

Technical Paper

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Acid Sulfate Soil Assessment

PRELIMINARY ACID SULFATE SOIL ASSESSMENT REPORT

FOR THE NORTH BYRON PARKLANDS PROJECT & CONCEPT PLAN APPLICATION

AT

NORTH BYRON PARKLANDS SITE, WOOYUNG, NSW

An assessment of potential and actual acid sulfate soils

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For:North Byron Parklands (C/- SJ Connelly CPP Pty Ltd)Report No.:EALQ2709Date:18 June 2010





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1 INTRODUCTION

EAL Consulting Services of the Environmental Analysis Laboratory (EAL) has been commissioned by North Byron Parklands (on behalf of Billinudgel Property Pty Ltd) to undertake a preliminary acid sulfate soil assessment for a proposed temporary place of assembly with camping and associated infrastructure at Jones Road, Wooyung, NSW (Fig. 1; Appendix 1).

This report is prepared in respect of a current Concept Plan and Project Application Environmental Assessment report (EA) for the North Byron Parklands (Parklands) project. This EA has been prepared on behalf of Billinyudgel Property trust (Billinudgel Property Pty Ltd). The total allotment area (i.e. North Byron Parklands) is approximately 263.4ha. The area assessed for this investigation (Proposed Cultural Event Site) is considered to be approximately 93 ha (Fig. 2; Appendix 1).

In accordance with the guidance provided in Stone et al. (1998), a preliminary assessment is required prior to the development of an effective Acid Sulfate Soil Management Plan (ASSMP). The requirements for the management and mitigation of ASS will be based upon the findings of this (and/or any other relevant) investigation(s) and a detailed description of the extraction/excavation activities associated with the proposed development of the site.

1.1 SCOPE OF WORKS

The objectives of this assessment are in accordance with Section 2 of the Acid Sulfate Soil Management Advisory Committee (ASSMAC) Assessment Guidelines (Stone et al. 1998):

".... To determine whether Acid Sulfate Soils are present and if works are likely to disturb these soils."

The following applies to this assessment;

- 1. To establish whether Acid Sulfate Soils are present on the site and if they are in such concentrations so as to warrant further investigations; and
- 2. To provide information to assist in decision-making.

Therefore, this preliminary assessment is used to identify the following:

- The presence and distribution of <u>potential</u> and/or <u>actual</u> acid sulfate soil(s) within the subject site;
- The potential for intersection and disturbance of <u>potential</u> and/or <u>actual</u> acid sulfate soil(s) as part of the development of the site.

The preliminary assessment will also:

- Discuss the current site conditions with respect to acid sulfate soils;
- Undertake a site-specific soil sampling and analysis program to identify the presence (or absence) of ASS and peat soils (utilising previously collected information (i.e. Coffey 2007 and APP 2007));
- Assess the need for further investigations;
- Provide an assessment of requirements and recommendations for acid sulfate soil management.

The relevant guidelines used for the investigation are as follows:

- Stone, Y., Ahern, C. and Blunden, B. (1998). *Acid Sulfate Soils Manual*, Acid Sulfate Soil Management Advisory Committee (ASSMAC) Wollongbar, NSW.
- Ahern, CR, McElnea AE, Sullivan LA (2004). *Acid Sulfate Soils Laboratory Methods Guidelines*. QLD DNRME.

1.2 SITE IDENTIFICATION

The property description(s) for the North Byron Parklands site, their areas and current zonings are provided below (as provided by SJ Connelly CPP 2009).

Lot/DP Description	Area (ha.)
Lot 403 and Part Lots 402,404 DP 755687	104.71
Lot 1 DP 1145020*	2.47
Part Lot 46 DP 755687	8.43
Part Lot 10 DP 875112	4.29
Part Lot 2 DP848618	8.9
Part Lot 30 DP880376	9.89
Part Lot 102 DP1001878	15.17
Part Lot 12 DP848618	2.05
TOTAL of APPLICATION AREA	155.91

The site is an irregular shaping of individual allotments located approximately 7.0 km north-west of the CBD of Brunswick Heads. The site is located in a coastal area and primary access is to be via a proposed access off the Tweed Valley Way within the sites southern extent.

1.3 PROPOSED DEVELOPMENT DESCRIPTION

The purpose of the North Byron Shire Parklands site is to provide a location to host cultural, arts and music events. The site is to contain areas for car parking and camping along with conference facilities a cultural centre and a mix of ecological restoration and agricultural uses. Fig. 2 (Appendix 1) illustrates the layout of the proposed development. Key development activities regarding ASS include:

• Construction of access roads, amenities block(s) and recreational facilities (as well as associated infrastructure; services and utilities) as depicted in Fig. 3.

1.4 ASS DEFINITIONS

The term 'acid sulfate soils' includes both 'potential' and 'actual' acid sulfate soils. Actual and potential acid sulfate soils are often found in the same soil profile, with actual acid sulfate soils generally overlying potential acid sulfate soil horizons.

"Actual acid sulfate soils" (or *sulfuric soils*) are soils containing highly acidic soil horizons or layers resulting from the oxidation of soil materials that are rich in sulfides, primarily pyrite. This oxidation produces acidity in excess of the sediment's capacity to neutralise the acidity resulting in soils of pH4.0 or less.

Isbell (2002) describes sulfuric soils as "soil material that has a pH less than 4 (1:1 by weight in water, or in a minimum of water to permit measurement) when measured in dry season conditions as a result of the oxidation of sulfidic materials (defined above). Evidence that low pH is caused by oxidation of sulfides is one of the following:

- yellow mottles and coatings of jarosite (hue of 2.5Y or yellower and chroma of about 6 or more).
- underlying sulfidic material."

"Potential acid sulfate soils" (or *sulfidic soils*) are soils that contain iron sulfides or sulfidic material that has not been exposed to air and oxidised. The field pH of these soils in their unoxidised state is>4.0. They may be neutral or slightly alkaline.

Isbell (2002) describes sulfidic soils as "a subsoil, waterlogged, mineral or organic material that contains oxidisable sulfur compounds, usually iron disulfide (e.g. pyrite, FeS_2), that has a field pH of 4 or more but which will become extremely acid when drained. Sulfidic material is identified by a drop in pH by at least 0.5 unit to 4 or less (1:1 by weight in water, or in a minimum of water to permit measurement) when a 10mm thick layer is incubated at field capacity for 8 weeks. For a quick screening test that is not definitive, a 10 g sample treated with 50 ml of 30 % H_2O_2 will show a fall in pH to 2.5 or less."

1.5 ASS RISK MAPPING

The subject site is depicted in the Department of Land and Water Conservation's (DLWC) *Burringbar/Pottsville* 1:25,000 Acid Sulfate Soil Risk Map Edition Two (DLWC 1997). Three (3) separate Risk classes have been identified across the subject, shown below in Table 1.

Risk Class	Probability of Occurrence	Landform Process	Landform Element	Elevation (m)
Lap2	Low	Alluvial	Plain	2 - 4
Lap2(p)	Low	Alluvial	Plain	2 - 4
Las1(p)	Low	Alluvial	Swamp	1 - 2

Table 1. Identified ASS Risk classes for the subject site

ASS occurrence within these landforms is typically highly localised, with disturbance and subsequent risk of exposure and oxidation primarily varying with elevation and depth of disturbance.

Byron Shire Council's LEP (1988) Clause 63 regulates and identifies works that have the potential to disturb ASS. The subject site is identified in Council's ASS Planning map with the indicated classes shown in Table 2.

ASS Risk Class	Specified Works
Class 2	Works below the ground surfaceWorks by which the water table is likely to be lowered
Class 3	 Works beyond 1 m below the natural ground surface Works by which the water table is likely to be lowered beyond 1 m below the natural ground surface

Table 3 REC ASS Diapping Classes (1000) identified for the s	
Table 2. BSC ASS Planning Classes (1988) identified for the se	ubiect site

The risk maps for determining the depth to the ASS layer utilised the relationship between ground surface elevated and the critical elevation for the upper level of ASS occurrence, being 1m AHD.

Fig. 3 (Appendix 1) illustrates the DLWC (1997) ASS Risk mapping for the site, on which BSC ASS planning maps are based.

2 ENVIRONMENTAL SETTING

2.1 TOPOGRAPHY AND HYDROLOGY

The subject site is intersected by three ridgelines. The majority of the site is at elevations of 10m or less. The foothill of a ridgeline intersects the southern-most corner of the site to an elevation of approximately 20m. The middle of the site is intersected by Jones Road (in a predominantly east west orientation) which also follows a ridgeline (Marshall's Ridges) to an elevation of approximately 30m. The north-western corner of the site rises to approximately 90m in elevation. Thus the subject site (and majority of study area) has a slope of 0 - 2%. Other areas of the site have slopes up to 20%.

The site has been extensively drained for agricultural purposes. A number of first order ephemeral streams and natural drainage paths descend the slopes of the three ridgelines intersecting the site to be intercepted by the constructed drainage paths in the sites north.

The southern section of the site is intersected by Yelgun Creek which is predominantly fed by draining the ridges and slopes to the west of the site.

2.2 LOCAL GEOLOGY AND SOILS

The geology of the site comprises three distinct geological units:

- 1. Rolling hills on metamorphics of the Neranleigh-Fernvale Group, associated with the *Billinudgel* (**bi**) erosional landscape, described by Morand (1996) as:
 - Deep (>100 cm), moderately well-drained Red Podzolic Soils (Dr2.21, DR4.21) on crests; moderately deep (70-100cm), moderately well-drained Yellow Earths (Gn3.74, Uf6.33) and Yellow Podzolic Soils (Dy3.11, Dy2.11) on slopes and better-drained areas;
 - These soils are depicted by Morand (1996) to occur within the central, northwestern and southernmost portions of the site above elevations of 10m AHD. BH4, BH9, BH10, BH11 and BH12 were excavated within the boundary zone between the raised ridgeline (i.e. **bi** soils) and the inner barrier dune system (i.e. **kib** soils).

 Low-lying, gently undulating Pleistocene sand sheets overlying peat and alluvium, associated with the *Kingscliff Variant b* (**kib**) aeolian and *Pottsville* (**po**) aeolian/swamp landscapes, described by Morand (1996) as:

Kingscliff Variant b:

- Deep (>200 cm), generally well-drained Podzols (Uc2.22, Uc2.21;
- These soils are depicted by Morand (1996) to occur within the northern and north-eastern sections of the site below 10m AHD. BH1 -3 and BH5 8 were excavated within the inner barrier dune system.

Pottsville:

- Deep (>300 cm), poorly drained Podzols and Humus Podzols (Uc2.33); deep (>300 cm), poorly drained Humic Gleys (Uf6.51) and Acid Peats (O) in very low depressions;
- These soils are depicted by Morand (1996) to occur within the south-eastern section of the site, also below 10m AHD. BH14 – BH17 were excavated within the **po** landscape.
- 3. Deep Quaternary alluvium (alluvial fans and valley infills) derived from surrounding metamorphics, associated with Ophir Glen (og) transferral landscape and Crabbes Creek (cr) alluvial landscape, described by Morand (1996) as:

Crabbes Creek:

- Deep (>200 cm), well-drained Brown Alluvial Clays and Clay Loams (Uf6.12, Um1.43) on lower terraces; deep (>200 cm), well-drained Brown Alluvial Clays (Uf6.12, Uf6.33, Uf6.53) on upper terraces;
- These soils were located in the south-western section of the site, west of the soils described as the po landscape (Morand 1996). Bh13 was excavated within the **cr** landscape..
- These soils are mapped in the central section of the site and in the southern most section of the site. Sampling did not occur in this area.

Ophir Glen:

- Deep (>100 cm), poorly drained Yellow Podzolic Soils (DY3.11); deep (>100 cm), moderately well-drained minimal Prairie Soils (Gn3.41). Deep (>100cm), poorly drained minimal Brown Podzolic Soils (Db3.11) on lower portions of some coastal fans;
- These soils are mapped in the central western section of the site. Sampling did not extend to this area.

Observations made of the soils encountered during this investigation are consistent with the Morand (1996) descriptions of the above soils with some localised variations between soil types typically associated with boundary overlapping.

2.3 LOCAL HYDROGEOLOGY

The soils of the low-lying coastal barrier within lands below 10m AHD are considered to represent a Coastal Sand Bed Groundwater System, supporting wetlands, terrestrial vegetation and hypogean ecosystems. Wetlands associated with this system are often referred to as groundwater windows as they typically indicate the groundwater levels in the surrounding sand beds and ridges (DLWC 2002). Maintenance of the existing salt water /fresh water interface is essential in order to prevent salt water intrusion following dewatering or excessive extraction of groundwater.

A search of existing licensed groundwater bores within 250m of the subject site was conducted using the NSW Natural Resource Atlas (NRATLAS 2010) website. One (1) licensed groundwater bore is located within the bounds of the site. This bore (GW305158) is located in the western section of Lot 102 DP1001878. GW305158 is licensed for both domestic and stock purposes. It has a final depth of 42m with a Standing Water level of 2.80m below ground level (bgl). The Water bearing zone is located between 22 to 38m bgl. Four (4) other licensed groundwater bores were identified within 250m of the site. Three (3) are licensed for monitoring purposes with the fourth being licensed for Domestic uses.

Groundwater table heights within low-lying alluvial and aeolian plains were found to be typically within a metre of the natural land surface (refer Borelogs; Appendix 2).

3 INVESTIGATION METHODOLOGY

3.1 GENERAL METHODOLOGY

The methodology used to conduct this preliminary ASS assessment included:

- A review of any available documentation that may be of assistance in establishing the presence of ASS within the subject area (e.g. mapping, assessments and investigations conducted for nearby developments as well as soil and water analyses);
- A site inspection/sampling effort to identify the subsurface conditions within the proposed areas of disturbance in order to ascertain if potential and/or actual acid generating layers are present;
- Identification of the potential for groundwater intercept, including existing groundwater bore searches and field excavations ; and
- Identification of the need for further ASS and groundwater investigation works.

3.2 SOIL SAMPLING AND ANALYSIS METHODOLOGY

Site assessments included subsurface investigations by way of borehole excavations. The methodology for subsoil investigations included:

- Field visual assessment of site indicators for presence of actual or potential acid sulfate soils;
- Boreholes were manually excavated in seventeen (17) locations across the site (Fig. 4; Appendix 1) in order identify local subsurface conditions and local water table heights;
- Samples were collected every 500 mm vertically down the excavated soil profile or from each soil horizon encountered during excavations;
- All sampling was undertaken by Troy Shepherd and Matt Pocock of EAL;
- All samples were collected using a stainless steel extendable (gouge) auger, decontaminated (DECON 90) between each sample collection point;
- Soil samples were sealed in double plastic bags to exclude all air and reduce oxidation. Samples were kept cold in an esky and immediately delivery to the EAL;

- All soil preparation and analysis was conducted by EAL using NATA (National Association of Testing Authorities) certified analysis. All soil samples collected were dried at 80°C. Samples were ground in a ring mill grinder to a fine powder (<10 micron) which was stored in sealed polypropylene vials. Samples are stored for greater than 12 months to allow retesting if required; and
- All samples (69) were subjected to Chromium Reducible Sulfur analysis (in accordance with Methods 21, 23 and 22B Stone et al. 1998) suite (including Titratable Actual Acidity (TAA) and CRS oxidisable sulphur) and thirty-nine (39) samples were subjected to Extractable sulfate sulfur analysis (in accordance with Method 23C Stone et al. 1998). All methods are NATA registered.

3.3 ASS ACTION CRITERIA

Stone et al. (1998) outlines the action criteria based on threshold values for oxidisable sulfur or acidity. These criteria are based on three (3) broad texture categories, as shown in Table 3 (below) and are intended to trigger the need for detailed acid sulfate soil management where development is planned.

		Approx.	Action C	Criteria
Texture Category	Texture Range	Clay Content (< 0.002mm) %	Sulfur Trail (%S oxidisable	Acid Trail mol H ⁺ /tonne
Coarse	Sands to Loamy Sands	5	0.03	19
Medium	Sandy Loams to Light Clays	5 - 40	0.06	37
Fine	Medium to Heavy Clays and Silty Clays	40	0.10	62

Table 3: Acid Sulfate Soil Action Criteria (Stone et al. 1998)

For projects that will disturb more than 1000 tonnes of ASS, the 0.03% % S trigger is typically adopted for all soil texture types. For the purpose of this assessment, the 0.03%S trigger and 19molH+/tonne trigger values have been adopted to signify. For the purpose of identifying AASS, extractable sulfate sulfur levels (%SKCl) of 0.03% have been adopted as the trigger for this assessment, in conjunction with the presence of underlying PASS indications.

4 PREVIOUSLY COLLATED INFORMATION

4.1 COFFEY GEOTECHNICS GEOTECHNICAL INVESTIGATION (MARCH 07)

Coffey Geotechnics have conducted an ASS assessment (March 2007) of the northern section of the site (as shown in Fig. 5; Appendix). Coffey's report indicates that the 2007 assessment of ASS consisted of the analysis of twelve (12) individual soil samples collected from the four (4) boreholes (HA1, HA2, HA3 and HA4). A review of the laboratory certificates (E7052; Coffey 2007) indicates that the soils collected were highly acidic with levels of oxidisable sulfur recorded as above limits of detection. Titratable Actual Acidity (TAA) results for E7052 shows that significant existing acidity is present within soils down the profile, and with the presence of detectable levels of elevated oxidisable sulfur levels, the soils from HA1 – HA4 were considered to be (actual) ASS.

4.2 APP ASS MANAGEMENT PLAN (JUNE 07)

Following the findings of the ASS assessment conducted by Coffey (March 2007), Ardill Payne and Partners (APP) prepared an Acid Sulfate Soil Management Plan (ASSMP) for the site. APP stated that in the event that excavations exceed the depth of the topsoil layer in class 3 areas, or if potential ASS soils are encountered, management and treatment actions will be required.

5 RESULTS

5.1 SOIL STRATIGRAPHY AND IDENTIFIED SOIL UNITS

Coffey (2007) summarised the stratigraphy of the site as follow:

- TOPSOIL: Silty Clays and Peats between 0.2m and 0.7m, overlying;
- ALLUVIAL SOIL: Firm to stiff Clays to 1.5m, OR;
- RESIDUAL SOIL: Stiff Silty Clay in the vicinity of elevated landscapes near Jones Road, overlying:
- EXTREMELY WEATHERED SILTSTONE: high strength bedrock with closely spaced defects beyond the maximum investigation depth.

EAL's subsurface investigation efforts indicate that the conditions as described above are consistent across the site within the specific geological units. In addition to the soil units identified by Cofffey (2007), EAL's investigation identified sands, sandy clays and indurated sands (coffee rock) within the alluvial landscapes below 10m AHD.

Highly organic peat soils and associated alluvial sands and clays were identified across the majority of the northern section of the site (Fig. 10; Appendix 1).

5.2 ANALYTICAL RESULTS

Sixty-nine (69) individual samples representative of the soil layers encountered during the excavation of the seventeen (17) boreholes were collected and forwarded for chemical analyses.

CRS and TAA analyses were conducted upon all of samples the collected. Thirty-nine (39) samples were screened for Extractable sulphate Sulphur, Extractable Calcium and Extractable Magnesium. Samples tested for these characteristics were based on the CRS and TAA analyses results. Analyses included SPOCAS Method 23 (Suspension Peroxide Oxidation Combined Acidity & Sulfate) and Scr - Method 22B ('Chromium Reducible Sulfur (CRS) technique) as specified in Ahern et al. (2004). Table 4 below provides a

summary of the laboratory analysis results with complete laboratory certificates provided in Appendix 3.

In addition to the ASS analysis of soils, five (5) samples of organic peat soil were collected and analysed to determine the organic matter content (%OM) for the purpose of identifying the potential bushfire hazard associated with peat soils. Table 5 (below) presents the results of these analyses.

r ite	e	Fine	62																							
NET ACIDITY Chromium Suite		Medium	37		318	67	36	250		258	34	78		465	6	22	95		134	124	85	104		465	35	87
Chro		Coarse	19									ļ														
Reduced Inorganic	Sultur mola H ⁺ /tonne				31	12	12	12		25	12	12		37	0	12	31		19	6	9	9		37	6	12
c Sulfur Iucible	Fine	Ţ																								
Reduced Inorganic Sulfur (%Chromium Reducible S)	Medium	900	000		0.05	0.02	0.02	0.02		0.04	0.02	0.02		0.06	< 0.01	0.02	0.05		0.03	0.01	0.01	0.01		0.06	0.01	0.02
Reduced (%Chro	Coarse	20.0	0.0																							
Acidity onne	Fine	67	70																							
Titratable Actual Acidity (TAA) mole H ⁺ /tonne (to pH 6.5)	Medium	75	ò		277	55	24	237		233	22	66		416	6	10	64		115	118	77	97		428	28	75
Titratab (TAA) ((Coarse	10	n T																							
Texture		a			Fine	Medium	Medium	Medium		Fine	Coarse	Medium		Medium	Coarse	Coarse	Medium		Medium	Fine	Fine	Fine		Coarse	Coarse	Medium
Depth (m bgl)		Action Criteria			0.0 - 0.3	0.4 - 0.6	0.9 - 1.1	1.3 - 1.5		0.0 - 0.3	0.4 – 0.6	0.9 - 1.1		0.0 – 0.3	0.5 - 0.7	0.9 - 1.1	1.3 - 1.5		0.0 – 0.3	0.3 - 0.5	0.6 – 0.8	1.3 - 1.5		0.0 – 0.3	0.4 - 0.6	0.7 – 0.9
Sample Depth (m 1 No.		Ac		BH 1	C 1/1	C 1/2	C 1/3	C 1/4	BH 2	C 2/1	C 2/2	C 2/3	BH 3	C 3/1	C 3/2	C 3/3	C 3/4	BH 4	C 4/1	C 4/2	C 4/3	C 4/4	BH 5	C 5/1	C 5/2	C 5/3

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0.01

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Medium

1.3 - 1.5

C 5/4

Sample No.	Depth (m bgl)	Texture	Titratat (TAA) (Titratable Actual Acidity (TAA) mole H ⁺ /tonne (to pH 6.5)	Acidity onne	Reduce (%Chr	Reduced Inorganic Sulfur (%Chromium Reducible S)	c Sulfur ducible	Reduced Inorganic	NET ACIDITY Chromium Suite
			Coarse	Medium	Fine	Coarse	Medium	Fine	Sulrur mole H ⁺ /tonne	mole H / tonne
	Action Criteria	D	19	37	62	0.03	0.06	0.1		CoarseMediumFine193762
BH 6				_						-
C 6/1	0.0 - 0.3	Coarse		373			0.08		50	423
C 6/2	0.4 – 0.6	Coarse		8			< 0.01		0	8
C 6/3	0.9 - 1.1	Coarse		7			< 0.01		0	7
C 6/4	1.3 – 1.5	Medium		57			0.05		31	88
BH 7										
C 7/1	0.0 – 0.3	Fine		98			0.02		12	111
C 7/2	0.4 – 0.6	Fine		71			0.01		6	77
C 7/3	0.9 - 1.1	Fine		57			0.01		9	67
C 7/4	1.3 - 1.5	Fine		156			0.01		6	168
BH 8										
C 8/1	0.0 – 0.3	Coarse		332			0.05		31	371
C 8/2		Coarse		8			< 0.01		0	8
C 8/3	0.9 - 1.1	Coarse		7			< 0.01		0	7
C 8/4	1.3 - 1.5	Medium		60			0.08		50	110
BH 9										
C 9/1	0.0 - 0.3	Fine		56			0.01		6	62
C 9/2	0.4 - 0.6	Fine		98			0.01		6	105
C 9/3	0.9 - 1.1	Fine		100			0.02		12	115
C 9/4	1.3 - 1.5	Fine		97			0.01		6	104
BH 10										
C 10/1	0.0 – 0.3	Fine		53			0.03		19	71
C 10/2	0.4 - 0.6	Fine		91			0.03		19	109
C 10/3	Т	Fine		96			0.02		12	109
C 10/4	1.3 - 1.5	Fine		98			0.02		12	113
BH 11										
C 11/1	0.0 - 0.3	Fine		203			0.04		25	228

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Sample No.	Depth (m bgl)	Texture	Titratak (TAA)	Titratable Actual (TAA) mole H ⁺ /1 (to pH 6.5)	l Acidity /tonne 5)	Reduce (%Chi	Reduced Inorganic Sulfu (%Chromium Reducible S)	ic Sulfur ducible	Reduced Inorganic	NET ACIDITY Chromium Suite	
	-		Coarse	Medium	Fine	Coarse	Medium	Fine	Sultur mole H ⁺ /tonne	mole H'/tonne	
•	Action Criteria	a	19	37	62	0.03	0.06	0.1		se Medium F	Ð
		ļ							ç	19 37 62	
	ı	ם בוופ ו		C/T			0.02		77	TOA	
C 11/3	-i 	Fine		149			0.02		12	163	
C 11/4	1.3 – 1.5	Fine		105			0.06		37	145	
BH 12											
C 12/1	0.0 – 0.3	Fine		180			0.03		19	199	
C 12/2	0.4 - 0.6	Fine		190			0.02		12	204	
C 12/3	0.9 - 1.1	Fine		111			0.02		12	127	
C 12/4	1.3 – 1.5	Fine		120			0.07		44	165	
BH 13											
C 13/1	0.0 - 0.3	Fine		72			0.01		6	86	
C 13/2	0.4 – 0.6	Fine		200			0.02		12	214	
C 13/3	0.9 - 1.1	Fine		186			0.01		6	196	
C 13/4	1.3 - 1.5	Fine		155			< 0.01		0	157	
BH 14											
C 14/1	0.0 – 0.3	Fine		62			0.02		12	74	
C 14/2	0.4 – 0.6	Fine		109			0.03		19	133	
C 14/3	0.9 - 1.1	Fine		191			0.02		12	207	
C 14/4	1.4 - 1.6	Coarse		29			< 0.01		0	30	
C 14/5	1.8 - 2.0	Coarse		25			0.01	_	6	31	
BH 15											
C 15/1	0.0 - 0.3	Fine		181			0.07		44	232	
C 15/2	0.4 - 0.6	Fine		223			0.12		75	315	
C 15/3	0.9 - 1.1	Fine		54			< 0.01	_	0	55	
C 15/4	1.4 - 1.6	Fine		138			< 0.01		0	141	
C 15/5	1.8 - 2.0	Medium		58			< 0.01		0	61	
BH 16											
C 16/1	0.0 - 0.3	Fine		67			0.04		25	92	

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Reduced Inorganic Sulfur (%Chromium Reducible S)	Coarse Medium	900	0.00	0.10	0.01	< 0.01	< 0.01		0.09	0.01	0.02
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Titratab (TAA) (1	Coarse	10	T								
Texture		a		Fine	Medium	Medium	Coarse		Fine	Medium	Coarse
Depth (m bgl)		Action Criteria		0.4 - 0.6	0.9 - 1.1	1.4 - 1.6	1.8 – 2.0		0.0 – 0.3	0.4 – 0.6	0.8 - 1.0
Sample No.		4		C 16/2	C 16/3	C 16/4	C 16/5	BH 17	C 17/1	C 17/2	C 17/3

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Table 5: Peat Soil Analysis Results

Analyte	Peat 2	Peat 3	Peat 4	Peat 5	Peat 7
Total Carbon (%)	16.52	31.05	32.28	16.13	20.23
Organic Matter (%)	28.9	54.3	56.5	28.2	35.4

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6 DISCUSSION

6.1 PRESENCE OF ASM

The presence of <u>potential</u> and <u>actual</u> acid sulfate soils within the study area has been confirmed during this preliminary assessment. As suggested by DLWC (1997) and BSC ASS risk mapping, the Acid Sulfate Materials (ASM) are predominantly located within the low-lying interbarrier flat, sporadically overlain by alluvial and fluvial sediment layers.

The soils of the site are naturally acidic, which is consistent with Morand (1996) descriptions. The analysis effort detected high levels of actual acidity throughout the soil profile, and in association with the low levels of potential sulfidic acidity, the majority of soils analysed recorded a net acidity (as per the Acid Base Accounting method) in excess of the relevant trigger criteria as defined by soil texture.

6.2 PRESENCE AND DISTRIBUTION OF POTENTIAL ASM

Analysis of samples collected from BH3, BH5 – 6, BH8, and BH15 – 16 shows that sporadic occurrences of soils containing oxidisable sulfur levels in excess of the action criteria (as identified in Stone et al (1998)) are present within lands across the site below 3.0m AHD. Oxidisable sulfur recorded in these twenty-two (22) boreholes ranged between < 0.01 ("Limit of Reporting") and 0.12 %Scr.

It is important to note that the CRS technique is more accurate, has lower detection limits and is not prone to interferences by organic matter. In the past, many sites have been falsely classified as 'Acid Sulfate Sites' but are only naturally occurring 'Organic Acid Sites' typical of coastal swamplands in this region.

As shown in Figs. 6 – 9, potential ASS is typically associated with the following layers:

- TOPSOILS Silty Clays and Peats, typically encountered in layers occurring at 3.0 1.5/1.0 m AHD within the northern (BH1 3 and BH5 8) and southern alluvial sediments (BH14 17);
- ALLUVIAL SOILS Clayey Sands and Sandy Clays, typically encountered in layers occurring below 1.0 m AHD within the northern alluvial sediments (in the vicinity of BH6);
- ALLUVIAL SOILS Fine to coarse grained Brown Indurated Sands, typically encountered in layers occurring at 1.0m AHD and restricted to the eastern barrier system (BH6 – 8).

6.3 PRESENCE AND DISTRIBUTION OF ACTUAL ASM

With regard to actual acidity, surface soils are most likely to oxidise to form actual acidity and hence, are the most important soils for actual acidity assessment. However, all soils were assessed in this study for actual acidity due to the porous nature (i.e. capacity for diffusion of oxygen into the soil profile) of sandy sediments encountered on site.

A comparison of the acidity concentrations determined using the acid trail (i.e.TPA) and sulfur trail (SCR in equivalent acidity units) can provide useful information on the source of acidity in the sample. Some acid soils have high TPA concentrations but the SCR may be low or even below the action limit, which may reflect organic acidity or acidity from oxidation and/or titration of metal (iron, aluminium or manganese) containing compounds. While this acidity is commonly not rapidly released into the environment in the short term, it should not be immediately dismissed as being of no consequence (Ahern, McElnea and Sullivan 2004). Current ASS action criteria guidelines do not distinguish between sources of acidity, only acidity concentration.

All excavated bores (BH 1 – 17) recorded Titratable Actual Acidity values above the adopted action criteria, indicating a likelihood of Actual ASS. Of the seventeen (17) bores, TAA values recorded in BH 1 – 3, BH 5 – 8 and BH 11 – 12 were considered to result from the artificial accentuation (by the KCl extraction procedure) of slow reacting, naturally occurring organic acids (such as humates, humic acids and fulvic acids) associated with the highly organic surface soils (peats).

The presence of Potential acidity (%Scr< 0.03) as well as Actual acidity (TAA < 19) typically indicates that the most likely source of existing (actual) acidity is the oxidation of sulfidic soil materials (i.e. potential acid sulfate soils). Additional AASS testing of select samples also showed that sulfidic acidity was relatively low in most soil samples indicating that although present, sulfuric acidity within the soil profile was not the dominant.

Nevertheless, as defined in Stone et al (1998), the acid trail values of the preliminary ASS assessment conducted across the NBP Parklands site characterises the soils of the site as Actual ASS and shall require specific treatment measures during construction of necessary infrastructure and services.

6.4 PRESENCE OF PEAT SOILS

As part of the ASS investigation, an assessment of the presence of peat soils across the site has been conducted for bushfire hazard purposes. Fig. 10 (Appendix 1) shows the assumed extent of peat soils across the northern section of the site. No indications of peat soils were encountered within the southern allotments below the ridgeline supporting Jones Road.

6.4.1 Potential Peat Fire Hazard

Peat soils under drought conditions, or having been significantly drained may represent a considerable fire risk. Table 5 (above) indicates that by volume, the peat soils present on site contain considerable percentages of organic matter (< 50%). The high organic matter content of these soils increases the risk of ignition, with such materials capable of concealed and continued burning of the significant fuel loads.

Additional information outside the scope of this investigation pertaining to the fire hazard(s) posed by these materials is expected to be provided in concurrently prepared bushfire investigations for the site.

6.5 POTENTIAL FOR DISTURBANCE OF ASM

Fig. 11 (appendix 1) illustrates the expected extent of ASS risk across the site and corresponding occurrence of ASS. The majority of ASS materials lie below 4m AHD. The provision of utilities (mains water and reticulated sewer, power, telecommunications etc.) is in all likelihood, a certainty, and such activities will require excavation to cater for both subsurface and aboveground infrastructure. In such cases where the likelihood of ASS disturbance is high, implications arise in terms of ASS oxidation as a result of these works. In association with acidic discharges to nearby sensitive environments (during and following construction efforts), the potential for damage to constructed services and structures (due to acidic corrosion) may also occur.

An associated danger of ASS oxidation is the effect of soil (and pore water) acidification upon the chemical composition of the soil and its components. The mobilisation of dissolved metals such as aluminium, iron, manganese and cadmium may have serious toxicological impacts upon aquatic and terrestrial biota exposed to suitably high concentrations of such substances. Elevated levels of mobilised trace heavy metals in soil and water can be toxic to aquatic life if released into the drainage system during high flow events or a rise in the local groundwater table. Stone et al. (1998) describes the variation of potential ASS impacts dependent upon the soil texture and mineralogy, demonstrating that certain characteristics inherent of a particular soil may reduce the acidification potential (such as the natural buffering capacity of a soil's clay or shell (i.e. CaCO3) content). The sand content and the absence of significant quantities of shell fragments observed within the collected samples indicates that the potential Acid Neutralising Capability (ANC) of the collected samples is most likely insignificant with respect to the overall net acid generating potential of analysed soils.

Any disturbance activities undertaken within the low-lying areas (i.e. lands < 3.om AHD) of the site without the implementation of suitable plan of management and appropriate handling practices would be expected to produce an impact following the acidification of the disturbed ASS bearing soil layers and the subsequent leaching of the acidic waters and any associated dissolved toxicants (Al3+ and Fe3+). The requirement for treatment and management of these soils will be dependent upon the nature and extent of soil disturbance associated with the proposed future development of the site.

6.5.1 Potential Acid Sulfate Material

Within the low-lying northern portion of the site, excavations below 3.0m AHD are expected to result in the disturbance of potential ASM associated with highly organic peat soils. Limited occurrences of indurated sands (or coffee rock) also present a significant ASS risk if disturbed. These materials are specifically limited to the northern (and principally north-eastern) sections of the site and occur at elevations below 1.5m AHD.

Potential ASM within the southern-most sections of the site are limited to silty clay/clay topsoils encountered below 3.0m AHD.

The excavations proposed as part of the NBP parklands development would result in the intersection and excavation of large quantities of potential ASM. Such works would require intensive acid sulfate soil management actions in order to prevent the generation of chronically acidic groundwater's and acidification by-products.

6.5.2 Actual Acid Sulfate Material

Actual ASM was found to be predominantly confined to the extremely low-lying areas of the site, associated with well drained recently deposited organic clays and clayey sands. Results of TAA analysis indicated that actual acidity consistently exceeded the action levels down the profile to the maximum depth of excavation.

The excavations proposed as part of the NBP parklands development would result in the intersection and excavation of large quantities of actual ASM. Such works would require intensive acid sulfate soil management actions in order to prevent the generation of chronically acidic groundwater's and acidification by-products.

6.6 **RECOMMENDATIONS**

The preparation of a site-specific Acid Sulfate Soil Management Plan (ASSMP) is required to suitably mitigate the potential impacts arising from the disturbance from ASM intercepted and disturbed as part of the proposed development activities.

A suitably tailored ASSMP will include the following:

- Identification of activities that are expected to intersect and disturb ASM;
- Identification of the ASS risks and identified ASS layers on site;
- The estimation of volumes of ASS requiring treatment and proposed treatment measures;

- Estimated liming rates and treatment procedures;
- Validation procedures and target criteria of treated soils;
- Monitoring protocols and target criteria for surface and groundwaters within the site; and
- Contingency procedures for ASS impacts associated with the development (including unidentified occurrences of ASS).

The ASSMP is to be prepared by a suitably experienced consultant and should encompass (but not be limited to) the items stipulated above.

7. CONCLUSION

The findings of the Preliminary ASS Assessment can be summarised as follows:

- Three (3) main landform units dominate the site: rolling hills and ridgelines on Naranleigh-Fernvale metamoprhics, low-lying Pleistocene sand sheets overlying peat and alluvium and deep Quaternary alluvium (alluvial fans and valley infills) derived from the surrounding elevated metamorphic hills and ridges;
- Topsoils at the site ranged from fine to medium silty/clayey sands (within low areas immediately adjacent hills and ridgelines), highly organic peat soils (silty high plasticity clay) and silty clays/sandy clays (within interbarrier alluvial plains) and ;silty clays upon midslopes of hills and ridgelines;
- Within the lands below 10m AHD, subsoils consist of high to medium plasticity silty clays/sandy clays and clays with sporadically distributed sand (lenses) and occurrences of indurated sands (coffee rock);
- Sixty-nine (69) individual samples were collected from seventeen (17) soil boreholes and analysed for TAA and %S_{CR}. Six (6) soil bores were found to contain potential ASM in excess of the adopted action criteria values (refer s. 3.3). All excavated boreholes recorded TAA values above the adopted action criteria, indicating a likelihood of Actual ASS;
- Analysis indicates that ASM is predominantly within soils below 3.0m AHD;
- The assumed extent of peat soils extends across the northern section of the site, confined to the north-eastern allotments (Lots 403 & 403 DP755687). No indications of peat soils were encountered within the southern and western allotments below the ridgeline supporting Jones Road;
- Groundwater heights were observed to mimic local topography with typical depths to groundwater recorded as 1.5m AHD within the low-lying alluvial and backbarrier plains.

Excavations proposed as part of the NBP Parklands development would result in the excavation and disturbance of identified ASM, triggering the need to implement comprehensive ASS management works as part of the development application.

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APPENDIX 1: FIGURES





Figure 1: Location of the NBP Site. (Source: Google maps http://maps.google.com.au/maps)



Figure 2: Early Design Plan NBP site



Figure 3: ASS Risk Mapping of the NBP site (DLWC 1997)



Figure 4: Soil sampling locations and section origins





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Figure 6: Geotechnical Long Section 1

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Figure 7: Geotechnical Long Section 2



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Figure 8: Geotechnical Long Section 3

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Figure 9: - Acid Sulfate Assessment - Section 4 autor/manual - Both Print Pristant, 1980 Villy Wry / Jose Rad, Vigar

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Figure 10: Assumed Extent of Peat soils

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Figure 11: Assumed Extent of ASS Risk and critical depths of occurrence
APPENDIX 2: SOIL BORELOGS

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Ground Water	Clegath (MI)	Graphia Log	Şali Symtasi	Soli Description (a di type, colour, plasticity, perticle characteristica, otter)	Sarple Celeoned	Moleture Status	Camintancy / Danily	Padd pH (1:5)	Brusteri p ¹⁴ (Percela	Newstran
	0.2	-	Pt	Black organic Post, root intrusions to 0.3m.	0-0.5m	۵	s	-	-	
!			9C	Light Grey Send of low plasticity and low dry strangth. Wet at 0.5m		W-W	ю	-	-	
rud ut 0.6eu			ec	Glack to Brown Coffee Rock of law plasticity and law dry exargets. Bendrois texteinided at: 1.8m bpj (Coffee Resis, refues)	0.9-1.1m 1.1-1.3m	W	мо	-	-	
Geographical and a close	&									
9월문날속(Rakates)	301 67489 6 04	ACH IGH 345 Penda yanda Sal pantet inal, dir er 3 Strady, dir er 3 Strady ander Rady ander Site Sa Clave 3 Sit, low han r, har frahe ant Clav, ha hat	TITLE	CLARGECTONICS CHARACTER CLARGECTONICS CHARACTER CC Dimension CC Dimens	ốoố-ji3 ±ậitas	i f i i i i i i i i i i i i i i i i i i	CONDUTTERC y lint. Turn Yell y Soft Soft Loost Loost Soft Downe Upton Downe		Leggesh Checkeds Engloyeen Hard Aust	_

U	outhern NIVER new way t	SITY		BORELOG				(1	$\sum_{i=1}^{n}$
	FIGUEST)		North Byro	n Partiende Heoyung, KBH			Extension	ENLE798		
	LICATIO	t.	BELIDESDE	957 658048T			Delta -	25 Per 10		
	print to		SJ Contail;	(CPP (on laskelf of NBP)			Sandanio Rice	847		
Stund Weter	Clepath (JMI)	Graphia Log	Gali Symbol	Soli Description (noli type, colour, plasticity, perticle characteristica, other)	Nample Collected	Moletary Garbus	Camintancy / Danalo	Padd pH (1:5)	Bosotroi p ¹⁴ (Percolulo	Respin
	0.2		Pι	Broven organic Pres	04.3m	D	5	-	-	
			cı.	Grange and Red mottled Gray Clay of medium placticity and medium dry strength. Rest intrusions.		0	F	-	-	
			a	Black Clay of motion plasticity and motion dry accergib.	6465m	D	Se .	-	-	
untimed	as	-	сн	Light Orange mottled Brey Clay of medium-high plasticity and medium day strength.	6.9-I.1m	D	Vit	-	-	
to ground maker arrow missed	_	-	сн	Light Onways motified Gwy Cley of high pleatieity and high dry strength. Increasing Onerga motifie with depth to approx. 60%.	1.3H.3n	D	Vit	-	-	
1 1 1 1	_ ^{a.}]			Barehole terreinsted at 1.5m bgi						
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き後ろいたが近い主いたらに	321 E A89	Post IGN 395 Postive product Seri graduat Rearist product Rearist product Rearist product Rearist product Rearist Rear		CLAURERCATENCE RECK CLAURERCATERS STOCKER RC DIFFERENCE DE STOCKEY Whathened DE STOCKEY Name P Stockey P Stockey P Stockey P Stock N Harme V Manuer V Manuer V Manuer V Manuer	Sottrastinas	2. E. S	Contentence y lart Tam Yan Yan Yan Yan Yan Yan Yan Yan Yan Yan		Leggesh Chestrati Chaijorean Hard Aust	_

U	outhern NIVER	SITY		BORELOG				(1	
	FIGUEST)		North Byro	n Partianda Yeleyung, Kilali			Estern no	EAL\$790		
	LICATE:	E.	BEJ GERT	NST BERG487			Delta -	11 Per 19		
	<u>1188</u>		SJ Contail;	(CPP (on laskelf of NBP)			Sandheio Rica	RH8		
Sraund Watar	Clegath (JMI)	Graphia Log	Sali Symbol	Soli Description (noli type, colcur, plasticity, perticle characteristics, other)	Sample Calleoned	Maisture Gartus	Camintancy / Damilo	Padd pH (1:5)	Bosotani pH (Percolule	ltenction
	0.2		Pt	Black organic Peak root intrusions to Q.Am.	0-0.5m	۵	s	-	-	
1			CL 6#	Top 100mm Black Clay transition zone to Gray Silly Sand of law plasticity and low dry strangth.	G.4-GLEm	94-94	FND	-	-	
R			sc	Elack Clayray Sand of loss planticity and loss dry strangth. (Coffee Reck)	034.1m 1.14.2m	- 14	Va	-	-	
Onumberiar announkanal at 0.75m byj	8_T 			Benehole termineted et: 1.2e byl (Coffee Reek refueel)						
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	FIGUEST)		North Syro	n Perkiende Hierpung, Kijiki			lafers and	EAL\$798		
	LICATE	E.	BELI DESDA	31 6580173			Delta -	25 Per 10		
	DURIT		SJ Contaily	(CIPF (on lashed of NBP)			Sandheio Rica	6H2		
Graund Water	Clegath (Jun)	Graphia Log	Sali Symbol	Soli Deteription (noli type, colcur, plasticity, perticle characteristics, other)	Kanple Caleonal	Moleture Status	Omintanoy / Damito	Padd pH (1:5)	Bountard pH (Perculate	Breation
	0.2		CL	Brown Clay (Loam), root intrusions to 0.2m.	64.3m	D	F	-	-	
	-		a	Red notified Brown Clay of medium plasticity and moderate dry strength.	6464m	0	St.	-	-	
	as		l a	Orange mottled Brown Diey of medium plasticity and moderate dry strength.		۵	9h	-	-	
premumorum anymoutined			ы	Overge resttief Grey Clay of high pleaticity and high sky strength. Buzzening lighter Grey with depth.	034.1n 134.3n	D	Vat	-	-	
lite gin	- ^a			Borehole terreinsted at 1.5m bgi						
eganerarian and the	201 67489 6 04	Ponte andre Ponte andre Sell gester Andre andre Red andre Site Se Site		CLAURENCENTRA STROKE CLAURENCENTRA STROKEL PE Environment ENV Experimental ENV Experimental PE Stroke Strakewood PE Stroke Strokewood PE Stroke PE	ชื่อชี้ารู้สิรรู้ที่จะมี	i feringen under sollen under	CONNECTOR (Int. Int. Int. Int. Int. Int. Int. Int.	4 3 3 1 17	Legyah Checkes Bajpress Hord Aud	

: U	outhern NIVER	SITY		BORELOG				(\mathbf{D}
	FIG/ISCT)		March Byro	n Perkiende Hierpung, Kiliki			Estern not	ENLE790		
	LICATE	Ł	BELI DEBO	44 65801.8T			Edia -	25 Per 10		
	0.000		SJ Contaily	(CPP (on lastist of NBP)			Sandario Res	BHTO		
Stand Weter	Depath (JM)	Graphia Log	Şadi Symtasi	Soli Description (noli type, colour, plasticity, perticle characteristice, other)	Sample Celeoned	Moleture Garbus	Camintancy / Danily	Padd pH (1:5)	Besetzet pH (Percelate	Reaction
	0.2		a	Gray Cay of nucleus plasticity and nucleusts dry strangth. Root intrusions to 0.5m.	0-0.5m	0	F-8:	-	-	
to ground and an annountered			ы	Oneige nertibel (approx. 20-50%) Grey Clay of High plasticity and high dry asrungth.	0.462m 0.94.1m 1.94.5m	D	Sa - 1781.	-	-	
				Barwhole, terreinsbed at T_Sm bgi						
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: U	outhern NIVER new way b	SITY		BORELOG					~	\sum_{i}
	FIG/ISCT)		North Syro	n Perlande Hecyung, Kibli			Estern me	ENLE790		
	LICATED.	E.	85106310	NEZ (6580110			Delta	25 Mar 10		
	DURA		SJ Contaily	(CPP (on lastist of NBP)			Sandheio Res	EHT 1		
Ground Water	Clepath (/m)	Graphia Log	5ail Symbol	Soli Description (noli type, colour, plasticity, perticle characteristics, other)	Sample Caleonad	Moleture Status	Camintancy / Damily	Padd pH (1:5)	Bosotred pt-1 (Percedule	Reportion
	0.2		Pa -	Brown organic Past of low plasticity and low dry strength. Boot behaviors to 0.5m.	0-0.5m	0	5	-	-	"
ila groundar anvourtunad			DH	Red mottled Gray Clay of High plasticity and high dry etrangch becowing lighter Gray with depth.	0.462m 0.94.1m 1.94.5m	D	¥8:	-	-	
5 cm				ikarwhole, terminated at T_Sm bgi						
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U	outhern NIVER	SITY		BORELOG					~	\sum
	FIGUEST)			n Farliands Yeogung, HBH			isters was	ENLE790		
	LOCATED	E.		42 45 10074			Edite:	25 Per 10		
			au centalij	(CPP (an issist of NBP)		r	Sectorio Res.	BHT2		
Staund Water	Clegath (m)	Graphia Log	Şali Symbol	Soli Description (soli type, colour, plasticity, perticle characteristics, other)	Sarple Celected	Molature Gartus	Camintancy / Danily	Padd pH (1:5)	Brunteri p ¹⁴ (Percela	Reston
	0.2		PR -	Brown organic Past of low plasticity and low dry strength. Boot intrasions to 0.5m.	0-0.5m	в	5	-	-	
ila groupdantar associationed			ы	Brown to Gray Clay of medium pineticity and moderate city exampts. Trace Ref and Grange mottle throughout.	0.442.6m 0.314.1m 1.314.5m	D	že	-	-	41
Seal				Barehole, terretnebed at 1.5m bgl						
₽ 00~₽ ₩₽\$₩₽₿₿	201 E.A43	ACH IICH 39% Penda yanke Sait pasiet Sait pasiet Sait yanke Rasiy yanke Rasiy yanke Say Sa Clava Sa Silu, low Jan Pasiet yahan Law, Jan Pasie Pasie Pasie Pasie	TTERM	Little Hard Hard Hard Hard Hard Hard Hard Hard	Soërjijszâitas	i f f arfandering	CONDUTTERCY Finite Team Sector Sec		Loggicali Classification Englectrom Haved Access	

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: U	outhern NIVER	SITY		BORELOG					~	\sum
	PROJECTI		•	n Ferliends Weeyung, HSM			Estern no r	ENLE790		
	LOCATION	E.		174 (6-6) 0.5			Delta:	16 Apr 10		
			SJ Contail;	(CRP (an lasks)" of NSP)			Sectorio Ros	BHT3		
Ground Watar	Clegath (JMC)	Graphia Log	Şali Symtasi	Soli Description (a di type, colour, plasticity, perticle characteristics, otter)	Sample Caleonad	Moleture Status	Canaistancy / Danily	Padd pH (1:5)	Beateri p ¹⁴ (Perovisi	Reportion
	0.2		æ	Brown Silky Clay (Losso) of law plasticity and low dry abrength. Root intrusion to D.Sm.	6412m	. D	St.	-	-	
	_		a.	Brawn to Dark Brown City of mailum platticity and resolution dry strangth.	OL-BLEM	. 0	Var	-	-	
rhumod	a		a.	Light Drange mattled Grey Clay of medium to high plastolity and nectarate dry strangth. Some line sand particles within layer metricled to top 100mm.	0.5-1.1m	D	VS:	-	-	
ila groundeafer anvounteed			۹.	Orange mottled Grey Clay (leavey mottle) of median planticity and moderate dry strangth. Trace from and particles increasing in occurrence from 1.25m log.	1.44.50	D	VSt	-	-	
ilta gra	".a			Bereinde terminated at 1.5m kgl.						
bå정상호성유용	201 EX 488	ACHIER SM Panie guales Sal quales and, dir or 3 Stratig dir or 3 Stratig Ratig guale (Stratig Charts 5 Site Sta Site Sta	TIDAT	CLAURERCONTENT RECORD	Son the state of the set	je fe Soletine Soleti	CONDUTTERCY y lint. Turn Yell y Soft Hot Soft Lotto Soft Downe Was Downe Was Downe Was Downe	ofors: 1 1 8	Leggest Classicals Stationers Hard Asia	_

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U	outhern NIVER	SITY		BORELOG					1	
	FROJECT)			n Fertiends Webyung, KBH			Enformance -	EALE790		
	Location 199	E .		GZ (86-18) 54			Edita:	19 Apr 10		
	<u>1186</u>		SJ Contaily	(CRP (on Labor of NBP)			Sandario Res.	BHT4	<i>.</i> -	
Ground Watar	Clegath (.m)	Graphia Log	Şali Symtasi	Soli Description (a oli type, colour, plasticity, perticle characteristics, other)	Sample Calaouad	Molecure Granus	Camintancy / Damily	Padd pH (1:5)	Beated p ¹⁴ (Perodo	Reserve
	0.2		8	Brown Silly Clay (Lonn) of law pleaticity and low dry abrengtis. Root intrusion to 0.2m.			P3	-	-	
	_		œ	Brown City of law to mediate plasticity and mediatate dry strength.		м	St.	-	-	
Jump	a		а	Black Clay (herd) of high planticity and high dry strength.		D-H	VS:	-	-	
Aur annau	_		a	Light Groupe Clay of modern planticity and moderate dry abangth. Trace fine condo increasing in occurrence than 1.5m bpl.		M	3	-	-	
Na graundealar amounteed			sc	Grey Cleyery Sand of low to medium plasticity and low dry strangth. Decreasing in clay content from 1.3m bgl.		М-М	Þ	-	-	
	2.0		594	Gray Sand of ice plasticity and ice dry strength.]	w	va	-	-	
	_			Screhols terminated at 2.0m bgl.						
900-PMEKekele	- 320.027488 0 0	Contraction and Provide spectra Gala granted and Galary spectra Status, Chen Status, San Status, San Status, San Charas, San C	TIME	CLUMERTANCE HEAR CLUMERTANCE HEAR RE Rendered Heal RE Expressive Vendered RE Rendered Parathered RE Rendered Parathered R Render R R Render R R Render R Render R R Render R Render R R Render R R Render R R Render R R Render R R Render R R R Render R R Render R R Render R R R R Render R R R R R R R R R R R R R R R R R R R	Soërfissşiras	t f f szekenet	Columniteren s lant.	ân de la compañía de	Leggesh Checkeds Sacjoneen Hard Aust	_

: U	new way to	SITY		BORELOG				(~	\geq
	FROJECT)		North Byro	n Pertonda Yaoyung, Kijali			Eden van	EAL\$798		
	LICATION	E.		80 (8-821 T			Delta	16 Apr 10		
			SJ Contaily	CPP (an ladel of HBP)			Sectorio Ros	BHTS		
Ground Weter	Clepath (m)	Graphia Log	Şali Symtasi	Soil Description (a oli type, colour, plaaticity, perticle characteristics, other)	Sample Calaonad	Moleture Startus	Consistency / Danielo	Padd pH (1:5)	Resetant phi (Percelui	Respired
	0.2		a	Brown Cay (Lean) of low plasticity and low dry atmosph. Reat, intrusion to 0.25m.		D	F	-	-	
			CL.	Back Cay of mattern pisaticity and maderate dry strength.	<u> </u>	0	St.	-	-	
	—		a	Black mattled Orange Cay of law plasticity and law dry strength. Trace fine sansk perdicies throughout.		D	F	-	-	
_,	a		a.	Gray Cay of needlans plasticity and needents dry strangth. Fine eards restricted to top 190awn.		M-M	51	-	-	"
Georránskor erecentórnel et 0,4m			а	Orange anattiled Gray Clay of high plasticity and high dry strangth.		W	VSL	-	-	
landar unav	2.0		e.	Gray Elay of mailium plasticity and moderate dry strength. Fina annua throughout.		w	\$e	-	-	
9 DAY				Sorvhois terminated at 2.0m bgl.						
9832823055c	201 67488 6 05	Contract of the sector of the	d Sted	CELEVITARES MON CLAURIFICATES CROSSLA RS Enders Ent The Environity Standard The Environity Standard RT Starts Manhaod R Roth Enders R Hot R Resc R R R R R R R R R R R R R R R R R R R	รือชีารู้สะรัฐสายอี	i feringen Soleringen	COMMITTERCE / Bart. Data Sam Vitil Vitil Vitil South Loose South Denses Vitil Denses Vitil Denses	7000017	Laggest Checkes Englement Hard Aust	-

	PROJECT: LOCATION CLIENT:		561 0551	n Panldanda Weoyung, NSW 63 6649138 y C77 (up bahati of N37)			Raference: Date: Date: Max.	EAL2766 16 Apr 10 59:16		
Graund Water	Depth (m)	Graphic Log	Sail Symbol	Soli Description (soil type, colour, plasticity, particle characteristics, «ther)	Sample Codected	Moleture Status	Consistency / Density	Pield pH (1:5)	Reacted pH (Permiqle	Rugetten
	0.2		a	Brown Clay (Learn) of low plasticity and low dry strength. Root intrusion to 0.2m.		. 0	F	-	-	
	[-		CL	Brown Clay of medium plasticity and moderate dry strength. Trace ine sands throughout.		D	F	-	-	-
	0.8		SW	Orange mobiled Grey Send of low plasticity and low dry strength.		D	(L	-	-	.
ı			CL	Brown Clay of medium plasticity and moderate sky strength. Trace fine cands throughout.		M-W	St.	-	-	-
£	-		SW	Dark Orange mottled Sand of Inv plasticity and low dry strength.		W	D	-	-	
금물물	1.0		a	Dark Overge motiled Clay of medium planticity and moderate dry enungeh. Trace free earch throughout.	<u> </u>	₩	2	-	-	
arçımlerder ancountered st 1.0m	2.0		SW	Orange mottled Saud of of low plasticity and low dry strength.		W	D	-	-	
Grounden				Borehole terminsted at 2.0m bgf.						
3QLPFM일일여의활용습	Ci	RCATION 37% Passive graded Wol qraded inset, site or 5 Ganzel, Chay Poole o grade Tist analytic Site Say, Say Clark Sit Chay, Jath of antic Chay, July Fast.	i Eineref Granad and Wess. Annes E Sand Sand Sand Minda Minda Minda Minda Minda Minda	2303/2303/2303/2302 2303/2303/2302 2303/2302 2303/2302 2303/2302 2303/2302 2403/20	₩ 5 5 8 8% H AM 1000	S S Sen S S S S S S S S S S S S S S S S	Conception y Sent art art art art art art art art art ar	706980TY	Laggid: Charlend: Radjonans Hard Auto	чв

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	PROJECT:			n Parklands Weoyung, NSW				Reference:	EAL2709		
	LOCATION	E C		348 6849146				Dated	16 Apr 10		
	<u>CLENT</u>		SJ Canaelly	y CPYP (an behalf of NBP)				Banohalo-My;	8017		
Graund Water	Depth (m)	Graphic Log	Soli Symbol	Soli Description (soli type, colour, plasticity, particle chara	cteristics, other)	Sample Collected	Moleture Status	Consistency / Densi &	Pield pH (1:5)	Reacted pH (Percette	Reaction
	0.2		a	Brown Clay (Learn) of low plasticity and k Root. Intrusion to 0.25m.	aw dry strength.		D.	F	-	-	
	-		a	Brown Clay of low plasticity and low dry sta sand throughout.	ength. Trace fine	<u> </u>	D	F	-	-	
	-		SW	Light Orange mottled White Sand of low p dry strength.	lasticity and low		D	L	-	-	
	<u>a</u>		a	Top 100mm Grey Clay of medium plastici dry strength with trace fine sends. Botton of machine plasticity and moderate d	200mm Red Clay		D	VSR	-	-	
No gravité néverité servange	1.6 2.0	- - - -		Barahola terminetasi et 1.4m bgi (
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APPENDIX 3: LAB ANALYSIS CERTIFICATES

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RESULTS OF ACID SULFATE SOL ANALYSIS are not applied with Contraction of Theme, 2010-14, Jack WINS Anthone restatuby wellow enc. Year Project Period Relater

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	TEXTURE	MOISTURE CONTENT		8 -	PEROXIDE S	CREENING T	TECHNIQUE	ACIDI	TITRATABLE ACTUAL ACIDITY (TAA)	EX EX	Extractable sulfate sulfur	REDUCE	REDUCED INORGANIC SULFUR	(HCL extract) S		NET ACIDITY Chromium Suite	LIME CALCULATION Chromium Suite
(note 6) (% mois	% mois	ture (g	_	Initial pHr 1 water Di	pHrox peroxide pH change	change	Reaction		(To pH 6.5)	96Skci	mole H ⁺ /tonne (AASS acidity)		(% chromium reducible S)	(as %SHOL - %Skd)		mole H ⁺ /tonne	kg CaCO ₃ /tonne DW (includes 1.5 safety Factor
ì	if total we wrinhe?	~	of total wet / g of oven weinht / dru with	-				pHkci	(mole H ⁺ /tonne)			(96Scr)	(mole H ⁺ /tonne)	(96SNMG)	(mole H*/tonne	(mole H'/tonne) (based on 96Scrs)	
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REGULTS OF ACID SULFATE SOL ANALYSS of each experiment Angle Internet of Burrit 2014-14, 14, 14, 1713 and the second structure of the second succession

LIME CALCULATION Chromium Suite kg CaCO ₃ /tonne DW	(includes 1.5 safety Factor when liming rate is *ve)	note 4 and 6	22 I I I I	គ្គីនព	នងអង្គ	46 78 787 87	2222	121 221 221	512 252 252	
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ACIDITY (TAA) (To pH 6.5)	(mole H ⁺ /tonne)		<u>ថ្ងៃនដ្</u> ល	952 22	응드바릴	35 SE DE LA	17522 1752	202 271 245 261	180 111 120	BERTS 1. All studies is the study called and shared proved interchender up on twice (private anglind interlaind generation) 2. All studies is the PEOPER methods and and an output called and the study of a study of an output called and "Control 2. Control and the study of the Studies of Control and Studies Studies and Studies and Study of a study of a study 2. All foreign and study of the study of the study of the Study of Study of the Study of Study of the Study of Study o
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CONTENT	(g moisture / g of oven drv eoli)		111 120 120 120	222 222	Ban 2 2 2	2222 2222	<u>ភ្នំត្</u> នភ្នំតំ	월 월 6 8 8 월 월 2 8 8	1299	france of Marine Con-
CON	(% moisture (g moisture of total wet / g of oven weight) dry exit)		7.00 9.40 2.12 1.2	44.8 16.7 25.1	542 174 2182 218	ន៍នឹងផ	22.7 2018 2018 2018	オオリト	11月 11月 11日 11日 11日 11日 11日 11日 11日 11日	d interfection interfection
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RESULTS OF SAMPLE/SOIL ANALYSIS

5 sample supplied by EAL Consulting on the 25 March, 2010 - Lab Job No. A7916 Analysis requested by Katle Whitney. Project: Spiender Wooyong

	Method	Sample 1 Peat 2	Sample 2 Peat 3	Sample 3 Peat 4	Sample 4 Peat 5	Sample 5 Peat 7
	, oN dol	A7916/1	A7916/2	A7916/3	A7916/4	A7916/5
Total Certoon (%C) Organic Matther (%)	LECO CNS2000 Analyser By calculation	16.52 28.9	31.05 54.3	32.28 56.5	16.13 28.2	20.23 35.4

Total

All results as dry weight DW - samples ware check at 60°C for 48hrs prior to cruching and analysis.
 Drganic Matter = (%C Total Carbon) x 1.75

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RESULTS OF ACID SULFATE SOL ANALYSIS

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anic aidiine	(m)	lab Code			Ľ		AUDIT (TAA) (To pH 6.5)	sundre sunur %Suci			SULFUR (% chromium reducible S)	(HCL extract) (as %Sur - %Stel)	SNAG		ka CaCO3/tonne DW	
			(note 6)	(% moisture of total wet	(g moisture / g of oven	pH _{KCI}	(mole H*/tonne)	2	(AASS acidity)	6	(mole H ⁺ /tonne)	(%S _{NAG})	(mole H*/tonne)	1 =	Ē	
Method No.				Meiditu	dry solij									note 5		
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