Yellow Pinch Water Treatment Plant

Geotechnical Investigation

Bega Valley Shire Council

20 October 2022

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Project name		Yellow Pinch WTP					
Document title		Yellow Pinch Water Treatment Plant | Geotechnical Investigation					
Project number		12538990					
File name		12538990-REP-A_Geotechnical Investigation Report - Yellowpinch WTP.docx					
Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S3	A	J.Mawbey	J.Thompson	<on file>	Catherine Sherry	<on file>	24.10.22

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1. Introduction

1.1 Project Background

Bega Valley Shire Council (BVSC) engaged GHD Pty Ltd (GHD) to undertake a geotechnical investigation of the site for a new Water Treatment Plant (WTP) located off Red Gum Road, Yellow Pinch, NSW. GHD understands that the primary objective of the geotechnical investigation was to provide geotechnical information on the subsurface conditions across the site to inform the planning for the proposed new WTP, the plant includes:

- Treatment plant facilities, including large structures and sludge lagoons/drying beds.
- New/upgraded access road to the north of site which will connect the WTP to local roads.

1.2 Purpose of this report

This document presents the results of the geotechnical investigation. The objective of the geotechnical investigation was to assess the subsurface conditions encountered at the site, and provide advice on the following:

- Excavation and groundwater conditions.
- Bearing capacity and strength of the soil and rock.
- Suitable footing types.
- Durability assessment.
- Flexible pavement design.
- Site preparation and earthworks.

This report should be read in conjunction with the limitations outlined in Section 1.3**.** and the general notes outlined in Appendix A. The site location is shown in Figure 1, Appendix B.

1.3 Limitations

This report has been prepared by GHD for Bega Valley Shire Council and may only be used and relied on by Bega Valley Shire Council for the purpose agreed between GHD and Bega Valley Shire Council as set out in Section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Bega Valley Shire Council arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Bega Valley Shire Council and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

2. Scope of work

The scope of work for the geotechnical investigation comprised the following:

- A walkover of the development site and surrounding areas to take observations and notes on the site conditions and potential geotechnical constraints.
- Clearing of services by a suitably qualified service agent engaged by GHD.
- Borehole drilling at eleven (11) locations using a track mounted drilling rig – to a maximum drilling depth of 13.80 metres below ground level (m bgl).
- Laboratory testing included the following:
    - Atterberg Limits with linear shrinkage - to verify field classification of soil samples.
    - Field moisture content - to determine the in-situ moisture content of soil samples.
    - Point load index strength testing - on suitable rock core samples to assess and verify field classification of strength.
    - Aggressivity testing to assess durability – to understand how chemically aggressive the soil is to concrete and steel.
    - California bearing ratio (4-day soak) - to determine the subgrade strength of the soils for pavement design purposes.
- Tabulate, review and check field logs and laboratory test results.
- Preparation of this report presenting the results of the investigation and geotechnical advice in relation to the objectives outlined in Section 1.2 above.

3. Methodology

Prior to the commencement of the intrusive geotechnical investigation works, the immediate area around each borehole location was scanned for underground services by a suitably qualified service locator. Site layout plans indicating the approximate location of the boreholes with respect to the proposed development area are presented in Appendix B.

A GHD Engineering Geologist was onsite full-time during fieldwork to log the subsurface conditions and collect, process, label, and store soil samples for testing. Boreholes BH01 to BH11 were drilled using a track mounted drilling rig, with termination depths ranging from 0.65 to 13.80 m bgl.

Boreholes BH01, BH03, BH05 and BH06 were drilled using augering techniques to TC-bit refusal or the top of highly weathered rock and continued using NMLC coring until a sufficient amount of rock core was obtained. Fourteen (14) rock and six (6) soil samples were sent by courier to GHD's Artarmon laboratory and a further seven (7) soil samples were sent to ALS for aggressivity testing. Both laboratories are NATA accredited.

Approximate coordinates of the borehole locations were recorded by the GHD engineering geologist using a handheld Global Positioning System (GPS) with an accuracy of +/- 5m.

On completion of drilling and logging, boreholes were backfilled using the excavated materials up to surface level and tamped using hand tools. A summary of the test location details is provided in Table 1.

Table 1 Summary of borehole details

Borehole ID	Easting m	Northing m	Depth (m bgl)	Termination	Date completed
BH01	752467	5916762	8.42	Target Depth	29/8/2022
BH02	752483	5916779	1.50	Refusal	29/8/2022
BH03	752500	5916798	8.40	Target Depth	29/8/2022
BH04	752496	5916822	1.20	Refusal	31/8/2022
BH05	752471	5916833	12.80	Target Depth	30/8/2022
BH06	752433	5916813	13.80	Target Depth	30/8/2022
BH07	752422	5916776	0.65	Refusal	30/8/2022
BH08	752520	5916902	1.1	Refusal	31/8/2022
BH09	752541	5916953	1.7	Refusal	31/8/2022
BH10	752479	5916883	2.0	Refusal	31/8/2022
BH11	752411	5916825	1.2	Refusal	30/8/2022

Table notes: All coordinates are in Zone 55H.

4. Desktop study

4.1 Geology

An extract from MinView (web mapping application from the Geological Survey of NSW) of the NSW Seamless Geology Version 2.1, mapped the site as undifferentiated sandstone and conglomerate, part of the Merimbula Group (Dme), late Devonian in age.

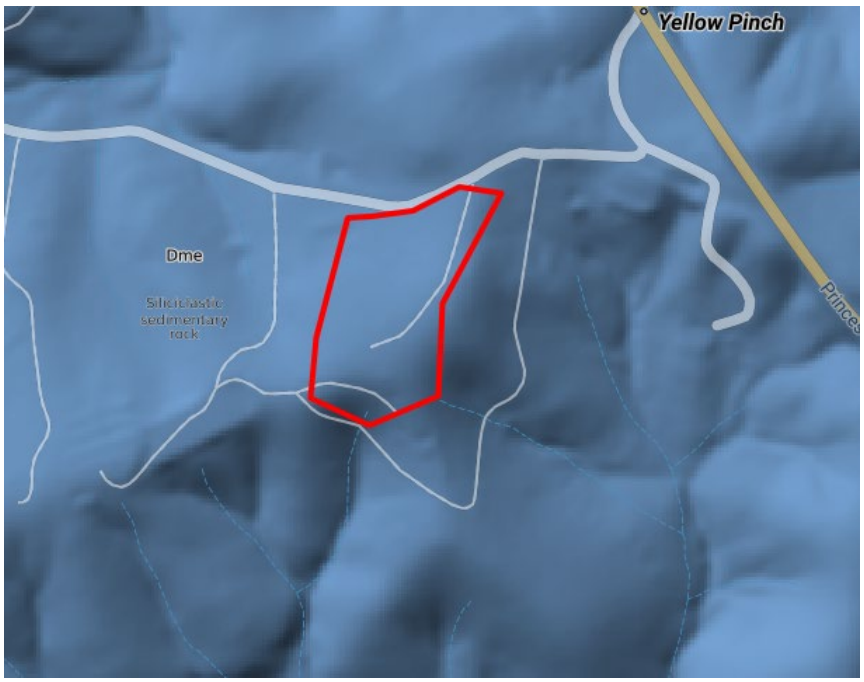

Figure 1. Regional geology of the site[1]. Approximate location of the site shown as red outline.

4.2 Site surface observations

A GHD Engineering Geologist observed the site conditions during the field investigation that took place between 29 August and 1 September 2022.

The proposed development site is situated approximately 7.5 km north-west of Merimbula, currently in use as a rural residential property off Red Gum Rd, as shown in Figure 1. The site is situated in an elevated area relative to the surrounding land, with near level to gentle grades over most of the site. The ground surface gradient increases to moderately steep slopes of around 10° on the northern, western and southern slopes outside the site, with 5-10° fall to the slopes east of the site.

The property is occupied by two single storey residential buildings, one older house supported on concrete block piers and another newer house supported on a concrete slab, other structures were noted on the property including multiple sheds, an inground swimming pool and an inground septic tank.

Vegetation over the site comprises a variety of plants including some medium to large trees and areas of undergrowth, with areas of patchy dry grass and bare soil areas. Medium dense forested areas occur beyond the perimeter of the site.

No permanent water bodies are present on the site. A minor area of soft ground was observed near the swimming pool, bare patches of ground were noted mainly where vehicle movements occur.

No rock outcrops were observed over the ground surface across the site, however rock outcrops of sandstone and conglomerate were observed just beyond and downslope of the site.

Multiple services included water and communication lines were noted onsite, including a power line easement running through the middle of the site. The access road to the property was unpaved and was observed to be slightly eroded, mainly from surface water runoff on the steeper sections of the access road.

Site photographs are presented below.

[1] Source: MinView (**https://minview.geoscience.nsw.gov.au**), Geological Survey of NSW, NSW Seamless Geology version 2.1, acquired on 28/09/2022

Photo 1 *Looking west towards the western side of the site, near BH07 (Photo taken 29 August 2022).*

Photo 2 *Looking north towards the residential property on the site, near BH07, (Photo taken 29 August 2022).*

Photo 3 *Looking west towards the residential property at the site, near BH01, (Photo taken 29 August 2022).*

Photo 4 *Looking east towards the eastern side of the site, near BH02, note inground septic tank and grade of slope in an easterly direction (Photo taken 29 August 2022).*

Photo 5 *Looking east towards the site from the northern side of the site, near BH04, note large established trees (Photo taken 30 August 2022).*

Photo 6 *Looking south along the access road/driveway towards the residential property, looking towards BH06 (Photo taken 30 August 2022).*

Photo 7 *Looking north along the access road/driveway away the residential property, near BH05, note relatively flat grade around the house and driveway areas (Photo taken 30 August 2022).*

Photo 8 *Looking west towards the power line easement from the access road/driveway towards BH06 (Photo taken 30 August 2022).*

Photo 9 *Looking east towards the residential property from the power line easement, towards BH06. Note the indicator pole showing buried communications cables in this area. (Photo taken 30 August 2022).*

Photo 10 *Looking south along the power line easement, note somewhat steeper grade of the slope in this area, near borehole BH10 (Photo taken 30 August 2022).*

Photo 11 *Looking northwest towards cleared area north of the power line easement, BH10 to right of the photo (Photo taken 30 August 2022).*

Photo 12 *Looking north, towards the area proposed for an access road, between BH08 and BH09 (Photo taken 30 August 2022).*

5. Results of investigation

The general subsurface conditions encountered in boreholes BH01 to BH11 are summarised in Table 2**.** Geotechnical logs of the boreholes are presented in Appendix C. Boreholes are situated at varying elevation levels across the site, approximate depth range of units will vary considerably between certain locations, refer to the borehole logs in Appendix C for accurate in-situ information for a particular area.

The borehole logs generally encountered a shallow residual soil layer, grading to into extremely weathered rock and then highly weathered rock. Rock strength and weathering were similar in most boreholes and strength generally did not increase with depth but remained relatively consistent throughout the profile. Fill was only encountered in one borehole, BH06, occurring as roadbase.

Table 2 Summary of subsurface soil and rock strata

Unit	Unit Description	Approximate depth range of unit (m bgl)	Boreholes encountered.
Fill (roadbase)	Sandy GRAVEL: fine to coarse grained sand, grey, brown, trace fine angular to sub-angular gravel, trace silt	0.0 to 0.25	BH06
Topsoil (natural topsoil)	Silty SAND: fine to coarse grained sand, brown, some sub-angular to sub-rounded fine to medium grained gravel, trace rootlets and organic matter	0.0 to 0.3	BH01, BH02, BH03, BH04, BH05, BH07, BH08, BH09, BH10, BH11
Residual/Extremely weathered sandstone (XW) [2]	Gravelly SAND: brown, orange fine to coarse grained sand, fine to coarse grained subangular to sub-rounded gravel, some clay	0.2 to 2.56	BH01, BH02, BH03, BH04, BH05, BH06, BH07, BH08, BH09, BH10, BH11
	Sandy CLAY or Clayey SAND: brown, orange, red mottled, fine to coarse grained, with fine to coarse angular to sub rounded gravel	0.5 to 2.67	BH02, BH03, BH04
Highly weathered rock [1]	Interbedded sandstone and conglomerate: SANDSTONE: fine to coarse grained, grey, brown, orange, yellow, red, massive with some indistinct beds, trace rip-up clasts CONGLOMERATE: fine to coarse grained, grey, brown, red, orange, brown, massive, fine to coarse sub-angular to rounded clasts up to 40mm	0.5 to 13.80	BH01, BH03, BH05, BH06, BH08 [3], BH09 [3]

Table notes:

[1] Note that this is the termination depth of the borehole and the ground conditions below this depth are unknown.

[2] Boundary between residual and extremely weathered rock is indistinct, treated as one unit for the purpose of this report.

[3] Boreholes were drilled using auguring techniques, refusing in highly weathered rock.

5.1 Laboratory test results

Fourteen (14) rock and six (6) soil samples were collected from the boreholes for laboratory geotechnical testing comprising:

– Six (6) moisture content tests on soil samples from different soil types and depths.
– Six (6) Atterberg limits tests with linear shrinkage testing, performed on soil samples taken from the residual to extremely weathered materials.
– Fourteen (14) point load strength index tests on rock core samples of varying depth, weathering, and strength.
– Two (2) California bearing ratio (CBR) tests on soil samples from areas proposed for pavement construction.

Laboratory test reports are presented in Appendix D, with a summary of test results presented in the tables below.

Table 3 Summary of moisture, Atterberg limits with linear shrinkage test results on soil samples

Borehole ID	Depth range (m)	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)
BH02	0.5-1.0	18.9	34	21	13	8.5
BH03	0.5-1.0	12.4	28	16	12	6.5
BH04	0.5-1.0	13.6	41	21	20	11.5
BH07	0.2-0.6	14.1	31	18	13	7.5
BH08	0.2-0.8	6.6	24	15	9	5.5
BH09	0.2-0.6	1.7	20	15	5	4.5

Table 4 Summary of point load test results on rock core samples

Borehole ID	Depth range (m)	Diametral Is50 (MPa)	Axial Is50 (MPa)	Strength
BH01	3.85 to 3.95	0.42	0.15	Low
BH01	6.62 to 6.79	0.05	0.05	Very low
BH01	7.61 to 7.79	0.08	0.05	Very low
BH01	8.11 to 8.27	1.07	0.94	Medium
BH03	6.99 to 7.10	0.11	0.11	Low
BH03	7.66 to 7.77	0.26	0.34	Medium
BH03	7.95 to 8.03	0.16	0.11	Low
BH05	4.49 to 4.59	0.04	0.09	Very low
BH05	6.85 to 6.70	0.76	0.73	Medium
BH05	10.83 to 11.0	0.16	0.35	Medium
BH06	4.92 to 5.0	0.25	0.26	Low
BH06	7.8 to 8.0	0.71	0.83	Medium
BH06	8.7 to 8.8	0.11	0.13	Low
BH06	11.6 to 11.7	0.66	0.86	Medium

Table 5 Summary of CBR test results

Borehole ID	Depth range (m)	Soil strata	Standard Maximum Dry Density – SMDD (t/m3)	Standard Optimum Moisture Content – SOMC (%)	4-day soaked CBR at 5.0mm penetration (%)
BH08	0.2 to 0.8	Residual/XW	1.96	11.0	16
BH09	0.2 to 0.6	Residual/XW	1.96	10.5	7

Table 6 Summary of soil aggressivity test results

Borehole ID	Sample Depth	Chloride (mg/kg)	Conductivity (uS/cm)	pH	Resistivity (ohm.cm)	Sulphate (mg/kg)
BH01	2.9 to 3.0	<10	33	4.4	30300	20
BH01	6.3 to 6.4	<10	17	5.2	58800	20
BH02	0.5 to 1.0	<10	10	5.3	100000	<10
BH03	4.9 to 5.0	<10	12	5.0	83300	10
BH04	0.5 to 1.0	<10	20	5.0	50000	20
BH05	3.1 to 3.2	140	87	4.4	11500	<10
BH06	8.3 to 8.4	<10	34	4.7	29400	50

5.2 Surface water and groundwater

No permanent surface water bodies were observed at the site. Groundwater inflows were not recorded for any of the boreholes within the soil profile. No groundwater wells were installed as part of the geotechnical investigation.

It should be noted that groundwater conditions may vary depending on factors other than weather and ground elevation, including man-made drainage paths, earthworks and other ground disturbance, type of vegetation, and variations in soil/rock conditions.

6. Discussion and recommendations

6.1 Site classification for proposed building sites

The location of the proposed infrastructure is understood to be in the vicinity of the current residential buildings on the site. The exact layout of the infrastructure is not yet confirmed; however, the approximate extent of the site is shown on Figure 1, Appendix B. Future earthworks in relation to the construction of the WTP infrastructure may result in site regrading, placement of fill, and cuts that may affect the site classification in accordance with Australian Standards AS2870-2011 *Residential Slabs and Footings*. The site classifications provided here are based on the ground levels and subsurface conditions encountered at the time of this investigation.

As discussed in Section 4.2, only shallow fill to a depth of 0.25m was encountered at BH06. Dense to very dense residual and extremely weathered soils were encountered at shallow depths (<0.5m) and up to depths of 2 m bgl. Some locations were noted to have slightly more plastic and cohesive clay soils, however this was limited to three locations, within relatively thin layers. The residual and extremely weathered rock units grade into highly weathered sedimentary rock. Where fill is encountered it should be assumed to be 'uncontrolled' and footings should not be founded directly in, or on this fill.

Based on the laboratory test results for the collected soil samples, the natural sandy soils encountered beneath the topsoil are essentially non-plastic or of very low plasticity and are likely to exhibit very low reactivity with changes in moisture content. In areas where clay soils were encountered, they are likely to exhibit low to moderate reactivity with changes in moisture. As final site levels for building platforms are not known for parts of the site, a preliminary site classification of M would apply in accordance with AS2870-2011 'Residential Slabs and Footings'.

Site classification is generally only applicable to residential and commercial buildings up to two levels, and therefore it is assumed for the proposed building developments, that the site classifications adopted will only apply to single or two storey buildings.

Site classifications should be re-assessed following any site earthworks to prepare cut to fill building platforms.

6.2 Building footings

Recommended geotechnical soil and rock parameters for the design of building footings are provided in the following sections.

6.2.1 Shallow footings

For the single storey buildings proposed it is understood that shallow footings are preferred. Recommended design parameters for shallow (high level) footings, founded in very dense residual or extremely weathered rock, are summarised in Table 7.

Table 7 Summary of geotechnical parameters for shallow footings

Unit	Effective Elastic Modulus E' (MPa)	Allowable Bearing Capacity (kPa)	Subgrade Reaction[1] (MPa/mm)
Dense to very dense residual soil or extremely weathered rock	75	250	0.125

Table Note:

[1] An upper bound increase of 50% and lower bound reduction of 50% subgrade reaction should be applied when assessing the foundation.

All footings should be founded below any topsoil, deleterious soils, uncontrolled fill (if encountered) or residual soils with a significant organic component (e.g. root affected soils). All footings for the same structure should be founded on strata of similar stiffness and reactivity to minimise the risk of differential movements.

All footing excavations should be inspected prior to installation of reinforcing steel by an experienced, qualified geotechnical consultant to confirm that the founding conditions are as described in this report. All loose material should be cleared from the bases of footing excavations before concrete is poured.

The recommended allowable bearing pressure provided above assume that the bearing surfaces are clean and free from spoil and other loose material, and free of water at the time of placement of concrete. We recommend that concrete for pad or strip footings be poured, or a blinding layer of concrete be placed on any founding surfaces as soon as practical following excavations to limit disturbance to the surface and any likely degradation of the exposed materials.

Shallow footings proportioned in accordance with the above recommendations should have load induced settlements of no greater than 1% of the footing width.

Footing design will need to consider the presence of site service trenches or other disturbed ground areas in close proximity to the footings, e.g., previous or existing service trenches.

Where uncontrolled fill, loose or disturbed soils, or soils with excessive root matter occur, we would recommend that this material be removed or all load bearing footings be extended to the weathered rock by means of closely spaced bored piers.

Engineering assessment of footing excavations should be undertaken by an experienced geotechnical engineer at the time of construction to confirm that the ground conditions encountered are consistent with the geotechnical model and assumed bearing pressures.

6.2.2 Bored piles

An alternative footing design option would include bored piles socketed into the underlying highly weathered rock. Piles could be limited to specific load bearing elements or concentrated loads such as columns for roof support. This section provides general advice and recommendations in relation to pile design and provides rock parameters for pile design.

For pile foundations, AS 2159-2009 requires that the ultimate design geotechnical strength is not less than the design action effect. The design geotechnical strength is calculated as the ultimate geotechnical strength multiplied by a geotechnical strength reduction factor.

Based on the assessment of the above factors and assumptions, an Average Risk Rating (ARR) for the design of piled foundation terminated in highly weathered bedrock may be adopted.

Based on Table 4.3.2 (C) of AS 2159-2009, an ARR of 3.0 to 3.5 is defined as moderate to high risk. The basic geotechnical strength reduction factor (ϕ_g) for single isolated piles (low redundancy system) founded into the weathered bedrock profile within the site is assessed to be 0.45.

Spacing of piles within a pile group should generally not be less than 2.5 times the pile diameters unless a comprehensive assessment of group interaction is undertaken and as a result it is confirmed this does not adversely affect the overall pile group. For piles subject to uplift loads, the geotechnical design strength shall be modified by multiplying by a factor of 0.7 in addition to the geotechnical strength reduction factor. A cone pull-out mode of failure shall be considered where appropriate for single piles.

Inspection of the foundation conditions and pile excavations shall be undertaken by an experienced geotechnical engineer to confirm the founding conditions and above values. All foundation excavations should be kept free of loose material and ponded water. The proposed piling methodology must consider equipment sufficient for drilling into the described subsurface conditions and account for locally higher strength rock.

Rock strength is defined within the Australian Standard (AS1726-1993) based on the point load strength test index, $I_{s(50)}$. The point load strength test is considered an index test which can be correlated with other rock strength tests [conventionally, uniaxial compressive strength (UCS)] to derive the compressive strength of rock.

The rock strength testing conducted on the project included the testing of three-point load strength index tests. The point load strength tests include both the axial orientation (parallel to the borehole axis) and diametral orientation (perpendicular to the rock core axis). Point load to UCS correlation factor of 20 has been adopted based on previous experience.

Table 8 outlines the rock parameters adopted in the geotechnical analysis based on logs and point load laboratory test results.

Table 8 Summary of adopted geotechnical parameters for bored pile foundations

Unit	Description	Ultimate End Bearing (MPa)	Rock Mass Elastic Modulus (MPa)[1]	Ultimate shaft adhesion kPa[2]
Rock - Sandstone/Conglomerate	HW Sandstone	8	300	400

Notes:
HW = highly weathered
1- At ultimate bearing pressure, large settlements greater than 5% of the minimum foundation dimensions are expected.
2- Based on a clean socket of roughness category R2 or better.

The selection of the footing system will depend on the final soil/rock profile, the building loads and load distribution, and sensitivity of the structures to settlement. In selecting the appropriate footing system, we recommend the building footings supporting heavy or concentrated loads including column loads, wall loads, or high floor loads be founded in highly weathered sandstone.

6.2.3 Durability

Soil or groundwater can cause chemical reactions that result in damage to buried concrete and steel structures. The exposure classifications for this site have been assessed in accordance with AS3600- 2018 ‘Concrete Structures’ and AS 2159 ‘Piling Design and installation’. The assessment is based on the aggressivity test results as presented in Table 6. The assessment of minimum concrete cover depends on the exposure classification and characteristic strength of concrete. The soils are predominately condition A.

The laboratory tests returned values that indicate the soils are mild to moderate exposure classification for concrete in soils. For a 50-year design life assuming moderate exposure classification, cast in place concrete structure must provide for a minimum concrete strength of 40 MPa with a minimum cover to reinforcement of 65 mm.

Based on the laboratory test results the exposure classification for steel in contact with soils above groundwater is assessed as non-aggressive. Where steel elements are to be in contact with soil, weathered rock or groundwater

we recommend further testing of the groundwater at the time of construction to assess the soil or weathered rock pH.

6.3 General site access and trafficability

No design drawings were available at the time of this report to inform earthworks design levels. The site has sufficient bearing capacity to support tracked earthmoving equipment however, rubber tyred equipment may experience difficulty with trafficability, particularly during or following prolonged or heavy rain.

Clearing of vegetation including the removal of large trees may be needed for access to the site with large earthmoving equipment. The current access road is in a poor condition in some areas and large trucks and floats may have difficulty accessing the site in the current state.

6.4 Material re-use potential

It is anticipated that earthworks required for the site will typically be associated with stripping vegetation and topsoil, preparation of building platforms, foundation excavations, pavements, services installations and landscaping. There is a potential for excavated materials to be re-used as fill areas. Topsoil should be stockpiled separately and may be reused for landscaping purposes subject to the waste classification and contamination status of this materials.

Excavated materials from the site that may be suitable for re-use as structural fill will include the residual gravelly sands and extremely to highly weathered rock, provided the maximum particle size of the weathered rock is limited to 100 mm and rocky materials contain sufficient fines to allow compaction requirements to be readily achieved. Where coarser less weathered rock materials are excavated, they may be re-used as structural fill provided the rock is processed by crushing to achieve a graded material with a maximum particle size of 100 mm.

Structural fill should be placed and compacted in 200 mm compacted thickness layers in accordance with AS3798 to at least 98% of Standard Maximum Dry Density (SMDD) at a moisture content within +/- 2% of Standard Optimum Moisture Content. For the upper 300 mm of fill placed within the roads and under building floor slabs, structural fill should be compacted to 100% of SMDD. If fill is to be placed close to existing structures or sensitive services, then it should be placed and compacted in layers without vibration unless otherwise advised by the geotechnical engineer.

Earthworks for the formation of roads and building platforms should be carried out in accordance with project specifications, or as a minimum in accordance with AS3798-2007 *Guidelines on Earthworks for Commercial and Residential Developments*.

Potential acidic soils and rock that exist on the site will need to be appropriately managed, a management plan for the excavating soils and rock should be considered for any excavation that exposes soils and excavated rock to the atmosphere.

6.5 Excavation conditions

Bulk excavations will be in either residual soil or possibly in weathered rock over some parts of the site. The topsoil, residual soil and extremely weathered materials are expected to be readily excavated by backhoe or small excavator (>5 t), while the highly to moderately weathered rock may be excavated with a 25 to 30 tonne excavator with a rock hammer or ripped with a D7 to D8 dozer.

It is noted that in this area that steeply dipping (>45°) rock beds can occur in the vicinity of this site, although these rock beds were not observed in the rock core sampled during the investigation. Some of the coarse-grained conglomerate rock is loosely bonded and may not be structurally sound once exposed in a cut. Care will need to be taken when excavating at the site where steeply dipping rock strata may be encountered - benching of vertical cut batters and possibly temporary shoring may need to be implemented during earthworks or trenching with permanent engineering controls considered for design level cuts (if required).

6.6 Subsoil drainage

Subsoil drainage should be provided along the high side of cut areas for building platforms and high side edges of access road or carpark pavements. Subsoil drains along roads or within carpark areas should be in good contact with the pavement subbase, and any granular select subgrade where required. The collected water must be drained to suitable outlets in the stormwater collection system.

Generally, subsoil drains will comprise a 100 mm slotted PVC pipe (Ag Pipe) surrounded by 20 mm clean aggregate and the entire drain should be wrapped in a geotextile fabric (for example Bidim A34 or equivalent). All subsoil drains should fall at a minimum 2% grade to dedicated drainage pits.

6.7 Preliminary design CBR for pavement design

The general site will be subject to ground improvement works and local excavations and filling, therefore a mid-point CBR value from the tested samples has been adopted for preliminary design purposes. The final subgrade CBR will depend on the type of imported material placed for the site preparation works. The preliminary design subgrade CBR is based on the gravelly sand soil encountered over most of the site. It is assumed that this or better material will be consistent over the majority of the proposed pavement footprint. Based on the laboratory CBR test results we recommend adopting a preliminary subgrade design CBR of 10%.

6.7.1 Pavement subgrade preparation

Where engineered select fill is required to replace any unsuitable subgrade materials, filling will need to be carried out under onsite guidance from the Geotechnical Inspection and Testing Authority (GITA) to ensure that the fill is adequately and uniformly compacted. For these areas, select fill material should satisfy the following requirements:

– Placed under the guidance of the GITA to the requirements of Level 1 of AS3798-2007.
– Free from contamination and deleterious matter such as root or plant matter or topsoil.
– Maximum particle size of 50 mm and contain sufficient fines to achieve compaction.
– Be a well graded, readily compactable and placed at a moisture content close to optimum, based on Standard Compaction.
– Tested to validate the assumed design subgrade CBR.
– Assessed and approved by appropriately experienced geotechnical engineer at the source or the borrow area prior to delivery to site.

6.7.2 General compaction requirements for flexible pavements

Following satisfactory performance of the exposed subgrade under proof rolling using a 12 tonne smooth drum roller without vibration, and subsequent satisfactory density test results, place and compact approved pavement material to the compaction requirements outlined in Table 9. Layer thicknesses for pavement materials should not exceed 200mm compacted thickness.

Compaction should be carried out using a 12 tonne smooth drum roller without vibration, for locations near buildings and potentially sensitive underground services that may already be constructed prior to pavement works.

Table 9 Minimum compaction requirements for pavement construction

Description	Compaction requirements	Moisture requirements[1]
Base – DGB20	Minimum 98% Modified MDD	-2% to 0% of OMC
Subbase – DGS40	Minimum 95% Modified MDD	-2% to 0% of OMC
Subgrade or General Fill Zone (top 300 mm)	Minimum 100% Standard MDD	-2% to 0% of OMC
General Fill Zone (deeper than 300 mm below top of subgrade)	Minimum 98% Standard MDD	-2% to 0% of OMC

Note: [1] – Negative means dry of optimum moisture content, MDD = Maximum Dry Density OMC = Optimum Moisture Content

Appendices

Appendix A

General Notes

GENERAL NOTES

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The report contains the results of a geotechnical investigation or study conducted for a specific purpose and client. The results may not be used or relied on by other parties, or used for other purposes, as they may contain neither adequate nor appropriate information. In particular, the investigation does not cover contamination issues unless specifically required to do so by the client.

To the maximum extent permitted by law, all implied warranties and conditions in relation to the services provided by GHD and the report are excluded unless they are expressly stated to apply in the report.

TEST HOLE LOGGING

The information on the test hole logs (boreholes, test pits, exposures etc.) is based on a visual and tactile assessment, except at the discrete locations where test information is available (field and/or laboratory results). The test hole logs include both factual data and inferred information. Moreover, the location of test holes should be considered approximate, unless noted otherwise (refer report). Reference should also be made to the relevant standard sheets for the explanation of logging procedures (Soil and Rock Descriptions, Core Log Sheet Notes etc.).

GROUNDWATER

Unless otherwise indicated, the water depths presented on the test hole logs are the depths of free water or seepage in the test hole recorded at the given time of measuring. The actual groundwater depth may differ from this recorded depth depending on material permeabilities (i.e. depending on response time of the measuring instrument). Further, variations of this depth could occur with time due to such effects as seasonal, environmental and tidal fluctuations or construction activities such as a change is ground surface level. Confirmation of groundwater levels, phreatic surfaces or piezometric pressures can only be made by appropriate surveys, instrumentation techniques and monitoring programmes.

INTERPRETATION OF RESULTS

The discussion or recommendations contained within this report normally are based on a site evaluation from discrete test hole data, often with only approximate locations (e.g. GPS). Generalised, idealised or inferred subsurface conditions (including any geotechnical cross-sections) have been assumed or prepared by interpolation and/or extrapolation of these data. As such these conditions are an interpretation and must be considered as a guide only.

CHANGE IN CONDITIONS

Local variations or anomalies in ground conditions do occur in the natural environment, particularly between discrete test hole locations or available observation sites. Additionally, certain design or construction procedures may have been assumed in assessing the soil-structure interaction behaviour of the site. Furthermore, conditions may change at the site from those encountered at the time of the geotechnical investigation through construction activities and constantly changing natural processes.

Any change in design, in construction methods, or in ground conditions as noted during construction, from those assumed or reported should be referred to GHD for appropriate assessment and comment.

GEOTECHNICAL VERIFICATION

Verification of the geotechnical assumptions and/or model is an integral part of the design process - investigation, construction verification, and performance monitoring. Variability is a feature of the natural environment and, in many instances, verification of soil or rock quality, or foundation levels, is required. There may be a requirement to extend foundation depths, to modify a foundation system and/or to conduct monitoring as a result of this natural variability. Allowance for verification by appropriate geotechnical personnel must be recognised and programmed for construction.

FOUNDATIONS

Where referred to in the report, the soil or rock quality, or the recommended depth of any foundation (piles, caissons, footings etc.) is an engineering estimate. The estimate is influenced, and perhaps limited, by the fieldwork method and testing carried out in connection with the site investigation, and other pertinent information as has been made available. The material quality and/or foundation depth remains, however, an estimate and therefore liable to variation. Foundation drawings, designs and specifications should provide for variations in the final depth, depending upon the ground conditions at each point of support, and allow for geotechnical verification.

REPRODUCTION OF REPORTS

Where it is desired to reproduce the information contained in our geotechnical report, or other technical information, for the inclusion in contract documents or engineering specification of the subject development, such reproductions must include at least all of the relevant test hole and test data, together with the appropriate Standard Description sheets and remarks made in the written report of a factual or descriptive nature.

Ref: DS5.5.1 Issue 0 Date: 05/10/2018

GLOSSARY OF SYMBOLS

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This standard sheet should be read in conjunction with all test hole log sheets and any idealised geological sections prepared for the investigation report.

GENERAL

Symbol	Description	Symbol	Description
D	Disturbed Sample	R	Rising Head Permeability Test
B	Bulk Sample	F	Falling Head Permeability Test
U(50)	Undisturbed Sampled (suffixed by sample size or tube diameter in mm if applicable)	PBT	Plate Bearing Test
CS	Core Sample (suffixed by diameter in mm)		Water Inflow (make)
ES	Soil sample for environmental sampling		Water Outflow (loss)
PID	Photoionisation Detector		Temporary Water Level
SPT	Standard Penetration Test (with blows per 0.15m)		Final Water Level
N	SPT Value		Point Load Test (axial)
HB/HW	SPT Hammer Bouncing/Hammer Weight		Point Load Test (diametric)
PP/HP	Pocket/Hand Penetrometer (suffixed by value kPa)	PL	Point Load (kPa)
PK	Packer Test (kPa)	IMP	Impression Device Test
PZ	Piezometer Installation	PM	Pressuremeter Test
SV/VS	Shear Vane Test (suffixed by value in kPa)		

SOIL SYMBOLS

Main Components				Minor Components			
	SAND		FILL		sandy		vegetation, roots
	GRAVEL		SILT		gravelly		silty
	CLAY		TOPSOIL		clayey	*Note: Natural soils are generally a combination of constituents, e.g. sandy CLAY*	

ROCK SYMBOLS

Sedimentary						Igneous			
	SANDSTONE		SILTSTONE		CONGLOMERATE		GRANITIC ROCK		IGNEOUS DYKE
	CLAYSTONE		SHALE		COAL		BASALTIC ROCK		

Note: Additional rock symbols may be allocated for a particular project

NATURAL DEFECTS *(Coding)*

Defect Type		Orientation					
Jt	Joint	For vertical non-oriented core ... “Dip” angle (eg. 5°) measured relative to horizontal.					
Pt	Parting	For inclined non-oriented core ... “Angle” measured relative to core axis.					
SS	Sheared Surface	For inclined oriented core ... “Dip” angle and “Dip Direction” angle (eg. 45°/225° mag.).					
WSm	Weathered Seam	**Orientation (con’t)**		**Roughness**		**Coating**	
SSm	Sheared Seam	VT	Vertical	Pol	Polished	Cn	Clean
CSm	Crushed Seam	HZ or 0°	Horizontal	So	Smooth	Sn	Stained
ISm	Infilled Seam	d / °	Degrees	Rf	Rough	Ve	Veneer
SZ	Sheared Zone			VR	Very Rough	Co	Coating
VN	Vein			Slk	Slickensided		
Shape				**Infilling / Common Materials**			
Pln	Planar	St	Stepped	CLAY	Clay	Mi	Micaceous
Cu	Curved	Ir	Irregular	Ca	Calcite	Mn	Manganese
Un	Undulating	Dis	Discontinuous	X	Carbonaceous	Py	Pyrite
Others				Kt	Chlorite	Qz	Quartz
OP	Open	CL	Closed	Ti	Tight	Fe	Iron Oxide	MU	Unidentified Mineral

Ref: DS6.5.3 Rev 1 Date : 25/09/2019

SOIL DESCRIPTION AND CLASSIFICATION

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Soil is described in general accordance with Australian Standard AS 1726-2017 (Geotechnical Site Investigations) in terms of visual and tactile properties, with potential refinement by laboratory testing. AS 1726 defines soil as particulate materials that occur in the ground and can be disaggregated or remoulded by hand in air or water without prior soaking. Classification of the soil is undertaken following description.

SOIL DESCRIPTION

The soil description includes a) Composition, b) Condition, c) Structure, d) Origin and e) Additional observations. 'FILL', 'TOPSOIL' or a 'MIXTURE OF SOIL AND COBBLES / BOULDERS' (with dominant fraction first) is denoted at the start of a soil description where applicable.

a) Soil Composition (soil name, colour, plasticity or particle characteristics, secondary and then minor components)

Soil Name: A soil is termed a *coarse grained soil* where the dry mass of sand and gravel particles exceeds 65% of the total. Soils with more than 35% fines (silt or clay particles) are termed *fine grained soils*. The soil name is made up of the primary soil component (in BLOCK letters), prefixed by applicable secondary component qualifiers. Minor components are applied as a qualifiers to the soil name (using the words 'with' or 'trace').

Particles are differentiated on the basis of size. 'Boulders' and 'cobbles' are outside the soil particle range, though their presence (and proportions) is noted. While individual particles may be designated as silt or clay based on grain size, fine grained soils are characterised as silt or clay based on tactile behaviour or Atterberg Limits, and not the relative composition of silt or clay sized particles.

Colour: The prominent colour is noted, followed by (spotted, mottled, streaked etc.) then secondary colours as applicable. Roughly equally proportioned colours are prefixed by (spotted, mottled, streaked etc.). Colour is described in its moist condition, though both wet and dry colours may also be provided if appropriate.

Plasticity: Fine grained soils are designated within standard ranges of plasticity based on tactile assessment or laboratory assessment of the Liquid Limit.

Particle Characteristics: The particle shape, particle distribution and particle size range within a coarse grained soil is described using standard terms. Particle composition may be described using rock or mineral names, with specific terms for carbonate soils.

Secondary and Minor Components: The primary soil is described and modified by secondary and minor components, with assessed ranges as tabulated.

Carbonate Soils: Carbonate content can be assessed by use of dilute '10%' HCl solution. Resulting clear sustained effervescence is interpreted as a *Carbonate soil* (approximately >50% carbonate), while weak or sporadic effervescence indicates *Calcareous soil* (< 50% carbonate). No effervescence is interpreted as a non-calcareous soil.

Organic and Peat Soils: Where identified, organic content is noted. *Organic soil* (2% to 25% organic matter) is usually identified by colour (usually dark grey/black) and odour (i.e. 'mouldy' or hydrogen sulphide odour). *Peat* (>25% organic matter) is identified by a spongy feel and fibrous texture. Peat soils' decomposition may be described as '*fibrous*' (little / no decomposition), '*pseudo-fibrous*' (moderate decomposition) or '*amorphous*' (full decomposition).

Fraction	Components		Particle Size (mm)
Oversize	BOULDERS		> 200
	COBBLES		63 - 200
Coarse grained soil particles	GRAVEL	Coarse	19 - 63
		Medium	6.7 -19
		Fine	2.36 - 6.7
	SAND	Coarse	0.6 - 2.36
		Medium	0.21 - 0.6
		Fine	0.075 - 0.21
Fine grained soil particles	SILT		0.002 - 0.075
	CLAY		< 0.002

Plasticity Terms (Fine Grained Soils)		Laboratory Liquid Limit Range
Silt	**Clay**	
N/A	N/A	(Non Plastic)
Low Plasticity	*Low Plasticity*	≤ 35%
	Medium Plasticity	> 35% and ≤ 50%
High Plasticity	*High Plasticity*	> 50%

Particle Distribution Terms (Coarse Grained Soils)	
Well graded	good representation of all particle sizes
Poorly graded	one or more intermediate sizes poorly represented
Gap graded	one or more intermediate sizes absent
Uniform	essentially of one size

Particle Shape Terms (Coarse Grained Soils)		
Rounded	*Sub-angular*	*Flaky or Platy*
Sub-rounded	*Angular*	*Elongated*

Secondary and Minor Components for Coarse Grained Soils			
Fines (%)	**Modifier** (as applicable)	**Accessory coarse (%)**	**Modifier** (as applicable)
≤ 5	*'trace silt / clay'*	≤ 15	*'trace sand / gravel'*
> 5, ≤ 12	*'with clay / silt'*	> 15, ≤ 30	*'with sand / gravel'*
> 12	*prefix 'silty / clayey'*	> 30	*prefix 'gravelly / sandy'*

Secondary and Minor Components for Fine Grained Soils	
% Coarse	**Modifier** (as applicable)
≤ 15	add *"trace sand / gravel"*
> 15, ≤ 30	add *"with sand / gravel"*
> 30	prefix soil *"sandy / gravelly"*

Ref: DS6.5.1.1 Rev 0 Date: 2/03/2018

SOIL DESCRIPTION AND CLASSIFICATION

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b) Soil Condition (moisture, relative density or consistency)

Moisture: Fine grained soils are described relative to plastic or liquid limits, while coarse grained soils are assessed based on appearance and feel. The observation of seepage or free water is noted on the test hole logs.

Moisture - Coarse Grained Soils

Term		Tactile Properties
Dry	*('D')*	Non-cohesive, free running
Moist	*('M')*	Feels cool, darkened colour, tends to stick together
Wet	*('W')*	Feels cool, darkened colour, tends to stick together, free water forms when handling

Moisture - Fine Grained Soils

Term		Tactile Properties
Moist, dry of plastic limit	*('w < PL')*	Hard and friable or powdery
Moist, near plastic limit	*('w ≈ PL')*	Can be moulded
Moist, wet of plastic limit	*('w > PL')*	Weakened, free water forms on hands with handling
Wet, near liquid limit	*('w ≈ LL')*	Highly weakened, tends to flow when tapped
Wet, wet of liquid limit	*('w > LL')*	Liquid consistency, soil flows

Relative Density (Non Cohesive Soils): The Density Index is inherently difficult to assess by visual or tactile means, and is normally assessed by penetration testing (e.g. SPT, DCP, PSP or CPT) with published correlations. Assessment may be affected by moisture and *in situ* stress conditions. Density Index assessment may be refined by combination of *in situ* density testing and laboratory reference maximum and minimum density ranges.

Consistency (Cohesive Soils): May be assessed by direct measurement (shear vane, CPT etc.), or approximate tactile correlations. Cohesive soils include fine grained soils, and coarse grained soils with sufficient fine grained components to induce cohesive behaviour. A 'design shear strength' must consider the mode of testing, the *in situ* moisture content and potential for variations of moisture which may affect the shear strength.

Relative Density (Non-Cohesive Soils)

Term and (Symbol)		Density Index (%)
Very Loose	*(VL)*	≤ 15
Loose	*(L)*	> 15 and ≤ 35
Medium Dense	*(MD)*	> 35 and ≤ 65
Dense	*(D)*	> 65 and ≤ 85
Very Dense	*(VD)*	> 85

Consistency assessment can be influenced by moisture variation.

Consistency (Cohesive Soils)

Term and (Symbol)		Tactile Properties	Undrained Shear Strength
Very Soft	*(VS)*	Extrudes between fingers when squeezed	< 12 kPa
Soft	*(S)*	Can be moulded by light finger pressure	12 - 25 kPa
Firm	*(F)*	Can be moulded by strong finger pressure	25 - 50 kPa
Stiff	*(St)*	Cannot be moulded by fingers	50 - 100 kPa
Very Stiff	*(VSt)*	Can be indented by thumb nail	100 - 200 kPa
Hard	*(H)*	Can be indented with difficulty by thumb nail	> 200 kPa
Friable	*(Fr)*	Easily crumbled or broken into small pieces by hand	-

c) Structure (zoning, defects, cementing)

Zoning: The *in situ* zoning is described using the terms below. *'Intermixed'* may be used for an irregular arrangement.

'layer' (a continuous zone across the exposed sample)

'lens' (a discontinuous layer with lenticular shape)

'pocket' (an irregular inclusion of different material).

'interbedded' or *"interlaminated'* (alternating soil types)

Defects: Described using terms below, with dimension orientation and spacing described where practical.

'parting' (an open or closed surface or crack sub parallel to layering with little / no tensile strength - open or closed)

'fissure' (as per a parting, though not parallel or sub parallel to layering – may include desiccation cracks)

'sheared seam' (zone of sub parallel near planar closely spaced intersecting smooth or slickensided fissures dividing the mass into lenticular or wedge shaped blocks)

'sheared surface' (a near planar, curved or undulating smooth, polished or slickensided surface, indicative of displacement)

'softened zone' (in clayey soils, usually adjacent to a defect with associated higher moisture content)

'tube' (tubular cavity, singly or one of a large number, often formed from root holes, animal burrows or tunnel erosion)

'tube cast' (an infilled tube – infill may vary from uncemented through to cemented or have rock properties)

'infilled seam' (sheet like soil body cutting through the soil mass, formed by infilling of open defects)

Cementation: Soils may be cemented by various substances (e.g. iron oxides and hydroxides, silica, calcium carbonate, gypsum), and the cementing agent shall be identified if practical. Cemented soils are described as:

'weakly cemented'	easily disaggregated by hand in air or water
'moderately cemented'	effort required to disaggregate the soil by hand in air or water

Materials extending beyond '*moderately cemented'* are encompassed within the rock strength range. Where consistent cementation throughout a soil mass is identified as a duricrust, it is described in accordance with duricrust rock descriptors. Where alternate descriptors of cementation development are applied for consistency with regional practices or geology, or client requirements, these are outlined separately.

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d) Origin

An interpretation is provided based on observations of landform, geology and fabric, and may further include assignment of a stratigraphic unit. The use of terms 'possibly' or 'probably' indicates a higher degree of uncertainty regarding the assessed origin or stratigraphic unit. Typical origin descriptors include:

Residual	Formed directly from in situ weathering with no visible structure or fabric of the parent soil or rock.
Extremely weathered	Formed directly from in situ weathering, with remnant and/or fabric from the parent rock.
Alluvial	Deposited by streams and rivers (may be applied more generically as transported by water).
Estuarine	Deposited in coastal estuaries, including sediments from inflowing rivers, streams, and tidal currents.
Marine	Deposited in a marine environment.
Lacustrine	Deposited in freshwater lakes.
Aeolian	Transported by wind.
Colluvial and Slopewash	Soil and rock debris transported down slopes by gravity (with or without assistance of water). Colluvium is typically applied to thicker / localised deposits, and slopewash for thinner / widespread deposits.
TOPSOIL	Surficial soil, typically with high levels of organic material. Topsoils buried by other transported soils are termed *'remnant topsoil'*. Tree roots within otherwise unaltered soil does not characterise topsoil.
FILL	Any material which has been placed by anthropogenic processes (i.e. human activity).

e) Additional Observations

Additional observations may be included to supplement the soil description. Additional observations may consist of notations relating to soil characteristics (odour, contamination, colour changes with time), inferred geology (with delineation of soil horizons or geological time scale) or notes on sampling and testing application (including the reliability, recovery, representativeness, or condition of samples or test conditions and limitations). If the material is assessed to be not representative, terms such as 'poor recovery', 'non-intact', 'recovered as' or 'probably' are applied.

SOIL CLASSIFICATION

Classification allocates the material within distinct soil groups assigned a two character Group Symbol:

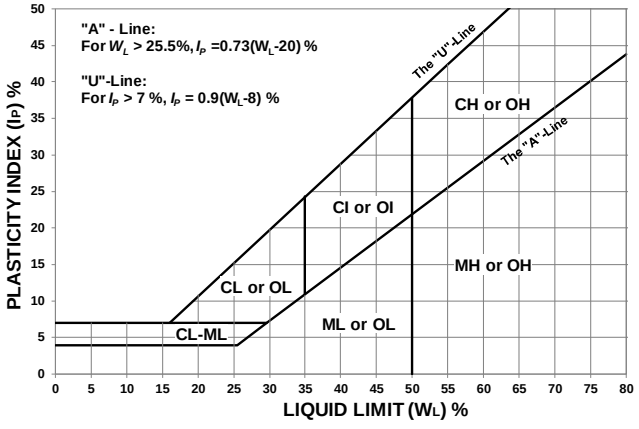
Coarse Grained Soils (sand and gravel: more than 65% of soil coarser than 0.075 mm)		
Major Division	**Group Symbol**	**Soil Group**
GRAVEL (more than half of the coarse fraction is > 2.36 mm)	GW	GRAVEL, well graded
	GP	GRAVEL, poorly graded
	GM	Silty GRAVEL
	GC	Clayey GRAVEL
SAND (more than half of the coarse fraction is < 2.36 mm)	SW	SAND, well graded
	SP	SAND, poorly graded
	SM	Silty SAND
	SC	Clayey SAND

Fine Grained Soils (silt and clay: more than 35% of soil finer than 0.075 mm)		
Major division	**Group Symbol**	**Soil Group**
SILT and CLAY (low to medium plasticity)	ML	SILT, low plasticity
	CL	CLAY, low plasticity
	CI	CLAY, medium plasticity
	OL	Organic SILT
SILT and CLAY (high plasticity)	MH	SILT, high plasticity
	CH	CLAY, high plasticity
	OH	Organic CLAY / SILT
Highly Organic	Pt	PEAT

Coarse grained soils with fines contents between 5% and 12% are provided a dual classification comprising the two group symbols separated by a dash, e.g. for a poorly graded gravel with between 5% and 12% silt fines (poorly graded 'GRAVEL with silt'), the classification is GP-GM.

For the purpose of classification, *poorly graded, uniform,* or *gap graded* soils are all designated as poorly graded. Soils that are dominated by boulders or cobbles are described separately and are not classified.

Classification is routinely undertaken based on tactile assessment with the soil description. Refinement of soil classification may be applied using laboratory assessment, including particle size distribution and Atterberg Limits. Atterberg Limits testing is applied to the sample portion finer than 0.425 mm. Fine grained soil components are assessed on the basis of regions defined within the Modified Casagrande Chart.



ROCK DESCRIPTION AND CLASSIFICATION

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Rock is described in general accordance with Australian Standard AS 1726-2017 (Geotechnical site investigations) in terms of visual and tactile properties, with potential refinement by laboratory testing. AS 1726 defines rock as any aggregate of minerals and/or organic materials that cannot be disaggregated by hand in air or water without prior soaking. The rock description and classification distinguishes between rock material, defects, structure and rock mass.

ROCK DESCRIPTION AND CLASSIFICATION

a) Description of rock material (rock name, grain size and type, colour, texture and fabric, inclusions or minor components, moisture content and durability)

Rock Name: Simple rock names are used to provide a reasonable engineering description rather than a precise geological classification. The rock name is chosen on the basis of origin, with common types summarised below. Additional, non-exhaustive, terminology is included in AS 1726. Rock names not described within AS 1726 may be adopted, with geological characteristics typically noted within accompanying text.

<table>
<tr><th rowspan="2">Grain Size (mm)</th><th colspan="4">Sedimentary</th><th colspan="2">Metamorphic</th><th colspan="3">Igneous</th></tr>
<tr><th colspan="2">Clastic or Detrital</th><th colspan="2">Carbonate</th><th rowspan="2">Pyroclastic</th><th rowspan="2">Foliated</th><th rowspan="2">Non-Foliated</th><th rowspan="2">Felsic</th><th rowspan="2">↔</th><th rowspan="2">Mafic</th></tr>
<tr><th colspan="2"></th><th>Low Porosity</th><th>Porous</th></tr>
<tr><td>>2.0</td><td colspan="2">CONGLOMERATE
(rounded grains in a finer matrix)

BRECCIA
(angular or irregular fragments in a finer matrix)</td><td rowspan="4">LIMESTONE
(Predominantly $CaCO_3$)

or

DOLOMITE
(Predominantly $CaMgCO_3$)</td><td>CALCIRUDITE</td><td>AGGLOMERATE
(rounded grains in a finer matrix)

VOLCANIC BRECCIA
(angular fragments in a finer matrix)</td><td>GNEISS</td><td>MARBLE
(carbonate)

QUARTZITE</td><td>GRANITE</td><td>DIORITE</td><td>GABBRO</td></tr>
<tr><td>2.0-0.06</td><td colspan="2">SANDSTONE</td><td>CALCARENITE</td><td>TUFF</td><td>SCHIST</td><td rowspan="3">SERPENTINITE

HORNFELS</td><td>MICRO-GRANITE</td><td>MICRO-DIORITE</td><td>DOLERITE</td></tr>
<tr><td>0.06-0.002</td><td rowspan="2">MUDSTONE
(silt and clay)</td><td>SILTSTONE
(mostly silt)</td><td>CALCISILTITE</td><td rowspan="2">Fine grained TUFF</td><td rowspan="2">PHYLLITE or SLATE</td><td rowspan="2">RHYOLITE</td><td rowspan="2">ANDESITE</td><td rowspan="2">BASALT</td></tr>
<tr><td><0.002</td><td>CLAYSTONE
(mostly clay)</td><td>CALCILUTITE</td></tr>
</table>

Reproduced with modification from Tables 15, 16 and 17, Clause 6.2.3.1, AS 1726-2017, Geotechnical site investigations.

Grain size: For rocks with predominantly sand sized grains the dominant or average grain size is described as follows:

Rock type	Coarse grained	Medium grained	Fine grained
Sedimentary rocks	Mainly 0.6 mm to 2 mm	Mainly 0.2 mm to 0.6 mm	Mainly 0.06 mm (just visible) to 0.2 mm
Igneous and metamorphic rocks	Mainly >2 mm	Mainly 0.06 mm to 2 mm	Mainly <0.6 mm (just visible)

Colour assists in rock identification and interpolation. Rock colour is generally described in a *"moist"* condition, using simple terms (e.g. grey, brown, etc.) and modified as necessary by *"pale"*, *"dark"*, or *"mottled"*. Borderline colours may be described as a combination of these colours (e.g. red-brown).

Texture refers to the arrangement of, or the relationship between, the component grains or crystals (e.g. porphyritic, crystalline or amorphous).

Fabric refers to visible grain arrangement along a preferential orientation or a layering. Fabric may be noted as *"indistinct"* (little effect on strength) or *"distinct"* (rock breaks more easily parallel to the fabric). Common terms include *"massive"* or *"flow banding"* (igneous), *"foliation"* or *"cleavage"* (metamorphic). Sedimentary layering is described as *"bedding"* or (where thickness < 20 mm) *"lamination"*. The typical orientation, spacing or thickness of these structural features can be described directly in millimetres and metres. Further quantification of bedding thickness applied by GHD is as follows:

Bedding Term	Thickness
Very thickly bedded	>2 m
Thickly bedded	0.6 to 2 m
Medium bedded	0.2 to 0.6 m
Thinly bedded	60 to 200 mm
Very thinly bedded	20 to 60 mm
Laminated	6 to 20 mm
Thinly laminated	<6 mm

Features, Inclusions and Minor Components are typically only described when those features could influence the engineering behaviour of the rock. Described features may include: gas bubbles in igneous rocks; veins of quartz, calcite or other minerals; pyrite crystals and nodules or bands of ironstone or carbonate; cross bedding in sandstone; clast or matrix support in conglomerates and breccia.

Moisture content may be described by the feel and appearance of the rock, as follows: *"dry"* (looks and feels dry), *"moist"* (feels cool, darkened in colour, but no water is visible on the surface), or *"wet"* (feels cool, darkened in colour, water film or droplets visible on the surface). The moisture content of rock cored with water may not represent in situ conditions.

Durability of rock samples is noted where there is an observed tendency of samples to crack, breakdown in water or otherwise deteriorate with exposure.

Ref: DS6.5.2.1 Issue 2.0 Date: 01/08/2019

ROCK DESCRIPTION AND CLASSIFICATION

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b) Classification of the rock material condition (strength, weathering and/or alteration)

Estimated Strength refers to the rock material and not the rock mass. The strength is defined in terms of uniaxial compressive strength (UCS), though is typically estimated by either tactile assessment or Point Load Strength Index ($Is_{(50)}$) (measured perpendicular to planar anisotropy). A correlation between $Is_{(50)}$ and UCS is adopted for classification, though is not intended for design purposes without appropriate supporting assessment. A field guide follows:

Term and (Symbol)		UCS (MPa)	$Is_{(50)}$ (MPa)	Field Guide
Very Low	*(VL)*	0.6 – 2	0.03 - 0.1	Material crumbles under firm blows with sharp end of geological pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 30 mm thick can be broken by finger pressure.
Low	*(L)*	2 - 6	0.1 - 0.3	Easily scored with knife; indentations 1 to 3 mm show in the specimen with firm blows of a geological pick point; has dull sound under hammer. A piece of core 150 mm long by 50 mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	*(M)*	6 - 20	0.3 - 1.0	Readily scored with a knife; a piece of core 150 mm long by 50 mm diameter can be broken by hand with difficulty.
High	*(H)*	20 - 60	1 - 3	A piece of core 150 mm long by 50 mm diameter cannot be broken by hand but can be broken by a geological pick with a single firm blow; rock rings under hammer.
Very High	*(VH)*	60 - 200	3 -10	Hand specimen breaks with geological pick after more than one blow; rock rings under hammer.
Extremely High	*(EH)*	>200	>10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

Based on Table 19, Clause 6.2.4.1, AS 1726-2017, Geotechnical site investigations. Refer to source document for further detail.

Material with strength less than *"very low"* is described using soil characteristics, with the presence of an original rock texture or fabric noted if relevant.

Weathering and Alteration: The process of weathering involves physical and chemical changes to the rock resulting from exposure near the earth's surface. A subjective scale for weathering is applied as follows:

Weathering Term and (Symbol)		Description
Residual Soil	*(RS)*	Material has weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported.
Extremely Weathered	*(XW)*	Material has weathered to such an extent that it has soil properties. Mass structure, material texture and fabric of original rock are still visible.
Highly Weathered	*(HW)*	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Moderately Weathered	*(MW)*	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable, but shows little or no change of strength from fresh rock.
Slightly Weathered	*(SW)*	Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.
Fresh	*(Fr)*	Rock shows no sign of decomposition of individual minerals or colour changes.

Modified based on Table 20, Clause 6.2.4.2, AS 1726-2017, Geotechnical site investigations. Refer to source document for further detail.

Where physical and chemical changes to the rock are caused by hot gases or liquids at depth, the process is called alteration. Unlike weathering, the distribution of altered material may occur at any depth and show no relationship to topography. Where alteration minerals are identified the terms *"extremely altered" (XA)*, *"highly altered" (HA)*, *"moderately altered" (MA)* and *"slightly altered" (SA)* can be used to describe the physical and chemical changes described above.

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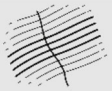
c) Description of defects (defect type, orientation, roughness and shape, coatings and composition of seams, spacing, length, openness and thickness, block shape)

Defects often control the overall engineering behaviour of a rock mass. AS 1726 defines a defect as “a discontinuity, fracture, break or void in the material or materials across which there is little or no tensile strength”. Describing the type, character and distribution of natural defects is an essential part of the description of many rock masses.

Commonly described characteristics of defects within a rock mass include type, orientation, roughness and shape, coatings and composition of seams, aperture, persistence, spacing and block shape.

The degree of detail required for defect descriptions depends on project requirements. All defects judged of engineering significance for the site and project are described individually. Where appropriate, generalised descriptions for less significant, or multiple similar, defects can be provided for delineated parts of rock core or exposures. A general description of delineated defect sets is provided when sufficient orientation data is available.

Defect Type is described using the terms summarised below. On core logs, only natural defects across which the core is discontinuous are described (i.e. inferred artificial fractures such as drill breaks are excluded). Incipient defects are described using the relevant texture or fabric terms. Healed defects (those that have been re-cemented by minerals such as chlorite or calcite) are described using the prefix “healed” (e.g. healed joint).

Type and (Symbol)		Description	Diagram
Parting	(Pt)	A surface or crack across which the rock has little or no tensile strength. Parallel or sub-parallel to layering (e.g. bedding) or a planar anisotropy in the rock material (e.g. cleavage). May be open or closed.	
Joint	(Jt)	A surface or crack with no apparent shear displacement and across which the rock has little or no tensile strength, but which is not parallel or subparallel to layering or to planar anisotropy in the rock material. May be open or closed.	
Sheared Surface	(SS)	A near planar, curved or undulating surface which is usually smooth, polished or slickensided and which shows evidence of shear displacement.	
Sheared Zone	(SZ)	Zone of rock material with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge-shaped blocks.	
Sheared Seam	(SSm)	Seam of soil material with roughly parallel almost planar boundaries, composed of soil materials with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge-shaped blocks.	
Crushed Seam	(CSm)	Seam of soil material with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock material which may be more weathered than the host rock. The seam has soil properties.	
Infilled Seam	(ISm)	Seam of soil material usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1 mm thick may be described as a veneer or coating on a joint surface.	
Extremely Weathered Seam	(WSm)	Seam of soil material, often with gradational boundaries. Formed by weathering of the rock material in place.	

Modified based on Table 22, Clause 6.2.5.2, AS 1726-2017, Geotechnical site investigations. Refer to source document for further detail.

Defect Orientation is recorded as the “dip” (maximum angle of the mean plane, measured from horizontal) and the “dip direction” (azimuth of the dip, measured clockwise from true north). Dip and dip direction is expressed in degrees, with two-digit and three-digit numbers respectively, separated by a slash (e.g. 45/090). For vertical boreholes, the defect dip is measured as the acute angle from horizontal. Rock core extracted from vertical boreholes is generally not oriented, so the dip direction cannot be directly measured. For non-oriented inclined boreholes, a defect “alpha” (α) angle is measured as the acute angle from the core axis. For vertical and non-oriented inclined boreholes, the dip direction can sometimes be estimated from the relationship of the defect to a well-defined site structure such as fabric. For oriented inclined boreholes, the measurement of the defect orientation is carried out and recorded in a form suited to the particular device being used and later processed to report true dip and dip direction.

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Roughness and Shape of the defect surface combine to have significant influence on shear strength. Standard descriptions and abbreviations include:

Roughness and (Symbol)		Description
Very Rough	(VR)	Many large surface irregularities (amplitude generally more than 1 mm). Feels like, or coarser than very coarse sand paper.
Rough	(Rf)	Many small surface irregularities (amplitude generally less than 1 mm). Feels like fine to coarse sand paper.
Smooth	(So)	Smooth to touch. Few or no surface irregularities.
Polished	(Pol)	Shiny smooth surface.
Slickensided	(Slk)	Grooved or striated surface, usually polished.

Shape and (Symbol)		Description
Planar	(Pln	The defect does not vary in orientation.
Curved	(Cu)	The defect has a gradual change in orientation.
Undulating	(Un)	The defect has a wavy surface.
Stepped	(St)	The defect has one or more well defined steps.
Irregular	(Ir)	The defect has many sharp changes of orientation.

Although the surface roughness of defects can be described at small (10-100 mm) scales of observation, the overall shape of the defect surface can usually be observed only at medium (0.1-1 m) and large (>1 m) scale.

Where it is necessary to assess the shear strength of a defect, observations are generally made at multiple scales. Surface roughness may also be characterised by using the joint roughness coefficient (JRC) profiles established by Barton and Choubey (1977). Where large-scale observations are possible, further measurement of defect "waviness" (angle of the asperities relative to the overall dip angle of the plane) is made.

Coatings and Composition of Seams: Many defects have surface coatings, which can affect their shear strength. Standard descriptions include:

Coating and (Symbol)		Description
Clean	(Cn)	No visible coating.
Stained	(Sn)	No visible coating but surfaces are discoloured.
Veneer	(Ve)	A visible coating of soil or mineral substance, but too thin to be measured may be patchy.
Coating	(Co)	A visible coating up to 1 mm thick. Soil material greater than 1 mm thick is described using defect terms (e.g. infilled seam). Rock material greater than 1 mm thick is described as a vein (Vn).

Common Minerals and (Symbol)	
Clay	(CLAY)
Calcite	(Ca)
Carbonaceous	(X)
Chlorite	(Kt)
Iron Oxide	(Fe)
Micaceous	(Mi)
Manganese	(Mn)
Pyrite	(Py)
Quartz	(Qz)

The composition of seams are described using soil description terms as given on the SOIL DESCRIPTION AND CLASSIFICATION Standard Sheet. Where possible the mineralogy of coatings is identified. Common mineral coatings include:

Aperture: Defects across which there is little or no tensile strength can be either *"open"* (*Op*) or *"closed"* (*Cl*). For rock core, the width of the "open" defect is measured whilst still in the core barrel splits. The descriptor *"tight"* (*Ti*) can only apply to healed or incipient defects (i.e. veins, foliation, etc.).

Persistence and Spacing of defects is described directly in millimetres and metres. If the measurement of defect persistence is limited by the extent of the exposure, the end conditions are noted (i.e. 0, 1 or 2 defect ends observed). The spacing between defects of similar orientation (i.e. within a specific defect set) is recorded when possible.

The frequency of defects within rock core can be measured as either: the spacing between successive defects; or the "Fracture Index", which is the number of defects per metre of core.

Spacing Term	Thickness
Very wide	>2 m
Wide	0.6 to 2 m
Medium	0.2 to 0.6 m
Closely	60 to 200 mm
Very closely	20 to 60 mm
Extremely closely	6 to 20 mm

Block Shape: Where it is considered significant, block shape can be described using the subjective terms as follows:

Block Shape	Description
Polyhedral	Irregular discontinuities without arrangement into distinct sets, and of small persistence.
Tabular	One dominant set of parallel discontinuities, for example bedding planes, with other non-continuous joints; thickness of blocks much less than length or width.
Prismatic	Two dominant sets of discontinuities, approximately orthogonal and parallel, with a third irregular set; thickness of blocks much less than length or width.
Equidimensional	Three dominant sets of discontinuities, approximately orthogonal, with occasional irregular joints, giving equidimensional blocks.
Rhomboidal	Three (or more) dominant, mutually oblique, sets of joints giving oblique-shaped, equidimensional blocks.
Columnar	Several, usually more than three sets of continuous, parallel joints usually crossed by irregular joints; lengths much greater than other dimensions.

Modified based on Table 23, Clause 6.2.5.7, AS 1726-2017, Geotechnical site investigations. Refer to source document for further detail.

Ref: DS6.5.2.1 Issue 2.0 Date: 01/08/2019

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d) Interpreted stratigraphic unit

Stratigraphic units may be interpreted and reported, in accordance with The Australian Stratigraphic Units Database (ASUD). The terms *"possibly"* or *"probably"* indicate increased uncertainty in this interpretation.

e) Geological structure

After describing the rock material and defects, an interpretation of the nature and configuration of rock mass defects may be presented in logs, charts, 2D sections and 3D models (e.g. dipping strata, folds, unconformities, weathering profiles, defect sets, geological faults, etc.).

PARAMETERS RELATED TO CORE DRILLING

Drill Depth and Core Loss: Drilling intervals are shown on GHD Core Log Sheets by depth increments and horizontal marker lines.

"Core loss", or its inverse "total core recovery" (TCR), is measured as a percentage of the core run. If the location of the core loss is known, or strongly suspected, it is shown in a region of the column bounded by dashed horizontal lines. If unknown, core loss is assigned to the bottom of a core run.

Rock Quality Designation (RQD), described by Deere et al. (1989), may be recorded on GHD Core Log Sheets.

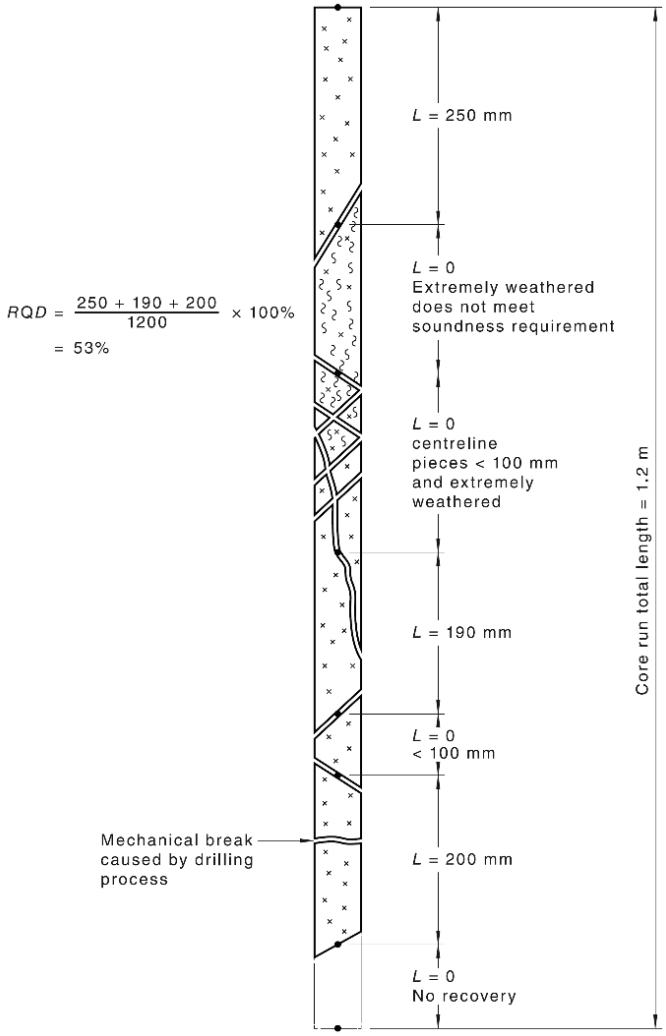
For certain projects, such as tunnelling or underground mining investigations, rock mass ratings or classifications can be required as part of the design process. The RQD forms a component of these rock mass ratings and provides a quantitative estimate of rock mass quality from rock core logs.

The rock core must be "N" sized (nominally 50 mm) or greater for derivation of RQD. The RQD is expressed as a percentage of intact rock core (excluding residual soil and extremely weathered rock) greater than 100 mm in length over the total selected core length.

Deere et al. (1989) recommends measuring lengths of core along the centreline, as shown right.

RQD is expressed as:

$$RQD = \frac{\sum Length\ of\ sound\ core\ pieces > 100\ mm\ in\ length}{Length\ of\ core\ run}\ x\ 100\%$$



RQD measurement procedure
(reproduced from Figure 13, Clause 6.2.9.4, AS 1726-2017, Geotechnical site investigations)

ROCK MASS CLASSIFICATION

Rock mass classification schemes may be used to represent the engineering characteristics of a rock mass. A large variety of classification schemes have been developed by various authors, ranging from simple to complex. All of the schemes are limited in their application and many rock mass classification systems assume that the rock mass is isotropic, which is rarely the case.

References

STANDARDS AUSTRALIA (2017). AS 1726-2017. GEOTECHNICAL SITE INVESTIGATIONS.
BARTON, N. AND CHOUBEY, V. (1977). THE SHEAR STRENGTH OF ROCK JOINTS IN THEORY AND PRACTICE. ROCK MECHANICS 10, 1-54. SPRINGER.
DEERE, D.U. AND DEERE, D.W. (1989). ROCK QUALITY DESIGNATION (RQD) AFTER TWENTY YEARS. CONTRACT REPORT GL-89-1. ARMY CORPS OF ENGINEERS. WASHINGTON DC, 1989.

LABORATORY TESTING

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GENERAL

Samples extracted during the fieldwork stage of a site investigation may be “disturbed” or “undisturbed” (as generally indicated on the test hole logs) depending upon the nature and purpose of the sample as well as the method of extraction, transportation, extrusion and testing. This aspect should be taken into account when assessing test results, which must of necessity, reflect the effects of such disturbance.

All soil properties (as measured by laboratory testing) exhibit inherent variability and thus a certain statistical number of tests is required in order to predict an average property with any degree of confidence. The site variability of soil strata, future changes in moisture and other conditions and the discrete sampling positions must also be considered when assessing the representative nature of the laboratory programme.

Certain laboratory test results provide interpreted soil properties as derived by conventional mathematical procedures. The applicability of such properties to engineering design must be assessed with due regard to the site, sample condition, procedure and project in hand.

TESTING

Laboratory testing is normally carried out in accordance with Australian Standard AS 1289 as amended, or in NSW, Roads and Maritime Services (RMS) standards when specified. The routine Australian Standard tests are as follows:

Moisture Content	AS1289 2.1.1	
Liquid Limit	AS1289 3.1.1	collectively known as Atterberg Limits
Plastic Limit	AS1289 3.2.1	
Plasticity Index	AS1289 3.3.1	
Linear Shrinkage	AS1289 3.4.1	
Particle Density	AS1289 3.5.1	
Particle Size Distribution	AS1289 3.6.1, 3.6.2 and 3.6.3	
Emerson Class Number	AS1289 3.8.1	collectively, Dispersive Classification
Percent Dispersion	AS1289 3.8.2	
Pinhole Dispersion Classification	AS1289 3.8.3	
Hole Erosion (HE)	GHD Method	
No Erosion Filter (NEF)	GHD Method	
Organic Matter	AS1289 4.1.1	
Sulphate Content	AS1289 4.2.1	
pH Value	AS1289 4.3.1	
Resistivity	AS1289 4.4.1	
Standard Compaction	AS1289 5.1.1	
Modified Compaction	AS1289 5.2.1	
Dry Density Ratio	AS1289 5.4.1	
Minimum Density	AS1289 5.5.1	
Density Index	AS1289 5.6.1	
California Bearing Ratio	AS1289 6.1.1 and 6.1.2	
Shear Box	AS1289 6.2.2	
Undrained Triaxial Shear	AS1289 6.4.1 and 6.4.2	
One Dimensional Consolidation	AS1289 6.6.1	
Permeability Testing	AS1289 6.7.1, 6.7.2 and 6.7.3	

Where tests are used which are not covered by appropriate standard procedures, details are given in the report.

LABORATORIES

Our Australian laboratories are NATA accredited to AS ISO / IEC17025 for the listed tests.

The oedometer, triaxial and shear box equipment are fully automated for continuous operation using computer controlled data acquisition, processing and plotting systems.

Ref: DS5.5.2 Issue 0 Date: 05/10/2018

CONE PENETRATION (CPT/CPTU) TESTING

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SCOPE

The Cone Penetration Test (CPT) comprises the measurement of soil resistance in response to a steel cone pushed into the ground at a constant rate. The CPTU (or piezo cone) test involves sophisticated equipment yet is simple in operation and provides rapid, almost continuous traces of soil response, with good repeatability.

The CPT/CPTU test is commonly employed as a means of extrapolation of discrete borehole data for a particular site. The interpretation of CPT and CPTU results without appropriate borehole data correlation must be considered for guide purposes only and should not be used in isolation for detailed design.

EQUIPMENT AND METHOD

The steel cone consists of a 37 mm diameter, 60° cone, hydraulically pushed vertically down into the soil profile. The piezo probe includes the measurement of cone resistance (q_c), friction sleeve (f_s), inclinometer and pore pressure (u) whilst the friction cone used for CPT testing includes cone resistance and friction sleeve readings only. The porous element of the piezo cone is situated on the cylindrical shaft immediately behind the cone. The rate of penetration for both cones is approximately 20 mm/sec with readings taken usually at 20 mm intervals throughout the profile.

The CPTU test is typically initiated by inserting the pre-saturated probe into a pre-drilled hole below the ground water table. The probe is then permitted to achieve temperature stabilisation prior to conducting the penetration test.

The CPT/CPTU readings are measured using load cells and strain gauges set in the probe. The signals from these gauges are transmitted to an analogue/digital converter. The digitised data is then recorded and stored on a lap-top computer for later analysis. In particular, data reduction includes processing of the q_c results recorded with the piezo cone to total resistance (q_t) values using the corresponding pore pressure value in accordance with published procedures.

The piezo cone can also be used to perform pore pressure dissipation measurements at selected test levels to determine the localised lateral drainage characteristics of the subsoil. Depending on the rate of dissipation, the excess pore pressure is recorded during the dissipation test until a nominated degree of dissipation is achieved.

The cone penetration test is terminated once the probe reaches refusal, when the rods behind the probe cannot be advanced further due to resistance developed along the rods or when the force required to advance the rods exceeds the capacity of the testing vehicle or frame. The probe is then withdrawn from the ground and the readings corrected to take into account effects of the temperature variation at depth.

INTERPRETATION

The CPT and CPTU results can be used to assess the soil profile at specific test locations and to estimate soil strength and consolidation characteristics. As mentioned previously, such interpretations are generally performed in association with discrete borehole data.

In particular, the interpretations must take account of the soil type (and consequent drainage conditions), soil strength, sensitivity and stress history (i.e. normally or over-consolidated). Details of these are beyond the scope of this explanation sheet.

Ref: 5.4.4 Issue 0 Date: 05/10/2018

DYNAMIC CONE PENETROMETER (DCP) TESTING

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SCOPE

The Dynamic Cone Penetrometer (DCP) test comprises the measurement of the soil resistance to a steel rod driven into the ground by a dropped weight.

The DCP test is a simple manual test used in both sandy and clayey soils. The test is a measure of the shear strength of the soil at relatively shallow depth.

EQUIPMENT AND METHOD

A general description of the dynamic penetrometer apparatus used by our firm is presented in Australian Standard AS 1289.6.3.2. The equipment utilises a 9 kg sliding weight with a drop height of 510 mm. It is fitted with a conical tip. The equipment can be adjusted for a fall of 600 mm and use of a blunt tip in accordance with AS 1289.6.3.3.

The test data are generally recorded as the number of blows (n) per 50 mm of penetration. For specific applications (such as pavement investigations), the data may be collected in the reverse form, i.e. as mm per blow. The results are presented either in tabular or graphic form for reporting purposes.

INTERPRETATION

The interpretation of the DCP results is generally based on the assumption that the measured resistance is a function of soil strength. A profile of soil strength (cohesive soils) or density index (cohesionless soils) can thus be established. The test often can be used to qualitatively indicate the presence of soft or loose zones within a soil profile.

The energy of the system per unit area is similar to that of the larger Standard Penetration Test (SPT). Thus, the common relationships of SPT and other parameters can be used as a means of estimating soil properties, after appropriate site specific consideration. The interpretations from the test are approximate only, and this is particularly pertinent to sand profiles where the magnitude of confinement stress is important in the assessment of the results.

Interpretation of the DCP penetration rate at depth must be conducted with due regard to rod friction effects. In particular, care must be exercised with soft clay profiles where rod resistance may have an unconservative impact on the results. Care must also be exercised with soil profiles containing larger particles such as gravels and cobbles where penetration rate can be affected if the DCP tip strikes or glances off such particles.

In-situ California Bearing Ratio (CBR) values of clay soil subgrades are sometimes interpreted directly from DCP test results for use in road pavement design. In this case, the correlation between DCP and CBR based on that published in AUSTROADS Pavement Structural Design guide (AGPT02-17 Part 2) may be applied. This correlation should be verified by site specific laboratory testing, where appropriate. In addition, the effects of moisture content variations (in-situ versus design conditions) must be considered, as the DCP test only reflects the shear strength of the soil at the time of testing. Further information can be found in AUSTROADS Geotechnical Investigation and Design guide (AGRD07-08 Part 7).

Ref: DS5.4.3 Rev 0 Date: 05/10/2018

REACTIVE SOILS SITE MANAGEMENT PRECAUTIONS

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These precautions are considered supplementary to any structural and/or foundation design measures for the subject building, and are intended for distribution to the prospective building owner / occupier.

Reactive clays are prone to heave/shrink movements with changes in soil moisture content due to natural or artificial means. The basic design philosophy employed for the building is to provide a foundation/superstructure adequate to accommodate ground movements due to extreme seasonal moisture changes only. The possibility of other abnormal and/or localised moisture changes (the cause of most building distress) has been assumed to be controlled by the following site management procedures.

In particular, leaking plumbing or blocked drains should be repaired promptly and site grading maintained to prevent ponding near foundations. Garden watering, particularly by fixed systems, should be controlled carefully to avoid gross over-watering. On the other hand, proper garden maintenance should produce year round uniform moisture conditions.

Trees and shrubs can cause a substantial drying of the clay soil profile and associated shrinking of reactive clays. This effect is most likely to result in damage when added to the drying from a drought or a long dry spell. The problem can be avoided by planting trees at substantial distances from the building. The distance depends upon the species, soil conditions, and site classification.

Problems during droughts can be minimised by extensive pruning (thus reducing water demand) and/or providing trees with adequate water. This watering can be achieved by boreholes or trenches dug well into the clay between the tree and the footing. To avoid settlement problems, the holes or trenches should not be too close to the footing and should be filled with compacted screenings. The installation of root barriers is another option. Frequent moderate watering during dry periods also should assist in minimising the extraction of excessive moisture from beneath the foundation of the building by trees and other vegetation as well as the environmental effects.

This action should also be immediately undertaken by the owner / occupier if brickwork cracking due to tree drying is noticed. Most reactive clay failures can be avoided or the effects minimised by controlling the combined drying effects of trees and drought.

The owner / occupier should also appreciate that on reactive clays it is virtually impossible to design an economic foundation system which will totally prevent movement. Some minor aesthetic cracking, while undesirable, will occur in a significant proportion of houses. In addition, some minor problems should be expected with jamming of windows and doors, especially during the settling-in period or following a major drought, and such repairs should be regarded as part of normal building maintenance. Even significant masonry cracking with widths over 5mm usually has little influence on the function of the wall and presents an aesthetic problem. Just as it is difficult to design an immovable footing system, it is almost impossible to provide remedial measures that will prevent further movements if distress does occur. Consequently, extreme remedial measures should not be undertaken for minor problems.

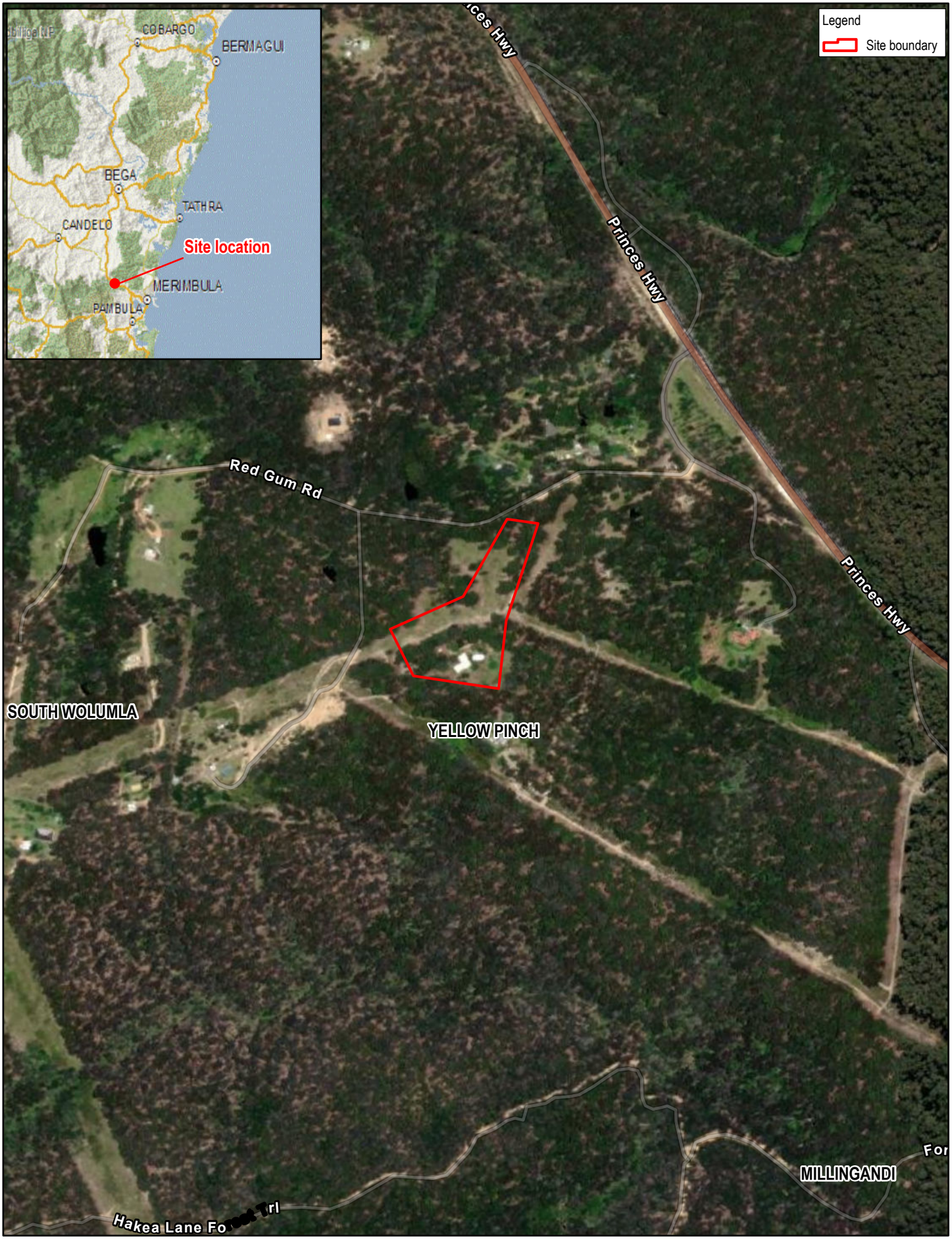
Advice on these matters is addressed in Australian Standard AS2870 “Residential slabs and footings”. In particular the designer, owner and occupier are referred to Appendix B “Foundation Performance and Maintenance” in AS2870.

Useful information for homeowners can also be found in CSIRO Building Technology File BTF 18-2011 “Foundation Maintenance and Footing Performance: A Homeowner’s Guide”, available through CSIRO Publishing.

Ref: DS5.4.1 Rev 0 Date: 04/10/2018

Appendix B

Figures



Paper Size ISO A4

0 100 200

Meters

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Bega Valley Shire Council
Yellow Pinch WTP

Project No. **12538990**
Revision No. **A**
Date **04/10/2022**

Site locality

FIGURE 1

\\ghdnet\ghd\AU\Sydney\Projects\23\12538990\GIS\Maps\Deliverables\12538990_YellowPinchWTP\12538990_YellowPinchWTP.aprx
Print date: 20 Oct 2022 - 12:20

Data source: World Hillshade: Esri, CGIAR
Hybrid Reference Layer: Esri Community Maps Contributors, Vicmap, Geoscape, Esri, HERE, Garmin, Foursquare, METI/NASA, USGS
OEHBasemap2:
World Imagery: Maxar. Created by: dschmidt

Paper Size ISO A4

0 10 20 30 40

Meters

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Bega Valley Shire Council
Yellow Pinch WTP

Approximate Borehole Test Locations

Project No. **12538990**
Revision No. **A**
Date **04/10/2022**

FIGURE 2

\\ghdnet\ghd\AU\Sydney\Projects\23\12538990\GIS\Maps\Deliverables\12538990_YellowPinchWTP\12538990_YellowPinchWTP.aprx
Print date: 20 Oct 2022 - 12:19

Data source: NSW_Imagery: © Department of Customer Service 2020. Created by: dschmidt

Appendix C

Borehole Logs

BOREHOLE LOG SHEET

Client : Bega Valley Shire Council

Project : Yellowpinch Water Treatment Plant - Geotechnical Investigation

Location : Yellow Pinch, NSW

HOLE No. BH01

SHEET 1 OF 3

Position : 752467.0 E 5916462.0 N MGA94/ 55 **Surface RL:** - **Angle from Horiz. :** 90° **Processed :** SBO

Rig Type : Hanjin D8 **Mounting:** Track **Contractor :** Total Drilling Pty Ltd **Driller :** TM **Checked :** JNM

Date Started : 29/8/2022 **Date Completed :** 29/8/2022 **Logged by :** JNM **Date:** 17/10/2022

DRILLING					MATERIAL					
SCALE (m)	Drilling Method	Hole Support \ Casing	Water	Samples & Tests	Depth metres	Graphic Log	USC Symbol	Description [FILL/TOPSOIL/COBBLES/BOULDERS/-] SOIL NAME: plasticity / primary particle characteristics, colour, secondary and minor components, zoning (origin) and ROCK NAME: grain size, colour, fabric / texture, inclusions or minor components, durability, strength, weathering / alteration, defects	Moisture Condition	Consistency / Density Index	Comments/ Observations
1	TC-bit auger	Nil	Groundwater Not Encountered	ES	0.30		SM	[TOPSOIL]: Silty SAND: fine to coarse grained, brown, some sub-angular to sub-rounded gravel, trace rootlets and organic matter.	M	VD	
2					2.55		SW	Gravelly SAND: fine to coarse grained, brown, with sub-angular to angular grave (residual grading to extremely weathered rock).	M	VD	
3								Start of coring at 2.55 metres. For cored interval, see Core Log Sheet.			
4											
5											

See standard sheets for details of abbreviations & basis of descriptions

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Job No. 12538990

CORE LOG SHEET

GEO_COREHOLE_NO VISUAL_AS1726 2017 12538990 YELLOW PINCH WTP.GPJ GHD_GEO_TEMPLATE 2.00.GDT 25/10/22

Client : Bega Valley Shire Council

Project : Yellowpinch Water Treatment Plant - Geotechnical Investigation

Location : Yellow Pinch, NSW

HOLE No. BH01

SHEET 2 OF 3

Position : 752467.0 E 5916462.0 N MGA94/ 55	**Surface RL:** -	**Angle from Horiz. :** 90°	**Processed :** SBO
Rig Type : Hanjin D8	**Mounting:** Track	**Contractor :** Total Drilling Pty Ltd	**Driller :** TM	**Checked :** JNM
Casing Dia. : HQ	**Barrel (m) :** 3.0m	**Bit :** Diamond (impreg)	**Bit Condition :** Good	**Date:** 17/10/2022
Date Started : 29/8/2022	**Date Completed :** 29/8/2022	**Logged by :** JNM	**Date Logged :** 29/08/2022	

DRILLING						MATERIAL					NATURAL FRACTURES	
Progress								Description		Estimated Strength $Is_{(50)}$ MPa ● - Axial ○ - Diametral	Spacing (mm)	Additional Data
SCALE (m)	Drilling & Casing	Water	Drill Depth (m)	(Core Loss / Run %)	Samples / RQD (%)	Depth metres	Graphic Log	ROCK NAME: grain size, colour, fabric and texture, inclusions or minor components, moisture, durability and [COBBLES / BOULDERS / FILL / TOPSOIL] then SOIL NAME: colour, plasticity / primary particle characteristics, secondary and minor components, zoning (origin)	Weathering	Soil 0.03 VL 0.1 L 0.3 M 1 H 3 VH 10 EH	20 40 100 300 1000	(joints, partings, seams, zones and veins) Defect type: orientation, roughness and shape, composition or coating, aperture and thickness, other.
1												
2								Start of coring at 2.55 metres. For Non Cored interval, see Borehole Log Sheet.				
						2.55		CONGLOMERATE: fine to coarse grained, rounded to sub-rounded clasts (2-60mm), brown, orange, grey.	XW			
3			3.00	(0)	(0)	3.00						
						3.05		CORE LOSS: 50mm				
	NMLC coring /HQ Casing	(0% LOSS)		(5)	(0)			CONGLOMERATE: fine to coarse grained, rounded to sub-rounded clasts (2-60mm), brown, orange, grey.	XW			
						3.80		SANDSTONE: fine to coarse grained, grey, brown, disturbed bedding, mud clasts, large clay seams common.				3.85m, Pt, 50°, Rf, Pln
4			4.00						HW			4.18-4.23m, Sm, 0°, CLAY 4.29-4.31m, Sm, 60°, CLAY 4.39-4.42m, Sm, 70°, Gravelly CLAY
									XW			
									HW			4.89-4.90m, Sm, 45°, CLAY
5						5.00						

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CORE LOG SHEET

Client : Bega Valley Shire Council

Project : Yellowpinch Water Treatment Plant - Geotechnical Investigation

Location : Yellow Pinch, NSW

HOLE No. BH01

SHEET 3 OF 3

Position : 752467.0 E 5916462.0 N MGA94/ 55	**Surface RL:** -	**Angle from Horiz. :** 90°	**Processed :** SBO
Rig Type : Hanjin D8	**Mounting:** Track	**Contractor :** Total Drilling Pty Ltd	**Driller :** TM	**Checked :** JNM
Casing Dia. : HQ	**Barrel (m) :** 3.0m	**Bit :** Diamond (impreg)	**Bit Condition :** Good	**Date:** 17/10/2022
Date Started : 29/8/2022	**Date Completed :** 29/8/2022	**Logged by :** JNM	**Date Logged :** 29/08/2022	

DRILLING | **MATERIAL** | **NATURAL FRACTURES**

Progress

SCALE (m) | Drilling & Casing | Water | Drill Depth (m) | (Core Loss / Run %) | Samples / RQD (%) | Depth metres | Graphic Log

Description
ROCK NAME: grain size, colour, fabric and texture, inclusions or minor components, moisture, durability and [COBBLES / BOULDERS / FILL / TOPSOIL] then SOIL NAME: colour, plasticity / primary particle characteristics, secondary and minor components, zoning (origin)

Weathering | **Estimated Strength $Is_{(50)}$ MPa** (● - Axial, ○ - Diametral) | **Spacing (mm)**

Additional Data
(joints, partings, seams, zones and veins)
Defect type: orientation, roughness and shape, composition or coating, aperture and thickness, other.

SCALE (m)	Drilling & Casing	Water	Drill Depth (m)	(Core Loss / Run %)	Samples / RQD (%)	Depth metres	Graphic Log	Description	Weathering	Estimated Strength $Is_{(50)}$ MPa	Spacing (mm)	Additional Data
				(0)	(74)			CLAYSTONE: red, brown, massive, disturbed bedding.				5.00-5.30m, multiple Sm's, 0-90°, CLAY (1-2mm)
						5.30		SANDSTONE: fine to coarse grained, grey, brown, disturbed bedding, mud clasts, large clay seams common.	HW			5.48-5.51m, Sm, 45°, Gravelly CLAY
									XW			
6			6.00						HW			
	NMLC coring /HQ Casing	(0% LOSS)							XW			
												6.90m, Jt, 80°, Rf, Ir, Cn
7				(0)	(81)	7.30		CONGLOMERATE: fine to coarse grained, rounded to sub-rounded clasts (2-60mm), pale brown.	HW			
						7.62		SANDSTONE: fine to coarse grained, grey, brown, disturbed bedding, mud clasts, large clay seams common.				
8								From 8.1m, colour is brown.				8.30m, Jt, 65°, Rf, Pln, Cn
			8.42			8.42		End of Borehole at 8.42 metres.				
9												
10												

Soil | VL 0.03 | L 0.1 | M 0.3 | H 1 | VH 3 | EH 10

20 | 40 | 100 | 300 | 1000

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PointID : BH01 Depth Range: 2.55 - 7.00 m

PointID : BH01 Depth Range: 7.00 - 8.42 m

	Bega Valley Shire Council Yellowpinch Water Treatment Plant - Geotechnical Investigation Yellow Pinch NSW Core Photographs	DRAWN H Warr	DATE 12/10/2022
		CHECKED J Mawbey	DATE 12/10/2022
		SCALE Not To Scale	A4
		PROJECT No 12538990	FIGURE No BH01 1/1

BOREHOLE LOG SHEET

GEO_BOREHOLE_AS1726 2017 12538990 YELLOW PINCH WTP.GPJ GHD_GEO_TEMPLATE 2.00.GDT 25/10/22

Client : Bega Valley Shire Council

Project : Yellowpinch Water Treatment Plant - Geotechnical Investigation

Location : Yellow Pinch, NSW

HOLE No. BH02

SHEET 1 OF 1

Position : 752483.0 E 5916779.0 N MGA94/ 55	**Surface RL:** -	**Angle from Horiz. :** 90°		**Processed :** SBO
Rig Type : Hanjin D8	**Mounting:** Track	**Contractor :** Total Drilling Pty Ltd	**Driller :** TM	**Checked :** JNM
Date Started : 29/8/2022	**Date Completed :** 29/8/2022	**Logged by :** JNM		**Date:** 17/10/2022

DRILLING					MATERIAL						
SCALE (m)	Drilling Method	Hole Support \ Casing	Water	Samples & Tests	Depth metres	Graphic Log	USC Symbol	Description [FILL/TOPSOIL/COBBLES/BOULDERS/-] SOIL NAME: plasticity / primary particle characteristics, colour, secondary and minor components, zoning (origin) and ROCK NAME: grain size, colour, fabric / texture, inclusions or minor components, durability, strength, weathering / alteration, defects	Moisture Condition	Consistency / Density Index	Comments/ Observations
0	TC-bit auger	Nil	Groundwater Not Encountered		0.00		SM	[TOPSOIL]: Silty SAND: fine to coarse grained, dark brown, trace fine gravel, rootlets and organic matter.	M	MD	
					0.30		SW	Gravelly SAND: fine to coarse grained, brown, angular to sub-angular gravel, trace clay (residual grading to extremely weathered).	M	D-VD	
					0.50		SC	Sandy CLAY: brown, orange, red mottled, fine to coarse grained sand, with fine to coarse, angular to sub-rounded gravel (extremely weathered conglomerate).	w=PL	St-VSt	
1				SPT 2/2/5 N=7							
				SPT 7/12 for 70mm HB N=ref	1.50			From 1.3m, Clayey GRAVEL (extremely weathered).			
								End of borehole at 1.50 metres. Refusal			
2											
3											
4											
5											

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BOREHOLE LOG SHEET

Client : Bega Valley Shire Council

Project : Yellowpinch Water Treatment Plant - Geotechnical Investigation

Location : Yellow Pinch, NSW

HOLE No. BH03

SHEET 1 OF 3

Position : 752500.0 E 5916789.0 N MGA94/ 55	**Surface RL:** -	**Angle from Horiz. :** 90°		**Processed :** SBO
Rig Type : Hanjin D8	**Mounting:** Track	**Contractor :** Total Drilling Pty Ltd	**Driller :** TM	**Checked :** JNM
Date Started : 29/8/2022	**Date Completed :** 29/8/2022	**Logged by :** JNM		**Date:** 17/10/2022

DRILLING					MATERIAL						
SCALE (m)	Drilling Method	Hole Support \ Casing	Water	Samples & Tests	Depth metres	Graphic Log	USC Symbol	Description [FILL/TOPSOIL/COBBLES/BOULDERS/-] SOIL NAME: plasticity / primary particle characteristics, colour, secondary and minor components, zoning (origin) and ROCK NAME: grain size, colour, fabric / texture, inclusions or minor components, durability, strength, weathering / alteration, defects	Moisture Condition	Consistency / Density Index	Comments/ Observations
0	TC-bit auger	Nil	Groundwater Not Encountered		0.00		SM	[TOPSOIL]: Silty SAND: fine to coarse grained, dark brown, trace fine gravel, rootlets and organic matter.	M	MD	
					0.20		SW	Gravelly SAND: fine to coarse grained, brown, angular to sub-angular gravel, some clay (residual grading to extremely weathered).	M	D-VD	
				SPT 4/8/14 N=22	0.70		SC	Sandy CLAY: brown, orange, red mottled, fine to coarse grained sand, with fine to coarse, angular to sub-rounded gravel (extremely weathered rock).	w=PL	St	0.75m, PP=300kPa
1				SPT 8 for 50mm HB N=ref							
2					2.67			Start of coring at 2.67 metres. For cored interval, see Core Log Sheet.			
3											
4											
5											

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CORE LOG SHEET

GEO_COREHOLE_NO VISUAL_AS1726 2017 12538990 YELLOW PINCH WTP.GPJ GHD_GEO_TEMPLATE 2.00.GDT 25/10/22

Client : Bega Valley Shire Council

Project : Yellowpinch Water Treatment Plant - Geotechnical Investigation

HOLE No. BH03

Location : Yellow Pinch, NSW

Position : 752500.0 E 5916789.0 N MGA94/ 55	**Surface RL:** -	**Angle from Horiz. :** 90°	**Processed :** SBO
Rig Type : Hanjin D8	**Mounting:** Track	**Contractor :** Total Drilling Pty Ltd	**Driller :** TM	**Checked :** JNM
Casing Dia. : HQ	**Barrel (m) :** 3.0m	**Bit :** Diamond (impreg)	**Bit Condition :** Good	**Date:** 17/10/2022
Date Started : 29/8/2022	**Date Completed :** 29/8/2022	**Logged by :** JNM	**Date Logged :** 30/08/2022	

DRILLING | **MATERIAL** | **NATURAL FRACTURES**

SCALE (m)	Drilling & Casing	Water	Drill Depth (m)	(Core Loss / Run %)	Samples / RQD (%)	Depth metres	Graphic Log	Description	Weathering	Estimated Strength $Is_{(50)}$ MPa (● Axial ○ Diametral)	Spacing (mm)	Additional Data
								ROCK NAME: grain size, colour, fabric and texture, inclusions or minor components, moisture, durability and [COBBLES / BOULDERS / FILL / TOPSOIL] then SOIL NAME: colour, plasticity / primary particle characteristics, secondary and minor components, zoning (origin)		Soil 0.03 VL 0.1 L 0.3 M 1 H 3 VH 10 EH	20 40 100 300 1000	(joints, partings, seams, zones and veins) Defect type: orientation, roughness and shape, composition or coating, aperture and thickness, other.
1												
2								Start of coring at 2.67 metres. For Non Cored interval, see Borehole Log Sheet.				
						2.67		CORE LOSS: 440mm				
3						3.11						3.05-5.25m, XW Rock-damage from boxing
	NMLC coring /HQ Casing	(0% LOSS)		(44)	(0)			SANDSTONE: fine to coarse grained, pale brown, yellow, orange, red, iron staining, trace fine, sub-rounded clasts, massive.	XW			
			3.67						HW			3.60m, Pt, 0°, Rf, Pln, Cn
4												3.80m, Jt, 70°, Rf, Pln, Fe
				(0)	(0)				XW			4.30m, Jt, 75°, Rf, Pln, Ve
5												

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CORE LOG SHEET

GEO_COREHOLE_NO VISUAL_AS1726 2017 12538990 YELLOW PINCH WTP.GPJ GHD_GEO_TEMPLATE 2.00.GDT 25/10/22

Client : Bega Valley Shire Council

Project : Yellowpinch Water Treatment Plant - Geotechnical Investigation

Location : Yellow Pinch, NSW

HOLE No. BH03

SHEET 3 OF 3

Position : 752500.0 E 5916789.0 N MGA94/ 55	**Surface RL:** -	**Angle from Horiz. :** 90°	**Processed :** SBO
Rig Type : Hanjin D8	**Mounting:** Track	**Contractor :** Total Drilling Pty Ltd	**Driller :** TM	**Checked :** JNM
Casing Dia. : HQ	**Barrel (m) :** 3.0m	**Bit :** Diamond (impreg)	**Bit Condition :** Good	**Date:** 17/10/2022
Date Started : 29/8/2022	**Date Completed :** 29/8/2022	**Logged by :** JNM	**Date Logged :** 30/08/2022	

DRILLING						MATERIAL					NATURAL FRACTURES	
Progress												
SCALE (m)	Drilling & Casing	Water	Drill Depth (m)	(Core Loss / Run %)	Samples / RQD (%)	Depth metres	Graphic Log	Description ROCK NAME: grain size, colour, fabric and texture, inclusions or minor components, moisture, durability and [COBBLES / BOULDERS / FILL / TOPSOIL] then SOIL NAME: colour, plasticity / primary particle characteristics, secondary and minor components, zoning (origin)	Weathering	Estimated Strength $Is_{(50)}$ MPa (● - Axial, ○ - Diametral) Soil, 0.03, VL, 0.1, L, 0.3, M, 1, H, 3, VH, 10, EH	Spacing (mm) 20, 40, 100, 300, 1000	Additional Data (joints, partings, seams, zones and veins) Defect type: orientation, roughness and shape, composition or coating, aperture and thickness, other.
6	NMLC coring /HQ Casing	(0% LOSS)	5.40	(0)	(25)	6.15		SANDSTONE: as previous.	XW HW XW			
6			6.20			6.15		SANDSTONE (60%)/BRECCIA (40%): sandstone is fine to coarse grained, pale brown, yellow, orange, red, iron staining, trace fine, sub-rounded clasts, massive, breccia is fine to coarse grained, pale brown/grey, orange, red, iron staining, angular to sub-angular clasts up to 20mm.	HW			6.60-6.80m, Jt, 85°, Rf, Ir, Cn
7				(0)	(77)	7.50		SANDSTONE (50%)/CLAYSTONE (50%): sandstone is fine to coarse grained, pale brown, yellow, orange, red, iron staining, trace fine, sub-rounded clasts, massive, claystone is red, brown, orange, massive.				
8			8.40			8.40		End of Borehole at 8.40 metres.				8.10-8.40m, highly fractured
9												
10												

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Job No. 12538990

PointID : BH03 Depth Range: 2.67 - 7.10 m

PointID : BH03 Depth Range: 7.10 - 8.40 m

GHD	Bega Valley Shire Council Yellowpinch Water Treatment Plant - Geotechnical Investigation Yellow Pinch NSW Core Photographs	DRAWN H Warr	DATE 12/10/2022
		CHECKED J Mawbey	DATE 12/10/2022
		SCALE Not To Scale	A4
		PROJECT No 12538990	FIGURE No BH03 1/1

BOREHOLE LOG SHEET

GEO_BOREHOLE_AS1726 2017 12538990 YELLOW PINCH WTP.GPJ GHD_GEO_TEMPLATE 2.00.GDT 25/10/22

Client : Bega Valley Shire Council

Project : Yellowpinch Water Treatment Plant - Geotechnical Investigation

Location : Yellow Pinch, NSW

HOLE No. BH04

SHEET 1 OF 1

Position : 752496.0 E 5916822.0 N MGA94/ 55 **Surface RL:** - **Angle from Horiz. :** 90° **Processed :** SBO

Rig Type : Hanjin D8 **Mounting:** Track **Contractor :** Total Drilling Pty Ltd **Driller :** TM **Checked :** JNM

Date Started : 31/8/2022 **Date Completed :** 31/8/2022 **Logged by :** JNM **Date:** 17/10/2022

DRILLING					MATERIAL						
SCALE (m)	Drilling Method	Hole Support \ Casing	Water	Samples & Tests	Depth metres	Graphic Log	USC Symbol	Description [FILL/TOPSOIL/COBBLES/BOULDERS/-] SOIL NAME: plasticity / primary particle characteristics, colour, secondary and minor components, zoning (origin) and ROCK NAME: grain size, colour, fabric / texture, inclusions or minor components, durability, strength, weathering / alteration, defects	Moisture Condition	Consistency / Density Index	Comments/ Observations
1	TC-bit auger	Nil	Groundwater Not Encountered	SPT 5/16 for 40mm DB N=ref	0.20		SM	[TOPSOIL]: Silty SAND: fine to coarse grained, dark brown, trace fine gravel, rootlets and organic matter.	M	MD	
							SW	Gravelly SAND: fine to coarse grained, brown, angular to sub-rounded gravel, some clay (residual grading to extremely weathered).	M	D-VD	
					0.80		SC	Sandy CLAY: brown, orange, fine to coarse grained sand, with fine to coarse, angular to sub-rounded gravel (extremely weathered conglomerate).	w= PL	VD	
					1.20			End of borehole at 1.20 metres. TC Refusal			
2											
3											
4											
5											

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Job No. **12538990**

BOREHOLE LOG SHEET

Client : Bega Valley Shire Council

Project : Yellowpinch Water Treatment Plant - Geotechnical Investigation

Location : Yellow Pinch, NSW

HOLE No. BH05

SHEET 1 OF 4

Position : 752471.0 E 5916833.0 N MGA94/ 55	**Surface RL:** -	**Angle from Horiz. :** 90°		**Processed :** SBO
Rig Type : Hanjin D8	**Mounting:** Track	**Contractor :** Total Drilling Pty Ltd	**Driller :** TM	**Checked :** JNM
Date Started : 30/8/2022	**Date Completed :** 30/8/2022	**Logged by :** JNM		**Date:** 17/10/2022

DRILLING					MATERIAL						
SCALE (m)	Drilling Method	Hole Support \ Casing	Water	Samples & Tests	Depth metres	Graphic Log	USC Symbol	Description [FILL/TOPSOIL/COBBLES/BOULDERS/-] SOIL NAME: plasticity / primary particle characteristics, colour, secondary and minor components, zoning (origin) and ROCK NAME: grain size, colour, fabric / texture, inclusions or minor components, durability, strength, weathering / alteration, defects	Moisture Condition	Consistency / Density Index	Comments/ Observations
0	TC-bit auger	Nil	Groundwater Not Encountered	SPT 6/10/18 N=28	0.15		SM	[TOPSOIL]: Silty SAND: fine to coarse grained, brown, grey, trace fine, angular to sub-angular gravel, rootlets and organic matter.	SM	MD	
							SW	Gravelly SAND: fine to coarse grained, brown, orange, fine to coarse, angular to sub-rounded gravel (residual grading to extremely weathered).	SM	D-VD	
					0.50		SW	Gravelly SAND: fine to coarse grained, brown, red, fine to coarse, angular to sub-angular gravel, trace clay (extremely weathered rock).	M	VD	
1											
2											From 2.5m, increased resistance
3					2.99			Start of coring at 2.99 metres. For cored interval, see Core Log Sheet.			
4											
5											

See standard sheets for details of abbreviations & basis of descriptions

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Job No. 12538990

CORE LOG SHEET

Client : Bega Valley Shire Council

Project : Yellowpinch Water Treatment Plant - Geotechnical Investigation

Location : Yellow Pinch, NSW

HOLE No. BH05

SHEET 2 OF 4

Position : 752471.0 E 5916833.0 N MGA94/ 55	**Surface RL:** -	**Angle from Horiz. :** 90°	**Processed :** SBO
Rig Type : Hanjin D8	**Mounting:** Track	**Contractor :** Total Drilling Pty Ltd	**Driller :** TM	**Checked :** JNM
Casing Dia. : HQ	**Barrel (m) :** 3.0m	**Bit :** Diamond (impreg)	**Bit Condition :** Good	**Date:** 17/10/2022
Date Started : 30/8/2022	**Date Completed :** 30/8/2022	**Logged by :** JNM	**Date Logged :** 30/08/2022	

DRILLING						MATERIAL					NATURAL FRACTURES	
Progress								Description		Estimated Strength $Is_{(50)}$ MPa	Spacing (mm)	Additional Data
SCALE (m)	Drilling & Casing	Water	Drill Depth (m)	(Core Loss / Run %)	Samples / RQD (%)	Depth metres	Graphic Log	ROCK NAME: grain size, colour, fabric and texture, inclusions or minor components, moisture, durability and [COBBLES / BOULDERS / FILL / TOPSOIL] then SOIL NAME: colour, plasticity / primary particle characteristics, secondary and minor components, zoning (origin)	Weathering	●- Axial ○- Diametral Soil 0.03 VL 0.1 L 0.3 M 1 H 3 VH 10 EH	20 40 100 300 1000	(joints, partings, seams, zones and veins) Defect type: orientation, roughness and shape, composition or coating, aperture and thickness, other.
1												
2												
3						2.99		Start of coring at 2.99 metres. For Non Cored interval, see Borehole Log Sheet.				
4	NMLC coring /HQ Casing	(0% LOSS)	3.95	(0)	(100)			SANDSTONE (80%)/CONGLOMERATE (20%): sandstone is fine to coarse grained, brown, red, orange, pale brown, massive, trace mud clasts, conglomerate is fine to coarse grained, rounded to sub-rounded clasts up to 5mm, brown, orange, red, pale grey.	HW			-3.30-3.50m, damage from drilling -3.40m, Pt, 5°, Rf, Pln, Cn
									XW			
				(0)	(78)				HW			-4.28m, Pt, 15°, Rf, Pln, Cn -4.32m, Pt, 10°, Rf, Pln, Cn -4.40m, Pt, 20°, Rf, Pln, Cn
			4.60									
5									XW			

See standard sheets for details of abbreviations & basis of descriptions

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CONSULTING GEOTECHNICAL ENGINEERS AND GEOLOGISTS

Job No. 12538990

CORE LOG SHEET

GEO_COREHOLE_NO VISUAL_AS1726 2017 12538990 YELLOW PINCH WTP.GPJ GHD_GEO_TEMPLATE 2.00.GDT 25/10/22

Client : Bega Valley Shire Council

Project : Yellowpinch Water Treatment Plant - Geotechnical Investigation

Location : Yellow Pinch, NSW

HOLE No. BH05

SHEET 3 OF 4

Position : 752471.0 E 5916833.0 N MGA94/ 55	**Surface RL:** -	**Angle from Horiz. :** 90°	**Processed :** SBO
Rig Type : Hanjin D8	**Mounting:** Track	**Contractor :** Total Drilling Pty Ltd	**Driller :** TM	**Checked :** JNM
Casing Dia. : HQ	**Barrel (m) :** 3.0m	**Bit :** Diamond (impreg)	**Bit Condition :** Good	**Date:** 17/10/2022
Date Started : 30/8/2022	**Date Completed :** 30/8/2022	**Logged by :** JNM	**Date Logged :** 30/08/2022	

DRILLING | **MATERIAL** | **NATURAL FRACTURES**

Progress

SCALE (m) | Drilling & Casing | Water | Drill Depth (m) | (Core Loss / Run %) | Samples / RQD (%) | Depth metres | Graphic Log

Description
ROCK NAME: grain size, colour, fabric and texture, inclusions or minor components, moisture, durability and [COBBLES / BOULDERS / FILL / TOPSOIL] then SOIL NAME: colour, plasticity / primary particle characteristics, secondary and minor components, zoning (origin)

Weathering | **Estimated Strength $Is_{(50)}$ MPa** (● - Axial, ○ - Diametral) | **Spacing (mm)** | **Additional Data** (joints, partings, seams, zones and veins) Defect type: orientation, roughness and shape, composition or coating, aperture and thickness, other.

Drill Depth (m)	(Core Loss / Run %)	Samples / RQD (%)	Description	Weathering	Additional Data
	(0)	(47)	SANDSTONE (80%)/CONGLOMERATE (20%): as previous.		5.20m, Jt, 35°, Rf, Pln, Cn
5.54				HW	
	(0)	(94)			6.10-6.80m, highly fractured, damage caused by drilling and boxing 6.15m, Jt, 40°, Rf, Pln, Cn 6.22m, Jt, 45°, Rf, Pln, Cn
6.80				MW	7.08m, Jt, 50°, Rf, Pln, Ve
	(0)	(75)		HW	
				XW	
8.51				HW	8.70m, Jt, 60°, Rf, Pln, Cn
	(0)	(100)			9.30m, Pt, 5°, Rf, Pln, Cn

NMLC coring /HQ Casing (0% LOSS)

See standard sheets for details of abbreviations & basis of descriptions

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CORE LOG SHEET

GEO_COREHOLE_NO VISUAL_AS1726 2017 12538990 YELLOW PINCH WTP.GPJ GHD_GEO_TEMPLATE 2.00.GDT 25/10/22

Client : Bega Valley Shire Council

Project : Yellowpinch Water Treatment Plant - Geotechnical Investigation

Location : Yellow Pinch, NSW

HOLE No. BH05

SHEET 4 OF 4

Position : 752471.0 E 5916833.0 N MGA94/ 55	**Surface RL:** -	**Angle from Horiz. :** 90°	**Processed :** SBO
Rig Type : Hanjin D8	**Mounting:** Track	**Contractor :** Total Drilling Pty Ltd	**Driller :** TM	**Checked :** JNM
Casing Dia. : HQ	**Barrel (m) :** 3.0m	**Bit :** Diamond (impreg)	**Bit Condition :** Good	**Date:** 17/10/2022
Date Started : 30/8/2022	**Date Completed :** 30/8/2022	**Logged by :** JNM	**Date Logged :** 30/08/2022	

DRILLING						MATERIAL				NATURAL FRACTURES	
Progress											
SCALE (m)	Drilling & Casing	Water	Drill Depth (m)	(Core Loss / Run %)	Samples / RQD (%)	Depth metres	Graphic Log	Description ROCK NAME: grain size, colour, fabric and texture, inclusions or minor components, moisture, durability and [COBBLES / BOULDERS / FILL / TOPSOIL] then SOIL NAME: colour, plasticity / primary particle characteristics, secondary and minor components, zoning (origin)	Weathering	Estimated Strength $Is_{(50)}$ MPa ● - Axial ○ - Diametral Soil 0.03 VL 0.1 L 0.3 M 1 H 3 VH 10 EH	Spacing (mm) 20 40 100 300 1000	Additional Data (joints, partings, seams, zones and veins) Defect type: orientation, roughness and shape, composition or coating, aperture and thickness, other.
11	NMLC coring /HQ Casing	(0% LOSS)	10.02	(0)	(68)			SANDSTONE (80%)/CONGLOMERATE (20%): as previous.	HW			10.10-10.30m, multiple healed Jt, 45-60°, Pln, Cl 10.50-10.80m, highly fractured, damage caused by drilling and boxing
12			12.80			12.80		End of Borehole at 12.80 metres.				12.50-12.80m, damage caused by drilling and boxing
13												
14												
15												

See standard sheets for details of abbreviations & basis of descriptions

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Job No. 12538990

PointID : BH05 Depth Range: 2.99 - 7.00 m

PointID : BH05 Depth Range: 7.00 - 12.00 m

	Bega Valley Shire Council Yellowpinch Water Treatment Plant - Geotechnical Investigation Yellow Pinch NSW Core Photographs	DRAWN H Warr	DATE 12/10/2022
		CHECKED J Mawbey	DATE 12/10/2022
		SCALE Not To Scale	A4
		PROJECT No 12538990	FIGURE No BH05 1/2

PointID : BH05 Depth Range: 12.00 - 12.80 m

Bega Valley Shire Council Yellowpinch Water Treatment Plant - Geotechnical Investigation Yellow Pinch NSW Core Photographs	DRAWN H Warr	DATE 12/10/2022	
	CHECKED J Mawbey	DATE 12/10/2022	
	SCALE Not To Scale		A4
	PROJECT No 12538990	FIGURE No BH05 2/2	

BOREHOLE LOG SHEET

GEO_BOREHOLE_AS1726 2017 12538990 YELLOW PINCH WTP.GPJ GHD_GEO_TEMPLATE 2.00.GDT 25/10/22

Client : Bega Valley Shire Council

Project : Yellowpinch Water Treatment Plant - Geotechnical Investigation

Location : Yellow Pinch, NSW

HOLE No. BH06

SHEET 1 OF 4

Position : 752433.0 E 5916813.0 N MGA94/ 55	**Surface RL:** -	**Angle from Horiz. :** 90°			**Processed :** SBO
Rig Type : Hanjin D8	**Mounting:** Track	**Contractor :** Total Drilling Pty Ltd	**Driller :** TM		**Checked :** JNM
Date Started : 30/8/2022	**Date Completed :** 30/8/2022	**Logged by :** JNM			**Date:** 17/10/2022

DRILLING					MATERIAL						
SCALE (m)	Drilling Method	Hole Support \ Casing	Water	Samples & Tests	Depth metres	Graphic Log	USC Symbol	Description [FILL/TOPSOIL/COBBLES/BOULDERS/-] SOIL NAME: plasticity / primary particle characteristics, colour, secondary and minor components, zoning (origin) and ROCK NAME: grain size, colour, fabric / texture, inclusions or minor components, durability, strength, weathering / alteration, defects	Moisture Condition	Consistency / Density Index	Comments/ Observations
0	TC-bit auger	Nil	Groundwater Not Encountered		0.25			[FILL]: Sandy GRAVEL: fine to coarse, angular to sub-angular, grey, trace silt (roadbase).	D	D	
				B			SW	Gravelly SAND: fine to coarse grained, brown, fine to coarse, angular gravel (residual grading to extremely weathered rock).	D	D	
1				SPT 4/7 for 80mm HB N=ref					SM		
								From 1.3m, with clay.	M	VD	
2					2.56						
								Start of coring at 2.56 metres. For cored interval, see Core Log Sheet.			
3											
4											
5											

See standard sheets for details of abbreviations & basis of descriptions

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Job No. 12538990

CORE LOG SHEET

Client : Bega Valley Shire Council

Project : Yellowpinch Water Treatment Plant - Geotechnical Investigation

Location : Yellow Pinch, NSW

HOLE No. BH06

Position : 752433.0 E 5916813.0 N MGA94/ 55	**Surface RL:** -	**Angle from Horiz. :** 90°		**Processed :** SBO
Rig Type : Hanjin D8	**Mounting:** Track	**Contractor :** Total Drilling Pty Ltd	**Driller :** TM	**Checked :** JNM
Casing Dia. : HQ	**Barrel (m) :** 3.0m	**Bit :** Diamond (impreg)	**Bit Condition :** Good	**Date:** 17/10/2022
Date Started : 30/8/2022	**Date Completed :** 30/8/2022	**Logged by :** JNM	**Date Logged :** 30/08/2022	

DRILLING						MATERIAL				NATURAL FRACTURES		
Progress												
SCALE (m)	Drilling & Casing	Water	Drill Depth (m)	(Core Loss / Run %)	Samples / RQD (%)	Depth metres	Graphic Log	Description ROCK NAME: grain size, colour, fabric and texture, inclusions or minor components, moisture, durability and [COBBLES / BOULDERS / FILL / TOPSOIL] then SOIL NAME: colour, plasticity / primary particle characteristics, secondary and minor components, zoning (origin)	Weathering	Estimated Strength $Is_{(50)}$ MPa ●- Axial ○- Diametral Soil 0.03 VL 0.1 L 0.3 M 1 H 3 VH 10 EH	Spacing (mm) 20 40 100 300 1000	Additional Data (joints, partings, seams, zones and veins) Defect type: orientation, roughness and shape, composition or coating, aperture and thickness, other.
1												
2						2.56		Start of coring at 2.56 metres. For Non Cored interval, see Borehole Log Sheet.				
3	NMLC coring /HQ Casing (0% LOSS)		3.50	(0)	(17)	2.56		Interbedded SANDSTONE (85%)/CONGLOMERATE (15%): fine to medium grained, grey, brown, fine to coarse grained conglomerate, sub-rounded to angular clasts, highly fractured.	HW			NTR: Possible fining up sequence,damage to core between fine and coarse grained beds - core loss assumed between finer grained beds 2.62m, Jt, 45°, Rf, Ir, Cn 2.68m, Jt, 40°, Rf, Pln, Cn 2.72m, Jt, 45°, Rf, Pln, Cn 2.85m, Jt, 45°, Rf, Pln, Cn 3.10m, Pt, 0°, Rf, Pln, Cn 3.25m, Jt, 15°, Rf, Pln, Cn
4						3.46		CORE LOSS: 300mm				3.82m, Pt, 0°, Rf, Pln, Cn
						3.76		Interbedded SANDSTONE (85%)/CONGLOMERATE (15%): as above.	HW			
						3.88		CORE LOSS 140mm.				4.15m, Jt, 80°, Rf, Ir, Ve
						4.02		Interbedded SANDSTONE (85%)/CONGLOMERATE (15%): as above.	HW			4.25-4.35m, highly fractured, damage from drilling
						4.35		CORE LOSS: 90mm.				4.40-4.80m, highly fractured, damage from drilling
				(28)	(24)	4.44		Interbedded SANDSTONE (85%)/CONGLOMERATE (15%): as above.	HW			
5												4.90m, Pt, 0°, Rf, Pln, Cn

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CORE LOG SHEET

GEO_COREHOLE_NO VISUAL_AS1726 2017 12538990 YELLOW PINCH WTP.GPJ GHD_GEO_TEMPLATE 2.00.GDT 25/10/22

Client : Bega Valley Shire Council

Project : Yellowpinch Water Treatment Plant - Geotechnical Investigation

Location : Yellow Pinch, NSW

HOLE No. BH06

SHEET 3 OF 4

Position : 752433.0 E 5916813.0 N MGA94/ 55	**Surface RL:** -	**Angle from Horiz. :** 90°	**Processed :** SBO
Rig Type : Hanjin D8	**Mounting:** Track	**Contractor :** Total Drilling Pty Ltd	**Driller :** TM	**Checked :** JNM
Casing Dia. : HQ	**Barrel (m) :** 3.0m	**Bit :** Diamond (impreg)	**Bit Condition :** Good	**Date:** 17/10/2022
Date Started : 30/8/2022	**Date Completed :** 30/8/2022	**Logged by :** JNM	**Date Logged :** 30/08/2022	

DRILLING

Progress

SCALE (m) | Drilling & Casing | Water | Drill Depth (m) | (Core Loss / Run %) | Samples / RQD (%)

MATERIAL

Depth metres | Graphic Log | **Description** (ROCK NAME: grain size, colour, fabric and texture, inclusions or minor components, moisture, durability and [COBBLES / BOULDERS / FILL / TOPSOIL] then SOIL NAME: colour, plasticity / primary particle characteristics, secondary and minor components, zoning (origin)) | Weathering | **Estimated Strength $Is_{(50)}$ MPa** (● - Axial, ○ - Diametral) Soil | 0.03 | VL | 0.1 | L | 0.3 | M | 1 | H | 3 | VH | 10 | EH

NATURAL FRACTURES

Spacing (mm) 20 | 40 | 100 | 300 | 1000

Additional Data (joints, partings, seams, zones and veins) Defect type: orientation, roughness and shape, composition or coating, aperture and thickness, other.

Depth	Description	Weathering	Additional Data
	Interbedded SANDSTONE/ CONGLOMERATE (95%:5%): as previous.	HW	
5.36			5.36-5.90m, highly fractured, damage from drilling
5.57	CORE LOSS 110mm		
5.68	SANDSTONE: fine to medium grained, grey, brown.	HW	
6.00	CORE LOSS 220mm (38) (0)		
6.22			
6.27	SANDSTONE: as above.	HW	
6.41	CORE LOSS 140mm.		
6.47	SANDSTONE: as above.	HW	
6.58	CORE LOSS 110mm		
	CLAYSTONE: brown, orange, pale grey, very thinly laminated at 0°, distinct bedding.	HW	6.75-6.85m, Jt, 80°, Rf, Ir, Cn
6.89			
6.90	CORE LOSS: 520mm.		
7.42			
	SANDSTONE: fine to coarse grained, brown, orange, red, pale grey, indistinct bedding, some disturbed bedding, some fine to coarse, sub-angular to rounded clasts up to 4mm. (35) (35)		7.75m, Jt, 15°, Rf, Pln, Cn
			8.10-8.20m, highly fractured, Jt, 10-50°, Rf, Ir, Ti
8.37		HW	
	(0) (100)		
9.25			

NMLC coring /HQ Casing (0% LOSS)

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CORE LOG SHEET

GEO_COREHOLE_NO VISUAL_AS1726 2017 12538990 YELLOW PINCH WTP.GPJ GHD_GEO_TEMPLATE 2.00.GDT 25/10/22

Client : Bega Valley Shire Council

Project : Yellowpinch Water Treatment Plant - Geotechnical Investigation

Location : Yellow Pinch, NSW

HOLE No. BH06

SHEET 4 OF 4

Position : 752433.0 E 5916813.0 N MGA94/ 55	**Surface RL:** -	**Angle from Horiz. :** 90°	**Processed :** SBO
Rig Type : Hanjin D8	**Mounting:** Track	**Contractor :** Total Drilling Pty Ltd	**Driller :** TM	**Checked :** JNM
Casing Dia. : HQ	**Barrel (m) :** 3.0m	**Bit :** Diamond (impreg)	**Bit Condition :** Good	**Date:** 17/10/2022
Date Started : 30/8/2022	**Date Completed :** 30/8/2022	**Logged by :** JNM	**Date Logged :** 30/08/2022	

DRILLING | **MATERIAL** | **NATURAL FRACTURES**

Progress

SCALE (m)	Drilling & Casing	Water	Drill Depth (m)	(Core Loss / Run %)	Samples / RQD (%)	Depth metres	Graphic Log	Description	Weathering	Estimated Strength $Is_{(50)}$ MPa (● - Axial, ○ - Diametral)	Spacing (mm)	Additional Data
								ROCK NAME: grain size, colour, fabric and texture, inclusions or minor components, moisture, durability and [COBBLES / BOULDERS / FILL / TOPSOIL] then SOIL NAME: colour, plasticity / primary particle characteristics, secondary and minor components, zoning (origin)		Soil, 0.03, VL, 0.1, L, 0.3, M, 1, H, 3, VH, 10, EH	20, 40, 100, 300, 1000	(joints, partings, seams, zones and veins) Defect type: orientation, roughness and shape, composition or coating, aperture and thickness, other.
11	NMLC coring /HQ Casing	(0% LOSS)		(0)	(100)			SANDSTONE: as previous.				
			11.37			11.65		CLAYSTONE: red, pale grey, highly fractured, indistinct bedding.				
						11.80		SANDSTONE (75%)/CONGLOMERATE (25%): sandstone is fine to coarse grained, grey, pale grey, brown, red, massive, conglomerate is fine to coarse grained, angular to rounded clasts up to 4mm, grey, pale grey.	HW			11.90-12.00m, Jt, 75°, Rf, Cu, Cn
12				(0)	(100)							
13			13.80			13.80		End of Borehole at 13.80 metres.				
14												
15												

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Job No. 12538990

PointID : BH06 Depth Range: 2.56 - 7.00 m

PointID : BH06 Depth Range: 7.00 - 12.00 m

	Bega Valley Shire Council Yellowpinch Water Treatment Plant - Geotechnical Investigation Yellow Pinch NSW Core Photographs	DRAWN H Warr	DATE 12/10/2022
		CHECKED J Mawbey	DATE 12/10/2022
		SCALE Not To Scale	A4
		PROJECT No 12538990	FIGURE No BH06 1/2

PointID : BH06 Depth Range: 12.00 - 13.80 m

Bega Valley Shire Council Yellowpinch Water Treatment Plant - Geotechnical Investigation Yellow Pinch NSW Core Photographs	DRAWN H Warr	DATE 12/10/2022	
	CHECKED J Mawbey	DATE 12/10/2022	
	SCALE Not To Scale		A4
	PROJECT No 12538990	FIGURE No BH06 2/2	

BOREHOLE LOG SHEET

GEO_BOREHOLE_AS1726 2017 12538990 YELLOW PINCH WTP.GPJ GHD_GEO_TEMPLATE 2.00.GDT 25/10/22

Client : Bega Valley Shire Council

Project : Yellowpinch Water Treatment Plant - Geotechnical Investigation

Location : Yellow Pinch, NSW

HOLE No. BH07

SHEET 1 OF 1

Position : 752422.0 E 5916776.0 N MGA94/ 55 **Surface RL:** - **Angle from Horiz. :** 90° **Processed :** SBO

Rig Type : Hanjin D8 **Mounting:** Track **Contractor :** Total Drilling Pty Ltd **Driller :** TM **Checked :** JNM

Date Started : 30/8/2022 **Date Completed :** 30/8/2022 **Logged by :** JNM **Date:** 17/10/2022

DRILLING					MATERIAL						
SCALE (m)	Drilling Method	Hole Support \ Casing	Water	Samples & Tests	Depth metres	Graphic Log	USC Symbol	Description [FILL/TOPSOIL/COBBLES/BOULDERS/-] SOIL NAME: plasticity / primary particle characteristics, colour, secondary and minor components, zoning (origin) and ROCK NAME: grain size, colour, fabric / texture, inclusions or minor components, durability, strength, weathering / alteration, defects	Moisture Condition	Consistency / Density Index	Comments/ Observations
	TC-bit auger	Nil	Groundwater Not Encountered	SPT 6 for 30mm HB N=ref	0.20		SM	[TOPSOIL]: Silty SAND: fine to coarse grained, brown, grey, trace fine, angular to sub-angular gravel, rootlets and organic matter.	SM	MD	
					0.65		SW	Gravelly SAND: fine to coarse grained, brown, orange, fine to coarse, angular to sub-rounded gravel (residual grading to extremely weathered).	SM	D-VD	
								End of borehole at 0.65 metres. TC Refusal			

1 2 3 4 5

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Job No. **12538990**

BOREHOLE LOG SHEET

GEO_BOREHOLE_AS1726 2017 12538990 YELLOW PINCH WTP.GPJ GHD_GEO_TEMPLATE 2.00.GDT 25/10/22

Client : Bega Valley Shire Council

Project : Yellowpinch Water Treatment Plant - Geotechnical Investigation

Location : Yellow Pinch, NSW

HOLE No. BH08

SHEET 1 OF 1

Position : 752520.0 E 5916902.0 N MGA94/ 55	**Surface RL:** -	**Angle from Horiz. :** 90°		**Processed :** SBO
Rig Type : Hanjin D8	**Mounting:** Track	**Contractor :** Total Drilling Pty Ltd	**Driller :** TM	**Checked :** JNM
Date Started : 31/8/2022	**Date Completed :** 31/8/2022	**Logged by :** JNM		**Date:** 17/10/2022

DRILLING					MATERIAL						
SCALE (m)	Drilling Method	Hole Support \ Casing	Water	Samples & Tests	Depth metres	Graphic Log	USC Symbol	Description [FILL/TOPSOIL/COBBLES/BOULDERS/-] SOIL NAME: plasticity / primary particle characteristics, colour, secondary and minor components, zoning (origin) and ROCK NAME: grain size, colour, fabric / texture, inclusions or minor components, durability, strength, weathering / alteration, defects	Moisture Condition	Consistency / Density Index	Comments/ Observations
0	TC-bit auger	Nil	Groundwater Not Encountered	B	0.10		SM SW	[TOPSOIL]: Silty SAND: fine to coarse grained, brown, grey, trace fine, angular to sub-angular gravel, rootlets and organic matter. Gravelly SAND: fine to coarse grained, brown orange, fine to coarse, angular to sub-rounded gravel, trace clay (residual grading to extremely weathered).	SM M	MD D	
					0.80		-	SANDSTONE: fine to coarse grained, brown, recovered as Gravelly SAND, fine to coarse grained, brown (highly weathered sandstone).	-	VD	
1				SPT 3/15/- HB N=ref	1.10			End of borehole at 1.10 metres. TC Refusal			
2											
3											
4											
5											

See standard sheets for details of abbreviations & basis of descriptions

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BOREHOLE LOG SHEET

GEO_BOREHOLE_AS1726 2017 12538990 YELLOW PINCH WTP.GPJ GHD_GEO_TEMPLATE 2.00.GDT 25/10/22

Client : Bega Valley Shire Council

Project : Yellowpinch Water Treatment Plant - Geotechnical Investigation

Location : Yellow Pinch, NSW

HOLE No. BH09

SHEET 1 OF 1

Position : 752541.0 E 5916953.0 N MGA94/ 55	**Surface RL:** -	**Angle from Horiz. :** 90°		**Processed :** SBO
Rig Type : Hanjin D8	**Mounting:** Track	**Contractor :** Total Drilling Pty Ltd	**Driller :** TM	**Checked :** JNM
Date Started : 31/8/2022	**Date Completed :** 31/8/2022	**Logged by :** JNM		**Date:** 17/10/2022

DRILLING					MATERIAL						
SCALE (m)	Drilling Method	Hole Support \ Casing	Water	Samples & Tests	Depth metres	Graphic Log	USC Symbol	Description [FILL/TOPSOIL/COBBLES/BOULDERS/-] SOIL NAME: plasticity / primary particle characteristics, colour, secondary and minor components, zoning (origin) and ROCK NAME: grain size, colour, fabric / texture, inclusions or minor components, durability, strength, weathering / alteration, defects	Moisture Condition	Consistency / Density Index	Comments/ Observations
1	TC-bit auger	Nil	Groundwater Not Encountered	SPT 5/12/13 N=25 SPT 9/5 for 70mm HB N=ref	0.10		SM	[TOPSOIL]: Silty SAND: fine to coarse grained, brown, grey, trace fine, angular to sub-angular gravel, rootlets and organic matter.	SM	MD	
							SW	Gravelly SAND: fine to coarse grained, brown, orange, fine to coarse, angular to sub-rounded gravel, trace clay (residual grading to extremely weathered).	M	D	
					0.50		-	SANDSTONE: fine to coarse grained, brown, recovered as Gravelly SAND, fine to coarse grained, brown (highly weathered sandstone).	-	VD	
					1.70			End of borehole at 1.70 metres. TC Refusal			
2											
3											
4											
5											

See standard sheets for details of abbreviations & basis of descriptions

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BOREHOLE LOG SHEET

GEO_BOREHOLE_AS1726 2017 12538990 YELLOW PINCH WTP.GPJ GHD_GEO_TEMPLATE 2.00.GDT 25/10/22

Client : Bega Valley Shire Council

Project : Yellowpinch Water Treatment Plant - Geotechnical Investigation

HOLE No. BH10

Location : Yellow Pinch, NSW

SHEET 1 OF 1

Position : 752479.0 E 5916883.0 N MGA94/ 55	**Surface RL:** -	**Angle from Horiz. :** 90°		**Processed :** SBO
Rig Type : Hanjin D8	**Mounting:** Track	**Contractor :** Total Drilling Pty Ltd	**Driller :** TM	**Checked :** JNM
Date Started : 31/8/2022	**Date Completed :** 31/8/2022	**Logged by :** JNM		**Date:** 17/10/2022

DRILLING					MATERIAL						
SCALE (m)	Drilling Method	Hole Support \ Casing	Water	Samples & Tests	Depth metres	Graphic Log	USC Symbol	Description [FILL/TOPSOIL/COBBLES/BOULDERS/-] SOIL NAME: plasticity / primary particle characteristics, colour, secondary and minor components, zoning (origin) and ROCK NAME: grain size, colour, fabric / texture, inclusions or minor components, durability, strength, weathering / alteration, defects	Moisture Condition	Consistency / Density Index	Comments/ Observations
1	TC-bit auger	Nil	Groundwater Not Encountered	SPT 5/8/9 N=17	0.15		SM	[TOPSOIL]: Silty SAND: fine to coarse grained, brown, grey, trace fine, angular to sub-angular gravel, rootlets and organic matter.	SM	MD	
							SW	Gravelly SAND: fine to coarse grained, brown, orange, fine to coarse, angular to sub-rounded gravel, trace clay (residual grading to extremely weathered).	M	D	
					0.40		SW	Gravelly SAND: fine to coarse grained, brown, orange, grey, fine to coarse, angular to sub-rounded gravel, some clay (extremely weathered rock).	M	D-VD	
				SPT 6/6 for 50mm DB N=ref	2.00						
2								End of borehole at 2.00 metres. TC Refusal			
3											
4											
5											

See standard sheets for details of abbreviations & basis of descriptions

GHD
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CONSULTING GEOTECHNICAL ENGINEERS AND GEOLOGISTS

Job No. 12538990

BOREHOLE LOG SHEET

GEO_BOREHOLE_AS1726 2017 12538990 YELLOW PINCH WTP.GPJ GHD_GEO_TEMPLATE 2.00.GDT 25/10/22

Client : Bega Valley Shire Council

Project : Yellowpinch Water Treatment Plant - Geotechnical Investigation

Location : Yellow Pinch, NSW

HOLE No. BH11

SHEET 1 OF 1

Position : 752411.0 E 5916825.0 N MGA94/ 55	**Surface RL:** -	**Angle from Horiz. :** 90°		**Processed :** SBO
Rig Type : Hanjin D8	**Mounting:** Track	**Contractor :** Total Drilling Pty Ltd	**Driller :** TM	**Checked :** JNM
Date Started : 30/8/2022	**Date Completed :** 30/8/2022	**Logged by :** JNM		**Date:** 17/10/2022

DRILLING					MATERIAL						
SCALE (m)	Drilling Method	Hole Support \ Casing	Water	Samples & Tests	Depth metres	Graphic Log	USC Symbol	Description [FILL/TOPSOIL/COBBLES/BOULDERS/-] SOIL NAME: plasticity / primary particle characteristics, colour, secondary and minor components, zoning (origin) and ROCK NAME: grain size, colour, fabric / texture, inclusions or minor components, durability, strength, weathering / alteration, defects	Moisture Condition	Consistency / Density Index	Comments/ Observations
1	TC-bit auger	Nil	Groundwater Not Encountered	SPT 6/10 for 140mm DB N=ref	0.20		SM	[TOPSOIL]: Silty SAND: fine to coarse grained, brown, grey, trace fine, angular to sub-angular gravel, rootlets and organic matter.	SM	MD	
					1.20		SW	Gravelly SAND: fine to coarse grained, brown, orange, fine to coarse, angular to sub-rounded gravel (residual grading to extremely weathered).	SM	D-VD	
								End of borehole at 1.20 metres. TC Refusal			
2											
3											
4											
5											

See standard sheets for details of abbreviations & basis of descriptions

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CONSULTING GEOTECHNICAL ENGINEERS AND GEOLOGISTS

Job No. **12538990**

Appendix D

Laboratory Reports

Sydney Laboratory
Unit 5 / 43 Herbert St
Artarmon NSW 2064
email: artarmon@ghd.com.au
web: ghd.com.au/ghdgeotechnics
Tel: (02) 9462 4860
Fax: (02) 9462 4710

Report No: SYD2202325
Issue No: 1

Point Load Strength Index - Report

Client:	Bega Valley Shire Council
Project:	Yellowpinch Water Treatment Plant
Location:	Yellowpinch, NSW
Job No.:	12538990
Borehole / Sample No.:	BH01
Test Method:	AS4133.4.1

NATA
Accredited for compliance with ISO / IEC 17025 - Testing
Laboratory Accreditation No. 679

Authorised Signatory: D. Brooke

Date of issue : 10/10/21

Test Results

Depth (m)	Test Type (D,A,I)	Dimensions D (mm)	L (mm)	W (mm)	De (mm)	Results Load, P (kN)	Failure Mode (1,2,3..)	Is (MPa)	Is_{50} (MPa)	Sample Description Rock Type	Structure	Moisture
3.85	D	51.6	46.7		51.6	1.09	3	0.41	**0.42**	SS	MA	As Rec'd
	A	46.7		51.6	55.4	0.43	3	0.14	**0.15**	SS	MA	As Rec'd
6.62	D	51.3	43.3		51.3	0.14	3	0.05	**0.05**	SS	MA	As Rec'd
	A	43.3		51.3	53.2	0.13	3	0.05	**0.05**	SS	MA	As Rec'd
7.61	D	51.8	46.4		51.8	0.22	3	0.08	**0.08**	CR	MA	As Rec'd
	A	46.4		51.8	55.3	0.16	4(J)	0.05	**0.05**	CR	MA	As Rec'd
8.11	D	51.6	43.8		51.6	2.8	3	1.05	**1.07**	SS	MA	As Rec'd
	A	43.8		51.6	53.6	2.63	3	0.91	**0.94**	SS	MA	As Rec'd

Comments (if applicable):

MOISTURE
(W) Wet
(M) Moist
(D) Dry
(AD) As Drilled
(AR) As Received

ROCK TYPE
(SS) Sandstone
(ST) Siltstone
(SH) Shale
(CR) Conglomerate
(MSS) Meta Sandtone
(MST) Meta Siltstone

STRUCTRUE
(MA) Massive
(BE) Bedded
(IB) Interbedded
(LA) Laminated
(CR) Crystalline

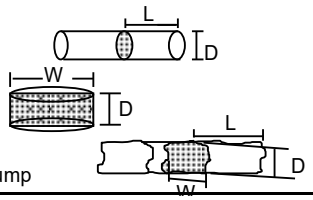
FAILURE MODE
1 = Fracture through fabric oblique to bedding
2 = Fracture along bedding
3 = Fracture through rock mass
4 = Fracture influenced by pre-existing:
(J) Joint plane, (M) Microfracture, (F) Foliation, (V) Vein
5 = Partial fracture or chip (Invalid result)

TEST TYPES

D = Diametral

A = Axial

I = Irregular Lump



L > 0.5 D

0.6W < D < W

0.6W < D < W

Time Since Sampling = Days

Storage:

- [ ] CORE BOX
- [ ] UNDER COVER
- [X] WRAPPED
- [ ] OPEN AIR
- [ ] UNWRAPPED
- [ ] UNKNOWN

Sampled By:	GHD Geotech
Date Sampled:	not known
Tested By:	DW
Date Tested:	7/10/22

Sydney Laboratory
Unit 5 / 43 Herbert St
Artarmon NSW 2064
email: artarmon@ghd.com.au
web: ghd.com.au/ghdgeotechnics
Tel: (02) 9462 4860
Fax: (02) 9462 4710

Report No: SYD2202326
Issue No: 1

Point Load Strength Index - Report

Client:	Bega Valley Shire Council
Project:	Yellowpinch Water Treatment Plant
Location:	Yellowpinch, NSW
Job No.:	12538990
Borehole / Sample No.:	BH03
Test Method:	AS4133.4.1

NATA
Accredited for compliance with ISO / IEC 17025 - Testing
Laboratory Accreditation No. 679

Authorised Signatory: D. Brooke

Date of issue : 10/10/22

Test Results

Depth (m)	Test Type (D,A,I)	Dimensions D (mm)	L (mm)	W (mm)	De (mm)	Results Load, P (kN)	Failure Mode (1,2,3..)	Is (MPa)	Is_{50} (MPa)	Sample Description Rock Type	Structure	Moisture
6.99	D	50.8	46.6		50.8	0.27	3	0.10	**0.11**	SS	MA	As Rec'd
	A	46.6		50.8	54.9	0.31	3	0.10	**0.11**	SS	MA	As Rec'd
7.66	D	51.2	45.4		51.2	0.67	4(J)	0.26	**0.26**	CR	MA	As Rec'd
	A	45.4		51.2	54.4	0.96	3	0.32	**0.34**	CR	MA	As Rec'd
7.95	D	51.5	50.3		51.5	0.41	3	0.15	**0.16**	SS	MA	As Rec'd
	A	50.3		51.5	57.4	0.33	3	0.10	**0.11**	SS	MA	As Rec'd

Comments (if applicable):

MOISTURE
(W) Wet
(M) Moist
(D) Dry
(AD) As Drilled
(AR) As Received

ROCK TYPE
(CR) Conglomerate
(SS) Sandstone
(SH) Shale
(G) Granitic
(MSS) Meta Sandtone
(MST) Meta Siltstone

STRUCTRUE
(MA) Massive
(BE) Bedded
(IB) Interbedded
(LA) Laminated
(CR) Crystalline

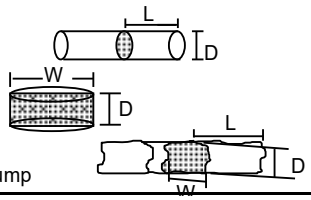
FAILURE MODE
1 = Fracture through fabric oblique to bedding
2 = Fracture along bedding
3 = Fracture through rock mass
4 = Fracture influenced by pre-existing:
(J) Joint plane, (M) Microfracture, (F) Foliation, (V) Vein
5 = Partial fracture or chip (Invalid result)

TEST TYPES

D = Diametral

A = Axial

I = Irregular Lump



L > 0.5 D

0.6W < D < W

0.6W < D < W

Time Since Sampling = Days

Storage:

- [ ] CORE BOX
- [ ] UNDER COVER
- [X] WRAPPED
- [ ] OPEN AIR
- [ ] UNWRAPPED
- [ ] UNKNOWN

Sampled By:	GHD Geotech
Date Sampled:	not known
Tested By:	DW
Date Tested:	7/10/22

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Unit 5 / 43 Herbert St
Artarmon NSW 2064
email: artarmon@ghd.com.au
web: ghd.com.au/ghdgeotechnics
Tel: (02) 9462 4860
Fax: (02) 9462 4710

Report No: SYD2202327
Issue No: 1

Point Load Strength Index - Report

Client:	Bega Valley Shire Council
Project:	Yellowpinch Water Treatment Plant
Location:	Yellowpinch, NSW
Job No.:	12538990
Borehole / Sample No.:	BH05
Test Method:	AS4133.4.1

NATA
Accredited for compliance with ISO / IEC 17025 - Testing
Laboratory Accreditation No. 679

Authorised Signatory: D. Brooke

Date of issue : 10/10/22

Test Results

Depth (m)	Test Type (D,A,I)	Dimensions D (mm)	L (mm)	W (mm)	De (mm)	Results Load, P (kN)	Failure Mode (1,2,3..)	Is (MPa)	Is_{50} (MPa)	Sample Description Rock Type	Structure	Moisture
4.49	D	50.3	45.5		50.3	0.09	3	0.04	**0.04**	SS	MA	As Rec'd
	A	45.5		50.3	54.0	0.26	3	0.09	**0.09**	SS	MA	As Rec'd
6.85	D	51.2	42.4		51.2	1.96	3	0.75	**0.76**	SS	MA	As Rec'd
	A	42.4		51.2	52.6	1.96	3	0.71	**0.73**	SS	MA	As Rec'd
10.83	D	51.6	42.5		51.6	0.42	3	0.16	**0.16**	SS	MA	As Rec'd
	A	42.5		51.6	52.8	0.94	3	0.34	**0.35**	SS	MA	As Rec'd

Comments (if applicable):

MOISTURE
(W) Wet
(M) Moist
(D) Dry
(AD) As Drilled
(AR) As Received

ROCK TYPE
(SS) Sandstone
(ST) Siltstone
(SH) Shale
(G) Granitic
(MSS) Meta Sandtone
(MST) Meta Siltstone

STRUCTRUE
(MA) Massive
(BE) Bedded
(IB) Interbedded
(LA) Laminated
(CR) Crystalline

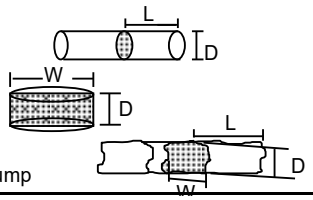
FAILURE MODE
1 = Fracture through fabric oblique to bedding
2 = Fracture along bedding
3 = Fracture through rock mass
4 = Fracture influenced by pre-existing:
(J) Joint plane, (M) Microfracture, (F) Foliation, (V) Vein
5 = Partial fracture or chip (Invalid result)

TEST TYPES

D = Diametral

A = Axial

I = Irregular Lump



L > 0.5 D

0.6W < D < W

0.6W < D < W

Time Since Sampling = Days

Storage:

- [ ] CORE BOX
- [ ] UNDER COVER
- [X] WRAPPED
- [ ] OPEN AIR
- [ ] UNWRAPPED
- [ ] UNKNOWN

Sampled By:	GHD Geotech
Date Sampled:	not known
Tested By:	DW
Date Tested:	7/10/22

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Fax: (02) 9462 4710

Report No: SYD2202328
Issue No: 1

Point Load Strength Index - Report

Client:	Bega Valley Shire Council
Project:	Yellowpinch Water Treatment Plant
Location:	Yellowpinch, NSW
Job No.:	12538990
Borehole / Sample No.:	BH06
Test Method:	AS4133.4.1

NATA
Accredited for compliance with ISO / IEC 17025 - Testing
Laboratory Accreditation No. 679

Authorised Signatory: D. Brooke

Date of issue : 10/10/22

Test Results

Depth (m)	Test Type (D,A,I)	Dimensions D (mm)	L (mm)	W (mm)	De (mm)	Results Load, P (kN)	Failure Mode (1,2,3..)	Is (MPa)	Is_{50} (MPa)	Sample Description Rock Type	Structure	Moisture
4.92	D	49.3	36.0		49.3	0.61	3	0.25	**0.25**	SS	MA	As Rec'd
	A	36.0		49.3	47.5	0.6	3	0.27	**0.26**	SS	MA	As Rec'd
7.80	D	50.8	45.8		50.8	1.83	3	0.71	**0.71**	SS	MA	As Rec'd
	A	45.8		50.8	54.4	2.38	3	0.80	**0.83**	SS	MA	As Rec'd
8.70	D	50.7	42.9		50.7	0.28	3	0.11	**0.11**	SS	MA	As Rec'd
	A	42.9		50.7	52.6	0.34	3	0.12	**0.13**	SS	MA	As Rec'd
11.60	D	50.8	41.7		50.8	1.69	3	0.65	**0.66**	SS	MA	As Rec'd
	A	41.7		50.8	51.9	2.28	3	0.85	**0.86**	SS	MA	As Rec'd

Comments (if applicable):

MOISTURE
(W) Wet
(M) Moist
(D) Dry
(AD) As Drilled
(AR) As Received

ROCK TYPE
(SS) Sandstone
(ST) Siltstone
(SH) Shale
(G) Granitic
(MSS) Meta Sandtone
(MST) Meta Siltstone

STRUCTRUE
(MA) Massive
(BE) Bedded
(IB) Interbedded
(LA) Laminated
(CR) Crystalline

FAILURE MODE
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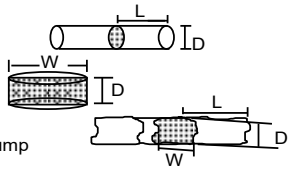
4 = Fracture influenced by pre-existing:
(J) Joint plane, (M) Microfracture, (F) Foliation, (V) Vein
5 = Partial fracture or chip (Invalid result)

TEST TYPES
D = Diametral
A = Axial
I = Irregular Lump



L > 0.5 D
0.6W < D < W
0.6W < D < W

Time Since Sampling = Days
Storage:
CORE BOX
[X] WRAPPED
[ ] UNWRAPPED
[ ] UNDER COVER
[ ] OPEN AIR
[ ] UNKNOWN

Sampled By: GHD Geotech
Date Sampled: not known
Tested By: DW
Date Tested: 7/10/22

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Tel: (02) 9462 4860
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Material Test Report

Report No: SYD2202278
Issue No: 1

Client: Bega Valley Shire Council
PO Box 492
Bega NSW 2550

Project: 12538990

Accredited for compliance with ISO / IEC 17025 - Testing

NATA Accreditation No: 679

Approved Signatory: D.P Brooke

Date of Issue: 18/10/2022

Sample Details

GHD Sample No	SYD22-0433-01
Sampled By	Sampled by GHD Geotechnical
	CLAY: with sand & gravel, mottled brown/grey/red
Client Location	Yellowpinch Water Treatment Plant
BH / TP No.	BH02
Depth (m)	0.5 - 1.0

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	18.9	
Date Tested		5/10/2022	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	8.5	
Mould Length (mm)		125	
Crumbling		No	
Curling		No	
Cracking		No	
Liquid Limit (%)	AS 1289.3.1.1	34	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	21	
Plasticity Index (%)	AS 1289.3.3.1	13	
Date Tested		12/10/2022	

Comments

N/A

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Fax:(02) 9462 4710

Material Test Report

Report No: SYD2202279
Issue No: 1

Client: Bega Valley Shire Council
PO Box 492
Bega NSW 2550

Project: 12538990

Accredited for compliance with ISO / IEC 17025 - Testing

NATA Accreditation No: 679

Approved Signatory: D.P Brooke

Date of Issue: 18/10/2022

Sample Details

GHD Sample No	SYD22-0433-02
Sampled By	Sampled by GHD Geotechnical
	Clayey SAND: with gravel, pale brown
Client Location	Yellowpinch Water Treatment Plant
BH / TP No.	BH03
Depth (m)	0.5 - 1.0

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	12.4	
Date Tested		5/10/2022	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	6.5	
Mould Length (mm)		125	
Crumbling		No	
Curling		No	
Cracking		No	
Liquid Limit (%)	AS 1289.3.1.1	28	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	16	
Plasticity Index (%)	AS 1289.3.3.1	12	
Date Tested		12/10/2022	

Comments

N/A

Sydney Laboratory
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Fax:(02) 9462 4710

Material Test Report

Report No: SYD2202280
Issue No: 1

Client: Bega Valley Shire Council
PO Box 492
Bega NSW 2550

Project: 12538990

Accredited for compliance with ISO / IEC 17025 - Testing

NATA Accreditation No: 679

Approved Signatory: D.P Brooke

Date of Issue: 18/10/2022

Sample Details

GHD Sample No	SYD22-0433-03
Sampled By	Sampled by GHD Geotechnical
	Clayey SAND: with gravel, pale brown
Client Location	Yellowpinch Water Treatment Plant
BH / TP No.	BH04
Depth (m)	0.5 - 1.0

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	13.6	
Date Tested		5/10/2022	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	11.5	
Mould Length (mm)		125.1	
Crumbling		No	
Curling		Yes	
Cracking		No	
Liquid Limit (%)	AS 1289.3.1.1	41	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	21	
Plasticity Index (%)	AS 1289.3.3.1	20	
Date Tested		12/10/2022	

Comments

N/A

Sydney Laboratory
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web: www.ghd.com.au/ghdgeotechnics
Tel: (02) 9462 4860
Fax:(02) 9462 4710

Material Test Report

Report No: SYD2202282
Issue No: 1

Client: Bega Valley Shire Council
PO Box 492
Bega NSW 2550

Project: 12538990

Accredited for compliance with ISO / IEC 17025 - Testing

NATA Accreditation No: 679

Approved Signatory: D.P Brooke

Date of Issue: 18/10/2022

Sample Details

GHD Sample No	SYD22-0433-05
Sampled By	Sampled by GHD Geotechnical
	Sandy CLAY: brown mottled grey/red
Client Location	Yellowpinch Water Treatment Plant
BH / TP No.	BH07
Depth (m)	0.2 - 0.5

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	14.1	
Date Tested		5/10/2022	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	7.5	
Mould Length (mm)		125	
Crumbling		No	
Curling		No	
Cracking		No	
Liquid Limit (%)	AS 1289.3.1.1	31	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	18	
Plasticity Index (%)	AS 1289.3.3.1	13	
Date Tested		12/10/2022	

Comments

N/A

Sydney Laboratory
Unit 5/43 Herbert St
Artarmon NSW 2064
email: artarmon@ghd.com.au
web: www.ghd.com.au/ghdgeotechnics
Tel: (02) 9462 4860
Fax:(02) 9462 4710

Material Test Report

Report No: SYD2202281
Issue No: 1

Client: Bega Valley Shire Council
PO Box 492
Bega NSW 2550

Project: 12538990

Accredited for compliance with ISO / IEC 17025 - Testing

NATA Accreditation No: 679

Approved Signatory: D.P Brooke

Date of Issue: 18/10/2022

Sample Details

GHD Sample No	SYD22-0433-04
Sampled By	Sampled by GHD Geotechnical
	Clayey SAND: with gravel, pale brown
Client Location	Yellowpinch Water Treatment Plant
BH / TP No.	BH08
Depth (m)	0.2 - 0.8

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	6.6	
Date Tested		5/10/2022	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	5.5	
Mould Length (mm)		125	
Crumbling		No	
Curling		No	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	24	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	15	
Plasticity Index (%)	AS 1289.3.3.1	9	
Date Tested		12/10/2022	
Standard MDD (t/m³)	AS 1289.5.1.1 - 2017	**1.96**	
Standard OMC (%)		**11.0**	
Retained Sieve (mm)		19	
Oversize Material (%)		2	
Curing Time (h)		48	
LL Method		AS 1289.3.1.1	
Date Tested		7/10/2022	
CBR at 5.0mm (%)	AS 1289.6.1.1 - 2017	**16**	
Dry Density before Soaking (t/m³)		1.93	
Density Ratio before Soaking (%)		98.5	
Moisture Content before Soaking (%)		10.6	
Moisture Ratio before Soaking (%)		98.0	
Dry Density after Soaking (t/m³)		1.93	
Density Ratio after Soaking (%)		98.5	
Swell (%)		0.0	

Comments

N/A

Sydney Laboratory
Unit 5/43 Herbert St
Artarmon NSW 2064
email: artarmon@ghd.com.au
web: www.ghd.com.au/ghdgeotechnics
Tel: (02) 9462 4860
Fax:(02) 9462 4710

Material Test Report

Report No: SYD2202281
Issue No: 1

Client: Bega Valley Shire Council
PO Box 492
Bega NSW 2550

Project: 12538990

Accredited for compliance with ISO / IEC 17025 - Testing

NATA Accreditation No: 679

Approved Signatory: D.P Brooke

Date of Issue: 18/10/2022

Sample Details

GHD Sample No	SYD22-0433-04
Sampled By	Sampled by GHD Geotechnical
	Clayey SAND: with gravel, pale brown
Client Location	Yellowpinch Water Treatment Plant
BH / TP No.	BH08
Depth (m)	0.2 - 0.8

Test Results

Description	Method	Result	Limits
Moisture Content of Top 30mm (%)		11.7	
Moisture Content of Remaining Depth (%)		11.4	
Compaction Hammer Used		Standard	
Surcharge Mass (kg)		4.50	
Period of Soaking (Days)		4	
Retained on 19 mm Sieve (%)		2	
CBR Moisture Content Method		AS 1289.2.1.1	
Sample Curing Time (h)		48	
Plasticity Method		AS 1289.3.1.1	
Sample Moisture Content		AS 1289.2.1.1	
Date Tested		14/10/2022	

Comments

N/A

Sydney Laboratory
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Artarmon NSW 2064
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Material Test Report

Report No: SYD2202283
Issue No: 1

Client: Bega Valley Shire Council
PO Box 492
Bega NSW 2550

Project: 12538990

Accredited for compliance with ISO / IEC 17025 - Testing

NATA Accreditation No: 679

Approved Signatory: D.P Brooke

Date of Issue: 18/10/2022

Sample Details

GHD Sample No	SYD22-0433-06
Sampled By	Sampled by GHD Geotechnical
	Sandy SILTY CLAY: with gravel, pale grey brown
Client Location	Yellowpinch Water Treatment Plant
BH / TP No.	BH09
Depth (m)	0.2 - 0.6

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	1.7	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	4.5	
Mould Length (mm)		125	
Crumbling		No	
Curling		No	
Cracking		No	
Liquid Limit (%)	AS 1289.3.1.1	20	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	15	
Plasticity Index (%)	AS 1289.3.3.1	5	
Date Tested		12/10/2022	
Standard MDD (t/m³)	AS 1289.5.1.1 - 2017	**1.96**	
Standard OMC (%)		**10.5**	
Retained Sieve (mm)		19	
Oversize Material (%)		10	
Curing Time (h)		48	
LL Method		AS 1289.3.1.1	
Date Tested		7/10/2022	
CBR at 5.0mm (%)	AS 1289.6.1.1 - 2017	**7**	
Dry Density before Soaking (t/m³)		1.92	
Density Ratio before Soaking (%)		98.0	
Moisture Content before Soaking (%)		10.7	
Moisture Ratio before Soaking (%)		103.0	
Dry Density after Soaking (t/m³)		1.92	
Density Ratio after Soaking (%)		98.0	
Swell (%)		0.0	
Moisture Content of Top 30mm (%)		10.6	

Comments

N/A

Sydney Laboratory
Unit 5/43 Herbert St
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email: artarmon@ghd.com.au
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Material Test Report

Report No: SYD2202283
Issue No: 1

Client: Bega Valley Shire Council
PO Box 492
Bega NSW 2550

Project: 12538990

Accredited for compliance with ISO / IEC 17025 - Testing

NATA Accreditation No: 679

Approved Signatory: D.P Brooke

Date of Issue: 18/10/2022

Sample Details

GHD Sample No	SYD22-0433-06
Sampled By	Sampled by GHD Geotechnical
	Sandy SILTY CLAY: with gravel, pale grey brown
Client Location	Yellowpinch Water Treatment Plant
BH / TP No.	BH09
Depth (m)	0.2 - 0.6

Test Results

Description	Method	Result	Limits
Moisture Content of Remaining Depth (%)		11.0	
Compaction Hammer Used		Standard	
Surcharge Mass (kg)		4.50	
Period of Soaking (Days)		4	
Retained on 19 mm Sieve (%)		10	
CBR Moisture Content Method		AS 1289.2.1.1	
Sample Curing Time (h)		48	
Plasticity Method		AS 1289.3.1.1	
Sample Moisture Content		AS 1289.2.1.1	
Date Tested		14/10/2022	

Comments

N/A

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2231528**	Page	: 1 of 4
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: Casey Macgee	Contact	: Sarah Mathew
Address	: LEVEL 15, 133 CASTLEREAGH STREET SYDNEY NSW, AUSTRALIA 2000	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: ----	Telephone	: +61-2-8784 8555
Project	: 12538990 Yellowpinck WTP GI	Date Samples Received	: 02-Sep-2022 18:45
Order number	: ----	Date Analysis Commenced	: 08-Sep-2022
C-O-C number	: ----	Issue Date	: 06-Oct-2022 18:14
Sampler	: Jarrad Mawbey		
Site	:		
Quote number	: SY/058/22		
No. of samples received	: 7		
No. of samples analysed	: 7		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Senior Chemist - Inorganics	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contract for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Corrosion assessment for Concrete and Steel piles in soil per Australian Standard AS2159-2009 uses a combination of soil and groundwater data (Tables 6.4.2 C & 6.5.2 C). In the absence of groundwater data, assessment has been made against soil criteria only. Refer to AS2159-2009 section 6.4 for further interpretation of corrosion assessment. ALS is not NATA accredited for Corrosion Assessment comments
- EA167: Soil Condition A – High permeability soils (e.g. sands and gravels) which are in groundwater
- EA167: Soil Condition B – Low permeability soils (e.g. silts and clays) or all soils above groundwater

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	BH01_2.9-3.0	BH01_6.3-6.4	BH02_0.5-1.0	BH03_4.9-5.0	BH04_0.5-1.0
			Sampling date / time	02-Sep-2022 00:00	02-Sep-2022 00:00	02-Sep-2022 00:00	02-Sep-2022 00:00	02-Sep-2022 00:00
Compound	CAS Number	LOR	Unit	ES2231528-001	ES2231528-002	ES2231528-003	ES2231528-004	ES2231528-005
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	4.4	5.2	5.3	5.0	5.0
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	33	17	10	12	20
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	16.2	9.9	17.3	12.0	12.4
EA080: Resistivity								
Resistivity at 25°C	----	1	ohm cm	30300	58800	100000	83300	50000
EA167: Corrosion Classification (per AS2159-2009)								
Ø Exposure Classification - Concrete Piles Soil Condition A	----	-	-	Severe	Moderate	Moderate	Moderate	Moderate
Ø Exposure Classification - Concrete Piles Soil Condition B	----	-	-	Moderate	Mild	Mild	Mild	Mild
Ø Exposure Classification - Steel Piles Soil Condition A	----	-	-	Mild	Non Aggressive	Non Aggressive	Mild	Mild
Ø Exposure Classification - Steel Piles Soil Condition B	----	-	-	Non Aggressive	Non Aggressive	Non Aggressive	Non Aggressive	Non Aggressive
ED040S: Soluble Major Anions								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	20	20	<10	10	20
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	<10	<10	<10	<10

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	BH05_3.1-3.2	BH06_8.3-8.4	----	----	----
			Sampling date / time	02-Sep-2022 00:00	02-Sep-2022 00:00	----	----	----
Compound	CAS Number	LOR	Unit	ES2231528-006	ES2231528-007	--------	--------	--------
				Result	Result	----	----	----
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**4.4**	**4.7**	----	----	----
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**87**	**34**	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**15.1**	**17.6**	----	----	----
EA080: Resistivity								
Resistivity at 25°C	----	1	ohm cm	**11500**	**29400**	----	----	----
EA167: Corrosion Classification (per AS2159-2009)								
Ø Exposure Classification - Concrete Piles Soil Condition A	----	-	-	**Severe**	**Moderate**	----	----	----
Ø Exposure Classification - Concrete Piles Soil Condition B	----	-	-	**Moderate**	**Mild**	----	----	----
Ø Exposure Classification - Steel Piles Soil Condition A	----	-	-	**Mild**	**Mild**	----	----	----
Ø Exposure Classification - Steel Piles Soil Condition B	----	-	-	**Non Aggressive**	**Non Aggressive**	----	----	----
ED040S: Soluble Major Anions								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	**50**	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	**140**	**10**	----	----	----

ALS Environmental

QUALITY CONTROL REPORT

Work Order	: **ES2231528**	Page	: 1 of 3
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: Casey Macgee	Contact	: Sarah Mathew
Address	: LEVEL 15, 133 CASTLEREAGH STREET SYDNEY NSW, AUSTRALIA 2000	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: ----	Telephone	: +61-2-8784 8555
Project	: 12538990 Yellowpinck WTP GI	Date Samples Received	: 02-Sep-2022
Order number	: ----	Date Analysis Commenced	: 08-Sep-2022
C-O-C number	: ----	Issue Date	: 06-Oct-2022
Sampler	: Jarrad Mawbey		
Site	:		
Quote number	: SY/058/22		
No. of samples received	: 7		
No. of samples analysed	: 7		

ilac-MRA NATA
Accreditation No. 825
Accredited for compliance with ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Senior Chemist - Inorganics	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Acceptable RPD (%)*
EA002: pH 1:5 (Soils) (QC Lot: 4568756)									
ES2231923-004	Anonymous	EA002: pH Value	----	0.1	pH Unit	8.2	8.2	0.0	0% - 20%
ES2231528-004	BH03_4.9-5.0	EA002: pH Value	----	0.1	pH Unit	5.0	5.0	0.0	0% - 20%
EA010: Conductivity (1:5) (QC Lot: 4568755)									
ES2231923-004	Anonymous	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	125	128	2.7	0% - 20%
ES2231528-004	BH03_4.9-5.0	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	12	11	0.0	0% - 50%
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 4568759)									
ES2231528-003	BH02_0.5-1.0	EA055: Moisture Content	----	0.1	%	17.3	17.5	1.3	0% - 20%
ES2231924-002	Anonymous	EA055: Moisture Content	----	0.1	%	5.1	5.1	0.0	No Limit
ED040S: Soluble Major Anions (QC Lot: 4568754)									
ES2231528-004	BH03_4.9-5.0	ED040S: Sulfate as SO4 2-	14808-79-8	10	mg/kg	10	10	0.0	No Limit
ED045G: Chloride by Discrete Analyser (QC Lot: 4568753)									
ES2231528-004	BH03_4.9-5.0	ED045G: Chloride	16887-00-6	10	mg/kg	<10	<10	0.0	No Limit

Method Blank (MB) and Laboratory Control Sample (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Acceptable Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA002: pH 1:5 (Soils) (QCLot: 4568756)								
EA002: pH Value	----	----	pH Unit	----	4 pH Unit	100	98.8	101
				----	7 pH Unit	99.4	99.2	100
EA010: Conductivity (1:5) (QCLot: 4568755)								
EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	1412 µS/cm	108	92.0	108
ED040S: Soluble Major Anions (QCLot: 4568754)								
ED040S: Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	750 mg/kg	102	80.0	120
ED045G: Chloride by Discrete Analyser (QCLot: 4568753)								
ED045G: Chloride	16887-00-6	10	mg/kg	<10	250 mg/kg	101	75.0	125
				<10	5000 mg/kg	101	79.0	117

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **SOIL**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Acceptable Limits (%)	
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
ED045G: Chloride by Discrete Analyser (QCLot: 4568753)							
ES2231528-001	BH01_2.9-3.0	ED045G: Chloride	16887-00-6	250 mg/kg	106	70.0	130

ALS Environmental

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **ES2231528**	Page	: 1 of 5
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: Casey Macgee	Telephone	: +61-2-8784 8555
Project	: 12538990 Yellowpinck WTP GI	Date Samples Received	: 02-Sep-2022
Site	:	Issue Date	: 06-Oct-2022
Sampler	: Jarrad Mawbey	No. of samples received	: 7
Order number	: ----	No. of samples analysed	: 7

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **NO Matrix Spike outliers occur.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **NO Quality Control Sample Frequency Outliers exist.**

Outliers : Analysis Holding Time Compliance

Matrix: **SOIL**

Method / Container / Client Sample ID(s)	Extraction / Preparation			Analysis		
	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA002: pH 1:5 (Soils)						
Soil Glass Jar - Unpreserved						
BH01_2.9-3.0, BH01_6.3-6.4, BH02_0.5-1.0, BH03_4.9-5.0, BH04_0.5-1.0, BH05_3.1-3.2, BH06_8.3-8.4	----	----	----	09-Sep-2022	08-Sep-2022	**1**

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA002: pH 1:5 (Soils)							
Soil Glass Jar - Unpreserved (EA002)							
BH01_2.9-3.0, BH01_6.3-6.4, BH02_0.5-1.0, BH03_4.9-5.0, BH04_0.5-1.0, BH05_3.1-3.2, BH06_8.3-8.4	**02-Sep-2022**	**08-Sep-2022**	09-Sep-2022	✓	**09-Sep-2022**	08-Sep-2022	×
EA010: Conductivity (1:5)							
Soil Glass Jar - Unpreserved (EA010)							
BH01_2.9-3.0, BH01_6.3-6.4, BH02_0.5-1.0, BH03_4.9-5.0, BH04_0.5-1.0, BH05_3.1-3.2, BH06_8.3-8.4	**02-Sep-2022**	**08-Sep-2022**	09-Sep-2022	✓	**09-Sep-2022**	06-Oct-2022	✓
EA055: Moisture Content (Dried @ 105-110°C)							
Soil Glass Jar - Unpreserved (EA055)							
BH01_2.9-3.0, BH01_6.3-6.4, BH02_0.5-1.0, BH03_4.9-5.0, BH04_0.5-1.0, BH05_3.1-3.2, BH06_8.3-8.4	**02-Sep-2022**	**----**	----	----	**08-Sep-2022**	16-Sep-2022	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
ED040S: Soluble Major Anions							
Soil Glass Jar - Unpreserved (ED040S)							
BH01_2.9-3.0, BH01_6.3-6.4, BH02_0.5-1.0, BH03_4.9-5.0, BH04_0.5-1.0, BH05_3.1-3.2, BH06_8.3-8.4	**02-Sep-2022**	**08-Sep-2022**	30-Sep-2022	✓	**09-Sep-2022**	06-Oct-2022	✓
ED045G: Chloride by Discrete Analyser							
Soil Glass Jar - Unpreserved (ED045G)							
BH01_2.9-3.0, BH01_6.3-6.4, BH02_0.5-1.0, BH03_4.9-5.0, BH04_0.5-1.0, BH05_3.1-3.2, BH06_8.3-8.4	**02-Sep-2022**	**08-Sep-2022**	30-Sep-2022	✓	**09-Sep-2022**	06-Oct-2022	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Chloride Soluble By Discrete Analyser	ED045G	1	7	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Anions - Soluble	ED040S	1	7	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Moisture Content	EA055	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Chloride Soluble By Discrete Analyser	ED045G	2	7	**28.57**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Anions - Soluble	ED040S	1	7	**14.29**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Chloride Soluble By Discrete Analyser	ED045G	1	7	**14.29**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Anions - Soluble	ED040S	1	7	**14.29**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Chloride Soluble By Discrete Analyser	ED045G	1	7	**14.29**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
pH (1:5)	EA002	SOIL	In house: Referenced to Rayment and Lyons 4A1 and APHA 4500H+. pH is determined on soil samples after a 1:5 soil/water leach. This method is compliant with NEPM Schedule B(3).
Electrical Conductivity (1:5)	EA010	SOIL	In house: Referenced to Rayment and Lyons 3A1 and APHA 2510. Conductivity is determined on soil samples using a 1:5 soil/water leach. This method is compliant with NEPM Schedule B(3).
Moisture Content	EA055	SOIL	In house: A gravimetric procedure based on weight loss over a 12 hour drying period at 105-110 degrees C. This method is compliant with NEPM Schedule B(3).
Resistivity (1:5)	EA080	SOIL	In house: Calculated from Electrical Conductivity
Corrosion Classification for Steel and Concrete Piles	* EA167	SOIL	In house: Exposure classification is determined according to Australian Standard AS2159-2009.
Major Anions - Soluble	ED040S	SOIL	In house: Soluble Anions are determined off a 1:5 soil / water extract by ICPAES.
Chloride Soluble By Discrete Analyser	ED045G	SOIL	In house: Referenced to APHA APHA 4500 Cl - G. The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm. Analysis is performed on a 1:5 soil / water leachate.

Preparation Methods	Method	Matrix	Method Descriptions
1:5 solid / water leach for soluble analytes	EN34	SOIL	10 g of soil is mixed with 50 mL of reagent grade water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.

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