Appendix J

Acid Sulfate Soil Supporting Documents

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Australian Soil And Concrete Testing P/L

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Acid Sulfate Soil Investigation

For

Proposed Riverside Tourist Cabin Development

At

Lot 4 (DP 1022342) New Entrance Road
South West Rocks NSW 2431

Prepared For
Shannon Pacific P/L
PO Box 52
South West Rocks NSW 2431

Reference Number: 1616-001-ASS
30th October 2009

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1 Introduction

Australian Soil and Concrete Testing P/L (ASCT) have been engaged by Shannon Pacific P/L to undertake an acid sulfate soil investigation for a proposed Riverside Tourist Cabin development at Lot 4 (DP 1022342) New Entrance Road, South West Rocks, NSW. The broad aim of the acid sulfate soil investigation is to determine whether acid sulfate soil (ASS) is present at the site. If so, the extent, severity and type of ASS will need to be ascertained. The investigation also aims to determine the liming rate required to neutralise ASS should it be present at the site.

2 Acid Sulfate Soil

2.1 Background

ASS typically occurs in low-lying coastal areas. Developments involving excavation or lowering of the water table may result in the oxidation of sulfur (predominately in the form of pyrite) contained within these soils and the subsequent generation of acid discharge from the soil. The resultant discharge may find its way into the groundwater or stormwater and eventually into natural aquatic environments. The acidic run-off may lower the pH of the receiving water system, increase the concentration of metals and reduce the natural buffering capacity of the receiving waters.

There are two basic types of ASS. Actual Acid Sulfate Soils (AASS) are soils where the pyrites have been oxidised and sulfuric acid is present. Potential Acid Sulfate Soils (PASS) have not been oxidised and sulfuric acid has not yet been generated.

PASS in anaerobic conditions such as below the water table do not present an environmental hazard. However, if conditions change from anaerobic to aerobic, the pyrite in PASS will oxidise to form sulfuric acid. Oxidation can occur by either lowering the water table or removing the soil from below the water table, such as excavation.

2.2 ASS Management Principles and Guidelines

The following principles are in accordance with the Acid Sulfate Soil Management Advisory Committee (ASSMAC) Management Guidelines (1998) and are the fundamental strategies that underpin the management of ASS.

2.2.1 Avoidance

This is the soundest strategy and the proposed works should always attempt to modify work practices in order to avoid unnecessarily exposing or disturbing ASS. The proposed works should also where possible avoid activities that result in the fluctuation of the groundwater, in particular the lowering of groundwater.

2.2.2 Minimisation

Appropriate handling techniques and treatment of excavated soil are to be used to minimise and or prevent the disturbance of ASS. Furthermore, earthworks activities should be managed to minimise or mitigate the potential of ASS to impact on the surrounding environment.

2.2.3 Neutralisation

Sufficient neutralising agent should be incorporated into excavated soils in order to neutralise acid that is generated over time due to the gradual oxidation of ASS. Neutralising agent should also be applied to acidified water run-off and any remaining water ‘in-situ’ (within the pore spaces of the material being excavated) that has become acidified.

3 The Proposed Development

The proposed development will be located in the southwest corner of the lot and covers an area of 1.07 hectares. It will include nine one and two bedroom tourist cabins as well as grassed open spaces, landscaped grounds and a paved access road off Marlin Drive to the south of the site. The site is reasonably flat and it is understood the proposed development will not require any significant excavation works. A plan of the proposed development is displayed in figure 3.

4 The Site

4.1 Site Description

The site is located in a low-lying coastal area and has good access off New Entrance Road to the west as shown on the locality map in figure 1. The proposed development site is currently vacant land but is bordered by the Riverside Tavern to the north, Marlin Drive to the south and by wetland vegetation to the east. Furthermore, the Macleay River is located approximately 50m to the west of the proposed development site just beyond New Entrance Road. The site is predominately cleared with some scattered, small to medium Casuarina trees and the ground surface contains good grass cover and slopes about 1% east towards the adjacent wetlands. Underground services including power, phone, water and sewer run along the road reserve of New Entrance Road to the west of the site.

4.2 Subsurface Conditions

The site contains natural alluvial and marine soil and generally consists of clayey sandy silt overlying silty sand and sand. Groundwater inflows were also encountered in the boreholes from about 1.3 m below the ground surface. A summary of the sub-surface conditions found at the investigation site is displayed in table 1 below and the full geotechnical borehole logs have been included in the geotechnical report compiled by ASCT (Ref: 064-001, dated 30/10/09).

Table 1: Summary of sub-surface conditions at the proposed development site.

Soil Type	Description	Depth (m)
A	Sandy Clayey Silt: Brown	0.0 – 0.5
B	Silty Sand: Brown	0.5 – 1.0
C	Sand: Dark Grey	1.0 – 2.0
D	Groundwater	Below 1.3

The acid sulfate soil risk map shown in figure 2 has the site situated in an area that has a high probability of acid sulfate soil from 1.0m below the ground surface.

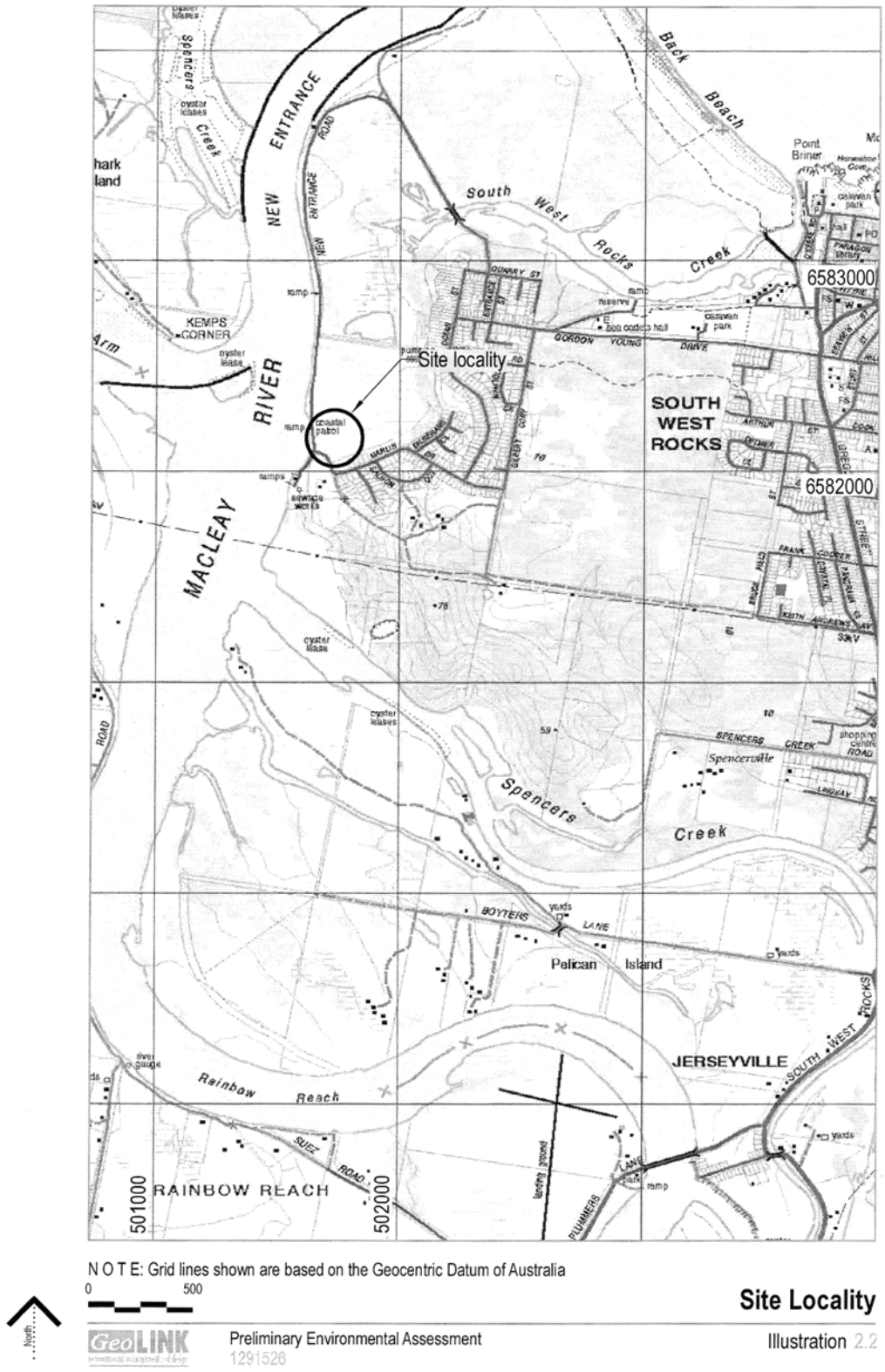

Figure 1: locality map of the South West Rocks area showing the location of the proposed Riverside Tourist Cabin development.

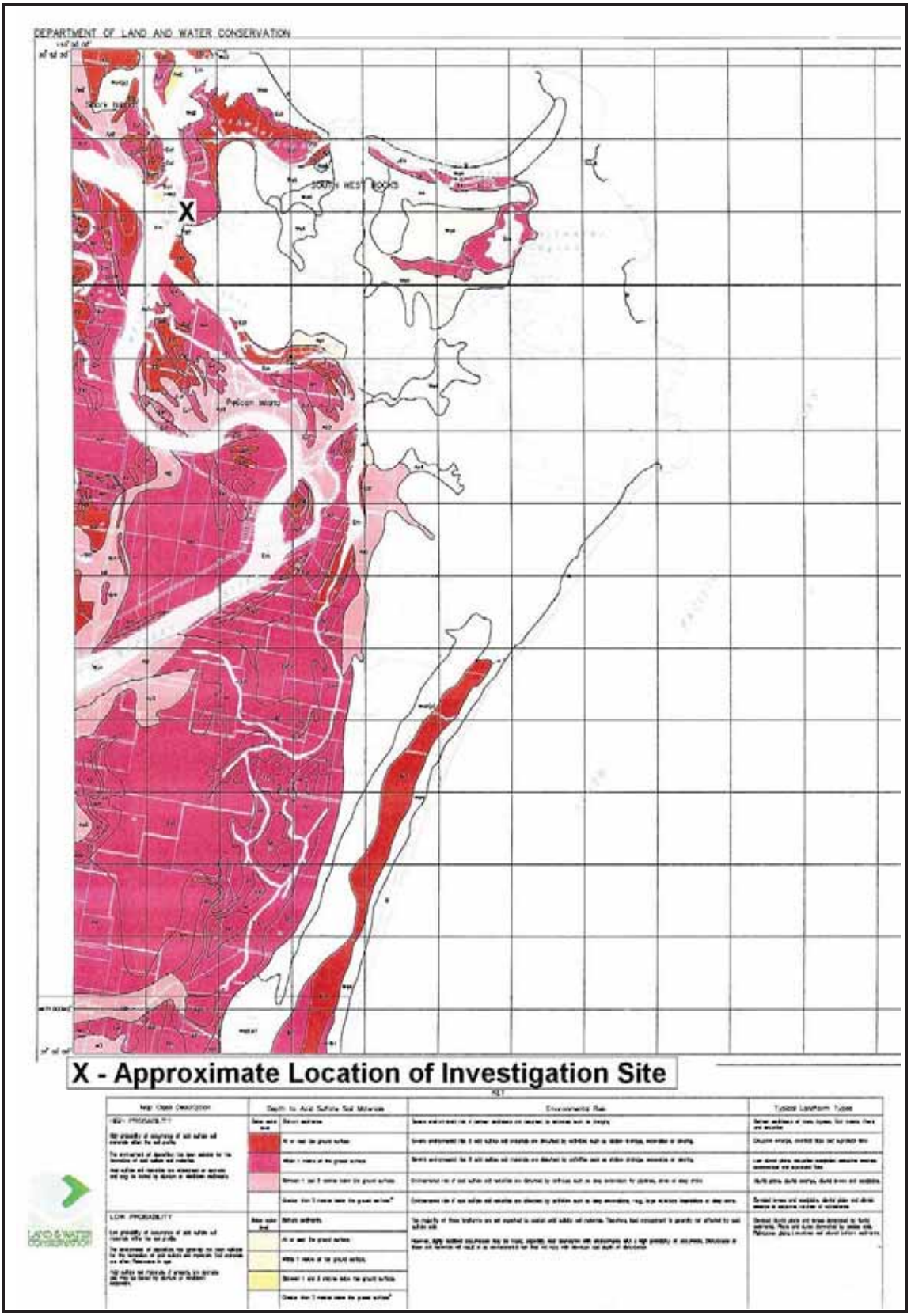

Figure 1: A section of the Land and Water Conservation Department acid sulfate soil risk map showing the approximate location of the proposed development site.

5 The Investigation

5.1 Scope of Work

The scope of work for the Acid Sulfate Soil Investigation included:

- Drilling of three boreholes across the proposed development site.
- Collection of soil samples from the boreholes at 0.5m intervals to a final drilling depth of 2.0m.
- Analysis of all samples for field pH (pH_f) and field peroxide pH (pH_{fox}) to provide initial indication of PASS/AASS.
- Laboratory analysis of soil to determine % chromium reducible sulfur ($\%S_{cr}$), total actual acidity (TAA), net acidity and liming rates.
- Summary of ASS Analysis results.

5.2 Soil Sampling

Soil sampling was conducted in accordance with the ASSMAC guidelines (1998) and included:

- The drilling of three boreholes across the proposed development site on 7/10/09 and the locations of the boreholes are displayed in figure 3.
- Sampling was undertaken by staff of ASCT, namely by Greg McIlwain (Senior Geotechnician).
- The boreholes were drilled to a depth of 2.0m and soil samples were collected at 0.5m depth intervals to yield a total of 12 samples.
- The boreholes were drilled with a solid flight power auger and the samples were collected with a hand held Jarret auger and stainless steel mixing bowls and scoops.
- All sampling equipment was washed with clean water between each sample and sampling location.
- Samples were placed in zip lock plastic bags and transferred immediately to an esky with ice for storage. They were stored on ice before being frozen in storage at ASCT's Toormina laboratory. Six days later the samples were transferred to ASCT's Ballina laboratory where they were thawed and tested for field pH (pH_f) and field peroxide pH (pH_{fox}) in accordance with ASSMAC test method codes 21Af and 21Bf respectively. Furthermore, pH_{fox} testing was carried out using 30 % hydrogen peroxide adjusted to pH 5.5.
- On the basis of field testing, three samples were transferred under ASCT's chain of custody conditions to the Environmental Analysis Laboratory (EAL, Lismore) for analysis of % chromium reducible sulfur ($\%S_{cr}$ – Method 22B), total actual acidity (TAA), net acidity and liming requirements (SPOCAS Method 23). The chain of custody documentation has been included in Appendix B of this report.

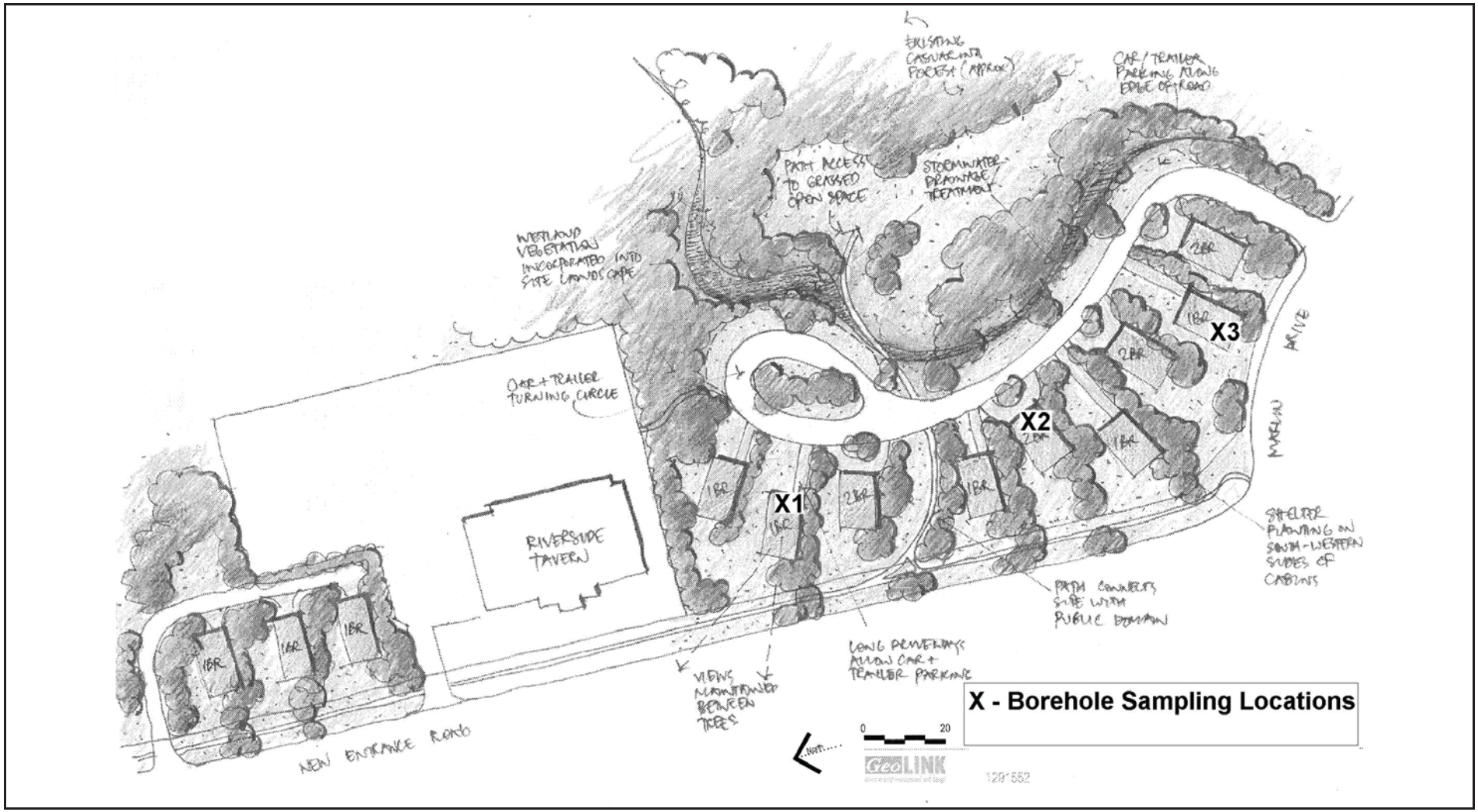

Figure 2: plan of the proposed Riverside Tourist Cabin development at South West Rocks, showing the acid sulfate sampling locations.

6 Results

6.1 Field Testing

A summary of the field testing results is displayed in table 2 and they indicate the site may contain ASS, with all samples except sample 1 showing significant reactions with hydrogen peroxide. Samples from soil type C (sand: dark grey) had the strongest reaction followed by soil type B (silty sand: brown) and the weakest reactions were evident in soil type A (sandy clayey silt: brown). The different degrees of soil type reactivity also correspond to an increase in reactivity with depth in the soil profile. On the basis of the field testing results, sample numbers 3, 6 and 9 were selected for full laboratory analysis.

Table 2: Summary of Field Testing Results.

Sample Number	Soil Strata	Sample Source	Sample Depth (m)	Sample Description	pH_f	pH_{fox}	$pH_f - pH_{fox}$	PASS/AASS Indication*
1	A	BH 1	0.5	Sandy Clayey Silt: Brown	5.39	4.49	0.90	Non-PASS/AASS
2	A	"	1.0	Sandy Silty Clay: Brown	5.52	**3.83**	**1.69**	**Possible PASS**
3	C	"	1.5	Sand: Dark Grey	4.45	**1.74**	**2.71**	**PASS/AASS Very Likely**
4	C	"	2.0	"	4.95	**1.97**	**2.98**	**PASS Very Likely**
5	A	BH 2	0.5	Sandy Clayey Silt: Brown	5.29	**3.87**	**1.42**	**PASS Very Likely**
6	B	"	1.0	Silty Sand: Brown	4.97	**3.35**	**1.62**	**PASS Very Likely**
7	C	"	1.5	Sand: Dark Grey	4.43	**1.85**	**2.58**	**PASS/AASS Very Likely**
8	C	"	2.0	"	4.69	**1.83**	**2.86**	**PASS Very Likely**
9	A	BH 3	0.5	Sandy Clayey Silt: Brown	5.46	**3.64**	**1.82**	**PASS Very Likely**
10	B	"	1.0	Silty Sand: Brown	5.23	**3.62**	**1.61**	**PASS Very Likely**
11	C	"	1.5	Sand: Dark Grey	5.15	**2.46**	**2.69**	**PASS Very Likely**
12	C	"	2.0	"	5.58	**1.91**	**3.67**	**PASS Very Likely**

* Indications are based on the ASSMAC guidelines and are determined as follows:

- Non-PASS/AASS if → $pH_f - pH_{fox} < 1.0$, $pH_f > 4.5$
- Possible PASS if → $5 < pH_f > 3$, and $pH_f - pH_{fox} > 1.0$
- PASS very likely if → $pH_f - pH_{fox} > 1.5$
- AASS present if → $pH_f < 4.0$

The field peroxide test is only an indicative test that is used to guide the selection of laboratory test samples. Furthermore, the test is least reliable in the sandy soil types that were encountered at the proposed development site. Care must be taken when interpreting the reaction in these soils types as organic matter and other constituents such as manganese oxide can also cause a reaction.

6.2 Laboratory Testing

On the basis of field testing the most reactive soil samples from each soil type (samples 3, 6 & 9) were submitted to the Environmental Analysis Laboratory (EAL, Lismore) for analysis of % chromium reducible sulfur ($\%S_{cr}$), titratable actual acidity (TAA), net acidity and liming rate. A summary of the laboratory results are displayed in table 3 and the complete results have been included in appendix A of this report. The laboratory results are based on the following:

- **Non-Actual Acid Sulfate Soils** (Non-AASS) – Laboratory testing indicates these soils have a titratable actual acidity (TAA) and reduced inorganic sulfur content ($\%S_{crs}$) below the ASSMAC action criteria and are not considered to present an environmental hazard.
- **Non-Potential Acid Sulfate Soils** (Non-PASS) – Laboratory testing indicates these soils have a reduced inorganic sulfur content ($\%S_{cr}$) below the ASSMAC action criteria and are not considered to present an environmental hazard
- **Potential Acid Sulfate Soils** (PASS) – Laboratory testing indicates these soils have reduced inorganic sulfur content ($\%S_{crs}$) above the ASSMAC action criteria they may

generate sulfuric acid and may present an environmental hazard. Management of these soils will be required.

- **Actual Acid Sulfate Soils** (AASS) – Laboratory testing indicates that these soils have a titratable actual acidity (TAA) and reduced inorganic sulfur content (%S_{crs}) above the ASSMAC action criteria. These soils may leach acid and will require management.
- **Acidic Soils** – Laboratory testing indicates that these soils have a net acidity (based on %S_{cr}) above the ASSMAC action criteria, but they have reduced inorganic sulfur content below the ASSMAC action criteria. These soils may present an environmental hazard and may require management.

Table 3: Summary of laboratory test results.

Sample Number	3	6	9
Sample Location	BH 1	BH 2	BH 3
Depth (m)	1.5	1.0	0.5
Soil Strata	C	B	A
Texture	Coarse	Coarse	Medium
Titratable Actual Acidity (TAA) (mole H^+/tonne)	**39**	**33**	**47**
ASSMAC AASS Action Criteria[1] (mole H^+/tonne)	18	18	36
Reduced Inorganic Sulfur (%S_{cr})	**0.58**	0.01	<0.01
ASSMAC PASS Action Criteria[1] (%S_{cr})	0.03	0.03	0.06
Net Acidity (based on %S_{cr})	**400**	**40**	**47**
Acidic Soil Action Criteria[1] (mole H^+/tonne)	18	18	36
Acid Sulfate Potential	**PASS/AASS**	**ACIDIC**	**ACIDIC**
Limining Rate[2] (kg $CaCO_3$/tonne DW[3])	**30.1**	**3.0**	**3.6**

[1] Action criteria taken from the ASSMAC guidelines and is based on less than1000 tonnes of soil to be disturbed and is also dependent on soil texture.
[2] The laboratory calculated liming rate is based on the results of testing and has been determined using a safety factor of 1.5.
[3] DW – Dry Weight.

The laboratory testing shows that all parameters analysed for sample 3, including TAA, reduced inorganic sulfur and net acidity were above the relevant ASSMAC action criteria. Therefore, sample 3 (soil type C) can be classified as PASS/AASS. Laboratory testing also determined a liming rate of 30.1 kg $CaCo_3$ (lime)/t of soil which will be necessary to neutralise this soil type.

Samples 6 and 9 from soil types B and A respectively both had TAA and net acidity above the relevant ASSMAC action criteria, however, they had reduced inorganic sulfur contents below the ASSMAC action criteria. Therefore, the laboratory results indicate that samples 6 and 9 contain mild actual acidity. This acidity may be the result of previously oxidised ASS soil or soluble aluminium and iron from other acid forming coastal processes. Soils with actual acidity are common in coastal areas of Northern NSW and based on the data available soil types B and A would be classed as “acidic” rather than “acid sulfate”. Laboratory testing has also determined liming rates of 3.0 and 3.6 kg $CaCo_3$ (lime)/t of soil for soil types B and A respectively in order to bring these soil types to a neutral pH range.

7 Acid Sulfate Soil Summary

The field and laboratory testing together with the general site information have enabled the following conclusions to be made:

- Soil type A (sandy clayey silt: brown) that generally exists on the site from 0.0 – 0.5m below the existing ground level was found to be mildly acidic and can be treated with lime at a rate of 3.6 kg $CaCo_3$ (lime)/t of soil.
- Soil type B (silty sand: brown) that generally exists on the site from 0.5 – 1.0m below the existing ground level was found to be mildly acidic and can be treated with lime at a rate of 3.0 kg $CaCo_3$ (lime)/t of soil.
- Soil type C (sand: dark grey) that generally exists on the site from 1.0 – 2.0m below the existing ground level was found to be PASS/AASS and will require treatment at 30.1 kg $CaCo_3$ (lime)/t of soil, this is the maximum calculated liming rate for this soil type and therefore should be sufficient to neutralise the worst case PASS/AASS.

8 Limitations

This report relies on information supplied by the client and the results of investigations conducted in accordance with accepted practices and standards. The report is intended to represent a reasonable interpretation of the appropriate legislation and the condition of the site at the time of the investigation. However, due to these elements being subject to change over time the report under no circumstances can be considered to represent the definitive state of the site at all times.

Finally, should any problem or concern arise that needs clarification or assistance the client should not hesitate to contact our office.

Yours Faithfully,
Australian Soil and Concrete Testing Pty.Ltd.

Ben Hart
Environmental Officer
(B. App. Sc)

Brian Dick
Managing Director

9 References

DPI Qld, 2003. *Acid Sulfate Soils Laboratory Methods Guidelines*.

Stone, Y, Ahern C R, and Blunden B (1998). *Acid Sulfate Soils Manual 1998. Acid Sulfate Soil Management Advisory Committee* (ASSMAC), Wollongbar, NSW, Australia.

APPENDIX A – Laboratory Analysis Results

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RESULTS OF ACID SULFATE SOIL ANALYSIS

3 samples supplied by Australian Soil & Concrete Testing on 14th October 2009 - Lab Job No. A5749
Analysis requested by Brian Dick - **Your Project: 1616-001**

Sample No.	Depth (m)	EAL lab code	TEXTURE (note 6)	MOISTURE CONTENT moisture of total wet weight)	moisture / g of oven dry soil)	TITRATABLE ACTUAL ACIDITY (TAA) (To pH 6.5) pH$_{KCl}$	(moles H$^+$/tonne)	REDUCED INORGANIC SULFUR (% chromium reducible S) (%Scr)	(mole H$^+$/tonne)	ACID NEUTRALISING CAPACITY (ANC$_{BT}$) (% $CaCO_3$)	(mole H$^+$/tonne)	NET ACIDITY Chromium Suite mole H$^+$/tonne	(based on %Sers)	LIME CALCULATION Chromium Suite kg $CaCO_3$/tonne DW (includes 1.5 safety Factor)
Method No.						23A	23F	22B	a- 22B	19A2	a-19A2	note 5		note 4 and 6
3	1.5	A57493/1	Coarse	21.9	0.28	4.70	39	0.58	362	..	0	400		30.1
6	1.0	A57493/2	Coarse	16.3	0.19	4.78	33	0.01	6	..	0	40		3.0
9	0.5	A57493/3	Medium	14.1	0.16	4.72	47	<0.01	0	..	0	47		3.6

required if pH$_{KCl}$ < 6.5

NOTE:
1 - All analysis is Dry Weight (DW) - samples dried and ground immediately upon arrival (unless supplied dried and ground)
2 - Samples analysed by SPOCAS method 23 (ie Suspension Peroxide Oxidation Combined Acidity & sulfate) and 'Chromium Reducible Sulfur' technique (Scr - Method 22B)
3 - Methods from Ahern, CR., McElnea AE., Sullivan LA (2004). ***Acid Sulfate Soils Laboratory Methods Guidelines***, QLD DNRME.
4 - Bulk Density is required for liming rate calculations per soil volume. Lab. Bulk Density is no longer applicable - field bulk density dry's can be used and dried/ weighed in the laboratory.
5 - **ABA Equation 'Net Acidity – Potential Sulfidic Acidity (ie. Scrs or Sos) + Actual Acidity + Retained Acidity - measured ANCFF (with FF currently defaulted to 1.5)**
6 - The neutralising requirement, lime calculation, includes a 1.5 safety margin for acid neutralisation (an increased safety factor may be required in some cases)
7 - For Texture: coarse = sands to loamy sands; medium = sandy loams to light clays; fine = medium to heavy clays and silty clays
8 - ... denotes not requested or required
9 - SCREENING, CRS, TAA and ANC are NATA accredited but other SPOCAS segments are currently not NATA accredited
10- Results at or below detection limits are replaced with '0' for calculation purposes
11 - Projects that disturb >1000 tonnes of soil, the ≥0.03% S classification guideline would apply (refer to acid sulfate management guidelines).

(Classification of potential acid sulfate material if: coarse Scr≥0.03% S or 19mole H$^+$/t; medium Scr≥0.06% S or 37mole H$^+$/t; fine Scr≥0.1% S or 62mole H$^+$/t) - as per QUASSIT Guidelines

NATA

Environmental Analysis Laboratory, Southern Cross University.
Tel: 02 6620 3678, website: scu.edu.au/eal

checked: .....

APPENDIX B – Chain of Custody Documentation

AUSTRALIAN SOIL AND CONCRETE TESTING P/L A.B.N.49 050 539 930

Unit 7/17 Southern Cross Drive, P.O. Box 5120 Ballina NSW 2478. Telephone: 02 6686 8567, Fax: 02 6686 8396

A5749

ASCT Doc. No. A18 Rev. 03- 3/7/07 - CC

Laboratory Test Program

South West Rocks

Client :	Shannon Pacific	Project no :	1616 - 001
Location :	Proposed Building Area.	Requested By:	Agent
Sampled By :	Client	Sample Type :	Soil
		Project :	Riverside Tourist Cabins
		Test methods :	ETL
		Date Sampled :	7.10.09

Lab Sample No	Sample Source	Sample Description	Depth of Sample (m)	AS-PAVK 10													
11307	A3	Sand: Pale Grey	1.5	/													
"	B2	Sand: Brown	1.0	/													
"	C1	Sandy Clayey Silt: Brown	0.5	/													

Comments:

Signed: _____ Date: 14.10.09

(Approved Signatory)

Signed: _____ Date: 14/10/09

(Receiving Authority)

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Sampling performed at ASCT P/L Ballina

NATA Accredited Laboratory Number 3229

Acid Sulfate Soil Management Plan

J1 Acid Sulfate Soil Management Principles

The following principles of Acid Sulfate Soil Management are in accordance with the Acid Sulfate Soil Management Advisory Committee (ASSMAC) Management Guidelines (1998) and are the fundamental strategies that underpin the management of ASS:

- *avoidance* is the soundest strategy and the proposed works should always attempt to modify work practices in order to avoid unnecessarily exposing or disturbing ASS. The proposed works should also where possible avoid activities that result in the fluctuation of the groundwater, in particular the lowering of groundwater;
- *minimisation* of the disturbance of ASS materials. Appropriate handling techniques and treatment of excavated soil are to be used to minimise and or prevent the disturbance of ASS. Furthermore, earthworks activities should be managed to minimise or mitigate the potential of ASS to impact on the surrounding environment; and
- *neutralisation of* excavated soils using lime in order to neutralise acid that is generated over time due to the gradual oxidation of ASS. Neutralising agent should also be applied to acidified water run-off and any remaining water 'in-situ' (within the pore spaces of the material being excavated) that has become acidified.

The proposed works aim to employ a combination of these management techniques as follows:

- avoidance:
  - excavation of footings for the cabins are approximately 1 m depth, and will occur on 1 m of fill over the existing ground level. Therefore excavation is unlikely to extend beyond 0.3 m below the existing ground level. Disturbance of ASS materials will therefore be avoided, given that analysis indicated that ASS materials are located at depths of greater than 1 m below existing ground level;
  - excavation for pathways and internal roads will generally occur within the filled area. Minor excavation into the natural soil horizon may occur where pathways and stormwater swales are constructed outside the filled area. Excavation is expected to be up to a maximum depth of approximately 0.5 m. As analysis indicated that ASS materials are located at greater than 1 m depth below the natural soil horizon, exposure will be avoided.
  - construction of the wetland will involve excavation to a depth of 0.4 m below existing ground levels. Analysis results indicate that AASS and PASS soil horizons occur at depths of greater than 1 m below the ground surface, and therefore exposure of ASS materials will be avoided. Geotechnical investigations also indicate that groundwater occurs at depths of 1.3 m, therefore the wetland will avoid interception with the watertable;
- minimisation:
  - trenching for laying of services for water and sewerage outside the filled area will disturb the natural soil profile to a depth of approximately 1 m. ASS materials are expected to occur at soil horizons greater than 1 m depth. Additionally, excavation, laying of services and reburial would generally occur within a 24 hour period, minimising exposure and oxidation of any ASS materials (treatment of ASS is not required when reburial of ASS material can occur within 24 hours of initial excavation).

J2 Monitoring

Any excavated soil stockpiled on the site (excluding imported clean fill) will be subject to ongoing assessment for the presence of AASS or PASS. Analysis of soil pH is to be undertaken daily for the first week and weekly thereafter if there is no significant change.

ASCT soil sampling results indicated a natural soil pH_f (field pH) of 5.0 to 5.5 in acidic soils to a depth of 1 m. Should pH_f of stockpiled soil drop below 5.0 the contingency plan outlined below is to be implemented.

J3 Contingency Plan

The following contingency measures are to be implemented in the event that:

- excavation extends beyond 1 m depth below the existing soil profile (as opposed to the filled soil profile),
- if it is suspected that ASS has been excavated; or
- stockpiled excavated soil pH_f drops below 5.0.

A field guide for identification of acid sulfate soils is attached at Appendix J.

J3.1 Mitigation Measures

The following mitigation measures are to be implemented where excavation is beyond 1 m depth below the natural ground surface or if ASS soils are identified during excavation works or if the pH of excavated stockpiled soil drops below 4.5:

- the treatment and handling of ASS must be carried out in accordance with standard Occupational Health and Safety guidelines;
- soils identified as PASS and/or AASS shall be disturbed to a minimum;
- the time ASS materials are exposed to the atmosphere shall be minimised by backfill as soon as possible; and
- where excavated ASS material will be exposed for more than 24 hours, it must be treated by neutralising with the application of lime (refer to recommended liming rate and procedure below).

Should temporary stockpiling of soils be required for longer than 24 hours the following additional mitigation measures are to be implemented:

- excavated ASS material will be separated from overlying topsoil and temporarily stockpiled. Where ASS burial cannot be completed within 24 hours, or if there is surplus of ASS material, the liming procedure detailed below should be adopted;
- if ASS material must be stockpiled temporarily, the stockpile area must be located away from waterways;
- the stockpiles are to be bunded, and soils covered to slow oxidation and prevent ingress of rainfall;
- treatment using the liming procedure (outlined below) should immediately follow excavation; and
- upstream sediment control and flow diversion and downstream leachate collection measures should be installed around the stockpiles.

J3.2 Liming and Treatment Procedure for ASS

1. Lime the base of the stockpile pad 5 mm thick layer of fine grade-1 agricultural lime;
2. Spread excavated ASS onto the pad in layers 10 – 30 cm thick;
3. Apply lime at a standard rate of 30 kg of lime per tonne of soil from between 1 m and 2 m depth below natural ground surface.

   Note: - no liming is recommended for soils within 1.0m of the natural ground surface;
   - 1 bag of lime = 25 kg;
   - windy conditions should be avoided for safety and efficiency;
4. Cultivate lime into the ASS layer well, preferably using a rotary hoe. Ensure an even homogenous mix of soil and lime is created before spreading the next soil layer;
5. Repeat steps 2 – 4 as required; and
6. pH of the neutralised soils is to be monitored twice a day following liming for one week, to ensure there is adequate lime application. The pH of the neutralised soil needs to be in the range of 5.5 to

8.5. If pH is below this level additional small amounts of lime should be added to bring the soil to the range of 5.5 to 8.5.

ASS treated in this way can be used as fill.

J3.3 Minor Trenching for Services

Where service trenches can be refilled within 24 hours, excavated ASS material should be separated from overlying topsoil and temporarily stockpiled. Once trenching and laying of services is completed, ASS material should be returned to the trench first followed by the topsoil. Where ASS burial cannot be completed within 24 hours, or if there is surplus of ASS material, the liming procedure above should be adopted.

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13th January 2011

Simon Waterworth
Senior Planner/Principal
GeoLINK
PO Box 1446
COFFS HARBOUR NSW 2450

Dear Sir,
Australian Soil and Concrete Testing P/L (ASCT) at your request have reviewed an Acid Sulfate Soil Management Plan (ASSMP) that has been prepared by GeoLINK, Coffs Harbour for the proposed Riverside Tourist Cabin development at Lot 4 New Entrance Road, South West Rocks, NSW (DP 1022342). The ASSMP was reviewed in conjunction with the Acid Sulfate Soil Investigation report prepared for the site by ASCT on 30/10/09 (reference number: 1616-001-ASS).

Subsequent to the review of the documents listed above ASCT fully endorse the ASSMP.

Finally, should any problem or concern arise that needs clarification or assistance please do not hesitate to contact our office.

Yours Faithfully,
Australian Soil and Concrete Testing P/L

Ben Hart
Environmental Officer
(B. App. Sc)

Brian Dick
Managing Director

Identifying Acid Sulfate Soils

J5 Potential Acid Sulfate Soil (PASS)

J5.1 PASS Characteristics

- waterlogged soils – unripe muds (soft, sticky and can be squeezed between fingers, blue grey or dark greenish grey mud with a high water content), silty sands or sands (mid to dark grey) or bottom sediments (dark grey to black e.g. iron monosulfides 'black oozes') possibly exposed at sides and bottom of drains or cuttings, or in boreholes;
- peat or peaty soils;
- coffee rock horizons; or
- a sulfurous smell e.g. hydrogen sulfide or 'rotten egg' gas.

Plate J1 Potential ASS Soil Profile

Plate J2 Potential ASS Soil Profile

Source: http://www.ccma.vic.gov.au/soilhealth/photos.htm

J5.2 Water Characteristics

- Waterlogged soils;
- water pH usually neutral but may be acidic; or
- oily looking iron bacterial surface scum (the similar appearances of iron bacterial scum and a hydrocarbon slick can be differentiated by disturbing the surface with a stick: bacterial scum will separate if agitated whereas a hydrocarbon slick will adhere to the stick upon removal).

NB: Caution should be taken when inspecting highly altered landscapes in the field (e.g. where inert fill has been placed over ASS material, dredge spoil, etc). Soil, water and landscape indicators may be masked by past landscape and drainage modifications and this should be taken into consideration when determining borehole locations.

J5.3 Vegetation Characteristics

- Dominant vegetation is tolerant of salt, acid and/or waterlogging conditions e.g. mangroves, saltcouch, Common Reed (*Phragmites australis* - a tall acid tolerant grass species), swamp-tolerant reeds, rushes, paperbarks (*Melaleuca spp*.) and swamp oak (*Casuarina spp*.).

J5.4 Field Indicators for PASS Characteristics

- Typically waterlogged, unripe muds (soft, buttery texture, blue grey or dark greenish grey) or estuarine silty sands or sands (mid to dark grey) or bottom sediments of estuaries and tidal lakes (dark grey to black);
- offensive odour, predominantly due to 'rotten egg gas' (hydrogen sulfide H_2S).

J6 Actual Acid Sulfate Soil (AASS)

J6.1 Characteristics

- Presence of corroded shell;
- sulfurous smell e.g. hydrogen sulfide or 'rotten egg' gas; and any jarositic horizons or substantial iron oxide mottling in surface encrustations or in any material dredged or excavated and left exposed.

Plate J3 Potential ASS Soil Profile

Plate J4 Potential ASS Soil Profile

Source: http://www.ccma.vic.gov.au/soilhealth/photos.htm

J6.2 Water Characteristics

- water of pH <5.5 (and particularly <4.5) in surface water bodies, drains or groundwater (this is not a definitive indicator as organic acids may contribute to low pH in some environments such as *Melaleuca* swamps);
- unusually clear or milky blue-green water flowing from or within the area (aluminium released by ASS acts as a flocculating agent);
- extensive iron stains on any drain or pond surfaces, or iron-stained water and ochre deposits; and
- oily looking bacterial surface scum (differentiated from a hydrocarbon slick of similar appearance as described for PASS).

J6.3 Vegetation Characteristics

- dead, dying, stunted vegetation;
- scalded or bare low-lying areas; and
- poor vegetation regrowth in previously disturbed areas.

J6.4 Infrastructure

- corrosion of concrete and/or steel structures (including foundations, fences, masonry/brick walls, pipes).

NB: May also be due to excessive salinity or to salinity in combination with AASS.

J6.5 Field Indicators for AASS Materials and Conditions

- Unusually clear or milky blue-green drainage water within or flowing from the area (Aluminium released by the ASS acts as a flocculating agent);
- extensive iron stains on any drain or pond surfaces, or iron-stained water and ochre deposits;
- Jarosite containing horizons or iron oxide mottling in auger holes or recently dug surfaces;
- Jarosite present in surface encrustations or in any material dredged or excavated and left exposed;
- corrosion of concrete and/or steel structures;
- dominance of mangroves, reeds, rushes and other swamp-tolerant vegetation; and
- sulphurous (H_2S) smell after rain following a dry spell, or when the soils are oxidised or disturbed.

The straw-coloured material in the black clay in Plate J5 is the mineral Jarosite appearing along the root channels. Jarosite is evidence that there is oxidised ASS. It is found in places where the ASS has been disturbed (excavated or drained) so that the previously inundated ASS layers have been exposed to air.

Plate J5 Jarosite along root channels

Source: http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/soil_acid_sulfate_soils

Plate J6 Sulfidic material in Acid Sulfate Soil formed in the River Murray under permanently waterlogged or saturated conditions under 75 to 100 cm of water

Source: Government of South Australia Information Sheet: Acid Sulfate Soils along the Lower Murray River

Plate J7 White and yellow salt efflorescences on soil surface and with bright yellow mottles in cracks

Source: Government of South Australia Information Sheet: Acid Sulfate Soils along the Lower Murray River

Plate J8 Monosulfidic black ooze (MBO) material exposed in shallow backswamp wetlands

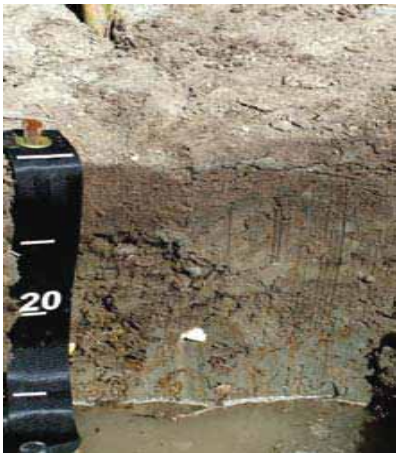

Plate J9 Soil profile showing white and yellow salt efflorescences on the surface with sulfuric material. Soil becomes acidic (pH <4) after drainage. Sulfidic material dark grey to black; grey matrix with light brown mottles in heavy clay. Only if disturbed will this layer become acidic (pH >4)

Source: Government of South Australia Information Sheet: Acid Sulfate Soils along the Lower Murray River

J7 Sources

South Australia EPA (2007), *Contamination Site Guidelines for Acid Sulfate Soil Material*. South Australia, November 2007.

Government of South Australia (2007), *nformation Sheet: Acid Sulfate Soils along the Lower Murray River*. SA December 2007.

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Department of Environment - Land and Water Quality Branch, (2006). *Draft dentification and investigation of Acid Sulfate Soils: Acid Sulfate Soils Guideline Series.*

Western Australia EPA (2006), *Draft dentification and nvestigation of Acid Sulfate Soils,* [Accessed online June 2009] http://portal.environment.wa.gov.au/pls/portal/docs/PAGE/DOE_ADMIN/GUIDELINE_REPOSITORY/DRAFT%20ASS%20INVESTIGATION%20AND%20IDENTIFICATION%20GUIDELINE.PDF

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