Douglas Partners
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Integrated Practical Solutions

Acid Sulfate Soil Management Plan

Proposed Alterations and Additions
1015 Barrenjoey Road, Palm Beach

Prepared for
John Boyd Properties

Project 45391.04
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Acid Sulfate Soil Management Plan
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1. Introduction

Douglas Partners Pty Ltd (DP) has been engaged by John Boyd Properties to complete this acid sulfate soil management plan (ASSMP) in relation to the proposed alterations and additions work at 1015 Barrenjoey Road, Palm Beach (the site). The report was prepared in general accordance with DP's proposal dated 6 June 2021.

The area subject to this ASSMP is defined by the excavation areas related to the proposed development as described in Section 2. DP has previously completed a preliminary contamination and acid sulfate soil assessment at the site (DP 2008a)[1]. DP (2008a) identified potential acid sulfate soils (PASS) at the site. The site is presented in Drawing 1 and Survey Plan No 21251, Appendix B.

This ASSMP has been prepared with reference to the Acid Sulfate Soils Management Advisory Committee (ASSMAC), *Acid Sulfate Soils Manual,* 1998 and other guidance (refer to Section 4) and describes the proposed development, potential off-site impacts, responsibilities, and operational requirements. This ASSMP also outlines for consideration additional investigations to further inform treatment requirements (e.g., presence / absence of acid sulfate soil, liming rate, etc.).

This ASSMP must be read in conjunction with the notes provided in Appendix A and other explanatory information and should be kept in its entirety without separation of individual pages or sections.

2. Site Identification and Proposed Works

The site is located on the south-western side of Barrenjoey Road, between the road and Pittwater, at the southern end of Sandy Beach. The site comprises a rectangular area of 1119 square metres, with a width of about 15 m and a length of about 75 m. The site is identified as Lot 54 of DP 14682. A site layout is presented in Drawing 1, Appendix A.

The site typically slopes gently in a south-westerly direction from the road to the beach, with surface levels falling from about RL 2.0 to about RL 1.5. At the time of the investigation (DP, 2008a) the site was occupied by a two-storey sandstone and clad residence with a slate roof. A clad garage with terrace roof adjoined the north-eastern side of the residence and a detached timber deck and attached service rooms is located approximately 15 m to the south-west of the main residence.

Reference to the supplied structural design drawings for the existing residence indicates that the structures are founded on screw piles.

[1] Douglas Partners Pty Ltd, *Report on Preliminary Contamination and Acid Sulphate Soil Assessment, 1015 Barrenjoey Road, Palm Beach*, Report 45391, dated March 2008 (DP 2008a)

The remainder of the site around the existing structures is generally covered by grass lawns or paved. The lawn between the residence and the detached timber deck has been raised approximately 0.6 m above the general level of the adjacent properties and is supported by sandstone clad retaining walls.

The adjacent properties to the north-west and south-east are occupied by two and three storey residences which extend to within a couple of metres of the common boundaries.

The proposed works will involve an upper storey addition to the front of the building (as viewed from Barrenjoey Road) for a rumpus room space, two guest bedrooms and a bathroom. The upper storey addition will be located above the existing ground level garage and over the existing driveway.

The proposed works will also involve a proposed in ground swimming pool and surrounding fence, and a small deck addition on the Pittwater frontage.

The footprints of the proposed alterations and additions are indicated on Drawing 1, Appendix B.

3. Summary of ASS at the Site

3.1 Background on ASS

Acid sulfate soils (ASS) are naturally occurring sediments that contain iron sulphides, primarily pyrite, commonly deposited in estuarine environments. The occurrence of ASS is associated with areas or regions that have previously been or are currently estuarine environments. Due to changes in sea level or geomorphologic changes to coastal systems, these sediments are often overlain by terrestrial sediments. Moreover, it is noted that whilst ASS are not typically associated with fill, DP has previously encountered this scenario in reclaimed and alluvial areas where ASS has been recorded in the fill, possibly due to a degree of turbation (mixing) occurring with natural and fill sediments either through natural or manmade processes.

When ASS are exposed to air (e.g., due to bulk excavation or dewatering), the oxygen reacts with iron sulphides in the sediment, producing sulphuric acid. This acid can be produced in large quantities and is highly mobile in water. The sulphuric acid can drain into waterways causing severe short and long term socio-economic and environmental impacts, including damage to man-made structures and natural ecosystems.

ASS can also affect human health, including eye irritation and dermatitis from short term exposure of sensitive individuals. Long term exposure to untreated ASS and mobilised heavy metals can have more severe effects on some individuals.

ASS can either be classified as ‘actual acid sulphate soils’ (AASS) which are soils that have already reacted with oxygen to produce acid, or ‘potential acid sulphate soils’ (PASS). PASS are soils containing iron sulphide that have not been exposed to oxygen (e.g., soils below the water table). PASS therefore, have not produced sulphuric acid, but have the potential to do so if exposure to oxygen occurs. For the purposes of this report the term PASS is only used for soils which meet the requirements of EPA *Waste Classification Guidelines* (2014) Part 4 as summarised in Appendix D.

ASS field and laboratory based Action Criteria for determining if material is classified as PASS / AASS is provided in Section D2, Appendix D.

3.2 Soil Profile and Groundwater

Previous investigations by DP included boreholes and CPTs. The conditions encountered in the boreholes was generally described as brown sand, silty sand and clayey sand fill to a depth of up to 0.5 m. Fill was underlain by black clayey sand in Bore 6 and yellow and grey sand layers in all other bores. Fragments of asbestos cement were noticed on the ground surface around Bore 5 (driveway), in the garden beds along the northern fence of the property and between the existing house and the southern fence. Based on the on-site observations, the asbestos cement fragments appeared to be debris of damaged building material left on the ground surface rather than inclusions in the general filling.

Table 1 summarises the subsurface profile encountered during the contamination investigation reported in DP (2008a). The referenced borehole locations are shown on Drawing 1, Appendix A.

Table 1: Subsurface Profile

Sampling Location	Filling / Topsoil (m bgl)	Clayey sand (m bgl)	Yellow Sand (m bgl)	Grey Sand (m bgl)	Completion Depth (m bgl)
1	0-0.05		0.05-2	2-3	3
2	0-0.1		0.1-3		3
3	0-0.1		0.1-1	1-3	3
4	0-0.5		0.5-2	2-3	3
5	0-0.5			0.5-3	3
6	0-0.5	0.5-3			3

The results of the CPTs indicate that most of the site is underlain by sand to depths of more than 14 m, with a few thin layers of silty sand and silty clay. CPT 5, the most northern test, was terminated at a depth of 10 m within very stiff to hard clay which is possibly the top of the weathered rock profile.

The monitoring of the groundwater indicated that at the time of investigation the groundwater was typically about 1 m below existing ground levels, but the water levels are likely to be affected by the tidal variations in Pittwater.

3.3 ASS Results for the Site (DP, 2008a)

The results of the previous acid sulfate soil investigation and borehole logs are provided in Appendix C. The previous investigation found the following:

- The Spos exceeded the adopted action criteria (0.03%S) in sample 5/2.5-3.0 (0.048%S) and sample 6/2.5-3.0 (0.33%S);
- The natural soil was classified as PASS and an acid sulfate soil management plan was recommended; and
- An ASSMP was prepared for the proposed redevelopment works in 2008 (DP 2008b)[2]. A liming rate of 16 kg/tonne was recommended.

The ASSMP is updated in this report as required for the proposed new development works.

3.4 Waste Classification Results for the Site (DP, 2008a)

DP (2008a) included a waste classification for soils that may be removed from the site as part of the proposed development. It is noted that since the report was completed the waste classification guidelines have been revised. DP (2008a) classified the fill at the site as Inert Waste (a category that no longer exists) for the purposes of off-site disposal. Under the current waste classification guidelines the previous test results would generally be consistent with a General Solid Waste (non-putrescible) classification.

Asbestos containing materials (ACM) were observed on the site surface, as noted in Section 3.2. DP recommended that the ACM be removed and the removal validated. If asbestos is present in the fill the material would be classified, as a minimum, as Special Waste (asbestos).

With respect to the natural soil DP (2008a) noted that PASS cannot be classified as virgin excavated natural material. Treated PASS would, at a minimum, be classified General Solid Waste subject to the confirmation that the material has been successfully treated (neutralised) in accordance with this ASSMP.

The above should be considered preliminary advice only. However, as per Section 7.3 any soils disposed from the site must be assessed in accordance with NSW EPA Waste Classification Guidelines 2014.

4. Guidelines

This ASSMP is devised on the basis of the following guidelines endorsed by the NSW EPA and with reference to other national guidelines where considered appropriate:

- Acid Sulphate Soils Management Advisory Committee (ASSMAC) *Acid Sulphate Soils Management Guidelines* (1998) (Stone, Ahern, & Blunden, 1998).

[2] *Report on Preliminary Acid Sulphate Soil Management Plan, Proposed New Residence, 1015 Barrenjoey Road, Palm Beach*, Project 45391.01 dated August 2008 (DP 2008b).

- NSW Environment Protection Authority (EPA) *Waste Classification Guidelines* (2014) (NSW EPA, 2014).
- NSW Roads and Traffic Authority (RTA) *Technical Guideline: Guidelines for the Management of Acid Sulfate Materials: Acid Sulfate Soils, Acid Sulfate Rock and Monosulfidic Black Ooze* (NSW RTA, 2005).
- 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 2018).
- QASSIT/Qld NRM&E/SCU/NatCASS/QASSMAC/ASSMAC Acid Sulfate Soils Laboratory Methods Guidelines Version 2.1 - June 2004. Published by Department of Natural Resources, Mines and Energy, Indooroopilly, Queensland, Australia (Qld NRM&E, 2004) (this guideline supersedes the laboratory section of ASSMAC, 1998).

5. Management Options and Proposed Management Strategies

5.1 Application of ASS Management

The ASS investigation reported in DP (2008a) indicated that PASS are likely to be present in the natural sands at the site. This ASSMP therefore applies to natural sands to be disturbed as part of the proposed works, unless otherwise confirmed by additional sampling and laboratory analysis not to be PASS.

5.2 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.

For all management strategies dust should be kept to a minimum, and long sleeves, pants and gloves should be worn by workers in direct contact with untreated ASS.

6. Further Assessment of Potential ASS / Non-ASS Materials

Given that the potential to encounter ASS generally increases in probability with depth in high risk areas, and that the preliminary ASS investigation characterised all the natural sand as PASS, it is possible that the shallower / near surface material could be re-classified if subject to further assessment. Therefore, additional ASS investigations could be undertaken to attempt to better define the vertical extent of PASS present at the site and reduce the ASS treatment and management requirements.

It is noted that if additional investigations are not undertaken, all natural sands bgl are to be assumed to be PASS and managed in accordance with this ASSMP.

On this basis additional works may comprise:

- Investigations to at least 0.5 m below the final depth of soil disturbance (i.e., pile depth, service excavation);
- A minimum of four boreholes drilled in the footprint of the proposed works.
- Collection of samples at regular intervals (i.e., approximately 0.5-1 m intervals);
- Screening of samples for indication on the potential presence of ASS;
- Laboratory analysis (e.g., SCr) of selected samples based on the screening results and to provide delineation through the subsurface profile (both vertically and laterally); and
- Assessment report which determines the presence / absence of ASS within the range to be disturbed by the works and if ASS management of disturbed soils is required.

7. ASS Management

The management requirements for this plan are detailed in this section and the following sections. On site neutralisation, management, monitoring and verification of ASS should be undertaken as required using the methodology given below.

7.1 On-Site Treatment

7.1.1 Treatment Process for Soils

The general process for the treatment of ASS is as follows:

- Prepare a treatment pad as described in Section 7.1.3. Manage ASS 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 material with plastic sheeting to reduce the formation of leachate;
- Excavate, transport and stockpile ASS material to the treatment area in sealed trucks (or other plant as appropriate);

- Spread the ASS material onto the guard layer in layers of up to 0.3 m thick, 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;
- If using a skip bin, spread the ASS into the bin in layers of up to 0.3 m thick, taking care not to churn up the lime guard layer;
- Let the ASS dry to facilitate lime mixing (if too wet, then adequate mixing of lime cannot be achieved). This may be assisted by stockpiling prior to spreading over the treatment area(s);
- Apply ag lime to the stockpiled soil (refer to Section 7.1.2 and Appendix E for treatment rate information) over each spread layer and harrow / mix thoroughly prior to spreading the next layer. Use of a rotary plough equipment (e.g., auger bucket) should be considered to assist with achieving a consistent mix of lime in the clay. Take care not to excavate into the lining of the treatment pad;
- Assess the success of the treatment using verification testing in accordance with Section 8. Samples should be collected using plant to ensure sampling characterises the full depth of material in the treated layer. The verification testing has two components: field screening and laboratory analysis. Laboratory analysis is to be undertaken after the field screening results have passed;
- If field screening results indicate that additional neutralisation is required, add additional lime and mix;
- Once field screening results have passed, an additional layer(s) of ASS can be added and treated as long as a methodology exists for treating any underlying layer that fails the laboratory testing;
- When verification testing indicates that lime neutralisation is complete, then the stockpiled soil may be removed from the treatment pad, or left on the pad for additional soil to be treated on (as required);
- Continue the spreading / liming / mixing cycle until excavation and stockpiling of ASS is finished. This can be done one layer at a time, or with multiple ASS layers placed on top of each other;
- When verification testing indicates that lime neutralisation is complete, then the soil may be removed from the treatment area and disposed off-site to a suitable facility or reused on site subject to its suitability from both a contamination and geotechnical perspective; and
- Management of water as per Section 9.

Due to the potential for asbestos contamination in soils as outlined in Section 3.4, appropriate controls are to be implemented should asbestos be identified in soils requiring ASS treatment.

7.1.2 Liming Rate

Based on the results of DP (2008a), the liming rates calculated from DP (2008a) are 2.7 and 4.3 kg$CaCO_3$/t. These rates provide a general indication of the required liming rates given the variation in the soil. Further testing of the material under Section 6 or once stockpiled can confirm the required liming rate. Alternatively, depending on the quantity of soil, a worst-case liming rate based on the current laboratory results may be adopted as an initial approach (with confirmation on the suitability of the liming rate applied required by validation testing).

Reference should be made to Appendix E for the equations for calculation liming rates.

7.1.3 Neutralisation Pads and Treatment of Soils

On-site treatment can be undertaken on a prepared treatment pad, with a leachate collection system. These need to be of sufficient size and capacity to allow treatment of the required volumes of soil in the required time frames, with an allowance for some “batches” of treated soil not meeting the required neutralisation criteria and requiring additional treatment.

The key features of the treatment area and design considerations are summarised below and shown in Figure 1 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) or 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. If the hardstand concrete (or suitably sealed asphalt surface) is utilised as a treatment pad, then no lining would be required subject to initial inspection confirming it is in good condition;
- **Guard Layer** - A guard layer of fine agricultural lime (‘ag lime’) is to be applied over the pad to neutralise downward seepage at a rate of 20% of the liming rate per 1 m^2 and for every 1 m height of the stockpile. The guard layer should be re-applied following removal of treated soils and 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
- **Bunded** - 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 1 below, shows a cross section of a typical treatment pad, should a pad be used.

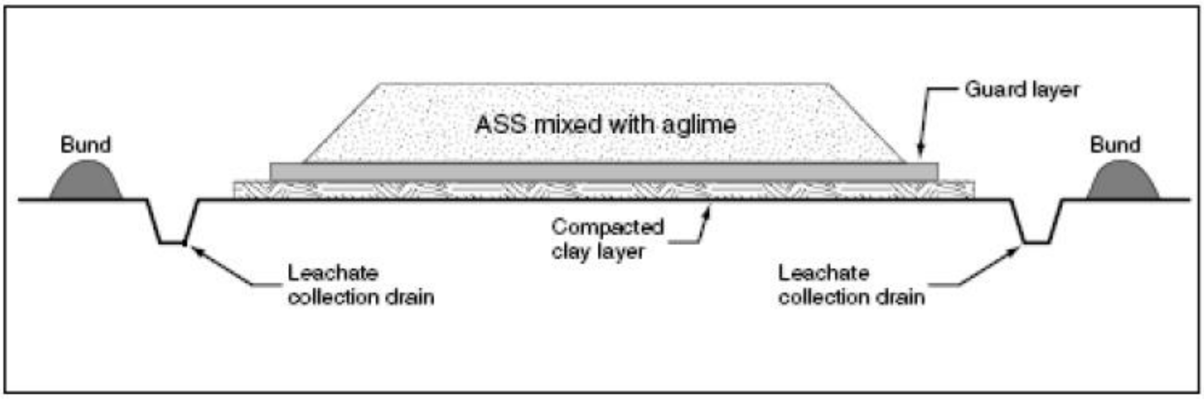


Figure 1: Schematic cross-section of a treatment pad, including clay layer (or hardstand concrete layer), guard layer, leachate collection system and containment with bunding.

Whilst it is standard practice to construct treatment areas for ASS, given the relatively small volume of impacted soils that may be progressively generated by the works (as indicated in Section 2) consideration may be given to the temporary storage and / or treatment to take place in small manageable batches, as follows:

- Place manageable volumes in a sealed container such as a lined metal skip bin;
- HDPE sheet liner to line the bin;
- Application of a thin (10 kg/m^2) ag lime guard layer dispersed over the bottom of the bin liner; and
- Plastic covering over the material pile to cover from wind and rain.

It is anticipated that this treatment system will be the preferred approach for the works, given that only minor excavations are proposed.

7.2 Neutralisation Materials for Soils

Agricultural lime, commonly known as ag lime, 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, ag lime is slightly alkaline (pH of 8.5 to 9), non-corrosive, of low solubility and does not present handling problems. Ag lime comprises calcium carbonate ($CaCO_3$), typically made from limestone that has been finely ground and sieved to a fine powder.

Ag lime with the following properties is the preferred neutralising agent:

- Fine ground (particle size of at least <0.5 mm; but preferably <0.3 mm);
- At least 95% (but preferably 98% or more) calcium carbonate by weight;
- Neutralising value of at least 95%, but preferably equal to or greater than 98%;
- Produce alkalinity in the pH 7 to pH 9 range;
- Low solubility; and
- Dry.

Ag lime requires no special handling, however, it would be advisable to cover any ag lime stockpiles with plastic sheeting (e.g., tarpaulin) both to minimise wind erosion and wetting, as the material is more difficult to spread when wet.

Ag lime with a neutralising value (NV) of 95% to 98% is recommended. There could be economic justification for using a less pure grade of ag lime, however, this would require a higher application rate, requiring the lime dosing rates given in Section 9.4 to be adjusted accordingly. Potential cost savings from using less pure material may be offset by the corresponding increase in required volumes, the transport and disposal costs.

Coarse grained calcite is not recommended, as one of the products of the neutralisation reaction is gypsum ($CaSO_4.2H_2O$) which has a relatively low solubility and tends to coat the reacting calcite grain, forming a partial barrier against further reaction.

Gypsum may also give off hydrogen sulphide in reaction with acidic conditions and can itself result in the generation of sulphuric acid.

Dolomitic ag lime, or magnesium blend ag lime, should not be used as these materials impose environmental risks from overdosing with the potential to damage estuarine ecosystems.

Due to its low solubility in water, ag lime 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.

An alternative neutralising material can be used subject to prior approval by a suitably qualified scientist or engineer.

7.3 Off-Site Disposal of Soils

If treated or untreated material is to be disposed of offsite, assessment and material tracking will be undertaken in accordance with the requirements of the POEO Act 1997. Transport and disposal will be undertaken in accordance with the Protection of the Environment Operations (Waste) Regulation 2014 (POEO Waste Regulation) and EPA (2014).

All contractors transporting waste from site must be licenced to transport the classification of waste and must only dispose of the waste at a facility that is licenced to accept the waste classification.

7.4 On-Site Retention of Soils

Subject to conditions and verification testing outlined in section 7.1.1, treated soils may be retained and reused on site from an ASS perspective. Consideration should, however, be given to the suitability of these soils for on-site reuse from contamination, geotechnical and / or other perspectives.

7.5 Alternate Strategy or Contingency Plan

Where on-site treatment of ASS is not possible, off-site disposal under alternative management options are described in Appendices D and F.

8. Verification Testing of Treated Materials

The verification testing frequency of treated ASS is presented in Table 2 below. Section D3, Appendix D outlines the adopted criteria to verify the success of the neutralisation treatment.

Table 2: Verification Testing Frequency

Test	Frequency
Field test: pHF and pHFox screening	Field test: • 3 samples per material type of treated soil; and • 5 samples per 100 m^3 of treated soil; and • 3 samples per treatment batch.
Laboratory analysis: SPOCAS / SCr Method (preferred)	Laboratory analysis: • 1 sample per material type of treated soil; and • 1 sample per 75 m^3 of treated soil; and • 2 samples per treatment batch.

The soil contained within the bunded treatment area should not be removed until the target values presented in Section D3 (Appendix D) have been achieved.

It should be noted that laboratory tests will require a minimum of four 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.

9. 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 provides some margin for unattended weekend or holiday periods as well as heavy rain periods.

The presence of ASS on-site potentially impacts upon the groundwater and surface water, requiring treatment. All water which has come into contact with ASS requires assessment prior to off-site disposal. The screening criteria and water monitoring frequencies required for stormwater disposal are to be confirmed by Council.

In addition, the pH of all ponded drainage water around the confines of the treatment bunds should be measured daily and results assessed against the criteria provided in

The below sections provide general strategies for management, assessment and disposal of water leaching from stockpiled ASS, or required to be managed to facilitate the proposed works.

Further advice is to be sought from the environmental consultant information for managing water impacted by ASS as and when required.

9.1 Leachate and Surface Water Collection

All water that has been in contact with ASS / assumed ASS, and is not part of the general creek flow, must be managed, assessed, treated and appropriately disposed off-site.

9.2 Water Storage and Treatment

Water from ASS leachate will be stored in a tank or lined drains / detention basin.

As 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.

9.3 Water Assessment for Disposal

Minimum recommended monitoring and testing of water to be managed is provided in Table 3, below.

Table 3: Suggested Water Monitoring Frequencies and Target Levels for Water Disposal to Stormwater and

<table>
<tr><th>Test</th><th>Frequency / Location</th><th>Target Level</th></tr>
<tr><td>pH</td><td rowspan="3">Water detention basin / tank (and treatment plant if applicable):
• During storage / treatment as required to allow timely treatment;
• Less than 24 hours prior to any planned discharge;
• Daily during discharge period; and
• For unplanned discharges (i.e., due to rain), within 5 days of the cessation of the rainfall event
Creek:
• Up-gradient of works prior to and then daily during soil disturbance works to provide a baseline; and
• Down-gradient of works prior to and then daily during soil disturbance works to monitor for impacts of surface water quality from the works.</td><td>• pH 6.5 to 8.5</td></tr>
<tr><td>Total Suspended Solids (TSS)</td><td>• ≤50 mg/L or equivalent turbidity measure (in NTU) where a statistical correlation between the TSS and turbidity has been determined</td></tr>
<tr><td>Oil and Grease</td><td>• None observable</td></tr>
<tr><td>Iron (total and soluble)</td><td>Water detention basin / tank (and treatment plant if applicable):
• Visual Assessment:
  • Daily during discharge.
• Laboratory Analysis:
  • Immediately prior to disposal; and
  • Weekly checks during discharge period; and
  • As required based on visual observations.</td><td>• No obvious sign of iron staining / settlement
• ≤0.3 mg/L filterable iron</td></tr>
</table>

Test	Frequency / Location	Target Level

	Creek:
	• Visual Assessment:
	  • Daily during discharge.
	• Laboratory analysis:
	  • As required based on visual observations.	

Metals (aluminium, arsenic, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, zinc)	Water detention basin / tank (and treatment plant if applicable):
	• Laboratory Analysis
	  • One round of testing before first disposal of impacted water; and
	  • If first round of testing exceeds target levels, then further testing prior to disposal is required.
	  • As required based on visual observations.
	Creek:
	• Laboratory Analysis:
	  • As required based on visual observations.
		• ANZG (2018) Trigger Levels for 95% Level of Protection for marine water ecosystems if no conditions are available.
		• Background levels for surface waters within the receiving body.

9.4 Treatment

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

Treatment of water is commonly required for pH and TSS. Aeration and removal of TSS also generally decreases metal concentrations in the water.

If a suitable treatment method for man-made contaminants in the water to be disposed of (e.g., oil and grease or metals) cannot be implemented, an alternate disposal method may be required (e.g., to 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).

If impacts to surface water within the receiving body are being experienced, consideration should be given to applying a light covering / dusting of the exposed soils with lime and supplemented with a regularly monitoring of the pH until levels return to baseline readings. Care should be undertaken not to overdose with lime, and hence a progressive application and monitoring approach should be implemented. Use of sediment controls and programming of works when creek water levels are lower should also assist with reducing the generation of suspended solids in the surface waters and the associated potential increase in mobility of contaminants.

9.5 Water Discharge

Water requiring off-site discharge should be disposed in accordance with the POEO Act 1997, relevant guidelines, consents and licences. Consent for discharge should be obtained from the relevant authorities, where appropriate. The approval body for discharge into the stormwater system is Council. Once site water has been effectively treated and assessed to meet the discharge criteria, it can be discharged in accordance with the requirements of the development consent of the relevant consent authority.

10. General Site Monitoring

General site monitoring requirements pertinent to the ASS which should be implemented by responsible parties are provided in Table 4 below.

Table 4: General Monitoring Requirements

Task	Frequency	Standard	Reporting / Record Keeping	Responsibility
Site inspection	Daily	Visual (e.g., staining) /olfactory (e.g., sulfuric odours) signs of ASS	File note	Site supervisor
Monitoring of disturbed excavation areas that are in ASS	Daily	Visual until backfilled or for two days following completion of works.	File note	Site supervisor
Monitoring of ASS treatment area/s	Daily during treatment	Visual pH testing until results show ASS or leachate has been neutralised (refer Section 8 and Appendix D for criteria and testing requirements)	File note and results of pH testing to be recorded in field sheets	Site supervisor
Dewatering excavation in ASS (if required)	Prior to planned discharge	Treated and tested to demonstrate compliance with requirements prior to discharge.	Field sheets and site records	Site supervisor / environmental consultant

11. Emergency Incident Response Plan

Site work activities which may cause potential environmental threats are summarised in Table 5 below together with recommendations for "Emergency Response Procedures".

Table 5: Emergency Response Procedures

Works	Potential Environmental Threat	Emergency Response
Excavations / Soils Disturbance	Impacts to groundwater / surface water due to release of elevated acid (via PASS oxidisation) into creek from excavations.	• Inform site foreman and project manager / environmental officer; • Determine pH of groundwater / surface water in creek; • Implement sediment controls down-gradient of impacted areas (as appropriate); • Applying light dosing of lime to exposed soils (refer to Sections 7.1, 7.2 and 9.4); and • If appropriate (following consultation with the environmental consultant) drain pit to tanks for
Treatment / Neutralisation	Soil washes or slips outside of bunded treatment area	• Inform site foreman and project manager / environmental officer; • Estimate volume of material breeching bund; • Conduct pH analysis of adjacent water collection points (e.g., open trenches, stormwater pits, etc.) and correct pH if potentially impacted (if feasible); • Remove breeched soil into a bunded treatment area; and • Over-excavate impacted area to 0.2 m depth
	Breach in containment bund	• Inform site foreman and project manager / environmental officer; • Close breach in bund; and • Conduct pH analysis of adjacent water collection points (e.g., open trenches, stormwater pits, etc.) and correct pH if potentially impacted (if feasible).

For all site works where incidents which pose an environmental threat, an incident report must be completed in order that:

- The cause of the incident may be determined;
- Determine how the incident occurred;
- Additional control measures may be implemented; and
- Work procedures may be modified to reduce the likelihood of the incident re-occurring.

12. Reporting and Record Keeping

It is good practise for the contractor to maintain a record of treatment of ASS. Such record should include the following details:

- Date;
- Location / area;
- Time of excavation;
- Neutralisation process undertaken;
- Lime rate utilised;
- Results of monitoring;
- Assessment, treatment and management of groundwater;
- Disposal permits or authority;
- Disposal location(s) and times; and
- Tonnages and disposal / transfer dockets (if applicable).

A record should also be maintained confirming contingency measures and additional treatment if undertaken. A final report should be issued upon completion of the works presenting the monitoring regime and results and confirming that adverse environmental impact has not occurred during the works.

13. Conclusions

This ASSMP provides management methods and procedures to minimise the environmental impacts resulting from the disturbance of ASS during the proposed alterations and additions to the site, discussed herein. It also provides recommendations for neutralisation and treatment methods for the ASS, verification testing requirements, groundwater management strategies and emergency response procedures.

14. References

- Acid Sulphate Soils Management Advisory Committee (ASSMAC) *Acid Sulphate Soils Management Guidelines* (1998) (Stone, Ahern, & Blunden, 1998).
- Douglas Partners Pty Ltd Report on Preliminary Contamination and Acid Sulphate Soil Assessment, 1015 Barrenjoey Road, Palm Beach, Report 45391, dated March 2008 (DP 2008a)
- Douglas Partners Pty Ltd Report on Preliminary Acid Sulphate Soil Management Plan, Proposed New Residence, 1015 Barrenjoey Road, Palm Beach, Project 45391.01 dated August 2008 (DP 2008b).
- NSW Environment Protection Authority (EPA) *Waste Classification Guidelines* (2014) (NSW EPA, 2014).

- NSW Roads and Traffic Authority (RTA) *Technical Guideline: Guidelines for the Management of Acid Sulfate Materials: Acid Sulfate Soils, Acid Sulfate Rock and Monosulfidic Black Ooze* (NSW RTA, 2005).
- 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 2018).
- QASSIT/Qld NRM&E/SCU/NatCASS/QASSMAC/ASSMAC Acid Sulfate Soils Laboratory Methods Guidelines Version 2.1 – June 2004. Published by Department of Natural Resources, Mines and Energy, Indooroopilly, Queensland, Australia (Qld NRM&E, 2004) (this guideline supersedes the laboratory section of ASSMAC, 1998).

15. Limitations

Douglas Partners (DP) has prepared this report for this project at 1015 Barrenjoey Road, Palm Beach in accordance with DP's email proposal dated 6 July 2022. The work was carried in accordance with DP's Conditions of Engagement.

This report is provided for the exclusive use of Mr John Boyd and his agents and only for the purposes as described in the report. It should not be used by or be relied upon for other projects or purposes on the same or another site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this 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 previous investigations. 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 (geotechnical / environmental / groundwater) 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.

Douglas Partners Pty Ltd

Appendix A

Notes About this Report

Introduction

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

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

Copyright

This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

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

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

Groundwater

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

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

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

Reports

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

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

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

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

About this Report

Site Anomalies

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

Information for Contractual Purposes

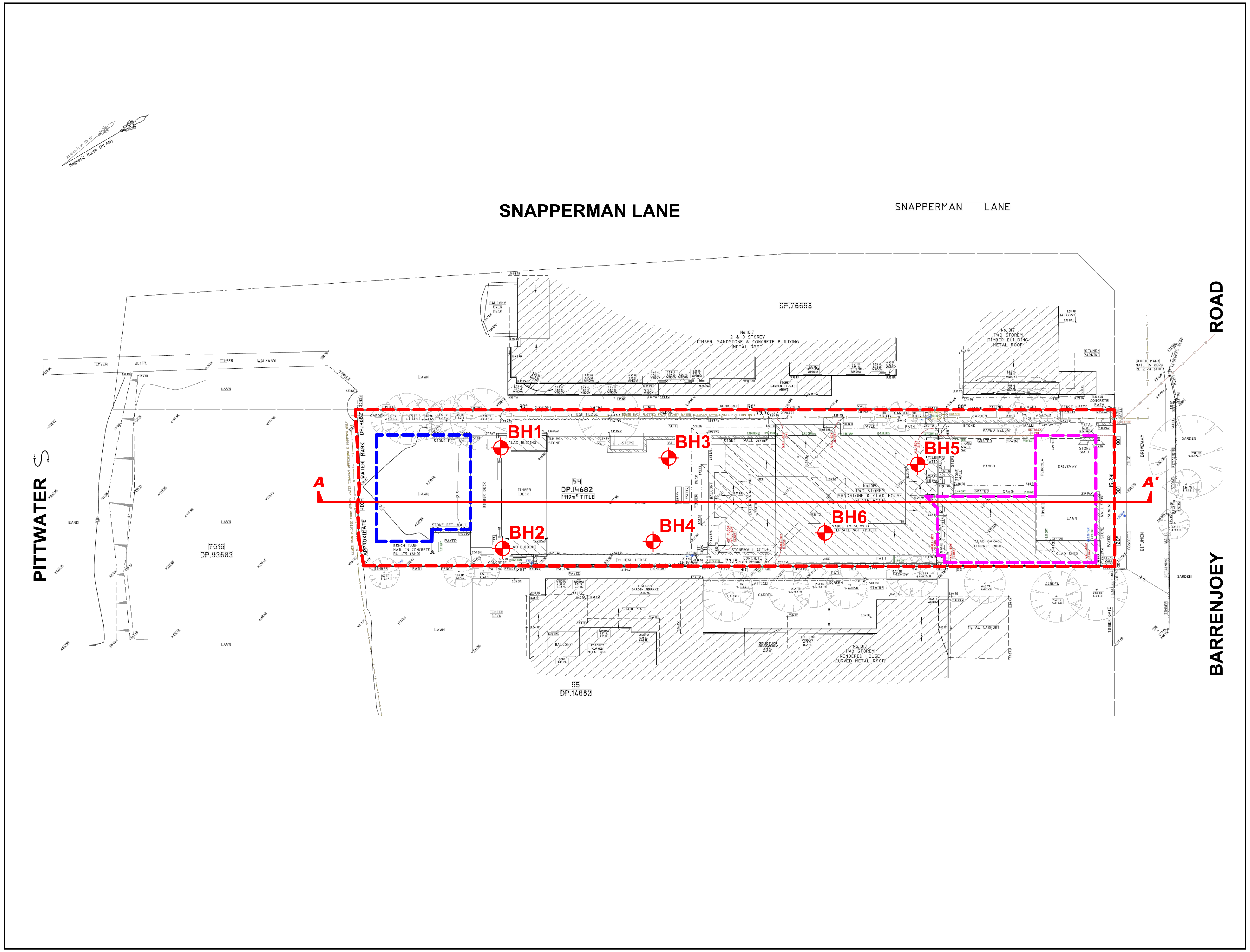
Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate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

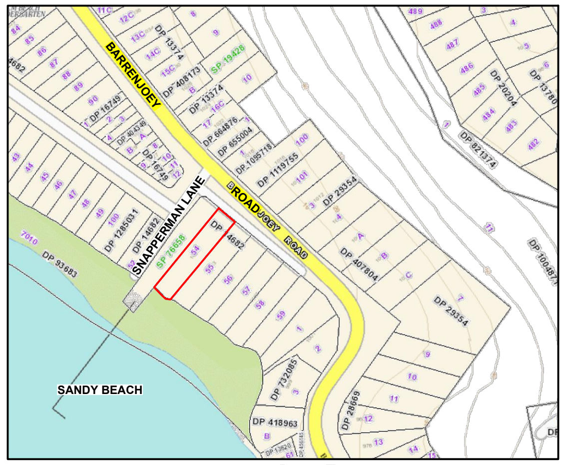
Site Inspection

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

Appendix B

Drawing





Locality Plan

LEGEND

- Approximate Site Boundary
- Previous Test Bore + CPT
- Proposed Swimming Pool Outline
- Proposed Upper Storey Additions
- Geological Cross Section A-A' (Refer to Drawing 2)

NOTE:
1: Base Survey Plan from CMS Surveyors Pty Ltd, 21251detail-Issue 1 (Dated 07/04/2022)

0 2 4 6 8 10 15 20 30 40m
1:400 @ A3

Douglas Partners
Geotechnics | Environment | Groundwater

CLIENT: Mr. John Boyd		TITLE: **Site Plan**
OFFICE: Sydney	DRAWN BY: CC	**Proposed Alterations and Additions**
SCALE: 1:400 @ A3	DATE: 02.09.2022	**1015 Barrenjoey Road, Palm Beach**

PROJECT No:	45391.04
DRAWING No:	1
REVISION:	0

Appendix C

DP (2008) Summary of ASS Results and Borehole Logs

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Results of Acid Sulphate Soil Screening and SPOCAS Analysis (from DP Report 45391)

Sample ID	Sample Description+	Screening Results				SPOCAS Results								
		pH^			Strength of Reaction^^	pH^			Acid Trail (mol H^+/tonne)			Sulphur Trail (%)		
		field (H_2O)	Ox	Change		KCl	Ox	Change	TAA	TPA	TSA	S_{KCL}	S_p	S_{POS}
1/1.0-1.5	yelow fine to medium grained sand	8.4	7.8	-0.6	1	-	-	-	-	-	-	-	-	-
1/2.5-3.0	grey fine to medium grained sand with some shells	8.3	7.1	-1.2	2	-	-	-	-	-	-	-	-	-
2/1.0-1.5	yelow fine to medium grained sand	8.7	7.8	-0.9	2	-	-	-	-	-	-	-	-	-
2/1.5-2.0		8.4	7.4	-1	1	-	-	-	-	-	-	-	-	-
2/2.5-3.0		8.4	7.4	-1	1	-	-	-	-	-	-	-	-	-
3/0-0.1	dark brown silty sand filling with organic matter and roots	8.7	7.6	-1.1	2	-	-	-	-	-	-	-	-	-
3/1.0-1.5	grey fine to medium grained sand	7.7	6.9	-0.8	2	-	-	-	-	-	-	-	-	-
3/2.5-3.0	grey fine to medium grained sand with some shell inclusions	8	6	-2	2	-	-	-	-	-	-	-	-	-
4/0-0.5	dark brown clayey sand filling with organic matter and roots	8.4	7.2	-1.2	2	-	-	-	-	-	-	-	-	-
4/0.5-1.0	yelow fine to medium grained sand	8.19	7.9	-0.29	2	-	-	-	-	-	-	-	-	-
4/1.0-2.0		8.1	7	-1.1	2	-	-	-	-	-	-	-	-	-
4/2.0-3.0	grey fine to medium grained sand with some shell inclusions	7.7	6.7	-1	2	-	-	-	-	-	-	-	-	-
5/0-0.5	dark brown silty sand filling with organic matter, roots, ceramic and asbestos fragments	8.3	7	-1.3	3	-	-	-	-	-	-	-	-	-
5/1.0-1.5	grey fine to medium grained sand	7.9	6.7	-1.2	1	-	-	-	-	-	-	-	-	-
5/2.5-3.0	grey fine to medium grained sand with some shell inclusions	7.6	4	-3.6	2	8.2	3.7	-4.5	<5	5	5	<0.005	0.05	**0.048**
6/0.5-1.0	black clayey sand	8	6.7	-1.3	2	-	-	-	-	-	-	-	-	-
6/2.5-3.0	black clayey sand with some shell inclusions	7.7	5.5	-2.2	3	9	7.1	-1.9	<5	5	5	0.011	0.34	**0.33**
Assessment Criteria														
Guideline		<4*	<3.5**	≤-1**	-	<4*	<3.5**	≤-1**	-	-	18#	-	-	0.03#

Notes: field non-oxidised pH (taken in field)
KCl non-oxidised pH (taken in laboratory)
Ox oxidised pH
Change Ox pH – field/KCl pH
TAA Total Actual Acidity
TPA Total Potential Acidity
TSA Total Sulphidic Acidity (TPA-TAA)
KCl extractable sulphur
S_P peroxide sulphur (after peroxide digestion)
S peroxide oxidisable sulphur ($S_P – S_{KCl}$)
\+ provides brief description only, full material description given in Test Bore Reports, Appendix C
* for Actual Acid Sulphate Soil
** Indicative value only, for Potential Acid Sulphate Soil
\# ASSMAC Action Criteria for disturbance of more than 1000 tonnes, all textures

^^Strength of Reaction
1 denotes no or slight reaction
2 denotes moderate reaction
3 denotes vigorous reaction
4 denotes 'volcanic' reaction

BOREHOLE LOG

CLIENT: John Boyd
PROJECT: New Residence
LOCATION: 1015 Barrenjoey Road, Palm Beach

SURFACE LEVEL: 1.50
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 1
PROJECT No: 45391
DATE: 13 Feb 08
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	FILLING (topsoil) - dark brown silty sand filling with some organic matter, roots, moist		A	0.0 – 0.05				
		SAND - very loose to loose, yellow, fine to medium grained sand, damp							
1		- yellow sand, saturated		A	1.0			▼ (1.0)	
				S	1.0 – 1.45		3,4,3 N = 7		
0				S	1.5 – 1.95		1,0,2 N = 2		
2	2.0	SAND - very loose to loose, grey fine to medium grained sand, with some shells, saturated		S	2.0 – 2.45		1,0,2 N = 2		
-1				A	2.45 – 2.5				
				S	2.5 – 2.95		2,4,3 N = 7		
3				S	3.0 – 3.45		1,2,1 N = 3		
-2	3.45	Bore discontinued at 3.45m - target depth reached			3.45				
4									
-3									

RIG: Auger **DRILLER:** E Grima **LOGGED:** GN **CASING:** Uncased
TYPE OF BORING: Solid flight auger
WATER OBSERVATIONS: Free groundwater observed at 1.0m during drilling
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: [handwritten initials]
Date: 3/8/08

Douglas Partners
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BOREHOLE LOG

CLIENT: John Boyd	**SURFACE LEVEL:** 1.57	**BORE No:** 2
PROJECT: New Residence	**EASTING:**	**PROJECT No:** 45391
LOCATION: 1015 Barrenjoey Road, Palm Beach	**NORTHING:**	**DATE:** 13 Feb 08
	DIP/AZIMUTH: 90°/--	**SHEET** 1 **OF** 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.1	FILLING (topsoil) - dark brown silty sand filling, with some organic matter and roots		A	0.0 / 0.1				Gatic cover; Backfill
		SAND - very loose to loose, yellow fine to medium grained sand, damp							Bentonite
									Backfilled with gravel
	1	- yellow sand, saturated		A	1.0			▼ 13-02-08	
				S			2,2,4 N = 6		
0		- shell inclusions		A	1.45 / 1.5				
				S			1,1,1 N = 2		
	2				1.95 / 2.0				Machine slotted PVC screen
				S			1,1,4 N = 5		
-1				A	2.45 / 2.5				
				S			3,3,5 N = 8		
	3				2.95 / 3.0				End cap
				S			2,1,2 N = 3		
-2	3.45	Bore discontinued at 3.45m - target depth reached			3.45				
	4								
-3									

RIG: Auger **DRILLER:** E Grima **LOGGED:** GN **CASING:** Uncased

TYPE OF BORING: Solid flight auger

WATER OBSERVATIONS: Free groundwater observed at 1.0m during drilling

REMARKS: Groundwater level measured on 13/02/08 - 1.0m bgl

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: [illegible]
Date: 3/08

Douglas Partners
Geotechnics · Environment · Groundwater

BOREHOLE LOG

CLIENT: John Boyd
PROJECT: New Residence
LOCATION: 1015 Barrenjoey Road, Palm Beach

SURFACE LEVEL: 1.40
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 3
PROJECT No: 45391
DATE: 13 Feb 08
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.1	FILLING (topsoil) - dark brown silty sand filling, with some organic matter and roots, moist		A	0.0 / 0.1				
		SAND - yellow fine to medium grained sand, damp							
	1.0	SAND - very loose to loose, grey, fine to medium grained sand, saturated		A	1.0			▼	
				S	1.45		1,1,2 N = 3		
				S	1.5 / 1.95		2,2,3 N = 5		
		- shell inclusions		S	2.0 / 2.45		1,2,1 N = 3		
				A	2.45 / 2.5				
				S	2.5 / 2.95		1,1,1 N = 2		
				S	3.0 / 3.45		1,2,1 N = 3		
	3.45	Bore discontinued at 3.45m - target depth reached							

RIG: Auger DRILLER: E Grima LOGGED: GN CASING: Uncased

TYPE OF BORING: Solid flight auger

WATER OBSERVATIONS: Free groundwater observed at 1.0m during drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: [handwritten initials]
Date: 3/08

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BOREHOLE LOG

CLIENT: John Boyd
PROJECT: New Residence
LOCATION: 1015 Barrenjoey Road, Palm Beach

SURFACE LEVEL: 1.50
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 4
PROJECT No: 45391
DATE: 13 Feb 08
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		FILLING - dark brown clayey sand filling, with some organic matter and roots, moist		A	0.0 0.05				
	0.5	SAND - very loose, yellow fine to medium grained sand, damp		A	0.5				
1		- yellow sand, saturated		A	1.0			▼	1
				S	1.45		2,2,1 N = 3		
0				S	1.5 1.95		1,0,1 N = 1		
2	2.0	SAND - very loose, grey fine to medium grained sand with some shells, saturated		A	2.0				2
				S	2.45		1,1,2 N = 3		
-1				S	2.5 2.95		1,1,2 N = 3		
3				S	3.0 3.45		1,1,0 N = 1		3
-2	3.45	Bore discontinued at 3.45m - target depth reached							
4									4
-3									

RIG: Auger **DRILLER:** E Grima **LOGGED:** GN **CASING:** Uncased
TYPE OF BORING: Solid flight auger
WATER OBSERVATIONS: Free groundwater observed at 1.0m during drilling
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: 7M
Date: 3/08

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BOREHOLE LOG

CLIENT: John Boyd
PROJECT: New Residence
LOCATION: 1015 Barrenjoey Road, Palm Beach

SURFACE LEVEL: 1.62
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 5
PROJECT No: 45391
DATE: 13 Feb 08
SHEET 1 **OF** 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		FILLING - dark brown silty sand filling, with some organic matter and roots, ceramic and asbestos fragment		A	0.0				Gatic cover; Backfill; Bentonite
	0.5	SAND - very loose, grey fine to medium grained sand, damp			0.5				Backfilled with gravel
1	1	- grey sand, saturated		A*	1.0			▼ (1)	
				S	1.0–1.45		2,2,3 N = 5		
0				S	1.5–1.95		1,0,1 N = 1		
	2	- shell inclusions		S	2.0–2.45		1,0,0 N = 0		Machine slotted PVC screen
-1				A	2.45–2.5				
				S	2.5–2.95		1,0,1 N = 1		
	3			S	3.0–3.45		1,1,1 N = 2		End cap (3)
-2	3.45	Bore discontinued at 3.45m - target depth reached			3.45				
	4								
-3									

RIG: Auger **DRILLER:** E Grima **LOGGED:** GN **CASING:** Uncased
TYPE OF BORING: Solid flight auger
WATER OBSERVATIONS: Free groundwater observed at 1.0m during drilling
REMARKS: *Replicate sample BD1/130208 collected

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: [handwritten initials]
Date: 3/08

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BOREHOLE LOG

CLIENT: John Boyd
PROJECT: New Residence
LOCATION: 1015 Barrenjoey Road, Palm Beach

SURFACE LEVEL: 1.64
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 6
PROJECT No: 45391
DATE: 13 Feb 08
SHEET 1 OF 1

Depth (m)	Description of Strata	Sample Type	Sample Depth	Results & Comments	Water
0.0	FILLING - dark brown silty sand filling, with some organic matter and rootlets, moist	A	0.0–0.5		
0.5	CLAYEY SAND - very loose, black clayey sand, damp	A	0.5–1.0		
1.0	- clayey sand, saturated	S	1.0–1.45	1,0,1 N = 1	▼ 1.0
		S	1.5–1.95	1,1,2 N = 3	
2.0	- shell inclusions	S	2.0–2.45	1,1,0 N = 1	
		A S	2.5–2.95	1,0,1 N = 1	
		S	3.0–3.45	1,1,1 N = 2	
3.45	Bore discontinued at 3.45m - target depth reached				

RIG: Auger
DRILLER: E Grima
LOGGED: GN
CASING: Uncased

TYPE OF BORING: Solid flight auger

WATER OBSERVATIONS: Free groundwater observed at 1.0m during drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▽ Water level

CHECKED
Initials: [handwritten initials]
Date: 3/08

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Sampling

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

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

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

Test Pits

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

Large Diameter Augers

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

Continuous Spiral Flight Augers

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

Non-core Rotary Drilling

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

Continuous Core Drilling

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

Standard Penetration Tests

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

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

The test results are reported in the following form.

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

  4,6,7
  N=13

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

  15, 30/40 mm

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

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

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

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

Description and Classification Methods

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

Soil Types

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

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

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

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

Definitions of grading terms used are:

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

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

In fine grained soils (>35% fines)

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

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

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

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

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

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

Soil Descriptions

Cohesive Soils

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

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

Cohesionless Soils

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

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

Soil Origin

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

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

Moisture Condition – Coarse Grained Soils

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

- Dry (D) Non-cohesive and free-running.
- Moist (M) Soil feels cool, darkened in colour.

  Soil tends to stick together.

  Sand forms weak ball but breaks easily.
- Wet (W) Soil feels cool, darkened in colour.

  Soil tends to stick together, free water forms when handling.

Moisture Condition – Fine Grained Soils

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

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

Rock Strength

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

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

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

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

Degree of Weathering

The degree of weathering of rock is classified as follows:

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

Rock Descriptions

Degree of Fracturing

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

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

Rock Quality Designation

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

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

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

Stratification Spacing

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

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

Symbols & Abbreviations

Douglas Partners

Introduction

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

Drilling or Excavation Methods

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

Water

▷	Water seep
▽	Water level

Sampling and Testing

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

Description of Defects in Rock

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

Defect Type

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

Orientation

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

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

Coating or Infilling Term

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

Coating Descriptor

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

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

Other

fg	fragmented
bnd	band
qtz	quartz

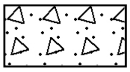
Symbols & Abbreviations

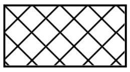
Graphic Symbols for Soil and Rock

General

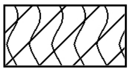
 Asphalt

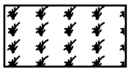
 Road base

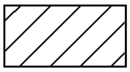
 Concrete

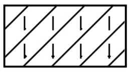
 Filling

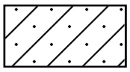
Soils

 Topsoil

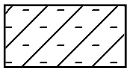
 Peat

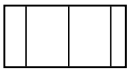
 Clay

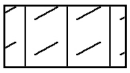
 Silty clay

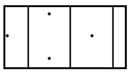
 Sandy clay

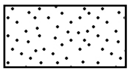
 Gravelly clay

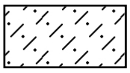
 Shaly clay

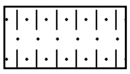
 Silt

 Clayey silt

 Sandy silt

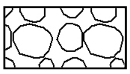
 Sand

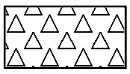
 Clayey sand

 Silty sand

 Gravel

 Sandy gravel

 Cobbles, boulders

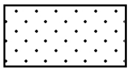
 Talus

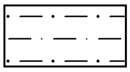
Sedimentary Rocks

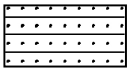
 Boulder conglomerate

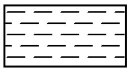
 Conglomerate

 Conglomeratic sandstone

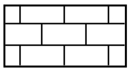
 Sandstone

 Siltstone

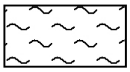
 Laminite

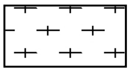
 Mudstone, claystone, shale

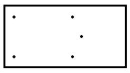
 Coal

 Limestone

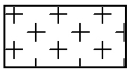
Metamorphic Rocks

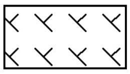
 Slate, phyllite, schist

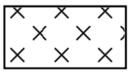
 Gneiss

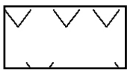
 Quartzite

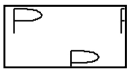
Igneous Rocks

 Granite

 Dolerite, basalt, andesite

 Dacite, epidote

 Tuff, breccia

 Porphyry

Appendix D

Action Criteria and Treatment Verification

Appendix D
Action Criteria and Treatment Verification
1015 Barrenjoey Road, Palm Beach

D1.0 Introduction

This appendix details the Acid Sulfate Soil (ASS) action criteria, ASS treatment verification criteria, equations for net acidity and waste classification criteria. The action criteria are based on Sullivan *et al* (2018).

D2.0 Action Criteria

The following section provides the action criteria to determine if material is classified as ASS and therefore if ASS management is required.

D2.1 Field Screening

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

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 (pH of oxidised sample) is less than 3.5;
- 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.

D2.2 Laboratory Analysis

The action criteria triggers are the basis for determining if an Acid Sulfate Soil Management Plan (ASSMP) is required. They are based on Net Acidity (refer Section D3.2.1 for further detail). 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 material tested is equal to or greater than the action criteria a detailed ASSMP needs to be prepared.

The test results can be used to evaluate the presence / absence of ASS through comparison with the action criteria. If the results indicate the absence of ASS, treatment is not required. The following Table D1 provides the action criteria taken from Table 4.4, ASSMAC (1998).

Table D1: Action Criteria

Type of Material		Net Acidity#			
		1-1000 t Materials Disturbed		>1000 t Materials Disturbed	
Texture Range (NCST 2009)*	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

* If bulk density values are not available for the conversion of cubic meters to tonnes of soil, then the default bulk densities based on the soil texture in Table D2, may be used.

\# Net Acidity can only include a soil material's measured Acid Neutralising Capacity where this measure has been corroborated by other data (for example slab incubation data) that demonstrates the soil material does not experience acidification during complete oxidation under field conditions (Equation D1). Where the Acid Neutralising Capacity has not been corroborated, the Net Acidity must be determined using Equation D2.

Table D2: Default Bulk Densities Based on Soil Texture

Texture	Bulk Density (t/m^3)
Sand	1.8
Loamy Sand	1.8
Sandy Loam	1.7
Loam	1.6
Silty Loam	1.5
Clay Loam	1.5
Clay	1.4
Peat	1.0

D3.0 Verification of Treatment

The treatment of ASS typically comprises the addition of a neutralising agent such as lime. The actual treatment requirements, including the lime addition quantities, are outlined in the ASSMP. The following section provides the equations and methods of verifying that the neutralisation treatment has been successful / completed.

D3.1 Field Screening

Field screening results generally indicate that the soils have been successfully neutralised if the following conditions are met. When soils do meet the following criteria, confirmatory laboratory testing should be undertaken (noting that field results are a screen only and should not be taken in isolation as a means of verification).

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

D3.2 Laboratory Testing

The material will be considered to successfully treated where:

- pHKCL is ≥ 6.5;
- TAA (total actual acidity) = 0; and
- Net acidity ≤ 0. Net Acidity must be determined by one of the methods outlined in Section D3.2.1.

Note: Where TAA and net acidity are calculated to be less than the laboratory reporting limit, the result is assumed to be 0 for the purpose of the above.

D3.2.1 Net Acidity

Net acidity is the quantitative measure of the acidity hazard of ASS materials. It is determined from an Acid Base Accounting (ABA) approach using either:

- Equation D1 - When the effectiveness of a soil material's measured Acid Neutralising Capacity has been corroborated by other data demonstrating the soil material does not experience acidification during complete oxidation under field conditions; or
- Equation D2 - When the effectiveness of a soil material's measured Acid Neutralising Capacity has not been corroborated by other data; or
- Equation D3 - 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.

Equations D1 and D2 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 D3 is used to determine the neutralisation treatment has been successful.

Equation D1 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 D2 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 D3 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)

D4.0 Off-Site Disposal Requirements

Prior to disposal off-site the treated material must be classified in accordance with the relevant guidelines. The following subsections discuss disposal options.

D4.1 Waste Classification

If soil is disposed to landfill post treatment, it must be classified in accordance with the POEO Act, including the current guidelines, namely the NSW EPA (2014) *Waste Classification Guidelines - Part 1; Classifying Waste* and *Part 4: Acid Sulfate Soils* (NSW EPA, 2014).

Referenced should also be made to DP (2021) for additional waste classification information.

D4.2 Disposal as PASS

Further guidance for the disposal of untreated natural material as PASS is provided in Appendix F of this ASSMP.

D4.3 Virgin Excavated Natural Material

In addition, the following additional information is provided with respect to natural soils.

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 sulphidic 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.’

ASS and treated ASS cannot be classified as VENM.

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Appendix E

Liming Rate Equations

Appendix E
Liming Rate Equations
1015 Barrenjoey Road, Palm Beach

E1. Introduction

This Appendix provides the equations for the calculation of liming rates.

E2. Liming Rates

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

Equation E1:

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

Equation E2:

Neutralising Material Required (kg $CaCO_3$/m3 soil) = D (tonne/m3) 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 D;
- 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 D 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 where it includes a safety factor of 1.5, 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. Material will only be considered to have been successfully treated when all soil has been verified in accordance with Section 8.

Based on the previous results the provisional liming rates are calculated:

Equation 1:			
Neutralising Material Required (kg CaCO3/tonne soil)	=	Net acidity (mol H+/t) / 19.98) x FOS x 100/ENV	
	=	(35/19.98)*1.5*(100/98)	
	=	2.7	kg lime per tonne
Equation 2:			
Neutralising Material Required (kg CaCO3/m3 soil	=	D (tonne/m3) x (Net acidity (mol H+/t) / 19.98) x FOS x 100/ENV	
		=1.6*(35/19.98)*1.5*(100/98)	
		4.3	kg lime per m^3

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Appendix F

Contingency Options to On-Site Treatment

Appendix F
Contingency Options to On-Site Treatment
1015 Barrenjoey Road, Palm Beach

F1. Introduction

This Appendix provides the contingency options to on-site treatment of ASS.

F2. Off-Site Treatment and Disposal

Where on-site treatment of AASS is not possible and / or practical then off-site treatment at a facility appropriately licenced to accept and treat such material can be considered. Once a licensed facility is nominated for the treatment of ASS, the below general procedure should be followed for off-site treatment:

- Loading the material 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 material to the treatment facility;
- Once the ASS has been accepted by treatment facility they will treat and manage it in accordance with ASSMAC (1998) and their Environmental Protection License (EPL) conditions, subject to the verification procedures documented herein. The indicative liming rate based on current data is provided in DP (2020) and referenced in Section 7.1.2 of the ASSMP;
- Verification of the treatment of the ASS and classification of the soil by an Environmental Consultant in accordance with Section 8 of this ASSMP; and
- Transport of the treated and verified ASS back to the site, or a nominated and licensed disposal facility.

F3. Off-Site Disposal as PASS

For PASS associated with natural soils the following management options are available.

F3.1 PASS Criteria

EPA (2014), Part 4 states that:

'*Potential ASS may be disposed of in water below the permanent water table, provided:*

- *This occurs before they have had a chance to oxidise, i.e., within 24 hours of excavation; and*
- *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*.'

For the purposes of this ASSMP, PASS is defined in accordance with the NSW EPA (2014) *Waste Classification Guidelines, 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.

EPA (2014) allows direct disposal of ASS which are classified as PASS and managed as below:

- The soils meet the definition of VENM in all aspects other than the presence of sulphidic 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 sulphidic 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.

F3.2 Disposal as PASS

The below works are to be undertaken by an appropriately trained staff:

- Agreement with receiving site on acceptance times for trucks, and allowable time lapse between excavation and acceptance by receiving site;
- Materials kept wet at all times, and are to be sprayed with water if required to keep them wet;
- Recording of the excavation date, time and source chainage of the excavated material;
- Inspection of the excavated material for moisture content, material texture / signs of contamination concern, such as anthropogenic odours, staining or inclusions by nominated personnel involved in the management / handling of the soils;
- Limited to natural soils not impacted by fill other contaminants;

- Measuring the pH in at least one sample per 50 $m^3$and a minimum of five per shift, using a calibrated pH meter;
- If the pH is less than or equal to 6.5, the material will not be classified as PASS, and the material is to be segregated for further assessment and treatment;
- Loading the material into trucks and ensuring the material 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 is estimated to be at least 2 t/m^3). This should be taken into consideration when loading trucks to ensure that trucks are not over loaded;
- Material is to 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 material 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 has been accepted by the receiving site, they are required to manage it in accordance with the their EPL conditions; and
- Any material which is rejected by receiving site is to be transported back to the site and managed in accordance with the ASSMP.

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