NEILLY GROUP
ENGINEERING

CATCHMENT SOLUTIONS

REEF TRUST IV COLLINSDALE STATION FITZROY RIVER CHANNEL AVULSION REMEDIATION DETAIL DESIGN

APRIL 2019

Document Control

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3	05/04/2019	Adam Neilly	Final	Brett Twycross	Adam Neilly

Executive Summary

Neilly Group Engineering was engaged by Catchment Solutions to develop detailed design of remediation works for the channel avulsion between the Fitzroy River and Louisa Creek located on Collinsdale Station, approximately 36km north-west of Rockhampton, Queensland.

A site inspection was conducted by Adam Neilly (Neilly Group Engineering) on the 9th of April and 11th of July 2018. The erosion consists of a channel avulsion path that has formed between the Fitzroy River and Louisa Creek on Collinsdale Station. The channel avulsion path is approximately 190m in length, 90m wide and ranges in depth from 4m to deeper than 10m. An 'island' remains in the centre of the avulsion path, which indicates that the channel avulsion is not complete and can be characterised as a partial channel avulsion.

In order to remediate the avulsion path that has formed between the Fitzroy River and Louisa Creek as a result of flood flows from the Fitzroy River, the following remediation elements are proposed:

- Bank battering of the vertical bank on the eastern side of the channel avulsion path to a stable batter slope of 1V:5H;
- Utilising the material won from the battering of the vertical bank to construct a landform in the centre of the avulsion path with a 10m wide crest and 1V:10H batters to reduce the frequency of overtopping from the Fitzroy River;
- Excavation of an existing farm dam located to the south of the works to win material that will be suitable as topsoil for the landform and battering works, as the topsoil recovered from the battering of the vertical bank will not be enough to cover all works. This includes the construction of a formal rock chute spillway on the modified dam to reduce ongoing erosion risk associated with the dam;
- Undertaking intensive revegetation of all works including hydro-mulching, seeding, planting of trees and shrubs and irrigation of revegetation works using solar pumps from the Fitzroy River; and
- Upgrading and maintaining an access track which will be required during construction. The access track crosses Louisa Creek which includes a simple rock lined bed level crossing to ensure it remains trafficable should minor rain events occur during construction.

An overview of the proposed bank battering and landform works are shown in Figure S-1 below, with the farm dam excavation and rock chute spillway works shown in Figure S- 2 .

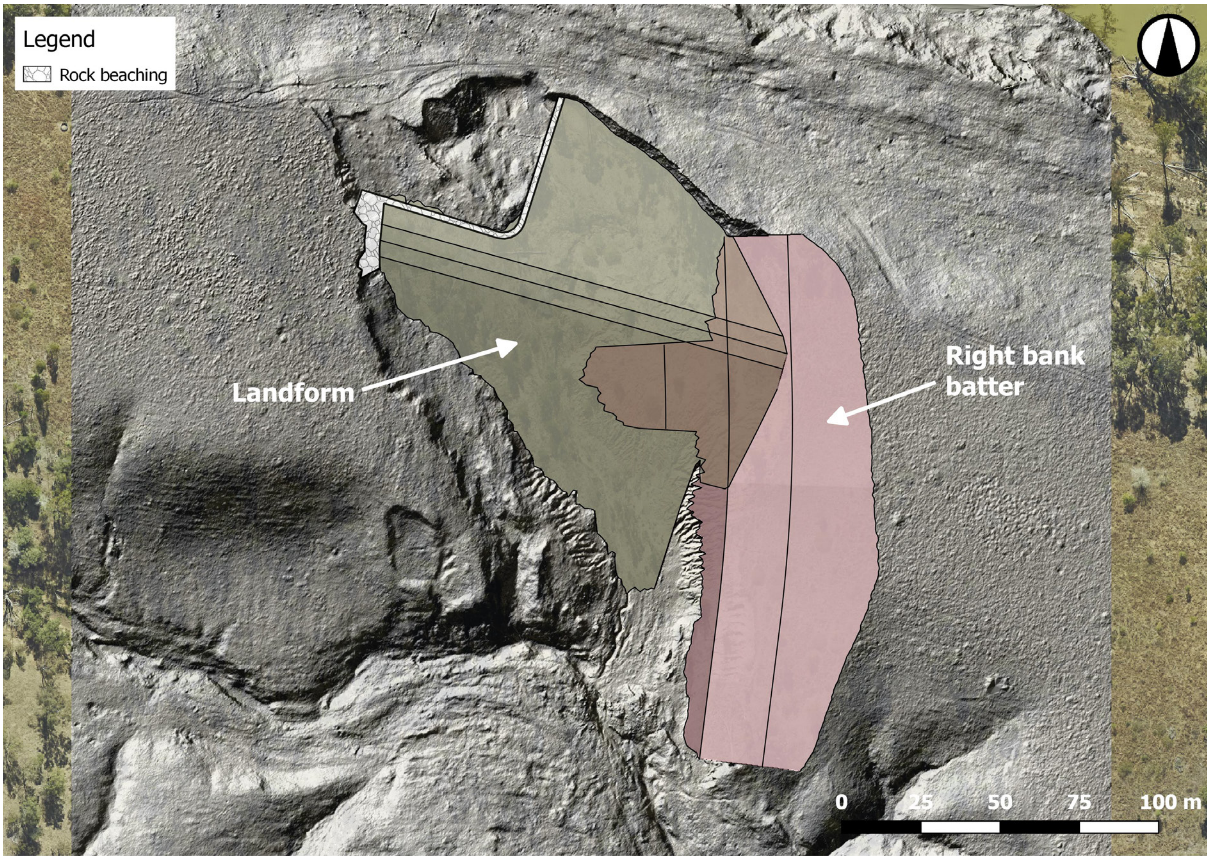

Figure S-1. Overview of proposed bank battering and landform works

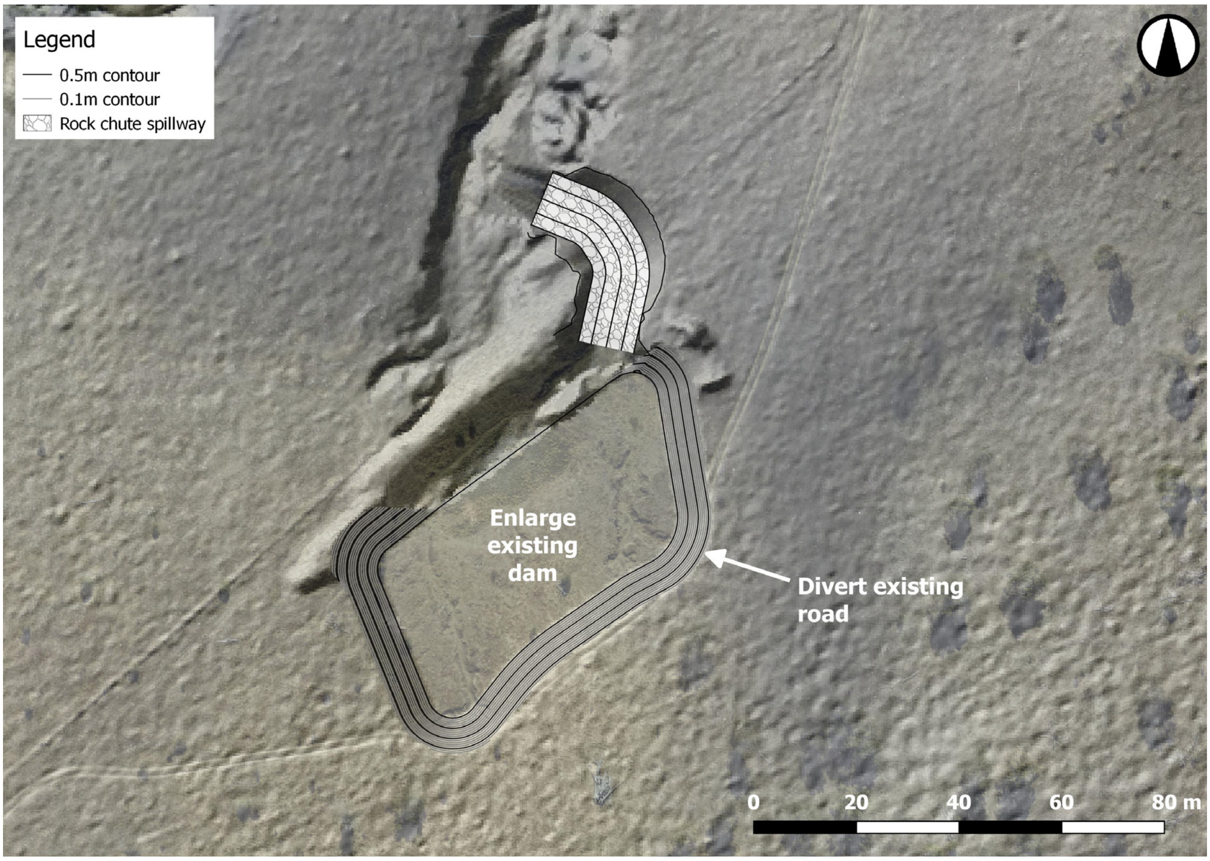

Figure S- 2. Overview of proposed farm dam excavation and rock chute spillway works

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Acronyms

Acronym	Meaning
AEP	Average Exceedance Probability
ARI	Average Recurrence Interval

Introduction

Neilly Group Engineering were engaged by Catchment Solutions to develop detail design of remediation works for the channel avulsion between the Fitzroy River and Louisa Creek located on Collinsdale Station, approximately 36km north-west of Rockhampton (see Figure 1).

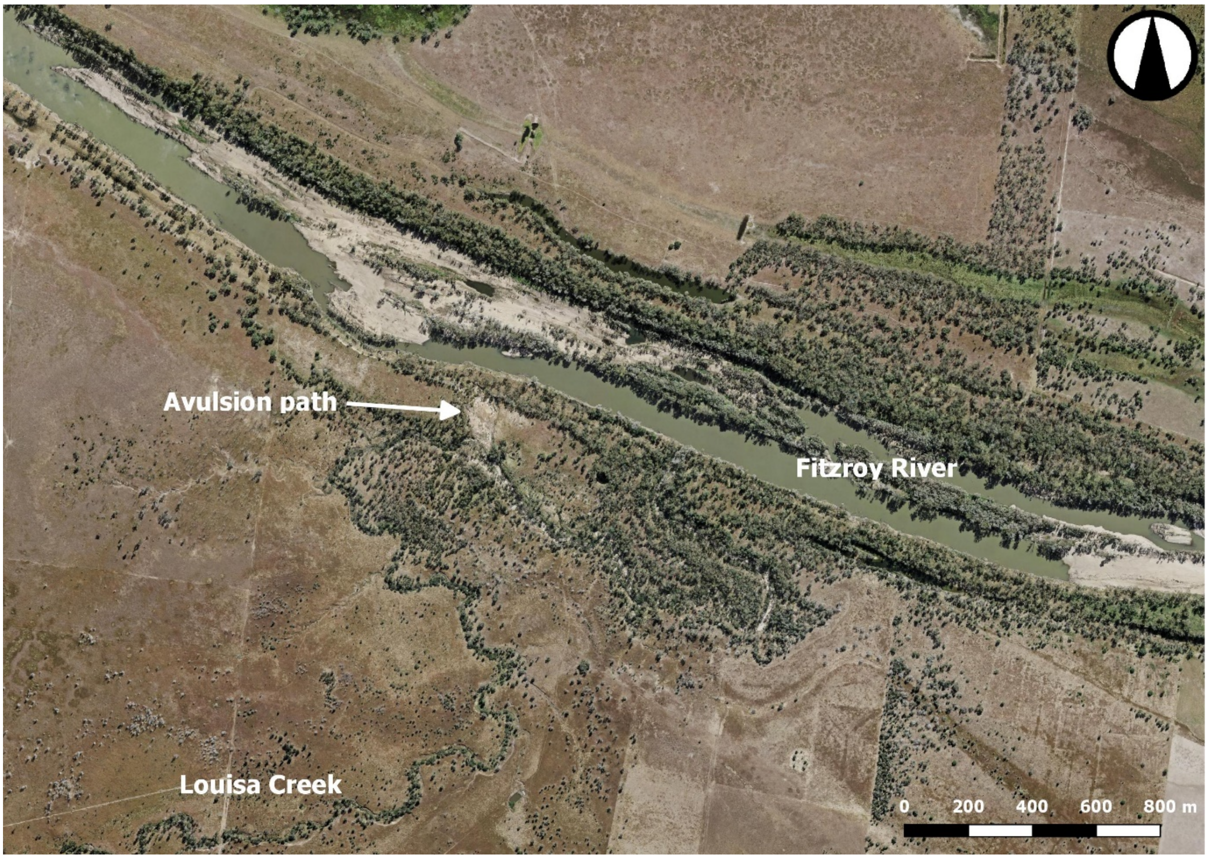

Figure 1. Site overview

This report presents the detail design of the remediation of the channel avulsion, following on from the investigation and sediment loss assessment that was presented in *Reef Trust IV Collinsdale Station Fitzroy River Channel Avulsion Investigation* (Neilly Group Engineering, 2018a) and the concept design that was presented in *Reef Trust IV Collinsdale Station Fitzroy River Channel Avulsion Remediation Concept Design* (Neilly Group Engineering, 2018b).

Detail design

In order to remediate the avulsion path that has formed between the Fitzroy River and Louisa Creek as a result of flood flows from the Fitzroy River, the following remediation elements are proposed:

- Bank battering of the vertical bank on the eastern side of the channel avulsion path to a stable batter slope of 1V:5H;
- Utilising the material won from the battering of the vertical bank to construct a landform in the centre of the avulsion path with a 10m wide crest and 1V:10H batters to reduce the frequency of overtopping from the Fitzroy River;
- Excavation of an existing farm dam located to the south of the works to win material that will be suitable as topsoil for the landform and battering works, as the topsoil recovered from the battering of the vertical bank will not be enough to cover all works. This includes the construction of a formal rock chute spillway on the modified dam to reduce ongoing erosion risk associated with the dam;
- Undertaking intensive revegetation of all works including hydro-mulching, seeding, planting of trees and shrubs and irrigation of revegetation works using solar pumps from the Fitzroy River; and
- Upgrading and maintaining an access track which will be required during construction. The access track crosses Louisa Creek which includes a simple rock lined bed level crossing to ensure it remains trafficable should minor rain events occur during construction. Refer to drawings 133-7-1-C001 – C002 by Tetra Consulting for details on the access track design.

Refer to Figure 2 below for an overview of the landform and bank battering works and to Figure 3 for an overview of the dam excavation and rock chute spillway works.

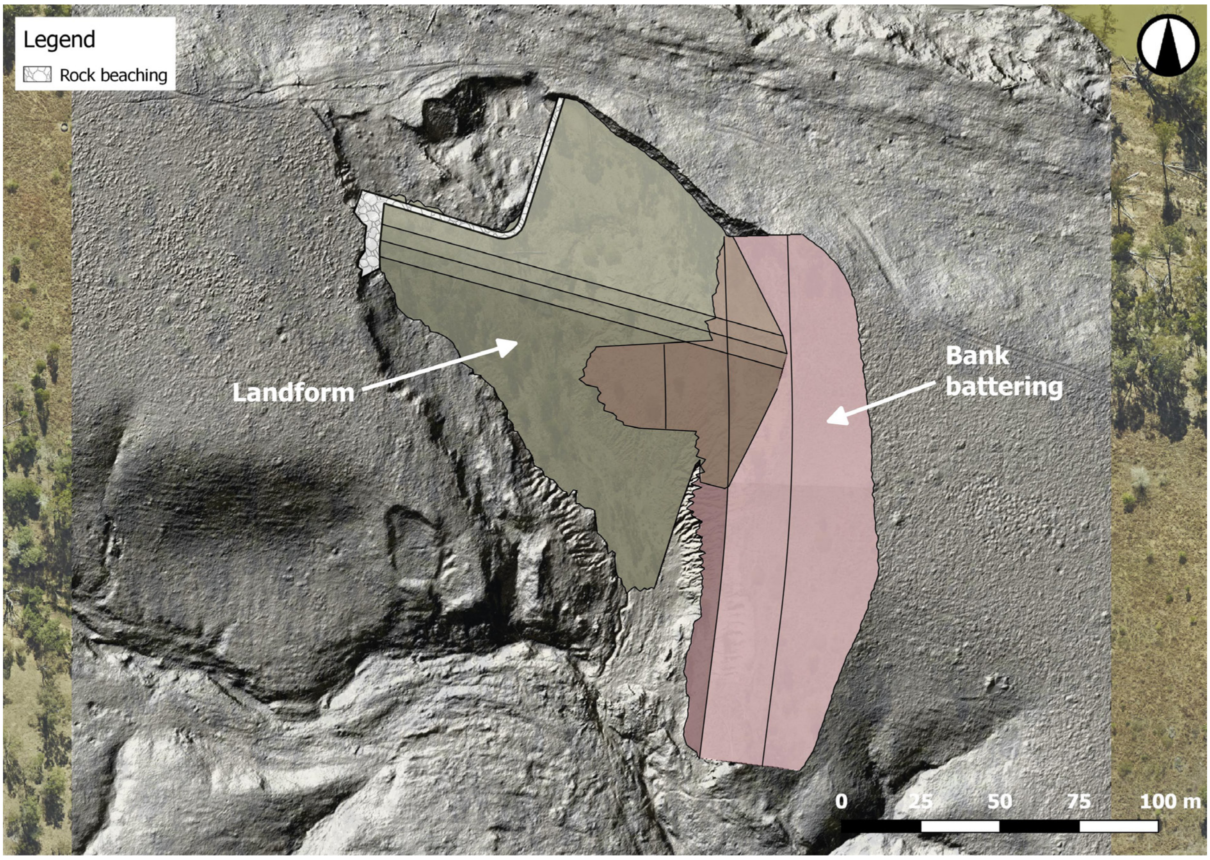

Figure 2. Overview of landform and bank battering remediation works

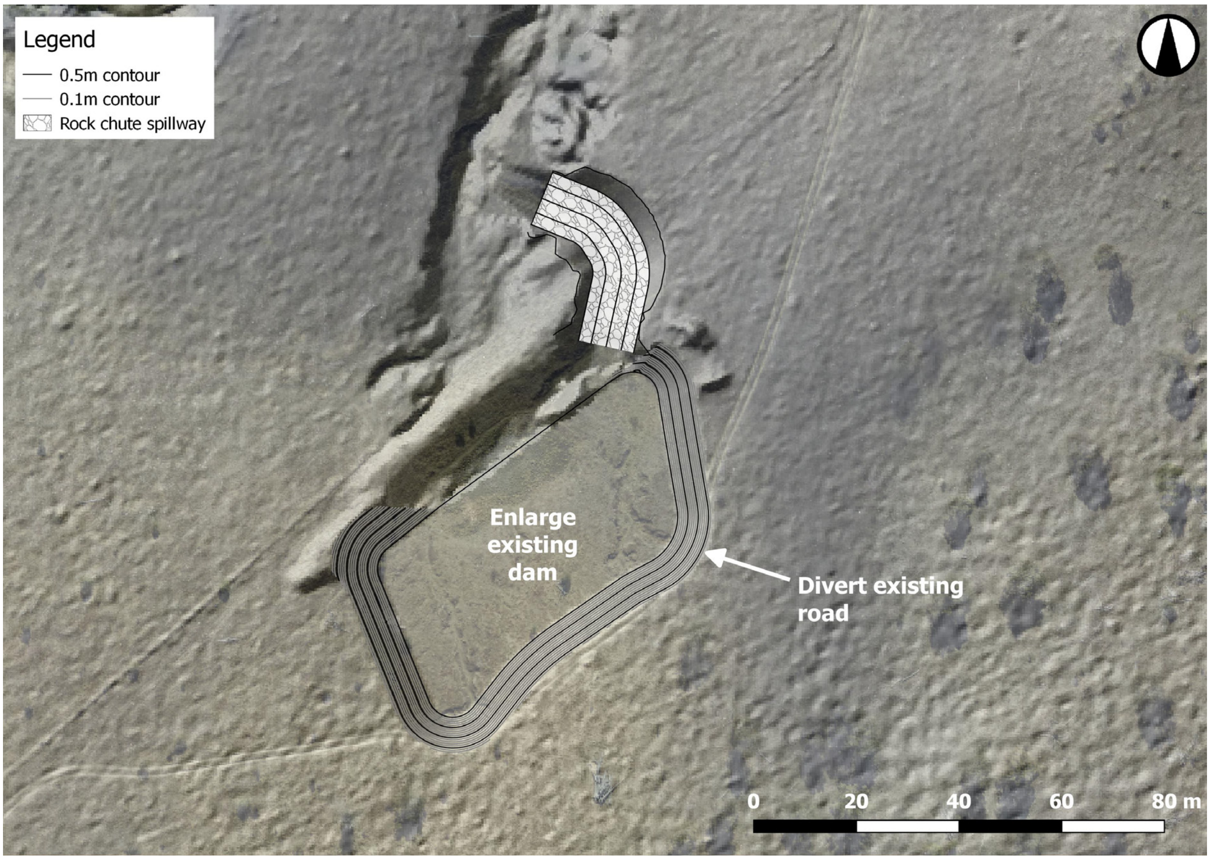

Figure 3. Overview of farm dam excavation and rock chute spillway works

1.1 Bank battering and Landform

A geotechnical investigation of the materials present in the location of the proposed bank battering and landform works was undertaken by Douglas Partners and is included as Attachment A of this report. The report stated the following regarding batter slopes:

- Cut batters in the predominantly stiff or stronger silty clay soils to a maximum depth of 4 m may be formed at temporary batters of 1V:1H or permanent batters of 1V:2H. The temporary batter slopes are suggested with respect to slope stability only and do not allow for lateral stress relaxation.
- Permanent soil slopes or embankments may need to be flattened to 1V:3H or less, to allow vehicular access for maintenance of any proposed revegetation.

Bank battering of the vertical bank on the eastern side of the channel avulsion path has been designed to a significantly flatter batter slope than recommended by the geotechnical investigation to ensure a stable bank batter, particularly given that the batters will have slope lengths of up to 50m. A batter slope of 1V:5H has been adopted, which will also allow for the excavation of sufficient material to construct the proposed Landform.

The geotechnical report states that the material won from the bank battering will be suitable for the fill material to construct the landform, with the following stated in the report:

- The existing filling material won from excavation at the site is assessed as being suitable for re-use as structural filling provided it is screened to remove any organics and/or deleterious materials, and particles greater than 75 mm in size. Such use is contingent upon site preparation and fill placement undertaken in accordance with good construction practices and the recommendations elsewhere in this report.

The landform has been designed to a height that will reduce the frequency at which the Fitzroy River can overtop the avulsion path, as well as utilising suitable batter slopes and revegetation to reduce ongoing erosion risk. It is anticipated that once vegetation, particularly trees and shrubs, have established, the landform and battered bank will have the resilience to cope with instances when the Fitzroy River overtops the landform.

The Landform has been designed with a 10m wide crest, with a cross fall of three percent away from a central crown. The batter slopes from the crest down to the existing surface have been designed at 1V:10H to reduce the risk of erosion occurring during overtopping events.

In order to quantify the frequency at which the Fitzroy River is likely to overtop the proposed works, 2D flood modelling was undertaken of the 5% and 2% AEP design flood events in the Fitzroy River. The maximum flood depths for each of these events are presented in Figure 4 and Figure 5 respectively. The 2D flood modelling illustrates that the landform does not overtop in the 5% AEP design flood event, yet overtops in the 2% AEP design flood event. Design flood events between the 5% and 2% AEP were not modelled, hence the landform can be considered to have flood immunity greater than the 5% AEP but less than the 2% AEP.

Maximum flood velocities are also presented for the 2% AEP for two scenarios utilising different Manning's 'n' roughness coefficients to represent different stages of vegetation growth on the landform and adjacent right bank battering as follows:

- Utilising a Manning's 'n' roughness coefficient of 0.04 to represent the works soon after construction, after grasses have established yet no trees or shrubs are present.
- Utilising a Manning's 'n' roughness coefficient of 0.08 to represent the works after trees and shrubs have grown to a size where they will impact on the roughness of the terrain, which is likely to be within a five to ten-year period.

The maximum flood velocities for the 2% AEP for the soon after construction scenario are presented in Figure 6. The 2D flood modelling illustrates the crest of the landform experiences maximum velocities in the order of 3.5m/s, which are likely to cause erosion. Figure 7 presents the maximum flood velocities for the 2% AEP for the scenario after five to ten years where trees and shrubs have grown to a size where they will impact on the roughness of the terrain. The 2D flood modelling illustrates that the velocities over the crest of the landform have significantly reduced to approximately 2.2m/s. It is anticipated that this lower velocity coupled with the structural support provided by the roots of the grasses, trees and shrubs should allow the landform to be resistant to erosion in a 2% AEP flood event. The modelling of these two scenarios indicates that there will be a period between construction of the landform and the establishment of vegetation where the landform will be vulnerable to erosion in large flood events. To quantify this risk, there is a 9.6% chance of a 2% AEP occurring in a 5-year period and a 18.3% chance in a 10-year period. Given the considerable costs of rock armouring the crest of the landform, this risk has been considered to be acceptable.

The maximum flood velocities also indicate that higher velocities will be concentrated on the Louisa Creek face of the landform on its western flank. Subsequently, rock beaching has been included on this location, as well as the interface of the northern edge of the landform with the existing terrain.

Figure 8 and Figure 9 show the maximum flood depths and maximum velocities for the 2% AEP for the scenario where flows are only present in Louisa Creek with no flows in the Fitzroy River. This scenario was modelled to determine if the flows from Louisa Creek would pose an erosion risk to the works. The 2D modelling illustrates that the velocities against the toe of the works from Louisa Creek flows are less than 0.5m/s for the 2% AEP. It is unlikely that these will pose any erosion risk to the works and subsequently, rock beaching has not been proposed on the Louisa Creek toe of bank of the works.

1.2 Farm dam and rock chute spillway

It has been proposed to excavate an existing farm dam in order to win material for topsoiling of the landform and bank battering works. The farm dam is located approximately 1.2km south of the proposed bank battering and landform works.

It has been proposed to excavate the existing farm dam to an elevation of 12.5m AHD (from up to 14m AHD) to an expanded footprint of 3,111 m^2. It is anticipated that approximately 2,498m^3 of material will require excavation. The storage of the dam is limited by the height of the proposed rock chute spillway in the current gullied bywash of the dam. In order to fit within project cost constraints, the rock chute spillway could only be designed with a crest elevation of 13m AHD, which is 1m above the bywash gully bed level and 0.5m above the majority of the proposed dam bed level. With the expanded footprint of the dam bed it will provide the dam with approximately 1.5ML of storage.

The material excavated from the dam, as well as 445 m^3 excavated from the rock chute foundation, will be transported to the bank battering and landform site to be used as topsoil, in conjunction with gypsum amelioration, as the geotechnical report identified that the material in the farm dam is dispersive in places. The remaining 268m^3 of excavated material will require spoiling nearby in consultation with the landholder. It has been proposed that the material is spread at a suitable location nearby to a thickness of 300mm and ameliorated with gypsum. Hydromulching with pasture seed of the dam batters is recommended to assist in the establishment of vegetation which will reduce rill erosion and potential gullying risk on the dam batters, particularly from overland flows entering the dam on its southern flank.

The rock chute spillway has been designed using:

- The *Technical Guidelines for Waterway Management* (DSE, 2007).
- Iterative design and 2D flood modelling in conjunction with the software package CHUTE.

For this farm dam and spillway scenario, the hydraulics are too complex for the Excel based software CHUTE to accurately predict, due to the interaction of the dam outflow with backwater into the gully from Louisa Creek. Subsequently, it was determined that 2D hydrodynamic flood modelling would be required to accurately predict the complex hydraulics and subsequent hydraulic parameters within the rock chute. A rock chute spillway was designed to fit within the existing spillway and was subsequently modelled for the 2% AEP design flood event.

Figure 10 and Figure 11 present maximum flood depths and maximum velocities for the 2% AEP at the farm dam with the proposed farm dam excavation and rock chute spillway included. Maximum velocities of up to 3.8m/s occur within the rock chute spillway. Previous experience in designing rock chutes using the software package CHUTE where the hydraulics are not complex determined that a D_{50} of 500mm is suitable for flow rates of up to 4m/s.

One such example are the rock chutes that have been designed for the Bannockburn Station gullies and are presented in *Bannockburn Station Reef Trust IV Gully Repair Design* (Neilly Group Engineering, 2018c). In this instance, both rock chutes were sized using the software package CHUTE and modelled using 2D hydrodynamic flood modelling. Velocities of up to 4m/s occur within the rock chutes for a corresponding rock size determined by CHUTE of D_{50} = 500mm.

The rock chute spillway profile was designed to the characteristics presented in Table 1 below.

Table 1. Rock chute spillway design summary

Characteristic	Units	Value
Factor of safety in design	-	1
Crest length	m	3
Chute length	m	15
Chute drop	m	1
Chute width	m	6
Apron length	m	16.6
Vertical height of abutment protection	m	1
Rock beaching size (D_{50})	mm	500

Further details of the detail design can be found in the Drawings as Attachment B and in the *Technical Specification: Reef Trust IV Collinsdale Station Fitzroy River Channel Avulsion Remediation* (Neilly Group Engineering, 2019).

In order to further justify the costs associated with the excavation of the farm dam and construction of a rock chute spillway, the annual fine sediment loss was estimated. In order to undertake this estimation, the following survey data was obtained for the Farm Dam location:

- LiDAR data captured in 2008 in LAS format obtained from the Department of Natural Resources, Mines and Energy (DNRME).
- LiDAR data captured in 2018 in LAS format commissioned by Catchment Solutions.

A DTM was generated for each data set and a DTM of difference was produced to compare 2018 to 2008. A volume calculation undertaken using 12d Model determined that within the gully channel downstream of the dam, 979 m^3 of material has been lost in the period between 2018 and 2008. This volume formed the basis for the historical erosion sediment assessment presented below in Table 2 below. This assessment estimates that the proposed dam works will prevent erosion at a rate of 51 tonnes/year.

Table 2. Historical erosion sediment assessment of the farm dam gully

Parameter	Value
Property name	Collinsdale Station Dam
Date	15/03/2019
Person completing assessment	Adam Neilly
Latitude (decimal degrees)	-23.144057
Longitude (decimal degrees)	150.281505
Erosion Control Activity numbers	1, 2, 8
Erosion: Historical total sediment supply from site (m3)	979
Erosion: Time period (yr)	10
Soil: Estimated dry bulk density (t/m3)	1.61*
Soil: Estimated % silt + clay (proportion)	0.8*
Erosion: Historical fine sediment supply from sites (t/yr)	126
Erosion: Control effectiveness (proportion)	0.6
Erosion: TSS at site (t/yr)	76
Fine sediment delivery efficiency to coast (proportion)	0.67
Total TSS saving at coast (t/yr)	51
Maximum cost-effectiveness $ per t/yr at coast	500
Maximum cost ($)	25,345

** based on soil testing undertaken by Catchment Solutions*

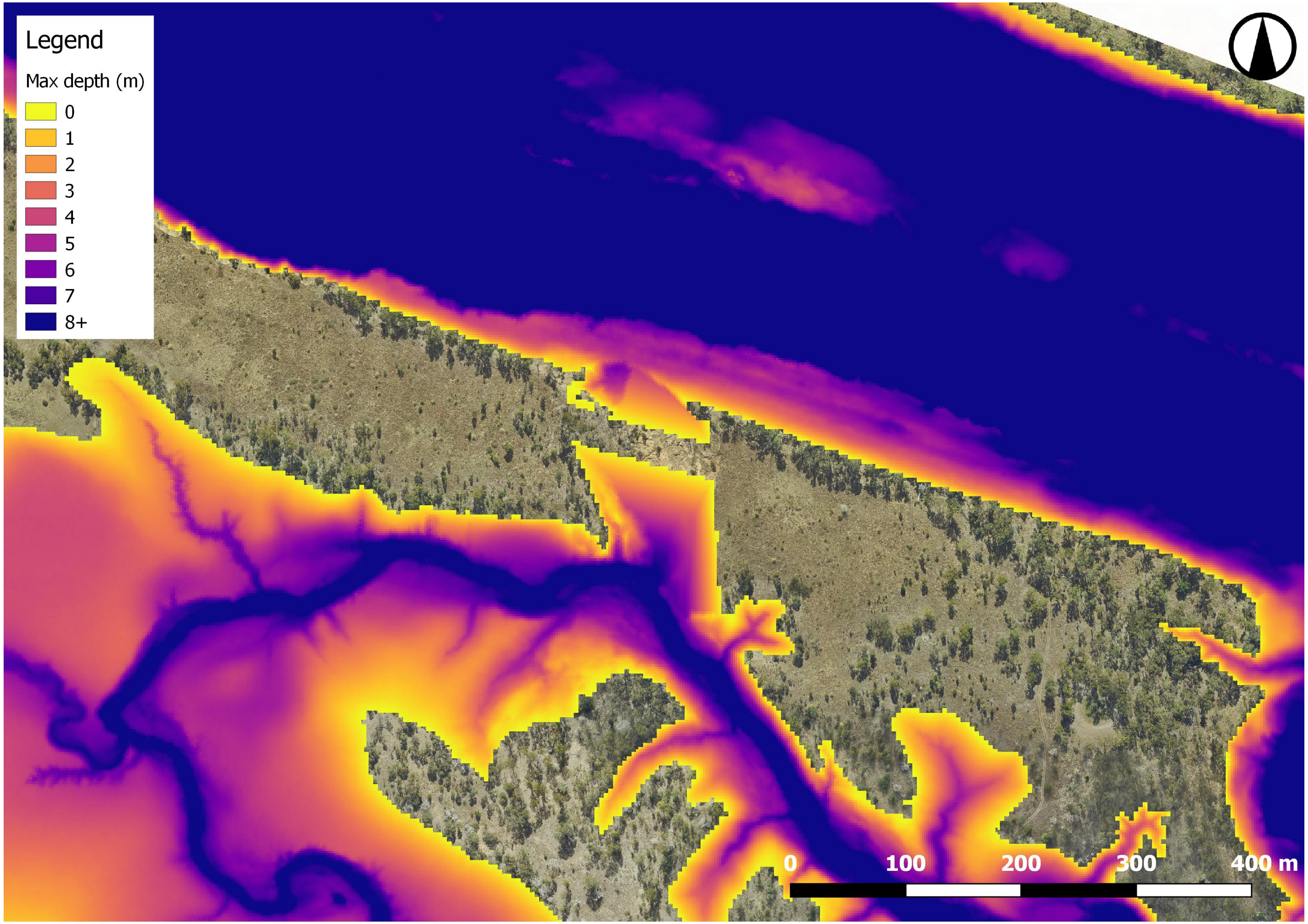

Figure 4. 5% AEP maximum flood depths with proposed detail design included in terrain model

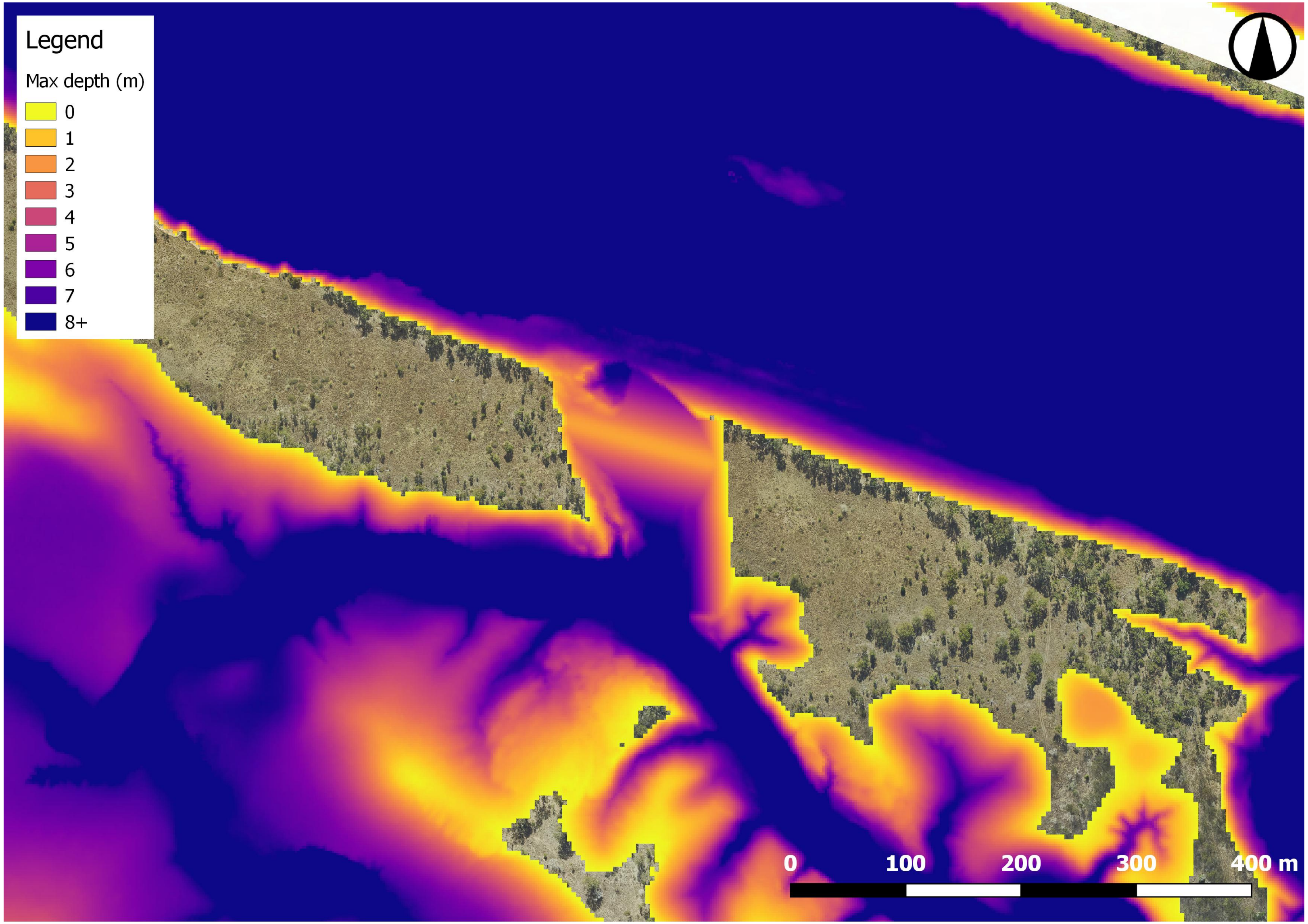

Figure 5. 2% AEP maximum flood depths with proposed detail design included in terrain model

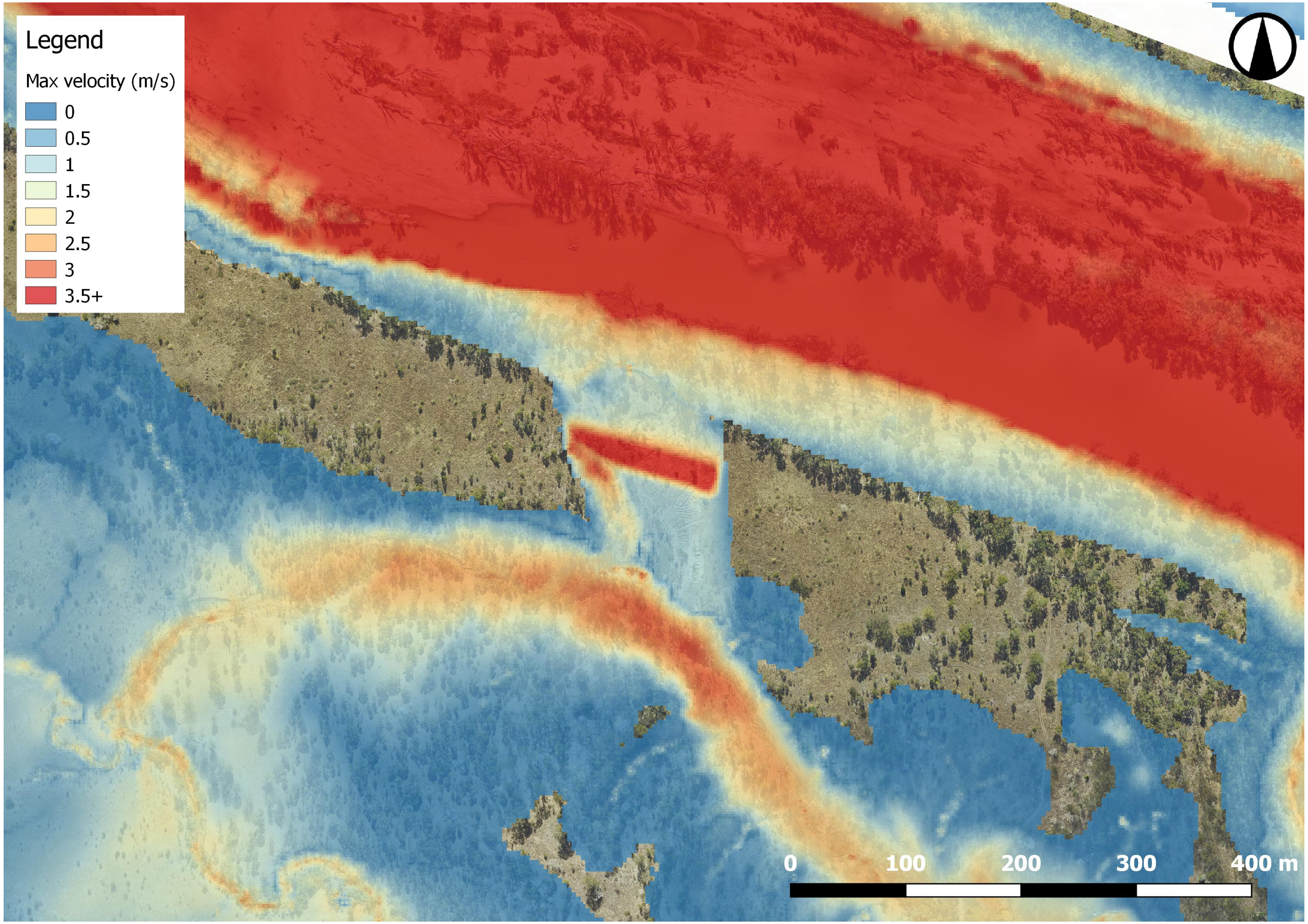

Figure 6. 2% AEP maximum velocities with proposed detail design included in terrain model where n=0.04

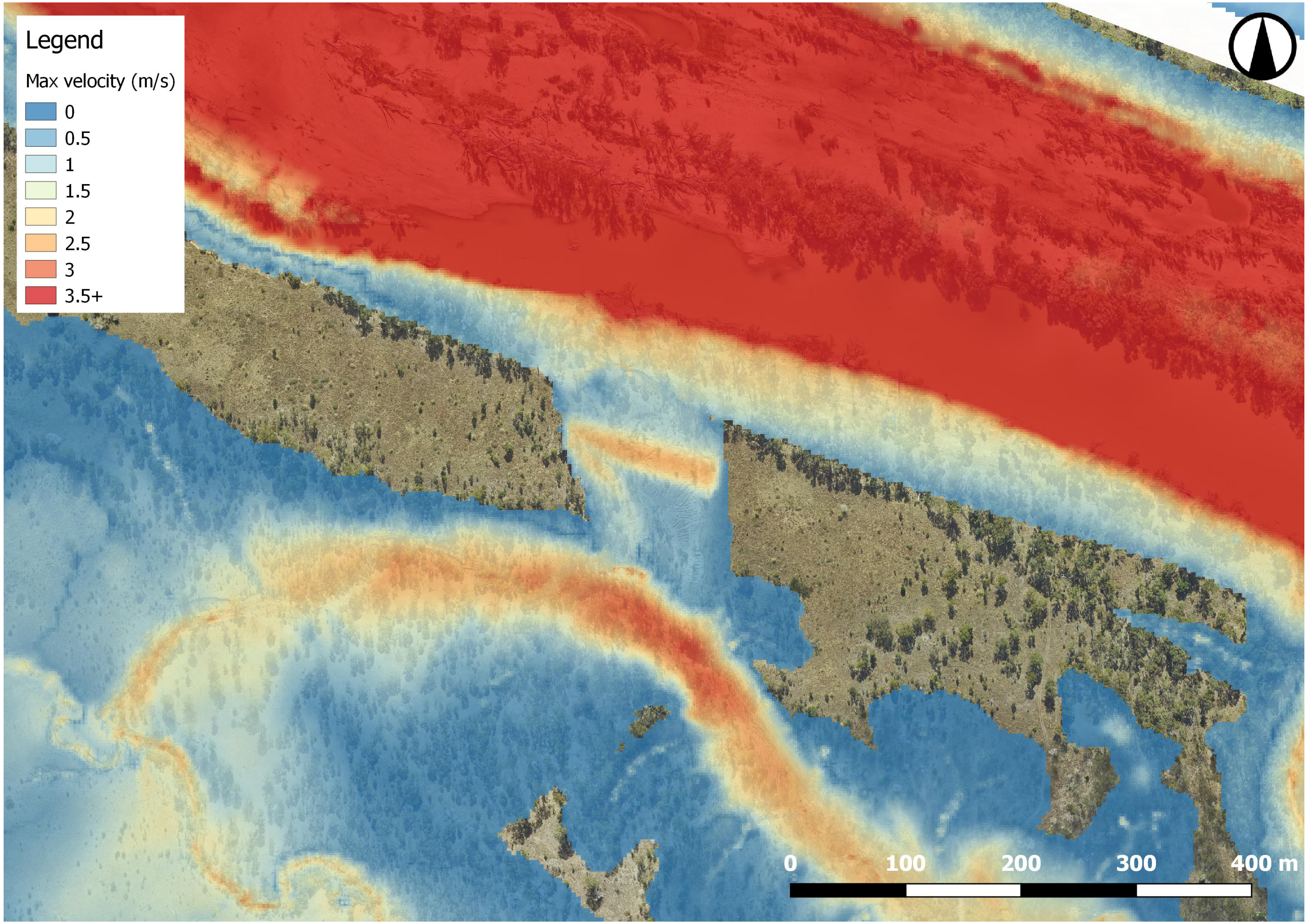

Figure 7. 2% AEP maximum velocities with proposed detail design included in terrain model where n=0.08

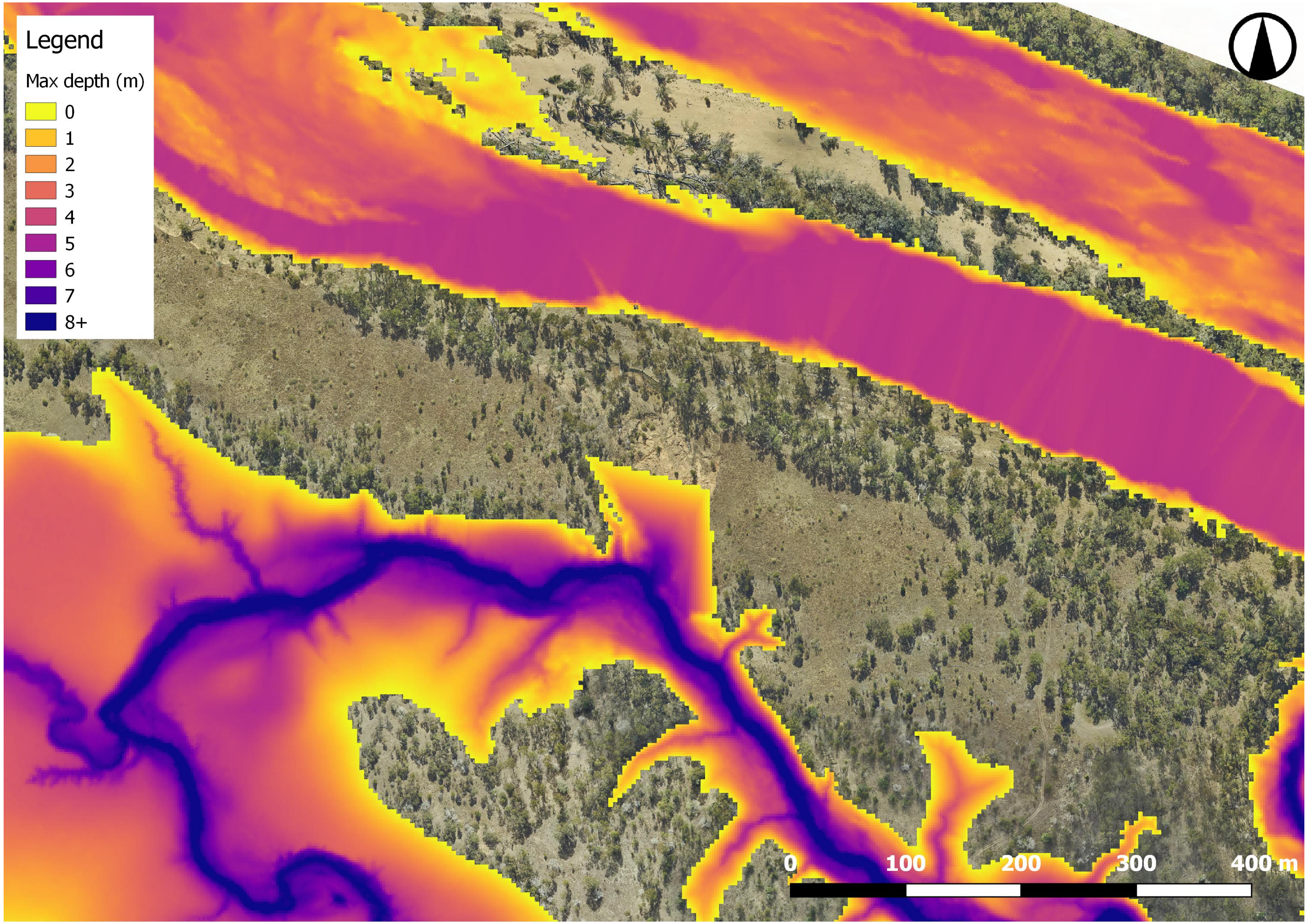

Figure 8. 2% AEP maximum flood depths from Louisa Creek flows only with proposed detail design included in terrain model

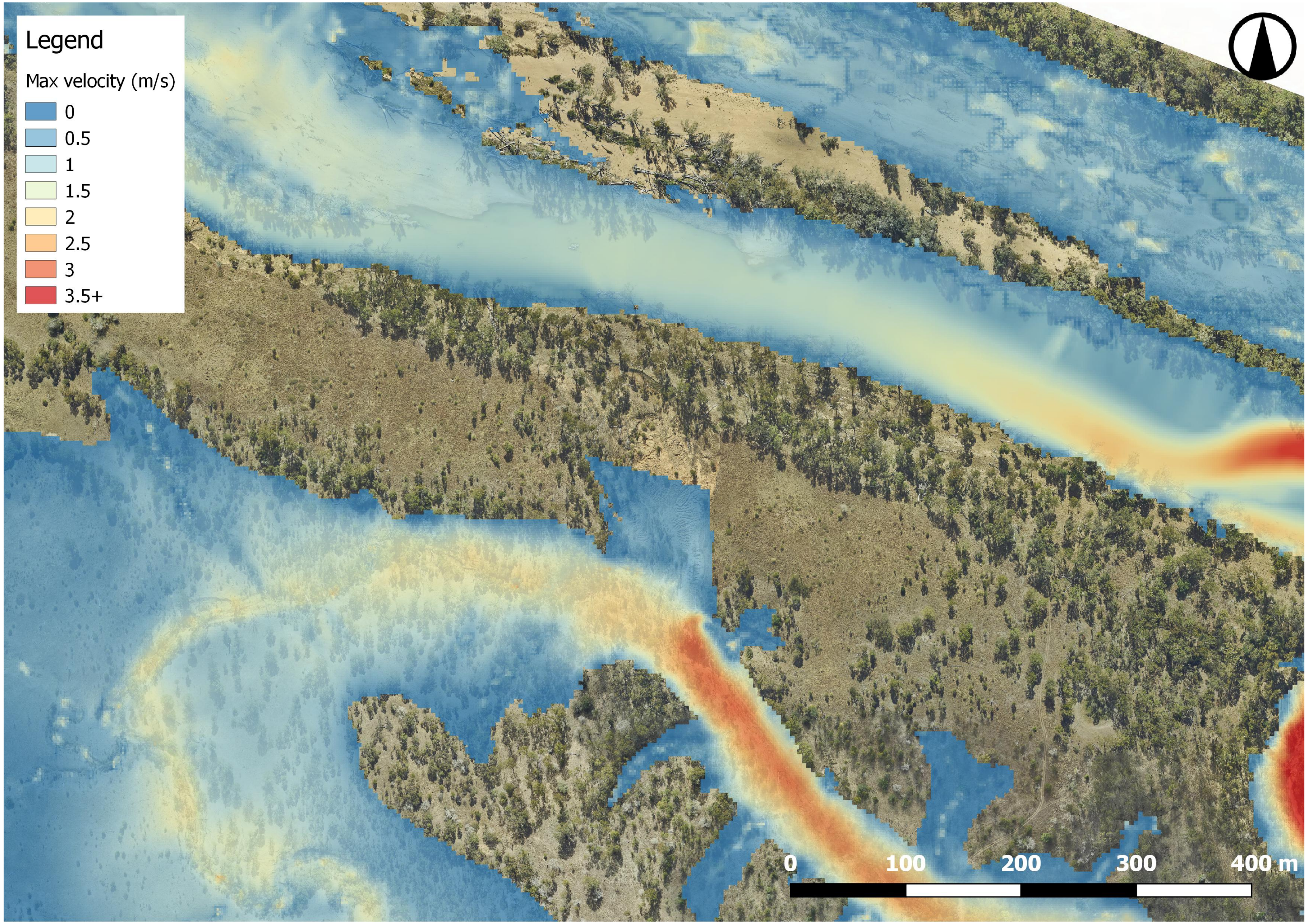

Figure 9. 2% AEP maximum velocities from Louisa Creek flows only with proposed detail design included in terrain model

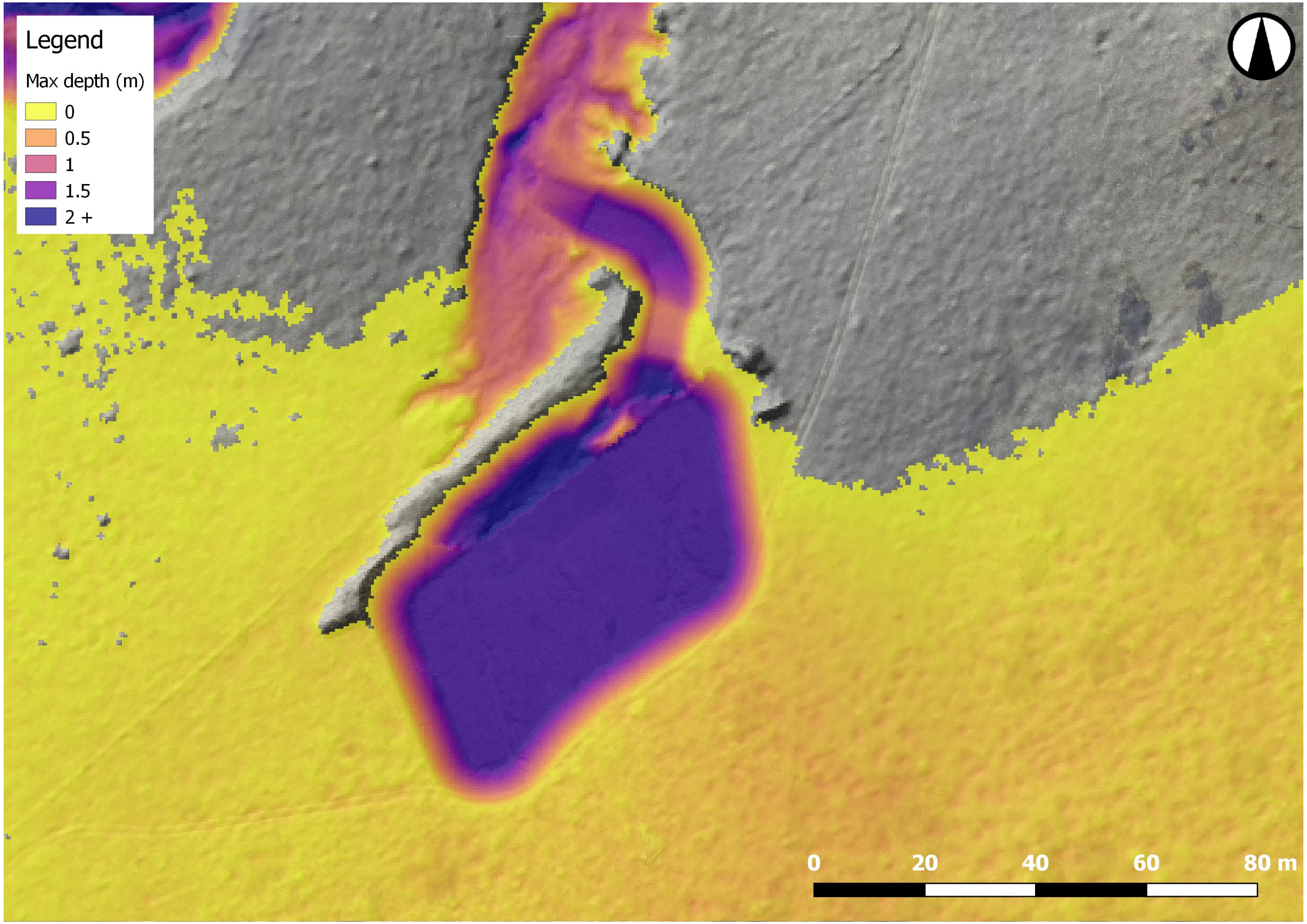

Figure 10. 2% AEP maximum flood depths at farm dam with proposed dam and rock chute spillway detail design included in terrain model

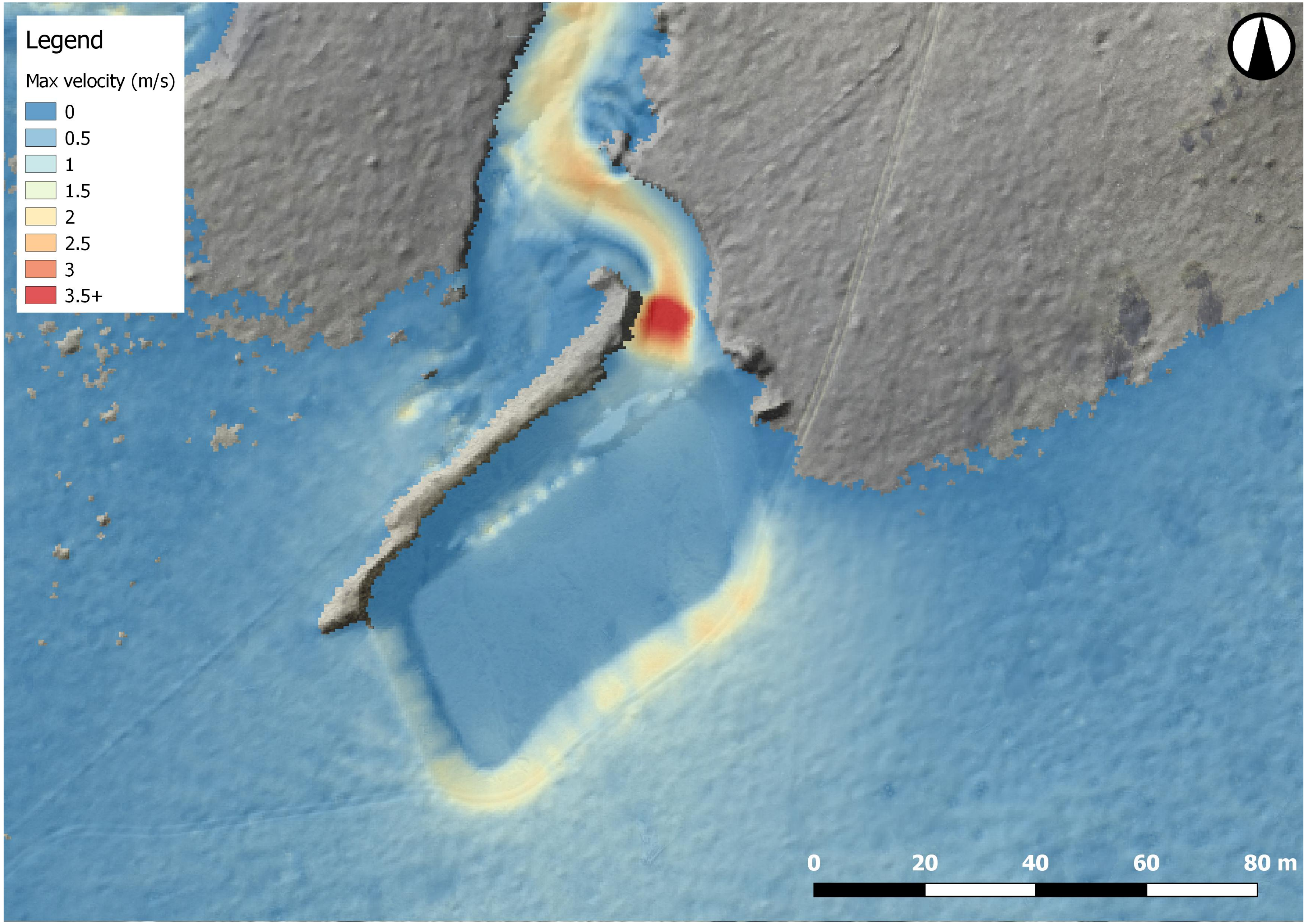

Figure 11. 2% AEP maximum velocities at farm dam with proposed dam and rock chute spillway detail design included in terrain model

Schedule of quantities

Table 3 below outlines the schedule of quantities for the implementation of the proposed works.

Table 3. Schedule of quantities for implementation of proposed works

Item	Material/Equipment	Units	Quantity
1.0	**Mobilisation/Demobilisation**		
1.1	Site Mobilisation	Item	1
1.2	Site Demobilisation	Item	1
2.0	**Bank battering of vertical bank**		
2.1	Clear and grub works footprint	m^2	9,257
2.2	Topsoil strip and cart to stockpile (nominal 300mm)	m^3	1,378
2.3	Bank battering of vertical bank (cut)	m^3	20,649
2.4	Bank battering of vertical bank (fill)	m^3	279
2.5	Placement of topsoil on battered slope (nominal 300mm)	m^3	2,098
2.6	Supply of gypsum to central landform (nominal 10 tonnes per hectare)	tonnes	7
2.7	Application and incorporation of gypsum into topsoil on central landform (incorporated to nominal 150mm depth)	tonnes	7
2.8	Application of Hydromulch with seed mix on battered bank (nominal 60mm thickness)	m^2	6,994
3.0	**Formation of central landform**		
3.1	Clear and grub works footprint	m^2	8,005
3.2	Foundation preparation prior to fill	m^2	8,005
3.3	Formation of central landform (fill)	m^3	20,699
3.4	Supply of granular filter rock for rock beaching (D50 = 25mm)	m^3	34
3.5	Placement of granular filter rock for rock beaching	m^3	34
3.6	Supply of rock for rock beaching (D50 = 500mm)	m^3	341
3.7	Placement of rock for rock beaching	m^3	341
3.8	Placement of topsoil on central landform (nominal 300mm)	m^3	3,077
3.9	Supply of gypsum to central landform (nominal 10 tonnes per hectare)	tonnes	10
3.10	Application and incorporation of gypsum into topsoil on central landform (incorporated to nominal 150mm depth)	tonnes	10
3.11	Application of Hydromulch with seed mix on central landform (nominal 60mm thickness)	m^2	10,257
4.0	**Excavation of farm dam and construction of rock chute spillway**		
4.1	Clear and grub farm dam footprint	m	3,111
4.2	Clear and grub rock chute spillway footprint	m	608
4.3	Excavation of farm dam and cart to avulsion site stockpile for topsoiling (nominal top 0.5m thickness)	m^3	2,498
4.4	Excavation to rock chute spillway foundation level and cart to avulsion site for topsoiling	m^3	445
4.5	Excavation to rock chute spillway foundation level and cart to stockpile	m^3	268
4.6	Spreading of material from stockpile in area designated by landholder (nominal 300mm thickness)	m^2	893

Item	Material/Equipment	Units	Quantity
4.7	Supply of gypsum to farm dam (nominal 10 tonnes per hectare)	tonnes	0.89
4.8	Application and incorporation of gypsum into spread out material excavated from farm dam (incorporated to nominal 150mm depth)	tonnes	0.89
4.9	Placement of fill to rock chute spillway foundation level	m^3	38
4.10	Supply of geotextile (length required, 4m wide roll) for rock chute spillway	m	30
4.11	Placement of geotextile for rock chute spillway	m	30
4.12	Supply of granular filter rock (D50 = 25mm)	m^3	43
4.13	Placement of granular filter rock (nominal 100mm thickness)	m^3	43
4.14	Supply of rock for rock beaching (D50 = 500mm)	m^3	444
4.15	Placement of rock for rock beaching	m^3	444
4.16	Placement of topsoil on rock chute spillway upper batters (nominal 300mm thickness)	m^3	61
4.17	Application of Hydromulch with seed mix on farm dam batters (nominal 60mm thickness)	m	1,967
4.18	Application of Hydromulch with seed mix on rock chute spillway upper batters (nominal 60mm thickness)	m	202

References

Department of Sustainability and Environment (DSE) (2007). *Technical Guidelines for Waterway Management,* Department of Sustainability and Environment, Victoria

Neilly Group Engineering, 2019. *Technical Specification: Reef Trust IV Collinsdale Station Fitzroy River Channel Avulsion Remediation*, prepared by Neilly Group Engineering for Catchment Solutions

Neilly Group Engineering, 2018a. *Reef Trust IV Collinsdale Station Fitzroy River Channel Avulsion Investigation,* prepared by Neilly Group Engineering for Catchment Solutions

Neilly Group Engineering, 2018b. *Reef Trust IV Collinsdale Station Fitzroy River Channel Avulsion Remediation Concept Design,* prepared by Neilly Group Engineering for Catchment Solutions

Neilly Group Engineering, 2018c. *Bannockburn Station Reef Trust IV Gully Repair Design,* prepared by Neilly Group Engineering for Catchment Solutions

Attachment A: Geotechnical Investigation

Douglas Partners

Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on
Geotechnical Investigation

Fitzroy River Avulsion Rehabilitation
Collinsdale Station, Garnant

Prepared for
Catchment Solutions Pty Limited

Project 93963.00
January 2019

Douglas Partners
Geotechnics / Environment / Groundwater

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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		18/02/2019
Reviewer	pp.	18/02/2019

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Report on Geotechnical Investigation
Fitzroy River Avulsion Rehabilitation
Collinsdale Station, Garnant

1. Introduction

This report presents the results of a geotechnical investigation undertaken in association with proposed rehabilitation of an avulsion site on the banks of the Fitzroy River, at Collinsdale Station, Garnant. The investigation was commissioned in an email dated 5 December 2018 by Mr Philip Jeston of Catchment Solutions Pty Limited and was undertaken in accordance with Douglas Partners' proposal TWN180299 dated 30/10/2018.

We understand that the proposed project involves the localised remediation of eroding gullies and stream banks in the lower Fitzroy River.

It is understood that geotechnical investigation is required to provide information on the following:

- Site description including visual assessment of surface conditions, failures, erodible material etc.;
- Soil and groundwater conditions at the field test locations;
- Comments on excavatability of in-situ soils and suggested batter slopes (for design by others);
- Comments on suitability of excavated soils for re-use as engineered filling;
- Comments on the erodibility (dispersivity) of the site soils, including preliminary comments on amelioration, as appropriate.

The investigation included the excavation of nine test pits and laboratory testing of selected samples. The details of the field work are presented in this report, together with comments and recommendations on the issues listed above.

2. Site Description

The site is located on the bank and flood plain of the Fitzroy River, at Collinsdale Station, Garnet, approximately 30 km north west of Rockhampton (refer Drawing 1 in Appendix A). It comprises an approximately 1.8 ha area along the banks of the Fitzroy River and Louisa Creek, and a farm dam of approximately 0.6 ha in area. Central coordinates of the avulsion area are -23.134862°S, 150.280981°E, and of the farm dam are -23.144139°S, 150.281557°E. Available information indicates that the surface elevation ranges from approximately 21 m AHD top of bank to 11 m within the river bed and approximately 15 m AHD in the vicinity of the farm dam. General topography of the property allow water to drain to the north and east, in the general direction of the Fitzroy River.

The overall site comprises undulating topography and is largely used for pastoral (cattle grazing) activities.

3. Geology

Geological mapping indicated the project site (both the area proposed for rehabilitation, and the borrow pit/farm dam) to be probably underlain by Quaternary aged alluvium typically comprising clays, silts, sands and gravels. The Borrow Pit / Farm Dam is close to a geological boundary with Late Devonian – Early Carboniferous sandstone, siltstone, conglomerate and breccia with basaltic, andesitic and felsic volcanic clasts of the Mount Alma formation, likely to comprise residual clay soils.

Field work generally encountered silty sand/ sandy silt underlain by silty sandy clay/ silty clayey sand at the proposed rehabilitation site, which was considered to be alluvial in origin and therefore in agreement with the mapped geology. Test pits at the farm dam encountered high plasticity silt clay though-out the investigation depth and the soils are considered likely to have been derived from volcanic parent material. The ground conditions were therefore considered to be in agreement with the neighbouring geological unit, rather than that which had been mapped.

4. Field Work Methods

The field work was undertaken on 12 December 2018 and comprised nine test pits (designated as Pits 1 to 9) to between 0.9 m and 2.1 m depth (target 2 m depth):

- Pits 1 to 3 were situated within the base of the avulsion;
- Pits 4 to 6 were situated on the top of bank adjacent to the avulsed area; and
- Pits 7 to 9 were situated close to an existing farm dam, within the footprint of the proposed borrow area.

The approximate test locations are shown with respect to existing site features on Drawing 1 in Appendix A.

The test pits were excavated using a Kubota UFF-4 6 tonne excavator fitted with a 450 mm toothed bucket. Termination at 0.9 m depth in Pit 1 was due to very slow excavation through hard sandy silty clay.

Dynamic cone penetrometer tests (DCPs) were conducted in accordance with test method AS1289.6.3.2 adjacent to the test pit locations to depths of between 0.5 m and 2.4 m.

All field work was completed in the presence of an experienced geo-environmental scientist who set out the test locations, supervised the test pitting operations and sampled and logged the test pits.

At the completion of excavation, the pits were backfilled with excavated spoil and compacted using the excavator bucket. Excess material was mounded at the test locations, and track rolled.

The coordinates at each test location were recorded using a hand-held GPS unit with GDA94 as the datum. Survey information was not available for levels.

5. Field work Results

Field work was undertaken in three distinct areas at the site:

- The avulsed area (proposed fill) (Pits 1 to 3);
- The adjacent top of bank (proposed cut) (Pits 4 to 6); and
- A disused farm dam (proposed borrow area) (Pits 7 to 9).

Ground conditions at the three areas generally comprised:

- The avulsed area was typically devoid of topsoil and generally comprised medium dense silty sand to approximately 0.3 m depth in some instances, underlain by dense or hard orange-brown silty clayey sand or silty sandy clay. Premature refusal was caused by very dense/ hard silty clayey sand/silty sandy clay at 0.9 m depth in Pit 1. A representation of the avulsed area is presented in Figure 1.
    - Comprised large areas of bare ground, with only scattered grasses and woody vegetation.
    - 'Worming' was evident on exposed faces.
    - Small channels of sand and silt were evident throughout.
- The pits excavated on the top of bank, proposed for cut as part of the rehabilitation project, generally encountered very stiff/hard clayey silt or medium dense silty clayey sand to depths of between 02 m and 0.6 m depth, underlain by very stiff to hard sandy silty clay or sandy clay to 1.2 m depth in Pit 5 and 2 m depth in Pit 6. Dense brown sand with silt or silty sand was encountered from 0.5 m in Pit 4 underlying the clayey silt topsoil, and from 1.2 m depth in Pit 5.
    - Undisturbed area did not exhibit symptoms of erosion.
    - >75 %ground cover of pasture grasses, with some woody regrowth.
- Ground conditions at the disused farm dam (proposed borrow area) generally encountered stiff to very stiff, dark brown or brown silty clay for the depth of investigation, with some surface cracking observed to approximately 0.4 m depth.
    - Moderate to heavy grazing pressure from cattle evident.
    - Incision of eastern edge of dam wall was evident (refer Figure 2).

No free groundwater was observed during the excavation of the test pits. Groundwater levels are dependent on seasonal variations in rainfall and would therefore vary with time, and as the Rockhampton region experiences distinctly seasonal rainfall patterns, this variation could be substantial.

Figure 1: Photo looking approximately south along the eroded face of the avulsed area (Bank is approximately 5 m tall).

Figure 2: Photo looking approximately North to incised dam wall (left), with excavator backfilling Test Pit 7.

6. Laboratory Testing

Laboratory testing was performed on selected bulk, disturbed and 'undisturbed' samples from the test pits and bores, and comprised the following:

- Atterberg limits and linear shrinkage (plasticity);
- Particle size distribution (wash sieve);
- Maximum Dry Density;
- pH, Electrical Conductivity (EC), Emerson crumb, exchangeable cations and cation exchange capacity (CEC), and water soluble cations;and
- Permeability tests.

The results of the laboratory testing are provided in the test report sheets presented in Appendix C and are summarised in Tables 1 to 4. It should be noted that, with the exception of oedometer results, only the results of testing within the stadium development area have been included in this report. All oedometer test results have been included in this report in order to maximise the information available for analysis. The balance of laboratory testing will be included in the Entertainment Centre and Ancillary Facilities report to be issued separately.

Table 1: Results of Plasticity Testing

Location	Depth (m)	W_F (%)	W_L (%)	W_P (%)	PI (%)	LS (%)	Description
Pit 1	0.5-0.9	8.2	27	17	10	7.0	Silty clayey sand/ Silty sandy clay
Pit 2	1.5-2.0	11.6	26	17	9	5.0	Silty clayey sand/ Silty sandy clay
Pit 4	1.8-2.0	3.8	23	NO	NP	0.0	Sand with silt
Pit 6	0.0-0.2	2.4	22	NO	NP	0.0	Silty clayey sand
Pit 6	0.3-0.6	2.8	23	NO	NP	0.0	Silty clayey sand
Pit 8	1.1-1.5	23.4	60	21	39	17.0	Silty clay

Legend: W_F – field moisture content; W_L – liquid limit; W_P – plastic limit
PI – plasticity index; LS – linear shrinkage; NO – Not obtainable
NP – Non-plastic

Table 2: Results of Particle Size Distribution Testing and Maximum Dry Density

Location	Depth (m)	Max. Dry Density (t/m^3)	Clay/Silt (%)	Sand (%)	Gravel (%)	Description
Pit 1	0.5-0.9	1.75	57	43	0	Silty clayey sand/ Silty sandy clay
Pit 2	1.5-2.0	1.77	57	43	0	Silty clayey sand/ Silty sandy clay
Pit 3	0.5-1.0	1.77	-	-	-	Sandy silty clay/ Clayey sandy silt
Pit 4	1.8-2.0	1.82	1	99	0	Sand with silt
Pit 5	1.5-2.0	1.81	-	-	-	Silty sand
Pit 6	0.0-0.2	-	21	79	0	Silty clayey sand
Pit 6	0.3-0.6	1.73	17	83	0	Silty clayey sand
Pit 7	0-0.5	1.54	-	-	-	Silty clay
Pit 8	1.1-1.5	1.61	91	9	0	Silty clay
Pit 9	0-0.5	1.42	-	-	-	Silty clay

Table 3: Results of pH, EC, ESP, SAR and Emerson Class Number Testing

Location	Depth (m)	Emerson Class No	pH	EC (µS/cm)	ESP (%)	SAR	Description
Pit 1	0.5-0.9	5	7.5	20	0.7	0.2	Silty clayey sand/ Silty sandy clay
Pit 2	1.5-2.0	5	8.1	16	2.0	0.5	Silty clayey sand/ Silty sandy clay
Pit 3	0.5-1.0	5	7.9	14	3.2	0.3	Sandy silty clay/ Clayey sandy silt
Pit 4	1.8-2.0	5	7.3	20	<0.1	<0.2	Sand with silt
Pit 5	1.8-2.0	5	7.3	13	1.2	0.3	Silty sand
Pit 6	0-0.2	8	7	40	<0.1	<0.2	Silty clayey sand
Pit 7	0-0.5	4	6.7	160	7.4	1.7	Silty clay
Pit 8	1.1-1.5	4	7.1	1100	24.1	13	Silty clay
Pit 9	0-0.5	4	6.4	110	5.4	1.6	Silty clay

Table 1: Results of Laboratory Testing – Falling Head Permeability and Standard Compaction

Location	Depth (m)	FMC (%)	OMC (%)	MDD (t/m3)	K (m/sec)	Description
Pit 1	0.5-0.9	8.2	13.5	1.75	3x10-10	Silty clayey sand/ Silty sandy clay
Pit 3	0.5-1.0	8.6	14.5	1.77	3x10-10	Silty clayey sand/ Silty sandy clay
Pit 6	0.3-0.6	2.8	12.5	1.73	3x10-8	Silty clayey sand
Pit 8	1.1-1.5	23.4	23.5	1.61	2x10-10	Silty clay

Where FMC = Field moisture content; MDD = Maximum dry density
OMC = Optimum moisture content; K = Coefficient of Permeability

7. Proposed Development

We understand that the proposed project involves the localised remediation of an eroding gully and stream bank in the lower Fitzroy River utilising locally sourced materials.

8. Comments

8.1 Excavatability and Batters

Based on the soil conditions encountered within the depth of the pits, it is estimated that bulk excavation may be undertaken by small to medium sized excavation plant such as 10-15 tonne hydraulic excavators (or similar).

The existing filling material won from excavation at the site is assessed as being suitable for re-use as structural filling provided it is screened to remove any organics and/or deleterious materials, and particles greater than 75 mm in size. Such use is contingent upon site preparation and fill placement undertaken in accordance with good construction practices and the recommendations elsewhere in this report.
Based on the conditions encountered in the pits, it is assessed that bulk excavation of the topsoil and residual clay soils may be undertaken by medium sized excavation plant such as 10-15 tonne hydraulic excavators (or similar). Larger equipment would assist to increase productivity rates.

Battering of the excavation would likely be the most economic option. Cut batters in the predominantly stiff or stronger silty clay soils to a maximum depth of 4 m may be formed at temporary batters of 1H:1V or permanent batters of 2H:1V. The temporary batter slopes are suggested with respect to slope stability only and do not allow for lateral stress relaxation.

Permanent soil slopes or embankments may need to be flattened to 3H:1V or less, to allow vehicular access for maintenance of any proposed revegetation. It is also recommended that all batters incorporate crest and toe drains, and be covered with vegetation (or similar) to provide erosion protection.

Temporary excavations up to 1 m in depth may remain near vertical for short periods of time, provided that they remain dry at the time of construction and provided there are no loads, services, structures or traffic located within a distance from the crest of the batter equal to the slope height.

8.2 Soil Erosion

Fine grained soils are prevalent at the site, and the Emerson class tests (Class 4, 5 and 8) indicate that the near surface are slightly to moderately dispersive.

During construction, erosion control measures at the surface will require detailed design; however, it is expected that, as a minimum, measures will need to include silt fences, hay bales and measures to limit water runoff velocity (such as swales or benches) at the downslope boundaries of the site, and prompt installation of topsoiling and grassing or hydro mulching in completed areas. A sedimentation dam may also be required where bulk earthworks operations require large volumes of soil disturbance at the site.

It is recommended that adequate lined collector drainage be installed at the top/crest of all batters and that all clean drainage be discharged off-site via lined channels.

Soil erodibility by water occurs when erosion susceptible soils become detached and transported by the water flow. Erosion can occur in both granular and cohesive soils, but those most at risk include the following:

i. silts and fine sands with low organic content; and
ii. dispersive clays (usually sodic clays).

Silt and sand mixtures were encountered to depths of up to 0.3 m within the eroded area, and up to 0.6 m depth in the proposed cut area immediately adjacent to the eroded landscape, and sand fraction grain size generally varied from fine to medium within these units. The presence of coarse sand fractions is likely to reduce the erosion potential of these soils, so it is recommended that these soils be protected from flows of water during construction.

The potential for fine grained soils (clays) to undergo dispersive type erosion can be measured by their Emerson class. The samples tested generally returned Emerson Class numbers 4 and 5, with one topsoil sample (Pit 6 0 to 0.2 m depth) returning an 8. Fell et al (Ref 2) suggests that soils with an Emerson Class of 4 or less should be treated with caution in construction of water retention structures due to their dispersive nature.

Alternatively, Brisbane City Council (Ref 5) has adopted a simplified interpretation of the Emerson Class numbers as follows:

- Classes 1 and 2 in clay soils are considered to be associated with very high potential for erosion;
- Class 3 with high potential;
- Classes 7 and 8 with a low potential; and
- Classes 4 to 6 less definitive and generally medium potential.

This *implies low to medium dispersion* potential for the soils tested.

Other factors which can impact on the level of dispersion of a soil is pH and exchangeable sodium percentage (ESP).

- pH values for the soils tested were slightly acidic to slightly alkaline (6.4 to 8.1), suggesting that pH is unlikely to be affecting the dispersion potential of the site soils.
- ESP ranged from <0.1% to 3.0% in both the eroded area and the adjacent high bank, proposed for reshaping as part of the rehabilitation process, thus indicating that sodic soil conditions are unlikely to be driving soil erosion at the site. However, soils from the proposed borrow area, exhibited ESP of approximately 5% to 24% indicating sodic to strongly sodic conditions (Ref 4).

On the basis of the various tests performed and visual observations, including active incision within the proposed borrow area, it is considered that the clay soils at the site will have medium potential for dispersive type erosion to occur under fresh water flows, especially given the relatively flat and level nature of the site.

Further, based on data presented in the Queensland Soil Conservation Handbook (Ref 3), soil will scour in an open channel situation, at relatively low gradients, for a range of velocities greater than the following:

- from approximately 0.5 m/s, for bare ground; and
- up to approximately 1.5 m/s to 2 m/s, for well-maintained grass cover.

It follows that where site soils are subjected to flows generally greater than 0.5 m/s, either on batter slopes or in drainage channels, protection should be applied against potential surface erosion. Some typical methods adopted are outlined as follows:

- Erosion Mats – typically made of jute, coconut fibre or polypropylene, may be used in a concentrated flow situation to protect against relatively low velocities;
- Root Reinforcing Mats – typically geo-synthetic, these may be used in conjunction with a permanent grass cover and form protection during propagation of the root system;
- Hydro-mulch – typically comprises the sprayed application of seed and fertiliser through a hydro-seeder, followed by the sprayed application of a wood-fibre, straw or other organic material, combined with a ‘tackifier’ such as PVA glue or bitumen emulsion; not effective for erosion control of steep slopes unless combined with other methods;
- Cellular Confinement Products, or Geo-cells – comprise three-dimensional honeycomb HDPE mesh, and may be used to protect and allow grass growth (as in the case of root reinforcing mats

above), but are also used to aid vehicle trafficking in temporary roads, creek crossings, or across sand dunes;

- Rock Blankets, or Rip Rap – can be used, as an alternative to vegetation, against a variety of flow velocities, or against wave attack, using empirical formulae of wave size or velocity against mean rock size, but may require filter layer(s) of rock and/ or geotextile against the underlying soil, particularly where the primary armour rock is relatively coarse, in order to fully protect against erosion;
- Gabions or Reno Mattresses – are a type of rock blanket where wire baskets (plastic coated against corrosion, if required) are filled with selected rock, of relatively uniform grading, to form either a series of stacked cubic or rectangular units (gabions) or long units placed down the full slope length (reno matresses);
- Pump Grouted Mattresses – comprise a fabricated (possibly nylon) sock or mattress which is placed against the soil and pumped full of grout or concrete, and typically contains a grid of 'dimples' each containing a filter 'button' to facilitate dissipation of pore pressure; and
- Concrete Lined Channels – are used in drain or open-channel situations where non-porous protection from relatively high flow velocities is required.
- The choice of protection materials in any given application will depend upon their availability, durability (in terms of the design life of the structure), and cost.

8.3 Dispersive Soil Management

Sodic, and therefore potentially dispersive soils have been identified in the borrow pit area of the site (refer Table 3). Careful management of potentially dispersive soils is necessary to prevent environmental harm to receiving environments. Where it will not be possible to avoid disturbance of dispersive soils during the proposed works they will require management.

Subsoils from the proposed borrow area should not be used to construct drainage or diversion channels, earth bunds, or spillways. Wherever possible, these soils should be buried on-site under non-dispersive material. Ponding of water on potentially dispersive soils is to be avoided.

Broad scale chemical amelioration of soil, such as with gypsum and organic matter, over exposed soil surfaces will be required to reduce potential dispersivity and improve soil structure. Based on the available analytical results, an application rate of approximately approximately 13 t of gypsum powder per hectare (1.3 kg/m^2) is considered sufficient if treatment is to be undertaken on both the topsoil and subsoil (to 0.5 m treatment depth) from the proposed borrow area. A rate of up to 75 t of gypsum powder per hectare (7.5 kg/m^2) would be considered necessary should amelioration be required only for exposed subsoil materials (to a treatment depth of 0.5 m). Based on a site area of approximately 18,000 m^2, it estimated that up to 24 t of gypsum would be required to treat the imported topsoil to a depth of approximately 0.5 m.

A spray-on ameliorant mixed with a soil binder or copolymer could be applied to the finished surface using a standard water truck to provide effective erosion protection.

On completion of earthworks, any dispersive soils that remain exposed would require stabilisation by treatment with gypsum, then covered with topsoil and revegetated to provide at least 70% ground cover.

9. Limitations

Douglas Partners (DP) has prepared this report for this project at Collinsdale Station in accordance with DP's proposal TWN180299 dated 9 November 2018 and acceptance received from Mr Philip Jeston on behalf of Catchment Solutions Pty Ltd dated 5 December 2018. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Catchment Solutions Pty Ltd and its consultants for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the geotechnical components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

10. References

1. Australian Standard AS2870-2011, 'Residential Slabs and Footings', April 2011, Standards Australia
2. Fell, R, MacGregor, P, and Stapledon, D, "Geotechnical Engineering of Earth Embankment Dams", AA Balkema, 1992
3. Queensland Department of Primary Industries, "Soil Conservation Handbook, Part 9 – Design of Structures", Revised Edition, 1992.
4. Northcote, KH and Skene, JKM, "Australian soils with saline and sodic properties", CSIRO Australia, Soil Publication No 27, Canberra, 1972.

Douglas Partners Pty Ltd

Appendix A

About This Report
Drawing 1 – Site and Test Location Plan

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

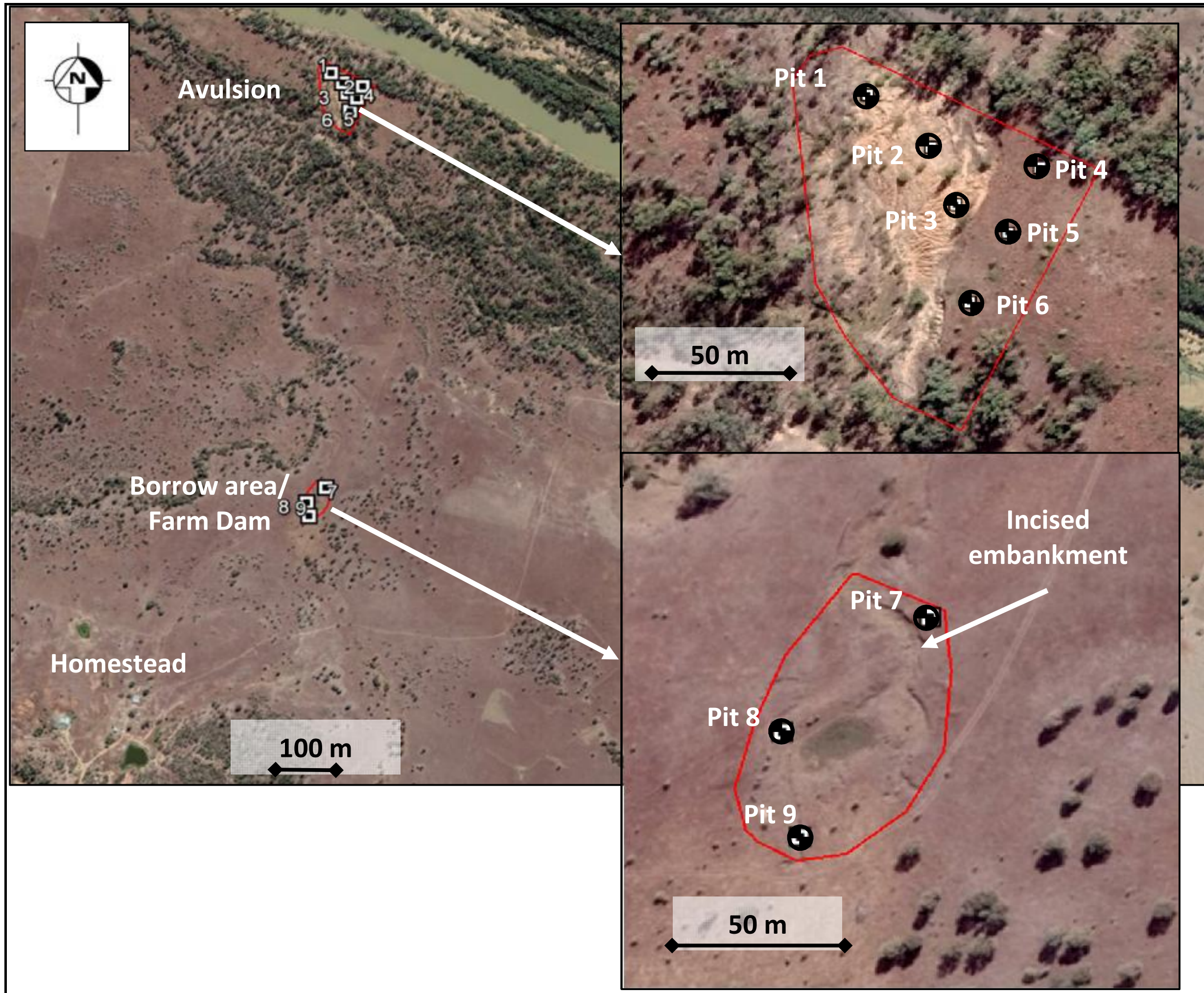
In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

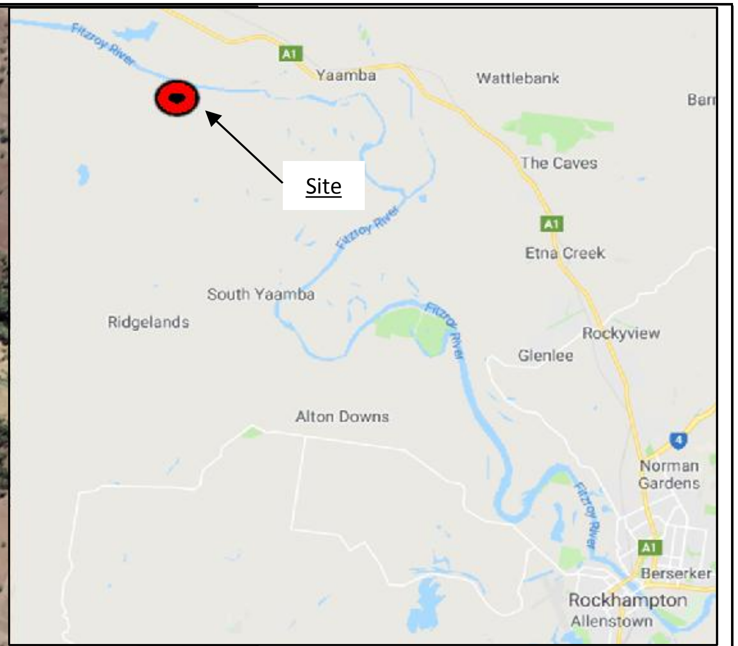
Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.





Notes:

1. Test location Plan modified from Google Earth Imagery (July 2018)
2. Site Locality Plan adapted from Google maps
3. Scale is approximate only

Legend:

Approximate boundary of sites

Test Location and Number

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Catchment Solutions Pty Ltd	**Site and Test Location Plan**	PROJECT No: 93963.00
	OFFICE: Townsville	**Fitzroy River Avulsion Rehabilitation**	DWG No: 1
	DATE: Jan 2019	**Colinsdale Station, Garnant**	REVISION: 0

Appendix B

Field Work Results

Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Soil Descriptions

Douglas Partners

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726-1993, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Descriptions

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.

Symbols & Abbreviations

Douglas Partners

Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling or Excavation Methods

C	Core drilling
R	Rotary drilling
SFA	Spiral flight augers
NMLC	Diamond core - 52 mm dia
NQ	Diamond core - 47 mm dia
HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia

Water

▷	Water seep
▽	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	Pocket penetrometer (kPa)
PID	Photo ionisation detector
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

Defect Type

B	Bedding plane
Cs	Clay seam
Cv	Cleavage
Cz	Crushed zone
Ds	Decomposed seam
F	Fault
J	Joint
Lam	Lamination
Pt	Parting
Sz	Sheared Zone
V	Vein

Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

h	horizontal
v	vertical
sh	sub-horizontal
sv	sub-vertical

Coating or Infilling Term

cln	clean
co	coating
he	healed
inf	infilled
stn	stained
ti	tight
vn	veneer

Coating Descriptor

ca	calcite
cbs	carbonaceous
cly	clay
fe	iron oxide
mn	manganese
slt	silty

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

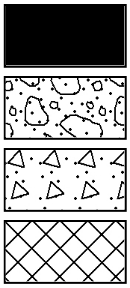
Other

fg	fragmented
bnd	band
qtz	quartz

Symbols & Abbreviations

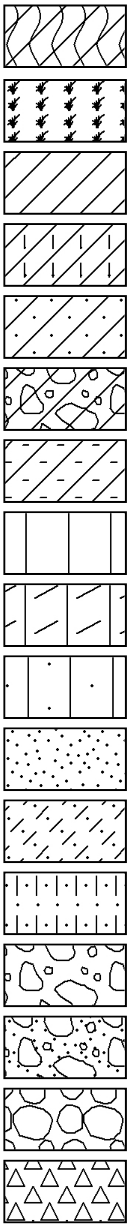
Graphic Symbols for Soil and Rock

General



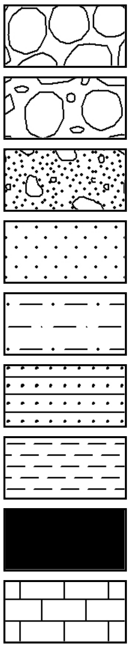
- Asphalt
- Road base
- Concrete
- Filling

Soils



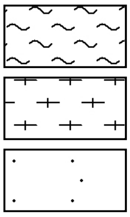
- Topsoil
- Peat
- Clay
- Silty clay
- Sandy clay
- Gravelly clay
- Shaly clay
- Silt
- Clayey silt
- Sandy silt
- Sand
- Clayey sand
- Silty sand
- Gravel
- Sandy gravel
- Cobbles, boulders
- Talus

Sedimentary Rocks



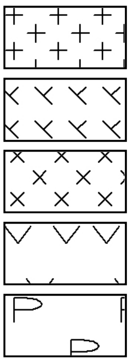
- Boulder conglomerate
- Conglomerate
- Conglomeratic sandstone
- Sandstone
- Siltstone
- Laminite
- Mudstone, claystone, shale
- Coal
- Limestone

Metamorphic Rocks



- Slate, phyllite, schist
- Gneiss
- Quartzite

Igneous Rocks



- Granite
- Dolerite, basalt, andesite
- Dacite, epidote
- Tuff, breccia
- Porphyry

BOREHOLE LOG

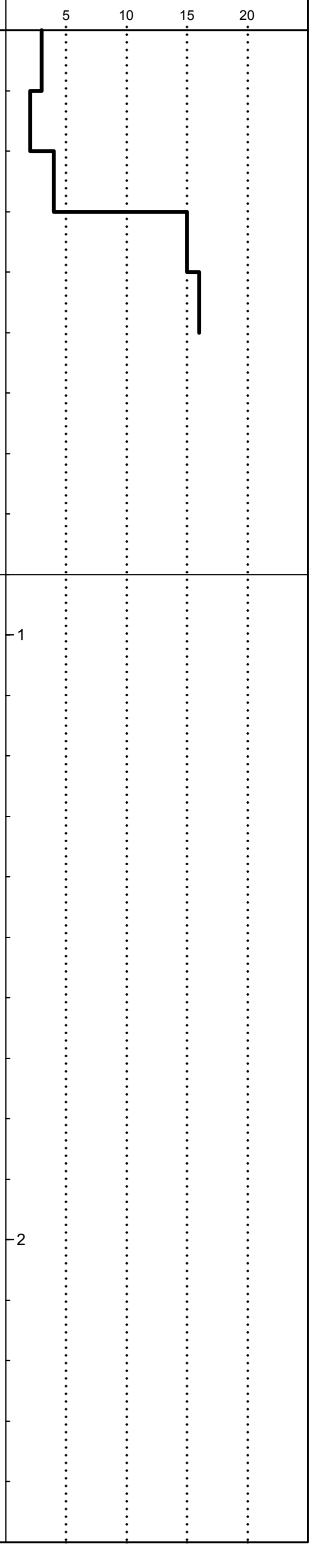
CLIENT: Catchment Solutions Pty Limited
PROJECT: Fitzroy River Avulsion Rehabilitation
LOCATION: Collinsdale Station, Garnant

SURFACE LEVEL: 15 m AHD
EASTING: 332606
NORTHING: 7439143
DIP/AZIMUTH: 90°/--

BORE No: 1
PROJECT No: 93963.00
DATE: 12/12/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
15		SILTY SAND - Medium dense orange brown silty fine to coarse grained sand; moist						
	0.3	SILTY CLAYEY SAND/SILTY SANDY CLAY - Very dense/hard orange brown silty clayey sand/silty sandy clay; fine to coarse grained sand fraction; moist		B	0.5 – 0.9			
	0.9	Bore discontinued at 0.9m depth - due to extremely slow digging through very dense sand/hard clay						
14	1							
13	2							

Dynamic Penetrometer Test (blows per 100mm)



RIG: Kubota U55-4 6 Tonne excavator wit**DRILLER:** wide toothed bucket
LOGGED: DAL
CASING: Nil
TYPE OF BORING:
WATER OBSERVATIONS: No free groundwater observed
REMARKS: Location coordinates are in GDA94/MGA Zone 55K. Surface levels interpolated from Rockhampton Regional Council mapping service

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

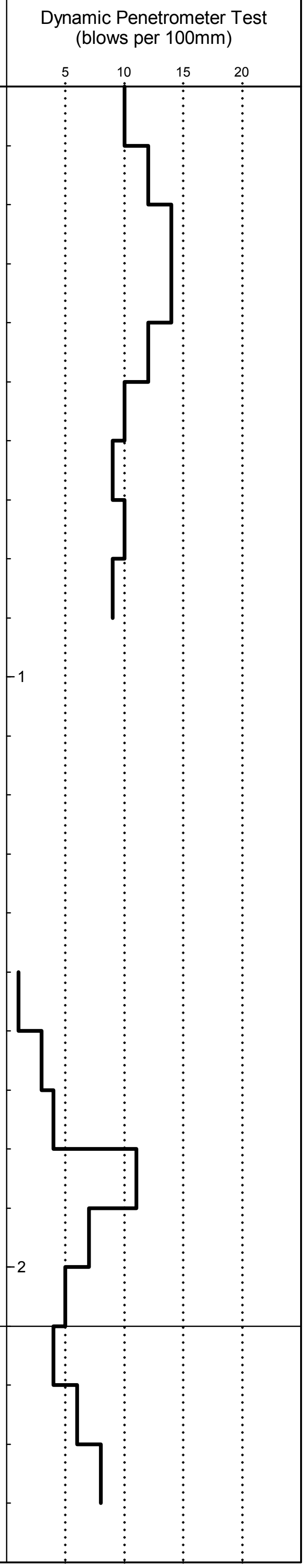
BOREHOLE LOG

CLIENT: Catchment Solutions Pty Limited
PROJECT: Fitzroy River Avulsion Rehabilitation
LOCATION: Collinsdale Station, Garnant

SURFACE LEVEL: 15 m AHD
EASTING: 221539
NORTHING: 7439150
DIP/AZIMUTH: 90°/--

BORE No: 2
PROJECT No: 93963.00
DATE: 12/12/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
15	0.0	SILTY SANDY CLAY - Hard yellow brown silty sandy clay; fine to coarse grained sand fraction; moist						
				B	0.5 – 1.0			
14	1							
	1.5	CLAYEY SILTY SAND/SILTY SANDY CLAY - Soft to very stiff/loose to dense yellow brown clayey silty sand/silty sandy clay; fine to coarse grained sand fraction; moist		B	1.5 – 2.0			
13	2							
	2.1	Bore discontinued at 2.1m depth - limit of investigation						



RIG: Kubota U55-4 6 Tonne excavator with 450mm wide toothed bucket **DRILLER:**
LOGGED: DAL
CASING: Nil
TYPE OF BORING:
WATER OBSERVATIONS: No free groundwater observed
REMARKS: Location coordinates are in GDA94/MGA Zone 55K. Surface levels interpolated from Rockhampton Regional Council mapping service

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

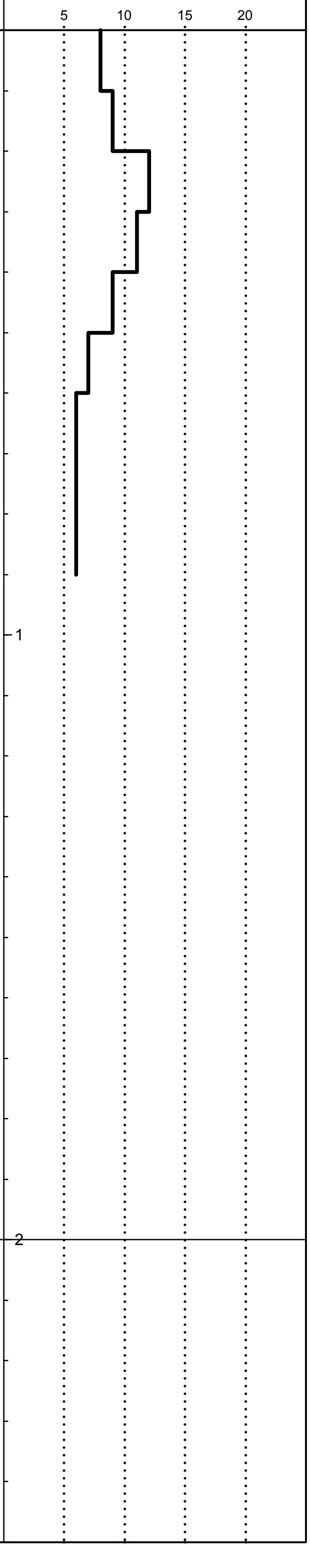
CLIENT: Catchment Solutions Pty Limited
PROJECT: Fitzroy River Avulsion Rehabilitation
LOCATION: Collinsdale Station, Garnant

SURFACE LEVEL: 15 m AHD
EASTING: 221555
NORTHING: 7439122
DIP/AZIMUTH: 90°/--

BORE No: 3
PROJECT No: 93963.00
DATE: 12/12/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
15	0.0	SANDY SILTY CLAY/CLAYEY SANDY SILT - Hard becoming very stiff brown sandy silty clay/clayey sandy silt; fine to coarse grained sand fraction; moist		B	0.5–1.0			
14	1			B	1.5–2.0			
13	2 2.0	Bore discontinued at 2.0m depth - limit of investigation			2.0			

Dynamic Penetrometer Test (blows per 100mm)



RIG: Kubota U55-4 6 Tonne excavator with 450mm wide toothed bucket **DRILLER:**
LOGGED: DAL
CASING: Nil
TYPE OF BORING:
WATER OBSERVATIONS: No free groundwater observed
REMARKS: Location coordinates are in GDA94/MGA Zone 55K. Surface levels interpolated from Rockhampton Regional Council mapping service

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

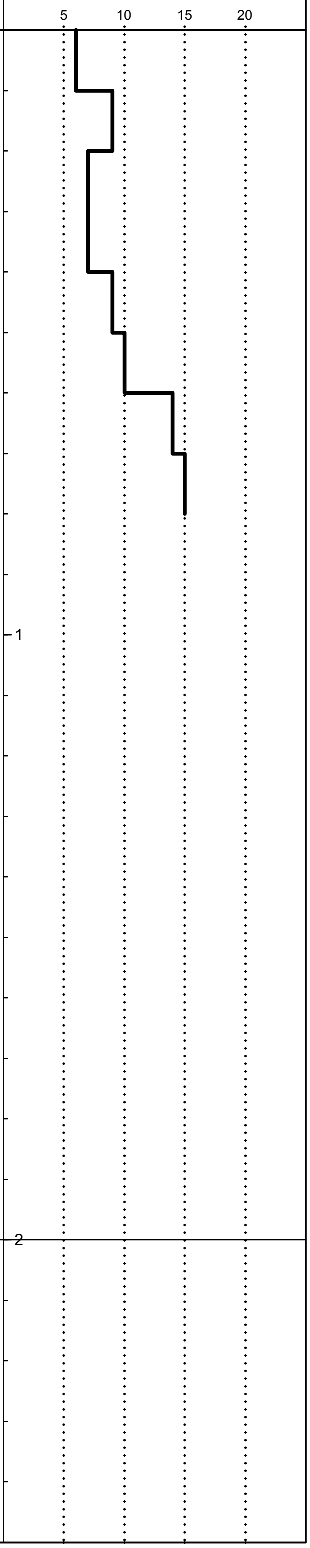
CLIENT: Catchment Solutions Pty Limited
PROJECT: Fitzroy River Avulsion Rehabilitation
LOCATION: Collinsdale Station, Garnant

SURFACE LEVEL: 23 m AHD
EASTING: 221594
NORTHING: 7439147
DIP/AZIMUTH: 90°/--

BORE No: 4
PROJECT No: 93963.00
DATE: 12/12/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
23		CLAYEY SILT - Very stiff/hard grey clayey silt with some fine to medium grained sand; dry						
	0.5	SAND - Dense brown fine to medium grained sand with trace of silt; dry		B	0.5			
22	1	- becoming orange brown below 1m depth			1.0			
				B	1.8			
21	2 2.0	Bore discontinued at 2.0m depth - limit of investigation			2.0			

Dynamic Penetrometer Test (blows per 100mm)



RIG: Kubota U55-4 6 Tonne excavator with 450mm wide toothed bucket **DRILLER:**
LOGGED: DAL
CASING: Nil
TYPE OF BORING:
WATER OBSERVATIONS: No free groundwater observed
REMARKS: Location coordinates are in GDA94/MGA Zone 55K. Surface levels interpolated from Rockhampton Regional Council mapping service

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

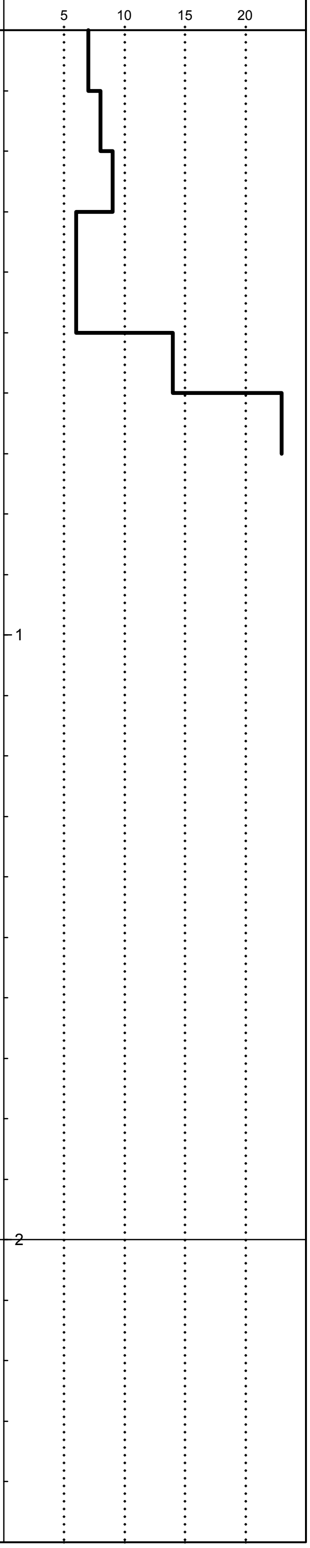
CLIENT: Catchment Solutions Pty Limited
PROJECT: Fitzroy River Avulsion Rehabilitation
LOCATION: Collinsdale Station, Garnant

SURFACE LEVEL: 23 m AHD
EASTING: 221583
NORTHING: 7439111
DIP/AZIMUTH: 90°/--

BORE No: 5
PROJECT No: 93963.00
DATE: 12/12/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
23	0	CLAYEY SILT - Dense grey clayey silt with some fine to coarse grained sand; dry					
	0.2	SANDY SILTY CLAY - Very stiff brown sandy silty clay; fine to coarse grained sand fraction; dry					
	0.55	SANDY CLAY - Hard brown sandy clay; fine to coarse grained sand fraction; dry	B	0.6 – 1.0			
22	1						
	1.2	SILTY SAND - Dense brown silty fine to coarse grained sand; contains some clay lenses; dry	B	1.5 – 2.0			
21	2.0	Bore discontinued at 2.0m depth - limit of investigation					

Dynamic Penetrometer Test (blows per 100mm)



RIG: Kubota U55-4 6 Tonne excavator with 450mm wide toothed bucket **DRILLER:**
LOGGED: DAL
CASING: Nil
TYPE OF BORING:
WATER OBSERVATIONS: No free groundwater observed
REMARKS: Location coordinates are in GDA94/MGA Zone 55K. Surface levels interpolated from Rockhampton Regional Council mapping service

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

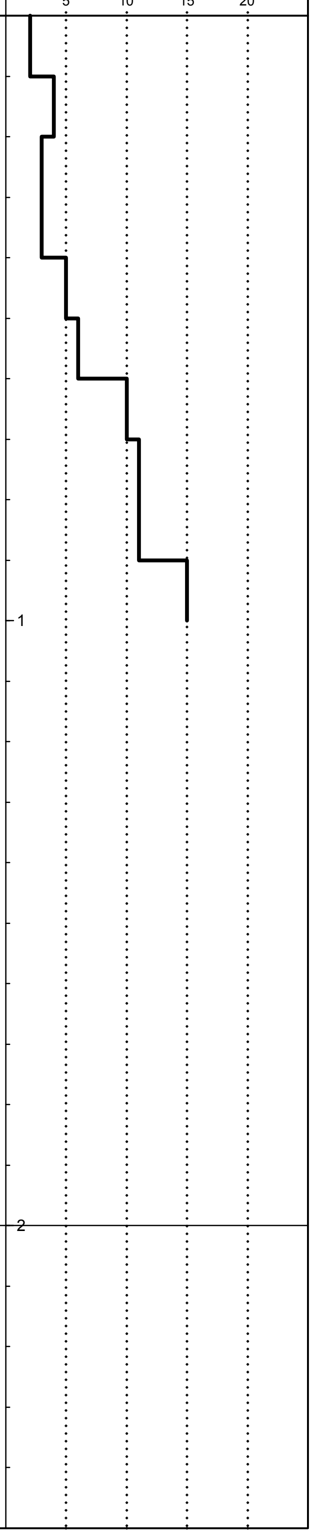
CLIENT: Catchment Solutions Pty Limited
PROJECT: Fitzroy River Avulsion Rehabilitation
LOCATION: Collinsdale Station, Garnant

SURFACE LEVEL: 23 m AHD
EASTING: 221569
NORTHING: 7439072
DIP/AZIMUTH: 90°/--

BORE No: 6
PROJECT No: 93963.00
DATE: 12/12/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
23		SILTY CLAYEY SAND - Medium dense grey brown silty clayey fine to coarse grained sand; dry		D	0.0 – 0.2			
				B	0.3 – 0.6			
	0.6	SANDY CLAY - Hard brown sandy clay; fine to coarse grained sand fraction dry		B	0.6 – 1.0			
22	1							
21	2 2.0	Bore discontinued at 2.0m depth - limit of investigation						

Dynamic Penetrometer Test (blows per 100mm)



RIG: Kubota U55-4 6 Tonne excavator with 450mm wide toothed bucket **DRILLER:**
LOGGED: DAL
CASING: Nil
TYPE OF BORING:
WATER OBSERVATIONS: No free groundwater observed
REMARKS: Location coordinates are in GDA94/MGA Zone 55K. Surface levels interpolated from Rockhampton Regional Council mapping service

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

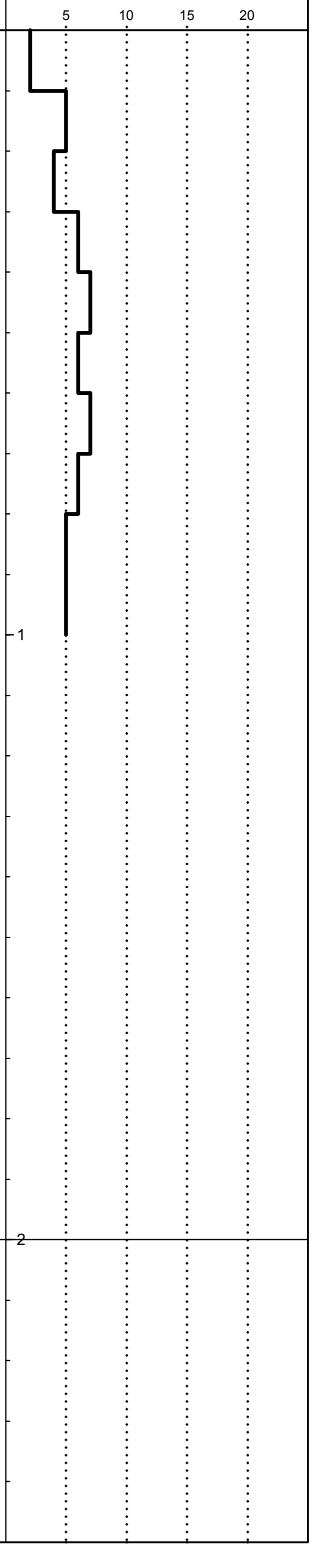
CLIENT: Catchment Solutions Pty Limited
PROJECT: Fitzroy River Avulsion Rehabilitation
LOCATION: Collinsdale Station, Garnant

SURFACE LEVEL: 12 m AHD
EASTING: 221652
NORTHING: 7437986
DIP/AZIMUTH: 90°/--

BORE No: 7
PROJECT No: 93963.00
DATE: 12/12/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
12		SILTY CLAY - Very stiff dark brown silty clay with some fine to coarse grained sand; moist		B	0.0 – 0.5			
	0.9	SILTY CLAY - Very stiff yellow brown silty clay; moist						
11	1			B	1.0 – 1.5			
10	2 / 2.0	Bore discontinued at 2.0m depth - limit of investigation						

Dynamic Penetrometer Test (blows per 100mm)



RIG: Kubota U55-4 6 Tonne excavator with 450mm wide toothed bucket **DRILLER:**
LOGGED: DAL
CASING: Nil

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Location coordinates are in GDA94/MGA Zone 55K. Surface levels interpolated from Rockhampton Regional Council mapping service

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

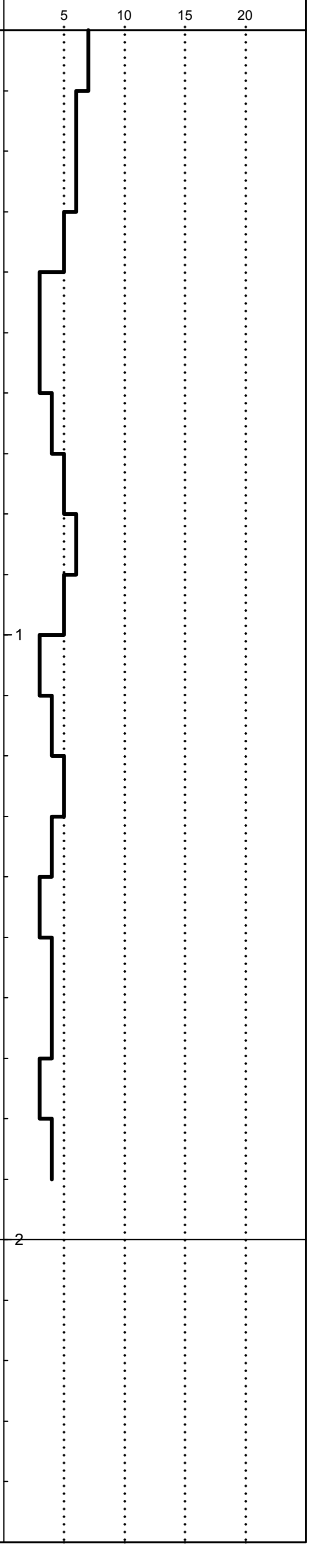
CLIENT: Catchment Solutions Pty Limited
PROJECT: Fitzroy River Avulsion Rehabilitation
LOCATION: Collinsdale Station, Garnant

SURFACE LEVEL: 12 m AHD
EASTING: 221607
NORTHING: 7437937
DIP/AZIMUTH: 90°/--

BORE No: 8
PROJECT No: 93963.00
DATE: 12/12/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
12		SILTY CLAY - stiff to very stiff dark brown silty clay with some fine to coarse grained sand; moist		B	0.0 – 0.5			
11	1							
	1.1	SILTY CLAY - Stiff yellow brown silty clay; moist		B	1.1 – 1.5			
10	2 2.0	Bore discontinued at 2.0m depth - limit of investigation						

Dynamic Penetrometer Test (blows per 100mm)



RIG: Kubota U55-4 6 Tonne excavator with 450mm wide toothed bucket **DRILLER:**
LOGGED: DAL
CASING: Nil
TYPE OF BORING:
WATER OBSERVATIONS: No free groundwater observed
REMARKS: Location coordinates are in GDA94/MGA Zone 55K. Surface levels interpolated from Rockhampton Regional Council mapping service

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

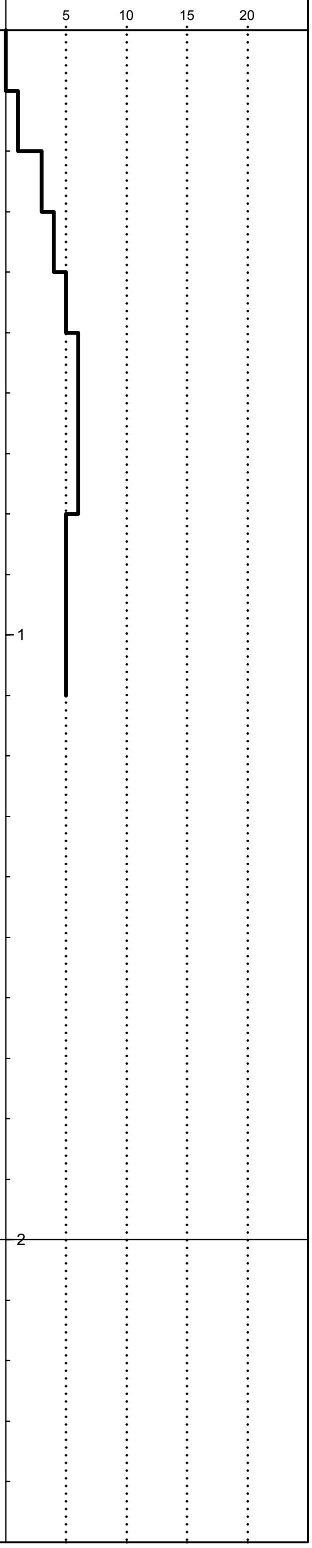
CLIENT: Catchment Solutions Pty Limited
PROJECT: Fitzroy River Avulsion Rehabilitation
LOCATION: Collinsdale Station, Garnant

SURFACE LEVEL: 12 m AHD
EASTING: 221619
NORTHING: 7437898
DIP/AZIMUTH: 90°/--

BORE No: 9
PROJECT No: 93963.00
DATE: 12/12/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
12	0.0	SILTY CLAY - Soft becoming very stiff dark brown silty clay with fine to coarse grained sand; moist			0.0			
11	1				0.5			
	1.2	SILTY CLAY - Estimated to be stiff yellow brown silty clay; moist		B	1.2 1.6			
10	2 / 2.0	Bore discontinued at 2.0m depth - limit of investigation						

Dynamic Penetrometer Test (blows per 100mm)



RIG: Kubota U55-4 6 Tonne excavator with 450mm wide toothed bucket **DRILLER:** **LOGGED:** DAL **CASING:** Nil

TYPE OF BORING:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Location coordinates are in GDA94/MGA Zone 55K. Surface levels interpolated from Rockhampton Regional Council mapping service

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