Far North District Council
Te Kaunihera o Tai Tokerau ki te Raki

HE ARA TĀMATA
CREATING GREAT PLACES
Supporting our people

Private Bag 752, Kaikohe 0440, New Zealand
ask.us@fndc.govt.nz
0800 920 029
fndc.govt.nz

Request for approval of engineering plans and reports required by conditions of Resource Consent or Consent Notice

1. Applicant details (Consent Holder or Property Owner):

Name/s: (please write all names in full) Waitoto Developments Limited

[redacted]

Phone numbers: [redacted] Home:

Email:

☐ **Check this box if the you wish to be included in correspondence regarding this application.**

2. Designer/Engineer contact details (Contact Person):

Name/s: (please write all names in full) [redacted]

Contact phone number: [redacted]

Email:

3. Primary Contact details:

(Please specify which person identified above is the primary point of contact):

Name/s: [redacted]

4. The document number for which these plan(s) or report(s) relate:

Please note the Resource Consent or Consent Notice reference below. Please ensure the correct suffix is used if there are any variations or objections associated with this application.

Resource Consent Number: 2180493-RMAVAR/A, Decision - Variation to Consent Conditions (s127)

5. Conditions to be approved:

List the conditions to which this request relates and specify which documents relate to each.

If additional space is required, please attach a summary document.

Condition	Document reference	Drawing numbers
3(c) iv, v & vi	Construction Management & Engineering Design Report 20-6-25	All
	Drawings 23-7-25, pole lengths & FNDC EES	All

6. Does this application include any of the following (tick where appropriate):

Infrastructure:	To be vested:	Upgrades:	New connection:
Roads		Yes	
Street lighting			
Wastewater			
Stormwater	Yes	Yes	
Potable Water			

7. Please note any associated Building Consent reference (if applicable):

Retaining wall number to come.

9. Billing details:

This identifies the person or entity that will be responsible for paying any invoices or receiving any refunds associated with processing this request for approval of engineering plans and reports. Staff time required to process this approval will be charged on completion of the work. Please also refer to the council's Fees and Charges document (available at www.fndc.govt.nz). A deposit is payable when you submit this request.

Name/s: (please write all names in full) Rod Haines, (Waitoto Developments Limited)

Postal address: [redacted]

Post code:

Phone numbers: Work: [redacted] Home:

Fax: Email: [redacted]

Name of bill payer: Rod Haines (please print)

Signature: [redacted] signature of bill payer – mandatory) Date: 25/8/2025

Important information:

Privacy information: Once this application is lodged with the council it becomes public information. Please advise us if there is sensitive information included in this request. The information you have provided on this form is required so that your application for approval can be processed. The information will be stored on the council's property files and held by the Far North District Council and will be made available on request.

Declaration: The information I have supplied with this application is true and complete to the best of my knowledge.

Name: Steven Smith (please print)

Signature:

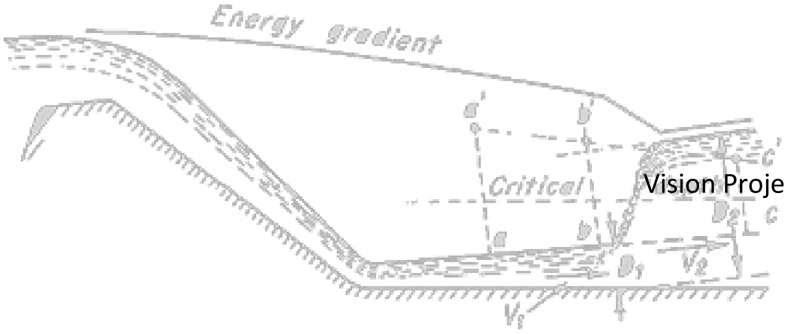
[redacted]

Date: 25/8/2025

Waitoto Developments

FLAGSTAFF SUBDIVISION, LOT 2 DP497245, RUSSELL

SITE SUITABILITY REPORT



Vision Project Ref: 12587

22/07/2016

TABLE OF CONTENTS

1 INTRODUCTION 4

2 SCOPE OF WORK 4

3 INDUSTRY GUIDANCE 5

4 SITE DESCRIPTION 6

4.1 Existing Site 6

4.2 Proposed Development 6

4.3 Geology 7

4.4 District Plan Zoning 7

4.5 Hazard mapping 7

4.6 Site Topography 8

5 GROUND CONDITIONS 8

5.1 Subsurface Conditions 8

5.1.1 Topsoil 8

5.1.2 Colluvium 9

5.1.3 Recent Alluvium 9

5.1.4 Residual Soil 9

5.1.5 Waipapa Group Bedrock 9

5.2 Groundwater 9

6 NATURAL HAZARDS 10

6.1 Erosion 10

6.2 Avulsion 10

6.3 Falling debris 10

6.4 Subsidence 10

6.5 Slippage 10

6.6 Inundation 10

6.7 Special soils 10

6.8 Subsequent use 11

7 LAND STABILITY 11

7.1 Stability of the gully head 11

7.2 Stability of shallow slides 11

7.3 Effluent disposal 12

8 SITE EARTHWORKS 12

8.1 Site fills 12

8.2 Site Cuts 12

8.3 Infrastructure 12

9 FOUNDATIONS 13

10 VEHICLE ACCESS 13

10.1 Access off Tapeka Road 13

10.2 Access off Prospect Street 13

10.3 Internal Access Roads 14

11 STORMWATER MANAGEMENT 14

12 ONSITE WASTEWATER DISPOSAL 15

12.1 Assumptions for Assessment 15

12.2 Site Constraints 16

12.3 Onsite Wastewater Disposal – Lots 1, 2 and 4 16

12.4 Onsite Wastewater Disposal – Lot 3 16

12.5 Cost Estimate 17

13 WATER SUPPLY 18

13.1 Potable Water Supply 18

13.2 Fire Fighting 18

14 TELECOMMUNICATIONS AND POWER 18

15 NATIONAL ENVIRONMENTAL STANDARD 18

16 RECOMMENDED CONSENT CONDITIONS 19

17 CONCLUSIONS 20

18 LIMITATIONS 20

APPENDICES

Appendix A:	Williams and King subdivision layout plan

1 INTRODUCTION

Vision Consulting Engineers Limited (VISION) was commissioned by Waitoto Developments to provide a site suitability report to accompany a resource consent application to the Far North District Council (FNDC) for the residential subdivision of Lot 2 DP497245, Flagstaff Road, Russell (Flagstaff Subdivision). It is proposed to subdivide the land into 4 residential lots, refer to attached Williams and King proposed subdivision plan in Appendix A.

2 SCOPE OF WORK

The scope of work for the site suitability report is to assess land stability and suitability, stormwater, wastewater, vehicle access, earthworks, natural hazards and water supply (including fire fighting) for the proposed development as defined on the Williams and King survey drawing included in Appendix A.

The site suitability report is based on previous reports provided by Williams and King and obtained from the resource consent file for 15 Flagstaff Road, Russell (RC2060154). The reports used in this assessment are listed below:

- Fraser Thomas Limited, Waitoto Developments Ltd, Proposed Subdivision to create 10 Lots at Flagstaff Road, Russell, Engineering Report to Accompany Resource Consent Application, dated 12 August 2005, reference 37640.
- Fraser Thomas Limited, On-site Effluent Disposal for proposed Flagstaff Development, dated 24 August 2006, reference 31649.
- Fraser Thomas Limited, Waitoto Developments Ltd, Proposed Residential Subdivision at Flagstaff Road, Russell, Geotechnical Investigation Report, dated November 2006, reference 60365.
- Fraser Thomas Limited, Waitoto Developments Ltd, Proposed Subdivision Flagstaff Hill Resource Consent Application No. 2060154, Wastewater Treatment and Disposal Report, dated 14 February 2007, reference 31649.
- Fraser Thomas Limited, Waitoto Subdivision : RC2060154, Supplementary Report on Roading Issues, dated 14 February 2007, reference 37640.
- Duffill Watts and King Limited, RC2060154, Waitoto Developments Subdivision, Flagstaff Hill, Russell, Engineering Assessment, dated 4 May, 2007.

- Duffill Watts and King Limited, Far North District Council, Review of Proposal for Residential Subdivision at Flagstaff Road, Russell, dated 8 May 2007, reference file no. 287/3/2.
- Tonkin and Taylor, Waitoto Developments – Flagstaff Hill, Russell, Geotechnical Review, dated 20 June 2007, reference 24568.
- Duffill Watts and King Limited, Statement of Evidence by Michael John Winch on behalf of the respondent, dated 28 June 2007, reference ENV-2006-AKL-00850.
- Haigh Workman Limited, Engineering Report for Proposed Subdivision Lot 12 DP422340, Flagstaff Road, Russell for Waitoto Developments Ltd, dated January 2016, reference 16 002.

It should be noted that the Fraser Thomas site suitability addendum report (referenced in the Haigh Workman report) was not able to be sourced for review as part of this report.

3 INDUSTRY GUIDANCE

This report has been prepared in accordance with the requirements of the Far North District Council Engineering Standards & Guidelines 2004 - Revised March 2009 and with reference to the District Plan; Section 106 of the Resource Management Act (RMA) and NZS4404:2010.

4 SITE DESCRIPTION

4.1 Existing Site

The Flagstaff Subdivision is located to the north of the township of Russell, at Lot 2 DP497245, Flagstaff Road. The site is approximately 3.8422 hectares (ha) and is located within a valley bounded by Flagstaff Road to the west, to the north by a ridge line that extends across the site to the east and south towards Prospect Road.

The majority of the site is covered in native bush and two ephemeral water courses run in a north-south orientation through the gully, meeting at Lot 10 DP422340 to the south of the site. The watercourse then passes through the northern end of Russell township and discharges into Kororareka Bay. A general site plan is presented in Figure 1 below.

Figure 1 – Site Location Plan (site boundary indicative only)

4.2 Proposed Development

The Williams and King proposed subdivision plan included in Appendix A presents the subdivision of Lot 2 DP497245 which involves subdividing the site into 4 new lots, Lots 1 to 4, with all lots proposed to be residential lots.

Lot 1 will be accessed off a right of way (ROW) Tapeka Road, where residential Lots 2 to 4 will be accessed off Prospect Street which is located immediately south of the site.

4.3 Geology

The 1:250,000 geological map of Whangarei indicates that the site is generally underlain by greywacke of the Waipapa Group. The Waipapa Group is described as massive to thinnly bedded, lithic volcaniclastic metasandstone and argillite, with tectonically enclosed basalt, chert and silceou.

During the site investigation carried out by Fraser Thomas Ltd, the material encountered across the site was inferred to be weathering products of the greywacke and argillite. However material inferred to be colluvium was encountered generally within the lower parts of the site.

4.4 District Plan Zoning

The site is zoned Coastal Living with respect to the Far North District Council District Plan.

4.5 Council hazard mapping

The Northland Regional Council (NRC) and Far North District Council (FNDC) hazard layers have been reviewed. According to the NRC and FNDC hazard layers the site is not located in an area susceptible to:

- Landslide
- Special soils
- Erosion
- Flooding
- Coastal Flooding
- Coastal Hazards
- Tsunamai

4.6 Site Topography

A site walkover and a review of historic aerial photographs (1951) was undertaken by Fraser Thomas Limited as part of the geotechnical report and the following observations were made regarding the topography of the site:

- The site is generally located on side slopes associated with three slightly sloping ridges
- West and south trending ridges generally extend along the northern and eastern site boundaries respectively.
- The side slopes associated with these ridges are generally steep and slope between approximately 25 and 40 degrees to the horizontal, 1V:2.14H to 1V:1.19H.
- A head scarp was evident in the historic aerial photograph dated 1951 on the southern facing side slope near the northern boundary of the site.
- An existing head scarp, approximately 3.0m in vertical height and approximately 25m wide was observed along the lower parts of the west facing side slopes at the site.
- An existing gully is located at the toe of the side slopes present at the site. The gully extends to the south through the central portion of the site. Two shallow streams, approximately 2 metres wide extend to the base of the gully. The gully is well vegetated.

5 GROUND CONDITIONS

5.1 Subsurface Conditions

Ground investigations have been carried out at the site by Fraser Thomas Limited in 2006 and Haigh Workman Limited in January 2016. Fraser Thomas carried out a geotechnical investigation at the site comprising 8 hand auger boreholes, 6 test pits and 2 machine boreholes. Haigh Workman carried out a geotechnical investigation comprising of 1 hand augured borehole.

The ground conditions encountered during the investigations generally indicate that the site is underlain by soils which are inferred to be weathered greywacke and argillites. Material inferred to be colluvium, associate with past instability at the site was encountered within the lower areas of the site.

5.1.1 Topsoil

Topsoil was encountered at all borehole and test pit locations. The thickness of the topsoil ranged from 0.05m to 0.2m below existing ground surface level.

5.1.2 Colluvium

Colluvium was encountered at some test locations and was generally encountered to depths of 1.2 to 2.6m below existing ground surface level. The colluviums typically comprised silty clay intermixed with siltstone and sandstone fragments and was stiff to very stiff with an undrained shear strength ranging from 75 kPa to greater than 215kPa.

5.1.3 Recent Alluvium

Recent alluvium was encountered in a borehole completed to the south of the site, however it is inferred that the alluvium may be present adjacent to the south-western boundary of the site. The recent alluvium comprised soft to stiff organic and inorganic silty clay. Undrained shear strengths measured in the alluvium ranged from 10 to 100kPa.

5.1.4 Residual Soil

Residual soil encountered across the site typically consisted of stiff to very stiff silty clay. Undrained shear strengths measured within the residual soil ranged from 115 to greater than 240kPa.

5.1.5 Waipapa Group Bedrock

The residual soils at the site are inferred to be underlain by highly to slightly weathered rock. The depth to bedrock has been inferred to be between 1.2 and 4.3m below existing ground surface level based on Dynamic Cone Penetrometer (DCP) results, test pit and borehole logs.

5.2 Groundwater

Groundwater levels were measured in boreholes and test pits during the site investigation carried out by Fraser Thomas Limited and the groundwater levels within piezometers installed in machine borehole M1 and M2 were measured on the 9 November 2006. Groundwater was not encountered during the site investigation. However groundwater levels of 11.8m below ground level (mbgl) and 9.9m bgl were recorded in M1 and M2 respectively on the 9 November 2006.

6 NATURAL HAZARDS

With regard to the natural hazards included in RMA Section 106, VISION provides the following assessment.

6.1 Erosion

The site is considered to have a low erosion potential. It is recommended that existing vegetation is maintained wherever possible and cut slopes are protected against erosion.

6.2 Avulsion

Fraser Thomas' review of historic aerial photography indicates that the course of the ephemeral streams have remained relatively unchanged since 1951. This indicates that channel regression is minimal and the risk to the proposed development of erosion or avulsion associated with the streams changing course is low.

6.3 Falling debris

There are no sources of falling debris at the site.

6.4 Subsidence

It is recommended that all buildings within the subdivision have specific engineered foundations. Due to this requirement, the risk associated with subsidence (vertical settlement) is considered to be low.

6.5 Slippage

It is recommended that specific geotechnical investigations and assessment are carried out during detailed design to assess stability. Retaining walls and/or palisade walls and/or deflection walls may be required to protect dwellings, appurtenant structures, and ROW's from potential slippage hazards. If these measures are implemented, the risk of slippage at the site is considered to be low.

6.6 Inundation

The proposed building platforms and ROW's are not considered to be at risk due to inundation from flooding, stormwater overflow paths or coastal inundation. Therefore the risk associated with inundation is considered to be low.

6.7 Special soils

No special soils have been identified as being present at the building platforms and ROW's. Therefore the risk associated with special soils is considered low.

6.8 Subsequent use

Proposed changes to the land include the development of residential dwellings and associated infrastructure. Such development is considered unlikely to adversely affect or worsen the site's susceptibility to material damage.

In summary, the land proposed to be developed as the Flagstaff Subdivision is considered to be unlikely to be subject to material damage by erosion, falling debris, subsidence, slippage, or inundation from any source if the engineering recommendations within this report are adopted.

7 LAND STABILITY

An assessment of the stability of the land was carried out by Fraser Thomas Limited as part of their geotechnical investigation report. The report was reviewed by Tonkin and Taylor who generally agreed with the original assessment. Tonkin and Taylor raised the following stability issues for the site which are discussed in the following sections:

- Stability at the head of the gully – Lot 1, in the north-western corner of the site
- Stability of shallow slips over all lots excluding the lower portions of Lot 3, and 4 and Lot 2 (formerly Lot 5 and 6)
- Effluent of effluent disposal on slope stability

7.1 Stability of the gully head

The topography of the gully indicates a potential for deep seated failure. Machine boreholes completed by Fraser Thomas at the site did not identify any shear seams within the rock mass and the stability analysis carried out indicated that the factor of safety of the slope under winter groundwater levels was greater than 2.2. Therefore the risk of deep seated movement is considered to be low. Tonkin and Taylor concurred with Fraser Thomas' assessment.

7.2 Stability of shallow slides

The existing topography of the site includes steep slopes up to approximately 57 degrees. Stability analysis carried out by Fraser Thomas indicate factors of safety of greater than 1.5 and 1.2 for wet winter and extreme transient groundwater levels respectively for shallow landslides. However Tonkin and Taylor reference a shallow slip that occurred immediately to the south of the site (7 Flagstaff Road) following a severe storm event in March 2007 affecting a slope of approximately 35 degrees which resulted in damage to the rear of the dwelling.

Tonkin and Taylor recommend that stabilisation measures are implemented within the subdivision to prevent potential damage occurring to dwellings from shallow landslides by either a series of tiered walls upslope of the dwelling or a debris wall at the rear of dwellings to prevent slope debris impacting the dwelling.

7.3 Effluent disposal

Tonkin and Taylor recommend that stability measures should be considered to ensure stability of the septic tank and recirculating textile filter as well as the dripper irrigation system.

The risk of land instability for the site can be mitigated with specific engineer designed foundations for all buildings and the use of retaining walls and/or palisade walls, deflection walls and engineered batter slopes. It is recommended that all building platforms and the land appurtenant to the building platforms are assessed by a chartered professional engineer experienced in geotechnical engineering.

8 SITE EARTHWORKS

Earthworks will be required in portions of the site to form ROWs, driveways and building platforms. At this stage, the volume of earthworks is not able to be provided. The following recommendations are provided regarding earthworks at the site.

It is recommended that the existing vegetation on the slopes of the site be retained and protected from damage by felling and clearing wherever possible.

8.1 Site fills

It is recommended that fill slopes are constructed at a maximum batter slope of 1V:2H to a maximum height of 1.0m. All fill slopes greater than 1.0m in height are to be engineer designed by a chartered professional engineer experienced in geotechnical engineering.

8.2 Site Cuts

It is recommended that cut slopes are constructed at a maximum slope angle of 1V:3H to a maximum height of 1.0m. All cut slopes greater than 1.0m in height are to be engineer designed by a chartered professional engineer experienced in geotechnical engineering.

8.3 Infrastructure

It is not anticipated that there will be any geotechnical constraints associated with trenching for the buried infrastructure.

Groundwater is considered to be deep and was generally encountered beyond 9.9m depth. Perched water above this depth is anticipated during winter and severe storm events. Sumps and submersible pumps may be required to remove water from the base of excavations following periods of intensive rain events.

9 FOUNDATIONS

The site is considered to be suitable for building light timber framed houses generally in accordance with NZS3604, however foundations are to be specifically engineered designed. Foundations are likely to be either concrete slab-on grade or piled foundations. Where concrete slab-on grade foundations are used leading edge piles or palisade walls may be required adjacent to sloping ground. Any weak or unsuitable materials present beneath shallow foundations shall be removed and replaced with engineer certified fill in accordance with NZS4404.

It is recommended that all foundations are specifically engineer designed by a chartered professional engineer experienced in geotechnical engineering.

10 VEHICLE ACCESS

All access to the subdivision will be via private driveways finished with a concrete surface. There are two proposed access points to the Flagstaff subdivision:

- Via the existing ROW off Tapeka Road, providing access to Lot 1
- Via a new ROW off Prospect Street, providing access to Lots 2 to 4

10.1 Access off Tapeka Road

Lot 1 will be accessed via the existing ROW off Tapeka Road in the north-western corner of the site.

The existing access has been assessed by Haigh Workman as generally achieving the requirements for a double domestic crossing given in the FNDC Engineering Standards Drawing FNDC/S/6B.

No upgrade or improvement to the existing crossing is required as part of the subdivision.

10.2 Access off Prospect Street

Lots 2 to 4 will be accessed via a new ROW off Prospect Street located to the south of the site. The Fraser Thomas Engineering Report indicates that there is an existing steep 3 to 3.5m wide concrete driveway at the northern end of Prospect Street, servicing the existing houses. The existing concrete driveway on the public road section of Prospect Street has a maximum gradient of approximately 1V:3.3H.

It is proposed to share this drive up the hill and then diverge with a new drive at an average grade of approximately 1 in 4.

It is recommended that Prospect Street from Little Queen Street to ROW C is formed as a 5.0m wide concrete accessway in general accordance with Appendix 3B of the FNDC District Plan. This is in line with the previously granted resource consent (RC2080941). However the existing gradient (1V:3.3H) of Prospect Street is recommended to be retained to prevent altering access to the existing properties that use the driveway. The low speed nature of the driveway has also been taken into consideration. The emphasis for design will be on safety and not speed.

10.3 Internal Access Roads

Access roads formed within the subdivision are likely to require earthworks comprising of cuts and fills. As discussed in Section 8 it is recommended that fill slopes are constructed at a maximum batter slope of 1V:2H and cut slopes are constructed at a maximum slope angle of 1V:3H to a maximum height of 1.0m.

It is recommended that the stability of access roads are assessed by a chartered professional engineer experienced in geotechnical engineering. Retaining walls may be required to stabilise cut slopes or fill batters.

11 STORMWATER MANAGEMENT

Stormwater management at the site will be designed in accordance with FNDC District Plan Rules regarding impermeable surfaces and stormwater attenuation. The site is zoned Coastal Living and the permitted activities for impermeable surfaces defined within the District Plan states that the maximum proportion of the gross site area covered by buildings and other impermeable surfaces shall be 10% or 600m^2, whichever is the lesser. Upon completion of the development civil works, the impermeable surfaces at the site will not exceed the permitted criteria.

It is worth noting that Lots 1 and 3 are likely to require stormwater attenuation at the time of building consent. It is recommended that stormwater design is carried out by a chartered professional engineer in accordance with ARC Technical Publication TP10: Stormwater Treatment Devices – Design Guideline Manual if the proposed buildings and associated areas exceed the permitted threshold.

It is recommended that all concentrated stormwater discharges from house sites be piped to the base of the gully to prevent water soaking into the ground. Disposal of stormwater that relies on soakage should not be permitted.

VISION understand that the downstream flooding risk of Russell township previously reported by Duffill Watts and Haigh Workman Limited has been mitigated by the recent upgrading of the Russell stormwater system (comms. Craig Ambler).

12 ONSITE WASTEWATER DISPOSAL

The proposed Flagstaff Subdivision site lies outside of the area of benefit for the Russell wastewater scheme. VISION approached FNDC to seek approval for connecting the subdivision into the existing reticulation system in Prospect Street, however this was declined due to:

- The subject site being outside the scheme area of benefit and so has not be contributing towards the capital costs of the scheme;
- The Russell treatment plant is now marginally under capacity during peak loads and as such doesn’t have any spare capacity to cater for properties outside the area of benefit.

It is therefore proposed to dispose of wastewater on each lot via an onsite wastewater disposal.

12.1 Assumptions for Assessment

For the purpose of the site suitability report, it has been assumed that each lot will include a modern 4 bedroom dwelling (6 people). In addition the following design parameters have been assumed:

- Design flows of 160 litres/day per person (each dwelling contains dual flush toilets, low water use dishwasher and no garbage grinder)
- Design loading rates of 1-2 L/m^2/day
- Irrigation area of between 1,290 and 1,560m^2 (including reserve) for the above design loading rates.

12.2 Site Constraints

The following site constraints have been identified for the overall site:

- Steeply sloping topography
- Low topsoil depths overlying soils with poor drainage characteristics
- Potential for down-slope transmission of treated effluent (particularly in times of significant rainfall) leading to possible contamination of the two watercourses present at the site.
- Proximity to site boundaries and watercourses

Given these constraints, it is considered that the following systems are likely to be suitable for the sites as discussed in the following sections.

12.3 Onsite Wastewater Disposal – Lots 1, 2 and 4

Secondary treatment with pressure compensating drip irrigation (PCDI) lines using a design loading rate of 1-2 L/m^2/day based on the individual site constraints. Lots 1, 2 and 4 are expected to have sufficient area using permitted setbacks.

12.4 Onsite Wastewater Disposal – Lot 3

It may be possible to install a system as described for the other proposed lots, however Lot 3 has limited area available for land application of secondary treated effluent. If insufficient area is found using permitted setbacks, tertiary treatment or advanced tertiary treatment may be required with appropriate discharge consents.

12.5 Cost Estimate

Costs associated with the installation of these systems are anticipated to be as follows:

Secondary Treatment with PCDI	$12,000 - $14,000
Advanced Secondary Treatment with PCDI	$14,000 - $16,000
Tertiary & Advanced Tertiary Treatment (including consents)	$18,000 - $30,000

These prices are estimates only and should be confirmed by a contractor.

It is recommended that the design of the onsite wastewater disposal is undertaken by a chartered professional engineer experienced in onsite wastewater disposal. The final system design and layout will be dependent on the location of the building platform and associated structures (water tanks, driveways, etc.). The location of the irrigation field should be determined in consultation with a chartered professional engineer experienced in geotechnical engineering to assess the potential impact on slope stability.

If the recommendations provided for onsite wastewater disposal are adhered to, the disposal of treated effluent is expected to have a minimal effect on the environment.

13 WATER SUPPLY

13.1 Potable Water Supply

Water supply will be from water collected from building roofs and stored in water tanks. It is recommended that systems should be fitted with either a first flush device or filtration to improve water quality.

13.2 Fire Fighting

FNDC Engineering standards require that a water supply is provided that is adequate for fire fighting purposes. As discussed above water supply for the development will be via stored rainwater. For a single family home without a sprinkler system, the New Zealand Fire Service Fire Fighting Water Supplies code of practise SNZ PAS 4509:2008 recommends a minimum water storage capacity of 45m^3 within 90m of the dwelling for firefighting purposes where water supply is from a non-reticulated system.

It is recommended that provision of water storage to meet the requirement of the rural fire service for fire fighting purposes be required for each dwelling.

14 TELECOMMUNICATIONS AND POWER

Telecommunication and power services are expected to access each proposed dwelling via ROW's proposed as part of the subdivision.

15 NATIONAL ENVIRONMENTAL STANDARD

National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health Regulations 2011 (NES; MfE, 2011a) came into effect in January 2012. The standard provides regulations to ensure that land affected by contaminants in soil is appropriately identified and assessment prior to development and if necessary remediated or the contaminants are contained to make the land safe for human use.

The Hazardous Activities and Industries List (HAIL) identify activities and industries that are considered likely to cause land contamination resulting from hazardous substance use, storage or disposal. The intention of the HAIL is to identify land where hazardous substances could cause or may have caused land contamination.

VISION has not been engaged to assess the site in terms of the NES.

16 RECOMMENDED CONSENT CONDITIONS

The following resource consent conditions are recommended to ensure that the subdivision is completed in accordance with the recommendations provided in this report:

- All building platforms and the land appurtenant to the building platforms are to be assessed by a chartered professional engineer experienced in geotechnical engineering.
- The existing vegetation on the slopes of the site are to be retained and protected from damage by felling and clearing wherever possible.
- Fill slopes are constructed at a maximum batter slope of 1V:2H and cut slopes are constructed at maximum slope angle of 1V:3H to a maximum height of 1.0m. All fill batters or cut slopes greater than 1.0m in height are to be engineer designed by a chartered professional engineer experienced in geotechnical engineering.
- All foundations are to be specifically engineer designed by a chartered professional engineer experienced in geotechnical engineering.
- Prospect Street from Little Queen Street to ROW C is to be formed as a 5.0m wide concrete accessway in general accordance with Appendix 3B of the FNDC District Plan. This is in line with the previously granted resource consent (RC2080941). However the existing gradient (1V:3.3H) of Prospect Street is recommended to be retained to prevent altering access to the existing properties that use the driveway.
- The stability of access roads are to be assessed by a chartered professional engineer experienced in geotechnical engineering. Retaining walls may be required to stabilise cut slopes or fill batters.
- Consent Notices:
    - Stormwater design is carried out by a chartered professional engineer in accordance with ARC Technical Publication TP10: Stormwater Treatment Devices – Design Guideline Manual.
    - All concentrated stormwater discharges from house sites be piped to the base of the gully to prevent water soaking into the ground. Disposal of stormwater that relies on soakage should not be permitted.
    - The design of the onsite wastewater disposal is undertaken by a chartered professional engineer experienced in onsite wastewater disposal. The location of the irrigation field is to be determined in consultation with a chartered professional engineer experienced in geotechnical engineering to assess the potential impact on slope stability.

- Potable water storage systems should be fitted with either a first flush device or filtration to improve water quality
- Water storage to meet the minimum requirement for fire fighting purposes in accordance with SNZ PAS 4509:2008 is required for each dwelling.

17 CONCLUSIONS

Provided the recommendations given in this report are adhered to, the subject site is considered to be suitable for the proposed subdivision depicted on the attached Williams and King Subdivision plan. On completion of the subdivision development and the formation of building platform, each dwelling and the land appurtenant to the dwellings are unlikely to be subject to material damage by erosion, subsidence, slippage, or inundation from any source. Furthermore, the development of the house sites is not likely to accelerate, worsen, or result in material damage to that land, other land, or structure by erosion, subsidence, slippage, or inundation from any source.

18 LIMITATIONS

This report has been prepared solely for the use of our client, Waitoto Developments, and their professional advisers and the Far North District Council in relation to the specific project described herein.

Information, opinions and recommendations contained in this report cannot be used for any other purpose or by any other entity without our review and written consent. Vision Consulting Engineers Ltd accepts no liability or responsibility whatsoever for or in respect of any use or reliance upon this report by any third party.

Opinions given in this report are based on a review of previous reports prepared by others. The nature and continuity of the subsurface materials are inferred and it must be appreciated that actual conditions could vary from that described herein.

If you have any queries or you require any further clarification on any aspects of this report, please contact the undersigned.

For and on behalf of Vision Consulting Engineers Limited

Prepared by

Dan Simmonds
BEng (Civil)

Senior Geotechnical Engineer

Prepared by & reviewed by

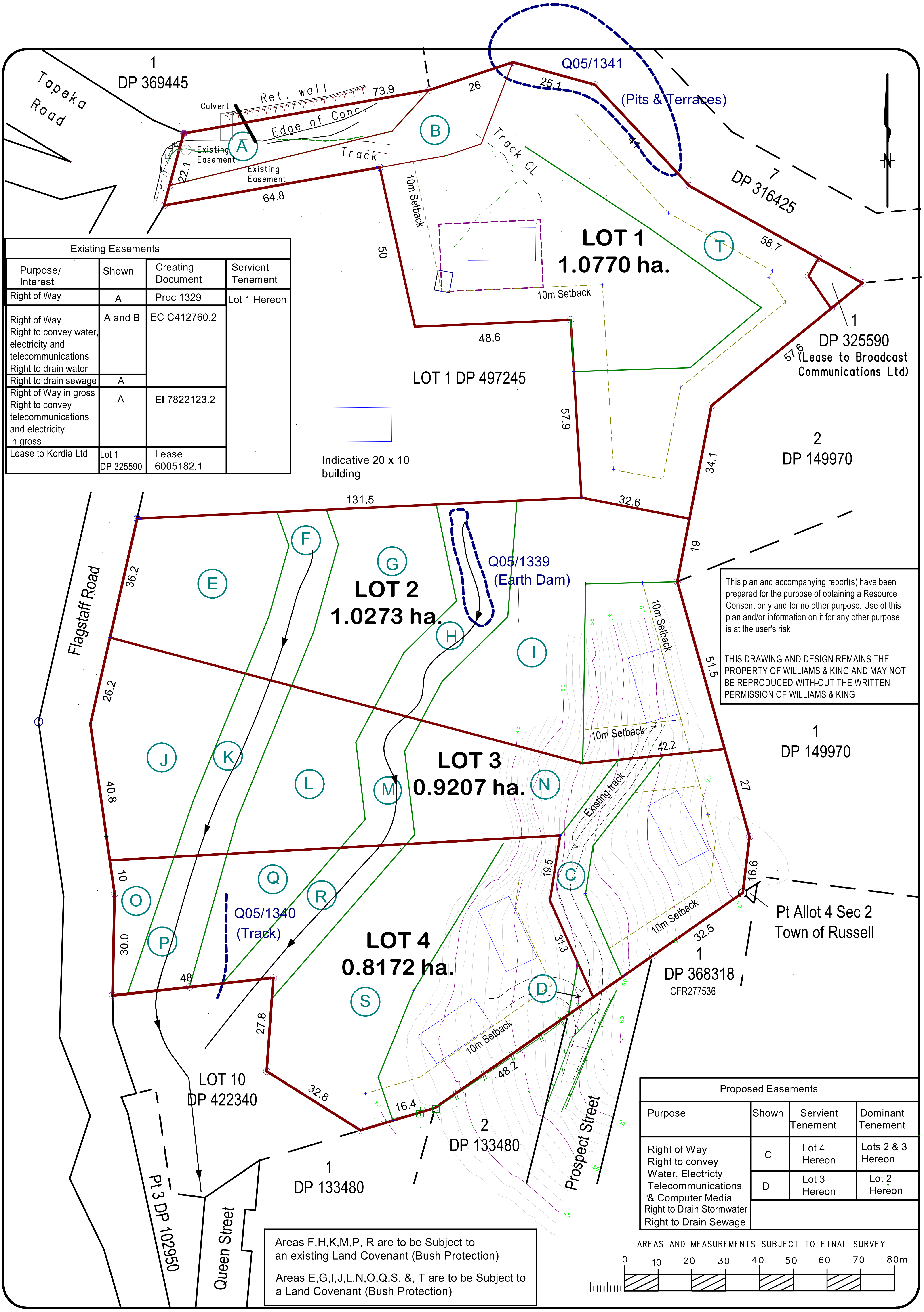
Ben C. Perry

Ben Perry
MIPENZ CPEng

Managing Director

Appendix A – Williams and King Proposed Subdivision Plan.

Appendix A – Williams and King Subdivision Plan



Existing Easements

Purpose/ Interest	Shown	Creating Document	Servient Tenement
Right of Way	A	Proc 1329	Lot 1 Hereon
Right of Way Right to convey water, electricity and telecommunications Right to drain water	A and B	EC C412760.2	
Right to drain sewage	A		
Right of Way in gross Right to convey telecommunications and electricity in gross	A	EI 7822123.2	
Lease to Kordia Ltd	Lot 1 DP 325590	Lease 6005182.1	

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Proposed Easements

Purpose	Shown	Servient Tenement	Dominant Tenement
Right of Way Right to convey Water, Electricty Telecommunications & Computer Media Right to Drain Stormwater Right to Drain Sewage	C	Lot 4 Hereon	Lots 2 & 3 Hereon
	D	Lot 3 Hereon	Lot 2 Hereon

Areas F,H,K,M,P, R are to be Subject to an existing Land Covenant (Bush Protection)

Areas E,G,I,J,L,N,O,Q,S, &, T are to be Subject to a Land Covenant (Bush Protection)

WILLIAMS AND KING
Registered Land Surveyors, Planners & Land Development Consultants
Ph: (09) 407 6030
Fax: (09) 407 6032
Email: Kerikeri@saps.co.nz
27 Hobson Ave,
PO Box 937, Kerikeri

Proposed Subdivision of LOT 2 DP 497245

	Name	Date
Survey		
Design	WF	15/4/2016
Drawn		
Ver	4	20/7/2016

ORIGINAL SCALE	SHEET SIZE
1:1000	A3

File Ref:
21460
Waitoto Developments Ltd

Volume of new Prospect Street earthworks

Cut

Road section

Length m	Width m	Area 1 m^2	Depth m	Depth % m	Compacted Volume 1 m^3
128	5.75	736.0	0.275	0.75	151.8
					Allow 170m^3

Batter from 100 to 128m Western side

Length m	Width m	Area 2 m^2	Depth m	Depth % m	Compacted Volume 2 m^3
28	7	196.0	1.8	0.4	141.1
					Allow 150m^3

Attenuation tank leveling, Western side

Length m	Width m	Area 3 m^2	Depth m	Depth % m	Compacted Volume 3 m^3
5	5	25.0	1.8	0.2	9.0
					Allow 10m^3

Manholes, Western side

Number	Dia m	Area 4 m^2	Depth m	Depth % m	Compacted Volume 4 m^3
4	1.5	7.1	1.8	1	12.7
					Allow 15m^3

Cut volume (compacted)

Total 345.0

Fill

Road section

Length m	Width m	Area 5 m^2	Depth m	Depth % m	Compacted Volume 5 m^3
128	5.85	748.8	0.125	1	93.6
					Allow 100m^3

Attenuation tank leveling, Western side

Length m	Width m	Area 6 m^2	Depth m	Depth % m	Compacted Volume 6 m^3
5	5	25.0	0.15	1	3.8
					Allow 4m^3

Manholes, Western side

Number	Dia m	Area 7 m^2	Depth m	Depth % m	Compacted Volume 7 m^3
4	1.5	7.1	0.15	1	1.1
					Allow 2m^3

Fill volume (compacted)

Total 106.0

20yr

1 **Rational method** 48hr

Pre – Development Catchment area & water flow

	Roof & decks 1 (m^2)	Concrete & smooth seal 2 (m^2)	Metaled area Or rough seal 3 (m^2)	Other Impervious 4 (m^2)	Vegetation 5 (m^2)	Bush 6 (m^2)
(Original water flow) **Total area.** **Area (m^2)**						
600.00	0	0	0	0	600	0
Runoff coefficient	Ci (coefficient)	Ci (coefficient)	Ci (coefficient)	Ci (coefficient)	Ci (coefficient)	Ci (coefficient)
Use “C” values from FNDC TR55 chart	0.00	0.00	0.00	0.00	0.65	0.00
Generally do not use slope adjustment Ci factor if using TR55	0.96	0.96	0.8	0.53	0.65	0.44
Rainfall intensity	I (mm/hr)	I (mm/hr)	I (mm/hr)	I (mm/hr)	I (mm/hr)	I (mm/hr)
Rainfall Data from NIWA. Hirds 4, RCP6, 2081-2100	1.49	1.49	1.49	1.49	1.49	1.49
Use an appropriate event for the situation						
Flow rate of surface water	Qc (m^3/sec)	Qc (m^3/sec)	Qc (m^3/sec)	Qc (m^3/sec)	Qc (m^3/sec)	Qc (m^3/sec)
	0.000	0.000	0.000	0.000	0.000	0.00000
Pre – development flow	Qp (m^3/sec)	Qp (L/sec)				
of developed area	0.0002	0.16				

Pre-development
Slope
%
10
Ci correction
0.00

Post-development
Slope
%
10
Ci correction
0.00

Rational method

Roof & decks 1 (m^2)	Concrete & smooth seal 2 (m^2)
0.00	0.00
Ci (coefficient)	Ci (coefficient)
0.00	0.00
I (mm/hr)	I (mm/hr)
2.92	2.92
Qc (m^3/sec)	Qc (m^3/sec)
0.000	0.000
Qp (m^3/sec)	Qp (L/sec)
0.000	0.3

Post – Development Catchment area & water flow

	Any area where there is a change in the impermeability values				**Pre-development area penalty where there i a change in impermeable surfaces but not collected in attenuation system**		**Not included in post-devel. Attenuation calcs.** Any area where there is no change in the impermeability values	
Total area. **Area (m^2)**	Roof & decks 1 (m^2)	Concrete & smooth seal 2 (m^2)	Metaled area Or rough seal 3 (m^2)	Vegetation 4 (m^2)	Concrete & smooth seal 5 (m^2)	Metaled area or vegetation 6 (m^2)	Metaled area or seal 7 (m^2)	Vegetation 8 (m^2)
600.00	0	600	0	0	0	0	0	0
OK	Ci (coefficient)	Ci (coefficient)	Ci (coefficient)	Ci (coefficient)	Ci (coefficient)	Ci (coefficient)	Ci (coefficient)	Ci (coefficient)
Use “C” values from FNDC TR55 chart	0.00	0.96	0.00	0	0.2	0.3	0.00	0
Generally do not use slope adjustment Ci factor if using TR55	0.96	0.96	0.85	0.49	"C" value difference between Pre & Post		0.59	0.63
					Maximum value 0.2 (at the moment)			
Rainfall intensity rate	I (mm/hr)	I (mm/hr)	I (mm/hr)	I (mm/hr)	I (mm/hr)	I (mm/hr)	I (mm/hr)	I (mm/hr)
Rainfall Data from NIWA. Hirds 4, RCP6, 2081-2100	1.79	1.79	1.79	1.79	1.49	1.49	1.49	1.49
Use an appropriate event for the situation								
Flow rate of surface water	Qc (m^3/sec)	Qc (m^3/sec)	Qc (m^3/sec)	Qc (m^3/sec)	Qc (m^3/sec)	Qc (m^3/sec)	Qc (m^3/sec)	Qc (m^3/sec)
	0.000	0.000	0.00000	0.000	0.000	0.000	0.000	0.00000
	Qc (L/sec)	Qc (L/sec)	Qc (L/sec)	Qc (L/sec)	Qc (L/sec)	Qc (L/sec)	Qc (L/sec)	Qc (L/sec)
	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00

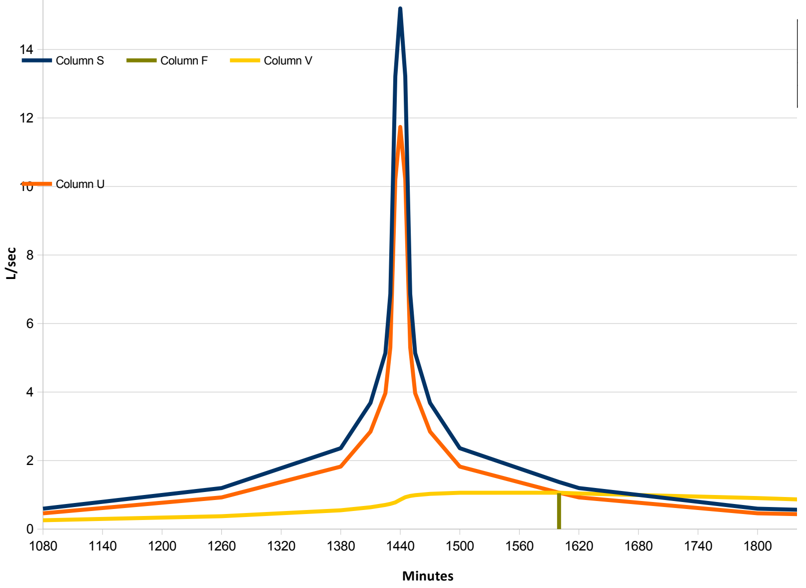
Any area where there is a change in the impermeability values	
Roof & decks 1 (m^2)	Concrete & smooth seal 2 (m^2)
0.00	600.00
Ci (coefficient)	Ci (coefficient)
0.00	0.96
I (mm/hr)	I (mm/hr)
3.50	3.50
Qc (m^3/sec)	Qc (m^3/sec)
0.000	0.001
Qc (L/sec)	Qc (L/sec)
0.00	0.56
Total in attenuation system calc's	
Qa (m^3/sec)	Qa (L/sec)
0.0002	0.24

Total included in attenuation system calc's	Qa (m^3/sec)	Qa (L/sec)
Post – Pre development flow	0.0001	0.1247
Post – Pre development flow without penalty factor	Qtpp (m^3/sec)	Qtpp (L/sec)
Post – Pre development flow	0.0001	0.12
Total post development flow		
Developed flow + undeveloped flow	Qatt (m^3/sec)	Qatt (L/sec)
	0.0003	0.29
0 to 10min		

Total impermeable excluded from attenuation system collection	
Qby (m^3/sec)	Qby (L/sec)
0.000	0.00

Total no change, excluded from attenuation system calc's	
Qby (m^3/sec)	Qby (L/sec)
0.000	0.00

24hr comparision of final overall flow through storage system



1b **Rational method** 48hr

Total Catchment Post-Development area & flow collected **Will be Zero if pre & post impermeable areas are the same** Only has an affect if larger area is collected post-development	**Do not include areas from Post – Development Catchment area & water flow (above)**					
Total area. **Area (m^2)**	Roof & decks 1 (m^2)	Concrete & smooth seal 2 (m^2)	Metaled area Or rough seal 3 (m^2)	Other Impervious 4 (m^2)	Vegetation 5 (m^2)	Bush 6 (m^2)
0.00	0	0	0	0	0	0
Runoff coefficient	Ci (coefficient)	Ci (coefficient)	Ci (coefficient)	Ci (coefficient)	Ci (coefficient)	Ci (coefficient)
Use “C” values from FNDC TR55 chart	0.00	0.00	0.00	0.00	0.00	0.00
Generally do not use slope adjustment Ci factor if using TR55	0.96	0.96	0.8	0.53	0.44	0.59
Rainfall intensity	I (mm/hr)	I (mm/hr)	I (mm/hr)	I (mm/hr)	I (mm/hr)	I (mm/hr)
Rainfall Data from NIWA. Hirds 4, RCP6, 2081-2100	1.49	1.49	1.49	1.49	1.49	1.49
Use an appropriate event for the situation						
Flow rate of surface water	Qc (m^3/sec)	Qc (m^3/sec)	Qc (m^3/sec)	Qc (m^3/sec)	Qc (m^3/sec)	Qc (m^3/sec)
	0.000	0.000	0.000	0.000	0.000	0.000
Catchment area pre – development flow	Qcap (m^3/sec)	Qcap (L/sec)				
	0.0000	0.000				

2

						Calculation (initial)	**Calculation (final)**	Num. Of tanks	**Slope out control (volume)**		
				Calculation (initial)	Calculation (initial)	usable height	**Additional area**	1	1930min (row4235)	2130min (row4435)	2160min (line4465)
	Round	Square		Total tank area	Total tank volume	hmax (m)	m^2	r (m)	0.00681	0.00601	0.0058935
Select 1 for type of tank/area, 0 for other	1	0		m^2	m^3	2.355	Nil	1.85	0.02019	0.01740	0.0169806
Estimate storage volume			Tank radius	10.18	23.97	OK	**Total area**	m^2 for fixed H68 height	1.33744	1.13827	1.108715
Adjust to match max Vstored	Num. Of tanks		r (m)		**Initial calculation**	OK	Same as initial	10.75		If using slope control	0.029559
Round area	1		1.8	10.18	**hstor max.**	2.355	**Final volume (Use this)**	Not used			Diff. = 0.0015+-0.0005
	Num. Of tanks	Width	Length	m^2	**Vstored max.**	23.970	23.97	Trench width	**160 minute crossover**		minute steps
Square/rectangular area	3	6	2	36.00	**Vstored min.**	0.167		11.47	1500	1600	1620
	20/40	**30% compacted**	**Void in metal**	**103.0 m^3**	**0.05 to3.5% left @ 48hr**	0.70	**Additional Volume**	Trench length	0.00236	0.00137	0.00120
Short tube, 0.76	Orifice type “u”	g		**120m^2**		OK	Same as initial	20	0.00106	0.00106	0.00104
Thin sharp, 0.62	0.76	9.8067			**Graph, 24hr after peak, Vstored 2880m**	1.358	Not used	m^2 for fixed H68 height	-0.00130	-0.00031	-0.00016
					Max.10% left @ 48hr from initial calc.	5.66	5.66	229.40		**Minimise L90**	
					or add extra volume			Not used		Line to compare pre-development original	
	48hr	24hr	12hr	6hr	2hr	60	30	20	10	line with crossover line changes at point	
Pre – development flow	C20	L20	U20	AD20	AM20	AV20	BE20	BN20	BW20	minute steps	Qpre (L/sec)
3 **of developed area**	0.00016	0.00032	0.00060	0.00120	0.00236	0.00368	0.00514	0.00687	0.01322	1445	13.2
							Slope factor			1450	6.9
Pre–development flow matches 2hr 40min. Intensity	Qp (m^3/sec)	Qp (L/sec)		**Qin max.**		48hr program	adjustment at			1455	5.1
Uses (160min.crossover O126) as a source value	0.00106	1.0621		0.01021		Min.crossover	Min.crossover			1470	3.7
Do not change	OK					Chart point (min.)	Chart point (min.)	1080min (K2305)	2520min (K5185)	1500	2.4
For calculation purposes this section changes	Dia check	Dia	Area	**Qout 1600 (L/sec)**	Qout (m^3/sec)	1600	0.91	Qod (L/sec)	Qod (L/sec)	1620	1.2
the dia only and thereby the area	0.0162	0.01618	0.0002	1.048	0.00105	1600	peak flow	0.25711	0.25225	1800	0.6
The information is not used for anything else		16.18		0		23.33	Chart point (max.)	0.00487	Diff. >0 normally	2160	0.3
	If additional storage is required use the original/initial orifice size and calc. height					**160min. Volume m^3**	0.15				

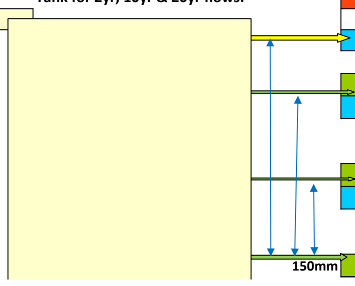
4

Calculate maximum storage volume

Chart intensity hr values steps used	Chart intensity accumulated minute steps	Storm duration- THR (hr)	Storm duration- Event data, TMINS mins	Attenuation calc. total Direct to Atten. Qa (L/sec)	Catchment pre-devel. plus orifice flow out Qtin (L/sec)	**CC (x 1.2)** Intensity. **Post-devel** I, (mm/hr) Current x 1.2	**Russell** **Current(0 deg)** **Pre-devl** I, (mm/hr) 20 yr (current)	**CC (x 1.2)** Intensity. **Post-devel** I, (mm)	**Current(0 deg)** **Pre-devl** I, (mm)	**CC (x 1.2)** Intensity. **Post-devel** I, (mm/hr) 100 yr	**Current(0 deg)** **Pre-devl** I, (mm/hr) 100 yr
48	720	12.00	720	0.12	0.12	5.6	4.7	21.46	17.88	1.8	1.5
24	1080	6.00	360	0.24	0.24	9.5	7.9	21.02	17.52	3.5	2.9
12	1260	3.00	180	0.46	0.46	15.5	12.9	19.80	16.50	6.6	5.5
6	1380	2.00	120	0.92	0.92	24.4	20.3	26.52	22.10	13.3	11.1
2	1410	0.50	30	1.82	1.82	46.6	38.8	13.08	10.90	26.2	21.8
1	1425	0.25	15	2.84	2.84	67.0	55.8	10.20	8.50	40.8	34.0
0.5	1430	0.08	5	3.97	3.97	93.1	77.6	4.74	3.95	56.9	47.4
0.3333	1435	0.08	5	5.30	5.30	111.2	92.7	6.34	5.28	76.1	63.4
0.16666	1440	0.08	5	10.21	10.21	146.4	122.0	12.2	10.2	146.4	122.0
0.16666	1445	0.08	5	10.21	10.21	146.4	122.0	12.2	10.2	146.4	122.0
0.3333	1450	0.08	5	5.30	5.30	111.2	92.7	6.3	5.3	76.1	63.4
0.5	1455	0.08	5	3.97	3.97	93.1	77.6	4.7	4.0	56.9	47.4
1	1470	0.25	15	2.84	2.84	67.0	55.8	10.2	8.5	40.8	34.0
2	1500	0.50	30	1.82	1.82	46.6	38.8	13.1	10.9	26.2	21.8
6	1620	2.00	120	0.92	0.92	24.4	20.3	26.5	22.1	13.3	11.1
12	1800	3.00	180	0.46	0.46	15.5	12.9	19.8	16.5	6.6	5.5
24	2160	6.00	360	0.24	0.24	9.5	7.9	21.0	17.5	3.5	2.9
48	2880	12.00	720	0.12	0.12	5.6	4.7	21.5	17.9	1.8	1.5

		48					**Sum 48hr depth**	**Sum 48hr depth**	**Corr, intensity 160min.**
				Qout max.	**Qout max.**	**Calc. Vstored max.**	270.7	225.6	15.4
Catchment flow Qpat (cell MAX(P109:P130)	**Qcap max.**	Qp (m^3/sec)	Qp (L/sec)	(m^3/sec)	(L/sec)	Vol. stored, (m^3)	**Sum 24hr depth**	**Sum 24hr depth**	
Catchment flow = orifice flow out + catchment	3.150	0.0011	1.1	0.00106	1.06	23.970	227.8	189.8	
pre-development flow	Not used			**Suitable 100yr/secondary outlet flow unavailable**		OK	**Sum 12hr depth**	**Sum 12hr depth**	
For calculation purposes this section changes	Dia check	Dia	Area	**Tank for 2yr, 10yr & 20yr flows.**		OK	185.8	154.8	
the dia only and thereby the area	0.0162	0.01618	0.0002			overflow pipe	**Sum 6hr depth**	**Sum 6hr depth**	
The information is not used for anything else		16.18				2355 mm height	146.2	121.8	

Use this orifice size for final design, or 10mm dia. minimum



	Sum 2hr depth	**Sum 2hr depth**
0 mm Orf dia	93.1	77.6
2047 mm height	**Sum 1hr depth**	**Sum 1hr depth**
	67.0	55.8
	Sum 0.5hr depth	**Sum 0.5hr depth**
10 mm Orf dia	46.6	38.8
1322 mm height	**Sum 0.333hr depth**	**Sum 0.333hr depth**
	37.1	30.9
	Sum 0.167hr depth	**Sum 0.167hr depth**
14 mm Orf dia	24.4	20.3

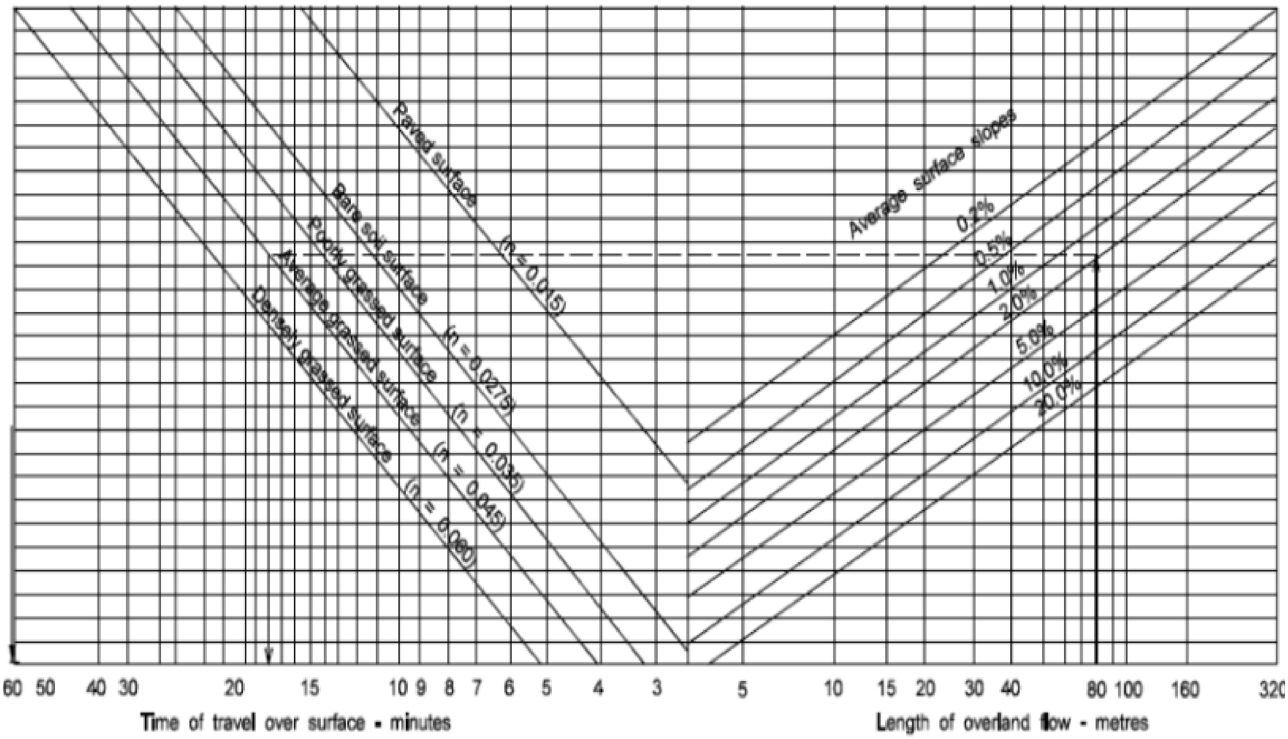
Catchment calculations (lowest/final section)

WDC & FNDC EES.	**Horton value**	**Max. distance**	**Max. height**	**Slope**
	n	**L (km)**	**H (m)**	**%**
	0.045	0.132	37	28.0
FNDC				
Overland flow graph, pg158	**TC (minutes)**			
TC, US Soil	12.59			
			Area of	**Q**
	I10 (100yr event)	**10 min.**	**catchment**	**Q100 = C*I10*A/360**
I, (Hirds chart)	**mm/hr**	**+ 20% (10 min CC)**	**A (ha)**	**(m^3/s)**
100yr	159	190.8	0.42	0.1670
Catchment size 420m^2	**C (av.)**		**A (m^2)**	**(m^3/s)**
type C soil	0.75		4200	0.1670
				0.1670

Calculations for Access culvert on Road (130m)

Access Channel Area	**Use 100% of Q**		**Longitudinal slope “s”**	
	Volume flow m^3/s	**Manning coe.**	**Slo H:V**	**length**
	0.167	0.011	3.64	13
	A x R^0.67		**Slope %**	**Depth change**
	0.004		27.5	3.57
	Pipe dia.	**Check**	**Q possible**	**Q percent available**
	0.375	**OK**	1.0861	650.5
				Min 20% margin
	Water area	**Wet perimeter**	**Hydr Radius**	**A x R^0.67**
	0.110	1.178	0.094	0.023
		CPAA manual fig.3.3		
Check for head waters		**HW/D**	**Check**	
1.81 x Q/D^2.5	3.509	1.600	**OK**	
	HW	**Confirm heading up**		
	0.600	**Inlet Head**		

OVERLAND FLOW GRAPH



FORMULA $t = \frac{107n \sqrt[3]{\ell}}{\sqrt[5]{s}}$

Where:-
t = time of travel over surface in minutes
n = Horton's values for the surface
ℓ = length of flow in metres
s = slope of surface in %

EXAMPLE
Length of over land flow 80m
Average slope of surface 2%

HAIGH WORKMAN LTD
Civil & Structural Engineers

Retaining Wall Design Report for Lot 1 Access

Lot 2, DP 497245
Flagstaff Road, Russell

for

Waitoto Developments Ltd

Haigh Workman reference 18 260

December 2018

Phone: +64 9 407 8327 • Fax: +64 9 407 8378 • info@haighworkman.co.nz • www.haighworkman.co.nz

PO Box 89 • 6 Fairway Drive • Kerikeri 0245 • New Zealand

Revision History

Revision Nº	Issued By	Description	Date
A	Wayne Thorburn	Design Report	13 December 2018

Prepared by

Wayne Thorburn

Senior Geotechnical Engineer

CMEngNZ, CPEng

Approved by

John Papesch

Senior Civil Engineer / Director

MEngNZ

TABLE OF CONTENTS

Revision History i

1 Introduction 3

1.1 General 3

1.2 Scope of Works 3

1.3 Site Description 3

2 Geotechnical Ground Model and Design Parameters 4

2.1 Published Geology 4

2.2 Visual Inspection 5

2.3 Site Investigation 5

2.4 Subsoil Conditions 5

2.5 Geotechnical Ground Model 6

3 Retaining Wall Analysis Methodology 6

3.1 General 6

3.2 Seismic Design Criteria 7

3.3 Retaining Wall Design Criteria 7

3.4 Retaining Wall Design 8

3.5 Construction Recommendations and Safety in Design 9

4 Limitations 10

Appendix A – Drawings 11

Appendix B – Site Investigation Logs (Hand Auger) 12

Appendix C – CPT Soundings 13

Appendix D – Stability Models 14

Appendix E – Retaining Wall Calculations 15

TABLES

Table 1 - Geotechnical Design Parameters........6
Table 2 - Retaining wall design criteria........7
Table 3 - Retaining Wall Design Summary........9
Table 4 - Timber lagging details........9

FIGURES

Figure 1 – Retaining Wall Location (Lot 1 Access)........3
Figure 2 - Geology Map (1,250,000)........4
Figure 3 – Retaining Wall Methodology (RW02)........8

1 *Introduction*

1.1 General

Haigh Workman Limited (Haigh Workman) was engaged by Waitoto Developments Ltd (the Client) to design retaining walls to allow safe access into the Lot 1. A retaining wall is required to support an existing cut face, with an in-ground buried wall required to support the accessway from further instability downslope. The approximate location of the retaining walls is shown in Figure 1.

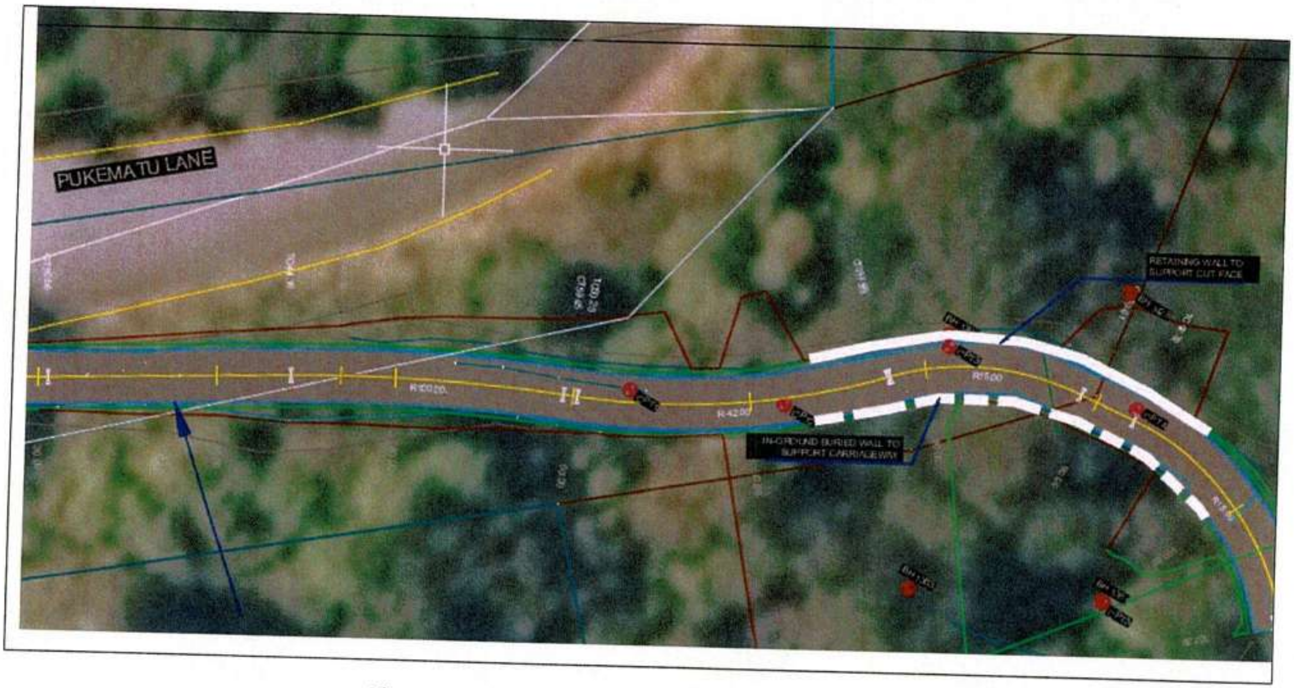


Figure 1 – Retaining Wall Location (Lot 1 Access)

1.2 Scope of Works

The scope of works undertaken to design the retaining wall comprised the following:

- Five CPTs and four hand augered boreholes undertaken by Underground Investigation Ltd;
- Develop a geotechnical ground model for retaining wall design;
- Geotechnical and structural design of a cantilever pole wall;
- Preparation of retaining wall design drawings to accompany consent application.

1.3 Site Description

The site is irregular in plan shape, approximately 3.85 hectares in plan area. North-south ridgelines border the eastern and western boundaries, with site access via a broad spur along the northern boundary at the highest elevation point for the site. The site is generally sloping down towards the south, with natural slope angles up to 30 degrees in areas. Excavations have been undertaken to create accessways, resulting in over-steep cuts (>55 degrees), with fill material placed over the existing slopes in an uncontrolled manner.

2 Geotechnical Ground Model and Design Parameters

2.1 Published Geology

The published geology map of Whangarei (scale 1:250,000, 2009) identifies the site as Waipapa Group (TJw), massive to thin bedded, lithic volcaniclastic metasandstone and argillite.

Further reference to the published soil and rock maps of Bay of Islands (scale 1:100,000, 1981) indicate the basement rock mass is mapped as sandstone and mudstone (greywacke and argillite), fine to medium grained sandstone interbedded with grey to black mudstone and minor siliceous, igneous and calcareous rocks, thinly to thickly bedded with some massive units, closely fractured and veined. Weathered to yellow-brown soft sandy clay to depths of 30 m, well to moderately drained soils.

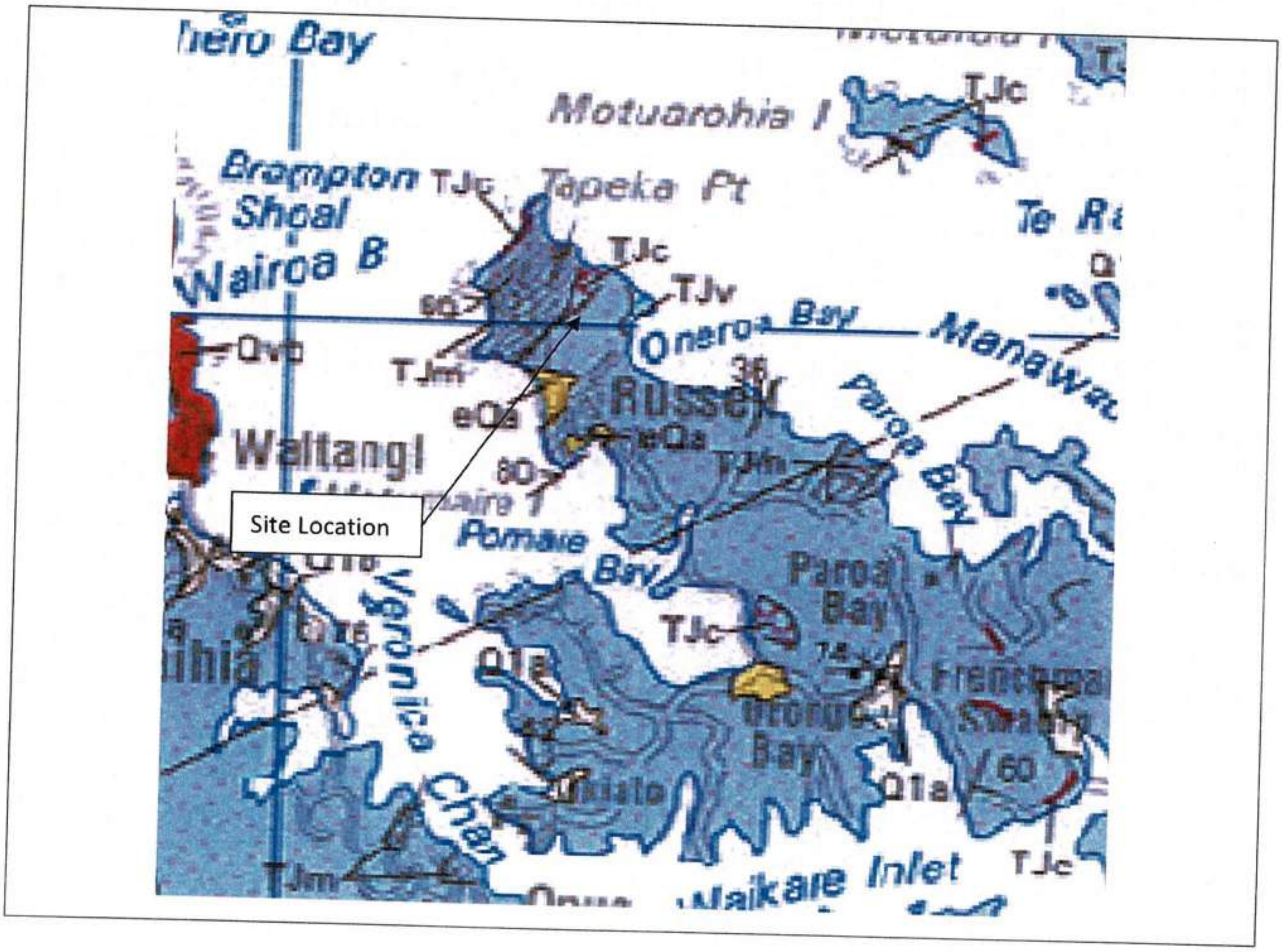


Figure 2 - Geology Map (1,250,000)

2.2 Visual Inspection

Based upon our site inspection and information from geological maps, we consider the subsoils are typically comprised of residual Greywacke rock, comprising very stiff fine-grained soils, i.e. silts and clays. The existing cut face comprised residual soils, which due of the over steepened cut face, show signs of instability at several locations.

Tension cracks were also observed where fill has been placed over the edge of the existing slope faces. Vegetation was also observed within the fill, indicating that fill had been placed in an uncontrolled manner and further instability downslope of the accessway is imminent, and further damage to the accessway is anticipated.

A LIM report has not been sought and is not subject to this review, which would be prudent to obtain for any further information about the area that may be recorded on Councils GIS database which could otherwise cause restrictions or highlight land hazards that may be raised at the time of building development.

2.3 Site Investigation

Site investigations were undertaken by Underground Investigation Ltd on 04 October and 16 October 2018. The investigation comprised the following:

- Four hand augered boreholes to a maximum depth of 3.0 mbgl (BH01 to BH04); and
- Five CPT soundings advanced to a maximum depth of 10.1 m (CPT01 to CPT05).

CPT soundings were undertaken till the anchors pulled out. Underground Investigation Ltd provided a cone penetration rig attached to a remote controlled, rubber tracked machine to test and record ground information. CPT soundings are presented in Appendix C.

Hand auger investigations were logged in accordance with The New Zealand Geotechnical Society, "Guidelines for the Field Classification and Description of Soil and Rock for Engineering Purposes" (2005). A hand shear vane with 19 mm blade was used to measure the Vane Shear Strength of the in-situ material. Readings were taken at the base of the auger hole every 0.5 m of depth. All shear strengths shown on the appended logs are Vane Shear Strengths in accordance with the NZGS; "Test Method for determining the Vane Shear Strength of a Cohesive Soil using a Hand-held Shear Vane", 2001.

2.4 Subsoil Conditions

The investigations confirmed the mapped geology with very stiff residual greywacke soils encountered at the surface. A softened zone was encountered across the site, which has been interpreted from the hand augered boreholes and the CPT soundings, a geological cross section has been prepared to present the ground model interpreted from the subsoil investigations.

Ground water level was not encountered during the investigation. Elevated groundwater may be experienced during winter or sustained wet periods. Generally, due to the site topography, rain water will flow overland following the existing site contours. Surface drainage around the proposed wall should be considered to divert any overland flows away from the proposed retaining wall and existing dwelling. For the purposes of design, the groundwater level has been applied to the softer soils observed across the site, coupled with a steady-state flow net to establish the groundwater regime under static conditions. This is shown on the stability models presented within Appendix D.

2.5 Geotechnical Ground Model

A geotechnical ground model was developed from the available site investigation data and is presented in Appendix A.

The geotechnical design parameters recommended in Table 1 are based on the interpretation of the results of the investigations carried out onsite, in-situ test results, empirical relationships, and local experience.

Table 1 - Geotechnical Design Parameters

Material Unit	Unit Weight, γ (kN/m^3)	Effective cohesion, c' (kPa)	Effective Friction Angle, φ' (degrees)	Undrained shear strength, S_u (kPa)	Young's Modulus, E' (MPa)
Very stiff – Residual Greywacke	18	7	32	150	25
Softened zone – Greywacke	18	5	30	50 - 100	15
Completely weathered Greywacke	19	10	34	200	50
Highly weathered Greywacke	20	50	35	>500	70
Drainage Metal	20	0	35	-	-

3 Retaining Wall Analysis Methodology

3.1 General

A retaining wall is required to support an existing cut face along the proposed accessway into Lot 1, with an in-ground palisade wall required to support the accessway from further downslope failures, and to provide additional shear strength for global stability across the site. A maximum retained height of 3.0 m has been designed for the cut slope wall (RW01), with an allowance for 2.0 m of soil to regress from the downslope palisade wall (RW02). Additional trimming of the cut slope will be undertaken to provide enough drainage media behind RW01, as shown on the appended drawings.

Back analysis of the existing slopes was undertake using limit equilibrium software Slide, using the steady state finite element analysis module to determine the groundwater level. Further stability modelling was undertaken to determine the increase in shear capacity required within the slide mass to achieve a generally accepted factor of safety (FoS) of 1.5 for long-term static conditions.

Deflection limits have been selected based on the wall type and consequence of any lateral movement. For RW01, horizontal deflection at the top of the wall has been limited to 150 mm (under static conditions). RW02 will be supporting the accessway, therefore deflections need to limited to less than 50 mm (under static conditions).

Detailed design has assessed the following failure modes:

- Kick-out;

- Yielding of structural elements.

The retaining wall is designed using the soil parameters presented in Table 1

3.2 Seismic Design Criteria

For structural design of earth retaining structures, the design horizontal ground acceleration to be used in computing seismic inertia forces is as follows:

$$C_o g = C_h(T_0) Z R_u S_p g$$

- $C_h(T_0) = 1.33$ (Class C)
- ZRu = 0.13 (minimum value)
- $S_p = 0.8$ (Class C)

$C_0 g = 0.14$ g

3.3 Retaining Wall Design Criteria

The design criteria for the retaining walls is shown in Table 2.

Table 2 - Retaining wall design criteria

Retaining Wall No.	Max. Design Height (m)	Surcharge
RW01	3.0	Sloping ground behind wall (Max. 50 degrees, typical 30 degrees) *
RW02	2.0	Vehicle surcharge, 10 kPa. Sloping ground in front of wall.

* *Sloping ground behind the wall is expected erode to some degree. Maintenance may be required to ensure the accessway can be used, i.e. spoil removed.*

The design of the retaining walls has been carried out using the methodology suggested by Poulos (1995) and Day (1999) for stabilisation of slope with piles. Poulos suggested an evenly distributed lateral soil pressure diagram behind a pile in an unstable slope. Whereas, Day suggests the design procedures and the allowable spacing for different material type. For the types of soils at this site, residual Greywacke rock, we have adopted a pile spacing of 1.0 m.

The design of the wall was carried out with the following steps according to Day's suggestion for the design of slope stabilisation with piles:

- Carried out slope stability analyses to determine the location and minimum length of the pile to obtain an adequate FoS.
- Carried out slope stability analyses and enforced the slip surface pass through the pile to determine the depth of the failure plane and the minimum shear capacity of the pile.

- Input the above information to WALLAP v6.06, using the strength factor method and the 2-D Finite element model to determine the required embedment depth, internal forces and displacement of the pile.

As shown in Figure 3, the barrier wall has been assessed for the shear force in the pile estimated at the target FoS in the Slide analysis. To represent this, the shear force estimated to act on the pile is applied as a series of horizontal loads along the length of the pile within the failure surface. The sloping ground has been modelled as negative surcharge.

Seismic conditions were modelled within Slide using undrained soil parameters. The shear reinforcement required by the piles has estimated to provide adequate factors of safety, i.e. greater than 1.0 under ULS conditions. This has been treated as an additional horizontal load to determine the bending moment and shear force requirement of the timber poles.

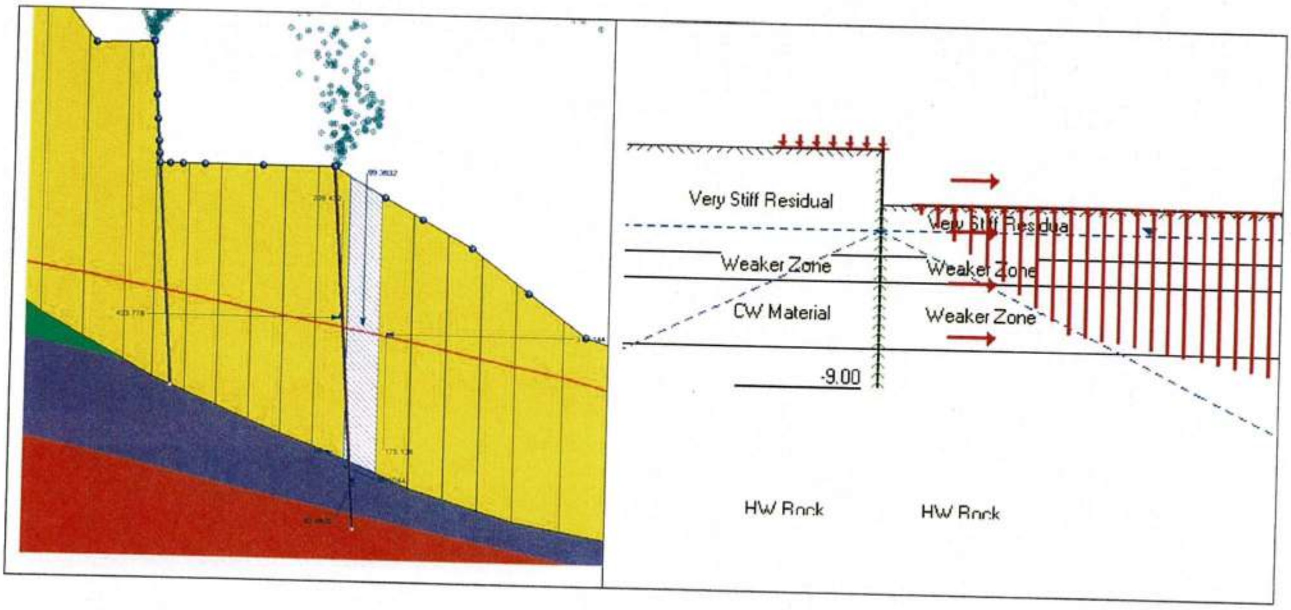


Figure 3 – Retaining Wall Methodology (RW02)

3.4 Retaining Wall Design

A summary of the design is presented in Table 3. Design drawings and detailed calculations are provided in Appendix A and Appendix E, respectively. The bending moment and shear force values given below have not been factored as the lateral forces applied to the retaining wall model are taken from the stability model with a factor of safety of 1.5 for global stability.

The retaining wall is composed of high-density timber poles encased in 17.5 MPa of concrete with grade G8 timber horizontal planks, or rough sawn 150 x 50mm H4 treated lagging. Design actions, deflections and length of embedment were derived from the analysis undertaken using Wallap. Drainage must be installed behind the wall, with the drainage pipe outlet located downslope of the retaining wall.

Table 3 - Retaining Wall Design Summary

Wall Properties	RW01 – Cut face	RW01 downslope – Palisade Wall
Max. Retained Height (H)	3.0 m	1.0 m
Pile Spacing (c/c)	1.0 m	1.0 m
Pole type	400 mm SED – High Density	400 mm SED – High Density
Embedment Length (L)	6.0 m	8.0 m
Total Pile Length (H + L)	9.0 m	9.0 m
Encasement	17.5 MPa Concrete in a 600 mm diameter augered hole	17.5 MPa Concrete in a 600 mm diameter augered hole
Bending Moment	133 kNm	34.3 kNm
Shear Force	90 kN (Slide)	90 kN (Slide)
Deflection	148 mm (163 mm DCLS seismic loading)	37 mm (42 mm DCLS seismic loading)

DCLS – Damage Control Limit State (NZTA Bridge Manual, SP/M/022, Third Edition, Amendment 3, October 2018)

Horizontal timber rails between the poles are to span a minimum of two pole spacings. Timber lagging details are provided in Table 4, with depths from top of wall.

Table 4 - Timber lagging details

Single rails (50 mm thick)	Double rails (100 mm thick)	Triple Rails (150 mm thick)
0 to 0.6 m	0.6 to 2.7 m	2.7 to 3.0 m

3.5 Construction Recommendations and Safety in Design

General

Care should be taken during construction not to induce further instability through removing material from the toe of the slopes. Temporary support will be required if excavations are left open and protection measures, i.e. polyethene sheets on cut face, should be considered to reduce the effects of erosion from adverse weather conditions.

The pile should not be left open for extended periods of time (i.e. overnight) prior to concrete being poured to reduce the likelihood of pile hole collapse.

It is envisaged that the wall will be constructed during the summer months. Groundwater may accumulate in the pile holes during construction and must be pumped out prior to concreting. We recommened pile holes are bored and concrete poured on the same day to reduce the risk of collapse and water ingress.

Provided the construction methodology is continuous and the pile holes are not left open for extended periods, the holes are not expected to require casing. If the ground conditions vary outside those assumed in this report, then the design may need to be changed or altered to ensure adequate performance.

Inspections

During excavation and construction of the proposed walls, the site should be examined by an engineer competent to judge whether the exposed subsoils are compatible with the inferred conditions on which the report has been based. It is important that we be contacted if there is any variation in subsoil conditions from those described in this report.

Inspections of the retaining wall construction is required for a PS4 to be provided by Haigh Workman. Inspections will be required at the following points:

- Bored pile hole inspections at each retaining wall location;
- Inspection of the poles (must be high density poles) before placement;
- Concrete dockets, high density poles, and timber lagging dockets to be provided to Engineer;
- Inspection of the drainage coil and drainage material before it is placed.

All pile holes must be clear of water prior to pouring concrete. The Contractor must have a pump onsite and be ready to pump the holes dry.

4 Limitations

This report has been prepared for the use of Waitoto Developments Ltd with respect to the brief outlined to us. This report is to be used by our Client and their Consultants and may be relied upon when considering geotechnical advice. Furthermore, this report may be utilised in the preparation of building and/or resource consent applications with local authorities. The information and opinions contained within this report shall not be used in other context for any other purpose without prior review and agreement by Haigh Workman Ltd.

The recommendations given in this report are based on site data from discrete locations and prepared specifically for the structures shown on the attached drawings. If any changes are made, we must be allowed to review the new development proposal to ensure that the recommendations of this report remain valid. Inferences about the subsoil conditions away from the test locations have been made but cannot be guaranteed. We have inferred a geotechnical model that can be applied for our analyses. However, variations in ground conditions from those described in this report could exist across the site. Should conditions encountered differ to those outlined in this report we ask that we be given the opportunity to review the continued applicability of our recommendations.

Appendix A – Drawings

Drawing No.	Title	Scale
18 260_GEO	Geotechnical Investigation Plan	1:500
18 260_GEO1	Geological Section – Lot 1 Access	1:200
18 260_2P6	ROWs A& B Retaining Plan	1:250
18 260_2DE1	ROWs A & B Retaining Typical Details	1:50

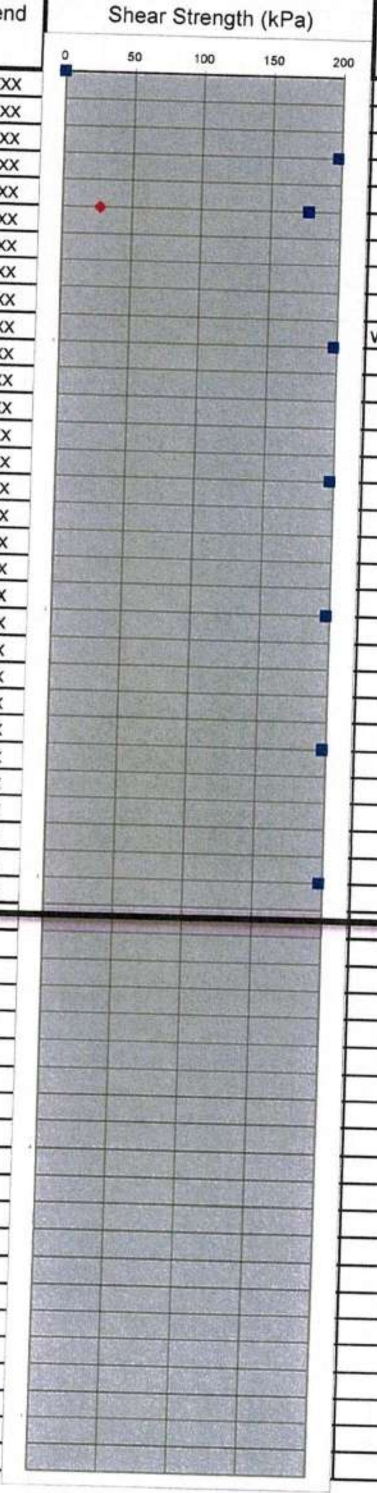
Appendix B – Site Investigation Logs (Hand Auger)

Borehole Log

BH1

UNDERGROUND INVESTIGATION

Client	HW - Flagstaff Hill
Location	Russell
Project	Proposed Retaining Wall
Date	16/10/2018
Drilling Method:	Hand Auger
Diameter:	50mm
Logged:	CG
Checked:	
SV Serial	2422


Shear Strength (kPa)

Soil Description	Depth	Legend	Moisture	Sample, Other Tests, Remarks.
clayey SILT, some sand, light brown / brown, very stiff, moist.	0.0	xxxxxxxx	moist	
		xxxxxxxx		
		xxxxxxxx		
		xxxxxxxx		197++
		xxxxxxxx		
light brown / greyish white / dark brown	0.5	xxxxxxxx		177/27
		xxxxxxxx		
		xxxxxxxx		
		xxxxxxxx		
clayey SILT, whitish grey / reddish dark brown, very stiff, wet.		xxxxxxxx	wet	
	1.0	xxxxxxxx		197++
		xxxxxxxx		
		xxxxxxxx		
some sand 1.3-1.8m		xxxxxxxx		
		xxxxxxxx		
	1.5	xxxxxxxx		197++
		xxxxxxxx		
		xxxxxxxx		
		xxxxxxxx		
		xxxxxxxx		
	2.0	xxxxxxxx		197++
clayey SILT, some sand, reddish brown / greyish white / light brown, rock matrix visible, very stiff, wet		xxxxxxxx		
		xxxxxxxx		
		xxxxxxxx		
		xxxxxxxx		
	2.5	xxxxxxxx		UTP
		xxxxxxxx		
		xxxxxxxx		
		xxxxxxxx		
		xxxxxxxx		
	3.0	xxxxxxxx		UTP
EOB 3.0m target depth.				
	3.5			
	4.0			
	4.5			
	5.0			

Soils Legend

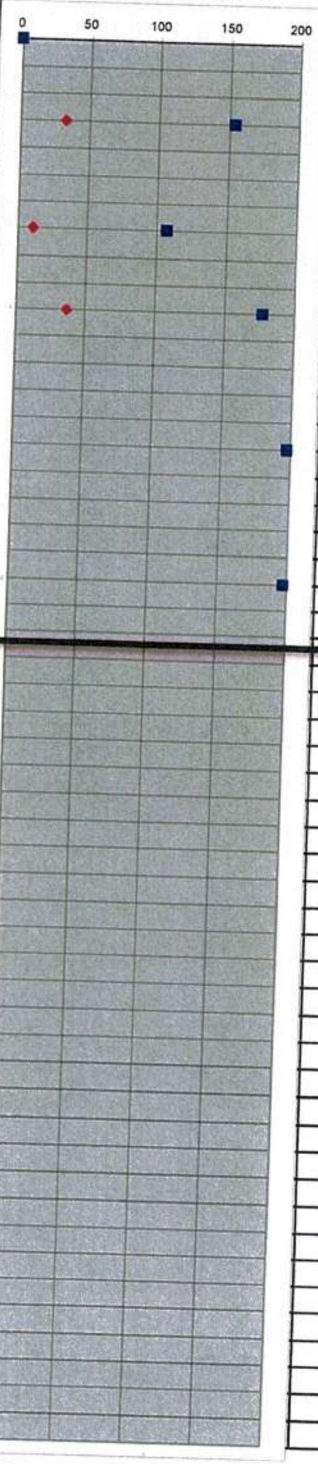
Topsoil	\\\\\\\\\\\\\\	Fill	//////////////	Clay	------------	Silt	xxxxxxxx
Sand	.o.o.o.o.o.o.o.o	Peat	....	Gravel	⊓⊓⊓⊓⊓	Rock	▲▲▲▲

Borehole Log

BH2

UNDERGROUND INVESTIGATION

Client	HW - Flagstaff Hill				
Location	Russell				
Project	Proposed Retaining Wall				
Date	16/10/2018				
Drilling Method: Hand Auger	Diameter: 50mm	Logged: CG	Checked:	SV Serial	2422

Soil Description	Depth	Legend	Shear Strength (kPa)	Moisture	Sample, Other Tests, Remarks.
TOPSOIL, 50mm, dark brown, moist	0.0	\\\\\\\\\\\\\\\\		moist	
silty CLAY, brown / light brown, very stiff, moist		\\\\\\\\\\\\\\\\			

		------------			154/33

	0.5	------------			

		------------			108/11

	1.0	------------			177/37

		------------			
clayey SILT, light brown / ligh grey / reddish brown, very stiff, wet.	1.5	xxxxxxxx		wet	197++
		xxxxxxxx			
		xxxxxxxx			
		xxxxxxxx			
		xxxxxxxx			
	2.0	xxxxxxxx			UTP
		xxxxxxxx			
UTP EOB 2.05m.					
	2.5				
	3.0				
	3.5				
	4.0				
	4.5				
	5.0				

Soils Legend

Topsoil	\\\\\\\\\\\\\\\\	Fill	////////////////	Clay	------------	Silt	xxxxxxxx
Sand	.0.0.0.0.0.0.0.0	Peat	::::::::::::::::	Gravel	┌┬┬┬┬┐	Rock	▲▲▲▲

UNDERGROUND INVESTIGATION

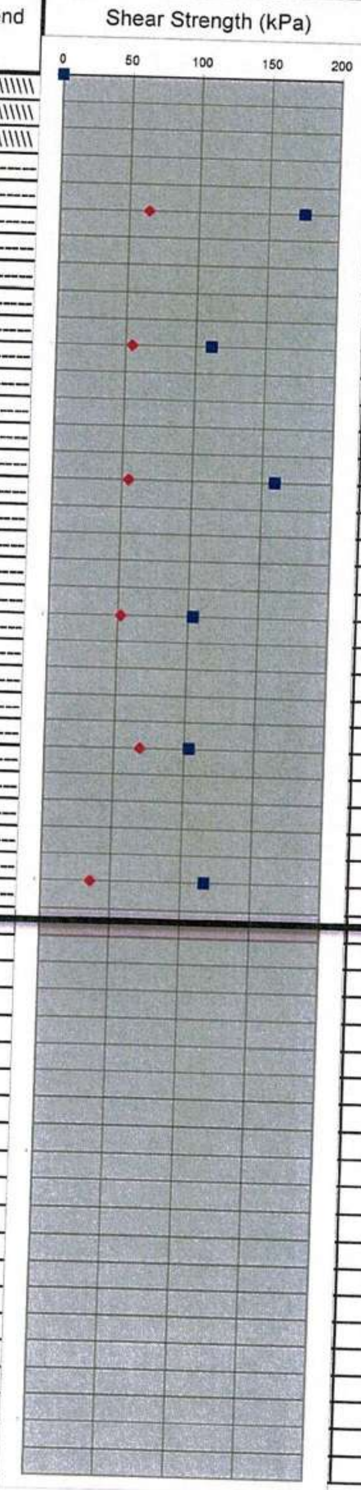
Borehole Log

BH3

Client	HW - Flagstaff Hill
Location	Russell
Project	Proposed Retaining Wall
Date	16/10/2018

Drilling Method: Hand Auger
Diameter: 50mm
Logged: CG
Checked:
SV Serial 2422

Soil Description	Depth	Legend	Moisture	Sample, Other Tests, Remarks.
TOPSOIL, 250mm, dark brown, wet.	0.0	\\\\\\\\\\\\\\	wet	
		\\\\\\\\\\\\\\		
silty CLAY, some gravel, yellowish brown / brown / reddish brown (gravel), very stiff, wet.		\\\\\\\\\\\\\\		
	0.5	------------		176/64
silty CLAY, light brown / reddish brown / white, very stiff, wet.	1.0	------------		112/54
	1.5	------------		159/54
	2.0	------------		104/52
	2.5	------------		104/68
	3.0	------------		117/35
EOB 3.0m tareget depth.				
	3.5			
	4.0			
	4.5			
	5.0			



Soils Legend

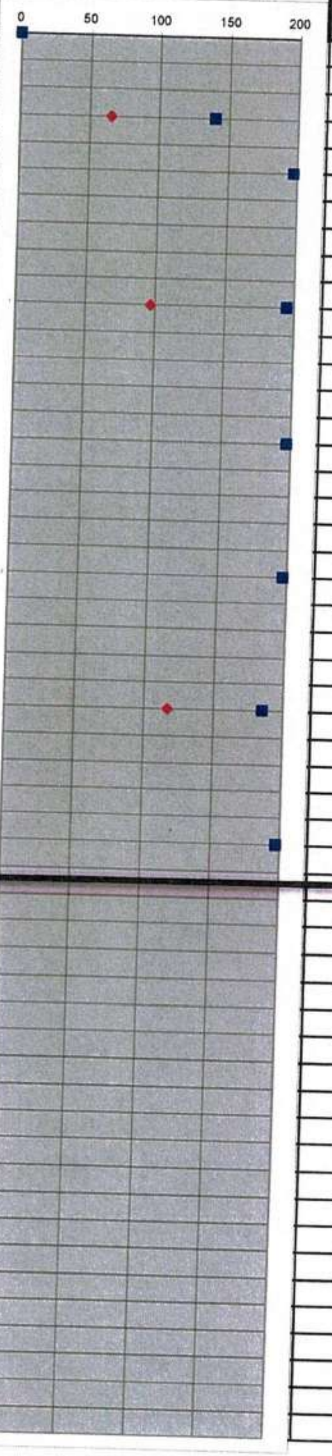
Topsoil	\\\\\\\\\\\\\\	Fill	//////////////	Clay	------------	Silt	xxxxxxxx
Sand	.0.0.0.0.0.0.0	Peat	::::::::::::::	Gravel	┌┌┌┌┌	Rock	▲▲▲▲

UNDERGROUND INVESTIGATION

Borehole Log

BH4

Client: HW - Flagstaff Hill
Location: Russell
Project: Proposed Retaining Wall
Date: 16/10/2018
Drilling Method: Hand Auger
Diameter: 50mm
Logged: CG
Checked:
SV Serial: 2422

Soil Description	Depth	Legend	Shear Strength (kPa)	Moisture	Sample, Other Tests, Remarks.
silty CLAY, yellowish brown / brown, very stiff, wet.	0.0	----------		wet	

		----------			
some sandy gravel (brown) 0.3m - 1.3m		----------			140/65

	0.5	----------			197++

	1.0	----------			195/97

		----------			
silty CLAY, yellowish brown / greyish white, very stiff, wet.		----------			

	1.5	----------			197++

	2.0	----------			197++

/ reddish brown, silt fraction increasing		----------			

	2.5	----------			185/117

	3.0	----------			197++
EOB 3.0m target depth.					
	3.5				
	4.0				
	4.5				
	5.0				

Soils Legend

Topsoil	\\\\\\\\\\\\\\	Fill	//////////////	Clay	----------	Silt	XXXXXXXX
Sand	.0.0.0.0.0.0.0	Peat	::::::::::::::	Gravel	┌┬┬┬┬	Rock	▲▲▲▲

Appendix C – CPT Soundings

UNDERGROUND INVESTIGATION

CPT Test Information

Test Hole Number	CPT01	Job Identifier	HW Flagstaff
Test Date	4/10/2018	Operator	Craig Greenfield
CPT Rig Type	Georig 220 with Screw Anchors	Cone Type	Nova Cone 100MPa
Cone Serial Number	4595	Battery Voltage Start	6.42
Start Recording	10:38:00 AM	Finish Recording	11:05:00 AM
Pre Drill Depth	NA	Ground Water Depth	
Data Interval	10mm	Total Penetration Depth (m)	9.325
Date of Last Calibration		Metres To Next Calibration	312
		Test ended due to:	Anchor Failure

Zero Value Change % FSO

	Point Resistance	Pore Pressure	Sleeve Friction
End of test with tip loosened	0.05%	0.12%	0.04%

Dissipation Testing

Test No	Depth (m)	Duration (secs)	Comments

Notes and Comments

Data loss (typically at rod change points). Either deleted or averaged

qc	fs	u
0.52	0.52	0.53
1.53	2.53-2.54	4.53-4.54
2.53	4.54	5.54
3.53-3.54	6.54	6.54
7.54	7.54	7.17-7.18
8.53		7.54

UNDERGROUND
INVESTIGATION

CPT Test Information

Test Hole Number	CPT02	Job Identifier	HW Flagstaff
Test Date	4/10/2018	Operator	Craig Greenfield
CPT Rig Type	Georig 220 with Screw Anchors	Cone Type	Nova Cone 100MPa
Cone Serial Number	5233	Battery Voltage Start	6.18
Start Recording	11:47:00 AM	Finish Recording	12:07:00 PM
Pre Drill Depth	NA	Ground Water Depth	
Data Interval	10mm	Total Penetration Depth (m)	7.55
Date of Last Calibration		Metres To Next Calibration	1150
		Test ended due to:	anchor failure

Zero Value Change % FSO

	Point Resistance	Pore Pressure	Sleeve Friction
End of test with tip loosened	0.01%	0.04%	0.10%

Dissipation Testing

Test No	Depth (m)	Duration (secs)	Comments

Notes and Comments

	qc	fs	u
Data loss corrected (typically at rod change points). Either deleted or averaged	0.54	2.54	2.54
	2.54-2.55	3.87	5.54
	3.55	5.55	6.55
	4.53-4.54	6.55	
	5.55		
	6.55		

UNDERGROUND
INVESTIGATION

CPT Test Information

Test Hole Number	CPT03	Job Identifier	HW Flagstaff
Test Date	4/10/2018	Operator	Craig Greenfield
CPT Rig Type	Georig 220 with Screw Anchors	Cone Type	Nova Cone 100MPa
Cone Serial Number	4595	Battery Voltage Start	6.14
Start Recording	1:31:00 PM	Finish Recording	1:49:00 PM
Pre Drill Depth	NA	Ground Water Depth	
Data Interval	10mm	Total Penetration Depth (m)	5.98
Date of Last Calibration		Metres To Next Calibration	303
		Test ended due to:	anchor failure

Zero Value Change % FSO

	Point Resistance	Pore Pressure	Sleeve Friction
End of test with tip loosened	0.02%	0.26%	0.00%

Dissipation Testing

Test No	Depth (m)	Duration (secs)	Comments

Notes and Comments

	qc	fs	u
Data loss (typically at rod change points). Either deleted or averaged	0.56-0.57	0.56	0.55
	1.56		3.55
	2.56		
	3.56		
	4.54-4.55		

UNDERGROUND
INVESTIGATION

CPT Test Information

Test Hole Number	CPT04	Job Identifier	HW Flagstaff
Test Date	4/10/2018	Operator	Craig Greenfield
CPT Rig Type	Georig 220 with Screw Anchors	Cone Type	Nova Cone 100MPa
Cone Serial Number	5233	Battery Voltage Start	6.55
Start Recording	2:48:00 PM	Finish Recording	3:15:00 PM
Pre Drill Depth	NA	Ground Water Depth	
Data Interval	10mm	Total Penetration Depth (m)	10.09
Date of Last Calibration		Metres To Next Calibration	1142
		Test ended due to:	Anchor falure

Zero Value Change % FSO

	Point Resistance	Pore Pressure	Sleeve Friction
End of test with tip loosened	0.08%	0.02%	0.02%

Dissipation Testing

Test No	Depth (m)	Duration (secs)	Comments

Notes and Comments

	qc	fs	u
Data loss (typically at rod change points). Either deleted or averaged	0.45-0.46	0.45	3.46-3.47
	1.45	1.45-1.46	4.46
	2.46	2.46	5.48-5.49
	2.45-2.46	4.46	
	5.46	8.47	
	7.46	9.47	
	8.47		
	9.47-9.48		

UNDERGROUND
INVESTIGATION

CPT Test Information

Test Hole Number	CPT05	Job Identifier	HW Flagstaff
Test Date	4/10/2018	Operator	Craig Greenfield
CPT Rig Type	Georig 220 with Screw Anchors	Cone Type	Nova Cone 100MPa
Cone Serial Number	4595	Battery Voltage Start	6.42
Start Recording	3:56:00 PM	Finish Recording	4:17:00 PM
Pre Drill Depth	NA	Ground Water Depth	
Data Interval	10mm	Total Penetration Depth (m)	6.98
Date of Last Calibration		Metres To Next Calibration	297
		Test ended due to:	anchor failure

Zero Value Change % FSO

	Point Resistance	Pore Pressure	Sleeve Friction
End of test with tip loosened	0.04%	0.05%	0.00%

Dissipation Testing

Test No	Depth (m)	Duration (secs)	Comments

Notes and Comments

Data loss corrected (typically at rod change points). Either deleted or averaged

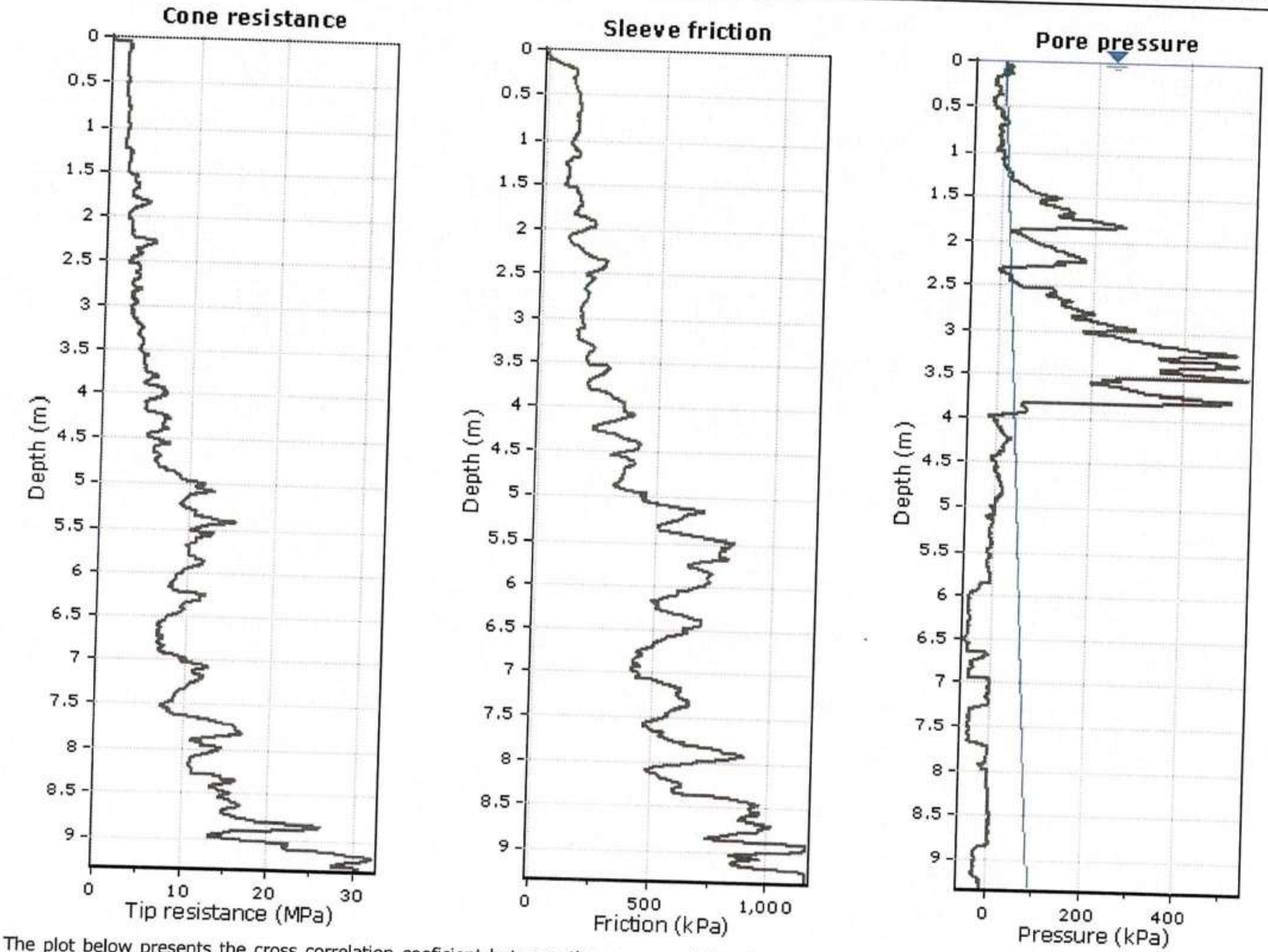
qc	fs	u
0.55	0.55-0.56	0.19
1.55	1.55-1.56	2.55-2.56
2.55	2.55-2.56	3.56
4.56	6.56	4.56
5.56		5.56-5.57
6.56		

Underground Investigation Limited

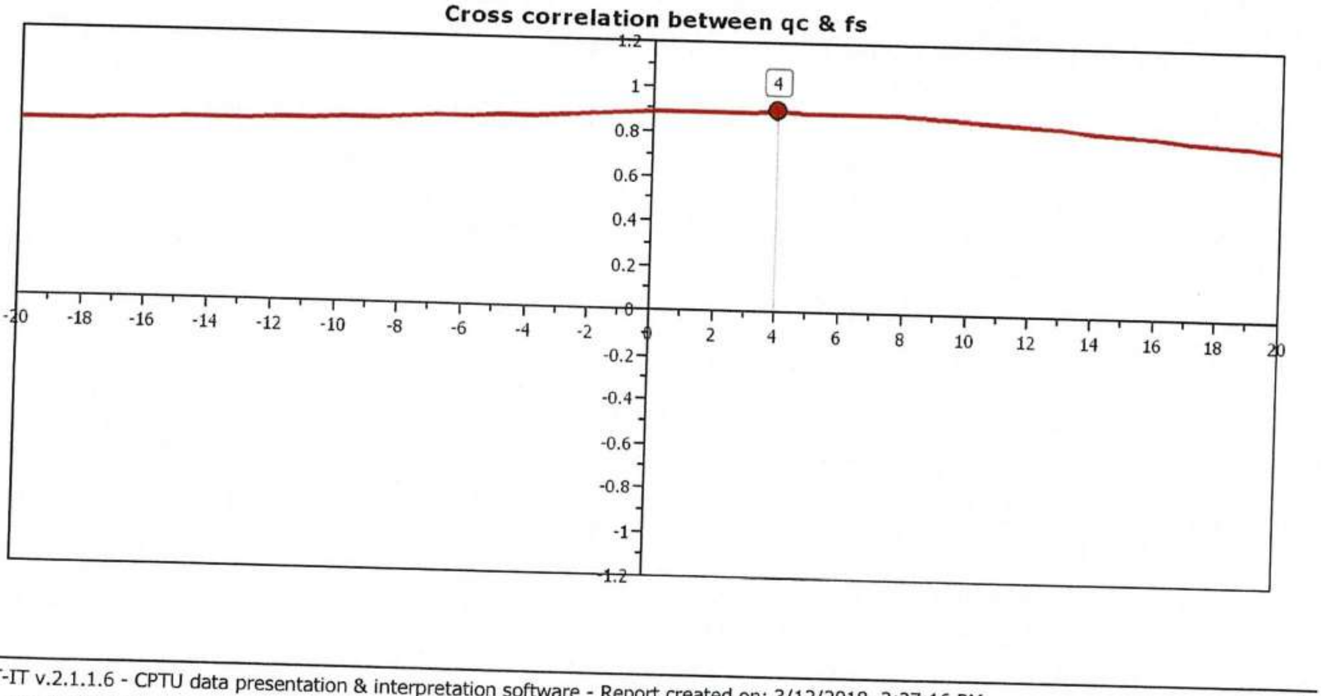
CPT: CPT1

Total depth: 9.32 m, Date: 9/10/2018
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).

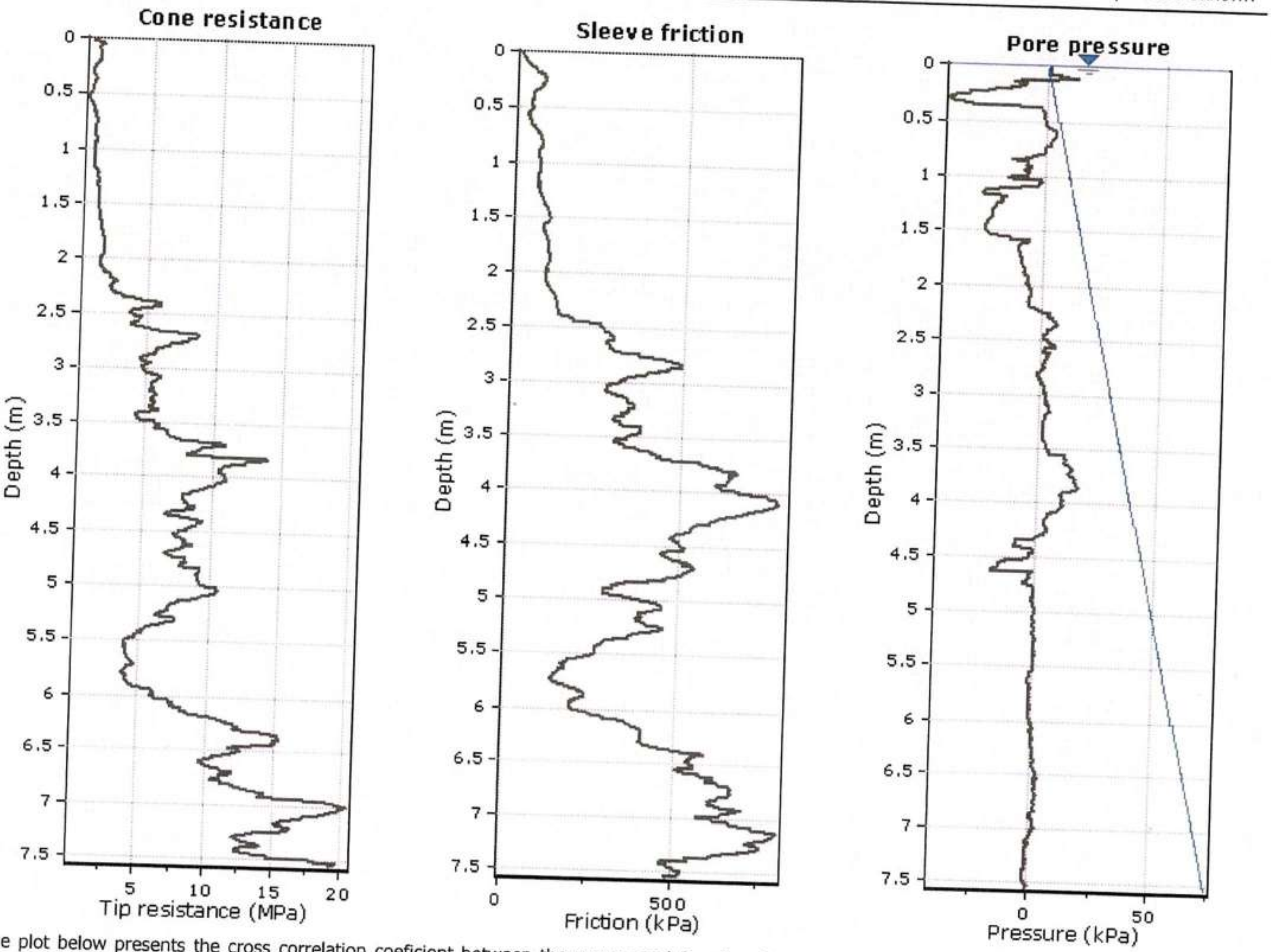


Project:

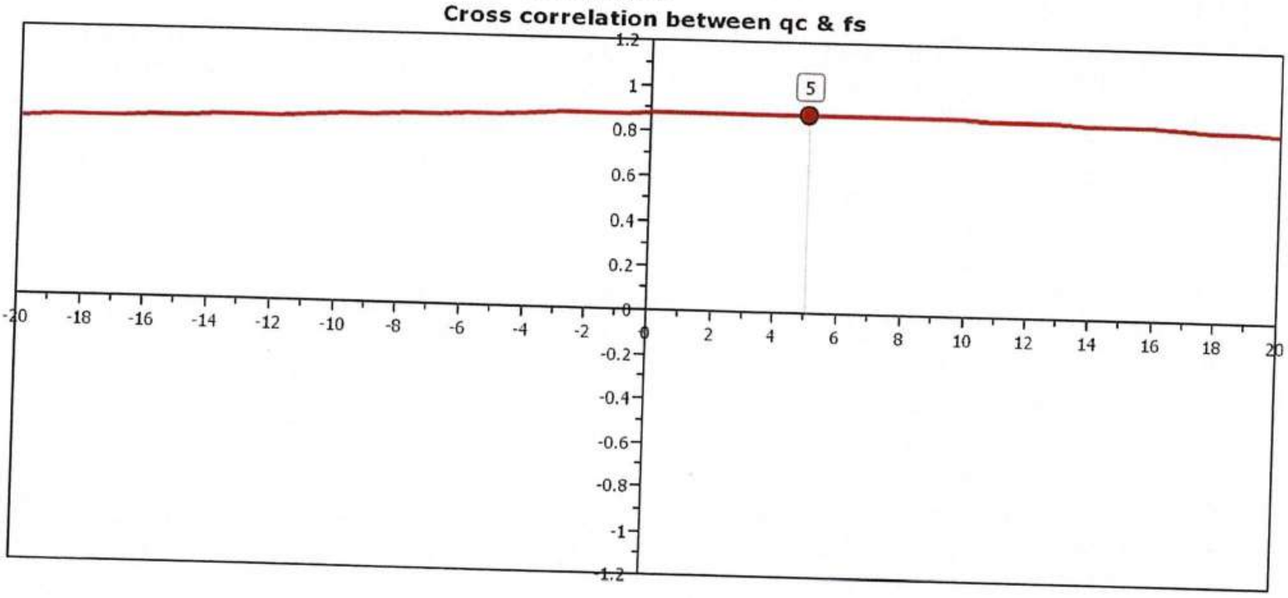
Location:

CPT: CPT2

Total depth: 7.55 m, Date: 9/10/2018
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).

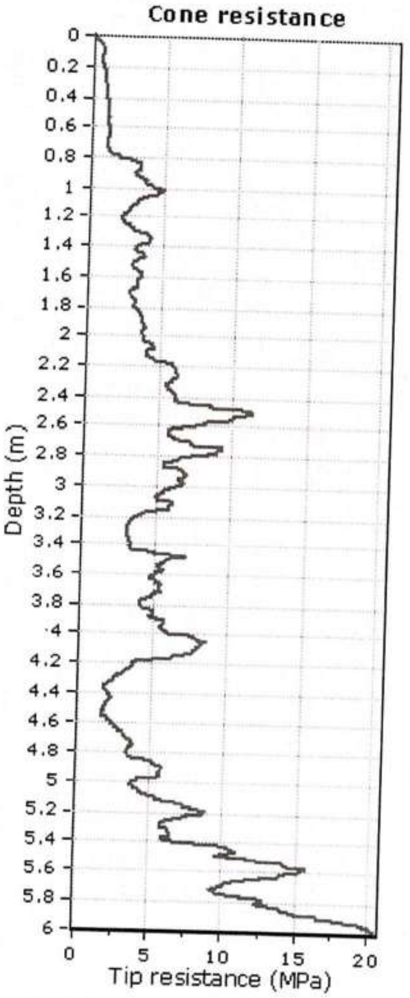


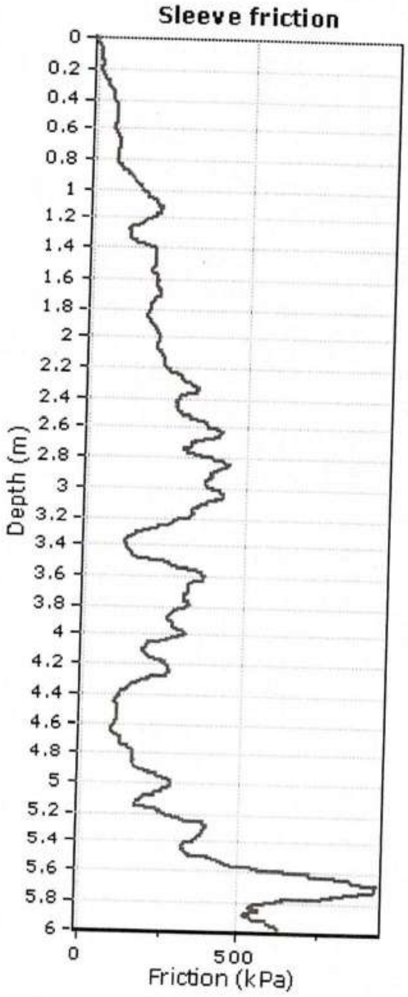
Underground Investigation Limited

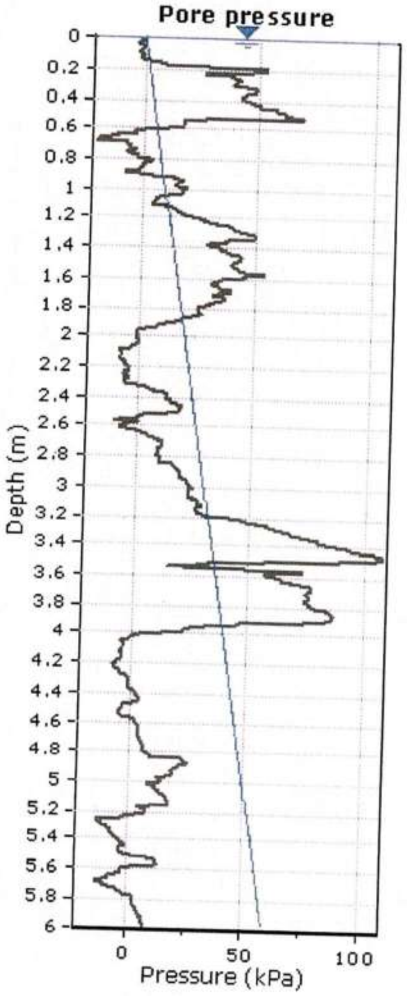
CPT: CPT3

Total depth: 5.98 m, Date: 9/10/2018
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

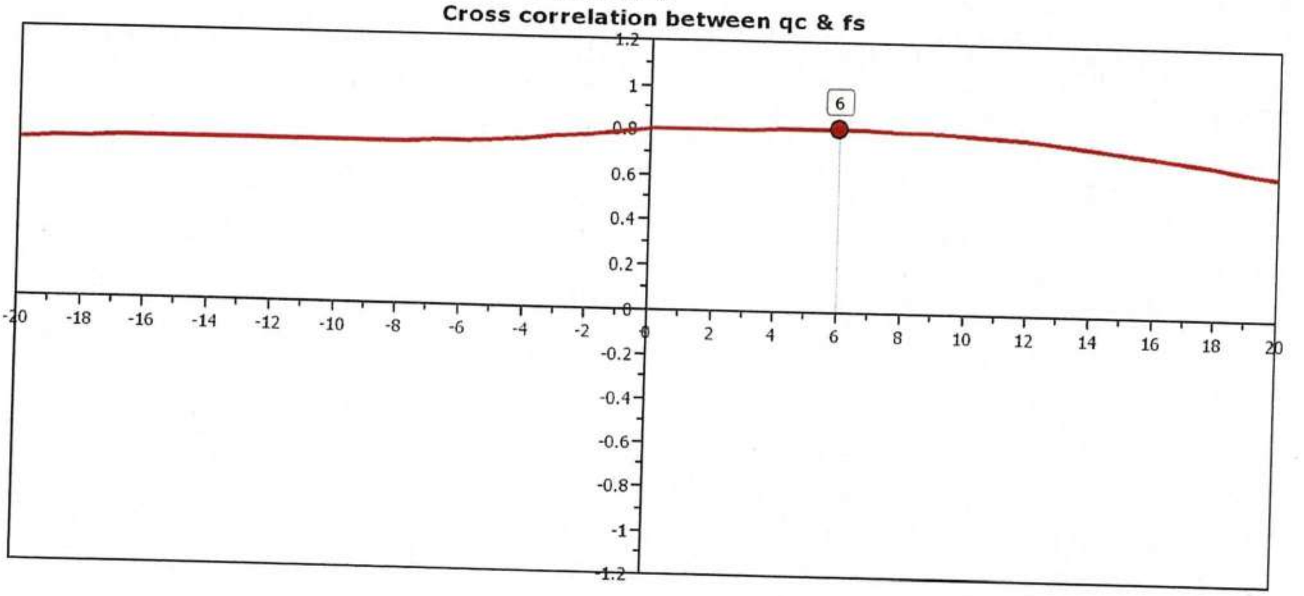
Project:
Location:







The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).

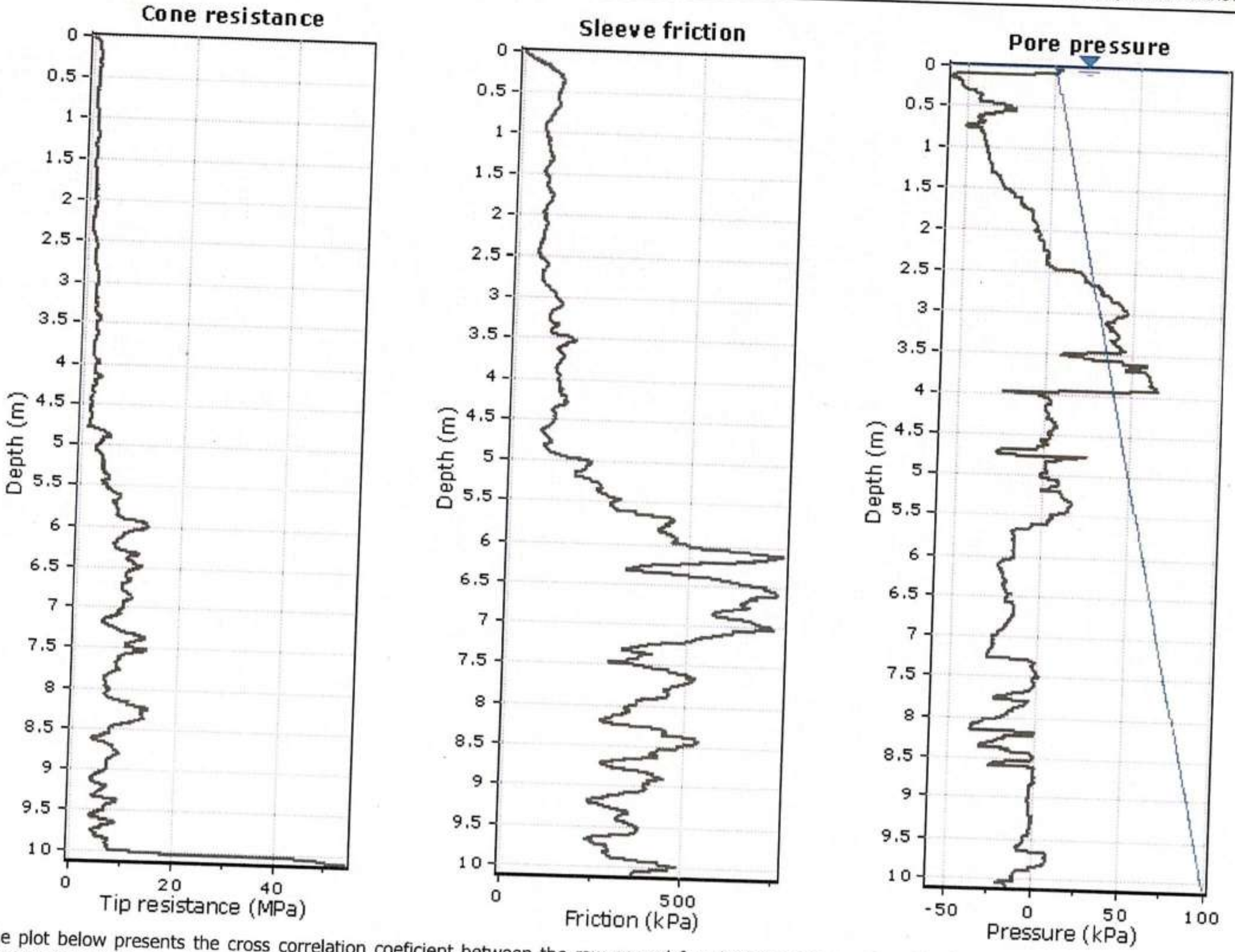


Project:

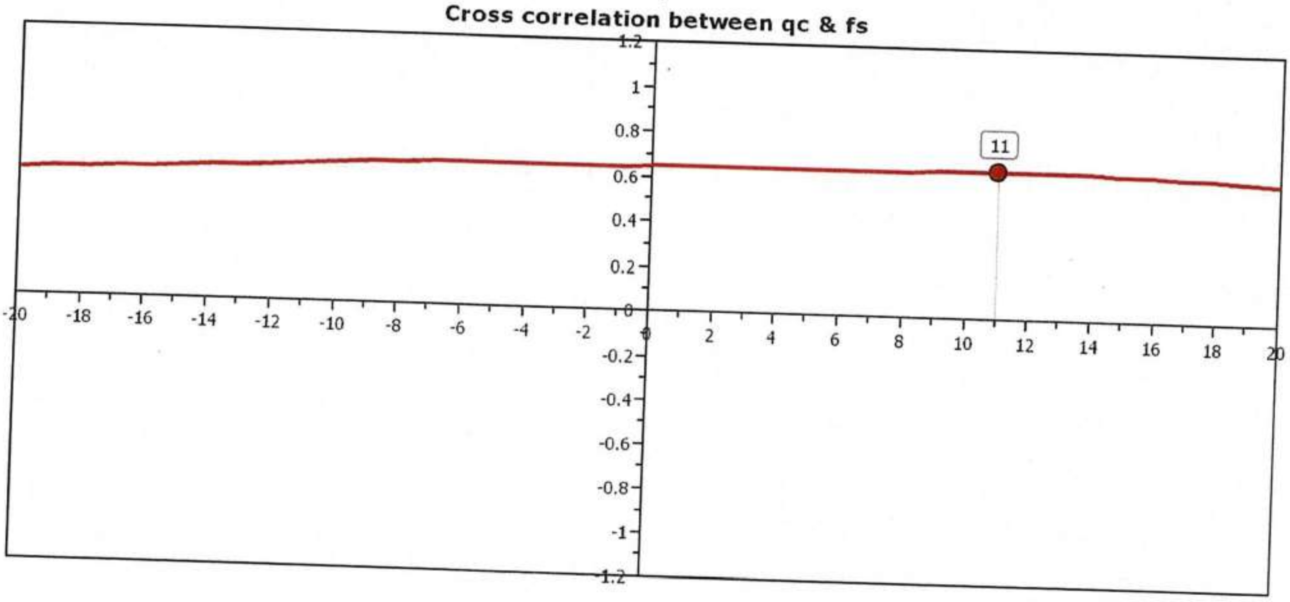
Location:

CPT: CPT4

Total depth: 10.09 m, Date: 9/10/2018
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).

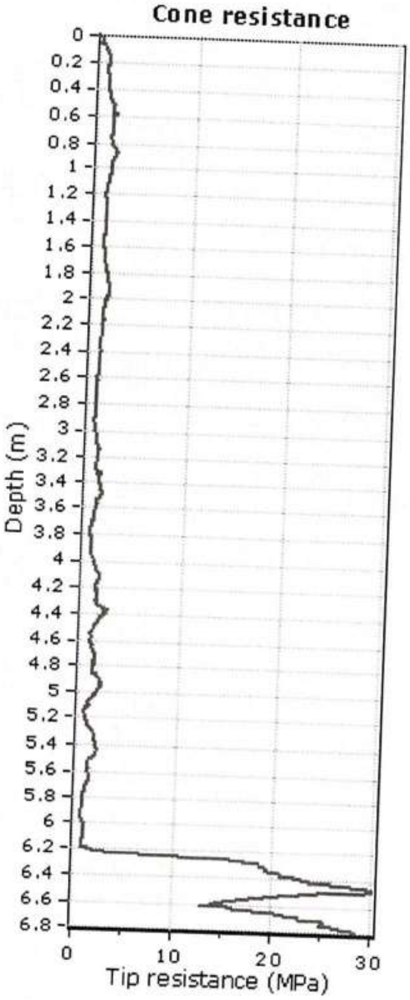


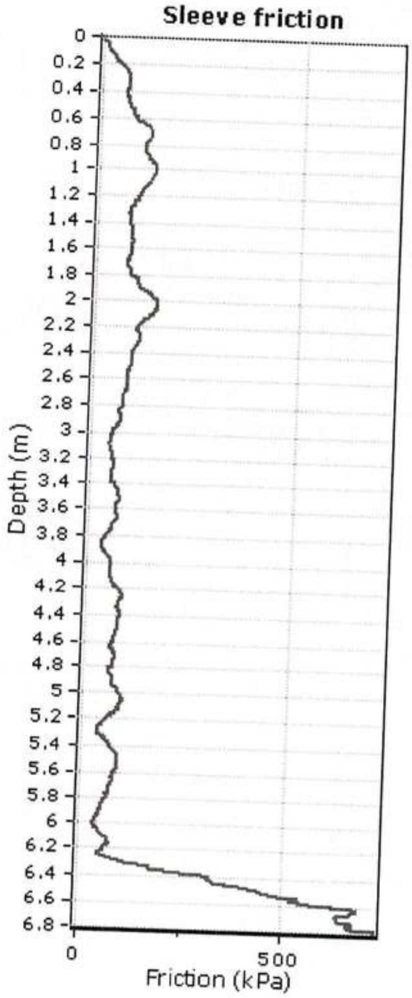
CPT: CPT5

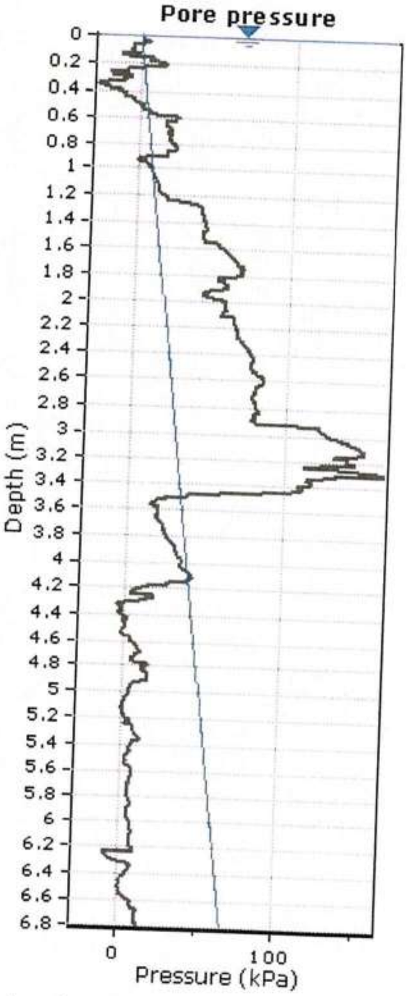
Total depth: 6.79 m, Date: 9/10/2018
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:

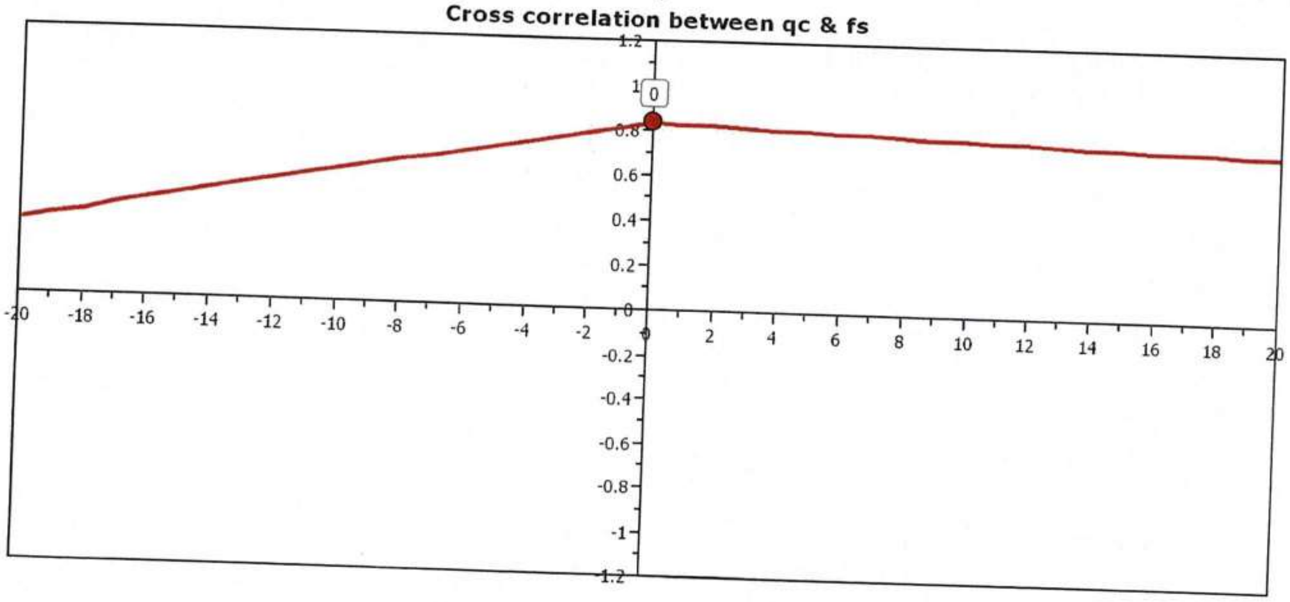
Location:



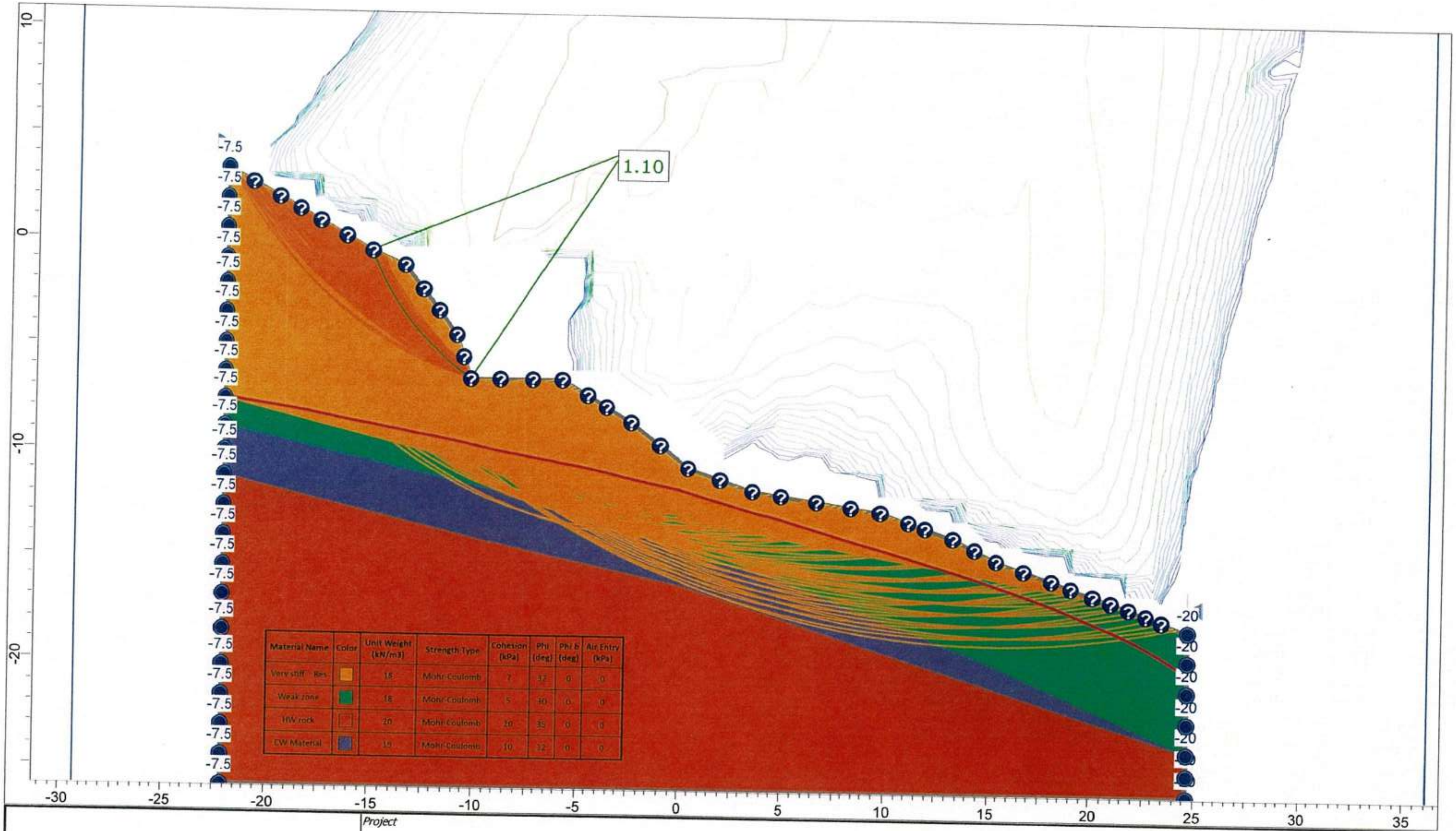




The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



Appendix D – Stability Models

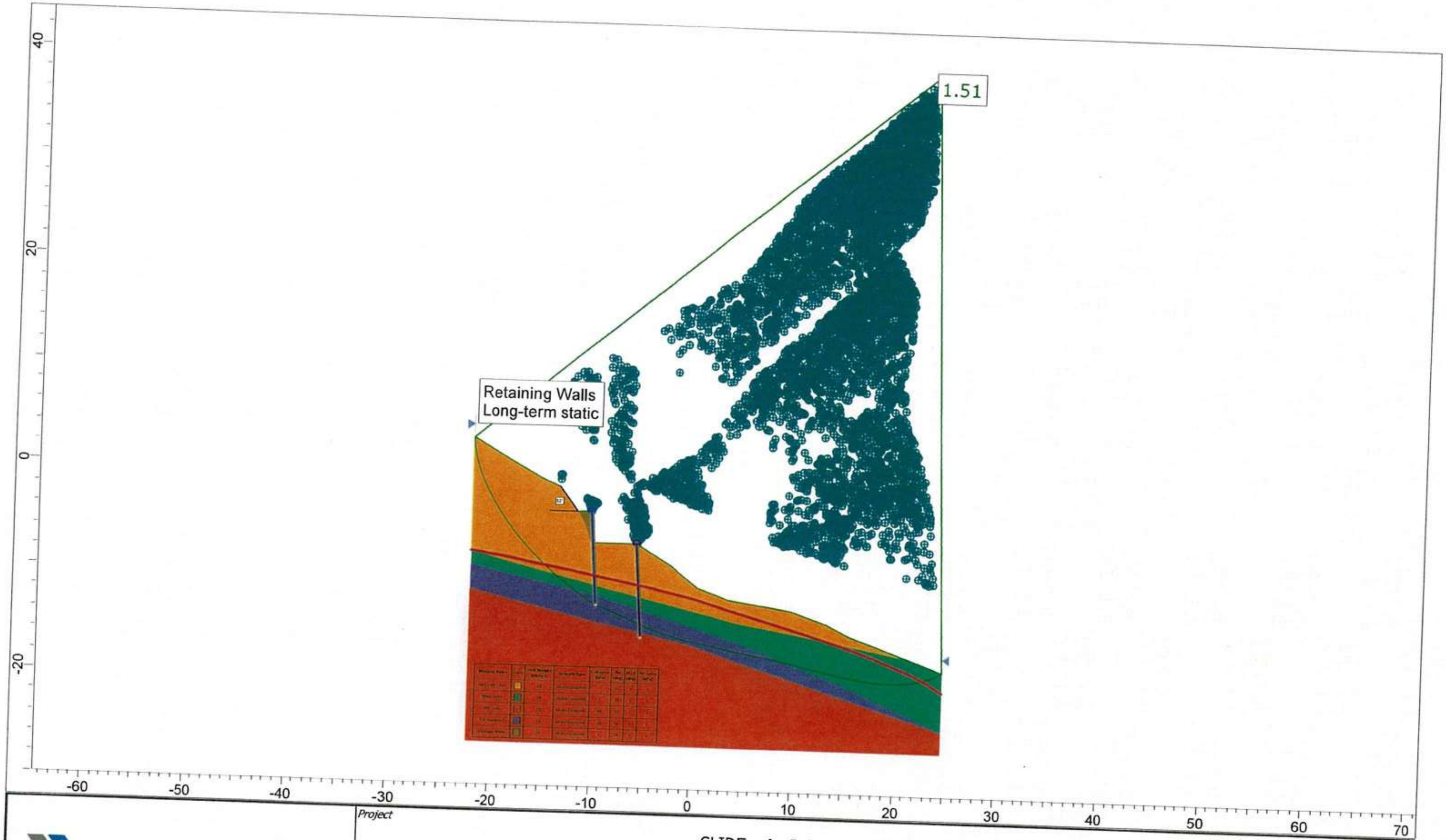


Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Phi b (deg)	Air Entry (kPa)
Very stiff - Res	🟧	18	Mohr-Coulomb	7	32	0	0
Weak zone	🟩	18	Mohr-Coulomb	5	30	0	0
HW rock	🟥	20	Mohr-Coulomb	20	35	0	0
CW Material	🟦	19	Mohr-Coulomb	10	22	0	0

HAIGH WORKMAN LTD
Civil & Structural Engineers

Project	SLIDE - An Interactive Slope Stability Program
Analysis Description	
Drawn By	
Scale	1:250
Company	
Date	27/11/2018, 3:30:27 PM
File Name	Existing.slim

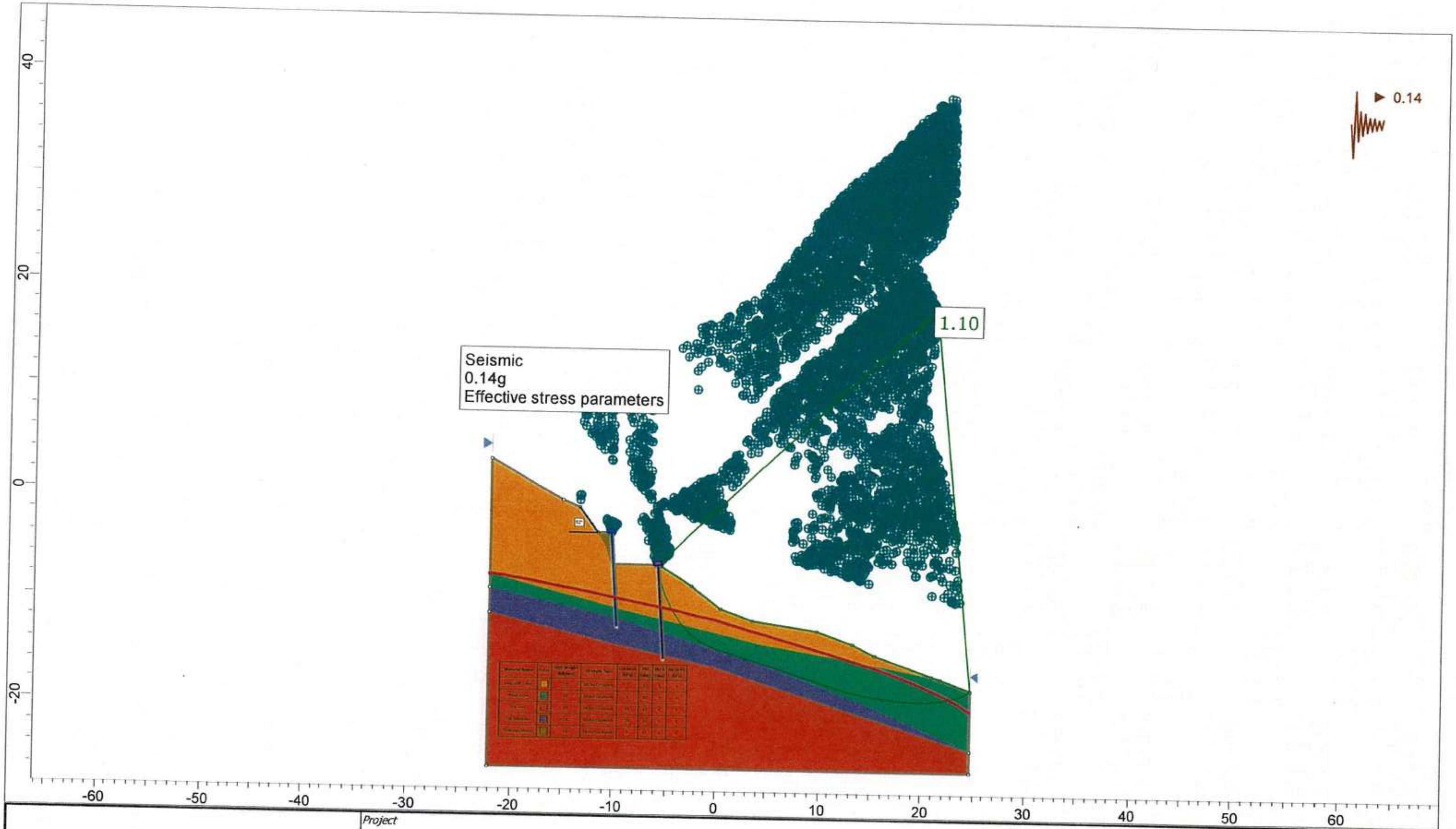
SLIDEINTERPRET 7.036



HAIGH WORKMAN LTD
Civil & Structural Engineers

SLIDEINTERPRET 7.036

Project	SLIDE - An Interactive Slope Stability Program
Analysis Description	
Drawn By	
Scale	1:500
Company	
Date	27/11/2018, 3:30:27 PM
File Name	RW-multiple.slmd



HAIGH WORKMAN LTD
Civil & Structural Engineers

Project: SLIDE - An Interactive Slope Stability Program

Analysis Description

Drawn By

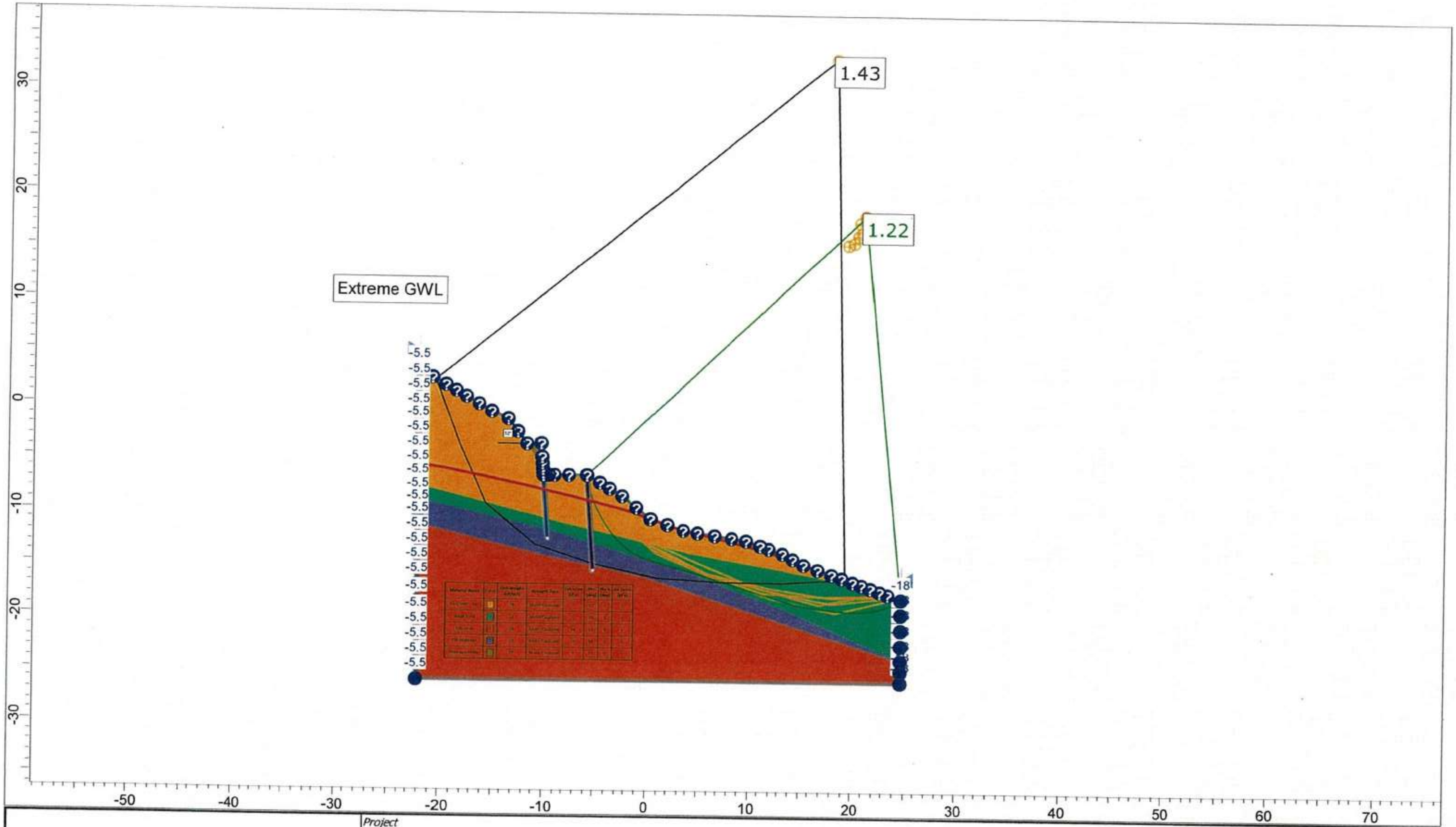
Scale: 1:500

Company

Date: 27/11/2018, 3:30:27 PM

File Name: RW-multiple_seismic.slmd

SLIDEINTERPRET 7.036



HAIGH WORKMAN LTD Civil & Structural Engineers	*Project*	SLIDE - An Interactive Slope Stability Program		
	Analysis Description			
	Drawn By		*Scale* 1:500	*Company*
SLIDEINTERPRET 7.036	*Date*	27/11/2018, 3:30:27 PM	*File Name*	RW-multiple_ext gw.slmd

Appendix E – Retaining Wall Calculations

Project Name:

Flagstaff Hill

Subject:

Input parameters for Wallap

Job No.: 18 260
Doc No.:

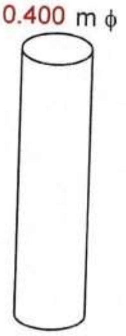
By: Wayne Thorburn
Verified By:

Date:
Date:

Material Properties for Timber Pole

1.21E+07

E =	12.10	GPa	(Young Modulus) [MGS8, NZS3603 Amendement 4, Table 2.3]
	1.21E+07	kPa	
ρ =	450	kg/m^3	(Density)
S =	1	m c/c	(Spacing between piles)
A =	0.126	m^2	(Sectional Area)
I =	1.25664E-03	m^4	(Area Moment of Inertia)
			per pile
EA =	**1.521E+06**	$kN/m = [kN/m^2][m^2]/[m]$	
EI =	**15205.31**	$kNm^2/m = [kN/m^2][m^4]/[m]$	
w =	**0.555**	$kN/m/m = [kg/m^3][m/s^2][m^2]/[m]$	
I	1.257E-03	m^4/m	per unit length of wall
EI	15205.31	$kNm^2/m = [kN/m^2][m^4]/[m]$	per unit length of wall



```
HAIGH WORKMAN
Program: WALLAP  Version 6.06  Revision A50.B69.R53      | Sheet No.
                          Licensed from GEOSOLVE         | Job No.
Data filename/Run ID: Wallap_slide_seismic               | Made by :    WT
Flagstaff Hill                                           |
Retaining Wall Check                                     | Date:13-12-2018
---------------------------------------------------------| Checked :
------------------------------------------------------------------------------

INPUT DATA                                                  Units: kN,m

SOIL PROFILE
Stratum   Elevation of
  no.     top of stratum    ----------------- Soil types ------------------
   1          0.00          Left side                  Right side
   2         -4.00          1  Very Stiff Residual     1  Very Stiff Residual
   3         -5.00          2  Weaker Zone             2  Weaker Zone
   4         -7.50          4  CW Material             4  CW Material
                            3  HW Rock                 3  HW Rock

SOIL PROPERTIES
                     Bulk    Young's   At rest  Consol  Active  Passive
-- Soil type --    density   Modulus    coeff.  state.  limit    limit    Cohesion
No. Description     kN/m3   Eh,kN/m2     Ko     NC/OC    Ka       Kp        kN/m2
   (Datum elev.)            (dEh/dy )  (dKo/dy) ( Nu )  ( Kac ) ( Kpc )  ( dc/dy )
 1  Very Stiff      18.00     25000     0.470    OC     0.259    4.236      7.000d
    Residual                                  (0.350) (1.185) ( 5.179)
 2  Weaker Zone     18.00     15000     0.500    OC     0.284    3.878      5.000d
                                              (0.350) (1.240) ( 4.985)
 3  HW Rock         20.00     70000     0.430    OC     0.229    5.153     50.00d
                                              (0.350) (1.101) ( 5.931)
 4  CW Material     19.00     50000     0.440    OC     0.240    4.858     10.00d
                                              (0.350) (1.127) ( 5.719)

Additional soil parameters associated with Ka and Kp
                          --- parameters for Ka ---   --- parameters for Kp ---
                           Soil     Wall     Back-      Soil     Wall     Back-
------- Soil type -------  friction adhesion fill      friction adhesion fill
No. Description             angle   coeff.   angle     angle    coeff.   angle
 1  Very Stiff Residual     32.00   0.670    0.00      32.00    0.271    0.00
 2  Weaker Zone             30.00   0.660    0.00      30.00    0.302    0.00
 3  HW Rock                 35.00   0.609    0.00      35.00    0.292    0.00
 4  CW Material             34.00   0.612    0.00      34.00    0.294    0.00

GROUND WATER CONDITIONS
 Density of water = 10.00 kN/m3

                                     Left side        Right side
Initial water table elevation         -10.00            -10.00

Automatic water pressure balancing at toe of wall :  No

WALL PROPERTIES

                    Type of structure = Soldier Pile Wall
                  Soldier Pile width =  0.40 m
                Soldier Pile spacing =  1.00 m
         Passive mobilisation factor =  3.00
              Elevation of toe of wall = -5.50
        Maximum finite element length =  0.40 m
             Youngs modulus of wall E = 1.2100E+07 kN/m2
         Moment of inertia of wall I = 1.2570E-03 m4/m run
                                     = 1.2570E-03 m4 per pile
                                 E.I = 15210 kN.m2/m run
               Yield Moment of wall = Not defined
```

HORIZONTAL and MOMENT LOADS/RESTRAINTS

```
Load             Horizontal    Moment       Moment      Partial
 no.  Elevation     load        load       restraint    factor
                  kN/m run   kN.m/m run  kN.m/m/rad   (Category)
  1      3.00      30.00         0            0          N/A
  2      0.00      30.00         0            0          N/A
  3     -3.00      30.00         0            0          N/A
  4      3.00      2.000         0            0          N/A
  5      0.00      2.000         0            0          N/A
  6     -3.00      2.000         0            0          N/A
```

SURCHARGE LOADS

```
Surch          Distance   Length     Width        Surcharge         Equiv. Partial
-arge            from     parallel   perpend. -----  kN/m2  -----   soil   factor/
 no.    Elev.    wall     to wall    to wall  Near edge  Far edge   type   Category
  1     0.00    0.00(L)    30.00       3.20     54.00     91.20     N/A      N/A
  2     0.00    3.40(L)    30.00       6.80     91.20    161.20     N/A      N/A
  3     0.00   -3.90(R)    30.00       9.70      0.00    -96.84     N/A      N/A
  4     0.00  -13.60(R)    30.00      27.70    -96.84   -187.00     N/A      N/A

    Note: L = Left side,  R = Right side
          A trapezoidal surcharge is defined by two values:
          N = at edge near to wall,  F = at edge far from wall
```

CONSTRUCTION STAGES

```
Construction    Stage description
  stage no.     ----------------------------------------------------------
      1         Apply surcharge no.1 at elevation 0.00
      2         Apply surcharge no.2 at elevation 0.00
      3         Apply surcharge no.3 at elevation 0.00
      4         Apply surcharge no.4 at elevation 0.00
      5         Change EI of wall to 15210 kN.m2/m run
                Yield moment not defined
                Reset wall displacements to zero at this stage
      6         Apply load no.1 at elevation 3.00
      7         Apply load no.2 at elevation 0.00
      8         Apply load no.3 at elevation -3.00
      9         Apply load no.4 at elevation 3.00
     10         Apply load no.5 at elevation 0.00
     11         Apply load no.6 at elevation -3.00
```

FACTORS OF SAFETY and ANALYSIS OPTIONS

```
Stability analysis:
 Method of analysis  -  Strength Factor method
 Factor on soil strength for calculating wall depth = 1.50

Parameters for undrained strata:
 Minimum equivalent fluid density              =   5.00 kN/m3
 Maximum depth of water filled tension crack  =   0.00 m

Bending moment and displacement calculation:
 Method  -  2-D finite element model
 Open Tension Crack analysis? - No
 Soil arching modelled?  -    No
 Non-linear Modulus Parameter (L) = 0 m

Boundary conditions:
 Length of wall (normal to plane of analysis) = 52.00 m

 Width of excavation on Left  side of wall  = 20.00 m
 Width of excavation on Right side of wall  = 50.00 m

 Distance to rigid boundary on Left side  = 20.00 m
 Distance to rigid boundary on Right side = 20.00 m
 Elevation of rigid lower boundary = -10.00

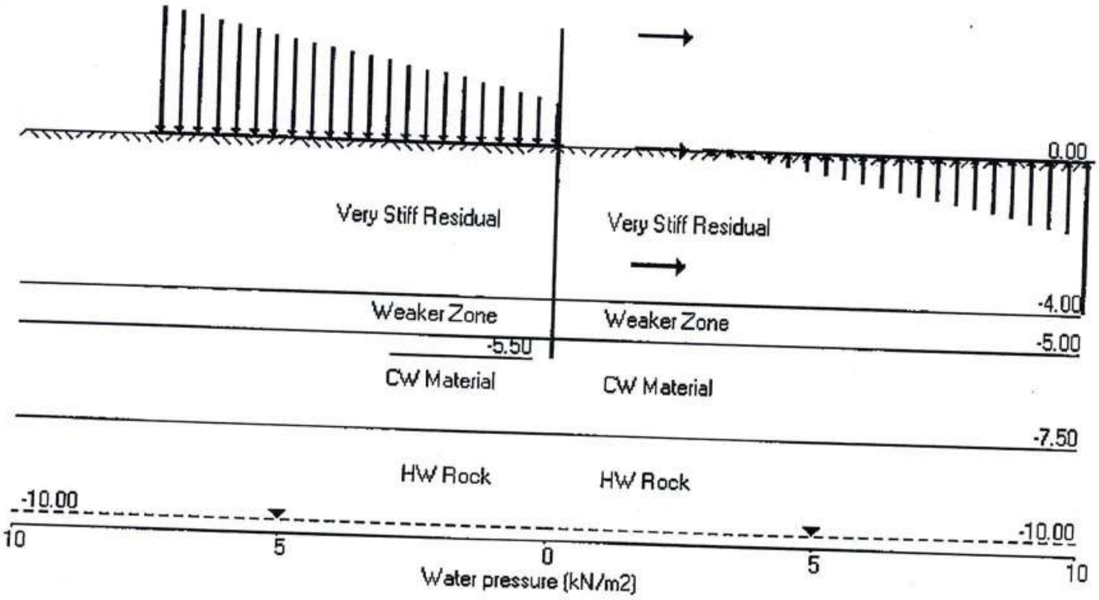
 Lower rigid boundary at elevation -10.00 - Smooth
 Rigid boundary on Left side              - Smooth
 Rigid boundary on Right side             - Smooth
 Wall / soil interface                     - Rough
```

```
OUTPUT OPTIONS

 Stage ------ Stage description ----------- ------- Output options -------
  no.                                       Displacement  Active,  Graph.
                                            Bending mom.  Passive  output
                                            Shear force  pressures
   1 Apply surcharge no.1 at elev. 0.00         No          No       No
   2 Apply surcharge no.2 at elev. 0.00         No          No       No
   3 Apply surcharge no.3 at elev. 0.00         No          No       No
   4 Apply surcharge no.4 at elev. 0.00         No          No       No
   5 Change EI of wall to 15210kN.m2/m run      No          No       No
   6 Apply load no.1 at elev. 3.00              No          No       No
   7 Apply load no.2 at elev. 0.00              No          No       No
   8 Apply load no.3 at elev. -3.00             No          No       No
   9 Apply load no.4 at elev. 3.00              No          No       No
  10 Apply load no.5 at elev. 0.00              No          No       No
  11 Apply load no.6 at elev. -3.00             No          No       No
   * Summary output                             Yes         -        Yes
```

Units: kN,m

Stage No.11 Apply load no.6 at elev. -3.00



```
Stage No. 11   Apply load no.6 at elevation -3.00               Units: kN,m

STABILITY ANALYSIS of Soldier Pile Wall according to Strength Factor method
 Factor of safety on soil strength

                                       FoS for toe       Toe elev. for
                                       elev. =   -5.50    FoS = 1.500
                                       ---------------   -------------
Stage  --- G.L. ---   Strut   Factor  Moment     Toe    Wall      Direction
 No.   Act.   Pass.   Elev.     of    equilib.   elev.  Penetr       of
                               Safety  at elev.          -ation     failure
 11    0.00   0.00    Cant.    1.849    -5.01    -4.31   4.31       L to R

BENDING MOMENT and DISPLACEMENT ANALYSIS of Soldier Pile Wall
 Analysis options
 Soldier Pile width = 0.40m;   spacing = 1.00m
 Passive mobilisation factor = 3.000
 Length of wall perpendicular to section = 52.00m
 2-D finite element model.    Soil arching not modelled.
 Soil deformations are elastic until the active or passive limit is reached

 Rigid boundaries:         Left side 20.00 from wall         Smooth boundary
                          Right side 20.00 from wall         Smooth boundary
 Lower rigid boundary at elevation -10.00                    Smooth boundary

   *** Wall displacements reset to zero at stage 5

Node    Y      Nett       Wall      Wall       Shear    Bending    Strut
 no.  coord  pressure     disp.   rotation     force    moment     forces
                kN/m2       m        rad.       kN/m    kN.m/m      kN/m
  1    3.00      0.00     0.163   3.59E-02      32.0      -0.0     -32.0
  2    2.70      0.00     0.153   3.58E-02      32.0       9.6
  3    2.40      0.00     0.142   3.55E-02      32.0      19.2
  4    2.00      0.00     0.128   3.48E-02      32.0      32.0
  5    1.60      0.00     0.114   3.38E-02      32.0      44.8
  6    1.20      0.00     0.101   3.25E-02      32.0      57.6
  7    0.80      0.00     0.088   3.08E-02      32.0      70.4
  8    0.40      0.00     0.076   2.88E-02      32.0      83.2
  9    0.00      0.00     0.065   2.64E-02      32.0      96.0     -32.0
               -30.48     0.065   2.64E-02      64.0      96.0
 10   -0.40    -58.37     0.055   2.35E-02      46.2     119.2
 11   -0.80    -86.03     0.046   2.02E-02      17.4     133.1
 12   -1.20    -97.06     0.039   1.66E-02     -19.3     133.2
 13   -1.60    -48.67     0.033   1.32E-02     -48.4     117.7
 14   -2.00    -16.90     0.028   1.04E-02     -61.5      94.5
 15   -2.40      3.50     0.024   8.16E-03     -64.2      68.6
 16   -2.70      9.53     0.022   6.91E-03     -62.3      49.5
 17   -3.00     10.44     0.020   6.02E-03     -59.3      31.3     -32.0
                10.44     0.020   6.02E-03     -27.3      31.3
 18   -3.30     12.44     0.019   5.38E-03     -23.8      23.6
 19   -3.60     18.24     0.017   4.86E-03     -19.2      17.0
 20   -4.00     31.11     0.015   4.31E-03      -9.4      10.8
                35.79     0.015   4.31E-03      -9.4      10.8
 21   -4.40     10.51     0.014   3.86E-03      -0.1       9.9
 22   -4.70     -2.84     0.012   3.55E-03       1.1      10.4
 23   -5.00    -23.75     0.011   3.29E-03      -2.9      10.6
              -122.18     0.011   3.29E-03      -2.9      10.6
 24   -5.25    -23.96     0.011   3.15E-03     -21.2       6.0
 25   -5.50    138.26     0.010   3.11E-03      -6.9      -0.0
```

```
Stage No.11  Apply load no.6 at elevation -3.00                          (continued)

 Node     Y       Nett         Wall        Wall       Shear    Bending    Strut
  no.   coord   pressure       disp.     rotation     force    moment     forces
                  kN/m2          m         rad.        kN/m    kN.m/m     kN/m
  26    -5.60    -0.49         0.010           0       -0.0       0.0
  27    -6.55     0.09         0.009           0       -0.2       0.0
  28    -7.50     9.19         0.008           0        4.2       0.0
                 -6.95         0.008           0        4.2       0.0
  29    -8.75     0.11         0.008           0       -0.1       0.0
  30   -10.00     0.02         0.008           0        0.0       0.0

 Node     Y      ------------------------ LEFT side -------------------------------
  no.   coord            ------- Effective stresses -------
                 Water    Vertic   Active   Passive              Total     Adjusted
                 press.    -al     limit     limit     Earth     earth       soil
                 kN/m2    kN/m2    kN/m2     kN/m2   pressure   pressure   modulus
                                                       kN/m2      kN/m2     kN/m2
   1     3.00     0.00     0.00     0.00      0.00      0.00       0.00       0.0
   2     2.70     0.00     0.00     0.00      0.00      0.00       0.00       0.0
   3     2.40     0.00     0.00     0.00      0.00      0.00       0.00       0.0
   4     2.00     0.00     0.00     0.00      0.00      0.00       0.00       0.0
   5     1.60     0.00     0.00     0.00      0.00      0.00       0.00       0.0
   6     1.20     0.00     0.00     0.00      0.00      0.00       0.00       0.0
   7     0.80     0.00     0.00     0.00      0.00      0.00       0.00       0.0
   8     0.40     0.00     0.00     0.00      0.00      0.00       0.00       0.0
   9     0.00     0.00     0.00     0.00      0.00      0.00       0.00       0.0
                  0.00    54.00     5.72    264.99      5.74       5.74       0.0
  10    -0.40     0.00    64.14     8.35    307.93      8.35       5.74     24930
  11    -0.80     0.00    74.16    10.95    350.38     10.95       8.35a    24930
  12    -1.20     0.00    83.98    13.50    391.98     13.50      10.95a    24930
  13    -1.60     0.00    93.57    15.98    432.60     15.98      13.50a    24930
  14    -2.00     0.00   102.93    18.41    472.26     26.26      15.98a    24930
  15    -2.40     0.00   112.09    20.79    511.05     40.23      26.26     24930
  16    -2.70     0.00   118.83    22.54    539.62     46.01      40.23     24930
  17    -3.00     0.00   125.47    24.26    567.74     49.19      46.01     24930
  18    -3.30     0.00   132.01    25.96    595.43     52.87      49.19     24930
  19    -3.60     0.00   138.44    27.63    622.68     58.41      52.87     24930
  20    -4.00     0.00   146.85    29.81    658.32     68.29      58.41     24930
                  0.00   146.85    35.48    594.42     72.79      68.29     24930
  21    -4.40     0.00   155.08    37.81    626.31     63.75      72.79     14958
  22    -4.70     0.00   161.11    39.52    649.72     59.72      63.75     14958
  23    -5.00     0.00   167.04    41.21    672.71     51.89      59.72     14958
                  0.00   167.04    28.79    868.61     28.79      51.89     14958
  24    -5.25     0.00   172.15    30.01    893.41     48.38      28.79a    49860
  25    -5.50     0.00   177.18    31.22    917.85    148.75      48.38     49860
  26    -5.60     0.00   179.17    31.70    927.52     62.86     148.75     49860
  27    -6.55     0.00   197.52    36.10   1016.66     70.43      62.86     49860
  28    -7.50     0.00   214.94    40.28   1101.28     82.02      70.43     49860
                  0.00   214.94     0.00   1404.18     72.58      82.02     49860
  29    -8.75     0.00   237.97     0.00   1522.85     85.42      72.58     69804
  30   -10.00     0.00   260.06     4.62   1636.68     94.52      85.42     69804
                                                                  94.52     69804

 Node     Y      ------------------------ RIGHT side ------------------------------
  no.   coord            ------- Effective stresses -------
                 Water    Vertic   Active   Passive              Total     Adjusted
                 press.    -al     limit     limit     Earth     earth       soil
                 kN/m2    kN/m2    kN/m2     kN/m2   pressure   pressure   modulus
                                                       kN/m2      kN/m2     kN/m2
   1     3.00     0.00     0.00     0.00      0.00      0.00       0.00       0.0
   2     2.70     0.00     0.00     0.00      0.00      0.00       0.00       0.0
   3     2.40     0.00     0.00     0.00      0.00      0.00       0.00       0.0
   4     2.00     0.00     0.00     0.00      0.00      0.00       0.00       0.0
                                                                   0.00       0.0
```

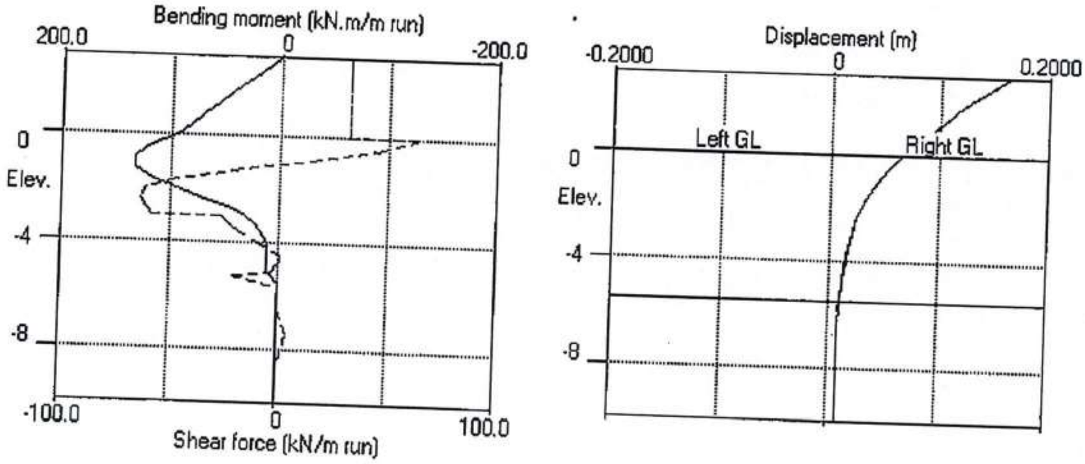
```
Stage No.11  Apply load no.6 at elevation -3.00                     (continued)

Node     Y      ----------------------- RIGHT side -----------------------------
 no.   coord              ------- Effective stresses -------
                Water   Vertic  Active   Passive    Earth      Total    Adjusted
                press.    -al   limit     limit    pressure    earth      soil
                kN/m2   kN/m2   kN/m2     kN/m2     kN/m2    pressure   modulus
                                                              kN/m2      kN/m2
  5     1.60     0.00    0.00    0.00      0.00      0.00      0.00        0.0
  6     1.20     0.00    0.00    0.00      0.00      0.00      0.00        0.0
  7     0.80     0.00    0.00    0.00      0.00      0.00      0.00        0.0
  8     0.40     0.00    0.00    0.00      0.00      0.00      0.00        0.0
  9     0.00     0.00    0.00    0.00      0.00      0.00      0.00        0.0
                 0.00    0.00    0.00     36.25     36.22     36.22      24930
 10    -0.40     0.00    7.19    0.00     66.71     66.71     66.71p     24930
 11    -0.80     0.00   14.34    0.00     96.98     96.98     96.98p     24930
 12    -1.20     0.00   21.40    0.00    126.88    110.56    110.56      24930
 13    -1.60     0.00   28.34    0.00    156.29     64.65     64.65      24930
 14    -2.00     0.00   35.15    0.82    185.13     43.16     43.16      24930
 15    -2.40     0.00   41.82    2.56    213.41     36.73     36.73      24930
 16    -2.70     0.00   46.74    3.83    234.24     36.49     36.49      24930
 17    -3.00     0.00   51.59    5.09    254.79     38.76     38.76      24930
 18    -3.30     0.00   56.38    6.33    275.06     40.43     40.43      24930
 19    -3.60     0.00   61.11    7.56    295.10     40.17     40.17      24930
 20    -4.00     0.00   67.34    9.18    321.49     37.18     37.18      24930
                 0.00   67.34   12.91    286.06     37.00     37.00      14958
 21    -4.40     0.00   73.50   14.66    309.95     53.24     53.24      14958
 22    -4.70     0.00   78.09   15.96    327.74     62.57     62.57      14958
 23    -5.00     0.00   82.65   17.25    345.43     75.64     75.64      14958
                 0.00   82.65    8.55    458.65    150.97    150.97      49860
 24    -5.25     0.00   86.69    9.52    478.27     72.33     72.33      49860
 25    -5.50     0.00   90.71   10.48    497.84     10.48     10.48a     49860
 26    -5.60     0.00   92.32   10.87    505.66     63.36     63.36      49860
 27    -6.55     0.00  107.60   14.53    579.86     70.34     70.34      49860
 28    -7.50     0.00  122.93   18.21    654.32     72.83     72.83      49860
                 0.00  122.93    0.00    930.02     79.53     79.53      69804
 29    -8.75     0.00  144.55    0.00   1041.46     85.31     85.31      69804
 30   -10.00     0.00  166.51    0.00   1154.61     94.50     94.50      69804

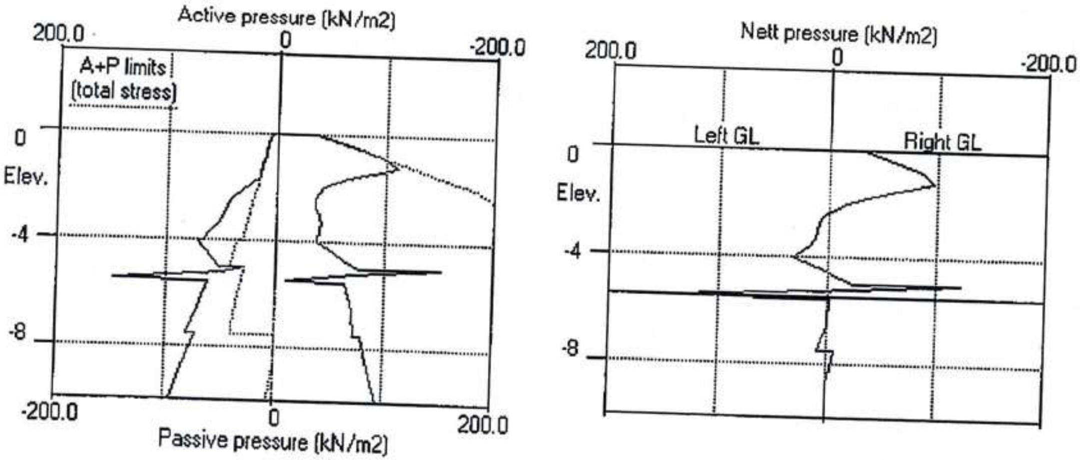
Note:      10.48a  Soil pressure at active limit
           96.98p  Soil pressure at passive limit
```

```
HAIGH WORKMAN
Program: WALLAP  Version 6.06  Revision A50.B69.R53        | Sheet No.
                           Licensed from GEOSOLVE          | Job No.
Data filename/Run ID: Wallap_slide_seismic                 | Made by :    WT
Flagstaff Hill                                             |
Retaining Wall Check                                       | Date:13-12-2018
-----------------------------------------------------------| Checked :
---------------------------------------------------------------------------
                                                Units: kN,m
```

Stage No.11 Apply load no.6 at elev. -3.00



Stage No.11 Apply load no.6 at elev. -3.00



```
HAIGH WORKMAN
Program: WALLAP  Version 6.06  Revision A50.B69.R53          | Sheet No.
                             Licensed from GEOSOLVE          | Job No.
Data filename/Run ID: Wallap_slide_seismic                   | Made by :     WT
Flagstaff Hill                                               |
Retaining Wall Check                                         | Date:13-12-2018
-------------------------------------------------------------| Checked :
------------------------------------------------------------------------------

Summary of results                                          Units: kN,m

STABILITY ANALYSIS of Soldier Pile Wall according to Strength Factor method
 Factor of safety on soil strength

                                        FoS for toe        Toe elev. for
                                        elev. =   -5.50     FoS = 1.500
                                        ---------------    -------------
Stage  --- G.L. ---    Strut    Factor  Moment        Toe    Wall      Direction
 No.    Act.   Pass.   Elev.      of    equilib.     elev.  Penetr        of
                                Safety  at elev.             -ation     failure
  1     0.00   0.00    Cant.   Conditions not suitable for FoS calc.
  2     0.00   0.00    Cant.   Conditions not suitable for FoS calc.
  3     0.00   0.00    Cant.   Conditions not suitable for FoS calc.
  4     0.00   0.00    Cant.   Conditions not suitable for FoS calc.
  5     0.00   0.00            No analysis at this stage
  6     0.00   0.00    Cant.    2.300    -5.07       -3.40    3.40       L to R
  7     0.00   0.00    Cant.    1.986    -5.01       -4.09    4.09       L to R
  8     0.00   0.00    Cant.    1.896    -5.02       -4.15    4.15       L to R
  9     0.00   0.00    Cant.    1.869    -5.02       -4.25    4.25       L to R
 10     0.00   0.00    Cant.    1.854    -5.01       -4.30    4.30       L to R
 11     0.00   0.00    Cant.    1.849    -5.01       -4.31    4.31       L to R
```

```
HAIGH WORKMAN
Program: WALLAP  Version 6.06  Revision A50.B69.R53          | Sheet No.
                               Licensed from GEOSOLVE        | Job No.
Data filename/Run ID: Wallap_slide_seismic                   | Made by :      WT
Flagstaff Hill                                               |
Retaining Wall Check                                         | Date:13-12-2018
-------------------------------------------------------------| Checked :
---------------------------------------------------------------------------------
```

```
Summary of results                                           Units: kN,m

BENDING MOMENT and DISPLACEMENT ANALYSIS of Soldier Pile Wall
  Analysis options
  Soldier Pile width = 0.40m;  spacing = 1.00m
  Passive mobilisation factor = 3.000
  Length of wall perpendicular to section = 52.00m
  2-D finite element model.   Soil arching not modelled.
  Soil deformations are elastic until the active or passive limit is reached

  Rigid boundaries:        Left side 20.00 from wall          Smooth boundary
                          Right side 20.00 from wall          Smooth boundary
  Lower rigid boundary at elevation -10.00                     Smooth boundary

Bending moment, shear force and displacement envelopes
Node    Y       Displacement          Bending moment          Shear force
 no.  coord   maximum  minimum     maximum   minimum      maximum   minimum
                 m        m        kN.m/m    kN.m/m        kN/m      kN/m
  1    3.00    0.163    0.000         0.0      -0.0         32.0       0.0
  2    2.70    0.153    0.000         9.6       0.0         32.0       0.0
  3    2.40    0.142    0.000        19.2       0.0         32.0       0.0
  4    2.00    0.128    0.000        32.0       0.0         32.0       0.0
  5    1.60    0.114    0.000        44.8       0.0         32.0       0.0
  6    1.20    0.101    0.000        57.6       0.0         32.0       0.0
  7    0.80    0.088    0.000        70.4       0.0         32.0       0.0
  8    0.40    0.076    0.000        83.2       0.0         32.0       0.0
  9    0.00    0.065    0.000        96.0       0.0         32.0       0.0
 10   -0.40    0.055    0.000       119.2      -1.4         64.0       0.0
 11   -0.80    0.046    0.000       133.1      -2.6         46.2      -3.4
 12   -1.20    0.039    0.000       133.2      -3.4         17.4     -15.4
 13   -1.60    0.033    0.000       117.7      -3.8          0.0     -38.8
 14   -2.00    0.028    0.000        94.6      -3.9          0.0     -48.5
 15   -2.40    0.024    0.000        68.8      -4.0          0.0     -61.5
 16   -2.70    0.022    0.000        49.8      -4.4          0.0     -64.2
 17   -3.00    0.020    0.000        36.3      -4.9          0.0     -62.3
 18   -3.30    0.019    0.000        25.7      -5.6          0.0     -59.3
 19   -3.60    0.017    0.000        17.4      -6.4          0.0     -31.6
 20   -4.00    0.015    0.000        10.9      -7.4          0.0     -23.9
 21   -4.40    0.014    0.000         9.9      -6.5          0.5     -12.0
 22   -4.70    0.012    0.000        10.4      -4.3          5.3      -1.7
 23   -5.00    0.011    0.000        10.6      -0.9          9.4       0.0
 24   -5.25    0.011    0.000         6.0       0.0         12.9      -2.9
 25   -5.50    0.010    0.000         0.0      -0.0          1.7     -21.2
 26   -5.60    0.010    0.000         0.0       0.0          0.0      -6.9
 27   -6.55    0.009    0.000         0.0       0.0          0.0      -0.0
 28   -7.50    0.008    0.000         0.0       0.0          0.4      -0.2
 29   -8.75    0.008    0.000         0.0       0.0          4.2       0.0
 30  -10.00    0.008    0.000         0.0       0.0          0.4      -0.1
                                                               0.0       0.0
```

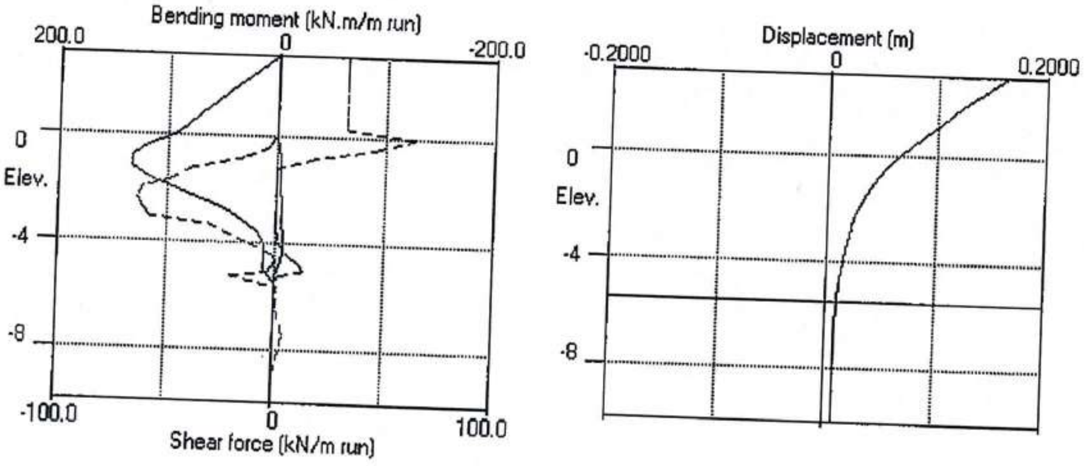
```
-------------------------------------------------------------------------------
Summary of results    (continued)

Maximum and minimum bending moment and shear force at each stage
Stage  --------- Bending moment --------    ---------- Shear force ----------
 no.   maximum   elev.   minimum   elev.    maximum   elev.   minimum   elev.
       kN.m/m            kN.m/m              kN/m              kN/m
  1       0.8   -5.25     -4.8    -4.00        7.9   -5.00      -3.4   -0.40
  2       0.4   -5.25     -7.1    -4.00       12.2   -5.00      -3.1   -0.40
  3       0.3   -5.25     -7.4    -4.00       12.8   -5.00      -3.1   -0.40
  4       0.3   -5.25     -7.4    -4.00       12.9   -5.00      -3.0   -0.40
  5    No calculation at this stage
  6      99.9   -0.80     -0.0     3.00       30.0    3.00     -46.5   -1.60
  7     123.9   -0.80     -0.0     3.00       60.0    0.00     -54.4   -2.00
  8     124.0   -0.80     -0.0     3.00       60.0    0.00     -59.3   -2.40
  9     131.5   -0.80     -0.0     3.00       62.0    0.00     -62.7   -2.40
 10     133.2   -1.20     -0.0     3.00       64.0    0.00     -63.7   -2.40
 11     133.2   -1.20     -0.0     3.00       64.0    0.00     -64.2   -2.40

Maximum and minimum displacement at each stage
Stage -------- Displacement ---------    Stage description
 no.  maximum  elev.   minimum  elev.    -----------------
         m                m
  1    0.007   -1.60   0.000    3.00    Apply surcharge no.1 at elev. 0.00
  2    0.009   -3.00   0.000    3.00    Apply surcharge no.2 at elev. 0.00
  3    0.010   -3.00   0.000    3.00    Apply surcharge no.3 at elev. 0.00
  4    0.010   -3.30   0.000    3.00    Apply surcharge no.4 at elev. 0.00
  5    Wall displacements reset to zero Change EI of wall to 15210kN.m2/m run
  6    0.098    3.00   0.000    3.00    Apply load no.1 at elev. 3.00
  7    0.148    3.00   0.000    3.00    Apply load no.2 at elev. 0.00
  8    0.148    3.00   0.000    3.00    Apply load no.3 at elev. -3.00
  9    0.160    3.00   0.000    3.00    Apply load no.4 at elev. 3.00
 10    0.163    3.00   0.000    3.00    Apply load no.5 at elev. 0.00
 11    0.163    3.00   0.000    3.00    Apply load no.6 at elev. -3.00
```

```
HAIGH WORKMAN
Program: WALLAP  Version 6.06  Revision A50.B69.R53          | Sheet No.
                                  Licensed from GEOSOLVE    | Job No.
Data filename/Run ID: Wallap_slide_seismic                  | Made by :    WT
Flagstaff Hill                                              |
Retaining Wall Check                                        | Date:13-12-2018
----------------------------------------------------------- | Checked :
------------------------------------------------------------------------------
                                                            Units: kN,m
```

Bending moment, shear force, displacement envelopes



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HAIGH WORKMAN
Program: WALLAP  Version 6.06  Revision A50.B69.R53          | Sheet No.
                            Licensed from GEOSOLVE           | Job No.
Data filename/Run ID: Wallap_slide_check_DS_seis             | Made by :    WT
Flagstaff Hill                                               |
Retaining Wall Check                                         | Date:13-12-2018
-------------------------------------------------------------| Checked :
--------------------------------------------------------------------------------

INPUT DATA                                                   Units: kN,m

SOIL PROFILE
Stratum    Elevation of       ------------------ Soil types ------------------
  no.      top of stratum      Left side                   Right side
   1           0.00           1  Very Stiff Residual     1  Very Stiff Residual
   2          -4.00           2  Weaker Zone             2  Weaker Zone
   3          -5.00           2  Weaker Zone             2  Weaker Zone
   4          -7.50           3  HW Rock                 3  HW Rock

SOIL PROPERTIES
                     Bulk     Young's   At rest  Consol   Active   Passive
-- Soil type --    density   Modulus    coeff.  state.   limit     limit    Cohesion
No. Description     kN/m3   Eh,kN/m2     Ko     NC/OC     Ka        Kp       kN/m2
   (Datum elev.)            (dEh/dy )  (dKo/dy) (  Nu ) ( Kac ) (  Kpc )  ( dc/dy )
 1  Very Stiff      18.00     25000     0.470     OC     0.259     4.236
    Residual                                                                 7.000d
                                                (0.350) (1.185) ( 5.179)
 2  Weaker Zone     18.00     15000     0.500     OC     0.284     3.878
                                                                             5.000d
                                                (0.350) (1.240) ( 4.985)
 3  HW Rock         20.00     70000     0.430     OC     0.229     5.153
                                                                             50.00d
                                                (0.350) (1.101) ( 5.931)
 4  CW Material     19.00     50000     0.440     OC     0.240     4.858
                                                                             10.00d
                                                (0.350) (1.127) ( 5.719)

Additional soil parameters associated with Ka and Kp
                                  --- parameters for Ka ---  --- parameters for Kp ---
                                   Soil     Wall    Back-     Soil     Wall    Back-
------- Soil type -------        friction adhesion  fill    friction adhesion  fill
No. Description                   angle    coeff.   angle    angle    coeff.   angle
 1  Very Stiff Residual           32.00    0.670    0.00     32.00    0.271    0.00
 2  Weaker Zone                   30.00    0.660    0.00     30.00    0.302    0.00
 3  HW Rock                       35.00    0.609    0.00     35.00    0.292    0.00
 4  CW Material                   34.00    0.612    0.00     34.00    0.294    0.00

GROUND WATER CONDITIONS
 Density of water = 10.00 kN/m3
                                         Left side      Right side
 Initial water table elevation             -3.00          -3.00

Automatic water pressure balancing at toe of wall : Yes

WALL PROPERTIES

                        Type of structure = Soldier Pile Wall
                      Soldier Pile width =  0.30 m
                    Soldier Pile spacing =  1.00 m
             Passive mobilisation factor =  3.00
                   Elevation of toe of wall = -9.00
            Maximum finite element length =  0.50 m
                  Youngs modulus of wall E = 1.2100E+07 kN/m2
              Moment of inertia of wall I = 1.2570E-03 m4/m run
                                          = 1.2570E-03 m4 per pile
                                      E.I = 15210 kN.m2/m run
                     Yield Moment of wall = Not defined
```

```
HORIZONTAL and MOMENT LOADS/RESTRAINTS
 Load            Horizontal     Moment
  no.  Elevation    load         load      Moment      Partial
                  kN/m run   kN.m/m run  restraint    factor
                                         kN.m/m/rad  (Category)
  1      -1.00     22.50         0           0          N/A
  2      -3.00     22.50         0           0          N/A
  3      -5.00     22.50         0           0          N/A
  4      -7.00     22.50         0           0          N/A
  5      -1.00     1.500         0           0          N/A
  6      -3.00     1.500         0           0          N/A
  7      -5.00     1.500         0           0          N/A
  8      -7.00     1.500         0           0          N/A

SURCHARGE LOADS
Surch          Distance  Length     Width                           Equiv. Partial
-arge            from    parallel  perpend. ----- Surcharge -----   soil   factor/
 no.   Elev.     wall    to wall   to wall  ----- kN/m2    -----    type   Category
                                            Near edge   Far edge
  1     0.00   0.00(L)    30.00      4.00     10.00        =        N/A      N/A
  2     0.00   3.40(L)    30.00      6.80     91.20     161.20      N/A      N/A
  3    -2.00  -1.00(R)    30.00      6.00      0.00     -96.84      N/A      N/A
  4    -2.00  -7.00(R)    30.00     23.70    -96.84    -187.00      N/A      N/A

    Note: L = Left side,  R = Right side
          A trapezoidal surcharge is defined by two values:
          N = at edge near to wall,  F = at edge far from wall

CONSTRUCTION STAGES
Construction    Stage description
  stage no.     -----------------------------------------------------
     1          Apply surcharge no.3 at elevation -2.00
     2          Apply surcharge no.4 at elevation -2.00
     3          Change EI of wall to 15210 kN.m2/m run
                Yield moment not defined
                Reset wall displacements to zero at this stage
     4          Excavate to elevation -2.00 on RIGHT side
     5          Apply load no.1 at elevation -1.00
     6          Apply load no.2 at elevation -3.00
     7          Apply load no.3 at elevation -5.00
     8          Apply load no.4 at elevation -7.00
     9          Apply surcharge no.1 at elevation 0.00
    10          Apply load no.5 at elevation -1.00
    11          Apply load no.6 at elevation -3.00
    12          Apply load no.7 at elevation -5.00
    13          Apply load no.8 at elevation -7.00

FACTORS OF SAFETY and ANALYSIS OPTIONS

Stability analysis:
 Method of analysis  -  Strength Factor method
 Factor on soil strength for calculating wall depth = 1.50

Parameters for undrained strata:
 Minimum equivalent fluid density                 =    5.00 kN/m3
 Maximum depth of water filled tension crack      =    0.00 m

Bending moment and displacement calculation:
 Method  -  2-D finite element model
 Open Tension Crack analysis? - No
 Soil arching modelled?  -  Yes
 Non-linear Modulus Parameter (L) = 0 m

Boundary conditions:
 Length of wall (normal to plane of analysis) = 52.00 m

 Width of excavation on Left  side of wall  = 20.00 m
 Width of excavation on Right side of wall  = 50.00 m

 Distance to rigid boundary on Left side  = 20.00 m
 Distance to rigid boundary on Right side = 20.00 m
 Elevation of rigid lower boundary = -20.00

 Lower rigid boundary at elevation -20.00 - Smooth
 Rigid boundary on Left side              - Smooth
```

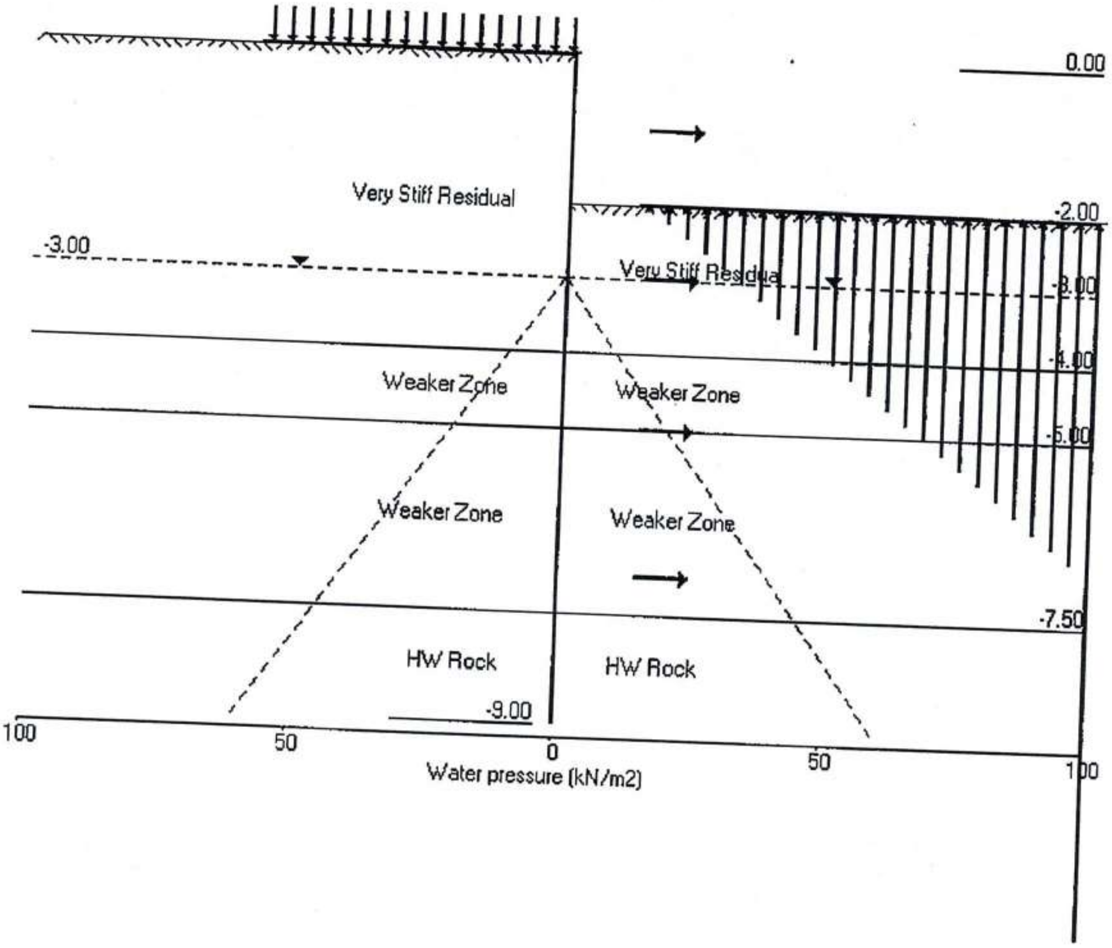
Rigid boundary on Right side
Wall / soil interface - Smooth
- Rough

```
OUTPUT OPTIONS

 Stage ------ Stage description ----------- ------- Output options -------
  no.                                       Displacement  Active,  Graph.
                                            Bending mom.  Passive  output
   1 Apply surcharge no.3 at elev. -2.00    Shear force  pressures
   2 Apply surcharge no.4 at elev. -2.00         No          No       No
   3 Change EI of wall to 15210kN.m2/m run       No          No       No
   4 Excav. to elev. -2.00 on RIGHT side         No          No       No
   5 Apply load no.1 at elev. -1.00              No          No       No
   6 Apply load no.2 at elev. -3.00              No          No       No
   7 Apply load no.3 at elev. -5.00              No          No       No
   8 Apply load no.4 at elev. -7.00              No          No       No
   9 Apply surcharge no.1 at elev. 0.00          Yes         Yes      No
  10 Apply load no.5 at elev. -1.00              No          No       No
  11 Apply load no.6 at elev. -3.00              Yes         Yes      No
  12 Apply load no.7 at elev. -5.00              Yes         Yes      Yes
  13 Apply load no.8 at elev. -7.00              No          No       No
   * Summary output                              No          No       No
                                                 Yes         -        Yes
```

```
HAIGH WORKMAN
Program: WALLAP  Version 6.06  Revision A50.B69.R53      | Sheet No.
                              Licensed from GEOSOLVE      | Job No.
Data filename/Run ID: Wallap_slide_check_DS_seis          | Made by :    WT
Flagstaff Hill                                            |
Retaining Wall Check                                      | Date:13-12-2018
--------------------------------------------------------- | Checked :
-----------------------------------------------------------------------------
                                                     Units: kN,m
```

Stage No.13 Apply load no.8 at elev. -7.00



```
Stage No. 13   Apply load no.8 at elevation -7.00             Units: kN,m

STABILITY ANALYSIS of Soldier Pile Wall according to Strength Factor method
 Factor of safety on soil strength

                                  FoS for toe         Toe elev. for
                                  elev. =   -9.00      FoS = 1.500
                                  ---------------     -------------
Stage  --- G.L. ---    Strut     Factor  Moment        Toe    Wall      Direction
 No.   Act.    Pass.   Elev.       of    equilib.     elev.  Penetr        of
                                 Safety  at elev.             -ation     failure
 13    0.00   -2.00    Cant.     1.658     -8.53     -6.94    4.94       L to R

BENDING MOMENT and DISPLACEMENT ANALYSIS of Soldier Pile Wall
 Analysis options
 Soldier Pile width = 0.30m;  spacing = 1.00m
 Passive mobilisation factor = 3.000
 Length of wall perpendicular to section = 52.00m
 2-D finite element model.    Soil arching modelled.
 Soil deformations are elastic until the active or passive limit is reached

 Rigid boundaries:        Left side 20.00 from wall          Smooth boundary
                         Right side 20.00 from wall          Smooth boundary
Lower rigid boundary at elevation -20.00                     Smooth boundary

  *** Wall displacements reset to zero at stage 3

Node    Y       Nett       Wall      Wall       Shear    Bending    Strut
 no.  coord   pressure     disp.   rotation     force    moment     forces
                kN/m2        m       rad.       kN/m     kN.m/m     kN/m
  1    0.00      0.03      0.042   7.47E-03      0.0       0.0
  2   -0.50      0.03      0.038   7.47E-03      0.0       0.2
  3   -1.00      0.02      0.034   7.46E-03      0.0       0.4      -24.0
                 0.02      0.034   7.46E-03     24.0       0.4
  4   -1.50      1.26      0.030   7.26E-03     24.3      12.5
  5   -2.00      3.54      0.027   6.66E-03     25.5      25.1
               -29.43      0.027   6.66E-03     25.5      25.1
  6   -2.50    -60.31      0.024   5.72E-03      3.1      34.3
  7   -3.00    -46.20      0.021   4.72E-03    -23.5      28.3      -24.0
               -46.20      0.021   4.72E-03      0.5      28.3
  8   -3.50    -17.23      0.019   3.91E-03    -15.4      22.8
  9   -4.00      0.98      0.017   3.34E-03    -19.4      13.1
                11.97      0.017   3.34E-03    -19.4      13.1
 10   -4.50     -0.71      0.016   3.03E-03    -16.6       4.9
 11   -5.00     -4.38      0.014   2.95E-03    -17.9      -3.4      -24.0
                -4.38      0.014   2.95E-03      6.1      -3.4
 12   -5.50     -3.33      0.013   2.93E-03      4.2      -0.8
 13   -6.00     -0.83      0.011   2.83E-03      3.1       0.9
 14   -6.50      1.33      0.010   2.66E-03      3.3       2.4
 15   -7.00      0.49      0.009   2.47E-03      3.7       4.3      -24.0
                 0.49      0.009   2.47E-03     27.7       4.3
 16   -7.50     -4.91      0.007   2.08E-03     26.6      18.3
              -111.06      0.007   2.08E-03     26.6      18.3
 17   -8.00    -36.09      0.007   1.54E-03    -10.2      17.8
 18   -8.50      5.30      0.006   1.15E-03    -17.9       8.2
 19   -9.00     52.93      0.005   1.03E-03     -3.3       0.0
 20   -9.13     -0.80      0.005          0     -0.1       0.0
 21  -10.56      0.13      0.005          0     -0.5       0.0
 22  -12.00     -0.05      0.004          0     -0.5       0.0
```

```
---------------------------------------------------------------------------
Stage No.13  Apply load no.8 at elevation -7.00                 (continued)

Node    Y       Nett       Wall       Wall        Shear    Bending    Strut
no.   coord   pressure     disp.    rotation      force    moment     forces
                kN/m2       m         rad.        kN/m     kN.m/m     kN/m
 23  -14.00      0.15     0.004        0          -0.4       0.0
 24  -16.00      0.11     0.003        0          -0.1       0.0
 25  -18.00      0.08     0.003        0           0.1       0.0
 26  -20.00     -0.17     0.003        0           0.0       0.0

Node    Y      -----------------------  LEFT side -------------------------
no.   coord             ------- Effective stresses -------
               Water    Vertic  Active   Passive              Total     Adjusted
               press.    -al    limit     limit     Earth      earth       soil
               kN/m2   kN/m2    kN/m2     kN/m2    pressure   pressure   modulus
                                                    kN/m2      kN/m2      kN/m2
  1    0.00     0.00    10.00    0.00      78.61     0.03       0.03      24911
  2   -0.50     0.00    18.99    0.00     116.70     0.03       0.03      24911
  3   -1.00     0.00    27.94    0.00     154.59     0.02       0.02      24911
  4   -1.50     0.00    36.81    1.26     192.17     1.26       1.26a     24911
  5   -2.00     0.00    45.59    3.54     229.38     3.54       3.54a     24911
                0.00    45.59    3.54     206.44     3.54       3.54a     24911
  6   -2.50     0.00    54.30    5.79     239.63     5.80       5.80a     24911
  7   -3.00     0.00    62.95    8.04     272.61    15.47      15.47      24911
  8   -3.50     5.00    66.56    8.98     286.39    23.94      28.94      24911
  9   -4.00    10.00    70.16    9.91     300.11    29.57      39.57      24911
               10.00    70.16   13.71     267.31    33.01      43.01      14947
 10   -4.50    15.00    73.76   14.73     279.86    26.02      41.02      14947
 11   -5.00    20.00    77.36   15.75     292.44    23.78      43.78      14947
 12   -5.50    25.00    80.98   16.78     305.07    24.27      49.27      14947
 13   -6.00    30.00    84.62   17.81     317.77    25.79      55.79      14947
 14   -6.50    35.00    88.28   18.85     330.54    27.42      62.42      14947
 15   -7.00    40.00    91.96   19.90     343.38    27.84      67.84      14947
 16   -7.50    45.00    95.66   20.95     356.29    26.17      71.17      14947
               45.00    95.66    0.00     710.54     0.00      45.00a     69752
 17   -8.00    50.00   100.37    0.00     732.42     7.12      57.12      69752
 18   -8.50    55.00   105.11    0.00     754.39    28.53      83.53      69752
 19   -9.00    60.00   109.87    0.00     776.44    53.43     113.43      69752
               60.00   109.87    0.00     862.71    53.43     113.43      69752
 20   -9.13    61.25   111.06    0.00     868.85    26.47      87.72      69752
 21  -10.56    75.63   124.82    0.00     939.76    30.89     106.51      69752
 22  -12.00    90.00   138.68    0.00    1011.20    35.19     125.19      69752
 23  -14.00   110.00   158.10    0.00    1111.27    42.39     152.39      69752
 24  -16.00   130.00   177.64    0.00    1211.95    50.14     180.14      69752
 25  -18.00   150.00   197.26    0.00    1313.09    58.41     208.41      69752
 26  -20.00   170.00   216.96    0.00    1414.57    66.94     236.94      69752

Node    Y      -----------------------  RIGHT side ------------------------
no.   coord             ------- Effective stresses -------
               Water    Vertic  Active   Passive              Total     Adjusted
               press.    -al    limit     limit     Earth      earth       soil
               kN/m2   kN/m2    kN/m2     kN/m2    pressure   pressure   modulus
                                                    kN/m2      kN/m2      kN/m2
  1    0.00     0.00     0.00    0.00       0.00     0.00       0.00        0.0
  2   -0.50     0.00     0.00    0.00       0.00     0.00       0.00        0.0
  3   -1.00     0.00     0.00    0.00       0.00     0.00       0.00        0.0
  4   -1.50     0.00     0.00    0.00       0.00     0.00       0.00        0.0
  5   -2.00     0.00     0.00    0.00       0.00     0.00       0.00        0.0
                0.00     0.00    0.00      32.98    32.97      32.97      24922
  6   -2.50     0.00     8.63    0.00      66.12    66.10      66.10      24922
  7   -3.00     0.00    15.86    0.00      93.89    61.68      61.68      24922
  8   -3.50     5.00    16.90    0.00      97.95    41.17      46.17      24922
  9   -4.00    10.00    17.33    0.00      99.68    28.59      38.59      24922
               10.00    17.33    0.00      84.28    21.05      31.05      14953
```

```
Run ID. Wallap_slide_check_DS_seis
Flagstaff Hill                                                    | Sheet No.
Retaining Wall Check                                              | Date:13-12-2018
----------------------------------------------------------------- | Checked :
------------------------------------------------------------------------------------

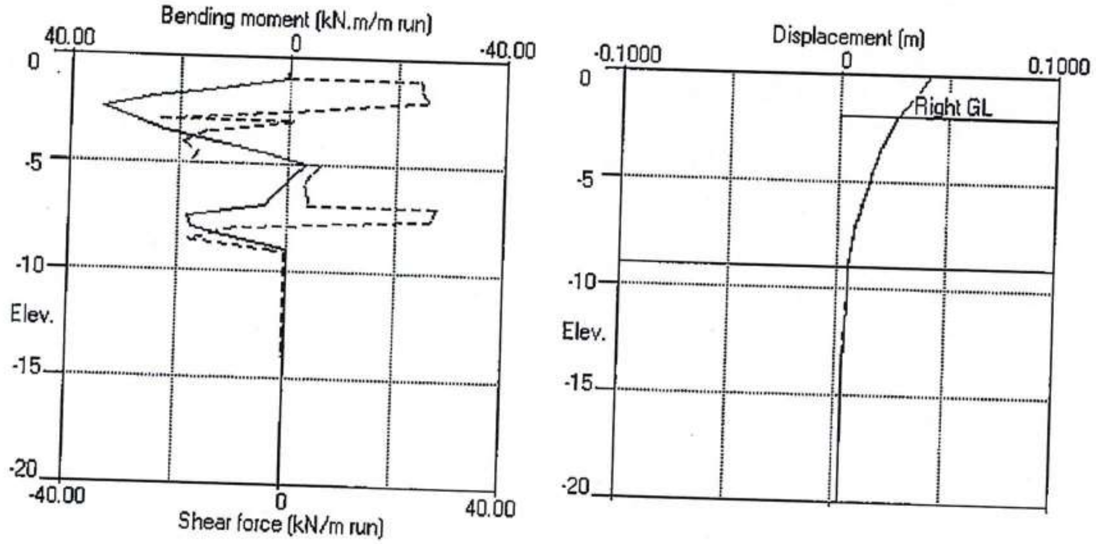
Stage No.13  Apply load no.8 at elevation -7.00                         (continued)

Node    Y    ------------------------ RIGHT side ---------------------------------
 no.  coord          ------- Effective stresses -------
             Water   Vertic  Active  Passive             Total     Adjusted
             press.   -al    limit   limit     Earth     earth       soil
             kN/m2   kN/m2   kN/m2   kN/m2    pressure  pressure   modulus
                                               kN/m2     kN/m2      kN/m2
 10   -4.50   15.00   17.51   0.00    85.02    26.73     41.73      14953
 11   -5.00   20.00   17.65   0.00    85.60    28.16     48.16      14953
 12   -5.50   25.00   17.86   0.00    86.43    27.60     52.60      14953
 13   -6.00   30.00   18.21   0.00    87.76    26.62     56.62      14953
 14   -6.50   35.00   18.74   0.00    89.73    26.09     61.09      14953
 15   -7.00   40.00   19.48   0.00    92.42    27.35     67.35      14953
 16   -7.50   45.00   20.45   0.00    95.88    31.08     76.08      14953
              45.00   20.45   0.00   361.73   111.06    156.06      69781
 17   -8.00   50.00   22.63   0.00   371.87    43.21     93.21      69781
 18   -8.50   55.00   25.04   0.00   383.04    23.23     78.23      69781
 19   -9.00   60.00   27.67   0.00   395.24     0.50     60.50      69781
              60.00   27.67   0.00   439.15     0.50     60.50      69781
 20   -9.13   61.25   28.36   0.00   442.71    27.27     88.52      69781
 21  -10.56   75.63   37.21   0.00   488.30    30.76    106.39      69781
 22  -12.00   90.00   47.55   0.00   541.61    35.23    125.23      69781
 23  -14.00  110.00   63.99   0.00   626.28    42.23    152.23      69781
 24  -16.00  130.00   82.26   0.00   720.46    50.03    180.03      69781
 25  -18.00  150.00  101.90   0.00   821.68    58.33    208.33      69781
 26  -20.00  170.00  122.55   0.00   928.06    67.11    237.11      69781

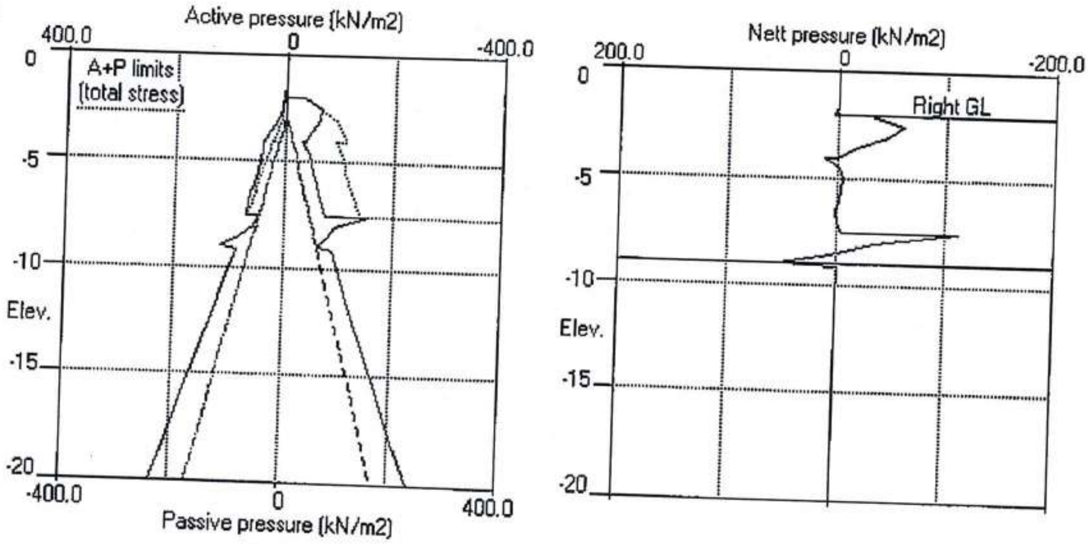
Note:      45.00a  Soil pressure at active limit
          123.45p  Soil pressure at passive limit
```

```
HAIGH WORKMAN                                                          | Sheet No.
Program: WALLAP  Version 6.06  Revision A50.B69.R53                    | Job No.
                               Licensed from GEOSOLVE                  | Made by :     WT
Data filename/Run ID: Wallap_slide_check_DS_seis                       |
Flagstaff Hill                                                         |
Retaining Wall Check                                                   | Date:13-12-2018
                                                                       | Checked :
-------------------------------------------------------------------------------------------
                                                                   Units: kN,m
```

Stage No.13 Apply load no.8 at elev. -7.00



Stage No.13 Apply load no.8 at elev. -7.00



```
HAIGH WORKMAN
Program: WALLAP  Version 6.06  Revision A50.B69.R53             | Sheet No.
                               Licensed from GEOSOLVE           | Job No.
Data filename/Run ID: Wallap_slide_check_DS_seis                | Made by :    WT
Flagstaff Hill                                                  |
Retaining Wall Check                                            | Date:13-12-2018
----------------------------------------------------------------| Checked :
-------------------------------------------------------------------------------

Summary of results                                              Units: kN,m

STABILITY ANALYSIS of Soldier Pile Wall according to Strength Factor method
 Factor of safety on soil strength

                                      FoS for toe         Toe elev. for
                                      elev. =   -9.00      FoS = 1.500
                                      ---------------     -------------
Stage   --- G.L. ---     Strut        Factor   Moment      Toe     Wall       Direction
 No.    Act.    Pass.    Elev.          of     equilib.   elev.  .Penetr         of
                                      Safety   at elev.           -ation       failure
  1     0.00    0.00     Cant.   Conditions not suitable for FoS calc.
  2     0.00    0.00     Cant.   Conditions not suitable for FoS calc.
  3     0.00    0.00             No analysis at this stage
  4     0.00   -2.00     Cant.    2.554    -8.66      -2.65     0.65         L to R
  5     0.00   -2.00     Cant.    2.183    -8.55      -4.73     2.73         L to R
  6     0.00   -2.00     Cant.    1.967    -8.51      -5.45     3.45         L to R
  7     0.00   -2.00     Cant.    1.854    -8.51      -5.42     3.42         L to R
  8     0.00   -2.00     Cant.    1.817    -8.54      -5.42     3.42         L to R
  9     0.00   -2.00     Cant.    1.686    -8.54      -6.59     4.59         L to R
 10     0.00   -2.00     Cant.    1.674    -8.53      -6.78     4.78         L to R
 11     0.00   -2.00     Cant.    1.666    -8.53      -6.89     4.89         L to R
 12     0.00   -2.00     Cant.    1.660    -8.53      -6.94     4.94         L to R
 13     0.00   -2.00     Cant.    1.658    -8.53      -6.94     4.94         L to R
```

```
Summary of results                                      Units: kN,m

BENDING MOMENT and DISPLACEMENT ANALYSIS of Soldier Pile Wall
 Analysis options
  Soldier Pile width = 0.30m;  spacing = 1.00m
  Passive mobilisation factor = 3.000
  Length of wall perpendicular to section = 52.00m
  2-D finite element model.    Soil arching modelled.
  Soil deformations are elastic until the active or passive limit is reached

  Rigid boundaries:      Left side 20.00 from wall       Smooth boundary
                        Right side 20.00 from wall       Smooth boundary
 Lower rigid boundary at elevation -20.00                Smooth boundary

Bending moment, shear force and displacement envelopes
Node    Y        Displacement        Bending moment        Shear force
 no.  coord    maximum  minimum    maximum  minimum     maximum  minimum
                  m        m       kN.m/m   kN.m/m       kN/m     kN/m
  1    0.00     0.042    0.000       0.0     -0.0         0.0      0.0
  2   -0.50     0.038    0.000       0.2     -0.0         0.2      0.0
  3   -1.00     0.034    0.000       0.6      0.0        24.0      0.0
  4   -1.50     0.030    0.000      12.5      0.0        24.3      0.0
  5   -2.00     0.027    0.000      25.1      0.0        25.5      0.0
  6   -2.50     0.024    0.000      34.3      0.0         3.1     -0.8
  7   -3.00     0.021    0.000      28.3      0.0         0.5    -24.8
  8   -3.50     0.019    0.000      22.8     -0.6         0.0    -17.3
  9   -4.00     0.017    0.000      13.1     -2.9         0.0    -19.5
 10   -4.50     0.016    0.000       5.7     -5.1         0.0    -16.6
 11   -5.00     0.014    0.000       2.7     -6.5         6.5    -17.9
 12   -5.50     0.013    0.000       1.1     -7.2         5.5     -1.9
 13   -6.00     0.011    0.000       1.0     -6.8         6.0     -0.4
 14   -6.50     0.010    0.000       3.8     -5.0         8.5      0.0
 15   -7.00     0.009    0.000       9.0     -1.9        27.7      0.0
 16   -7.50     0.007    0.000      18.4      0.0        26.6      0.0
 17   -8.00     0.007    0.000      17.8      0.0         0.0    -10.4
 18   -8.50     0.006    0.000       8.2      0.0         0.0    -17.9
 19   -9.00     0.005    0.000       0.0      0.0         0.0     -3.3
 20   -9.13     0.005    0.000       0.0      0.0         0.0     -0.1
 21  -10.56     0.005    0.000       0.0      0.0         0.1     -0.6
 22  -12.00     0.004    0.000       0.0      0.0         0.2     -0.6
 23  -14.00     0.004    0.000       0.0      0.0         0.4     -0.5
 24  -16.00     0.003    0.000       0.0      0.0         0.4     -0.2
 25  -18.00     0.003    0.000       0.0      0.0         0.4     -0.0
 26  -20.00     0.003    0.000       0.0      0.0         0.0     -0.0
```

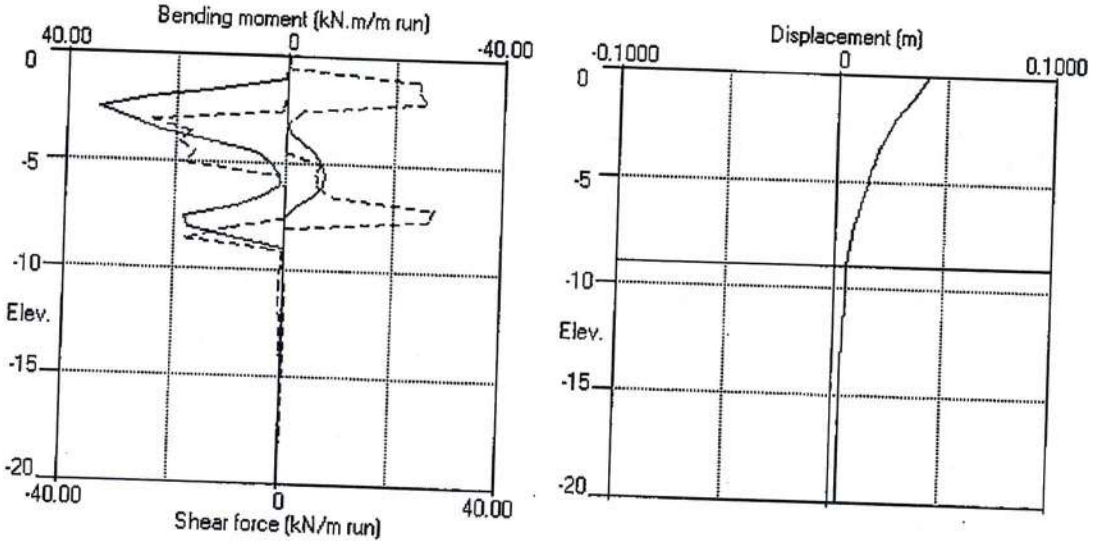
```
Summary of results    (continued)

Maximum and minimum bending moment and shear force at each stage
Stage  --------- Bending moment --------    ---------- Shear force ----------
 no.   maximum   elev.   minimum   elev.    maximum   elev.   minimum   elev.
       kN.m/m            kN.m/m              kN/m             kN/m
  1       1.4   -8.00      -2.8   -6.00        5.7   -7.50      -2.1   -4.00
  2       1.7   -8.00      -3.5   -6.00        7.9   -7.50      -2.4   -4.00
  3    No calculation at this stage
  4       6.8   -8.00      -7.2   -5.50       16.7   -7.50      -6.9   -8.50
  5      30.7   -2.50      -1.7   -6.00       22.8   -2.00     -17.3   -3.50
  6      30.7   -2.50       0.0    0.00       22.8   -2.00     -24.6   -3.00
  7      31.6   -2.50      -5.3   -5.00       23.2   -2.00     -24.8   -3.00
  8      31.8   -2.50      -4.7   -5.00       25.4   -7.00     -24.4   -3.00
  9      31.9   -2.50      -4.5   -5.00       26.7   -7.00     -23.4   -3.00
 10      34.2   -2.50      -3.2   -5.00       26.8   -7.00     -23.1   -3.00
 11      34.2   -2.50      -2.9   -5.00       26.8   -7.00     -23.5   -3.00
 12      34.2   -2.50      -3.5   -5.00       26.8   -7.00     -23.5   -3.00
 13      34.3   -2.50      -3.4   -5.00       27.7   -7.00     -23.5   -3.00

Maximum and minimum displacement at each stage
Stage -------- Displacement ---------     Stage description
 no.  maximum  elev.   minimum  elev.     -----------------
        m                 m
  1    0.002   -6.00    0.000    0.00    Apply surcharge no.3 at elev. -2.00
  2    0.004  -20.00    0.000    0.00    Apply surcharge no.4 at elev. -2.00
  3    Wall displacements reset to zero  Change EI of wall to 15210kN.m2/m run
  4    0.005   -3.50    0.000    0.00    Excav. to elev. -2.00 on RIGHT side
  5    0.027    0.00    0.000    0.00    Apply load no.1 at elev. -1.00
  6    0.033    0.00    0.000    0.00    Apply load no.2 at elev. -3.00
  7    0.034    0.00    0.000    0.00    Apply load no.3 at elev. -5.00
  8    0.034    0.00    0.000    0.00    Apply load no.4 at elev. -7.00
  9    0.037    0.00    0.000    0.00    Apply surcharge no.1 at elev. 0.00
 10    0.041    0.00    0.000    0.00    Apply load no.5 at elev. -1.00
 11    0.042    0.00    0.000    0.00    Apply load no.6 at elev. -3.00
 12    0.042    0.00    0.000    0.00    Apply load no.7 at elev. -5.00
 13    0.042    0.00    0.000    0.00    Apply load no.8 at elev. -7.00
```

```
HAIGH WORKMAN                                                        | Sheet No.
Program: WALLAP  Version 6.06  Revision A50.B69.R53                  | Job No.
                                    Licensed from GEOSOLVE           | Made by :    WT
Data filename/Run ID: Wallap_slide_check_DS_seis                     |
Flagstaff Hill                                                       |
Retaining Wall Check                                                 | Date:13-12-2018
---------------------------------------------------------------------| Checked :
--------------------------------------------------------------------------------------
                                                               Units: kN,m
```

Bending moment, shear force, displacement envelopes



Structural Design of Timber Pole to NZS 3603:1993

Timber Pole Size and Section Properties

Pole Diameter "d" = 400 mm

Increase in pole diameter due to taper mm/m = 6 mm

Depth from the top of the pole to the maximum moment (zero 4.20 m

Pole Diameter "d_b " @ point of max moment = 425.2 mm

Section Modulus "Z" @ point of max moment = 7547092 mm^3

Depth from the top of the pole to maximum shear H = 3.0 m

Pole Diameter "d_s" @ point of max shear = 418 mm

Section Area "A_s" @ point of max shear = 102921 mm^2

Check for Flexural Capacity

Timber Grade (High or Normal) high

Bending Stress, f_b = 52 MPa

Strength Reduction Factor, ϕ = 0.8

Duration Factor, k_1 = 0.6

Factor for Trimming or Shaving under flexural load, k_{20} = 0.85 (for f_b)

Steaming Factor under flexural load, k_{21} = 0.85 (for f_b)

Dry Factor under flexural load, k_{22} (Default 1) = 1 (for f_b)

$\phi M_n = \phi k_1 k_{20} k_{21} k_{22} f_b Z$ = **136.10** **kNm**

Compare with M^* = **133.00** **kNm**

Percentage of Moment capacity utilised 98%

OK for flexural strength & optimum design achieved

Check for Shear Capacity

Shear Stress, f_s = 3.5 MPa

Strength Reduction Factor, ϕ = 0.8

Duration Factor, k_1 = 0.6

Factor for Trimming or Shaving under shear load, k_{20} = 1.0 (for f_s)

Steaming Factor under shear load, k_{21} = 0.9 (for f_s)

Dry Factor under shear load, k_{22} (Default 1) = 1 (for f_s)

$\phi V_n = \phi k_1 k_{20} k_{21} k_{22} f_s A_s$ = **155.62** **kN**

Compare with V^* = **90.0** **kN**

Percentage of Moment capacity utilised 58%

Ok for Shear Capacity!

Project	Flagstaff Hill
Client	Waitoto Developments Ltd
Job No	18 260
Date	13/12/2018
Calculated by:	W. Thorburn
Reviewed by:	J. Papesch
Comments	Lagging Desing

Factored load on the plank at the base of the wall = **64.65** **kPa**

Inputs

1	c/c spacing (m)
3	Height (m)
43	kPa
1.5	Load factor
3	Rails Required

Structural Design of Lagging to NZS 3603:1993

Timber Lagging: Structural actions

Lagging width b = 45

Lagging depth d = 145

For a maximum soil pressure of 64.6487996779117 kPa.

The UDL on lagging "d" = 9.37 kN/m

Lagging Span "L" = 1 m

Maximum factored moment $M^* = 1/8\ dL^2$ **1.172** **kNm**

Under Flexure, calculate the minimum lagging depth for moment capacity

Retained Height	Lagging Details	Rails Required
0 - 0.6 m	50 x 150 mm	1
0.6 - 2.7 m	100 x 150 mm	2
2.7 m - 3.0 m	150 x 150 mm	3

Bending Stress, f_b = 11.7 MPa

Shear Stress, f_s = 2.4 MPa

No of parallel support elements, n = 3

Strength Reduction Factor, ϕ = 0.8

Duration Factor, k_1 = 0.6

Parallel Support Factor , k_4 = 1.00

Grid System Factor, k_5 = 1.00

Section modulus of lagging, $Z = bd^2/6$ = 440438 mm^3

$\phi M_n = \phi k_1 k_4 k_5 f_b Z$ = **2.473** **kNm**

Percentage of lagging moment capacity utilised 47%

Lagging OK for Moment Capacity!

Check for Shear Capacity

For x lagging. Shear surface area = 4350.0 mm^2

$\phi V_n = \phi k_1 k_4 k_5 f_s A_s$ = **5.011** **kN**

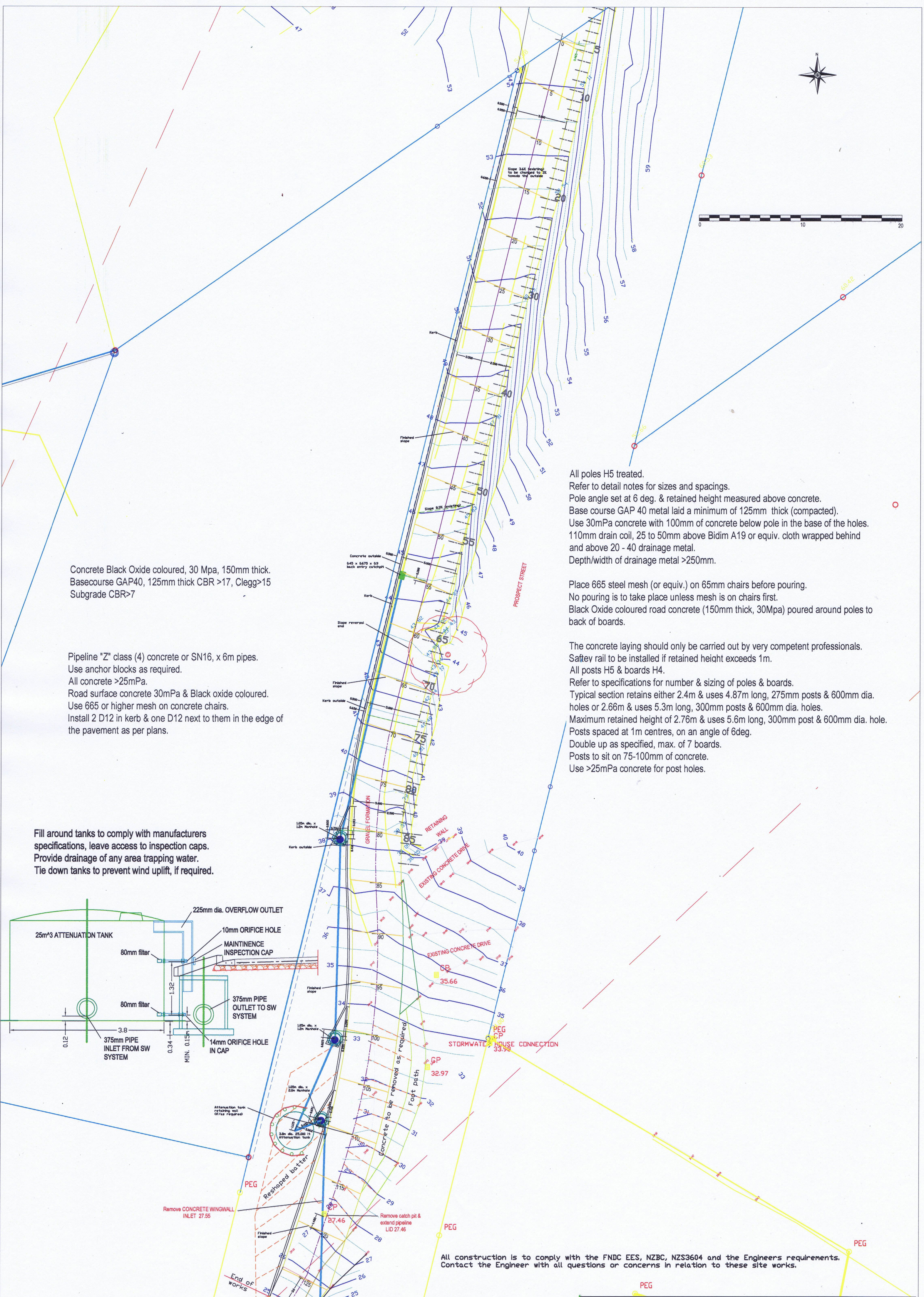
Compare with V* = **5.859** **kN**

$$V^* = 0.625wL$$

Percentage of Shear capacity utilised 117%

Lagging has insufficient Shear Capacity, Try bigger size or adjust wall geometry!

Use x 0 lagging, spanning continuously across a minimum of 2 pole spacings



All poles H5 treated.
Refer to detail notes for sizes and spacings.
Pole angle set at 6 deg. & retained height measured above concrete.
Base course GAP 40 metal laid a minimum of 125mm thick (compacted).
Use 30mPa concrete with 100mm of concrete below pole in the base of the holes.
110mm drain coil, 25 to 50mm above Bidim A19 or equiv. cloth wrapped behind and above 20 - 40 drainage metal.
Depth/width of drainage metal >250mm.

Place 665 steel mesh (or equiv.) on 65mm chairs before pouring.
No pouring is to take place unless mesh is on chairs first.
Black Oxide coloured road concrete (150mm thick, 30Mpa) poured around poles to back of boards.

The concrete laying should only be carried out by very competent professionals.
Saftey rail to be installed if retained height exceeds 1m.
All posts H5 & boards H4.
Refer to specifications for number & sizing of poles & boards.
Typical section retains either 2.4m & uses 4.87m long, 275mm posts & 600mm dia. holes or 2.66m & uses 5.3m long, 300mm posts & 600mm dia. holes.
Maximum retained height of 2.76m & uses 5.6m long, 300mm post & 600mm dia. hole.
Posts spaced at 1m centres, on an angle of 6deg.
Double up as specified, max. of 7 boards.
Posts to sit on 75-100mm of concrete.
Use >25mPa concrete for post holes.

Concrete Black Oxide coloured, 30 Mpa, 150mm thick.
Basecourse GAP40, 125mm thick CBR >17, Clegg>15
Subgrade CBR>7

Pipeline "Z" class (4) concrete or SN16, x 6m pipes.
Use anchor blocks as required.
All concrete >25mPa.
Road surface concrete 30mPa & Black oxide coloured.
Use 665 or higher mesh on concrete chairs.
Install 2 D12 in kerb & one D12 next to them in the edge of the pavement as per plans.

Fill around tanks to comply with manufacturers specifications, leave access to inspection caps.
Provide drainage of any area trapping water.
Tie down tanks to prevent wind uplift, if required.

All construction is to comply with the FNDC EES, NZBC, NZS3604 and the Engineers requirements.
Contact the Engineer with all questions or concerns in relation to these site works.

R. HAINES. PROSPECT STREET, RUSSELL. LOT 2 DP 586857	ANSED	Drawn by Steven Smith Dated 12/6/2025	Drawing Number 1 of 6	Revision A00
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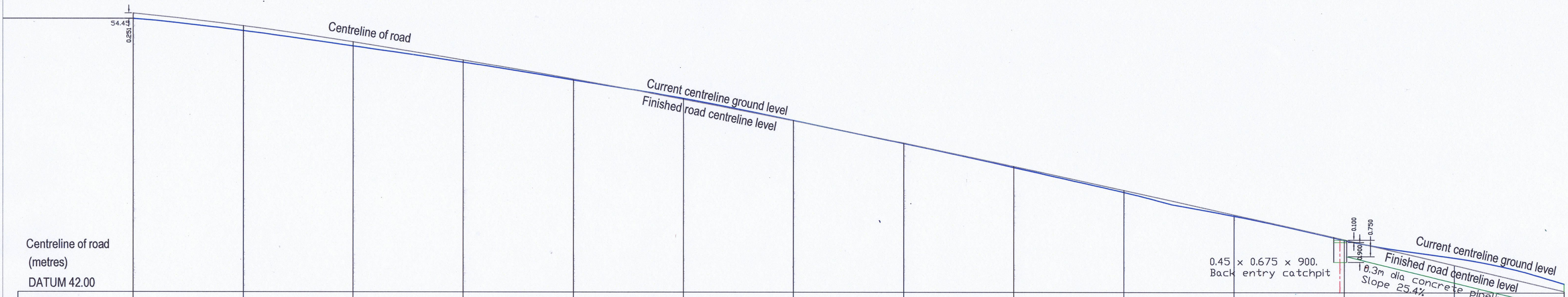

Centreline of road
(metres)
DATUM 42.00

FINISHED GRADIENTS	11.5%	14.6%	16.3%	17.4%	18.4%	19.5%	20.3%	21.2%	21.7%	22.4%	22.6%	23.0%	24.0%	
FORMATION LEVEL	54.70	54.13	53.39	52.58	51.71	50.79	49.82	48.80	47.74	46.66	45.54	44.41	43.26	42.06
EXISTING & PROJECTED GROUND LEVEL	54.45	53.9	53.21	52.47	51.66	50.83	49.82	48.78	47.69	46.56	45.47	44.38	43.58	42.40
FINISHED LEVEL FILL (CUT)	0.251	0.223	0.187	0.107	0.052	-0.038	-0.006	0.019	0.049	0.098	0.07	0.03	-0.32	-0.34
DISTANCE ALONG ROAD CENTRELINE	0	5	10	15	20	25	30	35	40	45	50	55	60	65

Scale 1:1 (Horizontal-Vertical)

ROW LONG SECTION
0 to 65m

Pipeline "Z" class (4) concrete or SN16, x 6m pipes.
Use anchor blocks as required.
All concrete >25mPa.
Road surface concrete 30mPa.
Use 665 or higher mesh on concrete chairs.
Install 2 D12 in kerb & one D12 next to them in
the edge of the pavement as per plans.

All construction is to comply with the FNDC EES, NZBC, NZS3604 and the Engineers requirements.
Contact the Engineer with all questions or concerns in relation to these site works.

0 1 2 3 4 5 6 7 8 9 10

R. HAINES. PROSPECT STREET, RUSSELL.
LOT 2 DP 586857

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Dated 12/6/2025
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Revision A00
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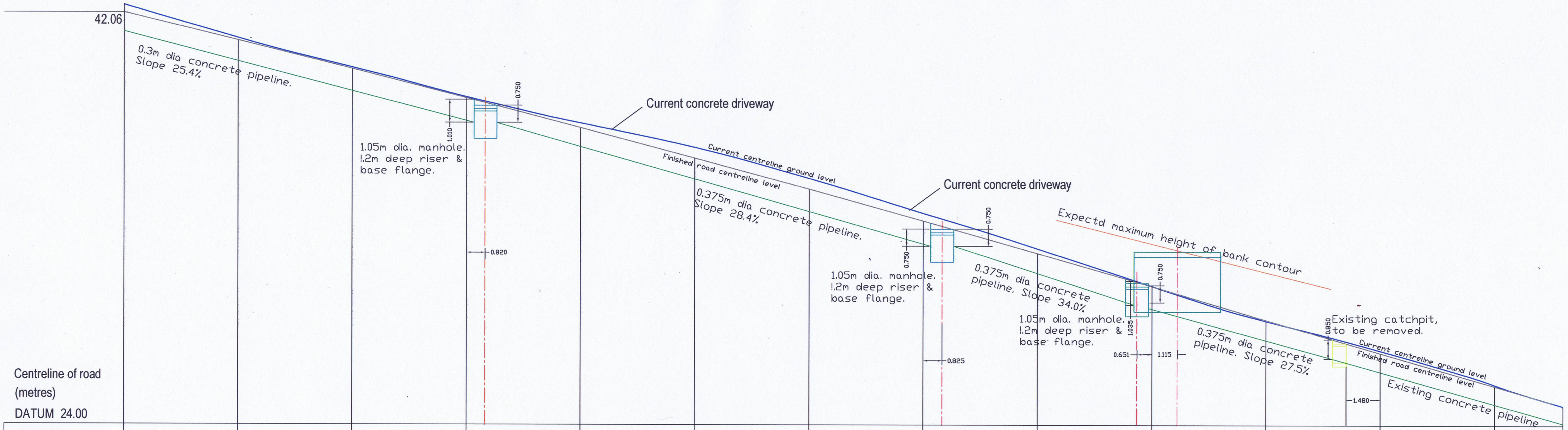

FINISHED GRADIENTS	24.0%	25.2%	25.4%	26.0%	26.8%	27.0%	27.8%	28.2%	28.8%	29.8%	28.8%	28.8%	24.3%	
FORMATION LEVEL	42.06	40.86	39.60	38.33	37.03	35.69	34.34	32.95	31.54	30.10	28.61	27.17	25.73	25.00
EXISTING & PROJECTED GROUND LEVEL	42.40	40.95	39.66	38.37	37.23	36.16	34.81	33.29	31.74	30.10	28.58	27.28	25.79	25.00
FINISHED LEVEL FILL (CUT)	-0.34	-0.09	-0.06	-0.04	-0.2	-0.47	-0.47	-0.34	-0.2	0.00	0.03	-0.11	-0.06	0.00
DISTANCE ALONG ROAD CENTRELINE	65	70	75	80	85	90	95	100	105	110	115	120	125	128

ROW LONG SECTION
65 to 128m

Pipeline "Z" class (4) concrete or SN16, x 6m pipes.
Use anchor blocks as required.
All concrete >25mPa.
Road surface concrete 30mPa & Black Oxide coloured.
Use 665 or higher mesh on concrete chairs.
Install 2 D12 in kerb & one D12 next to them in the
edge of the pavement as per plans.

All construction is to comply with the FNDC EES, NZBC, NZS3604 and the Engineers requirements.
Contact the Engineer with all questions or concerns in relation to these site works.

0 1 2 3 4 5 6 7 8 9 10

R. HAINES. PROSPECT STREET, RUSSELL.
LOT 2 DP 586857

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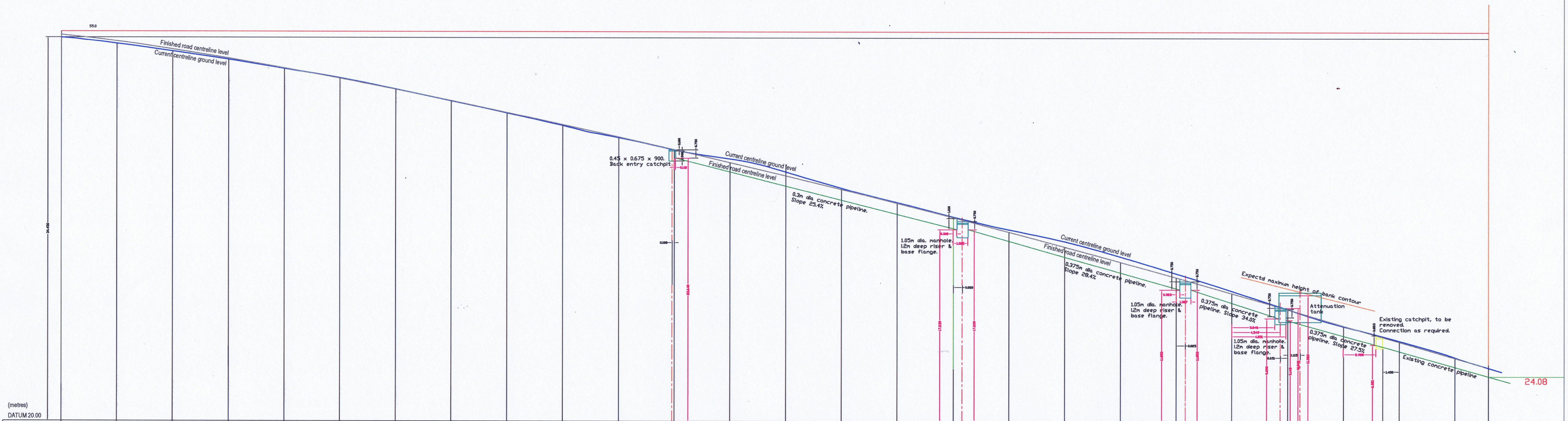
Dated 12/6/2025	EMAIL: ansed@xtra.co.nz	



GRADIENTS	11.5%	14.6%	16.3%	17.4%	18.4%	19.5%	20.3%	21.2%	21.7%	22.4%	22.6%	23.0%	24.0%	24.0%	25.2%	25.4%	26.0%	26.8%	27.0%	27.8%	28.2%	28.8%	29.8%	28.8%	28.8%	24.3%	
FORMATION LEVEL	54.70	54.13	53.39	52.58	51.71	50.79	49.82	48.80	47.74	46.66	45.54	44.41	43.26	42.06	40.86	39.60	38.33	37.03	35.69	34.34	32.95	31.54	30.10	28.61	27.17	25.73	25.00
EXISTING & PROJECTED GROUND LEVEL	54.45	53.9	53.21	52.47	51.66	50.83	49.82	48.78	47.69	46.56	45.47	44.38	43.58	42.40	40.95	39.66	38.37	37.23	36.16	34.81	33.29	31.74	30.10	28.58	27.28	25.79	25.00
FILL (CUT)	0.251	0.223	0.187	0.107	0.052	-0.038	-0.006	0.019	0.049	0.098	0.07	0.03	-0.32	-0.34	-0.09	-0.06	-0.04	-0.2	-0.47	-0.47	-0.34	-0.2	0.00	0.03	-0.11	-0.06	0.00
DISTANCE FROM ROAD END	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	128

Scale 1:1 (Horizontal-Vertical)

ROW LONG SECTION

Pipeline 'Z' class (4) concrete or SN16, x 6m pipes.
Use anchor blocks as required.
All concrete >25mPa.
Road surface concrete 30mPa.
Use 665 or higher mesh on concrete chairs.
Install 2 D12 in kerb & one D12 next to then in
the edge of the pavement as per plans.

All construction is to comply with the FNDC EES, NZBC, NZS3604 and the Engineers requirements.
Contact the Engineer with all questions or concerns in relation to these site works.

R. HAINES. PROSPECT STREET, RUSSELL.
LOT 2 DP 586857

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12/6/2025

Drawing Number
4 of 6

Revision
A00

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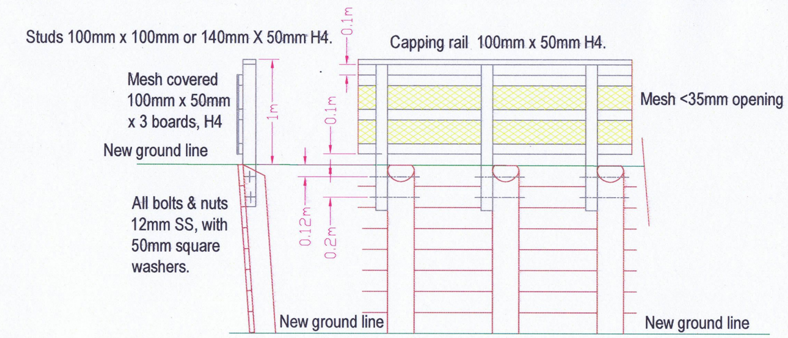
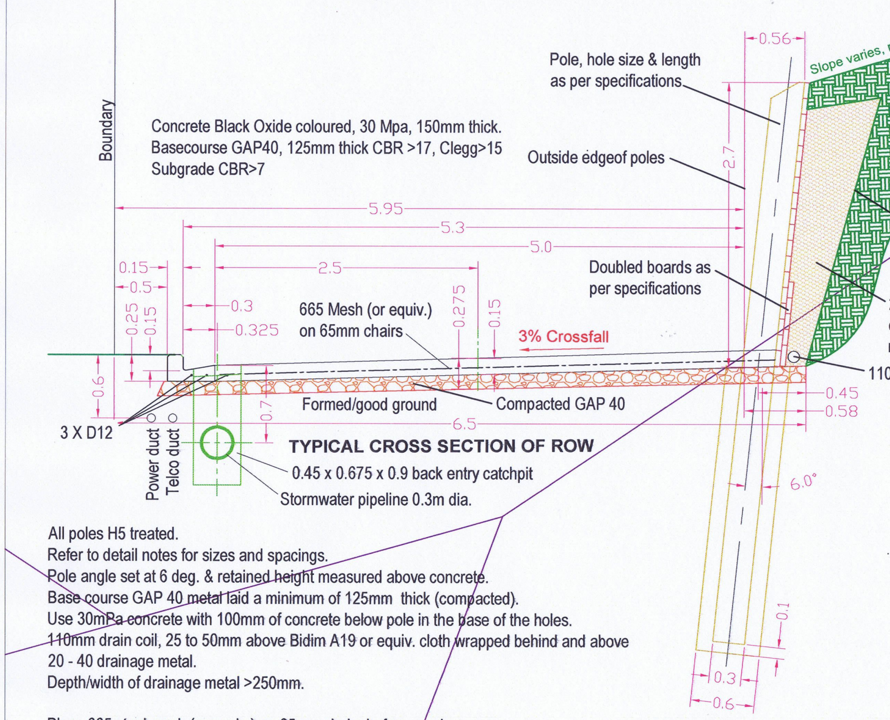


TYPICAL RETAINING WALL SECTION

To be used where the ground/surface on one side of wall is less than 1m from the top & the other side of wall is more than 1m.



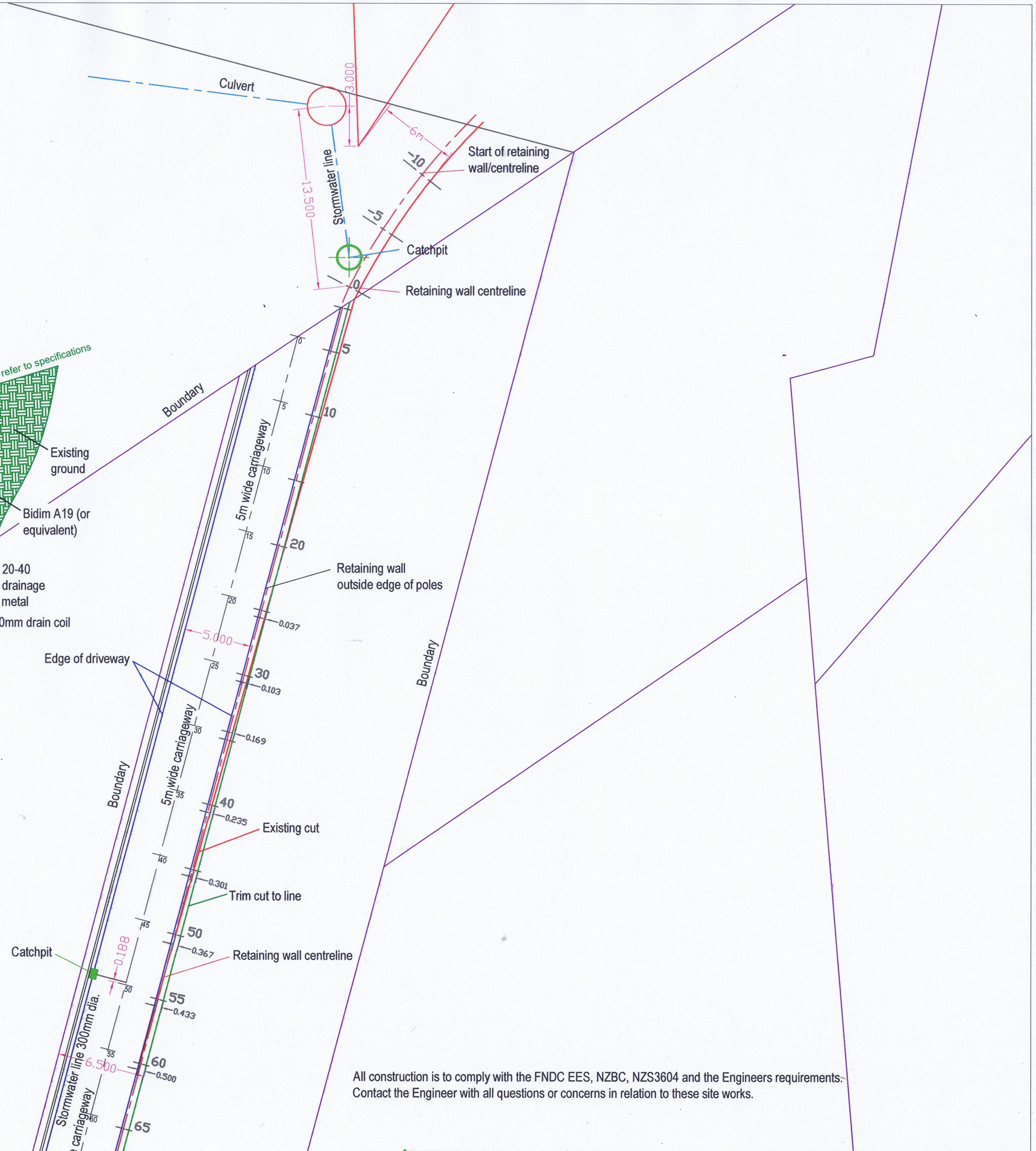
TYPICAL CROSS SECTION OF ROW

All poles H5 treated.
Refer to detail notes for sizes and spacings.
Pole angle set at 6 deg. & retained height measured above concrete.
Base course GAP 40 metal laid a minimum of 125mm thick (compacted).
Use 30mPa concrete with 100mm of concrete below pole in the base of the holes.
110mm drain coil, 25 to 50mm above Bidim A19 or equiv. cloth wrapped behind and above 20 - 40 drainage metal.
Depth/width of drainage metal >250mm.

Place 665 steel mesh (or equiv.) on 65mm chairs before pouring.
No pouring is to take place unless mesh is on chairs first.
ROW concrete (150mm thick, 30Mpa) poured around poles to back of boards.

The concrete laying should only be carried out by very competent professionals.
Saftey rail to be installed if retained height exceeds 1m.

All posts H5 & boards H4.
Refer to specifications for number & sizing of poles & boards.
Typical section retains either 2.4m & uses 4.87m long, 275mm posts & 600mm dia. holes or 2.66m & uses 5.3m long, 300mm posts & 600mm dia. holes.
Maximum retained height of 2.76m & uses 5.6m long, 300mm post & 600mm dia. hole.
Posts spaced at 1m centres, on an angle of 6deg.
Double up as specified, max. of 7 boards.
Posts to sit on 75-100mm of concrete.
Use >25mPa concrete



All construction is to comply with the FNDC EES, NZBC, NZS3604 and the Engineers requirements.
Contact the Engineer with all questions or concerns in relation to these site works.

R. HAINES. PROSPECT STREET, RUSSELL. LOT 2 DP 586857	ANSED	Drawn by Steven Smith Dated 12/6/2025	Drawing Number 5 of 6	Revision A00
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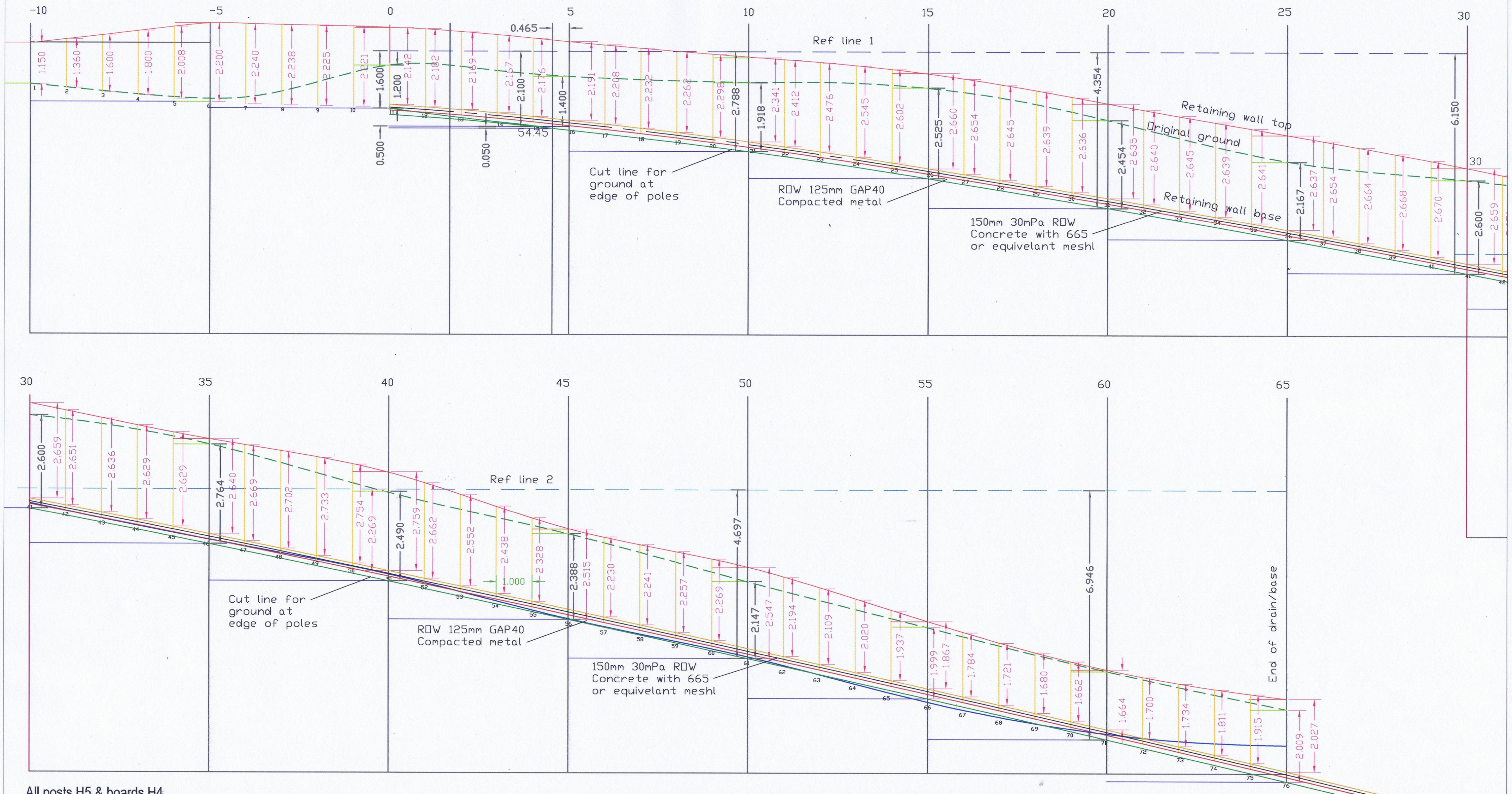

LONGITUDINAL RETAINING WALL SECTIONS & POLE HEIGHTS

No major new earthworks required for this section of retaining wall apart from boring pole holes & minor triming.

All posts H5 & boards H4.
Refer to specifications for number & sizing of poles & boards.
Typical section retains either 2.4m & uses 4.87m long, 275mm posts & 600mm dia. holes or 2.66m & uses 5.3m long, 300mm posts & 600mm dia. holes.
Maximum retained height of 2.76m & uses 5.6m long, 300mm post & 600mm dia. hole.
Posts spaced at 1m centres, on an angle of 6deg.
Double up as specified, max. of 7 boards.
Posts to sit on 75-100mm of concrete.
Use >25mPa concrete

Saftey rail to be installed if retained height exceeds 1m.

R. HAINES. PROSPECT STREET, RUSSELL.
LOT 2 DP 586857

ANSED

Drawn by
Steven Smith
Dated
12/6/2025

Drawing Number
6 of 6

Revision
A00

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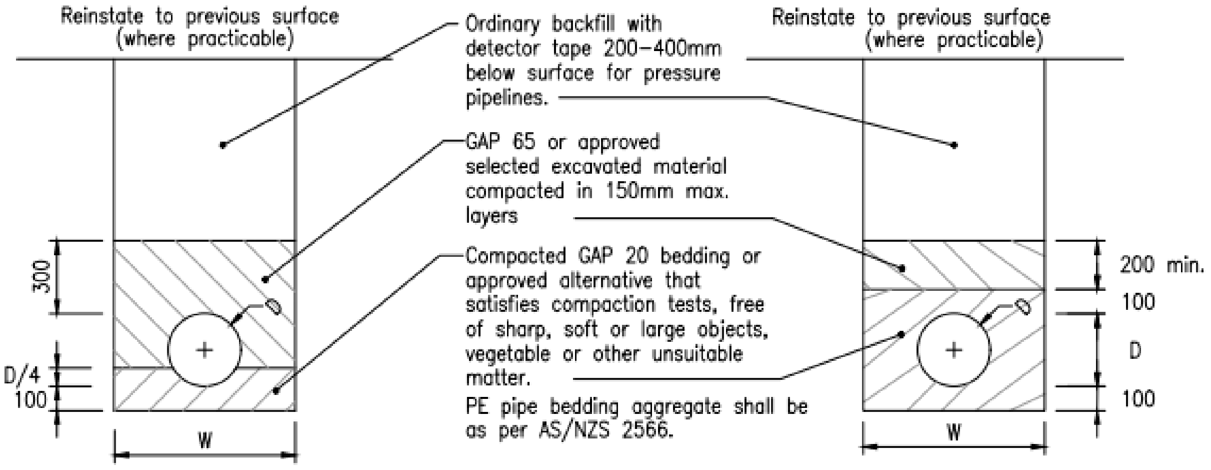
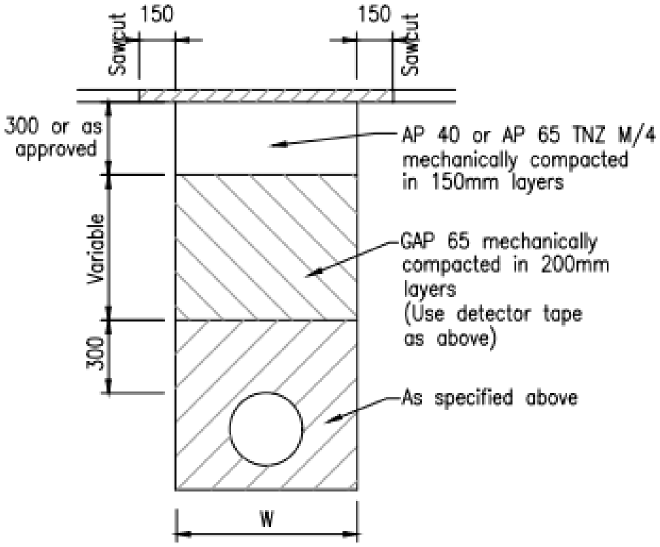


CONCRETE, DUCTILE IRON, STEEL OR VITRIFIED CLAY PIPE

(Where specifically approved)

PVC, PE & PP PIPE

(PVC & PP not approved for water supply)



ADDITIONAL BACKFILL REQUIREMENTS UNDER CARRIAGEWAYS

(All types of pipe)

W	TYPE OF PIPE
D + 600	Steel, DI
D + 450	Concrete
D + 450	Vitrified clay
D + 400	uPVC, PE & PP

Variations in W require additional design compensation.

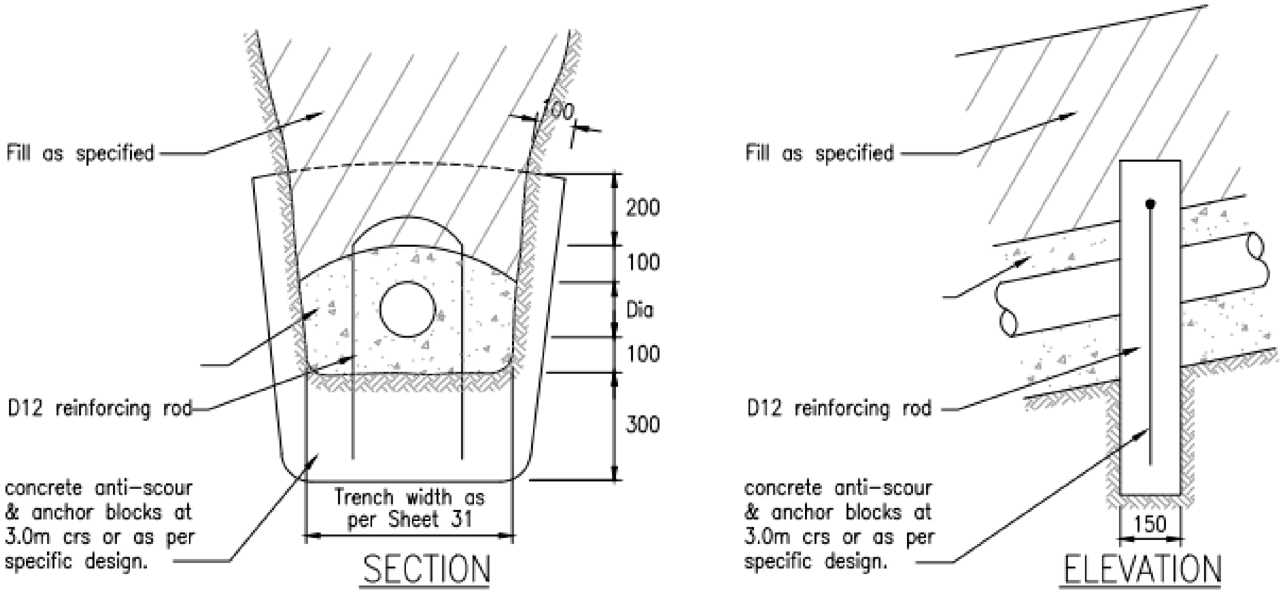
NOTES

1. Concrete pipes to be RCRRJ to AS/ NZS 4058 installed to manufacturers requirements.
2. Ordinary backfill shall be free from stones or rocks greater than 150mm nominal diameter compacted in 300mm layers.
3. Replace topsoil to original depth as necessary.
4. Existing sealed roadway excavations are to be resurfaced with 50mm of asphaltic concrete.
5. Clegg Hammer test:
   0–300mm depth range Clegg reading not less than 45.
   300mm–1.5m depth range Clegg reading not less than 30.
   1.5m–top of pipe bedding material Clegg reading not less than 25.
6. PRIVATEWAY base course metalling within pipe trenches may be in accordance with the Privateway Standards.
7. Trench width shall not exceed W at the pipe crown level.
8. Unsatisfactory trench material is to be undercut and replaced with compacted hardfill.
   In poor soils such as swamp, peat, and in rock the minimum depth of granular bedding material below the invert is to be 200mm or specific design as necessary.
9. Pipelines at 1:8 gradient or steeper shall have cement stabilised bedding and/or surrounds.
10. Pipelines at 1:3 gradient or steeper shall have weak mix concrete bedding (10MPa) in accordance with Sheet 32. Large pipes will require specific pier design.
11. Concrete bedding shall be allowed to cure for 48 hours prior to backfilling.
12. Backfilling – carriageways may be with 'flowable fill' (low strength fly–ash concrete).
13. Granular bedding is to satisfy N.Z.S. 7643 Appendix B.
14. Minimum cover over pipes (unless specifically designed or protected in accordance with sheet 32).
    A. 600mm if not subjected to traffic loading
    B. 900mm under carriageways and trafficed areas.
15. Sand is not permitted as PE Pipe Bedding

PIPE BEDDING & BACKFILL
(FOR ALL ENVIRONMENTS)

FAR NORTH DISTRICT COUNCIL
ENGINEERING STANDARDS

Date: FEB 2022
Revision: 0.2
Scale: AS SHOWN
SHEET No. 31



SECTION

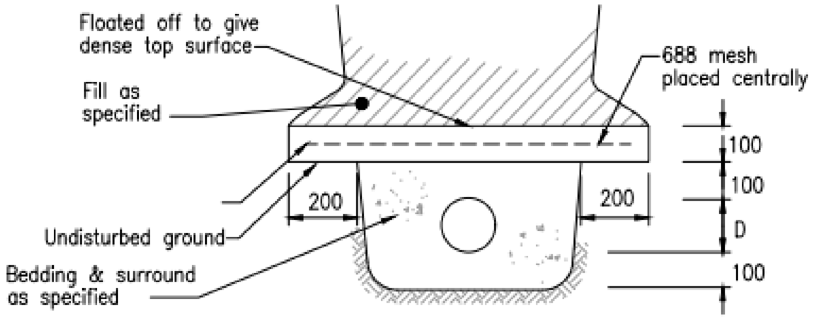
ELEVATION

STEEP PIPE DETAILS

(For pipeline gradients 1:3 or steeper and diameter ⩽ 450mm)

NOTES:

1) Some variation is possible using aluminium plate cut off walls bolted to larger diameter pipes.
2) Larger diameter pipes will require specific pier design to counter the downward component of water and pipe weight.

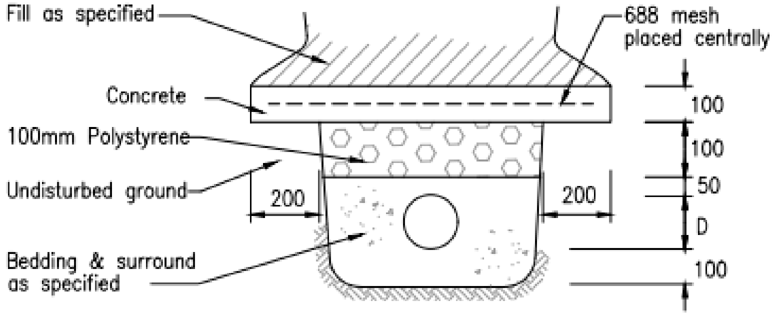


REINFORCED CONCRETE SLAB PROTECTION FOR STORMWATER AND WASTEWATER

(Where additional loading or other requirements necessitate)

GENERAL:

A. All concrete to be 20MPa at 28 days as per NZS 3104:2021
B. Cement stabilised bedding and back fill: 1 part cement to 20 parts aggregate.
C. Allow 48 hours curing prior to back filling any concrete or stabilised material.
. Slab protection to be laid in lengths no greater than 2.0M



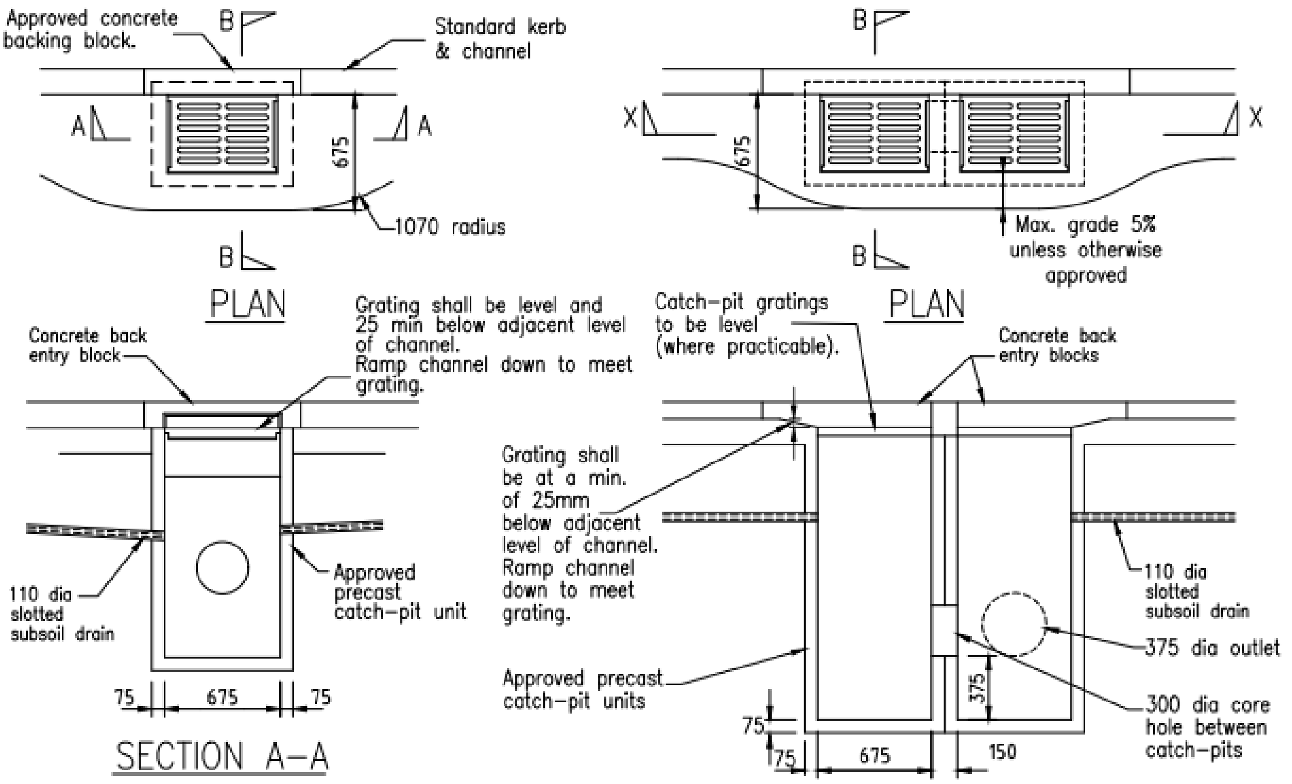
REINFORCED CONCRETE SLAB PROTECTION FOR WATER PIPELINES

PIPE PROTECTION AND BULKHEAD DETAILS
(FOR ALL ENVIRONMENTS)

FAR NORTH DISTRICT COUNCIL
ENGINEERING STANDARDS

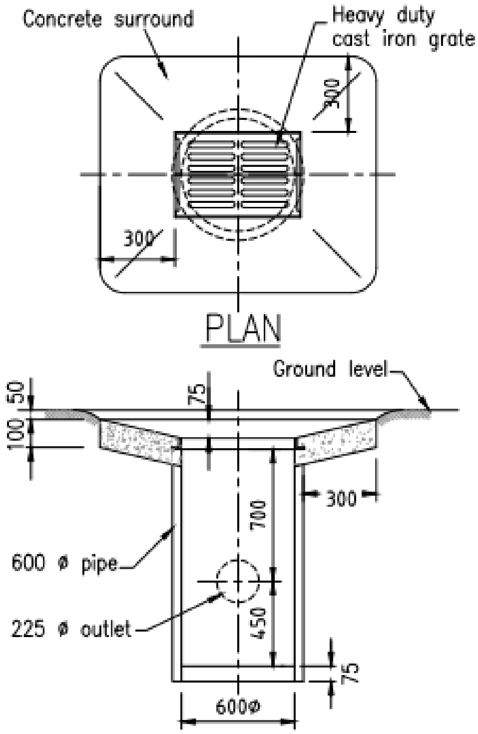
Date:	FEB 2022
Revision:	0.2
Scale:	AS SHOWN
SHEET No.	32

Sheet 34 Catch-Pit Details

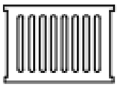


SECTION A–A
SINGLE CATCH–PIT

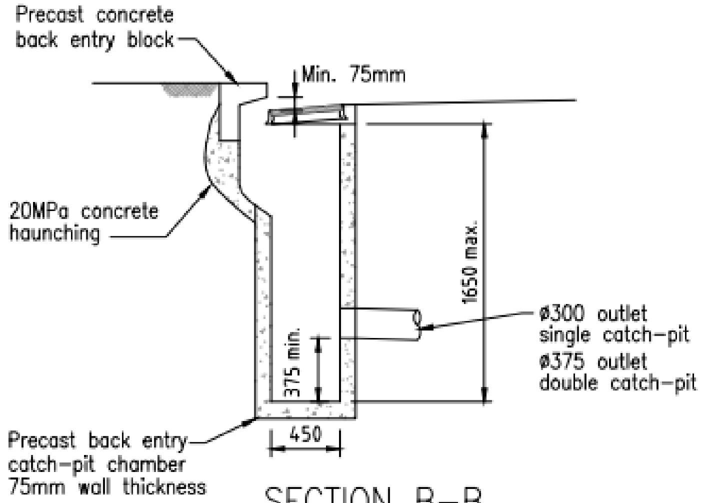
SECTION X–X
DOUBLE CATCH–PIT



SECTION
FIELD CATCH–PIT DETAIL



ALTERNATIVE CAST IRON GRATE CONFIGURATION
(perpendicular slots) for cycle routes



SECTION B–B

NOTES:

1. Concrete to be ordinary grade (20MPa) in accordance with NZS 3104:2021
2. Catch-pit outlet pipes to be 1:100 min gradient.
3. Mega catch-pits require specific design and approval.
4. Grates to be cycle friendly. Refer Section 3.2.14.6.

CATCH–PIT DETAILS
FOR ENVIRONMENTS LIVING 1 AND 2, AND BUSINESS 1–5

FAR NORTH DISTRICT COUNCIL
ENGINEERING STANDARDS

Date: FEB 2022
Revision: 0.2
Scale: AS SHOWN
SHEET No. 34

Retaining wall A poles & details

Distance	Number	Description	New ground Loaded Wall height	**Concrete >=25mPa** **Pole slope 6deg.** Back slope Degrees	Hole size	Diameter	Below finished level Hole depth	(does not include 100mm of concrete at bottom of hole) Actual post overall length	Spacing (m)	Doubled boards
-10	A1	End post	1.15	25	0.45	0.15	1.3	2.38	1	0
-9	A2	Support post	1.36	25	0.45	0.15	1.55	2.84	1	0
-8	A3	Support post	1.6	25	0.45	0.175	1.79	3.32	1	0
-7	A4	Support post	1.8	25	0.45	0.2	1.98	3.71	1	2
-6	A5	Support post	2.01	25	0.45	0.225	2.18	4.12	1	3
-5	A6	Support post	2.2	25	0.45	0.25	2.35	4.48	1	5
-4	A7	Support post	2.24	24.0	0.45	0.25	2.36	4.53	1	5
-3	A8	Support post	2.24	23.1	0.45	0.25	2.33	4.5	1	5
-2	A9	Support post	2.23	22.1	0.45	0.25	2.29	4.45	1	5
-1	A10	Support post	2.22	21.2	0.45	0.25	2.25	4.4	1	4
0	A11	Support post	2.15	20.2	0.45	0.25	2.36	4.44	1	4
1	A12	Support post	2.18	20.2	0.45	0.25	2.43	4.54	1	4
2	A13	Support post	2.17	20.3	0.45	0.25	2.49	4.59	1	4
3	A14	Support post	2.17	20.3	0.45	0.25	2.53	4.63	1	4
4	A15	Support post	2.18	20.4	0.6	0.25	2.57	4.68	1	4
5	A16	Support post	2.19	20.4	0.6	0.25	2.58	4.7	1	4
6	A17	Support post	2.21	21.3	0.6	0.25	2.61	4.75	1	5
7	A18	Support post	2.23	22.2	0.6	0.25	2.62	4.78	1	5
8	A19	Support post	2.26	23.2	0.6	0.25	2.62	4.81	1	5
9	A20	Support post	2.3	24.1	0.6	0.275	2.56	4.79	1	6
10	A21	Support post	2.34	25	0.6	0.275	2.6	4.87	1	6
11	A22	Support post	2.41	24.6	0.6	0.275	2.62	4.96	1	6
12	A23	Support post	2.48	24.2	0.6	0.275	2.65	5.06	1	6
13	A24	Support post	2.55	23.8	0.6	0.275	2.69	5.17	1	7
14	A25	Support post	2.60	23.4	0.6	0.275	2.74	5.27	1	7
15	A26	Support post	2.66	23	0.6	0.3	2.71	5.3	1	7
16	A27	Support post	2.65	23	0.6	0.3	2.72	5.3	1	7
17	A28	Support post	2.65	23	0.6	0.3	2.72	5.3	1	7
18	A29	Support post	2.64	23	0.6	0.3	2.73	5.3	1	7
19	A30	Support post	2.64	23	0.6	0.3	2.73	5.3	1	7
20	A31	Support post	2.64	23	0.6	0.3	2.73	5.3	1	7
21	A32	Support post	2.64	22.4	0.6	0.3	2.71	5.28	1	7
22	A33	Support post	2.65	21.8	0.6	0.275	2.74	5.32	1	7
23	A34	Support post	2.64	21.2	0.6	0.275	2.7	5.27	1	7
24	A35	Support post	2.64	20.6	0.6	0.275	2.68	5.25	1	7
25	A36	Support post	2.64	20	0.6	0.275	2.67	5.24	1	7
26	A37	Support post	2.65	20	0.6	0.275	2.72	5.3	1	7
27	A38	Support post	2.66	20	0.6	0.3	2.72	5.31	1	7
28	A39	Support post	2.67	20	0.6	0.3	2.77	5.37	1	7
29	A40	Support post	2.67	20	0.6	0.3	2.84	5.44	1	7
30	A41	Support post	2.66	20	0.6	0.3	2.91	5.5	1	7
31	A42	Support post	2.65	20	0.6	0.3	2.92	5.5	1	7
32	A43	Support post	2.64	20	0.6	0.3	2.93	5.5	1	7
33	A44	Support post	2.63	20	0.6	0.3	2.94	5.5	1	7
34	A45	Support post	2.63	20	0.6	0.3	2.94	5.5	1	7
35	A46	Support post	2.64	20	0.6	0.3	2.93	5.5	1	7
36	A47	Support post	2.67	20	0.6	0.3	2.92	5.52	1	7
37	A48	Support post	2.7	20	0.6	0.3	2.91	5.54	1	7
38	A49	Support post	2.73	20	0.6	0.3	2.91	5.57	1	7
39	A50	Support post	2.75	20	0.6	0.3	2.91	5.59	1	7
40	A51	Support post	2.76	20	0.6	0.3	2.92	5.61	1	7
41	A52	Support post	2.66	20	0.6	0.3	2.87	5.46	1	7
42	A53	Support post	2.55	20	0.6	0.3	2.83	5.31	1	7
43	A54	Support post	2.44	20	0.6	0.275	2.84	5.21	1	6
44	A55	Support post	2.33	20	0.6	0.275	2.8	5.06	1	6
45	A56	Support post	2.52	20	0.6	0.275	2.46	4.91	1	5
46	A57	Support post	2.23	19.2	0.6	0.275	2.73	4.89	1	5
47	A58	Support post	2.24	18.4	0.6	0.275	2.7	4.87	1	5
48	A59	Support post	2.26	17.6	0.6	0.25	2.72	4.91	1	5
49	A60	Support post	2.27	16.8	0.6	0.25	2.69	4.89	1	5
50	A61	Support post	2.55	16.0	0.6	0.25	2.39	4.87	1	4
51	A62	Support post	2.19	15.8	0.6	0.25	2.64	4.76	1	4
52	A63	Support post	2.11	15.6	0.45	0.25	2.61	4.65	1	3
53	A64	Support post	2.02	15.4	0.45	0.25	2.6	4.55	1	3
54	A65	Support post	1.94	15.2	0.45	0.25	2.57	4.44	1	3
55	A66	Support post	1.87	15.0	0.45	0.225	2.58	4.38	1	2
56	A67	Support post	1.78	14.8	0.45	0.225	2.48	4.19	1	2
57	A68	Support post	1.72	14.6	0.45	0.225	2.35	4	1	1
58	A69	Support post	1.68	14.4	0.45	0.2	2.25	3.86	1	0
59	A70	Support post	1.66	14.2	0.45	0.2	2.08	3.67	1	0
60	A71	Support post	1.66	14.0	0.45	0.2	1.89	3.48	1	0
61	A72	Support post	1.7	11.2	0.45	0.175	1.66	3.29	1	0
62	A73	Support post	1.73	8.4	0.45	0.175	1.4	3.06	1	0
63	A74	Support post	1.81	5.6	0.45	0.15	1.14	2.88	1	0
64	A75	Support post	1.92	2.8	0.45	0.15	0.81	2.66	1	0
65	A76	End post	2.03	0.0	0.45	0.15	0.49	2.45	1	0

Pole slope 6deg. **Concrete >=25mPa**	Hole size	Diameter	Hole depth Below finished level	length Actual post overall (does not include 100mm of concrete at bottom of hole)	Spacing (m)	Doubled boards