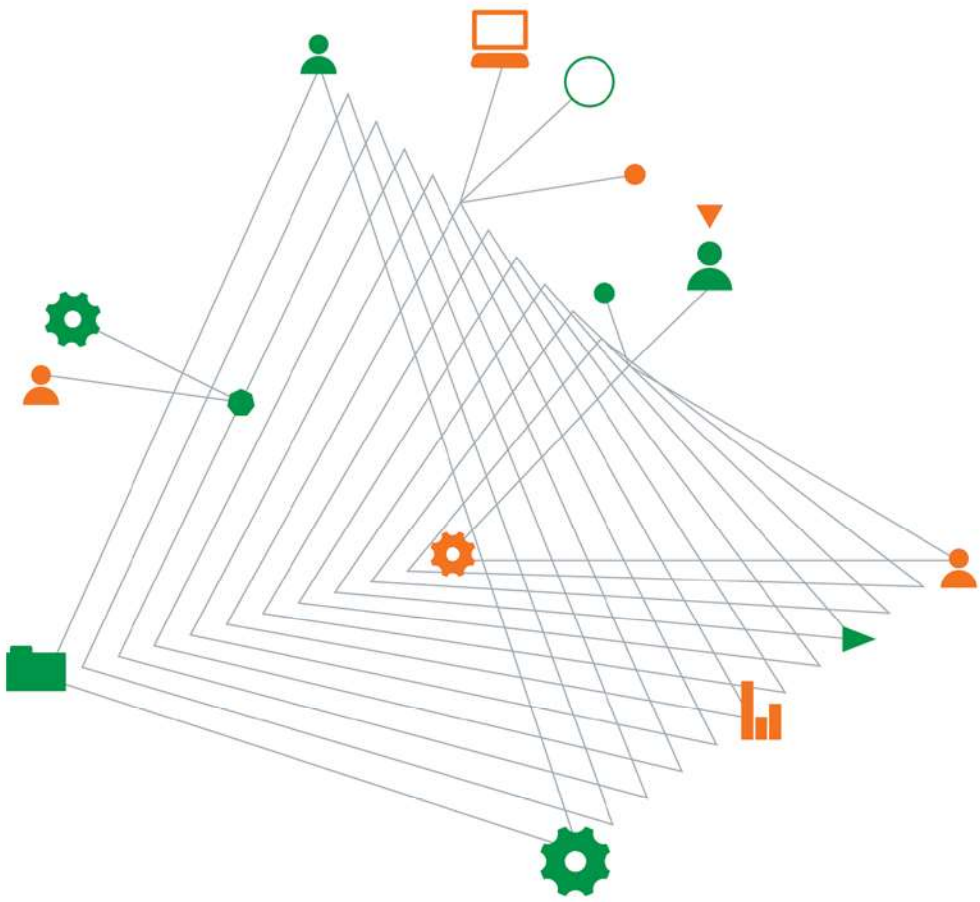
Frasers Property Australia Pty Ltd

Acid sulfate soil management plan

Precinct A Shell Cove, NSW

25 October 2017



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Acid sulfate soil management plan

Prepared for
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Abbreviations

AHD	Australian Height Datum
AASS	Actual Acid Sulfate Soils
ASS	Acid Sulfate Soils
ASSMAC	Acid Sulfate Soils Management Advisory Committee
ASSMP	Acid Sulfate Soil Management Plan
Bgs	below ground surface
BH	Borehole
NAGP	Net Acid Generation Potential
NATA	National Association of Testing Authorities
NSW EPA	New South Wales Environment Protection Authority
PASS	Potential Acid Sulfate Soils
SPOCAS	Suspension Peroxide Oxidation Combined Acidity and Sulfate
$\mathbf{S_{CR}}$	Chromium Reducible Sulfur
$\mathbf{S_{POS}}$	Peroxide Oxidisable Sulfur
TAA	Titratable Actual Acidity
TP	Test Pit

EXECUTIVE SUMMARY

Coffey was commissioned to prepare this Acid Sulfate Soil Management Plan for the proposed subdivision at Precinct A within the Shell Cove Boat Harbour Precinct, Shellharbour, NSW. The proposed subdivision is located in the southern part of the greater Shell Cove Boat Harbour Precinct.

This plan addresses Part 3A Concept Plan Consent Conditions (Part D 12 – Acid Sulfate Soils) which require an acid sulfate soil management plan to be prepared by a suitably qualified person in accordance with the NSW Acid Sulfate Soil Manual (1998). This plan examines how the pre-loading process and treatment of acid sulfate soils will be staged and managed especially regarding the impacts of trenches (for service and drainage) on groundwater and acid leachate.

The objective of the plan is to reduce the potential environmental impacts associated with the disturbance of acid sulfate soils within the area of the proposed works. This plan presents a framework for the approach and methodology of acid sulfate soil management at the site during the preparation of the subdivision to be followed by the contactor and its subcontractors.

Numerous previous reports have been carried out at the site assessing geotechnical and acid sulfate soil issues. Based on the review of the available soils and geological information plus the laboratory results, the risk of encountering acid sulfate soil is considered to be highest in the northern portion of Precinct A.

This northern portion of Precinct A is lower lying and has been filled by 2m to 3m of non-acid sulfate soil fill to set the bulk earthworks levels for this subdivision. It is considered unlikely and low risk that following construction up to 'Bulk Earthwork' level, that acid sulfate soil materials will be encountered on a large scale, except for some service trenches (sewer and stormwater).

The likelihood of encountering acid sulfate soil in other parts of the subdivision are low, however it should be noted that if any works occur that have the potential to lower the groundwater table in adjacent areas where ASS are present, then these activities will also need to be managed.

This plan presents management procedures for acid sulfate soils which generally comprise:

i. Appointment of an appropriately qualified person to manage the ASS issues during the earthwork activities;

ii. Avoid disturbance of acid sulfate soil wherever practical;

iii. Where avoidance is impractical and earthworks are proposed in the high risk areas of Precinct A carry out additional assessment and laboratory testing to assess liming rates and include in an addendum to this plan;

iv. Make regular observations and carry out field screening of excavated soil within the high risk area and within close proximity to this area. This will be required for excavations that are of sufficient depth that may intersect the former ground surface (following filling) to assess the potential presence of acid sulfate soils during excavation activities;

v. If dewatering is required, carry out regular surface water and groundwater monitoring to assess if the surface water or groundwater has been impacted by oxidation of ASS;

vi. Manage the materials that are assessed to potentially be acid sulfate soils through temporary stockpiling and return to excavations within similar soil horizon as soon as practical to lower the risk of oxidation. Material that is surplus to requirements will be neutralised with lime.

1. Introduction

1.1 Background

This Acid Sulfate Soil Management Plan (ASSMP) has been prepared for the proposed subdivision at Precinct A within the Shell Cove Boat Harbour Precinct, Shellharbour, NSW (Figure 1. Hereafter referred to as ‘the site’). The ASSMP was prepared in accordance with our proposal dated 23 August 2017 (Ref: WOLEN209869-P02). The proposed subdivision (including boat maintenance facility and boat ramp car park) is located in the south eastern part of the greater Shell Cove Boat Harbour Precinct (refer Figure 1).

The Shell Cove Boat Harbour Precinct is currently being constructed and filling is being carried out up to ‘Bulk Earthworks level’ by others. ‘Bulk Earthworks’ level can be defined as the level very close to the final ‘subdivision’ level (say within 0.3m to 0.5m), accounting for future minor cutting and filling for detailed roadways, footpaths and other works.

As part of this boat harbour construction activity, acid sulfate soil (ASS) issues are currently being managed by others and a land platform area will be delivered that will ultimately not be affected by ASS at the ground surface. This ASSMP is therefore understood to be applicable for subdivision developments, post construction and filling of the land platform up to ‘Bulk Earthworks’ level, and is written from this perspective.

This ASSMP presents a framework for the approach and methodology of ASS management at the site during the preparation of the subdivision to be followed by the contactor and its subcontractors. The ASSMP provides a basis for ASS management, however, it is important to note that this document is not a specification.

This ASSMP is not intended for specific developments within the subdivision, for which construction details are not yet available, but the general process for management that will be applicable.

1.2 Objectives

We understand that an ASSMP is required to be prepared by a suitably qualified person in accordance with the NSW Acid Sulfate Soil Manual (1998) in order to address the following planning requirements:

- Part 3A Concept Plan Consent Conditions (Part D 12 – Acid Sulfate Soils). The consent condition also requests that the ASSMP examine how the pre-loading process and treatment of acid sulfate soils (ASS) will be staged and managed throughout the life of each stage especially regarding the impacts of trenches (for service and drainage) on groundwater and acid leachate;
- Statement of Commitments (Part 4.7.3 - Acid Sulfate Soils). The statement of commitments requires the proponent to treat any disturbed ASS material in accordance with the ASS Management Advisory Committee Guidelines’;

The objective of the ASSMP is to reduce the potential environmental impacts associated with the disturbance of ASS within the area of the proposed works.

The ASSMP is prepared in general accordance with the Acid Sulfate Soils Assessment Guidelines (Ahern et al, 1998a) and the Acid Sulfate Soils Management Guidelines (Ahern et al, 1998b) in the Acid Sulfate Soil Manual, published by the Acid Sulfate Soils Management Advisory Committee (ASSMAC). Reference has also been made to the Queensland ASS Technical Manual Soil Management Guidelines v4.0 (Dear et al 2014).

1.3 Previous reports

Multiple investigations have been carried out across the broader Shell Cove Boat Harbour Precinct. In compiling this ASSMP, the majority of information regarding the distribution of ASS has been summarised from the following reports:

- Coffey (2003) Geotechnical and Acid Sulfate Soil Assessment (Ref: SC2058/1-AH)
- Coffey (2003) Stage 2 Geotechnical and Acid Sulfate Soil Assessment and Groundwater Study (Ref: SC2058/2-BR)
- Coffey (2007) Stage 3 Geotechnical Investigation Report (Ref: GEOTUNAN02058AM-AN)
- Coffey (2013). Pavement Thickness Design, Shell Cove Boulevard, CH0M to 255M (Ref: GEOTWOLL03424AA-AD)

The location of former sample locations, engineering logs and soil descriptions are included in these previous reports. Relevant former sampling locations are reproduced in Figure 2 of this ASSMP. Figure 3 shows the inferred extent of ASS and inferred ASS thickness. Engineering logs and soil descriptions for the previous sampling locations have not been reproduced in this ASSMP. These reports should be read in conjunction with the ASSMP.

1.4 Project description

The proposed subdivision comprises a mix of roads, residential lots, future medium density Lots, a future boat maintenance facility and future boat ramp car park and associated underground services. A cut and fill drawing for this precinct was provided by consultants working for Frasers and presents the final cut to fill based on original (pre-construction) site levels. This figure is produced as Figure 4. The figure indicates that there is generally filling occurring across this precinct relative to original pre-construction levels, except for some cut (typically less than 0.5m in the central area and a small amount in the north-west). Between about 1m to 3m of existing structural fill is present in the northern parts.

The depth of fill placed over the estuarine and/or alluvial soils that may contain ASS, will be important in assessing whether these soils may be exposed by site excavations in the future. In the lower lying areas that are to be filled, the placement of fill will also increase the effective depth below final subdivision level to the water table. There may be localised excavation beyond this depth to install underground services such as sewer lines. There are no plans at this stage for larger underground structures such as pumping stations, but sewer and stormwater pipes will need installation and some of these may go down to around RL -1m AHD, as advised by Frasers.

2 Physical setting

2.1 Site description

The site is shown in Figure 1. Proposed Precinct A is a smaller subset of the broader boat harbour precinct. The location of Precinct A is shown in Figures 1 and 2. Precinct A forms an irregular shaped area approximately 9ha and is situated in the south-eastern part of the broader Shell Cove Boat Harbour Precinct.

In general terms, the broader Shell Cove Boat Harbour area can be described as follows:

- The western areas are situated on alluvial or residual soils, with a slight rise to the west;
- The central area was a degraded coastal wetland underlain by estuarine soils which have been assessed to be ASS. The majority of this area has been excavated to create the Boat Harbour. Soft soil areas have already been preloaded;
- The Boat Harbour is located between coastal sand dunes to the east and alluvial and residual terrain to the west and south.

Approximately the north half of Precinct A lies on estuarine sediments whilst the southern half lies over residual soil/extremely weather rock terrain units.

2.2 Geotechnical units and subsurface profile

The subsurface conditions across the broader Boat Harbour Precinct have been summarised from previous reports (Coffey 2004, Coffey 2014, and Coffey 2015) as follows:

Unit 1 **Fill**, which is divided into two subunits – Units 1A and 1B:

Unit 1A ‘**Clean’ Fill** comprising gravelly clay and clay of medium to high plasticity with some cobbles. This material is generally in a moist and stiff condition.

Unit 1B **Refuse Fill** comprising mixtures of waste materials such as bricks, glass, car bodies, wire and general household refuse with a varying proportion of gravelly clay or clayey gravel.

Unit 2 **Littoral Sands** consisting typically of an upper layer of sand and a lower layer of silty sand/sandy silt. These materials are inferred to have been deposited in a combination of beach and dune environments. This unit is inferred to be generally in a loose to medium dense condition.

Unit 3 **Estuarine Sediments (Acid Sulfate Soils)** The estuarine sediments are generally dark grey to black in colour and have a high moisture content. The estuarine sediments are divided into two subunits – Units 3A and 3B as described below:

Unit 3A **Sand**: comprising silty sand and sand: this unit was generally loose to medium dense and encountered in the eastern parts of the precinct at the interface with the Unit 2 Littoral sands.

Unit 3B **Silt/Clay**: comprising clayey silt/silty clay and clay: This unit was generally very soft to firm. Some organic material and sandy lenses were encountered within this unit.

Unit 4 **Alluvium** consisting of silty clay, sandy clay and gravelly clay of medium to high plasticity. This unit was generally mottled brown, grey, dark brown and/or orange-brown and contained some fine subrounded gravel. This unit was generally stiff to very stiff with some firm zones.

Unit 5 **Residual Soil/Extremely Weathered Rock** which is gravelly clay/clayey gravel derived from insitu weathered latite. The consistency of this unit ranges from very stiff to hard. This unit tends to grade from residual soil to extremely weathered rock with increasing depth.

Unit 6 **Rock**, consisting of highly weathered to fresh Latite, divided into two sub units 6A and 6B. Both units were porphyritic and massive.

Unit 6A **Highly to Moderately Weathered Latite** which is brown and contains some clayey infilled joints and seams. The rock is generally medium to high strength with a defect spacing of less than 100mm. Whilst Unit 6A is highly fractured and contains many defects, some high to extremely high strength rock bands are present.

Unit 6B **Moderately Weathered to Fresh Latite** which is generally grey to dark grey and of high to extremely high strength. The occurrence of rock defects is less than in Unit 6A.

The groundwater table in the former wetland area is likely to be variable based on seasonal fluctuations and rainfall. Coffey has monitored two piezometers (CGBH27 and CGBH28) installed within Precinct A on six occasions from July 2014 to April 2017 with groundwater levels ranging between 1.94mAHD and -0.14m AHD. The levels are influenced by a combination of seasonal variations (rainfall), drawdown from harbour construction and possibly tides.

2.3 Acid sulfate soil occurrence

Based on the results of previous site investigations and mapping, the approximate extent of ASS has been assessed.

Information on the extent of ASS was collected during previous investigations by Coffey from field mapping, logging of test pits, boreholes and vibrocores, ASS screening and laboratory testing. This information was used to compliment previously existing data to better assess the extent of ASS at the site. ASS have been assessed as occurring within the Estuarine (Unit 3) soils and the extent of ASS has therefore been based on the extent of the Unit 3 soils.

Other information which was used in conjunction with the above included historical aerial photographs (dated 1948, 1966 and 2003), 1997 ASS Risk Map (Albion Park, 1:25,000) published by the former Department of Land and Water Conservation, 1:25,000 Albion Park Topographic Map, survey plans and surface contour plans.

Field mapping of the potential extent of ASS which corresponds to Estuarine (Unit 3) soil was carried out by a Senior Environmental Engineer from Coffey in 2004. Field mapping of the potential extent of ASS was mainly based on observations of the local topography and surface conditions and complimented with information from a desk based review as described above.

A Global Positioning System (GPS) was used to obtain co-ordinates of site features and ground points approximating the potential extent of the ASS around the northern, western and southern perimeters of the site.

The extent of ASS previously inferred by Coffey is reproduced in Figure 2 and also included in Figure 3 and 4. Figure 2 also shows previous test locations where estuarine soils (Unit 3) have been inferred to be identified (represented as a red dot), and the locations where this unit is not likely to be present due to the presence of deeper alluvial soils, residual soils or rock (represented as a blue dot). The site has been overlain onto this figure. These areas have already been preloaded, with the surcharge subsequently removed leaving the remaining structural fill soils close to the proposed final levels.

The inferred thickness of ASS had also been assessed previously by Coffey based on existing subsurface data and is reproduced as Figure 3 with Precinct A overlayed.

Figure 4 shows the cut to fill with an overlay of the inferred extent of ASS.

Acid sulfate soils

2.4 Background

Coastal acid sulfate soils are commonly found in low lying coastal floodplains, estuaries, rivers and creeks. They are naturally occurring sediments rich in iron sulfides that form sulfuric acid when exposed to oxygen. Acid sulfate soils include potential acid sulfate soils (PASS) and actual acid sulfate soils (AASS).

Potential acid sulfate (PASS) soils are soils which contain iron sulfides or sulfidic material. In their undisturbed state, PASS may exhibit a pH of 4 or greater, and may be slightly alkaline. When exposed to air, the sulfides in PASS oxidise and can release significant quantities of acid. Following oxidation, the pH of these soils may fall considerably below pH 3.5.

Actual acid sulfate soils (AASS) are highly acidic soils resulting from the oxidation of iron sulfides or sulfidic material present in the soil profile. AASS are formed through the disturbance of PASS, which may be a result of either natural disturbances (e.g. regional fall in groundwater levels which exposes PASS to oxygen) or human disturbances (e.g. excavating PASS). AASS are typically characterised by pale yellow mottles, coating of soils with jarosite and pH of 4 or less.

2.5 Existing laboratory data

Laboratory data on ASS has been collected during multiple previous assessments across the Shell Cove Boat Harbour Precinct, confirming that the estuarine soil units (Unit 3) are ASS. Several hundred investigation locations have been excavated across the Shell Cove Boat Harbour Precinct since the early 1980's. ASS laboratory analysis has been carried out on over one hundred samples, since the mid 1990's. Coffey has previously collated and reviewed the bulk of the available data. As the data spans a few decades, the laboratory test methods adopted have changed with advances in knowledge and laboratory techniques, progressing as follows:

- Net Acid Generation Potential (NAGP)
- Peroxide Oxidisable Combined Acidity and Sulfate (POCAS) method
- Suspended Oxidisable Combined Acidity and Sulfate (SPOCAS) method
- Chromium Reducible Sulfur (SCR) method

The results are therefore not directly comparable, but coupled with soil logging, historical aerial photography, survey data, topographic maps, acid sulfate soil risk maps and surface mapping there is a reasonable degree of certainty when identifying ASS from non ASS. Figure 3 presents the inferred extent of ASS across the Shell Cove Boat Harbour Precinct, based on an interpretation of the available data including the laboratory results and indicates that ASS encroach into Precinct A in the north.

Within the Estuarine (Unit 3) soils, the upper parts of the soil have been shown to be Actual ASS (AASS) and lower parts to be Potential ASS (PASS).

2.6 Groundwater

Excavation dewatering can result in drawdown of the water table locally and in some circumstances affect ASS. The main risk of prolonged acidification is within the Unit 3A PASS sands. As oxidation occurs much more rapidly in sands than in clays, then the oxidation of these sands is a greater risk than the PASS clay soils (Coffey 2015). Unit 3A sands are inferred to be located in the eastern part of Precinct A.

Deep harbour excavation to a maximum dewatering level of -9.5mAHD has recorded drawdowns in nearby piezometers of greater than 8m.

There are currently ten piezometers in the groundwater monitoring network within the identified ASS area of the Shell Cove Boat Harbour development. These have been monitored by Coffey intermittently to check for changes in pH. Two of these are in the current site. Based on the results of the six construction groundwater monitoring events, pH values remain above pH 6 and have shown minor fluctuations less than 1 pH unit at all monitoring locations between September 2014 and April 2017.

pH fluctuations of 1 pH unit or less may be related to climatic factors and natural changes in groundwater chemistry. Regular seasonal monitoring is required to assess the influence of construction dewatering on groundwater pH fluctuations.

Based on the available results, potential oxidation of PASS has, to date, not impacted groundwater pH values. It is important to note that oxidation of PASS may still be occurring beneath the site in areas where groundwater levels are drawn down due to dewatering. A subsequent decrease in groundwater pH may only be observed when groundwater levels recover following re-saturation of oxidised PASS material, often referred to as the ‘first flush’.

2.7 Action levels

In order to assess the significance of the ASS potential, previous soil results have been compared to action levels presented in the ASSMAC (1998) Acid Sulfate Soil Manual with the estuarine soil (Unit 3) assessed to be ASS.

The ASSMAC (1998) action levels are based on oxidisable sulfur concentrations for three differing soil textures. There are separate action levels depending if the amount of soil disturbed as a result of the proposed works is less than or greater than 1,000 tonnes.

The ASSMAC action criteria triggers the need to prepare a management plan and obtain development consent. The action criteria are based on oxidisable sulfur concentrations for three differing soil textures. The manual provides different action levels depending on the amount of ASS that is to be disturbed. It is generally accepted that net acidity, using acid base accounting (ABA) should be used for comparison to trigger levels.

Depending on the amount of soils disturbed during the project, any future results will need to be compared to the appropriate criteria listed below. If there is doubt about the amount of soil to be disturbed, the more conservative criteria should be adopted. The action criteria provided in the ASSMAC manual are summarised in Table 1 below.

Table 1: ASSMAC (1998) Acid Sulfate Soil Action Criteria*

Soil Texture Category	Approximate Clay Content (%)	Action Criteria (<1000 tonnes)[1]		Action Criteria (>1000 tonnes)[2]	
		Sulfur Trail Net Acidity	Acid Trail Net Acidity	Sulfur Trail Net Acidity	Acid Trail Net Acidity
		(S_{POS} or S_{CR}) (%)	TAA, TPA or TSA (mol H^+/tonne)	(S_{POS} or S_{CR}) (%)	TAA, TPA or TSA (mol H^+/tonne)
Coarse	<5%	0.03	18	0.03	18
Medium	5% to 40%	0.06	36	0.03	18
Fine	>40%	0.1	62	0.03	18

***Notes**:*

1 - Action criteria where less than 1000 tonnes of ASS is to be disturbed

2 - Action criteria where greater than 1000 tonnes of ASS is to be disturbed

Net Acidity calculated using acid base accounting

S_{POS} Peroxide oxidisable sulphur

S_{CR} Chromium reducible sulphur

TAA Total Actual Acidity

TPA Total Potential Acidity

TSA Total Sulfidic Acidity

2.8 Comparison of existing ASS laboratory results to action levels

Coffey previously compared soil analytical results collected across the greater Boat Harbour site to the criteria above. Exceedences of the above criteria were consistent across the Estuarine (Unit 3) soils. The range of values recorded for titratable actual acidity (TAA) and oxidisable sulfur (S_{POS} or S_{CR}) are provided in Table 2 below. Net acidity has not been used below due to differing laboratory methods.

Table 2: Typical Analytical Result Ranges

Parameter	Typical Range
TAA	0 molesH$^+$/tonne to 212 molesH$^+$/tonne
S_{Pos}	0.009% to 5.1%
S_{CR}	0.066% to 1.2%

2.9 Summary of ASS risk

A drawing provided to Coffey showing indicative finished surface levels in the proposed work areas is presented as Figure 4.

Based on the review of the available soils and geological information plus the laboratory results, the risk of ASS is considered to be highest in the northern half of Precinct A where Estuarine (Unit 3) ASS have been identified. Following completion of land filling activities up to 'Bulk Earthworks' level by others in Precinct A, the ASS materials will therefore be capped with 2m to 3m of non-ASS.

ASS would only be at risk of being disturbed by excavations that extend through the non-ASS materials. These excavations could include:

- Localised excavation and smaller scale earthworks;
- Trenching for services/pipe work; and
- Installation of piles that involves soil removal.

Sewer and stormwater service trenches will require excavation to around RL -1mAHD and some of these excavations within the area of inferred ASS, have a high likelihood of intersecting estuarine ASS materials. Groundwater gauging by Coffey has shown that due to drawdown in the Boat Harbour excavation groundwater is generally unlikely to be intersected unless there are significant rain events.

Coffey report GEOTUNAN02058AO-CH indicated in Section 3.2.2 that *"The structural platform (i.e. fill layer) will be constructed over the ASS to support building and road loads. The structural platform shall act as a capping layer to the ASS"*. Where ASS occurs in localised areas or is tapering to shallow depths and future finished levels are close to existing surface levels, ASS could be removed prior to placement of the fill. Where this occurs, there will be no constraints relating to ASS for these localised areas. The removed ASS will need to be treated as outlined in Section 5.7 of this ASSMP.

The preloading occurring as part of the boat harbour construction will be completed fully prior to construction of the subdivisions within these areas, and therefore there will be no significant adverse effects from preloading on ASS issues.

3 Principles for mitigating impacts from Acid Sulfate Soils

The following is an outline of the general principles for mitigating impacts associated with identified ASS as per ASSMAC (1998):

i. Avoid land where ASS occur;

ii. Avoid disturbing ASS soils if present on the property and avoid lowering the water table;

iii. Prevent the oxidation of sulfides;

iv. Neutralising acid as it is produced;

v. Separate out and treat the sulfidic component (i.e. pyrite) by sluicing if this material is very sandy; and

vi. Immediate burial of excavated ASS below the permanent water table

4 Management plan and procedures for Acid Sulfate Soils

4.1 General

The monitoring and management of ASS will be the responsibility of the Contractor. Once the actual construction scenario is defined, an addendum to this ASSMP shall be prepared using the framework provided by this general ASSMP, if it is assessed that the proposed work could intersect and disturb ASS. The addendum will either be prepared by the contractor or by the Principal's representative in consultation with the Contractor. The addendum will require review and approval by the Superintendent.

Previous sampling carried out across the wider Shell Cove Boat Harbour Precinct is considered sufficient for the general assessment of ASS, however the specific data within the area of the proposed subdivision is limited and should not be relied on for delineation purposes and/or assessment of liming rates.

The following general management procedures are considered applicable for construction of the subdivision:-

1. Appointment of an appropriately qualified person to manage the ASS issues during the earthwork activities;
2. Avoid disturbance of ASS wherever practical;
3. Where avoidance is impractical and earthworks are proposed in the high risk areas of Precinct A, carry out additional assessment and laboratory testing to assess liming rates and include in an addendum ASSMP;
4. Make regular observations and carry out field screening of excavated soil within the high risk area and within close proximity to this area. This will be required for excavations that are of sufficient depth that may intersect the former ground surface (following filling) to assess the potential presence of acid sulfate soils during excavation activities;
5. If dewatering is required, carry out regular surface water and groundwater monitoring to assess if the surface water or groundwater has been impacted by oxidation of ASS;
6. Manage the materials that are assessed to potentially be acid sulfate soils through temporary stockpiling and return to excavations within similar soil horizon as soon as practical to lower the risk of oxidation. Material that is surplus to requirements will be neutralised with lime.

These procedures are further discussed in the following sections.

4.2 Training, roles and responsibilities

The earthworks contractor should appoint an appropriately trained person who is responsible for managing the ASS issues during the earthwork activities.

This person should be familiar with:

- Council and other relevant statutory requirements;
- Recognition of ASS materials;

- Acid sulfate soil testing and treatment procedures;
- Onsite management of ASS materials, including implementing management procedures.

The classification of ASS materials during construction should be carried out by personnel trained in the identification of ASS and be based on visual classification and the field screening test. If required, a suitably qualified Environmental Consultant could be engaged to assist or train the Contractor in the identification of ASS.

4.3 Additional assessment

Depending on the final subdivision layout and proposed ground disturbances, the Principal or the Contractor may request additional assessment works to further refine the likely extent of ASS and/or assess indicative liming rates.

The results and liming rates of any additional assessment would be incorporated into the addendum ASSMP.

4.4 Visual assessment and screening

4.4.1 Visual classification

The preliminary visual checking of potential ASS will be based on material type, colour and consistency. Grey, dark grey and black, very soft to soft, occasionally firm clays and sandy and dark grey to grey clayey sands and sands will be classified as suspected acid sulfate soils.

Alluvial soils, residual soils and rock will not be classified as ASS. Alluvial and residual soils are typically stiff to very stiff clays, brown, and orange brown.

4.4.2 Field test classification and pH monitoring

A field screening test using hydrogen peroxide (H_2O_2) will be performed regularly on the excavated soils when excavations intersect natural soils within and within close proximity to the inferred area of ASS. This will also apply if any suspected ASS are encountered in any other part of the subdivision. The test will be used to assess the potential presence of ASS. The peroxide screening test will be undertaken based on Appendix I of the Acid Sulfate Soils Assessment Guidelines (Ahern et al, 1998a). Soils that record a pH of below 4, following oxidation with H_2O_2 , will be managed as acid sulfate soils.

Based on the results of pH monitoring, visual assessment and field screening, selected soil samples (at a minimum rate of 10% of screened samples) will be sent for laboratory analysis using the chromium reducible suite (Scr) method to confirm the peroxide screening test results. The frequency of testing can be reduced or omitted within areas where ASS are visually confirmed. The testing will be more suited on fringe areas and areas where there is potential ambiguity on the presence/absence of ASS. Some testing in ASS would be required for assessment of liming rates.

4.5 Management of excavated ASS

Where ASS are identified following the procedures outlined in Section 5.4, excavated soils will be either placed in temporary stockpiles or transported directly to a specially prepared treatment pad for liming.

4.5.1 Excavations/trenches

ASS could be encountered during trenching or excavations within and in close proximity to the area inferred to contain Estuarine (Unit 3) soils. This may occur in services installation trenches, and if deep excavations (greater than about 2m to 3m) are required in impacted zones. Excavated ASS material will be used to backfill trenches only if it can be placed within a similar depth interval of where the ASS were encountered, subject to:

- This backfilling occurring within a short period of time following excavation (See 'Temporary Stockpiling' - Section 5.5.2); and
- The material is not showing signs of oxidation (See 'Temporary Stockpiling' - Section 5.5.2).

Suspected ASS should not be placed at levels higher in the soil profile unless it has been treated and validated.

Excess spoil that cannot be returned into trenches/excavations will be treated as per Section 5.6.

4.5.2 Temporary stockpiling

The types of ASS material that are likely to be encountered during excavation, if excavations extend beyond future layers of fill, are mainly clays (fine textured). Based on this texture, short term stockpiling should not exceed 3 nights[1]. The addendum ASSMP is to detail how stockpiling will be minimised by preparing a detailed earthworks strategy that documents:

- The timing and volumes of soil to be stockpiled and returned to excavations;
- Temporary stockpile locations;
- Measures to prevent potential impacts relating to the oxidation of ASS on surface water and groundwater. As some of the upper estuarine soil layers could be AASS, adequate controls for management of potential leachate/runoff from the stockpiles will be required. This may include:
  - Stockpiling of soils on a compacted clay base to limit infiltration or use of plastic sheeting;
  - Setting up bunding and leachate collection in addition to sediment and erosion controls;
  - Using a guard layer of lime across the base of the stockpiling area.
- ASS that is likely to be stockpiled longer than 3 days will need to be treated. If surface run-off water is collected, then a water sample must be tested in the field for pH;
- If the pH results indicate the water is acidic (i.e. pH is below 4), then the procedures in Section 5.7 should be implemented.

4.5.3 Management of excess ASS spoil

Excess material that cannot be returned to trenches/excavations will be removed from temporary stockpiles to a specially prepared liming pad and treated as per Section 5.6.1.

[1] Table 11-1 of Dear et al (2014) – See Appendix A

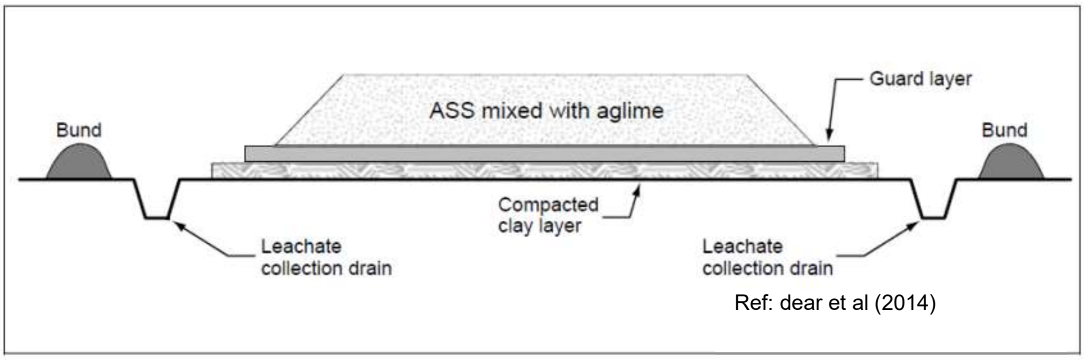
4.6 ASS treatment and validation

4.6.1 Treatment pad and liming methodology

Laboratory testing should be carried out from representative soil samples collected from the stockpiles to assess the liming rate. Depending on the volume of the stockpile, a minimum of three samples, or 1 per 200m^3, should be collected. The soil samples should be tested for acid sulfate soils based on the S_{cr} method to assess the liming rate.

The type and amount of lime to be applied should be such that a neutralising value (NV) of at least 95 can be achieved. The NV should be identified prior to mixing. NV relates to the purity of the lime and an NV of 100 is preferred to ensure that the lime is effective in neutralising the potential acid. Fine powdered agricultural lime ($CaCO_3$) generally has an NV of 90% to 100% whilst other manufactured forms of lime can have an NV as low as 80%. Where NV is below 100, the factor of safety, hence the amount of lime will have to be adjusted accordingly.

The design of the treatment pad should be in general accordance with Figure 8-1, page 50, of Dear et al (2014), reproduced below.



Schematic cross-section of a treatment pad, including a compacted clay layer, guard layer, leachate collection system and containment with bunding.

The following procedures (or other equivalent) should be undertaken for the treatment pad and liming:

- The treatment pad should be located at least 40m, from a permanent waterway or creek and if possible placed in a topographically high area to avoid inundation following heavy rain. The area should be appropriately bunded and provision made to collect run-off water.
- Spreading of the soil in thin (<200mm) layers on impervious pads within the boundary of the site works.
- A guard layer of neutralising agents should be provided at the base of the pad prior to the addition of ASS as per page 48 of Dear et al which states: The minimum guard layer rate beneath any treated-in-place ASS will be 5kg fine aglime per m^2 per vertical metre of fill. Where the highest detected sum of existing and potential acidity is more than 1.0% S-equivalent, the rate will be at minimum 10 kg fine aglime per m^2 per vertical metre of fill; and
- Addition of lime by hand (depending on amount) or light weight truck followed by mixing, using light weight rotovators or similar tools. Depending on soil consistency, mixing with an excavator in small batches may also be acceptable. The amount of lime to be added will be determined based on the results of laboratory analysis taking into consideration existing acidity, potential

acidity, retained acidity and acid neutralising potential. A factor of safety should also be applied to the lime rate calculation of between1.5 and 2 and will depend on the likely area of reuse for this material and environmental sensitivity.

- The amount of lime to be kept on site for emergencies will be assessed by the Contractor.

4.6.2 Performance criteria and verification testing

In order to demonstrate that appropriate quantities of lime have been used, a lime register shall be maintained by the Contractor. The register shall list the amount of lime delivered to the site, verified by delivery dockets, and where/when the lime has been used. The lime usage shall quantify areas limed and soil volumes treated, liming rates and quantities of lime used. The amount of lime to be kept on-site for emergencies will be assessed by the Contractor.

A validation plan shall be prepared in consultation with an experienced ASS consultant which will be based on Section 8.2 of Dear et al (2014) and will depend on the quantities and production rates of ASS treatment. The principals should be as follows:

- Minimum 3 test samples or 1 sample per 250m3;
- Each test sample to be made from a composite of six individual samples;
- Samples to be tested using the S_{CR} suite with full acid base accounting including retained acidity.

Assuming the soil type is medium- and fine-textured material (sandy loams, light clays, heavy clays and silty clays), the performance criteria will be:

- No single sample shall exceed a net acidity of 62 mol H+/tonne (0.10% S).
- If any single sample is between 0 and 62 mol H^+/tonne (0.00 to 0.10% S), then the average of any four spatially adjacent samples (including the exceeding sample) shall have an average net acidity of zero or less.

4.6.3 Reuse of treated ASS

Once ASS is successfully limed and validated this material could be used on site as fill, subject to the material being:

- Geotechnically suitable for the proposed use;
- Placed above the water table;
- Placed greater than 50m away from any receiving drainage or surface water feature unless approved otherwise by a suitably qualified environmental consultant[2].

Alternatively the limed material can be disposed off site to landfill once appropriately classified following the procedures in the NSW EPA (2014) Waste Classification Guidelines: Part 1 Classifying Waste and NSW DECC (2008) Waste Classification Guidelines: Part 4 Acid Sulfate Soils.

[2] Approval will depend on the quantity of material to be placed, depth, location and sensitivity of potential receiving waters. Limed material can sometimes increase pH in receiving waters which can be undesirable.

4.7 Rate for emergency liming

4.7.1 Emergency liming of soil

Where emergency liming is required and additional laboratory testing results are not readily available, the liming of acid sulfate soils may be carried out at a rate of about 20kg agricultural lime ($CaCO_3$) per tonne of soils. The emergency liming rate is a temporary measure to lower the immediate risk to the environment and may not be sufficient for complete neutralisation.

4.7.2 Emergency liming of water

Where emergency liming of water is required either from dewatering or run-off from stockpiles, and laboratory testing results are not available, liming of acidic water may be carried out at a rate such that residual lime is present and the pH of the water is not less than 6. The emergency liming rate is a temporary measure to lower the immediate risk to the environment and may not be sufficient for complete neutralisation.

4.8 Dewatering of groundwater

Excavation and dewatering can lower the water table and cause oxidation of ASS. Sometimes large excavations and prolonged dewatering can draw down the water table considerable distances from the edge of the excavation and although the excavation may not be within ASS, the drawdown could affect ASS in nearby areas.

At this stage dewatering is not proposed and may only be required in some areas of deeper services trenches. Should excavations intersect the groundwater table and require dewatering, or if any excavation is of sufficient size and depth that it could impact on the groundwater table, then consideration will need to be given to potential impacts on ASS.

4.8.1 Treatment of acidic water

Should acidification of water occur, the following general procedures should be followed:

- Water is to be placed in an acid-resistant holding tank or pond, and samples collected to assess the pH, electrical conductivity, chloride, sulfate ions, and heavy metals and any other parameters listed on any site specific licenses or approval conditions;
- Lime, or other suitable neutralising agent, will be added to the water at a rate assessed from the results of the testing;
- Following treatment with lime, the water will be sampled and tested again for the parameters listed in the first bullet point above;
- The results of the water testing must be compared to the results of baseline monitoring of receiving bodies. If the water results are similar to the results of the baseline monitoring of the receiving body, then the water will be considered suitable for disposal to the receiving body. Permission from the relevant regulatory authority (i.e. NSW Office of Water) must be obtained before disposal;
- If the water is not suitable for disposal in the environment, the water must either be treated to become suitable for disposal to the environment (i.e. use of a pH dosing equipment), or be removed and disposed by a licensed liquid waste contractor.

4.8.2 Groundwater and surface water monitoring

If design details suggest that ASS are likely to be intersected, a groundwater and surface water monitoring system will be required to confirm that impacts from potential oxidation of ASS are being appropriately managed.

Nearby surface water bodies and drains should be monitored for pH and electrical conductivity. The frequency of testing should be assessed based on the construction timetable and the length of time each excavation/trench remains open.

Baseline data should be collected from existing drains and surface water bodies as well as groundwater prior to the commencement of excavation. Baseline data should include laboratory analysis of samples for pH, electrical conductivity, chloride sulfate ions, and heavy metals.

4.9 Monitoring testing and reporting

Monitoring testing and reporting of soil and groundwater will be carried out in accordance with best practice industry standards. Complete records of all testing, treatment and monitoring should be kept by the contractor.

Monitoring and testing of surface water will be carried out in accordance with the relevant sections of the National Water Quality Management Strategy (1994). In particular the following guidelines will be referenced and used where appropriate:

- National Environment Protection (Assessment of Site Contamination) Measure (1999);
- NSW EPA Waste Classification Guidelines (2014);
- Australian and New Zealand Guidelines for the Protection of Fresh and Marine Waters (2000);
- Australian Guidelines for Water Quality Monitoring and Protection (2000);
- Dear, S E et al (2014). Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines

5 Limitations

This ASSMP is prepared based on the current level of understanding of the site and the proposed subdivision development. It should be reviewed and updated progressively as work is completed and/or changes made to the construction timing and sequencing excavations. It is assumed that an addendum will be prepared by the successful contractor using management procedures of this ASSMP as a framework based on additional sampling and testing.

This ASSMP is not intended for specific developments within the subdivision, for which construction details are not yet available, but the general process for management will be applicable.

The findings contained in this report are the result of discrete/specific methodologies used in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the general condition of the site. Under no circumstances, however, can it be considered that these findings represent the actual state of this site at all points.

This plan has been prepared based on existing information regarding acid sulfate soils at the site. The actual subsurface conditions encountered during the project could differ from that relied on for this report.

This plan does not address geotechnical or contamination issues.

6 References

1. Ahem CR, Stone Y and Blunden B (1998a) *Acid Sulfate Soils Assessment Guidelines*, Acid Sulphate Soils Management Advisory Committee, Wollongbar, NSW;
2. Ahem CR, Stone Y and Blunden B (1998b) *Acid Sulfate Soils Management Guidelines*, Acid Sulphate Soils Management Advisory Committee, Wollongbar, NSW;
3. ANZECC/ARMCANZ (2014) National Water Quality Management Strategy
4. Coffey (2003) Geotechnical and Acid Sulfate Soil Assessment (Ref: SC2058/1-AH)
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7. Coffey (2013) Pavement Thickness Design, Shell Cove Boulevard, CH0M to 255M (Ref: GEOTWOLL03424AA-AD)
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10. Coffey Geotechnics Pty Ltd (2015a), Construction Groundwater Monitoring, Shell Cove Boat Harbour, Shellharbour NSW, Report No. GEOTWOLL02058CF-AA, 30 June 2015.
11. Coffey Geotechnics Pty Ltd (2015b), Shell Cove Boat Harbour Construction Risk Assessment – PASS Sands Oxidation, Report No. GEOTWOLL02058CG-AA, 17 December 2015.
12. Coffey Geotechnics Pty Ltd (2016), Construction Groundwater Monitoring, Shell Cove Boat Harbour, Shellharbour NSW, Report No. GEOTWOLL02058CG-AB, 27 May 2016.
13. Coffey Services Australia Pty Ltd (2017), Construction Groundwater Monitoring, Shell Cove Boat Harbour, Shellharbour NSW, Report No. GEOTWOLL02058CI-AB, 17 May 2017.
14. Dear, S-E., Ahern, C. R., O'Brien, L. E., Dobos, S. K., McElnea, A. E., Moore, N. G. & Watling, K. M., (2014). Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines. Brisbane: Department of Science, Information Technology, Innovation and the Arts, Queensland Government.
15. Ahearn CR, McElnea AE, Sullivan LA (2004) *Acid Sulfate Soil Laboratory Methods Guidelines in Queensland Acid Sulfate Soils Manual.* Department of Natural Resources Mines and Energy Indooroopilly, Queensland, Australia;
16. National Environmental Protection Council (1999) National Environmental Protection (Assessment of Site Contamination) Measure 1999 (Amended 2013), Schedule B (1) – Guideline on the Investigation Levels for Soil and Groundwater
17. ANZECC (2000) Australian Water Quality Guidelines for Fresh and Marine Waters. Australian and New Zealand Environment & Conservation Council. ISBN 0-642-18297-3.

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Important information about your **Coffey** Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

Important information about your **Coffey** Report

Data should not be separated from the report*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way. Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction,
speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.

Figures

revision no.	description	drawn	approved	date
A	ORIGINAL ISSUE	MF	MF	19/10/17

drawn	MF / AW
approved	MF
date	19 / 10 / 17
scale	AS SHOWNP
original size	A3

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client:	FRASERS PROPERTY GROUP PTY LTD
project:	ACID SULFATE SOIL MANAGEMENT PLAN SHELL COVE BOATHARBOUR - PRECINCT A
title:	SITE LOCALITY PLAN
project no:	754-WOLEN209869
figure no:	FIGURE 1
rev:	SA

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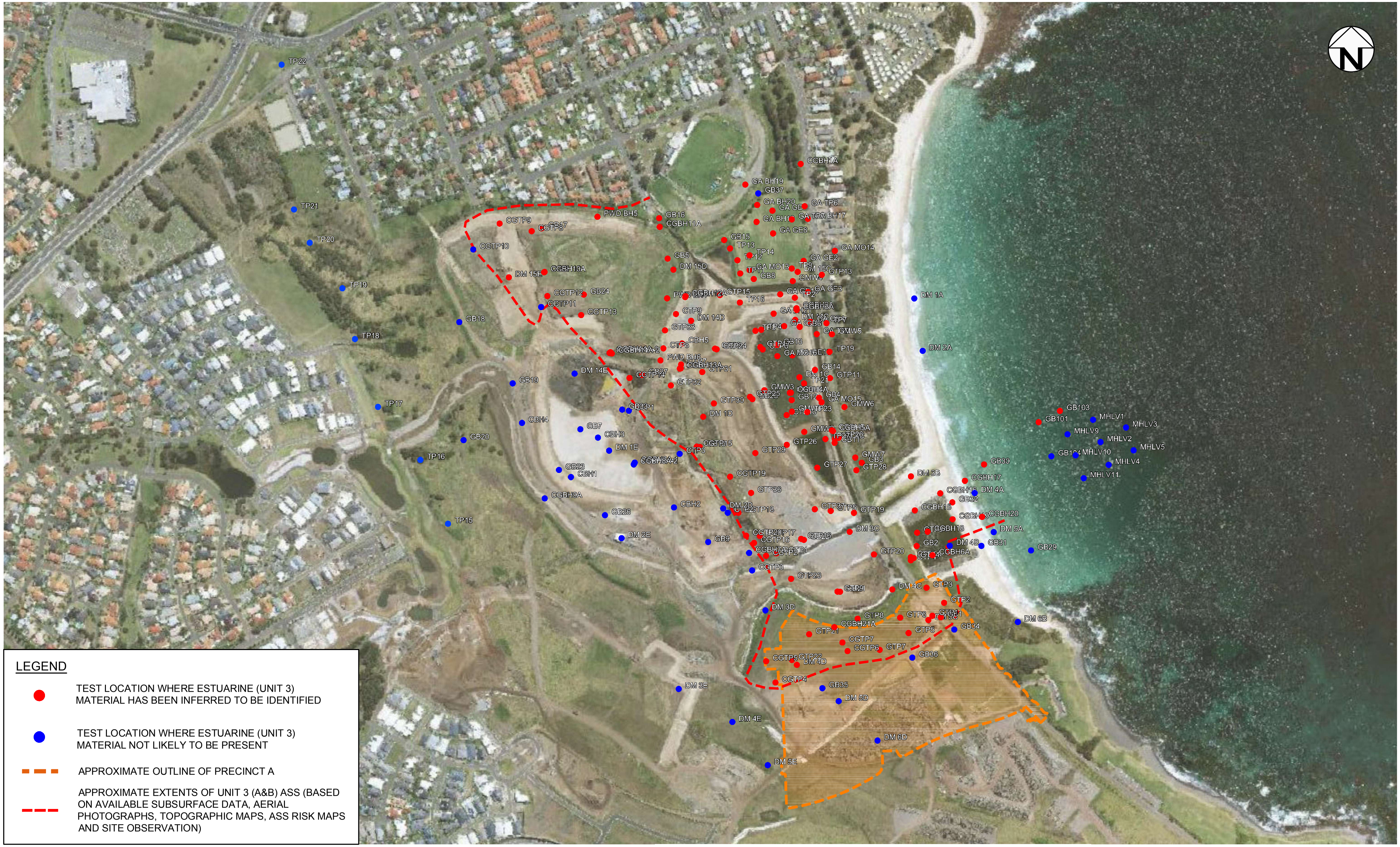

LEGEND

- ● TEST LOCATION WHERE ESTUARINE (UNIT 3) MATERIAL HAS BEEN INFERRED TO BE IDENTIFIED
- ● TEST LOCATION WHERE ESTUARINE (UNIT 3) MATERIAL NOT LIKELY TO BE PRESENT
- APPROXIMATE OUTLINE OF PRECINCT A
- APPROXIMATE EXTENTS OF UNIT 3 (A&B) ASS (BASED ON AVAILABLE SUBSURFACE DATA, AERIAL PHOTOGRAPHS, TOPOGRAPHIC MAPS, ASS RISK MAPS AND SITE OBSERVATION)

50 0 50 100 150 200

Scale (metres) 1:6000

no.	description	drawn	approved	date
A	ORIGINAL ISSUE	MF	MF	19/10/17

revision

drawn	MF / AW
approved	MF
date	19 / 10 / 17
scale	AS SHOWN
original size	A3

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client: FRASERS PROPERTY GROUP PTY LTD

project: ACID SULFATE SOIL MANAGEMENT PLAN
SHELL COVE BOATHARBOUR - PRECINCT A

title: INTERPRETED EXTENT OF ESTUARINE (UNIT 3) ASS MATERIAL

project no: 754-WOLEN209869 | figure no: FIGURE 2 | rev: A

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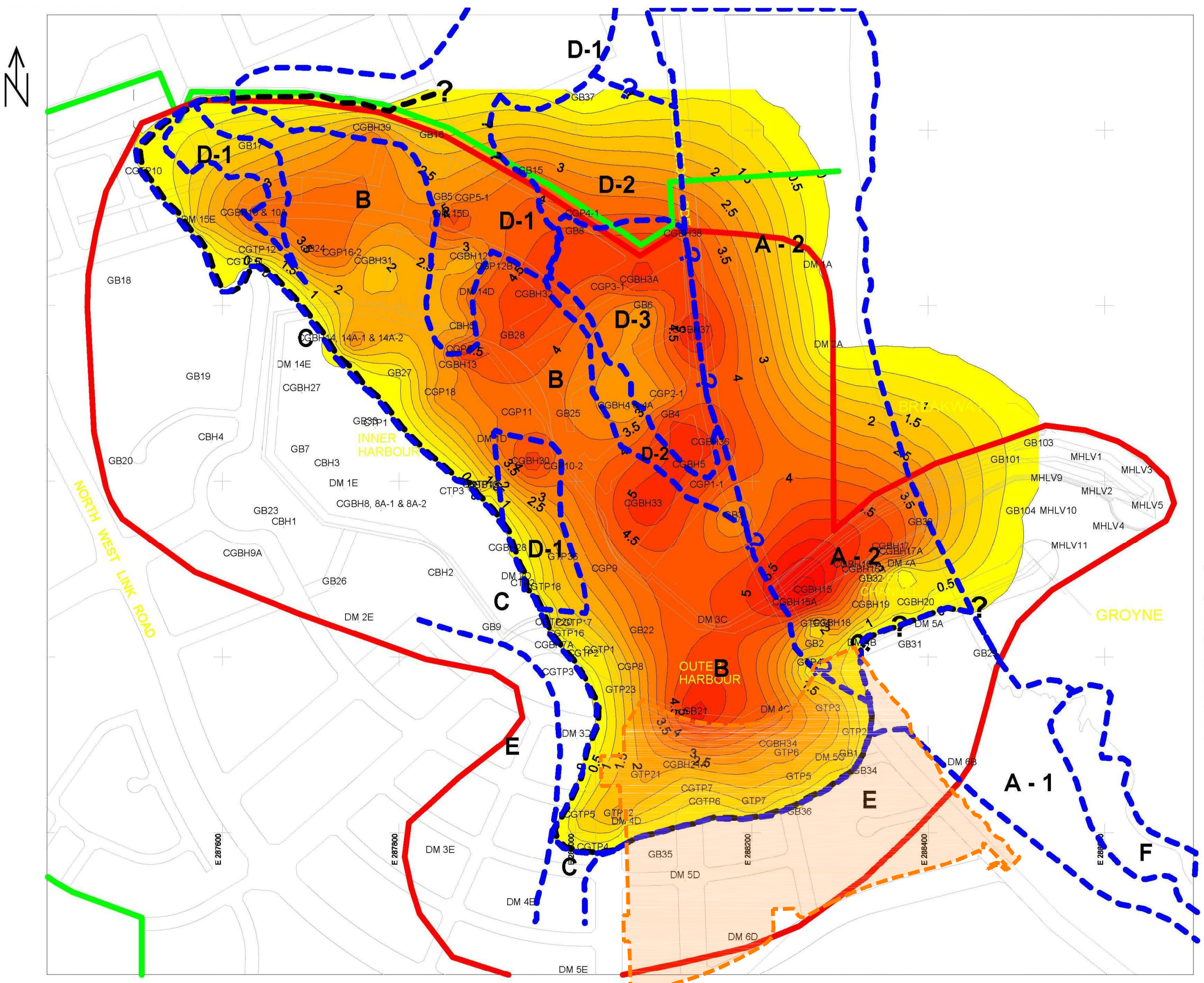

Approximate Thickness (m) of Estuarine (Unit 3B)

7, 6.5, 6, 5.5, 5, 4.5, 4, 3.5, 3, 2.5, 2, 1.5, 1, 0.5, 0

Terrain Units:

A-1 - LITTORAL SANDS - IMMEDIATELY UNDERLAIN BY UNIT 4 OR 5 SOILS
A-2 - LITTORAL SANDS - IMMEDIATELY UNDERLAIN BY UNIT 3 SOILS
B - ESTUARINE SEDIMENTS
C - ALLUVIUM
D-1 - "CLEAN" FILL
D-2 - REFUSE FILL: G.L <4m AHD
D-3 - REFUSE FILL: G.L >4m AHD
E - RESIDUAL SOIL / EXTREMELY WEATHERED ROCK
F - ROCK

LEGEND:

- Approximate extent of Unit 3 (A&B)(ASS) (based on available subsurface data, aerial photographs, topographic map, ASS risk map and site observations)
- Area of investigation works for Shell Cove Boatharbour
- Shell Cove Site Boundary
- CGP1 Test Location
- APPROXIMATE OUTLINE OF PRECINCT A

Note: Contouring programme (Surfer) extrapolates contours beyond the approximate extent of ASS. This figure is a graphical representation only. The thicknesses shown have been inferred from current and previous borehole information.

no.	description	drawn	approved	date
A	ORIGINAL ISSUE	MF	MF	19/10/17

revision

Scale (metres) 1:5000 (50 0 50 100 150 200 250)

SOURCE: COFFEY GEOTECHNICS, GEOTUNAN02058AM-AF, APRIL 2007.

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date	19 / 10 / 17
scale	AS SHOWN
original size	A3

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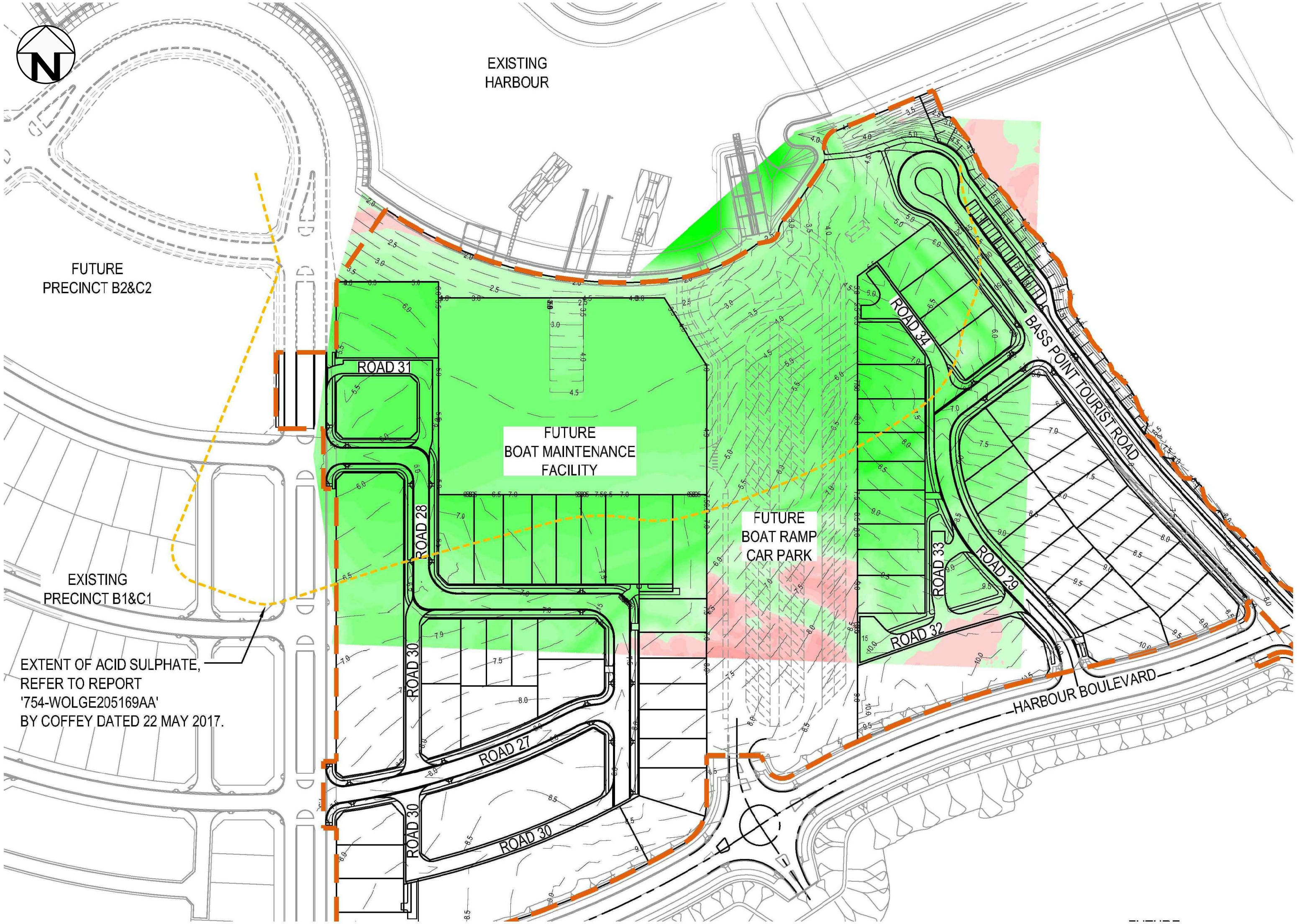
client: FRASERS PROPERTY GROUP PTY LTD

project: ACID SULFATE SOIL MANAGEMENT PLAN SHELL COVE BOATHARBOUR - PRECINCT A

title: INTERPRETED THICKNESS OF ESTUARINE UNIT 3 (A+B)

project no: 754-WOLEN209869 | figure no: FIGURE 3 | rev: A



CUT AND FILL LEGEND

- PROPOSED WORKS BOUNDARY
- 2.0 DESIGN CONTOURS (0.25m INTERVAL)
- 2.0 EXISTING CONTOURS
- EXISTING BOUNDARY

DEPTH RANGE LEGEND

LOWER		UPPER	
-99999	to	-3.5	DEPTH OF FILL
-3.5	to	-3	
-3	to	-2.5	
-2.5	to	-2	
-2	to	-1.5	
-1.5	to	-1	
-1	to	-0.5	
-.5	to	0.00	
0.000	to	.5	DEPTH OF CUT
.5	to	1.0	
1.0	to	1.5	
1.5	to	2	
2	to	2.5	
2.5	to	3	
3	to	3.5	
3.5	to	9999	

FILL 159451 m³
CUT -2167 m³
BALANCE = 157283m³

NOTES

VOLUMES CALCULATED BASED ON THE FOLLOWING ASSUMPTIONS:

1. VOLUME AND DEPTHS BASED ON SURVEY AVAILABLE AT DESIGN PHASE AND AREA P3 - REV4 - PRE-CONSTRUCTION GROUND RL POINTS SUBJECT TO CONFIRMATION ONCE UPDATED SURVEY IS AVAILABLE.
2. CONTOURS DISPLAY AS THE DESIGN CONTOURS.
3. CUT AND FILL VOLUMES ARE TO FINISHED SURFACE LEVEL.

LEGEND

- APPROXIMATE OUTLINE OF PRECINCT A

revision no.	description	drawn	approved	date
A	ORIGINAL ISSUE	MF	MF	19/10/17

20 0 20 40 60 80 100

Scale (metres) 1:2000

SOURCE: ARCADIS - 10006310 - SKE-015

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date	19 / 10 / 17
scale	AS SHOWN
original size	A3

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client: FRASERS PROPERTY GROUP PTY LTD

project: ACID SULFATE SOIL MANAGEMENT PLAN SHELL COVE BOATHARBOUR - PRECINCT A

title: CUT TO FILL BASED ON PRE-CONSTRUCTION GROUND SURFACE

project no: 754-WOLEN209869 figure no: FIGURE 4 rev: A

Appendix A - Maximum periods of short term stockpiling

11. High-risk management strategies

Several ASS management strategies involve considerable environmental risk as there is limited documentation of their successful use. Assessment managers may require detailed risk assessment information (potentially including pilot trials) before they can be satisfied that these risks can be effectively managed without impact on the environmental values of the receiving environment. **If sufficient scientific justification cannot be provided, the following activities will not be supported.**

11.1 Stockpiling acid sulfate soils

The risks of stockpiling large volumes of untreated ASS may be high even over the short-term. Stockpiling small volumes of untreated ASS should only be undertaken as a short-term activity. For example:

- Part of a day's extraction of clay may be stockpiled over a weekend before strategic reburial.
- Due to poor weather conditions or problems with obtaining laboratory results, treatment scheduling may be disrupted, leading to the creation of small stockpiles before changes can be made to earthworks programs.

All ASS EM plans must allow extra space in treatment areas for such contingencies.

ASS tip 28: Stockpiling

On becoming aware of an emerging situation that will result in the need for some stockpiling, action should be taken to:

- prevent further increases in stockpile volumes or the duration these remain untreated
- quickly treat the stockpiles that have resulted.

It can be more efficient to treat (and verify) the stockpile as it grows. This will obviate the need to manage the stockpiled soil as recommended in this section.

11.1.1 Environmental risk

The risks associated with stockpiling increase with the rate at which the materials dewater. Coarsely textured, highly permeable, well-sorted sandy soils will drain or dewater at a faster rate than fine-textured, poorly sorted soils. The rate of oxygen transport to the sulfides within sandy soils is likely to be high. The risk will multiply if the pH of the material being stockpiled drops to 4 or less, if there is limited organic matter present, or if the material has high levels of sulfides. The rate of oxidation of these soils can be rapid (hours), particularly in hot conditions.

Note: Oxidation rates are related to temperature, and so the risks increase in hotter conditions.

If soils have been excavated and stockpiled with no regard to layers or horizons of soil that require different liming rates, the soil's spatial predictability will be lost. This increases the risk of incorrect liming rates being applied. Stockpiles will need to be resampled before treatment. Sampling rates may need to be double or triple that of an undisturbed profile, as extrapolation of liming rates from fewer samples would be statistically unreliable.

Substantial quantities of acid can build up in stockpiles if they are left in oxidising conditions for even short periods. Management of acidic leachate can become a concern. Large stockpiles are difficult to neutralise, primarily due to the earthmoving needed. Determining liming rates for such oxidised materials may cost more because tests will need to check the existing and retained acidity as well as the potential acidity. Representative sampling of the stockpile must be performed. Refer to the latest version of the Laboratory Methods Guidelines or AS4969 for information on analysing soils with retained acidity. Generally, the highest laboratory result will need to be employed in calculating treatment rates because of variability within a stockpile and changes due to oxidation.

ASS tip 29: Secondary sulfate salts

Secondary sulfate salts (e.g. jarosite) may dissolve and produce acid with wetting and drying of the stockpiles. Jarosite, and other acid-forming salts, may be 'stores' of acidity that do not need further oxygen to generate acid. These salts may form the main component of acidity in older stockpiles established prior to regulation of ASS disturbance.

Due to varying solubilities, some of these salts may be measured by the titratable actual acidity (TAA) test, while others such as jarosite will need extra testing to measure their retained acidity, for example, suspension peroxide oxidation combined acidity and sulfur (SPOCAS) method or S_{NAS} (net acid-soluble sulfur). Existing and retained acidity are not accounted for by S_{CR}, S_{POS}, or S_{TOS} tests. See the latest Laboratory Methods Guidelines or AS4969.

11.1.2 Management considerations

Stockpiling untreated ASS should be minimised by preparing a detailed earthworks strategy that documents the timing of soil volumes to be moved, treatment locations and capacity of those areas to accept materials. Stockpiling may mean double-handling and increased earthmoving costs. It is important to account for risk from inclement weather and plan for other contingencies.

Short-term stockpiles

The recommended maximum time for which soils can be temporarily stockpiled without treatment is detailed in Table 11-1.

Table 11-1: Indicative maximum periods for short term stockpiling of untreated ASS.

Type of material		Maximum acceptable duration of stockpiling
Texture range National Committee on Soil and Terrain (NCST, 2009)	**Approximate clay content (%)**	
Coarse Sands to loamy sands and peats	< 5	Overnight (18 hours)
Medium Sandy loams to light clays	5−40	2 nights (42 hours)
Fine Medium to heavy clays and silty clays	> 40	3 nights, e.g. a weekend (66 hours)

Under some circumstances these figures may be too conservative, and under others not conservative enough (e.g. during hot weather some sands may begin to oxidise within a matter of hours). It is recommended that appropriate operational delay times be decided (preferably well before the creation of the stockpile) for the specific circumstances. A guard layer under short-term stockpiles will be needed. A neutralising agent (e.g. aglime) should also be spread over the stockpile to limit the generation of acidity from the surface of the stockpile, but this will not prevent acid exiting the stockpile via leachates emerging near the base. Temporary bunding is needed around the stockpiles to collect any leachate, soil or lime washed off during overnight/weekend storms or rainfall events.

The total volume of material that is placed in short-term stockpiles should not exceed 20% of a day's total extraction, as immediate treatment should be the norm.

Note: These timeframes do not apply to monosulfidic black oozes (MBOs). It is not acceptable to stockpile untreated MBOs under any circumstances.

ASS tip 30: Guard layer rate for stockpiles

The minimum guard layer rate beneath any stockpiled ASS will be 5 kilograms fine aglime per m^2 per vertical metre of fill. Where the highest detected sum of existing and potential acidity is more than 1.0% S-equivalent, the rate will be at minimum 10 kilograms fine aglime per m^2 per vertical metre of fill.

Note: Reapplication of the guard layer will be necessary under areas of repeated temporary stockpiling.

Longer-term stockpiles

Any stockpiling exceeding the above timeframes is unacceptable. If ASS is required to be stored for longer than the above timeframes, it must be fully treated. Regulatory agencies should be notified of the existence of historical stockpiles and consulted on their management. If stockpiles are assessed as likely to cause environmental harm, then voluntary submission of an environmental management program under the *Environmental Protection Act 1994* is recommended. Failure to act on signs of high environmental risk may result in other action being taken under the Act.

11.1.3 Stockpiles of topsoil

It is routine practice to scrape topsoil before filling, and store it until it is needed for top dressing. Some of the management options listed above may be appropriate for managing topsoil stockpiles if they contain low levels of sulfides. Low levels of sulfides or existing acidity may occur in topsoils as a result of 'overstripping' that has occurred during its collection, or it may be intrinsic to the topsoil.

All topsoil should be tested before stripping and stockpiling. Neutralisation of the potential and existing acidity of any acid sulfate topsoil will be needed. It will be safer and probably cheaper and easier to neutralise sulfide-containing topsoil as it is scraped and placed. For example, the appropriate amount of neutralising agent can be spread over the topsoil and, using a reverse scraper, the lime incorporated before stripping; further mixing occurs as the soils are placed into the stockpiles.

11.1.4 Stockpiles and preloading

Soils are preloaded in many coastal development sites after the sites have been 'filled' to increase the rate of consolidation and resulting settlement. In the past, untreated ASS has been used as preload. This is unacceptable due to the potential risks to the environment associated with acidic leachate generated within the preload material. Acid sulfate soils that have been fully treated and