

APPENDIX E

Acid Sulphate Soil Investigation





REPORT ON ACID SULFATE SOIL INVESTIGATION

EAST POINT RISING SEWER MAIN, EAST POINT, NT

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1	13 September 2011	Jemma Dyer	JAD	Andrew Williams	AW

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REPORT ON ACID SULFATE SOIL INVESTIGATION EAST POINT RISING SEWER MAIN, EAST POINT, NT

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Our Ref U32527

Contact Jemma Dyer / Andrew Williams

13 September 2011

1. LETTER OF TRANSMITTAL

Power Water Corporation
GPO Box 4150
Darwin
NT 0800

Attention: Skefos Tsoukalis

REPORT ON ACID SULFATE SOIL INVESTIGATION AT EAST POINT RISING SEWER MAIN, EAST POINT, NT

Dear Sir,

This report presents the findings of the Geotechnical and Acid Sulfate Soil (ASS) investigation undertaken in August 2011 for the East Point rising sewer main, East Point, NT.

The findings of this investigation are as follows:

- The section of the alignment investigated is located across a low lying transitional area between dry land and a semi-tidal mangrove landscape.
- The subsurface soil conditions generally consisted of an upper layer of fill overlying a clay or sand layer of alluvium/marine sediment. The deeper soils were clay, sand and gravel and are likely to be of residual origin. Extremely to highly weathered rock was encountered in the lowest depth of some boreholes.
- Acid sulfate soil (ASS) was indicated by field screening in six (6) of the sample locations. Chromium suite testing of ten (10) soil samples has confirmed that low levels of ASS are present in four (4) locations across the site.
- Lime treatment of ASS will be required along this section of the alignment as construction techniques are likely to promote acid sulfate production.

Cardno UNG will be pleased to discuss the findings of this report with the project team and provide any additional information you may require.

Yours faithfully,



Andrew Williams
Senior Engineering Geologist
BSc.(Hons), Pg.Dip., CGeol
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Jemma Dyer
Engineering Geologist MS.Env.Mgmt.,
BSc. (Hons) Post.Grad.Cert, AGS
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2. INTRODUCTION

Cardno Ullman & Nolan Geotechnic (NT) Pty Ltd (Cardno UNG) were commissioned by Power and Water Corporation to undertake an acid sulfate soil (ASS) investigation of the subject site at East point, NT ('the site').

The object of the investigation was to assess the proposed development of the site and discuss the likelihood of ASS presence based on a field investigation programme and laboratory test results.

The investigation undertaken included field investigations and laboratory testing in general accordance with the following documentation:

- Australian Standards AS1289 – Methods of Testing Soil for Engineering Purposes
- QASSIT "Guidelines for Acid Sulphate Soil Investigations".

3. SCOPE OF WORK

3.1 GEOTECHNICAL INVESTIGATION

3.1.1 Fieldwork

The field investigation was undertaken August 2011 by undertaking eight (8) boreholes using a combination of hand and machine augers to depths ranging from 0.75 – 4.00m. ASS samples were obtained at 0.25m intervals for each borehole, sealed, double-bagged and placed in cold storage. Following field screening, representative samples were sent to ALS laboratories, a specialist analytical laboratory located in Brisbane, for chromium suite analysis.

The boreholes were sampled and logged on site by an experienced Soil Technician in accordance with AS1726. The locations were numbered by Cardno UNG and are shown in Figure 1, presented in Appendix A at the end of this report. Site photographs and borehole logs are also presented in Appendix A.

All samples were transported to the Cardno UNG Darwin laboratory upon completion of the fieldwork.

3.2 Laboratory Testing

Field pH screening was undertaken in accordance with QASSIT guidelines, at 250mm intervals to depths ranging from 0.75m to 4.00m for all boreholes. A total of ten (10) samples were sent to ALS Laboratories in Brisbane for Chromium Suite testing. Laboratory testing was undertaken in accordance with QASSIT guidelines. Field screening results are presented in Section 5 and discussed in Section 6 of this report. ALS Laboratory results are presented in Appendix B.

4. SITE DESCRIPTION

The proposed rising main alignment runs from the existing Ludmilla Sewage Treatment Plant the northern edge of East Point approximately 3.0km to the northwest. The majority of the alignment traverses near level terrain of clear grassland and relatively open pockets of bush and scrub.

The investigation site is an approximate 350m section of the alignment closest to the Ludmilla sewage treatment plant. The area runs through relatively dense and mature bush and transitional mangrove environment extending from Ludmilla Creek. This area is particularly low relief and sections are likely to become inundated during king tides and storm surge events.

5. GROUND CONDITIONS

5.1 Regional Geology

The solid geology of the subject area is described in the Northern Territory Geological Survey (NTGS) 1:100,000 Geological Map Series titled DARWIN and associated map, Sheet 5073.

The predominant rock member in the immediate area is the horizontally bedded, Darwin Member of the Bathurst Island Formation. This member underlies most of Darwin City and extensively areas to the north, due the very gradual dipping strata (~0.1 degrees) to the north. The formation consists of radiolarian claystone, sandy claystone, glauconitic sandstone and a basal conglomerate deposited in the Cretaceous under a shallow marine or paralic, low energy environment.

During the Late Cretaceous and Early Tertiary, alteration of the original smectitic clays to kaolinite, has occurred along with redistribution of silica and iron oxides. This has resulted in the formation of a duracrust, common in the upper few meters, known locally as porcellanite. Porcellanite can be best seen in exposures outcropping along the sea-cliff edges around the northern tip of East Point.

Rocky outcrops are generally scarce in the inland areas, often covered by a thin layer of Quaternary alluvium or colluvium or capped by laterite and saprolite soils, formed from the weathering of the bedrock.

5.2 Subsurface Conditions

The subsurface soil conditions at the site generally consisted of a surface layer of topsoil and fill overlying natural alluvial/marine deposits and residual soil/extremely weathered rock.

The fill ranged in depth from 0.35 – 0.50m in BH3 and BH5 to 1.25 – 1.50m in BH5 and BH6. The alluvial/marine deposit was generally a dark coloured clay or sand ranging in thickness from 0.25 – 1.25m thick. The underlying clay and gravelly soil is likely to be of residual in nature and extended through to the base of a number of boreholes. BH1 and BH2 encountered extremely to highly weathered rock at depths of 2.6 and 2.4m and BH3 and BH5 (machine auger) encountered a very dense layer of that could not be penetrated with the auger. This layer is likely to be the porcellanite bedrock.

5.3 Groundwater

Groundwater was only encountered in BH1 and BH2 at a depth of 1.0 and 1.25m. Groundwater is however likely to fluctuate significantly due to both seasonal and tidal influences. Groundwater is also likely to occur as a perched water table over the less permeable (clay) layers. Both surface and groundwater movements are likely to tend northwest towards Ludmilla Creek.

5.4 ASS Field Screening

Table 1 summarises the results of ASS field screening.

Table 1: ASS field screening results

Sample ID	Depth (m)	pH _{KCL}	pH _{ox}	Reaction Description
BH1	0.00-0.25	5.84	3.88	Slight
	0.25-0.50	5.86	4.53	Nil
	0.50-0.75	5.93	4.50	Slight
	0.75-1.00	5.63	4.83	Moderate
	1.00-1.25	5.81	4.62	Slight
	1.25-1.50	5.82	4.20	Slight
	1.50-1.75	5.82	4.75	Nil
	2.00-2.25	5.97	4.72	Nil
	2.25-2.50	5.77	4.66	Nil
	2.50-2.75	5.75	4.86	Nil
	2.75-3.00	6.00	4.80	Nil
	3.00-3.25	5.46	4.77	Nil
	3.25-3.50	5.63	4.63	Nil
	3.50-3.75	5.47	4.72	Nil
	3.75-4.0	5.88	4.84	Nil

Sample ID	Depth (m)	pH _{KCL}	pH _{ox}	Reaction Description
BH2	0.00-0.25	5.90	4.41	Slight
	0.25-0.50	4.70	4.53	Nil
	0.50-0.75	4.77	4.52	Nil
	0.75-1.00	4.90	4.75	Slight
	1.00-1.25	4.80	4.38	Slight
	1.25-1.50	4.95	4.76	Slight
	1.50-1.75	5.02	4.07	Nil
	1.75-2.00	5.60	4.68	Nil
	2.00-2.25	5.57	4.75	Nil
	2.25-2.50	4.79	4.44	Nil
	2.50-2.75	4.81	4.41	Nil
	2.75-3.00	4.58	4.45	Nil
	3.00-3.25	4.61	4.32	Slight
	3.25-3.50	5.97	4.66	Moderate
	3.50-3.75	5.59	4.58	High
	3.75-4.00	5.76	5.18	High

BH3	0.00-0.25	6.12	4.78	Nil
	0.25-0.50	5.64	4.65	Slight
	0.50-0.75	6.06	4.65	Nil
	0.75-1.00	5.79	4.73	Slight
	1.00-1.25	5.80	4.54	Moderate
	1.25-1.50	5.51	4.60	Nil
	1.50-1.75	5.52	4.59	Slight
	1.75-2.00	5.48	4.58	Slight

BH4	0.00-0.25	4.97	4.65	Nil
	0.25-0.50	4.21	4.66	Nil
	0.50-0.75	6.03	4.67	Nil

BH5	0.00-0.25	5.75	4.84	Nil
	0.25-0.50	5.84	4.87	Slight
	0.50-0.75	5.86	4.83	Nil
	0.75-1.00	5.87	4.49	Nil
	1.00-1.25	5.78	4.48	Slight
	1.25-1.50	6.22	4.84	Nil
	1.50-1.75	5.63	4.82	Nil
	1.75-2.00	5.81	4.86	Nil
	2.00-2.25	5.67	4.85	Slight
	2.25-2.50	5.79	5.12	Nil
	2.50-2.75	6.12	5.22	Nil

Sample ID	Depth (m)	pH _{KCL}	pH _{ox}	Reaction Description
BH6	0.00-0.25	6.06	5.07	Nil
	0.25-0.50	6.13	5.00	Nil
	0.50-0.75	6.02	4.86	Nil
	0.75-1.00	6.31	4.88	Slight
	1.00-1.25	6.69	5.01	Slight
	1.25-1.50	6.16	4.95	Nil
	1.50-1.75	6.86	4.90	Slight
	1.75-2.00	6.09	4.81	Slight
	2.00-2.25	5.95	4.80	Slight
	2.25-2.50	6.47	4.37	Slight
	2.50-2.75	5.87	4.89	Nil
	2.75-3.00	5.99	4.68	Slight
	3.00-3.25	5.60	4.71	Nil
	3.25-3.50	5.67	4.68	Slight
	3.35-3.75	6.33	5.31	Nil
	3.75-4.00	5.57	4.49	Slight

BH7	0.00-0.25	4.68	4.25	Nil
	0.25-0.50	5.24	4.28	Nil
	0.50-0.75	5.35	4.53	Nil

BH8	0.00-0.25	4.45	4.45	Slight
	0.25-0.50	5.31	4.52	Slight
	0.50-0.75	4.90	4.11	Slight
	0.75-1.00	3.86	3.55	Slight
	1.00-1.25	4.75	3.65	Slight
	1.25-1.50	4.27	2.39	Moderate
	1.50-1.75	3.92	1.55	Moderate
	1.75-2.00	3.59	1.34	High
	2.00-2.25	3.53	3.28	Slight
	2.25-2.50	4.11	3.95	Slight
	2.50-2.75	4.55	4.56	Nil
	2.75-3.00	4.44	4.86	Nil
	3.00-3.25	4.63	4.67	Nil
	3.25-3.50	4.61	4.34	Slight
	3.50-3.75	4.90	4.59	Slight
	3.75-4.00	4.24	4.56	Slight

6. ACID SULFATE SOIL ASSESSMENT AND DISCUSSION

ASS was indicated in the field screening of samples collected from six (6) of the eight (8) investigation locations. Further laboratory testing was undertaken on ten (10) of the samples taken for field testing, to confirm the presence of ASS. Four (4) test locations were confirmed as having ASS present. Laboratory and the theoretical net acidity for these ten samples have been calculated and are shown in Table 2 below.

AASS is generally indicated by a pH_{KCL} screening results showing a pH of less than 4 and a TAA (m/t) of greater than 18. Potential Acid Sulfate Soils (PASS) are generally indicated by a pH_{ox} result less than 3 or one that is significantly lower than the pH_{KCL} result. Based on these guidelines, the results show the presence of both AASS and PASS at various locations and depth along this section of the alignment.

Consequently, management of these potentially acid producing soils will be required if disturbance to them is likely to occur. The most likely form of disturbance is via excavation of the subsoils at the time of foundation construction. Heavy machinery used in the construction process may cause gouging and turning of the subsoils and therefore may also contribute to the production of oxidation of ASS.

If these disturbances during construction works are envisaged, treatment of subsoils with lime will be required. Estimated liming rates are presented in Table 2. The treatment process should be specified in a ASS Management Plan, compiled for this site, separate from this report.

Table 2: Summary of Acid Sulfate Test Results

Investigation	Borehole	Depth (m)	pH KCl	TAA m/t	s-TAA %S	S Cr %S	s-NAS %S	ABA (1) Net Acid %S	Liming Rates (kg/T)	Liming Rates (kg/m ³)
U&N 2011	BH1	0.0-0.25	4.80	27	0.04	0.04	n/a	0.05	2.00	4.0
U&N 2011	BH1	0.75-1.00	5.10	12	0.02	0.02	n/a	0.02	1.00	1.6
U&N 2011	BH2	3.25-3.50	5.60	5	0.01	0.02	n/a	0.02	<1	1.6
U&N 2011	BH2	3.75-4.00	6.30	2	0.00	0.02	n/a	0.02	<1	1.6
U&N 2011	BH5	1.00-1.25	7.60	2	0.00	0.02	n/a	0.02	<1	1.6
U&N 2011	BH5	2.00-2.25	6.30	2	0.00	0.02	n/a	0.02	<1	1.6
U&N 2011	BH6	1.75-2.00	6.80	2	0.00	0.02	n/a	0.03	1.00	2.4
U&N 2011	BH6	1.75-3.00	6.60	2	0.00	0.02	n/a	0.02	<1	1.6
U&N 2011	BH8	1.25-1.50	4.50	32	0.05	0.05	n/a	0.10	4.00	8.0
U&N 2011	BH8	1.75-2.00	4.70	24	0.04	0.04	n/a	0.04	2.00	3.2

7. LIMITATIONS

Geotechnical and environmental services are provided by Cardno Ullman & Nolan Geotechnic Pty Ltd (Cardno UNG) in accordance with generally accepted professional engineering and geologic practice in the area where these services are rendered. The client acknowledges that the present standard in the engineering, geologic and environmental profession does not include a guarantee of perfection, and no other warranty, expressed or implied, is extended by Cardno UNG.

It is the reader's responsibility to verify the correct interpretation and intention of the recommendations presented herein. Cardno UNG assumes no responsibility for misunderstandings or improper interpretations that result in unsatisfactory or unsafe work products. It is the reader's further responsibility to acquire copies of any supplemental reports, addenda or responses to public agency reviews that may supersede recommendations in this report.

The findings presented in this report have been based on the investigation described herein by Cardno UNG. There are always some variations in subsurface conditions across the site, which cannot be fully defined by investigation. It is unlikely that the measurements and values obtained from sampling and testing during the investigation will represent the extreme conditions that may exist within the site. Hence it is recommended that if any ground conditions significantly different to those described in this report are encountered during construction, further advice should be immediately sought from Cardno UNG.

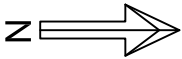
It is recommended that Cardno UNG be commissioned to provide a review of design and documentation to confirm that the intents of the geotechnical and environmental report are properly reflected in the designs.

This report has been prepared specifically for Power and Water Corporation. Information contained in this report should not be construed as appropriate for any other purposes or for other users.

We appreciate this opportunity to be of service. Please contact Cardno UNG if you have any enquires regarding the findings of this report or if you require further assistance.

APPENDIX A

Site Plan, Borehole Logs, Site Photographs



LEGEND



Borehole locations

Proposed alignment (approximate)

Drawn by
B. PARRY

Checked by
A. WILLIAMS

Date
30.8.11

Date
30.8.11

32527-1B

Cardno
Ullman & Nolan
Geotechnic Pty Ltd
76 Bedford Road, Waverley, NT 0600
Phone: (08) 86344633 Fax: (08) 86344659

CLIENT: POWER WATER CORPORATION

JOB NO: U32527

PROJECT: ASS Investigation, East Point Rising Main

LOCATION: Ludmilla STP - East Point

SCALE at A3
NOT TO SCALE

DRAWING No.
Fig. 1

CLIENT: Power & Water Corporation
PROJECT: East Point Rising Sewer Main
LOCATION: East Point, Darwin, NT
UN JOB NO: U32527
LOGGED BY: GC DATE: 11-8-11
REPORT ON: Descriptive Borehole Logs
MACHINERY: IH3100 Drill Rig/Hand Auger

BOREHOLE NO	DEPTH (m)	MATERIAL DESCRIPTION			
BH1 Machine Auger	0.25-0.55	Clayey Sand ; very dark brown, fine to coarse grained, moist.			
		MPS 10	LL 40	P75 40	(SC)
	0.55-1.00	Sandy Clayey Gravel ; yellow brown, mottled red, fine to medium grained, sub angular to sub rounded, sand is fine to coarse grained, moist to wet. WATER TABLE AT 1.0m			
		MPS 20	LL 40	P75 35	(GC)
	1.00-2.15	Sandy Gravelly Clay ; brown, gravel is fine to medium grained, sub angular to sub rounded, sand is fine to coarse grained, wet.			
		MPS 15	LL 50	P75 45	(CI)
	2.15-2.60	Sandy Clay ; pale grey, mottled red brown and pale blue, wet.			
		MPS 10	LL 40	P75 70	(CI)
	2.60-4.00 Borehole Terminated at 4.0m	Extremely/Highly Weathered Rock ; pale yellow and grey, clayey, gravelly sand.			
		MPS 20	LL 30	P75 20	(GC)

BH2 Machine Auger	0.00-0.50	Clayey Sandy Gravel; dark brown, fine to medium grained, sub angular to sub rounded, sand is fine to coarse grained, dry to moist. TOPSOIL/FILL			
		MPS 10	LL 35	P75 20	(GC)
	0.50-1.25	Sandy Clay; brown, mottled grey and red, sand is fine to coarse grained, with gravel, dry to moist.			
		WATER TABLE AT 1.25m			
		MPS 4	LL 45	P75 60	(CI)
	1.25-1.75	Clay; red, mottled orange, with sand and gravel, dry to moist.			
		MPS 6	LL 50	P75 75	(CI)
	1.75-2.40	Gravelly Sandy Clay; red orange, sand is fine to coarse grained, gravel is fine grained, sub angular to sub rounded, moist.			
		MPS 10	LL 55	P75 55	(CH)
	2.40-4.00 Borehole Terminated at 4.0m	Extremely/Highly Weathered Rock; pale yellow, brown and red, clayey, gravelly sand, dry to moist.			

BH3 Machine Auger	0.00-0.35	Sandy Clayey Gravel; orange brown, fine to medium grained, sub angular to sub rounded, sand is fine to coarse grained, dry to moist. FILL			
		MPS 10	LL 35	P75 40	(GC)
	0.35-1.75	Sandy Clay; grey, sand is fine to coarse grained, moist to wet.			
		MPS 2	LL 45	P75 65	(CI)
	1.75-2.00 Borehole Refused at 2.0m	Sandy Clayey Gravel; red brown, mottled grey, fine grained, sub angular to sub rounded, sand is fine to coarse grained, dry to moist.			
		MPS 15	LL 30	P75 35	(GC)

BH4 Hand Auger	0.00-0.40	Sandy Clay; brown, sand is fine to coarse grained, moist to wet.			
		MPS 15	LL 30	P75 20	(SC)
	0.40-0.75	Gravelly Sandy Clay; red brown, sand is fine to coarse grained, gravel is fine grained, sub angular to sub rounded, wet.			
	Borehole refused at 0.75m	MPS 10	LL 35	P75 20	(CI)

BH5 Machine Auger	0.00-1.25	Clayey Sandy Gravel; brown, fine grained, sub angular to sub rounded, sand is fine to coarse grained, dry. FILL			
		MPS 30	LL 30	P75 20	(GC)
	1.25-2.00	Gravelly Sandy Clay; brown, sand is fine to coarse grained, gravel is fine grained, sub angular to sub rounded, moist to wet.			
		MPS 5	LL 35	P75 50	(CI)
	2.00-2.75 Borehole Refused at 2.75m	Clayey Sandy Gravel; red brown, mottled grey, fine grained, angular to sub angular, sand is fine to coarse grained, moist.			
		MPS 10	LL 30	P75 20	(GC)

BH6 Machine Auger	0.00-1.50	Clayey Sandy Gravel; brown, fine grained, sub angular to sub rounded, sand is fine to coarse grained, dry. FILL			
		MPS 30	LL 30	P75 20	(GC)
	1.50-1.75	Gravelly Sandy Clay; dark grey brown, sand is fine to coarse grained, gravel is fine grained, sub angular to sub rounded, moist.			
		MPS 10	LL 50	P75 50	(CI)
	1.75-2.25	Sandy Clay; grey, sand is fine to coarse grained, moist.			
		MPS 2	LL 60	P75 60	(CH)
	2.25-3.00	Clayey Sandy Gravel; red brown, mottled grey, fine to medium grained, angular to sub angular, sand is fine to coarse grained, moist.			
		MPS 10	LL 30	P75 20	(GC)
	3.00-4.00 Borehole Refused at 2.75m	Gravelly Sandy Clay; dark brown, sand is fine to coarse grained, gravel is fine to coarse grained, sub angular to sub rounded, moist.			
		MPS 30	LL 40	P75 45	(CI)

BH7	0.00-0.50	Gravelly Silty Sand; brown, fine to coarse grained, gravel is fine to medium grained, sub angular to sub rounded, loose, moist to wet. FILL/COLLIVIUUM			
		MPS 15	LL 25	P75 30	(SM)
	0.50-0.75 Borehole Refusal 0.7m	Clay; blue brown, mottled brown, moist to wet. ALLUVIUM/MARINE			
		MPS 10	LL 60	P75 85	(CH)

BH8 Machine Auger	0.00-0.50	Clayey Sandy Gravel; dark brown, fine to medium grained, sub angular to sub rounded, sand is fine to coarse grained, dry to moist. TOPSOIL/FILL			
		MPS 10	LL 35	P75 20	(GC)
	0.50-1.00	Clay; brown orange, with sand, dry to moist.			
		MPS 2	LL 35	P75 80	(CI)
	1.00-2.25	Clay; brown, mottled red grey, moist to wet. WATER TABLE AT 1.25m			
		MPS 5	LL 40	P75 90	(CI)
	2.25-3.25	Clay; grey red, dry to moist.			
		MPS 2	LL 45	P75 95	(CI)
	3.25-4.00 Borehole Terminated at 4.0m	Gravelly Sandy Clay; grey orange, sand is fine to coarse grained gravel is fine to medium grained, sub angular to sub rounded, dry to moist.			

Checked By:



Date: 12/9/11

By visual assessment

MPS Maximum Particle Size
LL Liquid Limit
P75 Percentage of material passing 0.075mm sieve

Site Photographs



Photo 1: looking west across the open drain/creek flowing across the alignment between BH1 and BH8



Photo 2: Mature bush in the area of BH2



Photo 3: low lying area at the location of BH7

APPENDIX B

ALS Laboratory Test Results



Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: EB1116404	Page	: 1 of 4
Client	: CARDNO ULLMAN & NOLAN GEOTECHNIC PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MR BEN PARRY	Contact	: Customer Services
Address	: PO BOX 39623 WINNELLI NT, AUSTRALIA 0821	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: ben.parry@cardno.com.au	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 08 89844983	Telephone	: +61 7 3243 7222
Facsimile	: +61 08 89844659	Facsimile	: +61 7 3243 7218
Project	: U32527	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: UN 1503	Date Samples Received	: 16-AUG-2011
C-O-C number	: ----	Issue Date	: 25-AUG-2011
Sampler	: GC	No. of samples received	: 10
Site	: East Point	No. of samples analysed	: 10
Quote number	: EN/024/10		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Myles.Clark	Acid Sulfate Soils Supervisor	Brisbane Acid Sulphate Soils

Environmental Division Brisbane
Part of the **ALS Laboratory Group**

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A Campbell Brothers Limited Company



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

- **ASS: EA033 (CRS Suite):** Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO_3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m³ in-situ soil', multiply 'reported results' x 'wet bulk density of soil in t/m³'.
- **ASS: EA033 (CRS Suite):** Retained Acidity not required because pH KCl greater than or equal to 4.5



Analytical Results

Sub-Matrix: SOIL

Client sample ID

Client sampling date / time

Compound	CAS Number	LOR	Unit	BH1:0-0.25	BH1:0.75-1.00	BH2:3.25-3.50	BH5:1.00-1.25	BH5:2.00-2.25
				[15-AUG-2011]	[15-AUG-2011]	[15-AUG-2011]	[15-AUG-2011]	[15-AUG-2011]
				EB1116404-001	EB1116404-002	EB1116404-003	EB1116404-004	EB1116404-005
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	4.8	5.1	5.6	7.6	6.3
Titratable Actual Acidity (23F)	----	2	mole H+ / t	27	12	5	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	0.04	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	0.006	<0.005	0.005	<0.005	0.005
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	<10	<10	<10	<10
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	----	----	----	0.97	----
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	----	----	----	194	----
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	----	----	----	0.31	----
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	1.5	1.5
Net Acidity (sulfur units)	----	0.02	% S	0.05	0.02	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	31	15	<10	<10	<10
Liming Rate	----	1	kg CaCO3/t	2	1	<1	<1	<1



Analytical Results

Sub-Matrix: SOIL

Client sample ID

Client sampling date / time

Compound	CAS Number	LOR	Unit	BH6:1.75-2.00	BH6:1.75-3.00	BH8:1.25-1.50	BH8:1.75-2.00	BH Z:3.75-4.00
				[15-AUG-2011]	[15-AUG-2011]	[15-AUG-2011]	[15-AUG-2011]	[15-AUG-2011]
				EB1116404-006	EB1116404-007	EB1116404-008	EB1116404-009	EB1116404-010
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	6.8	6.6	4.5	4.7	6.3
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	32	24	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.05	0.04	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.005	% S	0.065	<0.005	0.046	0.005	0.006
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	41	<10	28	<10	<10
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	0.18	0.15	----	----	----
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	36	30	----	----	----
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	0.06	0.05	----	----	----
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	1.5	1.5
Net Acidity (sulfur units)	----	0.02	% S	0.03	<0.02	0.10	0.04	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	17	<10	60	27	<10
Liming Rate	----	1	kg CaCO3/t	1	<1	4	2	<1



Environmental Division

QUALITY CONTROL REPORT

Work Order	: EB1116404	Page	: 1 of 5
Client	: CARDNO ULLMAN & NOLAN GEOTECHNIC PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MR BEN PARRY	Contact	: Customer Services
Address	: PO BOX 39623 WINNELLI NT, AUSTRALIA 0821	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: ben.parry@cardno.com.au	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 08 89844983	Telephone	: +61 7 3243 7222
Facsimile	: +61 08 89844659	Facsimile	: +61 7 3243 7218
Project	: U32527	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: East Point	Date Samples Received	: 16-AUG-2011
C-O-C number	: ----	Issue Date	: 25-AUG-2011
Sampler	: GC	No. of samples received	: 10
Order number	: UN 1503	No. of samples analysed	: 10
Quote number	: EN/024/10		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits



WORLD RECOGNISED
ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in
accordance with NATA
accreditation requirements.

Accredited for compliance with
ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

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Myles.Clark	Acid Sulfate Soils Supervisor	Brisbane Acid Sulphate Soils

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Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key :
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
= Indicates failed QC



Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA033-A: Actual Acidity (QC Lot: 1921945)									
EB1116404-001	BH1:0-0.25	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	0.04	0.04	0.0	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	27	28	0.0	0% - 50%
		EA033: pH KCl (23A)	----	0.1	pH Unit	4.8	4.8	0.0	0% - 20%
EB1116506-001	Anonymous	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.0	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	0.0	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	8.6	8.6	0.0	0% - 20%
EA033-B: Potential Acidity (QC Lot: 1921945)									
EB1116404-001	BH1:0-0.25	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	0.006	0.006	0.0	No Limit
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	<10	0.0	No Limit
EB1116506-001	Anonymous	EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	<0.005	0.0	No Limit
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	<10	0.0	No Limit
EA033-C: Acid Neutralising Capacity (QC Lot: 1921945)									
EB1116506-001	Anonymous	EA033: Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	1.04	1.15	9.3	0% - 20%
		EA033: sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	0.33	0.37	9.3	0% - 20%
		EA033: acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	209	229	9.3	0% - 20%



Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result			LCS	Low
EA033-A: Actual Acidity (QCLot: 1921945)								
EA033: pH KCl (23A)	----	0.1	pH Unit	----	4.5 pH Unit	100	93	120
EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	30 mole H+ / t	94.7	93	120
EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	----	----	----	----
EA033-B: Potential Acidity (QCLot: 1921945)								
EA033: Chromium Reducible Sulfur (22B)	----	0.005	% S	<0.005	.28 % S	84.1	80	120
EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	----	----	----	----
EA033-C: Acid Neutralising Capacity (QCLot: 1921945)								
EA033: Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	<0.01	10 % CaCO3	102	89	111
EA033: acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	<10	----	----	----	----
EA033: sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	<0.01	----	----	----	----



Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) Results are required to be reported.**