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REPORT ON GEOTECHNICAL SITE INVESTIGATION

for

PROPOSED NEW TEACHING BLOCK

at

THE KINGS SCHOOL, 87-129 PENNANT HILLS ROAD, NORTH PARRAMATTA, NSW

Prepared For

The Kings School

Project No.: 2022-155

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TABLE OF CONTENTS

APPENDICES

1 Notes Relating to this Report

2 Figure 1 and Figure 2 – Site Plan

Borehole Log sheets and Dynamic Penetrometer Test Results

3 Laboratory Test Results

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PROPOSED DEVELOPMENT EXECUTIVE SUMMARY

This State Significant Development Application (SSDA) seeks consent for the staged redevelopment of The King's School, including:

- **Concept Proposal for the provision of new and upgraded facilities, including:**
  - Building envelope for a new Sports Pavilion within the western sports field precinct (subject to further detailed approval).
  - Building envelope for a new Boarding House within the northern residential precinct to the north of the Doyle Sports Fields and adjacent building envelope for Staff Quarters (subject to further detailed approval).
  - Building envelope for a new Day Boy House between Dalmas House and Burkitt House, including the associated relocation of Ryrie Road (subject to further detailed approval).
  - Earthworks and the associated demolition of existing buildings and structures, and removal of trees and landscaping.
  - Staged increase in staff and student numbers.
  - Detailed Stage 1 works (as outlined below).
- **Detailed Stage 1 works, including:**
  - Earthworks and the associated demolition and existing buildings and structures.
  - Traffic upgrade works including the construction of a new vehicular entrance into the site from Masons Drive, new drop-off pick up facilities, internal access roads and increased car parking and bus parking.
  - The construction of a new Staff Residence Building comprising residences for staff and their families within the Senior School Boarding Precinct.
  - The construction of a new building for Science, Technology, Engineering, Arts and Maths (the 'STEAM building') within the Senior School and associated landscaping.
  - The staged construction of new buildings required to upgrade the Preparatory School, including:
    - Construction of a new Performing Arts and Music Centre comprising a dedicated performance space and music practice rooms to the northwest of Horrocks Road.

    - Construction of a new General Learning Unit building comprising additional classrooms / general learning spaces adjacent to the existing dam.
    - Upgrades to pedestrian access throughout the school.
    - Staged increase in staff and student numbers.
- The removal and replacement of trees and associated landscaping.

This Geotechnical Report is concerned with the proposed new STEAM Building and Crozier Geotechnical Consultants (CGC) has not undertaken geotechnical investigations for any others element of the site developments.

1. INTRODUCTION:

This report details the results of a geotechnical investigation carried out for a proposed new teaching block at The Kings School, 87-129 Pennant Hills Road, North Parramatta, NSW. The investigation was undertaken by Crozier Geotechnical Consultants (CGC) at the request of TSA Project Management on behalf of the client The Kings School.

The geotechnical investigation and reporting requested by the client is required to support the State Significant Development Application (SSDA) and for use in the design and construction works. A fee proposal (Fee Proposal P22-248, Dated: 9 May 2022) was submitted to the client and subsequently accepted to undertake the nominated scope.

This investigation comprised:

a) A DBYD Plan review and on-site clearance of test locations by an accredited service clearance contractor
b) Geotechnical inspection and mapping of the site and adjacent properties by a Senior Engineering Geologist.
c) A photographic record of existing site conditions.
d) Geotechnical boreholes and in situ site testing.
e) Geotechnical/Chemical laboratory testing in NATA accredited laboratories.

The geotechnical investigation was undertaken in conjunction with a geo-environmental investigation by EBG Environmental Consultants, the results of which are presented in a separate report by EBG.

The following documents were supplied and relied upon for the preparation of the proposal, investigation and reporting:

For Tender Purposes:

- Request for Proposal from TSA Management, Dated: 27 April 2022

Following Award:

- Summary Concept Design, STEAM Building, Dated 5.27.2022

Following Submission of Draft Report

- Survey Plan – Rygate Surveyors, Reference No.: 79725, Rev A, Date: 16/09/21
- Architectural Drawings – BVN Architects, Project No.: 2108012, Drawings: AR-DA-10B 00-00 to AR-DA10B 03-00 (4 drawings), AR-DA-10C XX-01 and 02, AR-DA-10D-XX-01 and 02 and AR-53B 00-00, 01-00 and 02-00.

2. PROPOSED DEVELOPMENT:

Based on the information provided it is understood the works are to comprise the construction of a three-storey teaching block (STEAM Building) which will require excavation to approximately 3.0m depth underlying the south end of the proposed structure reducing towards the north.

3. SITE FEATURES:

3.1. Location, Topography and Description:

The site of the Kings School is irregular in shape and covers an area of approximately 115 hectares in plan as determined from the provided tender documentation. The location of the proposed new teaching block (STEAM) is located within the east of the school grounds and occupies an area of approximately 1300m^2.

Based on the provided survey drawing the ground surface underlying the proposed STEAM block ranges between a high of approximately RL81.2m and a low of RL78.1m For the purposes of this report, the site is defined as the footprint of proposed STEAM building, an aerial view of both the location of the grounds of the school and the proposed STEAM building is provided in Photograph 1.

Photograph 1: Aerial view of the Kings School grounds (outlined red) and the location of the proposed new teaching block (highlighted yellow)

The site is located within a grassed playing field to the west of Russell Road and approximately 45m from the east boundary of the Kings School grounds. Teaching blocks/workshops lie to the north, south and west of the site with a car park to the east.

To the north and south of the site, gentle north sloping batter slopes are present. The wider topography of the area slopes away from a topographic high broadly within the location of Pennant Hills Road approximately 300m to the south of the site. The topography of the wider area is shown on Extract 1.

Extract 1: Extract from OpenStreetMap with site location indicated (circled black)

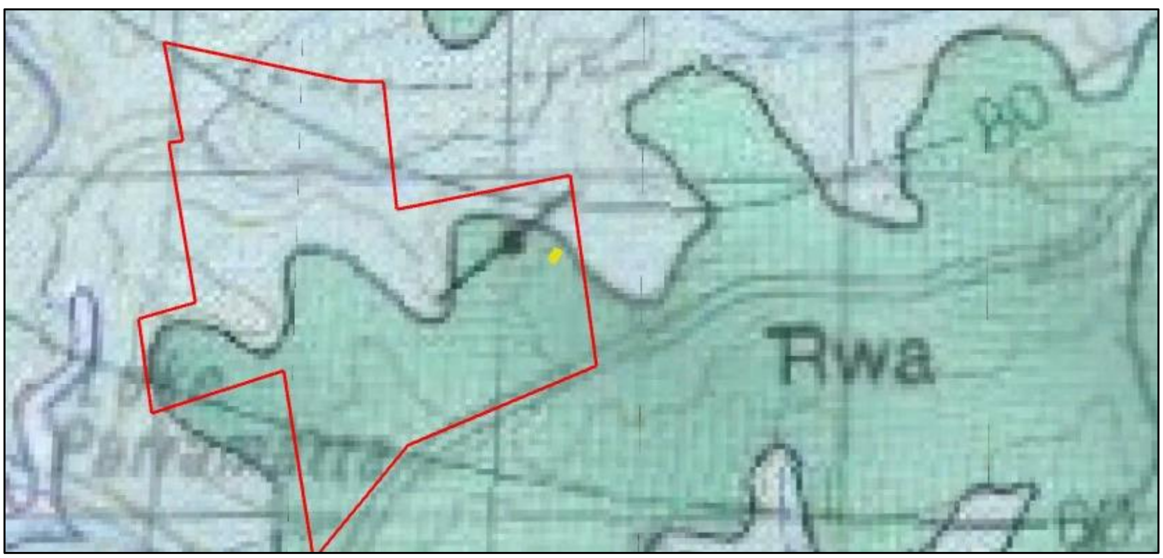
General views of the site and surrounding area are provided in Photographs 2 and 3.


Photograph 2: View of the location of the proposed STEAM building looking broadly north

Photograph 3: View of the site looking broadly south

3.2. Geology:

Reference to the Penrith 1:100,000 Geological Series sheet (9030) indicates that the site is in an area underlain by deposits of the Wianamatta Group Shales (Rwa). This rock unit generally comprises an interbedded sequence of shale and laminite which are prone to weather at the surface to clays of medium to high plasticity.

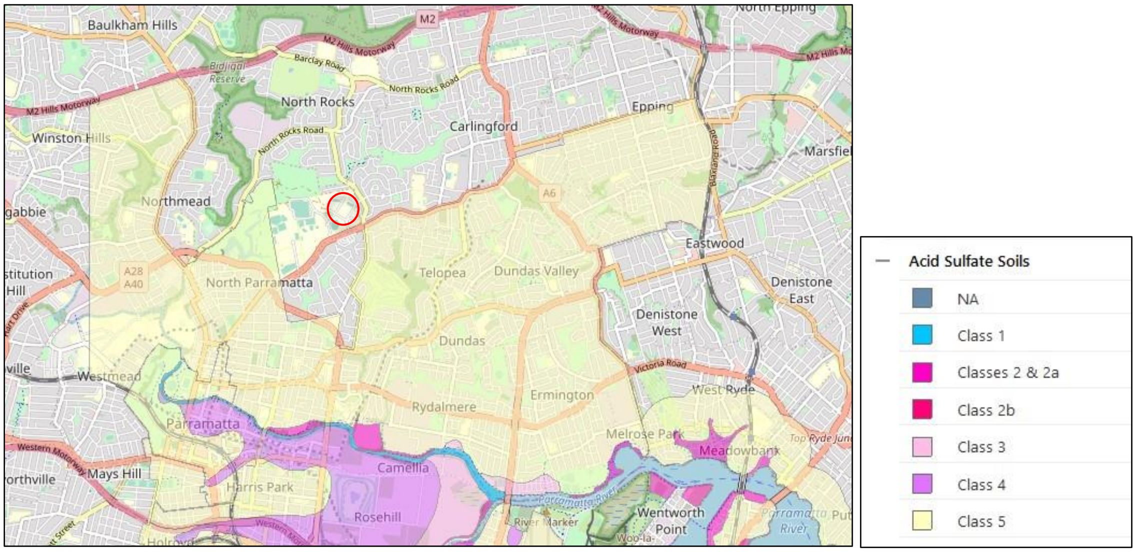


Extract 2: Extract from the 9130 Sydney Series sheet with school grounds (outlined red) and location of the proposed STEAM building (highlighted yellow) indicated.

The Hawkesbury Sandstone is shown to the north of the site however the boundaries should be considered approximate at a 1:100,000 scale.

3.3 Acid Sulphate Soils

Reference to the NSW Government spatial data website (SEED mapping tool) indicates that the site does not lie within an Acid Sulphate Soils Class 1 to 5. An extract of the SEED map with the ASS occurrence layer overlain is provided as Extract 3.



Extract 3: Extract from the NSW Government SEED mapping tool showing ASS in relation to the approximate site location (circled red)

3.4 Salinity

Reference to the NSW Government spatial data website (SEED mapping tool) indicates that the site lies within an area of moderate salinity potential near the boundary of a very low salinity potential area. An extract of the SEED map with the salinity potential layer overlain is provided as Extract 4.

Extract 4: Extract from the NSW Government SEED mapping tool showing Salinity Potential in relation to the approximate site location (circled red)

4. FIELD WORK:

4.1. Methods:

The field investigation comprised a walk over inspection of the site and a subsurface investigation, both of which were supervised/undertaken on the 14 July 2022 by a Senior Engineering Geologist.

The walk over inspection comprised geological/geomorphological field mapping and observation of structures/conditions within and adjacent to the site to assess topography, slopes and existing structures. The inspection was restricted to observations made from the ground surface of the site or adjacent, accessible land. Photographs of relevant observations were taken for inclusion in the report and to allow the creation of a photographic record to be made prior to commencement of construction works within the site.

The sub-surface investigation comprised the drilling of four boreholes (BH1 to BH4) using a restricted access rubber tyred drill rig operating spiral flight augers in conjunction with a tungsten carbide bit.

Logging was undertaken in accordance with AS1726:2017 'Geotechnical Site Investigations' and small disturbed, samples were retrieved from the boreholes and select samples were subsequently submitted to NATA accredited geotechnical/chemical testing laboratories.

DCP testing was carried out from ground surface adjacent to the boreholes in accordance with AS1289.6.3.2 – 1997, "Determination of the penetration resistance of a soil – 9kg Dynamic Cone Penetrometer".

Prior to commencement of the intrusive works the test locations were cleared by an accredited underground services location contractor.

On completion, all boreholes were backfilled with arisings and surface compacted.

Test locations were positioned by measurement from existing site features.

Explanatory notes are included in Appendix: 1. Mapping information and test locations are shown on Figure: 1, a geological cross section is provided as Figure 2, along with detailed Borehole Log sheets and Dynamic Penetrometer Test Sheets in Appendix: 2. Geotechnical and Chemical laboratory test results are provided in Appendix: 3 when they become available.

4.2 Ground Conditions:

For a description of the subsurface conditions encountered at the test locations, the Borehole Log Reports and Dynamic Penetrometer Test Sheets should be consulted, however a very broad description is provided below.

Unit	Strata Description
FILL	Fill comprising gravelly clay of varying colours including dark brown, red brown, grey and orange was encountered in all boreholes to a maximum depth of 1.9m (BH3). Within BH2 possible fill was encountered to 0.75m depth where auger refusal was encountered. The obstruction may represent a boulder within the fill or bedrock. In general, the fill appeared to increase in thickness towards the north. The fill retrieved from the boreholes did not contain any man-made, deleterious material and the fill resembled the natural site soils indicating it likely represents site won, reworked soil.
CLAY (Residual Soil)	This deposit was encountered in all the boreholes underlying the fill (with the possible exception of BH2) and comprised stiff to hard red brown, locally orange and grey high plasticity clay which is interpreted as representing a residual soil. The deposit extended to 2.7m, 3.5m and 3.3m in BH1, BH3 and BH4 respectively. The boundary between the residual clay soil and weathered bedrock appeared gradational and should be considered approximate.
SHALE (Wianamatta Group Shales)	This deposit was encountered in all the boreholes (with the possible exception of BH2) and comprised very low to low to medium strength shale. BH1, BH3 and BH4 refused within low to medium strength bedrock at depths of 4.0m, 3.9m and 3.9m respectively. BH2 refused at 0.75m depth within either bedrock or a boulder within the fill.

A free-standing ground water table or significant water seepage were not identified within any of the boreholes or observed on the DCP rods on extraction.

4.3 Field Mapping/Walkover

The walkover inspection of the site and surrounding area did not identify any obvious geotechnical constraints to the development. No significant cracking, settlement, or movement was observed within the structures adjacent to the proposed new teaching block. Some cracking was observed within a walkway to the west of the site however it is not considered to represent a geotechnical issue. (See Photograph 4).

Photograph 4: Views of the cracking in an access ramp to the west of the site

Signs of some poor drainage were observed to the north of the site with rutting and ponded water present within an area of grass (See Photograph 5). The field investigation was undertaken following a period of rainfall.

Photograph 5: View of ponded water/rutting to the south of the site looking east

5.0 LABORATORY TESTING:

Geotechnical and chemical testing has been undertaken at NATA accredited Geotechnical/Chemical laboratories and the results are summarised and discussed in the following sections. The laboratory test Report Sheets and Certificates of Analysis are included in Appendix: 3.

It should be noted that the laboratory descriptions provided for the samples tested are based on the inspection of individual laboratory test samples only. No allowance has been made in laboratory sample descriptions for sampling, sub-sampling or test methodology in determination of mass material properties. Estimates of mass material properties are provided on each individual borehole log sheet and should be read in conjunction with the laboratory test results.

5.1 Moisture Content

Three soil samples were sent for measurement of moisture content and the results are summarised in the table below.

Summary of Reported Moisture Content Results

Location	Laboratory Description	Moisture Content (%)
BH1, 0.6 – 0.8m	Silty Clay	29.9
BH3, 2.0 – 2.2m	Silty Clay	29.5
BH4, 2.6 – 2.8m	Silty Clay	26.2

5.2 Plasticity

Three samples of soil were tested for measurement of plasticity using Atterberg limit test methods. The reported test results are summarised in the table below, together with the soil classification.

Summary of reported Plasticity Results

Sample Location	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Sample Classification*1
BH1, 0.6 – 0.8m	81	25	56	CH
BH3, 2.0 – 2.2m	84	26	58	CH
BH4, 2.6 – 2.8m	79	26	58	CH

*1 Australian Standard AS1726 – 2017 *Geotechnical site investigations*

The test results indicate that the samples tested were predominately high plasticity.

5.3 Aggressivity Potential

Four soil samples recovered from the boreholes were tested to determine the corrosion potential of the site soils to provide durability classification for new steel pile and concrete structures as per AS2159 and to determine Electrical Conductivity to enable an assessment of potential salinity. The reported results are summarised below in the Table below and the Certificate of Analysis is provided in Appendix: 3.

Summary of Reported Chemical Analysis

Borehole	Depth (m)	pH	Electrical Conductivity (µS/cm)	Resistivity (ohm/cm)	Chloride, Cl (mg/kg)	Sulphate, SO4 (mg/kg)
BH1	1.5 – 1.7	4.2	140	7,143	170	10
BH1	2.3 – 2.5	4.3	150	6,666	180	10
BH3	2.8 – 3.0	5.0	150	14,925	27	61
BH4	1.5 – 1.7	4.8	58	17,241	29	42

6.0 CHEMICAL TESTING ASSESSMENT

6.1 Corrosion Potential

The results of the soil chemical testing undertaken on the soil samples were compared against the Australian Standard AS 2159 – 2009 Pile Design and Installation.

The results were compared against Table 6.4.2 (C) Exposure Classification for Concrete Piles – Piles in Soil. The results indicate that the soils recovered from the boreholes were '**non-aggressive**' to concrete with respect and chloride and '**moderate to mild**' with respect to pH.

The results were also compared against Table 6.5.2 (C) Exposure Classification for Steel Piles – Piles in Soil. The results indicate that the soils recovered from the boreholes were '**non-aggressive**' to steel regarding pH, Chlorides and electrical resistivity.

6.2 Salinity Potential

The criteria adopted to assess the level of risk posed by potential salinity underlying the site has been derived from NSW EPA Booklet – *Site Investigation for Urban Salinity 2002* and the criteria provided for the recommended testing protocol is provided in the tables below.

Electrical Conductivity (ECe) threshold criteria:

Salinity Classification	Electrical Conductivity ECe (dS/m)	Comments
Non – saline	< 2	Salinity effects mostly negligible
Slightly saline	2 - 4	Yields of very sensitive crops may be affected
Moderately saline	4 – 8	Yields of many crops affected
Very saline	8 - 16	Only tolerant crops yield satisfactorily
Highly saline	> 16	Only a few very tolerant crops yield satisfactorily

Multiplication Factors for Converting EC1:5 to ECe

Clay Soil Texture Group	Multiplication Factor
Light Medium Clays: plastic and smooth, will form a ribbon 7.5cm	8
Medium Clay: handles like plasticine, forms rods without fracture	7
Heavy clays: rolled to thread 32-4mm and then formed into a Ring	6

Based on the classification systems provided in the tables above and on the results of the chemical laboratory testing provided in Section 4.3, the following table indicates the appropriate classification for salinity for the samples tested.

Salinity – Laboratory Analysis Classification as per 'Site Investigation for Urban Salinity'

Location	Soil Texture Group	Multiplication Factors	ECe (dS/m)	Salinity Class
BH1, 1.5 – 1.7m	Heavy Clays	6	0.85	(<2) Non saline
BH1, 2.3 – 2.5m	Heavy Clays	6	0.90	(<2) Non saline
BH3, 2.8 – 3.0m	Heavy Clays	6	0.40	(<2) Non saline
BH4, 1.5 – 1.7m	Heavy Clays	6	0.35	(<2) Non saline

Based on the results of the electrical conductivity testing and soil texture it is considered the soils tested are classed **'Non-Saline'** with mostly negligible effect.

7.0 GEOTECHNICAL ASSESSMENT

The ground conditions underlying the site comprised up to 1.9m of clay fill which appeared to increase in thickness towards the north. Underlying the fill, stiff to hard, high plasticity residual clay soils were encountered to a maximum depth of 3.5m within BH3 underlain in turn by shale which graded from very low to medium strength in which all boreholes refused at around 4m depth, with the exception of BH2 which refused at a significantly shallower depth (0.75m). It is considered that the refusal depth within BH2 may be due to the presence of a boulder however this is not confirmed.

The investigation did not identify any likely landslip hazards which may impact the adjoining school buildings, which all appeared in good condition.

Groundwater was not encountered within any of the boreholes and potential adverse impacts on groundwater are not envisaged during or following completion of the development works.

Significant signs of excessive shrink-swell movements associated with the soils underlying the site were not identified in the existing school structures. As there is a mature tree near the proposed new building, the effects of this tree on the clay soils underlying the site will need to be determined prior to confirmation of slab design. Where the impact of the tree has not impacted the soils under the proposed new building, shrink swell soil movement between 3mm and 25mm is anticipated subject to the depth/location of proposed cut and assuming all soils are protected from future abnormal moisture content variation. The moisture condition of the soils in proximity to the mature tree should be determined prior to finalization of slab and/or cut off wall design.

It is envisaged that standard mechanical plant (e.g. hydraulic excavator fitted with bucket) will be sufficient to complete excavations within the site. However, there is the potential that the shallow refusal depth encountered in BH2 is a result of a ridge of shallow bedrock therefore it is recommended that a test pit investigation is undertaken prior to determination of excavation plant to determine whether the obstruction was fill or bedrock.

Generally, generation of damaging vibrations is not anticipated based on the results of BH1, BH3 and BH4 however if the obstruction encountered in BH2 represents bedrock, vibration generation may result from the use of rock excavation equipment. The nearest structure to the proposed excavation appears to be around 12m away therefore, vibration damage via the use of rock excavation equipment is low. Preliminary hammer weights/separation distances are provided in Section 6.1.

There appears to be sufficient space to create batter slopes adjacent to the proposed excavation within the south of the site therefore pre-excavation support is unlikely necessary.

The fill encountered in the boreholes appeared to vary in degree of compaction and may not be controlled fill. If the fill cannot be shown to be controlled, consideration should be given to the potential for adverse variation to exist in both the composition and degree of compaction. The presence of voids within uncontrolled fill as well as potential soft/loose zones or inclusions of deleterious materials may lead to potentially significant future total and differential settlements, occurring possibly over relatively short distances.

Due to the depth to bedrock and assumed depth of excavation within the south of the site (estimated 3m) all new 'major 'footings should extend through the fill and natural clay soils and bear within the low to medium strength shale bedrock to reduce the potential for differential settlements. Allowable bearing pressures for the soils/bedrock encountered suitable for 'shallow' footings are provided in Section 6.1.

Driven piles are not considered suitable for the site due to the potential for the generation of vibration which may damage existing, adjacent structures.

The use of clay soils as a fill under new structures should be avoided and non-expansive granular soils are recommended within these areas.

The site is not located with an ASS Risk zone and an ASS Management Plan will not be required for the development. Due to the observed site geology and the site elevation (RL>30.0m), there is no likelihood of intersecting Acid Sulfate Soils below the site, whilst the proposed works will have no impact on the water table external to the site. Therefore, in line with the Preliminary Assessment guidelines of the NSW Acid Sulfate Soils Manual, no further investigation or reporting into these soils is required and an ASS Management Plan is not required.

The site soils tested are classified non-saline therefore a Salinity Management Plan will not be required.

The recommendations and conclusions in this report are based on an investigation utilising only surface observations and a limited number of boreholes therefore some minor variation to the interpreted sub-surface conditions is possible, especially between test locations. The results of the investigation provide a reasonable basis for the SSDA analysis and preliminary structural design. It is considered that the proposed development is suitable for the ground conditions underlying the site.

7.1 Design & Construction Recommendations:

Design and construction recommendations are tabulated below:

7.1.1. Footings:

Site Classification as per AS2870 – 2011 for new footing design	Due to the thickness of fill a site Class P is considered appropriate.
Sub-grade material and Maximum Allowable Bearing Pressures for shallow footings	Controlled Fill: 100kPa* Uncontrolled Fill: Not recommended. Stiff Silty Clay: 100kPa*[1] Very Stiff Silty Clay: 200kPa*[1] Hard Silty Clay: >400kPa Very low strength bedrock: 750kPa Low to medium strength bedrock: 1500kPa * *Placed in accordance with AS3798 – 2007 Guidelines on Earthworks for commercial and residential developments* *[1] Only recommended for lightweight settlement tolerant structures.

Maximum Allowable Bearing Pressures for piles

Material	Strength	Allowable Shaft Adhesion (kPa)**	Allowable End Bearing (kPa)*
Clay	Very Stiff Hard	15 20	200 400
Shale	Very Low Low to medium	40 200	750 1500

*Providing 4 times pile diameter embedment.

**For tension reduce allowable shaft adhesion by 30%

Site sub-soil classification as per *Structural design actions AS1170.4 – 2007, Part 4: Earthquake actions in Australia*	B_e – Rock site

Remarks: All new footings must be inspected and tested by an experienced geotechnical professional before concrete or steel are placed to verify the bearing capacity and the in-situ nature of the founding strata due to its easily disturbed state. This is mandatory to allow them to be 'certified' at the end of the project. All new footings be founded within material of similar strength to reduce the potential differential settlement.

7.1.2. Excavation:		
Depth of Excavation	Estimated at 3.0m	
Distance of Excavation to Neighbouring Properties/structures	Not applicable-The nearest boundary is approximately 40m east of the site. The nearest structure is a school building approximately 12m from the excavation.	
Type of Material to be Excavated	Clay fill to 1.9m depth although estimated at typically less than 1.0m for the majority of the excavation.	
	>1.9m Stiff to hard clay.	

Guidelines for un-surcharged batter slopes for are tabulated below:

Material	Safe Batter Slope (H:V)	
	Short Term/ Temporary	Long Term/ Permanent
Uncontrolled clay fill*	1.5:1	2.5:1
Stiff to Hard Silty Clay	1:1	2:1

*Preliminary only- potentially highly variable

Remarks: Seepage through soils can also reduce the stability of batter slopes and invoke the need to implement additional support measures. Where safe batter slopes are not implemented the stability of the excavation cannot be guaranteed until the installation of permanent support measures. This should also be considered with respect to safe working conditions. Geotechnical inspection of batters will be required at regular intervals. Sub-vertical batter slopes in clayey soils can stand unsupported over very short time frames however CGC cannot certify or recommend this approach.

Equipment for Excavation	Topsoil, fills and natural clay soils	Excavator with bucket
Recommended Vibration Limits (Maximum Peak Particle Velocity (PPV))	Unlikely required unless BH3 refused on bedrock at 0.75m depth then 5mm/s	
Vibration Calibration Tests Required	Not required	
Full time vibration Monitoring Required	Not required	
Geotechnical Inspection Requirement	Yes, recommended that these inspections be undertaken as per below mentioned sequence: • For assessment of proposed and constructed batter slopes • Where unexpected ground conditions are identified, or any other concerns are held.	

	• Following footing excavations to confirm founding material strength
Dilapidation Surveys Requirement	Not required
Remarks: Water ingress into exposed excavations/cuttings can result in erosion and stability concerns in soils. Drainage measures will need to be in place during excavation works to divert any surface flow away from any excavation crest and batter slopes, whilst any groundwater seepage must be controlled within the excavation and prevented from ponding or saturating slopes/batters.	

7.1.3 Retaining Structures:	
Required	Required within the south of the structure
Types	Steel reinforced concrete/concrete block walls post excavation designed in accordance with Australian Standards AS4678-2002 Earth Retaining Structures would likely be suitable.
Parameters for calculating pressures acting on retaining walls for the materials likely to be retained:	

Material	Unit Weight (kN/m3)	Long Term (Drained)	Earth Pressure Coefficients		Passive Earth Pressure Coefficient *
			Active (Ka)	At Rest (K_0)	
Fill	18	$\phi' = 29°$	0.35	0.52	N/A
Clay	20	$\phi' = 30°$	0.33	0.47	3.25

Remarks: In suggesting these parameters it is assumed that the retaining walls will be fully drained with suitable subsoil drains provided at the rear of the wall footings. If this is not done, then the walls should be designed to support full hydrostatic pressure in addition to pressures due to the soil backfill. It is suggested that the retaining walls should be back filled with free-draining granular material (preferably not recycled concrete) which is only lightly compacted in order to minimize horizontal stresses.

Retaining structures near site boundaries or existing structures should be designed with the use of at rest (K_0) earth pressure coefficients to reduce the risk of movement in the excavation support and resulting surface movement in adjoining areas. Backfilled retaining walls within the site, away from site boundaries or existing structures, that may deflect can utilize active earth pressure coefficients (Ka).

Numerical Analysis Design Parameters

Where retaining structures are to be designed using numerical analysis tools (e.g Wallap or similar), the tables below provide preliminary material properties.

Material Strength Properties

Material	Strength	Undrained Analysis		Drained Analysis*	
		Cohesion (c_u) (kPa)	Friction (φ_u) Degrees	Cohesion (c') (kPa)	Friction (φ') Degrees
Silty Clay	stiff	50	0	5	26
	very stiff	100			
	hard	200			
Shale	very low	350 – 450	29	50	28
	low	-	33	100	35

**May be highly variable*

Material	Strength	Young's Modulus E Mpa
Silty Clay	stiff	10 - 30
	very stiff	15 - 40
	hard	40 - 70
Shale	very low	50 - 100
	low	100 - 500
	medium	400 - 3000

Modulus of Subgrade Reaction:

As modulus of subgrade reaction is not an inherent soil/rock property, but is dependent on foundation size, depth and founding conditions, appropriate values for soil modulus must be determined based on proposed footing type/depth/ dimension etc. as part of detailed design.

Semi-empirical relations can be used to estimate the modulus of sub-grade reaction from settlement Youngs modulus E and size of the loaded area. An approximate relationship proposed by Vesic (refer J.E. Bowles 1997 Foundation Analysis and Design) can be used to calculate the value of k_s for vertical loading as follows:

$$k_s \approx \frac{E}{\mathrm{B}\,(1-\mathrm{v}2)}$$

Poisons Ratio for soils – 0.25	Bulk Density for Shale – 24 kN/m^3
Wall Friction (adhesion) Coefficient – 0.2 (below 1.5m depth on active side or below slab)	

7.1.4. Drainage and Hydrogeology		
Groundwater Table or Seepage identified in Investigation		Not encountered
Excavation likely to intersect	Water Table	No

	Seepage	Minor seepage likely in clay fill and at intersection with bedrock
Site Location and Topography		Gently north sloping
Impact of development on local hydrogeology		Negligible
Onsite Stormwater Disposal		Unlikely suitable due to clay soils.
Remarks: Trenches, as well as all new building gutters, down pipes and stormwater intercept trenches should be connected to a stormwater system designed by a Hydraulic Engineer which discharges to a stormwater system off site.		

7.1.5 Slab/Pavements and Fill

Preliminary design of on-ground slabs and pavements cast over natural soil or controlled fill subgrade could be based on the 'soaked' parameters presented below.

Sub-grade material	CBR (%)	Modulus of Subgrade Reaction (kPa/mm)
Clay	3 - 4	10 – 20

Remarks:

Any fill that is used to support structure loads/on ground slabs etc. should be controlled (i.e. placed in layers not exceeding 250mm loose thickness) and uniformly compacted to an appropriate engineering specification. It is suggested that a minimum dry density ratio of 100% (Standard) be adopted within building areas.

Subgrade properties are expected to be variable within the site following excavation and additional testing should be undertaken at the time of construction in order to confirm subgrade design values.

Geotechnical testing as set out in Section 8 of Australian Standard AS3798 – 2007 *Guidelines on Earthworks for commercial and residential developments* would be required to achieve adequate control of fill placement for engineered footing design and construction.

It is recommended that earthworks in settlement sensitive areas be placed under 'Level 1' geotechnical supervision/testing.

Reuse of the site won natural clay soils as fill may be feasible provided where cohesive soils are used as structural fill, an allowance is made for higher shrink swell movements than the 'M' site classification provided in Section 6.1.1 due to potential lateral confinement following the removal of vertical cracks within the soils during the compaction process.

Any fill which is over-wet, contains organic matter should be removed or treated prior to use as fill. Where the use of clay soil is used as structural fill (which is not recommended) it should be placed 1% - 2% wet of optimum to reduce the potential for swell on rehydration. Due to the expansive soils underlying the site, it is suggested on any ground slabs (if proposed) be fully dowelled, that joints between slabs be sealed and that slab edges should be separated from edge restraint to minimise potential damage from surface movements caused by subgrade moisture variations. Allowance should be made in design for the effect of differential slab movements (due to reactive soil behaviour) if slabs are cast over differing subgrade types (e.g. controlled fill, natural silty clay soils).

8. CONCLUSION:

The ground conditions encountered underlying the site comprised clay fill to a maximum of 1.9m then natural stiff to hard residual clay soils in turn underlain by very low to low to medium strength shale bedrock at depths of around 4.0m. Groundwater was not encountered.

BH2 refused on a possible boulder although this is not confirmed. A test pit should be undertaken within the vicinity of BH2 to confirm ground conditions.

An ASS management plan will not be required for the development.

The site soils tested are classified non-saline therefore a Salinity Management Plan will not be required.

New footings for the proposed main site structures could comprise shallow pad, strip or piers bearing off/in the very low to low to medium shale bedrock to reduce the potential for differential settlement.

No significant geotechnical risks were identified within the site soils, and it is considered the site is suitable for the proposed new structures provided the recommendations of this report are adhered to.

Prepared by:

Kieron Nicholson
Senior Engineering Geologist

Reviewed by:

Troy Crozier
Principal
MIE Aust. MAIG. RPGeo-Geotechnical & Engineering
Registration No.: 10197

9. REFERENCES:

1. Geological Society Engineering Group Working Party 1972, "The preparation of maps and plans in terms of engineering geology" Quarterly Journal Engineering Geology, Volume 5, Pages 295 - 382.
2. C. W. Fetter 1995, "Applied Hydrology" by Prentice Hall. V. Gardiner & R. Dackombe 1983, "Geomorphological Field Manual" by George Allen & Unwin
3. Australian Standard AS 2870 – 2011, Residential Slabs and Footings – Construction
4. Australian Standard AS3798 – 2007 *Guidelines on Earthworks for commercial and residential developments*
5. Australian Standard AS1170.4 – 2007, Part 4: Earthquake actions in Australia
6. Australian Standard AS1726:2017 'Geotechnical Site Investigations'

Appendix 1

Crozier Geotechnical Consultants ABN: 96 113 453 624
Unit 12/ 42-46 Wattle Road Phone: (02) 9939 1882
Brookvale NSW 2100 Email: info@croziergeotech.com.au
Crozier Geotechnical Consultants, a division of PJC Geo-Engineering Pty Ltd

NOTES RELATING TO THIS REPORT

Introduction

These notes have been provided to amplify the geotechnical report in regard to classification methods, specialist field procedures and certain matters relating to the Discussion and Comments section. Not all, of course, are necessarily relevant to all reports.

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

Description and classification Methods

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

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (eg. Sandy clay) on the following bases:

Soil Classification	Particle Size
Clay	less than 0.002 mm
Silt	0.002 to 0.06 mm
Sand	0.06 to 2.00 mm
Gravel	2.00 to 60.00mm

Cohesive soils are classified on the basis of strength either by laboratory testing or engineering examination. The strength terms are defined as follows:

Classification	Undrained Shear Strength kPa
Very soft	Less than 12
Soft	12 - 25
Firm	25 – 50
Stiff	50 – 100
Very stiff	100 - 200
Hard	Greater than 200

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration tests (SPT) or Dutch cone penetrometer tests (CPT) as below:

Relative Density	SPT “N” Value (blows/300mm)	CPT Cone Value (Qc – MPa)
Very loose	less than 5	less than 2
Loose	5 – 10	2 – 5
Medium dense	10 – 30	5 -15
Dense	30 – 50	15 – 25
Very dense	greater than 50	greater than 25

Rock types are classified by their geological names. Where relevant, further information regarding rock classification is given on the following sheet.

Sampling

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

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

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

Drilling Methods

The following is a brief summary of drilling methods currently adopted by the company and some comments on their use and application.

Test Pits – these are excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descent into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (eg. Pengo) – the hole is advanced by a rotating plate or short spiral auger, generally 300mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling.

Continuous Sample Drilling – the hole is advanced by pushing a 100mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling soils, since moisture content is unchanged and soil structure, strength, etc. is only marginally affected.

Continuous Spiral Flight Augers – the hole is advanced using 90 – 115mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPT's or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling - the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from 'feel' and rate of penetration.

Rotary Mud Drilling – similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. From SPT).

Continuous Core Drilling – a continuous core sample is obtained using a diamond-tipped core barrel, usually 50mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

Standard penetration tests (abbreviated as SPT) are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedures is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" – Test 6.3.1.

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

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150mm of say 4, 6 and 7
  as 4, 6, 7 then N = 13
- In the case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm then as 15, 30/40mm.

The results of the test can be related empirically to the engineering properties of the soil. Occasionally, the test method is used to obtain samples in 50mm diameter thin wall sample tubes in clay. In such circumstances, the test results are shown on the borelogs in brackets.

Cone Penetrometer Testing and Interpretation

Cone penetrometer testing (sometimes referred to as Dutch Cone – abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in Australia Standard 1289, Test 6.4.1.

In tests, a 35mm diameter rod with a cone-tipped end is pushed continually into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on a separte 130mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected buy electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) their information is plotted on a computer screen and at the end of the test is stored on the computer for later plotting of the results.

The information provided on the plotted results comprises: -

- Cone resistance – the actual end bearing force divided by the cross-sectional area of the cone – expressed in MPa.
- Sleeve friction – the frictional force on the sleeve divided by the surface area – expressed in kPa.
- Friction ratio - the ratio of sleeve friction to cone resistance, expressed in percent.

There are two scales available for measurement of cone resistance. The lower scale (0 – 5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main scale (0 – 50 MPa) is less sensitive and is shown as a full line. The ratios of the sleeve friction to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios 1% - 2% are commonly encountered in sands and very soft clays rising to 4% - 10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range: -

Q_c (MPa) = (0.4 to 0.6) N blows (blows per 300mm)

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range: -

Q_c = (12 to 18) C_u

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculations of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes, etc. This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on soil classification is required, direct drilling and sampling may be preferable.

Dynamic Penetrometers

Dynamic penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150mm increments of penetration. Normally, there is a depth limitation of 1.2m but this may be extended in certain conditions by the use of extension rods.

Two relatively similar tests are used.

- Perth sand penetrometer – a 16mm diameter flattened rod is driven with a 9kg hammer, dropping 600mm (AS1289, Test 6.3.3). The test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
- Cone penetrometer (sometimes known as Scala Penetrometer) – a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS 1289, Test 6.3.2). The test was developed initially for pavement sub-grade investigations, and published correlations of the test results with California bearing ratio have been published by various Road Authorities.

Laboratory Testing

Laboratory testing is generally carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedure used are given on the individual report forms.

Borehole Logs

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

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

Details of the type and method of sampling are given in the report and the following sample codes are on the borehole logs where applicable:

D	Disturbed Sample	E	Environmental sample	DT	Diatube
B	Bulk Sample	PP	Pocket Penetrometer Test		
U50	50mm Undisturbed Tube Sample	SPT	Standard Penetration Test		
U63	63mm " " " " "	C	Core		

Ground Water

Where ground water levels are measured in boreholes there are several potential problems:

- In low permeability soils, ground water although present, may enter the hole slowly or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report.
- The use of water or mud as a drilling fluid will mask any ground water inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water observations are to be made. More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be interference from a perched water table.

Engineering Reports

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. A three-storey building), the information and interpretation may not be relevant if the design proposal is changed (eg. to a twenty-storey building). If this happens, the Company will be pleased to review the report and the sufficiency of the investigation work.

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

- unexpected variations in ground conditions – the potential for this will depend partly on bore spacing and sampling frequency,
- changes in policy or interpretation of policy by statutory authorities,
- the actions of contractors responding to commercial pressures,

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

Site Anomalies

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

Reproduction of Information for Contractual Purposes

Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", published by the Institution of Engineers Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a special ally edited document. The Company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

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

CROZIER
GEOTECHNICAL CONSULTANTS

Appendix 2

0 20 40

SCALE: 1:800

SITE PLAN & TEST LOCATIONS FIGURE 1.

CROZIER
GEOTECHNICAL CONSULTANTS

Crozier Geotechnical
Unit 12, 42-46 Wattle Road
Brookvale NSW 2100
ABN: 96 113 453 624
Phone: (02) 9939 1882
Fax: (02) 9939 1883
Crozier Geotechnical is a division of PJC Geo-Engineering Pty Ltd

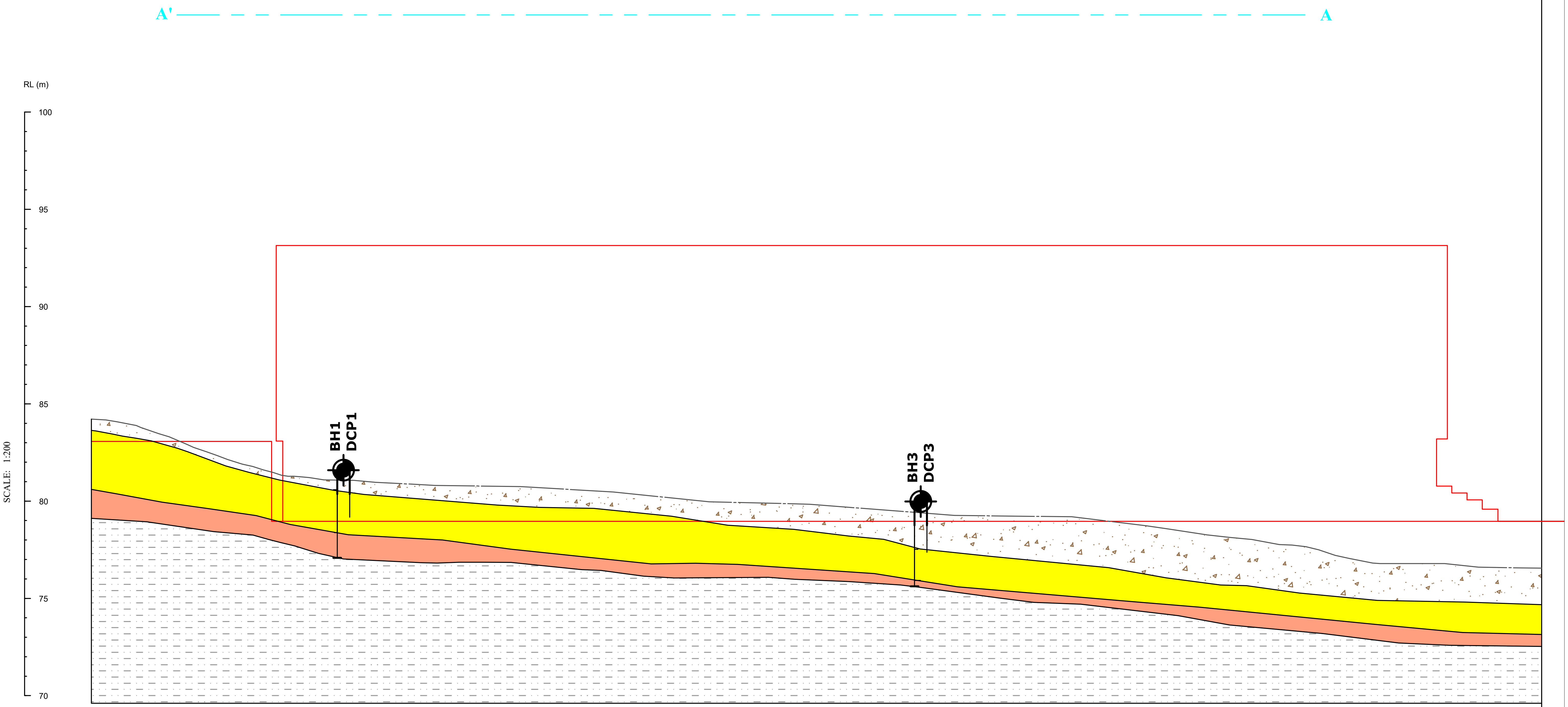
LEGEND

EXISTING STRUCTURES	(blue line)
OUTLINE OF PROPOSED WORKS	(red line)
BH DCP	AUGER / DYNAMIC CONE PENETROMETER LOCATION
A — A'	CROSS-SECTION REFERENCE LINE

SCALE:	1:800 @ A3
DRAWING:	FIGURE 1
DATE:	09 /2022
APPROVED BY:	TMC
DRAWN BY:	JD
PROJECT:	2022-155

PREPARED FOR:
The Kings School

ADDRESS:
87-129 Pennant Hills Road, North Parramatta



0 1 2 3 4 5 6 7 8 9 10

SCALE: 1:200

VL - Very Loose	VS - Very Soft	ELS - Extremely Low Strength	EW - Extremely Weathered	fg - Fine Grained
L - Loose	S - Soft	VLS - Very Low Strength	HW - Highly Weathered	mg - Medium Grained
MD - Medium Dense	F - Firm	LS - Low Strength	DW - Distinctly Weathered	cg - Coarse Grained
D - Dense	St - Stiff	MS - Medium Strength	MW - Moderately Weathered	MAS - Massive
VD - Very Dense	VSt - Very Stiff	HS - High Strength	SW - Slightly Weathered	BD - Bedded
	H - Hard	VHS - Very High Strength	FR - Fresh	OC - Outcrop

NB. FOR LOCATION OF SECTION A-A', PLEASE REFER TO FIGURE 1. SITE PLAN AND TEST LOCATIONS

SECTION A FIGURE 2.

CROZIER
GEOTECHNICAL CONSULTANTS

Crozier Geotechnical
Unit 12, 42-46 Wattle Road
Brookvale NSW 2100
ABN: 96 113 453 624
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LEGEND

BH DCP AUGER / DYNAMIC CONE PENETROMETER LOCATION

EXISTING STRUCTURES

PROPOSED WORKS

SOIL/FILL

CLAY

SHALE (VLS)

SHALE (LS-MS)

A —— A' SECTION LINE

SCALE: 1:400 @ A3
DRAWING: FIGURE 2
DATE: 10/2022

APPROVED BY: TMC
DRAWN BY: JC
PROJECT: 2022-155

PREPARED FOR:
The Kings School

ADDRESS:
87-129 Pennant Hills Road, North Parramatta

BOREHOLE LOG

CLIENT: **The Kings School** **DATE:** 14/07/2022 **BORE No.:** 1

PROJECT: **Steam Teaching Block** **PROJECT No.:** 2022-155 **SHEET:** 1 of 1

LOCATION: **The School, 87-129 Pennant Hills Road North Parramatta** **SURFACE LEVEL:** RL81.2m

Depth (m)	Classification	Description of Strata PRIMARY SOIL - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling		In Situ Testing	
			Type	Tests	Type	Results
0.00		FILL: Dark brown gravelly clay, moist, fine to medium subangular gravel				
0.50	CH	CLAY: Hard, orange brown mottled grey clay, moist, trace subangular gravel of shale (Residual Soils)				
			D	0.60 0.80		
1.00			(U50)	1.00 1.10		
1.50		…mottled pale grey	D	1.50 1.70		
1.90		…tending to extremely weathered shale				
2.00			D	2.30 2.50		
2.70		SHALE: Extremely low to very low strength, grey (Wianamatta Group)				
3.00						
3.10		...low strength zones				
4.00		End of borehole at 4.0m depth within low strength shale.				

RIG: Dingo Restricted Access DRILLER: AC

METHOD: Spiral Flight Auger LOGGED: KN

GROUND WATER OBSERVATIONS: Not encountered

REMARKS: CHECKED:

BOREHOLE LOG

CLIENT: The Kings School | **DATE:** 14/07/2022 | **BORE No.:** 2

PROJECT: Steam Teaching Block | **PROJECT No.:** 2022-155 | **SHEET:** 1 of 1

LOCATION: The School, 87-129 Pennant Hills Road North Parramatta | **SURFACE LEVEL:** RL80.6m

Depth (m) 0.00	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling Type	Sampling Tests	In Situ Testing Type	In Situ Testing Results
		FILL: Stiff, dark brown gravelly clay, moist fine to medium grained gravel.				
0.30		CLAY: Hard, red brown, with fine to medium grained subangular gravel of shale (Possible Fill)	D	0.40 0.50		
0.70		SHALE: Very low strength, grey (Possible Boulder in Fill) …grey mottled orange				
		Auger refusal at 0.75m depth on possible boulder/low to medium strength bedrock				

RIG: Dingo Restricted Access

DRILLER: AC

METHOD: Spiral Flight Auger

LOGGED: KN

GROUND WATER OBSERVATIONS: Not encountered

REMARKS:

CHECKED:

BOREHOLE LOG

CLIENT: The Kings School **DATE:** 14/07/2022 **BORE No.:** 3

PROJECT: Steam Teaching Block **PROJECT No.:** 2022-155 **SHEET:** 1 of 1

LOCATION: The School, 87-129 Pennant Hills Road North Parramatta **SURFACE LEVEL:** RL80.35m

Depth (m) 0.00	Classification	Description of Strata PRIMARY SOIL - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling Type	Sampling Tests	In Situ Testing Type	In Situ Testing Results
		FILL: Stiff, dark brown gravelly clay, moist fine to medium grained gravel of shale.				
0.40		…very soft zone at 0.3-0.4m depth				
0.90		…orange brown				
			D	1.00 1.20		
			D	1.60 1.80		
1.90	CH	CLAY: Stiff, red brown, with fine to medium, subangular gravel of shale. (Residual Soils)	D	2.00 2.20		
2.80		…grey mottled red	D	2.80 3.00		
3.50		SHALE: Very low strength, grey, zones of low strength (Wianamatta Group)				
3.80		Refusal at 3.9m depth in low to medium strength shale				

RIG: Dingo Restricted Access DRILLER: AC

METHOD: Spiral Flight Auger LOGGED: KN

GROUND WATER OBSERVATIONS: Not encountered

REMARKS: CHECKED:

BOREHOLE LOG

CLIENT: The Kings School | **DATE:** 14/07/2022 | **BORE No.:** 4

PROJECT: Steam Teaching Block | **PROJECT No.:** 2022-155 | **SHEET:** 1 of 1

LOCATION: The School, 87-129 Pennant Hills Road North Parramatta | **SURFACE LEVEL:** RL80.1m

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling Type	Sampling Tests	In Situ Testing Type	In Situ Testing Results
0.00		FILL: Stiff, dark brown gravelly clay, moist fine to medium grained gravel of shale.				
0.90		…brown and red				
1.40	CH	CLAY: Stiff, red brown, with fine to medium, subangular gravel of shale. (Residual Soils)	D	1.50 1.70		
2.00		…very stiff				
2.30		…hard				
2.50		…grey mottled red	D	2.60 2.80		
3.30		SHALE: Extremely low to very low strength, pale grey brown (Wianamatta Group)				
3.50		…orange and yellow				
3.90		Auger refusal at 3.9m depth in low to medium strength shale				

RIG: Dingo Restricted Access | DRILLER: AC

METHOD: Spiral Flight Auger | LOGGED: KN

GROUND WATER OBSERVATIONS: Not encountered

REMARKS: | CHECKED:

DYNAMIC PENETROMETER TEST SHEET

CLIENT: The Kings School | **DATE:** 14/07/2022

PROJECT: STEAM Teachning Block | **PROJECT No.:** 2022-155

LOCATION: The Kings School, 87-129 Pennant Hills Road, North Parramatta | **SHEET:** 1 of 1

	Test Location									
Depth (m)	1	1B	2	3	4					
0.00 - 0.10	2	--	4	3	2					
0.10 - 0.20	4	--	3	4	4					
0.20 - 0.30	5	--	5	4	5					
0.30 - 0.40	3	--	6	1	4					
0.40 - 0.50	6	--	6	4	6					
0.50 - 0.60	7	--	5	6	6					
0.60 - 0.70	12	--	20	5	4					
0.70 - 0.80	10	--	HB 0.7m	4	7					
0.80 - 0.90	8	--		2	8					
0.90 - 1.00	9	--		4	11					
1.00 - 1.10	9	5		6	12					
1.10 - 1.20	12	6		7	11					
1.20 - 1.30	10	8		7	9					
1.30 - 1.40	13	11		5	8					
1.40 - 1.50	11	10		5	4					
1.50 - 1.60	11	9		6	4					
1.60 - 1.70	14	15		5	4					
1.70 - 1.80	17	12		8	4					
1.80 - 1.90	19	16		12	5					
1.90 - 2.00		20		17	5					
2.00 - 2.10		25			6					
2.10 - 2.20					6					
2.20 - 2.30					8					
2.30 - 2.40					9					
2.40 - 2.50					14					
2.50 - 2.60					18					
2.60 - 2.70					12					
2.70 - 2.80					8					
2.80 - 2.90					11					
2.90 - 3.00										
3.00 - 3.10										
3.10 - 3.20										
3.20 - 3.30										
3.30 - 3.40										
3.40 - 3.50										
3.50 - 3.60										
3.60 - 3.70										
3.70 - 3.80										
3.80 - 3.90										
3.90 - 4.00										

TEST METHOD: AS 1289. F3.2, CONE PENETROMETER
AS 1289. F3.3, PERTH SAND PENETROMETER

REMARKS:
(B) Test hammer bouncing upon refusal on solid object
-- No test undertaken at this level due to prior excavation of soils

CROZIER
GEOTECHNICAL CONSULTANTS

Appendix 3

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 302268

Client Details

Client	Crozier Geotechnical Consultants
Attention	Kieron Nicholson
Address	Unit 12/42-46 Wattle Rd, Brookvale, NSW, 2100

Sample Details

Your Reference	**2022-155 The Kings School, North Parramatta**
Number of Samples	4 Soil
Date samples received	04/08/2022
Date completed instructions received	04/08/2022

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	09/08/2022
Date of Issue	09/08/2022

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Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Priya Samarawickrama, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

Misc Inorg - Soil					
Our Reference		302268-1	302268-2	302268-3	302268-4
Your Reference	UNITS	BH1, 1.5-1.7	BH1, 2.3-2.5	BH3, 2.8-3.0	BH4, 1.5-1.7
Date Sampled		14/07/2022	14/07/2022	14/07/2022	14/07/2022
Type of sample		Soil	Soil	Soil	Soil
Date prepared	-	08/08/2022	08/08/2022	08/08/2022	08/08/2022
Date analysed	-	08/08/2022	08/08/2022	08/08/2022	08/08/2022
pH 1:5 soil:water	pH Units	4.2	4.3	5.0	4.8
Electrical Conductivity 1:5 soil:water	µS/cm	140	150	67	58
Chloride, Cl 1:5 soil:water	mg/kg	170	180	27	29
Sulphate, SO4 1:5 soil:water	mg/kg	10	10	61	42

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25°C in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.

QUALITY CONTROL: Misc Inorg - Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			08/08/2022	[NT]	[NT]	[NT]	[NT]	08/08/2022	[NT]
Date analysed	-			08/08/2022	[NT]	[NT]	[NT]	[NT]	08/08/2022	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	[NT]	[NT]	101	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	[NT]	[NT]	[NT]	[NT]	104	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	96	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	93	[NT]

Result Definitions	
NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

pH/EC
Samples were out of the recommended holding time for this analysis.

MOISTURE CONTENT TEST REPORT

Client	Crozier Geotech	**Job #**	S21714-1
Address	Unit 12/ 42-46 Wattle Street Brookvale NSW 2100	**Report #**	S79093-MC
Project	The Kings School Parramatta (2022-155)		

Test Procedure

- ☑ AS 1289 2.1.1 Determination of the moisture content of a soil - Oven drying method (Standard method).
- ☐ AS4133 1.1.1 Determination of the moisture content of rock - Oven drying method (standard method)
- ☐ RMS T120 Moisture content of road construction materials (Standard method)
- ☐ RMS T262 Determination of moisture content of aggregates (Standard method)

Sampling Sampled by Client - results apply to the sample as received **Date Sampled** 14/07/2022

Preparation Prepared in accordance with the test method **Date Tested** 8/08/2022

Sample #	Source	Sample Description	Moisture Content %
S79093	BH1 0.60-0.80m	Silty CLAY	**29.9**
S79094	BH3 2.0-2.20m	Silty CLAY	**29.5**
S79095	BH4 2.60-2.80m	Silty CLAY	**26.2**

Notes

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full. Results relate only to the samples tested.

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

9/08/2022

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
14 Carter St
Lidcombe NSW 2141

SOIL CLASSIFICATION REPORT

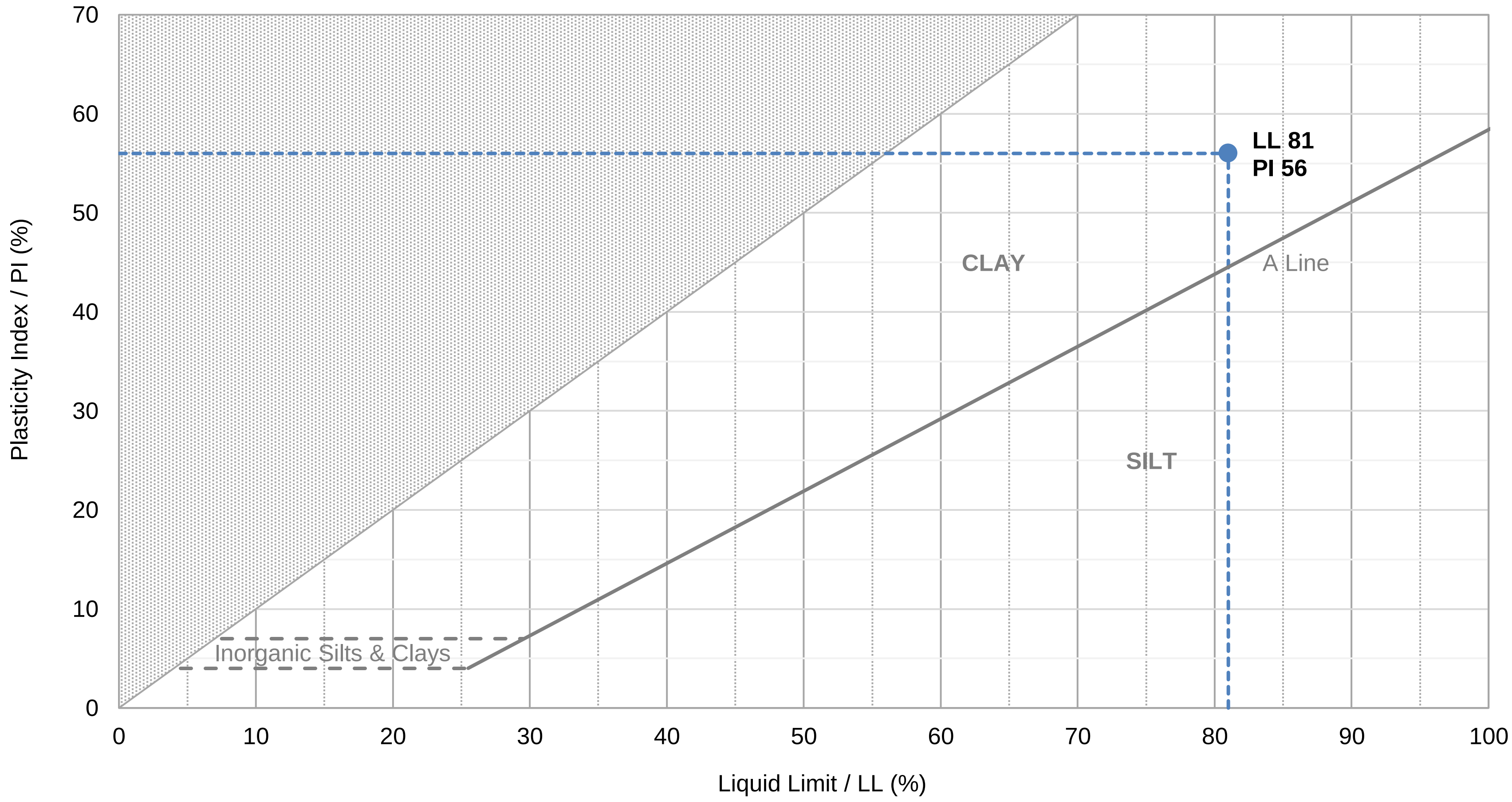
Client	Crozier Geotech	**Source**	BH1 0.60-0.80m
Address	Unit 12/ 42-46 Wattle Street Brookvale NSW 2100	**Sample Description**	Silty CLAY
Project	The Kings School Parramatta (2022-155)	**Report No.**	S79093-PI
Job No.	S21714-1	**Lab No.**	S79093

Test Procedure

- ☑ AS1289 3.1.1 Liquid Limit - Four point Casagrande method
- ☐ AS1289 3.1.2 Liquid Limit - One point Casagrande method
- ☑ AS1289 3.2.1 Plastic Limit - Standard method
- ☑ AS1289 3.3.1 Calculation of the Plasticity Index
- ☐ AS1289 3.4.1 Linear Shrinkage - Standard method

Sampling	Sampled by Client - results apply to the sample as received	**Date Sampled**	14/07/2022
Preparation	Prepared in accordance with the test method	**Date Tested**	12/08/2022

Plasticity Chart for Classification of Fine-Grained Soils
AS 1726:2017 Clause 6.1.6 (Figure 5)



Preparation	
Method of Preparation	**Dry Sieved**
History of the Sample	**Air Dried**

Results	
Liquid Limit / LL (%)	**81**
Plastic Limit (%)	**25**
Plasticity Index / PI (%)	**56**
Linear Shrinkage (%)	**-**
Condition upon Drying	**N/A**

Notes

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NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

15/08/2022

Date:

Macquarie Geotechnical
14 Carter St
Lidcombe NSW 2141

SOIL CLASSIFICATION REPORT

Client	Crozier Geotech	**Source**	BH3 2.0-2.20m
Address	Unit 12/ 42-46 Wattle Street Brookvale NSW 2100	**Sample Description**	Silty CLAY
Project	The Kings School Parramatta (2022-155)	**Report No.**	S79094-PI
Job No.	S21714-1	**Lab No.**	S79094

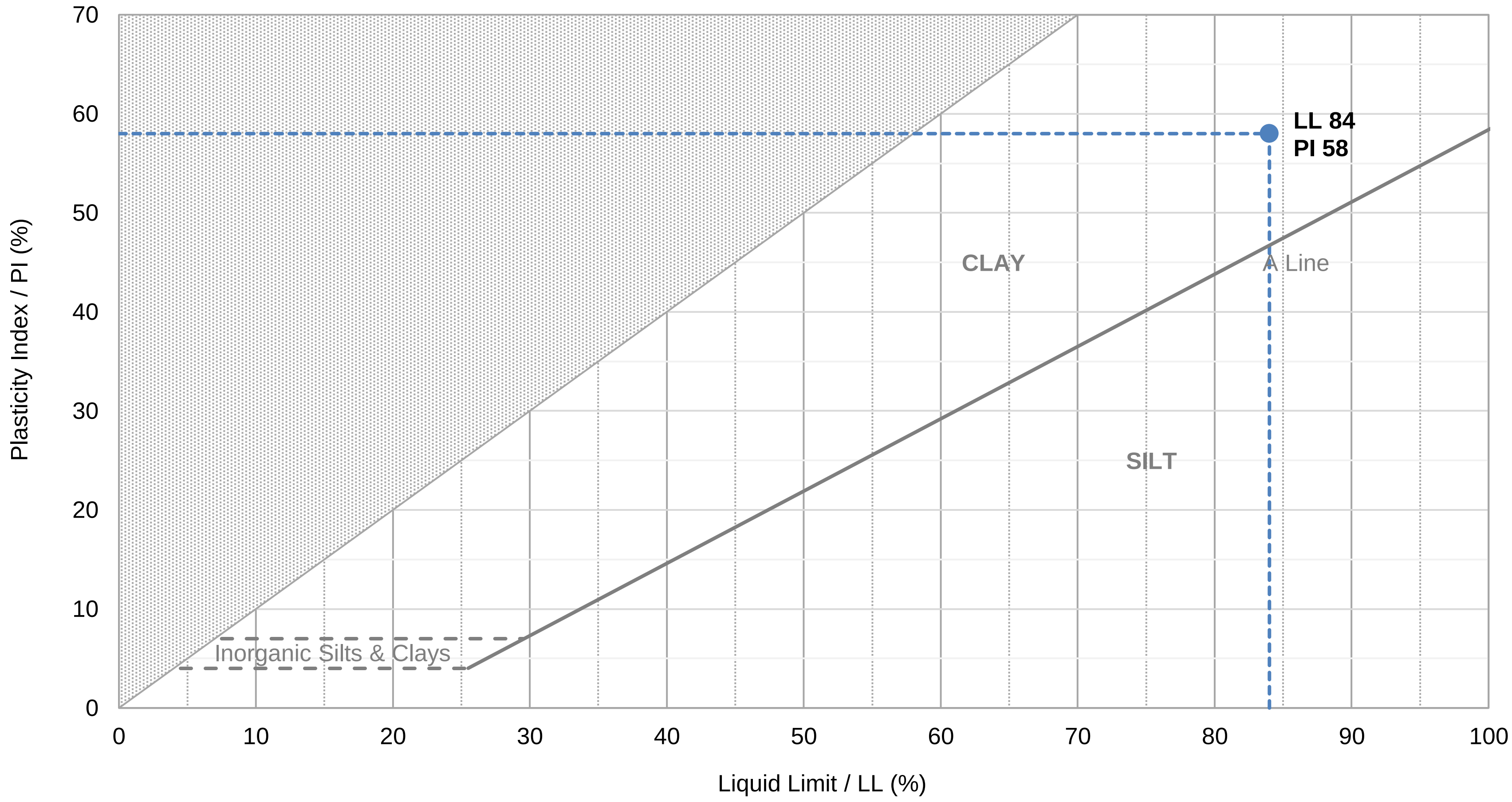
Test Procedure

- ☑ AS1289 3.1.1 Liquid Limit - Four point Casagrande method
- ☐ AS1289 3.1.2 Liquid Limit - One point Casagrande method
- ☑ AS1289 3.2.1 Plastic Limit - Standard method
- ☑ AS1289 3.3.1 Calculation of the Plasticity Index
- ☐ AS1289 3.4.1 Linear Shrinkage - Standard method

Sampling	Sampled by Client - results apply to the sample as received	**Date Sampled**	14/07/2022
Preparation	Prepared in accordance with the test method	**Date Tested**	11/08/2022

Plasticity Chart for Classification of Fine-Grained Soils

AS 1726:2017 Clause 6.1.6 (Figure 5)



Preparation	
Method of Preparation	**Dry Sieved**
History of the Sample	**Air Dried**

Results	
Liquid Limit / LL (%)	**84**
Plastic Limit (%)	**26**
Plasticity Index / PI (%)	**58**
Linear Shrinkage (%)	**-**
Condition upon Drying	**N/A**

Notes

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Authorised Signatory:

Chris Lloyd

12/08/2022

Date:

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14 Carter St
Lidcombe NSW 2141

SOIL CLASSIFICATION REPORT

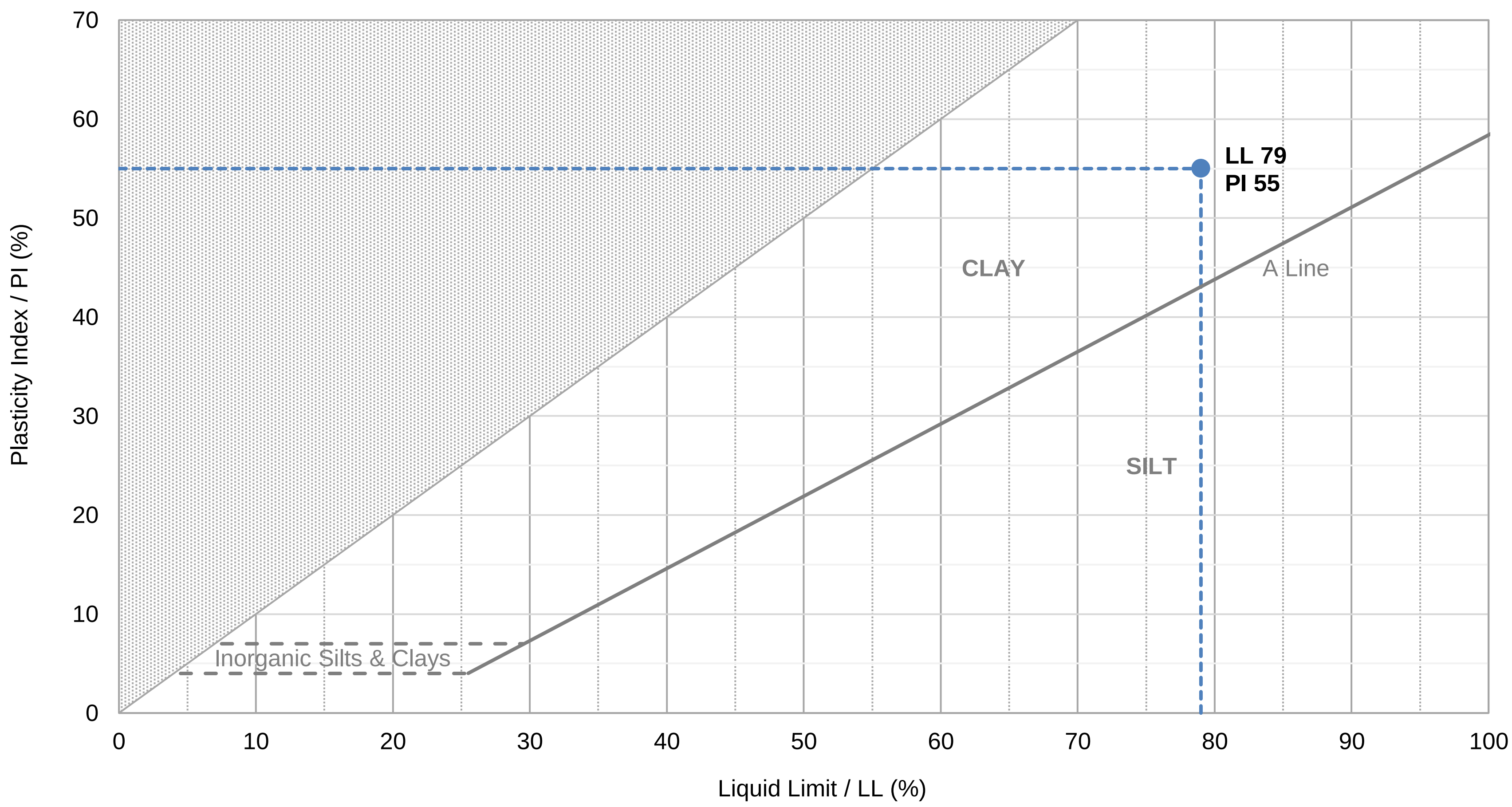
Client	Crozier Geotech	**Source**	BH4 2.60-2.80m
Address	Unit 12/ 42-46 Wattle Street Brookvale NSW 2100	**Sample Description**	Silty CLAY
Project	The Kings School Parramatta (2022-155)	**Report No.**	S79095-PI
Job No.	S21714-1	**Lab No.**	S79095

Test Procedure

☑	AS1289 3.1.1	Liquid Limit - Four point Casagrande method
☐	AS1289 3.1.2	Liquid Limit - One point Casagrande method
☑	AS1289 3.2.1	Plastic Limit - Standard method
☑	AS1289 3.3.1	Calculation of the Plasticity Index
☐	AS1289 3.4.1	Linear Shrinkage - Standard method

Sampling	Sampled by Client - results apply to the sample as received	**Date Sampled**	14/07/2022
Preparation	Prepared in accordance with the test method	**Date Tested**	12/08/2022

Plasticity Chart for Classification of Fine-Grained Soils
AS 1726:2017 Clause 6.1.6 (Figure 5)



Preparation

Method of Preparation	**Dry Sieved**
History of the Sample	**Air Dried**

Results

Liquid Limit / LL (%)	**79**
Plastic Limit (%)	**24**
Plasticity Index / PI (%)	**55**
Linear Shrinkage (%)	**-**
Condition upon Drying	**N/A**

Notes

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