ACID SULFATE SOILS,

BAJOOL – PORT ALMA AREA,

CENTRAL QUEENSLAND COAST

D J Ross

Queensland Government
Natural Resources and Water

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Department of Natural Resources and Water
PO Box 1762
ROCKHAMPTON QLD 4700

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Summary

Acid sulfate soil mapping has been undertaken at 1:50 000 scale for a section of the Fitzroy River lower estuary from Bajool to Port Alma. The mapping identifies areas of both actual acid sulfate soils and potential acid sulfate soils and their depth of occurrence. The land containing acid sulfate soils occurs mainly within the tidal zone with an elevation of less than 5m Australian Height Datum.

Within the Bajool – Port Alma survey area, there are 6,908.3 ha of land mapped with acid sulfate soils. Actual acid sulfate soils total 1,325 ha, and potential acid sulfate soils 5,583.3 ha. A further 3,253.2 ha of disturbed land, and land with limited field assessment are likely to contain acid sulfate soils.

Descriptions of the acid sulfate soil map units are presented in this report. Chemical data for selected depth samples are appended. Sample site locations and the distribution of acid sulfate soils are illustrated on the accompanying Acid Sulfate Soils map.

A map presenting acid sulfate soil hazard for the area has also been included. This map is an assessment of the acid sulfate soil mapping and chemical data in which land is classified into four classes of acid generation potential. The four classes are very low, low, moderate and high. The distribution of soils with potential for acid generation is shown on the Acid Sulfate Hazard map.

The acid sulfate soils are dominantly heavy clay sediments, and saturated with a shallow or perched watertable. Actual acid sulfate soils are greyish brown in colour with pale yellow mottles overlying grey to greenish grey substrate materials with some organic matter. Potential acid sulfate soils are typically greenish grey to dark grey in colour with some organic materials.

Fifty-two percent of the area assessed with actual and potential acid sulfate soils has acid sulfate soil layers within 1 m depth from the soil surface. Layers of moderate acid generation potential occur within 1m depth from the soil surface over much of the area.

Oxidisable sulfur levels of up to 3.5% and potential acidities up to 2,529 mol H^+/t were recorded on a supratidal flat. At slightly lower elevations, the intertidal flats have up to 2.3% oxidisable sulfur and potential acidities to 1,396 mol H^+/t. These levels are lower than the levels previously recorded for survey areas for the southern portion of the Central Queensland coast.

Six piezometers or shallow groundwater monitoring bores were installed to determine the characteristics of the shallow groundwater draining into the estuary. Field results indicate very low to low levels of dissolved oxygen during the latter part of the sampling period, and elevated electrical conductivity readings in all of the standing waters of the bores.

1. Introduction

A mapping project to identify the extent of acid sulfate soils at six coastal locations in Central Queensland has been initiated by the Fitzroy Basin Association, Mackay Whitsunday Natural Resource Management Group, and the Department of Natural Resources and Water (NRW) with funding support from the Natural Heritage Trust (NHT). Priority areas for mapping are centred around the Rockhampton and Mackay districts. As well as providing substantial in kind support, NRW was contracted to assist in identifying areas for mapping, undertaking field surveys and to provide laboratory analysis of soil and water samples.

The Bajool - Port Alma area is the second of three priority areas to be mapped along the southern Central Queensland coast. It is situated in the lower Fitzroy River estuary approximately 40 km by road south of Rockhampton (Figure 1). The survey area is largely characterised by saltpans, contains extensive saltworks, and the port facilities for Rockhampton City. The survey area is approximately 10,200 ha in area.

Reconnaissance sampling of acid sulfate soils along the southern part of the Central Queensland coast (Ross 2002) had identified acid sulfate soils at several locations on the lower Fitzroy River floodplain and estuary. Fish kills occur occasionally in local creeks draining into the estuary and it is unknown if these are related to acid sulfate soil presence or disturbance. A major expansion of saltworks has been proposed within the survey area. This mapping project provides a representative area of acid sulfate soil mapping for the lower Fitzroy River estuary. It has been undertaken at 1:50 000 scale and represents a medium intensity survey with the maps and report intended for planning purposes. Map unit description and chemical data from laboratory analyses are presented in this report.

Acid sulfate soils (ASS) are soils or sediments containing sulfides (primarily pyrite) or an acid producing layer as the result of the oxidation of sulfides. They commonly occur on tidal land and low-lying very poorly drained coastal land at elevations less than 5m AHD (Australian Height Datum). Excavating soil or sediment, extracting groundwater or filling land may cause disturbance of acid sulfate soils. When exposed to air, sulfides oxidise to produce sulfuric acid. Disturbed land can release acid, aluminium, iron and heavy metals into drainage waters affecting aquatic plants and animals. Concrete and steel infrastructure including pipes, foundations and bridges are susceptible to acidic corrosion leading to accelerated structural failure (Ahern *et al*. 1988, Powell and Martins 2005). Other potential impacts include the deoxygenation of waterways (Bush *et al*. 2004) and the excess iron stimulating blooms of cyanobacteria such as *Lyngbya majuscula* or fireweed.

Both actual acid sulfate soil (AASS) and potential acid sulfate soils (PASS) occur throughout the survey area. AASS are soils or sediments containing highly acidic soil horizons or layers caused by the oxidation of soil materials that are rich in iron sulfides, primarily pyrite. This oxidation produces hydrogen ions in excess of the sediments capacity to neutralise the acidity, resulting in soils or sediments of pH 4 or less. PASS are soils or sediment containing iron sulfides or sulfidic materials that have not been exposed to air and oxidised. The field pH of these soils or sediment in there undisturbed state is pH 4 or more, and may be neutral or slightly alkaline (Anon 2002).

Figure 1. Location of the survey area.

2. Survey Area

The lower Fitzroy River estuary from Port Alma to Bajool consists mainly of bare saltpan and mangrove mudflat with occasional areas of slightly elevated marine couch flat and low lying plains. Saltworks occupy a substantial area of the saltpan at Port Alma and Bajool. Mangrove communities are restricted to the tidal creek banks and channels extending into the saltpan. Grey and river mangroves are common with the red mangrove mostly found in tidal channels. Landward of the tidal zone lies gently sloping alluvial plains with remnant blue-gum, belah or gum-topped box communities.

Broad-scale geological mapping of the survey area has been compiled by Blake *et al*. (2001). Most of the sulfidic sediments assessed in this investigation occur in Quaternary (Holocene) estuarine mud and sand deposits in saltpans and mangrove mudflats at elevations <5m AHD. They also occur in clay sediments of an area mapped as the low terrace of Inkerman and Eight Mile Creeks, and beneath elevated areas of Fitzroy River floodplain alluvium. The only outcrop of hard rock observed in the survey area occurs immediately north of the meander bend of Raglan Creek at Port Alma.

Recent studies and sediment dating (Brooke *et al*.; Bostock *et al*. 2006) indicate the Fitzroy River estuary prograded to its present position in southern Keppel Bay about 6,000 years ago. A relatively thick layer (>4m) of clay sediment has generally been deposited over channel/marine sands. The current estuarine floodplain has little accommodation space for further sediment deposition, and relatively little sediment appears to be accumulating in Keppel Bay. Tidal creeks, mangrove areas and the estuary mouth are areas where current sediment accumulation occurs (Brooke *et al*. 2006).

Bajool - Port Alma is the major production area of solar evaporated salt in Queensland. Sea water is used for most of the current salt production and has largely replaced the pumping of brine from groundwater sources. Port Alma, the ocean port for the city of Rockhampton, currently imports ammonium nitrate, explosives and general cargo. Exports include frozen beef, tallow, and explosives (Anon 2006). Recreational fishing in the streams and channels of the Fitzroy estuary is a significant land use activity.

3. Methods

Sites for description and assessment were selected using a free survey technique (Reid 1988) with the aid of 1:25 000 scale colour aerial photographs. The accompanying acid sulfate soil map has been compiled at 1:50 000 scale and meets the sampling requirements for medium intensity soil mapping. Areas with actual acid sulfate soils (AASS) and potential acid sulfate soils (PASS) at various depths are shown on the map from field observation and interpretation. Acid sulfate soil information collected during a previous survey (Ross 2002) is used in the compilation. The map reference was adopted from the Queensland Acid Sulfate Soil Investigation Team (QASSIT). Site and soil description follows the Australian Soil and Land Survey Field Handbook (McDonald *et al*. 1990).

Most of the saltpan and mangrove mudflat sampling was undertaken using a 60mm diameter stainless steel Dormer gouge auger following removal of the unsaturated heavy clay layer by spade (Figure 2). Saturated clay and / or silt layers were sampled to 1.8m depth or to the depth of hand penetration. Hydraulically driven stainless steel push tubes (75mm diameter) combined with tapered gouge augers (73, 60 and 48mm diameter) and push rods were used to sample sites with clay sediments and vehicle access (Figure 3). Deep sampling was undertaken using Geoprobe® percussion coring equipment (Figure 4).

Field pH tests and Electrical Conductivity (EC) tests were carried out using a WP81 pH-conductivity meter fitted with an IJ44 pH electrode. Field pH (pH_F) and field pH peroxide (pH_{FOX}) measurements were determined at 0.25m intervals or less to the depth of sampling in accordance with QASSIT guidelines (Ahern *et al*. 1998). Dissolved oxygen of piezometer waters was measured using a WP82Y Dissolved Oxygen-Temperature meter fitted with a YSI 5739 field probe. Piezometer installation followed the standards outlined in Minimum Construction Requirements for Water Bores in Australia (Anon 2004).

Following field pH tests, samples for laboratory analysis at each site were selected from the upper depth of occurrence of the acid sulfate soil layer, for confirmation of the depth category for mapping. The lower depth of occurrence of the ASS layer was also usually sampled at each site. More frequent sampling down the soil profile occurred at Geoprobe cored sites. Selected samples were placed in a portable refrigerator / freezer and packed frozen for dispatch to Brisbane by overnight air express.

Selected soil samples from each site were analysed for peroxide oxidisable sulfur, titratable actual acidity and titratable potential acidity using the Suspension Peroxide Oxidation Combined Acidity and Sulfur (SPOCAS) method (Ahern *et al*. 2004). Laboratory results are given in Appendix 1. Selected samples with jarosite or a field pH ≤ 5 were analysed for retained acidity by the Net Acid Soluble Sulfur (S_{NAS}) method (Ahern *et al*. 2004), and the results listed in Appendix 2.


Figure 2. Gouge auger sampling, supratidal flat, Bajool.


Figure 3. Push tube sampling, elevated plain, Pelican Creek.


Figure 4. Geoprobe core sampling, alluvial plain, Twelve Mile Creek.

4. Description of the soil map units

The depth to an actual acid sulfate soil (AASS) layer and/or potential acid sulfate soil (PASS) layer on relatively undisturbed land is shown on the accompanying soil map by an alphanumeric code. The alpha component A refers to an AASS layer, the alpha component S to a PASS layer while the numerical component (for example 0,1,2 etc) refers to the depth at which these layers occur. The alphanumeric codes are used separately (for example A0) or combined (for example A0S0) where the map unit contains AASS layers overlying PASS layers. Where there is varying depth to an acid sulfate soil layer within a mapping unit a forward slash is used, for example S1/S2. The acid sulfate soil map units, of relatively undisturbed land, depict varying depths to the acid sulfate soil layer, are coloured using shades of red and are overlain with yellow dots where AASS is present.

Additional information is provided (by code) for areas of soils with a strongly acid soil layer (pH >4 <5), for example a1S1 and for those containing carbonate materials (subscript N). Other map units indicate ASS on disturbed lands (S_{DL}) or areas where there was limited assessment due to restricted access (S_{LA}). The distribution of land where there is a low probability of ASS occurring below an elevation of 5m AHD (LP) is also shown on the map.

There are 6,908.3 ha of acid sulfate soils mapped within the survey area. This area contains approximately 1,325 ha of land with AASS and 5,583.3 ha of land with PASS (Table 1). Other map units (S_{DL}, S_{LA}) indicating areas of land where ASS are likely to occur, total 3,253.2 ha.

4.1 *Actual Acid Sulfate Soils on Relatively Undisturbed Land*

A0S0 (AASS layer and PASS layer within 0.5m depth)

Two relatively small map unit areas are represented by the code A0S0. One is located adjacent to Casuarina Creek at Port Alma and the other adjacent to Inkerman Creek south of the Bajool saltworks. The landform is an infrequently inundated supratidal flat or bare saltpan. The soils have a thin brown, structured, heavy clay surface horizon overlying a grey or greyish brown clay subsoil of similar thickness with pale yellow jarosite mottles. The underlying PASS layers are dark grey or greenish grey silty medium clays with some organic materials.

Titratable Actual Acidity (TAA) in the AASS layer is low (21 to 51 mol H^+/t) and retained acidity negligible (3 to 9 mol H^+/t). Oxidisable sulfur levels in the potential acid sulfate soil layers range from 0.53 to 1.73%.

A0S1 (AASS layer within 0.5m depth, PASS layer 0.5 to 1m depth)

The A0S1 map units are mostly located adjacent to and south of the Port Alma saltworks, with one mapped area situated east of the Bajool saltworks. These supratidal flats or saltpans appear to be only marginally elevated to the adjoining saltpan with potential acid sulfate soils. The soils have a dark greyish brown to dark brown, massive or moderately structured heavy clay surface horizon overlying grey or greyish brown medium heavy clay subsoils with red mottles, and yellow jarositic mottles. At less than 1m depth the potential acid sulfate soil layers are dark grey or dark greenish grey silty or medium clays with organic fragments.

The levels of oxidisable sulfur in the actual acid sulfate soil layers range from 0.01 to 0.06% and actual acidity from <10 to 19 mol H^+/t. Retained acidity values range from negligible to significant levels (<10 to 369 mol H^+/t). Oxidisable sulfur values in the unoxidised substrate range from 0.8 to 1.83% with corresponding Net Acidities of 391 to 1,180 mol H^+/t.

Table 1. Area of map units.

Map Unit	Map Unit Area (ha)	Percentage of Area Assessed (%)
Actual acid sulfate soils		
A0S0	24.4	0.23
A0S1	280.9	2.73
A0S2	92.2	0.90
A1S2	581.6	5.67
A2	103.8	1.01
A2S2	93.9	0.91
A2S3	24.5	0.24
A3	102.4	1.00
A3S3	21.3	0.21
Total	**1325.0**	**12.90**
Potential acid sulfate soils		
a0S0	62.6	0.61
S0	599.5	5.85
S0/S1	1298.8	12.65
$S0S1_N$	71.1	0.69
a0S1	145.3	1.41
S1	2224.5	21.66
a1S2	429.1	4.18
S2	722.9	7.01
S3	29.5	0.29
Total	**5583.3**	**54.35**
Acid sulfate on undisturbed land		
S_{LA}	274.1	2.67
Acid sulfate on disturbed land		
S_{DL}	2979.1	29.00
Low probability ASS land		
LP	111.4	1.08
Total area	**10272.9**	**100**

A0S2 (AASS layer within 0.5m depth, PASS layer 1 to 2m depth

Supratidal flats adjoining Eight Mile and Twelve Mile creeks and an elevated area of marine couch plain near the south west corner of the survey area (Figure 5) comprise this mapping unit. The soils are strongly acid (field pH <4) throughout. The top 1 to 2m contains a thick layer with jarosite with low levels of actual and peroxide acidity. Seasonally wet areas of the map units have soils with an organic enriched surface horizon.

The grey or dark grey heavy clay subsoils are structured with red, orange and yellow mottles in the upper subsoil (Figure 6) grading to structure-less lower subsoils with some pale yellow jarosite mottles. These are underlain by layers of grey or greenish grey light to medium clays with some organic fragments.

Laboratory analysis of the actual acid sulfate soil layers indicate most are fully oxidised with very low levels of oxidisable sulfur (<0.01 to 0.04%). Actual acidity of these oxidised soils is low (<50 mol H^+/t), while retained acidity is significant (134 to 370 mol H^+/t). Peroxide acidity of the unoxidised layers at depth range from 135 to 1,160 mol H^+/t.

A1S2 (AASS layer 0.5 to 1m depth, PASS layer 1 to 2m depth)

The largest area of actual acid sulfate soils recorded in the survey area (581.6 ha) are represented by this map unit. The landform is dominantly a supratidal flat (bare saltpan) with some slightly elevated areas with marine couch and samphire. Isolated clumps of she-oak (*Casuarina* species) occur throughout the map units adjacent to Inkerman and Raglan creeks. Tidal inundation appears to be less frequent in comparison with adjacent saltpan areas.

The soils are well structured dark brown or black heavy clays grading to greyish brown or grey mottled clays. A moderately thick (0.8m) layer containing jarosite overlies grey to dark grey saturated clays with some organic fragments. Titratable Actual Acidity levels of the layers containing jarosite are low (<50 mol H^+/t). Retained acidity of these layers is generally higher and ranges from <10 to 298 mol H^+/t. Peroxide acidity for the unoxidised substrate is commonly less than 500, with a maximum level of 1,137 mol H^+/t recorded in one map unit.

A2 and **A3** (AASS layer 1 to 3m depth, no PASS layer)

These map unit areas partly form the brine pond walls of the Port Alma saltworks. Much of the elevated plains represented by this unit (Figure 7) contain open woodland of blue gum (*Eucalyptus tereticornis*) with a ground cover of dominantly marine couch. The soils are dark grey to black cracking clays with normal gilgai micro-relief. They overlie a very thick acid layer (2m) of saturated grey heavy clay with jarosite which is underlain by un-saturated mottled clay below 3.5 m depth.

Laboratory results indicate the soil profiles to be fully oxidised with negligible levels of peroxide oxidisable sulfur (<0.01%). Actual acidity and retained acidity of the very thick jarosite layer is low (10 to 33 mol H^+/t) and (6 to 84 mol H^+/t), respectively.

A2S2 and **A2S3** (AASS layer 1 to 2m depth, PASS layer 1 to 3m depth)

Marine couch flats (extratidal flats) with isolated shrubs or blue gum trees represent this map unit. They are situated along the meander plain of Inkerman Creek. The soils are structured dark grey or olive brown heavy clays overlying a thick grey layer (1m) containing jarosite. Fine sandy or silty sediments can be present in the deep substrate.

Oxidisable sulfur levels of the ASS layers containing jarosite are negligible (<0.2%), and actual acidity levels very low (<46 mol H^+/t). Retained acidity levels are low (5 to 143 mol H^+/t). The PASS layers contain moderate (0.45 to 0.8%) levels of oxidisable sulfur in the upper substrate increasing to a maximum level of 1.2% at 2 to 3m depth.

Figure 5. Marine couch plain, A0S2 map unit, Bajool.

Figure 6. AASS layer with jarosite over greenish grey PASS layer.

Figure 7. Elevated plain with blue gum woodland, A3 map unit.

A3S3 (AASS layer and PASS layer 2 to 3m depth)

This small map unit adjoins the Bajool saltworks along the Bajool Port Alma road. The landform is an extratidal flat (marine couch flat) with some bare saltpan areas and samphires. The soils are mottled greyish brown heavy clays with a moderately thick (0.5m) layer containing jarosite below 2m depth. At 4m depth the grey medium clay PASS layer overlies layers of sandy clay with some shell fragments, which in turn is underlain by pale brown single-grain sand.

Oxidisable sulfur levels in the medium clay PASS layer are moderate (0.31 to 0.44%), while the level recorded for the underlying sandy clay at 4.3m depth is low (0.14%). Negligible levels of oxidisable sulfur (<0.01%) are indicated for AASS layer and for the pale brown sand substrate.

4.2 *Potential Acid Sulfate Soils on Relatively Undisturbed Land*

a0S0 (Strongly acidic layer and PASS layer within 0.5m depth)

This single map unit is located within the meander bend of Raglan Creek at Port Alma and immediately north of the low rise of country rock (map code NA). The landform is a supratidal flat (bare saltpan). The soils have a thin brown surface layer and a mottled strongly acidic subsoil layer within 0.5m depth of the soil surface. Field pH of the strongly acidic subsoil layer is 4.2 to 4.4. The underlying greenish grey silty clay substrate is slightly acid to neutral with some organic fragments.

Oxidisable sulfur and actual acidity levels in the strongly acidic layer are negligible (<0.02% and <12 mol H^+/t respectively). Retained acidity measurement of this layer from two of the sampling sites exceeds the Action Criteria (Ahern *et al*. 1998) requiring treatment. Moderate levels of oxidisable sulfur (0.8 to 1.4%) and acid generation potential (305 to 809 mol H^+/t) occur in the greenish grey substrate.

S0 (PASS layer within 0.5m depth)

Two areas comprise this map unit. They are located at Port Alma and within a meander loop of Inkerman Creek at Bajool. The map unit at Port Alma is largely supratidal (bare saltpan) but includes some intertidal areas associated with mangrove mudflats. The Bajool unit is represented by a supratidal flat.

The soils are either dark grey, greenish grey or mottled grey medium to heavy clays with a brown or dark greyish brown surface horizon. Layers with organic materials are present within the saturated sediments below 0.5m depth, particularly at sites with mangrove cover. The levels of oxidisable sulfur range from 0.5 to 2.3%, but are commonly <1% throughout the map unit.

S0/S1 (PASS layer 0 to 1m depth)

This map unit area with varying depth to the PASS layer (0 to 1m), is substantial in size (1,298.8 ha) and represents 12.65% of the area of potential acid sulfate soils. The area is located between the Bajool saltworks and Port Alma, and occupies much of the tidal flats between Inkerman and Casuarina creeks. The landform is largely supratidal flats (bare saltpan) with significant areas of intertidal flats (mangrove mudflat).

The soils near Port Alma, particularly north of the Bajool Port Alma road, generally have lighter textures with layers of light clay overlying layers of fine sandy clay with some shell fragments. The levels of oxidisable sulfur and net acidity in the 0 to 0.5m and 0.5 to 1m depth categories are moderate (0.33 to 1.07% and 219 to 678 mol H^+/t respectively). Below 1m depth negligible levels of net acidity (<10 mol H^+/t) can occur in layers with shell fragments. Fine textured clays elsewhere also generally contain moderate levels of oxidisable sulfur and net acidity (0.31 to1.26%, 214 to 766 mol H^+/t) for the same depth categories, with a higher level (2%, 1300 mol H^+/t) recorded at one sampling site.

S0S1$_N$ (PASS layer within 0.5m depth, PASS layer 0.5 to 1m depth with carbonate materials)

Potential acid sulfate soils occur in the supratidal flat and in the silty clay sediments underlying the shell levee along the bank of Casuarina Creek at Port Alma (Figure 8). The soil profile of the supratidal flat is essentially a grey clay with a brown surface layer. The level of oxidisable sulfur and net acidity is moderate (0.61%, 421 mol H^+/t) at 0.3 to 0.5m depth. Below 0.5m depth there is no measurable potential acidity in the profile and almost sufficient carbonate material to neutralise the level of oxidisable present (0.5%).

The shell levee deposit has weak profile development with an organic enriched, strongly alkaline, layer of brown shell. Below the shell deposit the buried marine clay has a moderate level of oxidisable sulfur (0.6%) and potential acidity (276 mol H^+/t). Lower greenish grey silty clay layers contain up to 0.77% oxidisable sulfur and no measurable potential acidity.

a0S1 (Strongly acidic layer within 0.5m depth, PASS layer 0.5 to 1m depth)

These map units represent supratidal flats (bare saltpans) and are located at Port Alma. The soils have a thin brown surface layer and a mottled strongly acidic subsoil layer within 0.5m depth of the soil surface. Field pH of the strongly acidic subsoil layer ranges from 4.1 to 4.6 units. The underlying dark grey or greenish grey silty clay substrate is slightly acid to neutral with some organic fragments and occasionally coarse shell.

Oxidisable sulfur and actual acidity levels in the strongly acidic layer are negligible (<0.01% and <14 mol H^+/t). Retained acidity measurement of this layer indicates only one site to exceed the Action Criteria (Ahern *et al*. 1998) requiring treatment. Moderate levels of oxidisable sulfur (0.6 to 1.4%) occur throughout the underlying PASS layers.

S1 (PASS layer 0.5 to 1m depth)

The S1 map units extend from Eight Mile Creek at Bajool to Port Alma and make up 21.66% of the area of potential acid sulfate soils. They are mostly associated with supratidal and intertidal flats forming a complex mosaic pattern of saltpan, mangrove areas and tidal channels adjacent to the larger tidal creeks. Relict mangrove channels of Inkerman Creek (Figure 9) and extensive bare saltpans also form the map unit.

The soils have a moderately thick surface layer of brown or dark greyish brown heavy clay overlying a mottled layer of grey or dark grey medium or heavy clay. These layers grade to greenish grey or grey clay sediments. The levels of oxidisable sulfur are moderate (<1%) throughout these map units with a range from 0.26 to 2.56%.

a1S2 (Strongly acid layer 0.5 to 1m depth, PASS layer 1 to 2m depth)

A large supratidal flat west of Twelve Mile Creek with some isolated patches of marine couch and samphire, and a small area of supratidal flat with samphires and mangroves west of the Port Alma saltworks comprise this map unit. The soils are structure-less greyish brown or dark grey heavy clays with a moderately thick (1m) strongly acidic subsoil layer (field pH 4.1 to 4.9). The underlying grey or dark grey PASS layer is also strongly acidic with some organic fragments.

Negligible levels of oxidisable sulfur (<0.02%) and actual acidity (<10 mol H^+/t) are recorded for the surface and subsoil layers. Retained acidity measurement of one selected sample of the strongly acidic subsoil layer was negligible (4 mol H^+/t). At sites where the PASS layer was sampled, the levels of oxidisable sulfur range from low to moderate (0.11 to 0.82%).

S2 (PASS layer 1 to 2m depth)

The S2 map units are scattered throughout the survey area from Eight Mile Creek to the Port Alma saltworks, with the largest unit located east of Twelve Mile Creek. The landform is dominantly a supratidal flat but includes intertidal areas with mangrove cover. The soils are grey, dark greyish brown or dark grey structure-less heavy clays, which were mostly not penetrable by gouge auger below 1.5m depth. Deeper sampling in one of the map units by Geoprobe® percussion coring indicates the PASS layer continues to 5m depth where it overlies greenish grey non-sulfidic clay (Figure 10).

The levels of oxidisable sulfur throughout the map units in the upper PASS layers range from very low to moderate (0.03 to 0.78%), with some sites having no measurable potential acidity. The deeper sampling indicates much higher levels of oxidisable sulfur (1.3 to1.6%) from 2.8 to 4.8m depth, and decreasing to 0.49% at 5m depth.

S3 (PASS layer 2 to 3m depth)

This single map unit located in the south west corner of the survey area consists of an elevated plain and a small area of tidal flat adjacent to Inkerman Creek. The vegetation is dominantly marine couch with patches of samphire. A small clump of blue-gum trees occur within the unit. The soils are well structured greyish brown heavy clays with a black surface layer. Organic fragments are present in the saturated greenish grey PASS layer below 2m depth. Negligible levels of oxidisable sulfur (<0.02%) are recorded for samples to 2m depth. The levels of oxidisable sulfur and net acidity at 2.8 to 3m depth range from 0.77 to 1.03% and 416 to 600 mol H^+/t, respectively.

Figure 8. Shell deposit Casuarina Creek, $S0S1_N$ map unit.

Figure 9. Relict mangrove channel, Inkerman Creek, S1 map unit.

Figure 10. PASS layer overlying non-sulfidic clay, S2 map unit.

4.3 *Acid Sulfate on Relatively Undisturbed Land*

S_{LA} (Limited field assessment and landform indicating ASS)

The S_{LA} map unit contains tidal channels, intertidal flats and supratidal flats indicating the presence of acid sulfate soils. Much of the unit is bounded by Casuarina Creek and pondage banks of the Port Alma saltworks. Limited sampling was undertaken along a narrow intertidal flat with mangrove cover near the eastern boundary of the map unit.

The intertidal flat had acid sulfate soil layers at 0.4 to 0.6m depth with moderate levels of oxidisable sulfur (0.4%), increasing to 1.3% below 1m depth. Sampling from a more elevated tidal creek bank indicates that acid sulfate soil layers occur at greater depth (>1m) with similar levels of oxidisable sulfur (0.5%).

4.4 *Acid Sulfate on Disturbed Land*

S_{DL} (Disturbed land likely to contain acid sulfate soils)

These map units represent the extensive area occupied by saltworks and a small area with port facilities at Port Alma, and total 2,979.1 ha in area. The surrounding landform and nearby occurrence of acid sulfate soils would indicate their likely presence within these disturbed lands. Sampling is restricted to a few locations outside of the salt concentrating ponds (Figure 11).

Deep sampling at the Bajool production plant indicates an actual acid sulfate soil layer with jarosite, within fine sandy sediments from 2.2 to 4.3m depth overlying pale brown coarse sand to 10.8m depth. Negligible levels of oxidisable sulfur (<0.02%) actual and potential acidity (<10 mol H^+/t) are recorded throughout the sediment profile, and for the actual acid sulfate soil layer. The actual acid sulfate soil layer contains a very low level of retained acidity (20 to 46 mol H^+/t) and is almost fully oxidised.

Within this map unit an actual acid sulfate soil layer occurs within the soil surface layer of a tidal drainage channel between embankments at the Port Alma saltworks (Figure 12). The underlying potential acid sulfate soil layers contain variable levels of oxidisable sulfur and shell fragments to 4.8m depth. Net acidity for these layers range from <10 to 535 mol H^+/t.

Sampling on the tidal flat behind the salt stockpile and buildings at Port Alma indicates acid sulfate soils are likely to underlie the port facilities. Moderate levels of oxidisable sulfur (1.3%) and potential acidity (712 mol H^+/t) were found in clay sediment to 2m depth. Shelly sediment at 3m depth contained 0.7% oxidisable sulfur and no measurable potential acidity.

Figure 11. Salt concentrating pond, Port Alma, S_{DL} map unit.

Figure 12. Tidal drainage channel, Port Alma, S_{DL} map unit.

4.5 *Land with a Low Probability of Acid Sulfate Soil Occurrence*

LP (Land predominantly < 5m AHD with low probability of ASS occurrence)

Relatively small areas of alluvial plain and tidal flat comprise this map unit. Most are located in the south west corner of the survey area. The soils associated with the alluvial plains are dark greyish brown or black cracking clays with normal gilgai micro-relief and are non-acid sulfate soils to the depth sampled (3.5m). Acid sulfate soil with 0.2% oxidisable sulfur was recorded in a drainage line in the map unit adjoining Eight Mile Creek, but was too small to separate at the scale of mapping. Dark grey heavy clays occur within the tidal flat areas usually with angular gravels in the substrate below 1.5m depth. The levels of oxidisable sulfur are negligible (< 0.01%) and net acidity (< 10 mol H^+/t) to the depth sampled (2.6m).

5. Water Quality Monitoring

Six piezometers or shallow groundwater monitoring bores were installed to determine the characteristics of the shallow groundwater draining into the estuary (Figure 13). During installation of the six piezometers watertable depth ranged from 0.8 to 3m. Despite the high clay content of the soils and dry conditions over the sampling period, the piezometers have yielded adequate water for sampling. Two piezometers are located within the Twelve Mile Creek Reserve, one along Hourigan Creek and Raglan Creek within the Raglan Racecourse Reserve, and one at Inkerman and Eight Mile Creeks.

The piezometers are installed in acid sulfate soils, two of these soils containing actual acid sulfate soil layers (piezometers D and F). The soil profile at each site has been sampled for a comprehensive chemical analysis to assist in the interpretation of the water quality results. Field testing and water sampling was undertaken on a monthly basis since September 2006. Field tests are pH, Electrical Conductivity (EC) and Dissolved Oxygen (DO).

Field results (Table 2) indicate very low to low dissolved oxygen (1.8 to 12.1% saturation) in all of the standing waters of the bores since November 2006. Slightly acidic water (field pH 5.5 to 5.9) is associated with piezometer F. The waters are brackish or have elevated conductivity readings (27.6 to 116.4 dS/m).

Figure 13. Installation of piezometer F, Eight Mile Creek.

Table 2. Field measurements of shallow groundwater monitoring bores.

Piezometer	Locality	Date sampled	pH	EC (dS/m)	DO (%sat)
A	Hourigan Creek	26-09-06	6.8	33.6	5.3
		27-10-06	6.9	42.5	2.4
		20-11-06	6.8	40.9	3.1
		19-12-06	6.7	49.8	2.2
		5-02-07	6.9	54.1	3.3
		26-02-07	6.8	56.2	2.4
B	Raglan Creek	26-09-06	6.6	32.4	11.7
		27-10-06	6.6	42.3	14.4
		20-11-06	7.0	40.0	12.1
		19-12-06	6.6	50.0	3.3
		17-01-07	6.7	44.3	4.5
		26-02-07	6.7	44.6	3.5
C	Twelve Mile Creek	26-09-06	6.9	28.9	36.1
		27-10-06	6.8	37.2	31.6
		20-11-06	6.7	34.6	11.4
		19-12-06	6.7	37.2	5.8
		5-02-07	6.9	40.8	5.3
		26-02-07	6.7	41.5	4.8
D	Twelve Mile Creek	26-09-06	6.5	27.6	2.5
		27-10-06	6.4	36.3	2.9
		20-11-06	6.5	35.3	3.4
		19-12-06	6.5	38.2	1.8
		5-02-07	6.6	38.1	5.0
		26-02-07	6.7	38.7	3.6
E	Inkerman Creek	26-09-06	6.7	52.2	13.6
		27-10-06	6.7	68.8	11.7
		20-11-06	6.5	60.0	5.1
		19-12-06	6.5	75.8	5.3
		5-02-07	6.7	77.6	6.8
		26-02-07	6.6	74.1	4.2
F	Eight Mile Creek	26-09-06	5.7	82.7	9.0
		27-10-06	5.5	107.3	7.6
		20-11-06	5.5	89.2	5.9
		19-12-06	5.7	115.3	5.0
		5-02-07	5.6	114.1	4.8
		26-02-07	5.9	116.4	5.4

6. Discussion

The acid sulfate soils throughout the survey area generally contain moderate levels of peroxide oxidisable sulfur (<1.5%) and acid generation potential (<1000 mol H^+/t). These levels are significantly lower in comparison with levels recorded in the nearby Narrows area (Ross 2005), and at Gladstone and Yeppoon (Ross 2003, 2004), within similar landforms. Low amounts of organic materials in the soil profiles and the dominance of grey and river mangroves are characteristics of this survey area and may provide an explanation for the lower levels of sulfides in the area.

Since much of the survey area consists of saltpans (supratidal flats), the dominant soil type would normally be expected to be an actual acid sulfate soil as is common on dry tropics saltpans throughout the southern Central Queensland coast. The area occupied by actual acid sulfate soils is 1,325ha or 12.9%. The local watertable is likely to be a significant determinant in preventing the oxidation of sulfides in areas where actual acid sulfate soils are absent. Likewise the high clay content of these soils (70 to 80%) may prevent drying and sulfide oxidation.

The acid sulfate soils of the area are wet with a shallow watertable, and are classified within the Australian Soil Classification (Isbell 1996) as Hydrosols. Sulfidic Hydrosols or potential acid sulfate soils are dominant throughout the survey area. Sulfuric Hydrosols, containing both actual and potential acid sulfate soil layers are associated with some of the supratidal flats (saltpans) and the slightly elevated marine couch flats (extratidal flats). Other soil orders in the survey area overlying acid sulfate soils are Vertosols and Dermosols.

The depth to the acid sulfate soil layer on these tidal flats is less predictable than occurs elsewhere on tidal flats along the southern Central Queensland coast. The intertidal flats or mangrove mudflats contain clay levees along the tidal channels at several locations and are slightly elevated in relation to the adjacent saltpan or supratidal flat. Consequently the depth to the potential acid sulfate soil layer is greater at these locations. The depth to the acid sulfate soil layer on the supratidal flats or saltpans can be quite variable ranging from 0.4 to 1.8m without any surface indicators. This variable depth may be the result of channel infill.

Wind erosion occurs on the extensive areas of bare saltpan or supratidal flat south of Inkerman Creek (Figure 14). With wetting and drying from rainfall or tidal inundation, the resulting fine granular surface layer is susceptible to wind erosion. Some of the wind transported material has formed clay veneers on the saltpans which have been colonised by vegetation over time. The outer elevated margin of the clay veneer enhances water and nutrient retention.

Saltworks in the area commenced operation in 1958 using underground natural brines. It is likely most of the saltworks are situated on former saltpan and mangrove mudflat and contain acid sulfate soils. If acid sulfate soils were disturbed during construction of the pond walls there is currently no evidence of the effects of disturbance around these walls.

Figure 14. Wind erosion, Inkerman Creek.

The Laboratory Methods Guidelines (Ahern *et al*. 2004) use an acid base accounting approach for predicting Net Acidity from sulfide oxidation of acid sulfate soils. For this survey, net acidity (moles H^+/tonne) is calculated as follows and the results listed in Appendix 1:

pH KCL ≥ 6.5, Net Acidity = 623.7 x S_{POS} – (332.7 x CaA + 548.4 x MgA);

pH KCL < 6.5, Net Acidity = 623.7 x S_{POS} + TAA + (467.8 x S_{NAS});

pH KCL < 6.5, Net Acidity = 623.7 x S_{POS} + TAA.

Calculated Net Acidity is generally higher than the measured Titratable Peroxide Acidity and in some samples the difference is substantial. For example, site CQA973 1.6-1.8m depth sample (Appendix 1) has a calculated Net Acidity of 269 mol H^+/t greater than the measured Titratable Peroxide Acidity. The complexity of acid sulfate soil chemistry, and reasons why acidity measured by titration methods are not consistent with acidity predicted from sulfur analysis, are outlined in the Acid Sulfate Soil Laboratory Methods Guidelines (Ahern *et al*. 2004). These differences are possibly due to organic matter and organic acidity effects, or there may be acid neutralising components in the soils other than calcium and magnesium.

Thirty six samples with marked differences between net acidity and titratable peroxide acidity were analysed for chromium reducible sulfur and acid neutralising capacity (Table 3). The chromium reducible sulfur (S_{CR}) results indicate peroxide oxidisable sulfur (S_{POS}) is not elevated by organic sulfur in the selected samples. The acid neutralising capacity (ANC_{BT}) results indicate the presence of other neutralising components in these samples, other than reacted calcium and magnesium determined by the SPOCAS method.

Table 3. Peroxide oxidisable sulfur, chromium reducible sulfur, and acid neutralising capacity for selected depth samples.

Site No	**Depth (m)**	**S_{POS} [1] (%)**	**S_{CR} [2] (%)**	**ANC_{BT} [3] (% $CaCO_3$)**
CQA853	1.6-1.8	0.82	0.87	2.2
CQA854	0.5-0.7	0.72	0.68	2.1
CQA857	1.6-1.8	0.39	0.36	2.0
CQA859	1.6-1.8	1.22	1.19	5.4
CQA861	1.0-1.2	1.08	1.07	2.6
CQA861	1.6-1.8	0.70	0.75	2.3
CQA864	1.6-1.8	0.35	0.37	1.7
CQA881	0.8-1.0	<0.01	<0.02	<0.5
CQA893	0.4-0.6	<0.01	<0.02	<0.5
CQA897	0.8-1.0	0.57	0.66	1.7
CQA897	1.6-1.8	0.58	0.65	2.2
CQA907	1.3-1.5	0.62	0.53	1.5
CQA909	1.5-1.8	1.19	1.00	0.6
CQA924	1.8-2.0	0.85	1.01	<0.5
CQA924	2.8-3.0	0.45	0.56	1.5
CQA936	1.5-1.8	1.08	1.05	2.3
CQA939	0.7-0.9	<0.01	<0.02	<0.5
CQA940	1.0-1.2	<0.01	<0.02	<0.5
CQA940	1.5-1.8	0.27	0.27	<0.5
CQA942	0.46-0.6	0.54	0.54	1.8
CQA942	0.7-0.9	0.91	0.92	3.5
CQA944	0.8-1.0	0.82	0.81	2.1
CQA944	1.5-1.8	0.73	0.71	2.3
CQA945	1.5-1.8	1.31	1.16	1.6
CQA946	1.5-1.8	0.86	0.82	1.5
CQA948	0.8-1.0	1.09	1.10	2.4
CQA949	1.0-1.2	0.34	0.43	1.5
CQA951	1.5-1.8	0.52	0.45	1.8
CQA953	3.8-4.0	0.60	0.63	1.7
CQA953	4.0-4.3	0.98	1.00	2.1
CQA958	1.5-1.8	0.37	0.37	0.8
CQA964	0.8-1.0	1.11	1.03	1.2
CQA970	1.2-1.4	0.32	0.37	1.0
CQA971	1.6-1.8	1.18	1.03	1.8
CQA973	1.6-1.8	1.22	1.14	3.9
CQA977	1.6-1.8	0.82	0.75	2.6

[1] Peroxide oxidisable sulfur (Ahern *et al*. 2004).

[2] Chromium reducible sulfur (Ahern *et al*.2004).

[3] Acid Neutralising Capacity Back Titration (Ahern *et al*. 2004).

The accompanying acid sulfate soil map is essentially a map of *depth* to the acid sulfate soil layers. An indication of risk, depending on the type and extent of disturbance, can be inferred from the depth to an actual acid sulfate soil and/or potential acid sulfate soil layer. For example, draining land with potential acid sulfate soil layers at very shallow depth (<0.5m), within the S0 mapping units would be considered a high risk activity. However the map units provide no indication of the levels of sulfides, actual acidity or acid generation potential provided at 1:50 000 scale mapping. Mapping units with the same depth code can contain quite variable levels of sulfides, existing and potential acidity and consequently varying levels of risk.

Acid sulfate soil risk maps which predict the distribution of acid sulfate soils, based on an assessment of the geomorphic environment, have been produced for coastal areas of New South Wales (Flewin *et al*. 1996). The maps identify the areas at risk and likely depth to the occurrence of acid sulfate soils. Three risk classes are used (High, Low and No Known Occurrence) and these can be related to land use activities that may expose acid sulfate soils, creating an environmental risk. Unlike risk maps, hazard maps are based on more objective criteria with limited interpretation.

The potential acid generation of particular areas of land is illustrated on the accompanying acid sulfate soil *hazard* map. Four classes of acid generation potential are used (Very Low, Low, Moderate and High) based on the concentration of sulfides (peroxide oxidisable sulfur content, S_{POS}) and corresponding acid generation potential (Net Acidity). Criteria used to establish the classes are given in Table 4.

Table 4. Acid sulfate hazard classes.

Class	Criteria
Very Low	S_{POS} <0.03% and Net Acidity = 18 to 80 mol H^+/t S_{POS} >0.03% and Net Acidity = 0 to <18 mol H^+/t Low probability areas
Low	S_{POS} >0.03% and Net Acidity ≥ 18 to 200 mol H^+/t
Moderate	S_{POS} >0.35% and Net Acidity ≥ 200 to <1000 mol H^+/t
High	S_{POS} >1.5% and Net Acidity >1000 mol H^+/t

Depth to the acid sulfate soil layer is not used in the class criteria because the higher concentrations of sulfides and acid generation potential mostly occur at shallow depth and are associated with clayey sediments. Lower concentrations of sulfides and lower acid generation potential can occur at greater depth and can be associated with sandy or shelly sediments. For convenience of use, the depth to the acid sulfate soil layer with significant potential acidity has been placed on the mapping units of the hazard map. The hazard map should be read in conjunction with the accompanying acid sulfate soil map.

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APPENDIX 1

SPOCAS data for samples at selected depths

ABBREVIATIONS

S_{POS} Peroxide oxidisable sulfur

TAA Titratable actual acidity

TPA Titratable peroxide acidity

Site No	Depth (m)	Locality	Landform	S_{POS} %	TAA mol H^+/t	TPA mol H^+/t	Net Acidity mol H^+/t
853	0.4-0.6	Port Alma	Supratidal	0.67	42	420	463
	0.8-1.0		Flat	0.74	<10	327	432
	1.6-1.8			0.82	<10	97	315
854	0.5-0.7	Port Alma	Supratidal	0.72	<10	74	294
	0.8-1.0		Flat	1.57	<10	687	870
	1.6-1.8			1.63	<10	714	904
855	0.4-0.6	Port Alma	Intertidal	0.22	<10	<10	110
	0.8-1.0		Flat	1.42	<10	791	894
	1.6-1.8			0.95	<10	442	547
856	0.4-0.6	Port Alma	Supratidal	0.82	<10	440	519
	0.8-1.0		Flat	0.80	<10	398	482
	1.6-1.8			1.47	<10	860	925
857	0.8-1.0	Port Alma	Supratidal	0.09	<10	<10	31
	1.2-1.4		Flat	0.11	<10	<10	39
	1.6-1.8			0.39	<10	<10	122
858	0.4-0.6	Port Alma	Supratidal	0.97	24	578	631
	0.8-1.0		Flat	0.96	<10	518	608
	1.6-1.8			1.03	<10	356	523
859	0.7-0.9	Port Alma	Intertidal	0.68	<10	269	353
	1.0-1.2		Flat	0.69	<10	167	335
	1.6-1.8			1.22	<10	<10	363
860	0.4-0.6	Port Alma	Supratidal	0.09	<10	<10	36
	0.8-1.0		Flat	0.31	<10	119	204
	1.6-1.8			0.84	<10	357	468
861	0.6-0.8	Port Alma	Intertidal	0.07	<10	<10	18
	1.0-1.2		Flat	1.08	<10	213	486
	1.6-1.8			0.70	<10	80	282
862	0.5-0.7	Port Alma	Supratidal	<0.01	<10	<10	<10
	0.8-1.0		Flat	0.57	<10	240	329
	1.6-1.8			1.16	<10	661	697
863	0.3-0.5	Port Alma	Supratidal	0.02	<10	<10	21
	0.8-1.0		Flat	0.84	<10	445	534
	1.0-1.2			0.88	<10	317	457
	1.6-1.8			0.80	<10	225	391
864	0.8-1.0	Port Alma	Supratidal	<0.01	<10	<10	<10
	1.0-1.2		Flat	0.26	<10	<10	76
	1.6-1.8			0.35	<10	14	156
865	0.6-0.8	Port Alma	Supratidal	0.01	<10	<10	<10
	1.0-1.2		Flat	0.06	<10	<10	<10
	1.6-1.8			0.22	<10	<10	65
866	0.2-0.4	Port Alma	Intertidal	0.11	<10	<10	50
	0.5-0.7		Flat	0.87	<10	416	492
	1.0-1.2			0.38	<10	109	206
	1.6-1.8			1.16	<10	617	675
867	0.4-0.6	Port Alma	Supratidal	1.06	<10	652	669
	0.8-1.0		Flat	0.91	<10	512	579
	1.6-1.8			0.99	<10	541	630
868	0.8-1.0	Port Alma	Supratidal	0.42	<10	157	236
	1.3-1.5		Flat	0.94	<10	428	537
	1.6-1.8			1.12	<10	532	642

Site No	Depth (m)	Locality	Landform	S_{POS} %	TAA mol H^+/t	TPA mol H^+/t	Net Acidity mol H^+/t
869	0.4-0.6	Port Alma	Supratidal	0.07	<10	<10	37
	0.8-1.0		Flat	0.59	<10	196	305
	1.6-1.8			1.03	<10	318	521
870	0.5-0.7	Bajool	Supratidal	0.61	<10	263	372
	0.9-1.1		Flat	1.26	<10	659	766
	1.6-1.8			1.44	<10	788	862
871	0.3-0.5	Bajool	Supratidal	0.02	<10	<10	<10
	0.8-1.0		Flat	<0.01	<10	<10	<10
	1.6-1.8			0.04	<10	<10	<10
872	0.3-0.5	Bajool	Supratidal	0.70	<10	256	380
	0.8-1.0		Flat	2.09	<10	1256	1290
	1.6-1.8			0.87	<10	339	483
873	.15-0.3	Bajool	Supratidal	0.27	<10	125	180
	0.3-0.5		Flat	0.68	21	393	442
	0.8-1.0			1.52	13	921	962
	1.6-1.8			1.69	<10	958	1070
874	0.3-0.5	Bajool	Supratidal	0.06	16	36	53
	0.8-1.0		Flat	0.01	18	16	27
	1.6-1.8			1.20	<10	609	726
875	0.4-0.6	Bajool	Supratidal	<0.01	<10	<10	<10
	0.8-1.0		Flat	<0.01	<10	<10	<10
	1.3-1.5			<0.01	<10	<10	<10
876	0.3-0.5	Bajool	Supratidal	<0.01	<10	<10	<10
	1.6-1.8		Flat	0.26	<10	<10	105
877	0.3-0.5	Bajool	Supratidal	<0.01	13	<10	16
	0.6-0.8		Flat	<0.01	20	12	23
	1.0-1.2			<0.01	<10	<10	<10
	1.6-1.8			0.68	<10	322	387
878	0.4-0.6	Bajool	Supratidal	<0.01	49	19	86
	0.8-1.0		Flat	0.01	38	11	43
	1.6-1.8			0.43	<10	175	254
879	0.5-0.7	Bajool	Supratidal	<0.01	28	<10	31
	0.8-1.0		Flat	<0.01	25	<10	28
	1.1-1.3			0.04	<10	<10	22
	1.6-1.8			0.67	<10	309	386
880	0.6-0.8	Bajool	Extratidal	<0.01	<10	<10	<10
	1.0-1.2		Flat	<0.01	<10	<10	<10
	1.6-1.8			<0.01	<10	<10	<10
881	0.4-0.6	Bajool	Supratidal	<0.01	<10	<10	<10
	0.8-1.0		Flat	<0.01	29	<10	84
	1.6-1.8			<0.01	23	<10	26
882	0.3-0.5	Bajool	Drainage	<0.01	<10	<10	13
	0.8-1.0		Depression	<0.01	32	11	37
	1.3-1.5			<0.01	24	<10	27
	1.6-1.8			0.04	21	11	46
883	0.4-0.6	Bajool	Supratidal	<0.01	<10	<10	13
	0.8-1.0		Flat	<0.01	<10	<10	13
	1.6-1.8			0.15	<10	<10	43

Site No	Depth (m)	Locality	Landform	S_{POS} %	TAA mol H^+/t	TPA mol H^+/t	Net Acidity mol H^+/t
884	0.3-0.5	Bajool	Supratidal	<0.01	<10	<10	<10
	0.8-1.0		Flat	<0.01	<10	<10	13
	1.3-1.5			0.08	24	44	73
	1.6-1.8			1.16	<10	665	736
885	0.7-0.9	Bajool	Supratidal	<0.01	<10	<10	<10
	1.6-1.8		Flat	<0.01	<10	<10	<10
	2.4-2.6			<0.01	<10	<10	<10
886	0.3-0.5	Bajool	Supratidal	<0.01	12	<10	15
	0.8-1.0		Flat	0.56	63	371	441
	1.3-1.5			1.31	11	725	828
	2.0-2.2			1.20	<10	571	719
	2.8-3.0			0.85	<10	323	471
887	0.8-1.0	Inkerman	Tidal	<0.01	10	<10	13
	1.8-2.0	Creek	Creek	0.63	<10	277	401
	2.8-3.0			1.55	<10	850	975
888	0.8-1.0	Twelve Mile	Stream	0.02	<10	<10	20
	1.8-2.0	Creek	Channel	<0.01	<10	<10	13
	2.8-3.0			<0.01	<10	<10	13
889	0.7-0.9	Twelve Mile	Drainage	<0.01	<10	<10	<10
	1.3-1.5	Creek	Depression	<0.01	<10	<10	13
	2.2-2.4			<0.01	34	21	38
	2.8-3.0			0.43	11	215	282
890	0.8-1.0	Twelve Mile	Alluvial	<0.01	<10	<10	13
	1.8-2.0	Creek	Plain	<0.01	<10	<10	13
	2.8-3.0			<0.01	<10	<10	13
891	0.8-1.0	Twelve Mile	Stream	<0.01	<10	<10	<10
	1.8-2.0	Creek	Channel	<0.01	<10	<10	<10
892	0.4-0.6	Bajool	Marine	<0.01	24	14	397
	1.3-1.5		Plain	<0.01	25	14	46
	2.0-2.2			0.30	<10	135	194
	2.5-2.7			0.46	<10	124	268
893	0.4-0.6	Bajool	Marine	<0.01	29	13	39
	0.6-0.8		Plain	<0.01	34	18	182
	1.3-1.5			<0.01	47	63	50
	1.8-2.0			0.99	13	585	628
	2.5-2.7			0.78	<10	301	457
894	1.8-2.0	Bajool	Alluvial	<0.01	<10	<10	<10
	2.8-3.0		Plain	<0.01	<10	<10	<10
895	0.5-0.7	Inkerman	Supratidal	0.01	<10	<10	<10
	0.8-1.0	Creek	Flat	0.17	<10	46	99
	1.6-1.8			1.00	<10	567	633
896	0.4-0.6	Inkerman	Supratidal	<0.01	14	<10	17
	0.8-1.0	Creek	Flat	0.01	<10	<10	18
	1.6-1.8			0.20	<10	104	134
897	0.1-0.3	Inkerman	Tidal	1.22	<10	544	687
	0.4-0.6	Creek	Creek	1.16	<10	593	692
	0.8-1.0			0.57	<10	122	311
	1.6-1.8			0.58	<10	56	290
898	0.3-0.5	Inkerman	Supratidal	<0.01	<10	<10	<10
	0.8-1.0	Creek	Flat	<0.01	<10	<10	<10
	1.5-1.7			0.21	<10	101	140

Site No	Depth (m)	Locality	Landform	S_{POS} %	TAA mol H^+/t	TPA mol H^+/t	Net Acidity mol H^+/t
899	0.2-0.3	Inkerman	Supratidal	0.02	<10	<10	21
	0.3-0.5	Creek	Flat	1.34	23	773	859
	0.8-1.0			1.69	56	1033	1110
	1.6-1.8			1.12	<10	561	709
900	0.9-1.1	Inkerman	Supratidal	1.16	13	633	739
	1.3-1.5	Creek	Flat	1.25	<10	623	789
	1.5-1.7			1.40	17	750	888
901	0.6-0.8	Inkerman	Supratidal	0.15	<10	<10	34
	0.8-1.0	Creek	Flat	0.15	<10	<10	<10
	1.4-1.6			0.23	<10	<10	34
902	0.3-0.5	Port Alma	Supratidal	0.01	<10	<10	18
	0.8-1.0		Flat	0.13	<10	<10	34
	1.3-1.5			0.15	<10	<10	40
903	0.5-0.7	Port Alma	Supratidal	0.75	<10	324	477
	0.9-1.1		Flat	0.71	<10	286	451
	1.6-1.8			1.51	13	826	956
904	0.3-0.5	Bajool	Supratidal	0.02	<10	<10	<10
	0.6-0.8		Flat	0.09	<10	<10	<10
	0.8-1.0			0.10	<10	<10	<10
905	0.3-0.5	Casuarina	Supratidal	0.02	<10	<10	<10
	0.7-0.9	Creek	Flat	0.93	<10	450	589
	1.2-1.4			0.70	<10	272	391
906	0.4-0.6	Bajool	Supratidal	1.56	30	900	1000
	0.9-1.1		Flat	1.58	19	876	1000
	1.6-1.8			1.38	16	778	874
907	0.4-0.6	Bajool	Supratidal	0.01	<10	<10	<10
	1.0-1.2		Flat	0.17	<10	<10	40
	1.3-1.5			0.62	<10	134	281
908	0.3-0.5	Casuarina	Supratidal	0.02	<10	<10	<10
	0.8-1.0	Creek	Flat	0.02	<10	<10	<10
	1.2-1.5			0.10	<10	<10	38
909	0.6-0.8	Bajool	Supratidal	1.83	15	1033	1150
	1.0-1.2		Flat	2.64	26	1442	1670
	1.5-1.8			1.19	<10	586	749
910	0.4-0.6	Bajool	Supratidal	0.02	<10	<10	23
	0.6-0.8		Flat	1.20	42	695	791
	1.0-1.2			1.30	<10	684	821
	1.6-1.8			1.19	<10	623	753
911	0.6-0.8	Inkerman	Supratidal	0.02	<10	<10	<10
	1.0-1.2	Creek	Flat	0.92	<10	419	582
	1.6-1.8			1.26	<10	635	794
912	0.5-0.7	Bajool	Supratidal	0.01	<10	<10	19
	0.9-1.05		Flat	0.53	30	270	361
	1.4-1.6			0.68	<10	248	369
913	0.4-0.6	Bajool	Supratidal	0.01	<10	<10	13
	0.8-1.0		Flat	0.15	<10	12	55
	1.2-1.4			0.15	<10	<10	61
914	0.6-0.8	Inkerman	Supratidal	0.01	19	14	28
	1.0-1.2	Creek	Flat	0.02	26	14	47
	1.6-1.8			1.06	33	600	695

Site No	Depth (m)	Locality	Landform	S_{POS} %	TAA mol H^+/t	TPA mol H^+/t	Net Acidity mol H^+/t
915	0.5-0.7	Port Alma	Supratidal	0.71	<10	13	271
	0.8-1.0		Flat	0.92	<10	88	342
	1.6-1.8			0.98	<10	214	456
916	0.6-0.8	Port Alma	Supratidal	0.11	<10	<10	64
	0.9-1.1		Flat	0.64	<10	297	411
	1.6-1.8			0.79	<10	353	500
917	0.4-0.6	Inkerman	Supratidal	0.87	51	500	596
	0.8-1.0	Creek	Flat	0.77	<10	334	448
	1.5-1.8			1.27	<10	644	805
918	0.0-0.1	Bajool	Swamp	0.06	12	<10	51
	0.3-0.5			0.01	<10	<10	16
	0.8-1.0			<0.01	<10	<10	13
	1.2-1.5			<0.01	20	13	24
919	0.2-0.4	Bajool	Supratidal	0.04	19	31	41
	0.5-0.7		Flat	0.07	26	37	69
	0.8-1.0			1.05	16	550	610
	1.5-1.8			1.01	<10	513	643
920	0.3-0.5	Inkerman	Extratidal	<0.01	<10	<10	<10
	0.8-1.0	Creek	Flat	<0.01	33	20	39
	1.5-1.8			0.79	20	424	515
921	0.7-0.9	Inkerman	Supratidal	1.23	14	680	778
	1.0-1.2	Creek	Flat	1.52	<10	864	960
	1.5-1.8			1.29	20	734	823
922	0.4-0.6	Bajool	Extratidal	<0.01	<10	<10	13
	1.0-1.2		Flat	<0.01	28	17	32
	1.8-2.0			<0.01	46	25	113
	2.3-2.5			0.66	22	396	435
	2.8-3.0			1.10	<10	550	606
923	1.0-1.2	Inkerman	Extratidal	<0.01	<10	<10	13
	1.8-2.0	Creek	Flat	<0.01	<10	<10	13
	2.7-2.9			<0.01	15	<10	18
924	0.8-1.0	Bajool	Drainage	<0.01	20	<10	23
	1.3-1.5		Depression	<0.01	23	18	84
	1.8-2.0			0.85	36	537	570
	2.8-3.0			0.45	<10	84	245
925	0.3-0.5	Inkerman	Supratidal	<0.01	<10	<10	13
	0.8-1.0	Creek	Flat	1.57	110	1134	1150
	1.6-1.8			1.34	16	796	853
926	0.3-0.5	Bajool	Supratidal	<0.01	<10	<10	<10
	0.8-1.0		Flat	0.50	55	355	452
	1.5-1.8			0.71	<10	296	410
927	0.3-0.5	Bajool	Supratidal	<0.01	<10	<10	<10
	0.8-1.0		Flat	<0.01	<10	<10	13
	1.2-1.4			0.49	<10	237	317
928	0.4-0.6	Bajool	Supratidal	<0.01	<10	<10	<10
	0.8-1.0		Flat	0.40	<10	163	261
	1.5-1.8			0.56	<10	230	327
929	0.3-0.5	Bajool	Supratidal	<0.01	<10	<10	13
	0.8-1.0		Flat	0.74	<10	393	473
	1.5-1.8			1.12	20	658	721

Site No	Depth (m)	Locality	Landform	S_{POS} %	TAA mol H^+/t	TPA mol H^+/t	Net Acidity mol H^+/t
930	0.4-0.6	Bajool	Supratidal	<0.01	23	<10	270
	0.8-1.0		Flat	<0.01	26	<10	196
	1.6-1.8			0.55	13	269	356
931	0.3-0.5	Bajool	Supratidal	<0.01	<10	<10	13
	0.8-1.0		Flat	<0.01	<10	<10	13
	1.6-1.8			0.17	<10	<10	79
932	0.3-0.5	Bajool	Supratidal	<0.01	<10	<10	<10
	0.8-1.0		Flat	0.43	<10	217	280
	1.6-1.8			0.70	<10	315	446
933	0.6-0.8	Casuarina	Intertidal	1.49	12	826	943
	1.1-1.3	Creek	Flat	1.24	<10	624	785
	1.6-1.8			1.15	<10	562	728
934	0.7-0.9	Bajool	Supratidal	0.40	<10	137	217
	1.1-1.3		Flat	1.55	10	844	976
	1.6-1.8			2.45	<10	1360	1500
935	0.5-0.7	Casuarina	Supratidal	1.47	82	945	1000
	1.0-1.2	Creek	Flat	1.36	26	771	873
	1.6-1.8			0.82	<10	396	524
936	0.3-0.5	Casuarina	Intertidal	0.17	<10	<10	44
	0.8-1.0	Creek	Flat	1.53	<10	484	780
	1.5-1.8			1.08	<10	279	520
937	0.6-0.8	Casuarina	Intertidal	0.15	<10	<10	78
	1.0-1.2	Creek	Flat	0.42	<10	168	242
	1.5-1.8			0.90	<10	435	534
938	0.3-0.5	Bajool	Plain	<0.01	16	<10	19
	0.8-1.0			<0.01	18	<10	21
	1.6-1.9			<0.01	51	33	72
939	0.3-0.5	Bajool	Plain	0.01	<10	<10	17
	0.7-0.9			<0.01	22	10	200
	1.6-1.8			<0.01	38	19	44
940	0.3-0.5	Bajool	Plain	<0.01	41	19	45
	1.0-1.2			<0.01	81	84	382
	1.5-1.8			0.27	150	350	598
941	0.3-0.5	Casuarina	Intertidal	1.14	<10	559	655
	0.8-1.0	Creek	Flat	1.32	14	765	839
	1.5-1.8			1.28	<10	553	730
942	0.46-0.6	Casuarina	Supratidal	0.54	<10	10	202
	0.7-0.9	Creek	Flat	0.91	<10	10	284
	1.5-1.8			0.31	<10	<10	<10
943	0.6-0.8	Casuarina	Supratidal	0.03	<10	<10	<10
	1.1-1.3	Creek	Flat	0.11	14	33	80
	1.5-1.8			1.02	47	573	681
944	0.4-0.6	Casuarina	Supratidal	0.76	<10	354	486
	0.8-1.0	Creek	Flat	0.82	<10	103	345
	1.5-1.8			0.73	<10	31	263
945	0.2-0.4	Port Alma	Supratidal	<0.01	<10	<10	<10
	0.5-0.7		Flat	0.66	<10	350	421
	1.0-1.2			0.94	<10	372	527
	1.5-1.8			1.31	<10	447	702

Site No	Depth (m)	Locality	Landform	S_{POS} %	TAA mol H^+/t	TPA mol H^+/t	Net Acidity mol H^+/t
946	0.4-0.6	Port Alma	Supratidal	0.75	10	389	478
	0.8-1.0		Flat	0.66	<10	291	422
	1.5-1.8			0.86	<10	247	438
947	0.6-0.8	Casuarina	Tidal	0.08	<10	<10	38
	1.0-1.2	Creek	Creek	0.65	<10	330	389
	1.5-1.8			1.20	<10	693	725
948	0.4-0.6	Port Alma	Supratidal	0.99	21	599	636
	0.8-1.0		Flat	1.09	<10	217	459
	1.5-1.8			0.53	<10	<10	24
949	0.5-0.7	Port Alma	Supratidal	0.33	<10	163	219
	1.0-1.2		Flat	0.34	<10	38	163
	1.5-1.8			0.33	<10	<10	84
950	0.3-0.5	Port Alma	Supratidal	<0.01	<10	<10	<10
	0.8-1.0		Flat	<0.01	<10	<10	<10
	1.5-1.6			<0.01	<10	<10	<10
951	0.6-0.8	Casuarina	Supratidal	0.12	<10	<10	46
	0.8-1.0	Creek	Flat	0.27	<10	<10	73
	1.5-1.8			0.52	<10	22	205
952	0.4-0.6	Port Alma	Supratidal	1.07	<10	559	678
	0.8-1.0		Flat	0.74	<10	344	470
	1.5-1.8			0.37	<10	127	217
953	1.8-2.0	Inkerman	Plain	<0.01	<10	<10	13
	2.8-3.0	Creek		0.02	<10	<10	<10
	3.8-4.0			0.60	<10	107	279
	4.0-4.3			0.98	<10	227	449
954	0.45-0.6	Inkerman	Supratidal	0.02	<10	<10	<10
	0.8-1.0	Creek	Flat	0.02	<10	<10	<10
	1.5-1.8			2.03	<10	1137	1230
955	0.5-0.7	Bajool	Supratidal	<0.01	<10	<10	13
	0.8-1.0		Flat	0.01	16	<10	19
	1.5-1.8			0.73	<10	304	415
956	0.3-0.5	Inkerman	Supratidal	0.20	<10	<10	24
	0.8-1.0	Creek	Flat	<0.01	<10	<10	13
	1.4-1.6			0.81	31	410	538
957	0.3-0.5	Inkerman	Supratidal	0.20	<10	<10	20
	0.8-1.0	Creek	Flat	<0.01	<10	<10	13
	1.5-1.7			<0.01	10	<10	13
958	0.3-0.5	Bajool	Supratidal	<0.01	<10	<10	<10
	0.8-1.0		Flat	<0.01	<10	<10	13
	1.5-1.8			0.37	<10	104	242
959	0.3-0.5	Inkerman	Drainage	0.02	<10	<10	25
	0.8-1.0	Creek	Depression	1.94	45	1186	1250
	1.5-1.8			1.13	<10	532	714
960	0.6-0.8	Bajool	Supratidal	0.04	18	<10	43
	1.0-1.2		Flat	0.03	25	<10	79
	1.7-1.9			0.27	27	143	196
961	0.4-0.6	Bajool	Supratidal	0.03	18	<10	174
	0.8-1.0		Flat	0.01	30	12	97
	1.5-1.8			0.49	<10	214	318
962	0.3-0.5	Bajool	Supratidal	<0.01	<10	<10	<10
	1.0-1.2		Flat	<0.01	<10	<10	<10

Site No	Depth (m)	Locality	Landform	S_{POS} %	TAA mol H^+/t	TPA mol H^+/t	Net Acidity mol H^+/t
963	0.4-0.6	Bajool	Supratidal	0.06	<10	<10	33
	0.8-1.0		Flat	0.88	<10	418	559
	1.5-1.8			1.02	<10	484	645
964	0.3-0.5	Bajool	Supratidal	0.02	<10	<10	25
	0.8-1.0		Flat	1.11	<10	455	621
	1.0-1.2			0.23	<10	17	112
	1.5-1.8			0.06	15	<10	54
965	0.1-0.3	Bajool	Supratidal	<0.01	<10	<10	<10
	0.4-0.6		Flat	<0.01	<10	<10	<10
966	0.3-0.5	Bajool	Supratidal	0.02	<10	<10	<10
	0.8-1.0		Flat	<0.01	<10	<10	<10
	1.2-1.4			<0.01	<10	<10	<10
967	0.3-0.5	Bajool	Supratidal	0.01	<10	<10	<10
	0.8-1.0		Flat	<0.01	<10	<10	<10
	1.1-1.3			<0.01	<10	<10	<10
968	0.3-0.5	Bajool	Supratidal	<0.01	<10	<10	13
	0.8-1.0		Flat	1.34	49	847	887
	1.5-1.8			1.36	<10	767	861
969	0.3-0.8	Inkerman	Supratidal	0.01	<10	<10	<10
	0.8-1.0	Creek	Flat	0.27	<10	99	163
	1.5-1.8			1.11	<10	537	648
970	0.6-0.8	Inkerman	Supratidal	0.05	12	13	44
	1.0-1.2	Creek	Flat	0.51	<10	253	329
	1.2-1.4			0.32	<10	55	167
971	0.4-0.6	Raglan	Supratidal	1.16	<10	490	570
	0.8-1.0	Creek	Flat	1.13	<10	480	580
	1.6-1.8			1.18	<10	398	559
972	0.3-0.5	Port Alma	Supratidal	0.02	12	<10	26
	0.8-1.0		Flat	1.23	<10	597	694
	1.6-1.8			0.81	<10	229	378
973	0.1-0.3	Port Alma	Supratidal	0.02	<10	<10	20
	0.4-0.6		Flat	0.98	40	554	651
	0.8-1.0			1.25	<10	370	560
	1.6-1.8			1.22	<10	36	305
974	0.3-0.5	Port Alma	Supratidal	0.01	<10	<10	17
	0.6-0.8		Flat	0.83	<10	425	525
	1.6-1.8			1.49	<10	700	809
975	0.4-0.6	Port Alma	Supratidal	1.07	<10	479	522
	0.8-1.0		Flat	1.79	12	985	1130
	1.6-1.8			1.30	<10	654	820
976	0.4-0.6	Casuarina	Intertidal	0.86	<10	338	437
	0.8-1.0	Creek	Flat	2.32	<10	1396	1460
	1.6-1.8			2.24	<10	1218	1410
977	0.4-0.6	Port Alma	Supratidal	0.93	<10	457	590
	0.8-1.0		Flat	1.26	<10	544	680
	1.6-1.8			0.82	<10	34	222
978	0.4-0.6	Port Alma	Supratidal	1.75	<10	979	1100
	0.8-1.0		Flat	2.02	<10	1102	1270
	1.6-1.8			1.36	<10	724	855

Site No	Depth (m)	Locality	Landform	S_{POS} %	TAA mol H^+/t	TPA mol H^+/t	Net Acidity mol H^+/t
979	0.6-0.8	Casuarina	Levee	0.59	<10	276	377
	1.0-1.2	Creek		0.78	<10	127	319
	1.5-1.8			0.77	<10	<10	234
980	0.3-0.5	Casuarina	Creek	0.04	<10	<10	<10
	0.8-1.0	Creek	Bank	0.03	<10	<10	29
	1.5-1.8			0.50	<10	225	324
981	0.2-0.4	Port Alma	Supratidal	0.02	21	<10	42
	0.8-1.0		Flat	1.73	12	947	1090
	1.5-1.8			0.53	<10	198	242
982	0.3-0.5	Port Alma	Supratidal	0.61	39	345	421
	0.8-1.0		Flat	0.52	<10	<10	77
	1.5-1.8			0.55	<10	<10	20
983	0.4-0.6	Port Alma	Supratidal	0.68	<10	279	326
	0.8-1.0		Flat	0.85	<10	355	387
	1.5-1.8			0.78	<10	348	391
984	0.4-0.6	Casuarina	Intertidal	0.43	<10	57	173
	0.8-1.0	Creek	Flat	1.09	<10	476	593
	1.5-1.8			1.37	<10	620	726
985	0.3-0.5	Port Alma	Supratidal	0.02	<10	<10	<10
	0.8-1.0		Flat	0.29	<10	62	124
	1.5-1.8			1.38	25	785	889
986	0.4-0.6	Casuarina	Supratidal	0.57	<10	198	335
	0.8-1.0	Creek	Flat	0.72	<10	311	459
	1.5-1.8			0.95	16	494	611
987	0.3-0.5	Casuarina	Intertidal	0.22	<10	<10	85
	0.8-1.0	Creek	Flat	1.02	<10	484	649
	1.5-1.8			0.61	<10	264	388
988	0.4-0.6	Casuarina	Intertidal	0.02	<10	<10	<10
	0.8-1.0	Creek	Flat	0.15	<10	<10	83
	1.5-1.8			2.05	20	1172	1300
989	0.3-0.5	Port Alma	Supratidal	<0.01	14	<10	17
	0.8-1.0		Flat	0.37	<10	<10	68
	1.5-1.8			0.49	<10	<10	156
990	0.1-0.3	Port Alma	Supratidal	0.01	14	<10	23
	0.8-1.0		Flat	1.07	32	594	699
	0.5-1.8			1.00	<10	59	317
991	0.2-0.4	Port Alma	Supratidal	<0.01	<10	<10	<10
	0.8-1.0		Flat	0.62	<10	209	291
	1.4-1.6			0.46	<10	<10	106
992	0.4-0.6	Bajool	Supratidal	0.98	<10	479	590
	0.8-1.0		Flat	1.12	<10	468	607
	1.6-1.8			0.93	<10	355	476
993	0.5-0.7	Bajool	Supratidal	1.24	19	644	790
	1.0-1.2		Flat	0.91	<10	237	427
	1.5-1.8			0.62	<10	68	329
994	0.3-0.5	Bajool	Supratidal	0.18	29	105	144
	0.8-1.0		Flat	0.58	<10	121	242
	1.5-1.8			1.19	37	104	778
995	1.5-1.7	Bajool	Extratidal	0.02	36	33	192
	2.0-2.2		Flat	<0.01	42	20	46
	2.6-2.8			0.49	<10	375	298

Site No	Depth (m)	Locality	Landform	S_{POS} %	TAA mol H^+/t	TPA mol H^+/t	Net Acidity mol H^+/t
996	0.8-1.0	Bajool	Tidal	0.04	<10	<10	19
	1.3-1.5		Creek	0.09	<10	<10	38
	1.8-2.0			0.48	<10	155	265
	2.8-3.0			0.41	<10	10	178
997	0.8-1.0	Hourigan	Tidal	1.01	<10	506	597
	1.3-1.5	Creek	Creek	1.27	<10	641	750
	1.8-2.0			1.02	<10	458	585
	2.8-3.1			1.56	<10	836	932
998	1.1-1.3	Raglan	Supratidal	1.32	<10	758	806
	1.8-2.0	Creek	Flat	1.98	<10	1185	1210
	2.2-2.5			1.69	<10	925	1030
	2.8-3.1			0.71	<10	195	380
999	2.7-3.0	Twelve	Plain	0.01	<10	<10	<10
	3.4-3.8	Mile Creek		0.62	<10	<10	240
	4.0-4.8			0.62	<10	222	339
	5.5-6.0			0.16	<10	10	<10
1000	2.3-2.6	Twelve	Drainage	0.01	30	13	37
	2.8-3.0	Mile Creek	Depression	0.54	<10	168	286
	3.8-4.0			0.42	<10	100	289
1001	1.5-1.8	Bajool	Extratidal	0.01	30	13	41
	2.3-2.6		Flat	0.55	18	314	361
	3.0-3.3			0.72	<10	249	398
1002	0.2-0.4	Bajool	Supratidal	0.04	31	<10	205
	0.8-1.0		Flat	0.02	42	13	189
	1.5-1.8			1.79	55	1160	1170
1003	0.8-1.0	Bajool	Supratidal	0.03	<10	<10	<10
	1.5-1.8		Flat	0.11	<10	<10	<10
1004	0.5-0.7	Bajool	Supratidal	0.11	<10	<10	63
	1.0-1.2		Flat	0.33	<10	135	200
	1.5-1.8			1.09	<10	599	690
1005	0.8-1.0	Bajool	Supratidal	<0.01	<10	<10	<10
	1.5-1.8		Flat	0.47	<10	204	287
1006	0.8-1.0	Bajool	Supratidal	<0.01	<10	<10	<10
	1.5-1.8		Flat	0.02	<10	<10	47
1007	0.8-1.0	Bajool	Supratidal	0.02	<10	<10	<10
	1.3-1.5		Flat	0.01	<10	<10	<10
1008	0.3-0.5	Port Alma	Supratidal	<0.01	<10	<10	<10
	0.8-1.0		Flat	1.92	23	1402	1220
	1.5-1.8			1.37	<10	726	835
1009	0.3-0.5	Port Alma	Supratidal	<0.01	15	<10	18
	0.8-1.0		Flat	1.40	65	907	938
	1.5-1.8			1.83	41	1219	1180
1010	0.1-0.3	Port Alma	Supratidal	0.02	10	<10	22
	0.8-1.0		Flat	1.36	56	817	904
	1.5-1.8			1.34	<10	513	738
1011	0.4-0.5	Port Alma	Supratidal	0.01	<10	<10	18
	0.8-1.0		Flat	0.89	58	546	614
	1.5-1.8			1.30	40	727	857
1012	0.3-0.5	Port Alma	Supratidal	0.02	18	<10	30
	0.8-1.0		Flat	0.42	<10	166	276
	1.5-1.8			0.46	<10	38	207

Site No	Depth (m)	Locality	Landform	S_{POS} %	TAA mol H^+/t	TPA mol H^+/t	Net Acidity mol H^+/t
1013	0.5-0.7	Bajool	Supratidal	1.87	43	1028	1230
	1.1-1.2		Flat	1.36	57	795	921
	1.5-1.8			1.88	65	1138	1270
1014	0.3-0.5	Bajool	Supratidal	0.05	<10	<10	26
	0.8-1.0		Flat	0.85	<10	355	495
	1.5-1.8			1.37	22	690	898
1015	1.8-2.0	Bajool	Extratidal	0.01	29	16	69
	2.8-3.0		Flat	0.64	<10	301	419
	3.6-3.9			0.60	<10	251	388
1016	0.3-0.5	Bajool	Supratidal	0.03	<10	<10	29
	0.8-1.0		Flat	1.10	42	618	744
	1.5-1.8			1.48	<10	750	958
1017	0.4-0.6	Bajool	Supratidal	0.04	<10	<10	11
	0.8-1.0		Flat	1.26	<10	352	648
	1.5-1.8			0.79	<10	163	382
1018	0.8-1.0	Port Alma	Plain	<0.01	<10	<10	<10
	1.8-2.0			<0.01	<10	<10	<10
	3.3-3.5			<0.01	<10	<10	<10
1019	0.8-1.0	Port Alma	Plain	0.01	<10	<10	17
	1.8-20			<0.01	24	12	111
	2.8-3.0			<0.01	33	16	92
	3.8-4.0			<0.01	<10	<10	<10
1020	0.6-0.8	Port Alma	Plain	<0.01	<10	<10	<10
	1.8-2.0			0.01	26	15	34
	2.8-3.0			<0.01	29	14	32
	3.8-4.0			0.03	<10	<10	<10
1021	0.8-1.0	Pelican	Drainage	0.03	<10	<10	10
	1.5-1.7	Creek	Depression	2.14	<10	1245	1340
	2.6-2.8			0.46	<10	12	184
1022	1.3-1.5	Port Alma	Plain	<0.01	<10	<10	<10
	2.0-2.3			<0.01	10	<10	13
1023	2.0-2.3	Port Alma	Supratidal	<0.01	22	12	25
	2.6-2.8		Flat	<0.01	28	14	37
1024	0.3-0.5	Port Alma	Supratidal	0.01	20	<10	28
	0.8-1.0		Flat	1.08	25	564	698
	1.6-1.8			1.27	13	665	807
1025	0.6-0.8	Inkerman	Supratidal	0.74	<10	350	470
	0.8-1.0	Creek	Flat	0.88	<10	432	560
	1.3-1.5			0.81	<10	340	515
	1.8-2.0			1.56	<10	707	909
	2.8-3.0			2.56	36	1448	1630
1026	0.5-0.7	Inkerman	Supratidal	0.02	<10	<10	21
	0.8-1.0	Creek	Flat	0.26	10	127	171
	1.4-1.6			0.09	<10	<10	29
1027	0.6-0.8	Inkerman	Supratidal	0.02	<10	<10	<10
	1.3-1.5	Creek	Flat	0.08	34	60	91
	1.8-2.0			0.89	41	361	469
	2.8-3.0			0.23	<10	109	152
1028	0.4-0.6	Port Alma	Supratidal	0.01	11	<10	20
	0.8-1.0		Flat	1.00	27	560	652
	1.5-1.8			1.07	14	551	681

Site No	Depth (m)	Locality	Landform	S_{POS} %	TAA mol H^+/t	TPA mol H^+/t	Net Acidity mol H^+/t
1029	0.8-1.0	Bajool	Extratidal	<0.01	<10	<10	13
	1.8-2.0		Flat	<0.01	<10	<10	13
	2.3-2.5			<0.01	<10	<10	13
	2.8-3.0			0.31	37	164	228
	3.8-4.0			0.44	26	241	297
	4.3-4.5			0.14	<10	59	98
	4.6-4.8			<0.01	<10	<10	<10
1030	0.0-0.2	Port Alma	Drainage	0.07	24	36	69
	0.8-1.0		Depression	0.84	<10	410	535
	1.8-2.0			0.10	<10	<10	54
	2.8-3.0			0.98	<10	232	477
	3.8-4.0			0.46	<10	<10	<10
	4.6-4.8			0.91	<10	56	346
1031	0.8-1.0	Bajool	Embankment	<0.01	<10	<10	<10
	1.8-2.0			<0.01	<10	<10	<10
	2.8-3.0			<0.01	<10	<10	59
	3.8-4.0			<0.01	<10	<10	33
	4.8-5.0			0.01	<10	<10	16
	5.8-6.0			0.02	<10	<10	<10
	6.8-7.0			0.01	<10	<10	<10
	7.8-8.0			<0.01	<10	<10	<10
	8.8-9.0			0.01	<10	<10	<10
	9.8-10.0			<0.01	<10	<10	<10
	10.3-10.5			0.02	<10	<10	<10
1032	0.8-1.0	Bajool	Supratidal	<0.01	<10	<10	<10
	1.8-2.0		Flat	0.78	<10	145	364
	2.8-3.0			1.58	<10	938	992
	3.8-4.0			1.32	<10	698	799
	4.6-4.8			1.61	<10	444	807
	4.8-5.0			0.49	<10	122	250
	5.8-6.0			0.01	<10	<10	<10
1033	0.3-0.5	Bajool	Supratidal	<0.01	33	12	37
	0.8-1.0		Flat	0.70	13	341	450
	1.3-1.5			0.01	<10	<10	18
	1.8-2.0			1.00	<10	521	634
	2.8-3.0			1.41	9	507	760
1034	0.4-0.6	Bajool	Supratidal	0.68	<10	304	387
	0.8-1.0		Flat	3.57	110	2529	2330
	1.5-1.7			2.21	32	1346	1410
	1.8-2.0			1.71	26	1007	1090
	2.6-2.9			1.06	<10	498	627
1035	0.5-0.7	Casuarina	Intertidal	0.88	<10	368	499
	1.0-1.2	Creek	Flat	0.40	<10	98	207
	1.7-1.9			0.52	<10	120	283
	2.0-2.2			1.49	<10	673	872
	2.7-3.0			1.39	<10	523	758
1036	0.3-0.5	Raglan	Tidal Creek	<0.01	<10	<10	<10
	0.8-1.0	Creek		0.12	<10	17	68
	1.5-1.8			1.34	<10	663	849
1037	0.6-0.8	Port Alma	Supratidal	0.02	<10	<10	19
	0.9-1.1		Flat	0.73	11	381	466
	1.5-1.8			0.87	<10	333	481

Site No	Depth (m)	Locality	Landform	S_{POS} %	TAA mol H^+/t	TPA mol H^+/t	Net Acidity mol H^+/t
1038	0.6-0.8	Port Alma	Supratidal	0.02	10	<10	24
	1.0-1.2		Flat	0.44	20	210	295
	1.5-1.8			0.84	<10	345	480
1039	0.35-0.55	Port Alma	Supratidal	0.29	<10	114	193
	0.8-1.0		Flat	0.17	<10	<10	81
	1.5-1.8			0.78	<10	320	451
1040	0.3-0.5	Port Alma	Supratidal	<0.01	<10	<10	13
	0.8-1.0		Flat	0.95	<10	378	513
	1.5-1.8			0.55	<10	173	279
1041	0.3-0.5	Raglan	Supratidal	<0.01	<10	<10	<10
	0.6-0.8	Creek	Flat	0.15	<10	15	103
	1.6-1.8			1.16	18	525	633
1042	0.4-0.6	Raglan	Supratidal	0.15	<10	<10	49
	0.8-1.0	Creek	Flat	1.18	<10	459	678
	1.6-1.8			1.00	<10	500	633
1043	0.3-0.5	Raglan	Supratidal	0.04	<10	<10	34
	0.8-1.0	Creek	Flat	1.00	<10	519	635
	1.6-1.8			0.99	<10	411	569
1044	0.2-0.4	Raglan	Supratidal	<0.01	<10	<10	<10
	0.8-1.0	Creek	Flat	<0.01	13	<10	93
	1.6-1.8			<0.01	13	<10	36
1045	0.4-0.6	Raglan	Creek	<0.01	<10	<10	<10
	0.8-1.0	Creek	Bank	1.44	25	846	924
	1.6-1.8			1.22	<10	1004	710
1046	0.8-1.0	Bajool	Supratidal	<0.01	14	<10	18
	1.4-1.6		Flat	0.02	35	14	178
	2.0-2.3			0.87	34	512	578
1047	0.3-0.5	Bajool	Supratidal	<0.01	<10	<10	<10
	0.8-1.0		Flat	0.52	<10	214	334
	1.4-1.7			1.59	<10	809	1000
1048	0.3-0.5	Bajool	Supratidal	<0.01	<10	<10	13
	0.8-1.0		Flat	0.47	14	225	309
	1.5-1.8			0.82	<10	356	464
1049	0.3-0.5	Bajool	Supratidal	<0.01	<10	<10	13
	0.8-1.0		Flat	<0.01	12	<10	15
	1.8-2.0			0.03	<10	<10	10
1050	0.4-0.6	Bajool	Supratidal	<0.01	<10	<10	13
	0.8-1.0		Flat	<0.01	15	<10	18
	1.3-1.6			0.25	22	136	180
1051	0.3-0.5	Bajool	Supratidal	<0.01	<10	<10	<10
	0.8-1.0		Flat	0.01	<10	<10	<10
	1.6-1.8			0.02	<10	<10	<10
1052	0.4-0.6	Bajool	Supratidal	<0.01	<10	<10	<10
	0.8-1.0		Flat	<0.01	<10	<10	<10
	1.6-1.8			<0.01	<10	<10	<10
1053	0.6-0.8	Bajool	Plain	<0.01	<10	<10	<10
	1.7-1.9			0.02	<10	<10	<10
	2.8-3.0			0.77	<10	274	416
1054	0.8-1.0	Bajool	Plain	<0.01	18	<10	21
	1.8-2.0			<0.01	31	<10	34
	2.8-3.0			1.08	<10	378	600

APPENDIX 2

Retained acidity for selected samples with jarosite or field pH ≤ 5

Site No	Depth (m)	Texture[1] Category	Field pH[2]	S_{NAS}[3] (%)	s-S_{NAS}[4] (%)	a-S_{NAS}[5] (mol H^+/t)
CQA863	0.3-0.5	Fine	4.2	<0.005	0	0
CQA873	0.15-0.3	Fine	3.7	<0.005	0	0
CQA874	0.3-0.5	Fine	3.6	<0.005	0	0
CQA874	0.8-1.0	Fine	3.4	<0.005	0	0
CQA877	0.3-0.5	Fine	3.9	<0.005	0	0
CQA878	0.4-0.6	Fine	3.7	0.072	0.054	34
CQA878	0.8-1.0	Fine	3.8	0.005	0.004	2
CQA879	0.5-0.7	Fine	3.9	<0.005	0	0
CQA881	0.8-1.0	Fine	3.9	0.111	0.083	52
CQA881	1.6-1.8	Fine	3.6	0.058	0.044	27
CQA882	0.8-1.0	Fine	3.9	0.005	0.004	2
CQA884	1.3-1.5	Fine	3.8	0.027	0.020	13
CQA884	1.6-1.8	Fine	5.3	<0.005	0	0
CQA886	0.8-1.0	Fine	3.0	0.064	0.048	30
CQA889	2.2-2.4	Fine	4.0	<0.005	0	0
CQA892	0.4-0.6	Fine	4.0	0.791	0.593	370
CQA892	1.3-1.5	Medium	3.8	0.039	0.029	18
CQA893	0.4-0.6	Fine	3.9	0.015	0.011	7
CQA893	0.6-0.8	Fine	3.4	0.309	0.232	145
CQA899	0.2-0.3	Fine	5.0	0.147	0.110	69
CQA910	0.4-0.6	Fine	3.6	0.156	0.117	73
CQA914	0.65-0.8	Fine	3.9	0.006	0.005	3
CQA914	1.0-1.2	Fine	3.6	0.021	0.016	10
CQA917	0.4-0.6	Fine	3.3	0.007	0.005	3
CQA918	1.2-1.5	Fine	3.9	<0.005	0	0
CQA919	0.2-0.4	Fine	4.2	0.253	0.190	118
CQA919	0.5-0.7	Fine	3.3	<0.005	0	0
CQA920	0.8-1.0	Fine	3.0	0.006	0.005	3
CQA922	1.0-1.2	Fine	3.8	<0.005	0	0
CQA922	1.8-2.0	Fine	3.2	0.136	0.102	64
CQA923	2.7-2.9	Fine	4.1	<0.005	0	0
CQA924	0.8-1.0	Fine	4.1	0.044	0.033	21
CQA924	1.3-1.5	Fine	3.7	0.124	0.093	58
CQA924	1.8-2.0	Fine	3.9	<0.005	0	0
CQA925	0.8-1.0	Fine	2.5	0.128	0.096	60
CQA926	0.8-1.0	Fine	2.6	0.187	0.140	87
CQA930	0.4-0.6	Fine	3.2	0.522	0.392	244
CQA930	0.8-1.0	Fine	3.1	0.356	0.267	167
CQA938	0.8-1.0	Fine	3.7	<0.005	0	0
CQA938	1.6-1.9	Fine	3.3	0.038	0.029	18
CQA939	0.7-0.9	Fine	4.3	0.374	0.281	175
CQA939	1.6-1.8	Fine	3.5	0.007	0.005	3
CQA940	0.3-0.5	Fine	3.9	<0.005	0	0
CQA940	1.0-1.2	Fine	3.1	0.637	0.478	298
CQA940	1.5-1.8	Fine	2.9	0.596	0.447	279

Site No	Depth (m)	Texture[1] Category	Field pH[2]	S_{NAS}[3] (%)	s-S_{NAS}[4] (%)	a-S_{NAS}[5] (mol H^+/t)
CQA943	1.1-1.3	Fine	4.1	0.008	0.006	4
CQA945	0.2-0.4	Fine	4.5	0.005	0.004	2
CQA959	0.3-0.5	Fine	4.0	<0.005	0	0
CQA960	0.6-0.8	Fine	3.4	0.100	0.075	47
CQA960	1.0-1.2	Fine	3.2	0.080	0.060	37
CQA961	0.4-0.6	Fine	2.7	0.292	0.219	137
CQA961	0.8-1.0	Fine	2.5	0.126	0.024	59
CQA964	0.3-0.5	Fine	4.4	0.191	0.143	89
CQA970	0.6-0.8	Fine	3.3	<0.005	0	0
CQA972	0.3-0.5	Fine	4.4	0.194	0.146	90
CQA973	0.1-0.3	Fine	4.4	<0.005	0	0
CQA974	0.3-0.5	Fine	4.2	0.476	0.357	223
CQA981	0.2-0.4	Fine	3.6	0.020	0.015	9
CQA990	0.1-0.3	Fine	4.1	0.047	0.035	22
CQA991	0.2-0.4	Fine	4.6	<0.005	0	0
CQA995	1.5-1.7	Fine	3.9	0.305	0.229	143
CQA995	2.0-2.2	Fine	3.4	<0.005	0	0
CQA1000	2.3-2.6	Fine	4.0	<0.005	0	0
CQA1001	1.5-1.8	Fine	3.9	0.010	0.007	5
CQA1002	0.2-0.4	Fine	4.0	0.319	0.239	149
CQA1002	0.8-1.0	Fine	3.3	0.287	0.215	134
CQA1009	0.3-0.5	Fine	4.4	0.300	0.225	140
CQA1010	0.1-0.3	Fine	4.1	0.799	0.599	369
CQA1011	0.4-0.5	Fine	4.8	0.185	0.138	86
CQA1012	0.3-0.5	Fine	4.3	0.012	0.009	6
CQA1015	1.8-2.0	Fine	3.8	0.066	0.049	31
CQA1019	1.8-2.0	Fine	4.3	0.179	0.134	84
CQA1019	2.8-3.0	Fine	4.0	0.119	0.089	56
CQA1020	2.8-3.0	Fine	4.2	<0.005	0	0
CQA1023	2.0-2.3	Fine	3.9	0.033	0.025	15
CQA1023	2.6-2.8	Fine	4.1	0.012	0.009	6
CQA1024	0.3-0.5	Fine	3.6	0.024	0.018	11
CQA1027	1.3-1.5	Fine	3.7	0.014	0.010	5
CQA1031	2.8-3.0	Fine	3.0	0.099	0.074	46
CQA1031	3.8-4.0	Medium	3.5	0.043	0.032	20
CQA1033	0.3-0.5	Fine	3.4	<0.005	0	0
CQA1044	0.8-1.0	Fine	3.5	0.165	0.124	77
CQA1046	0.8-1.0	Fine	3.4	<0.005	0	0
CQA1046	1.4-1.6	Fine	3.1	0.291	0.218	136

[1]Ahern *et al.* (1998)
[2] Field pH before oxidation.
[3] Net acid soluble Sulfur (Ahern *et al.* 2004)
[4] Equivalent % pyrite Sulfur.
[5] Equivalent acidity units.