

Riverbend

Earthworks Strategy

Infrastructure Master Plan

To:	Brandon Bouda (EDQ)
From:	Dan Collins (Colliers Engineering and Design)
Project Name:	Riverbend
Date:	2 September 2024
Our Reference:	20-0190-IMP-EWKS_1

1. Introduction

Colliers Engineering & Design Pty Ltd have been engaged by Celestino Developments Pty Ltd for the purposes of preparing an Earthworks Strategy Infrastructure Master Plan in support of a Priority Development Area (PDA) Development Application to:

- A. Support a context plan application: and
- B. Support a future reconfiguration of lot application.

Over land located at Teviot Road, Riverbend described as Lots 101, 102, 104, 105 & 106 on SP254145 and Lot 800 on SP247625 and as shown below. Geographically, the development will be located within the proposed Riverbend Development Precinct and is bounded by Teviot Road and existing rural-residential allotments and associated infrastructure to the north and west, Logan River and associated tributaries to the south and existing rural-residential, associated infrastructure and former agricultural land to the east.



FIGURE 1: SITE LOCATION

1.1. Context Plan

The Structure Plan (4123001-01Q, dated 02/08/2024 prepared by Place Design Group) that is proposed over the site can be found in **Attachment A**. This comprises:

- Existing contours and indicative block pattern layout;
- Proposed District Centre location;
- Development uses including, sports parks, parks and conservation corridors; and
- Potential school site location

1.2. Requirements of the Infrastructure Management Plan

This Infrastructure Management Plan will be assessed against:

- The provisions of the PDA Development Scheme in force at the date of Approval;
- The applicable EDQ Guideline(s) in effect at the date of the Approval; and

- Any further requirements set out in a condition of the Approval

An endorsed infrastructure master plan may be replaced by submitting for compliance assessment a new infrastructure master plan for endorsement, which is subsequently endorsed.

Where a context plan area strategy is inconsistent with an endorsed infrastructure master plan the amendment to the infrastructure master plan may be limited to address the inconsistency.

1.3. Definitions

Developer	means the owner and developer of a parcel of land within the Approved Land at the relevant time.
IFF	means the Infrastructure Funding Framework (July 2021) of the EDQ.
IFFCOA	means the Infrastructure Funding Framework, Crediting and Offset Arrangements (November 2018) of the EDQ.
ICOP	means the Infrastructure Charging and Offset Plan Greater Flagstone Urban Development Area (June 2020) of the EDQ.
LCC	means Logan City Council.
IMP	means Infrastructure Master Plan.
EDQ	means the Minister for Economic Development Queensland established under the <i>Economic Development Act 2012</i> , which supersedes the Urban Land Development Authority and repeals the <i>Urban Land Development Authority Act 2007 (Qld)</i> .
PDA Development Scheme	means the Greater Flagstone Urban Development Area Development Scheme (October 2011).
PDA Guidelines	means the EDQ guidelines in effect at the time of the Approval (with due regard given to EDQ guidelines subsequently adopted).
QUDM	means Queensland Urban Drainage Manual
Subject Land	means the parcel of land described as Lots 101, 102, 104, 105 & 106 on SP254145 and Lot 800 on SP247625
Supporting Documents	means the documents contained in the attachments.

1.4. Standards

- All earthworks will be carried out in accordance with LCC's design and construction manual and standards, and all relevant Australian Standards.
- The earthworks strategy takes account of EDQ PDA Guideline No. 15 (May 2015) and is generally in accordance with Section 3.6 of Logan City Council's Planning Scheme Policy 5 – Infrastructure
- The design of any earth retaining structures will be generally in accordance with Section 3.3.6 of Logan City Council's Planning Scheme Policy 5 – Infrastructure and Section 3 of AS 4678:2002 - Earth Retaining structures and be designed for a design life of 60 years.
- Investigations and design will generally comply with AS3798-2007- Guidelines on Earthworks for Commercial and Residential Developments
- The proposed E&SC measures will be supported by an Erosion and Sediment Control Plan Checklist in accordance with "Best Practice Erosion and Sediment Control" published by the International Erosion Control Association (Australasia) November 2008, with relevant plans certified by an RPEQ engineer or a CPESC Professional.
- Prior to completion of Pre-Construction Certification, a quantitative assessment of the waterway stability objectives will be undertaken in accordance with the State Planning Policy July 2017.

1.5. Innovation and Flexibility

Earthworks delivery will optimise onsite cut to fill operations across the site. A bulk earthworks strategy for the site will be provided with the first application due to the slope constraints on the site. This provides flexibility and leaves open opportunities for the adoption of best practices and innovation in the future.

Whilst proposals are based on a conventional approach, the EDQ initiative to identify more cost-effective, sustainable and innovative strategies for consideration in Flagstone is strongly supported.

Phasing of the earthworks may be introduced and will be confirmed through the individual stage approvals process that will be informed by further detailed design.

2. Proposed Earthworks

2.1. Overall planning and delivery principles

The proposed development predominantly consists of benched residential allotments, which requires bulk earthworks and retaining structures to facilitate.

Civil earthworks for the proposed development will be undertaken generally in accordance with AS3798-2007 and the design objectives as follows:

- Earthworks to be undertaken to deliver saleable allotments and minimise cut and fill across the site.
- Roads to generally follow the natural topography to minimise cut and fill across the site.
- Lots to grade to the road where possible, unless required otherwise due to the natural topography.
- Maximum driveway earthworks grade of 1 in 4, with an ideal grade being 1 in 5, noting that final driveway(s) by others.
- All earthworks areas will be stabilised with sediment and erosion control measures in accordance with Council Standards
- Retaining wall heights to be generally up to 2.5m in height, unless constrained by natural topography.
- Side retaining wall heights to be generally up to 1.5m in height, unless constrained by natural topography.
- Retaining walls facing external boundary of non-residential land to be wholly located within the lot and generally to a maximum height of 1.5m unless constrained by natural topography.
- Earthworks strategy to follow the requirements of the flood investigations provided by Northrop that identifies the requirements for minimum flood levels to be achieved for adequate lot levels and interface batters to conservation zones. Additionally it is noted that the proposed filling does not cause any significant impacts without undertaking any compensatory earthworks.

2.2. Sedimentation and Erosion Control

The objectives of the erosion and sediment control for the development is to ensure adequate erosion and sediment control measures are implemented prior to the commencement of works and are maintained throughout construction so that runoff is appropriately treated in accordance with best practice standards.

The erosion and sediment control strategy will identify potential environmental risks associated with the development. Specifically, water quality, erodible soils, and environmental impacts to adjoining land and existing roads will be addressed. These risks will be mitigated by designing generally in accordance with ICEA Best Practice Erosion & Sediment Control Guidelines (*November 2008*) and through the implementation of approved site management measures at the time of construction.

Erosion and sediment control measures will be employed as required throughout construction. Measures will consist of diversion drains, temporary sediment basins, silt fences and check dams. Diversion drains will be designed to separate 'dirty water' from 'clean water' and appropriately manage the stormwater discharge during construction to minimise sediment laden runoff into the surrounding waterways. Sediment fences

will serve to trap sediment in minor storm events while rock check dams would act to reduce the velocity of stormwater runoff therefore reducing the transportation of 'dirty water'.

Throughout construction, all disturbed areas will be stabilised and rehabilitated as soon as practical to minimise exposure of these areas to 'dirty water' runoff. Regular stormwater discharge locations will be incorporated to reduce the volume of concentrated flow, facilitating easier site management during construction. Sediment basins will be constructed at appropriate locations in accordance with best practice standards at the time of the engineering design so that sediment laden water can be captured and treated prior to discharge.

An Erosion and Sediment Control Program and Plan will be prepared by an RPEQ or CPESC during the Operational Works phase to confirm the site-specific ESC requirements. All erosion and sediment control measures will be implemented in accordance with best practice requirements.

2.3. Dispersive Soils

Dispersive soils have the tendency to release and form the colloidal "cloud" upon contact with water and can also occur within a still body of water. If dispersive soils are encountered during detailed design analysis or construction phase, control measures would be required. This could include (but not limited to) the use of non-dispersive topsoil material, compaction of back fill and soil treatment with agricultural gypsum.

We refer you to the dispersive soils management plan prepared by Lambert & Rehbein for further information on the management of dispersive soils throughout the site.

Investigations have demonstrated adequate measures for flooding and earthworks can be provided. Further specific analysis will be undertaken for channel modifications at future operational works applications.

2.4. Conceptual Earthworks Environment management

Earthworks operations are generally situated above RL30, as such it is not anticipated earthworks operations will encounter Acid Sulphate Soils (ASS). Should the presence of ASS be noted during the construction phase appropriate investigations will be undertaken by a suitably qualified geotechnical engineer prior to commencement of contract works. If present, a management plan to be prepared and strictly adhered to by the nominated contractor and monitored by the geotechnical engineer throughout the construction phase.

Topsoil samples revealed Emerson Class 3 and 6 materials indicating a predominately low to medium dispersion risk. Subsoil / weathered sandstone samples revealed Class 2, 3 and 5 materials indicating a

predominately moderate to high dispersion risk. Further details of the soil dispersion and required management considerations are detailed in the Dispersive Soil Management Plan (DSMP) report as prepared by Lambert and Rehbein. These measures have been taken into account in the earthworks design. Should dispersive soils be encountered during earthworks operations, proposed management strategies as outlined in the DSMP are to be implemented and maintained throughout the construction phase.

Where earthworks are proposed within the existing flood plain, as described in the most current version of the Logan Planning Scheme and the Jimboomba Celestino Master Planning Concept Stormwater Management Plan, compensatory earthworks are to be undertaken at appropriate locations to ensure flood plain storage is not adversely affected development works.

It is anticipated that earthworks operations will generally be conventional and managed accordingly without posing significant increased risk to the surrounding environment.

2.5. Conceptual Earthworks Overview

The proposed works will generally be contained within the area described above and will generally consist of cut and fill operations to establish design levels, prepare the proposed road formations and shape the temporary sediment and water quality basins. Excavations will generally encounter clay, shaly clay and weathered shale.

It is anticipated that there will be no requirement for importation of engineered fill. All filling works will be undertaken in accordance with 'AS3798 – Guidelines for Commercial and Residential Developments', this may include a requirement for Level 1 certification.

Any stockpiled material, including topsoil shall be located as far away as possible from the Logan River and associated tributaries. Sediment fences shall be installed on the downstream side of stockpiles and embankment formation, and all embankment formations shall be stabilised by hydro seeding or hydro mulching.

Bulk earthworks volumes are approximate only and are subject to change pending final coordination and detailed civil design. It should be noted the abovementioned volumes do not take into account possible unsuitable material and spoil generated from utility service and stormwater drainage trenching.

The conceptual earthworks design has been prepared with due consideration of several civil engineering disciplines including roads and traffic, water supply, sewerage and stormwater quality and quantity. The conceptual earthworks design will maintain, as far as practicable, natural grades of the existing topography. The site will be re-graded to ensure vertical alignments of the proposed road network are compliant with all relevant standards and to provide suitably graded allotments.

Interface works with adjoining properties are to be kept to a minimum. This will be achieved by ensuring, where practicable, design surface levels match existing pre-development surface levels. Where levels cannot be matched interface works are to occur generally within the confines of the development site and or appropriately designed retaining structures utilised to limit works within adjoining properties. Where these outcomes cannot be reasonably achieved the project team is to seek and obtain permission from adjoining property owners to undertake works within their properties.

Where possible, it is proposed to limit retaining structures wherever possible. In situations where this is not practicable due to constraints imposed by surrounding infrastructure and the desire to maintain natural grades, retaining structures will be limited to a maximum height of 2.5m.

3. Supporting Documents and Related Reports

Earthworks shall be designed, constructed, managed and monitored generally in accordance with the recommendations outlined in the following documents:

- Riverbend, Jimboomba Concept Earthworks Master Plan as prepared by Colliers Engineering & Design Pty Ltd (Dated 12th August 2024); and
- Riverside, Jimboomba Conceptual Earthworks Master Plan as prepared by Calibre (QLD) Pty. Ltd. (Dated: 18th October 2017):
- Riverbend, Jimboomba Site Based Stormwater Management Plan as prepared by Northrop Consulting Engineers (Dated: 27th August 2024):
- Jimboomba Celestino Master Planning Concept Stormwater Management Plan as prepared by Calibre (QLD) Pty. Ltd. (Dated: 20th April 2017):
- Broadscale Geotechnical Investigation Riverside Development, Jimboomba as prepared by Pacific Geotech Consulting Geotechnical Engineers (Doc. Ref.: PG-7818; Dated: 16 November 2022);
- Geotechnical Investigation and Broadscale Landslide Hazard Assessment - Riverbend and Teviot Brook Developments Teviot Road, Jimboomba as prepared by SGS Australia Pty. Ltd (Doc. Ref.: SGSE.16.220.GI.R01 Rev0; Dated: 20 January 2017);
- Dispersive Soil Management Plan – Teviot Road & Bushland Road, Riverbend Boulevard as prepared by Lambert & Rehbein (Doc. Ref.: B16288DER001 RevA; Dated: 27 February 2017); and
- AS3798-2007 – Guidelines on Earthworks for Commercial and Residential Development

Additionally, we provide the following responses to the Logan Planning Scheme 2015 Version 2.1 Filling and Excavation Code in support of the compliance assessment condition response:

Performance Outcomes	Acceptable Outcomes	Response(s)
Protection of Natural Processes and Ecosystems		
P01 The discharge of sediments and pollutants from filling or excavation does not adversely affect a waterway or the stormwater network.	A01 The discharge of sediments and pollutants to a waterway or stormwater network complies with Part 3.3 - Filling and excavation standards in Planning Scheme Policy 5 - Infrastructure.	Discharge of sediments into a waterway to be managed in accordance with Part 3.3 - Filling and excavation standards in Planning Scheme Policy 5 - Infrastructure.
P02 Topsoil and spoil stockpiled on the premises do not adversely affect natural processes and ecosystems.	A02 Topsoil and spoil is stockpiled to comply with Part 3.3 - Filling and excavation standards in Planning Scheme policy 5 – Infrastructure	Topsoil and spoil to be stockpiled in accordance with Part 3.3 - Filling and excavation standards in Planning Scheme Policy 5 - Infrastructure.
P03 Filling is carried out using stable, solid and clean earth, free of organic and putrescible waste, rubbish and refuse material.	A03 Filling complies with Part 3.3 - Filling and Excavation standards in Planning Scheme Policy 5 - Infrastructure.	Filling to be undertaken in accordance with Part 3.3 - Filling and excavation standards in Planning Scheme Policy 5 - Infrastructure.
Protection of Existing and Planned Infrastructure		
P04 Filling is carried out using stable, solid and clean earth, free of organic and putrescible waste, rubbish and refuse material.	A04 Filling or excavation works comply with Part 3.3 - Filling and Excavation standards in Planning Scheme Policy 5 - Infrastructure.	Filling to be undertaken in accordance with Part 3.3 - Filling and excavation standards in Planning Scheme Policy 5 - Infrastructure.
Protection and Enhancement of Health and Safety and Premises		
P05 Filling or excavation works do not adversely affect personal health and safety.	A05 Filling or excavation works comply with Part 3.3 - Filling and Excavation standards in Planning Scheme Policy 5 – Infrastructure.	Filling and or excavation to be undertaken in accordance with Part 3.3 - Filling and excavation standards in Planning Scheme Policy 5 - Infrastructure.

Surface Water Flow		
P06 Surface water drainage does not cause any of the following: (a) ponding on any premises; or (b) a hazard or adversely affect personal health and safety and premises; or (c) diversion or concentration of flow from or onto adjoining premises or infrastructure.	A06 Surface water drainage complies with Part 3.3 - Filling and Excavation standards in Planning Scheme Policy 5 – Infrastructure.	Surface water to be managed in accordance with Part 3.3 - Filling and excavation standards in Planning Scheme Policy 5 - Infrastructure.
Batters		
P07 A batter: (a) does not adversely affect the natural physical processes and ecosystems; (b) protects existing and planned infrastructure; (c) is safe, stable and easily maintained; (d) is landscaped to enhance visual amenity.	A07 A batter is designed and constructed to comply with the standards specified in Section 3.3.6 - Batters and retaining walls in Planning Scheme Policy 5 - Infrastructure.	Batters to be designed and constructed in accordance with Section 3.3.6 - Batters and retaining walls in Planning Scheme Policy 5 - Infrastructure

Retaining Walls		
P08 A retaining wall: (a) is not constructed of timber and are no located on existing or proposed lot boundaries, or movement networks; (b) does not adversely affect the natural physical processes and ecosystems; (c) is located to avoid conflict with adjoining premises; (d) is located such that existing and planned infrastructure is not adversely affected; (e) protects the visual amenity of adjoining premises or a public open space; (f) is located within the premises that is being filled; (g) is located within the premises that is cut and is designed to take any surcharge loading allowable on the uphill lot; (h) is safe and stable; (i) enables easy access for maintenance.	A08 A retaining wall is designed and constructed to comply with the standards specified in Section 3.3.6.2 - Retaining walls in Planning Scheme Policy 5 - Infrastructure.	Retaining structures to be designed and constructed in accordance with Section 3.3.6.2 - Retaining walls in Planning Scheme Policy 5 - Infrastructure.
Filling of a Dam		
P09 The filling of a dam: (a) does not adversely affect the natural physical processes and ecosystems; (b) creates a safe and stable surface; (c) is integrated into the landscape.	A09 The filling of a dam complies with Part 3.3 – Filling and excavation standards in Planning Scheme Policy 5–Infrastructure.	Filling of dams, if encountered, to be undertaken in accordance with Part 3.3 – Filling and excavation standards in Planning Scheme Policy 5–Infrastructure.

4. Concluding Remarks

This earthworks infrastructure master plan outlines the intended strategy for the earthworks of the overall development and summarises the planned reporting and design details to be provided as a part of future applications. This information has been prepared to support the context plan application.

5. Disclaimer

This report is prepared by Colliers Engineering & Design for exclusive use by its client only. No responsibility is accepted for the use of or reliance upon this report in whole or in part by any third party.

The sole purpose of this report and the associated services performed by Colliers Engineering & Design is to display information in accordance with the scope of services set out in the contract/quotation between Colliers Engineering & Design and its client. The scope of works and services were defined by the requests of the client, by the time and budgetary constraints imposed by the client, and by the availability of access to site/s and information.

This report is prepared with information supplied by the client and possibly others which is presumed to be accurate and complete. No responsibility is accepted for information that is withheld, incorrect or that is inaccurate, nor for changes to the conditions over the passage of time or from latent circumstance or conditions. No warranty or guarantee is made in relation to the data, findings and conclusions expressed in this report.

This report has been compiled at the level of detail specified in the report and no responsibility is accepted for interpretations made at more detailed levels than so indicated.

Attachments

Attachment A	Context Plan
Attachment B	Preliminary Engineering Plans
Attachment C	Broadscale Geotechnical Investigation as prepared by Pacific Geotech Consulting Geotechnical Engineers
Attachment D	Geotechnical Investigation and Broadscale Landslide Hazard Assessment as prepared by SGS Australia Pty Ltd
Attachment E	Dispersive Soils Management Plan as prepared by Lambert & Rehbein

PROJECT

RIVERBEND

CLIENT



NOTES

ALL LOT NUMBER AND DIMENSIONS (INCLUDING AREAS) ARE APPROXIMATE ONLY AND SUBJECT TO FURTHER DESIGN DEVELOPMENT.

ALL DIMENSIONS HAVE BEEN ROUNDED TO THE NEAREST 0.1 METRES AND ALL AREAS HAVE BEEN ROUNDED TO THE NEAREST SQUARE METRE.

THE BOUNDARIES ON THIS PLAN SHOULD NOT BE USED FOR THE FINAL DESIGN AND ARE SUBJECT TO FINAL DETAILED DESIGN BY ENGINEERS.

INFORMATION ON THIS PLAN ARE FROM THE FOLLOWING SOURCES:

SITE BOUNDARIES: COLLIERS (JUNE 2024)
ADJOINING CADASTRE: QSPATIAL
DESIGN CONTOURS: COLLIERS (JUNE 2024)
AERIAL PHOTOGRAPHY: NEARMAP
TEVIOT ROAD DETAIL: COLLIERS (OCTOBER 2023)

DRAFT

ISSUE	CODE	ISSUE DESCRIPTION	BY	CHK	DATE
-	PRE	FOR REVIEW	TD	TD	20/04/2023
A	PRE	FOR REVIEW	TD	TD	21/04/2023
B	PRE	FOR REVIEW	TD	TD	21/04/2023
C	PRE	FOR REVIEW	TD	TD	03/05/2023
D	PRE	FOR REVIEW	NV	TD	07/06/2023
E	PRE	FOR REVIEW	NV	TD	30/08/2023
F	PRE	FOR REVIEW	NV	TD	01/11/2023
G	PRE	FOR REVIEW	NV	TD	02/11/2023
H	PRE	FOR REVIEW	NV	TD	02/11/2023
I	PRE	FOR REVIEW	NV	TD	10/11/2023
J	PRE	FOR REVIEW	NV	TD	13/11/2023
K	PRE	FOR REVIEW	NV	TD	13/11/2023
L	PRE	FOR REVIEW	NV	TD	20/02/2024
M	PRE	FOR REVIEW	NV	TD	28/03/2024
N	PRE	FOR REVIEW	NV	TD	04/03/2024
O	PRE	FOR REVIEW	NV	TD	08/04/2024
P	PRE	REVISED DISTRICT CENTRE	NV	TD	30/07/2024
Q	PRE	FINAL ISSUE	NV	TD	02/08/2024

PRE - Preliminary | CA - Council Approval | T - Tender | CON - Construction

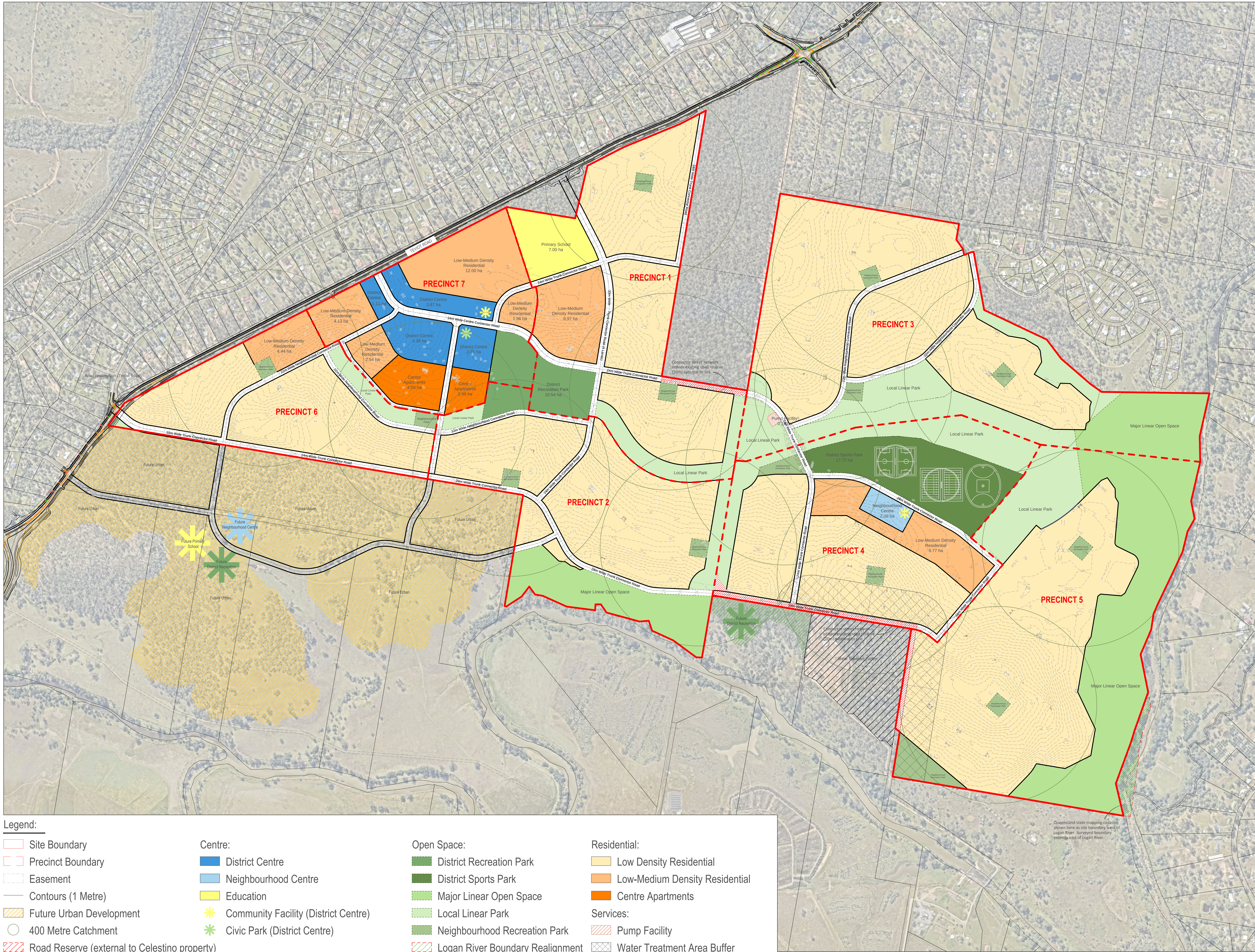
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STRUCTURE PLAN -
RIVERBEND

DESIGN : TD
DOCUMENT : TD / NV
PROJECT : 4123001
1:5,000 @ A0

DRAWING NUMBER
4123001-01

REVISION
Q



Legend:

- Site Boundary

Precinct Boundary

Easement

Contours (1 Metre)

Future Urban Development

400 Metre Catchment

Road Reserve (external to Celestino property)
- Centre:

District Centre

Neighbourhood Centre

Education

Community Facility (District Centre)

Civic Park (District Centre)
- Open Space:

District Recreation Park

District Sports Park

Major Linear Open Space

Local Linear Park

Neighbourhood Recreation Park

Logan River Boundary Realignment
- Residential:

Low Density Residential

Low-Medium Density Residential

Centre Apartments

Services:

Pump Facility

Water Treatment Area Buffer

PROPOSED RESIDENTIAL DEVELOPMENT

CONCEPT EARTHWORKS MASTER PLAN

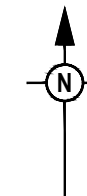
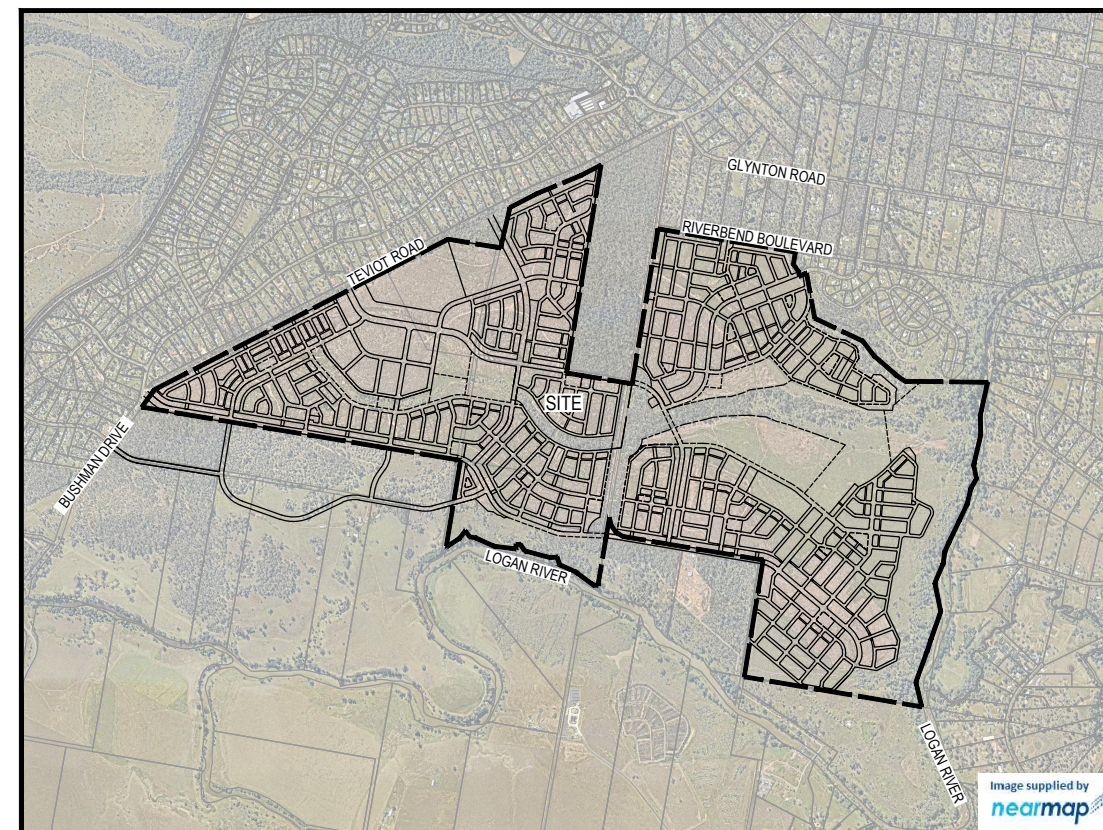
RIVERBEND, JIMBOOMBA

FOR 'CELESTINO DEVELOPMENTS PTY LTD'

DRAWING LIST

CONCEPT EARTHWORKS MASTER PLAN

20-0190-P100	COVER PLAN
20-0190-P101	OVERALL LAYOUT PLAN
20-0190-P102	DEPTH OF CUT/FILL PLAN
20-0190-P103	CONCEPT BULK EARTHWORKS LAYOUT PLAN SHEET 1 OF 7
20-0190-P104	CONCEPT BULK EARTHWORKS LAYOUT PLAN SHEET 2 OF 7
20-0190-P105	CONCEPT BULK EARTHWORKS LAYOUT PLAN SHEET 3 OF 7
20-0190-P106	CONCEPT BULK EARTHWORKS LAYOUT PLAN SHEET 4 OF 7
20-0190-P107	CONCEPT BULK EARTHWORKS LAYOUT PLAN SHEET 5 OF 7
20-0190-P108	CONCEPT BULK EARTHWORKS LAYOUT PLAN SHEET 6 OF 7
20-0190-P109	CONCEPT BULK EARTHWORKS LAYOUT PLAN SHEET 7 OF 7
20-0190-P110	CONCEPT BULK EARTHWORKS SECTIONS SHEET 1 OF 5
20-0190-P111	CONCEPT BULK EARTHWORKS SECTIONS SHEET 2 OF 5
20-0190-P112	CONCEPT BULK EARTHWORKS SECTIONS SHEET 3 OF 5
20-0190-P113	CONCEPT BULK EARTHWORKS SECTIONS SHEET 4 OF 5
20-0190-P114	CONCEPT BULK EARTHWORKS SECTIONS SHEET 5 OF 5



PROJECT INFORMATION SUMMARY:
No. OF LOTS = N/A
AREA OF SITE = 394.66
RP DESCRIPTION LOT 102 ON SP 254145 LOT 104 ON SP 254145 LOT 800 ON SP 247625
DATUM LEVEL AND LOCATION PM172605 RL 43.030 AHD LOCATED RIVERBEND BOULEVAED JIMBOOMBA
LOCAL AUTHORITY: LOGAN CITY COUNCIL
COUNCIL REFERENCE NUMBER:

LOCALITY PLAN

SCALE 1:20000 (A1)
SCALE 1:40000 (A3)

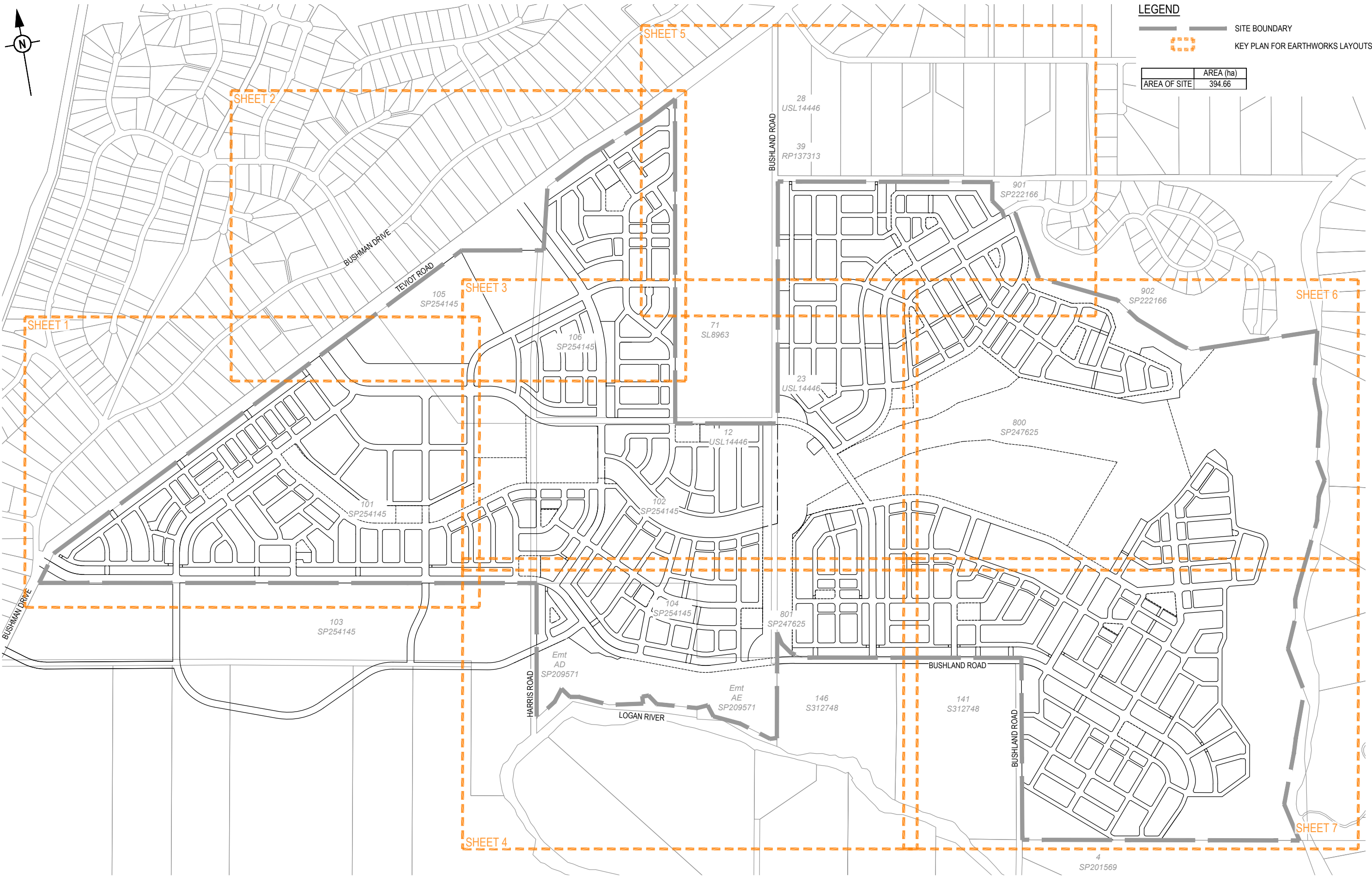
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B	31.05.24	ML	ML	AMENDED ROADS						
C	07.06.24	ML	ML	PLANS AMENDED						
D	12.06.24	ML	BA	PLANS UPDATED						
					DESIGN	APPROVED DANIEL COLLINS	DATE 12.08.24			
						FOR AND ON BEHALF OF COLLIERS INTERNATIONAL ENGINEERING & DESIGN PTY LTD				
								ASSOCIATED CONSULTANT	RIVERBEND JIMBOOMBA	PROJECT No. 20-0190 DRAWING No. P100 REVISION D



LEGEND

- SITE BOUNDARY
- KEY PLAN FOR EARTHWORKS LAYOUTS

	AREA (ha)
AREA OF SITE	394.66



REV	DATE	DESIGN	DRAWN	REVISION DETAILS
A	07.05.24	ML	BA	ORIGINAL ISSUE
B	31.05.24	ML	ML	AMENDED ROADS
C	07.06.24	ML	ML	PLANS AMENDED
D	12.08.24	ML	BA	PLANS UPDATED

DRAWN	STATUS
	NOT FOR CONSTRUCTION
DESIGN	APPROVED DANIEL COLLINS RPEQ 18631 DATE 12.08.24 FOR AND ON BEHALF OF COLLIER'S INTERNATIONAL ENGINEERING & DESIGN PTY LTD



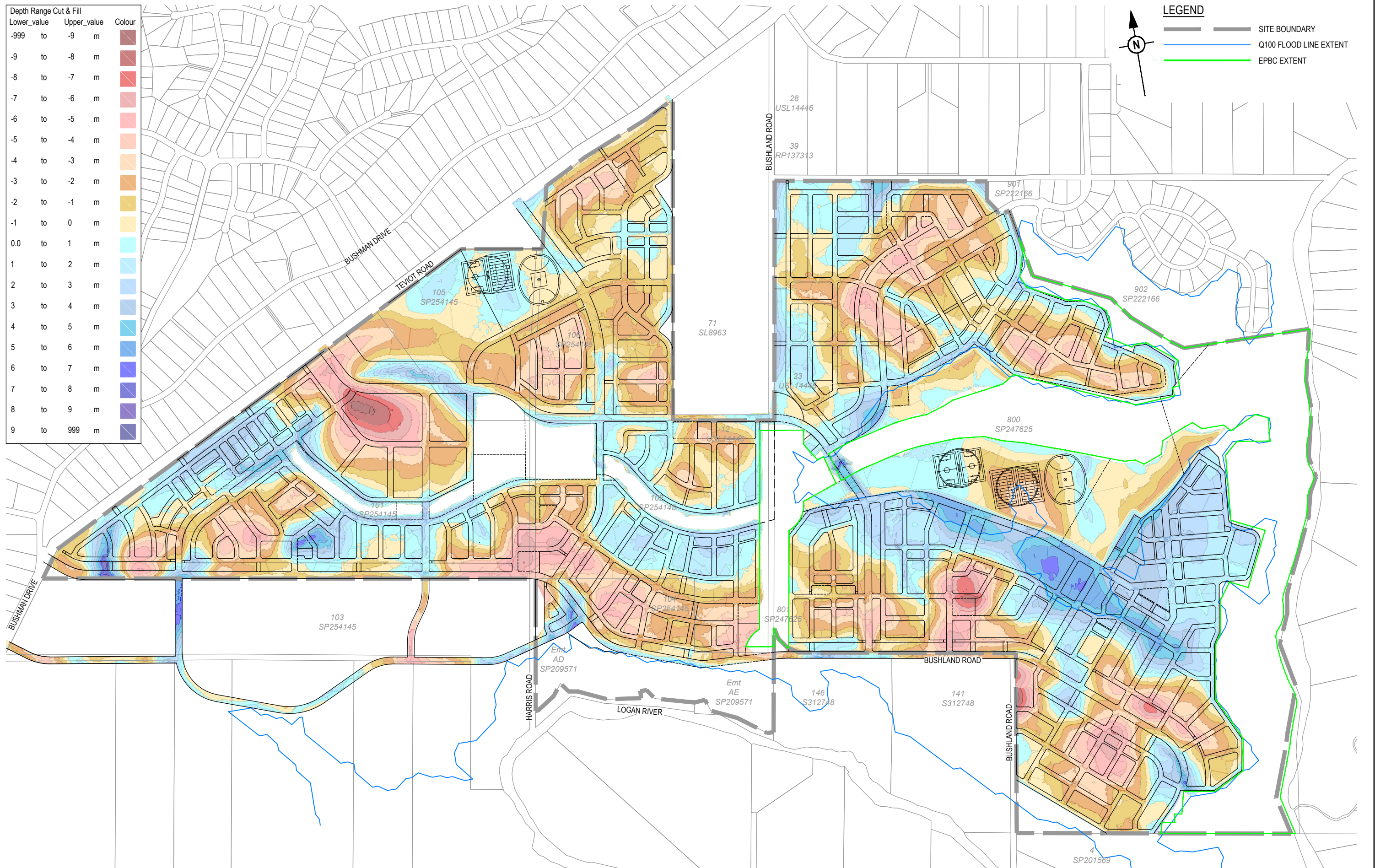
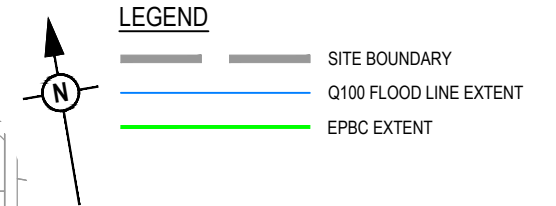
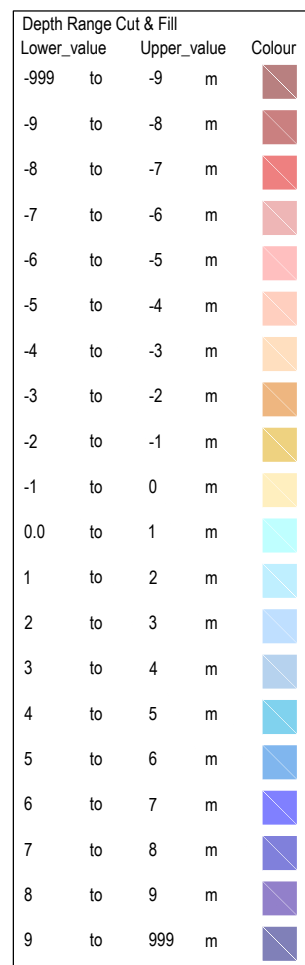
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CLIENT
CELESTINO DEVELOPMENTS PTY LTD
ASSOCIATED CONSULTANT

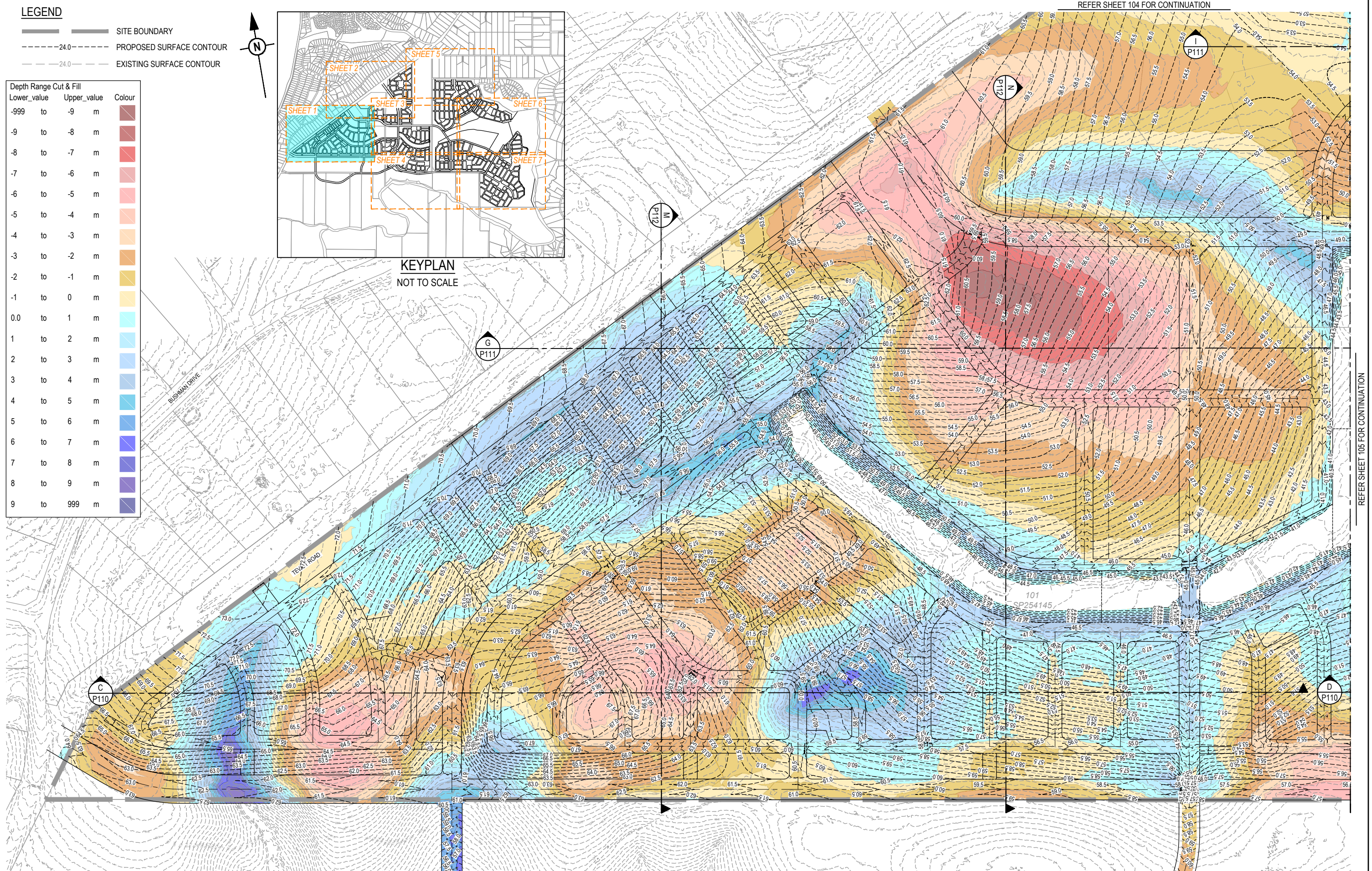
PROJECT NAME
RIVERBEND
RIVERBEND JIMBOOMBA

DRAWING TITLE		
OVERALL LAYOUT PLAN		
PROJECT No. 20-0190	DRAWING No. P101	REVISION D

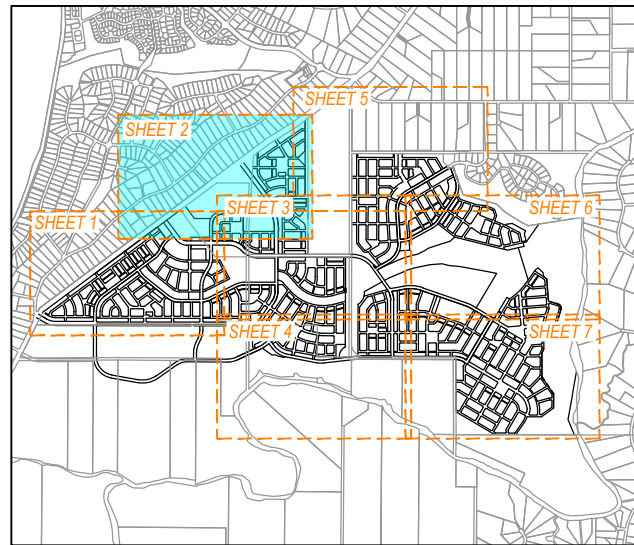
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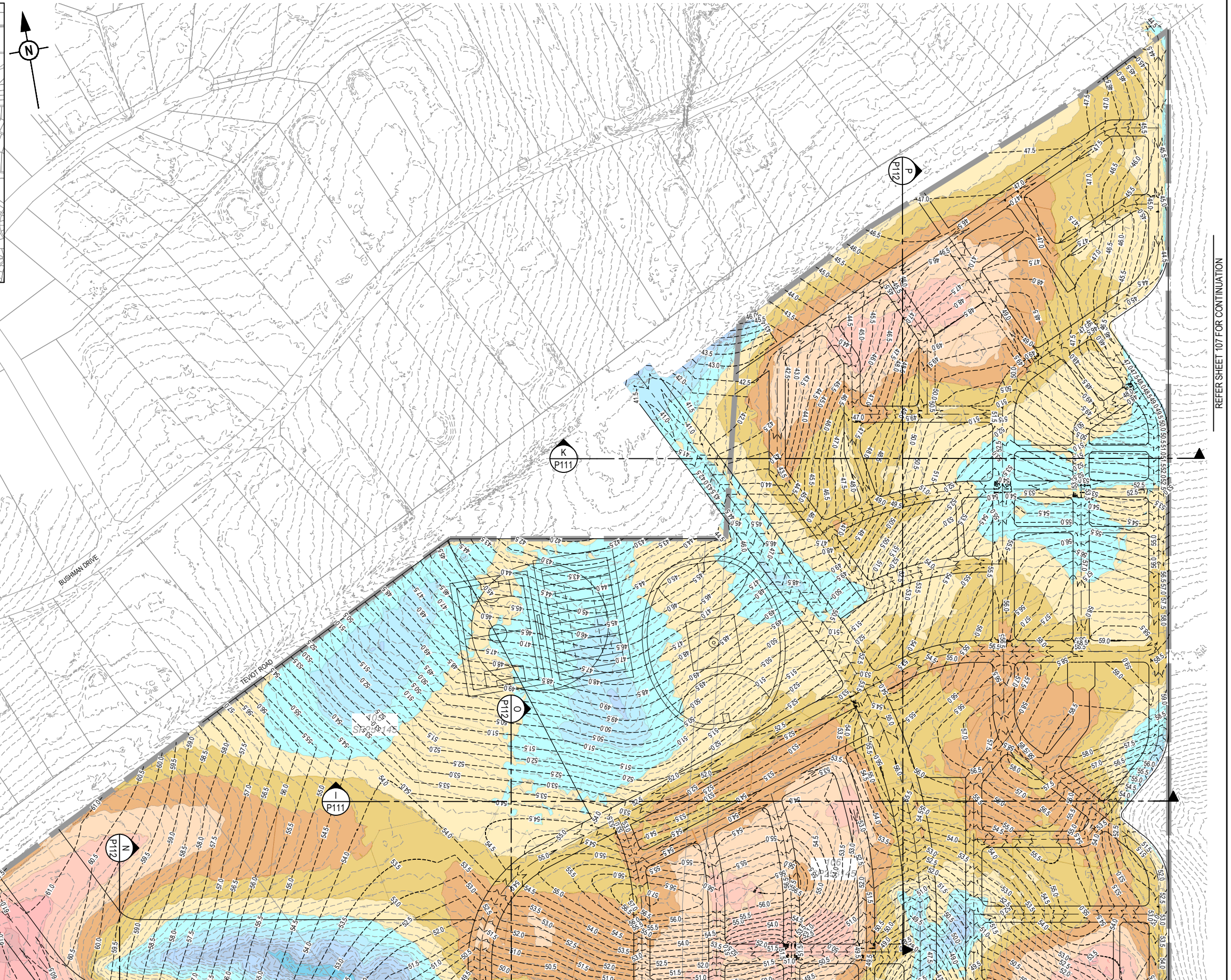
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B	31.05.24	ML	ML	AMENDED ROADS																		
C	07.06.24	ML	ML	PLANS AMENDED																		
D	12.08.24	ML	BA	PLANS UPDATED																		
								DESIGN			APPROVED		DATE									
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							FOR AND ON BEHALF OF COLLIER'S INTERNATIONAL ENGINEERING & DESIGN PTY LTD															



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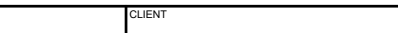


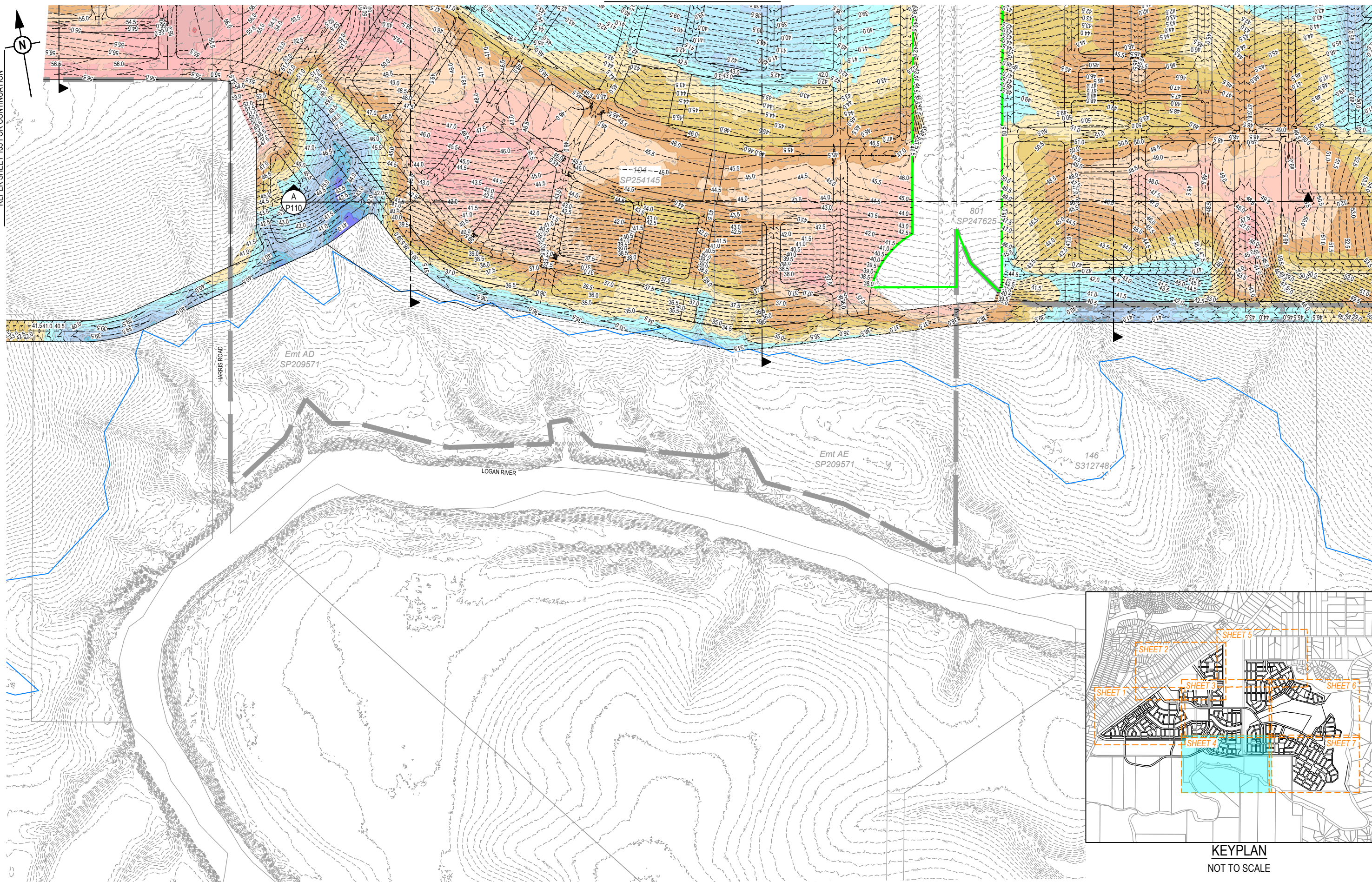
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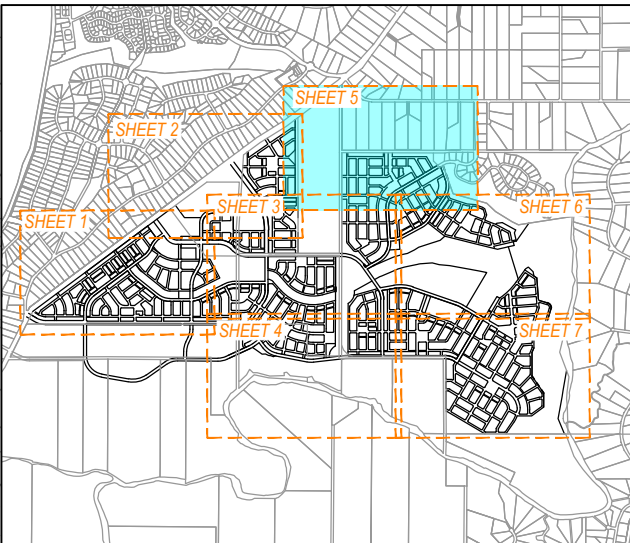
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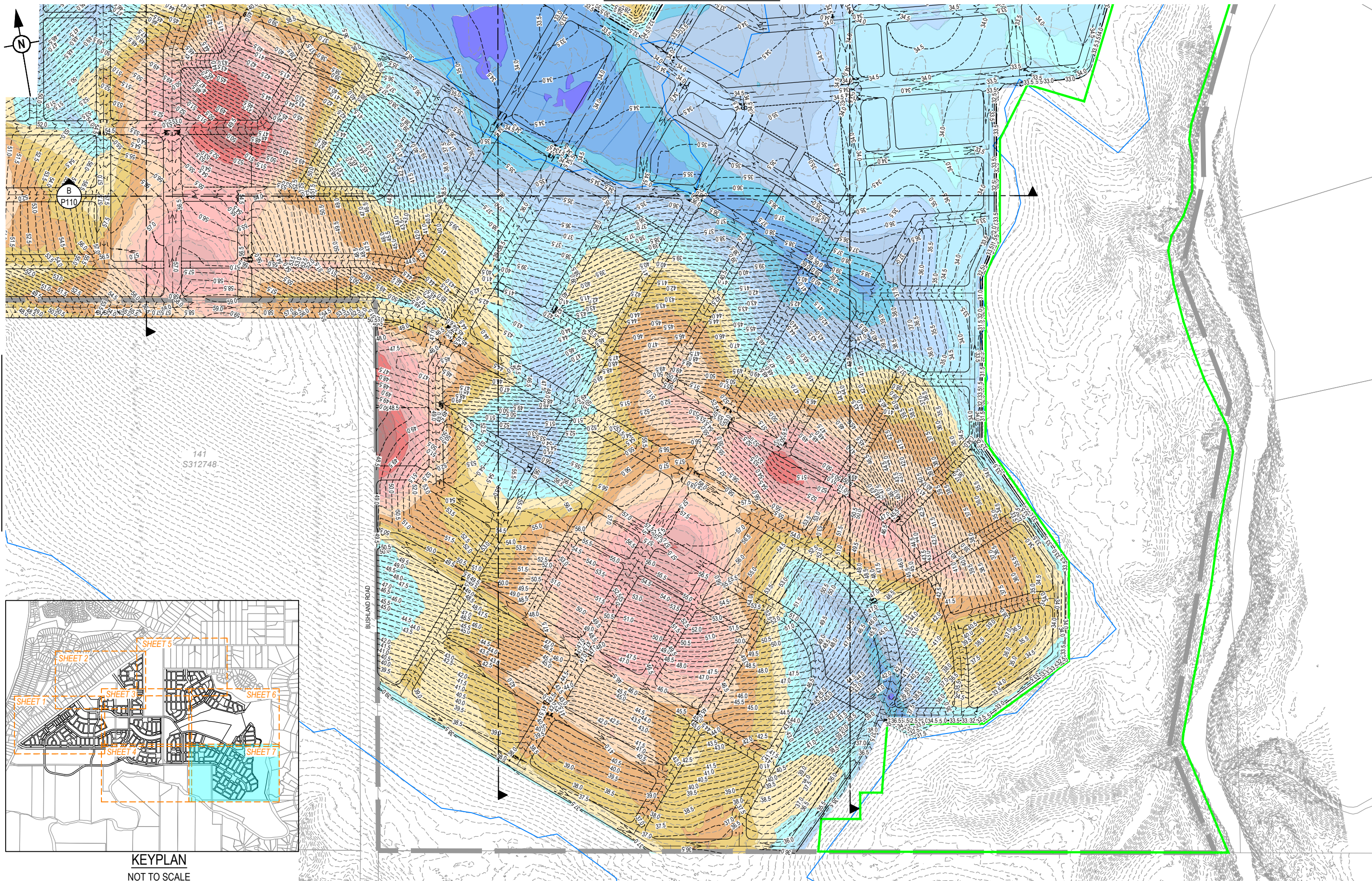
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DRAWING No.
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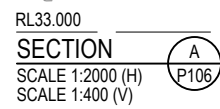
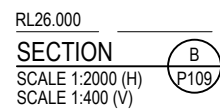
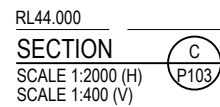
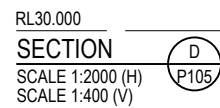
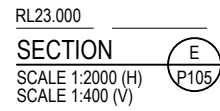
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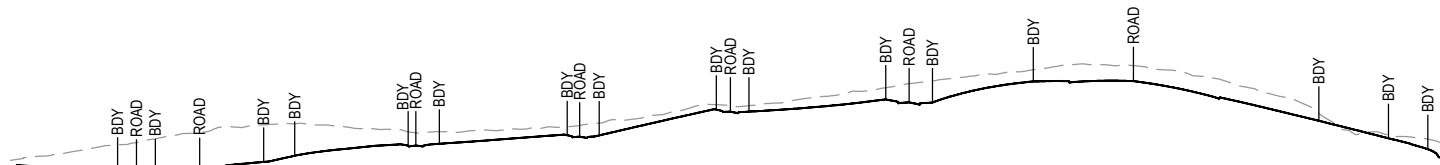




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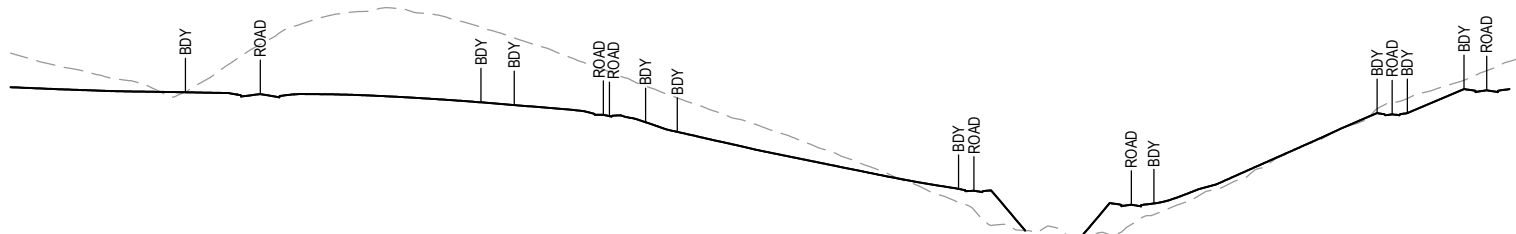
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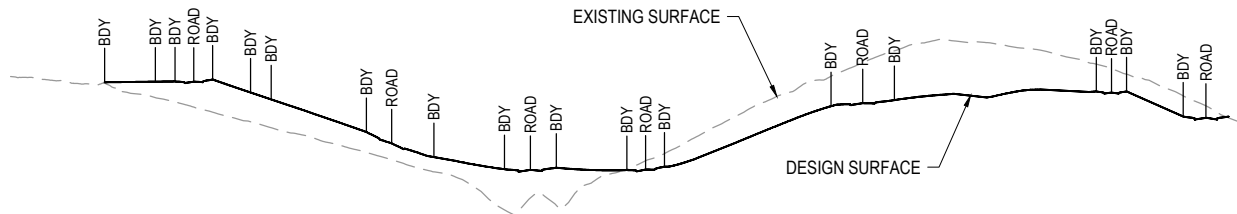
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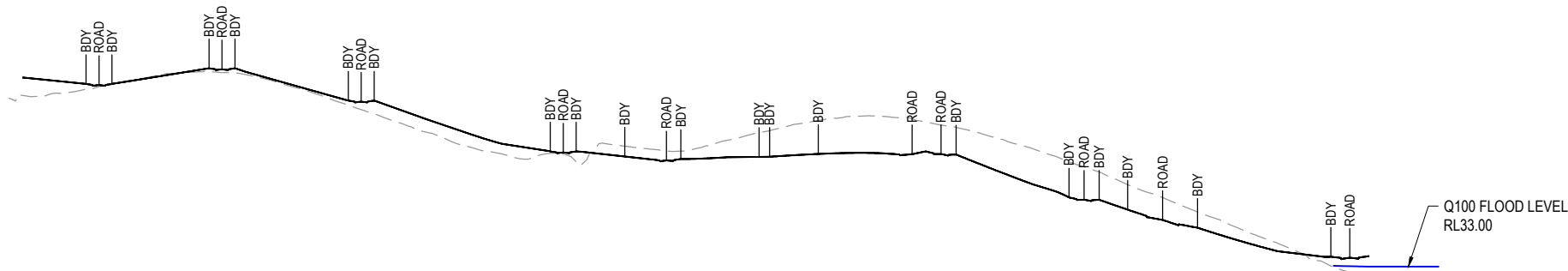
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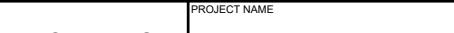
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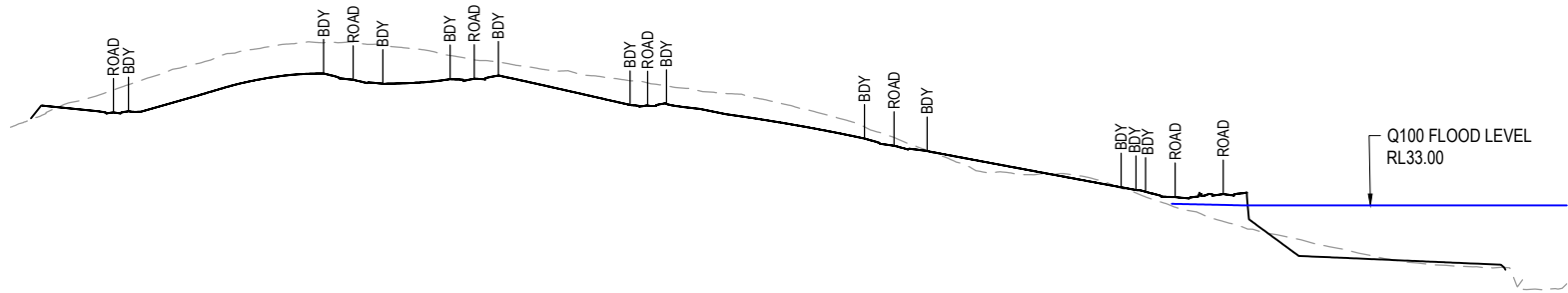


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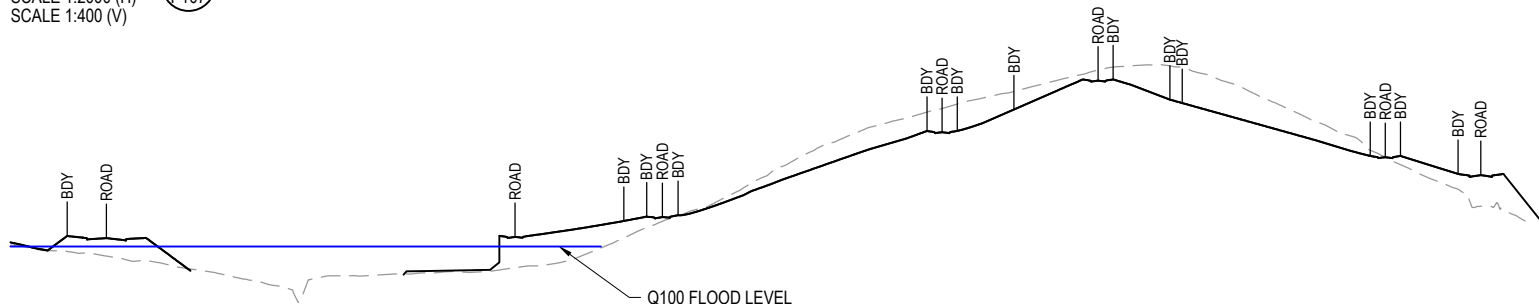


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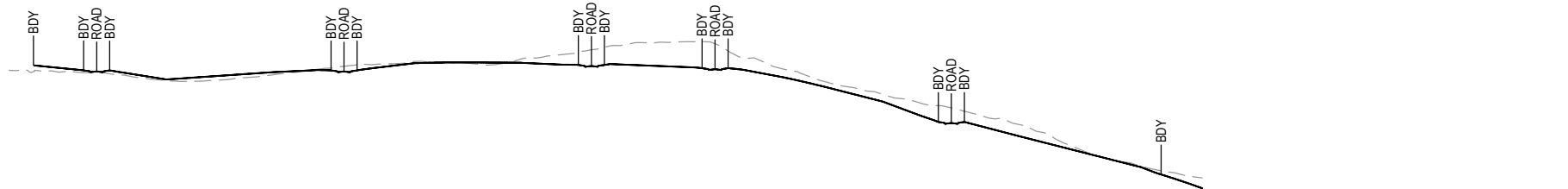
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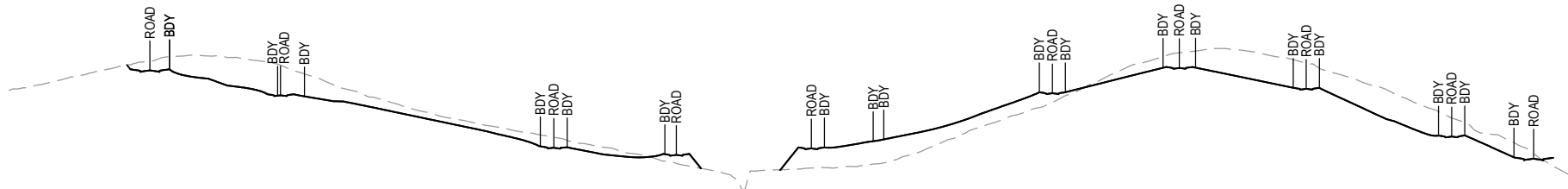
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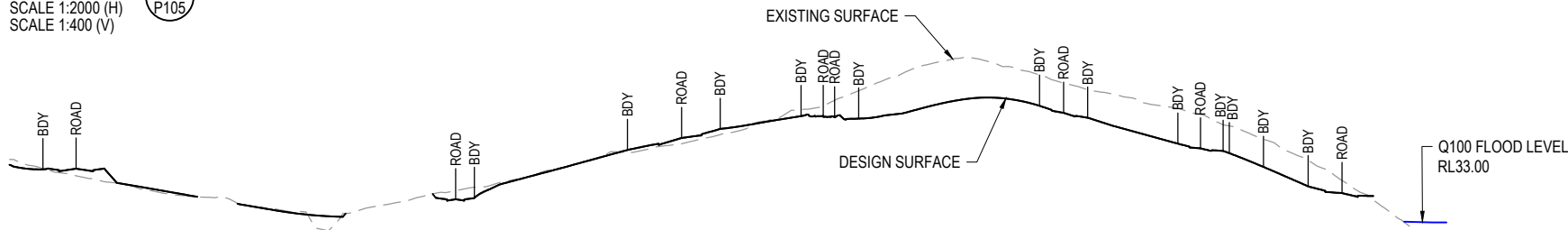
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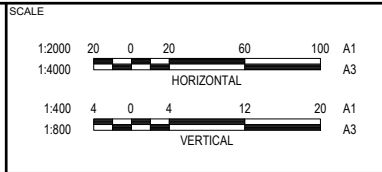


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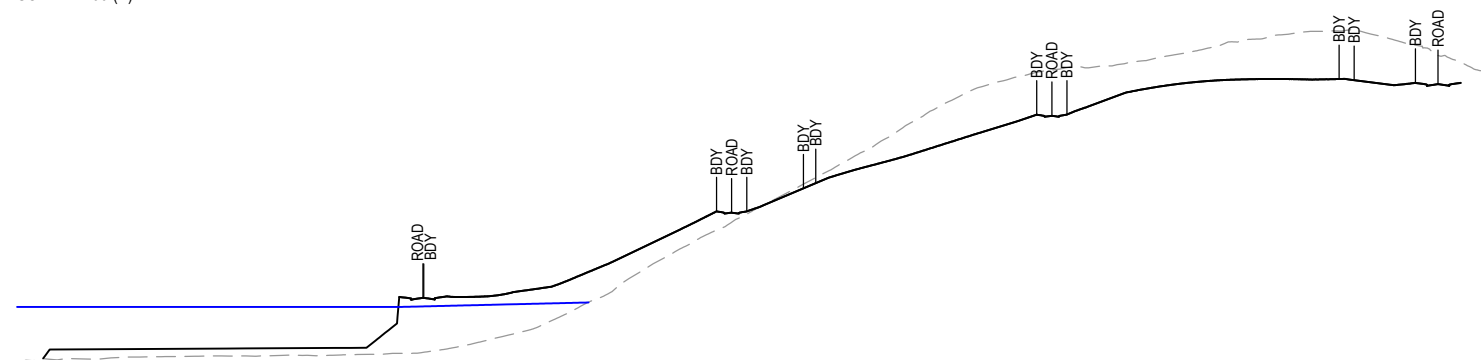
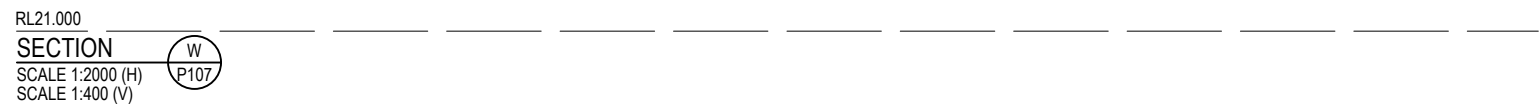
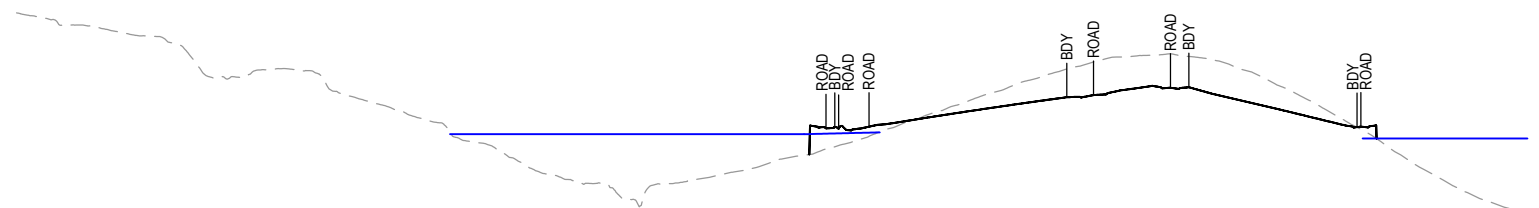
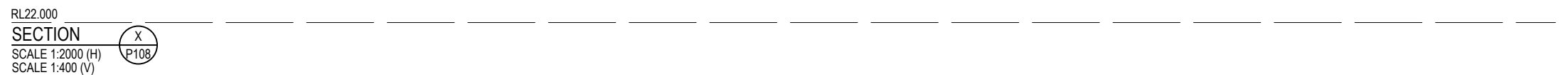
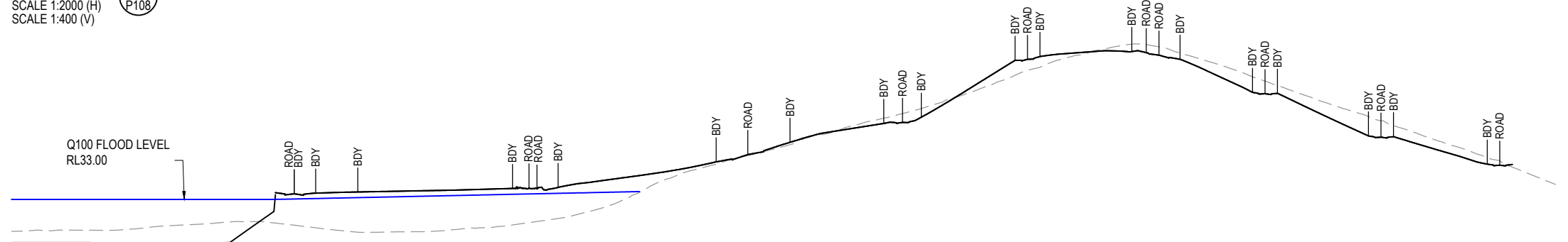
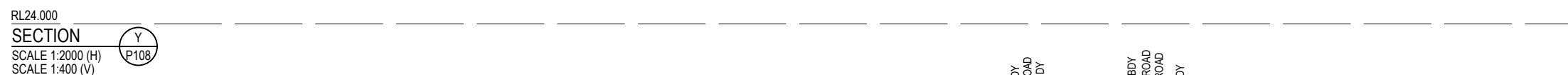
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CLIENT	CELESTINO DEVELOPMENTS PTY LTD
ASSOCIATED CONSULTANT	

PROJECT NAME	RIVERBEND
	RIVERBEND JIMBOOMBA

DRAWING TITLE	CONCEPT BULK EARTHWORKS SECTIONS SHEET 4 OF 5
PROJECT No.	20-0190
DRAWING No.	P113
REVISION	D



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						FOR AND ON BEHALF OF COLLIER'S INTERNATIONAL ENGINEERING & DESIGN PTY LTD												



GEOTECHNICAL REPORT: Proposed Residential Subdivision

Riverside Development

Jimboomba

Celestino Developments Pty Ltd

November 2022

PG-7818

P: (07) 5636 4680 | **F:** (07) 5636 0286

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A: 3 Jowett Street, Coomera QLD 4209

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ABN: 62 615 248 952

Ref: PG-7818, 2022-11-08, GR VER 1
Author: Leigh Bexley

16th November, 2022

Celestino Developments Pty Ltd
Email: matthew@goodrock.com.au
CC: andrew@goodrock.com.au

ATTENTION: MATTHEW BUIKSTRA

Dear Sir,

**BROADSCALE GEOTECHNICAL INVESTIGATION - PROPOSED RESIDENTIAL
SUBDIVISION
RIVERSIDE DEVELOPMENT, JIMBOOMBA**

Enclosed is a copy of our report for the above project dated November 2022. An electronic copy of the report has been issued.

Should you have any queries regarding this report, please do not hesitate to contact Leigh Bexley or Peter Elkington at this office.

Yours faithfully,

P. ELKINGTON (RPEQ 7226)

For and on behalf of
PACIFIC GEOTECH PTY LTD



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Appendices

Appendix A

Notes Relating to this Report

Appendix B

Test Pit Record Sheets

Appendix C

Laboratory Test Certificates

Appendix D

Site Plan

1.0 INTRODUCTION

This report contains the results of the broadscale geotechnical investigation and provides advice and recommendations relating to the following:

- Subsurface conditions in accordance with AS 1726-2017
- Groundwater conditions
- Broadscale site classification in accordance with AS 2870-2011
- Preliminary foundation recommendations including:
 - o High level and deep support options
 - o Bearing capacity and skin friction design values
- Earthworks recommendations
 - o Suitability of cut for use as fill
 - o Compaction standards
 - o Stripping requirements
 - o Trafficability
 - o Excavatability
 - o Temporary and permanent safe batter angles for cuts and fills
- Retaining wall design parameters
- Indicative pavement design parameters
- Site management and construction considerations
- Preliminary slope stability commentary

It should be noted that this report is a broadscale geotechnical investigation of the site only. A more detailed investigation of the site is recommended when the site has been properly cleared of vegetation and more access is available.

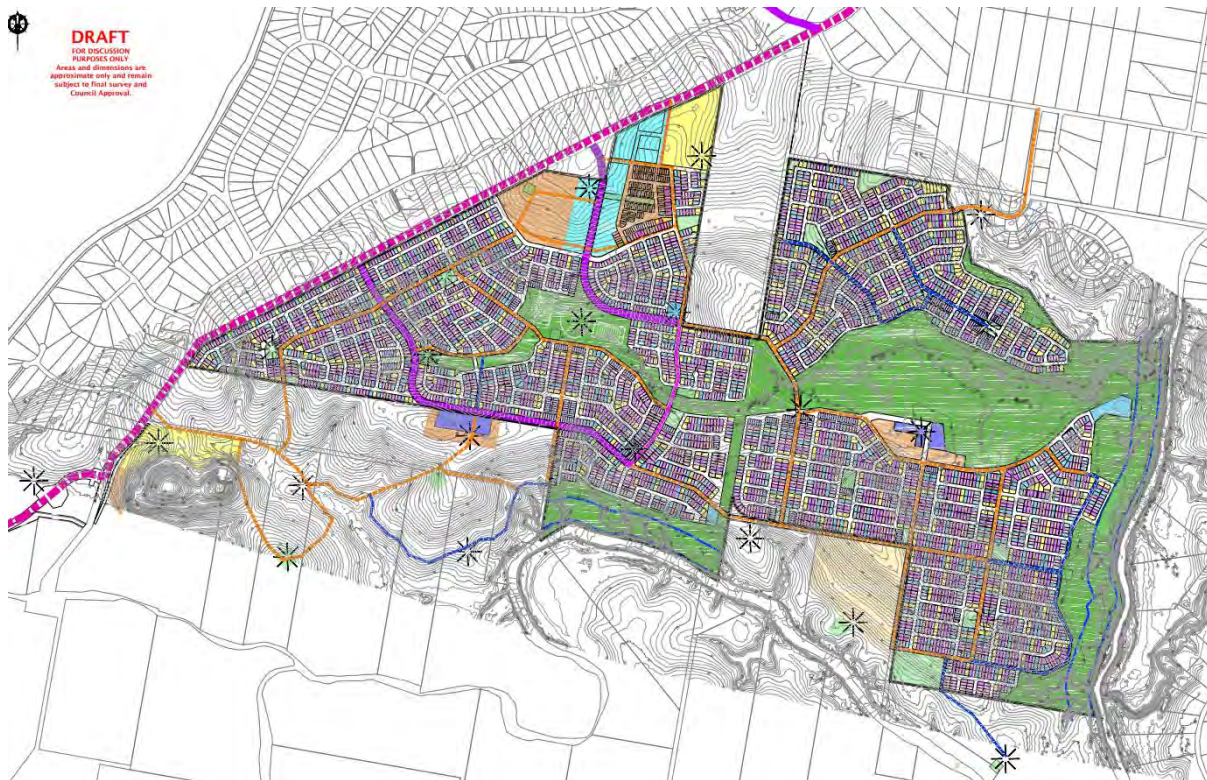
Proposed Development

It is understood that the proposed development is to comprise the subdivision of the site into several hundred residential Lots with associated parks and roads covering an area of approximately 550ha.

Earthworks are envisaged to consist of cuts up to approximately 6m in the elevated areas of the site and fills up to approximately 7m in the low lying areas of the site to form a relatively flat area for the proposed development with associated cut and fill batters and retaining walls. Excavations up to approximately 10m in depth are also proposed in localised areas for the proposed Sewer Gravity Main and Rising Main.

A plan of the proposed development is indicated below.

PROPOSED LAYOUT



2.0 METHODOLOGY

The geotechnical investigation comprised the excavation of forty eight (48) test pits (TP01 to TP48) using a 36t excavator fitted with a 1.5m wide toothed bucket. The test pits were excavated at various locations throughout the development areas of the site as well as along the alignment of the sewer gravity main and rising main. The test pits were excavated to depths ranging between 0.65m and 7.0m below the existing ground surface.

The soil classification descriptions and field tests were carried out in general accordance with Australian Standards.

AS 1726

Geotechnical Site Investigations

AS 1289

Methods of Testing Soils for Engineering Purposes

Site photographs are shown in the site description below. The logs of the test pits including the DCP test results are presented in Appendix B. The laboratory test certificates are presented in Appendix C whilst a Site Plan showing contours as well as the location of the test pits is attached in Appendix D to this report.

3.0 SITE DESCRIPTION

The site of the proposed residential development is located at Riverside Development, Jimboomba and forms a large irregular shaped Lot which is approximately 4.5km long, east to west and 2.5km wide, north to south. The site comprises relatively flat or gentle to mild sloping undulating terrain of approximately 10° or less with localised areas ranging up to approximately 15° in slope angle. No major earthworks appear to have been carried out at the site at the time of the investigation.

The site is drained by a main drainage channel which aligns in an east to west lineation through the centre of the site with the direction of flow to the east. This main drainage channel is approximately 10m to 20m wide within the western portion of the site with gentle to mild sloping banks. The main drainage channel widens within the eastern portion of the site and forms a floodplain area which ranges up to approximately 800m across. The main drainage channel then directs all water into the Logan River which aligns the eastern boundary of the site. The main drainage channel and associated floodplain area is flanked to the north and south by the gentle to mild sloping terrain.

Several smaller drainage features also branch off this main drainage channel intercepting surface water to the north and south and then directing the water into the main drainage channel. Most of the main drainage channel including the floodplain area to the east is to remain as a natural drainage feature with only some areas at the far eastern end of the floodplain area on the southern side of the main drainage corridor to be filled as part of the proposed development. Several of the smaller drainage features within the sloping areas of the site are also proposed to be filled as part of the earthworks at the site. Most of these drainage features including the main drainage channel display evidence of erosion within the base of the drainage features throughout the site.

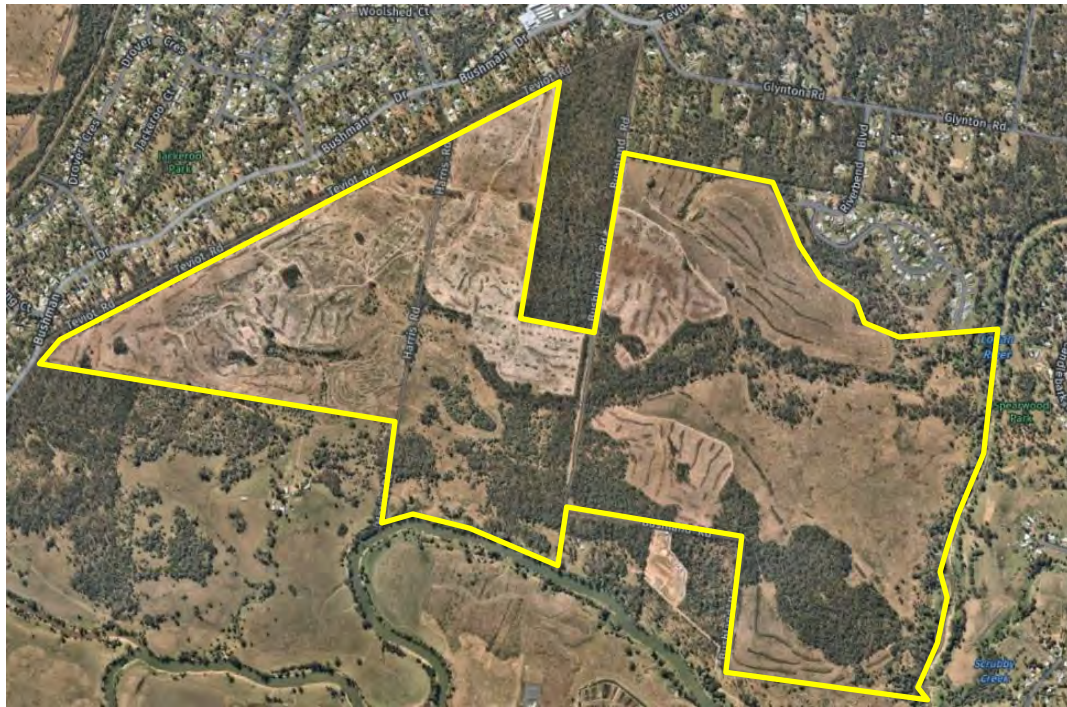
At the time of the investigation, the site had been cleared of vegetation but comprised numerous areas where stockpiles of timber or scattered timber was evident at the surface. The surface had also been tyned in numerous areas. This combination of stockpiled and scattered timber as well as the tyned ground surface created extreme difficulties in accessing the site. The floodplain area supported low to medium high grass whilst moderate to dense tree vegetation was evident along the main drainage corridor at the time of the investigation.

Several dams as well as ponded areas within the main drainage channel are evident at the site. These dams and ponded areas are proposed to remain as part of the proposed development.

Access to the site is via a small gravel driveway (Bushland Drive) off Teviot Road in the central northern end of the site. Numerous tracks have also been formed to provide access throughout the site.

Refer following aerial and site photographs for typical site conditions.

AERIAL IMAGE



SITE PHOTOGRAPHS



Plate 1 – Gentle and mild sloping undulating terrain in far western portion of the site.



Plate 2 – Gentle and mild sloping undulating terrain in western portion of the site.



Plate 3 – Main drainage channel in far western portion of the site.



Plate 4 – Shallow rock exposed in test pit TP02 in far western portion of the site.



Plate 5 – Dam within main drainage channel in central western portion of the site.



Plate 6 – Gentle sloping terrain in the central portion of site on northern side of main drainage channel near test pit TP21 which has been stripped and tyned.



Plate 7 – Drainage features within mild sloping terrain near test pit TP16.



Plate 8 – Gentle sloping terrain in central portion of site on southern side of main drainage channel near test pit TP14.



Plate 9 – Floodplain area in eastern portion of site with main drainage channel on left.



Plate 10 – Timber scattered across mild sloping terrain in south eastern corner of south.



Plate 11– Erosion within drainage feature within north eastern portion of the site.



Plate 12 – Gentle and mild sloping terrain within north eastern portion of the site extending down to main drainage channel.



Plate 13 – Gentle and mild sloping undulating terrain in north eastern portion of site.



Plate 14 – Gentle sloping drainage feature in northern portion of site near TP23.

4.0 GEOTECHNICAL MODEL

The results of the excavation of test pits indicates that the subsurface conditions typically encountered at the site comprise topsoil at the surface underlain by natural loose silty sand with some gravel layers extending to depths of approximately 0.3 to 0.5m. The natural sands are underlain by stiff to hard, silty clay and sandy clay which overlies highly weathered (HW) sandstone and siltstone rock of very low and low strength but becoming moderately weathered (MW) and slightly weathered (SW) and medium and high strength with depth extending to the test pit termination/refusal depths.

In the drainage features and floodplain areas, the topsoils and loose, sands extend to slightly deeper depths and some soft to firm and firm clays are also encountered in the upper soil profile extending to depths of up to approximately 0.5m to 0.8m. The weathered rock is also typically encountered at depths of typically greater than 3.0m to 4.0m in these areas with several test pits terminated at the required depths in natural clay.

Table 1 presents a summary of the likely subsurface profile. The test pit record sheets are appended to this report.

TABLE 1 - SUBSURFACE PROFILE SUMMARY

TP No.	NATURAL								TP TD
	Silty SAND/Clayey SAND		Silty CLAY/Sandy CLAY			BEDROCK			
	Very Loose/ Loose	Medium Dense	Soft/Firm /Firm to Stiff	Stiff	Very Stiff /Hard	Very Low /Low (XW/HW)	Low to Medium/ Medium (MW)	Medium to High /High (SW)	
TP01	0.0-0.3	NE	NE	0.3-0.9	0.9-1.4	1.4-1.7	NE	1.7-TD	2.0*
TP02	NE	0.0-0.35	0.3-0.45	0.45-0.6	NE	0.6-0.7	0.7-0.8	0.8-TD	1.7*
TP03	0.0-0.3	NE	0.3-0.5	0.5-1.0	1.0-1.9	1.9-2.6	NE	2.6-TD	3.0*
TP04	0.0-0.1	0.5-2.5	NE	0.1-0.5	2.5-2.8	2.8-3.0	NE	3.0-TD	3.7*
TP05	0.0-0.05	NE	0.05-0.7	NE	NE	0.7-1.2	NE	1.2-TD	1.8*
TP06	0.0-0.25	NE	NE	0.25-0.7	0.7-1.0	NE	1.0-1.3	1.3-TD	1.5*
TP07	0.0-0.3	NE	NE	0.3-0.7	0.7-1.3	1.3-2.8	2.8-TD	NE	3.1
TP08	0.0-1.9	NE	NE	1.9-2.3	2.3-3.3	3.3-TD	NE	NE	3.4
TP09	0.0-0.4	NE	NE	0.4-1.0	1.0-1.6	1.6-2.6	2.6-TD	NE	3.0
TP10	0.0-0.15	NE	0.15-0.4	NE	NE	0.4-0.8	NE	0.8-TD	1.2*
TP11	0.0-0.15	NE	NE	0.15-0.4	0.4-2.7	2.7-3.5	3.5-TD	NE	4.0
TP12	0.0-0.1	NE	0.1-0.7	NE	0.7-1.2	1.2-TD	NE	NE	3.0
TP13	0.0-0.15	NE	0.15-0.8	NE	0.8-1.8	1.8-2.2	2.2-TD	NE	4.0
TP14	0.0-0.65	NE	NE	NE	0.65-1.0	1.0-1.8	1.8-2.5	2.5-TD	3.0*
TP15	0.0-0.2	NE	NE	0.2-0.4	0.4-TD	NE	NE	NE	6.0
TP16	0.0-0.1	NE	NE	NE	0.1-0.5	0.5-2.6	2.6-TD	NE	3.0
TP17	0.0-0.6	NE	NE	0.6-1.0	1.0-2.0	2.0-2.5	2.5-2.8	2.8-TD	3.5*
TP18	0.0-0.3	NE	NE	0.3-1.2	1.2-1.8	1.8-TD	NE	NE	4.1
TP19	0.0-0.15	NE	NE	0.15-1.3	1.3-3.1	3.1-3.3	NE	3.3-TD	3.6*
TP20	0.0-0.55	NE	NE	NE	0.55-1.2	1.2-2.1	NE	2.1-TD	2.3*
TP21	0.2-0.4	NE	0.0-0.2	NE	0.4-1.5	1.5-2.0	NE	2.0-2.2	2.2*
TP22	0.0-0.2	NE	NE	0.2-0.8	0.8-1.0	1.0-TD	NE	NE	4.0
TP23	0.0-0.5	NE	NE	0.5-1.0	1.0-2.0	2.0-2.2	NE	2.2-TD	2.3*
TP24	0.0-0.5	NE	NE	NE	NE	0.5-0.6	NE	0.6-TD	0.65*
TP25	0.0-0.2	NE	NE	0.2-1.1	1.1-2.3	2.3-TD	NE	NE	3.0
TP26	0.0-0.2	NE	NE	0.2-0.7	0.7-1.1	1.1-1.3	1.3-2.6	2.6-TD	2.9*
TP27	0.15-0.3	NE	0.0-0.15	0.3-0.7	0.7-2.5	2.5-3.5	3.5-TD	NE	3.7
TP28	0.0-0.15	NE	NE	0.15-1.3	1.3-4.3	4.3-TD	NE	NE	6.0
TP29	0.0-0.08	NE	NE	0.08-0.5	0.5-0.7 1.1-4.5	0.7-1.1 4.5-TD	NE	NE	6.0
TP30	0.0-0.4	NE	0.4-0.6	0.6-0.8	0.8-1.3	1.3-1.8	1.8-2.6	2.6-TD	2.8*
TP31	0.0-0.6	NE	NE	0.6-1.0	1.0-1.8	1.8-2.2	2.2-TD	NE	3.5
TP32	0.0-0.3	NE	NE	NE	0.3-0.5	0.5-0.9	0.9-1.4	1.4-TD	1.5*
TP33	0.0-0.3	NE	NE	NE	NE	0.3-0.6	NE	0.6-TD	1.0*
TP34	0.0-0.1	NE	0.1-0.3	0.3-0.5	0.5-2.5	2.5-3.3	NE	3.3-TD	3.5*
TP35	0.0-0.3	NE	NE	0.3-1.7	1.7-TD	NE	NE	NE	7.0
TP36	0.0-0.1	NE	0.1-0.4	NE	0.4-2.6	2.6-TD	NE	NE	6.0
TP37	0.0-0.1	NE	NE	0.1-1.3	1.3-TD	NE	NE	NE	4.0
TP38	0.0-0.15	NE	0.6-1.1	0.15-0.6	1.1-TD	NE	NE	NE	6.0
TP39	0.0-0.1	NE	0.1-0.3	0.3-1.6	1.6-TD	NE	NE	NE	5.0
TP40	0.0-1.2	NE	NE	NE	1.2-2.2	2.2-TD	NE	NE	4.0
TP41	0.0-0.3	NE	NE	NE	0.3-1.3	1.3-5.5	5.5-TD	NE	6.0
TP42	0.0-0.05	NE	0.05-0.4	0.4-1.6	1.6-TD	NE	NE	NE	4.0
TP43	0.0-0.15	NE	0.15-0.7	0.7-1.3	1.3-TD	NE	NE	NE	3.0
TP44	0.0-0.15	0.15-0.6	NE	NE	0.6-2.4	2.4-2.9	2.9-3.5	3.5-TD	3.8*
TP45	0.0-0.35	NE	NE	0.35-0.55	0.55-1.3	1.3-TD	NE	NE	5.6
TP46	0.0-0.5	NE	NE	0.5-1.3	1.3-2.2	2.2-TD	NE	NE	3.0
TP47	0.0-0.3	NE	NE	NE	0.3-1.7	1.7-5.2	NE	5.2-TD	5.5*
TP48	0.0-0.3	NE	0.3-0.6	NE	0.6-1.6	1.6-2.2	2.2-2.4	2.4-TD	2.5*

Notes:

1. All depths in metres below ground level at time of investigation.
2. NE - Not Encountered; TD - Termination Depth; *Test Pit Refusal.

5.0 GROUNDWATER

No standing groundwater was encountered in any of the test pits excavated during the investigation. Some minor groundwater seepage was evident within the sand based soils at the surface within several test pits most likely associated with the test pits being excavated following a rainfall event.

Groundwater and seepage may be expected within the surficial sand based soils and along the natural soil/rock interface as well as within the drainage features following rainfall events.

6.0 LABORATORY TESTING

Laboratory testing was carried out on samples of the natural clay soils retrieved from the site investigation program and was directed towards assessing the strength of the weathered rock, reactivity and characteristic properties of the natural soils as well as the subgrade strength of the encountered materials. The following laboratory tests were carried out as part of the investigation:-

- Shrink/Swell index tests
- Atterberg limits tests
- Particle size distribution tests
- Unconfined compressive strength tests
- Soaked CBR tests
- Point load strength index tests

The results of the laboratory testing are presented as certificates and are attached in Appendix C to this report.

7.0 INDICATIVE SITE CLASSIFICATION

In areas where weak unsuitable soils are encountered at the surface (ie drainage features), these areas would be classified as Class 'P' sites in accordance with AS2870.

Based on the results of Shrink/Swell Index testing, in areas where the stiff or better natural clay soil is encountered at the surface or where weak unsuitable soils have been removed to expose the stiff or better natural clay soil, a typical indicative site classification of Class 'M' is anticipated in accordance with AS2870 with characteristic ground surface movements ranging up to 30mm to 40mm estimated. However, it is expected that in localised areas where natural clay soil is exposed at the surface, a site classification of Class 'H1' can be expected with characteristic ground surface movements ranging up to 50mm estimated.

If the natural clay soil is to be reused as structural fill in the upper levels of the soil profile, this may also result in a site classification of Class 'H1' or possibly a higher classification.

In areas where excavations are carried out to expose weathered rock at the surface, a site classification of Class 'S' can be adopted in accordance with AS2870.

It is recommended that Pacific Geotech be engaged during the bulk earthworks operation to ensure earthworks are designed to ensure an optimal site classification result following the bulk earthworks operation can be achieved.

It is recommended that the readers satisfy themselves that the use of AS 2870-2011 is applicable for the proposed design and the above site classification re-confirmed following the completion of the bulk earthworks operation.

8.0 INDICATIVE BUILDING FOUNDATIONS

High level footings may be adopted for the support of the proposed buildings in areas where stiff or better natural clay soils or weathered rock is encountered at the surface or where structural fill material has been placed provided suitable control and certification of the earthworks operation has been undertaken.

In areas where weak unsuitable soils or uncontrolled fill material is encountered and is excessive for high level footings, the unsuitable material and uncontrolled fill should be removed or the footings should be deepened to penetrate the weak unsuitable soils or uncontrolled fill material to found into the stiff or better natural soils or weathered rock. This may require the installation of excavated piers or a deep foundation system.

8.1 High Level Footings

In areas where stiff or better natural clay soil or weathered rock is encountered at the surface or where the existing uncontrolled fill material and weak soils have been removed and replaced with controlled and certified structural fill material, high level strip or pad footings could be considered.

The design of high-level footings founding in new controlled fill, stiff or better natural clay soil or weathered rock at a minimum depth of 0.5m below the finished ground surface can be based on the allowable bearing pressures presented in Table 2 below.

TABLE 2 – INDICATIVE ALLOWABLE DESIGN PARAMETERS FOR HIGH LEVEL FOOTINGS

Material ⁽¹⁾		Allowable Bearing Pressure (kPa) ⁽³⁾
Uncontrolled Fill		Not Recommended
Controlled Fill ⁽²⁾		100
Natural Clay	Stiff	100
	Very Stiff	200
	Hard	400
XW/HW Rock	Extremely Low/Very Low Strength	500
Notes:		
1. All founding material should be verified by a suitably qualified geotechnical engineer or engineering geologist during construction.		
2. In accordance with AS3798-2007 and certified as controlled fill.		
3. Based on a factor of safety of 3.0.		

Where the foundation for the building foundation founds in different materials, consideration should be given to articulating the foundation system to tolerate potential differential settlement across the structure.

Where footings are located adjacent to excavations such as batters, retaining walls or underground service trenches, it is recommended that the footings be deepened to found at least 200mm below a line drawn up at 45 degrees from the base of the trench.

8.2 Deep Footings

In areas where excessive weak unsuitable soils or uncontrolled fill material is encountered at the surface or a high level foundation system is not considered to be the preferred foundation option, a deep foundation system could be adopted. A deep foundation system comprising of screw piles, driven timber piles or bored piles for more highly loaded structures founding through the weak unsuitable soils and uncontrolled fill and into the natural clay soil or weathered rock could be considered.

The deep foundation system should be designed in accordance with the recommendations of AS 2159-2009 'Piling - Design and Installation'.

The ultimate geotechnical strength ($R_{d,ug}$) of piles can be calculated using the unfactored, preliminary ultimate shaft adhesion and end bearing values given in Table 3. The $R_{d,ug}$ values given in Table 3 will need to be multiplied by a suitable geotechnical strength reduction factor (ϕ_g) to obtain the design geotechnical strength ($R_{d,g}$) of piles. In accordance with AS2159-2009, the ϕ_g value must be determined by the designer, but based on the anticipated site, design and installation risk factors, a ϕ_g value of 0.48 is recommended. Higher values may be applicable with suitable supervision.

If working stress methods are used in the pile design, the preliminary $R_{d,ug}$ values given in Table 3 will need to be divided by a factor of safety of 2.5 to calculate the maximum single pile working load.

TABLE 3 – PRELIMINARY ULTIMATE (UNFACTORED) PILE DESIGN PARAMETERS

Material		Ultimate Geotechnical Shaft Adhesion (kPa)	Ultimate Geotechnical End Bearing Pressure (kPa) ⁽³⁾	
			$L \leq 4D$ ⁽²⁾	$L \geq 4D$ ⁽²⁾
Fill		NC ⁽¹⁾	NR ⁽¹⁾	NR ⁽¹⁾
Natural Clay Soils	Stiff	25	300	450
	Very Stiff	35	600	900
	Hard	50	900	1800
XW/HW Bedrock	ELS/VLS	90	1800	2700
Notes:				
(1) NC – Not considered; NR – Not recommended.				
(2) L – Total pier length; D – Pile diameter.				
(3) ELS - Extremely Low Strength; VLS – Very Low Strength.				

Construction Considerations

If bored piers are adopted, the bases of the bored pile holes must be thoroughly cleaned of all loose soil and rock debris using a proper cleaning tool. The practice of adding water and spinning the auger is generally not acceptable. If there is any doubt as to the effectiveness of the base cleaning, the base resistance must be ignored.

No groundwater or seepage was encountered in the boreholes at the time of drilling and is not expected to be encountered during bored pile installation. If seepage is encountered, inflow rates are generally expected to be slow and the pile holes will need to be poured immediately following the excavation of the holes. If significant seepage is encountered, the holes will need to be lined with steel liners which must be socketed into low permeability material to achieve an impermeable seal against any water charged soils above.

Alternatively, groundwater seepages may be controllable by pumping, otherwise requiring the piles to be constructed under water or bentonite using tremie methods. Shaft adhesion must be ignored for the portion of the pile that is permanently lined. As an alternative to bored piles, grout injected CFA piles could be adopted.

Drilling piles is not only dependent on the subsurface profile characteristics, but also the type (power and size) of the bored pile drilling rig, drilling teeth, size of pile, etc. It is recommended that a specialist drilling contractor be consulted to be able to manage the above conditions and materials encountered.

During construction, it is recommended that footing inspections be undertaken by Pacific Geotech, following excavation, to confirm the specified founding strata has been reached.

9.0 SAFE BATTER SLOPE ANGLES

It is understood that cut and fill batters ranging up to approximately 3m in height may be required as part of the proposed earthworks development.

Maximum safe cut batter angles for the different materials encountered on site are shown below in Table 4 for unsurcharged batters less than 3.0m high. Where surcharges are located within H(m) (height of the batter) of the top of the batter, then some reduction in the design angle will be required.

TABLE 4 – SAFE BATTER ANGLES FOR CUTS

Material	Short Term	Long Term
Structural fill	45° (1V:1H)	26° (1V:2H)
Medium Dense or Better Sands	45° (1V:1H)	26° (1V:2H)
Stiff or better Natural Clay Soils	45° (1V:1H)	26° (1V:2H)
XW/HW Rock	63° (2V:1H)	45° (1V:1H)

Structural fill batters should be overconstructed and trimmed back at no steeper than 2(H):1(V) or 26°.

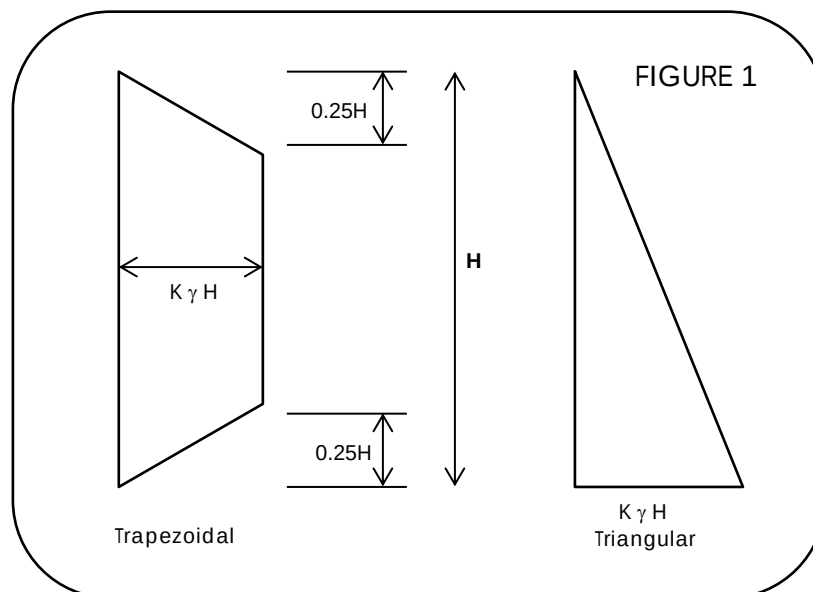
It is essential that all exposed permanent batters be suitably protected from erosion and scour. Upslope surficial water flows should also be directed away from the batters limiting the ingress of water into the fill. The pavement drainage system may be sufficient for some batters.

For excavations of a very short term nature, and subject to assessment of factors such as the conditions at the time of excavation, length of time excavations are to remain open, working conditions/requirements and most importantly the rock structure in the cut face, etc., steeper excavations could be possible. Pacific Geotech should be contacted to determine an appropriate profile when construction details have been finalised.

10.0 PERMANENT RETAINING WALLS

Retaining walls should be specifically engineer designed in accordance with AS 4678-2002 (Ref 9) and be based on the geotechnical conditions at the final wall alignment.

The design of flexible retaining walls could be undertaken using a triangular pressure distribution and the earth pressure parameters given in Table 5. Flexible walls are those which are free to rotate or tilt (such as cantilevered walls) and should be designed using active (K_a) earth pressure coefficient. Rigid walls are those which are restrained against rotation or tilt (i.e. single anchored/propped walls) and should be designed using the at-rest earth pressure (K_o) and a trapezoidal pressure distribution as per Figure 1.



Passive resistance (K_p) at the toe of the wall should be ignored in the zone where future disturbance (e.g. services trenches) could occur.

The effects of surcharge in the retained zone should be included by multiplying the vertical pressure developed by the surcharge by the appropriate lateral earth pressure coefficient. Allowance should also be made for the surcharge due to sloping crests if applicable.

TABLE 5 - INDICATIVE EARTH PRESSURE COEFFICIENTS (NON-SLOPING CREST BACKFILL)

Material	Unit Weight (kN/m ³)	Cohesion c' (kPa)	Friction Angle (degrees)	Active Ka	At Rest Ko	Passive Kp
Natural Sands – Medium Dense	20	0	32	0.31	0.49	3.25
Natural Clays – Stiff	20	2	26	0.39	0.56	2.57
Natural Clays – Very Stiff/Hard	20	3	28	0.35	0.53	2.77
XW/HW Rock	23	8	34	0.28	0.44	3.55

Notes: * Depends on fill material type and level of compaction. Assumes material compacted under 'Level 1' supervision.

The generalized lateral earth pressure distribution is given as:

$$p = K\gamma H + Kq + \sigma L \text{ (kPa)}$$

- K is either K_a , K_o , or K_p for “active”, “at rest” or “passive” earth pressure conditions, respectively
- γ (kN/m³) is the relevant density of the soil or rock
- H (m) is the distance down from the top of the wall
- q (kPa) is any uniform surface surcharge load behind the wall
- σL (kPa) is the lateral pressure on the wall resulting from adjacent surcharges.

It is assumed that no groundwater is present and adequate drainage will be provided behind the wall.

It is recommended that the design parameters for retaining walls presented in this section be confirmed by on-site inspection when the subsurface conditions are exposed during construction.

Preference should be given to adopting thin soil layers and using small hand-controlled compaction equipment during backfilling against retaining walls. This is in order to limit the stress applied to the walls during construction. Should heavy compaction be required, then wall stresses will be well in excess of K_o and temporary propping should be used.

Clay backfill should not be placed dry of optimum moisture content, as this can lead to increased future swelling with changes to moisture content or inundation from water creating additional load on the back of the wall.

It is recommended that all retaining walls be drained for full height in order to minimise hydrostatic pressure build-up behind the wall. Additional guidelines on wall drainage are provided in Appendix G of AS 4678-2002.

11.0 SITE PREPARATION AND STRIPPING DEPTHS

Prior to the placement of fill there are several issues and requirements which must be addressed regarding the surficial soils at the site. These issues include trees, grass, weak unsuitable soils and topsoil at the surface. This will most likely require the removal of the upper 0.1m to 0.3m of topsoil in most natural sloping areas but possibly ranging up to approximately 0.8m locally in areas where the natural soils have been disturbed as part of the stripping operation or unsuitable weak soils are evident at the surface such as dams or drainage features which are to be filled.

11.1 Trafficability

Trafficability conditions were extremely limited during the investigation with conventional 4WD vehicles repeatedly bogged. Significant problems may be anticipated during wet weather for even light weight 4WD vehicles.

The soils on site are sensitive to repetitive vehicle loading and water (i.e. they will lose strength through repetitive vehicle loading or if they become overly moist or wet). Further, seepage may also result in a subsequent loss of strength. This may limit trafficability and create difficulties for earthworks operations. This situation would be more pronounced given the stripping and grubbing that has been undertaken.

Problems have arisen from disturbance of the upper level soil fabric with removal of vegetation. The depressions formed are likely to result in water traps and potential softening of adjacent and underlying soils.

Partial or complete removal of upper level soils, i.e. the silty/clayey sand, and placement of a bridging layer, may be required to allow access for light weight construction vehicles should these soils become saturated and weakened at the time of construction. We recommend that the earthworks contract includes a PC item to account for the partial and complete removal scenario.

It is recommended that after stripping, clearing and grubbing, the exposed surface in the construction area be proof rolled (where appropriate) to assist in identifying weak areas and to improve trafficability. In areas of cut, proof rolling may be deferred until after the cut operation.

Use of dedicated construction tracks to control site traffic is recommended.

The use of a shallow drainage network is likely to be required to facilitate/improve trafficability across to the site.

Maintaining adequate drainage conditions is essential. It should be ensured that runoff is diverted away from the construction area to prevent ponding of water. In addition, the construction area should be "sealed" at the completion of each day and in the event of rain.

Potential trafficability problems with this site should not be underestimated. The site will very quickly become untrafficable if appropriate seepage and drainage control measures, along with construction practices appropriate for site conditions, are not maintained.

Nevertheless, the contractor should fully inform himself of the ground conditions on site prior to commencement of earthworks. This requirement should be explicit in any earthworks. This requirement should be explicit in any earthworks specifications or contract.

The following treatment action is recommended within the development area prior to the placement of structural fill:-

- Remove all trees, root balls, grass, topsoil, uncontrolled fill and surface irregularities such as eroded areas from the existing ground surface which is expected to typically extend to depths ranging up to approximately 0.1m to 0.3m in natural sloping areas but possibly up to approximately 0.8m or more where weak unsuitable soils are present (i.e. dams, drainage features, and disturbed material during the stripping operation).
- The stripped ground surface should be proof rolled under Pacific Geotech's supervision using a large vibrating roller, to identify areas of weak surficial soils and to compact the upper level material.
- Depressions formed by the removal of vegetation root balls or other features/inground elements should have all disturbed soil removed to expose competent natural soil and be backfilled with compacted and suitably moisture conditioned select fill material.
- Where the ground surface slopes, the stripped surface should be suitably benched prior to filling.

12.0 RECOMMENDATIONS FOR FILLING

It is anticipated that filling may be carried out as part of the works at the site ranging up to 7m in thickness. Broad recommendations for filling are as follows:-

- In areas which are to be filled, all trees, grass, weed zones, uncontrolled fill, unsuitable weak soils, organic matter and debris must be removed from the existing ground surface to expose competent natural soil.
- No filling or development should take place within any recent past surface irregularities such as washouts, hummocky terrain, seepage zones, uncontrolled fill or erosion features without detailed assessment by Pacific Geotech. If filling or development is to occur in these areas, surface irregularities must be removed prior to development and appropriate drainage provisions must be implemented.
- All filling onsite including fill used in the construction of any proposed batters and behind retaining walls is placed and compacted to at least 95% Standard

Maximum Dry Density and is "Controlled Fill" in accordance with A.S. 2870 (Clause 6.4.2 (a)) – "Residential Slabs and Footings" and A.S. 3798.

- Where the ground surface slopes, the stripped surface is benched prior to filling and the fill supported by engineered retaining walls or battered to the appropriate angles described in Section 9.0 above.
- Fill slopes should be over-filled and trimmed back to design profile to ensure compaction in the outer zones.
- Vertical heights of natural soil and fill batters should incorporate appropriate benches at every 2.5m height interval. When the earthworks design has been finalised, Pacific Geotech should review to ensure suitable stability of the site is maintained.
- Where filling is to be carried out over sands at the surface, some treatment of the surficial sandy soils following stripping may be required. Where silty sands/clayey sands which contain excessive fines are exposed, these materials typically perform poorly when wet of optimum moisture content and trafficability in this material is typically poor. Particular attention should be paid to ensuring sufficient coverage of these materials is available with structural fill to provide a suitable bridging/capping layer. Some over-excavation and replacement of these sands may be required near the cut fill interface to allow trafficability in the long term. It is recommended that these areas be further assessed on part of the detailed geotechnical investigation for the site.
- The majority of the soils on site will be suitable for re-use as structural fill, provided the material is free of organic matter and deleterious material. The wet, weak unsuitable soils from the base of the dams and drainage features are not considered suitable and should be removed from site or appropriately moisture conditioned to bring them to optimum moisture content. If the clays are overly moist, difficulty in achieving compaction of the materials will be encountered and moisture conditioning will be required.
- Some difficulties in compacting the natural sands and clays of high plasticity are expected as these materials typically require a placement moisture content very close to optimum moisture content to achieve adequate compaction. A placement moisture content of $\pm 2\%$ of optimum moisture content is recommended.
- When filling, consideration could be given to the exclusion of rock pieces with greatest dimensions of 50mm to 75mm or greater from areas where trenching and piling may occur, as large rock pieces could impede the trenching and piling operations. This may require the crushing of the rock materials from deeper in the cuts.
- Imported fill should be of fair to good quality with a minimum Soaked CBR value of 10%, a maximum $I_{ss}=1.0\%$ and a maximum particle size of 75mm.

- All filling should be undertaken in layer thicknesses of approximately 250mm (or as appropriate for the compaction equipment being used). Fill should be compacted to at least 95% Standard Maximum Dry Density at a placement moisture content of $\pm 2\%$ of Optimum Moisture Content (OMC) and be "Controlled Fill" in accordance with A.S. 2870 (Clause 6.4.2 (a)) – "Residential Slabs and Footings" and A.S. 3798.
- Field density testing should be carried out to check the standard of compaction achieved and the placement moisture content. The frequency and extent of testing should be as per guidelines in AS.3798-2007.

13.0 EXCAVATION CONDITIONS

The information and advice presented in this section of the report is based on the conditions encountered in the test pits excavated within the development area only. Variations in these conditions will occur across the site and must be expected.

Excavations at the site are expected to involve cuts up to approximately 3m in localised elevated areas to the west and up to approximately 6m in localised elevated areas to the east to form relatively flat areas for the proposed development. Cuts to a depth of up to approximately 6m are likely to encounter mainly natural sand and clays as well as extremely weathered (XW) and highly weathered (HW) sandstone and siltstone rock of very low and low strength which becomes moderately weathered (MW) and slightly weathered and medium and high strength with depth.

On the basis of the field investigation undertaken, excavations to the depths shown in Table 1 should be able to be achieved with medium sized Dozers (say Cat D6) or medium to large sized excavators (say >20tonne) fitted with general purpose and toothed buckets.

Excavations beyond these depths and to the required design excavation levels should be able to be achieved with large sized Dozers (say Cat D9 but to be confirmed) or large sized excavators (say >35 to 50 tonne plus) fitted with general purpose and toothed buckets. Localised areas beyond the refusal depths shown in Table 1 may require the use of ripper attachments for the above plant to achieve economic excavation rates or possibly hydraulic rock breakers, particularly where localised zones of less weathered stronger rock is encountered.

Consideration of the presence of high level rock at these localised areas across the site should be made in the earthworks contract.

No significant groundwater issues are expected to be encountered in excavations for this site under normal weather conditions but significant issues with the upper level silty sands could be expected.

14.0 INDICATIVE PAVEMENT DESIGN PARAMETERS

Soaked CBR laboratory testing was conducted on samples of the natural soils and weathered rock from numerous test pits throughout the site. The results of the soaked CBR tests are shown in Table 6 below.

TABLE 6 – SOAKED CBR TEST RESULTS

Test Pit No	Depth	Material	Soaked CBR Value (%)
TP07	0.3 – 0.6	Silty Clay (CH)	2.0
TP11	0.8 – 1.0	Silty Clay (CI-CH)	4.0
TP12	0.3 – 0.6	Silty Clay (CH)	3.5
TP14	0.3 – 0.5	Silty Sand (SM)	35.0
TP14	0.8 – 1.2	Sandy Clay (CI)	4.0
TP21	1.5 – 2.0	HW Sandstone	11.0
TP22	2.5 - 3.5	HW Siltstone	3.0
TP27	0.15 - 0.3	Clayey Sand (SC)	18.0
TP37	0.5 - 1.0	Silty Clay (CI-CH)	3.5
TP44	0.4 - 0.6	Clayey Gravelly Sand (SC)	45.0
TP45	4.1 - 5.1	HW Siltstone	9.0

Considering the nature of the natural soils and weathered rock at the site, the following preliminary design CBR values and modulus of subgrade reaction values shown in Table 7 below are suggested for each material type forming the subgrade for the pavement design and should be confirmed on site.

TABLE 7 – PRELIMINARY DESIGN CBR VALUES

Material	Design CBR Value (%)	Modulus of Subgrade Reaction (kPa/mm)
Natural Sands	8-12	35-55
Natural Gravels	8-12	35-55
Natural Clays	2-4	20-30
XW/HW Sandstone Rock	8-10	35-50
MW/SW Sandstone Rock	10-15	50-60
XW/HW Siltstone Rock	3-6	25-40
MW/SW Siltstone Rock	6-9	40-50

These values should be confirmed with additional on-site sampling and testing following the bulk earthworks operation on site.

Specific additional construction considerations are offered in regard to the construction of the pavements on the site:-

- Suitable subsurface drainage should be installed around the perimeter of the pavements, particularly where silty sands are expected.
- The use of suitable bridging layers may be required where silty sands are present across the excavation.

- It should be ensured that the subgrade of the pavement is suitably graded to allow any seepage to flow from under the pavement to the perimeter drains.
- Pavement materials should comply with MRS 11.05 specifications and the corresponding minimum dry density ratios are recommended:

Lower Sub-base	(Type 2.5)	95% (Modified)
Sub-base	(Type 2.3)	95% (Modified)
Base	(Type 2.1)	98% (Modified)
- Inspections and testing should be carried out by Pacific Geotech following the completion of the bulk earthworks to confirm subgrade conditions across the pavement areas.

15.0 GENERAL RECOMMENDATIONS FOR DEVELOPMENT

To maintain the long term performance of the proposed development, good management of the soil conditions and the development is vital throughout the life of the development.

The following are some specific comments with respect to site management and general development at the site:

- The ground surface around the perimeter of the buildings should slope away from the structure and fall to the stormwater system. Water should not be allowed to pond adjacent to the buildings.
- Founding soils should not be allowed to become saturated. Saturation of the on-site material will result in an increase in potential ground surface movements.
- Service trenches under the buildings should be kept to a minimum.
- Footings should be poured immediately after excavation. If footings cannot be poured on the same day as excavation, a blinding layer of 50mm thickness is recommended.
- Trees, garden beds and other vegetation should be planted at a distance at least equivalent to their mature height away from the structures. This will assist in minimising shrinkage movements in the expansive on-soils.
- Trafficability across most of the development areas of the site at the time of the investigation was assessed to be fair to poor. In areas which had been tyned trafficability was assessed to be extremely poor. If significant rainfall events occur during the earthworks operation, difficulties could be experienced in trafficking the exposed surface, particularly following stripping of the ground surface to expose the natural sand and clay soils as well as within the drainage features prior to stripping and filling. Site trafficability may be improved by constructing haulage roads into and on the site or placing rock along high traffic areas. The use of shallow open drains through the clayey/silty sands may be required to facilitate construction.

- All permanent excavations exceeding 1.0m must be supported by adequately engineered retaining walls incorporating drainage or battered at appropriate angles.
- If retaining walls are proposed, all retaining walls must be individually designed to have a factor of safety of at least 1.5 with respect to internal stability, including sliding and overturning. This is the responsibility of the retaining wall designer.
- When earthworks have been finalised, a global stability assessment must be carried out to confirm that a long term factor of safety in excess of 1.5 against geotechnical instability can be achieved for all proposed earthworks including all cut and fill batters and retaining structures.

16.0 STABILITY COMMENTARY

There is no evidence of existing or recent past slope instability involving small scale or large scale movements of significant quantities of soil or rock in a short duration event such as a slip or landslide within the development areas of the site.

The site typically comprises relatively flat or gentle to mild undulating terrain of approximately 10° or less with localised areas ranging up to approximately 15° throughout the site. In the gentle and mild sloping terrain the weathered rock is encountered at typically shallow depths below the existing ground surface. The likelihood of slope movement in the form of deep seated failures through the soil or rockmass is therefore considered to be very low, due to the relatively shallow depths to bedrock and the estimated friction angle of the natural soil and rock being higher than the angle of the slope.

On this basis, there are not expected to be any major geotechnical constraints associated with the stability of the site providing the recommendations stated in this report are followed and appropriately designed and constructed drainage structures and implemented as part of the residential development throughout the site.

17.0 LIMITATIONS

We have prepared this report for the Proposed Residential Subdivision at Riverside Development, Jimboomba. The report is provided for the exclusive use of Celestino Developments Pty Ltd, for this project only and for the purposes outlined in the report. It should not be used by, or relied upon, for other projects on the same or different sites or by a third party. In preparing this report, we have relied upon information provided by the client or their agents.

The results are indicative of the subsurface conditions on site only at the specific testing locations. Subsurface conditions can change between test locations and the design and construction should take the spacing of the testing and testing methods adopted and the potential for variation between the test locations.

It is recommended that Pacific Geotech be engaged to provide advice and ensure the development is undertaken in accordance with the assumptions made in writing this report.

This is not to reduce the level of responsibility accepted by Pacific Geotech, but rather to ensure that the parties who may rely on the information contained in this report are aware of the responsibilities they assume in doing so.

L. BEXLEY

P. ELKINGTON (RPEQ 7226)

For and on behalf of
PACIFIC GEOTECH PTY LTD

APPENDICES

APPENDIX A

NOTES RELATING TO THIS REPORT

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.

Every care has been taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical conditions and contains recommendations or suggestions for design and construction. However, unexpected variations in ground conditions will occur. The potential for this will depend partly on testing, spacing and sampling frequency.

If variations are identified, Pacific Geotech would be pleased to assist with additional investigations or advice to resolve the matter.

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This report is the property of Pacific Geotech Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Terms of Engagement of proposal. Unauthorised use of this report 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.

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.

Description and Classification Methods

The description and classification of soils and rocks used in this report are based on AS 1726.

Soil types are described according to the predominating particle size and behaviour as set out in the attached Unified Soil Classification Table qualified by the percent of

other particles present (e.g. sandy clay) as set out below:

Soil Classification	Particle Size
Clay	less than 0.002mm
Silty	0.002 to 0.06mm
Sand	0.06 to 2mm
Gravel	2 to 60mm

Non-cohesive soils are classified on the basis of relative density which can be correlated from the results of Standard Penetration Test (SPT) as below:

Relative Density	SPT 'N' Value (blows/300mm)
Very Loose	less than 4
Loose	4 – 10
Medium Dense	10 – 30
Dense	30 – 50
Very Dense	greater than 50

Cohesive soils are classified on the basis of strength (consistency) and can be quantified by the Pocket Penetrometer test, Vane Shear test, laboratory testing or engineering examination. The strength terms are defined as follows:

Classification	Unconfined Compressive Strength kPa
Very Soft	less than 25
Soft	25 - 50
Firm	50 – 100
Stiff	100 – 200
Very Stiff	200 - 400
Hard	greater than 400
Friable	strength not attainable – soil crumbles

Rock types are classified by their geological names, together with descriptive terms regarding weathering, strength, defects, etc.

Planarity	
CU	Curved
DIS	Discontinuous
IR	Irregular
PR	Planar
ST	Stepped
UN	Undulose

Roughness	
POL	Polished
RJ	Rough
S	Smooth
SL	Slickened
VR	Very Rough

Defects	Type
BP	Bedding Parting
CL	Cleavage
CO	Contact
CS	Crushed Seam
CZ	Crushed Zone
DB	Drilling Break
DK	Dyke
DL	Drill Lift
DZ	Decomposed Zone
FC	Fracture
FL	Foliation
FZ	Fracture Zone
HB	Handling Break
IS	Infilled Seam
JT	Joint
H	Schistosity
SI	Sill
SM	Seam
SS	Shear Seam
SZ	Shear Zone
VN	Vein
VO	Void

Sampling

Sampling is undertaken during the fieldwork to allow examination of the soil or rock and to allow laboratory testing to be undertaken.

Disturbed samples taken during drilling provide information on plasticity, grain size, colour, moisture content and minor constituents. Bulk samples are similar but of greater volume required for some test procedures such as CBR testing.

Undisturbed samples are taken by pushing a thin-walled sample tube, usually 50mm diameter (known as a U50), into the soil and collecting a sample of the soil contained 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.

Details of the type and method of sampling used are given on the attached logs.

Investigation Methods

Test Pits: These are typically undertaken with a backhoe or a tracked excavator, allowing examination of the insitu soils. Limitations of test pits are the problems associated with collapse of the pits, disturbance and difficulty of reinstatement and the consequent effects on close-by structures. Care must be taken if construction is to be carried out near test pit locations to either properly recompact the backfill during construction or to design and construct the structure so as not to be adversely affected by poorly compacted backfill at the test pit location.

Hand Auger Drilling: A borehole of typical diameter of between 50mm to 75mm advance manually operated equipment. Premature refusal of the hand augers can occur on a variety of materials such as fill, gravel, hard clays and collapse of the borehole (typically in non-cohesive soil).

Continuous Spiral flight Augers: The borehole is advanced using 65mm to 100mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling and insitu testing. Augers of up to 300mm in diameter are used to recover larger volumes of sample. Samples are returned to the surface by the flights or may be collected after withdrawal of the auger flights. Samples can be disturbed and layers may become mixed. Augering below the groundwater table can be less reliable than augering above the water table.

A Tungsten Carbide (TC) bit for auger drilling into rock can be used to indicate rock strength and continuity by variation in drilling resistance and from examination of recovered rock fragments but provides only an indication of the likely rock strength. Where rock strengths may have a significant impact on construction feasibility or costs, then further investigation by means of cored boreholes may be warranted.

Wash Boring: The borehole is advanced by a bit attached to the end of a hollow rod string, with water being pumped down the drill rods and returned up the annulus of the borehole, carrying the drill cuttings. Changes in stratification can be determined from the return, together with information from "feel" and rate of penetration.

The borehole can be stabilised through the use of drilling mud as a circulating fluid. The term 'mud' encompasses a range of products ranging from bentonite to polymers such as Revert or Biogel.

Continuous Core Drilling: A continuous core sample is obtained using a diamond tipped core barrel. This technique provides a reliable (but relatively expensive) method of investigation. In rocks, an NMLC triple tube core barrel is used, which gives a core of about 50mm diameter. The length of core recovered is compared to the length drilled and any length not recovered is shown as CORE LOSS.

Standard Penetration Tests: Standard Penetration Tests (SPT) are used mainly in non-cohesive soils, but can also be used in cohesive soils as a means of indicating density or strength and also of obtaining a disturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposed", Test 6.3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube with a tapered shoe, under the impact of a 63kg hammer, with a free fall of 760mm. The sample is driven in three successive 150mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense soils, hard clays or weak rock, the full 450mm 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 150mm of , say, 4, 6 and 7 blows, as
N = 13
4, 6, 7
- In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm, as
N > 30
15, 30/40mm

Cone Penetrometer Testing (CPT): Cone Penetrometer Testing with or without pore pressure measurement (CPTu) is carried out

using a Cone Penetrometer in general accordance with AS 1289 6.5.1, 1999.

In the tests, a 36mm diameter rod with a conical tip is pushed continuously into the soil, the reaction being provided by a hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the fractional resistance on a separate 135mm long sleeve, immediately behind the cone. Pore Pressure is recovered through a pore ring located either within, or more usually immediately behind the cone/tip.

As penetration occurs (at a rate of approximately 20mm per second) and data is recorded every 20mm of penetration, the results are presented graphically.

The information provided on the plot comprises:

- Cone resistance – expressed in mPa
- Sleeve friction – expressed in kPa
- Friction ratio – the ratio of sleeve friction to cone resistance expressed as a percentage.
- Pore pressure in kPa
- Tilt of probe (in degrees).

The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1% to 2% are commonly encountered in sands and rising to 2% to as high as 8%, and higher in organic soils. Soil descriptions based on cone resistance and friction ratios are only inferred and must not be considered as exact.

Stratification can be inferred from the cone and friction traces and from experience and information from nearby boreholes, etc. Where shown, this information is presented for general guidance, but must be regarded as interpretive.

Dynamic Cone Penetrometers:

Dynamic Cone Penetrometer (DCP) tests are carried out by driving a 16mm diameter rod into the ground with a 9kg sliding hammer dropping 510mm and counting the blows for successive 100mm increments of penetration.



Logs

The borehole or test pit logs are an interpretation of the subsurface conditions, and their reliability will depend to some extent on the frequency of sampling and the method of drilling or excavation.

Interpretation of the information shown on the logs, and its application to design and construction, should therefore take into account the spacing of the boreholes or test pits, the method of drilling or excavation, the frequency of sampling and testing and the possibility of other than "straight line" variations between the boreholes or test pits. Subsurface conditions between boreholes or test pits may vary significantly from conditions encountered at the borehole or test pit locations.

Groundwater

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

- Although groundwater may be present, in low permeability soils it may enter the hole slowly or perhaps not at all during the time it 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 and may not be the same at the time of construction.
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be flushed from the hole and drilling mud must be washed out of the hole or 'reverted' chemically if water observations are to be made.

More reliable measurements can be made by installing standpipes from which ongoing monitoring can be undertaken.

Fill

The present of fill materials can often be determined only by the inclusion of foreign objects (e.g. bricks, steel ,etc.) or by distinctly unusual colour, texture or fabric. Identification of the extent of fill materials will also depend on investigation methods and frequency. Where natural soils similar to those at the site are used

for fill, it may be difficult to reliably determine the extent of the fill.

Laboratory Testing

Laboratory testing is carried out in general accordance with Australian Standard 1289 'Methods of Testing Soil for Engineering Purposes'.

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, the company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some later stage.

Review of Design

Where major civil or structural developments are proposed or where only a limited investigation has been completed or where the geotechnical conditions/constraints are quite complex, it is prudent to have a design review.

Site Inspection

Pacific Geotech would be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related:

Requirements could range from:

- i. a site visit to confirm that conditions exposed are no worse than those interpreted, to
- ii. a visit to assist the contractor or other site personnel in identifying various soil/rock types such as appropriate footing or pier founding depths, or
- iii. full time engineering present on site.

APPENDIX B

TEST PIT RECORD SHEETS

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 17/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E			U50 0.40-0.50 m			0.30		SM	NATURAL SAND (SM): Medium dense, firm, fine to medium grained, low plasticity, brown, with low plasticity clay, with fine to medium sized gravel, organic, moist (topsoil with organics).
	0.90					CI-CH	Sandy CLAY (CI-CH): Stiff, medium to high plasticity, orange brown mottled pale grey, fine to medium grained sand, w > pl.		
	1.40					CL-CI	Sandy CLAY (CL-CI): Hard, low to medium plasticity, pale orange brown mottled grey, fine to medium grained sand, w > pl.		
	1.70					SANDSTONE (HW): Highly weathered, very low strength, fine grained, pale yellow brown, distinct dry.			
	2.00					SANDSTONE (MW): Moderately weathered, medium to high strength, fine grained, orange brown mottled pale grey, distinct dry.			
						2	Hole Terminated at 2.00 m		
						3			
						4			
						5			
						6			
						7			
<u>Method</u> AS - Auger RR - Rock Roller WB - Washbore <u>Support</u> C - Casing <u>Water</u> Level (Date) Inflow <u>Samples and Tests</u> U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample <u>Classification Symbols and Soil Descriptions</u> Based on Unified Soil Classification System <u>Remarks</u> 1. Seepage noted at 0.30m. 2. Test pit refusal at 2.0m.									

Project No.: PG-7818

 Client: Celestino Developments Pty Ltd
 Project Name: Proposed Residential Subdivision
 Hole Location: Riverside Development, Jimboomba
 Hole Position:

 Commenced: 17/10/2022
 Logged By: JT
 Checked By:

 Drill Model and Mounting: 35 tonne
 Hole Diameter: 0.3 mm

 RL Surface: No survey
 Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E			D 0.70-0.80 m			0.15		SM	NATURAL Silty SAND (SM): Medium dense, fine to medium grained, dark brown, moist (topsoil with organics).
						0.35		SM	Silty SAND (SM): Medium dense, fine to medium grained, brown, moist.
						0.45		CL-CI	Sandy CLAY (CL-CI): Firm, low to medium plasticity, pale orange brown mottled grey, fine grained sand, w ~ pl.
						0.60		CL-CI	Sandy CLAY (CL-CI): Stiff, low to medium plasticity, pale orange brown mottled grey, fine to medium grained sand, w ~ pl.
						0.70			SANDSTONE (HW): Highly weathered, low strength, fine grained, pale orange brown, distinct dry.
						0.80			SANDSTONE (MW): Moderately weathered, medium strength, fine grained, pale orange brown, distinct dry.
						1.70			SANDSTONE (SW): Slightly weathered, medium to high strength, fine grained, pale yellow brown, distinct dry.
									Hole Terminated at 1.70 m
						2			
						3			
						4			
						5			
						6			
						7			
Method AS - Auger RR - Rock Roller WB - Washbore							Water  Level (Date)  Inflow		Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample
Support C - Casing							Classification Symbols and Soil Descriptions Based on Unified Soil Classification System		Remarks 1. Groundwater not encountered. 2. Test pit refusal at 1.70m.

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 17/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E			U50 0.60-0.80 m			0.15		SM	NATURAL Silty SAND (SM): Loose, fine to medium grained, dark brown, with low plasticity clay, wet to moist (topsoil with organics).
						0.30		SM	
						0.50		CI	Silty SAND (SM): Loose, medium grained, pale grey brown, with low plasticity clay, moist.
						0.60		CI	Sandy CLAY (CI): Firm to stiff, medium plasticity, grey mottled orange brown, fine grained sand, w ~ pl.
						1.00		CI-CH	Sandy CLAY (CI): Stiff, medium plasticity, grey, fine grained sand, w ~ pl.
						1.60		CI	Sandy CLAY (CI-CH): Stiff to very stiff, medium to high plasticity, pale yellow brown, fine grained sand, w ~ pl.
						1.90		CI	Sandy CLAY (CI): Very stiff, medium plasticity, pale yellow brown, fine to medium grained sand, w ~ pl.
						2.60		CL	Sandy CLAY (CL): Hard, low plasticity, pale yellow brown, fine grained sand, w < pl.
						3.00			SANDSTONE (HW): Highly weathered, very low strength, fine grained, orange red brown, distinct dry.
									SANDSTONE (MW): Moderately weathered, medium to high strength, fine grained, red orange brown, distinct dry.
						3			Hole Terminated at 3.00 m
						4			
						5			
						6			
						7			

Method
AS - Auger
RR - Rock Roller
WB - Washbore

Support
C - Casing

Water
 Level (Date)
 Inflow

Samples and Tests
U - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
B - Bulk Sample

Classification Symbols and Soil Descriptions
Based on Unified Soil Classification System

Remarks
1. Groundwater not encountered.
2. Test pit refusal at 3.0m.

Project No.: PG-7818

 Client: Celestino Developments Pty Ltd
 Project Name: Proposed Residential Subdivision
 Hole Location: Riverside Development, Jimboomba
 Hole Position:

 Commenced: 17/10/2022
 Logged By: JT
 Checked By:

 Drill Model and Mounting: 35 tonne
 Hole Diameter: 0.3 mm

 RL Surface: No survey
 Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.10		SM	NATURAL Silty SAND (SM): Loose to medium dense, fine grained, brown, with low plasticity clay, moist.
						0.50		CI	Sandy CLAY (CI): Stiff, medium plasticity, dark grey-brown, fine grained sand, w > pl.
						1.20		SC	Clayey SAND (SC): Medium dense, medium grained, pale yellow brown, low to medium plasticity clay, trace coarse sized gravel, wet.
						2.00		SC	Clayey SAND (SC): Loose to medium dense, fine to medium grained, dark grey-brown, low plasticity clay, with medium to coarse sized gravel, wet.
						2.50		SM	Silty SAND (SM): Medium dense to dense, fine grained, pale grey brown, with low to medium plasticity clay, with medium to coarse sized gravel, wet.
						2.80		CI	Sandy CLAY (CI): Very stiff, medium plasticity, pale grey brown orange, fine grained sand, w ~ pl.
						3.00			SANDSTONE (HW): Highly weathered, low strength, fine grained, pale yellow brown, distinct dry.
						3.70			SANDSTONE (MW): Moderately weathered, medium to high strength, fine grained, pale yellow brown, distinct dry.
									Hole Terminated at 3.70 m
						4			
						5			
						6			
						7			
Method AS - Auger RR - Rock Roller WB - Washbore							Water  Level (Date)  Inflow		Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample
Support C - Casing							Classification Symbols and Soil Descriptions Based on Unified Soil Classification System		Remarks 1. Seepage noted at 1.10m. 2. Test pit refusal at 3.70m.

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 17/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E			U50 0.30-0.40 m			0.05		SM	NATURAL Silty SAND (SM): Loose to medium dense, fine to medium grained, dark brown, with medium plasticity clay, moist to dry (topsoil with organics).
						0.70		CI	Silty CLAY (CI): Firm to stiff, medium plasticity, pale yellow brown, with fine grained sand, w ~ pl.
						0.90			SANDSTONE (HW): Highly weathered, low strength, fine grained, pale orange brown, distinct dry.
						1.20			SILTSTONE (HW): Highly weathered, low strength, medium grained, pale grey, distinct dry.
						1.80			SANDSTONE (HW): Highly weathered, medium to high strength, fine grained, pale yellow brown, distinct dry.
						2			Hole Terminated at 1.80 m
						3			
						4			
						5			
						6			
						7			
Method AS - Auger RR - Rock Roller WB - Washbore							Water Level (Date) Inflow		Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample
Support C - Casing							Classification Symbols and Soil Descriptions Based on Unified Soil Classification System		Remarks 1. Groundwater not encountered. 2. Test pit refusal at 1.80m.

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 17/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description			
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional	
E						0.25		SM	NATURAL Silty SAND (SM): Loose to medium dense, fine to medium grained, dark brown, trace medium plasticity clay, moist.	
						0.70		CL-CI	Sandy CLAY (CL-CI): Stiff, low to medium plasticity, orange brown mottled grey, fine grained sand, w ~ pl.	
						0.85		CH	Sandy CLAY (CH): Very stiff, high plasticity, grey mottled orange brown, fine grained sand, w ~ pl.	
						1.00		CL-CI	Sandy CLAY (CL-CI): Hard, low to medium plasticity, grey mottled orange brown, fine grained sand, w ~ pl.	
						1.30			SANDSTONE (HW): Highly weathered, medium strength, fine grained, brown yellow, distinct dry.	
						1.50			SANDSTONE (SW): Slightly weathered, high strength, fine grained, pale yellow brown, distinct dry.	
						2			Hole Terminated at 1.50 m	
						3				
						4				
						5				
						6				
						7				
<u>Method</u> AS - Auger RR - Rock Roller WB- Washbore							<u>Water</u>  Level (Date)  Inflow		<u>Samples and Tests</u> U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample	<u>Remarks</u> 1. Groundwater not encountered. 2. Test pit refusal at 1.50m.
<u>Support</u> C - Casing							<u>Classification Symbols and Soil Descriptions</u> Based on Unified Soil Classification System			

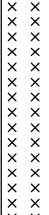
Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 17/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E			B 0.30-0.80 m U50 0.40-0.55 m			0.30		SM	NATURAL Silty SAND (SM): Loose, fine grained, brown, trace low plasticity clay, moist.
						0.70		CH	Silty CLAY (CH): Stiff, high plasticity, orange brown mottled grey, trace fine to medium grained sand, w ~ pl
						1.00		CH	Silty CLAY (CH): Very stiff, high plasticity, grey, trace fine grained sand, w ~ pl
						1.30		CL-CI	Silty CLAY (CL-CI): Hard, low to medium plasticity, grey orange red, w ~ pl
						2.80			SILTSTONE (HW): Highly weathered, very low strength, fine grained, pale grey mottled red orange purple yellow pink, distinct dry.
						3.10			SILTSTONE (MW): Moderately weathered, medium strength, fine grained, pale grey red orange, distinct dry.
									Hole Terminated at 3.10 m
						4			
						5			
						6			
						7			
Method AS - Auger RR - Rock Roller WB - Washbore Water  Level (Date)  Inflow Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample Support C - Casing Classification Symbols and Soil Descriptions Based on Unified Soil Classification System Remarks 1. Groundwater not encountered.									

Project No.: PG-7818

 Client: Celestino Developments Pty Ltd
 Project Name: Proposed Residential Subdivision
 Hole Location: Riverside Development, Jimboomba
 Hole Position:

 Commenced: 17/10/2022
 Logged By: JT
 Checked By:

 Drill Model and Mounting: 35 tonne
 Hole Diameter: 0.3 mm

 RL Surface: No survey
 Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.15		SM	NATURAL Silty SAND (SM): Loose, medium grained, brown orange, with low plasticity clay, moist.
						0.60		SC	Clayey SAND (SC): Loose, medium grained, grey brown, low plasticity clay, moist (organics).
						1.00		SC	Clayey SAND (SC): Loose, medium grained, pale grey-brown, low plasticity clay, wet.
						1.90		CL-CI	Sandy CLAY (CL-CI): Stiff, low to medium plasticity, pale orange brown, medium grained sand, w ~ ll.
						2.30		CL	Sandy CLAY (CL): Hard, low plasticity, pale yellow brown, fine grained sand, w ~ pl.
						3.00			SANDSTONE (HW): Highly weathered, low strength, fine grained, red orange yellow, distinct dry.
						3.40			Hole Terminated at 3.40 m
						4.00			
						5.00			
						6.00			
						7.00			
Method AS - Auger RR - Rock Roller WB - Washbore							Water  Level (Date)  Inflow		Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample
Support C - Casing							Classification Symbols and Soil Descriptions Based on Unified Soil Classification System		Remarks 1. Seepage noted at 0.60m.

Project No.: PG-7818

 Client: Celestino Developments Pty Ltd
 Project Name: Proposed Residential Subdivision
 Hole Location: Riverside Development, Jimboomba
 Hole Position:

 Commenced: 17/10/2022
 Logged By: JT
 Checked By:

 Drill Model and Mounting: 35 tonne
 Hole Diameter: 0.3 mm

 RL Surface: No survey
 Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E			B 0.40-1.00 m U 50 0.40-0.55 m			0.20		SM	NATURAL Silty SAND (SM): Loose, fine to medium grained, dark brown, with low plasticity clay, moist to dry.
						0.40		SM	Silty SAND (SM): Very loose, fine grained, pale grey brown, with low plasticity clay, moist
								CI	Silty CLAY (CI): Stiff, medium plasticity, pale grey brown, with fine grained sand, w ~ pl
						1.00		CH	Silty CLAY (CH): Very stiff, high plasticity, pale grey-brown, trace fine grained sand, w ~ pl
						1.30		CI	Silty CLAY (CI): Hard, medium plasticity, pale grey-brown, trace fine grained sand, w > pl
						1.60		CI	Silty CLAY (CI): Hard, medium plasticity, pale grey-brown, trace fine grained sand, w > pl
									SANDSTONE (HW): Highly weathered, very low strength, fine grained, brown yellow, distinct dry.
						2.20			SANDSTONE (HW): Highly weathered, low strength, fine grained, pale grey-brown, distinct dry.
						2.60			SANDSTONE (MW): Moderately weathered, medium strength, fine grained, pale yellow brown, distinct dry.
						3.00			SANDSTONE (MW): Moderately weathered, medium strength, fine grained, pale yellow brown, distinct dry.
						3			Hole Terminated at 3.00 m
						4			
						5			
						6			
						7			

Method
 AS - Auger
 RR - Rock Roller
 WB - Washbore

Water
 Level (Date)
 Inflow

Samples and Tests
 U - Undisturbed Sample
 D - Disturbed Sample
 SPT - Standard Penetration Test
 B - Bulk Sample

Classification Symbols and Soil Descriptions
 Based on Unified Soil Classification System

Support
 C - Casing

Remarks
 1. Groundwater not encountered.

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 18/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.15		SM	NATURAL Silty SAND (SM): Very loose, fine to medium grained, brown, trace low plasticity clay, moist.
						0.40		CL-CI	Sandy CLAY (CL-CI): Soft to firm, low to medium plasticity, grey, fine to medium grained sand, w > ll.
						0.80			SANDSTONE (HW): Highly weathered, low strength, fine grained, orange yellow white, distinct dry.
						1.20			SANDSTONE (MW): Moderately weathered, medium to high strength, fine grained, grey orange brown, distinct dry.
									Hole Terminated at 1.20 m
						2			
						3			
						4			
						5			
						6			
						7			
Method AS - Auger RR - Rock Roller WB - Washbore Support C - Casing Water  Level (Date)  Inflow Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample Classification Symbols and Soil Descriptions Based on Unified Soil Classification System Remarks 1. Seepage noted at 0.20m. 2. Test pit refusal at 1.20m.									

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 18/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E			U50 0.40-0.60 m B 0.70-1.20 m			0.15	</		

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 18/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E			B 0.30-0.60 m U50 0.30-0.45 m			0.10		SM	NATURAL Silty SAND (SM): Very loose to loose, fine grained, dark brown, with medium plasticity clay, moist.
						0.70		CH	Silty CLAY (CH): Firm, high plasticity, brown grey green, with fine grained sand, w ~ pl.
						1.20		CL	Silty CLAY (CL): Hard, low plasticity, grey orange yellow, w ~ pl.
						1.60			SILTSTONE (HW): Highly weathered, low strength, fine grained, yellow orange grey, distinct dry.
						2.00			SILTSTONE (HW): Highly weathered, low strength, fine grained, pale yellow brown, distinct dry.
						3.00			Hole Terminated at 3.00 m
						4.00			
						5.00			
						6.00			
						7.00			
Method AS - Auger RR - Rock Roller WB - Washbore							Water  Level (Date)  Inflow		Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample
Support C - Casing							Classification Symbols and Soil Descriptions Based on Unified Soil Classification System		Remarks 1. Groundwater not encountered.

Project No.: PG-7818

 Client: Celestino Developments Pty Ltd
 Project Name: Proposed Residential Subdivision
 Hole Location: Riverside Development, Jimboomba
 Hole Position:

 Commenced: 18/10/2022
 Logged By: JT
 Checked By:

 Drill Model and Mounting: 35 tonne
 Hole Diameter: 0.3 mm

 RL Surface: No survey
 Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.15		SM	NATURAL Silty SAND (SM): Very loose to loose, fine grained, dark brown, with low plasticity clay, dry.
								CI	Silty CLAY (CI): Firm, medium plasticity, grey mottled red orange, trace fine grained sand, w ~ pl.
						0.80			
						1.20		CH	Silty Sandy CLAY (CH): Very stiff, high plasticity, grey mottled orange red, fine grained sand, w ~ pl.
						1.80		CL	Sandy CLAY (CL): Hard, low plasticity, pale orange brown mottled grey, fine grained sand, w ~ pl.
						2.20			
									SANDSTONE (HW): Highly weathered, very low strength, fine grained, orange red white, distinct dry.
									SANDSTONE (MW): Moderately weathered, low to medium strength, fine grained, red orange white, distinct dry.
						3			
						4			
						4.00			Hole Terminated at 4.00 m
						5			
						6			
						7			
Method AS - Auger RR - Rock Roller WB - Washbore Water ☒ Level (Date) ☐ Inflow Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample Support C - Casing Classification Symbols and Soil Descriptions Based on Unified Soil Classification System Remarks 1. Groundwater not encountered.									

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 18/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.15		SM	NATURAL Silty SAND (SM): Loose, fine to medium grained, brown, trace low plasticity clay, dry.
								SM	Silty SAND (SM): Loose, fine to medium grained, pale orange brown, dry.
						0.65		CI	Sandy CLAY (CI): Very stiff, medium plasticity, orange brown, medium grained sand, trace medium sized gravel, w < pl.
					1	1.00			SANDSTONE (HW): Highly weathered, very low strength, medium grained, orange red, distinct dry.
						1.80			SANDSTONE (HW): Highly weathered, medium strength, fine to medium grained, pale orange brown, distinct dry.
					2	2.50			SANDSTONE (MW): Moderately weathered, medium to high strength, fine grained, red mottled orange brown, distinct dry.
					3	3.00			SANDSTONE (MW): Moderately weathered, medium to high strength, fine grained, red mottled orange brown, distinct dry.
									Hole Terminated at 3.00 m
						4			
						5			
					6				
					7				

Project No.: PG-7818

 Client: Celestino Developments Pty Ltd
 Project Name: Proposed Residential Subdivision
 Hole Location: Riverside Development, Jimboomba
 Hole Position:

 Commenced: 18/10/2022
 Logged By: JT
 Checked By:

 Drill Model and Mounting: 35 tonne
 Hole Diameter: 0.3 mm

 RL Surface: No survey
 Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.20		SM	NATURAL Silty SAND (SM): Very loose, fine to medium grained, brown, with low plasticity clay, dry (organics).
						0.40		CI	Silty CLAY (CI): Stiff, medium plasticity, grey, with fine grained sand, w ~ pl.
								CH	Silty CLAY (CH): Very stiff, high plasticity, grey brown, trace fine grained sand, w ~ pl.
						1			
						1.30			
						1.50		CL-CI	Silty CLAY (CL-CI): Hard, low to medium plasticity, grey brown, trace fine grained sand, w < pl.
								CI	Silty CLAY (CI): Hard, medium plasticity, grey white pale grey, trace fine grained sand, w ~ pl (trace of xw siltstone).
						2			
						3			
						4			
						4.00		CL	Silty CLAY (CL): Hard, low plasticity, pale grey dark grey mottled dark grey-brown, w ~ pl (with xw siltstone layering).
						5			
						6			
						6.00			
									Hole Terminated at 6.00 m
						7			

Method
 AS - Auger
 RR - Rock Roller
 WB - Washbore

Water
 Level (Date)
 Inflow

Samples and Tests
 U - Undisturbed Sample
 D - Disturbed Sample
 SPT - Standard Penetration Test
 B - Bulk Sample

Classification Symbols and Soil Descriptions
 Based on Unified Soil Classification System

Support
 C - Casing

Remarks
 1. Groundwater not encountered.

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 18/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.10		SM	NATURAL Silty SAND (SM): Very loose to loose, medium grained, brown, dry (organics).
						0.40		CI	Sandy CLAY (CI): Very stiff, medium plasticity, pale grey mottled red orange, medium grained sand, w ~ pl.
						0.50		CL	Sandy CLAY (CL): Hard, low plasticity, pale yellow brown, fine to medium grained sand, w < pl.
						1.00			SANDSTONE (HW): Highly weathered, very low strength, medium grained, brown yellow, distinct dry.
						2.60			SANDSTONE (HW): Highly weathered, low strength, medium grained, pale yellow brown, distinct dry.
						3.00			SANDSTONE (HW): Highly weathered, low to medium strength, medium grained, pale orange brown, distinct dry.
						3			Hole Terminated at 3.00 m
						4			
						5			
						6			
						7			
Method AS - Auger RR - Rock Roller WB- Washbore Support C - Casing Water Level (Date) Inflow Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample Classification Symbols and Soil Descriptions Based on Unified Soil Classification System							Remarks 1. Groundwater not encountered.		

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 18/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description				
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional		
E						0.15		SM	NATURAL Silty SAND (SM): Very loose, fine to medium grained, brown, dry (root matter).		
						0.30		SM	Silty SAND (SM): Loose to medium dense, medium grained, pale grey brown, dry.		
						0.60		SM	Silty SAND (SM): Loose, fine to medium grained, grey white brown, with low plasticity clay, wet.		
						1.00		CH	Sandy CLAY (CH): Stiff, high plasticity, grey mottled red orange, fine grained sand, w ~ pl.		
						1.60		CH	Sandy CLAY (CH): Very stiff, high plasticity, grey mottled red orange, fine to medium grained sand, w ~ pl.		
						1.80		CI	Sandy CLAY (CI): Very stiff, medium plasticity, grey mottled red orange, fine grained sand, w ~ pl.		
						2.00		CL	Sandy CLAY (CL): Hard, low plasticity, grey brown, fine grained sand, w ~ pl.		
						2.50			SANDSTONE (HW): Highly weathered, very low strength, fine to medium grained, pale yellow brown, distinct dry.		
						2.80			SANDSTONE (HW): Highly weathered, medium strength, medium grained, pale yellow brown, distinct dry.		
						3.50			SANDSTONE (MW): Moderately weathered, medium to high strength, fine grained, pale grey yellow, distinct dry.		
						4			Hole Terminated at 3.50 m		
						5					
						6					
						7					
<u>Method</u> AS - Auger RR - Rock Roller WB- Washbore							<u>Water</u>  Level (Date)  Inflow		<u>Samples and Tests</u> U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample		<u>Remarks</u> 1. Groundwater not encountered. 2. Test pit refusal at 3.50m.
<u>Support</u> C - Casing							<u>Classification Symbols and Soil Descriptions</u> Based on Unified Soil Classification System				

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 18/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.10		SM	NATURAL Silty SAND (SM): Very loose, medium grained, brown, dry.
						0.30		SM	Silty SAND (SM): Loose, medium grained, grey white, dry.
								CI	Silty CLAY (CI): Stiff, medium plasticity, grey mottled red orange, w ~ pl.
						1			
						1.20		CL	Silty CLAY (CL): Hard, low plasticity, pale grey, w ~ pl.
						1.80			
						2			SANDSTONE (HW): Highly weathered, low strength, medium grained, brown brown yellow orange white, distinct dry.
						2.70			
						3			SANDSTONE (HW): Highly weathered, low strength, fine to medium grained, white red orange, distinct dry.
						4			
						4.10			Hole Terminated at 4.10 m
						5			
						6			
						7			
Method AS - Auger RR - Rock Roller WB - Washbore							Water ☒ Level (Date) ☐ Inflow		Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample
Support C - Casing							Classification Symbols and Soil Descriptions Based on Unified Soil Classification System		Remarks 1. Groundwater not encountered.

Project No.: PG-7818

 Client: Celestino Developments Pty Ltd
 Project Name: Proposed Residential Subdivision
 Hole Location: Riverside Development, Jimboomba
 Hole Position:

 Commenced: 18/10/2022
 Logged By: JT
 Checked By:

 Drill Model and Mounting: 35 tonne
 Hole Diameter: 0.3 mm

 RL Surface: No survey
 Datum: AHD Operator: LB

Drilling Information							Soil Description			
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional	
E			U50 0.50-0.90 m			0.15		SM	NATURAL Silty SAND (SM): Very loose, medium grained, brown, dry (organics).	
					0.40		CH	Silty CLAY (CH): Stiff to very stiff, high plasticity, grey mottled orange brown, w > pl.		
							CH	Silty CLAY (CH): Stiff, high plasticity, grey mottled red orange, w ~ pl.		
					1					
					1.30		CI	Silty CLAY (CI): Very stiff, medium plasticity, grey mottled orange brown, w ~ pl.		
					2					
					1.90		CL	Silty CLAY (CL): Hard, low plasticity, grey mottled orange brown, w ~ pl.		
					3					
					3.10					SANDSTONE (HW): Highly weathered, low strength, medium grained, brown yellow grey, distinct dry.
		3.30					SANDSTONE (MW): Moderately weathered, medium to high strength, fine grained, red orange white, distinct dry.			
		3.60								
						4			Hole Terminated at 3.60 m	
						5				
						6				
						7				
Method AS - Auger RR - Rock Roller WB - Washbore Water  Level (Date)  Inflow Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample Support C - Casing Classification Symbols and Soil Descriptions Based on Unified Soil Classification System Remarks 1. Groundwater not encountered. 2. Test pit refusal at 3.60m.										

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 19/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E			U50 0.60-0.80 m			0.20		SM	NATURAL Silty SAND (SM): Loose, medium grained, brown, dry (organics root matter).
						0.55		SM	Silty SAND (SM): Loose, medium grained, grey brown, dry.
						1		CI	Sandy CLAY (CI): Hard, medium plasticity, red mottled grey, fine grained sand, w ~ pl.
						1.20			SANDSTONE (HW): Highly weathered, very low strength, medium grained, pale orange brown pale yellow brown, distinct dry.
						2			SANDSTONE (MW-SW): Moderately to slightly weathered, medium to high strength, fine grained, pale yellow brown pale orange brown, distinct dry.
						2.10 2.30			Hole Terminated at 2.30 m
						3			
						4			
						5			
						6			
						7			
Method AS - Auger RR - Rock Roller WB - Washbore Support C - Casing Water  Level (Date)  Inflow Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample Classification Symbols and Soil Descriptions Based on Unified Soil Classification System							Remarks 1. Groundwater not encountered.		

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 18/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description			
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional	
E						0.20		CL	NATURAL Silty CLAY (CL): Very soft, low plasticity, brown, with fine to medium grained sand, w < pl.	
						0.40		SM	Silty SAND (SM): Very loose, fine to medium grained, pale grey brown, trace low plasticity clay, dry.	
								CH	Silty CLAY (CH): Very stiff, high plasticity, grey mottled orange brown, with fine to medium grained sand, w ~ pl.	
						0.80				
						1.00		CI	Silty CLAY (CI): Hard, medium plasticity, grey mottled yellow orange, trace fine grained sand, w ~ pl.	
								CL	Silty CLAY (CL): Hard, low plasticity, pale yellow brown, w ~ pl.	
						1.50				
									SANDSTONE (HW): Highly weathered, low strength, fine grained, brown yellow, distinct dry.	
						2.00				
						2.20			SANDSTONE (MW): Moderately weathered, medium to high strength, fine grained, brown grey white, distinct dry.	
									Hole Terminated at 2.20 m	
						3				
						4				
						5				
						6				
						7				
<u>Method</u> AS - Auger RR - Rock Roller WB - Washbore <u>Support</u> C - Casing <u>Water</u>  Level (Date)  Inflow <u>Samples and Tests</u> U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample <u>Classification Symbols and Soil Descriptions</u> Based on Unified Soil Classification System <u>Remarks</u> 1. Groundwater not encountered. 2. Test pit refusal at 2.20m.										

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 21/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.20		SM	NATURAL Silty SAND (SM): Very loose, medium grained, brown, wet.
						0.50		SM	Silty SAND (SM): Loose, medium grained, white grey, wet.
						1.00		CH	Silty Sandy CLAY (CH): Stiff to very stiff, high plasticity, grey mottled red orange, medium grained sand, w ~ pl.
						1.60		CH	Silty CLAY (CH): Very stiff, high plasticity, grey mottled red orange, w ~ pl.
						2.00		CL	Silty CLAY (CL): Hard, low plasticity, pale yellow brown, w ~ pl.
						2.20			SANDSTONE (HW): Highly weathered, low strength, fine grained, pale yellow brown, dry.
						2.30			SANDSTONE (SW): Slightly weathered, high strength, fine grained, pale yellow brown, dry.
									Hole Terminated at 2.30 m
						3			
						4			
					5				
					6				
					7				
							</		

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 21/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.15		SM	NATURAL Silty SAND (SM): Very loose, medium grained, brown, wet.
						0.50		SM	Silty SAND (SM): Loose, medium to coarse grained, pale grey brown, with medium plasticity clay, moist.
						0.60			SANDSTONE (HW): Highly weathered, low strength, fine grained, brown yellow, dry.
						0.65			SANDSTONE (SW): Slightly weathered, high strength, fine to medium grained, pale yellow brown, dry. Hole Terminated at 0.65 m
						1			
						2			
						3			
						4			
						5			
						6			
						7			
Method AS - Auger RR - Rock Roller WB - Washbore							Water  Level (Date)  Inflow		Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample
Support C - Casing							Classification Symbols and Soil Descriptions Based on Unified Soil Classification System		Remarks 1. Groundwater not encountered. 2. Test pit refusal at 0.65m.

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 21/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E			U50 0.30-0.45 m			0.10		SM	NATURAL Silty SAND (SM): Loose, medium grained, brown, moist.
	0.20	SM				Silty SAND (SM): Loose, medium grained, grey brown, moist.			
		CH				Silty CLAY (CH): Stiff, high plasticity, red orange mottled grey, trace fine grained sand, w ~ pl.			
	1								
	1.10	CH				Silty CLAY (CH): Very stiff, high plasticity, red orange mottled grey, trace fine grained sand, w ~ pl.			
	1.50								
		CI-CH				Silty CLAY (CI-CH): Very stiff, medium to high plasticity, pale yellow brown mottled grey, trace fine grained sand, w ~ pl.			
	2								
	2.30								
						SILTSTONE (HW): Highly weathered, low strength, fine to medium grained, pale yellow brown, distinct dry.			
					3	3.00		Hole Terminated at 3.00 m	
						4			
						5			
						6			
						7			
Method AS - Auger RR - Rock Roller WB - Washbore Support C - Casing Water Level (Date) Inflow Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample Classification Symbols and Soil Descriptions Based on Unified Soil Classification System Remarks 1. Groundwater not encountered.									

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 21/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E			U50 0.30-0.45 m			0.20		SC	NATURAL Clayey SAND (SC): Loose, fine to medium grained, brown, low plasticity clay, wet.
								CH	Silty CLAY (CH): Stiff, high plasticity, pale yellow brown mottled grey, trace fine grained sand, w ~ pl.
						0.70			
						0.90		CH	Silty CLAY (CH): Very stiff, high plasticity, pale orange brown, w ~ pl.
						1.10		CL	Silty CLAY (CL): Hard, low plasticity, pale yellow brown, w ~ pl.
						1.30			
									SILTSTONE (HW): Highly weathered, very low strength, medium grained, pale yellow brown, distinct dry.
									SILTSTONE (MW): Moderately weathered, medium strength, fine to medium grained, pale yellow brown, distinct dry.
						2.60			
						2.90			SILTSTONE (MW): Moderately weathered, medium to high strength, fine grained, pale yellow brown, distinct dry.
						3			Hole Terminated at 2.90 m
						4			
						5			
						6			
						7			
Method AS - Auger RR - Rock Roller WB - Washbore Water  Level (Date)  Inflow Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample Support C - Casing Classification Symbols and Soil Descriptions Based on Unified Soil Classification System Remarks 1. Groundwater not encountered. 2. Test pit refusal at 2.90m.									

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 21/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E			B 0.20-0.40 m			0.15		OL	NATURAL Sandy SILT (OL): Very soft, low plasticity, brown, medium grained sand, organic, w ~ pl.
						0.30		SC	Clayey SAND (SC): Very loose to loose, medium grained, grey brown, medium plasticity clay, wet.
			U50 0.60-0.80 m			0.70		CH	Silty CLAY (CH): Stiff, high plasticity, pale grey mottled red orange, w ~ pl.
						1		CH	Sandy CLAY (CH): Very stiff, high plasticity, grey mottled red orange, fine to medium grained sand, w ~ pl.
						2			
						2.30			
						2.50		CL	Sandy CLAY (CL): Hard, low plasticity, mottled pale yellow brown red orange, fine to medium grained sand, w ~ pl.
						3			SANDSTONE (HW): Highly weathered, very low strength, medium grained, pale yellow brown, dry.
						3.50			
						3.70			SANDSTONE (HW): Highly weathered, medium strength, fine grained, brown yellow, dry.
						4			Hole Terminated at 3.70 m
						5			
						6			
						7			
Method AS - Auger RR - Rock Roller WB - Washbore							Water ☒ Level (Date) ☐ Inflow		Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample
Support C - Casing							Classification Symbols and Soil Descriptions Based on Unified Soil Classification System		Remarks 1. Groundwater not encountered.

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 20/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.15		SM	NATURAL Silty SAND (SM): Very loose, fine to medium grained, brown, wet.
						0.30		CH	Silty CLAY (CH): Stiff, high plasticity, pale yellow brown, w > pl.
								CH	Silty CLAY (CH): Stiff, high plasticity, grey mottled red orange, w ~ pl.
						1			
						1.30		CH	Silty CLAY (CH): Very stiff, high plasticity, grey mottled red orange, w ~ pl.
						2			
						2.80		CH	Silty CLAY (CH): Hard, high plasticity, pale grey-brown pale grey, w ~ pl.
						3.30		CH	Silty CLAY (CH): Hard, high plasticity, grey mottled red orange, w ~ pl.
						4			
						4.30			
					5			SILTSTONE (HW): Highly weathered, very low strength, fine grained, grey pale grey, distinct dry.	
					5.50			SANDSTONE (HW): Highly weathered, very low strength, fine to medium grained, pale yellow brown with red orange, distinct dry.	
					6	6.00			Hole Terminated at 6.00 m
					7				
<u>Method</u> AS - Auger RR - Rock Roller WB - Washbore <u>Support</u> C - Casing <u>Water</u> Level (Date) Inflow <u>Samples and Tests</u> U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample <u>Classification Symbols and Soil Descriptions</u> Based on Unified Soil Classification System <u>Remarks</u> 1. Groundwater not encountered.									

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 21/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E			D 0.80-1.00 m			0.08		SM	NATURAL Silty SAND (SM): Loose, fine grained, brown, moist.
		0.20				CL	Silty CLAY (CL): Soft, low plasticity, pale grey-brown, with medium to coarse sized gravel, trace fine grained sand, w > pl.		
		0.50				CH	Sandy CLAY (CH): Firm, high plasticity, red orange, fine grained sand, with fine to medium sized gravel, w ~ pl.		
		0.70				CH	Silty CLAY (CH): Very stiff, high plasticity, red orange brown, trace fine sized gravel, trace fine to medium grained sand, w ~ pl.		
		1.10				CI-CH	SANDSTONE (HW): Highly weathered, low strength, medium grained, orange red, distinct dry.		
			D 5.00-6.00 m			1.70		CL-CI	Silty CLAY (CI-CH): Very stiff, medium to high plasticity, grey mottled red orange, trace fine grained sand, w ~ pl.
		2.50				CL	Silty CLAY (CL-CI): Very stiff to hard, low to medium plasticity, white mottled red orange, w ~ pl.		
		4.50				CL	Silty CLAY (CL): Hard, low plasticity, pale grey, w < pl.		
		6.00					SILTSTONE (HW): Highly weathered, low strength, fine grained, white orange red, distinct dry.		
		6.00					Hole Terminated at 6.00 m		
					7				
<u>Method</u> AS - Auger RR - Rock Roller WB - Washbore <u>Support</u> C - Casing <u>Water</u> Level (Date) Inflow <u>Samples and Tests</u> U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample <u>Classification Symbols and Soil Descriptions</u> Based on Unified Soil Classification System <u>Remarks</u> 1. Groundwater not encountered.									

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 21/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.15		SM	NATURAL Silty SAND (SM): Loose, fine to medium grained, brown, trace low to medium plasticity clay, moist.
						0.40		SM	Silty SAND (SM): Loose, medium grained, pale grey brown, moist.
						0.60		CH	Silty CLAY (CH): Firm to stiff, high plasticity, pale grey-brown, w ~ pl.
						0.80		CH	Sandy CLAY (CH): Stiff, high plasticity, pale grey-brown, fine grained sand, w ~ pl.
						1.00		CH	Silty CLAY (CH): Very stiff, high plasticity, pale grey-brown, w ~ pl.
						1.30		CL	Silty CLAY (CL): Hard, low plasticity, pale yellow brown, w < pl.
						1.80			SANDSTONE: Highly weathered, very low strength, medium grained, pale orange brown, distinct dry.
						2.60			SANDSTONE: Moderately weathered, medium strength, fine to medium grained, pale orange brown, distinct dry.
						2.80			SANDSTONE: Slightly weathered, high strength, fine grained, pale yellow brown, distinct dry.
						3			Hole Terminated at 2.80 m
					4				
					5				
					6				
					7				
Method AS - Auger RR - Rock Roller WB- Washbore Support C - Casing Water Level (Date) Inflow Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample Classification Symbols and Soil Descriptions Based on Unified Soil Classification System							Remarks 1. Groundwater not encountered. 2. Test pit refusal at 2.80m.		

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 21/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E			U 0.60-0.80 m			0.20		SM	NATURAL Silty SAND (SM): Very loose to loose, fine to medium grained, brown, trace medium plasticity clay, wet.
					0.40		SC	Clayey SAND (SC): Very loose, medium grained, grey white, low plasticity clay, with medium to coarse sized gravel, wet.	
					0.60		SM	Silty SAND (SM): Very loose, medium grained, white grey, with medium to coarse sized gravel, wet.	
					1.00		CH	Sandy CLAY (CH): Stiff, high plasticity, grey mottled red orange, fine to medium grained sand, w ~ pl.	
					1.60		CH	Silty CLAY (CH): Very stiff, high plasticity, grey mottled red orange, trace medium grained sand, w ~ pl.	
					1.80		CL	Silty CLAY (CL): Hard, low plasticity, pale grey-brown, trace fine grained sand, w ~ pl.	
					2.20			SANDSTONE (HW): Highly weathered, very low strength, fine grained, pale yellow brown, dry.	
					3.50			SANDSTONE (HW): Highly weathered, medium strength, medium grained, pale yellow brown, dry.	
								Hole Terminated at 3.50 m	
						4			
						5			
						6			
						7			
<u>Method</u> AS - Auger RR - Rock Roller WB - Washbore <u>Support</u> C - Casing <u>Water</u>  Level (Date)  Inflow <u>Samples and Tests</u> U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample <u>Classification Symbols and Soil Descriptions</u> Based on Unified Soil Classification System							<u>Remarks</u> 1. Groundwater not encountered.		

Project No.: PG-7818

 Client: Celestino Developments Pty Ltd
 Project Name: Proposed Residential Subdivision
 Hole Location: Riverside Development, Jimboomba
 Hole Position:

 Commenced: 21/10/2022
 Logged By: JT
 Checked By:

 Drill Model and Mounting: 35 tonne
 Hole Diameter: 0.3 mm

 RL Surface: No survey
 Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.10		SM	NATURAL Silty SAND (SM): Loose, fine to medium grained, dark grey, with low plasticity clay, wet (organics).
						0.30		SM	Silty SAND (SM): Loose, fine to medium grained, grey, with low plasticity clay, wet.
						0.45		CH	Sandy CLAY (CH): Very stiff, high plasticity, orange brown mottled grey, fine to medium grained sand, w > pl.
						0.50		CH	Sandy CLAY (CH): Hard, high plasticity, pale orange brown mottled pale grey, fine to medium grained sand, w > pl.
						0.90			SANDSTONE (HW): Highly weathered, low strength, fine to medium grained, pale orange brown mottled pale grey, dry.
						1			SANDSTONE (MW): Moderately weathered, medium strength, fine to medium grained, pale orange brown mottled pale grey, dry.
						1.40			SANDSTONE (SW): Slightly weathered, high strength, fine to medium grained, pale orange brown mottled pale grey, dry.
						1.50			Hole Terminated at 1.50 m
						2			
						3			
						4			
						5			
						6			
						7			

Method

 AS - Auger
 RR - Rock Roller
 WB - Washbore

Water
 Level (Date)
 Inflow

Samples and Tests

 U - Undisturbed Sample
 D - Disturbed Sample
 SPT - Standard Penetration Test
 B - Bulk Sample

Remarks

 1. Groundwater not encountered.
 2. Test pit refusal at 1.50m.

Support

C - Casing

Classification Symbols and Soil Descriptions

Based on Unified Soil Classification System

Project No.: PG-7818

 Client: Celestino Developments Pty Ltd
 Project Name: Proposed Residential Subdivision
 Hole Location: Riverside Development, Jimboomba
 Hole Position:

 Commenced: 21/10/2022
 Logged By: JT
 Checked By:

 Drill Model and Mounting: 35 tonne
 Hole Diameter: 0.3 mm

 RL Surface: No survey
 Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.10		SM	NATURAL Silty SAND (SM): Loose, fine grained, brown, with low plasticity clay, wet.
						0.30		SM	Silty SAND (SM): Loose, fine to medium grained, pale grey mottled orange brown, trace low plasticity clay, wet.
						0.60			SANDSTONE (HW): Highly weathered, low strength, fine to medium grained, pale yellow brown, distinct dry.
						1.00			SANDSTONE (MW): Moderately weathered, medium to high strength, medium grained, pale yellow brown, distinct dry.
						1			Hole Terminated at 1.00 m
						2			
						3			
						4			
						5			
						6			
						7			

Method
 AS - Auger
 RR - Rock Roller
 WB - Washbore

Water
 Level (Date)
 Inflow

Samples and Tests
 U - Undisturbed Sample
 D - Disturbed Sample
 SPT - Standard Penetration Test
 B - Bulk Sample

Classification Symbols and Soil Descriptions
 Based on Unified Soil Classification System

Support
 C - Casing

Remarks
 1. Groundwater not encountered.
 2. Test pit refusal at 1.0m.

Project No.: PG-7818

 Client: Celestino Developments Pty Ltd
 Project Name: Proposed Residential Subdivision
 Hole Location: Riverside Development, Jimboomba
 Hole Position:

 Commenced: 19/10/2022
 Logged By: JT
 Checked By:

 Drill Model and Mounting: 35 tonne
 Hole Diameter: 0.3 mm

 RL Surface: No survey
 Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.10		SM	NATURAL Silty SAND (SM): Loose, medium grained, brown, wet.
						0.30		CI-CH	Sandy CLAY (CI-CH): Soft to firm, medium to high plasticity, grey mottled orange brown, fine grained sand, w ~ pl.
						0.50		CH	Silty CLAY (CH): Stiff, high plasticity, grey brown, trace fine grained sand, w ~ pl.
								CH	Silty CLAY (CH): Very stiff, high plasticity, grey brown, trace fine grained sand, w ~ pl.
						1			
						1.90		CL	Sandy CLAY (CL): Hard, low plasticity, pale grey mottled red orange, fine to medium grained sand, w > pl.
						2.50			
						3			SANDSTONE (HW): Highly weathered, low strength, medium grained, pale orange brown red, distinct dry.
						3.30			
						3.50			SANDSTONE (MW): Moderately weathered, high strength, medium grained, brown orange red, distinct dry.
									Hole Terminated at 3.50 m
						4			
						5			
						6			
						7			
Method AS - Auger RR - Rock Roller WB - Washbore							Water ☒ Level (Date) ☐ Inflow		Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample
Support C - Casing							Classification Symbols and Soil Descriptions Based on Unified Soil Classification System		Remarks 1. Groundwater not encountered.

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 19/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description			
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional	
E			U50 0.40-0.55 m			0.30		SM	NATURAL Silty SAND (SM): Very loose, medium grained, grey brown, wet.	
						1		CH	Silty CLAY (CH): Stiff, high plasticity, pale grey-brown, w > pl.	
						1.70				
						2		CI-CH	Silty CLAY (CI-CH): Very stiff, medium to high plasticity, pale grey mottled red orange, w ~ pl.	
						2.10		CH	Silty CLAY (CH): Hard, high plasticity, dark grey-brown, w ~ pl (becoming slightly fissured).	
						3				
						4				
						4.50		CI	Silty CLAY (CI): Hard, medium plasticity, dark grey-brown, w ~ pl.	
						5				
						6				
						7	7.00			
									Hole Terminated at 7.00 m	
Method AS - Auger RR - Rock Roller WB- Washbore Support C - Casing							Water Level (Date) Inflow Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample Classification Symbols and Soil Descriptions Based on Unified Soil Classification System			Remarks 1. Groundwater not encountered.

Project No.: PG-7818

 Client: Celestino Developments Pty Ltd
 Project Name: Proposed Residential Subdivision
 Hole Location: Riverside Development, Jimboomba
 Hole Position:

 Commenced: 20/10/2022
 Logged By: JT
 Checked By:

 Drill Model and Mounting: 35 tonne
 Hole Diameter: 0.3 mm

 RL Surface: No survey
 Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.10		SM	NATURAL Silty SAND (SM): Loose, medium grained, brown, moist.
						0.20		CI	Silty CLAY (CI): Firm, medium plasticity, grey brown, with fine grained sand, w ~ pl.
						0.40		CL-CI	Silty CLAY (CL-CI): Soft to firm, low to medium plasticity, pale grey-brown, with fine grained sand, w > pl.
								CI-CH	Silty CLAY (CI-CH): Very stiff, medium to high plasticity, red orange mottled grey brown, w ~ pl.
						1.20		CL	Sandy CLAY (CL): Hard, low plasticity, pale yellow brown, fine grained sand, w < pl.
						1.70		CL-CI	Sandy CLAY (CL-CI): Hard, low to medium plasticity, pale yellow brown, fine grained sand, w ~ pl.
						2.60			
						3.50			SANDSTONE (HW): Highly weathered, very low strength, fine to medium grained, pale orange brown, distinct dry.
						4.00			SANDSTONE (HW): Highly weathered, low strength, medium grained, pale yellow brown grey, distinct dry.
						6.00			
									Hole Terminated at 6.00 m
						7.00			
Method AS - Auger RR - Rock Roller WB - Washbore							Water ☒ Level (Date) ☐ Inflow		Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample
Support C - Casing							Classification Symbols and Soil Descriptions Based on Unified Soil Classification System		Remarks 1. Groundwater not encountered.

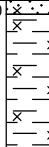
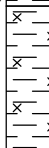
Project No.: PG-7818

 Client: Celestino Developments Pty Ltd
 Project Name: Proposed Residential Subdivision
 Hole Location: Riverside Development, Jimboomba
 Hole Position:

 Commenced: 19/10/2022
 Logged By: JT
 Checked By:

 Drill Model and Mounting: 35 tonne
 Hole Diameter: 0.3 mm

 RL Surface: No survey
 Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.10		SM	NATURAL Silty SAND (SM): Loose, medium grained, brown, with low plasticity clay, moist to dry.
						1		CI-CH	Silty CLAY (CI-CH): Stiff, medium to high plasticity, pale yellow brown, with medium grained sand, w ~ pl.
						1.30		CI-CH	Silty CLAY (CI-CH): Very stiff, medium to high plasticity, grey pale orange brown, with fine grained sand, w ~ pl.
						2			
						3			
						3.50			
						4		CL	Silty CLAY (CL): Hard, low plasticity, pale orange brown, with medium grained sand, w ~ pl.
						4.00			
									Hole Terminated at 4.00 m
						5			
						6			
						7			

Method
 AS - Auger
 RR - Rock Roller
 WB - Washbore

Support
 C - Casing

Water
 Level (Date)
 Inflow

Samples and Tests
 U - Undisturbed Sample
 D - Disturbed Sample
 SPT - Standard Penetration Test
 B - Bulk Sample

Classification Symbols and Soil Descriptions
 Based on Unified Soil Classification System

Remarks
 1. Groundwater not encountered.

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 19/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.15		SM	NATURAL Silty SAND (SM): Loose, medium grained, brown, moist.
								CH	Silty CLAY (CH): Loose to medium dense, stiff, high plasticity, brown pale yellow brown, with medium grained sand, w ~ pl.
						0.60		CH	Silty CLAY (CH): Firm to stiff, high plasticity, grey white brown, trace fine grained sand, w ~ pl.
						1.10		CH	Silty CLAY (CH): Very stiff, high plasticity, pale grey brown, w ~ pl.
						1.60		CH	Silty CLAY (CH): Very stiff, high plasticity, pale grey brown, trace medium grained sand, w ~ pl.
						1.80		CI-CH	Sandy CLAY (CI-CH): Very stiff, medium to high plasticity, grey brown, medium grained sand, w ~ pl.
						2			
						3			
						4			
						5.10		CI	Sandy CLAY (CI): Hard, medium plasticity, pale yellow brown grey, medium grained sand, w ~ pl.
					6	6.00			Hole Terminated at 6.00 m
						7			
Method AS - Auger RR - Rock Roller WB- Washbore Support C - Casing Water Level (Date) Inflow Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample Classification Symbols and Soil Descriptions Based on Unified Soil Classification System							Remarks 1. Groundwater not encountered.		

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 19/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.10		SM	NATURAL Silty SAND (SM): Loose, medium grained, brown, moist.
						0.30		CH	Silty CLAY (CH): Firm to stiff, high plasticity, grey white brown, w ~ pl.
								CH	Silty CLAY (CH): Stiff, high plasticity, grey pale grey, w ~ pl.
						1			
						1.60		CH	Silty CLAY (CH): Very stiff, high plasticity, grey mottled brown, w ~ pl.
						2			
						2.30		CI	Silty CLAY (CI): Hard, medium plasticity, dark grey, w ~ pl.
						2.80		CI	Silty CLAY (CI): Very stiff, medium plasticity, grey white, w ~ pl.
						3			
						3.20		CL-CI	Silty CLAY (CL-CI): Hard, low to medium plasticity, grey, w ~ pl.
						5			Hole Terminated at 5.00 m
						6			
						7			
Method AS - Auger RR - Rock Roller WB - Washbore							Water ☒ Level (Date) ☐ Inflow		Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample
Support C - Casing							Classification Symbols and Soil Descriptions Based on Unified Soil Classification System		Remarks 1. Groundwater not encountered.

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 19/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.40		SM	NATURAL Silty SAND (SM): Very loose to loose, fine to medium grained, brown dark brown, wet.
						1.20		SM	Silty SAND (SM): Loose, medium grained, brown, with low plasticity clay, wet.
						1.50		CI	Sandy CLAY (CI): Very stiff, medium plasticity, grey mottled pale red brown, medium grained sand, w ~ pl.
						2.20		CL	Silty CLAY (CL): Hard, low plasticity, pale orange brown, w ~ pl.
						3.30			SANDSTONE (HW): Highly weathered, low strength, medium grained, orange grey red, distinct dry.
						4.00			SILTSTONE (HW): Highly weathered, low strength, fine grained, pale grey, distinct dry.
						4			Hole Terminated at 4.00 m
						5			
						6			
						7			
Method AS - Auger RR - Rock Roller WB - Washbore Support C - Casing Water  Level (Date)  Inflow Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample Classification Symbols and Soil Descriptions Based on Unified Soil Classification System							Remarks 1. Groundwater not encountered.		

Project No.: PG-7818

 Client: Celestino Developments Pty Ltd
 Project Name: Proposed Residential Subdivision
 Hole Location: Riverside Development, Jimboomba
 Hole Position:

 Commenced: 19/10/2022
 Logged By: JT
 Checked By:

 Drill Model and Mounting: 35 tonne
 Hole Diameter: 0.3 mm

 RL Surface: No survey
 Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.15		SM	NATURAL Silty SAND (SM): Loose, medium grained, brown, dry.
						0.30		SM	Silty SAND (SM): Loose, fine grained, grey brown, dry.
								CI	Silty CLAY (CI): Very stiff, medium plasticity, red orange mottled grey, trace fine grained sand, w ~ pl.
						0.70		CL	Silty CLAY (CL): Hard, low plasticity, pale grey pale yellow brown, trace fine grained sand, w < pl.
						1			
						1.30			
						2			SILTSTONE (HW): Highly weathered, low strength, fine grained, pale yellow brown pale grey, distinct dry.
						3			
						3.20			SANDSTONE (HW): Highly weathered, low strength, medium grained, brown orange, distinct dry.
						4			
						4.50			SANDSTONE (HW): Highly weathered, low strength, medium grained, brown yellow red, distinct dry.
						5			
						5.50			SANDSTONE (HW): Highly weathered, low to medium strength, medium grained, pale yellow brown red, distinct dry.
						6			Hole Terminated at 6.00 m
						7			

Method

 AS - Auger
 RR - Rock Roller
 WB - Washbore

Water
 Level (Date)
 Inflow

Samples and Tests

 U - Undisturbed Sample
 D - Disturbed Sample
 SPT - Standard Penetration Test
 B - Bulk Sample

Remarks

1. Groundwater not encountered.

Support

C - Casing

Classification Symbols and Soil Descriptions

Based on Unified Soil Classification System

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 19/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.05		SM	NATURAL Silty SAND (SM): Very loose, fine grained, brown grey, with low to medium plasticity clay, wet.
						0.40		CI-CH	Silty CLAY (CI-CH): Soft, medium to high plasticity, pale grey mottled orange brown, w ~ pl.
								CH	Silty CLAY (CH): Stiff, high plasticity, pale grey mottled orange brown, w ~ pl.
						1			
						1.60			
						2		CH	Silty CLAY (CH): Very stiff, high plasticity, grey mottled pale grey and orange brown, w ~ pl.
						2.00		CH	Silty CLAY (CH): Very stiff, high plasticity, pale yellow brown grey, with fine grained sand, w ~ pl.
						3			
						4			
						4.00			
									Hole Terminated at 4.00 m
						5			
						6			
						7			
Method AS - Auger RR - Rock Roller WB - Washbore							Water  Level (Date)  Inflow		Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample
Support C - Casing							Classification Symbols and Soil Descriptions Based on Unified Soil Classification System		Remarks 1. Groundwater not encountered.

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 19/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.15		SM	NATURAL Silty SAND (SM): Loose, medium grained, brown, with medium plasticity clay, moist.
								CH	Silty CLAY (CH): Firm to stiff, high plasticity, grey mottled red orange, trace fine grained sand, w ~ pl.
						0.70		CH	Silty CLAY (CH): Stiff, high plasticity, pale yellow brown, trace medium grained sand, w ~ pl.
						1.30		CH	Silty CLAY (CH): Very stiff, high plasticity, brown yellow grey, w ~ pl.
						3.40		CI	Silty CLAY (CI): Hard, medium plasticity, dark grey mottled orange yellow brown, w ~ pl.
						3.70			Hole Terminated at 3.70 m
						4			
						5			
						6			
						7			
Method AS - Auger RR - Rock Roller WB- Washbore Support C - Casing Water  Level (Date)  Inflow Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample Classification Symbols and Soil Descriptions Based on Unified Soil Classification System Remarks 1. Groundwater not encountered.									

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 19/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E			B 0.20-0.50 m			0.15		SM	NATURAL Silty SAND (SM): Loose, fine to medium grained, brown, with medium sized gravel, dry.
						0.30		SM	Silty SAND (SM): Medium dense, medium to coarse grained, pale yellow brown grey, with medium to coarse sized gravel, wet.
			U50 0.60-0.70 m			0.60		SC	Clayey Gravelly SAND (SC) Loose, fine to medium grained, pale yellow brown grey, with medium to coarse sized gravel, wet.
						0.90		CH	Sandy CLAY (CH): Very stiff, high plasticity, pale orange brown grey, medium grained sand, w ~ pl.
						1.50		CH	Sandy CLAY (CH): Very stiff, high plasticity, grey orange brown, medium grained sand, w ~ pl.
						2.40		CH	Sandy CLAY (CH): Hard, high plasticity, pale grey pale yellow brown, fine grained sand, w ~ pl.
						2.90			SANDSTONE (HW): Highly weathered, low strength, fine grained, pale orange brown red orange, distinct dry.
						3.50			SANDSTONE (MW): Moderately weathered, medium strength, fine grained, orange red pale orange brown, distinct dry.
						3.80			SANDSTONE (SW): Slightly weathered, high strength, medium grained, orange red pale orange brown, distinct dry.
									Hole Terminated at 3.80 m
						4			
						5			
						6			
						7			
Method AS - Auger RR - Rock Roller WB - Washbore							Water  Level (Date)  Inflow		Samples and Tests U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample
Support C - Casing							Classification Symbols and Soil Descriptions Based on Unified Soil Classification System		Remarks 1. Groundwater not encountered. 2. Test pit refusal at 3.80m.

Project No.: PG-7818

Client: Celestino Developments Pty Ltd
Project Name: Proposed Residential Subdivision
Hole Location: Riverside Development, Jimboomba
Hole Position:

Commenced: 20/10/2022
Logged By: JT
Checked By:

Drill Model and Mounting: 35 tonne
Hole Diameter: 0.3 mm

RL Surface: No survey
Datum: AHD Operator: LB

Drilling Information							Soil Description			
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional	
E			U50 0.40-0.55 m			0.10		SM	NATURAL Silty SAND (SM): Loose, medium grained, brown, with fine to medium sized gravel, wet.	
		0.35				SM	Silty SAND (SM): Loose, medium grained, grey brown, with medium to coarse sized gravel, wet.			
		0.55				CI	Silty CLAY (CI): Stiff, medium plasticity, red mottled medium grey, with fine grained sand, w ~ pl.			
		0.70				CI	Silty CLAY (CI): Very stiff, medium plasticity, red mottled medium grey, with fine grained sand, w ~ pl.			
		1.00				CL	Silty CLAY (CL): Hard, low plasticity, pale yellow brown, trace fine grained sand, w < pl.			
		1.30								
		2.00					SANDSTONE (HW): Highly weathered, very low to low strength, fine to medium grained, red pale yellow brown, distinct dry.			
		2.20					SANDSTONE (HW): Highly weathered, low strength, fine grained, pale grey-brown with red, distinct dry.			
		3.00					SILTSTONE (HW): Highly weathered, very low to low strength, fine grained, pale grey-brown, distinct dry.			
		5.60								
						6			Hole Terminated at 5.60 m	
						7				
<u>Method</u> AS - Auger RR - Rock Roller WB - Washbore <u>Support</u> C - Casing							<u>Water</u> Level (Date) Inflow <u>Samples and Tests</u> U - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test B - Bulk Sample <u>Classification Symbols and Soil Descriptions</u> Based on Unified Soil Classification System			<u>Remarks</u> 1. Groundwater not encountered.

Project No.: PG-7818

 Client: Celestino Developments Pty Ltd
 Project Name: Proposed Residential Subdivision
 Hole Location: Riverside Development, Jimboomba
 Hole Position:

 Commenced: 20/10/2022
 Logged By: JT
 Checked By:

 Drill Model and Mounting: 35 tonne
 Hole Diameter: 0.3 mm

 RL Surface: No survey
 Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E			U50 0.60-0.80 m			0.15		SM	NATURAL Silty SAND (SM): Loose, medium grained, brown, moist.
						0.50		SM	Silty SAND (SM): Very loose to loose, medium grained, pale grey-brown, wet.
						1		CH	Silty CLAY (CH): Stiff, high plasticity, pale grey mottled orange yellow, with fine grained sand, w ~ pl.
						1.30		CL-CI	Silty CLAY (CL-CI): Very stiff, low to medium plasticity, pale orange brown with yellow, with fine grained sand, w ~ pl.
						1.60		CL	Sandy CLAY (CL): Hard, low plasticity, pale orange brown with yellow, fine grained sand, w < pl.
						2.20			SANDSTONE (HW): Highly weathered, very low to low strength, medium grained, pale orange brown white red, distinct dry.
						3			Hole Terminated at 3.00 m
						4			
						5			
						6			
						7			

Method
 AS - Auger
 RR - Rock Roller
 WB - Washbore

Water
 Level (Date)
 Inflow

Samples and Tests
 U - Undisturbed Sample
 D - Disturbed Sample
 SPT - Standard Penetration Test
 B - Bulk Sample

Classification Symbols and Soil Descriptions
 Based on Unified Soil Classification System

Support
 C - Casing

Remarks
 1. Groundwater not encountered.

Project No.: PG-7818

 Client: Celestino Developments Pty Ltd
 Project Name: Proposed Residential Subdivision
 Hole Location: Riverside Development, Jimboomba
 Hole Position:

 Commenced: 20/10/2022
 Logged By: JT
 Checked By:

 Drill Model and Mounting: 35 tonne
 Hole Diameter: 0.3 mm

 RL Surface: No survey
 Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.15		SM	NATURAL Silty SAND (SM): Loose, fine to medium grained, brown, moist.
						0.30		SM	Silty SAND (SM): Loose, medium grained, pale grey brown, with medium to coarse sized gravel, moist.
						0.50		CI	Sandy CLAY (CI): Very stiff, medium plasticity, pale orange brown red, medium grained sand, w ~ pl.
								CI	Sandy CLAY (CI): Hard, medium plasticity, orange, medium grained sand, w ~ pl.
						1			
						1.30		CL	Silty CLAY (CL): Hard, low plasticity, pale orange brown, trace medium grained sand, w ~ pl.
						1.70			
						2			SANDSTONE (HW): Highly weathered, low strength, medium grained, pale grey-brown orange, distinct dry.
						3			
						3.20			SANDSTONE (HW): Highly weathered, low strength, fine grained, pale orange brown red, distinct dry.
						4			
						5			
						5.20			SANDSTONE (MW): Moderately weathered, medium to high strength, medium grained, pale yellow brown, distinct dry.
						5.50			
									Hole Terminated at 5.50 m
						6			
						7			

Method
 AS - Auger
 RR - Rock Roller
 WB - Washbore

Water
 Level (Date)
 Inflow

Samples and Tests
 U - Undisturbed Sample
 D - Disturbed Sample
 SPT - Standard Penetration Test
 B - Bulk Sample

Support
 C - Casing

Classification Symbols and Soil Descriptions
 Based on Unified Soil Classification System

Remarks
 1. Groundwater not encountered.
 2. Test pit refusal at 5.50m.

Project No.: PG-7818

 Client: Celestino Developments Pty Ltd
 Project Name: Proposed Residential Subdivision
 Hole Location: Riverside Development, Jimboomba
 Hole Position:

 Commenced: 20/10/2022
 Logged By: JT
 Checked By:

 Drill Model and Mounting: 35 tonne
 Hole Diameter: 0.3 mm

 RL Surface: No survey
 Datum: AHD Operator: LB

Drilling Information							Soil Description		
Method	Casing	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional
E						0.15		SM	NATURAL Silty SAND (SM): Loose, medium grained, brown, moist.
						0.30		SM	Silty SAND (SM): Loose, medium grained, grey brown, with medium to coarse sized gravel, wet.
						0.60		CI	Silty CLAY (CI): Firm, medium plasticity, pale yellow brown, trace fine grained sand, w ~ pl.
						0.90		CH	Silty CLAY (CH): Very stiff, high plasticity, red pale yellow brown, trace fine grained sand, w ~ pl.
						1.20		CI	Silty CLAY (CI): Very stiff to hard, medium plasticity, pale yellow brown mottled red, trace fine grained sand, w ~ pl.
						1.60		CL	Sandy CLAY (CL): Hard, low plasticity, pale yellow brown red with, fine to medium grained sand, w < pl.
						2.00			SANDSTONE (HW): Highly weathered, very low to low strength, medium grained, pale yellow brown with orange red, distinct dry.
						2.20			SANDSTONE (HW): Highly weathered, low strength, fine to medium grained, pale yellow brown, distinct dry.
						2.40			SANDSTONE (MW): Moderately weathered, medium strength, fine to medium grained, pale yellow brown, distinct dry.
						2.50			SANDSTONE (SW): Slightly weathered, high strength, fine grained, pale yellow brown pale grey-brown, distinct dry.
						3			Hole Terminated at 2.50 m
						4			
						5			
						6			
						7			

Method

 AS - Auger
 RR - Rock Roller
 WB - Washbore

Water
 Level (Date)
 Inflow

Samples and Tests

 U - Undisturbed Sample
 D - Disturbed Sample
 SPT - Standard Penetration Test
 B - Bulk Sample

Remarks

 1. Groundwater not encountered.
 2. Test pit refusal at 2.50m.

Support

C - Casing

Classification Symbols and Soil Descriptions

Based on Unified Soil Classification System

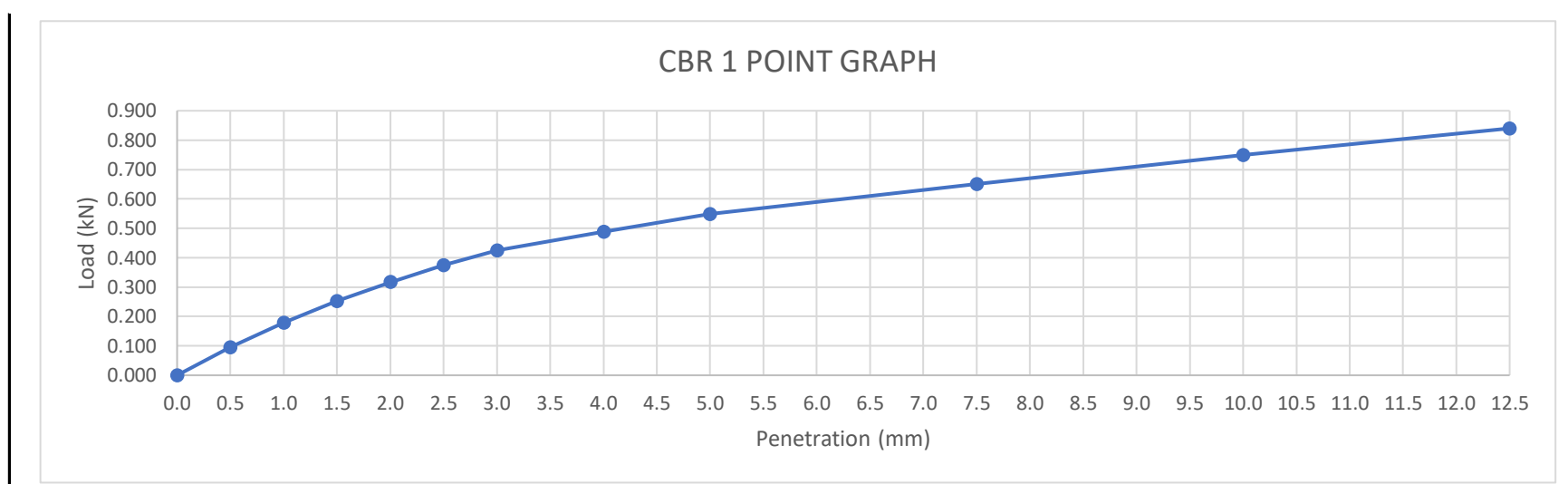
APPENDIX C

LABORATORY TEST CERTIFICATES

CALIFORNIA BEARING RATIO REPORT (1 POINT)			
CLIENT:	Celestino Developments	PROJECT NUMBER:	PG - 7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818 - CBR-01 (TP22)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	15/11/2022
PROJECT ADDRESS:	Riverside Development	TEST METHOD:	AS 1289.6.1.1

SAMPLE LOCATION:	TP 22 (2.3m - 3.5m)
SAMPLING METHOD:	AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	20/10/2022
DATE TESTED:	FALSE
PREPERATION METHOD:	AS 1289.1.1
MOISTURE CONTENT METHOD:	AS1289.2.1.1
MATERIAL TYPE:	Siltstone, brown

MAXIMUM DRY DENSITY (t/m ³):	1.64
OPTIMUM MOISTURE CONTENT (%):	20.5
COMPACTIVE EFFORT:	Standard
COMPACTION METHOD:	AS1289.5.1.1
LABORATORY DENSITY RATIO:	100.0
LABORATORY MOISTURE RATIO:	98.5
DRY DENSITY BEFORE SOAK (t/m ³):	1.65
DRY DENSITY AFTER SOAK (t/m ³):	1.65
FIELD MOISTURE CONTENT:	17.1
MOISTURE CONTENT AT COMPACTION BEFORE SOAK (%):	20.2
MOISTURE CONTENT OF TOP 30mm AFTER PENETRATION (%):	27.1
MOISTURE CONTENT REST OF SAMPLE AFTER PENETRATION (%):	22.8
SWELL (%):	2.0
CBR SURCHARGE (Kg):	4.5
SOAKING PERIOD (Days):	4
CURING TIME (Hours):	24
PERCENTAGE OVERSIZE MATERIAL RETAINED ON 19mm SIEVE (%):	0
METHOD OF ESTABLISHING PLASTICITY:	Visual/Tactile Assessment
CBR 2.5mm (%):	3.0
CBR 5mm (%):	3.0
CBR VALUE (%):	3.0



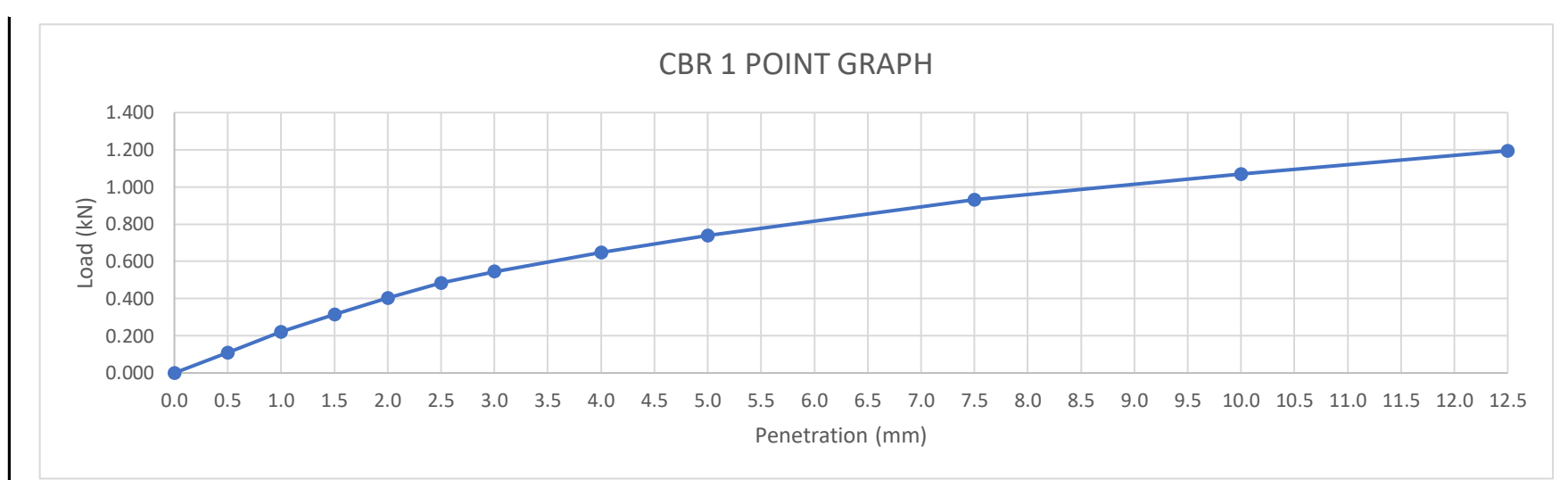
REMARKS / VARIATIONS:	
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CALIFORNIA BEARING RATIO REPORT (1 POINT)			
CLIENT:	Celestino Developments	PROJECT NUMBER:	PG - 7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818 - CBR-02 (TP37)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	15/11/2022
PROJECT ADDRESS:	Riverside Development	TEST METHOD:	AS 1289.6.1.1

SAMPLE LOCATION:	TP 37 (0.5m - 1.0m)
SAMPLING METHOD:	AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	20/10/2022
DATE TESTED:	FALSE
PREPERATION METHOD:	AS 1289.1.1
MOISTURE CONTENT METHOD:	AS1289.2.1.1
MATERIAL TYPE:	Sandy Clay, Orange Brown

MAXIMUM DRY DENSITY (t/m ³):	1.79
OPTIMUM MOISTURE CONTENT (%):	17.0
COMPACTIVE EFFORT:	Standard
COMPACTION METHOD:	AS1289.5.1.1
LABORATORY DENSITY RATIO:	101.0
LABORATORY MOISTURE RATIO:	101
DRY DENSITY BEFORE SOAK (t/m ³):	1.80
DRY DENSITY AFTER SOAK (t/m ³):	1.80
FIELD MOISTURE CONTENT:	13.0
MOISTURE CONTENT AT COMPACTION BEFORE SOAK (%):	17.2
MOISTURE CONTENT OF TOP 30mm AFTER PENETRATION (%):	19.2
MOISTURE CONTENT REST OF SAMPLE AFTER PENETRATION (%):	17.0
SWELL (%):	1.0
CBR SURCHARGE (Kg):	4.5
SOAKING PERIOD (Days):	4
CURING TIME (Hours):	70
PERCENTAGE OVERSIZE MATERIAL RETAINED ON 19mm SIEVE (%):	-
METHOD OF ESTABLISHING PLASTICITY:	Visual/Tactile Assessment
CBR 2.5mm (%):	3.5
CBR 5mm (%):	3.5
CBR VALUE (%):	3.5



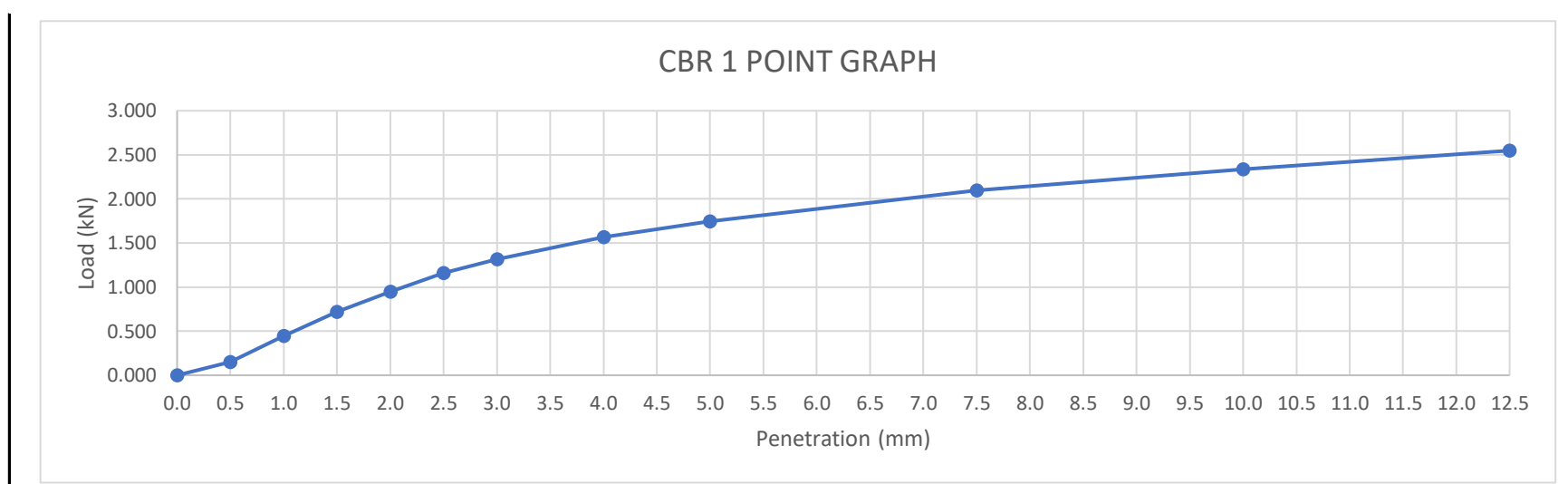
REMARKS / VARIATIONS:	
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CALIFORNIA BEARING RATIO REPORT (1 POINT)			
CLIENT:	Celestino Developments	PROJECT NUMBER:	PG - 7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818 - CBR-03 (TP45)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	15/11/2022
PROJECT ADDRESS:	Riverside Development	TEST METHOD:	AS 1289.6.1.1

SAMPLE LOCATION:	TP 45 (4.1m - 5.1m)
SAMPLING METHOD:	AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	20/10/2022
DATE TESTED:	FALSE
PREPERATION METHOD:	AS 1289.1.1
MOISTURE CONTENT METHOD:	AS1289.2.1.1
MATERIAL TYPE:	Sandy Clay, Beige

MAXIMUM DRY DENSITY (t/m ³):	1.62
OPTIMUM MOISTURE CONTENT (%):	20.3
COMPACTIVE EFFORT:	Standard
COMPACTION METHOD:	AS1289.5.1.1
LABORATORY DENSITY RATIO:	100.0
LABORATORY MOISTURE RATIO:	101
DRY DENSITY BEFORE SOAK (t/m ³):	1.62
DRY DENSITY AFTER SOAK (t/m ³):	1.62
FIELD MOISTURE CONTENT:	17.9
MOISTURE CONTENT AT COMPACTION BEFORE SOAK (%):	20.5
MOISTURE CONTENT OF TOP 30mm AFTER PENETRATION (%):	25.6
MOISTURE CONTENT REST OF SAMPLE AFTER PENETRATION (%):	21.9
SWELL (%):	1.0
CBR SURCHARGE (Kg):	4.5
SOAKING PERIOD (Days):	4
CURING TIME (Hours):	71
PERCENTAGE OVERSIZE MATERIAL RETAINED ON 19mm SIEVE (%):	0
METHOD OF ESTABLISHING PLASTICITY:	Visual/Tactile Assessment
CBR 2.5mm (%):	9.0
CBR 5mm (%):	9.0
CBR VALUE (%):	9.0



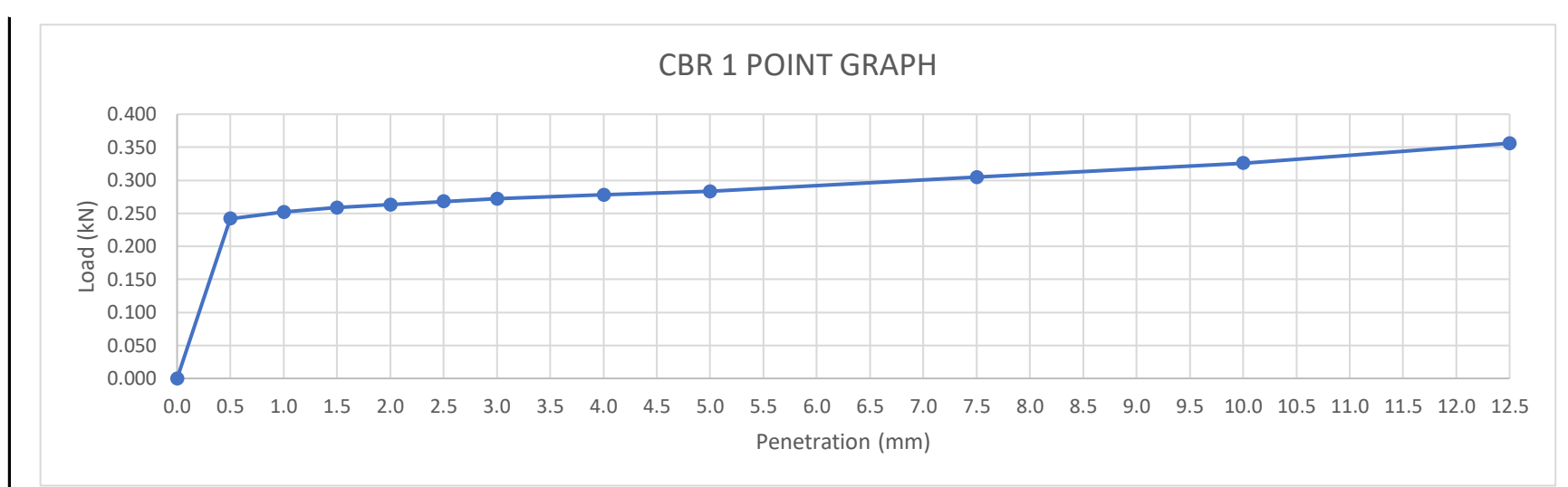
REMARKS / VARIATIONS:	
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CALIFORNIA BEARING RATIO REPORT (1 POINT)			
CLIENT:	Celestino Developments	PROJECT NUMBER:	PG - 7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818 - CBR-04 (TP07)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	15/11/2022
PROJECT ADDRESS:	Riverside Development	TEST METHOD:	AS 1289.6.1.1

SAMPLE LOCATION:	TP 07 (0.3m - 6.0m)
SAMPLING METHOD:	AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	17/10/2022
DATE TESTED:	FALSE
PREPERATION METHOD:	AS 1289.1.1
MOISTURE CONTENT METHOD:	AS1289.2.1.1
MATERIAL TYPE:	Sandy Clay, Beige

MAXIMUM DRY DENSITY (t/m ³):	1.53
OPTIMUM MOISTURE CONTENT (%):	22.6
COMPACTIVE EFFORT:	Standard
COMPACTION METHOD:	AS1289.5.1.1
LABORATORY DENSITY RATIO:	100.0
LABORATORY MOISTURE RATIO:	99.5
DRY DENSITY BEFORE SOAK (t/m ³):	1.53
DRY DENSITY AFTER SOAK (t/m ³):	1.53
FIELD MOISTURE CONTENT:	18.0
MOISTURE CONTENT AT COMPACTION BEFORE SOAK (%):	22.5
MOISTURE CONTENT OF TOP 30mm AFTER PENETRATION (%):	38.3
MOISTURE CONTENT REST OF SAMPLE AFTER PENETRATION (%):	30.9
SWELL (%):	8.0
CBR SURCHARGE (Kg):	4.5
SOAKING PERIOD (Days):	4
CURING TIME (Hours):	48
PERCENTAGE OVERSIZE MATERIAL RETAINED ON 19mm SIEVE (%):	0
METHOD OF ESTABLISHING PLASTICITY:	Visual/Tactile Assessment
CBR 2.5mm (%):	2.0
CBR 5mm (%):	1.5
CBR VALUE (%):	2.0



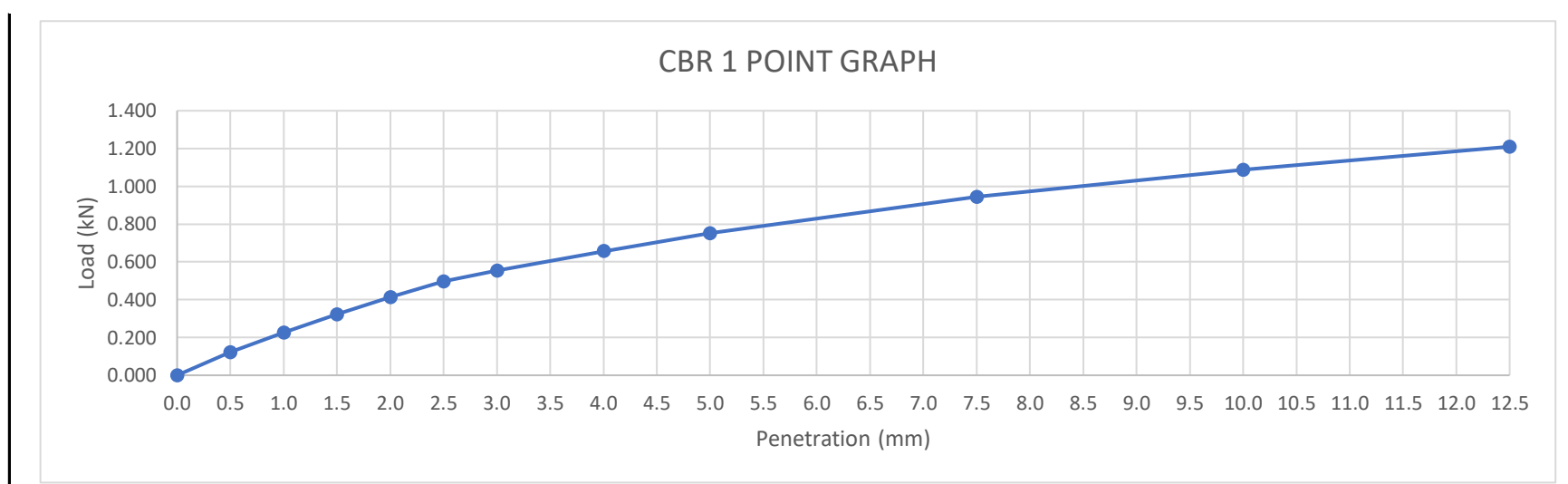
REMARKS / VARIATIONS:	
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CALIFORNIA BEARING RATIO REPORT (1 POINT)			
CLIENT:	Celestino Developments	PROJECT NUMBER:	PG - 7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818 - CBR-05 (TP11)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	15/11/2022
PROJECT ADDRESS:	Riverside Development	TEST METHOD:	AS 1289.6.1.1

SAMPLE LOCATION:	TP 11 (0.8m - 1.2m)
SAMPLING METHOD:	AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	17/10/2022
DATE TESTED:	FALSE
PREPERATION METHOD:	AS 1289.1.1
MOISTURE CONTENT METHOD:	AS1289.2.1.1
MATERIAL TYPE:	Sandy Clay, Brown

MAXIMUM DRY DENSITY (t/m ³):	1.79
OPTIMUM MOISTURE CONTENT (%):	15.5
COMPACTIVE EFFORT:	Standard
COMPACTION METHOD:	AS1289.5.1.1
LABORATORY DENSITY RATIO:	99.0
LABORATORY MOISTURE RATIO:	102
DRY DENSITY BEFORE SOAK (t/m ³):	1.78
DRY DENSITY AFTER SOAK (t/m ³):	1.78
FIELD MOISTURE CONTENT:	13.1
MOISTURE CONTENT AT COMPACTION BEFORE SOAK (%):	15.8
MOISTURE CONTENT OF TOP 30mm AFTER PENETRATION (%):	20.0
MOISTURE CONTENT REST OF SAMPLE AFTER PENETRATION (%):	17.1
SWELL (%):	1.0
CBR SURCHARGE (Kg):	4.5
SOAKING PERIOD (Days):	4
CURING TIME (Hours):	48
PERCENTAGE OVERSIZE MATERIAL RETAINED ON 19mm SIEVE (%):	0
METHOD OF ESTABLISHING PLASTICITY:	Visual/Tactile Assessment
CBR 2.5mm (%):	4.0
CBR 5mm (%):	4.0
CBR VALUE (%):	4.0



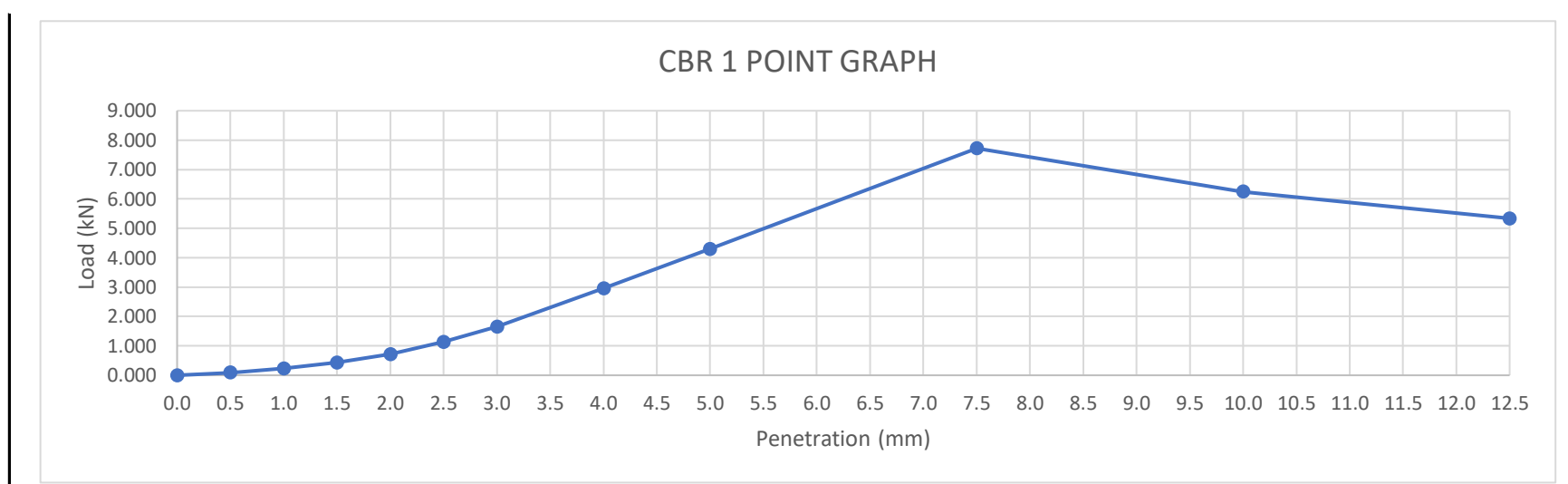
REMARKS / VARIATIONS:	
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CALIFORNIA BEARING RATIO REPORT (1 POINT)			
CLIENT:	Celestino Developments	PROJECT NUMBER:	PG - 7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818 - CBR-06 (TP14) - (0.3m-0.5m)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	15/11/2022
PROJECT ADDRESS:	Riverside Development	TEST METHOD:	AS 1289.6.1.1

SAMPLE LOCATION:	TP 14 (0.3m - 0.5m)
SAMPLING METHOD:	AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	17/10/2022
DATE TESTED:	FALSE
PREPERATION METHOD:	AS 1289.1.1
MOISTURE CONTENT METHOD:	AS1289.2.1.1
MATERIAL TYPE:	Clayey Sand, Brown

MAXIMUM DRY DENSITY (t/m ³):	1.86
OPTIMUM MOISTURE CONTENT (%):	11.0
COMPACTIVE EFFORT:	Standard
COMPACTION METHOD:	AS1289.5.1.1
LABORATORY DENSITY RATIO:	99.0
LABORATORY MOISTURE RATIO:	102.5
DRY DENSITY BEFORE SOAK (t/m ³):	1.85
DRY DENSITY AFTER SOAK (t/m ³):	1.85
FIELD MOISTURE CONTENT:	8.0
MOISTURE CONTENT AT COMPACTION BEFORE SOAK (%):	11.3
MOISTURE CONTENT OF TOP 30mm AFTER PENETRATION (%):	13.2
MOISTURE CONTENT REST OF SAMPLE AFTER PENETRATION (%):	12.3
SWELL (%):	0.0
CBR SURCHARGE (Kg):	4.5
SOAKING PERIOD (Days):	4
CURING TIME (Hours):	48
PERCENTAGE OVERSIZE MATERIAL RETAINED ON 19mm SIEVE (%):	0
METHOD OF ESTABLISHING PLASTICITY:	Visual/Tactile Assessment
CBR 2.5mm (%):	25.0
CBR 5mm (%):	35.0
CBR VALUE (%):	35.0



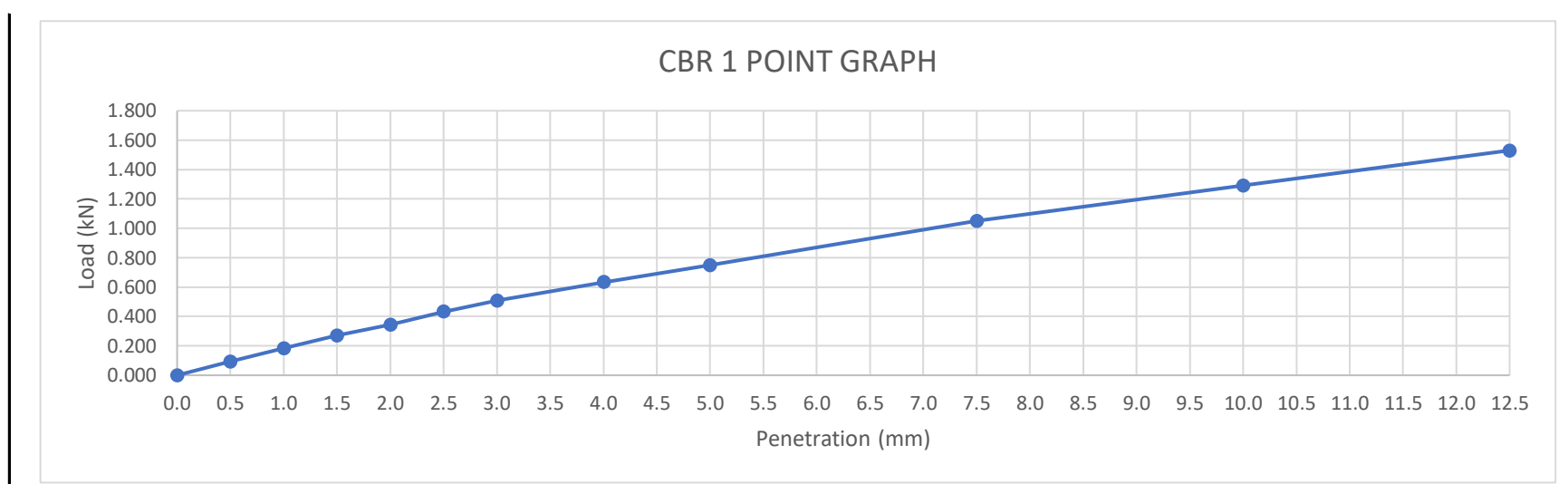
REMARKS / VARIATIONS:	
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CALIFORNIA BEARING RATIO REPORT (1 POINT)			
CLIENT:	Celestino Developments	PROJECT NUMBER:	PG - 7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818 - CBR-07 (TP14) - (0.8m-1.2m)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	15/11/2022
PROJECT ADDRESS:	Riverside Development	TEST METHOD:	AS 1289.6.1.1

SAMPLE LOCATION:	TP 14 (0.8m - 1.2m)
SAMPLING METHOD:	AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	17/10/2022
DATE TESTED:	FALSE
PREPERATION METHOD:	AS 1289.1.1
MOISTURE CONTENT METHOD:	AS1289.2.1.1
MATERIAL TYPE:	Sandy clay, Brown

MAXIMUM DRY DENSITY (t/m ³):	1.86
OPTIMUM MOISTURE CONTENT (%):	14.4
COMPACTIVE EFFORT:	Standard
COMPACTION METHOD:	AS1289.5.1.1
LABORATORY DENSITY RATIO:	100.0
LABORATORY MOISTURE RATIO:	100
DRY DENSITY BEFORE SOAK (t/m ³):	1.86
DRY DENSITY AFTER SOAK (t/m ³):	1.86
FIELD MOISTURE CONTENT:	12.2
MOISTURE CONTENT AT COMPACTION BEFORE SOAK (%):	14.4
MOISTURE CONTENT OF TOP 30mm AFTER PENETRATION (%):	16.5
MOISTURE CONTENT REST OF SAMPLE AFTER PENETRATION (%):	15.7
SWELL (%):	0.0
CBR SURCHARGE (Kg):	4.5
SOAKING PERIOD (Days):	4
CURING TIME (Hours):	48
PERCENTAGE OVERSIZE MATERIAL RETAINED ON 19mm SIEVE (%):	0
METHOD OF ESTABLISHING PLASTICITY:	Visual/Tactile Assessment
CBR 2.5mm (%):	3.5
CBR 5mm (%):	4.0
CBR VALUE (%):	4.0



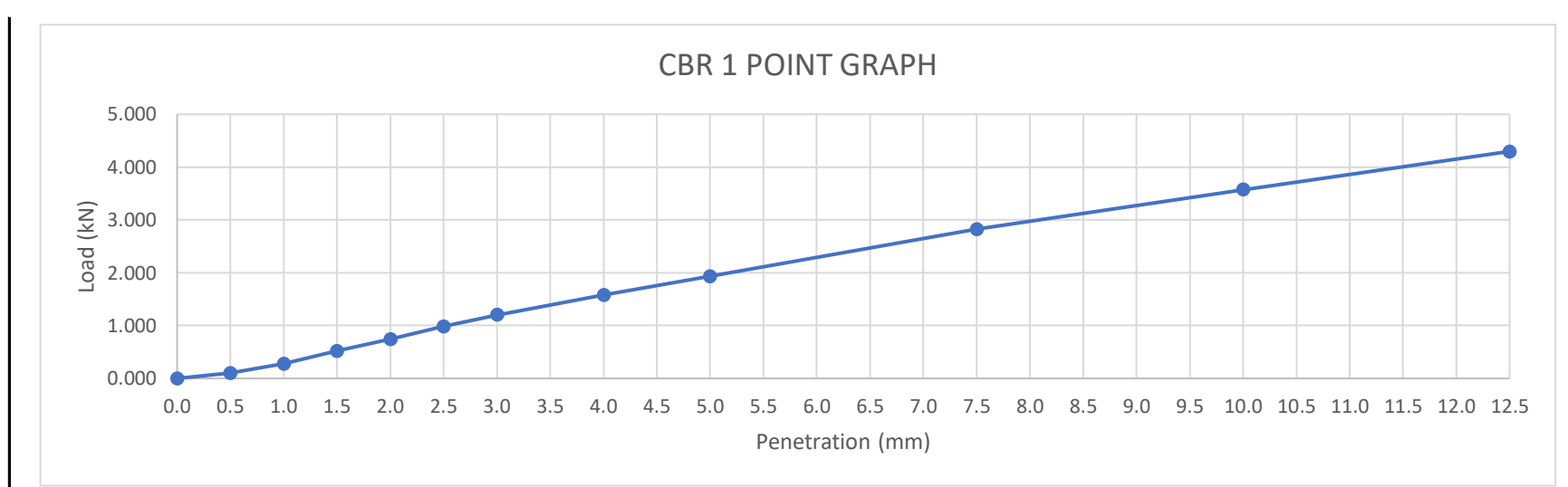
REMARKS / VARIATIONS:	
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CALIFORNIA BEARING RATIO REPORT (1 POINT)			
CLIENT:	Celestino Developments	PROJECT NUMBER:	PG - 7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818 - CBR-08 (TP21)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	15/11/2022
PROJECT ADDRESS:	Riverside Development	TEST METHOD:	AS 1289.6.1.1

SAMPLE LOCATION:	TP 21 (1.5m - 2.0m)
SAMPLING METHOD:	AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	17/10/2022
DATE TESTED:	FALSE
PREPERATION METHOD:	AS 1289.1.1
MOISTURE CONTENT METHOD:	AS1289.2.1.1
MATERIAL TYPE:	Clayey, Sanstone

MAXIMUM DRY DENSITY (t/m ³):	1.79
OPTIMUM MOISTURE CONTENT (%):	15.0
COMPACTIVE EFFORT:	Standard
COMPACTION METHOD:	AS1289.5.1.1
LABORATORY DENSITY RATIO:	100.0
LABORATORY MOISTURE RATIO:	99.5
DRY DENSITY BEFORE SOAK (t/m ³):	1.79
DRY DENSITY AFTER SOAK (t/m ³):	1.79
FIELD MOISTURE CONTENT:	10.2
MOISTURE CONTENT AT COMPACTION BEFORE SOAK (%):	14.9
MOISTURE CONTENT OF TOP 30mm AFTER PENETRATION (%):	16.8
MOISTURE CONTENT REST OF SAMPLE AFTER PENETRATION (%):	17.4
SWELL (%):	0.0
CBR SURCHARGE (Kg):	4.5
SOAKING PERIOD (Days):	4
CURING TIME (Hours):	72
PERCENTAGE OVERSIZE MATERIAL RETAINED ON 19mm SIEVE (%):	0
METHOD OF ESTABLISHING PLASTICITY:	Visual/Tactile Assessment
CBR 2.5mm (%):	9.0
CBR 5mm (%):	11.0
CBR VALUE (%):	11.0



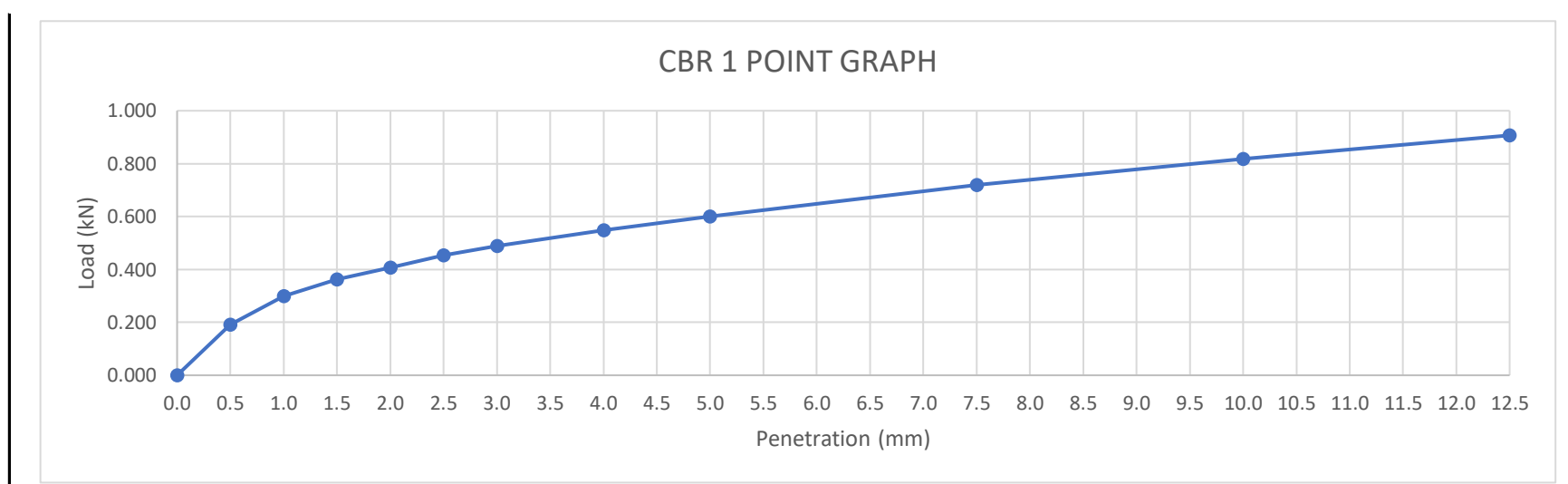
REMARKS / VARIATIONS:	
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CALIFORNIA BEARING RATIO REPORT (1 POINT)			
CLIENT:	Celestino Developments	PROJECT NUMBER:	PG - 7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818 - CBR-09 (TP12)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	15/11/2022
PROJECT ADDRESS:	Riverside Development	TEST METHOD:	AS 1289.6.1.1

SAMPLE LOCATION:	TP 12 (0.3m - 0.6m)
SAMPLING METHOD:	AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	20/10/2022
DATE TESTED:	FALSE
PREPERATION METHOD:	AS 1289.1.1
MOISTURE CONTENT METHOD:	AS1289.2.1.1
MATERIAL TYPE:	Sandy Clay, brown

MAXIMUM DRY DENSITY (t/m ³):	1.58
OPTIMUM MOISTURE CONTENT (%):	25.6
COMPACTIVE EFFORT:	Standard
COMPACTION METHOD:	AS1289.5.1.1
LABORATORY DENSITY RATIO:	99.0
LABORATORY MOISTURE RATIO:	98.5
DRY DENSITY BEFORE SOAK (t/m ³):	1.56
DRY DENSITY AFTER SOAK (t/m ³):	1.56
FIELD MOISTURE CONTENT:	25.8
MOISTURE CONTENT AT COMPACTION BEFORE SOAK (%):	25.2
MOISTURE CONTENT OF TOP 30mm AFTER PENETRATION (%):	32.1
MOISTURE CONTENT REST OF SAMPLE AFTER PENETRATION (%):	25.8
SWELL (%):	2.0
CBR SURCHARGE (Kg):	4.5
SOAKING PERIOD (Days):	4
CURING TIME (Hours):	48
PERCENTAGE OVERSIZE MATERIAL RETAINED ON 19mm SIEVE (%):	0
METHOD OF ESTABLISHING PLASTICITY:	Visual/Tactile Assessment
CBR 2.5mm (%):	3.5
CBR 5mm (%):	3.0
CBR VALUE (%):	3.5



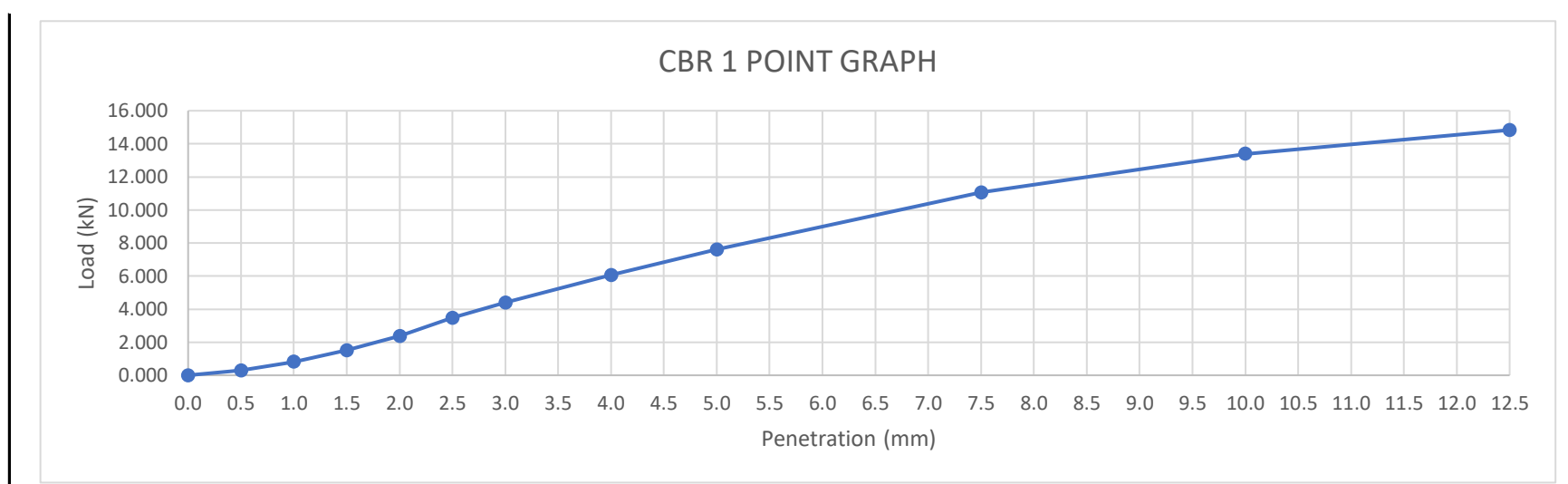
REMARKS / VARIATIONS:	
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CALIFORNIA BEARING RATIO REPORT (1 POINT)			
CLIENT:	Celestino Developments	PROJECT NUMBER:	PG - 7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818 - CBR-10 (TP44)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	15/11/2022
PROJECT ADDRESS:	Riverside Development	TEST METHOD:	AS 1289.6.1.1

SAMPLE LOCATION:	TP 44 (0.4m - 0.6m)
SAMPLING METHOD:	AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	20/10/2022
DATE TESTED:	FALSE
PREPERATION METHOD:	AS 1289.1.1
MOISTURE CONTENT METHOD:	AS1289.2.1.1
MATERIAL TYPE:	Clayey Gravelly Sand, brown

MAXIMUM DRY DENSITY (t/m ³):	2.05
OPTIMUM MOISTURE CONTENT (%):	9.5
COMPACTIVE EFFORT:	Standard
COMPACTION METHOD:	AS1289.5.1.1
LABORATORY DENSITY RATIO:	100.0
LABORATORY MOISTURE RATIO:	99.5
DRY DENSITY BEFORE SOAK (t/m ³):	2.05
DRY DENSITY AFTER SOAK (t/m ³):	2.05
FIELD MOISTURE CONTENT:	9.4
MOISTURE CONTENT AT COMPACTION BEFORE SOAK (%):	9.4
MOISTURE CONTENT OF TOP 30mm AFTER PENETRATION (%):	10.4
MOISTURE CONTENT REST OF SAMPLE AFTER PENETRATION (%):	9.3
SWELL (%):	0.0
CBR SURCHARGE (Kg):	4.5
SOAKING PERIOD (Days):	4
CURING TIME (Hours):	48
PERCENTAGE OVERSIZE MATERIAL RETAINED ON 19mm SIEVE (%):	0
METHOD OF ESTABLISHING PLASTICITY:	Visual/Tactile Assessment
CBR 2.5mm (%):	40.0
CBR 5mm (%):	45.0
CBR VALUE (%):	45.0



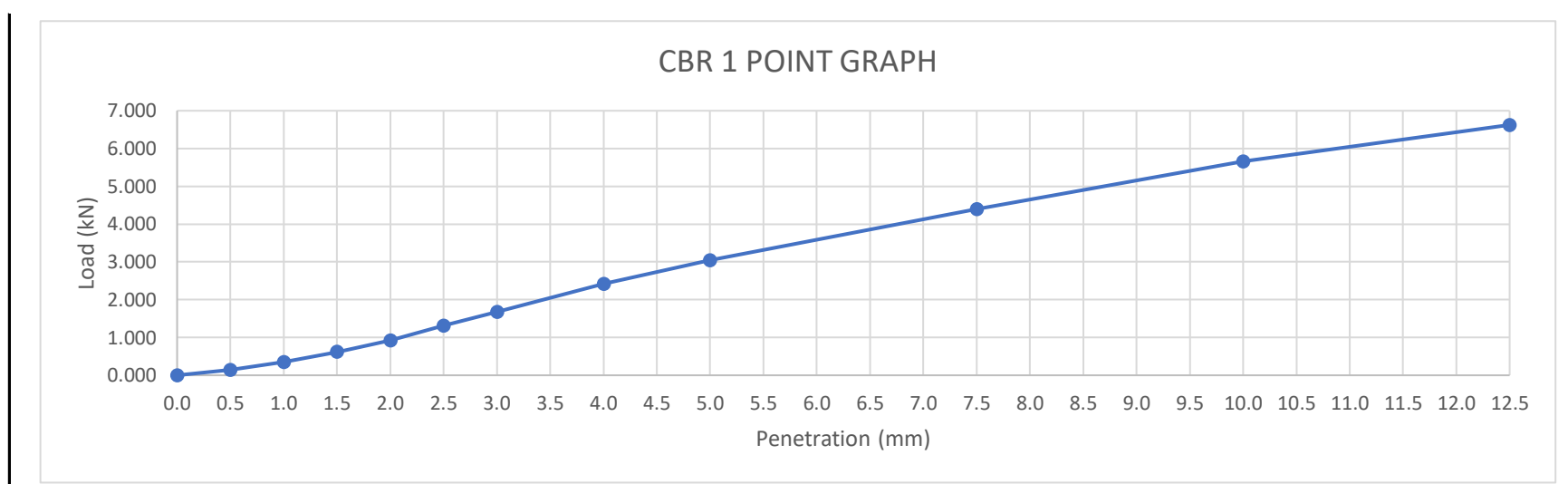
REMARKS / VARIATIONS:	
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CALIFORNIA BEARING RATIO REPORT (1 POINT)			
CLIENT:	Celestino Developments	PROJECT NUMBER:	PG - 7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818 - CBR-11 (TP27)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	15/11/2022
PROJECT ADDRESS:	Riverside Development	TEST METHOD:	AS 1289.6.1.1

SAMPLE LOCATION:	TP 27 (0.15m - 0.3m)
SAMPLING METHOD:	AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	20/10/2022
DATE TESTED:	FALSE
PREPERATION METHOD:	AS 1289.1.1
MOISTURE CONTENT METHOD:	AS1289.2.1.1
MATERIAL TYPE:	Clayey Sand Grey

MAXIMUM DRY DENSITY (t/m ³):	2.07
OPTIMUM MOISTURE CONTENT (%):	7.1
COMPACTIVE EFFORT:	Standard
COMPACTION METHOD:	AS1289.5.1.1
LABORATORY DENSITY RATIO:	100.0
LABORATORY MOISTURE RATIO:	100.5
DRY DENSITY BEFORE SOAK (t/m ³):	2.07
DRY DENSITY AFTER SOAK (t/m ³):	2.07
FIELD MOISTURE CONTENT:	2.2
MOISTURE CONTENT AT COMPACTION BEFORE SOAK (%):	7.1
MOISTURE CONTENT OF TOP 30mm AFTER PENETRATION (%):	8.0
MOISTURE CONTENT REST OF SAMPLE AFTER PENETRATION (%):	7.6
SWELL (%):	0.0
CBR SURCHARGE (Kg):	4.5
SOAKING PERIOD (Days):	4
CURING TIME (Hours):	48
PERCENTAGE OVERSIZE MATERIAL RETAINED ON 19mm SIEVE (%):	0
METHOD OF ESTABLISHING PLASTICITY:	Visual/Tactile Assessment
CBR 2.5mm (%):	14.0
CBR 5mm (%):	18.0
CBR VALUE (%):	18.0



REMARKS / VARIATIONS:	
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ATTERBERG LIMITS INDEX REPORT			
CLIENT:	Celestino Developments	PROJECT NUMBER:	PG-7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818-ATT-01 (TP07)
PROJECT:	Broadscale Geotech Investigation	REPORT DATE:	14/11/2022
PROJECT ADDRESS:	Riverside Development	TEST METHOD:	AS 1289.3.1.2, 3.2.1, 3.3.1, 3.4.1 & 2.1.1

SAMPLE LOCATION:	TP07 @ 0.3m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	18/10/2022
DATE TESTED:	9/11/2022
SAMPLE HISTORY:	Oven Dried
PREPERATION METHOD:	Dry Sieved
MATERIAL TYPE:	Silty CLAY

LIQUID LIMIT (%):	57
PLASTIC LIMIT (%):	20
PLASTICITY INDEX (%):	38
LINEAR SHRINKAGE (%):	20.5
MOULD LENGTH (mm):	126
CRACKING:	no
CRUMBLING OR CURLING:	no

REMARKS:

ER 002



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www.pacgeo.com.au
 ABN: 62 615 248 952



ATTERBERG LIMITS INDEX REPORT			
CLIENT:	Celestino Developments	PROJECT NUMBER:	PG-7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818-ATT-02 (TP09)
PROJECT:	Broadscale Geotech Investigation	REPORT DATE:	14/11/2022
PROJECT ADDRESS:	Riverside Development	TEST METHOD:	AS 1289.3.1.2, 3.2.1, 3.3.1, 3.4.1 & 2.1.1

SAMPLE LOCATION:	TP09 @ 0.4m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	17/10/2022
DATE TESTED:	9/11/2022
SAMPLE HISTORY:	Oven Dried
PREPERATION METHOD:	Dry Sieved
MATERIAL TYPE:	Sandy CLAY

LIQUID LIMIT (%):	35
PLASTIC LIMIT (%):	15
PLASTICITY INDEX (%):	20
LINEAR SHRINKAGE (%):	13.5
MOULD LENGTH (mm):	126
CRACKING:	no
CRUMBLING OR CURLING:	no

REMARKS:

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ATTERBERG LIMITS INDEX REPORT			
CLIENT:	Celestino Developments	PROJECT NUMBER:	PG-7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818-ATT-03 (TP12)
PROJECT:	Broadscale Geotech Investigation	REPORT DATE:	14/11/2022
PROJECT ADDRESS:	Riverside Development	TEST METHOD:	AS 1289.3.1.2, 3.2.1, 3.3.1, 3.4.1 & 2.1.1

SAMPLE LOCATION:	TP12 @ 0.3m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	18/10/2022
DATE TESTED:	10/11/2022
SAMPLE HISTORY:	Oven Dried
PREPERATION METHOD:	Dry Sieved
MATERIAL TYPE:	Silty CLAY

LIQUID LIMIT (%):	41
PLASTIC LIMIT (%):	19
PLASTICITY INDEX (%):	21
LINEAR SHRINKAGE (%):	14.0
MOULD LENGTH (mm):	127
CRACKING:	no
CRUMBLING OR CURLING:	no

REMARKS:

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ATTERBERG LIMITS INDEX REPORT			
CLIENT:	Celestino Developments	PROJECT NUMBER:	PG-7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818-ATT-04 (TP22)
PROJECT:	Broadscale Geotech Investigation	REPORT DATE:	14/11/2022
PROJECT ADDRESS:	Riverside Development	TEST METHOD:	AS 1289.3.1.2, 3.2.1, 3.3.1, 3.4.1 & 2.1.1

SAMPLE LOCATION:	TP22 @ 2.5-3.5m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	-
DATE TESTED:	10/11/2022
SAMPLE HISTORY:	Oven Dried
PREPERATION METHOD:	Dry Sieved
MATERIAL TYPE:	Silty CLAY

LIQUID LIMIT (%):	47
PLASTIC LIMIT (%):	23
PLASTICITY INDEX (%):	24
LINEAR SHRINKAGE (%):	15.5
MOULD LENGTH (mm):	125
CRACKING:	yes
CRUMBLING OR CURLING:	no

REMARKS:

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ATTERBERG LIMITS INDEX REPORT			
CLIENT:	Celestino Developments	PROJECT NUMBER:	PG-7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818-ATT-05 (TP44)
PROJECT:	Broadscale Geotech Investigation	REPORT DATE:	14/11/2022
PROJECT ADDRESS:	Riverside Development	TEST METHOD:	AS 1289.3.1.2, 3.2.1, 3.3.1, 3.4.1 & 2.1.1

SAMPLE LOCATION:	TP44 @ 0.4-0.6m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	-
DATE TESTED:	11/11/2022
SAMPLE HISTORY:	Oven Dried
PREPERATION METHOD:	Dry Sieved
MATERIAL TYPE:	Clayey Gravelly SAND

LIQUID LIMIT (%):	14
PLASTIC LIMIT (%):	11
PLASTICITY INDEX (%):	2
LINEAR SHRINKAGE (%):	1.5
MOULD LENGTH (mm):	126
CRACKING:	no
CRUMBLING OR CURLING:	no

REMARKS:

ER 002



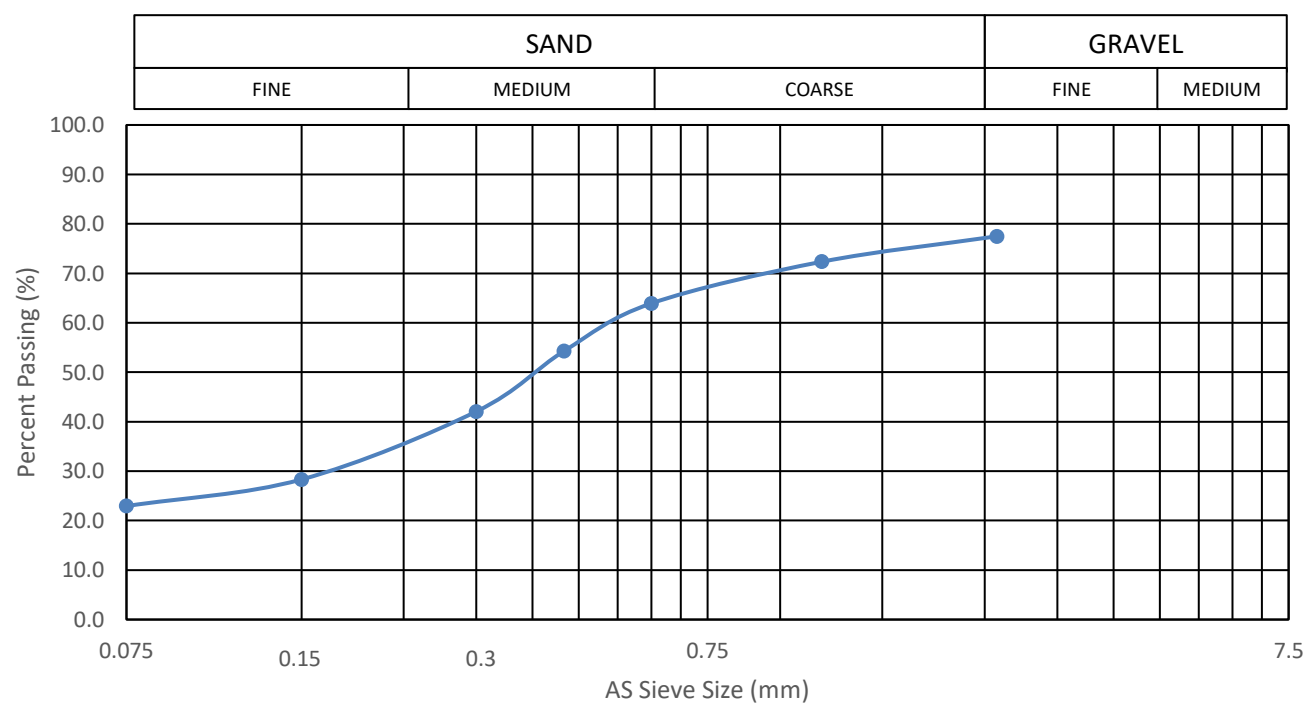
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Particle Size Distribution Report			
Client:	Celestino Developments	Project Number:	PG-7818
Client Address:	-	Report Number:	PG-7818-PSD-01 (TP44)
Project Address:	Riverside Development	Report Date:	23/08/2022
Project Name:	Broadscale Geotech Investigation	Test Method:	Test Method AS1289.3.6.1

SAMPLE LOCATION:	TP44 @ 0.4-0.6m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	20/10/2022
DATE TESTED:	11/11/2022
MATERIAL TYPE:	(SC) Clayey Gravelly SAND

AS Sieve Size (mm):	Percent Passing (%):
2.36	77
1.18	72
0.600	64
0.425	54
0.300	42
0.150	28
0.075	23



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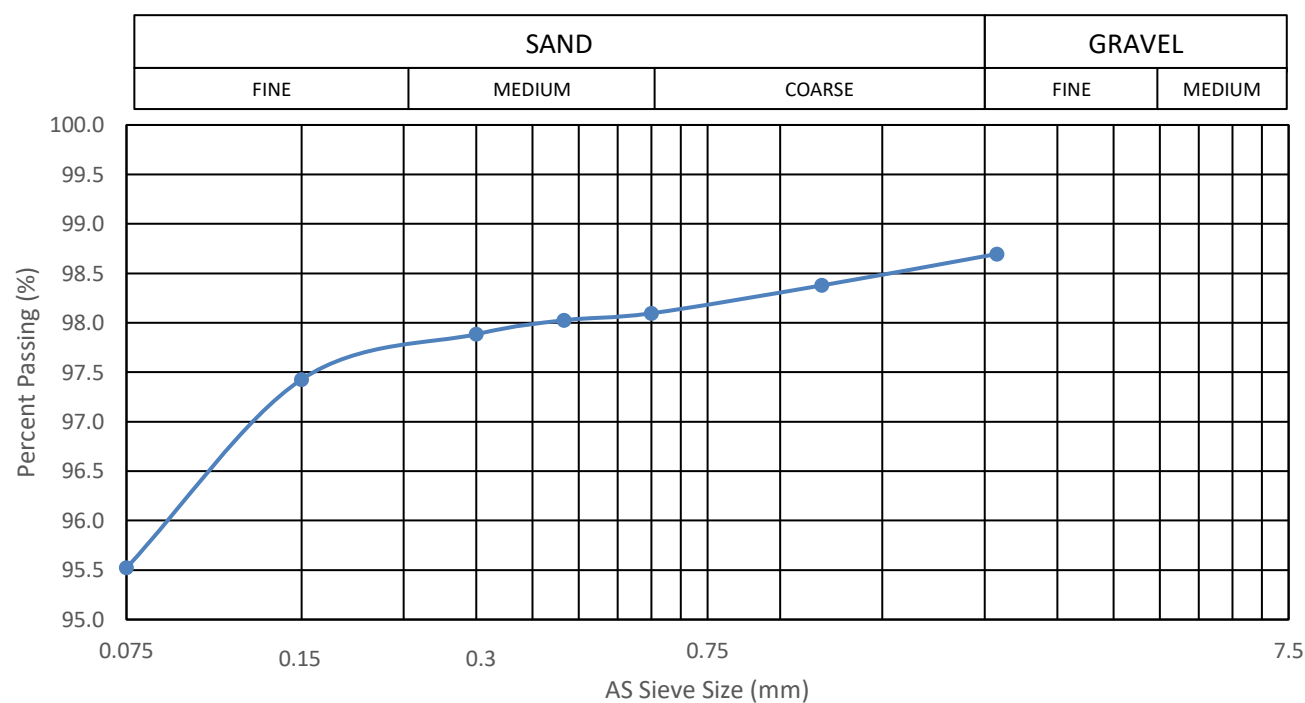
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Particle Size Distribution Report			
Client:	Celestino Developments	Project Number:	PG-7818
Client Address:	-	Report Number:	PG-7818-PSD-02 (TP22)
Project Address:	Riverside Development	Report Date:	23/08/2022
Project Name:	Broadscale Geotech Investigation	Test Method:	Test Method AS1289.3.6.1

SAMPLE LOCATION:	TP22 @ 2.5-3.5m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	-
DATE TESTED:	11/11/2022
MATERIAL TYPE:	(CH) Silty CLAY

AS Sieve Size (mm):	Percent Passing (%):
2.36	99
1.18	98
0.600	98
0.425	98
0.300	98
0.150	97
0.075	96



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SHRINK SWELL INDEX REPORT

CLIENT:	Celestino Developments	PROJECT NUMBER:	PG-7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818-SS-01 (TP01)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	27/10/2022
PROJECT LOCATION:	Riverside Development	TEST METHOD:	AS 1289.7.1.1 & 2.1.1

SAMPLE LOCATION:	TP01 @ 0.4m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	17/10/2022
DATE TESTED:	24/10/2022
MATERIAL TYPE:	Silty CLAY

SHRINKAGE MOISTURE CONTENT (%):	14.8
SHRINKAGE (%):	2.0
SWELL MOISTURE CONTENT INITIAL (%):	15.4
SWELL MOISTURE CONTENT FINAL (%):	20.9
SWELL (%):	0.2
UNIT WEIGHT (t/m ³):	1.93
SHRINK SWELL INDEX I_{ss} (%):	1.2
CRACKING:	slight
CRUMBLING:	no
ESTIMATED PERCENTAGE OF INERT INCLUSIONS (%):	0

REMARKS:

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SHRINK SWELL INDEX REPORT

CLIENT:	Celestino Developments	PROJECT NUMBER:	PG-7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818-SS-02 (TP03)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	27/10/2022
PROJECT LOCATION:	Riverside Development	TEST METHOD:	AS 1289.7.1.1 & 2.1.1

SAMPLE LOCATION:	TP03 @ 0.6m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	17/10/2022
DATE TESTED:	24/10/2022
MATERIAL TYPE:	Silty CLAY

SHRINKAGE MOISTURE CONTENT (%):	12.1
SHRINKAGE (%):	2.4
SWELL MOISTURE CONTENT INITIAL (%):	12.8
SWELL MOISTURE CONTENT FINAL (%):	20.9
SWELL (%):	1.7
UNIT WEIGHT (t/m ³):	2.12
SHRINK SWELL INDEX I_{ss} (%):	1.8
CRACKING:	slight
CRUMBLING:	no
ESTIMATED PERCENTAGE OF INERT INCLUSIONS (%):	0

REMARKS:

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SHRINK SWELL INDEX REPORT

CLIENT:	Celestino Developments	PROJECT NUMBER:	PG-7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818-SS-03 (TP05)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	27/10/2022
PROJECT LOCATION:	Riverside Development	TEST METHOD:	AS 1289.7.1.1 & 2.1.1

SAMPLE LOCATION:	TP05 @ 0.3m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	24/10/2022
DATE TESTED:	24/10/2022
MATERIAL TYPE:	Silty CLAY

SHRINKAGE MOISTURE CONTENT (%):	16.2
SHRINKAGE (%):	2.2
SWELL MOISTURE CONTENT INITIAL (%):	18.6
SWELL MOISTURE CONTENT FINAL (%):	25.9
SWELL (%):	2.0
UNIT WEIGHT (t/m ³):	2.03
SHRINK SWELL INDEX I_{ss} (%):	1.8
CRACKING:	no
CRUMBLING:	no
ESTIMATED PERCENTAGE OF INERT INCLUSIONS (%):	0

REMARKS:

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SHRINK SWELL INDEX REPORT

CLIENT:	Celestino Developments	PROJECT NUMBER:	PG-7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818-SS-04 (TP07)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	
PROJECT LOCATION:	Riverside Development	TEST METHOD:	AS 1289.7.1.1 & 2.1.1

SAMPLE LOCATION:	TP07 @ 0.4m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	17/10/2022
DATE TESTED:	24/10/2022
MATERIAL TYPE:	Silty CLAY

SHRINKAGE MOISTURE CONTENT (%):	19.9
SHRINKAGE (%):	7.0
SWELL MOISTURE CONTENT INITIAL (%):	22.8
SWELL MOISTURE CONTENT FINAL (%):	-296.5
SWELL (%):	1.1
UNIT WEIGHT (t/m ³):	1.77
SHRINK SWELL INDEX I_{ss} (%):	4.2
CRACKING:	no
CRUMBLING:	no
ESTIMATED PERCENTAGE OF INERT INCLUSIONS (%):	0

REMARKS:

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SHRINK SWELL INDEX REPORT

CLIENT:	Celestino Developments	PROJECT NUMBER:	PG-7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818-SS-05 (TP09)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	28/10/2022
PROJECT LOCATION:	Riverside Development	TEST METHOD:	AS 1289.7.1.1 & 2.1.1

SAMPLE LOCATION:	TP09 @ 0.4m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	17/10/2022
DATE TESTED:	26/10/2022
MATERIAL TYPE:	Silty CLAY

SHRINKAGE MOISTURE CONTENT (%):	14.8
SHRINKAGE (%):	4.0
SWELL MOISTURE CONTENT INITIAL (%):	16.4
SWELL MOISTURE CONTENT FINAL (%):	20.9
SWELL (%):	1.8
UNIT WEIGHT (t/m ³):	2.17
SHRINK SWELL INDEX I_{ss} (%):	2.7
CRACKING:	no
CRUMBLING:	no
ESTIMATED PERCENTAGE OF INERT INCLUSIONS (%):	0

REMARKS:

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SHRINK SWELL INDEX REPORT

CLIENT:	Celestino Developments	PROJECT NUMBER:	PG-7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818-SS-06 (TP11)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	28/10/2022
PROJECT LOCATION:	Riverside Development	TEST METHOD:	AS 1289.7.1.1 & 2.1.1

SAMPLE LOCATION:	TP11 @ 0.4m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	17/10/2022
DATE TESTED:	26/10/2022
MATERIAL TYPE:	Silty CLAY

SHRINKAGE MOISTURE CONTENT (%):	14.3
SHRINKAGE (%):	4.3
SWELL MOISTURE CONTENT INITIAL (%):	14.8
SWELL MOISTURE CONTENT FINAL (%):	24.5
SWELL (%):	2.9
UNIT WEIGHT (t/m ³):	2.06
SHRINK SWELL INDEX I_{ss} (%):	3.2
CRACKING:	no
CRUMBLING:	no
ESTIMATED PERCENTAGE OF INERT INCLUSIONS (%):	0

REMARKS:

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SHRINK SWELL INDEX REPORT

CLIENT:	Celestino Developments	PROJECT NUMBER:	PG-7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818-SS-07 (TP12)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	28/10/2022
PROJECT LOCATION:	Riverside Development	TEST METHOD:	AS 1289.7.1.1 & 2.1.1

SAMPLE LOCATION:	TP12 @ 0.3m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	17/10/2022
DATE TESTED:	26/10/2022
MATERIAL TYPE:	Silty CLAY

SHRINKAGE MOISTURE CONTENT (%):	17.2
SHRINKAGE (%):	4.9
SWELL MOISTURE CONTENT INITIAL (%):	18.7
SWELL MOISTURE CONTENT FINAL (%):	31.0
SWELL (%):	2.1
UNIT WEIGHT (t/m ³):	1.77
SHRINK SWELL INDEX I_{ss} (%):	3.3
CRACKING:	slight
CRUMBLING:	no
ESTIMATED PERCENTAGE OF INERT INCLUSIONS (%):	0

REMARKS:

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SHRINK SWELL INDEX REPORT

CLIENT:	Celestino Developments	PROJECT NUMBER:	PG-7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818-SS-08 (TP19)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	31/10/2022
PROJECT LOCATION:	Riverside Development	TEST METHOD:	AS 1289.7.1.1 & 2.1.1

SAMPLE LOCATION:	TP19 @ 0.5m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	17/10/2022
DATE TESTED:	27/10/2022
MATERIAL TYPE:	Silty CLAY

SHRINKAGE MOISTURE CONTENT (%):	14.7
SHRINKAGE (%):	4.2
SWELL MOISTURE CONTENT INITIAL (%):	12.4
SWELL MOISTURE CONTENT FINAL (%):	26.4
SWELL (%):	1.8
UNIT WEIGHT (t/m ³):	1.84
SHRINK SWELL INDEX I_{ss} (%):	2.8
CRACKING:	slight
CRUMBLING:	no
ESTIMATED PERCENTAGE OF INERT INCLUSIONS (%):	0

REMARKS:

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SHRINK SWELL INDEX REPORT

CLIENT:	Celestino Developments	PROJECT NUMBER:	PG-7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818-SS-09 (TP35)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	31/10/2022
PROJECT LOCATION:	Riverside Development	TEST METHOD:	AS 1289.7.1.1 & 2.1.1

SAMPLE LOCATION:	TP35 @ 0.4m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	20/10/2022
DATE TESTED:	27/10/2022
MATERIAL TYPE:	Silty CLAY

SHRINKAGE MOISTURE CONTENT (%):	17.4
SHRINKAGE (%):	6.0
SWELL MOISTURE CONTENT INITIAL (%):	18.5
SWELL MOISTURE CONTENT FINAL (%):	27.0
SWELL (%):	1.3
UNIT WEIGHT (t/m ³):	2.03
SHRINK SWELL INDEX I_{ss} (%):	3.7
CRACKING:	slight
CRUMBLING:	no
ESTIMATED PERCENTAGE OF INERT INCLUSIONS (%):	0

REMARKS:

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SHRINK SWELL INDEX REPORT

CLIENT:	Celestino Developments	PROJECT NUMBER:	PG-7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818-SS-10 (TP45)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	31/10/2022
PROJECT LOCATION:	Riverside Development	TEST METHOD:	AS 1289.7.1.1 & 2.1.1

SAMPLE LOCATION:	TP45 @ 0.5m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	20/10/2022
DATE TESTED:	27/10/2022
MATERIAL TYPE:	Silty CLAY

SHRINKAGE MOISTURE CONTENT (%):	18.8
SHRINKAGE (%):	2.8
SWELL MOISTURE CONTENT INITIAL (%):	20.9
SWELL MOISTURE CONTENT FINAL (%):	27.3
SWELL (%):	0.7
UNIT WEIGHT (t/m ³):	2.01
SHRINK SWELL INDEX I_{ss} (%):	1.8
CRACKING:	no
CRUMBLING:	no
ESTIMATED PERCENTAGE OF INERT INCLUSIONS (%):	0

REMARKS:

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SHRINK SWELL INDEX REPORT

CLIENT:	Celestino Developments	PROJECT NUMBER:	PG-7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818-SS-11 (TP46)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	31/10/2022
PROJECT LOCATION:	Riverside Development	TEST METHOD:	AS 1289.7.1.1 & 2.1.1

SAMPLE LOCATION:	TP46 @ 0.6m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	20/10/2022
DATE TESTED:	27/10/2022
MATERIAL TYPE:	Silty CLAY

SHRINKAGE MOISTURE CONTENT (%):	19.4
SHRINKAGE (%):	2.9
SWELL MOISTURE CONTENT INITIAL (%):	19.1
SWELL MOISTURE CONTENT FINAL (%):	27.5
SWELL (%):	1.0
UNIT WEIGHT (t/m ³):	1.89
SHRINK SWELL INDEX I_{ss} (%):	1.9
CRACKING:	moderate
CRUMBLING:	no
ESTIMATED PERCENTAGE OF INERT INCLUSIONS (%):	0

REMARKS:

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SHRINK SWELL INDEX REPORT

CLIENT:	Celestino Developments	PROJECT NUMBER:	PG-7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818-SS-12 (TP20)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	1/11/2022
PROJECT LOCATION:	Riverside Development	TEST METHOD:	AS 1289.7.1.1 & 2.1.1

SAMPLE LOCATION:	TP20 @ 0.5m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	19/10/2022
DATE TESTED:	28/10/2022
MATERIAL TYPE:	Silty CLAY

SHRINKAGE MOISTURE CONTENT (%):	19.5
SHRINKAGE (%):	2.7
SWELL MOISTURE CONTENT INITIAL (%):	15.7
SWELL MOISTURE CONTENT FINAL (%):	22.4
SWELL (%):	4.5
UNIT WEIGHT (t/m ³):	2.21
SHRINK SWELL INDEX I_{ss} (%):	2.8
CRACKING:	slight
CRUMBLING:	no
ESTIMATED PERCENTAGE OF INERT INCLUSIONS (%):	0

REMARKS:

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SHRINK SWELL INDEX REPORT

CLIENT:	Celestino Developments	PROJECT NUMBER:	PG-7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818-SS-13 (TP22)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	1/11/2022
PROJECT LOCATION:	Riverside Development	TEST METHOD:	AS 1289.7.1.1 & 2.1.1

SAMPLE LOCATION:	TP22 @ 0.2m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	19/10/2022
DATE TESTED:	28/10/2022
MATERIAL TYPE:	Silty CLAY

SHRINKAGE MOISTURE CONTENT (%):	18.0
SHRINKAGE (%):	4.0
SWELL MOISTURE CONTENT INITIAL (%):	21.9
SWELL MOISTURE CONTENT FINAL (%):	26.9
SWELL (%):	5.6
UNIT WEIGHT (t/m ³):	2.07
SHRINK SWELL INDEX I_{ss} (%):	3.8
CRACKING:	no
CRUMBLING:	no
ESTIMATED PERCENTAGE OF INERT INCLUSIONS (%):	0

REMARKS:

ER 004



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SHRINK SWELL INDEX REPORT

CLIENT:	Celestino Developments	PROJECT NUMBER:	PG-7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818-SS-14 (TP25)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	2/11/2022
PROJECT LOCATION:	Riverside Development	TEST METHOD:	AS 1289.7.1.1 & 2.1.1

SAMPLE LOCATION:	TP25 @ 0.3m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	19/10/2022
DATE TESTED:	31/10/2022
MATERIAL TYPE:	Silty CLAY

SHRINKAGE MOISTURE CONTENT (%):	19.8
SHRINKAGE (%):	7.0
SWELL MOISTURE CONTENT INITIAL (%):	21.5
SWELL MOISTURE CONTENT FINAL (%):	33.2
SWELL (%):	1.7
UNIT WEIGHT (t/m ³):	1.87
SHRINK SWELL INDEX I_{ss} (%):	4.3
CRACKING:	slight
CRUMBLING:	no
ESTIMATED PERCENTAGE OF INERT INCLUSIONS (%):	0

REMARKS:

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SHRINK SWELL INDEX REPORT

CLIENT:	Celestino Developments	PROJECT NUMBER:	PG-7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818-SS-15 (TP26)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	2/11/2022
PROJECT LOCATION:	Riverside Development	TEST METHOD:	AS 1289.7.1.1 & 2.1.1

SAMPLE LOCATION:	TP26 @ 0.3m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	19/10/2022
DATE TESTED:	31/10/2022
MATERIAL TYPE:	Silty CLAY

SHRINKAGE MOISTURE CONTENT (%):	17.1
SHRINKAGE (%):	5.2
SWELL MOISTURE CONTENT INITIAL (%):	18.1
SWELL MOISTURE CONTENT FINAL (%):	29.5
SWELL (%):	1.0
UNIT WEIGHT (t/m ³):	1.78
SHRINK SWELL INDEX I_{ss} (%):	3.2
CRACKING:	slight
CRUMBLING:	no
ESTIMATED PERCENTAGE OF INERT INCLUSIONS (%):	0

REMARKS:

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SHRINK SWELL INDEX REPORT

CLIENT:	Celestino Developments	PROJECT NUMBER:	PG-7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818-SS-16 (TP27)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	2/11/2022
PROJECT LOCATION:	Riverside Development	TEST METHOD:	AS 1289.7.1.1 & 2.1.1

SAMPLE LOCATION:	TP 27 @ 0.6m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	19/10/2022
DATE TESTED:	31/10/2022
MATERIAL TYPE:	Silty CLAY

SHRINKAGE MOISTURE CONTENT (%):	18.0
SHRINKAGE (%):	3.9
SWELL MOISTURE CONTENT INITIAL (%):	24.8
SWELL MOISTURE CONTENT FINAL (%):	31.2
SWELL (%):	0.0
UNIT WEIGHT (t/m ³):	1.89
SHRINK SWELL INDEX I_{ss} (%):	2.2
CRACKING:	no
CRUMBLING:	no
ESTIMATED PERCENTAGE OF INERT INCLUSIONS (%):	0

REMARKS:

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SHRINK SWELL INDEX REPORT

CLIENT:	Celestino Developments	PROJECT NUMBER:	PG-7818
CLIENT ADDRESS:	-	REPORT NUMBER:	PG-7818-SS-17 (TP31)
PROJECT NAME:	Broadscale Geotech Investigation	REPORT DATE:	2/11/2022
PROJECT LOCATION:	Riverside Development	TEST METHOD:	AS 1289.7.1.1 & 2.1.1

SAMPLE LOCATION:	TP31 @ 0.6m
SAMPLE NUMBER:	-
SAMPLING METHOD:	SAMPLE AS SUPPLIED
SAMPLED BY:	PACIFIC GEOTECH
DATE SAMPLED:	19/10/2022
DATE TESTED:	31/10/2022
MATERIAL TYPE:	Sandy CLAY

SHRINKAGE MOISTURE CONTENT (%):	14.0
SHRINKAGE (%):	2.6
SWELL MOISTURE CONTENT INITIAL (%):	14.5
SWELL MOISTURE CONTENT FINAL (%):	20.4
SWELL (%):	0.5
UNIT WEIGHT (t/m ³):	1.95
SHRINK SWELL INDEX I_{ss} (%):	1.6
CRACKING:	no
CRUMBLING:	no
ESTIMATED PERCENTAGE OF INERT INCLUSIONS (%):	5

REMARKS:

ER 004

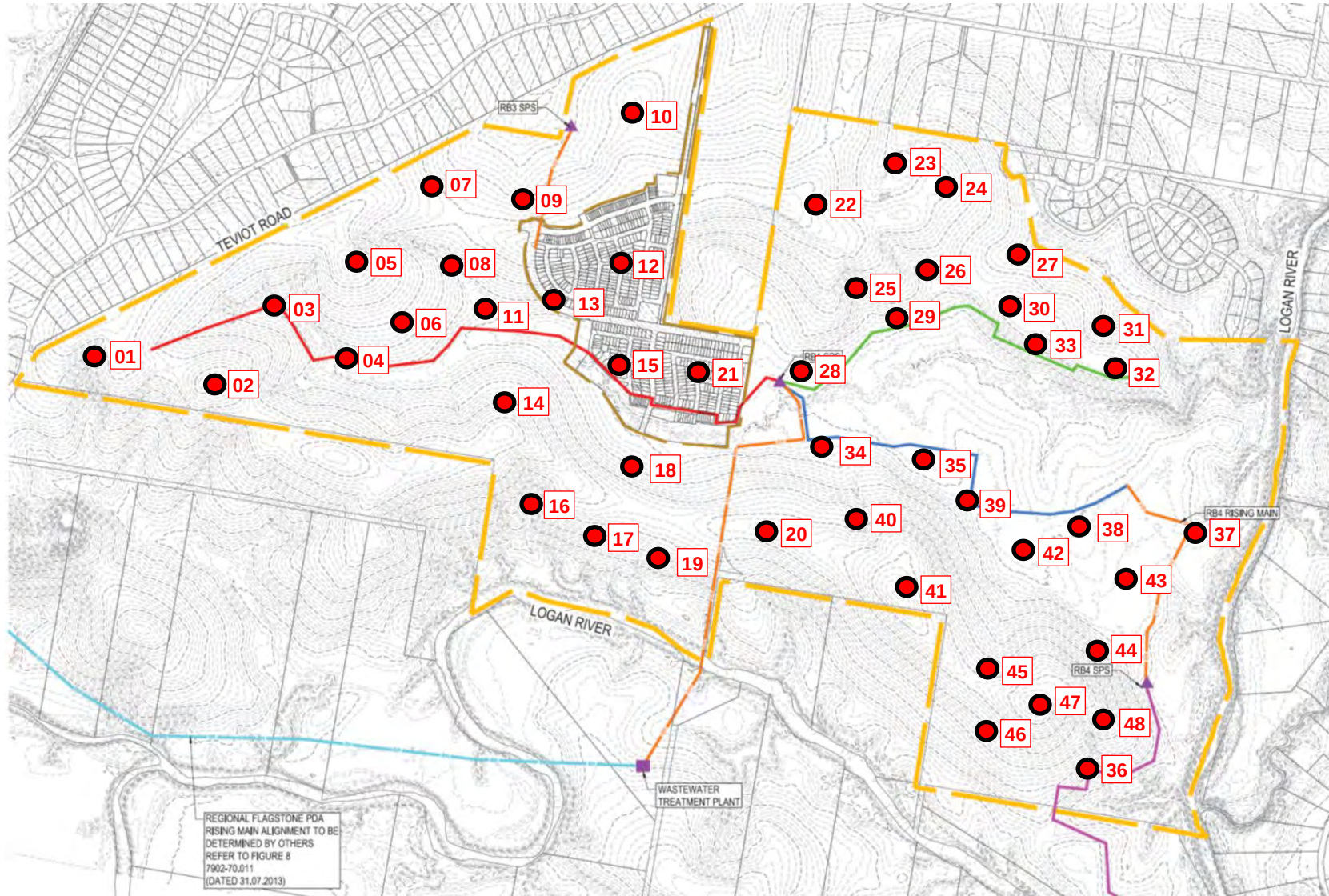


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APPENDIX D

SITE PLAN



Drawn ER	Project:	Proposed Residential Subdivision	Drawing No. PG-7818-01	A4
Date OCT22	Location:	Riverside Development, Jimboomba		
Checked	Client:	Celestino Developments Pty Ltd		



GEOTECHNICAL INVESTIGATION AND BROADSCALE LANDSLIDE HAZARD ASSESSMENT

CELESTINO PTY LIMITED

RIVERBEND AND TEVOIT BROOK DEVELOPMENTS
TEVIOT ROAD, JIMBOOMBA

SGSE/16/220

20 JANUARY 2017

COMPLIANCE ENDORSEMENT
referred to in the PDA
DEVELOPMENT APPROVAL

Approval no: DEV2016/811

Date: 14 December 2017



Queensland
Government

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DOCUMENT CONTROL SHEET

SGS Australia Pty Ltd ABN 44 000 964 278 Lawnton Office: PO Box 370 LAWNTON QLD 4501 Telephone: (07) 3481 9444 Email: au.ind.admin@sgs.com	Project No.	SGSE/16/220
	Document No:	SGSE.16.220.GI.R01
	Title:	Geotechnical Investigation and Broadscale Landslide Hazard Assessment
	Project Manager:	Robert Maxwell
	Author:	Robert Maxwell
	Client:	Celestino Pty Limited
	Client Contact:	Lloyd Gomez
	Synopsis:	Geotechnical investigation for proposed residential subdivision development incorporating an assessment of slope stability and landslide hazard potential

REVISION AND CHECKING HISTORY

Revision Number	Date	Checked by	Issued by
0	20.01.2017	C Barclay	R Maxwell

DISTRIBUTION

Destination	Revision			
	Original	-	-	-
Client	pdf			
SGS File	1			
SGS Database	1			

LIMITATIONS

This report has been prepared for the sole use of the client and the client's immediate representatives and agents. It is fundamental in the application of this report that the report, including appendices, is read in its entirety and fully understood. Please contact SGS Australia Pty Ltd (Lawnton Office) for additional explanation if any of the report content is not fully understood.

This report is not a guarantee that the site ground conditions will behave in accordance with the interpretation set out herein, but rather our opinion as to the correct interpretations based on the results of site investigations, in situ testing and/or laboratory testing in accordance with generally accepted consulting practice. To the best of our knowledge, information contained in this report is accurate at the date of issue. The interpretation of scientific data, however, often involves both professional and subjective judgments. As such, interpretation is open to error. In addition, site conditions are subject to change in a limited time and there remains a risk that the site ground conditions will differ from these interpretations.

SUMMARY

The following section provides a summary of the preliminary geotechnical investigation carried out for the proposed residential subdivision developments "Riverbend and Teviot Brook" at Teviot Road, Jimboomba. This summary must be read in conjunction with the report and appendices.

1. Typical Soil Profiles
 - Topsoil varying in depth to 0.2m overlying silty sands extending to depths up to 0.4m;
 - Overlying residual clays with strengths increasing with depth from stiff to hard.
2. Rock
 - Extremely low to distinctly weathered sandstone with strengths from extremely to low strength, underlay the residual clays.
3. Groundwater
 - Groundwater was encountered in borehole BH6 at a depth of 2.0m below existing ground surface level, at the time of the investigation.
 - Seepage may develop elsewhere, forming perched water in the more permeable layers or adjacent to other sources of moisture ingress (alongside drainage channel and wetland area).
4. Reactivity
 - Y_s range 40mm to 80mm
Highly to Extreme (H to E) reactivity
5. CBR values
 - Range 1.5% to 25%
6. Site Issues/Problems
 - Numerous trees across site potentially creating abnormal moisture conditions and 'P' site classifications.
 - Presence of uncontrolled fill in the vicinity of existing access tracks and possibly more widespread evidenced by small mounds and stockpiles.
 - Presence of high plasticity clays which may decrease in strength and consistency once disturbed and/or moisture affected resulting in reduced trafficability.
 - Near surface silty sands susceptible to moisture and loss of strength.
 - Depth of unsuitable materials is likely to be variable along drainage channel with potential sediment deposits within the lower floodplain.
 - Potential excavation difficulties in relatively strong rock.
 - Topsoil samples revealed Emerson Class 3 and 6 materials indicating a predominately low to medium dispersion risk. Subsoil/weathered sandstone samples revealed Class 2, 3 and 5 materials indicating a predominately moderate to high dispersion risk.

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All appendices should be carefully read in conjunction with this report

This report has been prepared for the sole use of the client and the client's immediate representatives and agents. It is fundamental in the application of this report that the report, including appendices, is read in its entirety and fully understood. Please contact SGS Australia for additional explanation if any of the report content is not fully understood.

This report is not a guarantee that the site ground conditions will behave in accordance with the geotechnical interpretation set out herein, but rather our opinion as to the correct geotechnical interpretations based on the results of site investigations, insitu testing and laboratory testing, in accordance with appropriate Australian Standards and related engineering principles. There remains a risk that the site ground conditions will differ from these geotechnical interpretations.

1 INTRODUCTION

This report presents the results and interpretations of a geotechnical investigation carried out by SGS Australia for the proposed residential subdivision developments "Riverbend and Teviot Brook" at Teviot Road, Jimboomba.

The investigation was commissioned by Mr Lloyd Gomez of Celestino Pty Limited.

It is understood that the proposed development is for a master planned development within the Greater Flagstone Development Area. The site encompasses an area in the order of 500ha located at Lot 101,102,104,105 and 106 on SP254145 and Lot 800 on SP247625 and is bound by Logan River to the south and east and Teviot Road to the north-west.

The development will involve the creation of residential allotments and the construction of associated municipal infrastructures including roadways, underground services, open space areas / drainage reserves, a district centre adjacent to Teviot Road and several neighbourhood centres throughout the site.

It is further understood a Preliminary Approval Application for Material Change of Use is being prepared for the site. To address potential site constraints, a geotechnical investigation has been undertaken to assess the general soil conditions and identify geotechnical constraints at the site to facilitate civil and irrigation designs at the master plan stage plus setting design constraints for future MCU and ROL applications.

Figure 1 Location Plan



(Source: DNRM Historical Aerial Images 1:100,000 - 2009)

The investigation was carried out in general accordance with the SGS Australia proposal (SGSE/16P/220) dated 30th September 2016.

The investigation and interpretation of results was carried out in general accordance with the following reference materials:

- AS 1726 "Geotechnical Site Investigations"
- AS 1289 "Testing of Soils for Engineering Purposes"
- AS 1547 "On-site Domestic Wastewater Management"
- AS 2870 "Residential Slabs and Footings"
- AS 3798 "Guidelines on earthworks for commercial and residential developments"
- Department of Housing and Public Works (DHPW3) "Queensland Plumbing and Wastewater Code"
- Sadegh-Vaziri M, Taylor B (2002) "Implementation of Landslide Risk Management on the City of Gold Coast" Australian Geomechanics Society, Barton, ACT, Australia
- MacGregor P, Taylor B (2001) "A Method of Zoning Landslide Hazard" Australian Geomechanics Society, Barton, ACT, Australia.
- AGS Landslide Zone Working Group (2007) "Guideline for Landslide Risk Susceptibility, Hazard and Risk Zoning for Land Use Planning" Australian Geomechanics Society (AGS 2007a); and AGS Landslide Taskforce, Landslide Practise Note Working Group (2007) "Practice Note Guidelines for Landslide Risk Management" Australian Geomechanics Society (AGS 2007c).
- AGS Landslide Taskforce, Slope Management and Maintenance Working Group (2007) "The Australian Geoguides for Slope Management and Maintenance" Australian Geomechanics Society (AGS 2007e).

Relevant definitions and detailed site investigation procedures are provided in Appendix A.

2 INVESTIGATION PROCEDURE

The field investigation was carried out on 7th, 8th, and 9th November, 2016 and comprised the following stages:

- a) Site investigation in accordance with AS 1726 "Geotechnical Site Investigations"
 - * Drilling of twenty-two (22) boreholes to a target depth of 4.5m (borehole locations are shown on the site sketch in Appendix B). Due to the presence of low strength weathered rock, five (5) of the boreholes were terminated prior to target depth.
 - * Site and landform mapping by an experienced senior geotechnical engineer.
 - * Soil classification by a field geotechnical engineer.
 - * Sampling of representative soils for laboratory analysis.
 - * Dynamic cone penetrometer (DCP) testing adjacent each borehole in order to assess the relative density and strength consistency of the subsurface soils.
 - * Pocket penetrometer (PP) in undisturbed samples to estimate the undrained shear strength (Cu).
- b) Laboratory testing in accordance with AS 1289 "Testing of Soils for Engineering Purposes" (where applicable)
 - * Shrink/swell index to allow ground surface movement predictions.
 - * Moisture/density relationship (standard compaction) and 4-day soaked CBR for preliminary pavement design application.
 - * Emerson Class, pH and electrical conductivity (in soil) to assess the potential dispersive nature of the soils.
 - * Particle size distribution and dispersion index to assess the potential dispersive nature of the soils encountered at the site.
 - * Agricultural Suite to assess the site soil conditions within the proposed irrigation areas and included:
 - Saturated hydraulic conductivity
 - Particle size distribution
 - Emerson class number
 - pH and electrical conductivity
 - Organic matter
 - Organic carbon
 - Exchangeable cations
 - Cation exchange capacity
 - Exchangeable sodium percentage (ESP)
 - Total nitrogen and total phosphorus
 - Colwell phosphorous
 - P sorption capacity

3 INVESTIGATION RESULTS

3.1 SITE DESCRIPTION

The site under investigation can be generally divided into two land parcels; (east and west) by Bushland Road extending north to south from the existing Teviot Road and Glynton Road intersection.

The eastern land parcel is typically rectangular in shape with the western boundary fronting Bushland Road; the southern and northern boundaries neighbour existing rural properties; and the eastern boundary situated along the Logan River. Two distinct ridge lines projecting in a north western to south eastern orientation straddle the eastern land parcel and centrally divided by a watercourse traversing in an easterly direction toward the Logan River. A relatively level open plain associated with an upper flood plain of the Logan River, which straddles the eastern extent of the watercourse. The watercourse connects with a second watercourse along the northern boundary where it forms narrow deeply incised gully travelling in a north easterly direction and eventually releasing into the Logan River. Photographs below illustrate.



Eastern Parcel - Open Plain



Eastern Parcel - Open Plain adjacent to Watercourse



Deeply incised Gully - North Eastern Boundary



Sandstone outcrops within backs of deeply incised gully - North Eastern Boundary

The northern ridgeline has undergone recent regrowth vegetation with timber pushed into stockpiles. The open areas were well grassed with occasional regrowth vegetation and small clusters and singular mature natives particularly along watercourses and gullies. The southern ridgeline of the site was heavily vegetated and access was limited to some portions of this area. The vegetation comprised a combination of native and some exotic plant species. In the more elevated areas of the site weathered sandstone was exposed on the surface with rock outcrops evident in the southern ridgeline. Photographs below illustrate.



Southern Ridgeline



Sandstone outcrop at surface - Southern Ridgeline

The western land parcel is typically triangular in shape with the north western boundary fronting Teviot Road; the southern boundaries neighbour existing rural properties and Logan River; and the eastern boundary fronting Bushland Road. The topography typically slopes from the northern and southern boundaries towards a centrally located undefined watercourse/open gully which traverses in an easterly direction toward the eastern land parcel. Several earthfill dams were situated along the watercourse. Photographs below illustrate.



Undefined watercourse / open gully



Undefined watercourse / open gully



Western Parcel - Earth Dam



Western Parcel - Dam Wall

Several existing farm tracks were present at the time of the investigation. The farm tracks predominantly traversed the fence lines, yards and ridgelines.

Signs of erosion were evident in the existing farm tracks and watercourses, typically on the edges of the banks. Photographs below illustrate.



Signs of Erosion - Farm Track



Signs of Erosion - Gully

The banks adjacent to the Logan River generally ranged in slopes up to 20% to 80% (15 to 40 degrees) and typically comprised surface alluvium deposits overlying residual clays and sandstone. Vertical slopes were observed in some sections associated with small gullies.

The majority of the slopes were heavily vegetated, with timber debris scattered the length of the embankment and the water edge. At the time of the investigation, the river water level was considered to be low. Refer to photo below.

There were a number of eroded gullies observed which capture and channel overland flows from the crest of the slope down to the Logan River. The mid slope profiles of these gullies were considered to have steep sides which would open out in the lower slope at the point of discharge into the river.

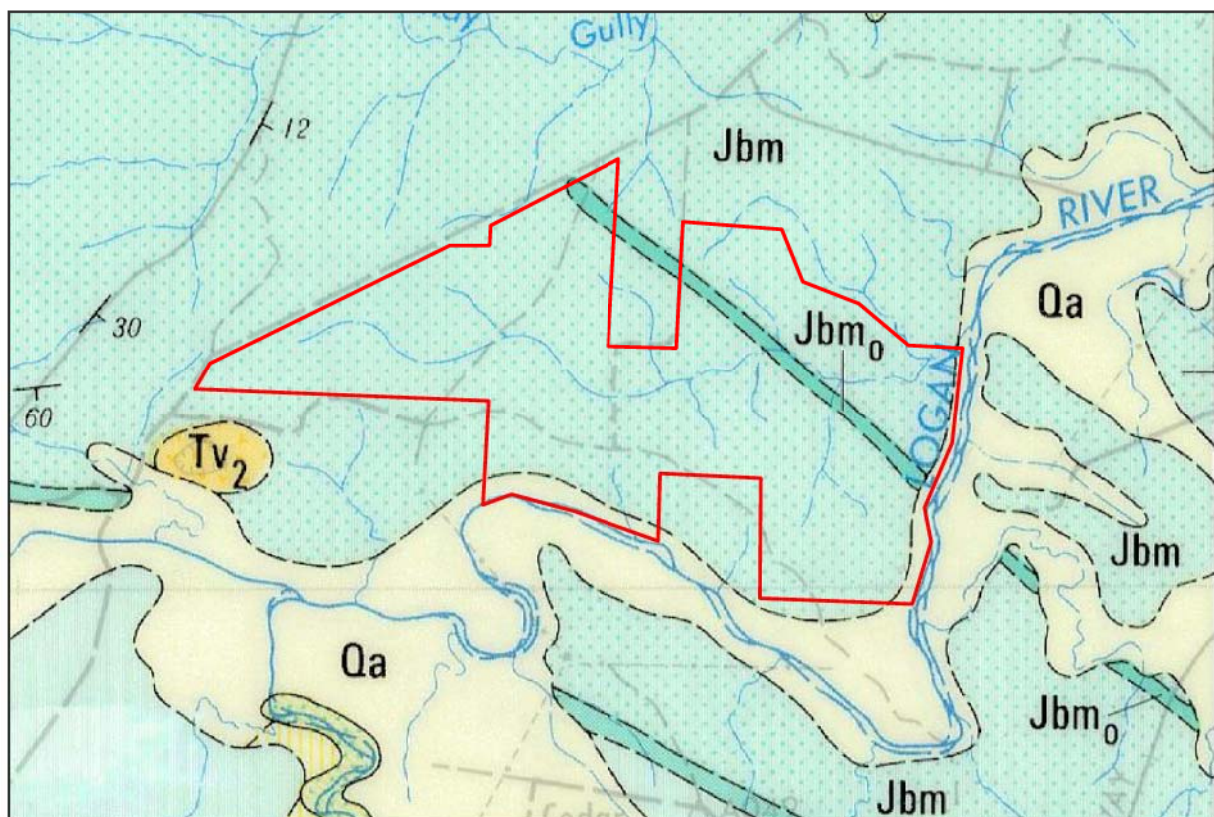


Logan River - Timber Debris

3.2 REGIONAL GEOLOGY

The regional geology as described by the Department of Mines geology map for Ipswich (Sheet 9442) is as follows:

Geological Unit / Rock Name:	Jbm - Marburg Formation
Age:	Early Jurassic
Lithology:	Lithic or feldspathic, labile to sub-labile sandstone, siltstone, shale and coal.
Additional Features:	The area immediately straddling the Logan River is described as Qa - undifferentiated floodplain and river terrace resulting from alluvial deposition during the Quaternary period. The lithology comprises sand, silt, gravel and clay. Jbm _o – Chamositic oolite



The sandstones of Southeast Queensland were deposited on broad river plains on the largely stabilised continent in the latest Triassic to Jurassic times between about 215 to 180 million years ago. Initially, coarse sand and gravel were washed down, in part from erosion of the newly unroofed granites of the New England region, to form the Woogaroo Subgroup and the Myrtle Creek Sandstone. They were succeeded by finer and generally thinner beds of sandstone with beds of siltstone and mudstone of the Marburg Subgroup. The sandstone beds have generally remained horizontal or are only gently inclined.

The thicker sandstone units are relatively resistant to erosion and form rounded hills with sporadic local cliff lines on thicker, more massive beds around its flanks. Small undercut caves are often eroded into the cliff faces. Ridge crests are often flat topped, reflecting the gentle inclination of the beds. Thin sandstone units, soft shale and siltstone sections have weathered to low topography.¹

¹ Willmott W (2004) "Rocks and Landscapes of the National Parks of Southern Queensland" Geological Society of Australia, Queensland Division.

Erosion rates and slope forming processes on natural slopes are generally relatively slow to moderate and will typically involve:

- Insitu weathering of the parent rock to form residual soil. The thickness of the residual soil layer can range from nil (ie. intact rock exposed) to many meters.
- Gradual erosion of the residual soil layer and down slope movement of the eroded particles. Erosion rates which under normal circumstances should be relatively consistent can be significantly increased by events such as vegetation clearing, ground disturbance and extreme rainfall periods.
- Accumulation of eroded material on lower slopes and gullies (colluvium) and in streams (alluvium). The thickness of colluvial layers can range from negligible on upper slopes and crests, to several meters on lower slopes and gullies, but is generally less than one (1) metre thick.
- Small to large wedges and blocks of rock separating along defect lines at rock outcrops along cliff lines, ridges, eroded gullies and streams. The rock pieces move downslope (sometimes rapidly on very steep slopes) to contribute to colluvium and alluvium.

3.3 SUBSURFACE PROFILE

The soil profiles encountered in the boreholes were generally consistent with the regional geological descriptions and comprised topsoils overlying clayey sands and sandy clays transitioning to weathered sandstone; and in areas of the site weathered sandstone was exposed on the surface.

Typically, a layer of 50mm to 100mm topsoil was encountered across the development site. The depth of unsuitable materials is likely to be variable along the central watercourse / drainage reserves with potential sediment deposits within the dams and floodplain area.

It should be noted that there is a high probability that uncontrolled fill may be encountered across the site with evidence of small soil and vegetation debris stockpiles observed at the time of the investigation. Fill material was also observed within the existing dam walls and along the existing access roads that traverses the site.

There were areas of the site that were inaccessible at the time of the investigation due to heavy vegetation cover. No assessment of the subsoil profiles could be made in these areas, however it is expected that the geology across the site to be consistent.

Detailed soil profiles are provided in the Engineering Borehole Logs in Appendix C and a summary of the borehole data is provided in the following table.

Table 1 Summary of Soil Profiles

B/hole No.	Natural Ground (m)							
	Silty SAND / SILT	CLAY		SAND		XW SANDSTONE	XW – DW SANDSTONE	DW SANDSTONE
		Stiff	Very Stiff to Hard	Loose	Medium Dense	EL	VL	LS
1	0.0-0.1		0.1-0.6			0.6-1.3	1.3-4.5	
2	0.0-0.1		0.1-1.1			1.1-1.4		1.4-1.5*
3	0.0-0.2		0.2-0.7 1.5-2.7		0.7-1.5		2.7-4.5	
4	0.0-0.2		0.2-0.6			0.6-1.4	1.4-2.0	2.0-2.2*
5	0.0-0.2		0.4-0.5		0.2-0.4	0.5-0.8	0.8-4.5	
6	0.0-0.1	0.1-0.6	3.3-4.5	2.0-3.3	0.6-2.0			
7	0.0-0.14	0.5-1.1	0.14-0.5 1.1-4.5					
8	0.0-0.2		0.2-2.6			2.6-3.2	3.2-4.5	

B/hole No.	Natural Ground (m)							
	Silty SAND / SILT	CLAY		SAND		XW SANDSTONE	XW – DW SANDSTONE	DW SANDSTONE
		Stiff	Very Stiff to Hard	Loose	Medium Dense	EL	VL	LS
9	0.0-0.11		0.11-0.5			0.5-2.6	2.6-4.5	
10	0.0-0.4	1.0-2.6	0.4-1.0			2.6-2.8	2.8-4.5	
11	0.0-0.2	0.2-0.4	0.4-1.4			1.4-4.5		
12	0.0-0.2		0.2-1.2			1.2-1.4	1.4-4.1	
13	0.0-0.2		0.2-4.5					
14	0.0-0.05		0.05-1.7			1.7-2.2	2.2-2.8	2.8-3.0*
15	0.0-0.15		0.15-0.8			0.8-1.0	1.0-1.8	1.8-3.0
16	0.0-0.2	0.5-1.4	0.2-0.5 1.4-2.6			2.6-2.8	2.8-3.8	3.8-4.5
17	0.0-0.15		0.15-1.2		1.2-4.5			
18	0.0-0.4	0.4-1.1	1.1-4.5					
19	0.0-0.1	0.1-0.7	0.7-3.8			3.8-4.5		
20	0.0-0.18		0.18-4.5					
21	0.0-0.2		0.2-0.5			0.5-0.7	0.7-4.5	
22	0.0-0.09		0.09-0.5			0.5-0.7	0.7-1.4	1.4-1.5*

* Borehole terminated prior to target depth

XW – Extremely weathered
EL – Extremely low strength

DW – Distinctly weathered
VL – Very low strength

LS – Low strength

A site plan with borehole locations is provided in Appendix C.

3.4 GROUNDWATER

Groundwater was encountered in borehole BH6 at a depth of 2.0m below ground surface at the time of investigation. Groundwater seepage may also develop forming perched water in the more permeable layers during/following extended wet weather periods or adjacent to other sources of moisture ingress (e.g. leaking services or irrigation systems).

Based on the borehole data it is considered that development of seepage and perched groundwater may be possible at the soil/rock interface.

3.5 LABORATORY TEST RESULTS

Laboratory testing was carried out on selected samples taken from the proposed development site. Test reports are provided in Appendix D and results are summarised in the following table.

Table 2 Summary of Laboratory Geotechnical Test Results

B/hole No.	Depth (m)	Soil Description	Moisture/Density Relationship (Standard)		Soaked CBR (%)	Shrink-Swell Index (Iss)	Emerson Class	pH	Electrical Conductivity (mS/cm)
			MDD (t/m ³)	OMC (%)					
BH1	0.1-0.6	(CH) CLAY	1.62	21.0	1.5				
BH2	0.1-0.3	(CH) CLAY					5	6.0	0.03
BH5	0.15-0.3	(SC) Clayey SAND	1.93	13.0	25				
BH6	0.0-0.1	(MH) Clayey SILT					3	5.9	0.04

B/hole No.	Depth (m)	Soil Description	Moisture/Density Relationship (Standard)		Soaked CBR (%)	Shrink-Swell Index (Iss)	Emerson Class	pH	Electrical Conductivity (mS/cm)
			MDD (t/m ³)	OMC (%)					
BH6	0.1-0.3	(CH) CLAY					3	5.1	0.02
BH6	0.6-1.1	(CI) Sandy CLAY	1.83	14.0	8				
BH7	0.6	(CH) CLAY				6.0			
BH8	0.0-0.09	(MH) Clayey SILT					3	4.7	0.02
BH8	0.2-0.5	(CH) CLAY					3	4.8	0.01
BH8	0.5	(CH) CLAY				4.9			
BH11	0.5	(CH) CLAY				6.1			
BH12	0.5-1.0	(CI) Sandy CLAY	1.68	19.0	1.5				
BH13	1.0	(CH) CLAY				5.0			
BH14	0.9	(CI) Sandy CLAY				1.0			
BH16	0.0-0.2	(CH) CLAY					3	5.4	0.07
BH16	0.2-1.0	(CH) CLAY with silt	1.68	20.0	2.0	4.6	2	5.0	0.04
BH17	1.2-2.0	(CI) Sandy CLAY	1.75	14.0	2.0				
BH18	0.0-0.1	(CL) CLAY					6	5.6	0.04
BH18	0.1-0.4	(CH) CLAY					3	6.0	0.03
BH18	0.4-1.0	(CH) Sandy CLAY	1.57	23.5	4.0	2.6			
BH19	0.5-1.0	(CH) Sandy CLAY	1.66	20.0	2.5				
BH20	0.7	(CH) Silty CLAY				3.3			
Creek	Surface	(MH) Clayey SILT					3	5.0	0.03

Notes:

1. Moisture/Density Relationship: MDD – Maximum Dry Density, OMC – Optimum Moisture Content
2. Soaked CBR determined at nominal 100% Dry Density Ratio at OMC

Agricultural suite testing was undertaken on topsoil and subsoil samples collected from the proposed irrigation areas (Borehole locations BH13, 14, 15, 19, 21, 22). The results of the testing are provided in Appendix D of this report.

4 ENGINEERING ASSESSMENT

4.1 ASSESSMENT OF IN-SITU SOILS

On the basis of the soil profiles observed at the time of the investigation and the subsequent laboratory testing it is expected that the majority of the development site shall predominately comprise topsoil to a maximum depth of 0.4m overlying sand and residual clays. An average topsoil stripping depth of 105mm may be applicable for preliminary design.

Furthermore, based on subsurface profiles encountered across the site, there is potential for the interception of extremely low to medium strength sandstone during the earthworks. It is anticipated that the bulk earthworks will extend into the underlying sandstone.

4.2 SITE REACTIVITY

4.2.1 PRELIMINARY SITE CLASSIFICATION

The predicted surface movement (Y_s) that could occur on this site has been assessed in accordance with the methodology provided in AS 2870 "Residential Slabs and Footings".

It is understood that ultimately this project proposes the construction of standard residential buildings as described in AS 2870. It should be the responsibility of the designer to ensure that the AS 2870 methodology and derived parameters are applicable for this site and the proposed structures.

The results of the site investigation, in-situ testing and laboratory testing indicate the following site reactivity parameters in accordance with AS 2870-2011 for the site in its current condition. The final site classification will be subject to the outcomes of the earthworks conducted during development of this site.

EXISTING SITE CLASSIFICATION 'P'

The 'P' classification is based on the presence of:

- Assumed abnormal moisture conditions as a result of existing trees.

The following predicted surface movement values apply for the existing soil profiles:

Existing worst case – (i.e. Full Clay Profile)	
Predicted Surface Movement (Y_s)	70 – 80mm
Equivalent Reactivity	Extreme (E)

NOTES:

- The site reactivity and classification provided is based on the ground conditions and levels at the time of the investigation. Alteration of these conditions (e.g. by cutting and/or filling) may result in a change of site reactivity and classification.
- The above predicted surface movements (Y_s) have been calculated using a 1.8m clay profile for various existing and potential conditions.
- The above ground surface movement estimates would be reduced where non-reactive material overlies the clay or where clay thickness area limited (i.e. DW sandstone).

At the time of reporting the extent of proposed earthworks was unknown. However, it is envisaged that excavations of up to 3.0m depth below natural surface level will be required to construct the allotments, roads and infrastructure.

The following predicted surface movement provides an indication of what maybe expected post earthworks phase.

	Predicted (after $\geq 0.9\text{m}$ or greater cut – natural onsite clays)	Predicted (after controlled, cut to fill earthwork – onsite clays)	Predicted (after $\geq 1.0\text{m}$ controlled fill earthworks using; select fill material*)
Predicted Surface Movement (Y_s)	110 - 130	110 – 130mm	40 – 60mm
Equivalent Reactivity	Extreme	Extreme	High

Notes:

- * Predicted surface movement is based on a maximum shrink-swell index of 2.0. Refer to Section 4.2.2 – Structural Fill Considerations
- * Earthworks conducted under Level 1 geotechnical inspection and testing in accordance Clause 8.2 of AS3798. Refer to Section 4.4.3 of this report.

4.2.2 STRUCTURAL FILL CONSIDERATIONS

Borrowed Site Fill

With the exception of the organic rich soils (topsoil), materials encountered in the boreholes are considered suitable for use as structural filling provided that the engineering properties of the excavated and compacted materials are considered in earthworks planning and the subsequent engineering design. In particular, the following issues should be considered.

The clay soils encountered in the boreholes were in the extreme reactivity range when assessed as a natural profile. Based on the principles outlined in AS2870 (Clause 2.4.6), when the same material (same I_{ss}) is placed as controlled fill, the reactivity increases by a factor in the order of 1.2 to 1.6 depending on the depth of the controlled fill layer.

The inherent mixing and blending of materials associated with cutting and filling will sometimes reduce the shrink-swell index (I_{ss}) properties of the fill with a subsequent reduction in the effect of increased reactivity associated with controlled fill. However, shrink-swell properties of the fill cannot be assessed until filling is completed. It is therefore recommended that consideration be given to the possibility of reactivity increasing in controlled fill by up to 60%.

Furthermore, the weathered sandstone material encountered in the boreholes may be a more preferable borrow material for use as structural fill. Further investigation and testing will be necessary to ascertain the extent and suitability of the sandstone material for use as structural fill and/or select fill material.

Based on the borehole data, it is considered likely that excavation in the weathered rock may produce some large intact rocks in the excavated material. A maximum rock size of 2/3 of the compacted layer thickness is recommended. Assuming large compaction plant (eg. Cat. 815) and a nominal compacted layer thickness of 300mm, this will limit rock size in the fill to approximately 200mm. It is therefore recommended that some consideration be given to the possibility of the necessity to remove oversize rock from the fill.

Imported Fill

If imported fill is required to make up earthwork deficiencies, the following issues should be considered in relation to the geotechnical properties of the fill.

- Availability and cost
- Potential advantages and disadvantages of good or poor quality fill
- Desired project outcomes

For example, if good quality (high cost) imported fill is specified with little or no design (or cost) advantage gained, then the additional cost of the fill may not be justified. However, in some cases, significant cost advantages can be gained (eg. in pavements, retaining walls and footings) by specifying a minimum quality. It is suggested that for costing purposes, a generic specification be nominated to be refined if and when required during construction, depending on the circumstances.

Reactivity and site classification is often a major consideration, more so on residential developments. On filled sites, the site classification is influenced by the shrink-swell properties of the fill and the depth of the fill layer. Assuming a full controlled fill profile ($H_s=1.8\text{m}$) following may be used as a guide in specifying a maximum shrink-swell index for imported fill.

• Shrink-Swell Index (Iss)	1.0	2.0	3.0	4.0
• Predicted Surface Movement – Ys (mm)	20	41	61	81
• Equivalent Site Class (AS 2870)	'M'	'H1'	'H2'	'E'

As a minimum, the following properties are recommended for imported fill.

• Maximum stone size (mm)	-	150
• Passing 19.0mm sieve (%)	-	70 – 100
• Passing 0.075mm sieve (%)	-	15 – 40
• Minimum soaked CBR (%)	-	5.0*
• Maximum shrink-swell index	-	1.0*

* Samples remoulded at 100% standard compaction at optimum moisture content.

4.2.3 ASSESSMENT OF EXISTING VEGETATION

Trees can affect building foundation performance in reactive clay by removing soil moisture, which induces volume change (shrinkage) in the soil.

The effect of trees on a site classification (and subsequent footing design and performance) is assessed based on:

- The site classification (considering reactivity);
- The distance between trees and the closest point to the building; and
- The mature height of the trees.

The criteria are expressed as a minimum ratio of the distance of a tree from the building divided by the mature height of the tree.

The potential mature height of a particular tree species can vary with the condition of the tree, climate, soil types, drainage and other site-specific variables. SGS personnel are not qualified, and have not attempted, to estimate the mature height of any existing trees (if applicable). The distance/height ratio also depends on the final building locations, which were unknown at the time of this investigation. However, once these final building locations are known, and the distance/height ratio of any tree is less than the value nominated below, then a 'P' site classification will apply.

The design engineer shall ensure that appropriate actions are taken (eg. tree removal, structural design, etc) if, at the time of construction, the distance/height ratio of any existing tree(s) is below the following value.

<u>Site Classification</u>	<u>Minimum Distance/Height Ratio</u>
M	0.75
H	1.00
E	1.50

Where rows or groups of trees are involved, the above minimum distance/height ratio should be doubled. Any tree removal, particularly prior to building construction, must consider potential surface heave (rebound) associated with the re-establishment of soil moisture equilibrium conditions.

4.3 FOUNDATIONS

The type and depth of foundation system for residential subdivision construction will be dependent on the post development earthwork outcomes including depths of fill (uncontrolled or controlled), loading, soil reactivity within the footing zone of influence and landscaping.

Raft and high level strip and pad footing foundations are anticipated for lightly loaded, settlement-tolerant structures, with stiffening to suit the site classification. Conversely, heavy loaded and settlement-intolerant structures and towers with uplift or lateral loads may require bored pile foundations.

Where footings are founded in materials of differing compressibility (such as may occur where the thickness of any controlled fill is variable beneath the structure), there is a potential for differential settlement across the structure, which must be accounted for in design through careful articulation and construction material types. For structures that are susceptible to differential movements, it is recommended that all footings be founded in the same strength strata, through the use of deepened pedestals and piled foundations extending into the less compressible residual soils or underlying weathered rock.

For preliminary considerations, Table 3 below presents expected allowable bearing pressure parameters for shallow footing systems for the materials encountered onsite.

Table 3 Allowable Bearing Pressure for Shallow Footing Systems

Material Unit	Allowable Bearing Pressure q_a (kPa) (FOS= 3)
Topsoil / Sands	N.A.
Natural stiff (or stronger) residual CLAYS	100
SANDSTONE extremely low strength (or stronger)	500
Controlled FILL *	100

N.A. – Not Advised

** Based on the fill complying completely with the requirements in AS3798 and being placed under Level 1 conditions and certified by a Geotechnical Engineer (RPEQ).*

These parameters would need to be confirmed during site investigation and classification post construction when specific building application details are known.

For retaining wall footings, these above values should be reduced by one-third to allow for lateral load effects.

These allowable values are based on a factor of safety of 3 against bearing capacity failure. For shallow footings, it is considered that settlements subjected to the above applied loading will be less than 1% to 2% of the footing width.

4.4 RETAINING WALLS

It is envisaged that retaining walls would be required for the proposed residential developments. The design of flexible or rigid walls could be undertaken using triangular distribution methods. Flexible walls are those which are free to rotate or tilt (such as cantilevered walls) and should be designed using an active earth pressure coefficient (K_a). Rigid walls are those which are restrained against rotation or tilt (anchored/propped walls) and should be designed using the at rest earth pressure coefficient (K_0). It is recommended that all retaining walls include a full height drainage system in order to minimise hydrostatic pressure build-up behind the walls.

Table 4 provides unfactored characteristic values for unit weight, friction and cohesion for material types encountered at the site. Selection of the appropriate values will depend on the type of insitu materials present, the geometry of the excavated surface and the type and condition of the backfill material. At the time of reporting these details were not available. Consideration of these issues will be necessary to determine design earth pressures.

Table 4 Soil Strength Characteristics (Unfactored)

Material Type	Drained Cohesion c' (kPa)	Drained Friction Angle ϕ' (degrees)	Unit Weight γ (kN/m ³)
Controlled FILL and Natural stiff (or stronger) CLAYS	3	24	20
Extremely low strength SANDSTONE (or stronger)	5	27	22

Material strength factors for strength and serviceability limit states are given as:

$$\text{Design cohesion value } (C^*) = \Phi_{uc} C'$$

$$\text{Design internal friction angle } (\phi^*) = \tan^{-1} (\Phi_{u\phi} (\tan \phi))$$

where:

Φ_{uc} = Partial design (uncertainty) factor for characteristics cohesion of soil

$\Phi_{u\phi}$ = Partial design (uncertainty) factor for characteristic internal friction angle of soil

Appropriate uncertainty factors should be selected from Tables 5.1(A) and 5.1(B) of AS 4678-2002.

Resisting forces to sliding are provided by the shear resistance at the footing/soil interface and the passive resistance in front of the base (or key). Base sliding resistance (F_r) may be determined as follows:

$$F_r = F_n \tan \delta + B \times c_b$$

where:

F_n = sum of vertical forces acting on the base

δ = $2/3 \phi^*$

B = base width

c_b = $2/3 C^*$

Retaining structures should be designed for ultimate and serviceability limit states and in accordance with applicable design models and methods (refer Appendix E of AS4678).

Notes:

- Refer to Section 4.3 for recommended allowable base bearing pressures.
- Retaining wall earth pressure coefficients are provided in Appendix E of this report.
- The above values must be confirmed by an experienced geotechnical professional at the time of initial excavations.
- Drainage should be designed, constructed and maintained in accordance with Clause 3.6 of AS4678.

- Consideration should be given to any possible adverse effects from construction on adjacent land and/or structures.
- Where the insitu or fill materials have significant shrink/swell characteristics (class M or higher), then the impact of these soils on active, passive, sliding and bearing parameters should be considered.
- All structures must be designed to resist a minimum live load of 1.5 x 5 kPa.

4.5 EARTHWORKS

It is recommended that the following site preparation and earthworks procedures be carried out for the proposed development.

Geotechnical inspection and testing involvement should, as a minimum, include the activities labelled "(GITA)" in this section of the report.

4.5.1 EARTHWORK PREPARATION (GROUND SURFACE TREATMENT)

It is recommended that preparation for earthworks should include the following:

1. **Removal of all organic rich (topsoil), near surface sands and uncontrolled fill (if encountered)** material from all cut and structural fill areas. Topsoil and unsuitable materials may be deeper along creek/gully lines, in areas of dense vegetation and in previously cultivated areas, where applicable. **Topsoil is not considered suitable for use as structural fill.**
2. Inspection of the stripped structural fill area to assess adequate topsoil stripping and the presence and extent of any existing (uncontrolled) fill. All uncontrolled fill should be removed down to a sound natural base and stockpiled to assess suitability for re-use as structural fill. **(GITA)**
3. Tining of structural fill areas to a nominal depth of 300mm. This will break up and disperse remaining fine root fibre and assist with the removal of larger roots and stumps. Spacing between tines should not exceed 500mm.
4. Remove larger roots and stumps.
5. Moisture condition tined areas as necessary to achieve a standard moisture ratio in the approximate range of 85% to 95% for sand soils (silty sand, clayey sand) and 95% to 110% for clay soils (clay, silty clay, sandy clay). **(GITA)**
6. Compact and proof roll structural fill areas (including areas under batters) with compaction equipment of similar capacity to the plant proposed to compact and traffic the fill. **(GITA)**
7. Remove any soft/loose (unsound) areas down to a sound base. Replace with suitable materials and compact. **(GITA)**
8. Test for compaction compliance (minimum 95% standard compaction). **(GITA)**
9. Effective diversion and removal of all surface water from the prepared fill foundation (or subgrade) shall be maintained and monitored at all times during construction.

4.5.2 FILLING

Filling procedures as a minimum should include the following:

1. Fill areas with slopes > 20% should be benched to "key" the fill into the natural ground and minimise the risk of slip occurring at the fill/natural interface. Benches should be cut at regular intervals (maximum 5m spacings) along the contour to a minimum width of 0.5m. **(GITA)**
2. Depressions formed by the removal of trees, footings, underground services, etc should have all disturbed and softened soil removed and be backfilled with compacted approved material. **(GITA)**
3. Place fill in layers of suitable thickness for the capacity of the compaction plant available. A maximum (compacted) layer thickness of 300mm is recommended. **(GITA)**
4. Moisture condition incoming fill as necessary (before compaction) to achieve a standard moisture ratio in the approximate range as follows: **(GITA)**
 - Silty and Clayey SAND - 85% to 95%
 - CLAY, Silty and Sandy CLAY - 95% to 110%
5. Compact fill to the minimum dry density ratio as follows: **(GITA)**
 - Building areas - 95% (standard)
 - Pavement areas - top 300mm - 100 % (standard)
- below top 300mm - 95 % (standard)

4.5.3 EARTHWORKS SUPERVISION AND CERTIFICATION

Earthworks should be carried out in a systematic and responsible manner in accordance with the relevant parts of AS 3798 – 2007, and project specifications.

It is recommended that all earthworks be carried out under Level 1 geotechnical inspection and testing arrangements as detailed in Clause 8.2 of AS 3798. It is further recommended that as a minimum, the Level 1 statement of compliance include the following:

- A statement of certification that the fill foundation comprises either:
 1. Natural ground compliant with Table 5.1 of AS 3798; or
 2. Previous controlled fill compliant with Table 5.1 of AS 3798; or
 3. A geotechnical engineered alternative previously documented and approved by the superintendent.
- A statement of certification that the testing frequency for all fill compiles with Table 8.1 of AS 3798.
- A statement of certification that all fill compaction complies with Table 5.1 of AS 3798.
- A statement of certification for all other specified geotechnical items, for example:
 - Maximum particle size
 - Material quality (CBR, Shrink-Swell, etc)
 - Placement moisture content
- A statement of certification that the GITA complied with the requirements in Clause 8.2 of AS 3798.
- Certification by a Registered Professional Engineer of Queensland (RPEQ).

It is recommended that the specification writer include these requirements in the project specification and also in pre-start discussions.

The attached earthwork notes (Appendix F) should be considered and implemented during design and construction phases as appropriate.

4.6 CONSTRUCTION CONSIDERATIONS

4.6.1 TRAFFICABILITY

Trafficability conditions will in general decrease once vegetation and topsoil has been disturbed and would be further exacerbated if wet weather occurs in the period pending, or after commencement of earthworks.

The sand and clay soils encountered on the site are extremely sensitive to water and subsequent loss of strength, traction and trafficability in wet conditions. Repeated loading of very moist soils may also lead to further loss of strength. Particular care should be given in traversing the lower lying areas of the site during and following prolonged wet weather periods.

This report cannot predict what soil moisture conditions may prevail at the start of earthworks. It is therefore strongly recommended that the contractor (and other interested parties) become familiar with the site surface and subsurface conditions at the time of tendering and immediately prior to the start of earthworks.

As a matter of caution, it is recommended that temporary catch drains or mounds be constructed to divert overland flow away from cut and fill areas during earthworks. All earthworks areas should be maintained to ensure they are free draining at all times.

4.6.2 EXCAVATION CHARACTERISTICS

Excavation characteristics of soil, and to a lesser extent, weathered rock, can be crudely assessed based on the depth of penetration of the drilling rig using various bit attachments. However, it should be noted that excavation properties of weathered rock are largely dependent on the rock structure and in particular defect type, width, spacing and continuity. This information cannot be obtained from borehole drilling.

Rock properties which influence excavation characteristics (type, strength, weathering and structure) can vary both vertically and horizontally over very short distances. Therefore, any inference provided from borehole data must be considered as a guide only.

Excavations for footings and service trenches are expected to encounter near surface medium dense sands, stiff (or stronger) clays and extremely low strength (or stronger) rock. It is considered that bulk excavation of these residual soils and extremely weathered rock would be possible using conventional mechanical equipment such as small to medium plant (eg D4 – D6 or equivalent in bulk earthworks and 15t – 20t excavator in trenching) using multiple tines.

Where very low (or stronger) strength rock is encountered, medium to large plant (eg D6 – D10 or equivalent in bulk earthworks and large excavator (20 – 25t) in trenching) using a single tine may be required.

Where excavations extend into medium (or stronger) strength rock, specialised equipment (eg. 30t single ripper, rock breakers, etc or possibly explosives) may be required to expedite construction.

The following Table 5 provides a summary of the rock strength profiles for each borehole.

Table 5 Rock Strength Profile

Borehole No.	Weathered SANDSTONE (m)		
	Extremely Low Strength	Very Low Strength	Low to Medium Strength
1	0.6-1.3	1.3-4.5	
2	1.1-1.4		1.4-1.5*
3		2.7-4.5	
4	0.6-1.4	1.4-2.0	2.0-2.2*
5	0.5-0.8	0.8-4.5	
6		0.6-3.0	
8	2.6-3.2	3.2-4.5	
9	0.5-2.6	2.6-4.5	
10	2.6-2.8	2.8-4.5	
11	1.4-4.5		
12	1.2-1.4	1.4-4.1	
14	1.7-2.2	2.2-2.8	2.8-3.0*
15	0.8-1.0	1.0-1.8	1.8-3.0
16	2.6-2.8	2.8-3.8	3.8-4.5
19	3.8-4.5		
21	0.5-0.7	0.7-4.5	
22	0.5-0.7	0.7-1.4	1.4-1.5*

* Depth of borehole refusal using a tungsten carbide drill bit.

High plasticity clays may soften when wet and/or disturbed and become difficult to excavate with potential face failure. As such we recommend that any earthworks or foundation excavations are undertaken in dry weather conditions and appropriately support mechanism implemented. Provision should be made for effective diversion of surface water from outside the site. The surface runoff from the site should be treated to remove excess sediments before discharge.

Personnel should not be permitted to enter confined excavations in excess of 1.5m depth unless such excavations are battered or shored appropriately, and will need to be assessed at the time of construction.

Where excavation adjacent to existing structures is required, the Contractor should assess potential affects (i.e. vibration effects) on nearby structures.

4.6.3 BATTERS

If the geometry and the location of structures and/or services permit, battered slopes may be adopted. Provided slopes are **protected from groundwater** and surface water effects, the maximum slope angles provided in the following table may be used with a relatively low risk of instability (to achieve a factor of safety of greater than 1.5) for un-surcharged batters up to **3.0m** in vertical height. Where groundwater is encountered and/or where batters are higher than 3m, an additional assessment must be made on a case by case basis.

Table 6 Recommended Batter Slopes

Subsoil Material	Maximum Slope ⁽¹⁾	
	Temporary	Permanent
Controlled FILL ⁽²⁾ / Stiff (or stronger) CLAYS / Extremely Low Strength SANDSTONE	1V : 1H	1V : 3H
Loose to Medium Dense SANDS	1V : 2H	1V : 4H
Very Low Strength (or stronger) SANDSTONE	1V : 1H	1V : 1.5H

Note:

- (1) To be assessed and confirmed during construction earthworks and prior to final trimming of batters.
(2) Assumes fill is placed under level 1 condition in accordance with AS 3798, and certified as controlled fill by a Geotechnical Engineer (RPEQ).

All fill batters must be over filled, compacted and cut back to the design shape and alignment to ensure that the entire fill embankment including the exposed batter face is well compacted.

No surcharge loadings or services should be located or placed within 2.0m of the crest of an unsupported batter cut. Surface water should be diverted away from the crests of batter slopes. Permanent slopes should be protected from erosion by providing suitable vegetative or other erosion resistant cover.

Structures should not be founded, or services located, within the zone of influence above the batter.

If insufficient space exists for the construction of batters at the above maximum slopes, positive excavation support will be required in order to prevent instability.

4.7 SOIL DISPERSION

Soil dispersion is the tendency of the clay fraction of the soil to release and form a colloidal 'cloud' upon contact with water and can even occur within a still water body (i.e. without the influence of slope, mechanical action or run-off velocity).

4.7.1 EMERSON CLASS RESULTS

An Emerson number of 1 indicates a strongly dispersive soil, an Emerson number of 2 indicates a high risk of significant soil dispersion; an Emerson number of 3 indicates a moderate risk of significant soil dispersion; whilst an Emerson number ranging between 4 and 8 indicates a soil with low to negligible dispersion tendencies.

Emerson Class testing undertaken on four (4) topsoil samples across the proposed development area revealed Class 3 and 6 materials indicating a predominately low to moderate dispersion risk.

Emerson Class testing undertaken on six(6) subsoil samples varying in depths across the proposed development area revealed predominately Class 2, 3 and 5 materials indicating a moderate to high dispersion risk.

4.7.2 DISPERSION SOIL MANAGEMENT PLAN

Further details of the soil dispersion testing and required management considerations (where required) have been included in the accompanying Dispersive Soil Management Plan (DSMP) report prepared by Lambert and Rehbein.

4.8 PAVEMENTS

Laboratory testing was carried out on the expected subgrade material sampled from boreholes BH1, BH5, BH6, BH12, BH16, BH17, BH18 and BH19. The California Bearing Ratio (CBR) value represents the "strength" of the material when nominally compacted to 100% Standard Dry Density Ratio (SDDR) at the Optimum Moisture Content (OMC) and soaked for four (4) days. It should be noted that the CBR value is simply an index of strength at that particular density and moisture condition. The same material at a different density and moisture condition is likely to yield a lower or higher CBR value depending on the density and moisture circumstances existing at the time of testing. The modulus of subgrade reaction is derived from the CBR value based on published correlations.

Based on the laboratory test results the following values are recommended for preliminary pavement design considerations.

Table 7 Preliminary Pavement Parameters

B/hole No.	Depth (m)	Material Type	Field Moisture Content (%)	Maximum Dry Density (t/m ³)	Optimum Moisture Content (%)	Soaked CBR Value (%)	Modulus of Subgrade Reaction k (kPa/mm)
BH1	0.1-0.6	(CH) CLAY	18.5	1.62	21.0	1.5	15
BH5	0.15-0.3	(SC) Clayey SAND	6.6	1.93	13.0	25	76
BH6	0.6-1.1	(CI) Sandy CLAY	19.1	1.83	14.0	8	48
BH12	0.5-1.0	(CI) Sandy CLAY	16.9	1.68	19.0	1.5	15
BH16	0.2-1.0	(CH) CLAY with silt	20.9	1.68	20.0	2.0	18
BH17	1.2-2.0	(CI) Sandy CLAY	12.5	1.75	14.0	2.0	18
BH18	0.4-1.0	(CH) Sandy CLAY	25.5	1.57	23.5	4.0	32
BH19	0.5-1.0	(CH) Sandy CLAY	20.1	1.66	20.0	2.5	23

The laboratory test results reported CBR values ranging between 1.5% and 25% for samples collected throughout the proposed development site. Due to the variability of the subgrade soils sampled across the site at the time of the investigation, and considering the subgrade was not completely exposed, a soaked CBR value of 1.5 to 2.0% within the residual clays is recommended for preliminary design considerations. Additional testing will be required when the subgrade soils are exposed during construction.

NOTES:

- Use of the above values (in preliminary design) assumes that the subgrade will be compacted uniformly to a minimum SDDR of 100% and that the pavement will be well drained during construction and in-service.
- The above values must be confirmed during construction after the preliminary subgrade has been exposed. This may require additional testing if different materials are encountered in the exposed surface.
- The attached "CBR Standard Notes and Performance Warnings" (Appendix G) must be considered and implemented during the design and construction phases as appropriate.
- Pavement materials conforming with Logan City Council specification, MRS 11.05 specification (for unbound pavements) and corresponding density are recommended as follows:

Layer	Material	Min. Modified Dry Density Ratio (%)
Base (top) course	Subtype 2.1	95
Subbase (bottom) course	Subtype 2.3	95
Lower Subbase course	Subtype 2.5	95

5 BROADSCALE LANDSLIDE HAZARD ASSESSMENT

A broadscale landslide hazard assessment was conducted in general accordance with the Australian Geomechanics Society (AGS) Landslide Zone Working Group (2007) "Guideline for Landslide Risk Susceptibility, Hazard and Risk Zoning for Land Use Planning" Australian Geomechanics Society (AGS 2007a); and AGS Landslide Taskforce, Landslide Practise Note Working Group (2007) "Practice Note Guidelines for Landslide Risk Management" Australian Geomechanics Society (AGS 2007c). Reference has also been made to the Logan City Council's Planning Scheme, 2015 - Landslide Hazard and Steep Slopes mapping of the proposed development site.

5.1 POTENTIAL LANDSLIDE HAZARDS

The review of existing natural slopes can be explained by the presence of fill embankments of several farm dams, Sandstone ridges within the Marburg Formation, bank erosion associated with overland drainage pathway (gullies/creeks) and the Logan River banks. Based on a site walkover conducted by an experienced senior geotechnical engineer (RPEQ), the following hazards were identified:

Hazard A – Dam Embankments

Potential landslides associated with several farm dams (Dam 1, 2 and 3) situated within the eastern and western parcel of land (refer to the site plan in Appendix B).

The fill embankments range up to approximately 40° in magnitude. Significant erosion was observed within the fill embankment to Dam 1, evidenced by the downslope flow of the embankment materials and subsequent deterioration of the embankment (refer to photograph below).

Potential landslides are considered to be small to medium, rapid earth and debris slides identified within the fill materials.

Based on site observations (i.e. the existing failed embankment), the potential landslide travel distance would be considered to be in the range of approximately 10 to 20m.



Dam 1 – Failed Embankment



Dam 3 – Located within eastern land parcel

Hazard B – Deeply Incised Gullies

Potential landslides associated with the deeply incised gullies located along the central watercourse, at the northeastern boundary of the site and several locations adjacent to the Logan River.

Potential landslides are considered to be small to medium sized, moderate to rapid earth, debris and rock slides, topples and falls, associated with soil and rock materials. It is also considered that continuing active erosion of the soil/rock will exacerbate the landslide risk.

Based on the relatively steep slopes and alluvium profiles at the base of the embankments, the potential travel distance is considered to be less than approximately 20m.



Gully / Watercourse



Gully / Watercourse

Hazard C – Ridges/Hillslopes (Sandstone)

Potential landslides associated with the ridge/hillslopes straddling the northern and southern extents of the site.

The hillslopes generally ranged up to approximately 13% (8°) in magnitude. Evidence of shallow sandstone in areas and surface boulders (refer to photograph below).

Potential landslides are considered to be small sized, moderate to rapid earth, debris and rock slides, topples and falls, associated with soil and rock materials.

Based on the relatively long slopes, the potential travel distance is considered to be less than approximately 50m.



Sandstone Ridge



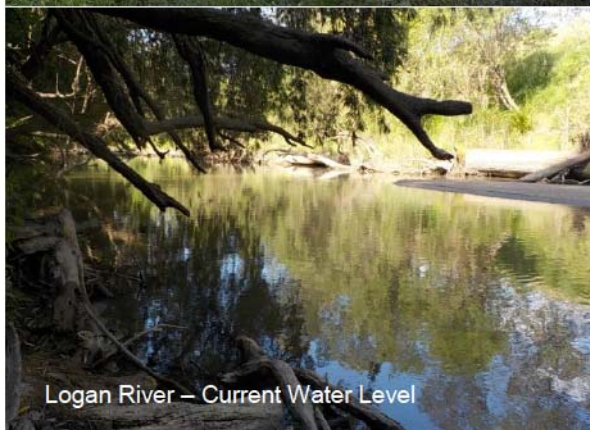
Sandstone Ridge

Hazard D – Logan River Embankments

Potential landslides associated with the steep banks of the Logan River at the eastern and southern boundary (section of approx. 880m length) of the site. The river embankments generally ranged in slopes up to 20% to 80% (15° to 40°) and typically comprised surface alluvium deposits overlying residual clays and sandstone. Vertical slopes were observed in some sections associated with small gullies.

Potential landslides are considered to be medium to large sized, moderate to rapid earth, debris and rock slides, rock topples and rock falls, associated with soil and rock materials. It is also considered that continuing active erosion of the soil/rock during flood events will exacerbate the landslide risk.

Based on the relatively site observations, the potential travel distance is considered to be less than approximately 30m.



The areas where potential Hazards A, B, C and D are predominant, can be identified in Figure 2 in Appendix H.

5.2 ANNUAL PROBABILITY

Hazard A – Dam Embankments

The annual probability for earth and debris slides within the fill embankments to occur is considered to be **likely** based on:

- Slope magnitudes ranging up to approximately 40° (fill embankments).
- Evidence of existing failed dam embankment and deterioration.
- Uncontrolled fill material associated with dam embankments (clay).

Hazard B – Deeply Incised Gullies

The annual probability for earth slides, debris slides, rock slides, topples and falls associated with the gully banks to occur is considered to be **possible to likely** based on:

- Observed existing landslide activities and active erosion.
- Slope magnitudes in excess of 30 degrees and near vertical in some sections.
- An alluvial profile at the crest of the embankment supported by stronger more competent residual clay and sandstone profile.

Hazard C – Ridges/Hillslopes (Sandstone)

The annual probability for earth and debris slides and rock slides, topples and falls to occur is considered to be **rare** based on:

- Slope magnitudes across the area less than 15°.
- No observed landslide activity within this part of the site.
- Predominately natural residual soil profile overlying relatively shallow bedrock (Sandstone).

Hazard D – Logan River Embankments

The annual probability for earth and debris slides and rock slides, topples and falls to occur is considered to be **likely** based on:

- Slope magnitudes generally ranging up to approximately 40° and near vertical in some sections (small gullies).
- Evidence of landslide instability observed in sections of the River embankment. Signs of active erosion of the soil/rock during large river flows (flood events).
- An alluvial profile at the base of the embankment supporting a stronger more competent residual clay and sandstone profile.

5.3 LANDSLIDE RISK ASSESSMENT

Landslide risk is assessed as the product of the annual probability (Hazard) and consequences to life and property.

5.3.1 RISK ASSESSMENT FOR LOSS OF LIFE

The risk assessment for loss of life of an individual is based on the following factors:

- The annual probability of the landslide (hazard).
- The probability of spatial impact of the landslide impacting a building (location) taking into account the travel distance and travel direction given the event.
- The temporal spatial probability (e.g. of the building or location being occupied by the individual) given the spatial impact and allowing for the possibility of evacuation given there is warning of the landslide.
- The vulnerability of the individual (probability of loss of life of the individual given the impact).

Based on the site assessment and collated data, the risk to loss of life across the site is considered to be **acceptable**.

5.3.2 RISK ASSESSMENT FOR DAMAGE TO PROPERTY

Risk assessment for damage to property is assessed based on the risk matrix as shown in the following table.

Table 8 Property Value Risk Matrix

Likelihood (with indicative value of approximate annual probability)		Consequences to Property (with indicative approximate cost of damage)				
		Catastrophic 200%	Major 60%	Medium 20%	Minor 5%	Nil 0.5%
Almost Certain	10 ⁻¹	VH	VH	VH	H	M
Likely	10 ⁻²	VH	VH	H	M	L
Possible	10 ⁻³	VH	H	M	M	VL
Unlikely	10 ⁻⁴	H	M	L	L	VL
Rare	10 ⁻⁵	M	L	L	VL	VL
Barely Credible	10 ⁻⁶	L	VL	VL	VL	VL

Hazard A – Dam Embankments

The consequence to property is considered to be **medium**. Therefore, based on a **likely** annual probability of a landslide occurring and a **medium** consequence to property, the site is considered to have a **high qualitative risk level**.

Hazard B – Deeply Incised Gullies

The consequence to property is considered to be **medium** on the basis that the proposed development (property) is not assessed to be at risk. Therefore, based on a **possible to likely** annual probability of a landslide occurring and a **medium** consequence to property, the site is considered to have a **medium to high qualitative risk level**.

Hazard C – Ridges/Hillslopes (Sandstone)

The consequence to property is considered to be **medium to major** on the basis that the proposed development (property) is not assessed to be at risk. Therefore, based on a **rare** annual probability of a landslide occurring and a **medium to major** consequence to property, the site is considered to have a **low qualitative risk level**.

Hazard D – Logan River Embankments

The consequence to property is considered to be **medium to major** on the basis that the proposed development (property) is not assessed to be at risk. Therefore, based on a **likely** annual probability of a landslide occurring and a **medium** consequence to property, the site is considered to have a **high to very high qualitative risk level**.

5.4 PROPOSED DEVELOPMENT STABILITY ASSESSMENT (HAZARD A, B AND C)

On the basis of the broadscale landslide risk assessment findings, the proposed development site is considered suitable for the proposed development, subject to the following design, construction and management guidelines and recommendations being implemented to reduce/maintain the risk level for damage to property to an acceptable level.

5.4.1 RECOMMENDATIONS

Hazard A – Dam Embankments

The landslide hazard frequency analysis indicates for Hazard A area in its present condition has a “high” qualitative risk of landslide instability.

It is envisaged that the existing farm dams and tracks **will not** form part of the final development. Furthermore, it is recommended that all uncontrolled fill (existing farm dam embankments, stockpiles, etc) will be removed during development works, thereby eliminating the landslide risk associated with Hazard A. To ensure reduce/maintain the risk of landslide instability to an acceptable level, all proposed future dams/bunds shall be designed and certified by a suitability qualified RPEQ Engineer. Additionally, all earthworks shall be conducted in accordance with the recommendations provided in Section 4.5 of this report.

Hazard B – Deeply Incised Gullies

The landslide hazard frequency analysis indicates for Hazard B area in its present condition has a “medium to high” qualitative risk of landslide instability.

It is recommended that planning and civil design be implemented to ensure a minimum horizontal setback distance of 15m is provided and maintained, between the crest of the creek/gully banks and all proposed development works to mitigate the overall risk of landslide instability to the development. This setback distance to properties and infrastructure is supported by the slope stability modelling outcomes presenting **FOS of greater than 1.5**.

Hazard C – Ridges/Hillslopes (Sandstone)

The landslide hazard frequency analysis indicates for Hazard C Areas in its present condition has a “low” qualitative risk of landslide instability. These areas are considered suitable for construction provided that the earthworks and construction considerations given in this report are adopted.

Stability across the site will be largely dependent on the provision of adequate drainage control. This is both during construction as well as post development. It has been assumed that due consideration has been given to the control of site and stormwater drainage management during the construction program. Furthermore, it is expected that all drainage systems will be designed and constructed in accordance with recognised building practices and standards, including all roof water and rainwater tank overflows being connected to appropriate stormwater outlet points.

Removal of vegetation should be kept to a minimum. Vegetation removal should only be undertaken where it is necessary in order to construct building platforms. However, the presence of trees and the impacts on site classification should also be considered. Refer to Section 4.2.3 for additional comments.

It is understood that earthworks will be undertaken as part of developing the allotments and infrastructure, therefore it should be noted that if cut/fill earthworks or retaining walls are proposed for building platform construction, the design levels and platform configurations proposed shall be reviewed and analysed in detail prior to the commencement of any earthworks to confirm the theoretical stability factor of safety (FOS) against failure is less greater than or equal to 1.5. Additionally, during the construction stage of the project, inspection and certification of the cut/fill batters and retaining walls should be carried out to ensure that the FOS can be achieved or whether remediation works are required.

All earthworks shall be conducted in accordance with the recommendations provided in Section 4.5 of this report.

Reference shall also be made to *The Australian Geoguides for Slope Management and Maintenance* provided in Appendix I for additional good construction practises for hillside development.

5.5 LOGAN RIVER EMBANKMENT STABILITY ASSESSMENT (HAZARD D)

It is expected that ongoing erosion in the lower slope/bank areas will occur in flood events due to the nature of the transient alluvial sands and clays and river movements. Flood waters and associated erosion may result in further bank failure in the soil profiles with the weathered sandstone.

To assess the embankment stability and determine failure surfaces in factor of safety terms, global stability modelling has been undertaken along the river embankment. An embankment profile was selected to capture the typical worst case bank configurations (ie. steep rock profile and deep alluvial sand bank) as well as a representation of the general embankment configuration.

Stability modelling of the typical worst case embankment profile was undertaken using the proprietary software program SLIDE Version 5.0 by linear analysis using Mohr-Coulomb material behaviour inputs. Morgenstern and Price's Method (1967) and the Bishop Simplified Method were implemented to determine the stability of failure surfaces.

5.5.1 GLOBAL STABILITY MODELLING

The Morgenstern and Price Method is an extension of the method of slices for determining the slope stability. By assuming the inclinations of the side forces follow a prescribed pattern, called $f(x)$; side force inclinations can be the same or can vary from slice to slice; side force inclinations are calculated in the process of solution so that all conditions of equilibrium are satisfied. This method is applicable for any shape of a slip surface.

The Morgenstern and Price Method has been statistically shown to produce factor of safety (FOS) values within a few percent of 'true' values.

Furthermore, in order to approximate the worst-case slip failure for each slope surface model, multiple analysis and restraints were chosen for the vertical components of the slip surface, resulting in the evaluation of approximately 5000 slip geometries per modelled slope surface.

For this assessment and proposed development a long term factor of safety of 1.5 is considered appropriate.

Two (2) scenarios have been modelled for the typical worst case cross section;

1. Steady state with current configuration (ie. alluvium and rock profile);
2. Rapid draw-down with current configuration; (ie. elevated porewater pressure).

A river level of RL13m was adopted for the steady state scenario and a 'Q100' (AEP 1%) rapid draw-down flood event of approximately RL31m was adopted for the rapid drawdown scenario.

Mohr-Coulomb and Hoek-Brown material behaviour parameters adopted for the subsurface models were estimated using the results from the field investigation, laboratory testing and published data.

Modelling results are provided in Appendix J.

On review of the modelling outcomes, it recommended that a minimum horizontal setback distance of 30m from the OM-05 Flood Hazard Overlay extents shall be maintained for all proposed development works, to maintain and mitigate the overall risk to the development. This setback distance to properties is supported by the slope stability modelling outcomes presenting **FOS of greater than 1.5**.

A low landslide risk has been assigned for Hazard D (ie. Logan River bank), on the basis that no residential properties or infrastructure development is proposed in setback area, therefore mitigating the consequence of potential landslides.

Moreover, subject to the guidelines provided below, in addition to the recommendations for earthworks provided in Section 4.5 of this report being adopted, construction of proposed development is unlikely to impact on the long term stability of the river bank.

5.5.2 RECOMMENDATIONS

In order to further reduce the landslide hazard risk and minimise the risk of future instability of the Logan River banks, adequate controls in terms of drainage, vegetation retention and surcharge minimization will need to be considered both during construction and throughout the life of the development.

The following construction and management guidelines are therefore recommended:

1. No development or structures to be located within Hazard D zone (within the 30m minimum horizontal setback distance, unless specific engineering analysis and design has been undertaken to confirm the theoretical stability factor of safety (FOS) against failure is less greater than or equal to 1.5.
2. Avoid the removal of vegetation on the bank slope.
3. No overland flow is to be directed over the crest of the slope towards the Logan River.

Reference shall also be made to *The Australian Geoguides for Slope Management and Maintenance* provided in Appendix I for additional good construction practises for hillside development.

6 COMMENTS AND LIMITATIONS

The development and any associated infrastructure should be designed to accommodate for the ground conditions reported and which otherwise may be encountered during construction.

The geotechnical parameters given in this report should be considered as preliminary only and subject to confirming inspections, and potentially additional testing by an experienced geotechnical professional at the construction stage. SGS offer inspection services and it is recommended that the client and their agents and contractors avail themselves of these services.

The interpretation of geotechnical reports and the preferred or proposed engineering outcomes are often compromised by the non-continuity of geotechnical consultants on a project. In addition, there is an inherent potential for a conflict of interest and therefore increased potential for inappropriate administration of the geotechnical specification when the GITA is commissioned by the contractor.

For these reasons, it is strongly recommended that:

1. SGS be commissioned as the Geotechnical Engineering Consultant and the GITA for all geotechnical related activities associated with this project; and
2. The Geotechnical Engineering Consultant and the GITA are commission independently of the contractor.

SGS cannot accept any responsibility for any interpretations and/or application of the contents of this report by any other Geotechnical Engineering Consultant or GITA.

SGS AUSTRALIA PTY LTD

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APPENDIX A: NOTES RELATING TO THIS REPORT

INTRODUCTION

The following notes are intended to complement the report and assist the reader in interpreting the report in regard to investigation procedures, definitions, terminology and limitations. Not all notes are necessarily relevant to this report.

The ground exhibits a variety of properties and characteristics which vary from place to place and can also change with time, weather patterns, changes in vegetation and human interaction. A geotechnical investigation puts into practice accepted methods and procedures to gather data relevant to the site and the proposed development. This report may contain such data obtained from drilling, excavation, inspection, sampling and testing. If so, the data are directly relevant to the ground at the place and time of the actual test sites. The client should be aware that in some cases soil conditions can change dramatically over short distances therefore conditions other than those represented in this report may occur on the site.

SITE INVESTIGATION PROCEDURES

a) Subsurface Investigations

Borehole/test locations are generally located to gain maximum coverage over the site giving consideration to contrasting topography. However, on occasions existing structures or other access restrictions do not permit ideal borehole locations.

Subsurface investigations may be carried out using one or more of the following methods:

- **Test Pits:** Test pits can be excavated by power equipment (backhoe, excavator etc) or in some cases by hand. Hand excavated test pits are usually limited to a maximum depth of about 1m.
- **Hand Auger:** Hand auger equipment is normally only used where drill rig access is unavailable. Hand auger refusal may occur on materials which could have otherwise been drilled if drill rig access was available.
- **Drill Rig:** **Spiral Flight Auger:** Spiral flight auger drilling is more economical and is usually adopted if ground conditions are suitable. Samples are returned to the surface by the flights or may otherwise be taken from the base of the borehole. Various drill bits may be attached to the auger during drilling. The depth of refusal of the different bit types can provide a useful indication of the strength of the material.
- **Drill Rig Wash Drilling:** Wash drilling is normally used below the water table when collapsing soils are encountered. Steel casing is pushed to support the collapsing soil and water is pumped through the drill rods to advance the borehole. The rods are withdrawn to allow sampling and testing at the base of the borehole.

b) Insitu Testing

- **Dynamic Cone Penetrometer:** The Dynamic Cone Penetrometer (DCP) test is carried out using a cone of 20mm diameter with a 30° tapered tip attached to steel rods of smaller diameter. The cone is driven by a 9kg hammer falling 510mm and results are recorded in blows per 100mm penetration. DCP test results can be used to estimate bearing capacity and insitu California Bearing Ratio. The test procedure is described in Australian Standard AS1289 6.3.2.
- **Standard Penetration Test:** The Standard Penetration Test (SPT) is carried out using a standard split steel tube sampler driven by a 63.5kg mass falling 760mm. Results are recorded in number of blows per 150mm penetration for a maximum depth of 450mm. The SPT "N" value is the sum of the blows for the 2nd and 3rd 150mm increments. The first 150mm is referred to as the seating penetration. In cases where the number of blows per 150mm exceeds 20, the result is recorded as 20/penetration (mm) and the 'N' value determined by linear interpolation. The SPT N value can be used to estimate allowable bearing pressure for foundations. The test procedure is detailed in Australian Standard AS1289 6.3.1.
- **Pocket Penetrometer:** The Pocket Penetrometer (PP) is used on undisturbed samples as a relatively simple and economical method of estimating the unconfined compressive strength of clay soils. The cohesive (undrained) shear strength (C_u) is generally taken as 0.5 of the PP value.

c) Sampling

The type and frequency of sampling and testing on a site is dependent on several issues including:

- * number and depth of boreholes
- * variability of soil types and conditions
- * type and magnitude of the development
- **Undisturbed Samples:** Undisturbed samples are taken by pushing a thin walled steel tube, 50mm diameter (U50) into cohesive soils. U50 samples are necessary for laboratory testing such as shrink-swell index, consolidation, shear strength etc.
- **Disturbed Samples:** Disturbed samples (D) are taken from drill augers, hand auger or open test pits. Disturbed samples are generally used for laboratory testing such as Atterberg Limits, Moisture Content, California Bearing Ratio, Particle Size Distribution etc.

d) Site Description

Underground Services: If underground services (sewer, stormwater etc) were observed during the site investigation, a record of the observation will usually be made on the site description notes included in this report. It should be noted however that our commission **does not** typically extend to locating underground services.

As underground services can potentially affect a structure in the vicinity, it is important that any underground services are located and considered in the development of the site.

- **Site Sketch:** The site sketch is intended only as a general pictorial of relative locations of boreholes and site features. Any dimensions, slope directions, magnitudes, feature orientation, north point, etc are approximate and should be used as a guide only.

e) *Soil and Rock Descriptions*

Soil and rock descriptions contained in this report are in general accordance with Appendix A2 and A3 of AS1726 'Geotechnical Site Investigations'. Details of the soil profiles provided in the Engineering Borehole Logs are based on visual descriptions of the soils and rock on site. Some soil descriptions may differ marginally from the format as described in AS1726, but this will in no way affect the results of this investigation.

- **Controlled Fill:** Controlled fill as described in this report refers to:

- (1) sand fill up to 0.8m deep and non-sand fill up to 0.4m deep which has been placed in layers not more than 150mm thick and compacted with mechanical compaction equipment.

or

- (2) fill which has been supervised and tested and for which a statement has been provided certifying compliance with Table 5.1 of AS3798 "Guidelines on Earthworks for Residential and Commercial Developments". The statement of compliance can only be provided by the Geotechnical Testing Authority under a Level 1 commission as defined in Appendix B of AS3798

and

- (3) subject to the results of this investigation verifying the quality of the fill.

- **Uncontrolled Fill:** Uncontrolled fill is described as any fill not meeting the requirements of controlled fill as defined above.

SITE CLASSIFICATION

Site Classification as defined in AS2870 "Residential Slabs and Footings" is divided into various classes depending on the y_s (predicted surface movement) and other relevant ground conditions.

The classes are:

CLASS	SOIL TYPE	y_s (mm)
A	stable (sand or rock)	
S	slightly reactive clay	$0 < y_s \leq 20$
M	moderately reactive clay	$20 < y_s \leq 40$
H1	highly reactive clay	$40 < y_s \leq 60$
H2	(very) highly reactive clay	$60 < y_s \leq 75$
E	extremely reactive clay	$y_s > 75$
P	problem	

Problem Site: Problem sites include those which are filled, have soft and/or collapsing soils, have soils subject to erosion, subject to abnormal moisture conditions, have bearing pressure $< 100\text{kPa}$ and any other sites which do not otherwise comply with class A, S, M, H or E requirements.

- **Effect of Trees:** Trees can have a significant drying effect resulting in abnormal moisture conditions of the soils in the vicinity of the tree(s). On reactive clay sites, this can have the effect of dramatically increasing the predicted surface movement (y_s) within the zone of influence of the tree(s). Past, present and future trees all potentially affect the site classification and subsequent footing and slab design. When it is known that large trees have been removed from a site, the site classifier or footing design engineer should be advised of the size, location and date of removal, so that appropriate consideration can be given to the footing design.

As recommended, and in accordance with AS2870, our preferred option for determination of Instability Index is by a combination of the shrink-swell index and identification of the soil profile. In some cases where shrink-swell index testing is not practicable, soil classification testing (Atterberg Limits and Particle Size Distribution) may have been used.

Values used in determination of the y_s value were:

- * soil profiles - refer borehole logs
- * shrinkage index - refer laboratory results
- * extreme suction change - 1.2pF
- * depth of suction change - 1.5 to 2.3
- * cracked zone - 0.5Hs (zero for reactive clay on controlled filled sites < 5 years old)
- * α cracked zone - 1.0
- * α uncracked zone - $2.0 - z/5$

where z = depth from ground surface to the centroid of the layer under consideration.

Provision of y_s values and/or site classification is intended for use in residential applications only. Where this information has been provided in non-residential cases it is done so as supplementary information only and may not be suitable for application to AS2870 design principles.

EARTHWORKS

All earthworks should be carried out in strict accordance with the full requirements of Australian Standard AS 3798 "Guidelines on Earthworks for Commercial and Residential Developments". If local authority requirements apply to the earthworks and differ from AS 3798 the more stringent requirements should be adopted. Unless approved, the following materials are generally not suitable for use as structural filling:

- * Organic Soils - topsoils, severely root affected soils and peat
- * Materials which may be contaminated with toxic substances through past site usages.
- * Filling which contains wood, metal, plastic, boulders and other deleterious materials.
- * Any other materials which have deleterious engineering properties.

Any earthworks carried out after the site investigation will change the findings of the report. Particular care and consideration should be given to the site reactivity and classification which is likely to change with cutting and/or filling of the site.

On cut-and-fill sloping sites the fill shall be controlled and extend a minimum of 1m past the edge of any construction areas. Embankment slopes shall be protected from erosion and be not steeper than two horizontal to one vertical. The suitability of any such embankments shall be verified by an experienced geotechnical engineer prior to construction.

GROUNDWATER

Groundwater levels (where encountered) are provided on the borelog sheets.

Generally, groundwater or seepage tends to travel in the more permeable layers over less permeable materials (ie. along sand/clay interfaces, fill/natural interfaces, etc.) and in joints of rock.

Bulk earthworks (ie. cut/fill or fill operations) should not be carried out during wet periods and should be delayed sufficiently to ensure the moisture content of the materials approximates the optimum moisture content for compaction.

Should footing excavation commence during or following an extended wet period and where the soil profile comprises sandy soils or sandy soils overlying clays, the surface sands will tend to collapse during trench excavations requiring temporary shoring and the construction of a sump area from which groundwater can be pumped. Under no circumstances should softening of foundation soils be allowed to occur.

It is advised that a test pit be excavated to assess ground conditions prior to commencing trench excavations or earthworks if prevailing weather conditions are poor.

SITE MANAGEMENT

The short and long term serviceability of the development is largely dependent upon a responsible approach by the developer, builder and the owner/occupant towards drainage, landscaping and vegetation. The following basic requirements apply to most developments.

- * **Surface Drainage**
Site preparations should include provision for slopes of no less than 1 vertical in 20 horizontal away from structures for a distance of at least 2m where possible. Spoon drains and catch drains should be constructed where necessary to direct surface drainage away from the structure.
- * **Landscaping**
Landscaping should be planned to ensure excessive watering and/or water ponding areas do not occur. Landscaping areas should be considered in the design of site drainage systems.
- * **Vegetation**
To reduce (but not eliminate) the possibility of damage to structural elements, trees should be restricted to a distance of no closer than 1.5 times the mature height from the structure.

A more extensive discussion on site management is contained in the CSIRO document "Guides to Home Owners on Foundation Maintenance and Footing Performance" and its recommendations should be followed in full.

THE REPORT

This report was compiled in accordance with the relevant standards, sound geotechnical practices and general market requirements as appropriate.

Unless instructed otherwise, this investigation and report does not address the following issues:

- * Existing and/or proposed mining influence
- * Slope stability
- * Specific site drainage requirements and potential effects
- * Contamination and/or hazardous materials on the site
- * Specific effects of post investigative works on the site
- * Existing underground services

The client should understand that whilst our investigation and report has been conducted within appropriate guidelines and with suitable diligence to accurately determine the ground conditions, on occasion, construction (earthworks/excavations) may indicate ground conditions differing from those shown in this report. Should this occur, SGS, should be advised immediately for further advice.

The work undertaken and reported is intended for the sole use of the client named on this report for the specific purpose of determining the parameters necessary for the design and construction of the development outlined. It may not contain sufficient information for other purposes. It is intended that this report will provide advice on geotechnical and related issues only and that SGS **will not** accept any responsibility for any structural design which does not fully consider and correctly apply the findings of this report.

It is important for the client to understand that long term serviceability of the structure will require all the findings of this report to be considered and undertaken. No responsibility will be accepted where these are not put into effect prior to commencement or in conjunction with construction as required.

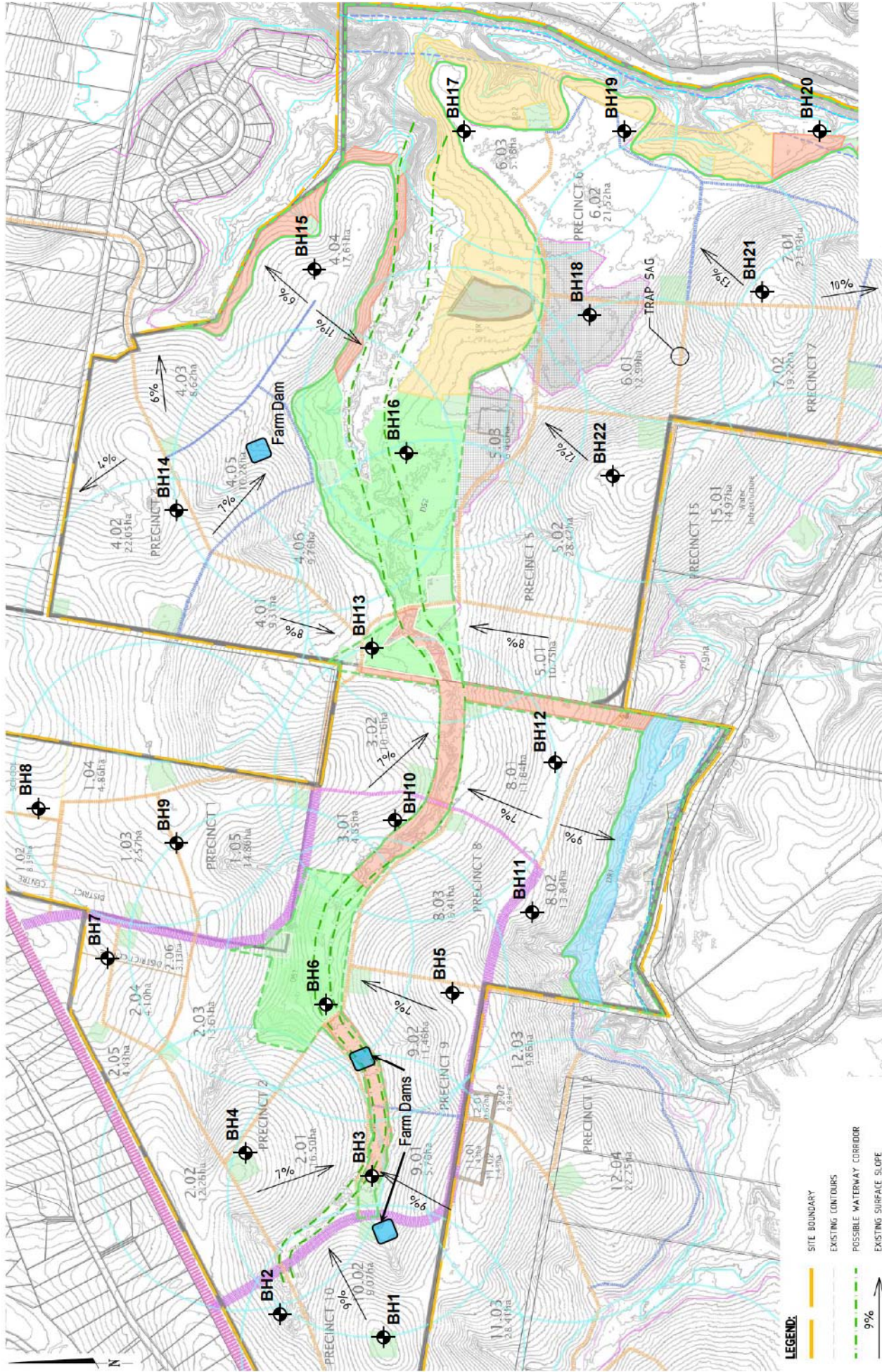
Any bearing capacity parameters provided in the report must be considered as preliminary only and should be confirmed by an experienced geotechnical engineer during construction.

INSPECTIONS

SGS provides inspection services for any geotechnical issues in relation to this report. We encourage the client, their designers and contractors, to make use of this service to verify the findings of the report, particularly if there is any doubt regarding the ground conditions being encountered during construction.



APPENDIX B: SITE PLAN – BOREHOLE LOCATIONS



SGS

SGS Australia Pty Ltd
ABN 44 000 964 278
Unit 1/18 Leanne Crescent
Lawnton, QLD 4501
t +61 (7) 3481 9444
www.sgs.com

TITLE		DRAWING NO.	
GEOTECHNICAL INVESTIGATION LOCATION PLAN		SGSE.16.220.SP01	
JOB LOCATION		SCALE	
RIVERBEND / TEVIOT BROOK, JIMBOOMBA QLD		SCALE NOT SHOWN	
CLIENT		DATE	SIZE
CELESTINO PTY LIMITED		20.01.16	A4



APPENDIX C: BOREHOLE RECORDS, SAMPLING AND INSITU TEST RESULTS



BOREHOLE LOG

BOREHOLE NO.: **BH1**
SHEET: 1 OF 1

Engineering and Environmental Consultants
Ph 3481 9444
AU.IND.Lawnton@sgs.com

CLIENT:	CELESTINO PTY LIMITED	DATE COMMENCED:	9.11.2016
PROJECT:	GEOTECHNICAL INVESTIGATION	DATE COMPLETED:	9.11.2016
LOCATION:	TEVIOT ROAD, JIMBOOMBA	LOGGED BY:	J.SIPPEL
JOB NUMBER:	SGSE/16/220	CHECKED BY:	R. MAXWELL

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Easting:	494729.00	Surface R.L.:
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northing:	6921439.00	Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SA/TC	Open Hole	7					SM	NATURAL - Silty SAND, fine to medium grained, grey (TOPSOIL - 80mm)	D	MD		D		
		8					CH	Silty CLAY, high plasticity, grey mottled orange, red	M	VSt				
		7												
		6										CBR		
		5		0.5										
		7												
		23					XW	SANDSTONE, fine to medium grained, yellow, grey, trace of high plasticity clay lenses	D-M	EL				
		>25												
		-		1.0										
		-					DW	SANDSTONE, fine to medium grained, brown, grey	D	EL				
				1.5										
				2.0										
				2.5										
				3.0										
				3.5										
				4.0										
				4.5										

End of BH1 at 4.5m



BOREHOLE LOG

BOREHOLE NO.: **BH2**

SHEET: 1 OF 1

Engineering and Environmental Consultants
Ph 3481 9444
AU.IND.Lawton@sgs.com

CLIENT:	CELESTINO PTY LIMITED	DATE COMMENCED:	9.11.2016
PROJECT:	GEOTECHNICAL INVESTIGATION	DATE COMPLETED:	9.11.2016
LOCATION:	TEVIOT ROAD, JIMBOOMBA	LOGGED BY:	J.SIPPEL
JOB NUMBER:	SGSE/16/220	CHECKED BY:	R. MAXWELL

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Easting:	494805.00	Surface R.L.:	
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northing:	6921680.00	Datum:	

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SA/TC	Open Hole	7					SM	NATURAL - Silty SAND, fine to medium grained, grey (TOPSOIL - 90mm)	D	MD		D		
		9					CH	Silty Sandy CLAY, high plasticity, grey mottled orange, fine to medium grained sand, trace fine sized sub-rounded gravel	M	H		D		
		8												
		6												
		5		0.5										
		5												
		6												
		4												
		4		1.0										
		5												
		6												
		9					XW	SANDSTONE, fine to medium grained, yellow, grey	D	EL				
		13												
		>25					DW	SANDSTONE, fine grained, yellow, grey	D	M				
				1.5										
								End of BH2 at 1.5m					Maximum TC Bit Refusal @ 1.5m depth	
				2.0										
				2.5										
				3.0										
				3.5										
				4.0										
				4.5										

BOREHOLE LOG

BOREHOLE NO.: **BH4**

SHEET: 1 OF 1

CLIENT: **CELESTINO PTY LIMITED** DATE COMMENCED: **9.11.2016**
PROJECT: **GEOTECHNICAL INVESTIGATION** DATE COMPLETED: **9.11.2016**
LOCATION: **TEVIOT ROAD, JIMBOOMBA** LOGGED BY: **J.SIPPEL**
JOB NUMBER: **SGSE/16/220** CHECKED BY: **R. MAXWELL**

Drill Contractor: **SGS AUSTRALIA** Bore Size: **100mm** Hole Angle: **-90°** Easting: **495591.00** Surface R.L.:
Drill Model: **DTS05** Drill Fluid: **-** Bearing: **-** Northing: **6921815.00** Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SA/TC	Open Hole	4			Matburg Formation		SM	NATURAL - Silty SAND, fine grained, grey (TOPSOIL - 90mm)	D	MD		D		
		4												
		5					CH	Silty CLAY, high plasticity, grey mottled orange	D-M	VSt				
		5		0.5								D		
		5												
		6												
		>25					DW	SANDSTONE, fine to medium grained, orange, yellow and grey	D	VL				
		-		1.0										
		-					XW	SANDSTONE, fine to medium grained, orange, grey and yellow, with high plasticity clay lenses	D-M	EL-VL				
		-		1.5			DW	SANDSTONE, fine to medium grained, orange, grey and yellow, with high plasticity clay lenses	D	VL				
				2.0			DW	SANDSTONE, fine to medium grained, orange, grey and yellow, with high plasticity clay lenses	D	LS				
				2.5				End of BH4 at 2.2m					Maximum TC Bit Refusal @ 2.2m depth	
				3.0										
				3.5										
				4.0										
				4.5										



BOREHOLE LOG

BOREHOLE NO.: **BH5**

SHEET: 1 OF 1

Engineering and Environmental Consultants
Ph 3481 9444
AU.IND.Lawnton@sgs.com

CLIENT:	CELESTINO PTY LIMITED	DATE COMMENCED:	8.11.2016
PROJECT:	GEOTECHNICAL INVESTIGATION	DATE COMPLETED:	8.11.2016
LOCATION:	TEVIOT ROAD, JIMBOOMBA	LOGGED BY:	J.SIPPEL
JOB NUMBER:	SGSE/16/220	CHECKED BY:	R. MAXWELL

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Easting:	495903.00	Surface R.L.:	
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northing:	6921355.00	Datum:	

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SA/TC	Open Hole	4					SM	NATURAL - Silty SAND, fine grained, grey-brown (TOPSOIL - 200mm)	D	MD		D		
		4												
		6					SP	SAND, fine to medium grained, grey, yellow brown, with silt	D	MD		D		
		9												
		7		0.5			CH	Silty Sandy CLAY, high plasticity, grey mottled red and orange	M	VSt				
		9					XW	SANDSTONE, fine to medium grained, orange, grey and yellow	D	EL				
		9												
		7												
		>25					DW	SANDSTONE, fine to medium grained, orange, grey and yellow	D	VL				
		-		1.0										
				1.5										
				2.0										
				2.5										
				3.0										
				3.5										
				4.0										
				4.5										

End of BH5 at 4.5m

CLIENT: CELESTINO PTY LIMITED	DATE COMMENCED: 8.11.2016
PROJECT: GEOTECHNICAL INVESTIGATION	DATE COMPLETED: 8.11.2016
LOCATION: TEVIOT ROAD, JIMBOOMBA	LOGGED BY: J.SIPPEL
JOB NUMBER: SGSE/16/220	CHECKED BY: R. MAXWELL

Drill Contractor: SGS AUSTRALIA	Bore Size: 100mm	Hole Angle: -90°	Easting: 495864.00	Surface R.L.:
Drill Model: DTS05	Drill Fluid: -	Bearing: 	Northing: 6921664.00	Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water		
SA/TC	Open Hole	15			Alluvium		MH	NATURAL - Sandy SILT, medium to high plasticity, grey, fine grained sand (TOPSOIL - 100mm)	D	MD		D	PP=510kPa REC=120mm			
		3					CH	Silty CLAY, high plasticity, grey mottled orange	M	St-VSt		D				
		3														
		3														
		3		0.5											U ₅₀	
		4														
		2					SC	Clayey SAND, fine to medium grained, orange mottled grey and yellow	M-W	L-MD						
		3														
		2														
		3		1.0											CBR	
		4														
		4														
		5														
		5		1.5												
		5														
		5														
		5														
		3		2.0			SC	Clayey SAND, fine to medium grained, orange mottled grey and yellow	W	L-MD						
		2			Marburg Formation											
		1														
		2														
		3		2.5												
		7														
		1														
		1														
		2														
		4														
		3		3.0												
		2														
		3														
		5			CH	Silty Sandy CLAY, high plasticity, grey mottled orange, with fine to medium grained sand	M	VSt								
		9		3.5												
		7														
		7														
		10														
		14														
		11		4.0												
								</								

End of BH6 at 4.5m

BOREHOLE LOG

BOREHOLE NO.: **BH7**

SHEET: 1 OF 1

CLIENT:	CELESTINO PTY LIMITED	DATE COMMENCED:	9.11.2016
PROJECT:	GEOTECHNICAL INVESTIGATION	DATE COMPLETED:	9.11.2016
LOCATION:	TEVIOT ROAD, JIMBOOMBA	LOGGED BY:	J.SIPPEL
JOB NUMBER:	SGSE/16/220	CHECKED BY:	R. MAXWELL

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Easting:	496011.00	Surface R.L.:
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northing:	6922257.00	Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water	
SA/TC	Open Hole	5			Marburg Formation		SM	NATURAL - Silty SAND, fine to medium grained, grey (TOPSOIL - 140mm)	D	MD		D	PP=250kPa REC=260mm		
		5					CH	Silty CLAY, high plasticity, grey mottled red, trace fine to medium grained sand	D-M	VSt		D			
		5													
		5													
		4		0.5											
		3					CH	Silty CLAY, high plasticity, grey mottled red, trace fine to medium grained sand	M	St					
		2													
		1													U ₅₀
		1													
		2		1.0											
		2													
		4					CH	Silty CLAY, high plasticity, grey mottled red, orange, trace fine to coarse sized sub-angular gravel	M	VSt					
		4													
		4													
		5		1.5											
		5													
		5													
		7													
		7		2.0											
	</														

CLIENT: CELESTINO PTY LIMITED	DATE COMMENCED: 9.11.2016
PROJECT: GEOTECHNICAL INVESTIGATION	DATE COMPLETED: 9.11.2016
LOCATION: TEVIOT ROAD, JIMBOOMBA	LOGGED BY: J.SIPPEL
JOB NUMBER: SGSE/16/220	CHECKED BY: R. MAXWELL

Drill Contractor: SGS AUSTRALIA	Bore Size: 100mm	Hole Angle: -90°	Easting: 496284.00	Surface R.L.:
Drill Model: DTS05	Drill Fluid: -	Bearing: 	Northing: 6922174.00	Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SA/TC	Open Hole	4			Marburg Formation		SM	NATURAL - Silty SAND, fine to medium grained, grey (TOPSOIL - 90mm)	D	MD		D	PP=550kPa REC=140mm	
		6												
		5					CH	Silty CLAY, high plasticity, grey mottled orange and red, with fine sized sub-rounded gravel	M	VSt		D		
		4		0.5										
		4					CH	Silty CLAY, high plasticity, grey-brown mottled red, trace fine to medium grained sand	M	VSt		U ₅₀		
		4												
		5												
		6												
		6		1.0										
		5					CH	Silty CLAY, high plasticity, grey mottled red, yellow and orange	M	VSt				
		4												
		6												
		7												
		9		1.5										
		10												
		8					CI	Silty Sandy CLAY, medium to high plasticity, grey mottled red and orange, fine to medium grained sand	M	H				
		9												
		11												
		12		2.0										
							CH	Silty CLAY, high plasticity, grey mottled red and orange	M	VSt				
				2.5										
							XW	SANDSTONE, fine to medium grained, grey and red, with high plasticity clay lenses	D-M	EL				
				3.0										
							XW	SANDSTONE, fine to medium grained, grey and red, with high plasticity clay lenses	D	EL				
				3.5										
				4.0										
				4.5										

End of BH8 at 4.5m



BOREHOLE LOG

BOREHOLE NO.: **BH9**
SHEET: 1 OF 1

Engineering and Environmental Consultants
Ph 3481 9444
AU.IND.Lawnton@sgs.com

CLIENT:	CELESTINO PTY LIMITED	DATE COMMENCED:	9.11.2016
PROJECT:	GEOTECHNICAL INVESTIGATION	DATE COMPLETED:	9.11.2016
LOCATION:	TEVIOT ROAD, JIMBOOMBA	LOGGED BY:	J.SIPPEL
JOB NUMBER:	SGSE/16/220	CHECKED BY:	R. MAXWELL

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Easting:	496148.00	Surface R.L.:
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northing:	6921963.00	Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SA/TC	Open Hole	3					SM	NATURAL - Silty SAND, fine grained, grey (TOPSOIL - 110mm)	D	L-MD		D		
		5					CH	Silty CLAY, high plasticity, grey mottled yellow and orange, trace of fine to medium grained sand	D-M	St-VSt		D		
		3												
		4												
		5		0.5										
		9					XW	SANDSTONE, fine to medium grained, grey, yellow and orange, with tree roots	D	EL				
		>25												
		-												
		-		1.0										
		-												
							XW	SANDSTONE, fine to medium grained, grey, yellow and orange	D	EL-VL				
				1.5										
				2.0										
				2.5										
							DW	SANDSTONE, fine to medium grained, grey, yellow and orange	D	VL				
				3.0										
				3.5										
				4.0										
				4.5										

End of BH9 at 4.5m

BOREHOLE LOG

BOREHOLE NO.: **BH10**

SHEET: 1 OF 1

CLIENT:	CELESTINO PTY LIMITED	DATE COMMENCED:	8.11.2016
PROJECT:	GEOTECHNICAL INVESTIGATION	DATE COMPLETED:	8.11.2016
LOCATION:	TEVIOT ROAD, JIMBOOMBA	LOGGED BY:	J.SIPPEL
JOB NUMBER:	SGSE/16/220	CHECKED BY:	R. MAXWELL

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Easting:	496218.00	Surface R.L.:
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northing:	6921392.00	Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SA/TC	Open Hole	6			Marburg Formation		SM	NATURAL - Silty SAND, fine to medium grained, grey-brown (TOPSOIL -100mm)	D	MD		D		
		5												
		5												
		5												
		10		0.5			CI	Silty Sandy CLAY, medium to high plasticity, grey mottled orange and yellow, fine to coarse grained sand	M	VSt-H		D		
		6												
		5												
		5												
		6												
		6		1.0										
		3					CH	Silty CLAY, high plasticity, grey mottled orange	M	St				
		2												
		3												
		2												
		3		1.5										
		3												
		4												
		4												
		4		2.0										
		5												
		6												
		6												
		6												
		7		2.5			XW	SANDSTONE, fine to medium grained, grey, yellow and orange	D	EL				
		7												
		9												
		20												
		>25					DW	SANDSTONE, fine to medium grained, grey, yellow and orange	D	VL				
		-		3.0										
							XW	SANDSTONE, fine to medium grained, grey, yellow and orange	D-M	EL-VL				
				3.5										
				4.0			DW	SANDSTONE, fine to medium grained, red, orange and grey	D	VL				
				4.5										

End of BH10 at 4.5m



BOREHOLE LOG

BOREHOLE NO.: **BH11**

SHEET: 1 OF 1

Engineering and Environmental Consultants
Ph 3481 9444
AU.IND.Lawnton@sgs.com

CLIENT:	CELESTINO PTY LIMITED	DATE COMMENCED:	8.11.2016
PROJECT:	GEOTECHNICAL INVESTIGATION	DATE COMPLETED:	8.11.2016
LOCATION:	TEVIOT ROAD, JIMBOOMBA	LOGGED BY:	J.SIPPEL
JOB NUMBER:	SGSE/16/220	CHECKED BY:	R. MAXWELL

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Easting:	496312.00	Surface R.L.:
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northing:	6921017.00	Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SA/TC	Open Hole	3					SM	NATURAL - Silty SAND, fine to medium grained, grey (TOPSOIL - 120mm)	D	L-MD		D	PP>600kPa REC=200mm	
		2												
		3					CH	Silty CLAY, high plasticity, grey mottled red and orange	M	St				
		3										D		
		4		0.5			CH	Silty CLAY, high plasticity, grey mottled yellow and orange	M	VSt				
		4												
		4												
		4												
		4		1.0										
		5												
		5												
		6												
		7												
		>25		1.5			XW	SANDSTONE, fine to medium grained, orange-brown	D	EL-VL				
		-												
		-												
		-												
		-		2.0			XW	SANDSTONE, fine to medium grained, with high plasticity clay lenses, grey mottled red and orange	D-M	EL				
		-												
		-												
		-		2.5										
		-												
		-												
		-		3.0										
		-												
		-												
		-		3.5										
		-												
		-												
		-		4.0										
		-												
		-												
		-		4.5										

End of BH11 at 4.5m



SHEET: 1 OF 1

DATE COMMENCED: **8.11.2016**
DATE COMPLETED: **8.11.2016**
LOGGED BY: **J.SIPPEL**
CHECKED BY: **R. MAXWELL**

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Easting:	496502.00	Surface R.L.:	
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northing:	6921026.00	Datum:	

[illegible]

End of BH12 at 4.5m

Engineering and Environmental Consultants
Ph 3481 9444
AU.IND.Lawnton@sgs.com

CLIENT: **CELESTINO PTY LIMITED**
PROJECT: **GEOTECHNICAL INVESTIGATION**
LOCATION: **TEVIOT ROAD, JIMBOOMBA**
JOB NUMBER: **SGSE/16/220**

DATE COMMENCED: **8.11.2016**
DATE COMPLETED: **8.11.2016**
LOGGED BY: **J.SIPPEL**
CHECKED BY: **R. MAXWELL**

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Easting:	496822.00	Surface R.L.:	
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northing:	6921586.00	Datum:	

[illegible]

End of BH13 at 4.5m

BOREHOLE LOG

BOREHOLE NO.: **BH14**

SHEET: 1 OF 1

CLIENT:	CELESTINO PTY LIMITED	DATE COMMENCED:	7.11.2016
PROJECT:	GEOTECHNICAL INVESTIGATION	DATE COMPLETED:	7.11.2016
LOCATION:	TEVIOT ROAD, JIMBOOMBA	LOGGED BY:	J.SIPPEL
JOB NUMBER:	SGSE/16/220	CHECKED BY:	R. MAXWELL

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Easting:	497186.00	Surface R.L.:
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northing:	6922134.00	Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SA/TC	Open Hole	9			Marburg Formation		SM	NATURAL - Silty SAND, fine to medium grained, grey (TOPSOIL - 50mm)	D	MD		D	PP>600kPa REC=185mm	
		13					CH	Silty CLAY, high plasticity, grey mottled orange brown, trace of fine to medium grained sand	M	VSt		D		
		6												
		5												
		6		0.5										
		5												
		6												
		8					CH	Sandy CLAY, high plasticity, grey-brown, fine grained sand, with silt	M	VSt				
		7												
		5		1.0								U ₅₀		
		-												
		4					CH	Sandy CLAY, high plasticity, grey-brown mottled orange brown, fine grained sand, with silt	D-M	VSt				
		7												
		7		1.5										
		5												
		11												
		20/70					XW	SANDSTONE, fine grained, yellow-brown, with high plasticity clay lenses	D	EL		D		
				2.0										
							DW	SANDSTONE, fine grained, grey-brown and yellow-brown, with high plasticity clay lenses	D	VL		D		
				2.5										
							DW	SANDSTONE, fine grained, grey-brown and yellow-brown, with high plasticity clay lenses		VL-L				
				3.0										
								End of BH14 at 3m					Maximum TC Bit Refusal @ 3.0m depth	
				3.5										
				4.0										
				4.5										



BOREHOLE LOG

BOREHOLE NO.: **BH15**

SHEET: 1 OF 1

Engineering and Environmental Consultants
Ph 3481 9444
AU.IND.Lawnton@sgs.com

CLIENT:	CELESTINO PTY LIMITED	DATE COMMENCED:	7.11.2016
PROJECT:	GEOTECHNICAL INVESTIGATION	DATE COMPLETED:	7.11.2016
LOCATION:	TEVIOT ROAD, JIMBOOMBA	LOGGED BY:	J.SIPPEL
JOB NUMBER:	SGSE/16/220	CHECKED BY:	R. MAXWELL

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Easting:	497889.00	Surface R.L.:	
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northing:	6921693.00	Datum:	

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SA/TC	Open Hole	5			Marburg Formation		SM	NATURAL - Silty SAND, fine to medium grained, grey (TOPSOIL - 60mm)	D	MD		D		
		5					CH	Silty Sandy CLAY, medium to high plasticity, brown mottled grey and orange	M	VSt				
		7												
		9												
		7		0.5			CH	Silty Sandy CLAY, medium to high plasticity, orange mottled yellow and grey	M	VSt				
		6										D		
		5												
		17												
		20/60					XW	SANDSTONE, fine to medium grained, orange and yellow	D	EL				
				1.0			DW	SANDSTONE, fine to medium grained, orange and yellow, with high plasticity clays	D	VL				
				1.5										
				2.0			DW	SANDSTONE, fine to medium grained, orange and yellow, with high plasticity clays	D	VL-LS				
				2.5										
				3.0										
								End of BH15 at 3m						
				3.5										
				4.0										
				4.5										

BOREHOLE LOG

BOREHOLE NO.: **BH16**

SHEET: 1 OF 1

CLIENT:	CELESTINO PTY LIMITED	DATE COMMENCED:	7.11.2016
PROJECT:	GEOTECHNICAL INVESTIGATION	DATE COMPLETED:	7.11.2016
LOCATION:	TEVIOT ROAD, JIMBOOMBA	LOGGED BY:	J.SIPPEL
JOB NUMBER:	SGSE/16/220	CHECKED BY:	R. MAXWELL

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Easting:	497060.00	Surface R.L.:	
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northing:	6921282.00	Datum:	

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SA/TC	Open Hole	5			Alluvium		MH	Sandy SILT, medium plasticity, grey-brown, fine to medium grained sand, with organics (TOPSOIL - 110mm)	D	VSt		D	PP=350kPa REC=170mm PP=100kPa REC=205mm	
		4					CH	Silty CLAY, high plasticity, orange-brown mottled grey, trace of fine grained sand	D-M	VSt				
		4												
		4		0.5			CH	Silty CLAY, high plasticity, grey mottled orange, red-brown	M	St		U ₅₀		
		2										CBR		
		2												
		1												
		1		1.0			CH	Silty CLAY, high plasticity, grey mottled orange, red-brown	M	St		U ₅₀		
		3												
		4												
		3												
		4												
		5		1.5			CH	Silty CLAY, high plasticity, grey mottled orange, red-brown	M	VSt				
		6												
		5												
		5												
		-		2.0										
		-												
		4												
		3												
		3												
		4		2.5										
		5												
		10					XW	SANDSTONE, fine to medium grained, yellow and orange, trace of clay lenses	D	EL				
		20/30					XW	SANDSTONE, fine to medium grained, yellow and orange, trace of clay lenses	D	VL				
				3.0										
				3.5										
				4.0			DW	SANDSTONE, fine to medium grained, yellow and orange, trace of clay lenses	D	VL-LS				
				4.5										

End of BH16 at 4.5m



SHEET: 1 OF 1

DATE COMMENCED: **7.11.2016**
DATE COMPLETED: **7.11.2016**
LOGGED BY: **J.SIPPEL**
CHECKED BY: **R. MAXWELL**

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Easting:	498366.00	Surface R.L.:	
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northing:	6921245.00	Datum:	

[illegible]

End of BH17 at 4.5m

BOREHOLE LOG

BOREHOLE NO.: **BH18**

SHEET: 1 OF 1

CLIENT:	CELESTINO PTY LIMITED	DATE COMMENCED:	7.11.2016
PROJECT:	GEOTECHNICAL INVESTIGATION	DATE COMPLETED:	7.11.2016
LOCATION:	TEVIOT ROAD, JIMBOOMBA	LOGGED BY:	J.SIPPEL
JOB NUMBER:	SGSE/16/220	CHECKED BY:	R. MAXWELL

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Easting:	497748.00	Surface R.L.:
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northing:	6920894.00	Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SA/TC	Open Hole	4			Alluvium		MH	NATURAL - Clayey SILT, high plasticity, grey-brown, with fine grained sand (TOPSOIL - 100mm)	D	VSt		D	PP=250kPa REC=130mm	
		6					MH	Clayey SILT, high plasticity, grey-brown	D-M	VSt				
		4										D		
		4												
		3		0.5	Marburg Formation		CH	Silty CLAY, high plasticity, grey mottled yellow and orange-brown, trace of fine grained sand	M	St		CBR U ₅₀		
		2												
		2												
		2												
		2		1.0										
		2												
		4					CH	Silty CLAY, high plasticity, grey mottled yellow and orange-brown, trace of fine grained sand	M	St-VSt				
		6												
		7		1.5										
		8												
		10												
		10												
		9		2.0			CH	Silty CLAY, high plasticity, orange-brown mottled grey, with fine to medium grained sand, trace of fine sized sub-rounded gravel	M	VSt				
		11												
		10												
				2.5										
				3.0										
				3.5			CH	Silty CLAY, high plasticity, orange-brown mottled grey, with fine to medium grained sand, trace of fine sized sub-rounded gravel	M	H				
				4.0										
				4.5										

End of BH18 at 4.5m



BOREHOLE LOG

BOREHOLE NO.: **BH20**

SHEET: 1 OF 1

Engineering and Environmental Consultants
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CLIENT:	CELESTINO PTY LIMITED	DATE COMMENCED:	7.11.2016
PROJECT:	GEOTECHNICAL INVESTIGATION	DATE COMPLETED:	7.11.2016
LOCATION:	TEVIOT ROAD, JIMBOOMBA	LOGGED BY:	J.SIPPEL
JOB NUMBER:	SGSE/16/220	CHECKED BY:	R. MAXWELL

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Easting:	498288.00	Surface R.L.:	
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northing:	6920270.00	Datum:	

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SA/TC	Open Hole	5			Marburg Formation		SM	NATURAL - Silty SAND, fine grained, grey (TOPSOIL - 180mm)	D	MD		D	PP>600kPa REC=185mm	
		6					CH	Silty Sandy CLAY, high plasticity, grey-brown mottled yellow, fine grained sand	D-M	VSt		D		
		6		0.5										
		5												
		5											PP>600kPa REC=185mm	
		5												
		6												
		6												
		5		1.0			CH	Silty Sandy CLAY, high plasticity, grey-brown mottled yellow, with fine sized rounded gravel	M	VSt-H		U ₅₀		
		5											PP>600kPa REC=250mm	
		-												
		5												
		6												
		8		1.5										
		7												
		10												
		7												
		6												
		5		2.0										
		7												
		10												
		13												
		14		2.5										
		15												
		9												
		9												
		9												
		10												
		11		3.0										
		-					CH	Silty CLAY, high plasticity, grey	M	VSt		U ₅₀		
				3.5									PP>600kPa REC=250mm	
							CH	Silty Sandy CLAY, high plasticity, grey mottled orange, fine to medium grained sand, trace of calcite	M	VSt				
				4.0										
				4.5										

End of BH20 at 4.5m



BOREHOLE LOG

BOREHOLE NO.: **BH21**

SHEET: 1 OF 1

Engineering and Environmental Consultants
Ph 3481 9444
AU.IND.Lawnton@sgs.com

CLIENT:	CELESTINO PTY LIMITED	DATE COMMENCED:	9.11.2016
PROJECT:	GEOTECHNICAL INVESTIGATION	DATE COMPLETED:	9.11.2016
LOCATION:	TEVIOT ROAD, JIMBOOMBA	LOGGED BY:	J.SIPPEL
JOB NUMBER:	SGSE/16/220	CHECKED BY:	R. MAXWELL

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Easting:	497810.00	Surface R.L.:
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northing:	6920369.00	Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SA/TC	Open Hole	10					SM	NATURAL - Silty SAND, fine grained, grey (TOPSOIL - 110mm)	D	D		D		
		13												
		9					CH	Silty Sandy CLAY, medium to high plasticity, grey-yellow mottled orange, fine grained sand	M	VSt-H				
		8										D		
		7		0.5			XW	SANDSTONE, fine to medium grained, yellow, grey and orange	D	EL				
		8												
		7					XW	SANDSTONE, fine to medium grained, yellow, grey and orange	D	VL				
		>25												
				1.0										
				1.5										
				2.0			XW	SANDSTONE, fine to medium grained, yellow, grey and orange, with high plasticity clay lenses	D-M	EL-VL				
				2.5										
				3.0										
				3.5										
				4.0										
				4.5			DW	SANDSTONE, fine to medium grained, grey-yellow	D	VL				

End of BH21 at 4.5m

BOREHOLE LOG

BOREHOLE NO.: **BH22**

SHEET: 1 OF 1

CLIENT:	CELESTINO PTY LIMITED	DATE COMMENCED:	9.11.2016
PROJECT:	GEOTECHNICAL INVESTIGATION	DATE COMPLETED:	9.11.2016
LOCATION:	TEVIOT ROAD, JIMBOOMBA	LOGGED BY:	J.SIPPEL
JOB NUMBER:	SGSE/16/220	CHECKED BY:	R. MAXWELL

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Easting:	497388.00	Surface R.L.:
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northing:	6920860.00	Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SA/TC	Open Hole	7					SM	NATURAL - Silty SAND, fine grained, grey (TOPSOIL - 90mm)	D	MD		D		
		9					CH	Silty Sandy CLAY, high plasticity, red brown, fine grained sand, with fine sized sub-rounded gravel	D	H				
		9										D		
		9												
		8		0.5			XW	SANDSTONE, fine to medium grained, yellow-grey	D	EL				
		>25					DW	SANDSTONE, fine grained, orange grey	D	VL				
				1.0			XW	SANDSTONE, fine grained, orange grey, with white high plasticity clay lenses	D	EL-VL		CBR		
				1.5			DW	SANDSTONE, fine grained, orange grey	D	LS				
								End of BH22 at 1.5m					Maximum TC Bit Refusal @ 1.5m depth	
				2.0										
				2.5										
				3.0										
				3.5										
				4.0										
				4.5										



APPENDIX D: LABORATORY TEST RESULTS

AU.IND.Admin@sgs.com
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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	11/11/2016
SGS Job Number:	16-55-800	Sample No:	16-LT-3453
Lab:	Lawnton	Sample ID:	BH7 (0.6 - 0.6)

Shrink-Swell Index

AS 1289.7.1.1 Undisturbed

Sample Data

Sample Type:	U50
Depth (m):	0.6
Borehole Number:	7
Sample Description:	(CH) CLAY red, grey

SWELL TEST

Initial Moisture Content (%):	22.2
Final Moisture Content (%):	32.6
Total Swell (%):	8.67

SHRINKAGE TEST

Moisture Content (%):	19.4
Shrinkage (%):	6.5

SHRINK - SWELL

INDEX (Iss):	6.0
--------------	-----

Estimated Inert Inclusions (%):	5
Extent of Crumbling:	Nil
Extent of Cracking:	Nil

Note: Sampled in accordance with AS1289.1.3.1 Clause 3.1.3.2

Authorised

Signatory:  (Bradley Woodroffe, Technician)

Date: 7/12/2016

Client Address: 1/18 Leanne Crescent Lawnton Qld 4501

Site No.: 4984
Cert No.: 16-LT-3453-Z300
Form No.

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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	11/11/2016
SGS Job Number:	16-55-800	Sample No:	16-LT-3454
Lab:	Lawnton	Sample ID:	BH8 (0.5 - 0.5)

Shrink-Swell Index

AS 1289.7.1.1 Undisturbed

Sample Data

Sample Type:

Depth (m): (0.5 - 0.5)

Borehole Number: 8

Sample Description: (CH) CLAY brown

SWELL TEST

Initial Moisture Content (%): 18.8

Final Moisture Content (%): 24.7

Total Swell (%): 6.71

SHRINKAGE TEST

Moisture Content (%): 18.9

Shrinkage (%): 5.4

SHRINK - SWELL

INDEX (Iss): 4.9

Estimated Inert Inclusions (%): 5

Extent of Crumbling: Nil

Extent of Cracking: Nil

Note: Sampled in accordance with AS1289.1.3.1 Clause 3.1.3.2

Authorised

Signatory:  (Bradley Woodroffe, Technician)

Date: 7/12/2016

Client Address: 1/18 Leanne Crescent Lawnton Qld 4501

Site No.: 4984
Cert No.: 16-LT-3454-Z300
Form No.

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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	11/11/2016
SGS Job Number:	16-55-800	Sample No:	16-LT-3455
Lab:	Lawnton	Sample ID:	BH11 (0.5 - 0.5)

Shrink-Swell Index

AS 1289.7.1.1 Undisturbed

Sample Data

Sample Type:	U50
Depth (m):	0.5
Borehole Number:	BH11
Sample Description:	(CH) CLAY grey, pale brown

SWELL TEST

Initial Moisture Content (%):	19.4
Final Moisture Content (%):	29.7
Total Swell (%):	10.95

SHRINKAGE TEST

Moisture Content (%):	17.8
Shrinkage (%):	5.4

SHRINK - SWELL

INDEX (Iss):	6.1
--------------	-----

Estimated Inert Inclusions (%):	5
Extent of Crumbling:	Nil
Extent of Cracking:	Nil

Note: Sampled in accordance with AS1289.1.3.1 Clause 3.1.3.2

Authorised

Signatory:  (Bradley Woodroffe, Technician)

Date: 7/12/2016

Client Address: 1/18 Leanne Crescent Lawnton Qld 4501

Site No.: 4984
Cert No.: 16-LT-3455-Z300
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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	11/11/2016
SGS Job Number:	16-55-800	Sample No:	16-LT-3456
Lab:	Lawnton	Sample ID:	BH13 (1.0 - 1.0)

Shrink-Swell Index

AS 1289.7.1.1 Undisturbed

Sample Data

Sample Type:	U50
Depth (m):	1.0
Borehole Number:	13
Sample Description:	(CH) CLAY brown

SWELL TEST

Initial Moisture Content (%):	19.0
Final Moisture Content (%):	26.9
Total Swell (%):	6.90

SHRINKAGE TEST

Moisture Content (%):	18.6
Shrinkage (%):	5.5

SHRINK - SWELL

INDEX (Iss):	5.0
--------------	-----

Estimated Inert Inclusions (%):	Nil
Extent of Crumbling:	Nil
Extent of Cracking:	Nil

Note: Sampled in accordance with AS1289.1.3.1 Clause 3.1.3.2

Authorised

Signatory:  (Bradley Woodroffe, Technician)

Date: 7/12/2016

Client Address: 1/18 Leanne Crescent Lawnton Qld 4501

Site No.: 4984
Cert No.: 16-LT-3456-Z300
Form No.

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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	11/11/2016
SGS Job Number:	16-55-800	Sample No:	16-LT-3457
Lab:	Lawnton	Sample ID:	BH14 (0.9 - 0.9)

Shrink-Swell Index

AS 1289.7.1.1 Undisturbed

Sample Data

Sample Type:	U50
Depth (m):	0.9
Borehole Number:	BH14
Sample Description:	(CI) Sandy CLAY dark brown

SWELL TEST

Initial Moisture Content (%):	9.9
Final Moisture Content (%):	13.4
Total Swell (%):	2.63

SHRINKAGE TEST

Moisture Content (%):	10.0
Shrinkage (%):	0.6

SHRINK - SWELL

INDEX (Iss):	1.0
--------------	-----

Estimated Inert Inclusions (%):	5
Extent of Crumbling:	Nil
Extent of Cracking:	Nil

Note: Sampled in accordance with AS1289.1.3.1 Clause 3.1.3.2

Authorised
Signatory:

(Bradley Woodroffe, Technician)

Date: 7/12/2016

Client Address: 1/18 Leanne Crescent Lawnton Qld 4501

Site No.: 4984
Cert No.: 16-LT-3457-Z300
Form No.

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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	11/11/2016
SGS Job Number:	16-55-800	Sample No:	16-LT-3458
Lab:	Lawnton	Sample ID:	BH16 (0.7 - 0.7)

Shrink-Swell Index

AS 1289.7.1.1 Undisturbed

Sample Data

Sample Type:	U50
Depth (m):	0.7
Borehole Number:	16
Sample Description:	(CH) CLAY brown

SWELL TEST

Initial Moisture Content (%):	22.5
Final Moisture Content (%):	26.5
Total Swell (%):	2.06

SHRINKAGE TEST

Moisture Content (%):	21.5
Shrinkage (%):	7.2

SHRINK - SWELL

INDEX (Iss):	4.6
---------------------	------------

Estimated Inert Inclusions (%):	5
Extent of Crumbling:	Nil
Extent of Cracking:	Nil

Note: Sampled in accordance with AS1289.1.3.1 Clause 3.1.3.2

Authorised
Signatory:

(Bradley Woodroffe, Technician)

Date: 7/12/2016

Client Address: 1/18 Leanne Crescent Lawnton Qld 4501

Site No.: 4984
Cert No.: 16-LT-3458-Z300
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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	11/11/2016
SGS Job Number:	16-55-800	Sample No:	16-LT-3459
Lab:	Lawnton	Sample ID:	BH18 (0.5 - 0.5)

Shrink-Swell Index

AS 1289.7.1.1 Undisturbed

Sample Data

Sample Type:	U50
Depth (m):	0.5
Borehole Number:	BH18
Sample Description:	(CH) CLAY brown

SWELL TEST

Initial Moisture Content (%):	19.8
Final Moisture Content (%):	20.4
Total Swell (%):	0.00

SHRINKAGE TEST

Moisture Content (%):	21.9
Shrinkage (%):	4.7

SHRINK - SWELL

INDEX (Iss):	2.6
---------------------	------------

Estimated Inert Inclusions (%):	5
Extent of Crumbling:	Nil
Extent of Cracking:	Nil

Note: Sampled in accordance with AS1289.1.3.1 Clause 3.1.3.2

Authorised
Signatory:

(Bradley Woodroffe, Technician)

Date: 7/12/2016

Client Address: 1/18 Leanne Crescent Lawnton Qld 4501

Site No.: 4984
Cert No.: 16-LT-3459-Z300
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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	11/11/2016
SGS Job Number:	16-55-800	Sample No:	16-LT-3460
Lab:	Lawnton	Sample ID:	BH20 (0.7 - 0.7)

Shrink-Swell Index

AS 1289.7.1.1 Undisturbed

Sample Data

Sample Type:	U50
Depth (m):	0.7
Borehole Number:	20
Sample Description:	(CH) Silty CLAY brown

SWELL TEST

Initial Moisture Content (%):	16.2
Final Moisture Content (%):	22.0
Total Swell (%):	5.59

SHRINKAGE TEST

Moisture Content (%):	15.5
Shrinkage (%):	3.2

SHRINK - SWELL

INDEX (Iss):	3.3
---------------------	------------

Estimated Inert Inclusions (%):	5
Extent of Crumbling:	Nil
Extent of Cracking:	Nil

Note: Sampled in accordance with AS1289.1.3.1 Clause 3.1.3.2

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Signatory:  (Bradley Woodroffe, Technician)

Date: 7/12/2016

Client Address: 1/18 Leanne Crescent Lawnton Qld 4501

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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Order No:		Project:	SGSE/16/220
Tested Date:	1/11/2016	Location:	Teviot Road, Jimboomba
SGS Job Number:	16-55-799	Sample No:	16-LT-3444
Lab:	Lawnton	Sample ID:	BH1 (100 - 600)

California Bearing Ratio

AS1289.6.1.1 - Soaked

CBR Value @ 2.5mm: 1.5

Sample Data

Sample Description: (CH) CLAY with silt - Brown
Location: BH1
Sampling Method:
Date Sampled: 9/11/16
Depth (mm): (100 - 600)
Maximum Dry Density (t/m³): 1.62
Optimum Moisture Content (%): 21.0
Field Moisture Content (%): 18.5
Mass of Surcharge (kg): 4.5
No. of Days Soaked: 4
Retained on 19.0mm Sieve (%): -
+19.0mm Excluded (Yes/No): Yes

Compaction Data

Laboratory Moisture Ratio (%): 95
Laboratory Density Ratio (%): 101
Target Moisture Ratio (%): 100
Target Density Ratio (%): 100
Target Compactive Effort: Standard

Soak Data

Swell (%): 5.0
Dry Density After Soak (t/m³): 1.56
Moisture Content - Top 30mm (%): 31.8
Moisture Content - Remaining (%): -
Test Methods: AS1289.2.1.1, AS1289.5.1.1.

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised

Signatory:

(Dave Gregson)

Date: 22/11/2016



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Site No.: 4984
Cert No.: 16-LT-3444-S500
Form No.

Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Order No:		Project:	SGSE/16/220
Tested Date:	1/11/2016	Location:	Teviot Road, Jimboomba
SGS Job Number:	16-55-799	Sample No:	16-LT-3445
Lab:	Lawnton	Sample ID:	BH5 (150 - 300)

California Bearing Ratio

AS1289.6.1.1 - Soaked

CBR Value @ 5.0mm: 25

Sample Data

Sample Description: (SC) Clayey SAND - Brown
Location: BH5
Sampling Method:
Date Sampled: 8/11/16
Depth (mm): (150 - 300)
Maximum Dry Density (t/m³): 1.93
Optimum Moisture Content (%): 13.0
Field Moisture Content (%): 6.6
Mass of Surcharge (kg): 4.5
No. of Days Soaked: 4
Retained on 19.0mm Sieve (%): -
+19.0mm Excluded (Yes/No): Yes

Compaction Data

Laboratory Moisture Ratio (%): 95
Laboratory Density Ratio (%): 101
Target Moisture Ratio (%): 100
Target Density Ratio (%): 100
Target Compactive Effort: Standard

Soak Data

Swell (%): 0.0
Dry Density After Soak (t/m³): 1.95
Moisture Content - Top 30mm (%): 13.4
Moisture Content - Remaining (%): -
Test Methods: AS1289.2.1.1, AS1289.5.1.1.

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

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Signatory:



(Dave Gregson)

Date: 22/11/2016



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Order No:		Project:	SGSE/16/220
Tested Date:	17/11/2016	Location:	Teviot Road, Jimboomba
SGS Job Number:	16-55-799	Sample No:	16-LT-3446
Lab:	Lawnton	Sample ID:	BH6 (600 - 1100)

California Bearing Ratio

AS1289.6.1.1 - Soaked

CBR Value @ 5.0mm: 8

Sample Data

Sample Description: (CI) Sandy CLAY - Brown
Location: BH6
Sampling Method:
Date Sampled: 8/11/16
Depth (mm): (600 - 1100)
Maximum Dry Density (t/m³): 1.83
Optimum Moisture Content (%): 14.0
Field Moisture Content (%): 19.1
Mass of Surcharge (kg): 4.5
No. of Days Soaked: 4
Retained on 19.0mm Sieve (%): -
+19.0mm Excluded (Yes/No): Yes

Compaction Data

Laboratory Moisture Ratio (%): 99
Laboratory Density Ratio (%): 100
Target Moisture Ratio (%): 100
Target Density Ratio (%): 100
Target Compactive Effort: Standard

Soak Data

Swell (%): 0.5
Dry Density After Soak (t/m³): 1.82
Moisture Content - Top 30mm (%): 15.0
Moisture Content - Remaining (%): -
Test Methods: AS1289.2.1.1, AS1289.5.1.1.

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

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Signatory:

(Dave Gregson)

Date: 23/11/2016



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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Order No:		Project:	SGSE/16/220
Tested Date:	1/11/2016	Location:	Teviot Road, Jimboomba
SGS Job Number:	16-55-799	Sample No:	16-LT-3447
Lab:	Lawnton	Sample ID:	BH12 (500 - 1000)

California Bearing Ratio

AS1289.6.1.1 - Soaked

CBR Value @ 2.5mm: 1.5

Sample Data

Sample Description: (CI) Sandy CLAY - Brown
Location: BH12
Sampling Method:
Date Sampled: 8/11/16
Depth (mm): (500 - 1000)
Maximum Dry Density (t/m³): 1.68
Optimum Moisture Content (%): 19.0
Field Moisture Content (%): 16.9
Mass of Surcharge (kg): 4.5
No. of Days Soaked: 4
Retained on 19.0mm Sieve (%): -
+19.0mm Excluded (Yes/No): Yes

Compaction Data

Laboratory Moisture Ratio (%): 98
Laboratory Density Ratio (%): 100
Target Moisture Ratio (%): 100
Target Density Ratio (%): 100
Target Compactive Effort: Standard

Soak Data

Swell (%): 5.5
Dry Density After Soak (t/m³): 1.59
Moisture Content - Top 30mm (%): 29.1
Moisture Content - Remaining (%): -
Test Methods: AS1289.2.1.1, AS1289.5.1.1.

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

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Signatory:

(Dave Gregson)

Date: 22/11/2016



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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Order No:		Project:	SGSE/16/220
Tested Date:	1/11/2016	Location:	Teviot Road, Jimboomba
SGS Job Number:	16-55-799	Sample No:	16-LT-3448
Lab:	Lawnton	Sample ID:	BH16 (200 - 1000)

California Bearing Ratio

AS1289.6.1.1 - Soaked

CBR Value @ 2.5mm: 2.0

Sample Data

Sample Description: (CH) CLAY with silt - Brown
Location: BH16
Sampling Method:
Date Sampled: 7/11/16
Depth (mm): (200 - 1000)
Maximum Dry Density (t/m³): 1.68
Optimum Moisture Content (%): 20.0
Field Moisture Content (%): 20.9
Mass of Surcharge (kg): 4.5
No. of Days Soaked: 4
Retained on 19.0mm Sieve (%): -
+19.0mm Excluded (Yes/No): Yes

Compaction Data

Laboratory Moisture Ratio (%): 95
Laboratory Density Ratio (%): 100
Target Moisture Ratio (%): 100
Target Density Ratio (%): 100
Target Compactive Effort: Standard

Soak Data

Swell (%): 3.5
Dry Density After Soak (t/m³): 1.63
Moisture Content - Top 30mm (%): 28.0
Moisture Content - Remaining (%): -
Test Methods: AS1289.2.1.1, AS1289.5.1.1.

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

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Signatory:

(Dave Gregson)

Date: 22/11/2016



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Accreditation No.: 2418

Site No.: 4984
Cert No.: 16-LT-3448-S500
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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Order No:		Project:	SGSE/16/220
Tested Date:	14/11/2016	Location:	Teviot Road, Jimboomba
SGS Job Number:	16-55-799	Sample No:	16-LT-3449
Lab:	Lawnton	Sample ID:	BH17 (1200 - 2000)

California Bearing Ratio

AS1289.6.1.1 - Soaked

CBR Value @ 5.0mm: 2.0

Sample Data

Sample Description: (CI) Sandy CLAY - Brown
Location: BH17
Sampling Method:
Date Sampled: 7/11/16
Depth (mm): (1200 - 2000)
Maximum Dry Density (t/m³): 1.75
Optimum Moisture Content (%): 14.0
Field Moisture Content (%): 12.5
Mass of Surcharge (kg): 4.5
No. of Days Soaked: 4
Retained on 19.0mm Sieve (%): -
+19.0mm Excluded (Yes/No): Yes

Compaction Data

Laboratory Moisture Ratio (%): 97
Laboratory Density Ratio (%): 100
Target Moisture Ratio (%): 100
Target Density Ratio (%): 100
Target Compactive Effort: Standard

Soak Data

Swell (%): 3.0
Dry Density After Soak (t/m³): 1.70
Moisture Content - Top 30mm (%): 20.6
Moisture Content - Remaining (%): -
Test Methods: AS1289.2.1.1, AS1289.5.1.1.

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised

Signatory:



(Dave Gregson)

Date: 22/11/2016



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Client Address: 1/18 Leanne Crescent Lawnton Qld 4501
Accreditation No.: 2418

Site No.: 4984
Cert No.: 16-LT-3449-S500
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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Order No:		Project:	SGSE/16/220
Tested Date:	21/11/2016	Location:	Teviot Road, Jimboomba
SGS Job Number:	16-55-799	Sample No:	16-LT-3450
Lab:	Lawnton	Sample ID:	BH18 (400 - 1000)

California Bearing Ratio

AS1289.6.1.1 - Soaked

CBR Value @ 2.5mm: 4.0

Sample Data

Sample Description: (CH) Sandy CLAY - Brown
Location: BH18
Sampling Method:
Date Sampled: 7/11/16
Depth (mm): (400 - 1000)
Maximum Dry Density (t/m³): 1.57
Optimum Moisture Content (%): 23.5
Field Moisture Content (%): 25.5
Mass of Surcharge (kg): 4.5
No. of Days Soaked: 4
Retained on 19.0mm Sieve (%): -
+19.0mm Excluded (Yes/No): Yes

Compaction Data

Laboratory Moisture Ratio (%): 98
Laboratory Density Ratio (%): 100
Target Moisture Ratio (%): 100
Target Density Ratio (%): 100
Target Compactive Effort: Standard

Soak Data

Swell (%): 2.0
Dry Density After Soak (t/m³): 1.55
Moisture Content - Top 30mm (%): 26.9
Moisture Content - Remaining (%): -
Test Methods: AS1289.2.1.1, AS1289.5.1.1.

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

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Signatory:

(Dave Gregson)

Date: 23/11/2016



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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Order No:		Project:	SGSE/16/220
Tested Date:	1/11/2016	Location:	Teviot Road, Jimboomba
SGS Job Number:	16-55-799	Sample No:	16-LT-3451
Lab:	Lawnton	Sample ID:	BH19 (500 - 1000)

California Bearing Ratio

AS1289.6.1.1 - Soaked

CBR Value @ 2.5mm: 2.5

Sample Data

Sample Description: (CI) Sandy CLAY - Brown
Location: BH19
Sampling Method:
Date Sampled: 7/11/16
Depth (mm): (500 - 1000)
Maximum Dry Density (t/m³): 1.66
Optimum Moisture Content (%): 20.0
Field Moisture Content (%): 20.1
Mass of Surcharge (kg): 4.5
No. of Days Soaked: 4
Retained on 19.0mm Sieve (%): -
+19.0mm Excluded (Yes/No): Yes

Compaction Data

Laboratory Moisture Ratio (%): 99
Laboratory Density Ratio (%): 100
Target Moisture Ratio (%): 100
Target Density Ratio (%): 100
Target Compactive Effort: Standard

Soak Data

Swell (%): 3.0
Dry Density After Soak (t/m³): 1.62
Moisture Content - Top 30mm (%): 26.9
Moisture Content - Remaining (%): -
Test Methods: AS1289.2.1.1, AS1289.5.1.1.

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

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Signatory:

(Dave Gregson)

Date: 22/11/2016



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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	16/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3492
Lab:	Lawnton	Sample ID:	BH2 (0.1 - 0.3)

Determination of Emerson Class Number

AS1289.3.8.1

Soil Description	(CH) CLAY brown
Source of Material:	INSITU
Date Sampled:	9/11/2016
Type of Water:	RAIN
Temperature of Water (°C):	23.5

Emerson Class Number:	5
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Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised
Signatory:

(Bradley Woodroffe, Technician)

Date: 7/12/2016



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Client Address: 1/18 Leanne Crescent Lawnton Qld 4501
Accreditation No.: 2418Site No.: 4984
Cert No.: 16-LT-3492-S318
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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	16/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3492
Lab:	Lawnton	Sample ID:	BH2 (0.1 - 0.3)

pH – Soil or Water

AS1289.4.3.1 (Electrometric)

pH Value

6.0

Note: EC = 0.03mS/cm

Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised
Signatory:

(Bradley Woodroffe, Technician)

Date: 7/12/2016



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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	16/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3493
Lab:	Lawnton	Sample ID:	BH6 (0.1 - 0.3)

Determination of Emerson Class Number

AS1289.3.8.1

Soil Description	(CH) CLAY brown
Source of Material:	INSITU
Date Sampled:	8/11/2016
Type of Water:	RAIN WATER
Temperature of Water (°C):	23.5

Emerson Class Number:	3
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Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised
Signatory:

(Bradley Woodroffe, Technician)

Date: 7/12/2016



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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	16/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3493
Lab:	Lawnton	Sample ID:	BH6 (0.1 - 0.3)

pH – Soil or Water

AS1289.4.3.1 (Electrometric)

pH Value

5.1

Note: EC = 0.02mS/cm

Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised
Signatory:

(Bradley Woodroffe, Technician)

Date: 7/12/2016



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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	16/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3494
Lab:	Lawnton	Sample ID:	BH6 (0.0 - 0.1)

Determination of Emerson Class Number

AS1289.3.8.1

Soil Description	(MH) Clayey SILT
Source of Material:	INSITU
Date Sampled:	8/11/2016
Type of Water:	RAIN
Temperature of Water (°C):	23.5

Emerson Class Number: **3**

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

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Signatory:

(Bradley Woodroffe, Technician)

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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	16/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3494
Lab:	Lawnton	Sample ID:	BH6 (0.0 - 0.1)

pH – Soil or Water

AS1289.4.3.1 (Electrometric)

pH Value

5.9

Note: EC = 0.04mS/cm

Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

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Signatory:

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Date: 7/12/2016



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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	16/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3495
Lab:	Lawnton	Sample ID:	BH8 (0.0 - 0.09)

Determination of Emerson Class Number

AS1289.3.8.1

Soil Description	(MH) Clayey SILT
Source of Material:	INSITU
Date Sampled:	8/11/2016
Type of Water:	RAIN
Temperature of Water (°C):	23.5

Emerson Class Number:	3
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Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised
Signatory:

(Bradley Woodroffe, Technician)

Date: 7/12/2016



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Accreditation No.: 2418Site No.: 4984
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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	16/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3495
Lab:	Lawnton	Sample ID:	BH8 (0.0 - 0.09)

pH – Soil or Water

AS1289.4.3.1 (Electrometric)

pH Value

4.7

Note: EC = 0.02mS/cm

Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised
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(Bradley Woodroffe, Technician)

Date: 7/12/2016



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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	16/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3496
Lab:	Lawnton	Sample ID:	BH8 (0.2 - 0.5)

Determination of Emerson Class Number

AS1289.3.8.1

Soil Description	(CH) CLAY brown
Source of Material:	INSITU
Date Sampled:	8-Nov
Type of Water:	RAIN
Temperature of Water (°C):	23.5

Emerson Class Number:	3
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Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised
Signatory:

(Bradley Woodroffe, Technician)

Date: 7/12/2016



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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	16/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3496
Lab:	Lawnton	Sample ID:	BH8 (0.2 - 0.5)

pH – Soil or Water

AS1289.4.3.1 (Electrometric)

pH Value

4.8

Note: EC = 0.01mS/cm

Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	17/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3497
Lab:	Lawnton	Sample ID:	Creek Surface

Determination of Emerson Class Number

AS1289.3.8.1

Soil Description	(ML) Clayey SILT
Source of Material:	INSITU
Date Sampled:	7/11/2016
Type of Water:	RAIN
Temperature of Water (°C):	21.2

Emerson Class Number: **3**

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

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(Bradley Woodroffe, Technician)

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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	17/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3497
Lab:	Lawnton	Sample ID:	Creek Surface

pH – Soil or Water

AS1289.4.3.1 (Electrometric)

pH Value

5.0

Note: EC = 0.03mS/cm

Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	17/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3498
Lab:	Lawnton	Sample ID:	BH16 (0.0 - 0.2)

Determination of Emerson Class Number

AS1289.3.8.1

Soil Description	(CH) CLAY brown
Source of Material:	INSITU
Date Sampled:	7/11/2016
Type of Water:	RAIN
Temperature of Water (°C):	21.2

Emerson Class Number:	3
-----------------------	---

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised
Signatory:

(Bradley Woodroffe, Technician)

Date: 7/12/2016



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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	17/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3498
Lab:	Lawnton	Sample ID:	BH16 (0.0 - 0.2)

pH – Soil or Water

AS1289.4.3.1 (Electrometric)

pH Value

5.4

Note: EC = 0.07mS/cm

Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

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(Bradley Woodroffe, Technician)

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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	17/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3499
Lab:	Lawnton	Sample ID:	BH16 (0.2 - 0.5)

Determination of Emerson Class Number

AS1289.3.8.1

Soil Description	(CH) CLAY brown
Source of Material:	INSITU
Date Sampled:	7/11/2016
Type of Water:	RAIN
Temperature of Water (°C):	21.2

Emerson Class Number:	2
-----------------------	---

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised
Signatory:

(Bradley Woodroffe, Technician)

Date: 7/12/2016



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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	17/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3499
Lab:	Lawnton	Sample ID:	BH16 (0.2 - 0.5)

pH – Soil or Water

AS1289.4.3.1 (Electrometric)

pH Value

5.0

Note: EC = 0.04mS/cm

Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised
Signatory:

(Bradley Woodroffe, Technician)

Date: 7/12/2016



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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	17/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3500
Lab:	Lawnton	Sample ID:	BH18 (0.0 - 0.1)

Determination of Emerson Class Number

AS1289.3.8.1

Soil Description	(CL) CLAY brown
Source of Material:	INSITU
Date Sampled:	7/11/2016
Type of Water:	RAIN
Temperature of Water (°C):	21.2

Emerson Class Number: 6

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised
Signatory:



(Bradley Woodroffe, Technician)

Date: 7/12/2016



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Client Address: 1/18 Leanne Crescent Lawnton Qld 4501
Accreditation No.: 2418

Site No.: 4984
Cert No.: 16-LT-3500-S318
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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	17/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3500
Lab:	Lawnton	Sample ID:	BH18 (0.0 - 0.1)

pH – Soil or Water

AS1289.4.3.1 (Electrometric)

pH Value

5.6

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised
Signatory:

(Bradley Woodroffe, Technician)

Date: 7/12/2016



Accredited for compliance with ISO/IEC 17025 - Testing

Client Address: 1/18 Leanne Crescent Lawnton Qld 4501
Accreditation No.: 2418Site No.: 4984
Cert No.: 16-LT-3500-S902
Page No: 1

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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	17/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3501
Lab:	Lawnton	Sample ID:	BH18 (0.1 - 0.4)

Determination of Emerson Class Number

AS1289.3.8.1

Soil Description	(CH) CLAY brown
Source of Material:	INSITU
Date Sampled:	7/11/2016
Type of Water:	RAIN
Temperature of Water (°C):	21.2

Emerson Class Number:	3
-----------------------	---

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised
Signatory:

(Bradley Woodroffe, Technician)

Date: 7/12/2016



Accredited for compliance with ISO/IEC 17025 - Testing

Client Address: 1/18 Leanne Crescent Lawnton Qld 4501
Accreditation No.: 2418Site No.: 4984
Cert No.: 16-LT-3501-S318
Page 1 of 1

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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	17/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3501
Lab:	Lawnton	Sample ID:	BH18 (0.1 - 0.4)

pH – Soil or Water

AS1289.4.3.1 (Electrometric)

pH Value

6.0

Note: EC = 0.03mS/cm

Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised
Signatory:

(Bradley Woodroffe, Technician)

Date: 7/12/2016



Accredited for compliance with ISO/IEC 17025 - Testing

Client Address: 1/18 Leanne Crescent Lawnton Qld 4501
Accreditation No.: 2418Site No.: 4984
Cert No.: 16-LT-3501-S902
Page 1 of 1

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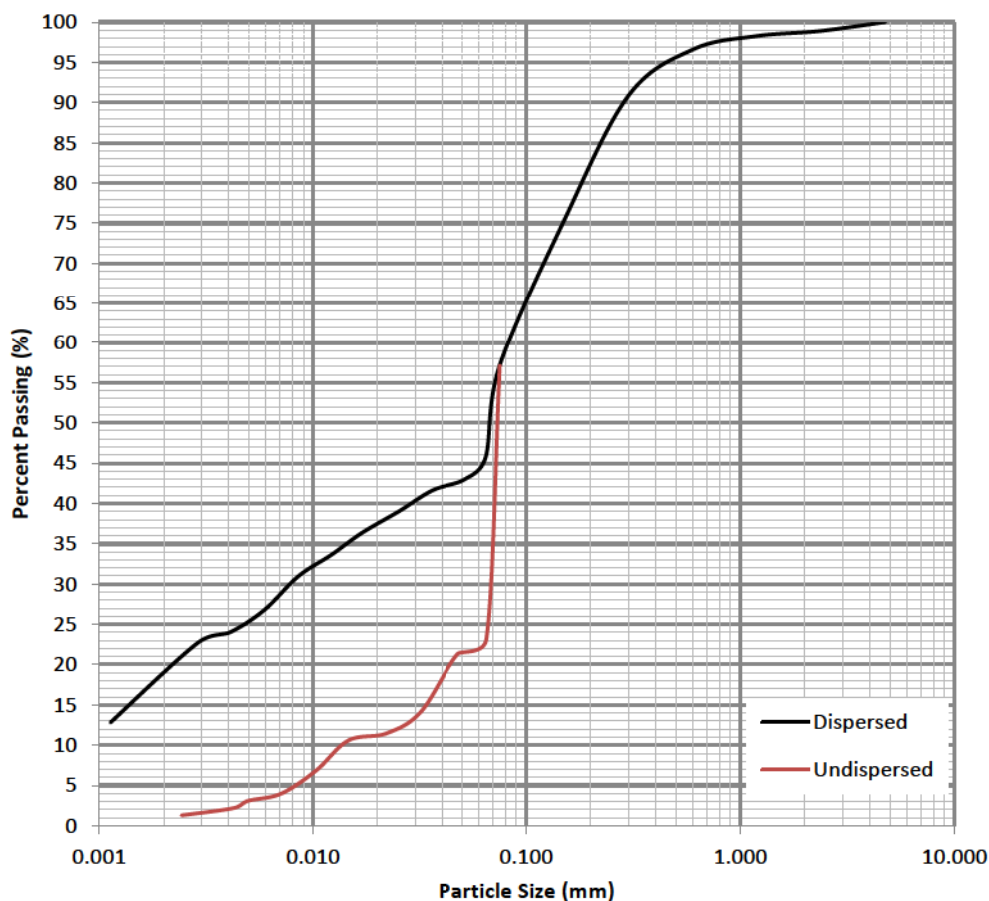
1/18 LEANNE CRESCENT, LAWNTON
OFFICE: (07) 3881 3511 FAX: (07) 3881 3513

PARTICLE SIZE DISTRIBUTION with PERCENTAGE DISPERSION TEST REPORT

Test Method: AS1289.3.8.2 & AS1289.3.6.3

Client: Celestino Pty Ltd	Report No.: -
Project: Teviot Road, Jimboomba	Report Date: 16/01/2017
Job No.: SGSE/16/220	Sampled Date: 8/11/2016
Bore Number: 6	Depth: 0.0-0.1
Sample Number: 16-LT-3494	Hydrometer Type: ASTM Type 152H
Dispersion Method: Mechanical Stirrer with baffle	Pretreatment Loss: 0%

Sieve Size (mm)	Passing Passing (%)
37.5	
26.5	
19.0	
9.5	
4.75	100
2.36	99
1.18	98
0.600	97
0.300	91
0.150	75
0.075	57
0.064	46
0.051	43
0.036	42
0.025	39
0.017	36
0.012	34
0.0085	31
0.0059	27
0.0041	24
0.0029	23
0.0011	13
#N/A	#N/A



% passing 0.005mm (Dispersed sample)	25	(%)
% passing 0.005mm (Undispersed sample)	3	(%)
Percent Dispersion (Dispersion Index)	12	(%)
Percent Dispersible Soil	3.4	(%)
>2.36mm GRAVEL	1	(%)
2.36 - 0.020mm SAND	62	(%)
0.020 - 0.002mm SILT	20	(%)
<0.002mm CLAY	18	(%)

Remarks Particle Density (T/m^3) = 2.65

B WOODROFFE

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GEOTECHNICAL & ENVIRONMENTAL CONSULTANTS

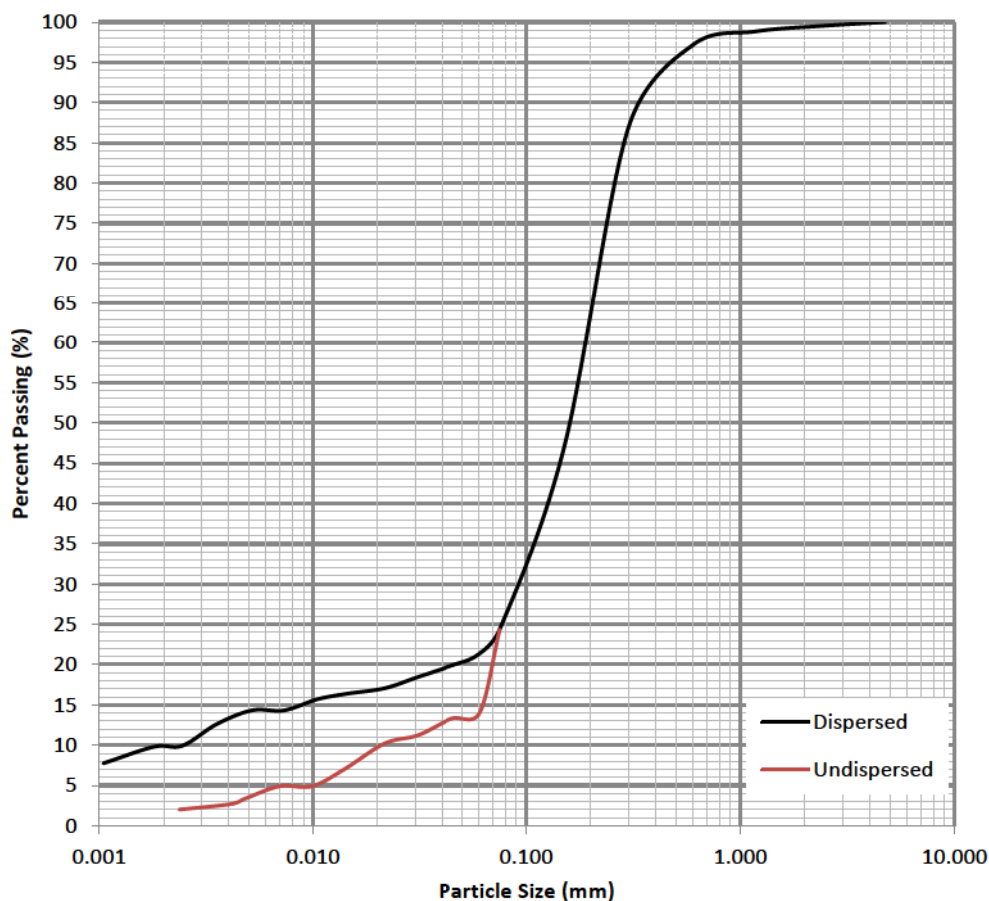
1/18 LEANNE CRESCENT, LAWNTON
OFFICE: (07) 3881 3511 FAX: (07) 3881 3513

PARTICLE SIZE DISTRIBUTION with PERCENTAGE DISPERSION TEST REPORT

Test Method: AS1289.3.8.2 & AS1289.3.6.3

Client:	Celestino Pty Ltd	Report No.:	-
Project:	Teviot Road, Jimboomba	Report Date:	16/01/2017
Job No.:	SGSE/16/220	Sampled Date:	8/11/2016
Sample Location:	Creek Surface	Depth:	-
Sample Number:	16-LT-3497	Hydrometer Type:	ASTM Type 152H
Dispersion Method:	Mechanical Stirrer with baffle	Pretreatment Loss:	0%

Sieve Size (mm)	Passing (%)
37.5	
26.5	
19.0	
9.5	
4.75	100
2.36	100
1.18	99
0.600	97
0.300	87
0.150	47
0.075	24
0.059	21
0.044	20
0.031	18
0.021	17
0.014	16
0.010	16
0.0073	14
0.0052	14
0.0035	13
0.0024	10
0.0018	10
0.0010	8



% passing 0.005mm (Dispersed sample)	14	(%)
% passing 0.005mm (Undispersed sample)	4	(%)
Percent Dispersion (Dispersion Index)	25	(%)
Percent Dispersible Soil	3.4	(%)
>2.36mm	GRAVEL	0 (%)
2.36 - 0.020mm	SAND	83 (%)
0.020 - 0.002mm	SILT	7 (%)
<0.002mm	CLAY	10 (%)

Remarks Particle Density (T/m^3) = 2.65

B WOODROFFE

APPROVED SIGNATORY

CLIENT DETAILS

Contact Cassandra Barclay
Client SGS INDUSTRIAL CMT LAWNTON
Address U1/18 LEANNE CRESCENT
LAWNTON QLD 4501

Telephone 07 3881 3511
Facsimile 07 3881 3513
Email cassandra.barclay@sgs.com

Project **SGSE/16/220**
Order Number (Not specified)
Samples 12

LABORATORY DETAILS

Manager Jon Dicker
Laboratory SGS Cairns Environmental
Address Unit 2, 58 Comport St
Portsmith QLD 4870

Telephone +61 07 4035 5111
Facsimile +61 07 4035 5122
Email AU.Environmental.Cairns@sgs.com

SGS Reference **CE124027 R0**
Date Received 17 Nov 2016
Date Reported 08 Dec 2016

COMMENTS

Accredited for compliance with ISO/IEC 17025. NATA accredited laboratory 2562(3146)

Please see attached report for permeability (constant head) subcontracted to Soil Conservation Service, 709 Gundy Road, SCONE NSW 2337, SCO16/208R1.

SIGNATORIES



Anthony Nilsson
Operations Manager



Jon Dicker
Manager Northern QLD



Leanne Orsmond
Quality & Microbiology Coordinator



Maristela Ganzan
Metals Team Leader

Parameter	Units	LOR
Sample Number	CE124027.001	CE124027.002
Sample Matrix	Soil	Soil
Sample Date	08 Nov 2016	08 Nov 2016
Sample Name	BH13_0.0-0.2	BH13_0.2-1.0
		CE124027.003
		Soil
		07 Nov 2016
		BH14_0.0-0.05
		CE124027.004
		Soil
		07 Nov 2016
		BH14_0.5-0.3

Moisture Content Method: AN002 Tested: 17/11/2016

% Moisture	%w/w	0.5	5.9	17	2.5	12
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Emerson Class Number Method: AN009 Tested: 21/11/2016

Emerson Class Number	No unit	1	8	8	2	1
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Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 23/11/2016

Total Organic Carbon	%w/w	0.05	2.1	0.28	1.4	0.36
Organic Matter	%w/w	0.1	3.6	0.49	2.4	0.61

Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 23/11/2016

Exchangeable Sodium, Na	mg/kg	2	61	800	63	480
Exchangeable Sodium, Na	meq/100g	0.01	0.26	3.5	0.27	2.1
Exchangeable Sodium Percentage	%	0.1	6.0	30.4	7.3	21.6
Exchangeable Potassium, K	mg/kg	2	66	85	130	100
Exchangeable Potassium, K	meq/100g	0.01	0.17	0.22	0.33	0.26
Exchangeable Potassium Percentage	%	0.1	3.8	1.9	8.8	2.7
Exchangeable Calcium, Ca	mg/kg	2	420	160	280	68
Exchangeable Calcium, Ca	meq/100g	0.01	2.1	0.80	1.4	0.34
Exchangeable Calcium Percentage	%	0.1	48.3	7.0	37.3	3.5
Exchangeable Magnesium, Mg	mg/kg	2	220	840	210	850
Exchangeable Magnesium, Mg	meq/100g	0.02	1.8	6.9	1.8	7.0
Exchangeable Magnesium Percentage	%	0.1	41.8	60.7	46.6	72.2
Cation Exchange Capacity	meq/100g	0.02	4.4	11	3.8	9.7
Sodium Adsorption Ratio	No unit	0.1	0.2	1.8	0.2	1.1
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	1.2	0.1	0.8	<0.1
Exchangeable Magnesium/Exchangeable Potassium Ratio*	No unit	0.1	10.9	31.8	5.3	26.9
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-	-	-	-

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 24/11/2016

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	0.1	0.2	6.5	0.6
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 23/11/2016

Total Kjeldahl Nitrogen	mg/kg	5	1300	330	850	350
Total Nitrogen	mg/kg	10	1300	330	860	350



ANALYTICAL REPORT

CE124027 R0

Parameter	Sample Number	CE124027.001	CE124027.002	CE124027.003	CE124027.004
	Sample Matrix	Soil	Soil	Soil	Soil
	Sample Date	08 Nov 2016	08 Nov 2016	07 Nov 2016	07 Nov 2016
	Sample Name	BH13_0.0-0.2	BH13_0.2-1.0	BH14_0.0-0.05	BH14_0.5-0.3
Units		LOR			

Total Phosphorus by Kjeldahl Digestion DA in Soil Method: AN279/AN293(Sydney only) Tested: 23/11/2016

Total Phosphorus (Kjeldahl Digestion)	mg/kg	2	240	80	120	140
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Colwell Phosphorus Method: AN015 Tested: 24/11/2016

Colwell Phosphorus	mg/kg	1	6	1	5	2
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Phosphorus Absorption Method: AN239 Tested: 23/11/2016

Phosphorus Absorption*	mg/kg	1	570	730	250	540
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Sample Subcontracted Method: Tested: 8/12/2016

Sample Subcontracted*	No unit	-	See attached	See attached	See attached	See attached
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Parameter	Units	LOR
Sample Number	CE124027.005	CE124027.006
Sample Matrix	Soil	Soil
Sample Date	07 Nov 2016	07 Nov 2016
Sample Name	BH15_0.0-0.15	BH15_0.5-0.7
		CE124027.007
		Soil
		07 Nov 2016
		BH19_0.0-0.1
		CE124027.008
		Soil
		07 Nov 2016
		BH19_0.1-0.5

Moisture Content Method: AN002 Tested: 17/11/2016

% Moisture	%w/w	0.5	0.7	12	5.8	17
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Emerson Class Number Method: AN009 Tested: 21/11/2016

Emerson Class Number	No unit	1	8	1	8	1
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Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 23/11/2016

Total Organic Carbon	%w/w	0.05	1.2	0.26	3.1	0.40
Organic Matter	%w/w	0.1	2.1	0.45	5.4	0.69

Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 23/11/2016

Exchangeable Sodium, Na	mg/kg	2	110	740	120	1100
Exchangeable Sodium, Na	meq/100g	0.01	0.46	3.2	0.53	4.7
Exchangeable Sodium Percentage	%	0.1	16.2	22.9	4.2	18.9
Exchangeable Potassium, K	mg/kg	2	130	170	150	140
Exchangeable Potassium, K	meq/100g	0.01	0.33	0.45	0.37	0.37
Exchangeable Potassium Percentage	%	0.1	11.5	3.2	3.0	1.5
Exchangeable Calcium, Ca	mg/kg	2	200	120	1300	1500
Exchangeable Calcium, Ca	meq/100g	0.01	0.99	0.58	6.5	7.5
Exchangeable Calcium Percentage	%	0.1	35.0	4.2	51.5	30.2
Exchangeable Magnesium, Mg	mg/kg	2	130	1200	630	1500
Exchangeable Magnesium, Mg	meq/100g	0.02	1.1	9.8	5.2	12
Exchangeable Magnesium Percentage	%	0.1	37.2	69.8	41.3	49.4
Cation Exchange Capacity	meq/100g	0.02	2.8	14	13	25
Sodium Adsorption Ratio	No unit	0.1	0.5	1.4	0.2	1.5
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	0.9	<0.1	1.2	0.6
Exchangeable Magnesium/Exchangeable Potassium Ratio*	No unit	0.1	3.2	22.0	13.8	33.3
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-	-	-	-

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 24/11/2016

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	0.4	0.2	0.2	<0.1
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 23/11/2016

Total Kjeldahl Nitrogen	mg/kg	5	630	250	1500	290
Total Nitrogen	mg/kg	10	630	250	1500	290



ANALYTICAL REPORT

CE124027 R0

Parameter	Sample Number	CE124027.005	CE124027.006	CE124027.007	CE124027.008
	Sample Matrix	Soil	Soil	Soil	Soil
	Sample Date	07 Nov 2016	07 Nov 2016	07 Nov 2016	07 Nov 2016
	Sample Name	BH15_0.0-0.15	BH15_0.5-0.7	BH19_0.0-0.1	BH19_0.1-0.5
Units		LOR			

Total Phosphorus by Kjeldahl Digestion DA in Soil Method: AN279/AN293(Sydney only) Tested: 23/11/2016

Total Phosphorus (Kjeldahl Digestion)	mg/kg	2	73	97	340	130
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Colwell Phosphorus Method: AN015 Tested: 24/11/2016

Colwell Phosphorus	mg/kg	1	5	2	10	2
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Phosphorus Absorption Method: AN239 Tested: 23/11/2016

Phosphorus Absorption*	mg/kg	1	140	390	430	520
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Sample Subcontracted Method: Tested: 8/12/2016

Sample Subcontracted*	No unit	-	See attached	See attached	See attached	See attached
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Parameter	Units	LOR
Sample Number	CE124027.009	CE124027.010
Sample Matrix	Soil	Soil
Sample Date	08 Nov 2016	08 Nov 2016
Sample Name	BH21_0.0-0.11	BH21_0.2-0.5
		BH22_0.0-0.09
		BH22_0.09-0.5

Moisture Content Method: AN002 Tested: 17/11/2016

% Moisture	%w/w	0.5	2.9	12	5.0	14
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Emerson Class Number Method: AN009 Tested: 21/11/2016

Emerson Class Number	No unit	1	8	1	1	6
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Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 23/11/2016

Total Organic Carbon	%w/w	0.05	3.1	0.52	5.0	0.58
Organic Matter	%w/w	0.1	5.3	0.89	8.7	0.99

Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 23/11/2016

Exchangeable Sodium, Na	mg/kg	2	12	130	150	290
Exchangeable Sodium, Na	meq/100g	0.01	0.05	0.55	0.64	1.3
Exchangeable Sodium Percentage	%	0.1	1.6	9.4	6.7	10.5
Exchangeable Potassium, K	mg/kg	2	210	210	390	390
Exchangeable Potassium, K	meq/100g	0.01	0.53	0.52	0.99	1.0
Exchangeable Potassium Percentage	%	0.1	16.4	8.9	10.4	8.3
Exchangeable Calcium, Ca	mg/kg	2	270	11	670	11
Exchangeable Calcium, Ca	meq/100g	0.01	1.3	0.06	3.3	0.06
Exchangeable Calcium Percentage	%	0.1	41.6	1.0	35.2	0.5
Exchangeable Magnesium, Mg	mg/kg	2	160	580	560	1200
Exchangeable Magnesium, Mg	meq/100g	0.02	1.3	4.7	4.5	9.7
Exchangeable Magnesium Percentage	%	0.1	40.4	80.7	47.7	80.7
Cation Exchange Capacity	meq/100g	0.02	3.2	5.9	9.5	12
Sodium Adsorption Ratio	No unit	0.1	<0.1	0.4	0.3	0.6
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	1.0	<0.1	0.7	<0.1
Exchangeable Magnesium/Exchangeable Potassium Ratio*	No unit	0.1	2.5	9.0	4.6	9.7
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-	-	-	-

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 24/11/2016

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	0.7	0.1	2.1	3.6
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 23/11/2016

Total Kjeldahl Nitrogen	mg/kg	5	1500	1500	4700	480
Total Nitrogen	mg/kg	10	1500	1500	4700	490



ANALYTICAL REPORT

CE124027 R0

Parameter	Sample Number	CE124027.009	CE124027.010	CE124027.011	CE124027.012
	Sample Matrix	Soil	Soil	Soil	Soil
	Sample Date	08 Nov 2016	08 Nov 2016	08 Nov 2016	08 Nov 2016
	Sample Name	BH21_0.0-0.11	BH21_0.2-0.5	BH22_0.0-0.09	BH22_0.09-0.5
Units		LOR			

Total Phosphorus by Kjeldahl Digestion DA in Soil Method: AN279/AN293(Sydney only) Tested: 23/11/2016

Total Phosphorus (Kjeldahl Digestion)	mg/kg	2	260	270	640	170
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Colwell Phosphorus Method: AN015 Tested: 24/11/2016

Colwell Phosphorus	mg/kg	1	10	2	20	3
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Phosphorus Absorption Method: AN239 Tested: 23/11/2016

Phosphorus Absorption*	mg/kg	1	360	570	390	690
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Sample Subcontracted Method: Tested: 8/12/2016

Sample Subcontracted*	No unit	-	See attached	See attached	See attached	See attached
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MB blank results are compared to the Limit of Reporting

LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.

DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Colwell Phosphorus Method: ME-(AU)-[ENV]AN015

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Colwell Phosphorus	LB041276	mg/kg	1	<1	0 - 2%	112%

Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: ME-(AU)-[ENV]AN122

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Exchangeable Sodium, Na	LB041233	mg/kg	2		1 - 6%	101%
Exchangeable Sodium, Na	LB041233	meq/100g	0.01	<0.01	1 - 6%	NA
Exchangeable Sodium Percentage	LB041233	%	0.1		0 - 1%	NA
Exchangeable Potassium, K	LB041233	mg/kg	2		0 - 6%	108%
Exchangeable Potassium, K	LB041233	meq/100g	0.01	<0.01	0 - 6%	NA
Exchangeable Potassium Percentage	LB041233	%	0.1		0%	NA
Exchangeable Calcium, Ca	LB041233	mg/kg	2		2 - 6%	105%
Exchangeable Calcium, Ca	LB041233	meq/100g	0.01	<0.01	2 - 6%	NA
Exchangeable Calcium Percentage	LB041233	%	0.1		0 - 2%	NA
Exchangeable Magnesium, Mg	LB041233	mg/kg	2		3 - 6%	104%
Exchangeable Magnesium, Mg	LB041233	meq/100g	0.02	<0.02	3 - 6%	NA
Exchangeable Magnesium Percentage	LB041233	%	0.1		0 - 2%	NA
Cation Exchange Capacity	LB041233	meq/100g	0.02	<0.02	0 - 6%	NA
Sodium Adsorption Ratio	LB041233	No unit	0.1		1 - 3%	NA
Exchangeable Calcium/Exchangeable Magnesium Ratio	LB041233	No unit	0.1		0 - 5%	NA

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: ME-(AU)-[ENV]AN248

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Nitrate/Nitrite Nitrogen, NOx as N	LB041268	mg/kg	0.1	<0.1	7 - 21%	105%

Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: ME-(AU)-[ENV]AN281

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Kjeldahl Nitrogen	LB041235	mg/kg	5	<5	2%	98%

Total Organic Carbon by Heanes Oxidation Method: ME-(AU)-[ENV]AN273

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Total Organic Carbon	LB041236	%w/w	0.05	<0.05	9 - 23%	95%	119%
Organic Matter	LB041236	%w/w	0.1	<0.10	9 - 23%	NA	NA

MB blank results are compared to the Limit of Reporting

LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.

DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Total Phosphorus by Kjeldahl Digestion DA in Soil Method: ME-(AU)-[ENV]AN279/AN293(Sydney only)

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Phosphorus (Kjeldahl Digestion)	LB041235	mg/kg	2	<2	0%	109%

METHOD

METHODOLOGY SUMMARY

AN002	The test is carried out by drying (at either 40°C or 105°C) a known mass of sample in a weighed evaporating basin. After fully dry the sample is re-weighed. Samples such as sludge and sediment having high percentages of moisture will take some time in a drying oven for complete removal of water.						
AN009	The method follows AS1289 3.8.1 - 2006. Soils are divided into seven classes on the basis of their coherence in water, with one further class being distinguished by the presence of calcium-rich minerals. Class 1: Air-dried crumbs of soil show a strong dispersion reaction, i.e., a colloidal cloud covers nearly the whole of the bottom of the beaker, usually in a very thin layer. The reaction should be evident within 10min. In extreme cases all the water in the beaker becomes cloudy, leaving only a coarse residue in a cloud of clay.						
AN009	Class 2: Air-dried crumbs of soil show a moderate to slight reaction. A moderate reaction consists of an easily recognisable cloud of colloids in suspension, usually spreading in thin streaks on the bottom of the beaker. A slight reaction consists of the bare hint of cloud in water at the surface of the crumbs. Class 3: The soil remoulded at the plastic limit disperses in water. Class 4: The remoulded soil does not disperse in water. Calcium carbonate (calcite) or calcium sulfate (gypsum) is present. Class 5: The remoulded soil does not disperse in water and the 1:5 soil/water suspension remains dispersed after 5 min.						
AN009	Class 6: The remoulded soil does not disperse in water and the 1:5 soil/water suspension begins to flocculate within 5 min. Class 7: The air-dried crumbs of soil remain coherent in water and swells. Class 8: The air-dried crumbs of soil remain coherent in water and do not swell.						
AN015	Soil sample is extracted in an end over end roller in 0.5 N sodium bicarbonate at pH 8.5 with the supernatant liquor analysed for Phosphorous. Orthophosphate anion (PO ₄ ³⁻) is reacted with ammonium molybdate and potassium antimony tartrate in sulfuric acid solution. The resulting phospho-molybdate complex is reduced, using ascorbic acid, to an intense blue coloured complex Molybdenum Blue. The absorbance of this complex is measured at 880 nm by Discrete Analyser, and compared with calibration standards to obtain the concentration of orthophosphate in the sample. Based on Rayment & Higginson 9B1.						
AN122	Exchangeable Cations, CEC and ESP: Soil sample is extracted in 1 M Ammonium Acetate at pH=7 (or 1M Ammonium Chloride at pH=7) with cations (Na, K, Ca & Mg) then determined by ICP OES/ICP MS and reported as Exchangeable Cations. For saline soils, these results can be corrected for water soluble cations and reported as Exchangeable cations in meq/100g or soil can be pre-treated (aqueous ethanol/aqueous glycerol) prior to extraction. Cation Exchange Capacity (CEC) is the sum of the exchangeable cations in meq/100g.						
AN122	The Exchangeable Sodium Percentage (ESP) is calculated as the exchangeable sodium divided by the CEC (all in meq/100g) times 100. ESP can be used to categorise the sodicity of the soil as below: <table> <tr> <td>ESP < 6%</td><td>non-sodic</td></tr> <tr> <td>ESP 6-15%</td><td>sodic</td></tr> <tr> <td>ESP > 15%</td><td>strongly sodic</td></tr> </table> Method is referenced to Rayment and Higginson, 1992, sections 15D3 and 15N1.-	ESP < 6%	non-sodic	ESP 6-15%	sodic	ESP > 15%	strongly sodic
ESP < 6%	non-sodic						
ESP 6-15%	sodic						
ESP > 15%	strongly sodic						
AN239	A soil's capacity for sorbing (fixing) P is related to its texture and clay mineralogy: sorption increases with increasing clay content. The sorption capacity of a soil is estimated as mg P sorbed/kg soil.						
AN248	Nitrate / Nitrite in extract by Auto Analyser: In an acidic medium, nitrate is reduced quantitatively to nitrite by cadmium metal. This nitrite plus any original nitrite is determined as an intense red-pink azo dye at 540 nm following diazotisation with sulphanilamide and subsequent coupling with N-(1-naphthyl) ethylenediamine dihydrochloride. Reference APHA 4500-NO ₃ - F.						
AN273	The sample is digested in Dichromate / Sulfuric Acid to oxidise the organic carbon. The determination is completed colourimetrically by Aquakem Discrete Analyser at 600 nm. Based on Rayment & Higginson 6B1.						

METHOD

AN281

METHODOLOGY SUMMARY

The sample is heated in the presence of Sulphuric acid, K₂SO₄ and CuSO₄ for two and half hours using a temperature controlled digestion block. Amino Nitrogen of many organic materials is converted to ammonium ion. Free ammonia also is converted to ammonium. The digest is cooled and placed on the Aquakem 250 discrete analyser for Ammonia determination.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
**	Indicative data, theoretical holding time exceeded.	QFL	QC result is below the lower tolerance
		-	The sample was not analysed for this analyte
		NVL	Not Validated

Samples analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calculated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the "Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.

Note that in terms of units of radioactivity:

- 1 Bq is equivalent to 27 pCi
- 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here : <http://www.sgs.com.au/~media/Local/Australia/Documents/Technical%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf>

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SOIL TEST REPORT

Page 1 of 2

Scone Research Centre

REPORT NO: SCO16/208R1

REPORT TO: Shey Goddard
SGS Australia Pty Ltd
Unit 2, 58 Comport Street
Portsmith QLD 4870

REPORT ON: Twelve Soil Samples
Your Reference: CE124027

PRELIMINARY RESULTS

ISSUED: Not Issued

REPORT STATUS: Final

DATE REPORTED: 7 December 2016

METHODS: Information on test procedures can be obtained from Scone
Research Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED
THIS DOCUMENT MAY NOT BE REPRODUCED EXCEPT IN FULL

L Dunn
Scone Laboratory

SOIL CONSERVATION SERVICE
Scone Research Centre

Page 2 of 2

Report No: SCO16/208R1
Client Reference: Shey Goddard
SGS Australia Pty Ltd
Unit 2, 58 Comport Street
Portsmouth QLD 4870

Lab No	Method	P17C/1	
	Sample Id	Saturated Hydraulic Conductivity (mm/hr)	BD* (t/m ³)
1	CE124027-001	3	1.20
2	CE124027-002	7	1.16
3	CE124027-003	4	1.63
4	CE124027-004	3	1.33
5	CE124027-005	9	1.48
6	CE124027-006	<1	1.28
7	CE124027-007	27	1.16
8	CE124027-008	2	1.12
9	CE124027-009	7	1.42
10	CE124027-010	6	1.47
11	CE124027-011	2	1.32
12	CE124027-012	17	1.30

BD* = bulk density of recompact material at which hydraulic conductivity was determined

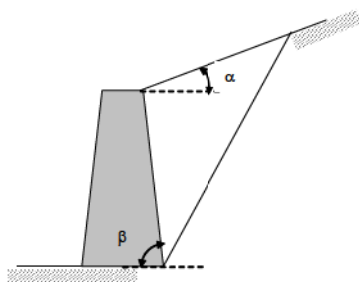


END OF TEST REPORT



APPENDIX E: EARTH PRESSURE COEFFICIENTS

Rankine							Rankine						
Coulomb $\delta = 2/3 \phi$							Coulomb $\delta = 2/3 \phi$						
phi (ϕ)	alpha (α)	beta (β)	K _a	K _p	K _a	K _p	phi (ϕ)	alpha (α)	beta (β)	K _a	K _p	K _a	K _p
20	0	90	0.490	2.040	0.438	2.888	30	10	80	0.350	2.775	0.438	7.162
20	0	85	0.490	2.040	0.474	2.636	30	10	75	0.350	2.775	0.497	6.156
20	0	80	0.490	2.040	0.514	2.446	30	15	90	0.373	2.502	0.371	15.422
20	0	75	0.490	2.040	0.559	2.304	30	15	85	0.373	2.502	0.422	11.625
20	5	90	0.500	1.986	0.474	3.482	30	15	80	0.373	2.502	0.480	9.306
20	5	85	0.500	1.986	0.515	3.147	30	15	75	0.373	2.502	0.548	7.800
20	5	80	0.500	1.986	0.560	2.901	30	20	90	0.414	2.132	0.414	23.373
20	5	75	0.500	1.986	0.612	2.720	30	20	85	0.414	2.132	0.473	16.347
20	10	90	0.531	1.826	0.524	4.205	30	20	80	0.414	2.132	0.540	12.451
20	10	85	0.531	1.826	0.570	3.754	30	20	75	0.414	2.132	0.620	10.079
20	10	80	0.531	1.826	0.623	3.428	35	0	90	0.271	3.690	0.244	9.962
20	10	75	0.531	1.826	0.683	3.193	35	0	85	0.271	3.690	0.282	7.861
20	15	90	0.603	1.548	0.604	5.122	35	0	80	0.271	3.690	0.323	6.466
20	15	85	0.603	1.548	0.659	4.498	35	0	75	0.271	3.690	0.371	5.499
20	15	80	0.603	1.548	0.721	4.056	35	5	90	0.274	3.627	0.258	14.227
20	15	75	0.603	1.548	0.795	3.742	35	5	85	0.274	3.627	0.299	10.741
20	20	90	0.940	0.940	0.907	6.335	35	5	80	0.274	3.627	0.345	8.563
20	20	85	0.940	0.940	0.990	5.442	35	5	75	0.274	3.627	0.397	7.121
20	20	80	0.940	0.940	1.089	4.827	35	10	90	0.282	3.442	0.275	21.540
20	20	75	0.940	0.940	1.208	4.399	35	10	85	0.282	3.442	0.319	15.231
25	0	90	0.406	2.464	0.361	4.079	35	10	80	0.282	3.442	0.370	11.618
25	0	85	0.406	2.464	0.398	3.594	35	10	75	0.282	3.442	0.428	9.366
25	0	80	0.406	2.464	0.440	3.235	35	15	90	0.297	3.144	0.295	35.931
25	0	75	0.406	2.464	0.486	2.966	35	15	85	0.297	3.144	0.344	22.919
25	5	90	0.412	2.410	0.387	5.105	35	15	80	0.297	3.144	0.400	16.376
25	5	85	0.412	2.410	0.429	4.429	35	15	75	0.297	3.144	0.466	12.631
25	5	80	0.412	2.410	0.475	3.941	35	20	90	0.322	2.745	0.323	71.496
25	5	75	0.412	2.410	0.528	3.586	35	20	85	0.322	2.745	0.377	38.021
25	10	90	0.431	2.251	0.421	6.462	35	20	80	0.322	2.745	0.440	24.509
25	10	85	0.431	2.251	0.467	5.493	35	20	75	0.322	2.745	0.515	17.710
25	10	80	0.431	2.251	0.520	4.814	40	0	90	0.217	4.599	0.200	18.717
25	10	75	0.431	2.251	0.581	4.330	40	0	85	0.217	4.599	0.236	13.345
25	15	90	0.469	1.987	0.468	8.350	40	0	80	0.217	4.599	0.277	10.176
25	15	85	0.469	1.987	0.521	6.902	40	0	75	0.217	4.599	0.325	8.156
25	15	80	0.469	1.987	0.582	5.927	40	5	90	0.219	4.527	0.210	30.811
25	15	75	0.469	1.987	0.652	5.251	40	5	85	0.219	4.527	0.249	20.119
25	20	90	0.547	1.614	0.546	11.144	40	5	80	0.219	4.527	0.294	14.492
25	20	85	0.547	1.614	0.609	8.863	40	5	75	0.219	4.527	0.346	11.173
25	20	80	0.547	1.614	0.682	7.402	40	10	90	0.225	4.316	0.221	58.459
25	20	75	0.547	1.614	0.768	6.426	40	10	85	0.225	4.316	0.264	32.905
30	0	90	0.333	3.000	0.297	6.105	40	10	80	0.225	4.316	0.312	21.710
30	0	85	0.333	3.000	0.335	5.138	40	10	75	0.225	4.316	0.370	15.813
30	0	80	0.333	3.000	0.377	4.450	40	15	90	0.235	3.977	0.235	148.38
30	0	75	0.333	3.000	0.425	3.949	40	15	85	0.235	3.977	0.281	62.074
30	5	90	0.337	2.943	0.316	8.049	40	15	80	0.235	3.977	0.335	35.309
30	5	85	0.337	2.943	0.358	6.605	40	15	75	0.235	3.977	0.398	23.557
30	5	80	0.337	2.943	0.404	5.616	40	20	90	0.250	3.526	0.253	908.69
30	5	75	0.337	2.943	0.458	4.917	40	20	85	0.250	3.526	0.303	156.74
30	10	90	0.350	2.775	0.340	10.903	40	20	80	0.250	3.526	0.363	66.270
30	10	85	0.350	2.775	0.386	8.639	40	20	75	0.250	3.526	0.433	38.121





APPENDIX F: EARTHWORKS NOTES

PROJECT: LEVEL 1 EARTHWORKS CONTROL

These instructions apply to this project unless otherwise addressed in the job specifications or subsequently by the superintendent.

(A) PRIOR TO FILLING

- (1) Topsoil and organic matter must be stripped to the nominated depth from the proposed cut and fill areas.
- (2) The superintendent or GTA should be notified if the required stripping exceeds the nominated depth.
- (3) Any existing (uncontrolled) fill must be either removed or investigated, approved and documented.
- (4) The stripped natural surface (fill foundation) must be inspected, proof rolled and approved.
- (5) Any unsound areas are subject to supplementary site instructions (in general, the fill foundation is subject to the same compaction requirements as the fill). The practice of "bridging" over soft, unstable and wet fill foundation is generally not acceptable.

(B) FILLING

- (6) If necessary, the fill material must be moisture conditioned as required.
 - a) Too wet - dry fill to within a moisture range that the specified density can be achieved and the fill area is not deflecting (surface heaving) under construction traffic to the detriment of the fill in general.
 - b) Too dry - moisten the fill to within a moisture range that the specified density can be achieved.
 - c) The fill should be mixed to ensure reasonably uniform distribution of the moisture.
- (7) Remove excessive vegetation (sticks, stumps, etc.) as required.
- (8) Place fill in layers generally not exceeding 200mm thick and compact to specification (larger or more efficient compaction equipment may enable the placement of thicker fill layers).
- (9) The fill must be tested at the rate of:
 - a) Minimum of one (1) test every 2nd layer (each 400mm lift)
 - b) Minimum of one (1) test/500m³ of fill - large scale project
 - c) Minimum of one (1) test/200m³ of fill - small scale projector as directed by the GTA or superintendent
- (10) Areas represented by a failed test must be reworked and retested and a positive result obtained prior to placing additional fill.
- (11) Where fill abuts against sloping ground, benches should be cut in the ground generally to a depth of 200mm to 300mm.
- (12) Fill should be placed in near horizontal layers of uniform thickness deposited systematically across the fill area.
- (13) If topsoil is stockpiled adjacent to the fill area, care should be taken to ensure that structural fill does not encroach into the stockpile area.
- (14) The maximum particle size of rocks within the layer after compaction should not exceed two-thirds of the compacted layer thickness.
- (15) Equipment and haul roads should be selected to avoid the overloading (and development of surface heaving) of the fill areas.
- (16) If the filling programme is interrupted (eg. by rainfall periods), the interrupted surface must be inspected and assessed prior to placing additional fill (i.e. in accordance with "(A)").

PROJECT: LEVEL 1 EARTHWORKS CONTROL

These notes apply to this project unless otherwise instructed by the project superintendent.

(A) TEST PROCEDURES

Test procedures to be used on the site will be selected from the following:

- AS1289 5.1.1 Dry Density/Moisture Content Relationship (Standard Compaction)
- AS1289 5.2.1 Dry Density/Moisture Content Relationship (Modified Compaction)
- AS1289 5.3.1 Determination of the Field Density of a Soil (Sand Replacement)
- AS1289 5.4.1 Dry Density Ratio, Moisture Variation and Moisture Ratio
- AS1289 5.5.1 Determination of the Minimum and Maximum Dry Density of a Cohesionless Material
- AS1289 5.6.1 Density Index for a Cohesionless Material
- AS1289 5.7.1 Half Density Ratio and Moisture Variation
- AS1289 5.8.1 Determination of the Field Density of a Soil (Nuclear Gauge)

(B) CONTRACTORS RESPONSIBILITIES

Construction/Compaction Equipment

Careful consideration should be given to the selection of compaction equipment and the proportion of compaction equipment to incoming fill quantities. The plant should be capable of compacting all of the fill area including its edges, batters, irregular surfaces and junctions with the natural ground.

Construction Equipment Operators

It is the responsibility of the contractor to ensure that operators are adequately trained in the basic standard practices and requirements of earthwork construction (eg. rolling patterns, benching, appropriate layer thicknesses, etc.).

Notification of Filling

The Geotechnical Testing Authority relies on the Contractor, Constructor or Superintendent to advise when the filling operation will commence, or re-commence following delay periods. Level 1 certification cannot be given for fill placed without the knowledge of the Geotechnical Testing Authority.

Specification Compliance

Regardless of the role of the Geotechnical Testing Authority, the contractor is responsible for complying with all aspects of the specification including the quality, placement methods and compaction of the fill.

(C) UNSUITABLE MATERIALS

In relation to structural filling, unsuitable materials may be termed either "unsuitable" or "temporary unsuitable".

1) *Unsuitable*

Unless otherwise approved by the superintendent, the following materials are not suitable for forming any part of structural filling. At the direction of the superintendent, unsuitable materials should either be removed to spoil or used in non-structural areas (eg. park areas, footpaths, etc.).

- organic soils - topsoils, severely root affected soils and peat
- materials which may be contaminated with toxic substances through past site usages
- filling which contains wood, metal, plastic, boulders and other deleterious materials
- any other materials which have deleterious engineering properties

2) *Temporary Unsuitable*

"Temporary unsuitable" refers to materials which are deemed unsuitable for use as structural fill in the present condition but may be rectified for subsequent use by some form of treatment.

Typical examples of temporary unsuitable materials and appropriate treatments are shown below:

<u>Temporary Unsuitable Material</u>	<u>Possible Remedial Treatment</u>
Material too wet	Spread and Dry
Excessive oversize	Screen/remove oversize
Excessive organics (sticks/stumps)	Remove sticks/stumps

(D) REACTIVE CLAYS

Soil reactivity is a term which refers to the volume change (shrinking and swelling) of clay soils undergoing moisture change. Reactive clay soils swell when wetted up and shrink when dried out. This characteristic is measured in the laboratory and used extensively for residential site classification and footing design. The following issues should be considered.

- 1) The site classification of a lot is not only affected by filling of the lot but also by the reactivity characteristics of the soils used to fill the lot.
- 2) Clay soils placed in a new environment (fill) will, over a period, adjust to equilibrium conditions (moisture and density). Clay soils which are over dried and over compacted (beyond equilibrium conditions) may result in a fill area with a high swell potential.

A Modified Compaction specification will often necessitate the drying of clay soils well beyond the equilibrium conditions to meet the specification requirements. In temperate climates, the Standard Compaction Optimum Moisture Content is more likely to approximate the equilibrium moisture content (AS 3798 - 2007 Clause 5.3).

(E) SANDY SOILS (SILTY SANDS AND CLAYEY SANDS)

Sandy soils are generally prone to loss of strength and stability (heaving under load) as the moisture content approaches the standard optimum moisture content. The condition generally worsens as the moisture content increases above the optimum moisture content. This condition can develop and be evident on fill areas that may otherwise comply with the density requirement. As a general rule, the moisture content should be maintained approximately 1% to 3% dry of the optimum moisture content (standard compaction).

(F) TOPSOILING

Spreading of topsoil in excessive quantities over controlled fill may reduce the likelihood of a site being re-classified from a 'P' site. As a general rule, topsoil depth should be restricted to about 100mm in proposed building areas.

(G) COMPACTION STANDARDS

Unless otherwise notified, the compaction standard specified by the local authority will be adopted as the density acceptance/rejection criteria.

(H) CONTROLLED FILL ACCEPTANCE/REJECTION CRITERIA

Any combination of the following issues may influence an acceptance/rejection instruction on a section of fill presented for testing.

- density testing
- load testing - deflection/surface heaving
- quality of fill - organics/deleterious materials
- consistency of compaction

(I) EXCLUSIONS

Unless specifically requested Level 1 compaction control does not address the following issues:

- slope stability
- reactive soils
- soft natural soils and/or pre-existing (uncontrolled) fill on the site outside of the nominated controlled fill area
- soils which may be contaminated with toxic substances
- backfill to service trenches, subsequent to the controlled fill commission or when not included in the controlled fill commission
- site drainage
- topsoil placed subsequent to completion of controlled filling
- where the filling exceeds 5m, advice from a geotechnical professional should be sought



APPENDIX G: STANDARD CBR NOTES AND PERFORMANCE WARNINGS

SAMPLING

At the time of sampling, earthworks had not been carried out and the proposed subgrade had not been exposed.

As the subgrade was not exposed, and could not be viewed at the time of sampling, some of the samples may not be representative of predominant or worst case soil types.

Soil type boundaries (representing the soaked CBR samples) should be established when bulk earthworks is completed and the proposed subgrade is exposed.

Sampling frequency/location was in accordance with the instruction received from our client.

Unless otherwise instructed, samples are generally recovered from the zone of extreme pavement thickness, i.e. 00 - 500mm below design subgrade level.

TESTING

Testing was carried out in accordance with A.S. 1289 "Methods of Testing Soils for Engineering Purposes", A.S. 1289 6.1.1.

The test specimen was nominally placed at the Optimum Moisture Content and to the expected required density of the subgrade.

In accordance with the test procedure, the test specimen was soaked for a period of four (4) days with a surcharge mass of 4.5kg. This surcharge mass is approximately equivalent to the pressure applied by a 2.0 T/m³ insitu density pavement thickness of 150mm (Refer to A.S. 1289 6.1.1, Figure 7 for full minimum pavement thickness requirements).

The minimum pavement thickness should be at least equivalent to the pavement thickness represented by the surcharge mass, refer to AS1289.6.1.1, Figure 7 for full minimum pavement thickness requirements

Test method A.S. 1289 6.1.1 allows for any +19.0mm material to be replaced in the test portion by -19.0mm + 4.75mm material. Unless otherwise instructed by our client, +19.0mm material will be excluded from the test portion.

PERFORMANCE WARNINGS

Sandy Soils (Sands, Silty Sands and Clayey Sands)

Sandy soils are generally prone to loss of strength, reduced insitu C.B.R. and stability (heaving under load) as the moisture content approaches the standard compaction optimum moisture content. The condition generally worsens proportionally with increasing moisture content (above the optimum moisture content).

The C.B.R. value obtained on the laboratory test specimen is only representative of the material at the nominated density and moisture content.

Serviceable drainage, both surface and sub-surface (side drains) and uniform conforming density is critical to the sound performance of sandy subgrades. Provided that this is achieved, the subgrade insitu C.B.R. value should approximate the laboratory C.B.R. value for the representative soil types.

Seepage zones are common in sandy soils, particularly following rainfall periods. Wet sandy soils and seepage within the depth zone affected by loading (eg. by construction traffic) can be highly detrimental to the trafficability, workability and performance on subgrades and road pavements.

The permeability of compacted Silty and Clayey Sand subgrades is generally low, ensuring good serviceability provided that the sub-surface drainage is adequate.

Clayey Soils (Clays, Sandy Clays and Silty Clays)

Clay soils generally have very low permeability and as a result, construction and performance problems associated with wet weather are usually confined to the exposed surface of the subgrade. However, workability problems can occur in poorly drained areas or after prolonged wet periods.

The C.B.R. value obtained on the laboratory test specimen is generally representative of the material in "the worst case", after four (4) days of continuous soaking. Most clay soils are reactive, to varying extents and swell when exposed to water. As a general rule, increasing swell is proportional to the decreasing C.B.R. value on most clay soils. Dry "baked out" clay subgrades can produce insitu C.B.R. values far in excess of the laboratory Soaked C.B.R. value.

Excessive drying and compaction of clay subgrades can be detrimental to the long term performance to some pavements. Upon wetting up to the "equilibrium moisture" some clay subgrades can swell resulting in deformation and weakening to the pavement.

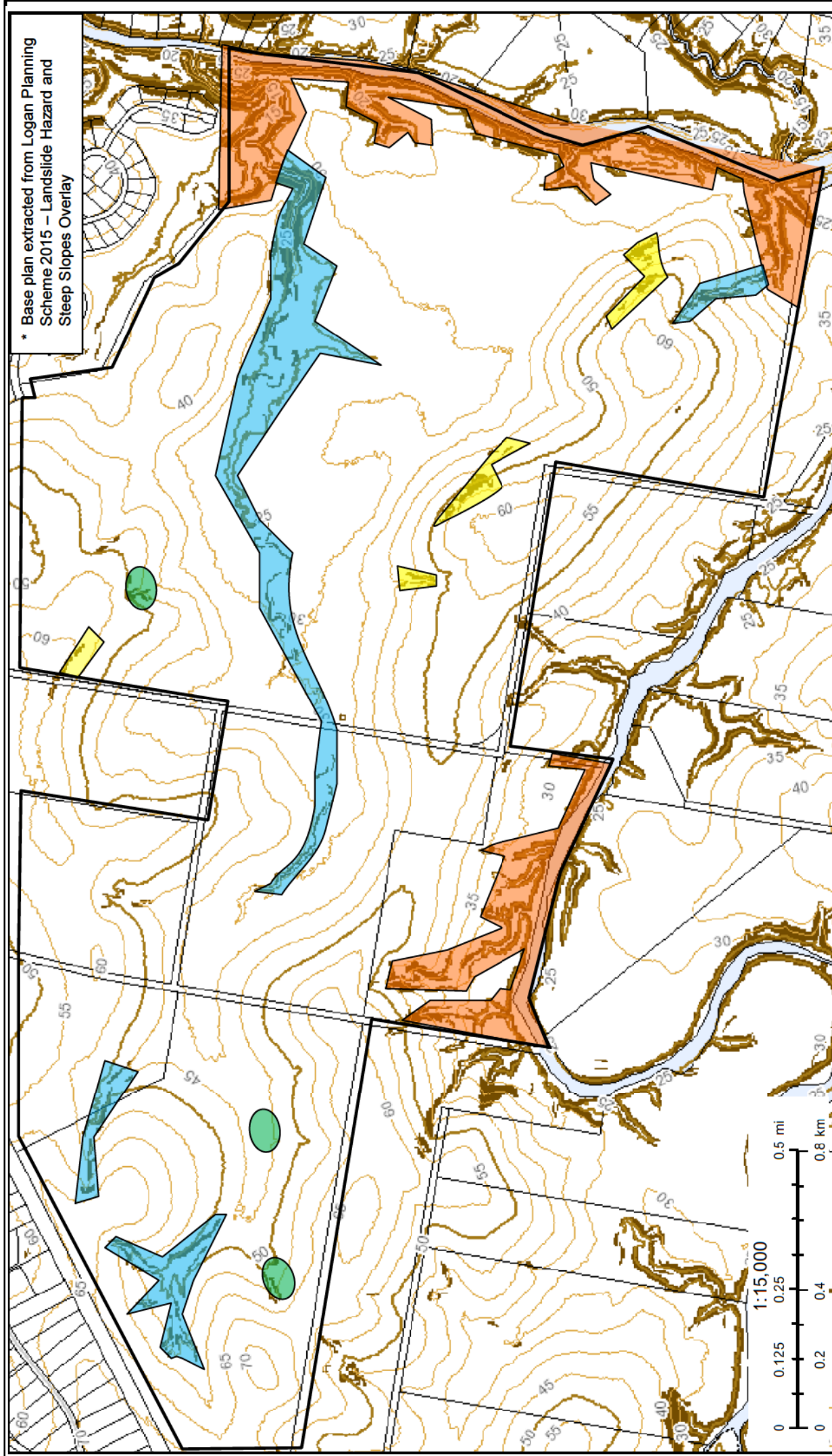
CONSTRUCTION

Care should be taken when backfilling services (sewer/stormwater etc.) in the pavement area to ensure that materials in the top 500mm of backfill is not of lesser C.B.R. than the C.B.R. representing that section of pavement.

Should additional earthworks of any kind be carried out after the soil boundaries have been established, the boundaries may become invalid and should be re-confirmed.



APPENDIX H: POTENTIAL LANDSLIDE HAZARD AREAS



POTENTIAL LANDSLIDE HAZARD AREAS/ZONES

- HAZARD A - Dam Embankments
- HAZARD B - Deeply Incised Gullies / Creeks
- HAZARD C - Ridges/Hillslopes (Sandstone)
- HAZARD D - Logan River Embankments

SGS

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TITLE
POTENTIAL LANDSLIDE HAZARD AREAS/ZONES

JOB LOCATION
RIVERBEND / TEVIOT BROOK, JIMBOOMBA QLD

CUSTOMER
CELESTINO PTY LIMITED

DATE
20.1.17

DRAWING NO.
SGSE.16.220.SP02

SCALE
AS SHOWN

DRAWN
RM

SIZE
A4



**APPENDIX I: AUSTRALIAN GEOGUIDES FOR SLOPE MANAGEMENT AND
MAINTENANCE**

AUSTRALIAN GEOGUIDE LR1 (INTRODUCTION)

INTRODUCTION TO LANDSLIDE RISK

Photographs courtesy of Greg Kotze and Tony Phillips



AUSTRALIAN GEOGUIDES

The **Australian GeoGuides (LR series)** are a set of information sheets on the subject of landslide risk management and maintenance, published by the Australian Geomechanics Society (AGS). They provide background information intended to help people without specialist technical knowledge understand the basic issues involved. Topics covered include:

LR1 - Introduction	LR2 - Landslides	LR3 - Landslides in Soil
LR4 - Landslides in Rock	LR5 - Water & Drainage	LR6 - Retaining Walls
LR7 - Landslide Risk	LR8 - Hillside Construction	LR9 - Effluent & Surface Water Disposal
LR10 - Coastal Landslides	LR11 - Record Keeping	

The GeoGuides explain why slopes and retaining structures can be a hazard and what can be done with appropriate professional advice and local authority approval (if required) to remove, or reduce, the risk they represent.

Preparation of the GeoGuides has been funded by Australian governments through the National Disaster Mitigation Program (NDMP). This is a national program aimed at identifying and addressing natural disaster risk priorities across Australia. Technical input has been provided by experienced geotechnical engineers, engineering geologists and local government and government agency representatives from around Australia.

BACKGROUND

A number of landslides and cliff collapses occurred in Australia in the 1980's and 1990's in which lives were lost. Of these the Thredbo landslide probably received the most publicity, but there were several others. During this period the AGS issued a number of advisory notes to practitioners in relation to the assessment of landslide risk and its reduction. Building on these notes, and responding to changes in technology, a technical paper known as AGS2000 was prepared. It was followed in 2002 by an intensive nation-wide educational campaign attended by a large number of interested professionals from government departments and private industry. This resulted in an increased awareness of the risks associated with unstable slopes and a changed approach in many government departments responsible for regional planning, domestic development, roads, railways and the maintenance of natural features such as cliffs.

STATUS OF THE GEOGUIDES

The GeoGuides reflect the essence of good practice as perceived by a large number of geotechnical engineers, engineering geologists and other practitioners such as local government planners. **The GeoGuides are generic and do not, and cannot, constitute advice in relation to a specific situation. This must be sought from a geotechnical practitioner with first hand knowledge of the site.** It is expected that some local councils will refer to the GeoGuides and their companion publications in planning and building legislation. Check with your local council to see how it regards these documents. Companion publications to the GeoGuides are:

- AGS (2007a) Guideline for Landslide Susceptibility, Hazard and Risk Zoning for Land Use Management Australian Geomechanics Society, *Australian Geomechanics*, Vol 42, No1 and its associated commentary (AGS 2007b).
- AGS (2007c). Practice Note Guidelines for Landslide Risk Management. Australian Geomechanics Society, *Australian Geomechanics*, Vol 42, No1 2007, and its associated "Commentary" (AGS 2007d).

Copies of the above documents are available on the AGS website www.australiangeomechanics.org

AUSTRALIAN GEOGUIDE LR1 (INTRODUCTION)

TERMINOLOGY

Terminology tends to change with time and place and with the context in which it is used. The terms listed below have the following meanings in the GeoGuides:

Consequence	the outcome, or potential outcome, arising from the occurrence of a landslide expressed quantitatively, or qualitatively, in terms of loss, disadvantage, damage, injury, or loss of life.
Discontinuity	in relation to the ground is a crack, a bedding plane (a boundary between strata) or fault (a plane along which the ground has sheared) which forms a plane of weakness and reduces the overall strength of the ground.
Equilibrium	the condition when the forces on a mass of soil or rock in the ground, or on a retaining structure, are equal and opposite.
Factor of safety (FOS)	theoretically the forces available to prevent a part of the ground, or a retaining structure, from moving divided by those trying to move it. A FOS of one or less indicates that failure is likely to occur, but not how likely it is. To allow for unknowns and to limit movements engineers always aim to achieve a FOS significantly larger than one.
Failure	when part of the ground experiences movement as a result of the out of balance forces on it. Failure of a retaining structure means it is no longer able to fulfil its intended function.
Geotechnical practitioner	when referred to in the Australian GeoGuides (LR series), is a professional geotechnical engineer, or engineering geologist, with chartered status in a recognised national professional institution and relevant training, experience and core competencies in landslide risk assessment and management. In some government departments, technical officers are specifically trained to undertake some of the functions of a geotechnical practitioner.
Hazard	a condition with the potential for causing an undesirable consequence. In relation to landslides this includes the location, size, speed, distance of travel and the likelihood of its occurrence within a given period of time.
Landslide	the movement, or the potential movement, of a mass of rock, debris, or earth down a slope.
Likelihood	a qualitative description of probability, or frequency, of occurrence.
Partial saturation	the condition in the ground above the water table where both air and water are present as well as soil, or rock.
Perched water table	a water table above the true water table supported by a low permeability stratum.
Permeability	a measure of the ability of the ground to allow water to flow through it.
Risk	a measure of the probability and severity of an adverse effect to life, health, property or the environment.
Slip failure	landslide.
Stable	the condition when failure will not occur. Over geological time no part of the ground can be considered stable. Over short periods (eg the life of a structure) stability implies a very low likelihood of failure.
Retaining structure	anything built by humans which is intended to support the ground and inhibit failure.
Structure	in relation to rock, or soil, means the spacing, extent, orientation and type of discontinuities found in the ground at a particular location.
Tension crack	a distinct open crack that normally develops in the ground around a landslide and indicates actual, or imminent, failure.
Water table	the level in the ground below which it is saturated and the voids are filled with water.



Photograph courtesy of Phil Flentje

AUSTRALIAN GEOGUIDE LR2 (LANDSLIDES)

LANDSLIDES

What is a Landslide?

Any movement of a mass of rock, debris, or earth, down a slope, constitutes a "landslide". Landslides take many forms, some of which are illustrated. More information can be obtained from Geoscience Australia, or by visiting its Australian Landslide Database at www.ga.gov.au/urban/factsheets/landslide.jsp. Aspects of the impact of landslides on buildings are dealt with in the book "Guideline Document Landslide Hazards" published by the Australian Building Codes Board and referenced in the Building Code of Australia. This document can be purchased over the internet at the Australian Building Codes Board's website www.abcb.gov.au.

Landslides vary in size. They can be small and localised or very large, sometimes extending for kilometres and involving millions of tonnes of soil or rock. It is important to realise that even a 1 cubic metre boulder of soil, or rock, weighs at least 2 tonnes. If it falls, or slides, it is large enough to kill a person, crush a car, or cause serious structural damage to a house. The material in a landslide may travel downhill well beyond the point where the failure first occurred, leaving destruction in its wake. It may also leave an unstable slope in the ground behind it, which has the potential to fail again, causing the landslide to extend (regress) uphill, or expand sideways. For all these reasons, both "potential" and "actual" landslides must be taken very seriously. They present a real threat to life and property and require proper management.

Identification of landslide risk is a complex task and must be undertaken by a geotechnical practitioner (GeoGuide LR1) with specialist experience in slope stability assessment and slope stabilisation.

What Causes a Landslide?

Landslides occur as a result of local geological and groundwater conditions, but can be exacerbated by inappropriate development (GeoGuide LR8), exceptional weather, earthquakes and other factors. Some slopes and cliffs never seem to change, but are actually on the verge of failing. Others, often moderate slopes (Table 1), move continuously, but so slowly that it is not apparent to a casual observer. In both cases, small changes in conditions can trigger a landslide with serious consequences. Wetting up of the ground (which may involve a rise in ground water table) is the single most important cause of landslides (GeoGuide LR5). This is why they often occur during, or soon after, heavy rain. Inappropriate development often results in small scale landslides which are very expensive in human terms because of the proximity of housing and people.

Does a Landslide Affect You?

Any slope, cliff, cutting, or fill embankment may be a hazard which has the potential to impact on people, property, roads and services. Some tell-tale signs that might indicate that a landslide is occurring are listed below:

- open cracks, or steps, along contours
- ground water seepage, or springs
- bulging in the lower part of the slope
- hummocky ground
- trees leaning down slope, or with exposed roots
- debris/fallen rocks at the foot of a cliff
- tilted power poles, or fences
- cracked or distorted structures

These indications of instability may be seen on almost any slope and are not necessarily confined to the steeper ones (Table 1). Advice should be sought from a geotechnical practitioner if any of them are observed. Landslides do not respect property boundaries. As mentioned above they can "run-out" from above, "regress" from below, or expand sideways, so a landslide hazard affecting your property may actually exist on someone else's land.

Local councils are usually aware of slope instability problems within their jurisdiction and often have specific development and maintenance requirements. **Your local council is the first place to make enquiries if you are responsible for any sort of development or own or occupy property on or near sloping land or a cliff.**

TABLE 1 - Slope Descriptions

Appearance	Slope Angle	Maximum Gradient	Slope Characteristics
Gentle	0° - 10°	1 on 6	Easy walking.
Moderate	10° - 18°	1 on 3	Walkable. Can drive and manoeuvre a car on driveway
Steep	18° - 27°	1 on 2	Walkable with effort. Possible to drive straight up or down roughened concrete driveway, but cannot practically manoeuvre a car.
Very Steep	27° - 45°	1 on 1	Can only climb slope by cl utching at vegetation, rocks etc.
Extreme	45° - 64°	1 on 0.5	Need rope access to climb slope
Cliff	64° - 84°	1 on 0.1	Appears vertical. Can abseil down.
Vertical or Overhang	84° - 90±°	Infinite	Appears to o verhang. Abseiler likely to lose contact with the face.

Some typical landslides which could affect residential housing are illustrated below:

AUSTRALIAN GEOGUIDE LR2 (LANDSLIDES)

Rotational or circular slip failures (Figure 1) - can occur on moderate to very steep soil and weathered rock slopes (Table 1). The sliding surface of the moving mass tends to be deep seated. Tension cracks may open at the top of the slope and bulging may occur at the toe. The ground may move in discrete "steps" separated by long periods without movement. More rapid movement may occur after heavy rain.

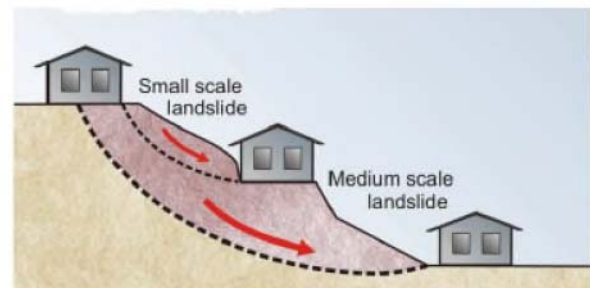


Figure 1

Translational slip failures (Figure 2) - tend to occur on moderate to very steep slopes (Table 1) where soil, or weak rock, overlies stronger strata. The sliding mass is often relatively shallow. It can move, or deform slowly (creep) over long periods of time. Extensive linear cracks and hummocks sometimes form along the contours. The sliding mass may accelerate after heavy rain.



Figure 2

Wedge failures (Figure 3) - normally only occur on extreme slopes, or cliffs (Table 1), where discontinuities in the rock are inclined steeply downwards out of the face.

Rock falls (Figure 3) - tend to occur from cliffs and overhangs (Table 1).

Cliffs may remain apparently unchanged for hundreds of years. Collections of boulders at the foot of a cliff may indicate that rock falls are ongoing. Wedge failures and rock falls do not "creep". Familiarity with a particular local situation can instil a false sense of security since failure, when it occurs, is usually sudden and catastrophic.

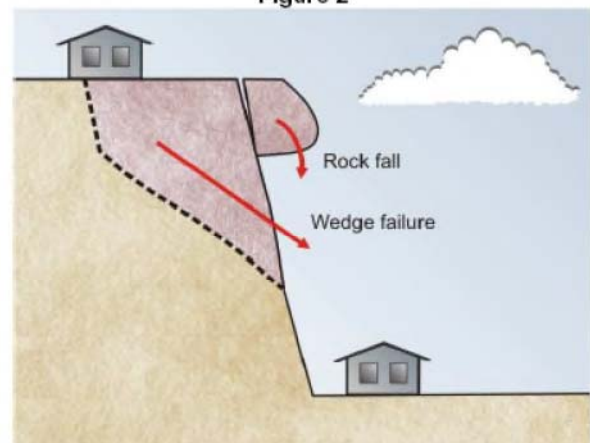


Figure 3

Debris flows and mud slides (Figure 4) - may occur in the foothills of ranges, where erosion has formed valleys which slope down to the plains below. The valley bottoms are often lined with loose eroded material (debris) which can "flow" if it becomes saturated during and after heavy rain. Debris flows are likely to occur with little warning; they travel a long way and often involve large volumes of soil. The consequences can be devastating.

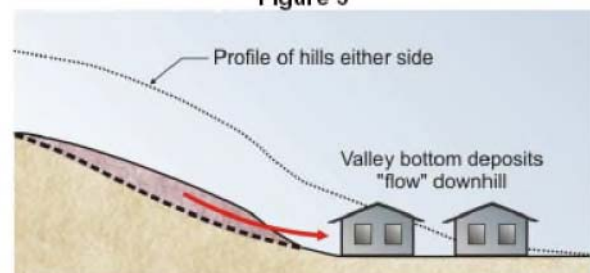


Figure 4

More information relevant to your particular situation may be found in other Australian GeoGuides:

- | | |
|-----------------------------------|--|
| • GeoGuide LR1 - Introduction | • GeoGuide LR7 - Landslide Risk |
| • GeoGuide LR3 - Soil Slopes | • GeoGuide LR8 - Hillside Construction |
| • GeoGuide LR4 - Rock Slopes | • GeoGuide LR9 - Effluent & Surface Water Disposal |
| • GeoGuide LR5 - Water & Drainage | • GeoGuide LR10 - Coastal Landslides |
| • GeoGuide LR6 - Retaining Walls | • GeoGuide LR11 - Record Keeping |

The Australian GeoGuides (LR series) are a set of publications intended for property owners; local councils; planning authorities; developers; insurers; lawyers and, in fact, anyone who lives with, or has an interest in, a natural or engineered slope, a cutting, or an excavation. They are intended to help you understand why slopes and retaining structures can be a hazard and what can be done with appropriate professional advice and local council approval (if required) to remove, reduce, or minimise the risk they represent. The GeoGuides have been prepared by the [Australian Geomechanics Society](#), a specialist technical society within Engineers Australia, the national peak body for all engineering disciplines in Australia, whose members are professional geotechnical engineers and engineering geologists with a particular interest in ground engineering. The GeoGuides have been funded under the Australian governments' National Disaster Mitigation Program.

LANDSLIDES IN SOIL

Landslides occur on soil slopes and the consequences can include damage to property and loss of life. Soil slopes exist in all parts of Australia and can even occur in places where rock outcrops can be seen on the surface. If you live on, or below, a soil slope it is important to understand why a landslide might occur and what you can do to reduce the risk it presents.

It is always worth asking the question "why is this slope here?", because the answer often leads to an understanding of what might happen in the future. Slopes are usually formed by weathering (breakdown) and erosion (physical movement) of the natural ground - the "parent material". Many factors are involved including rain, wind, chemical change, temperature variation, plant growth, animal activity and our own human enthusiasm for development. The general process is outlined in Figure 1.

The upper levels of the parent material progressively weather over thousands, or millions, of years, losing strength. This can result in a surface layer which looks similar to the parent material (although its colour has probably changed) but has the strength of a soil - this is called "residual soil". At some stage the weathered surface layer is exposed to the elements and fragments are transported down the slope. In this context a fragment could be a single sand grain, a boulder, or a landslide. The time scale could be anything from a few seconds to many thousands of years. The transported fragments often collect on the lower slopes and form a new soil layer that blankets the original slope - "colluvium". If material reaches a river or the sea it is deposited as "alluvium" or as a "marine deposit". With appropriate changes in river and sea level this material can again find itself on the surface to commence another cycle of weathering and erosion. In places often, but not only, near the coast, this can include sand sized fragments which form beaches and are sometimes blown back onto the land to form dunes.

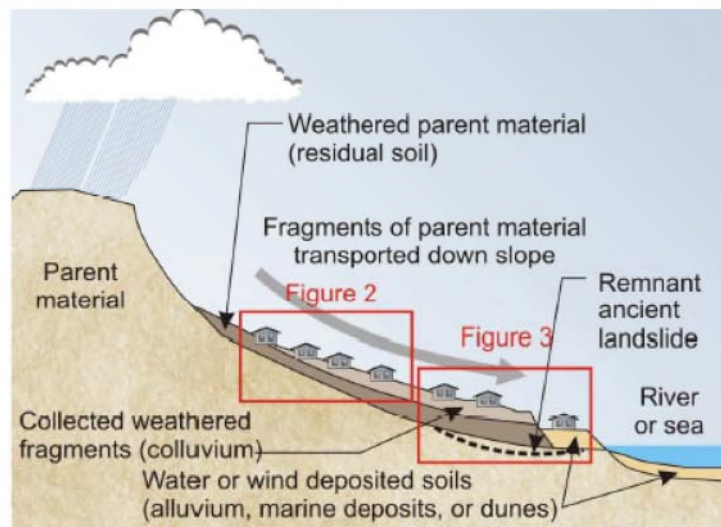


Figure 1

Landslides can occur almost anywhere on a soil slope. Slides can be rotational, translational, or debris flows (see GeoGuide LR2) and may have a number of causes.

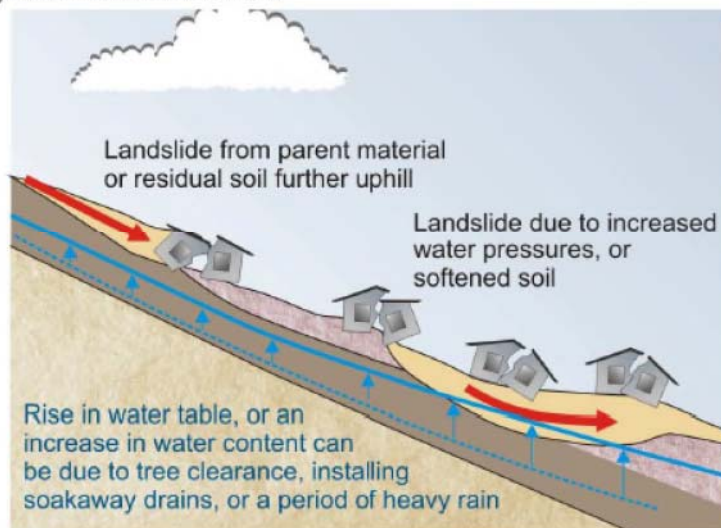


Figure 2

AUSTRALIAN GEOGUIDE LR3 (LANDSLIDES IN SOIL)

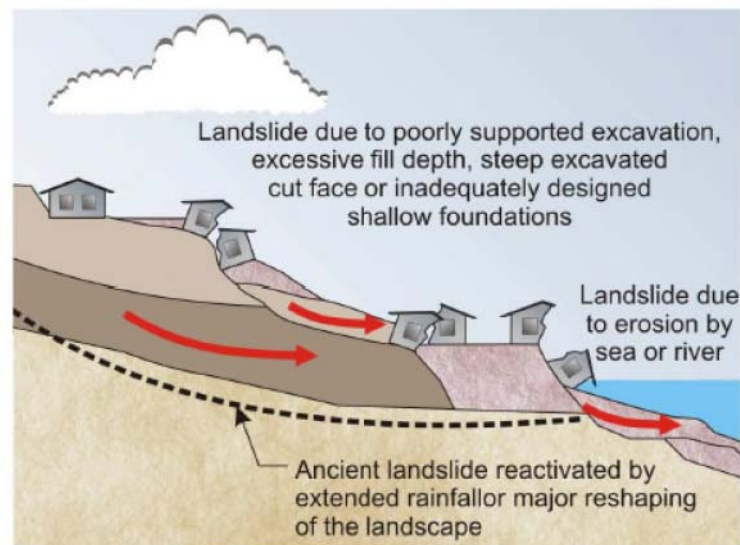


Figure 3

Some of the more common causes of landslides in soil are:

- 1) Falls of the parent material or residual soil from above, due to natural weathering processes (Figure 2).
- 2) Increased moisture content and consequent softening of the soil, or a rise in the water table. These can be due to excessive tree clearance, ill-considered soak-away drainage or septic systems, or heavy rainfall (Figure 2).
- 3) Excavation without adequate support, increased surface load from fill placement, or inadequately designed shallow foundations (Figure 3).
- 4) Natural erosion at the toe of the slope due to scour by a river or the sea (Figure 3).
- 5) Re-activation of an ancient landslide (Figure 3).

Most soil slopes appear stable, but they all achieved their present shape through a process of weathering and erosion and are often sensitive to minor changes in the factors that affect their stability. As a general rule, human activities only improve the situation if they have been designed to do so. Once this idea is understood, it is probably easy to see why the following basic rules are so important and should not be ignored without seeking site specific advice from a geotechnical practitioner:

- Do not clear trees unnecessarily.
- Do not cut into a slope without supporting the excavated face with an engineer designed structure.
- Do not add weight to a slope by placing earth fill or constructing buildings with inadequately designed shallow foundations (Note: in certain circumstances weight is added to the toe of a slope to inhibit landslide movement, but this must be carried out in accordance with a proper engineering design).
- Do not allow water from storm water drains, or from septic waste or effluent disposal systems to soak into the ground where it could trigger a landslide.

More information in relation to good and poor hillside construction practice is given in GeoGuide LR8. With appropriate engineering input it is often possible to reduce the likelihood, or consequences, of a landslide and so reduce the risk to property and to life. Such measures can include the construction of properly designed storm water and sub-soil drains, surface protection (GeoGuide LR5) and retaining walls (GeoGuide LR6). **Design should be undertaken by a geotechnical practitioner and will normally require local council approval.**

More information relevant to your particular situation may be found in other Australian GeoGuides:

- | | |
|-------------------------------------|--|
| • GeoGuide LR1 - Introduction | • GeoGuide LR7 - Landslide Risk |
| • GeoGuide LR2 - Landslides | • GeoGuide LR8 - Hillside Construction |
| • GeoGuide LR4 - Landslides in Rock | • GeoGuide LR9 - Effluent & Surface Water Disposal |
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LANDSLIDES IN ROCK

Rocks have been formed by many different geological processes and may have been subjected to intense pressure, large scale distortion, extreme temperature and chemical change. As a result there are many different rock types and their condition varies enormously. Rock strength varies and is often significantly reduced by the presence of discontinuities (GeoGuide LR1). You may think that rock lasts forever, but in reality it weathers under the combined effects of water, wind, chemical change, temperature variation, plant growth and animal activity and erodes with time. Rock is often the parent material that ends up forming soil slopes (GeoGuide LR3). Inevitably different rocks have different physical and chemical characteristics and they weather and erode to form different types of soil.

Weathering can lead to landslides (GeoGuide LR2) on rock slopes. The type of landslide depends on the nature of rock, the way it has weathered and the presence or absence of discontinuities. It is hard to generalise, though normally a specific combination of discontinuities and material types will be the determining factor and these are often underground and out of sight. Typical examples are provided in the figures 1 to 4. A geotechnical practitioner can assess the landslide risk and propose appropriate maintenance measures. This often entails making geological observations over an area significantly larger than the site and a review of available background information, including records of known landslides and aerial photographs. Depending on the amount of information available, geotechnical investigation may or may not be needed. Every site is different and every site has to be assessed individually.

It is impossible to predict exactly when a landslide will occur on a rock slope, but failure is normally sudden and the consequences can be catastrophic.



Figure 1 - Failure of an undercut block

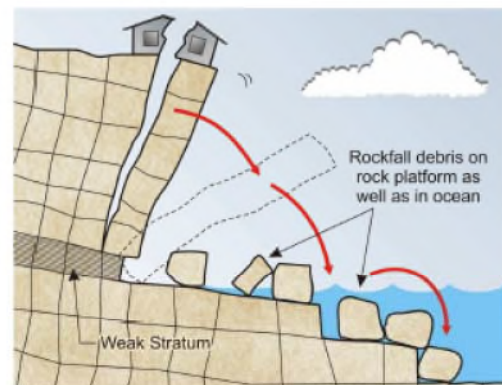


Figure 2 - Toppling failure

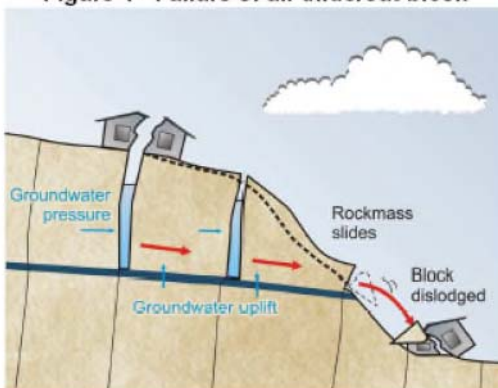


Figure 3 - Block slide on weak layer

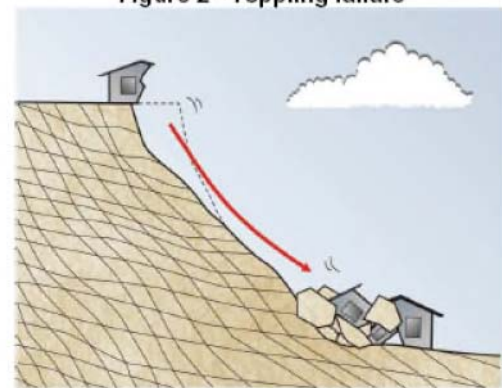


Figure 4 - Wedge failure along discontinuities

If the landslide risk is assessed as being anything other than Low, or Very Low, (GeoGuide LR7) it may be possible to carry out work aimed at reducing the level of risk.

The most common options are:

- 1) Trimming the slope to remove hazardous blocks of rock.
- 2) Bolting, or anchoring, to fix hazardous blocks in position and prevent movement.
- 3) Installation of catch fences and other rockfall protection measures to limit the impact of rockfalls.
- 4) Deep drainage designed to limit changes in the ground water table (GeoGuide LR5).

Although such measures can be effective, they need inspection and on-going maintenance (GeoGuide LR11) if they are to be effective for periods equivalent to the life of a house. **Design should be undertaken by a geotechnical practitioner and will normally require local council approval.** It should be appreciated that it may not be viable to carry out remedial works in all circumstances: for example where the landslide is on someone else's property, where the cost is out of proportion to the value of the property, or where the risk inherent in carrying out the work is actually greater than the risk of leaving things as they are. In situations such as these, development may be considered inappropriate.

AUSTRALIAN GEOGUIDE LR4 (LANDSLIDES IN ROCK)

ROCK SLOPE HAZARD REDUCTION MEASURES

Removal of loose blocks - may be effective but, depending on rock type, ongoing erosion can result in more blocks becoming unstable within a matter of years. Routine inspection, every 5 or so years, may be required to detect this.

Rock bolts and rock anchors (Figure 5) - can be installed in the ground to improve its strength and prevent individual blocks from falling. Rock bolts are usually tightened using a torque wrench, whilst rock anchors carry higher loads and require jacking. Both can be designed to be "permanent" using stainless steel, or sheathing, to inhibit corrosion, but the cost can be up to 10 times that of the "temporary" alternative. You should inspect rock bolts and rock anchors for signs of water seepage, rusting and deterioration around the heads at least once every 5 years. If you notice any of these warning signs, have them checked by a geotechnical practitioner. It is recommended that you keep copies of design drawings and maintenance records (GeoGuide LR11) for the anchors on your site and pass them on to the new owner should you sell.

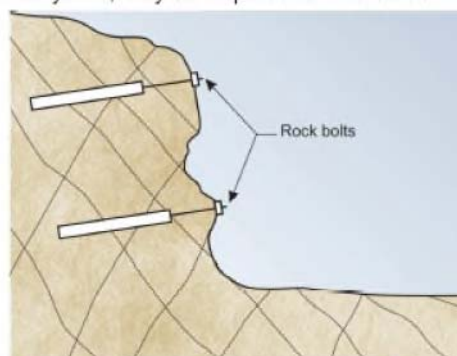


Figure 5

Rock fall netting, catch fences and catch pits (Figure 6) - are designed to catch or control falling rocks and prevent them from damaging nearby property. You should inspect them at least once every 5 years, and after major falls, and arrange for fallen and trapped rocks to be removed if they appear to be filling up. Check for signs of corrosion and replace steel elements and fixings before they lose significant strength.

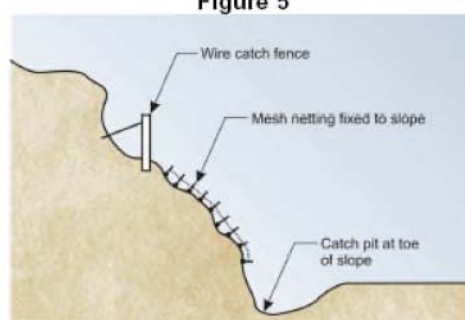


Figure 6

Cut-off drains (Figure 7) - can be used to intercept surface water run-off and reduce flows down the cliff face. Suitable drains are often excavated into the rock, or constructed from mounds of concrete, or stabilised soil, depending on conditions. Drains must be laid to a fall of at least 1% so they drain adequately. Frequent inspection is needed to ensure they are not blocked and continue to function as intended.

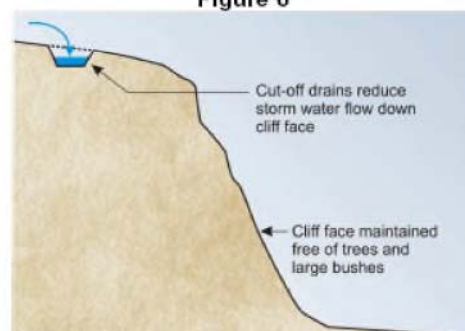


Figure 7

Natural cliffs and bluffs - often present the greatest hazard and yet are easily overlooked, because they have "been there forever". They can exist above a building, road, or beach, presenting the risk of a rock falling onto whatever is below. They also sometimes support buildings with a fine view to the horizon. Cliffs should be observed frequently to ensure that they are not deteriorating. You may find it convenient to use binoculars to look for signs of exposed "fresh" rock on the face, where a recent fall has occurred, or to go to the foot of the cliff from time to time to see if debris is collecting. A thorough inspection of a cliff face is often a major task requiring the use of rope access methods and should only be undertaken by an appropriately qualified professional. If tension cracks are observed in the ground at the top of a cliff take immediate action, since they could indicate imminent failure. **If you have any concerns at all about the possibility of a rock fall seek advice from a geotechnical practitioner.**

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- | | |
|-------------------------------------|--|
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WATER, DRAINAGE & SURFACE PROTECTION

One way or another, water usually plays a critical part in initiating a landslide (GeoGuide LR2). For this reason, it is a key factor to be controlled on sites with more than a low landslide risk (GeoGuide LR7).

Groundwater and Groundwater Flow

The ground is permeable and water flows through it as illustrated in Figure 1. When rain falls on the ground, some of it runs along the surface ("surface water run-off") and some soaks in, becoming groundwater. Groundwater seeps downwards along any path it can find until it meets the water table: the local level below which the ground is saturated. If it reaches the water table, groundwater either comes to a halt in what is effectively underground storage, or it continues to flow downwards, often towards a spring where it can seep out and become surface water again. Above the water table the ground is said to be "partially saturated", because it contains both water and air. Suctions can develop in the partially saturated zone which have the effect of holding the ground together and reducing the risk of a landslide. Vegetation and trees in particular draw large quantities of water out of the ground on a daily basis from the partially saturated zone. This lowers the water table and increases suctions, both of which reduce the likelihood of a landslide occurring.

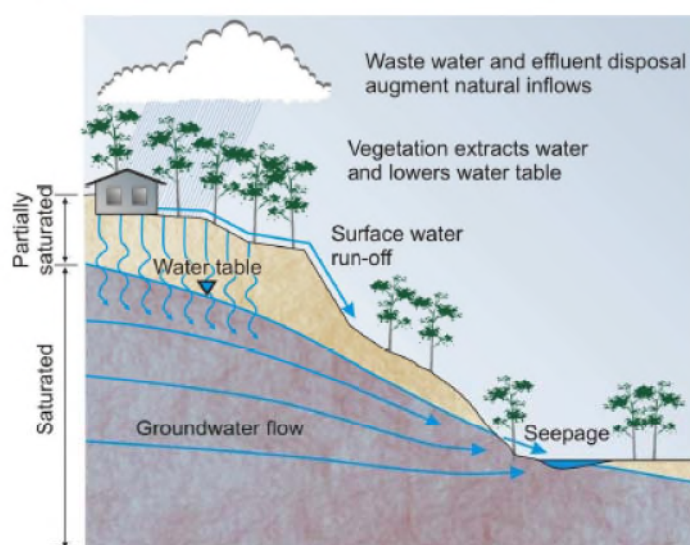


Figure 1 - Groundwater flow

Groundwater Flow and Landslides

The landslide risk in a hillside can be affected by increase in soak-away drainage or the construction of retaining walls which inhibit groundwater flow. The groundwater is likely to rise after heavy rain, but it can also rise when human interference upsets the delicate natural balance. Activities such as felling trees and earthworks can lead to:

- a reduction in the beneficial suctions in the partially saturated zone above the water table,
- increased static water pressures below the water table,
- increased hydraulic pressures due to groundwater flow,
- loss of strength, or softening, of clay rich strata,
- loss of natural cementing in some strata,
- transportation of soil particles.

Any of these effects, or a combination of them, can lead to landslides like those illustrated in GeoGuides LR2, LR3 and LR4.

Limiting the Effect of Water

Site clearance and construction must be carefully considered if changes in groundwater conditions are to be limited. GeoGuide LR8 considers good and poor development practices. Not surprisingly much of the advice relates to sensible treatment of water and is not repeated here. Adoption of appropriate techniques should make it possible to either maintain the current ground water table, or even cause it to drop, by limiting inflow to the ground.

If drainage measures and surface protection are relied on to keep the risk of a landslide to a tolerable level, it is important that they are inspected routinely and maintained (GeoGuide LR11).

The following techniques may be considered to limit the destabilising effects of rising groundwater due to development and are illustrated in Figure 2.

AUSTRALIAN GEOGUIDE LR5 (WATER & DRAINAGE)

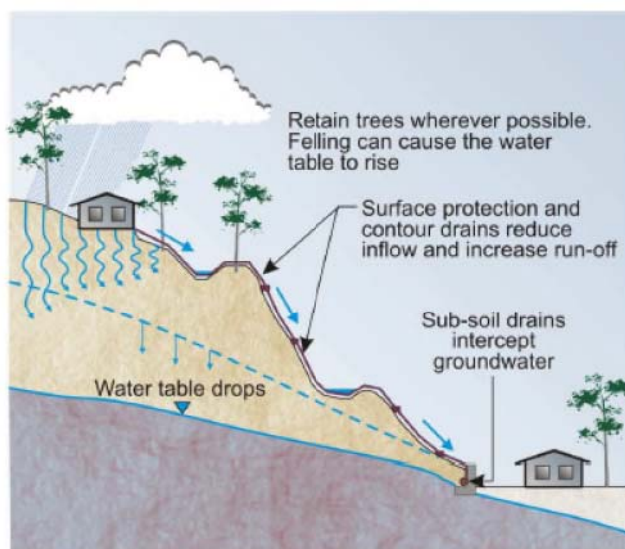


Figure 2 - Techniques used to control groundwater flow

Surface water drains (dish drains, or table drains) - are often used to prevent scour and limit inflow to a slope. Other than in rock, they are relatively ineffective unless they have an impermeable lining. You should clear them regularly, and as required, and not less than once a year. If you live in an area with seasonal rainfall, it is best to do this near the end of the dry season. If you notice that soil or rock debris is falling from the slope above, determine the source and take appropriate action. This may mean you have to seek advice from a geotechnical practitioner.

Surface protection - is sometimes used in addition to surface water drainage to prevent scour and minimise water inflow to a slope. You should inspect concrete, shotcrete or stone pitching for cracking and other signs of deterioration at least once a year. Make sure that weepholes are free of obstructions and able to drain. If the protection is deteriorating, you should seek advice from a geotechnical practitioner.

Sub-soil drains - are often constructed behind retaining walls and on hillsides to intercept groundwater. Their function is to remove water from the ground through an appropriate outlet. It is important that subsoil drains are designed to complement other measures being used. They should be laid in a sand, or gravel, bed and protected with a graded stone or geotextile filter to reduce the chance of clogging. Sub-soil drains should always be laid to a fall of at least 1 vertical on 100 horizontal. Ideally the high end should be brought to the surface, so it can be flushed with water from time to time as part of routine maintenance procedures.

Deep, underground drains - are usually only used in extreme circumstances, where the landslide risk is assessed as not being tolerable and other stabilisation measures are considered to be impractical. They work by permanently lowering the water table in a slope. They are not often used in domestic scale developments, but if you have any on your site be aware that professional maintenance is essential. If they are not maintained and stop working, the water table will rise and a landslide may even occur during normal weather conditions. Both an increase or a reduction in the normal flow from deep drains could indicate a problem if it appears to be unrelated to recent rainfall. If changes of this sort are observed, you should have the drains and your site checked by a geotechnical practitioner.

Documentation - design drawings and specifications for geotechnical measures intended to minimise landslide risk can be of great assistance to a geotechnical specialist, or structural engineer, called in to inspect and report on them. Copies of available documentation should be retained and passed to the new owner when the property is sold (GeoGuide LR11). You should also request details of an appropriate maintenance program for drainage works from the designer and keep that information with other relevant documentation and maintenance records.

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RETAINING WALLS

Retaining walls are used to support cuts and fills. Some are built in the open and backfill is placed behind them (gravity walls). Others are inserted into the ground (cast *in situ* or driven piles) and the ground is subsequently excavated on one side. Retaining walls, like all man-made structures, have a finite life. Properly engineered walls should last 50 years, or more, without needing significant repairs. However, not all walls fit this category. Some, particularly those built by inexperienced tradesmen without engineering input, can deflect and even fail because they are unable to withstand the pressures that develop in the ground around them or because the materials from which they are built deteriorate with time. **Design of retaining walls more than 900mm high should be undertaken by a geotechnical practitioner or structural engineer and normally require local council approval.**

Retaining walls have to withstand the weight of the ground on the high side, any water pressure forces that develop, any additional load (surcharge) on the ground surface and sometimes swelling pressures from expansive clays. These forces are resisted by the wall itself and the ground on the low side. Engineers calculate the forces that the retained ground, the water, and the surcharge impose on a wall (the disturbing force) as well as the maximum force that the wall and ground on the low side can provide to resist them (the restoring force). The ratio of the restoring force to the disturbing force is called the "factor of safety" (GeoGuide LR1). Permanent retaining walls designed in accordance with accepted engineering standards will normally have a factor of safety in the range 1.5 to 2.

Never add surcharge to the high side of a wall (e.g. place fill, erect a structure, stockpile bulk materials, or park vehicles) unless you know the wall has been designed with that purpose in mind.

Never more than lightly water plants on the high side of a retaining wall.

Never excavate at the toe of a retaining wall.

Any of these actions will reduce the factor of safety of the wall and could lead to failure. If in doubt about any aspect of an existing retaining wall, or changes you would like to make near one, seek advice from a geotechnical practitioner, or a structural engineer. This GeoGuide sets out basic inspection requirements for retaining walls and identifies some common signs that might indicate all is not well. GeoGuide LR11 provides information about records that should be kept.

GRAVITY WALLS

Gravity walls are so called because they rely on their own weight (the force of gravity) to hold the ground behind in place.

Formed concrete and reinforced blockwork walls (Figure 1) - should be built so the backfill can drain. They should be inspected at least once a year. Look for signs of tilting, bulging, cracking, or a drop in ground level on the high side, as any of these may indicate that the wall has started to fail. Look for rust staining, which may indicate that the steel reinforcement is deteriorating and the wall is losing structural strength ("concrete cancer"). Ensure that weep holes are clear and that water is able to drain at all times, as high water pressures behind the wall can lead to sudden and catastrophic failure.

Concrete "crib" walls (Figure 2) - should be filled with clean gravel, or "blue metal" with a nominated grading. Sometimes soil is used to reduce cost, but this is undesirable, from an engineering perspective, unless internal drainage is incorporated in the wall's construction. Without backfill drainage, a soil filled crib wall is likely to have a lower factor of safety than is required. Crib walls should be inspected as for formed concrete walls. In addition, you should check that material is not being lost through the structure of the wall, which has large gaps through it.

Timber "crib" walls - should be checked as for concrete crib walls. In addition, check the condition of the timber. Once individual elements show signs of rotting, it is necessary to have the wall replaced. If you are uncertain seek advice from a geotechnical practitioner, or a structural engineer.

Masonry walls: natural stone, brick, or interlocking blocks (Figure 3) - more than about 1m high, should be wider at the bottom than at the top and include specific measures to permit drainage of the backfill. They should be checked as for formed concrete walls. Natural stone walls should be inspected for signs of deterioration of the individual blocks: strength loss, corners becoming rounded, cracks appearing, or debris from the blocks collecting at the foot of the wall.

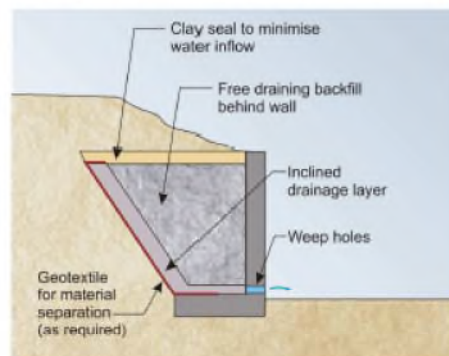


Figure 1- Typical formed concrete wall

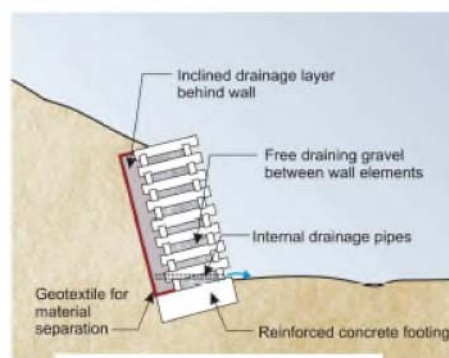


Figure 2 -Typical crib

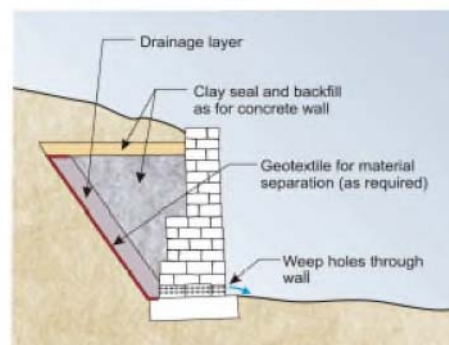


Figure 3 -Typical masonry wall

AUSTRALIAN GEOGUIDE LR6 (RETAINING WALLS)

Old Masonry walls (Figure 4) - Many old masonry retaining walls have not been built in accordance with modern design standards and often have a low "factor of safety" (GeoGuide LR1). They may therefore be close to failure and a minor change in their condition, or loading, could initiate collapse. You need to take particular care with such structures and seek professional advice sooner rather than later. Although masonry walls sometimes deflect significantly over long periods of time collapse, when it occurs, is usually sudden and can be catastrophic. Familiarity with a particular situation can instil a false sense of confidence.

Reinforced soil walls (Figure 5) - are made of compacted select fill in which layers of reinforcement are buried to form a "reinforced soil zone". The reinforcement is all important, because it holds the soil "wall" together. Reinforcement may be steel strip, or mesh, or a variety of geosynthetic ("plastic") products. The facing panels are there to protect the soil "wall" from erosion and give it a finished appearance.

Most reinforced soil walls are proprietary products. Construction should be carried out strictly in accordance with the manufacturer's instructions. Inspection and maintenance should be the same as for formed concrete and concrete block walls. If unusual materials such as timber, or used tyres, are used as a facing it should be checked to see that it is not rotting, or perishing.

OTHER WALLS

Cantilevered and anchored walls (Figure 6) - rely on earth pressure on the low side, rather than self-weight, to provide the restoring force and an adequate factor of safety. These walls may comprise:

- a line of touching bored piers (contiguous bored pile wall) or
- sprayed concrete panels between bored piers (shotcrete wall) or
- horizontal timber or concrete planks spanning between upright timber or steel soldier piles or
- steel sheet piles.

Depending on the form of construction and ground conditions, walls in excess of 3 m height normally require at least one row of permanent ground anchors.

INSPECTION

All walls should be inspected at least once a year, looking for tilting and other signs of deterioration. Concrete walls should be inspected for cracking and rust stains as for formed concrete gravity walls. Contiguous bored pile walls can have gaps between the piles - look for loss of soil from behind which can become a major difficulty if it is not corrected. Timber walls should be inspected for rot, as for timber crib walls. Steel sheet piles should be inspected for signs of rusting. In addition, you should make sure that ground anchors are maintained as described in GeoGuide LR4 under the heading "Rock bolts and rock anchors".

One of the most important issues for walls is that their internal drainage systems are operational. Frequently verify that internal drainage pipes and surface interception drains around the wall are not blocked nor have become inoperative.

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- | | |
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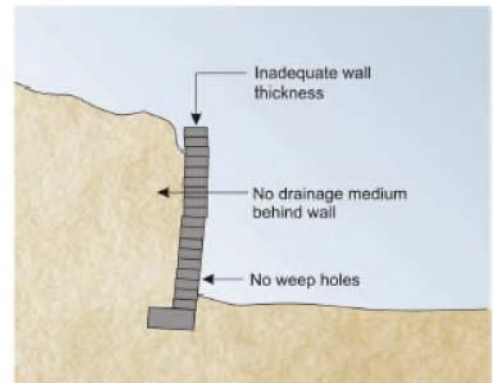


Figure 4 - Poorly built masonry wall

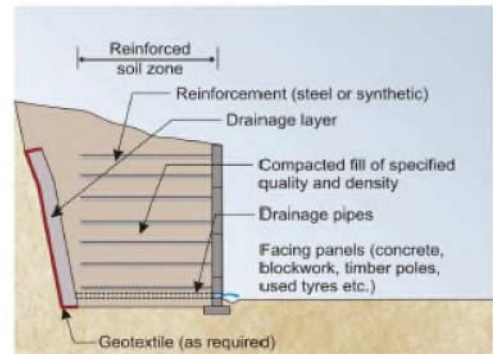


Figure 5 - Typical reinforced soil wall

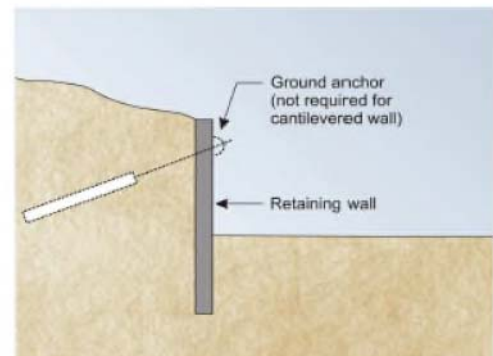


Figure 6 - Typical cantilevered or anchored wall

AUSTRALIAN GEOGUIDE LR7 (LANDSLIDE RISK)

LANDSLIDE RISK

Concept of Risk

Risk is a familiar term, but what does it really mean? It can be defined as *"a measure of the probability and severity of an adverse effect to health, property, or the environment."* This definition may seem a bit complicated. In relation to landslides, geotechnical practitioners (GeoGuide LR1) are required to assess risk in terms of the likelihood that a particular landslide will occur and the possible consequences. This is called landslide risk assessment. The consequences of a landslide are many and varied, but our concerns normally focus on loss of, or damage to, property and loss of life.

Landslide Risk Assessment

Some local councils in Australia are aware of the potential for landslides within their jurisdiction and have responded by designating specific "landslide hazard zones". Development in these areas is often covered by special regulations. If you are contemplating building, or buying an existing house, particularly in a hilly area, or near cliffs, go first for information to your local council.

Landslide risk assessment must be undertaken by a geotechnical practitioner. It may involve visual inspection, geological mapping, geotechnical investigation and monitoring to identify:

- potential landslides (there may be more than one that could impact on your site)
- the likelihood that they will occur
- the damage that could result
- the cost of disruption and repairs and
- the extent to which lives could be lost.

Risk assessment is a predictive exercise, but since the ground and the processes involved are complex, prediction tends to lack precision. If you commission a

landslide risk assessment for a particular site you should expect to receive a report prepared in accordance with current professional guidelines and in a form that is acceptable to your local council, or planning authority.

Risk to Property

Table 1 indicates the terms used to describe risk to property. Each risk level depends on an assessment of how likely a landslide is to occur and its consequences in dollar terms. "Likelihood" is the chance of it happening in any one year, as indicated in Table 2. "Consequences" are related to the cost of repairs and temporary loss of use if a landslide occurs. These two factors are combined by the geotechnical practitioner to determine the Qualitative Risk.

TABLE 2: LIKELIHOOD

Likelihood	Annual Probability
Almost Certain	1:10
Likely	1:100
Possible	1:1,000
Unlikely	1:10,000
Rare	1:100,000
Barely credible	1:1,000,000

The terms "unacceptable", "may be tolerated", etc. in Table 1 indicate how most people react to an assessed risk level. However, some people will always be more prepared, or better able, to tolerate a higher risk level than others.

Some local councils and planning authorities stipulate a maximum tolerable level of risk to property for developments within their jurisdictions. In these situations the risk must be assessed by a geotechnical practitioner. If stabilisation works are needed to meet the stipulated requirements these will normally have to be carried out as part of the development, or consent will be withheld.

TABLE 1: RISK TO PROPERTY

Qualitative Risk		Significance - Geotechnical engineering requirements
Very high	VH	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low. May be too expensive and not practical. Work likely to cost more than the value of the property.
High	H	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to acceptable level. Work would cost a substantial sum in relation to the value of the property.
Moderate	M	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as possible.
Low	L	Usually acceptable to regulators. Where treatment has been needed to reduce the risk to this level, ongoing maintenance is required.
Very Low	VL	Acceptable. Manage by normal slope maintenance procedures.

AUSTRALIAN GEOGUIDE LR7 (LANDSLIDE RISK)

Risk to Life

Most of us have some difficulty grappling with the concept of risk and deciding whether, or not, we are prepared to accept it. However, without doing any sort of analysis, or commissioning a report from an "expert", we all take risks every day. One of them is the risk of being killed in an accident. This is worth thinking about, because it tells us a lot about ourselves and can help to put an assessed risk into a meaningful context. By identifying activities that we either are, or are not, prepared to engage in we can get some indication of the maximum level of risk that we are prepared to take. This knowledge can help us to decide whether we really are able to accept a particular risk, or to tolerate a particular likelihood of loss, or damage, to our property (Table 2).

In Table 3, data from NSW for the years 1998 to 2002, and other sources, is presented. A risk of 1 in 100,000 means that, in any one year, 1 person is killed for every 100,000 people undertaking that particular activity. The NSW data assumes that the whole population undertakes the activity. That is, we are all at risk of being killed in a fire, or of choking on our food, but it is reasonable to assume that only people who go deep sea fishing run a risk of being killed while doing it.

It can be seen that the risks of dying as a result of falling, using a motor vehicle, or engaging in water-related activities (including bathing) are all greater than 1:100,000 and yet few people actively avoid situations where these risks are present. Some people are averse to flying and yet it represents a lower risk than choking to death on food. Importantly, the data also indicate that, even when the risk of dying as a consequence of a particular event is very small, it could still happen to any one of us any day. If this were not so, no one would ever be struck by lightning.

Most local councils and planning authorities that stipulate a tolerable risk to property also stipulate a tolerable risk to life. The AGS Practice Note Guideline recommends that 1:100,000 is tolerable in newly

developed areas, where works can be carried out as part of the development to limit risk. The tolerable level is raised to 1:10,000 in established areas, where specific landslide hazards may have existed for many years. The distinction is deliberate and intended to prevent the concept of landslide risk management, for its own sake, becoming an unreasonable financial burden on existing communities. Acceptable risk is usually taken to be one tenth of the tolerable risk (1:1,000,000 for new developments and 1:100,000 for established areas) and efforts should be made to attain these where it is practicable and financially realistic to do so.

TABLE 3: RISK TO LIFE

Risk (deaths per participant per year)	Activity/Event Leading to Death (NSW data unless noted)
1:1,000	Deep sea fishing (UK)
1:1,000 to 1:10,000	Motor cycling, horse riding, ultra-light flying (Canada)
1:23,000	Motor vehicle use
1:30,000	Fall
1:70,000	Drowning
1:180,000	Fire/burn
1:660,000	Choking on food
1:1,000,000	Scheduled airlines (Canada)
1:2,300,000	Train travel
1:32,000,000	Lightning strike

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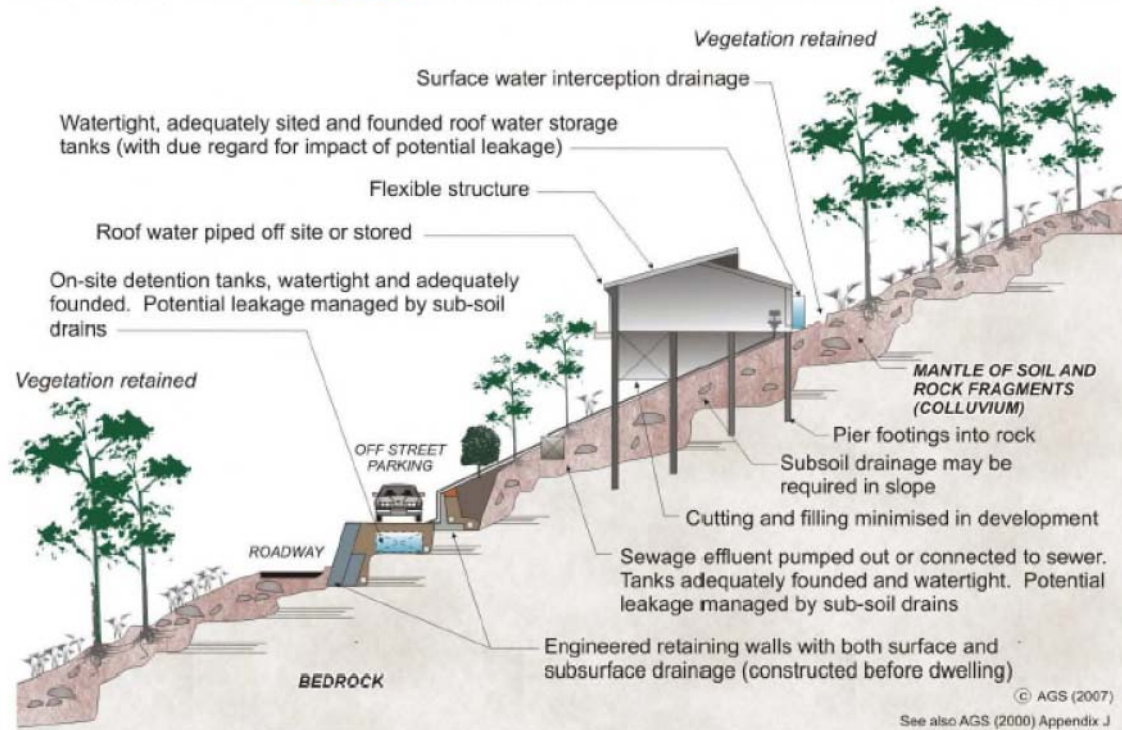
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AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

HILLSIDE CONSTRUCTION PRACTICE

Sensible development practices are required when building on hillsides, particularly if the hillside has more than a low risk of instability (GeoGuide LR7). Only building techniques intended to maintain, or reduce, the overall level of landslide risk should be considered. Examples of good hillside construction practice are illustrated below.

EXAMPLES OF GOOD HILLSIDE CONSTRUCTION PRACTICE



WHY ARE THESE PRACTICES GOOD?

Roadways and parking areas - are paved and incorporate kerbs which prevent water discharging straight into the hillside (GeoGuide LR5).

Cuttings - are supported by retaining walls (GeoGuide LR6).

Retaining walls - are engineer designed to withstand the lateral earth pressures and surcharges expected, and include drains to prevent water pressures developing in the backfill. Where the ground slopes steeply down towards the high side of a retaining wall, the disturbing force (see GeoGuide LR6) can be two or more times that in level ground. Retaining walls must be designed taking these forces into account.

Sewage - whether treated or not is either taken away in pipes or contained in properly founded tanks so it cannot soak into the ground.

Surface water - from roofs and other hard surfaces is piped away to a suitable discharge point rather than being allowed to infiltrate into the ground. Preferably, the discharge point will be in a natural creek where ground water exits, rather than enters, the ground. Shallow, lined, drains on the surface can fulfil the same purpose (GeoGuide LR5).

Surface loads - are minimised. No fill embankments have been built. The house is a lightweight structure. Foundation loads have been taken down below the level at which a landslide is likely to occur and, preferably, to rock. This sort of construction is probably not applicable to soil slopes (GeoGuide LR3). If you are uncertain whether your site has rock near the surface, or is essentially a soil slope, you should engage a geotechnical practitioner to find out.

Flexible structures - have been used because they can tolerate a certain amount of movement with minimal signs of distress and maintain their functionality.

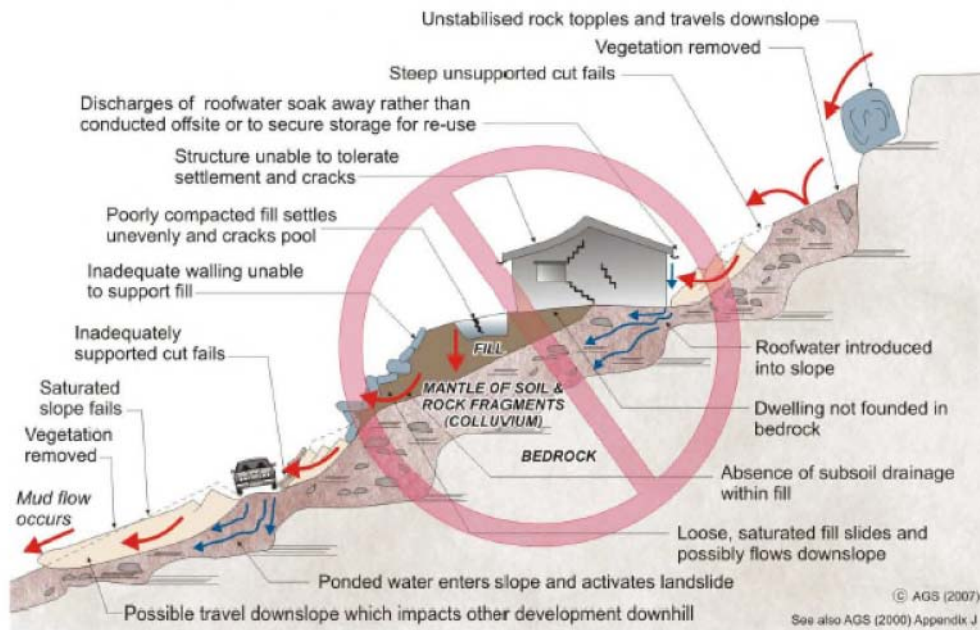
Vegetation clearance - on soil slopes has been kept to a reasonable minimum. Trees, and to a lesser extent smaller vegetation, take large quantities of water out of the ground every day. This lowers the ground water table, which in turn helps to maintain the stability of the slope. Large scale clearing can result in a rise in water table with a consequent increase in the likelihood of a landslide (GeoGuide LR5). An exception may have to be made to this rule on steep rock slopes where trees have little effect on the water table, but their roots pose a landslide hazard by dislodging boulders.

Possible effects of ignoring good construction practices are illustrated on page 2. Unfortunately, these poor construction practices are not as unusual as you might think and are often chosen because, on the face of it, they will save the developer, or owner, money. You should not lose sight of the fact that the cost and anguish associated with any one of the disasters illustrated, is likely to more than wipe out any apparent savings at the outset.

ADOPT GOOD PRACTICE ON HILLSIDE SITES

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

EXAMPLES OF **POOR** HILLSIDE CONSTRUCTION PRACTICE



WHY ARE THESE PRACTICES POOR?

Roadways and parking areas - are unsurfaced and lack proper table drains (gutters) causing surface water to pond and soak into the ground.

Cut and fill - has been used to balance earthworks quantities and level the site leaving unstable cut faces and added large surface loads to the ground. Failure to compact the fill properly has led to settlement, which will probably continue for several years after completion. The house and pool have been built on the fill and have settled with it and cracked. Leakage from the cracked pool and the applied surface loads from the fill have combined to cause landslides.

Retaining walls - have been avoided, to minimise cost, and hand placed rock walls used instead. Without applying engineering design principles, the walls have failed to provide the required support to the ground and have failed, creating a very dangerous situation.

A heavy, rigid, house - has been built on shallow, conventional, footings. Not only has the brickwork cracked because of the resulting ground movements, but it has also become involved in a man-made landslide.

Soak-away drainage - has been used for sewage and surface water run-off from roofs and pavements. This water soaks into the ground and raises the water table (GeoGuide LR5). Subsoil drains that run along the contours should be avoided for the same reason. If felt necessary, subsoil drains should run steeply downhill in a chevron, or herring bone, pattern. This may conflict with the requirements for effluent and surface water disposal (GeoGuide LR9) and if so, you will need to seek professional advice.

Rock debris - from landslides higher up on the slope seems likely to pass through the site. Such locations are often referred to by geotechnical practitioners as "debris flow paths". Rock is normally even denser than ordinary fill, so even quite modest boulders are likely to weigh many tonnes and do a lot of damage once they start to roll. Boulders have been known to travel hundreds of metres downhill leaving behind a trail of destruction.

Vegetation - has been completely cleared, leading to a possible rise in the water table and increased landslide risk (GeoGuide LR5).

DON'T CUT CORNERS ON HILLSIDE SITES - OBTAIN ADVICE FROM A GEOTECHNICAL PRACTITIONER

More information relevant to your particular situation may be found in other Australian GeoGuides:

- | | |
|-------------------------------------|--|
| • GeoGuide LR1 - Introduction | • GeoGuide LR6 - Retaining Walls |
| • GeoGuide LR2 - Landslides | • GeoGuide LR7 - Landslide Risk |
| • GeoGuide LR3 - Landslides in Soil | • GeoGuide LR9 - Effluent & Surface Water Disposal |
| • GeoGuide LR4 - Landslides in Rock | • GeoGuide LR10 - Coastal Landslides |
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EFFLUENT AND SURFACE WATER DISPOSAL

EFFLUENT AND WASTEWATER

All households generate effluent and wastewater. The disposal of these products and their impact on the environment are key considerations in the planning of safe and sustainable communities. Cities and townships generally have reticulated water, sewer and stormwater systems, which are designed to deliver water and dispose of effluent and wastewater with minimal impact on the environment. However, many smaller communities and metropolitan fringe suburbs throughout Australia are un-sewered. Some of these are located in hillside or coastal settings where landslides present a hazard.

Processes by which wastewater can affect slope stability

As explained in GeoGuides LR3 and LR5, groundwater variations have a significant impact on slope stability. Inappropriate disposal of effluent and wastewater may result in the ground becoming saturated. The result is equivalent to a localised rise of the groundwater table and may have the potential to cause a landslide (GeoGuides LR2, LR5 and LR8).

On-site effluent disposal

In un-sewered areas disposal of effluent must be achieved through suitable methods. These methods usually involve containment within the boundaries of the site ("on-site disposal"). State environment protection agencies and local government authorities can usually provide advice on suitable disposal systems for your area. Such systems may include:

- *Septic systems*, which involve a storage/digestion tank for solids, with disposal of the liquid effluent via absorption trenches and beds, leach drains, or soak wells. Such systems are best suited to areas not prone to landslides.
- *Aerobic treatment units* which incorporate an individual household treatment plant to aid breakdown of the waste into a higher quality effluent. Such effluent is further treated and disposed of by surface or sub-surface irrigation, sub-soil dripper, or shallow leach drain system.
- *Nutrient retentive leaching systems* which utilise septic tanks to process the solid and liquid wastes in conjunction with discharge of the effluent through sand filters, media filters, mound systems and nutrient retentive leaching systems, which strip the effluent of nutrients.

Toilet (and sometimes kitchen) waste is known as *black water*. Other, less contaminated, wastewater streams from showers, baths and laundries are known as *grey water*. *Grey water re-use systems* allow a household to conserve water from bathrooms, kitchens and laundries, for re-use on gardens and lawns.

Recommendations for effluent disposal

In areas prone to landslide hazard, it is recommended that whatever effluent disposal system is employed, it should be designed by a qualified professional, familiar with how such a system can impact on the local environment. Local council, and in some instances state environment protection agency, approval is usually required as well. Many local authorities require a site assessment report, which covers all relevant issues. If approved, the report's recommendations must be incorporated in the system design. Reduction in the volume of effluent is beneficial so composting toilets and highly rated (i.e. low consumption) water appliances are recommended. It should be noted that in some state and local government jurisdictions there are restrictions on the alternative measures that can be applied. Consideration should be given to applying treated wastewater to land at low rates and over as large an area as possible. Further guidance can be found in Australian Standard AS/NZS 1547:2000 On-site domestic wastewater management.

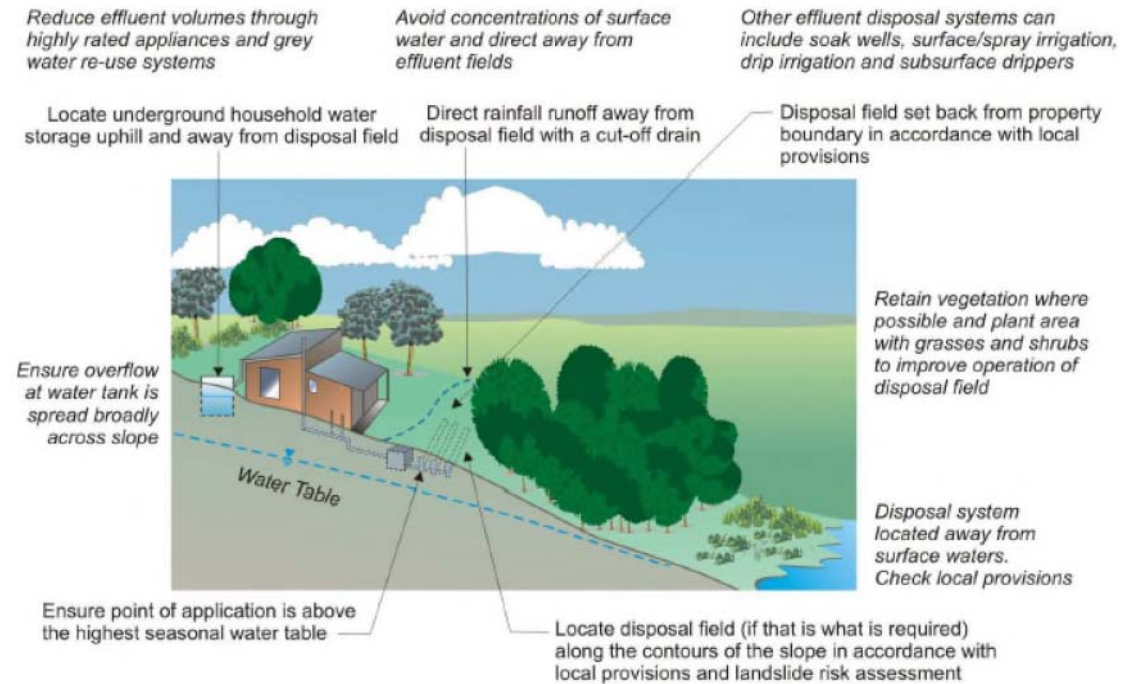
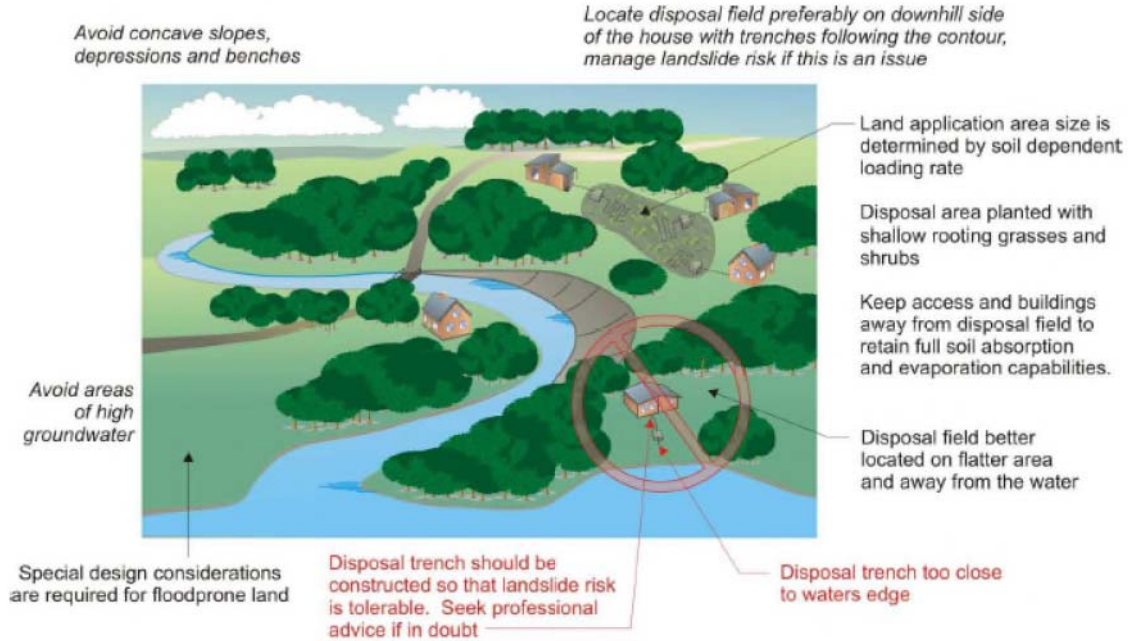
Effluent disposal fields should be sited with due consideration to the overall landscape and the individual characteristics of the property. Some guidance is provided. In particular, effluent fields should be located downslope of the building, away from stormwater, or *grey water*, discharge areas and where there is minimal potential for downstream pollution. Set backs and buffer distances vary from state to state and local requirements should be adhered to. All systems require regular maintenance and inspection. Efficient operation of the system must be a priority for property owners/occupiers to ensure safe and sustainable communities. Responsibility for maintenance rests with owners.

SURFACE WATER DRAINAGE

Attention to on-site surface water management is also important. Runoff from developments, including buildings, decks, access tracks and hardstand areas should be collected and discharged away from the development and other effluent disposal fields. Particular care must be given to the design of overflows on water tanks, as this is often overlooked. Discharge from any development should be spread out as much as possible, unless it can be directed to an existing natural water course. Ponding of water on hillsides and the concentration of water flows on slopes must be avoided.

It is recommended that a specific drainage plan and strategy should be developed in conjunction with the effluent disposal system for sites with a high potential for slope instability. Maintenance of the surface water drainage system is as important as maintenance of the effluent disposal system and again the responsibility rests with owners.

AUSTRALIAN GEOGUIDE LR9 (EFFLUENT DISPOSAL)



Note: Adapted from EPA Vic. Publication 451 (March 1996) "Code of Practice - Septic Tanks", which was sourced from Vic. Department of Planning and Loddon-Campaspe Regional Planning Authority.

More information relevant to your particular situation may be found in other Australian GeoGuides:

- GeoGuide LR1 - Introduction
- GeoGuide LR2 - Landslides
- GeoGuide LR3 - Landslides in Soil
- GeoGuide LR4 - Landslides in Rock
- GeoGuide LR5 - Water & Drainage
- GeoGuide LR6 - Retaining Walls
- GeoGuide LR7 - Landslide Risk
- GeoGuide LR8 - Hillside Construction
- GeoGuide LR10 - Coastal Landslides
- GeoGuide LR11 - Record Keeping

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AUSTRALIAN GEOGUIDE LR10 (COASTAL LANDSLIDES)

LANDSLIDES IN THE COASTAL ENVIRONMENT

Coastal Instability

The coast presents a particularly dynamic environment where change is often the norm. Hazards exist in relation to both cliffs and sand dunes. The coast is also the most heavily populated part of Australia and always regarded as "prime" real estate, because of the views and access to waterways and beaches.



Photo courtesy Greg Kotze

Waves, wind and salt spray play a significant part, causing dunes to move and cliff-faces to erode well above sea level. Our response is often to try to neutralise these effects by doing such things as dumping rock in the sea, building groynes, dredging, or carrying out dune stabilisation. Such works can be very effective, but ongoing maintenance is usually needed and total reconstruction may be necessary after a relatively short working life.

Of particular significance are extreme events that cause destruction on a scale that ignores our efforts at coastal protection. Records show that cliffs have collapsed, taking with them backyards which had been relied upon as a buffer between a house and the ocean. Sand dunes have also been washed away resulting in the dramatic loss of homes and infrastructure. As with most landslide issues, even though such events may be infrequent, they could happen tomorrow. It is easy to be lulled into a false sense of security on a calm day.

In coastal areas, typical landslide hazards (GeoGuides LR1 to LR4) are compounded by coastal erosion which, over time, undercuts cliffs and eventually results in failure. In the case of sand dunes, dune erosion and dune slumping have equally dramatic effects. Coastal locations are subject to particular processes relating to fluctuating water tables, inundation under storm tides and direct wave attack. Large sections of our more sandy coastline are receding under present sea conditions. The hazards are progressive and likely to be exacerbated through climate change.

Coastal Development

If you own, or are responsible for, a coastal property it is important that you understand that, where the shore line is receding, there is a greater landslide risk than would be the case on a similar site inland. The view may make the risk worthwhile, but does not reduce it.

Coastal Landslides

Coastal landslides are little different from other landslides in that the signs of failure (GeoGuides LR2) and the causes (LR3, LR4 & LR5) are largely the same. The main difference relates to the overriding influence of wave impact, tidal movement, salt spray and high winds.

Cliff failures

In addition to the processes that produce cliff instability on inland cliffs, coastal cliffs are also subjected to repeated cycles of wetting and drying which can be accompanied by the expansive effect of salt crystal growth in gaps in the rocks. These processes accelerate the deterioration of coastal cliffs. At the base of cliffs, direct wave attack and the impact of boulders moved by wave action causes undercutting and hence instability of the overall face. Figure 2 of GeoGuide LR4 provides an example. Whilst the processes leading to coastal cliff collapse may take years, failure tends to be catastrophic and with little warning. In many cases, waves produced by large oceanic storms are the trigger assisted by rainfall to produce collapse. These are also the conditions in which you are more likely to be inside your home and oblivious to unusual noises or movements associated with imminent failure.

Sand dune escarpment and slope failures

An understanding of coastal processes is essential when determining beach erosion potential. Waves produced by large oceanic storms can erode beaches and cut escarpments into dunes. These may be of relatively short duration, when beach rebuilding happens after the storm, but can be a permanent feature where long term beach recession is taking place. In many locations, houses and infrastructure are sited on or immediately behind coastal dunes. After an escarpment has eroded, those assets may be lost or damaged by subsequent slumping of the dune. It is important that, on erodible coastal soils, the potential for landward incursion of an erosion escarpment is determined. Having done this, the likelihood of slope instability can be established as part of the landslide risk management process. Injury, death and structural damage have occurred around the Australian coast from collapsing sand escarpments.



Photo courtesy DNR NSW

AUSTRALIAN GEOGUIDE LR10 (COASTAL LANDSLIDES)

The large scale and potentially high speed of coastal erosion processes means that major civil engineering work and large cost is normally involved in their control. The installation of rock bolts (LR4), drainage (LR5), or retaining walls (LR6) on a single house site may be necessary to provide local stability, but are unlikely to withstand the attack of a large storm on a beach or cliff-line.

BUILDING NEAR CLIFFS AND HEADLANDS

Coastal cliffs and headlands exist because the rock that they are made from is able to resist erosion. Even so, cliff-faces are not immune and will continue to collapse (Figure 1) by one or other of the mechanisms shown on GeoGuide LR4. If you live on a coastal cliff, you should undertake inspection and maintenance as recommended in LR4 and the other GeoGuides, as appropriate. The top of the cliff, its face, and its base should be inspected frequently for signs of recent rock falls, opening of cracks, and heavy seepage which might indicate imminent failure. Since the sea can remove fallen rocks rapidly, inspections should be made shortly after every major storm as a matter of course. **If collapses are occurring seek advice from an appropriately experienced geotechnical practitioner. Advise you local council if you believe erosion is rapid or accelerating.**

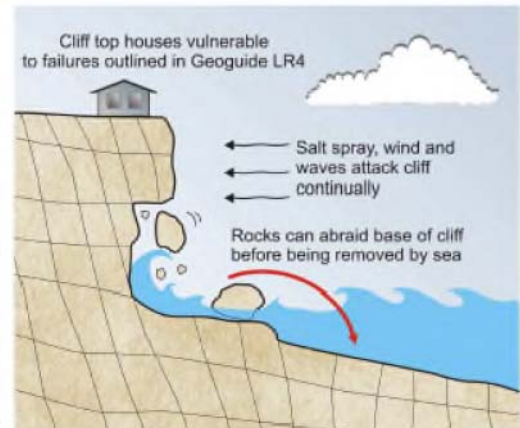


Figure 1

Building on Coastal Dunes

Any excavation in a natural dune slope is inherently unstable and must be supported and maintained (GeoGuide LR6). Dunes are particularly susceptible to ongoing erosion by wind and wave action and extreme changes can occur in a single storm. Whilst vegetation can help to stabilise dunes in the right circumstances, unfortunately a single storm has the potential to cut well into dunes and, in some cases, remove an entire low lying dune system or shift the mouth of a river. **As for cliffs, it is appropriate to observe the effects of major storms on the coastline. If erosion is causing the coastline to recede at an appreciable rate, seek advice from suitably experienced geotechnical and coastal engineering practitioners and bring it to the attention of the local council.**



Photo courtesy DNR NSW

CLIMATE CHANGE

The coastal zone will experience the most direct physical impacts of climate change. A number of reviews of global data indicate a general trend of sea level rise over the last century of 0.1 - 0.2 metres. Current rates of global average sea level rise, measured from satellite altimeter data over the last decade, exceed 3 mm/year and are accelerating. The most authoritative and recent (at the time of writing) report on climate change (IPCC, 2007) predicts a global average sea level rise of between 0.2 and 0.8 metres by 2100, compared with the 1980 - 1999 levels (the higher value includes the maximum allowance of 0.2 m to account for uncertainty associated with ice sheet dynamics).

In addition to sea level rise, climate change is also likely to result in changes in wave heights and direction, coastal wind strengths and rainfall intensity, all of which have the capacity

to impact adversely on coastal dunes and cliff-faces. A Guideline for responding to the effects of climate change in coastal areas was published by Engineers Australia in 2004.

References

- Engineers Australia 2004 'Guidelines for responding to the effects of climate change in coastal and ocean engineering.' The National Committee on Coastal and Ocean Engineering, Engineers Australia, updated 2004.
- IPCC (2007) *Climate Change 2007: The Physical Science Basis*. Summary for Policy Makers. Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC).
- Nielsen, A.F., Lord D.B. and Poulos, H.G. (1992). 'Dune Stability Considerations for Building Foundations', *Aust. Civil Eng. Transactions* CE No.2, 167-174.

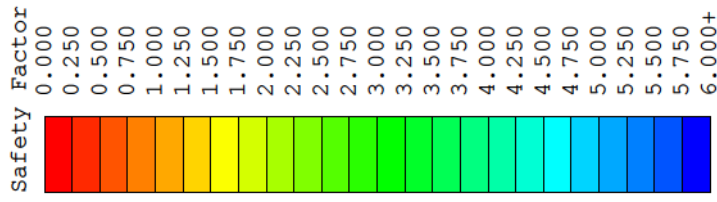
More information relevant to your particular situation may be found in other Australian GeoGuides:

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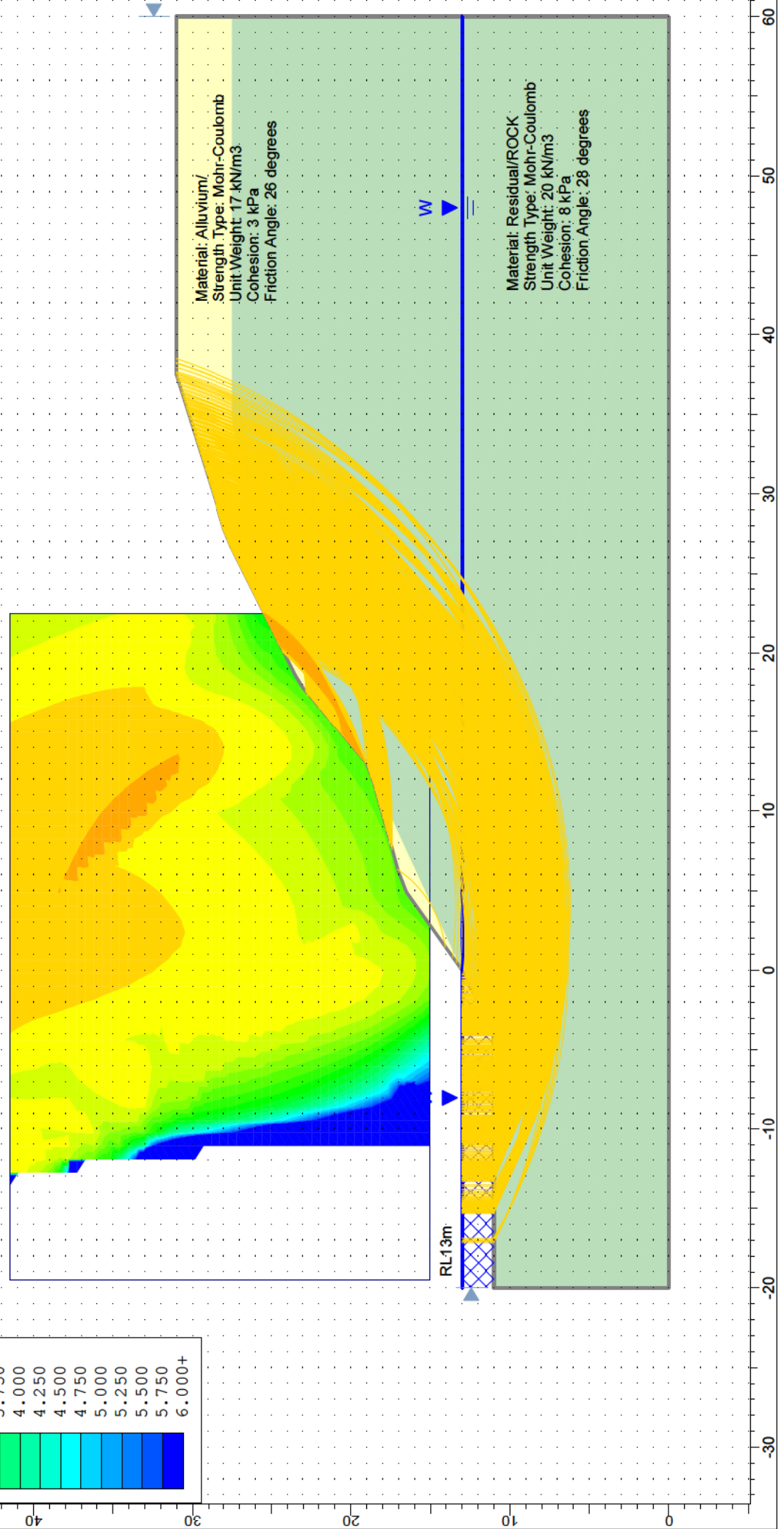


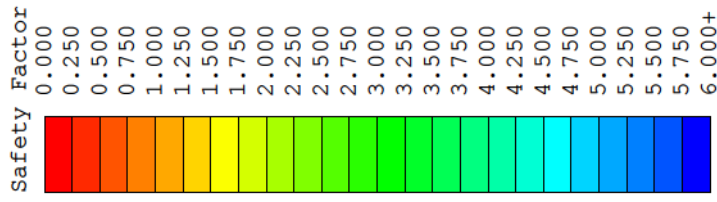
APPENDIX J: SLIDE GLOBAL STABILITY MODELLING



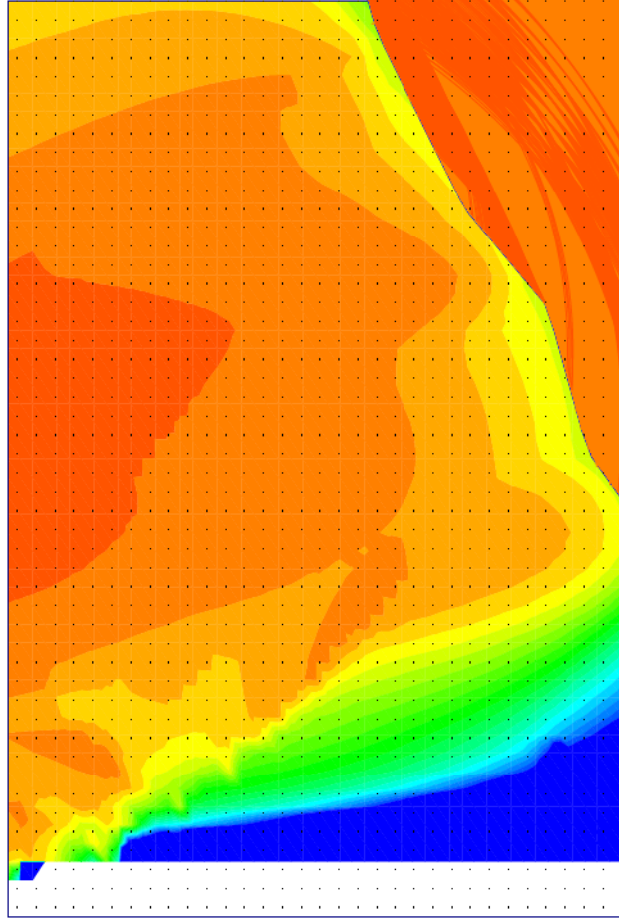
SGSE/16/220
RIVERBEND / TEVIOT BROOK, JIMBOOMBA
GLOBAL STABILITY ANALYSIS
LOGAN RIVER BANK - SECTION A

STEADY STATE CONDITION





SGSE/16/220
RIVERBEND / TEVIOT BROOK, JIMBOOMBA
GLOBAL STABILITY ANALYSIS
LOGAN RIVER BANK - SECTION A
RAPID DRAWDOWN CONDITION



Flood Level - RL31m

Minimum Setback Distance 30m

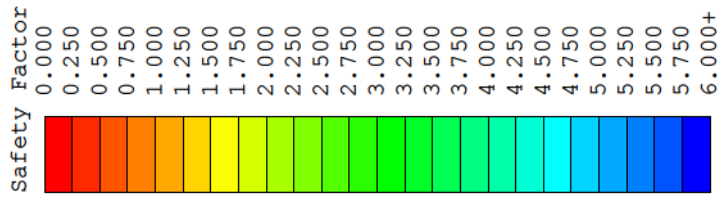
W

Material: Alluvium
Strength Type: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion: 3 kPa
Friction Angle: 26 degrees

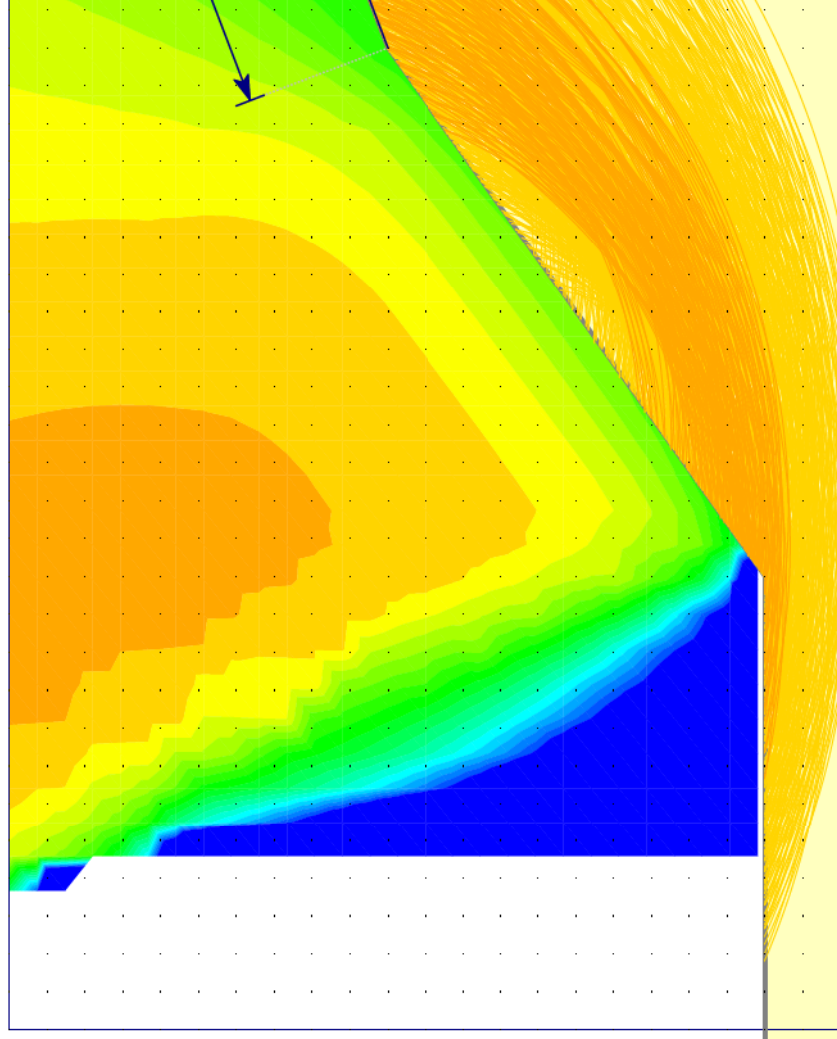
RL13m

Material: Residual/ROCK
Strength Type: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion: 8 kPa
Friction Angle: 28 degrees





SGS/16/220
RIVERBEND / TEVIOT BROOK, JIMBOOMBA
GLOBAL STABILITY ANALYSIS
NORTH EASTERN GULLY



Material: Residual
Strength Type: Mohr-Coulomb
Unit Weight: 19 kN/m³
Cohesion: 5 kPa
Friction Angle: 27 degrees

DATE 27 February 2016
CONTACT STUART MACKENZIE
REFERENCE B16288DER001

COMPLIANCE ENDORSEMENT
referred to in the PDA
DEVELOPMENT APPROVAL



Approval no: DEV2016/811

Date: 14 December 2017

B16288DER001 – Dispersive Soil Management Plan
Teviot Road & Bushland Road, Riverbend Boulevard
For SGS on behalf of Celestino Pty Limited

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FIGURE 1 – SITE LOCATION PLAN

FIGURE 2 – EROSION RISK MAP

APPENDIX A

SGS GEOTECHNICAL INVESTIGATION LOCATION PLAN

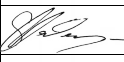
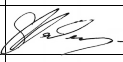
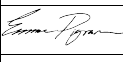
APPENDIX B

SGS BORELOGS

APPENDIX C

LABORATORY CERTIFICATES

Document Control Page

Revision	Date	Description	Author	Signature	Verifier	Signature	Approver	Signature
A	27.02.17	FINAL	SM		MD		EP	

1.0 INTRODUCTION

Lambert and Rehbein Pty Ltd (Qld) was commissioned by SGS Australia (SGS) on behalf of Celestino Pty Limited to prepare a Dispersive Soil Management Plan (DSMP) for the residential development at 72 Riverbend Boulevard, Jimboomba or Lots 800 on SP247625 and Lots 101,102,104,105,106 on SP254145. The location of the site is presented in Figure 1 in the Figures Section.

This Report has been prepared to address the requirements outlined in ICC's Planning Scheme & Implementation Guideline No. 28 – *Dispersive Soil Management* due to exceedances of thresholds outlined in Table 3.1 'Thresholds for Dispersive Soil Management Plan'. The aim of this report is to identify any dispersive soils on site, if any, delineate potentially dispersive soils and recommend management strategies for on-site implementation.

The DSMP satisfies the conditions of requirement as outlined in ICC Implementation Guideline Number 28 and considers the International Erosion Control Association (IECA) Australasia "*Best Practice Erosion & Sediment Control*" (BPESC) document. This report aims to control erosion and limit sediment transportation from site and therefore minimise impact on receiving waterways.

The content and recommendations of this report should be integrated with stormwater management undertaken in accordance with Implementation Guideline No. 24 – Stormwater Management and Erosion and Sediment Control Plan prepared by a CPESC and/or RPEQ.

1.1 EXISTING SITE AND DEVELOPMENT PROPOSAL

It is understood the proposed project will comprise of 27 construction stages including pavements, storm water basins, residential and commercial allotments, recreational facilities and associated civil infrastructure.

From aerial photography (Queensland Globe, 2016), the site appears to be heavily vegetated along the northern and eastern boundaries with isolated patches of vegetation over the majority of the site. Little vegetation is present near the river along the southern boundary.

The site location and boundaries and recent aerial photography are shown on Figure 1 in the Figures Section.

1.2 TOPOGRAPHY

The topography of the project area is essential to assessment due to slopes increasing erosion risk. ICC's Guideline 28 suggests soil disturbance areas with slopes greater than 20% should be avoided. The site currently peaks in the northern corner of the site at approximately 62 m AHD, generally sloping towards the Logan River at the eastern boundary to an elevation of approximately 25 m AHD. Plate 1 below shows the current topography of the site.

The site as a whole general slopes at about 6% all culminating towards the Logan River. Slopes of approximately 8% to 13% in the eastern portion of the site grade towards the existing waterway corridor situated in the middle of the site. Mitigation measures to avoid the dispersion of soils may be required, refer to Section 5 in this report.

Due to the significant slope towards the waterway corridor, there is a much higher risk of erosion occurring and should be considered as having potential for soil erosion.

Contours and slope percentages are presented in the SGS Geotechnical Investigation Location Plan shown in Appendix A in the Appendices Section.



Plate 1: 10m Elevation Contours (Google Earth, 2016)

1.3 HYDROLOGY

Under existing conditions, overland flow predominately falls towards an existing water corridor and continues east from the west boundary of the site in the direction of the Logan River. Contour maps also show several other discharge points at the north eastern boundary. The southern and south eastern boundaries of the site are subject to flooding from Logan River.

Currently there is no drainage infrastructure in place to manage neither runoff nor stormwater pipes. All runoff on site is subject to the existing topography of the site.

1.4 REGIONAL GEOLOGY

A recent review of the Department of Employment, Economic Development and Innovation (DEEDI) 2011, *Queensland Geological Mapping (Polygonised Vector) Data Images of 1:250 000 Geological Map Sheets*, Queensland Government: Brisbane indicates the site is underlain by the following regional geology:

Green: Jurassic Age Gatton Sandstone, Formation comprising 'Lithic labile and felspathic labile sandstone';

Aqua: Quaternary Age Quaternary Alluvium, Formation comprising 'Clay, silt, sand, gravel, flood-plain alluvium';

Purple: Jurassic Age Koukandowie Formation, Formation comprising 'Lithofeldspathic labile and sublabile to quartzose sandstone, siltstone, shale, minor coal, ferruginous oolite marker'; and

Pink: Tertiary Age Tertiary Volcanic, Formation comprising 'Basalt, minor volcanic breccia'.

A copy of the search results are presented below in Plate 2.



Plate 2: Queensland Geological Mapping Data Images, 1:250 000

The location and boundaries of the site are shown in Figure 1 in the Figures Section. A copy of the SGS borehole logs are attached in Appendix B.

1.5 SOIL MAPPING AND INITIAL EROSION HAZARD POTENTIAL

A number of existing Government resources are available to provide additional data within, and surrounding the investigation area in terms of soil mapping. Soil mapping information was taken from the following government sources:

- Moreton Region Land Resource Areas (Scale 1:250,000), Department of Primary Industries, Brisbane, 1994 (accessed via Queensland Government's Soil Globe).

1.5.1 MORETON REGION LAND RESOURCE AREAS

The Moreton Region Land Resources Areas Map (accessed via Queensland Soil Globe) indicated the Land Resource Area as '7b – Marburg Forest'. The following information was derived from the mapping:

- Landform – Undulating hills and rises, steep hills and mountains;
- Soils – Sandy Solodics, Loamy Solodics, Soloths, Yellow Podzolics, Red Podzolics, non-calci brown soils, Lithosols;
- Geology – Sandstone, Siltstone, Shale Conglomerate, Predominantly sandstones of the Marburg Formation and Esk Beds; and
- Vegetation – Eucalypt open forest, some areas of softwood scrub.

An excerpt of the Moreton Region Land Resources Areas Map including the site location is shown below in Plate 3.



Plate 3: Moreton Region Land Resource Areas (Scale 1:250,000)

1.6 VEGETATION

Based on aerial imagery and previous investigations conducted, the vegetation of the site is largely fragmented eucalypt forests. The majority of the site vegetation is present along the north western boundary, with isolated patches of bushland across the remainder of the site.

Refer to aerial photography (Google Maps, July 2016) on Figure 1 in the Figures Section for the condition and location of present on site vegetation.

2.0 PREVIOUS INVESTIGATIONS

A previous *Concept Stormwater Management Plan* by *Calibre Consulting* was carried out in 2016 at the site. The aim of this investigation was to analyse the present hydrological system of the region to determine both changes due to urbanisation of the area and management strategies required to deal with said changes. The report concluded that a definite increase of off runoff would occur, with rainwater detentions infrastructure required to reduce flow toward Teviot Road.

An *Ecological Assessment Report* by *Saunders Havill Group* was conducted in 2016. The aim of this report was to identify the present ecological value of the existing site. The report concluded the site has experienced significant deforestation in the past resulting in largely fragmented bushland across the site.

3.0 SITE INVESTIGATION AND SOIL ASSESSMENT

Site investigation and soil assessment was conducted by SGS on the 9th of November 2016 to assess the soil profile and collect samples for analysis.

Typical activities that increase the risk of exposing dispersive subsoils to rainfall and stormwater include:

- The removal of topsoil;
- Soil excavation and ground profiling;
- Trenching and supply of services;
- Road and culvert construction; and
- The construction of dams and detention basins.

Identification of dispersive soils includes visually observing the surface of a site for tunnelling and erosion of dispersive soils and laboratory testing to identify dispersive soils. For this investigation, results from previous geotechnical reports (SGS, 2016) were reviewed as well as additional collection of samples for pH, Electrical Conductivity (EC), Emerson Class, Particle Size Distribution and Percentage Dispersion Test Report analysis at a NATA Accredited soil laboratory (SGS Australia).

3.1 SOIL DESCRIPTION

A total of 22 boreholes were advanced using drill rig to a maximum depth of 4.5 m below ground level (bgl) with the majority of locations experiencing refusal on sandstone/siltstone. Soil profiles across the site consists largely silty/sandy clay overlying extremely weathered sandstone. No tunnelling or visual signs of dispersive soils were observed during the site investigation.

Depth to natural rock varied from surface to 1.0 m bgl in the western portion of site. Across the central and eastern portion of the site, depth to natural rock largely varies between 2m-4.5m.

Borehole logs are shown in Appendix B in the Appendices Section.

The locations of boreholes at the site are shown in Appendix A in the Appendices Section.

3.2 SOIL SAMPLING AND ANALYSIS

Soil samples were collected from representative soil profiles at each borehole location. Based on soil profiles observed during the advancement of boreholes, samples were submitted for analysis to a NATA accredited laboratory to assess their dispersive characteristics. Topsoils and subsoils were targeted during analysis as they are most likely to be dispersive considering the shallow depth of the regional geology at the site.

Soils were placed in individually snap-locked bags for transportation to NATA accredited SGS Laboratories. The analytical schedule for soils included pH, EC, Emerson Class, Particle Size Distribution and Percentage Dispersion Test Report.

The table below describes the different potential soil types present

Soil Type	Description
MH	Natural -Sandy SILT, medium to high plasticity, grey fine grained sand
SM	Natural – Silty SAND, fine to medium grained, grey
CH	Silty CLAY, high plasticity, grey mottled orange
SC	Clayey SAND, fine to medium grained, orange mottled grey and yellow
CL	Silty Sandy CLAY, medium to high plasticity, grey mottled red and orange, fine to medium grained sand
DW	SANDSTONE, fine to medium grained, grey, yellow and orange
XW	SANDSTONE, fine to medium grained, grey, yellow, and orange

3.2.1 INTERPRETATION OF LABORATORY RESULTS

The Emerson Class aggregate test is used as an indicator of dispersive soils. The test is used to classify the behaviour of soil aggregates when a soil sample is placed in water, based on rating the amount and severity of slaking and clay dispersion. Soil properties such as pH and EC can inhibit dispersion, requiring interpretation of laboratory results.

Table 1, below describes the degree of dispersion.

Table 1 Emerson Class Descriptions

Emerson Class	Description
1	Aggregates express high tunnel erosion susceptibility
2	Aggregates express some degree of tunnel erosion susceptibility
3	Aggregates are generally stable and indicate a more desirable material for earthworks, additional laboratory results are required to confirm suitability
4 & 5	Aggregates are generally stable and suitable for earthworks
6 & 7	Aggregates are generally stable and suitable for earthworks
8	Aggregates do not express any degree of dispersion

Particle Dispersion Tests is a standard laboratory procedure for the determination of the particle size distribution of a soil.

Percentage Dispersion Tests are a way of indicating the potential for dispersion and tunnelling susceptibility of soils. The dispersion percentage is the ratio of the soil material <0.002 mm after

limited mechanical dispersion without dispersants to the total material, <0.002 mm, expressed as a percentage. As it is necessary to know the total soil material <0.002 mm, this procedure is carried out in conjunction with a Particle Size Distribution test.

Results of the Dispersion Index (DI) test (AS 1289 3.8.2), undertaken on the most dispersive soils (i.e. the lowest Emerson Class Number), should be interpreted as follows:

Soils are dispersive where the combined percentage of clay (<0.002 mm) plus half the percentage of Silt (0.002-0.02 mm), expressed as a decimal fraction, then multiplied by the Dispersion Index (DI); is greater than 10%.

For Example, a soil sample with 20% clay & 18% silt with a DI of 40%, would have a dispersion percentage of: $(0.20 + 0.09) \times 40 = 11.6\%$; would be considered a 'Dispersive Soil'.

4.0 SOIL RESULTS

Laboratory analysis was undertaken to define soil dispersion potential, soil electro-chemistry and soil erosion potential and are shown below in Table 2 and discussed in subsequent sections.

Laboratory certificates are attached in Appendix C in the Appendices Section.

Table 2 Erosion/Dispersion Hazard Test Results

Area Assessed	Sample Location and Depth	Soil Type	Emerson Class No.	pH	EC (mS/cm)	Dispersion Index (%)	Passing 0.002 mm (%)	Passing 0.02 mm	Percent Dispersion (%) (>10% = Dispersive)
BH 2	0.1-0.3	CH	5	6.0	0.03	-	-	-	-
BH 6	0.0 – 0.1	MH	3	5.9	0.04	12	18	20	3.4
BH 6	0.1 – 0.3	CH	3	5.1	0.02	-	-	-	-
BH 8	0.0 – 0.1	MH	3	4.7	0.02	-	-	-	-
BH 8	0.2 – 0.5	CH	3	4.8	0.01	-	-	-	-
BH 13	0.0 – 0.2	SM	8	-	-	-	-	-	-
BH 13	0.2 – 1.0	CH	8	-	-	-	-	-	-
BH 14	0.0 – 0.3	CH	2	-	-	-	-	-	-
BH 14	0.3 – 0.5	CH	1	-	-	-	-	-	-
BH 15	0.0 – 0.15	SM	8	-	-	-	-	-	-
BH 15	0.5 – 0.7	CH	1	-	-	-	-	-	-
BH 16	0.0 – 0.2	CH	3	5.4	0.07	-	-	-	-
BH 16	0.2 – 0.5	CH	2	5.0	0.04	-	-	-	-
BH 18	0.0 – 0.1	CL	6	5.6	-	-	-	-	-
BH 18	0.1 – 0.4	CH	3	6.0	0.03	-	-	-	-
BH 19	0.0 – 0.1	SM	8	-	-	-	-	-	-
BH 19	0.1 – 0.5	CH	1	-	-	-	-	-	-
BH 21	0.0 – 0.11	CH	8	-	-	-	-	-	-
BH 21	0.2 – 0.5	CH	1	-	-	-	-	-	-
BH 22	0.0 – 0.09	SM	1	-	-	-	-	-	-
BH 22	0.09 – 0.5	XW	6	-	-	-	-	-	-
CREEK	Surface	ML	3	5.0	0.03	25	10	7	3.4

- = Analysis not undertaken

4.1 EMERSON CLASS

Emerson Class results indicated Emerson Class Numbers indicative of 'low' to 'negligible' dispersion tendencies in most soils. Emerson Class results in the eastern portion of the site for silty clays indicated 'moderate' and 'high' risk of soil dispersion.

4.2 ELECTRO-CHEMISTRY

Soils are generally saline if they have an EC of approximately 0.5 mS/cm or greater and will usually resist (to some degree) dispersion. Laboratory analysis indicates soils across the site are generally below 0.5 mS/cm with the exception of BH16_0.0-0.2 (0.07 mS/cm). Analytical results indicated topsoils and subsoils on site are slightly acidic.

4.3 PERCENT DISPERSION

Percent dispersion calculations, as outlined in Section 3.3.2 of this report, were calculated for samples BH6_0.0-0.1 (topsoil) and CREEK (surface) taken from separate soil profiles in the area of the site classified as the most susceptible to erosion. Both samples were below Brisbane City Council's Percentage Dispersion Threshold of 10%.

4.4 RESULTS DISCUSSION

Based on the above results, soil profiles analysed at the site are considered stable and appropriate for earthworks with the exception of silty clays (subsoils) observed in the eastern portion of the site, displaying properties of dispersive soils during analysis. Considering the slope of the site and visual evidence of rock outcrops and existing tunnelling and gully erosion nearby, management strategies should be implemented during earthworks.

The classification of dispersive soils should also take into consideration the following:

- Slope gradients;
- Unstable/hazardous terrain;
- Flood inundation lines;
- Rock outcrops; and
- Existing signs of erosion onsite or nearby.

5.0 PROPOSED MANAGEMENT RECOMMENDATIONS

The above investigation and results have confirmed soils with the potential to disperse into surrounding waterways and impact on significant environmental receptors. As per the Ipswich Planning Scheme – Implementation Guideline No. 28, developments within areas containing dispersive soils are required to provide management strategies to mitigate potential soil erosion and reduce sediment loads to surrounding water courses.

It is understood bulk earthworks including 'cut to fill' are part of the scope of works for the proposed development. To effectively manage dispersive soils, certain activities on site must be considered which promote erosion. These activities include:

- Removal of top soil;
- Excavations;
- Trenches and supply of services; and
- Roads and culverts.

The following management strategies are typically used to manage dispersive soils:

- Identification and avoidance;
- Separation of topsoil and subsoil;
- Soil re-compaction;
- Chemical amelioration;
- Use of sand and block barriers to reduce the risk to tunnel erosion; and
- Use of non-dispersive topsoil and revegetation.

5.1 AVOIDANCE

Given that earthworks are essential for the proposed development, completely avoiding activities which affect dispersive soils may not be practical, however, minimising disturbance of subsoils is strongly recommended where possible. Where practical, excavations should be limited to <0.15 m depth (i.e. within topsoil) to avoid excavating and exposing dispersive subsoils.

5.2 SOIL COMPACTION

By compacting the surface of exposed subsoils and excavated subsoils prior to topsoiling and revegetation, the entry of water into subsoil can be reduced, limiting the opportunity for tunnel erosion to develop. Compacting soils are also more resistant to sheet erosion than loose soils. Compaction should occur immediately following the clearing of vegetation and stripping of topsoil and after chemical amelioration. Compaction standards required for residential purposes are likely to mean that this management strategy will not be difficult to adopt. Note that at least 100

mm of uncompacted soil is required to allow adequate plant establishment for revegetation, which equates to existing topsoil depths. Disturbed areas which are topsoiled with less than 100 mm will require a depth of uncompacted subsoil which has been treated with gypsum to address sodicity sand blocks and barriers.

The use of sand blocks and barriers has been successful in the prevention of tunnel erosion along linear services. Sand blocks are installed perpendicular to service trenches with geotextile fabric on the down gradient side of the block. The sand filters sediment from internal water flow and directs water to the soil surface, which blocks the development of tunnel erosion. The depth of the sand block is determined by the depth of dispersive soils and its span is determined by the width of tunnelling. To complement the subsurface sand barrier, a run-on diversion mound should be placed up gradient of the sand block prior to final topsoil. The purpose of the diversion mound is to prevent run-on entering the sand blocks. Gypsum is also applied (5% by weight) to the sand to further inhibit dispersion. An example of sand and block barriers is illustrated in Plate 5 below.

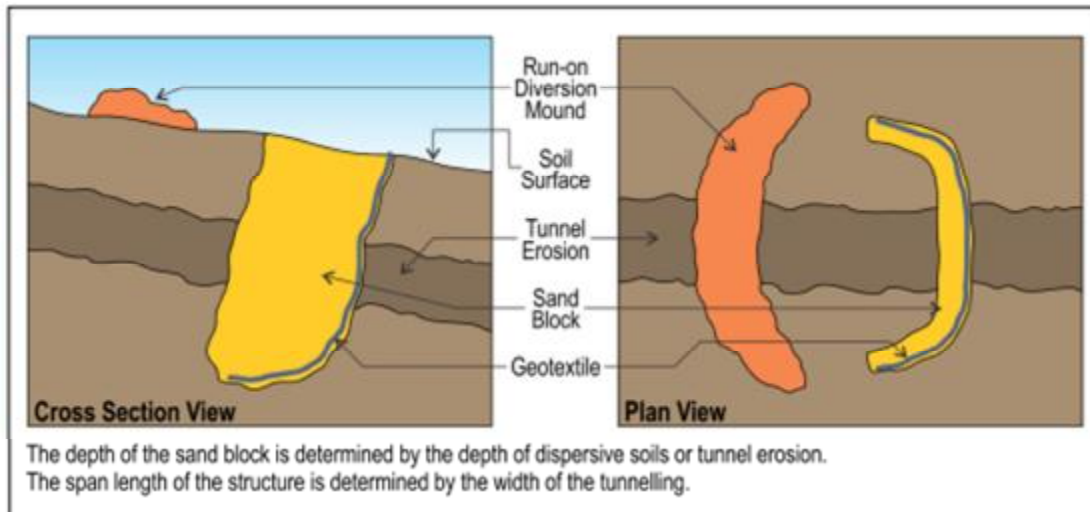


Plate 5: Modified Sand Block Design (ICC, 2016)

The spacing of these barriers should consider the final grade of disturbed areas. Table 3 below presents a guideline to aid in the spacing of tunnel erosion barriers.

Table 3 Tunnel Erosion - Sand and Block Barriers

Final Slope (%)	Spacing (m)	Comments
0-2	200	Sand and block barriers are recommended to be installed at the middle point of the slope run and be spaced according to the final slope of the area
3-5	100	
>5	75	

5.3 TOPSOILING AND REVEGETATION

The use of non-dispersive topsoil and revegetation to stabilise the soil is a strategy which has been successfully used to reduce the likelihood of subsoil dispersion and initiation of tunnel erosion. Subsoils (in-situ and excavated) must be covered with at least 150 mm of topsoil, however, reinstatement of the original 100 mm+ of topsoil is strongly recommended due to the hostile subsoil conditions. Fertiliser application is recommended to encourage rapid and sustained plant growth in order to stabilise exposed soils and minimise erosion. Application of fertiliser is recommended at a rate of 60 kg/ha DAP or equivalent.

5.4 RUNOFF MANAGEMENT

Finally, the management of dispersive soils not only needs to consider the prevention of erosion but also the management of sediment laden runoff from dispersive soil areas.

Sediment basins should be used to capture sediment laden runoff, thus preventing the movement of turbid waters to the receiving environment. These basins are the final control measure to ensure sediment laden water is not released to the receiving environment.

6.0 EROSION RISK MAPPING

An Erosion Risk Map has been produced based on site investigations, soil profiles, topography, governmental soil mapping and analytical results. This map aims to identify zones of various erosion risks. A classification system for the soils has been developed and implemented taking into account the aforementioned variables. The Erosion Risk Map is shown as Figure 2 in the Figures Section.

7.0 CONCLUSION

Soil profile logging, sampling and analysis was undertaken at 22 borehole locations and one grab sample location at the site to assess whether dispersive soils are likely to be disturbed as part of the proposed earthworks. Results show that the area under investigation contains 'low to negligible' dispersive soils across the majority of the site with 'moderate to high' dispersive subsoils in the eastern portion of the site. It is understood cut to fill bulk earthworks are a part of works for the development. Based on laboratory results silty clays in the eastern portion of the site below existing topsoil are considered to be at high risk of dispersion if exposed. The Ipswich Planning Scheme – Implementation Guideline No. 28 requires management of these soils for the proposed development.

Based on these results, an Erosion Risk Map (Figure 2) showing potential dispersive soil areas and their associated risk factor has been included in the Figures Section.

Sediment basins and associated drainage should be installed prior to vegetation clearing or bulk earthworks.

Dispersive soils management recommendations in Section 5.0 of this report include preventative measures to reduce the risk of erosion and management of the effects of soil dispersion. The following control measures are recommended for implementation across the site:

During bulk earthworks

- Stage the clearance of existing vegetation and bulk earthworks on site as to maximise the stabilisation of potential dispersive soils on site;
- Stabilise, hydro-mulch or mulch any stockpiles which are planned to remain unused for prolonged periods of time;
- Compact soil immediately following disturbance during bulk earthworks;
- Ensure soil compaction is to the required compaction rate and is completed under Level 1 supervision; and
- Ensure adequate stormwater planning for the management of sediment basins.

Post bulk earthworks

- Place a minimum of 150 mm of non-dispersive topsoil and revegetate areas which are not scheduled for future earthworks;
- Employ the installation of sand blocks and barriers during the installation of services; and
- Ensure sediment basin management is compliant with relevant authorities.

The recommendations outlined in the DSMP should be undertaken in conjunction with an Erosion and Sediment Control Plan as well as a Stormwater Management Plan.

8.0 REFERENCES

Brisbane City Council (2001), Soil Sampling and Testing Guideline for Erosion Potential, Version 3

Department of Employment, Economic Development and Innovation 2011, *GEOLDATA – SHEET NO_9442, Scale 1:25,000*, (DVD-ROM), Queensland Government: Brisbane.
<http://www.deedi.qld.gov.au/>

Ipswich City Council (2013). Ipswich Planning Scheme Implementation Guideline (No. 28), *Dispersive Soil Management*

NearMap 2016, Jimboomba, viewed between December 2016 and February 2017
<<http://nearmap.com/>>

Queensland Globe 2016, *Google Earth*, Bellbird Park, viewed and December 2016,
<<http://earth.google.com/>>

9.0 LIMITATIONS

Lambert & Rehbein (SEQ) Pty Ltd has prepared this report for the use of SGS *Australia* and Celestino Pty Limited in accordance with the usual care and thoroughness of the consulting profession. It is based on current practices and professional standards at the time of the investigation. Opinions and judgements expressed, herein, which are based on our understanding and interpretation of current regulatory standards, should not be construed as legal opinions. This report may not be relied upon by any other party, with the exception of the Ipswich City Council and the appointed Earthworks Contractor, without the explicit written agreement of Lambert & Rehbein. No other warranty, expressed or implied, is made as to the professional advice included in this report.

The scope of work undertaken, and sources of information used by Lambert & Rehbein in this report, were limited to that detailed in communications with SGS *Australia*. Lambert & Rehbein has made no independent verification of this information beyond the agreed scope of works and Lambert & Rehbein assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to Lambert & Rehbein was false.

This report was prepared between *December 2016* and February 2017 and is based on the conditions encountered and information reviewed at the time of preparations. Lambert & Rehbein disclaims responsibility for any changes that may have occurred after this time. We do not assume any liability for misinterpretation or items not visible, accessible or present at the subject site during the time of works.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This report contains information obtained by interview(s), review of documentation, inspection, sampling, testing or other means of investigation. This information is directly relevant only to the points in the ground where they were obtained at the time of the assessment. The borehole logs indicate the inferred ground conditions only at the specific locations tested. The precision with which conditions are indicated depends largely on the frequency and method of sampling, and the uniformity of conditions as constrained by the project budget limitations. The behaviour of groundwater and some aspects of soil and groundwater are complex. Our conclusions are based upon the analytical data presented in this report and professional experience. Given that the agreed scope of work performed was limited and governed by budgetary constraints, Lambert & Rehbein does not guarantee that dispersive soils do not exist at the subject site.

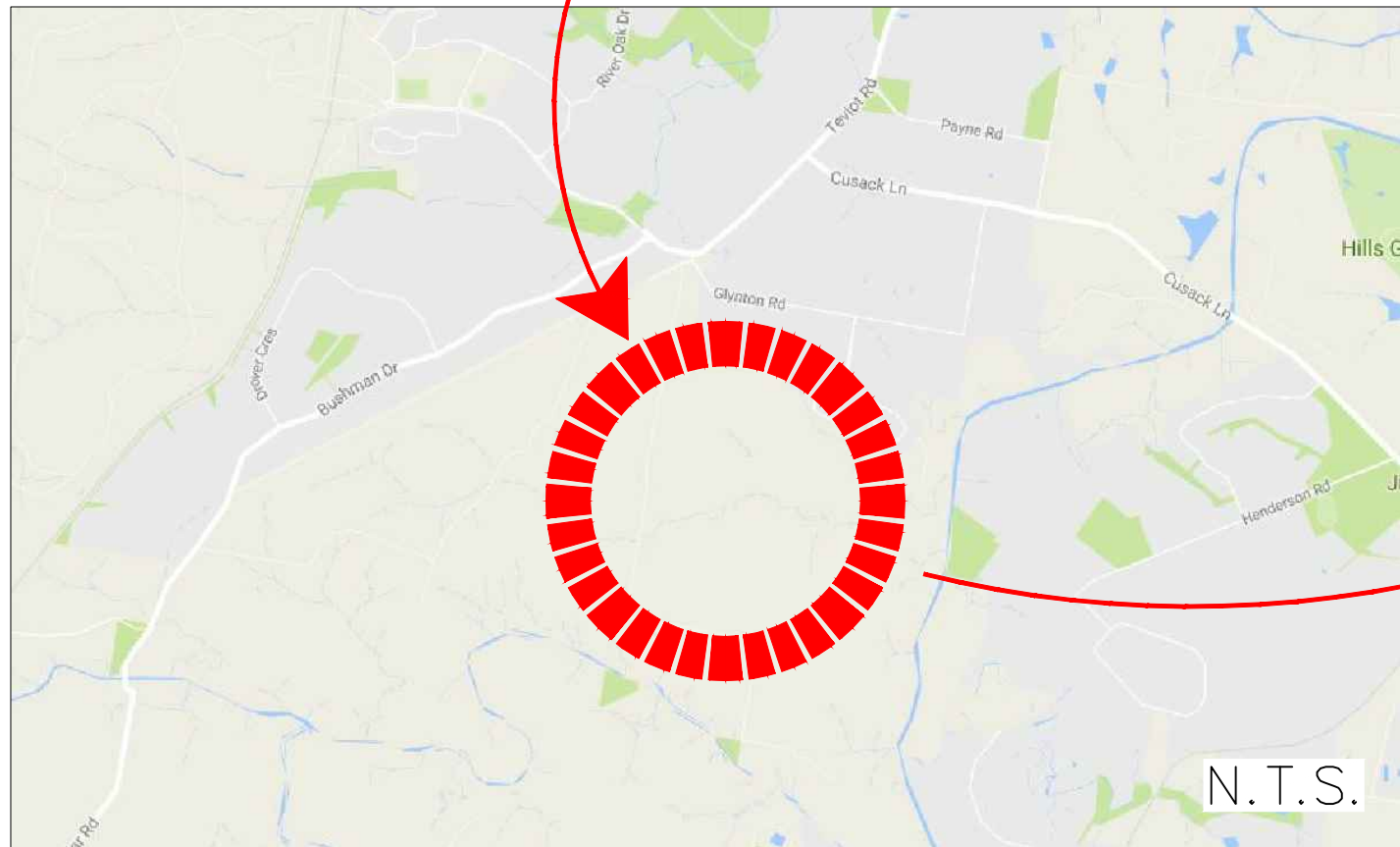
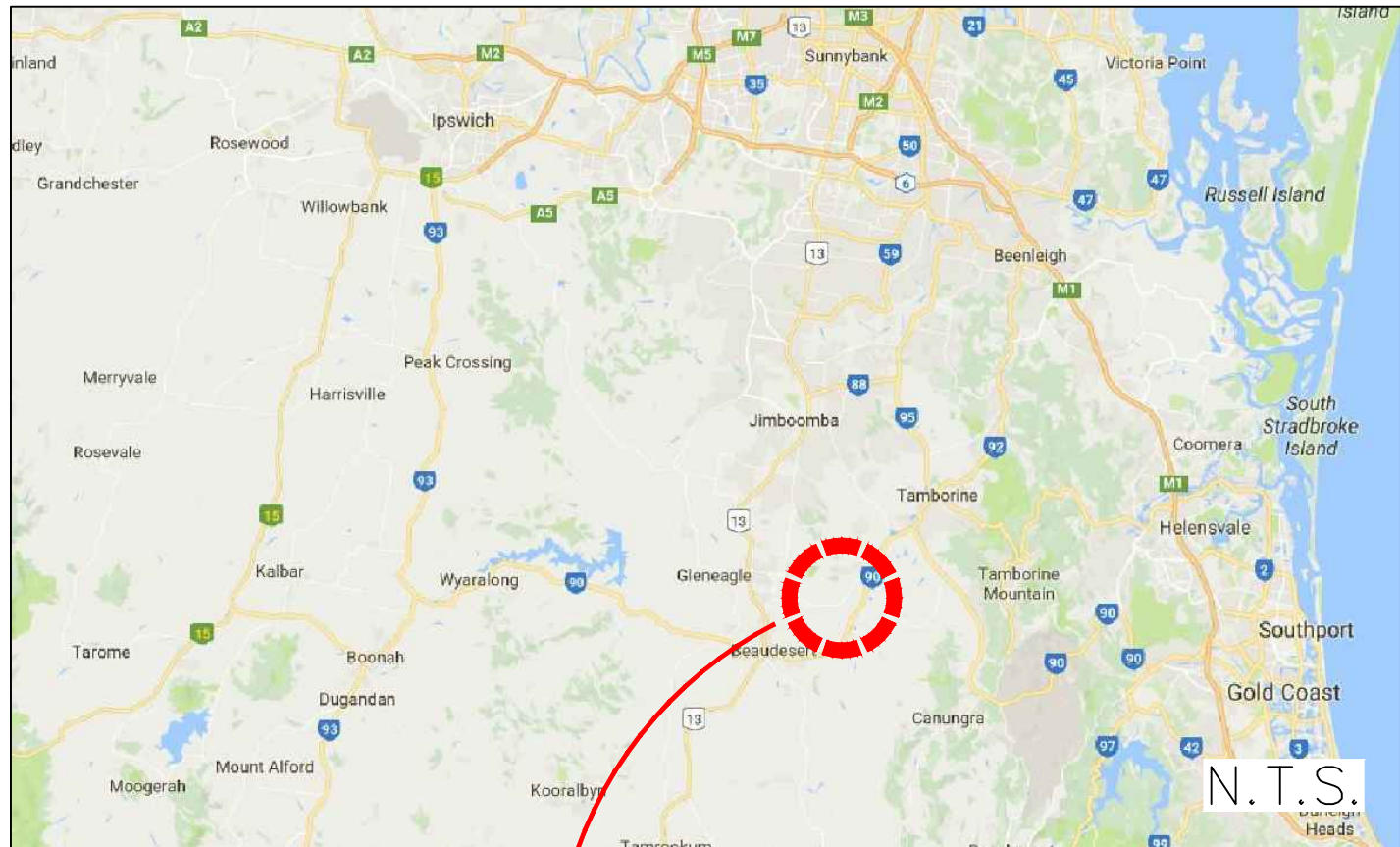
There are no investigative or remedial works which are thorough enough to preclude the presence of material, which presently or in the future, may be considered hazardous at the site. As regulatory evaluation criteria are constantly changing, where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, Lambert & Rehbein must be notified of any such findings and be provided with an opportunity to review the recommendations of this report.

Whilst to the best of our knowledge information contained in this report is accurate at the date of issue, subsurface condition, including groundwater levels can change in a limited time. Therefore this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.

FIGURES

FIGURE 1 – SITE LOCATION PLAN

FIGURE 2 – EROSION RISK MAP



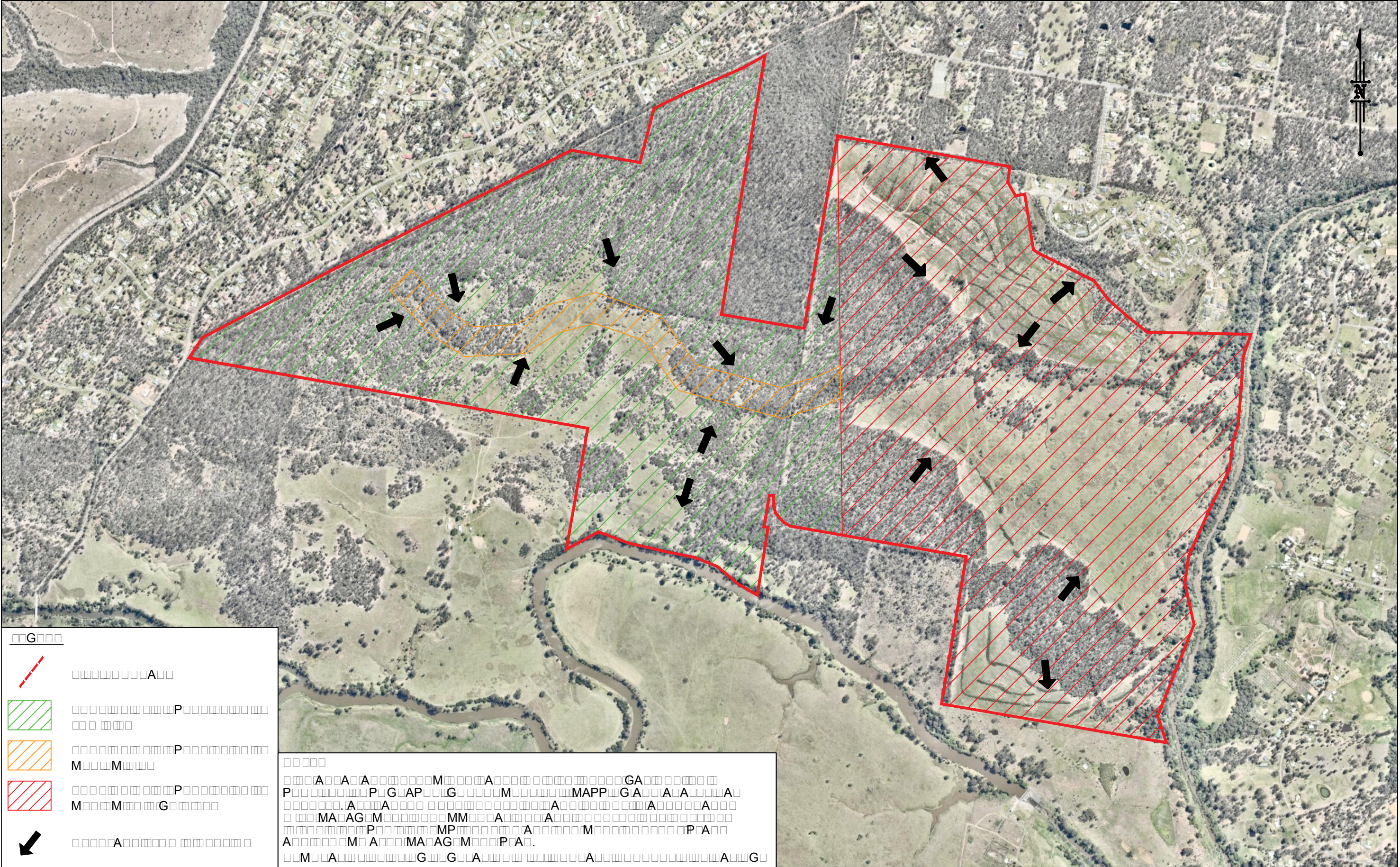
Project:
DISPERSIVE SOILS MANAGEMENT PLAN
TEVIOT ROAD & BUSHLAND ROAD, RIVERBEND BOULEVARD,
JIMBOOMBA

Client:
SGS Australia on behalf of Celestino Pty Limited
 Title:
SITE LOCATION PLAN

LAMBERT & REHBEIN
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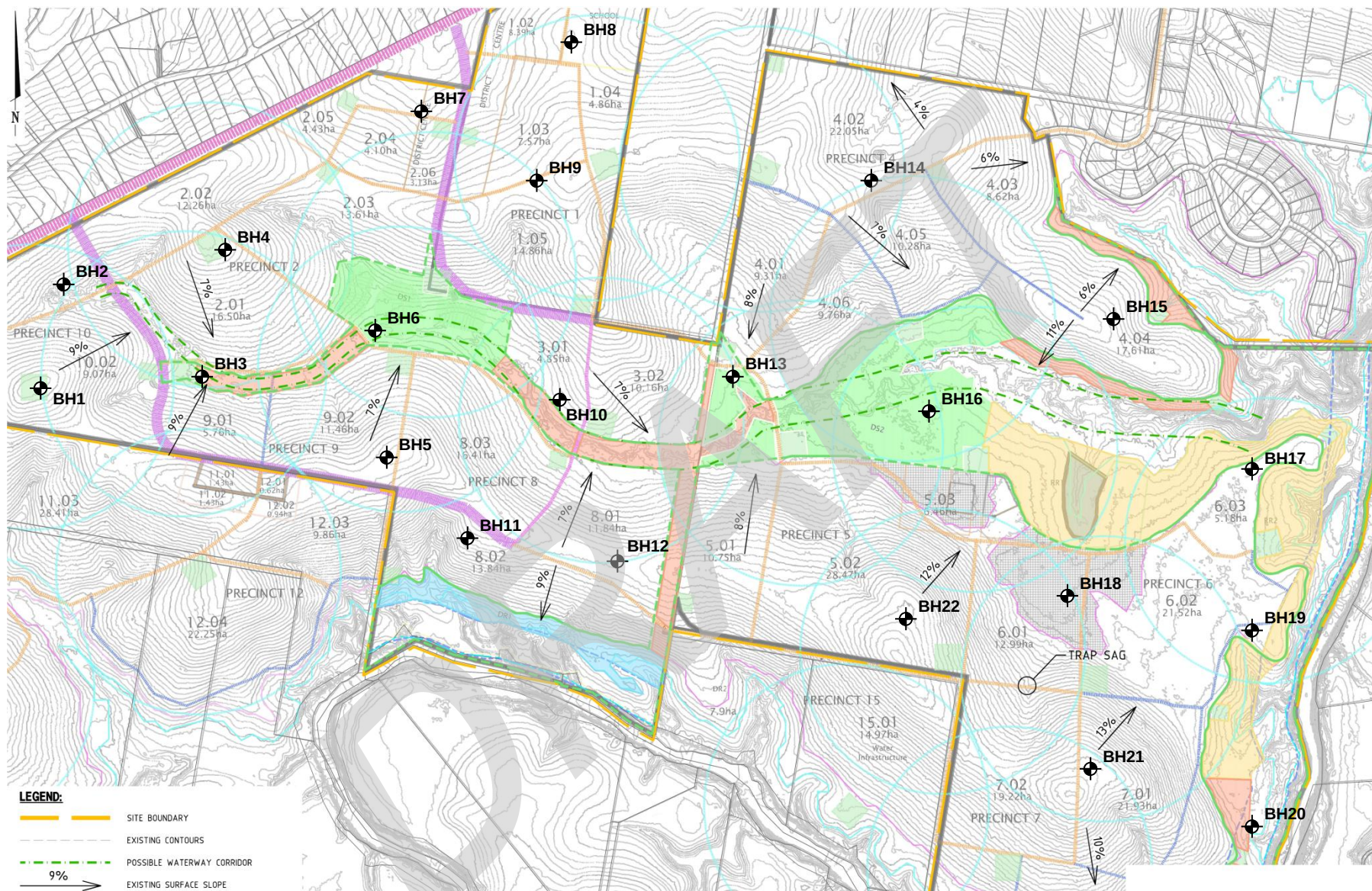
Figure No: AS SHOWN
FIGURE 1
 Scale: 1:15,000 (A3)
 File Ref: AS SHOWN

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APPENDIX A

SGS GEOTECHNICAL INVESTIGATION LOCATION PLAN



 SGS Australia Pty Ltd ABN 44 000 964 278 Unit 1/ 18 Leanne Crescent Lawnton, QLD 4501 t +61 (7) 3481 9444 www.sgs.com	TITLE GEOTECHNICAL INVESTIGATION LOCATION PLAN		DRAWING NO. SGSE.16.220.SP01	
	JOB LOCATION RIVERBEND / TEVIOT BROOK, JIMBOOMBA QLD		SCALE SCALE NOT SHOWN	
	CLIENT CELESTINO PTY LIMITED	DATE 11.11.16	DRAWN RM	SIZE A4

APPENDIX B

SGS BORELOGS

BOREHOLE LOG

BOREHOLE NO.: **BH1**

SHEET: 1 OF 1

CLIENT:	CELESTINO PTY LIMITED	DATE COMMENCED:	9.11.2016
PROJECT:	GEOTECHNICAL INVESTIGATION	DATE COMPLETED:	9.11.2016
LOCATION:	TEVIOT ROAD, JIMBOOMBA	LOGGED BY:	J.SIPPEL
JOB NUMBER:	SGSE/16/220	CHECKED BY:	R. MAXWELL

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Easting:	494729.00	Surface R.L.:	
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northing:	6921439.00	Datum:	

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SATC	Open Hole	7					SM	NATURAL - Silty SAND, fine to medium grained, grey (TOPSOIL - 80mm)	D	MD		D		
		8					CH	Silty CLAY, high plasticity, grey mottled orange, red	M	VSt				
		7												
		6												
		5		0.5								CBR		
		7												
		23					XW	SANDSTONE, fine to medium grained, yellow, grey, trace of high plasticity clay lenses	D-M	EL				
		>25												
		-		1.0										
		-					DW	SANDSTONE, fine to medium grained, brown, grey	D	EL				
				1.5										
				2.0										
				2.5										
				3.0										
				3.5										
				4.0										
				4.5										

End of BH1 at 4.5m

CLIENT: CELESTINO PTY LIMITED	DATE COMMENCED: 8.11.2016
PROJECT: GEOTECHNICAL INVESTIGATION	DATE COMPLETED: 8.11.2016
LOCATION: TEVIOT ROAD, JIMBOOMBA	LOGGED BY: J.SIPPEL
JOB NUMBER: SGSE/16/220	CHECKED BY: R. MAXWELL

Drill Contractor: SGS AUSTRALIA	Bore Size: 100mm	Hole Angle: -90°	Easting: 496218.00	Surface R.L.:
Drill Model: DTS05	Drill Fluid: -	Bearing: 	Northing: 6921392.00	Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SATC	Open Hole	6					SM	NATURAL - Silty SAND, fine to medium grained, grey-brown (TOPSOIL -100mm)	D	MD		D		
		5												
		5												
		5												
		10		0.5			CI	Silty Sandy CLAY, medium to high plasticity, grey mottled orange and yellow, fine to coarse grained sand	M	VSt-H		D		
		6												
		5												
		5												
		6												
		6		1.0										
		3					CH	Silty CLAY, high plasticity, grey mottled orange	M	St				
		2												
		3												
		2												
		3		1.5										
		3												
		4												
		4												
		4												
		4		2.0										
		5												
		6												
		6												
		6												
		7		2.5										
		7												
		9					XW	SANDSTONE, fine to medium grained, grey, yellow and orange	D	EL				
		20												
		>25					DW	SANDSTONE, fine to medium grained, grey, yellow and orange	D	VL				
		-		3.0										
							XW	SANDSTONE, fine to medium grained, grey, yellow and orange	D-M	EL-VL				
				3.5										
				4.0			DW	SANDSTONE, fine to medium grained, red, orange and grey	D	VL				
				4.5										

End of BH10 at 4.5m

BOREHOLE LOG

BOREHOLE NO.: **BH11**

SHEET: 1 OF 1

CLIENT: **CELESTINO PTY LIMITED** DATE COMMENCED: **8.11.2016**
PROJECT: **GEOTECHNICAL INVESTIGATION** DATE COMPLETED: **8.11.2016**
LOCATION: **TEVIOT ROAD, JIMBOOMBA** LOGGED BY: **J.SIPPEL**
JOB NUMBER: **SGSE/16/220** CHECKED BY: **R. MAXWELL**

Drill Contractor: **SGS AUSTRALIA** Bore Size: **100mm** Hole Angle: **-90°** Easting: **496312.00** Surface R.L.:
Drill Model: **DTS05** Drill Fluid: **-** Bearing: Northing: **6921017.00** Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SATC	Open Hole	3					SM	NATURAL - Silty SAND, fine to medium grained, grey (TOPSOIL - 120mm)	D	L-MD		D	PP>600kPa REC=200mm	
		2												
		3					CH	Silty CLAY, high plasticity, grey mottled red and orange	M	St				
		3												
		4		0.5			CH	Silty CLAY, high plasticity, grey mottled yellow and orange	M	VSt				
		4												
		4												
		4												
		4												
		4		1.0										
		5												
		5												
		6												
		7												
		>25		1.5			XW	SANDSTONE, fine to medium grained, orange-brown	D	EL-VL				
		-												
		-												
		-												
		-												
		-		2.0			XW	SANDSTONE, fine to medium grained, with high plasticity clay lenses, grey mottled red and orange	D-M	EL				
				2.5										
				3.0										
				3.5										
				4.0										
				4.5										

End of BH11 at 4.5m

CLIENT: CELESTINO PTY LIMITED	DATE COMMENCED: 8.11.2016
PROJECT: GEOTECHNICAL INVESTIGATION	DATE COMPLETED: 8.11.2016
LOCATION: TEVIOT ROAD, JIMBOOMBA	LOGGED BY: J.SIPPEL
JOB NUMBER: SGSE/16/220	CHECKED BY: R. MAXWELL

Drill Contractor: SGS AUSTRALIA	Bore Size: 100mm	Hole Angle: -90°	Easting: 496502.00	Surface R.L.:
Drill Model: DTS05	Drill Fluid: -	Bearing: 	Northing: 6921026.00	Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SATC	Open Hole		11				SM	NATURAL - Silty SAND, fine grained, grey (TOPSOIL - 60mm)	D	D		D		
			11											
			6				CH	Silty CLAY, high plasticity, red mottled grey, trace fine to medium grained sand	M	VSt				
			5									D		
			5	0.5										
			6				CH	Silty CLAY, high plasticity, grey mottled yellow and orange	M	VSt				
			6											
			6									CBR		
			8											
			7	1.0										
			6											
			7											
			8				XW	SANDSTONE, fine to medium grained, orange, yellow and grey	D-M	EL				
			8											
		20/95		1.5			XW	SANDSTONE, fine to medium grained, orange, yellow and grey	D	VL				
				2.0			XW	SANDSTONE, fine to medium grained, orange, yellow and grey, with high plasticity lenses	M	EL-VL				
				2.5										
				3.0										
				3.5										
				4.0										
				4.5			DW	SANDSTONE, fine to medium grained, yellow and grey	D	VL				

End of BH12 at 4.5m

BOREHOLE LOG

BOREHOLE NO.: **BH14**

SHEET: 1 OF 1

CLIENT: **CELESTINO PTY LIMITED** DATE COMMENCED: **7.11.2016**
PROJECT: **GEOTECHNICAL INVESTIGATION** DATE COMPLETED: **7.11.2016**
LOCATION: **TEVIOT ROAD, JIMBOOMBA** LOGGED BY: **J.SIPPEL**
JOB NUMBER: **SGSE/16/220** CHECKED BY: **R. MAXWELL**

Drill Contractor: **SGS AUSTRALIA** Bore Size: **100mm** Hole Angle: **-90°** Easting: **497186.00** Surface R.L.:
Drill Model: **DTS05** Drill Fluid: **-** Bearing: **-** Northing: **6922134.00** Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SAVTC	Open Hole	9			Marburg Formation		SM	NATURAL - Silty SAND, fine to medium grained, grey (TOPSOIL - 50mm)	D	MD		D	PP>600kPa REC=185mm	
		13					CH	Silty CLAY, high plasticity, grey mottled orange brown, trace of fine to medium grained sand	M	VSt		D		
		6												
		5												
		6		0.5										
		5												
		6												
		8					CH	Sandy CLAY, high plasticity, grey-brown, fine grained sand, with silt	M	VSt				
		7												
		5		1.0								U ₅₀		
		-												
		4												
		7					CH	Sandy CLAY, high plasticity, grey-brown mottled orange brown, fine grained sand, with silt	D-M	VSt				
		7		1.5										
		5												
		11												
		20/70					XW	SANDSTONE, fine grained, yellow-brown, with high plasticity clay lenses	D	EL		D		
				2.0										
							DW	SANDSTONE, fine grained, grey-brown and yellow-brown, with high plasticity clay lenses	D	VL		D		
				2.5										
							DW	SANDSTONE, fine grained, grey-brown and yellow-brown, with high plasticity clay lenses		VL-L				
				3.0										
								End of BH14 at 3m					Maximum TC Bit Refusal @ 3.0m depth	
				3.5										
				4.0										
				4.5										



BOREHOLE LOG

BOREHOLE NO.: **BH15**

SHEET: 1 OF 1

Engineering and Environmental Consultants
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AU.IND.Lawnton@sgs.com

CLIENT:	CELESTINO PTY LIMITED	DATE COMMENCED:	7.11.2016
PROJECT:	GEOTECHNICAL INVESTIGATION	DATE COMPLETED:	7.11.2016
LOCATION:	TEVIOT ROAD, JIMBOOMBA	LOGGED BY:	J.SIPPEL
JOB NUMBER:	SGSE/16/220	CHECKED BY:	R. MAXWELL

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Easting:	497889.00	Surface R.L.:	
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northing:	6921693.00	Datum:	

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SAVTC	Open Hole		5				SM	NATURAL - Silty SAND, fine to medium grained, grey	D	MD		D		
			5				CH	Silty Sandy CLAY, medium to high plasticity, brown mottled grey and orange	M	VSt				
			7											
			9				CH	Silty Sandy CLAY, medium to high plasticity, orange mottled yellow and grey	M	VSt				
			7	0.5										
			6									D		
			5											
			17											
			20/60				XW	SANDSTONE, fine to medium grained, orange and yellow	D	EL				
				1.0			DW	SANDSTONE, fine to medium grained, orange and yellow, with high plasticity clays	D	VL				
				1.5										
				2.0			DW	SANDSTONE, fine to medium grained, orange and yellow, with high plasticity clays	D	VL-LS				
				2.5										
				3.0										
								End of BH15 at 3m						
				3.5										
				4.0										
				4.5										

CLIENT: CELESTINO PTY LIMITED	DATE COMMENCED: 7.11.2016
PROJECT: GEOTECHNICAL INVESTIGATION	DATE COMPLETED: 7.11.2016
LOCATION: TEVIOT ROAD, JIMBOOMBA	LOGGED BY: J.SIPPEL
JOB NUMBER: SGSE/16/220	CHECKED BY: R. MAXWELL

Drill Contractor: SGS AUSTRALIA	Bore Size: 100mm	Hole Angle: -90°	Easting: 497060.00	Surface R.L.:
Drill Model: DTS05	Drill Fluid: -	Bearing: 	Northing: 6921282.00	Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SATC	Open Hole	5			Alluvium		MH	Sandy SILT, medium plasticity, grey-brown, fine to medium grained sand, with organics (TOPSOIL - 110mm)	D	VSt		D	PP=350kPa REC=170mm	
		4					CH	Silty CLAY, high plasticity, orange-brown mottled grey, trace of fine grained sand	D-M	VSt				
		4												
		4		0.5			CH	Silty CLAY, high plasticity, grey mottled orange, red-brown	M	St		U ₅₀		
		2										CBR		
		2											PP=100kPa REC=205mm	
		1												
		1		1.0			CH	Silty CLAY, high plasticity, grey mottled orange, red-brown	M	St		U ₅₀		
		3												
		4												
		3												
		4												
		5		1.5			CH	Silty CLAY, high plasticity, grey mottled orange, red-brown	M	VSt				
		6												
		5												
		5												
		5												
		-		2.0										
		-												
		4												
		3												
		3												
		4		2.5										
		5												
		10					XW	SANDSTONE, fine to medium grained, yellow and orange, trace of clay lenses	D	EL				
		20/30					XW	SANDSTONE, fine to medium grained, yellow and orange, trace of clay lenses	D	VL				
				3.0										
				3.5										
				4.0			DW	SANDSTONE, fine to medium grained, yellow and orange, trace of clay lenses	D	VL-LS				
				4.5										

End of BH16 at 4.5m

BOREHOLE LOG

BOREHOLE NO.: **BH18**

SHEET: 1 OF 1

CLIENT: **CELESTINO PTY LIMITED** DATE COMMENCED: **7.11.2016**
PROJECT: **GEOTECHNICAL INVESTIGATION** DATE COMPLETED: **7.11.2016**
LOCATION: **TEVIOT ROAD, JIMBOOMBA** LOGGED BY: **J.SIPPEL**
JOB NUMBER: **SGSE/16/220** CHECKED BY: **R. MAXWELL**

Drill Contractor: **SGS AUSTRALIA** Bore Size: **100mm** Hole Angle: **-90°** Easting: **497748.00** Surface R.L.:
Drill Model: **DTS05** Drill Fluid: **-** Bearing: **-** Northing: **6920894.00** Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SATC	Open Hole	4			Alluvium		MH	NATURAL - Clayey SILT, high plasticity, grey-brown, with fine grained sand (TOPSOIL - 100mm)	D	VSt		D		
		6					MH	Clayey SILT, high plasticity, grey-brown	D-M	VSt				
		4												
		4												
		3		0.5	Marburg Formation		CH	Silty CLAY, high plasticity, grey mottled yellow and orange-brown, trace of fine grained sand	M	St				
		2												
		2												
		2												
		2		1.0										
		2												
		4					CH	Silty CLAY, high plasticity, grey mottled yellow and orange-brown, trace of fine grained sand	M	St-VSt				
		6												
		7		1.5										
		8												
		10												
		10												
		9					CH	Silty CLAY, high plasticity, orange-brown mottled grey, with fine to medium grained sand, trace of fine sized sub-rounded gravel	M	VSt				
		11		2.0										
		10												
				2.5										
				3.0										
							CH	Silty CLAY, high plasticity, orange-brown mottled grey, with fine to medium grained sand, trace of fine sized sub-rounded gravel	M	H				
				3.5										
				4.0										
				4.5										

End of BH18 at 4.5m



BOREHOLE LOG

BOREHOLE NO.: **BH2**

SHEET: 1 OF 1

Engineering and Environmental Consultants
Ph 3481 9444
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CLIENT:	CELESTINO PTY LIMITED	DATE COMMENCED:	9.11.2016
PROJECT:	GEOTECHNICAL INVESTIGATION	DATE COMPLETED:	9.11.2016
LOCATION:	TEVIOT ROAD, JIMBOOMBA	LOGGED BY:	J.SIPPEL
JOB NUMBER:	SGSE/16/220	CHECKED BY:	R. MAXWELL

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Easting:	494805.00	Surface R.L.:	
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northing:	6921680.00	Datum:	

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water		
S/ATC	Open Hole	7			Marburg Formation		SM	NATURAL - Silty SAND, fine to medium grained, grey (TOPSOIL - 90mm)	D	MD		D				
		9		CH			Silty Sandy CLAY, high plasticity, grey mottled orange, fine to medium grained sand, trace fine sized sub-rounded gravel	M	H		D					
		8														
		6														
		5	0.5													
		5														
		6														
		4														
		4		1.0												
		5														
		6														
		9						XW	SANDSTONE, fine to medium grained, yellow, grey	D	EL					
		13														
>25			1.5	DW	SANDSTONE, fine grained, yellow, grey	D	M									
				1.5			End of BH2 at 1.5m					Maximum TC Bit Refusal @ 1.5m depth				
				2.0												
				2.5												
				3.0												
				3.5												
				4.0												
				4.5												

BOREHOLE LOG

BOREHOLE NO.: **BH21**

SHEET: 1 OF 1

CLIENT:	CELESTINO PTY LIMITED	DATE COMMENCED:	9.11.2016
PROJECT:	GEOTECHNICAL INVESTIGATION	DATE COMPLETED:	9.11.2016
LOCATION:	TEVIOT ROAD, JIMBOOMBA	LOGGED BY:	J.SIPPEL
JOB NUMBER:	SGSE/16/220	CHECKED BY:	R. MAXWELL

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Easting:	497810.00	Surface R.L.:
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northing:	6920369.00	Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SATC	Open Hole	10					SM	NATURAL - Silty SAND, fine grained, grey (TOPSOIL - 110mm)	D	D		D		
		13												
		9					CH	Silty Sandy CLAY, medium to high plasticity, grey-yellow mottled orange, fine grained sand	M	VSt-H				
		8										D		
		7		0.5			XW	SANDSTONE, fine to medium grained, yellow, grey and orange	D	EL				
		8												
		7					XW	SANDSTONE, fine to medium grained, yellow, grey and orange	D	VL				
		>25												
				1.0										
				1.5										
SATC	Open Hole			2.0			XW	SANDSTONE, fine to medium grained, yellow, grey and orange, with high plasticity clay lenses	D-M	EL-VL				
				2.5										
				3.0										
				3.5										
				4.0										
				4.5			DW	SANDSTONE, fine to medium grained, grey-yellow	D	VL				

End of BH21 at 4.5m

BOREHOLE LOG

BOREHOLE NO.: **BH22**

SHEET: 1 OF 1

CLIENT:	CELESTINO PTY LIMITED	DATE COMMENCED:	9.11.2016
PROJECT:	GEOTECHNICAL INVESTIGATION	DATE COMPLETED:	9.11.2016
LOCATION:	TEVIOT ROAD, JIMBOOMBA	LOGGED BY:	J.SIPPEL
JOB NUMBER:	SGSE/16/220	CHECKED BY:	R. MAXWELL

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Easting:	497388.00	Surface R.L.:
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northing:	6920860.00	Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
S/ATC	Open Hole	7					SM	NATURAL - Silty SAND, fine grained, grey (TOPSOIL - 90mm)	D	MD		D		
		9					CH	Silty Sandy CLAY, high plasticity, red brown, fine grained sand, with fine sized sub-rounded gravel	D	H				
		9												
		9												
		8		0.5										
		>25					XW	SANDSTONE, fine to medium grained, yellow-grey	D	EL				
							DW	SANDSTONE, fine grained, orange grey	D	VL				
				1.0			XW	SANDSTONE, fine grained, orange grey, with white high plasticity clay lenses	D	EL-VL		CBR		
				1.5			DW	SANDSTONE, fine grained, orange grey	D	LS				
								End of BH22 at 1.5m					Maximum TC Bit Refusal @ 1.5m depth	
				2.0										
				2.5										
				3.0										
				3.5										
				4.0										
				4.5										

BOREHOLE LOG

BOREHOLE NO.: **BH4**

SHEET: 1 OF 1

CLIENT: **CELESTINO PTY LIMITED** DATE COMMENCED: **9.11.2016**
PROJECT: **GEOTECHNICAL INVESTIGATION** DATE COMPLETED: **9.11.2016**
LOCATION: **TEVIOT ROAD, JIMBOOMBA** LOGGED BY: **J.SIPPEL**
JOB NUMBER: **SGSE/16/220** CHECKED BY: **R. MAXWELL**

Drill Contractor: **SGS AUSTRALIA** Bore Size: **100mm** Hole Angle: **-90°** Easting: **495591.00** Surface R.L.:
Drill Model: **DTS05** Drill Fluid: **-** Bearing: Northing: **6921815.00** Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SA/TC	Open Hole	4			Marburg Formation		SM	NATURAL - Silty SAND, fine grained, grey (TOPSOIL - 90mm)	D	MD		D		
		4												
		5					CH	Silty CLAY, high plasticity, grey mottled orange	D-M	VSt				
		5		0.5								D		
		5												
		6												
		>25					DW	SANDSTONE, fine to medium grained, orange, yellow and grey	D	VL				
		-												
		-		1.0			XW	SANDSTONE, fine to medium grained, orange, grey and yellow, with high plasticity clay lenses	D-M	EL-VL				
		-					DW	SANDSTONE, fine to medium grained, orange, grey and yellow, with high plasticity clay lenses	D	VL				
				1.5										
				2.0			DW	SANDSTONE, fine to medium grained, orange, grey and yellow, with high plasticity clay lenses	D	LS				
				2.2				End of BH4 at 2.2m					Maximum TC Bit Refusal @ 2.2m depth	
				2.5										
				3.0										
				3.5										
				4.0										
				4.5										



BOREHOLE LOG

BOREHOLE NO.: **BH5**

SHEET: 1 OF 1

Engineering and Environmental Consultants
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AU.JND.Lawnton@sgs.com

CLIENT:	CELESTINO PTY LIMITED	DATE COMMENCED:	8.11.2016
PROJECT:	GEOTECHNICAL INVESTIGATION	DATE COMPLETED:	8.11.2016
LOCATION:	TEVIOT ROAD, JIMBOOMBA	LOGGED BY:	J.SIPPEL
JOB NUMBER:	SGSE/16/220	CHECKED BY:	R. MAXWELL

Drill Contractor:	SGS AUSTRALIA	Bore Size:	100mm	Hole Angle:	-90°	Eastings:	495903.00	Surface R.L.:	
Drill Model:	DTS05	Drill Fluid:	-	Bearing:		Northings:	6921355.00	Datum:	

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SATC	Open Hole	4					SM	NATURAL - Silty SAND, fine grained, grey-brown (TOPSOIL - 200mm)	D	MD		D		
		4												
		6					SP	SAND, fine to medium grained, grey, yellow brown, with silt	D	MD		D		
		9												
		7		0.5			CH	Silty Sandy CLAY, high plasticity, grey mottled red and orange	M	VSt				
		9					XW	SANDSTONE, fine to medium grained, orange, grey and yellow	D	EL				
		9												
		7												
		>25					DW	SANDSTONE, fine to medium grained, orange, grey and yellow	D	VL				
		-		1.0										
				1.5										
				2.0										
				2.5										
				3.0										
				3.5										
				4.0										
				4.5										

End of BH5 at 4.5m

BOREHOLE LOG

BOREHOLE NO.: **BH6**

SHEET: 1 OF 1

CLIENT: **CELESTINO PTY LIMITED** DATE COMMENCED: **8.11.2016**
PROJECT: **GEOTECHNICAL INVESTIGATION** DATE COMPLETED: **8.11.2016**
LOCATION: **TEVIOT ROAD, JIMBOOMBA** LOGGED BY: **J.SIPPEL**
JOB NUMBER: **SGSE/16/220** CHECKED BY: **R. MAXWELL**

Drill Contractor: **SGS AUSTRALIA** Bore Size: **100mm** Hole Angle: **-90°** Easting: **495864.00** Surface R.L.:
Drill Model: **DTS05** Drill Fluid: **-** Bearing: **-** Northing: **6921664.00** Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SAVTC	Open Hole	15			Alluvium		MH	NATURAL - Sandy SILT, medium to high plasticity, grey, fine grained sand	D	MD		D	PP=510kPa REC=120mm	
		3					CH	Silty CLAY, high plasticity, grey mottled orange	M	St-VSt		D		
		3												
		3												
		3		0.5								U ₅₀		
		4												
		2					SC	Clayey SAND, fine to medium grained, orange mottled grey and yellow	M-W	L-MD				
		3												
		2												
		3		1.0								CBR		
		3												
		4												
		4												
		5		1.5										
		5												
		5												
		5												
		5		2.0	SC	Clayey SAND, fine to medium grained, orange mottled grey and yellow	W	L-MD						
		3												
		2												
		1												
		2												
		3		2.5										
		7												
		1												
		1												
		2												
		4		3.0										
		3												
		2												
3														
5		3.5	Marburg Formation		CH	Silty Sandy CLAY, high plasticity, grey mottled orange, with fine to medium grained sand	M	VSt						
9														
7														
7														
10														
14														
11		4.0												

CLIENT: **CELESTINO PTY LIMITED** DATE COMMENCED: **9.11.2016**
PROJECT: **GEOTECHNICAL INVESTIGATION** DATE COMPLETED: **9.11.2016**
LOCATION: **TEVIOT ROAD, JIMBOOMBA** LOGGED BY: **J.SIPPEL**
JOB NUMBER: **SGSE/16/220** CHECKED BY: **R. MAXWELL**

Drill Contractor: **SGS AUSTRALIA** Bore Size: **100mm** Hole Angle: **-90°** Easting: **496284.00** Surface R.L.:
Drill Model: **DTS05** Drill Fluid: **-** Bearing: Northing: **6922174.00** Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SATC	Open Hole	4					SM	NATURAL - Silty SAND, fine to medium grained, grey (TOPSOIL - 90mm)	D	MD		D	PP=550kPa REC=140mm	
		6												
		5					CH	Silty CLAY, high plasticity, grey mottled orange and red, with fine sized sub-rounded gravel	M	VSt		D		
		4												
		3		0.5			CH	Silty CLAY, high plasticity, grey-brown mottled red, trace fine to medium grained sand	M	VSt		U ₅₀		
		4												
		4												
		5												
		6												
		6		1.0			CH	Silty CLAY, high plasticity, grey mottled red, yellow and orange	M	VSt				
		5												
		4												
		6												
		7												
		9		1.5			CI	Silty Sandy CLAY, medium to high plasticity, grey mottled red and orange, fine to medium grained sand	M	H				
		10												
		8												
		9												
		11												
		12		2.0			CH	Silty CLAY, high plasticity, grey mottled red and orange	M	VSt				
				2.5										
							XW	SANDSTONE, fine to medium grained, grey and red, with high plasticity clay lenses	D-M	EL				
				3.0										
							XW	SANDSTONE, fine to medium grained, grey and red, with high plasticity clay lenses	D	EL				
				3.5										
				4.0										
				4.5										

End of BH8 at 4.5m



BOREHOLE LOG

BOREHOLE NO.: **BH9**
SHEET: 1 OF 1

Engineering and Environmental Consultants
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CLIENT: **CELESTINO PTY LIMITED** DATE COMMENCED: **9.11.2016**
PROJECT: **GEOTECHNICAL INVESTIGATION** DATE COMPLETED: **9.11.2016**
LOCATION: **TEVIOT ROAD, JIMBOOMBA** LOGGED BY: **J.SIPPEL**
JOB NUMBER: **SGSE/16/220** CHECKED BY: **R. MAXWELL**

Drill Contractor: SGS AUSTRALIA Bore Size: 100mm Hole Angle: -90° Easting: 496148.00 Surface R.L.:
Drill Model: DTS05 Drill Fluid: - Bearing: Northing: 6921963.00 Datum:

Method	Casing	DCP	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	Sample / Test	Field Records / Comments	Water
SATC	Open Hole	3					SM	NATURAL - Silty SAND, fine grained, grey	D	L-MD		D		
		5					CH	Silty CLAY, high plasticity, grey mottled yellow and orange, trace of fine to medium grained sand	D-M	St-VSt		D		
		3												
		4												
		5		0.5										
		9					XW	SANDSTONE, fine to medium grained, grey, yellow and orange, with tree roots	D	EL				
		>25												
		-												
		-		1.0										
		-												
							XW	SANDSTONE, fine to medium grained, grey, yellow and orange	D	EL-VL				
				1.5										
				2.0										
				2.5										
							DW	SANDSTONE, fine to medium grained, grey, yellow and orange	D	VL				
				3.0										
				3.5										
				4.0										
				4.5										

End of BH9 at 4.5m

APPENDIX C

LABORATORY CERTIFICATES

CLIENT DETAILS

Contact **Cassandra Barclay**
 Client **SGS INDUSTRIAL CMT LAWNTON**
 Address **U1/18 LEANNE CRESCENT
 LAWNTON QLD 4501**

Telephone **07 3881 3511**
 Facsimile **07 3881 3513**
 Email **cassandra.barclay@sgs.com**

Project **SGSE/16/220**
 Order Number **(Not specified)**
 Samples **12**

LABORATORY DETAILS

Manager **Jon Dicker**
 Laboratory **SGS Cairns Environmental**
 Address **Unit 2, 58 Comport St
 Portsmith QLD 4870**

Telephone **+61 07 4035 5111**
 Facsimile **+61 07 4035 5122**
 Email **AU.Environmental.Cairns@sgs.com**

SGS Reference **CE124027 R0**
 Date Received **17 Nov 2016**
 Date Reported **08 Dec 2016**

COMMENTS

Accredited for compliance with ISO/IEC 17025. NATA accredited laboratory 2562(3146)

Please see attached report for permeability (constant head) subcontracted to Soil Conservation Service, 709 Gundy Road, SCONE NSW 2337, SCO16/208R1.

SIGNATORIES



Anthony Nilsson
 Operations Manager



Jon Dicker
 Manager Northern QLD



Leanne Orsmond
 Quality & Microbiology Coordinator



Maristela Ganzan
 Metals Team Leader

Parameter	Units	LOR	Sample Number	CE124027.001	CE124027.002	CE124027.003	CE124027.004
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	08 Nov 2016	08 Nov 2016	07 Nov 2016	07 Nov 2016
			Sample Name	BH13_0.0-0.2	BH13_0.2-1.0	BH14_0.0-0.05	BH14_0.5-0.3

Moisture Content Method: AN002 Tested: 17/11/2016

% Moisture	%w/w	0.5	5.9	17	2.5	12
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Emerson Class Number Method: AN009 Tested: 21/11/2016

Emerson Class Number	No unit	1	8	8	2	1
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Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 23/11/2016

Total Organic Carbon	%w/w	0.05	2.1	0.28	1.4	0.36
Organic Matter	%w/w	0.1	3.6	0.49	2.4	0.61

Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 23/11/2016

Exchangeable Sodium, Na	mg/kg	2	61	800	63	480
Exchangeable Sodium, Na	meq/100g	0.01	0.26	3.5	0.27	2.1
Exchangeable Sodium Percentage	%	0.1	6.0	30.4	7.3	21.6
Exchangeable Potassium, K	mg/kg	2	66	85	130	100
Exchangeable Potassium, K	meq/100g	0.01	0.17	0.22	0.33	0.26
Exchangeable Potassium Percentage	%	0.1	3.8	1.9	8.8	2.7
Exchangeable Calcium, Ca	mg/kg	2	420	160	280	68
Exchangeable Calcium, Ca	meq/100g	0.01	2.1	0.80	1.4	0.34
Exchangeable Calcium Percentage	%	0.1	48.3	7.0	37.3	3.5
Exchangeable Magnesium, Mg	mg/kg	2	220	840	210	850
Exchangeable Magnesium, Mg	meq/100g	0.02	1.8	6.9	1.8	7.0
Exchangeable Magnesium Percentage	%	0.1	41.8	60.7	46.6	72.2
Cation Exchange Capacity	meq/100g	0.02	4.4	11	3.8	9.7
Sodium Adsorption Ratio	No unit	0.1	0.2	1.8	0.2	1.1
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	1.2	0.1	0.8	<0.1
Exchangeable Magnesium/Exchangeable Potassium Ratio*	No unit	0.1	10.9	31.8	5.3	26.9
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-	-	-	-

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 24/11/2016

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	0.1	0.2	6.5	0.6
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 23/11/2016

Total Kjeldahl Nitrogen	mg/kg	5	1300	330	850	350
Total Nitrogen	mg/kg	10	1300	330	860	350



ANALYTICAL REPORT

CE124027 R0

Parameter	Sample Number	CE124027.001	CE124027.002	CE124027.003	CE124027.004
	Sample Matrix	Soil	Soil	Soil	Soil
	Sample Date	08 Nov 2016	08 Nov 2016	07 Nov 2016	07 Nov 2016
	Sample Name	BH13_0.0-0.2	BH13_0.2-1.0	BH14_0.0-0.05	BH14_0.5-0.3
	Units	LOR			

Total Phosphorus by Kjeldahl Digestion DA in Soil Method: AN279/AN293(Sydney only) Tested: 23/11/2016

Total Phosphorus (Kjeldahl Digestion)	mg/kg	2	240	80	120	140
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Colwell Phosphorus Method: AN015 Tested: 24/11/2016

Colwell Phosphorus	mg/kg	1	6	1	5	2
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Phosphorus Absorption Method: AN239 Tested: 23/11/2016

Phosphorus Absorption*	mg/kg	1	570	730	250	540
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Sample Subcontracted Method: Tested: 8/12/2016

Sample Subcontracted*	No unit	-	See attached	See attached	See attached	See attached
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Parameter	Units	LOR
Sample Number	CE124027.005	CE124027.006
Sample Matrix	Soil	Soil
Sample Date	07 Nov 2016	07 Nov 2016
Sample Name	BH15_0.0-0.15	BH15_0.5-0.7
		BH19_0.0-0.1
		BH19_0.1-0.5

Moisture Content Method: AN002 Tested: 17/11/2016

% Moisture	%w/w	0.5	0.7	12	5.8	17
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Emerson Class Number Method: AN009 Tested: 21/11/2016

Emerson Class Number	No unit	1	8	1	8	1
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Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 23/11/2016

Total Organic Carbon	%w/w	0.05	1.2	0.26	3.1	0.40
Organic Matter	%w/w	0.1	2.1	0.45	5.4	0.69

Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 23/11/2016

Exchangeable Sodium, Na	mg/kg	2	110	740	120	1100
Exchangeable Sodium, Na	meq/100g	0.01	0.46	3.2	0.53	4.7
Exchangeable Sodium Percentage	%	0.1	16.2	22.9	4.2	18.9
Exchangeable Potassium, K	mg/kg	2	130	170	150	140
Exchangeable Potassium, K	meq/100g	0.01	0.33	0.45	0.37	0.37
Exchangeable Potassium Percentage	%	0.1	11.5	3.2	3.0	1.5
Exchangeable Calcium, Ca	mg/kg	2	200	120	1300	1500
Exchangeable Calcium, Ca	meq/100g	0.01	0.99	0.58	6.5	7.5
Exchangeable Calcium Percentage	%	0.1	35.0	4.2	51.5	30.2
Exchangeable Magnesium, Mg	mg/kg	2	130	1200	630	1500
Exchangeable Magnesium, Mg	meq/100g	0.02	1.1	9.8	5.2	12
Exchangeable Magnesium Percentage	%	0.1	37.2	69.8	41.3	49.4
Cation Exchange Capacity	meq/100g	0.02	2.8	14	13	25
Sodium Adsorption Ratio	No unit	0.1	0.5	1.4	0.2	1.5
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	0.9	<0.1	1.2	0.6
Exchangeable Magnesium/Exchangeable Potassium Ratio*	No unit	0.1	3.2	22.0	13.8	33.3
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-	-	-	-

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 24/11/2016

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	0.4	0.2	0.2	<0.1
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 23/11/2016

Total Kjeldahl Nitrogen	mg/kg	5	630	250	1500	290
Total Nitrogen	mg/kg	10	630	250	1500	290



ANALYTICAL REPORT

CE124027 R0

Parameter	Sample Number	CE124027.005	CE124027.006	CE124027.007	CE124027.008
	Sample Matrix	Soil	Soil	Soil	Soil
	Sample Date	07 Nov 2016	07 Nov 2016	07 Nov 2016	07 Nov 2016
	Sample Name	BH15_0.0-0.15	BH15_0.5-0.7	BH19_0.0-0.1	BH19_0.1-0.5
Units		LOR			

Total Phosphorus by Kjeldahl Digestion DA in Soil Method: AN279/AN293(Sydney only) Tested: 23/11/2016

Total Phosphorus (Kjeldahl Digestion)	mg/kg	2	73	97	340	130
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Colwell Phosphorus Method: AN015 Tested: 24/11/2016

Colwell Phosphorus	mg/kg	1	5	2	10	2
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Phosphorus Absorption Method: AN239 Tested: 23/11/2016

Phosphorus Absorption*	mg/kg	1	140	390	430	520
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Sample Subcontracted Method: Tested: 8/12/2016

Sample Subcontracted*	No unit	-	See attached	See attached	See attached	See attached
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Parameter	Units	LOR
Sample Number	CE124027.009	CE124027.010
Sample Matrix	Soil	Soil
Sample Date	08 Nov 2016	08 Nov 2016
Sample Name	BH21_0.0-0.11	BH21_0.2-0.5
		BH22_0.0-0.09
		BH22_0.09-0.5

Moisture Content Method: AN002 Tested: 17/11/2016

% Moisture	%w/w	0.5	2.9	12	5.0	14
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Emerson Class Number Method: AN009 Tested: 21/11/2016

Emerson Class Number	No unit	1	8	1	1	6
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Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 23/11/2016

Total Organic Carbon	%w/w	0.05	3.1	0.52	5.0	0.58
Organic Matter	%w/w	0.1	5.3	0.89	8.7	0.99

Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 23/11/2016

Exchangeable Sodium, Na	mg/kg	2	12	130	150	290
Exchangeable Sodium, Na	meq/100g	0.01	0.05	0.55	0.64	1.3
Exchangeable Sodium Percentage	%	0.1	1.6	9.4	6.7	10.5
Exchangeable Potassium, K	mg/kg	2	210	210	390	390
Exchangeable Potassium, K	meq/100g	0.01	0.53	0.52	0.99	1.0
Exchangeable Potassium Percentage	%	0.1	16.4	8.9	10.4	8.3
Exchangeable Calcium, Ca	mg/kg	2	270	11	670	11
Exchangeable Calcium, Ca	meq/100g	0.01	1.3	0.06	3.3	0.06
Exchangeable Calcium Percentage	%	0.1	41.6	1.0	35.2	0.5
Exchangeable Magnesium, Mg	mg/kg	2	160	580	560	1200
Exchangeable Magnesium, Mg	meq/100g	0.02	1.3	4.7	4.5	9.7
Exchangeable Magnesium Percentage	%	0.1	40.4	80.7	47.7	80.7
Cation Exchange Capacity	meq/100g	0.02	3.2	5.9	9.5	12
Sodium Adsorption Ratio	No unit	0.1	<0.1	0.4	0.3	0.6
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	1.0	<0.1	0.7	<0.1
Exchangeable Magnesium/Exchangeable Potassium Ratio*	No unit	0.1	2.5	9.0	4.6	9.7
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-	-	-	-

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 24/11/2016

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	0.7	0.1	2.1	3.6
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 23/11/2016

Total Kjeldahl Nitrogen	mg/kg	5	1500	1500	4700	480
Total Nitrogen	mg/kg	10	1500	1500	4700	490



ANALYTICAL REPORT

CE124027 R0

Parameter	Sample Number	CE124027.009	CE124027.010	CE124027.011	CE124027.012
	Sample Matrix	Soil	Soil	Soil	Soil
	Sample Date	08 Nov 2016	08 Nov 2016	08 Nov 2016	08 Nov 2016
	Sample Name	BH21_0.0-0.11	BH21_0.2-0.5	BH22_0.0-0.09	BH22_0.09-0.5
Units		LOR			

Total Phosphorus by Kjeldahl Digestion DA in Soil Method: AN279/AN293(Sydney only) Tested: 23/11/2016

Total Phosphorus (Kjeldahl Digestion)	mg/kg	2	260	270	640	170
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Colwell Phosphorus Method: AN015 Tested: 24/11/2016

Colwell Phosphorus	mg/kg	1	10	2	20	3
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Phosphorus Absorption Method: AN239 Tested: 23/11/2016

Phosphorus Absorption*	mg/kg	1	360	570	390	690
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Sample Subcontracted Method: Tested: 8/12/2016

Sample Subcontracted*	No unit	-	See attached	See attached	See attached	See attached
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MB blank results are compared to the Limit of Reporting

LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.

DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Colwell Phosphorus Method: ME-(AU)-[ENV]AN015

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Colwell Phosphorus	LB041276	mg/kg	1	<1	0 - 2%	112%

Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: ME-(AU)-[ENV]AN122

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Exchangeable Sodium, Na	LB041233	mg/kg	2		1 - 6%	101%
Exchangeable Sodium, Na	LB041233	meq/100g	0.01	<0.01	1 - 6%	NA
Exchangeable Sodium Percentage	LB041233	%	0.1		0 - 1%	NA
Exchangeable Potassium, K	LB041233	mg/kg	2		0 - 6%	108%
Exchangeable Potassium, K	LB041233	meq/100g	0.01	<0.01	0 - 6%	NA
Exchangeable Potassium Percentage	LB041233	%	0.1		0%	NA
Exchangeable Calcium, Ca	LB041233	mg/kg	2		2 - 6%	105%
Exchangeable Calcium, Ca	LB041233	meq/100g	0.01	<0.01	2 - 6%	NA
Exchangeable Calcium Percentage	LB041233	%	0.1		0 - 2%	NA
Exchangeable Magnesium, Mg	LB041233	mg/kg	2		3 - 6%	104%
Exchangeable Magnesium, Mg	LB041233	meq/100g	0.02	<0.02	3 - 6%	NA
Exchangeable Magnesium Percentage	LB041233	%	0.1		0 - 2%	NA
Cation Exchange Capacity	LB041233	meq/100g	0.02	<0.02	0 - 6%	NA
Sodium Adsorption Ratio	LB041233	No unit	0.1		1 - 3%	NA
Exchangeable Calcium/Exchangeable Magnesium Ratio	LB041233	No unit	0.1		0 - 5%	NA

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: ME-(AU)-[ENV]AN248

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Nitrate/Nitrite Nitrogen, NOx as N	LB041268	mg/kg	0.1	<0.1	7 - 21%	105%

Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: ME-(AU)-[ENV]AN281

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Kjeldahl Nitrogen	LB041235	mg/kg	5	<5	2%	98%

Total Organic Carbon by Heanes Oxidation Method: ME-(AU)-[ENV]AN273

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Total Organic Carbon	LB041236	%w/w	0.05	<0.05	9 - 23%	95%	119%
Organic Matter	LB041236	%w/w	0.1	<0.10	9 - 23%	NA	NA

MB blank results are compared to the Limit of Reporting

LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.

DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Total Phosphorus by Kjeldahl Digestion DA in Soil Method: ME-(AU)-[ENV]AN279/AN293(Sydney only)

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Phosphorus (Kjeldahl Digestion)	LB041235	mg/kg	2	<2	0%	109%

METHOD

METHODOLOGY SUMMARY

AN002	The test is carried out by drying (at either 40°C or 105°C) a known mass of sample in a weighed evaporating basin. After fully dry the sample is re-weighed. Samples such as sludge and sediment having high percentages of moisture will take some time in a drying oven for complete removal of water.						
AN009	The method follows AS1289 3.8.1 - 2006. Soils are divided into seven classes on the basis of their coherence in water, with one further class being distinguished by the presence of calcium-rich minerals. Class 1: Air-dried crumbs of soil show a strong dispersion reaction, i.e., a colloidal cloud covers nearly the whole of the bottom of the beaker, usually in a very thin layer. The reaction should be evident within 10min. In extreme cases all the water in the beaker becomes cloudy, leaving only a coarse residue in a cloud of clay.						
AN009	Class 2: Air-dried crumbs of soil show a moderate to slight reaction. A moderate reaction consists of an easily recognisable cloud of colloids in suspension, usually spreading in thin streaks on the bottom of the beaker. A slight reaction consists of the bare hint of cloud in water at the surface of the crumbs. Class 3: The soil remoulded at the plastic limit disperses in water. Class 4: The remoulded soil does not disperse in water. Calcium carbonate (calcite) or calcium sulfate (gypsum) is present. Class 5: The remoulded soil does not disperse in water and the 1:5 soil/water suspension remains dispersed after 5 min.						
AN009	Class 6: The remoulded soil does not disperse in water and the 1:5 soil/water suspension begins to flocculate within 5 min. Class 7: The air-dried crumbs of soil remain coherent in water and swells. Class 8: The air-dried crumbs of soil remain coherent in water and do not swell.						
AN015	Soil sample is extracted in an end over end roller in 0.5 N sodium bicarbonate at pH 8.5 with the supernatant liquor analysed for Phosphorous. Orthophosphate anion (PO ₄ ³⁻) is reacted with ammonium molybdate and potassium antimony tartrate in sulfuric acid solution. The resulting phospho-molybdate complex is reduced, using ascorbic acid, to an intense blue coloured complex Molybdenum Blue. The absorbance of this complex is measured at 880 nm by Discrete Analyser, and compared with calibration standards to obtain the concentration of orthophosphate in the sample. Based on Rayment & Higginson 9B1.						
AN122	Exchangeable Cations, CEC and ESP: Soil sample is extracted in 1 M Ammonium Acetate at pH=7 (or 1M Ammonium Chloride at pH=7) with cations (Na, K, Ca & Mg) then determined by ICP OES/ICP MS and reported as Exchangeable Cations. For saline soils, these results can be corrected for water soluble cations and reported as Exchangeable cations in meq/100g or soil can be pre-treated (aqueous ethanol/aqueous glycerol) prior to extraction. Cation Exchange Capacity (CEC) is the sum of the exchangeable cations in meq/100g.						
AN122	The Exchangeable Sodium Percentage (ESP) is calculated as the exchangeable sodium divided by the CEC (all in meq/100g) times 100. ESP can be used to categorise the sodicity of the soil as below: <table> <tr> <td>ESP < 6%</td><td>non-sodic</td></tr> <tr> <td>ESP 6-15%</td><td>sodic</td></tr> <tr> <td>ESP >15%</td><td>strongly sodic</td></tr> </table> Method is referenced to Rayment and Higginson, 1992, sections 15D3 and 15N1.-	ESP < 6%	non-sodic	ESP 6-15%	sodic	ESP >15%	strongly sodic
ESP < 6%	non-sodic						
ESP 6-15%	sodic						
ESP >15%	strongly sodic						
AN239	A soil's capacity for sorbing (fixing) P is related to its texture and clay mineralogy: sorption increases with increasing clay content. The sorption capacity of a soil is estimated as mg P sorbed/kg soil.						
AN248	Nitrate / Nitrite in extract by Auto Analyser: In an acidic medium, nitrate is reduced quantitatively to nitrite by cadmium metal. This nitrite plus any original nitrite is determined as an intense red-pink azo dye at 540 nm following diazotisation with sulphanilamide and subsequent coupling with N-(1-naphthyl) ethylenediamine dihydrochloride. Reference APHA 4500-NO ₃ - F.						
AN273	The sample is digested in Dichromate / Sulfuric Acid to oxidise the organic carbon. The determination is completed colourimetrically by Aquakem Discrete Analyser at 600 nm. Based on Rayment & Higginson 6B1.						

METHOD

AN281

METHODOLOGY SUMMARY

The sample is heated in the presence of Sulphuric acid, K₂SO₄ and CuSO₄ for two and half hours using a temperature controlled digestion block. Amino Nitrogen of many organic materials is converted to ammonium ion. Free ammonia also is converted to ammonium. The digest is cooled and placed on the Aquakem 250 discrete analyser for Ammonia determination.

FOOTNOTES

IS Insufficient sample for analysis.
 LNR Sample listed, but not received.
 * NATA accreditation does not cover the performance of this service.
 ** Indicative data, theoretical holding time exceeded.

LOR Limit of Reporting
 ↑↓ Raised or Lowered Limit of Reporting
 QFH QC result is above the upper tolerance
 QFL QC result is below the lower tolerance
 - The sample was not analysed for this analyte
 NVL Not Validated

Samples analysed as received.
 Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calculated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the "Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.

Note that in terms of units of radioactivity:

- 1 Bq is equivalent to 27 pCi
- 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here : <http://www.sgs.com.au/~media/Local/Australia/Documents/Technical%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf>

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SOIL TEST REPORT

Page 1 of 2

Scone Research Centre

REPORT NO: SCO16/208R1

REPORT TO: Shey Goddard
SGS Australia Pty Ltd
Unit 2, 58 Comport Street
Portsmith QLD 4870

REPORT ON: Twelve Soil Samples
Your Reference: CE124027

PRELIMINARY RESULTS

ISSUED: Not Issued

REPORT STATUS: Final

DATE REPORTED: 7 December 2016

METHODS: Information on test procedures can be obtained from Scone
Research Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED
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L Dunn
Scone Laboratory

SOIL CONSERVATION SERVICE
Scone Research Centre

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Report No: SCO16/208R1
Client Reference: Shey Goddard
SGS Australia Pty Ltd
Unit 2, 58 Comport Street
Portsmith QLD 4870

Lab No	Method	P17C/1	
	Sample Id	Saturated Hydraulic Conductivity (mm/hr)	BD* (t/m ³)
1	CE124027-001	3	1.20
2	CE124027-002	7	1.16
3	CE124027-003	4	1.63
4	CE124027-004	3	1.33
5	CE124027-005	9	1.48
6	CE124027-006	<1	1.28
7	CE124027-007	27	1.16
8	CE124027-008	2	1.12
9	CE124027-009	7	1.42
10	CE124027-010	6	1.47
11	CE124027-011	2	1.32
12	CE124027-012	17	1.30

BD* = bulk density of recompacted material at which hydraulic conductivity was determined



END OF TEST REPORT

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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	16/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3492
Lab:	Lawnton	Sample ID:	BH2 (0.1 - 0.3)

Determination of Emerson Class Number

AS1289.3.8.1

Soil Description	(CH) CLAY brown
Source of Material:	INSITU
Date Sampled:	9/11/2016
Type of Water:	RAIN
Temperature of Water (°C):	23.5

Emerson Class Number: 5

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised
Signatory:

(Bradley Woodroffe, Technician)

Date: 7/12/2016



Accredited for compliance with ISO/IEC 17025 - Testing

Client Address: 1/18 Leanne Crescent Lawnton Qld 4501
Accreditation No.: 2418Site No.: 4984
Cert No.: 16-LT-3492-S318
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Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	16/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3492
Lab:	Lawnton	Sample ID:	BH2 (0.1 - 0.3)

pH – Soil or Water

AS1289.4.3.1 (Electrometric)

pH Value

6.0

Note: EC = 0.03mS/cm

Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised
Signatory:

(Bradley Woodroffe, Technician)

Date: 7/12/2016

Client Address: 1/18 Leanne Crescent Lawnton Qld 4501
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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	16/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3493
Lab:	Lawnton	Sample ID:	BH6 (0.1 - 0.3)

Determination of Emerson Class Number

AS1289.3.8.1

Soil Description	(CH) CLAY brown
Source of Material:	INSITU
Date Sampled:	8/11/2016
Type of Water:	RAIN WATER
Temperature of Water (°C):	23.5

Emerson Class Number: **3**

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised
Signatory:

(Bradley Woodroffe, Technician)

Date: 7/12/2016



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Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	16/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3493
Lab:	Lawnton	Sample ID:	BH6 (0.1 - 0.3)

pH – Soil or Water

AS1289.4.3.1 (Electrometric)

pH Value

5.1

Note: EC = 0.02mS/cm

Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

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Date: 7/12/2016

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Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	16/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3494
Lab:	Lawnton	Sample ID:	BH6 (0.0 - 0.1)

Determination of Emerson Class Number

AS1289.3.8.1

Soil Description	(MH) Clayey SILT
Source of Material:	INSITU
Date Sampled:	8/11/2016
Type of Water:	RAIN
Temperature of Water (°C):	23.5

Emerson Class Number: **3**

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised

Signatory: (Bradley Woodroffe, Technician)

Date: 7/12/2016



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Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	16/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3494
Lab:	Lawnton	Sample ID:	BH6 (0.0 - 0.1)

pH – Soil or Water

AS1289.4.3.1 (Electrometric)

pH Value

5.9

Note: EC = 0.04mS/cm

Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

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Date: 7/12/2016



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Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	16/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3495
Lab:	Lawnton	Sample ID:	BH8 (0.0 - 0.09)

Determination of Emerson Class Number

AS1289.3.8.1

Soil Description	(MH) Clayey SILT
Source of Material:	INSITU
Date Sampled:	8/11/2016
Type of Water:	RAIN
Temperature of Water (°C):	23.5

Emerson Class Number:	3
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Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

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Signatory:  (Bradley Woodroffe, Technician)

Date: 7/12/2016



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Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	16/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3495
Lab:	Lawnton	Sample ID:	BH8 (0.0 - 0.09)

pH – Soil or Water

AS1289.4.3.1 (Electrometric)

pH Value

4.7

Note: EC = 0.02mS/cm

Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

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Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	16/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3496
Lab:	Lawnton	Sample ID:	BH8 (0.2 - 0.5)

Determination of Emerson Class Number

AS1289.3.8.1

Soil Description	(CH) CLAY brown
Source of Material:	INSITU
Date Sampled:	8-Nov
Type of Water:	RAIN
Temperature of Water (°C):	23.5

Emerson Class Number:	3
-----------------------	---

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised

Signatory:  (Bradley Woodroffe, Technician)

Date: 7/12/2016



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Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	16/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3496
Lab:	Lawnton	Sample ID:	BH8 (0.2 - 0.5)

pH – Soil or Water

AS1289.4.3.1 (Electrometric)

pH Value

4.8

Note: EC = 0.01mS/cm

Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

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Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	17/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3497
Lab:	Lawnton	Sample ID:	Creek Surface

Determination of Emerson Class Number

AS1289.3.8.1

Soil Description	(ML) Clayey SILT
Source of Material:	INSITU
Date Sampled:	7/11/2016
Type of Water:	RAIN
Temperature of Water (°C):	21.2

Emerson Class Number:	3
-----------------------	---

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised

Signatory:  (Bradley Woodroffe, Technician)

Date: 7/12/2016



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Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	17/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3497
Lab:	Lawnton	Sample ID:	Creek Surface

pH – Soil or Water

AS1289.4.3.1 (Electrometric)

pH Value

5.0

Note: EC = 0.03mS/cm

Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised
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(Bradley Woodroffe, Technician)

Date: 7/12/2016

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Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	17/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3498
Lab:	Lawnton	Sample ID:	BH16 (0.0 - 0.2)

Determination of Emerson Class Number

AS1289.3.8.1

Soil Description	(CH) CLAY brown
Source of Material:	INSITU
Date Sampled:	7/11/2016
Type of Water:	RAIN
Temperature of Water (°C):	21.2

Emerson Class Number:	3
-----------------------	---

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised

Signatory:  (Bradley Woodroffe, Technician)

Date: 7/12/2016



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Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	17/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3498
Lab:	Lawnton	Sample ID:	BH16 (0.0 - 0.2)

pH – Soil or Water

AS1289.4.3.1 (Electrometric)

pH Value

5.4

Note: EC = 0.07mS/cm

Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

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Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	17/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3499
Lab:	Lawnton	Sample ID:	BH16 (0.2 - 0.5)

Determination of Emerson Class Number

AS1289.3.8.1

Soil Description	(CH) CLAY brown
Source of Material:	INSITU
Date Sampled:	7/11/2016
Type of Water:	RAIN
Temperature of Water (°C):	21.2

Emerson Class Number:	2
-----------------------	---

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised

Signatory:  (Bradley Woodroffe, Technician)

Date: 7/12/2016



Accredited for compliance with ISO/IEC 17025 - Testing

Client Address: 1/18 Leanne Crescent Lawnton Qld 4501
Accreditation No.: 2418Site No.: 4984
Cert No.: 16-LT-3499-S318

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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	17/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3499
Lab:	Lawnton	Sample ID:	BH16 (0.2 - 0.5)

pH – Soil or Water

AS1289.4.3.1 (Electrometric)

pH Value

5.0

Note: EC = 0.04mS/cm

Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised

Signatory:  (Bradley Woodroffe, Technician)

Date: 7/12/2016



Accredited for compliance with ISO/IEC 17025 - Testing

Client Address: 1/18 Leanne Crescent Lawnton Qld 4501
Accreditation No.: 2418Site No.: 4984
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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	17/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3500
Lab:	Lawnton	Sample ID:	BH18 (0.0 - 0.1)

Determination of Emerson Class Number

AS1289.3.8.1

Soil Description	(CL) CLAY brown
Source of Material:	INSITU
Date Sampled:	7/11/2016
Type of Water:	RAIN
Temperature of Water (°C):	21.2

Emerson Class Number: 6

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised

Signatory: (Bradley Woodroffe, Technician)

Date: 7/12/2016



Accredited for compliance with ISO/IEC 17025 - Testing

Client Address: 1/18 Leanne Crescent Lawnton Qld 4501
Accreditation No.: 2418Site No.: 4984
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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	17/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3500
Lab:	Lawnton	Sample ID:	BH18 (0.0 - 0.1)

pH – Soil or Water

AS1289.4.3.1 (Electrometric)

pH Value

5.6

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised
Signatory:

(Bradley Woodroffe, Technician)

Date: 7/12/2016

Client Address: 1/18 Leanne Crescent Lawnton Qld 4501
Accreditation No.: 2418

Accredited for compliance with ISO/IEC 17025 - Testing

Site No.: 4984
Cert No.: 16-LT-3500-S902
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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	17/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3501
Lab:	Lawnton	Sample ID:	BH18 (0.1 - 0.4)

Determination of Emerson Class Number

AS1289.3.8.1

Soil Description	(CH) CLAY brown
Source of Material:	INSITU
Date Sampled:	7/11/2016
Type of Water:	RAIN
Temperature of Water (°C):	21.2

Emerson Class Number:	3
-----------------------	---

Note: Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised

Signatory:  (Bradley Woodroffe, Technician)

Date: 7/12/2016



Accredited for compliance with ISO/IEC 17025 - Testing

Client Address: 1/18 Leanne Crescent Lawnton Qld 4501
Accreditation No.: 2418Site No.: 4984
Cert No.: 16-LT-3501-S318

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Client:	SGS Australia Pty Ltd (Engineering & Environmental 5105.426)	Client Job No:	
Project:	SGSE/16/220	Order No:	
Location:	Teviot Road, Jimboomba	Tested Date:	17/11/2016
SGS Job Number:	16-55-811	Sample No:	16-LT-3501
Lab:	Lawnton	Sample ID:	BH18 (0.1 - 0.4)

pH – Soil or Water

AS1289.4.3.1 (Electrometric)

pH Value

6.0

Note: EC = 0.03mS/cm

Sampled by SGS Australia Pty Ltd according to AS1289.1.2.1 (6.5.3) Insitu - Power Auger

Authorised
Signatory:

(Bradley Woodroffe, Technician)

Date: 7/12/2016

Client Address: 1/18 Leanne Crescent Lawnton Qld 4501
Accreditation No.: 2418

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Site No.: 4984
Cert No.: 16-LT-3501-S902
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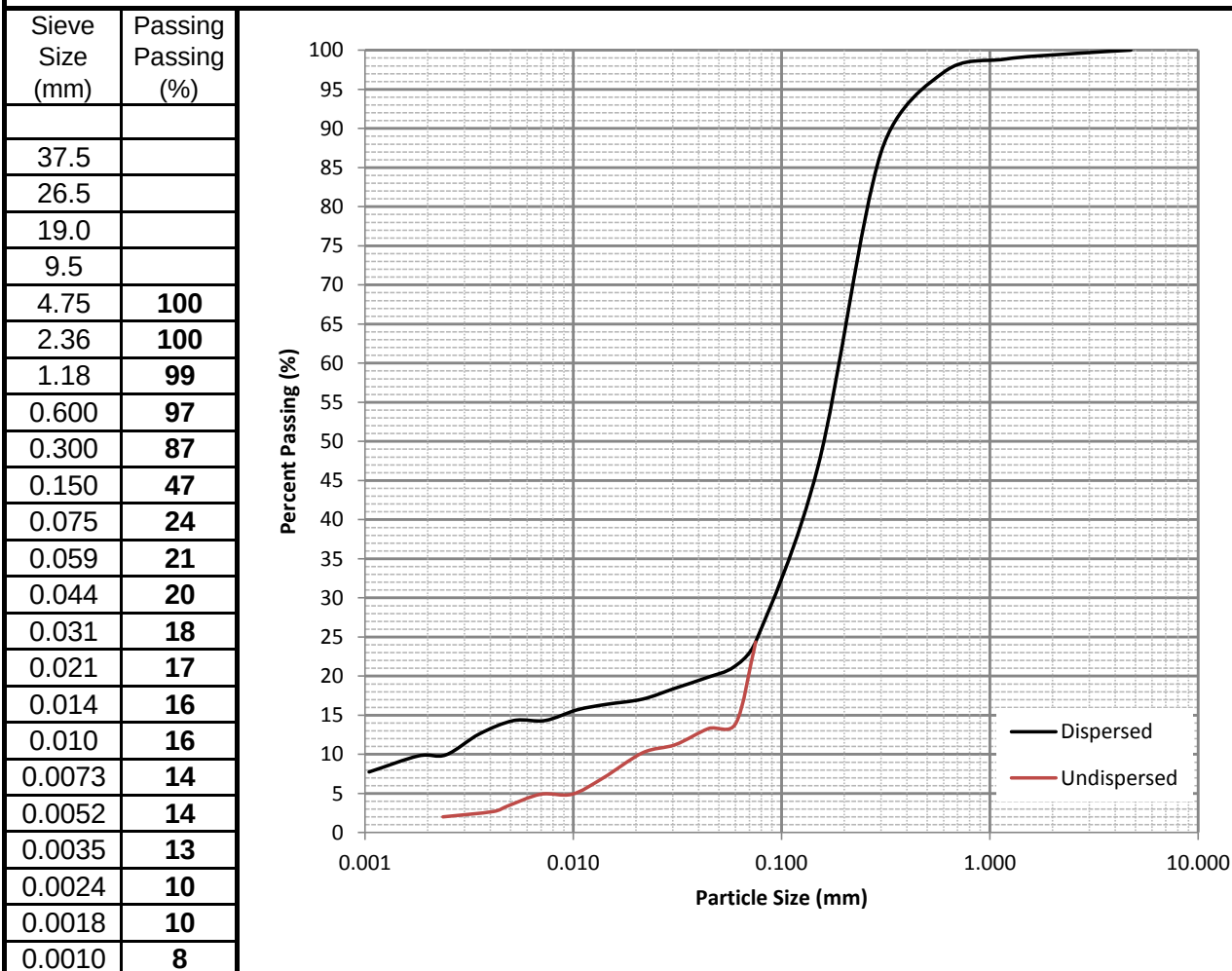
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1/18 LEANNE CRESCENT, LAWNTON
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PARTICLE SIZE DISTRIBUTION with PERCENTAGE DISPERSION TEST REPORT

Test Method: AS1289.3.8.2 & AS1289.3.6.3

Client:	Celestino Pty Ltd	Report No.:	-
Project:	Teviot Road, Jimboomba	Report Date:	16/01/2017
Job No.:	SGSE/16/220	Sampled Date:	8/11/2016
Sample Location:	Creek Surface	Depth:	-
Sample Number:	16-LT-3497	Hydrometer Type:	ASTM Type 152H
Dispersion Method:	Mechanical Stirrer with baffle	Pretreatment Loss:	0%



% passing 0.005mm (Dispersed sample)	14	(%)
% passing 0.005mm (Undispersed sample)	4	(%)
Percent Dispersion (Dispersion Index)	25	(%)
Percent Dispersible Soil	3.4	(%)
>2.36mm GRAVEL	0	(%)
2.36 - 0.020mm SAND	83	(%)
0.020 - 0.002mm SILT	7	(%)
<0.002mm CLAY	10	(%)

Remarks Particle Density (T/m³) = 2.65


B WOODROFFE

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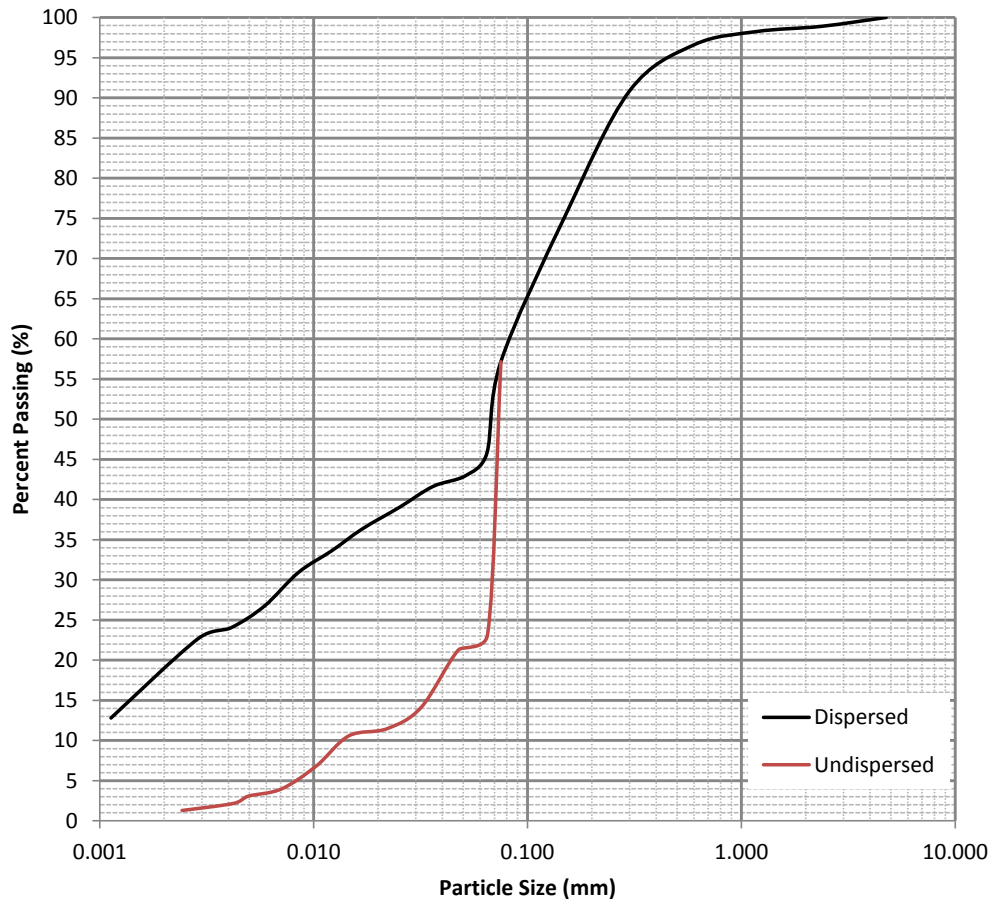
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PARTICLE SIZE DISTRIBUTION with PERCENTAGE DISPERSION TEST REPORT

Test Method: AS1289.3.8.2 & AS1289.3.6.3

Client:	Celestino Pty Ltd	Report No.:	-
Project:	Teviot Road, Jimboomba	Report Date:	16/01/2017
Job No.:	SGSE/16/220	Sampled Date:	8/11/2016
Bore Number:	6	Depth:	0.0-0.1
Sample Number:	16-LT-3494	Hydrometer Type:	ASTM Type 152H
Dispersion Method:	Mechanical Stirrer with baffle	Pretreatment Loss:	0%

Sieve Size (mm)	Passing Passing (%)
37.5	
26.5	
19.0	
9.5	
4.75	100
2.36	99
1.18	98
0.600	97
0.300	91
0.150	75
0.075	57
0.064	46
0.051	43
0.036	42
0.025	39
0.017	36
0.012	34
0.0085	31
0.0059	27
0.0041	24
0.0029	23
0.0011	13
#N/A	#N/A



% passing 0.005mm (Dispersed sample)	25	(%)
% passing 0.005mm (Undispersed sample)	3	(%)
Percent Dispersion (Dispersion Index)	12	(%)
Percent Dispersible Soil	3.4	(%)
>2.36mm GRAVEL	1	(%)
2.36 - 0.020mm SAND	62	(%)
0.020 - 0.002mm SILT	20	(%)
<0.002mm CLAY	18	(%)

Remarks Particle Density (T/m³) = 2.65

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