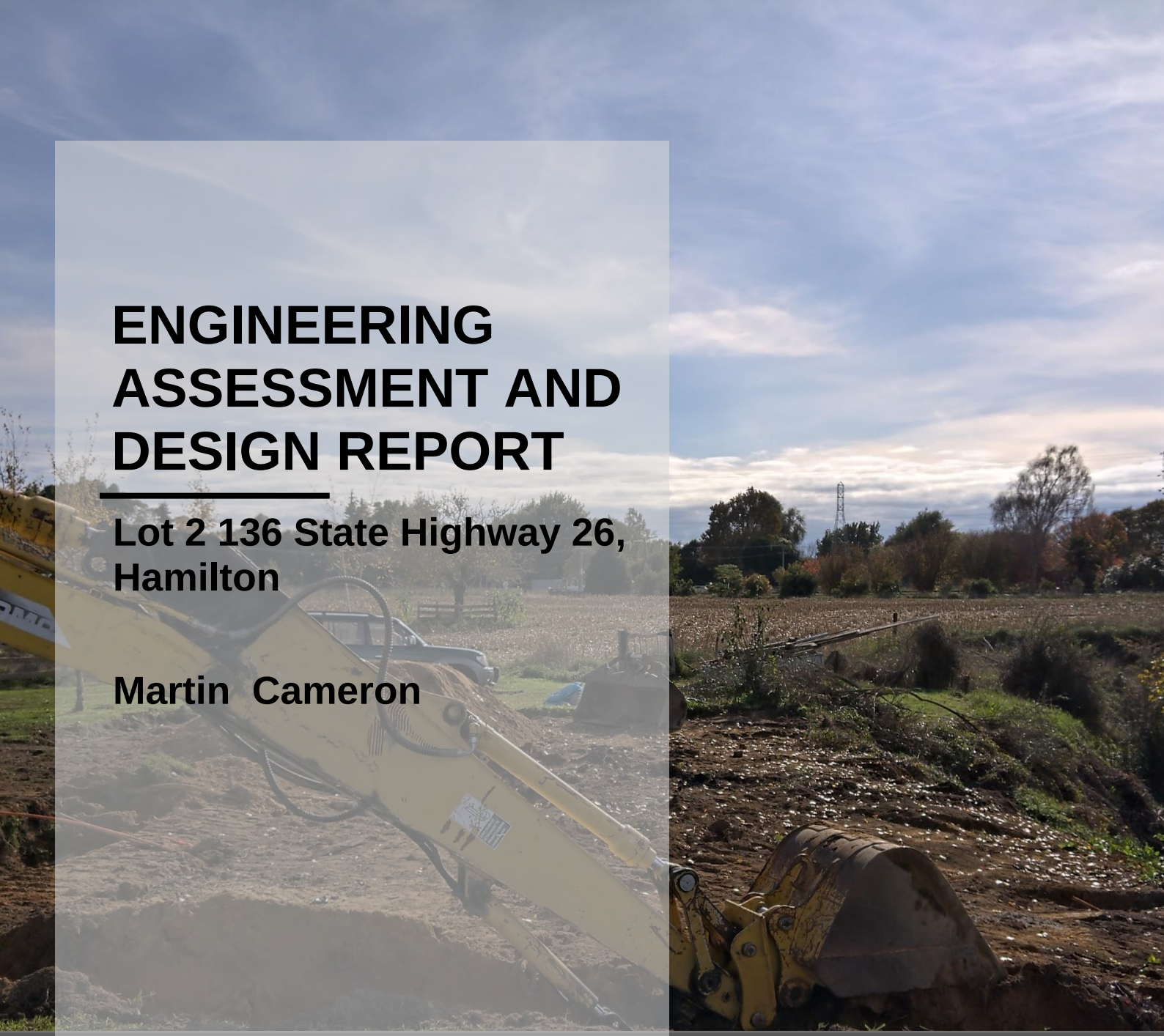

ENGINEERING ASSESSMENT AND DESIGN REPORT

Lot 2 136 State Highway 26, Hamilton

Martin Cameron

25 FEBRUARY 2022

PROJECT NO. 11122

TITUS

CONSULTING ENGINEERS

Approved for issue by:

X Tony Richardson

Digitally signed by Tony Richardson
DN: cn=Tony Richardson, c=NZ, o=Titus Civil Ltd, email=tonyr@tituscivil.co.nz
Date: 2022.02.25 17:45:49 +13'00'

Anthony Richardson CPEng 1026340
Principal Project Engineer

DOCUMENT HISTORY AND STATUS

Rev.	Issued To	Date	Prepared	Reviewed	Approved
A	Martin Cameron	20/05/2020	RM	MH/JV	TR
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C	Martin Cameron	19/06/2020	RM	TR	TR
D	Martin Cameron	29/01/2021	RM	TR	TR
E	Martin Cameron	2/02/2021	RM	TR	TR
F1	Martin Cameron	11/10/2021	RM / JV	JV / TR	TR
G	Martin Cameron	25/02/2022	BV	TR	TR

RECORD OF REVISION CHANGES

Revision B – Revised slope stability recommendations.

Revision C – Model revised to reduce height of slope by 2m through onsite earthworks.

Revision D – Section 5: Slope Stability Assessment updated with new design of basement. WW Design updated

Revision E – Section 2.4: Changed recommendation table title

Revision F – Revised dwelling orientation, SW/WW locations, and proposed rainwater tank

Revision G- Updated report as per below RFI

Resource Consent Application – Further information request

Application number:	010.2022.00012090.001
Applicant:	Martin Joseph Cameron
Address:	2/136 SH 26, RD 6, Hamilton 3286
Proposed activity:	Detached Dwelling located partially within the Gully Hazard 6m Setback

In accordance with section 92 of the Resource Management Act 1991 (RMA), the following information is requested to enable me to make an accurate and informed assessment.

The following information is requested:

Geotechnical

Council's Consultant Geotechnical Engineer has reviewed the Engineering Design and Assessment Report prepared by Titus Consulting Engineers and has requested the following information:

1. We note that investigations are of limited depth (2m) and undertaken prior to earthworks. Please discuss how the deeper soils have been assessed at the site noting that earthworks the order of 2m have been undertaken and no site-specific deeper testing undertaken to confirm suitability of bearing layers or soil conditions and govern the slope stability model.

- . Additional site-specific testing was carried out on the 24/02/22 to assess the deeper soils onsite These results confirm the bearing capacity and soil conditions of the underlying layers. – results are in Appendix B and Section 2.2. Deeper soil parameters utilised in the slope stability analyst has been extracted from the CPT data as indicated.

2. The slope stability assessment and liquefaction analysis has adopted peak ground accelerations which have been superseded in November 2021 update of MBIE Module 1. Please revise accordingly using the updated values provided by MBIE.

- The slope stability and liquefaction assessments have been updated to adopt the new MBIE peak ground accelerations. There was no change in terms of liquefaction risk. In terms of slope stability, the new seismic values have been adopted and modelled on the proposed dwelling slope stability model. The existing piling that is proposed for the site is sufficient to mitigate any changes due to the change in seismic values. Refer to Appendix I for updated liquefaction results and Appendix J (Proposed dwelling) for updated slope stability model.

3. Please provide a site plan which includes appropriate referencing to the CPT data (i.e. number the CPTs for cross referencing purposes).

- The CPTs have been numbered - refer to Appendix A

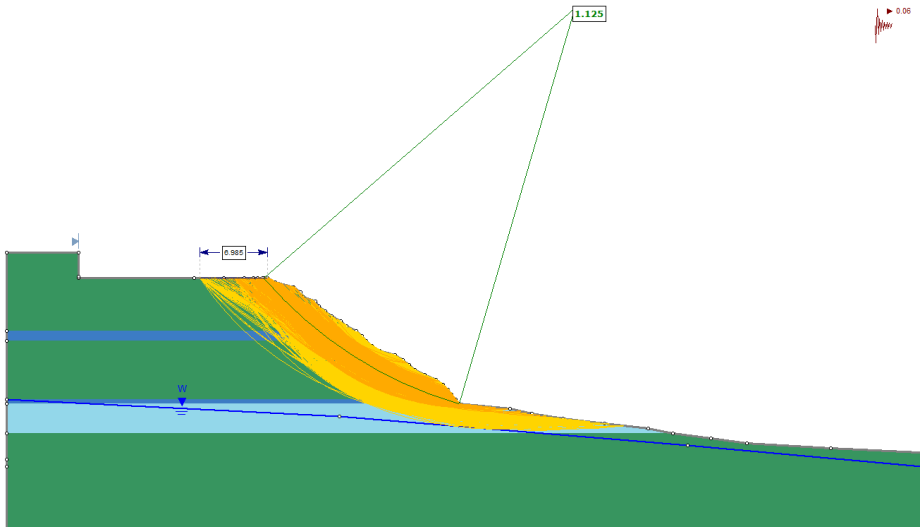
4. Please confirm the site setback requirements in relation to slopes which are unretained. I.e. what set back is to be adopted along the slope where no stability measures are implemented. We note that only the building with piled foundations has been assessed not the slopes which do not have shear piles (i.e. driveway, rainwater tanks).

- As per section 5.12 of this report a 7.0m setback is required. The slope was modelled at its steepest point; therefore, this gives the most conservative setback for the overall slope. Referring to the client's architectural plan the tanks and driveway are set back 6m from the slope, this shall be updated during construction on site.

5. Please confirm whether the rainwater and wastewater treatment tanks are at potential risk of slope instability. While they lie beyond the 6m gully hazard set back, this does not translate directly into no risk of instability beyond this line.

- We confirm that the septic and rainwater tanks are setback 7.0m from the top of slope, as per the slope stability modelling under gravity and SLS conditions (IL1) the slope is considered stable.

As below the SLS case provides the critical setback requirement.



Slope model failure arcs with FOS<1.5 shown for ILS SLS Case

TITUS Consulting Engineers

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Ph: 07 242 0017

Email: office@tituscivil.co.nz

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Overview

TITUS CIVIL Consulting Engineers has been engaged by Martin Cameron to perform an engineering assessment and design report for a storey timber-framed building at Lot 2 136 State Highway 26.

The report includes the following.

- Section 2: Site and Soils Assessment.
- Section 3: Stormwater Assessment and Design.
- Section 4: Wastewater Assessment and Design.
- Section 5: Slope Stability Assessment.

The assessments and design meet the requirements of the local authority, Hamilton City Council, and the following technical documents.

- The building code,
- NZS3604:2011,
- District Plan,
- Any current ICMP,
- Waikato Regional Council Plan, and
- AS/NZS 1547/2012

1.2 Site Details

The site is currently a newly subdivided lifestyle block with a large gully at the back of the section. The site is bordered by a gully system to the east, a field to the north (used for cultivation), and a residential house and garage to the south / south west. The area near the proposed foundation is gently sloping to the north. The location of the house is close to the top of a slope joining the gully system to the east.

The large gully system is approximately 3km upstream from where it enters the Waikato River.

Figure 1 shows a photo of the proposed dwelling location.

Figure 1: Site Photo

1.3 Planning Requirements

The following requirements based on the Regional Council Plan, Consent Notices and Subdivisional Reports are noted, and have been duly considered in the proposed recommendations.

The following is taken from the resource consent from HCC:

> *(2)(7) Any contaminated soil is to be removed under controlled conditions to a licensed waste facility or landfill for disposal in accordance with the RAP, and with the requirements of the disposal site and the relevant authority. Receipts of transport and disposal are required to be provided in the Site Validation Report.*

- An area of lead contaminated ground from near the previously existing cow shed has been removed and disposed of on the day of the site investigation.

The following is taken from the Geotechnical report for lot 4 of the same subdivision and gives a setback of 7.5m for a dwelling along the same gully slope that lot 2 is on:

Slope Stability Assessment

- The conducted slope stability assessment indicates a development building setback of at least 7.5m from the crest of the slope. Building within the setback zone is feasible but specifically designed foundations (such as piles) will be required.

2 SITE AND SOILS ASSESSMENT

2.1 Assessment Parameters

This section details findings of a site and soils assessment in accordance with NZS3604:2011 cl. 3.1.3.1 Determination of 'Good Ground'. The investigation is in relation to the construction of a new single storey timber-framed building.

In particular the investigation focussed on assessing:

- The bearing capacity of the soil in accordance with NZBC – B1 (New Zealand Building Code),
- Checking for organic and peat soils,
- Checking for soft and very soft clays containing gravel or other hard material and,
- Checking for uncontrolled fill.

NZBC requires 5 blows per 100mm down to a depth of twice the footing width or 3 blows per 100mm at greater depths to establish good ground in terms of bearing capacity of soils.

Foundations outside of the scope of NZBC or proprietary specifications require *specific engineering design* (SED).

The proposed building has a floor area of approx. 250m^2 and various foundation options are being considered.

2.2 Soil Investigation

The site assessment conducted on 12th of May 2020 included the following:

- General site walkover
- Hand Auger Tests: 4
- Scala Penetrometer Tests: 4
- Shear Vane Tests: 7
- Soakage Test: 1

Test locations are shown in Appendix A.

Topsoil was found at a depth of 200mm on site in borehole 5 but not in boreholes 1 to 4 as they were located beneath the removed cowshed foundations. Underlying soils consist predominantly of sand. Overall, the boreholes showed interbedded layers of sand and silt with little correlation between boreholes.

No soft clays were found on the site (kPa < 25).

Organic material was found in borehole 2 under the propsed dwelling location. The material is suspected to be a dump site associated with the previously existing cow shed. This material was only found in an isolated area and was removed on the day of inspection of the removal of contaminated soil from the site.

Soakage testing yielded a raw soakage rate of 900mm/hr. An appropriate factor of safety shall be applied before use in design calculations.

The water table was not found in any borehole to a depth of 2.0m. The water table was found at 13.0m in the CPTs on the adjacent lot.

Further site assessment conducted on 24th February 2022 (Labelled HA6 – HA 9) included the following:

- General site walkover
- Hand Auger Tests: 4
- Scala Penetrometer Tests: 4
- Shear Vane Tests: 6

Test locations are shown in Appendix A.

Testing was carried out on the 24th of February 2022 to determine the soil conditions following the earthworks that have taken place onsite. A silty layer was found to a depth of 800mm across all the boreholes. Below the silt layer a medium to coarse brownish grey sand is found to a depth of 2000mm. Borehole 7 refused due to non- retrieval at a depth of 1100mm. All boreholes have confirmed adequate bearing capacity as per the foundation recommendations.

2.3 Preliminary Liquefaction Assessment

2.3.1 Geological Setting

According to GNS (GNS Science, 2019), the underlying geology of the site is classified as (Late Pleistocene) river deposits (Hinuera Formation), as shown in Appendix D. This is described as cross-bedded pumice sand, silt, and gravel with interbedded peat. The Late Pleistocene sediments are approximately up to 27,000 years old. The site sits on a geological boundary between Hinuera Formation and Holocene sediments. This boundary will sit somewhere on the slope where eroded sediments have been deposited. Given the nearby gully and the free draining nature of the Hinuera Formation it is assumed that the long-term water table is located near the base of the gully.

2.3.2 Seismic Parameters

Table 1 below summarises the seismic parameters adopted for the site:

Table 1: Seismic parameters (Module 1 MDIE/NZGS)

Module 1 MBIE/NZGS				
Importance Level 2				
Design Life:			50 Years	
Ground Acceleration (SLS)			**Ground Acceleration (ULS)**	
Hamilton			Hamilton	
Class D			Class D	
1/25			1/500	
M_{eff}	5.9		M_{eff}	5.9
PGA, a_{max} (g)	**0.06**		PGA, a_{max} (g)	**0.25**

The site is located within the Waikato Basin which is generally known for deep sedimentary soils and deep basement rock. Development of a preliminary model of the fundamental site period (T0) across the Waikato Basin has shown that most places within the Waikato Basin

have fundamental periods longer than 0.6s and hence should be categorised as Site Class D. (Jeong & Wotherspoon, 2019)

Therefore, Subsoil Class D – Deep or Soft Soil (NZS 1170.5:2004) may be adopted for this site.

2.3.3 Liquefaction Susceptibility

A comparison between the ideal conditions for liquefaction occurrence and conditions found for each proposed lot assessed is shown in Table 2 below;

Table 2: Conditions for liquefaction occurrence

Soil conditions considered susceptible to liquefaction occurrence	Site
Holocene to Late Pleistocene sediments	Yes
Cohesionless	Yes
Non-cohesive silt to medium to fine sand	Yes*
Loosely packed	Yes*
Shallow water table (<4m)	No
Thick non-liquefiable crust at the ground surface	Unlikely

**Limited layers*

Due to underlying geology and according to Hamilton City Liquefaction Report prepared by Tonkin & Taylor it is indicated that liquefaction damage is possible. Due to the depth to water table and the free draining nature of the gully systems around Hamilton, liquefaction damage at the site is considered unlikely and no mitigation measures are recommended.

Note: In order to determine if any layers are susceptible to liquefaction below the base of the slope which may affect slope stability a detailed liquefaction assessment of the CPTs using CLIQ has been carried out, refer to Appendix I.

2.4 Recommendations

The following foundations options are suitable given the soil conditions on site, however, are subject to confirmation of the specific requirements of the recommended foundation, the slope on site and any filling proposed for the site.

2.4.1 SED Piled Foundation

An SED Piled Foundation shall be designed as summarised below and as per the slope stability assessment (in Section 5).

Table 3: Foundation Parameters

SED Piled Raft for House	
Minimum depth of excavation for sand pad to good ground	1200mm below original proposed ground level
Minimum Pile Depth	5.0m
Maximum Out-of-Plane Spacing	2.0m
Backfill material	Sand (Granular fill (brown rock) below 500mm)
Compaction standard	8 blows/300mm (Scala penetrometer) 270kPa
Inspections required	1 - Sub grade prior to back fill 2 - Compacted and finished sand pad
Foundation type	SED Piled raft
Comments	The foundation designer shall ensure the foundation is appropriate as per Section 5.
Piles for Concrete Foundation	
Minimum Pile Depth	5.0m
Maximum Out-of-Plane Spacing	2.0m
Inspections required	Pile driving / base of bored pile holes as applicable
Foundation type	SED pile foundation
Comments	The foundation designer shall ensure the foundation is appropriate as per Section 5

The piling and foundations shall be inspected in accordance with council and building code requriements.

3 STORMWATER ASSESSMENT AND DESIGN

3.1 Design Parameters

- Lot Size: 1,413m^2
- Proposed roof area: approx. 250m^2
- Design storms:
  - Primary: 10yr ARI
  - Secondary: 100yr ARI
- Rainfall data: Ruakura Rainfall data
- Climate change: 2.1 degrees warming
- Soakage rate: 900mm/hr (tested 12th of May 2020) – adopted 225mm/hr. Refer to Appendix C for results.
- Water table was determined to be 13.0m below the ground surface in the CPT logs from the neighbouring lot 4.

Figure 2 below summarises the catchment characteristics that have been adopted.

TANK DESIGN CALCULATIONS AND OUTPUTS

Rainfall Location	Event	ARI
Hamilton	Primary	10
	Secondary	100

Catchment	Area (m2)		C
	Existing	Proposed	
Grass	280		0.30
Roof		280	0.95
Concrete			0.90
Gravel			0.70
Other			-
TOTAL	**280**	**280**	
Composite C	0.3	0.95	
Adopted C	**0.30**	**0.95**	

Existing	Input / Select
Proposed	Answer

Existing Catchment Characteristics, Time of Concentration (Tc)	
Average grassed surface	0.045
Length of flow path (m)	20.00
Slope (%)	3.00
Tc (min)	10.49

Existing Q(max) (l/s) (interpolated wrt Tc)	2.12
Proposed Q(max) (l/s)	7.89

Figure 2: Stormwater Design Parameters

3.1.1 Attenuation Tank

It is proposed that the roof runoff from the design storm is attenuated in a rainwater tank and released via a 35mm orifice to match the existing flow rate. The minimum detention storage is 5,000L. The proposed tank size is 1 X 25,000L and may be located at the Client's discretion given that Council's requirements are met. The orifice should be located 560mm below the invert of the overflow pipe.

The rainwater tank outlet and overflow shall discharge to the level spreader at the base of the slope.

Subsurface water drains shall be sized in accordance with Acceptable Solutions and Verification Methods for New Zealand Building Code Clause E1 Surface Water (E1/AS1) Section 3.

3.1.2 Soakage from other impermeable surfaces

The stormwater runoff from the impermeable driveway has been designed to be routed to the nearby soakage pit. The soakage pit is to be 900mm in diameter and a minimum of 1.8m deep. Overflow from this device shall flow to the level spreader at the base of the gully.

3.1.3 Secondary flow path

The stormwater runoff from impermeable surfaces has been designed to be routed via the rainwater tank and soakage pit. The overflow from these devices shall discharge to the bottom of the nearby gully as far as possible from the slope beneath the proposed dwelling.

3.2 Operation and maintenance

It is recommended that first flush devices are installed upstream of the rainwater tank and that these devices are regularly checked and cleaned along with the catchpit filters and overflow pipes.

3.3 Construction Monitoring

TITUS CIVIL Consulting Engineers have been engaged to perform inspections of the storm water system during construction.

4 WASTEWATER ASSESSMENT AND DESIGN

4.1 Design Parameters

The following design parameters have been adopted to design the system to meet the requirements:

- Water supply to the property will be reticulated community supply
- 5-bedroom home
- 8 people occupancy
- 145L/day/person
- Peak daily flow 1,160L/day
- The soil at the site is classified as a soil category 2 - Sandy loams (AS/NZS 1547:2012).
- Council planning maps show no flooding risk for the site.

4.1.1 Water Use Requirements

The following water use requirements are noted:

- Design information of 145L/day/person is based of AS/NZS 1547:2012. This requires the proposed building to have **FULL** water reduction fixtures.
- standard water reduction fixtures include reduced flush 6/3 litre water closets, shower flow restrictors, aerator faucets, front-load washing machines and flow/pressure control valves on all water-use outlets (9L/min maximum). Baths should also be discouraged.

4.2 Treatment Design

4.2.1 Secondary Treatment System

Both primary and secondary treatment will be provided by an Ecocycle Fusion Treatment Plant (or similar). This system includes a 4,500-litre chamber for primary treatment, and a 1,500-litre treatment unit chamber. It has an emergency storage of 2,000 litres. It can treat up to 1,600 litres of wastewater per day. This system has been tested by the On-site Effluent Treatment National Testing Programme (OSET) based at the Rotorua/ BOP wastewater plant and complies with the NZ Standards for on-site wastewater management and Waikato Regional Council conditions for rule 3.5.7.6 of the Waikato Regional Plan.

The proposed system has been designed as per the table below.

Table 4: System Specifications

Min Septic Tank (L)	24hr settling volume (L)	Scum and sludge capacity (L)	Max Pump out frequency (Yrs)
4500	1160	3200	5
DLR recommended (mm/d)	DLR adopted (mm/d)	Daily Flow (L/day)	Basal area (m^2)
10-25	35	1160	34

The Ecocycle Fusion Treatment Plant is an environmentally sustainable recirculating packed bed bio filter for aerobic secondary treatment of wastewater. The system performs significantly higher than the standard required by AS/NZS1547:2012.

The system has been tested and provides for the following:

- BOD_5 <10g/m^3 average
- Suspended solids <10g/m^3 average
- 10:10 Standard

Attached to this report is the following documentation:

- Certification confirming that the system has undergone testing to comply with the NZ Standards for on-site wastewater management and the Waikato Regional Plan rule 3.5.7.6.
- Manufacturer's technical specifications for the tank and treatment plant.
- System warranty.
- Owner's operation and maintenance guidelines.
- Planting guideline.

4.2.2 Wastewater Disposal

Primary and secondary treatment will be achieved using a septic tank and a treatment facility with disposal through LPED Beds. The design is outlined in the Table below.

Table 5: Disposal Method Specifications

Disposal Method	Beds
Specification	
Number of beds	2
Length (m)	10
Width (m)	1.8
Spacing (m)	1
Basal area (m^2)	34
Total area (m^2)	43 + 43 Reserve Area

Appendix F provides an indicative layout of the proposed wastewater system and typical details.

4.3 Maintenance, Operation and Planting

Maintenance and Operation of the system shall be as per the manufacturers specifications, AS/NZS 1547:2012 and the recommendations contained in the appendices.

Planting shall be as per AS/NZS 1547:2012 and the recommendations contained in the appendices.

4.4 Inspections

TITUS CIVIL Consulting Engineers should be engaged to inspect the installation of the Septic Treatment and Land Disposal Systems prior to any excavations and pipe installations being buried.

5 SLOPE STABILITY ASSESSMENT

5.1 Assessment parameters

This slope stability assessment will consider the stability of the existing slope as well as the proposed plans with the basement cut into the slope, thus reducing the effective height of the slope. The assessment also considers strength loss in liquefiable layers following a ULS event.

The slope has been modelled using SLIDE 2018 software under several loading and ground water conditions. The report details the results of the assessment under the following loading conditions:

- Gravity (drained)
- Gravity (drained, elevated water table)
- SLS (Serviceability Limit State) – (drained)
- ULS (Ultimate Limit State) – (drained)
- Post Liquefied Conditions

The slope has been modelled in the three following scenarios:

- Existing conditions (prior to any earthworks undertaken on site)
- Proposed cutdown and dwelling
- Proposed cutdown and dwelling with strength loss layers due to liquefaction caused by a ULS earthquake.

Proposed slope cutting and dwelling foundation has been modelled to the specifications outlined in the latest engineering plans by Don Crowie Draughting & Design Services. Foundation Pile depths have been modelled to required depths to be founded below predicted failure arcs and to provide overall stability.

5.2 Historic Land Use

The site has previously been used as a milking shed that existed from pre-1938 until recent removal following subdivision of the land.

5.3 New Zealand Geotechnical Database

The New Zealand Geotechnical database has no entries close to the site. CPT logs from lot 4 of the subdivision have been used to determine the geological parameters in the slope model. The locations of the CPT logs are shown in Appendix A.

5.4 Geological Setting

Refer to section 2.3.1 *Geological Setting.*

5.5 Site Observations

The slope runs across the site from north to south. The slope separates flat (<5%) land above it to the west from the vegetated gully below it. Vegetation on the slope itself has been cleared in preparation for specialised planting. There were no outcrops of rock found on site. This is consistent with the geology of the Hamilton basin which has deep soils and deep bedrock.

The slope ranges in steepness from 7 degrees to a maximum of 40 degrees with an average slope of 27 degrees or 51% incline. Two large poplar trees are present at the top of the slope. Figure 3 below shows the slope below the proposed dwelling location. The loose material seen on the slope in Figure 3 is sand from the removal of the milking shed foundation. No evidence of slope instability was seen during the site inspection.

Figure 3: Photo of slope from below proposed dwelling location.

5.6 General

Slope stability modelling has been undertaken using Slide 2018 by RocScience using the Morgenstern-Price method to analyse the slope. The cross section of the slope was based on contour data taken from HCC 3 waters online mapping service. Location of the slope modelled is attached in Appendix A and Slope models are attached in Appendix H.

The factors of safety (FOS) as summarised in Table 7 has been adopted as appropriate for the loading conditions:

Table 7: FOS Standard Requirements

Modelled Loading Condition	FOS Required
Gravity Conditions	1.5
Gravity Conditions (elevated water table)	1.3
Seismic SLS (Serviceability Limit State)	1.4
Seismic ULS (Ultimate Limit State)	1
Post Liquefaction	1.1

5.7 Adopted Subsurface Conditions

The stratigraphy as determined by TITUS Consulting Engineers with reference to CPT logs for lot 4 undertaken by OPUS, has been separated into the different materials displayed in the Table below.

Table 8: Material characteristics

Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Vertical Strength Ratio	Minimum Shear Strength (kPa)	Water Surface	Hu Type	Hu
Coarse Sands		17.5	20.7	Mohr-Coulomb	2	36			Water Surface	Automatically Calculated	
Medium Sands		17	20.7	Mohr-Coulomb	2	34			Water Surface	Automatically Calculated	
Silty Sands and Sandy Silts		17	19.7	Mohr-Coulomb	6	32			Water Surface	Automatically Calculated	
Liquefied Layer		17		Vertical Stress Ratio			0.15	5	Water Surface	Custom	0
Concrete Slab		25		Mohr-Coulomb	700	0			Water Surface	Custom	1

5.8 Groundwater Model

The water table has been modelled at 12.0m below the ground surface at the top of the slope and 0.3m below the surface at the bottom except in the elevated water table conditions.

The elevated water table has been modelled at 8m below the ground surface at the top of the slope and at the ground surface at the bottom of the slope as the gully is expected to flood during a large storm event.

5.9 Loading

Loadings applied to each model are shown in the Table below. The location of loadings may be found in Appendix H.

Table 9: Surcharges to be present in slope profile.

Surcharge	Load	Load Type
Proposed Dwelling	25 kN/m^2	Uniformly Distributed
Deck	5 kN/m^2	Uniformly Distributed

5.10 Supports

The properties of supports modelled are displayed in the Table below.

Table 10: Support properties

Type	Out of plane Spacing	Shear Strength - Static	Shear Strength - Transient	Depth
200 mm SED High Density Timber Pile (with 8mm/m taper)	2.0 m	40 kN	67 kN	3.6 and 5.0m as applicable

5.11 Slope Stability Results

Under existing conditions, the model shows failure arcs below the required FOS up to 11.8m back from the crest of the slope during ULS and SLS conditions. The gravity condition had failure arcs below the required FOS up to 1.4m back from the crest of the slope.

Under the proposed slope cutting and dwelling foundation scenario the gravity and elevated water scenarios meet the required FOS required. The FOS reached for the dwelling under the SLS condition was 1.55 and the FOS reached under ULS conditions was 1.11. Both of these meet the required FOS for their conditions.

The strength loss scenario gave a FOS of 1.002 under ULS conditions.

Table 11 below shows the minimum FOS achieved for the modelled foundation under various seismic loading conditions as specified in Section 5.6 of this report.

Table 11: Worst Case failure plane FOS

Modelled Loading Condition	Minimum Global FOS (Existing)	FOS Reached (Proposed with house and piling)
Gravity Conditions	1.42	>1.5
Gravity Conditions (elevated water table)	1.42	>1.3
Seismic SLS (Serviceability Limit State)	1.28	>1.4
Seismic ULS (Ultimate Limit State)	0.93	>1
Liquefied Condition	>1.2	>1.1

5.12 Recommendations

It is proposed the site is cut down 3.0m as per the site development plans.

To improve stability of the slope the following recommendations have been made:

- The dwelling should be setback at least 5.5m from the new top of the slope after cutting down with piling as modelled.
- The modelled foundation is based on 200mm diameter piles as per the Engineering Plans with a minimum embedment depth of 5.0m and 3.6m as modelled.
- The rest of the foundation piles will be designed by a suitably qualified engineer to be in accordance with suitable depths as outlined in section 2.4.1 of this report.
- Appropriate vegetation should be planted on the slope as to improve stability and avoid erosion.
- No overland flow paths should be directed onto or towards the slope.
- No undercutting of the slope should be undertaken without due consideration to slope stability.

6 LIMITATIONS

This report does not assess risk of contamination of soils. This report does not provide a foundation design.

Testing portrays a limited percentage of ground conditions at Lot 2 136 State Highway 26 and may not be representative of all soils present on site.

Assessment of the water table depth and moisture content is subject to seasonal variation.

During excavation and construction, the site should be examined by a suitably qualified engineer in order to assess whether the exposed subsoils are compatible with the inferred soil conditions on which the recommendations have been based and potentially further investigation and design rationalisation may be required. Flooding and FFL requirements has not been assessed as part of this stormwater design.

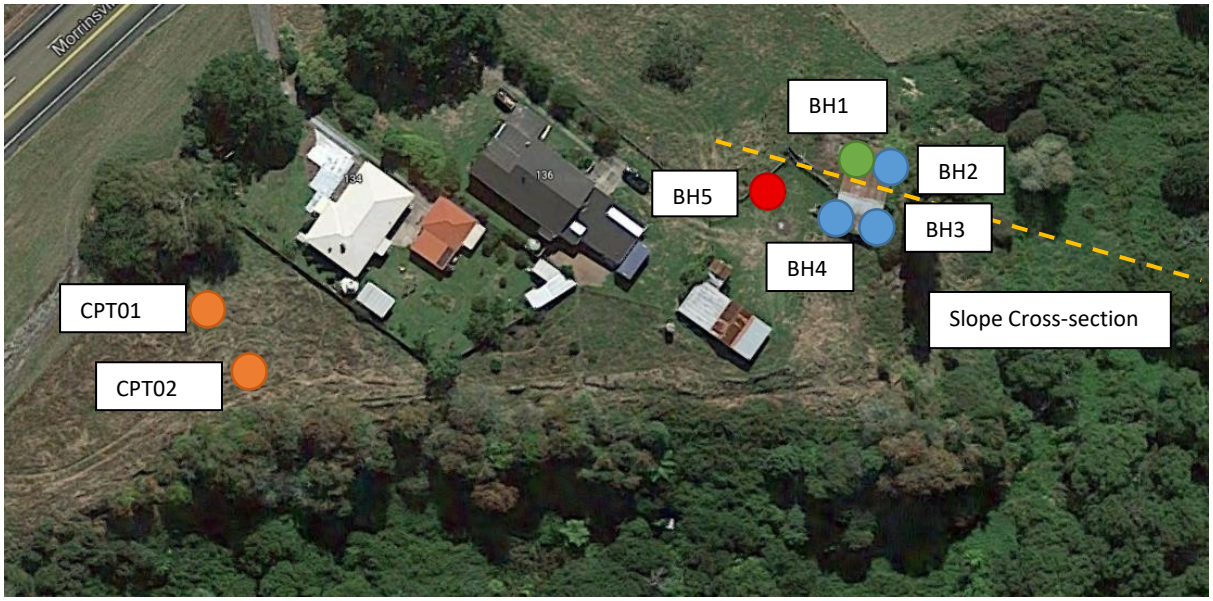
This report has been prepared solely for Martin Cameron, its professional advisors, and local authorities in relation to Lot 2 136 State Highway 26. No liability is accepted for its use for any other purpose or by any other entity. Reliance by other parties or future owners of the property on the information or opinions contained in the report shall be verified with TITUS CIVIL Consulting Engineers.

Should you be in any doubt as to the recommendations of this report it is essential that you discuss these issues with TITUS CIVIL Consulting Engineers prior to proceeding with any work based on this report.

APPENDICES

APPENDIX A - Proposed Site Layout Plan

Test locations 12/05/2020



Test location 24/02/2022

APPENDIX B - Soil Investigation Bore Logs

Testing from the 15/05/2020

TITUS CONSULTING ENGINEERS

Log: BH1

Address: Lot 2 State Highway 26
Date: 12/05/2020
Testers: RM
Project №: 11122

Water Table:	Depth (mm):	Geology:	Graphic Log:	Material Description:	Blows /100mm:	Shear Strength (kPa): Undrained:	Remoulded:	Sensitivity:
Not Found	0–300	Hinuera Formation		Medium SAND, yellowish orange and brown, poorly graded, moist, very loose	0, 0, 0			
	300–700			SILT with some sand, yellowish grey, low plasticity, moist, stiff	3, 2, 3, 2	91	53	1.7
	700–1400			SILT with some sand, light yellowish brown, low plasticity, moist, stiff	3, 2, 2, 4, 6, 4, 4	91	30	3
	1400–2100			*End of Borehole @1400mm*	5, 4, 6, 6, 5	91	61	1.5

TITUS CONSULTING ENGINEERS

Log: BH2

Address: Lot 2 State Highway 26
Date: 12/05/2020
Testers: RM
Project №: 11122

Water Table:	Depth (mm):	Geology:	Graphic Log:	Material Description:	Blows /100mm: 5 10 15	Shear Strength (kPa): Undrained:	Remoulded:	Sensitivity:
Not Found	100	Hinuera Formation		Medium SAND, yellowish brown, poorly graded, moist, very loose	0			
	200				0			
	300			Black, organics	0			
	400				0			
	500				0			
	600				0			
	700				0			
	800				1			
	900			Medium SAND, yellowish brown, poorly graded, moist, very loose to loose	2			
	1000				1			
	1100			SILT, grey, low plasticity, moist, stiff	3	91	61	1.5
	1200				2			
	1300				2			
	1400				3			
	1500			Medium to coarse SAND with some silt, brown, well graded, moist, medium dense	5			
	1600				5			
	1700				5			
	1800				4			
	1900				5			
	2000							
	2100			*End of Borehole @2000mm*				

TITUS CONSULTING ENGINEERS

Log: BH3

Address: Lot 2 State Highway 26
Date: 12/05/2020
Testers: RM
Project №: 11122

Water Table:	Depth (mm):	Geology:	Graphic Log:	Material Description:	Blows /100mm: (5 10 15)		Shear Strength (kPa): Undrained:	Remoulded:	Sensitivity:
Not Found	100	Hinuera Formation		Fine SAND with minor silt, brown, well graded, moist, very loose		0			
	200					0			
	300					0			
	400			SILT, brownish grey, low plasticity, moist, stiff		2	91	38	2.4
	500					1			
	600					3			
	700			Medium SAND, yellowish brown, poorly graded, moist, loose to medium dense		2			
	800					3			
	900					2			
	1000					5			
	1100					3			
	1200			Silty fine SAND, light brown, well graded, moist, loose		3			
	1300					5			
	1400					5			
	1500			SILT with some sand, light yellowish brown, low plasticity, moist, very stiff		8	206	53	3.9
	1600					5			
	1700			Medium to coarse SAND, brownish orange, well graded, moist, medium dense		5			
	1800					6			
	1900								
	2000								
	2100			*End of Borehole @2000mm*					

TITUS CONSULTING ENGINEERS

Log: BH4

Address: Lot 2 State Highway 26
Date: 12/05/2020
Testers: RM
Project №: 11122

Water Table:	Depth (mm):	Geology:	Graphic Log:	Material Description:	Blows /100mm: (5 10 15)		Shear Strength (kPa): Undrained:	Remoulded:	Sensitivity:
Not Found	100	Hinuera Formation		Medium SAND, brownish orange, poorly graded, moist, very loose		0			
	200					0			
	300					0			
	400					1			
	500			Sandy SILT, yellowish brown, low plasticity, moist, stiff		2	84	38	2.2
	600					1			
	700					2			
	800					3	99	69	1.4
	900			Silty medium to coarse SAND, dark brownish orange, well graded, moist, very loose to medium dense		3			
	1000					2			
	1100					1			
	1200			Silty SAND, greyish brown, well graded, moist, loose		3			
	1300					4			
	1400					5			
	1500					4			
	1600			Coarse SAND, yellowish brown, poorly graded, moist, medium dense to dense		4			
	1700					5			
	1800					5			
	1900					8			
	2000								
	2100			*End of Borehole @2000mm*					

TITUS CONSULTING ENGINEERS

Log: BH5

Address: Lot 2 State Highway 26
Date: 12/05/2020
Testers: RM

Project №: 11122

Water Table:	Depth (mm):	Geology:	Graphic Log:	Material Description:	Blows /100mm: 5 10 15	Shear Strength (kPa): Undrained:	Remoulded:	Sensitivity:
Not Found	100	Undefined		Topsoil				
	200							
	300			Medium SAND, yellowish brown, poorly graded, moist				
	400							
	500							
	600			SILT, light brown, low plasticity, moist				
	700							
	800							
	900							
	1000	Hinuera Formation		Fine to medium SAND, brownish orange, well graded, moist				
	1100							
	1200							
	1300							
	1400			Medium to coarse SAND, brown, well graded, moist				
	1500							
	1600							
	1700							
	1800							
	1900							
	2000							
	2100			*End of Borehole @2000mm*				

Testing from the 24/02/2022

TITUS CONSULTING ENGINEERS

Log: 1 of 1

HA6

Address: Lot 2 State Highway 26
Date: 24/02/2022
Testers: BrianaV, PetaM

Project №: 11122

Water Table:	Depth (mm):	Geology:	Graphic Log:	Material Description:	Blows /100mm:	Shear Strength (kPa): Undrained:	Remoulded:	Sensitivity:
Not Found	100	Hinuera Formation		Silty medium SAND, grey, well graded, dry, very loose	0			
	200				0			
	300				0			
	400				1			
	500			Sandy SILT, grey, low plasticity, moist, stiff	2	96	30	3.2
	600				2			
	700				5			
	800				5			
	900			Medium SAND, brownish grey, poorly graded, moist, medium dense to dense	8			
	1000				9			
	1100				6			
	1200				5			
	1300			Medium to coarse SAND, brownish grey, well graded, moist, medium dense to dense	5			
	1400				8			
	1500				11			
	1600				10			
	1700				6			
	1800			Coarse SAND, dark grey, poorly graded, moist, medium dense	10			
	1900				11			
	2000							
	2100			*End of Borehole @2000mm*				

TITUS
CONSULTING ENGINEERS

Log: 1 of 1

HA7

Address: Lot 2 State Highway 26
Date: 24/02/2022
Testers: BrianaV, PetaM

Project №: 11122

Water Table:	Depth (mm):	Geology:	Graphic Log:	Material Description:	Blows /100mm:	Shear Strength (kPa): Undrained:	Remoulded:	Sensitivity:
Not Found	100	Hinuera Formation		Sandy SILT, grey, low plasticity, dry, stiff	0			
	200				0			
	300				7	82	30	2.8
	400				5			
	500				6			
	600				5			
	700			SILT, grey, low plasticity, moist, stiff to very stiff	3	156	45	3.5
	800				3			
	900				5			
	1000				9	134	37	3.6
	1100				8			
	1200			*Borehole terminated due to non-retrieval @1100mm*	10			
	1300				8			
	1400				7			
	1500				6			
	1600				11			
	1700				9			
	1800				8			
	1900				9			
	2000							
	2100							

TITUS CONSULTING ENGINEERS

Log: 1 of 1

HA8

Address: Lot 2 State Highway 26
Date: 24/02/2022
Testers: BrianaV, PetaM

Project №: 11122

Water Table:	Depth (mm):	Geology:	Graphic Log:	Material Description:	Blows /100mm: (5 10 15)		Shear Strength (kPa): Undrained:	Remoulded:	Sensitivity:
Not Found	100	Hinuera Formation		Silty fine SAND, grey, well graded, dry, very loose to medium dense		0			
	200					0			
	300					0			
	400					5			
	500			Sandy SILT, grey, low plasticity, dry to moist, very stiff		4	148	52	2.9
	600					3			
	700			Silty fine SAND, grey, well graded, medium dense		5			
	800			Coarse SAND, brownish grey, poorly graded, moist, medium dense to dense		5			
	900					8			
	1000					9			
	1100					9			
	1200					8			
	1300					6			
	1400					9			
	1500			Coarse SAND, dark brownish grey, poorly graded, moist, medium dense		11			
	1600					9			
	1700					8			
	1800					10			
	1900					10			
	2000								
	2100			*End of Borehole @2000mm*					

TITUS CONSULTING ENGINEERS

Log: 1 of 1

HA9

Address: Lot 2 State Highway 26
Date: 24/02/2022
Testers: BrianaV, PetaM

Project №: 11122

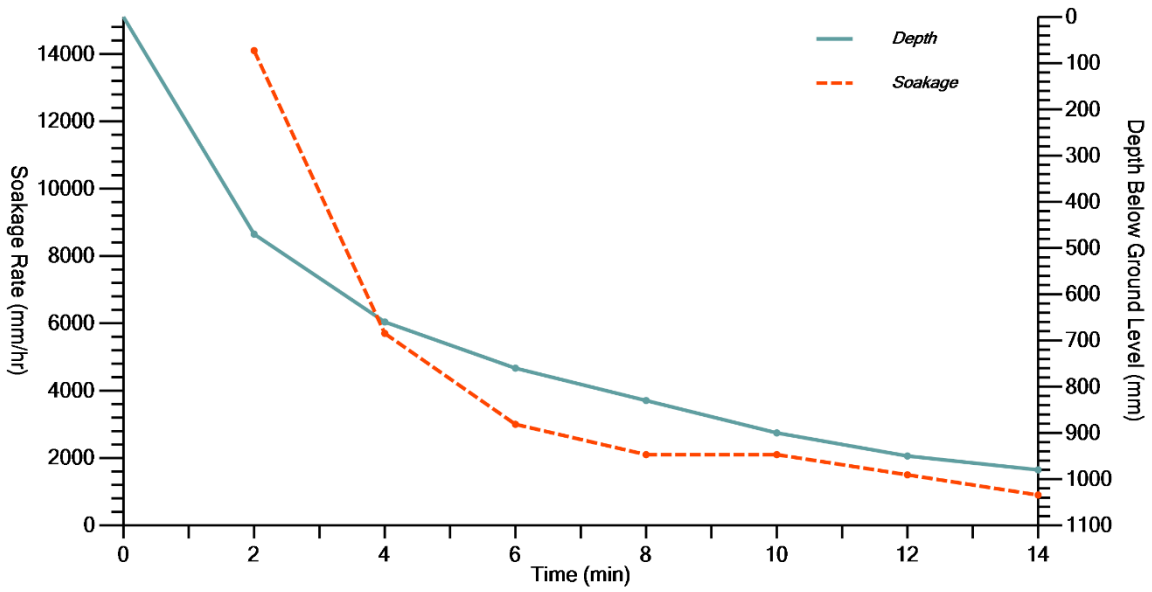
Water Table:	Depth (mm):	Geology:	Graphic Log:	Material Description:	Blows /100mm: 5 10 15		Shear Strength (kPa): Undrained:	Remoulded:	Sensitivity:
Not Found	100	Hinuera Formation		SILT, grey, low plasticity, dry to moist, stiff		0			
	200					0			
	300					0	89	30	3
	400					6			
	500			Fine SAND, grey, poorly graded, moist, medium dense to dense		7			
	600					5			
	700			Coarse SAND, brownish grey, poorly graded, moist, medium dense to dense		8			
	800					10			
	900					9			
	1000					6			
	1100					9			
	1200			Coarse SAND, dark brownish grey, poorly graded, moist, medium dense		9			
	1300					8			
	1400					11			
	1500					10			
	1600					8			
	1700					9			
	1800					9			
	1900					10			
	2000								
	2100			*End of Borehole @2000mm*					

APPENDIX C - Percolation Test

TITUS CONSULTING ENGINEERS

Percolation Test Sheet

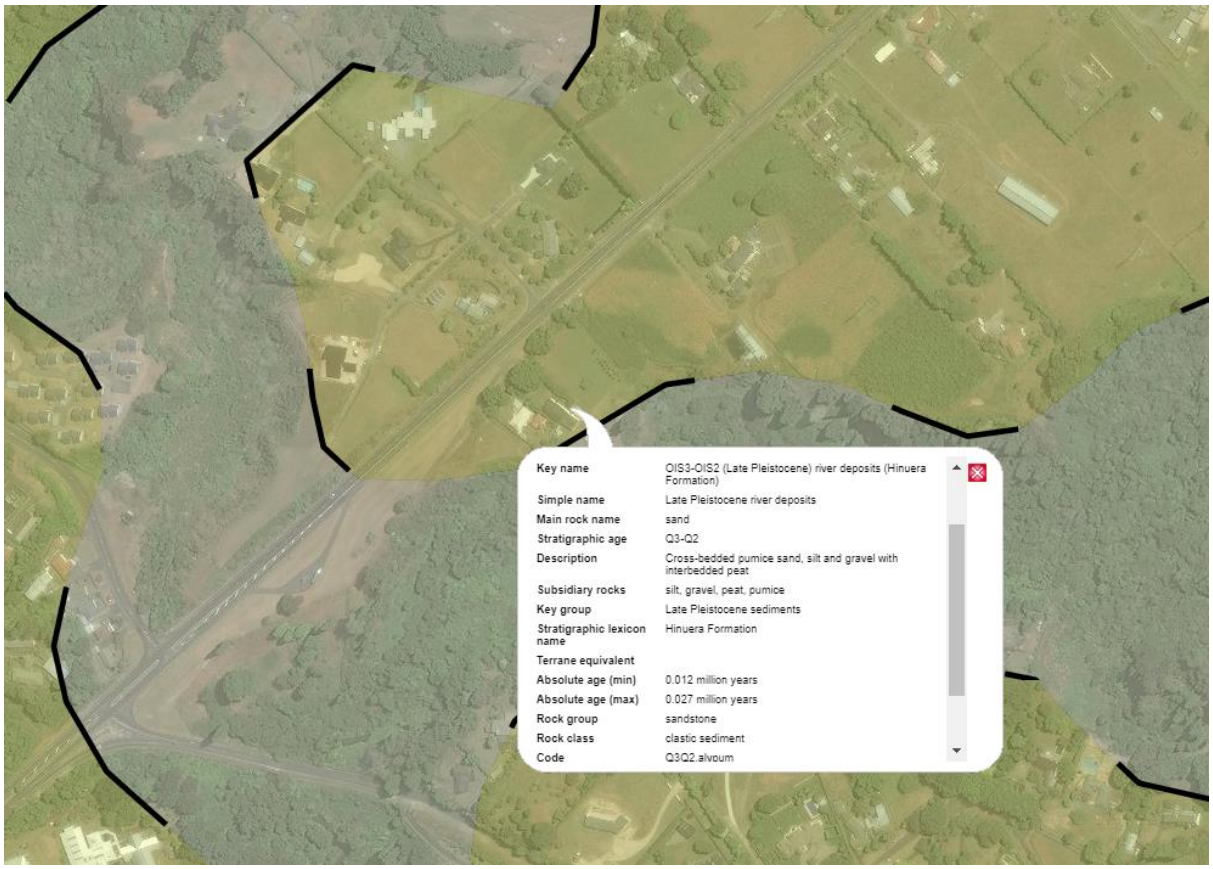
Project ID 11122
Address Lot 2 State Highway 26



Reading	Time Elapsed (min)	Drop (mm)	Soakage Rate (mm/hr)	Refill
1	2	470	14100	
2	4	190	5700	
3	6	100	3000	
4	8	70	2100	
5	10	70	2100	
6	12	50	1500	
7	14	30	900	

Log	BH1
Date	12/05/2020
Staff	RM
BH Depth	1400 mm
Ground Water	Not Encountered
Main Soil Type	SILT
Seasonal Variation	Conservative
Raw Soakage	900 mm/hr

APPENDIX D - Underlying Geology



APPENDIX E - Proposed Stormwater & Wastewater Layout Plans

Attached separately

APPENDIX F - Calculation Sheets

TANK DESIGN CALCULATIONS AND OUTPUTS

Existing	Input / Select
Proposed	Answer

Rainfall Location	Event	ARI
Hamilton	Primary	10
	Secondary	100

Catchment	Area (m2)		C
	Existing	Proposed	
Grass	280		0.30
Roof		280	0.95
Concrete			0.90
Gravel			0.70
Other			-
TOTAL	**280**	**280**	
Composite C	0.3	0.95	
Adopted C	**0.30**	**0.95**	

Existing Catchment Characteristics, Time of Concentration (Tc)	
Average grassed surface	0.045
Length of flow path (m)	20.00
Slope (%)	3.00
Tc (min)	10.49

Existing Q(max) (l/s) (interpolated wrt Tc)	2.12
Proposed Q(max) (l/s)	7.89

ARI	10									
Duration(min)	10	20	30	60	120	360	720	1440	2880	4320
Delta t (min)	10	10	30	60	240	360	720	1440	1440	
Delta Q (l/s)	-0.5	-0.3	-0.4	-0.4	-0.3	-0.1	-0.1	0.0	0.0	
Intensity	91.9	69.1	57.1	38.7	23.6	10.6	6.7	4.1	2.5	1.8
Intensity CC	107.2	80.3	66.1	44.7	27.1	12.1	7.6	4.7	2.8	2.0
Existing Q (l/s)	2.1	1.6	1.3	0.9	0.6	0.2	0.2	0.1	0.1	0.0
Proposed Q (l/s)	7.9	5.9	4.9	3.3	2.0	0.9	0.6	0.3	0.2	0.1

ARI	10									
Duration	10m	20m	30m	60m	2h	6h	12h	24h	48h	72h
Depth EX	16.2	24.5	29.6	36.4	42.7	57.3	77.5	93.3	113.4	121.1
Depth CC	17.9	26.8	33.1	44.7	54.3	72.3	91.3	112.1	135.2	142.3
Existing Vol m3	1.4	2.1	2.5	3.1	3.6	4.8	6.5	7.8	9.5	10.2
Proposed Vol m3	4.8	7.1	8.8	11.9	14.4	19.2	24.3	29.8	36.0	37.9

Effective Tank Dia (m)	3.4	effective head m		0.56	Sharp edge					
ARI	10.0	orifice size mm		36.2	Cd	0.62				
Duration	10m	20m	30m	60m	2h	6h	12h	24h	48h	72h
Volume in	4.8	7.1	8.8	11.9	14.4	19.2	24.3	29.8	36.0	37.9
Volume out	1.3	2.5	3.8	7.6	15.3	45.8	91.5	183.0	366.0	549.0
Volume store	3.5	4.6	**5.0**	4.3	-0.8	-26.5	-67.2	-153.2	-330.1	-511.2

Tank Calc

Height	2.80	**Capacities**	
Volume (m3)	25.00	Run off reuse (m3)	20.0
Volume MAX (m3)	4.99	Detention (m3)	5.0
Diameter (m)	3.37		

APPENDIX G - Key Do's & Don'ts for the Householder

DO

- Minimise your water use.
- Minimise the length of showers.
- Use showers in preference to baths.
- Use bio-degradable soaps and cleaners
- Check all your cleaning products to see if they are suitable for septic tanks.
- Minimise use of strong toilet cleaners.
- Scrape all plates and dishes to remove as much fat and grease as possible. Clean with paper towels and place in the rubbish.
- Report/fix all leaking taps as soon as possible.
- Use phosphate free/low phosphorus based laundry detergents.

DO NOT

- Don't pour any toxic/strong chemicals (paint, oil, grease, paint thinners, pesticides down any drains).
- Don't flush any products down the toilet, other than standard toilet paper.
- Don't discard any drugs down the sink or toilet.
- Don't use strong cleaners.
- Don't tip chlorine cleaners or disinfectant based products into the system.
- Don't use huge amounts of cleaners.
- Don't use chemical drain cleaning products.
- Don't do all your laundry on one day.
- Don't install in-sink garbage grinders. If a grinder exists, don't discharge high volumes of scraps, especially carbohydrates or fats/oils down it.
- Don't put coffee grounds down the sink.

APPENDIX H - Maintenance, Operation and Planting Recommendations

Attached separately

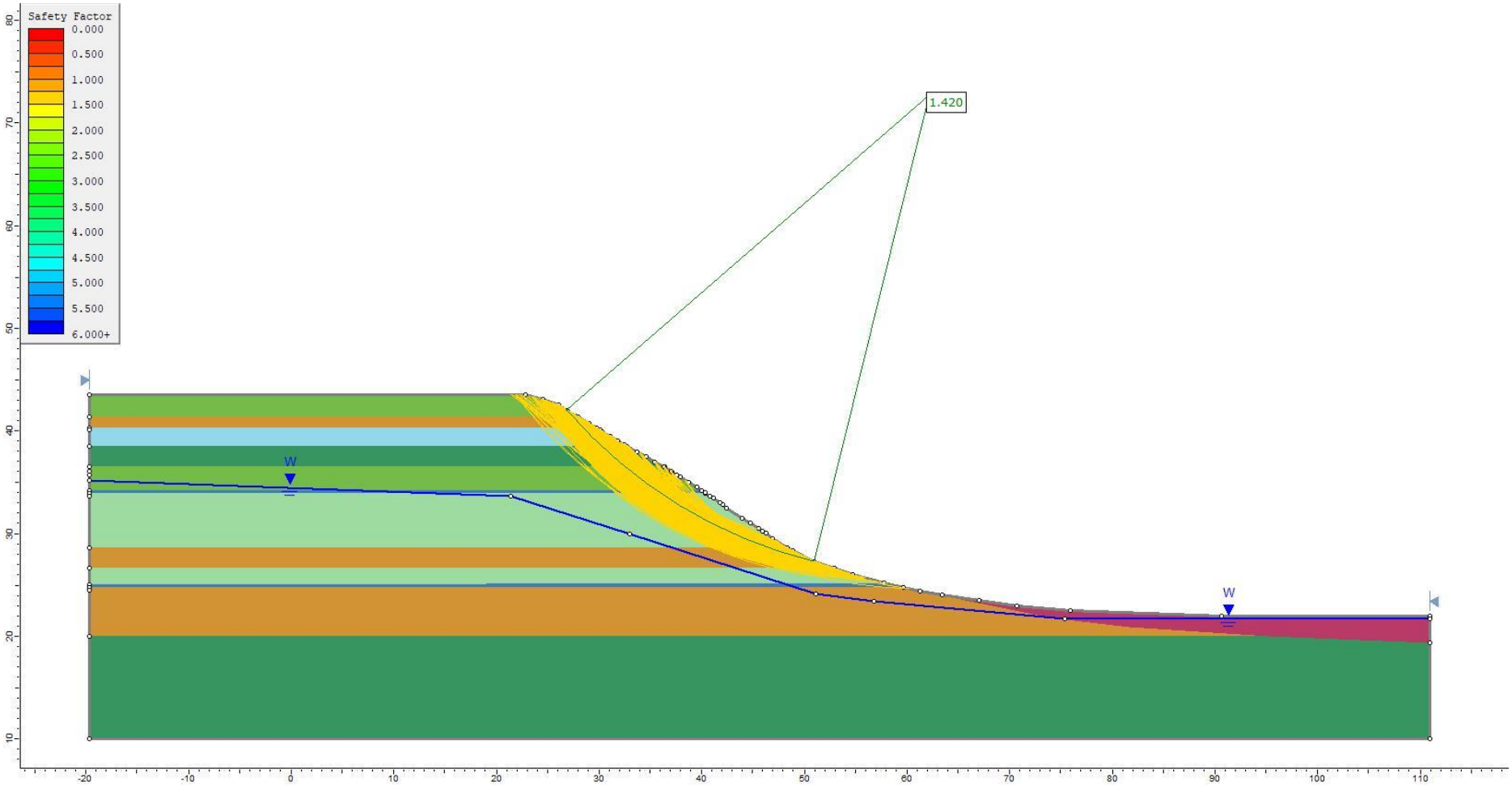
APPENDIX I – Liquefaction Assessment Results

Attached separately

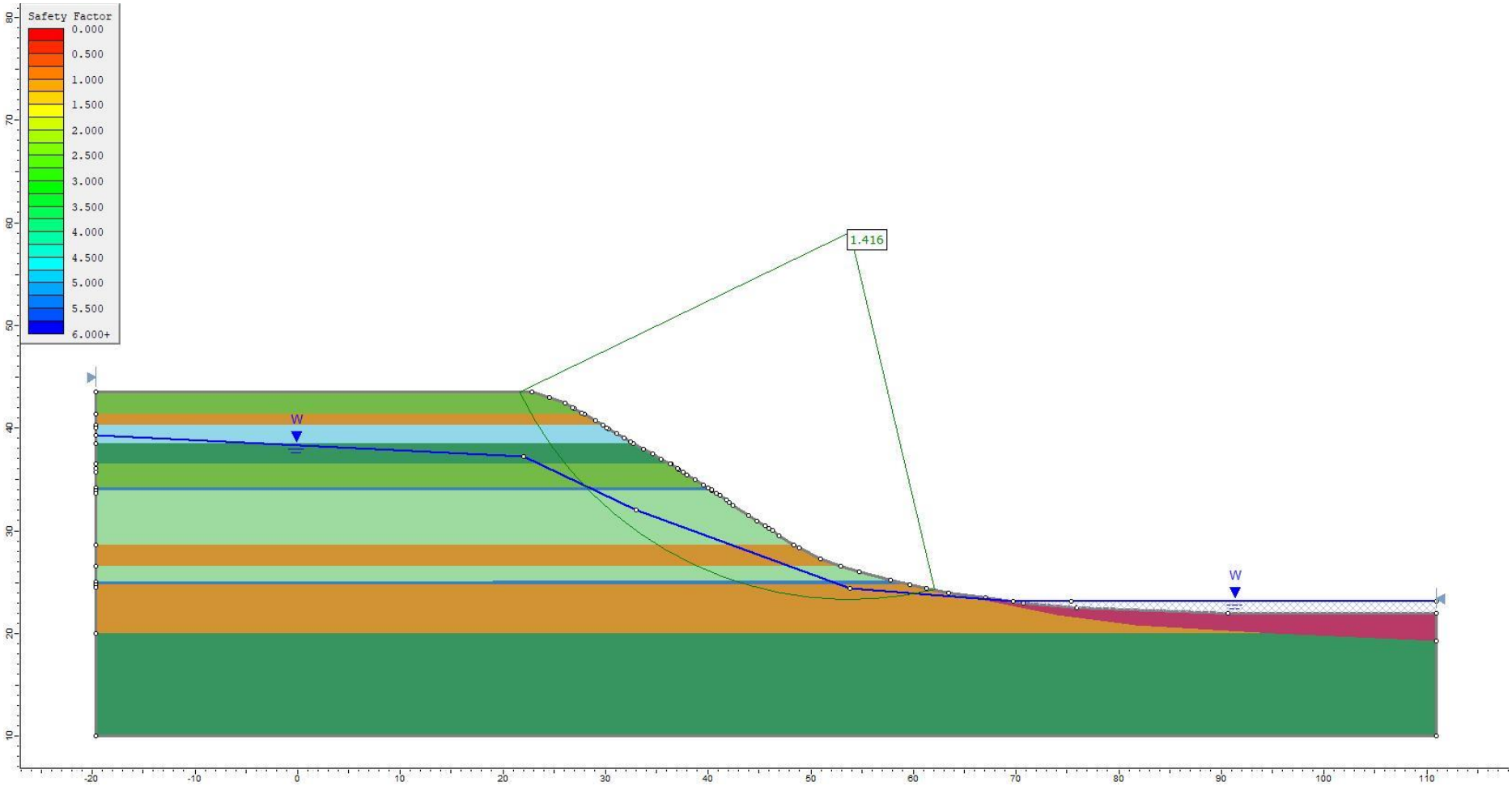
APPENDIX J – Slope Stability Models

EXISTING SLOPE (Modelled in 2020)

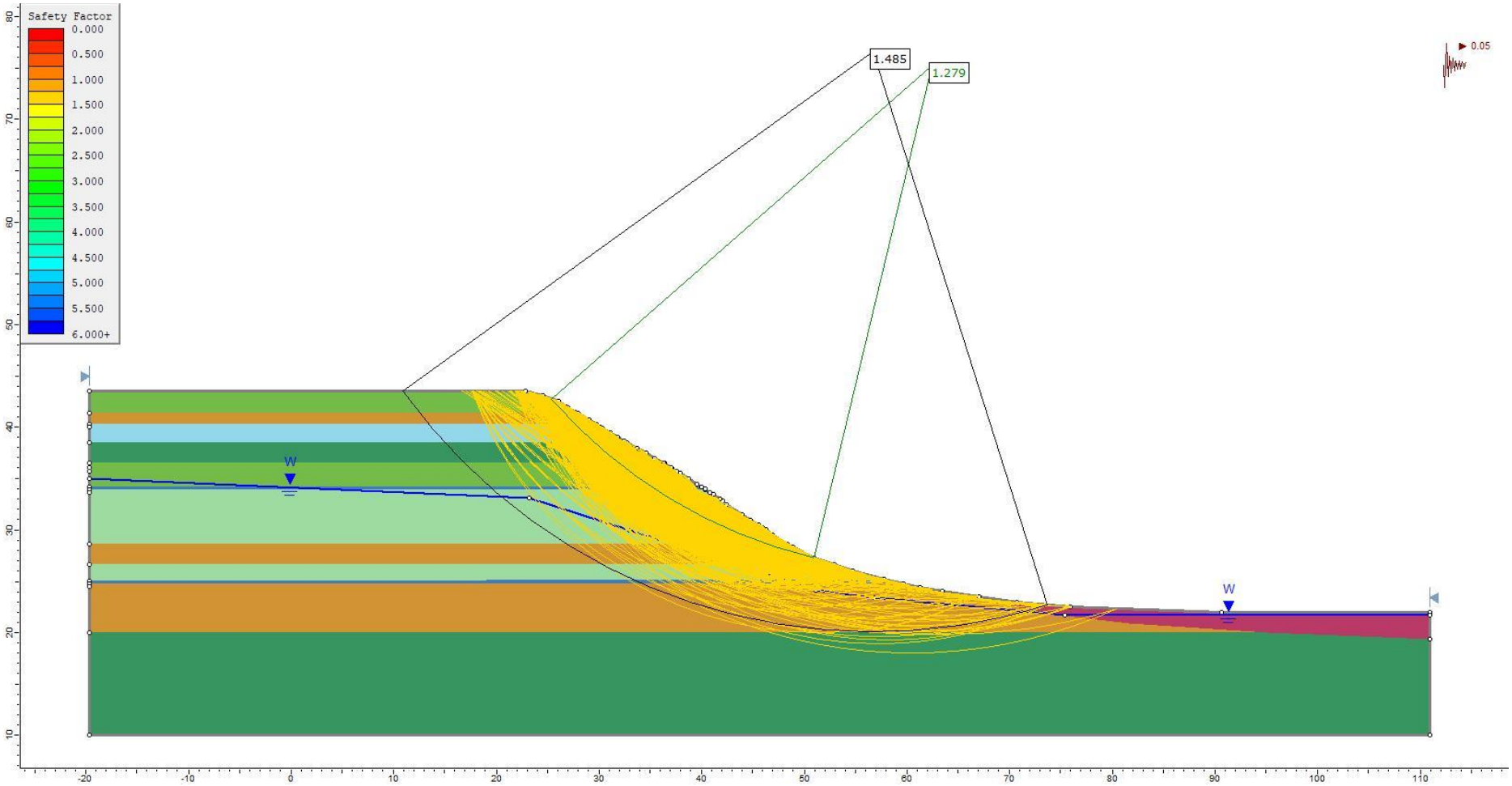
Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Water Surface	Hu Type	Ru
Topsoil		17	19.7	Mohr-Coulomb	2	28		Water Surface	Automatically Calculated	
Coarse Dense Sands		18	20.7	Mohr-Coulomb	2	40		Water Surface	Automatically Calculated	
Coarse Sands		18	20.7	Mohr-Coulomb	2	38		Water Surface	Automatically Calculated	
Medium to Coarse Sands		18	20.7	Mohr-Coulomb	2	37		Water Surface	Automatically Calculated	
Medium Sands		18	20.7	Mohr-Coulomb	2	36		Water Surface	Automatically Calculated	
Medium to Fine Sands		19	21	Mohr-Coulomb	2	35		Water Surface	Automatically Calculated	
Fine Silts		17	19.7	Mohr-Coulomb	3	32		Water Surface	Automatically Calculated	
Holocene Sediments		13	14	Mohr-Coulomb	0	32		Water Surface	Automatically Calculated	
Free Draining hardfill		18	20.7	Mohr-Coulomb	2	37		Water Surface	Automatically Calculated	
Concrete Retaining Wall		25		Undrained	650		Constant	None		0
Concrete Floor		24		Mohr-Coulomb	30	40		None		0
Liquefied Layer		18	20.7	Undrained	5		Constant	Water Surface	Automatically Calculated	



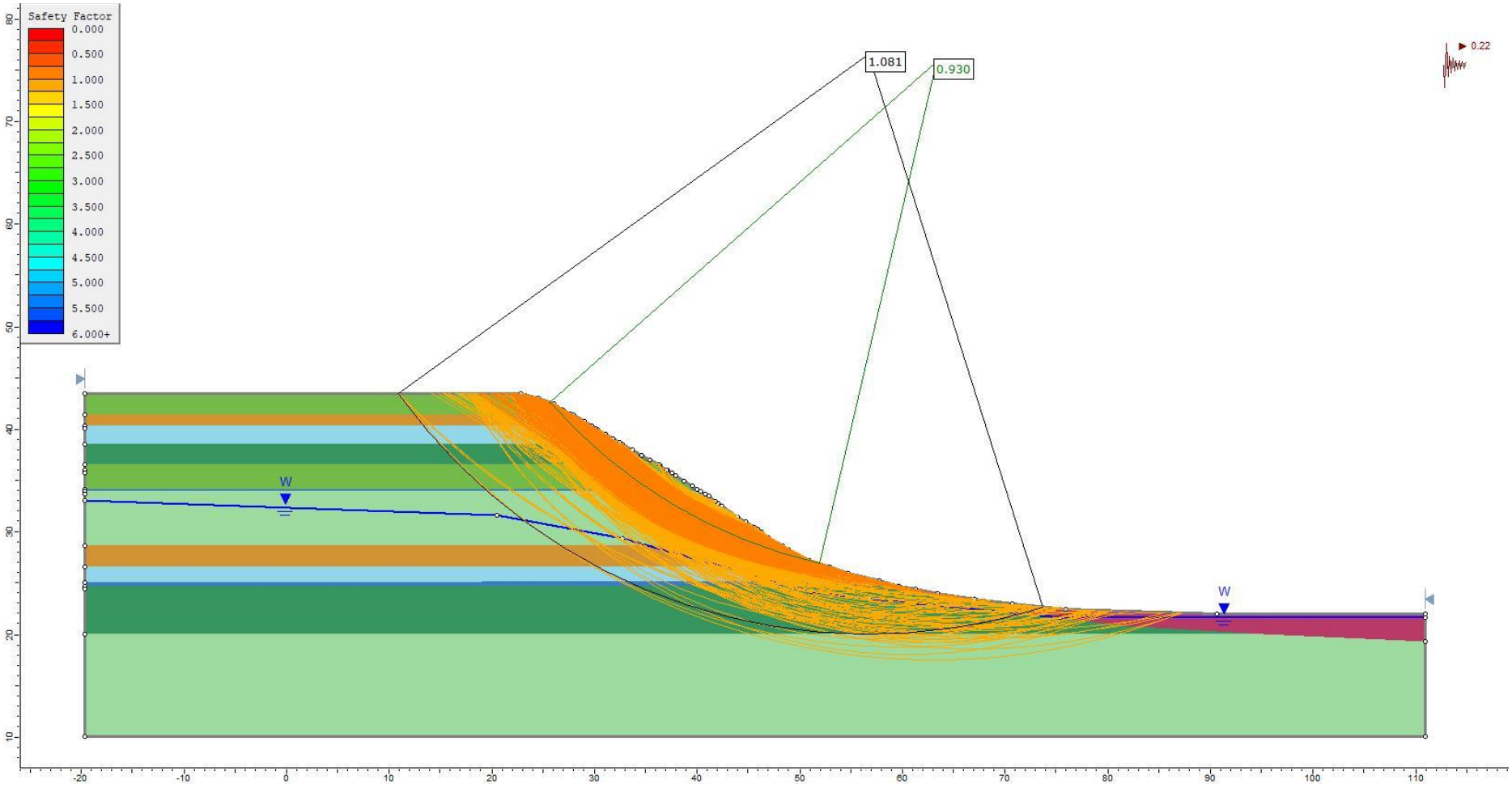
SLIDE 2018 model – Existing Site – Gravity Conditions – FOS required: 1.5



SLIDE 2018 model – Existing Site – Gravity Conditions –Elevated water table - FOS required: 1.3

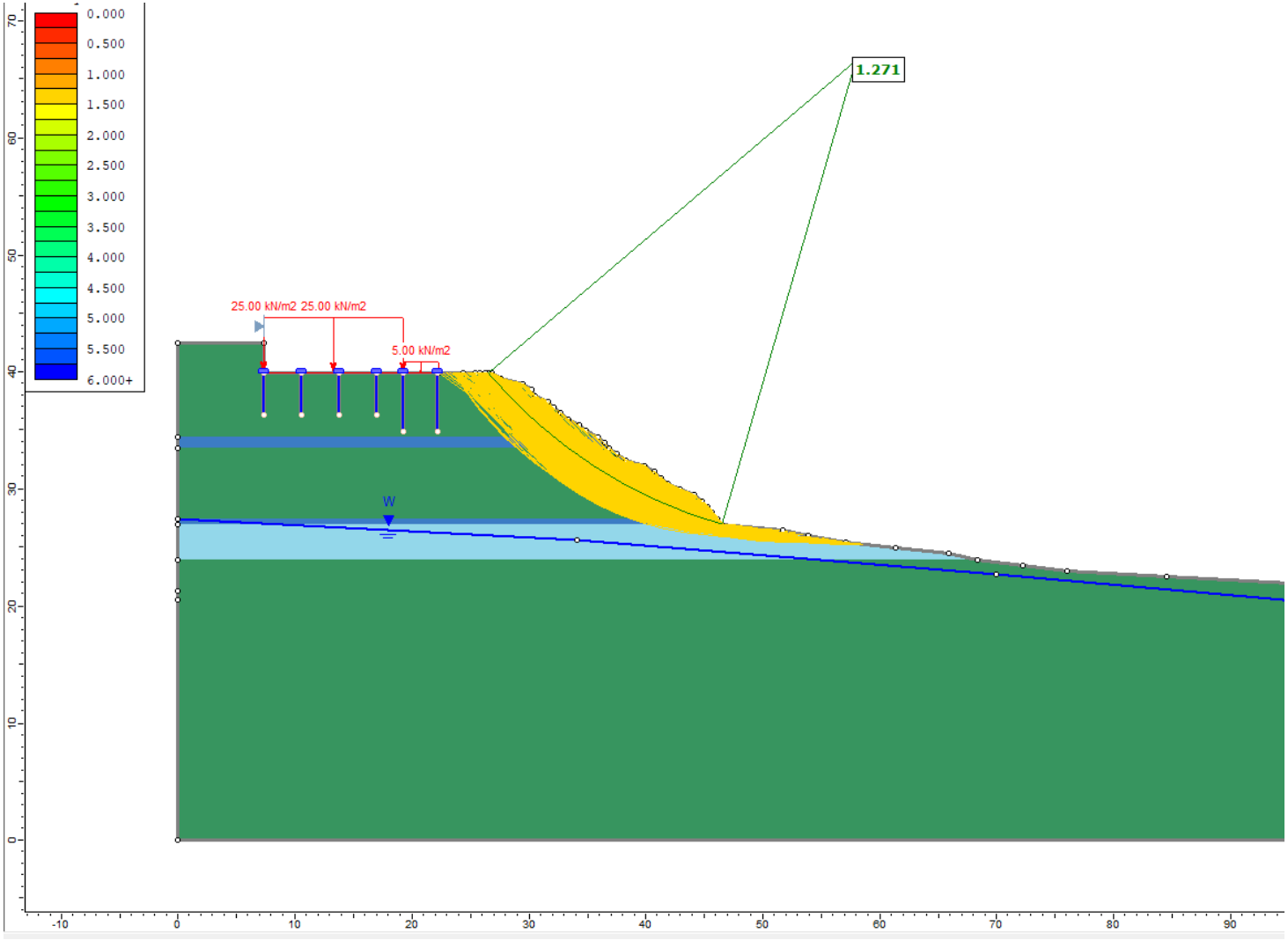


SLIDE 2018 model – Existing Site - SLS (Serviceability Limit State) – FOS required: 1.5

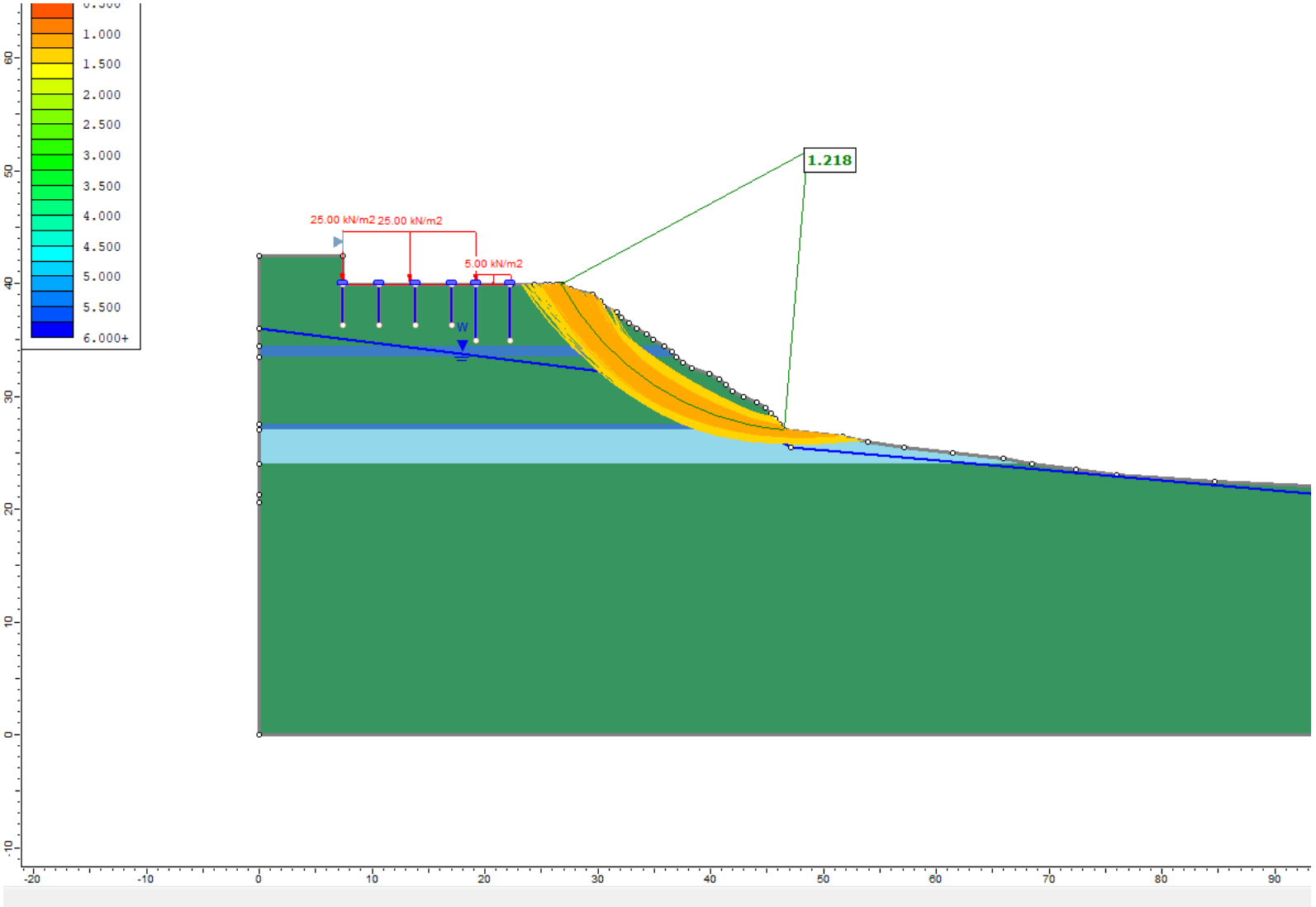


SLIDE 2018 model – Existing Site - ULS (Ultimate Limit State) – FOS required: 1.1

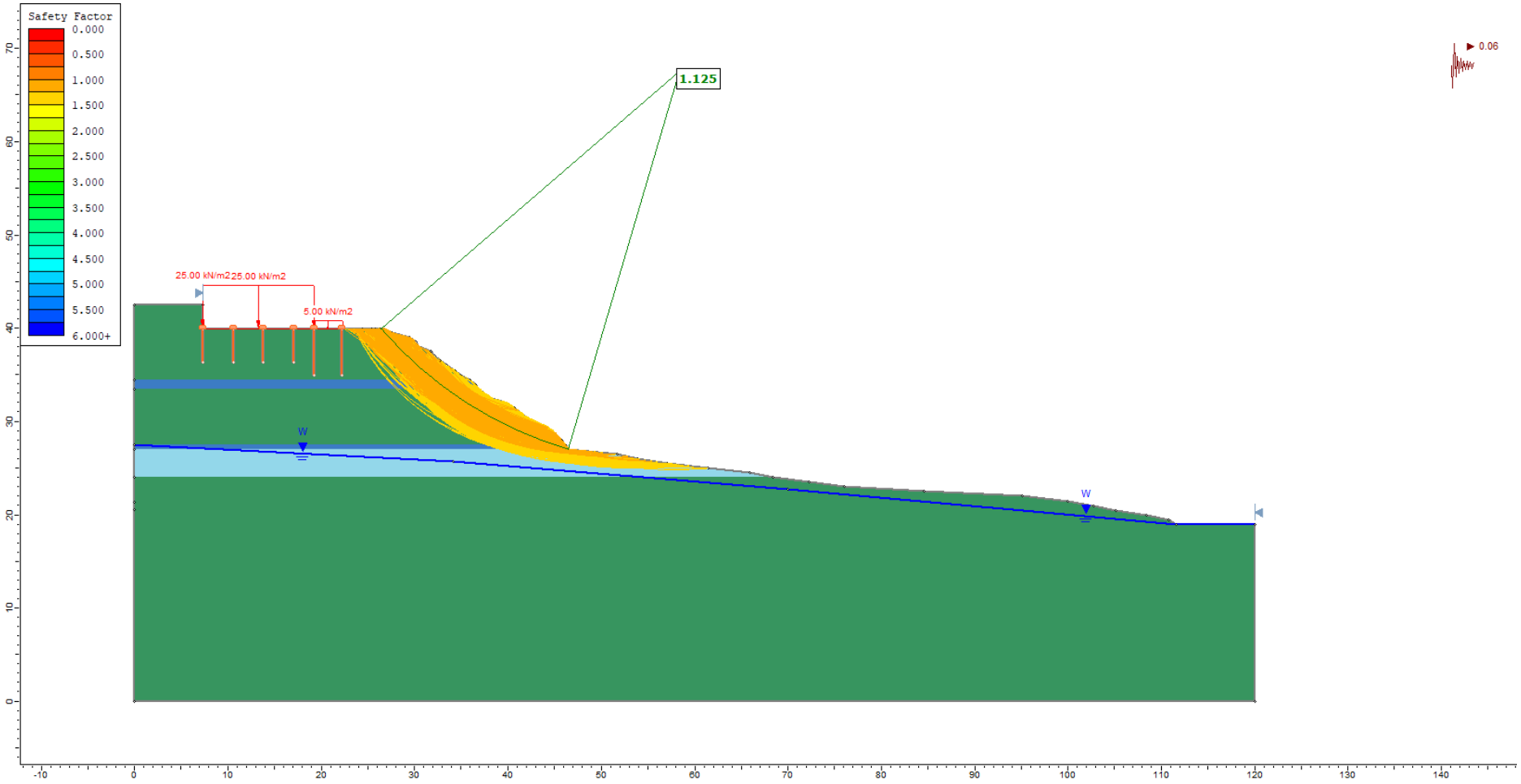
PROPOSED DWELLING (modelled on the 25/02/2022)



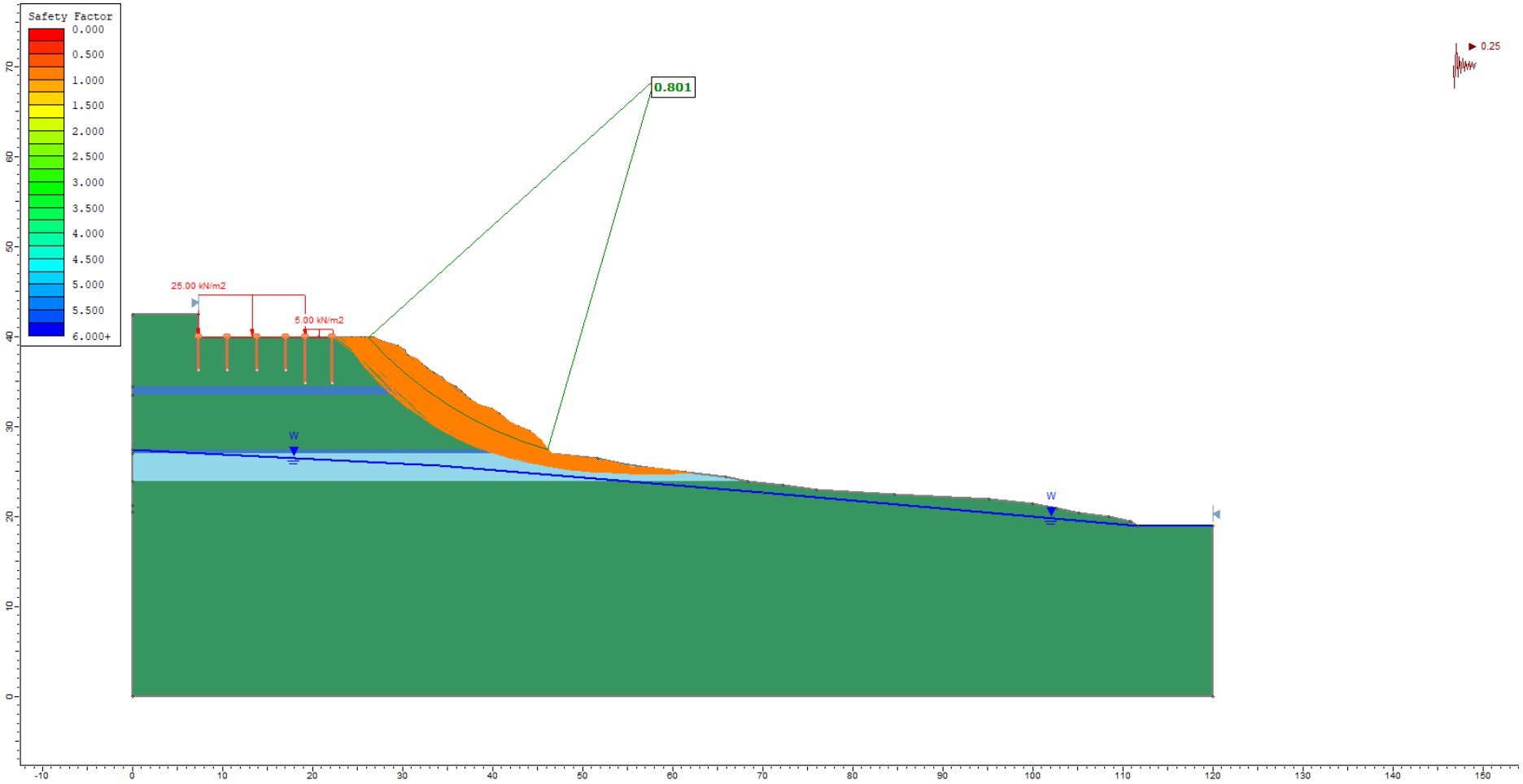
SLIDE model – Proposed Dwelling – Gravity Conditions – FOS required: 1.5



SLIDE model – Proposed Dwelling – Gravity Conditions –Elevated water table - FOS required: 1.3

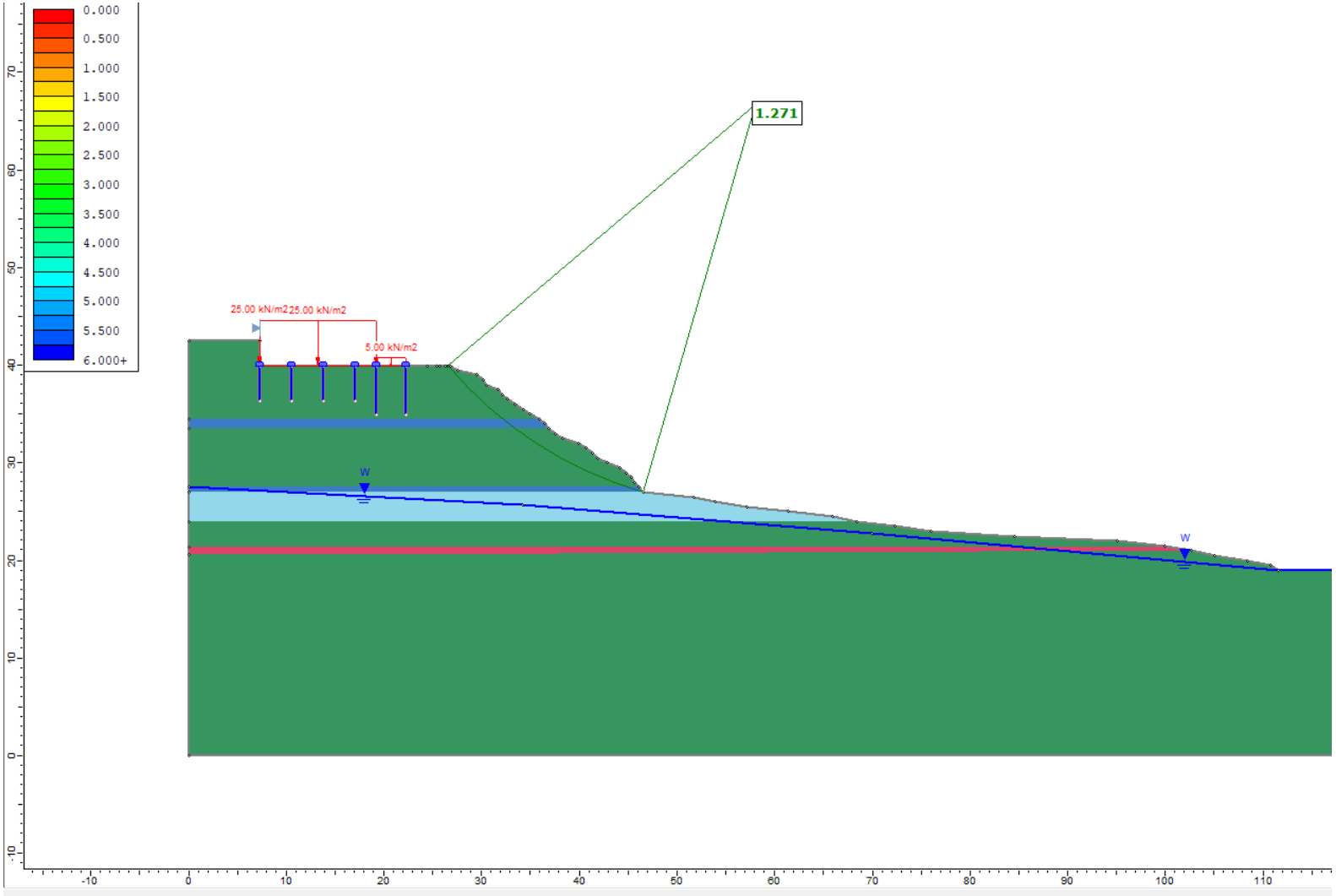


SLIDE model – Proposed Dwelling - SLS (Serviceability Limit State) – FOS required: 1.4



SLIDE model – Proposed Dwelling - ULS (Ultimate Limit State) – FOS required: 1.0

STRENGTH LOSS / Liquefied condition



SLIDE model – Proposed Dwelling – Strength Loss