ACID SULFATE SOIL MANAGEMENT PLAN
FOR 81 GOW STREET PADSTOW 2211

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ACID SULFATE SOILS RELATED ACRONYMS AND GLOSSARY

For the purposes of this report, the spelling of the word sulfate will be adopted to be consistent with the nomenclature of the International Union of Pure and Applied Chemistry (IUPAC).

Acid neutralising capacity (ANC) the soils natural resistance to acid generation. It is the number of moles of protons per unit mass of soil required to raise the pH of the soil by one pH unit. ANC is measured as percentage CaCO3.

Acid Sulfate Soil (ASS) soil containing iron sulfides deposited during either the Pleistocene or Holocene geological periods (Quaternary aged) as sea levels rose and fell.

Actual Acid Sulfate Soil (AASS) soil in which soil sulfides are undergoing oxidation and producing more acid than the soils ANC, leading to a net acid generation.

Cation Exchange Capacity (CEC) maximum positive charge required to balance the negative charge on colloids (clays and other charged particles) is called the cation exchange capacity. The units are milliequivalents per 100 grams of material or centimoles of charge per kilogram of exchanger.

Electrolytic conductivity (EC) measure of the extent to which water conducts an electrical current and is related to the total concentration and relative proportions of the dissolved ionised substances within the water, and the temperature at which the determination is made.

Net acid generation potential (NAGP) difference between the TOS and ANC reported on a kilogram H_2SO_4 production per tonne of soil.

Net acidity (NA) oxidisable sulfur + existing acid – buffering capacity

pH logarithmic index for the concentration of hydrogen ions in an aqueous solution, which is used as a measure of acidity. The activity of hydrogen ions is of great importance in many reactions involving dissolved substances. Therefore, the pH value determines the solubility of many elements.

SPOCAS Suspended Peroxide Oxidisable Combined Acidity And Sulfate laboratory procedure.

Potential Acid Sulfate Soil (PASS) soil that contains sulfidic material that has not been oxidised but poses a considerable environmental risk should oxidation occur.

Redox Reduction-Oxidation state of a chemical or solution.

Redox potential (Eh) oxidation/reduction potential of the soil or water measured as millivolt potential difference between a platinum electrode and the standard hydrogen electrode.

SPOCAS Suspension Peroxide Oxidisable Combined Acidity and Sulfate laboratory procedure.

Total Acidity (TA) difference between the soil CEC and ANC.

Total Actual Acidity (TAA) moles of titratable protons per unit mass of soil displaced by an unbuffered KCl solution, otherwise known as the salt-replaceable acidity.

Total Dissolved Solids (TDS) total dissolved solids comprise dissociated compounds and undissociated compounds, but not suspended material, colloids or dissolved gases. This does not account for loss of CO_2 from bicarbonate caused by the test procedure. The TDS content can amount to less than 10mg/L in rain and snow, 100mg/L in steam from water in regions with relatively insoluble.

Total Oxidisable Sulfur (TOS) maximum oxidisable sulfur present and represents the maximum production of acid possible from sulfide oxidation.

1. INTRODUCTION

Benbow Environmental was commissioned by Gow Street Recycling Centre Pty Ltd to prepare an Acid Sulfate Soil Management Plan (ASS MP) for the proposed works to be undertaken at 81 Gow St Padstow, 2211, NSW (the "Site"), within the Canterbury-Bankstown Local Government Area.

A management plan is required as the Site is on Class 5 land as identified in the ASS Map of *Bankstown Local Environmental Plan 2015* (Bankstown LEP 2015). Actual ASS was identified onsite during a previous Detailed Site Investigation. The proposed works involve excavation for silo footings and inground pits.

1.1 ASS BACKGROUND

Acid Sulfate Soils (ASS) are naturally occurring soils and sediments that contain iron sulfides, most commonly pyrite. If left undisturbed these soils are benign, if exposed to air the iron sulfides within the soil react with oxygen and water to produce sulfuric acid. Once initiated, the process is accelerated by soil bacteria. The acid generated can allow naturally occurring metals held within soils, to be released into the environment causing toxic stress. ASS can be divided into two categories:

- Actual Acid Sulfate Soils (AASS) contain highly acidic soil layers (sulfuric material) caused by aeration or sulfidic material rich in iron sulfides. The majority of the sulfuric material is composed of organic soil material which has pH <4 and can be usually identified by the occurrence of bright yellow jarosite mottles.

- Potential Acid Sulfate Soils (PASS) contain high levels of iron sulfides or sulfidic material that have not been exposed to air and oxidised. PASS can include waterlogged soils, rich in pyrite, and usually tend to be very dark and soft soils, blue grey or dark greenish-grey coloured.

ASS occurs predominantly on coastal lowlands, with elevations generally below 5 m Australian Height Datum (AHD), but they can also occur in inland environments.

The presence of ASS indicates potential risks to surface and ground water quality, soil strength and stability, habitat character and agricultural productivity on adjoining lands. ASS will damage built structures and foundations and will readily corrode timber, steel and concrete.

1.2 PLANNING REQUIREMENTS

This section outlines the statutory planning control most relevant to the proposed works. Specific objectives and requirements for development with acid sulfate soils concerns are set out under Clause 6.1 of the Kogarah LEP 2012, as follows:

> ***6.1 Acid sulfate soils***
>
> *(1) The objective of this clause is to ensure that development does not disturb, expose or drain acid sulfate soils and cause environmental damage.*

(2) Development consent is required for the carrying out of works described in the Table to this subclause on land shown on the Acid Sulfate Soils Map as being of the class specified for those works.

Class of land	Works
1	**Any works.**
2	Works below the natural ground surface. Works by which the watertable is likely to be lowered.
3	Works more than 1 metre below the natural ground surface. Works by which the watertable is likely to be lowered more than 1 metre below the natural ground surface.
4	Works more than 2 metres below the natural ground surface. Works by which the watertable is likely to be lowered more than 2 metres below the natural ground surface.
5	Works within 500 metres of adjacent Class 1, 2, 3 or 4 land that is below 5 metres Australian Height Datum and by which the watertable is likely to be lowered below 1 metre Australian Height Datum on adjacent Class 1, 2, 3 or 4 land.

(3) Development consent must not be granted under this clause for the carrying out of works unless an acid sulfate soils management plan has been prepared for the proposed works in accordance with the Acid Sulfate Soils Manual and has been provided to the consent authority.

(4) Despite subclause (2), development consent is not required under this clause for the carrying out of works if:

(a) a preliminary assessment of the proposed works prepared in accordance with the Acid Sulfate Soils Manual indicates that an acid sulfate soils management plan is not required for the works, and
(b) the preliminary assessment has been provided to the consent authority and the consent authority has confirmed the assessment by notice in writing to the person proposing to carry out the works.

(5) Despite subclause (2), development consent is not required under this clause for the carrying out of any of the following works by a public authority (including ancillary work such as excavation, construction of access ways or the supply of power):

(a) emergency work, being the repair or replacement of the works of the public authority required to be carried out urgently because the works have been damaged, have ceased to function or pose a risk to the environment or to public health and safety,
(b) routine maintenance work, being the periodic inspection, cleaning, repair or replacement of the works of the public authority (other than work that involves the disturbance of more than 1 tonne of soil),
(c) minor work, being work that costs less than $20,000 (other than drainage work).

> *(6) Despite subclause (2), development consent is not required under this clause to carry out any works if:*
>
> > *(a) the works involve the disturbance of less than 1 tonne of soil, such as occurs in carrying out agriculture, the construction or maintenance of drains, extractive industries, dredging, the construction of artificial water bodies (including canals, dams and detention basins), foundations or flood mitigation works, or*
> > *(b) the works are not likely to lower the watertable.*

As stated under clause 6.1(2), development consent is required for the carrying out of any works on Class 5 land as specified in the Acid Sulfate Soils Map. Furthermore, as stated under clause 6.1(3), development consent is not to be granted unless an ASS management plan has been prepared for the proposed works in accordance with the ASS Manual.

1.3 MANAGEMENT PLAN OBJECTIVE

The objective of this management plan is to address the regulatory requirements for the proposed development as reported in Section 1.2 and minimise the risk to the environment from ASS by:

- Providing procedures for identifying the areas of PASS and/or ASS;
- Providing procedures for treatment to reduce the risk to the environment due to the disturbance of PASS and/or ASS during the proposed demolition and construction works; and
- Providing documentation and monitoring procedures for implementation during demolition and construction works.

In line with regulatory requirements, this ASS Management Plan is prepared in accordance with the *Acid Sulfate Soils Manual* published by the Acid Sulfate Soils Management Advisory Committee (ASSMAC), in 1998. Two sections of the ASS Manual are of particular relevance and have been followed in the preparation of this management plan: the *Acid Sulfate Soils Management Guidelines* and the *Acid Sulfate Soils Management Plan Guidelines* which outline the best practice in handling and managing potential and actual acid sulfate soils.

2. DESCRIPTION OF PROPOSAL

2.1 SUBJECT SITE DETAILS

The subject Site is located at Table 2-1, and consists of a single rectangular lot. Site identification and land use information is summarised below;

Table 2-1: Site Details

Address	81 Gow Street Padstow NSW, 2211
Lot and DP Numbers	Lot A, DP103140
Local Government Area	Canterbury-Bankstown
Approximate Site Area	10,400 m^2
Current Land Zoning	IN1 – General Industrial

Source: https://www.planningportal.nsw.gov.au/

Figure 2-2 shows an aerial view of the subject site boundaries and its surroundings, as well as the area categorised as Class 5 land in the ASS Map of the Bankstown LEP 2015.

2.2 SITE GEOMORPHOLOGY

2.3 SOIL CLASSIFICATION AND GEOLOGY

The 'Sydney 1:100 000 Geological Map Sheet 9130' describes the geological composition of the area as *Ashfield Shale (Rwa)* which is part of the Wianamatta Group and comprises of dark grey to black claystone-siltstone and fine sandstone-siltstone laminate.

The soil map 'Soil Landscape of Sydney 1:100,000 Sheet 9130' shows that the subject site is located in a 'Blacktown' (bt) area and is described as follows:

> *Blacktown (bt)*
>
> *Landscape – gently undulating rises on Wianamatta Group shales and Hawkesbury shale. Local relief to 30 m, slopes are usually <5%. Broad rounded crests and ridges with gently inclined slopes. Cleared Eucalypt woodland and tall open forest (wet sclerophyll forests).*
>
> *Soils – shallow to moderately deep (<100 cm) Red and Brown Podzolic Soils (Dr3.21, Dr3.11, Db2.11) on crests, upper slopes and well-drained areas, deep (150-300 cm) Yellow Podzolic Soils and Soloths (Dy2.11, Dy3.11) on lower slopes and in areas of poor drainage.*
>
> *Limitations – moderately reactive highly plastic subsoil, low soil fertility, poor soil drainage.*

2.4 ACID SULFATE SOILS (ASS)

The Site is located on Class 5 land of the Bankstown Council's Local Environmental Plan (LEP) 2015 ASS map. Class 5 areas are generally at low risk of containing ASSs. However, soil sampling conducted during a detailed site investigation in 2019 revealed the onsite presence of Actual ASS (AASS). As per Council's LEP 2015, development consent is required for works in Class 5 areas that are located within 500 m of adjacent class 1, 2, 3 or 4 land that is below 5 metres AHD and by which the water table is likely to be lowered below 1 metre AHD on adjacent class 1, 2, 3 or 4 land. Class 2 land is approximately 365 m north-east of the site perimeter,

> *6.1 Acid sulfate soils*
>
> *(2) Development consent is required for the carrying out of works described in the Table to this subclause on land shown on the Acid Sulfate Soils Map as being of the class specified for those works.*
>
> *Class of land Works*
>
> *5 Works within 500 metres of adjacent Class 1, 2, 3 or 4 land that is below 5 metres Australian Height Datum and by which the watertable is likely to be lowered below 1 metre Australian Height Datum on adjacent Class 1, 2, 3 or 4 land.*

Acid Sulfate Soils (ASS) are naturally occurring soils and sediments that formed (mainly) within the last 10,000 years, when at the end of the last Ice Age, rising sea-levels caused the formation of new coastal landscapes and tidal waterways through sedimentation. The waterlogged sediments were rich in organic material and contained bacteria that converted sulfate from tidal waters, and iron from the sediments, into iron disulfide (predominantly iron pyrite). When exposed to air, iron sulfides oxidise and produce sulfuric acid.

If left undisturbed ASS remain benign. However, if drained, excavated or exposed to air (such as by a lowering of the water table), oxygen reacts with the soil's pyrite to form sulfuric acid, sometimes in very large quantities (for every 1 tonne of completely oxidised sulfidic material, 1.6 tonnes of pure sulfuric acid are produced). Within ASS are naturally occurring traces of metals such as iron, aluminium and arsenic. If acid forms, it can dissolve the metals and move them into the surrounding environment. Rainfall can aid this process moving acid and dissolved metals into adjoining land and nearby waterways. Accumulation of acids and metals becomes toxic to plants and animals, especially aquatic organisms (can cause massive fish kills). Human built structures are highly susceptible to ASS, as acid will slowly corrode timber, concrete, steel, roads and building foundations.

ASS can be divided into two categories:

- Actual Acid Sulfate Soil (AASS) – These are highly acidic soil layers (with a pH <4), that contain iron sulfides that have previously been exposed to oxygen. These soils can contain some acid-neutralising material that can reduce the acid-generating process until the soil is again exposed to oxygen. AASS is usually identified by the occurrence of bright yellow jarosite mottles (an oxidation by-product).

- Potential Acid Sulfate Soil (PASS) - These are typically water-logged soils containing high levels of iron sulfides that has <u>not been</u> exposed to air and oxidised but have the *potential* to do so. PASS layers may comprise of clay, sand or loamy mixtures. They are typically soft, very dark, blue grey or dark greenish-grey coloured.

ASS occur predominantly on coastal lowlands, with elevations generally below 5 m Australian Height Datum (AHD), but do occur within inland environments.

The presence of ASS generally indicates potential risks to surface and or groundwater quality, soil strength, stability, habitat character and agricultural productivity on adjoining lands, as well as presenting challenges for the design and maintenance of infrastructure in acid sulfate environments.

Figure 2-1: Aerial Photograph of Site's Local Setting

Source: Land and Property Information – SixMaps

↑N Not to scale	LEGEND: 🟨 Site boundary	Benbow Environmental 25-27 Sherwood Road Northmead NSW 2152

Figure 2-2: Site Plans. Arrows Denote Areas to be Excavated

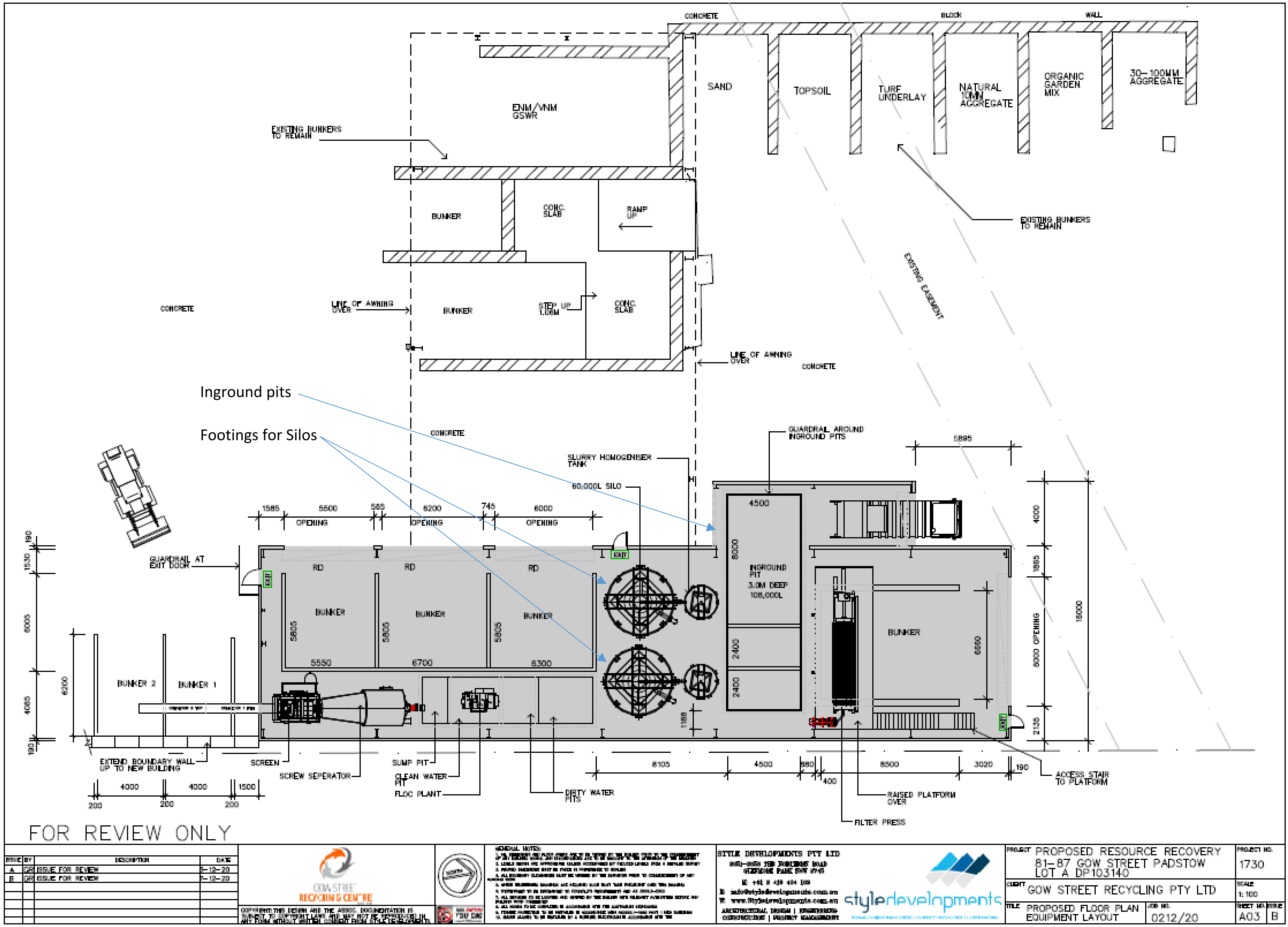
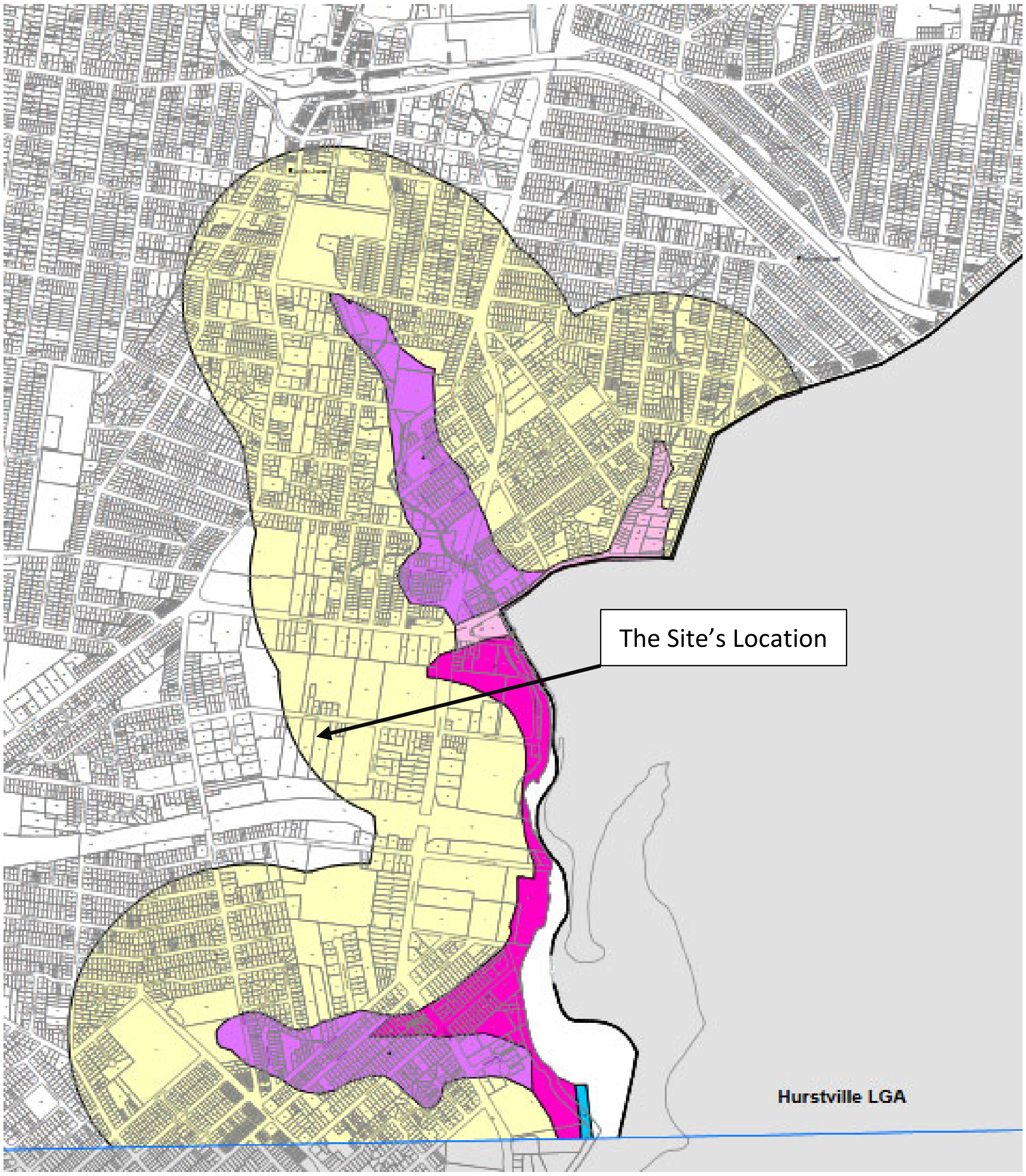


Figure 2-3: Bankstown LEP 2015 Acid Sulfate Soil Map



3. PROCEDURE FOR IDENTIFICATION

This procedure provides guidance on the correct screening for any AASS or PASS that may be present in the excavated material or excavation pits resulting from the proposed works at the subject site. In accordance with the ASS Manual (ASSMAC, 1998), field screening as well as laboratory testing is to be used in the identification of acid sulfate soils. The detailed methodology is outlined in the following sections for both types of testing.

3.1 FIELD SCREENING

Field pH (pH_F) and peroxide pH (pH_{FOX}) tests have been developed for a rapid assessment in the field of the likelihood of ASS, as they have minimal set up cost and are easy to perform. Field pH and peroxide pH are used as an indication of the actual acidity level in the soil (AASS) and the potential acidity (PASS) level in the soil, respectively. The field pH is measured from a simple solution of water and soil, while the peroxide pH is measured after a reaction of the soil with peroxide has occurred.

It is important to note that peroxide is an extremely dangerous chemical that must be handled, diluted, stored and applied with extreme care and in accordance with the Safety Data Sheet. Furthermore, field peroxide results are prone to false positives due to the additional oxidation of organic matter, which may be particularly high in certain soils.

3.1.1 Staging of Excavation

Excavation onsite should be staged to allow for the identification of any ASS throughout the soil profile. Excavation should proceed at intervals of every 0.5 m depth across the whole area where soil is to be removed, creating separate stockpiles for each 0.5 m layer until the required depth is reached. ASSs are naturally occurring and as such do not form homogenously. A site may contain non-ASS layers above an ASS layer (or the opposite). Layers are likely to differ in acidity and thus in treatment. Separating soils makes handling and treatment more manageable plus keeping non-ASS separate from ASS reduces overall costs, as ASSs require treatment (more cost) and attract higher disposal costs.

As the Site has sufficient land for treatment and temporary storage of excavated soil, the design of this Management Plan allows for separate stockpiles. For the underground pits, the area to be excavated is approx. 13 m x 4.5 m down to 3.0 m depth. Thus six stockpiles each containing ~ 30 cubic metres of soil material. Stockpiling of soil taken from footings may need to be measured differently depending on the excavation method chosen. If the excavation method is by drilling, it may be more practical to collect a number of metres (depth) of soil, due to the narrowness of the bore hole and thus its small soil volume. One to two cubic metres of soil would be a manageable volume to treat.

3.1.2 Sampling Methods

Collect a representative sample of soil from each stockpile by using a stainless-steel scoop. Divide the sample in two soil sub-samples for each stockpile, and place into 150 mL wide-mouth glass jars. The two soil sub-samples, for pH_F and pH_{FOX} measurements, must be collected simultaneously from the same location to ensure equal depth and soil characteristics. Approximately 5 g to 10 g of soil should be collected for each sub-sample. Glass jars should be used as the testing vessel to ensure heat resistance during peroxide reaction, which may result in heat and steam generation.

Between each sample collection, the sampling equipment must be cleaned in order to avoid cross contamination by washing and scrubbing and then rinsing the utensils with deionised water.

3.1.3 Testing Procedure

Field pH test should be carried out in accordance with Appendix 1 of the Acid Sulfate Soil Manual, Assessment Guidelines. The procedure for field pH test (pH_F) is outlined below:

1. The pH field meter must be calibrated prior the undertaking of the field pH testing.
2. Sub-sample for pH_F to be collected and labelled with Sample ID and name of test.
3. Sufficient deionised water is to be placed in testing vessel until the soil and water mixture forms a thick paste. This should be done within 10 minutes of sample collection to reduce the risk of sulfide oxidation and incorrect pH reading.
4. The pH should be measured with the spear point electrode of a field pH meter and the value recorded on a data sheet.

The procedure for field pH peroxide test (pH_{FOX}) is outlined below:

1. Chemicals for testing are to be prepared in advance. A 30% hydrogen peroxide (H_2O_2) solution is buffered with sodium hydroxide (NaOH) to a pH of 4.4–5.5 before testing on site.
2. Sub-samples for pH_{FOX} are to be collected and labelled with Sample ID and name of test.
3. A few millilitres of the 30% H_2O_2 with adjusted pH are to be added to the testing vessel, with sufficient peroxide to cover all soil with the solution. The mixture must be stirred – allow approximately 15 minutes for initial reaction time.
4. The reaction of soil and peroxide must be rated using a XXXX scale (as per Table 3-1). The rate of the reaction generally indicates the level of sulfides present but is dependent on soil texture, soil organic content and the soil's natural buffering abilities.
5. Small amounts of peroxide may be added over time until the soil/peroxide mixture reaction slows down, or no further reaction occurs. Allow the mixture to cool down to ambient temperature.
6. The pH should be measured with the spear point electrode of a field pH meter and the value recorded on a data sheet.

Table 3-1: Soil Reaction Rating Scale for pH_{FOX} Test

Scale Rating	Description
X	Slight reaction - Slightly audible but no visible effervescence
XX	Moderate reaction - Audible and slightly visible effervescence
XXX	High reaction - Moderate visible effervescence
XXXX	Very vigorous reaction - Strong visible effervescence, gas evolution and heat generation commonly >80°C

3.1.4 Assessment Criteria for Field Screening

The ASS Manual (ASSMAC, 1998) gives the following trigger values indicating presence of AASS and PASS.

For pH_F, if the soil paste is pH <4, oxidation of sulfides has probably occurred in the past, indicating that an actual acid sulfate soil (AASS) is present. For pH_{FOX}, a combination of three factors is used to determine presence of sulfides or potential acid sulfate soils (PASS):

- *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. This reaction should be rated.*
- *A pH_{FOX} value at least one unit below field pH_F* may *indicate PASS. The greater the difference between the two measurements, the more indicative the value is of PASS. The lower the final pH_{FOX} value is, the better the indication of a positive result.*
- *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.*

In summary, the field test results should be compared to the following table to determine the subsequent action required.

Table 3-2: Interpretation of Field pH Tests

pH_F	pH_{Fox}	Δ pH*	Δ Temp.[#]	Reaction	Action required
≥5.0	≥4.5	≤1.0	<5.0 C°	X to XX	Very unlikely to contain ASS. No action required. Keep one sample if required to show laboratory confirmation to consent authority for re-use of soil on site.
<5.0	<4.5	>1.0	>5.0 C°	XX to XXX	Possibility of containing ASS. Send representative samples to laboratory from each stockpile in this range to confirm presence/absence of ASS.
<4.0	<3.0	>1.0	>10.0 C°	XXX to XXXX	Very likely to contain ASS. Move soils to treatment pad. Send a representative sample to laboratory from stockpile that recorded the strongest reaction or lowest pH to obtain initial liming rates.

*Difference between pH_F and pH_{Fox}.
[#] Temperature difference (increment) after the reaction with peroxide.

As indicated in the table above, the ASS Manual advises to confirm results with laboratory testing. Analytical confirmation of field screening is especially needed for pH_{FOX} results between pH 3 and pH 4, which give an ambiguous indication of sulfide presence.

Where results show clear likelihood of ASS presence, samples should be sent to the laboratory to obtain the initial liming rates for treatment. The sample returning the highest liming rate is the rate to be adopted. These soils are to be treated onsite in accordance with the *Procedure for Treatment* outlined in Section 4.

Sample collection for laboratory testing and details about laboratory procedures and action criteria are outlined in the following section.

3.2 LABORATORY TESTING

Soil samples selected for laboratory testing should be sent to a NATA accredited laboratory, such as ALS Environmental, which carries out analytical methods based on well-established and internationally recognised procedures, in line with the ASS Manual requirement.

3.2.1 Sampling Methods

Soil samples are to be collected by using a stainless-steel scoop and placed into polyethylene bags, which can be supplied by the laboratory of choice.

Approximately 50 g of soil should be collected for each sample. The soil must be packed tightly into the bags, eliminating excess air space or voids. Between each sample collection, the sampling equipment is to be cleaned or new equipment should be used, in order to avoid cross contamination, by washing, scrubbing and then rinsing the utensils with deionised water. Samples should be placed into a chilled esky until delivery to laboratory, within 24 h from sampling. Chain of Custody forms are to be completed with required information and submitted to the lab along with the samples.

The laboratory method that should be used is the *Suspension Peroxide Oxidation-Combined Acidity and Sulfate method* (SPOCAS), in accordance with the ASS Manual. In-house quality control tests should include Laboratory Duplicates, Method Blank and Laboratory Control Spike.

3.2.2 Assessment Criteria for Analytical Results

The ASS Manual (ASSMAC, 1998) gives the following action criteria for ASS (Table 3-3), based on the percentage of oxidisable sulfur (S_{POS}) or equivalent total actual acidity (TAA) or total potential acidity (TPA) for broad categories of soil types. Where proposed works disturb more than 1,000 tonnes of possible ASS, the action criteria for coarse textured soils applies to all soil types. It should be noted that the proposed works are not expected to disturb more than 1,000 tonnes of soil, and the action criteria for 1 to 1,000 tonnes disturbed would likely apply.

Soils that exceed these criteria are to be treated onsite in accordance with the *Procedure for Treatment* outlined in Section 4.

Based on the soil logs from the previous Phase II investigation conducted by BE in 2019 (191290-02_Phase II_Rev2), the soils are considered Fine Texture - Medium to heavy clays and silty clays (see Table 3-3 below).

Table 3-3: NSW ASS Assessment Guidelines Criteria with the Site's Class Highlighted in Bold

Type of Material		Action Criteria 1-1000 tonnes disturbed	
Texture	Approx. Clay Content	Sulfur trail S_{TOS} <u>or</u> S_{POS} (%S)	Acid trail TAA/TSA/TPA (mole H^+/t)
Coarse Texture – Sands to loamy sands	≤5	0.03	18
Medium Texture – Sandy loams to light clays	5-40	0.06	36
Fine Texture – **Medium to heavy clays and silty clays**	≥40	**0.10**	**62**

4. PROCEDURE FOR STOCKPILING

It is important to note that any soil suspecting of containing ASS much be treated accordingly.
Acid Sulfate Soils (ASS) are naturally occurring soils and sediments that formed under waterlogged conditions. They contain iron sulfide (predominantly pyrite). When in a waterlogged, or anoxic environment, ASS remain benign. However, if drained, excavated or exposed to air, sulfides react with oxygen to form sulfuric acid, sometimes in very large quantities (for every 1 tonne of completely oxidised sulfidic material, 1.6 tonnes of pure sulfuric acid are produced). ASS contains traces of metals such as iron, aluminium and arsenic. Once acid forms, it mobilises any metals held within the soil. Rainfall washes this mixture into the surrounding environment, polluting land and nearby waterways. Accumulation of acids and metals becomes toxic to plants and animals, especially aquatic organisms. Built structures are highly susceptible to ASS, as acid will slowly corrode concrete, steel, roads and building foundations.

This is why it is important to correctly store excavated soil so acid production does not occur and acid is not released into the environment.

Stockpiled soil cannot be placed directly onto grass or bare earth but must be placed on an impermeable layer. Appropriate material for this purpose includes clay (0.5 m thick), concrete layer or thick, hardy plastic sheeting covered by geocloth. Once each stockpile has been created, samples should be taken to assess their ASS potential. The stockpiled soil needs to be kept damp to prevent any (potential) acidification from occurring. Do not soak the soil as this will cause structural weakness within the stockpile, possibly leading it to collapse. Excessive water can also create leachate. Once samples are collected the stockpile needs to be completely covered by geocloth and kept damp. If results later reveal that ASS are *not* present, then the soil can be removed off site subject to the EPA's waste regulation requirements.

Once a soil's acid status has been determined, the non-ASS should be removed leaving the remaining stockpiles for treatment.

The soil treatment area should be separate from the excavated stockpiled. To facilitate adequate treatment and ensure each stockpile's integrity, it is recommended that treatment stockpiles should be of trapezoidal shaped (see Figure 5-2 for diagram). For the purposes of illustration and utilising the predicted onsite excavated volumes of soils, treatment stockpile sizes and geometry are provided in Table 5-1 below. For the footing soil material, it is recommended a similar pattern be adopted dependant on the excavated volume of material.

Table 4-1: Suggested Stockpile Treatment Volumes

Treatment Batches*	Stockpile ID/ Layers	Volume (m^3)	Height (m)	Length (m)	Width 1 (m)	Width 2 (m)
Treatment Batch 3	SP1	30	2.0	8.6	4.0	3.0
	SP2	30				
Treatment Batch 2	SP3	30	2.0	8.6	4.0	3.0
	SP4	30				
Treatment Batch 1	SP5	30	2.0	8.6	4.0	3.0
	SP6	30				

5. PROCEDURE FOR TREATMENT

This procedure provides guidance on the correct treatment of excavated material that has failed the field screening or laboratory testing outlined in the *Procedure for Identification* in Section 3 and is, therefore, likely/confirmed to be ASS.

With the correct treatment, the excavated material will be suitable for reuse on the Site or for disposal at a licensed facility (note that for off-site disposal a waste classification assessment must be carried out). Procedures are also provided for the treatment of any leachate that may arise from the previous soil processing.

5.1 TREATMENT AREA

A designated treatment area for ASS must be prepared on-site, preferably before the commencement of proposed excavation works. Alternatively, the treatment area can be constructed once the field screening indicates potential presence of any ASS; however, allowances should be made during the construction/excavation planning phase to allocate sufficient land and funds for the installation of an ASS treatment area.

An ASS treatment area usually includes five components: a treatment pad, clay layer, lime/guard layer, a leachate collection drain and bunding. A schematic cross-section of a typical ASS treatment area is presented in Figure 5-1.

The treatment area should be prepared as follows:

- This management plan allows for three treatment pads, each pad being 8.5 m x 4.0 m. The pad/s should be prepared on relatively level or gently sloping ground to minimise instability issues, and with a natural or shaped fall to the leachate collection drain and on-site detention basin.

- Line the treatment pad with a layer of compacted clay (to a thickness of 0.5 m approximately) or with a geo-synthetic liner, which must be approved by the environmental consultant. A concrete pad may also be suitable subject to the construction details and location.

- Apply a ‘guard layer’ made of fine agricultural lime over the compacted clay or geo-synthetic liner to neutralise downwards seepage. Approximately 10 kg of agricultural lime should be applied for each metre height of the stockpile across a square metre of the treatment pad (i.e. if a treatment stockpile height of 1.5 m is proposed, the guard layer would need to comprise 15 kg of lime for each m^2 of surface area). For the suggested treatment pads this equates to 15 kg x 21 m^2 approx. 319 kg for each pad. The suggested height of the completed pad is 1.6 m (see Figure 5-2 for a diagram of the suggested stockpile shape)

    - ▸ Note that the guard layer should be re-applied after each round of ASS treatment, before a new load of untreated ASS is stockpiled on the pad;

- Excavate a drain around the circumference of the treatment pad to collect and contain any leachate. The drain should be lined with impermeable material and covered with a layer of fine lime, applied to neutralise any possible leachate migrating from the stockpiled material.

  - The drain should direct water into an appropriately sized detention basin, the base of which has been prepared in the same manner as the treatment pad. Alternatively, water from the drain can be pumped into on-site tanks for storage, and future testing and treatment.

- Construct a bund surrounding the treatment pad and leachate collection drain. The inner bund sloped should be lined with an impermeable material and covered with a layer of agricultural lime.
- The most efficient shaped stockpile to build for this purpose is a trapezoidal (see Figure 5-2).

Figure 5-1: Schematic Cross-section of ASS Treatment Area (from Dear et al. 2014)

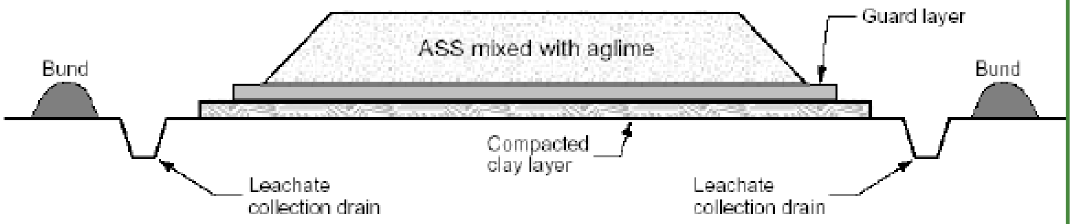
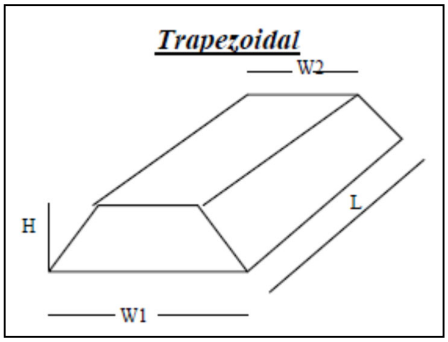


Figure 5-2: Trapezoidal Shaped Stockpile



H = 2.0 m
L = 8.6 m
W1 = 4.0 m
W2 = 3.0 m
Volume = 60.2 m^3

5.2 NEUTRALISING AGENT

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

Agricultural lime consists of calcium carbonate ($CaCO_3$), typically made from limestone that has been finely ground and sieved to a fine powder. It is generally desirable to use ag lime with a purity of 95% or better (i.e. with a neutralising value of 95 or more). The lime should be fine and dry, as texture and moisture can also decrease the effective neutralising value.

An alternative neutralising material can be used subject to prior approval by a suitably qualified environmental consultant.

5.2.1 Application Rates

The application rate of ag lime, or any other suitable material, shall be calculated based on the analytical result provided by the laboratory and on the neutralising value of the neutralising agent. The required liming rate can be calculated from one of the following formulas, sourced from DER (2015):

Equation 1

$$\text{Neutralising Material Required (kg } CaCO_3\text{/tonne soil)} =$$
$$= \text{Net acidity } (\%S \times 30.59) \times 1.02 \times FOS \times 100/ENV$$

Equation 2

$$\text{Neutralising Material Required (kg } CaCO_3/m^3 \text{ soil)} =$$
$$= D\ (\text{tonne}/m^3) \times \text{Net acidity } (\%S \times 30.59) \times 1.02 \times FOS \times 100/ENV10$$

Where:

- %S = net acidity (% S units). This value is obtained from the SPOCAS/chromium suite analytical results and should be the “worst case” (largest percentage) result of the acid or sulfur trails of all samples;
- 30.59 is a conversion factor for %S to kg H_2SO_4/tonne;
- 1.02 is used to convert units of sulfuric acid (H_2SO_4) to units of calcium carbonate ($CaCO_3$);
- FOS (Factor of Safety): a minimum FOS value of 1.5 should be adopted; and
- ENV (Effective Neutralising Value): calculated based on the molecular weight, particle size and purity of the neutralising agent – it is approximately 95% for fine ag lime.

It should be noted that the soils’ acid production will vary both horizontally and vertically through the ASS profile due to the variability of natural systems. The liming rate to be calculated from the analytical results should, therefore, be considered as an initial indication, and pH monitoring should be conducted during treatment to assess the progress of the neutralisation and the need for further liming.

5.3 SOIL TREATMENT PROCESS

The following steps outline the treatment process that should be followed for all stockpiled material potentially identified as/confirmed to be ASS.

1) For small volumes of soil, transport the excavated material to the designated treatment area illustrated in Section 5.1; while for larger volumes, delineate the stockpile to commence treatment on location and isolate from general site traffic.

2) Spread the soil to be treated in manageable volumes on top of the treatment pad, to ensure effective treatment of all material:
   - Log the approximate volume of material to be treated as well as the treatment location (treatment pad or in situ);
   - Spread out the material on treatment pad in a layer between 0.2 m and 0.5 m high (depending on the mixing equipment to be used) for effective mixing;

  - In the event of wet weather, stop works and cover the stockpiled material with a plastic sheet to reduce the formation of leachate; and
  - Let the material dry to facilitate lime mixing.

3) Apply agricultural lime by distributing it evenly across the surface of the spread-out stockpile; use liming rate calculated as per Section 5.2.1.

4) Undertake thorough mixing of the excavated material with the applied lime:
   - Mechanical mixing should be performed with a rotary hoe or disc plough; and
   - Ensure that lime is incorporated within the full depth of the stockpile.

5) Collect representative samples of the treated material to determine if further treatment is required:
   - Sample at a rate of 1 sample per 25 m^3 of treated material; and
   - Record sample ID with sequential and traceable nomenclature, including a code for the location and sample number.

6) Undertake field screening on the collected samples, in accordance with the testing procedure outlined in Section 3.1.3 , and compare results with criteria in Section 3.1.4:
   - For samples unlikely to be ASS, send representative sample to laboratory in order to confirm positive results (validation testing): the level of treatment is likely to have been sufficient;
   - For samples that still show some indication of ASS, send representative samples to selected laboratory in order to determine a more accurate liming rate, then repeat the treatment process by following steps 3) to 6); and
   - For representative samples: sample at a rate of 1 sample per 250 m^3.

7) Compare laboratory results with the Action Criteria listed in Table 3-3 (Section 3.2.2):
   - If laboratory results exceed the sulfur or acid trail criteria, further treatment is still necessary, and a qualified environmental consultant may need to be engaged;
   - If laboratory results are below the sulfur or acid trail criteria, the material can be removed from the treatment pad and is deemed suitable for reuse on site, or for disposal to a licenced facility (upon undertaking of waste classification).

5.4 WATER MANAGEMENT

Water is the main mechanism by which acid and metals from oxidised ASS are mobilised and transported. As such, appropriate management of water is essential to effectively avoid potential adverse impacts from ASS. The procedure outlined below can be used for the management of any water that has been in contact with ASS, such as leachate from the ASS treatment area. It should be noted that the proposed works are not expected to require any groundwater dewatering.

The following points briefly outline the management, assessment, treatment and disposal of water that has been in contact with ASS:

- Water from the ASS treatment/storage area should be collected in the lined drains/detention basin constructed in accordance with Section 5.1, or in a tank. The stored water should not be in direct contact with groundwater or surface water and should be stored away from overland flow paths. Any other water which may have come into contact with ASS should also be collected in an on-site detention basin or tank.

- If the necessary depth of excavation is below the water table then dewatering is expected to be required for the proposed works. Any water extracted as part of dewatering needs to be collected, assessed and treated in accordance with these procedures as having potentially been impacted by ASS.

- All water which has potentially come into contact with ASS and has been contained and collected on site will require assessment by a qualified environmental consultant. A variety of parameters may be required to undergo laboratory analysis, depending on field measurements and visual assessments.

- Daily pH checks of the leachate drains must also be undertaken by the Site Manager or staff with environmental duties. The pH should range from 6.5 to 8.5 and should not drop more than 0.5 pH units between daily measurements during the ASS treatment works. If the pH is outside of its range or has dropped significantly, emergency response should be undertaken immediately (treatment of leachate as described below).

- Treatment of water within bunded areas/leachate drains may include dosing with hydrated lime, at appropriate rates, to ensure a discharge pH of 6.5 to 8.5. Care must be taken when using hydrated lime to avoid overcorrecting pH levels. Alternatively, passive pH neutralising filters such as limestone gravel in mesh bags can also be used to treat the leachate.

- Based on the assessment of a variety of water quality parameters, other treatment may be required to meet the adopted water quality criteria outlined in the table below. A qualified environmental consultant should be engaged.

Table 5-1: Suggested Target Levels for Water Discharge into Stormwater

Water Parameters/Contaminants	Target Levels
pH	pH 6.5 – 8.5
Total Suspended Solids (TSS)	<50 mg/L of TSS or ≤8 NTU (for turbidity)
Oil and grease	<10 mg/L
Iron (total and soluble)	≤0.3 mg/L filterable iron No signs of iron staining or settlement
Metals incl. arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, zinc.	ANZECC (2000) Trigger Levels for 95% Protection for freshwater ecosystems

5.5 DISPOSAL OF TREATED ASS

Where treated ASS cannot be reused onsite, its off-site disposal must comply with the Waste Classification Guidelines by the NSW EPA (see EPA 2014a and 2014b) and the *Protection of the Environment Operations (POEO) Act 1997*.

Part 4 of the Waste Classification Guidelines (EPA 2014b) states that ASS must be treated (neutralised) prior to acceptance by a landfill; unless it is to be disposed of as PASS to an appropriately licensed landfill. It should be noted that disposal of untreated PASS below the water table was not considered in this ASS Management Plan, due to the unfeasibility of complying with the stringent time limitations imposed for this option.

After treatment, the soil should be chemically assessed in accordance with Part 1 of the Waste Classification Guidelines (EPA 2014a). This will determine whether any other contaminants are present in the material. When the classification has been established, the soil should be sent to a landfill that can lawfully accept that classification of waste. The treated ASS would (at a minimum) be classifiable as General Solid Waste; however, chemical testing would indicate if a higher classification would apply.

Prior arrangements should be made with the landfill to ensure that it is licensed to accept the waste. Furthermore, the landfill should be informed that the ASS has been treated with neutralising techniques that are in accordance with ASSMAC (1998).

6. PROCEDURES FOR IMPLEMENTATION

The following sections describe procedures and action that will assist in the correct implementation of this ASS Management Plan.

6.1 ROLES AND RESPONSIBILITIES

Roles and responsibilities for implementing this ASS Management Plan are defined in Table 6-1.

Although not a statutory requirement, it is preferable that sample collection, field screening and ASS treatment be undertaken by a qualified environmental consultant; alternatively, ASS identification may be performed by the Site Manager or other construction personnel with environmental duties, such as erosion and sediment control responsibilities. However, due to the various contingencies and errors that may arise from the ASS treatment process, it is strongly recommended that an environmental consultant is engaged to monitor the remediation works.

Each employee is responsible for protecting the environment and implementing environmental procedures. Ultimate responsibility lies with the Principal Contractor/Site Manager. If unsure of what to do in a given situation, employees must contact the Principal Contractor/Site Manager.

Table 6-1: Roles and Responsibilities

Role	Responsibilities
Principal Contractor/ Site Manager	• Review the management plan ensuring that each person who is to carry out the proposed works is made aware of the plan and is appropriately trained to fulfil the plan’s objectives. • Make arrangements for ensuring compliance with the requirements for ASS management at the site.
Site Manager / Staff with Environmental Duties	• Stage the excavation works as indicated in the plan. • Undertake sampling, field and laboratory testing, and assessment of possible ASS in accordance with the procedures and methods outlined in the plan. • Plan and make arrangement for any required remediation works to be undertaken in accordance with the plan. • Monitor the pH level of leachate drains daily and before disposal and adjust pH to the adopted target levels.
Excavator driver	• Ensure that staging of the excavation works and stockpiling of excavated material is undertaken as indicated in the plan.
Environmental Consultant	• If not performed by the site manager or other site worker, undertake sampling, testing and assessment of possible ASS. • Guide and monitor any required remediation works. • Assess and, if required, treat any water which has potentially come into contact with ASS (e.g. leachate and groundwater).
All Workers and Sub-Contractors	• Responsible for carrying out construction activities in accordance with the procedures outlined in this ASS management plan. • Responsible for informing the Principal Contractor of any issues with implementing the plan.

6.2 ENVIRONMENTAL TRAINING

All workers and contractors directly involved in excavation and/or the management of ASS at the subject site shall undertake environmental training. Training can be undertaken either in-house or, more formally, through environmental consultants.

6.3 RECORD KEEPING

ASSMAC (1998) does not require formal reporting of ASS management; however, it is important to maintain appropriate record keeping of the identification and treatment processes to show compliance with the guidelines. Records must be kept for all field and laboratory tests undertaken, as well as for the excavation works details, such as dates, tonnages of material excavated and identified as ASS.

Records for the material that was treated and is suitable for reuse/disposal must also be maintained and includes the level of treatment received (i.e. the liming rate applied) and the location of the final destination, which may be on the subject site (records must include depth and coordinates of reused treated soil) or at a waste management facility (records must include landfill location, landfill licence and dockets).

All records should be maintained for at least a year upon completion of the excavation works potentially disturbing ASS and must be made available, upon request, to the consent authorities.

7. CONCLUDING REMARKS

Benbow Environmental was commissioned by Gow St Recycling Centre to prepare an Acid Sulfate Soils Management Plan (ASS MP) for the proposed works to be undertaken at 81-87 Gow Street Padstow NSW 2211 within the local government area of Canterbury-Bankstown

The management plan forms part of the development application for the construction of a dewatering plant Site is identified as being within a Class 5 ASS area (as per the *Bankstown LEP 2015 Acid Sulfate Soil Map*). The proposed works involve excavation for inground tanks and building footings.

Acid sulfate soils potentially may be encountered during the site's excavation works. This management plan provides detailed information for their onsite identification, field screening and laboratory testing. In the event ASS are found, the procedure for their correct handling and treatment is provided. This requires the application of agricultural lime to the affected soils, on a designated treatment pad or in situ, followed by thorough mixing and laboratory confirmation.

Provided that the Site manager and/or construction personnel understand the issues involved and takes an active role in the management of the process, any ASS encountered can be dealt with in a manner that satisfies regulatory requirements by following this management plan. However, it is strongly recommended that an environmental consultant assist in the treatment process of any ASS that may be encountered on site.

This concludes the report.

Damien Thomas	R T Benbow
Environmental Scientist	Principal Consultant

8. LIMITATIONS

Our services for this project are carried out in accordance with our current professional standards for site assessment investigations. No guarantees are either expressed or implied.

This report has been prepared solely for the use of *Gow St Recycling Centre*, as per our agreement for providing environmental services. Only *Gow St Recycling Centre* is entitled to rely upon the findings in the report within the scope of work described in this report. Otherwise, no responsibility is accepted for the use of any part of the report by another in any other context or for any other purpose.

Although all due care has been taken in the preparation of this study, no warranty is given, nor liability accepted (except that otherwise required by law) in relation to any of the information contained within this document. We accept no responsibility for the accuracy of any data or information provided to us by *Gow St Recycling Centre* for the purposes of preparing this report.

Any opinions and judgements expressed herein, which are based on our understanding and interpretation of current regulatory standards, should not be construed as legal advice.

9. REFERENCES

ANZECC (2000) *Australian Water Quality Guidelines for Fresh and Marine Waters*, Australian and New Zealand Environment and Conservation Council (ANZECC), Kingston, Canberra ACT 2604.

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