GREENCAP
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Office 2 / 120 Smith Street
Wollongong NSW 2500
Australia

TEMPERATURE INVESTIGATION - DATA REVIEW

November 2018
J153825-01

NSW Department Of Education

Cringila Public School
35 Sheffield St, Cringila NSW 2502

C107826 : RC

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Document Control

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Report Name:	Temperature Investigation Report – Data Review		
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1	**6/11/2018**	Electronic	Greg Mott	Senior Group Leader, School Infrastructure NSW, Southern NSW AMU

Temperature Investigation Report – Data Review

NSW Department of Education

Cringila Public School

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1. Introduction

At the request of the NSW Department of Education, Greencap Pty Ltd were engaged to undertake a review of temperature data collected during various temperature investigations within the northwest region of the playground area at Cringila Public School, 35 Sheffield Street, Cringila NSW 2502. The site location is indicated on **Figure 1** within this report.

2. General Site History and Background

The site has been used as public school since the late 1970s. Historical information indicates the western and southern sections of the site were levelled with fill containing coal wash between the late 1960s and early 1970s[1], prior to the establishment of the school buildings.

The site has a history of sub-surface hotspots associated with the fill material containing coal wash waste. These events were first observed on-site in 1994 along the southern boundary of the school (New Environment 2001). In 2002, the areas along the western ridge of the school boundary were also found to exhibit elevated temperatures within the subsurface. Historical records indicate a series of investigations and associated remedial actions were undertaken at these areas between the period 1994-2017.

In September 2017, NSW Environmental Protection Authority (EPA) was notified by Fire and Rescue NSW regarding a sub-surface fire at the west of the site boundary. As a result of this event, NSW EPA issued a Clean-Up Notice (Notice No. 1557944 dated 25th October 2017), which listed a number of directions to take Clean-Up actions.

The Clean-Up Notice also required the site be subject to a Section B Statutory Site Audit. Consequently, NSW EPA Accredited Site Auditor Chris Jewell (C.M. Jewell & Associates Pty Ltd) was engaged by the Department of Education to conduct the Site Audit.

To undertake necessary Clean-Up actions, a Remediation Options Analysis and Feasibility Study (ROAFS) and a Remediation Action Plan (RAP) were required. This Temperature Report has been prepared to supplement the necessary temperature data for these two key reports (RAP and ROAFS).

3. Project Objectives and Scope

The primary objective of this investigation report was to gather information and data for the ROAFS and RAP. The scope undertaken to prepare this report was as follows:

- Review site history and review previous works undertaken on the site to understand site history;
- Investigate surface, near surface and subsurface temperature profile data;
- Undertake a review and evaluation of temperature profile data to further understand the spatial extent of the hotspot within the northwest playground area at the site; and
- Provide temperature profile information to help inform the Feasibility Study and the Remediation Action Plan (RAP) being developed for the site.

4. Project Timeline

Below is a project timeline of objectives and milestones achieved throughout Greencap's engagement by the NSW Department of Education. Refer also to **Appendix A: Project Progress Chart.**

4.1 Stage 1: Initial Site inspections and Review of Site History

An initial inspection of the site was undertaken on 31st October 2017 following a meeting with NSW Department of Education to assess the immediate risks on the site. At the time of the inspection the following was identified:

- Grass around the concrete pad was very brown indicative of deterioration due to heat exposure;
- Elevated surface temperatures in the vicinity of the concrete pad, small mound and old internal fence-line;
- No visual smoke or vapours were evident at the time of the inspection; and
- The site was adequately secure with a temporary fence installed around the area of concern.

[1] A former development application approved by Wollongong City Council (D67/144) indicated Australian Iron and Steel Pty Ltd (BHP), a former site owner, had received authorization to import fill material to the site in 1968 (New Environment 2001).

After discussion with NSW Department of Education the following actions were implemented to reduce the immediate risks on the site:

- Remove vegetation from immediate areas adjacent the area of concern;
- Place sand across the surface of the areas of concern within the north western portion of the site to immediately reduce potential ignition of dried vegetation/grass;
- Schedule daily site inspections to monitor and assess the identified risk factors at the site; and
- Investigate appropriate temperature monitoring equipment and methods to be implemented at the site.

Following on from the initial site inspection Greencap undertook a desktop assessment of previous temperature investigation and remediation works conducted at the site. Site inspections were also carried out by Greencap to locate temperature monitoring wells from previous remediation works and to assess their feasibility to use. A review of the site remediation history indicated that the site is historically split into three areas which have had remediation works undertaken at various times since 2001 (refer to **Figure 1** below).

Figure 1: Site Plan 1: Created from historical review of site works – 2001-2018

Legend	
	Southern Playground Area (Area 1) – Previous Remediation Works 2001-2004
	Western Playground Area (Area 2) – Previous Remediation Works 2004-2006
	Northwest Playground Area - Current Area of Concern

A review of the site history and the occurrence of underground hotspots is briefly summarised below:

- Prior to 2001 – Area was infilled with waste products from local industry. From previous investigations and remediation by New Environment and Avopiling, much of the fill is coal wash with some blast furnace (slag-like) materials.
- 2001 – Hotspot identified in Southern Playground Area (Area 1);
- 2001-2003 – Investigation and successful remediation program of Southern Playground Area (Area 1). Three (3) Hotspots identified Eastern, Central, and Western Hotspots. Works Undertaken by New Environment – Bentonite slurry injection.

- 2003-2004 – Investigation of Western Area of Playground (Area 2).
- 2004-2006 – Remediation of Western Area of Playground (Area 2). Works undertaken by Avopiling – Inert gas injection.
- September 2017 – Evidence of steam/smoke emanating from Northwest Area of Playground within fenced area of site. NSW Fire Services, NSW EPA and NSW Department of Education attended Site.

4.2 Stage 2: Initial Surface and Near Surface Temperature Profiling

Following the initial site inspection, Greencap gathered temperature readings at the surface and near surface (0.3m depth) across the site to determine the lateral extent of the hotspot. Evaluation of this data identified the following:

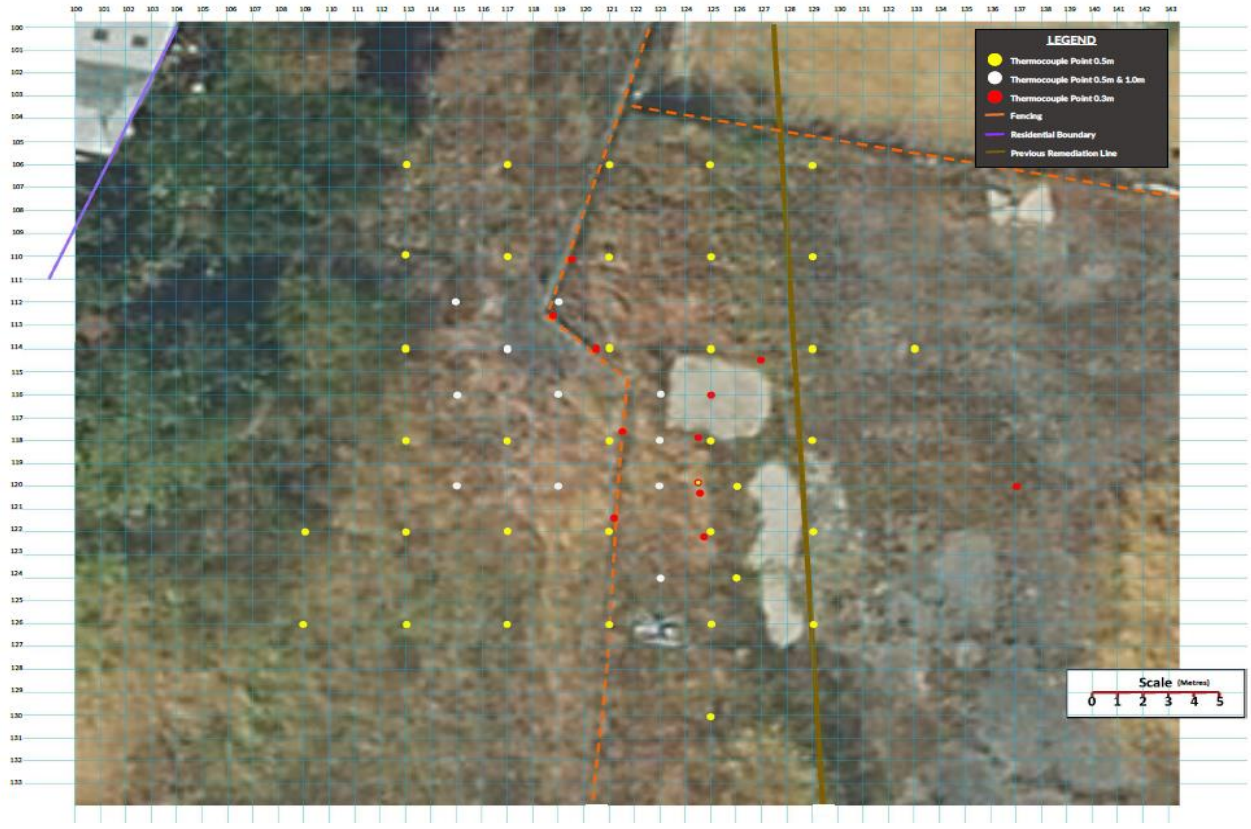
- Surface temperatures in this area generally ranged from 35-70°C with the highest temperature usually recorded on the northern side of a small mound directly west of the concrete pad.
- Near surface (0.3m depth) temperatures in the hotspot area generally ranged from 34-195°C with the highest temperature usually recorded on the northern side of the small mound directly west of the concrete pad.
- Greencap located and assessed temperature data from five (5) identified pre-existing Avopiling thermocouple well monitoring locations. It is understood these were installed during previous investigation and remediation works within the Western Playground Area (Area 2) at the site.

The comparison of temperature at 0.3m depth versus temperature at the surface provided information to assess if greater temperature was correlated to greater depth. Greencap utilised this data to develop a targeted near-surface temperature profile plan to further delineate the extent of the hotspot.

4.3 Stage 3: Targeted Near Surface Temperature Profiling

Subsequent the preliminary surface and near surface temperature investigation, Greencap identified the need for additional near-surface temperature data to further delineate the extent of the hotspot.

Near surface thermocouples were installed at various locations to target depths of 0.5m and 1m. Thermocouples were installed on a cross-sectional grid format across the area of concern (refer to **Figure 2** below).



- During the period of monitoring, near surface (0.5m depth) temperatures in the hotspot area generally ranged from 25-200^{o}C with the highest temperatures usually recorded on the northern side of the small mound directly west of the concrete pad.
- Temperatures recorded at 1m depth correlated with those recorded at 0.5m depth, indicating that greater temperatures may have been associated with greater depth.

4.4 Stage 4: Site Clean-up/Make-Safe Works

4.4.1 Risk Log

As part of the ongoing engagement, Greencap was requested by NSW Department of Education to prepare a site-specific Risk Log for the north western hotspot. The purpose of the Assessment was to gather relevant information and data to provide a profile of risk at the site. The Risk Log included an assessment of the hazards and risk factors posed by the north western hotspot in relation to the environment and human health. The Risk Log was requested as part of the interim Site Management Plan developed for the site.

4.4.2 Site Clean-up and Make-Safe Works

Ongoing inspections of the site throughout February and March 2018 identified further risk factors for potential combustion at the surface. After discussion with the NSW Department of Education, the following actions were implemented to reduce the risks identified on the site:

- Remove vegetation from areas within the area of concern;
- Placement of sand (approximately 100mm) across the surface of the area of concern to reduce the potential for ignition of dried vegetation/grass;
- Install a permanent and secure fence around the boundary of the site;
- Reinforce the exclusion zone around the north western hotspot; and
- Continue to undertake regular inspections to monitor the condition of the site.

4.4.3 Community Consultation

As per the engagement, Greencap attended consultation meetings with multiple stakeholders, including the school community and residents as well as the Department of Education and the Environmental Protection Authority (EPA) regarding the strategies implemented to monitor and mitigate any risks posed by the site in its current condition.

4.5 Stage 5: Ongoing Monitoring and Environmental Site Investigations

Greencap continue to undertake regular site inspections to monitor the potential risk of combustion at the surface and to further develop the near surface temperature profile within the area of concern.

Phase 1 and Phase 2 Environmental Site Assessments were undertaken at the site under the engagement of Greencap's environmental investigation works program, as required.

4.6 Stage 6: Targeted Subsurface Temperature Profiling

Greencap undertook a review and analysis of available data to develop a targeted subsurface temperature sampling plan to further understand the spatial extent of the hotspot. Greencap undertook the following:

- Six (6) subsurface thermocouple monitoring wells were installed in targeted locations across the north western hotspot via drill rig apparatus to the complete depth of the coal wash fill (monitoring wells TB-01 – TB-06). Monitoring sensors were affixed at various depths throughout the strata to provide a vertical temperature profile. Refer to **Appendix E: Temperature Monitoring Well Locations** and **Appendix G: Site Plan and Borehole Logs.**
- An additional monitoring well (TB-07) was installed by hand to a maximum depth of 3m, on the slope of the embankment in the northern portion of the site.
- Subsurface temperature profiling information was analysed and evaluated to help to inform the Feasibility Study and the Remediation Action Plan (RAP) currently being developed for the site.

5. Temperature Data Analysis

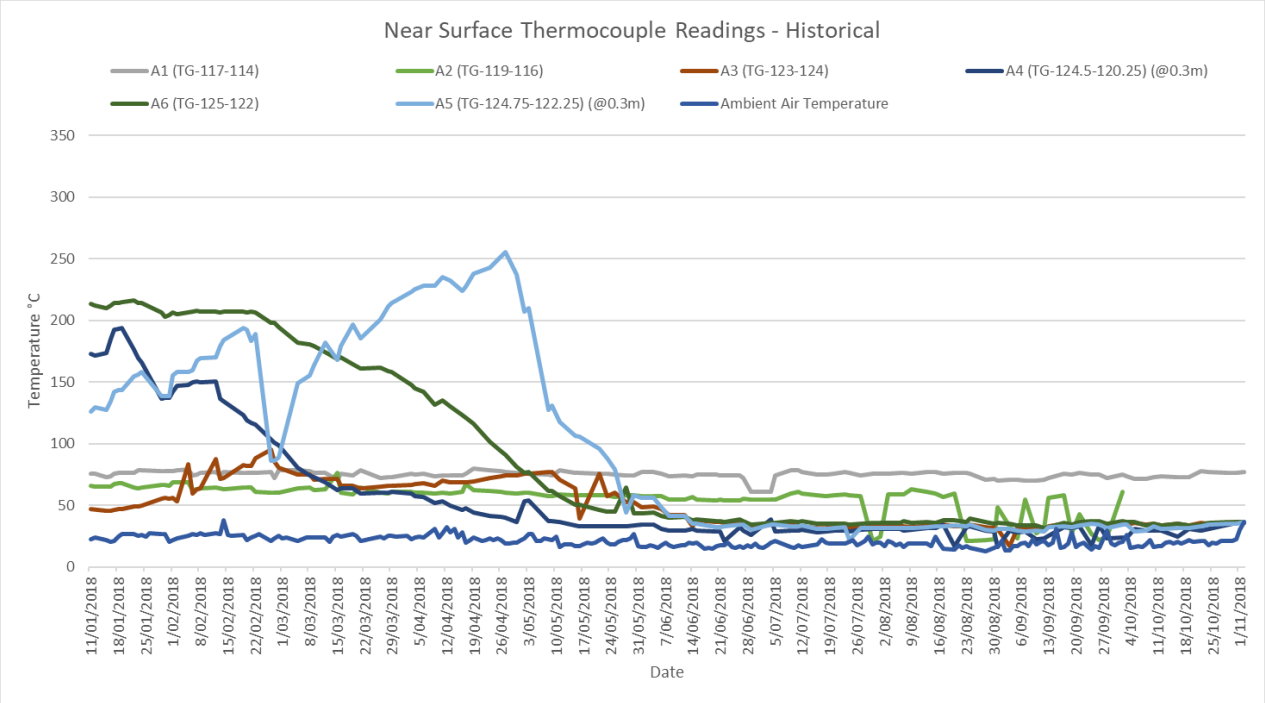
5.1 Evaluation of Surface and Near Surface Temperature Data

Prior to the placement of sand, near surface temperatures generally ranged between 40-130ºC with the highest temperatures usually recorded adjacent to the small mound directly west of the concrete pad (Reference points TA124.75-122.25 @ 0.3m depth and TA-125-122 @ 0.5m depth). Following the placement of sand across the north western hotspot in April 2018, surface and near surface (0.3m, 0.5m and 1m depth) temperatures in the hotspot area all appear to have decreased markedly and stabilised. As of 2nd November 2018, near surface temperatures at 0.5m depth in the hotspot area generally range from 20-73ºC, with the highest temperatures usually recorded on the embankment in the northern portion of the site (reference point TA-121-110-0.5m). Currently, near surface temperatures at 1m depth generally range from 35-84ºC, with the peak temperature recorded on the embankment in the northern portion of the site (reference point TA-115-116-1m).

Fluctuations in surface temperature are evident following significant rain events. Surface temperature also correlates with the ambient air temperature and the range of direct sunlight throughout the day.

Temperature isotherms have been plotted on a site map to show an illustration of the near surface temperatures in a spatial context. Refer to **Appendix B: Near Surface Temperature Isotherm Map (0.5m depth)**.

Historical data from selected near surface thermocouple monitoring points have been collated and present below in **Figure 3**.



5.2 Evaluation of Pre-existing Avopiling Thermocouple Well Monitoring Data

Greencap continue to take periodical temperature recordings from five (5) pre-existing Avopiling thermocouple monitoring wells installed across the north western and western playground areas at the site. An analysis of the average temperatures recorded over a 12-month period is presented in **Appendix C: Pre-existing Avopiling Thermocouple Well Monitoring Graph.** Average temperatures ranged between 22-39ºC. Temperatures over the period of monitoring appear to be consistent with expected background temperatures within the subsurface.

5.3 Evaluation of Subsurface Temperature Data

A total of six (6) subsurface thermocouple monitoring wells were installed in targeted locations across the north western hotspot via drill rig apparatus to the complete depth of the coal wash fill (approximately 8-10mBGL). Thermocouple sensors were affixed at various depths within each well to provide a vertical profile of subsurface temperatures.

Average subsurface temperatures within the hotspot area ranged from 22-172^{o}C, with the highest temperatures usually recorded on the embankment in the northern portion of the site (reference points TB-02 and TB-03) at depths of 7-8mBGL. Elevated temperature readings within the near surface (i.e. 1-3mBGL) were observed to be correlated with elevated temperatures at greater depths.

In order to delineate the spatial extent of the hotspot, subsurface temperature monitoring wells were installed in various areas beyond the immediate area of concern. Monitoring points TB-01, TB-04 and TB-05 were installed adjacent to the northwest hotspot towards the school boundary to the east and towards the playing fields to the west. Monitoring point TB-06 was installed immediately south of the hotspot area, within the Western Playground remediation area (Area 2).

Readings from monitoring points TB-01, TB-04 and TB-05 indicate temperatures within these locations are consistent with expected background temperatures within the subsurface. Temperatures recorded at Monitoring point TB-06 were slightly elevated, indicating some influence from radiant heat throughout the profile from the subsurface hotspot.

Refer to figures in **Appendix D: Subsurface Temperature Monitoring Graph** for location-specific subsurface temperature profiles. Refer to the location of subsurface temperature monitoring points in **Appendix E: Temperature Monitoring Well Locations.**

6. Discussion

6.1 Temperature Profiling

The Near Surface Isotherm Temperature Map (**Appendix B**) indicates areas where temperatures were above those considered to be general background (i.e. temperatures above 30^{o}C). The temperatures at the near surface and within the subsurface may be variable across the hotspot due to inconsistencies in the consolidation and compaction of the subsurface fill material.

6.2 Field Observations

During the installation of Subsurface temperature monitoring wells, Greencap consultants logged relevant information into bore-log worksheets (**Appendix G: Site Plan and Borehole Logs**). Field consultants logged visual and olfactory indications of active combustion processes within the coal wash fill material. Subsurface materials at various depths were screened with the use of hand-held heat sensing equipment. Multi-RAE gas detectors were used to 'spot-check' air quality parameters to determine the extent of atmospheric pollutants (gases) within the vicinity of the subsurface investigation areas during geotechnical and thermocouple installation works.

Visual and olfactory indicators of combustion (fumes and combustion odour) were noted at TB-02, TB-03 and TB-07 through the profile during drilling and installation. These indicators were in correlation with elevated temperature readings recorded during field screening by a hand-held infrared temperature thermometer. These observations and data were in line with the elevated subsurface temperatures recorded from thermocouples over several days of monitoring.

6.3 Sampling Limitations

This report presents findings from monitoring locations installed at representative locations, as well as data obtained from features from previous investigation and remediation activities at the site (such as pre-existing Avopiling temperature monitoring wells in the Western Playground area, Area 2).

The monitoring network used for this investigation is considered sufficient for the purpose of this investigation. It should be noted that, increased monitoring density may be required for the validation stage during and/or after the planned remediation works.

6.4 Reliance on Additional Data

This report is to be read in conjunction with the environmental investigation reports developed for the site and is to be used for guidance purposes only. The RAP will encompass the findings of the environmental investigations addressing land contamination and geotechnical aspects.

From previous experience with subsurface hotspots and combustion, the successful treatment and remediation of such sites is largely due to the adoption of a careful methodical approach which includes gathering data prior to treatment, assessing potential treatment techniques and ongoing monitoring to measure the effectiveness of the chosen remediation strategy.

7. References

New Environment (2001), *Preliminary Site Assessment Cringila Public School,* Report No. 3484/1/ESR, Date of Report: 22 June 2001.

NSW Department of Education

Near Surface Temperature Report – Historical Data Review

Cringila Public School, 35 Sheffield Street, Cringila NSW 2502

Appendix A: Project Progress Chart

Year		2017						2018																				Status
Task Description		**Oct – Nov**				**Dec**		**Jan - Feb**				**Mar - Apr**				**May - Jun**				**Jul - Aug**				**Sep – Oct**				
Week		*1-2*	*3-4*	*5-6*	*7-8*	*1-2*	*3-4*	*1-2*	*3-4*	*5-6*	*7-8*	*1-2*	*3-4*	*5-6*	*7-8*	*1-2*	*3-4*	*5-6*	*7-8*	*1-2*	*3-4*	*5-6*	*7-8*	*1-2*	*3-4*	*5-6*	*7-8*	
Stage 1	Initial Site Inspection																											Complete
	Review of Site History																											Complete
Stage 2	Surface & near surface Temp Profiling																											Complete
	Data Evaluation																											Complete
	Existing Thermocouple Well Monitoring																											On-going
Stage 3	Targeted near surface temp profiling																											Complete
	Data Evaluation																											Complete
Stage 4	Risk Log																											Complete
	Site clean-up and make safe works																											Complete
	Community Consultation																											On-going
Stage 5	Preliminary Site Investigations																											Complete
	Continuation of site Inspections																											On-going
Stage 6	Subsurface Temperature Profiling																											On-going
	Data Evaluation																											Complete
	Provide Temperature Investigation Report																											Complete

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Appendix B: Temperature Profile - Isotherm Map (0.5m depth)

CRINGILA HOTSPOT

NEAR SURFACE ISOTHERM MAP (0.5M)

N

LEGEND

- Thermocouple Monitoring Point (0.5m)
- Fencing
- Residential Boundary
- Previous Remediation Line
- Sand Coverage Area
- >30°C

>40°

>60°

>70°

Scale (m)

0 1 2 3 4 5

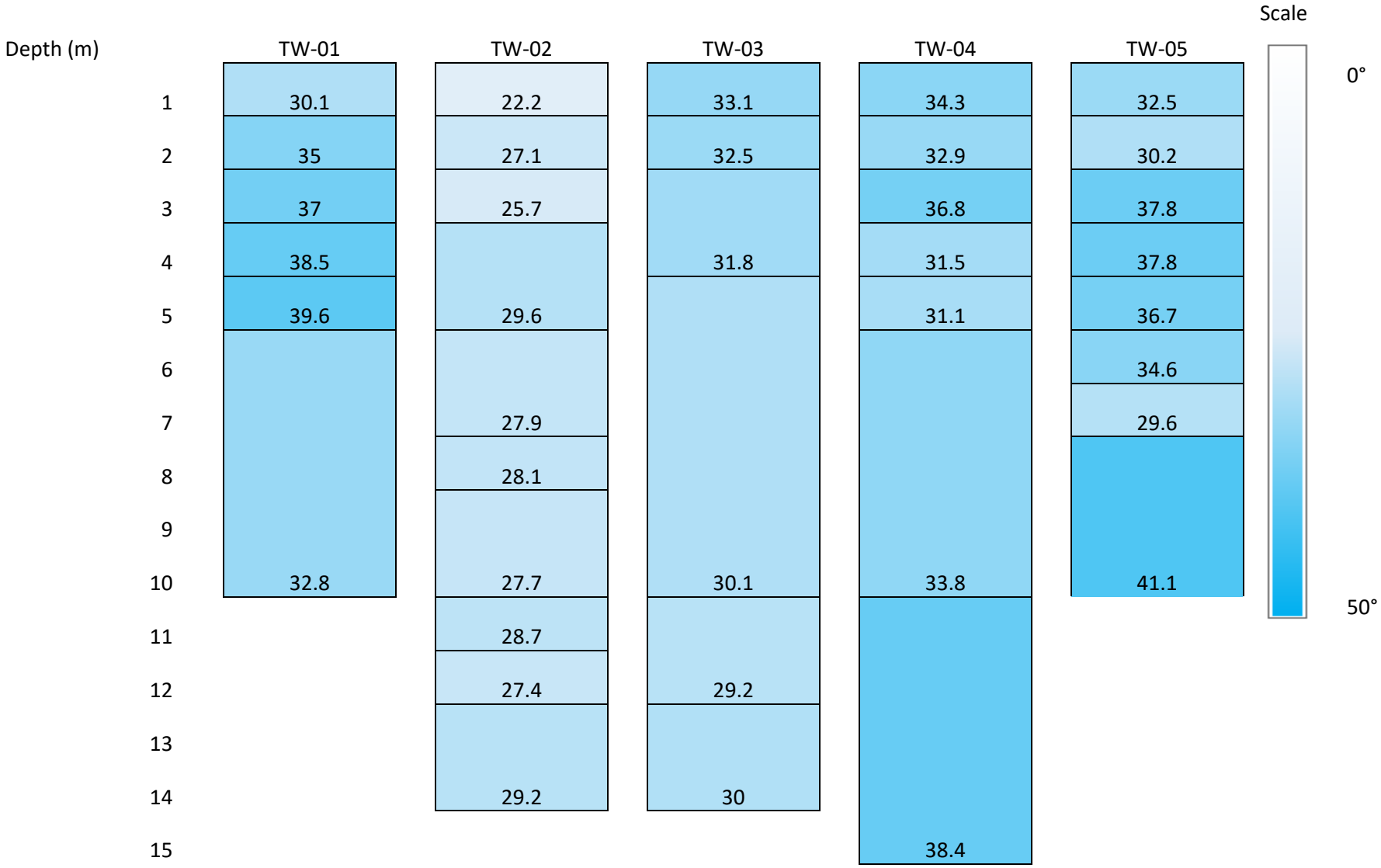
NSW Department of Education

Near Surface Temperature Report – Historical Data Review

Cringila Public School, 35 Sheffield Street, Cringila NSW 2502

Appendix C: Pre-existing Avopiling Thermocouple Well Graph

Appendix C – Pre-existing Avopiling Thermocouple Well Monitoring Graph (Averages)



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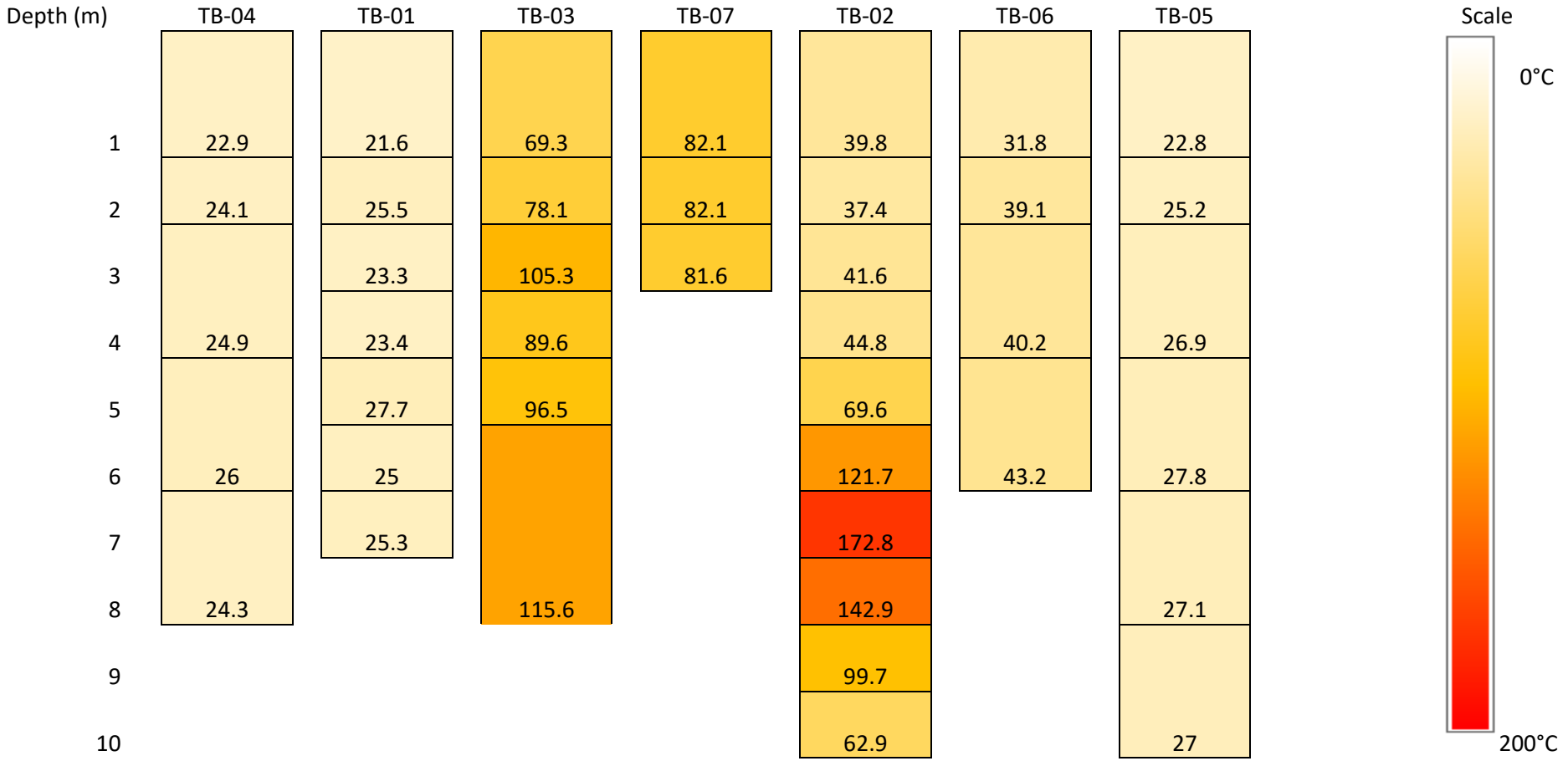
Cringila Public School, 35 Sheffield Street, Cringila NSW 2502

Appendix D: Subsurface Temperature Monitoring Graph

Appendix D – Subsurface Temperature Well Monitoring Graph (Averages)



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Cringila Public School, 35 Sheffield Street, Cringila NSW 2502

Appendix E: Temperature Monitoring Well Locations


Legend:
Thermocouples installed October 2018
Thermocouple wells installed after previous remediation
Current hotspot area
Previously remediated area
TB-07
TB-03
TB-01
TB-05
TB-02
TW-02
TW-01
TB-06
TB-04
TW-03
TW-04
TW-05
N

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Appendix F: Field Photograph Log

Photo 1. Initial Site Assessment – 31st October 2017 – Area of Concrete Pad

Photo 2. Initial Site Assessment – 31st October 2017 – Area of Concrete Pad

Photo 3. Initial Site Assessment – 31st October 2017 – Area of Concrete Pad covered with wet sand

Photo 4. Initial Site Assessment – 31st October 2017 – Area of Concrete Pad covered with wet sand

Photo 5. Hand-held Temperature Probe – Near Surface (0.3m epth) –November 2017 – internal northern fence line

Photo 6. Hand-held Temperature Probe – Near Surface – November 2017 – internal northern fence line

Photo 7. Construction and Installation of Thermocouples - (0.3m depth) –November 2017

Photo 8. Monitoring of Thermocouples - (0.3m depth) – internal northern fence line

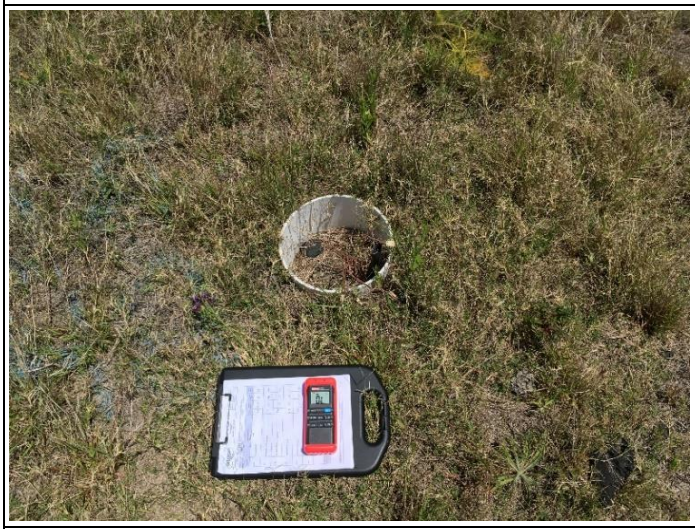

Photo 9. Monitoring of pre-existing Avopiling Thermocouple Wells –Western Playground area

Photo 10. Placement of Sand across area of concern – April 2018

Photo 11. Placement of Sand across area of concern – April 2018

Photo 12. Ongoing near surface temperature monitoring across area of concern – April 2018

	
Photo 13. Geotechnical investigation and Installation of Subsurface Thermocouples – October 2018	**Photo 14.** Installation and Monitoring of Subsurface Thermocouples – October 2018

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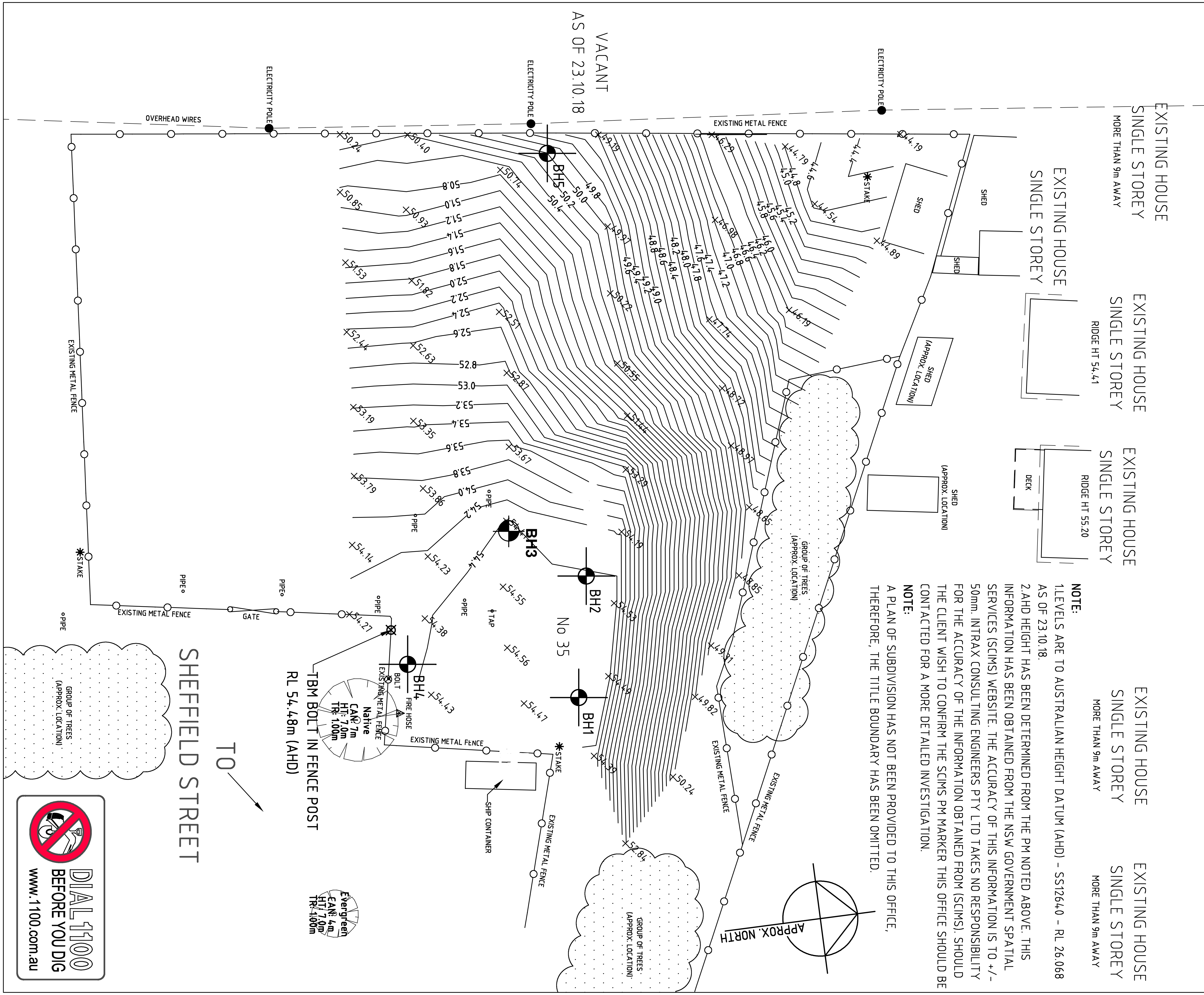
Appendix G: Site Plan and Borehole Logs



Ver.	Remark/Comment	Date:	Appr.
A	ORIGINAL SURVEY	23.10.18	

CHECK BEARINGS & DISTANCES WITH A CLEAR COPY OF TITLE

LEVELS ARE TO AHD
200mm CONTOUR INTERVAL

THIS IS NOT A BOUNDARY IDENTIFICATION SURVEY

THE TITLE FOR THIS PLAN HAS BEEN COMPILED USING PLANS SUPPLIED BY THE CLIENT. IN MOST CASES THESE ARE PRELIMINARY SUBDIVISION PLANS. FINAL APPROVED PLANS WILL SHOW ANY CHANGES TO TITLE DIMENSIONS AND EASEMENTS. AS CHANGES BETWEEN PRELIMINARY AND FINAL APPROVED PLANS ARE COMMON, THE DIMENSIONS AND EASEMENTS MUST BE VERIFIED WITH APPROVED PLANS OF SUBDIVISION BEFORE ISSUING PLANS FOR CONSTRUCTION.

Title: DETAILED FEATURE SURVEY

Client: GREENCAP PTY LTD

Address:
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Field: A.W.	Drawn: Z.Z.
Date: 23.10.18	Scale: 1:300 @ A3
Job Number: 117755	Checked: / Version: A

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Borehole Log:	**BH1**	**Sheet:**	**1 of 1**
Client:	Greencap	Drill Rig:	Geoprobe 7822 DT
Project:	Coal Embankment	Logged:	RS
Location:	35 Sheffield Street, Cringila, NSW	Date:	18/10/2018

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Method	Depth (metres)	DCP blows count	Material Description	Soil Classification	Moisture	Consistency / Density	Structure, Origin, Water and Additional Observations	Disturbed Samples (D)
MA		SP	SAND, fine to medium grained, pale grey, some grass rootlets				FILL	
			COAL Wash					SPT at 0.5m - 3,2,2 N=4
	1.00							
	2.00							SPT at 2.0m - 2,3,3 N=6
	3.00							SPT at 3.5m - 4,3,3 N=6
	4.00							
	5.00							SPT at 5.0m - 2,2,2 N=4
	6.00							SPT at 6.5m - 5,4,2 N=6
	7.00		CLAY, medium plasticity, green mottled grey, trace of fine to medium gravel and sand				ALLUVIUM	
	8.00		Latite, extremelly weathered, fine to medium grained grey				ROCK	SPT at 8.0m +15b N>15
			Groundwater was not encountered BH1 terminated at 8.1m depth					
	9.00							
	10.00							

This borehole log is to be read in conjunction with the explanatory notes appended to the set of logs. This borehole log is not be reproduced without the full inclusion of all explanatory notes.

Borehole Log:	**BH2**	**Sheet:**	**1 of 2**
Client:	Greencap	Drill Rig:	Geoprobe 7822 DT
Project:	Coal Embankment	Logged:	RS
Location:	35 Sheffield Street, Cringila, NSW	Date:	18/10/2018

Intrax Engineering Confidence — Civil, Forensic, Hydraulic, Structural, Surveying, Residential, Geotechnical, Building Services

Method	Depth (metres)	DCP blows count	Material Description	Soil Classification	Moisture	Consistency / Density	Structure, Origin, Water and Additional Observations	Disturbed Samples (D)
		SP	SAND, fine to medium grained, pale grey, some grass rootlets	SP	M		FILL	
			COAL Wash					SPT at 0.5m - 0,0,0 N=0
	1.00							
	2.00							SPT at 2.0m - 3,4,5 N=9
	3.00							
								SPT at 3.5m - 2,2,3 N=5
	4.00							
MA	5.00							
	6.00							
	7.00							
	8.00							
	9.00							
	10.00		Continue on page 2					

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Borehole Log:	**BH2**	**Sheet:**	**2 of 2**
Client:	Greencap	Drill Rig:	Geoprobe 7822 DT
Project:	Coal Embankment	Logged:	RS
Location:	35 Sheffield Street, Cringila, NSW	Date:	18/10/2018

Intrax Engineering Confidence — Civil, Forensic, Hydraulic, Structural, Surveying, Residential, Geotechnical, Building Services

Method	Depth (metres)	DCP blows count	Material Description	Soil Classification	Moisture	Consistency / Density	Structure, Origin, Water and Additional Observations	Disturbed Samples (D)
MA		SP	CLAY, medium plasticity, green mottled grey, trace of fine to medium gravel and sand	Cl	>PL	Vst	ALLUVIUM	
	10.50		Groundwater was not encountered BH2 terminated at 10.5m depth					
	11.50							
	12.50							
	13.50							
	14.50							
	15.50							
	16.50							
	17.50							
	18.50							
	19.50							

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Borehole Log:	**BH3**	**Sheet:**	**1 of 2**
Client:	Greencap	Drill Rig:	Geoprobe 7822 DT
Project:	Coal Embankment	Logged:	RS
Location:	35 Sheffield Street, Cringila, NSW	Date:	18/10/2018

Intrax Engineering Confidence — Civil, Forensic, Hydraulic, Structural, Surveying, Residential, Geotechnical, Building Services

Method	Depth (metres)	DCP blows count	Material Description	Soil Classification	Moisture	Consistency / Density	Structure, Origin, Water and Additional Observations	Disturbed Samples (D)
		SP	SAND, fine to medium grained, pale grey, some grass rootlets	SP	M		FILL	
			COAL Wash and Slag with some concrete pieces at 1.8m depth					SPT at 0.5m - 1,1,1 N=2
	1.00							
	2.00							SPT at 2.0m - 0,1,1 N=2
	3.00							
								SPT at 3.5m - 1,3,1 N=4
	4.00							
MA	5.00							SPT at 5.0m - 2,1,2 N=3
	6.00							
								SPT at 6.5m - 2,1,3 N=4
	7.00							
	8.00							SPT at 8.0m - 5,4,5 N=9
	9.00							
	10.00		Continue on page 2					

This borehole log is to be read in conjunction with the explanatory notes appended to the set of logs. This borehole log is not be reproduced without the full inclusion of all explanatory notes.

Borehole Log: BH3 **Sheet:** 2 of 2
Client: Greencap Drill Rig: Geoprobe 7822 DT
Project: Coal Embankment Logged: RS
Location: 35 Sheffield Street, Cringila, NSW Date: 18/10/2018

Intrax Engineering Confidence
Civil Forensic Hydraulic Structural Surveying Residential Geotechnical Building Services

Method	Depth (metres)	DCP blows count	Material Description	Soil Classification	Moisture	Consistency / Density	Structure, Origin, Water and Additional Observations	Disturbed Samples (D)
MA		SP	CLAY, medium plasticity, green mottled grey, trace of fine to medium gravel and sand	CL/CI	>PL	Vst	ALLUVIUM	
	10.50		Latite, extremelly weathered, fine to medium grained, grey				ROCK	SPT at 10.5m +15b, N>+15
			Groundwater was not encountered BH3 terminated at 10.7m depth					
	11.50							
	12.50							
	13.50							
	14.50							
	15.50							
	16.50							
	17.50							
	18.50							
	19.50							

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Borehole Log:	**BH4**	**Sheet:**	**1 of 1**
Client:	Greencap	Drill Rig:	Geoprobe 7822 DT
Project:	Coal Embankment	Logged:	RS
Location:	35 Sheffield Street, Cringila, NSW	Date:	19/10/2018

Intrax Engineering Confidence — Civil, Forensic, Hydraulic, Structural, Surveying, Residential, Geotechnical, Building Services

Method	Depth (metres)	DCP blows count	Material Description	Soil Classification	Moisture	Consistency / Density	Structure, Origin, Water and Additional Observations	Disturbed Samples (D)
PT		SP	SAND, fine to medium grained, pale grey, some grass rootlets	SP	M		FILL	
			COAL Wash and SLAG with some broken pieces of concrete					
	1.00							
	2.00							
	3.00							
	4.00							
	5.00							
	6.00							SPT at 6.4m, 2,2,2 N=4
MA	7.00							
	8.00							SPT at 8.0m, 2,2,4 N=6
	9.00		CLAY, medium plasticity, green mottled grey, some fine to medium gravel	CI	>PL	Vst	ALLUVIUM	
			Groundwater was not encountered BH1 terminated at 8.1m depth					
	10.00							

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Borehole Log: BH5 **Sheet:** 1 of 2

Client: Greencap Drill Rig: Geoprobe 7822 DT

Project: Coal Embankment Logged: RS

Location: 35 Sheffield Street, Cringila, NSW Date: 19/10/2018

Intrax Engineering Confidence — Civil, Forensic, Hydraulic, Structural, Surveying, Residential, Geotechnical, Building Services

Method	Depth (metres)	DCP blows count	Material Description	Soil Classification	Moisture	Consistency / Density	Structure, Origin, Water and Additional Observations	Disturbed Samples (D)
MA		SP	SAND, fine to medium grained, pale grey, some grass rootlets	SP	M		FILL	
			COAL Wash and Slag with some broken pieces of concreteat 1.0m depth					SPT at 0.5m - 3,4,5 N=9
	1.00							
	2.00							SPT at 2.0m - 6,9,8 N=17
	3.00							
								SPT at 3.5m +13 N>+13
	4.00							
	5.00							SPT at 5.0m - 7,3,3 N=6
	6.00							
								SPT at 6.5m - 6,4,4 N=8
	7.00							
	8.00							
	9.00							
	10.00		Continue on page 2					

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Borehole Log:	**BH5**	**Sheet:**	**2 of 2**
Client:	Greencap	Drill Rig:	Geoprobe 7822 DT
Project:	Coal Embankment	Logged:	RS
Location:	35 Sheffield Street, Cringila, NSW	Date:	18/10/2018

Intrax Engineering Confidence
Civil Forensic Hydraulic Structural Surveying Residential Geotechnical Building Services

Method	Depth (metres)	DCP blows count	Material Description	Soil Classification	Moisture	Consistency / Density	Structure, Origin, Water and Additional Observations	Disturbed Samples (D)
MA			CLAY, medium to high plasticity, green mottled grey, trace of fine to medium gravel and sand	CI/CH	>PL	Vst	ALLUVIUM	
	10.50		Groundwater was not encountered BH5 terminated at 10.5m depth					
	11.50							
	12.50							
	13.50							
	14.50							
	15.50							
	16.50							
	17.50							
	18.50							
	19.50							

This borehole log is to be read in conjunction with the explanatory notes appended to the set of logs. This borehole log is not be reproduced without the full inclusion of all explanatory notes.

EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT LOGS

DRILLING/EXCAVATION METHOD

HA	Hand Auger	W	Washbore	PT	Push Tube
MA-	Mechanical Auger Drilling	HQ	Diamond Core - 63 mm	EX	Excavator
-V	V-Bit	NMLC	Diamond Core - 52 mm	HAD	Hollow Auger Drilling
-TC	TC-Bit, e.g. ADT	NQ	Diamond Core - 47 mm		

PENETRATION/EXCAVATION RESISTANCE

L	Low resistance. Rapid penetration possible with little effort from the equipment used.
M	Medium resistance. Excavation/possible at an acceptable rate with moderate effort from the equipment used
H	High resistance. Further penetration is possible at a slow rate and requires significant effort from the equipment
R	Refusal or Practical Refusal. No further progress possible without the risk of damage or unacceptable wear to the digging implement or machine.

These assessments are subjective and are dependent on many factors including the equipment power, weight, condition or excavation or drilling tools, and experience of the operator.

WATER

∇	Water level at date shown	$\Leftarrow$	Partial water loss
$\Rightarrow$	Water inflow	$\|\Leftarrow\|$	Complete water loss

NO	Ground Water Not Observed: Ground water obersvation not possible. Ground water may or may not be present
NE	Ground Water Not Encountered: Ground water was not evident during excavation or a short time after completion. However, groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/test pit been left open for a longer period.

SAMPLING AND TESTING

SPT	Standard Penetration Test to AS1289.6.3.1 - 2004
3,6,9 N=15	3,6,9 = blows per 150mm. N = blows per final 300mm penetration
30/80mm	Practical refusal, with blows and depth of penetration before refusal occurred
RW	Penetration caused under rod weight only
HW	Penetration caused under hammer and rod weight only
HB	Hammer bounce without penetration
R	Refusal to test
DCP	Dynamic Cone Penetrometer Test to AS1289.6.3.2 - 1997
DCP (p)	Dynamic Cone Penetrometer Test to AS1289.6.3.3 - 1997 Perth Sand Penetrometer
6	6 = blows per 100mm of penetration

DS	Disturbed sample
BDS	Bulk disturbed sample
U63	Undisturbed thin wall push tube sample, nominal sample diameter denoted in millimetres
W	Water sample
G	Gas sample
V	pilcon shear vane (kPa)
PP	Pocket penetrometer (kPa)
FP	Field permeability test over section noted
ES	Environmental sample
PI	Plastic Index (%)
PL	Plastic Limit (%)
LL	Liquid Limit (%)
MC	Moisture Content (%)
CBR	Californian Bearing Ration (%)

ROCK CORE RECOVERY

TCR = Total Core Recovery (%)

$$= \frac{Length\ of\ core\ recovered}{Length\ of\ core\ run} \times 100$$

RQD = Rock Quality Designation (%)

$$= \frac{\sum Axial\ lengths\ of\ core > 100\ mm}{Length\ of\ core\ run} \times 100$$

EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT LOGS - SOIL DESCRIPTION (AS1726 - 2017)

SOIL CLASSIFICATION SYSTEM

Coarse Grained Soil

- **GW** Well graded gravels, gravel-sand mixtures, little or no fines
- **GP** Poorly-graded gravels, gravel-sand mixtures, little or no fines, uniform gravels
- **GM** Silty gravels, gravel-sand-silt mixtures
- **GC** Clayey gravels, gravel-sand-clay mixtures
- **SW** Well-graded sands, gravelly sands, little or no fines
- **SP** Poorly-graded sands, gravelly sand, little or no fines
- **SM** Silty sands, sand-silt mixtures
- **SC** Clayey sands, sand-clay mixtures

Fine Grained Soils

- **ML** Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or silts with low plasticity
- **CL, CI** Inorganic clays of low to medium plasticity, gravelly clays, sandy clays
- **OL** Organic silts and organic silty clays of low plasticity
- **MH** Inorganic silts, micaceous or diatomaceous fine sand for silty soils
- **CH** Inorganic clays of high plasticity
- **OH** Organic clays of medium to high plasticity, organic silts
- **PT** Peat, humus, swamp soils with high organic contents

First Letter: G = Gravel, S = Sand, M = Silt, C = Clay; Second Letter: W = Well-graded, P = Poorly-graded, M = Mixture, O = Organic, L = Low plasticity, H = High plasticity

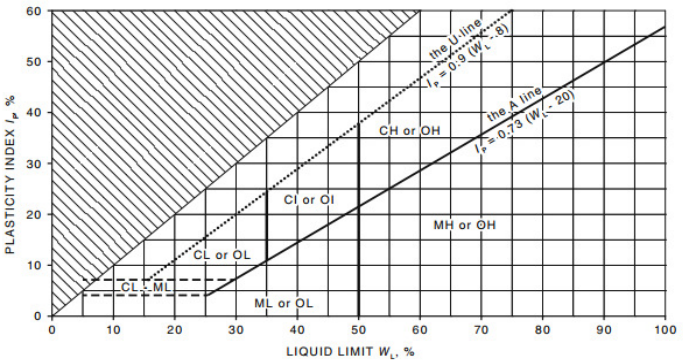
Soils may be a combination of multiple soil classifications where borderline

PARTICLE SIZE

Soil	Major Division	Sub-Division	Particle Size (mm)
Coarse	Boulders		>200
	Cobbles		63 - 200
	Gravel	Coarse	20 - 63
		Medium	6 - 20
		Fine	2.36 - 6
	Sand	Coarse	0.6 - 2.36
		Medium	0.2 - 0.6
		Fine	0.075 - 0.2
Fine	Silt		0.002 - 0.075
	Clay		< 0.002

0.075mm is the approximate minimum particle size discernible by eye

PLASTICITY CHART



MOISTURE CONDITION

Coarse	D	Dry	Sands and gravels are free flowing.
	M	Moist	Soils are darker than in the dry condition and may feel cool. Sands and gravels tend to cohere.
	W	Wet	Soils exude free water. Sands and gravels tend to cohere.
Fine	PL	Plastic Limit	Moisture content of fine grain soils are described; as below plastic limit (<PL), near to plastic limit (=PL), above plastic limit (>PL), near to the liquid limit (=LL), or above the liquid limit (>LL)
	LL	Liquid Limit	

CONSISTENCY AND DENSITY

Fine Grained Soils

			Pocket Pentrometer Reading (kPa)
VS	Very Soft	Exudes between fingers when squeezed	<25
S	Soft	Can be moulded by light finger pressure	20 - 50
F	Firm	Can be moulded by strong finger pressure	50 - 100
St	Stiff	Cannot be moulded by fingers. Can be indented by thumb	100 - 200
VSt	Very Stiff	Can be indented by thumb nail	200 - 400
H	Hard	Can be indented by thumb nail with difficulty	>400

Coarse Grained Soil

		Density Index %	'N' Value
VL	Very Loose	≤15	0 - 4
L	Loose	15 - 35	4 - 10
MD	Medium Dense	35 - 65	10 - 30
D	Dense	65 - 85	30 - 50
VD	Very Dense	>85	>50

SECONDARY OR MINOR SOIL COMPONENTS

Designation of components	In coarse grained soils				In fine grained soils	
	%Fines	Terminology	%Accessory Coarse Fraction	Terminology	%Sand/gravel	Terminology
Minor	≤5	'trace' clay/silt	≤15	'trace' sand/gravel	≤15	'trace' sand/gravel
	5 - 12	'with' clay/silt	15 - 30	'with' sand/gravel	15 - 30	'with' sand/gravel
Secondary	> 15	Prefix silty or clayey	>30	Prefix sandy or gravelly	>30	Prefix sandy or gravelly

EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT LOGS - ROCK DESCRIPTION (AS1726 - 2017)

STRENGTH OF INTACT ROCK

Symbol	Term	Point Load Index, (I_{s50}) MPa	Field Guide to Strength
VL	Very Low	$0.03 \le I_{s50} < 0.1$	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; pieces up to 30mm thick can be broken by finger pressure
L	Low	$0.1 \le I_{s50} < 0.3$	Easily scored with knife; indentations 1mm to 3mm after firm blow with pick point; core 150mm long and 50mm diameter can be broken by hand; sharp edges of core friable
M	Medium	$0.3 \le I_{s50} < 1.0$	Readily scored with knife; core 150mm long and 50mm diameter can be broken by hand with difficulty
H	High	$1.0 \le I_{s50} < 3$	Core 150mm long and 50mm diameter cannot be broken by hand but can be broken by single firm blow of pick; rock rings under hammer
VH	Very High	$3 \le I_{s50} < 10$	Hand held specimen breaks with pick after more than one blow; rock rings under hammer
EH	Extremely High	$10 \le I_{s50}$	Specimen requires many pick blows to break intact rock, rock rings under hammer

Material with rock strength less than 'Very Low' are described using soil properties

DEGREE OF ROCK WEATHERING

Term		Symbol		Definition
Residual Soil		RS		Soil derived from the weathering of rock; the mass structure and material fabric are no longer evident the soil has not been significantly transported.
Extremely Weathered		XW		Material is weathered to such an extent that it has soil properties, i.e. it either disintegrates or can be remoulded, in water. Fabric of original rock still visible.
Highly Weathered	Distinctly Weathered	HW	DW	Rock strength is changed by weathering. 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 recognizable. Some minerals are decomposed to clay minerals. Porosity may be increased by leach, 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 slightly discoloured but shows little or no change of strength from fresh rock
Fresh		FR		Rock shows no sign of decomposition or staining

Distinctly Weathered is to be used when it is not possible to differentiate between highly and moderately weathered.

Extremely Weathered material is to be described using soil properties

ROCK MASS PROPERTIES

Term	Separation of Stratification Planes
Thinly laminated	< 6mm
Laminated	6mm to 20 mm
Very thinly bedded	20mm to 60mm
Thinly bedded	60mm to 200mm
Medium bedded	0.2m to 0.6m
Thickly bedded	0.6m to 2.0m
Massive	< 2m

Term	Description
Fragmented	Primarily fragments < 20mm length and mostly of width < core diameter
Highly fractured	Core lengths generally less than 20mm to 40mm with occasional fragments
Fractured	Core lengths mainly 30mm to 100mm with occasional shorter and longer pieces
Slightly fractured	Core lengths generally 0.3m to 1.0m with occasional longer and shorter sections
Unbroken	Core has no fractures

DEFECT TYPES AND DESCRIPTIONS

Defect Type		Defect Shape		Surface Roughness		Defect Coatings	
BR	Bedding parting	PL	Planar	VR	Very rough	CL	Clean
JT	Joint	ST	Stepped	RO	Rough	ST	Stained
SR	Sheared surface	CR	Curved	SM	Smooth	VN	Veneer
SZ	Sheared zone	IR	Irregular	PO	Polished	CT	Coating
SS	Sheared seam	UN	Undulating	SL	Slickenside		
CS	Crushed seam						
IS	Infill seam						
XS	Extremely Weathered Seam						

Vertical Boreholes - The dip of the defect is given from the horizontal

Inclined Boreholes - The angle of the defect is given from the core axis