

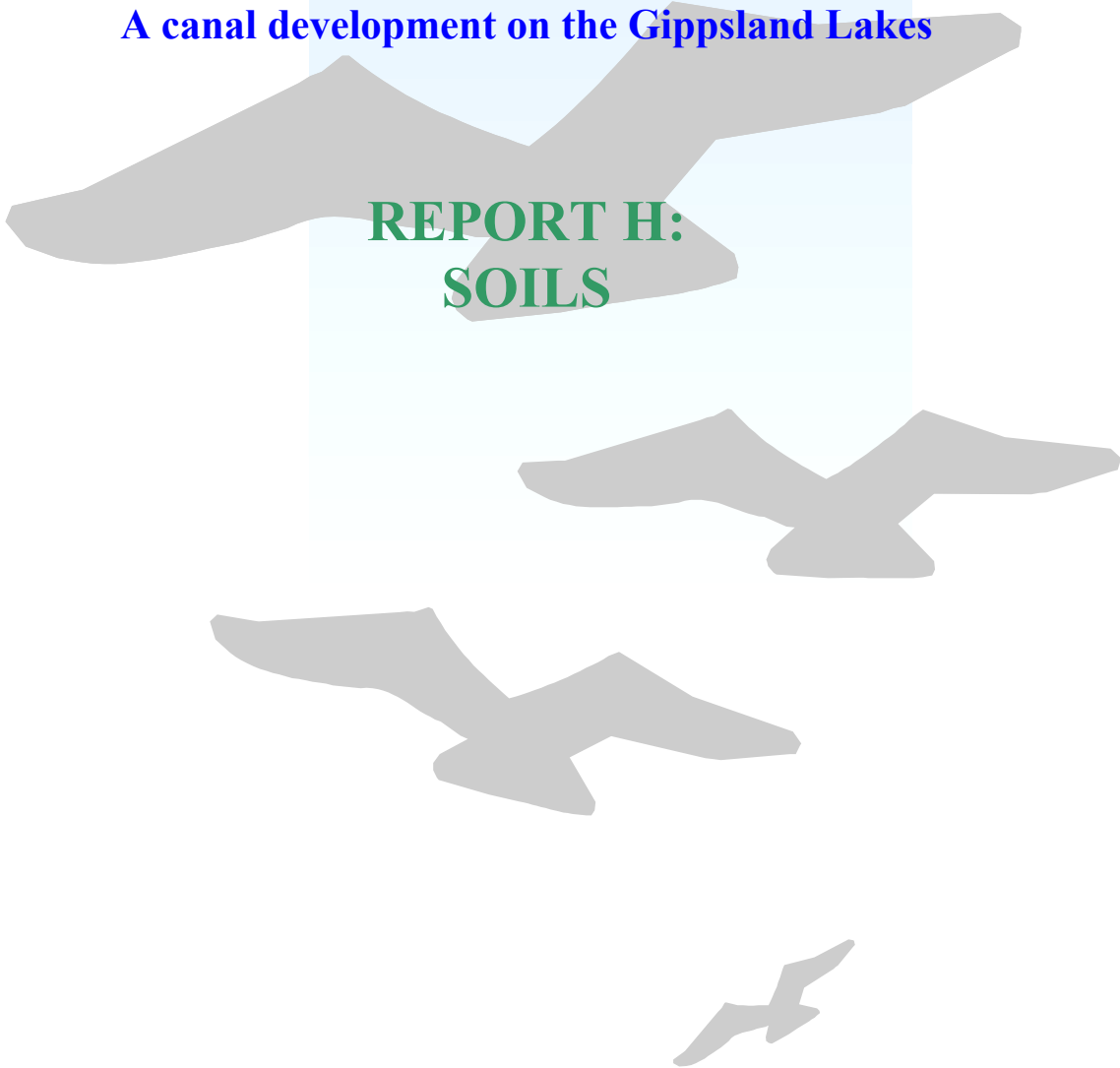


ENVIRONMENT EFFECTS STUDY

WELLINGTON WATERS

A canal development on the Gippsland Lakes

**REPORT H:
SOILS**



REPORT

ACID SULFATE SOIL ASSESSMENT WELLINGTON WATERS CANAL ESTATE LAKE WELLINGTON, VICTORIA

Prepared for:
Wellington Waters

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EXECUTIVE SUMMARY

Meinhardt (Vic) Pty Ltd (Meinhardt) was commissioned by Wellington Waters to undertake an acid sulfate soil assessment of the proposed residential development located along the southern shores of Lake Wellington (area formerly known as Pelican Cove). The site can be formally described as the Wellington Waters Canal Estate, Seacombe – Sperm Whale Head Road, Seacombe. Lake Wellington forms the northern boundary of the site.

Field tests indicated that there were no actual acid sulfate soils identified within the six sample locations. Testing for potential acid sulfate soils indicated positive results at all six locations. Reaction strengths were medium to high strength reactions with strong effervescing in most samples.

Laboratory results confirmed the presence of potential acid sulfate soils. Three of the soil samples had a sulfur trail exceeding the acid sulfate soil criteria. Acid trail results were reflective of sulfur trail results and soil types. Four of the samples exceeded the acid trail soil criteria. Soil samples with sand content contained lower quantities of acid than samples with a clay content.

Based on the results, the sediments are considered potential acid sulfate soils and if exposed to oxygen may oxidise producing acid leachate. Consequently a management plan needs to be prepared to handle the acid sulfate soil produced during excavation.

Management procedures suggested to minimise the impact of PASS on the development include:

- potential blending with local calcareous dune sands which are likely to have a significant buffering capacity;
- liming with locally derived lime with sufficient liming to buffer all acid calculated to be generated;
- burial of material beneath the water; or
- diversion of the canal around the acid sulfate soil zones.

In consideration of the above conclusions, Meinhardt recommend:

- a more detailed investigation in to the extent of PASS across the site; and
- the preparation of an Acid Sulfate Soil Management Plan to handle the acid sulfate soil during excavation.

TABLE OF CONTENTS

	EXECUTIVE SUMMARY	i
	LIST OF APPENDICES	iii
	LIST OF TABLES.....	iii
	LIST OF FIGURES.....	iii
1.	INTRODUCTION	1
1.1	OBJECTIVES	1
1.2	SCOPE OF WORK.....	1
2.	SITE DESCRIPTION	2
2.1	SITE CHARACTERISTICS.....	2
2.2	REGIONAL GEOLOGY	2
2.3	REGIONAL HYDROGEOLOGY	2
2.4	FUTURE LAND USES.....	3
3.	ACID SULFATE SOIL ASSESSMENT	4
3.1	ASS DISTRIBUTION	4
3.2	FIELD INDICATORS OF ASS	4
3.3	SITE SPECIFIC GEOLOGY	5
3.4	FIELD TESTS.....	5
3.5	LABORATORY ASSESSMENT METHODOLOGY	6
3.6	CRITERIA FOR ACID SULFATE SOILS	6
3.7	SUMMARY OF ANALYTICAL RESULTS	6
4.	DISCUSSION	9
5.	MANAGEMENT OF SULFIDIC SEDIMENTS	10
5.1	OPTION 1 – AVOID PROBLEM AREAS	10
5.2	OPTION 2 – MINIMISATION OF DISTURBANCE	10
5.3	OPTION 3 – BLENDING WITH DUNE SANDS	10
5.4	OPTION 4 - NEUTRALISATION WITH LIME	10
5.5	OPTION 5 – BURIAL OF MATERIAL BENEATH WATER	12
6.	CONCLUSION.....	13

LIST OF APPENDICES

APPENDIX A	Figures
APPENDIX B	Borelogs
APPENDIX C	Laboratory Certificates
APPENDIX D	Field Results

LIST OF TABLES

Table 2.1	Summary of Site Characteristics	2
Table 2.2	Regional Hydrogeology	3
Table 3.3	Acid Sulfate Soil Criteria.....	6
Table 3.4	Soil Analytical Results	8
Table 5.1	Acid sulfate soil conversions and lime quantities.....	12

LIST OF FIGURES

Figure 1	Site Plan and Sample Location Plan
Figure 2	Geology Plan
Figure 3	Acid Sulfate Soil Plan

1. INTRODUCTION

Meinhardt (Vic) Pty Ltd (Meinhardt) was commissioned by Wellington Waters to undertake an acid sulfate soil assessment of the proposed residential development located along the southern shores of Lake Wellington (area formerly known as Pelican Cove). The site can be formally described as the Wellington Waters Canal Estate, Seacombe – Sperm Whale Head Road, Seacombe. Lake Wellington forms the northern boundary of the site.

The area to be investigated is to be constructed into a canal system, with housing located directly adjacent to the canals. The excavated material from the canals is to be used as fill on the land designated for housing.

This report has been prepared based on a desktop study and a field investigation. It has been prepared in accordance with the *Industrial Waste Management Policy (Waste Acid Sulfate Soils) 1999*, the Environment Protection Authority's Publication 655 *Acid Sulfate Soil and Rock* and the NSW *Acid Sulfate Soils Manual*.

1.1 OBJECTIVES

The objectives of this study were to:

- assess potential sulfidic sediments in the area to be developed; and
- delineate the extent of sulfidic sediments present onsite.

1.2 SCOPE OF WORK

The scope of work undertaken on the Wellington Waters site included:

- desktop study to assess the likelihood of acid sulfate soils on the site and their potential distribution;
- field investigation, in which six (6) locations were hand augered;
- field testing for actual acid sulfate soils (AASS) and potential acid sulfate soils (PASS) of forty-six (46) soil samples;
- laboratory analysis of acid generating potential, using the POCAS method, on five soil samples; and
- preparation of a brief acid sulfate soil assessment report.

2. SITE DESCRIPTION**2.1 SITE CHARACTERISTICS**

The following information provides a summary of the site characteristics.

Table 2.1 Summary of Site Characteristics

Site Characteristic	Comment
Size and orientation of the site	The area of the Wellington Waters Estate is approximately 2800 hectares. The site is generally aligned east west, and follows the contours of Lake Wellington in the north.
Current Land Zoning	The site is currently zoned "Rural Zone".
General Topography	The site is gently contoured with no steep slopes. The northern portion of the site is swampy, with a number of shallow lakes.
Distance / Direction to surface water	The nearest surface water feature is Lake Wellington which is located along the northern boundary of the site. Lake Reeve and Bass Strait lie approximately 5 km to the south of the site. McLennans Strait is located approximately 2 km northeast of the site and joins Lake Victoria approximately 7 km northeast of the site. There are a number of shallow surface water features on site.
Surrounding site uses	The surrounding land is predominantly rural, with a national park to the south and northeast of the site, and paddocks to the west (refer Figure 1, Appendix A).

2.2 REGIONAL GEOLOGY

The Geological Survey of Victoria 1:250,000 Series Sale Map Sheet (SJ 55-11, Edition 2, May 1997) indicates the site is underlain by Quaternary deposits of dunal and swamp origin. There are three surface geologies on the site:

- Quaternary, Pleistocene, Aeolian: dune deposits, sand, clay and calcareous sand;
- Quaternary, Holocene to Pleistocene, Aeolian: coastal and inland dunes, dune sand, some swamp deposits; and
- Quaternary, Mostly Holocene, Paludal: lagoon and swamp deposits, silt, clay (refer Figure 2, Appendix A).

2.3 REGIONAL HYDROGEOLOGY

A summary of the regional hydrogeology is presented in the table below.

Table 2.2 Regional Hydrogeology

Regional Hydrogeology	Comment
Depth of regional groundwater	Standing water levels in the area are expected to be intercepted at approximately 2 to 5 metres below ground level (mBGL).
Expected regional flow direction and discharge point	Groundwater in the water table aquifer often discharges to rivers, streams and wetlands. In the vicinity of the site, this includes Lake Wellington, McLennans Strait and onsite surface water features.
Groundwater quality and protected beneficial uses under the State Environment Protection Policy (Groundwaters of Victoria)	<p>Groundwater in the vicinity of Lake Wellington has a reported salinity of 3,501 – 13,000 mg/L TDS. The groundwater SEPP requires the protection of the following groundwater beneficial uses:</p> <ul style="list-style-type: none"> • Maintenance of ecosystems; • Stock watering; • Industrial water use; • Primary contact / recreation; and • Buildings and structures. <p>The most sensitive beneficial uses listed above are considered to be maintenance of ecosystems and stock watering.</p> <p>Groundwater on the southern half of the site has a reported salinity of 1,001 – 3,500 mg/L TDS. The groundwater SEPP requires the protection of the following groundwater beneficial uses:</p> <ul style="list-style-type: none"> • Maintenance of Ecosystems; • Potable mineral water; • Irrigation; • Stock watering; • Industrial water use; • Primary contact / recreation; and • Buildings and structures. <p>The most sensitive beneficial use listed above is considered to be maintenance of ecosystems. Potable mineral water requires specified mineral content as per the SEPP (Waters of Victoria).</p> <p>The higher TDS range is associated with Lake Wellington and seepage from Lake Wellington intruding on groundwater beneath the site.</p>
Location and use of nearby groundwater extraction wells (within 2 km of site)	There are 23 groundwater extraction wells within the vicinity of the site. They are all located to the west of the site and are used for investigation purposes.

2.4 FUTURE LAND USES

The site is to be developed with the following features:

- an 8 km canal able to accommodate large recreational boats;
- the creation of a 600 acre wildlife refuge;
- a new 4 star resort with a health / sport / water activity / eco-tourism / country emphasis;
- approximately 500 houses with water frontage; and
- a new boating destination with marina and boat service facilities.¹

¹ www.wellingtonwaters.com.au

3. ACID SULFATE SOIL ASSESSMENT

3.1 ASS DISTRIBUTION

Based on the State of Victoria (Department of Natural Resources and Environment, July 2002) Coastal Acid Sulfate Soil Hazard, Sale T8321 Map Sheet, the Wellington Waters Canal Estate is located within “probable Acid Sulfate Soils” (refer Figure 3, Appendix A). A sample point near the site, which was deeper than 1 metre, was classified as “Low Acid Sulfate Soils”.

3.2 FIELD INDICATORS OF ASS

A number of site and soil indicators can be used to assess the likelihood of ASS presence. These are outlined in Table 3.1.

Table 3.1 Field Indicators

Indicator	Site Assessment
Vegetation – existing or evidence of former vegetation types	<p>A number of vegetation species can be used to identify areas that may have potential for ASS. These include mangroves (marine), saltwater couch (salt tolerant), melaleucas, casuarinas and phragmites (salt and acid tolerant).</p> <p>There were significant areas of open forest dominated by <i>Melaleuca quinquenervia</i> (Paperbark) in the northern half of the site. Some of these forest areas were significantly stunted, sick or dead.</p> <p>Swampy areas were generally covered by Glasswort species (succulent) and Pigface. The pigface appeared to be receding in higher salt affected areas.</p>
Fish kills	There have been no fish kills reported in the region.
Iron staining	An iron floc was observed in surface water near testpit TP4 (refer Photograph 1). The floc coated the surface and had settled to the bottom.
Water quality – including the colour and clarity	The water quality, with the exception of the iron floc, did not appear to be affected by ASS. No cloudy or blue-green coloured water (associated with the presence of aluminium) was observed.
Low pH of water	The pH of the surface water was not measured, however, there were no observed variations within the aquatic vegetation across the site, and the vegetation was not dominated by acid tolerant species such as water lilies.
Destruction of infrastructure – such as corrosion of concrete	No evidence of corrosion of concrete was observed.
Soil stability – cracking is often evident of soils taken from a marine environment	Soil cracking was observed in the vicinity of testpit TP5. The soil was a sticky grey mud, which formed a mosaic effect as it dried out and cracked. Vegetation in this area was receding.
Drains, ditches and cuttings	Drains and cuttings were not observed to demonstrate evidence of ASS.
Sulfide odours	Sulfide odours were identified within the majority of the testpit locations at depths ranging from 0.5 to 2.2 mBGL.
Shells – indicative of a marine influence	The soils within the region are known to be of marine origin, and this was confirmed by the

Indicator	Site Assessment
	presence of shells within the upper profile, and evidence of broken down shell fragments within the soil.
Jarosite – straw coloured material indicative of ASS	Jarosite was identified within testpit TP6 within the surface soil to an approximate depth of 0.3 mBGL.
Augered / drilled profile	Refer section 3.3.
Field Tests	Refer section 3.4.

3.3 SITE SPECIFIC GEOLOGY

Six locations were drilled using a backhoe and hand augers to a maximum depth of 4 mBGL. The geology encountered on-site during the site investigation is summarised in Figure 2, Appendix A. A copy of the borelogs is attached in Appendix B.

The main soil types identified across the site were:

- Silty clay (peat); dark brown, highly organic.
- Sand; light brown – grey brown.
- Sandy clay; grey – grey green.

Groundwater was encountered between 0.5 and 0.8 mBGL.

3.4 FIELD TESTS

Two field tests can be conducted to determine the presence of actual Acid Sulfate Soils (AASS) and potential Acid Sulfate Soils (PASS). The field pH_F test is used to determine if there are AASS present on the site. The test involves the dilution of a soil sample with deionised water, into which a pH probe is inserted. The pH_F of AASS tends to be ≤ 4 , with the sulfides oxidised in the past. The pH_F of PASS tends to be neutral.

The field pH_{FOX} test is used as an indicator of PASS present on the site. The pH_{FOX} test tests for the presence of unoxidised sulfides and therefore PASS. A sample of soil is oxidised with hydrogen peroxide. The resulting reaction is observed, with potentially positive reactions including one or more of the following:

- change in colour of the soil from grey tones to brown tones;
- effervescence;
- the release of sulphurous odours;
- a substantial depression in pH below pH_F ;
- resultant $pH < 3$.

The change in pH from pH_F to pH_{FOX} gives an indication of the presence of sulfidic material.

- 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 soil. 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.
- For $pH_{FOX} 4 - 5$ the test is neither positive nor negative. Sulfides 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 sulfides present.

- For $\text{pH}_{\text{FOX}} > 5$ and little or no drop in pH from the field value, little net acid generating ability is indicated.

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

1. a reaction with hydrogen peroxide;
2. a much lower pH_{FOX} than field pH_{F} ; and
3. the actual value of pH_{FOX} .

A total of forty-six soil samples were tested for AASS and PASS (refer Figure 1, Appendix A). Soil samples were tested from each soil type for AASS and PASS. Preliminary field results indicated that no AASS is present on site, however PASS were identified at all six test locations. Field results have been summarised in Appendix D.

Organic matter and other soil constituents such as manganese oxides can also cause a reaction with the hydrogen peroxide. Laboratory analysis is required to conclusively determine whether field reactions are due to sulfide oxidation or alternate causes, and to therefore conclusively determine whether PASS is present.

3.5 LABORATORY ASSESSMENT METHODOLOGY

Five soil samples were analysed using the Peroxide oxidation – combined acidity and sulfate (POCAS) method. The POCAS method measures two indicators of potential acidity:

- The sulfur trail – The sulfur trail is a measure of oxidisable sulfur and is expressed as a percentage of the dry weight of the soil; and
- The acid trail – The acid trail measures the total sulfidic acidity and is typically expressed in mol H^+ ions per tonne of dry soil.

3.6 CRITERIA FOR ACID SULFATE SOILS

The criteria, as per Environment Protection Authority publication 655, for determining whether soils are classified as acid sulfate soils is outlined in Table 3.2. The relevant criteria for the Wellington Waters Canal Estate depends on the soil type (texture) and analytical method used.

Table 3.2 Acid Sulfate Soil Criteria

Soil or sediment texture	Criteria	
	Sulfur Trail % oxidisable sulfur (oven-dry basis)	Acid Trail mol H^+ / tonne (oven-dry basis)
Sands to loamy sands	0.03	18
Sandy loams to light clays	0.06	36
Medium to heavy clays and silty clays	0.1	62

3.7 SUMMARY OF ANALYTICAL RESULTS

Meinhardt undertook drilling on the 6th and 7th November 2002. Six bores were drilled and sampled. Laboratory analysis of five soil samples was undertaken by MGT Environmental Consulting. Table 3.3 summarises the analytical results – shaded cells indicate exceedence of criteria.

Table 3.3 Soil Analytical Results

Sample Number	Soil Type	Sulfur Trail (%S)		Acid Trail (mol H ⁺ / tonne)	
		Relevant criteria	Laboratory result	Relevant criteria	Laboratory result
TP1-04	Sandy Clay	0.06	0.64	36	350
TP2-01	Silty Clay (Peat)	0.1	0.14	62	1000
TP3-06	Sand	0.03	0.04	18	48
TP5-04	Clayey Sand	0.06	0.05	36	75
TP6-03	Silty Clay	0.1	0.02	62	49

Copies of all laboratory certificates are included in Appendix C.

4. DISCUSSION

The proposed canal will be excavated to a maximum depth of 3 metres, into the natural sand and clayey sand. The excavated material from the canal is to be used as fill on the land designated for housing.

Field tests indicated that there were no actual acid sulfate soils identified within the six sample locations. Testing for potential acid sulfate soils indicated positive results at all six locations. Reaction strengths were medium to high strength reactions with strong effervescing in most samples.

Laboratory results confirmed the presence of potential acid sulfate soils. Three of the soil samples had a sulfur trail exceeding the acid sulfate soil criteria. Four of the samples analysed by the sulfur trail had acid trail results reflective of sulfur trail results and soil types. Soil samples with sand content contained lower quantities of acid than samples with a clay content.

The sample TP2-01, taken from the shallow silty clay (peat) had a low field test reaction, however its sulfur trail exceeded the relevant criteria, and the sample reported the highest acid trail result (1000 mol H⁺ / tonne). Reactions within the silty clay are slower due to the density and particle size of the soil material. It takes longer for soil particles to be exposed to oxygen, whereas within sandy soils, which are looser in density, there is a greater portion of air voids contained within the soil material. The percentage sulfur in the remaining samples correlated with the strength of the field tests. The remaining samples contained sand and therefore were more likely to react faster than a clay sample.

The sample TP6-03 did not indicate an exceedence of the criteria for either the sulfur trail or an acid trail, however, this sample contained jarosite. Jarosite is a partial oxidation product of pyrite contained within the soil matrix, and is therefore indicative of sulfide, which was present in the soil matrix. The presence of jarosite indicates that some of the sulfides have oxidised due to exposure of the sediments to the oxygen. The relatively low concentrations of acid produced in this sample, during the laboratory analysis is indicative that only small concentrations of sulfides remain to be oxidised. The presence of jarosite indicates that these sediments will have produced some sulfuric acid in the past.

Based on these results, the sediments are considered potential acid sulfate soils and if exposed to oxygen may oxidise producing acid leachate. Consequently a management plan needs to be prepared to handle the acid sulfate soil produced during excavation.

5. MANAGEMENT OF SULFIDIC SEDIMENTS

Inappropriate management of PASS may result in degraded areas, long term engineering problems, reduced productivity and less profitable outcomes. A number of management options are available to treat acid sulfate soils. Selection is based on the site characteristics, the volume of soil to be disturbed, the hydrology of the site and the environmental sensitivity of the site.

5.1 OPTION 1 – AVOID PROBLEM AREAS

Avoidance, by not disturbing or developing areas affected by PASS, is often the most environmentally responsible and cheapest option. Potential acid sulfate soils are located across the northern portion of the site as indicated in Figure 3. Excavation of ASS can be minimised by diverting the canal around the ASS zones i.e. locating the canal further south. The complete avoidance of problem areas cannot be achieved on this site since the canals connect to Wellington Lake.

Activities that may result in the groundwater being lowered should also be avoided. Groundwater fluctuations can result in PASS being exposed to oxygen during lowering of the groundwater. When the groundwater rises again, it can take generated acid to the surface. Therefore it is preferable to keep the groundwater level steady to prevent large flushes of acid.

5.2 OPTION 2 – MINIMISATION OF DISTURBANCE

As Option 1 is unachievable, an alternative is to minimise the disturbance of PASS. The parts of the canal that are connected to the Lake cannot be easily moved, however, the extension of the canal can be moved further south where there are no PASS. In addition, excavations should not be left exposed for extended periods of time, and where possible, excavations should be kept above the groundwater level.

Restriction of works to those areas with low sulfide content will reduce liming requirements, leaving the high sulfide areas. However, a more detailed investigation would be required in order to delineate the acid generating potential of the sediments throughout the proximity of the proposed canal.

5.3 OPTION 3 – BLENDING WITH DUNE SANDS

Local calcareous dune sands may have the potential to buffer acid production in PASS. The suitability of dune sands would need to be assessed to determine the exact buffering capacity and the volume of sand required. If suitable, this material could be blended with the PASS at a specified level, based on laboratory analysis results.

5.4 OPTION 4 - NEUTRALISATION WITH LIME

Soil may be further neutralised with the use of lime. As the silty clay is to be used as a surcharge, precautions must be taken to ensure that acidic leachate is not produced in the soil. Lime has an alkaline pH and buffers any acid produced. The quantity of lime required must be sufficient to neutralise all the sulfidic material present plus a safety factor of 1.5. Table 5.1 gives an approximate calculation of the quantity of lime required as based on the laboratory results, in addition to the calculations made.

Table 5.1 Acid sulfate soil conversions and lime quantities

Sample Number	Oxid. S (%)	Moles H ⁺ / kg (S% x 0.6237)	Moles H ⁺ / t or moles H ⁺ / m ³ (S% x 623.7)	Kg H ₂ SO ₄ / tonne or kg H ₂ SO ₄ / m ³ (S% x 30.59)	Kg lime / tonne soil or kg lime / m ³ Safety factor = 1.5
TP1-04	0.64	0.399	399.17	19.6	29.4
TP2-01	0.14	0.087	87.32	4.3	6.4
TP3-06	0.04	0.025	24.95	1.2	1.8
TP5-04	0.05	0.031	31.18	1.5	2.3
TP6-03	0.02	0.012	12.47	0.6	0.9

The acid sulfate soils should be separated from other soils during the excavation, to reduce the quantities of soil requiring treatment. Application methods include:

- Mixing lime with excavated soil prior to placement as fill;
- Establishing a lime buffer so that stormwater containing acid from soil has to pass through the buffer where it is neutralised prior to reaching a drain, groundwater or natural water body.
- Establishing a lime buffer at the face of any recent excavation, which exposes acid sulfate soils by sand bagging the face and incorporating lime under and in the sandbag so that the acid leachate flows through the sandbags.

Monitoring of pH should be carried out regularly during and after the neutralisation procedures to establish the effectiveness of the treatment.

5.5 OPTION 5 – BURIAL OF MATERIAL BENEATH WATER

Excavated sulfidic material can be disposed before it has had a change to oxidise by either placing the material at the bottom of the canals (and therefore below the water) or placing within a wetland or water body which has an appropriate water balance.

6. CONCLUSION

This report presents the results of an acid sulfate soil investigation undertaken in November 2002. Field works included field pH testing and peroxide oxidation of soils. Five samples were analysed for sulfidic material by NATA accredited laboratory MGT Environmental Consulting.

The main soil types identified across the site were:

- Silty clay (peat); dark brown, highly organic.
- Sand; light brown – grey brown.
- Sandy clay; grey – grey green.

Groundwater was encountered between 0.5 and 0.8 mBGL 2 mBGL.

Field tests indicated the presence of potential acid sulfate soils in all six sample locations. Laboratory analysis was conducted on five samples with PASS confirmed in four of the five samples. The sixth sample contained jarosite, which is a positive indicator of acid sulfate soils. Based on these results, the sediments were considered to be potential acid sulfate soils.

Management procedures suggested to minimise the impact of PASS on the development include:

- potential blending with local calcareous dune sands which are likely to have a significant buffering capacity;
- liming with locally derived lime with sufficient neutralisation capacity to buffer all acid calculated to be generated;
- burial of material beneath the water; or
- diversion of the canal around the acid sulfate soil zones.

In consideration of the above conclusions, Meinhardt recommend:

- a more detailed investigation in to the extent of PASS across the site; and
- the preparation of an Acid Sulfate Soil Management Plan to handle the acid sulfate soil during excavation.

APPENDIX A Figures

APPENDIX B Borelogs

APPENDIX C Laboratory Certificates

APPENDIX D Field Results