APPENDIX B11

Construction Acid Sulfate Materials Management Plan

Whytes Lane to Pimlico Road Early Works – Wave 2

Woolgoolga to Ballina Pacific Highway Upgrade

OCTOBER 2015

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Glossary / Abbreviations

ASM	Acid Sulfate Materials
bgl	Below ground level
CEMP	Construction Environmental Management Plan
CoA	Condition of approval
DP&I	Former NSW Department of Planning and Infrastructure (now DP&E)
DP&E	NSW Department of Planning and Environment
EIS	Woolgoolga to Ballina Pacific Highway Upgrade Environmental Impact Statement (December, 2012)
EPA	NSW Environment Protection Authority
EP&A Act	*NSW Environmental Planning and Assessment Act 1979*
EPBC Act	*Commonwealth Environmental Protection and Biodiversity Conservation Act 1999*
EPL	Environment Protection Licence
EWMS	Environmental Work Method Statements
CHMP	Construction Heritage Management Plan
Minister, the	NSW Minister for Planning
NPW Act	*NSW National Parks and Wildlife Act 1974*
OEH	NSW Office of Environment and Heritage
PASS	Potential Acid Sulfate Soil
PoEO Act	*NSW Protection of the Environment Operations Act 1997*
Project, the	Whytes Lane to Pimlico Road Early Works – Wave 2
Secretary	Secretary of the Department of Planning and Environment
SEE Civil	SEE Civil Pty Ltd
SPIR	Woolgoolga to Ballina Pacific Highway Upgrade Submissions Preferred Infrastructure Report (November, 2013)
SSI	State Significant Infrastructure
RMS, Roads and Maritime Services	NSW Roads and Maritime

1 Introduction

1.1 Context

This Construction Acid Sulfate Materials Management Plan (CASMMP or Plan) forms part of the Construction Environmental Management Plan (CEMP) for the upgrade of the Whytes Lane to Pimlico Road Early Works – Wave 2 (the Project).

This CASSMP has been prepared to address the requirements of the Minister's Conditions of Approval (CoA), project specifications and the mitigation measures listed in the Pacific Highway Upgrade Woolgoolga to Ballina Environmental Impact Statement (EIS) and all applicable legislation.

Wave 2 (the Project) is located within Section 11 of the Woolgoolga to Ballina Pacific Highway Upgrade. Wave 2 of the Early Works (soft soil treatments) is to allow the future upgrade of the section of HW10 Pacific Highway, Woolgoolga to Ballina. The Project specifically covers the following soft soil site as detailed below:

- Soft Soil Site 11 – between Whytes Lane and Pimlico Road (W2P) (STN 159,900 to STN 163,800).

1.2 Background

The Pacific Highway Upgrade Woolgoolga to Ballina EIS (RMS 2012) assessed potential acid sulfate materials impacts from construction of the Project.

The EIS identified that the Project lies within an area of high probability of acid sulfate soil occurrence between 1 and 3 metres below ground level (bgl).Additional management measures were provided within the Woolgoolga to Ballina Submissions / Preferred Infrastructure Report Nov 2013, with applicable management measures from that report included in Section 5 of this CASMMP.

The Project is anticipated to engage minor volumes of potential acid sulfate material based on the works predominantly involving surface grubbing and filling over areas of identified acid sulfate material at depths of approximately 1 to 3 metres below ground level.

Acid sulfate soil risk mapping is shown in the sensitive area plans in Appendix A5 of the CEMP.

1.2.1 Acid Sulfate Soil Characterisation

Acid Sulfate Soils (ASS) can be defined as "naturally occurring soil and sediment containing iron sulfides, principally the mineral iron pyrite, or containing acidic products of the oxidation of sulfides. When sulfides are exposed to air, oxidation takes place and sulfuric acid is ultimately produced when the soil's capacity to neutralise the acidity is exceeded. As long as the sulfide soils remain under the water table, oxidation cannot occur and the soils are quite harmless and can remain so indefinitely" (National Working Party on Acid Sulfate Soils 2000, p. 5).

Actual ASS can be defined as "soils containing highly acidic soil horizons or layers, resulting from the oxidation of soil materials that are rich in iron sulfides. This oxidation produces hydrogen ions in excess of the sediment's capacity to neutralise the acidity, resulting in soils of pH of 4 or less when measured in dry season conditions. These soils can usually be recognised by the presence of pale yellow mottles and coatings of jarosite" (RTA 2005).

Potential ASS (PASS) can be defined as "soils which contain iron sulfides or sulfidic material which has not been exposed to air and oxidised. The field pH of these soils in their undisturbed state is usually 4 or more (and may be neutral or even slightly alkaline)" (RTA 2005).

Appendix 1 to the ASSMAC Assessment Guidelines state that field pH (pHF) readings of less than or equal to 4 indicate the presence of actual ASS. pHF values of greater than 4 but less than 5.5 may be the result of previous or limited oxidation of sulfides, but does not confirm the presence of actual ASS. Additional information relating to field pH testing can be found in Appendix A.

Similarly, the ASSMAC Guidelines state that field peroxide (pHFOX) values and their analysis provide a stronger indication of the presence of PASS. Appendix A provides further details of field peroxide testing. Indicators to look for in these tests include the following:

- pHFOX < 3
- The more the pHFOX drops below 3, the more positive the presence of sulfides
- pHFOX value is at least one pH unit below the pHF value
- Observed ‘strong’ reaction with peroxide.

1.3 Environmental management systems overview

The overall Environmental Management System for the Project is described in the Construction Environmental Management Plan (CEMP).

The CASMMP is part of the environmental management framework for the Project, as described in Section 4.1 of the CEMP.

Management measures identified in this Plan will be incorporated into site or activity specific Environmental Work Method Statements (EWMS). EWMS will be developed and signed off by environment and management representatives prior to associated works and construction personnel will be required to undertake works in accordance with the identified requirements and associated mitigation measures.

Used together, the CEMP, strategies, procedures and EWMS form management guides that clearly identify required environmental management actions for reference by SEE Civil personnel and sub-contractors.

The review and document control processes for this Plan are described in Section 1.6 and Chapters 9 and 10 of the CEMP.

2 Purpose and objectives

2.1 Purpose

This CASMMP has been prepared to detail how SEE Civil proposes to manage and control environmental issues relating to Acid Sulfate Materials (ASM), handling and disposal associated with the construction of the Project.

The CASMMP is a Sub Plan to the Construction Environmental Management Plan (CEMP) and is applicable to all staff, employees and subcontractors throughout the duration of the contract until project completion.

This plan has been prepared to address the applicable statutory requirements and aims to ensure that the commitments with regard to ASM are met.

2.2 Objectives

The objective of this CASMMP is to provide management strategies to contain, mitigate and avoid impacts from ASM and to provide management plans for those activities where disturbance of ASM is unavoidable. The main objectives of the Plan are to:

- present principles and guidelines to aid in minimising impacts on the local environment;
- implement appropriate measures to ensure compliance with all relevant legislative requirements, CoA, project specifications and the Environmental Protection Licence (EPL) for the Project;
- describe the practical measures and best management practices to be included in design and construction to prevent or mitigate potential impacts relating to ASM;
- outline the roles and responsibilities of those involved in the implementation of ASM management controls;
- outline an effective implementation, monitoring, auditing and reporting framework; and
- provide an efficient, simplified and diligent approach to addressing the issue of ASM.

2.3 Targets

The following targets have been established for the management of acid sulfate materials during the Project:

- Ensure full compliance with the relevant legislative requirements, CoA, project specifications and RMS specifications; and
- Ensuring training on acid sulfate materials management is provided to all construction personnel through site inductions.

3 Environmental requirements

3.1 Relevant legislation and guidelines

3.1.1 Legislation

Legislation applicable to ASM management for the Project includes:

Commonwealth

- *Environment Protection and Biodiversity Conservation Act 2000*

NSW

- *Protection of the Environment Operations Act 1997 (POEO Act)*
- *Protection of the Environment Operations (General) Regulation 2009.*
- *Protection of the Environment Operations (Waste) Regulation 2005.*
- *Environment Planning and Assessment Act 1979 (EP&A Act)*
- *Waste Avoidance and Resource Recovery Act 2001*
- *Water Management Act 2000*
- *Water Act NSW 1912*
- *Native Vegetation Act 2003*
- *Fisheries Management Act 1994*
- *Contaminated Land Management Act 1997*
- *Coastal Protection Act 1979*
- *Environmentally Hazardous Chemicals Act 1985*
- *Threatened Species Conservation Act 1995*
- *National Parks and Wildlife Act 1974 (NPW Act)*
- State Environmental Planning Policy No.71 – Coastal Protection (SEPP 71)
- State Environmental Planning Policy No.14 – Coastal Wetlands (SEPP 14)

The applicability of all legislation to the project is detailed further in Appendix A1 of the CEMP.

3.1.2 Guidelines and standards

Best management practice guidelines, technical resources and standards relevant to the ASM management include the following:

- RMS Guidelines for the Management of Acid Sulfate Materials (RTA 2005).
- NSW Acid Sulfate Soil Manual (Acid Sulfate Soils Management Advisory Committee (ASSMAC) 1998).
- NSW Acid Sulfate Soil Risk Maps and Acid Sulfate Soil Planning Maps (Department of Infrastructure, Planning and Natural Resources).
- Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils (ASS) in Queensland (QASSIT), Department of Natural Resources, Resources Sciences Centre, Indooroopilly –. (Ahern C R, Ahern M R and Powell B 1998a).

- Queensland Acid Sulfate Soil Technical Manual – Soil Management Guidelines Version 3.8 QASSIT (S E Dear, N G Moore, S K Dobbs, K M Watling and C R Ahern 2002).
- Waste Classification Guidelines Part 1: Classifying waste (EPA, 2014).
- Waste Classification Guidelines Part 4: Acid sulfate soils (EPA, 2014)
- RMS QA Specification G36 – Environmental Protection, adjusted for this project (Version HW10 Pacific Highway Upgrade, Woolgoolga to Ballina Early Works – Wave 2, December 2014 Addendum 2).
- RMS QA Specification G1 cl 15 – Job Specific Requirements, adjusted for this project (Version HW10 Pacific Highway Upgrade, Woolgoolga to Ballina Early Works – Wave 2, December 2014 Addendum 2).

A description of the relevant guidelines and standards has been detailed further in Appendix A1 of the CEMP.

3.2 Minister's Conditions of Approval

The CoA relevant to this Plan are listed Table 3 1. A document reference is also included to indicate where the condition is addressed in this Plan or other Project management documents.

Table 3-1 Conditions of Approval relevant to the CASMPP

CoA No.	Condition Requirements	Document Reference
D26 (c) (v)	As part of the Construction Environmental Management Plan for the SSI, the Applicant shall prepare and implement: (c) a Construction Soil and Water Quality Management Plan to manage surface and groundwater impacts during construction of the SSI. The Plan shall be developed in consultation with the EPA, DPI (Fisheries), NOW, , DoE and the relevant council and include, but not necessarily be limited to: (viii) an Acid Sulfate Soils contingency plan, consistent with the Acid Sulfate Soils Manual, to deal with the unexpected discovery of actual or potential acid sulfate soils, including procedures for the investigation, handling, treatment and management of such soils and water seepage;	This plan & CSWQMP

4 Existing environment

The following section summarises existing potential ASM located within and adjacent to the Project area. The key reference document is Chapter 9 of the EIS.

4.1 Topography and soil characteristics

The topography throughout the Project is variable but can be broadly categorised as ‘lowland’. Lowland areas are predominately associated with the Clarence and Richmond river floodplains and occur where elevations are less than about 15 m AHD. This is the dominant landform within Section 11 of the Pacific Highway Upgrade between Woolgoolga and Ballina, with the Richmond River floodplain existing between Coolgardie (to the south) and Emigrant Creek (to the north), bounded by the Blackwall Range to the west. The overall upgrade project generally traverses the geological sequence of the Clarence-Moreton Basin, an extensive Mesozoic age sedimentary basin extending from southern Queensland to the NSW North Coast and comprising sedimentary rocks about 2.5 to 4 km thick. Both the northern and southern extents of the Pacific Highway Upgrade project extend beyond the sedimentary basin, with the underlying Palaeozoic basement rocks of the New England Fold Belt outcropping at Woolgoolga and Ballina.

As Section 11 consists of a relatively flat, low lying area; slope stability issues are not considered to be a likely concern.

However, the most common soil landscape within Section 11 is alluvial soils. These are typically highly acidic, highly erodible, of low bearing strength and subject to flood hazards. Consequently, the presence of acid sulfate soils (ASS) or potential acid sulfate soils (PASS) is a key consideration for the Project.

PASS contain iron sulfides (pyrites), which may oxidise when exposed to air, resulting in soil acidification and dissolved acid and metal discharge into nearby surface water bodies via surface water runoff and groundwater flows. Soil acidification and dissolved acid runoff can result in detrimental impacts on the health of land and aquatic plants and animals. The acid sulfate soil analyses in the EIS indicated that both actual and potential acid sulate soils are present, including broad areas of high risk acid sulfate soils and some areas of low risk acid sulfate soils (see Appendix A5 of the CEMP).

The entire Project length is identified in the EIS (Figure 9-22 in the EIS) to have a “high probability” of occurrence of ASM. The northern extent of the Project is mapped as a high probability of occurrence within 1 metre of the ground surface, whilst the majority of the Project is mapped as having a high probability of occurrence between 1 and 3 metres below ground surface. Since the acid neutralising capacity of the soils is insufficient to neutralise the total potential acidity present in the soils, appropriate acid sulfate soil management practices will be required.

The environmental risk management workshop undertaken concluded the Project poses a low risk of encountering acid sulfate material as only minor excavations are proposed, and therefore any potential impacts as a result of the works will be minimal. The minor excavations and potential for displacement of ASM is determined to be of low risk for the Project. Water from wick drains and pre loading areas will be tested for acid. If acid is detected, it will be treated with lime prior to discharging. With these measures and others identified in the CSWQMP (Appendix B4 to CEMP) in place, and considering minimal disturbance to acid sulfate soils, wick drain seepage water is considered to be of low risk to the Project.

5 Environmental aspects and impacts

5.1 Construction environmental aspects

The Project's construction environmental activities can have a direct and decisive impact on the environment and can contribute to a larger environmental change.

The most significant construction activities which could impact upon ASM sites, features and items include:

- demolition and site clearing;
- excavation and other associated earthworks;
- establishing stockpiling locations and transport routes;
- establishment of ancillary structures and site compounds; and
- vibration generated from construction works.

The Aspects and Impacts Register can be found in Appendix A2 of the main CEMP.

5.2 Construction environmental impacts

ASM occur along the road corridor at specific locations associated with low lying areas containing sulfate and sulphide minerals as demonstrated in Figure 9-22 of the EIS. The aspects, potential impacts and risk associated with these locations are related to the design of the road foremost, and secondly the construction techniques used to construct the road. The main adverse impacts that could occur during road construction through landscapes containing ASM if not managed appropriately are:

- generation of additional acidity from in situ ASM disturbance;
- export of existing acidity upon disturbance and wetting;
- generation of low pH waters (surface and groundwater) and potentially elevated dissolved metals;
- impacts on sensitive environments (flora and fauna);
- potential for soil structural decline;
- potential for infrastructure decline due to aggressivity to structures (corrosion etc);
- effects being of both short and long term consequence; and
- community perceptions of the project.

The usual management tool for excavated ASM is neutralisation with fine agricultural lime in accordance with the ASSMAC guidelines, as outlined in Appendix A.

The following sections provide a summary of the primary construction activities which have the potential to interact with ASM and the potential impacts that could be expected.

5.2.1 Filling low lying soft ground

Filling of low lying soft ground areas (back swamps, floodplain and marshlands) generally occurs during road construction to raise the road grade. Embankments are used to provide solid foundation for construction of the road and to be within the desired road design requirements. Filling is often undertaken using materials from cuttings, borrow areas and external sources. The quality and chemistry of the imported material can vary depending on its origin. Potential impacts of filling low lying soft ground areas include:

- upward heaving of surface and sub – surface soils at the edge of the embankment when the filling rate does not allow for even settlement (ground failure). This may lead to generation of acid from ASM layers previously in an anoxic soil horizon;
- settlement of ASM beneath the embankment when preloading and surcharging occurs;
- generation of acid spikes from ASM layers pushed into the shallow groundwater;
- where wick drains are used to accelerate consolidation, the water quality may be poor;
- where extremely soft soils are encountered, load induced groundwater flow may occur as water is squeezed out of the pore space of the consolidated sediments (typically clays); and
- as settlement of materials under the embankment occurs, a reduction in permeability and storage of water in materials (less space due to compaction) occurs also. This may lead to slight mounding of groundwater on one side of the embankment and slight lowering on the other side (dependant on geology, hydrology and settlement).

5.2.2 Shallow excavations

Shallow excavation is required for road infrastructure such as longitudinal drainage, pipes, culverts, geotechnically unsuitable material, pile caps, signposting, services and open channels. The majority of these types of excavations are generally less than 3.0m below ground level and usually not more than 1.5m. Often in low lying areas containing ASM, groundwater may be intercepted during excavations. Potential impacts of shallow excavations due to ASM include:

- excavation of ASM with the immediate ability to export acid and potentially dissolved metals upon wetting;
- excavation of ASM with the potential to generate acid upon exposure to oxygen and acidify;
- exposure of the cut faces of excavations to oxygen and water that may generate additional acidity or mobilise existing acidity;
- water quality reduction over short timeframes due to acid spikes and elevated dissolved metal concentrations;
- long term water quality issues (low pH, elevated total acidity, soluble sulfate, insoluble iron hydroxides and metals, principally Al, Fe, Mn and Zn). This especially applies to shallow drainage cut into ASM. Aesthetically drains and water appear unclean and stagnant;
- seepage of affected water into the shallow groundwater which may affect a larger initial area of disturbance;
- shallow dewatering for box culverts and discharge of potentially acidic water into adjacent surface water bodies;
- associated water quality impacts on sensitive receptors (flora and fauna); and
- increased aggressivity towards concrete and steel structures that water flows against and soil sits against. Steel will corrode quicker and the bonding of cement will break down faster to show underlying aggregate and possibly weaken structures over time.

5.2.3 Diverting small open drainage lines

Road design often requires some form of drainage diversion. Diversion of small open drains for vehicular access or road alignment is generally required. Diverting of drainage lines will usually only disturb ASM. Potential impacts of diverting small open drainage lines due to ASM include:

- excavation of ASM with the immediate ability to export acid and potentially dissolved metals upon wetting;
- excavation of ASM with the potential to generate acid upon exposure to oxygen and acidify;
- exposure of the cut faces of excavations to oxygen and water that may generate additional acidity or mobilise existing acidity;
- water quality reduction over short timeframes due to acid spikes and elevated dissolved metal concentrations;
- long term water quality issues (low pH, elevated total acidity, soluble sulfate, insoluble iron hydroxides and metals, principally Al, Fe, Mn and Zn). This especially applies to shallow drainage cut into ASM. Aesthetically drains and water appear unclean and stagnant;
- seepage of affected water into the shallow groundwater which may affect a larger initial area of disturbance;
- associated water quality impacts on sensitive receptors (flora and fauna); and
- increased aggressivity towards concrete and steel structures that water flows against and soil sits against. Steel will corrode quicker and the bonding of cement will break down faster to show underlying aggregate and possibly weaken structures over time.

6 Environmental mitigation and management

During construction activities, environmental management measures are to be undertaken to reduce the risk of adverse environmental issues or incidents due to disturbance of ASM. The following general construction activities have been identified as potentially disturbing ASM along the road corridor:

- grubbing and topsoil stripping;
- shallow excavations; and
- any engineered filling requirements.
-

The following sub sections and Appendices A and B of this Plan provide environmental management measures to limit adverse impacts to the environment. In all areas of disturbance, review of sampling locations, sample depths and results will be completed to provide site specific data.

RMS specifications G1, G36, G38 and G40 outline requirements for managing ASM and shall be adhered to throughout the Project.

6.1 Grubbing and topsoil stripping

Where topsoil and surface vegetation (generally including upper 0.2m of soil) are grubbed in ASM areas with a high probability of occurrence within 1 metre of the ground surface identified (refer Appendix A5 of CEMP), surface liming will occur within 24hr of disturbance. Liming will generally include ‘dusting’ (2.5 – 5kg/m^2) the area stripped with a fine aglime to neutralise any organic or non – organic acidity that may be generated due to disturbance and diffusion of oxygen to surface soils. If topsoil (excluding plant matter) is stockpiled then dose with fine aglime at calculated rates. Where calculated rates are unavailable, use 20kg/m^3 for clays and silty clays and 10kg/m^3 for sands. Natural topsoil will generally have very high organics and low inorganic sulphur.

Grubbing and topsoil stripping will be undertaken in accordance with RMS specifications, including G40.

6.2 Shallow excavations

Where shallow excavations occur, the following steps will be undertaken:

- identify the location of disturbance against sampling locations and results;
- determine and document the construction activity and controls;
- determine approximate volume of ASM that may be disturbed;
- determine the liming rates required to neutralise all disturbed ASM;
- spread a ‘dusting’ of fine aglime over the exposed surface of ASM following excavations to help neutralise any immediate acidity generated prior to commencing further works. Note: no topsoil stripping is proposed;
- collect all excavated ASM impacted and place in a containment area for amelioration (Appendix A – B). Separation of ASS and PASS material will be determined subject to volumes disturbed and profile encountered;
- apply aglime to excavated faces at a rate of 5kg/m^2 to limit acid generation;
- monitor any pooled water within the excavation for acidity issues daily (pH, Electrical Conductivity (EC), Dissolved Oxygen (DO) and turbidity);

- treat any water with acidity issues at rates indicated in CSWMP and Appendix A of this Plan; and
- monitor disturbed area for any acidity issues (Appendix A).

6.3 Any engineered filling requirements

Although filling activities do not generally disturb the ground, they can during construction disturb soil profile or groundwater flows where settlement is uneven and upward heaving at the edge (failure) occurs. As fillings are designed and constructed using safety factors and construction rates to negate failure, it is anticipated that upward heaving will be limited (if any). Where filling on soft compressible ground occurs the following monitoring will be conducted:

- groundwater level and quality monitoring on a monthly basis at all monitoring wells adjacent to the filling zones. Quality monitoring to measure pH, EC, DO, and turbidity;
- documenting of water quality results and observations;
- collation of all pre-construction groundwater data and comparison to data recorded during filling timeframe;
- identifying any significant differences in water levels and quality that may have occurred;
- re-assessing groundwater monitoring based regime based on results obtained;
- weekly visual observation of embankment batters and toe edge areas to determine if there are any acidity or groundwater daylighting issues; and
- where wick drains are used to speed up settlement, water quality of drained water will be assessed and contained if necessary in drains and holding ponds, and treated prior to surface discharge.

The above mitigation and management measures are fully described in the CSWQMP (Appendix B4 to the CEMP).

6.4 General works

Where disturbance in ASM areas occurs, weekly observations of the construction area will be undertaken to detect any potential acidity issues. Truck movements and overall disturbance of surface sediments can lead to some increases in acid production due to the oxidation or pyrite, exchange of existing acidity is previously acidified soils and breakdown of organic matter that will release organic acids. Where there is an acidity issue, lime application at low rates of 2.5kg/m^2 or a ‘dusting’ will be used to limit or adjust any build-up of acid. Due regard for pH sensitive environments such as estuarine areas and impacts on flora and fauna will be made through site specific observations and expert recommendations.

6.4.1 Stockpiling and treating soils

All excavated ASM will be stockpiled in a low permeability bunded area capable of containing all materials and associated leachate that may be produced either by seepage (drying) or rainfall. No ASM will be stockpiled for any longer than one day without adequate bunding and containment. Typical stockpiling sketches are shown in Appendix A. The following stockpile construction elements must be used:

- Stockpiles will be placed away from creek lines, flow lines, and any other type of water body where possible.
- A low permeability dense clay with minimal sand and coarse materials will be used for bunding and base materials.

- Clay will be compacted to reduce permeability further.
- A base layer of >80 micron plastic sheeting or geo - synthetic may be used to reduce permeability when suitable fill is unavailable.
- Bunds must be high enough to contain all materials stockpiled and leave some room at the base for leachate to collect and drain to a low point, discharge point (sump) or attached holding pond. Bunding will be designed in accordance with the stockpile management procedure (Appendix B4 of CEMP), RMS QA Specification G1 and the Blue Book.
- Line the bund with a clay lining mixed with neutralising agent (50kg/m3) and a minimum 500mm thick.
- A 'guard layer' of mixed clay and aglime will be used above the base layer (0.3m thick) to immediately neutralise acidity from placed materials. The 'guard layer' will be mixed with non-ASM clay at a minimum rate of 20kg/m³ for all materials and up to 50kg/m³ for highly acidic or potentially acidic materials >125 molH+/t or 0.2%S.

ASM stockpiled materials will be placed as follows:

- Layers not to exceed 0.5m depth and preferably 0.15 - 0.3m to allow for efficient mixing and drying of potentially wet sediments.
- When materials are sufficiently dry (not saturated) apply aglime at the calculated rates for the material and spread evenly and mix thoroughly (several times as required).
- Sample for validation testing as required (Appendix A).
- Check validation results and either re – lime if required, compact for the next layer or place in a separate placement area for ASM that has passed the validation process.
- Earthworks processes may require adjustment to suit the requirements of processing and treatment of ASM.
- Materials are to be stockpiled in batches in order to eliminate the risk of mixing materials of different ASM properties and management requirements
- The stockpile site must be above the 1 in 20 ARI flood level.

Short to medium term stockpiling of ASM outside the ASM treatment area will only be undertaken when transport to or treatment in the treatment area is not possible. In this case, stockpiling will be appropriately bunded and in accordance with the following table:

Table 6-1 Stockpiling of ASM

Type of Material		Maximum Duration of Stockpiling Prior to Treatment
Texture Range	***Approx Clay Content (%)***	***Days***
Coarse Texture (Sands to loamy sands)	<5	Overnight
Medium Texture (Sandy loams to light clays)	5-40	2.5
Fine Texture (Medium to	>40	5

Type of Material		Maximum Duration of Stockpiling Prior to Treatment
Texture Range	*Approx Clay Content (%)*	*Days*
heavy clays and silt clays)		

6.4.2 Leachate and water liming

Ponded leachate from excavated ASM materials should not be appreciably acidic, since the management protocols have been formulated to prevent build-up of significant acidity. However, heavy or sustained rainfall during excavation, especially over weekends, may produce leachate from excavated stockpiles, which have pH less than the receiving water, since they have not had sufficient time to contact and react with the neutralising agent.

In the above instances, and in cases where ponded leachate needs “finishing” before discharge to natural waterways, a calcium hydroxide solution will be used for rapid neutralisation as per the Construction Soil and Water Management Plan (Appendix B4 of CEMP) and Appendix A of this plan.

6.5 Management and mitigation measures

A range of environmental requirements and control measures are identified in the various environmental documents, including the Submission / Preferred Infrastructure Report (November 2013), the Conditions of Approval and relevant RMS documents. Specific measures and requirements to address impacts from ASM are outlined in Table 5 2.

To meet the requirements of RMS QA Specification G1, a specialist sub-contractor would be engaged acceptable to RMS to undertake the sampling and testing of ASM.

Table 6-2 ASM management and mitigation measures

	Measure / Requirement	Project Stage	Accountability	Reference
ASS1	Acidic soils will be managed in accordance with the geotechnical investigation as per the contract specifications and all technical and laboratory reports will be attached to contract documents.	Construction	Construction Manager/ ESR	Good practice
ASS2	Stockpiles containing potential acid sulfate soils will be lined, bunded and covered in accordance with relevant guidelines.	Construction	Construction Manager/ ESR	Submissions / PIR (SSW15)
ASS3	The design and location of ASM treatment areas will be marked on EWMSs, Appendix A5 of the CEMP and other relevant plans.	Pre-construction / Construction	Construction Manager/ ESRESR	Good practice
ASS4	Aglime or other ASM treatment material suppliers and storage locations will be finalised prior to construction and stores of these materials will be established for on-site ASM treatment.	Pre-construction/ Construction	Construction Manager/ ESRESR	Good practice
ASS5	All relevant construction personnel and contractors will be trained in the requirements of this Plan and will be aware of the location of the ASM treatment areas and their personal obligations to report excavated ASM or ASM material to their supervisor.	Pre-construction/ Construction	Construction Manager/ ESRESR	Good practice
ASS6	The ASM Contingency Procedure (Appendix B) will be followed when ASM is unexpectedly encountered during excavation / construction activities. Detailed assessment by qualified soil specialist required.	Construction	Construction Manager/ ESRESR	Good practice
ASS7	The time of exposure of ASM will be minimised to reduce acid production and resulting impacts by: • Programming excavations to ensure that excavations in ASM areas are left open for the minimum time possible with the objective of wherever possible having temporary excavations refilled within 24 hours. • All ASM stockpiles that require more than 24 hrs (temporary storage) will be stabilised with lime to prevent acid generation.	Construction	Construction Manager/ ESRESR	Good practice
ASS8	Clearing and grubbing in areas of expected ASM will be managed so that exposure of soils to oxidisation is minimised.	Construction	Construction Manager/ ESRESR	Good practice
ASS9	Where excavations have the potential to discharge water to the surrounding environment, barriers of limestone will be put in place to neutralise acidic runoff, as guided by the CSWQMP (Appendix B4 to the CEMP). These barriers will consist of sand bags or similar being placed in drainage lines to direct runoff into the sand bag barrier. The	Construction	Construction Manager/ ESRESR	Good practice

	Measure / Requirement	Project Stage	Accountability	Reference
	barrier will contain limestone, and potentially acidic water will contact the limestone leading to (partial) neutralisation prior to the water flowing out of the sandbag barrier and to surrounding waters (refer Appendix A).			
ASS10	Disturbed ASM areas will be capped with clean fill (VENM/ENM or suitably approved fill from Project site) at a typical depth of 0.5m or covered with aglime (5kg/m2) to reduce exposure of soils and reduce the generation of acid (Appendix A)	Construction	Construction Manager/ ESRESR	Good practice
ASS11	ASM treatment areas will be located in accordance with Appendix A.	Construction	Construction Manager/ ESRESR	Good practice
ASS12	Bunded, impervious ASM treatment areas will be constructed to treat ASM.. Treatment areas will be constructed using impervious clay or plastic sheeting covered by geotextile fabric layer and sandstone base, with the outside batters of bund walls topsoiled and stabilised.	Construction	Construction Manager/ ESRESR	Good practice
ASS13	Prior to operation of an acid sulfate soil treatment area, an Internal Permit will need to be signed off by the ESR. This permit requires permeability tests to be undertaken by an industry accepted method to verify that the treatment area base, bunds and leachate ponds are impermeable.	Construction	Construction Manager/ ESRESR	Good practice
ASS14	The ASM treatment areas will be designed to have the capacity to treat the estimated ASM for the duration of the Project plus a safety factor contingency in the event of excess unexpected material. The treatment area will also provide enough capacity to capture and treat runoff/stormwater.	Construction	Construction Manager/ ESRESR	Good practice
ASS15	Spoil will only be transferred to ASM treatment areas if ASM field testing is either positive or inconclusive, as outlined in RMS QA Specification G1 Cl 15.1 and Appendix A. This is to ensure that overly wet soil, which is not ASM is not utilising resources required for ASM.	Construction	Construction Manager/ ESRESR	Good practice
ASS16	A supply of aglime or other suitable treatment material will be stored in the treatment areas in adequate quantities to treat the planned volumes of disturbed ASM soils. These stockpiles will be stored with adequate controls to prevent erosion of material from wind and water in accordance with the CSWMP (Appendix B4 of CEMP).	Construction	Construction Manager/ ESRESR	Good practice
ASS17	Diversion banks or bunds around the ASM treatment areas will be	Construction	Construction Manager/	Good practice

	Measure / Requirement	Project Stage	Accountability	Reference
	established to prevent run-on or lowland waters entering the ASM bunded area.		ESRESR	
ASS18	Drains leading from treatment areas to the leachate pond will be lined with intermittent limestone barriers to neutralise any acidic runoff prior to collection. This will assist to limit the need to treat acidic leachate using hydrated lime (refer Appendix A).	Construction	Construction Manager/ ESRESR	Good practice
ASS19	Short to medium term (strictly no longer than 18 hours) stockpiling of ASM will only be undertaken when transport to or treatment in the treatment area is not possible. This is a last resort measure caused by unanticipated delays including but not limited to access issues or equipment failure. In this case, stockpiling will be in accordance with the CSWMP (CEMP Appendix B4). Stockpiles will be adequately bunded to prevent acid impacts.	Construction	Construction Manager/ ESRESR	Good practice
ASS20	ASM will be treated in accordance with the Treatment of ASM Procedure (Appendix A).	Construction	Construction Manager/ ESRESR	Good practice
ASS21	Run-off captured from areas affected by ASM (including treatment and construction areas) will be managed to ensure that leachate criteria are met.	Construction	Construction Manager/ ESRESR	Good practice
ASS22	Containment strategies will be identified and implemented prior to working in areas containing ASM to ensure that any acidic leachate associated with the oxidisation of ASM is contained for treatment or removal and is prevented from entering downstream watercourses. These will be detailed in the EWMS.	Construction	Construction Manager/ ESRESR	Good practice
ASS23	When water is present in the leachate pond, field pH monitoring of leachate ponds will be undertaken at least weekly and after each rain even causing runoff , to determine water pH and appropriate treatment requirements.	Construction	Construction Manager/ ESRESR	Good practice
ASS24	Water from wick drains will be monitored for potential ASS related impacts. If water is found to be acidic then it will be either captured, if providing quantities permit, and transported to the ASS leachate pond for treatment; or treated at the source using aglime.	Construction	Construction Manager/ ESRESR	Good practice
ASS25	Mitigation works will be implemented in accordance with Guidelines for the Management of Acid Sulfate Materials (Roads and Maritime 2005) and Waste Classification Guidelines Part 4: Acid Sulfate Soils (EPA	Construction	Construction Manager/ ESR	Good practice

	Measure / Requirement	Project Stage	Accountability	Reference
	2014)			
ASS26	ASM stockpiles will be isolated from other stockpiled non-ASM materials.	Construction	Construction Manager/ ESR	Good practice
ASS27	Surplus excavated material from within the Project corridor (although not expected) will be assessed by a qualified soil specialist by field screening pH and peroxide analysis and/or laboratory analysis, to determine if appropriate for reuse on site.	Construction	Construction Manager/ ESR	Good practice
ASS28	No ASS or PASS will be imported to site.	Construction	Construction Manager/ ESR	Good practice
ASS29	No untreated ASS or PASS will be exported from site.	Construction	Construction Manager/ ESR	Good practice
ASS30	In the unlikely event ASM is to be transported from site for off-site disposal, it will be undertaken by a licenced regulated waste provider for lawful disposal at Lismore Waste Facility 313 Wyrallah Road, East Lismore, NSW 2480.~~the CWEMP (Appendix B7 to the CEMP).~~	Construction	Construction Manager/ ESR	Good practice

7 Compliance management

7.1 Roles and responsibilities

The Project Team's organisational structure and overall roles and responsibilities are outlined in Section 4.2 of the CEMP. Specific responsibilities for the implementation of environmental controls are detailed in Section 5 of this Plan.

7.2 Training

All employees, contractors and utility staff working on site will undergo site induction training relating to actions to be taken in the event that ASM is discovered or suspected. The induction training will address elements related to ASM including:

- Targeted Toolbox training regarding identification of ASM, roles and responsibilities and EWMS will be regularly provided to maintain awareness of onsite environmental issues. Targeted training will also be provided on practices, controls to avoid disturbance and impacts from ASM and on the rapid response to and reporting of all environmental incidents.

Further details regarding staff induction and training are outlined in Section 5 of the CEMP.

7.3 Monitoring and inspection

Inspections of ASM areas will occur for the duration of the project. Reporting on results of the inspections and monitoring as described in Table 7-1 will be through the Monthly Environmental Report.

Table 7-1 ASM monitoring

Monitoring				
Item	**Frequency**	**Applicable standards**	**Responsibility**	**Reporting**
Monitoring of groundwater	Refer Soil and Water Management Plan (Appendix B4 to CEMP) and Section 5.2	Set out in Soil and Water Management Plan (Appendix B4 to CEMP) and Section 3.1.2	ESR	Monthly Environmental Report
Monitor disturbed area for any acidity issues	Daily	Refer Section 3.1.2	ESR	Monthly Environmental Report
Monitor quality of water drained from wick drains	Refer Soil and Water Quality Management Plan (Appendix B4 to CEMP)	Refer Section 3.1.2	ESR	Monthly Environmental Report
Monitor any pooled water in shallow excavations for acidity issues	Daily	Refer Section 3.1.2	ESRESR	Monthly Environmental Report
When water is present in the leachate pond (ASM treatment area), monitor field pH to determine water pH and appropriate treatment requirements.	At least weekly and after each rain even causing runoff	Refer Section 3.1.2	ESRESR	Monthly Environmental Report

Monitoring				
Monitoring of ASM treatment areas	Daily	Refer Section 3.1.2	ESR	Monthly Environmental Report

General requirements and responsibilities in relation to monitoring and inspections are documented in Section 8 of the CEMP.

7.4 Auditing

Audits (both internal and external) will be undertaken to assess the effectiveness of environmental controls, compliance with this plan, CoA and other relevant approvals, licenses and guidelines.

Audit requirements are detailed in Section 8.3 of the CEMP.

7.5 Reporting

Reporting requirements and responsibilities are documented in Chapter 8 of the CEMP. These include specific reporting requirements associated with inspections.

8 Review and improvement

8.1 Continuous improvement

Continuous improvement of this Plan will be achieved by the ongoing evaluation of environmental management performance against environmental policies, objectives and targets for the purpose of identifying opportunities for improvement.

The continuous improvement process will be designed to:

- Identify areas of opportunity for improvement of environmental management and performance.
- Determine the cause or causes of non-conformances and deficiencies.
- Develop and implement a plan of corrective and preventative action to address any non-conformances and deficiencies.
- Verify the effectiveness of the corrective and preventative actions.
- Document any changes in procedures resulting from process improvement.
- Make comparisons with objectives and targets.

8.2 CASMMP update and amendment

The processes described in Chapter 8 and Chapter 9 of the CEMP may result in the need to update or revise this Plan. This will occur as needed.

Any revisions to the CASMMP will be in accordance with the process outlined in Section 1.6 of the CEMP.

A copy of the updated plan and changes will be distributed to all relevant stakeholders in accordance with the approved document control procedure – refer to Section 10.2 of the CEMP.

Appendix A
ASM Treatment Procedure

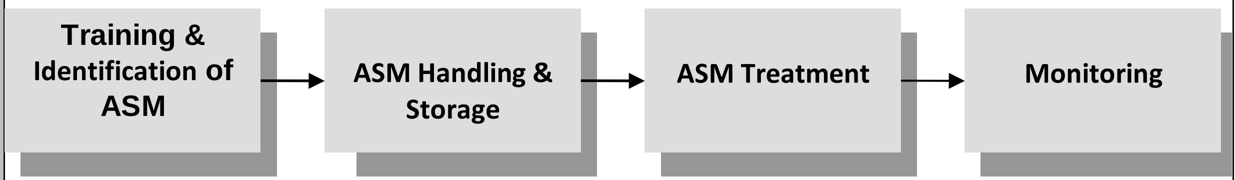
A1 Construction Procedure – Acid Sulfate Materials Management

Purpose: To define the method of testing, treatment and management to be used for Acid Sulfate Material (ASM).

<table>
<tr><td>Project No.:</td><td>396-1</td><td>Project Description:</td><td>Whytes Lane to Pimlico Road Early Works – Wave 2</td></tr>
<tr><td>Scope of Procedure</td><td colspan="3">
This procedure is applicable to activities conducted by SEE Civil personnel and subcontractors that have the potential to uncover/encounter Acid Sulfate Soils (ASS) and Potential Acid Sulfate Soils (PASS) such as excavations, earthworks and drainage.

This Construction Procedure details the requirements to manage ASS/PASS in accordance with the Construction Acid Sulfate Materials Management Plan, Environmental Protection Licence and Ministers Conditions of Approval.

The procedure details the process involved in the following elements of managing ASS/PASS:



Refer to attached Figure for ASS/PASS procedure flowchart.
</td></tr>
</table>

Procedure

1. Acid sulfate material encountered during excavation / construction activities
If ASS/PASS is encountered by chance during excavation / construction activities: ***STOP ALL WORK*** *in the immediate / affected area and follow the steps detailed in the* *Acid Sulfate Material Contingency Procedure*. If ASS/PASS is expected during excavation and test results are available to determine treatment rates, then proceed to **Step 4 of this procedure.**

2. Identification of Acid Sulfate Material
The identification of ASS/PASS shall be performed as detailed in Acid Sulfate Material Contingency procedure.

3. Personnel Protective Equipment (PPE)
Prior to any PASS / ASS management, appropriate personal protective equipment (PPE) is to be worn as per relevant MSDSs (e.g. for Lime). This may include: • Eye protection and/or face masks • Hard Hat • Rubber boots, gloves • Appropriate clothing (e.g. long sleeved shirts).

4. Acid Sulfate Material Storage and Handling

Organising the storage and handling of ASS/PASS is the responsibility of the Supervisor.

Storage

Acid sulfate material will be stored in a designated Acid Sulfate Treatment Area (ASTA).

Transport of ASS/PASS material

Transport of ASS / PASS material will be made via haulage trucks with adequate tailgates to prevent spillage of material onto public or construction access roads.

Haulage routes will be monitored routinely for ASS material and any spills cleaned up appropriately.

Acid Sulfate Treatment Area

The ASS / PASS treatment area will be constructed as per the treatment pad design guideline included at the end of this procedure. The location of treatment pads will identified on erosion and sediment control plans and included on sensitive area maps as identified. The Stockpile Management Protocol is to be completed and approval obtained from the Environmental Site Representative (ESR) prior to stockpile establishment in accordance with CoA D21.

Treatment pads are considered Ancillary Facilities under the CoA Definitions and sites that have not been identified and assessed in the documents listed in CoA A2 shall meet the requirements in clause B73. A checklist of these conditions is included in the Stockpile Management Protocol.

5. Acid Sulfate Material Treatment

Testing requirements

Sampling and testing for acid sulfate material shall be in accordance with ASSMAC Guidelines and undertaken by an appropriately qualified subcontractor acceptable to the Principal.

Acid sulfate material screen testing to identify acid sulfate soils shall be by pH_{FOX} (oxidised using 30 per cent H_2O_2 solution) testing as materials are excavated, then determine the level of acid sulfate content and treatment measures by undertaking SPOCAS Plus analysis testing. Preliminary assessment results for the soils shall be reported to the Principal in accordance with Table 2.4 and Clause 2.3 of the ASSMAC Guidelines, including recommendations for the proposed treatment of soil.

Neutralising Agent

Aglime will be stored at the ASTA in sufficient quantities to enable the treatment of acid sulfate material expected for the work activities being undertaken. The management of onsite treatment is the responsibility of the Supervisor, with assistance from the ESR.

Aglime will be covered with tarpaulin and stored in ‘dry areas’ to prevent runoff leaching into the surrounding area and to minimise dust.

Agricultural lime must comply with the following (minimum frequency of testing 1 per 1000 tonne):

(a) Fertilisers Act NSW 1985

(b) have a particle size distribution as follows as determined by AS 4489.2.1:

• Passing 4.75mm sieve – minimum 95%

• Passing 1.18mm sieve – minimum 50%

• Passing 0.075mm sieve – minimum 10% and maximum 90%

(c) have a minimum Neutralising Value of 85% in any standard particle size range as determined by AS 4489.6.1

(d) have a maximum moisture content of 10% as determined by AS 4489.8.1.

Prior to the establishment of aglime stockpiles outside the ASS treatment area, Stockpile Location Protocol (in accordance with CoA B73-B78) is to be completed and approval obtained from the Environmental Site Representative.

***In situ* treatment of acid sulfate material**

In situ treatment of acid sulfate material will be undertaken for exposed surfaces (batters/trenches) and works where the disturbed material will be used as backfill material after treatment, for example during excavation.

- Runoff shall be diverted away from exposed acid sulfate material.
- Cut batters and/or trenches shall be coated with fine aglime at a rate determined by the SPOCAS Plus test and the lime checked and re-limed as required on the advice of the 'appropriately qualified subcontractor'. Re-liming may be required on a daily basis during heavy rain or dewater activities
- Lime will be added over the top of the pre-disturbed soil in the appropriate quantities as determined by the SPOCAS Plus test results and thoroughly mixed.

Treatment within an ASTA

- Mixing lime through the acid sulfate material is undertaken using the following methodology. 1/3 of the total aglime required for the excavated material (determined from lab testing) will be placed as a bed over the proposed treatment location.
- ASS or PASS material is to be placed on top of the lime in a layer no greater than 350mm and allowed to dry sufficiently.
- When the material is dry (expected 1-2 days in dry weather), another 1/3 of the total lime shall be added to the top and sides of the stockpile and thoroughly mixed, using either small or large mechanical equipment such as a disc plough or rotary hoe attached to a tractor or other suitable equipment.
- The partially treated stockpile shall then be allowed to dry further if required.
- The remaining 1/3 of lime shall be added to the top and sides of the stockpile.
- Thoroughly mix the stockpile using a rotary hoe (either on a tractor or as an excavator attachment). Where an excavator is to be used increase the safety factor to 2-2.5 dependent on the difficulty of mixing lime into the material.
- Sample the treated material and test by laboratory analysis using the SPOCAS Plus method to confirm the neutralisation of the material (see Section 6)
- When the treated soil is confirmed as being neutral then it may be incorporated in the Work in accordance with the limitations identified in QA Specification G1, clause 15.2.2.
- In addition to the requirements of RMS R44, prior to placement of treated acid sulfate materials the Principal must be provided with certification that the material is suitable for reincorporation including original TS% test results, details of treatment(s) and confirmation of where the material is to be re-used. Submission under this clause constitutes a HOLD POINT.
- The final location of the neutral soil shall then be tracked and recorded using the Treated ASS Tracking Register.

For small quantities of ASS / PASS material, such as an individual truck load, lime will be mixed using an excavator bucket.

Note: the ratios of aglime to be added may be varied on approval by the ESR.

6. Treated Acid Sulfate Material Monitoring

Following mixing and additional drying, if required, the treated soil, including exposed batters, is to be tested by laboratory analysis using the SPOCAS Plus method to determine if the Action Criteria for determining the neutralisation of treated material has been met (Action Criteria shown in Table 1).

Treated acid sulfate material will be determined to be neutral if results for the acid and/or sulphur trails are below the criteria detailed in Table 1. Consideration must be given to the amount of treated soil and the soil texture. If any doubt exists over either factor, the lowest criteria of 0.03% oxidisable sulphur or 18 Mol H+ per tonne shall be used.

If testing shows the criteria are met, and the pH of the soils and leachate pond does not fall below pH 6.5 no further treatment is required and the material may be reused on site. A record of where this treated material is transported to must be kept via Treated ASS Tracking Register.

If these acid and sulphur criteria are not met, further mixing with additional treatment product is required on the relevant material until targets are met. The amount of additional treatment product can be determined from results of the sulphur and acid trails.

Verification testing rates

Minimum volumetric rates (depending on existing plus potential acidity) are:

- <0.5% S-equivalent (<312 mol H+/tonne) – 1 per 1000 m^3
- 0.5−2% S-equivalent (312−1247 mol H+/tonne) – 1 per 500 m^3
- >2% S-equivalent (>1247 mol H+/tonne) – 1 per 250 m^3.

The specialist Subcontractor acceptable to the Principal shall conduct composite sampling taken according to a random or stratified-random protocol. Sampling and testing frequency may be modified by the specialist Subcontractor in accordance with site conditions and industry best practice. Sampling will include verification testing following decommissioning of ASTA.

7. Treatment of water

Where wick drains are used to speed up settlement, water quality of drained water will be assessed and contained in drains and holding ponds, and treated prior to surface discharge.

When the pH of the leachate pond falls below 6.5 the water must be treated prior to discharge using hydrated lime in the ratio detailed in Table 2.

Discharge from leachate capture ponds shall be in accordance with procedures within Appendix B4 – Construction Soil and Water Quality Management Plan and the EWMS – Dewatering Activities.

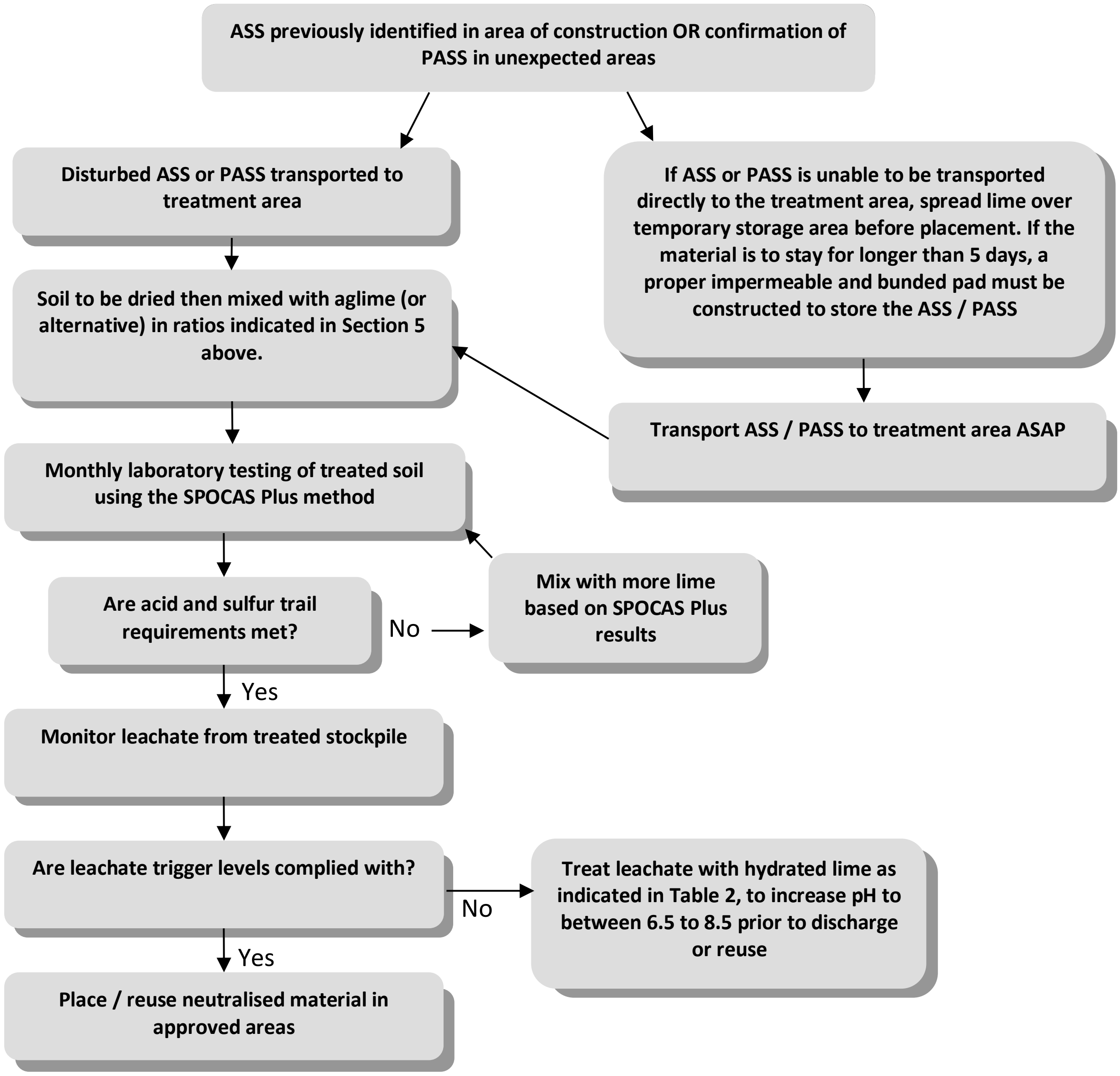
- **Training**

Site Specific Induction

Environmental Awareness Training – Acid Sulfate Soils Module.

Toolbox Talk – Acid Sulfate Soil Impacts.

The following flow chart details the summary of the steps required to effectively treat ASS / PASS



A2 Action Criteria for Management Intervention – Acid Sulfate Materials

Table 1 details the texture based action criteria for management of ASM disturbance. Where soils containing concentrations at or above the action criteria are disturbed, management of spoil is required.

Table 1: Action criteria based on the ASS analysis for three broad texture categories

Type of Material		Action Criteria 1- 1000 tonnes disturbed		Action Criteria > 1000 tonnes disturbed	
Texture range (McDonald et al. (1990)	Approx clay content (%<0.002 mm)	Sulphur trail % S oxidisable e.g. S_{TOS} or S_{POS}	Acid trail mol H+/tonne e.g. TPA or TSA	Sulphur trail % S oxidisable e.g. S_{TOS} or S_{POS}	Acid trail mol H+/tonne e.g. TPA or TSA
Coarse Texture Sands to loamy sands	≤5	0.03	18	0.03	18
Medium Texture Sandy loams to light clays	5 – 40	0.06	36	0.03	18
Fine Texture Medium to heavy clays and silty clays	≤40	0.1	62	0.03	18

Source: *Ahern et al. 1998*

A3 ASM Treatment Areas

Once the presence of acid sulfate material on site has been assessed by a suitably experienced and qualified soil scientist and an understanding of the proposed soil disturbance activities and quantities involved are established, acid sulfate material treatment areas will be identified, established and added to the Environmental Constraints Maps and recorded below.

In selecting possible locations for treatment areas, the following will be considered:

- Areas will be previously disturbed.
- Areas will not require clearing of native vegetation.
- Areas will be assessed to be of low conservation significance for flora, fauna, indigenous or non-indigenous heritage.
- Areas will be approved following the Stockpile Management Protocol.

The proposed stockpile area 11-1a (located on the southern side of McAndrews Lane) will be utilised to establish an ASM treatment area. The design of the treatment areas will be in accordance with the procedures set out in Appendix A2 ASM Treatment Pad Design.

A4 ASM Treatment Pad Design

Treatment Pad Design & Stockpile Construction Sketches

For treatment of large volumes of material, neutralisation will be carried out on a treatment/ liming pad. Stockpile areas for the Project will be established in accordance with CoA 21 if stockpiling is required. The following issues will be considered in the treatment pad design: schematic cross-section of a treatment pad, including a compacted clay layer, guard layer, leachate collection system and containment with bunding (refer to Fig A1 and A2).

The proposed stockpile area 11-1a (located on the southern side of McAdrews Lane) will be used for treating any unexpected ASM . Other methods of containing and treating materials insitu may be viable. In all cases, leachate will be contained in the stockpile area and treatment area will be bunded to prevent surface water entering treatment area. Due regard for sensitive receptors and environmental risk will also be accounted for in design, transport and placement.

1 Impervious base

A layer of compacted non-ASS clayey material (>0.1 metres thick) placed on the surface of the treatment pad can reduce the infiltration of leachate to the soil and groundwater. An impervious base is particularly beneficial if the treatment pad is situated in a sandy area. The base layer should be slightly domed or sloped to prevent leachate from pooling in the treatment pad area.

2 Guard layers

For situations where treated ASS will remain permanently in its treatment location, a guard layer of neutralising agent should be spread onto the soil surface of the treatment pad before the placement of soils (see Figure 1 below). This will reduce risk by neutralising acidic leachate generated in the treatment pile and not neutralised during the treatment process. This is especially relevant to the first layer of ASS that is placed for treatment before application of the neutralising agent. The guard layer will help protect groundwater quality. The guard layer should be employed as a precaution to neutralise acidity that has not been adequately treated during the soil neutralisation process.

The minimum guard layer rate beneath any treated-in-place 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 temporary treatment pads, as the guard layer is likely to be removed with the treated soil. Guard layers may need to be applied between each compacted ASS layer as a precaution in environmentally sensitive areas, areas with high levels of sulfides or where soils are difficult to mix.

<u>Stockpiling of acid sulfate material</u>

When stockpiling acid sulfate materials within the treatment pad is unavoidable, the following additional requirements shall apply:

• Line the bund with a clay lining mixed with neutralising agent (50kg/m3) and a minimum of 500mm thick

• The stockpile site must be above the 1 in 20 ARI flood level.

3 Containment

Stormwater runoff and leachates should be contained within treatment pads by suitable bunds and may be collected in a sump or retention pond. Diversion drains should be installed to prevent stormwater run-on into the treatment pad. Surface liming of earth bunds and diversion drains can help neutralise any acidic stormwater. Bunds and diversion drains should not be constructed out of untreated ASS or other materials that may be a source of contaminants to the environment. The materials used should have low permeability to avoid leakage. Waters should be monitored and if necessary treated before reuse or release.

4 Treatment pad location and dimensions

Treatment pads should be located on stable ground above the 1 in 20 ARI flood level, away from overland flow paths and preferably in a location where bund and leachate collection pond construction does not disturb in situ ASS.

Treatment pads should be set up to allow maximum treatment batch sizes of 500 m^3, as it is difficult to representatively sample larger batches, and re-treatment of large failed batches is expensive.

5 Decommissioning

Decommissioning will include verification testing to ensure no residual effect for acid sulfate material and restoration of the acid sulfate material treatment area to an agreed final landform.

Figure A1 Proposed Treatment pad design with treatment area and stockpile area

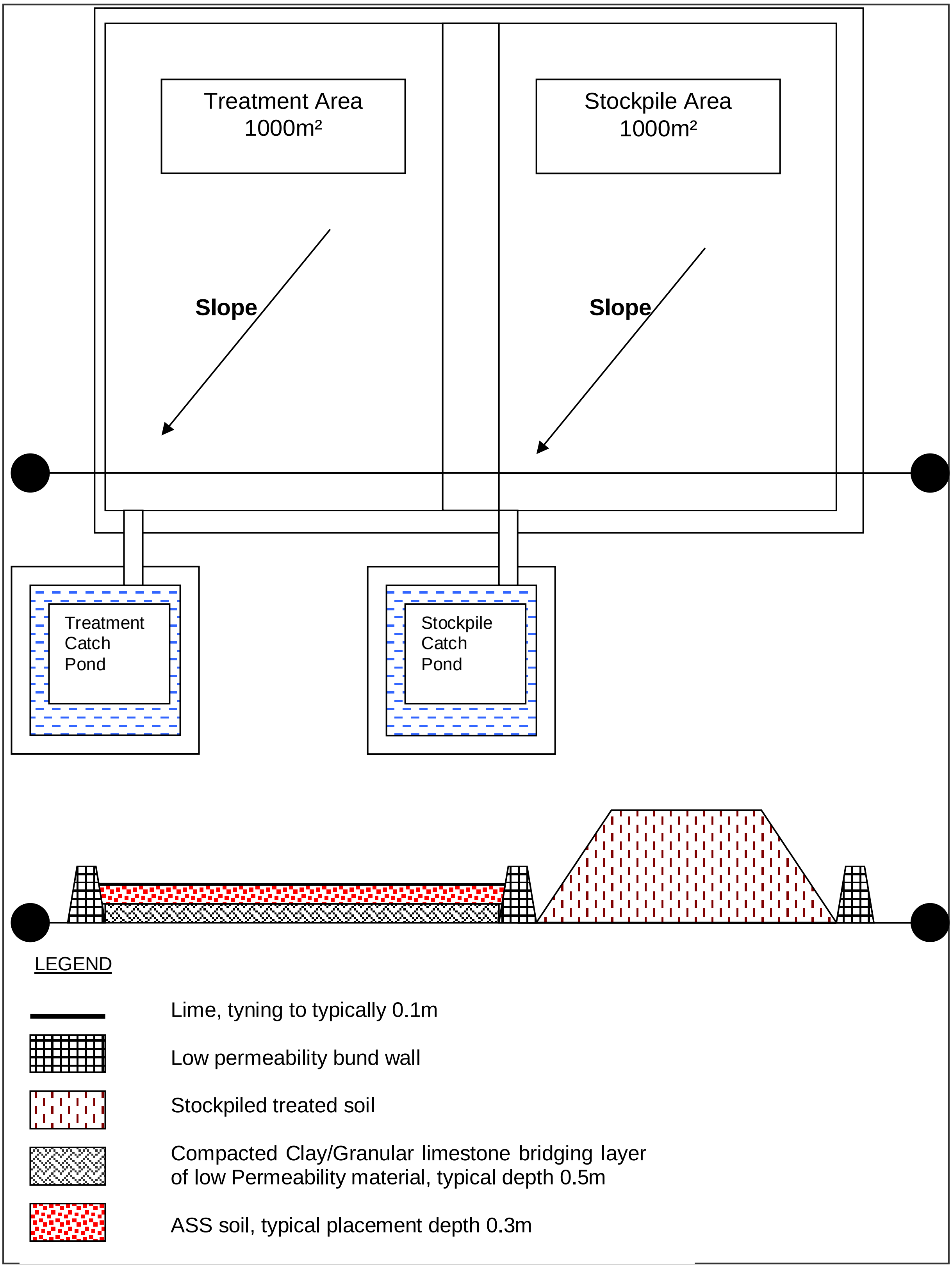
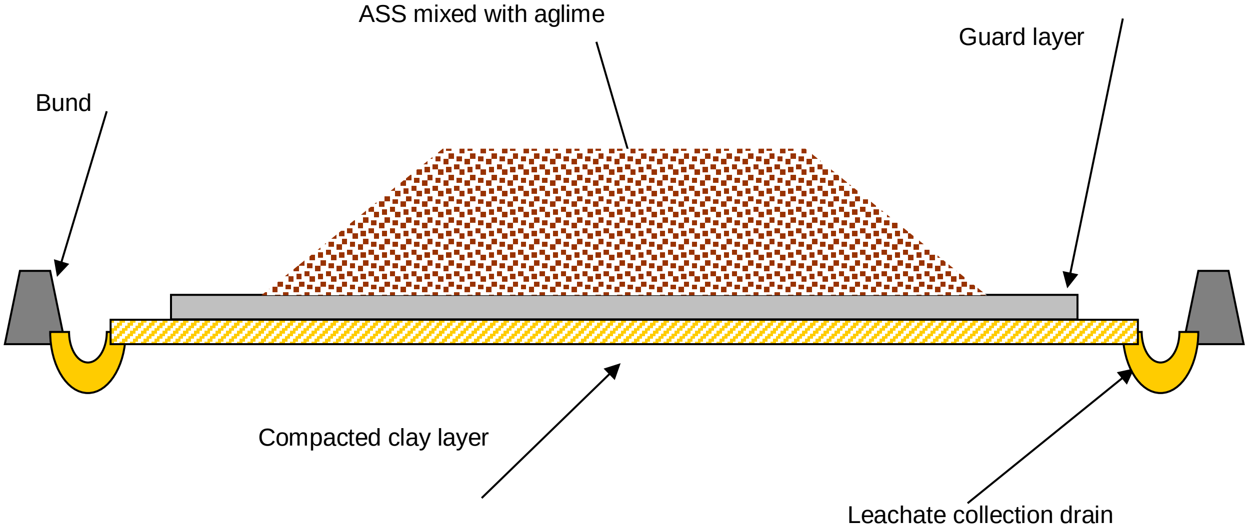


Figure A2 Cross section of land applied lime amended ASM



Photograph 1 Bunded treatment area for ASM and lime application

A5 Acid Sulfate Material Management – Materials, Neutralisation, Application and Validation

Neutralising Materials

For management or neutralisation of ASM soils, Agricultural lime (Aglime) (pH 8.2) is the safest neutralising agent. It equilibrates around a pH of 8.2 that is not generally harmful to plants, stock or humans and most aquatic ecology species. The main shortcoming associated with the use of lime is its insolubility in water. In general a finer grind is better. The Aglime purity should preferably be 90% or better, (that is, Neutralising Value [NV] > 90), unless there is a significant savings to be made by use of less pure Aglime. In the latter case, however, the individual lime dosing rates will need to be increased accordingly. The requirement for greater amounts of Aglime of lower purity should be borne in mind when assessing the supplies of this material, as the cost savings from less pure material may be offset by the need for more, and correspondingly higher total transport costs.

An Aglime store will be established at the compound site. Aglime is non-corrosive, and requires no special handling – it may be necessary to cover the stockpile with a tarpaulin or cover the stockpile with plastic, to minimise dust generation and prevent wetting, since it is then more difficult to spread. Intermittently, until such time as field testing suggests otherwise, a small quantity (minimum of 200kg) of Aglime will be stored on site. This will enable the regular treatment of soil and cater for any unexpected occurrences of 'hotter' ASM.

Neutralisation of Excavated ASM from Earthworks

Neutralising agents will be incorporated within all ASM. All cut batters shall be coated with fine aglime (or similar, refer to Appendix A2) at the rate of 5kg/m^2 and the lime coating will be checked and re-limed as necessary on a daily basis during periods of dewatering during construction excavation. The base of all fill areas where treated material is to be placed shall be treated with a neutralising agent forming a guard layer (as per Appendix A) prior to the placement of any fill soils to neutralise downward seepage of acidic drainage water. This application may need to be increased depending on stockpile height and acidity of the ASM through a detailed assessment.

Aglime rates will be quantified through analytical assessment to establish S% to determine an indicative level of treatment as specified in Table 2 below. Interpretation of analytical data will be conducted by ESR and an appropriately qualified consultant experienced in dealing with ASM management.

ASM must be sufficiently dry before neutralising is commenced so that the lime can be thoroughly mixed through the soil. Where moisture levels in soil are high, the soil must be dried by spreading and leaving open to the atmosphere. Drying can be accelerated by regular aeration by mechanical aid. Drying should be carried out on a guard layer as defined in Appendix A and protected from stormwater ingress.

Mixing of ASM with neutralising agent shall be carried out by spreading the soil in layers of not more than 300-400mm thick using an agricultural spreader and disc plough, rotary hoe or similar. Care shall be taken to ensure that mixing occurs throughout the depth of the layer prior to placement of new material.

Following the successful treatment of the material (as determined through the validation testing), the material shall be stockpiled with the appropriate Erosion and sediment controls, for reuse if possible.

Table 2: Estimating treatment levels and aglime required to treat total weight of disturbed Acid Sulfate Soils

The tonnes (t) of pure fine aglime, $CaCO_3$ required to fully treat the total weight/volume of acid sulfate soils (ASS) can be read from the table at the intersection of the weight of disturbed soil [row] with the existing plus potential acidity [column]. Where the exact weight or soil analysis figure does not appear in the heading of the row or column, use the next highest value.

Disturbed ASS (tonnes) (≈m^3×BD) †	**Soil Analysis# – Existing Acidity plus Potential Acidity (converted to equivalent S% units)**													
	0.03	*0.06*	*0.1*	*0.2*	*0.4*	*0.6*	*0.8*	*1*	*1.5*	*2*	*2.5*	*3*	*4*	*5*
1	0	0	0	0	0	0.03	0.04	0.05	0.1	0.1	0.1	0.1	0.2	0.2
5	0	0	0	0.05	0.1	0.1	0.2	0.2	0.4	0.5	0.6	0.7	0.9	1.2
10	0	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.7	0.9	1.2	1.4	1.9	2.3
50	0.1	0.1	0.2	0.5	0.9	1.4	1.9	2.3	3.5	4.7	5.9	7.0	9.4	12
100	0.1	0.3	0.5	0.9	1.9	2.8	3.7	4.7	7.0	9.4	12	14	19	23
200	0.3	0.6	0.9	1.9	3.7	5.6	7.5	9.4	14	19	23	28	37	47
250	0.4	0.7	1.2	2.3	4.7	7.0	9.4	12	18	23	29	35	47	59
350	0.5	1.0	1.6	3.3	6.6	10	13	16	25	33	41	49	66	82
500	0.7	1.4	2.3	4.7	9.4	14	19	23	35	47	59	70	94	117
600	0.8	1.7	2.8	5.6	11	17	22	28	42	56	70	84	112	140
750	1.1	2.1	3.5	7.0	14	21	28	35	53	70	88	105	140	176
900	1.3	2.5	4.2	8.4	17	25	34	42	63	84	105	126	168	211
1000	1.4	2.8	4.7	9.4	19	28	37	47	70	94	117	140	187	234
2000	2.8	5.6	9.4	19	37	56	75	94	140	187	234	281	374	468
5000	7.0	14	23	47	94	140	187	234	351	468	585	702	936	1170
10000	14	28	47	94	187	281	374	468	702	936	1170	1404	1872	2340

L	**Low treatment:** (≤0.1 tonnes lime)
M	**Medium treatment:** (>0.1 to 1 tonne lime)
H	**High treatment:** (>1 to 5 tonnes lime)
VH	**Very High treatment:** (>5 to 25 tonnes lime)
XH	**Extra High treatment:** (>25 tonnes lime)

Note: Lime rates are for pure fine aglime, $CaCO_3$ assuming an NV of 100% and using a safety factor of 1.5. A factor that accounts for Effective Neutralising Value is needed for commercial grade lime. (See the *Information Sheets* on *Neutralising Agents – Neutralising Considerations*).

† An approximate soil weight (tonnes) can be obtained from the calculated volume by multiplying volume (cubic m) by bulk density (t/m^3). (Use 1.7 if B.D. is not known.) Dense fine sandy soils may have a BD up to 1.7, and hence 100 m^3 of such soil may weigh up to 170 t. In these calculations, it is necessary to convert to dry soil masses, since analyses are reported on a dry weight basis.

Potential acidity can be determined by Chromium Reducible Sulfur (S_{CR}), Peroxide Oxidisable Sulfur (S_{POS}) and Total Oxidisable Sulfur (S_{TOS}). For samples with pH <5.5, the existing acidity must also be determined by appropriate laboratory analysis eg. Titratable Actual Acidity (TAA). Soils with retained acidity eg. jarosite or other similar insoluble compounds have a less available acidity and will require more detailed analysis. The amount of treatment required may be reduced if the self-neutralising capacity of the soil is appropriately measured. Consult the **Queensland Acid Sulfate Soils Technical Manual, Laboratory Methods Guidelines**.

Source: (based on soil analysis) (Queensland Acid Sulfate Soil Technical Manual, Soil Management Guidelines 2002)

ESR

Treatment of Acidic Waters

No single treatment approach can provide a total ‘walk-away’ solution, as all systems require a degree of monitoring and maintenance. Selection of the appropriate acid water treatment method (or combination of methods) invariably depends on site-specific conditions, including water composition and treatment targets.

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Neutralising acid leachate and drain water using lime

It is proposed that water for dust suppression and other construction applications may be drawn from the cane drain adjacent to the alignment. Drawdown of the water table may result in increased acidity of drain water. Ongoing water monitoring will be conducted to detect any changes in pH and ensure timely application of ameliorates. The liming rate for treating acid water should be carefully calculated to avoid the possibility of "overshooting" the optimum pH levels of 6.5 - 8.5. It should be noted that when neutralising acid water, no safety factor is used. However, monitoring of pH will be carried out regularly during neutralisation procedures.

When using alkaline materials, strict protocols must be established for the use, handling and monitoring of these materials.

Calculating the quantity of lime

The current pH is measured preferably with a recently calibrated pH detector. The desired pH is usually between 6.5 and 8.5 with pH 7 is normally targeted. The volume of water can be calculated by assuming 1 cu metre of acid water is equivalent to 1 kilolitre (1000 litre) and 1,000 cu metre is equivalent to 1 megalitre (ML).

As a general guide, Table 2 shows minimum quantities of pure lime, hydrated lime or sodium bicarbonate needed to treat dams or drains of 1 ML (1,000 m^3) capacity.

Table 2: Quantity of pure neutralising agent required to raise from existing pH to pH 7 for 1 megalitre of low salinity acid water.

Current Water pH	$[H^+]$ {mol/L}	H^+ in 1 Megalitre {mol}	Lime to neutralise 1 Megalitre {kg pure $CaCO_3$}	Hydr. lime to neutralise 1 Megalitre {kg pure $Ca(OH)_2$}	Pure $NaHCO_3$/ 1 Megalitre {kg }
0.5	.316	316,228	15,824	11,716	26,563
1.0	.1	100,000	5,004	3705	8390
1.5	.032	32,000	1,600	1185	2686
2.0	.01	10,000	500	370	839
2.5	.0032	3,200	160	118	269
3.0	.001	1,000	50	37	84
3.5	.00032	320	16	12	27
4.0	.0001	100	5	4	8.4
4.5	.000032	32	1.6	1.18	2.69
5.0	.00001	10	0.5	0.37	0.84
5.5	.0000032	3.2	0.16	0.12	0.27
6.0	.000001	1	0.05	0.037	0.08
6.5	.00000032	.32	0.016	0.12	0.027

Notes on Table 2: 1 m^3 = 1,000 litre = 1 Kilolitre = 0.001 Megalitre

- *Agricultural lime has very low solubility and may take considerable time to even partially react.*
- *Hydrated lime is more soluble than aglime and hence more suited to water treatment. However, as $Ca(OH)_2$ has a high water pH, incremental addition and thorough mixing is needed to prevent overshooting the desired pH. The water pH should be checked regularly after thorough mixing and time for equilibration before further addition of neutralising product.*
- *Weights of lime or hydrated lime are based on theoretical pure material and hence use of such amounts of commercial product will generally result in under treatment.*
- *To more accurately calculate the amount of commercial product required, the weight of lime from the table should be multiplied by a purity factor (100/ Neutralising Value for aglime) or (148/ Neutralising Value for hydrated lime).*
- *Calculations are based on low salinity water acidified by hydrogen ion, H^+ (acid) and do not take into account the considerable buffering capacity or acid producing reactions of some acid salts and soluble species of aluminium and iron. For example, as the pH increases towards 4, the precipitation of soluble ferric ion occurs, liberating more acid:*
- $Fe^{3+} + 3H_2O \rightarrow Fe(OH)_3 + 3H^+$
- *If neutralising substantial quantities of acid sulfate soil leachate, full laboratory analysis of the water will be necessary to adequately estimate the amount of neutralising material required.*

Application of lime to water

To increase the efficiency, lime should be mixed into a slurry before adding. A slurry can be prepared in a concrete truck, cement mixer or large vat with an agitator. Methods of application of the slurry on site may include:

- spraying the slurry over the water with a dispersion pump
- pumping the slurry into the waterbody with air sparging (compressed air delivered through pipes) to improve mixing once added to water
- using mobile water treatment equipment such as the 'Neutra- mill' and 'Aqua Fix' to dispense neutralising reagents to large water bodies.

A change in pH will not be instantaneous. The rate of neutralisation will vary with the solubility, fineness of the lime, the application technique and the acidity (pH) of the water.

The finer the lime (preferably microfine with the consistency of white dust) and the more agitated the water, the faster the lime will dissolve and become effective. The pH must be carefully monitored even after the desired pH has been reached. If the water has not reached the desired pH within two weeks, more lime may need to be added. Before additional lime is added, the lack of success should be investigated. Issues to consider may include:

- the quality of the lime being used
- the effectiveness of the application technique
- the existence of additional sources of acid leaching into the water body further acidifying the water.
- the lime has become lumpy and is sitting on the bottom

Neutralisation may be faster if higher rates are used, but is not recommended as it is expensive and resource wasteful. Moreover, over-dosing may result, though this is unlikely to be a concern with agricultural lime.

Validation of Ameliorated ASM

The objective of ameliorating ASM is to ensure that there is no chance that net acidity will be produced. Validation testing only occurs when soils have been treated (with a neutralising agent) to prevent any future acidification. If results of the validation testing indicate a failure to comply with the performance criteria, soil may need to be re – treated additional application of neutralising agent.

Soils that have been mixed with aglime will be analysed by either the SPOCAS Suite test methods at a rate of one sample per 250m³. All validation samples are to be recorded by GPS or survey, clearly marked on a map/sketch or otherwise recorded.

Where large quantities (>1,000m³) of ameliorated soils are involved and 'net acidity' rates are generally low (18 – <125 mol H+/t or 0.03 – 0.20 %S), a reduced rate of sampling may be appropriate subject to approval. A rate of one sample per 1,000m³ may be suitable for example.

The following performance criteria must be attained for soil that has been treated using neutralisation:

1. The neutralising capacity of the treated soil must exceed the existing plus potential acidity of the soil.
2. Post-neutralisation, the soil pH is to be greater than 5.5.
3. Excess neutralising agent should remain within the soil until all acid generation reactions are complete and the soil has no further capacity to generate acidity.

Samples of the treated soil should be taken and laboratory analysed to demonstrate compliance with the performance criteria (ie. verification testing). These performance criteria equate to there being no net acidity in the soil following neutralisation. Soil that has been treated by neutralisation techniques and has not met these criteria must be retreated until the above performance criteria are met.

If ameliorated ASM is going to be reused on site, due environmental regard for areas of placement should be assessed, documented and approved by the ESRESR. Assessment measures may include:

- Location of proposed placement areas and potential receptors (waterways, sensitive flora and fauna, structures).
- Stability and suitability of materials as select fill (especially clays).
- Suitability of soil type for plant growth.

A6 Field pH (pH_F) and Field Peroxide pH (pH_{FOX}) Testing

Field Testing Interpretation

Field tests have been developed for rapid field assessment of the likelihood of ASM. Field pH (pH_f) and field peroxide pH (pH_{fox}) screening will be conducted on all samples and methodology.

A combination of three factors is considered in arriving at a 'positive field sulfide identification':

a) a reaction with hydrogen peroxide;

b) a much lower pH_{fox} than field pH_f (▲pH) and

c) the actual value of pH_{fox}.

Factor (a) - The strength of the reaction with peroxide is a useful indicator but cannot be used alone. Organic matter and other soil constituents such as manganese oxides can also cause a reaction. Care must be exercised in interpreting a reaction on surface soils and high organic matter soils such as peat and some mangrove/estuarine muds and marine clays.

Factor (b) - A pH_{fox} value at least one unit below field pH_f may indicate ASM. The greater the difference between the two measurements (▲pH), the more indicative the value is of a PASS. The lower the final pH_{fox} value is, the better the indication of a positive result.

Factor (c) - If the pH_{fox} < 3, and the other two conditions apply, then it strongly indicates a PASS. The more the pH_{fox} drops below 3, the more positive the presence of sulfides.

A pH_{fox} 3-4 is less positive and laboratory analyses are needed to confirm if sulfides are present. (If only low pH peroxide is available, the field test is less discriminatory).

In the event that sand are sampled it is worth noting the action limit (0.03 % S) for sulphides may give confusing field test results and must be confirmed by laboratory analysis. Field testing can identify which samples require laboratory confirmation.

Interpretation of data is to be carried out by a suitably qualified environmental professional trained in ASM screening procedures

Method for Field pH (pHf)

Field pH (pHf) tests cannot be used as a substitute for laboratory ASM analysis. However, they are a necessary additional tool to establish field representation of laboratory data generated.

The procedure for the field pHf is outlined below:

1. Calibrate battery powered field pH meter according to manufacturer's instructions.
2. Prepare the test tubes in the test tube rack. Make sure the rack is marked with the depths so there is no confusion about the top and bottom of the profile. Use of separate racks for the pHf and pH_{fox} tests is recommended as contamination may occur when the pH_{fox} reactions are vigorus. As the soil:water paste is inclined to stick to the walls of tubes, it is best to use shallow, broad test tubes as this makes cleaning easier.
3. Conduct tests at intervals on the soil profile of 0.5 m or at least one test per horizon whichever is lesser.

4. Remove approximately 1 teaspoon of soil from the profile. Place approximately ½ teaspoon of that soil into the pHf test tube and place ½ teaspoon of the soil into the pH_{fox} test tube for the corresponding depth test. It is important that these two sub-samples come from the same depth and that they are similar in characteristics.
5. Place enough deionised water (or demineralised water if deionised water is not available; never use tap water) in the pHf test tube to make a paste similar to 'grout mix' or 'white sauce', stirring the soil:water paste with a skewer, strong tooth pick or similar to ensure all soil 'lumps' are removed. Do not leave the soil samples in the test tubes without water for more than 10 minutes.
6. Immediately place the spear point electrode (preferred method) into the test tube, ensuring that the spear point is totally submerged in the soil:water paste.
7. Measure the pHf using a pH meter with spear point electrode.
8. Wait for the reading to stabilise and record the pH measurement.
9. All measurements should be recorded on a data sheet.

Rating Soil Reactions of the pH_{fox} Test Using the XXXX Scale

The rate of the reaction generally indicates the level of sulfides present, but depends also on texture and other soil constituents. A soil containing very little sulfides may only rate an 'X' however a soil containing high levels of sulfides (remember the exact level of sulfides cannot be determined using the pH_{fox} test) is more likely to rate a 'XXXX' although there are exceptions. This rating scale alone should not be used to identify ASS. It is not a very reliable feature in isolation as there are other factors including manganese and organic acids which may trigger reactions. Reactions with organic matter tend to be more 'frothing' and don't tend to generate as much heat as sulfidic reactions. Manganese reactions will be quite extreme, but don't tend to lower the pH_{fox}. Table 1 indicates the reaction scale for pH_{fox} tests.

Table 1 Soil reaction scale for the pH_{fox} test

Reaction Scale	Rate of Reaction
X	Slight Reaction
XX	Moderate Reaction
XXX	High Reaction
XXXX	Very vigorous reaction, gas evolution and heat generation

Appendix B
ASM Contingency Procedures

B1 Contingency Procedure

Purpose: Acid Sulphate Soils (ASS) are the common name given to sediment and soils containing iron sulphides which when exposed to oxygen generate sulphuric acid. If untreated, runoff from ASS could cause the release of acid into the environment. Potential Acid Sulfate Soils (PASS) are rich in iron sulphides (pyrite) which if brought into contact with oxygen, oxidisation occurs and they become ASS. This procedure details the actions to be taken when Actual Acid Sulfate Soils (ASS) or Potential Acid Sulfate Soils (PASS) are unexpectedly encountered during excavation / construction activities. Consequences of not following this procedure could lead to significant impacts on the natural environment and conservation of biodiversity

Project No.:	396-1	**Project Description:**	Pacific Highway Upgrade - Woolgoolga to Ballina Early Works – Wave 2
Scope of Procedure	This procedure is applicable to all activities conducted by personnel that have the potential to uncover/disturb ASS/PASS. Refer to the attached figure for ASS/PASS Contingency Procedure flow chart.		

Procedure

1. Unexpected Disturbance of ASS / PASS

If on-site personnel suspect that ASS or PASS has been unexpectedly disturbed, stop work in the immediate vicinity, notify the Environmental Site Representative (ESR). The ESR is responsible for undertaking field pH testing of ASS/PASS.

ASS Characteristics:

Any of the following characteristics y indicate the presence of ASS:

- Soil pH of <4;
- A sulphurous smell following soil disturbance;
- Pale yellow surface encrustations;
- Excessive iron staining on drain surfaces or stream banks, or iron stained drain water and orange red ochre deposits around water bodies;
- Excessive corrosion of concrete and / or steel structures exposed to ground or drainage waters, or rapid corrosion of fresh steel in the soil; and
- Blue-grey, blue-green or grey waterlogged soils which smell of rotten egg gas.

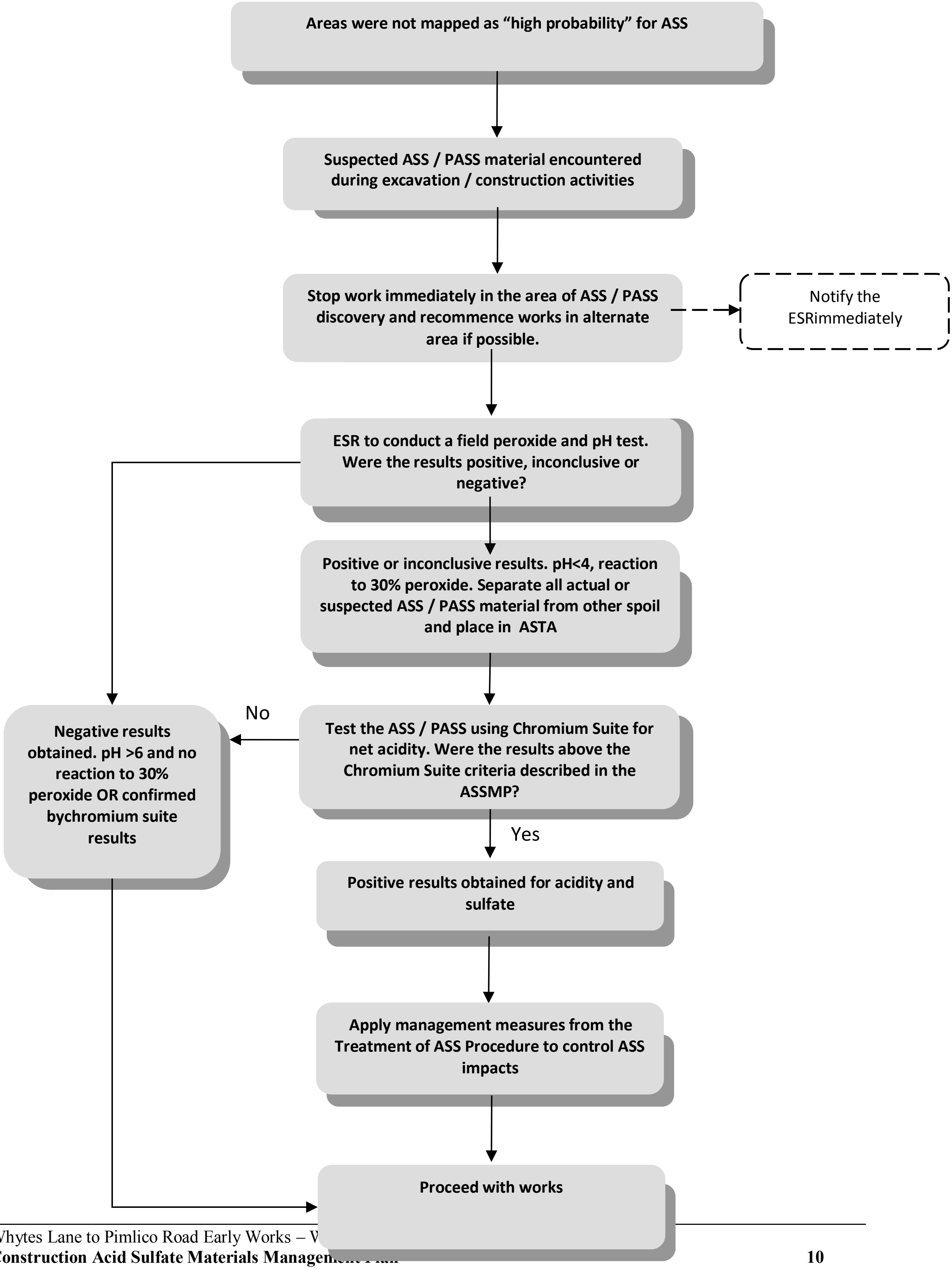
High risk indicators for PASS could include:

- Low position in the landscape;
- Soil from beneath the water table;
- Heavy textures;
- Dark colours; and
- Sulfur odour (rotten egg odour).

The ESR will undertake testing to determine the acidity (field pH test) and potential for acidity (field 30% peroxide test). The procedure for conducting the 30% field peroxide test and indicators of positive results are included at the end of this procedure.

If it is shown conclusively that the material is not ASS or PASS, construction can proceed as normal. If results are positive or inconclusive proceed to Step 2.

2. Positive or Inconclusive Field Test Result for ASS / PASS
If field tests are positive or inconclusive, laboratory analysis using the Chromium Suite will be required to determine if the material is in fact ASS and/or the required treatment rates based on the net acidity. In this event all disturbed undetermined material must be taken to an Acid Sulphate Treatment Area (ASTA) or temporarily stockpiled and bunded in accordance with the Acid Sulphate Sub Management Plan and Treatment of ASS Procedure. If the Chromium Suite laboratory testing results confirm the presence of ASS/PASS, the material will be treated in accordance with the above procedure with appropriate liming rates based on Chromium Suite analysis results.
3. Personal Protective Equipment (PPE)
Prior to any PASS / ASS treatment, appropriate personal protective equipment (PPE) is to be worn as per the MSDS (e.g. for Lime) This may include: Eye protection; Hard hat; Face mask; Rubber boots, gloves; and Appropriate clothing (e.g. long sleeved pants and shirts).


Areas were not mapped as "high probability" for ASS
Suspected ASS / PASS material encountered during excavation / construction activities
Stop work immediately in the area of ASS / PASS discovery and recommence works in alternate area if possible.
Notify the ESRimmediately
ESR to conduct a field peroxide and pH test. Were the results positive, inconclusive or negative?
Positive or inconclusive results. pH<4, reaction to 30% peroxide. Separate all actual or suspected ASS / PASS material from other spoil and place in ASTA
Test the ASS / PASS using Chromium Suite for net acidity. Were the results above the Chromium Suite criteria described in the ASSMP?
No
Negative results obtained. pH >6 and no reaction to 30% peroxide OR confirmed bychromium suite results
Yes
Positive results obtained for acidity and sulfate
Apply management measures from the Treatment of ASS Procedure to control ASS impacts
Proceed with works

Field pH and the 30% Peroxide Test

ASSMAC Assessment Guidelines

1 Field pH Test

The field pH (pHF) of actual ASS tends to be ≤ 4 while the field pH of PASS tends to be neutral. Field pH provides a useful quick indication of the likely presence and severity of "actual" acid sulfate soils. The field pH is a qualitative method only that cannot be used as a substitute for laboratory analysis in the identification of acid sulfate soils for assessment purposes.

Field pH readings should be taken at regular intervals down the soil profile. It is recommended this test be done every 0.25m down the profile but at least every 0.5m interval or horizon whichever is the lesser.

pH Indications:

- pH readings of pH ≤4, indicates that actual acid sulfate soil are present with the sulphides having been oxidised in the past, resulting in acid soil (and soil pore water) conditions.
- pH values >4 and <5.5 are acid and may be the result of some previous or limited oxidation of sulphides, but is not a definite confirmation of actual ASS. Substantial exchangeable / soluble aluminium and hydrogen ions usually exist at these pH values. Other factors such as excessive fertiliser use, organic acids or strong leaching can cause pH >4 - <5.5. Field pH alone cannot indicate potential ASS as they may be neutral to slightly alkaline when unoxidised.

In order to test for potential acid sulfate soils that contain unoxidised sulphides, peroxide is used to rapidly oxidise the iron sulphides (usually pyrite), resulting in the production of acid with a corresponding drop in pH.

Notes on pH equipment
Preferably a battery powered, field pH meter with a robust, spear point, double reference pH electrode should be used. The probe can be inserted directly into soft wet soils or soil mixed up into a paste with deionised water. Care must be exercised not to scratch the electrode on sandy or gravely soils. The probe should be standardised prior to use and regularly during use against standard solutions according to the manufacturers instructions. Alternatively, an approximate 1:5 ratio of soil:deionised water suspension can be made up in small tubes, hand shaken and pH of the solution measured. pH test strips can be used to give an approximate value (pH +/- 0.25). Raupach soil pH test kits should be used with caution as they can give erroneous results. Both these latter methods are based on mixed indicator solutions that give a pH dependant colour and are subject to interferences.

2 Field Peroxide pH Test

To test for the presence of unoxidised sulphides and therefore PASS, the oxidation of the soil with 30% (100 volume) hydrogen peroxide can be performed in the field. The most common method is:

A small sample of soil (approx. 5 g) is placed in a small glass container (e.g. short clear centrifuge tubes, clear tissue culture clusters or sample jar) and a small volume of peroxide is dropped onto the soil (20 mL).

Note: Allow the digested solution to cool after the reaction.

A pH probe will only measure to 60°C.

The reaction should be observed and rated. In some cases, the reaction may be instantaneous; in others, it may take 10 minutes or more. Heating over hot water or in the sun may be necessary to start the reaction on cool days, particularly if the peroxide is cold.

Potentially positive reactions for PASS includes one or more of the following:

- change in colour of the soil from grey tones to brown tones
- effervescence
- the release of sulphurous odours
- final pH of <3.5 and preferably < 3
- lowering of soil pH by at least one pH unit

The strength of the reaction is a useful indicator. The peroxide test is most useful and reliable with clays and loams containing low levels of organic matter. It is least useful on coffee rock, sands or gravels, particularly dredged sands with low levels of sulphuric material (e.g. <0.05 % S). With soils containing high organic matter (such as surface soils, peats, mangrove / estuarine muds, and marine clays), care must be exercised when interpreting the reaction as high levels of organic matter and other soil constituents particularly manganese oxides can also cause a reaction.

Note of caution with the use of peroxide
30 % hydrogen peroxide is a strong oxidising agent and should be handled carefully with appropriate eye and skin protection. This test should be only undertaken by trained personnel. The pH of analytical grade peroxide may be as low as 3 as manufacturers stabilise technical grade peroxide with acid, The peroxide pH should be checked on every new container and regularly before taking to the field and adjusted to 4.5 - 5.5 with a few drops of 0.1M NaOH if necessary. False field pH $_{FOX}$ readings could result if this step is not undertaken.

3 pH After Oxidation

The measurement of the change in the pH $_{FOX}$ following oxidation can give a useful indication of the presence of sulphuric material and can give an early indication of the distribution of sulphide down a core/ profile or across the site. The pH after oxidation test is <u>not</u> a substitute for analytical test results.

If the pH $_{FOX}$ value is at least one unit below field pH $_{F}$, it may indicate potential acid sulfate soils. The greater the difference between the two measurements, the more indicative the value is of a potential acid sulfate soils. The lower the final pH $_{FOX}$ value is, the better the indication of a positive result.

- If the pH $_{FOX}$ < 3 and there was a strong reaction to the peroxide, there is a high level of certainty of a potential acid sulfate soils. The more the pH $_{FOX}$ drops below 3, the more positive the presence of sulphides.
- A pH $_{FOX}$ 3-4 is less positive and laboratory analyses are needed to confirm if sulphides are present. Sands particularly may give confusing field test results and must be confirmed by laboratory analysis.
- For pH $_{FOX}$ 4-5 the test is neither positive nor negative. Sulphides may be present either in small quantities and be poorly reactive under quick test field conditions. In some cases, the sample may contain shell / carbonate that neutralises some or all acid produced by oxidation. In other cases, the pH $_{FOX}$ value may be due to the production of organic acids and there may be no sulphides present. In these cases, analysis for sulphur using the POCAS method would be the best to check for the presence of oxidisable sulphides.
- For pH >5 and little or no drop in pH from the field value, little net acid generating ability is indicated. Again, the sulphur trail of the POCAS method should be used to check some samples to confirm the absence of oxidisable sulphides.

Care is needed with interpretation of the result on highly reactive soils. Some soil minerals other than pyrite react vigorously with peroxide, particularly manganese but may only show small pH changes.

Note of caution with testing of soil with high organic content
Note: When selecting soil for testing it is advisable to avoid material high in organic matter as the oxidation of organic matter can lead to the generation of acid. However pH of soils containing organic matter and no pyrite do not generally stay below 4 on extended oxidation. In general positive tests on ‘apparently well drained’ surface soils should always be treated with caution and followed up with laboratory confirmation.

The field peroxide tests can be made more consistent if a fixed volume of soil (using a small scoop) is used, a consistent volume of peroxide is added and left to react for an hour, and the sample is made up to a fixed volume with deionised water before reading. However, such procedures take time in the field and are more suited to a ‘field shed’ situation. When effervescence (sometimes violent) has ceased, a few additional mL of peroxide should be added until the reaction appears complete. If the reaction is violent, it is recommended that deionised water be added to cool and dilute the reaction. The test may have to be repeated with a small amount of water added to the soil prior to peroxide addition. The pH^{FOX} of the resultant mixture is then measured.

B2 Potential Failure Modes, Contingencies and Remedial Actions

Table 1 (over page) identifies potential failure modes which may occur along the Project in relation to ASM. Potential consequences, likelihood of occurrence and possible remedial measures are identified for each failure mode.

The remedial measures provided are indicative only and would need to be carried out by a suitably qualified and experienced soil specialist in accordance with RMS’s Guideline for the Management of Acid Sulfate Materials (RTA 2005).

Table 1 Potential failure modes, contingencies and remedial action

Potential Failure Mode	Potential Consequence	Likelihood of Occurring	Contingency Measures	Possible Remediation Action
Lack of space to place excavated ASM.	Materials placed and untreated. Release of acidity into immediate surrounds.	Unlikely due to small quantities of materials to be excavated.	Monitoring of placement areas by ESR or delegate daily. Controls are in place i.e. initial guard layers, drainage, monitoring and abundance of available plant to manage soil.	Remove materials not placed in correct areas. Grade soil and apply lime at calculated rates within bunded treatment area. Verification testing of placed soil and clearance testing of temporary holding area. Assess possible relocation of ASM to other treatment pads within the project.
Failure of ASM validation testing.	Release of acidity into underlying soils and groundwater.	Unlikely - may occur in some samples due to pockets of slightly higher sulphide.	Rapid re-application of neutralising agent where required. Abundance of plant on site to carry out re-application and mixing.	Re - apply neutralising agent and repeat verification testing on placed soil.
Local flooding of stockpile area and movement of sediments or wash out of neutralising agent.	Movement of sediments containing sulphide off site. Wash out of neutralising agent.	Unlikely but not improbable during construction.	Majority of soil will be treated in 24hr. Neutralising agent will be incorporated into soil. Monitoring of surface and groundwater (ongoing).	Scrape up washed out sediments with machine and place back into original area. Re-apply neutralising agent where washed out. Divert surface water around stockpile areas.
Unacceptable impacts on groundwater such as: lowering/raising pH, increased metal toxicity.	Release into the environment with effects on flora, fauna, and groundwater dependant ecosystems.	Unlikely to occur. This would only occur if insufficient neutralising agent was incorporated into the soil and/or incorporated too late.	Monitoring to detect any impacts (ongoing). Remedial action where required.	Installation of 'lime curtains' or re-injection spear pumps within the shallow aquifer to raise pH to an acceptable level in line with background trends. Continued monitoring throughout the remedial stages until no appreciable impacts are identified.
Unacceptable impacts on surface water such as: lowering/raising pH, increased metal toxicity.	Release into the environment with effects on flora and fauna.	Unlikely to occur. This would only occur if insufficient neutralising agent was incorporated into the soil and/or incorporated too late.	Liming construction drainage lines at regular intervals. Re – direction of flow to holding ponds to monitor and treat water. Monitoring to detect any impacts (ongoing). Remedial action where required.	Re-liming of drainage lines and increasing lime application rates to materials to raise pH ASM impacted areas. Continued monitoring throughout the remedial stages until no appreciable impacts are identified and verification testing on amended soils and water have been satisfied.
Material not neutralised because insufficient neutralisation material is available.	Release of acidity into underlying soils and groundwater and into catch drains.	Very unlikely to occur.	Excavation will cease if neutralisation agent stock is inadequate. Monitoring of neutralising quantities on site daily. Coupling excavation rates to neutralising agent requirements. Ability to order neutralising agents to site within short time frames. Material not to leave treatment pads until verification testing can confirm adequate neutralising agent has been applied.	In the event groundwater or soils have been impacted, a groundwater reinjection of suitable neutralising agent to be applied in solution or developed into a groundwater interception trench to prevent off site migration of impacted groundwater or soils. . Continued monitoring throughout the remedial stages until no appreciable impacts are identified.

Potential Failure Mode	Potential Consequence	Likelihood of Occurring	Contingency Measures	Possible Remediation Action
Neutralisation rate below required rate: during construction.	Release of acidity into underlying soils and groundwater and into catch drains a] during construction.	Very unlikely. Investigations have identified liming rate requirements for soils and validation testing will provide final assessment of rate of dosing.	Material found to be insufficiently neutralised [through laboratory analysis] will be excavated and additional neutralisation agent will be applied to meet requirements.	In the event groundwater or soils have been impacted, a groundwater reinjection of suitable neutralising agent to be applied in solution or developed into a groundwater interception trench to prevent off site migration of impacted groundwater or soils. Continued monitoring throughout the remedial stages until no appreciable impacts are identified.
Neutralisation rate below required rate: after construction	Release of acidity into underlying soils and groundwater and into catch drains b] after construction	Extremely unlikely to occur because of the stringent validation process during construction.	Material found to be insufficiently neutralised [through laboratory analysis] will be excavated and additional neutralisation agent will be applied to meet requirements.	In the event groundwater or soils have been impacted, a long term impact model to be developed to identify suitable groundwater management methodology to prevent off site migration of impacted groundwater or soils.
Unexpected exposure of ASM	Generation of acidity	Unlikely, detailed investigations have delineated areas containing ASM.	Stop work, fill in disturbed materials if disturbed for <24hr. Containment strategies will be identified and implemented to ensure that any acidic leachate associated with the oxidation of acid sulfate soil is contained for treatment or removal and is prevented from entering downstream watercourses.	Continued monitoring throughout the remedial stages until no appreciable impacts are identified and verification of neutralisation has been achieved.