY AND TO BE CONFIRMED ON SITE.



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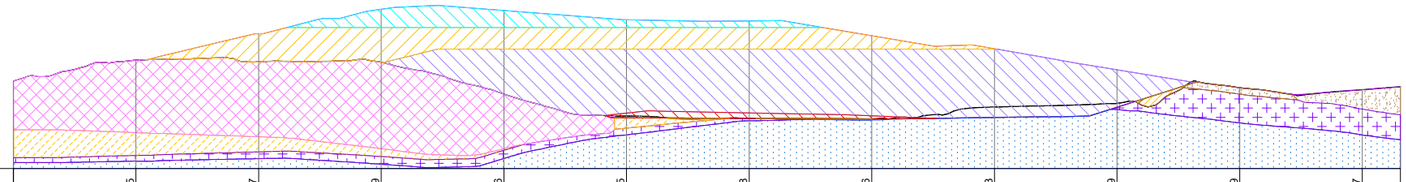
EXISTING LEVEL	16.46	17.03	16.72	16.94	17.83	16.36	19.30	20.14	20.34	26.56		
CUT/FILL	0.31	4.46	7.73	10.97	13.66	18.79	16.67	15.83	15.63	9.41		
STATION	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00	200.00	220.00	240.00	244.07

SECTION 01
SECTION BETWEEN CH: 0.00 AND 244.07



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SECTION 02
SECTION BETWEEN CH: 0.00 AND 226.20

LEGEND:

- TOPSOIL (UNIT 1)
- LANDFILL STAGE 01
- LANDFILL STAGE 02
- LANDFILL STAGE 03
- LANDFILL STAGE 04
- LANDFILL STAGE 05
- HISTORIC LANDFILL
- ALLUVIAL (UNIT 2)
- HIGHLY TO MODERATELY WEATHERED GREYWACKE, VERY WEAK TO WEAK SANDSTONE/SILTSTONE (UNIT 3b)
- SLIGHTLY WEATHERED TO FRESH, MODERATELY STRONG TO STRONG SANDSTONE/SILTSTONE (UNIT 3c)
- PROPOSED TOP OF PIT
- EXISTING GROUND

NOTE:
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SCALES: A1 1:500 , A3 1:1000
ORIGINAL SIZE: A1

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R.GOLDSMITH	R.GOLDSMITH	APPROVER

DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
VERIFIER	VERIFIER	YYYY-MM-DD

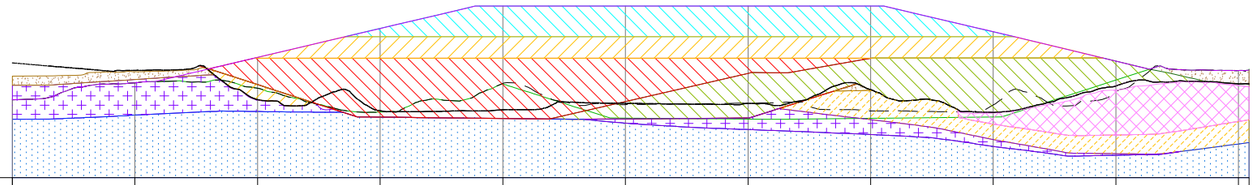
PRELIMINARY

PROJECT
CLUTHA DISTRICT COUNCIL
KAITANGATA HIGHWAY BALCLUTHA
MT COOEE LANDFILL DEVELOPMENT

TITLE
LANDFILL EXPANSION
SECTIONS STAGE 01 - STAGE 02

WSP PROJECT NO. (SUB-PROJECT): 6-CO082.00
SHEET NO.: C207
REVISION: A

NOTE:
GROUND CONDITIONS ARE INDICATIVE ONLY AND TO BE CONFIRMED ON SITE.



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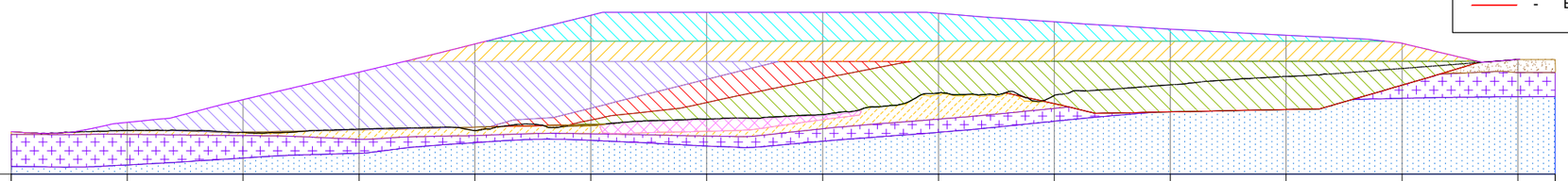
SECTION 03
SECTION BETWEEN CH: 0.00 AND 201.72

LEGEND:

- \- TOPSOIL (UNIT 1)
- \- LANDFILL STAGE 01
- \- LANDFILL STAGE 02
- \- LANDFILL STAGE 03
- \- LANDFILL STAGE 04
- \- LANDFILL STAGE 05
- \- HISTORIC LANDFILL
- \- ALLUVIAL (UNIT 2)
- \- HIGHLY TO MODERATELY WEATHERED GREYWACKE, VERY WEAK TO WEAK SANDSTONE/SILTSTONE (UNIT 3b)
- \- SLIGHTLY WEATHERED TO FRESH, MODERATELY STRONG TO STRONG SANDSTONE/SILTSTONE (UNIT 3c)
- \- PROPOSED TOP OF PIT
- \- EXISTING GROUND



Datum R.L. 8.00													
PROPOSED LEVEL	16.95	20.88	25.62	30.49	35.46	35.97	35.97	35.80	34.33	33.07	32.01	30.62	27.86	
EXISTING LEVEL	15.56	15.22	15.78	15.57	16.45	17.49	18.29	22.03	21.62	23.45	24.90			
CUT/FILL	1.39	5.66	9.84	14.93	19.01	18.48	17.68	13.77	12.72	9.62	7.11			
STATION	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00	200.00	220.00	240.00	260.00	266.42

SECTION 04
SECTION BETWEEN CH: 0.00 AND 266.42

NOTE:
THIS DRAWING IS TO BE REPRODUCED IN COLOUR

WORK IN PROGRESS

PRINTED 5/04/2023 11:01:45 am

REVISION	AMENDMENT	APPROVED	DATE
A	DRAFT FOR COMMENT		

Invercargill Office
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PO Box 647
Invercargill 9840
New Zealand

CIVIL

SCALES: A1 1:500 , A3 1:1000
ORIGINAL SIZE: A1

DRAWN	DESIGNED	APPROVED
R.GOLDSMITH	R.GOLDSMITH	APPROVER

DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
VERIFIER	VERIFIER	YYYY-MM-DD

PRELIMINARY

PROJECT
CLUTHA DISTRICT COUNCIL
KAITANGATA HIGHWAY BALCLUTHA
MT COOEE LANDFILL DEVELOPMENT

TITLE
LANDFILL EXPANSION
SECTIONS STAGE 01 - STAGE 02

WSP PROJECT NO. (SUB-PROJECT): 6-CO082.00
SHEET NO.: C208
REVISION: A

Appendix C
Machine Borehole Logs and Photographs

Borehole No. BH1

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350038 E 4873817 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 9 m
Location:	30m west of Kaitangata Hwy, south of oxidation ponds Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 11.6 m

Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
TS	TOPSOIL, grass, trace rootlets and trace fine quartz gravel. 0.40-0.50m - Woody organics present.											RC	80					Cement seal
Alluvium	Silty CLAY with trace gravel and rootlets, dark grey, homogenous. Soft to firm, moist, high plasticity. Gravel; coarse, subangular. Core loss.	8	1															
	Sandy SILT, light brown to brown, homogenous. Firm, moist to dry, low plasticity, micaceous. Sand; fine.				6	3// 1/2/1/2						SPT	100					
	Silty CLAY with trace sand and gravel, light brown with dark grey and brown specks, homogenous. Firm, moist, high plasticity. Gravel; fine, subangular. Sand; fine to coarse. 1.50m - Orange mottle.										Lab: 1.8 - 3.0m PSD and Atterberg Limits	RC	100					
	Sandy SILT, brown, homogenous. Firm, dry, low plasticity. Sand; fine. 1.80m - Becomes light brown.	7	2		5	2// 1/1/1/2						SPT	100					
	Silty fine to coarse SAND with trace rootlets, brown, homogenous. Loose, moist, micaceous. Silt; low plasticity.																	
	Becomes light grey to grey with trace of orange mottles, homogenous. Dry to moist, non-plastic, micaceous.	6	3									RC	100					
					7	2// 1/2/2/2					2.85-3.00m - Broken during removal from core catcher	SPT	100					
	Silty CLAY with trace sand, light grey with orange mottles throughout, homogenous. Soft to firm, moist, high plasticity, micaceous. Sand; fine to medium. 3.50m - Becomes firm.											RC	100					
	3.90m - Becomes light grey with trace orange mottles (less than above), homogenous.	4	4															
	Sandy SILT, light brownish grey, homogenous. Soft, non-plastic dry. Sand; fine to medium.				6	2// 2/1/2/1						SPT	100					
	Silty CLAY, light greenish grey, homogenous. Soft to firm, moist, high plasticity.										Lab: 4.4 - 6.1m PSD and Atterberg Limits	RC	100					
		4	5		1	0// 0/0/0/1						SPT	100					
	5.45-5.65m - Becomes light greyish green with trace green sandy laminations. 5.65-6.00m - Green sandy lenses. Becomes greenish grey.											RC	100					
		6	6		60+	13// 9/22/22/7 for 20mm						SPT	100		Rotary cored	PQ size wireline (85 mm nom. dia. core)		50 mm Blank pipe (8.2 m L) with grout backfill
	Silty CLAY with trace gravel and sand, dark grey with orange mottles, homogenous. Very soft, moist to wet, high plasticity. Gravel; fine to coarse, subangular to angular. Sand; fine to medium, subangular to subrounded.										6.70-9.35m - Rock broken up by drilling.	RC	100					
Caples Terrane	Slightly weathered, highly fractured, light brownish grey, fine fabric SANDSTONE; moderately strong; very closely spaced joints and white veins. Recovered as: sandy GRAVEL with some silt, light brown. Gravel and sand; fine to coarse, subangular. 7.50-8.00m - Gravel becomes; fine to coarse, coarser gravel is angular to subangular, finer gravel is rounded to subrounded.	2	7		60+	12// 14/46 for 75mm	MS	SW	VC			SPT	100					
												RC	100				SWL 2.35m	
		8	8		60+	60 for initial 110mm						SPT	100					
	Slightly weathered, highly fractured, light bluish grey, fine fabric SANDSTONE; moderately strong; closely spaced joints and white veins. Recovered as: Fine to coarse GRAVEL with minor sand, light greyish brown. Very dense, well graded, non-plastic. Gravel; coarser gravel is angular to subangular, finer gravel is rounded to subrounded. Sand; medium to coarse, rounded. 9.17-9.35m - Recovered as: fine to coarse GRAVEL with minor cobbles, light grey. Very dense, well graded. Gravel; subangular, Greywacke, mm-scale white veins. Cobbles: max 80mm.	0	9		60+	60 for initial 105mm			VC VC C VC C		Lab: 9.0 - 11.0m UCS testing 9.17-9.35m - Rock broken up by drilling. Any matrix appears to be lost due to drilling.	RC	100	0				
							S					SPT	100	0				
												RC	100	0				50 mm slotted pipe (3.0 m L)

31/10/2022

9/03/2023

BOREHOLE SOIL/ROCK LOG A4 - WSP MT COOEE BOREHOLE LOGS - V0.3.GPJ WSP-OPUS2019_VER11X.GDT 30/3/23

Notes:

SPT hammer energy ratio 91%
Shared Hydro / Geotech borehole
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	19/10/2022	*Finished:*	20/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH1

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350038 E 4873817 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 9 m
Location:	30m west of Kaitangata Hwy, south of oxidation ponds Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 11.6 m
Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m) / DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
Caples Terrane	Slightly weathered, fractured, light grey, fine fabric SANDSTONE; strong; white veins smooth and tight aperture. Recovered as: COBBLES, with some gravel and sand. Well graded. Cobbles and gravel; angular to subangular. Sand; fine to medium.*(continued)* 10.11-11.00m - Thinly laminated veins throughout. Veins are mostly white, some are greenish white. Apertures extremely closely spaced, very narrow. 10.40-10.60m - Heavily veined. Minor sand. 10.80-11.00m - Angular GRAVEL and COBBLES.	-2 / 11		60+	60 for initial 105mm	S	SW	VC			SPT	100	0	Rotary cored			
								C			RC	100	0				
								VC									
				60+	60 for initial 95mm			C			SPT	100	0				
								VC			RC	100	0				
	END OF BOREHOLE AT 11.6m - Target Depth Reached	12															
		-4 / 13															
		14															
		-6 / 15															
		16															
		-8 / 17															
		18															
		-10 / 19															

Notes:
SPT hammer energy ratio 91%
Shared Hydro / Geotech borehole
Core loss placed at end of run by default
123mm OD Rotary Coring

Started: 19/10/2022
Finished: 20/10/2022
Drilling Co.: McMillan Drilling
Drilling Rig: Hanjin D&B-8D - track
Logged by: C. Hall
Checked by: C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH1

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350038 E 4873817 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	11.6 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 9 m	*Inclination:*	Vertical
Location:	30m west of Kaitangata Hwy, south of oxidation ponds Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH1.1
BH1 Box 1: 0.0m - 2.4m

Photo BH1.2
BH1 Box 2: 2.4m - 4.45m

BOREHOLE SOIL/ROCK LOG A4 - WSP MT COOEE BOREHOLE LOGS - V0.3.GPJ WSP-OPUS2019_VER11X.GDT 30/3/23

Notes:
SPT hammer energy ratio 91%
Shared Hydro / Geotech borehole
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	19/10/2022	*Finished:*	20/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH1

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350038 E 4873817 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	11.6 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 9 m	*Inclination:*	Vertical
Location:	30m west of Kaitangata Hwy, south of oxidation ponds Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH1.3
BH1 Box 3: 4.45m - 7.0m

Photo BH1.4
BH1 Box 4: 7.0m - 9.35m

Notes:
SPT hammer energy ratio 91%
Shared Hydro / Geotech borehole
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	19/10/2022	*Finished:*	20/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH1

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350038 E 4873817 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	11.6 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 9 m	*Inclination:*	Vertical
Location:	30m west of Kaitangata Hwy, south of oxidation ponds Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH1.5
BH1 Box 5: 9.35m - 11.0m

Photo BH1.6
BH1 Box 6: 11.0m - 11.6m

Notes:
SPT hammer energy ratio 91%
Shared Hydro / Geotech borehole
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	19/10/2022	*Finished:*	20/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH1 (ROYDS)

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	Not established
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 116.39 m
Location:	Near Clutha River Bridge Mt Cooee Landfill, Balclutha	*Datum:*	

Depth: 15 m

Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m) / DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
TS	TOPSOIL with some fine gravel.	116 / 1															
Tuapeka Group Greywacke	Light grey moderate to widely jointed GREYWACKE. [TUAPEKA GROUP GREYWACKE] - weathered, fractured zone at top of layer - very hard - some quartz filled joints	114 / 2 112 / 4 110 / 6 108 / 8												Rotary open hole			4/03/2001 ▼ Slotted pipe

Notes:

Air Rotary drilling method. 150mm diameter.
Taken from Royds Garden Ltd borehole records.

Started: 28/01/1994 *Finished:* 28/01/1994

Drilling Co.: *Drilling Rig:*

Logged by: *Checked by:*

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH1 (ROYDS)

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	Not established
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 116.39 m
Location:	Near Clutha River Bridge Mt Cooee Landfill, Balclutha	*Datum:*	

Depth: 15 m
Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m) / DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
Tuapeka Group Greywacke	Light grey moderate to widely jointed GREYWACKE. [TUAPEKA GROUP GREYWACKE] - weathered, fractured zone at top of layer - very hard - some quartz filled joints*(continued)*	106 / 11 / 12 / 104 / 13 / 14 / 102 / 15												Rotary open hole			Slotted pipe
	END OF BOREHOLE AT 15m	16 / 100 / 17 / 18 / 98 / 19															

Notes:
Air Rotary drilling method. 150mm diameter.
Taken from Royds Garden Ltd borehole records.

Started: 28/01/1994
Finished: 28/01/1994
Drilling Co.:
Drilling Rig:
Logged by:
Checked by:

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH2

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350241 E 4873978 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 16 m
Location:	North of site, north side of railway Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 6 m

Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
TS	TOPSOIL.																	
Alluvium	GRAVEL with minor sand, brownish grey. Loose. Gravel; fine to coarse, subrounded, sandstone. Clay/silt/sand matrix inferred washed away. 0.70m - Some matrix present at 0.7m																	
	Core loss.	14	1									RC	55	0				
	Gravelly CLAY with some silt and minor sand, brown. Homogenous, soft, moist, high plasticity. Gravel; fine to coarse, angular, well graded.		2															
	Core loss.											RC	45	0				
Caples Terrane	Completely weathered grey and orange/brown, fine fabric SANDSTONE. Extremely weak. Recovered as: SILT with minor gravel and some sand and clay. Homogenous, stiff to very stiff, moist, low plasticity. Gravel; fine to medium, subangular. Sand; fine.		3				EW	CW	EC						Rotary cored	PQ size wireline (85 mm nom. dia. core)		13/10/2022 ▼ Cement seal
							W	SW	VC									
							EW	CW	EC			RC	80	0				50 mm slotted pipe (3.0 m L)
	Core loss.	12	4															
	Moderately weathered greenish grey, fine fabric SANDSTONE. Very weak to weak.						EW	CW	EC									
	Completely weathered grey and orangeish brown, indistinctly bedded SANDSTONE. Extremely weak. Residual soil recovered as: SILT with some clay. Homogenous, stiff to very stiff, moist, and low plasticity.		5				W	HW	C									
							VW		VC									
	Moderately weathered greenish grey, indistinctly bedded SANDSTONE. Very weak to weak.	10	6				W	MW	C			RC	100	30			SWL 1.00m	Grout
									VC									
	END OF BOREHOLE AT 6m - Target Depth Reached		7															
			8															
			9															
		6																

Notes:

Shallow groundwater well
Core loss placed at end of run by default
123mm OD Rotary Coring

Started: 18/10/2022 *Finished:* 19/10/2022

Drilling Co.: McMillan Drilling *Drilling Rig:* Hanjin D&B-8D - track

Logged by: N. Ahern *Checked by:* C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH2

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350241 E 4873978 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 16 m
Location:	North of site, north side of railway Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 6 m
Inclination: Vertical

PHOTOGRAPHS

Photo BH2.1
BH2 Box 1: 0.0m - 4.2m

Photo BH2.2
BH2 Box 2: 4.2m - 6.0m

Notes:
Shallow groundwater well
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	18/10/2022	*Finished:*	19/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	N. Ahern	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH2 (ROYDS)

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	Not established
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 109.29 m
Location:	Near gate to landfill Mt Cooee Landfill, Balclutha	*Datum:*	

Depth: 9.5 m
Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m) / DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
TS	TOPSOIL with some fine gravel.																
Pleistocene Glacial Deposits	Grey brown mottle yellow brown sandy silty fine GRAVEL.	1 108															
Tuapeka Group Greywacke	Light grey moderate to widely jointed GREYWACKE. - Weathered, fractured zone at top of layer - Very hard - Some quartz filled joints	2 3 106 4 5 104 6 7 102 8 9 100												Rotary open hole			
	END OF BOREHOLE AT 9.5m																

Notes:
Air Rotary drilling method. 150mm diameter.
Taken from Royds Garden Ltd borehole records.

Started: 30/01/1994
Finished: 30/01/1994
Drilling Co.:
Drilling Rig:
Logged by:
Checked by:

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH3

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350135 E 4873642 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 11 m
Location:	Western area of site, 15m north-east of Kaitangata Hwy Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 4.5 m
Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
TS	TOPSOIL.																	
Alluvium	SILT with some clay and minor sand, grey/dark brown, homogenous. Soft, moist, low plasticity. Sand; fine to medium.																	
	Clayey SILT with minor sand, light brownish orange. Homogenous, soft, moist, with low to medium plasticity. Sand; fine.																	
Caples Terrane	0.90-0.92m - Cobble of moderately weathered, light brown massive SANDSTONE. Weak.	10	1				EW	CW	EC			RC	100		Rotary cored	PQ size wireline (85 mm nom. dia. core)		Cement seal
	Completely weathered, brownish orange, fine fabric SANDSTONE. Extremely weak. Recovered as: sandy SILT with minor clay, brownish orange, homogenous. Stiff, dry to moist, low plasticity. Sand; fine to medium.								C									
	Highly weathered orange/brown, fine fabric SANDSTONE. Very weak. Recovered as: sandy GRAVEL with some cobbles and minor silt and clay, homogenous. Gravel; fine to coarse, subrounded. Cobbles; max 100mm, subrounded. Sand; fine to coarse.		2				VW	HW	EC			RC	65	0				31/10/2022
	Core loss.	8	3						C		2.40-2.50m - Core broken during removal from catcher.							1/02/2023
	Moderately weathered dark green/orange, fine fabric SANDSTONE. Weak. Orange staining on all joint faces. Recovered as: COBBLES with minor gravel. Cobbles; max 100mm, mostly subangular with some subrounded (due to drilling). Gravel; medium to coarse, subangular.								VC		3.00-4.30m - Possible weaker material washed out by drilling.							Blank (1.5 m L)
			4				W	MW	C			RC	80	0				50 mm slotted pipe (1.0 m L)
	Core loss.								VC								SWL 1.60m	Bentonite
	END OF BOREHOLE AT 4.5m - Target Depth Reached	6	5															
			6															
		4	7															
			8															
		2	9															

BOREHOLE SOIL/ROCK LOG A4 - WSP MT COOEE BOREHOLE LOGS - V0.3.GPJ WSP-OPUS2019_VER11X.GDT 30/3/23

Notes:
Shallow groundwater well
Core loss placed at end of run by default
123mm OD Rotary Coring

Started: 11/10/2022
Finished: 12/10/2022
Drilling Co.: McMillan Drilling
Drilling Rig: Hanjin D&B-8D - track
Logged by: N. Ahern
Checked by: C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH3

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350135 E 4873642 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	4.5 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 11 m	*Inclination:*	Vertical
Location:	Western area of site, 15m north-east of Kaitangata Hwy Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH3.1
BH3 Box 1: 0.0m - 3.0m

Photo BH3.2
BH3 Box 2: 3.0m - 4.5m

Notes:
Shallow groundwater well
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	11/10/2022	*Finished:*	12/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	N. Ahern	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH4

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350398 E 4873540 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 9 m
Location:	South-east corner of site Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 5.5 m
Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
TS	TOPSOIL with roots and grass.																	
Caples Terrane	Sandy GRAVEL with trace rootlets, light brown to grey. Loosely packed, well graded, non-plastic. Gravel; angular to subangular, greywacke. Sand; fine to coarse, subrounded. 0.50-0.80m - Gravel; subangular to subrounded. Coarse sand; subangular to angular. Core loss.	8	1								0.15-3.70m - Assumed some fines or weaker seams were present but these have been washed away by drilling.	RC	53	0	Rotary cored	PQ size wireline (85 mm nom. dia. core)	SWL 2.30m	Blank 1m Cmt. seal 31/10/2022 09/03/2023 50 mm slotted pipe (4.5 m L)
	Slightly weathered to moderately weathered, highly fractured, orangish brown, fine fabric SANDSTONE; extremely weak; extremely closely spaced tight white veins; extremely weathered defects. Recovered as: COBBLES with some gravel and trace silt and rootlets, orangey brown to grey. Cobbles and gravel; fine to coarse. Cobbles; max 100mm, subangular. Sand; fine to coarse, subangular to subrounded. Silt; dark grey, lensoidal. 2.20-2.40m - Trace pockets of dark grey silt. Core loss.	6	2				EW	MW	EC		1.50-5.50m - Fracturing due to drilling	RC	40	0				
	Slightly weathered to moderately weathered, highly fractured, dark grey SILTSTONE. Very weak, bedding is thinly laminated. Recovered as: Sandy GRAVEL with some cobbles and silt, dark grey with some orange and white veins. Sand; fine to coarse, angular to subangular. Gravel and cobbles; fine to coarse, subangular. Cobbles; max 60mm. Fines; non-plastic. Core loss.	4	3				VW	MW	EC			RC	80	0				
	Slightly weathered, highly fractured, dark bluish grey, fine fabric SILTSTONE. Weak. Mm scale mostly closed and oxidised defects. Recovered as: COBBLES with some gravel and trace silt, dark bluish grey with orange staining. Cobbles and gravel; fine to coarse, subangular. Cobbles; max 150mm. Sand; fine to coarse, subangular to subrounded. 5.00m - Slickenslides on one piece of gravel.	4	5				W	SW	VC	50 / 45	4.10m - J, 50° 4.20m - J, 45°	RC	100	0				
	END OF BOREHOLE AT 5.5m - Target Depth Reached	2	7															
		0	9															

BOREHOLE SOIL/ROCK LOG A4 - WSP MT COOEE BOREHOLE LOGS - V0.3.GPJ WSP-OPUS2019_VER11X.GDT 30/3/23

Notes:
Shallow groundwater well
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	27/10/2022	*Finished:*	27/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH4

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350398 E 4873540 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	5.5 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 9 m	*Inclination:*	Vertical
Location:	South-east corner of site Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH4.1
BH4 Box 1: 0.0m to 3.8m

Photo BH4.2
BH4 Box 2: 3.8m - 5.5m

Notes:
Shallow groundwater well
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	27/10/2022	*Finished:*	27/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.
Scale 1:50 @ A4

Borehole No. BH5

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350288 E 4873598 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 7 m
Location:	Southern area of site, 80m north-east of Kaitangata Hwy Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 3 m

Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
TS	TOPSOIL with some grass and rootlets and minor quartz sand.																	
Alluvium	Silty CLAY with trace sand, orangish brown, homogenous. Firm to stiff, moist, high plasticity. Sand; medium.																	
Alluvium	Silty CLAY with minor sand, light greyish orange with minor white specks and orange mottle, homogenous. Stiff, moist, high plasticity. 0.90m - Becomes orange. Soft to firm.	6	1								Lab: 0.4 - 1.1m PSD and permeability testing.	RC	100	0	Rotary cored	PQ size wireline (85 mm nom. dia. core)	SWL 2.30m	31/10/2022; Blank pipe 0.9 m; Slotted pipe 0.6 m; Grout
Caples Terrane	Highly weathered, brownish orange, fine fabric indistinctly bedded SANDSTONE. Weak to very weak; orange defects. 1.20m - Becomes moderately weathered to slightly weathered. 1.80-2.00m - Grades into slightly weathered.						VW	HW / SW	VC		Lab: 1.1 - 2.6m UCS testing.							
Caples Terrane	Moderately weathered, greenish grey, fine fabric indistinctly bedded SANDSTONE. Weak to very weak; orange staining along open defects.	4	2				W	MW / SW	C / VC	J10 at 2.15m; J10 at 2.50m	2.15m - J, 10°; 2.50m - J, 10°	RC	100	17				
	END OF BOREHOLE AT 3m - Target Depth Reached		3						C		2.90-3.00m - Core broken during removal from catcher.							
			4															
		2	5															
			6															
		0	7															
			8															
		-2	9															

Notes:

Shallow groundwater well
Core loss placed at end of run by default
123mm OD Rotary Coring

Started: 17/10/2022 *Finished:* 18/10/2022

Drilling Co.: McMillan Drilling *Drilling Rig:* Hanjin D&B-8D - track

Logged by: C. Hall *Checked by:* C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH5

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350288 E 4873598 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	3 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 7 m	*Inclination:*	Vertical
Location:	Southern area of site, 80m north-east of Kaitangata Hwy Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH5.1
BH5 Box 1: 0.0m to 2.2m

Photo BH5.2
BH5 Box 2: 2.2m to 3.0m

Notes:
Shallow groundwater well
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	17/10/2022	*Finished:*	18/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH6

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350315 E 4873694 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 21 m
Location:	Middle of site, southwest of excavation Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 9.45 m
Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
TS	TOPSOIL with some grass and rootlets, dark brown. 0.20m - Becomes orangish brown.																	
Caples Terrane	Moderately weathered, light brownish orange, highly fractured, SANDSTONE. Moderately strong. Recovered as: gravelly COBBLES with some sand. Cobbles; angular, max 100mm. Gravel; medium to coarse, angular. Core loss.	20	1				MS	MW	VC			RC	73		Rotary cored	PQ size wireline (85 mm nom. dia. core)		50 mm blank pipe (1.0 m L)
	Highly weathered, light brownish orange, highly fractured SANDSTONE. Weak. Recovered as: Sandy GRAVEL with some clay, orangish brown. Gravel; fine to coarse, subangular. Fines; high plasticity.		2		56	15// 10/13/15/18	W	HW	EC			SPT	100					
	2.30m - Re-drilled cobble. Core loss.	18	3									RC	38					
	Moderately weathered, light grey to dark grey, highly fractured SANDSTONE. Moderately strong. Recovered as: GRAVEL with some sand, light grey to dark grey. Gravel; fine to coarse, subangular.				60+	17// 14/16/21/9 for 25mm	MS	MW	VC			SPT	100					
	Core loss.		4									RC	38					
	Completely weathered, greenish grey, fine fabric SILTSTONE. Extremely weak. Recovered as: clayey SAND with trace silt. Sand; fine to medium. Fines; high plasticity.	16	5		60+	15// 13/26/21 for 45mm	EW	CW	EC			SPT	100					
	4.95-5.25m - Lenses of silty CLAY, greenish grey, homogenous. Soft, moist, high plasticity.						W	MW									SWL 2.20m	
	Moderately weathered, greenish grey, highly fractured fine fabric, indistinctly bedded SANDSTONE. Weak. Recovered as: sandy GRAVEL with some clay, bluish green. Gravel; medium to coarse. Fines; high plasticity.							SW	C		Lab: 5.3 - 9.45m UCS testing.	RC	100					
	Slightly weathered greenish blue, massive SILTSTONE. Weak to moderately strong. 5.70-5.90m - Moderately weathered, highly fractured along defects. Defects; open or extremely closed spaced and closed. 6.45-6.55m - Pockets of silty SAND with pockets of clay, bluish green, homogenous. Loose, non-plastic. 6.55-7.20m - Black stained defects throughout.		6					MW	VC									
					60+	15// 20/24/16 for 50mm	MS	SW	EC			SPT	100	0				
									C			RC	100	0				Grout
	Moderately weathered greenish blue, fine fabric SILTSTONE. Weak; black stained defects. Recovered as: COBBLES with some gravel and silt. Cobbles and gravel; angular. Gravel; medium to coarse. 7.00-7.20m - Grades into completely weathered rock. 7.20-7.50m - Recovered as: sandy GRAVEL with some silt, dark greenish grey to black. Loose, non-plastic. Gravel; fine to coarse, subrounded Siltstone.	14	7					CW										
					60+	36// 48/12 for 35mm	W		EC			SPT	90	0				
			8					MW										
	8.25m - Becomes slightly weathered, minor fractures, weak to moderately strong. Defects; closed aperture. Grainsize grading larger from Siltstone to Sandstone.							SW	C			RC	100	0				
	8.75-9.00m - Recovered as: sandy GRAVEL with some silt, dark greenish blue, homogenous. Loose. Gravel; highly weathered. 9.00-9.45m - Recovered as: silty SAND, greenish yellow, homogenous. Soft to firm, low plasticity. Sand; fine to medium.	12	9					HW									SWL 4.96m	
					60+	19// 22/38 for 75mm			EC			SPT	93	0				
	END OF BOREHOLE AT 9.45m - Target Depth Reached																	

31/10/2022

50 mm slotted pipe (1.5 m L)

Notes:

SPT hammer energy ratio 91%
Shared Hydro / Geotech borehole
Waiting on core box photos to calcuate RQD
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	12/10/2022	*Finished:*	18/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH6

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350315 E 4873694 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	9.45 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 21 m	*Inclination:*	Vertical
Location:	Middle of site, southwest of excavation Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH6.1
BH6 Box 1: 0.0m to 4.5m

Photo BH6.2
BH6 Box 2: 4.5m to 6.8m

Notes:
SPT hammer energy ratio 91%
Shared Hydro / Geotech borehole
Waiting on core box photos to calcuate RQD
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	12/10/2022	*Finished:*	18/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH6

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350315 E 4873694 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	9.45 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 21 m	*Inclination:*	Vertical
Location:	Middle of site, southwest of excavation Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH6.3
BH6 Box 3: 6.8m to 9.45m

Notes:
SPT hammer energy ratio 91%
Shared Hydro / Geotech borehole
Waiting on core box photos to calcuate RQD
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	12/10/2022	*Finished:*	18/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH7

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350492 E 4873800 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 25 m
Location:	Eastern most corner of site, 20m south of railway Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 6 m

Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
TS	TOPSOIL.																	
Caples Terrane	Moderately weathered light grey to light brown with orange mottle, fine fabric SANDSTONE. Weak to moderately strong. Recovered as: gravelly COBBLES with some sand. Cobbles and gravel; angular. Gravel; medium, subrounded. 0.20-0.70m - Coarse to fine gravel, sandy silty matrix inferred fines washed away. Core loss.	24	1				W	MW	EC / VC		0.20-6.00m - Fractures opened by drilling.	RC	75	0	Rotary cored	PQ size wireline (85 mm nom. dia. core)		Surrounding ground collapse Gravel
	Highly weathered, light brown with orange mottle, highly fractured, fine fabric SANDSTONE. Strong. Recovered as: Gravelly COBBLES. Gravel and cobbles; angular. 1.00-2.00m - Sand/silt matrix inferred washed away. 1.55m - Becomes completely weathered.				60	31// 34/26	S	HW	VC			RC	85	0				
	Slightly weathered light grey with some orange mottle, fractured, fine fabric SANDSTONE. Moderately strong.	22	2				MS	SW	C / VC	40	2.40m - J, 40°	RC	100	30				
	2.70-2.90m - Moderately fractured same materials as above, rootlets present. 2.90-3.20m - Recovered as: silty SAND, brownish orange. Loosely packed, dry to moist, low plasticity.		3								2.90-3.00m - Core broken during removal from catcher. Core inferred to be baked during drilling.							
	Moderately weathered dark grey with light brown and orange mottle, fractured, interbedded SANDSTONE and SILTSTONE. Sst = strong, siltst = weak. 3.60-4.05m - Becomes moderately thickly bedded and more mudstone dominant.						W	MW	VC / C / VC			RC	100	10				
	4.05-4.20m - Recovered as: medium to fine gravel with some silt and sand, greenish grey. Loosely packed, moist. Silt; low plasticity.		4								4.00-4.20m - Core broken during removal from catcher.							
	Slightly weathered dark grey with orange mottle, fractured, indistinctly bedded SILTSTONE. Moderately strong. 4.30-4.70m - Discontinuities: extremely closely spaced very narrow to closely spaced closed aperture. 4.90-5.20m - Discontinuities: becomes thinly bedded, thinly laminated, sub-horiztonal planar bedding. 5.20-5.40m - Orange staining increasing. 5.40-5.55m - Minor orange mottle.	20	5				MS / W	SW / MW	C	40 / 60	5.30m - J, 60° 5.31m - J, 40°	RC	80	0			SWL 5.05m	
	Core loss.																	
	END OF BOREHOLE AT 6m - Target Depth Reached	18	6 7 8 9															

BOREHOLE SOIL/ROCK LOG A4 - WSP MT COOEE BOREHOLE LOGS - V0.3.GPJ WSP-OPUS2019_VER11X.GDT 30/3/23

Notes:

SPT hammer energy ratio 91%
Geotechnical borehole
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	1/11/2022	*Finished:*	1/11/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	N. Ahern	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH7

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350492 E 4873800 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	6 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 25 m	*Inclination:*	Vertical
Location:	Eastern most corner of site, 20m south of railway Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH7.1
BH7 Box 1: 0.0m to 3.0m

Photo BH7.2
BH7 Box 2: 3.0m to 6.0m

Notes:
SPT hammer energy ratio 91%
Geotechnical borehole
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	1/11/2022	*Finished:*	1/11/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	N. Ahern	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH8

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350323 E 4873768 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 16 m
Location:	Eastern area of site, 80m north of BH06 Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 4.3 m
Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
Caples Terrane	Moderately weathered dark grey to greenish grey with white specks, highly fractured SANDSTONE. Weak. Recovered as: coarse to fine gravel, with some sand. Gravel; subangular. Sand; coarse. 0.20-0.40m - Becomes completely weathered.	14	1				W	MW	EC		Lab: 0.0 - 2.8m UCS testing. 0.40m - Vein, N	RC	100	0	Rotary cored	PQ size wireline (85 mm nom. dia. core)	SWL 0.60m	Grout
	Slightly weathered greenish grey with white specks, coarse grained, veined, indistinctly bedded SANDSTONE. Weak to moderately strong. 1.25-1.50m - Crushed zone. Recovered as: coarse to fine GRAVEL with minor sand. Gravel; angular. Sand; coarse. 1.50m - Becomes light greenish grey and coarse-grained.		2				VW MS	SW	W EC	Vein80	1.25m - CZ 1.50m - Vein, 80°, MW							
	2.50-4.30m - Crushed zone. Recovered as: COBBLES with some gravel and minor silt and sand. Cobbles and gravel; subangular, strong. Sand; fine to medium. 2.70-2.85m - Becomes moderately weathered. Very weak. Recovered as: COBBLES with some gravel and sand. Cobbles and gravel; subangular. Core loss.		3						C	Vein75	2.00m - Vein, 75°, N	RC	95	60				
	Moderately weathered greenish grey with minor white specks, coarse grained highly fractured, indistinctly bedded SANDSTONE. Very weak. Recovered as: COBBLES with some gravel and sand. Cobbles and gravel; subangular.	12	4				VW	HW	VC		2.50m - CZ							
							VW	HW	VC		3.05m - Vein, VN 3.10-4.10m - Highly factured insitu rock. Disturbed on removal from core catcher.	RC	90	53				
	END OF BOREHOLE AT 4.3m - Target Depth Reached		5															
		10	6															
			7															
		8	8															
			9															
			6															

BOREHOLE SOIL/ROCK LOG A4 - WSP MT COOEE BOREHOLE LOGS - V0.3.GPJ WSP-OPUS2019_VER11X.GDT 30/3/23

Notes:
Geotechnical borehole
Elevation is estimated from Google Earth
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	3/11/2022	*Finished:*	3/11/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	N. Ahern	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH8

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350323 E 4873768 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	4.3 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 16 m	*Inclination:*	Vertical
Location:	Eastern area of site, 80m north of BH06 Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH8.1
BH8 Box 1: 0.0m to 2.1m

Photo BH8.2
BH8 Box 2: 2.1m to 4.3m

Notes:
Geotechnical borehole
Elevation is estimated from Google Earth
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	3/11/2022	*Finished:*	3/11/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	N. Ahern	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH9

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350377 E 4873747 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 20 m
Location:	Eastern area of site, middle of excavation Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 6.9 m
Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m) / DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
Caples Terrane	Highly weathered to completely weathered light grey with some orange mottles, slightly interbedded SANDSTONE and SILTSTONE. Weak to moderately strong; bedding is thinly laminated and gently inclined, smooth undulating. Recovered as: cobbly GRAVEL with minor trace sand and silt. Cobbles; subangular to subrounded (possibly due to drilling). Gravel; fine to coarse, angular.	1		60+	42// 60 for 25mm	W	HW	EC			RC	60	0	Rotary cored	PQ size wireline (85 mm nom. dia. core)		Grout
	Core loss.										SPT	100					
	HW to CW interbedded SANDSTONE and SILTSTONE. As above.	18 2				W	HW	EC			RC	47	0				
	Core loss.																
	HW to CW interbedded SANDSTONE and SILTSTONE. As above.	3				W	HW	EC			RC	30	0				
	Core loss.	16 4									RC	0	0				
	Slightly weathered, dark grey with yellowy white veins, interbedded SANDSTONE and SILTSTONE. Moderately strong to strong. Bedding is thinly laminated, undulating smooth, very narrow to closed, fine grained. Veining is stepped.	5		60+	5// 1/46 for 25mm	EW MS	CW SW	EC C			SPT	100					
	4.50-4.70m - Completely weathered. Recovered as: silty SAND with minor gravel and cobbles, dark grey. Moist. Sand; coarse to medium. Gravel; fine to coarse, subangular. Silt; non-plastic.					S	SW	EC C EC VC		5.10-5.25m - Broken to gravel by drilling. 5.40-5.50m - Broken to gravel by drilling.	RC	100	50			SWL 1.70m	
	Slightly weathered, light bluish grey with minor white specks, indistinctly interbedded, fine fabric SANDSTONE and SILTSTONE. Strong. 5.90m - Becomes light grey and moderately strong.	14 6				MS		C C C EC	J35 J40	5.90m - J, 35°, SL, clean 6.00m - J, 40°, SL, clean 6.20-6.60m - Broken to gravel by drilling.	RC	100	0			SWL 0.00m	
	Core loss.																
	END OF BOREHOLE AT 6.9m - Target Depth Reached	7 12 8 9 10															

Notes:
SPT hammer energy ratio 91%
Geotechnical borehole
Elevation is estimated from Google Earth
Core loss placed at end of run by default
123mm OD Rotary Coring

Started: 2/11/2022 *Finished:* 3/11/2022
Drilling Co.: McMillan Drilling *Drilling Rig:* Hanjin D&B-8D - track
Logged by: N. Ahern *Checked by:* C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH9

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350377 E 4873747 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	6.9 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 20 m	*Inclination:*	Vertical
Location:	Eastern area of site, middle of excavation Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH9.1
BH9 Box 1: 0.0m to 5.5m

Photo BH9.2
BH9 Box 2: 5.5m to 6.9m

Notes:
SPT hammer energy ratio 91%
Geotechnical borehole
Elevation is estimated from Google Earth
Core loss placed at end of run by default
123mm OD Rotary Coring

Started:	2/11/2022	*Finished:*	3/11/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	N. Ahern	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH10

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350458 E 4873714 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 26 m
Location:	Eastern edge of site, 20m from boundary Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 10 m
Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: METHOD	DRILLING: CASING	BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
TS	TOPSOIL with grass and rootlets.																	
Fill	Clayey SILT with trace gravel, light brown with black specks, homogenous. Firm to stiff, moist, low plasticity. 0.65m - Becomes brownish orange and firm.											RC	100	0				
Caples Terrane	Completely weathered brownish orange highly fractured, fine fabric SANDSTONE. Extremely weak. Recovered as: SILT with some clay and trace gravel, homogenous. Firm, moist, low plasticity. Minor rootlets present. Gravel corestones are very weak. 1.42-2.75m - Remoulds to: clayey SAND with minor silt and gravel, orangish brown, homogenous. Moist, low plasticity. Gravel; fine to coarse, HW - CW Sandstone, very weak. Sand; medium to coarse, angular to subangular. Fines; Soft.	1			22	6// 5/5/6/6	EW	CW	EC			SPT	100	0				
		24	2									RC	100	0				
					57	13// 10/15/14/18						SPT	100	0				
	2.45-2.75m - Trace rootlets.											RC	100	0				
	Grading to highly weathered, dark brown with orange weathering and white specks, fractured, fine fabric SANDSTONE. Extremely weak. Recovered as: sandy GRAVEL with minor silt. Moist, non-plastic. Gravel; fine to coarse, angular to subangular. Sand; fine to coarse.	3			60+	21// 17/20/23 for 70mm		HW				SPT	100	0				
	Highly weathered, dark orangish brown highly fractured SANDSTONE. Very weak to weak. Recovered as: Sandy GRAVEL with some cobbles and minor silt. Low plasticity. Gravel; fine to medium, angular to subangular. Sand; fine to coarse, angular to subangular.	22	4				VW					RC	100	0			SWL nilm	
					57	18// 12/12/16/17						SPT	100	0				
	Moderately weathered, orangish brown fractured SANDSTONE. Weak. Recovered as: gravelly COBBLES with some sand. Cobbles and gravel; fine to coarse, cobbles max 100mm, subangular. Sand; medium to coarse, rounded.						W	MW	VC			RC	100	0				
	Slightly weathered, orangish brown with oxidised defects, fractured SANDSTONE. Moderately strong. Discontinuities; very closely spaced closed joints, cross-cutting and sub-vertical, rough to smooth planar.	5			60+	27// 51/9 for 5mm	MS	SW		J70 J60	5.30m - J, 70° 5.40m - J, 60°	SPT	100	0	Rotary cored	PQ size wireline (85 mm nom. dia. core)		50 mm blank pipe (1.0 m L) 9/11/2022 9/03/2023 50 mm slotted pipe (9.0 m L)
	5.60-5.70m - Highly fractured zone. Weak.						W	HW	EC			RC	100	0				
		20	6				MS	SW	VC	J60 J70	6.00m - J, 60°							
	6.10-6.15m - Crushed zone. Recovered as: sandy medium GRAVEL with minor silt. Subrounded.						VW	HW	EC		6.10m - CZ							
							MS	SW	VC C	J50 J70 J50	6.11m - J, 70° 6.15m - J, 70° 6.60-6.70m - Core broken during removal from catcher.	RC	100	0				
		7									6.85m - J, 50°							
	7.20-7.90m - Highly fractured zone.									J40	6.85m - J, 70° 6.95m - J, 50°	RC	100	8				
										J30 J30	7.20m - J, MN, silica coated 7.30m - J, 40° 7.60m - J, 30°							
	7.90-8.50m - Recovered as: COBBLES with some gravel and sand. Cobbles and gravel; angular to subangular, weak to very weak. 8.20-8.30m - Well-rounded coarse sized gravel.	18	8				W	MW	VC		7.75m - J, 30° 7.90-8.80m - Disturbed on removal from core catcher.							
	8.60-8.80m - Crushed zone. Recovered as: GRAVEL with some sand and minor silt. Gravel; fine to medium, subangular.						EW	CW	EC		8.60m - CZ	RC	75	0				
	Core loss.		9								9.00m - B, PL, silica coated							
	Slightly weathered, light and dark grey fractured and indistinctly bedded SILTSTONE. Moderately strong.						MS	MW	VC									
	9.50-9.60m - Crushed zone. Recovered as: GRAVEL with some sand. Gravel and sand; fine to coarse, subangular. 9.60-9.85m - Dark grey. Green and white vein	16					S	SW	C	J45	9.50m - CZ 9.51m - J, 45° 9.70m - B, ST, limonite stained	RC	95	0				

BOREHOLE SOIL/ROCK LOG A4 - WSP_MT COOEE BOREHOLE LOGS - V0.3.GPJ WSP-OPUS2019_VER11X.GDT 30/3/23

Notes:

SPT hammer energy ratio 91%
Geotechnical borehole
Core loss placed at end of run by default
123mm OD Rotary Coring
SWL 'nilm' indicates dry well measurement

Started:	28/10/2022	*Finished:*	31/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH10

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350458 E 4873714 N
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM
Project No.:	6-CO082.00	*R.L.:*	Approx. 26 m
Location:	Eastern edge of site, 20m from boundary Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016

Depth: 10 m
Inclination: Vertical

GEOLOGY	MAIN DESCRIPTION / DETAIL DESCRIPTION	R.L. (m)	DEPTH (m)	GRAPHIC LOG	TESTS: SPT 'N' VALUE	TESTS: SPT BLOW COUNTS OR SHEAR VALUE	ROCK STRENGTH	ROCK WEATHERING	ROCK DEFECT SPACING	DEFECT DIP (degrees 0–90)	DEFECTS / NOTES / OTHER TESTS	CORE: SAMPLE TYPE	CORE: TCR (%)	CORE: RQD (%)	DRILLING: DRILLING METHOD	DRILLING: CASING	DRILLING: BASE OF HOLE & WATER LEVEL	INSTALLATION DETAILS
	precipitation. Defects are subvertical. Core loss. END OF BOREHOLE AT 10m - Target Depth Reached	14 12 11 13 12 14 15 10 16 17 8 18 19 6																

Notes:
SPT hammer energy ratio 91%
Geotechnical borehole
Core loss placed at end of run by default
123mm OD Rotary Coring
SWL 'nilm' indicates dry well measurement

Started: 28/10/2022 *Finished:* 31/10/2022
Drilling Co.: McMillan Drilling *Drilling Rig:* Hanjin D&B-8D - track
Logged by: C. Hall *Checked by:* C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH10

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350458 E 4873714 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	10 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 26 m	*Inclination:*	Vertical
Location:	Eastern edge of site, 20m from boundary Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH10.1
BH10 Box 1: 0.0m to 2.5m

Photo BH10.2
BH10 Box 2: 2.5m to 5.0m

Notes:
SPT hammer energy ratio 91%
Geotechnical borehole
Core loss placed at end of run by default
123mm OD Rotary Coring
SWL 'nilm' indicates dry well measurement

Started:	28/10/2022	*Finished:*	31/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Borehole No. BH10

Project:	Mt Cooee Landfill - Development Plan	*Coordinates:*	1350458 E 4873714 N		
Client:	Clutha District Council (CDC)	*Ref. Grid:*	NZTM	*Depth:*	10 m
Project No.:	6-CO082.00	*R.L.:*	Approx. 26 m	*Inclination:*	Vertical
Location:	Eastern edge of site, 20m from boundary Mt Cooee Landfill, Balclutha	*Datum:*	NZ Vertical Datum 2016		

PHOTOGRAPHS

Photo BH10.3
BH10 Box 3: 5.0m to 7.2m

Photo BH10.4
BH10 Box 4: 7.2m to 10.0m

Notes:
SPT hammer energy ratio 91%
Geotechnical borehole
Core loss placed at end of run by default
123mm OD Rotary Coring
SWL 'nilm' indicates dry well measurement

Started:	28/10/2022	*Finished:*	31/10/2022
Drilling Co.:	McMillan Drilling	*Drilling Rig:*	Hanjin D&B-8D - track
Logged by:	C. Hall	*Checked by:*	C. Parkes

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

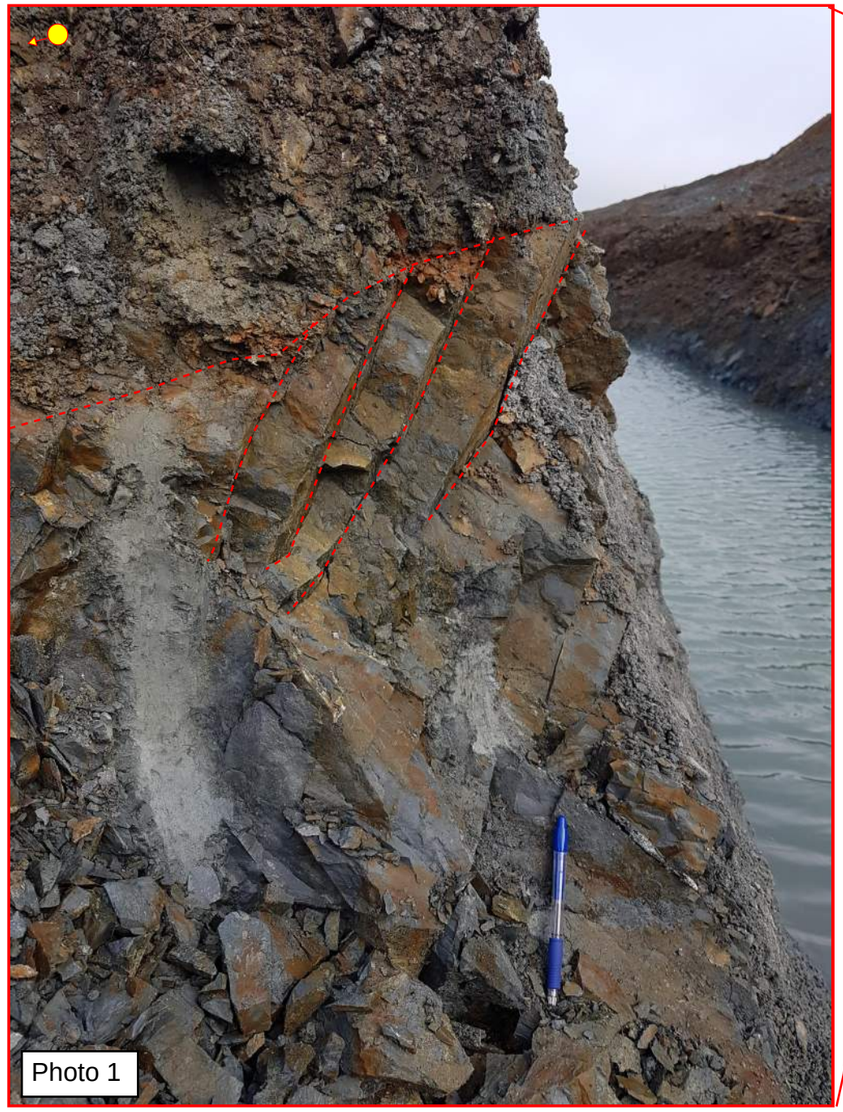
Scale 1:50 @ A4

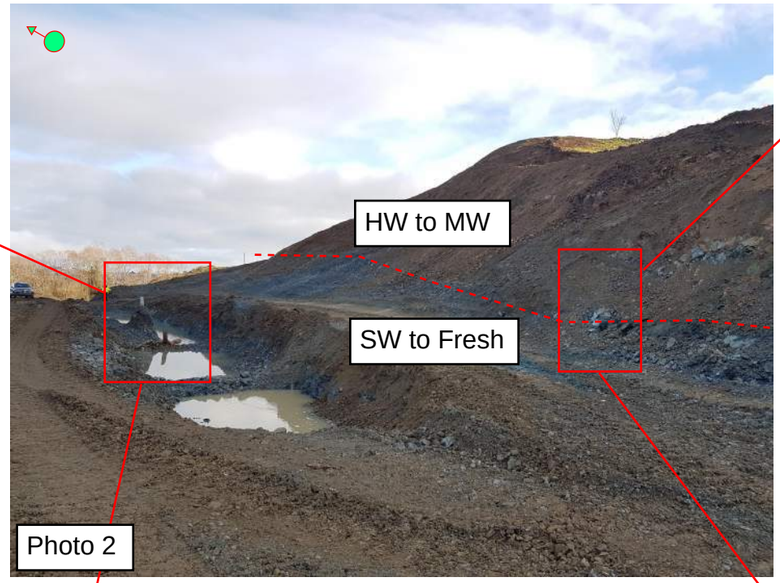
Appendix D
Geological Mapping Photographs and Geological Sections


2021 Site 1 observations
90
65
72
70
2021/2023 Site 2 observations
18
45
12
2023 Existing Cut slope Sections 1 to 3
23
2021/2023 Site 3 Landfill Expansion Area
Key:
Break in slope angle:
Approximate orientations of photographs:
Measured orientation of geological features:
Geological site mapping areas:
Inferred shear zones - approximate dip direction related to text direction
45
0
75
150 m

Photo 1 (below): Steeply dipping beds to the southwest

Photo 2 (right): 5 - 10 m thick SW - MW oxidised zone overlying interbedded sandstone and siltstone





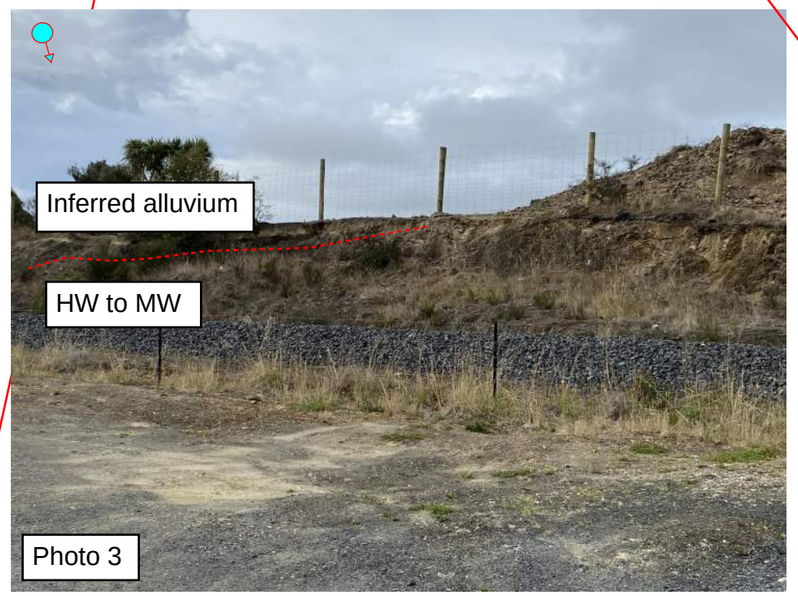


Photo 4 (above): Cataclasite shear zone observed, approximate dip angle is 45 to the west

Photo 3 (left): Inferred contact between alluvium and SW - MW sandstone and siltstone

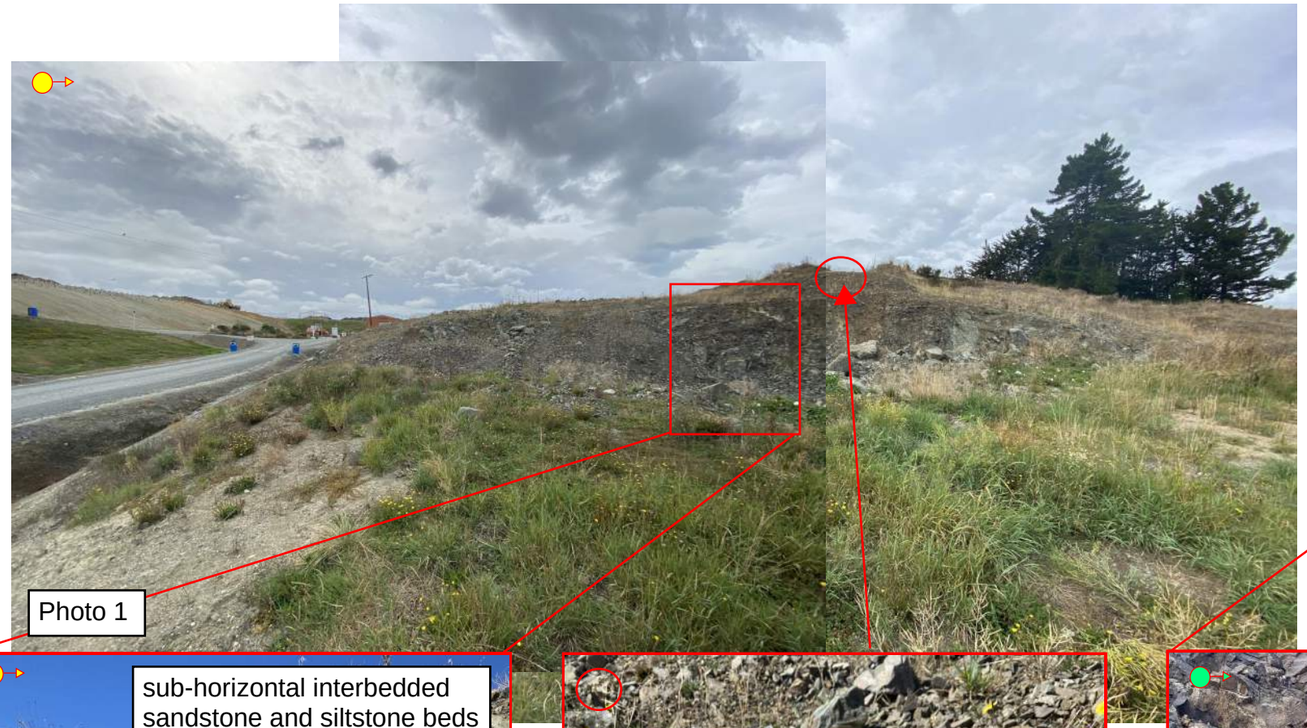
WSP
197 Rattray Street
Dunedin CBD
Dunedin 9016

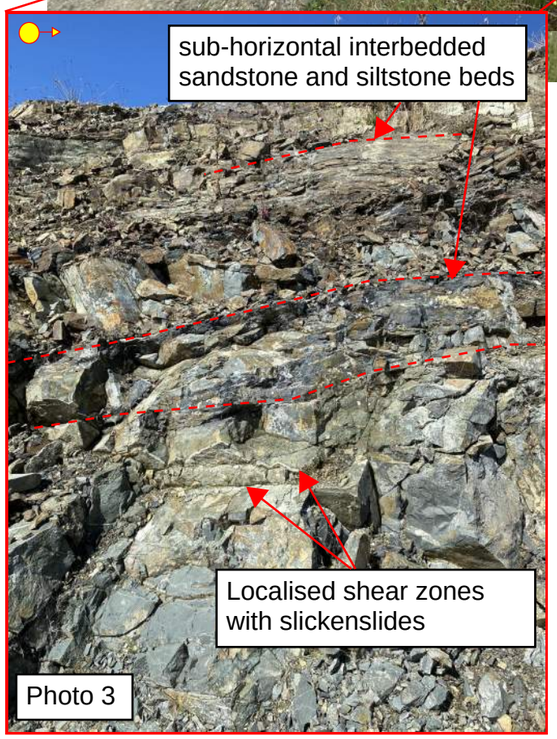
Project
Mt Cooee Landfill Expansion

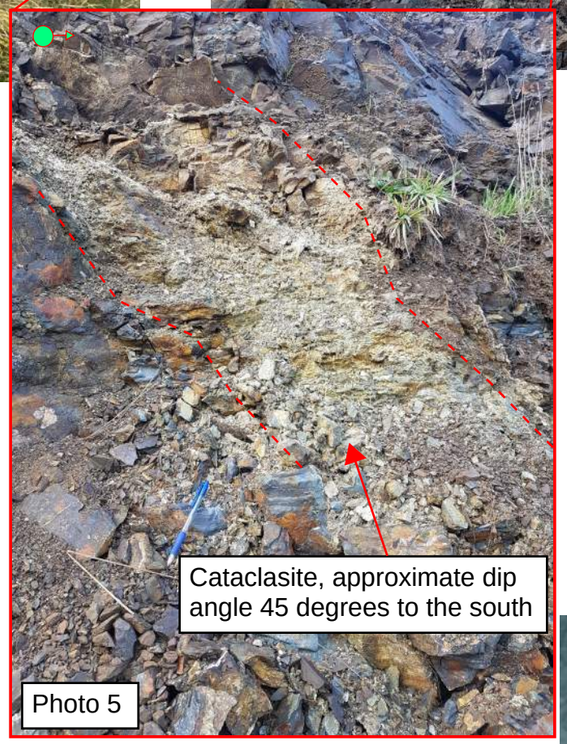
Description
Geological observation photographs - 2021 Site 1

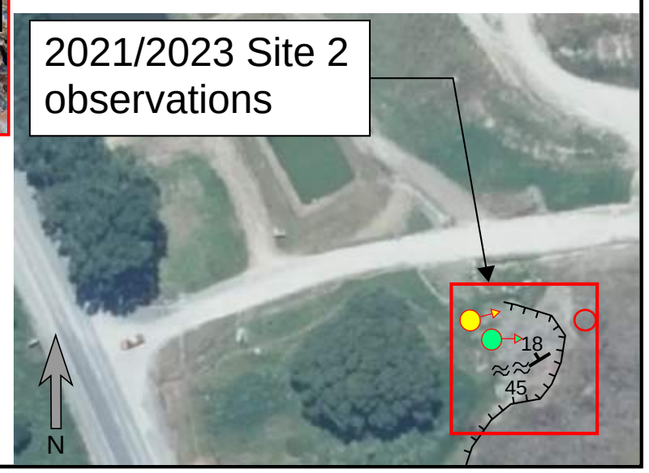
Drawn by
CH

Checked by
NT









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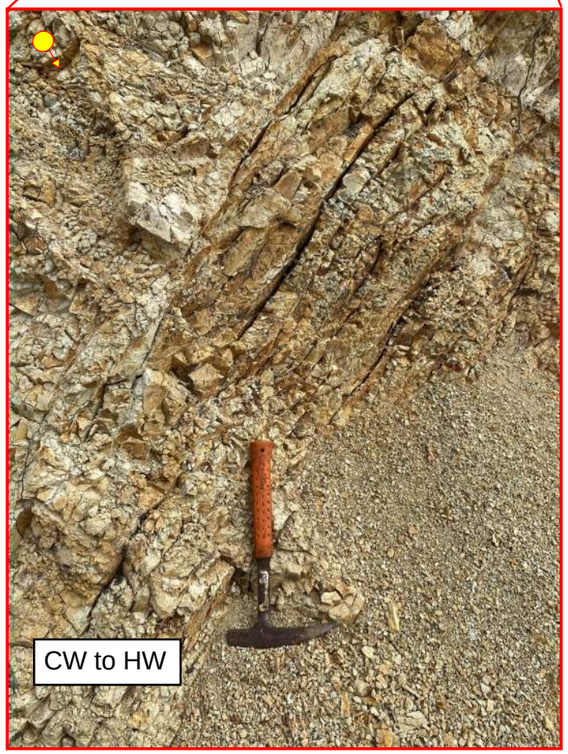
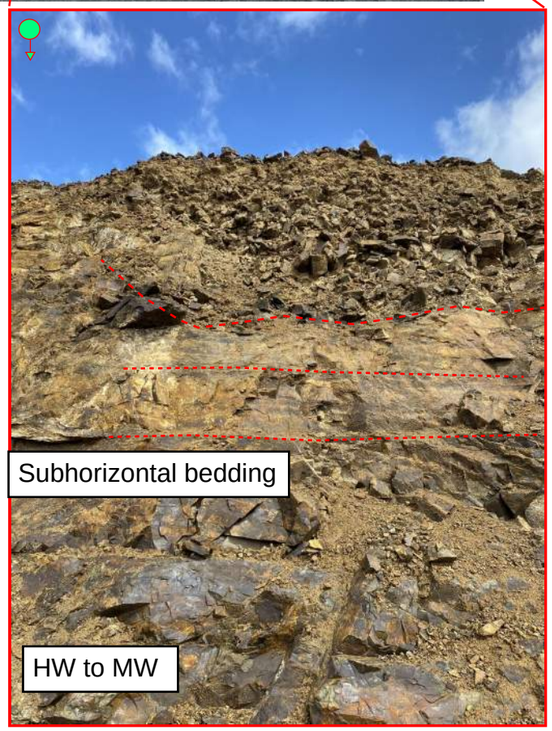
Dunedin CBD
Dunedin 9016

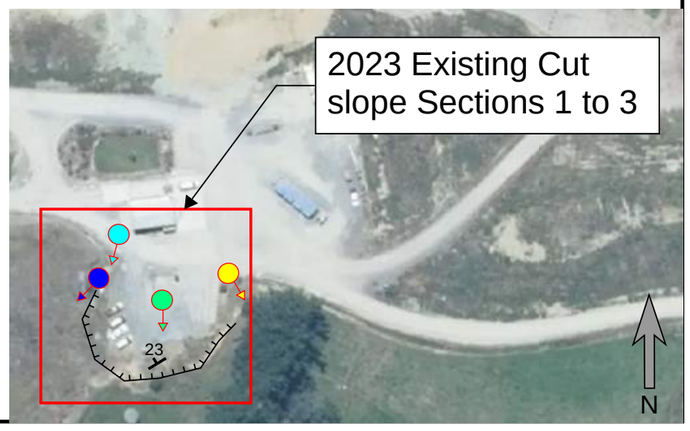
Project
Mt Cooee Landfill Expansion

Description
Geological observation photographs - 2021/2023 Site 2

Drawn by	Checked by
CH	NT







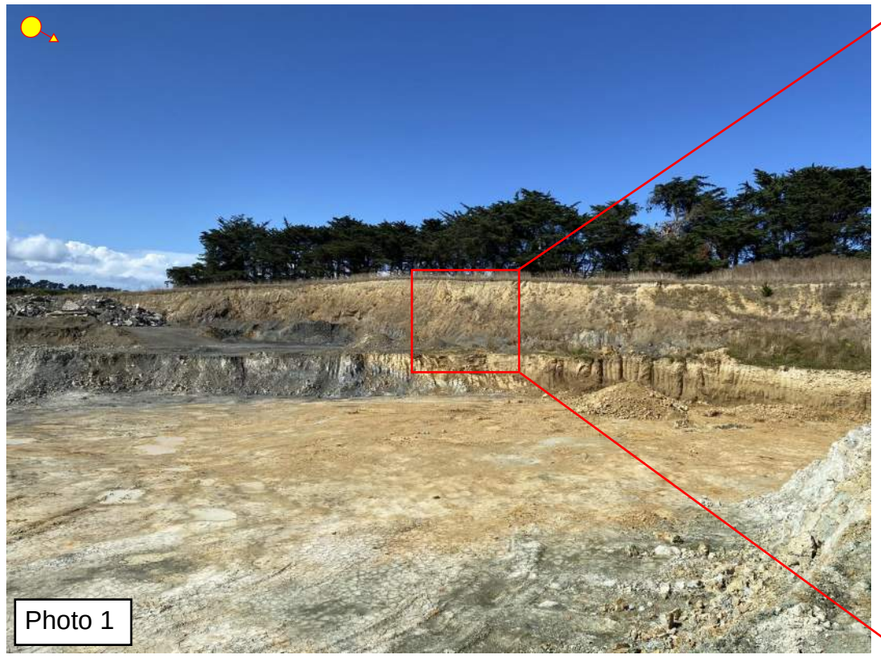
WSP
197 Rattray Street
Dunedin CBD
Dunedin 9016

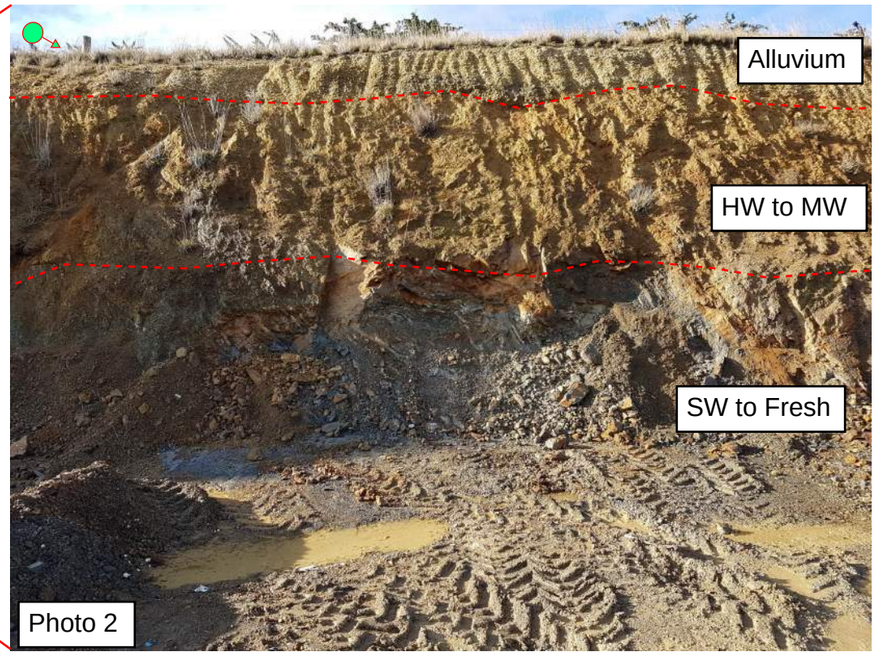
Project
Mt Cooee Landfill Expansion

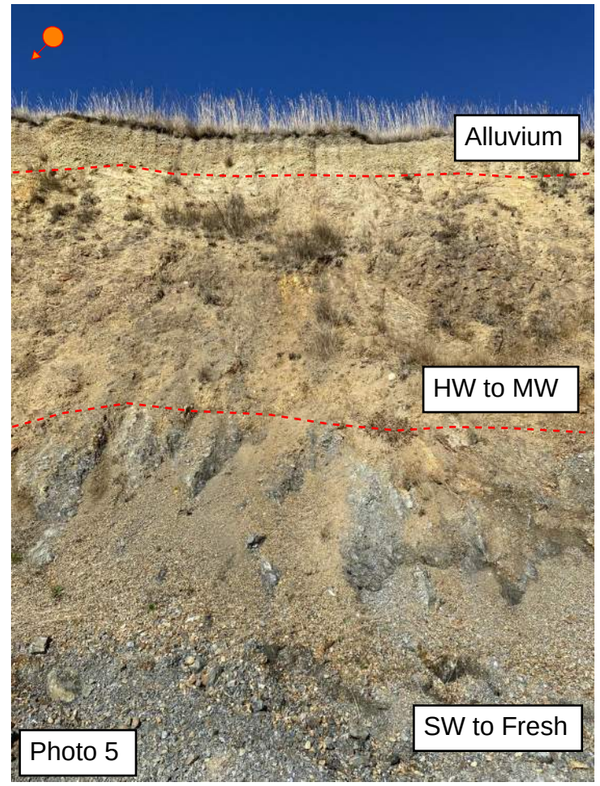
Description
Geological observation photographs - 2023 Existing cut slope sections

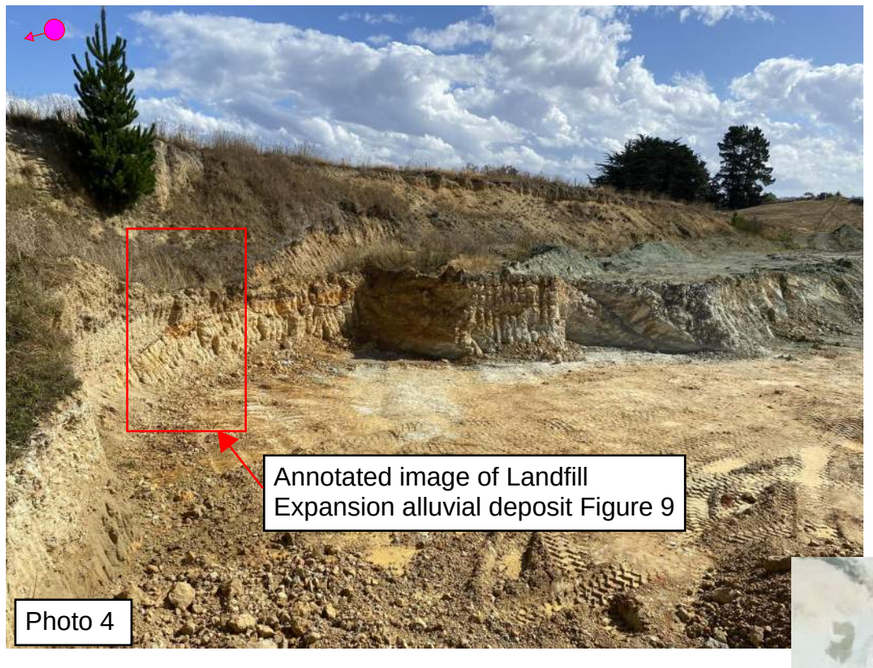
Drawn by
CH

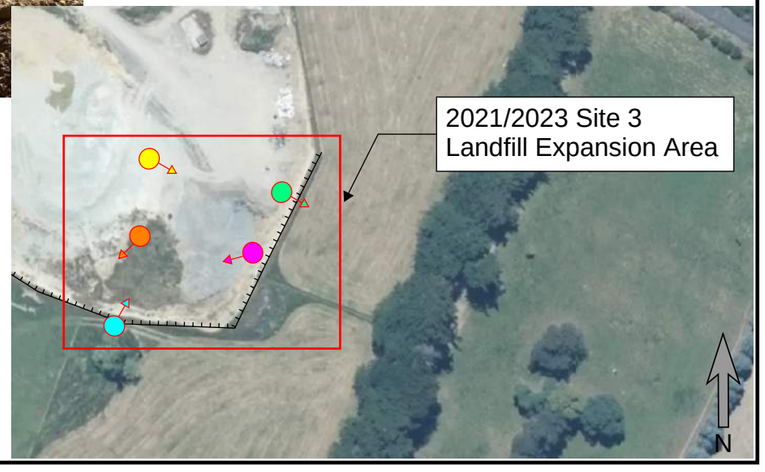
Checked by
NT











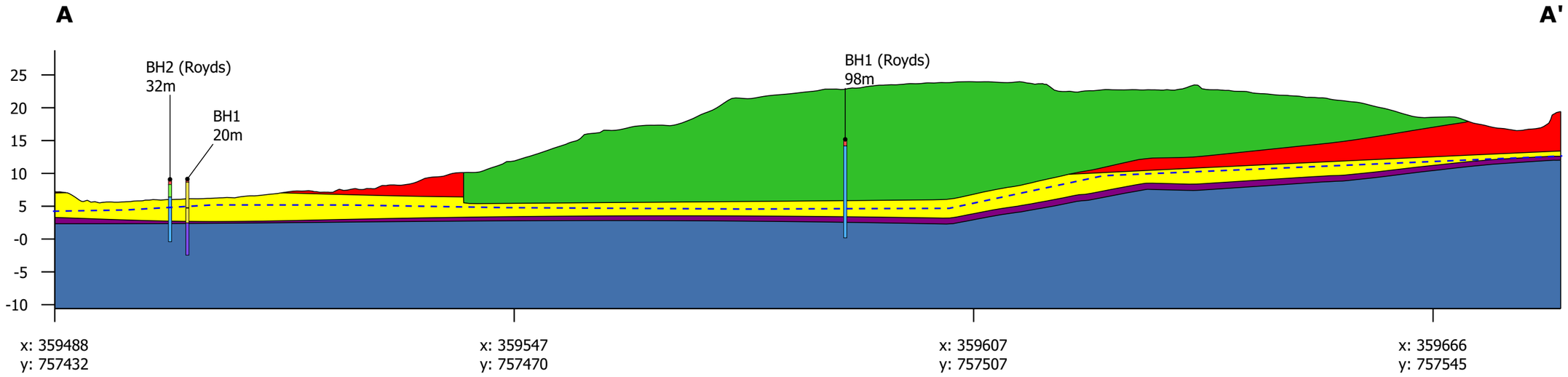
WSP
197 Rattray Street
Dunedin CBD
Dunedin 9016

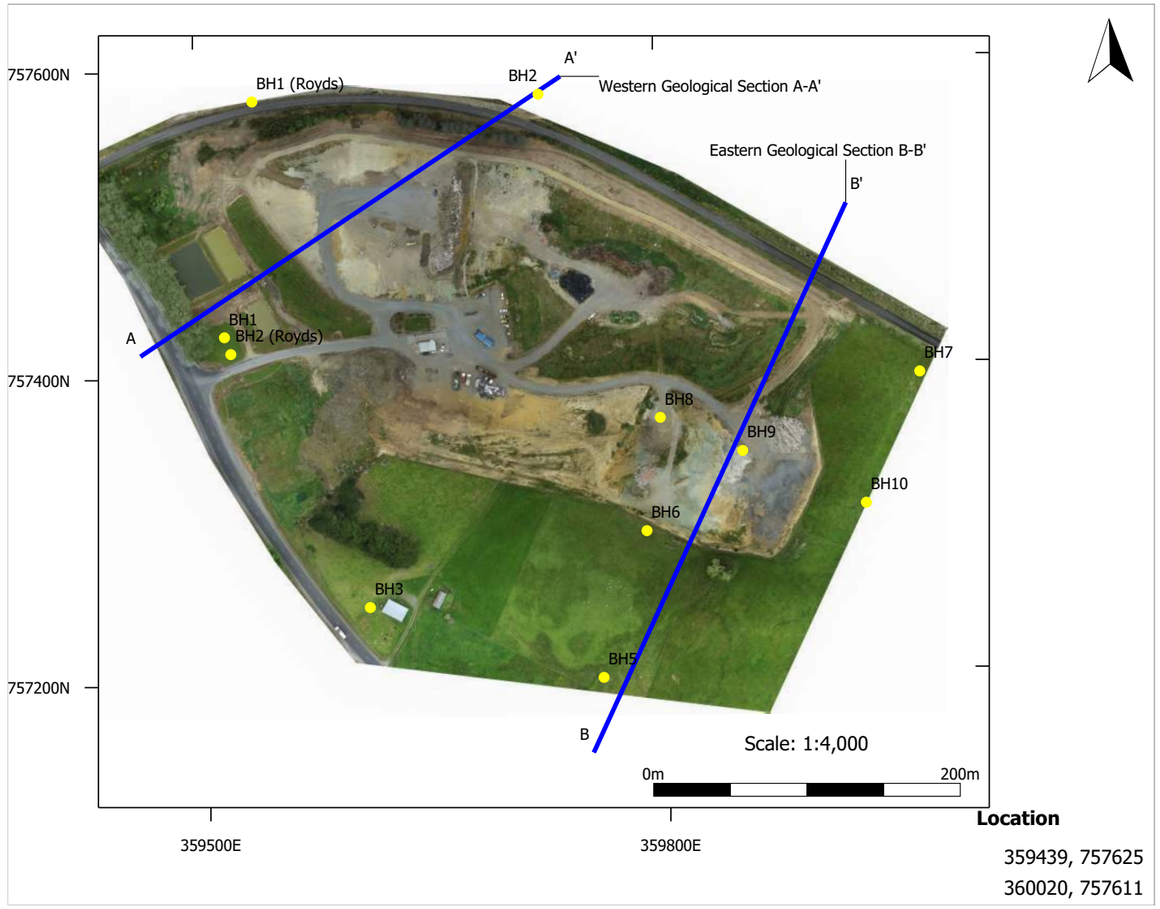
Project
Mt Cooee Landfill Expansion Site photographs

Description
Geological observation - 2021/2023 Landfill expansion area

Drawn by	Checked by
CH	NT

Western Geological Section A - A'





Legend

Geology model with proposed landfill

- Current Landfill
- Topsoil
- Alluvium
- HW to MW sandstone and siltstone
- SW to Fresh sandstone and siltstone
- Inferred Groundwater Table

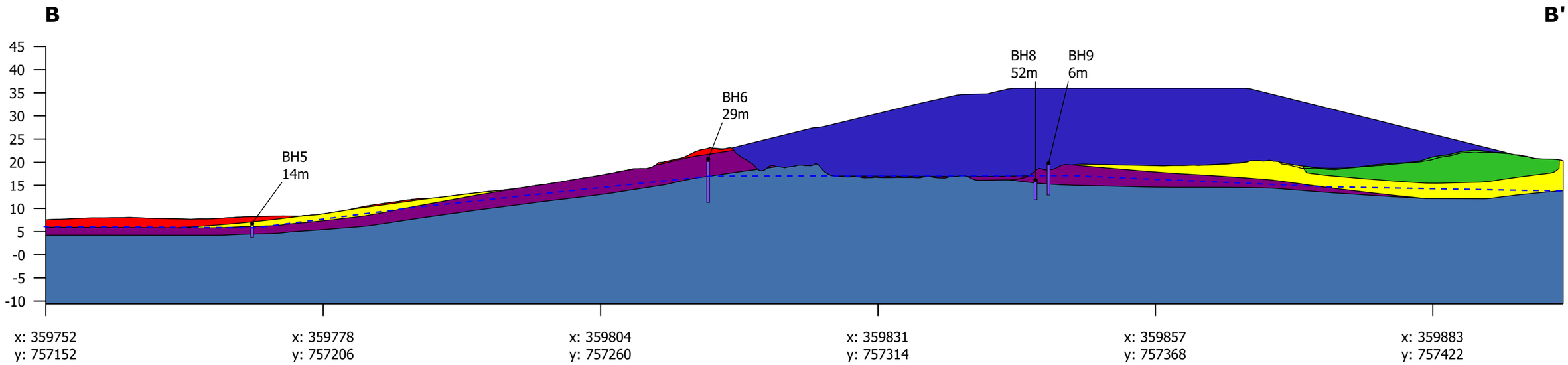
Notes:
Distance to borehole from section is given in metres below borehole ID.
Profile and geological contacts extrapolated based on borehole information. Actual conditions on-site may vary to those represented in these sections.

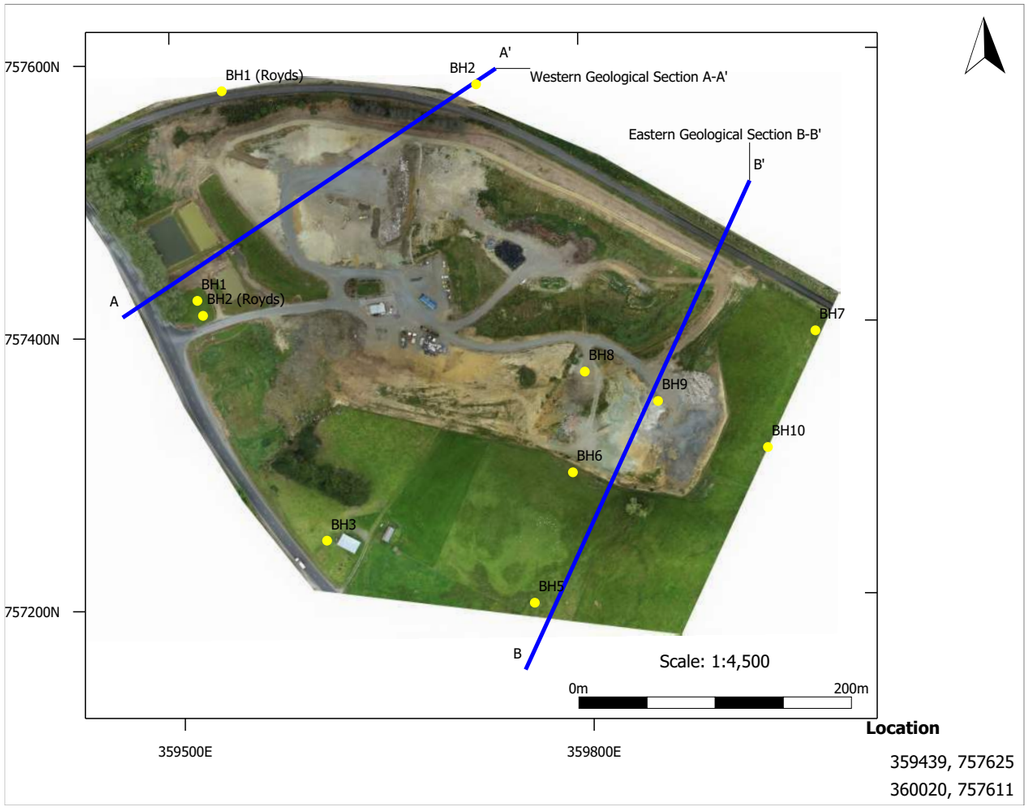
Location

A: 359488, 757432
A': 359682, 757555

Scale: 1:680
Vertical exaggeration: 1x
0m 50m

Eastern Geological Section B-B'





Legend

Geology model with proposed landfill

- Current Landfill
- Proposed Landfill
- Topsoil
- Alluvium
- HW to MW sandstone and siltstone
- SW to Fresh sandstone and siltstone
- Inferred Groundwater Table

Notes:
Distance to borehole from section is given in metres below borehole ID.
Profile and geological contacts extrapolated based on borehole information. Actual conditions on-site may vary to those represented in these sections.

Location

B: 359752, 757152
B': 359896, 757447

Scale: 1:880
Vertical exaggeration: 1x
0m 50m

Appendix E
Selected Liquefaction Assessment Outputs

WSP
Dunedin Office
197 Rattray St, Dunedin, 9016
New Zealand

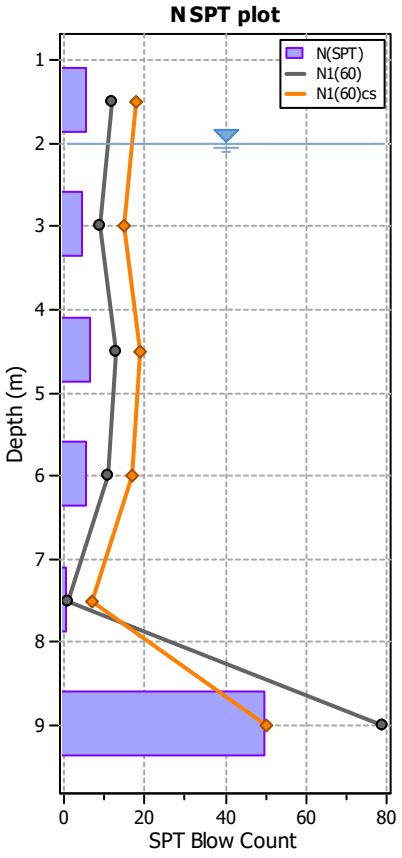
SPT BASED LIQUEFACTION ANALYSIS REPORT

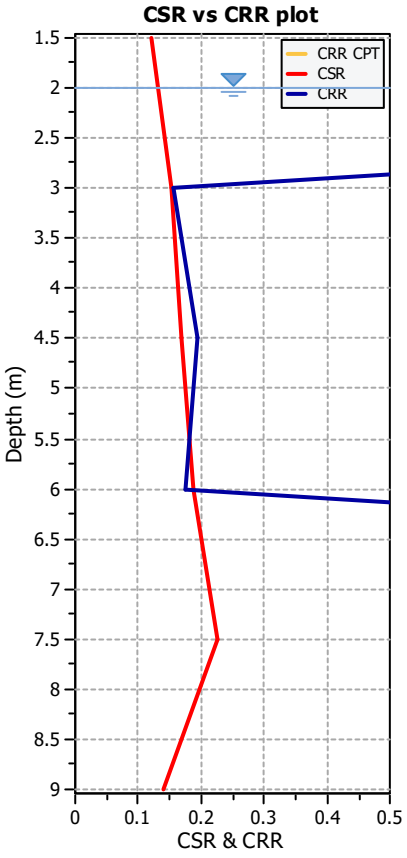
Project title : Mount Cooee Landfill Development **Location : Balclutha, Otago**

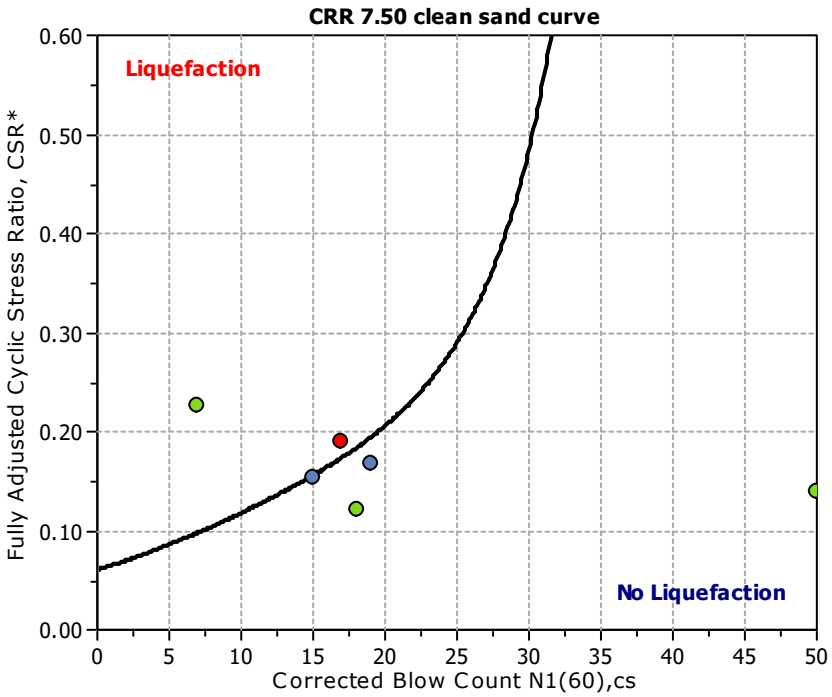
Borehole Name : BH1

:: Input parameters and analysis properties ::

Analysis method:	Idriss & Boulanger 2014	G.W.T. (in-situ):	2.00	EQ site conditions:	Same as initial
Fines correction method:	Idriss & Boulanger 2014	G.W.T. (earthq.):	2.00		
Sampling method:	Standard Sample	Earthquake magnitude M_w:	6.00		
Borehole diameter:	65 mm to 11 5mm	Peak ground acceleration:	0.26		
Rod length:	1.50	SPT results rounding mode:	Nearest		
Hammer energy ratio:	1.51				







:: Cyclic Stress Ratio fully adjusted (CSR*) numeric results ::

No	Depth (m)	Weight (kN/m³)	u_o (kPa)	σ_v (kPa)	Ext. Load (kPa)	σ'_v (kPa)	r_d	CSR	K_σ	MSF_{max}	MSF	CSR*
1	1.50	17.00	0.00	25.50	0.00	25.50	0.99	0.167	1.10	1.42	1.48	2.000
2	3.00	17.00	9.81	51.00	0.00	41.19	0.96	0.201	1.10	1.32	1.48	0.153
3	4.50	17.00	24.53	76.50	0.00	51.97	0.93	0.231	1.09	1.45	1.48	0.167
4	6.00	17.00	39.24	102.00	0.00	62.76	0.90	0.246	1.06	1.38	1.48	0.189
5	7.50	17.00	53.96	127.50	0.00	73.54	0.86	0.252	1.03	1.14	1.48	2.000
6	9.00	17.00	68.67	153.00	0.00	84.33	0.82	0.253	1.05	2.20	1.48	2.000

Abbreviations

Depth: Depth from free surface where SPT was performed (m) during eq.
u_0: Water pressure at test point (kPa) during eq.
σ_v: Total overburden pressure at test point (kPa) during eq.
σ_v': Effective overburden pressure based on GWT during earthquake (kPa) during eq.
r_d: Nonlinear shear mass factor
CSR: Cyclic Stress Ratio
MSF: Effective overburden stress factor
K_σ: Magnitude Scaling Factor
CSR*: CSR fully adjusted

Layer set as 'non-liquefiable due to have PI value of 14 from testing and BH description'

Rock, hence set as non-liquefiable

:: Cyclic Resistance Ratio (CRR) numeric results ::

No	Depth (m)	Fines %	u_o (kPa)	σ_v (kPa)	σ'_v (kPa)	N_{SPT}	C_N	C_R	C_B	C_S	C_E	$N_{1(60)}$	$\Delta(N_1)_{60}$	$N_{1(60),cs}$	$CRR_{7.5}$	F.S.
1	1.50	50.00	0.00	25.50	25.50	6	1.70	0.80	1.00	1.00	1.51	12	5.61	18	4.000	2.00
2	3.00	50.00	9.81	51.00	41.19	5	1.55	0.85	1.00	1.00	1.51	9	5.61	15	0.156	1.02
3	4.50	50.00	24.53	76.50	51.97	7	1.35	0.95	1.00	1.00	1.51	13	5.61	19	0.194	1.16
4	6.00	50.00	39.24	102.00	62.76	6	1.25	0.95	1.00	1.00	1.51	11	5.61	17	0.174	0.92
5	7.50	90.00	53.96	127.50	73.54	1	1.20	0.95	1.00	1.00	1.51	1	5.51	7	4.000	2.00
6	9.00	50.00	68.67	153.00	84.33	50	1.05	1.00	1.00	1.00	1.51	79	5.61	50	4.000	2.00

Abbreviations

Depth: Depth from free surface where SPT was performed (m)
Weight: Soil unit weight from previous test point to current (kN/m³)
u_0: Water pressure at test point (kPa)
σ_v: Total overburden pressure at test point (kPa)
σ_v': Effective overburden pressure based on in situ GWT (kPa)
N_{SPT}: Number of blows count in the field (blows/30 cm)
C_N: Overburden pressure factor
C_E: Energy ratio factor
C_B: Borehole diameter factor
C_R: Rod length factor
C_S: Sampling method factor
$N_{1(60)}$: Number of blows corrected for 60% energy
$\Delta N_{1(60),cs}$ Fines correction
$N_{1(60),cs}$: Number of blows corrected for 60% energy and fines
$CRR_{7.5}$: Cyclic Resistance Ratio for M_w 7.50
F.S.: Factor of safety against liquefaction

WSP
Dunedin Office
197 Rattray St, Dunedin, 9016
New Zealand

Sensitivity Assessment - Reduced Fines Contents

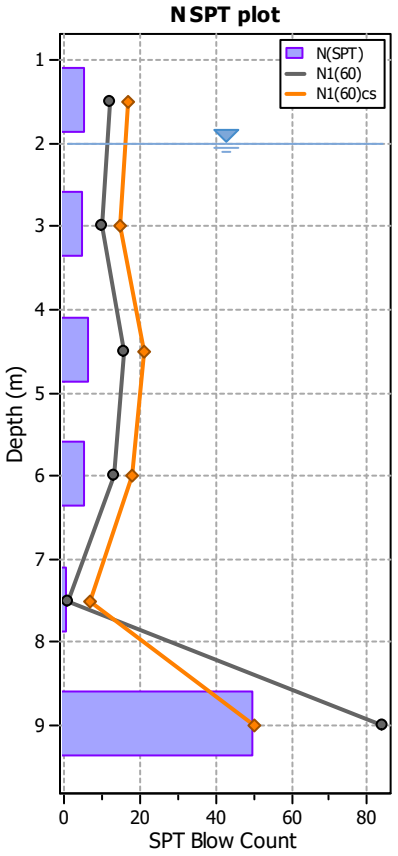
SPT BASED LIQUEFACTION ANALYSIS REPORT

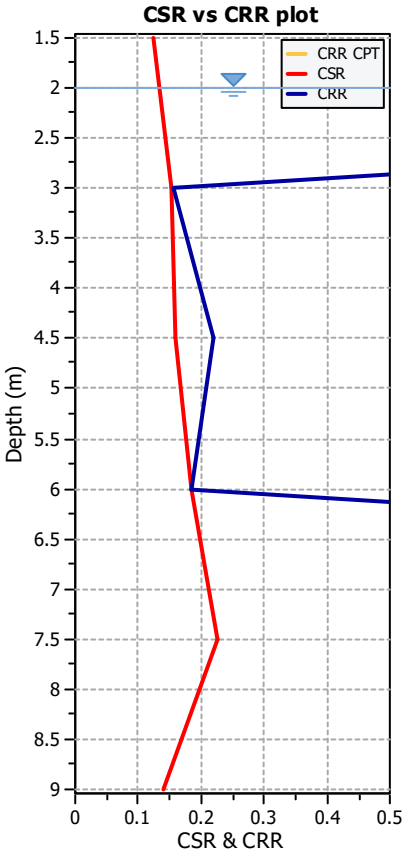
Project title : Mt Cooee Landfill Development **Location : Balclutha, Otago**

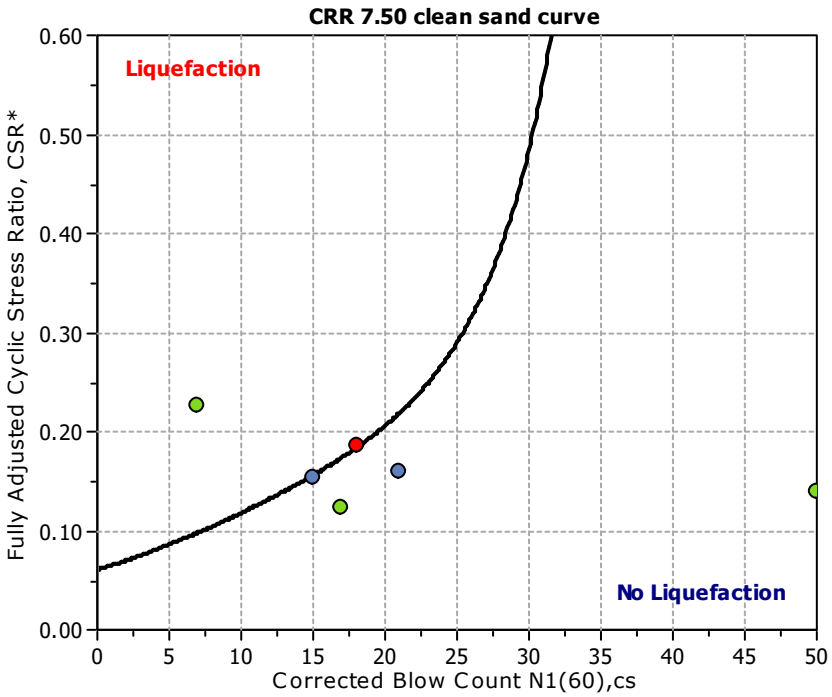
Borehole Name : BH1

:: Input parameters and analysis properties ::

Analysis method:	Idriss & Boulanger 2014	G.W.T. (in-situ):	0.00	EQ site conditions:	Same as initial
Fines correction method:	Idriss & Boulanger 2014	G.W.T. (earthq.):	2.00		
Sampling method:	Standard Sample	Earthquake magnitude M_w:	6.00		
Borehole diameter:	65 mm to 11 5mm	Peak ground acceleration:	0.26		
Rod length:	1.50	SPT results rounding mode:	Nearest		
Hammer energy ratio:	1.51				







:: Cyclic Stress Ratio fully adjusted (CSR*) numeric results ::

No	Depth (m)	Weight (kN/m³)	u_o (kPa)	σ_v (kPa)	Ext. Load (kPa)	σ'_v (kPa)	r_d	CSR	K_σ	MSF_{max}	MSF	CSR^*
1	1.50	17.00	0.00	25.50	0.00	25.50	0.99	0.167	1.10	1.38	1.48	2.000
2	3.00	17.00	9.81	51.00	0.00	41.19	0.96	0.201	1.10	1.32	1.48	0.153
3	4.50	17.00	24.53	76.50	0.00	51.97	0.93	0.231	1.09	1.53	1.48	0.160
4	6.00	17.00	39.24	102.00	0.00	62.76	0.90	0.246	1.06	1.42	1.48	0.186
5	7.50	17.00	53.96	127.50	0.00	73.54	0.86	0.252	1.03	1.14	1.48	2.000
6	9.00	17.00	68.67	153.00	0.00	84.33	0.82	0.253	1.05	2.20	1.48	2.000

Abbreviations

Depth: Depth from free surface where SPT was performed (m) during eq.
u_0: Water pressure at test point (kPa) during eq.
σ_v: Total overburden pressure at test point (kPa) during eq.
σ_v': Effective overburden pressure based on GWT during earthquake (kPa) during eq.
r_d: Nonlinear shear mass factor
CSR: Cyclic Stress Ratio
MSF: Effective overburden stress factor
K_σ: Magnitude Scaling Factor
CSR^*: CSR fully adjusted

Reduced fines contents, quite conservative

:: Cyclic Resistance Ratio (CRR) numeric results ::

No	Depth (m)	Fines %	u_o (kPa)	σ_v (kPa)	σ'_v (kPa)	N_{SPT}	C_N	C_R	C_B	C_S	C_E	$N_{1(60)}$	$\Delta(N_1)_{60}$	$N_{1(60),cs}$	$CRR_{7.5}$	F.S.
1	1.50	30.00	14.72	25.50	10.78	6	1.70	0.80	1.00	1.00	1.51	12	5.36	17	4.000	2.00
2	3.00	30.00	29.43	51.00	21.57	5	1.70	0.85	1.00	1.00	1.51	10	5.36	15	0.156	1.02
3	4.50	30.00	44.15	76.50	32.35	7	1.64	0.95	1.00	1.00	1.51	16	5.36	21	0.219	1.37
4	6.00	30.00	58.86	102.00	43.14	6	1.48	0.95	1.00	1.00	1.51	13	5.36	18	0.184	0.99
5	7.50	70.00	73.58	127.50	53.92	1	1.44	0.95	1.00	1.00	1.51	1	5.57	7	4.000	2.00
6	9.00	30.00	88.29	153.00	64.71	50	1.13	1.00	1.00	1.00	1.51	84	5.36	50	4.000	2.00

Abbreviations

Depth: Depth from free surface where SPT was performed (m)
Weight: Soil unit weight from previous test point to current (kN/m³)
u_0: Water pressure at test point (kPa)
σ_v: Total overburden pressure at test point (kPa)
σ_v': Effective overburden pressure based on in situ GWT (kPa)
N_{SPT}: Number of blows count in the field (blows/30 cm)
C_N: Overburden pressure factor
C_E: Energy ratio factor
C_B: Borehole diameter factor
C_R: Rod length factor
C_S: Sampling method factor
$N_{1(60)}$: Number of blows corrected for 60% energy
$\Delta N_{1(60),cs}$ Fines correction
$N_{1(60),cs}$: Number of blows corrected for 60% energy and fines
$CRR_{7.5}$: Cyclic Resistance Ratio for M_w 7.50
F.S.: Factor of safety against liquefaction

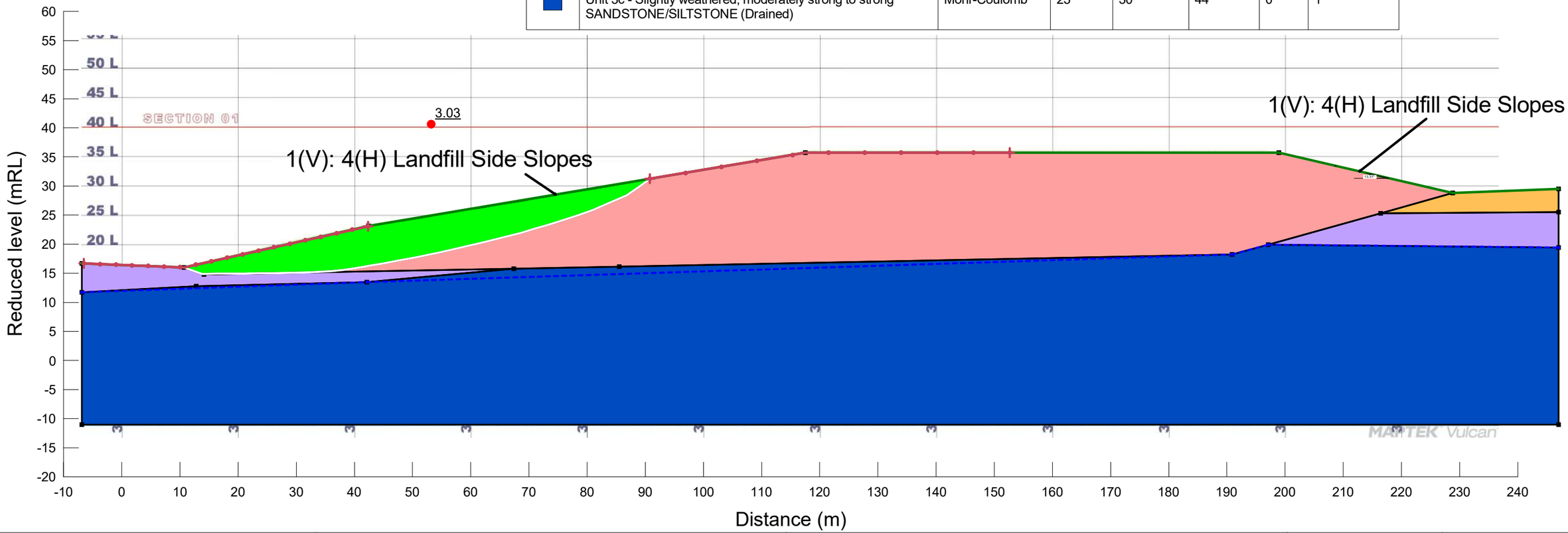
Appendix F
Selected Slope/W Outputs

Horz Seismic Coef.:

Method: Morgenstern-Price

Proposed Landfill - Section 1 Outputs

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Unit 2 - Alluvial Deposits (Drained)	Mohr-Coulomb	17	1	28	0	1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1



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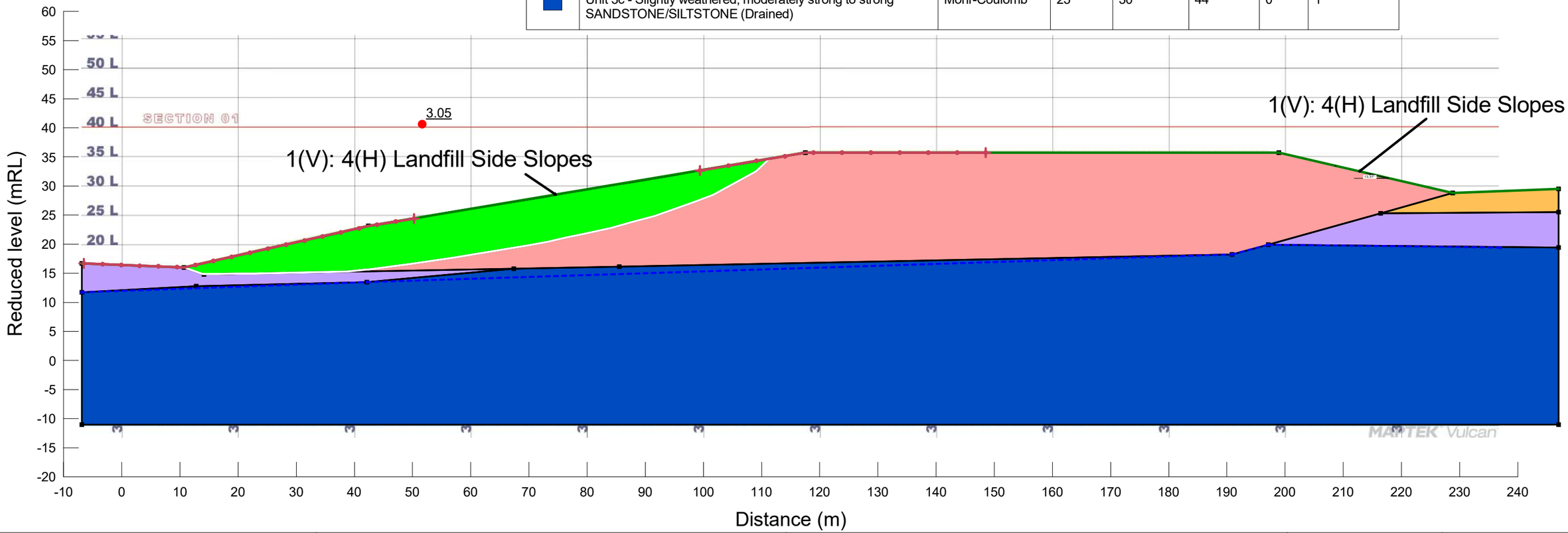
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.:

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Unit 2 - Alluvial Deposits (Drained)	Mohr-Coulomb	17	1	28	0	1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1



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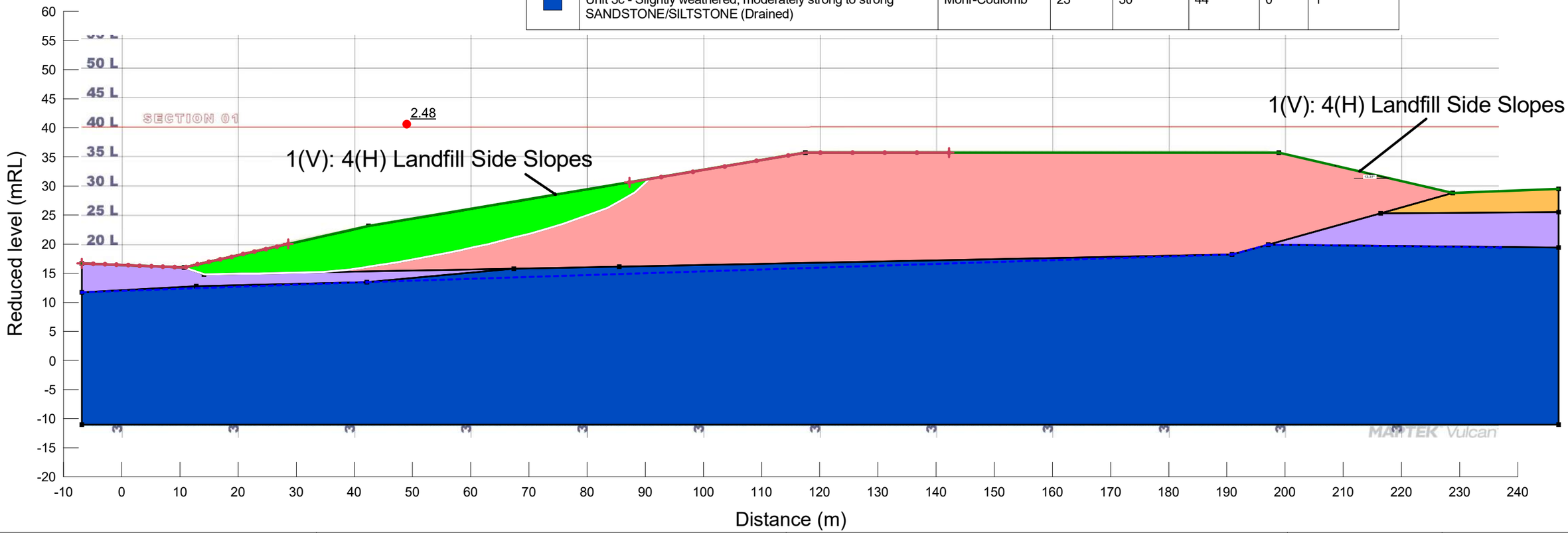
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.: 0.04

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Unit 2 - Alluvial Deposits (Drained)	Mohr-Coulomb	17	1	28	0	1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1



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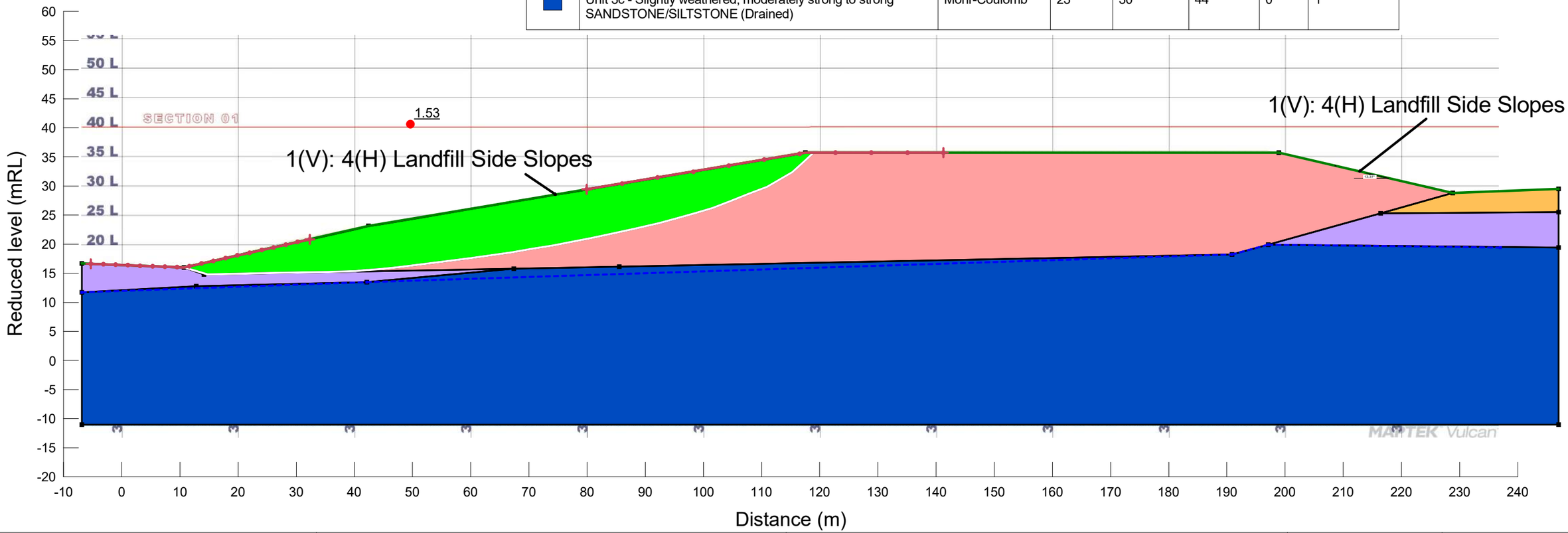
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.: 0.17

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Unit 2 - Alluvial Deposits (Drained)	Mohr-Coulomb	17	1	28	0	1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1



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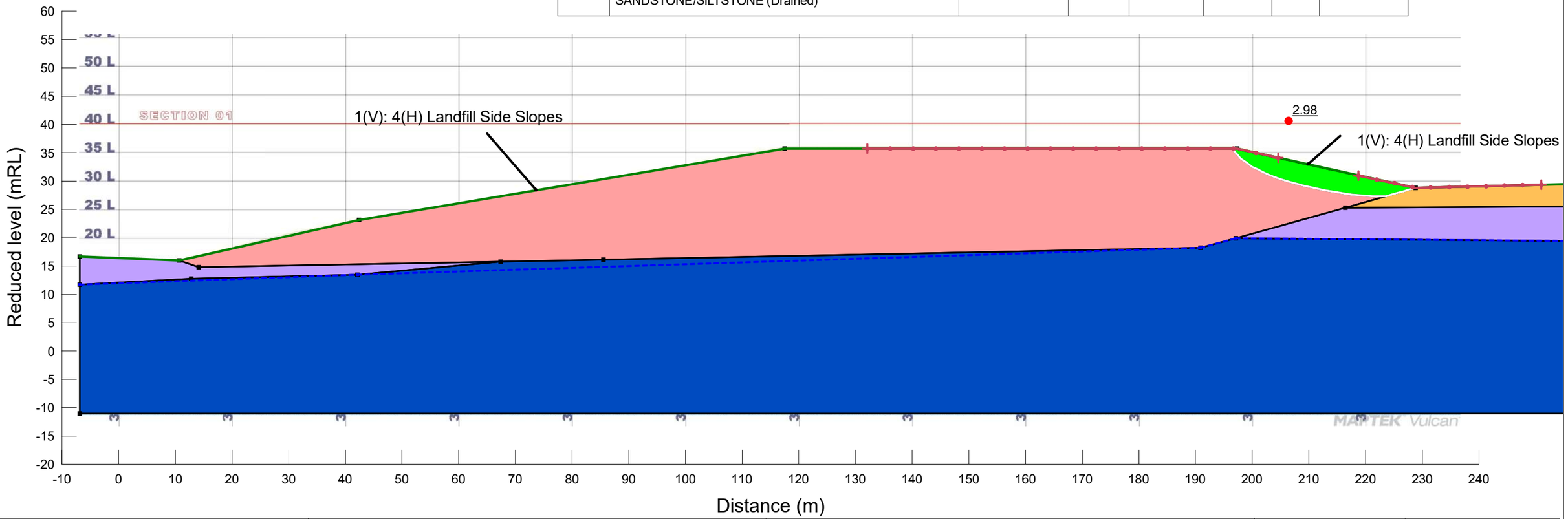
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.:

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Unit 2 - Alluvial Deposits (Drained)	Mohr-Coulomb	17	1	28	0	1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1



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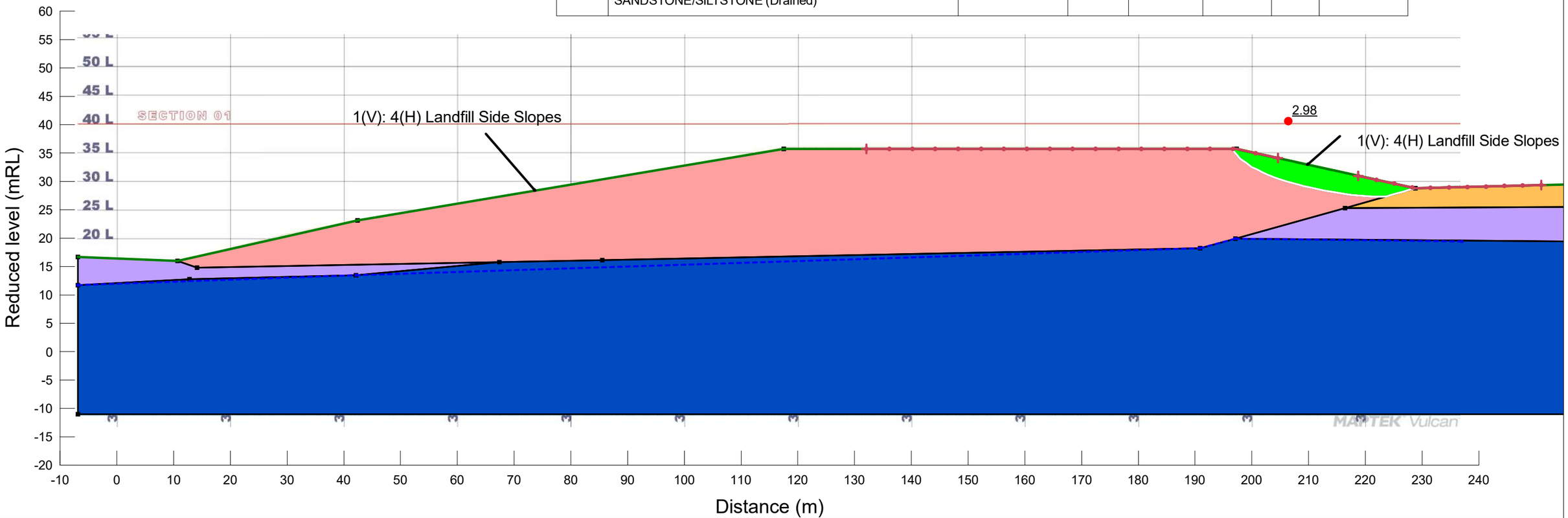
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.:

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Unit 2 - Alluvial Deposits (Drained)	Mohr-Coulomb	17	1	28	0	1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1



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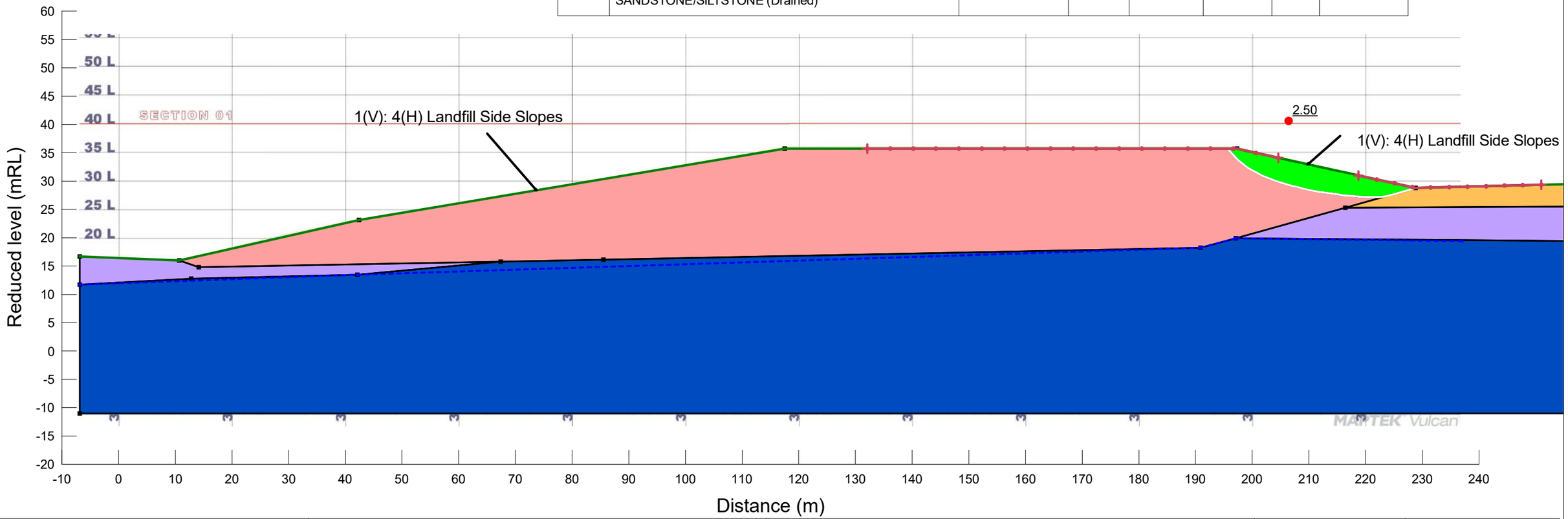
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.: 0.04

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Unit 2 - Alluvial Deposits (Drained)	Mohr-Coulomb	17	1	28	0	1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1



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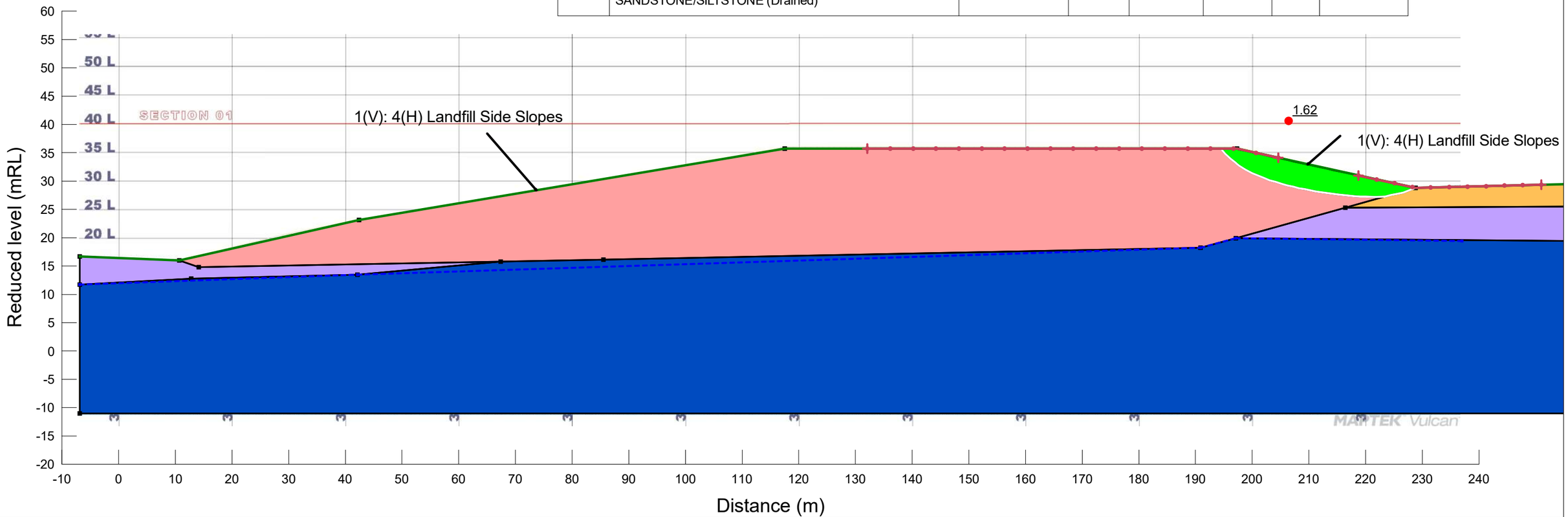
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.: 0.17

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Unit 2 - Alluvial Deposits (Drained)	Mohr-Coulomb	17	1	28	0	1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1



wsp	Mt Cooee Landfill Development Plan	2.4 Seismic - DCLS	6-CO082.00 / Date: 04/04/2023 / Scale: 1:700 / By: NT

U:\ProjectsNZ\6c\6-CO082.00 Mt Cooee Landfill - Development Plan & R\Home\Stage 2 - Geotech Interpretation\04 Slope Stability\SlopeW Files\Mount Cooee Landfill - Section 1 - Proposed.gsz, Taghipouran, Nima, 04/04/2023,02:49:31 pm

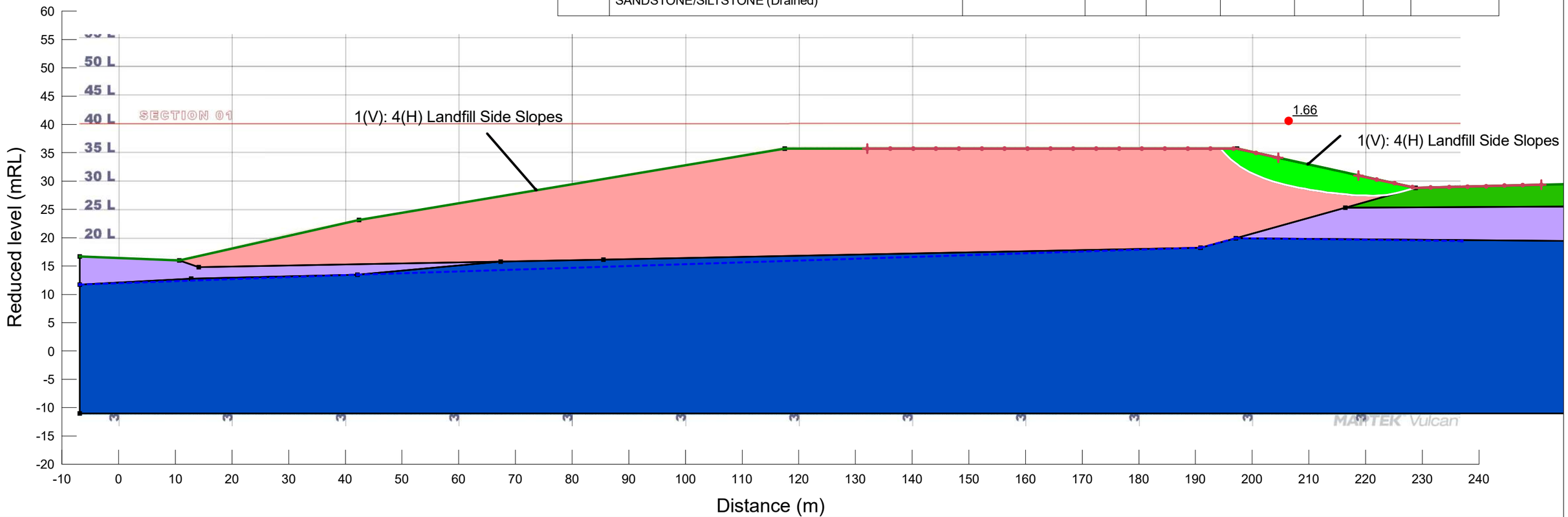
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.: 0.17

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Total Cohesion (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13		5	25	0	1
	Unit 2 - Alluvial Deposits (Undrained)	Undrained (Phi=0)	17	30				1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21		20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23		30	44	0	1



wsp	Mt Cooee Landfill Development Plan	2.5 Seismic - DCLS (Undrained sensitivity)	6-CO082.00 / Date: 04/04/2023 / Scale: 1:700 / By: NT

U:\ProjectsNZ\6c\6-CO082.00 Mt Cooee Landfill - Development Plan & R\Home\Stage 2 - Geotech Interpretation\04 Slope Stability\SlopeW Files\Mount Cooee Landfill - Section 1 - Proposed.gsz, Taghipouran, Nima, 04/04/2023,02:49:31 pm

DO NOT SCALE

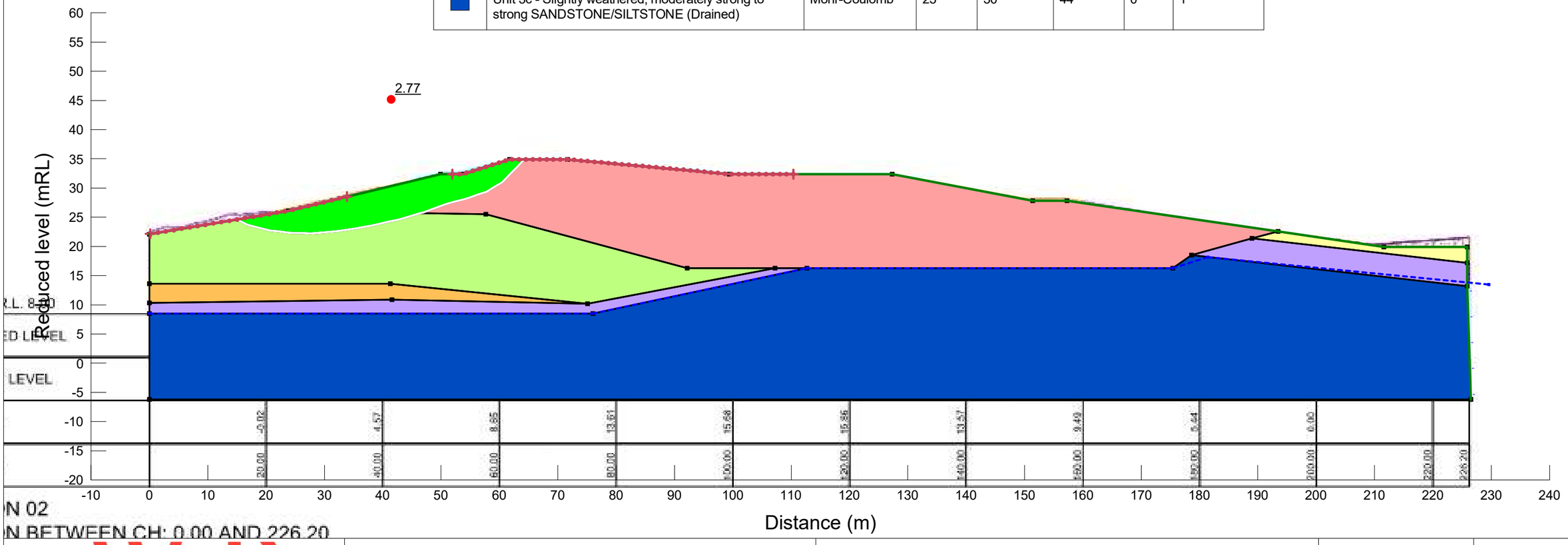
Version: 11.4.0.18

Horz Seismic Coef.:

Method: Morgenstern-Price

Proposed Landfill - Section 2 Outputs

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Existing Landfill (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Unit 1 - Topsoil	Mohr-Coulomb	16	1	25	0	1
	Unit 2 - Alluvial Deposits (Drained)	Mohr-Coulomb	17	1	28	0	1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1



N 02

N BETWEEN CH: 0.00 AND 226.20

WSP	Mt Cooee Landfill Development Plan	1.1 Static - Long term	6-CO082.00 / Date: 06/04/2023 / Scale: 1:700 / By: NT

U:\ProjectsNZ\6c\6-CO082.00 Mt Cooee Landfill - Development Plan & R\Home\Stage 2 - Geotech Interpretation\04 Slope Stability\SlopeW Files\Mount Cooee Landfill - Section 2 - Proposed.gsz, Taghipouran, Nima, 06/04/2023,01:19:33 pm

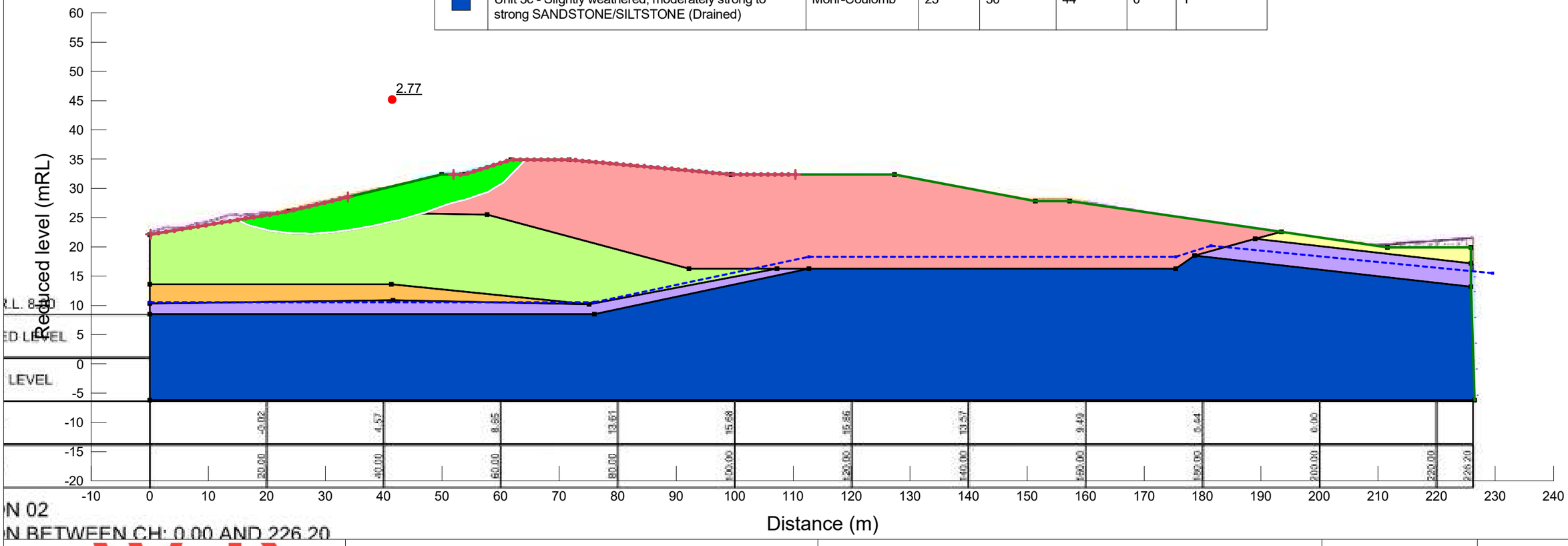
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.:

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Existing Landfill (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Unit 1 - Topsoil	Mohr-Coulomb	16	1	25	0	1
	Unit 2 - Alluvial Deposits (Drained)	Mohr-Coulomb	17	1	28	0	1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1



N 02

N BETWEEN CH: 0.00 AND 226.20

WSP	Mt Cooee Landfill Development Plan	1.2 Static - Short Term (High GWL)	6-CO082.00 / Date: 06/04/2023 / Scale: 1:700 / By: NT

U:\ProjectsNZ\6c\6-CO082.00 Mt Cooee Landfill - Development Plan & R\Home\Stage 2 - Geotech Interpretation\04 Slope Stability\SlopeW Files\Mount Cooee Landfill - Section 2 - Proposed.gsz, Taghipouran, Nima, 06/04/2023,01:19:33 pm

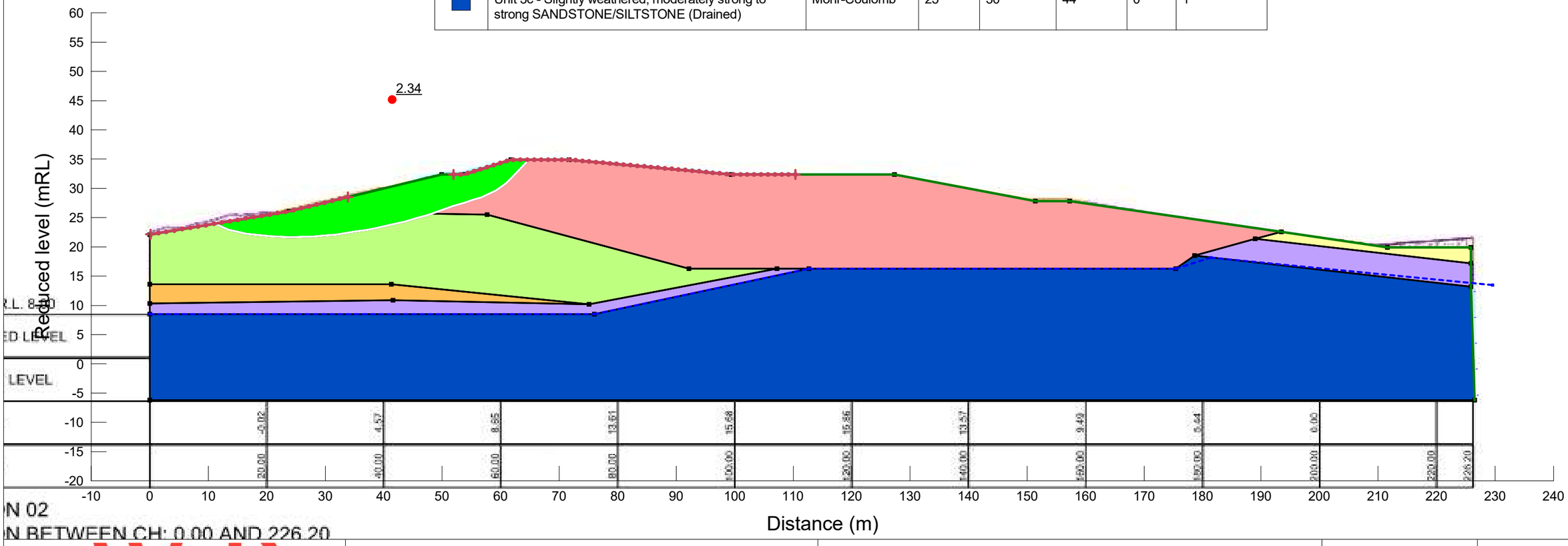
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.: 0.04

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Existing Landfill (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Unit 1 - Topsoil	Mohr-Coulomb	16	1	25	0	1
	Unit 2 - Alluvial Deposits (Drained)	Mohr-Coulomb	17	1	28	0	1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1



N 02

N BETWEEN CH: 0.00 AND 226.20

WSP	Mt Cooee Landfill Development Plan	1.3 Seismic - SLS	6-CO082.00 / Date: 06/04/2023 / Scale: 1:700 / By: NT

U:\ProjectsNZ\6c\6-CO082.00 Mt Cooee Landfill - Development Plan & R\Home\Stage 2 - Geotech Interpretation\04 Slope Stability\SlopeW Files\Mount Cooee Landfill - Section 2 - Proposed.gsz, Taghipouran, Nima, 06/04/2023,01:19:33 pm

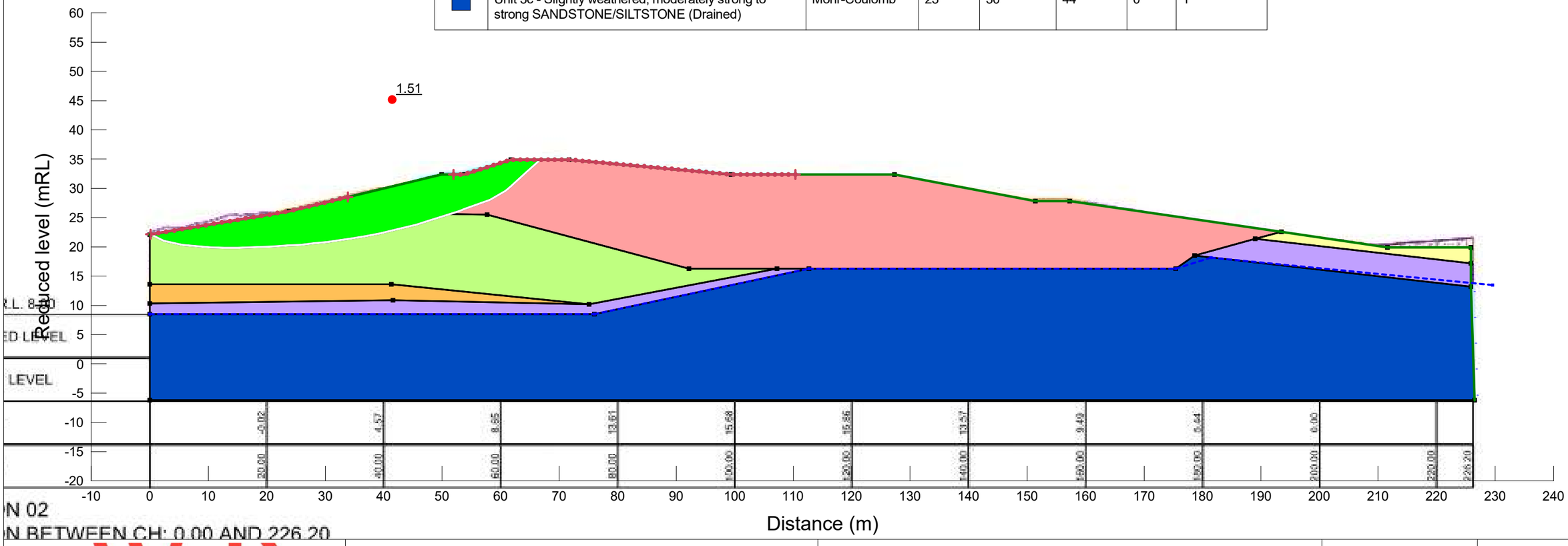
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.: 0.17

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Existing Landfill (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Unit 1 - Topsoil	Mohr-Coulomb	16	1	25	0	1
	Unit 2 - Alluvial Deposits (Drained)	Mohr-Coulomb	17	1	28	0	1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1



N 02

N BETWEEN CH: 0.00 AND 226.20

	Mt Cooee Landfill Development Plan	1.4 Seismic - DCLS	6-CO082.00 / Date: 06/04/2023 / Scale: 1:700 / By: NT

U:\ProjectsNZ\6c\6-CO082.00 Mt Cooee Landfill - Development Plan & R\Home\Stage 2 - Geotech Interpretation\04 Slope Stability\SlopeW Files\Mount Cooee Landfill - Section 2 - Proposed.gsz, Taghipouran, Nima, 06/04/2023,01:19:33 pm

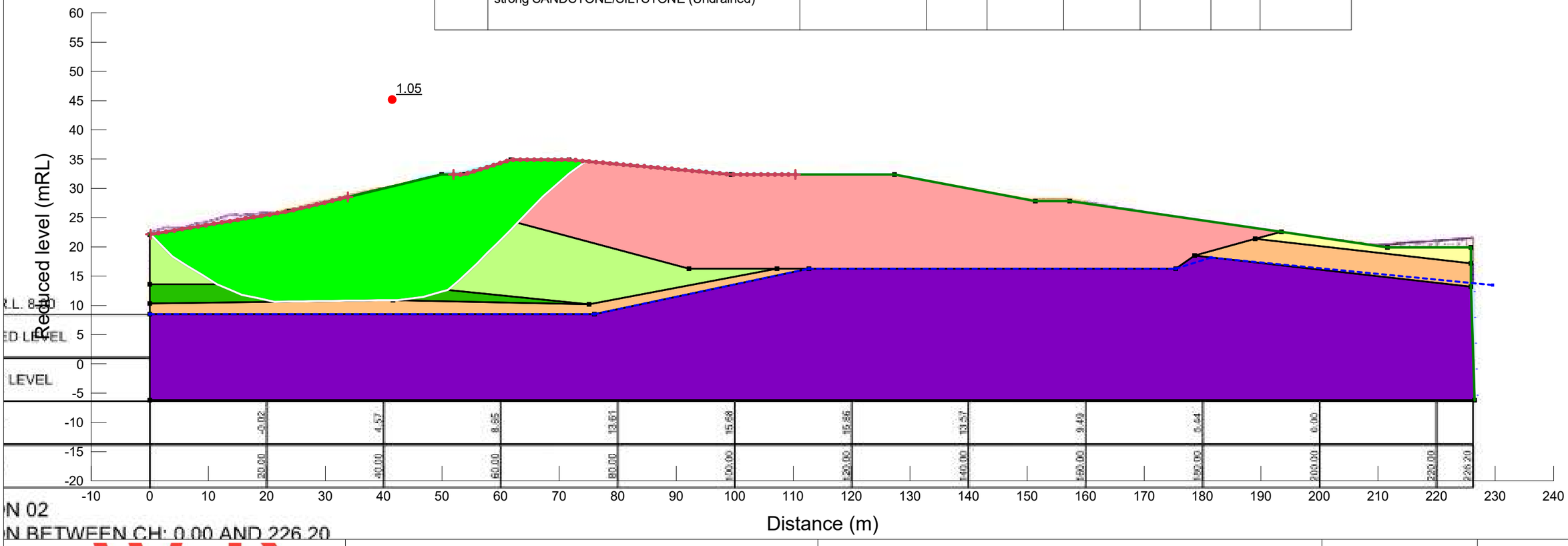
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.: 0.17

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Total Cohesion (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Existing Landfill (Drained) - Nominal Parameters	Mohr-Coulomb	13		5	25	0	1
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13		5	25	0	1
	Unit 1 - Topsoil	Mohr-Coulomb	16		1	25	0	1
	Unit 2 - Alluvial Deposits (Undrained)	Undrained (Phi=0)	17	30				1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Undrained)	Undrained (Phi=0)	21	400				1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Undrained)	Undrained (Phi=0)	23	750				1



N 02

N BETWEEN CH: 0.00 AND 226.20

WSP	Mt Cooee Landfill Development Plan	1.5 Seismic - DCLS (Undrained sensitivity)	6-CO082.00 / Date: 06/04/2023 / Scale: 1:700 / By: NT

U:\ProjectsNZ\6c\6-CO082.00 Mt Cooee Landfill - Development Plan & R\Home\Stage 2 - Geotech Interpretation\04 Slope Stability\SlopeW Files\Mount Cooee Landfill - Section 2 - Proposed.gsz, Taghipouran, Nima, 06/04/2023,01:19:33 pm

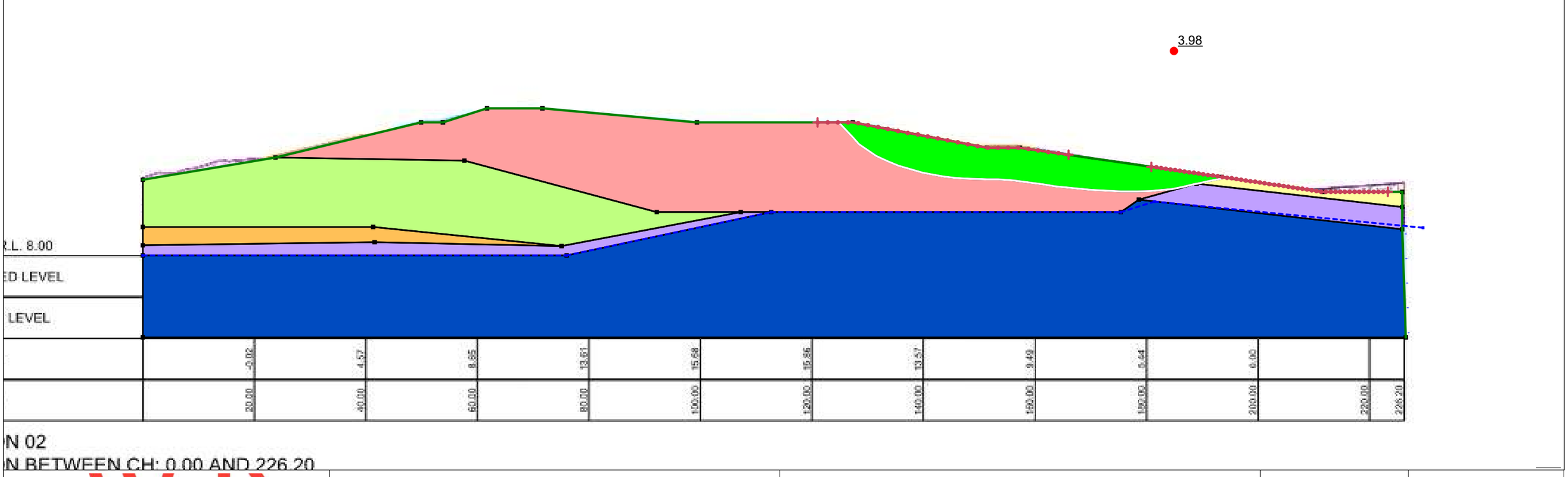
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.:

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Existing Landfill (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Unit 1 - Topsoil	Mohr-Coulomb	16	1	25	0	1
	Unit 2 - Alluvial Deposits (Drained)	Mohr-Coulomb	17	1	28	0	1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1



N 02

N BETWEEN CH: 0.00 AND 226.20

wsp	Mt Cooee Landfill Development Plan	2.1 Static - Long term	6-CO082.00 / Date: 06/04/2023 / Scale: 1:700 / By: NT

U:\ProjectsNZ\6c\6-CO082.00 Mt Cooee Landfill - Development Plan & R\Home\Stage 2 - Geotech Interpretation\04 Slope Stability\SlopeW Files\Mount Cooee Landfill - Section 2 - Proposed.gsz, Taghipouran, Nima, 06/04/2023,01:19:33 pm

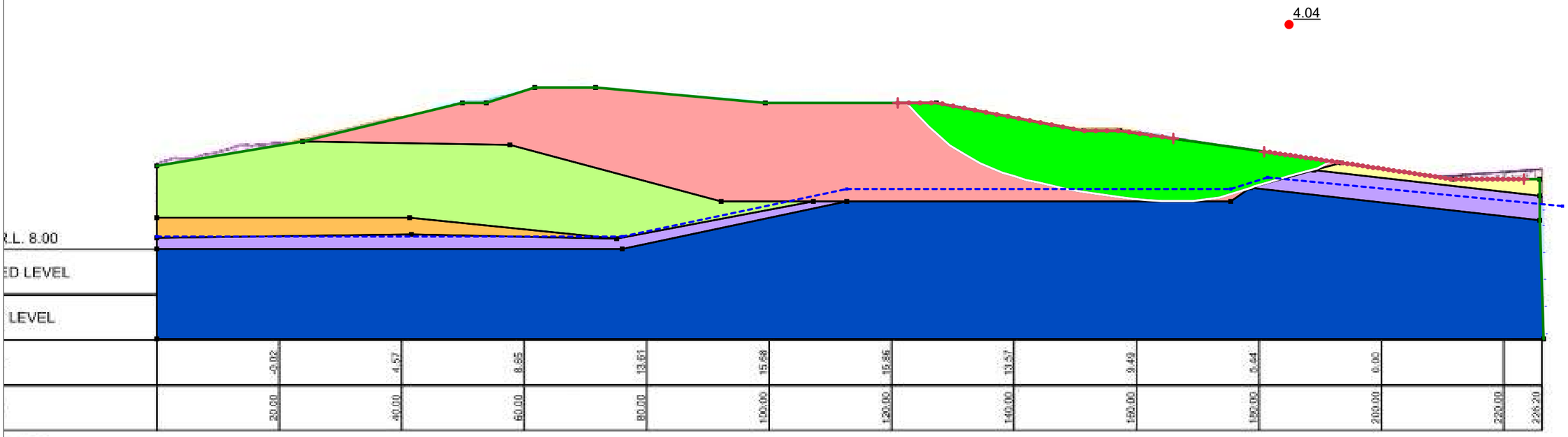
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.:

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Existing Landfill (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Unit 1 - Topsoil	Mohr-Coulomb	16	1	25	0	1
	Unit 2 - Alluvial Deposits (Drained)	Mohr-Coulomb	17	1	28	0	1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1



N 02

N BETWEEN CH: 0.00 AND 226.20

wsp	Mt Cooee Landfill Development Plan	2.2 Static - Short Term (High GWL)	6-CO082.00 / Date: 06/04/2023 / Scale: 1:700 / By: NT

U:\ProjectsNZ\6c\6-CO082.00 Mt Cooee Landfill - Development Plan & R\Home\Stage 2 - Geotech Interpretation\04 Slope Stability\SlopeW Files\Mount Cooee Landfill - Section 2 - Proposed.gsz, Taghipouran, Nima, 06/04/2023,01:19:33 pm

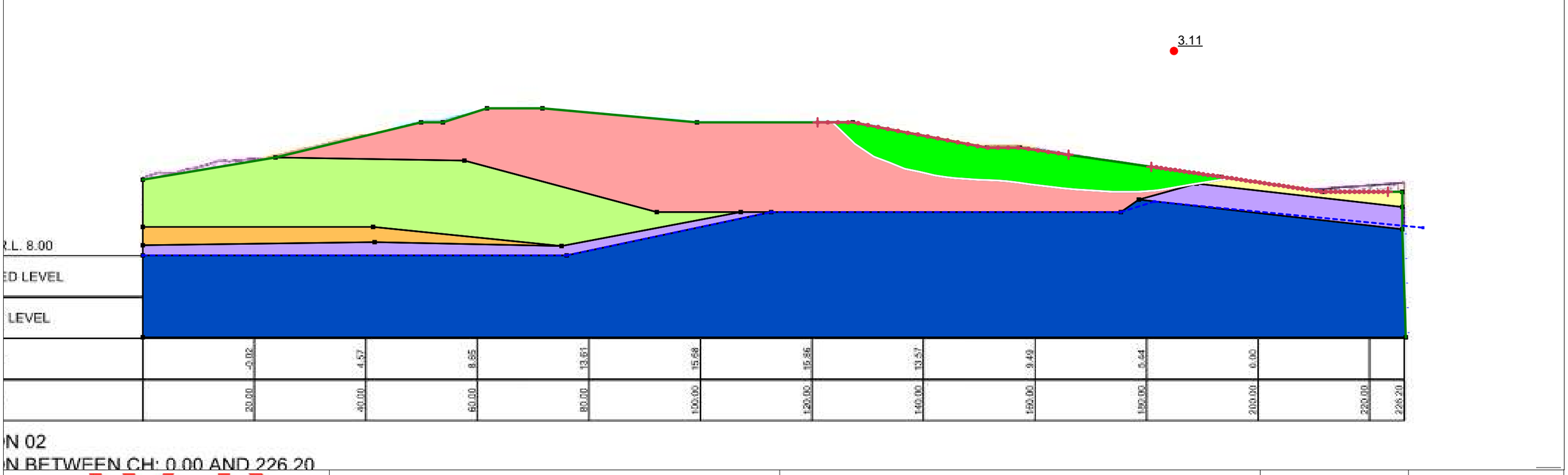
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.: 0.04

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Existing Landfill (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Unit 1 - Topsoil	Mohr-Coulomb	16	1	25	0	1
	Unit 2 - Alluvial Deposits (Drained)	Mohr-Coulomb	17	1	28	0	1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1



N 02

N BETWEEN CH: 0.00 AND 226.20

WSP	Mt Cooee Landfill Development Plan	2.3 Seismic - SLS	6-CO082.00 / Date: 06/04/2023 / Scale: 1:700 / By: NT

U:\ProjectsNZ\6c\6-CO082.00 Mt Cooee Landfill - Development Plan & R\Home\Stage 2 - Geotech Interpretation\04 Slope Stability\SlopeW Files\Mount Cooee Landfill - Section 2 - Proposed.gsz, Taghipouran, Nima, 06/04/2023,01:19:33 pm

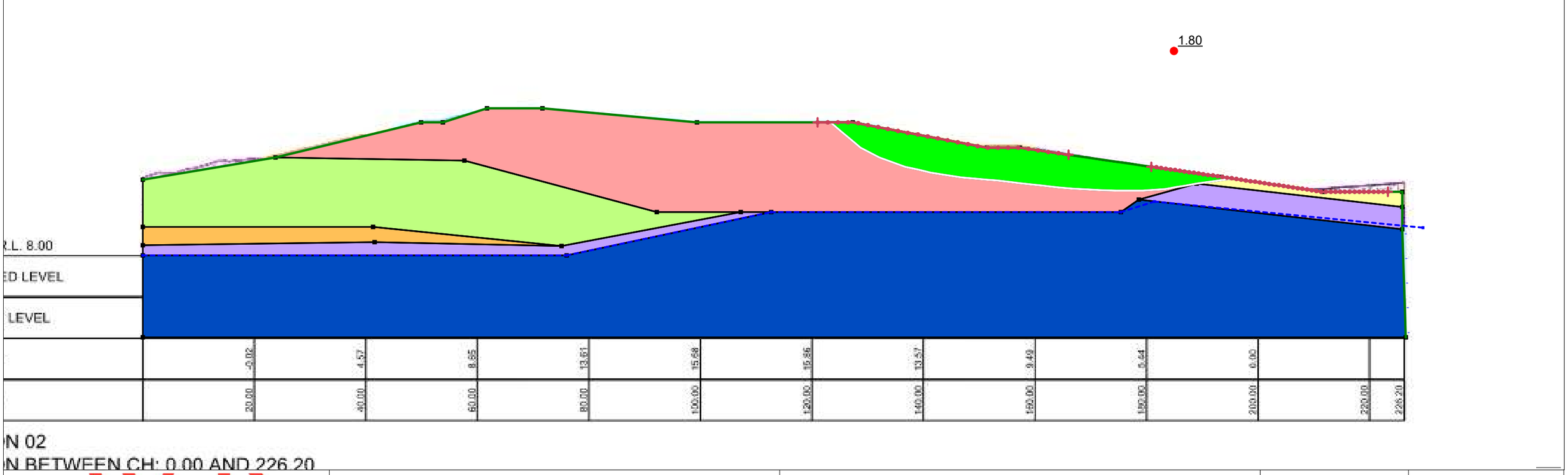
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.: 0.17

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Existing Landfill (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Unit 1 - Topsoil	Mohr-Coulomb	16	1	25	0	1
	Unit 2 - Alluvial Deposits (Drained)	Mohr-Coulomb	17	1	28	0	1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1



N 02

N BETWEEN CH: 0.00 AND 226.20

wsp	Mt Cooee Landfill Development Plan	2.4 Seismic - DCLS	6-CO082.00 / Date: 06/04/2023 / Scale: 1:700 / By: NT

U:\ProjectsNZ\6c\6-CO082.00 Mt Cooee Landfill - Development Plan & R\Home\Stage 2 - Geotech Interpretation\04 Slope Stability\SlopeW Files\Mount Cooee Landfill - Section 2 - Proposed.gsz, Taghipouran, Nima, 06/04/2023,01:19:33 pm

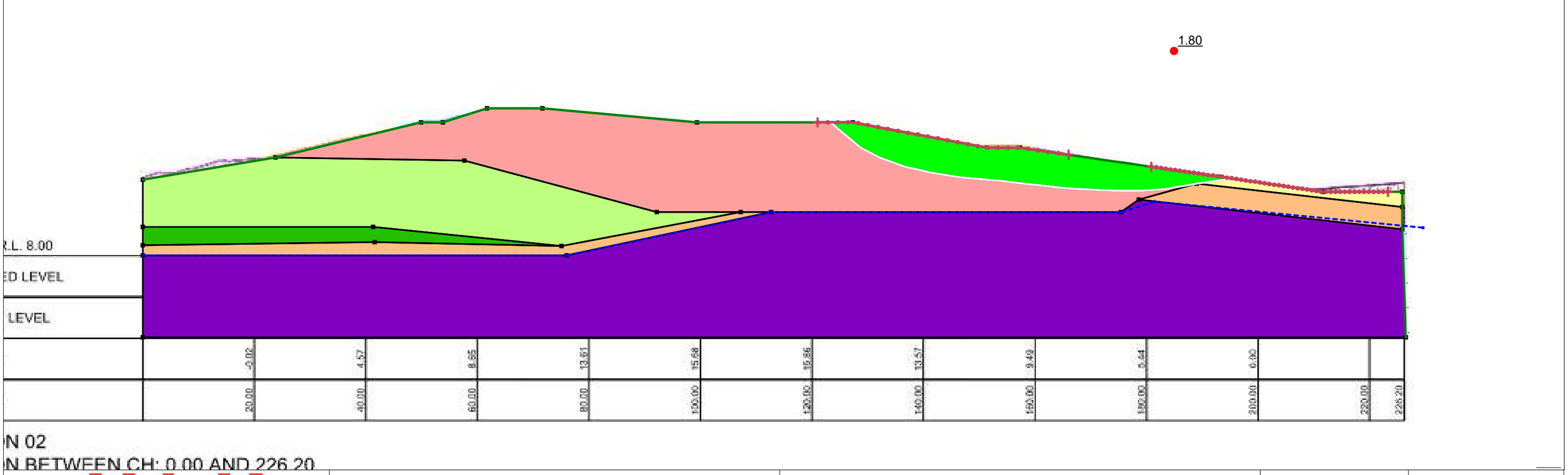
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.: 0.17

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Total Cohesion (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Existing Landfill (Drained) - Nominal Parameters	Mohr-Coulomb	13		5	25	0	1
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13		5	25	0	1
	Unit 1 - Topsoil	Mohr-Coulomb	16		1	25	0	1
	Unit 2 - Alluvial Deposits (Undrained)	Undrained (Phi=0)	17	30				1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Undrained)	Undrained (Phi=0)	21	400				1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Undrained)	Undrained (Phi=0)	23	750				1



N 02

N BETWEEN CH: 0.00 AND 226.20

wsp	Mt Cooee Landfill Development Plan	2.5 Seismic - DCLS (Undrained sensitivity)	6-CO082.00 / Date: 06/04/2023 / Scale: 1:700 / By: NT

U:\ProjectsNZ\6c\6-CO082.00 Mt Cooee Landfill - Development Plan & R\Home\Stage 2 - Geotech Interpretation\04 Slope Stability\SlopeW Files\Mount Cooee Landfill - Section 2 - Proposed.gsz, Taghipouran, Nima, 06/04/2023,01:19:33 pm

DO NOT SCALE

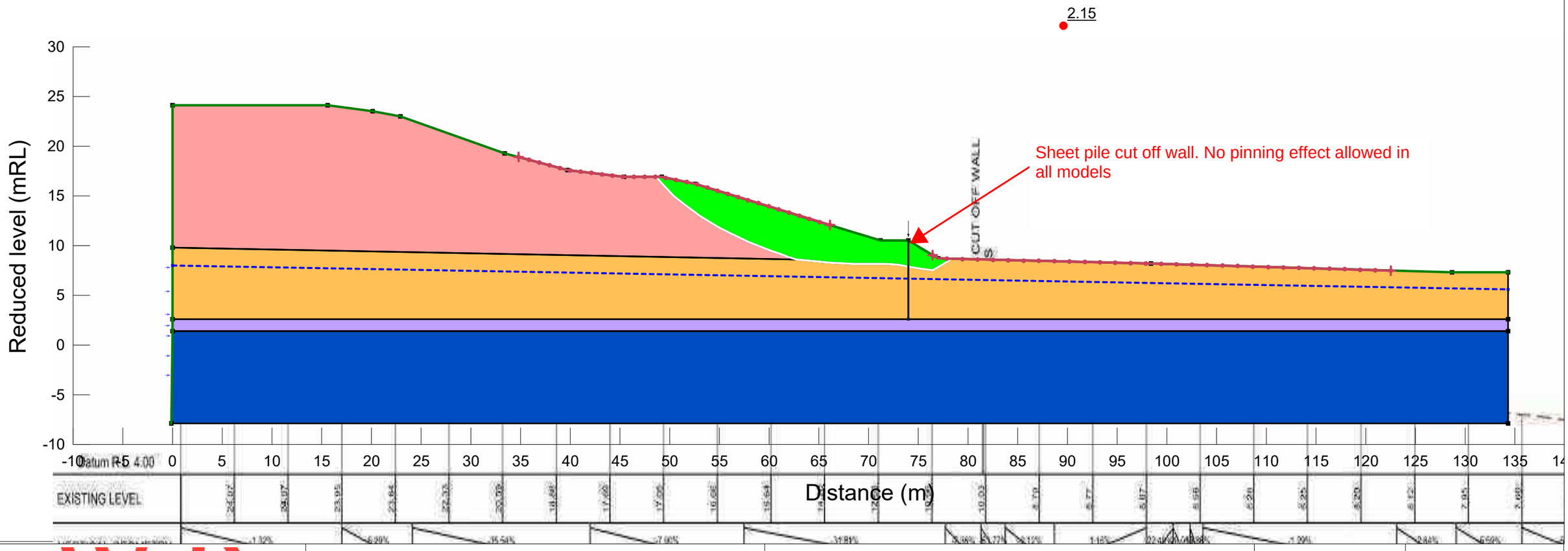
Version: 11.4.0.18

Horz Seismic Coef.:

Method: Morgenstern-Price

Existing Landfill Stability Outputs

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Existing Clay Bund (Drained)	Mohr-Coulomb	18	3	28	0	1
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Unit 2 - Alluvial Deposits (Drained)	Mohr-Coulomb	17	1	24	0	1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1



wsp	Mt Cooee Landfill Development Plan	1.1 Static - Long term	6-CO082.00 / Date: 06/04/2023 / Scale: 1:400 / By: NT

U:\ProjectsNZ\6c\6-CO082.00 Mt Cooee Landfill - Development Plan & R\Home\Stage 2 - Geotech Interpretation\04 Slope Stability\SlopeW Files\Mount Cooee Landfill - Existing Landfill Stability.gsz, Taghipouran, Nima, 06/04/2023,01:34:35 pm

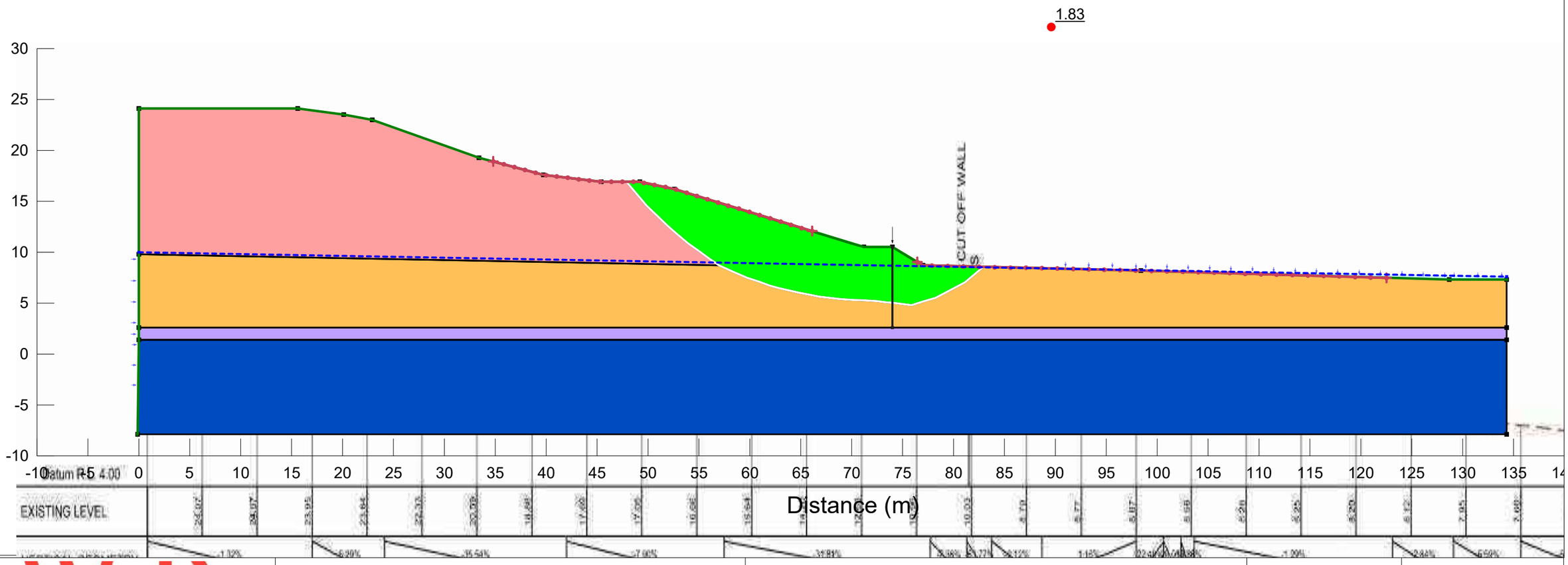
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.:

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Existing Clay Bund (Drained)	Mohr-Coulomb	18	3	28	0	1
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Unit 2 - Alluvial Deposits (Drained)	Mohr-Coulomb	17	1	24	0	1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1



wsp	Mt Cooee Landfill Development Plan	6-CO082.00	Date: 06/04/2023
	1.2 Static - Short Term (High GWL)	Scale: 1:400	By: NT

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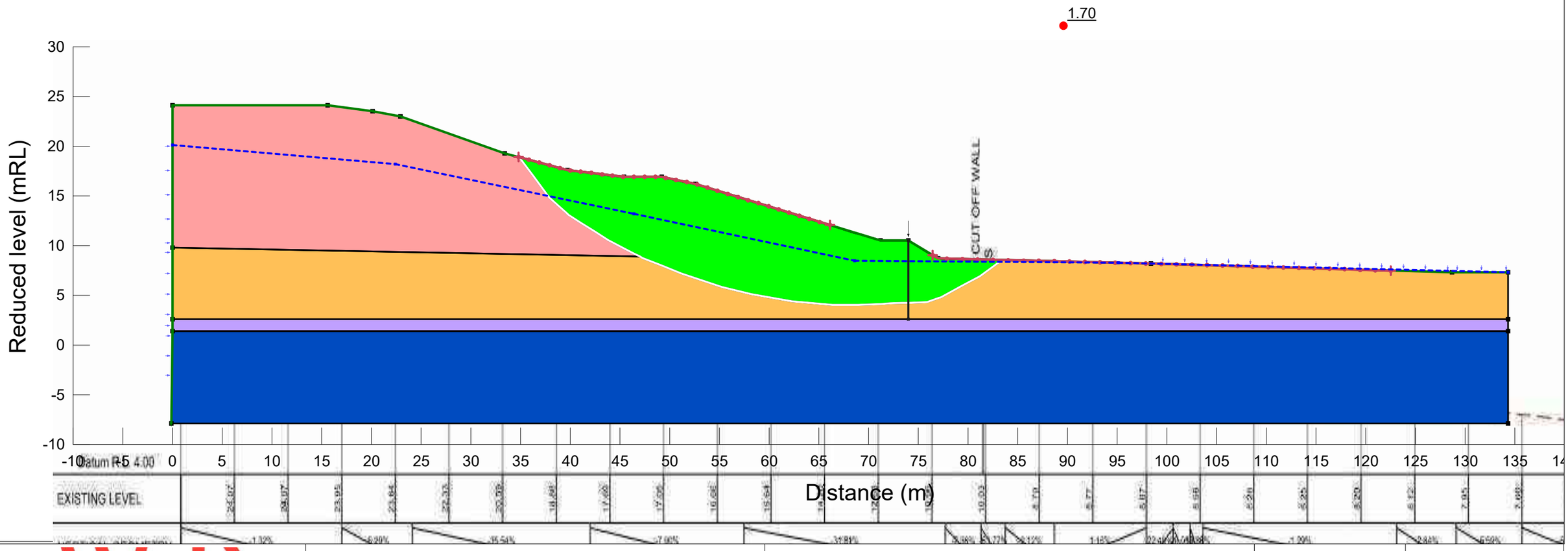
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.:

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Existing Clay Bund (Drained)	Mohr-Coulomb	18	3	28	0	1
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Unit 2 - Alluvial Deposits (Drained)	Mohr-Coulomb	17	1	24	0	1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1



wsp	Mt Cooee Landfill Development Plan	1.2 Static - Short Term (High GWL)sensitivity	6-CO082.00 / Date: 06/04/2023 / Scale: 1:400 / By: NT

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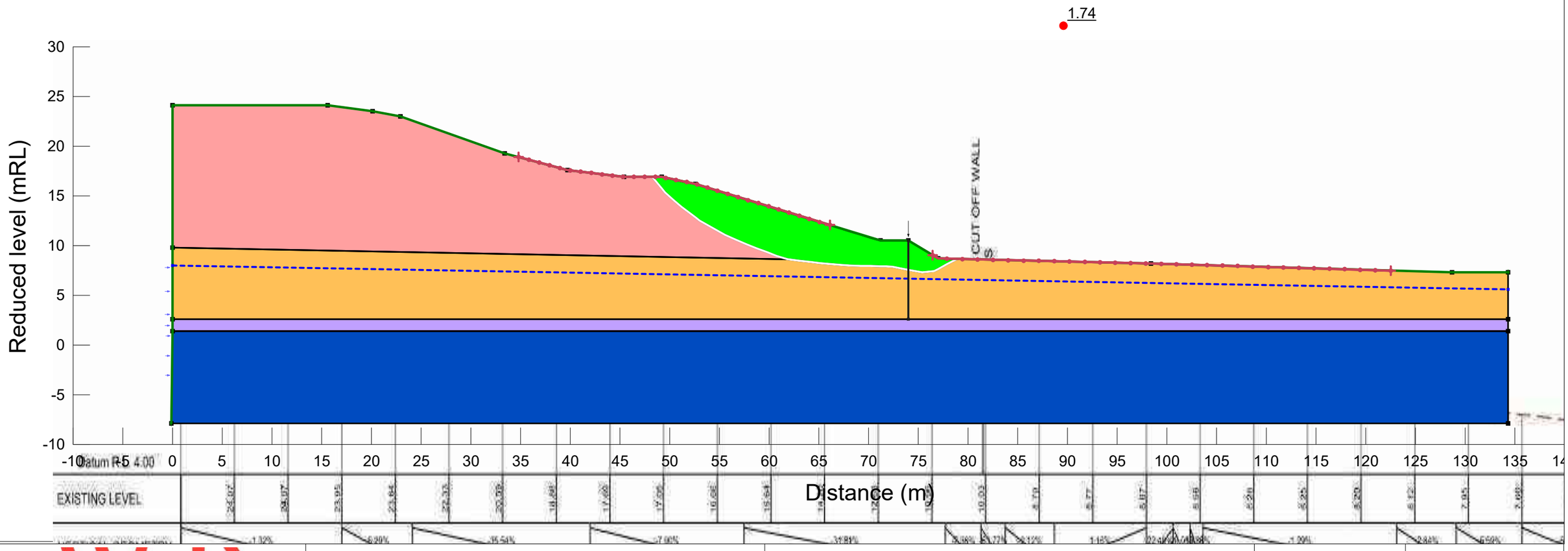
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.: 0.06

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Existing Clay Bund (Drained)	Mohr-Coulomb	18	3	28	0	1
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Unit 2 - Alluvial Deposits (Drained)	Mohr-Coulomb	17	1	24	0	1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1



wsp	Mt Cooee Landfill Development Plan	1.3 Seismic - SLS	6-CO082.00 / Date: 06/04/2023 / Scale: 1:400 / By: NT

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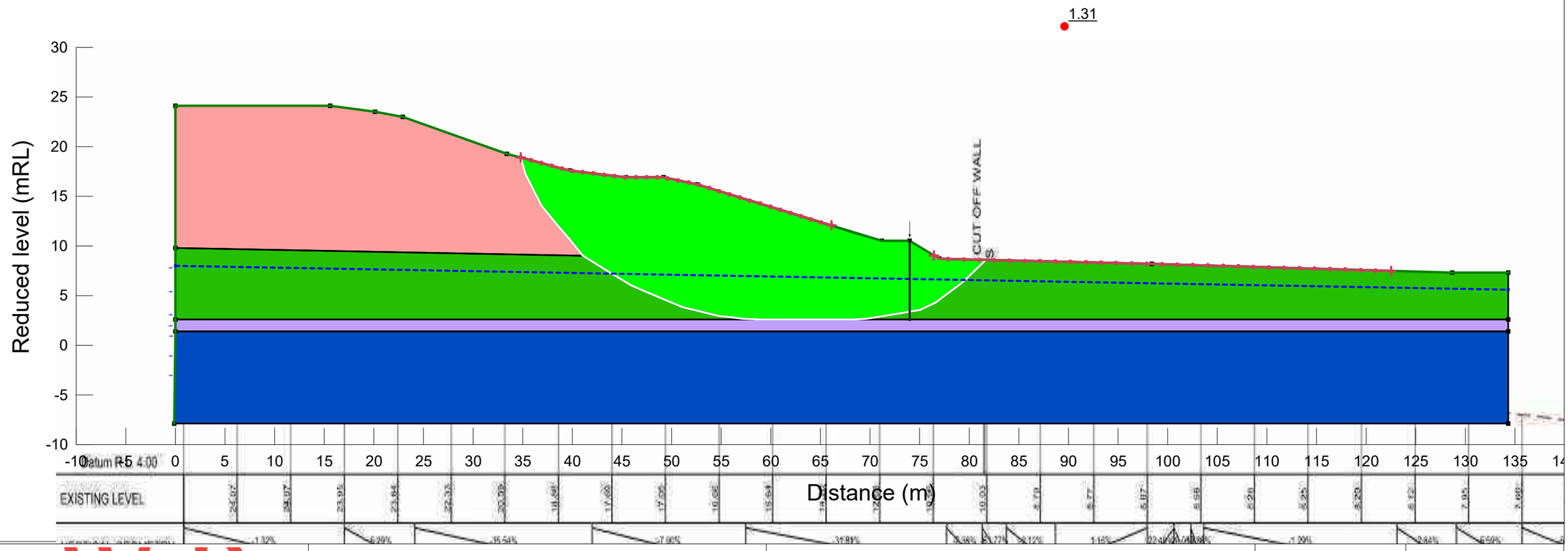
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.: 0.06

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Total Cohesion (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Existing Clay Bund (Drained)	Mohr-Coulomb	18		3	28	0	1
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13		5	25	0	1
	Unit 2 - Alluvial Deposits (Undrained)	Undrained (Phi=0)	17	30				1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21		20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23		30	44	0	1



wsp	Mt Cooee Landfill Development Plan	1.3 Seismic - SLS (Undrained)	6-CO082.00 / Date: 06/04/2023 / Scale: 1:400 / By: NT

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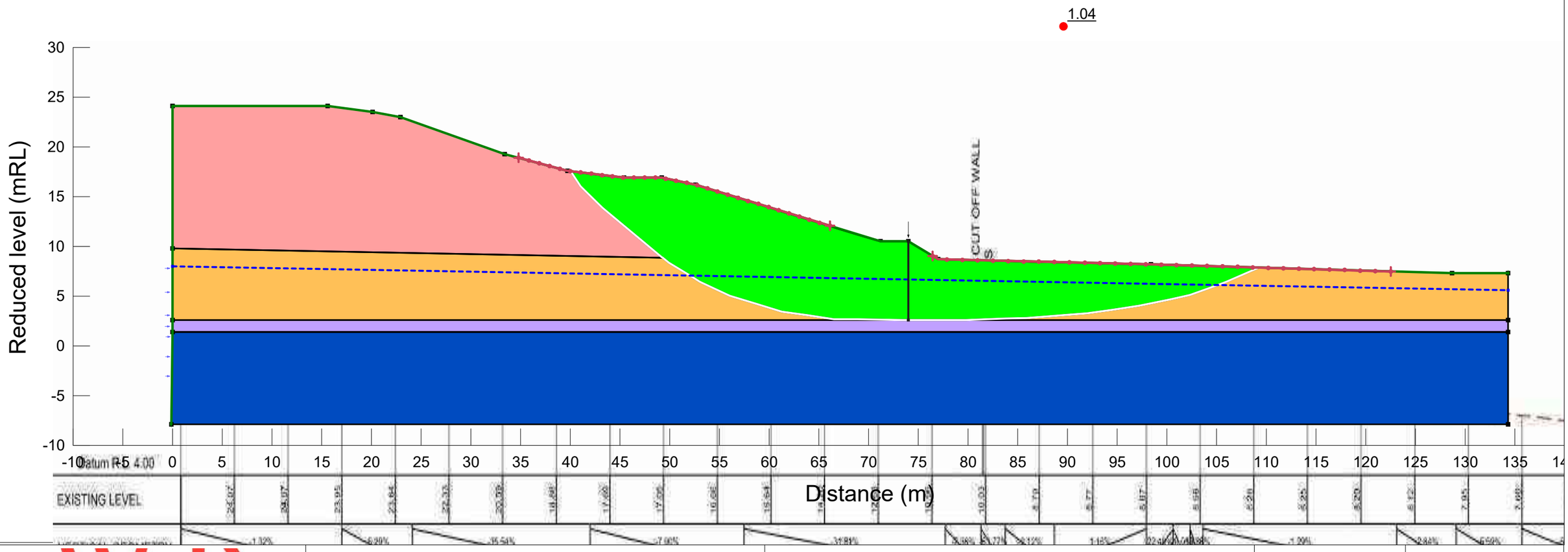
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.: 0.23

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Existing Clay Bund (Drained)	Mohr-Coulomb	18	3	28	0	1
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13	5	25	0	1
	Unit 2 - Alluvial Deposits (Drained)	Mohr-Coulomb	17	1	24	0	1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1



WSP	Mt Cooee Landfill Development Plan	1.4 Seismic - DCLS	6-CO082.00 / Date: 06/04/2023 / Scale: 1:400 / By: NT

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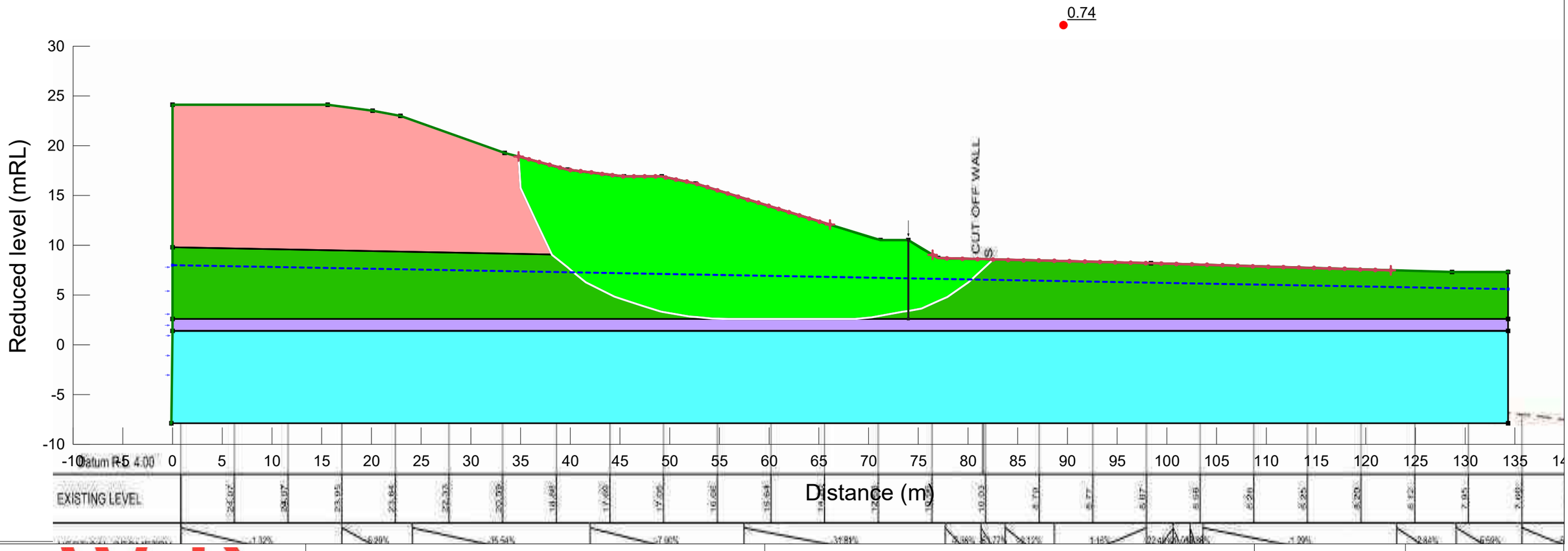
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.: 0.23

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Total Cohesion (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Existing Clay Bund (Drained)	Mohr-Coulomb	18		3	28	0	1
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13		5	25	0	1
	Unit 2 - Alluvial Deposits (Undrained)	Undrained (Phi=0)	17	30				1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21		20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Undrained)	Undrained (Phi=0)	23	750				1



wsp	Mt Cooee Landfill Development Plan	1.5 Seismic - DCLS (Undrained sensitivity)	6-CO082.00 / Date: 06/04/2023 / Scale: 1:400 / By: NT

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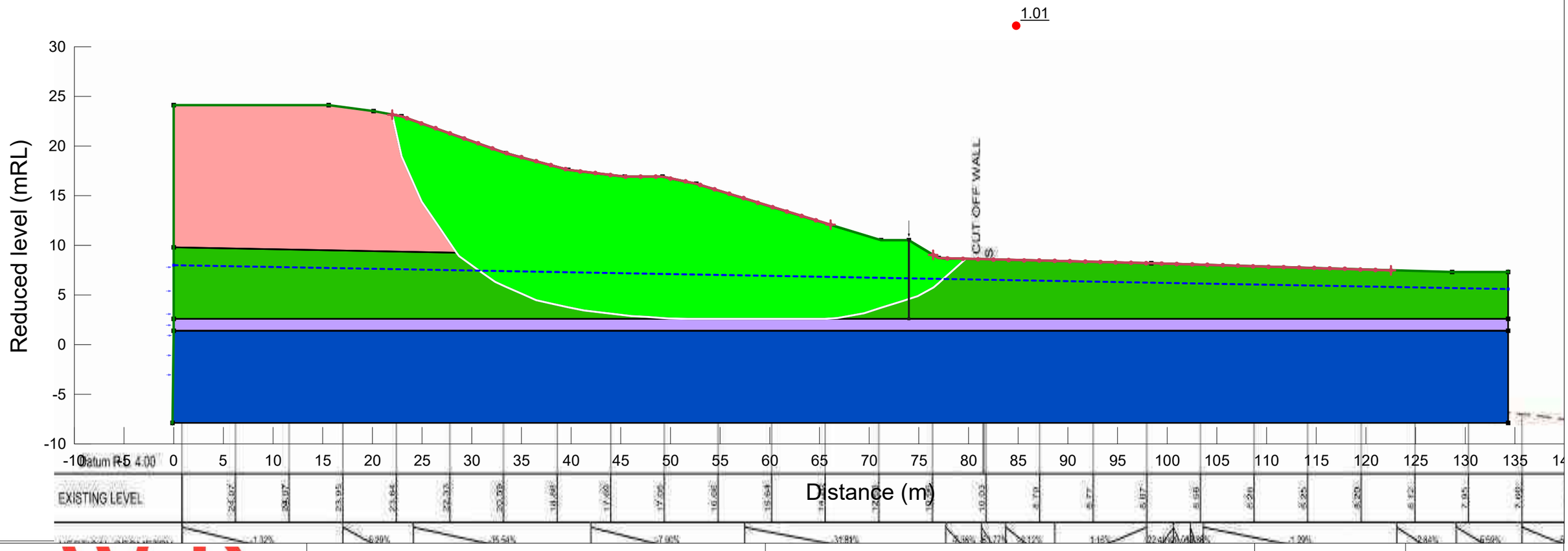
DO NOT SCALE

Version: 11.4.0.18

Horz Seismic Coef.: 0.08

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Total Cohesion (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Existing Clay Bund (Drained)	Mohr-Coulomb	18		3	28	0	1
	Refuse / Waste (Drained) - Nominal Parameters	Mohr-Coulomb	13		5	25	0	1
	Unit 2 - Alluvial Deposits (Undrained)	Undrained (Phi=0)	17	30				1
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21		20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23		30	44	0	1



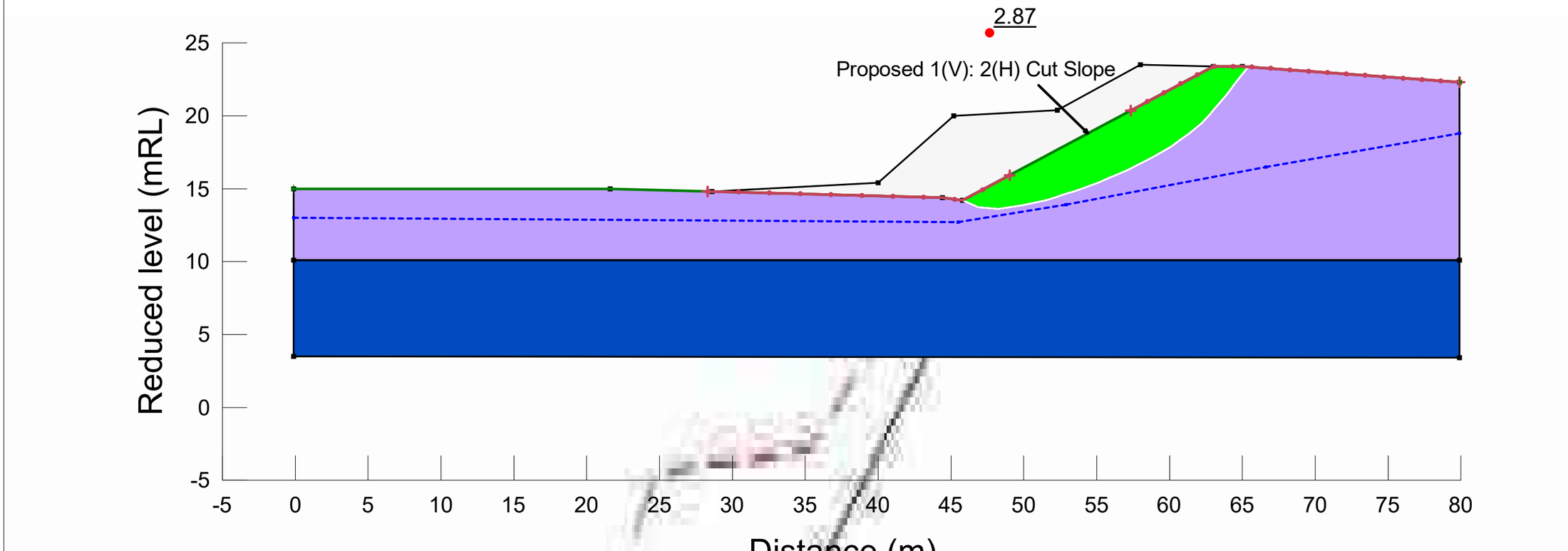
wsp	Mt Cooee Landfill Development Plan	1.6 Seismic - Yield Acceleration (Undrained)	6-CO082.00 / Date: 06/04/2023 / Scale: 1:400 / By: NT

Horz Seismic Coef.:

Method: Morgenstern-Price

Transfer Station Cut Stability Outputs

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1

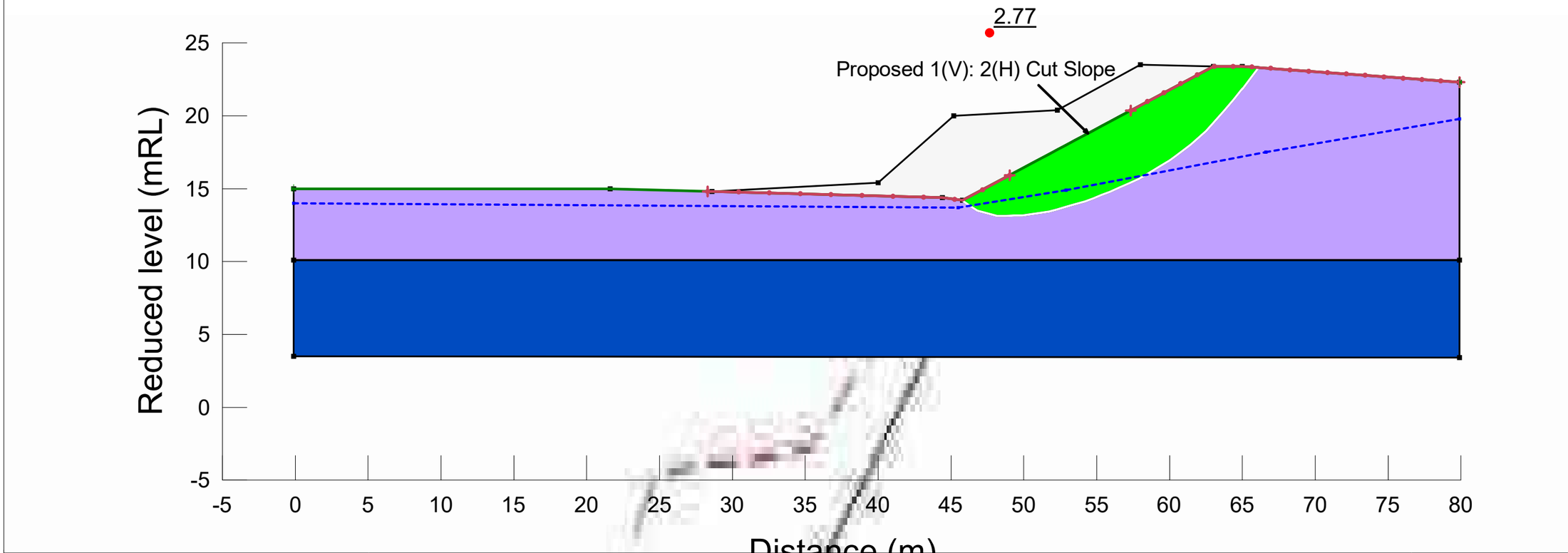


wsp	Mt Cooee Landfill Development Plan	1.1 Static - Long term (Unit 3b)	6-CO082.00 / Date: 06/04/2023
			Scale: 1:300 / By: NT

Horz Seismic Coef.:

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1

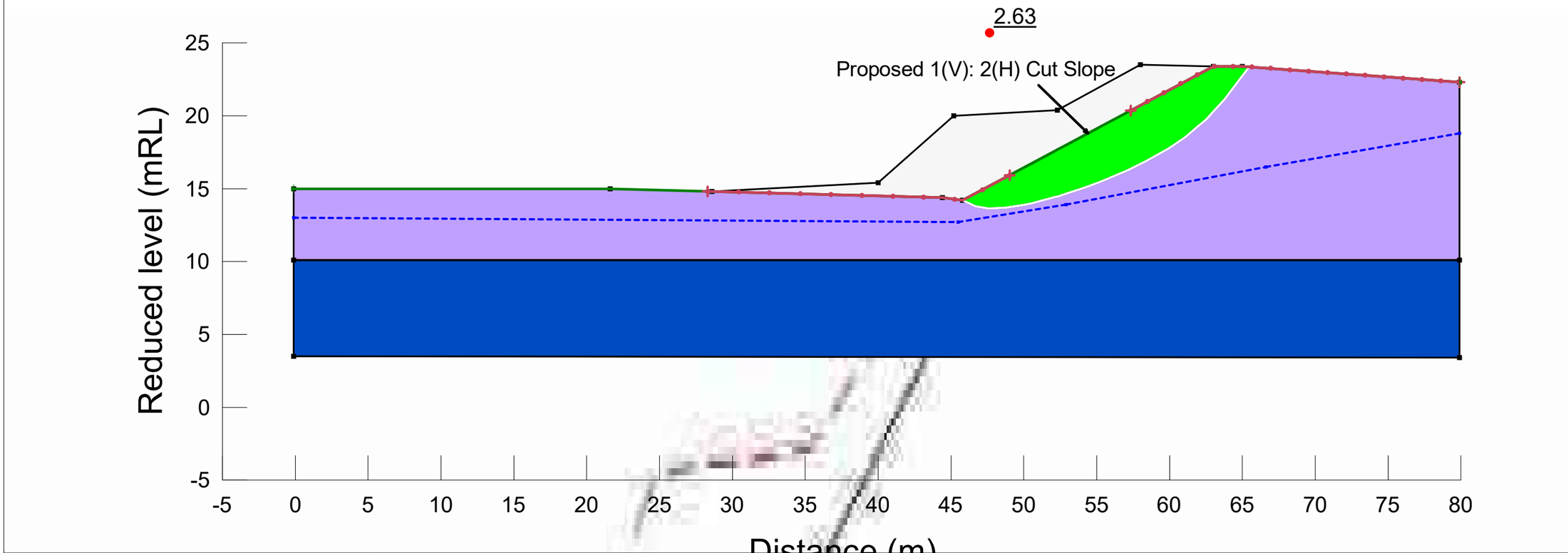


wsp	Mt Cooee Landfill Development Plan	1.2 Static - Short Term (High GWL)	6-CO082.00 / Date: 06/04/2023 / Scale: 1:300 / By: NT

Horz Seismic Coef.: 0.04

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1

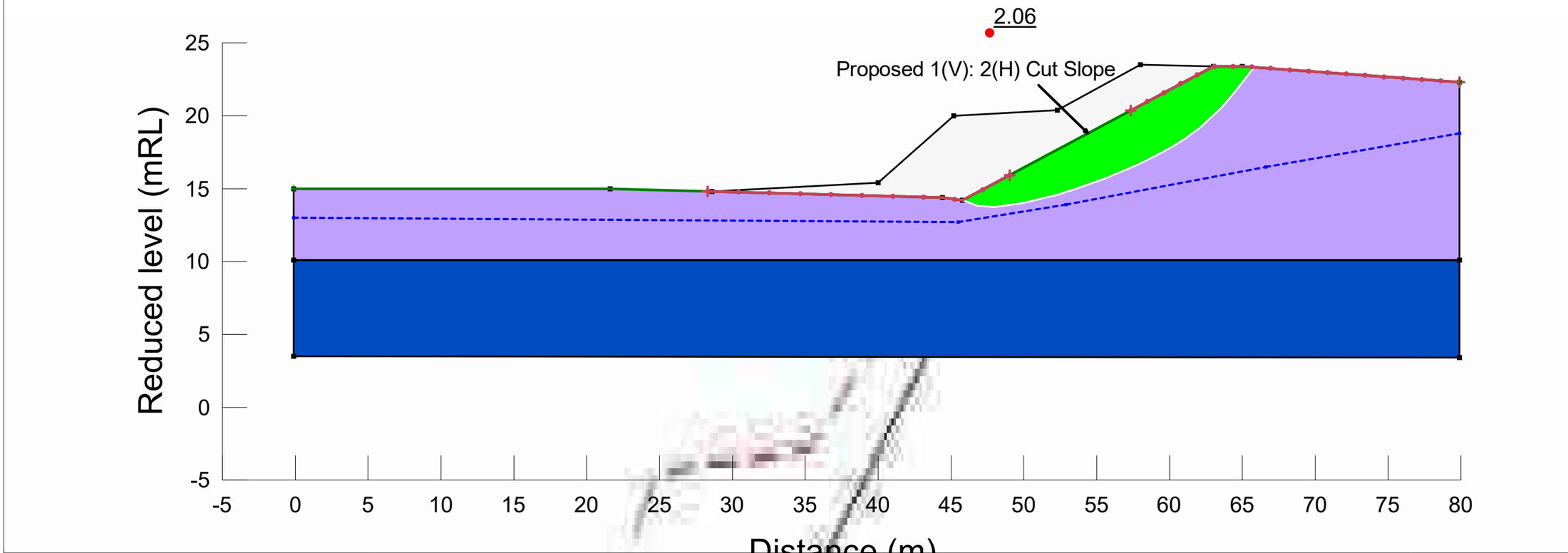


wsp	Mt Cooee Landfill Development Plan	1.3 Seismic - SLS	6-CO082.00 / Date: 06/04/2023
			Scale: 1:300 / By: NT

Horz Seismic Coef.: 0.17

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	21	20	40	0	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0	1

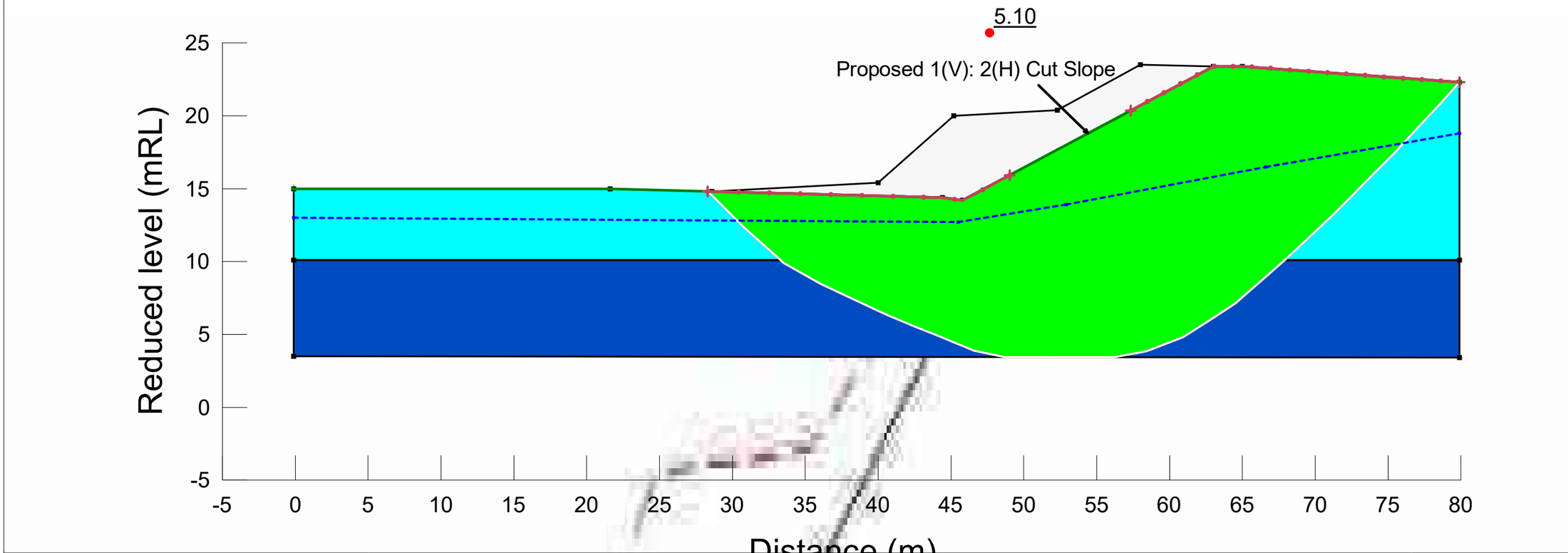


wsp	Mt Cooee Landfill Development Plan	1.4 Seismic - DCLS	6-CO082.00 / Date: 06/04/2023
			Scale: 1:300 / By: NT

Horz Seismic Coef.: 0.17

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Total Cohesion (kPa)	Piezom Surface
	Unit 3b - Highly to moderately weathered, very weak to weak SANDSTONE/SILTSTONE (Undrained)	Undrained (Phi=0)	21				400	1
	Unit 3c - Slightly weathered, moderately strong to strong SANDSTONE/SILTSTONE (Drained)	Mohr-Coulomb	23	30	44	0		1



wsp	Mt Cooee Landfill Development Plan	1.5 Seismic - DCLS (Undrained sensitivity)	6-CO082.00 / Date: 06/04/2023
			Scale: 1:300 / By: NT

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