Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Remediation Action Plan

Pendle Hill High School Development
Cornock Avenue, Toongabbie

Prepared for
TSA Management Pty Ltd

Project 86977.01
May 2021

Douglas Partners
Geotechnics / Environment / Groundwater

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

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1. Introduction

1.1 General

This Remediation Action Plan (RAP) describes the work required to remediate the proposed new building works at Pendle Hill High School (PHHS) at Cornock Avenue, Toongabbie (the overall 'PHHS Site', see Drawing 1, Appendix A). The RAP has only been prepared for the proposed building works identified as a State Significant Development within the area herein referred to as the 'Site' (see Drawing 1, Appendix A). The RAP was commissioned by School Infrastructure NSW (c/o TSA Management Pty Ltd) and was undertaken in accordance with Douglas Partners' proposal SYD201350 dated 7 December 2020.

DP have previously completed a Preliminary Site (Contamination) Investigation[1] (DP, 2020) and a supplementary contamination investigation[2] (DP, 2021) which included a preliminary waste classification. Asbestos as bonded asbestos containing material (ACM) and asbestos fines and friable asbestos (FA/AF) were identified within the northern portion of the site.

This RAP details the methods and procedures by which the remediation and site validation will be achieved. It is noted that this RAP includes additional investigations / data gap investigations which are required to be undertaken prior to remediation works. DP notes the site is within an operational school and given the friable nature of asbestos identified, these investigations should be undertaken after the site boundary has been properly demarcated, fenced off and appropriate controls are in place. It is intended that following implementation of the RAP, the site can be considered:

- Remediated to a condition which would prevent unacceptable risks to human health and / or the environment; and
- Suitable for the intended land-use.

It should be noted that this RAP does not form a detailed or quantitative specification for the proposed site remediation works, but rather represents a planning document which outlines the means by which site remediation can render the site suitable for the intended use.

The RAP establishes appropriate remediation objectives, strategies, methodologies and validation processes to enable remediation such that the site is suitable for the proposed land use. The RAP includes information on potential remediation methods, validation, waste classification, spoil management requirements and an unexpected finds protocol (UFP) and a contingency plan to manage

[1] DP *Report on Updated Preliminary Site Investigation with Limited Soil Sampling, Pendle Hill High School, Cornock Avenue, Toongabbie,* dated March 2020, reference 86977.00.R.004.Rev0 (DP, 2020)
[2] DP *Report on Supplementary Contamination Investigation, Pendle Hill High School Development, Cornock Avenue, Toongabbie,* dated March 2021, reference 86977.01.R.001.DftB (DP, 2021)

unexpected contamination issues which may be identified during the works. The results of the previous contaminated land investigations undertaken by DP at the site as discussed in Section 3.

As required by general requirement 19 of the Planning Secretary's Environmental Assessment Requirements (SEARS), this RAP has been developed with reference to the following:

- *National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended 2013)* [NEPM] (NEPC 2013);
- *Contaminated Sites, Sampling Design Guidelines* (NSW EPA 1995);
- *Guidelines for Consultants reporting on contaminated land, Contaminated Land Guidelines,* (NSW EPA, 2020); and
- *State Environmental Planning Policy No 55 - Remediation of Land* (DUAP & EPA 1998).

1.2 Site Information

The information on the site is presented in Table 1, below and site location shown on Drawing 1, Appendix A.

Table 1: Site Identification Details

Address	Cornock Avenue, Toongabbie
Lot Identification	Lot 101, Deposited Plan 1141329
Approximate Area	4600 m^2
Local Government	City of Parramatta Council

1.3 Proposed Development

We understand that the proposed development includes the construction of a new three-storey courtyard building on Binalong Road comprising:

- Two new 3 storey wings under a connected roof which will accommodate a library, staff unit, lecture theatre, multimedia and senior learning, administration unit and student amenities;
- External transport infrastructure upgrade works;
- New covered walkways and upgraded landscape; and
- New hardstand areas for bicycle parking.

Selected architectural drawings have been included in Appendix A and show the proposed development.

2. Remediation Goals and Objectives

The remediation goals of the RAP are to:

- Render the site suitable for the proposed land use;
- Maintain records of the remediation and earthworks undertaken, including validation as required;
- Mitigate adverse impacts on surrounding land and waterways during the remediation by the management of dust, water and noise emissions; and
- Maximise the protection of workers involved with remediation and earthworks.

In this regard, the objectives of the RAP are to:

- Establish an appropriate remediation strategy so as to render the site suitable, from a site contamination perspective, for the proposed development;
- Establish the remediation acceptance criteria (RAC) to be adopted for the site and the validation requirements to confirm the successful implementation of the remediation strategy;
- Establish appropriate environmental safeguards required to complete the remediation works in an environmentally acceptable manner;
- Establish appropriate work health and safety (WHS) procedures required to complete the remediation works in a manner that would not pose a threat to the health of site workers or users;
- Develop contingency plans and an unexpected finds protocol (UFP) for the various situations that may arise during the remediation programme; and
- Highlight the requirement for the works to be undertaken in accordance with a construction environmental management plan (CEMP) and a Work Health and Safety Plan prepared for the remediation works.

3. Site Information - Previous Reports

As referenced in Section 1, DP have previously undertaken a PSI (DP, 2020) and a supplementary contamination assessment (DP, 2021) at the site for contamination purposes and the reports were reviewed for the preparation of this RAP.

The PSI included a site walkover, a review of site geology, topography, hydrogeology and site history. The investigation also included intrusive testing which comprised the drilling and sampling of four boreholes within the carpark area. It is noted that a soil salinity investigation was carried out at the same time as DP, 2021 and was reported under a separate cover (DP, 2020a)[3]. The results of the previous reports are summarised below. Additionally, selected borehole logs from these investigations are presented in Appendix B.

Furthermore, following DP's investigation in 2021, an asbestos clearance[4] of the surface of the northern half of the site and south eastern corner of PHHS was undertaken by WSP and an associated asbestos management plan (AMP)[5] for those areas was prepared by WSP, both completed in February 2021.

[3] DP *Report on Salinity Investigation, Pendle Hill High School, Cornock Avenue, Toongabbie,* dated March 2020, reference 86977.01.R.002.DftA (DP, 2021a)

[4] WSP *Clearance Certificate – Asbestos Removal* dated 24 February 2021, reference 8395_ASB_230221_ClearanceCertificate (DP 2020a)

[5] WSP *Pendle Hill High School, Asbestos in Grounds Management Plan* dated 24 February 2021, reference 8395_ASB_230221_AMP (DP 2020b)

3.1 Site Geology, Topography and Hydrogeology

Reference to published regional maps indicates that the PHHS site is:

- Underlain by the residual Blacktown soil landscape (based on the 1:100 000 Soil Landscape Series mapping). These soils are from Wianamatta Group shales and Hawkesbury shales and typically consist of medium and high plasticity clays;
- Underlain by Ashfield Shale (based on the 1:100 000 Geological Series mapping), which typically comprises black to dark grey shale and laminite; and
- In an area of moderate salinity potential (based on the Salinity Potential in Western Sydney Mapping of 2002), however a soil salinity investigation (DP, 2021a) was undertaken on the site which indicated that for the soil samples tested, an exposure classification of 'mild' and 'non-aggressive' exists towards buried concrete and steel, respectively (in accordance with AS 2159-2009 Piling - Design and installation).

There is evidence of fill at the site, however this was not present on the mapping.

Reference to the NSW Water digital bore information indicates that there are no registered groundwater wells in close proximity to the site.

The nearest surface water receptor is the Pendle Creek which is located approximately 600 m west of the site. Based on local topography observed in the regional map information, groundwater is anticipated to flow westwards towards the creek.

3.2 Site History

DP (2020) identified that the PHHS Site had previously been used for agricultural purposes prior to being developed for a high school in the late 1960s with the surrounding areas developed into low-density residential dwellings.

The most significant risks associated with contamination at the PHHS Site were considered to be imported fill, previous site uses impacting fill / surficial soils and the risk associated with the demolition / renovation of existing buildings impacting fill / surficial soil. DP noted several sheds adjacent to the northern PHHS Site boundary were used as animal shelters as part of the school's agricultural curriculum.

3.3 Soil Subsurface Conditions and Groundwater

Based on the boreholes drilled as part of the investigations, the general sub-surface profile is shown in Table 2 below.

Table 2: Summary of Ground Profile

Depth Range (m below ground level [bgl])	Description
From 0 m bgl to depths of between 0.2 m bgl and 2.3 m bgl	TOPSOIL / FILL: • Topsoil encountered generally comprised of dark brown clayey silt with trace rootlets; • Fill encountered beneath the topsoil, generally red-brown, brown silty clay with ironstone and shale gravels; • Tile, brick and concrete fragments were identified within BH109N, BH109E, BH109S, BH109W and BH209; • Ash and clinker was observed in BH109N, BH109E, BH109S and BH109W at depths between 1.2 and 1.5 m bgl; and • It is noted that a potential concrete slab was underlying fill in BH109N, BH109E, BH109S, and BH109W at a depth of 1.5 m bgl.
Underlying the above to depths of between 0.2 m bgl and 3.0 m bgl	RESIDUAL SILTY CLAY: Red-brown, red and grey residual silty clay weathered from Ashfield Shale.
1.3 m bgl to 3.0 m bgl	SHALE: Pale grey and yellow-brown shale, highly to moderately weathered.

Anthropogenic material was observed in some boreholes (see Table 2) which included brick, concrete and tile. A fragment of ACM was identified within borehole BH109 in the DP (2020) investigation. There was no other apparent evidence of visual or olfactory impacts (e.g., staining or odours) to suggest the presence of contamination within the fill soils observed in the investigations. It is noted that fill identified as red-brown and brown silty clay with ironstone and shale gravels overlying the natural silty clay layers is possibly natural clay which has been reworked during prior levelling of the site.

Free groundwater was not observed during drilling in any borehole.

Borehole locations from the previous reports are presented on Drawing 2, Appendix A.

3.4 Soil Contamination and Preliminary Waste Classification

Asbestos as ACM was identified within borehole BH109 at a depth of between 1.0 to 1.5 m bgl during the DP (2020) investigation. Additional asbestos as AF/FA was identified within three boreholes, BH109E, BH109S and BH109W at depths between 0.05 to 1.5 m bgl during the DP (2021) supplementary investigation as refenced in Section 1.

Reported concentrations of all other contaminants were below the adopted site assessment criteria (SAC) for all samples analysed. The fragment of cement sheet tested positive for chrysotile asbestos.

The following preliminary waste classifications were provided:

- Fill around test location BH109, BH109E, BH109S and BH109W to depths of 1.5 m bgl was preliminarily classified *in situ* as general solid waste (special waste asbestos, non-putrescible, CT1); and
- Fill around test locations BH109N, BH104 and BH105 was preliminarily classified *in situ* as general solid waste (non-putrescible, CT1).

Contaminant levels in natural soil samples compared against published background levels indicated that in site soils are likely to be classified as virgin excavated natural material (VENM).

3.5 Conclusions and Recommendations

Based on the fill composition recorded from the bores, it appears likely that the northern portion of the playing field is impacted by asbestos (in fill) to some degree. Asbestos has been previously identified as an ACM fragment, but is disseminated as AF/FA in the fill matrix. The presence of anthropogenic material such as tile, brick and concrete may suggest that demolition wastes were used as fill and have a high likelihood of containing further asbestos. The supplementary assessment determined that asbestos as FA/AF was present within fill in the northern portion of the Site area, however the lateral and vertical extent of this impact is not yet known.

Based on the results presented in the previously referenced reports, it was considered that the northern portion of the playing field had a moderate to high potential to be impacted with asbestos contamination in soil and accordingly the following was recommended:

- Undertake an additional investigation to confirm the presence/absence of FA/AF in the topsoil (completed as part of WSP (2021a));
- Preparation of a site-specific asbestos management plan/temporary asbestos management plan (completed as part of WSP (2021b));
- Lateral and vertical delineation investigation of the fill and contamination (asbestos) identified in the vicinity of the BH109 location prior to commencement of works, ideally utilising test pit methodology during early works. Additionally, further investigation is required in the vicinity of boreholes BH203 and BH209 which indicated the presence of anthropogenic materials in the fill;
- Prepare a remediation action plan which would include and outline both the requirements of the detailed asbestos assessment (as discussed above) and potential remediation strategies, with a preferred approach dependent on the proposed works plan; and
- The preliminary waste classifications provided be confirmed by a suitably qualified environmental consultant, through either in situ or ex situ visual and/or analytical means, culminating in a formal waste classification to inform legal off-site disposal of surplus soils.

The sampling density of the previous investigations broadly met the sampling design guidelines outlined in Table A of NSW EPA *Sampling Design Guidelines 1995,* which recommend a minimum of 12 sampling locations for a site of approximately 0.4 ha.

DP notes that the additional intrusive investigations should not be undertaken until the site has been demarcated, fenced off and appropriate controls implemented, most likely during the initial stages of construction.

4. Conceptual Site Model

A Conceptual Site Model (CSM) is a representation of site-related information regarding contamination sources, receptors and exposure pathways between those sources and receptors. The CSM provides the framework for identifying how the site became contaminated and how potential receptors may be exposed to contamination either in the present or in the future i.e., it enables an assessment of the potential source - pathway - receptor linkages (complete pathways).

4.1 Areas of Environmental Concern

Based on the previous investigations, the following areas of environmental concern were identified (borehole locations shown on Drawing 2, Appendix A):

- Asbestos in fill in BH109, BH109E, BH109S and BH109W at depths between 0.005 to 1.5 m bgl;
- Boreholes BH203 and BH209, where the presence of anthropogenic materials in the fill indicates the potential presence of asbestos; and
- Boreholes BH201, BH202, BH204, BH206 and BH207, where fill was present to depths between 0.8 and 1.3 m bgl. Whilst no anthropogenic material was identified in these boreholes, however there is a possibility that filling adjacent to these bores may contain anthropogenic materials, including asbestos.

As such, the following potential sources of contamination and associated contaminants of potential concern (COPC) have been identified and are summarised in 3 below.

Table 3: Potential Contamination Sources and Associated Contaminants of Potential Concern

Potential Source	Description of Potential Contaminating Activity	Contaminants of Potential Concern
Fill and surficial soil (S1).	It is likely that fill was placed at the site to achieve existing design levels. As the source of fill is unknown, there is potential for contaminants to be present in any fill materials on site.	Asbestos.
Hazardous building materials in existing structures (S2).	Given the age of the existing structures, it is considered likely that hazardous building materials were used in the construction materials.	Asbestos, lead based paints, PCB capacitors, and SMF.

Notes: PCB - polychlorinated biphenyls
SMF - synthetic mineral fibre

DP notes that previous and current off-site activities do not appear to be impacting the site based on previous soil results.

4.2 Potential Receptors

The following potential receptors (R) have been identified:

Human Health Receptors:

R1 - Construction workers (during site redevelopment);

R2 - Future site users (students, staff, visitors); and

R3 - Land users in adjacent areas.

4.3 Potential Pathways

The following potential exposure pathways are primarily relevant to human receptors:

- P1 - Inhalation of fibres/dust and / or vapours; and
- P2 - Ingestion and dermal contact.

The possible pathways between the above sources (S1 and S2) and receptors (R1 to R3) are provided in Table 4.

Table 4: Summary of Potential Complete Pathways

Potential Source and COPC	Pathway	Receptor	Risk Management Action Recommended
S1 - Uncontrolled Fill Asbestos	P1 - Inhalation of dust and / or vapours	R1 - Construction workers R2 - Future site users R3 - Adjacent site users	Remediation of contaminants of concern. Implementation of appropriate work health and safety (WHS) controls during remediation works Implementation of UFP and contingency plan during construction works.
S2 - Existing buildings on-site / adjacent Asbestos, lead based paints, PCB capacitors, and synthetic mineral fibres (SMF)	P1 - Inhalation of dust and / or vapours P2 - Ingestion and dermal contact	R1 - Construction workers R2 - Future site users	A hazardous buildings material survey is conducted prior to refurbishment of any existing structures with a clearance certificate provided post removal.
	P1 - Inhalation of dust and / or vapours	R3 - Adjacent site users	

5. Remediation Options

Based on the results of the previous investigations, contamination was identified as ACM and AF/FA in the fill in the vicinity of borehole BH109, although the full extent of the contamination is not known.

Therefore, with reference to NEPC (2013)[6] and in consideration of the potential exposure pathways of the contaminated fill/soil and the proposed development, it is considered that the aforementioned area can be rendered suitable for use with respect to the contamination present by either:

a) Management of contaminated soils by placement at depth so as to minimise future disturbance and exposure. This management strategy would comprise the construction of a barrier (such as the proposed building slab) between site users and the contaminant of concern and preparation of a long term management plan to prevent future inadvertent exposure of the contaminated fill/soil to site users; and / or

b) Removal of contaminated soils from areas requiring excavation and disposal off-site. These areas will be further informed by the proposed additional investigations outlined in Section 6.1

Given the nature of the development (i.e., within a school), the preferred remediation approach will be Option B. Should option A be considered a more feasible approach, depending on the results of the additional investigations outlined herein, this RAP would have to be amended or addendum to the RAP prepared and enacted.

6. Adopted Remediation Strategy and Assessment

The remediation works must be conducted by experienced and appropriately licensed contractors. An experienced Environmental Consultant is to be engaged to inspect the progress of the works and to provide ongoing advice and recommendations as required. The success of the remediation works will be validated by the Environmental Consultant in consultation with other consultants (e.g., Geotechnical Engineer, Structural Engineer, Occupational Hygienist, etc.).

6.1 Additional Investigations

Prior to remediation, the following additional investigations are to be undertaken by a suitably qualified environmental consultant. Noting that a hazardous building materials (HAZMAT) survey is to be undertaken by a licenced occupational hygienist. The additional investigations should be undertaken once the site has been demarcated, fenced off and appropriate controls are in place.

The HAZMAT survey is to be undertaken prior to any demolition works and the remaining investigations are recommended to be undertaken after demolition works have been completed and a clearance for asbestos has been obtained.

If the results of these investigations impact the remediation approach or information outlined herein, this RAP is to be updated as required.

[6] National Environment Protection Council (NEPC) *National Environment Protection (Assessment of Site Contamination) Measure 1999* (amended 2013) (NEPC, 2013)

6.1.1 Delineation Investigation

Given the presence of asbestos as fragments and AF/FA around BH109, step out sampling by the Environmental Consultant is to be undertaken to gain a better understanding of the contaminant extent and the extent of contaminated soil (particularly friable asbestos) required for off-site disposal.

As a minimum, the additional investigations are to include:

Borehole 109:

- Excavate and soil sample two step-out 'rings' of four test pits (one bore in each direction for each ring) 0.5 m into natural soils or to a depth of 3 m. Test pits for the first ring are to be located 2 m from borehole BH109 (in each direction) with test pits for the second ring 5 m from borehole BH109.
- Step-out 'rings' are to be undertaken from BH109N to the north, BH109E to the east, BH109S to the south and BH109W to the west of BH109;
- Log soil description of each test pit;
- Collect samples at regular intervals, changes in strata and where signs of potential contamination are noted to the depth of investigation;
- Collect 10L bulk samples for asbestos sieving at regular intervals, changes in strata and where signs of potential contamination are noted to the depth of investigation;
- Despatch of samples for laboratory analysis of heavy metals, TRH, PAH, BTEX, OCP and asbestos;
- Comparison of the results against the remediation assessment criteria and waste classification criteria outlined in Section 7 to confirm suitability of the remedial approach in the area; and
- It is noted that where results from the step-out assessment do not delineate the extent of the contamination, additional step-out 'rings' may be required to be subsequently undertaken.

Following the delineation of the contamination hot spots around BH109 (plus any additional areas identified through the investigation), the extent of the 'contaminated soils' (i.e., exceeding the RAC outlined in Section 7) and hence the likely extent of remediation can be assessed and the following remediation options adopted:

- Contaminated soils are to be removed for off-site disposal in accordance with the procedure set out in Section 6.2.

DP notes that contaminated material may be capped on site, however, given the land use as a school and the friable nature of asbestos identified, it is recommended that the extent of friable asbestos be identified and removed off site if practical.

6.1.2 Data Gap Investigation

Boreholes BH201 to BH204, BH206, BH207 and BH209

This additional investigation is required to determine if the anthropogenic material identified within the fill in boreholes BH203 and BH209 (concrete and tile) also contains asbestos as in BH109 and / or is more widespread. Additionally, the fill identified in boreholes BH201, BH202, BH204, BH206 and BH207 was relatively deep (0.8 to 1.3 m bgl) and whilst no anthropogenic material was identified in these bores, there remains a possibility that adjacent fill may contain such materials, including asbestos. Under these circumstances the following should be undertaken:

- Excavate and sample the fill and soils in areas adjacent to and between the original borehole locations which showed significant thickness of fill (including those where anthropogenic materials were absent) using test pits extended 0.5 m into natural soils or to a depth of 3 m. Note that a minimum of 7 test pits would be required although additional test locations may be required (see step-outs below);
- Log soil description of each test pit;
- Collect samples at regular intervals, changes in strata and where signs of potential contamination are noted to the depth of investigation;
- Collect 10L bulk samples for asbestos sieving at regular intervals, changes in strata and where signs of potential contamination are noted to the depth of investigation;
- Despatch of samples for laboratory analysis of asbestos;
- Comparison of the results against the site assessment criteria and waste classification criteria outlined in Section 7 to confirm suitability of the remedial approach in the area; and
- It is noted that where results from the assessment identify asbestos, step-out 'rings' as per those proposed for BH109 (Section 6.1.1) may require to be subsequently undertaken.

6.1.3 Hazardous Building Materials

A HAZMAT survey of the buildings present on site must be undertaken by a licenced occupational hygienist and any identified hazardous building materials are to be removed appropriately by licenced contractor/s prior to building demolition.

Following building demolition, a clearance for asbestos of the demolition footprint and surrounding work areas is to be undertaken by a licenced occupational hygienist to ensure that there is no visible asbestos present on the surface (including top 100 mm where fill is exposed).

6.2 Off-Site Disposal of Contaminated Soils

The proposed sequence of works comprises:

a. Excavation by the Asbestos Contractor of any contaminated areas identified as a result of the above investigations. The excavations should remove the full depth of the filling layer containing the exceedance (based on visual observation), with approximate depths of 0.05 to 1.5 m bgl. The horizontal extent has not been determined but an initial excavation in the order of 5 m by 5 m would be appropriate;

b. Stockpiling by the Asbestos Contractor of the excavated soil for assessment, including waste classification assessment, by the Environmental Consultant;

c. Validation assessment by the Environmental Consultant of the resulting excavation pit in accordance with Section 7;

d. Provision by the Environmental Consultant of the results of the validation assessment to the Contractor/ Asbestos Contractor. If the assessment passes, no further excavation will be required;

e. If the validation assessment fails, further excavation by the Asbestos Contractor of the soils failing the validation assessment. Stockpiling of the excavated soils for assessment;

f. Repeat of items (c) to (e) until the excavation pit passes validation assessment;

g. Provision by the Environmental Consultant of the written advice of the results of the validation assessment;

h. Provision by the Environmental Consultant of the results of the stockpile assessment; and

i. Inclusion of the results by the Environmental Consultant in the Validation Report.

6.3 Validation of Remediation

Following the completion of the remediation works and the receipt of any related analytical results from the validation sampling, a Validation Report will be prepared in general accordance with the requirements of the *Consultants reporting on contaminated land, Contaminated Land Guidelines,* (NSW EPA, 2020).

This report will include:

- Details of the implementation of the RAP and any variations to the remediation strategy including unexpected finds;
- A rationale and justification for the validation strategy adopted;
- Results of any additional sampling, including validation sampling, undertaken during the remediation works;
- Evaluation against the Remediation Action Criteria (RAC) (where appropriate);
- Verification of regulatory compliance;
- A clear statement on whether the site is considered suitable for its intended land-use; and
- Any limitations, assumptions and uncertainties relevant to the conclusions of the report.

6.4 Waste Disposal

Any excavated spoil or surplus materials which require disposal off-site will need to be classified in accordance with *Waste Classification Guidelines* (NSW EPA, 2014). Any groundwater / seepage which requires removal during construction will also need to be assessed to determine appropriate treatment and / or disposal options.

6.5 Loading and Transport of Contaminated Material

Transport of contaminated material from the site shall be via a clearly delineated haul route and this route shall be used exclusively for entry and egress of vehicles used to transport contaminated materials within and away from the site.

Removal of waste materials from the site shall only be carried out by a contractor holding an appropriate license, consent or approvals (where required) to dispose the waste materials according to the classification outlined in NSW EPA *Waste Classification Guidelines* (NSW EPA, 2014) and with the appropriate approvals obtained from the NSW EPA, if required.

Details of all contaminated and spoil materials removed from the site (including VENM) shall be documented by the contractor with copies of weighbridge slips, trip tickets and consignment disposal confirmation (where appropriate) provided to the environmental consultant and the Principal / Principal's Representative (PR). A site log shall be maintained by the PR based on discrete excavation (numbered) locations to track disposed loads against on-site origin, location of the materials and sample numbers.

The proposed waste transport route will be outlined in a construction environmental management plan (CEMP) and truck dispatch shall be logged and recorded by the contractor for each load leaving the site. A record of the truck dispatch will be provided to the environmental consultant via the PR. As asbestos impacted soil will be involved, WasteLocate tracking will be required.

6.6 Disposal of Contaminated Material

All contaminated materials excavated and removed from the site shall be disposed of to an appropriately licensed landfill. Copies of all necessary approvals shall be given to the environmental consultant via the PR prior to any contaminated material being removed from the site. Copies of all consignment notes for the transport, receipt and disposal of the materials will be maintained as part of the site log and made available to the environmental consultant for inspection and reporting purposes upon request.

6.7 Imported Fill

Material imported to site shall be "clean filling", which is to be certified as VENM, as well as meeting the remediation acceptance criteria (Section 7) via a validation certificate by the contractor. The material should also comply with relevant legislation e.g., *Protection of Environment (Operations) Act 1997*.

Analytical results presented by the contractor to validate imported fill shall be NATA accredited and obtained at an appropriate frequency and sampling density according to the NSW EPA guidelines. Sampling density is discussed in Section 10.3.

Validation results will be presented in the final validation report along with details of site of origin, volume and date of receipt on the site.

7. Remediation Acceptance and Site Assessment Criteria

7.1 Remediation Acceptance Criteria

The remediation acceptance criteria (RAC) for any future proposed remediation works will be that no contamination presenting an unacceptable risk of harm to human health or the environment remains within the site. These have been adopted based on the site assessment criteria (SAC) outlined below, which are the adopted assessment criteria for any additional investigations, providing the proposed land use has not changed.

7.2 Site Assessment Criteria

The Site Assessment Criteria (SAC) provided herein are the initial assessment levels that will be considered as the first stage in determining if soils at the site meet the RAC, as listed above.

The SAC include both human- and ecological-based investigation levels applicable to a generic low density residential land use scenario and are based on Schedule B1, *National Environment Protection (Assessment of Site Contamination) Measure* 1999, as amended 2013 (NEPC, 2013). The NEPC guidelines are endorsed by the NSW EPA under the CLM Act 1997.

Whilst the NEPC (2013) thresholds are considered to be for "Tier 1" assessment, and are not intended to be used as clean up levels, given the limited quantity of chemically contaminated soils identified above the SAC at the site, it is considered that remediation to these "Tier 1" thresholds is likely to be more cost effective than establishing site specific risk-based thresholds. The RAC above do allow for risk-based assessment if considered prudent during the remediation works.

7.2.1 Health Investigation and Screening Levels

The Health Investigation Levels (HIL) and Health Screening Levels (HSL) are provided in Table 5, below.

HIL are applicable to assessing health risk arising *via* all relevant pathways of exposure for a range of metals and organic substances.

HSL are applicable to selected petroleum compounds and fractions to assess the risk to human health via inhalation and direct contact pathways. The HSL summarised below are for sandy soils between 0 to <1 m depth. Previous investigations have identified both sandy and clayey soils at the site, and HSL for sandy soils have therefore been adopted as a conservative measure. If silty or clayey soils, or contamination in deeper soils are being assessed, less conservative HSL may be appropriate in accordance with NEPC (2013) and if appropriate will be considered as part of the risk assessment under the RAC.

Table 5: Health Investigation and Screening Levels (HIL and HSL) in mg/kg Unless Otherwise Indicated

Contaminants		HIL- A and HSL- AB Direct Contact	HSL- AB Vapour Intrusion
Metals	Arsenic	100	
	Cadmium	20	
	Chromium (VI)	100	
	Copper	6,000	
	Lead	300	
	Mercury (inorganic)	40	
	Nickel	400	
	Zinc	7,400	
PAH	Benzo(a)pyrene TEQ[1]	3	
	Naphthalene	1400	3
	Total PAH	300	
TRH	C6 – C10 (less BTEX) [F1]	4,400	45
	>C10-C16 (less Naphthalene) [F2]	3,300	110
	>C16-C34 [F3]	4,500	
	>C34-C40 [F4]	6,300	
BTEX	Benzene	100	0.5
	Toluene	14,000	160
	Ethylbenzene	4,500	55
	Xylenes	12,000	40
Phenol	Pentachlorophenol (used as an initial screen)	100	
OCP	Aldrin + Dieldrin	6	
	Chlordane	50	
	DDT+DDE+DDD	240	
	Endosulfan	270	
	Endrin	10	
	Heptachlor	6	
	HCB	10	
	Methoxychlor	300	
OPP	Chlorpyrifos	160	
PCB[2]		1	

Notes:

1 sum of carcinogenic PAH

2 non dioxin-like PCBs only.

7.2.2 Ecological Investigation and Screening Levels

Ecological Investigation Levels (EIL) and Ecological Screening Levels (ESL) are applicable for assessing risk to terrestrial ecosystems (NEPC, 2013). The EIL and ESL apply to the top 2 m of soil.

The adopted EIL and ESL are provided in Table 6, along with notes on their assumptions. Previous investigations have identified both sandy and clayey soils at the site, and ESL for most conservative of either fine or coarse soils have therefore been adopted as a conservative measure as marked in the

below table. Were these assumptions are not met, further guidance on appropriate EIL/ESL may be referenced from NEPC (2013) as part of the risk assessment under the RAC.

Table 6: Ecological Investigation and Screening Levels (EIL and ESL) in mg/kg Unless Otherwise Indicated

Analyte		EIL/ ESL	Assumptions
EIL			
Metals	Arsenic	100	All EIL: - 80% protection level adopted, based on urban residential areas and public open space use - contamination is "aged" (>2 years); EIL marked with * (as applicable, assumptions based on DP, 2016b): - pH of 4.9 - clay content of 21.4 % w/w - CEC of 6.7 $cmol_c/kg$
	Copper	100*	
	Nickel	70*	
	Chromium III	520*	
	Lead	1,100	
	Zinc	230*	
PAH	Naphthalene	170	
OCP	DDT	180	
ESL			
TRH	C6 – C10 (less BTEX) [F1]	180 #	All ESL
	>C10-C16 (less Naphthalene) [F2]	120 #	- ESL marked with a ^ based on fine soils, all other ESL for coarse soils. These are the most conservative ESL respectively
	>C16-C34 [F3]	300	
	>C34-C40 [F4]	2,800	ESL marked with a # are moderate reliability; all other ESL are low reliability
BTEX	Benzene	50	
	Toluene	85	
	Ethylbenzene	70	
	Xylenes	45^	
PAH	Benzo(a)pyrene	0.7	

7.2.3 Management Limits Petroleum Hydrocarbons

In addition to appropriate consideration and application of the HSL and ESL, there are additional considerations which reflect the nature and properties of petroleum hydrocarbons, including:

- Formation of observable light non-aqueous phase liquids (LNAPL);
- Fire and explosion hazards; and
- Effects on buried infrastructure e.g., penetration of, or damage to, in-ground services.

Management Limits apply to any depth within the soil profile. A "coarse" soil texture has been adopted as a conservative measure based on both coarse and fine soils being encountered at the site. Were these assumptions are not met, further guidance on appropriate EIL/ESL may be referenced from NEPC (2013) and as part of the risk assessment under the RAC.

Table 7: Management Limits in mg/kg

Analyte		Management Limit
TRH	$C_6 – C_{10}$ (F1) #	700
	$>C_{10}$-C_{16} (F2) #	1,000
	$>C_{16}$-C_{34} (F3)	2,500
	$>C_{34}$-C_{40} (F4)	10,000

Separate management limits for BTEX and naphthalene are not available hence these have not been subtracted from the relevant fractions to obtain F1 and F2

7.2.4 Asbestos in Soil

NEPC (2013) defines the various asbestos types as follows:

Bonded ACM: Asbestos-containing material which is in sound condition, bound in a matrix of cement or resin, and cannot pass a 7 mm x 7 mm sieve;

FA: Fibrous asbestos material including severely weathered cement sheet, insulation products and woven asbestos material. This material is typically un-bonded or was previously bonded and is now significantly degraded and crumbling; and

AF: Asbestos fines including free fibres, small fibre bundles and also small fragments of bonded ACM that pass through a 7 mm x 7 mm sieve.

The asbestos Health Screening Levels (HSL) in Table 8 will be adopted.

Table 8: Health Screening Levels for Asbestos Contamination in Soil (% w/w)

Form of Asbestos	HSL (% w/w)
	Residential (HSL A) (residential with garden/ accessible soil)
Bonded ACM	0.01%
FA and AF	0.001 %
All Forms of Asbestos	No visible asbestos for surface soil

7.2.5 Aesthetic Considerations

Aesthetic issues relate to the presence of low-concern odours, staining, and non-hazardous inert foreign material (refuse) in soils resulting from human activity and include fragments such as concrete, metal, bricks, tile, pottery, glass, trivial amounts of bonded ACM, bitumen, ash, green waste, rubber, plastics and a wide variety of other waste materials (NEPC, 2013). For this RAP the asbestos HSL in Section 7.2.4 take precedence over the requirements of these aesthetic considerations.

Whilst there are no specific numeric aesthetic guidelines, NEPC (2013) calls for a balanced consideration of the quantity, type and distribution of foreign material or odours in relation to the land use and sensitivity. This includes consideration of small quantities of inert material and low odour

residues which may decrease over time, and inert materials that present no health hazard such as brick fragments and cement wastes.

The following characteristics are examples that would trigger further assessment:

- Highly malodorous soils or extracted groundwater (e.g., strong residual petroleum hydrocarbon odours, hydrogen sulphide in soil or extracted groundwater, organosulfur compounds);
- Hydrocarbon sheen on surface water;
- Discoloured chemical deposits or soil staining with chemical waste other than of a minor nature;
- Large monolithic deposits of otherwise low-risk material, e.g., gypsum as powder or plasterboard, cement kiln dust;
- Presence of putrescible refuse including material that may generate hazardous levels of methane such as deep-fill profile of green waste or large quantities of timber waste; and
- Soils containing residue from animal burial (e.g., former abattoir sites).

It should be noted that due to the site history, some of the above are considered highly unlikely.

7.3 Classification Assessment for Off-Site Disposal

All wastes will be assessed in accordance with the NSW *Protection of the Environment Operations Act* 1997 (POEO Act). For disposal to landfill, this will comprise assessment in accordance with the NSW Environment Protection Authority (EPA) *Waste Classification Guidelines* (2014). Refer to section 10.2 for full details.

8. Regulatory Requirements and Relevant Standards

All work must be conducted in accordance with development consent conditions and relevant regulatory criteria, including the following:

- NSW *Work Health and Safety Act* 2011 (WHS Act);
- NSW *Work Health and Safety Regulation* 2017 (WHS Regulation);
- NSW *Contaminated Land Management Act* 1997 (CLM Act);
- NSW *Protection of the Environment Operations Act* 1997 (POEO Act);
- National Environment Protection Council (NEPC) *National Environment Protection (Assessment of Site Contamination) Measure 1999 (amended 2013)* (NEPC, 2013);
- NSW EPA *Waste Classification Guidelines 2014* (EPA 2014);
- WA Department of Health, *Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia 2009* (WA DoH 2009);
- SafeWork NSW, *Code of Practice How to Manage and Control Asbestos in the Workplace* July 2020; and
- SafeWork NSW *Code of Practice How to Safely Remove Asbestos* July 2020.

9. Roles and Responsibilities

9.1 Principal

The Principal retains the overall responsibility for ensuring that this RAP is appropriately implemented. The Principal may nominate a representative (the Principal's Representative), who is responsible for overseeing the implementation of this RAP. The actual implementation of the RAP may be conducted by the Principal Contractor on behalf of the Principal.

9.2 Principal Contractor

The Principal Contractor (referred to hereon in as the Contractor) is foreseen to be the party responsible for the day-to-day implementation of this RAP and shall fulfil the responsibilities of the Principal Contractor as defined by SafeWork NSW. It is noted that the Contractor may appoint appropriately qualified sub-contractors or sub-consultants to assist in fulfilling the requirements of the procedures. The PC may appoint a Contractor's Site Manager (CR) to be responsible for site activities.

In addition to the implementation of the RAP it will be the Contractor's responsibility:

- To obtain specific related approvals as necessary to implement the earthworks, including for example, permits for the removal of asbestos-containing materials, SafeWork notification, etc.;
- To develop or request and review plans to manage site works, such as an asbestos management plan;
- That all site works and other related activities are undertaken in accordance with this RAP;
- To maintain all site records related to the implementation of this RAP;
- To estimate quantities related to remediation and provide quantities of placed and/or disposed materials resulting from the remedial works;
- To obtain sufficient information to engage and/or direct all required parties, including sub-contractors, to implement the requirements of the RAP other than those that are the direct responsibility of the Contractor;
- To manage the implementation of any recommendation made by those parties in relation to work undertaken in accordance with the RAP;
- To inform, if appropriate, the relevant regulatory authorities, of any non-conformances with the procedures and requirements of the RAP in accordance with the procedures outlined in this document;
- To retain records of any contingency actions;
- On completion of the project, to review the RAP records for completeness and update as necessary; and
- To recommend any modification to the general documentation which would further improve the environmental outcomes of this RAP.

9.3 Asbestos Contractor

The Asbestos Contractor (AC) will be responsible for undertaking all asbestos works involving any asbestos contaminated fill or asbestos that is required to be removed from buildings (e.g., see Section 6.1 for HAZMAT survey requirements) prior to demolition. The AC is to hold an appropriate licence for the removal of asbestos (issued by SafeWork NSW) in accordance with the WHS Regulations (i.e., Class A for friable works and Class A or B for non-friable works). The Asbestos Contractor can be the same as the Principal Contractor.

9.4 Sub-contractors

All sub-contractors will be inducted onto the site and informed of their responsibilities in relation to this RAP as part of this induction. Signing of the site induction is to include agreement by the sub-contractors to abide by the RAP requirements. Where necessary, sub-contractors will also be trained in accordance with the requirements of this document. All sub-contractors must conduct their operations in accordance with this RAP as well as all applicable regulatory requirements.

9.5 Environmental Consultant

The Environmental Consultant (EC) will provide advice on implementing this RAP.

The EC will be responsible for:

- Undertaking any data gap or further investigations required;
- Undertaking any required assessments where applicable (e.g., waste classification, site validation, etc.);
- Providing advice and recommendations arising from inspections;
- Reviewing documentation and results provided by the contractor (e.g., surveys, proposed materials to be imported); and
- Notifying their client with the results of any assessments and any observed non-conformances in a timely manner.

9.6 Occupational Hygienist

The Occupational Hygienist (OH) will provide advice on Work Health and Safety (WHS) issues related to any hazardous materials related works (e.g., asbestos, lead paint). The OH will hold an Asbestos Assessor Licence, where appropriate, in accordance with the WHS Regulations.

The OH will be responsible for:

- Developing an asbestos management plan (AMP);
- Any WHS plans and advice requested by the Contractor;
- Undertaking airborne asbestos monitoring, where necessary;

- Undertaking clearance inspections for hazardous materials;
- Providing advice and recommendations arising from monitoring and / or inspections; and
- Notifying their client with the results of any assessments and any observed non-conformances in a timely manner.

The EC and the OC can be the same entity.

9.7 Site Workers

All workers on site are responsible for observing the requirements of this and other management plans. These responsibilities include the following:

- Being inducted on site and advised of the general nature of the remediation/environmental issues at the site;
- Being aware of the requirements of this plan;
- Wearing appropriate PPE;
- Only entering restricted areas when permitted; and
- Requesting clarification when unclear of requirements of this or any other plans (e.g., SWMS).

10. General Site Management Considerations

This section provides general information which is to be considered during the remedial works.

10.1 Stockpiling of Soils

It is envisaged that temporary stockpiles will be formed during the works. Stockpiles must be managed to minimise the risk of dust generation and erosion given the likely presence of contaminants in some of the stockpiled materials. The measures required to achieve this should include:

- Restrict the height of stockpiles to reduce dust generation (less than 2 m);
- Place stockpiles of fill within the areas to be remediated (i.e., excavated);
- Construct suitable erosion and sediment control measures;
- Cover stockpiles at the end of each day or when not in use with plastic; and
- Keep temporary stockpiles moist, by using water spray where required.

10.2 Waste Disposal

All off-site disposals of waste soils are to be undertaken in accordance with the *Protection of the Environment Operations* (POEO) Act and the *Waste Classification Guidelines,* 2014 (NSW EPA, 2014). Copies of all necessary approvals from the receiving site shall be given to the Principal's Representative prior to any contaminated material being removed from the site. Preliminary waste classification has been provided in DP (2020) and summarised in Section 3.4 for reference.

The indicative sampling rate for validation / waste classification / assessment of stockpiled soils is (note actual frequency will be determined based on volume, contamination risk and homogeneity of the material):

- Stockpiles ≤250 m^3: one sample per 25 m^3 or a minimum of three samples; and
- Stockpiles >250 m^3: one sample per 100-250 m^3 and a minimum of three samples.

During excavation or stockpiling but prior to loading out the waste material is to be periodically inspected (and sampled) by the Environmental Consultant to confirm the waste classification of the material. Inspection of the waste for the presence of ash, clinker (coal) or slag should be noted to assess the suitability of applying the NSW EPA Immobilisation of Wastes (1999/05 or 2009/07) particularly around previous borehole BH109. No soil is to leave the site without a formal waste classification report.

Transport of spoil shall be via a clearly delineated, pre-defined haul route. Copies of all consignment notes for the transport, receipt and disposal of all materials are to be maintained as part of the site log and made available to the EC for inspection and reporting purposes upon request.

All relevant analysis results, as part of waste classification reports, shall be made available to the Contractor and proposed receiving site / waste facility to enable selection of a suitable disposal location which is legally able to accept the waste.

10.3 Importation of Soil

Any soil is to be imported onto the site will be certified and provided by an appropriately licenced supplier. Prior to importation appropriate documentation confirming the soil can be legally imported onto the site under the POEO Act and meets the RAC/SAC (outlined in Section 7) is to be provided to the Environmental Consultant for review. By preference, material imported onto the site will comprise virgin excavated natural material (VENM).

VENM is to be sampled for each source site at a minimum rate of three samples for the first 1,000 m^3 and then one sample per 1,000 m^3 thereafter.

Prior to importation appropriate documentation confirming the classification and any relevant certification needs to be provided to, and approved by, the EC. If necessary, the material should be inspected at the source site (and sampled if required) to confirm the classification given and to confirm that there are no apparent signs of contamination.

The material must be inspected during importation by the Contractor, and any materials not meeting the description given in the provided documentation or displaying signs of contamination are to be rejected. The EC is to conduct inspection(s) during and / or following importation to check the same. Additional testing of the imported material may be required, as recommended by the EC, commensurate with the documentation and the material type/classification.

Materials classified under RRO exemptions are not recommended for import onto the site.

11. Site Validation Plan

11.1 Data Quality Objectives and Indicators

The validation assessment is to be conducted in accordance with Data Quality Objectives (DQOs) and Quality Assurance / Quality Control (QA / QC) procedures to ensure the repeatability and reliability of the results.

The validation assessment will be planned in accordance with the following DQOs:

- State the Problem;
- Identify the Decision;
- Identify Inputs to the Decision;
- Define the Boundary of the Assessment;
- Develop a Decision Rule;
- Specify Acceptable Limits on Decision Errors; and
- Optimise the Design for Obtaining Data.

A checklist of Data Quality Indicators (DQI) in accordance with NEPC (2013) Schedule B2 is to be completed as part of the validation assessment. The DQIs are:

- Documentation completeness;
- Data completeness;
- Data comparability and representativeness; and
- Data precision and accuracy.

Based on a fulfilment of the DQOs and DQIs an assessment of the overall data quality is to be presented in the validation assessment report.

11.2 Site Inspections

The Environmental Consultant is to conduct periodic site inspections during each phase of the remediation works and when any issue of concern is identified. A record of the inspections and observations is to be provided as part of the Validation Assessment Report. This is to include a photographic record.

11.3 Validation Inspection and Sampling

Remediation of the areas requiring remediation will be considered complete upon removal and disposal off-site of the contaminated soils.

Validation inspections are required at various stages of the remediation works and the following describes the requirements for the various types of validation inspections and sampling events anticipated to be required.

Asbestos Clearance (post demolition)

When inspecting areas for the presence of ACM at the surface post demolition of structures. This is to be undertaken on a 3 m x 3 m cross grid pattern to confirm the absence of any visual identifiable asbestos. This can be undertaken by either the Environmental Consultant or the Occupational Hygienist.

Remediation Excavations

An inspection is required on completion of excavations to confirm removal of all contaminated soils within the remediation area(s) has occurred. The environmental consultant will validate the excavation footprint(s) as follows:

1. Visual inspection of the excavation;
2. Sampling and analysis of the (remaining) soil by the environmental consultant with reference to NEPC (2013) and guidelines as follows:
3. For small to medium excavations (base <500 m^2):
    a. Base of excavation: one sample per 25-50 m^2 or part thereof; and
    b. Walls of excavation: one sample per 10 linear metres and one sample per 1.5 m vertical height along the excavation side walls. Sample depths and materials to be logged in each case.
4. For large excavations (>500 m^2):
    a. Base of excavation: sampling on a grid at a density in accordance with the EPA *Contaminated Sites: Sampling Design Guidelines* (1995); and
    b. Walls of excavation: one sample per 15 linear metres and one sample per 1.5 m vertical height along the excavation side walls. Sample depths and materials to be logged in each case noting that validation samples at multiple depths may be required based on the observations of the environmental consultant.

5. Analysis of collected samples for (as a minimum) the contaminants of concern (such as lead, PAH (including B(a)P), TRH, OCP and asbestos) respective to the source of the material;
6. Where the reported concentration of the COC are greater than the RAC, further chase out of that location will be required and steps 1 to 5 will be repeated. The additional soil generated during the chase out will require remediation with reference to Section 6; and
7. A record of the validation is to be kept and included as part of the final validation report.

Stockpiled Material Footprints

In the scenario that contaminated soils are temporarily stockpiled in areas of the site which have been validated following the removal of contaminated soils or in an area which do not require remediation, the environmental consultant is to validate the stockpile footprint as follows:

- Visual inspection of stockpile footprint;
- Sampling and analysis of the soil by the environmental consultant with reference to NEPC (2013) and guidelines. Sampling is to be at a rate of one sample per 25-50 m^2 or part thereof and a minimum of three samples;
- Analysis of collected samples for (as a minimum) the contaminants of concern (such as lead, PAH (including B(a)P), TRH, OCP and asbestos) respective to the source of the material;
- Where the reported concentration of the COC is greater than the RAC, further excavation of the surface soils will be required, and the validation process repeated (as outlined above). The additional soil generated during the chase out will require remediation with reference to Section 6; and
- A record of the validation is to be kept and included as part of the final validation.

Areas Containing Unexpected Finds

For areas subject to unexpected finds, soil validation sampling is likely to be required once the unexpected finds have been removed. The sampling rate adopted by the Environmental Consultant is to be reflective of the works being assessed, area and risk. In this regard, reference should be made to the NSW EPA *Sampling Design Guidelines 1995* for general validation of areas and to Section 11.2 for validation associated with asbestos impacted areas.

Results of the validation sampling are to be compared to the RAC as outlined in Section 7.

11.4 Documentation Requirements

The following documents will need to be reviewed as part of the validation assessment by the Environmental Consultant. These are to include and be provided to the Environmental Consultant by the relevant parties.

- Any Licences and Approvals required for the remediation works;

- Transportation Record: this will comprise a record of all truck-loads of soil entering or leaving the site, including truck identification (e.g., registration number), date, time, load characteristics (i.e., classification, on-site source, destination);
- Disposal dockets: for any soil materials disposed off-site, the contractor will supply records of: transportation records, spoil source, spoil disposal location, receipt provided by the receiving waste facility (i.e., the receiving sites transportation records, WasteLocate tracking for asbestos, etc.);
- Imported materials records: records for any soil imported onto the site, including source site, classification reports, inspection records of soil upon receipt at site and transportation records;
- Records relating to the marker layers properties (data sheets) and delivery of the materials to site;
- Records relating to any unexpected finds and contingency plans implemented;
- Incident Reports: any WHS or Environmental Incidents which occur during the works will be documented and the PR and appropriate regulatory authority will be informed in accordance with regulatory requirements;
- Laboratory certificates and chain-of-custody documentation;
- Letters / memos as required to provide instruction or information to the Principal and Contractor;
- Airborne asbestos monitoring records;
- Visual clearance or asbestos removal records (if required);
- Inspections records from the Environmental Consultant and Occupational Hygienist; and
- Surveys of the levels of the remediated areas as outlined in Sections 6, including any other relevant construction quality assurance documents.

11.5 Validation Reporting

A validation assessment report is to be prepared for the site by the Environmental Consultant in accordance with NSW EPA *Guidelines for Consultants Reporting on Contaminated Land. Contaminated Land Guidelines: NSW Environment Protection Authority* (NSW EPA 2020) and other appropriate guidance documentation.

The validation report shall describe the methodology, results and conclusion of the assessment and make a clear statement regarding the suitability of the remediated areas (i.e., areas subject to subsurface disturbance) for the proposed land use as a school with access to soil (Residential A[7]).

12. Environmental Management Plan During Remediation and Construction

A construction environmental management plan (CEMP) is to be followed in conjunction with any other environmental management protocols stipulated in relevant SafeWork NSW, Australian Standard, Council and / or development consent conditions requirements. The CEMP shall be provided by the remediation and/or construction contractor(s) as appropriate.

[7] Residential A land use includes children's day care centres, preschools and primary schools

As a minimum, the site-specific CEMP shall detail the following:

- Works sequence and timeline;
- Health and Safety Protocols;
- Dust minimisation measures;
- Noise minimisation measures;
- Environment protection measures;
- Equipment to be used;
- Nominated landfill(s);
- Truck movements / site access / site egress;
- Proposed source(s) of materials for import, and methods of certification;
- Method(s) for surveying before and after physical barrier construction;
- Measures to prevent cross contamination between areas being remediated and those already remediated or not subject to remediation; and
- Method(s) for inspecting and certifying construction of the physical barrier systems or contaminated soil removal, including any hold points (*may be organised and commissioned by the Principal*).

The remediation and construction works shall be undertaken with all due regard to the minimisation of environmental effects and to meet all statutory requirements. The successful contractor shall have in place the site-specific CEMP such that work on the site complies with the requirements as laid down in relevant legislation, guidelines and codes.

The contractor shall also be responsible to ensure that the site works comply with the following conditions:

- Fugitive dust leaving the confines of the site is mitigated;
- No water containing any suspended matter or contaminants leaves the site in a manner which could pollute the environment;
- Vehicles shall be cleaned and secured so that no mud, soil or water are deposited on any public roadways or adjacent areas; and
- Noise and vibration levels at the site boundaries comply with the legislative requirements.

The appointed remediation and construction contractors will be provided with a copy of this RAP, any additional reports from delineation investigations and any other site management plans (e.g., CEMP) so that they are aware of the contamination status of the soils and building materials and the remediation methodology to be adopted. The reports should not, however, be used to estimate or quantify the amount of contaminated soils on the site, including asbestos contamination, for the purposes of tendering, planning or programming etc.

The following sub-sections provide details of the environmental management practices to be employed as a minimum at the site in order to minimise and / or prevent environmental impact as a result of the remediation and / or construction works. Again, it is noted that other statutory requirements must also be followed.

The following is intended for the period during development of the site.

12.1 Site Delineation

Each stage of remediation and construction is to be appropriately fenced off from the remainder of the property (where appropriate). The fencing will be designed to:

- Prevent unauthorised entry to the work site;
- Minimise the potential for cross contamination between areas requiring and not requiring remediation; and
- Capture and contain minor dust generation.

The fencing alignment applicable to each stage of works is to be included in the CEMP.

12.2 Dust Control

During working hours, water sprays are to be used to keep the surface of any works areas and stockpiled soils (which will be kept to a minimum) reasonably damp, in order to suppress any dust. Water used for dust suppression is to be only the minimum required to reduce dust generation and must not to be allowed to escape the confines of the works areas. If excessive dust is being generated, works are to cease until the dust is sufficiently suppressed.

During non-working hours, all soil stockpiles impacted or potentially impacted by contaminated materials are to be covered with plastic, securely weighted to ensure they are not blown away by strong winds.

As asbestos has been identified, air monitoring will be required during removal of asbestos from buildings and when handling / exposed soils impacted by ACM are on site, as directed by the Occupational Hygienist. Air monitoring devices are to be kept at locations nominated by an appointed Occupational Hygienist, which will generally be at the works area boundaries. If asbestos fibres are detected during the course of the works above acceptable limits, the remediation works will cease, and dust prevention measures improved. Should asbestos be identified in either the buildings or in the soil, then information regarding asbestos air monitoring requirements is to be incorporated into the AMP.

12.3 Soil / Sediment Containment

Industry standard sediment control measures (such as outlined in the ‘blue book’), including sediment fencing and / or hay bales, shall be installed where there is a potential for sediment to spill outside the construction area, neighbouring properties, public roads or the stormwater drainage lines.

The sediment control measures shall be regularly inspected and maintained by the site foreman. The Contractor is to carry out regular inspections.

12.4 Noise Management

Noise impacts will generally result from the excavators, truck movements and construction equipment within the site and surrounding streets, all of which have noise levels within levels normally expected at a construction site.

In order to minimise noise impacts during the remediation works, the following measures are to be implemented:

- Construction noise is to be confined to the hours stipulated by the development consent. No machinery / trucks are to be permitted access to the site outside these hours of operation;
- Signage at the site entrance providing contact details for the site superintendent, so that noise complaints can be readily addressed;
- Establishment and monitoring of a complaints log;
- All equipment and machinery are to comply with regulatory standards for noise generation;
- Fitting mobile equipment with exhaust mufflers, when and if required; and
- Adopting traffic management measures to reduce noise.

12.5 Odour Control

In order to control odours at the site boundaries, the following processes are to be adopted:

- All plant and equipment exhaust levels are to be monitored by the site foreman / superintendent to ensure acceptable levels. If unacceptable levels are determined, the equipment is to be replaced or repaired;
- If strong hydrocarbon odours are detected from any of the machinery a hydrocarbon mitigating agent is to be used;
- A complaints register is to be set up on-site for recording complaints, adjacent residents, etc., with respect to odours or dust. The complaints register is to be completed by the Site Superintendent, as well as the corrective actions implemented; and
- Once a complaint is received, the site superintendent is to implement a corrective action to rectify any problems associated with the odour or dust source.

Investigations performed to date have not identified any volatile contaminants in the soil that could generate odours and, therefore, odours are not anticipated or expected to be significant. If, however, odours are detected during the works the following protocol will be applied:

- Odour source and type of odour to be investigated by the Environmental Consultant. This could include air monitoring or sampling of any suspect media in addition to observations of physical conditions;
- Temporary covering of the source to mitigate odours whilst waiting for monitoring / analytical results. This could include the temporary reinstatement of ground conditions; and
- Assessing more permanent ways of dealing with the issue. This is to include disposal of odorous material off-site, the use of masking agents or the controlled progressive excavation, etc.

The re-use of odorous soils for construction purposes are not to be undertaken unless the material has been aerated or suitably treated and the odorous material assessed by the Environmental Consultant to be suitable and the odour to have adequately attenuated.

13. Work Health and Safety Plan

The remediation works contractor will be required to develop a Work Health and Safety Plan for the project. This plan should be developed in accordance with the relevant Work Health and Safety legislation and guidelines for NSW.

13.1 Specific Requirements for Asbestos

The WHS Act and associated Regulation has specific requirements for asbestos works. The Asbestos Assessor is responsible for providing advice on Regulatory requirements for asbestos works and the Asbestos Contractor is responsible for implementing these requirements. A summary of the WHS requirements with respect to asbestos is provided below.

13.1.1 Provision of Asbestos Register

The Principal or Contactor will provide the Asbestos Contractor and Asbestos Assessor with a copy of the Asbestos Register (if applicable) for the site prior to commencement of asbestos removal work.

13.1.2 Notification

SafeWork NSW must be notified by the Asbestos Contractor five days in advance of any licensable asbestos works.

The Asbestos Contractor must, before commencing the licensed asbestos removal work, inform the person with management or control of the workplace that asbestos removal works are to be conducted and the date the work will commence.
The person with management or control of the workplace must then ensure the following are informed:

- The person's workers and any other persons at the workplace;
- The person who commissioned the asbestos removal work; and
- Any person conducting a business or undertaking or occupying a premises at or adjacent to the workplace.

13.1.3 Asbestos Assessor

An Asbestos Assessor who is independent of the Asbestos Contractor is to be engaged by the Principal or Principal Contractor to provide WHS advice, air monitoring and asbestos clearances.

13.1.4 WHS Plans

The Asbestos Contractor will prepare, retain and provide the following plans complying with Regulatory requirements, including the WHS Regulation (2011), the Code of Practice 'How to Safely Remove Asbestos' and SafeWork NSW requirements:

- Safe Works Method Statement (SWMS): which will be specific to individual tasks undertaken at the site; and
- Asbestos Removal Control Plan (ARCP) which must be prepared for all licensable asbestos removal works.

These plans must be provided to the person who commissioned the work.

13.1.5 Licensed Contractor and Training

Asbestos removal works must be undertaken by an Asbestos Contractor with a Class A License (friable works) or Class B Licence (non-friable works) issued by SafeWork NSW.

All asbestos workers at the site must be appropriately trained and certified in asbestos removal works in accordance with the WHS Regulation 2011. In addition, they must be provided with specific training for the project, including in the requirements of the ARCP, the risks associated with the asbestos removal work, the health monitoring requirements and any other site-specific requirements.

The licensed asbestos removalist must keep records of all training works in accordance with the requirements of the WHS Regulation 2011.

13.1.6 Fencing and Signage

Prior to the commencement of the asbestos works, the area will be delineated by erecting barricades and affixing warning signs. The type of barricade should be in keeping with the risk and warning signs shall be specific to asbestos removal hazards and be clearly placed at all main entry points.

13.1.7 Restriction of Access

Access to the asbestos works area will be restricted to:

- Workers engaged in asbestos removal work;
- Other persons associated with the asbestos removal work; and
- Anyone allowed under the WHS Regulation or another law to be in the asbestos removal area.

13.1.8 Removal Methodology

The asbestos removal methodology will be detailed in the ARCP and approved by the Asbestos Assessor.

13.1.9 Airborne Asbestos Monitoring

The Asbestos Assessor will design and undertake a monitoring programme for airborne asbestos fibres.

13.1.10 Personal Protective Equipment

The personal protective equipment (PPE) will be detailed in the ARCP and approved by the Asbestos Assessor.

13.1.11 Decontamination and Asbestos Waste Disposal

The Asbestos Contractor must set up decontamination facilities that are appropriate for the specific works to be undertaken and prior to the commencement of the works. The facilities must be provided to decontaminate:

- The asbestos removal area;
- The asbestos treatment area;
- Any plant used in the asbestos removal area;
- Workers carrying out asbestos removal work; and
- Other persons who have access to the asbestos removal area.

The Asbestos Contractor must ensure that Asbestos Waste, including used PPE, is managed and disposed in accordance with the WHS Regulation 2011 and this RAP.

13.1.12 Clearance Inspection and Certificate

Upon completion of all asbestos removal works, the Asbestos Assessor is to undertake a visual clearance inspection. When they are satisfied the works area and immediate surrounding areas are free from any visible asbestos contamination (and any air monitoring results are below 0.01f/ml) then a final clearance certificate is issued.

14. Community Consultation

Community consultation (if required) will be undertaken in accordance with the planning approval for the project and any associated legislation and planning instruments referenced therein.

15. Unexpected Finds and Contingency Plans

15.1 Unexpected Finds Protocol

All site personnel are to be inducted into their responsibilities under this UFP, which should be included in the Contractors Site Management Plan (SMP).

All site personnel are required to report unexpected signs of environmental concerns to the Site Manager if observed during the course of their works e.g., petroleum, or other chemical odours, unnatural staining, potential contamination sources (such as buried drums or tanks) or chemical spills.

Should signs of concern be observed, the contractor is to, as soon as practical:

- Place barricades around the affected area and cease work in that area. Covering of the surface with a geofabric or similar is also to be undertaken, where required;
- Notify authorities needed to obtain emergency response for any health or environmental concerns (e.g., fire brigade);
- Notify the Principal's Representative of the occurrence;
- Notify any of the authorities that the Contractor is legally required to notify (e.g., EPA, Council); and
- Notify the Environmental Consultant.

The Principal's Representative is to notify any of the authorities which the Principal is legally required to notify (e.g., EPA, Council).

Following the immediate response in the UFP a contingency plan is to be implemented.

15.2 Contingency Plan

The contingency plan for any unexpected finds or additional finds of asbestos on the site is as follows:

- The Environmental Consultant (or Occupational Hygienist as appropriate) to inspect the issue of concern and determine the nature of the issue and the appropriate approach to assessing or (if appropriate) managing the issue;
- The Environmental Consultant (or Occupational Hygienist as appropriate) to undertake an assessment considered necessary to determine the management strategy for the area;
- If contamination is found and remediation action is considered necessary, a remediation strategy for the area is to be prepared by the Environmental Consultant;
- If a significant amount of asbestos is identified and subsequently a different remediation option is preferred (such as cap and contain on site), this remediation action plan would have to be amended or an addendum to this RAP prepared and enacted; and
- If the area or proposed remediation strategy is significantly different than that detailed in the RAP, the Consent Authority or Private Certifier (as appropriate) is to be provided notification of the proposed works.

16. Conclusion

Based on the fill composition recorded during previous investigations, it appears likely that the northern portion of the site is impacted by asbestos (in fill) to some degree. Asbestos has been previously identified as an ACM fragment, but is disseminated as AF/FA in the fill matrix. The presence of anthropogenic material such as tile, brick, concrete and glass may suggest that demolition wastes were used as fill and thus have a high likelihood of containing further asbestos.

It should be noted that the identification of asbestos in fill can be difficult due to the nature of the contaminant and the irregular nature of dispersal within soils and accordingly asbestos may be more widespread within the fill than has been identified hitherto and could extend into any filling materials which are present on the site.

Additional investigations are proposed in Section 6.1. The results of these investigations will need to be considered prior to undertaking remediation on the site.

It is considered that the area(s) requiring remediation can be rendered suitable for the proposed school development subject to appropriate remediation, management, and site validation in accordance with this RAP, including the additional investigations.

The success of the remediation is to be validated and reported as outlined herein.

Prior to commencing the construction works, the Environmental Consultant is to be informed of the proposed remedial approach to be adopted for each stage. If there are any proposed changes to the remediation approach outlined herein as a result of further testing, or any unexpected finds are discovered during works, then this RAP must be updated in consultation with the relevant parties.

17. References

DP (2020) DP *Report on Preliminary Site (Contamination) Investigation, Keighery Hotel Auburn Development, 51 Rawson Street, Auburn*, dated 24 April 2020, reference 99637.01.R.001.Rev0

DP (2020a) DP *Report on Preliminary Geotechnical Investigation, Keighery Hotel Auburn Development, 51 Rawson Street, Auburn,* dated April 2020, reference 99637.00.R.001.Rev0

NEPC. (2013). *National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended 2013) [NEPM].* Australian Government Publishing Services Canberra: National Environment Protection Council.

NSW EPA. (1995). *Contaminated Sites, Sampling Design Guidelines.* NSW Environment Protection Authority.

NSW EPA. (2014). *Waste Classification Guidelines, Part 1: Classifying Waste.* NSW Environment Protection Authority.

NSW EPA. (2014). *Waste Classification Guidelines, Part 2: Immobilisation of Waste.* NSW Environment Protection Authority.

NSW EPA. (2017). *Guidelines for the NSW Site Auditor Scheme (3rd Edition).* NSW Environment Protection Authority.

NSW EPA. (2020). *Guidelines for Consultants Reporting on Contaminated Land.* Contaminated Land Guidelines: NSW Environment Protection Authority.

18. Limitations

Douglas Partners (DP) has prepared this RAP for this project at Pendle Hill High School in accordance with DP's proposal SYD201350 dated 7 December 2020 and acceptance received from SINSW c/o TSA Management Pty Ltd (TSA). The work was carried out under variation DP_V01 of contract SINSW00145-19. This RAP is provided for the exclusive use of SINSW C/O TSA Management for this project only and for the purposes as described in the RAP. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this RAP, DP has necessarily relied upon information provided by the client and/or their agents.

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

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

The assessment of atypical safety hazards arising from this advice is restricted to the environmental components set out in this report and based on known project conditions and stated design advice and assumptions. While some recommendations for safe controls may be provided, detailed 'safety in design' assessment is outside the current scope of this RAP and requires additional project data and assessment.

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

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

Douglas Partners Pty Ltd

Appendix A

Notes About this Report

Drawing 1
Drawing 2
Select Architectural Drawing

About this Report

Douglas Partners

Introduction

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

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

Copyright

Borehole and Test Pit Logs

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

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

Groundwater

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

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

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

Reports

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

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

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

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

About this Report

Site Anomalies

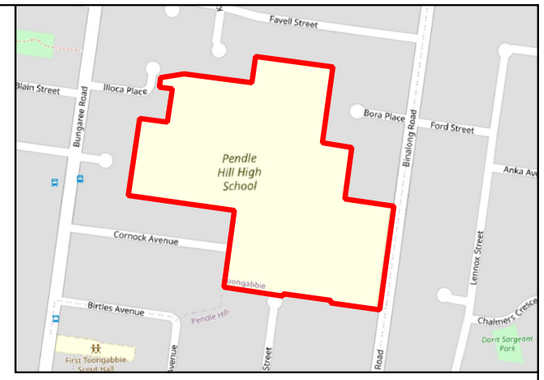
In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later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

Information for Contractual Purposes

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

Site Inspection

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



LOCALITY MAP

Notes:
1. Basemap from metromap.com.au (dated 07/12/2020).
2. Boundaries shown are approximate only.

Legend

- Approximate School Boundary
- Approximate Stage 2 Site Boundary

0 25 50 75 100 m

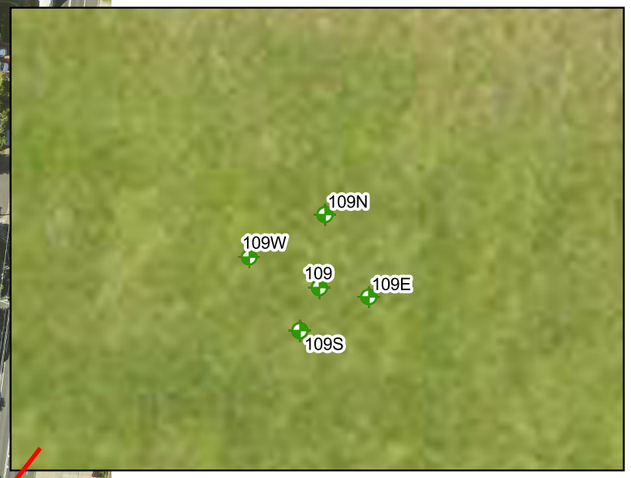
Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT:	TSA Management Pty Ltd		
OFFICE:	Sydney	DRAWN BY:	NW
SCALE:	1:1500 @ A3	DATE:	16.03.2021

TITLE: **Site Location Plan**
Supplementary Contamination Services
Cornock Avenue, Toongabbie

N

PROJECT No:	86977.01
DRAWING No:	1
REVISION:	0



Inset: Sample Locations around 109

Legend

- Approximate School Boundary
- Approximate Stage 2 Site Boundary
- DP (2021) Borehole Location
- DP (2020) Environmental Borehole Location
- DP (2020) Geotechnical and Environmental Borehole Location

0 25 50 75 m

Notes:
1. Basemap from metromap.com.au (dated 07/12/2020).
2. Boundaries and test locations shown are approximate only.

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT:	TSA Management Pty Ltd		
OFFICE:	Sydney	DRAWN BY:	NW
SCALE:	1:1200 @ A3	DATE:	17.03.2021

TITLE: **Borehole Location Plan**
Supplementary Contamination Services
Cornock Avenue, Toongabbie

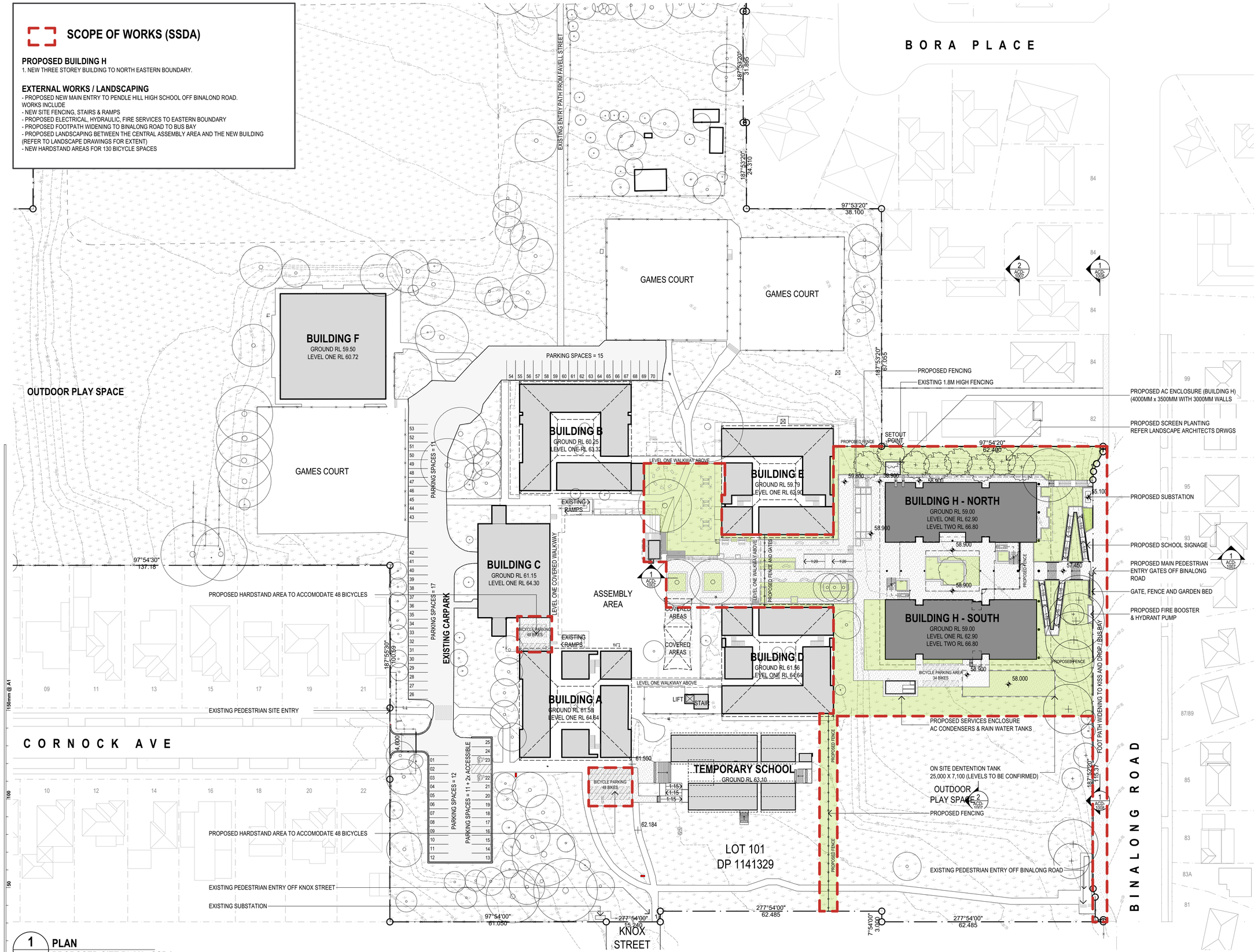
N

PROJECT No:	86977.01
DRAWING No:	2
REVISION:	0

SCOPE OF WORKS (SSDA)

PROPOSED BUILDING H
1. NEW THREE STOREY BUILDING TO NORTH EASTERN BOUNDARY.

EXTERNAL WORKS / LANDSCAPING
- PROPOSED NEW MAIN ENTRY TO PENDLE HILL HIGH SCHOOL OFF BINALOND ROAD.
WORKS INCLUDE
- NEW SITE FENCING, STAIRS & RAMPS
- PROPOSED ELECTRICAL, HYDRAULIC, FIRE SERVICES TO EASTERN BOUNDARY
- PROPOSED FOOTPATH WIDENING TO BINALONG ROAD TO BUS BAY
- PROPOSED LANDSCAPING BETWEEN THE CENTRAL ASSEMBLY AREA AND THE NEW BUILDING
(REFER TO LANDSCAPE DRAWINGS FOR EXTENT)
- NEW HARDSTAND AREAS FOR 130 BICYCLE SPACES



SITE PLAN LEGEND

- EXISTING BUILDINGS
- PROPOSED BUILDINGS (SSDA)
- PROPOSED REFURBISHED AREAS (CDC)
- EXISTING PAVING
- PROPOSED PAVING
- EXISTING ASPHALT
- PROPOSED ASPHALT
- EXISTING LANDSCAPING
- PROPOSED LANDSCAPING
- EXISTING FENCING
- PROPOSED FENCING
- EXISTING TREES
- TREES TO BE REMOVED
- PROPOSED TREES
- PROPOSED SPOT LEVEL (0.000)
- EXISTING SPOT LEVEL (0.000)

REV.	DESCRIPTION	DATE	INIT.
P1	PRELIMINARY ISSUE	14/01/2021	AP
P2	CONSULTANT ISSUE	29/01/2021	AP
P3	TSG REVIEW ISSUE	10/02/2021	AP
P4	REVISED TSG ISSUE	17/02/2021	AP
	ISSUED TO PENDLE HILL HIGH SCHOOL		AP
P5	SDRP ISSUE	23/02/2021	AP
P6	CONSULTANT ISSUE	01/03/2021	AP
P7	PRELIMINARY SSD ISSUE	10/03/2021	AP

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SYDNEY

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Paul Trotter fraia		NSW 7177	QLD 2646
Ryan Loveday raia			QLD 4500

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PHASE **SCHEMATIC DESIGN**

CLIENT SCHOOL INFRASTRUCTURE NSW

PROJECT PENDLE HILL HIGH SCHOOL

ADDRESS 19-21 CORNOCK AVENUE
PENDLE HILL, NSW, 2146

DRAWING **PROPOSED SITE PLAN**

Figured dimensions take precedence over scale dimensions. Contractors must verify all dimensions on site before commencing any work or making shop drawings.

PROJECT NUMBER	DIRECTOR	CHECKED
7068TO01	JW	

DRAWING NUMBER **ACD-1002** REVISION **P7**

1 PLAN
PROPOSED SITE PLAN - SSDA
SCALE: 1:500

150mm @ A1 — 50 — 100 — 150mm @ A1

plot date: Wednesday, 10 March 2021, 4:53 PM
file location: BIMcloud: SYDBIMSYD - BIMcloud Basic for ARCHICAD 23/7068TO01 - PHHS - SITE FILE

Appendix B

Selected Borehole Logs

BOREHOLE LOG

CLIENT: School Infrastructure NSW
PROJECT: Pendle Hill High School
LOCATION: Cornock Ave, Toongabbie

SURFACE LEVEL: 57.6 AHD
EASTING: 311434.8
NORTHING: 6258825.9
DIP/AZIMUTH: 90°/--

BORE No: BH103
PROJECT No: 86977.00
DATE: 22/1/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
57	0.0	FILL/TOPSOIL: Clayey SILT ML, low plasticity, dark red and brown, trace rootlets, w<PL		A/E	0.1		PID = 1		
					0.2				
	0.3	FILL/Silty CLAY CL-CI: low to medium plasticity, pale brown and grey, trace ironstone gravel, w<PL (possibly residual)		A/E	0.4		PID = 3		
					0.5				
	0.7	Silty CLAY CI-CH: medium to high plasticity, red and pale grey, trace ironstone gravel, w<PL, very stiff, residual		A/E	0.9		PID = 2		
	1				1.0				1
	1.1	Silty CLAY CH: high plasticity, red and pale grey, trace ironstone gravel, w<PL, hard, relict rock texture, residual (extremely weathered shale)		S			9,20,B refusal PID = 3		
	1.3	SHALE: grey and yellow-brown, with ironstone bands, inferred low strength, highly to moderately weathered, Ashfield Shale			1.3				
56				A/E	1.45		PID = 3		
					1.5				
				A	1.8		PID = 4		
	1.9	Bore discontinued at 1.9m on shale Auger refusal			1.9				
	2								2
55									
	3								3
54									
	4								4
53									

RIG: Multi-Drill **DRILLER:** SK (Traccess Drilling) **LOGGED:** KR **CASING:** UNCASED

TYPE OF BORING: Solid Flight Auger (TC-bit) to 1.9m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: School Infrastructure NSW
PROJECT: Pendle Hill High School
LOCATION: Cornock Ave, Toongabbie

SURFACE LEVEL: 60.2 AHD
EASTING: 311417.5
NORTHING: 6258776.7
DIP/AZIMUTH: 90°/--

BORE No: BH104
PROJECT No: 86977.00
DATE: 22/1/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
60	0.1	FILL/TOPSOIL: Clayey SILT ML, low plasticity, dark brown, trace rootlets, w<PL, generally in a firm condition		A/E	0.1 0.2		PID = 4		
	0.3	Silty CLAY CI-CH: medium to high plasticity, dark red-brown, w<PL, stiff to very stiff, residual		A/E	0.4 0.5		PID = 5 0.5-1.5m: Bulk Sample		
		- Below 0.7m depth: pale grey and red-brown		A/E	0.9 1.0		PID = 5		
59	1			S			6,8,20/100 refusal PID = 4		1
	1.3	Silty CLAY CH: high plasticity, pale grey and red-brown, with ironstone gravel, w<PL, hard, relict rock texture, residual (extremely weathered shale)		A/E	1.4 1.45		PID = 5		
	1.6	SHALE: grey and yellow-brown, with ironstone bands, inferred low strength, highly to moderately weathered, Ashfield Shale		A S	1.5 1.6 1.62		PID = 7 10/20,B refusal PID = 6		
	1.7	Bore discontinued at 1.7m on shale Auger refusal							
58	2								2
57	3								3
56	4								4

RIG: Multi-Drill **DRILLER:** SK (Traccess Drilling) **LOGGED:** KR **CASING:** UNCASED

TYPE OF BORING: Solid Flight Auger (TC-bit) to 1.7m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: Location coordinates are in MGA94 Zone 56. Bulk sample taken from 0.5-1.5m

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: School Infrastructure NSW
PROJECT: Pendle Hill High School
LOCATION: Cornock Ave, Toongabbie

SURFACE LEVEL: 59.2 AHD
EASTING: 311468.2
NORTHING: 6258750
DIP/AZIMUTH: 90°/--

BORE No: BH105
PROJECT No: 86977.00
DATE: 22/1/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
59	0.1	FILL/TOPSOIL: Clayey SILT ML, low plasticity, dark red and dark brown, trace rootlets, w<PL		A/E	0.1		PID = 5		
	0.2				0.2				
	0.3	Silty CLAY: grey and red-brown, w<PL, very stiff, relict rock texture, residual (extremely weathered shale)			0.3		0.3-1.0m: Bulk Sample		
	0.4			A/E	0.4		PID = 4		
	0.5	- Below 0.7m depth: pale grey			0.5				
	0.9			A/E	0.9		PID = 4		
1	1.0				1.0				1
58	1.1	SHALE: grey and yellow-brown, with ironstone bands and hard clay seams, inferred low strength, highly to moderately weathered, Ashfield Shale		S			20,B refusal PID = 4		
	1.3			A/E	1.3		PID = 5		
	1.4				1.4				
	1.7			A	1.7		PID = 6		
	1.8	Bore discontinued at 1.8m on shale Auger refusal			1.8				
57	2								2
56	3								3
55	4								4

RIG: Multi-Drill **DRILLER:** SK (Traccess Drilling) **LOGGED:** KR **CASING:** UNCASED

TYPE OF BORING: Solid Flight Auger (TC-bit) to 1.8m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: Location coordinates are in MGA94 Zone 56. Bulk sample taken from 0.3-1.0m

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: School Infrastructure NSW
PROJECT: Pendle Hill High School
LOCATION: Cornock Ave, Toongabbie

SURFACE LEVEL: 62.3 AHD
EASTING: 311392.1
NORTHING: 6258718.6
DIP/AZIMUTH: 90°/--

BORE No: BH106
PROJECT No: 86977.00
DATE: 22/1/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
62	0.1	FILL/TOPSOIL: Clayey SILT ML, low plasticity, brown, trace rootlets, w<PL, generally in a firm condition		A/E	0.1 0.2		PID = 4		
	0.3	Silty CLAY CI-CH: medium to high plasticity, pale grey and red-brown, w<PL, stiff to very stiff, residual		A/E*	0.4 0.5		PID = 4		
		- Below 0.7m depth: pale grey and red-brown							
	0.8	Silty CLAY CH: high plasticity, pale grey and red-brown, w<PL, hard, relict rock texture, residual (extremely weathered shale)		A/E S	0.9 1.0 1.15		PID = 4 20,B refusal PID = 3		
61	1								1
	1.4	SHALE: grey and yellow-brown, with ironstone bands, inferred low strength, highly to moderately weathered, Ashfield Shale		A/E S	1.3 1.4 1.42		PID = 4 20/20,R refusal (no sample)		
	1.5	Bore discontinued at 1.5m on shale Auger refusal							
60	2								2
59	3								3
58	4								4

RIG: Multi-Drill **DRILLER:** SK (Traccess Drilling) **LOGGED:** KR **CASING:** UNCASED

TYPE OF BORING: Solid Flight Auger (TC-bit) to 1.5m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: Location coordinates are in MGA94 Zone 56. * Blind duplicate BD7/20200122 taken from 0.4-0.5m

SAMPLING & IN SITU TESTING LEGEND

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

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: School Infrastructure NSW
PROJECT: Pendle Hill High School
LOCATION: Cornock Ave, Toongabbie

SURFACE LEVEL: 58.6 AHD
EASTING: 311478.9
NORTHING: 6258786
DIP/AZIMUTH: 90°/--

BORE No: BH109
PROJECT No: 86977.00
DATE: 22/1/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
58	0.05	FILL/TOPSOIL: Clayey SILT ML, low plasticity, brown, trace rootlets, w<PL, generally in a firm condition		A/E	0.1		PID = 2		
		FILL/Silty CLAY CI-CH: medium to high plasticity, red-brown and grey, with subangular ironstone and shale gravel, w<PL (possibly reworked residual soil), inferred firm to stiff			0.2				
				A/E*	0.4		PID = 1		
		Between 0.5-1.0m depth: trace fragments of fibrous (possible asbestos) containing material			0.5				
				A					
	1			A/E	0.9		PID = 1		1
					1.0				
		Between 1.4-1.5m depth: with clinker fragments		A/E	1.4		PID = 1		
	1.5	CONCRETE SLAB		A/E	1.5		PID = 2		
57	1.6	Silty CLAY CI-CH: medium to high plasticity, red-brown, w<PL, inferred stiff, residual			1.6				
				A/E	1.9		PID = 1.0		
	2				2.0				2
	2.2	Silty CLAY CH: high plasticity, pale grey, w<PL, hard, relict rock texture, residual (extremely weathered shale)							
				A/E	2.4		PID < 1		
56	2.6	SHALE: pale grey and yellow-brown, with ironstone bands, inferred low strength, highly to moderately weathered, Ashfield Shale			2.5				
	3								3
	3.3	Bore discontinued at 3.3m on shale Auger refusal							
55									
	4								4
54									

RIG: Multi-Drill **DRILLER:** SK (Traccess Drilling) **LOGGED:** KR **CASING:** UNCASED

TYPE OF BORING: Solid Flight Auger (TC-bit) to 3.3m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: Location coordinates are in MGA94 Zone 56. * Blind duplicate BD8/20200122 taken from 0.4-0.5m

SAMPLING & IN SITU TESTING LEGEND

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

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: SINSW c/o TSA Management
PROJECT: Pendle Hill High School, Proposed Development
LOCATION: Cornock Avenue, Toongabbie

SURFACE LEVEL: 58.7 AHD
EASTING: 6258786
NORTHING: 311479.5
DIP/AZIMUTH: 90°/--

BORE No: BH109E
PROJECT No: 86977.01
DATE: 21-1-2021
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
58	0.05	FILL/TOPSOIL: Clayey SILT ML, low plasticity, brown, trace rootlets, w<PL, generally in a firm condition			0.05				
		FILL/Silty CLAY: medium to high plasticity, red-brown and grey with ironstone and shale gravel, tile, brick and concrete fragments, generally in a firm to stiff condition		A			PID<3ppm Sieve sample taken at 0.05-1.0		
					0.5				
				A			PID<3ppm		
	1				1.0				1
		Between 1.2-1.5m depth: with ash and clinker fragments		A			PID<3ppm		
57	1.5	Bore discontinued at 1.5m Refusal on concrete			1.5				
	2								2
56									
	3								3
55									
	4								4
54									

RIG: IHI 3.5 tonne excavator **DRILLER:** A&A **LOGGED:** TG **CASING:** Nil
TYPE OF BORING: 300mm Solid Flight Auger
WATER OBSERVATIONS: No Free Groundwater Observed
REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: SINSW c/o TSA Management
PROJECT: Pendle Hill High School, Proposed Development
LOCATION: Cornock Avenue, Toongabbie

SURFACE LEVEL: 58.7 AHD
EASTING: 6258787
NORTHING: 311478.9
DIP/AZIMUTH: 90°/--

BORE No: BH109N
PROJECT No: 86977.01
DATE: 21-1-2021
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
58	0.05	FILL/TOPSOIL: Clayey SILT ML, low plasticity, brown, trace rootlets, w<PL, generally in a firm condition			0.05				
		FILL/Silty CLAY: medium to high plasticity, red-brown and grey with ironstone and shale gravel, tile and concrete fragments, generally in a firm to stiff condition		A			PID<3 ppm Sieve samples taken at 0.05-1.0 and 1.0-1.5		
					0.5				
				A*			PID<3 ppm		
	1				1.0				1
		Between 1.3-1.5m depth: with ash and clinker fragments		A			PID<3 ppm		
	1.5	Bore discontinued at 1.5m Refusal on concrete			1.5				
57	2								2
56	3								3
55	4								4
54									

RIG: IHI 3.5 tonne excavator **DRILLER:** A&A **LOGGED:** TG **CASING:** Nil

TYPE OF BORING: 300mm Solid Flight Auger

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: Location coordinates are in MGA94 Zone 56.
* Replicate sample BD1/20210121 taken at 0.5-1.0m

SAMPLING & IN SITU TESTING LEGEND

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

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: SINSW c/o TSA Management
PROJECT: Pendle Hill High School, Proposed Development
LOCATION: Cornock Avenue, Toongabbie

SURFACE LEVEL: 58.7 AHD
EASTING: 6258785.5
NORTHING: 311478.5
DIP/AZIMUTH: 90°/--

BORE No: BH109S
PROJECT No: 86977.01
DATE: 21-1-2021
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	FILL/TOPSOIL: Clayey SILT ML, low plasticity, brown, trace rootlets, w<PL, generally in a firm condition			0.05				
		FILL/Silty CLAY: medium to high plasticity, red-brown and grey with ironstone and shale gravel, tile, brick and concrete fragments, generally in a firm to stiff condition		A			PID<3ppm Sieve samples taken at 0.05-1.0 and 1.0-1.5		
					0.5				
58				A			PID<3ppm		
	1				1.0				1
		Between 1.2-1.5m depth: with ash and clinker fragments		A			PID<3ppm		
	1.5	Bore discontinued at 1.5m Refusal on concrete			1.5				
57									
	2								2
56									
	3								3
55									
	4								4
54									

RIG: IHI 3.5 tonne excavator **DRILLER:** A&A **LOGGED:** TG **CASING:** Nil
TYPE OF BORING: 300mm Solid Flight Auger
WATER OBSERVATIONS: No Free Groundwater Observed
REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

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

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: SINSW c/o TSA Management
PROJECT: Pendle Hill High School, Proposed Development
LOCATION: Cornock Avenue, Toongabbie

SURFACE LEVEL: 58.6 AHD
EASTING: 6258786.5
NORTHING: 311477.9
DIP/AZIMUTH: 90°/--

BORE No: BH109W
PROJECT No: 86977.01
DATE: 21-1-2021
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
58	0.05	FILL/TOPSOIL: Clayey SILT ML, low plasticity, brown, trace rootlets, w<PL, generally in a firm condition			0.05				
		FILL/Silty CLAY: medium to high plasticity, red-brown and grey with ironstone and shale gravel, tile, brick and concrete fragments, generally in a firm to stiff condition		A			PID<3 ppm Sieve samples taken at 0.05-1.0 and 1.0-1.5		
					0.5				
				A			PID<3 ppm		
	1				1.0				1
		Between 1.3-1.5m depth: with ash and clinker fragments		A			PID<3 ppm		
57	1.5	Bore discontinued at 1.5m Refusal on concrete			1.5				
	2								2
56									
	3								3
55									
	4								4
54									

RIG: IHI 3.5 tonne excavator **DRILLER:** A&A **LOGGED:** TG **CASING:** Nil
TYPE OF BORING: 300mm Solid Flight Auger
WATER OBSERVATIONS: No Free Groundwater Observed
REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: School Infrastructure NSW
PROJECT: Pendle Hill High School
LOCATION: Cornock Ave, Toongabbie

SURFACE LEVEL: 61.7 AHD
EASTING: 311464.4
NORTHING: 6258695.6
DIP/AZIMUTH: 90°/--

BORE No: BH110
PROJECT No: 86977.00
DATE: 22/1/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
61	0.3	FILL/TOPSOIL: Clayey SILT ML, low plasticity, dark brown, trace rootlets, w<PL		A/E	0.1 0.2		PID = 3		
	0.8	Silty CLAY CI-CH: medium to high plasticity, red-brown and grey, w<PL, inferred stilff, residual		A/E	0.4 0.5		PID = 4		
	1	Silty CLAY: red-brown and grey, trace ironstone gravel, w<PL, hard, relict rock texture, residual (extremely weathered shale)		A/E	0.9 1.0		PID = 3		1
60	1.3	SHALE: pale grey and yellow-brown, low strength with very low strength and ironstone bands, highly to moderately weathered, Ashfield Shale		A/E	1.4 1.5		PID = 3		
	2			A/E	1.9		PID = 2		2
	2.0	Bore discontinued at 2.0m on shale Auger refusal			2.0				
59	3								3
58	4								4
57									

RIG: Multi-Drill **DRILLER:** SK (Traccess Drilling) **LOGGED:** KR **CASING:** UNCASED

TYPE OF BORING: Solid Flight Auger (TC-bit) to 2.0m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: SINSW c/o TSA Management
PROJECT: Pendle Hill High School, Proposed Development
LOCATION: Cornock Avenue, Toongabbie

SURFACE LEVEL: 58.0 AHD
EASTING: 6258802
NORTHING: 311458.1
DIP/AZIMUTH: 90°/--

BORE No: BH201
PROJECT No: 86977.01
DATE: 22-1-2021
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
58	0.25	FILL/Silty CLAY: low plasticity, trace rootlets, shale and ironstone gravel, w<PL, generally in a firm condition		A	0.1 0.2				
		FILL/Silty CLAY: medium plasticity, red-brown and grey, with ironstone and shale gravel, trace rootlets, w<PL, generally in a firm to stiff condition		A	0.5 0.6				
57	1			A	1.0 1.1				1
	1.3	SHALE: grey and yellow-brown, with ironstone bands and hard clay seams, inferred low strength, highly weathered, dry.		A	1.4				
	1.5	Bore discontinued at 1.5m Refusal on shale			1.5				
56	2								2
55	3								3
54	4								4

RIG: IHI 3.5 tonne excavator **DRILLER:** A&A **LOGGED:** TG **CASING:** Nil
TYPE OF BORING: 100mm Solid Flight Auger
WATER OBSERVATIONS: No Free Groundwater Observed
REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: SINSW c/o TSA Management
PROJECT: Pendle Hill High School, Proposed Development
LOCATION: Cornock Avenue, Toongabbie

SURFACE LEVEL: 59.1 AHD
EASTING: 6258788.5
NORTHING: 311447.1
DIP/AZIMUTH: 90°/--

BORE No: BH202
PROJECT No: 86977.01
DATE: 21-1-2021
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
59	0.15	FILL/TOPSOIL: Clayey SILT ML, low plasticity, dark red and brown, trace rootlets, w<PL		A	0.1				
		FILL/ Silty CLAY: medium to high plasticity, red-brown and grey with ironstone and shale gravels, w<PL, generally in a firm to stiff condition			0.15				
				A	0.5				
					0.6				
58	1			A	1.0				1
					1.1				
	1.3	Silty CLAY: grey and red-brown mottled, very stiff, relict rock texture, residual							
				A	1.5				
					1.6				
57	2			A	2.0				2
					2.1				
	2.2	SHALE: grey and yellow-brown, with ironstone bands and hard clay seams, inferred low strength, highly weathered, dry.							
				A	2.5				
	2.6	Bore discontinued at 2.6m Refusal on shale			2.6				
56	3								3
55	4								4

RIG: IHI 3.5 tonne excavator **DRILLER:** A&A **LOGGED:** TG **CASING:** Nil
TYPE OF BORING: 100mm Solid Flight Auger
WATER OBSERVATIONS: No Free Groundwater Observed
REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: SINSW c/o TSA Management
PROJECT: Pendle Hill High School, Proposed Development
LOCATION: Cornock Avenue, Toongabbie

SURFACE LEVEL: 58.3 AHD
EASTING: 6258781.6
NORTHING: 311498
DIP/AZIMUTH: 90°/--

BORE No: BH203
PROJECT No: 86977.01
DATE: 22-1-2021
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
58	0.15	FILL/TOPSOIL: Clayey SILT ML, low plasticity, brown, trace rootlets, w<PL, generally in a firm condition		A	0.1				
		FILL/Silty CLAY: medium to high plasticity, red-brown and grey with ironstone and shale gravel, tile and concrete fragments, generally in a firm to stiff condition			0.15				
				A	0.5				
					0.6				
57	1			A	1.0				1
					1.1				
				A	1.5				
					1.6				
56	2			A	2.0				2
					2.1				
	2.3	Silty CLAY: grey and red-brown mottled, very stiff, relict rock texture, residual		A	2.5				
					2.6				
				A	2.9				
55	3								3
	3.0	Bore discontinued at 3.0m Target Depth Achieved			3.0				
54	4								4

RIG: IHI 3.5 tonne excavator **DRILLER:** A&A **LOGGED:** TG **CASING:** Nil

TYPE OF BORING: 100mm Solid Flight Auger

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: SINSW c/o TSA Management
PROJECT: Pendle Hill High School, Proposed Development
LOCATION: Cornock Avenue, Toongabbie

SURFACE LEVEL: 59.2 AHD
EASTING: 6258768.3
NORTHING: 311458.1
DIP/AZIMUTH: 90°/--

BORE No: BH204
PROJECT No: 86977.01
DATE: 21-1-2021
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
59	0.15	FILL/TOPSOIL: Clayey SILT ML, low plasticity, dark red and brown, trace rootlets, w<PL, generally in a firm condition		A	0.1 0.15				
		FILL/ Silty CLAY: medium to high plasticity, red-brown and grey with ironstone and shale gravels, w<PL, generally in a firm to stiff condition		A	0.5 0.6				
	0.8	Silty CLAY: grey and red-brown mottled, very stiff, relict rock texture, residual		A	1.0 1.1				
58	1			A	1.5 1.6				1
	1.7	SHALE: grey and yellow-brown, with ironstone bands and hard clay seams, inferred low strength, highly weathered, dry		A	2.0 2.1				
57	2								2
	2.2	Bore discontinued at 2.2m Refusal on shale							
56	3								3
55	4								4

RIG: IHI 3.5 tonne excavator **DRILLER:** A&A **LOGGED:** TG **CASING:** Nil
TYPE OF BORING: 100mm Solid Flight Auger
WATER OBSERVATIONS: No Free Groundwater Observed
REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: SINSW c/o TSA Management
PROJECT: Pendle Hill High School, Proposed Development
LOCATION: Cornock Avenue, Toongabbie

SURFACE LEVEL: 59.6 AHD
EASTING: 6258756.1
NORTHING: 311442.9
DIP/AZIMUTH: 90°/--

BORE No: BH205
PROJECT No: 86977.01
DATE: 21-1-2021
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
59	0.2	FILL/TOPSOIL: Clayey SILT ML, low plasticity, dark red and brown, trace rootlets, w<PL, generally in a firm condition		A	0.1				
					0.2				
		Silty CLAY: grey and red-brown mottled, very stiff, relict rock texture, residual		A	0.5				
					0.6				
	1			A	1.0				1
					1.1				
				A	1.5				
58	1.6	SHALE: grey and yellow-brown, with ironstone bands and hard clay seams, inferred low strength, highly weathered, dry			1.6				
	2			A	2.0				2
	2.1	Bore discontinued at 2.1m Refusal on shale			2.1				
57									
	3								3
56									
	4								4
55									

RIG: IHI 3.5 tonne excavator **DRILLER:** A&A **LOGGED:** TG **CASING:** Nil
TYPE OF BORING: 100mm Solid Flight Auger
WATER OBSERVATIONS: No Free Groundwater Observed
REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: SINSW c/o TSA Management
PROJECT: Pendle Hill High School, Proposed Development
LOCATION: Cornock Avenue, Toongabbie

SURFACE LEVEL: 58.9 AHD
EASTING: 6258759.1
NORTHING: 311482.6
DIP/AZIMUTH: 90°/--

BORE No: BH206
PROJECT No: 86977.01
DATE: 22-1-2021
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
58	0.2	FILL/TOPSOIL: Clayey SILT ML, low plasticity, dark red and brown, trace rootlets, w<PL, generally in a firm condition		A	0.1 0.2				
		FILL/ Silty CLAY: medium to high plasticity, red-brown and grey with ironstone and shale gravels, w<PL, generally in a firm to stiff condition		A	0.5 0.6				
	1			A	1.0 1.1				1
	1.3	Silty CLAY: grey and red-brown mottled, very stiff, relict rock texture, residual		A	1.5 1.6				
57	1.8	SHALE: grey and yellow-brown, with ironstone bands and hard clay seams, inferred low strength, highly weathered, dry		A	2.0 2.1				
	2								2
	2.3	Bore discontinued at 2.3m Refusal on shale							
56	3								3
55	4								4
54									

RIG: IHI 3.5 tonne excavator **DRILLER:** A&A **LOGGED:** TG **CASING:** Nil
TYPE OF BORING: 100mm Solid Flight Auger
WATER OBSERVATIONS: No Free Groundwater Observed
REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: SINSW c/o TSA Management
PROJECT: Pendle Hill High School, Proposed Development
LOCATION: Cornock Avenue, Toongabbie

SURFACE LEVEL: 58.4 AHD
EASTING: 6258750.1
NORTHING: 311496.9
DIP/AZIMUTH: 90°/--

BORE No: BH207
PROJECT No: 86977.01
DATE: 22-1-2021
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
58	0.05	FILL/TOPSOIL: Clayey SILT ML, low plasticity, dark red and brown, trace rootlets, w<PL, generally in a firm condition		A	0.1				
					0.2				
		FILL/ Silty CLAY: medium to high plasticity, red-brown and grey with ironstone and shale gravels, w<PL, generally in a firm to stiff condition		A	0.5				
					0.6				
	1			A	1.0				1
					1.1				
57	1.2	Silty CLAY: grey and red-brown mottled, very stiff, relict rock texture, residual		A	1.5				
					1.6				
	1.7	SHALE: grey and yellow-brown, with ironstone bands and hard clay seams, inferred low strength, highly weathered, dry							
	2			A	2.0				2
					2.1				
56	2.2	Bore discontinued at 2.2m Refusal on shale							
	3								3
55									
	4								4
54									

RIG: IHI 3.5 tonne excavator **DRILLER:** A&A **LOGGED:** TG **CASING:** Nil
TYPE OF BORING: 100mm Solid Flight Auger
WATER OBSERVATIONS: No Free Groundwater Observed
REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: SINSW c/o TSA Management
PROJECT: Pendle Hill High School, Proposed Development
LOCATION: Cornock Avenue, Toongabbie

SURFACE LEVEL: 59.5 AHD
EASTING: 6258743.7
NORTHING: 311454.3
DIP/AZIMUTH: 90°/--

BORE No: BH208
PROJECT No: 86977.01
DATE: 21-1-2021
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
59	0.25	FILL/TOPSOIL: Clayey SILT ML, low plasticity, dark red and brown, trace rootlets, w<PL, generally in a firm condition		A	0.1 0.2				
		Silty CLAY: grey and red-brown mottled, very stiff, relict rock texture, residual		A	0.6 0.7				
	1			A	1.0 1.1				1
58	1.6			A	1.5 1.6				
		SHALE: grey and yellow-brown, with ironstone bands and hard clay seams, inferred low strength, highly weathered, dry		A	2.0 2.1				
	2								2
57				A	2.5 2.6				
	3	3.0		A	2.9 3.0				3
		Bore discontinued at 3.0m Target Depth Achieved							
56	4								4
55									

RIG: IHI 3.5 tonne excavator **DRILLER:** A&A **LOGGED:** TG **CASING:** Nil
TYPE OF BORING: 100mm Solid Flight Auger
WATER OBSERVATIONS: No Free Groundwater Observed
REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: SINSW c/o TSA Management
PROJECT: Pendle Hill High School, Proposed Development
LOCATION: Cornock Avenue, Toongabbie

SURFACE LEVEL: 58.4 AHD
EASTING: 6258767.7
NORTHING: 311496.6
DIP/AZIMUTH: 90°/--

BORE No: BH209
PROJECT No: 86977.01
DATE: 22-1-2021
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		FILL/TOPSOIL: Clayey SILT ML, low plasticity, brown, trace rootlets, w<PL, generally in a firm condition		A	0.1				
	0.2	FILL/Silty CLAY: medium to high plasticity, red-brown and grey with ironstone and shale gravel, tile and concrete fragments, generally in a firm to stiff condition		A	0.2 0.5 0.6				
58	1			A	1.0 1.1				1
57				A	1.5 1.6				
	1.8	Silty CLAY: grey and red-brown mottled, very stiff, relict rock texture, residual		A	2.0 2.1				
	2								2
	2.3	SHALE: grey and yellow-brown, with ironstone bands and hard clay seams, inferred low strength, highly weathered, dry.		A	2.5				
56	2.6	Bore discontinued at 2.6m Refusal on shale			2.6				
	3								3
55									
	4								4
54									

RIG: IHI 3.5 tonne excavator **DRILLER:** A&A **LOGGED:** TG **CASING:** Nil

TYPE OF BORING: 100mm Solid Flight Auger

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

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

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Sampling Methods

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Sampling

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

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

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

Test Pits

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

Large Diameter Augers

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

Continuous Spiral Flight Augers

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

Non-core Rotary Drilling

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

Continuous Core Drilling

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

Standard Penetration Tests

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

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

The test results are reported in the following form.

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

  4,6,7
  N=13

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

  15, 30/40 mm

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

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

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

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

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are generally based on Australian Standard AS1726:2017, Geotechnical Site Investigations. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

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

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

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

Type	Particle size (mm)
Coarse gravel	19 - 63
Medium gravel	6.7 - 19
Fine gravel	2.36 – 6.7
Coarse sand	0.6 - 2.36
Medium sand	0.21 - 0.6
Fine sand	0.075 - 0.21

Definitions of grading terms used are:

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

The proportions of secondary constituents of soils are described as follows:

In fine grained soils (>35% fines)

Term	Proportion of sand or gravel	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	>30%	Sandy Clay
With	15 – 30%	Clay with sand
Trace	0 - 15%	Clay with trace sand

In coarse grained soils (>65% coarse)
- with clays or silts

Term	Proportion of fines	Example
And	Specify	Sand (70%) and Clay (30%)
Adjective	>12%	Clayey Sand
With	5 - 12%	Sand with clay
Trace	0 - 5%	Sand with trace clay

In coarse grained soils (>65% coarse)
- with coarser fraction

Term	Proportion of coarser fraction	Example
And	Specify	Sand (60%) and Gravel (40%)
Adjective	>30%	Gravelly Sand
With	15 - 30%	Sand with gravel
Trace	0 - 15%	Sand with trace gravel

The presence of cobbles and boulders shall be specifically noted by beginning the description with ‘Mix of Soil and Cobbles/Boulders’ with the word order indicating the dominant first and the proportion of cobbles and boulders described together.

Soil Descriptions

Cohesive Soils

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

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	VS	<12
Soft	S	12 - 25
Firm	F	25 - 50
Stiff	St	50 - 100
Very stiff	VSt	100 - 200
Hard	H	>200
Friable	Fr	-

Cohesionless Soils

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

Relative Density	Abbreviation	Density Index (%)
Very loose	VL	<15
Loose	L	15-35
Medium dense	MD	35-65
Dense	D	65-85
Very dense	VD	>85

Soil Origin

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

- Residual soil - derived from in-situ weathering of the underlying rock;
- Extremely weathered material – formed from in-situ weathering of geological formations. Has soil strength but retains the structure or fabric of the parent rock;
- Alluvial soil – deposited by streams and rivers;
- Estuarine soil – deposited in coastal estuaries;
- Marine soil – deposited in a marine environment;
- Lacustrine soil – deposited in freshwater lakes;
- Aeolian soil – carried and deposited by wind;
- Colluvial soil – soil and rock debris transported down slopes by gravity;
- Topsoil – mantle of surface soil, often with high levels of organic material.
- Fill – any material which has been moved by man.

Moisture Condition – Coarse Grained Soils

For coarse grained soils the moisture condition should be described by appearance and feel using the following terms:

- Dry (D) Non-cohesive and free-running.
- Moist (M) Soil feels cool, darkened in colour.
  Soil tends to stick together.
  Sand forms weak ball but breaks easily.
- Wet (W) Soil feels cool, darkened in colour.
  Soil tends to stick together, free water forms when handling.

Moisture Condition – Fine Grained Soils

For fine grained soils the assessment of moisture content is relative to their plastic limit or liquid limit, as follows:

- ‘Moist, dry of plastic limit’ or ‘w <PL’ (i.e. hard and friable or powdery).
- ‘Moist, near plastic limit’ or ‘w ≈ PL (i.e. soil can be moulded at moisture content approximately equal to the plastic limit).
- ‘Moist, wet of plastic limit’ or ‘w >PL’ (i.e. soils usually weakened and free water forms on the hands when handling).
- ‘Wet’ or ‘w ≈LL’ (i.e. near the liquid limit).
- ‘Wet’ or ‘w >LL’ (i.e. wet of the liquid limit).

Rock Strength

Rock strength is defined by the Unconfined Compressive Strength and it refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects.

The Point Load Strength Index $Is_{(50)}$ is commonly used to provide an estimate of the rock strength and site specific correlations should be developed to allow UCS values to be determined. The point load strength test procedure is described by Australian Standard AS4133.4.1-2007. The terms used to describe rock strength are as follows:

Strength Term	Abbreviation	Unconfined Compressive Strength MPa	Point Load Index * $Is_{(50)}$ MPa
Very low	VL	0.6 - 2	0.03 - 0.1
Low	L	2 - 6	0.1 - 0.3
Medium	M	6 - 20	0.3 - 1.0
High	H	20 - 60	1 - 3
Very high	VH	60 - 200	3 - 10
Extremely high	EH	>200	>10

* Assumes a ratio of 20:1 for UCS to $Is_{(50)}$. It should be noted that the UCS to $Is_{(50)}$ ratio varies significantly for different rock types and specific ratios should be determined for each site.

Degree of Weathering

The degree of weathering of rock is classified as follows:

Term	Abbreviation	Description
Residual Soil	RS	Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported.
Extremely weathered	XW	Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible
Highly weathered	HW	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Moderately weathered	MW	The whole of the rock material is discoloured , usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable, but shows little or no change of strength from fresh rock.
Slightly weathered	SW	Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.
Fresh	FR	No signs of decomposition or staining.
Note: If HW and MW cannot be differentiated use DW (see below)		
Distinctly weathered	DW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching or may be decreased due to deposition of weathered products in pores.

Rock Descriptions

Degree of Fracturing

The following classification applies to the spacing of natural fractures in diamond drill cores. It includes bedding plane partings, joints and other defects, but excludes drilling breaks.

Term	Description
Fragmented	Fragments of <20 mm
Highly Fractured	Core lengths of 20-40 mm with occasional fragments
Fractured	Core lengths of 30-100 mm with occasional shorter and longer sections
Slightly Fractured	Core lengths of 300 mm or longer with occasional sections of 100-300 mm
Unbroken	Core contains very few fractures

Rock Quality Designation

The quality of the cored rock can be measured using the Rock Quality Designation (RQD) index, defined as:

$$\text{RQD \%} = \frac{\text{cumulative length of 'sound' core sections} \geq \text{100 mm long}}{\text{total drilled length of section being assessed}}$$

where 'sound' rock is assessed to be rock of low strength or stronger. The RQD applies only to natural fractures. If the core is broken by drilling or handling (i.e. drilling breaks) then the broken pieces are fitted back together and are not included in the calculation of RQD.

Stratification Spacing

For sedimentary rocks the following terms may be used to describe the spacing of bedding partings:

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

Symbols & Abbreviations

Introduction

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

Drilling or Excavation Methods

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

Water

▷	Water seep
▽	Water level

Sampling and Testing

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

Description of Defects in Rock

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

Defect Type

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

Orientation

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

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

Coating or Infilling Term

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

Coating Descriptor

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

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

Other

fg	fragmented
bnd	band
qtz	quartz

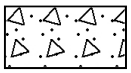
Symbols & Abbreviations

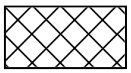
Graphic Symbols for Soil and Rock

General

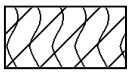

Asphalt

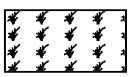

Road base

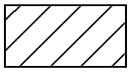

Concrete

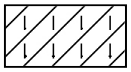

Filling

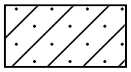
Soils


Topsoil

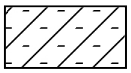

Peat

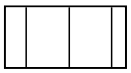

Clay

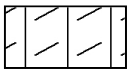

Silty clay

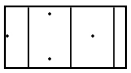

Sandy clay

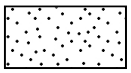

Gravelly clay

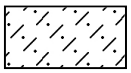

Shaly clay

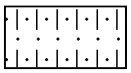

Silt


Clayey silt


Sandy silt

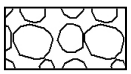

Sand

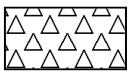

Clayey sand


Silty sand


Gravel

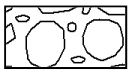

Sandy gravel


Cobbles, boulders

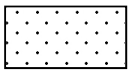

Talus

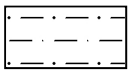
Sedimentary Rocks

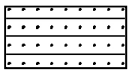

Boulder conglomerate

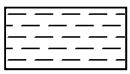

Conglomerate


Conglomeratic sandstone

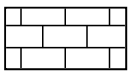

Sandstone


Siltstone

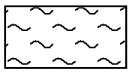

Laminite

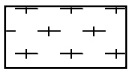

Mudstone, claystone, shale

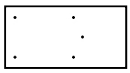

Coal


Limestone

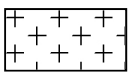
Metamorphic Rocks

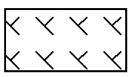

Slate, phyllite, schist

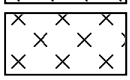

Gneiss

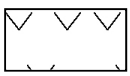

Quartzite

Igneous Rocks


Granite


Dolerite, basalt, andesite


Dacite, epidote


Tuff, breccia


Porphyry