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Integrated Practical Solutions

Remediation Action Plan

Botany Aquatic Centre Stage 1
Cnr Myrtle St and Jasmine St, Botany

Prepared for
CO-OP STUDIO PTY LTD

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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.

	Signature	Date
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Executive Summary

This Remediation Action Plan (RAP) was developed for the proposed Botany Aquatic Centre Stage 1 redevelopment (the site) located at Cnr Myrtle St and Jasmine St, Botany.

The primary objective of the RAP is to remove and / or to mitigate associated risks of potential environmental and human health impacts posed by contamination identified during previous investigations and any unidentified contamination uncovered during earthworks (as unexpected finds) such that the site can be rendered suitable for the proposed development.

In this regard, this RAP establishes:

- An appropriate remedial strategy so as to render the site suitable, from a contamination perspective, for the proposed development;
- The remediation acceptance criteria to be adopted for the remediation of the site and the validation requirements to verify the successful implementation of the remediation strategy;
- Appropriate environmental safeguards required to complete the remediation works in an environmentally acceptable manner;
- Appropriate occupational, health and safety (OH&S) procedures required to complete the remediation works in a manner that would not pose a threat to the health of site workers or users; and
- A framework to minimise environmental risk on the site and the surrounding environment.

This RAP primarily describes the management of the identified contamination through the relocation and encapsulation of contaminated soils to be retained on site. A contingency strategy is provided for the excavation and off-site disposal of contaminated soils. Further detail is provided within this document, including management strategies, validation, responsibilities, and reporting requirements.

The proposed remediation (capping) strategy outlined herein requires development and implementation of a long-term environmental management plan (EMP). The site owner and relevant planning authority must agree to the EMP, and the EMP must be reasonably, legally enforceable.

Overall, it is considered that the site can be rendered suitable for the proposed development subject to proper implementation of the remediation procedures, unexpected finds protocols, completion of the validation assessment detailed in this RAP.

This document also provides an acid sulfate soils management plan (ASSMP).

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1. Introduction

Douglas Partners Pty Ltd (DP) was commissioned by A W Edwards Pty Ltd to prepare a Remediation Action Plan (RAP) for the proposed recreational development located at Cnr Myrtle St and Jasmine St, Botany (as shown in Drawing 1, Appendix A), being the Botany Aquatic Centre Stage 1 (the “site”, as shown on Drawing 1, Appendix A) development. The report was prepared in accordance with DP’s proposal 201489.01.P.002 dated 25 February 2021 and acceptance received by Tristan Balogh of CO-OP STUDIO PTY LTD dated 9 March 2021.

In the preparation of this RAP, reference has been made to the following guidelines:

- National Environment Protection Council (NEPC) *National Environment Protection (Assessment of Site Contamination) Measure 1999* (as amended in 2013) (NEPC, 2013);
- NSW EPA, *Sampling Design Guidelines* (NSW EPA, 1995);
- NSW EPA, *Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Land* (NSW EPA, 2020);
- NSW EPA *Contaminated Sites Guidelines for the NSW Site Auditor Scheme* 3rd Edition (NSW EPA, 2017);
- NSW EPA Waste Classification Guidelines, Part 1: Classifying Waste (NSW EPA, 2014);
- NSW EPA Waste Classification Guidelines Part 2: Immobilisation of Waste (NSW EPA, 2014);
- State Environmental Planning Policy 55 (SEPP55) - Remediation of Land (NSW DUAP/EPA, 1998); and
- WA DOH, *Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia* (WA DoH, 2009).

The overall objective of the remediation programme outlined in this RAP is to render the site suitable, from a contamination perspective, for the proposed development. The objectives of the RAP are listed in Section 2.

An acid sulfate soils management plan (ASSMP) has been developed and presented as part of this document (refer Section 13).

2. Objective

The scope of the RAP has been established on the basis of the findings of the previous investigations, site observations and proposed development details.

The primary objective of the RAP is to remove and/or to mitigate associated risks of potential environmental and human health impacts posed by identified contamination and further contamination uncovered during earthworks (as unexpected finds) such that the site can be rendered suitable for the proposed development.

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

- An appropriate remedial strategy so as to render the site suitable, from a contamination perspective, for the proposed development;
- The remediation acceptance criteria to be adopted for the remediation of the site and the validation requirements to verify the successful implementation of the remediation strategy;
- Appropriate environmental safeguards required to complete the remediation works in an environmentally acceptable manner;
- Appropriate occupational, health and safety (OH&S) procedures required to complete the remediation works in a manner that would not pose a threat to the health of site workers or users; and
- A framework to minimise environmental risk on the site and the surrounding environment.

3. Site Identification

Site Address	Cnr Myrtle St and Jasmine St, Botany
Legal Description	Part of Lot 1, Deposited Plan 1148910
Approximate Area	1725 m^2 (combined two areas as shown on Drawing 1, Appendix A)
Zoning	Zone RE1 Public Recreation
Local Council Area	Bayside Council
Current Use	Recreational Facility - Botany Aquatic Centre
Uses surrounding the aquatic centre	North - Industrial and Port Botany freight rail line East - Port Botany freight rail line, then Eastlakes Golf Club South - Myrtle Street, then residential West - Booralee Park

4. Proposed Development

It is understood that the proposed Stage 1 development is to include the construction of water slides, an out-door aqua play area (i.e., splash pads), single storey change room and associated plant room. As all structures are to be on-grade it is understood that there will be minimal changes to existing site levels, other than associated for general levelling purposes and otherwise minimal excavation of soils for foundations and supports.

The proposed Stage 1 works is also understood to comprise the demolition of an existing kid's pool and associated structures in the south of the existing aquatic centre. Proposed cut and fill mark ups (Drawings DA201A and DA501A, Appendix A) showing the proposed land indicate that the majority of the site requires fill to raise the site level with localised cut for the plant room.

5. Review of Previous Reports

The results of the review presented in the Detailed Site Investigation (DSI) (DP, 2021) report is summarised below in the following Sections 5.1 to 5.4. The DSI is the most recent report produced for the site and therefore contains the most relevant information pertaining to history and identified contamination within the site.

5.1 Site History Summary

Site history information suggested that the site was originally acquired by the current owner(s) in 1943 through the process of being appointed trustee of crown reserve land. Historical aerial photographs suggested that the site began being actively used as an aquatic centre sometime following construction works circa 1960 and the completed circa 1970. Prior to that the site was a part of a larger commercial / industrial facility which contained two large warehouses and apparently stored shipping containers or similar at various times between about 1940 and 1965. The actual activities at the site during this time are not known.

It was further noted that immediately to the east of the site that the eastern portion of the larger lot was previously visibly separated from the aquatic centre with possible usage including the storage of materials, soils and / or waste.

5.2 Topography, Geology and Hydrogeology

5.2.1 Topography

The topographic contours indicate the site is relatively flat around RL 6 - 8 m AHD with regional topography sloping to the west and north-west of the site.

5.2.2 Geology and Soil Landscape

Reference to the Sydney 1:100 000 Geological Series indicates that the site is underlain by Quaternary Period marine sediment, comprising medium to fine-grained sand with podsols. The mapping also indicates that sediments underlying Mill Stream to the north and west of the site comprise peat, sandy peat and mud.

Reference to the Sydney 1:100 000 Soil Landscape Series Sheet indicates that the western half of the aquatic centre is within in an area underlain by disturbed terrain. The eastern half of the aquatic centre is located within the Tuggerah Soil Landscape which generally comprises gently undulating to rolling aeolian coastal dunefields. However, based on the mapping it is considered possible that the entirety of the aquatic centre is within the disturbed terrain given the proximity and potential overlap of the mapping areas.

5.2.3 Surface Water and Groundwater

The nearest surface water bodies are Lachlan Swamps, located hydraulically up-gradient of the site, about 450 metres to the north-east, and Mill Pond located hydraulically down-gradient, about 850 metres to the west.

The inferred groundwater flow direction was previously determined through the measurement of groundwater levels within the larger aquatic centre lot area to be to the south-west (DP, 2020), which is in general accordance with the regional topography. The measured standing water levels previously ranged from 1.3 to 2.9 m bgl. It is noted however, that groundwater levels will change with temporal and climatic variance.

5.2.4 Acid Sulfate Soils

Reference to NSW Department of Planning, Industry and Environment Acid Sulfate Soil (ASS) mapping indicates that soils on the site are considered Class 4; located within an area of low probability of ASS occurrence.

It was noted however, given the location within an area of disturbed terrain there exists uncertainty regarding the acid sulfate risk for any disturbed soils, which may include ASS materials previously deposited onto the site.

5.2.5 Subsurface Conditions

Subsurface conditions within the site were summarised as:

- FILL / Silty SAND and SAND: Typically, fine to medium, dark brown to grey, with various inclusions of organics, igneous gravel, clay and anthropogenic materials including asphaltic gravel, brick and ceramic fragments, clinker and metal. A hydrocarbon odour was also intermittently present. This fill layer was generally present to depths of 0 m to 1.9 m bgl;
- ASH / FLY ASH: Typically, with clinker and fine to coarse asphaltic gravel as well as various inclusions of clay and presence of a strong hydrocarbon odour. This layer was generally present to depths of 0.4 m to 1 m bgl; and

- SAND: Fine to medium, grey, yellow, orange and brown, occasionally with a trace of silt, generally present below 0.6-1.0 m bgl, however was also present from up to 0.55 m bgl.

There were some signs of contamination observed within the fill layers, including staining and a hydrocarbon odour. No asbestos containing material was observed on site, however, it is noted that building rubble such as glass, tile, brick and concrete fragments and metal wire noted which may indicate the presence of hazardous building materials, including asbestos. Asbestos was previously identified at two of the of the Prensa (2018) test locations to the east of the current site (TP5 & TP6), within the larger aquatic centre area.

5.3 Summary of Identified Contamination

Table 2 below presents a summary of previously identified contamination within the site exceeding a recreation, public open space land - use scenario (refer Section 8 for relevant criteria). Section 9.1 provides a summary of these results in relation to the adopted site assessment criteria (SAC) / remediation acceptance criteria (RAC) and their significance. Previous reported summary tables for soil, groundwater and waste classification are attached in Appendix C.

Table 1: Previously Identified Contamination (Soil)

Sample IDs	Contaminants
Health-Based Exceedances	
BH4/0.9-1.0, BH6/0.5-0.6, BH9/0.5-0.6, BH10/0.4-0.5, BH12/0.5-0.6, BH18/0.4-0.5, BH19/0.4-0.5, BH22/0.4-0.5 and BH27/1.4-1.5	Carcinogenic PAH (as BaP TEQ) and/or Total PAH
BH19/0.4-0.5 and BH22/0.4-0.5	TRH (vapour intrusion)
Environmental-Based Exceedances	
BH2/0.4-0.5 (Prensa 2018 borehole), BH9/0.5-0.6, BH10/0.4-0.5, BH12/0.5-0.6, BH18/0.4-0.5, BH19/0.4-0.5, BH22/0.4-0.5 and BH27/1.4-1.5	TRH
BH4/0.9-1.0, BH6/0.5-0.6, BH9/0.5-0.6, BH10/0.4-0.5, BH12/0.5-0.6, BH18/0.4-0.5, BH19/0.4-0.5, BH22/0.4-0.5 and BH27/1.4-1.5	B(a)P
BH4/0.9-1.0, BH6/0.5-0.6, BH9/0.5-0.6, BH18/0.4-0.5, BH22/0.4-0.5 and BH27/1.4-1.5	Metals (Zinc and/or Copper)
BH19/0.4-0.5	Naphthalene

Based on previous results from the larger aquatic centre area, and the presence of anthropogenic materials in the fill it was considered likely that asbestos containing materials are present in-between test locations and / or in unobserved parts of the site.

All previous analytical results for groundwater samples were found to be within the SAC with the exception of minor exceedances for metals (Cd, Cu and Zn). These exceedances were previously considered to represent diffuse urban-sourced background contaminant levels typical of groundwater in the Sydney metropolitan area and / or a reflection of the natural minerology of the aquifer matrix (soil / rock) and were therefore not considered significant. Low levels of BTEX (as toluene) and PAH were detected below the SAC and were considered likely to have leached from the soils within the site.

No further assessment or management of groundwater was considered to be required. The remediation approach for contaminants in soil is considered to assist in minimising potential leaching of low level contaminants from soil.

5.4 Waste Classification

Fill across the site was previously preliminarily classified as General Solid Waste (non-putrescible) in accordance with the NSW EPA (2014) waste classification guidelines, with the exception of:

Restricted Solid Waste (RSW) for the following locations:

- B(a)P in BH6/0.50.6 (18 mg/kg), BH10/0.4-0.5 (duplicate sample, 22 mg/kg) and BH27/1.4-1.5 m (23 mg/kg); and
- Total PAH in BH9/0.5-0.6 (400 mg/kg).

and Hazardous Waste for the following samples:

- B(a)P in BH22/0.4-0.5 (520 mg/kg), BH19/0.4-0.5 (350 mg/kg), BH18/0.4-0.5 (72 mg/kg, BH12/0.5-0.6 (68 mg/kg) and BH9/0.5-0.6 (33 mg/kg); and
- Total PAH in BH22/0.4-0.5 (10000 mg/kg), BH19/0.4-0.5 (7200 mg/kg), BH18/0.4-0.5 (1200 mg/kg) and BH17/0.4-0.5 (1300 mg/kg).

Samples classified as RSW and Hazardous Waste are contaminated with PAH, notably as B(a)P. Ash and clinker material were encountered across the site, including in the boreholes with elevated concentrations of B(a)P and PAH, and are considered likely to be the source of the elevated concentrations of B(a)P and PAH in the soil.

The NSW EPA *Immobilisation of Contaminants in Waste 1999/05* is a general immobilisation approval for ash/coal-contaminated materials, which allows waste classification for such materials based on their leachability concentration (TCLP) value alone. Given the low leachability of B(a)P and PAH in the samples analysed, it is considered the immobilisation approval could be applied to the samples containing concentrations of B(a)P and PAH which exceeded the GSW and RSW criteria. Therefore, the fill across the site where ash and clinker were observed may be classifiable as GSW under the *Immobilisation of Contaminants in Waste 1999/05.* Usage of the immobilisation order will require further *ex-situ* confirmation of compliance with the *Immobilisation of Contaminants in Waste 1999/05*.

It was previously noted for the potential for asbestos to be present in other sections of the site. As such whilst the above classifications were preliminary in nature, and it is considered a possibility that soils in other areas are classifiable as Special Waste (Asbestos).

Classification of underlying natural soils would be required to be conducted following removal of all fill and / or during *ex-situ* analysis. It is noted that due to the presence of AASS and PASS within parts of the larger lot, the natural soils will require further analysis to confirm the presence or absence of ASS.

5.5 Acid Sulfate Soils

The ASS results were previously noted to exceed screening criteria at multiple locations within the current site and within the larger aquatic centre, indicating the potential presence of ASS. Based on the field screening results and descriptions of the soils encountered, additional chromium reducible sulfur (Scr) testing was previously requested on six samples (BH3, BH13, BH17, BH21, BH25 and BH32). Sulfur odours were also noted both in the Prensa (2018) investigation and previous DP investigation (DP, 2020).

Based on the results it was previously considered that:

- ASS is present in certain natural soils underlying the site, due to the findings of ASS in BH3 between depths of 1.9 - 2 m (as confirmed by laboratory analysis);
- It is likely PASS is also present in the deeper layers of natural soils, particularly in indurated sands; and
- It is very likely PASS resides around and generally below the groundwater table (i.e., approximately 2 m bgl).

6. 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 the future i.e., it enables an assessment of the potential source - pathway - receptor linkages (complete pathways).

Potential Sources

Based on the historical information and site walkover, the following potential sources of contamination and associated contaminants of potential concern (COPC) have been identified. Previously identified contamination is summarised in Table 1.

- S1: Fill: Associated with levelling, demolition of former buildings adjacent to the site and potential burying of waste and imported fill.
    - COPC include metals, total recoverable hydrocarbons (TRH), benzene, toluene, ethylbenzene, xylene (BTEX), polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), organochlorine pesticides (OCP), phenols and asbestos.

- S2: Previous land-use: i.e., warehousing (unknown activities at the time).
    - COPC include metals, TRH, BTEX, PAH, VOC (e.g., solvents, degreasers).
- S3: Disturbance of Acid Sulfate Soils.
    - COPC include ASS properties.

Potential Receptors

The following potential human receptors have been identified:

- R1: Current users [aquatic centre staff and attendees];
- R2: Construction and maintenance workers;
- R3: End users [aquatic centre staff and attendees]; and
- R4: Adjacent site users [industrial workers and recreational users].

The following potential environmental receptors have been identified:

- R5: Surface water [Mill Stream; fresh];
- R6: Groundwater; and
- R7: Terrestrial ecology.

Potential Pathways

The following potential pathways have been identified:

- P1: Ingestion and dermal contact;
- P2: Inhalation of dust and / or vapours;
- P3: Surface water run-off;
- P4: Lateral migration of groundwater providing base flow to water bodies;
- P5: Leaching of contaminants and vertical migration into groundwater; and
- P6: Contact with terrestrial ecology.

Summary of Potentially Complete Exposure Pathways

A ‘source - pathway - receptor’ approach has been used to assess the potential risks of harm being caused to human or environmental receptors from contamination sources on or in the vicinity of the site, via exposure pathways (potential complete pathways). The possible pathways between the above sources (S1 to S3) and receptors (R1 to R7) are provided in below Table 2.

Table 2: Summary of Potentially Complete Exposure Pathways

Source and COPC	Transport Pathway	Receptor	Risk Management Action
S1: Fill Metals, TRH, BTEX, PAH, OCP and asbestos S2: Previous Warehousing Metals, TRH, BTEX, PAH, VOC	P1: Ingestion and dermal contact P2: Inhalation of dust and/or vapours P3: Surface water run-off P4: Lateral migration of groundwater providing base flow to water bodies P5: Leaching of contaminants and vertical migration into groundwater	R1: Current users R2: Construction and maintenance workers R3: End users R4: Adjacent site users	Management of identified contamination through a RAP (i.e., this document)
	P2: Inhalation of dust and/or vapours	R4: Adjacent site users	
	P3: Surface water run-off P4: Lateral migration of groundwater providing base flow to water bodies	R5: Surface water	
	P5: Leaching of contaminants and vertical migration into groundwater	R6: Groundwater	
	P6: Contact with terrestrial ecology	R7: Terrestrial ecology	
S3: Disturbance of identified ASS ASS exposure	P1: Ingestion and dermal contact	R2: Construction and maintenance workers	Management under the ASSMP presented in this RAP.

7. Data Quality Objectives

In order to attain the remediation objective as set out in Section 2 the following seven step data quality objective (DQO) process provided in Appendix B, Schedule B2 of NEPC (2013) will be implemented. The DQO process is outlined as follows:

(a) State the Problem

The 'problem' under consideration is the implementation of an appropriate remediation action plan to document that any previously identified contamination and unexpected finds and waste classification / disposal procedures are managed appropriately such that the remediated site will be suitable for the proposed development and that the remedial works pose no unacceptable risks to human health or to the environment.

The various parties involved in this decision process, include:

- The site owner;
- The principal / principal's representative;
- The planning authority (Bayside Council); and
- The Environmental Consultant (DP) for the investigation and remediation planning works.

(b) Identify the Decision

Based on the findings of the previous investigations, site observations and the proposed development details, the principal decision is to adopt an appropriate remediation strategy to address the problem. The proposed strategy needs to be developed following the consideration of viable options. Assessment and classification requirements for imported soil will also be outlined in this RAP.

(c) Identify Inputs to the Decision

Inputs to the decision include:

- Previous reports cited in Section 5; and
- Guidelines cited in Section 1.

The primary inputs in adopting a remediation strategy are as follows:

- The areas of potential contamination derived from known historical site activities identified from the site history review outlined in previous DP reports;
- The investigation findings reported previously, as outlined in Sections 5 and 9;
- The adopted SAC / RAC, refer Section 8 and DP (2021);
- The limitations associated with the construction site (e.g., available space and timing); and
- Proposed land use and design of the proposed development.

(d) Define the Boundary of the Assessment

The site consists of two separated areas situated within the larger Botany Aquatic Centre, located at the corner of Myrtle and Jasmine Streets. The site (and the boundary of the larger aquatic centre) is shown on Drawing 1, Appendix A.

(e) Develop a Decision Rule

The successful implementation of the RAP is assessed on the basis of RAC provided in Section 8. The decision rule is the comparison of the analytical results against the relevant guidelines and background concentrations where relevant.

(f) Specify Acceptable Limits on Decision Errors

Specific limits for this project will generally be in accordance with the appropriate guidelines from NEPC (2013) for the collection of environmental samples. In order that the results are accurate and reproducible, appropriate and adequate quality assurance and quality control (QA / QC) measures and evaluations will be incorporated into the validation sampling and testing regime.

(g) Optimize the Design for Obtaining Data

In order to maximise to opportunity of collection of representative data as part of the validation process, the sampling regime is based on the size of remediation areas and their extent of environmental concern. In addition, in order to attain an acceptable level of data quality, QA / QC procedures will be adopted as part of the RAP requirements.

If the DQOs are not met, then the reasons as to why they were not achieved will be critically examined. If the situation cannot be easily rectified or is unique to the site, then assessment of future actions required will be discussed and implemented where applicable.

7.1 Data Quality Indicators

DP's quality assurance (QA) and quality control (QC) procedures will be adopted throughout the field sampling programme (validation) to ensure sampling precision and accuracy and prevent cross contamination.

The quality controls of documentation completeness, data completeness, data comparability, data representativeness, precision and accuracy for sampling and analysis, if required, are described in Table 3.

Table 3: Data Quality Indicators

Quality Control	Achievement Evaluation Procedure
Documentation completeness	Completion of field and laboratory chain-of-custody documentation, completion of validation sample plans.
Data completeness	Sampling density according to provisions in the approved RAP, and analysis of appropriate determinants based on site history and on-site observation.
Data comparability and representativeness	Use of NATA accredited laboratories, use of consistent sampling technique.
Precision and accuracy for sampling and analysis	Achievement of 30-50% RPD for heavy metals and organics respectively for replicate analysis, acceptable levels for laboratory QC criteria.

8. Remediation Acceptance Criteria

The remediation works will be validated as meeting an acceptable standard for the proposed land use. The validation will be undertaken by the Environmental Consultant by means of visual inspection, field screening, recovery and analysis of samples and review of any available plans, as discussed below.

This section provides remediation acceptance criteria (RAC), which will be used to judge the success or otherwise of the remediation by the consultant.

8.1 Site Suitability

The SAC / RAC for the identified COPC are based on the health investigation levels (HIL), health screening levels (HSL), ecological investigation levels (EIL) and ecological screening levels (ESL) in accordance with Schedule B1 of NEPC (2013). Petroleum based health screening levels for direct contact have been adopted from the CRC CARE Technical Report no.10 (CRC CARE, 2011) as referenced by NEPC (2013).

The investigation and screening levels applied in the current investigation comprise levels adopted for an open space and recreational land use. Residential land-use has been adopted as an initial conservative screen for potential vapour intrusion risks for any enclosed structures, given the absence of similar investigation and screening levels for an open space or recreational land use.

It is currently understood that no proposed childcare facilities are planned as a part of the proposed development.

Appendix B outlines in more detail the relevant investigation and screening levels adopted for soil and groundwater. All site specific and / or theoretical assumptions relevant to the selection of the investigation and screening levels have been outlined in each sub-section as required.

Appendix F outlines proposed site specific HIL for both B(a)P TEQ and Total PAH. Refer to further discussion in Section 9.4.2.

8.2 Classification Assessment for Off-Site Disposal

All wastes will be assessed in accordance with the POEO Act 1997.

For disposal to landfill, this will comprise assessment in accordance with the NSW Environment Protection Authority (EPA) *Waste Classification Guidelines* (2014).

For re-use off-site, soil will be assessed in accordance with other EPA guidance or licences under the POEO Act, and may include:

- Resource recovery orders issued by EPA under the Protection of the Environment Operations (Waste) Regulation 2014; and Guidance on assessment of VENM.

It is also noted that recycling facilities with an appropriate Environment Protection License (EPL) may accept some of the soils that comply with their EPL conditions.

8.3 Aesthetics

Clause 3.6, Schedule B1 of NEPC (2013) outlines aesthetic considerations when undertaking a site assessment. Some examples of characteristics or situations that may need to be considered in the assessment outcome include odorous soils, hydrocarbon sheen (e.g., surface water), soil staining and putrescible refuse.

The assessment of such finds at the site will be as stated in the unexpected finds protocol in Section 12. If the assessment identified no real human health or ecological risk, the find might be removed on the grounds of aesthetics or relocated (e.g., at depth).

8.4 VENM

The POEO Act defines virgin excavated natural material (VENM) as:

‘*natural material (such as clay, gravel, sand, soil or rock fines):*

(a) that has been excavated or quarried from areas that are not contaminated with manufactured chemicals, or with process residues, as a result of industrial, commercial, mining or agricultural activities and

(b) that does not contain any sulfidic ores or soils or any other waste and includes excavated natural material that meets such criteria for virgin excavated natural material as may be approved for the time being pursuant to an EPA Gazettal notice.’

VENM is a waste that has been pre-classified as general solid waste (non-putrescible) under EPA (2014).

Additional advice is provided on the EPA web site[1]. This advice states:

- Generators of VENM must assess the past and present activities on the site. The possibility that a previous land use has caused contamination of a site must be considered when assessing whether an excavated material is VENM. Land uses that could result in contaminants being present in an excavated material are listed on the web site. The list is not exhaustive, and an excavated material may still be contaminated even where none of these activities have previously occurred on a site. Activities not directly related to a site may also lead to contamination, including diffuse sources of pollution such as contaminated groundwater that migrates under a site, or dust settling out from industrial emissions. Generators of VENM must consider these factors;
- Generators of excavated material should review the applicable Acid Sulfate Soil Risk Maps to determine the probability of acid sulfate soils being present at the site at which VENM excavation is proposed. The waste cannot be classified as VENM if the Acid Sulfate Soil Risk Maps identify a high probability of occurrence of acid sulfate soils or potential acid sulfate soils, unless it has undergone chemical assessment in accordance with the Acid Sulfate Soils Assessment Guidelines and the updated Acid Sulfate Soils Laboratory Method Guidelines Version 2.1 - June 2004;
- By definition, VENM cannot contain any other waste, or be ‘made’ from processed soils. Excavated material that has been processed in any way cannot be classified as VENM; and
- Classification of excavated material as VENM requires certainty that all aspects of the definition are met. Chemical testing may be required to ascertain whether an excavated material is contaminated with manufactured chemicals or process residues, or whether it contains sulfidic ores or soils.

As a means of assessing the presence of manufactured chemicals or process residues, the analytical data for samples of natural soils are typically compared against published background concentrations.

Given the identified presence of PASS in natural soils further assessment of ASS should be performed as per the ASSMP outlined in Section 13.

Imported VENM will also be required to be compared against the RAC as listed in Section 8.1. Sampling requirements for imported materials are outlined in Section 14.3.

Assessment of soils off-site disposal or of VENM will be conducted in accordance with either Section 14.4 (*in-situ*) or as per Section 14.2.

8.5 Imported Material under a Resource Recovery Order

As stated in Section 14.3, all proposed imported materials (including DGB, landscaping and temporary fill for platforms) will be assessed as being legally able to be imported to the site, and suitable under the proposed development. Material proposed to be imported to the site must comprise one of the following:

- VENM; or
- Materials complying with a Resource Recovery Order (RRO) allowing land application.

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[1] http://www.epa.nsw.gov.au/waste/virgin-material.htm, titled 'Virgin Excavated Natural Material’

Materials meeting an appropriate RRO, or multiple RROs must also meet the RAC as discussed in Section 8.1.

9. Remedial Action Plan

9.1 Contamination Status

Table 4 below includes a summary of identified contamination exceeding the adopted SAC / RAC. Previous reported summary tables for soil, groundwater and waste classification are attached in Appendix C.

Table 4: Summary exceedances of SAC / RAC

Sample ID	HIL / HSL C Exceedance(s) (Measured mg/kg | SAC mg/kg)	EIL / ESL C Exceedance(s) (Measured mg/kg | SAC mg/kg)
BH2/0.4-0.5 (Prensa 2018)	-	TRH F3 (300 | 300)
BH4/0.9-1.0	B(a)P TEQ (4.2 | 3)	*B(a)P (2.9 | 0.7)* Zinc (380 | 350)
BH6/0.5-0.6	B(a)P TEQ (26 | 3) Total PAH (310 | 300)	*B(a)P (18 | 0.7)* Zinc (610 | 350)
BH9/0.5-0.6	B(a)P TEQ (49 | 3), Total PAH (400 | 300)	Copper (130 | 130) TRH F3 (1400 | 300) B(a)P (33 | 0.7)
BH10/0.4-0.5	B(a)P TEQ (14 | 3), *B(a)P TEQ (33 | 3) *Total PAH (300 | 300)	*B(a)P (9.8 | 0.7)* *TRH F3 (680 | 300) **B(a)P (22 | 0.7)*
BH12/0.5-0.6	B(a)P TEQ (100| 3), Total PAH (640 | 300	TPH F3 (1200|300) B(a)P (68 | 0.7)
BH18/0.4-0.5	B(a)P TEQ (110 | 3), Total PAH (1200 | 300)	Copper (160 | 130) TPH F2 (200 | 120) **TPH F3 (4000 | 300)** B(a)P (72 | 0.7)
BH19/0.4-0.5	B(a)P TEQ (510 | 3) TPH F2 (130 | 110 VI) Total PAH (7200 | 300)	TPH F2 (1000 | 120) TPH F3 (1500 | 300) Naphthalene (490 | 170) B(a)P (350 | 0.7)

Sample ID	HIL / HSL C Exceedance(s) (Measured mg/kg | SAC mg/kg)	EIL / ESL C Exceedance(s) (Measured mg/kg | SAC mg/kg)
BH22/0.4-0.5	B(a)P TEQ (730 | 3) Total PAH (10000 | 300) TPH F2 (520 | 110 VI)	Copper (220 | 130) TPH F2 (520 | 120) **TPH F3 (6600 | 300)** Naphthalene (290 | 170) B(a)P (520 | 0.7)
BH27/1.4-1.5	B(a)P TEQ (34 | 3) Total PAH (430 | 300)	Copper (140 | 130) Zinc (590 | 350) TRH F3 (880 | 300) *B(a)P (23| 0.7)*

Note - Results in bold refer to an exceedance of both ML and HIL/HSL or EIL/ESL.
* - results from blind duplicate
B(a)P - benzo(a)pyrene
B(a)P TEQ - benzo(a)pyrene toxic equivalent quotient
F2 - TRH fractions C_{10}-C_{16} minus naphthalene
F3 - TRH fractions C_{16} – C_{34}
VI – Exceedance for vapour intrusion

It is noted that exceedances of the ESL for B(a)P within 33 mg/kg (given in italics) are not considered to be significant when considered against the higher reliability CRC Care ecological guidelines for urban residential and public open space (CRC CARE, 2017). However, it is noted that a number of locations exceed the higher reliability CRC CARE guideline.

Based on previous results from the larger aquatic centre area, and the presence of anthropogenic materials in the fill it is considered likely that asbestos containing materials are present in-between test locations and / or in unobserved parts of the site.

Given the depth and variable distribution of the contaminants, it is considered that the results are associated with the fill placed across the site (and the larger Aquatic Centre). Higher concentrations of TRH / TPH and PAH are considered largely associated with the encountered fly ash layers and inclusions of asphalt, ash and clinker in fill, generally from depths of 0.4 m. It is therefore considered possible that surficial fill (i.e., topsoil to depths of 0.2 to 0.3 m) may be further assessed for beneficial re-use, provided if appropriately separated from the underlying contaminated fill.

9.2 Remediation Goal

The remediation goal is to remove and / or to mitigate associated risks of potential environmental and human health impacts posed by identified contamination and contamination uncovered during earthworks (as unexpected finds) such that the site can be rendered suitable for the proposed development.

9.3 Extent of Remediation

On the basis of the summary presented in Section 9.1, it is not considered efficient or potentially even feasible to isolate and delineate locations of identified contaminated fill at depth. Fill is inherently heterogeneous and therefore the potential for contaminants to be present between already sampled locations is high. As noted in Section 9.1, it is considered that surficial fill (i.e., topsoil) if appropriately segregated may be further assessed for beneficial re-use, which may result in reduced waste generation and / or volume of soils requiring capping.

Otherwise, for the purposes of this RAP, all fill within the site is to be considered contaminated or potentially contaminated, and required to be managed in accordance with this RAP, unless shown through further assessment to be suitable for retention within the site without remediation.

The overall remediation strategy for the site is:

- That all soils remaining within the site as part of the development are assessed as being suitable, from a contamination perspective, for the intended land use; or otherwise, are encapsulated under a suitability constructed capping and marker layer, and managed under a long-term environmental management plan (EMP); and
- To make provision such that all soils removed from the site are disposed in accordance with an appropriate waste classification or exemption.

The proposed development of the site does not require the excavation of significant quantities of soil and generally is understood to require fill to reach design levels and, as such, the intention is to retain soils within the site where possible and where suitable.

Based on previous results no further management of groundwater (in terms of contamination) is considered to be required. Refer to Section 13 for discussion on management regarding acid sulfate soils and potential impacts on water / groundwater.

9.4 Typical Remedial Options Available

A number of remedial options were reviewed based on the soil contaminants identified to date (i.e., asbestos and lead and EIL/ESL exceedances for copper, zinc, lead and PAH). The suitability of the remedial options was examined in accordance with a number of relevant documents, including, *inter alia*, the following:

- NSW EPA, *Contaminated Land Management, Guidelines for the NSW Site Auditor Scheme* (3rd edition);
- WA DoH *Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia* (WA DoH, 2009) and
- NSW Department of Environment and Climate Change (DECC) *Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2008* (UPSS Regulation).

Possible remedial options to achieve the remedial objectives are identified as follows:

- No action;
- Further assessment of material for on-site re-use;
- On-site treatment of contaminated material for on-site re-use;
- On-site burial of contaminated material under a suitable physical barrier (cap); and
- Removal of contaminated material to landfill.

9.4.1 No Action

The “No Action” option involves no remedial response to the contamination identified on the subject site. This option was not considered appropriate for the following reasons:

- The proposed development will include excavations and therefore a management strategy for excavated soils is required; and
- Based on the proposed land-use and detected concentrations of contaminants (at concentrations exceeding the SAC), appropriate management arrangements and procedures would be required to manage / alleviate the impacts of the contamination as a minimum.

9.4.2 Further Assessment for On-Site Re-Use

Further assessment of fill soils at the site can be undertaken as below.

9.4.2.1 PAH

The identified contamination summarised in Section 9.1 has been compared against Tier 1 generic land-use criteria. It is noted that these levels are not intended to be clean-up levels or remediation end-goals.

An initial Tier 2 risk assessment which considers deviations in the site usage from the generic assumptions adopted in NEPC (2013), regarding site specific details such as land-use and the nature of the identified contamination may provide less conservative investigation levels, which overall, may reduce the extent of soils requiring remediation. It is noted that this would not likely impact locations which significantly exceed the currently adopted HIL (e.g., more than 2.5 times), as Tier 2 assumptions would still be relatively conservative. However, this option is considered to provide a relatively straightforward method to reduce the potential extent of remediation required, and therefore is considered to be preferable under sustainability considerations. Appendix F provides proposed site specific HIL for both B(a)P and Total PAH, which may be more applicable as an initial remediation goal.

The relative magnitude of the proposed site specific HIL for B(a)P (i.e., 8 mg/kg vs default 3 mg/kg) as compared to the detected exceedances (i.e., 4.2 to 730 mg/kg) indicates that the majority of the contamination would still require management through another option.

A detailed Tier 3 risk assessment would consider further detailed site specific information regarding land-use and contaminant pathways / properties and would therefore provide investigation levels which are more accurate and less conservative than the generic or Tier 2 levels. However, it is noted that a Tier 3 assessment would likely involve higher costs, and may only be necessary following a Tier 2 assessment.

It is considered that further assessment of soils against the currently adopted generic land-use criteria would not substantially change the extent of the currently identified contamination.

9.4.2.2 TRH / TPH

It is noted overall the elevated TRH / TPH levels were detected at the same locations / depths as PAH contamination. Therefore, the elevated levels of TRH/TPH would be effectively managed through the management of the higher concentrations of PAH (i.e., as outlined in Section 9.4.2).

9.4.2.3 Asbestos

To assess the suitability of fill impacted (or potentially impacted) with asbestos, an assessment of asbestos concentrations in accordance with WA DoH (2009) can be conducted. The guideline is recognised in NEPC (2013) as an appropriate approach for the assessment of asbestos contamination.

Soils sampled, screened and analysed in accordance with WA DoH (2009), and meeting the HSLs listed in Section 8.1 and Appendix B of this RAP, could be assessed as being suitable to retain within the site, either with no additional management, or beneath a nominal surface layer of topsoil or fill (as the HSL requires no visible asbestos in the surface). Relocation of soils to less sensitive areas of the site is also possible using this process.

9.4.2.4 EIL / ESL Exceedances

Soils retained in areas of proposed landscaping may be re-assessed for suitability through additional sampling and assessment against the applicable EILs and ESLs. If found to be suitable, the soils could remain without any further action. Otherwise, the soils could be removed and relocated to other areas of the site not subject to landscaping.

Alternatively, a horticulturalist should be consulted to advise on suitable plant species or soil mixes that can be used to manage potential impacts on plant growth.

Any retained soils would still need to meet health-based investigation levels.

9.4.3 Treatment of Contaminated Material

Treatment of contaminated material within the site may comprise the following as per the relevant contaminants.

9.4.3.1 Asbestos

Provided no friable asbestos is present in the soils, material impacted with bonded asbestos can be treated through a process of “emu picking” in the presence of an Occupational Hygienist or Environmental Consultant to remove observed fragments of bonded ACM. The materials would then be assessed for being retained on-site or otherwise as through the process outlined in Section 9.4.2.

This process has the benefit of retaining suitable soils on site, rather than adding to the landfill volumes and transporting asbestos impacted soils on public roads.

This process has limitations including:

- Available space on site to spread soils (in batches) for the emu picking process;
- Available space for stockpiling treated soils (in batches);
- The potential for dust generation carrying asbestos fines which may cause cross contamination and noting pedestrians at the site boundary, workers within the site and workers in the neighbouring properties;
- The requirement for asbestos air monitoring and reporting; and
- The additional time required to implement the process.

9.4.3.2 PAH

There exists a number of treatment options for PAH, including B(a)P as outlined in Table 5 below, further detail is provided in CRC Care Technical Report No. 39 (CRC CARE, 2017):

Table 5: PAH Remediation Technologies

Methodology		Notes
In-Situ		
Biological	Enhanced bioremediation	i.e., breakdown via soil microorganisms It is noted this method is generally applicable for non-sensitive uses and end-point concentrations are difficult to target. B(a)P is also noted to be a recalcitrant contaminant.
	Bioventing	Generally, not applicable for B(a)P
	Natural attenuation	B(a)P is a recalcitrant contaminant and generally does not degrade under standard conditions.
	Phytoremediation.	Developmental and uncertain for B(a)P
Physical	Electrokinetic separation	Generally, not applicable for B(a)P
	Soil flushing	Mobilisation of contaminants with surfactant or solvent. Uncertainty regarding final concentrations. Can spread contaminants, requires management of contaminated eluent.
	Solidification/stabilisation	Chemical fixing/immobilisation of contaminants. Applicable only for mobile contaminants. Contaminants ultimately remain in place.
	Chemical oxidation	Difficulty in determining optimal oxidant doses, not a widespread technology.

Methodology		Notes
	In-situ thermal treatment	Widely applied overseas.
	In-situ soldering	Developmental stage technology
Ex-Situ (following excavation)		
Biological	Land farming	Generally, not applicable to B(a)P. Otherwise can reduce lower molecular weight PAHs
	Slurry phase treatment	
	Biopiles / composting	
	Mycodegradation	
Physical	Soil flushing	As per in-situ.
	Solidification/stabilisation	As per in-situ. Consideration must be given to soil re-use given immobilised contaminants remain in soil.
	Thermal desorption	Generally, well understood, high establishment costs
	Chemical oxidation	Developmental
	Pyrolysis	Not widely used in Australia.
	Incineration	Community concern, by-product pollution.

Given the relatively small scale of the proposed excavation in-situ technologies are generally not considered to be feasible and / or cost-effective. *Ex-situ* treatment methods present options which may be beneficial under sustainability principles, however, consideration would need to be given to a cost-benefit analysis compared to other options (i.e., Sections 9.4.4 and 9.4.5).

9.4.4 On-Site Burial and Capping

Physical barrier (or encapsulation) systems involve the placement / installation of a layer of suitable capping material such as validated soils or permanent pavement over the contaminated filling that would act as a barrier and limit the exposure of site users to the contaminants.

This option is considered to be viable given the following:

- Physical, generally non-leaching contamination (e.g., asbestos, lead and low-level PAH); and
- Generally low-level contamination.

However, this option requires available space at depth (accounting for final design levels that need to accommodate the capping thickness) for placement of the impacted material, and the excavation and management of the material removed to accommodate the impacted material. Consideration should also be given to local groundwater levels which may limit the practicable depth of any containment (i.e., due to geotechnical constraints and the potential for leaching of contaminants). Any volatile contaminants are also considered only generally suitable if there are no enclosed spaces (e.g., buildings, plant room) above the encapsulation area.

The process also requires diligent tracking of material to avoid cross-contamination, and the accurate surveying of the burial area and final capping construction.

This option requires a long-term EMP and a suitable mechanism to provide notification and enforcement of the EMP, including provision of a statement on the Section 10.7 planning certificates for the site, or a covenant registered on the title to land under s.88B of the Conveyancing Act 1919 which relates to the EMP. In addition, future management of contamination remaining on site would require that the site owner and relevant planning authority must agree to the EMP, the provision of the notice on title, and would require that the EMP is reasonably, legally enforceable.

An assessment of suitable capping areas for the site is given below (with reference to the supplied cut and fill markup in Appendix A):

Table 6. Potential Capping Areas

Area	Suitability	Notes
External concrete surfaces	Retain existing fill and relocation of other fill to area.	To be finished with concrete slab, area requires fill to reach design levels. External areas with no enclosed structures suitable for volatile / semi-volatile contaminants
Splash pad		
Central landscaping areas (i.e., beneath slides)	Retain existing fill and relocation of other fill to area.	Requires fill to reach design levels. To be finished with soft landscaping. Will require thicker capping limiting burial volume. External area with no enclosed structure suitable for volatile / semi-volatile contaminants.
Plant room and peripheral concrete areas	Retain existing fill, relocation of non-volatile contaminated fill only.	To be finished with concrete slab, may require minimal excavation to allow for minimum capping thickness at western end (i.e., near heat pumps), reducing available volume.
Balance tank	Unlikely	Requires cut for design depths. May only be suitable for capping if excavation depth is extended further beneath design levels, final depths may be limited by groundwater. Capping beneath groundwater will require further assessment of PAH / TRH contaminated fill to assess leachability into groundwater

Area	Suitability	Notes
Toddler splash pool (southern separate portion of the site)	No	To be demolished and re-finished with soft landscaping, only currently requires minimal fill to reach design levels. Capping would require excavation of deeper borrow pit.
Peripheral landscaping areas	No	Small narrow sections at edges of site unsuitable for capping i.e., elevated risk of disturbance from future development. Landform will also require gradual sloping to meet new elevated levels limiting available space for design capping thicknesses. May require relocation of fill from these areas to areas approved for capping.

9.4.5 Removal of Contaminated Material to Landfill

Off-site disposal of contaminated material is considered a suitable option for managing human health and environmental impacts from the contaminated materials, particularly in view of the planned excavation as a part of the proposed development i.e., piling, service trenches, general site levelling, etc.

The removal of material to landfill would involve a formal waste classification and transport of contaminated material to an EPA licensed landfill. Tracking and disposal records would need to be retained for inclusion in the site validation report. This option is viable for all soils at the site.

This option generally has higher cost implications, fills available landfill space, and requires the transporting of contaminated materials on public roads. However, this may be considered an option where retaining impacted fill may not be practicable or desirable and may otherwise pose a risk of cross-contamination.

9.5 Remediation Approach

9.5.1 Hazardous Building Materials

The proposed works within the site will include the demolition of some existing structures. Based on previous site observations the structures present (i.e., kids pool and BBQ shelters) within the site are considered to have a relatively low risk for hazardous building materials (HBM) to be present.

Prior to undertaking any such works a hazardous building materials survey may assist in identifying any potential HBM (e.g., asbestos materials in brick mortar, mastic, etc.). Should hazardous building materials be identified, these will be removed and managed under relevant codes of practices (refer Section 11) and an asbestos removal control plan (ACRP). Any asbestos removal during this process will be documented so as to be included in the validation reporting requirements as set out in this document.

9.5.2 Adopted Remediation Approach

On the basis of the discussion of remediation options above, previous discussions with the client and the details of the proposed development, the adopted remediation approach is as follows:

- Relocation and encapsulation of all contaminated fill in parts of the site according to the following hierarchy based on the assessment in Section 9.4.4:
    - Splashpad area and external areas of the slide structures (beneath concrete surfaces);
    - The plant room building; and
    - External landscaping (i.e., beneath the slide structures).
- As a contingency, removal and off-site disposal of any surplus contaminated fill which cannot be relocated under a capping area (i.e., due to volume constraints or from any hot spots of leachable contaminants) and does not meet the RAC.

Further detail on the remediation approach is presented in the following Section 10.

10. Remediation Procedures and Sequence

The detailed procedures and sequence for the remediation work will rest with the Contractor and will depend upon the equipment to be used and the overall sequence of any demolition, excavation and development. The broad sequence of works will otherwise follow the order of the following subsections.

The Principal and / or Contractor must obtain all required approvals, licences and permissions prior to commencement of remediation works, and implement relevant conditions.

The requirements for the management of asbestos are detailed in Section 11. Given the risk for asbestos contamination it is recommended that as a minimum works including the disturbance of fill are conducted under asbestos conditions as advised by the Occupational Hygienist.

The following sub-sections provide the details for each of the steps outlined in Section 9.5.2.

10.1 Relocation of Fill Material to Capping Areas

The following will apply for areas in which material is to be relocated to capping areas. The areas anticipated to require relocation and the depth of contamination in each area is summarised below in Table 7.

Table 7: Summary Depth of Fill Previously Observed for Areas Requiring Relocation of Fill

Area	Estimated Depth of Fill (and Associated Boreholes)
Balance tank	1.0 m (BH18), 0.55-0.65 m (BH9, BH10)
Toddler splash pool (southern separate portion of the site)	0.7 m (BH6). Note deeper fill was observed to the west outside this area up to 1.8 m (BH4 and BH27)
Peripheral landscaping areas	0.55-0.6 m (BH10, BH20), 1.0 m, (BH19, BH22)

The sequence will be as follows:

- Removal of existing structures within the area;
- *(optional)* excavation of surficial topsoil fill, supervised by the Environmental Consultant (i.e., to maximum depth of ~0.2-0.3 m) to be stockpiled separately and assessed by the Environmental Consultant as per Section 15.2. If suitable the material may be beneficially re-used elsewhere within the site;
- Excavate all fill in the area extending until encountering natural soils. Reference should be given to Table 7 for indicative depths, or as otherwise advised by the Environmental Consultant;
- Excavated soils will be temporarily stockpiled or directly transported to the proposed capping area (if already prepared as per Section 10.3);
- Visual inspection of the excavation by the Environmental Consultant to visually confirm the depth of excavation, and the presence of natural soils, as indicated by the Environmental Consultant further excavation may be required;
- Validation sampling by the Environmental Consultant from the base of excavation at the rates specified in Section 15.2;
- Analysis of recovered validation samples for a range of contaminants identified in the CSM and / or as per the identified contaminants exceeding the SAC / RAC, (specifically for PAH and asbestos);
- *(Optional)* Where asbestos is detected conduct site suitability assessment as below:
  - Collect ~10 L bulk samples from each sampling location;
  - Manual on-site screening of each ~10 L bulk sample through a 7 mm sieve, and weighing recovered ACM retained on the sieve;
  - Calculate the asbestos % w/w for each 10 L bulk sample, and compare against the RAC; and
  - Collect a 500 ml sub-sample for each ~10 L sample for laboratory analysis of AF and FA to calculate the asbestos % w/w and compare against the RAC. This sample may only be analysed where ACM is found in the bulk sample and / or there is a suspicion of potential AF or FA (at the discretion of the Environmental Consultant).
- QA / QC analysis as per industry standards;
- If any areas do not meet the adopted SAC / RAC, then conduct further delineation as per Section 10.2 or bulk excavation to a nominal further depth e.g., 0.3-0.5 m further (may be suitable if widespread exceedances are noted). If implemented, the site specific HIL for PAH will be utilised instead of the default NEPC (2013) HIL to indicate if this step is required: and
- Once validated excavation may continue into natural soils (refer to Section 13 for management of ASS) and / or be backfilled with suitable materials (refer Section 14.3) to achieve design levels.

10.2 Delineation and Remediation of Contamination

The following process with apply to localised exceedances of the RAC identified through validation sampling during relocation of fill to capping areas (see Section 10.1). This procedure may also be applicable where localised areas of significant contamination is observed as unexpected finds (e.g., significant quantities of asbestos, pits etc.) which may present a health risk to workers and otherwise be unsuitable to be re-located under a capping area.

The process is as follows:

- Excavation of soils around the identified location to a nominal 5 x 5 m lateral extent and to the depth of contamination extent (or otherwise advised by the Environmental Consultant);
- Excavated soils will be stockpiled (where practicable) and assessed for off-site disposal (or on-site relocation in the case of ESL or EIL exceedances), or otherwise directly disposed of as per Section 14;
- Visual inspection of the excavation by the Environmental Consultant;
- Collection of samples from the walls and base of the excavation at the rates specified in Section 15.2;
- Analysis of recovered samples for a range of contaminants identified in the CSM and / or as per the identified contaminants exceeding the SAC / RAC, and specifically for asbestos contamination (*if detected*):
    - Collect ~10 L bulk samples from each sampling location;
    - Manual on-site screening of each ~10 L bulk sample through a 7 mm sieve, and weighing recovered ACM retained on the sieve;
    - Calculate the asbestos % w/w for each 10 L bulk sample, and compare against the RAC; and
    - Collect a 500 ml sub-sample for each ~10 L sample for laboratory analysis of AF and FA to calculate the asbestos % w/w and compare against the RAC. This sample may only be analysed where ACM is found in the bulk sample and / or there is a suspicion of potential AF or FA (at the discretion of the Environmental Consultant).
- QA / QC analysis as per industry standards.

If recovered samples exceed the SAC / RAC the excavation will be expanded as advised by the Environmental Consultant and the above steps repeated as necessary. If implemented, the site specific HIL for PAH will be utilised (where applicable) instead of the default NEPC (2013) HIL to determine where further remediation is warranted.

10.3 Capping Areas

- Removal of existing structures within the area;
- *(optional)* excavation of surficial topsoil fill, supervised by the Environmental Consultant (i.e., to maximum depth of ~0.2-0.3 m) to be stockpiled and assessed by the Environmental Consultant as per Section 15.2. If suitable the material may be beneficially reused outside or above the capping layer;

- Initial earthworks prior to installation of the marker layer:
    - Excavation of fill material to allow for the minimum capping thickness (refer Section 10.3.1), and any localised detailed excavation (e.g., services, footings) to be temporarily stockpiled for relocation to another capping area (space / volume permitting) or otherwise any excess fill assessed for off-site disposal as per Section 14.2;

      AND / OR
    - Relocation of fill from other parts of the site to the area, allowing for the final minimum capping thickness (refer Section 10.3.1) and final design levels.
- Inspection of the final levels by an Occupational Hygienist / Environmental Consultant to determine if any gross contamination is present at the ground surface, for the purposes of worker health and safety;
- Survey the location (GPS coordinates to within 50 mm of its true position) and height (AHD within 10 mm of its true level) of final excavation surface (or the top of the burial cell) to allow a record of the location / level to be included in an EMP for the site and provide base levels for the capping material. As a minimum, survey points in the order of every 15-20 m^2 and every 2-5 m along its boundary would be suitable. Survey locations and results are to be recorded on site survey drawings;
- Inspection and characterisation of the final levels at the rates set out in Section 15.3, by an Environmental Consultant prior to installation of the marker layer;
- Cover the impacted soils with a suitable geotextile marker layer. The geotextile is to be a different colour to both the impacted fill and capping material above to assist with visual identification post capping (in the event of subsequent excavations). Separate rolls of the marker layer will be placed in strips with an overlap of 300 mm;
- Place a minimum thickness capping layer comprising virgin excavated natural material (VENM) or other appropriate materials complying with a RRO (and the RAC) over the marker layer. Refer to Section 10.3.1 below for further discussion regarding capping designs and minimum thicknesses. It is recommended that where practicable this material should preferably be a cohesive soil (e.g., non-dispersive clay), particularly for any soft capping areas, to minimise the potential for erosion in the future. Under hard capping areas (such as concrete) the use of a suitably compacted basecourse material would be suitable. Further design considerations related to materials suitability may be informed by other civil, horticultural requirements, etc.;
- Undertake a survey to confirm that the thickness of the capping layer meets the minimum design thickness requirements (refer specifications discussion in Section 10.3.1). If areas do not meet the specified thickness, then additional VENM / approved material is to be placed and compacted / worked and the subject area re-surveyed at the same locations and overlaid on the initial survey drawing to confirm design compliance;
- Inspection of the final capping layer by an Environmental Consultant; and
- Install final surface finish of capping area.

10.3.1 Indicative Capping Designs

The following sections outline indicative capping designs for different final ground surfaces.

Note, should there be specific compaction requirements regarding soils or other design requirements, these are to be confirmed with the relevant consultants (e.g., civil, landscaping, services, structural and geotechnical, etc.). The figures provided in the following section are not to scale, and are indicative only.

10.3.1.1 'Hard' Capping Areas

The design outlined below in Figure 1 is considered to be applicable for areas to be covered in hardstand such as slabs, concrete, paved areas, etc. In this design the capping material may either comprise VENM or ENM (refer Section 14.3 for requirements).

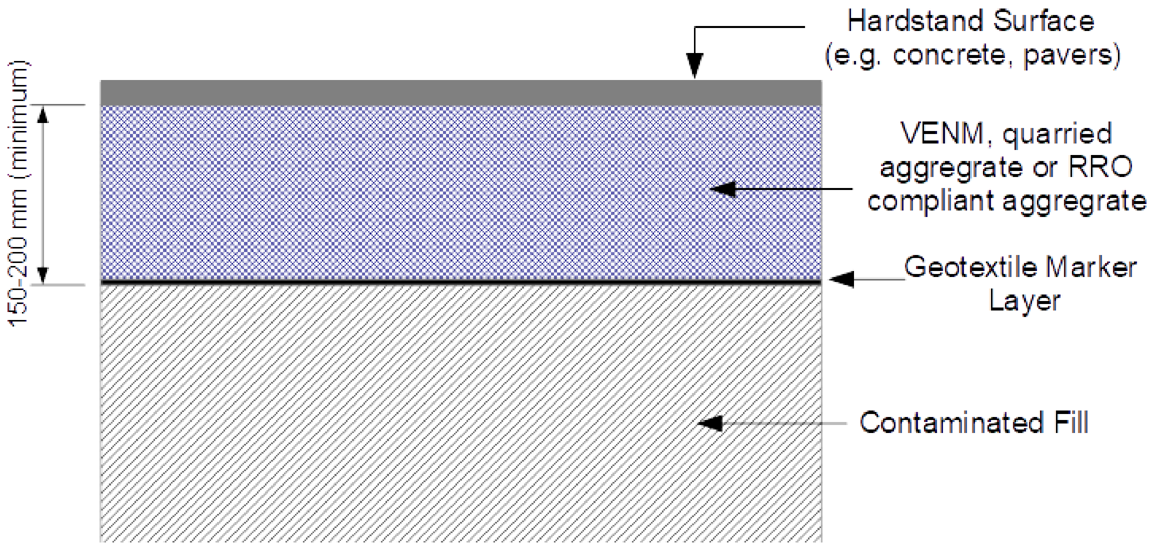

Figure 1: Indicative design for capping layer in areas of hardstand (minimum thickness shown)

10.3.1.2 Service Trenches

Figure 2 below indicates how buried services may be incorporated into the encapsulation. It is noted within this design that the geotextile marker layer is to line the entire trench which is excavated into the contaminated material.

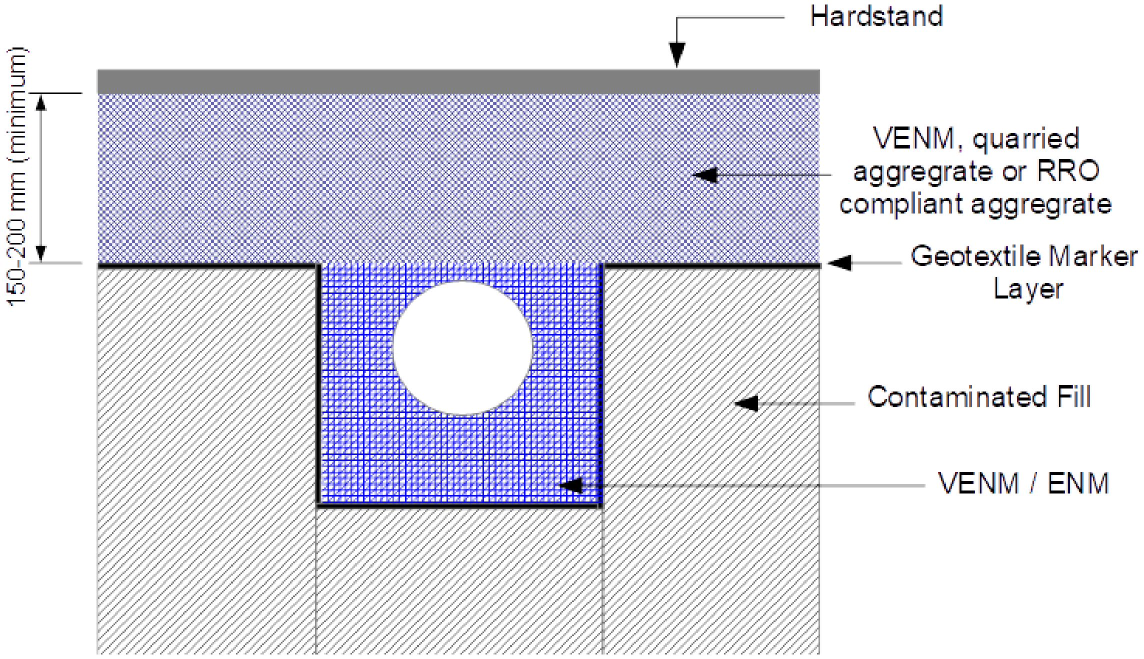

Figure 2: Indicative capping design for buried services (minimum thickness shown)

It is noted that placement of services in contaminated fill with the marker layer placed above the installed service will mean that any future maintenance or alteration of the services retained below the marker layer would entail cutting through the marker layer and therefore additional management procedures needing to be implemented will be set out in an EMP, including re-instatement of both the capping materials and marker layer. This approach would also require confirmation from the relevant utility provider for any active services to be retained under the marker layer. This method is generally not considered suitable unless no practicable alternatives are available.

10.3.1.3 Landscaping Areas

Figure 3 provides an indicative capping design for garden bed areas / tree areas. It is noted that the VENM (or approved alternative materials) capping layer may also need to fulfill specific horticultural requirements in addition to the requirements set out in Section 14.3.

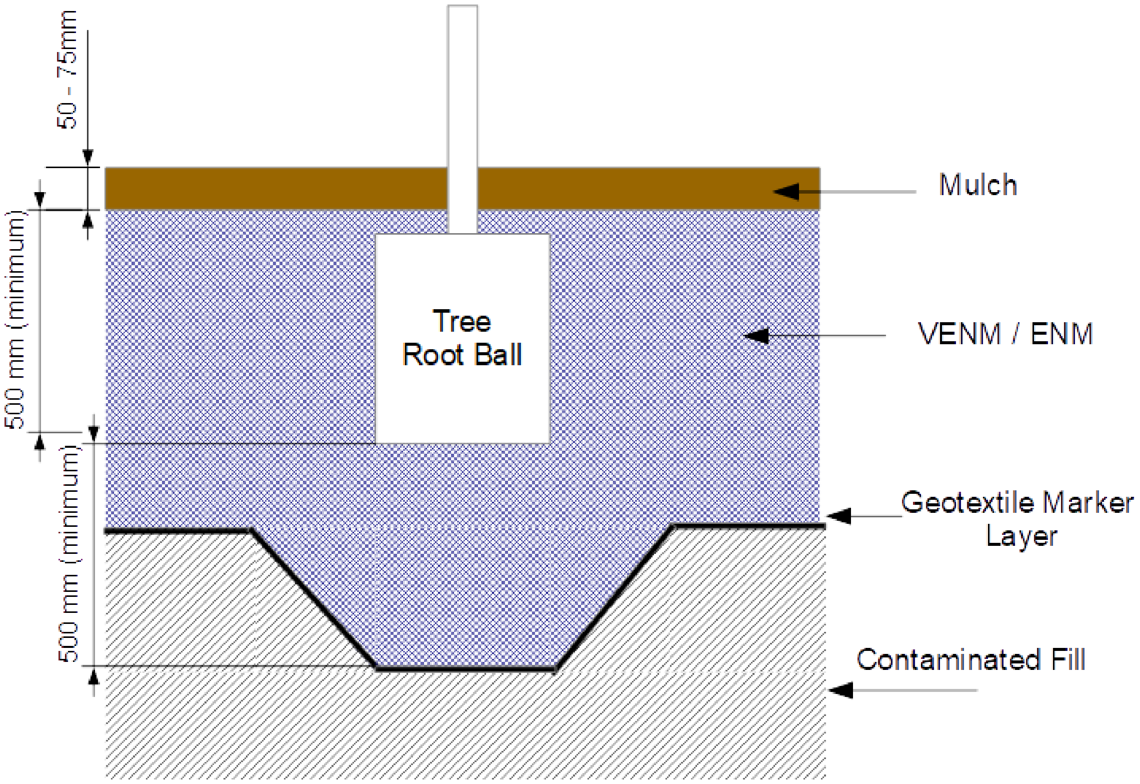

Figure 3: Indicative capping design for new garden beds / tree areas (minimum thickness shown)

In the case of larger trees (and therefore larger root balls) it is recommended, where practicable, to increase the VENM (or alternative approved material) capping thickness to avoid breaching the marker layer with the tree roots. This may be achieved by ‘mounding’ within the garden beds and / or deeper excavation and removal of the contaminated fill and / or planting trees with shallow roots.

Figure 4 provides an indicative design for capping areas which are to be finished with a grassed surface. It is noted again that the VENM (or alternative approved material) layer may also need to meet landscaping requirements.

Figure 5 provides an indicative design for edging details such as where soft and hard capping areas may meet.

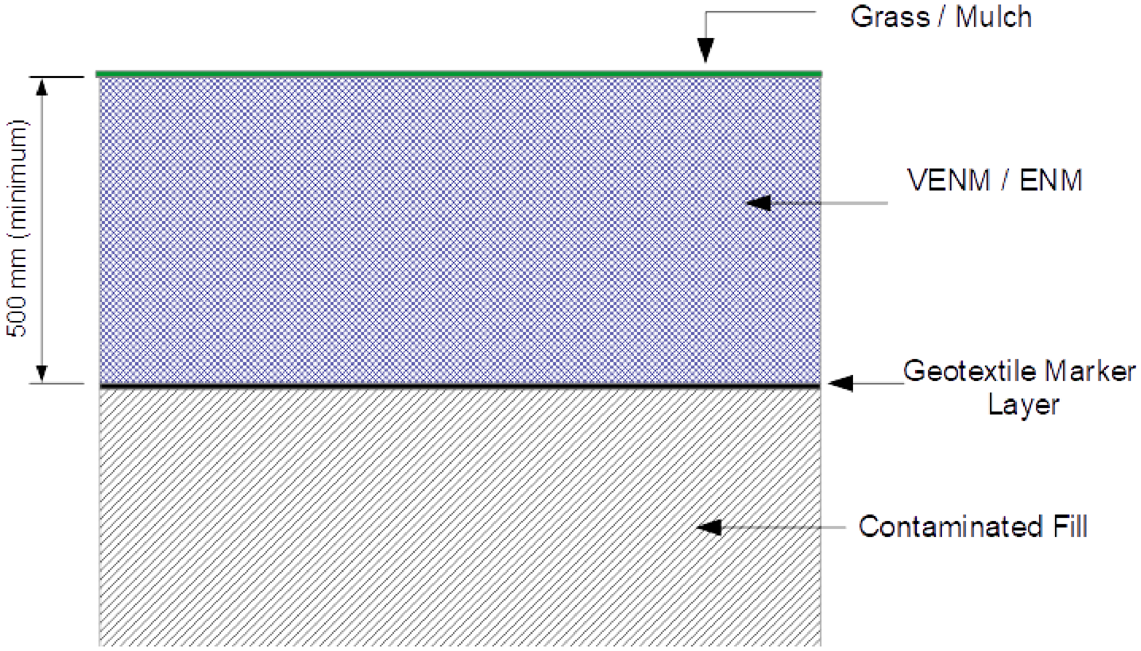

Figure 4: Indicative capping design for grassed areas (minimum thickness shown)

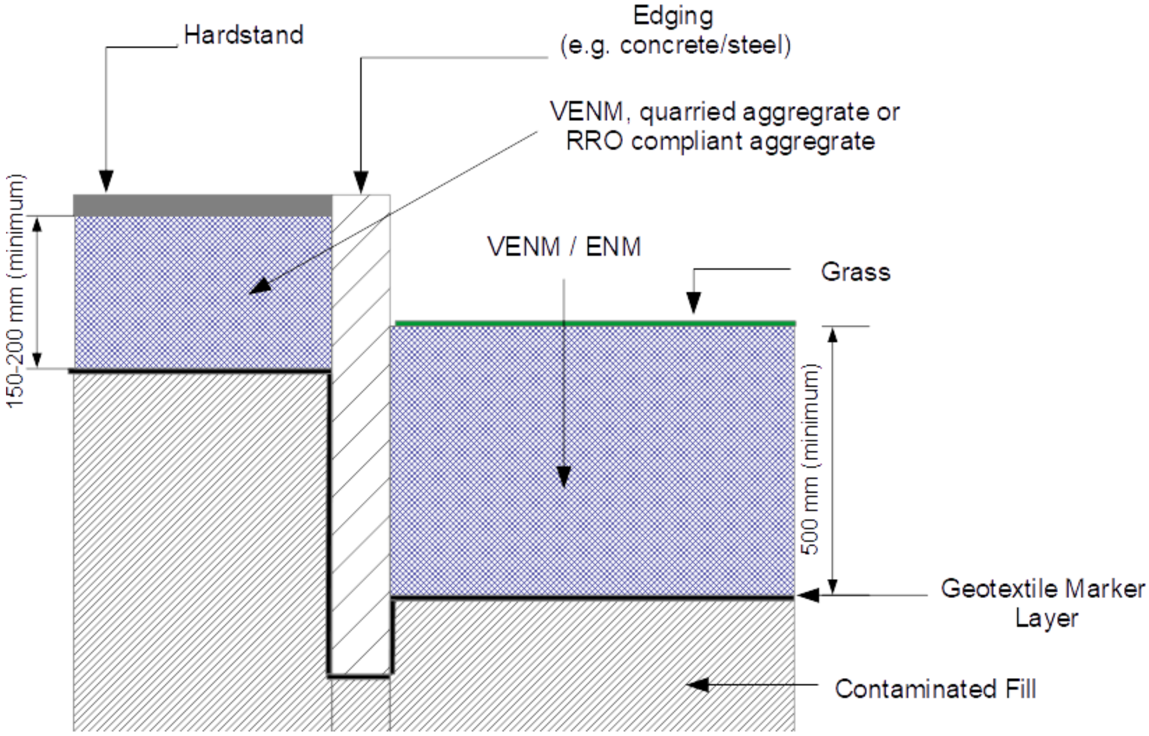

Figure 5: Indicative capping design for edging details (minimum thickness shown)

10.4 Piling Works

Following removal of contaminated fill (as per Section 10.1) or completion of a capping area (Section 10.3) piling works are to be conducted (as required) with the following general considerations and procedures:

Given the potential presence of asbestos materials in fill, TRH / PAH contaminated fill and ASS in natural soils it is considered highly likely that cross contamination of soils will occur for any methods which will result in spoil generation e.g., CFA piling. Less disruptive methods such as screw in or displacement piles may result in significantly less generation of cross contaminated soils to be managed and are preferable from a contamination point of view provided, they meet other requirements (e.g., geotechnical, structural).

Given the risk for asbestos contamination it is recommended that as a minimum the works are conducted under asbestos conditions as advised by the Occupational Hygienist.

- Prepare piling works area around the pile location, if practicable this will include a physical barrier (e.g., HDPE sheeting) around the piling location to minimise mixing of soils with the placed capping layer or any other materials placed on top of the cap. The work area will also provide adequate space to stockpile spoil onto a layer of plastic HDPE sheeting;
- If known asbestos is observed prior to works commencing, or is within an area where known asbestos has been capped, then further management may be required as directed by the Occupational Hygienist;
- Following completion of piling at each location any cross contaminated surficial soils will be scraped and added to the stockpiled soils for assessment;
- Excess piling spoil will be assessed by the Environmental Consultant for placement under a separate section of capping (if not yet completed) or otherwise for off-site disposal including:
  - Assessment for ASS as per Section 13. If detected soils will require treatment and verification sampling as per Section 13; and
  - Assessment for waste disposal as (if surplus) as per Section 14.
- Inspection and validation of the piling works area and stockpile footprint following completion of piling by the Environmental Consultant, including at minimum sampling for asbestos (AF / FA), metals, PAH and TRH at the rates set out in Section 15 (i.e., at minimum one sample at the piling location and one beneath the stockpile footprint once removed). Based on the visual inspection and laboratory results, further remedial excavation may be required if cross-contamination has occurred.

10.5 Contingency Strategy: Off-Site Disposal of Fill

The following section will apply for any areas where fill is not to be relocated underneath a capping area (Section 10.1) or otherwise to be capped (Section 10.3). It is anticipated this contingency strategy may be required due to volume constraints in capping areas (i.e., smaller volumes of ‘excess’ fill), or for detailed excavation following completion of capping.

The contingency strategy is as follows:

- Excavate fill in the area nominal depth until encountering natural soils;
- Excavated soils will be stockpiled (where practicable) and assessed / waste classified for off-site disposal, or otherwise directly disposed of as per Section 14;
- Visual inspection of the excavation by the Environmental Consultant to visually confirm the depth of excavation, and the presence of natural soils;
- Validation sampling by the Environmental Consultant from the base of excavation at the rates specified in Section 15.2;
- Analysis of recovered validation samples for a range of contaminants identified in the CSM and / or as per the identified contaminants exceeding the SAC / RAC, (specifically for PAH and asbestos);
- *(Optional)* Where asbestos is detected conduct site suitability assessment as below:
  - Collect ~10 L bulk samples from each sampling location;
  - Manual on-site screening of each ~10 L bulk sample through a 7 mm sieve, and weighing recovered ACM retained on the sieve;
  - Calculate the asbestos % w/w for each 10 L bulk sample, and compare against the RAC; and
  - Collect a 500 ml sub-sample for each ~10 L sample for laboratory analysis of AF and FA to calculate the asbestos % w/w and compare against the RAC. This sample may only be analysed where ACM is found in the bulk sample and / or there is a suspicion of potential AF or FA (at the discretion of the Environmental Consultant).
- QA / QC analysis as per industry standards; and
- If any areas do not meet the adopted SAC / RAC, then conduct further delineation as per Section 10.1.1. If implemented, the site specific HIL for PAH will be utilised instead of the default NEPC (2013) HIL to indicate if this step is required.

10.5.1 Management of EIL / ESL Exceedances

Any residual exceedances of environmental based investigation levels, which otherwise do not exceed health-based SAC / RAC may be potentially managed through consultation with a horticulturalist e.g., by selecting appropriate plant species, or my relocating to areas within the site (e.g., pavements) where there are lower or non-existent ecological risks. This option is only considered to be a contingency where the remediation actions outlined previously are not able to be implemented, and further testing by the Environmental Consultant has demonstrated that there are no human health risks.

11. Contingency for Asbestos Contamination

In the event that asbestos is found during the course of the civil or construction works, this section outlines contingency actions to be adopted.

11.1 Unexpected Asbestos Finds

If suspected asbestos materials are encountered during works where not anticipated to be present:

- Immediately stop work and notify the Site Supervisor;
- Move away (minimum 10 m) from the suspicious materials, and leave all tools;
- Site supervisor to create exclusion zone around the suspicious materials and erect signage “Danger Asbestos - Do Not Enter”;
- Occupational Hygienist / Environmental Consultant to inspect / sample the material to confirm if asbestos or not. The Occupational Hygienist / Environmental Consultant can instruct works to continue in a different area of the building if deemed safe to do so;
- If asbestos; the Asbestos Contractor will continue to remove the ACM (once all hazards & risks assessed), decontaminate area, obtain clearance certificate from an Occupational Hygienist and dispose of material to a licensed landfill facility, in accordance with an ARCP;
- Occupational Hygienist / Environmental Consultant to inspect the area confirm that no other unidentified asbestos present;
- Environmental Consultant to inspect area and / or review documentation to assess if additional targeted delineation and validation is required; and
- Following issue of a clearance certificate and the recommendations of the Environmental Consultant, workers can resume work under normal conditions.

11.2 Emu Picking

If emu picking of bonded ACM is determined by the Environmental Consultant to be an appropriate process to adopt to allow for fill soils to be retained, the emu picking process (if adopted) and subsequent validation will be as set out below. This process may be applicable in areas where assessment of fill to be retained exceeds the SAC / RAC for asbestos.

a) Designation by the Principal / Principal’s representative of a location for the spreading and treatment of the impacted soils, or otherwise the demarcation of an *in-situ* area, with appropriate signage and isolation from nearby work areas. The area must have sufficient space for stockpiling and treatment of the asbestos impacted filling as described below;

b) It is preferable for the treatment area to be hardstand. Otherwise, the surface soils beneath would need to be stripped at the end of the process and managed in the same way as the treated materials (if to be relocated);

c) The treatment area must be managed in accordance with the general site management requirements, including fencing to prevent unauthorised access, implementation of a dust management system, suitable locations selected for asbestos air monitoring, and provision of an asbestos decontamination area (if considered warranted by the Occupational Hygienist or Environmental Consultant);

d) Progressive excavation of manageable volumes (if stockpiled) from the stockpile by the suitably licensed asbestos contractor (refer Section 11.4) and spreading in the treatment area to a nominal thickness of 0.1 m. It is recommended where practicable a Class A licensed contractor is used to minimise any potential delays if friable asbestos is detected / suspected

e) The licensed asbestos contractor will inspect the layered soil by walking along a 1 m transect grid. Observed ACM will be removed by hand, double bagged and stored on-site in the secure designated ACM waste storage area;

f) The Occupational Hygienist / asbestos assessor will inspect the soil and mark any observed ACM. The marked ACM will be removed by the asbestos contractor;

g) Steps (e) and (f) will be repeated until no ACM is observed during three consecutive inspections / passes;

h) All ACM collected will be disposed off-site at an appropriately licensed landfill facility, with disposal records retained for confirmation and inclusion in the site validation report;

i) The asbestos contactor will stockpile the treated material in a designated area separate from the treatment area for later re-assessment; and

j) The Environmental Consultant will undertake validation assessment of each stockpile or *in-situ* area and treatment area following completion of all works in accordance with Section 14.

11.3 Asbestos Management

11.3.1 Regulatory Framework

In New South Wales (NSW), occupational health and safety is regulated under the NSW Work Health and Safety Act 2011 (WHS Act) and the NSW Work Health and Safety Regulation 2017 (WHS Regulation). Additionally, there are a range of National Codes of Practice and Guidance Notes, Australian Standards and other guidelines relating to the management of asbestos and ACM in the workplace.

Safe Work Australia (SWA) has issued the following codes of practice that have been adopted in NSW:

- Code of Practice: How to Safely Remove Asbestos, Safe Work Australia, 2016 (SWA, 2016a);
- Code of Practice: How to Manage and Control Asbestos in the Workplace, Safe Work Australia, 2016 (SWA, 2016b); and
- NOHSC Guidance Note on the Membrane Filter Method for Estimating Airborne Asbestos Fibres 2nd Edition [NOHSC:3003(2005)].

These codes and guidance note detail the requirements for the identification, assessment and management of ACM in the workplace, including the specific controls required for asbestos and ACM removal. Electronic copies of these documents are available on the SWA website (www.safeworkaustralia.gov.au).

Asbestos waste is regulated under the *Protection of the Environment Operations* (POEO) Act 1997 and POEO (Waste) Regulation 2014, which are administered by the Environment and Protection Authority (EPA).

Wastes, including those containing asbestos, must be classified for disposal in accordance with the NSW EPA *Waste Classification Guidelines, Part 1: Classifying Waste,* November 2014 (EPA, 2014).

The Dangerous Goods (Road and Rail Transport) Regulation 2008 adopts uniform national requirements for the transport of dangerous goods (e.g., asbestos) including the requirements of the Australian Dangerous Goods Code.

Asbestos transporters and facilities receiving asbestos waste must report the movement of asbestos waste to the EPA. Entities involved with the transport or disposal of asbestos waste in NSW, or arranging the transport of asbestos waste in NSW, must use the EPA's online tool, WasteLocate.

All works must be conducted in accordance with the development consent conditions.

All works must be also undertaken in accordance with the relevant regulatory criteria, including *inter alia:*

- NSW Work Health and Safety Act 2011 (WHS Act);
- NSW Work Health and Safety Regulation 2011 (WHS Regulation);
- NSW Environmental Planning and Assessment Act 1979;
- NSW Environmental Protection and Biodiversity Conservation Act 1999;
- NSW Environmental Offences and Penalties Act 1996;
- NSW Environmentally Hazardous Chemicals Act 1985;
- NSW Protection of the Environment Operations Act 1997 (POEO Act);
- NSW Contaminated Land Management Act 1997;
- NSW Dangerous Goods (Road and Rail Transport) Act 2008; and
- NSW Dangerous Goods (Road and Rail Transport) Regulation 2009.

Reference to relevant Codes of Practice, Australian Standards and industry standards should also be made in determining appropriate safe work practices. These include, *inter alia:*

- National Occupational Health and Safety Commission (NOHSC) Code of Practice for the Safe Removal of Asbestos [2002(2005)];
- NOHSC Guidance Note on the Membrane Filter Method for Estimating Airborne Asbestos Fibres 2nd Edition [NOHSC:300392005)];
- NOHSC Code of Practice for the Management and Control of Asbestos in the Workplace [NOHSC:2018(2005)];

- NOHSC Guidance Note on the Interpretation of Exposure Standards for Atmospheric Contaminants in the Occupational Environment [NOHSC:3008 (1995)] 3rd edition;
- AS/NZS 1715:2009 Selection, Use and Maintenance of Respiratory Protective Devices;
- AS/NZS 1716:2012 Respiratory Protective Devices;
- AS/NZS 1716:2003/Amdt 1:2005: Respiratory protective devices;
- WorkCover NSW: Working with Asbestos: Guide 2008;
- WorkCover NSW: How to manage and control asbestos in the workplace: Code of practice; and
- WorkCover NSW: How to safely remove asbestos: Code of practice.

11.3.2 Notification

SafeWork NSW must be notified 5 days in advance of any asbestos works.

The asbestos contractor must, before commencing the licensed asbestos removal work, inform the following people that asbestos removal works are to be conducted and the date the work will commence:

- The person with management or control of the workplace and any adjacent occupied buildings;
- The entity / person who commissioned the asbestos removal work; and
- The person with management of control of the workplace must inform workers and any other persons in the workplace.

11.3.3 WHS Plans

The asbestos contractor will prepare the following plans complying with regulatory requirements, including the WHS Regulation and SafeWork NSW requirements:

- Safe Work Method Statements (SWMS); and
- Asbestos Removal Control Plan (ARCP). The ARCP must:
  - Be provided to the person who commissioned the work;
  - Include details of how the asbestos removal will be carried out, including the method to be used and the tools, equipment and personal protective equipment to be used;
  - Include details of the asbestos to be removed, including the location, type and condition of the asbestos; and
  - Be kept by the licensed asbestos contractor in accordance with the WHS Regulations.

The ARCP will also detail specific requirements relating to works in either non-friable or friable asbestos conditions. Based on results to date only bonded ACM has been detected, however, there is the potential for extremely damaged/weathered ACM to be present which will require management as friable asbestos.

11.3.4 Licensed Contractor Training

All asbestos workers at the site must be appropriately trained in asbestos works and in the ARCP. The training must include information on health risks associated with asbestos, and the rights of asbestos workers under the WHS Regulation.

The licensed asbestos removalist must keep records of all training works.

The Asbestos Contractor will hold either a Class A or B licence (issued by SafeWork NSW) as appropriate. For friable (Class A licence) works a certified supervisor must be present at all times, for bonded works > 10 m^2 (Class B licence) a certified supervisor must be readily available to the certified removalist workers.

11.3.5 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.

11.3.6 Airborne Asbestos Monitoring

Asbestos air monitoring during the remediation and civil works is recommended given the finds of ACM during previous investigations, the prevalence of asbestos in the former buildings on site and the sensitivity of nearby receptors (residential and hospital).

Monitoring for airborne asbestos fibres is to be carried out by the independent competent person or licenced asbestos assessor[2] during asbestos removal works, as required, to meet WHS (2011) and SafeWork NSW requirements. The competent person or licensed asbestos assessor will be responsible for determining when air monitoring is required, and an appropriate scope of monitoring for the works. As noted previously an assessor with a Class A licence is recommended in the event of any works related to friable asbestos.

Monitoring will be done in accordance with the NOHSC Guidance Note on the Membrane Filter Method for Estimating Airborne Asbestos Fibres 2nd Edition [NOHSC:300392005)].

11.3.7 Personal Protection Equipment

The following personal protective equipment (PPE), in addition to standard construction PPE, should be worn during works involving the handling and / or removal of soils impacted by asbestos (e.g., emu picking):

- Half-face P1/P2 respirator;
- Disposable coveralls (Tyvek suit or equivalent);

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[2] Refer to the Safework NSW Website for relevant definitions: https://www.safework.nsw.gov.au/hazards-a-z/asbestos2/what-is-asbestos/asbestos-professionals-who-does-what

- Gloves; and
- Safety glasses or safety goggles.

11.3.8 Decontamination and Asbestos Clearance

At the direction of the competent person or licenced asbestos assessor, facilities must be provided to decontaminate:

- The asbestos removal 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.

12. Unexpected Finds Protocol

12.1 General Unexpected Finds

An "Unexpected Finds Protocol" has been established to deal with unexpected findings and / or unplanned situations. This protocol is also applicable to any unexpected finds relating to potentially contaminated soils with a historical uncertainty that may be encountered during excavation works with the site. The protocol is as follows:

1. The contractor(s) undertaking any remediation, civil or construction works will be provided with a copy of the RAP (plus any amendment or addendum), including this UFP. The contractor(s) will nominate their site (project) manager who will be responsible for implementing the UFP;
2. Upon discovery of suspected (unexpected) contaminated material, the site (project) manager is to be notified and the affected area closed off by the use of barrier tape and warning signs (if appropriate) and sediment controls. Warning signs shall be specific to the findings and potential hazards and shall comply with the Australian Standard 1319-1994 - Safety Signs for the Occupational Environment;
3. A qualified Environmental Consultant is to be notified by the site manager to inspect the area and confirm the presence or otherwise of hazards or contamination, and to determine the method and extent of investigation or remediation works to be undertaken. A report detailing this information will be compiled by the Environmental Consultant and provided to the site manager, who will disseminate to the Principal (or their representative);
4. All work associated with the contaminated soil will be undertaken by an appropriately licensed contractor, as stipulated by the Environmental Consultant;
5. All works must comply with the provisions of the relevant legislation and guidelines;
6. Documentary evidence (weighbridge dockets) of appropriate disposal of the material is to be provided to the Principal (or their representative) if disposal occurs;
7. Details of all relevant activities are to be recorded in the site record system; and
8. Details of the remediation and validation works undertaken with respect to the unexpected find must be incorporated into the final validation report as prepared by the Environmental Consultant.

12.2 Underground Storage Tanks

In the event that any underground storage tank (UST) or any related appurtenances are unexpectedly discovered works in the area will cease and the Site Manager will be informed.

As per the underground petroleum storage system (UPSS) decommissioning, abandonment and removal guidance (DECCW NSW, 2010), removal is the preferred option for managing abandoned UPSS. Any identified tanks are to be decommissioned and excavated unless it can be demonstrated that removal is not practical.

The following codes of practice and standards should also be consulted:

1. WorkCover Code of Practice: Storage and handling of dangerous goods.;
2. AS1940-2004: Storage and handling of flammable and combustible liquids; and
3. AS4976-2008: Removal and disposal of underground petroleum storage tanks

Additional guidance in the following section has also been adopted from *Technical Note: Investigation of Service Sites* (NSW EPA, 2014) in addition to those outlined in Section 1.

The following management sequences will apply for the removal and/or decommissioning of the USTs identified in the north-west corner of the site:

1. The area will be closed off by the use of barrier tape and warning signs that comply with the Australian Standard 1319-1994 - Safety Signs for the Occupational Environment;
2. The UST will be exposed by careful excavation and examined for potential leaks and general condition. The Environmental Consultant will be engaged to inspect the UST prior to its removal; and
3. Prior to the removal or decommissioning of the UST, any residual product (liquid / vapour) will be removed from the tank and disposed of appropriately in accordance with Australian Standard (AS 4976 - 2008 *The Removal and Disposal of Petroleum Underground Storage Tanks*.

If The Tank Is To Be Removed:

1. The UST will be removed and the structures disposed of by a qualified contractor in accordance with AS 4976 - 2008. Disposal records will be provided to an Environmental Consultant for inclusion in a validation report;
2. All associated infrastructure (i.e., the remnants including fuel lines, etc.) will be removed and disposed in a similar manner, if present;
3. Excavate and stockpile impacted materials for further assessment prior to off-site disposal as per Section 14.1 and 14.2;
4. Collect validation samples from the tank pit at a minimum rate of one location per side wall or one sample per soil type and at the depth of observed groundwater, whichever is the greater and at least one sample in the excavation base. Note that the actual number of samples may vary depending on the size of the tank pit excavation and the degree of contamination, the soil profile encountered and the presence of groundwater;
5. Collect validation samples below the fuel lines (following removal). Validation samples will be collected at a rate of one sample per 5 m linear metres of the fuel lines;

6. The validation samples will be analysed at a NATA accredited laboratory for lead, TRH, BTEX, PAH. Additional analysis may be required as advised by the Environmental Consultant based on the contents of the tank;
7. If evidence of leaks is observed in the tank and / or tank pit, then further groundwater monitoring may be required as advised by an Environmental Consultant. Groundwater samples will be tested for common contaminants *inter alia:* TRH, BTEX, PAH, heavy metals and VOC. Additional analysis may be required subject to the determination of the product stored in the tank; and
8. Preparation of a validation report by an Environmental Consultant to be submitted to the relevant local authority.

As A Contingency, If The Tank Is Decommissioned *In-Situ*:

1. Fill the emptied tank with suitable inert substance as recommended by a qualified contractor (such as concretely slurry, sand or foam);
2. Where practical, associated infrastructure (i.e., the remnants including fuel lines, etc.) will be removed and disposed as noted above, if present;
3. Excavate and stockpile any excavated materials for further assessment prior to off-site disposal as per Section 14.1 and 14.2;
4. Collect validation samples from the excavation, at final levels surrounding the tank, at a minimum rate of one location per side wall (or side of the tank) or one sample per soil type and at the depth of observed groundwater, whichever is the greater and at least one sample near the base of the tank (if possible).
5. Collect validation samples below the fuel lines (following removal). Validation samples will be collected at a rate of one sample per 5 m linear metres of the fuel lines;
6. The validation samples will be analysed at a NATA accredited laboratory for lead, TRH, BTEX, PAH. Additional analysis may be required as advised by the Environmental Consultant based on the contents of the tank;
7. If evidence of leaks is observed in the excavation, then further groundwater monitoring may be required as advised by an Environmental Consultant. Groundwater samples will be tested for common contaminants *inter alia:* TRH, BTEX, PAH, heavy metals and VOC. Additional analysis may be required subject to the determination of the product stored in the tank; and
8. Preparation of a validation report by an Environmental Consultant to be submitted to the relevant local authority.

13. Acid Sulfate Soil Management

13.1 Management Options

ASSMAC (1998) provides the following potential management options:

- Non-excavation or minimal earthworks;
- On-site treatment, followed by off-site disposal;
- On-site treatment, followed by on-site re-use;
- Off-site treatment and disposal;
- On-site reburial without treatment (PASS only);
- Off-site reburial without treatment (PASS only); and
- Separation of ASS fines.

Based on the proposed development, on-site treatment followed by on-site reuse and / or off-site disposal has been identified as the preferred management option for acid sulfate soils (ASS), in accordance with the relevant guidelines and reference materials.

As outlined in the DSI (DP, 2021) it is currently considered possible that potential acid sulfate soils (PASS) are present in natural soils, particularly in indurated sands, or in soils near the groundwater table (i.e., approximately 2 m bgl).

13.2 Risk Categorisation

Dear *et al* (2014) relates environmental risk from ASS to the treatment level and volume of disturbance of ASS. Based on the tonnage of ASS to be disturbed (estimated < 1,000 tonnes) and the maximum net acidity (0.03% w/w S) and the indicative liming rates (as indicated in laboratory reports DP (2020) from < 0.75 to 1.6 kg $CaCO_3$/t), the proposed disturbance of the site soils is considered “Category M to H” or medium to high treatment.

Dear et al (2014) therefore confirms that a formal ASS Management Plan is required as part of the proposed development, and that the following practices are to be included:

- More detailed plans of disturbance and ASS investigation report (i.e., as documented in the DSI and this report);
- Treating soils according to their existing plus potential acidity with an appropriate amount of neutralising agent;
- Laboratory tests to verify that the ASS have been properly treated and that neutralising material has been thoroughly mixed throughout the soil;
- Substantial bunding of the site using non-ASS material to divert site run-on and collect all site runoff during earthworks which is in contact with identified PASS, or otherwise appropriately stored (e.g., skip bins);
- Monitoring the pH of any pools of water collected within bunding or sealed areas;

- All leachate from treatment pads and/or discharge water from excavations should be contained and must meet acceptable standards of pH, metal content (particularly iron and aluminium) and turbidity prior to release; and
- Preventing infiltration from passing through ASS to groundwater using impermeable materials. Otherwise, apply an extra layer of neutralising material to intercept and neutralise leachate from ASS.

The above points have been incorporated into this report in the following sections.

Whilst an environmental management plan or formal documentation of ASS management activities is not specified as per Dear *et. al*. (2014) (i.e., only for very high treatment and above), this document otherwise provides the procedures to implement them as a part of the remediation processes.

13.3 Proposed Management Strategy

The general process for the treatment of any natural soils suspected to contain PASS (i.e., near or below the groundwater table) is outlined below.

1. In each excavation area, excavate a nominal smaller volume of soil (e.g., up to 100 m^3) and store in a temporary stockpiling area (or otherwise as described in Section 13.3.2). Alternatively, proceed directly to Step 3;
2. Conduct field screening testing and / or laboratory analysis (refer Appendix E) to confirm or otherwise the presence of PASS (or AASS). If ASS is not present then no further action is required, unless other signs of ASS are noted during excavation (e.g., sulfur odours, iron staining from leachate, etc.). If ASS is present, proceed to Step 3;
3. Prepare a treatment pad (or sealed storage bin) as described in Section 13.3.2;
4. Where practicable separate fill materials from natural soils to prevent potential cross contamination (e.g., during piling);
5. Manage PASS during stockpiling and treatment to minimise dust and leachate generation (e.g., by covering, or lightly conditioning with water). If wet weather prevails, stop works and cover the stockpiled soil with plastic sheeting to mitigate leachate formation;
6. Transport PASS requiring treatment to the treatment area (the treatment area may also be the stockpile area if adequately prepared);
7. (Optional) Conduct testing on stockpiled soils to confirm (or otherwise) the presence of PASS, and specific liming rates. Alternatively, additional in-situ testing may be conducted to confirm soils requiring management. If the soils are within the action criteria skip to step 10.
8. Spread the PASS onto the guard layer in layers of up to 0.3 m thick, in the case of treatment pads, leaving a 1 m flat area between the toe of the spread soil and the containment bund or drain. When spreading the first soil layer, care should be taken not to churn up the lime guard layer;
9. Let the PASS dry to facilitate lime mixing (if too wet, then adequate mixing of lime cannot be achieved). Use of rotary plough equipment (e.g., auger bucket) may be appropriate for cohesive soils, where adequate mixing is difficult to achieve;

10. Apply agricultural lime (commonly known as aglime) to the stockpiled soil (refer to Section 13.3.1 for liming rates) over each spread layer and harrow / mix thoroughly prior to spreading the next layer;
11. The results of validation testing should confirm that the ASS have been adequately neutralised in each layer prior to placement of the next layer to be treated. If verification sampling indicates that additional neutralisation is required, add additional lime (at an appropriate liming rate) and mix as described above;
12. Continue the spreading / liming / harrowing / verification cycle until excavation is finished;
13. When verification testing indicates that lime neutralisation is complete (refer Appendix D), the soil may be removed from the treatment area for off-site disposal in accordance with waste classification, or alternatively, removed from the treatment area for on-site reuse in accordance with Section 14 and consideration to any other geotechnical considerations; and
14. Management of leachate water and groundwater may also be required where leachate is produced and / or if groundwater is impacted by the works.

13.3.1 Liming Rate

Based on the assessment results soils beneath the water table that are to be disturbed during excavation are to be treated using lime prior to off-site reuse or disposal unless confirmed otherwise by further analysis. Table 1 provides **indicative** liming rates for neutralisation of the ASS likely to be disturbed. The materials tested at BH3/1.9-2.0 have been used as the maximum previously identified.

Table 8: Indicative Liming Rates

Material	Maximum Net Acidity (%S)	Maximum Net Acidity (mol H+/tonne)	'Ag' Lime Application Rate for Treatment	
			Guard Layers # (kg/m^2 per m height)	Stockpiled Soil [b] (kg/tonne)
BH3/1.9-2.0	0.03[a]	21 [a]	5	1.6

[a] – 95% upper confidence limit (UCL) of the net acidity. Net Acidity to be determined based on the equation detailed in Appendix D.

[b] lime application rate calculated using maximum net acidity, and using equations in Appendix D

Where the highest detected sum of existing and potential acidity is more than 1.0% S-equivalent, the rate will be at minimum 10 kilograms fine aglime per m^2 per vertical metre of fill (Dear et al 2014)

As per the proposed management strategy it is recommended to conduct further testing on smaller volumes of excavated soils in each excavation area prior to commencing any more significant excavation. Additional laboratory analysis conducted during this procedure may be able to provide more accurate liming rates. The use of the rate in Table 8 should be used as an initial treatment quantity to be verified as outlined in section 13.6

13.3.2 Neutralisation Pads and Treatment of Soils

The key features of the treatment area and design considerations are summarised below and shown in Figure 2 below:

- **Treatment pad area** - The treatment pad should be of an appropriate area for the volume of soil to be treated / stored, and should be prepared on relatively level or gently sloping ground to minimise the risk of potential instability issues, with a fall to the local drainage sump;
- **Pad location** - The pad should be located as far as practical from any potential ecological receptors (such as drainage lines) which enter the stormwater system;
- **Lining** - An approved compacted clay layer (at least two layers to a combined compacted thickness of 0.5 m) or an approved geosynthetic liner (such as HDPE sheeting) should be used to line the pad. Where the subgrade soils comprise low permeability clay, no geosynthetic lining will be required;
- **Guard Layer** - A guard layer of fine agricultural lime ('aglime') should be applied over the clay subgrade or lining to neutralise downward seepage. This guard layer of lime should be applied at a rate appropriate to the soil to be treated (refer to Table 2 above) for every 1 m height of stockpiled soil;
- The guard layer should be re-applied following removal of treated soils prior to addition of untreated ASS;

  NOTE: if the stockpiled soils on the treatment pad are expected to be greater than 3 m in height, it is recommended that the guard layer be applied as a base guard layer, with interim guard layers through the height of the stockpile; and
- **Bunding** - The treatment pad should be bunded to contain and collect potential leachate runoff within the treatment pad area and to prevent surface water from entering the treatment pad. The inner bund slopes should be lined to prevent leachate seeping into the ground surface and sized to prevent overflow of untreated leachate onto the site.

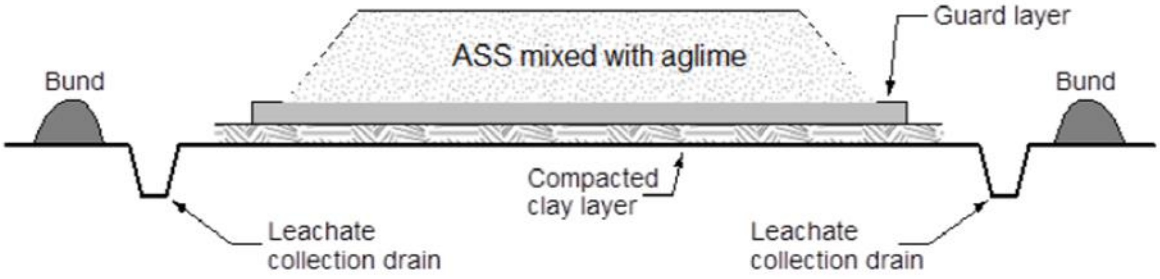

Figure 2: Schematic cross-section of a treatment pad, including clay layer, guard layer, leachate collection drain and bunding (Dear, et al., 2014)

13.3.3 Alternative Treatment Area Design

Alternatively, for smaller batches of soil it may be preferrable to store and treat soils within a sealed container e.g., skip bin. This option may be ideally suited if only minimal excavation of deeper soils is planned.

- **Bin size** - The bin should be of an appropriate volume for the soil to be treated / stored. Care should be taken to not overfill a container which may cause leachate, run-off or soils to overflow from the bin;
- **Lining** - Approved geosynthetic liner (such as HDPE sheeting) should be used to line the bin;
- **Cover** - The bin should be covered when not actively used to prevent potential accumulation of water from rain;
- **Guard layer** - A guard layer of fine agricultural lime (‘aglime’) should be applied over the base lining. This guard layer of lime should be applied at a rate appropriate to the soil to be treated (refer to Table 2 above) for every 1 m height of stockpiled soil; The guard layer should be re-applied following removal of treated soils prior to addition of untreated ASS; and
- **Leachate and water** - Any excess leachate or water collected within the bin will be managed as per Section 8 / Appendix G.

13.3.4 Neutralising Materials

Agricultural lime, commonly known as aglime, is the preferred neutralisation material for the management of ASS, as this material is usually the cheapest and most readily available product for acid neutralisation. Furthermore, aglime is slightly alkaline (pH of 8.5 to 9), non-corrosive, of low solubility and does not present handling problems if used correctly.

Aglime comprises calcium carbonate ($CaCO_3$), typically made from limestone that has been finely ground and sieved to a fine powder. Aglime with the following properties are the preferred neutralising agent:

- Purity of at least 95% or better (i.e., NV > 95, where NV is the neutralising value, a term used to rate the neutralising power of different forms of materials relative to pure, fine calcium carbonate which is designated NV = 100);

  NOTE: There could be economic justification for using a less pure grade of aglime, however, under these circumstances, the individual lime dosing rates described in Section 7.3.1 would need to be carefully considered, as the cost savings from using less pure material may be offset by the corresponding increase in the required volumes, and the transport and disposal costs; and
- Fine ground (at least <0.3 mm) and dry, as texture and moisture can decrease the effective NV.

Aglime requires no special handling, however, it would be advisable to cover any aglime stockpiles with a tarpaulin both to minimise wind erosion and wetting, as the material is more difficult to spread when wet.

Due to its low solubility in water, aglime is not suitable for the neutralisation of leachate, which requires a product with a very quick reaction and high solubility. The most suitable neutralising agent for leachate and retained drainage water is slaked lime or quicklime (calcium hydroxide). This is made by treating burnt lime (calcium oxide) with water (slaking) and comes as a fine white powder. It has a typical NV of about 135. Due to its very strong alkalinity (pH or about 12.5 to 13), slaked lime or quicklime should not be allowed to come into contact with the skin or be inhaled.

13.4 Alternate Strategy or Contingency Plan

Where the proposed primary management option is not possible, or practical, alternate or contingency strategies may be considered. These options are outlined in Appendix E, and include reburial of PASS below the water table, off-site treatment and disposal, and off-site disposal as PASS.

13.5 Water and Groundwater Management

Potential water and groundwater management strategies are provided in Appendix D, including relevant details for water collection, storage, assessment and treatment. These strategies are considered unlikely to be applicable if only limited deeper excavation is undertaken.

13.6 Verification Testing of Treated Soils

Based on a maximum “Category H” treatment level, verification testing of the ASS and drainage water (if present) is required to be conducted after the addition of lime to test whether or not mixing has been adequate, and to reduce the risk of acidic water being returned to watercourses. The verification testing frequency is presented in Table 9.

Potential Sulfidic Acidity is measured using either the Chromium Reducible Sulfur (SCr) method or the Suspension Peroxide Oxidation Combined Acidity (SPOCAS) method. The SCr method is recommended for all soil materials. However, the SPOCAS method is not recommended for soil materials with organic matter contents greater than 0.6% organic carbon, as the organic matter in many soil materials with organic carbon contents greater than 0.6% is capable of producing false positive identifications when using the SPOS method. The sulfur from organic matter, even at these relatively low concentrations, can be erroneously included in the SPOS determination at levels that exceed action criteria. Furthermore, if SPOS is used to quantify the Potential Sulfidic Acidity of soil materials, it is recommended at least 15% of samples are also analysed by the SCr method to allow verification of the SPOS values.

Table 9: ASS Verification Testing Frequency

Test	Frequency
Field test: pHF and pHFox screening Laboratory analysis: SPOCAS / SCr Method (preferred)	• One sample / soil type; OR • One sample / 500 m^3 of treated soil (whichever is the greater frequency); and • At least one sample / 200 mm to 300 mm deep soil treatment layer

In addition, the pH of all ponded drainage water around the confines of the treatment bunds (or pooled within skip bins) should be measured daily and results assessed against the criteria provided in Table 8. The soil and water contained within the bunded treatment area or bins should not be removed until the target values presented in Table 10 below have been achieved. Treatment of deeper soil layers should not be commenced until the existing surface layer has been validated and removed.

Table 10: Target Levels of Neutralised Soil and Water

Test	Component	Target Level
Monitoring of water	pH	6.5 < pH < 8.5
	Turbidity	To comply with either values determined in consultation with the Authority or less than local background levels (baseline monitoring required).
	Aluminium (Al) and Iron (Fe)	Establish local water quality data prior to site disturbance and ensure that these values are not exceeded.
	Dissolved Oxygen	To comply with either values determined in consultation with the Authority or less than local background levels (baseline monitoring required).
Field screening of soil	pH_F	$6.5 < pH_F \leq 8.5$
Acid based accounting of soil (Chromium Suite test method)	Net acidity (using appropriate fine factor) [a]	Zero or negative
	pH_{KCL}	$pH_{KCL} \geq 6.5$
	TAA	Zero

[a] determined using equations D2 Appendix D

It should be noted that laboratory tests may require up to five days turnaround, possibly longer, and hence sufficient time should be allowed in the treatment programme for such verification testing. Only appropriately skilled staff should collect and test verification samples. In addition to normal regular supervision of the soil management process, it is suggested that formal inspections be undertaken.

14. General Site Management

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

14.1 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 geofabric or plastic; and
- Keep temporary stockpiles moist, by using water spray where required.

Consideration should also be given to the management of asbestos, if encountered (Section 11) and ASS (Section 13).

14.2 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 NSW EPA *Waste Classification Guidelines,* 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. Consideration has also been given to the Victorian EPA sampling guidelines for larger stockpiles (EPA Victoria, 2009)

Assessment of the formed stockpiles will comprise:

- Determine the volume of the stockpile requiring investigation, noting that if survey data is available this will enable more accurate assessment of volume and therefore sampling requirements;
- Visually inspect the surface of the stockpile for bonded ACM. The presence of highly weathered / damaged fragments may indicate the presence of AF / FA;
- Identify the source of the stockpile and conduct a walkover that area;
- Excavate test pits into the stockpile at a rate of 1 per 70 m^3 or a minimum of three per stockpile, to assess for the potential presence of asbestos within the stockpile and other risk indicators (i.e., building materials). Noting that if asbestos was previously observed within the source area or

on the surface this step may be redundant as a single confirmed fragment will classify the stockpile as Special Waste (asbestos), if so, this process may skip to the next bullet point;

- Assessing of recovered samples for chemical contaminants (as identified in the CSM and per waste classification guidelines) using a combination of previous *in-situ* data and additional recovered samples collected from test pitting into the stockpile at the following rates:
  - For stockpiles < 250 m^3: 1 sample per 25 m^3 of material, or minimum of 3;
  - For stockpiles > 250 m^3, 1 sample per 25-250 m^3, (minimum of 6 samples), or as otherwise indicated by the Environmental Consultant, noting that highly heterogenous materials may necessitate a higher sampling frequency; and
  - For large stockpiles it is also recommended to collect and analyse a minimum 3 additional check samples if there is sufficient *in-situ* data.
- Preparation of a letter report by the Environmental Consultant providing a formal waste classification for with reference to the NSW EPA (2014) *Waste Classification Guidelines*.

Mixtures including natural soils which potentially contain ASS should also be assessed as per the ASSMP (Section 13) determine if any PASS or AASS is present. Further on-site treatment may be required for such materials and / or specific disposal requirements as per the nominated receiving facility.

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. All disposal dockets and other relevant tracking information, including NSW EPA WasteLocate data (in the case of asbestos waste) will be made available to the Environmental Consultant to be included in the site validation report.

14.3 Importation of Soil

All proposed imported materials (including DGB, landscaping and temporary filling for platforms) will be assessed as being legally able to be imported to the site, and suitable under the proposed development. Material proposed to be imported to the site must comprise one of the following:

- Virgin excavated natural material (VENM); or
- Materials complying with a Resource Recovery Order (RRO) allowing land application; and
- Meeting the site acceptance criteria.

Materials will be assessed at the following rates by an Environmental Consultant, or as otherwise advised based on the available documentation and/or previous results:

- RRO material: minimum of one sample per 100 m^3 of imported fill; and
- VENM: for each source site, three samples for the first 1,000 m^3 and then one sample per 1,000 m^3 thereafter.

15. Validation

15.1 Site Inspections

The Environmental Consultant is to conduct periodic site inspections during remediation works, when any issue of concern is identified under the UFP, and to assess the progress of remediation. A record of the inspections and observations, including a photographic record, will be provided as part of the validation assessment report.

Site inspections will also be conducted at the following key hold points:

- Completion of initial bulk excavation levels, as per Section 10.1.1;
- At the completion of any additional excavation as per Section 10.1.2;
- Upon reaching natural soils, to identify the presence of VENM and potential for AASS / PASS (if all fill is removed within an area); and
- Following the completion of any importation of soils (e.g., at final surface levels).

If the contingency capping strategy is undertaken the following hold points will also apply:

- At final excavation levels prior to installing the marker layer;
- After installation of the marker layer; and
- Following installation of the capping layer;

15.2 Validation Sample Collection and Analysis

It is proposed that any validation or additional site characterisation samples be collected and analysed at the following frequency:

- SAMPLES FROM SMALL EXCAVATIONS - one sample per 25 m^2 on the excavation base and one sample per 15 linear metres along the excavation side walls. Sample depths and materials to be logged in each case;
- SAMPLES FROM LARGE EXCAVATIONS - one sample per 100 m^2 on the excavation base and one sample per 25 linear metres along the excavation side walls. Sample depths and materials to be logged in each case; and
- LARGER VALIDATION AREAS - as per the NSW EPA sampling design guidelines (NSW EPA, 1995) and / or WA DOH asbestos guidelines (WA DoH, 2009).

Any assessment of stockpiles for site suitability will be conducted as per the rates set out in Section 14.2.

15.3 VENM

If assessment of VENM is required, the following procedure shall apply:

- Inspect the surface of the area to be assessed (ONLY AFTER FILL REMOVAL) to confirm the absence of formerly overlying fill;
- Recover samples at a rate as specified in Section 15.2;
- Submit the soil samples (plus QC samples) for analysis of the chemical contaminants identified in the overlying fill (even if at low concentrations), comprising as a minimum the following:
  - Eight priority metals (arsenic, cadmium, chromium, copper lead, mercury, nickel, zinc);
  - TRH / BTEX;
  - PAH;
  - Asbestos (identification only); and
  - Inclusion of industry standard QA / QC (refer Section 15.5).

Preparation of VENM classification reports (as required for off-site disposal) as required, or otherwise to be documented in the validation process.

15.4 Sample Collection and Handling

Appropriate sampling procedures will be undertaken to ensure that cross contamination does not occur, these will include:

- Use of standard operating procedures to ensure consistency between samples;
- The use of stainless steel or disposable sampling equipment;
- Decontamination of sampling equipment prior to the collection each sample;
- Labelling of the sample containers with individual and unique identification;
- The use of chain-of-custody documentation so that sample tracking and custody can be cross-checked at any point in the transfer of samples from the field to hand-over to the laboratory;
- Samples are stored under secure, temperature controlled conditions;
- The use of chain-of-custody documentation so that sample tracking and custody can be cross-checked at any point in the transfer of samples from the field to hand-over to the laboratory; and
- Recording field observation, including location and dimensions of excavations and stockpiles, sample locations and descriptions, and signs of potential concern.

15.5 Quality Assurance Plan

Quality assurance (QA) and quality control (QC) procedures will be integral to the validation assessment and will include those detailed in the following sections.

15.5.1 Data Quality Indicators

Field and laboratory procedures will be assessed against the following data quality indicators (DQIs):

- Completeness - a measure of the amount of usable data from a data collection activity;
- Comparability - the confidence (qualitative) that data may be considered to be equivalent for each sampling and analytical event;
- Representativeness - the confidence (qualitative) of data representativeness of media present on-site;
- Precision - a measure of variability or reproducibility of data; and
- Accuracy - a measure of closeness of the data to the ‘true’ value.

15.5.2 Quality Assurance and Quality Control Samples

The following QA / QC samples will be collected and analysed:

- 5% Intra-laboratory replicate samples, analysed at minimum for metals and PAH or otherwise for the same suite of contaminants as the primary sample;
- 5% Inter-laboratory replicate samples, analysed at minimum for metals and PAH or otherwise for the same suite of contaminants as the primary sample;
- Rinsate samples (1 per day where re-usable sampling equipment used); and
- Trip spikes and trip blanks for each batch of samples requiring analysis for volatile or semi-volatile contaminants (analysed for BTEX).

15.5.3 Field Quality Assurance and Quality Control

QA / QC procedures will be adopted throughout the field sampling program to ensure sampling precision and accuracy and prevent cross contamination.

This will comprise using sampling methods and collection and analysis of QA / QC samples in accordance with Section 15.7.

15.5.4 Laboratory Quality Assurance and Quality Control

NATA accredited laboratories will be used to conduct analysis where possible.

The laboratories will undertake in-house QA / QC procedures involving the routine testing of:

- Reagent blanks;
- Spike recovery analysis;
- Laboratory duplicate analysis;
- Analysis of control standards;
- Calibration standards and blanks; and
- Statistical analysis of QC data including control standards and recovery plots.

15.6 Documentation and Reporting

The following documents will be prepared / obtained by the relevant party, and provided to other parties (the Principal, Contractor, Environmental Consultant and / or Asbestos Assessor) as required. Documentation should be provided by the relevant parties in a timely manner to allow the works to be conducted efficiently.

15.6.1 Principal

The Principal will prepare / obtain the following documents:

- Any licences and approvals required for the works which are not the responsibility of the Contractor to provide.

15.6.2 Contractor

The Contractor will prepare / obtain the following documents:

- Any licences and approvals required for the works which are the responsibility of the Contractor to provide;
- Excavation and stockpiling records (i.e., tracking records): these will record the source of any stockpiled material, the date of excavation and any issues of concern;
- 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);
- Tip dockets: these comprise dockets of receipt provided by the receiving waste facility. Where the receiving site is not a waste facility (e.g., if VENM from the site is accepted for re-use on another site), a record of receipt from the receiving site will be supplied;
- 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; and
- Any other records of relevant works as set out in this document such as air monitoring reports, asbestos clearance records, unexpected finds documentation, etc.

Provision of survey drawings and supplementary documentation to the Environmental Consultant which will verify that the capping systems have been appropriately installed, including materials specifications, application of geotextile / maker layers appropriate thickness of VENM layers, pavements etc.

15.6.3 Environmental Consultant

The Environmental Consultant will prepare the following documents:

- Stockpile site suitability reports;
- Waste classification reports (as required);
- Advice on the suitability of soil proposed to be imported onto the site (if required); and

- Validation report, including records of the remediation and validation work undertaken and the results of the work. This will also comprise:
- A review of the supplied documentation by the Contractor to verify that the capping systems have been installed as per the RAP (this document) as a part of a Construction Quality Assurance (CQA) programme.

15.6.4 Asbestos Assessor / Occupational Hygienist

The Asbestos Assessor - Occupational Hygienist will prepare the following documents:

- Airborne asbestos monitoring records; and
- Visual clearance of asbestos removal.

15.7 Validation Reporting

In addition to those listed in Section 15.6, the following documents will need to be reviewed as part of the validation assessment by the Environmental Consultant at the completion of all remediation works. These are to include and be provided to the Environmental Consultant by the relevant parties:

- Records relating to any unexpected finds and contingency plans implemented;
- Survey drawings, material specification sheets and other documentation related to the installation of the physical barrier systems (if applicable);
- Laboratory certificates and chain-of-custody documentation; and
- Letters / memos as required which provide instruction or information to the principal or contractor; and
- Testing and any records for ASS management as outlined in Section 13.

The purpose of the documentation is to ensure the works are conducted in accordance with all applicable regulations and that appropriate records of the works are kept for future reference. Documentation should be provided by the relevant parties in a timely manner to allow the works to be conducted efficiently.

A validation assessment report will be prepared for the site by the Environmental Consultant in accordance with NSW EPA *Consultants reporting on contaminated Land: Contaminated land guidelines* (NSW EPA, 2020) and other appropriate guidance documentation. The validation report shall detail the methodology, results and conclusion of the assessment and make a clear statement regarding the suitability of the site for the proposed land use.

16. Roles and Responsibilities

Principal

The Principal is responsible for the environmental performance of the proposed remediation works, including implementation of acceptable environmental controls during all site works. The Principal will retain the overall responsibility for ensuring this RAP is appropriately implemented. The Principal is to nominate a representative (TBC), who is responsible for overseeing the implementation of this RAP. The actual implementation of the RAP will, however, be conducted by the Contractor on behalf of the Principal.

The Principal will also be responsible for acquiring all necessary approvals for the remediation works proposed, including approval from the consent authority.

Contractor and Site Manager

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 Contractor will nominate a Site Manager who will be responsible for day-to-day site management and first response to any unexpected finds encountered during works.

Asbestos Contractor

The Asbestos Contractor will be responsible for undertaking all asbestos works and will hold either a Class A or B licence (issued by SafeWork NSW) as appropriate. For friable (Class A) works a certified supervisor must be present at all times, for bonded works > 10 m^2 (Class B) a certified supervisor must be readily available to the certified removalist workers.

The Asbestos Contractor and Contractor can be the same entity.

Environmental Consultant

The Environmental Consultant will provide advice on implementing this RAP and validate that the site has been appropriately remediated. In general terms, the Environmental Consultant will:

- Provide advice to their client as required for the remediation works;
- Identify the extents of remediation areas, as outlined in Section 9;
- Undertake all validation assessment work, including inspections, sampling and reporting outlined in Section 10, 13 and 15;
- Provide advice and recommendations arising from inspections / observations;
- Notify their client with the results of any assessments and any observed non-conformances in a timely manner;
- Undertake the required waste classification assessments for disposal of liquid and solid wastes;
- Attend to unexpected finds as outlined in Section 12; and

- Validate and approve the use on any imported materials used in the civil works.

Occupational Hygienist

The Occupational Hygienist will provide advice on WHS issues related to the asbestos works. The Occupational Hygienist will be suitably qualified / licenced in accordance with the WHS Regulations 2011.

The Occupational Hygienist will:

- Prepare any WHS plans and advice requested by the Contractor;
- Undertake airborne asbestos monitoring (as required);
- Undertake visual clearance inspections;
- Provide advice and recommendations arising from monitoring and/or inspections;
- Notify their client with the results of any assessments and any observed non-conformances in a timely manner; and
- Issue clearance certification.

The Environmental Consultant and Occupational Hygienist can be the same entity.

Contact Details

The following table provides a list of personnel and contact details relevant to the remediation. The list should be filled in or updated as relevant personnel are appointed to the project.

Table 11: Contact Details

Role	Personnel / Contact	Contact Details (phone)
Principal		
Principal Contractor		
Site Manager		
Environmental Consultant	TBA	
Regulator	NSW EPA (pollution line)	131 555
	NSW EPA (general enquiries)	131 555
Consent Authority	Bayside Council	(02) 9093 6000
Utility Provider	Sydney Water	13 20 92
Utility Provider	Power	
Utility Provider	Gas	

Note: Table to be completed when the contact details are known.

17. Conclusions

The proposed remediation (capping) strategy outlined herein requires development and implementation of a long-term EMP. The site owner and relevant planning authority must agree to the EMP, and the EMP must be reasonably, legally enforceable.

Overall, it is considered that the site can be rendered suitable for the proposed recreational development subject to proper implementation of the remediation procedures, unexpected finds protocols, completion of the validation assessment detailed in this RAP.

18. References

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19. Limitations

Douglas Partners (DP) has prepared this report (or services) for this project at the Botany Aquatic Centre, Myrtle St, Botany, in accordance with DP's proposal 201489.01.P.002 dated 25 February 2021 and acceptance received by Tristan Balogh of CO-OP STUDIO PTY LTD dated 9 March 2021. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of CO-OP STUDIO PTY LTD for this project only and for the purposes as described in the report. 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, including other consultants or contractors, 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 report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report 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 this investigation. The accuracy of the advice provided by DP in this report 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 report and requires additional project data and assessment.

This report 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 report.

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

Asbestos has not been detected by observation and by laboratory analysis, on the surface of the site and in or in filling materials at the test locations sampled and analysed. However, asbestos has previously been identified in the nearby larger Aquatic Centre area. Building demolition materials, such as concrete, brick, terracotta and metal, were also located in previous below-ground filling, and these are considered as indicative of the possible presence of hazardous building materials (HBM), including asbestos.

Although the sampling plan adopted for this investigation is considered appropriate to achieve the stated project objectives, there are necessarily parts of the site that have not been sampled and analysed. This is either due to undetected variations in ground conditions and the investigation methods. It is therefore considered possible that HBM, including asbestos, may be present in unobserved or untested parts of the site, between and beyond sampling locations, and hence no warranty can be given that asbestos is not present.

Douglas Partners Pty Ltd

Appendix A

Notes About this Report

Drawings

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.

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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.

Site Anomalies

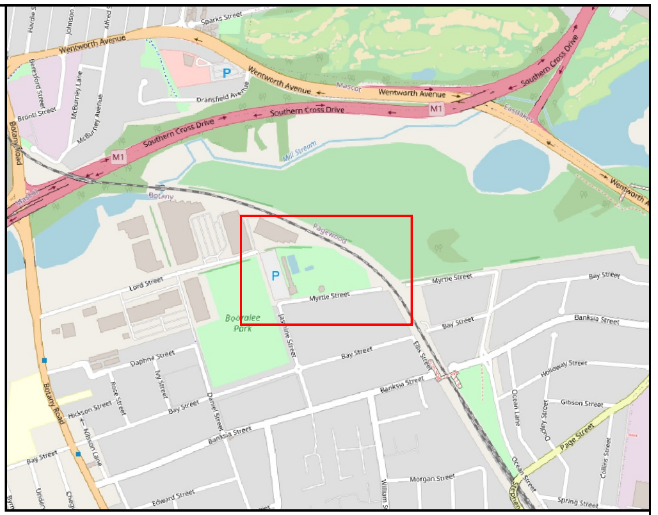
In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later 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 4/12/2020)

Legend

▭ Stage 1 Boundary (the site)

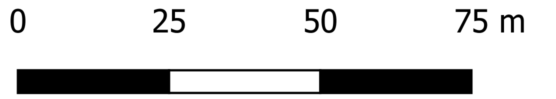
▭ Previous Investigation Area (DP 2020)

⊕ Geotechnical Borehole Locations (DP 2020)

⊕ Environmental Borehole Locations (DP 2020)

■ Test Pit (Prensa 2018)

⊕ Borehole (Prensa 2018)



Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT:	CO-OP Studio Pty Ltd		
OFFICE:	Sydney	DRAWN BY:	JJH
SCALE:	1:1250 @ A3	DATE:	11.03.2021

TITLE: **Site Overview and Previous Test Locations**
Botany Aquatic Centre Stage 1
Corner Myrtle and Jasmine Streets, Botany, NSW

N

PROJECT No:	201489.01
DRAWING No:	1
REVISION:	1

LOCALITY MAP

Notes:
1. Basemap from metromap.com.au (dated 4/12/2020)

Legend

▭ Stage 1 Boundary (the site)
● Geotechnical Borehole Locations (DP 2020)
● Environmental Borehole Locations (DP 2020)
● Test Pit (Prensa 2018)
● Borehole (Prensa 2018)

0 10 20 30 m

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT:	CO-OP Studio Pty Ltd		
OFFICE:	Sydney	DRAWN BY:	JJH
SCALE:	1:750 @ A3	DATE:	11.03.2021

TITLE: **Stage 1 - Previous Test Locations**
Botany Aquatic Centre Stage 1
Corner Myrtle and Jasmine Streets, Botany, NSW

N

PROJECT No:	201489.01
DRAWING No:	1
REVISION:	1

Notes

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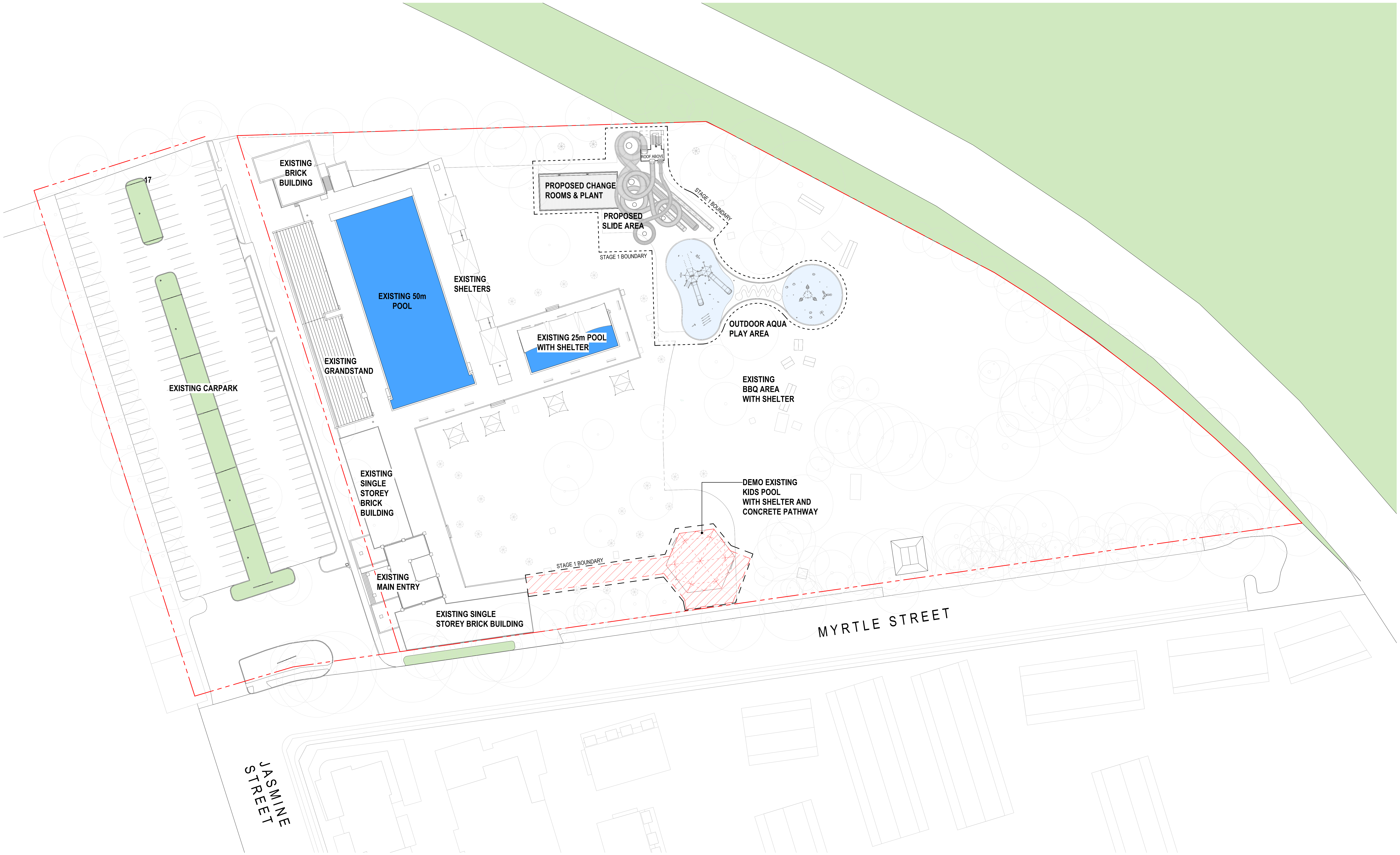

REV	DESCRIPTION	DATE	APP
B	ISSUE FOR COORDINATION	11/02/2021	TB
A	ISSUE FOR DRAFT DA	05/02/2021	TB

CLIENT BAYSIDE COUNCIL

CO-OP STUDIO
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PROJECT

BOTANY AQUATIC CENTRE - STAGE 01

PROJECT NUMBER

100239

DRAWING

SITE PLAN - STAGE 1

SCALE 1 : 500 @ A1

FOR APPROVAL
NOT TO BE USED DURING CONSTRUCTION

DRAWING NO. REVISION

DA112B

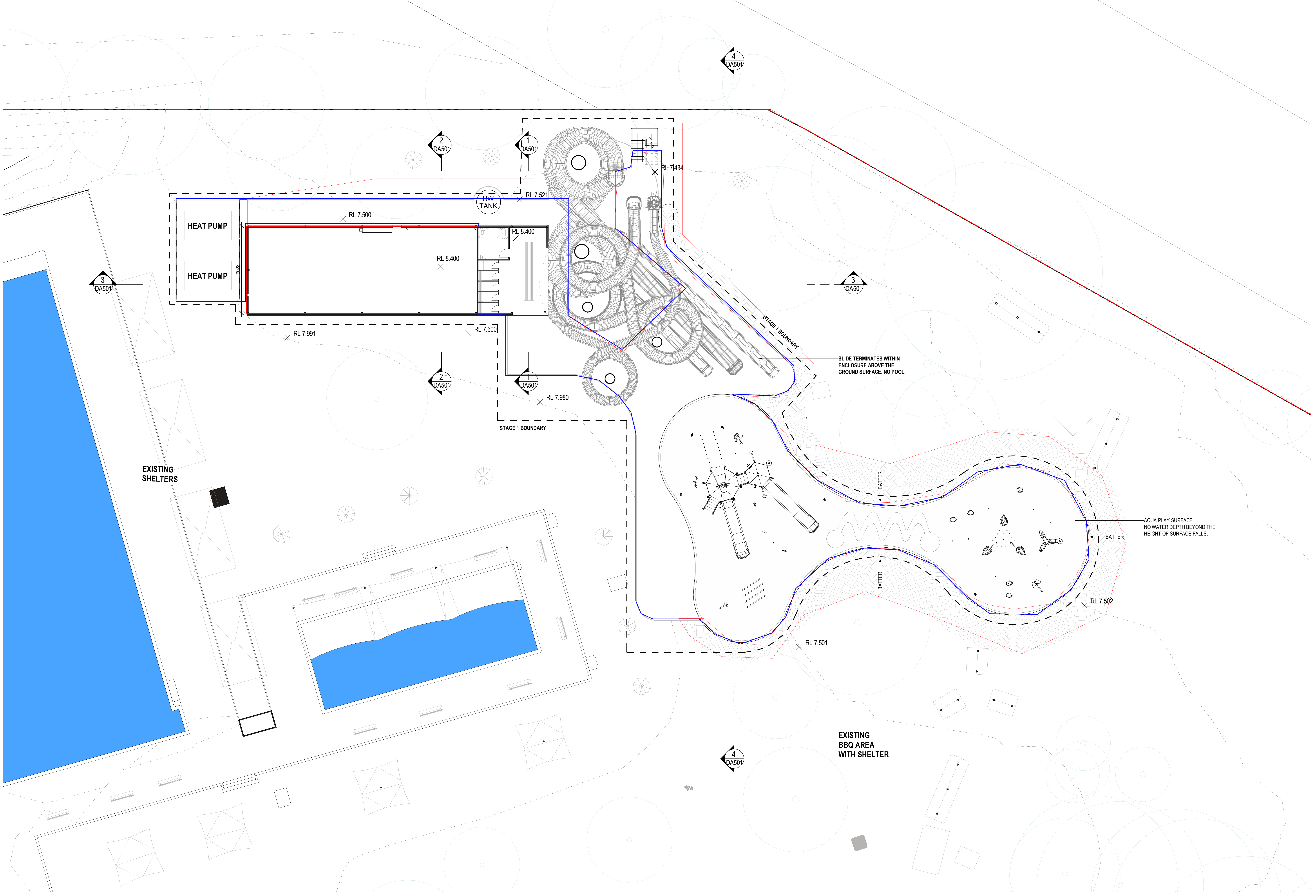
FILE NAME BIM 360://Botany Aquatic Centre/100239_Botany Aquatic Centre_R19_360.rvt

DATE PRINTED 24/02/2021 11:39:38 AM

🟥 EARTHWORKS REQUIRED TO BE CUT

🟦 AREA WHERE FILL IS REQUIRED & CAN BE RELOCATED UNDER CONCRETE SURFACE

⬜ AREA WHERE FILL IS REQUIRED FOR LANDSCAPE (NO CONCRETE)



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REV	DESCRIPTION	DATE	APP
A	ISSUED FOR DA	31/03/2021	TB

CLIENT BAYSIDE COUNCIL

CO-OP

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PROJECT

BOTANY AQUATIC
CENTRE - STAGE 01

PROJECT NUMBER

100239

DRAWING

GENERAL
ARRANGEMENT PLAN
- GROUND FLOOR

SCALE 1 : 200 @ A1

FILE NAME BIM 360://Botany Aquatic Centre/100239_Botany Aquatic Centre_R19_360.rvt

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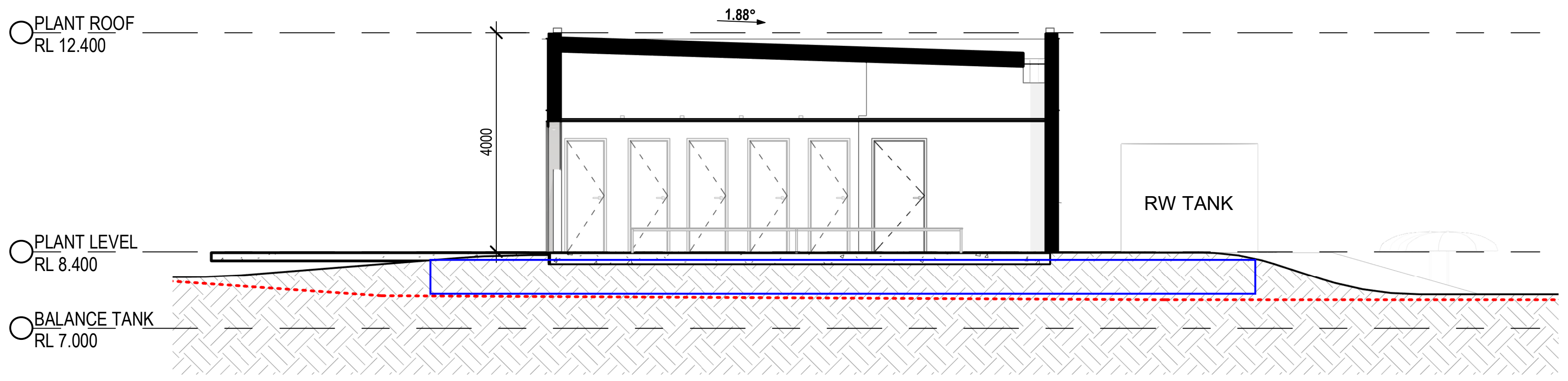
DA201A

DATE PRINTED 12/07/2021 6:25:02 PM



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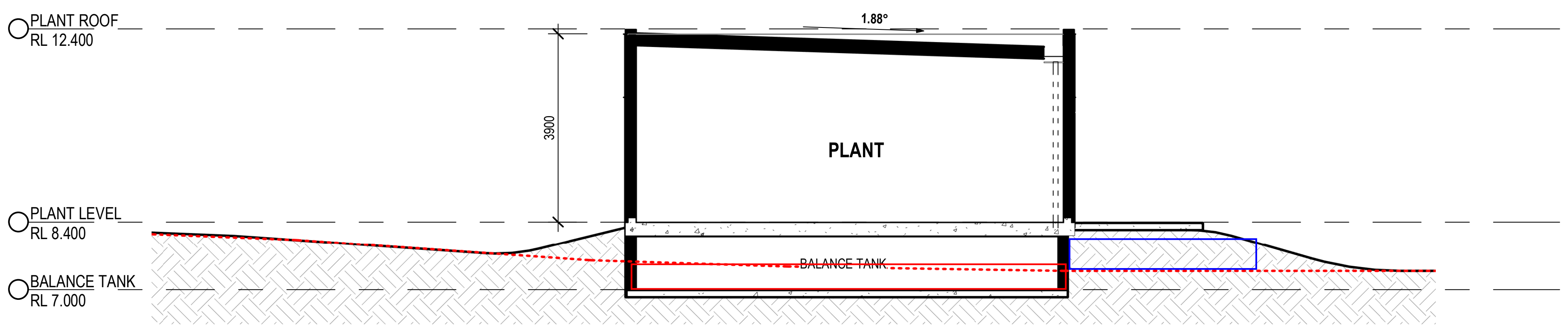

2 SECTION A2
DA201 1 : 100

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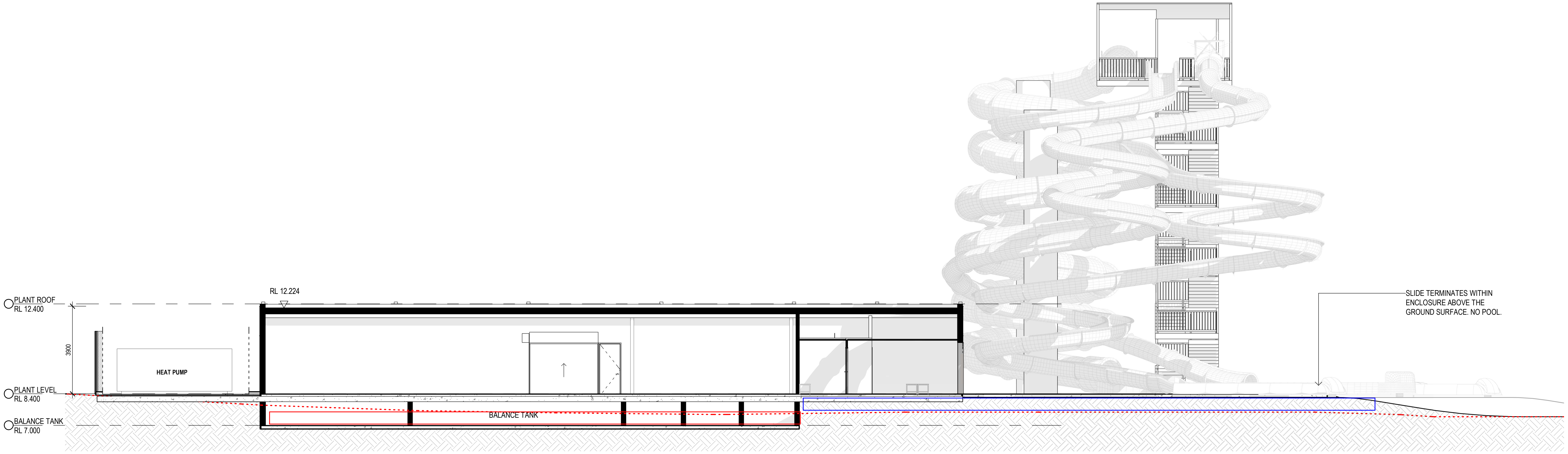

3 SECTION B
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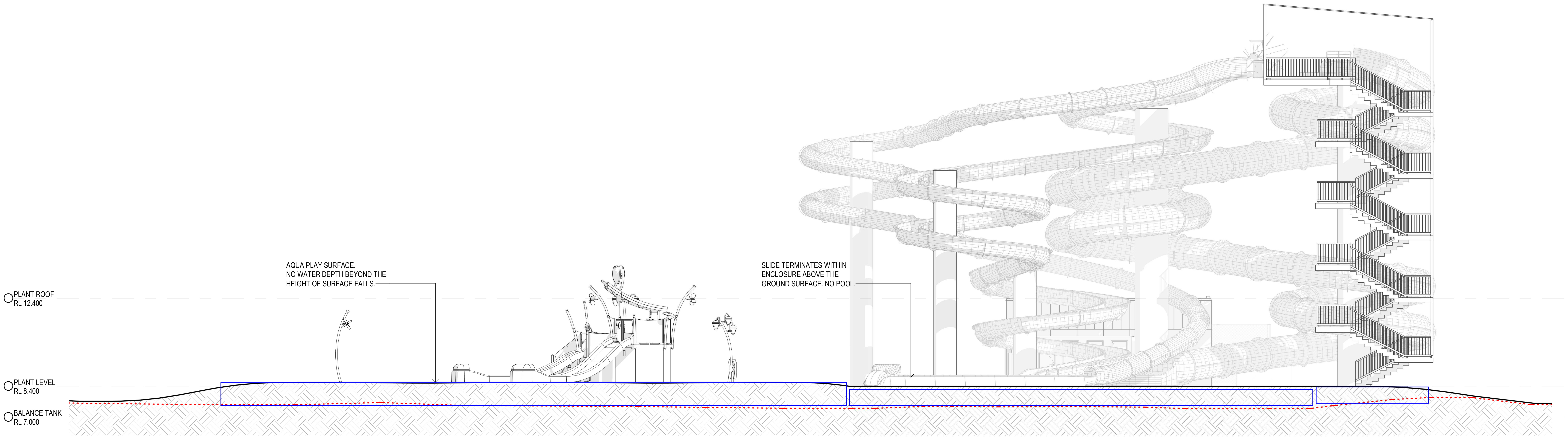
CLIENT BAYSIDE COUNCIL



4 SECTION A1
DA201 1 : 100

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PROJECT

BOTANY AQUATIC
CENTRE - STAGE 01

PROJECT NUMBER

100239

DRAWING

SECTIONS

SCALE 1 : 100 @ A1

FILE NAME BIM 360://Botany Aquatic Centre/100239_Botany Aquatic Centre_R19_360.rvt

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DRAWING NO. REVISION

DA501A

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Appendix B

Site Assessment Criteria / Remediation Acceptance Criteria

Appendix B - Site Assessment Criteria / Remediation Acceptance Criteria

The Site Assessment Criteria (SAC) applied in the current investigation is informed by the CSM which identified human and ecological receptors of potential contamination on the site (Section 5). Analytical results were assessed (as a Tier 1 assessment) against the SAC comprising the investigation and screening levels of 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. Petroleum based health screening levels for direct contact have been adopted from the *Cooperative Research Centre for Contamination Assessment and Remediation of the Environment (CRC CARE) Technical Report no.10 Health screening levels for petroleum hydrocarbons in soil and groundwater* (2011) as referenced by NEPC (2013).

The investigation and screening levels are applicable to generic land use settings and include consideration of, where relevant, the soil type and depth of contamination. The investigation and screening levels are not intended to be used as clean up levels. Rather, they establish concentrations above which further appropriate investigation (e.g., Tier 2 assessment) should be undertaken. They are intentionally conservative and are based on a reasonable worst-case scenario.

The investigation and screening levels applied in the current investigation comprise levels adopted for an open space / recreational land use scenario.

B1 Soil Contamination

B1.1 Health Investigation and Screening Levels

The Health Investigation Levels (HIL) and Health Screening Levels (HSL) are scientifically-based, generic assessment criteria designed to be used in the first stage (Tier 1) of an assessment of potential human health risk from chronic exposure to contaminants.

HILs are applicable to assessing health risk arising via all relevant pathways of exposure for a range of metals and organic substances. The HILs are generic to all soil types and apply generally to a depth of 3 m below ground surface. Site-specific conditions may determine the depth to which HILs apply for other land uses.

HSLs are applicable to selected petroleum compounds and fractions to assess the risk to human health via inhalation and direct contact pathways. HSLs have been developed for different land uses, soil types and depths to contamination.

The generic HIL and HSL are considered to be appropriate for the assessment of contamination at the site. Given the proposed land for a recreational facility use the adopted HIL and HSL are:

- HIL-C - recreational / open space C; and
- HSL-C - recreational / open space C.

Given that the proposed development does include enclosed structures (plant and change rooms) HSL A / B for vapour intrusion has been adopted as initial screening criteria given that HSL C (vapour) is not-limiting for all contaminants.

In addition, the HSL adopted are predicated on the inputs summarised in Table B1.

Table B1: Inputs to the Derivation of HSLs

Variable	Input	Rationale
Potential exposure pathway	Ingestion and dermal contact Inhalation of dust and/or vapours Surface water run-off Lateral migration of groundwater providing base flow to water bodies Direct contact*	All six potential exposure pathways are identified in the CSM. It is noted that direct contact HSLs are generally not the risk drivers for further site assessment for the same contamination source as the HSLs for vapour intrusion (NEPM, 2013).
Soil Type	Sand	Sandy fill was generally recorded across the site to depths ranging from 0 m to 2 m.
Depth to contamination	0 m to 1 m	Filling was generally present to depths ranging from 0 m to 2 m and may be retained on site. More conservative 0 - 1 m values have been adopted as initial screening values.

* Developed by CRC CARE (2011)

The adopted soil HIL and HSL for the potential contaminants of concern are presented in Table B2.

Table B2: Health Investigation and Screening Levels (HIL and HSL) in mg/kg Unless Otherwise Indicated

Contaminants		HIL- C and HSL- C Direct Contact	HSL - C Vapour Intrusion (All Depth Ranges)	HSL - A & B Vapour Intrusion (0-1 m)
Metals	Arsenic	300	-	-
	Cadmium	90	-	-
	Chromium (Total)	300	-	-
	Copper	17000	-	-
	Lead	60	-	-
	Mercury (inorganic)	80	-	-
	Nickel	1200	-	-
	Zinc	30000	-	-
PAH	Benzo(a)pyrene TEQ[1]	3 / 33 [3]	-	-
	Total PAH	300	-	-
TRH	F1	5100[3]	NL	45
	F2	3800[3]	NL	110
	F3	5300	-	-
	F4	7400	-	-
BTEX	Benzene	120	NL	0.5
	Toluene	18000	NL	160
	Ethylbenzene	5300	NL	55
	Xylenes	15000	NL	40
Phenol	Pentachlorophenol	120	-	-
OCP	Aldrin + Dieldrin	10	-	-
	Chlordane	70	-	-
	DDT+DDE+DDD	400	-	-
	Endosulfan	340	-	-
	Endrin	20	-	-
	Heptachlor	10	-	-
	HCB	10	-	-
	Methoxychlor	400	-	-
OPP	Chlorpyrifos	250	-	-
PCB[2]		1	-	

Notes:

[1] sum of carcinogenic PAH

[2] non-dioxin-like PCBs only'

[3] CRC Care 2017 high reliability guidelines, 85% protection of species, mean value.

B1.2 Ecological Investigation and Screening Levels

Ecological Investigation Levels (EIL) have been derived for selected metals and organic compounds and are applicable for assessing risk to terrestrial ecosystems (NEPC, 2013). EIL depend on specific soil physiochemical properties and land use scenarios and generally apply to the top 2 m of soil, which corresponds to the root zone and habitation zone of many species. The EIL is determined for a contaminant based on the sum of the ambient background concentration (ABC) and an added contaminant limit (ACL). The ABC of a contaminant is the soil concentration in a specific locality that is the sum of naturally occurring background levels and the contaminants levels that have been introduced from diffuse or non-point sources (e.g., motor vehicle emissions). The ACL is the added concentration (above the ABC) of a contaminant above which further appropriate investigation and evaluation of the impact on ecological values is required.

The EIL is calculated using the following formula:

EIL = ABC + ACL

The ABC is determined through direct measurement at an appropriate reference site (preferred) or through the use of methods defined by Olszowy et al *Trace element concentrations in soils from rural and urban areas of Australia*, Contaminated Sites monograph no. 4, South Australian Health Commission, Adelaide, Australia 1995 (Olszowy, 1995) or Hamon et al, *Geochemical indices allow estimation of heavy metal background concentrations in soils*, Global Biogeochemical Cycles, vol. 18, GB1014, (Hamon, 2004). ACL is based on the soil characteristics of pH, CEC and clay content.

EIL (and ACLs where appropriate) have been derived in NEPC (2013) for only a short list of contaminants comprising As, Cu, Cr (III), DDT, naphthalene, Ni, Pb and Zn.

The adopted EIL, derived from Tables 1B (1) to 1B (5), Schedule B1 of NEPC (2013) the *Interactive (Excel) Calculation Spreadsheet* are shown in the following Table B3. The following site-specific data and assumptions have been used to determine the EILs:

- A protection level of 95% of species has been adopted;
- The EILs will apply to the top 2 m of the soil profile;
- Given the likely source of soil contaminants (i.e., historical site use/fill) the contamination is considered as “aged” (>2 years);
- ABCs have been derived using the *Interactive (Excel) Calculation Spreadsheet* using input parameters of NSW for the State in which the site is located, and low for traffic volumes; and ACLs have been based on the lowest generic pH (4 pH) and CEC (5 cmol_c/kg) they represent the most conservative values;
- It is noted that Generic EILs for aged arsenic, fresh DDT and fresh naphthalene in soils are available from Table 1B (5) and as such, have not been provided a calculation; and
- EILs have been calculated using the formula EIL = ABC + ACL.

Table B3: Ecological Investigation Levels (EIL) in mg/kg

Analyte		EIL C	Comments
Metals	Arsenic	100	Adopted parameters: pH of 7 (mean value) CEC of 6 (mean value) Conservative clay content composition of 10% used. Iron not tested as EIL aged criteria was adopted Traffic Volume: Low
	Chromium (Total)	410	
	Copper	130	
	Lead	1100	
	Nickel	55	
	Zinc	350	
PAH	Naphthalene	170	
OCP	DDT	180	

B1.3 Ecological Screening Levels (ESL)

ESLs are used to assess the risk of selected petroleum hydrocarbon compounds, BTEX and benzo(a)pyrene to terrestrial ecosystems. ESL apply to the top 2 m of the soil profile as for EIL.

ESL have been derived in NEPC (2013) for petroleum fractions F1 to F4 as well as BTEX and Benzo(a)pyrene. Site specific data and assumptions as summarised in Table B4 have been used to determine the ESL. The adopted ESL, from Table 1B (6), Schedule B1 of NEPC (2013) are shown in Table B5.

Table B4: Inputs to the Derivation of ESL

Variable	Input	Rationale
Depth of ESL application	Top 2 m of the soil profile	The top 2 m depth below ground level corresponds to the root zone and habitation zone of many species.
Land use	Urban residential and public open space/ commercial and industrial	Proposed land use for redevelopment
Soil Texture	Coarse	The most conservative values based on filling present at the site.

Table B5: Ecological Screening Levels (ESL) in mg/kg

Analyte		ESL C
TRH	F1	180
	F2	120
	F3	300
	F4	2800
BTEX	Benzene	50
	Toluene	85
	Ethylbenzene	70
	Xylenes	105
PAH	Benzo(a)pyrene	0.7

B1.4 Management Limits - Petroleum Hydrocarbons

In addition to appropriate consideration and application of the HSL, 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 to avoid or minimise these potential effects have been adopted in NEPC (2013) as interim Tier 1 guidance. Management Limits have been derived in NEPC (2013) for the same four petroleum fractions as the HSL (F1 to F4). The adopted Management Limits, from Table 1B (7), Schedule B1 of NEPC (2013) are shown in the following Table B6. The following site specific data and assumptions have been used to determine the Management Limits:

- The Management Limits will apply to any depth within the soil profile;
- The Management Limits for commercial / industrial and recreational / public open space apply; and
- A coarse soil texture has been adopted due to the presence of sand in filling as well as being the more conservative limits.

Table B6: Management Limits in mg/kg

Analyte		Management Limit C
TRH	F1 #	700
	F2 #	1000
	F3	2500
	F4	10000

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

B1.5 Asbestos in Soil

Bonded asbestos-containing material (ACM) is the most common form of asbestos contamination across Australia, generally arising from:

- Inadequate removal and disposal practices during demolition of buildings containing asbestos products;
- Widespread dumping of asbestos products and asbestos containing fill on vacant land and development sites; and
- Commonly occurring in historical fill containing unsorted demolition materials.

Mining, manufacturing or distribution of asbestos products may result in sites being contaminated by friable asbestos including free fibres. Severe weathering or damage to bonded ACM may also result in the formation of friable asbestos comprising fibrous asbestos (FA) and / or asbestos fines (AF).

Asbestos only poses a risk to human health when asbestos fibres are made airborne and inhaled. If asbestos is bound in a matrix such as cement or resin, it is not readily made airborne except through substantial physical damage. Bonded ACM in sound condition represents a low human health risk, whilst both FA and AF materials have the potential to generate, or be associated with, free asbestos fibres. Consequently, FA and AF must be carefully managed to prevent the release of asbestos fibres into the air.

A limit of reporting of 0.1 g/kg was adopted for the previous investigation as an initial screen.

Where further assessment is required to confirm the suitability of any soils containing asbestos the following criteria will apply (NEPC 2013):

- Bonded ACM < 0.02 % w/w;
- FA and AF < 0.001 % w/w; and
- No visible asbestos in surface soils

B1.6 Acid Sulfate Soil

The following section provides the action criteria to determine if soils are classified as PASS / AASS.

B1.6.1 Field Screening

Field screening indicators do not form part of the Assessment Criteria as such but can be used to provide an indication of the ASS status and to assist in selecting samples for laboratory testing.

Field screening is indicative only and can give false positive and false negative indications of the presence of ASS. False positives can be caused by organic matter, which often “froths” during oxidation. False negatives can be caused by shells in the soil. Indicators of ASS from field screening comprise:

- Field pH is less than or equal to pH 4;
- pHfox is less than 3.0;
- A decrease of more than 1 pH unit from the field pH to the pHfox;
- Bubbling, production of heat or release of sulphur odours during pHfox testing; and

- Change in colour from grey to brown tones during oxidation.

B1.6.2 Laboratory Analysis

The action criteria trigger are the basis for determining if action (as per the adopted ASSMP) is required. They are based on Net Acidity. As clay content tends to influence a soil's natural buffering capacity, the action criteria are grouped by three broad texture categories - coarse, medium and fine. If the Net Acidity of any individual soil tested is equal to or greater than the action criterion a detailed ASS management will need to be prepared. Based on previously logged materials consisting of coarse textured sands and mixtures of sands, coarse textured criteria has been adopted (unless indicated otherwise).

Table B7: ASS Action Criteria

Type of Material		**Net Acidity**			
		1-1000 t materials disturbed		**>1000 t materials disturbed**	
Texture Range	**Approximate Clay Content %)**	**% S-equiv (oven dried basis)**	**Mol H+/t (oven dried basis)**	**% S-equiv (oven dried basis)**	**Mol H+/t (oven dried basis)**
Fine: light medium to heavy clay	*>40*	*≥ 0.1*	*≥ 62*	*≥ 0.03*	*≥ 18*
Medium: clayey sand to light clays	*5-40*	*≥ 0.06*	*≥ 36*	*≥ 0.03*	*≥ 18*
Coarse and Peats: sands to loamy sands	<5	≥ 0.03	≥ 18	≥ 0.03	≥ 18

B1.7 Waste Classification Criteria

B1.7.1 Fill

The waste classification should be conducted with reference to the NSW Environment Protection Authority (EPA) *Waste Classification Guidelines, Part 1: Classifying Waste*, November 2014 (NSW EPA, 2014).

NSW EPA (2014) contains a six step procedure for determining the type of waste and the waste classification. Part of the procedure, for materials not classified as special waste or pre-classified waste, is a comparison of analytical data initially against contaminant threshold (CT) values specific to a waste category. Alternatively, the data can be assessed against specific contaminant concentration (SCC) thresholds when used in conjunction with toxicity characteristic leaching procedure (TCLP) thresholds.

The CT, SCC and TCLP values can be found in Table 1 and Table 2 of NSW EPA (2014).

B1.7.2 Virgin Excavated Natural Material

The POEO Act defines virgin excavated natural material (VENM) as:

'*natural material (such as clay, gravel, sand, soil or rock fines):*

(a) that has been excavated or quarried from areas that are not contaminated with manufactured chemicals, or with process residues, as a result of industrial, commercial, mining or agricultural activities and

(b) that does not contain any sulfidic ores or soils or any other waste.

The following publications with background concentration ranges for Australian soils have been referenced in assessing the concentrations of analytes:

- Australian and New Zealand Environment and Conservation Council/National Health and Medical Research Council (ANZECC/NHMRC): *Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites* (1992), Environmental Soil Quality Guidelines Column A Background (ANZECC A) (ANZECC 1992); and
- Australian and New Zealand Environment and Conservation Council/National Health and Medical Research Council (ANZECC): *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (2000), Volume 3, Table 9.2.16 Datasets used to derive suggested upper background values for uncontaminated Australian soils (ANZECC 2000).

The VENM waste classification should be conducted with reference to the NSW Environment Protection Authority (EPA) *Waste Classification Guidelines, Part 1: Classifying Waste*, November 2014 (EPA, 2014).

B2 Groundwater

Mill Stream is considered the potential receptor of impacted groundwater from the site.

B2.1 Groundwater Investigation Levels

The ground investigation levels (GIL adopted in NEPC (2013) are based on:

- *Australian Drinking Water Guidelines* 2011 (NHMRC);
- *Guidelines for Managing Risk in Recreational Waters* 2008 (GMRRW); and
- *National water quality management strategy. Australian and New Zealand guidelines for fresh and marine water quality* 2000 (ANZECC, 2000).

It is noted that as of 29 August 2018, the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia.* (ANZG, 2018) replaced the ANZECC (2000). As such, the default guideline values (DGV) from the ANZG (2018) for marine water have been adopted and are shown in Table F8 below. It is noted that values for cadmium, chromium (III), lead, nickel and zinc are adjusted for a mean hardness level of 38 mg/kg $CaCO_3$ /L.

Table B8: Groundwater Investigation Levels (µg/L)

Analyte		Default Guideline Values (µg/L) ANZG (2018) [a] Freshwater
Dissolved Heavy Metals	Arsenic (III)	24 [c]
	Cadmium	0.2
	Chromium (Total)	4
	Copper	1.7
	Lead	4.6
	Mercury	0.6 [c]
	Nickel	13
	Zinc	9.8
PAH	Benzo(a)pyrene	0.1 [bd]
	Naphthalene	16 [bd]
OCP	Aldrin	0.001 [b]
	Dieldrin	0.01 [b]
	Chlordane	0.003 [cd]
	Heptachlor	0.01 [cd]
	DDT	0.006 [cd]
OPP	Diazinon	0.01
	Dimethoate	0.15
	Fenitrothion	0.2
	Parathion	0.004
Phenols	Phenol	50
BTEX	Benzene	950 [c]
	Toluene	180 [b]
	Ethylbenzene	80 [b]
	o-xylene	350 [b]
	m-xylene	75 [b]

NOTES
a: ANZG (2018) Default Guideline Values for a slightly to moderately disturbed system based on 95% level of species protection unless otherwise stated
b: insufficient data for reliable trigger value; unknown reliability or low reliability value used
c: moderate reliability value used
d: ANZG (2018) Default Guideline Values for a high conservation or ecological value system based on 99% level of species protection unless otherwise stated (bioaccumulation)

B2.2 Health Screening Levels

The generic HSL are considered to be appropriate for the assessment of contamination at the site. The adopted groundwater HSL for the potential contaminants of concern are presented in Table B10, with the inputs used in their derivation shown in Table B9.

Table B9: Inputs to the Derivation of HSLs

Variable	Input	Rationale
Soil Type	Sand	Sand has been adopted as filling across the site was mostly sand.
Depth to contamination	0 m to <3 m	Shallow groundwater levels recorded above 3 m bgl
Land Use	HSL C & HSL A/B	Recreational/ open space land use. HSL A/B adopted as conservative screen for enclosed structures

Table B10: Groundwater HSL C in µg/L

Analyte		HSL C	HSL A /B
TRH	C_6 – C_{10} (less BTEX) [F1]	NL	1000
	>C_{10}-C_{16} (less Naphthalene) [F2]	NL	1000
BTEX	Benzene	NL	800
	Toluene	NL	NL
	Ethylbenzene	NL	NL
	Xylene	NL	NL
PAH	Naphthalene	NL	NL

Note: NL -The solubility limit is defined as the groundwater concentration at which the water cannot dissolve any more of an individual chemical based on a petroleum mixture. The soil vapour which is in equilibrium with the groundwater will be at its maximum. If the derived groundwater HSL exceeds the water solubility limit, a soil-vapour source concentration for a petroleum mixture could not exceed a level that would result in the maximum allowable vapour risk for a given scenario. For these scenarios no HSL is presented for these chemicals. These are denoted as not limiting 'NL'.

Appendix C

Summary Results

Table 1A: Summary of Laboratory Results – Metals, TRH, BTEX, PAH (HIL-C/HSL-C)

			Metals										TRH & TPH in Soil												BTEX				PAH					
			Arsenic	Cadmium	Total Chromium	Copper	Lead	TCLP Lead	Mercury (inorganic)	Nickel	TCLP Nickel	Zinc	TRH C6 - C10	F1 ((C6-C10)-BTEX)	TRH >C10-C16	F2 (>C10-C16 less Naphthalene)	F3 (>C16-C34)	F4 (>C34-C40)	TPH (C10-C14) - Silica	TPH (>C10-C16) - Silica	TPH (C15-C28) - Silica	TPH >(C16-C34) - Silica	TPH (C29-C36) - Silica	TPH (>C34-C40) - Silica	Benzene	Toluene	Ethylbenzene	Total Xylenes	Naphthalene [b]	TCLP Naphthalene [b]	Benzo(a)pyrene (BaP)	TCLP Benzo(a)pyrene (BaP)	Benzo(a)pyrene TEQ	Total PAHs
		PQL	4	0.4	1	1	1	0.03	0.1	1	0.02	1	25	25	50	50	100	100	50	50	100	100	100	100	0.2	0.5	1	1	1	0.001	0.05	0.001	0.5	0.05
Sample ID	Depth	Sample Date	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/L	mg/kg	mg/kg	mg/L	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/L	mg/kg	mg/L	mg/kg	mg/kg
Site Assessment Criteria																																		
HIL C	-	-	300	90	300	17000	600	-	80	1200	-	30000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	300
HSL C - Vapour Intrusion	-	-	-	-	-	-	-	-	-	-	-	-	-	NL	-	NL	-	-	-	NL	-	-	-	-	NL	NL	NL	NL	-	-	-	-	-	-
HSL A / B - Vapour Intrusion	-	-	-	-	-	-	-	-	-	-	-	-	-	45	-	110	-	-	-	110	-	-	-	-	0.5	160	55	40	-	-	-	-	-	-
EIL/ ESL C	-	-	100	-	410	130	1100	-	-	55	-	350	-	180	-	120	300	2800	-	120	-	300	-	2800	50	85	70	105	170	-	0.7 / 33 [d]	-	-	-
Management Limit (ML)	-	-	-	-	-	-	-	-	-	-	-	-	-	700	-	1000	2500	10000	-	-	-	2500	-	10000	-	-	-	-	-	-	-	-	-	-
HSL C - Direct Contact (DC)	-	-	-	-	-	-	-	-	-	-	-	-	5100	-	3800	-	5300	7400	-	3800	-	5300	-	7400	120	18000	5300	15000	1900	-	-	-	-	-
Laboratory Results - Prensa 2018																																		
BH2	0-0.1 m	25/05/2018	9.3	<0.4	13	18	100	-	0.1	7	-	60	<20	<20	<50	<50	110	<100	-	-	-	-	-	-	<0.1	<0.1	<0.1	<0.3	<0.5	-	<0.5	-	1.2	<0.5
			300 100	90 NC	300 410	17000 130	600 1100	NC NC	1200 55	1200 55	NC NC	30000 350	NC NC	45 180	NC NC	110 120	NC 300	NC 2800	NC NC	110 NC	NC NC	NC 300	NC NC	NC 2800	0.5 50	160 85	55 70	40 105	NL 170	NC NC	NC 0.7	NC NC	3 NC	300 NC
BH2	0.4 - 0.5 m	25/05/2018	5.4	<0.4	12	23	280	-	<0.1	29	-	51	<20	<20	<50	<50	310	240	-	-	-		-	-	<0.1	<0.1	<0.1	<0.3	<0.5	-	<0.5	-	1.2	3.2
			300 100	90 NC	300 410	17000 130	600 1100	NC NC	1200 55	1200 55	NC NC	30000 350	NC NC	45 180	NC NC	110 120	NC 300	NC 2800	NC NC	110 NC	NC NC	NC 300	NC NC	NC 2800	0.5 50	160 85	55 70	40 105	NL 170	NC NC	NC 0.7	NC NC	3 NC	300 NC
Laboratory Results - DP 2020																																		
BH4	0.9 - 1 m	11/05/2020	<4	0.6	7	37	170	0.2	0.1	6	NT	380	<25	<25	<50	<50	240	160	NT	NT	NT	NT	NT	NT	<0.2	<0.5	<1	<1	<1	<0.001	2.9	<0.001	4.2	25
			300 100	90 NC	300 410	17000 130	600 1100	NC NC	1200 55	1200 55	NC NC	30000 350	NC NC	45 180	NC NC	110 120	NC 300	NC 2800	NC NC	110 120	NC NC	NC 300	NC NC	NC 2800	0.5 50	160 85	55 70	40 105	NL 170	NC NC	NC 0.7	NC NC	3 NC	300 NC
BH6	0.5 - 0.6 m	12/05/2020	<4	0.4	4	57	91	NT	<0.1	7	NT	610	<25	<25	120	120	140	480	NT	NT	NT	NT	NT	NT	<0.2	<0.5	<1	<1	14	0.023	18	<0.001	26	310
			300 100	90 NC	300 410	17000 130	600 1100	NC NC	1200 55	1200 55	NC NC	30000 350	NC NC	45 180	NC NC	110 120	NC 300	NC 2800	NC NC	110 120	NC NC	NC 300	NC NC	NC 2800	0.5 50	160 85	55 70	40 105	NL 170	NC NC	NC 0.7	NC NC	3 NC	300 NC
BH9	0.5 - 0.6 m	12/05/2020	7	<0.4	11	130	63	NT	0.2	10	NT	46	<25	<25	<50	<50	1400	430	NT	NT	NT	NT	NT	NT	<0.2	<0.5	<1	<1	1.8	<0.001	33	<0.001	49	400
			300 100	90 NC	300 410	17000 130	600 1100	NC NC	1200 55	1200 55	NC NC	30000 350	NC NC	45 180	NC NC	110 120	NC 300	NC 2800	NC NC	110 120	NC NC	NC 300	NC NC	NC 2800	0.5 50	160 85	55 70	40 105	NL 170	NC NC	NC 0.7	NC NC	3 NC	300 NC
BH10	0.4 - 0.5 m	11/05/2020	<4	<0.4	5	9	30	NT	<0.1	8	NT	61	<25	<25	<50	<50	200	<100	NT	NT	NT	NT	NT	NT	<0.2	<0.5	<1	<1	1.3	0.005	9.8	<0.001	14	130
			300 100	90 NC	300 410	17000 130	600 1100	NC NC	1200 55	1200 55	NC NC	30000 350	NC NC	45 180	NC NC	110 120	NC 300	NC 2800	NC NC	110 120	NC NC	NC 300	NC NC	NC 2800	0.5 50	160 85	55 70	40 105	NL 170	NC NC	NC 0.7	NC NC	3 NC	300 NC
BD1/110520	0.4 - 0.5 m	11/05/2020	<4	<0.4	6	14	37	NT	<0.1	10	NT	73	<25	<25	55	53	680	190	NT	NT	NT	NT	NT	NT	<0.2	<0.5	<1	<1	15	0.004	22	<0.001	33	300
			300 100	90 NC	300 410	17000 130	600 1100	NC NC	1200 55	1200 55	NC NC	30000 350	NC NC	45 180	NC NC	110 120	NC 300	NC 2800	NC NC	110 120	NC NC	NC 300	NC NC	NC 2800	0.5 50	160 85	55 70	40 105	NL 170	NC NC	NC 0.7	NC NC	3 NC	300 NC
BH11	0.9 - 1 m	11/05/2020	<4	<0.4	<1	1	<1	NT	<0.1	<1	NT	1	<25	<25	<50	<50	<100	<100	NT	NT	NT	NT	NT	NT	<0.2	<0.5	<1	<1	<1	NT	0.54	NT	0.7	8.3
			300 100	90 NC	300 410	17000 130	600 1100	NC NC	1200 55	1200 55	NC NC	30000 350	NC NC	45 180	NC NC	110 120	NC 300	NC 2800	NC NC	110 120	NC NC	NC 300	NC NC	NC 2800	0.5 50	160 85	55 70	40 105	NL 170	NC NC	NC 0.7	NC NC	3 NC	300 NC
BH11	1 - 1.3 m	11/05/2020	<4	<0.4	5	<1	2	NT	<0.1	1	NT	<1	<25	<25	<50	<50	<100	<100	NT	NT	NT	NT	NT	NT	<0.2	<0.5	<1	<1	<1	NT	<0.05	NT	<0.5	<0.05
			300 100	90 NC	300 410	17000 130	600 1100	NC NC	1200 55	1200 55	NC NC	30000 350	NC NC	45 180	NC NC	110 120	NC 300	NC 2800	NC NC	110 120	NC NC	NC 300	NC NC	NC 2800	0.5 50	160 85	55 70	40 105	NL 170	NC NC	NC 0.7	NC NC	3 NC	300 NC
BH12	0.5 - 0.6 m	12/05/2020	<4	0.9	19	46	54	NT	0.3	21	NT	280	<25	<25	74	69	3700	1100	<50	<50	760	1200	570	250	<0.2	<0.5	<1	<1	5	0.012	68	<0.001	100	640
			300 100	90 NC	300 410	17000 130	600 1100	NC NC	1200 55	1200 55	NC NC	30000 350	NC NC	45 180	NC NC	110 120	NC 300	NC 2800	NC NC	110 120	NC NC	NC 300	NC NC	NC 2800	0.5 50	160 85	55 70	40 105	NL 170	NC NC	NC 0.7	NC NC	3 NC	300 NC
BH18	0.4 - 0.5 m	19/05/2020	<4	<0.4	13	160	17	NT	<0.1	35	NT	87	<25	<25	200	200	**8100**	2200	<50	<50	2400	4000	2200	1500	<0.2	<0.5	<1	<1	<1	<0.001	72	<0.001	110	1200
			300 100	90 NC	300 410	17000 130	600 1100	NC NC	1200 55	1200 55	NC NC	30000 350	NC NC	45 180	NC NC	110 120	NC 300	NC 2800	NC NC	110 120	NC NC	NC 300	NC NC	NC 2800	0.5 50	160 85	55 70	40 105	NL 170	NC NC	NC 0.7	NC NC	3 NC	300 NC
BH18	0.9 - 1 m	19/05/2020	<4	<0.4	<1	2	25	NT	<0.1	<1	NT	4	<25	<25	<50	<50	<100	<100	NT	NT	NT	NT	NT	NT	<0.2	<0.5	<1	<1	<1	NT	0.2	NT	<0.5	2
			300 100	90 NC	300 410	17000 130	600 1100	NC NC	1200 55	1200 55	NC NC	30000 350	NC NC	45 180	NC NC	110 120	NC 300	NC 2800	NC NC	110 120	NC NC	NC 300	NC NC	NC 2800	0.5 50	160 85	55 70	40 105	NL 170	NC NC	NC 0.7	NC NC	3 NC	300 NC
BH19	0.4 - 0.5 m	19/05/2020	<4	<0.4	3	12	13	NT	<0.1	12	NT	16	<25	<25	1300	1000	**8100**	890	57	130	1300	1500	410	180	<0.2	<0.5	<1	<1	490	0.4	350	<0.001	510	7200
			300 100	90 NC	300 410	17000 130	600 1100	NC NC	1200 55	1200 55	NC NC	30000 350	NC NC	45 180	NC NC	110 120	NC 300	NC 2800	NC NC	110 120	NC NC	NC 300	NC NC	NC 2800	0.5 50	160 85	55 70	40 105	NL 170	NC NC	NC 0.7	NC NC	3 NC	300 NC
BH19	1.4 - 1.5 m	19/05/2020	<4	<0.4	1	2	2	NT	<0.1	<1	NT	1	<25	<25	<50	<50	<100	<100	NT	NT	NT	NT	NT	NT	<0.2	<0.5	<1	<1	<1	NT	0.2	NT	<0.5	3.3
			300 100	90 NC	300 410	17000 130	600 1100	NC NC	1200 55	1200 55	NC NC	30000 350	NC NC	45 180	NC NC	110 120	NC 300	NC 2800	NC NC	110 120	NC NC	NC 300	NC NC	NC 2800	0.5 50	160 85	55 70	40 105	NL 170	NC NC	NC 0.7	NC NC	3 NC	300 NC
BH20	0 - 0.1 m	19/05/2020	<4	<0.4	6	9	35	NT	<0.1	4	NT	20	<25	<25	<50	<50	<100	<100	NT	NT	NT	NT	NT	NT	<0.2	<0.5	<1	<1	<1	NT	0.2	NT	<0.5	1.8
			300 100	90 NC	300 410	17000 130	600 1100	NC NC	1200 55	1200 55	NC NC	30000 350	NC NC	45 180	NC NC	110 120	NC 300	NC 2800	NC NC	110 120	NC NC	NC 300	NC NC	NC 2800	0.5 50	160 85	55 70	40 105	NL 170	NC NC	NC 0.7	NC NC	3 NC	300 NC
BH21	0.4 - 0.5 m	19/05/2020	34	<0.4	5	24	21	NT	<0.1	54	0.07	21	<25	<25	<50	<50	<100	<100	NT	NT	NT	NT	NT	NT	<0.2	<0.5	<1	<1	<1	NT	0.3	NT	<0.5	5.8
			300 100	90 NC	300 410	17000 130	600 1100	NC NC	80 NC	1200 55	NC NC	30000 350	NC NC	45 180	NC NC	110 120	NC 300	NC 2800	NC NC	110 120	NC NC	NC 300	NC NC	NC 2800	0.5 50	160 85	55 70	40 105	NL 170	NC NC	NC 0.7	NC NC	3 NC	300 NC
BH21	1 - 1.1 m	19/05/2020	<4	<0.4	<1	2	<1	NT	<0.1	2	NT	2	<25	<25	<50	<50	<100	<100	NT	NT	NT	NT	NT	NT	<0.2	<0.5	<1	<1	<1	NT	0.06	NT	<0.5	0.3
			300 100	90 NC	300 410	17000 130	600 1100	NC NC	80 NC	1200 55	NC NC	30000 350	NC NC	45 180	NC NC	110 120	NC 300	NC 2800	NC NC	110 120	NC NC	NC 300	NC NC	NC 2800	0.5 50	160 85	55 70	40 105	NL 170	NC NC	NC 0.7	NC NC	3 NC	300 NC
BH22	0.4 - 0.5 m	19/05/2020	<4	<0.4	5	220	130	0.38	<0.1	23	NT	76	<25	<25	890	740	**8000**	930	140	520	5600	6600	1700	610	<0.2	<0.5	<1	<1	290	0.47	520	<0.001	730	10000
			300 100	90 NC	300 410	17000 130	600 1100	NC NC	1200 55	1200 55	NC NC	30000 350	NC NC	45 180	NC NC	110 120	NC 300	NC 2800	NC NC	110 120	NC NC	NC 300	NC NC	NC 2800	0.5 50	160 85	55 70	40 105	NL 170	NC NC	NC 0.7	NC NC	3 NC	300 NC
BH22	1.4 - 1.5 m	19/05/2020	<4	<0.4	<1	1	<1	NT	<0.1	<1	NT	4	<25	<25	<50	<50	<100	<100	NT	NT	NT	NT	NT	NT	<0.2	<0.5	<1	<1	<1	NT	0.1	NT	<0.5	2.7
			300 100	90 NC	300 410	17000 130	600 1100	NC NC	1200 55	1200 55	NC NC	30000 350	NC NC	45 180	NC NC	110 120	NC 300	NC 2800	NC NC	110 120	NC NC	NC 300	NC NC	NC 2800	0.5 50	160 85	55 70	40 105	NL 170	NC NC	NC 0.7	NC NC	3 NC	300 NC
BH27	1.4 - 1.5 m	18/05/2020	5	0.4	11	140	86	NT	0.1	32	NT	590	<25	<25	<50	<50	880	220	NT	NT	NT	NT	NT	NT	<0.2	<0.5	<1	<1	6.3	0.016	23	<0.001	34	430
			300 100	90 NC	300 410	17000 130	600 1100	NC NC	1200 55	1200 55	NC NC	30000 350	NC NC	45 180	NC NC	110 120	NC 300	NC 2800	NC NC	110 120	NC NC	NC 300	NC NC	NC 2800	0.5 50	160 85	55 70	40 105	NL 170	NC NC	NC 0.7	NC NC	3 NC	300 NC
BH40	0.4 - 0.5 m	19/05/2020	<4	<0.4	5	22	46	NT	<0.1	5	NT	40	<25	<25	<50	<50	<100	<100	NT	NT	NT	NT	NT	NT	<0.2	<0.5	<1	<1	<1	NT	0.5	NT	0.6	4.4
			300 100	90 NC	300 410	17000 130	600 1100	NC NC	1200 55	1200 55	NC NC	30000 350	NC NC	45 180	NC NC	110 120	NC 300	NC 2800	NC NC	110 120	NC NC	NC 300	NC NC	NC 2800	0.5 50	160 85	55 70	40 105	NL 170	NC NC	NC 0.7	NC NC	3 NC	300 NC

Lab result	
HIL/HSL value	EIL/ESL value

🟨 HIL/HSL exceedance 🟩 EIL/ESL exceedance 🟧 HIL/HSL and EIL/ESL exceedance ⬜ ML exceedance 🟥 ML and HIL/HSL or EIL/ESL exceedance

🟪 Indicates that asbestos has been detected by the lab below the PQL, refer to the lab report **Bold** = DC exceedance

Blue = Lab detections NT = Not tested NL = Non limiting NC = No criteria NA = Not applicable NAD = No asbestos detected

Notes:

HIL/HSL/DC	NEPC, Schedule B1 - HIL C (Recreational/Open Space), HSL C (Recreational/Open Space), DC HSL C (Recreational/Open Space)
EIL/ESL	NEPC, Schedule B1 - EIL UR/POS (Urban/Recreational/Public Open Space), ESL UR/POS (Urban/Recreational/Public Open Space)
ML	NEPC, Schedule B1 - ML R/P/POS (Residential, Parkland and Public Open Space)
a	QA/QC replicate of sample listed directly below the primary sample
b	Reported naphthalene laboratory result obtained from BTEXN suite
c	EIL/ESL criteria applies to DDT only
d	CRC Care 2017 high reliabilit guidelines (mean value)
*	Results obtained from Eurofins lab duplicate

Table 4A - Results of Laboratory Analysis for Acid Sulfate Soil Screening

			Screening Test (as reported by the laboratory)				S $_{CR}$ Full Suite						
Sample Location	Depth (m)	Soil Description	pH_F	pH_{FOX}	pH_F - pH_{FOX}	Strength of Reaction	pH $_{KCL}$	s-TAA pH 6.5	Chromium Reducible Sulfur	S_{NAS}	a-Net Acidity without ANCE	Liming rate without ANCE
							pH units	%w/w S			moles H +/t	kg $CaCO_3$/t
Larger Aquatic Centre Area												
BH1	0.9-1	Grey sand	8.1	5.9	2.2	Medium	-	-	-	-	-	-
BH1	1.9-2.0	Brown sand, moist	7.7	5.8	1.9	Low	-	-	-	-	-	-
BH1	2.5-2.95	Pale grey sand, saturated	7.2	5.7	1.5	Low	-	-	-	-	-	-
BH2	1.6-1.7	Brown sand, moist	5.6	4.4	1.2	Low	-	-	-	-	-	-
BH2	2-2.95	Pale grey sand, moist	7.2	5.9	1.3	Low	-	-	-	-	-	-
BH3	1.9-2.0	Dark brown sand with trace silt, moist	4.6	3.9	0.7	Low	4.8	**0.03**	**0.03**	NA	**21**	1.6
BH3	2.5-2.95	Dark brown sand with trace silt, saturated	6.8	6.1	0.7	Low	-	-	-	-	-	-
BH5	1-1.3	Gravelly sand fill, moist	8.1	5.7	2.4	Volcanic	-	-	-	-	-	-
BH5	2.5-2.95	Dark brown sand with trace silt, moist	7.5	5.7	1.8	Low	-	-	-	-	-	-
BH7	1.9-2	Pale grey sand, moist	8.8	6.3	2.5	Medium	-	-	-	-	-	-
BH7	2.5-2.95	Dark brown sand with trace silt, moist	7.3	5.9	1.4	Low	-	-	-	-	-	-
BH8	0.05-0.15	Silty sand fill, moist	6.6	4.2	2.4	Medium	-	-	-	-	-	-
BH8	2.5-2.95	Dark brown sand with trace silt, moist	7.4	5.5	1.9	Low	-	-	-	-	-	-
BH13	1.5-1.98	Pale yellow to brown sand, moist	4.4	3.6	0.8	Medium	4.8	0.01	<0.005	NA	9.8	<0.75
BH14	2.5-2.95	Pale grey sand, moist	7.3	6.1	1.2	High	-	-	-	-	-	-
BH15	1-1.45	Grey sand	9.9	7	2.9	High	-	-	-	-	-	-
BH17	2.4-2.5	Pale brown sand, saturated	7.5	5.8	1.7	Medium	-	-	-	-	-	-
BH17	3.5-3.95	Yellow-grey sand, saturated	6.9	5.6	1.3	Medium	-	-	-	-	-	-
BH17	5.5-5.95	Pale yellow sand, saturated	6.9	4.4	2.5	Medium	5.1	<0.01	<0.005	NA	5	<0.75
BH25	0.9-1	Fly ash	6.9	3.6	3.3	Medium	5.8	<0.01	<0.005	NA	<5	<0.75
BH28A	0.95-1.1	Brown sand, moist	7.2	4.7	2.5	High	-	-	-	-	-	-
BH28A	1.9-2.0	Pale grey sand, moist	7.3	4.9	2.4	High	-	-	-	-	-	-
BH29	1.5-1.7	Grey sand, moist	6.8	4	2.8	High	-	-	-	-	-	-
BH29	2-2.4	Orange-brown sand, moist	5.9	4.2	1.7	High	-	-	-	-	-	-
BH30	3.5-3.95	Grey sand, saturated	6.1	4.9	1.2	Low	-	-	-	-	-	-
BH30	5.5-5.95	Yellow-grey sand, saturated	6.6	5.8	0.8	Low	-	-	-	-	-	-
BH32	1.5-1.6	Dark brown sand fill	7.4	4.5	2.9	Medium	6.7	<0.01	<0.005	NA	<5	<0.75
BH33	2.4-2.5	Orange-brown sand, moist	6.9	4.8	2.1	Low	-	-	-	-	-	-
BH34	0.95-1.1	Pale grey sand, moist	7.1	4.2	2.9	High	-	-	-	-	-	-
BH34	1.5-1.95	Brown sand, moist	6.3	4.9	1.4	Medium	-	-	-	-	-	-
BH37	0.5-0.95	Silty sand fill, moist	7.1	4.8	2.3	Medium	-	-	-	-	-	-
BH37	1.5-1.95	Yellow to brown sand, moist	7	5.6	1.4	Medium	-	-	-	-	-	-
BH38	1.9-2	Grey sand, saturated	7.2	4.9	2.3	Medium	-	-	-	-	-	-
BH39	1.9-2	Grey sand, moist	7.6	4.7	2.9	High	-	-	-	-	-	-
BH40	2.4-2.5	Red-brown sand, saturated	7.2	4.8	2.4	Low	-	-	-	-	-	-
Current Site												
BH4	2.5-2.95	Pale brown sand, moist	7.4	5.5	1.9	Low	-	-	-	-	-	-
BH6	1-1.45	Pale grey sand, moist	5.3	2.5	2.8	Low	-	-	-	-	-	-
BH6	2.5-2.95	Pale grey sand, moist	5.9	5	0.9	Low	-	-	-	-	-	-
BH6	5.5-5.95	Pale grey sand, moist	6.5	5.3	1.2	Low	-	-	-	-	-	-
BH9	1-1.45	Brown sand with trace silt, moist	8.7	6.1	2.6	Low	-	-	-	-	-	-
BH9	5.5-5.95	Pale brown sand, saturated	7.6	5.6	2	Low	-	-	-	-	-	-
BH10	0.9-1.0	Pale brown sand, moist	7	4.6	2.4	Low	-	-	-	-	-	-
BH10	1-1.45	Dark brown sand, moist	6.9	5.1	1.8	Medium	-	-	-	-	-	-
BH10	2.5-2.95	Pale grey sand, saturated	6.7	4.9	1.8	Medium	-	-	-	-	-	-
BH11	1-1.3	Pale grey sand, moist	6.2	4.7	1.5	Low	-	-	-	-	-	-
BH11	4-4.45	Dark brown sand with trace silt, saturated	6.6	5.7	0.9	Low	-	-	-	-	-	-
BH12	1-1.45	Brown sand, moist	7.9	6.4	1.5	Low	-	-	-	-	-	-
BH12	3.5-3.95	Pale brown sand, moist	6.5	4.5	2	Low	-	-	-	-	-	-

BH18	0.9-1	Grey sand, moist	8.3	6.1	2.2	Medium	-	-	-	-	-	-
BH19	1.4-1.5	Yellow-orange sand, saturated	7.4	5.5	1.9	Low	-	-	-	-	-	-
BH21	1-1.1	Pale yellow sand, moist	7.5	3.3	4.2	Medium	5.6	<0.01	<0.005	NA	<5	<0.75
BH27	1.4-1.5	Sand fill, moist	6.9	4.8	2.1	High	-	-	-	-	-	-
ASSMAC (1998) Action Criteria												
Screening Levels	-	-	≤4	<3.5	≤1	-	-	-	-	-	-	-
Action Criteria (>1000 t)	-	-	-	-	-	-	-	0.03	0.03	-	18	-

Notes:

pH$_F$	non-oxidised pH (soil in distilled water) measures existing acidity
pH$_{FOX}$	oxidised pH (soil oxidised in hydrogen peroxide) measures potential acidity
pH$_F$ - pH$_{FOX}$	change in pH - the greater the difference from pH$_F$ to pHfox, the more likely of the soil being PASS
Strength of Reaction	chemical reaction may include colour change, effervescence (bubbling), gas evolution, heat and pungent/irritating odour (sulphur dioxide/hydrogen sulphide)
1	no or slight reaction
2	moderate reaction
3	vigorous reaction
4	high reaction
F	bubbling/frothy reaction indicative of organics
Indicative Values	screening/selection criteria for SPOCAS analysis
pH$_F$ <4	may indicate actual acidity
pH$_F$ = 4-5	may indicate an acid soil, but the cause of acidity needs further testing
pH$_{FOX}$ <3	may indicate potential acidity
pH$_F$ - pH$_{FOX}$ ≥1	may indicate PASS
▨	selected for Suspension Peroxide Oxidation Combined Acidity and Sulfur (SPOCAS) analysis
🟧	Exceedance of Action Criteria
*	Action Criteria based on disturbance of greater than 1000 tonnes of material (ASSMAC, 1998)

Appendix D

Supplementary Acid Sulfate Information

Appendix D
ASS Treatment
Cnr Myrtle St and Jasmine St, Botany

D1.0 Introduction

This appendix outlines:

- Acid sulfate soil treatment verification criteria;
- Equations for net acidity;
- Liming rate calculations; and
- Water and groundwater management.

D2.0 Verification of Treatment

The following section provides the equations and methods of verifying that the neutralisation treatment has been successful / completed.

D2.1 Field Screening

Field screening results will be considered to be acceptable when the results are below the adopted criteria. When soils do meet the following criteria, confirmatory laboratory testing should be undertaken.

- Field pHf is ≥ 6.5 (ideally between pH 6.5 and 8.5); and
- pHfox ≥ 5.5.

D2.2 Laboratory Testing

The soil will be considered successfully treated where:

- pH_{KCl} is ≥ 6.5;
- (total actual acidity) TAA = 0; and
- Net acidity ≤ 0. Net Acidity must be determined by one of the methods outlined in Section C2.2.1

D2.2.1 Net Acidity

Net Acidity is the quantitative measure of the acidity hazard of ASS. It is determined from an Acid Base Accounting (ABA) approach using one of the equations below. Equations C1 and C2 are used to determine the net acidity prior to treatment of ASS / PASS and therefore if acid sulfate soil treatment and / or management plan is required. Equation C3 is used to determine the neutralisation treatment has been successful:

- Equation C1 - when the effectiveness of a soil's measured Acid Neutralising Capacity has been corroborated by other data demonstrating the soil does not experience acidification during complete oxidation under field conditions, or
- Equation C2 - when the effectiveness of a soil's measured Acid Neutralising Capacity has not been corroborated by other data, or
- Equation C3 - when the effectiveness of a management approach involving the addition of liming materials is being verified post treatment via calculation of the Verification Net Acidity.

Equation C1 Net Acidity whereby acid neutralising capacity (ANC) has been corroborated by other data.

Net Acidity = potential sulfidic acidity + actual acidity + retained acidity - Acid Neutralising Capacity.

Net Acidity = Scr + S-TAA at pH 6.5 + SNAS - s-ANCBT.

Equation C2 Net Acidity whereby ANC has not been corroborated by other data.

Net Acidity = potential sulfidic acidity + actual acidity + retained acidity.

Net Acidity = Scr + S-TAA at pH 6.5 + SNAS.

Equation C3 Verification Net Acidity.

Verification Net Acidity = potential sulfidic acidity + actual acidity + retained acidity – (post neutralised Acid Neutralising Capacity - pre neutralised Acid Neutralising Capacity)

Verification Net Acidity = Scr + S-TAA at pH 6.5 + SNAS - (ANCBT of treated material - ANCBT of untreated material).

D3.0 Liming Rates

The required liming rate can be calculated from one of the following formulas.

Equation C4:

Neutralising Material Required (kg $CaCO_3$/tonne soil) = (Net acidity (mol H+/t) / 19.98) x FOS x 100/ENV.

Equation C5:

Neutralising Material Required (kg $CaCO_3/m^3$ soil) = D (tonne/m^3) x (Net acidity (mol H+/t) / 19.98) x FOS x 100/ENV

Where:

net acidity (mol H+/t) is derived using the 95% UCL of the Net Acidity (%S) using the methods in Appendix C;
19.98 converts to kg $CaCO_3$/tonne;
FOS (factor of safety) = a minimum value of 1.5 needs to be adopted, although values of up to 2 can be suitable;
ENV = Effective Neutralising Value (e.g., Approx. 98% for fine (0.3 mm grain size) ag lime with an NV of 98%).
D = bulk density, site specific results can be used, or the bulk densities in Table 2 of Appendix C should be used

Notes:

- The ENV is calculated based on the molecular weight, particle size and purity of the neutralising agent and should be assessed for proposed materials in accordance with ASSMAC (1998).
- Natural net acidity must not be used.

An initial liming rate based on the laboratory result calculation (excluding ANC) is considered appropriate based on it including a safety factor of 1.5 and the use of ag lime with an NV of at least 98% and a grain size of less than 0.5 mm.

The liming rate to be calculated from the analytical results should therefore be considered as a “starting point”, and pH monitoring should be conducted during treatment to assess the progress of the neutralisation, and need for additional mixing and / or addition of ag lime. Soil will only be considered to have been successfully treated when all soil has been verified in accordance with Section 13.6

D4.0 Disposal as PASS

Further guidance for the disposal of untreated soil as PASS (as a contingency strategy) is provided in Appendix E.

D5.0 Water and Groundwater Management

Water is the main mechanism by which acid and metals from oxidised ASS are mobilised and transported. Careful management of water is therefore paramount to effective management of potential adverse impacts from ASS. Management is required to provide control of treated waters for discharge, and provide some margin for unattended weekend or holiday periods as well as heavy rain periods.

The below sections provide potential strategies for management, assessment and disposal of water leaching from ASS, surface water and water from groundwater dewatering.

D5.1 Leachate and Surface Water Collection

All water that has been in contact with PASS / ASS / assumed ASS must be managed, assessed, treated and appropriately disposed of in accordance with any other consent conditions / EPL / dewatering management plan.

D5.2 Dewatering and Extracted Groundwater

In general, risks associated with dewatering in areas underlain by ASS include:

- Acidification of in situ soils drained within the dewatering cone of depression and difficulties associated with neutralising these in situ soils (this can also impact the possible PASS classification of some soils);
- Acidification of groundwater remaining within the dewatering cone of depression after the system has re-flooded;
- Iron, aluminium and heavy metal contamination of groundwater arising from mobilisation of these compounds under low pH conditions; and
- Acidification and contamination of surface water bodies which receive groundwater.

It is considered that there is the potential to expose soils within the proposed excavation areas to air which will allow some acidification to take place. However, the water and ASS from within these areas will be removed and treated, mitigating associated risks.

The dewatering should be designed to not significantly affect groundwater levels outside of the cut-off structures, and therefore the potential for oxidation of ASS outside of the excavation areas is expected to be limited.

The following dewatering risk management methods are recommended for the project:

- Drawdown outside of the excavation areas should be minimised; and
- Monitoring, treatment and disposal of water from dewatering effluent.

D5.3 Water Storage and Treatment

Water from dewatering and the ASS leachate should either be pumped directly to an on-site treatment plant for treatment or should be stored in a tank or lined drains/ detention basin prior to assessment / treatment.

At a minimum, the combined storage should be designed to store enough water to contain leachate and extracted water from a 1 in 10-year (1 hour) storm event.

D5.4 Water Assessment for Disposal

All water which has potentially come into contact with ASS requires assessment (and if necessary, treatment). Minimum recommended monitoring is provided in Table G1, below.

Table G1: Suggested Water Monitoring Frequencies and Target Levels for Disposal to Stormwater

Test	Frequency	Target Level for Disposal to Stormwater
pH	Water detention basin/ tank: • During storage/ treatment as required to allow timely treatment; • Less than 24 hours prior to any planned discharge; • Daily during discharge period. • For unplanned discharges (i.e. due to rain), within 5 days of the cessation of the rainfall event Treatment Plant: • During storage/ treatment as required to allow timely treatment; and • Daily during discharge period.	• pH 6.5 to 8.5
Total Suspended Solids (TSS)		• ≤50 mg/L or equivalent turbidity measure (in NTU) where a statistical correlation between the TSS and turbidity has been determined
Oil and Grease		• None observable
Iron (total and soluble)	Laboratory analysis: • Immediately prior to disposal; and • Weekly checks during discharge period; and • As required based on visual observations; and Visual assessment of discolouration: • Daily during discharge	• No obvious sign of iron staining/ settlement • ≤0.3 mg/L filterable iron • ≤0.8 µg/L filterable Aluminium @ < pH 6.5 • ≤55 µg/L filterable Aluminium @ > pH 6.5
Potential contaminants PAH, TRH, BTEX and metals (aluminium, arsenic, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, zinc)]	Laboratory analysis: • One round of testing before first disposal of ASS impacted water; • If first round of testing exceeds target levels then further testing prior to disposal is required	• ANZG (2018) Trigger Levels for 95% Level of Protection for marine ecosystems if no licence conditions are available

Notes:		
	PAH	Polycyclic aromatic hydrocarbons
	BTEX	Benzene, toluene, ethylbenzene, xylenes
	TRH	Total recoverable hydrocarbons

D5.5 Treatment

D5.5.1 General

The potential impacts of ASS on water generally comprise a decrease in pH, possible elevated TSS / turbidity, iron and other metals.

Treatment of water from construction sites is commonly required for pH and TSS. Aeration and removal of TSS also generally decreases metal concentrations in the water. Therefore, an on-site water treatment plant is considered likely to be suitable for treatment of ASS impacted water that has not been oxidised.

An alternate treatment method for pH is provided in Section C5.5.2 in case treatment of excess water above the capacity of the treatment plant is required.

If a suitable treatment method for man-made contaminants in the water (e.g. PAH, TRH, BTEX and metals, etc.) cannot be implemented, an alternate disposal method may be required (e.g., trucking off-site to a liquid waste disposal facility or disposal to sewer in accordance with a specific Trade Waste Agreement which would need to be obtained from Sydney Water).

D5.5.2 Alternate pH Treatment Method

It is noted that aglime is generally not suitable for the treatment of leachate due to its low solubility in water. A commercial pH adjustment product can be used, or else slaked lime as discussed below.

Alternative neutralisation materials include calcined magnesia (magnesium hydroxide, burnt magnesite, or magnesia) and calcium hydroxide (commonly called slaked or hydrated lime).

Calcined magnesia (magnesium hydroxide, burnt magnesite, or magnesia) is the recommended neutralising agent as it produces a two-step reaction, which proceeds rapidly at acidic pH and slows down as higher pH is approached, and hence reduces the potential for over-neutralisation. It should be added to the leachate as a slurry and mixing achieved via use of an agitator.

A calcium hydroxide (commonly called slaked or hydrated lime) solution can be produced by stirring calcium oxide (commonly called quicklime) into water, in a container of sufficient volume (for example, a plastic 200 litre drum). The slurry should be allowed to settle, and the clear solution (which will be caustic, with a pH of approximately 12.5 to 13) can be pumped or sprayed into the standing water in small amounts, with some agitation and monitoring. This procedure should be continued until the pH is adjusted to acceptable levels. Adequate care should be taken not to “overshoot” the desired pH with calcium hydroxide.

Quicklime is very reactive, and relatively corrosive (due to its caustic nature). When quicklime is mixed with water, the resulting reaction generates heat. Therefore, if utilised, the material should be added in increments to a large amount of water to control the reaction. Slaked or quicklime should not be allowed to come into contact with the skin or be inhaled during use.

The amount of neutraliser required to be added to the discharged groundwater can be calculated from the equation below:

Equation C6:

$$\text{Alkali Material Required (kg)} = \frac{M_{Alkali} \times 10^{-pH\ initial}}{2 \times 10^{3}} \times V$$

Where:
M_{Alkali} = molecular weight of alkali material (g/mole) (molecular weight of slaked lime ($Ca(OH)_2$) = 74 g/mole.)
pH initial = initial pH of leachate
V = volume of leachate (litres)

As a guide, the approximate quantities of slaked lime required to neutralise acidic water are provided in Table G2.

Table G2: Approximate Liming Rates for Water (based on slaked lime (kg of $Ca(OH)_2$))

Water pH	Volume		
	10 m^3	50 m^3	100 m^3
2	3.7	18.5	37
3	0.37	1.85	3.7
4	0.037	0.185	0.37
5	0.0037	0.0185	0.037
6	0.00037	0.00185	0.0037

D5.6 Water Discharge

Following treatment (if required) the water should be assessed to determine if it meets any specific EPL conditions or discharge criteria. Water meeting the conditions can then be disposed of accordingly.

D6.0 References

ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality;

ANZG (2018) Australian and New Zealand Guidelines for Fresh and Marine Water Quality;

NEPC (2013) National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended 2013);

Acid Sulfate Soils Management Advisory Committee (ASSMAC) Acid Sulfate Soils Management Guidelines (1998) (ASSMAC, 1998);

Dear, S-E., Ahern, C. R., O'Brien, L. E., Dobos, S. K., McElnea, A. E., Moore, N. G. & Watling, K. M., 2014. Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines. Brisbane: Department of Science, Information Technology, Innovation and the Arts, Queensland Government (Dear et al 2014);

NSW Environment Protection Authority (EPA) Waste Classification Guidelines (2014) (EPA, 2014);

NHMRC (2018) Australian Drinking Water Guidelines 6 2011 (v3.5 updated August 2018); and

Sullivan, L, Ward, N, Toppler, N and Lancaster, G 2018, National Acid Sulfate Soils Guidance: National acid sulfate soils identification and laboratory methods manual, Department of Agriculture and Water Resources, Canberra, ACT. CC BY 4.0 (Sullivan et al 2018a).

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Appendix E

Contingency Acid Sulfate Soil Management Strategies

Appendix E
Contingency Options to On-Site Treatment
Cnr Myrtle St and Jasmine St, Botany

E1.0 Introduction

This Appendix provides the contingency options to the selected ASS management option (i.e., on-site treatment).

E2.0 Reburial On-Site

Where possible (and if practical to do so) the PASS can be potentially reburied on site, below the water line / water table provided the soil meets the definition of PASS and the soil is reburied within 24 hours, before the soil has a chance to oxidise. This option would require further excavation in part(s) of the site to allow reburial which will generate further volumes of PASS and potential mixing with overlying fill, and is therefore not considered practicable, but has nonetheless been given for completeness.

Any PASS to be reburied must also meet SAC / RAC requirements.

For the purpose of this ASSMP PASS are defined by NSW Environment Protection Authority (EPA) Waste Classification Guidelines (2014) (EPA, 2014) Part 4 (Acid Sulfate Soils). PASS are defined as:

- They meet the definition of ‘virgin excavated natural material’ (VENM) under the Protection of the Environment Operations Act 1997, even though they contain sulfidic ores or soils.

Where VENM is defined as:

The Protection of the Environment Operations Act 1997 (POEO Act) defines virgin excavated natural material (VENM) as:

‘natural material (such as clay, gravel, sand, soil or rock fines):

(a) that has been excavated or quarried from areas that are not contaminated with manufactured chemicals, or with process residues, as a result of industrial, commercial, mining or agricultural activities and

(b) that does not contain any sulfidic ores or soils or any other waste and includes excavated natural material that meets such criteria for virgin excavated natural material as may be approved for the time being pursuant to an EPA Gazettal notice.’

E3.0 Off-Site Treatment and Disposal

Where on site treatment of PASS is not possible and / or practical then off-site treatment at a facility appropriately licenced to accept and treat such soil can be considered. The below general procedure should be followed for off-site treatment:

The below works will be undertaken:

- Loading the soil into trucks. Note if the soils are wet, they will be heavier than soils as normally transported at field moisture. This should be taken into consideration when loading trucks to ensure that trucks are not overloaded;
- Transport must be conducted in a sealed truck which prevents water leaking from the truck during transport;
- Completion of site records of the above and all information required by the treatment facility, and provision of copies of these records to the treatment facility;
- Transporting of soil to the treatment facility;
- Once the ASS have been accepted by treatment facility they will treat and manage it in accordance with ASSMAC (1998) and their site specific EPL conditions, subject to the verification procedures documented herein. The liming rate will be based on the liming rate presented in this report or based on results that supersede those presented herein), refer to Section 7.2 of this ASSMP;
- Verification of the treatment of the ASS and classification of the soil by an Environmental Consultant in; and
- Transport of the treated, classified ASS to the final receiving site / disposal facility.

E4.0 Off-Site Disposal as PASS

E4.1 PASS Criteria

EPA (2014), Part 4 states that 'Potential ASS may be disposed of in water below the permanent water table, provided:

- The soils meet the definition of VENM in all aspects other than the presence of sulfidic soils or ores;
- The pH of soils in their undisturbed state is pH 5.5 or more;
- The soil has not dried out or undergone any oxidation of its sulfidic minerals;
- Soil is received at the disposal point within 16 hours of excavation, and kept wet at all times between excavation and reburial at the disposal point;
- Appropriate records are provided to the receiving site with every truck load confirming that it meets the above criteria; and
- The receiving site meets its obligations under EPA (2014) and its Licence conditions.

For the purposes of this ASSMP, potential acid sulfate soils (PASS) are defined in accordance with the NSW Environment Protection Authority (EPA) Waste Classification Guidelines (2014) (EPA, 2014) Part 4 (Acid Sulfate Soils).

This classification is applicable for direct disposal of untreated PASS to a landfill licenced by the EPA to accept PASS.

E4.2 Disposal as PASS

The below works will be undertaken by appropriately trained staff:

- Agreement with receiving site on acceptance times for trucks, and allowable time lapse between excavation and acceptance by receiving site;
- Soils will be kept wet at all times, and should be sprayed with water if required to keep them wet;
- Recording of the excavation date, time and source chainage of the excavated soil;
- Inspection of the excavated soil for moisture content, material texture/ signs of contamination concern, such as anthropogenic odours, staining or inclusions by all personnel involved in the management / handling of the spoil;
- If signs of anthropogenic impact or fill are observed, the soil will not be pre-classified as PASS, and the soil will be segregated for further assessment;
- Measuring the pH in at least one sample per 50 m^3, or a minimum of 10 per shift, using a calibrated pH meter in accordance;
- If the pH is less than or equal to 6.5, the soil will not be classified as PASS, and the soil will be segregated for further assessment and treatment);
- Loading the soil into trucks and ensuring the soil is moist enough to prevent it drying out during transport. Note: due to the soils being wet, they will be heavier than soils as normally transported at field moisture (PASS estimated to be approximately 2 tonne/m^3). This should be taken into consideration when loading trucks to ensure that trucks are not overloaded;
- Soil should be loaded and transported as soon as possible to minimise the risk of oxidisation, which prevents it from being classified as PASS;
- Transport must be conducted in a sealed truck which prevents water leaking from the truck during transport;
- Completion of site records of the above;
- Completion of records of all information required by the receiving site, and provision of copies of these records to the receiving site, including copies sent with the truck driver for the load being carried;
- Transporting of soil meeting the PASS requirements to of the receiving site within 16 hours of excavation (or earlier if required by the receiving site);
- Once the PASS have been accepted by the receiving site they are required to manage it in accordance with the their EPL conditions. It is not the role of this document to discuss management of soil once they have been accepted by the receiving site; and
- Any soil which is rejected by receiving will be transported back to the site and managed in accordance with the ASSMP.

E5.0 References

ANZG (2018) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality;*

Acid Sulfate Soils Management Advisory Committee (ASSMAC) Acid Sulfate Soils Management Guidelines (1998) (ASSMAC, 1998);

NSW Environment Protection Authority (EPA) Waste Classification Guidelines (2014) (EPA, 2014); and

Sullivan, L, Ward, N, Toppler, N and Lancaster, G 2018, National Acid Sulfate Soils Guidance: National acid sulfate soils identification and laboratory methods manual, Department of Agriculture and Water Resources, Canberra, ACT. CC BY 4.0 (Sullivan *et a*l 2018a).

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Appendix F

Proposed Site Specific HIL Derivation

Appendix F
HIL Derivation - Benzo(a)Pyrene and Total PAH

F1.0 Background

Previous investigations have been conducted at the site culminating in a detailed site investigation (DSI) (DP, 2021) as summarised in this RAP. The DSI considered that the available data meets the required sampling densities (NSW EPA, 1995) for the total site area, requirements as set out in NEPC (2013) and the *Guidelines for Consultants Reporting on Contaminated Land* (NSW EPA, 2020).

It is therefore considered that the available data and information related to the proposed development is sufficient for a limited risk assessment of key contaminants, namely benzo(a)pyrene (B(a)P).

It is noted as per NEPC (2013) carcinogenic PAH are assessed utilising toxicity equivalence factors (TEF) (alternatively, toxicity equivalence quotients, [TEQ]) for a range of PAH compounds, as relative to the toxicity of B(a)P. The final risk is then expressed as a sum of the equivalent concentrations against the HIL for B(a)P. The HIL for Total PAH is then given as a factor of 100 applied to the B(a)P HIL.

F2.0 Assumptions

NEPC Schedule B7 and Appendix A2 (NEPC, 2013) outline the calculations and underlying assumptions used in the derivation of the generic HIL for the different land-use scenarios for polycyclic aromatic hydrocarbons (PAH). In the derivation of site-specific levels for BaP TEQ the following deviations have been made from the standard assumptions:

- Oral Bioavailability: 40% (*compared to 100%).*

The generic oral bioavailability defaults to a conservative value of 100% in the absence of site-specific assessments. Schedule B7 cites studies for bioavailability ranging from 14-40% and relative absorption factors for PAH of 28%. In addition, Schedule B7 notes that that BaP (and PAH) present in bitumen, is largely immobile and therefore has low bioavailability. Based on the encountered fill, inclusions ash and clinker, and a layer of fly ash were previously encountered. Toxicity characteristic leaching procedure (TCLP) analysis for previous and current results have resulted in leachable concentrations of PAH either below the laboratory quantification limit for all samples. It is therefore considered that the BaP (and PAH) present within the fill is relatively immobile. As such, a less conservative bioavailability of 40% has been adopted.

- Dermal Absorption Factor 2.6% (*compared to 6%).*

The generic value of 6% is adopted within Schedule B7 based on data for freshly spiked soil, as a worst-case scenario. As the fill across the site (based on field observations and site history documentation) is considered to be aged in nature the relatively less conservative value of 2.6% has been adopted as per Schedule B7 for the arithmetic mean based on data for aged soil.

F3.0 Proposed HIL

Based upon the above assumptions, equations outlined in Schedule B7, Appendix B of NEPC (2013) and the HIL calculation spreadsheet available from the ASC NEPM Toolbox website[1] the derivation of site-specific levels for BaP TEQ (and therefore Total PAH) is outlined on the attached Table F1, and summarised as (to one significant figure):

- HIL C BaP TEQ - 8 mg/kg
- HIL C Total PAH - 800 mg/kg

F4.0 References

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

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[1] http://www.nepc.gov.au/nepms/assessment-site-contamination/toolbox. Accessed 12 March 2021.

Derivation of Investigation Levels
HIL C - Recreational

Summary of Exposure Parameters		Abbreviation	units	Parameter	References/Notes
Soil and Dust Ingestion Rate	- Young children (0-5 years)	IR_{SC}	mg/day	50	50% of HIL A assumption, Schedule B7, Table 5
	- Adults	IR_{SA}	mg/day	25	50% of HIL A assumption, Schedule B7, Table 5
Surface Area of Skin	- Young children (0-5 years)	SA_C	cm^2/day	2700	As per enHealth (2012)
	- Adults	SA_A	cm^2/day	6300	As per enHealth (2012) for male and female combined
Soil-to-Skin Adherence Factor		AF	mg/cm^2/day	0.5	Schedule B7, Table 5
Time Spent Outdoors		ETo	hours	2	Schedule B7, Table 5
Time Spent Indoors		ETi	hours	0	Schedule B7, Table 5
Lung Retention Factor		RF	-	0.375	Schedule B7, Table 5
Particulate Emission Factor		PEFo	(m^3/kg)	2.6E+07	As per Equation 21 based assumptions presented in Schedule B7
Outdoor Air-to-Soil Gas Attenuation Factor		α	-	0.05	Value adopted as discussed in Section 5.5 of Schedule B7
Body weight	- Young children (0-5 years)	BW_C	kg	15	Schedule B7, Table 5
	- Adults	BW_A	kg	70	Schedule B7, Table 5
Exposure Frequency		EF	days/year	365	Schedule B7, Table 5
Exposure Duration	- Young children (0-5 years)	ED_C	years	6	Schedule B7, Table 5
	- Adults	ED_A	years	29	Schedule B7, Table 5
Averaging Time (non-carcinogenic)		AT_T	days	ED*365	Calculated based on ED for each relevant age group, multiplied by 24 hours for the assessment of inhalation exposures
Averaging Time (carcinogenic)		AT_{NT}	days	25550	Based on lifetime of 70 years, multiplied by 24 hours for the assessment of inhalation exposures

Threshold Calculations - Young Child Aged 2-3 years

Compound	**Toxicity Reference Value Oral (TRV$_O$)** (mg/kg/day)	**GI Absorption (GAF)** (unitless)	**Toxicity Reference Value Dermal (TRV$_D$)** (mg/kg/day)	**Oral Bioavailability BA$_O$ (%)**	**Dermal Absorption Factor (DAF)** (unitless)	**Background Intake Oral/Dermal (BI$_O$)** (% of TDI)	**Toxicity Reference Value Inhalation (TRV$_I$)** (mg/m^3)	**Tolerable Daily Intake Inhalation (TDI)** (mg/kg/day)	**Background Intake Inhalation (BIi)** (% of TC)		**Pathway Specific HILs (mg/kg)**			**Soil Vapour HIL (mg/m^3)** (eqn 12)	**Derived Interim Soil Gas HIL - Threshold (to 1 or 2 s.f.)** (mg/m3)	**Derived Soil HIL (not rounded)** (mg/kg) (eqn 2 for relevant pathways)	**Derived Soil HIL (to 1 or 2 s.f.)** (mg/kg)	**Pathways Included Dermal Absorption**	**Notes**
											Soil Ingestion (eqn 3)	**Dermal** (eqn 6)	**Dust** (eqn 9)						
arsenic	0.002	1	0.002	100%	0.005	50%	0.001	2.9E-04	0%		3.0E+02	2.2E+03	8.2E+05			264	**300**	**y**	
beryllium	0.002	0.007	0.000014	100%	0.001	30%	0.000020	5.7E-06	0%		4.2E+02	1.1E+02	1.6E+04			86	**90**	**y**	
boron	0.2			100%		65%	0.7	0.2	65%		2.1E+04	NA	2.0E+08			20998	**20000**	**n**	
cadmium	0.0008			100%		60%	0.000005	1.4E-06	20%		9.6E+01	NA	3.3E+03			93	**90**	**n**	
chromium (VI)	0.001			100%		10%	0.0001	2.9E-05	0%		2.7E+02	NA	8.2E+04			269	**300**	**n**	
cobalt	0.001	1	0.0014	100%	0.001	20%	0.0001	2.9E-05	0%		3.4E+02	1.2E+04	8.2E+04			326	**300**	**y**	
copper	0.14			100%		60%	0.49	0.14	60%		1.7E+04	NA	1.6E+08			16798	**17000**	**n**	
manganese	0.16			100%		50%	0.00015	4.3E-05	20%		2.4E+04	NA	9.8E+04			19296	**19000**	**n**	
methyl mercury	0.00023	1	0.00023	100%	0.001	80%	0.000805	0.00023	80%		1.4E+01	5.1E+02	1.3E+05			13	**13**	**y**	
mercury (inorganic)	0.0006	0.07	0.000042	100%	0.001	40%	0.0002	5.7E-05	10%		1.1E+02	2.8E+02	1.5E+05			78	**80**	**y**	
nickel	0.012	1	0.012	100%	0.005	60%	0.00002	5.7E-06	20%		1.4E+03	1.1E+04	1.3E+04			1157	**1200**	**y**	
selenium	0.006			100%		60%	0.021	0.006	60%		7.2E+02	NA	6.9E+06			720	**700**	**n**	
zinc	0.5	1	0.5	100%	0.001	80%	1.75	0.5	80%		3.0E+04	1.1E+06	2.9E+08			29208	**30000**	**y**	
cyanide (free) (no VI)	0.006	1	0.006	100%	0.1	50%	0.0008	2.29E-04	0%		9.0E+02	3.3E+02	6.6E+05			243	**240**	**y**	
TCE							0.002	0.001	10%		NA	NA	NA	4.3E-01	**0.4**				
1,1,1-TCA							5	1.4	0%		NA	NA	NA	1.2E+03	**1200**				
PCE							0.2	0.057	10%		NA	NA	NA	4.3E+01	**40**				
cis-1,2-dichloroethene							0.007	0.002	0%		NA	NA	NA	1.7E+00	**2**				
phenol	0.7	1	0.7	100%	0.1	30%	0.035	0.01	30%		1.5E+05	5.4E+04	2.0E+07			39651	**40000**	**y**	
pentachlorophenol	0.003	1	0.003	100%	0.24	0%	0.0105	0.003	0%		9.0E+02	1.4E+02	8.6E+06			120	**120**	**y**	
cresols	0.1	1	0.1	100%	0.1	50%	0.35	0.1	50%		1.5E+04	5.6E+03	1.4E+08			4054	**4000**	**y**	
DDX	0.002	1	0.002	100%	0.018	0%	0.007	0.002	0%		6.0E+02	1.2E+03	5.7E+06			404	**400**	**y**	
aldrin and dieldrin	0.0001	1	0.0001	100%	0.1	10%	0.00035	0.0001	10%		2.7E+01	1.0E+01	2.6E+05			7.3	**10**	**y**	
chlordane	0.0005	1	0.0005	100%	0.04	0%	0.00175	0.0005	0%		1.5E+02	1.4E+02	1.4E+06			72	**70**	**y**	
endosulfan	0.006	1	0.006	100%	0.1	30%	0.021	0.006	30%		1.3E+03	4.7E+02	1.2E+07			341	**340**	**y**	
endrin	0.0002	1	0.0002	100%	0.1	0%	0.0007	0.0002	0%		6.0E+01	2.2E+01	5.7E+05			16	**20**	**y**	
heptachlor	0.0001	1	0.0001	100%	0.1	0%	0.00035	0.0001	0%		3.0E+01	1.1E+01	2.9E+05			8.1	**10**	**y**	
HCB	0.00016	1	0.00016	100%	0.1	0%	0.00056	0.00016	0%		4.8E+01	1.8E+01	4.6E+05			13	**10**	**y**	
methoxychlor	0.005	1	0.005	100%	0.1	0%	0.0175	0.005	0%		1.5E+03	5.6E+02	1.4E+07			405	**400**	**y**	
mirex	0.0002	1	0.0002	100%	0.1	0%	0.0007	0.0002	0%		6.0E+01	2.2E+01	5.7E+05			16	**20**	**y**	
toxaphene	0.00035	1	0.00035	100%	0.1	10%	0.001225	0.00035	10%		9.5E+01	3.5E+01	9.0E+05			26	**30**	**y**	
2,4,5-T	0.01	1	0.01	100%	0.1	0%	0.035	0.01	0%		3.0E+03	1.1E+03	2.9E+07			811	**800**	**y**	
2,4-D	0.01	1	0.01	100%	0.05	0%	0.035	0.01	0%		3.0E+03	2.2E+03	2.9E+07			1277	**1300**	**y**	
MCPA	0.01	1	0.01	100%	0.1	0%	0.035	0.01	0%		3.0E+03	1.1E+03	2.9E+07			811	**800**	**y**	
MCPB	0.01	1	0.01	100%	0.1	0%	0.035	0.01	0%		3.0E+03	1.1E+03	2.9E+07			811	**800**	**y**	
mecoprop	0.01	1	0.01	100%	0.1	0%	0.035	0.01	0%		3.0E+03	1.1E+03	2.9E+07			811	**800**	**y**	
picloram	0.07	1	0.07	100%	0.1	0%	0.245	0.07	0%		2.1E+04	7.8E+03	2.0E+08			5676	**5700**	**y**	
atrazine	0.005	1	0.005	100%	0.1	0%	0.0175	0.005	0%		1.5E+03	5.6E+02	1.4E+07			405	**400**	**y**	
chlorpyrifos	0.003	1	0.003	100%	0.03	50%	0.0105	0.003	50%		4.5E+02	5.6E+02	4.3E+06			249	**250**	**y**	
bifenthrin	0.01	1	0.01	100%	0.1	10%	0.035	0.01	10%		2.7E+03	1.0E+03	2.6E+07			730	**730**	**y**	
PCBs	0.00002	1	0.00002	100%	0.14	0%	0.00007	0.00002	0%		6.0E+00	1.6E+00	5.7E+04			1.3	**1**	**y**	
PBDE Flame Retardants (Br1-Br9)	0.0001	1	0.0001	100%	0.1	80%	0.00035	0.0001	80%		6.0E+00	2.2E+00	5.7E+04			1.6	**2**	**y**	

NA Pathway not of significance for chemical assessed (refer to Appendix A for chemical-specific details)

Non-Threshold Effects - Lifetime Exposures [young child and adult]

Compound	**Toxicity Reference Value Oral (TRV$_O$)** $(mg/kg/day)^{-1}$	**GI Absorption (GAF)** (unitless)	**Non-Threshold Slope Factor Dermal (SFd)** $(mg/kg/day)^{-1}$	**Oral Bioavailability BA$_O$ (%)**	**Dermal Absorption Factor (DAF)** (unitless)		**Toxicity Reference Value Inhalation (TRV$_I$)** $(mg/m^3)^{-1}$	**Non-Threshold Slope Factor Inhalation (SFi)**		**Target Risk (TR)**	**Pathway Specific HILs (mg/kg)**			**Soil Vapour HIL (mg/m^3)** (eqns 13 and 14)	**Derived Interim Soil Gas IL - Threshold (to 1 or 2 s.f.)** (mg/m3)	**Derived Soil HIL (not rounded)** (mg/kg) (eqn 2 for relevant pathways)	**Derived Soil HIL (to 1 or 2 s.f.)** (mg/kg)	**Pathways Included Dermal Absorption**	**Notes**
											Soil Ingestion (eqns 4 and 5)	**Dermal** (eqns 7 and 8)	**Dust** (eqns 10 and 11)						
TCE							0.004	0.0140		1E-05	NA	NA	NA	1.2E+00	**1**				
vinyl chloride							0.0088	0.0308		1E-05	NA	NA	NA	5.5E-01	**0.5**				
benzo(a)pyrene	0.5	1	0.5	**40%**	**0.026**		1.43E-01	0.5		1E-05	1.2E+02	2.9E+01	1.1E+05			23.3	**20**		1
benzo(a)pyrene (Early-Life)	0.5	1	0.5	**40%**	**0.026**		1.43E-01	0.5		1E-05	2.8E+01	1.1E+01	4.3E+04			7.7	**8**		1

NA Pathway not of significance for chemical assessed (refer to Appendix A for chemical-specific details)

1 Refer to Appendix A for discussion on different calculations conducted for benzo(a)pyrene and basis for HIL adopted