APPENDIX B2 – WETLAND DESCRIPTIONS FOR ASSESSMENT OF ACID SULFATE SOIL MATERIALS IN THE LOCK 1 TO WELLINGTON REGION OF THE MURRAY-DARLING BASIN

CONTENTS

21 SUNNYSIDE - PAIWALLA SWAMP (UPSTREAM) WETLAND (WETLAND ID. 12118)

21.1 LOCATION AND SETTING DESCRIPTION

Sunnyside – Paiwalla Swamp (upstream) Wetland (Wetland ID. 12118) is the most northerly wetland in a continuum of three that form the Sunnyside complex which is situated on the eastern side of the River Murray. The wetland is geomorphically categorised as a Murray Gorge Basin (Pressey 1986) and is somewhat rectangular in shape, with a total surface area of 48 hectares. The wetland is bounded to the east by a cliff slope, to the south by a levee bank that separates it from the Sunnyside – Paiwalla Managed Wetland, and to the west it is open to the river with a gentle slope. Clusters of vegetation form a semi levee along the river bank however there are many wide open connection channels along the length of the wetland.

At the time when the soil survey was conducted in October 2008, the wetland was dry and there was no surface water. The soil surface was generally cracking with no vegetation growing or with isolated areas of *Aster subulatus* (wild Aster), and on the eastern side there was *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed) growing along the margins. Four sites were described and sampled and their locations are shown in Figure 21-1.

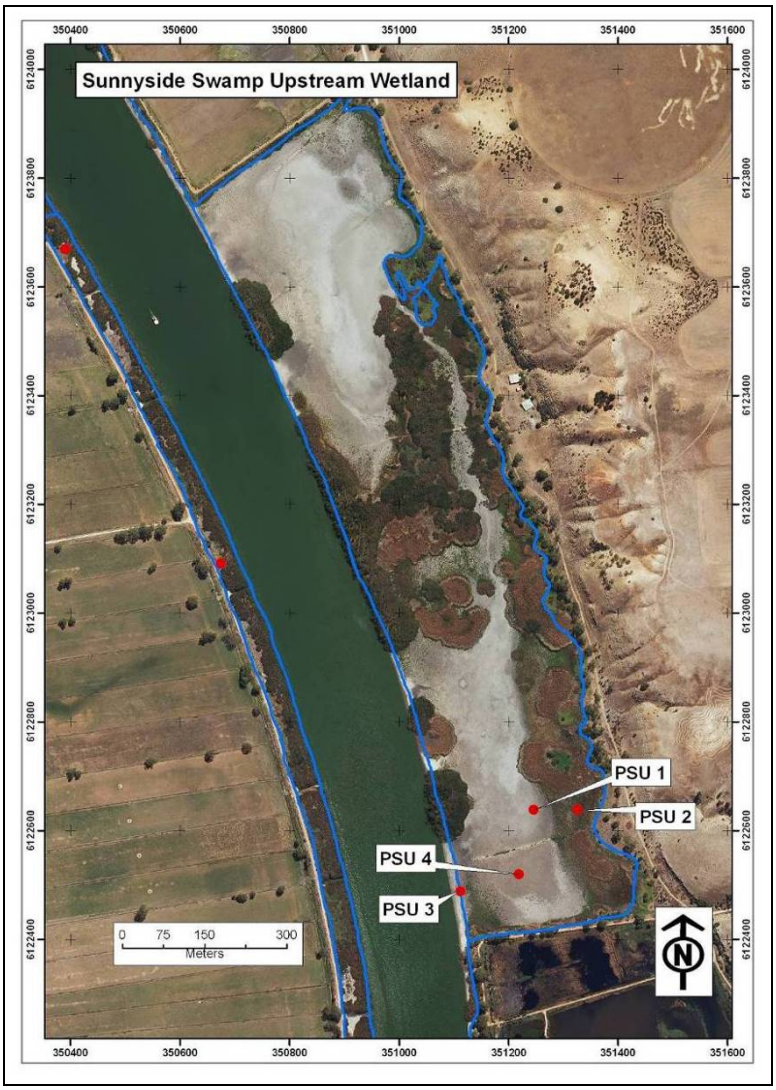


Figure 21-1. Sunnyside - Paiwalla Swamp (Upstream) Wetland and sample site locations.

21.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Four sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 21-1. Sites were located to form one transect through the wetland from the river to the cliff slope and to characterise the different surface and vegetation features. The site and soil profile descriptions are presented in Table 21-2 and Table 21-3.

Site PSU1 (Figure 21-2) occurred near the middle of the wetland where the surface was cracking with no vegetation. The soil consisted of grey, very firm, clay.

Site PSU2 (Figure 21-3) occurred in a high elevation area of the wetland where there was *Aster subulatus* (Aster-weed) growing with the surface cracking. The soil consisted of grey, clay, over an olive grey, clay with sulfurous odour.

Site PSU3 (Figure 21-4) occurred on a slightly raised area approximately 5 metres from the river. The soil consisted of dark grey, firm, clay with the upper 15 centimetres also containing sand down cracks between the soil columns.

Site PSU4 (Figure 21-5) occurred near the middle of the wetland where there was no vegetation and the surface was cracking. The soil consisted of dark grey, very firm, clay forming columnar structure, over a black, clay containing plant material over olive grey, firm, clay.

Table 21-1. Soil identification, subtype and general location description of sites for Sunnyside - Paiwalla Swamp (Upstream) Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
PSU1	351246	6122638	Hyposulfidic cracking clay soil	Mid elevation
PSU2	351327	6122638	Hypersulfidic cracking clay soil	High elevation, near to cliff
PSU3	351112	6122488	Other soil	Slightly raised area 5m from river water edge
PSU4	351219	6122519	Hyposulfidic cracking clay soil	Low elevation, between river bank and vegetation

Figure 21-2. Photographs of site PSU1, showing the site location where the surface was cracking with no vegetation was growing, and the soil profile of clay with soil cracks that have containing aggregates from the surface layers.

Figure 21-3. Photographs of site PSU2, showing the site location adjacent to *Aster subulatus* (Aster-weed) vegetation, and the soil profile of clay.

Figure 21-4. Photographs of site PSU3, showing the site location near the river and the soil profile of clay and cracks that have filled with soil material.

Figure 21-5. Photographs of site PSU4, showing the site landscape with no vegetation growing and surface cracks that have been filled and the soil profile of clay with cracks filled with aggregates from the surface layers.

21.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 21-4 and pH profiles are presented in Figure 21-6.

The pH_W data did not identify samples as sulfuric materials with a pH_W <4.

The pH_{INC} data for the subsoil layer of profile PSU2 identified a sample that on incubation declined below the critical value of pH<4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation.

The pH_{OX} data identified samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

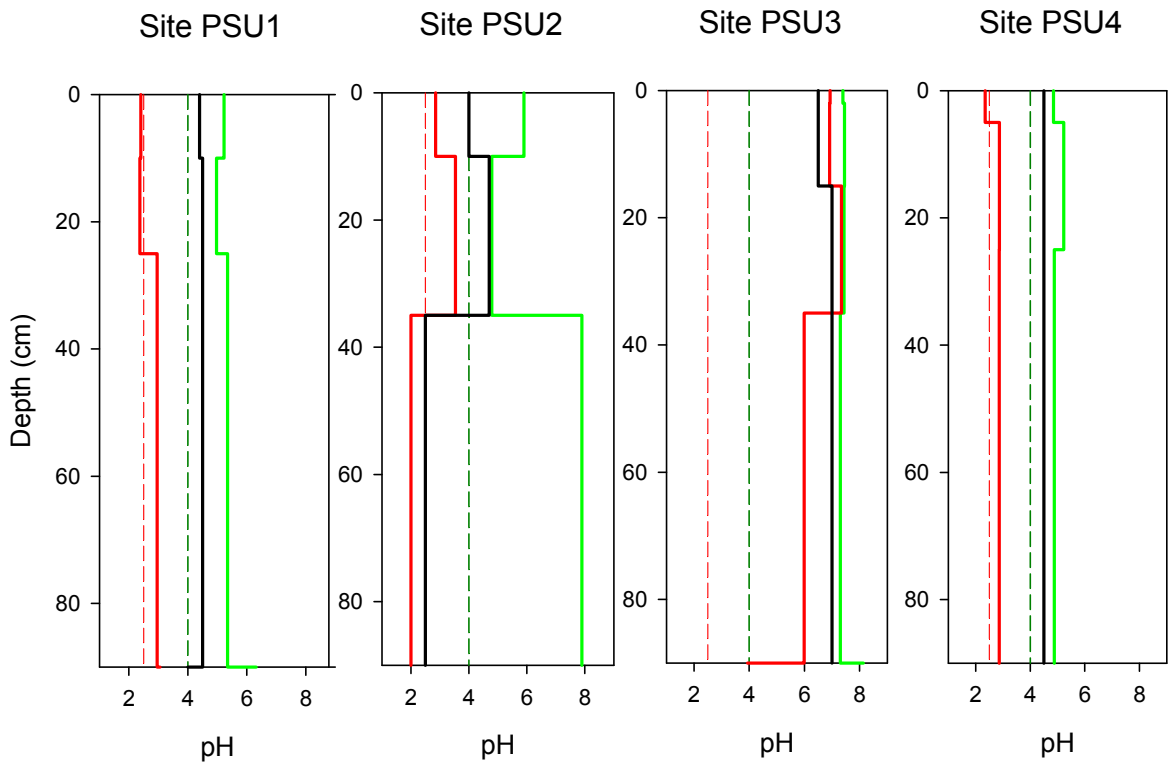


Figure 21-6. Depth profiles of soil pH for Sunnyside - Paiwalla Swamp (Upstream) wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data are provided in Table 21-4 and summarised in Figure 21-7.

Chromium reducible sulfur values ranged from below the detection limit to 0.88%S_{CR}. Sulfidic materials were detected in at least the subsoil layers for each profile.

Titratable actual acidity ranged from 0.78 to 41.86 mole H_+/tonne.

Retained acidity was not measured in any of the samples, as all samples had a pH_{KCl} of greater than 4.5.

Acid neutralising capacity value was measured in one subsoil sample for profile PSU3.

Net acidity values ranged from -63 to 549 mole H^+/tonne. One negative net acidity value was identified for the subsoil layer of profile PSU3, and all other values were low or medium values with one high value in the subsoil of PSU2.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 21-4 identified that surface layers in all profiles were above the critical trigger value of 100 mg/kg SO_4.

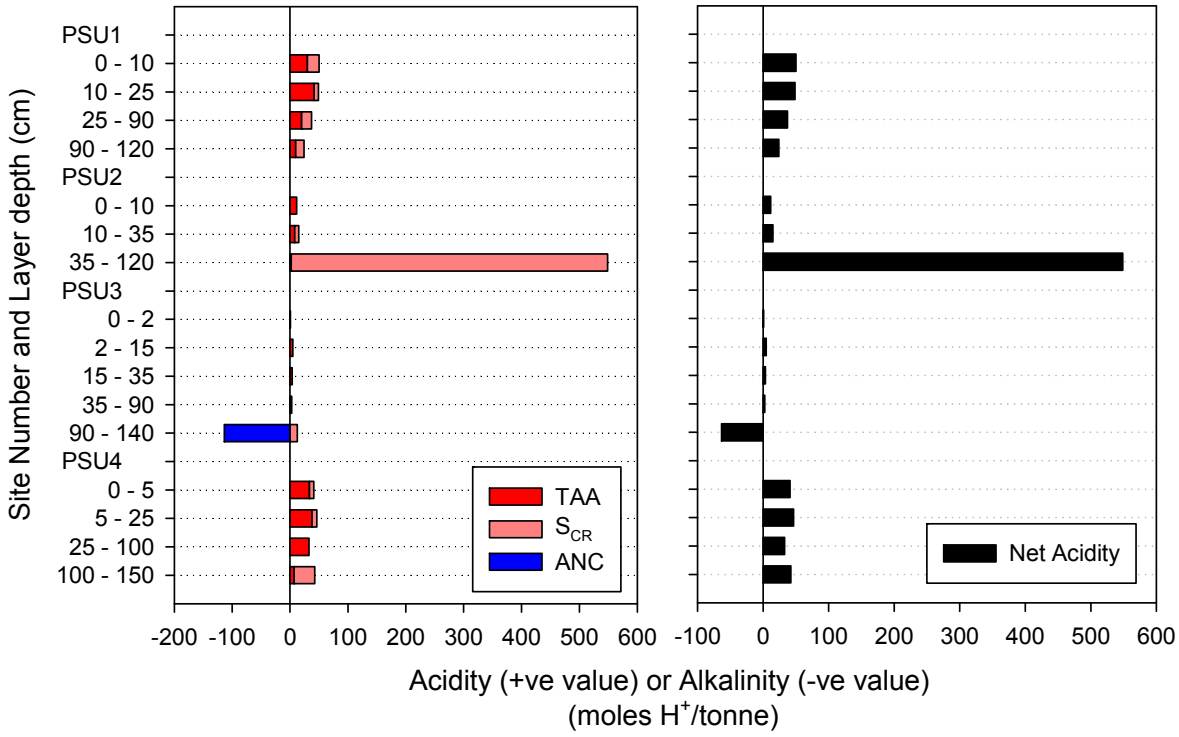


Figure 21-7. Acid base accounting depth profiles for Sunnyside - Paiwalla Swamp (Upstream) Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

21.4 DISCUSSION

Acid sulfate soil materials at Sunnyside - Paiwalla Swamp (Upstream) Wetland were identified as hypersulfidic for one subsoil sample in PSU3, hyposulfidic for most remaining samples, and most upper layer samples of profile PSU3 were characterised as other soil materials. The acid sulfate soil subtype classes identified were Hyposulfidic Cracking Clay Soil, Hypersulfidic cracking clay soil and Other Soil.

The soils throughout the wetland were generally firm and clayey textured and they had open cracks, and in some areas these cracks were filled with soil material from the breakdown of the surface layers.

Monosulfidic material was not observed but water soluble sulfate data identified that surface layers for the profiles throughout the wetland were in excess of the 100 mg/kg trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials at the Sunnyside - Paiwalla Swamp (Upstream) Wetland are:

- Acidification hazard: The data identified low, moderate or high net acidity values in layers for all profiles, and pH data identified surface and subsoil samples with values that were a potential acidification hazard due to oxidation. There is a medium to high level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there was potential for monosulfidic materials to form in the surface layers of soils on re-flooding, although the wetland was dry at the time of sampling and monosulfidic material was not observed. There is a high level of concern.
- Metal mobilisation: The medium to high acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

Summary of key findings for Sunnyside - Paiwalla Swamp (Upstream) Wetland:

Soil materials:	Hypersulfidic soil materials were identified in a surface layer and hyposulfidic soil materials were identified in surface and subsoil layers. The soils throughout were generally clay textured layers with surface cracks that occurred in most areas. Samples had low, moderate or high net acidity values and pH data identified samples with values that indicated potential acidification due to oxidation.
Acid sulfate soil identification:	• Hyposulfidic cracking clay soil – that occurred throughout the wetland. Dominant (>50%) in extent. • Hypersulfidic cracking clay soil – that occurred on the high elevation areas on the eastern side of the wetland. Minor (<25%) in extent. • Other Soil – that occurred around the margin near the river. Isolated (<10%) in extent.
Hazard assessment	• Acidification hazard – medium to high level of concern • De-oxygenation hazard – high level of concern • Metal mobilisation hazard – medium level of concern

Table 21-2. Site data for Sunnyside - Paiwalla Swamp (Upstream) Wetland.

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
PSU1	03-Sep-08	351246	6122638	Hyposulfidic cracking clay soil	30	cracking	Bare	Mid elevation
PSU2	03-Sep-08	351327	6122638	Hypersulfidic cracking clay soil	45	cracking	weeds	High elevation, near to cliff
PSU3	14-Oct-08	351112	6122488	Other soil	50	cracking, slightly	isolated plants	Low elevation, 5m from river water edge
PSU4	14-Oct-08	351219	6122519	Hyposulfidic cracking clay soil	50	cracking, crumbling and soft	Bare	Low elevation, between river bank and vegetation

Table 21-3. Soil description data for Sunnyside - Paiwalla Swamp (Upstream) Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
PSU1.1	0	10	soil pit	10YR 4/1	peaty clay loam	moist	5	10YR 8/1	in matrix along ped faces	angular blocky	extremely firm	white salts on surface
PSU1.2	10	25	soil pit	10YR 3/1	clay	moist	3	2.5YR 5/8	on surfaces along pores	subangular blocky	extremely firm	
PSU1.3	25	90	soil pit	10YR 3/1	clay	moist	3	2.5YR 5/8	on surfaces along pores	massive	very firm	
PSU1.4	90	120	push tube	5Y 5/2	clay loam	wet	3	2.5YR 5/8	on surfaces along pores	massive	firm	
PSU2.1	0	10	soil pit	10YR 3/1	clay loam	moist	0			subangular blocky	firm	
PSU2.2	10	35	soil pit	5Y 5/2	clay	moist	3	2.5YR 5/8	on surfaces along pores	massive	firm	
PSU2.3	35	120	push tube	5Y 5/2	clay	wet	0			massive	firm	sulfurous odour
PSU3.1	0	2	soil pit	2.5Y 4/1	clay	moist	0			platy	friable	
PSU3.2	2	15	soil pit	2.5Y 4/1	clay	moist	0			angular blocky	friable	sand down cracks
PSU3.3	15	35	soil pit	5Y 3/1	clay	moist	0			angular blocky	firm	very sticky
PSU3.4	35	90	soil pit	5Y 3/1	clay	moist	0			massive	firm	
PSU3.5	90	140	push tube	5Y 3/2	clay	wet	0			massive	firm	
PSU4.1	0	5	soil pit	2.5Y 4/2	peaty clay	moist	0			columnar	friable	white salts on surface
PSU4.2	5	25	soil pit	2.5Y 4/1	clay	moist	0			columnar	very firm	sand down cracks
PSU4.3	25	100	soil pit	5Y 2.5/1	clay	moist	0			subangular blocky	very firm	contains plant material
PSU4.4	100	150	push tube	5Y 2.5/1	clay	moist	5	5YR 5/8	in matrix adjacent to pores	massive	firm	

Table 21-4. Laboratory data for acid sulfate soil assessment of Sunnyside - Paiwalla Swamp (Upstream) Wetland.

(red printed values indicate data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
PSU1.1	0 - 10	medium	-	5.23	2.40	4.40	3097	4.75	30.05	0.03	-	50	hyposulfidic (S_{CR}<0.10%)
PSU1.2	10 - 25	fine	-	4.97	2.37	4.50	2281	4.62	41.86	0.01	-	49	hyposulfidic (S_{CR}<0.10%)
PSU1.3	25 - 90	fine	-	5.35	2.96	4.50	2577	4.69	20.03	0.03	-	37	hyposulfidic (S_{CR}<0.10%)
PSU1.4	90 - 120	medium	-	6.32	3.06	4.00	1534	5.24	9.82	0.02	-	24	hyposulfidic (S_{CR}<0.10%)
PSU2.1	0 - 10	medium	-	5.90	2.85	4.00	2420	5.24	11.68	< 0.01	-	12	other acidic incubation
PSU2.2	10 - 35	fine	-	4.79	3.54	4.70	4290	5.35	8.05	0.01	-	15	hyposulfidic (S_{CR}<0.10%)
PSU2.3	35 - 120	fine	-	7.90	2.00	2.50	2070	6.44	1.96	0.88	-	549	hypersulfidic
PSU3.1	0 - 2	fine	1,640	7.39	6.93	6.50	268	6.49	0.78	< 0.01	-	1	other soil material
PSU3.2	2 - 15	fine	640	7.45	6.91	6.50	165	6.11	4.86	< 0.01	-	5	other soil material
PSU3.3	15 - 35	fine	920	7.43	7.34	7.00	119	6.36	3.62	< 0.01	-	4	other soil material
PSU3.4	35 - 90	fine	1,000	7.30	5.99	7.00	113	6.46	2.75	< 0.01	-	3	other soil material
PSU3.5	90 - 140	fine	1,360	8.13	3.94	7.00	112	7.61	0.00	0.02	0.57	-63	hyposulfidic (S_{CR}<0.10%)
PSU4.1	0 - 5	fine	3690	4.85	2.35	4.50	5764	4.74	33.62	0.01	-	41	hyposulfidic (S_{CR}<0.10%)
PSU4.2	5 - 25	fine	940	5.23	2.87	4.50	1388	4.87	37.83	0.01	-	46	hyposulfidic (S_{CR}<0.10%)
PSU4.3	25 - 100	fine	1,320	4.88	2.86	4.50	1758	4.76	32.85	< 0.01	-	33	other acidic
PSU4.4	100 - 150	fine	1,130	6.17	3.27	4.50	777	5.68	7.27	0.06	-	43	hyposulfidic (S_{CR}<0.10%)

22 MYPOLONGA NORTH WETLAND (WETLAND ID. 12040)

22.1 LOCATION AND SETTING DESCRIPTION

Mypolonga North Wetland (Wetland ID. 12040) is situated on the western side of the River Murray, up river from Mypolonga Levee wetland. The wetland is geomorphically categorised as a channel-margin swale (Pressey 1986) and is linear in shape following the curve of the river, with a total surface area of 2 hectares. The wetland is bound to the southwest by a levee bank that separates it from farmland and to the northeast by a raised river bank area with *Salix* spp. (Willow trees) growing that separates it from the river. There are a number of water connection channels along the length of the wetland.

At the time when the soil survey was conducted in October 2008 the wetland was dry. Surrounding the wetland at a slightly higher elevation was *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed), and *Salix* spp. (Willow trees) growing on the raised bank that separated the wetland and river. Two sites were described and sampled and their locations are shown in Figure 22-1.

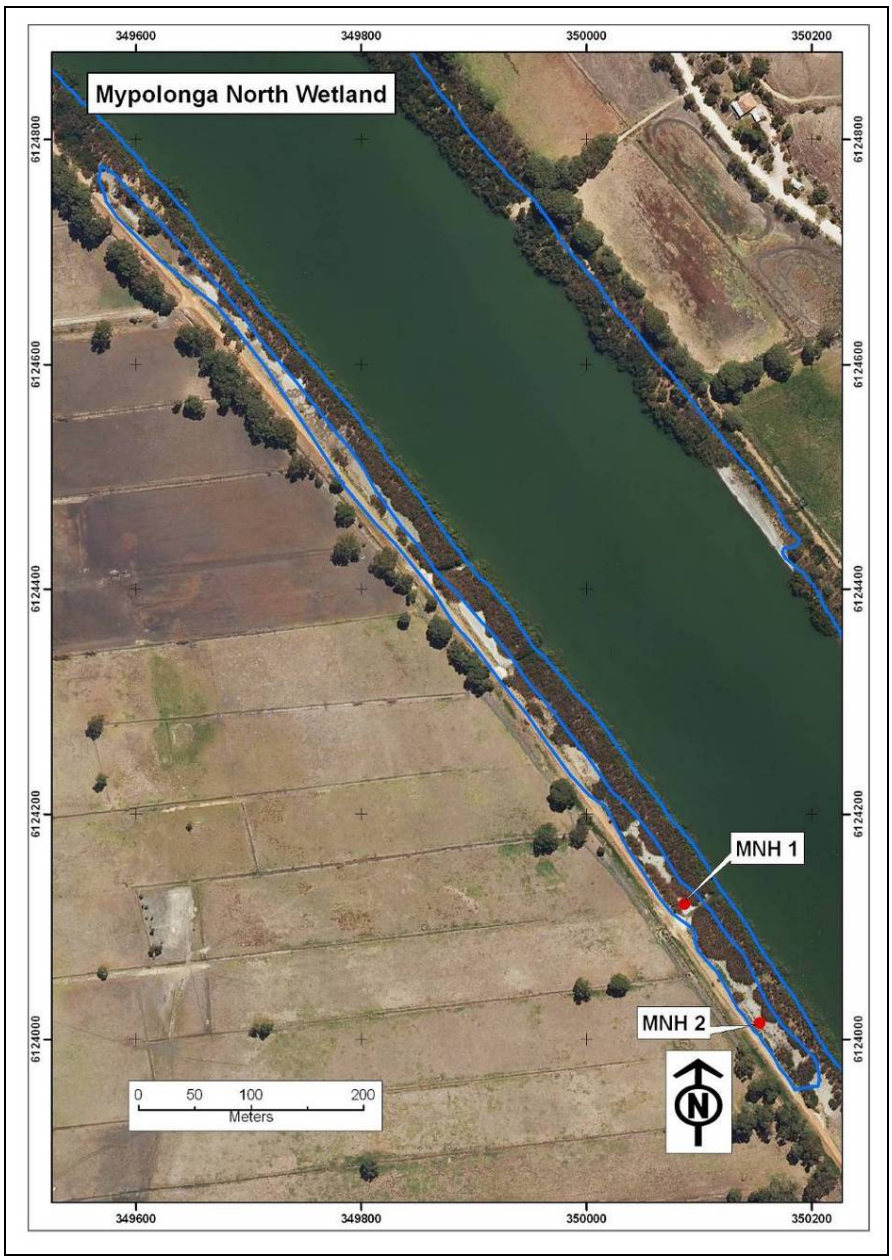


Figure 22-1. Mypolonga North Wetland and sample site locations.

22.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTIONS

Two sites were sampled and described. The acid sulfate soil subtype class and general location description are presented in Table 22-1. The sites were located to characterise an area near the inlet (MNH1) and the main wetland area (MNH2). The site and profile descriptions are presented in Table 22-2 and Table 22-3.

Site MNH1 (Figure 22-2) occurred where there was no vegetation growing and forms part of an inlet channel with a soft surface and water near the surface in cracks. The soil consisted of dark grey, clay with reddish brown stains on ped faces, over a black, firm, clay.

Site MNH2 (Figure 22-3) occurred in an area that has an extremely hard surface that was cracking and no vegetation. The soil consisted of a grey, extremely hard, clay with columnar structure, over a black, very firm, clay with plant material.

Table 22-1. Soil identification, subtype and general location description of sites for Mypolonga North Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
MNH1	350087	6124120	Sulfuric cracking clay soil	Low elevation, 5m from inlet channel
MNH2	350154	6124014	Sulfuric cracking clay soil	Low elevation

Figure 22-2. Photographs of site MNH1, showing the site location at an inlet channel area where water was near the surface that was soft and sealed, and the soil profile of firm clay.

Figure 22-3. Photographs of site MNH2, showing the site landscape in the main wetland area where there were large and deep soil cracks in the hard clay surface and the soil profile of hard clay and deep open cracks.

22.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 22-4 and pH profiles are presented in Figure 22-4.

The pH_W data for the surface layers in both profiles identified samples that were sulfuric materials with a pH_W <4.

The pH_{INC} data for both profiles identified samples that on incubation declined below the critical value of pH<4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation.

The pH_{OX} data for both profiles identified samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

Acid Base Accounting

The acid base accounting data are provided in Table 22-4 and summarised in Figure 22-5.

Chromium reducible sulfur values ranged from below the detection limit to 0.55%S_{CR}. Sulfidic materials were detected in nearly all layers for both profiles.

Titratable actual acidity values ranged from 15.44 to 239.57 mole H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present as most samples were below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity was not measured in any of the samples, as all samples had a pH_{KCl} of <6.5.

Net acidity values ranged from 32 to 581 mole H^+/tonne. All samples had moderate or high net acidity values.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 22-4 identified that surface layers in both profiles were above the critical trigger value of 100 mg/kg SO_4.

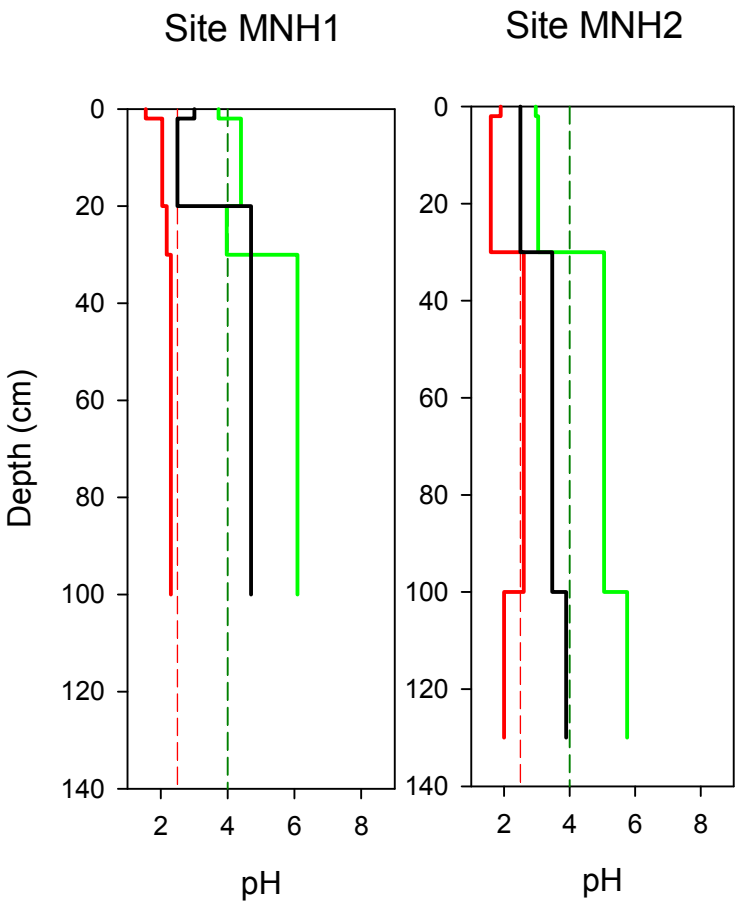


Figure 22-4. Depth profiles of soil pH for Mypolonga North Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

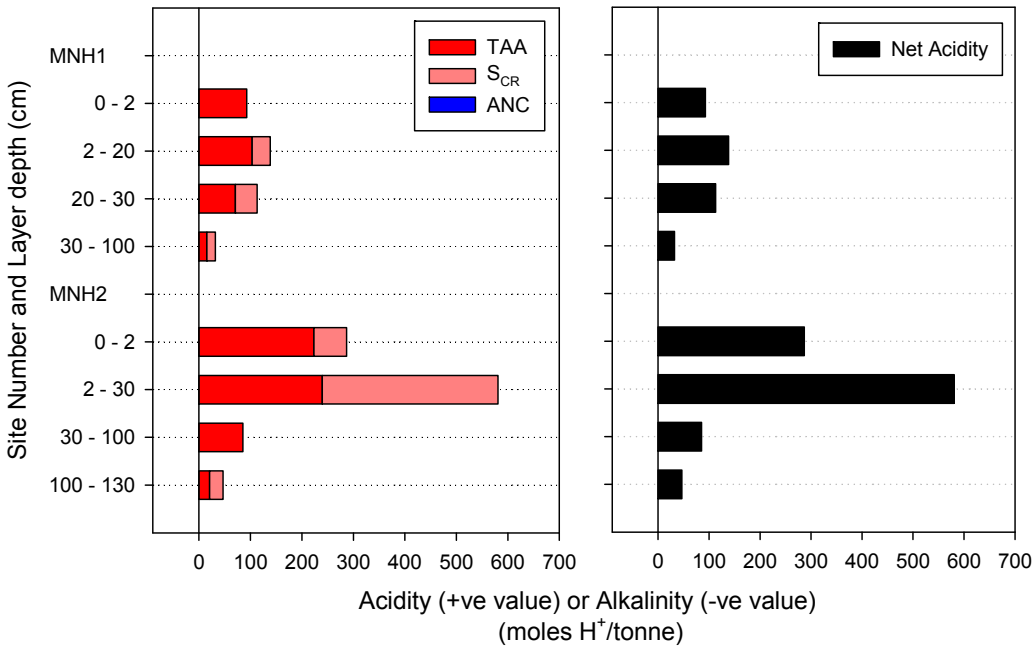


Figure 22-5. Acid base accounting depth profiles for Mypolonga North wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

22.4 DISCUSSION

Acid sulfate soil materials at Mypolonga North Wetland were identified as sulfuric that occurred in the upper layers of both profiles, and hypersulfidic and hyposulfidic in the lower subsoil layers, and one subsoil sample was characterised as other acidic soil material. The acid sulfate soil subtype class identified was Sulfuric Cracking Clay Soil.

The soils throughout the wetland were generally clayey textured and the surface layers had deep and wide cracks. Where the surfaces were dry the soil was extremely hard and where there was water near the surface it was soft.

Monosulfidic material was not observed but water soluble sulfate data identified that surface layers for the profiles throughout the wetland were in excess of the 100 mg/kg trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials at the Mypolonga North Wetland are:

- Acidification hazard: The data identified moderate or high net acidity values throughout both profiles, and pH data identified samples with values that were potential acidification hazard due to oxidation. There is a high level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there was potential for monosulfidic materials to form in the surface layers of soils on re-flooding, although the wetland was mostly dry at the time of sampling and monosulfidic material was not observed. There is a medium to high level of concern.
- Metal mobilisation: The high acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a high level of concern.

Summary of key findings for Mypolonga North Wetland:

Soil materials:	Sulfuric soil materials were identified in the upper soil layers and hypersulfidic or hyposulfidic soil materials were identified in the subsoil layers. The soils throughout were generally clay textured layers with large and deep cracks in the surface layers. Samples had moderate or high net acidity values and pH data identified samples with values that indicated potential acidification due to oxidation.
Acid sulfate soil identification:	• Sulfuric Cracking Clay Soil – that occurred throughout at low to mid elevation. Dominant (>50%) in extent.
Hazard assessment	• Acidification hazard – high level of concern • De-oxygenation hazard – medium to high level of concern • Metal mobilisation hazard – high level of concern

Table 22-2. Site data for Mypolonga North Wetland.

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
MNH1	10-Oct-08	350087	6124120	Sulfuric cracking clay soil	2	soft, with surface cracks	Bare	Low elevation, 5m from inlet channel
MNH2	10-Oct-08	350154	6124014	Sulfuric cracking clay soil	35	cracking, hard	Bare	Low elevation

Table 22-3. Soil description data for Mypolonga North Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
MNH1.1	0	2	soil pit	10YR 3/2	peaty clay	wet	0			massive	soft	
MNH1.2	2	20	soil pit	2.5Y 4/1	clay	wet	0			massive	firm	
MNH1.3	20	30	soil pit	2.5Y 3/1	clay	wet	0			massive	soft	
MNH1.4	30	100	push tube	2.5Y 3/1	clay	wet	0			massive	firm	contains some plant material
MNH2.1	0	2	soil pit	10YR 5/3	clay	dry	0			columnar	extremely hard	
MNH2.2	2	30	soil pit	10YR 5/1	clay	dry	0			columnar	extremely hard	
MNH2.3	30	100	soil pit	5Y 2.5/1	clay	wet	0			massive	very firm	
MNH2.4	100	130	push tube	5Y 2.5/1	peaty clay	wet	0			massive	firm	

Table 22-4. Laboratory data for acid sulfate soil assessment of Mypolonga North Wetland.

(red printed values indicate data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
MNH1.1	0 - 2	fine	390	3.73	1.55	3.00	1861	3.73	92.78	< 0.01	-	93	sulfuric
MNH1.2	2 - 20	fine	990	4.40	2.04	2.50	1405	3.74	103.28	0.06	-	138	hypersulfidic
MNH1.3	20 - 30	fine	1,190	3.97	2.18	4.70	2777	4.08	70.59	0.07	-	113	sulfuric
MNH1.4	30 - 100	fine	370	6.09	2.30	4.70	344	4.98	15.44	0.03	-	32	hyposulfidic (S_{CR}<0.10%)
MNH2.1	0 - 2	fine	1,930	2.97	1.90	2.50	8623	3.11	223.16	0.10	-	287	sulfuric
MNH2.2	2 - 30	fine	1,600	3.04	1.60	2.50	13112	3.22	239.57	0.55	-	581	sulfuric
MNH2.3	30 - 100	fine	720	5.05	2.60	3.47	2146	3.86	85.29	< 0.01	-	85	other acidic incubation
MNH2.4	100 - 130	fine	370	5.75	2.00	3.90	1164	5.05	20.45	0.04	-	47	hypersulfidic

23 PAIWALLA GULLY WETLAND (WETLAND ID. 12120)

23.1 LOCATION AND SETTING DESCRIPTION

Paiwalla Gully Wetland (Wetland ID. 12120) is situated on the eastern side of the River Murray, up river from the Sunnyside complex of wetlands. The wetland is a gully and is somewhat rectangular in shape with a total surface area of approximately 1 hectare. The wetland occurs along a dry stream bed that flows from the hills to the river and is bounded by the river banks. There is one water connection channel with the river and the wetland can be considered a slack water area as the only time water would flow from the catchment would be during rain events, otherwise river water would backfill the gully at times of normal river levels.

At the time when the soil survey was conducted in October 2008, the wetland was dry and there was no surface water. Surrounding the wetland at a slightly higher elevation were *Typha latifolia* (Bulrush), *Phragmites australis* (Common Reed) and *Persicaria lapathifolium* (Pale Knotweed) and *Salix* spp. (Willow trees) on the raised floodplain. Two sites were described and sampled and their locations are shown in Figure 23-1.

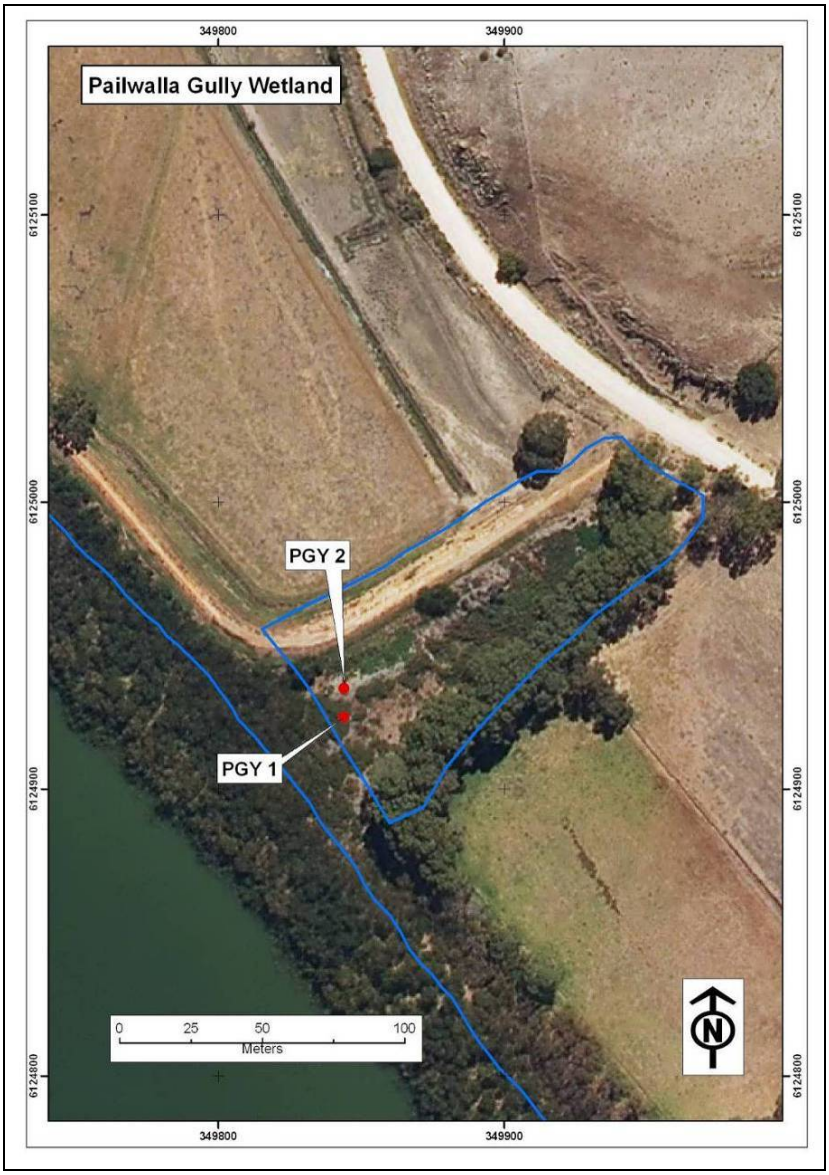


Figure 23-1. Paiwalla Gully Wetland and sample site locations.

23.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Two sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 23-1. Sites were located to characterise different landscape positions observed in the wetland, at mid elevation (PGY1) and low elevation (PGY2). The site and soil profile descriptions are presented in Table 23-2 and Table 23-3.

Site PGY1 (Figure 23-2) occurred at mid elevation near the dried stream channel. The soil consisted of grey, extremely hard, clay with columnar structure, over a black, very firm, clay with orange stains along root channels.

Site PGY2 (Figure 23-3) occurred in the lowest elevation area of the dry stream channel where there were large surface cracks. The soil consisted of grey, extremely hard, clay with columnar structure with white and red salts on the ped surfaces, over a brown, very firm, clay with orange mottles.

Table 23-1. Soil identification, subtype and general location description of sites for Paiwalla Gully Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
PGY1	349844	6124925	Sulfuric cracking clay soil	Mid elevation, on side of channel
PGY2	349844	6124935	Sulfuric cracking clay soil	Low elevation, in channel

Figure 23-2. Photograph of site PGY1, showing the site landscape with vegetation growing and cracking soil surface, and the soil profile of firm clay and cracks down to at least 60 cm depth.

Figure 23-3. Photograph of site PGY2, showing the site landscape of large columns with wide and deep cracks in the surface, and the soil profile of a soil column with white salts on the surfaces.

23.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 23-4 and pH profiles are presented in Figure 23-4.

The pH_W data for the surface layers of both profiles identified samples that were sulfuric materials with a pH_W <4.

The pH_{INC} data for the subsoil layers of both profiles identified samples that on incubation declined below the critical value of pH<4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation.

The pH_{OX} data for most layers in both profiles identified samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

Acid Base Accounting

The acid base accounting data are provided in Table 23-4 and summarised in Figure 23-5.

Chromium reducible sulfur values ranged from below the detection limit to 0.18%S_{CR}. Sulfidic materials were detected in the surface layers of both profiles and a subsoil layer of profile PGY2.

Titratable actual acidity ranged from 26.91 to 185.77 mole H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity could be present in some layers as samples were above the critical value of pH_{KCl} <4.5.

Acid neutralising capacity was not measured in any of the samples, as all samples had a pH_{KCl} of <6.5.

Net acidity values ranged from 27 to 272 mole H^+/tonne. All samples had moderate or high net acidity values.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 23-4 identified that surface layers in both profiles were above the critical trigger value of 100 mg/kg SO_4.

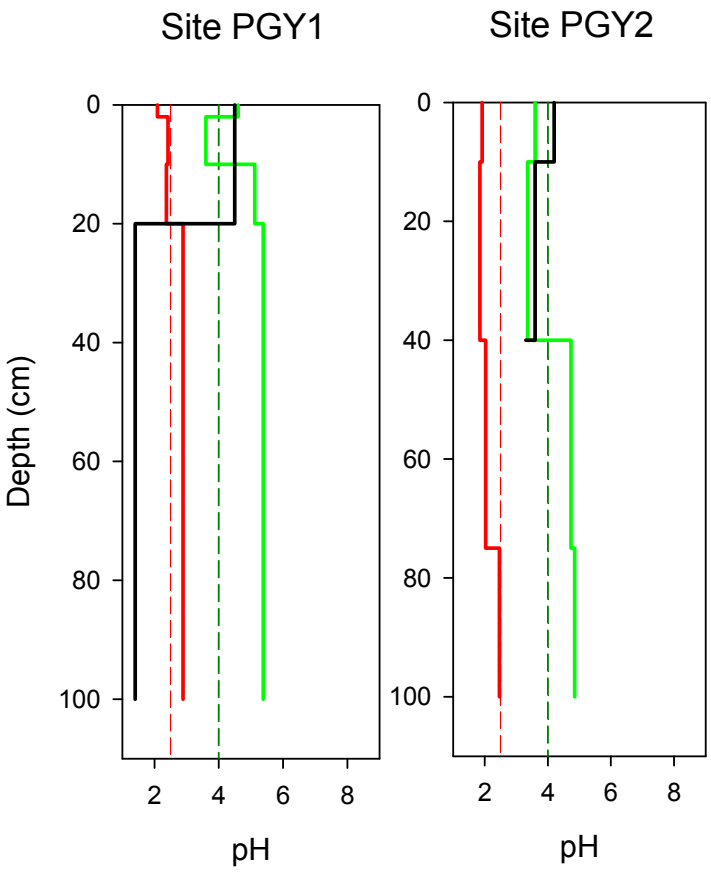


Figure 23-4. Depth profiles of soil pH for Paiwalla Gully Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

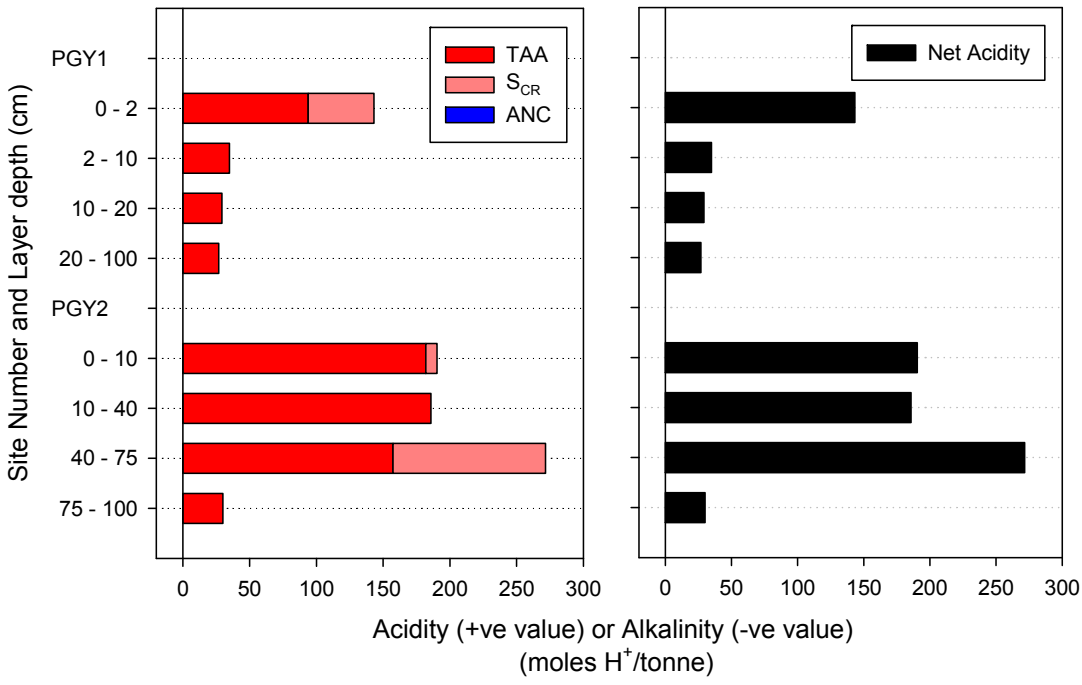


Figure 23-5. Acid base accounting depth profiles for Paiwalla Gully Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

23.4 DISCUSSION

Acid sulfate soil materials at Paiwalla Gully Wetland were identified as either sulfuric or hyposulfidic in the upper layers of the sampled profiles, and subsoil samples were characterised as either hypersulfidic or other acidic soil materials. The acid sulfate soil subtype class identified was Sulfuric Cracking Clay Soil.

The soils throughout the wetland were generally firm and clayey textured surface layers over soft peaty clays in the subsoil.

Monosulfidic material was not observed but water soluble sulfate data identified that surface layers for the profiles throughout the wetland were in excess of the 100 mg/kg trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials at the Paiwalla Gully Wetland are:

- Acidification hazard: The data identified moderate or high net acidity values throughout both profiles, and pH data identified samples with values that were potential acidification hazard due to oxidation. There is a high level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there is potential for monosulfidic materials to form in the surface layers of soils on re-flooding, although the wetland was dry at the time of sampling and monosulfidic material was not observed. There is a medium level of concern.
- Metal mobilisation: The high acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a high level of concern.

Summary of key findings for Paiwalla Gully Wetland:

Soil materials:	Sulfuric soil materials were identified in the upper soil layers and hypersulfidic or hyposulfidic soil materials were identified soil layers. The soils throughout were generally clay textured and had strong columnar structure with large and deep cracks into the soil. Samples had moderate or high net acidity values and pH data identified samples with values that indicated potential acidification due to oxidation.
Acid sulfate soil identification:	• Sulfuric Cracking Clay Soil – that occurred throughout. Dominant (>50%) in extent.
Hazard assessment	• Acidification hazard – high level of concern • De-oxygenation hazard – medium level of concern • Metal mobilisation hazard – high level of concern

Table 23-2. Site data for Paiwalla Gully Wetland.

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
PGY1	14-Oct-08	349844	6124925	Sulfuric cracking clay soil	Not reached	cracking, large	isolated plants	Mid elevation
PGY2	14-Oct-08	349844	6124935	Sulfuric cracking clay soil	75	cracking, large	Bare, few isolated plants	Low elevation, in channel

Table 23-3. Soil description data for Paiwalla Gully Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
PGY1.1	0	2	soil pit	10YR 4/2	clay	dry	0			angular blocky	extremely hard	red and white stains on the surface
PGY1.2	2	10	soil pit	10YR 4/1	clay	dry	0			columnar	extremely hard	
PGY1.3	10	20	soil pit	10YR 2/2	clay	moist	0			columnar	extremely firm	
PGY1.4	20	100	push tube	10YR 2/1	clay	moist	5	10YR 6/8	in matrix adjacent to pores	massive	very firm	
PGY2.1	0	10	soil pit	10YR 5/2	clay	dry	0			columnar	extremely hard	red and white salts on surface
PGY2.2	10	40	soil pit	10YR 4/2	clay	dry	0			columnar	rigid	
PGY2.3	40	75	soil pit	10YR 2/1	sandy clay loam	moist	25	10YR 6/8	in matrix adjacent to pores	massive	very firm	contains organic material
PGY2.4	75	100	push tube	10YR 2/2	clay	moist	0			massive	very firm	fine sand lenses

Table 23-4. Laboratory data for acid sulfate soil assessment of Paiwalla Gully Wetland.

(red printed values indicate data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
PGY1.1	0 - 2	fine	270	4.60	2.09	4.50	4529	4.05	93.91	0.08	-	143	hyposulfidic (S_{CR}<0.10%)
PGY1.2	2 - 10	fine	1,420	3.60	2.42	4.50	1166	4.80	34.90	< 0.01	-	35	sulfuric
PGY1.3	10 - 20	fine	1,420	5.12	2.37	4.50	1243	4.96	29.16	< 0.01	-	29	other acidic incubation
PGY1.4	20 - 100	fine	760	5.38	2.89	1.40	1702	5.13	26.91	< 0.01	-	27	other acidic incubation
PGY2.1	0 - 10	fine	640	3.60	1.92	4.20	7133	3.57	181.88	0.01	-	190	sulfuric
PGY2.2	10 - 40	fine	3,170	3.36	1.85	3.60	6899	3.50	185.77	< 0.01	-	186	sulfuric
PGY2.3	40 - 75	medium	1,940	4.73	2.03	3.30	8804	3.77	157.44	0.18	-	272	hypersulfidic
PGY2.4	75 - 100	fine	880	4.85	2.47	3.40	1621	4.44	29.98	< 0.01	-	30	other acidic incubation

24 WOODLANE WETLAND (WETLAND ID. 12711)

24.1 LOCATION AND SETTING DESCRIPTION

Woodlane Wetland (Wetland ID. 12711) is situated on the western side of the River Murray. The wetland is geomorphically categorised as a channel-margin swale (Pressey 1986) and forms a triangular shape, with a total surface area of approximately 1 hectare. The wetland is bounded to the south-west by a cliff and to the east by a levee bank. There is a water connection at the southern end to the river channel. At the time when the soil survey was conducted in October 2008, the wetland was dry and there was no surface water. The wetland generally had no vegetation growing on the cracking clay surface areas, fringing these areas were isolated areas of *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed) vegetation, and *Salix* spp. (Willow trees) on the raised bank/floodplain. One site was described and sampled and their locations are shown in Figure 24-1.

Figure 24-1. Woodlane Wetland and sample site locations.

24.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

One site was described and sampled. The acid sulfate soil subtype class and general landscape description is presented in Table 24-1. The site was located to characterise the low dominant area of the wetland. The site and soil profile descriptions are presented in Table 24-2 and Table 24-3.

Site WDE1 (Figure 24-2) occurred where no vegetation was growing with a surface area that was cracking and hard. The soil consisted of dark grey, extremely hard, clay with columnar structure, over a black, extremely firm, clay with columnar structure and many red mottles on ped faces.

Table 24-1. Site ID, subtype and general landscape description of sites for Woodlane Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General landscape description
WDE1	347389	6126747	Other acidic soil (cracking clay)	Low elevation, on bare cracking surface area

Figure 24-2: Photographs of site WDE1, showing the wetland landscape with plant material on the surface, and the soil profile of extremely hard clay with large and deep cracks forming columnar structures, and soil material filling the cracks.

24.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 24-4 and pH profiles are presented in Figure 24-3.

The pH_W data did not identify samples as sulfuric materials with a pH_W <4.

The pH_{INC} data did not identify samples that on incubation declined below the critical value of pH<4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation.

The pH_{OX} data for the surface layers identified samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

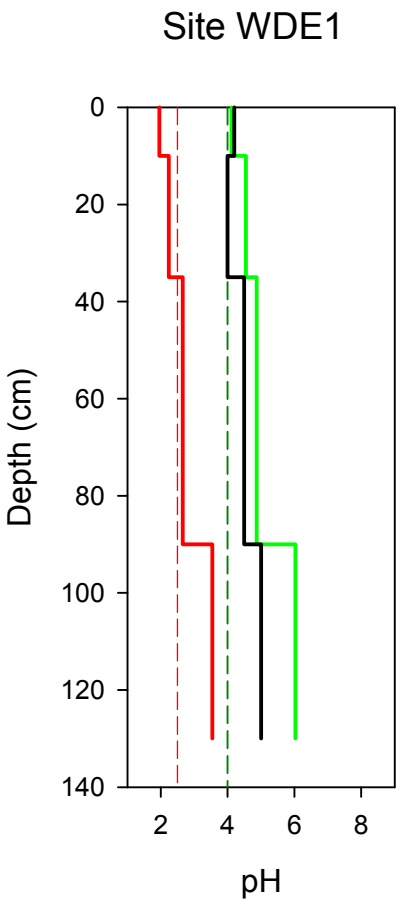


Figure 24-3. Depth profiles of soil pH for Woodlane Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data are provided in Table 24-4 and summarised in Figure 24-4.

Chromium reducible sulfur values were below the detection limit. Sulfidic materials were not detected.

Titratable actual acidity values ranged from 26.08 to 79.51 mole H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present as the surface layer samples were below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity was not measured in any of the samples, as all samples had a pH_{KCl} of < 6.5.

Net acidity values ranged from 36 to 80 mole H^+/tonne. All samples had moderate net acidity values.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 24-4 identified that surface layers were above the critical trigger value of 100 mg/kg SO_4.

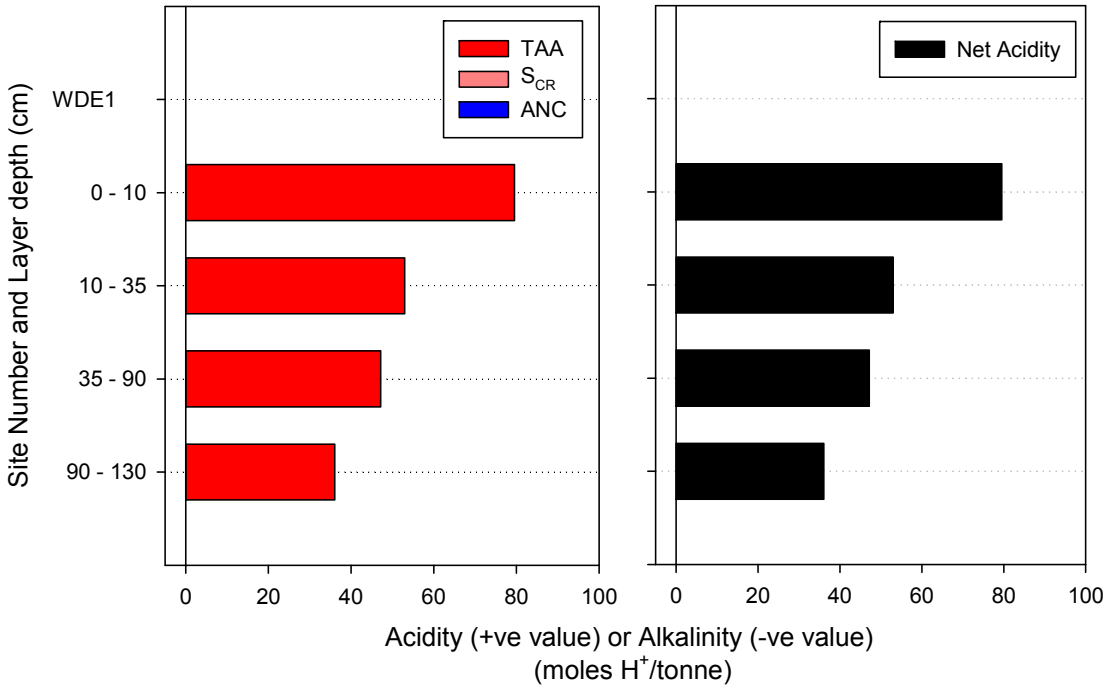


Figure 24-4. Acid base accounting depth profiles for Woodlane Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

24.4 DISCUSSION

Acid sulfate soil materials at Woodlane Wetland were not identified, all samples were characterised as other acidic soil materials. The acid sulfate soil subtype class identified was Other Acidic Soil (cracking clay).

The soils were extremely hard and clayey textured, with large and deep soil cracks forming columnar structures.

Monosulfidic material was not observed but water soluble sulfate data identified that surface layers for the profiles throughout the wetland were in excess of the 100 mg/kg trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials at the Woodlane Wetland are:

- Acidification hazard: The data identified moderate net acidity values throughout all of the profile, and pH_{OX} data identified surface layer samples with values that were potential acidification hazards due to oxidation. There is a medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there was potential for monosulfidic materials to form in the surface layers of soils on re-flooding, although the wetland was dry at the time of sampling and monosulfidic material was not observed. There is a medium level of concern.
- Metal mobilisation: The medium acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

Summary of key findings for Woodlane Wetland:

Soil materials:	Acid sulfate soil materials were not identified. The soils throughout were clay textured layers and extremely hard forming large columnar structures. Samples had moderate net acidity values and pH_{OX} data identified surface layer samples with values that indicated potential acidification due to oxidation.
Acid sulfate soil type identification:	• Other Acidic Soil (cracking clay) – that occurred throughout the main wetland area. Dominant (>50%) in extent.
Hazard assessment	• Acidification hazard – medium level of concern • De-oxygenation hazard – medium level of concern • Metal mobilisation hazard – medium level of concern

Table 24-2. Site data for Woodlane Wetland.

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
WDE1	15-Oct-08	347389	6126747	Other acidic soil (cracking clay)	120	cracking, crumbling, hard	Bare, few isolated plants	mid, mid area of wetland,

Table 24-3. Soil description data for Woodlane Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
WDE1.1	0	10	soil pit	2.5Y 5/2	clay	dry	25	7.5YR 5/8	in matrix along ped faces	angular blocky	rigid	
WDE1.2	10	35	soil pit	2.5Y 5/2	clay	dry	20	7.5YR 5/8	in matrix along ped faces	columnar	extremely hard	
WDE1.3	35	90	soil pit	2.5Y 2.5/1	clay	moist	30	7.5YR 5/8	in matrix along ped faces	columnar	extremely firm	
WDE1.4	90	130	push tube	2.5Y 2.5/1	clay	moist	0			massive	extremely firm	contains some plant material

Table 24-4. Laboratory data for acid sulfate soil assessment of Woodlane Wetland.

(red printed values indicate data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
WDE1.1	0 - 10	fine	1,470	4.12	1.96	4.20	1782	4.16	79.51	< 0.01	-	80	other acidic
WDE1.2	10 - 35	fine	2,540	4.55	2.24	4.00	1281	4.35	53.01	< 0.01	-	53	other acidic incubation
WDE1.3	35 - 90	fine	2,510	4.87	2.66	4.50	829	4.54	47.18	< 0.01	-	47	other acidic
WDE1.4	90 - 130	fine	1,880	6.03	3.54	5.00	250	4.84	36.08	< 0.01	-	36	other acidic incubation

25 POMPOOTA WETLAND (WETLAND ID. 12039)

25.1 LOCATION AND SETTING DESCRIPTION

Pompoota Wetland (Wetland ID. 12039) is situated on the eastern side of the River Murray. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is somewhat triangular in shape, with a total surface area of approximately three hectares. The wetland is bounded to the south-east and north by hills and to the west it is separated from the river by a river bank and *Salix* spp. (Willow trees). There is a water connection channel at the southern end. At the time when the soil survey was conducted in October 2008, the wetland was dry and there was no surface water. The wetland had cracking clay surface. *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed) were growing throughout the wetland, and trees were growing on the margins. Two sites were described and sampled and their locations are shown in Figure 25-1.

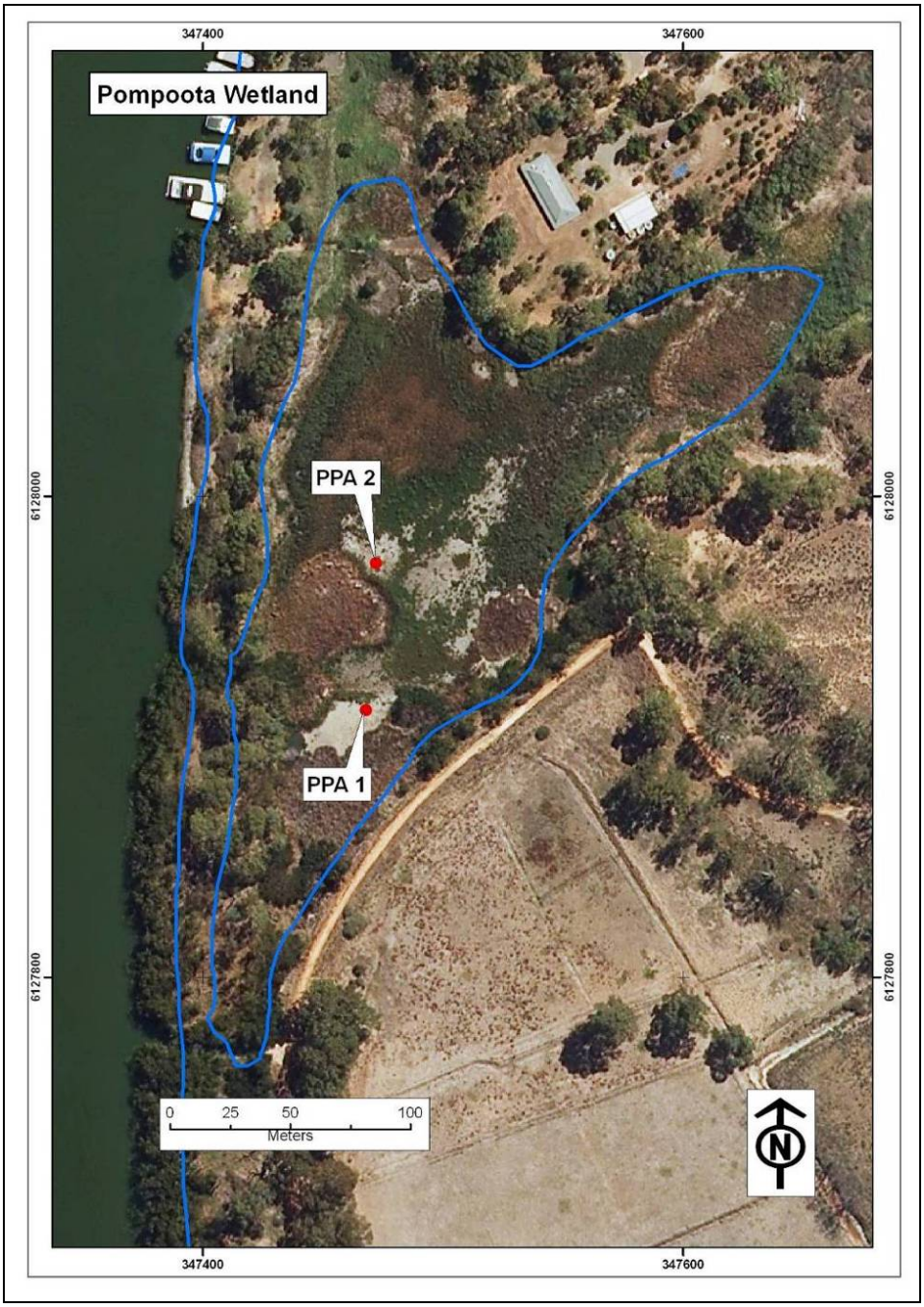


Figure 25-1. Pompoota Wetland and sample site locations.

25.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Two sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 25-1. Sites were located to characterise the main wetland features that included the main area where no vegetation was growing with a cracking clay surface area (PPA1) and amongst Bulrush vegetation (PPA2). The site and soil profile descriptions are presented in Table 25-2 and Table 25-3.

Site PPA1 (Figure 25-2) had a hard and cracking surface. The soil consisted of brown grey, peat, over dark grey, very firm, clay with columnar structure that had jarosite and salts on the column faces, over a black clayey peat.

Site PPA2 (Figure 25-3)had larger cracks in the surface.Tthe soil consisted of grey peat, over grey, rigid, clay with columnar structure, over dark grey very firm, sandy clay with some plant material.

Table 25-1. Soil identification, subtype and general location description of sites for Pompoota Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
PPA1	347468	6127911	Sulfuric cracking clay soil	Low elevation, bare surface cracking clay area
PPA2	347472	6127972	Sulfuric cracking clay soil	Mid elevation, adjacent to reeds

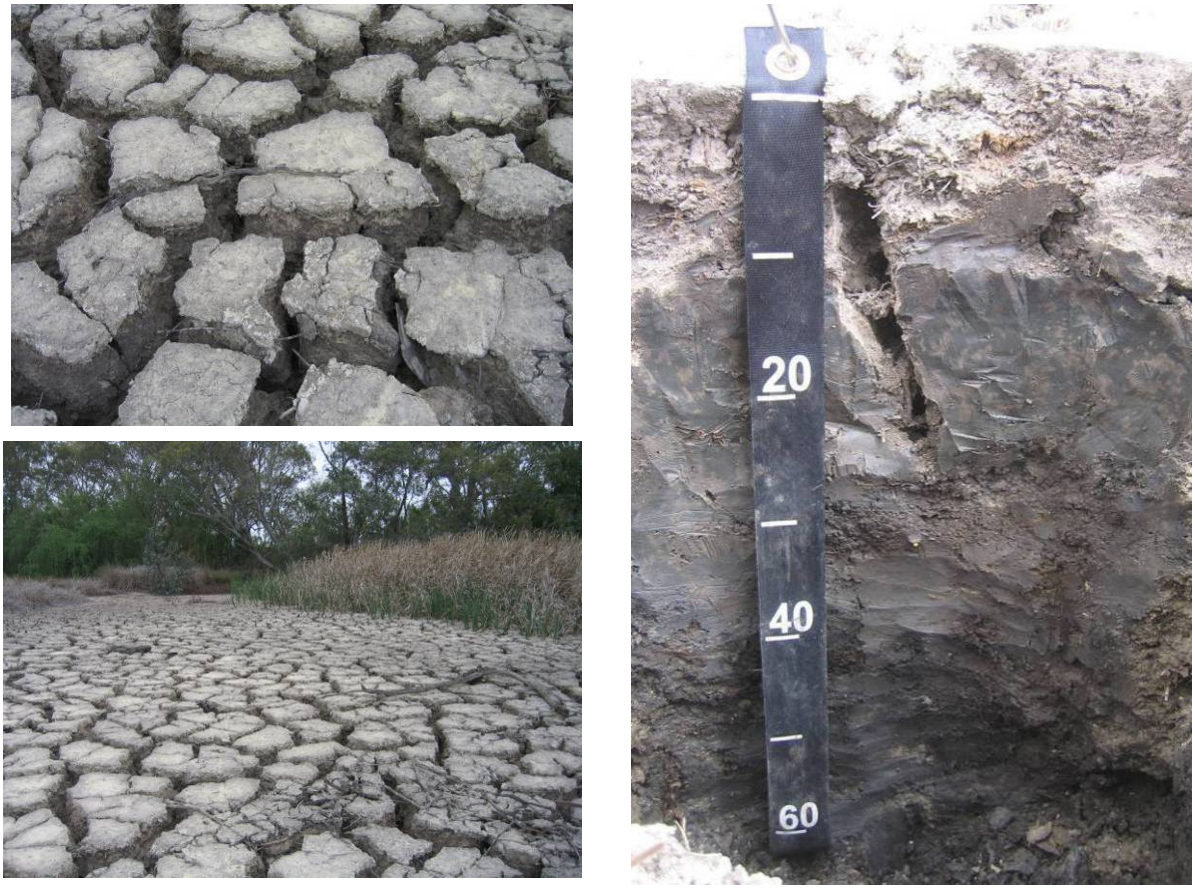


Figure 25-2. Photographs of site PPA1, showing the site landscape of large surface cracks and no vegetation growing, and the soil profile of grey peat over very firm clay with columnar structure.

Figure 25-3. Photographs of site PPA2, showing the site landscape where there were large surface cracks, and showing rigid clay with columnar structure.

25.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 25-4 and pH profiles are presented in Figure 25-4.

The pH_W data for surface layers of both profiles identified samples that were sulfuric material with a pH_W <4.

The pH_{INC} data for both profiles identified samples that on incubation declined below the critical value of pH<4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation.

The pH_{OX} data for the surface and subsoil layers of both profiles identified samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

Acid Base Accounting

The acid base accounting data are provided in Table 25-4 and summarised in Figure 25-5.

Chromium reducible sulfur values ranged from below the detection limit to 0.56 $\%S_{CR}$. Sulfidic materials were detected in both profiles.

Titratable actual acidity values ranged from 17.62 to 299.63 mole H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present in the upper layers of both profiles as samples were below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity was not measured in any of the samples, as all samples had a pH_{KCl} of <6.5.

Net acidity values ranged from 26 to 652 mole H^+/tonne. All samples had moderate or high net acidity values.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 25-4 identified that surface layers in both profiles were above the critical trigger value of 100 mg/kg SO_4.

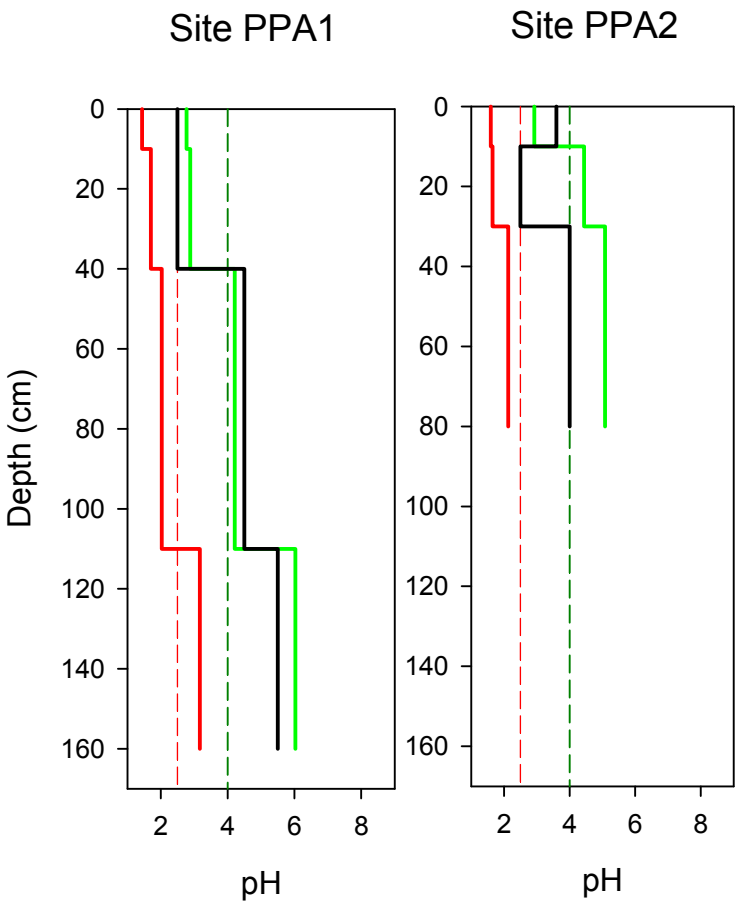


Figure 25-4. Depth profiles of soil pH for Pompoota Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

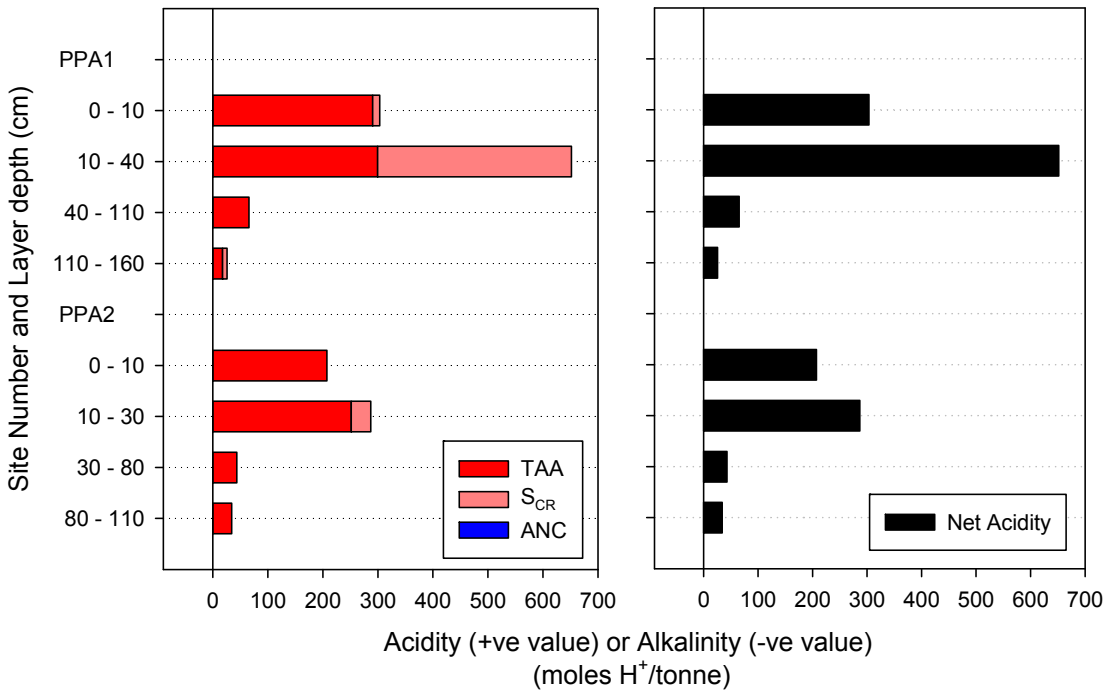


Figure 25-5. Acid base accounting depth profiles for Pompoota Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

25.4 DISCUSSION

Acid sulfate soil materials within Pompoota Wetland were identified as sulfuric in the surface layers and hypersulfidic or hyposulfidic in the subsoil layers, and some subsoil samples were characterised as other acidic soil materials. The acid sulfate soil subtype class identified was Sulfuric Cracking Clay Soil.

The soils were extremely hard and clayey textured, with large and deep soil cracks forming columnar structures.

Monosulfidic material was not observed but water soluble sulfate data identified that surface layers for the profiles throughout the wetland were in excess of the 100 mg/kg trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials in Pompoota Wetland are:

- Acidification hazard: The data identified moderate or high net acidity values throughout both of the profile, and pH data identified surface and subsoil layer samples with values that were potential acidification hazard due to oxidation. There is a high level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there was potential for monosulfidic materials to form in the surface layers of soils on re-flooding, although the wetland was dry at the time of sampling and monosulfidic material was not observed. There is a medium level of concern.
- Metal mobilisation: The high acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a high level of concern.

Summary of key findings for Pompoota Wetland:

Soil materials:	Sulfuric soil materials were identified in the upper soil layers, and hypersulfidic or hyposulfidic were identified in the subsoil layers. The soils throughout were clay textured layers and extremely hard forming large columnar structures. Samples had moderate or high net acidity values and pH data identified surface and subsoil layer samples with values that indicated potential acidification due to oxidation.
Acid sulfate soil identification:	• Sulfuric Cracking Clay Soil – that occurred throughout the wetland. Dominant (>50%) in extent.
Hazard assessment	• Acidification hazard – high level of concern • De-oxygenation hazard – medium level of concern • Metal mobilisation hazard – high level of concern

Table 25-2. Site data for Pompoota Wetland.

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
PPA1	14-Oct-08	347468	6127911	Sulfuric cracking clay soil	110	cracking, large, jarosite and salts on surface	Bare	Low elevation, bare surface cracking clay
PPA2	14-Oct-08	347472	6127972	Sulfuric cracking clay soil	100	cracking, large, hard	*Typha latifolia* (Bulrush)	Mid elevation, adjacent to reeds

Table 25-3. Soil description data for Pompoota Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
PPA1.1	0	10	soil pit	5Y 2.5/1	peat	moist	0			massive	friable	
PPA1.2	10	40	soil pit	5Y 4/1	clay	moist	0			columnar	very firm	salts on sides of columns
PPA1.3	40	110	soil pit	5Y 2.5/1	peaty clay	moist	0			massive	very firm	contains plant material, pockets of sand
PPA1.4	110	160	push tube	5Y 2.5/1	peaty clay	wet	0			massive	firm	contains plant material
PPA2.1	0	10	soil pit	2.5Y 4/2	peat	dry	0			massive	hard	light weight
PPA2.2	10	30	soil pit	2.5Y 4/1	clay	dry	0			columnar	rigid	
PPA2.3	30	80	soil pit	2.5Y 3/1	sandy clay loam	moist	0			massive	very firm	contains sand lenses
PPA2.4	80	110	push tube	2.5Y 2.5/1	clay	moist	0			massive	very firm	contains plant material

Table 25-4. Laboratory data for acid sulfate soil assessment of Pompoota Wetland.

(red printed values indicate data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
PPA1.1	0 - 10	fine	1,790	2.77	1.44	2.50	13374	3.28	290.40	0.02	-	303	sulfuric
PPA1.2	10 - 40	fine	4,320	2.88	1.70	2.50	12730	3.18	299.63	0.56	-	652	sulfuric
PPA1.3	40 - 110	fine	2,940	4.21	2.03	4.50	4595	4.11	65.46	< 0.01	-	65	other acidic
PPA1.4	110 - 160	fine	1,270	6.03	3.17	5.50	1348	5.48	17.62	0.01	-	26	hyposulfidic (S_{CR}<0.10%)
PPA2.1	0 - 10	fine	1,140	2.92	1.60	3.60	9982	3.33	207.19	< 0.01	-	207	sulfuric
PPA2.2	10 - 30	fine	2,660	4.44	1.65	2.50	10211	3.05	251.62	0.06	-	287	hypersulfidic
PPA2.3	30 - 80	medium	3,680	5.08	2.13	4.00	3441	4.40	43.35	< 0.01	-	43	other acidic incubation
PPA2.4	80 - 110	fine	-	-	-	-	1694	4.82	34.28	< 0.01	-	34	-

26 WALL LEVEE WETLAND (WETLAND ID. 12038)

26.1 LOCATION AND SETTING DESCRIPTION

Wall Levee Wetland (Wetland ID. 12038) is situated on the southern side of the River Murray. The wetland is geomorphically categorised as a channel-margin swale (Pressey 1986) and is somewhat elongated in shape and follows the curve of the river, with a total surface area of six hectares. The wetland is bounded to the southwest by a levee bank that separates it from the farm land and to the north-east by *Salix* spp. (Willow trees) growing on a raised bank that separates it from the river. There are a few water connection channels with the river distributed along the wetland. At the time when the soil survey was conducted in October 2008, the wetland was dry with no surface water. Grasses, reeds and river gum trees were growing throughout the wetland. Two sites were described and sampled and their locations are shown in Figure 26-1.

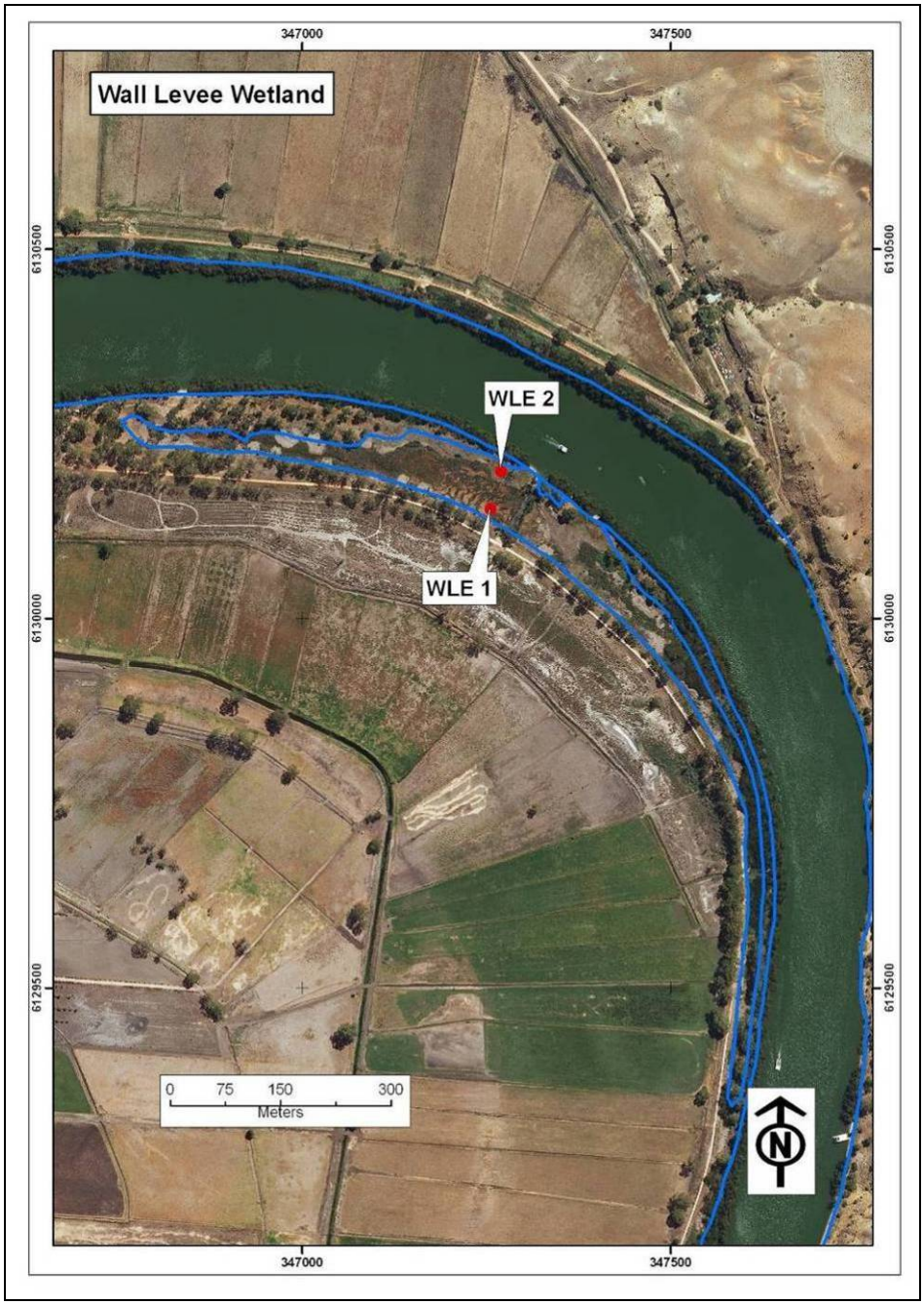


Figure 26-1. Wall Levee Wetland and sample site locations.

26.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Two sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 26-1. Sites were located to characterise the two main wetland areas, where the surface area was cracking (WLE1) and near the wetland margin (WLE2). The site and soil profile descriptions are presented in Table 26-2 and Table 26-3.

Site WLE1 (Figure 26-2) occurred in the middle of the wetland where the surface had plant material on it with isolated grasses and *Eucalyptus camaldulensis* (River Red Gum) growing. The soil consisted of brown, loose, sand, over black, very firm, clay with many yellowish brown mottles.

Site WLE2 (Figure 26-3) occurred on the river side of the wetland amongst *Typha latifolia* (Bulrush) growing on the higher margin areas of the wetland. The soil consisted of yellowish brown, friable, loamy sand, over black, very firm clay with many yellowish brown mottles.

Table 26-1. Soil identification, subtype and general location description of sites for Wall Levee Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
WLE1	347256	6130148	Other acidic soil	Low elevation, near middle of wetland
WLE2	347270	6130199	Other acidic soil	Low to mid elevation, where reeds were growing

Figure 26-2. Photographs of site WLE1, showing the site location where the surface was covered with plant material, and the soil profile of loose brown sand over black clay.

Figure 26-3. Photograph of site WLE2, showing the site landscape near the wetland margin and where reeds was growing, and the soil profile of brown loamy sand over clay.

26.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 26-4 and pH profiles are presented in Figure 26-4.

The pH_W data did not identify samples as sulfuric materials with a pH_W <4.

The pH_{INC} data did not identify samples that on incubation declined below the critical value of pH<4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation.

The pH_{OX} data for the surface layers of both profiles identified samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

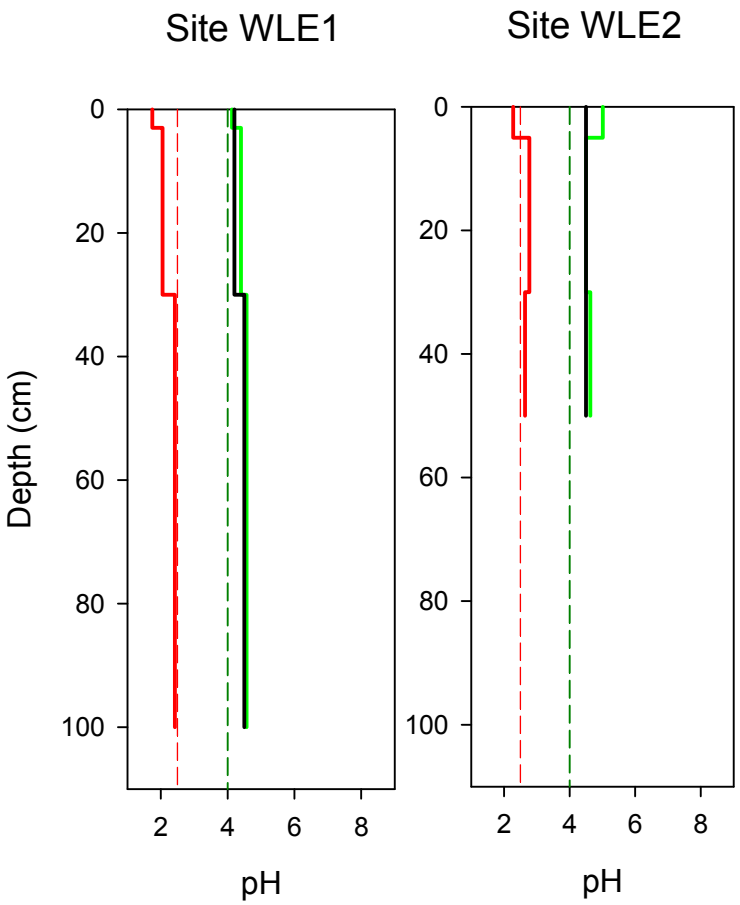


Figure 26-4. Depth profiles of soil pH for Wall Levee Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data are provided in Table 26-4 and summarised in Figure 26-5.

Chromium reducible sulfur values were below the detection limit. Sulfidic materials were not detected.

Titratable actual acidity values ranged from 5.75 to 37.29 mole H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present as the subsoil layer samples were below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity was not measured in any of the samples, as all samples had a pH_{KCl} of <6.5.

Net acidity values ranged from 6 to 37 mole H^+/tonne. All samples had low or moderate net acidity values.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 26-4 identified that surface layers in both profiles were above the critical trigger value of 100 mg/kg SO_4.

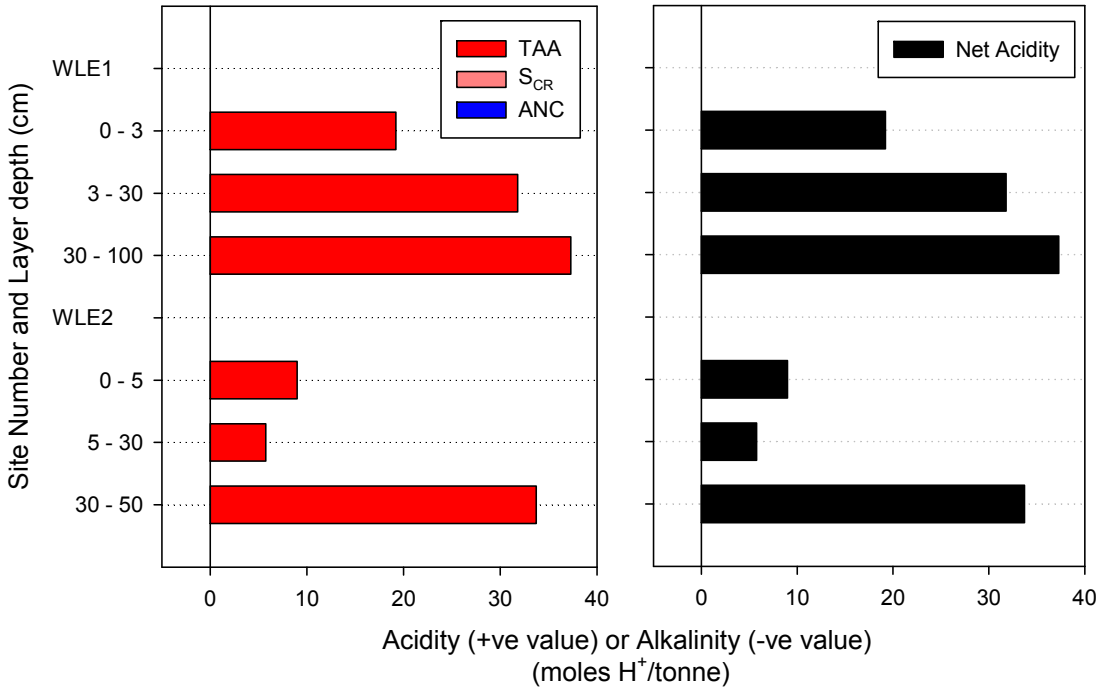


Figure 26-5. Acid base accounting depth profiles for Wall Levee Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

26.4 DISCUSSION

Acid sulfate soil materials at Wall Levee Wetland were not identified, all samples were characterised as other acidic soil materials. The acid sulfate soil subtype class identified was Other Acidic Soil.

The soils were loose and sandy at the surface and becoming very firm and clayey with depth in the subsoil layers.

Monosulfidic material was not observed but water soluble sulfate data identified that surface layers for the profiles throughout the wetland were in excess of the 100 mg/kg trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials at the Wall Levee Wetland are:

- Acidification hazard: The data identified low or moderate net acidity values throughout the profiles, and pH_{OX} data identified surface layer samples with values that were potential acidification hazard due to oxidation. There is a medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there was potential for monosulfidic materials to form in the surface layers of soils on re-flooding, although the wetland was dry at the time of sampling and monosulfidic material was not observed. There is a medium level of concern.
- Metal mobilisation: The medium acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

Summary of key findings for Wall Levee Wetland:

Soil materials:	Acid sulfate soil materials were not identified. The soils throughout were loose and sandy textured in the surface layers and became very firm and clayey in the subsoil layers. Samples had low or moderate net acidity values and pH_{OX} data identified surface layer samples with values that indicated potential acidification due to oxidation.
Acid sulfate soil identification:	• Other Acidic Soil – that occurred throughout the wetland. Dominant (>50%) in extent.
Hazard assessment	• Acidification hazard: medium level of concern • De-oxygenation hazard: medium level of concern • Metal mobilisation: medium level of concern

Table 26-2. Site data for Wall Levee Wetland.

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
WLE1	15-Oct-08	347256	6130148	Other acidic soil	Not reached	plant material	grasses, gums	Low elevation, near middle of wetland
WLE2	15-Oct-08	347270	6130199	Other acidic soil	Not reached	plant material	reeds	Low to mid elevation, where reeds were growing

Table 26-3. Soil description data for Wall Levee Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
WLE1.1	0	3	soil pit	10YR 6/2	sand	dry	0			single grain	loose	
WLE1.2	3	30	soil pit	10YR 4/1	sandy clay loam	moist	25	7.5YR 5/8	in matrix	massive	firm	
WLE1.3	30	100	push tube	10YR 2/1	clay	moist	15	7.5YR 5/8	in matrix	massive	very firm	
WLE2.1	0	5	soil pit	10YR 4/2	loamy sand	moist	0			single grain	friable	
WLE2.2	5	30	soil pit	10YR 5/2	sand	moist	25	7.5YR 5/8	in matrix	single grain	loose	
WLE2.3	30	50	soil pit	10YR 2/1	clay	moist	30	7.5YR 5/8	in matrix adjacent to pores	massive	very firm	too hard to dig below this layer

Table 26-4. Laboratory data for acid sulfate soil assessment of Wall Levee Wetland.

(red printed values indicate data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
WLE1.1	0 - 3	coarse	1,350	4.13	1.74	4.20	843	5.01	19.20	< 0.01	-	19	other acidic
WLE1.2	3 - 30	medium	970	4.40	2.05	4.20	1009	4.45	31.80	< 0.01	-	32	other acidic
WLE1.3	30 - 100	fine	860	4.57	2.42	4.50	804	4.52	37.29	< 0.01	-	37	other acidic
WLE2.1	0 - 5	coarse	230	5.01	2.28	4.50	220	5.41	8.99	< 0.01	-	9	other acidic incubation
WLE2.2	5 - 30	coarse	140	4.50	2.77	4.50	136	5.09	5.75	< 0.01	-	6	other acidic
WLE2.3	30 - 50	fine	950	4.63	2.64	4.50	1103	4.49	33.72	< 0.01	-	34	other acidic

27 WALL SWAMP WETLAND (WETLAND ID. 12037)

27.1 LOCATION AND SETTING DESCRIPTION

Wall Swamp Wetland (Wetland ID. 12037) is situated on the southern side of the River Murray. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and forms a somewhat half-circle segment shape, with a total surface area of 23 hectares. The wetland is bound to the south by hill slopes and to the north by a raised river bank that separates it from the river. There are a few narrow water connection channels with the river. At the time when the soil survey was conducted in November 2008, the wetland was dry and there was no surface water. The wetland generally had no vegetation growing in the main area and near the margins there were reeds, and *Salix* spp. (Willow trees) on the raised river bank. Three sites were described and sampled and their locations are shown in Figure 27-1.

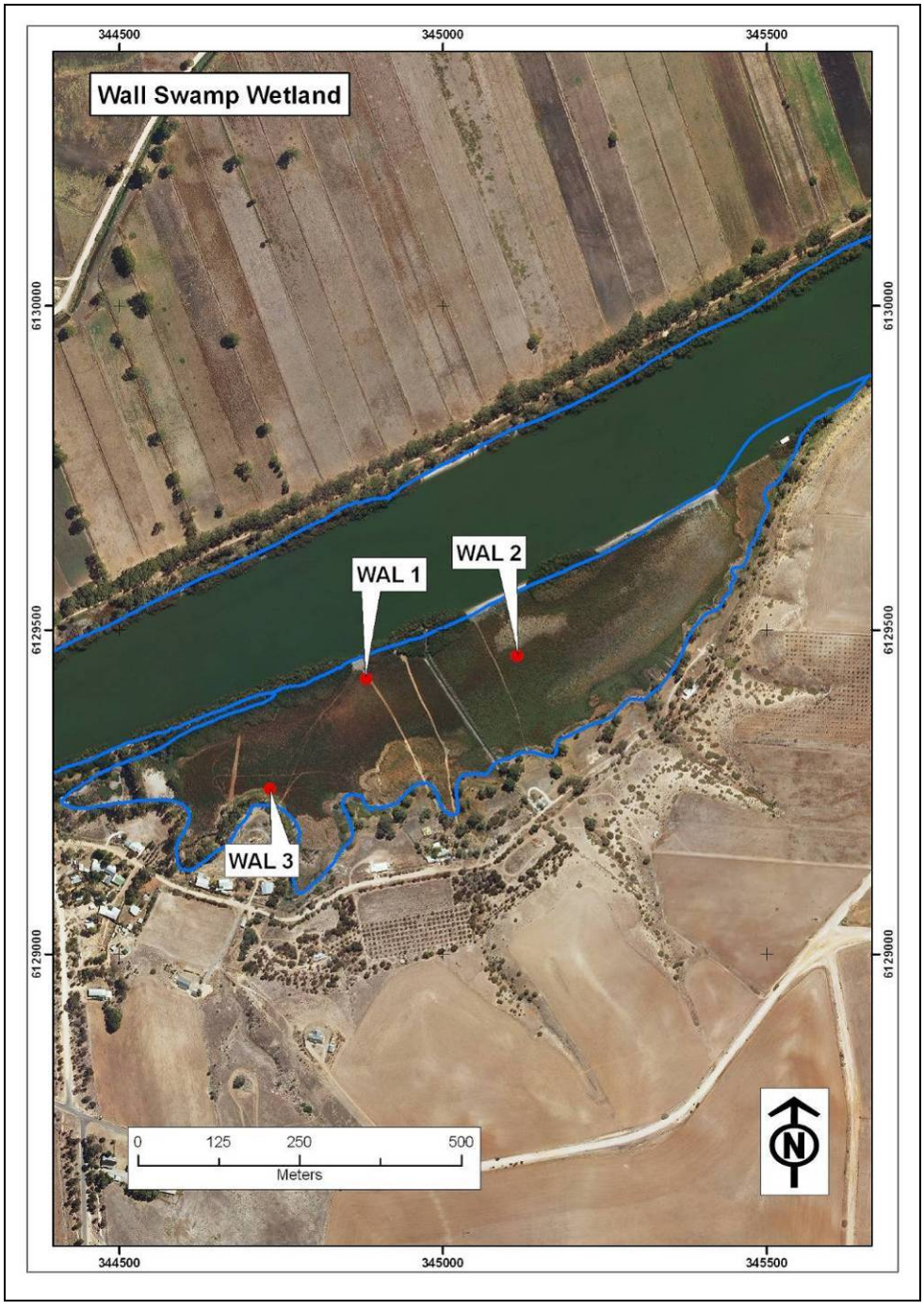


Figure 27-1. Wall Swamp Wetland and sample site locations.

27.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Three sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 27-1. Sites were located to characterise the main wetland surface features, where vegetation was growing on a cracking surface area (WAL1), hard cracking surface area (WAL2), and where rushes were growing on the margins (WAL3). The site and soil profile descriptions are presented in Table 27-2 and Table 27-3.

Site WAL1 (Figure 27-2) occurred in a mid elevation area where weeds, sedges and grasses were growing on a hard cracking soil surface. The soil consisted of black, rigid, clay with red mottles along root channels.

Site WAL2 (Figure 27-3) occurred in a low elevation area of the wetland where there was a hard cracking soil surface. The soil consisted of black, hard, clay with red mottles in root channels.

Site WAL3 (Figure 27-4) occurred in a higher elevation area of the wetland near the slopes where *Typha latifolia* (Bulrush) vegetation was growing on the wetland margins. The soil consisted of black, rigid, clay.

Table 27-1. Soil identification, subtype and general location description of sites for Wall Swamp Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
WAL1	344882	6129425	Hyposulfidic soil (cracking clay)	Mid elevation, *Persicaria lapathifolium* (Pale Knotweed)and reed grasses, cracking clay surface
WAL2	345115	6129460	Hyposulfidic soil (cracking clay)	Low elevation, bare surface area, cracking clay surface
WAL3	344733	6129255	Hyposulfidic soil (cracking clay)	High elevation, adjacent to reeds

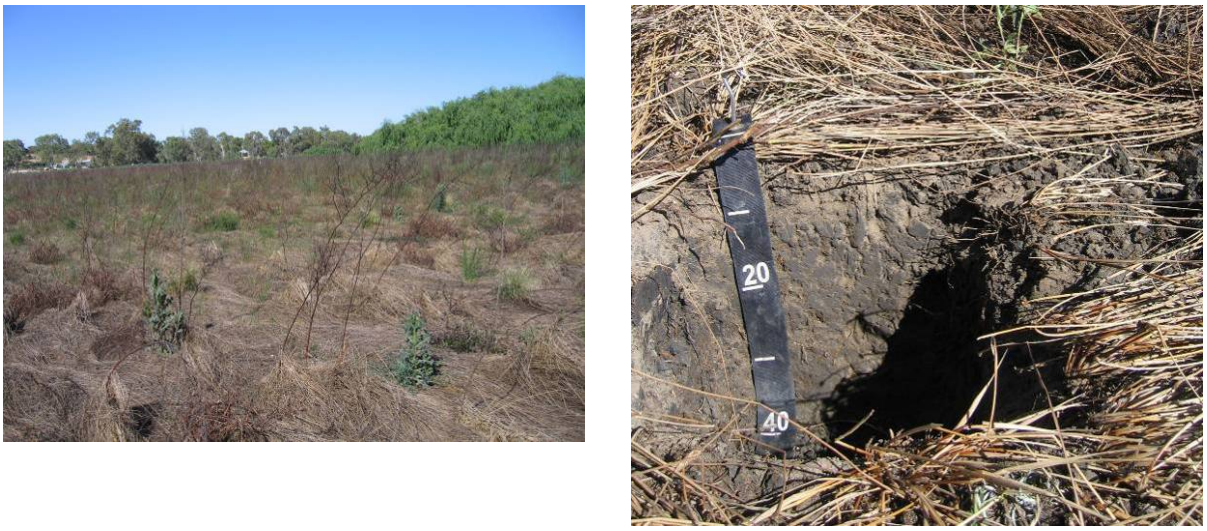


Figure 27-2. Photographs of site WAL1, showing the site landscape and main wetland area with *Aster subulatus* (Aster-weed), *Persicaria lapathifolium* (Pale Knotweed) and sedges growing and plant material on the hard cracking surface, and the soil profile of hard clay.

Figure 27-3. Photograph of site WAL2, showing the site landscape of *Persicaria lapathifolium* (Pale Knotweed), *Aster subulatus* (Aster-weed) and sedge species growing on a hard cracking surface, and the soil profile of hard clay with yellowish red mottles adjacent to root channels.

Figure 27-4. Photographs of site WAL3, showing the site landscape of reeds, *Persicaria lapathifolium* (Pale Knotweed), *Eucalyptus camaldulensis* (River Red Gum) and the soil profile of rigid clay.

27.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data was not obtained as samples were not available for analysis. Based on judgement of other similar soils it was assumed that:

The pH_W data would not identify sulfuric materials with a pH_W <4.

The pH_{INC} data would not identify samples that on incubation declined below the critical value of pH<4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation.

The pH_{OX} data may identify some samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

Acid Base Accounting

Acid base accounting data is provided in Table 27-4 and summarised in Figure 27-5.

Chromium reducible sulfur values ranged from 0.01 to 0.03 $\%S_{CR}$. Sulfidic materials were detected in all layers.

Titratable actual acidity values ranged from 10.24 to 55.87 mole H^+/tonne.

Retained acidity was not measured in any of the samples, as all samples had a pH_{KCl} of greater than 4.5.

Acid neutralising capacity was not measured in any of the samples, as all samples had a pH_{KCl} of < 6.5.

Net acidity values ranged from 23 to 66 mole H^+/tonne. All samples had moderate net acidity values.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 27-4 identified that surface layers in both profiles were above the critical trigger value of 100 mg/kg SO_4.

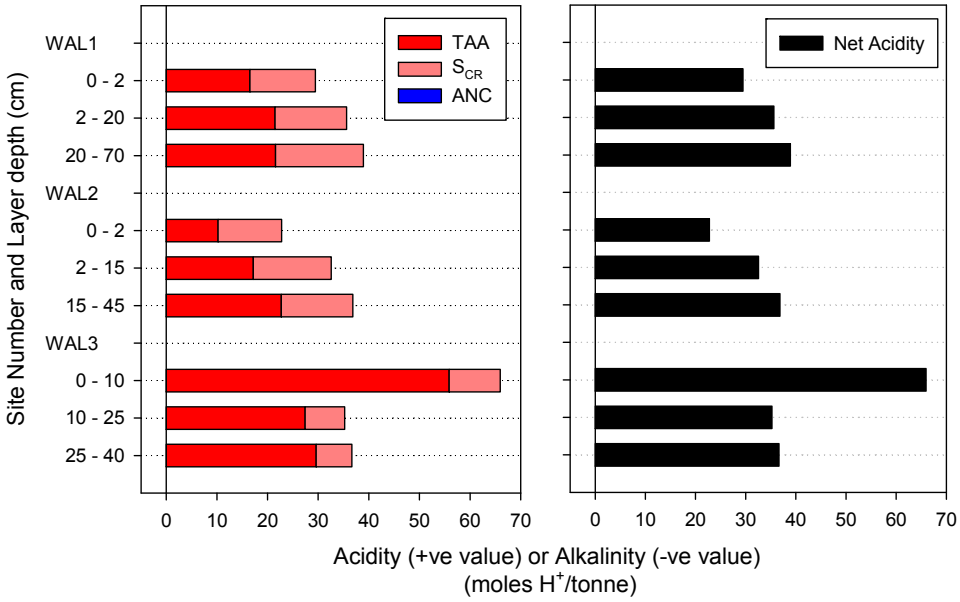


Figure 27-5. Acid base accounting depth profiles for Wall Swamp Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

27.4 DISCUSSION

Acid sulfate soil materials at Wall Swamp Wetland were identified as hyposulfidic. The acid sulfate soil subtype class identified was Hyposulfidic Soil (cracking clay).

The soils were extremely hard and clayey textured, with large and deep soil cracks forming columnar structures.

Monosulfidic material was not observed but water soluble sulfate data identified that surface layers for the profiles throughout the wetland were in excess of the 100 mg/kg trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials at the Wall Swamp Wetland are:

- Acidification hazard: The data identified moderate net acidity values for all profile samples. There is a medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there was potential for monosulfidic materials to form in the surface layers of soils on re-flooding, although the wetland was dry at the time of sampling and monosulfidic material was not observed. There is a medium level of concern.
- Metal mobilisation: The medium acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

Summary of key findings for Wall Swamp Wetland:

Soil materials:	Hyposulfidic soil materials were identified in the surface and subsoil layers. The soils throughout were clay textured layers and hard forming columnar structures. Samples had moderate net acidity values and pH data did not identify samples with values that indicated potential acidification due to oxidation.
Acid sulfate soil identification:	• Hyposulfidic Soil (cracking clay) – that occurred throughout the wetland. Dominant (>50%) in extent.
Hazard assessment	• Acidification hazard – medium level of concern • De-oxygenation hazard – medium level of concern • Metal mobilisation hazard – medium level of concern

Table 27-2. Site data for Wall Swamp Wetland.

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
WAL1	24-Nov-08	344882	6129425	Hyposulfidic soil (cracking clay)	Not reached	cracking, hard	Persicaria lapathifolium (Pale Knotweed)	Mid elevation, Persicaria lapathifolium (Pale Knotweed) and reed grasses, cracking clay surface
WAL2	24-Nov-08	345115	6129460	Hyposulfidic soil (cracking clay)	Not reached	cracking, hard	Persicaria lapathifolium (Pale Knotweed)	Low elevation, bare surface area, cracking clay surface
WAL3	24-Nov-08	344733	6129255	Hyposulfidic soil (cracking clay)	Not reached	cracking, hard	*Typha latifolia* (Bulrush)	High elevation, adjacent to reeds

Table 27-3. Soil description data for Wall Swamp Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
WAL1.1	0	2	soil pit	10YR 6/1	clay	dry	0			angular blocky	hard	
WAL1.2	2	20	soil pit	10YR 2/1	clay	dry	10		in matrix adjacent to pores	columnar	hard	
WAL1.3	20	70	push tube	10YR 2/1	clay	dry	10		in matrix adjacent to pores	massive	hard	
WAL2.1	0	2	push tube	10YR 5/1	clay	dry	0			angular blocky	hard	
WAL2.2	2	15	push tube	10YR 2/1	clay	dry	10		in matrix adjacent to pores	columnar	hard	
WAL2.3	15	45	push tube	10YR 2/1	clay	dry	10		in matrix adjacent to pores	massive	hard	
WAL3.1	0	10	soil pit	10YR 6/1	clay	dry	0			subangular blocky	rigid	
WAL3.2	10	25	soil pit	10YR 2/1	clay	dry	0			columnar	rigid	
WAL3.3	25	40	soil pit	10YR 2/1	clay	moist	5		in matrix along ped faces	massive	hard	

Table 27-4. Laboratory data for acid sulfate soil assessment of Wall Swamp Wetland.

(red printed values indicate data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
WAL1.1	0 - 2	fine	-	-	-	-	467	5.17	16.51	0.02	-	29	hyposulfidic (S_{CR}<0.10%)
WAL1.2	2 - 20	fine	-	-	-	-	251	5.04	21.48	0.02	-	36	hyposulfidic (S_{CR}<0.10%)
WAL1.3	20 - 70	fine	-	-	-	-	318	4.97	21.59	0.03	-	39	hyposulfidic (S_{CR}<0.10%)
WAL2.1	0 - 2	fine	-	-	-	-	278	5.56	10.24	0.02	-	23	hyposulfidic (S_{CR}<0.10%)
WAL2.2	2 - 15	fine	-	-	-	-	230	5.18	17.16	0.02	-	33	hyposulfidic (S_{CR}<0.10%)
WAL2.3	15 - 45	fine	-	-	-	-	914	4.98	22.71	0.02	-	37	hyposulfidic (S_{CR}<0.10%)
WAL3.1	0 - 10	fine	-	-	-	-	3150	4.49	55.87	0.02	-	66	hyposulfidic (S_{CR}<0.10%)
WAL3.2	10 - 25	fine	-	-	-	-	1367	4.85	27.44	0.01	-	35	hyposulfidic (S_{CR}<0.10%)
WAL3.3	25 - 40	fine	-	-	-	-	1080	5.01	29.62	0.01	-	37	hyposulfidic (S_{CR}<0.10%)

28 NEETA FLAT DEPRESSIONS WETLAND (WETLAND ID. 12712, 12713, 12720, 12721)

No field survey or assessment conducted for this wetland

29 REEDY CREEK WETLAND (WETLAND ID. 12017)

29.1 LOCATION AND SETTING DESCRIPTION

Reedy Creek Wetland (Wetland ID. 12017) is situated on the western side of the River Murray. The wetland is geomorphically categorised as a lentic (non-flowing) tributary (Pressey 1986) and is the flood plain of Reedy Creek before it reaches the River Murray, with a total surface area of 99 hectares. It is constrained by surrounding cliff and hills and to the northwest by a levee bank that separates it from farmed land, and it is separated from the river by a raised river bank. There are two wide connection channels with the river at the most down river end and approximately a third of the way up from there. At the time when the soil survey was conducted in October 2008 the wetland was dry and there was no surface water. Five sites were sampled and their locations are shown in Figure 29-1.

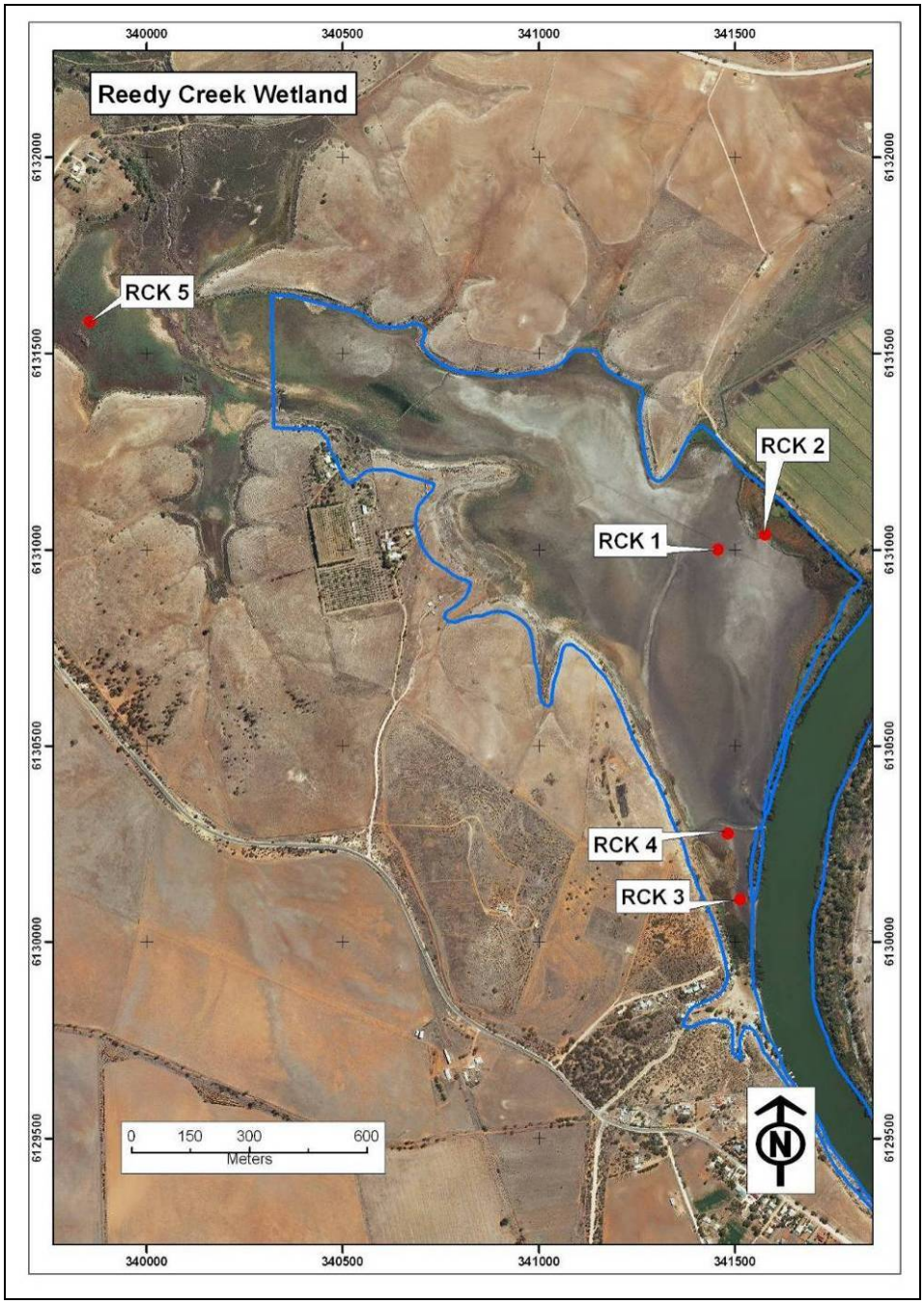


Figure 29-1. Reedy Creek Wetland and sample site locations.

29.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Five sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 29-1. The sites were paired and located in the middle low elevation area typical of most of the wetland (RCK1) and near the fringing area with cracks filled from windblown sand (RCK2). The other pair was located near the inlet (RCK3) and further away from the inlet (RCK4), both sites were typical of the low main wetland area near the river. A site was located above the wetland near the creek channel (RCK5). The site and soil profile descriptions are presented in Table 29-2 and Table 29-3.

Site RCK1 (Figure 29-2) occurred in a low area of the wetland to the north where the surface was bare. The soil consisted of black, extremely firm, clay columns, over black extremely firm clay with red mottles along root channels.

Site RCK2 (Figure 29-3) occurred on the edge of the wetland where *Typha latifolia* (Bulrush) vegetation was growing where the surface was cracking with salt accumulations. The soil consisted of grey, extremely firm, clay loam columns, over black, firm clay.

Site RCK3 (Figure 29-4) occurred in the inlet channel near the river where the surface was bare. The soil consisted of black, very firm, clay columns, over black, very firm, clay with orange mottles along pore surfaces.

Site RCK4 (Figure 29-5) occurred in a low area that was bare. The soil consisted of black, very firm, clay columns, over black, very firm, clay with orange mottles along pore surfaces.

Site RCK5 (Figure 29-6) occurred outside of the wetland boundary but was part of a long term monitoring area above the wetland. The soil consisted of brown grey, hard, clay, over black, very firm, clay.

Table 29-1. Soil identification, subtype and general location description of sites for Reedy Creek Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
RCK1	341458	6130999	Other soil (cracking clay)	Mid elevation, filled cracks of cracking clay soil area
RCK2	341578	6131037	Other soil (cracking clay)	Higher elevation, on the margins of the wetland where sandy encroaches and where *Phragmites australis* (Common Reed) and *Typha latifolia* (Bulrush) grow
RCK3	341514	6130108	Other soil (cracking clay)	Low elevation, filled cracks of cracking clay soil near inlet channel
RCK4	341483	6130276	Other soil (cracking clay)	Low to mid elevation, filled cracks of cracking clay soil area
RCK5	339856	6131580	Other soil (clay)	High elevation, clay soil in up creek area

Figure 29-2. Photographs of site RCK1, showing the site location where the surface was bare and crusted, and the soil profile of black clay.

Figure 29-3. Photograph of site RCK2, showing soil profile with cracks between columns that have filled with soil material.

Figure 29-4. Photographs of site RCK3, showing the site location with a bare soil surface, and the soil profile of black clay with reddish brown mottling.

Figure 29-5. Photographs of site RCK4, showing the landscape towards the adjacent cliffs, and the soil profile of black clay with mottling and the soil cracks that have been filled with soil material.

Figure 29-6. Photograph of site RCK5, showing the soil profile.

29.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data is presented in Table 29-4 and pH profiles are presented in Figure 29-7. For Site RCK1 pH data was not available but the values would be expected to be similar to Sites RCK2 and RCK4.

The pH_W data did not identify samples as sulfuric materials with a pH_W <4.

The pH_{INC} data did not identify samples that on incubation declined below the critical value of pH<4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation.

The pH_{OX} data for the surface layer of RCK2 identified samples that were below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming. All other profiles were above the critical value of pH_{OX} 2.5.

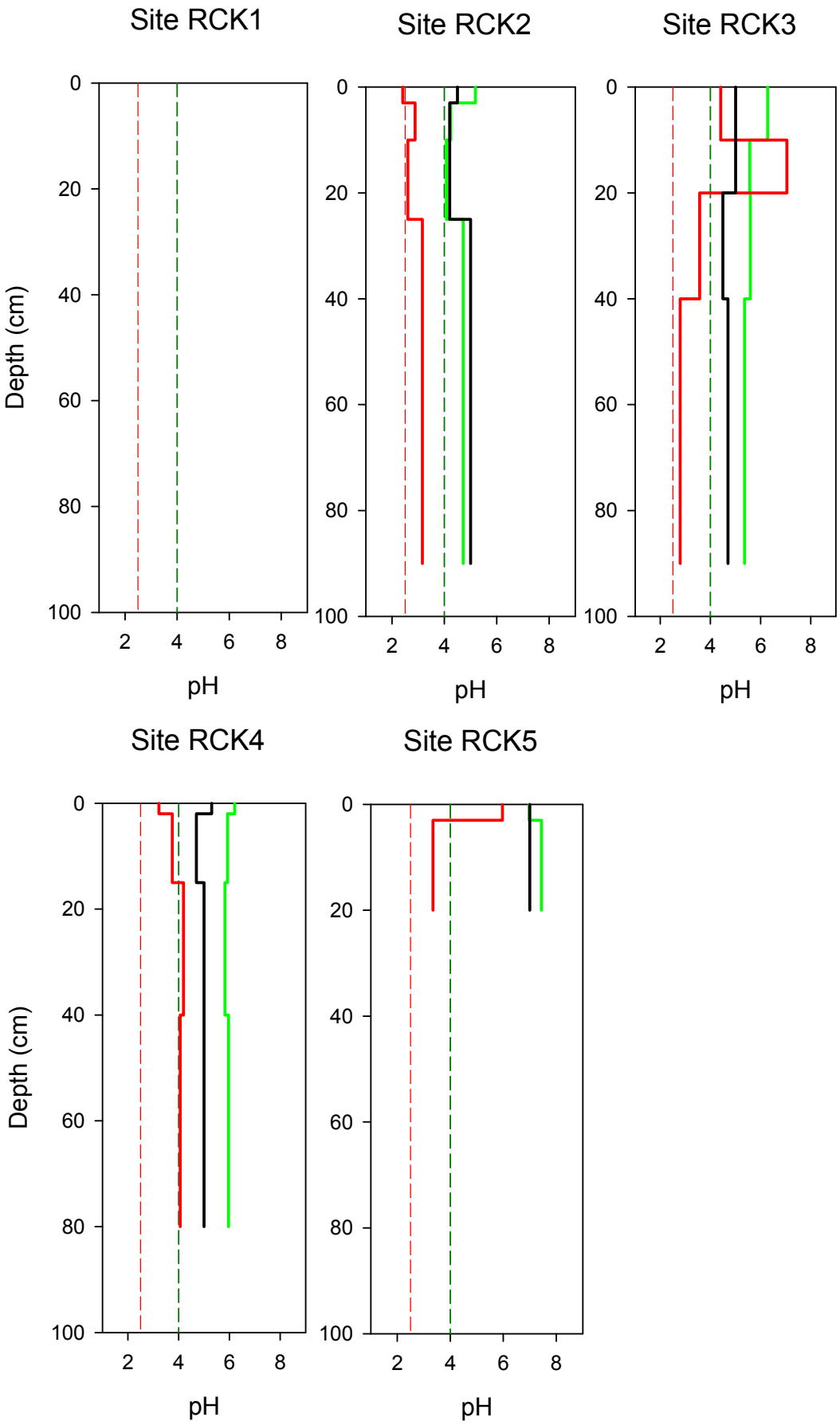


Figure 29-7. Depth profiles of soil pH for Reedy Creek Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data is provided in Table 29-4 and summarised in Figure 29-8.

Chromium reducible sulfur values ranged from below the limit of detection to 1.04 $\%S_{CR}$. Sulfidic materials were detected in the subsoil layers of profiles RCK3 and RCK5 whileall other samples were below the limit of detection.

Titratable actual acidity values ranged from 0 to 104.20 mole H^+/tonne. Concentrations were measured in all layers except for profile RCK5.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present in the subsurface and subsoil layers of profile RCK2 that were below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity values ranged from 0 to 4.27 $\%CaCO_3$, and were measured in all layers of profile RCK5.

Net acidity values ranged from -559 to 264 mole H^+/tonne. Moderate or low net acidity values occurred in all layers of profiles RCK1, RCK2, RCK3, and RCK4, and negative values occurred in the upper layers of profile RCK5 with a high value for the deeper subsoil layer.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 29-4 identified that surface layers for both profiles were above the trigger value of 100 mg/kg SO_4.

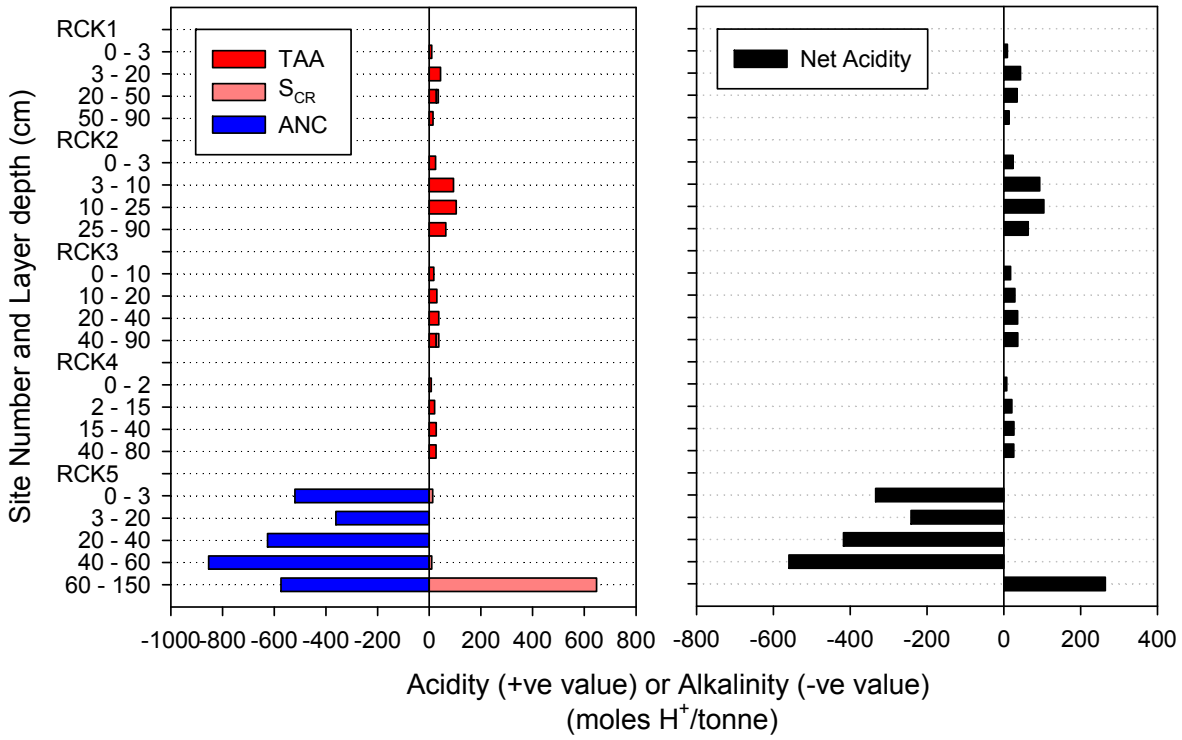


Figure 29-8. Acid base accounting depth profiles for Reedy Creek Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

29.4 DISCUSSION

Acid sulfate soil materials at Reedy Creek Wetland were identified in a few samples as hyposulfidic in profiles RCK3 and RCK5.

The cracking clay soil characteristics were generally uniform throughout the wetland and in many areas the cracks have filled with windblown sand or breakdown of the surface structure. The soils were acidic as shown by the moderate or low net acidity values due to titratable actual acidity and no acid neutralising capacity in the soil layers, and supported by the pH_W and pH_{INC} values < 5.0 that indicate a potential for the mobilisation of aluminium to occur. This would be of concern on the margins of the wetland where *Phragmites australis* (Common Reed) were growing with sand filling soil cracks and encroaching over the soils that have a low buffering capacity, but because of the higher elevations of these soils they were not likely to be inundated until the wetland water level was near full.

The potential hazards posed by acid sulfate soil materials at the Reedy Creek Wetland are:

- Acidification hazard: Acid sulfate soil materials were generally not identified except for one profile that was located outside the wetland boundary (RCK5), however the soils had acidic layers with pH <5. There is a low level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated a potential for monosulfidic materials to form in the surface layers of soils, although monosulfidic material was not observed. There is a high level of concern.
- Metal mobilisation: The low acidification hazard indicates that soil acidification potential was not likely to increase the solubility of metals. There is a low level of concern.

Summary of key findings for Reedy Creek Wetland:

Soil materials:	Soils were generally uniform throughout the wetland, with a black clay soil that had cracks which had been filled with surface aggregates or near the wetland margins with sand. Acid sulfate soil materials were identified in a few samples as hyposulfidic at a site outside the wetland boundary. Moderate or low acidity values occurred in most soil layers.
Acid sulfate soil identification:	• Other Soil (cracking clay) – that occurred throughout the wetland. Dominant (>50%) in extent.
Hazard assessment	• Acidification hazard – low level of concern • De-oxygenation hazard – high level of concern • Metal mobilisation hazard – low level of concern

Table 29-2. Site data for Reedy Creek Wetland

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
RCK1	17-Oct-08	341458	6130999	Other soil (cracking clay)	not reached	crumbling	Bare	low, up river,
RCK2	17-Oct-08	341578	6131037	Other soil (cracking clay)	65	cracking	*Typha latifolia* (Bulrush)	mid, edge, near low channel area, salts on surface
RCK3	17-Oct-08	341514	6130108	Other soil (cracking clay)	45	crumbling	Bare	low, mid way of channel to inlet (100m away),
RCK4	17-Oct-08	341483	6130276	Other soil (cracking clay)	not reached	crumbling	Bare	low, up channel from inlet
RCK5	17-Oct-08	339856	6131580	Other soil (clay)	80	crumbling	isolated weeds	high, salts on surface

Table 29-3. Soil description data for Reedy Creek Wetland

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
RCK1.1	0	3	soil pit	2.5Y 4/1	clay	dry	3	5YR 5/8	MPH	angular blocky	friable	
RCK1.2	3	20	soil pit	2.5Y 2.5/1	clay	moist	5	5YR 5/8	in matrix adjacent to pores	columnar	extremely firm	
RCK1.3	20	50	soil pit	2.5Y 2.5/1	clay	moist	20	5YR 5/8	in matrix adjacent to pores	massive	extremely firm	
RCK1.4	50	90	push tube	2.5Y 2.5/1	clay	moist	0			massive	extremely firm	
RCK2.1	0	3	soil pit	2.5Y 5/2	clay loam	dry	0			columnar	hard	
RCK2.2	3	10	soil pit	2.5Y 4/2	clay loam	moist	5	7.5YR 5/8	in matrix adjacent to pores	columnar	extremely firm	salts on sides of columns, plant material at base of layer
RCK2.3	10	25	soil pit	2.5Y 4/1	clay	moist	10	7.5YR 5/8	in matrix adjacent to pores	massive	firm	
RCK2.4	25	90	soil pit	2.5Y 2.5/1	clay	moist	3	7.5YR 5/8	in matrix adjacent to pores	massive	firm	

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
RCK3.1	0	10	soil pit	2.5Y 2.5/1	clay	moist	0			subangular blocky	friable	
RCK3.2	10	20	soil pit	2.5Y 2.5/1	clay	moist	3	5YR 5/8	in matrix adjacent to pores	columnar	very firm	contains 10% plant material
RCK3.3	20	40	soil pit	2.5Y 2.5/1	clay	moist	10	5YR 5/8	in matrix adjacent to pores	subangular blocky	very firm	contains 10% plant material
RCK3.4	40	90	push tube	5Y 4/2	clay	moist	10	5YR 5/8	in matrix adjacent to pores	massive	very firm	contains 5% plant material
RCK4.1	0	2	soil pit	2.5Y 5/2	peaty clay	dry	0			angular blocky	friable	
RCK4.2	2	15	soil pit	2.5Y 2.5/1	clay	moist	3	5YR 5/8	in matrix adjacent to pores	columnar	very firm	
RCK4.3	15	40	soil pit	2.5Y 2.5/1	clay	moist	10	5YR 5/8	in matrix along ped faces	columnar	very firm	
RCK4.4	40	80	push tube	2.5Y 2.5/1	clay	moist	20	5YR 5/8	in matrix along ped faces	massive	very firm	
RCK4.5	80	100	push tube	2.5Y 2.5/1	clay	moist	0			massive	very firm	
RCK5.1	0	3	soil pit	10YR 5/2	clay	dry	0			cloddy	extremely hard	
RCK5.2	3	20	soil pit	10YR 4/3	clay	dry	3	5YR 5/8	in matrix	subangular blocky	hard	
RCK5.3	20	40	soil pit	10YR 4/2	clay	dry	3	5YR 5/8	in matrix	subangular blocky	hard	
RCK5.4	40	60	push tube	10YR 4/1	clay	moist	0			massive	very firm	
RCK5.5	60	150	push tube	10YR 2/1	clay	moist	0			massive	very firm	

Table 29-4. Laboratory data for acid sulfate soil assessment of Reedy Creek Wetland.

(red printed values indicates data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
RCK1.1	0 - 3	Fine	-	-	-	-	5546	5.76	9.49	< 0.01	0.00	9	other acidic
RCK1.2	3 - 20	Fine	-	-	-	-	1519	4.87	43.89	< 0.01	0.00	44	other acidic
RCK1.3	20 - 50	Fine	-	-	-	-	1039	5.09	27.24	< 0.01	0.00	35	other acidic
RCK1.4	50 - 90	Fine	-	-	-	-	457	5.51	14.15	< 0.01	0.00	14	other acidic
RCK2.1	0 - 3	Medium	1,920	5.19	2.41	4.50	2637	4.79	24.43	< 0.01	0.00	24	other acidic
RCK2.2	3 - 10	Medium	1,670	4.24	2.88	4.20	3125	4.00	93.97	< 0.01	0.00	94	other acidic
RCK2.3	10 - 25	Fine	2,060	4.08	2.60	4.20	4542	3.95	104.20	< 0.01	0.00	104	other acidic
RCK2.4	25 - 90	Fine	1,310	4.72	3.16	5.00	2170	4.53	63.67	< 0.01	0.00	64	other acidic
RCK3.1	0 - 10	Fine	1,650	6.28	4.41	5.00	1105	5.22	17.79	< 0.01	0.00	18	other acidic
RCK3.2	10 - 20	Fine	740	5.57	7.05	5.00	548	4.77	29.17	< 0.01	0.00	29	other acidic
RCK3.3	20 - 40	Fine	390	5.59	3.57	4.50	265	4.53	36.46	< 0.01	0.00	36	other acidic
RCK3.4	40 - 90	Fine	640	5.36	2.79	4.70	412	4.86	26.93	0.02	0.00	37	hyposulfidic (S_{CR}<0.10%)
RCK4.1	0 - 2	Fine	4,120	6.21	3.22	5.30	1415	5.97	7.51	< 0.01	0.00	8	other acidic
RCK4.2	2 - 15	Fine	1,140	5.92	3.75	4.70	598	5.27	21.12	< 0.01	0.00	21	other acidic
RCK4.3	15 - 40	Fine	470	5.82	4.19	5.00	299	4.97	26.71	< 0.01	0.00	27	other acidic
RCK4.4	40 - 80	Fine	230	5.96	4.06	5.00	232	4.94	26.30	< 0.01	0.00	26	other acidic
RCK4.5	80 - 100	not sampled	-	-	-	-	-	-	-	-	-	-	-
RCK5.1	0 - 3	Fine	10,,660	6.98	5.97	7.00	8831	8.01	0.00	0.02	2.60	-334	hyposulfidic (S_{CR}<0.10%)
RCK5.2	3 - 20	Fine	8,030	7.44	3.35	7.00	1386	7.78	0.00	< 0.01	1.81	-241	other soil material
RCK5.3	20 - 40	Fine	-	-	-	-	1775	8.24	0.00	< 0.01	3.13	-417	other acidic
RCK5.4	40 - 60	Fine	-	-	-	-	2334	8.18	0.00	0.02	4.27	-559	hyposulfidic (S_{CR}<0.10%)
RCK5.5	60 - 150	Fine	-	-	-	-	2840	7.85	0.00	1.04	2.87	264	hyposulfidic (S_{CR}>0.10%)

30 BASEBY LEVEE WETLAND (WETLAND ID. 12714)

30.1 LOCATION AND SETTING DESCRIPTION

Baseby Levee Wetland (Wetland ID. 12714) is situated on the northern side of the River Murray, down river from the town of Mannum. The wetland is geomorphically categorised as a channel-margin swale (Pressey 1986) and is elongated in shape following the curve of the river, with a total surface area of 7 hectares. The wetland is bounded to the north by the levee bank and to the south by a river bank with *Salix* spp. (Willow trees) growing on. There were a few narrow water connection channels with the river however it is likely that at normal pool level (0.75 m AHD) that the river would overtop the river bank along the majority of the wetland. At the time when the soil survey was conducted in October 2008, the wetland was dry and there was no surface water. Grasses were growing in the wetland and there were isolated areas of *Eucalyptus camaldulensis* (River Red Gum) seedlings. Three sites were described and sampled and their locations are shown in Figure 30-1.

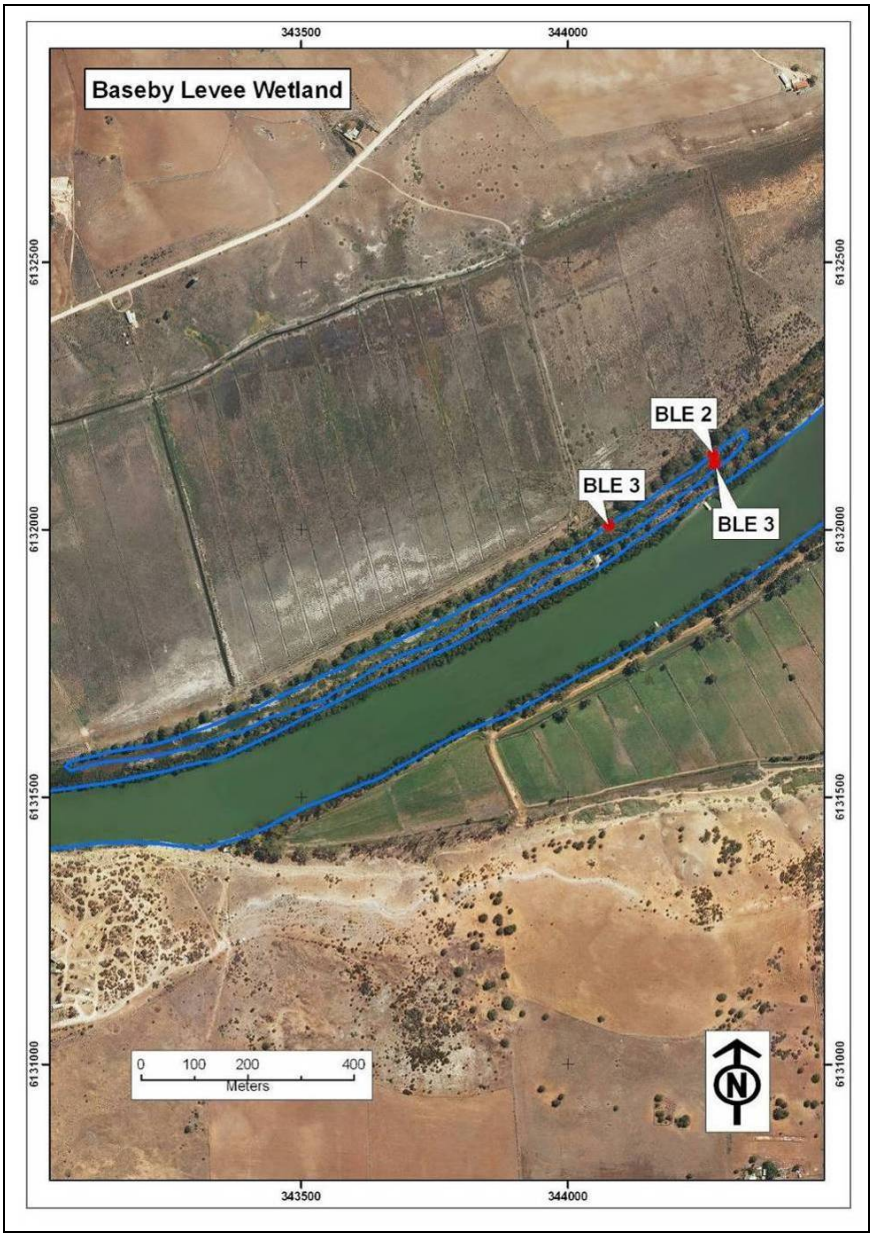


Figure 30-1. Baseby Levee Wetland and sample site locations.

30.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Three sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 30-1. Sites were located to characterise the main surface features and landscape positions in the wetland. The site and soil profile descriptions are presented in Table 30-2 and Table 30-3.

Site BLE1 (Figure 30-2) occurred on the river side of the wetland where grasses, sedges and trees were growing. The soil consisted of grey, extremely hard, sandy clay loam with orange mottles along pore channels, over clay that was too dry and hard to dig.

Site BLE2 (Figure 30-3) occurred in a low elevation area of the wetland that was not overgrown. The soil consisted of grey, hard, sandy clay loam with sand lenses, over a dark grey, extremely firm, clay loam.

Site BLE3 (Figure 30-4**)** occurred in a low area of the wetland near an inlet channel to the river where isolated Eucalyptus trees were growing. The soil consisted of dark grey, extremely hard, sandy clay loam, over dark grey, extremely firm, clay loam with orange mottles along pore channels.

Table 30-1. Soil identification, subtype and general location description of sites for Baseby Levee Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
BLE1	344277	6132122	Other acidic soil	Mid elevation, riverside of wetland amongst trees
BLE2	344273	6132140	Hyposulfidic cracking clay soil	Low elevation, mid channel
BLE3	344078	6132008	Other acidic soil (cracking clay)	Low elevation, 100m from inlet

Figure 30-2. Photographs of site BLE1, showing the site landscape on the river side of the wetland, and the soil of hard clay.

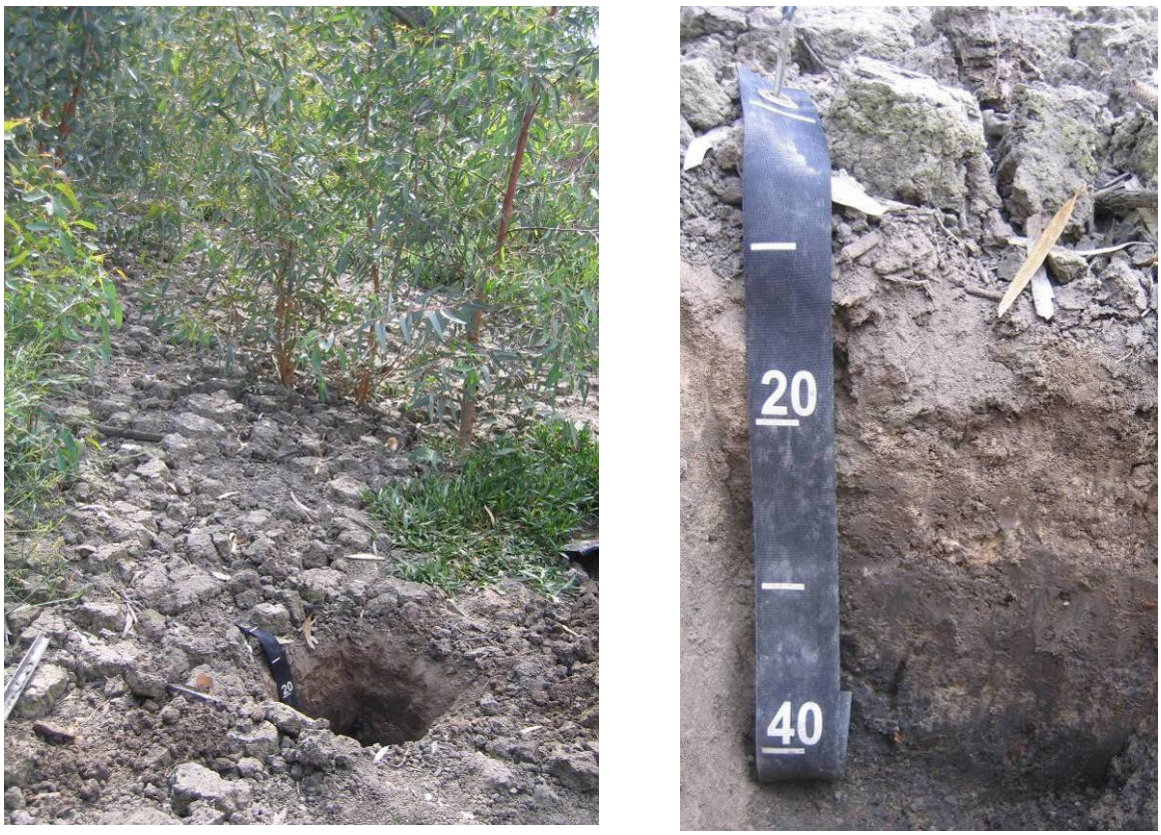


Figure 30-3. Photograph of the soil profile BLE2, showing the site location where the surface was cracking, and the soil consisted of hard sandy clay loam over clay with sand lenses.

Figure 30-4. Photograph of the soil profile BLE3, showing the site landscape near the inlet channel where river red gum saplings were growing, and the soil of hard sandy clay loam over clay loam.

30.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 30-4 and pH profiles are presented in Figure 30-5.

The pH_W data did not identify samples as sulfuric materials with a pH_W <4.

The pH_{INC} data did not identify samples that on incubation declined below the critical value of pH<4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation.

The pH_{OX} data for all profiles identified samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

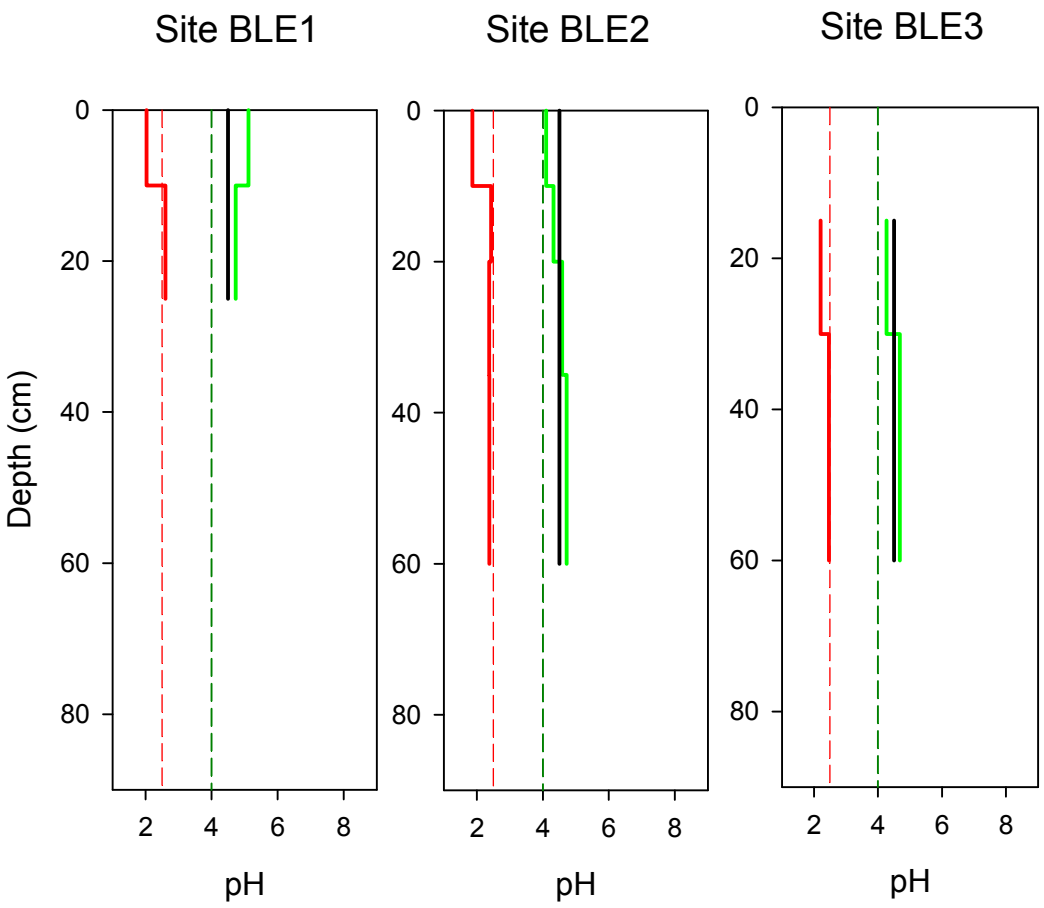


Figure 30-5. Depth profiles of soil pH for Baseby Levee Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data are provided in Table 30-4 and summarised in Figure 30-6.

Chromium reducible sulfur values ranged from below the detection limit to 0.03 %S_{CR}. Sulfidic materials were detected in the surface layers of profiles BLE1 and BLE2.

Titratable actual acidity values ranged from 9.32 to 166.62 mole H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present as some samples were below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity was not measured in any of the samples, as all samples had a pH_{KCl} of <6.5.

Net acidity values ranged from 9 to 174 mole H^+/tonne. Samples were low for BLE1 and all but the surface layer of profile BLE2, which was moderate. The surface layer of profile BLE3 was high but had a declining value with depth.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 30-4 identified that surface layers in all profiles were above the critical trigger value of 100 mg/kg SO_4.

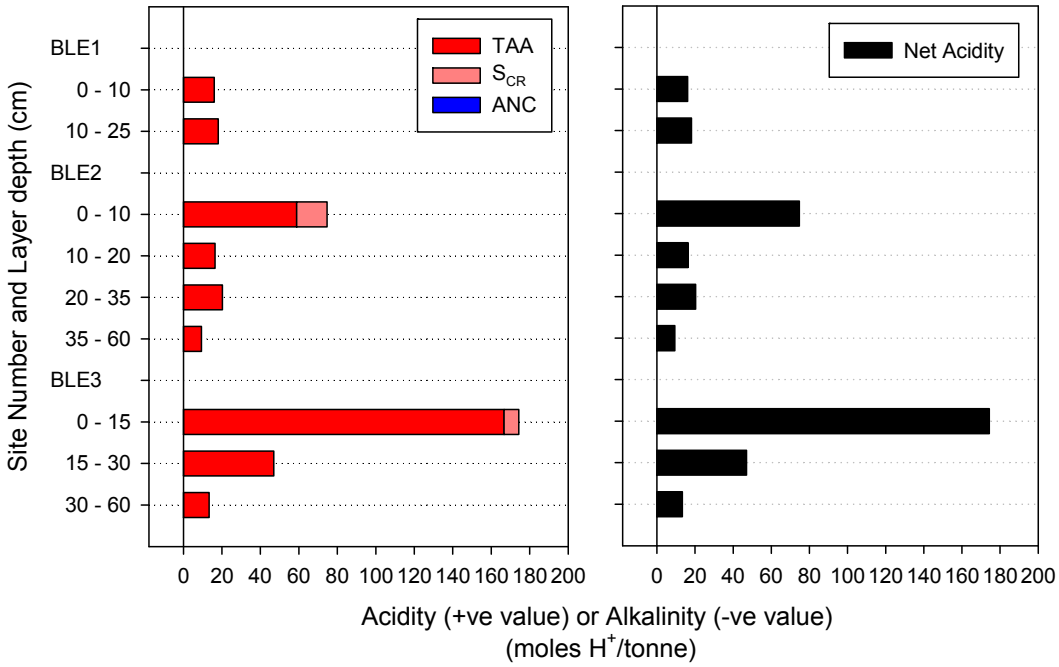


Figure 30-6. Acid base accounting depth profiles for Baseby Levee Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

30.4 DISCUSSION

Acid sulfate soil materials at Baseby Levee Wetland were identified as hyposulfidic in one surface layer of profile BLE2, all other samples were characterised as other acidic soil materials. The acid sulfate soil subtype classes identified were Hyposulfidic Cracking Clay Soil and Other Acidic Soil (cracking clay).

The soils were hard and clayey textured, with soil cracks forming columnar structures in the low elevation main areas of the wetland.

Monosulfidic material was not observed but water soluble sulfate data identified that surface layers for the profiles throughout the wetland were in excess of the 100 mg/kg trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials at Baseby Levee Wetland are:

- Acidification hazard: The data identified low, moderate or high net acidity values throughout the sampled profiles, and pH_{OX} data identified most samples with values that were potential acidification hazard due to oxidation. There is a medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there was potential for monosulfidic materials to form in the surface layers of soils on re-flooding, although the wetland was dry at the time of sampling and monosulfidic material was not observed. There is a medium level of concern.
- Metal mobilisation: The medium acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

Summary of key findings for Baseby Levee Wetland:

Soil materials:	Hyposulfidic soil materials were identified in a surface soil layer. The soils throughout were clay textured layers, hard and formed columnar structures and cracking surfaces in the main wetland area. Samples had low, moderate or high net acidity values and pH_{OX} data identified surface layer samples with values that indicated potential acidification due to oxidation.
Acid sulfate soil identification:	• Hyposulfidic Cracking Clay Soil – that occurred throughout the wetland at lower elevation. Dominant (>50%) in extent. • Other Acidic Soil – that occurred on the wetland margins. Minor (<25%) in extent.
Hazard assessment	• Acidification hazard – medium level of concern • De-oxygenation hazard – medium level of concern • Metal mobilisation hazard – medium level of concern

Table 30-2. Site data for Baseby Levee Wetland.

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
BLE1	17-Oct-08	344277	6132122	Other acidic soil	Not reached	plant material	grasses, gums	Mid elevation, riverside of wetland amongst trees
BLE2	17-Oct-08	344273	6132140	Hyposulfidic cracking clay soil	Not reached	cracking, cloddy	gums	Low elevation, mid channel
BLE3	17-Oct-08	344078	6132008	Other acidic soil (cracking clay)	Not reached	cracking	isolated gums	Low elevation, 100m from inlet

Table 30-3. Soil description data for Baseby Levee Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
BLE1.1	0	10	soil pit	2.5Y 5/2	sand	dry	0			single grain	loose	
BLE1.2	10	25	soil pit	2.5Y 4/2	sandy clay loam	dry	20	7.5YR 5/8	in matrix adjacent to pores	columnar	extremely hard	too hard to dig below this layer
BLE2.1	0	10	soil pit	2.5Y 4/2	peaty sandy clay loam	dry	0			subangular blocky	very firm	
BLE2.2	10	20	soil pit	2.5Y 4/1	sandy loam	dry	0			single grain	hard	
BLE2.3	20	35	soil pit	2.5Y 3/1	sandy clay loam	dry	10	7.5YR 5/8	in matrix	massive	hard	
BLE2.4	35	60	soil pit	2.5Y 3/1	clay loam	moist	15	7.5YR 5/8	in matrix	massive	extremely firm	too hard to dig below this layer
BLE3.1	0	15	soil pit	2.5Y 5/2	peaty sandy clay loam	dry	0			subangular blocky	extremely hard	
BLE3.2	15	30	soil pit	2.5Y 4/1	sandy clay loam	dry	20	7.5YR 5/8	in matrix	massive	extremely hard	
BLE3.3	30	60	soil pit	2.5Y 3/1	clay loam	moist	25	7.5YR 5/8	in matrix adjacent to pores	massive	extremely firm	too hard to dig below this layer

Table 30-4. Laboratory data for acid sulfate soil assessment of Baseby Levee Wetland.

(red printed values indicate data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
BLE1.1	0 - 10	coarse	180	5.12	2.03	4.50	738	5.40	16.02	< 0.01	-	16	other acidic incubation
BLE1.2	10 - 25	medium	37,300	4.73	2.60	4.50	1693	4.57	18.13	< 0.01	-	18	other acidic
BLE2.1	0 - 10	medium	2,120	4.10	1.86	4.50	6292	4.09	58.90	0.03	-	75	hyposulfidic (S_{CR}<0.10%)
BLE2.2	10 - 20	medium	950	4.32	2.43	4.50	579	4.53	16.42	< 0.01	-	16	other acidic
BLE2.3	20 - 35	medium	950	4.58	2.37	4.50	510	4.50	20.26	< 0.01	-	20	other acidic
BLE2.4	35 - 60	medium	470	4.72	2.38	4.50	323	4.68	9.32	< 0.01	-	9	other acidic
BLE3.1	0 - 15	medium	-	-	-	-	7461	3.57	166.62	0.01	-	174	-
BLE3.2	15 - 30	medium	670	4.27	2.21	4.50	675	4.16	46.95	< 0.01	-	47	other acidic
BLE3.3	30 - 60	medium	600	4.68	2.47	4.50	418	4.48	13.35	< 0.01	-	13	other acidic

31 COWIRRA LEVEE / LANDING WETLAND (WETLAND ID. 12020)

No field survey or assessment conducted for this wetland

32 MANNUM SWAMPS WETLAND (WETLAND ID. 12218, 12248, 12249)

32.1 LOCATION AND SETTING DESCRIPTION

Mannum Swamps Wetland (Wetland ID. 12218, 12248, 12249) is situated on the north-western side of the River Murray immediately up river from the town of Mannum. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is somewhat elongated in shape, with a total surface area of 198 hectares. It is bounded to the northwest by hill slopes and to the southeast by a raised river bank that has been colonised by *Salix* spp. (Willow trees) in significant portions. The wetland is open to the river at many locations and there are nine wide water connection channels. The wetland occurs in three main sections, the up-river section, the main mid river and down-river section. The main down river section is divided into 4 subsections by causeways. At the time when the soil survey was conducted in October 2008 the wetland was dry except for isolated areas of the up-river section where water was on the surface, probably sourced from ground water. Nine sites were sampled and their locations are shown in Figure 32-1.

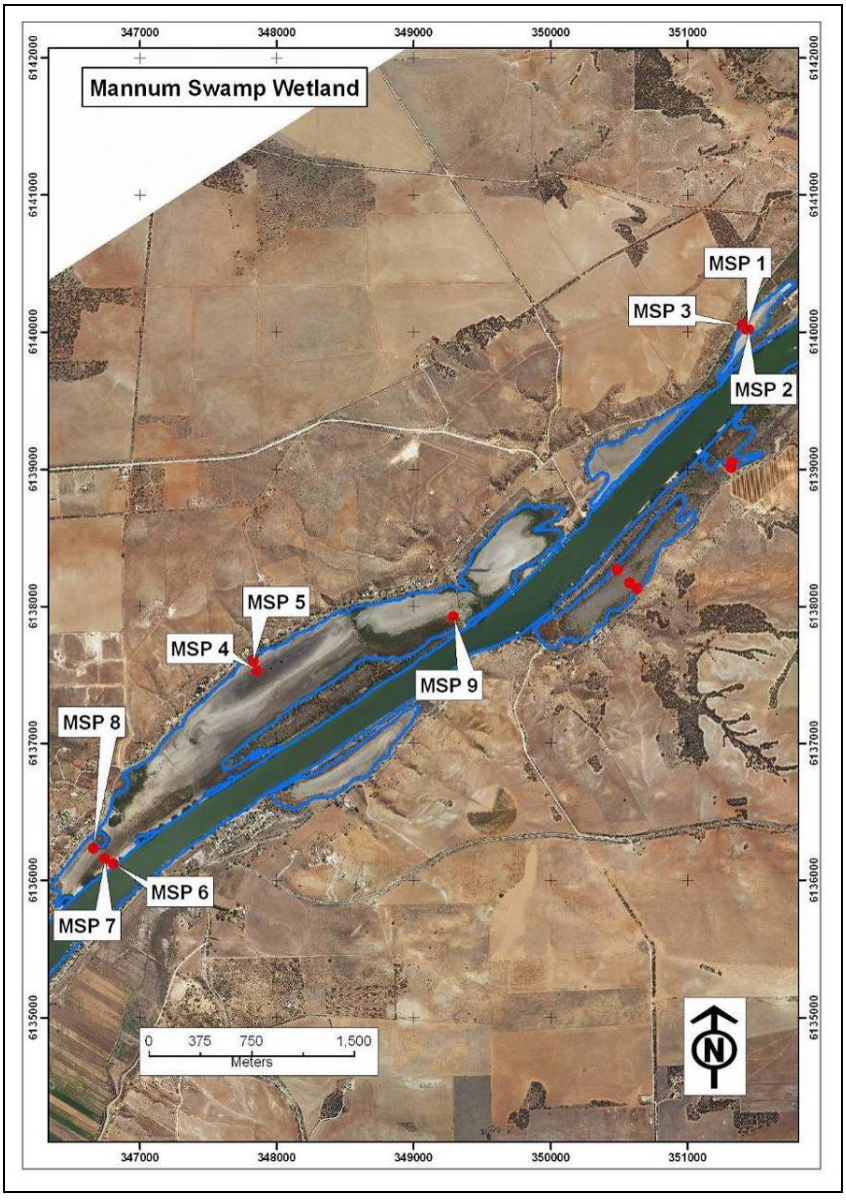


Figure 32-1. Mannum Swamps Wetland and sample site locations.

32.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Nine sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 32-1. The up river section transect included the inundated low area (MSP2), the bare soft area adjacent to the water (MSP1) and the fringing margin (MSP3). For the mid river section, sites characterised the dominant wetland area that was bare (MSP4), the adjacent high elevation fringing area (MSP5) and on a raised area between the wetland and the river channel, potentially a floodplain type area. The third transect at the down river end of the wetland was from the river bank (MSP7), the low elevation area (MSP8) and the fringing high elevation area (MSP9). The site and soil profile descriptions are presented in Table 32-2 and Table 32-3.

Up River Section

Site MSP1 (Figure 32-2) occurred in a bare area close to surface water and the surface was very soft andwet. The soil consisted of black, firm, clay, with plant material at depth.

Site MSP2 (Figure 32-3) occurred below shallow water, and the soil consisted of black, firm, clay.

Site MSP3 (Figure 32-4) occurred in *Phragmites australis* (Common Reed) along the margins of the wetland, and the soil consisted of black, very firm, clay.

Mid River Section

Site MSP4 (Figure 32-5) occurred in a bare cracking clay area. The soil consisted of dark grey, extremely hard, clay columns with salts on the column faces, over a black, friable, clayey peat, over olive, firm, clay.

Site MSP5 (Figure 32-6) occurred where *Phragmites australis* (Common Reed) grew at the higher elevation on the margins of the wetland. The soil consisted of grey, very firm, clay.

Site MSP9 (Figure 32-10) occurred where many weeds and river gums grew on a rise between the river and wetland. The soil consisted of black, extremely hard, clay columns with orange mottles.

Down River Section

Site MSP6 (Figure 32-7) occurred next to the river. The soil consisted of black, very firm, clay, over olive, very soft, peat.

Site MSP7 (Figure 32-8) occurred on a raised area between the river and lower areas of the wetland. The soil consisted of black, hard, clay with red mottles in the soil matrix, over a light grey, firm, sand loam.

Site MSP8 (Figure 32-9) occurred in a low area behind the raised river bank where the area was bare with a cracking surface. The soil consisted of black, rigid, clay columns with red mottles in the soil matrix.

Table 32-1. Soil identification, subtype and general location description of sites for Mannum Swamps Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
MSP1	351433	6140020	Hyposulfidic soil	Low to mid elevation, with no vegetation
MSP2	351447	6140014	Hyposulfidic soil	Low elevation, where there was surface water from a ground water seep
MSP3	351402	6140051	Hyposulfidic soil	High elevation, on the margins where *Phragmites australis* (Common Reed) grow in mid river section
MSP4	347855	6137530	Sulfuric cracking clay soil	Low to mid elevation, cracking clay soil areas in the middle section
MSP5	347830	6137599	Sulfuric soil	Higher elevation, on the margins where *Phragmites australis* (Common Reed) grow in the middle section
MSP6	346807	6136121	Hypersulfidic soil	Low elevation, on shoreline near river in the down river section
MSP7	346744	6136155	Other soil (clay)	On raised area between river and wetland in down-river section
MSP8	346662	6136234	Other soil (cracking clay)	Low elevation, cracking clay area where no vegetation grows in down-river section
MSP9	349292	6137920	Other soil (cracking clay)	On raised area between river and wetland in the middle section

Figure 32-2. Photographs of site MSP1, showing the site location where the surface was a soft clay, and the soil profile with the water table at approximately 15 cm.

Figure 32-3. Photograph of site MSP2, showing surface water probably from a ground water seep where the site was located.

Figure 32-4. Photographs of site MSP3, showing the wetland margin with *Phragmites australis* (Common Reed), and the soil profile of clay with the water table at 30 cm.

Figure 32-5. Photographs of site MSP4, showing the landscape towards the hill slope with a cracking clay surface, and the soil profile with distinct clay columns that has cracks extending down to 30 cm and deeper in some areas.

Figure 32-6. Photograph of site MSP5, showing the soil profile upper clay soil layers and the cracking clay surface.

Figure 32-7. Photographs of site MSP6, showing the landscape of the river bank down to the river with salt crusts on the surface, and the soil profile of clay with some mottling at depth near the water table.

Figure 32-8. Photograph of site MSP7, showing the soil profile of hard clay with a strongly aggregated structure.

Figure 32-9. Photograph of site MSP8 showing the soil profile of hard dry clay with a columnar structure.

Figure 32-10. Photograph of site MSP9, showing the soil profile of a hard dry clay structured soil with vegetation growing in the cracks that have filled with soil material.

32.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 32-4 and pH profiles are presented in Figure 32-11.

The pH_W data for the subsurface layers of profiles MSP4 and MSP5 identified samples as sulfuric materials with a pH_W <4. These soils were characteristic of a large area of the middle section area of the wetland.

The pH_{INC} data for the subsoil layers of profiles MSP4, MSP5, MSP6 and MSP8 identified samples that on incubation declined below the critical value of pH <4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation.

The pH_{OX} data for the surface and subsoil layers of profiles MSP4, MSP5 and MSP6 identified samples that were below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming..

Acid Base Accounting

The acid base accounting data is provided in Table 32-4 and summarised in Figure 32-12.

Chromium reducible sulfur values ranged from below detection limit of <0.01 to 0.18%S_{CR}. Sulfidic materials were detected in all layers for profiles MSP1, MSP2, MSP3, MSP4, MSP5, and in the lower subsoil layer of profiles MSP6 and MSP8.

Titratable actual acidity values ranged from 0 to 107.35 mole H^+/tonne. Concentrations were measured in all layers of profiles MSP4, MSP5, MSP6, MSP7, MSP8, and MSP9 where values tended to increase with depth down the profile.

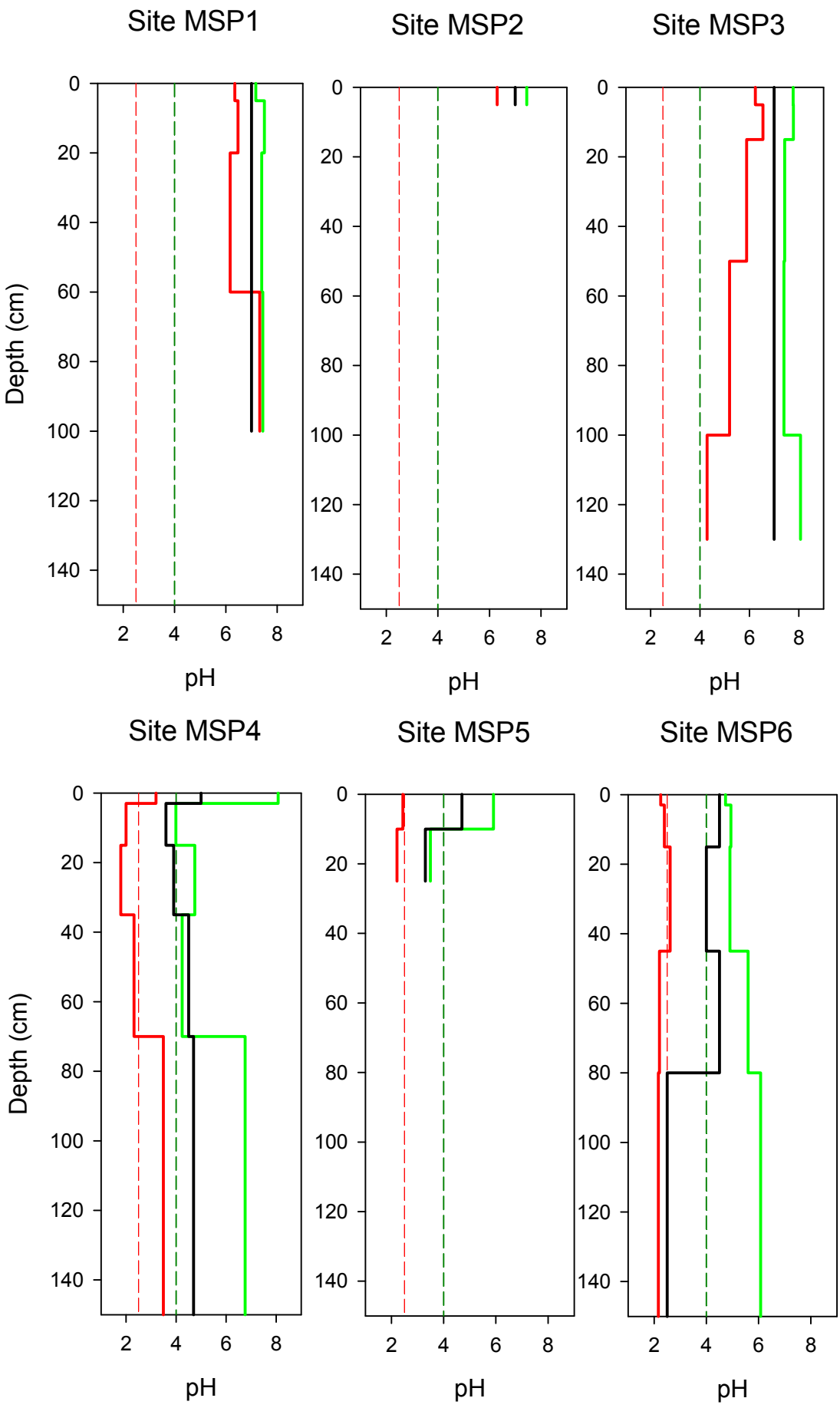
Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present in the subsurface layer of profiles MSP4 and MSP5 that were below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity values ranged from 0 to 10.34 %$CaCO_3$, and were measured in all layers for profiles MSP1, MSP2, and MSP3. These soils were located in the up river section of the wetland that had surface water probably from a ground water seep. For all other sites that occurred in the other sections of the wetland, acid neutralising capacity was not measured.

Net acidity values ranged from -1331 to 134 mole H^+/tonne. Negative net acidity values occurred in all layers of profiles MSP1, MSP2, and MSP3, and low, moderate or high values occurred in all other profile layers, the net acidity values tended to increase in value with depth.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 32-4 identified that surface layers for both profiles were above the trigger value of 100 mg/kg SO_4.


Site MSP1
Site MSP2
Site MSP3
Site MSP4
Site MSP5
Site MSP6
Depth (cm)
0
20
40
60
80
100
120
140
2
4
6
8
pH

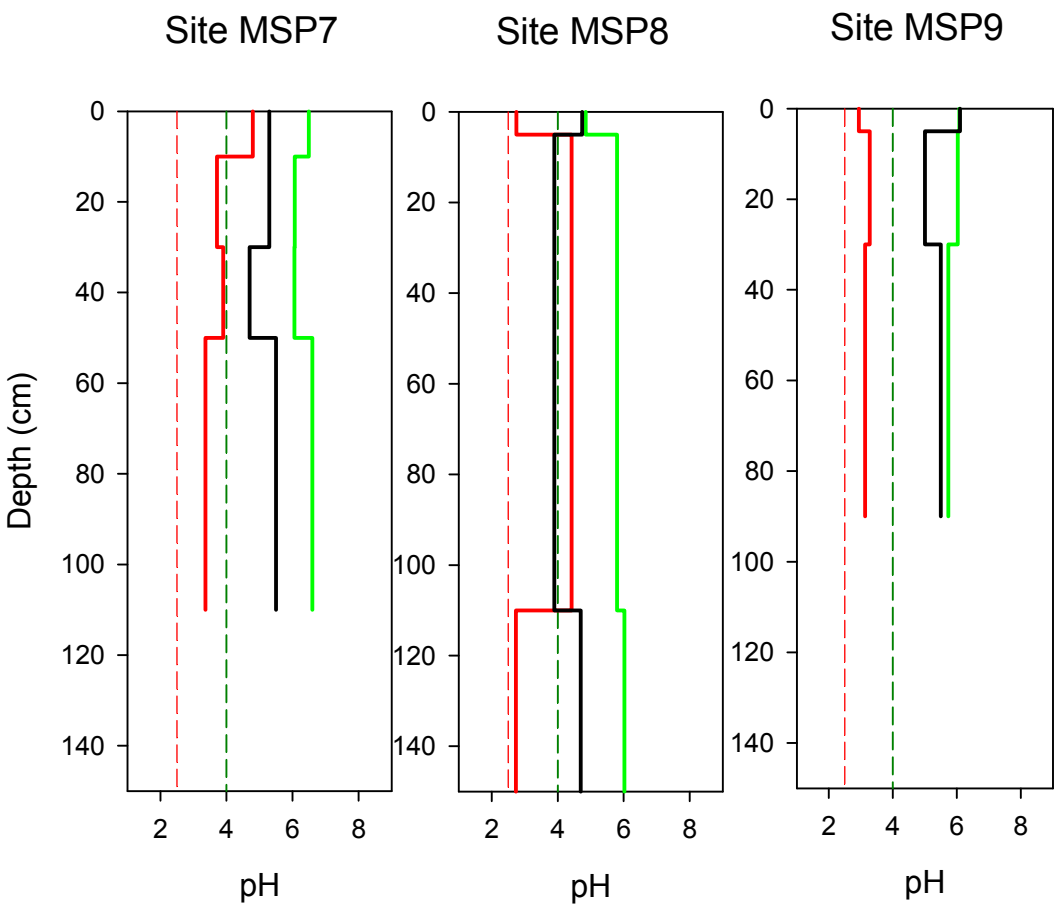


Figure 32-11. Depth profiles of soil pH for Mannum Swamps Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

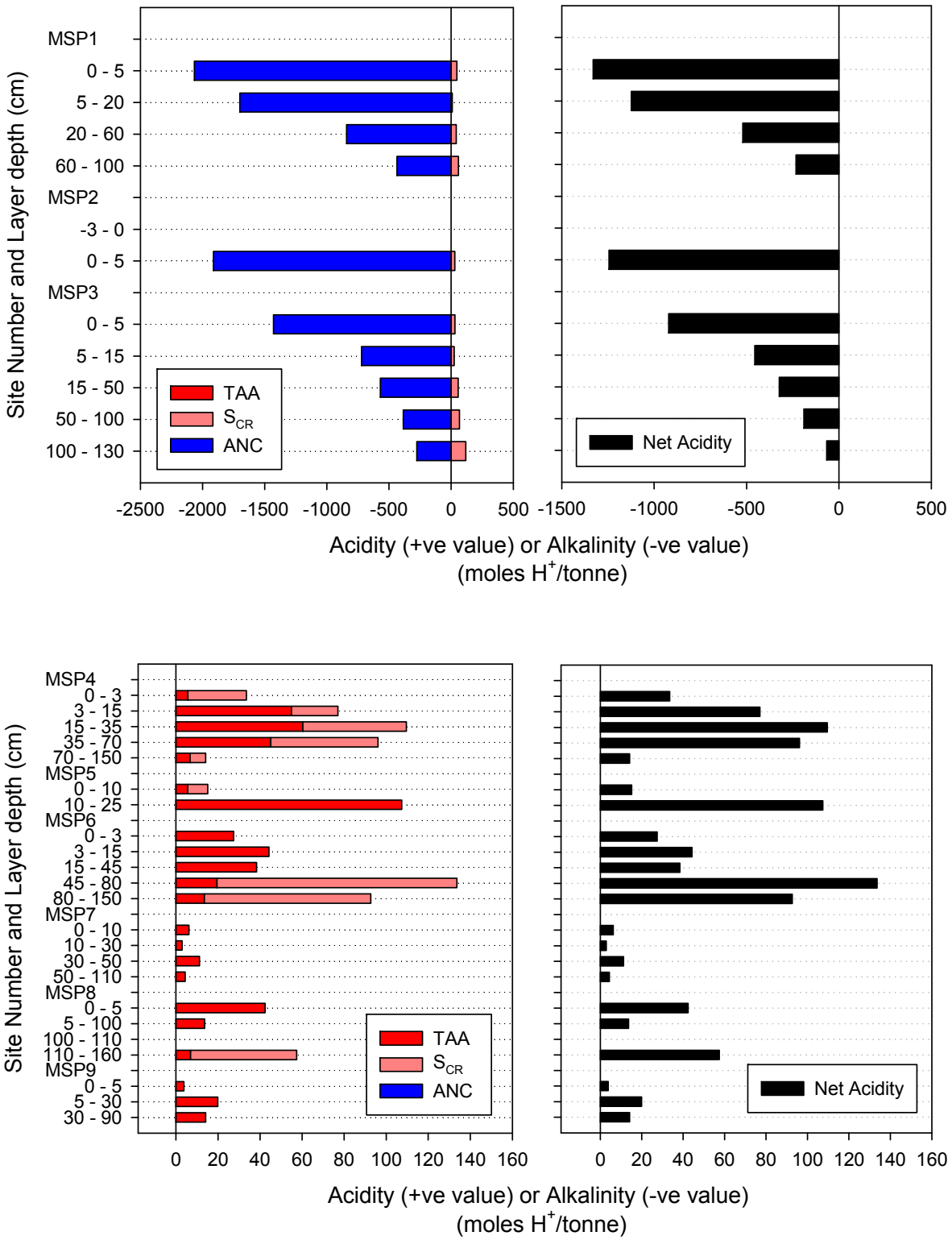


Figure 32-12. Acid base accounting depth profiles for Mannum Swamps Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

32.4 DISCUSSION

Acid sulfate soil materials at Mannum Swamps Wetland were identified as sulfuric in the near surface layer for the soils that occurred in the middle section of the wetland. Hypersulfidic or hyposulfidic soil materials were identified In other areas.

The soils were generally clayey forming columns with deep cracks that in some areas were filled with aggregates or windblown sand if near the margins.

Mannum Swamps Wetland stretches over a long distance adjacent to the river and was separated into three main sections (up-river, mid-river, and down-river) that have different types of acid sulfate soils.

The up-river section was not directly connected to the river. There was surface water in isolated areas of the wetland that were probably due to ground water discharge. The surface and subsoil layers were hyposulfidic and the net acidity was negative due to the acid neutralising capacity of the soil (possibly influenced by ground water); there were no soils of concern in this section.

The mid-river section has a number of connections with the river. Sulfuric soil materials occurred in the upper layers, with hypersulfidic and hyposulfidic soil materials in the subsoil. Sulfuric cracking clay soils occurred throughout the wetland and on the margins they were classified as sulfuric soils. Net acidity values were low, moderate or high, and tended to increase in value with depth. The wide connection areas between the wetland and river will result in these low elevation areas being one of the first locations to be in contact with water when water levels rise and there is a high level of concern for acidification hazard occurring. A raised bank separates the wetland from the river that has hyposulfidic soil material in the subsoil; this will have less of an impact on the acidification.

The down-river section has a connection with the river. No acid sulfate soil materials were identified in the surface or subsoil layers (except for a very deep hyposulfidic layer in profile MSP8), and the net acidity values were low or moderate.

The potential hazards posed by acid sulfate soil materials at the Mannum Swamps Wetland are:

- Acidification hazard: There is a low level of concern for up river section, high level of concern for mid river section and low to medium level of concern for down river section.
- De-oxygenation hazard: The water soluble sulfate data indicates a potential for monosulfidic materials to form in the surface layers of soils, monosulfidic material was not observed. There is a high level of concern.
- Metal mobilisation: There is a low level of concern for up river section, high level of concern for mid river section and low to medium level of concern for down river section.

Summary of key findings for Mannum Swamps Wetland:

Soil materials:	The soils were generally clayey throughout the wetland with columnar structures and deep cracks that in some areas were filled with surface aggregates or windblown sand near the hill side margins of the wetland. For the up-river section of the wetland acid sulfate soils material was not identified and the soils have a negative net acidity due to the high acid neutralising capacity in the soil layers. For the mid-river section of the wetland the upper soil layers were sulfuric with a low or moderate net acidity. Subsoil layers were hypersulfidic with a moderate or high net acidity. For the down-river section of the wetland the surface and subsoil layers, acid sulfate soil materials were not identified but they have a low or moderate net acidity.
Acid sulfate soil identification:	• Hyposulfidic Soil –that occurred throughout the up-river section. Dominant (>50%) in extent for this section of the wetland. • Sulfuric Cracking Clay Soil – that occurred in the low to mid elevations in the mid-river sections. Dominant (>50%) in extent for this section of the wetland. • Sulfuric Soil – that occurred on the margins in the mid-river section. Subdominant (<50%) in extent. • Hyposulfidic Soil – that occurred on the raised bank area between the river and wetland for the mid and down river sections of the wetland. Isolated (<10%) in extent. • Other soils (cracking clay) – that occurred in the down-river section. Dominant (>50%) in extent for this section of the wetland.
Hazard assessment:	• Acidification hazard – level of concern varies throughout the wetland from high in the mid section, medium in the down river section, and low in the up river section. • De-oxygenation hazard – high level of concern • Metal mobilisation hazard - level of concern varies throughout the wetland from high in the mid section, medium in the down river section, and low in the up river section.

Table 32-2. Site data for Mannum Swamps Wetland

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
MSP1	15-Oct-08	351433	6140020	Hyposulfidic soil	110	cracking, large, salts on surfaces	Bare	low, but not as low as nearby channel,
MSP2	15-Oct-08	351447	6140014	Hyposulfidic soil	-3	water	Water	low, in water,
MSP3	15-Oct-08	351402	6140051	Hyposulfidic soil	20	plant material	*Phragmites australis* (Common Reed)	high, in vegetation,
MSP4	15-Oct-08	347855	6137530	Sulfuric cracking clay soil	120	cracking, large 20cm deep, crumbling	Bare	low, representative of large flat area,
MSP5	15-Oct-08	347830	6137599	Sulfuric soil	not reached	plant material	*Phragmites australis* (Common Reed)	high, at wetland vegetation edge,
MSP6	15-Oct-08	346807	6136121	Hyposulfidic soil	60	sealed	isolated plants	low, 15m from river on start of river bank,
MSP7	15-Oct-08	346744	6136155	Other soil (clay)	not reached	crumbling	isolated plants	high, on rise up from river before lower wetland area,
MSP8	15-Oct-08	346662	6136234	Other soil (cracking clay)	120	cracking, crumbling	Bare	low,
MSP9	16-Oct-08	349292	6137920	Other soil (cracking clay)	not reached	cracking	weeds, gums	high, on rise up from river before lower wetland area,

Table 32-3. Soil description data for Mannum Swamps Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
MSP1.1	0	5	soil pit	5Y 3/1	clay	wet	0			angular blocky	soft	
MSP1.2	5	20	soil pit	5Y 3/1	clay	wet	0			angular blocky	friable	
MSP1.3	20	60	soil pit	5Y 2.5/1	clay	moist	0			massive	very firm	contains plant material
MSP1.4	60	100	push tube	5Y 2.5/1	clay	wet	0			subangular blocky	firm	contains plant material
MSP2.0	-3	0	water		water	wet	0					
MSP2.1	0	5	soil pit	5Y 3/1	clay	wet	0			subangular blocky	firm	layers below same as MSP1
MSP3.1	0	5	soil pit	5Y 3/1	clay	moist	0			subangular blocky	very firm	very sticky
MSP3.2	5	15	soil pit	5Y 2.5/1	clay	moist	0			subangular blocky	firm	
MSP3.3	15	50	soil pit	5Y 2.5/1	clay	moist	0			subangular blocky	friable	
MSP3.4	50	100	push tube	5Y 2.5/1	clay	moist	0			massive	very firm	
MSP3.5	100	130	push tube	5Y 6/1	clay	moist	0			massive	very firm	
MSP4.1	0	3	soil pit	2.5Y 6/1	clay	dry	0			cloddy	hard	
MSP4.2	3	15	soil pit	2.5Y 6/1	clay	dry	0			columnar	extremely hard	salts on outside faces of columns
MSP4.3	15	35	soil pit	2.5Y 3/1	clay	moist	0			massive	very firm	1cm peat layer at base
MSP4.4	35	70	soil pit	2.5Y 3/1	clay	moist	0			massive	friable	contains lenses of organic material and clay
MSP4.5	70	150	push tube	2.5Y 5/1	clay	moist	0			massive	firm	
MSP5.1	0	10	soil pit	2.5Y 5/2	loamy sand	dry	0			single grain	loose	contains plant material
MSP5.2	10	25	soil pit	2.5Y 5/1	clay	moist	0			massive	very firm	too hard to dig below this layer

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
MSP6.1	0	3	soil pit	2.5Y 5/2	clay loam	moist	0			massive	firm	variable depth
MSP6.2	3	15	soil pit	2.5Y 3/1	clay	moist	0			subangular blocky	very firm	mixed horizon from above and below
MSP6.3	15	45	soil pit	2.5Y 2.5/1	peaty clay	moist	0			massive	very firm	
MSP6.4	45	80	soil pit	2.5Y 4/1	clay	wet	0			massive	soft	plant material not decomposed
MSP6.5	80	150	push tube	2.5Y 4/1	peat	wet	0			massive	very soft	plant material not decomposed
MSP7.1	0	10	soil pit	2.5Y 4/1	clay	dry	20	7.5YR 5/8	in matrix	angular blocky	extremely hard	
MSP7.2	10	30	soil pit	2.5Y 3/1	clay	dry	25	7.5YR 5/8	in matrix	subangular blocky	hard	
MSP7.3	30	50	soil pit	2.5Y 2.5/1	clay	moist	30	5YR 5/8	in matrix	massive	firm	
MSP7.4	50	110	push tube	2.5Y 6/2	sandy loam	moist	0			single grain	firm	
MSP8.1	0	5	soil pit	2.5Y 4/1	clay	dry	5	7.5YR 5/8	in matrix	angular blocky	extremely hard	
MSP8.2	5	100	soil pit	2.5Y 4/1	clay	dry	10	7.5YR 5/8	in matrix	columnar	rigid	
MSP8.3	100	110	push tube	2.5Y 5/2	clay	moist	5	7.5YR 5/8	in matrix	massive	very firm	
MSP8.4	110	160	push tube	5Y 5/2	clay	moist	10	10YR 5/8	in matrix	massive	very firm	
MSP9.1	0	5	soil pit	5Y 5/1	clay	dry	0			subangular blocky	rigid	
MSP9.2	5	30	soil pit	5Y 2.5/1	clay	dry	5	7.5YR 5/6	in matrix	columnar	extremely hard	
MSP9.3	30	90	soil pit	5Y 2.5/1	clay	dry	25	7.5YR 5/6	in matrix adjacent to pores	massive	extremely hard	

Table 32-4. Laboratory data for acid sulfate soil assessment of Mannum Swamps Wetland.

(red printed values indicates data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
MSP1.1	0 - 5	Fine	20,930	7.17	6.35	7.00	3973	8.36	0.00	0.08	10.34	-1331	hyposulfidic (S_{CR}<0.10%)
MSP1.2	5 - 20	Fine	4,340	7.50	6.47	7.00	826	8.19	0.00	0.02	8.51	-1124	hyposulfidic (S_{CR}<0.10%)
MSP1.3	20 - 60	Fine	2,460	7.40	6.17	7.00	672	8.02	0.00	0.07	4.21	-520	hyposulfidic (S_{CR}<0.10%)
MSP1.4	60 - 100	Fine	5,370	7.44	7.32	7.00	1268	7.99	0.00	0.09	2.18	-232	hyposulfidic (S_{CR}<0.10%)
MSP2.0	-3 - 0	Water											water
MSP2.1	0 - 5	Fine	5,380	7.45	6.30	7.00	1119	8.21	0.00	0.05	9.57	-1244	hyposulfidic (S_{CR}<0.10%)
MSP3.1	0 - 5	Fine	4,220	7.77	6.24	7.00	2552	8.19	0.00	0.05	7.15	-922	hyposulfidic (S_{CR}<0.10%)
MSP3.2	5 - 15	Fine	4,190	7.78	6.55	7.00	1845	8.05	0.00	0.04	3.61	-456	hyposulfidic (S_{CR}<0.10%)
MSP3.3	15 - 50	Fine	5,600	7.43	5.89	7.00	2834	7.87	0.00	0.09	2.85	-323	hyposulfidic (S_{CR}<0.10%)
MSP3.4	50 - 100	Fine	5,680	7.40	5.20	7.00	2922	7.57	0.00	0.11	1.93	-189	hyposulfidic (S_{CR}≥0.10%)
MSP3.5	100 - 130	Fine	2,710	8.07	4.29	7.00	1998	8.37	0.00	0.19	1.38	-66	hyposulfidic (S_{CR}≥0.10%)
MSP4.1	0 - 3	Fine	1,510	8.08	3.20	5.00	2208	6.02	5.68	0.04	0.00	33	hyposulfidic (S_{CR}<0.10%)
MSP4.2	3 - 15	Fine	6,20	3.99	2.00	3.60	11201	4.36	54.98	0.04	0.00	77	sulfuric
MSP4.3	15 - 35	Fine	2,560	4.75	1.79	3.90	9533	4.53	60.34	0.08	0.00	110	hypersulfidic
MSP4.4	35 - 70	Fine	2,410	4.24	2.32	4.50	5051	4.54	45.07	0.08	0.00	96	hyposulfidic (S_{CR}<0.10%)
MSP4.5	70 - 150	Fine	18,280	6.76	3.49	4.70	314	5.86	6.71	0.01	0.00	14	hyposulfidic (S_{CR}<0.10%)
MSP5.1	0 - 10	Coarse	900	5.91	2.44	4.70	1876	5.74	5.60	0.02	0.00	15	hyposulfidic (S_{CR}<0.10%)
MSP5.2	10 - 25	Fine	3,800	3.49	2.21	3.30	8345	3.70	107.35	< 0.01	0.00	107	sulfuric

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
MSP6.1	0 - 3	Medium	1,150	4.73	2.25	4.50	1246	4.78	27.45	< 0.01	0.00	27	other acidic
MSP6.2	3 - 15	Fine	470	4.94	2.39	4.50	663	4.77	44.23	< 0.01	0.00	44	other acidic
MSP6.3	15 - 45	Fine	520	4.90	2.61	4.00	633	4.80	38.38	< 0.01	0.00	38	other acidic
MSP6.4	45 - 80	Fine	510	5.60	2.20	4.50	1130	5.24	19.50	0.18	0.00	134	hyposulfidic (S_{CR}≥0.10%)
MSP6.5	80 - 150	Fine	270	6.08	2.16	2.50	220	4.90	13.49	0.13	0.00	93	hypersulfidic
MSP7.1	0 - 10	Fine	740	6.49	4.80	5.30	246	5.85	6.19	< 0.01	0.00	6	other acidic
MSP7.2	10 - 30	Fine	300	6.07	3.71	5.30	138	5.70	2.87	< 0.01	0.00	3	other acidic
MSP7.3	30 - 50	Fine	280	6.06	3.90	4.70	337	5.48	11.17	< 0.01	0.00	11	other acidic
MSP7.4	50 - 110	Medium	410	6.60	3.36	5.50	618	5.52	4.36	< 0.01	0.00	4	other soil material
MSP8.1	0 - 5	Fine	2,820	4.85	2.75	4.70	1746	4.54	42.40	< 0.01	0.00	42	other acidic
MSP8.2	5 - 100	Fine	2,560	5.80	4.42	3.90	2800	5.00	13.63	< 0.01	0.00	14	other acidic
MSP8.3	100 - 110	Fine	-	-	-	-	-	-	-	-	-	-	-
MSP8.4	110 - 160	Fine	1,800	6.02	2.73	4.70	756	5.82	6.97	0.08	0.00	57	hyposulfidic (S_{CR}<0.10%)
MSP9.1	0 - 5	Fine	1,060	6.08	2.94	6.10	601	5.82	3.80	< 0.01	0.00	4	other soil material
MSP9.2	5 - 30	Fine	350	6.03	3.28	5.00	264	5.24	19.91	< 0.01	0.00	20	other acidic
MSP9.3	30 - 90	Fine	910	5.73	3.14	5.50	476	5.31	14.14	< 0.01	0.00	14	other soil material

33 TAWORRI WETLAND (WETLAND ID. 12205)

33.1 LOCATION AND SETTING DESCRIPTION

Taworri Wetland (Wetland ID. 12205) is situated on the eastern side of the River Murray, upriver from the town of Mannum. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is rectangular in shape, and is approximately 1.8 kilometres in length and approximately 300 metres at the widest, with a total surface area of 31 hectares. The wetland is bounded to the south-east by a cliff and hill slopes and to the north-west by a floodplain that separates it from the river. There are a few narrow water connection channels with the river. At the time when the soil survey was conducted in October 2008, the wetland was dry and there was no surface water. The wetland area generally had no vegetation growing with cracking clay surfaces and on the margins there were isolated areas of *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed) vegetation. Three sites were described and sampled and their locations are shown in Figure 33-1.

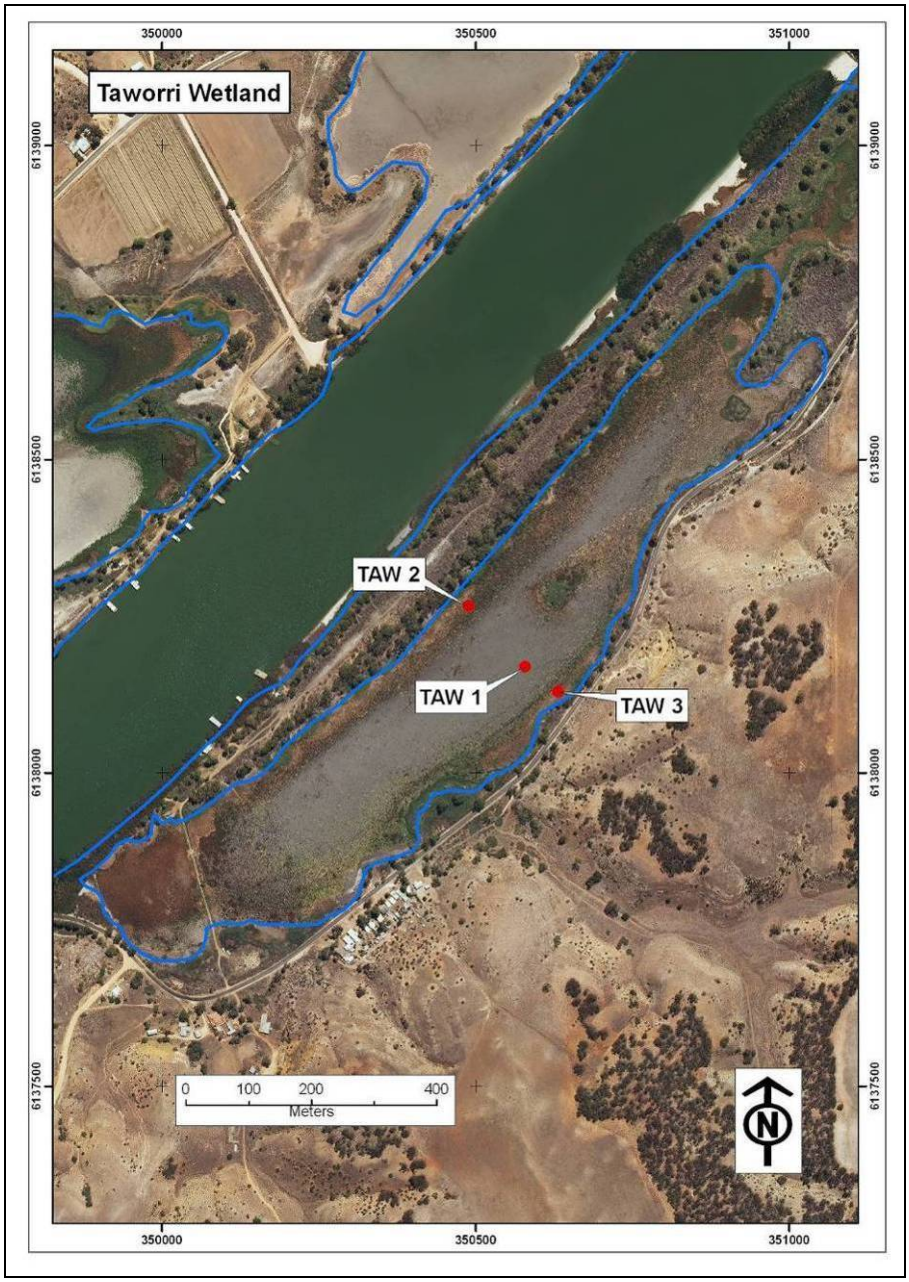


Figure 33-1. Taworri Wetland and sample site locations.

33.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Three sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 33-1. Sites were located to form one transect through the wetland, characterising the low main wetland area (TAW1), the river side at mid elevation (TAW2), and at high elevation on the hill slope side (TAW3). The site and soil descriptions are presented in Table 33-2 and Table 33-3.

Site TAW1 (Figure 33-2) occurred at low elevation in the main area of the wetland where no vegetation was growing. The soil consisted of grey, extremely hard, clay with columnar structure that was breaking down into aggregates, over a black, very firm, peaty clay.

Site TAW2 (Figure 33-3) occurred at mid elevation near the river where *Eucalyptus camaldulensis* (River Red Gum) seedlings were growing. The soil consisted of black, extremely hard, clay. Site TAW3 **(**Figure 33-4**)** occurred at high elevation on the wetland margin where reeds were growing, and the soil consisted of black, friable, peaty clay.

Table 33-1. Soil identification, subtype and general location description of sites for Taworri Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
TAW1	350579	6138169	Hyposulfidic soil	Low elevation
TAW2	350489	6138266	Other acidic soil (cracking clay)	Mid elevation
TAW3	350632	6138129	Sulfuric soil	High elevation

Figure 33-2. Photographs of site TAW1, showing the site landscape where the columns have broken down into aggregates and filled the cracks leaving an undulating surface topography, and the soil profile of clay aggregates over hard clay.

Figure 33-3. Photographs of site TAW2, showing the site landscape looking across the wetland from the river side to the cliff side, and the soil profile of extremely hard clay.

Figure 33-4. Photographs of site TAW3, showing the site landscape amongst *Phragmites australis* (Common Reed) vegetation on the wetland margin, and the soil profile of the upper friable peaty clay.

33.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 33-4 and pH profiles are presented in Figure 33-5.

The pH_W data for the surface layer of profile TAW3 identified sulfuric materials with a pH_W <4.

The pH_{INC} data did not identify samples that on incubation declined below the critical value of pH<4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation.

The pH_{OX} data identified samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

Acid Base Accounting

Acid base accounting data is provided in Table 33-4 and summarised in Figure 33-6.

Chromium reducible sulfur values ranged from below the detection limit to 0.11 %S. Sulfidic materials were detected in the surface layers of TAW1 and the subsoil layer of TAW3.

Titratable actual acidity values ranged from 3.56 to 120.32 mole H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present as the surface layer of TAW3 was below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity was not measured in any of the samples, as all samples had a pH_{KCl} of < 6.5.

Net acidity values ranged from 4 to 120 mole H^+/tonne. TAW1and TAW2 had moderate net acidity throughout the profile however it was low below a depth of one meter in TAW1. TAW3 had high net acidity in the surface that then decreased with depth.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 33-4 identified that surface layers in all profiles were above the critical trigger value of 100 mg/kg SO_4.

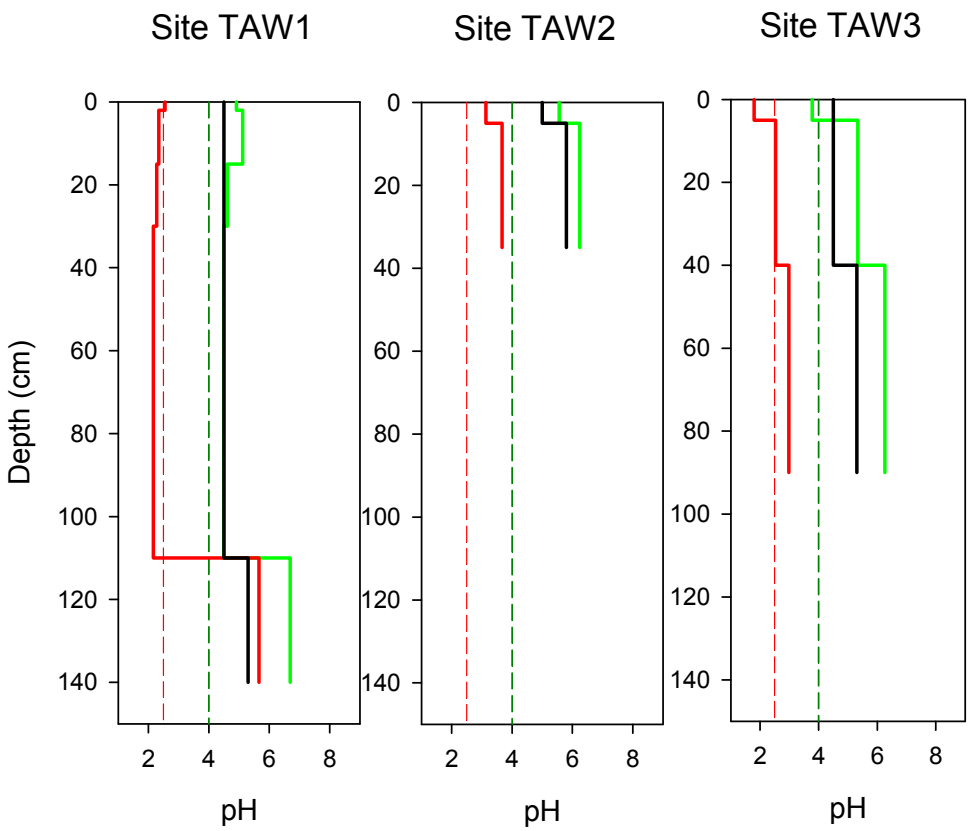


Figure 33-5. Depth profiles of soil pH for Taworri Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

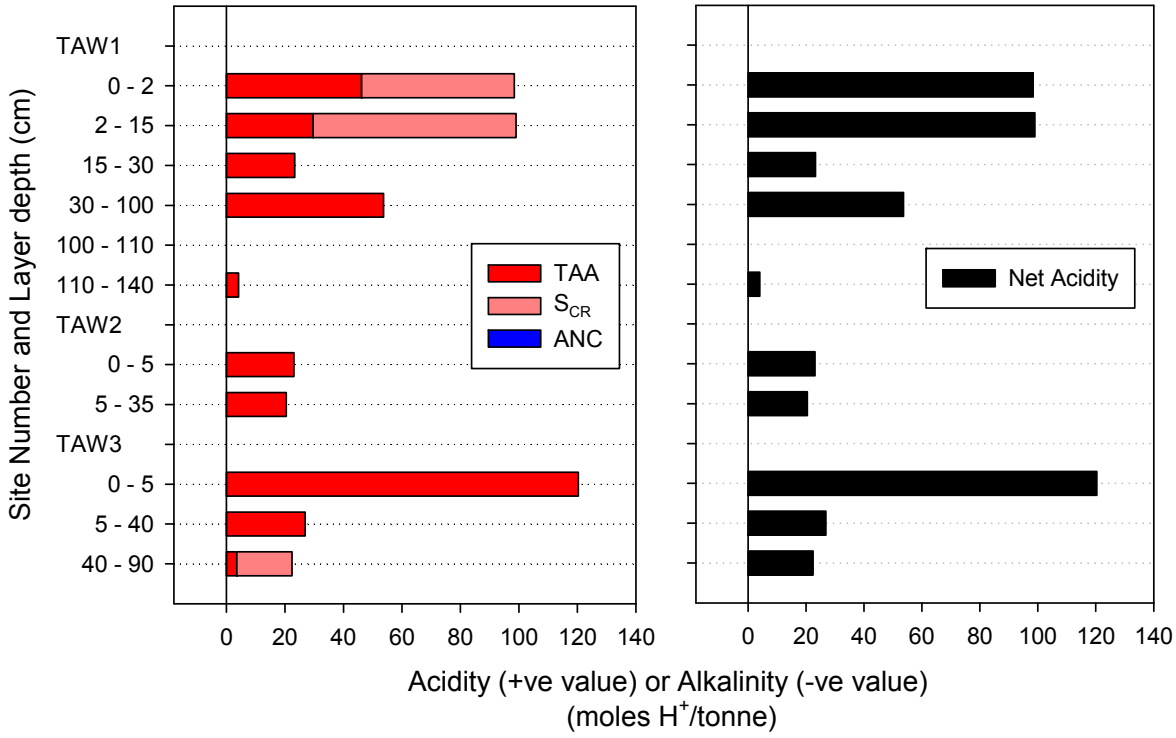


Figure 33-6. Acid base accounting depth profiles for Taworri Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

33.4 DISCUSSION

Acid sulfate soil materials at Taworri Wetland were identified as sulfuric in the surface layer of profile TAW3, and hyposulfidic in the surface layers of profile TAW1 and the subsoil of profile TAW3, other samples were characterised as other acidic soil materials. The acid sulfate soil subtype classes identified were Sulfuric Soil, Hyposulfidic Soil and Other Acidic Soil (cracking clay).

The soils in the main area of the wetland were extremely hard and clayey textured, with large and deep soil cracks that had been filled by aggregates from the breakdown of the surface layers, and on the wetland margins the soils were more friable peaty clays in the surface layers.

Monosulfidic material was not observed but water soluble sulfate data identified that surface layers for the profiles throughout the wetland were in excess of the 100 mg/kg trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials at Taworri Wetland are:

- Acidification hazard: The data identified moderate net acidity values throughout the profile TAW1, which is representative of the majority of soils in the wetland. Additionally pH data identified surface layer samples with values that were potential acidification hazard due to oxidation. There is a medium to high level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there was potential for monosulfidic materials to form in the surface layers of soils on re-flooding, although the wetland was dry at the time of sampling and monosulfidic material was not observed. There is a medium level of concern.
- Metal mobilisation: The medium to high acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

Summary of key findings for Taworri Wetland:

Soil materials:	Sulfuric soil materials were identified in a surface soil layer, and hyposulfidic soil materials were identified in a surface and subsoil layers. The soils in the main wetland area were clay textured layers, extremely hard, and formed large columnar structures with cracks that were filled with aggregates from the breakdown of the surface layer. Samples had low, moderate or high net acidity values and pH data identified samples with values that indicated potential acidification due to oxidation.
Acid sulfate soil identification:	• Hyposulfidic Soil – that occurred in the main wetland area. Dominant (>50%) in extent. • Sulfuric Soil – that occurred on the margins of the wetland. Minor (<25%) in extent. • Other Acidic Soil (cracking clay) – that occurred at mid elevations below the margins of the wetland. Minor (<25%) in extent.
Hazard assessment	• Acidification hazard – medium to high level of concern • De-oxygenation hazard – medium level of concern • Metal mobilisation hazard – medium level of concern

Table 33-2. Site data for Taworri Wetland.

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
TAW1	23-Oct-08	350579	6138169	Hyposulfidic soil	Not reached	crumbling	Bare	Low elevation
TAW2	23-Oct-08	350489	6138266	Other acidic soil (cracking clay)	Not reached	cracking, crumbling, hard	Eucalyptus camaldulensis (River Red Gum) trees	Mid elevation
TAW3	23-Oct-08	350632	6138129	Sulfuric soil	Not reached	plant material	*Phragmites australis* (Common Reed)	High elevation

Table 33-3. Soil description data for Taworri Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
TAW1.1	0	2	soil pit	2.5Y 6/1	clay	dry	0			angular blocky	extremely hard	
TAW1.2	2	15	soil pit	2.5Y 6/1	clay	dry	0			columnar	extremely hard	
TAW1.3	15	30	soil pit	2.5Y 4/1	peaty clay loam	moist	0			subangular blocky	firm	contains 20% plant material
TAW1.4	30	100	push tube	2.5Y 2.5/1	peaty clay	moist	0			massive	very firm	
TAW1.5	100	110	push tube	2.5Y 4/2	clay	moist	0			massive	firm	a transition horizon
TAW1.6	110	140	push tube	5Y 5/2	clay	moist	0			massive	firm	
TAW2.1	0	5	soil pit	2.5Y 2.5/1	clay	dry	0			angular blocky	extremely hard	
TAW2.2	5	35	soil pit	2.5Y 2.5/1	clay	dry	15	5YR 6/8	in matrix adjacent to pores	columnar	extremely hard	
TAW3.1	0	5	soil pit	2.5Y 2.5/1	peat	moist	0			subangular blocky	friable	
TAW3.2	5	40	soil pit	2.5Y 2.5/1	peaty clay	moist	15	5YR 6/8	in matrix adjacent to pores	massive	friable	contains plant material
TAW3.3	40	90	push tube	2.5Y 2.5/1	clay	moist	0			massive	firm	

Table 33-4. Laboratory data for acid sulfate soil assessment of Taworri Wetland.

(red printed values indicate data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
TAW1.1	0 - 2	fine	1,890	4.91	2.55	4.50	1642	4.58	46.23	0.08	-	98	hyposulfidic (S_{CR}<0.10%)
TAW1.2	2 - 15	fine	3,060	5.12	2.34	4.50	3746	4.88	29.64	0.11	-	99	hyposulfidic (S_{CR}≥0.10%)
TAW1.3	15 - 30	medium	4,610	4.61	2.27	4.50	2425	5.25	23.30	< 0.01	-	23	other acidic
TAW1.4	30 - 100	fine	2,430	4.49	2.16	4.50	4957	4.51	53.69	< 0.01	-	54	other acidic
TAW1.5	100 - 110	fine	-	-	-	-	-	-	-	-	-	-	-
TAW1.6	110 - 140	fine	2,720	6.69	5.66	5.30	651	6.11	4.09	< 0.01	-	4	other acidic incubation
TAW2.1	0 - 5	fine	1,490	5.56	3.14	5.00	807	5.19	23.09	< 0.01	-	23	other acidic incubation
TAW2.2	5 - 35	fine	920	6.24	3.67	5.80	353	5.40	20.43	< 0.01	-	20	other soil material
TAW3.1	0 - 5	fine	2,600	3.78	1.80	4.50	3093	3.84	120.32	< 0.01	-	120	sulfuric
TAW3.2	5 - 40	fine	1,750	5.34	2.53	4.50	1908	5.19	26.88	< 0.01	-	27	other acidic incubation
TAW3.3	40 - 90	fine	4,550	6.26	2.98	5.30	1642	6.25	3.56	0.03	-	22	hyposulfidic (S_{CR}<0.10%)

34 KIA WETLAND (WETLAND ID. 12030)

34.1 LOCATION AND SETTING DESCRIPTION

Kia Wetland (Wetland ID. 12030) is situated on the eastern side of the River Murray, immediately up river from Taworri Wetland and approximately 6 kilometres up river from the town of Mannum. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is an irregular shape, with a total surface area of 8 hectares. The wetland is bounded by surrounding floodplain and to the north-west by a slightly raised river bank. There is an excavated channel to the river at the southern end of the wetland and three wide connections between the river banks. At the time when the soil survey was conducted in October 2008 the wetland was dry and there was no surface water. Vegetation was growing throughout the wetland and included *Muehlenbeckia florulenta* (Lignum), *Conyza spp.* (Fleabane), various species of saltbush and reeds. Two sites were described and their locations are shown in Figure 34-1.

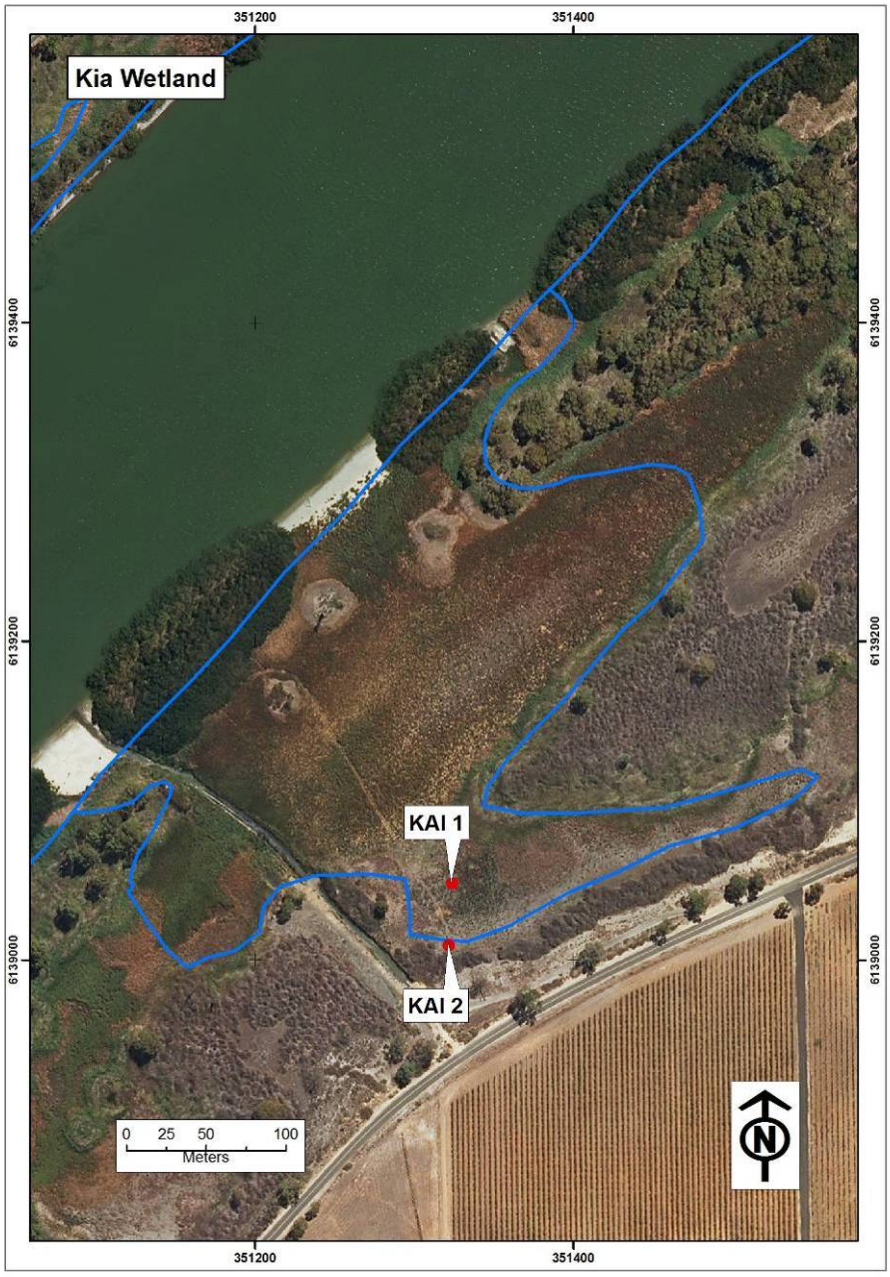


Figure 34-1. Kia Wetland and sample site locations.

34.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Two sites were described but they were not sampled (at the request of the landowner). The acid sulfate soil subtype class and general location description are presented in Table 34-1. Sites were located to characterise the low elevation area (KIA1) and on the wetland margin (KIA2). The site and soil profile descriptions are presented in Table 34-2 and Table 34-3.

Site KIA1 (Figure 34-2) occurred in a low elevation area of the wetland where *Conyza spp.* (Fleabane) vegetation was growing. The soil consisted of a black, rigid, clay that became too dry and hard to dig.

Site KIA2 (Figure 34-3) occurred in a mid elevation near the wetland margin where saltbush and reeds were growing. The soil consisted of black, hard, clay, over olive grey, firm, clay.

Table 34-1. Soil identification, subtype and general location description of sites for Kia Wetland.

Site ID	Easting m zone 54H	Northing m zone 54H	Acid sulfate soil subtype class	General location description
KIA1	351324	6139048	Other soil (cracking clay)	Low elevation, near centre of wetland
KIA2	351322	6139009	Other soil	Mid elevation, on margin with reeds growing

Figure 34-2. Photographs of site KIA1, showing the landscape of the wetland centre, and the soil profile showing the upper horizons of rigid, columnar and blocky structured clay soil.

Figure 34-3. Photographs of site KIA2, showing the soft surface, adjacent to the *Muehlenbeckia florulenta (*Lignum*)* on the wetland margin, and the soil profile of hard, blocky structured, clay.

34.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

No soil samples could be collected therefore no data is available.

Acid Base Accounting

No soil samples could be collected therefore no data is available

Water soluble sulfate

No soil samples could be collected therefore no data is available

34.4 DISCUSSION

Acid sulfate soil materials at Kia Wetland were not identified by laboratory data measurements as samples were not able to be collected. Based on observations of similar soils in the area it is likely that acid sulfate soil materials would not be identified and the soils characterised as other soil materials. Therefore, the acid sulfate soil subtype classes identified were Other Soil (cracking clay) and Other Soil.

The soils throughout the wetland were generally clays that were hard to rigid, with blocky or columnar structure.

Monosulfidic material was not observed but based on observations of similar soils in the area it is likely that water soluble sulfate data would identify that surface layers for the profiles throughout the wetland were in excess of the 100 mg/kg trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials at the Kia Wetland are:

- Acidification hazard: There is a low to medium level of concern.
- De-oxygenation hazard: There is a medium level of concern.
- Metal mobilisation: The low to medium acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a low level of concern.

Summary of key findings for Kia Wetland:

Soil materials:	It is inferred that acid sulfate soil materials would not be identified in any of the soil layers. The soils throughout were generally hard to rigid clays.
Acid sulfate soil identification:	• Other Soil (cracking clay) – that occurred in the lower elevation main areas of the wetland. Dominant (>50%) in extent. • Other Soil – that occurred on the margins of the wetland. Subdominant (<50%) in extent.
Hazard assessment	• Acidification hazard – low to medium level of concern. • De-oxygenation hazard – medium level of concern. • Metal mobilisation hazard – low level of concern.

Table 34-2. Site data for Kia Wetland.

Site Number	Sampled Date	Easting m zone 54H	Northing m zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
KIA1	23-Oct-08	351324	6139048	Other soil (cracking clay)	Not reached	cracking, salts	fleabane	Low elevation, near centre of wetland
KIA2	23-Oct-08	351322	6139009	Other soil	120	sealed, soft	saltbush, edge of reeds	Mid elevation, on edge of reeds

Table 34-3. Soil description data for Kia Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
KIA1.1	0	5	soil pit	2.5Y 5/1	clay	dry	0			angular blocky	rigid	salts on aggregate faces
KIA1.2	5	40	soil pit	2.5Y 2.5/1	clay	dry	0			columnar	rigid	too hard to dig below this layer
KIA2.1	0	10	soil pit	2.5Y 5/2	clay	dry	0			angular blocky	loose	
KIA2.2	10	30	soil pit	2.5Y 2.5/1	clay	dry	0			subangular blocky	hard	
KIA2.3	30	60	soil pit	2.5Y 2.5/1	clay	moist	0			subangular blocky	firm	
KIA2.4	60	140	push tube	5Y 5/2	clay	moist	0			massive	firm	

35 YOUNGHUSBAND WEST (DOWNSTREAM) WETLAND (WETLAND ID. 12247)

35.1 LOCATION AND SETTING DESCRIPTION

Younghusband West (Downstream) wetland (Wetland ID. 12247) is situated on the southern side of the River Murray, up river from the town of Mannum. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is somewhat linear in shape, over 5 kilometres in length parallel to the river and approximately 700 metres at the widest point, with a total surface area of 110 hectares. It is bounded to the south by hill slopes and to the north by floodplain that separates the wetland from the river. There are 2 wide water connection channels with the river. At the time when the soil survey was conducted in September 2008, the wetland had surface water in the centre, which was probably more related to recent rainfall rather than inflow from the river. There were large areas of bare cracking clay surfaces in the main low elevation area of the wetland and on the wetland margins at a slightly higher elevation *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed) were growing, with trees on the floodplain that separated the wetland and river. Six sites were described and sampled and their locations are shown in Figure 35-1.

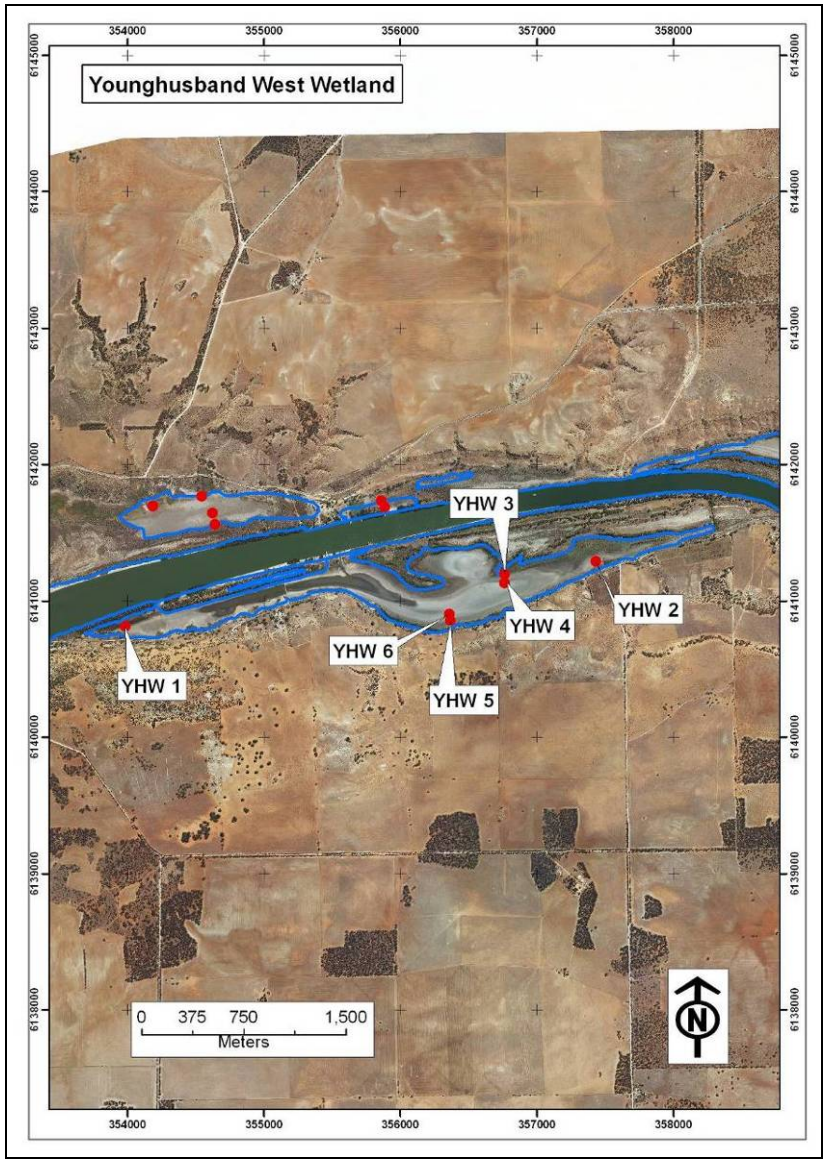


Figure 35-1. Younghusband West (Downstream) Wetland and sample site locations.

35.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Six sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 35-1. Sites were distributed throughout the wetland based on different surface features and locations in the wetland, a transect approach was not used. Site and soil profile descriptions are presented in Table 35-2 and Table 35-3.

Site YHW1 (Figure 35-2) occurred in the bare surface, cracking clay area in the down river end of the wetland. The soil consisted of grey to black, slightly rigid, clay.

Site YHW2 (Figure 35-3) occurred in bare surface, cracking clay area in the up river end of the wetland. The soil consisted of a black, very firm clay.

Site YHW3 (Figure 35-4) occurred at the edge of *Phragmites australis* (Common Reed) on the river side of the bare area. The soil consisted of black, very firm, clay.

Site YHW4 (Figure 35-5) occurred in bare surface, cracking clay area with a perched water table. The soil consisted of a black, very firm clay.

Site YHW5 (Figure 35-6) occurred in bare surface, cracking clay area adjacent to where water was perched at the surface. The soil consisted of a black, very firm clay.

Site YHW6 (Figure 35-7) occurred where water was on the surface, above the cracking clay surface. The soil consisted of a black, very firm clay.

Table 35-1. Soil identification, subtype and general location description for Younghusband West (Downstream) Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
YHW1	353985	6140811	Hyposulfidic cracking clay soil	Low elevation, cracking clay soil area
YHW2	357434	6141290	Hyposulfidic cracking clay soil	Low elevation, cracking clay soil area
YHW3	356764	6141196	Hyposulfidic soil	High elevation, on the margins where *Phragmites australis* (Common Reed) grow
YHW4	356767	6141129	Hyposulfidic cracking clay soil	Low elevation, cracking clay soil area
YHW5	356367	6140853	Sulfuric cracking clay soil	Low elevation, cracking clay soil area near surface water
YHW6	356362	6140903	Hyposulfidic cracking clay soil	Low elevation, cracking clay soil area with surface water

Figure 35-2: Photographs of site YHW1, showing the degrading bare cracking clay surface, and the soil profile of black rigid clay.

Figure 35-3. Photographs of site YHW2, showing the cracking clay surface, and the soil profile of black very firm clay.

Figure 35-4. Photographs of site YHW3, showing *Phragmites australis* (Common Reed) on the river side wetland margin, and the soil profile of black firm clay and the cracks filled with soil material.

Figure 35-5. Photographs of site YHW4, showing the bare moist cracked clay surface, and the soil profile of clay with the water table at 15 cm.

Figure 35-6. Photograph of site YHW5, showing the soil profile of firm clay with the water table at approximately 15 cm.

Figure 35-7. Photograph of site YHW6, showing the cracking clay surface below shallow surface water.

35.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 35-4 profiles for the sites are presented in Figure 35-8.

The pH_W data for the subsurface layer for profile YHW5 identified a sample as sulfuric materials with a pH_W <4.

The pH_{INC} data did not identify samples that on incubation declined below the critical value of pH <4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation

The pH_{OX} data for all surface layers and the subsoil layers of profiles YHW4 and YHW5 identified samples that were below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

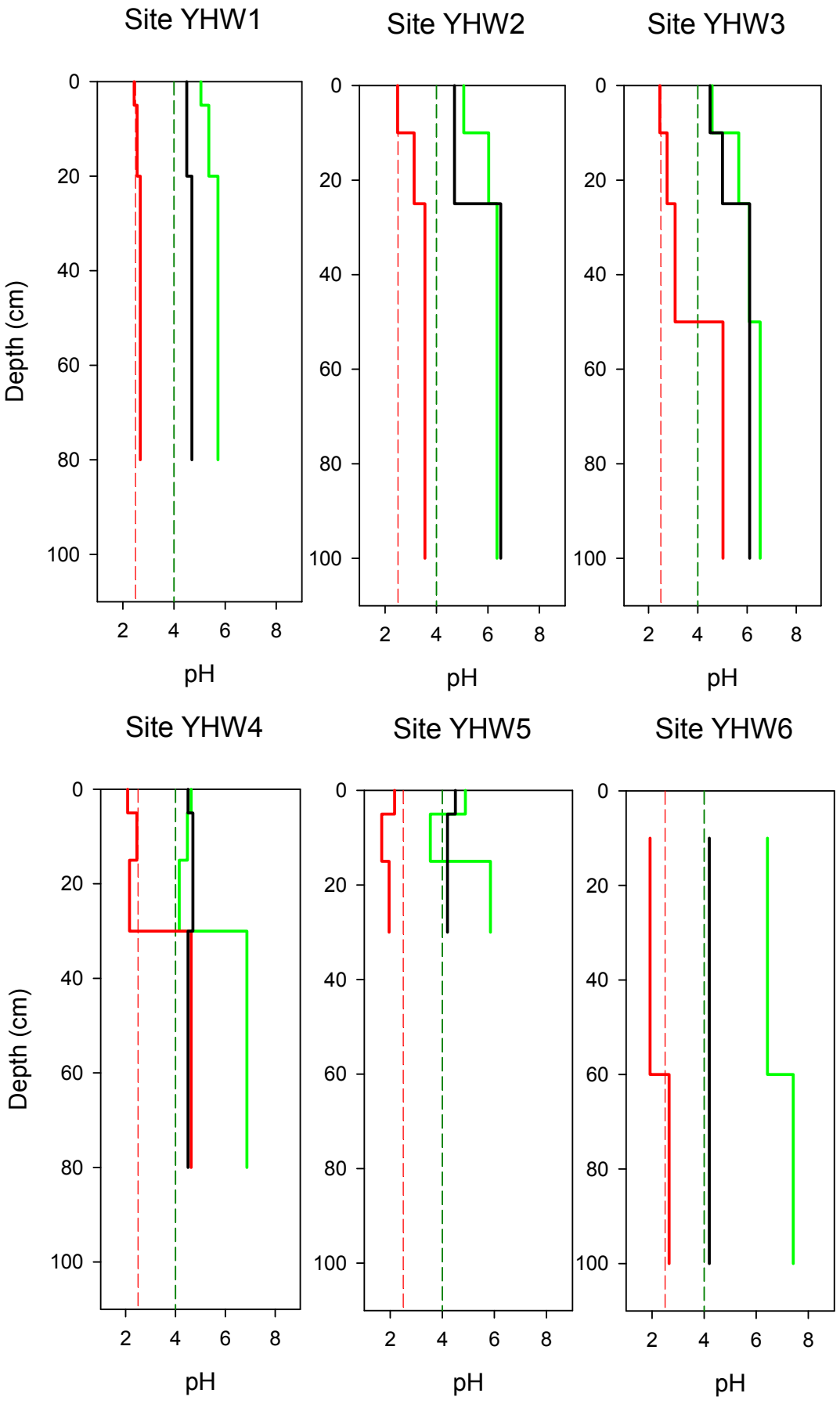


Figure 35-8. Depth profiles of soil pH for Younghusband West (Downstream) Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data is provided in Table 35-4 and summarised in Figure 35-9.

Chromium reducible sulfur values ranged from below the detection limit to 0.37 $\%S_{CR}$. Sulfidic materials were detected in at least one layer of each profile, and for profiles located in the main area of the wetland (profiles YHW4, YHW5 and YHW6) the values were higher and in all layers of the soil profile.

Titratable actual acidity values ranged from 2.34 to 117.17 mole H^+/tonne. Concentrations were measured in all layers.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present in the surface layers of profile YHW3, YHW4 and YHW5 that were below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity was not measured in any sampled layer.

Net acidity values ranged from 2 to 236 mole H^+/tonne. Moderate net acidity values occurred in profiles YHW1, YHW2 and YHW3 while high net acidity values occurred in YHW4, YHW5 and YHW6. The net acidity values tended to become higher with depth into the subsoil layers.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 35-4 identified that surface layers in all profiles were above the trigger value of 100 mg/kg SO_4.

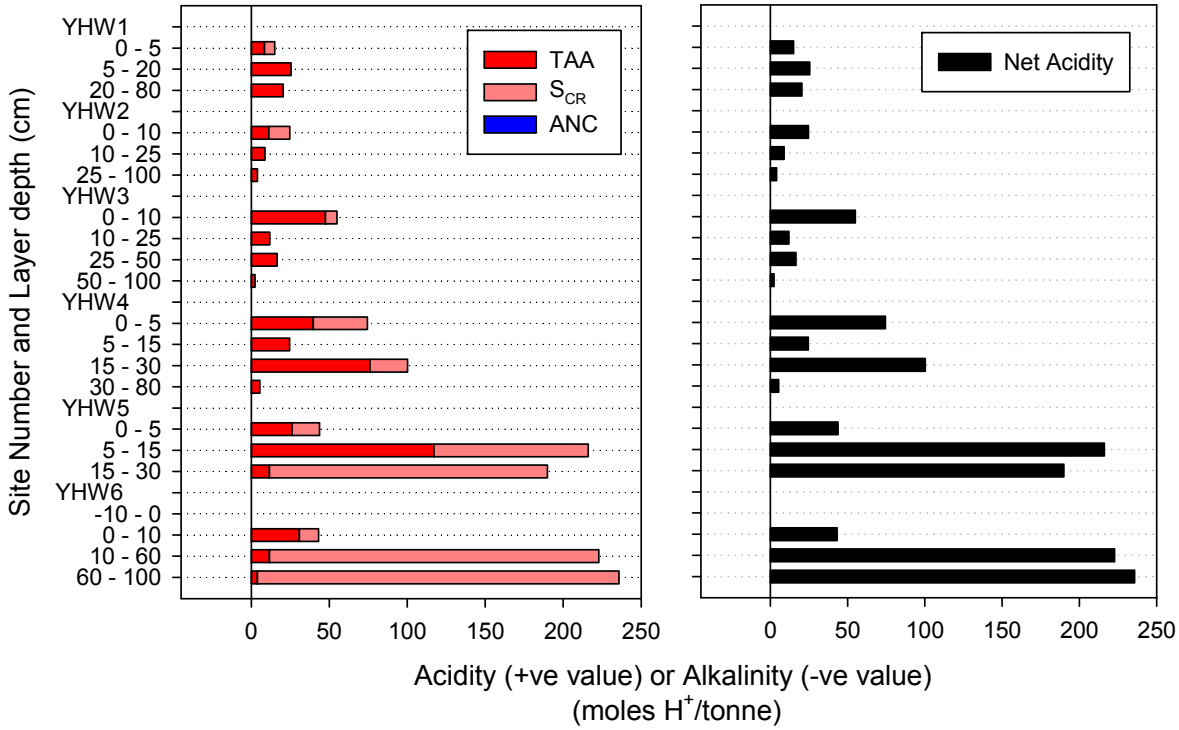


Figure 35-9. Acid base accounting depth profiles for Younghusband West (Downstream) Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

35.4 DISCUSSION

Acid sulfate soil materials at Younghusband West (downstream) Wetland were identified as sulfuric that occurred in isolated areas in low elevation areas near water (YHW5), and hyposulfidic generally in the surface layers throughout the wetland.

The soils throughout the wetland were clays that have cracking soil surfaces. The surface soil layer throughout the wetland was hyposulfidic, and in isolated areas near surface water they were sulfuric. The hyposulfidic surface soils had a low net acidity and this along with sulfuric material forming, indicates that these soils potentially could oxidise to sulfuric material.

The subsoil in the main low elevation areas of the wetland where the soils were hyposulfidic with a moderate or high net acidity, and on the mid to upper margins the subsoil was not characterised as an acid sulfate soil material.

The potential hazards posed by acid sulfate soil materials at the Younghusband West (downstream) Wetland are:

- Acidification hazard: The low elevation cracking clay soil area dominates the wetland and has a low or moderate net acidity. There is a low to medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated a potential for monosulfidic materials to form in the surface layers of soils, monosulfidic material was not observed. There is a high level of concern.
- Metal mobilisation: The low to medium acidification hazard indicates that soil acidification potential is not likely to increase the solubility of metals, but may be sufficient for mobilisation of aluminium. There is a low level of concern.

Summary of key findings for Younghusband West (Downstream) Wetland:

Soil materials:	The surface soil layers throughout the wetland were hyposulfidic with a low or moderate net acidity and in some isolated areas there were sulfuric soil materials near the surface. The subsoil layers were characterised as hyposulfidic in the main area of the wetland and as other acidic in the margin areas.
Acid sulfate soil identification:	• Hyposulfidic Cracking clay Soil – that occurred throughout the wetland. Dominant (>50%) in extent. • Hyposulfidic Soil – that occurred on the wetland margins. Minor (<25%) in extent. • Sulfuric Cracking Clay Soil – that occurred adjacent to surface water areas. Isolated (10%) in extent
Hazard assessment	• Acidification hazard – low to medium level of concern • De-oxygenation hazard – high level of concern • Metal mobilisation hazard – low level of concern

Table 35-2. Site data for Younghusband West (Downstream) Wetland.

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
YHW1	04-Sep-08	353985	6140811	Hyposulfidic cracking clay soil	not reached	cracking, crumbling	Bare	low, downstream end,
YHW2	04-Sep-08	357434	6141290	Hyposulfidic cracking clay soil	50	cracking, crumbling	Bare	low, downstream end,
YHW3	04-Sep-08	356764	6141196	Hyposulfidic soil	50	cracking	*Phragmites australis* (Common Reed)	high, at vegetation edge on river side,
YHW4	04-Sep-08	356767	6141129	Hyposulfidic cracking clay soil	10	cracking	Bare	low, water table pH4.7
YHW5	04-Sep-08	356367	6140853	Sulfuric cracking clay soil	10	cracking	weeds	mid,
YHW6	04-Sep-08	356362	6140903	Hyposulfidic cracking clay soil	-10	water	Water	low,

Table 35-3. Soil description data for Younghusband West (Downstream) Wetland

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
YHW1.1	0	5	soil pit	2.5Y 4/2	clay	dry	3	5YR 5/8	in matrix	angular blocky	slightly rigid	
YHW1.2	5	20	soil pit	2.5Y 3/2	clay	moist	3	5YR 6/6	in matrix	subangular blocky	slightly rigid	
YHW1.3	20	80	soil pit	2.5Y 2.5/1	clay	moist	0			subangular blocky	very firm	
YHW2.1	0	10	soil pit	2.5Y 4/2	clay	dry	3	5YR 5/8	on ped faces	angular blocky	slightly rigid	
YHW2.2	10	25	soil pit	2.5Y 3/2	clay	moist	3	5YR 6/6	in matrix	subangular blocky	extremely firm	
YHW2.3	25	100	soil pit	2.5Y 2.5/1	clay	moist	0			massive	very firm	
YHW3.1	0	10	soil pit	2.5Y 4/2	clay	dry	3	10YR 8/1	on ped faces	subangular blocky	slightly rigid	white salts on surface
YHW3.2	10	25	soil pit	2.5Y 3/2	clay	moist	3	10YR 6/8	in matrix	columnar	slightly rigid	
YHW3.3	25	50	soil pit	2.5Y 2.5/1	clay	moist	0			subangular blocky	very firm	
YHW3.4	50	100	push tube	2.5Y 2.5/1	clay	moist	0			massive	very firm	
YHW4.1	0	5	soil pit	2.5Y 4/2	clay loam	moist	0			angular blocky	soft	olive stains on surface
YHW4.2	5	15	soil pit	2.5Y 2.5/1	clay	moist	0			subangular blocky	soft	
YHW4.3	15	30	soil pit	2.5Y 2.5/1	clay	wet	0			subangular blocky	very firm	
YHW4.4	30	80	push tube	2.5Y 2.5/1	clay	wet	0			massive	very firm	
YHW5.1	0	5	soil pit	2.5Y 4/2	clay	moist	0			angular blocky	very firm	olive stains on surface
YHW5.2	5	15	soil pit	2.5Y 2.5/1	clay	wet	0			subangular blocky	friable	
YHW5.3	15	30	soil pit	2.5Y 2.5/1	clay	wet	0			massive	very firm	

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
YHW6.0	-10	0	water		water	wet	0					water
YHW6.1	0	10	soil pit	5Y 5/1	clay	wet	0			angular blocky	firm	olive stains on surface
YHW6.2	10	60	push tube	5Y 4/3	clay	wet	0			massive	very soft	
YHW6.3	60	100	push tube	5Y 2.5/1	clay	wet	0			massive	very firm	

Table 35-4. Laboratory data for acid sulfate soil assessment of Younghusband West (Downstream) Wetland.

(red printed values indicates data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
YHW1.1	0 - 5	Fine	-	5.05	2.44	4.50	2237	4.75	8.47	0.01	0.00	15	hyposulfidic (S_{CR}<0.10%)
YHW1.2	5 - 20	Fine	-	5.36	2.56	4.50	650	4.94	25.47	< 0.01	0.00	25	other acidic
YHW1.3	20 - 80	Fine	-	5.72	2.68	4.70	946	5.15	20.45	< 0.01	0.00	20	other acidic
YHW2.1	0 - 10	Fine	-	5.06	2.49	4.70	2337	5.23	11.29	0.02	0.00	25	hyposulfidic (S_{CR}<0.10%)
YHW2.2	10 - 25	Fine	-	6.03	3.13	4.70	1589	5.10	8.84	< 0.01	0.00	9	other acidic
YHW2.3	25 - 100	Fine	-	6.35	3.55	6.50	1178	6.01	3.99	< 0.01	0.00	4	other soil material
YHW3.1	0 - 10	Fine	-	4.58	2.46	4.50	2709	4.16	47.52	0.01	0.00	55	hyposulfidic (S_{CR}<0.10%)
YHW3.2	10 - 25	Fine	-	5.66	2.75	5.00	1458	5.25	11.95	< 0.01	0.00	12	other acidic
YHW3.3	25 - 50	Fine	-	6.09	3.08	6.10	1292	5.30	16.58	< 0.01	0.00	17	other soil material
YHW3.4	50 - 100	Fine	-	6.53	5.02	6.10	811	5.77	2.34	< 0.01	0.00	2	other soil material
YHW4.1	0 - 5	Medium	-	4.63	2.08	4.50	3359	4.25	39.76	0.06	0.00	75	hyposulfidic (S_{CR}<0.10%)
YHW4.2	5 - 15	Fine	-	4.48	2.45	4.70	2635	4.85	24.51	< 0.01	0.00	25	other acidic
YHW4.3	15 - 30	Fine	-	4.15	2.16	4.70	8308	3.91	76.15	0.04	0.00	100	hyposulfidic (S_{CR}<0.10%)
YHW4.4	30 - 80	Fine	-	6.86	4.63	4.50	2398	5.56	5.46	< 0.01	0.00	5	other acidic
YHW5.1	0 - 5	Fine	-	4.89	2.17	4.50	3191	4.58	26.12	0.03	0.00	44	hyposulfidic (S_{CR}<0.10%)
YHW5.2	5 - 15	Fine	-	3.54	1.67	4.20	10154	3.54	117.17	0.16	0.00	216	sulfuric
YHW5.3	15 - 30	Fine	-	5.85	1.96	4.20	5442	5.47	11.74	0.29	0.00	190	hyposulfidic (S_{CR}≥0.10%)
YHW6.0	-10 - 0	Water	-	-	-	-	-	-	-	-	-	-	water
YHW6.1	0 - 10	Fine	-	-	-	-	1676	4.65	30.91	0.02	0.00	43	-
YHW6.2	10 - 60	Fine	-	6.43	1.92	4.20	1526	5.65	11.71	0.34	0.00	223	hyposulfidic (S_{CR}≥0.10%)
YHW6.3	60 - 100	Fine	-	7.42	2.65	4.20	938	6.10	4.00	0.37	0.00	236	hyposulfidic (S_{CR}≥0.10%)

36 PELLARING FLAT WETLAND (WETLAND ID. 12115, 12116)

36.1 LOCATION AND SETTING DESCRIPTION

Pellaring Flat Wetland (Wetland ID. 12115, 12116) is situated on the northern side of the River Murray, immediately down river from Lake Carlet Wetland and opposite the down river end of Younghusband West Wetland. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is irregular in shape, with a total surface area of 37 hectares. The wetland is separated into two areas by a marina complex. The wetland is bounded to the north by hill slopes and to the south by floodplain and a raised river bank. There is no obvious water connection of the main wetland area with the river, and the smaller wetland section to the east graded down to the river forming a wide connection area. At the time when the soil survey was conducted in October 2008 the wetland was dry and there was no surface water, but there were many soft surface areas where the water table was near the surface. The wetland was dominantly a bare surface area and along the higher margins *Phragmites australis* (Common Reed) was growing. Six sites were described and sampled and their locations are shown in Figure 36-1.

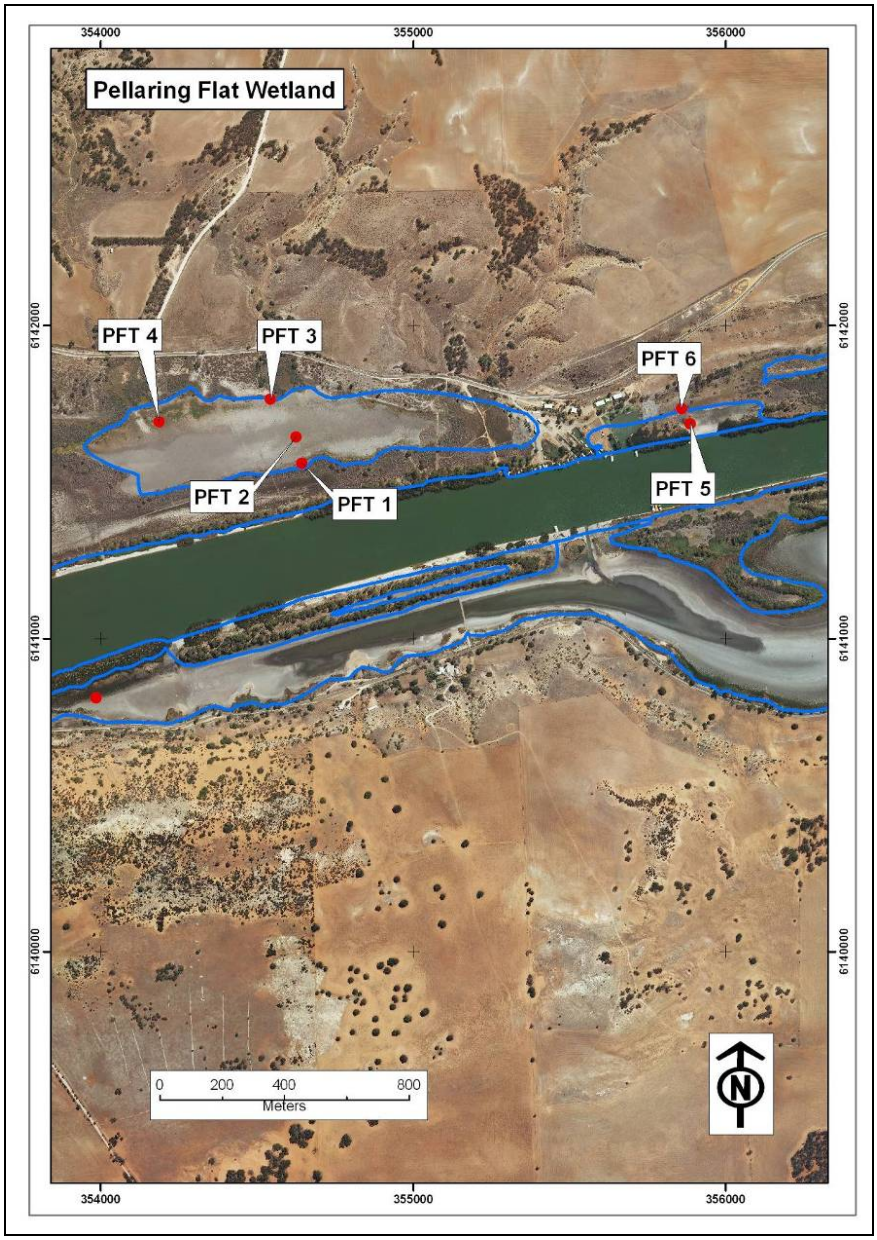


Figure 36-1. Pellaring Flat Wetland and sample site locations.

36.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Six sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 36-1. Three sites were located to form a cross-section through the wetland (PFT1, PFT2, PFT3), one site located at the western end (PFT4), and two sites located in the smaller eastern wetland section (PFT5 and PFT6). The site and soil profile descriptions are presented in Table 36-2 and Table 36-3.

Site PFT1 (Figure 36-2) occurred on the raised river side margin where *Phragmites australis* (Common Reed) was growing. The soil consisted of dark grey, very firm, clay, which became too dry and hard to dig below 40 cm depth.

Site PFT2 (Figure 36-3) occurred in the mid elevation area where the surface was bare and sealed. The soil consisted of grey, firm, clay, over an olive, firm, clay.

Site PFT3 (Figure 36-4) occurred on the hill slope side of the wetland where there was no vegetation and the surface was sandy and sealed with some salt crusts. The soil consisted of grey brown, firm, loamy sand, over a grey, firm, sandy loam with many orange mottles in the soil matrix.

Site PFT4 (Figure 36-5) occurred at the southern end of the wetland in a mid elevation position where grasses were growing. The soil consisted of grey brown, firm, loamy sand, over a grey, firm, sandy loam with many orange mottles in the soil matrix.

Site PFT5 (Figure 36-6) occurred in the eastern section of the wetland near to an inlet channel where the surface was soft and sandy. The soil consisted of black, extremely hard, clay with red mottles in the soil matrix.

Site PFT6 (Figure 36-7) occurred in the eastern section of the wetland on the hill slope side near the margin where reeds were growing. The soil consisted of black, rigid, clay that became too dry and hard to dig below 45 cm depth.

Table 36-1. Soil identification, subtype and general location description of sites for Pellaring Flat Wetland.

Site ID	Easting m zone 54H	Northing m zone 54H	Acid sulfate soil subtype class	General location description
PFT1	354644	6141560	Hyposulfidic soil	High elevation, adjacent to vegetation on wetland margin
PFT2	354626	6141644	Other soil	Mid elevation
PFT3	354544	6141765	Hyposulfidic soil	Mid to high elevation, in sandy surface area
PFT4	354188	6141692	Other soil	Mid elevation, at end of wetland
PFT5	355888	6141685	Other soil	Low elevation, in inlet channel between wetland and river
PFT6	355860	6141734	Hyposulfidic soil	Mid elevation, near margin where reed vegetation was growing

Figure 36-2. Photographs of site PFT1, showing the landscape of the wetland margin and reeds and the site location marked by the shovel handle amongst reeds.

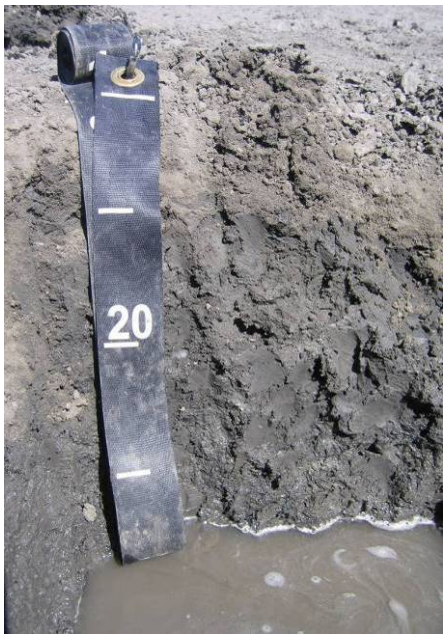


Figure 36-3. Photographs of site PFT2, showing the main wetland area of a sealed surface with no vegetation growing, and the soil profile of grey, firm, clay with the water table at 35 centimetres.

Figure 36-4. Photographs of site PFT3, showing the landscape near the wetland margin, and the soil profile of a thin sandy surface over a mottled, firm, sandy loam.

Figure 36-5. Photographs of site PFT4, showing the landscape of the western end of the wetland with some grasses growing on the sandy surface, and the soil profile of loamy sand over a firm, sandy loam, with the water table at 40 centimetres.

Figure 36-6. Photographs of site PFT5, showing the inlet channel, and the soil profile of black, extremely hard clay with red mottles in the matrix.

Figure 36-7. Photographs of site PFT6, showing the wetland with reed clumps growing near the wetland margin, and the soil profile of black, rigid, clay.

36.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 36-4 and pH profiles are presented in Figure 36-8.

The pH_W data did not identify sulfuric materials with a pH_W <4.

The pH_{INC} data did not identify samples that on incubation declined below the critical value of pH <4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric materials as a result of sulfide oxidation.

The pH_{OX} data did not identify samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

Acid Base Accounting

The acid base accounting data is provided in Table 36-4 and summarised in Figure 36-9.

Chromium reducible sulfur values ranged from below the limit of detection to 0.04 $\%S_{CR}$. Sulfidic materials were detected in the surface layers of profiles PFT1 and PFT3, and the subsoil layer of PFT6.

Titratable actual acidity values ranged from 0 to 50.17 mole H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples as no samples were below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity values ranged from 0 to 7.11 $\%CaCO_3$, and were measured in all layers of profiles PFT2, PFT3 and PFT4.

Net acidity values ranged from -947 to 57 mole H^+/tonne. Low and moderate net acidity values occurred in all layers of profiles PFT1, PFT5 and PFT6. Negative net acidity values occurred in profiles PF2, PF3 and PF4.

Water soluble sulfate

Water soluble sulfate data values shown in Table 36-4 identified that surface layers for all profiles were above the trigger value of 100 mg/kg SO_4.

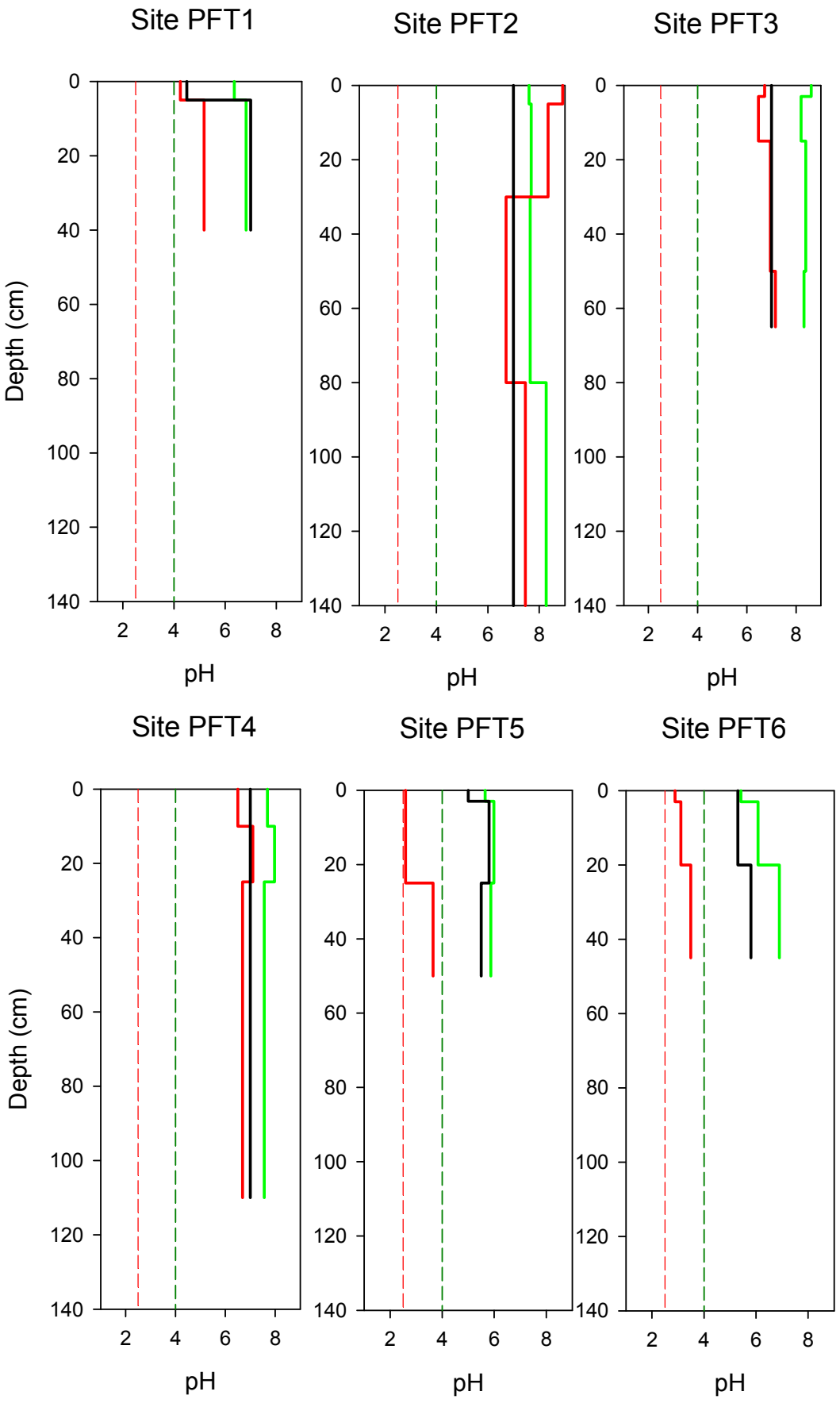


Figure 36-8. Depth profiles of soil pH for Pellaring Flat Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

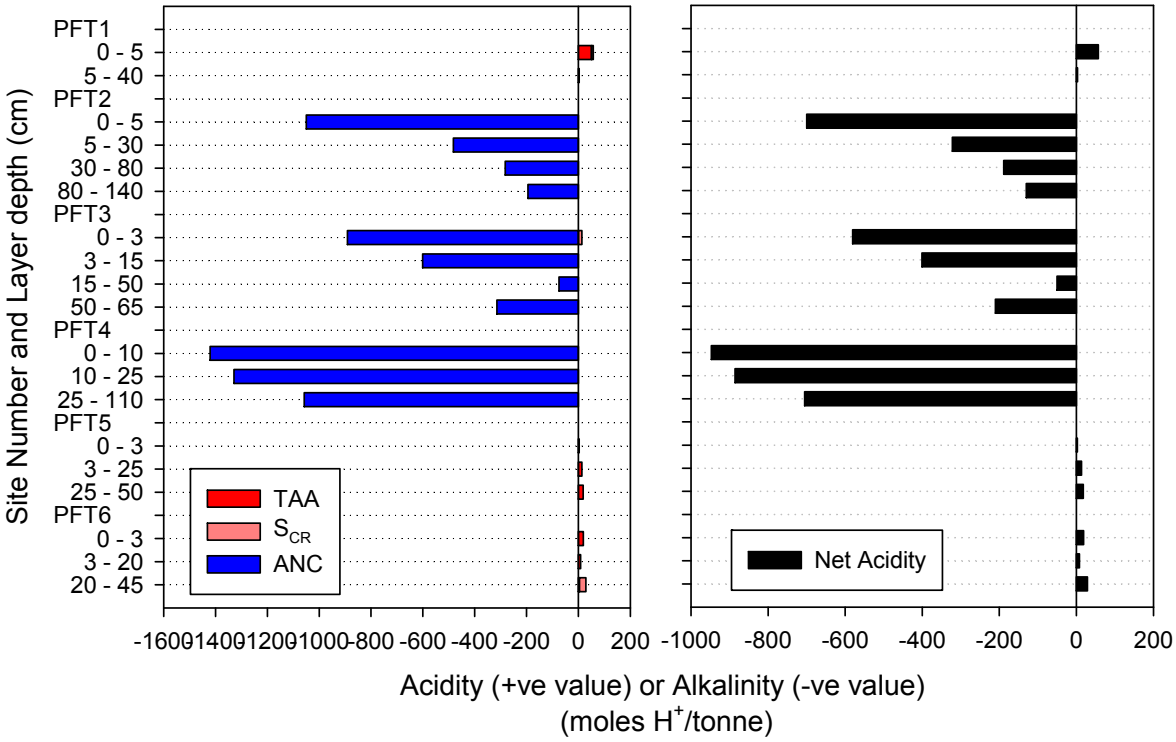


Figure 36-9. Acid base accounting depth profiles for Pellaring Flat Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

36.4 DISCUSSION

Acid sulfate soil materials at Pellaring Flat Wetland were identified as Hyposulfidic that occurred in the surface layers of profiles PFT1 and PFT3 that occurred on the wetland margins near reeds and the subsoil of profile PFT6. Most samples were characterised as Other Soil Material and a few samples as Other Acidic. The acid sulfate soil subtype classes identified were Hyposulfidic Soil or Other Soil.

The soils throughout the main wetland area were generally firm, clays and on the hill slope side of the wetland the soils were sandy loams. The eastern section of the wetland had black, extremely hard clays.

Monosulfidic material was not observed but water soluble sulfate data identified that surface layers for the profiles throughout the wetland were in excess of the 100 mg/kg trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials at the Pellaring Flat Wetland are:

- Acidification hazard: The data identified moderate net acidity values for a few surface and subsoil samples and most samples were low or negative net acidity values, and pH data did not identify potential acidification due to oxidation. There is a low level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated a potential for monosulfidic materials to form in the surface layers of soils, although monosulfidic material was not observed. There is a medium level of concern.
- Metal mobilisation: The low acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a low level of concern.

Summary of key findings for Pellaring Flat Wetland:

Soil materials:	Hyposulfidic soil materials were identified in a few surface and subsoil layers. The soils throughout were generally firm, clay textured layers with some areas of sandy textured soils. Generally samples had low or negative net acidity values, with only profiles PF1, PF5 and PF6 having positive net acidity values. The pH data did not identify potential acidification due to oxidation.
Acid sulfate soil identification:	• Other Soil – that occurred in the low elevation areas of the wetland. Dominant (>50%) in extent. • Hyposulfidic Soil – that occurred on the higher elevation margin areas of the wetland. Minor (<25%) in extent.
Hazard assessment	• Acidification hazard – low level of concern. • De-oxygenation hazard – medium level of concern. • Metal mobilisation hazard – low level of concern.

Table 36-2. Site data for Pellaring Flat Wetland.

Site Number	Sampled Date	Easting m zone 54H	Northing m zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
PFT1	16-Oct-08	354644	6141560	Hyposulfidic soil	Not reached	plant material	*Phragmites australis* (Common Reed)	High elevation, adjacent to vegetation on wetland margin
PFT2	16-Oct-08	354626	6141644	Other soil	35	sealed	Bare	Mid elevation
PFT3	16-Oct-08	354544	6141765	Hyposulfidic soil	60	sealed, salt crust	Bare	Mid to high elevation, in sandy surface area
PFT4	16-Oct-08	354188	6141692	Other soil	40	sealed	grasses	Mid elevation, at end of wetland
PFT5	16-Oct-08	355888	6141685	Other soil	Not reached	soft, sandy	weeds	Low elevation, in inlet channel between wetland and river
PFT6	16-Oct-08	355860	6141734	Hyposulfidic soil	Not reached	crumbling, hard	reeds	Mid elevation, near edge of reed vegetation

Table 36-3. Soil description data for Pellaring Flat Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
PFT1.1	0	5	push tube	5Y 3/1	peaty clay loam	moist	0			granular	friable	contains many roots
PFT1.2	5	40	push tube	5Y 2.5/1	clay	moist	0			massive	very firm	too hard to auger below this layer
PFT2.1	0	5	soil pit	5Y 4/1	clay	moist	0			subangular blocky	firm	
PFT2.2	5	30	soil pit	5Y 3/1	clay	moist	0			subangular blocky	very firm	
PFT2.3	30	80	soil pit	5Y 2.5/1	clay	moist	0			massive	friable	
PFT2.4	80	140	push tube	5Y 5/2	clay	moist	0			massive	friable	
PFT3.1	0	3	soil pit	2.5Y 5/2	sand	dry	0			single grain	loose	
PFT3.2	3	15	soil pit	5Y 5/2	loamy sand	moist	0			granular	firm	
PFT3.3	15	50	soil pit	5Y 5/3	sandy clay loam	moist	0			massive	very firm	
PFT3.4	50	65	push tube	5Y 5/6	sandy loam	moist	50	7.5YR 5/6	in matrix	massive	firm	too hard to auger below this layer
PFT4.1	0	10	soil pit	2.5Y 4/1	clay loam	moist	0			subangular blocky	friable	
PFT4.2	10	25	soil pit	2.5Y 2.5/1	clay	moist	0			massive	very firm	
PFT4.3	25	110	soil pit	2.5Y 3/1	clay	moist	0			massive	very firm	
PFT5.1	0	3	soil pit	2.5Y 5/1	loamy sand	dry	0			single grain	soft	
PFT5.2	3	25	soil pit	2.5Y 2.5/1	clay	dry	15	5YR 5/8	in matrix adjacent to pores	subangular blocky	extremely hard	
PFT5.3	25	50	soil pit	2.5Y 2.5/1	clay	moist	25	5YR 5/8	in matrix	subangular blocky	extremely firm	too hard to dig below this layer
PFT6.1	0	3	soil pit	2.5Y 4/1	clay	dry	0			angular blocky	rigid	
PFT6.2	3	20	soil pit	2.5Y 3/1	clay	dry	0			subangular blocky	rigid	
PFT6.3	20	45	soil pit	2.5Y 3/1	clay	dry	3	5YR 5/8	in matrix adjacent to pores	columnar	extremely hard	too hard to dig below this layer

Table 36-4. Laboratory data for acid sulfate soil assessment of Pellaring Flat Wetland.

(red printed values indicate data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
PFT1.1	0 - 5	medium	2,790	6.36	4.25	4.50	4994	4.60	50.17	0.01	-	57	hyposulfidic (S_{CR}<0.10%)
PFT1.2	5 - 40	fine	8,220	6.82	5.18	7.00	1469	6.25	3.08	< 0.01	-	3	other soil material
PFT2.1	0 - 5	fine	6,410	7.60	8.91	7.00	2285	8.47	0.00	< 0.01	5.25	-700	other soil material
PFT2.2	5 - 30	fine	6,320	7.69	8.34	7.00	1122	8.21	0.00	< 0.01	2.41	-322	other soil material
PFT2.3	30 - 80	fine	7,650	7.65	6.71	7.00	1130	7.36	0.00	< 0.01	1.42	-189	other soil material
PFT2.4	80 - 140	fine	6,230	8.27	7.46	7.00	1134	8.15	0.00	< 0.01	0.98	-130	other soil material
PFT3.1	0 - 3	coarse	7,300	8.61	6.72	7.00	610	9.38	0.00	0.02	4.46	-580	hyposulfidic (S_{CR}<0.10%)
PFT3.2	3 - 15	coarse	7,270	8.20	6.47	7.00	761	8.65	0.00	< 0.01	3.01	-401	other soil material
PFT3.3	15 - 50	medium	1,880	8.39	6.95	7.00	113	7.78	0.00	< 0.01	0.37	-50	other soil material
PFT3.4	50 - 65	medium	2,110	8.32	7.16	7.00	153	9.27	0.00	< 0.01	1.57	-210	other soil material
PFT4.1	0 - 10	medium	10,330	7.69	6.50	7.00	2154	8.47	0.00	< 0.01	7.11	-947	other soil material
PFT4.2	10 - 25	fine	2,380	7.97	7.10	7.00	498	8.32	0.00	< 0.01	6.65	-886	other soil material
PFT4.3	25 - 110	fine	3,750	7.56	6.69	7.00	680	8.18	0.00	< 0.01	5.29	-705	other soil material
PFT5.1	0 - 3	coarse	480	5.65	2.59	5.00	181	5.91	3.06	< 0.01	-	3	other acidic incubation
PFT5.2	3 - 25	fine	3,200	5.99	2.59	5.80	311	5.58	13.30	< 0.01	-	13	other soil material
PFT5.3	25 - 50	fine	690	5.87	3.65	5.50	470	5.26	18.24	< 0.01	-	18	other soil material
PFT6.1	0 - 3	fine	2,180	5.42	2.89	5.30	2795	5.18	18.96	< 0.01	-	19	other acidic
PFT6.2	3 - 20	fine	2,550	6.08	3.11	5.30	1545	5.96	8.22	< 0.01	-	8	other acidic incubation
PFT6.3	20 - 45	fine	510	6.90	3.49	5.80	1318	6.19	4.23	0.04	-	29	hyposulfidic (S_{CR}<0.10%)

37 LAKE CARLET WETLAND (WETLAND ID. 12716)

37.1 BACKGROUND

Lake Carlet Wetland (Wetland ID. 12716) is situated up river from the town of Mannum on the western side of the River Murray, across river from the Younghusband Wetland. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is elongated in shape, approximately 7.5 kilometres long, 1 kilometre at the widest point, and with a total surface area of 349 hectares.

This wetland was studied in 2007/08 as part of a separate monitoring investigation of acid sulfate soils, the work and data was presented in the report 'Acid sulfate soils in subaqueous, waterlogged and drained soil environments of nine wetlands below Blanchetown (Lock 1), South Australia: properties, genesis, risks and management' (Fitzpatrick, Shand, Thomas, Merry, Raven and Simpson, November 2008. Report prepared for South Australian Murray-Darling Basin Natural Resources Management Board. CSIRO Land and Water Science Report 42/08). Readers are referred to this report for detailed information, and here a summary of the findings are presented. Three sites were described and sampled (LCA1, LCA2, and LCA3) and their locations are shown in Figure 37-1. A follow-up survey was conducted in August 2009 to observe the condition of the wetland.

Figure 37-1. Lake Carlet Wetland and sample site locations.

37.2 DISCUSSION

Acid sulfate soil materials at Lake Carlet Wetland were identified as hypersulfidic that occurred throughout the surface layers of the wetland, and hypersulfidic or hyposulfidic in the subsoil layers.

The soils throughout the wetland were clays with soil cracks that extended into the upper subsoil. In some areas on the cliff-side of the wetland these cracks had been filled with wind blown sand. Near the up-river inlet there were shallow pockets of surface water and water in the soil cracks were acidic (follow-up August 2009 site visit), indicating the potential for hypersulfidic surface soil materials to oxidise and acidify water when there is contact.

The potential hazards posed by acid sulfate soil materials at the Lake Carlet Wetland are:

- Acidification hazard: Hypersulfidic soil material occurs throughout the wetland, the clay soils have deep cracks that extend into the subsoil clays and recent observations indicate that water in these cracks may become acidic. There is a medium to high level of concern.
- De-oxygenation hazard: No data was available, but based on judgement and comparison with other similar soils in the area there would be potential for monosulfidic materials to form in the surface layers of soils, although monosulfidic material was not observed. There is a high level of concern.
- Metal mobilisation hazard: The medium to high acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

Summary of key findings for Lake Carlet Wetland:

Soil materials:	The soils were clays with deep cracks that extended into the subsoil. The surface and subsoil layers throughout the wetland were hypersulfidic. In isolated high elevation areas the subsoil was hyposulfidic.
Acid sulfate soil identification:	• Hypersulfidic Cracking Clay Soils – that occurred throughout the wetland. Dominant (>50%) in extent.
Hazard assessment	• Acidification hazard – medium to high level of concern • De-oxygenation hazard – high level of concern • Metal mobilisation hazard – medium level of concern

38 YOUNGHUSBAND WETLAND (WETLAND ID. 12050, 12051, 12052)

38.1 LOCATION AND SETTING DESCRIPTION

Younghusband Wetland (Wetland ID. 12050, 12051, 12052) is situated on the southern side of the River Murray, almost opposite Lake Carlet. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is composed of three wetland areas that occurred over a 2.5 kilometre length, parallel to the river and approximately 200 metres at the widest point, with a total surface area of 18 hectares. It is bounded to the south by a road on the hill slope and to the north there is a raised bank/floodplain that separates it from the river. There is one wide water connection channel with the river through the raised bank and in some places where there is no bank the wetland area grades down to the river. At the time when the soil survey was conducted in September 2008, the wetland was dry. There were areas of bare soil surface, areas of cracking clay surfaces that were supporting weeds, and surrounding at a slightly higher elevation were *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed), with trees on the raised bank/floodplain. Five sites were described and sampled and their locations are shown in Figure 38-1.

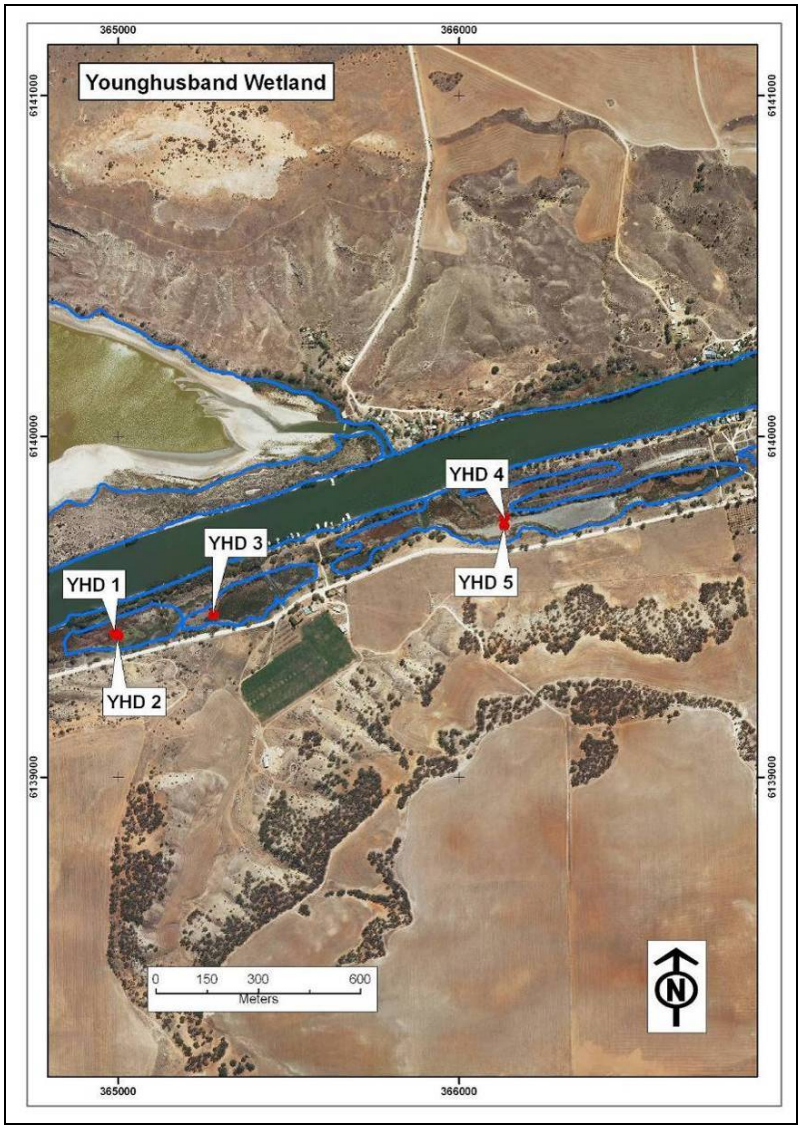


Figure 38-1. Younghusband Wetland and sample site locations.

38.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTIONS

Five sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 38-1. Sites were located to cover each of the wetland sections and paired to provide a site in the extensive low elevation areas (YHD1, YHD5, YHD3) and the higher elevation areas (YHD2, YHD4). The site and soil profile descriptions are presented in Table 38-2 and Table 38-3.

Site YHD1 (Figure 38-2) occurred in the bare cracking clay surface area, at the low elevation in the down river section of the wetland. The soil consisted of black, slightly rigid, clay.

Site YHD2 (Figure 38-3) occurred where there were *Phragmites australis* (Common Reed) on slightly elevated areas. The soil consisted of a dark brown, slightly rigid clay.

Site YHD3 (Figure 38-4) occurred in a bare area where there was Aster subulatus (Aster-weed) growing. The soil consisted of black, very firm, clay.

Site YHD4 (Figure 38-5) occurred on a slightly raised area on the river side of the wetland where there was *Typha latifolia* (Bulrush) growing. The soil consisted of a grey, very firm clay.

Site YHD5 (Figure 38-6) occurred in the lowest area of the wetland where the surface was bare with large columns forming a cracking clay area. The soil consisted of a dark grey, hard, clay with pockets of sand that have moved down the large cracks.

Table 38-1. Soil identification, subtype and general location description for Younghusband Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
YHD1	364992	6139423	Other soil (Cracking clay)	Low elevation, down river end
YHD2	365002	6139414	Other soil (clay)	Mid to High elevation, margins where *Phragmites australis* (Common Reed) grow
YHD3	365281	6139476	Other soil (clay)	Low elevation, bare surface areas
YHD4	366134	6139761	Hyposulfidic soil	Mid to high elevation, margins where *Typha latifolia* (Bulrush) grows
YHD5	366133	6139738	Sulfuric cracking clay soil	Low elevation, bare cracking clay areas up-river end

Figure 38-2. Photograph of site YHD1, showing the soil profile of black, rigid clay.

Figure 38-3. Photograph of site YHD2, showing the site location (marked by yellow shovel handle) amongst tall *Phragmites australis* (Common Reed).

Figure 38-4. Photograph of site YHD3, showing the soil profile of black, very firm clay.

Figure 38-5. Photograph of site YHD4, showing the soil profile of grey, very firm clay.

Figure 38-6. Photographs of site YHD5, showing site location in the cracking clay surface, and the soil profile with deep cracks to 40 cm and surface aggregates breaking down and filling the cracks.

38.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 38-4 and pH profiles are presented in Figure 38-7.

The pH_W data for the subsurface layer of profile YHD5 identified samples as sulfuric materials with a pH_W <4.

The pH_{INC} data did not identify samples that on incubation declined below the critical value of pH <4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation.

The pH_{OX} data for the surface layers of profiles YHD2, YHD4 and YHD5 identified samples that were below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

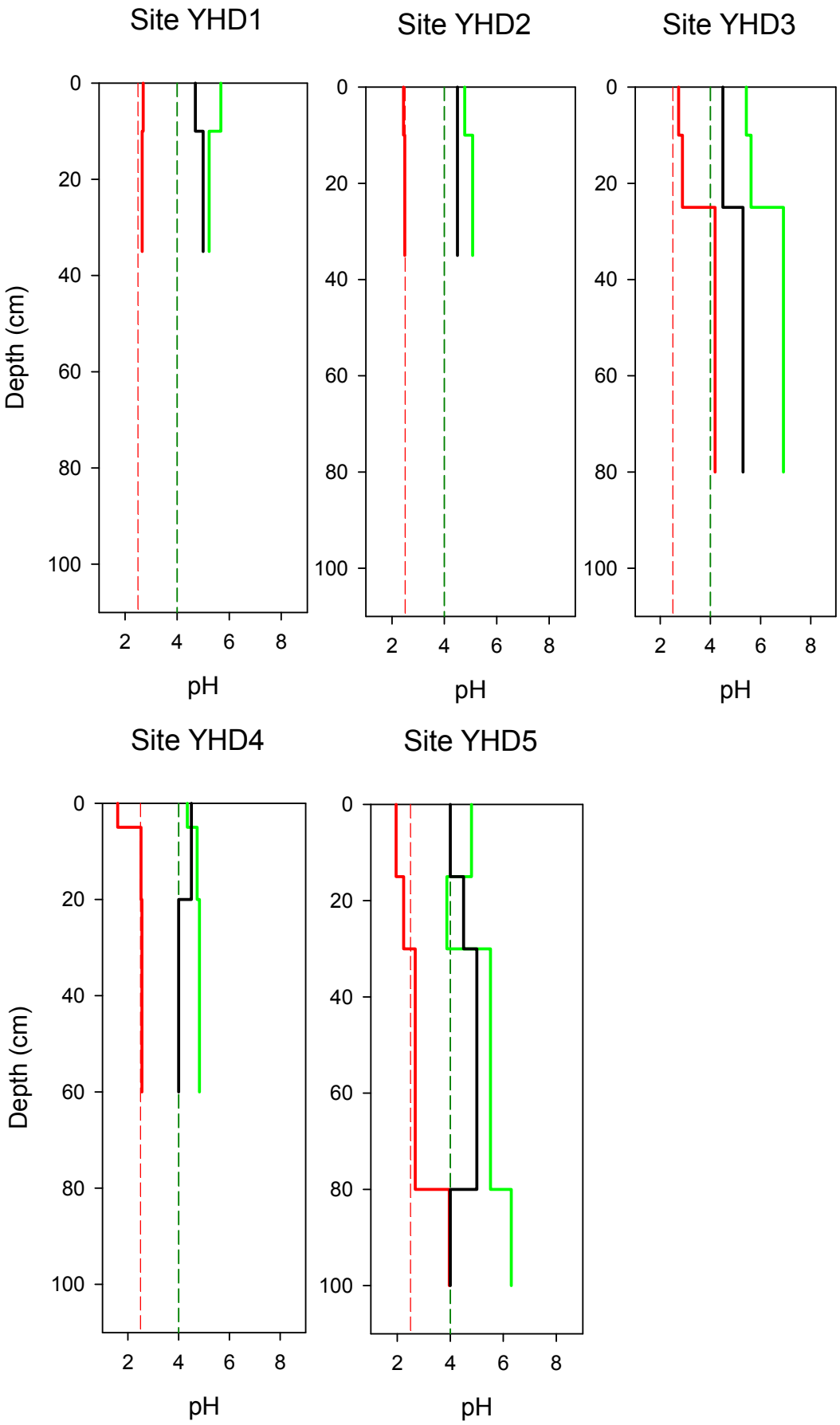


Figure 38-7. Depth profiles of soil pH for Younghusband Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data is provided in Table 38-4 and summarised in Figure 38-8.

Chromium reducible sulfur values ranged from below the limit of detection to 0.03 %S_{CR}. Sulfidic materials were identified in the surface layers of profiles YHD4 and YHD5, all other layers were below the limit of detection.

Titratable actual acidity values ranged from 6.32 to 94.33 mole H^+/tonne. Concentrations were measured in all layers.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present in the subsoil layer of profile YHD2, the surface layers of YHD4 and YHD5 that were below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity was not measured for any of the sampled layers.

Net acidity values ranged from 6 to 103 mole H^+/tonne. Moderate net acidity values generally occurred in most profiles, and some layers had low or high values.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 38-4 identified that surface layers were above the trigger value of 100 mg/kg SO_4.

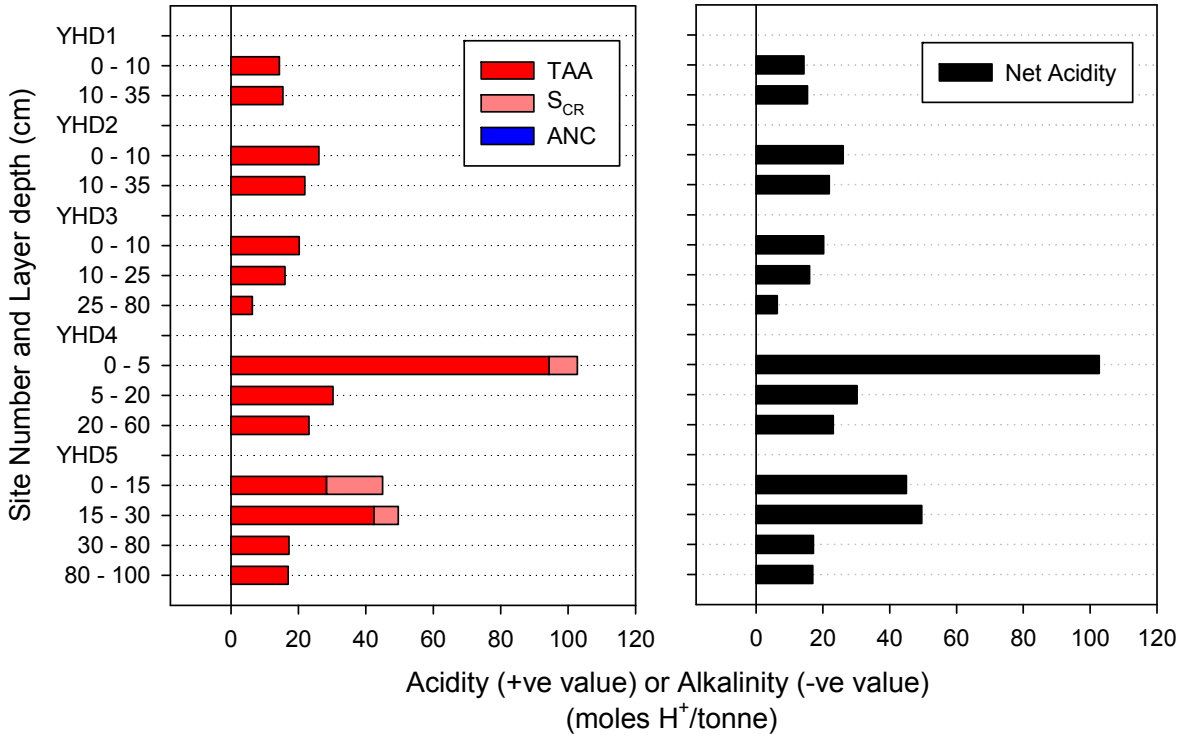


Figure 38-8. Acid base accounting depth profiles for Younghusband Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

38.4 DISCUSSION

Acid sulfate soil materials at Younghusband Wetland were identified as sulfuric for one sample in YHD5 that occurred in the low elevation area in the up-river section of the wetland, and hyposulfidic material was identified in the surface layers of profiles YHD4 and YHD5. Elsewhere acid sulfate soils were not identified but pH values were <5.0 identifying acidic soil materials.

In the up-river section of the wetland in the low depression areas where the soils were cracking, there were sulfuric or hyposulfidic soil materials that would be of concern for acidification hazard. This area appears to be the lowest area of the wetland where the water would collect and its proximity to the river in-let suggests that it would be a potential problem area upon initial re-wetting.

The potential hazards posed by acid sulfate soil materials at the Younghusband Wetland are:

- Acidification hazard: Except for an isolated area in the low elevation up-river section of the wetland where there was sulfuric material there were generally no samples of concern. There is a low to medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated a potential for monosulfidic materials to form in the surface layers of soils, monosulfidic material was not observed. There is a high level of concern
- Metal mobilisation: The low to medium acidification hazard indicates that soil acidification potential may increase the solubility of metals, soil acidity may be sufficient for mobilisation of aluminium. There is a low level of concern.

Summary of key findings for Younghusband Wetland:

Soil materials:	Generally, there were no acid sulfate soil materials in the wetland except for an isolated area in the up-river section where the soil surface was hyposulfidic or sulfuric. This acid sulfate soil area was associated with bare and cracking soil surfaces or on the margins where *Typha latifolia* (Bulrush) was growing. Elsewhere the soils were clayey.
Acid sulfate soil identification:	Cracking Clay Soil – that occurred throughout the down river section. Co-dominant (>25%) in extent. Other Soil (clayey) – that occurred throughout the wetland. Co-dominant (>25%) in extent. Hyposulfidic Soil – that occurred on the margins of the up-river section where *Typha latifolia* (Bulrush) was growing. Minor (<25%) in extent. Sulfuric Cracking Clay Soil – that occurred in bare surface cracking clay area in the up-river section. Isolated (<10 %) in extent.
Hazard assessment	Acidification hazard – low to medium level of concern, and a high level for isolated areas De-oxygenation hazard – high level of concern Metal mobilisation hazard – low level of concern

Table 38-2. Site data for Younghusband Wetland.

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
YHD1	04-Sep-08	364992	6139423	Other soil (Cracking clay)	not reached	cracking	weeds	low, near channel,
YHD2	04-Sep-08	365002	6139414	Other soil (clayey)	not reached	plant material	*Phragmites australis* (Common Reed)	high, vegetation edge,
YHD3	04-Sep-08	365281	6139476	Other soil (clayey)	not reached	cracking	*Aster subulatus* (Aster-weed)	low,
YHD4	04-Sep-08	366134	6139761	Hyposulfidic soil	not reached	cracking	Bulrushes	high, at vegetation edge on river side,
YHD5	04-Sep-08	366133	6139738	Sulfuric cracking clay soil	not reached	cracking, crumbling	Bare	low,

Table 38-3. Soil description data for Younghusband Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
YHD1.1	0	10	soil pit	10YR 5/1	clay loam	dry	3	7.5YR 6/6	in matrix	Subangular blocky	firm	
YHD1.2	10	35	soil pit	10YR 2/1	clay	moist	30	5YR 5/8	in matrix adjacent to pores	Subangular blocky	slightly rigid	too hard to dig below this layer
YHD2.1	0	10	soil pit	10YR 3/3	clay loam	dry	0			Subangular blocky	friable	
YHD2.2	10	35	soil pit	10YR 2/1	clay	moist	30	5YR 5/8	in matrix adjacent to pores	Subangular blocky	very firm	too hard to dig below this layer
YHD3.1	0	10	soil pit	10YR 3/3	clay	dry	3	5YR 5/8	in matrix	Subangular blocky	firm	
YHD3.2	10	25	soil pit	10YR 2/1	clay	moist	3	5YR 5/8	between peds	Subangular blocky	very firm	
YHD3.3	25	80	soil pit	10YR 2/1	clay	moist	30	5YR 5/8	between peds	Subangular blocky	slightly rigid	
YHD3.4	80	90	push tube	10YR 3/1	clay	moist	0			Massive	slightly rigid	too hard to dig below this layer
YHD4.1	0	5	soil pit	10YR 4/2	clay	moist	0			Subangular blocky	slightly rigid	
YHD4.2	5	20	soil pit	10YR 2/1	clay	moist	10	5YR 5/8	in matrix	Subangular blocky	firm	
YHD4.3	20	60	soil pit	10YR 2/1	clay	moist	30	5YR 5/8	in matrix	Subangular blocky	very firm	too hard to dig below this layer
YHD5.1	0	15	soil pit	10YR 6/3	clay	dry	0			angular blocky	slightly rigid	
YHD5.2	15	30	soil pit	10YR 4/1	clay	moist	3	5YR 5/8	in matrix	Columnar	slightly rigid	
YHD5.3	30	80	soil pit	10YR 2/1	clay	moist	5	5YR 5/8	in matrix	Massive	extremely firm	
YHD5.4	80	100	push tube	10YR 2/1	clay	moist	0			Massive	very firm	

Table 38-4. Laboratory data for acid sulfate soil assessment of Younghusband Wetland.

(red printed values indicates data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
YHD1.1	0 - 10	Medium	-	5.68	2.70	4.70	174	5.29	14.34	< 0.01	0.00	14	other acidic
YHD1.2	10 - 35	Fine	-	5.23	2.66	5.00	280	5.18	15.38	< 0.01	0.00	15	other acidic
YHD2.1	0 - 10	Medium	-	4.78	2.44	4.50	1656	4.58	26.04	< 0.01	0.00	26	other acidic
YHD2.2	10 - 35	Fine	-	5.08	2.49	4.50	673	4.43	21.89	< 0.01	0.00	22	other acidic
YHD3.1	0 - 10	Fine	-	5.43	2.73	4.50	1861	4.94	20.24	< 0.01	0.00	20	other acidic
YHD3.2	10 - 25	Fine	-	5.62	2.89	4.50	1459	5.06	16.00	< 0.01	0.00	16	other acidic
YHD3.3	25 - 80	Fine	-	6.91	4.19	5.30	785	5.92	6.32	< 0.01	0.00	6	other acidic
YHD3.4	80 - 90	Fine	-	-	-	-	-	-	-	-	-	-	-
YHD4.1	0 - 5	Fine	-	4.34	1.60	4.50	3514	3.75	94.33	0.01	0.00	103	hyposulfidic (S_{CR}<0.10%)
YHD4.2	5 - 20	Fine	-	4.73	2.52	4.50	1371	4.63	30.25	< 0.01	0.00	30	other acidic
YHD4.3	20 - 60	Fine	-	4.82	2.55	4.00	1121	4.67	23.14	< 0.01	0.00	23	other acidic
YHD5.1	0 - 15	Fine	-	4.80	1.96	4.00	2744	4.47	28.36	0.03	0.00	45	hyposulfidic (S_{CR}<0.10%)
YHD5.2	15 - 30	Fine	-	3.87	2.24	4.50	3284	4.28	42.40	0.01	0.00	50	sulfuric
YHD5.3	30 - 80	Fine	-	5.52	2.68	5.00	1436	5.14	17.17	< 0.01	0.00	17	other acidic
YHD5.4	80 - 100	Fine	-	6.30	3.96	4.00	897	5.33	16.93	< 0.01	0.00	17	other acidic

39 YOUNGHUSBAND POINT (UPSTREAM) WETLAND (WETLAND ID. 12717)

39.1 LOCATION AND SETTING DESCRIPTION

Younghusband Point (Upstream) Wetland (Wetland ID. 12717) is situated on the southern side of the River Murray, immediately up river from Younghusband Wetland. The wetland is an elongated sliver on the inside of a 90 degree bend in the river at least 200 meters away, with a total surface area of approximately 5 hectares. The wetland is bounded to the south by a steep slope and to the north by a floodplain that separates it from the river. There is a water connection channel with the river at the eastern end of the wetland. At the time of the soil survey in September 2008 the wetland was dry and there was no surface water. It was very difficult to recognise the wetland location due to disturbance of the entire area. There was an area of bare soil with cracking clay surfaces where weeds were growing and surrounding at a higher elevation was *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed). One site was described and sampled and the location is shown in Figure 39-1.

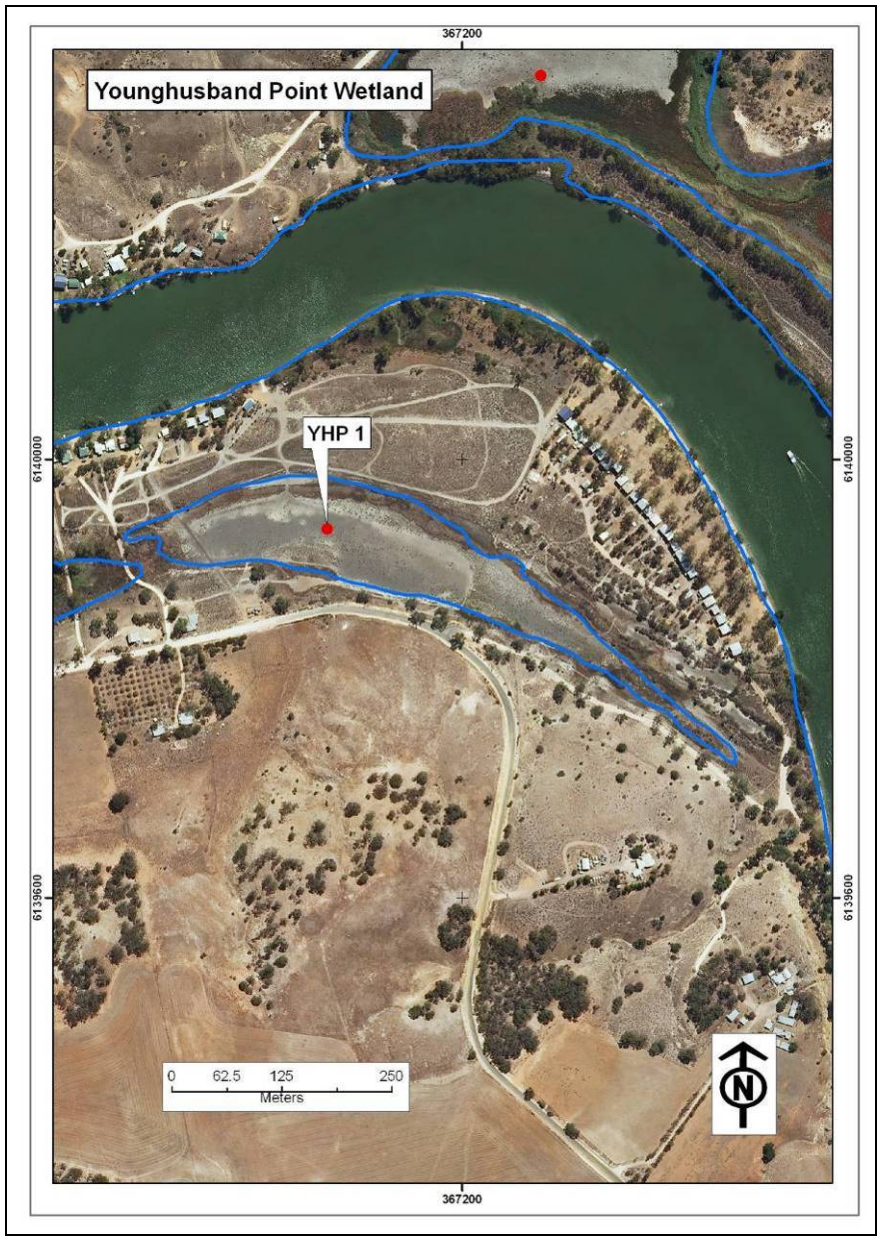


Figure 39-1. Younghusband Point (Upstream) Wetland and sample site locations.

39.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

The acid sulfate soil subtype class and general location description are presented in Table 39-1. The wetland was highly disturbed and therefore only one site was located on the dominant bare soil surface area. The site and soil profile descriptions are presented in Table 39-2 and Table 39-3.

Site YHP1 (Figure 39-2) occurred in the bare surface cracking clay areas. The soil consisted of grey, friable, granular structured clay, over black, very firm, blocky structured, clay.

Table 39-1. Soil identification, subtype and general location description of sites for Younghusband Point (Upstream) Wetland.

Site ID	Easting m zone 54H	Northing m zone 54H	Acid sulfate soil subtype class	General location description
YHP1	367051	6139956	Hyposulfidic soil	Bare cracking surface

Figure 39-2. Photographs of site YHP1, showing the main wetland area with a bare cracking surface and isolated clumps of salt tolerant vegetation, and the soil profile of friable, granular surface layer over very firm, blocky, clay.

39.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 39-4 and pH profiles are presented in Figure 39-3.

The pH_W data did not identify sulfuric materials with a pH_W <4.

The pH_{INC} data did not identify samples that on incubation declined below the critical value of pH <4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric materials as a result of sulfide oxidation.

The pH_{OX} data did not identify samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

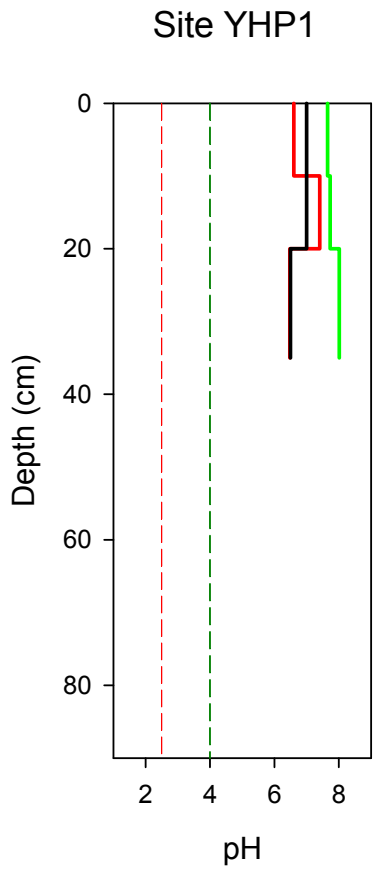


Figure 39-3. Depth profiles of soil pH for Younghusband Point Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data is provided in Table 39-4 and summarised in Figure 39-4.

Chromium reducible sulfur values ranged from below the limit of detection to 0.01 $\%S_{CR}$. Sulfidic materials were detected in the surface layer of profile YHP1.

Titratable actual acidity was not detected.

Analysis of retained acidity was not conducted on any of the samples, as all samples were above the critical value of pH_{KCl} <4.5.

Acid neutralising capacity values ranged from 1.27 to 6.67 $\%CaCO_3$, and were measured in all soil layers of profile YHP1.

Net acidity values ranged from -881 to -169 mole H^+/tonne. Negative net acidity values occurred in all layers of profile YHP1.

Water soluble sulfate

Water soluble sulfate data values shown in Table 39-4 identified that surface layers for both profiles were above the trigger value of 100 mg/kg SO_4.

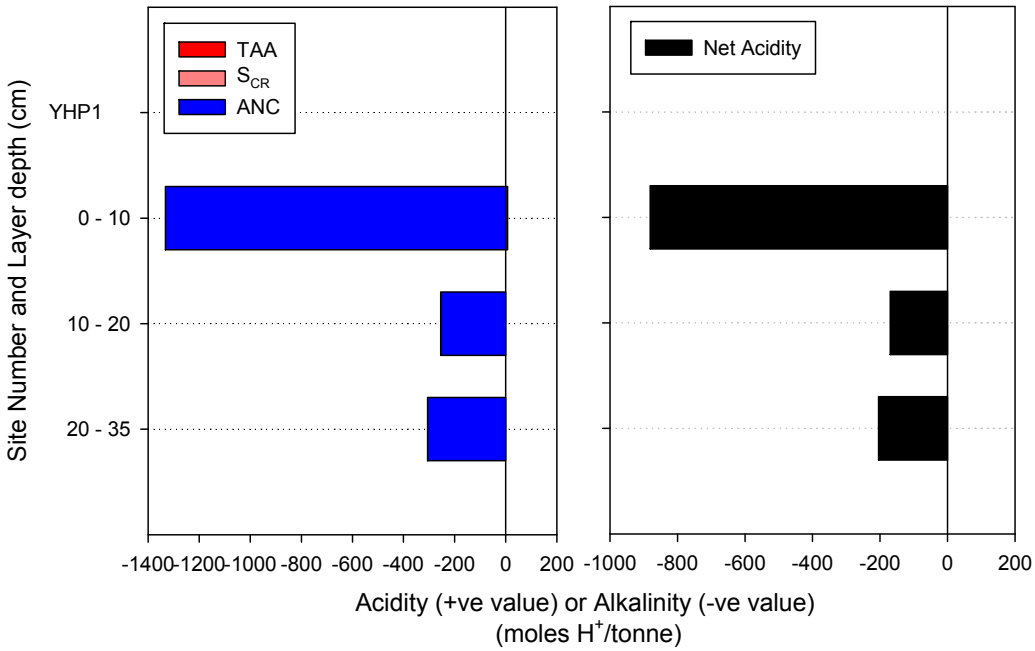


Figure 39-4. Acid base accounting depth profiles for Younghusband Point Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

39.4 DISCUSSION

Acid sulfate soil materials at Younghusband Point Wetland were identified as hyposulfidic in the surface layer profile YHP1 and the subsoil layers were characterised as other soil materials. The acid sulfate soil subtype classes identified was Hyposulfidic Soil.

The soils throughout the main wetland area were friable, granular structured, clay over black, slightly rigid, blocky clay.

Monosulfidic material was not observed but water soluble sulfate data identified that surface layers for the profile in the main area of the wetland were in excess of the 100 mg/kg trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials at the Younghusband Point Wetland are:

- Acidification hazard: The data identified negative net acidity values, and pH data did not identify potential acidification due to oxidation. There is a low level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated a potential for monosulfidic materials to form in the surface layers of soils, although monosulfidic material was not observed. There is a medium level of concern.
- Metal mobilisation: The low acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a low level of concern.

Summary of key findings for Younghusband Point Wetland:

Soil materials:	Hyposulfidic soil materials were identified in the surface layer. The soils throughout were clay textured. Soil layers had negative net acidity values and pH data did not identify potential acidification due to oxidation.
Acid sulfate soil identification:	• Hyposulfidic Soil – that occurred in the lower elevation main area of the wetland. Dominant (>50%) in extent.
Hazard assessment	• Acidification hazard – low level of concern. • De-oxygenation hazard – medium level of concern. • Metal mobilisation hazard – low level of concern.

Table 39-2. Site data for Younghusband Point (Upstream) Wetland.

Site Number	Sampled Date	Easting m zone 54H	Northing m zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
YHP1	04-Sep-08	367051	6139956	Hyposulfidic soil	Not reached	crust, crumbling	Bare	

Table 39-3. Soil description data for Younghusband Point (Upstream) Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
YHP1.1	0	10	soil pit	10YR 4/2	clay	dry	0			granular	friable	
YHP1.2	10	20	soil pit	10YR 2/1	clay	moist	0			subangular blocky	very firm	
YHP1.3	20	35	soil pit	10YR 2/1	clay	moist	0			subangular blocky	very firm	too hard to dig below this layer

Table 39-4. Laboratory data for acid sulfate soil assessment of Younghusband Point (Upstream) Wetland.

(red printed values indicate data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
YHP1.1	0 - 10	fine	-	7.65	6.60	7.00	3150	8.59	-	0.01	6.67	-881	hyposulfidic (S_{CR}<0.10%)
YHP1.2	10 - 20	fine	-	7.73	7.41	7.00	1514	7.62	-	< 0.01	1.27	-169	other soil material
YHP1.3	20 - 35	fine	-	8.02	6.48	6.50	1399	7.29	-	< 0.01	1.53	-204	other soil material

40 TEAL FLAT HUT (DOWNSTREAM) WETLAND (WETLAND ID. 12034)

40.1 LOCATION AND SETTING DESCRIPTION

Teal Flat Hut (Downstream) wetland (Wetland ID. 12034) is situated on the western side of the River Murray. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is irregular in shape, formed on the outer side of the river bend. It is divided into two sections by material washed into the wetland from an adjacent gully to the north and has a total surface area of 20 hectares. It is bounded to the north by a road and hill slope and to the south by a raised bank/floodplain that separates it from the river. There is one narrow water connection channel at the down river end of the wetland.

At the time when the soil survey was conducted in September 2008, the wetland was dry. The down river end of the wetland was dominated by large soil columns formed by cracking clay, the cracks were often greater than 10 centimetres wide and 50 centimetres deep, with water in most of the cracks, and the vegetation on the margins at slightly higher elevations was *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed). The up river section of the wetland had a cracking clay surface and there were many Eucalyptus camaldulensis (River Red Gum) seedlings forming a dense cover along with other vegetation that was growing. Three sites were described and sampled and their locations are shown in Figure 40-1.

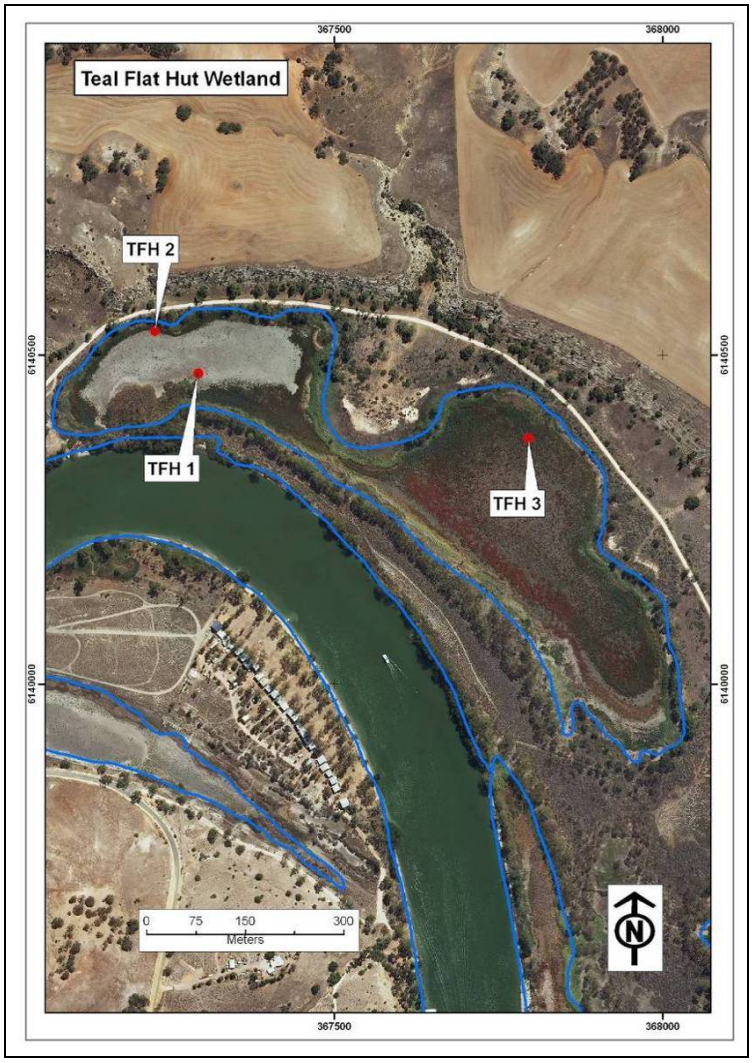


Figure 40-1. Teal Flat Hut (Downstream) Wetland and sample site locations.

40.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Three sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 40-1. Two sites were used to form a cross-section of the down-river section and the dominant features, in the low main wetland area (TFH1) and on the higher margin area (TFH2). One site (TFH3) was located to characterise the main area of the up-river section. The site and soil profile descriptions are presented in Table 40-2 and Table 40-3.

Site TFH1 (Figure 40-2) occurred in the bare surface, cracking clay area, that was at low elevation in the down river section of the wetland. The soil consisted of distinct columns of dark grey, very firm, clay with salt crystals on the soil surfaces over olive grey soft clay and then black friable clay.

Site TFH2 (Figure 40-3) occurred where there were *Phragmites australis* (Common Reed) on the slightly elevated margin areaThe soil consisted of distinct columns of grey, extremely firm, clay loam over black friable clay.

Site TFH3 (Figure 40-4) occurred in an area overgrown with *Persicaria lapathifolium* (Pale Knotweed), Eucalyptus camaldulensis (River Red Gum) seedlings and other plants The surface was cracking, and the soil consisted of columns of dark grey, very firm, clay.

Table 40-1. Soil identification, subtype and general location description for Teal Flat Hut (Downstream) Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
TFH1	367294	6140472	Sulfuric cracking clay soil	Low to mid elevation, cracking clay soil areas of the down-river section
TFH2	367228	6140536	Sulfuric cracking clay soil	Higher elevation, on the margins where *Phragmites australis* (Common Reed) grow
TFH3	367796	6140373	Hyposulfidic cracking clay soil	Low to mid elevation, cracking clay soil areas of the up-river section

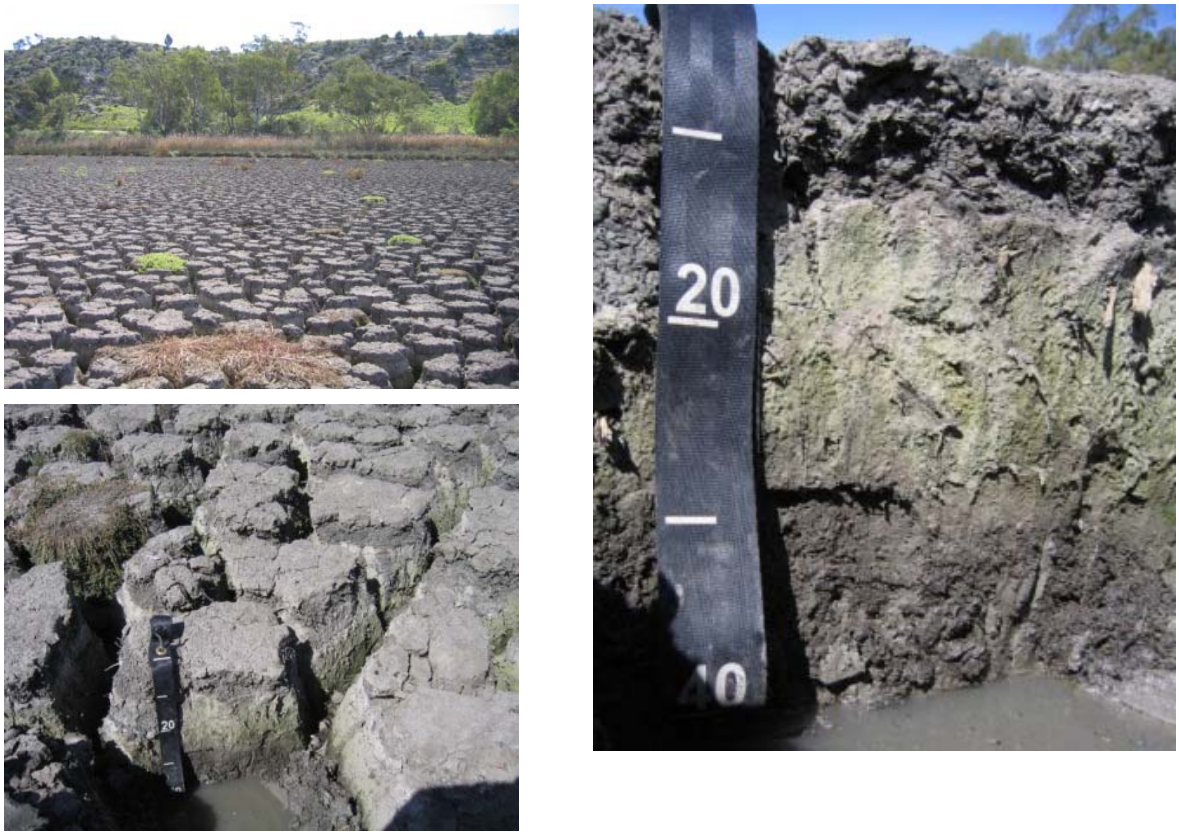


Figure 40-2. Photographs of site TFH1, showing the landscape dominated by the intact cracking clay surface, and the soil profile with cracks to more than 40 cm deep that were partly filled with soil aggregates and water.

Figure 40-3. Photograph of site TFH2 showing the large cracks in the clay soil, the vegetation growing around the wetland margin, and the soil profile of rigid clay columns with cracks to more than 40 cm and salt was forming on the surfaces.

Figure 40-4. Photograph of site TFH3, showing the soil profile of very firm clay and soil cracks filled with soil material.

40.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 40-4 and pH profiles are presented in Figure 40-5.

The pH_W data for the surface layers of profiles TFH1 and TFH2 identified samples as sulfuric materials with a pH_W <4.

The pH_{INC} data for the surface layers of profiles TFH1 and TFH2 identified samples that on incubation declined below the critical value of pH<4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation.

The pH_{OX} data for the surface and subsoil layers of profiles TFH1 and TFH2 identified samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

Acid Base Accounting

The acid base accounting data is provided in Table 40-4 and summarised in Figure 40-6.

Chromium reducible sulfur values ranged from below the detection limit of <0.01 to 0.18 $\%S_{CR}$. Sulfidic materials were detected in nearly all layers.

Titratable actual acidity values ranged from 0 to 185.44 mole H^+/tonne. Concentrations were measured in all but one sampled layer.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present in the surface layers of profiles TFH1 and TFH2 that were below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity values ranged from 0 to 0.89 $\%CaCO_3$, and were measured in subsoil layers of TFH1 and TFH2.

Net acidity values ranged from -86 to 241 mole H^+/tonne. High net acidity values occurred in the surface layers of profiles TFH1 and TFH2, other layers had moderate values and the deeper subsoils layers of profiles TFH1 and TFH2 had negative values.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 40-4 identified that surface layers were above the trigger value of 100 mg/kg SO_4.

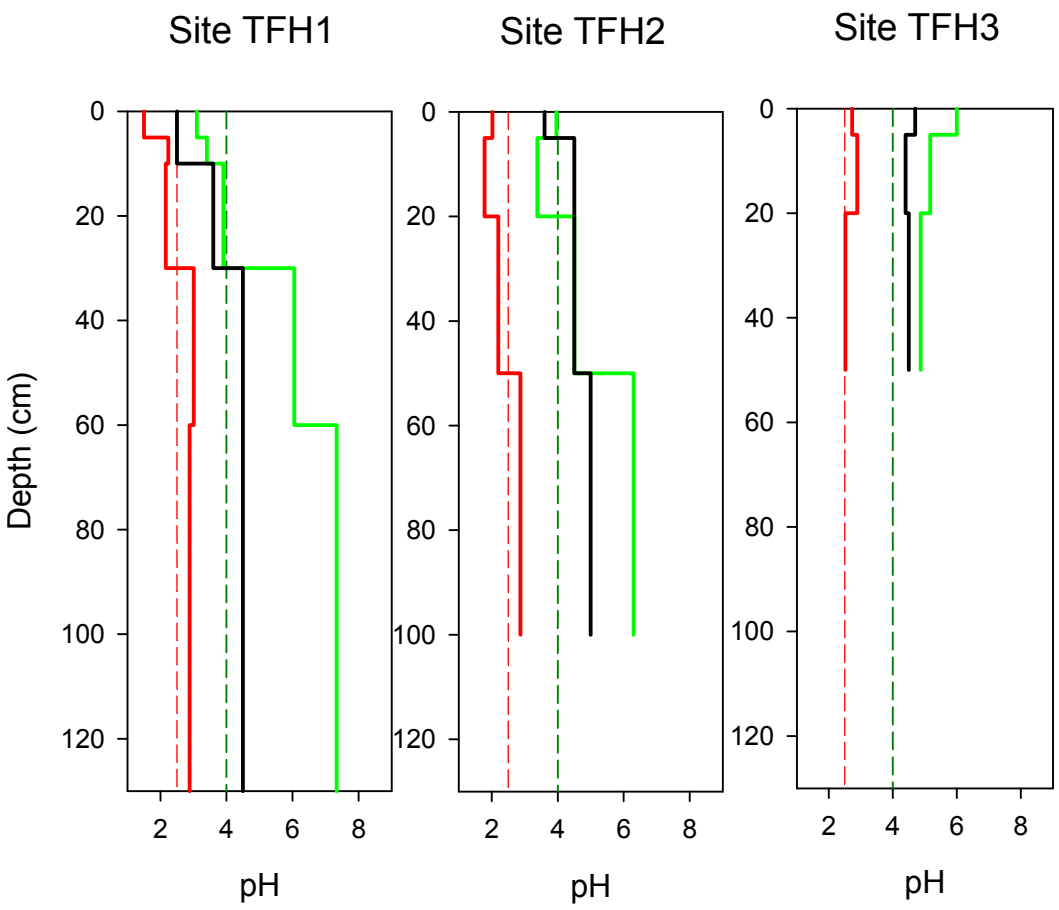


Figure 40-5. Depth profiles of soil pH for Teal Flat Hut (Downstream) Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

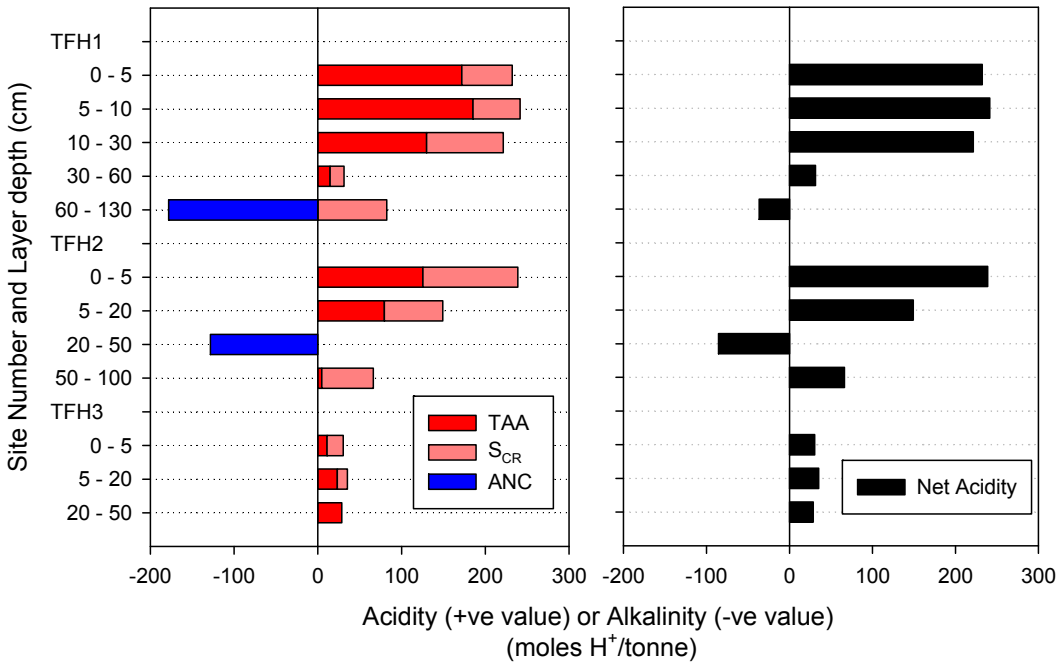


Figure 40-6. Acid base accounting depth profiles for Teal Flat Hut (Downstream) Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

40.4 DISCUSSION

Acid sulfate soil materials at Teal Flat Hut (Downstream) Wetland were identified as sulfuric that occurred in the surface soil layers throughout the down-river section of the wetland associated with the deep cracking clay soils. Hyposulfidic soil materials were identified in the up-river section of the wetland and in the lower subsoils of the down-river section.

The wetland was separated into two distinct sections, a down-river section that was characterised by bare surface wide cracks that extended deep into the subsoil, whereas the up-river section was overgrown with young Eucalyptus camaldulensis (River Red Gum) seedlings and cracks, if they existed, have filled with surface soil material. The down-river section had sulfuric material throughout the surface layers in the cracking clay areas but also in the sandy areas that fringe the margins at higher elevation. The soil cracks were wide and extending deep into the subsoils and if the water table level drops would allow rapid oxidation. This down-river section was connected to the river and of high concern.

The up-river section was of less concern as the surface soils were hyposulfidic, and the area appears to be at a higher elevation than the down-river section. The soil was very dry and overgrown (almost terrestrial) and does not appear to be connected to the river.

The potential hazards posed by acid sulfate soil materials at the Teal Flat Hut (Downstream) Wetland are:

- Acidification hazard: For the down river section of the wetland the surface layers were sulfuric and of concern, the up-river section was of less concern because it was at a higher elevation and the soils were characterised as hyposulfidic. There is a high level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated a potential for monosulfidic materials to form in the surface layers of soils, monosulfidic material was not observed. There is a high level of concern.
- Metal mobilisation: The high acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a high level of concern.

Summary of key findings for Teal Flat Hut (Downstream) Wetland:

Soil materials:	The surface soil layers were sulfuric, and the subsoil layers were hyposulfidic, these materials occurred throughout the down-river section of the wetland in the cracking clay soils. The up-river section of the wetland has hyposulfidic soil material and net acidity values characterising the soils as acidic.
Acid sulfate soil identification:	• Sulfuric Cracking Clay Soil – that occurred throughout the down-river section. Dominant (>50%) in extent for down-river section of the wetland. • Hyposulfidic Cracking Clay Soil – that occurred throughout the up-river section. Sub-dominant (<50%) in extent for the up-river section of the wetland.
Hazard assessment:	• Acidification hazard – high level of concern • De-oxygenation hazard – high level of concern • Metal mobilisation hazard – high level of concern

Table 40-2. Site data for Teal Flat Hut (Downstream) Wetland.

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
TFH1	09-Sep-08	367294	6140472	Sulfuric cracking clay soil	50	cracking	Bare	mid/low, riverside, watertable pH7.0
TFH2	09-Sep-08	367228	6140536	Sulfuric cracking clay soil	70	cracking	Bare	mid, edge next to *Phragmites australis* (Common Reed),
TFH3	09-Sep-08	367796	6140373	Hyposulfidic cracking clay soil	not reached	cracking, crumbling	*Persicaria lapathifolium* (Pale Knotweed)	mid,

Table 40-3. Soil description data for Teal Flat Hut (Downstream) Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
TFH1.1	0	5	soil pit	2.5Y 4/1	clay	moist	3	5YR 5/8	on ped faces	platy	very firm	
TFH1.2	5	10	soil pit	2.5Y 4/1	peaty clay	moist	0			columnar	extremely firm	
TFH1.3	10	30	soil pit	2.5Y 4/1	peaty clay	wet	5	10YR 8/1	on ped faces	columnar	very firm	white salts on surface
TFH1.4	30	60	soil pit	2.5Y 4/2	clay	wet	0			massive	Soft	
TFH1.5	60	130	push tube	2.5Y 3/1	clay	wet	0			massive	Friable	
TFH2.1	0	5	soil pit	2.5Y 5/1	peaty clay loam	moist	3	5YR 5/8	on ped faces	platy	very firm	
TFH2.2	5	20	soil pit	2.5Y 4/1	peaty clay loam	moist	5	10YR 8/1	on ped faces	columnar	extremely firm	white salts on surface
TFH2.3	20	50	soil pit	2.5Y 2.5/1	clay	moist	0			massive	Firm	
TFH2.4	50	100	push tube	2.5Y 2.5/2	clay	wet	0			massive	Friable	
TFH3.1	0	5	soil pit	2.5Y 4/1	clay	moist	3	5YR 5/8	on ped faces	angular blocky	Friable	
TFH3.2	5	20	soil pit	2.5Y 4/1	clay	moist	3	10YR 6/6	on ped faces	columnar	very firm	
TFH3.3	20	50	soil pit	2.5Y 3/1	clay	moist	0			massive	very firm	too hard to dig below

Table 40-4. Laboratory data for acid sulfate soil assessment of Teal Flat Hut (Downstream) Wetland.

(red printed values indicates data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
TFH1.1	0 - 5	Fine	-	3.10	1.50	2.50	768	3.37	171.97	0.10	0.00	232	sulfuric
TFH1.2	5 - 10	Fine	-	3.41	2.24	2.50	454	3.36	185.44	0.09	0.00	241	sulfuric
TFH1.3	10 - 30	Fine	-	3.91	2.16	3.60	466	3.60	130.11	0.15	0.00	222	sulfuric
TFH1.4	30 - 60	Fine	-	6.05	3.01	4.50	70	5.23	14.71	0.03	0.00	31	hyposulfidic (S_{CR}<0.10%)
TFH1.5	60 - 130	Fine	-	7.34	2.88	4.50	30	6.53	0.00	0.13	0.89	-36	hyposulfidic (S_{CR}≥0.10%)
TFH2.1	0 - 5	Medium	-	3.96	2.02	3.60	645	3.57	125.55	0.18	0.00	239	sulfuric
TFH2.2	5 - 20	Medium	-	3.38	1.78	4.50	1	3.87	79.62	0.11	0.00	149	sulfuric
TFH2.3	20 - 50	Fine	-	4.50	2.20	4.50	53	6.94	-	< 0.01	0.64	-86	other acidic
TFH2.4	50 - 100	Fine	-	6.30	2.87	5.00	67	6.33	4.84	0.10	0.00	66	hyposulfidic (S_{CR}<0.10%)
TFH3.1	0 - 5	Fine	-	6.00	2.73	4.70	226	5.53	11.12	0.03	0.00	30	hyposulfidic (S_{CR}<0.10%)
TFH3.2	5 - 20	Fine	-	5.17	2.89	4.40	359	4.92	23.39	0.02	0.00	35	hyposulfidic (S_{CR}<0.10%)
TFH3.3	20 - 50	Fine	-	4.87	2.52	4.50	330	4.70	28.60	< 0.01	0.00	29	other acidic

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