



## GEOTECHNICAL INVESTIGATION

Bank Stability Assessment  
Fitzroy River, Garnant

Report for: Alluvium Consulting Pty Ltd  
23332-002-Rev0  
29 November 2023

**Tectonic Geotechnical Pty Ltd**  
PO Box 899, Buderim QLD 4556  
Office: 07 5478 9016  
Email: [admin@tectonicgeo.com.au](mailto:admin@tectonicgeo.com.au)  
[www.tectonicgeo.com.au](http://www.tectonicgeo.com.au)  
A.B.N. 83 165 727 828

**tectonic**  
geotechnical & environmental engineers

## Document Review

Document No.	Revision	Prepared By	Reviewed By	Date Issued
002	0	Jarrad McVey	Ashley Davey	29 November 2023

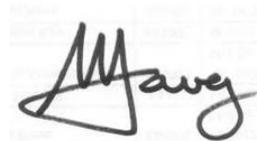
Document	Revision	Method of Delivery	Issued To
002	0	Electronic	Martin Grieve (martin.grieve@alluvium.com.au)
002	0	Electronic	James Teague (james.teague@alluvium.com.au)

Prepared By:



Jarrad McVey BEng  
Geotechnical Engineer

Reviewed By:



Ashley Davey RPEQ 8159  
Managing Director

## Executive Summary

This report details the results of a geotechnical investigation undertaken to assess the stability of eroding riverbanks at a site along Six Mile River, located at #275 Blanche Road, Garnant. The investigation was performed by Tectonic for Alluvium Consulting Pty Ltd (Alluvium), and comprised drilling of boreholes at two locations, *in situ* soil strength testing, and laboratory testing. This report summarises the results of the investigation, and provides recommendations regarding the following:

- Earthworks (including site preparation, excavatability and re-use of excavated materials);
- Potential erosion/scouring (including assessment of whether dispersive/slaking soils are present);
- Groundwater levels; and
- Conceptual slope stability analysis.

Previous assessments have been undertaken by Alluvium which suggest that there is a very high risk of further erosion at the site which could potentially threaten surrounding agricultural land and downstream infrastructure, along with releasing large amounts of sediment into the Great Barrier Reef Ecosystem. Alluvium has supplied preliminary sections indicating proposed flattening of riverbank profiles primarily by cut to achieve a grade of 1V:3H (33%). Site won fill may be used to infill the riverbank slopes.

The subsurface conditions encountered in the boreholes generally consisted of a surficial layer of topsoil, then very stiff to hard sandy/silty clays, of mostly low to medium plasticity to depths of 8.9 m and 13.1 m below ground level (BGL); then medium dense to very dense alluvial sands to depths of 15.5 m and 16 m BGL; underlain by interlayered stiff to very stiff clays and dense to very dense gravelly sands to the borehole terminations depths of 16 m and 16.5 m BGL.

Quantitative slope stability analysis indicates that the proposed stabilisation works would achieve long- and short-term factor of safety (FOS) values equalling or exceeding the current accepted industry standards of 1.5 and 1.3, respectively, and would significantly increase the FOS compared to the current geometry.

As the site generally contains steeply inclined to vertical erosion scarps, it is recommended that no personnel or plant work within 5 m of the crests of the riverbanks. It is envisaged that existing bank profiles would be flattened by large/long-reach excavators reaching out from safe positions behind or below the bank crests, followed by filling of depressions in the profile once safe batters are achieved, and exporting excess spoil from site.

Due to the potential adverse impacts from river flows and rainfall on constructability, it would be prudent to undertake the proposed works in the typically driest months of the year.

Excavations within the natural soils to the borehole termination depths are expected to be achievable using conventional earthmoving equipment such as tracked excavators with toothed buckets or small dozers. Driven piles (e.g. to create timber pile fields) should be feasible in the materials encountered in the boreholes, however pre-drilling would likely be required in the hard/dense materials. If proposed, the advice or a specialist piling contractor should be sought to determine the feasibility.

The proposed permanent bank batters of 1V:3H (33 %) are acceptable from a geotechnical viewpoint, with sufficient room existing for such batters. Temporary cuts may be formed at no steeper than 1V:1H in stiff (or stiffer)/medium dense (or denser) materials. These batter slopes assume that groundwater is not encountered, and that the works are undertaken during 'dry' weather conditions.

Temporary erosion protection (e.g. non-woven geosynthetic filter fabric, Jute matting etc.) should be installed to provide short term stabilisation to the banks following earthworks until vegetation is established for long term stabilisation. Specialist advice from an arborist must be sought to determine suitable plantings.

## Table of Contents

<b>1.0 INTRODUCTION</b> .....	<b>1</b>
<b>2.0 PROPOSED WORKS</b> .....	<b>1</b>
<b>3.0 SITE DESCRIPTION</b> .....	<b>1</b>
<b>4.0 METHOD OF INVESTIGATION</b> .....	<b>5</b>
4.1 Fieldwork .....	5
4.2 Laboratory Testing.....	5
<b>5.0 INVESTIGATION FINDINGS</b> .....	<b>6</b>
5.1 Geology .....	6
5.2 Subsurface Conditions.....	6
5.3 Geotechnical Laboratory Testing.....	7
<b>6.0 STABILITY ASSESSMENT</b> .....	<b>8</b>
<b>7.0 ENGINEERING ASSESSMENT</b> .....	<b>10</b>
7.1 Earthworks.....	10
7.1.1 Site Preparation and Trafficability .....	10
7.1.2 Excavations & Batter Slopes.....	11
7.1.3 Material Suitability for Re-Use & Erosion Protection .....	11
7.1.4 Filling.....	11
7.2 Geotechnical Parameters .....	12
<b>8.0 LIMITATIONS</b> .....	<b>12</b>
 <b>TABLES</b>	
Table 1: Summary of Atterberg Limits & Percent Fines Results.....	7
Table 2: Summary of ECN Tests.....	8
Table 3: Soil Parameters Adopted for Slope/W Analysis.....	8
Table 4: Slope/W analysis results .....	9
Table 5: Geotechnical Parameters .....	12

**TEXT FIGURES**

Text Figure 1: 2021 aerial image of the site and surrounds (courtesy QGlobe imagery) ..... 2

Text Figure 2: Oblique drone view of the site, looking south ..... 3

Text Figure 3 Near vertical drone imagery shown the site ..... 3

Text Figure 4: Looking east along Fitzroy River from the western end of the site ..... 4

Text Figure 5: Surrounding conditions, drone image looking west along Fitzroy River ..... 4

Text Figure 6: Extract of Ridglands Surface Geology Map..... 6

Text Figure 7: Summary of Atterberg Limits Testing ..... 7

**FIGURES**

Figure 1: Site Plan

**APPENDICES**

**APPENDIX A**

Borehole Reports and Explanatory Notes

**APPENDIX B**

Laboratory Test Certificates

**APPENDIX C**

Slope/W Outputs

**APPENDIX D**

Limitations

## 1.0 INTRODUCTION

This report details the results of a geotechnical investigation undertaken to assess the stability of eroding riverbanks at a site along the Fitzroy River, located at #275 Blanche Road, Garnant. The investigation was performed by Tectonic for Alluvium Consulting Pty Ltd (Alluvium), generally in accordance with our proposal P23315-Rev2, dated 9 October 2023.

The investigation comprised drilling of boreholes at two locations, *in situ* soil strength testing, and laboratory testing. This report summarises the results of the investigation, and provides recommendations regarding the following:

- Earthworks (including site preparation, excavatability, batter slopes and re-use of excavated materials);
- Potential erosion/scouring (including assessment of whether dispersive/slaking soils are present);
- Groundwater levels; and
- Conceptual slope stability analysis.

## 2.0 PROPOSED WORKS

The subject site is described as the Fitzroy River Site, located at the northern end of the property at 275 Blanche Road on the southern bank of the Fitzroy River. Previous assessments have been undertaken by Alluvium which suggest that there is a very high risk of further erosion at the site which could potentially threaten surrounding agricultural land and downstream infrastructure, along with releasing large amounts of sediment into the Fitzroy Basin.

Alluvium has indicated to us that the following remediation options have been considered:

- Bank battering and revegetation.
- Bank battering, revegetation and rock protection.
- Bank battering, revegetation, rock protection and pile fields.

Preliminary sections supplied to Tectonic indicate that the conceptual design includes battering the existing bank profiles (flattening) using mostly cut excavation. Some localised filling at the toes of the banks may be required at selected locations, such as where the design batter 'daylights' through an existing over steepened slump zone. Bank flattening would achieve a finished design grade in the order of about 1V:3H (33 %). Based on previous investigations completed by Tectonic for Alluvium, it is understood that a combination of rock toe protection at the upstream extents and pile fields may also be utilised.

## 3.0 SITE DESCRIPTION

The Fitzroy River is the lower course of the Fitzroy Basin catchment and drains into the Great Barrier Reef Marine Park at the mouth located to the east of Rockhampton. The Fitzroy River collects water from a large catchment that extends as far as Moranbah to the north, Clermont to the west and Taroom to the south.

The subject site is located at the northern end of 275 Blanche Road, Garnant, being about 40 km north-west ('as the crow flies') from Rockhampton. Surrounding lands comprised relatively flat, cleared pastoral ground that drops off steeply into the river. Sporadic groves of small and mature trees and shrubs were noted across the site, particularly around the riverbanks. The property was being used by CQ Organics as an organic beef farm at the time of the investigation. The investigation site comprised the southern bank of a relatively straight section of the meandering Fitzroy River that generally runs west to east. Significant evidence of erosion was observed at the site. An aerial image of the site locality and surrounds is provided in Text Figure 1 overleaf.



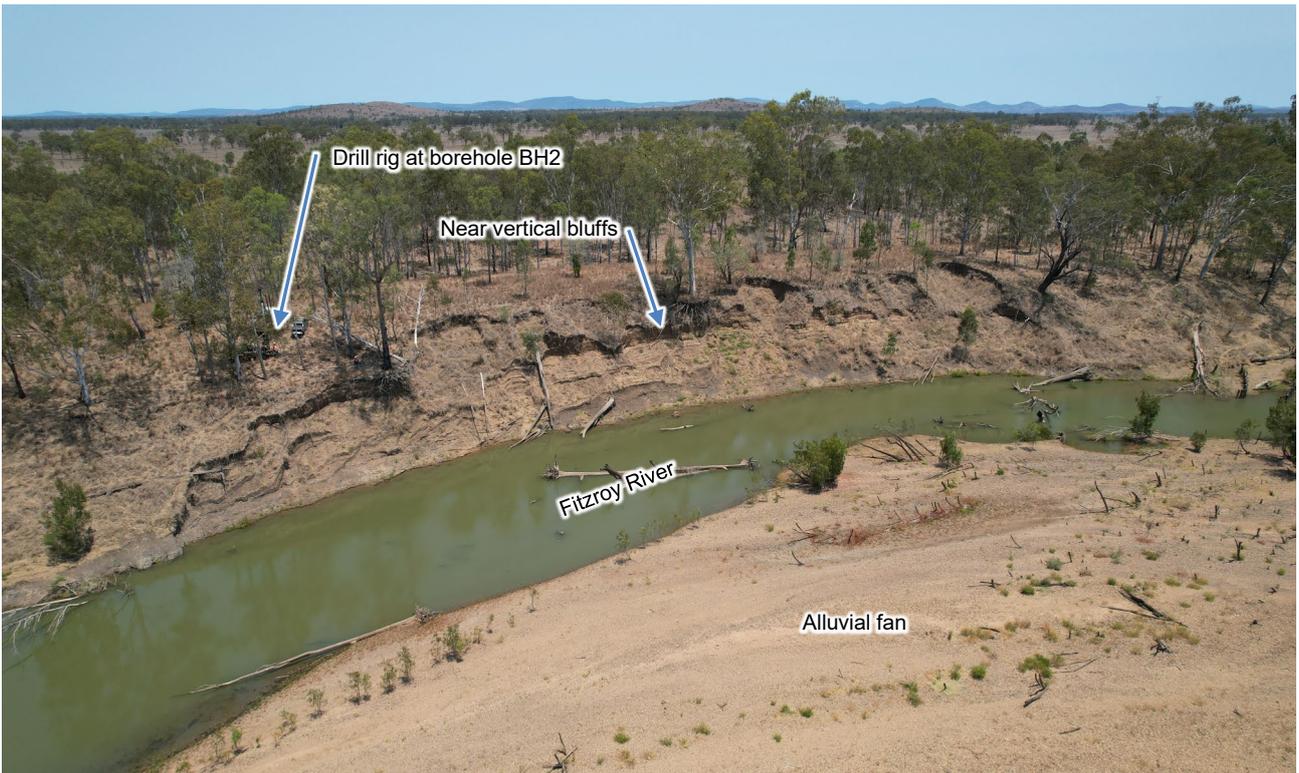
*Text Figure 1: 2021 aerial image of the site and surrounds (courtesy QGlobe imagery)*

The banks along the site featured a range of geometries, with significant evidence of erosion and previous bank slumping observed consistently, and debris fields present in multiple sections along the riverbed.

Generally, there was a near vertical upper bluff estimated to range between about 1 m and 7 m high developed beneath the crest, with slumped debris forming a lower bank estimated to range up to about 7 m high, which dipped into the river between about 35° and 45°. Materials exposed in the banks appeared to comprise mostly interlayered sandy clays and clayey sands. Irregular and overhanging crests were noted, with tension cracking observed behind the crest in the soil mass, which may cause the material to fail by 'sheeting off' the face and toppling from the crest. The overall height from the crest to the water surface was estimated to be in the order of about 14 m.

The riverbed generally comprised sands, gravel and, cobbles, with a large alluvial fan formed on the opposing bank. Vegetation behind the crest consisted of a zone of large mature trees followed by grassed grazing paddocks. The backslope of the riverbanks typically dipped away at about 20° towards a drainage line which ran parallel to the main riverbank. It appeared that the section of the river immediately to the west of the investigation site had previously been stabilised with a timber pile field.

Site conditions at the time of the investigation are illustrated in Text Figures 2 to 5 on the following pages.



*Text Figure 2: Oblique drone view of the site, looking south*



*Text Figure 3 Near vertical drone imagery shown the site*



*Text Figure 4: Looking east along Fitzroy River from the western end of the site*



*Text Figure 5: Surrounding conditions, drone image looking west along Fitzroy River*

## **4.0 METHOD OF INVESTIGATION**

### **4.1 Fieldwork**

An experienced geotechnical engineer undertook walkover mapping of the site and drone surveying of the riverbanks on 25 October 2023. This was followed by an intrusive investigation comprising two boreholes (designated BH1 and BH2) drilled to depths of 16 m and 16.5 m below ground level (BGL). The boreholes were drilled with a tracked vehicle mounted rotary rig utilising a combination of solid flight augering and cased wash boring methods. The rig was owned and operated by Drillsure Geotechnical Pty Ltd. Boreholes were drilled as close as possible to the locations nominated by Alluvium, having regard for safe setbacks from the riverbank crests.

*In situ* testing comprised standard penetration tests (SPTs) at regular intervals (generally 1.5 m spacing) within all boreholes. Pocket penetrometer (PP) testing was undertaken on relatively undisturbed auger cuttings and SPT samples in cohesive materials.

Fieldwork was undertaken in the presence of an experienced geotechnical engineer from Tectonic between 25 and 26 October 2023. The engineer was responsible for logging subsurface profiles in accordance with AS1726 *Geotechnical site investigations*, making groundwater observations, and recovering soil samples. All boreholes were backfilled with 'Octoplugs' and drilling spoil on completion, with excess spoil and drilling mud spread across well vegetated areas. Borehole locations were recorded using a handheld GNSS survey device with a reported accuracy to  $\pm 0.3$  m.

Borehole reports are attached in Appendix A, together with explanatory notes. Borehole locations are shown in Figure 1, attached at the end of this report.

### **4.2 Laboratory Testing**

Disturbed samples recovered from the boreholes were dispatched to Construction Sciences, a NATA accredited laboratory based in Kunda Park, for geotechnical testing. Laboratory testing was undertaken in accordance with Australian Standard AS 1289 *Method for Testing Soils for Engineering Purposes* and comprised:

- Four Atterberg Limits, Linear Shrinkage and Particle Size Distribution (PSD) tests for soil classification purposes.
- Three Emerson Class Number (ECN) tests for an assessment of soil dispersiveness.

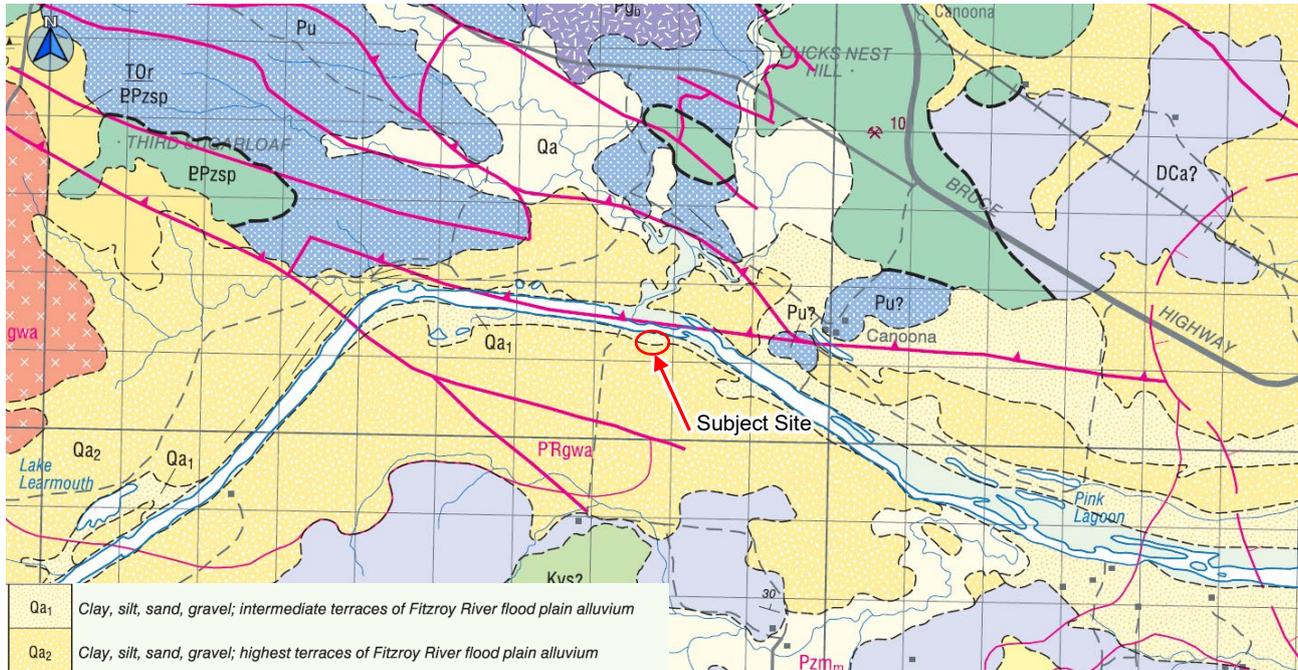
An ECN test could not be completed on the sample from borehole BH1 at 11.5 m to 11.95 m BGL due to the granular nature of the material, as shown in the PSD result.

Laboratory test results are summarised in Section 5.3. Laboratory certificates are attached in Appendix B.

## 5.0 INVESTIGATION FINDINGS

### 5.1 Geology

The 1:100,000 scale Ridgeland Surface Geology Map (DNRME, Sheet 8951, dated March 2006) indicates that the site is located at an interface of Quaternary age intermediate and highest terraces of the Fitzroy River flood plain alluvium, both comprising 'clay, silt, sand and gravel'. An extract of the relevant geological map is shown in Text Figure 6.



Text Figure 6: Extract of Ridgeland Surface Geology Map

### 5.2 Subsurface Conditions

The subsurface conditions encountered in the boreholes were generally consistent, summarised as follows:

- **Topsoil** – medium dense, silty sand from the ground surface to 0.1 m BGL; then
- **Alluvial Clays** – silty/sandy clays of generally low to medium plasticity and very stiff to hard consistency, interlayered with silty clayey sand layers up to 300 mm thick, to depths of 8.9 m and 13.1 m BGL; then
- **Alluvial Sands** – medium dense (BH1) and dense to very dense (BH2), fine to coarse grained sands to depths of 15.5 m and 16 m BGL; overlying
- **Interlayered Alluvial Soils** – comprising either stiff to very stiff, medium to high plasticity clays or dense to very dense, gravelly sands to the borehole termination depths of 16 m and 16.5 m BGL.

Due to the methodology adopted for the investigation, that being cased wash boring, and the introduction of drilling fluids and water from relatively shallow depths (generally 2.5 m BGL), it was not possible to measure groundwater within the scope of the investigation. Groundwater levels are broadly expected to be cognisant with the equivalent water level in the Fitzroy River channel, proliferating in more permeable horizons such as the deeper alluvial sands.

Detailed descriptions of the subsurface conditions encountered in the boreholes are provided in the borehole reports attached in Appendix A, along with definition sheets which describe terms and abbreviations used on the report sheets.

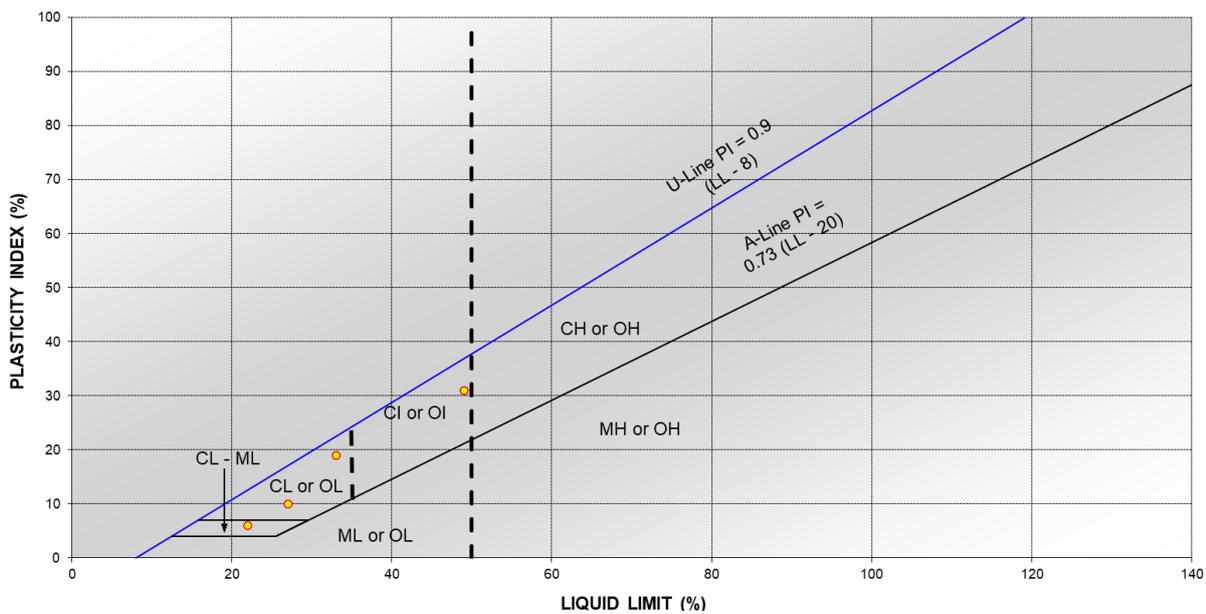
### 5.3 Geotechnical Laboratory Testing

Table 1 summarises the results of geotechnical soil classification laboratory testing conducted on samples recovered from the boreholes. Text Figure 7 also presents the test results graphically for reference and classification purposes. Laboratory reports are given in Appendix B.

**Table 1: Summary of Atterberg Limits & Percent Fines Results**

BH No.	Depth (m)	Atterberg Limits				Percent Fines (<0.075 mm)
		Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	
BH1	1.0 – 1.45	27	17	10	8.5	43
BH1	11.5 – 11.95	22	16	6	2.0	8
BH2	5.5 – 5.95	33	14	19	11.5	47
BH2	11.5 – 11.95	49	18	31	15.5	84

**UNIFIED SOIL CLASSIFICATION SYSTEM PLASTICITY (CASAGRANDE) CHART**



*Text Figure 7: Summary of Atterberg Limits Testing*

Laboratory testing indicates that the clays tested were of low to medium plasticity. PSD testing of the more clayey samples generally indicated the soils were silty/sandy clays with fine to medium grained sands. It is noted that the coarse-grained sample tested was a fine to coarse grained sand with low plasticity clay fines.

Table 2 below summarises the results of ECN tests conducted on samples recovered from the boreholes. Laboratory reports are given in Appendix B.

**Table 2: Summary of ECN Tests**

BH No.	Depth (m)	Sample Type	ECN
BH1	1.0 – 1.45	Sandy Clay	5
BH2	5.5 – 5.95	Sandy Clay	5
BH2	11.5 – 11.95	Silty Clay	5

Laboratory testing indicates that the soil samples tested had ECN values of 5, which indicates that during testing there was slaking and no dispersion before remoulding, and no dispersion after remoulding; however, some dispersion after slaking in a 1:5 soil/water suspension. These soils are estimated to have low to moderate erosion potential.

In general, it should be noted that although the sands are non-dispersive by their nature, where unprotected such materials would have a moderate to high erosion potential when exposed to fast flowing water, which would be expected during flood events.

## 6.0 STABILITY ASSESSMENT

Slope stability modelling has been carried out using Slope/W, to assess the factor of safety (FOS) against instability considering one critical section based on the proposed batter profiles provided by Alluvium.

A subsurface cross-section was developed in the area of borehole BH1 (Section A-A', ref. Figure 1) using the borehole information, along with the proposed ground surface profile advised by Alluvium. Some inferences regarding subsurface conditions have been made short distances away from test locations, and typically the more adverse ground conditions were adopted for the analysis.

A surcharge load of 5 kPa has been applied across the crest areas of the proposed batter profiles, to replicate potential transient live loads (e.g. excavators, etc.).

The soil parameters adopted for the analyses are summarised in Table 3 and are based on interpretation of the site investigation and laboratory test results which are consistent with the range of values recommended for similar materials in Appendix D of Australian Standard AS4678-2002 *Earth Retaining Structures*.

**Table 3: Soil Parameters Adopted for Slope/W Analysis**

Material Description	Unit Weight (kN/m <sup>3</sup> )	Effective Cohesion, c' (kPa)	Effective Friction Angle, $\phi'$ (°)
Stiff to Very Stiff Silty Clays	18	5	25
Very Stiff to Hard, Silty Sandy Clay	20	7	27
Medium Dense Sands	18	0	32
Dense (or Denser) Gravelly Sands	20	0	34
Site Won Fill	18	3	25

Analyses were undertaken to assess the global stability for both long-term, and more adverse short-term conditions. For long-term analysis, a groundwater level was generally adopted in the model using a piezometric line approximate to the riverbed level. Modelling assumes that any fill used will comprise reused cohesive based materials won from excavations into the riverbanks.

For the existing profile, a FOS value of 0.8 was recorded which is expected given the observed failures of the existing banks in the investigation area. From a global stability perspective, the modelling indicates that the reprofiling of the banks and works proposed by Alluvium would result in a significantly increased FOS, in excess of 1.5, which is the commonly adopted industry standard for long-term conditions.

Short-term conditions were modelled for an anticipated 'rapid drawdown' of the groundwater level following a flood event, resulting in an elevated piezometric line in the alluvial sands grading down to the approximate riverbed level. A FOS value of 1.3 was indicated from the modelling, being in line with the commonly adopted industry standard FOS value of 1.3 for short-term conditions.

The results of the analyses indicate acceptable FOS values can be achieved for the proposed batter profiles analysed, with the results presented in Table 4. Slope/W outputs are attached in Appendix C.

**Table 4: Slope/W analysis results**

Analysis	Description	Factor of Safety
Analysis 1 – Existing Profile	Long Term Conditions	0.8
Analysis 2 – Proposed Cut Batter	Long Term Conditions	1.8
Analysis 3 – Proposed Cut Batter	Short Term Conditions (Drained Parameters)	1.3

Considering the results of the investigation and Slope/W modelling, subject to the implementation of recommendations given in Section 7 for the proposed reprofiling works, it is assessed that there would be a **Low Risk** of global slope instability affecting the proposed riverbank profiles at the subject site in accordance with the Australian Geomechanics Society *Guidelines for Landslide Risk Management*, dated March 2007 (AGS 2007).

## 7.0 ENGINEERING ASSESSMENT

Riverbank stabilisation design had not been finalised at the time of reporting. However, we understand that the design principals will include re-profiling of the bank to 1V:3H (33%). Investigations for Alluvium previously completed by Tectonic have also included a combination of rock toe protection at the upstream extents and pile fields for the stabilisation of the riverbanks. It is anticipated that erosion matting may be placed on the finished bank slopes prior to revegetation.

The cause of erosion and instability at this site appears to be due to scour of the alluvial soils, in particular the sands lower in the banks, from fast flowing river water (fluvial erosion) during high flow events, leading to undercutting and bank collapse. This would be particularly concentrated on the outside of bends in the meandering channel (where flow velocity and turbulence are typically greater). ECN and PSD testing indicates that the upper clay soils have low to moderate erosion potential. The combination of these adverse factors ultimately appears to have resulted in the instability of the riverbanks.

Due to the steeply inclined to subvertical nature of the erosion scarps, it is recommended that construction personnel and plant maintain a minimum horizontal setback of 5 m from the crest areas of the riverbanks. It is envisaged that existing bank profiles would be flattened by large/long-reach excavators reaching out from safe positions behind or below the bank crests.

### 7.1 Earthworks

Earthworks for the stabilisation of the riverbanks are expected to comprise re-profiling followed by a revegetation program and possibly installation of rock toe protection and pile fields. It is understood that mostly cutting will be required to achieve the desired batter profiles; however, site won fill may be used to infill the backslope and parts of the trough behind the crest of the banks.

Due to the potential impacts of river flows and rainfall on constructability, it would be prudent to undertake the proposed works in the typically driest months of the year. It would be particularly important not to undertake any earthworks during or following heavy or prolonged rainfall. Unprotected batters would be highly susceptible to fluvial erosion during high rainfall and flood events.

#### 7.1.1 Site Preparation and Trafficability

Following clearing of vegetation (where required), trees stumps and large roots could be left in place to provide some reinforcement to the soils, however any organic rich topsoil should be stripped from the construction area and stockpiled. Topsoil materials should be excluded from structural fill; however, may be spread across the batter for revegetation purposes.

All failed materials and debris must be removed and cut back to expose intact natural soils to accommodate future filling, adhering to temporary stability constraints (i.e. batter/benched approach no steeper than 1V:1H, provided groundwater seepage is not encountered). This will include any materials behind the crest of the existing backscarps which show signs of slumping/tension cracking etc.

Care must be taken when working near the toe of the riverbank to ensure excavations do not adversely affect the banks by undermining. Due to the possibility of slumping of the riverbank during construction, the works should be conducted adopting a 'top down' approach, starting behind the riverbank crest and working down to the bed level. Care must also be taken when placing soil stockpiles (e.g. from site won stripping) on site. Stockpiles must be placed at least 10 m back from the riverbank crests and above flood levels.

After stripping and excavation to the design levels, the subgrade is expected to comprise mostly stiff (or stiffer) natural clays and medium dense (or denser) sands. Although relatively good trafficability should be encountered during 'dry' weather conditions, the soils could be subject to strength loss from repetitive vehicle loading (particularly from rubber tyred plant) or if they become wet. Due to the potential for poor trafficability during and after wet periods, placement of a minimum 150 mm thick granular working platform may be required on subgrades, particularly along haul roads, and across access and laydown areas.

Specific design would need to be carried out to determine working platform requirements for any heavy plant (e.g. mobile cranes and piling rigs), and a thicker rock fill platform may be required than suggested above. Tectonic can provide specific advice regarding working platform construction, if required.

In general, the site should be graded to shed surface water runoff away from construction areas. This may comprise graded surfaces or swale drains graded to discharge collected waters to a control point(s) before release off-site. Appropriate erosion and sediment control measures must be installed prior to commencement of earthworks at this site. It is anticipated that a silt curtain may need to be installed in the river around the work site, depending on river level at the time of construction.

### **7.1.2 Excavations & Batter Slopes**

Excavations within the natural soils to the borehole termination depths are expected to be achievable using conventional earth moving equipment such as tracked excavators with toothed buckets or small dozers. Driven piles should be feasible in the materials encountered in the boreholes, however pre-drilling of hard/dense soils would likely be required. If proposed, the advice of a specialised piling contractor should be sought to determine the feasibility.

The proposed permanent bank batters of 1V:3H (33 %) are acceptable from a geotechnical viewpoint, with sufficient room existing for such batters. Temporary cuts in the profile may be formed at no steeper than 1V:1H in stiff (or stiffer)/medium dense (or denser) materials. Any firm/loose (or weaker) soils should be temporarily battered at no more than 1V:1.5H. Flatter temporary batters will be required if groundwater seepage is encountered, or earthworks are undertaken during or after heavy or prolonged rainfall.

A stepped battering/benching profile may be adopted for temporary batters during construction (e.g. 1 m high batters and 1 m wide benches formed at 1V:1H overall). As recommended above, work must commence from behind the crest of the bank until a permissible temporary batter (i.e. 1V:1H to 1V:1.5H or flatter) is achieved before undertaking any works near the toe or below the crest of the river bank.

Permanent soil or fill batters will require erosion protection such as revegetation by landscaping (e.g. topsoil, Jute matting and planting), as soon as possible after the reprofiling. Non-woven geosynthetic filter fabric (e.g. Bidim A19 or equivalent) could be installed to provide short term protection from direct rainfall erosion to the banks during earthworks.

Any excavations required adjacent to nearby features (e.g. fence lines and trees), will need to be specifically designed to ensure that such features are not undermined.

### **7.1.3 Material Suitability for Re-Use & Erosion Protection**

Laboratory testing indicates that the upper clay samples tested had ECN values of 5 and therefore they are expected to have low to moderate erosion potential. Therefore, the clay soils where free of deleterious materials (e.g. organics etc.) are expected to be suitable for re-use as fill behind the crest of the riverbanks, subject to appropriate moisture adjustment; however, robust erosion protection (e.g. rock rip rap) may be required if the clay soils are to be reused near the toe of the reprofiled slopes.

As the existing sands are considered to have a moderate to high erosion potential (where unprotected), these materials are not considered suitable to be re-used as fill unless protected at the surface from erosion. Provided that sands and gravels are free of deleterious materials (e.g. organics, oversize etc.) they would be considered suitable for reuse off-site, subject to appropriate moisture adjustment.

Due to the likely high velocity of the river during flood events, fluvial erosion would be anticipated to affect the soils where unprotected. Therefore, it is recommended that surfaces of the final batters be protected as soon as possible after construction (e.g. Jute matting and revegetation).

Any erosion protection measures must be designed by a suitably qualified person. To achieve maximum erosion protection, riparian vegetation typically needs to include a mixture of overstorey, middle-storey, groundcover and macrophyte native plant species. Specialist advice from a qualified arborist must be sought to determine suitable plantings (grass, shrubs, trees) for this area.

### **7.1.4 Filling**

All fill should be compacted at moisture contents within the range of  $\pm 2$  % of optimum moisture content for Standard Compaction. Fill should be placed in maximum 200 mm thick (loose thickness) layers and be compacted by repeated rolling to achieve a dry density ratio of at least 95 % of the maximum DDR (Standard Compaction method), or 75 % of the Dry Density Index for cohesionless fills (e.g. sands).

Fill must be ‘benched’ into the natural soil, over-filled by 0.5 m (horizontally) and then trimmed back to the well compacted material.

## 7.2 Geotechnical Parameters

Table 5 below provides estimated geotechnical parameters for the typical soil layers encountered in the boreholes, based on empirical correlations using field data. Please refer to the borehole reports and explanatory notes in Appendix A for particle size and layer depths encountered during the investigation.

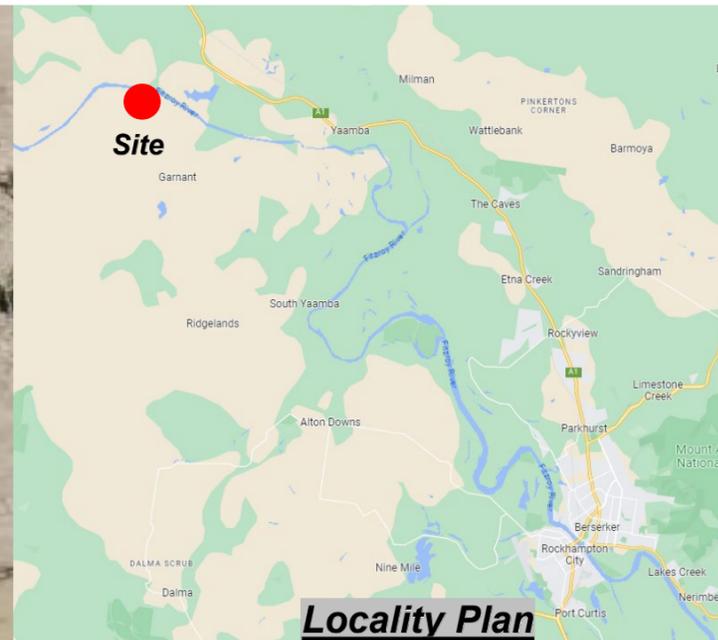
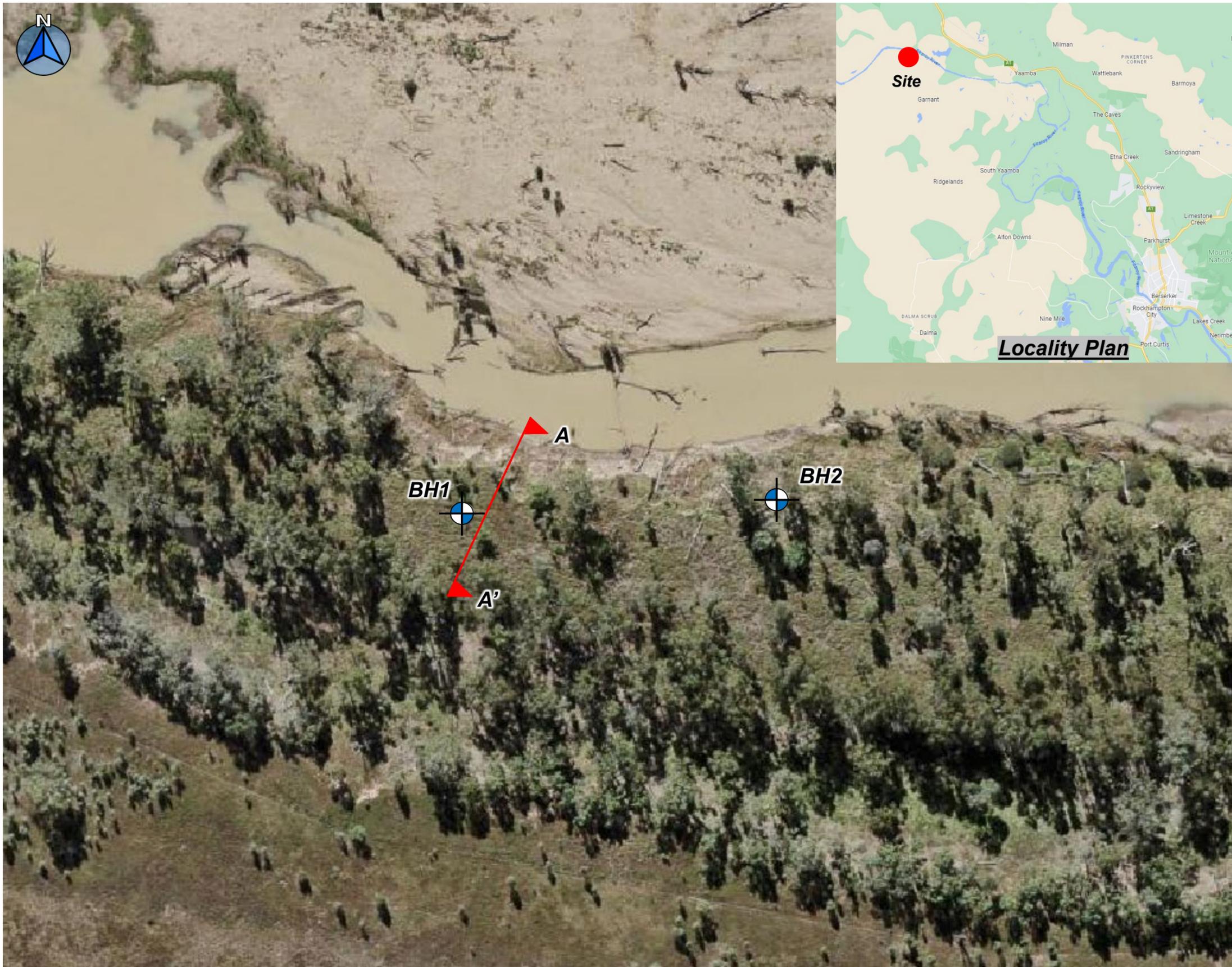
**Table 5: Geotechnical Parameters**

Material	Unit weight $\gamma$ (kN/m <sup>3</sup> )	Effective Friction angle $\phi'$ (°)	Effective Cohesion $c'$ (kPa)	Undrained Shear Strength $c_u$ (kPa)
Stiff to Very Stiff Silty Clays	18	5	25	50 to 100
Very Stiff to Hard, Silty Sandy Clay	20	7	27	100 to 200
Medium Dense Sands	18	0	32	NA
Dense (or Denser) Gravelly Sands	20	0	34	NA

Note: NA – Not Applicable

## 8.0 LIMITATIONS

Your attention is drawn to the document *Limitations*, which is included in Appendix D of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimise the risks associated with the services provided by Tectonic for this project.



PROJECT:  
**BANK STABILITY ASSESSMENT  
FITZROY RIVER, GARNANT**

TITLE:  
**SITE PLAN**

CLIENT:  
**ALLUVIUM CONSULTING**

DRAWN:  
**JM**

DATE:  
**07/11/2023**

CHECKED:  
**ACD**

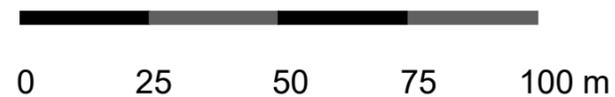
DATE:  
**21/11/2023**

SCALE:  
**AS SHOWN**

LEGEND:

-  APPROXIMATE BOREHOLE LOCATIONS
-  APPROXIMATE SLOPE/W SECTION

Notes: Aerial imagery courtesy of QGlobe, dated August 2021



PROJECT NO.:	FIGURE:	REV:
23332-002	1	0

# **APPENDIX A**

## **Borehole Reports & Explanatory Notes**

**Engineering Log - Borehole**

Project No.: 23332-002

Client: Alluvium Consulting	Commenced: 25/10/2023
Project Name: Proposed Bank Stabilisation	Completed: 25/10/2023
Hole Location: Fitzoy River, Garnant	Logged By: JM
Hole Position: 217495.0 m E 7441386.5 m N MGA2020 Zone 56	Checked By: MCC

Drill Model and Mounting: Hydrapower Scout	Inclination: -90°	RL Surface: 20.40 m
Hole Diameter: 100 mm	Bearing: 360°	Datum: AHD Operator: Drillsure

Drilling Information				Material Description and Observations										
Method	Penetration	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description soil type: plasticity or particle characteristics, secondary and minor components, colour	Moisture Condition	Consistency Relative Density	Pocket Penetrometer UCS (kPa)	Shear Vane Test (kPa)	Structure and Additional Observations	
AD/T RD	Groundwater not encountered above and not observed below 2.5m	DS 0.5-0.8m SPT 8,9,9 N=18		19.4	1		CL	Silty SAND, (TOPSOIL), fine to medium grained, brown, with rootlets	MD		500		0.00: TOPSOIL 0.10: ALLUVIAL	
		SPT 3,4,6 N=10		18.4	2			Silty Sandy CLAY, low plasticity, brown, fine to medium grained sand, interlayered with loose to medium dense silty clayey sand layers generally 200-300mm thick	VSt		450			
		SPT 6,9,11 N=20		17.4	3						500			
		SPT 6,9,11 N=20		16.4	4			becoming medium plasticity, interlayered with medium dense sand layers	D to M		500			
		SPT 6,9,9 N=18		15.4	5						450			
		SPT 6,11,12 N=23		14.4	6					H		450		
		SPT 6,11,12 N=23		13.4	7							500		
		SPT 4,5,8		12.4	8					VSt		350		

<p><b>Method</b></p> <p>AD/T - Auger Drilling TC Bit AD/V - Auger Drilling V Bit RT - Rotary Tri-cone Bit RD - Rotary Drilling NMLC - Rock Core HA - Hand Auger</p>	<p><b>Penetration</b></p> <p>VE - Very Easy E - Easy F - Firm H - Hard VH - Very hard</p>	<p><b>Water</b></p> <p>Level (Date) Inflow Partial Loss Complete Loss</p>	<p><b>Samples and Tests</b></p> <p>U## - Undisturbed Sample (## mm) DS - Disturbed Sample BDS - Bulk Disturbed Sample SPT - Standard Penetration Test</p>	<p><b>Moisture Condition</b></p> <p>D - Dry M - Moist W - Wet</p>	<p><b>Consistency/Relative Density</b></p> <p>VS - Very Soft S - Soft F - Firm VSt - Very Stiff H - Hard VL - Very Loose L - Loose MD - Medium Dense D - Dense VD - Very Dense Fr - Friable</p>
<p><b>Graphic Log/Core Loss</b></p> <p> Core recovered (hatching indicates material)  Core loss</p>		<p><b>Classification Symbols and Soil Descriptions</b></p> <p>Based on Unified Soil Classification System</p>		<p><b>Plastic Limit</b></p> <p>&lt; PL = PL &gt; PL</p>	

**Engineering Log - Borehole**

Project No.: 23332-002

Client: Alluvium Consulting	Commenced: 25/10/2023
Project Name: Proposed Bank Stabilisation	Completed: 25/10/2023
Hole Location: Fitzroy River, Garnant	Logged By: JM
Hole Position: 217495.0 m E 7441386.5 m N MGA2020 Zone 56	Checked By: MCC

Drill Model and Mounting: Hydrapower Scout	Inclination: -90°	RL Surface: 20.40 m
Hole Diameter: 100 mm	Bearing: 360°	Datum: AHD Operator: Drillsure

Drilling Information				Material Description and Observations																				
Method	Penetration	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description soil type: plasticity or particle characteristics, secondary and minor components, colour	Moisture Condition	Consistency Relative Density	Pocket Penetrometer UCS (kPa)	Shear Vane Test (kPa)	Structure and Additional Observations										
RD	Groundwater not encountered above and not observed below 2.5m		N=13	11.4	9	[Yellow dotted pattern]	SP	SAND, fine to coarse grained, yellow brown, with low plasticity clay, trace fine to coarse sized subrounded gravels	M	MD				8.90: RIVER SAND										
			SPT 8,9,14 N=23	10.4	10																			
			SPT 7,12,16 N=28	9.4	11																			
			SPT 7,13,15 N=28	8.4	12																			
				7.4	13																			
			SPT 7,13,15 N=28	6.4	14																			
				5.4	15																			
			SPT 2,17,30 N=47	4.4	16										CI-CH	Silty CLAY, medium to high plasticity, dark grey, trace fine grained sand	St to VSt							
															SP	Gravelly SAND, fine to coarse grained, grey, fine to coarse subrounded gravels, trace clay	D to VD							
																	3.4	17		Hole Terminated at 16.50 m Target depth				

<p><b>Method</b></p> <p>AD/T - Auger Drilling TC Bit AD/V - Auger Drilling V Bit RT - Rotary Tri-cone Bit RD - Rotary Drilling NMLC - Rock Core HA - Hand Auger</p>	<p><b>Penetration</b></p> <p>VE - Very Easy E - Easy F - Firm H - Hard VH - Very hard</p>	<p><b>Water</b></p> <p>Level (Date) Inflow Partial Loss Complete Loss</p>	<p><b>Samples and Tests</b></p> <p>U## - Undisturbed Sample (## mm) DS - Disturbed Sample BDS - Bulk Disturbed Sample SPT - Standard Penetration Test</p>	<p><b>Moisture Condition</b></p> <p>D - Dry M - Moist W - Wet</p>	<p><b>Consistency/Relative Density</b></p> <p>VS - Very Soft S - Soft F - Firm VSt - Very Stiff H - Hard VL - Very Loose L - Loose MD - Medium Dense D - Dense VD - Very Dense Fr - Friable</p>
<p><b>Graphic Log/Core Loss</b></p> <p>[Yellow dotted pattern] Core recovered (hatching indicates material) [Yellow solid pattern] Core loss</p>		<p><b>Classification Symbols and Soil Descriptions</b></p> <p>Based on Unified Soil Classification System</p>		<p><b>Plastic Limit</b></p> <p>&lt; PL = PL &gt; PL</p>	

TECTONIC 3.00.2 LIB.GLB Log 1 TECTONIC BOREHOLE 23332-002.GPJ <<DrawingFile>> Z71112023 23:23 10.02.00.04 Datagel Lab and In Situ Tool - DGD | Lib: Tectonic 3.00.2 2021-03-30 Proj: Tectonic 3.00.2 2021-03-30

**Engineering Log - Borehole**

Project No.: 23332-002

Client: Alluvium Consulting	Commenced: 25/10/2023
Project Name: Proposed Bank Stabilisation	Completed: 25/10/2023
Hole Location: Fitzoy River, Garnant	Logged By: JM
Hole Position: 217602.3 m E 7441387.5 m N MGA2020 Zone 56	Checked By: MCC

Drill Model and Mounting: Hydrapower Scout	Inclination: -90°	RL Surface: 18.00 m
Hole Diameter: 100 mm	Bearing: 360°	Datum: AHD Operator: Drillsure

Drilling Information				Material Description and Observations											
Method	Penetration	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description soil type: plasticity or particle characteristics, secondary and minor components, colour	Moisture Condition	Consistency Relative Density	Pocket Penetrometer UCS (kPa)	Shear Vane Test (kPa)	Structure and Additional Observations	
AD/T RD	Groundwater not encountered above and not observed below 2.5m		DS 0.4-0.7m		17.0	1		CL	Silty SAND, (TOPSOIL), fine to medium grained, brown, with rootlets	D to M	MD			0.00: TOPSOIL 0.10: ALLUVIAL	
			SPT 7,7,7 N=14		16.0	2		becoming dark brown							
			SPT 6,10,11 N=21		15.0	3									
			SPT 8,16,15 N=31		14.0	4									
			SPT 7,11,13 N=24		13.0	5									
			SPT 9,15,17 N=32		12.0	6									
			SPT 7,9,13		11.0	7									
					10.0	8									

<p><b>Method</b></p> <p>AD/T - Auger Drilling TC Bit AD/V - Auger Drilling V Bit RT - Rotary Tri-cone Bit RD - Rotary Drilling NMLC - Rock Core HA - Hand Auger</p>	<p><b>Penetration</b></p> <p>VE - Very Easy E - Easy F - Firm H - Hard VH - Very hard</p>	<p><b>Water</b></p> <p>Level (Date) Inflow Partial Loss Complete Loss</p>	<p><b>Samples and Tests</b></p> <p>U## - Undisturbed Sample (## mm) DS - Disturbed Sample BDS - Bulk Disturbed Sample SPT - Standard Penetration Test</p>	<p><b>Moisture Condition</b></p> <p>D - Dry M - Moist W - Wet</p>	<p><b>Consistency/Relative Density</b></p> <p>VS - Very Soft S - Soft F - Firm VSt - Very Stiff H - Hard VL - Very Loose L - Loose MD - Medium Dense D - Dense VD - Very Dense Fr - Friable</p>
<p><b>Graphic Log/Core Loss</b></p> <p> Core recovered (hatching indicates material)  Core loss</p>	<p><b>Classification Symbols and Soil Descriptions</b></p> <p>Based on Unified Soil Classification System</p>	<p><b>Plastic Limit</b></p> <p>&lt; PL = PL &gt; PL</p>			

**Engineering Log - Borehole**

Project No.: 23332-002

Client: Alluvium Consulting	Commenced: 25/10/2023
Project Name: Proposed Bank Stabilisation	Completed: 25/10/2023
Hole Location: Fitzroy River, Garnant	Logged By: JM
Hole Position: 217602.3 m E 7441387.5 m N MGA2020 Zone 56	Checked By: MCC

Drill Model and Mounting: Hydrapower Scout	Inclination: -90°	RL Surface: 18.00 m
Hole Diameter: 100 mm	Bearing: 360°	Datum: AHD Operator: Drillsure

Drilling Information				Material Description and Observations											
Method	Penetration	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description soil type: plasticity or particle characteristics, secondary and minor components, colour	Moisture Condition	Consistency Relative Density	Pocket Penetrometer UCS (kPa)	Shear Vane Test (kPa)	Structure and Additional Observations	
RD	Groundwater not encountered above and not observed below 2.5m		N=22	9.0	9				becoming dark brown ( <i>continued</i> )	M	VSt to H			10.00: ALLUVIAL	
			SPT 8,9,10 N=19	8.0	10	CI-CH	Silty CLAY, medium to high plasticity, dark brown, mottled brown, with fine to medium grained sand	500 *							
			SPT 6,6,7 N=13	7.0	11			270 *							
			SPT 19,28,30/70mm N*>60	6.0	12										
			SPT 23,19,19 N=38	5.0	13	SP	SAND, fine to coarse grained, brown, grey, with fine to coarse subrounded gravels	VD							13.10: ALLUVIAL
			SPT 6,9,15 N=24	4.0	14										
			SPT 23,19,19 N=38	3.0	15			with rotten timber	D						
			SPT 6,9,15 N=24	2.0	16		CI-CH	Sandy CLAY, medium to high plasticity, grey, fine to coarse grained sand	VSt		280 *				
				1.0	17			Hole Terminated at 16.00 m Target depth							

<p><b>Method</b></p> <p>AD/T - Auger Drilling TC Bit AD/V - Auger Drilling V Bit RT - Rotary Tri-cone Bit RD - Rotary Drilling NMLC - Rock Core HA - Hand Auger</p>	<p><b>Penetration</b></p> <p>VE - Very Easy E - Easy F - Firm H - Hard VH - Very hard</p>	<p><b>Water</b></p> <p>Level (Date) Inflow Partial Loss Complete Loss</p>	<p><b>Samples and Tests</b></p> <p>U## - Undisturbed Sample (## mm) DS - Disturbed Sample BDS - Bulk Disturbed Sample SPT - Standard Penetration Test</p>	<p><b>Moisture Condition</b></p> <p>D - Dry M - Moist W - Wet</p>	<p><b>Consistency/Relative Density</b></p> <p>VS - Very Soft S - Soft F - Firm VSt - Very Stiff H - Hard VL - Very Loose L - Loose MD - Medium Dense D - Dense VD - Very Dense Fr - Friable</p>
<p><b>Graphic Log/Core Loss</b></p> <p>Core recovered (hatching indicates material) Core loss</p>			<p><b>Classification Symbols and Soil Descriptions</b></p> <p>Based on Unified Soil Classification System</p>	<p><b>Plastic Limit</b></p> <p>&lt; PL = PL &gt; PL</p>	

TECTONIC 3.00.2 LIB.GLB Log 1 TECTONIC BOREHOLE 23332-002.GPJ <<Drawingfile>> Z71112023 23:23 10.02.00.04 D:\glb\lab and in situ\tool - dgd\ | Lib: Tectonic 3.00.2 2021-03-30 Proj: Tectonic 3.00.2 2021-03-30

**DRILLING/EXCAVATION METHOD**

AD*	Auger Drilling	RA	Rotary Air	BH	Tractor Mounted Backhoe
ADH	Hollow Auger	RD	Rotary Blade or Drag bit	EX	Tracked Hydraulic Excavator
HA	Hand Auger	RT	Rotary Tri-cone bit	HMLC	Core – 63mm
*T	TC-Bit			HQ	Core – 63mm
*V	V-Bit			NMLC	Core – 47mm
				NQ	Core – 52mm
				R	Ripper
				RH	Rock Hammer

**WATER**

GROUNDWATER NOT OBSERVED                      The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.

GROUNDWATER NOT ENCOUNTERED                      The borehole/test pit was dry soon after excavation. However, groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/test pit been left open for a longer period.

**SAMPLING AND TESTING**

SPT	Standard Penetration Test to AS1289.6.3.1-2004
5,4,10 N=14	5,4,10 = Blows per 150mm. N = Blows per 300mm penetration following 150mm seating
30/65mm	Where practical refusal occurs, the blows and penetration for that interval are reported
RW	Penetration occurred under the rod weight only
HW	Penetration occurred under the hammer and rod weight only
HB	Hammer double bouncing on anvil
DS	Disturbed sample
BDS	Bulk disturbed sample
SV	Field shear vane test expressed as uncorrected shear strength ( $s_v$ = peak value, $s_r$ = residual value)
PP	Pocket penetrometer test expressed as instrument reading in kPa
U50	Thin walled tube sample - number indicates nominal sample diameter in millimetres
DCP	Dynamic cone penetration test
CPT	Electronic cone penetration test
CPTu	Electronic cone penetration test with pore pressure (u) measurement

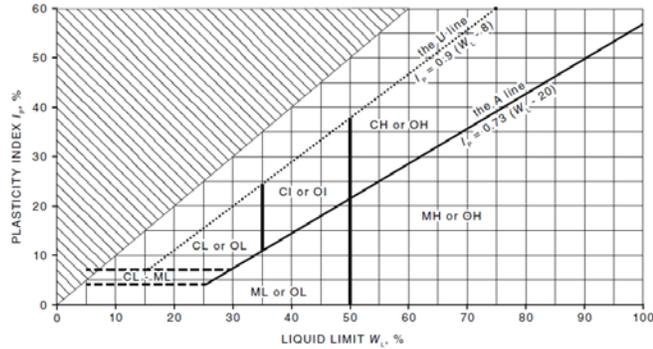
**CLASSIFICATION AND INFERRED STRATIGRAPHY**

Soil is classified and described in borehole and test pit logs using the preferred method given in AS1726 – 2017. The material properties are assessed in the field by visual/tactile methods.

**Particle Size**

**Plasticity Properties**

Major Division	Sub Division	Particle Size
BOULDERS		> 200 mm
COBBLES		63 to 200 mm
GRAVEL	Coarse	19 to 63 mm
	Medium	6.7 to 19 mm
	Fine	2.36 to 6.7 mm
SAND	Coarse	0.6 to 2.36 mm
	Medium	0.21 to 0.6 mm
	Fine	0.075 to 0.21
SILT		0.002 to 0.075
CLAY		< 0.002 mm



NOTE: The U line is an approximate upper bound for most materials. Data which plot above the U line may represent unusual/problem soil behavior, or unreliable data and should be considered carefully.

**MOISTURE CONDITION**

AS1726 - 2017

Symbol	Term	Description
D	Dry	Sands and gravels are free flowing. Clays & Silts may be brittle or friable and powdery.
M	Moist	Soils are darker than in the dry condition & may feel cool. Sands and gravels tend to cohere.
W	Wet	Soils exude free water. Sands and gravels tend to cohere.

**CONSISTENCY AND DENSITY**

AS1726 - 2017

Symbol	Term	Undrained Shear Strength	Symbol	Term	Density Index %	SPT "N" #
VS	Very Soft	0 to 12 kPa	VL	Very Loose	Less than 15	0 to 4
S	Soft	12 to 25 kPa	L	Loose	15 to 35	4 to 10
F	Firm	25 to 50 kPa	MD	Medium Dense	35 to 65	10 to 30
St	Stiff	50 to 100 kPa	D	Dense	65 to 85	30 to 50
VSt	Very Stiff	100 to 200 kPa	VD	Very Dense	Above 85	Above 50
H	Hard	Above 200 kPa				

In the absence of test results, consistency and density may be assessed from correlations with the observed behaviour of the material.

# SPT correlations are not stated in AS1726 – 2017, and may be subject to corrections for overburden pressure and equipment type.

# APPENDIX B

## Laboratory Test Certificates

## EMERSON CLASS NUMBER REPORT

Client: Tectonic Geotechnical Pty Ltd	Report Number: 3740/R/62692-1
Client Address: 924 David Low Way, Marcoola	Project Number: 3740/P/2437
Project: Fitzroy	Lot Number:
Location: Various	Internal Test Request: 3740/T/47328
Supplied To: Tectonic Geotechnical Pty Ltd	Client Reference/s: O/N 23332-002
Area Description:	Report Date / Page: 23/11/2023 <span style="float: right;">Page 1 of 1</span>

Test Procedures:	AS1289.3.8.1
------------------	--------------

Sample Number	3740/S/247976	3740/S/247978	3740/S/247979	
ID / Client ID	-	-	-	
Lot Number	-	-	-	
Date / Time Sampled	26/10/2023	26/10/2023	26/10/2023	
Date Tested	22/11/2023	22/11/2023	22/11/2023	
Material Source	Insitu	Insitu	Insitu	
Material Type	-	-	-	
Sampling Method	Tested As Received	Tested As Received	Tested As Received	
Prep Material > 53mm (%)	-	-	-	
Water Type	Distilled	Distilled	Distilled	
Water Temperature (°C)	23	23	23	
Borehole name	BH1	BH2	BH2	
Start Sample Depth (m)	1.0	5.5	11.5	
End Sample Depth (m)	1.45	5.95	11.95	
Soil Description	CL Sandy Clay, low plasticity	Clay w/ Sand	Clay w/ sand	
Emerson Class Description	Slakes. Dispersion in soil/water suspension.	Slakes. Dispersion in soil/water suspension.	Slakes. Dispersion in soil/water suspension.	
<b>Emerson Class Number</b>	<b>5</b>	<b>5</b>	<b>5</b>	

Remarks	Results apply to the sample/s as received.,
---------	---

	Accredited for compliance with ISO/IEC 17025 – Testing	
Accreditation Number: 1986 Corporate Site Number: 3740		Approved Signatory: Thomas Hewitt Form ID: W22Rep Rev 4

## QUALITY OF MATERIALS REPORT

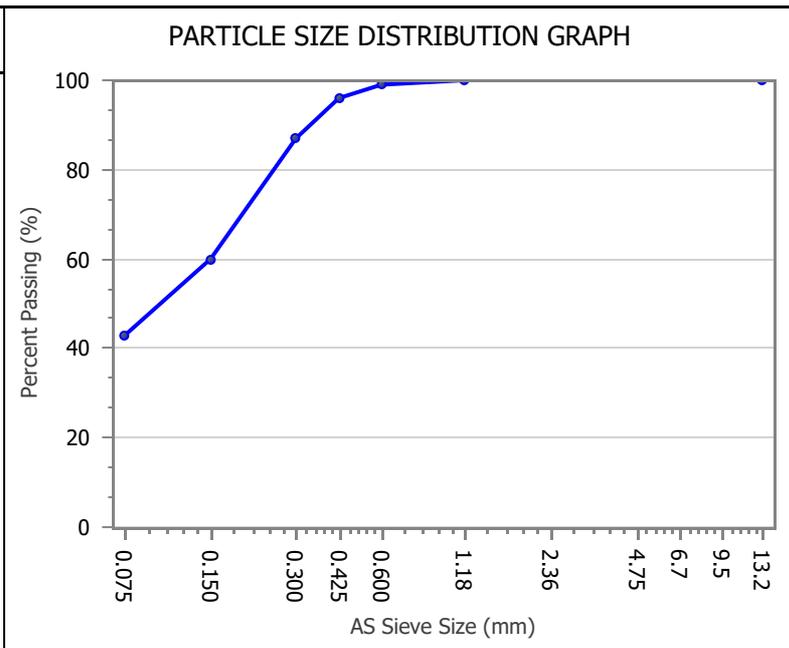
Client: Tectonic Geotechnical Pty Ltd	Report Number: 3740/R/62694-1
Client Address: 924 David Low Way, Marcoola	Project Number: 3740/P/2437
Project: Fitzroy	Lot Number:
Location: Various	Internal Test Request: 3740/T/47328
Supplied To: Tectonic Geotechnical Pty Ltd	Client Reference/s: O/N 23332-002
Area Description:	Report Date / Page: 24/11/2023 <span style="float: right;">Page 1 of 4</span>

Test Procedures AS1289.3.6.1, AS1289.3.1.2, AS1289.3.2.1, AS1289.3.4.1, AS1289.2.1.1, AS 1289.3.3.1

Sample Number 3740/S/247976	Borehole name BH1
Sampling Method Tested As Received	Start Sample Depth (m) 1.0
Date Sampled 26/10/2023	End Sample Depth (m) 1.45
Sampled By Client Sampled	(m)
Date Tested 6/11/2023	Material Source Insitu
PSD Preparation Washed	Material Type -
Atterberg Preparation Dry Sieved / Oven Dried	Prep Material > 53.0mm (%)

Material Description CL Sandy Clay, low plasticity

AS Sieve (mm)	Specification Minimum (%)	Percent Passing (%)	Specification Maximum (%)
13.2		100	
1.18		100	
0.600		99	
0.425		96	
0.300		87	
0.150		60	
0.075		43	



Test Result	Specification Minimum (%)	Result	Specification Maximum (%)	Test Result	Specification Minimum (%)	Result	Specification Maximum (%)
Liquid Limit (%)		27		0.075/0.425 Fines Ratio		0.45	
Plastic Limit (%)		17		PI x 0.425 Ratio (%)		960.0	
Plastic Index (%)		10		LS x 0.425 Ratio (%)		816.0	
Linear Shrinkage (%)		8.5		Shrinkage Observations		-	

Remarks Results apply to the sample/s as received.,

Accredited for compliance with ISO/IEC 17025 – Testing	
	Approved Signatory: Thomas Hewitt Form ID: W85Rep Rev 3
Accreditation Number: 1986 Corporate Site Number: 3740	

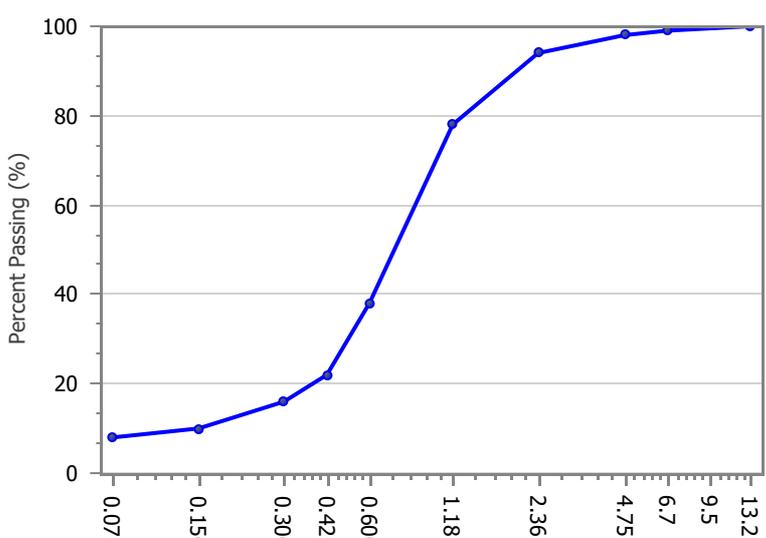
## QUALITY OF MATERIALS REPORT

Client: Tectonic Geotechnical Pty Ltd	Report Number: 3740/R/62694-1
Client Address: 924 David Low Way, Marcoola	Project Number: 3740/P/2437
Project: Fitzroy	Lot Number:
Location: Various	Internal Test Request: 3740/T/47328
Supplied To: Tectonic Geotechnical Pty Ltd	Client Reference/s: O/N 23332-002
Area Description:	Report Date / Page: 24/11/2023 <span style="float: right;">Page 2 of 4</span>

Test Procedures AS1289.3.6.1, AS1289.3.1.2, AS1289.3.2.1, AS1289.3.4.1, AS1289.2.1.1, AS 1289.3.3.1

Sample Number 3740/S/247977	Borehole name BH1
Sampling Method Tested As Received	Start Sample Depth (m) 11.5
Date Sampled 26/10/2023	End Sample Depth (m) 11.95
Sampled By Client Sampled	(m)
Date Tested 6/11/2023	Material Source Insitu
PSD Preparation Washed	Material Type -
Atterberg Preparation Dry Sieved / Oven Dried	Prep Material > 53.0mm (%)

Material Description SW Sand, well graded sand, trace of well graded gravel, with low plastic clay

AS Sieve (mm)	Specification Minimum (%)	Percent Passing (%)	Specification Maximum (%)	<b>PARTICLE SIZE DISTRIBUTION GRAPH</b> 
13.2		<b>100</b>		
6.7		<b>99</b>		
4.75		<b>98</b>		
2.36		<b>94</b>		
1.18		<b>78</b>		
0.600		<b>38</b>		
0.425		<b>22</b>		
0.300		<b>16</b>		
0.150		<b>10</b>		
0.075		<b>8</b>		

Test Result	Specification Minimum (%)	Result	Specification Maximum (%)	Test Result	Specification Minimum (%)	Result	Specification Maximum (%)
Liquid Limit (%)		<b>22</b>		0.075/0.425 Fines Ratio		<b>0.33</b>	
Plastic Limit (%)		<b>16</b>		PI x 0.425 Ratio (%)		<b>135.0</b>	
Plastic Index (%)		<b>6</b>		LS x 0.425 Ratio (%)		<b>45.0</b>	
Linear Shrinkage (%)		<b>2.0</b>		Shrinkage Observations		-	

Remarks Results apply to the sample/s as received.,

Accredited for compliance with ISO/IEC 17025 – Testing  	Accreditation Number: 1986 Corporate Site Number: 3740  <div style="text-align: right;">             Approved Signatory: Thomas Hewitt            Form ID: W85Rep Rev 3         </div>
--	--

## QUALITY OF MATERIALS REPORT

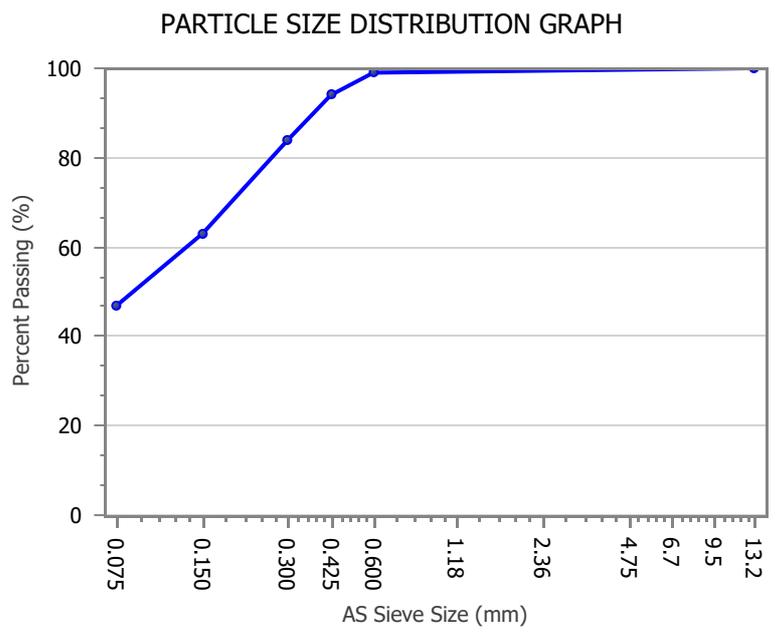
Client: Tectonic Geotechnical Pty Ltd	Report Number: 3740/R/62694-1
Client Address: 924 David Low Way, Marcoola	Project Number: 3740/P/2437
Project: Fitzroy	Lot Number:
Location: Various	Internal Test Request: 3740/T/47328
Supplied To: Tectonic Geotechnical Pty Ltd	Client Reference/s: O/N 23332-002
Area Description:	Report Date / Page: 24/11/2023 <span style="float: right;">Page 3 of 4</span>

Test Procedures AS1289.3.6.1, AS1289.3.1.2, AS1289.3.2.1, AS1289.3.4.1, AS1289.2.1.1, AS 1289.3.3.1

Sample Number 3740/S/247978	Borehole name BH2
Sampling Method Tested As Received	Start Sample Depth (m) 5.5
Date Sampled 26/10/2023	End Sample Depth (m) 5.95
Sampled By Client Sampled	(m)
Date Tested 6/11/2023	Material Source Insitu
PSD Preparation Washed	Material Type -
Atterberg Preparation Dry Sieved / Oven Dried	Prep Material > 53.0mm (%)

Material Description CL Sandy Clay, low plasticity, trace of gravel

AS Sieve (mm)	Specification Minimum (%)	Percent Passing (%)	Specification Maximum (%)
13.2		<b>100</b>	
0.600		<b>99</b>	
0.425		<b>94</b>	
0.300		<b>84</b>	
0.150		<b>63</b>	
0.075		<b>47</b>	



Test Result	Specification Minimum (%)	Result	Specification Maximum (%)	Test Result	Specification Minimum (%)	Result	Specification Maximum (%)
Liquid Limit (%)		<b>33</b>		0.075/0.425 Fines Ratio		<b>0.50</b>	
Plastic Limit (%)		<b>14</b>		PI x 0.425 Ratio (%)		<b>1795.5</b>	
Plastic Index (%)		<b>19</b>		LS x 0.425 Ratio (%)		<b>1086.8</b>	
Linear Shrinkage (%)		<b>11.5</b>		Shrinkage Observations		-	

Remarks Results apply to the sample/s as received.,

Accredited for compliance with ISO/IEC 17025 – Testing	
	Approved Signatory: Thomas Hewitt Form ID: W85Rep Rev 3
Accreditation Number: 1986 Corporate Site Number: 3740	

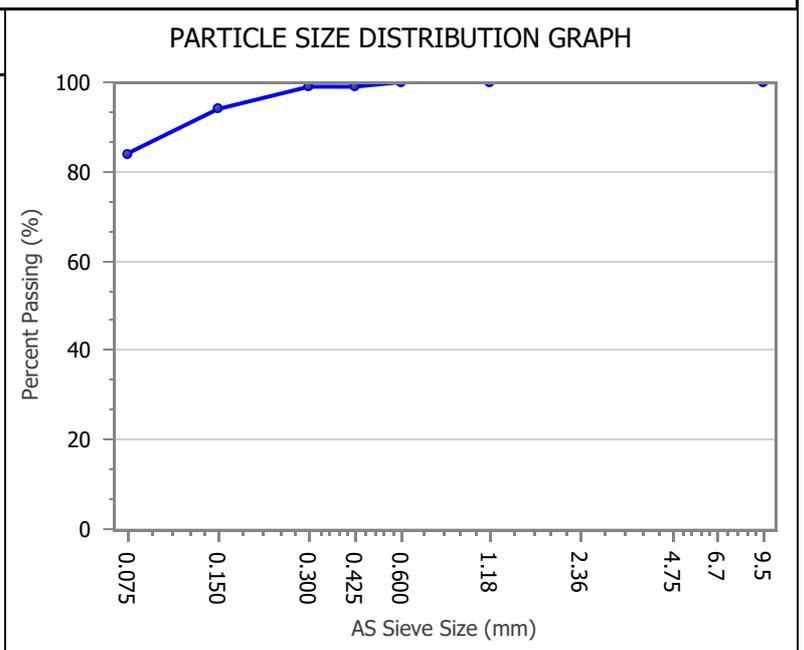
## QUALITY OF MATERIALS REPORT

Client: Tectonic Geotechnical Pty Ltd	Report Number: 3740/R/62694-1
Client Address: 924 David Low Way, Marcoola	Project Number: 3740/P/2437
Project: Fitzroy	Lot Number:
Location: Various	Internal Test Request: 3740/T/47328
Supplied To: Tectonic Geotechnical Pty Ltd	Client Reference/s: O/N 23332-002
Area Description:	Report Date / Page: 24/11/2023 <span style="float: right;">Page 4 of 4</span>

Test Procedures	AS1289.3.6.1, AS1289.3.1.2, AS1289.3.2.1, AS1289.3.4.1, AS1289.2.1.1, AS 1289.3.3.1		
Sample Number	3740/S/247979	Borehole name	BH2
Sampling Method	Tested As Received	Start Sample Depth (m)	11.5
Date Sampled	26/10/2023	End Sample Depth (m)	11.95
Sampled By	Client Sampled	(m)	
Date Tested	6/11/2023	Material Source	Insitu
PSD Preparation	Washed	Material Type	-
Atterberg Preparation	Dry Sieved / Oven Dried	Prep Material > 53.0mm (%)	

Material Description CI Clay, medium plasticity, with sand

AS Sieve (mm)	Specification Minimum (%)	Percent Passing (%)	Specification Maximum (%)
9.5		100	
1.18		100	
0.600		100	
0.425		99	
0.300		99	
0.150		94	
0.075		84	



Test Result	Specification Minimum (%)	Result	Specification Maximum (%)	Test Result	Specification Minimum (%)	Result	Specification Maximum (%)
Liquid Limit (%)		49		0.075/0.425 Fines Ratio		0.84	
Plastic Limit (%)		18		PI x 0.425 Ratio (%)		3075.2	
Plastic Index (%)		31		LS x 0.425 Ratio (%)		1537.6	
Linear Shrinkage (%)		15.5		Shrinkage Observations		-	

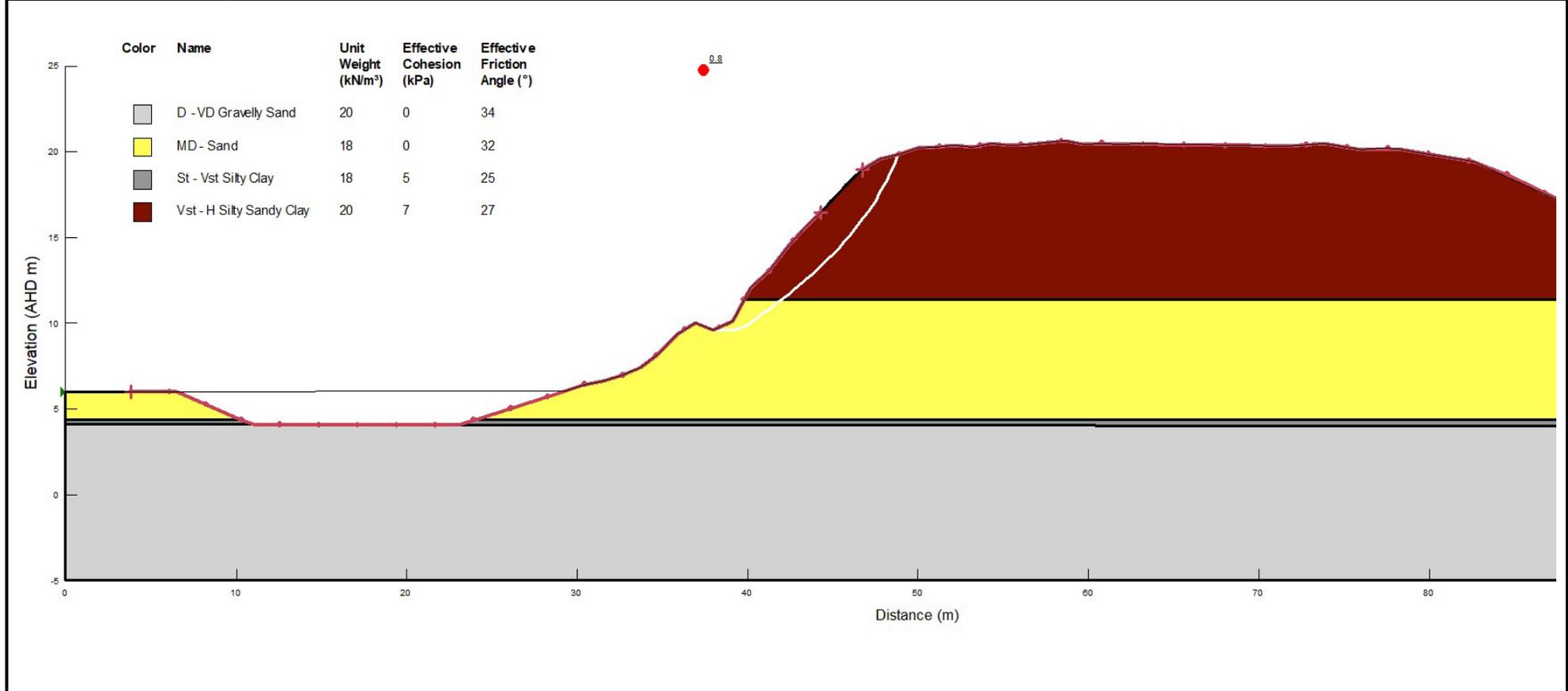
Remarks Results apply to the sample/s as received.,

	Accredited for compliance with ISO/IEC 17025 – Testing	
Accreditation Number: 1986 Corporate Site Number: 3740		Approved Signatory: Thomas Hewitt Form ID: W85Rep Rev 3

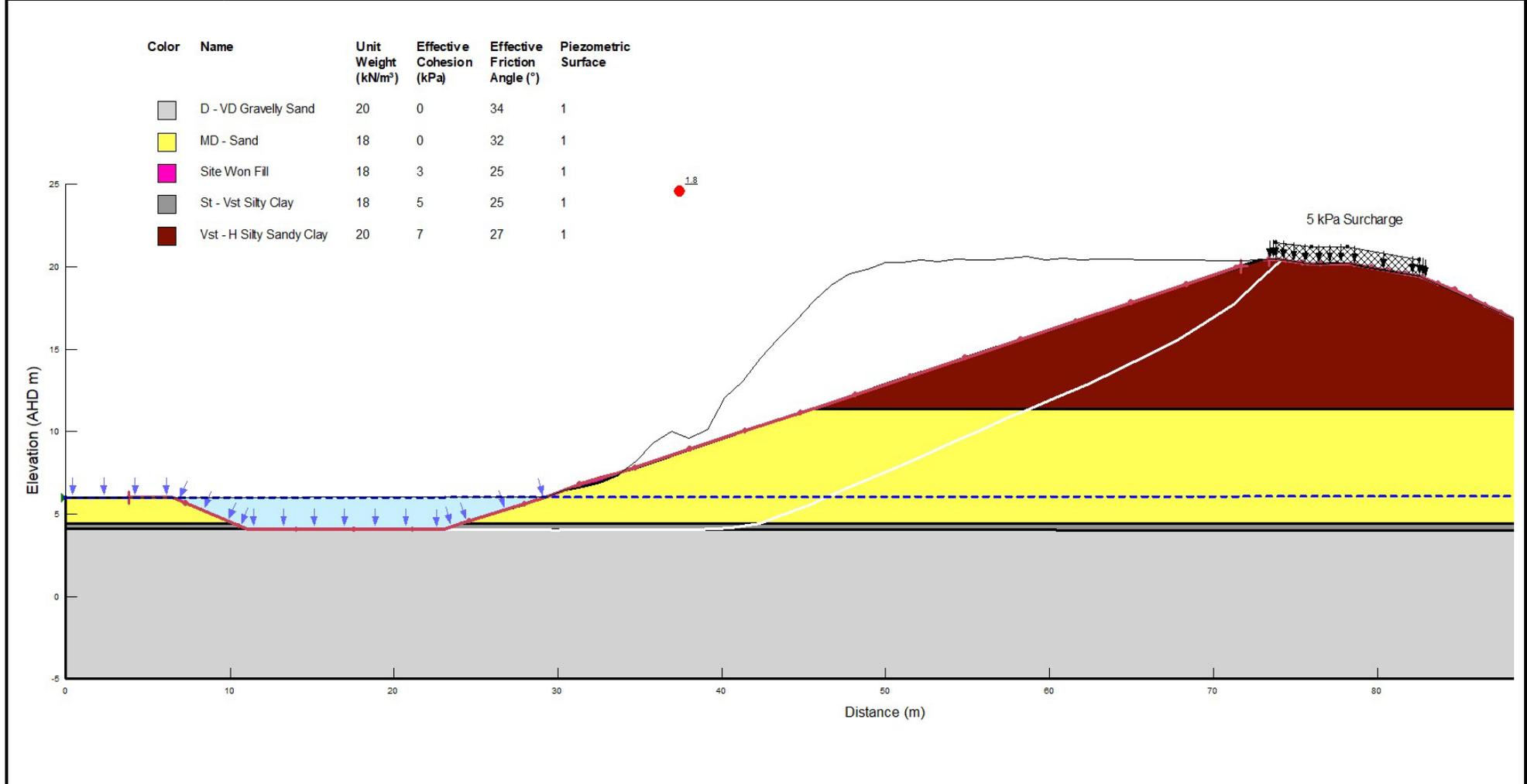
# APPENDIX C

## Slope/W Outputs

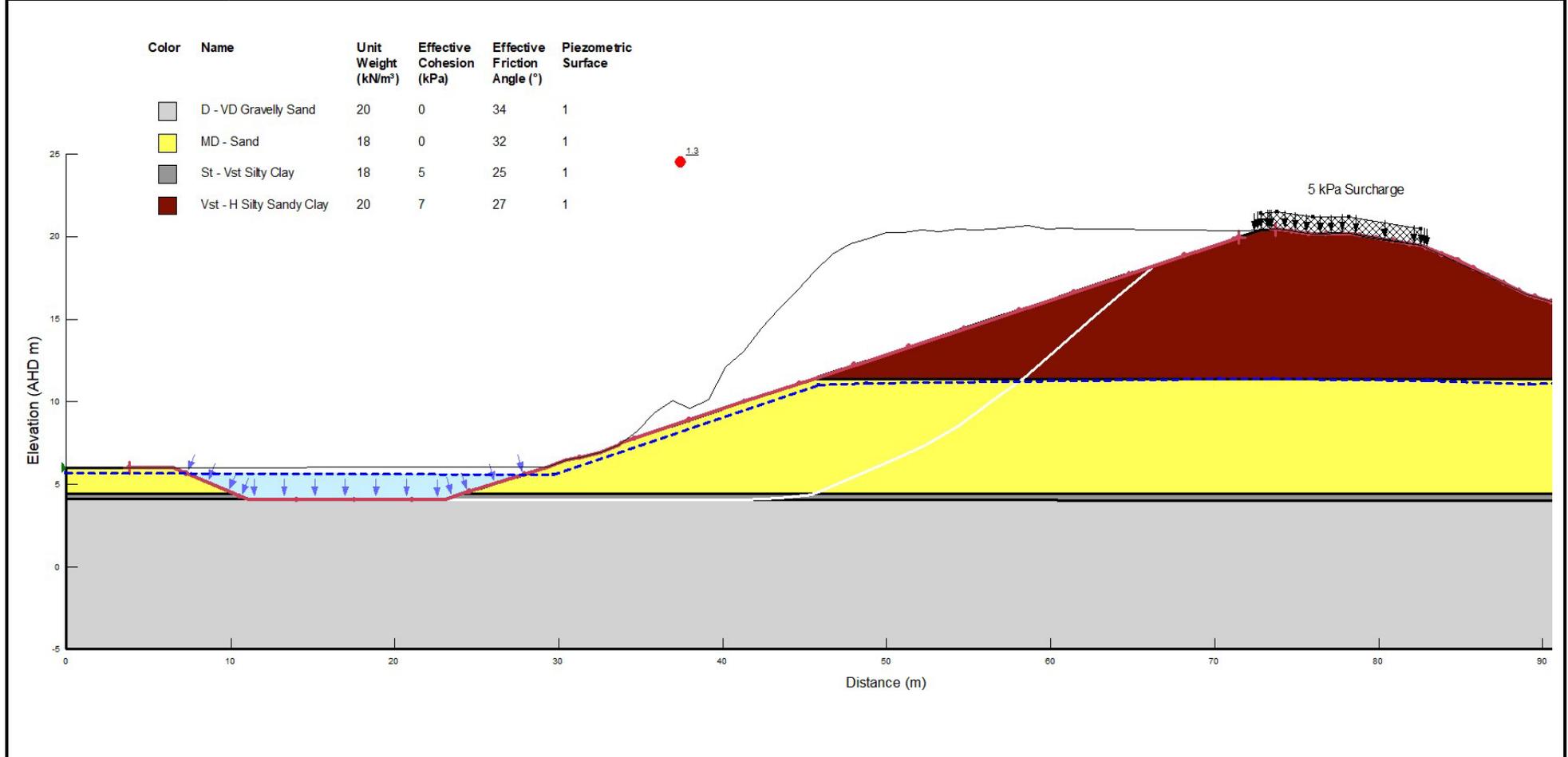
Project Name	Assessment of Bank Stability – Fitzroy River, Garnant
Project No.	23332
Report No.	23332-002
Title	Analysis 1 – Section A – A' - Existing Profile



Project Name	Assessment of Bank Stability – Fitzroy River, Garnant
Project No.	23332
Report No.	23332-002
Title	Analysis 2 – Section A – A' - Proposed Cut Batter, Long Term Conditions



Project Name	Assessment of Bank Stability – Fitzroy River, Garnant
Project No.	23332
Report No.	23332-002
Title	Analysis 3 – Section A – A' - Proposed Cut Batter, Short Term Conditions (Drained Parameters)



# APPENDIX D

## Limitations

## **LIMITATIONS**

This document has been prepared for the purpose outlined in Tectonic's proposal and no responsibility is accepted for the use of this document, in whole or in part, for any other purpose.

The scope of Tectonic's Services are as described in Tectonic's proposal, and are subject to restrictions and limitations. Tectonic did not perform a complete assessment of all possible conditions or circumstances that may exist at the site referenced in the report. If a service is not expressly indicated, do not assume it has been provided. If a matter is not addressed, do not assume that any determination has been made by Tectonic in regards to it.

Conditions may exist which were undetectable given that economic and time constraints limit the practical extent of geotechnical investigation. Variations in conditions may occur between investigation locations, and there may be special conditions pertaining to the site which have not been revealed by the investigation and which have not therefore been taken into account in the document. Where variations exist on site, additional studies and actions may be required.

Tectonic's opinions are based upon information that existed at the time that the work was performed. The passage of time, man-made or natural events, may alter the site conditions. It is understood that the Services undertaken allowed Tectonic to form an opinion of the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings, or any laws or regulations.

Any assessments made in the preparation of this document are based on the conditions indicated from published sources and the findings of the investigation described. Actual subsurface conditions may differ from those indicated in the document (e.g. between boreholes or test pits). No warranty is included, either express or implied, that the actual conditions will conform exactly to the assessments contained in this document.

Where data supplied by the client or other external sources, including previous site investigation data, have been used, it has been assumed that the information is correct unless otherwise stated. No responsibility is accepted by Tectonic for incomplete or inaccurate data supplied by others.

This document is provided for the sole use by the Client and its professional advisers. No responsibility whatsoever for the contents of this document will be accepted to any person other than the Client. Any use which a third party makes of this document, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Tectonic accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this document.