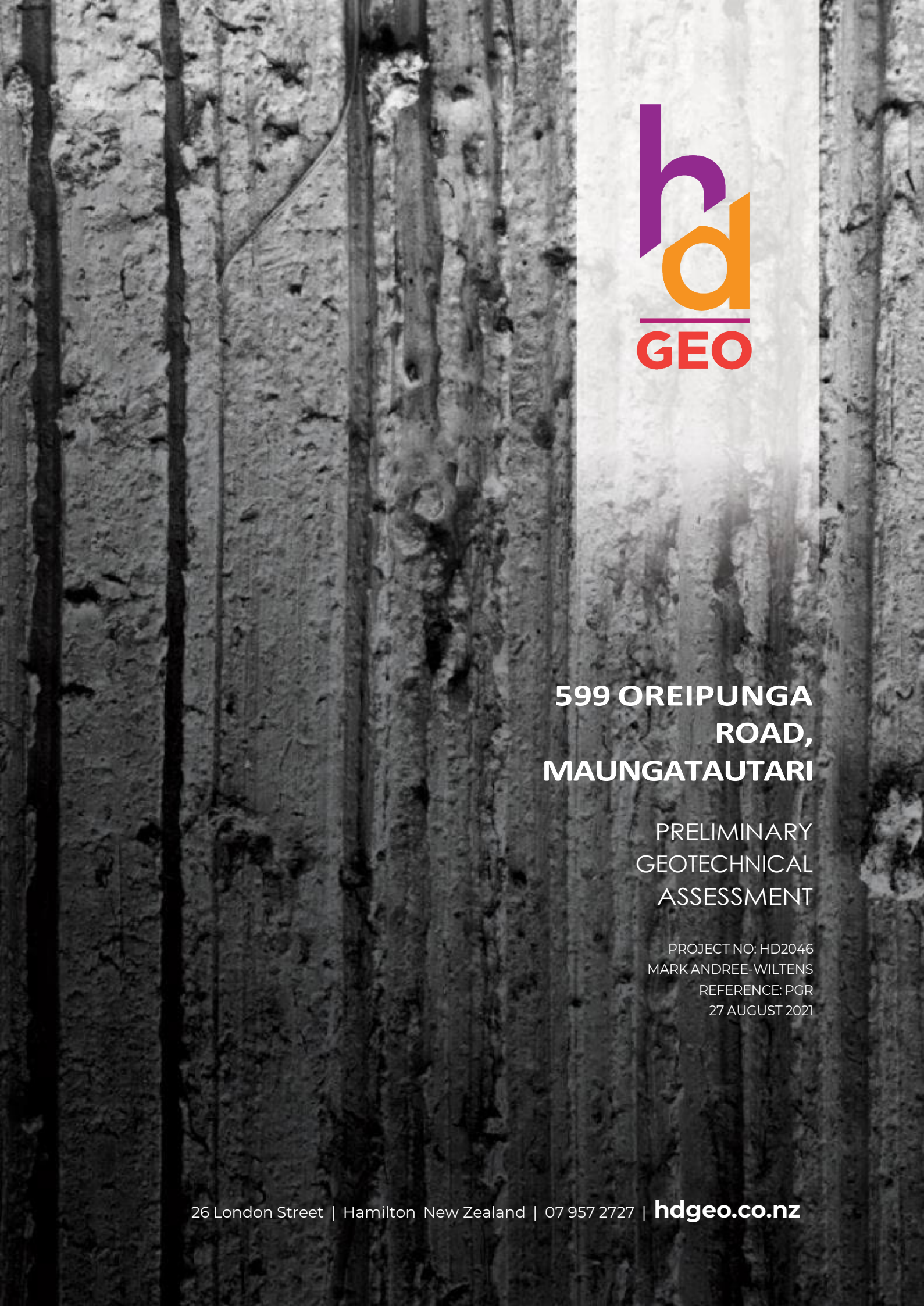
APPENDIX C

Preliminary Geotechnical Assessment – HdGeo



599 OREIPUNGA ROAD, MAUNGATAUTARI

PRELIMINARY GEOTECHNICAL ASSESSMENT

PROJECT NO: HD2046
MARK ANDREE-WILTENS
REFERENCE: PGR
27 AUGUST 2021

26 London Street | Hamilton New Zealand | 07 957 2727 | **hdgeo.co.nz**

Executive summary

Introduction

Mark Andree-Wiltens proposes to develop his existing farm located at 599 Oreipunga Road, Maungatautari into a sand quarry. We have been engaged to undertake a preliminary geotechnical assessment to assess the effects that the development may have on the surrounding area, and to give preliminary recommendations on how to develop the site.

This report presents the results of our investigation and assessment for the development of the quarry. A site plan showing the proposed quarry stages is included in Appendix A.

This report is intended to be submitted to the Waipa District Council and Waikato Regional Council in support of a resource consent application for the development of the quarry.

Our scope included

- a desktop study of the site to review existing information, including historical aerial images, geology maps, contour maps, and the NZ Geotechnical Database (NZGD)
- a site investigation, including 4 hand augers and 4 cone penetration tests across the site
- a drone survey of the site
- a quantitative slope stability assessment
- recommendations for developing the site including recommendations for slope setbacks and slope geometry

Our recommendations are

- an excavation restriction zone 20 m wide should be applied to the gully features on the site
- the final batters should be constructed at 2.5H:1V and maximum 10 m high, two batters can be separated by a 10 m horizontal bench
- groundwater seepage from perched groundwater must be controlled appropriately to avoid erosion
- more detailed assessment will be needed for any change in the recommended geometry above (higher or steeper)
- the final batters should be vegetated to mitigate erosion

Contents

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TECHNICAL DIRECTOR, PRINCIPAL ENGINEER

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Introduction

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Site description

The site is located at 599 Oreipunga Road, Maungatautari. It is bounded by Oreipunga Road to the west, the Waikato River (lake Karapiro) to the east and rural farmland to the north and south.

The site is formed by three distinct river terraces, the upper terrace is in the west and the lower terrace is in the east, bordering the Waikato River, and one terrace in between. The upper terrace is located at approximately 120 m above local datum[1], with the lower at approximately 80 m, and the intermediate at approximately 100 m.

There are several gully features running from the terraces to the Waikato River. There is a gully located in the northern side of site (gully a) and a gully on the southern side of site (gully b). These features both run west to east. These gully features are shown as natural wetlands on plans[2] provided.

There is an existing sand quarry covering an area approximately 300 m^2, located centrally in the site currently being mined. The sand quarry is currently 14 m deep at the deepest point.

A geomorphic map of the site is included in Appendix A

Proposed development

Mark Andree-Wiltens proposes to mine sand from the site in 5 stages across the river terraces. Four stages are proposed for the upper terrace and 1 for the lower terrace. A yield of up to 1,032,000 m^3 of sand is shown on plans provided.

[1] Waikato Regional Council Contours, Local Maps, https://waikatomaps.waikatoregion.govt.nz/Viewer/?map=8d6d6fda779b4e59951953ae97d0ec4a. Accessed 17/07/21

[2] Cogswell Surveys: Proposed Quarry Staging Plan. Drawing number: 11191-C-001. Dated: 08/03/21.

A proposed quarry staging plan is included in Appendix A.

Desk study

Geological setting

The geology map of the area[3] indicates that the site is underlain by the Late Pleistocene Hinuera Formation on the lower river terrace in the east and Early Pleistocene River Deposits on the upper river terrace in the west. The Hinuera Formation is described as cross-bedded pumice sand, silt and gravel with interbedded peat and the Early Pleistocene River Deposits are described as poorly to moderately sorted gravel with minor boulders, sand and silt underlying terraces; includes minor fan deposits and loess.

Aerial imagery

We have sourced aerial images of the site from Retrolens[4], Google Earth[5], and our drone survey[6]. Clear photos were available from 1944 to 2021. The photos show significant geomorphic changes to the site and its surroundings, summarised in Table 1 below. Relevant aerial images are included in Appendix B.

Table 1: Aerial imagery summary

Image year	Description of changes
1944 (Retrolens)	Three distinct river terraces can be seen on the site with several gullies heading east into the Waikato River. The upper two river terraces are pastured with the lower terrace exposed sand. No signs of mining the lower terrace can be seen at this stage.
1947 (Retrolens)	Substantial mining of sand can be seen on the lowest river terrace area beside the Waikato River.
1964 (Retrolens)	The lowest river terrace is covered by water. The completion of the Karapiro Dam has raised the water level.
1974 (Retrolens)	No significant changes can be seen on the site.
1981 (Retrolens)	A large slope failure has occurred on the southern side of a major tributary gully to the Waikato River. The head of this failure extends to the south and has formed a smaller gully type feature. The failed debris has flowed out of the gully creating a debris lobe in the Waikato River.
1995 (Retrolens)	The debris lobe identified in 1981 has become vegetated indicating that there has been no further significant failures at this location. Minor slope regression and debris lobes can been seen to the south of the previous failure indicating that the river banks are still marginally stable.
2019 (Google Earth Pro)	The gully formed from the 1981 slope failure is being filled. The current quarry site has been further mined. An area to the south of the current quarry site has been excavated.

[3] 1:250,000 Geological Map of New Zealand. New Zealand Geology Web Map. GNS, 2013. http://data.gns.cri.nz/. Accessed 17/07/21
[4] Sourced from https://retrolens.co.nz/ and licensed by LINZ CC-BY 3.0.
[5] Google Earth Pro
[6] HD Geo Ltd, Drone Survey, Completed 7 July 2021

2021 (Drone survey)	A small slope failure can be seen on the northern side of the gully on the northern side of site. The area of fill has been levelled and planted back into pasture.

NZGD

We have reviewed the NZ Geotechnical Database (NZGD) in the area of the site. The database has no information within 2 km of the site.

Site investigation

Our site investigation included a site walkover, 4 hand augers and 4 cone penetration tests (CPTs) across Stages 2 to 5 of the site.

From our site walkover, ignimbrite outcrops and cut faces of ignimbrite were noted around the bases of the gullies across the site. Cut faces on the northern side of Stage 4, around gully b, show a highly welded ignimbrite. Ignimbrite in the bases of gully b shows the ignimbrite being undermined and still stable.

From our walkover of the current quarry area it could be seen that very steep cut faces appear marginally stable. The materials in the quarry cut faces show interbedded layers of gravels, sands and silty sand.

On the natural slopes between the river terraces signs of soil creep, exaggerated by stock, was noted.

Shallow ground investigation

The materials we encountered on site during our hand auger investigation were consistent with the mapped geology across the two terraces. Ground conditions on the site are summarised in Table 2 below. Hand auger logs and locations are included in Appendix C.

Table 2: Ground conditions from hand auger investigation

Geologic unit	Average depth (m bgl)		Typical description	Typical strength
	Upper terrace	Lower terrace		
Topsoil	0.0 - 0.3	0.0 – 0.3	organic silt	N/A
Hinuera formation	0.3 - 3.0	N/A	sandy silt or, sand	loose to medium dense
Early Pleistocene River Deposits	N/A	0.3 – 3.0	sandy silt or, sand	medium dense

Deep ground investigation

Deeper ground conditions interpreted from the CPTs on the site are summarised below. CPT interpretations and locations are included in Appendix C.

Stage 2:

- interbedded clay, silty sand, and sandy silt to 13 m bgl

- clay to 21 m bgl
- interbedded silty sand, and sandy silt to 22.5 m bgl

The cone penetration test within Stage 2 (CPT01) refused at 22.5 m bgl with over 30 MPa cone resistance. This material has been inferred to be ignimbrite.

Stage 3:

- clay to 1 m bgl
- interbedded silty sand, and sandy silt to 7 m bgl
- interbedded silty sand, and silty clay to 13 m bgl
- interbedded silty sand, and very dense soils to 23 m bgl

The cone penetration test within Stage 3 (CPT02) refused at 23 m bgl with over 20 MPa cone resistance. This material has been inferred to be ignimbrite.

Stage 4:

- interbedded silty sand, and sandy silt to 18 m bgl
- interbedded clay, and silty clay to 30 m bgl

The cone penetration test within Stage 4 (CPT03) reached the target depth of 30 m bgl.

Stage 5:

- interbedded sand, and silty sand to 25 m bgl

The cone penetration test within Stage 5 (CPT04) refused at 25 m bgl with over 40 MPa cone resistance. This material has been inferred to be ignimbrite.

Groundwater

Groundwater was not encountered during the hand auger investigation to a depth of 3 m below ground level. A summary of where groundwater was encountered can be seen in Table 3.

Table 3: Groundwater summary

Location	CPT ID	Depth to groundwater (m bgl)	Comments
Stage 2	CPT 01	22.5	Groundwater was encountered at the base of the CPT when it refused. Perched on the inferred ignimbrite.
Stage 3	CPT 02	None	Minor perched groundwater layers between 7.5 and 11 m bgl.
Stage 4	CPT 03	None	Perched groundwater layers between 18 and 30 m bgl.
Stage 5	CPT 04	11.5	None.

Geotechnical assessment

Natural hazards

- **Earthquake:** The site subsoil class is C 'shallow soil'. Design peak ground acceleration for the 1 in 500-year average recurrence interval earthquake event is calculated[7] to be 0.27 g for stability assessment. For earthquake induced liquefaction see liquefaction section below.
- **Volcanic, geothermal, or sedimentation activity:** The site is not near any known active sources of these risks.
- **Landslips:** See slope stability section below.
- **Erosion:** No indications of erosion were observed during the site investigation, and we consider the site to be generally at low risk of damage due to erosion. The risk of erosion will elevate during construction of the batters as we expect groundwater seepage to occur in the near surface perched water tables. This risk will be managed through the site management plan and good construction management will mitigate the risk.
- **Subsidence:** Risk of the site to general subsidence is low.

Liquefaction

Liquefaction is unlikely to occur in the sand soils across stages 2 to 4 due to the absence of a shallow global ground water table within the sand soils.

We have undertaken a quantitative liquefaction assessment for Stage 5 where there is potential for liquefaction due to global groundwater being present within the sandy soils. We have analysed the CPT data using the proprietary software CLIQ (Geologismiki) and engineering calculations under the most recent guidelines[8]. We have used a groundwater level of 11.5 m bgl and a ULS PGA of 0.27 g.

Under ULS conditions, no liquefaction was predicted for the Stage 5 area.

Considering final topographic conditions, assuming Stage 5 has been mined by 7 m to become approximately level with the terrace below. The assessment predicts liquefaction to occur in the sand and silty sand layers from 12 m to 14 m and 16 m to 24 m below current ground level. We have assessed the Stage 5 stability under liquefied conditions – see Slope stability section below.

Specific assessment of liquefaction is needed if any structures are to be built across the site.

Slope stability

We have conducted a quantitative slope stability assessment using the proprietary software 'SLIDE' based on-site observations, aerial imagery, a site-specific survey and our experience in the area. Material parameters for our model were determined from site test information (CPT corelation), our experience in the area and from back assessment of the existing slopes. The parameters adopted are shown on the model outputs which are presented in Appendix D.

The Factor of Safety (FoS) requirements for the final geometry are:

- no less than 1.5 for long term, normal, static conditions
- no less than 1.2 for short term, seismic, elevated groundwater, and liquefied conditions

[7] New Zealand Transport Agency (October 2018). Bridge Manual (SP/M/022). Third edition, Amendment 3
[8] Ministry of Business Innovation and Employment (MBIE)/New Zealand Geotechnical Society (NZGS). Module 3: Identification, assessment and mitigation of liquefaction hazards. Dated May 2016

Aerial imagery assessment

The natural slopes surrounding the gully systems and the Waikato River are considered marginally stable with evidence of large-scale failures present on site and during the historic imagery review. The large-scale instability around gully a was caused by the elevation of groundwater from the construction of the Karapiro Dam. Modification of these slopes directly are not proposed but modification of the area surrounding the gullies are.

Back assessment

By assessing the slope geometry of the current quarry site, we were able to iterate our model until representative FoS values were achieved. A FoS of just over 1.0 during long term, normal ground water conditions was used as representative of the current slope conditions.

The results from this back assessment using the existing slope geometry provides validation of the soil parameters adopted for the assessment of the proposed batters.

Slope stability discussion

The natural slopes surrounding the gully systems are considered marginally stable with evidence of large-scale failures on site and during the historic imagery review. Modification of these slopes directly are not proposed but modification of the area surrounding the gullies are. Modification includes excavating areas nearby to mine sand. It would be beneficial to slope stability to be able to lower and modify the slopes surrounding these gullies to increase the stability. However we understand from an environmental standpoint this is likely not an option.

We recommend an excavation restriction zone of 20 m be applied to the gullies. Any future development or earthworks proposed within this 20 m zone should be assessed by a geotechnical engineer prior to any works commencing.

We have assessed batter slopes and benches to determine a suitable, and stable final geometry for the quarry. Final geometry of the batter slopes should be no steeper than 2.5H:1V and no higher than 10 m high. A 10 m horizontal bench can separate two, maximum 10 m high 2.5H:1V batter slopes. A schematic of the proposed final geometry can be seen in Figure 1 below.

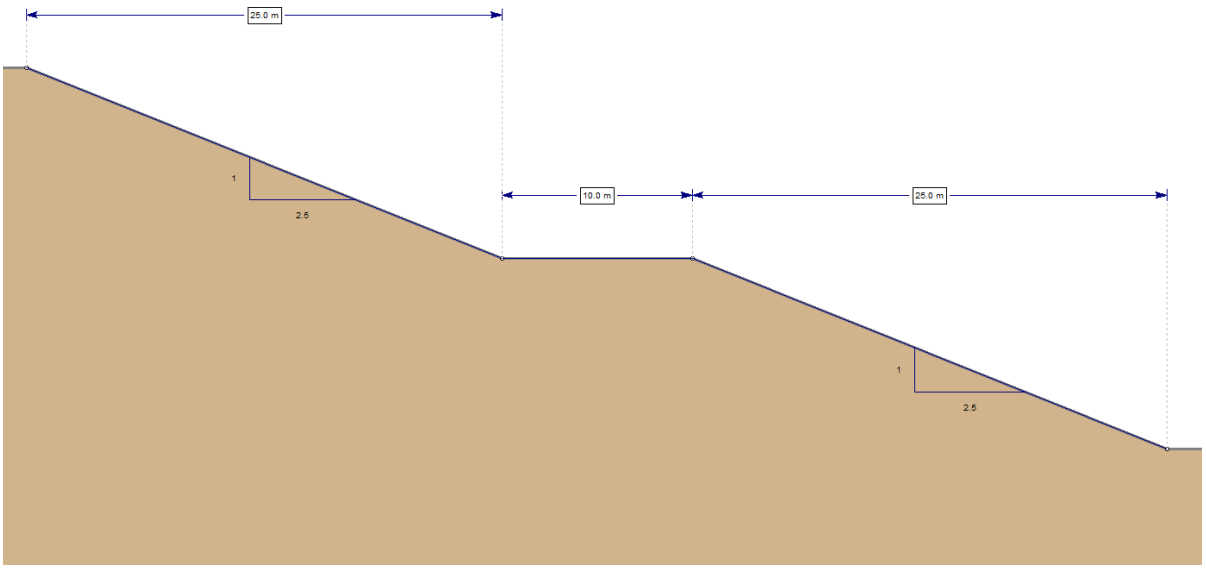


Figure 1: Final geometry of slopes

Stage 5 was assessed with an additional case of liquefied conditions, assuming it is to be lowered approximately 7 m to be level with the lower terrace. Under liquefied conditions with a 2.5H:1V, 7 m high batter slope the batter is stable with a factor of safety greater than 1.2.

We recommend that the final batters are re-vegetated to mitigate erosion. Small scale slumping may occur but can be remediated with an excavator when required. Any small-scale failures of the batters will not affect the quarry or land surrounding the quarry.

Groundwater modification

The construction of the final batter is likely to cause perched groundwater in the near surface silt and sand soils to drain. This may cause localised erosion and instability. However, the scale of any failure will be small and can be controlled with appropriate dewatering and or erosion control techniques during construction.

We expect that the regional ground water table will be lower than the base of any of the final quarry RL's.

Further work

Further assessment will be required if the geometry of the batters if they are to be higher or steeper than outlined above. Geotechnical input will be needed during operation of the quarry for any changes to the final slopes and/or staging plans.

We recommend a quarrying management plan is implemented to control activities in the quarry.

Summary

Based on our assessment, the proposed sand quarry is unlikely to cause any adverse geotechnical effects on the adjacent properties or identified gullies/wetlands, subject to the following recommendations:

- we recommend an excavation restriction zone of 20 m be applied to the gully features on the site
- the final batters should be constructed at 2.5H:1V and maximum 10 m high, two batters can be separated by a 10 m horizontal bench
- further assessment will be needed for any change in geometry to be higher or steeper
- the final batters should be vegetated to mitigate erosion
- groundwater seepage from perched groundwater must be controlled appropriately to avoid erosion
- a quarrying management plan that includes requirements for cuts, fills and erosion control should be prepared to guide quarrying activities.

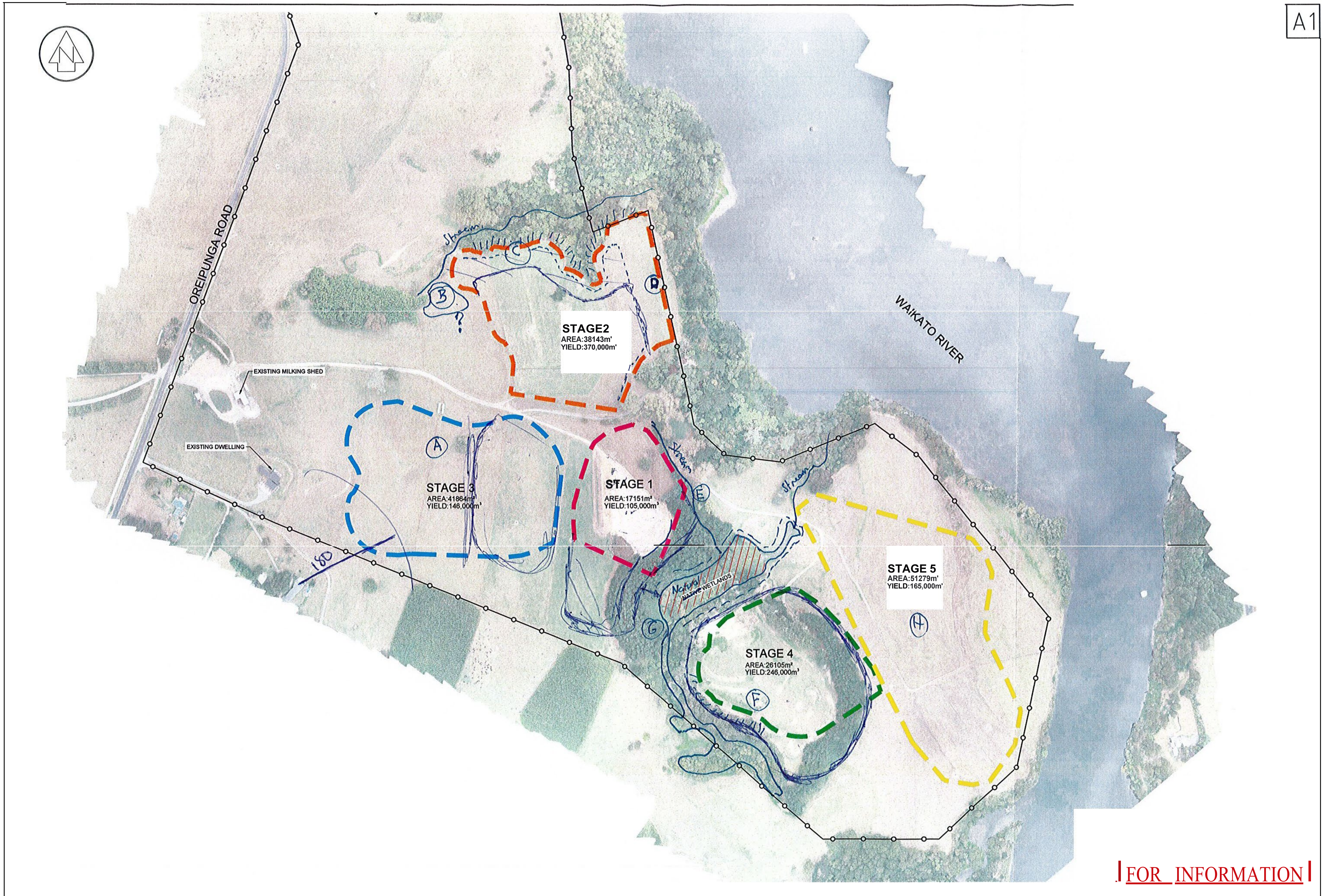
Limitation

This report has been prepared for our client, Mark Andree-Wiltens, their professional advisers, and the relevant local authority for the purposes detailed above and may not be relied on by any other party for any other purposes. This report contains a preliminary assessment to establish possible geotechnical end effects that may occur during the construction of a sand quarry based on a site walkover and testing in discrete locations. Inferences about the conditions at the site have been made based on the testing undertaken and our understanding of the highly variable geological environment in which the site lies.

Further geotechnical input will be required during the construction and operation or if any structures are to be built.

APPENDIX A – QUARRY STAGING PLAN AND GEOMORPHIC MAP

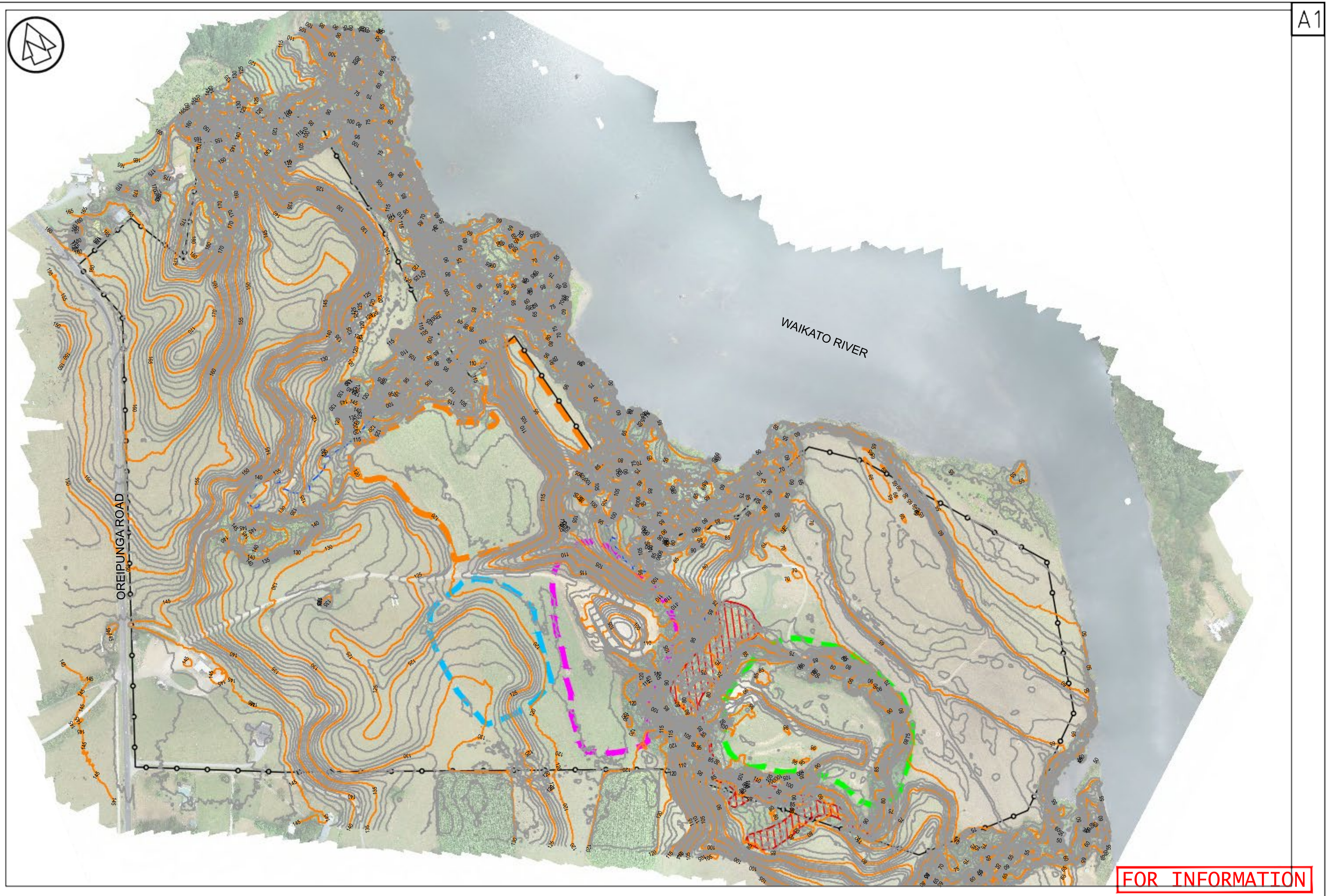
A1



FOR INFORMATION

COGSWELL SURVEYS www.cogswellsurveys.co.nz REF 11191	MARK ANDREE-WILTENS	PROJECT SANO QUARRY 590 OREIPUNGA ROAD	PROPOSED QUARRY STAGING PLAN	NOTES THIS DRAWING OR DESIGN REMAINS THE PROPERTY OF, AND MAY NOT BE REPRODUCED, WITHOUT THE WRITTEN PERMISSION OF COGSWELL SURVEYS LTD	1:2000 @A1 1:4000 @A3 DATE 08.03.21 DRAWING NUMBER 11191-(-001 REV A

A1



FOR INFORMATION

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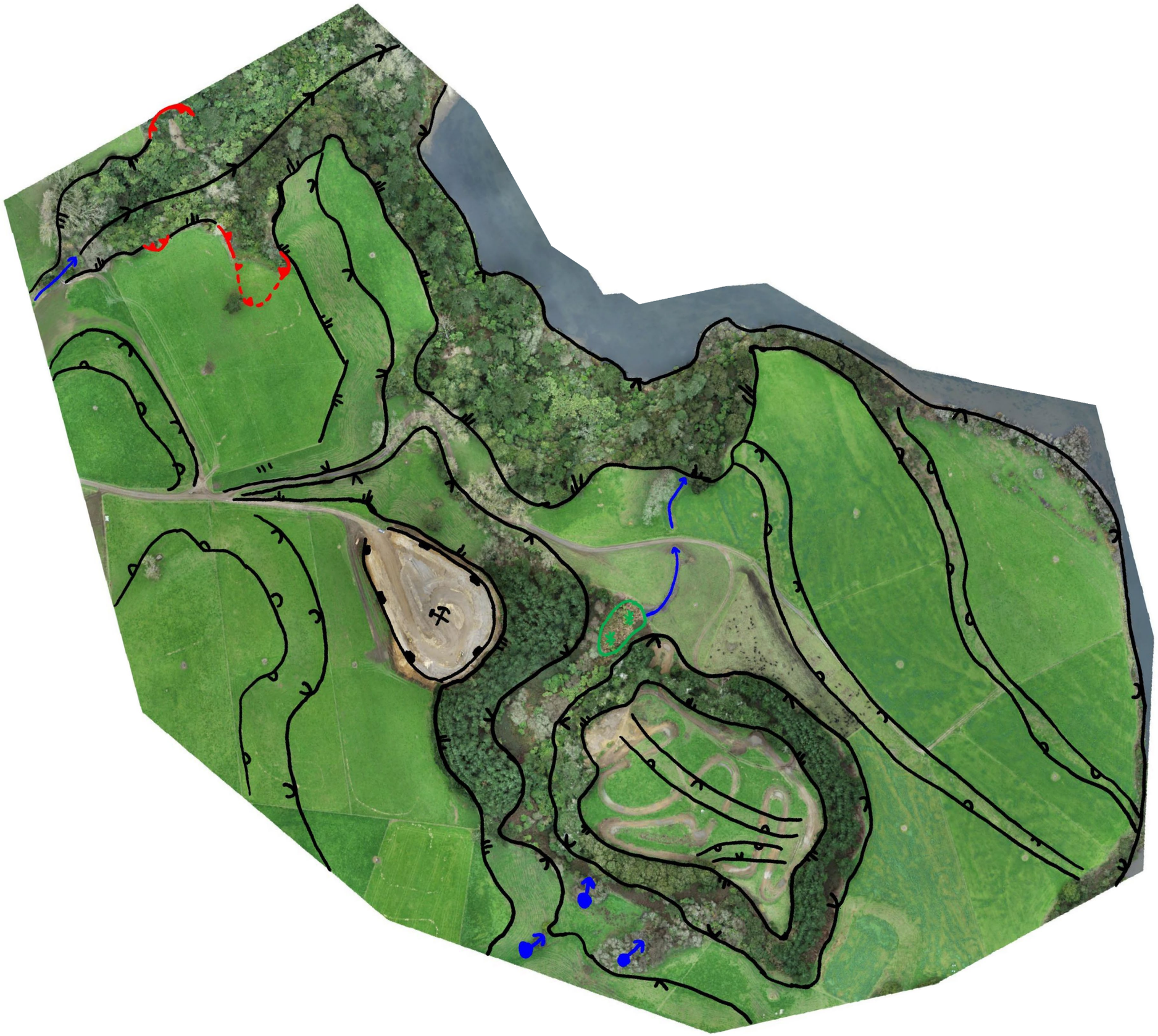
CLIENT
MARK ANDREE-WILTENS
REF 11191

PROJECT
SAND QUARRY
590 OREIPUNGA ROAD

TITLE
PROPOSED QUARRY
EXISTING CONTOURS PLAN

NOTES
1 LEVELS ARE IN TERMS OF NZVD2016
2 THE CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UNDERGROUND SERVICES PRIOR TO COMMENCING WORKS.
3 ALL WORKS AND MATERIALS TO COMPLY WITH REGIONAL INFRASTRUCTURE TECHNICAL SPECIFICATIONS (RITS)
4 A MEETING IS REQUIRED WITH THE CONTRACTOR AND ENGINEER PRIOR TO COMMENCING WORKS

SCALE 1:2000 @A1, 1:4000 @A3
DATE 20.08.21
DRAWING NUMBER 11191-C-002
REV A



Notes:

1. Image from HD Geo drone survey.

Legend:

Full geomorphic legend included on next page.

599 Oreipunga Road, Maungatautari

PROJECT No: HD2046

CLIENT: Mark Andree-Wiltens

TITLE: Geomorphic map

SCALE: N/A

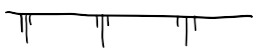
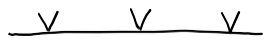
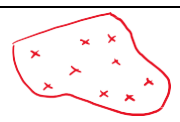
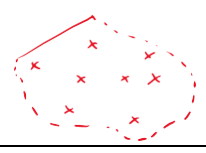
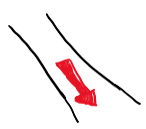
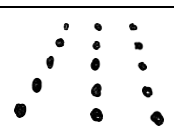
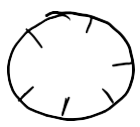
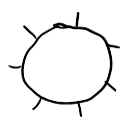
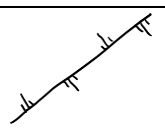
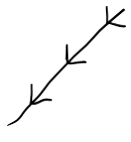
Drawing No: 01

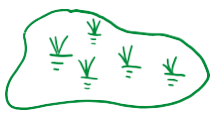
Drawing By: BK

Rev no:

1	Initial

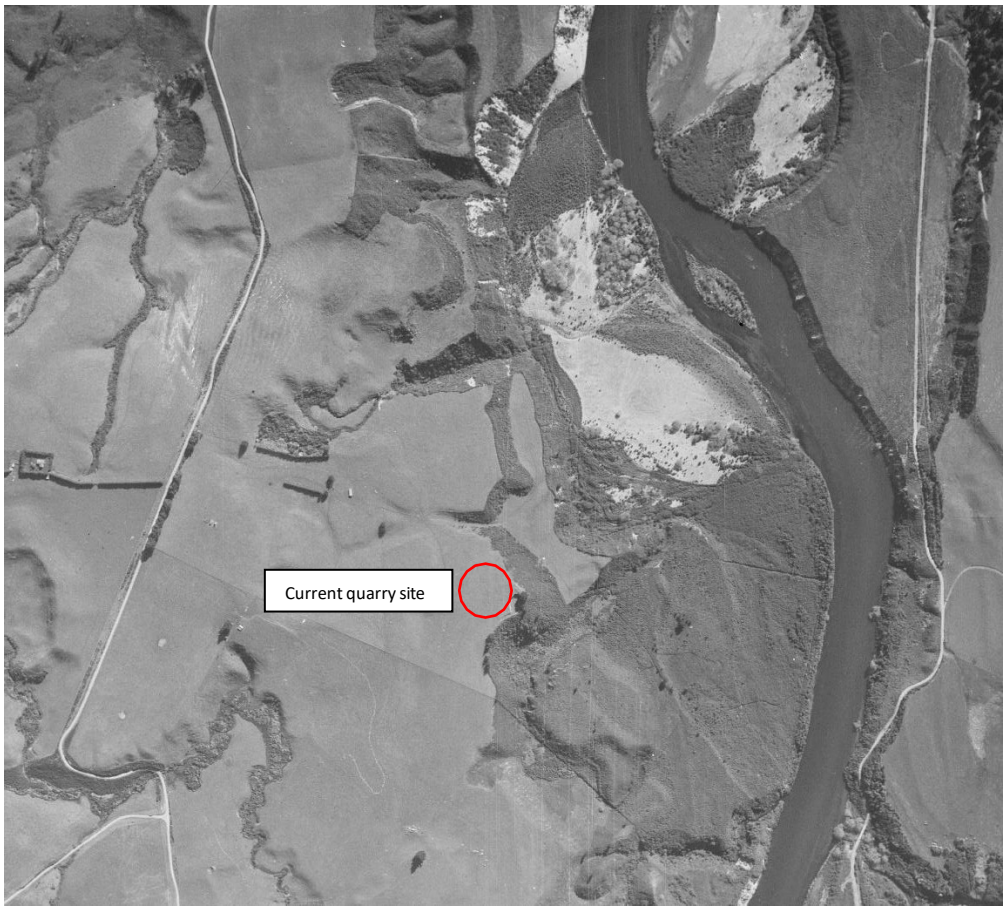
HD Geo geomorphology legend

Label	Symbol	Comments
Slope break convex - sharp		Points are down slope
Slope break convex - round		Top od the 'C' is down slope
Slope break concave - sharp		Bottom of 'V' is the bottom of slope
Slope break concave - round		Bottom of 'C' is the bottom of slope
Cliff bluff		Teeth going down slope
Slip/landslide scarp (known)		Points in the direction of failure
Slip/landslide scarp (inferred)		Points in the direction of failure
Slip/landslide debris (known)		Flat line along base of scarp
Slip/landslide debris (inferred)		Flat line along base of scarp
Debris flow		
Debris cone		
Debris slope (rock fall)		
Sink hole OR local depression		
Knoll		
Sharp ridge line		
Rounded ridge line		
V-shaped valley		Typically fluvially derived. Point of 'V' in direction of flow

U-shaped valley		Typically, glacially derived. Bottom of 'U' in direction of flow.
Hummocky terrain		Can be drawn over slip debris area (if applicable) to show surface expression.
Permanent water flow		
Ephemeral water flow		
Seepage		
Standing water		
Wetland/swamp		
Bedding - strike and dip or dip and dip direction (specify which)		Point of the 'T' in the direction of dip. Top of 'T' parallel with the strike of the plane.
Slope angle and direction		
Fault - normal		Ball and barb on the hanging wall. Arrow in the dip direction of the plane
Fault - thrust		Teeth on the hanging wall. Arrow in the dip direction of the plane
Fault - strike		This example shows a dextral fault. The opposite (far side moves to the left) is sinistral.
Mining or prospecting activity		Can include tunnel portals, old buildings, equipment or signs of prospecting

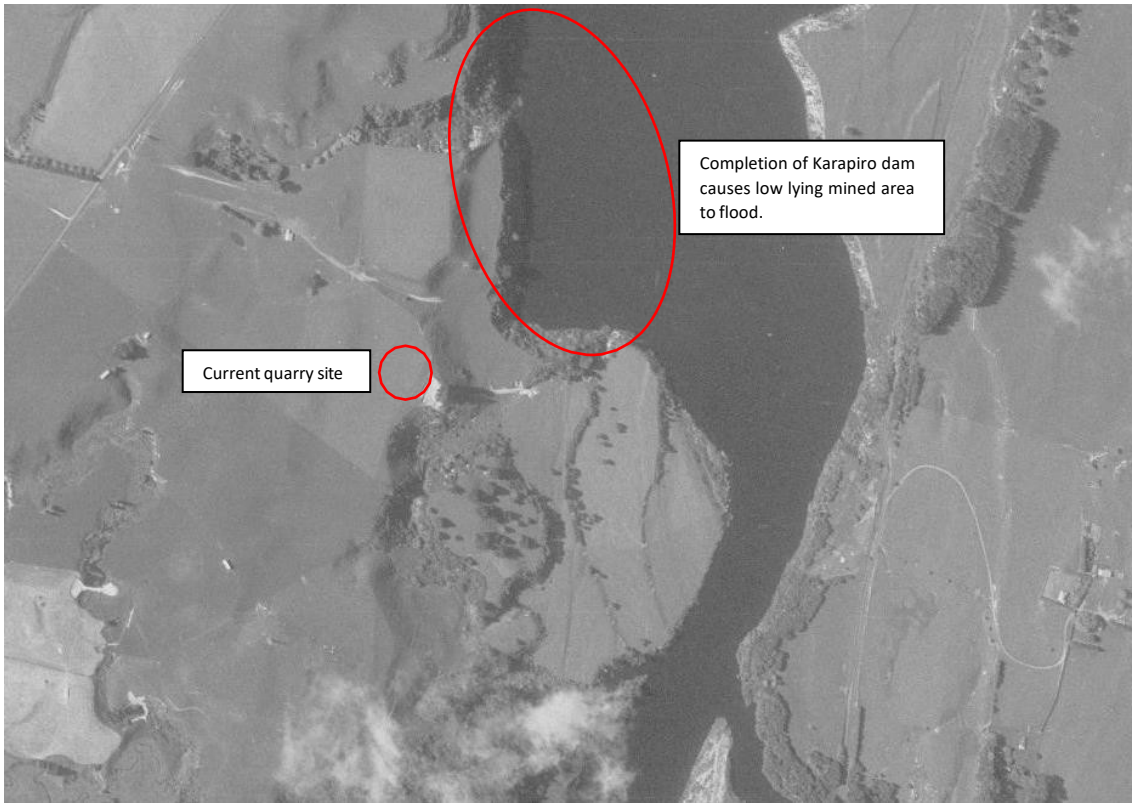
APPENDIX B – HISTORIC IMAGES

1944 – RETROLENS



1947 – RETROLENS

1964 – RETROLENS



1974 – RETROLENS

1981 – RETROLEN

1995 - RETROLENS

2019 – GOOGLE EARTH

2021 – DRONE MODEL

APPENDIX C – SITE INVESTIGATION DATA

Notes:

1. Image from Google Earth Pro.

Legend:

Cone penetration test

Hand auger

PROJECT: 599 Oreipunga Road, Maungatautari

PROJECT No: HD2046

CLIENT: Mark Andree-Wiltens

TITLE: Site investigation plan

SCALE: N/A

Drawing No: 01

Drawing By: BK

Rev no:

1	Initial

INVESTIGATION LOG

Client:	Cogswell Surveys Limited	**Job No.:**	HD2046
Project:	599 Oreipunga Road - Sand quarry	**No.:**	HA01
Location:	Northwestern portion of Stage 2.	**Date:**	07.07.21
Co-ordinates:	1832569mE, 5788567mN	**Logged By:**	AT
Elevation:	Ground	**Checked By:**	MM

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)	Legend	Scala Penetrometer (Blows / 100 mm)	Vane Shear Strength (kPa) Vane:	Water
Topsoil	TOPSOIL; dark brown. Moist; rootlets.	0.2	TS	2, 2, 2		
Hinuera Formation	Sandy SILT; light brown. Loose to medium dense; moist; sand, fine.	0.4		2, 1, 2		
		0.6		4		
	SAND, with minor silt; orange brown. Medium dense; moist; sand, fine to coarse.	0.8		3, 4		
	1.1 m: becomes loose.	1.0		6, 5		
		1.2		3, 2		
		1.4		2, 2		
	SILT; greyish white. Moist.	1.6		2, 3		
		1.8		4		
	Sandy SILT; light brown. Medium dense to dense; moist to wet; low dilatency; sand, fine.	2.0		5, 4		
		2.2		4, 5		
		2.4		5, 6		
		2.6		5, 6		
		2.8		7, 7		
	EOH: 3.00 m	3.0		8, 9		Groundwater Not Encountered

Scala Penetrometer scale: 2 4 6 8 10 12 14 16 18

Vane Shear Strength scale: 50 100 150 200 250

Photo

Remarks

End of borehole at 3.0 m - target depth. No groundwater encountered.

Shear Vanes

- Peak
- Remoulded

Water

- Standing Water Level
- Out flow
- In flow

Investigation Type

- [x] Hand Auger
- [ ] Investigation Pit
- [ ] Machine Borehole

INVESTIGATION LOG

Client:	Cogswell Surveys Limited
Project:	599 Oreipunga Road - Sand quarry
Location:	Centre of Stage 3.
Co-ordinates:	1832524mE, 5788333mN
Elevation:	Ground

Job No.:	HD2046
No.:	HA02
Date:	07.07.21
Logged By:	AT
Checked By:	MM

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)	Legend	Scala Penetrometer (Blows / 100 mm)	Vane Shear Strength (kPa)	Water
Topsoil	TOPSOIL; dark brown. Moist; rootlets.	0.2	TS	1, 2, 3		
Hinuera Formation	Sandy SILT; orange brown. Medium dense; moist; low dilatency; sand, fine.	0.4		3, 2, 3		
	1.0 m: becomes medium dense.	0.6		3, 3, 3		
		0.8		2, 3		
		1.0		5		
	SAND, with trace gravel; greyish brown. Loose; moist; well graded; sand, fine to coarse, pumiceous; gravel, fine.	1.2		3, 4		
		1.4		5, 4		
		1.6		5, 3		
		1.8		5, 4		
		2.0		6, 5		
		2.2		6, 6		
		2.4		5, 6		
		2.6		7, 6		
		2.8		5, 5, 5		
	EOH: 3.00 m	3.0				Groundwater Not Encountered

Photo

Remarks

End of borehole at 3.0 m - target depth. No groundwater encountered.

Shear Vanes

- Peak
- Remoulded

Water

- Standing Water Level
- Out flow
- In flow

Investigation Type

- [x] Hand Auger
- [ ] Investigation Pit
- [ ] Machine Borehole

INVESTIGATION LOG

Client:	Cogswell Surveys Limited	**Job No.:**	HD2046
Project:	599 Oreipunga Road - Sand quarry	**No.:**	HA03
Location:	North western portion of Stage 5.	**Date:**	07.07.21
Co-ordinates:	1832882mE, 5788258mN	**Logged By:**	AT
Elevation:	Ground	**Checked By:**	MM

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	TOPSOIL; dark brown. Moist; rootlets.	0.2
Hinuera Formation	SAND, with some silt; yellowish brown. Loose; dry; uniformly graded; sand, fine.	0.4 / 0.6 / 0.8 / 1.0
	SAND; white. Medium dense; moist; uniformly graded; sand, fine, pumiceous.	1.2 / 1.4 / 1.6 / 1.8 / 2.0 / 2.2 / 2.4 / 2.6 / 2.8
	EOH: 3.00 m	3.0

Legend

Scala Penetrometer (Blows / 100 mm)

Depth (m)	Blows / 100 mm
0.2	2, 2
0.4	3, 3, 3
0.6	2, 3
0.8	3, 3, 3
1.0	3, 3, 3
1.2	3, 3, 3, 3
1.4	3, 4
1.6	4, 4, 4
1.8	3, 3
2.0	4, 4
2.2	6
2.4	4, 4, 4
2.6	4, 5
2.8	5, 5, 5
3.0	5

Vane Shear Strength (kPa) — Vane:

Water: Groundwater Not Encountered

Photo

Remarks

End of borehole at 3.0 m - target depth. No groundwater encountered.

Shear Vanes
- Peak
- Remoulded

Water
- Standing Water Level
- Out flow
- In flow

Investigation Type
- [x] Hand Auger
- [ ] Investigation Pit
- [ ] Machine Borehole

INVESTIGATION LOG

Client:	Cogswell Surveys Limited
Project:	599 Oreipunga Road - Sand quarry
Location:	Outlet of natural wetland bordering Stage 4 and 5.
Co-ordinates:	1833051mE, 5788248mN
Elevation:	Ground

Job No.: HD2046
No.: HA04
Date: 07.07.21
Logged By: AT
Checked By: MM

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Uncontrolled Fill	SAND (SW); dark greyish black. Very loose; moist; well graded; sand, fine to coarse.	0.2
Buried topsoil	TOPSOIL; dark brown. Medium dense to loose; moist; rootlets.	0.4
Hinuera Formation	SAND, with some silt; orange brown. Medium dense; moist; well graded; sand, fine to coarse.	0.6, 0.8, 1.0
	SAND, with some silt; light brown. Medium dense; moist; uniformly graded; sand, fine.	1.2, 1.4, 1.6, 1.8
	SAND, with minor gravel; light greyish brown. Medium dense; moist; gap graded; sand, fine to medium, pumiceous; gravel, fine to medium.	2.0, 2.2, 2.4, 2.6, 2.8
	EOH: 3.00 m	3.0

Legend

Scala Penetrometer (Blows / 100 mm)

Depth (m)	Blows / 100 mm
0.0 – 0.2	2, 1
0.2 – 0.4	3, 2, 2
0.4 – 0.6	5, 7
0.6 – 0.8	5, 3
0.8 – 1.0	2, 3
1.0 – 1.2	5, 4
1.2 – 1.4	4, 5
1.4 – 1.6	5, 5
1.6 – 1.8	3, 4
1.8 – 2.0	2, 3
2.0 – 2.2	5, 5
2.2 – 2.4	4, 5
2.4 – 2.6	4, 5
2.6 – 2.8	5, 5
2.8 – 3.0	4, 5, 5

Vane Shear Strength (kPa)

Water: Groundwater Not Encountered

Photo

Remarks

End of borehole at 3.0 m - target depth. No groundwater encountered.

Shear Vanes
- Peak
- Remoulded

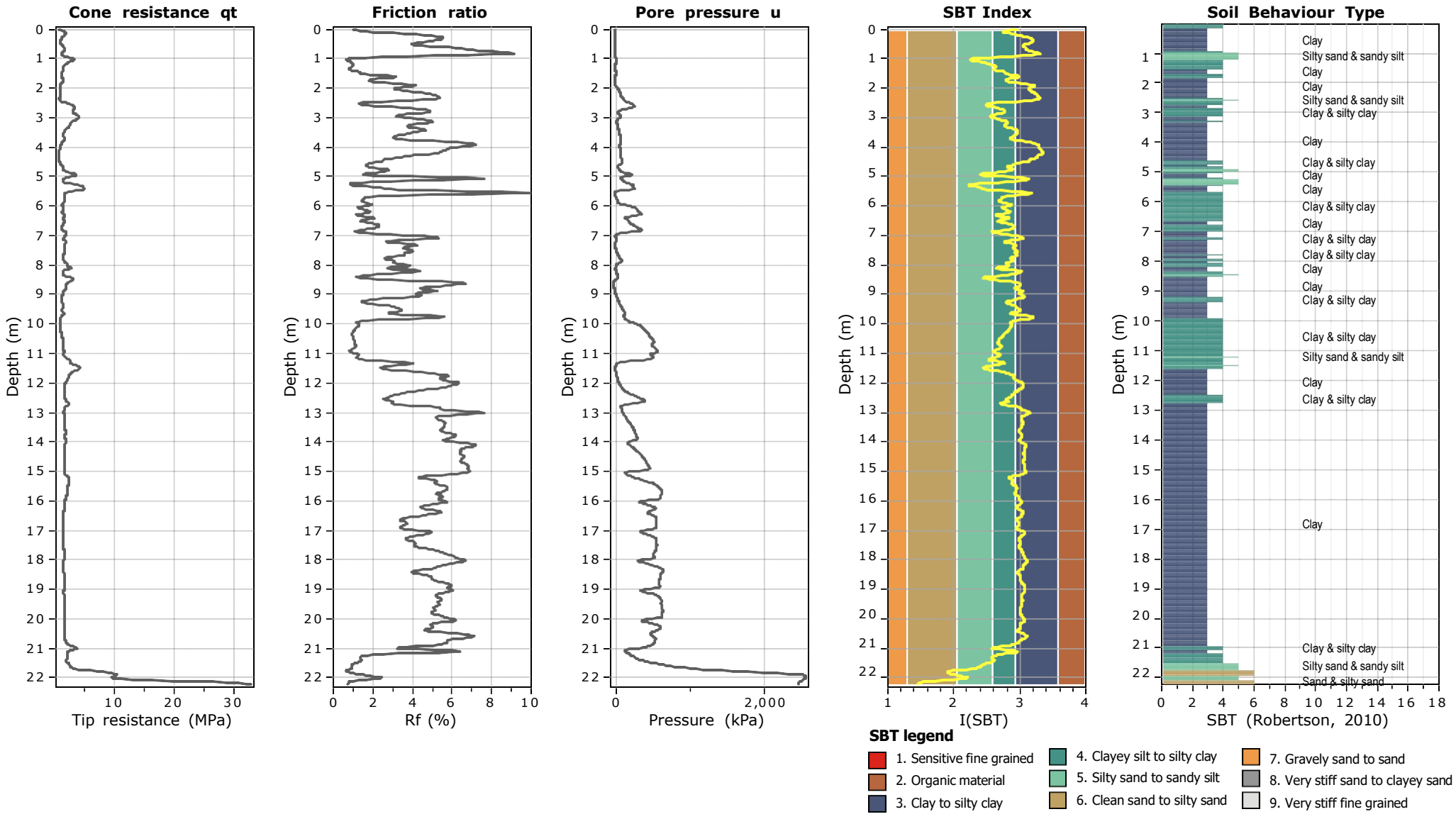
Water
- Standing Water Level
- Out flow
- In flow

Investigation Type
- [x] Hand Auger
- [ ] Investigation Pit
- [ ] Machine Borehole

HD Geo
PO Box 9266
Waikato Mail Centre, Hamilton
www.hdgeoi.co.nz

CPT: CPT01
Total depth: 22.22 m, Date: 14/07/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

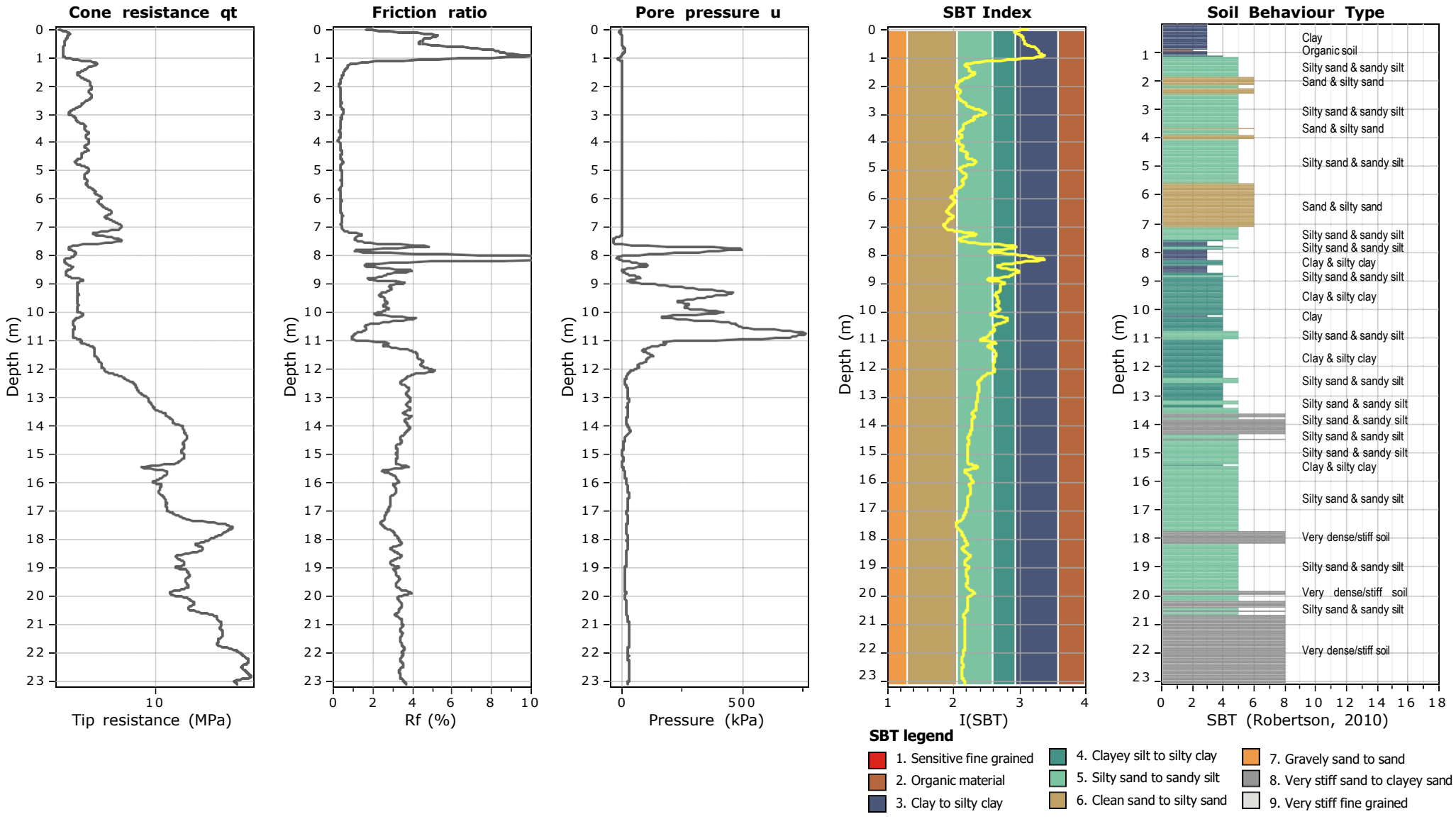
Project: Sand Quarry
Location: 599 Oreipunga Road, Kariparo



HD Geo
PO Box 9266
Waikato Mail Centre, Hamilton
www.hdgeoi.co.nz

CPT: CPT02
Total depth: 23.10 m, Date: 14/07/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

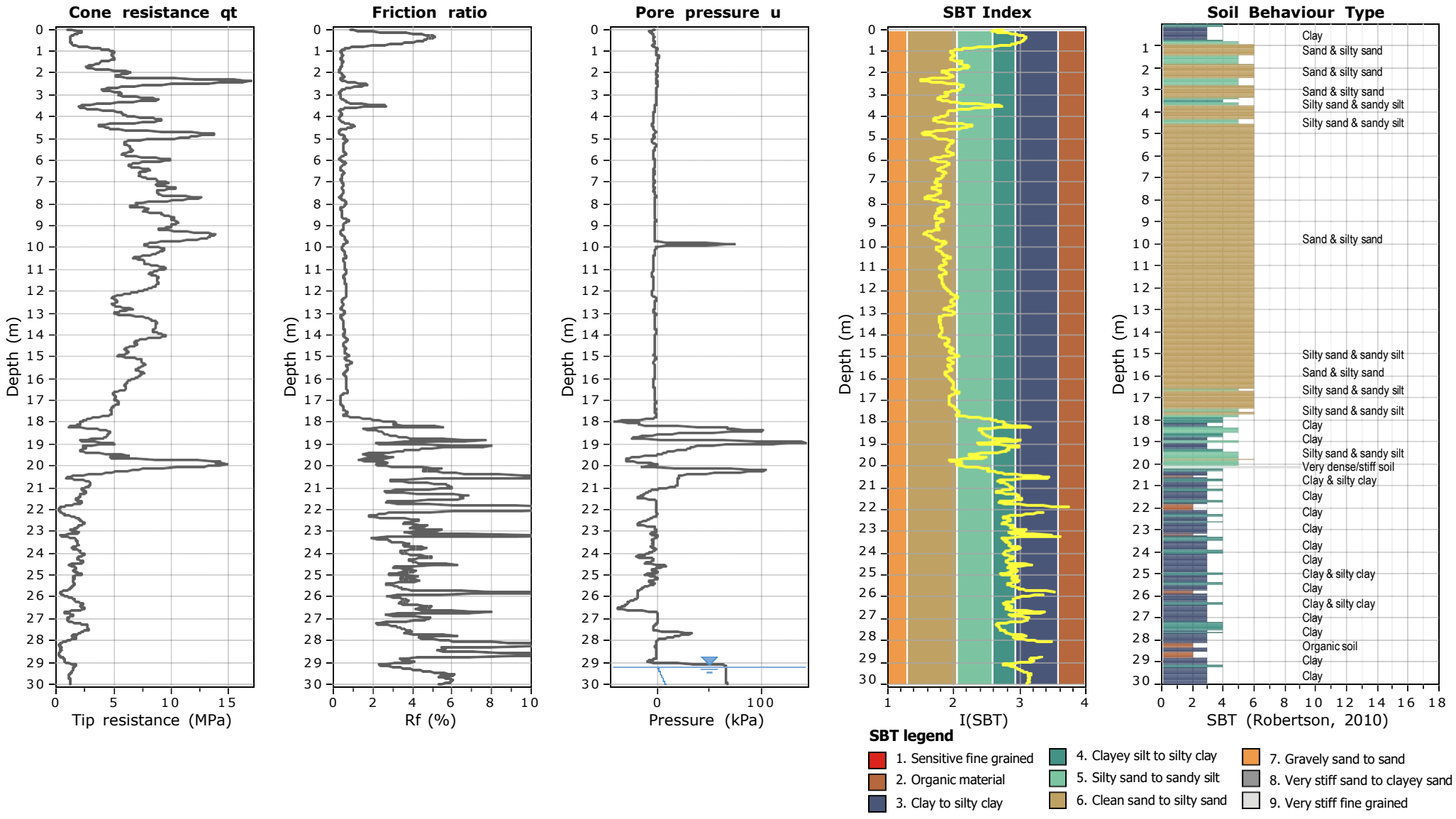
Project: Sand Quarry
Location: 599 Oreipunga Road, Kariparo



HD Geo
PO Box 9266
Waikato Mail Centre, Hamilton
www.hdgeoi.co.nz

CPT: CPT03
Total depth: 30.00 m, Date: 14/07/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

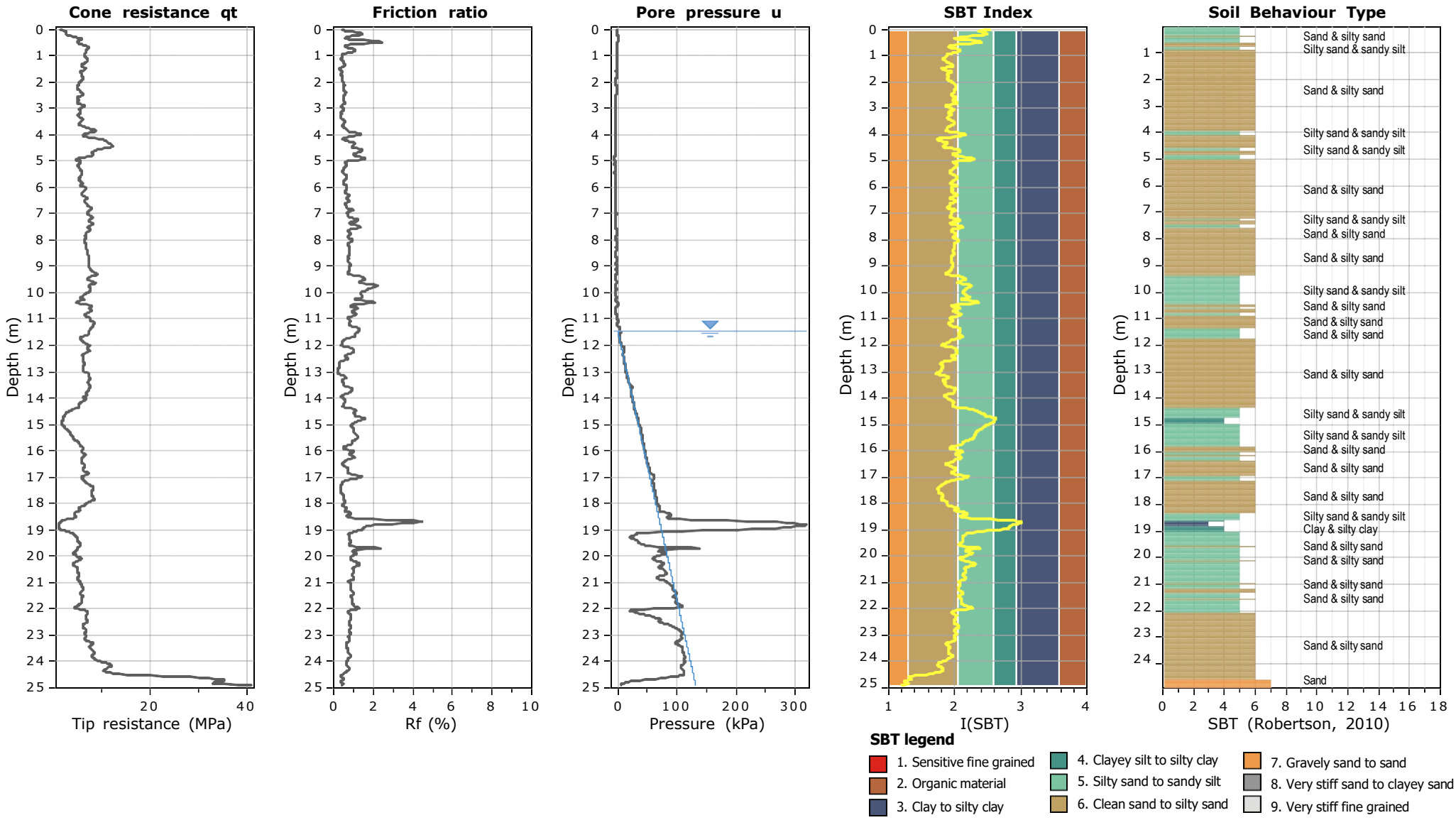
Project: Sand Quarry
Location: 599 Oreipunga Road, Kariparo



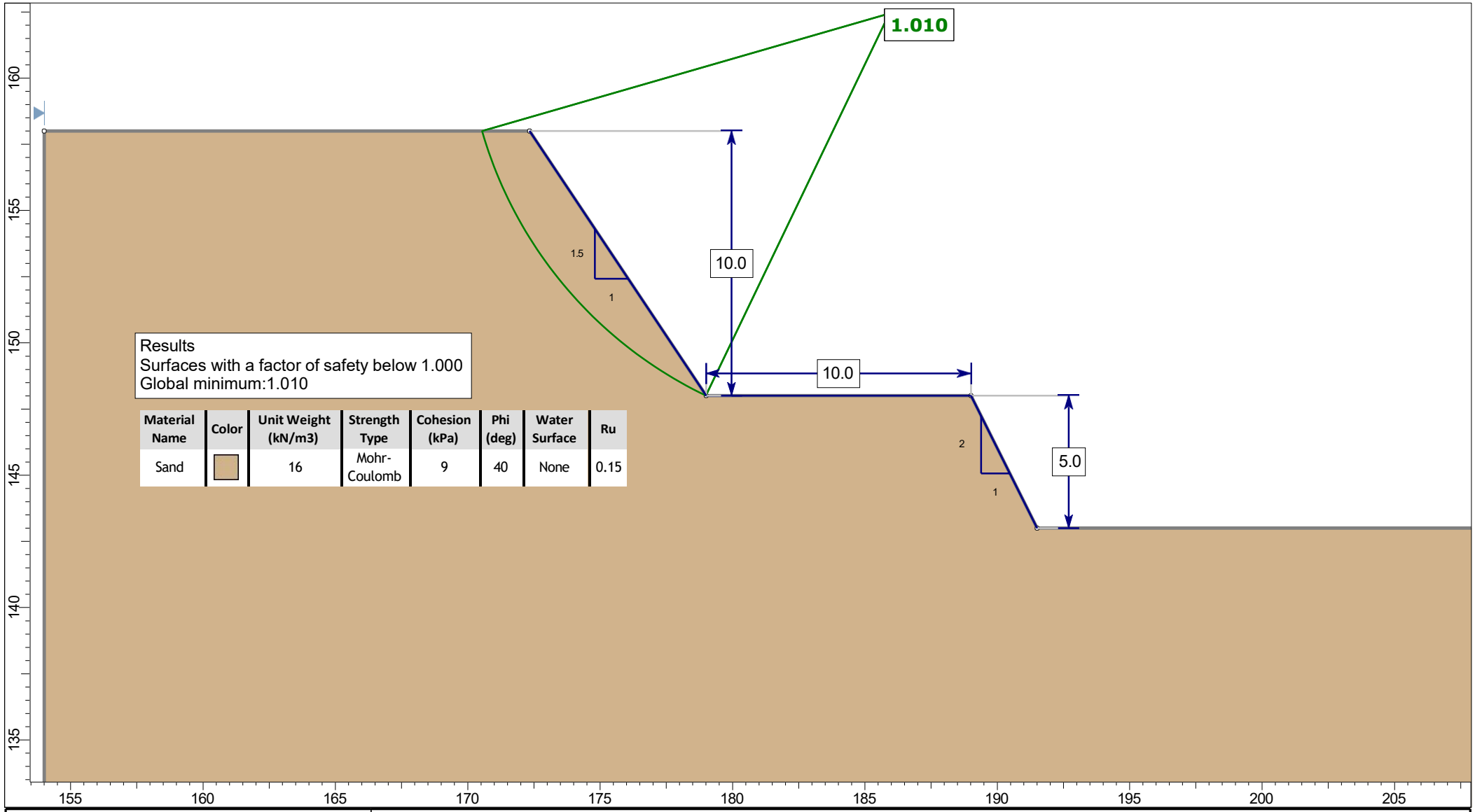
HD Geo
PO Box 9266
Waikato Mail Centre, Hamilton
www.hdgeoi.co.nz

CPT: CPT04
Total depth: 24.90 m, Date: 14/07/2021
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

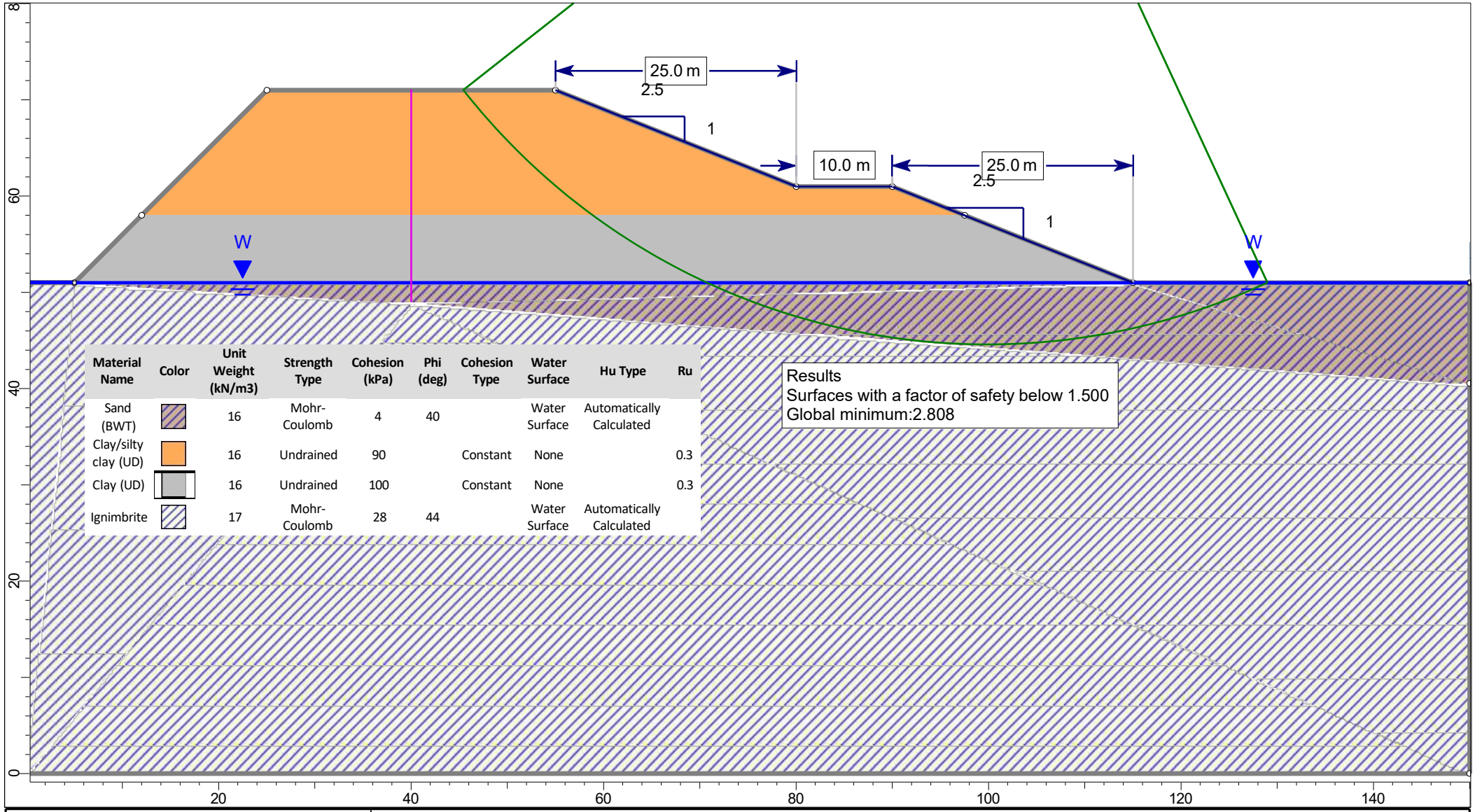
Project: Sand Quarry
Location: 599 Oreipunga Road, Kariparo



APPENDIX D – SLIDE OUTPUTS

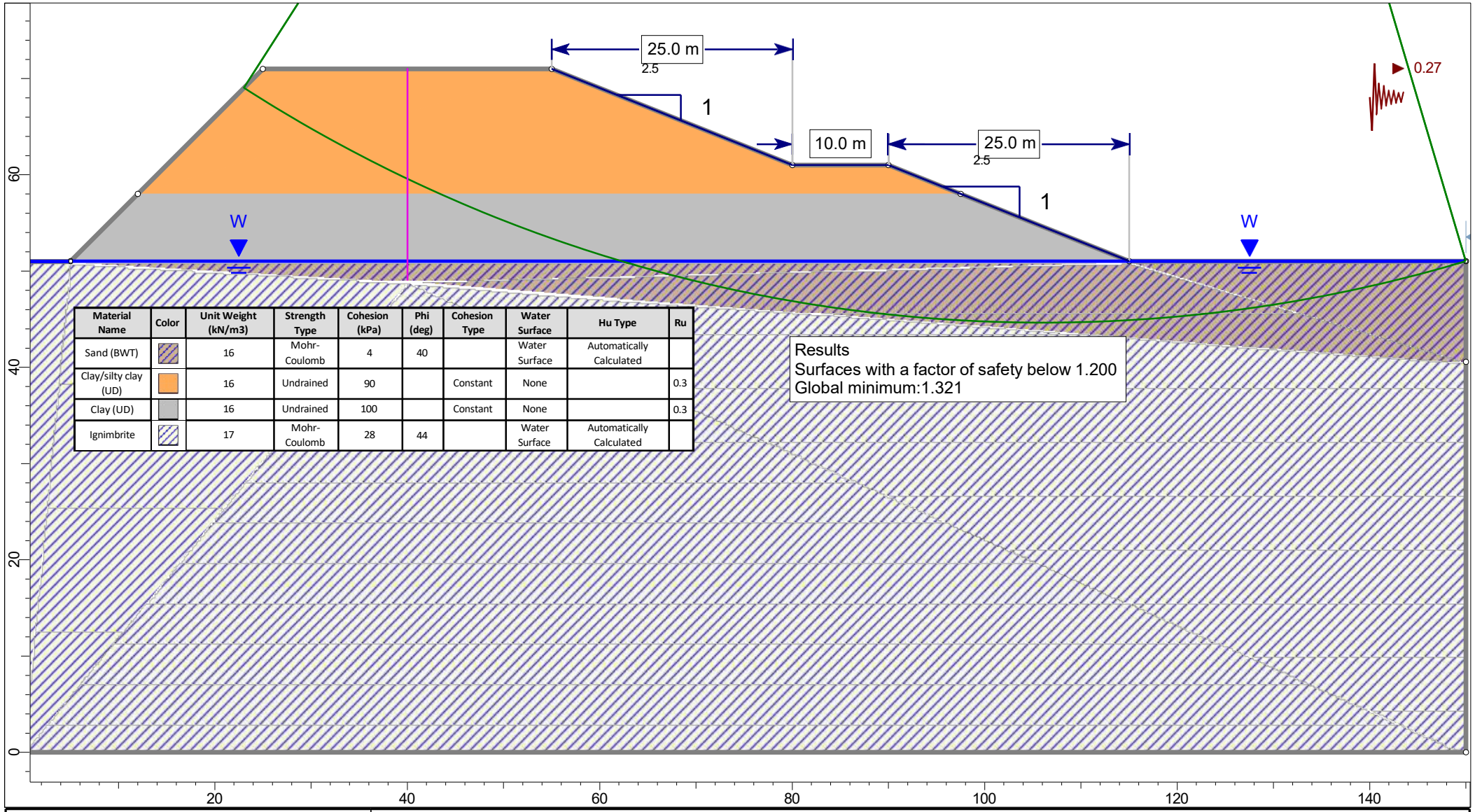


	Project	599 Oreipunga Road, Maungatautari	
	Group	Stage 1	Scenario: Back assessment
	Drawn By	Brad Kroef	Company: HD Geo Ltd
	Date	19/08/2021, 11:43:42 AM	File Name: HD2046_Stage 1 - Back assessment.slmd



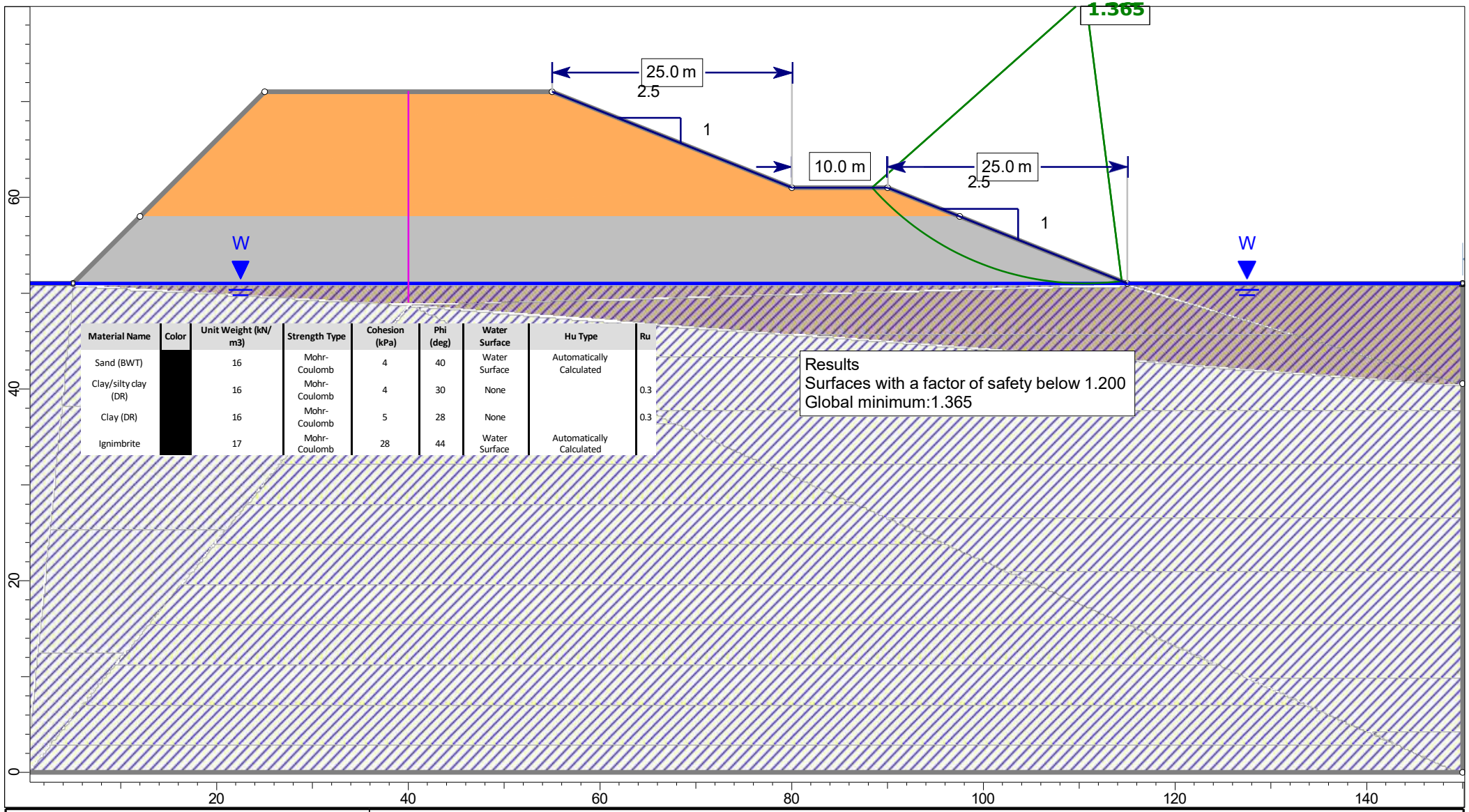
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Water Surface	Hu Type	Ru
Sand (BWT)		16	Mohr-Coulomb	4	40		Water Surface	Automatically Calculated	
Clay/silty clay (UD)		16	Undrained	90		Constant	None		0.3
Clay (UD)		16	Undrained	100		Constant	None		0.3
Ignimbrite		17	Mohr-Coulomb	28	44		Water Surface	Automatically Calculated	

Project	599 Oreipunga Road, Maungatautari		
Group	Stage 2 - Benched (2.5:1)	*Scenario*	Undrained
Drawn By	Brad Kroef	*Company*	HD Geo Ltd
Date	19/08/2021, 12:20:44 PM	*File Name*	HD2046_Slide (refined).slmd

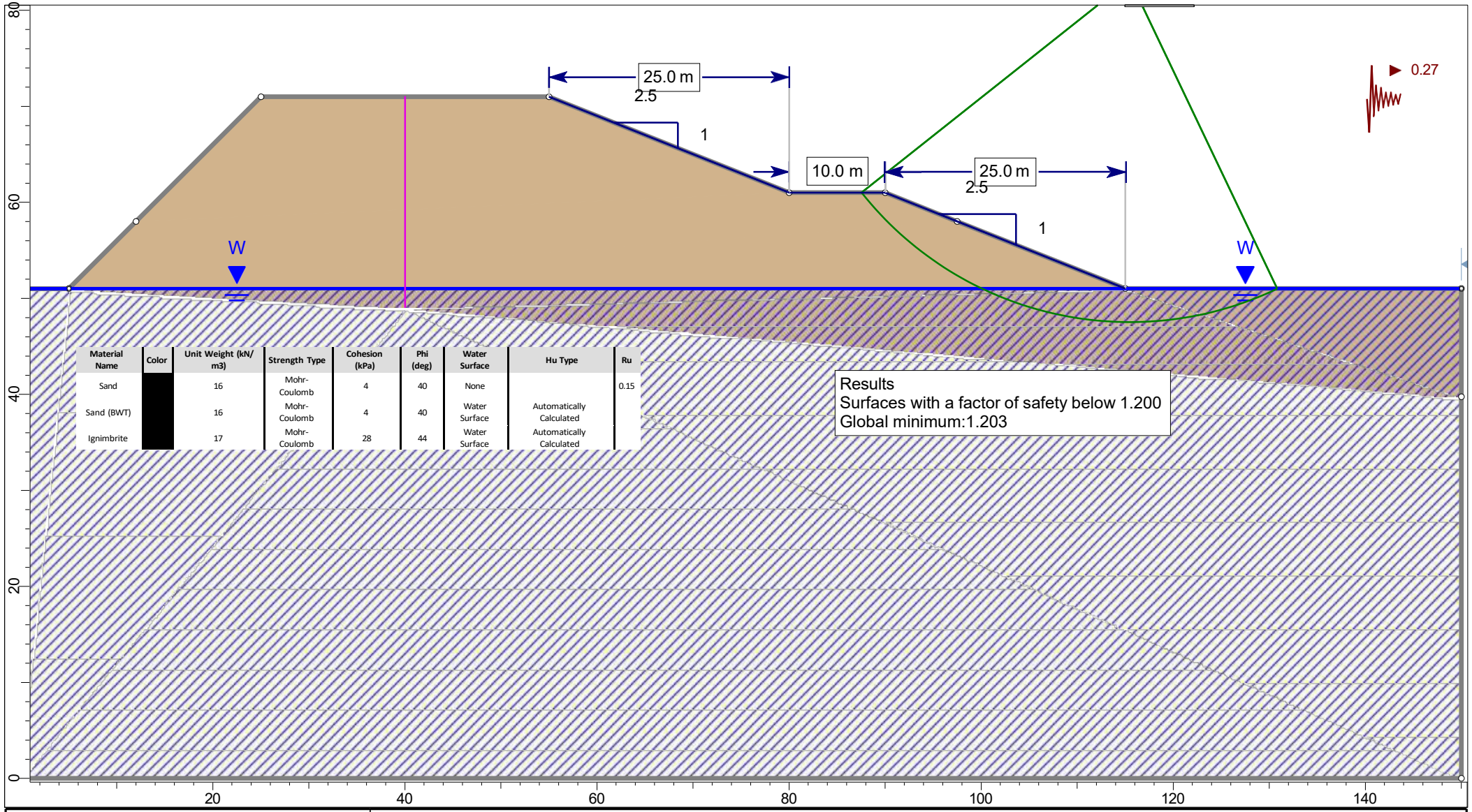


Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Water Surface	Hu Type	Ru
Sand (BWT)		16	Mohr-Coulomb	4	40		Water Surface	Automatically Calculated	
Clay/silty clay (UD)		16	Undrained	90		Constant	None		0.3
Clay (UD)		16	Undrained	100		Constant	None		0.3
Ignimbrite		17	Mohr-Coulomb	28	44		Water Surface	Automatically Calculated	

Project	599 Oreipunga Road, Maungatautari		
Group	Stage 2 - Benched (2.5:1)	*Scenario*	Undrained, siesmic
Drawn By	Brad Kroef	*Company*	HD Geo Ltd
Date	19/08/2021, 12:20:44 PM	*File Name*	HD2046_Slide (refined).slmd

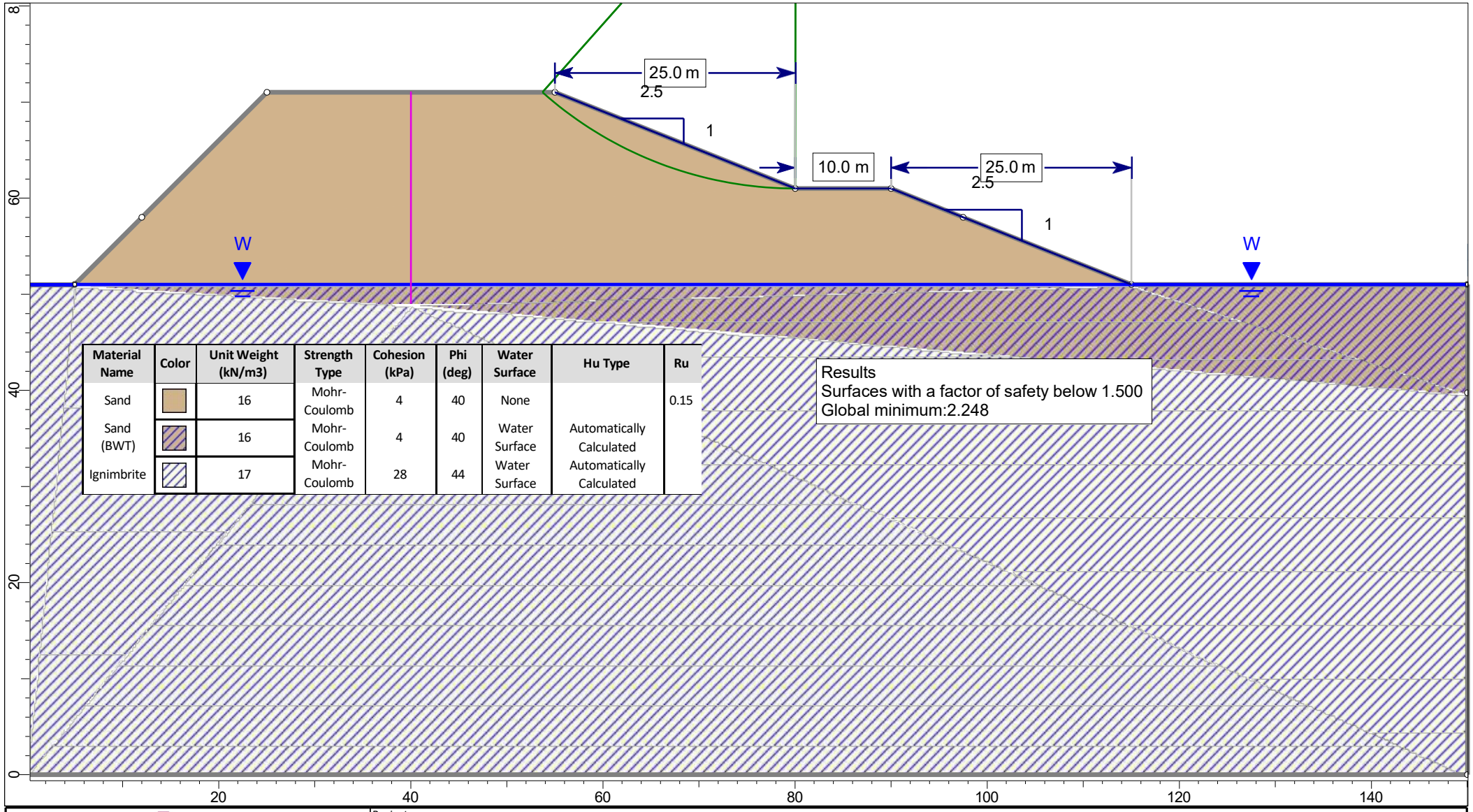


	Project	599 Oreipunga Road, Maungatautari	
	Group	Stage 2 - Benched (2.5:1)	*Scenario* Drained
	Drawn By	Brad Kroef	*Company* HD Geo Ltd
	Date	19/08/2021, 12:20:44 PM	*File Name* HD2046_Slide (refined).slmd



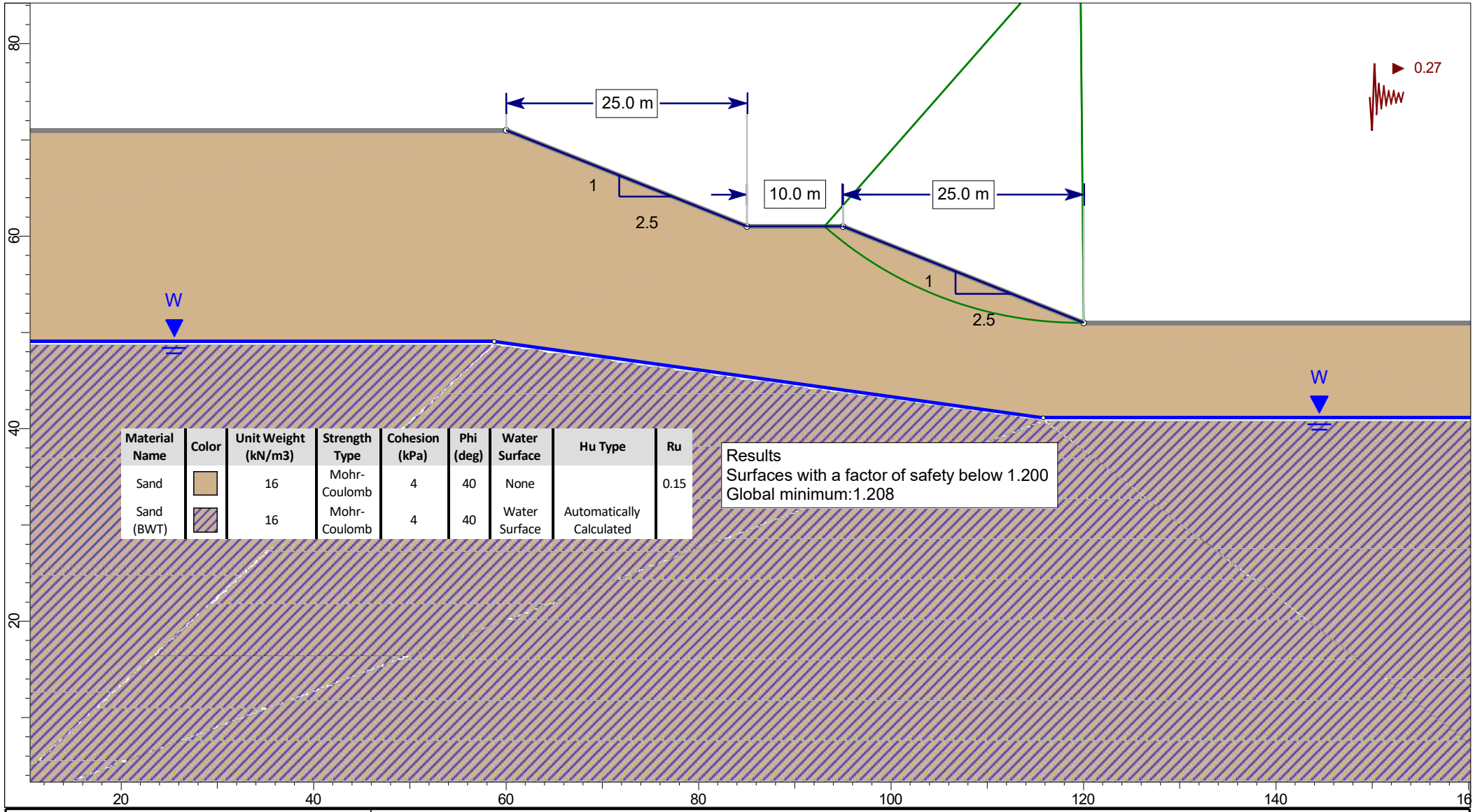
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Ru
Sand		16	Mohr-Coulomb	4	40	None		0.15
Sand (BWT)		16	Mohr-Coulomb	4	40	Water Surface	Automatically Calculated	
Ignimbrite		17	Mohr-Coulomb	28	44	Water Surface	Automatically Calculated	

Project	599 Oreipunga Road, Maungatautari		
Group	Stage 2 - Benched (2.5:1) - Sand	*Scenario*	Drained, siesmic
Drawn By	Brad Kroef	*Company*	HD Geo Ltd
Date	19/08/2021, 12:20:44 PM	*File Name*	HD2046_Slide (refined).slmd



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Ru
Sand		16	Mohr-Coulomb	4	40	None		0.15
Sand (BWT)		16	Mohr-Coulomb	4	40	Water Surface	Automatically Calculated	
Ignimbrite		17	Mohr-Coulomb	28	44	Water Surface	Automatically Calculated	

Project	599 Oreipunga Road, Maungatautari		
Group	Stage 2 - Benched (2.5:1) - Sand	Scenario	Drained
Drawn By	Brad Kroef	Company	HD Geo Ltd
Date	19/08/2021, 12:20:44 PM	File Name	HD2046_Slide (refined).slmd



Project	599 Oreipunga Road, Maungatautari		
Group	General - Benched (2.5:1)	Scenario	Drained, siesmic
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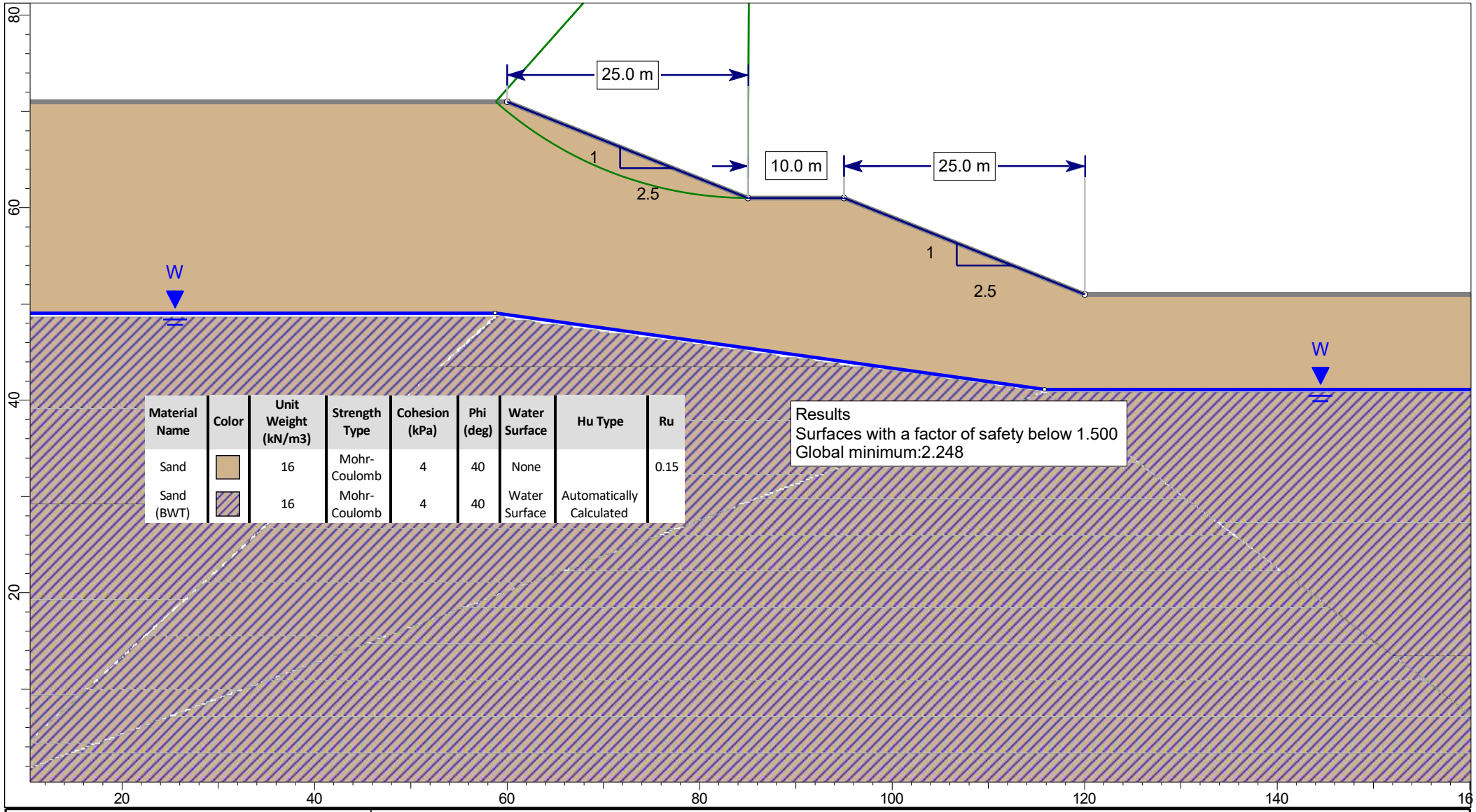
Date	19/08/2021, 12:20:44 PM	File Name	HD2046_Slide (refined).slmd



Project	599 Oreipunga Road, Maungatautari		
Group	General - Benched (2.5:1)	Scenario	Drained
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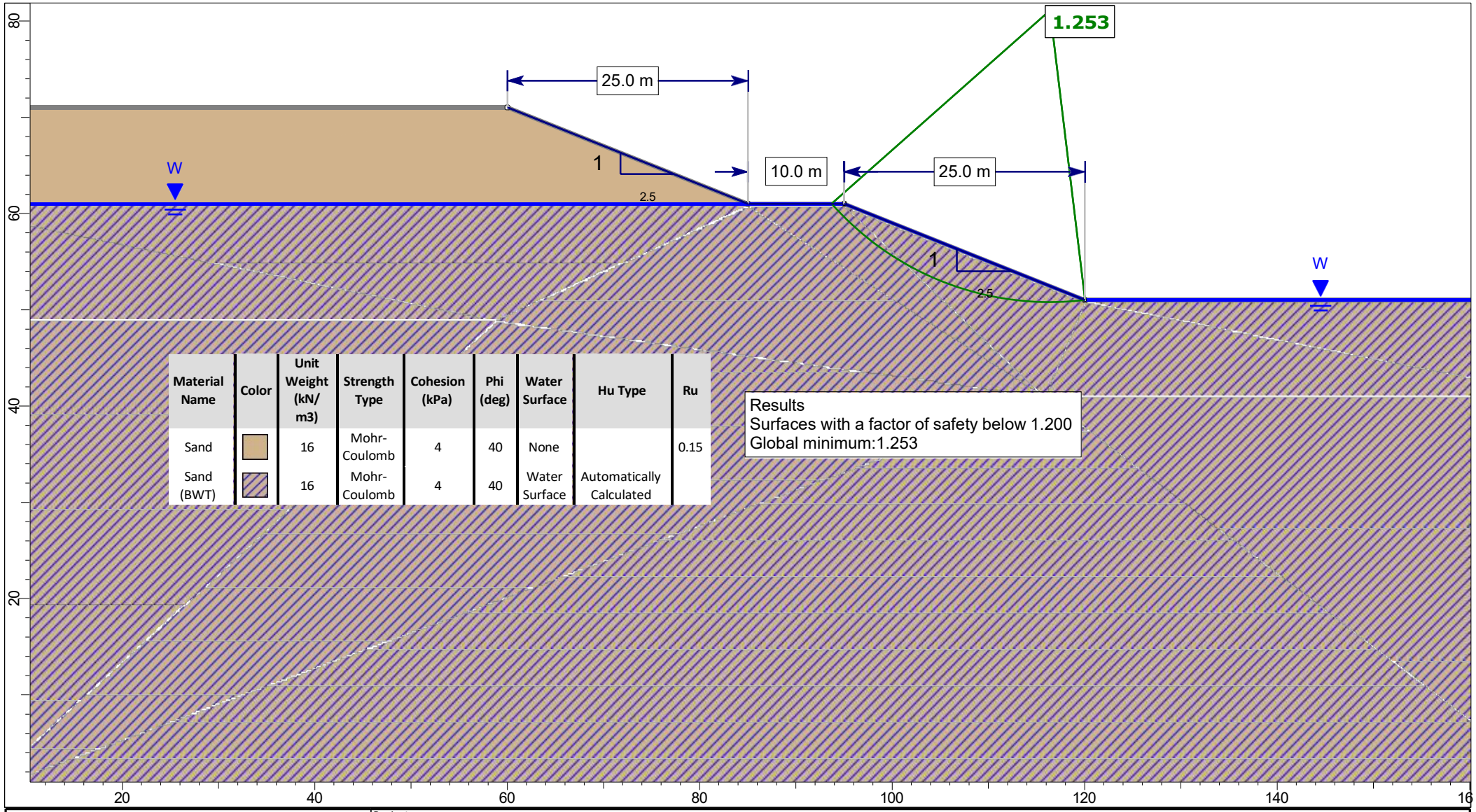

Project	599 Oreipunga Road, Maungatautari		
Group	General - Benched (2.5:1)	Scenario	Drained, elevated GWT
Drawn By	Brad Kroef	Company	HD Geo Ltd
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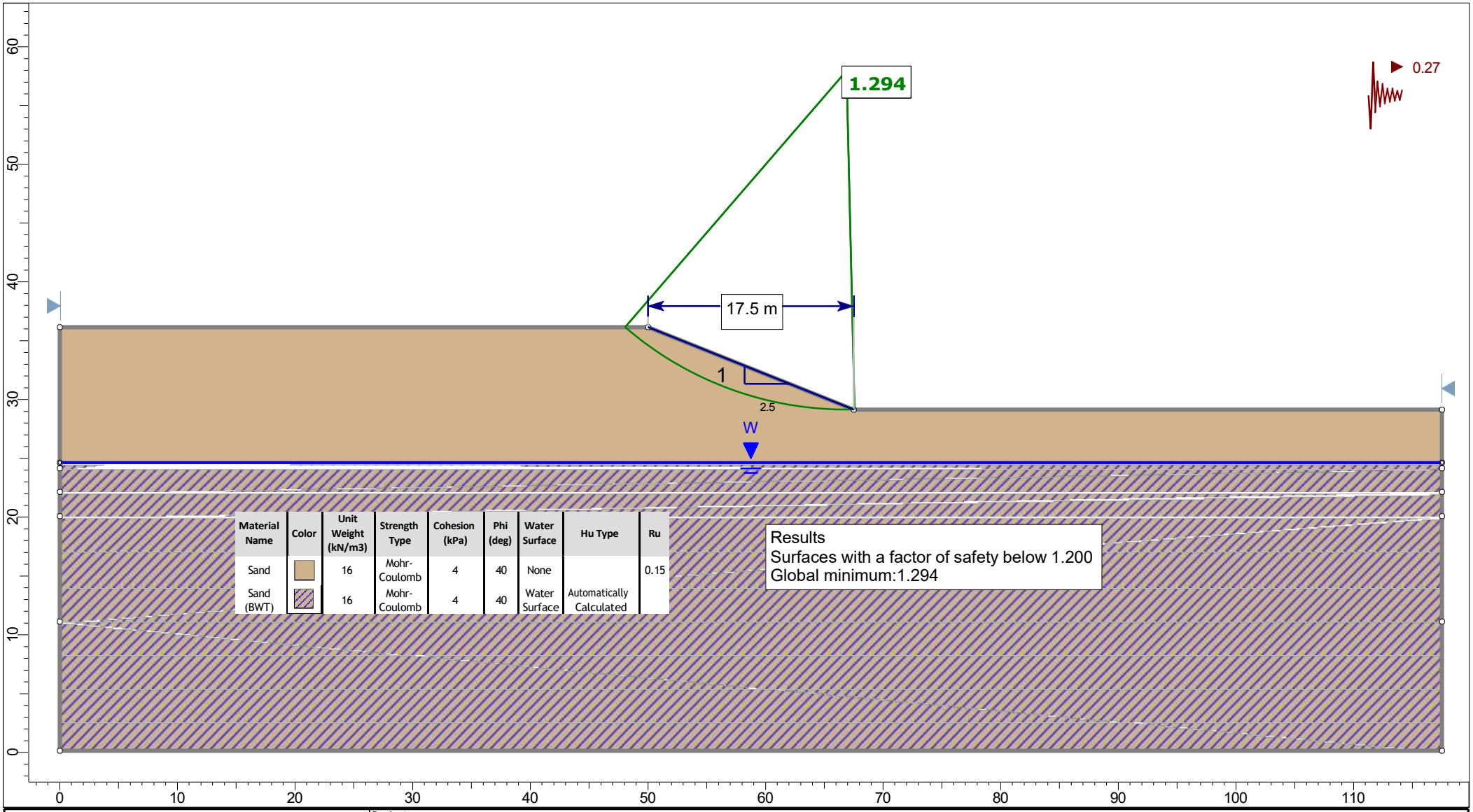

Project	599 Oreipunga Road, Maungatautari		
Group	Stage 5 - 2.5:1	*Scenario*	Drained, seismic
Drawn By	Brad Kroef	*Company*	HD Geo Ltd
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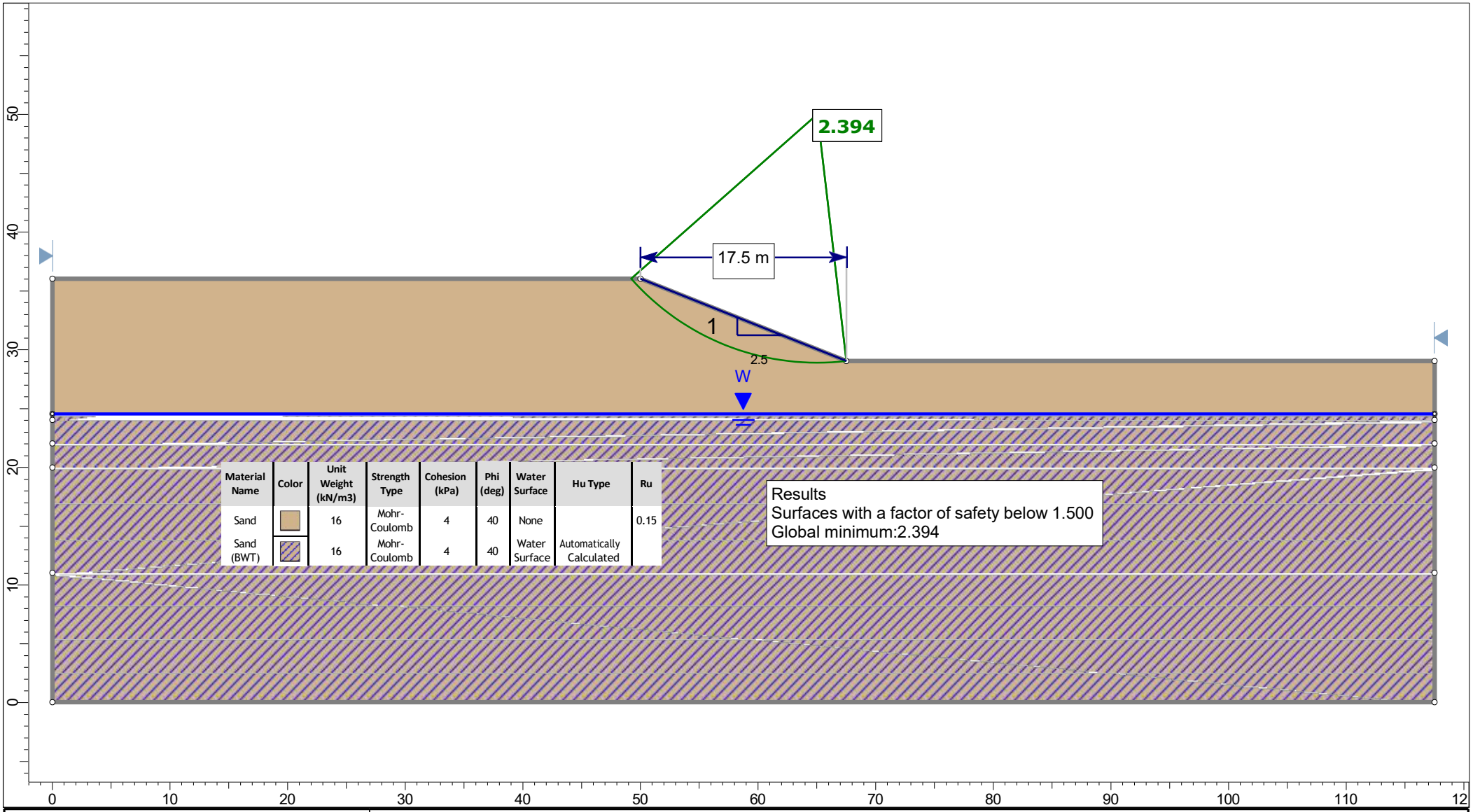

Project	599 Oreipunga Road, Maungatautari		
Group	Stage 5 - 2.5:1	Scenario	Drained
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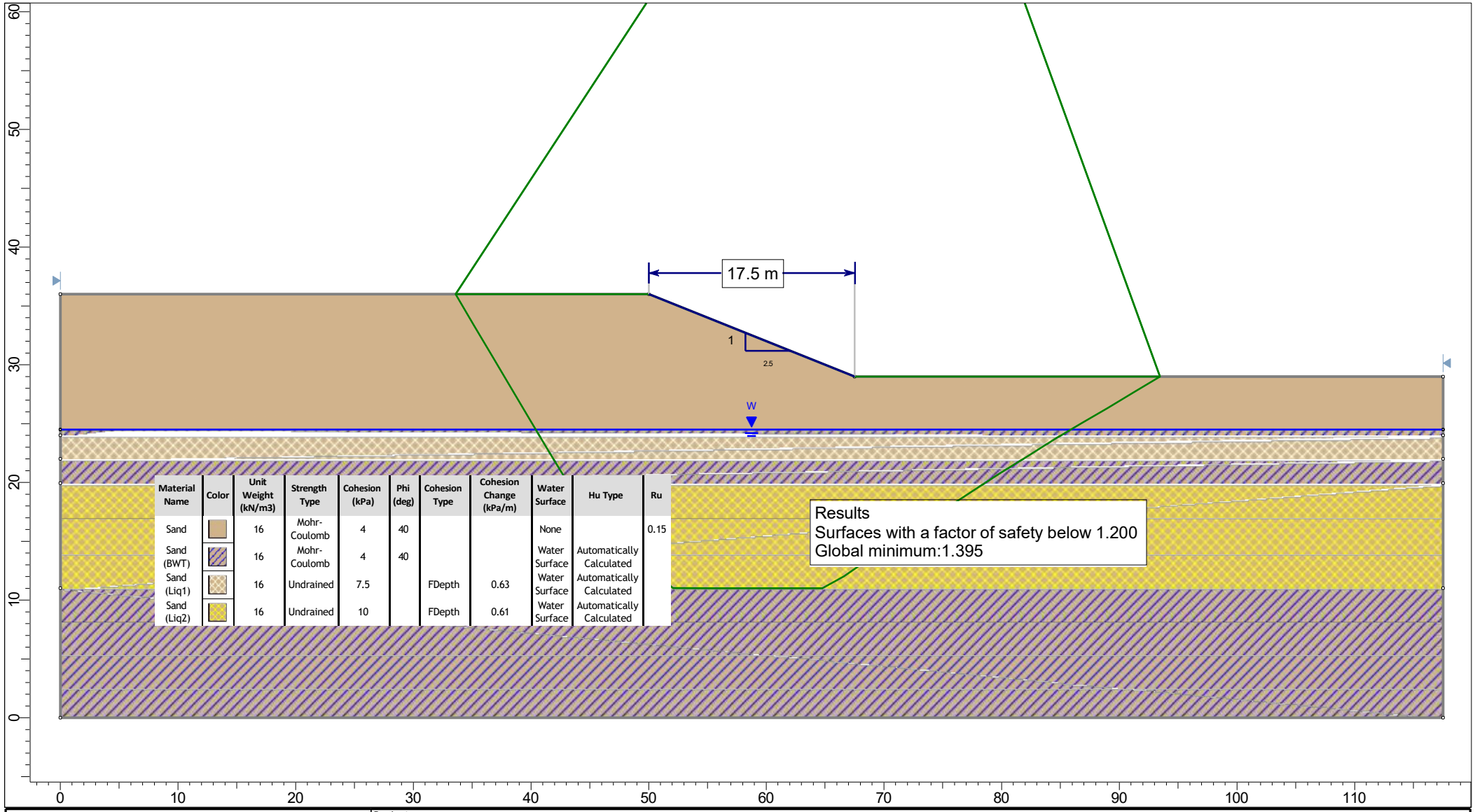

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Cohesion Change (kPa/m)	Water Surface	Hu Type	Ru
Sand		16	Mohr-Coulomb	4	40			None		0.15
Sand (BWT)		16	Mohr-Coulomb	4	40			Water Surface	Automatically Calculated	
Sand (Liq1)		16	Undrained	7.5		FDepth	0.63	Water Surface	Automatically Calculated	
Sand (Liq2)		16	Undrained	10		FDepth	0.61	Water Surface	Automatically Calculated	

Project	599 Oreipunga Road, Maungatautari		
Group	Stage 5 - 2.5:1	Scenario	Liquefied
Drawn By	Brad Kroef	Company	HD Geo Ltd
Date	27/08/2021, 12:48:08 PM	File Name	HD2046_Slide (refined).slmd