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# Acid sulfate soil neutralisation in reflooded environments around Lakes Alexandrina and Albert, South Australia; 2½ to 3½ years after re-flooding

**Prepared for:** Department of Environment, Water and Natural Resources, as part of the Coorong, Lower Lakes and Murray Mouth Program

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**Cover Photograph:**

Campbell Park, Lake Albert (LF10)
Photographer: Andrew Baker

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# EXECUTIVE SUMMARY

Drought from 2007 to mid 2010 caused large expanses of previously inundated sediments and subaqueous soils to be exposed around the margins of Lakes Albert and Alexandrina in South Australia. This exposed acid sulfate soil (ASS) materials that became progressively oxidised to greater and greater depths in the soil profiles. The resultant formation of sulfuric materials (pH < 4) produced significant water quality and ecological problems. From March 2010, increased rainfall within the Murray Darling Basin catchment caused inundation and neutralisation, to varying degrees, of these sulfuric materials.

As part the current study (Sampling-g), sampling of ASS was carried out around the margins of Lakes Albert and Alexandrina in February 2013. Prior to this study, soil sampling had been undertaken on seven occasions between November 2007 and June 2012 to assess the impacts of drought on ASS formation and the subsequent extent and rate of neutralisation of inundated soil material.

Prolonged inundation of oxidised ASS material can promote the onset of reducing conditions, that ultimately results in the reduction of sulfate to sulfide. Surface water may flush acidity ($H^+$) and trace metals either down through the profile and/or into the water column. The degree to which acidic soils had been neutralised following reflooding generally fell into four categories depending on time of inundation and degree of neutralisation (increase in soil pH/alkalinity):

1. Limited neutralisation throughout profile (inundated: 3 and 3½ years)
2. Limited neutralisation throughout profile (inundated: 2½ years)
3. Neutralisation of upper 20 to 40 cm of profile (inundated: 2½ years)
4. No significant neutralisation (inundated: 2½ years)

At the sites sampled, acidification hazards remained unchanged since the previous sampling that had been undertaken in June 2012. Minor increases in soil pH were observed at Point Sturt South (LF17) and Campbell Park (LF10-C) resulting in reclassification of soil material from sulfuric subaqueous to hypersulfidic subaqueous. Regardless, soil material at many of the sites studied continue to pose a high acidification hazard and on drying, is likely to further acidify or rapidly re-acidify and may impact surface waters and ecosystem health.

Future work should include continued annual monitoring of ASS in the Lower Lakes to provide important information about soil acid-neutralisation rates following inundation that will be used for management decision making.

# 1. INTRODUCTION

## 1.1 Background

From 2007 until mid 2010, reduced inflows from the River Murray to Lakes Alexandrina and Albert, South Australia occurred as a consequence of persistent drought in the Murray-Darling Basin. The combination of decreasing water levels and gently sloping near-shore lake beds caused large expanses of previously inundated sediments and subaqueous soils to be exposed. With continued lowering of water levels, acid sulfate soil (ASS) materials became progressively oxidised to greater and greater depths in the soil profiles. The resultant formation of sulfuric materials ($pH < 4$) produced significant water quality and ecological problems.

Increased rainfall within the Murray Darling Basin catchment, from March 2010, caused a rise in water levels and inundation of sulfuric materials that had formed in the previously dried margins of the Lower Lakes.

Prior to this study, soil sampling was undertaken on seven occasions between November 2007 and June 2012 to assess the impacts of drought on ASS formation and the subsequent extent and rate of inundated soil neutralisation (Baker *et al.* 2013). This investigation was undertaken to further asses ASS neutralisation and encompassed 17 study areas that were located around the margins of Lake Alexandrina, Lake Albert and tributaries (Figure 1-1). These were generally representative of the diverse environments encountered around the Lakes based on ASS investigations in the region since 2007 (e.g. Baker *et al.* 2010; Baker *et al.* 2013; Fitzpatrick *et al.* 2010; Fitzpatrick *et al.* 2008a; Fitzpatrick *et al.* 2008b; Fitzpatrick *et al.* 2009; Fitzpatrick *et al.* 2008c).


Figure 1-1 Map of the Lower Lakes and adjacent tributaries showing the locations of the 17 study areas.

# 2. FIELD AND LABORATORY METHODS

## 2.1 Field sampling of soils

As part of this study, sampling was carried out in February 2013 (phase “g” ; Table 2-1).

Representative study areas were selected around the margins of Lakes Alexandrina and Albert as well as from the tributaries (Finniss River and Currency Creek). Where possible, the sites sampled for this project were positioned within a few metres of former sampling sites that had been established as part of studies of ASS in Lake Alexandrina and Lake Albert (Baker *et al.* 2010; Baker *et al.* 2011; Fitzpatrick *et al.* 2010; Fitzpatrick *et al.* 2008a; Fitzpatrick *et al.* 2008b; Fitzpatrick *et al.* 2009; Fitzpatrick *et al.* 2008c). A summary of earlier samplings (phases “a” to “f” and “$h_{\#}$”) are presented in Baker *et al.* (2013) and Baker *et al.* (2011).

A Global Positioning System (GPS) was used to re-locate sample sites. Soil profile sampling was carried out by observable soil horizon and was achieved using spades and a range of auger types. Sampling was relatively shallow (< 1.0 m) to encompass the materials most likely to be influenced by oxidation.

At each site, GPS co-ordinates and site descriptions were recorded. Grid coordinate locations (WGS84 datum) are presented in Table 2-1. Photographs of the site were taken at photographic points that had been established in previous studies (Appendix 3). Approximately four soil cores were collected at each study site. Cores were stored in ice for transportation to the laboratory. In the laboratory, each core was photographed with a scale and soil horizons were subsampled (Appendix 4). Soil material was described and physical properties such as colour, consistency, structure and texture follow McDonald *et al.* (1990) (Appendix 2). The presence of ‘sulfidic’ smells (e.g., $H_2S$ – rotten egg gas and methyl thiols) as well as oxidising odours ($SO_2$) were recorded. Representative sub-samples were placed in plastic jars for acid-base accounting, electrical conductivity and pH measurements. Additional subsamples were collected in chip trays for morphological study and ageing experiments (analytical methods described in Appendix 1). The analytical data for these analyses are appended to this report (Appendices 5 and 6).

Table 2-1 Sampling g: February 2013 sampling dates and location of soil sampling sites. Eastings and Northings are based on the WGS84 datum, Zone 54H.

| Site ID | Locality | Sampling Date | Easting | Northing |
|---|---|---|---|---|
| LFg01-A | Wallys Landing and Wetland | 07/02/2013 | 303198 | 6079714 |
| LFg02-A | Point Sturt North | 20/02/2013 | 321247 | 6070294 |
| LFg02-D | Point Sturt North | 20/02/2013 | 321220 | 6070249 |
| LFg03-A | Milang | 07/02/2013 | 316106 | 6079440 |
| LFg04-A | Tolderol | 11/02/2013 | 331889 | 6083697 |
| LFg06-A | Poltalloch | 13/02/2013 | 338984 | 6070340 |
| LFg07-A | Waltowa | 05/02/2013 | 352351 | 6059112 |
| LFg08-A | Meningie | 05/02/2013 | 349066 | 6049328 |
| LFg08-B | Meningie | 05/02/2013 | 349053 | 6049398 |
| LFg10-A | Campbell Park | 13/02/2013 | 341307 | 6056483 |
| LFg10-C | Campbell Park | 13/02/2013 | 341114 | 6056623 |
| LFg12-B | Loveday Bay | 13/02/2013 | 326711 | 6061362 |
| LFg12-C | Loveday Bay | 13/02/2013 | 326420 | 6061713 |
| LFg13-A | Tauwitcherie | 07/02/2013 | 319050 | 6060550 |
| LFg15-B | Boggy Creek | 07/02/2013 | 311139 | 6065855 |
| LFg17-A | Point Sturt South | 20/02/2013 | 314849 | 6069780 |
| LFg17-B | Point Sturt South | 20/02/2013 | 314806 | 6069675 |
| LFg19-A | Dog Lake | 18/02/2013 | 332033 | 6086787 |
| LFg19-B | Dog Lake | 18/02/2013 | 331011 | 6085785 |
| LFg20-A | Boggy Lake | 18/02/2013 | 335054 | 6089352 |
| LFg20-B | Boggy Lake | 18/02/2013 | 334841 | 6090032 |
| LFg21-A | Windmill Site | 13/02/2013 | 345597 | 6064184 |
| LFg23-A | Lower Currency | 11/02/2013 | 301055 | 6072892 |
| LFg24-A | Lower Finniss | 11/02/2013 | 305780 | 6073929 |

# 3. RESULTS AND DISCUSSION

Acid-base accounting was carried out according to the methods described in Appendix 1 and comprised analyses for sulfide-S ($S_{CR}$ or Cr-reducible S), Retained Acidity (RA), Titratable Actual Acidity (TAA), Acid Neutralising Capacity (ANC) and Net Acidity (NA). Acid-base accounting and pH data ($pH_{OX}$, $pH_{INC}$ & $pH_{W}$), for each soil layer, are presented in (Figure 3-1). These data were used to inform the acidification hazard assessment that is presented in Table 3-1.

*LF01 - Wallys Landing and Wetland*: Soil profiles sampled comprised hypersulfidic and subaqueous clay soils with high acidification hazard (Table 3-1). Net acidity was very high (maximum of 1000 moles H+/tonne) and increased with depth (Figure 3-1). There was little ANC and acidification potentials were high (Table 3-1).

*LF02 – Point Sturt North*: Soil profiles sampled comprised sulfuric and hypersulfidic subaqueous soil with high acidification hazard (Table 3-1). At each site, net acidity was relatively high (maximum of 120 moles H+/tonne) and increased with depth (Figure 3-1). Acidification potentials were generally high throughout the profiles (Table 3-1).

*LF03 - Milang*: Soil profiles sampled comprised sulfuric and hypersulfidic subaqueous soil with high acidification hazard (Table 3-1). Net acidity was high (maximum of 250 moles H+/tonne) and was highest in the middle of the profile (Figure 3-1). There was little ANC and acidification potentials were generally high (Table 3-1).

*LF04 - Tolderol*: Soil profiles sampled comprised hypersulfidic subaqueous soil material with high acidification hazard (Table 3-1). Net acidity was high (maximum of 350 moles H+/tonne) and increased with depth (Figure 3-1). There was some ANC at depth and acidification potentials were high (Table 3-1).

*LF06 - Poltalloch*: Soil profiles sampled comprised hyposulfidic and hypersulfidic subaqueous soil material with low acidification hazard (Table 3-1). The net acidity was relatively low (maximum of 40 moles H+/tonne) and increased with depth (Figure 3-1). There was little ANC and acidification potentials ranged from low near surface to high at depth (Table 3-1).

*LF07 - Waltowa*: Soil profiles sampled comprised hypersulfidic subaqueous soils with medium acidification hazard (Table 3-1). Although net acidity was low (18 moles H+/tonne) in surface sands, they still posed a medium acidification hazard because of very limited buffering capacity (Figure 3-1). There was some ANC at depth and acidification potentials were high (Table 3-1).

*LF08 - Meningie*: Soil profiles sampled comprised hypersulfidic and hyposulfidic soil with medium acidification hazard ratings (Table 3-1). Net acidity increased with depth (maximum of 1000 moles H+/tonne) with moderate to high levels of ANC throughout the profile (maximum of 660 moles H+/tonne) (Figure 3-1). Acidification potential ranged from low at surface to high at depth (Table 3-1).

*LF10 – Campbell Park*: Soil profiles sampled comprised sulfuric and hypersulfidic subaqueous soils with high acidification hazard (Table 3-1). The profile sampled at the shoreline, in a reed bed (LF10-A), was classified as sulfuric subaqueous organic soil (Table 3-1). Net acidity increased with depth and soil material was classified as sulfuric below 26 cm (Figure 3-1). The profile sampled approximately 150 m into the lake (LF10-C) was classified as hypersulfidic soil with high acidification hazard and net acidity increased with depth (Table 3-1; Figure 3-1).

*LF12 – Loveday Bay*: Soil profiles sampled comprised hypersulfidic subaqueous soils with medium acidification hazard (Table 3-1). Net acidity increased with depth and acidity was dominated by $S_{CR}$ (Figure 3-1). No ANC was present and acidification potentials ranged from low to high throughout the profiles (Table 3-1).

*LF13 – Tauwitchere*: Soil profiles sampled comprised hypersulfidic subaqueous soils with low acidification hazard (Table 3-1). The upper portion of the profile (above 14 cm) had positive net acidity, high acidification potential and no ANC was present (Figure 3-1). The lower portion of the profile had negative net acidity, low acidification potential and very high levels of ANC (Figure 3-1).

*LF15 – Boggy Creek*: Soil profiles sampled comprised hypersulfidic subaqueous soils with medium acidification hazard (Table 3-1). The upper portion of the profile (above 27 cm) had positive net acidity, high acidification potential and no ANC was present (Figure 3-1). The lower portion of the profile had negative net acidity, low acidification potential and very high levels of ANC (Figure 3-1).

*LF17 – Point Sturt South*: Soil profiles sampled comprised hypersulfidic subaqueous soils with high acidification hazard (Table 3-1). They had positive net acidity that increased with depth, little or no ANC, relatively high acidity and high acidification potential (Figure 3-1; Table 3-1).

*LF19 – Dog Lake*: Soil profiles sampled comprised sulfuric and hypersulfidic subaqueous soils with high acidification hazard (Table 3-1). Net acidity was positive throughout the profiles but high levels of ANC was present at depth in profile LF19-B (Figure 3-1; Table 3-1). Acidification potential was high in both profiles from surface to depths of approximately 40 cm (Table 3-1).

*LF20 – Boggy Lake*: Soil profiles sampled comprised hypersulfidic subaqueous soils with high acidification hazard (Table 3-1). Net acidity was generally positive throughout the profiles and ANC was present at relatively low levels at depth (Figure 3-1; Table 3-1). Acidification potential was generally high throughout both profiles (Table 3-1).

*LF21 – Windmill Site*: Soil profiles sampled comprised hypersulfidic subaqueous soils with high acidification hazard (Table 3-1). Net acidity was positive throughout the profile, acidification potential was high, acidity was dominated by $S_{CR}$ and minor ANC was present (Figure 3-1; Table 3-1).

*LF23 – Lower Currency*: Soil profiles sampled comprised hypersulfidic subaqueous soils with medium acidification hazard (Table 3-1). The net acidity was relatively low (maximum of 40 moles H+/tonne) and increased with depth (Figure 3-1). Acidification potential ranged from medium at surface to high below a depth of 7 cm (Table 3-1).

*LF24 – Lower Finniss*: Soil profiles sampled comprised hypersulfidic subaqueous soils with high acidification hazard (Table 3-1). The net acidity was positive throughout the profile (maximum of 1000 moles H+/tonne) and increased with depth (Figure 3-1). Acidification potential was high throughout both profiles (Table 3-1).

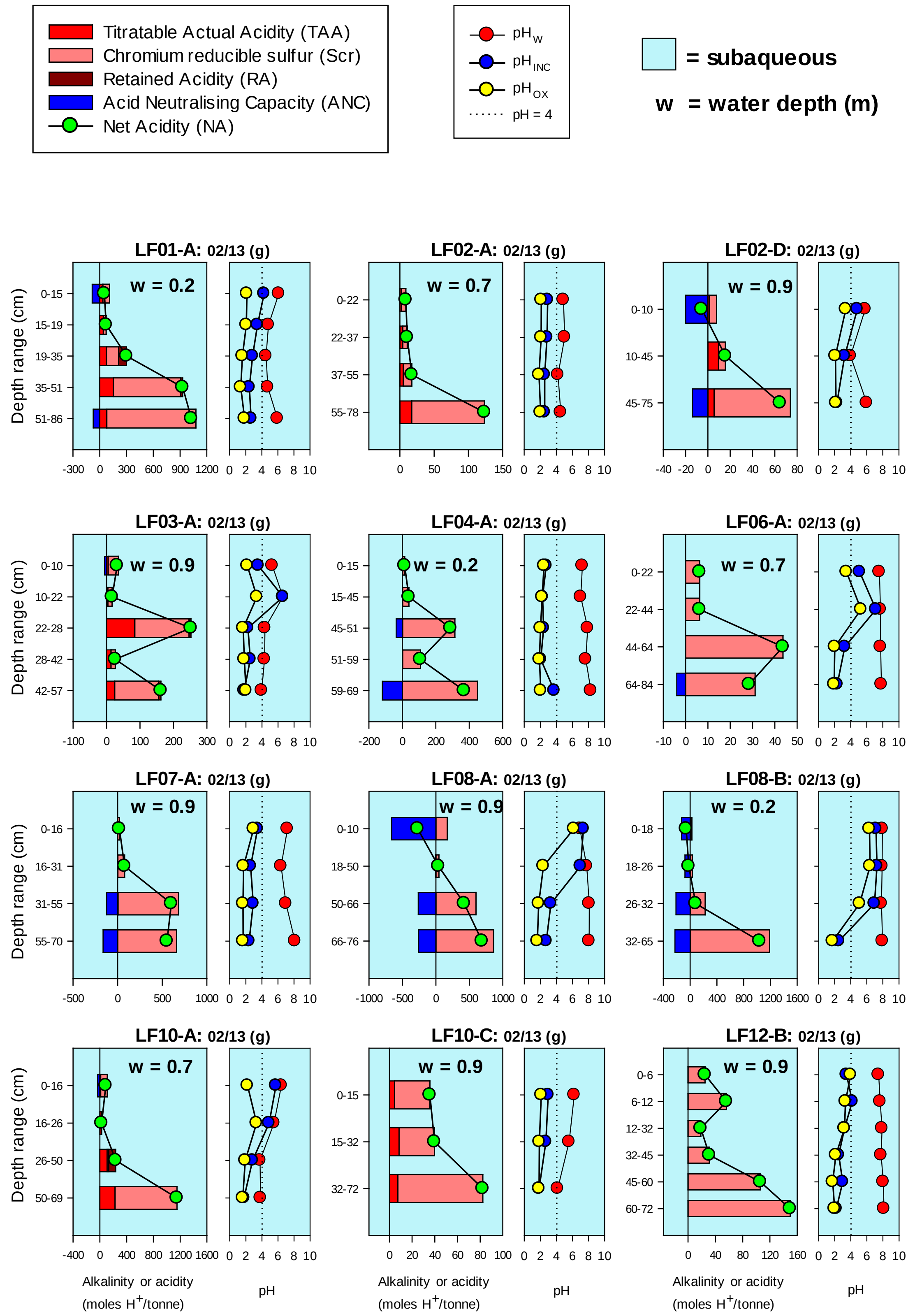


Figure 3-1 pH and acid-base accounting data plotted against depth for each profile collected in February 2013

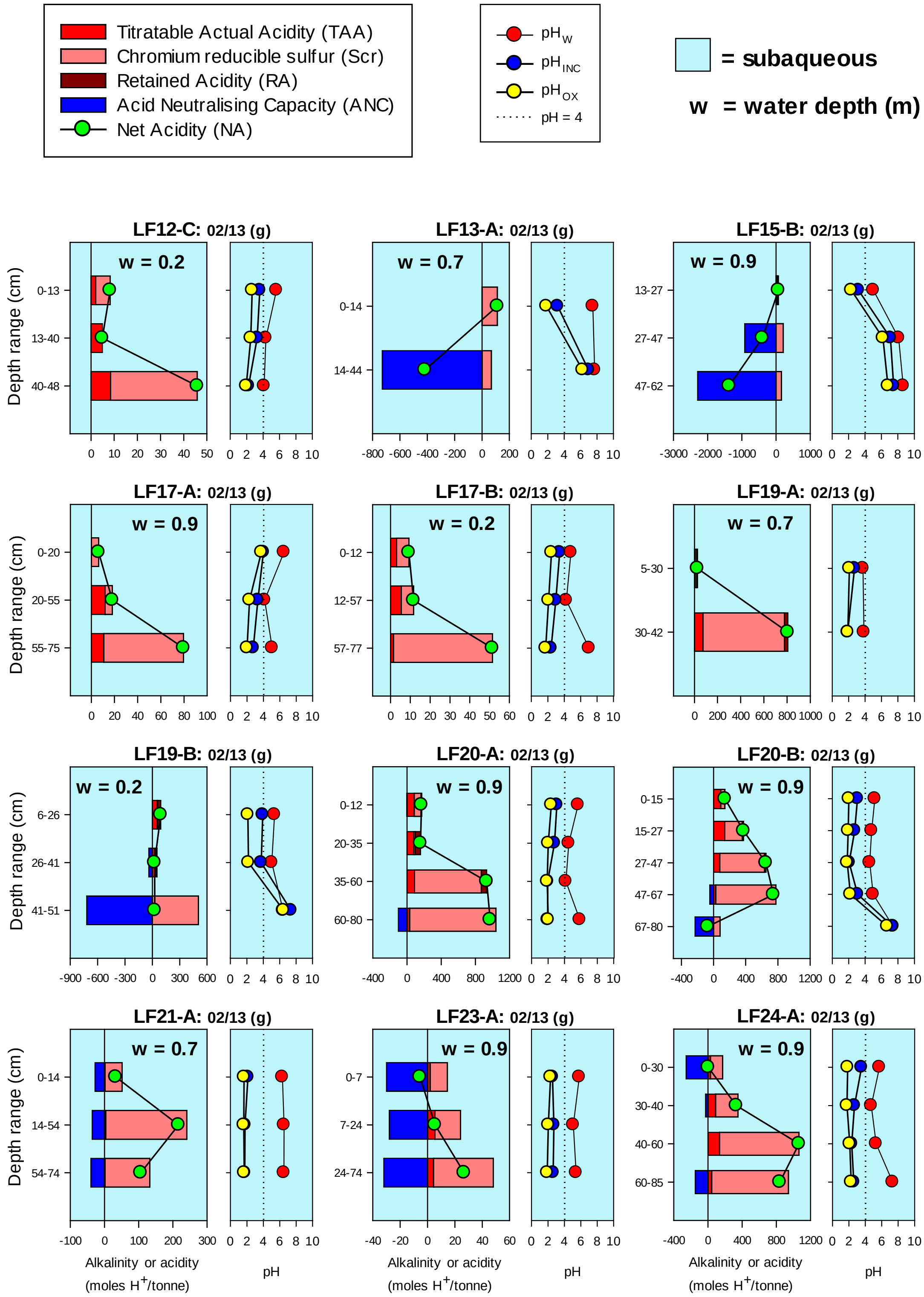


Figure 3.1 Cont. pH and acid-base accounting data plotted against depth for each profile collected in February 2013

Table 3-1 Summary of acidification potential, ASS material classification, ASS subtype classification and acidification hazard (* indicates sulfuric soil material). The soil texture in brackets following the ASS subtype classification indicates the dominant texture of the profile

| Sample | Depth (cm) | $pH_{OX}$ < 2.5 | $pH_{INC}$ < 4.0 | NA > 0 | Acidification potential | ASS material classification | ASS subtype classification | Acidification hazard |
|---|---|---|---|---|---|---|---|---|
| **LFg01** | | | | | | | | |
| LFg01-A.1 | 0-15 | 1 | 1 | 1 | 3 | Hypersulfidic hemic peat | Hypersulfidic subaqueous clay soil (clay) | High |
| LFg01-A.2 | 15-19 | 1 | 1 | 1 | 3 | Hypersulfidic sand | | |
| LFg01-A.3 | 19-35 | 1 | 1 | 1 | 3 | Hypersulfidic heavy sandy clay | | |
| LFg01-A.4 | 35-51 | 1 | 1 | 1 | 3 | Hypersulfidic heavy sandy clay | | |
| LFg01-A.5 | 51-86 | 1 | 1 | 1 | 3 | Hypersulfidic heavy clay | | |
| **LFg02** | | | | | | | | |
| LFg02-A.1 | 0-22 | 1 | 1 | 1 | 3 | Hypersulfidic silty sand | Hypersulfidic subaqueous soil (sand) | High |
| LFg02-A.2 | 22-37 | 1 | 1 | 1 | 3 | Hypersulfidic silty sand | | |
| LFg02-A.3 | 37-55 | 1 | 1 | 1 | 3 | Hypersulfidic silty sand | | |
| LFg02-A.4 | 55-78 | 1 | 1 | 1 | 3 | Hypersulfidic silty sand | | |
| LFg02-D.1 | 0-10 | 0 | 0 | 0 | 0 | Hyposulfidic sand | Sulfuric subaqueous soil (sand) | High |
| LFg02-D.2 | 10-45 | 1 | 1 | 1 | 3* | Sulfuric sand | | |
| LFg02-D.3 | 45-75 | 1 | 1 | 1 | 3 | Hypersulfidic sandy clay | | |
| **LFg03** | | | | | | | | |
| LFg03-A.1 | 0-10 | 1 | 1 | 1 | 3 | Hypersulfidic loamy sand | Sulfuric subaqueous soil (sand) | High |
| LFg03-A.2 | 10-22 | 0 | 0 | 1 | 1 | Hyposulfidic sand | | |
| LFg03-A.3 | 22-28 | 1 | 1 | 1 | 3 | Hypersulfidic heavy clay | | |
| LFg03-A.4 | 28-42 | 1 | 1 | 1 | 3 | Hypersulfidic loamy sand | | |
| LFg03-A.5 | 42-57 | 1 | 1 | 1 | 3* | Sulfuric loamy sand | | |
| **LFg04** | | | | | | | | |
| LFg04-A.1 | 0-15 | 1 | 1 | 1 | 3 | Hypersulfidic sand | Hypersulfidic subaqueous soil (sand) | High |
| LFg04-A.2 | 15-45 | 1 | 1 | 1 | 3 | Hypersulfidic sand | | |
| LFg04-A.3 | 45-51 | 1 | 1 | 1 | 3 | Hypersulfidic sandy clay | | |
| LFg04-A.4 | 51-59 | 1 | 1 | 1 | 3 | Hypersulfidic sand | | |
| LFg04-A.5 | 59-69 | 1 | 1 | 1 | 3 | Hypersulfidic sandy clay | | |
| **LFg06** | | | | | | | | |
| LFg06-A.1 | 0-22 | 0 | 0 | 1 | 1 | Hyposulfidic sand | Hypersulfidic subaqueous soil (sand) | Low |
| LFg06-A.2 | 22-44 | 0 | 0 | 1 | 1 | Hyposulfidic sand | | |
| LFg06-A.3 | 44-64 | 1 | 1 | 1 | 3 | Hypersulfidic sand | | |
| LFg06-A.4 | 64-84 | 1 | 1 | 1 | 3 | Hypersulfidic sand | | |
| **LFg07** | | | | | | | | |
| LFg07-A.1 | 0-16 | 0 | 1 | 1 | 2 | Hypersulfidic loamy sand | Hypersulfidic subaqueous clay soil (clay) | Medium |
| LFg07-A.2 | 16-31 | 1 | 1 | 1 | 3 | Hypersulfidic loamy sand | | |
| LFg07-A.3 | 31-55 | 1 | 1 | 1 | 3 | Hypersulfidic heavy clay | | |
| LFg07-A.4 | 55-70 | 1 | 1 | 1 | 3 | Hypersulfidic heavy calcareous clay | | |
| **LFg08** | | | | | | | | |
| LFg08-A.1 | 0-10 | 0 | 0 | 0 | 0 | Hyposulfidic monosulfidic gel | Hypersulfidic subaqueous clay soil (clay) | Medium |
| LFg08-A.3 | 18-50 | 1 | 0 | 1 | 2 | Hyposulfidic loamy sand | | |
| LFg08-A.4 | 50-66 | 1 | 1 | 1 | 3 | Hypersulfidic heavy clay | | |
| LFg08-A.5 | 66-76 | 1 | 1 | 1 | 3 | Hypersulfidic heavy clay | | |
| LFg08-B.1 | 0-18 | 0 | 0 | 0 | 0 | Hyposulfidic silty sand | Hypersulfidic subaqueous clay soil (clay) | Medium |
| LFg08-B.2 | 18-26 | 0 | 0 | 0 | 0 | Hyposulfidic loamy sand | | |
| LFg08-B.3 | 26-32 | 0 | 0 | 1 | 1 | Hyposulfidic heavy clay | | |
| LFg08-B.4 | 32-65 | 1 | 1 | 1 | 3 | Hypersulfidic heavy clay | | |
| **LFg10** | | | | | | | | |
| LFg10-A.1 | 0-16 | 1 | 0 | 1 | 2 | Hyposulfidic peat | Sulfuric subaqueous organic soil (clay) | High |
| LFg10-A.2 | 16-26 | 0 | 0 | 1 | 1 | Hyposulfidic sandy clay | | |
| LFg10-A.3 | 26-50 | 1 | 1 | 1 | 3* | Sulfuric heavy clay | | |
| LFg10-A.4 | 50-69 | 1 | 1 | 1 | 3* | Sulfuric heavy clay | | |
| LFg10-C.1 | 0-15 | 1 | 1 | 1 | 3 | Hypersulfidic clayey peat | Hypersulfidic subaqueous organic soil (sand) | High |
| LFg10-C.2 | 15-32 | 1 | 1 | 1 | 3 | Hypersulfidic clayey peat | | |
| LFg10-C.3 | 32-72 | 1 | 1 | 1 | 3 | Hypersulfidic sand | | |
| **LFg12** | | | | | | | | |
| LFg12-B.1 | 0-6 | 0 | 1 | 1 | 2 | Hypersulfidic sand | Hypersulfidic subaqueous soil (sand) | Medium |
| LFg12-B.2 | 6-12 | 0 | 1 | 1 | 2 | Hypersulfidic sand | | |
| LFg12-B.3 | 12-32 | 0 | 1 | 1 | 2 | Hypersulfidic sand | | |
| LFg12-B.4 | 32-45 | 1 | 1 | 1 | 3 | Hypersulfidic sand | | |
| LFg12-B.5 | 45-60 | 1 | 1 | 1 | 3 | Hypersulfidic sand | | |
| LFg12-B.6 | 60-72 | 1 | 1 | 1 | 3 | Hypersulfidic sandy clay | | |
| LFg12-C.1 | 0-13 | 0 | 1 | 1 | 2 | Hypersulfidic sand | Hypersulfidic subaqueous soil (sand) | Medium |
| LFg12-C.2 | 13-40 | 0 | 1 | 1 | 2 | Sand | | |
| LFg12-C.3 | 40-48 | 1 | 1 | 1 | 3 | Hypersulfidic sand | | |

| Sample | Depth (cm) | $pH_{OX}$ < 2.5 | $pH_{INC}$ < 4.0 | NA > 0 | Acidification potential | ASS material classification | ASS subtype classification | Acidification hazard |
|---|---|---|---|---|---|---|---|---|
| **LFg13** | | | | | | | | |
| LFg13-A.1 | 0-14 | 1 | 1 | 1 | **3** | Hypersufilidic fibric peat | Hypersulfidic subaqueous organic soil (sand) | **Low** |
| LFg13-A.2 | 14-44 | 0 | 0 | 0 | 0 | Hyposulfidic loamy sand | | |
| **LFg15** | | | | | | | | |
| LFg15-B.3 | 13-27 | 1 | 1 | 1 | **3** | Hypersufilidic sandy loam | Hypersulfidic subaqueous soil (sand) | **Medium** |
| LFg15-B.4 | 27-47 | 0 | 0 | 0 | 0 | Hyposulfidic clayey sand | | |
| LFg15-B.5 | 47-62 | 0 | 0 | 0 | 0 | Hyposulfidic clayey coarse sand | | |
| **LFg17** | | | | | | | | |
| LFg17-A.1 | 0-20 | 0 | 1 | 1 | 2 | Hypersufilidic sand | Hypersulfidic subaqueous soil (sand) | **High** |
| LFg17-A.2 | 20-55 | 1 | 1 | 1 | **3** | Hypersufilidic sand | | |
| LFg17-A.3 | 55-75 | 1 | 1 | 1 | **3** | Hypersufilidic clayey sand | | |
| LFg17-B.1 | 0-12 | 1 | 1 | 1 | **3** | Hypersufilidic sand | Hypersulfidic subaqueous soil (sand) | **High** |
| LFg17-B.2 | 12-57 | 1 | 1 | 1 | **3** | Hypersufilidic sand | | |
| LFg17-B.3 | 57-77 | 1 | 1 | 1 | **3** | Hypersufilidic sand | | |
| **LFg19** | | | | | | | | |
| LFg19-A.2 | 5-30 | 1 | 1 | 1 | **3*** | Sulfuric silty sand | Sulfuric subaqueous soil (sand) | **High** |
| LFg19-A.3 | 30-42 | 1 | 1 | 1 | **3*** | Sulfuric silty sandy clay | | |
| LFg19-B.2 | 6-26 | 1 | 1 | 1 | **3** | Hypersufilidic sandy clay | Hypersulfidic subaqueous clay soil (clay) | **Medium** |
| LFg19-B.3 | 26-41 | 1 | 1 | 1 | **3** | Hypersufilidic clay | | |
| LFg19-B.4 | 41-51 | 0 | 0 | 1 | 1 | Hyposulfidic silty clay | | |
| **LFg20** | | | | | | | | |
| LFg20-A.1 | 0-12 | 1 | 1 | 1 | **3** | Hypersufilidic sandy clay | Hypersulfidic subaqueous clay soil (clay) | **High** |
| LFg20-A.3 | 20-35 | 1 | 1 | 1 | **3** | Hypersufilidic sandy clay | | |
| LFg20-A.4 | 35-60 | 1 | 1 | 1 | **3** | Hypersufilidic heavy clay | | |
| LFg20-A.5 | 60-80 | 1 | 1 | 1 | **3** | Hypersufilidic heavy clay | | |
| LFg20-B.1 | 0-15 | 1 | 1 | 1 | **3** | Hypersufilidic sandy clay | Hypersulfidic subaqueous clay soil (clay) | **High** |
| LFg20-B.2 | 15-27 | 1 | 1 | 1 | **3** | Hypersufilidic heavy clay | | |
| LFg20-B.3 | 27-47 | 1 | 1 | 1 | **3** | Hypersufilidic sandy clay | | |
| LFg20-B.4 | 47-67 | 1 | 1 | 1 | **3** | Hypersufilidic clayey sand | | |
| LFg20-B.5 | 67-80 | 0 | 0 | 0 | 0 | Hyposulfidic silty sand | | |
| **LFg21** | | | | | | | | |
| LFg21-A.1 | 0-14 | 1 | 1 | 1 | **3** | Hypersufilidic sand | Hypersulfidic subaqueous soil (sand) | **High** |
| LFg21-A.2 | 14-54 | 1 | 1 | 1 | **3** | Hypersufilidic sand | | |
| LFg21-A.3 | 54-74 | 1 | 1 | 1 | **3** | Hypersufilidic sand | | |
| **LFg23** | | | | | | | | |
| LFg23-A.1 | 0-7 | 1 | 1 | 0 | 2 | Hypersufilidic sand | Hypersulfidic subaqueous soil (sand) | **Medium** |
| LFg23-A.2 | 7-24 | 1 | 1 | 1 | **3** | Hypersufilidic sand | | |
| LFg23-A.3 | 24-74 | 1 | 1 | 1 | **3** | Hypersufilidic sand | | |
| **LFg24** | | | | | | | | |
| LFg24-A.1 | 0-30 | 1 | 1 | 1 | **3** | Hypersufilidic hemic peat | Hypersulfidic subaqueous clay soil (clay) | **High** |
| LFg24-A.2 | 30-40 | 1 | 1 | 1 | **3** | Hypersufilidic heavy clay | | |
| LFg24-A.3 | 40-60 | 1 | 1 | 1 | **3** | Hypersufilidic heavy clay | | |
| LFg24-A.4 | 60-85 | 1 | 1 | 1 | **3** | Hypersufilidic heavy clay | | |

# 4. SUMMARY AND CONCLUSIONS

Post drought inundation of the study areas occurred in September/October 2010. At the time of Sampling-g (February 2013), study areas in Lakes Albert and Alexandrina had been inundated for approximately 2½ years (LF02 to LF24; Figure 1-1). In contrast, study areas in the Finnis River and Currency Creek had been inundated for between 3 and 3½ years because of the construction of the Clayton regulator and pumping water from Lake Alexandrina to the Goolwa Channel (over the regulator) in August/December 2009 (LF01, LF23 and LF24; Figure 1-1).

At the sites samples, acidification hazards remained unchanged (Table 3-1) since the previous sampling that had been undertaken in June 2012 (Baker *et al.* 2013). Minor increases in soil pH were observed at Point Sturt South (LF17) and Campbell Park (LF10-C) resulting in reclassification of soil material from sulfuric subaqueous to hypersulfidic subaqueous. Regardless, soil material at many of the sites studied continue to pose a high acidification hazard and on drying, is likely to further acidify or rapidly re-acidify and may impact surface waters and ecosystem health.

Generally, soil material that had remained non-acidic during drought conditions was relatively unaffected by reflooding and transformed from hyposulfidic and hypersulfidic to hyposulfidic subaqueous and hypersulfidic subaqueous (LF06 and LF08; Figure 1-1) (Baker *et al.* 2013). Since June 2012, these profiles have remained relatively unchanged and remain hyposulfidic subaqueous and hypersulfidic subaqueous.

In June 2012, acidic study sites at Wallys Landing and Wetland (LF01), Lower Currency (LF23) and Lower Finniss (LF24) had been partially neutralised following inundation for between 2½ and 3 years (Baker *et al.* 2013). At the time of Sampling-g (February 2013), soil material at these sites had remained relatively unchanged since June 2012 and was classified hypersulfidic subaqueous with high acidification hazard. In the Finniss River (LF01 and LF24; Figure 1-1), although prolonged inundation caused the transformation of previously sulfuric sediments to hypersulfidic subaqueous soil, net acidities remained very high and TAA and RA (only LF01) were still present in soil profiles (Figure 3-1). In the Lower Currency (LF23; Figure 1-1), net acidity was lower and it appears that reduction of sulfate and flushing of acidity, in the top 30 cm of the profile, caused soil material to convert from sulfuric to hypersulfidic subaqueous (Baker *et al.* 2013). Soil material at these sites pose a high acidification hazard and on drying, is likely to re-acidify rapidly and may impact upon surface waters.

In June 2012, the acidic study sites at Point Sturt South (LF17), Dog Lake (LF19) and Boggy Lake (LF20), and some of the acidic sites at Point Sturt North (LF02-D) and Campbell Park (LF10-A) showed no significant evidence of neutralisation following reflooding (Baker *et al.* 2013). Since June 2012 and following 29 months of inundation, there has been little change at these sites. Soil material remained sulfuric at Dog Lake (LF19), Point Sturt North (LF02-D) and Campbell Park (LF10-A). Minor increases in soil pH (< 0.4) meant that soil material at Point Sturt South (LF17) was reclassified from sulfuric subaqueous to hypersulfidic subaqueous. Regardless, there was only minor evidence of sulfate reduction and/or flushing of acidity at these sites.

In June 2012, acidic study sites at Milang (LF03) and Tolderol (LF04), and some of the acidic sites at Point Sturt North (LF02-A) and Campbell Park (LF10-C) showed limited evidence of neutralisation (Baker *et al.* 2013). Acidic soil material at these sites either transformed from sulfuric to hypersulfidic subaqueous and/or showed evidence of reduction of sulfate to sulfide (i.e. a lessening of TAA and/or RA with a corresponding increase in $S_{CR}$). Since June 2012 and following 29 months of inundation, there have been only minor changes at some of these sites. Soil conditions have remained relatively unchanged at Milang (LF03), Tolderol (LF04) and Point Sturt North (LF02-A) with soils being classified as hypersulfidic or sulfuric at depth. At Campbell Park (LF10-C), a slight increase in soil pH (3.9 to 4.15) at depth meant that these soil materials were reclassified from sulfuric subaqueous to hypersulfidic subaqueous. Generally, neutralised soil materials at these sites were still considered to pose a high acidification hazard and are likely to re-acidify rapidly upon drying.

The remainder of the acidic sites studied showed evidence of neutralisation that was restricted to the upper 20 to 40 cm of the profile (LF07, LF12, LF13 and LF15; Figure 1-1). In June 2012, soil material transformed from sulfuric to hypersulfidic/hyposulfidic subaqueous, showed evidence of reduction of sulfate to sulfide (i.e. a lessening of TAA and/or RA with a corresponding increase in $S_{CR}$) and/or flushing of acidity from surface sediments. Underlying hypersulfidic soil material was not significantly impacted by reflooding (Baker *et al.* 2013). At Tauwitcherie (LF13), net acidity of surface sediments changed from positive to negative and soil material transformed from sulfuric to hyposulfidic subaqueous. This was probably caused by the extreme heterogeneity of the soil within the read bed (i.e. distribution of organic matter) or flushing of acidity ($H^+$) from surface sediments (Baker *et al.* 2013). No significant changes were noted at these sites since they were sampled in June 2012. Except at Tauwitcherie (LF13), neutralised soil material at these sites was still considered to pose a high acidification hazard and is likely to re-acidify rapidly upon drying.

It is important to continue annual monitoring of ASS in the Lower Lakes to provide information about soil acid-neutralisation rates following inundation that will be used for management decision making if low flow conditions return to the Murray-Darling Basin.

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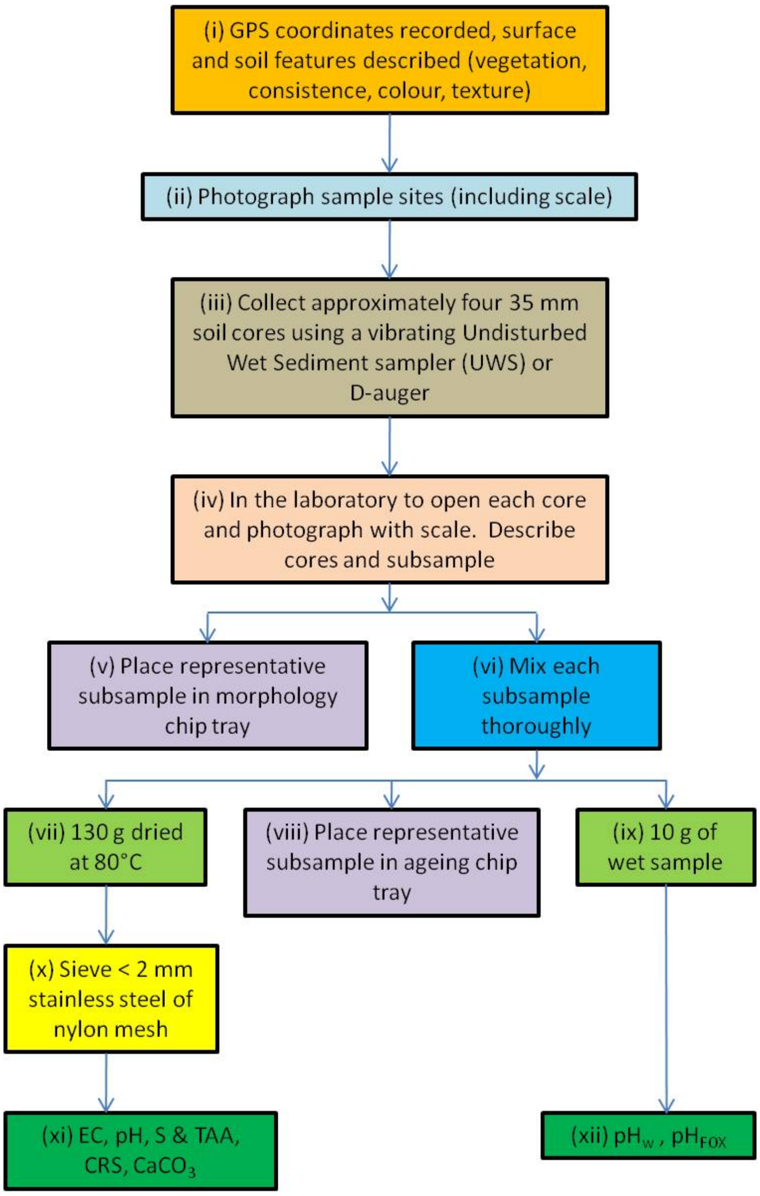
# Appendix 1 – Laboratory soil analysis methods

The general flowchart for soil sample collection and analysis is shown in (Appendix Figure 1.1). Air was excluded as far as possible from the samples. Following sampling, the soils were kept cool at 4°C until analysed. Samples for acid-base accounting were air dried at 80°C. Moisture contents were recorded and bulk densities estimated. Samples for sulfur suite analysis were sent to the Environmental Analysis Laboratory of Southern Cross University. Samples were also stored in chip trays to conduct incubation experiments to follow the course of potential acidification and confirm ASS status. Oven and air dried/moist samples and chip tray samples were kept for long-term storage to allow for future re-sampling and analysis, if required.




Appendix Figure 1.1 General flow chart for soil sampling and analysis.

# Methods used to assess acid generation potential

In order to assess the acid generation potential (AGP) of ASS, a range of methods were used. This required several parameters to be measured, as highlighted in Appendix Figure 1.1. An important consideration was also the mineralogical make-up of the soils, which may have enhanced or neutralised AGP. These also needed to be combined with field observations and placed into the geological and hydrological framework, so that laboratory-scale data could be interpreted at the larger landscape scale.

In nature, a number of oxidation reactions of sulfide minerals (principally pyrite: $FeS_2$) may occur, which produce acidity, including:

$$2FeS_2 + 7O_2 + 2H_2O \rightarrow 2Fe^{2+} + 4SO_4^{2-} + 4H^+$$

$$4FeS_2 + 15O_2 + 10H_2O \rightarrow 4FeOOH + 8H_2SO_4$$

A range of secondary minerals, such as jarosite, sideronatrite and schwertmannite may also form. Such minerals act as stores of acidity i.e. they may produce acidity upon dissolution. Therefore, any assessment needs to include the presence of such minerals in the soil catena.

There is debate as to the most realistic method to estimate if a soil will acidify, and the most effective method may vary according to the local environment and associated mineralogy of the soils. In this study, the three most generally accepted methods for ASS testing have been used:

i) pH testing after peroxide treatment,
ii) acid-base accounting, and
iii) incubation (ageing) testing using the chip-tray method.

These have different strengths and weaknesses and therefore all have been assessed in the current project. A summary is presented below.

**pH testing after peroxide treatment**
Hydrogen peroxide ($H_2O_2$) is a strong oxidising agent and is used to encourage the full oxidation of sulfide minerals (principally pyrite: $FeS_2$) and the subsequent production of acidity. Since peroxide is a strong oxidising agent, it can be argued that the resultant pH measured is a worst-case scenario, as in nature oxidation is rarely complete. In nature, the presence of carbonate minerals such as calcite ($CaCO_3$) may neutralise acid produced, however, in some cases the carbonate may not fully dissolve due to slow dissolution rates (reaction kinetics). The dissolution rates of individual minerals may be controlled by a number of factors, hence additional tests based on measuring the carbonate content are recommended.

**Acid-base accounting**
Acid-base accounting is a technique which balances the potential acid generated from the sum of sulfide-S ($S_{CR}$ or chromium-reducible S) and the titratable actual acidity (TAA) of the soil (AGP) with the total amount of potential alkalinity (ANC) generated. Details of the chemical methods used are given in Ahern *et al*. (2004). The ANC is usually only routinely measured when soil $pH_{KCl}$ (measured in a high ionic strength KCl solution) is greater than pH 6.5. When $pH_{KCl}$ is less than 4.5, this indicates that secondary less soluble acid-producing minerals such as jarosite are present. This is measured as retained acidity. The net acid generating potential (NAGP) is the acid generating potential (AGP) plus retained acidity minus ANC, which gives an indication of acid generation *if all components react fully*. Arguments against this technique include the fact that the form of carbonate may not be available to soil solutions (e.g. if it is coated and protected with organic material or iron oxides) or if it is in a form that is not particularly reactive (e.g. iron carbonates and dolomite ($CaMgCO_3$) have much slower reaction kinetics than calcite). Net acidity aims to take this into account by introducing a “fineness factor”, whereby net acidity is calculated by dividing the ANC by a factor of 1.5. However, the oxidation of pyrite to insoluble Fe oxides may also cause pyrite to not react fully if it becomes coated with protective secondary minerals. Thus, it may be difficult to assess acidification scenarios effectively.

Net Acidity (NA) = Potential Sulfidic Acidity (AGP) + Existing Acidity (TAA) + Retained Acidity (RA) – measured Acid Neutralising Capacity (ANC) / Fineness Factor (FF) and

Net Acid Generating Potential (NAGP) = Potential Sulfidic Acidity (AGP) – measured Acid Neutralising Capacity (ANC)

**Ageing experiment**
The third method used, which is often considered to represent a more realistic scenario for ASS testing is based on the 'incubation' of soil samples. A number of specific techniques are employed, but all are based on keeping the sample moist for a specified period (usually a number of weeks or months), which allows a more realistic oxidation of sulfide minerals to occur than that produced during peroxide testing. Although this may mimic nature more closely and does not force reactions to occur (as in the peroxide test) or rely on total 'potential' reaction, it can be argued that the complex processes occurring in the field are not represented e.g. exchange with sub-surface waters (containing ANC) or biogeochemical reactions. These should also be assessed, where possible, but often require a thorough understanding of water movement (e.g. groundwater) which, is often scenario specific.

The current practice in CSIRO Land and Water is to use all of the above techniques and, where possible, to monitor changes in the field during periods of drying to assess the most likely scenarios of acid generation and neutralisation.

# Acidification potential

Acidification potential was based on the above methods: peroxide pH ($pH_{OX}$), incubation pH ($pH_{INC}$) and net acidity (NA). The criteria listed below were used to assign acidification potential rankings.

(a) peroxide pH $\leq 2.5$
(b) NAGP > 0
(c) Ageing pH $\leq 4.0$

When a criterion was met, an acidification ranking point was allocated. These were then summed and an acidification potential category value was assigned between 0 and 3.

The acidification potential categories were: (i) 0 = very low potential, (ii) 1 = low potential, (iii) 2 = medium potential and (iv) 3 = high potential.

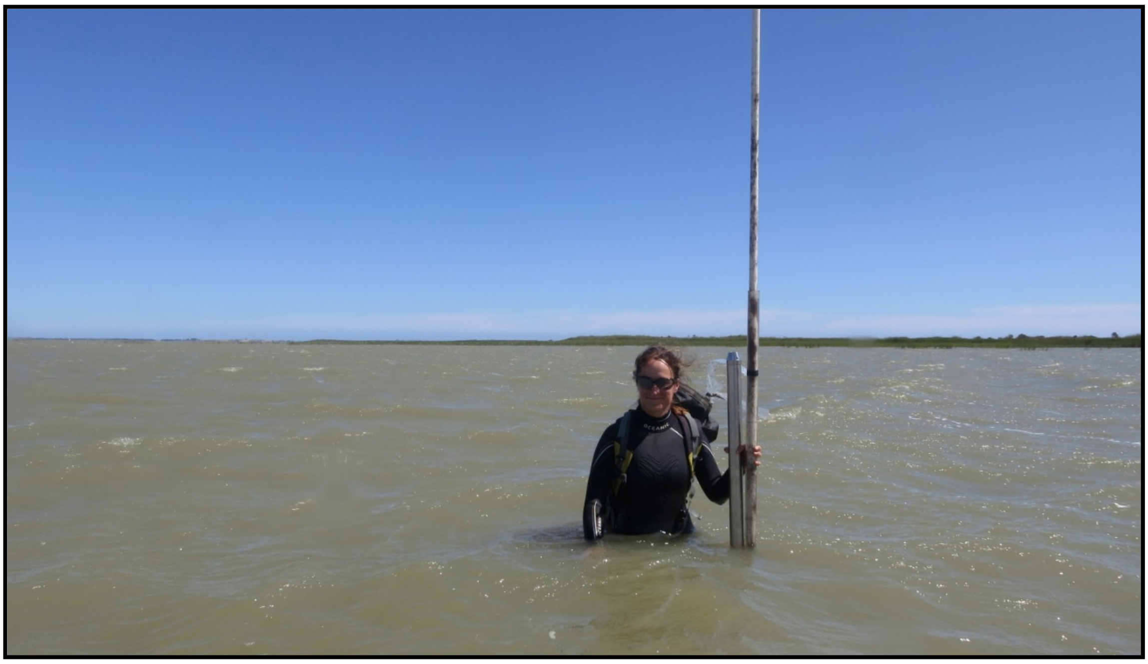
Where all three criteria were met for a soil sample (i.e. high potential), material was considered more likely to become sulfuric (Shand *et al.* 2009).

# Appendix 2 – Site photographs

LF01 - Wallys Landing and Wetland

LF02 – Point Sturt North

LF03 – Point Sturt South

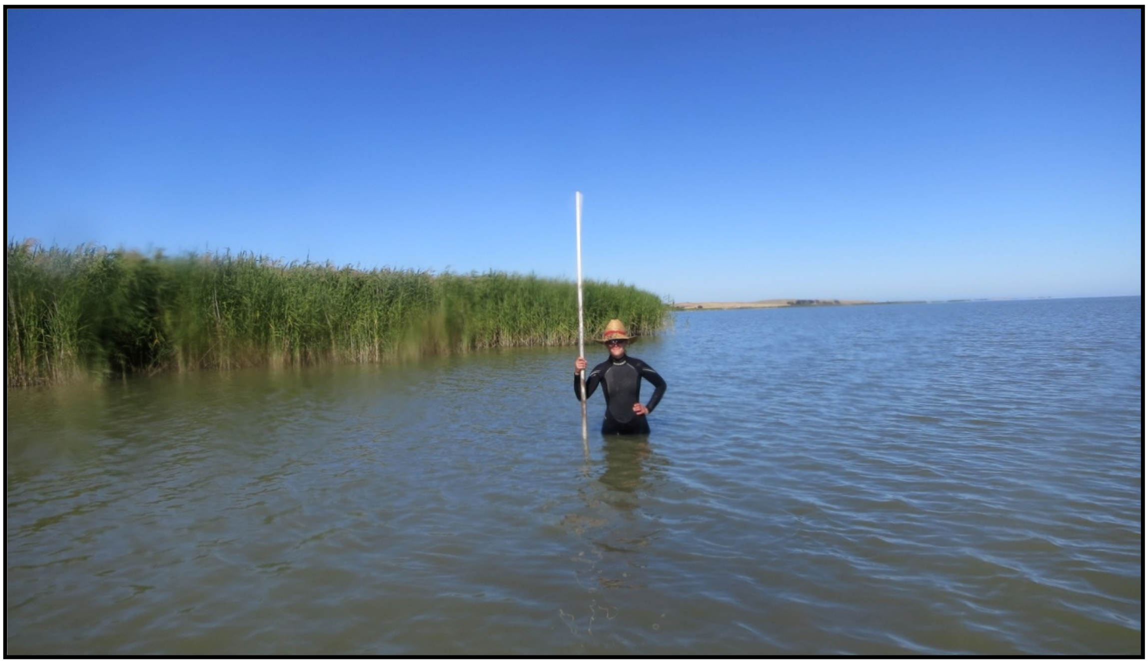


LF04 – Toolderol

LF06 – Poltalloch

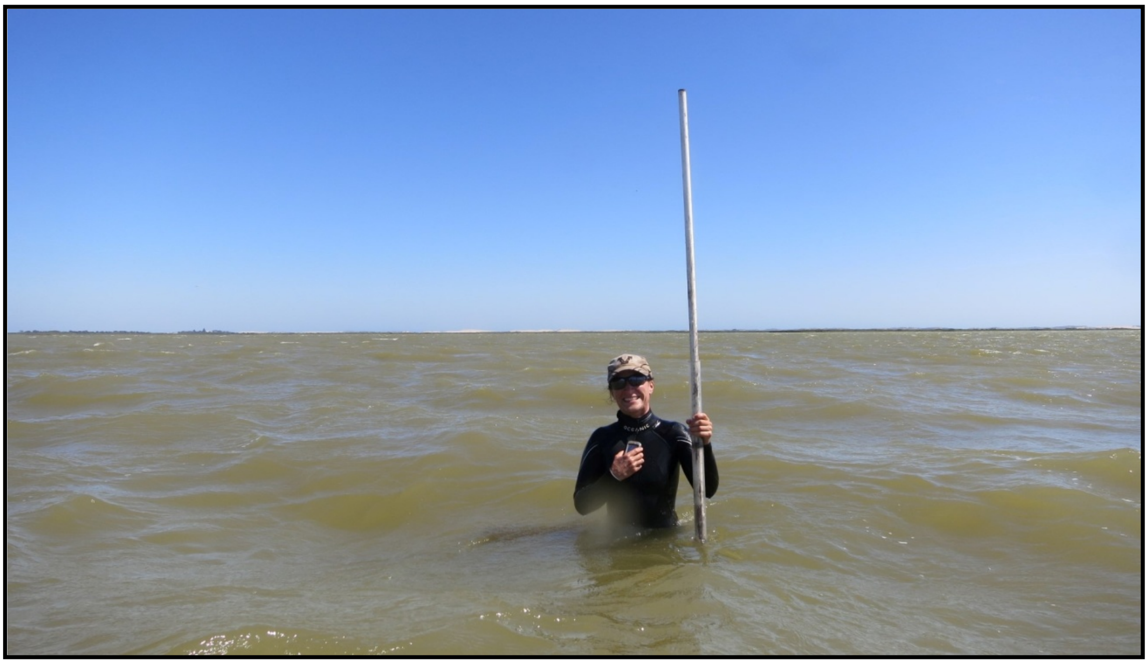
LF07 – Waltowa

LF08 – Meningie



LF10 – Campbell Park

LF12 – Loveday Bay



LF13 – Tauwitcherie

LF15 – Boggy Creek

LF17 – Point Sturt South

LF19 – Dog Lake

LF20 – Boggy Lake

LF21 – Windmill Site

LF23 – Lower Currency

LF24 – Lower Finnis

# Appendix 3 – Site and sample descriptions

## February 2013 sampling

| Sample ID | Locality description | Sampling tool | Upper depth (cm) | Lower depth (cm) | Morphology |
|---|---|---|---|---|---|
| LFg01-A.1 | **Wallys Landing and Wetland -** Middle of drainage ditch located to the north east of the Finniss River. **Subaqueous (1.1 m).** | | 0 | 15 | Black (2.5Y 2.5/1) hemic peat; breaking to polyhedral fragments; abrupt boundary. MBO not noted |
| LFg01-A.2 | | | 15 | 19 | Layer of mixed materials containing coarse rounded and sub-rounded quartz gravel (to ~ 1.5 cm) and coarse sand; abrupt boundary. |
| LFg01-A.3 | | | 19 | 35 | Dark olive grey (5Y 3/1) to olive grey in places (5Y 4/1) heavy sandy clay with lighter sandy laminations in places; paler colour thinly surrounding sub vertical root channels; clear to gradual boundary. |
| LFg01-A.4 | | | 35 | 51 | Very dark grey (5Y 3/1) heavy slightly sandy clay; rare sub-horizontal planar cracks; rare fine rootlets, diffuse boundary. |
| LFg01-A.5 | | | 51 | 86 | Very dark grey to black (5Y 3/1 to 2.5/1) heavy clay slightly spongy; strong vertical planar cracks. |
| LFg02-A.1 | **Point Sturt North –** Approximately 60 m offshore. **Subaqueous (0.6 m).**<br><br>This profile showed oxidation to the outer part of the cores on storage, cold, for nearly three days. | | 0 | 22 | Dark grey (5Y 4/1) slightly silty medium sand, oxidised surface layer (20 mm) with frequent black flecks, organic fragments and black mottling, irregular boundary. |
| LFg02-A.2 | | | 22 | 37 | Grey (5Y 5/1) slightly silty medium sand with occasional black mottling. Occasional very fine rootlets and vertical medium decayed roots. Occasional darker grey mottles. Yellow mottle noted in one core. |
| LFg02-A.3 | | | 37 | 55 | Grey (5Y 5/1) slightly silty medium sand with occasional darker grey and yellow mottling (jarosite?), occasional vertical medium decayed roots |
| LFg02-A.4 | | | 55 | 78 | Dark grey (5Y 4/1) slightly silty medium sand with occasional clayey sand and clay bands. Frequent decayed vertical medium roots and occasional fine horizontal roots. |
| LFg02-D.1 | Approximately 10 m offshore. **Subaqueous (0.4 m).** | | 0 | 10 | Grey (5Y 5/1) slightly silty fine to medium sand with occasional 2 mm bands of clayey sand. Occasional black mottling (frequent mottling in one core) and fine rootlets. Thin oxidised surface layer. |
| LFg02-D.2 | | | 10 | 45 | Greyish brown (2.5Y 5/2) slightly silty fine to medium sand with some indistinct mottles and fine laminations of yellowish orange and orange colour (2.5Y 6/4). Lower part of unit shows several 3-15 mm bands of grey (2.5Y 5/1) sand and bands of sand rich in |

| Sample ID | Locality description | Sampling tool | Upper depth (cm) | Lower depth (cm) | Morphology |
|---|---|---|---|---|---|
| | | | | | fragments of decaying organic material. Isolated pockets (2 mm) of yellowish brown staining (10YR 5/8) seen in the lower part of unit in two cores. |
| LFg02-D.3 | | | 45 | 75 | Dark grey (5Y 4/1) slightly silty fine to medium sand with clayey sand layers in places. Occasional layers of sand with frequent organic fragments in top of unit. Yellowish brown (10YR 5/8) halo around an organic fragment seen in lower part of one core. Layer of 2 mm shells over blue grey sandy clay seen in the base of one core. |
| LFg03-A.1 | **Milang -** Approximately 200 m offshore. **Subaqueous (0.9 m).** | | 0 | 10 | Dark grey (2.5Y 4/1) loamy fine to medium sand; frequent black mottles and bands, common fine roots; irregular boundary. |
| LFg03-A.2 | | | 10 | 22 | Grey (2.5Y 5/1) loamy fine to medium sand, with frequent black speckling; single bivalve shell (25 mm) in one core; fine rootlets; sharp boundary. |
| LFg03-A.3 | | | 22 | 28 | Dark greyish brown (2.5Y 4/2) loamy heavy clay with frequent decayed organic matter; occasional fine roots. Pale yellow mottles on decayed matter surrounds (jarosite?), sharp boundary. |
| LFg03-A.4 | | | 28 | 42 | Grey to greyish brown (2.5YR 5/1 to 5/2) loamy medium sand with frequent light yellow (jarosite?) mottles in upper 5 cm, occasional light yellow (jarosite?) mottling below; 2 cm clay band not noted; sharp boundary. |
| LFg03-A.5 | | | 42 | 57 | Dark grey (5Y 4/1) loamy medium sand, slightly clayey with occasional coarser lighter bands of sand |
| LFg04-A.1 | **Tolderol -** Approximately 80 m offshore. **Subaqueous (1.0 m).**<br><br>Some variability in layer thicknesses – A.2 varies from a few cm to~ 15 cm thick. | | 0 | 15 | Very dark grey (5Y3/1) medium sand, with laminations of darker material. |
| LFg04-A.2 | | | 15 | 45 | Grey (5Y 5/1) medium sand with < 5% yellow mottles (jarosite?), few coarse, dark brown root remnants and organic fragments, abrupt boundary. |
| LFg04-A.3 | | | 45 | 51 | Dark greenish grey (5GY 4/1) slightly sandy clay with occasional faint very dark grey laminations, occasional medium roots, abrupt boundary. Staining and jarosite not noted |
| LFg04-A.4 | | | 51 | 59 | Grey (5Y 5/1) medium sand with occasional roots. Rare black mottles present in one core. |
| LFg04-A.5 | | | 59 | 69 | Dark greenish grey (5Y 4/1) slightly sandy clay, occasional fine and medium roots. One core shows sandy clay |

| Sample ID | Locality description | Sampling tool | Upper depth (cm) | Lower depth (cm) | Morphology |
|---|---|---|---|---|---|
| LFg04-A.6 | | | 69 | 79 | Grey (5Y 5/1) medium sand with occasional roots. |
| LFg06-A.1 | **Poltalloch -** Approximately 200 m offshore. **Subaqueous (1.0 m).** | | 0 | 22 | Dark grey (5Y 4/1) medium sand with occasional black flecks and fine rootlets |
| LFg06-A.2 | | | 22 | 44 | Greyish brown (2.5Y 5/2) medium sand, uniform coloured with few brownish mottles and few fine shell fragments and occasional intact bivalve shells |
| LFg06-A.3 | | | 44 | 64 | Dark grey (5Y 4/1) medium sand with few darker mottles; few whole bivalve shells and fragments; peat fragment seen in one core. |
| LFg06-A.4 | | | 64 | 84 | Grey (5Y 5/1) medium sand with uniform colour and few fine shell fragments. |
| LFg07-A.1 | **Waltowa -** Approximately 100 m offshore. **Subaqueous (0.65 m).** | | 0 | 16 | Very dark grey (5Y 3/1) loamy sand with diffuse, grey (5Y 5/1, 40%) mottles and black mottles (20%) probably associated with organic matter; occasional fine roots. |
| LFg07-A.2 | | | 16 | 31 | Dark grey (5Y 4/1) loamy sand; common fine roots; lower boundary marked by thin horizontal bands of black organic matter; sharp boundary. Black 'ropey' monosulfidic material not noted. |
| LFg07-A.3 | | | 31 | 55 | Dark grey (5Y 4/1) heavy clay with some fine sand; soft, sticky and slightly spongy; lower boundary marked by 2 cm horizontal band of olive grey (5Y 4/2) material with fine shell fragments; sandy in upper 10 cm; abrupt boundary. |
| LFg07-A.4 | | | 55 | 70 | Dark grey to grey (5Y 4/1 to 5/1) heavy clay; soft, slightly spongy. |
| LFg07-A.5 | | | 70 | 72 | Grey (5Y 6/1) heavy sandy calcareous clay. Black mottles present in one core |
| LFg08-A.1 | **Meningie -** West of the Meningie jetty. Approximately 35 m offshore. **Subaqueous (0.75 m).**<br><br>The thicknesses of layers A.2 and A.3 were variable – average depth shown. | | 0 | 10 | Olive grey (5Y 4/2) with occasional black laminations; monosulfidic material; gel like consistency, slightly sandy in places |
| LFg08-A.2 | | | 10 | 18 | Very dark grey (5Y 3/1) loamy sand; soft, saturated; abrupt boundary. Coarse black organic matter and rootlets not seen |
| LFg08-A.3 | | | 18 | 50 | Dark grey (5Y 4/1) loamy sand with occasional darker mottles and layers of organic fragments; few shell fragments with a band at the base of the layer. |
| LFg08-A.4 | | | 50 | 66 | Dark grey to very dark grey (5Y 4/1 to 3/1) heavy clay with 2 cm bands of decomposing organic matter in the upper part; bands (8 mm) of coarse quartz sand near base of layer; shell fragments at base and top of unit, strong sulfidic smell; abrupt boundary. |
| LFg08-A.5 | | | 66 | 76 | Dark grey (5Y 4/1) heavy clay, very soft; intact shells, strong sulfidic smell. |

| Sample ID | Locality description | Sampling tool | Upper depth (cm) | Lower depth (cm) | Morphology |
|---|---|---|---|---|---|
| LFg08-B.1 | Approximately 125 m offshore. **Subaqueous (1.2 m).** A large amount of grey to dark grey water with clay was sampled above the soil surface. | | 0 | 18 | Dark grey (5Y 4/1) slightly silty sand; with occasional very dark grey (5Y 3/1) mottles, saturated, irregular boundary. |
| LFg08-B.2 | | | 18 | 26 | Black (2.5Y 2/1) loamy sand with some dark grey (5Y 4/1) sand bands, fine shell fragments not noted; sharp boundary. |
| LFg08-B.3 | | | 26 | 32 | Black (2.5Y 2/1 to 3/1) heavy clay; gradual boundary. |
| LFg08-B.4 | | | 32 | 65 | Dark grey (5Y 4/1) heavy clay; soft and spongy with shell fragments in top of unit, one core showed very thin sand lens; strong sulfidic smell. |
| LFg10-A.1 | **Campbell Park -** Approximately 5 m offshore. **Subaqueous (0.2 m).** Three of four cores had hemic peaty material at 10-14, 12-21 and 20-29 cm. | | 0 | 16 | Black (10YR 2/1) peat with 10 mm sand layer at base; abrupt boundary. |
| LFg10-A.2 | | | 16 | 26 | Grey (5Y 5/1) soft heavy slightly sandy clay with some fine rootlets and brown mottles |
| LFg10-A.3 | | | 26 | 50 | Grey (5Y 5/1) heavy clay with prominent yellow (5Y 8/6) mottles (jarosite?) associated with organic material (pH 4.5) |
| LFg10-A.4 | | | 50 | 69 | Dark grey (5Y 4/1) heavy clay with few old vertical root channels, yellow mottling in one core (jarosite?). |
| LFg10-C.1 | Approximately 125 m offshore. **Subaqueous (0.6 m).** There is some variability of depth of layers among the cores. | | 0 | 15 | Black (2.5Y 2.5/1) medium sand with frequent inclusions of decayed organic material. Loose and saturated. |
| LFg10-C.2 | | | 15 | 32 | Grey (2.5Y 5/1) with black laminations and mottles with associated organic material. Occasional clay pockets (20 mm); diffuse decomposing smell. |
| LFg10-C.3 | | | 32 | 72 | Dark grey to grey (5Y 4/1 to 5/1) medium sand, with uniform texture and frequent organic fragments in upper portion becoming rare with depth. One core shows black mottling and another yellowish brown mottles (10YR 5/8) |
| LFg12-B.1 | Approximately 250 m offshore. **Subaqueous (1.1 m).** | | 0 | 6 | Very disturbed black (5Y 2.5/1) medium sand with occasional organic fragments. No MBO noted. |
| LFg12-B.2 | | | 6 | 12 | Black organic medium sand with firm, sapric peat inclusion. Rootlets and smell not noted. |
| LFg12-B.3 | | | 12 | 32 | Very dark grey (5Y 3/1) medium sand with diffuse patches of dark grey (5Y 4/1) material. |
| LFg12-B.4 | | | 32 | 45 | Dark grey grading to grey (5Y 5/1 to 4/1) medium sand. Occasional black flecks and mottling in lower part of unit. Occasional organic |

| Sample ID | Locality description | Sampling tool | Upper depth (cm) | Lower depth (cm) | Morphology |
|---|---|---|---|---|---|
| | | | | | fragments. |
| LFg12-B.5 | | | 45 | 60 | Grey (5Y 5/1) medium sand with 20 mm clay bands at top and base of unit; frequent rootlets. |
| LFg12-B.6 | | | 60 | 72 | Dark grey (5Y 4/1) sandy clay with sandy lenses; occasional very fine roots; no sulfidic smell noted. |
| LFg12-C.1 | Approximately 50 m offshore. **Subaqueous (0.8 m).** | | 0 | 13 | Grey (5Y 5/1) medium sand with black flecks and black (2/5Y 2.5/1) mottling, with some organic matter fragments and fine roots. |
| LFg12-C.2 | | | 13 | 40 | Greyish brown (2.5Y 5/2) medium sand with some light brownish grey (2.5Y 6/2) mottles (pH 4.5 -jarosite?) especially towards the base; few medium roots. |
| LFg12-C.3 | | | 40 | 48 | Dark grey (5Y 4/1) medium sand with rare yellow (jarosite?) mottles with light grey (2.5Y 6/3) halo around mottle |
| LFg13-A.1 | **Tauwitchere -** Northern side of Tauwitchere Island in tall (> 2 m) reeds. Approximately 30 m offshore. **Subaqueous (0.8 m).** | | 0 | 14 | Black (2.5Y 2/0) fibric peat with clay in the upper part and sand towards the lower part; common coarse, medium and fine roots (live); strong sulfidic smell; clear boundary. |
| LFg13-A.2 | | | 14 | 44 | Dark grey (5Y 4/1) loamy sand with diffuse very dark grey to black mottles; some old, blackened roots; common coarse, medium and fine roots becoming occasional at depth; strong sulfidic smell; occasional shell fragments |
| LFg15-B.1 | Soil profile located on the northern side of the creek bed. **Subaqueous (0.85 m).** | | 0 | 3 | Black (2.5Y 2/1) sandy peat with common coarse organic material with some clay towards the base and sandy at top; clear boundary. |
| LFg15-B.2 | | | 3 | 13 | Dark grey (5Y 4/1) loamy sand, occasional black mottles in top with occasional fine rootlets. |
| LFg15-B.3 | | | 13 | 27 | Olive grey (5Y 5/2) medium sandy loam with occasional inclusions of grey, very clayey material; prominent pale yellow (5Y 7/3) jarosite (?) mottles (pH 4.5) following sub-vertical old root channels with haematite (?) in centre, sharp, irregular boundary. |
| LFg15-B.4 | | | 27 | 47 | Dark grey (5Y 4/1) clayey medium sand with frequent clay laminations. Occasional shell fragments and fine rootlets. No sulfidic smell noted |
| LFg15-B.5 | | | 47 | 62 | Dark grey (5Y 4/1) slightly clayey coarse sand. Occasional very soft clayey sand lenses. Occasional shell fragments and very fine rootlets. |
| LFg17-A.1 | **Point Sturt South -** Approximately 50 m offshore. **Subaqueous** | | 0 | 20 | Grey (5Y 5/1 to 4/1) becoming dark grey with depth slightly silty fine to medium sand. Clear boundary. This unit not present in one |

| Sample ID | Locality description | Sampling tool | Upper depth (cm) | Lower depth (cm) | Morphology |
|---|---|---|---|---|---|
| | **(0.5 m).** | | | | core |
| LFg17-A.2 | | | 20 | 55 | Greyish brown (2.5Y 5/2) slightly silty fine to medium sand with occasional 5-10 mm clayey sand and clay bands. Orange brown (10YR 6/6) mottling in upper part of unit becoming faint yellow (jarosite?) in lower areas. Very fine very rare rootlets, clear boundary. |
| LFg17-A.3 | | | 55 | 75 | Dark grey (5Y 4/1) slightly silty fine to medium sand with clayey sand bands and organic rich darker bands (5Y 3/1). One core showed a single yellow mottle. |
| LFg17-B.1 | Approximately 140 m offshore. **Subaqueous (0.7 m).** | | 0 | 12 | Greyish brown (2.5Y 5/2) slightly silty fine to medium sand with black (5Y 2.5/1) mottling. Saturated and disturbed. |
| LFg17-B.2 | | | 12 | 57 | Grey (2.5Y 5/1) uniform slightly silty fine to medium sand. Occasional fine rootlets. 1 core showed yellow (5Y 7/3) mottling (jarosite?) in centre of unit. 2 cores showed black mottling at base of unit. |
| LFg17-B.3 | | | 57 | 77 | Dark grey (5Y 4/1) slightly silty fine to medium sand. 2 cores show lighter grey mottling with the unit. Clayey sand band at base. |
| LFg19-A.1 | **Dog Lake -** Approximately 130 m offshore. **Subaqueous (0.8 m).** | | 0 | 5 | Dark grey (5R 4/1) slightly silty sand with frequent very fine rootlets. |
| LFg19-A.2 | | | 5 | 30 | Dark greyish brown (2.5YR 4/2) slightly silty medium sand grading to grey (5y 5/1) at base of unit. 10 % yellow mottles (jarosite?) occasionally present in horizontal bands. Very fine rootlets present in upper half of the unit. |
| LFg19-A.3 | | | 30 | 42 | Dark greenish grey (5y 3-4/1) very silty sandy clay with 5-10 % yellow (5y 7/8) mottling (jarosite?) |
| LFg19-B.1 | Approximately 400 m offshore approximately 1.5 km closer to the terminus of Dog Lake than site LFe19-A. **Subaqueous (0.8 m).** | | 0 | 6 | Very dark grey (5Y 2.5-3/1) to black silty slightly clayey fine to medium sand with black monosulfide gel at surface |
| LFg19-B.2 | | | 6 | 26 | Greyish brown (2.5Y 4/2) sandy clay (one core slightly clayey fine sand) with uniform colour. Frequent fine rootlets in top of unit. One core show occasional mica flecks. |
| LFg19-B.3 | | | 26 | 41 | Grey (5Y 5/1) uniform soft clay; rare faint yellow mottles (jarosite?) in lower part of unit. One core shows unit as firm heavy clay. |
| LFg19-B.4 | | | 41 | 51 | Dark olive grey (5GY 4/1-2) firm heavy slightly sandy silty clay. Frequent fine yellow mottles in top of unit becoming brown (10YR 3/3) mottles after 20 mm. Occasional brown mottling in base of unit. |
| LFg20-A.1 | **Boggy Lake -** Approximately 300 m offshore. **Subaqueous (1.1** | | 0 | 12 | Very dark grey slightly sandy clay with very frequent black (5y |

| Sample ID | Locality description | Sampling tool | Upper depth (cm) | Lower depth (cm) | Morphology |
|---|---|---|---|---|---|
| | **m).** | | | | 2.5/1) mottles. Frequent organic fragments and occasional fine live roots. Black (2.5Y 2/0) monosulfidic gel present at surface and in cracks. |
| LFg20-A.2 | | | 12 | 20 | Olive grey (5y 4/2) heavy firm clay with frequent fine live roots and occasional faint yellow mottling (jarosite?) in root channels. This layer not seen in one core. |
| LFg20-A.3 | | | 20 | 35 | Grey (5Y 5/1) sandy clay with 10 % yellow mottling (jarosite) mottles, common fine and medium live (vertical and horizontal) roots. |
| LFg20-A.4 | | | 35 | 60 | Dark grey (2.5Y 4/1) homogenous firm heavy clay with some yellow jarosite mottles (jarosite?) associated with vertical root channels in upper part of unit. Frequent fine and medium rootlets. |
| LFg20-A.5 | | | 60 | 80 | Dark grey (2.5Y 4/1) homogenous heavy clay; contains few fine, live roots. Softer than unit above. |
| LFg20-B.1 | Approximately 300 m offshore. **Subaqueous (1.1 m).** | | 0 | 15 | Very dark greyish brown (2.5Y 3/2) very sandy clay with frequent black mottling and fine organic matter and very fine live rootlets. One core shows clayey sand. |
| LFg20-B.2 | | | 15 | 27 | Dark greyish brown (5Y 4/2) heavy clay with < 5 % diffuse yellowish brown mottles on margins of vertical root channels. |
| LFg20-B.3 | | | 27 | 47 | Grey (5Y 5/1) sandy clay; with weak jarosite mottles on margins of vertical root channels; very fine rootlets and occasional sandy bands. |
| LFg20-B.4 | | | 47 | 67 | Dark grey (5Y 4/1) clayey silty fine to medium sand; with clay bands; few fine roots; one core shows occasional mica fragments. |
| LFg20-B.5 | | | 67 | 80 | Dark olive grey (5Y 3/2) very silty fine sand; few mica flakes; paler mottles noted in one core. Single weakly calcareous pale grey (5Y 6/1) nodule (20 mm) seen in one core. |
| LFg21-A.1 | **Windmill Site -** Approximately 100 m offshore. **Subaqueous (0.65 m).** | | 0 | 14 | Very dark grey (5Y 3/1) medium sand; saturated, loose; fine black particles of organic matter. |
| LFg21-A.2 | | | 14 | 54 | Grey (2.5Y 5/1) medium sand irregularly interbedded with fine sand and clay layers. Sand becoming medium to coarse towards base of unit. Common brown decayed roots and live rootlets. One core shows 40 mm dark grey (5Y 4/1) clay band at base. |
| LFg21-A.3 | | | 54 | 74 | Grey (5Y 5/1) medium sand, mostly uniform but with occasional organic fragments. |
| LFg23-A.1 | **Lower Currency -** Approximately 60 m offshore. **Subaqueous (1.05 m).** | | 0 | 7 | Very dark grey (5Y 3/1) medium sand, with occasional black flecks; (this layer was very disturbed in all 4 cores). |
| LFg23-A.2 | | | 7 | 24 | Olive grey (5Y 5/2) medium sand, grey clay pocket (20 mm) seen in one core; wavy boundary. |
| LFg23-A.3 | | | 24 | 74 | Light grey (5Y 5/1) medium sand, homogenous texture. Soft grey clay band (50 mm) seen in one core. Rare black mottles, jarosite |

| Sample ID | Locality description | Sampling tool | Upper depth (cm) | Lower depth (cm) | Morphology |
|---|---|---|---|---|---|
| | | | | | mottles not seen. |
| LFg24-A.1 | **Lower Finniss -** Approximately 125 m offshore. **Subaqueous (1.0 m).** | | 0 | 30 | Black becoming very dark brown with depth (10YR 2/1 to 2/2) hemic peat with very dark grey clayey material in the upper few cm; clear to abrupt boundary. |
| LFg24-A.2 | | | 30 | 40 | Dark grey (5Y 4/1) heavy clay; common fine and medium roots and decomposing root material; slight sulfidic smell; clear boundary. Jarosite not noted. |
| LFg24-A.3 | | | 40 | 60 | Very dark grey (5Y 3/1) heavy clay with planar vertical cracks; few medium and fine roots; clear irregular boundary. |
| LFg24-A.4 | | | 60 | 85 | Very dark grey (5Y 3/1) heavy clay, softer than above. |

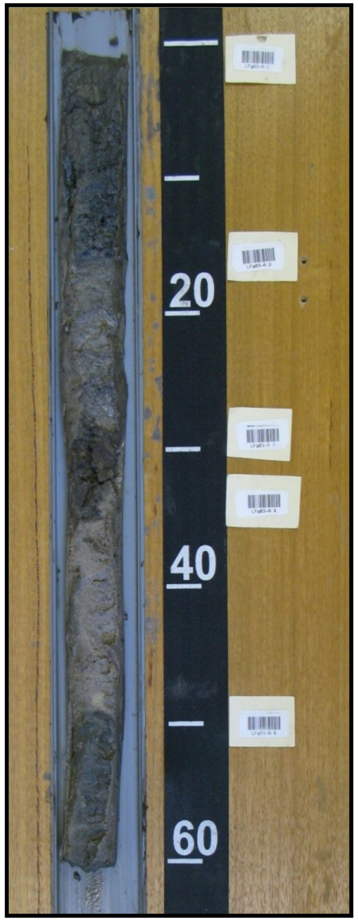
# Appendix 4 – Profile photographs

Wallys Landing and Wetland: LFg01-A


Point Sturt North: LFg02-A


Point Sturt North: LFg02-B


Milang: LFg03-A



Tolderol: LFg04-A


Poltalloch: LFg06-A


Waltowa: LFg07-A


Meningie: LFg08-A

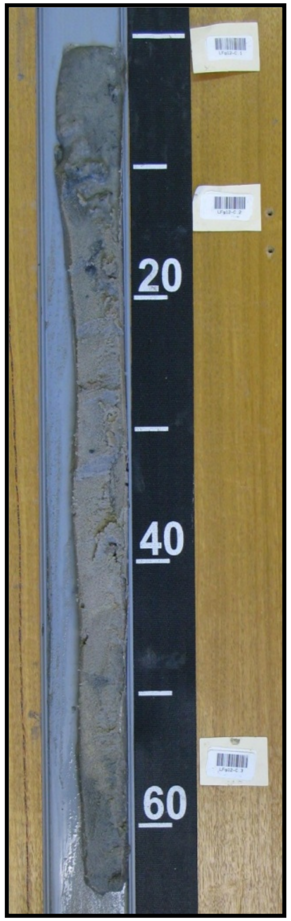
Meningie: LFg08-B


Campbell Park: LFg10-A

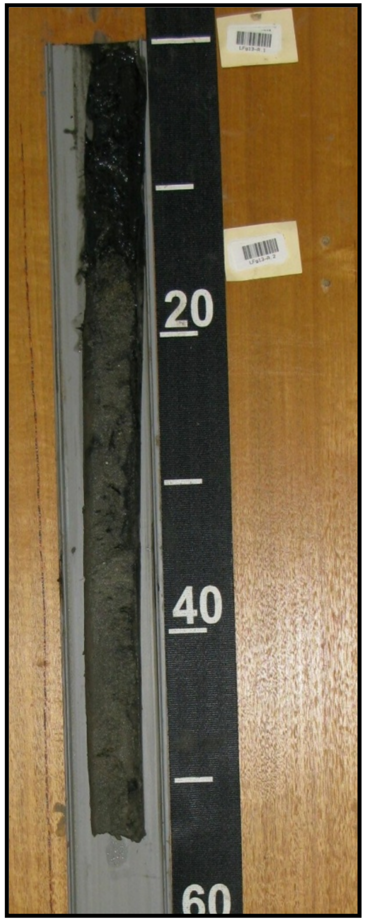

Campbell Park: LFg10-C


Loveday Bay: LFg12-B

Loveday Bay: LFg12-C




Tauwitcherie: LFg13-A




Boggy Creek: LFg15-B


Point Sturt South: LFg17-A

Point Sturt South: LFg17-B


Dog Lake: LFg19-A


Dog Lake: LFg19-B


Boggy Lake: LFg20-A

Boggy Lake: LFg20-B


Windmill Site: LFg21-A


Lower Currency: LFg23-A


Lower Finnis: LFg24-A

# Appendix 5 – Soil moisture, bulk density, EC and pH

**Notes: pH incubation values between 4 and 5.5 are highlighted in orange and values less than 4 are highlighted in bold red.**

**February 2013 sampling**

| Sample ID | Wet weight (g) | Dry weight (g) | Moisture (%) | Bulk density (g cm$^{-3}$) | pH Water | EC (ms cm$^{-1}$) | pH peroxide | pH incubation, Time = 0 weeks | pH incubation, Time > 10 weeks |
|---|---|---|---|---|---|---|---|---|---|
| LFg01-A.1 | 122.71 | 78.40 | 67.25 | 1.12 | 6.11 | 0.68 | 2.14 | 6.25 | **3.94** |
| LFg01-A.2 | 75.58 | 57.07 | 39.09 | 1.90 | 4.83 | 1.99 | 2.07 | 5.52 | **3.19** |
| LFg01-A.3 | 127.08 | 85.68 | 56.57 | 1.22 | 4.52 | 3.31 | 1.58 | 4.79 | **2.51** |
| LFg01-A.4 | 106.01 | 56.31 | 106.61 | 1.88 | 4.75 | 2.76 | 1.38 | 4.72 | **1.80** |
| LFg01-A.5 | 99.26 | 47.44 | 148.31 | 0.68 | 5.95 | 8.02 | 1.86 | 6.21 | **1.90** |
| LFg02-A.1 | 73.88 | 60.69 | 25.88 | 2.02 | 4.89 | 0.27 | 2.13 | 5.66 | **2.67** |
| LFg02-A.2 | 68.94 | 57.44 | 25.58 | 0.82 | 5.04 | 0.38 | 2.11 | 5.18 | **2.58** |
| LFg02-A.3 | 75.59 | 63.61 | 22.23 | 2.12 | 4.20 | 0.19 | 1.83 | 4.72 | **2.15** |
| LFg02-A.4 | 75.21 | 59.74 | 32.74 | 0.85 | 4.54 | 1.22 | 2.04 | 4.11 | **2.00** |
| LFg02-D.1 | 76.18 | 61.79 | 27.61 | 2.06 | 5.82 | 0.04 | 3.39 | 5.93 | 4.76 |
| LFg02-D.2 | 74.09 | 60.07 | 29.48 | 0.86 | 3.98 | 0.58 | 2.10 | **3.99** | **2.99** |
| LFg02-D.3 | 73.87 | 57.64 | 33.88 | 1.92 | 5.99 | 1.33 | 2.17 | 5.26 | **2.00** |
| LFg03-A.1 | 137.11 | 108.13 | 30.31 | 1.54 | 5.29 | 0.25 | 2.17 | 6.00 | **2.90** |
| LFg03-A.2 | 139.86 | 110.95 | 28.55 | 3.70 | 6.61 | 0.72 | 3.37 | 6.02 | 7.08 |
| LFg03-A.3 | 62.20 | 36.68 | 105.57 | 0.52 | 4.37 | 1.27 | 1.67 | 4.54 | **1.90** |
| LFg03-A.4 | 140.66 | 112.11 | 27.87 | 3.74 | 4.33 | 0.33 | 1.81 | 4.41 | **2.33** |
| LFg03-A.5 | 71.74 | 53.08 | 45.99 | 0.76 | 3.97 | 0.49 | 2.02 | **3.99** | **1.57** |
| LFg04-A.1 | 126.97 | 104.42 | 23.80 | 3.48 | 7.23 | 0.46 | 2.46 | 6.98 | **2.79** |
| LFg04-A.2 | 121.35 | 100.00 | 24.40 | 1.43 | 7.03 | 0.95 | 2.22 | 7.35 | **2.05** |
| LFg04-A.3 | 45.07 | 35.12 | 39.14 | 1.17 | 7.89 | 2.83 | 2.03 | 6.91 | **1.83** |
| LFg04-A.4 | 132.52 | 105.97 | 28.41 | 1.51 | 7.65 | 1.52 | 1.89 | 7.58 | **1.77** |

| Sample ID | Wet weight (g) | Dry weight (g) | Moisture (%) | Bulk density (g cm$^{-3}$) | pH Water | EC (ms cm$^{-1}$) | pH peroxide | pH incubation, Time = 0 weeks | pH incubation, Time > 10 weeks |
|---|---|---|---|---|---|---|---|---|---|
| LFg04-A.5 | 47.12 | 30.78 | 77.55 | 1.03 | 8.30 | 2.37 | 2.05 | 7.30 | **2.46** |
| LFg04-A.6 | | | | | 8.17 | 2.45 | 2.31 | 7.76 | **1.80** |
| LFg06-A.1 | 72.31 | 59.94 | 24.63 | 2.00 | 7.58 | 0.90 | 3.48 | 7.07 | 4.88 |
| LFg06-A.2 | 71.13 | 59.99 | 23.47 | 0.86 | 7.70 | 1.01 | 5.28 | 7.63 | 7.20 |
| LFg06-A.3 | 70.70 | 60.25 | 20.68 | 2.01 | 7.73 | 0.89 | 2.03 | 7.96 | **2.19** |
| LFg06-A.4 | 69.01 | 59.27 | 20.82 | 0.85 | 7.83 | 1.34 | 1.94 | 8.07 | **2.01** |
| LFg07-A.1 | 129.66 | 100.66 | 31.89 | 3.36 | 7.19 | 0.16 | 2.97 | 6.78 | **3.32** |
| LFg07-A.2 | 125.78 | 91.80 | 42.85 | 1.31 | 6.38 | 0.48 | 1.72 | 6.42 | **2.29** |
| LFg07-A.3 | 98.85 | 44.19 | 158.46 | 1.47 | 7.00 | 2.31 | 1.65 | 6.73 | **1.72** |
| LFg07-A.4 | 88.02 | 42.18 | 154.45 | 0.60 | 8.11 | 3.17 | 1.67 | 7.63 | **1.60** |
| LFg07-A.5 | | | | | 8.84 | 1.75 | 6.83 | 7.94 | 7.11 |
| LFg08-A.1 | 87.95 | 27.23 | 412.10 | 0.39 | 6.92 | 2.04 | 6.17 | 6.40 | 6.90 |
| LFg08-A.2 | | | | | 7.54 | 3.45 | 4.88 | 7.21 | **3.84** |
| LFg08-A.3 | 144.57 | 117.14 | 26.22 | 1.67 | 7.76 | 1.44 | 2.38 | 7.39 | 6.55 |
| LFg08-A.4 | 104.13 | 44.74 | 169.50 | 1.49 | 8.08 | 12.80 | 1.78 | 7.05 | **2.20** |
| LFg08-A.5 | 98.08 | 45.01 | 163.24 | 0.64 | 8.07 | 9.78 | 1.61 | 7.04 | **1.61** |
| LFg08-B.1 | 141.70 | 115.40 | 24.88 | 3.85 | 7.94 | 0.79 | 6.33 | 7.67 | 6.80 |
| LFg08-B.2 | 133.87 | 109.98 | 24.51 | 1.57 | 7.91 | 1.22 | 6.41 | 7.84 | 7.02 |
| LFg08-B.3 | 107.32 | 51.70 | 132.43 | 1.72 | 7.83 | 4.36 | 5.11 | 7.27 | 7.10 |
| LFg08-B.4 | 94.87 | 35.88 | 252.32 | 0.51 | 7.96 | 8.49 | 1.75 | 7.19 | **1.51** |
| LFg10-A.1 | 55.80 | 29.63 | 131.34 | 0.99 | 6.42 | 1.10 | 2.20 | 6.49 | 4.82 |
| LFg10-A.2 | 62.09 | 36.03 | 110.76 | 0.51 | 5.50 | 1.99 | 3.34 | 5.30 | 4.60 |
| LFg10-A.3 | 61.61 | 35.72 | 99.47 | 1.19 | 3.77 | 3.31 | 1.92 | **3.57** | **2.58** |
| LFg10-A.4 | 55.44 | 26.16 | 214.47 | 0.37 | 3.83 | 3.95 | 1.62 | **2.32** | **1.54** |
| LFg10-C.1 | 73.57 | 55.23 | 40.27 | 1.84 | 6.22 | 0.34 | 2.11 | 6.50 | **2.77** |
| LFg10-C.2 | 140.00 | 105.64 | 36.89 | 1.51 | 5.58 | 0.19 | 1.87 | 5.92 | **2.43** |

| Sample ID | Wet weight (g) | Dry weight (g) | Moisture (%) | Bulk density (g cm$^{-3}$) | pH Water | EC (ms cm$^{-1}$) | pH peroxide | pH incubation, Time = 0 weeks | pH incubation, Time > 10 weeks |
|---|---|---|---|---|---|---|---|---|---|
| LFg10-C.3 | 74.93 | 62.32 | 23.95 | 2.08 | 4.15 | 0.21 | 1.83 | 4.00 | **1.48** |
| LFg12-B.1 | 74.49 | 59.10 | 33.01 | 0.84 | 7.47 | 0.41 | 3.99 | 7.66 | **3.33** |
| LFg12-B.2 | 137.10 | 109.55 | 27.59 | 3.65 | 7.65 | 1.36 | 3.35 | 7.41 | **2.40** |
| LFg12-B.3 | 136.13 | 112.05 | 24.18 | 1.60 | 7.90 | 1.41 | 3.23 | 7.88 | **2.87** |
| LFg12-B.4 | 122.92 | 101.81 | 22.92 | 3.39 | 7.78 | 1.86 | 2.14 | 7.77 | **2.21** |
| LFg12-B.5 | 136.86 | 102.24 | 38.58 | 1.46 | 8.05 | 0.30 | 1.75 | 7.67 | **2.10** |
| LFg12-B.6 | 116.12 | 84.41 | 42.45 | 2.81 | 8.13 | 1.01 | 1.99 | 8.00 | **1.90** |
| LFg12-C.1 | 138.90 | 112.74 | 26.09 | 1.61 | 5.63 | 0.16 | 2.66 | 5.02 | **3.41** |
| LFg12-C.2 | 128.78 | 105.37 | 24.46 | 3.51 | 4.34 | 0.06 | 2.50 | 4.33 | **3.10** |
| LFg12-C.3 | 68.18 | 55.51 | 29.48 | 0.79 | 4.12 | 0.38 | 1.93 | **3.91** | **1.92** |
| LFg13-A.1 | 58.13 | 29.80 | 140.92 | 0.99 | 7.49 | 0.77 | 1.84 | 6.89 | **2.93** |
| LFg13-A.2 | 138.74 | 109.74 | 29.83 | 1.57 | 7.70 | 3.25 | 6.24 | 7.69 | 6.77 |
| LFg15-B.1 | | | | | 6.29 | 0.51 | 2.11 | 6.30 | **3.79** |
| LFg15-B.2 | | | | | 5.46 | 0.79 | 2.43 | 5.96 | **3.73** |
| LFg15-B.3 | 127.50 | 92.41 | 42.42 | 3.08 | 5.02 | 0.52 | 2.33 | 5.29 | **2.95** |
| LFg15-B.4 | 131.59 | 92.82 | 48.27 | 1.33 | 8.10 | 1.42 | 6.18 | 7.65 | 7.20 |
| LFg15-B.5 | 122.13 | 87.24 | 45.00 | 2.91 | 8.66 | 0.61 | 6.80 | 7.97 | 7.34 |
| LFg17-A.1 | 71.64 | 60.56 | 23.04 | 0.87 | 6.51 | 0.05 | 3.75 | 5.93 | **3.74** |
| LFg17-A.2 | 75.47 | 60.51 | 29.42 | 2.02 | 4.16 | 0.20 | 2.31 | 4.03 | **3.11** |
| LFg17-A.3 | 77.42 | 61.72 | 31.90 | 0.88 | 5.06 | 0.41 | 2.00 | 4.63 | **2.28** |
| LFg17-B.1 | 72.11 | 59.38 | 25.63 | 1.98 | 4.81 | 0.06 | 2.44 | 5.36 | **3.36** |
| LFg17-B.2 | 73.89 | 60.16 | 28.80 | 0.86 | 4.25 | 1.52 | 2.09 | 4.64 | **2.82** |
| LFg17-B.3 | 77.66 | 62.36 | 29.05 | 2.08 | 7.01 | 0.27 | 1.73 | 6.53 | **1.95** |
| LFg19-A.1 | 75.13 | 58.08 | 37.41 | 0.83 | 4.52 | 0.86 | 2.07 | 4.43 | **3.50** |
| LFg19-A.2 | 73.62 | 57.31 | 34.25 | 1.91 | 3.74 | 0.47 | 2.09 | **3.56** | **2.80** |
| LFg19-A.3 | 83.82 | 68.72 | 26.86 | 0.98 | 3.87 | 1.25 | 1.91 | **3.52** | **1.87** |

| Sample ID | Wet weight (g) | Dry weight (g) | Moisture (%) | Bulk density (g cm$^{-3}$) | pH Water | EC (ms cm$^{-1}$) | pH peroxide | pH incubation, Time = 0 weeks | pH incubation, Time > 10 weeks |
|---|---|---|---|---|---|---|---|---|---|
| LFg19-B.1 | | | | | 6.23 | 0.30 | 2.49 | 6.25 | **3.40** |
| LFg19-B.2 | 67.29 | 45.30 | 67.03 | 0.65 | 5.38 | 0.16 | 2.12 | 5.49 | **3.81** |
| LFg19-B.3 | 66.73 | 43.68 | 67.81 | 1.46 | 5.04 | 0.77 | 2.19 | 5.06 | **3.74** |
| LFg19-B.4 | 72.87 | 54.04 | 45.33 | 0.77 | 6.41 | 2.67 | 6.46 | 6.24 | 7.11 |
| LFg20-A.1 | 58.53 | 31.51 | 123.86 | 1.05 | 5.66 | 1.64 | 2.39 | 5.90 | **3.03** |
| LFg20-A.2 | 54.68 | 26.65 | 198.02 | 0.38 | 4.77 | 0.56 | 2.47 | 5.21 | **3.03** |
| LFg20-A.3 | 63.82 | 40.03 | 78.46 | 1.33 | 4.53 | 1.38 | 2.03 | 4.35 | **2.62** |
| LFg20-A.4 | 60.61 | 34.28 | 120.89 | 0.49 | 4.17 | 1.55 | 1.88 | **3.72** | **1.70** |
| LFg20-A.5 | 60.47 | 33.99 | 109.02 | 1.13 | 5.86 | 2.28 | 2.03 | 4.93 | **1.69** |
| LFg20-B.1 | 56.92 | 29.37 | 163.25 | 0.42 | 5.19 | 1.52 | 2.02 | 5.78 | **2.97** |
| LFg20-B.2 | | | | | 4.79 | 1.65 | 1.93 | 5.20 | **2.47** |
| LFg20-B.3 | 61.53 | 36.57 | 103.74 | 0.52 | 4.56 | 1.46 | 1.82 | 4.56 | **1.84** |
| LFg20-B.4 | 72.36 | 53.05 | 44.54 | 1.77 | 4.98 | 0.88 | 2.20 | 5.25 | **2.02** |
| LFg20-B.5 | 80.13 | 64.74 | 29.44 | 0.92 | 7.41 | 0.40 | 6.70 | 6.70 | 6.83 |
| LFg21-A.1 | 74.32 | 60.15 | 28.07 | 2.01 | 6.32 | 0.48 | 1.65 | 6.59 | **2.08** |
| LFg21-A.2 | 72.82 | 58.92 | 29.94 | 0.84 | 6.53 | 2.28 | 1.61 | 6.45 | **1.25** |
| LFg21-A.3 | 73.55 | 62.63 | 20.63 | 2.09 | 6.51 | 2.08 | 1.67 | 7.54 | **1.36** |
| LFg23-A.1 | 76.25 | 63.94 | 23.92 | 0.91 | 5.81 | 1.90 | 2.31 | 5.68 | **2.46** |
| LFg23-A.2 | 139.60 | 113.65 | 24.96 | 3.79 | 5.09 | 0.50 | 2.04 | 5.23 | **2.00** |
| LFg23-A.3 | 147.89 | 123.22 | 22.28 | 1.76 | 5.43 | 0.31 | 1.91 | 5.80 | **1.97** |
| LFg24-A.1 | 93.14 | 35.30 | 225.90 | 1.18 | 5.72 | 2.73 | 1.85 | 5.20 | **3.46** |
| LFg24-A.2 | 101.19 | 47.43 | 153.95 | 0.68 | 4.73 | 8.01 | 1.76 | 4.76 | **2.28** |
| LFg24-A.3 | 95.66 | 39.21 | 191.32 | 1.31 | 5.32 | 8.60 | 2.10 | 5.17 | **1.75** |
| LFg24-A.4 | 97.18 | 38.00 | 232.08 | 0.54 | 7.34 | 5.77 | 2.28 | 6.31 | **1.80** |

# Appendix 6 – Acid – base accounting data

*** NOTE:**

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

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

## June 2012 sampling

| I.D. | Texture | Total Organic Carbon %C | Titratable actual acidity (TAA) | | Reduced inorganic sulfur % chromium reducible | | Retained acidity<br>Required if $pH_{KCL}$ <4.5 | | Acid neutralising capacity ($ANC_{BT}$)<br>Required if $pH_{KCl}$ > 6.5 | | Net acidity Chromium suite<br>mole H+/tonne | Lime calculation Chromium suite<br>kg $CaCO_3$/tonne DW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (LECO after acid) | $pH_{KCl}$ | (To pH 6.5) mole H+/tonne | $\%S_{CR}$ | mole H+/tonne | HCL extract as $\%S_{HCL}$ - $\%S_{kcl}$<br>$\%S_{NAG}$ | $S_{NAS}$<br>mole H+/tonne | % $CaCO_3$ | mole H+/tonne | based on %Scrs | (includes 1.5 safety Factor when liming rate is +ve) |
| | Note 6 | | | | | | | | | | Note 5 | Notes 4 & 6 |
| **LFg01-A.1** | Fine | 4.04 | 4.93 | 34 | 0.12 | 75 | .. | 0 | 0.43 | 86 | 52 | 3.9 |
| **LFg01-A.2** | Fine | 1.37 | 4.64 | 40 | 0.05 | 31 | .. | 0 | 0.00 | 0 | 71 | 5.3 |
| **LFg01-A.3** | Fine | 1.51 | 3.68 | 75 | 0.22 | 137 | 0.187 | 87 | 0.00 | 0 | 300 | 22.5 |
| **LFg01-A.4** | Fine | 3.37 | 3.61 | 150 | 1.21 | 755 | 0.053 | 25 | 0.00 | 0 | 929 | 69.7 |
| **LFg01-A.5** | Fine | 4.83 | 4.12 | 79 | 1.60 | 998 | 0.000 | 0 | 0.37 | 74 | 1028 | 77.1 |
| **LFg02-A.1** | Coarse | 0.22 | 5.98 | 3 | 0.01 | 6 | .. | 0 | 0.00 | 0 | 9 | 0.7 |
| **LFg02-A.2** | Coarse | 0.21 | 5.91 | 5 | 0.01 | 6 | .. | 0 | 0.00 | 0 | 11 | 0.8 |
| **LFg02-A.3** | Coarse | 0.22 | 5.12 | 5 | 0.02 | 12 | .. | 0 | 0.00 | 0 | 17 | 1.3 |
| **LFg02-A.4** | Medium | 0.35 | 4.60 | 17 | 0.17 | 106 | .. | 0 | 0.00 | 0 | 123 | 9.3 |
| **LFg02-D.1** | Medium | 0.20 | 6.29 | 2 | 0.01 | 6 | .. | 0 | 0.10 | 20 | -6 | -0.3 |
| **LFg02-D.2** | Medium | 0.27 | 4.59 | 9 | 0.01 | 6 | .. | 0 | 0.00 | 0 | 16 | 1.2 |
| **LFg02-D.3** | Medium | 0.28 | 4.95 | 6 | 0.11 | 69 | .. | 0 | 0.07 | 14 | 65 | 4.9 |
| **LFg03-A.1** | Medium | 0.44 | 5.21 | 5 | 0.05 | 31 | .. | 0 | 0.03 | 6 | 32 | 2.4 |
| **LFg03-A.2** | Coarse | 0.39 | 5.81 | 4 | 0.02 | 12 | .. | 0 | 0.00 | 0 | 16 | 1.2 |
| **LFg03-A.3** | Medium | 2.24 | 3.88 | 84 | 0.26 | 162 | 0.013 | 6 | 0.00 | 0 | 252 | 18.9 |
| **LFg03-A.4** | Medium | 0.38 | 4.55 | 13 | 0.02 | 12 | .. | 0 | 0.00 | 0 | 26 | 1.9 |
| **LFg03-A.5** | Medium | 0.62 | 4.33 | 24 | 0.21 | 131 | 0.016 | 7 | 0.00 | 0 | 163 | 12.2 |
| **LFg04-A.1** | Coarse | 0.20 | 6.36 | 1 | 0.02 | 12 | .. | 0 | 0.00 | 0 | 13 | 1.0 |
| **LFg04-A.2** | Coarse | 0.23 | 6.37 | 1 | 0.06 | 37 | .. | 0 | 0.00 | 0 | 38 | 2.9 |
| **LFg04-A.3** | Fine | 0.54 | 6.45 | 2 | 0.50 | 312 | .. | 0 | 0.19 | 38 | 288 | 21.6 |
| **LFg04-A.4** | Medium | 0.23 | 6.41 | 2 | 0.17 | 106 | .. | 0 | 0.00 | 0 | 108 | 8.1 |
| **LFg04-A.5** | Medium | 0.82 | 7.61 | 0 | 0.72 | 449 | .. | 0 | 0.60 | 120 | 369 | 27.7 |
| **LFg06-A.1** | Coarse | 0.20 | 7.44 | 0 | 0.01 | 6 | .. | 0 | 0.00 | 0 | 6 | 0.5 |
| **LFg06-A.2** | Coarse | 0.17 | 8.50 | 0 | 0.01 | 6 | .. | 0 | 0.00 | 0 | 6 | 0.5 |
| **LFg06-A.3** | Coarse | 0.17 | 8.85 | 0 | 0.07 | 44 | .. | 0 | 0.00 | 0 | 44 | 3.3 |
| **LFg06-A.4** | Coarse | 0.21 | 7.65 | 0 | 0.05 | 31 | .. | 0 | 0.02 | 4 | 29 | 2.1 |
| **LFg07-A.1** | Medium | 0.39 | 7.05 | 0 | 0.03 | 19 | .. | 0 | 0.00 | 0 | 19 | 1.4 |
| **LFg07-A.2** | Medium | 0.68 | 6.14 | 3 | 0.12 | 75 | .. | 0 | 0.00 | 0 | 77 | 5.8 |
| **LFg07-A.3** | Fine | 3.86 | 6.32 | 4 | 1.09 | 680 | .. | 0 | 0.62 | 124 | 601 | 45.1 |
| **LFg07-A.4** | Fine | 2.47 | 7.79 | 0 | 1.06 | 661 | .. | 0 | 0.82 | 164 | 552 | 41.4 |
| **LFg08-A.1** | Fine | 3.55 | 8.17 | 0 | 0.27 | 168 | .. | 0 | 3.31 | 661 | -272 | -13.6 |
| **LFg08-A.3** | Medium | 0.27 | 8.82 | 0 | 0.07 | 44 | .. | 0 | 0.04 | 8 | 38 | 2.9 |
| **LFg08-A.4** | Fine | 3.52 | 7.89 | 0 | 0.96 | 599 | .. | 0 | 1.33 | 266 | 422 | 31.6 |
| **LFg08-A.5** | Fine | 2.80 | 9.35 | 0 | 1.38 | 861 | .. | 0 | 1.30 | 260 | 688 | 51.6 |
| **LFg08-B.1** | Coarse | 0.21 | 9.19 | 0 | 0.04 | 25 | .. | 0 | 0.64 | 128 | -60 | -3.0 |

## Appendix 6 – Acid – base accounting data

| I.D. | Texture | Total Organic Carbon %C | Titratable actual acidity (TAA) | | Reduced inorganic sulfur % chromium reducible | | Retained acidity<br>Required if $pH_{KCL}$ <4.5 | | Acid neutralising capacity ($ANC_{BT}$)<br>Required if $pH_{KCl}$ > 6.5 | | Net acidity Chromium suite<br>mole H+/tonne | Lime calculation Chromium suite<br>kg $CaCO_3$/tonne DW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (LECO after acid) | $pH_{KCl}$ | (To pH 6.5) mole H+/tonne | $\%S_{CR}$ | mole H+/tonne | HCL extract as $\%S_{HCL}$ - $\%S_{kcl}$<br>$\%S_{NAG}$ | $S_{NAS}$<br>mole H+/tonne | % $CaCO_3$ | mole H+/tonne | based on %Scrs | (includes 1.5 safety Factor when liming rate is +ve) |
| | Note 6 | | | | | | | | | | Note 5 | Notes 4 & 6 |
| **LFg08-B.2** | Coarse | 0.33 | 8.13 | 0 | 0.05 | 31 | .. | 0 | 0.39 | 78 | -21 | -1.0 |
| **LFg08-B.3** | Fine | 2.78 | 7.56 | 0 | 0.36 | 225 | .. | 0 | 1.06 | 212 | 83 | 6.3 |
| **LFg08-B.4** | Fine | 3.02 | 7.16 | 0 | 1.91 | 1191 | .. | 0 | 1.14 | 228 | 1039 | 78.0 |
| **LFg10-A.1** | Fine | 8.73 | 5.64 | 11 | 0.16 | 100 | .. | 0 | 0.17 | 34 | 88 | 6.6 |
| **LFg10-A.2** | Fine | 1.03 | 4.77 | 20 | 0.01 | 6 | .. | 0 | 0.00 | 0 | 26 | 2.0 |
| **LFg10-A.3** | Fine | 1.43 | 3.42 | 108 | 0.04 | 25 | 0.223 | 104 | 0.00 | 0 | 237 | 17.8 |
| **LFg10-A.4** | Fine | 3.06 | 3.41 | 228 | 1.48 | 923 | 0.000 | 0 | 0.00 | 0 | 1151 | 86.3 |
| **LFg10-C.1** | Fine | 0.74 | 6.03 | 5 | 0.05 | 31 | .. | 0 | 0.00 | 0 | 36 | 2.7 |
| **LFg10-C.2** | Medium | 0.68 | 4.81 | 9 | 0.05 | 31 | .. | 0 | 0.00 | 0 | 40 | 3.0 |
| **LFg10-C.3** | Coarse | 0.26 | 5.14 | 8 | 0.12 | 75 | .. | 0 | 0.00 | 0 | 82 | 6.2 |
| **LFg12-B.1** | Coarse | 0.38 | 6.57 | 0 | 0.04 | 25 | .. | 0 | 0.00 | 0 | 25 | 1.9 |
| **LFg12-B.2** | Coarse | 0.48 | 6.64 | 0 | 0.09 | 56 | .. | 0 | 0.00 | 0 | 56 | 4.2 |
| **LFg12-B.3** | Coarse | 0.27 | 7.52 | 0 | 0.03 | 19 | .. | 0 | 0.00 | 0 | 19 | 1.4 |
| **LFg12-B.4** | Coarse | 0.21 | 7.71 | 0 | 0.05 | 31 | .. | 0 | 0.00 | 0 | 31 | 2.3 |
| **LFg12-B.5** | Medium | 0.51 | 6.76 | 0 | 0.17 | 106 | .. | 0 | 0.00 | 0 | 106 | 8.0 |
| **LFg12-B.6** | Medium | 0.52 | 6.82 | 0 | 0.24 | 150 | .. | 0 | 0.00 | 0 | 150 | 11.2 |
| **LFg12-C.1** | Medium | 0.24 | 5.82 | 2 | 0.01 | 6 | .. | 0 | 0.00 | 0 | 8 | 0.6 |
| **LFg12-C.2** | Medium | 0.27 | 4.92 | 5 | <0.01 | 0 | .. | 0 | 0.00 | 0 | 5 | 0.4 |
| **LFg12-C.3** | Medium | 0.28 | 5.11 | 8 | 0.06 | 37 | .. | 0 | 0.00 | 0 | 46 | 3.4 |
| **LFg13-A.1** | Fine | 3.41 | 6.68 | 0 | 0.18 | 112 | .. | 0 | 0.00 | 0 | 112 | 8.4 |
| **LFg13-A.2** | Medium | 0.34 | 8.73 | 0 | 0.11 | 69 | .. | 0 | 3.65 | 729 | -418 | -20.9 |
| **LFg15-B.3** | Fine | 0.56 | 4.32 | 16 | 0.05 | 31 | 0.047 | 22 | 0.00 | 0 | 69 | 5.2 |
| **LFg15-B.4** | Fine | 0.49 | 8.95 | 0 | 0.34 | 212 | .. | 0 | 4.56 | 911 | -395 | -19.8 |
| **LFg15-B.5** | Medium | 0.37 | 9.17 | 0 | 0.26 | 162 | .. | 0 | 11.48 | 2294 | -1367 | -68.3 |
| **LFg17-A.1** | Coarse | 0.15 | 7.78 | 0 | 0.01 | 6 | .. | 0 | 0.00 | 0 | 6 | 0.5 |
| **LFg17-A.2** | Fine | 0.25 | 4.56 | 12 | 0.01 | 6 | .. | 0 | 0.00 | 0 | 18 | 1.4 |
| **LFg17-A.3** | Medium | 0.38 | 4.61 | 11 | 0.11 | 69 | .. | 0 | 0.00 | 0 | 80 | 6.0 |
| **LFg17-B.1** | Medium | 0.27 | 5.55 | 3 | 0.01 | 6 | .. | 0 | 0.00 | 0 | 9 | 0.7 |
| **LFg17-B.2** | Medium | 0.22 | 4.92 | 5 | 0.01 | 6 | .. | 0 | 0.00 | 0 | 12 | 0.9 |
| **LFg17-B.3** | Medium | 0.24 | 5.88 | 2 | 0.08 | 50 | .. | 0 | 0.00 | 0 | 51 | 3.9 |
| **LFg19-A.2** | Fine | 0.87 | 4.55 | 13 | 0.02 | 12 | .. | 0 | 0.00 | 0 | 26 | 1.9 |
| **LFg19-A.3** | Fine | 0.19 | 3.89 | 73 | 1.13 | 705 | 0.062 | 29 | 0.00 | 0 | 807 | 60.5 |
| **LFg19-B.2** | Medium | 0.41 | 3.86 | 52 | 0.01 | 6 | 0.070 | 33 | 0.00 | 0 | 91 | 6.8 |
| **LFg19-B.3** | Fine | 1.01 | 4.16 | 25 | 0.02 | 12 | 0.027 | 13 | 0.20 | 40 | 24 | 1.8 |
| **LFg19-B.4** | Fine | 0.25 | 7.65 | 0 | 0.81 | 505 | .. | 0 | 3.60 | 719 | 26 | 1.9 |
| **LFg20-A.1** | Fine | 2.31 | 3.61 | 83 | 0.13 | 81 | 0.014 | 7 | 0.02 | 4 | 168 | 12.6 |
| **LFg20-A.3** | Fine | 1.07 | 3.46 | 78 | 0.03 | 19 | 0.128 | 60 | 0.00 | 0 | 157 | 11.7 |

| I.D. | Texture | Total Organic Carbon %C | Titratable actual acidity (TAA) | | Reduced inorganic sulfur % chromium reducible | | Retained acidity | | Acid neutralising capacity ($ANC_{BT}$) | | Net acidity Chromium suite | Lime calculation Chromium suite |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Required if $pH_{KCL}$ <4.5 | | Required if $pH_{KCl}$ > 6.5 | | mole H+/tonne | kg $CaCO_3$/tonne DW |
| | | (LECO after acid) | $pH_{KCl}$ | (To pH 6.5) mole H+/tonne | $\%S_{CR}$ | mole H+/tonne | HCL extract as $\%S_{HCL}$ - $\%S_{kcl}$ $\%S_{NAG}$ | $S_{NAS}$ mole H+/tonne | % $CaCO_3$ | mole H+/tonne | based on %Scrs | (includes 1.5 safety Factor when liming rate is +ve) |
| | Note 6 | | | | | | | | | | Note 5 | Notes 4 & 6 |
| **LFg20-A.4** | Fine | 1.09 | 3.46 | 88 | 1.25 | 780 | 0.136 | 64 | 0.00 | 0 | 931 | 69.8 |
| **LFg20-A.5** | Fine | 1.02 | 4.31 | 30 | 1.62 | 1010 | 0.000 | 0 | 0.51 | 102 | 972 | 72.9 |
| **LFg20-B.1** | Fine | 2.88 | 3.65 | 90 | 0.08 | 50 | 0.006 | 3 | 0.00 | 0 | 142 | 10.7 |
| **LFg20-B.2** | Fine | 3.01 | 3.37 | 139 | 0.35 | 218 | 0.034 | 16 | 0.00 | 0 | 373 | 28.0 |
| **LFg20-B.3** | Fine | 1.26 | 3.66 | 79 | 0.89 | 555 | 0.039 | 18 | 0.00 | 0 | 652 | 48.9 |
| **LFg20-B.4** | Fine | 0.42 | 4.23 | 28 | 1.20 | 748 | 0.000 | 0 | 0.24 | 48 | 744 | 55.8 |
| **LFg20-B.5** | Fine | 0.19 | 8.81 | 0 | 0.13 | 81 | .. | 0 | 1.16 | 232 | -73 | -3.7 |
| **LFg21-A.1** | Coarse | 0.26 | 6.14 | 2 | 0.08 | 50 | .. | 0 | 0.14 | 28 | 33 | 2.5 |
| **LFg21-A.2** | Coarse | 0.31 | 5.74 | 4 | 0.38 | 237 | .. | 0 | 0.18 | 36 | 217 | 16.2 |
| **LFg21-A.3** | Coarse | 0.19 | 6.31 | 2 | 0.21 | 131 | .. | 0 | 0.20 | 40 | 106 | 7.9 |
| **LFg23-A.1** | Coarse | 0.16 | 6.00 | 2 | 0.02 | 12 | .. | 0 | 0.15 | 30 | -6 | -0.3 |
| **LFg23-A.2** | Coarse | 0.23 | 4.91 | 5 | 0.03 | 19 | .. | 0 | 0.14 | 28 | 5 | 0.4 |
| **LFg23-A.3** | Medium | 0.21 | 5.09 | 4 | 0.07 | 44 | .. | 0 | 0.16 | 32 | 27 | 2.0 |
| **LFg24-A.1** | Fine | 14.20 | 5.42 | 29 | 0.23 | 143 | .. | 0 | 1.28 | 256 | 2 | 0.2 |
| **LFg24-A.2** | Fine | 3.62 | 3.62 | 90 | 0.42 | 262 | .. | 0 | 0.14 | 28 | 333 | 25.0 |
| **LFg24-A.3** | Fine | 2.38 | 3.50 | 136 | 1.49 | 929 | .. | 0 | 0.00 | 0 | 1065 | 79.9 |
| **LFg24-A.4** | Fine | 1.96 | 4.23 | 44 | 1.44 | 898 | .. | 0 | 0.75 | 150 | 842 | 63.1 |

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