APPENDIX B4 – WETLAND DESCRIPTIONS FOR ASSESSMENT OF ACID SULFATE SOIL MATERIALS IN THE LOCK 1 TO WELLINGTON REGION OF THE MURRAY-DARLING BASIN

CONTENTS

61 GREENWAYS LANDING WETLAND (WETLAND ID. 12724)

61.1 LOCATION AND SETTING DESCRIPTION

Greenways Landing Wetland (Wetland ID. 12724) is situated on the eastern side of the River Murray. The wetland is elongated in shape, approximately 1 kilometre long and 100 metres at its widest, with a total surface area of 6 hectares. The wetland is bounded to the east by a cliff slope and to the west a raised bank and floodplain area that separates it from the river. There is one narrow water connection channel at the northern end of the wetland. At the time when the soil survey was conducted in September 2008, the wetland was dry. One site was described and sampled and the location is shown in Figure 61-1.

Figure 61-1. Greenways Landing Wetland and sample site locations.

61.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

One site was described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 61-1. The wetland location was impossible to locate on the ground and the site was located outside the defined wetland boundary in an area that had more characteristic wetland features. No other sites were located because of the uncertainty of the wetland location. The site and soil profile descriptions are presented in Table 61-2 and Table 61-3.

Site GWL1 (Figure 61-2) occurred at a low elevation area amongst *Muehlenbeckia florulenta (*Lignum*)* vegetation. The soil consisted of light grey, firm, clay, over pale grey, very firm, clay that was too dry and hard to dig below 55 centimetres depth.

Table 61-1. Soil identification, subtype and general location description for Greenways Landing Wetland.

Site ID	Easting m zone 54H	Northing m zone 54H	Acid sulfate soil subtype class	General location description
GWL1	376987	6163710	Other soil	Low elevation

Figure 61-2. Photographs of site GWL1, showing the landscape dominated by *Muehlenbeckia florulenta (*Lignum*)* vegetation, and the soil profile of firm, blocky, clay.

61.3 LABORATORY DATA ASSESSMENT

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

The pH data are provided in Table 61-4 and pH profiles are presented in Figure 61-3.

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.

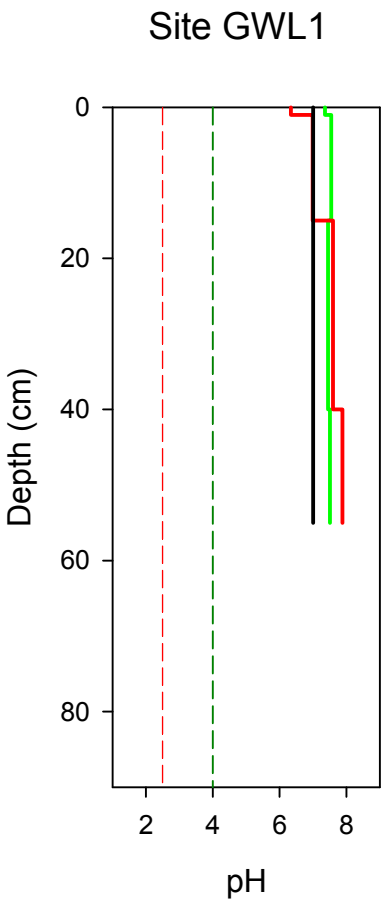

Figure 61-3. Depth profiles of soil pH for Greenways Landing Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data is provided in Table 61-4 and summarised in Figure 61-4.

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

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 0.77 to 9.68 $\%CaCO_3$, and were measured in the all soil layers of the profile.

Net acidity values ranged from -1282 to -103 mole H^+/tonne. Negative net acidity values occurred in all layers of the soil profile.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 61-4 identified that surface layers were above the critical trigger value of 100 mg/kg SO_4.

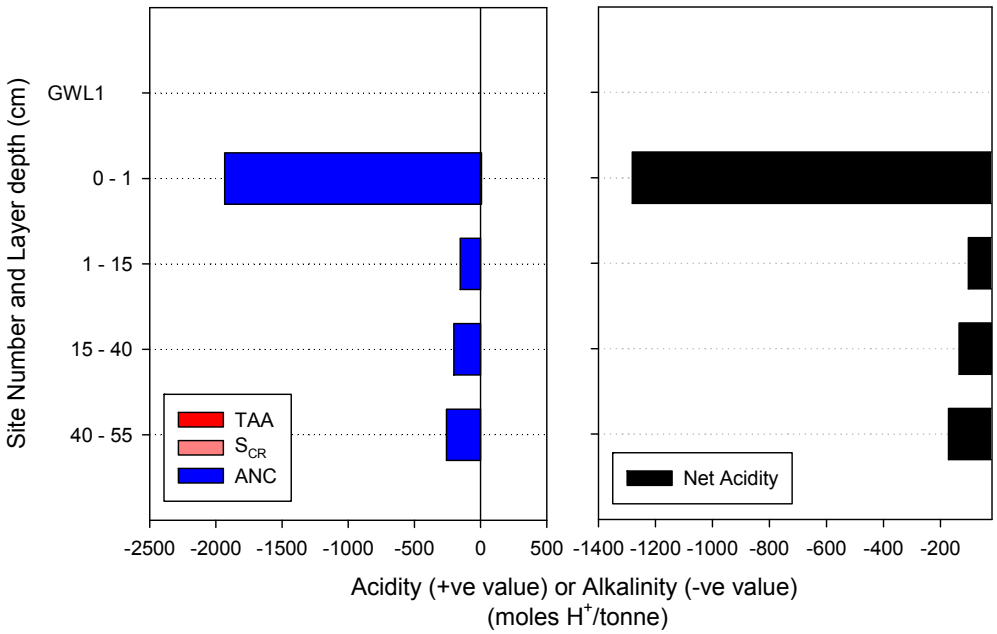

Figure 61-4. Acid base accounting depth profiles for Greenways Landing Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

61.4 DISCUSSION

Acid sulfate soil materials at Greenways Landing Wetland were identified as hyposulfidic for the surface layer and the rest of the samples were characterised as other soil materials. The acid sulfate soil subtype class identified was Other Soil. The 1 centimetre surface layer was too thin to be considered in determining the soil classification and the chromium reducible sulfur value that was at the minimum detection limit.

The soils throughout the wetland were friable, blocky structured clay over very firm, massive clay.

Monosulfidic material was not observed but water soluble sulfate data identified that surface layers for the profile 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 Greenways Landing Wetland are:

- Acidification hazard: The data identified negative net acidity values throughout both profiles, 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 is not likely to increase the solubility of metals. There is a low level of concern.

Summary of key findings for Greenways Landing Wetland:

Soil materials:	Hyposulfidic soil materials were identified in the very thin surface soil layer. The soils throughout were generally friable, blocky structured clay, over very firm, massive, clay. All samples had net acidity values and pH data did not identify potential acidification due to oxidation.
Acid sulfate soil identification:	• Other Soil – that occurred in the 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 61-2. Site data for Greenways Landing 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
GWL1	03-Sep-08	376987	6163710	Other soil	50	sealed, moss	*Muehlenbeckia florulenta (*Lignum*)*	Low elevation

Table 61-3. Soil description data for Greenways Landing 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
GWL1.1	0	1	soil pit	10YR 5/3	clay	moist	0			platy	firm	
GWL1.2	1	15	soil pit	10YR 4/2	clay	moist	0			subangular blocky	friable	
GWL1.3	15	40	soil pit	10YR 4/1	clay	moist	3	5YR 5/8	in matrix	subangular blocky	firm	
GWL1.4	40	55	soil pit	10YR 5/1	clay	moist	0			massive	very firm	

Table 61-4. Laboratory data for acid sulfate soil assessment of Greenways Landing 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
GWL1.1	0 - 1	fine	-	7.36	6.34	7.00	12253	8.41	-	0.01	9.68	-1282	hyposulfidic (S_{CR}<0.10%)
GWL1.2	1 - 15	fine	-	7.55	6.99	7.00	2431	7.56	-	< 0.01	0.77	-103	other soil material
GWL1.3	15 - 40	fine	-	7.45	7.60	7.00	2986	7.91	-	< 0.01	1.02	-135	other soil material
GWL1.4	40 - 55	fine	-	7.51	7.88	7.00	2782	8.03	-	< 0.01	1.29	-172	other soil material

62 PREISS LANDING WETLAND (WETLAND ID. 12109)

62.1 LOCATION AND SETTING DESCRIPTION

Preiss Landing Wetland (Wetland ID. 12109) is situated on the western side of the River Murray. The wetland is geomorphically categorised as a lentic channel (Pressey 1986) and is a thin sliver parallel to the river, approximately 1.5 kilometres in length and 100 to 200 metres wide, with a total surface area of 6 hectares. It is bounded to the west by a road and hill slope and to the east by a raised terrace that separates the wetland from the river. There is one narrow water connection channel with the river at about midway in the wetland. At the time when the soil survey was conducted in August 2008, the wetland had water in the depression channel. The soil surface fringing the water was soft clay and on the slightly elevated locations there was *Phragmites australis* (Common Reed) vegetation. Two sites were described and sampled and their locations are shown in Figure 62-1.

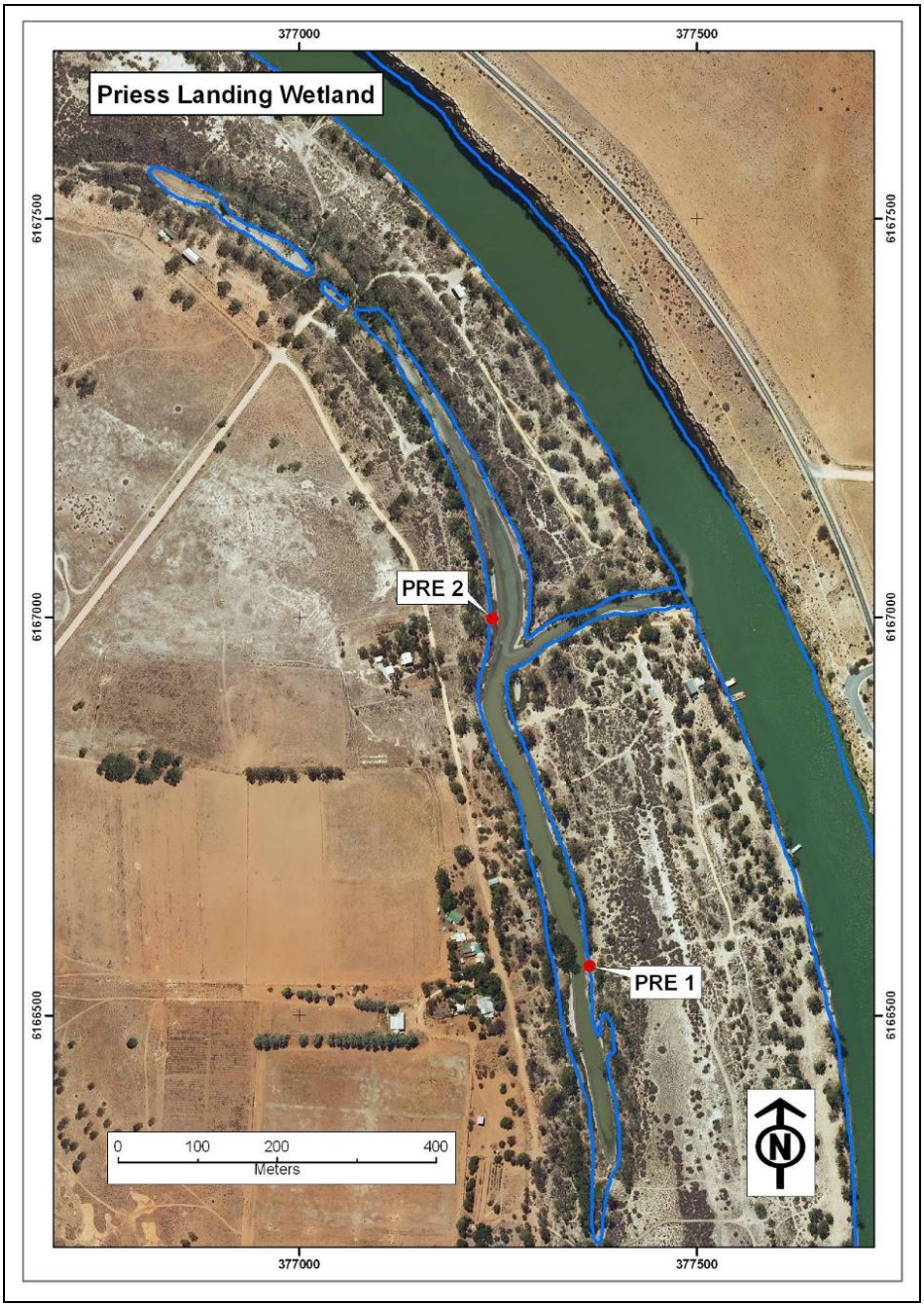

Figure 62-1. Preiss Landing Wetland and sample site locations.

62.2 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 62-1. The sites were located adjacent to the water channels at two locations. The site and soil profile descriptions are presented in Table 62-2 and Table 62-3.

Site PRE1 (Figure 62-2) occurred next to the water in the channel depression, the water table in the pit was about 80 centimetres deep therefore the surface water was not a groundwater window but instead perched above the sealed soft clay surface. The soil consisted of black, friable clay, over a brown to black, soft, peaty clay that had a sulfurous odour.

Site PRE2 (Figure 62-3) occurred where there was *Phragmites australis* (Common Reed) vegetation growing at a slightly higher elevation along the margins of the bare clay surface next to the surface water. The soil consisted of grey, soft clay, over black, firm clay.

Table 62-1. Soil identification, subtype and general location description of sites for Preiss Landing Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
PRE1	377366	6166562	Hyposulfidic cracking clay soil	Low to mid elevation, throughout
PRE2	377243	6166998	Sulfuric soil	Mid to high elevation, margin areas

Figure 62-2. Photographs of site PRE1, showing the site adjacent to the water channel, and the soil profile with no water in it suggesting that the water was perched above the sealed clay surface.

Figure 62-3. Photograph of the soil profile PRE2, showing the soft clay soil.

62.3 LABORATORY DATA ASSESSMENT

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

The pH data are provided in Table 62-4 and pH profiles are presented in Figure 62-4.

The pH_W data for the surface layer of profile PRE2 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 subsoil layer of profile PRE1 and the surface layer of profile PRE2 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.

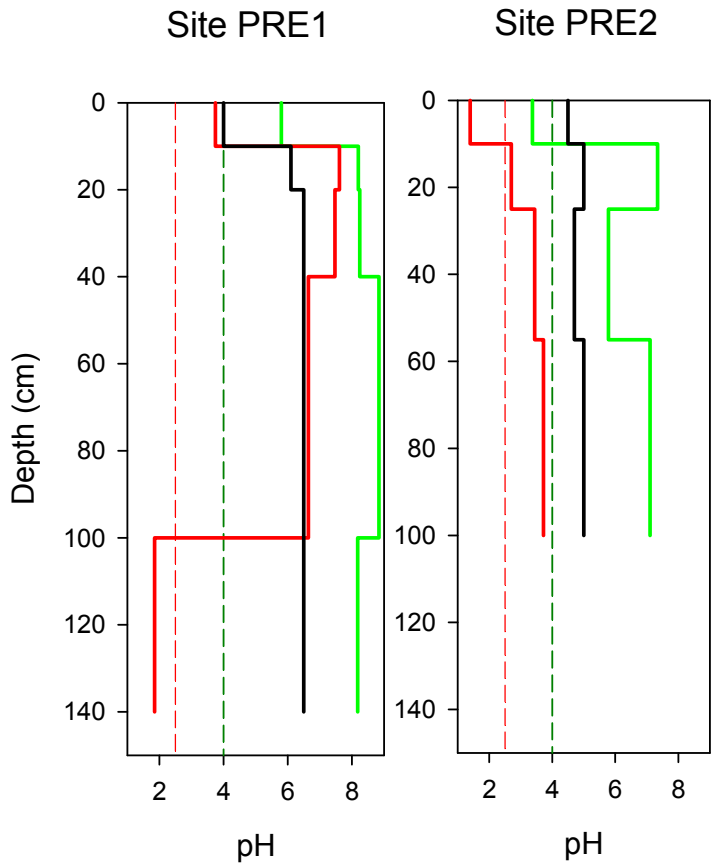

Figure 62-4. Depth profiles of soil pH for Preiss Landing Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data is provided in Table 62-4 and summarised in Figure 62-5.

Chromium reducible sulfur values ranged from below the limit of detection to 0.25 $\%S_{CR}$. Sulfidic materials were detected in the lower subsoil layers of profile PRE1 and the surface layers of profile PRE2.

Titratable actual acidity values ranged from 0 to 13.81 mole H^+/tonne. Concentrations were measured in all layers of profile PRE2 and the surface layer of profile PRE1.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present in the surface layer of profile PRE2 that was below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity values ranged from 0 to 1.18 $\%CaCO_3$, and were measured in layers of profile PRE1 and not detected in layers of profile PRE2.

Net acidity values ranged from -130 to 21 mole H^+/tonne. Low net acidity values occurred in the surface layer of profile PRE1 and negative values in layers below. Moderate net acidity value occurred in the surface layer of profile PRE2 and low net acidity values in the layers below.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 62-4 identified that surface layers were above the trigger value of 100 mg/kg SO_4.

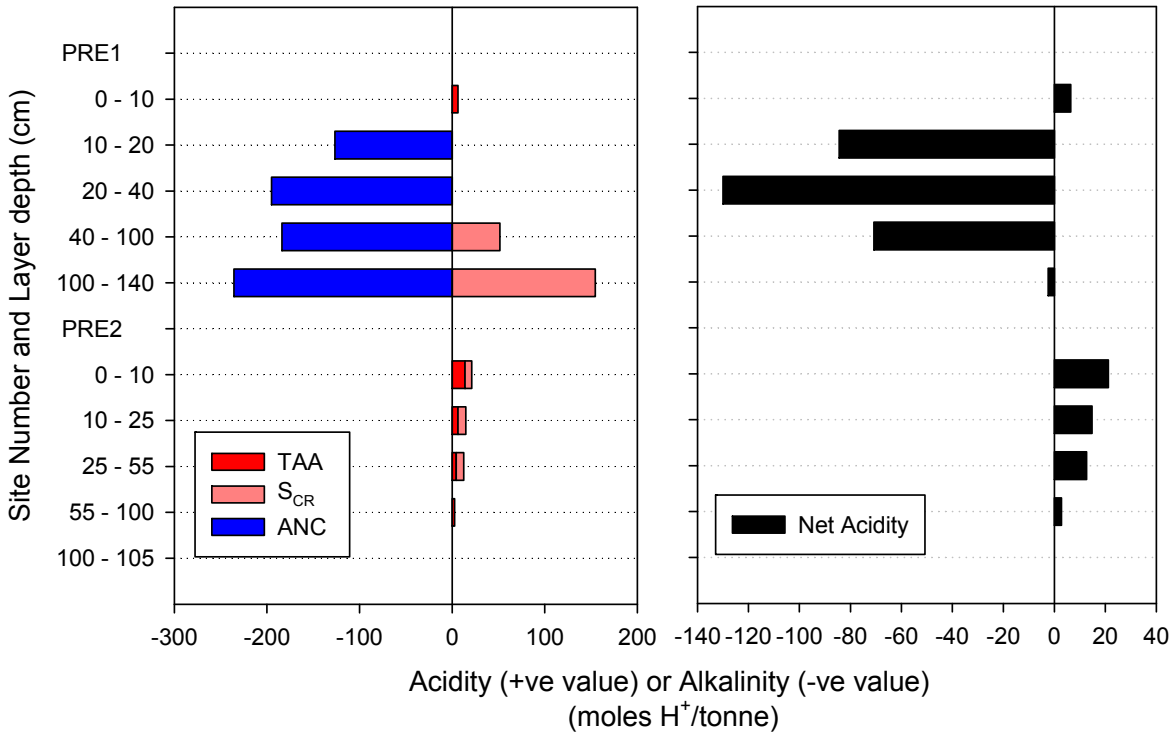

Figure 62-5. Acid base accounting depth profiles for Preiss Landing Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

62.4 DISCUSSION

Acid sulfate soil materials at Preiss Landing Wetland were identified as sulfuric on the wetland margins associated with sandy surface soils. Other soil layers were characterised as hyposulfidic or acidic.

The soils on the margin of the water channel were a 10 cm deep sandy surface over clay. The water in the channel was from the connection with the river and the continued linkage has probably assisted with maintaining an absence of acid sulfate soil materials by refreshing the wetland waters to neutralise what acidity forms.

Soils on the margin of the wetland were dry in the upper layers and have sulfuric material, indicating that if the wetland water level drops further, then potentially more sulfuric material could form.

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

- Acidification hazard: Sulfuric soil material would form in the surface layer if it was allowed to dry and oxidise but the acidity capacity was low because the material was sandy and the continual refreshing of the water is likely to neutralise what acidity develops. There is a 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 hazard: 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 Preiss Landing Wetland:

Soil materials:	The sandy surface layer and clay subsoil layers for the main area of the wetland adjacent to the water channel were as hyposulfidic or other soil materials. On the high elevation areas of the wetland that had dried there was a sulfuric sandy surface in isolated areas.
Acid sulfate soil identification:	• Hyposulfidic Cracking Clay Soil – that occurred throughout the wetland at lower elevation and associated with the inlet channel. Dominant (>50%) in extent. • Sulfuric Soil – that occurred on the higher elevation sandy margins. Minor (<25%) in extent.
Hazard assessment	• Acidification hazard – medium level of concern • De-oxygenation hazard – high level of concern • Metal mobilisation hazard – medium level of concern

Table 62-2. Site data for Preiss Landing 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
PRE1	28-Aug-08	377366	6166562	Hyposulfidic cracking clay soil	80	soft, crust	Bare	low, near down river water inlet,
PRE2	28-Aug-08	377243	6166998	Sulfuric soil	not reached	loose, sand	*Phragmites australis* (Common Reed)	high, up from water,

Table 62-3. Soil description data for Preiss Landing 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
PRE1.1	0	10	soil pit	2.5Y 5/1	loamy sand	moist	10	2.5Y 6/6	in matrix	single grain	very friable	
PRE1.2	10	20	soil pit	2.5Y 4/1	clay	moist	10	2.5Y 6/6	in matrix	subangular blocky	friable	
PRE1.3	20	40	soil pit	2.5Y 2.5/1	clay	moist	0			subangular blocky	firm	
PRE1.4	40	100	soil pit	2.5Y 2.5/1	clay	moist	0			massive	firm	
PRE1.5	100	140	push tube	2.5Y 2.5/1	clay	wet	0			massive	firm	contains plant material, sulphurous odour
PRE2.1	0	10	soil pit	2.5Y 6/2	sand	moist	10	2.5Y 6/6	in matrix	single grain	loose	
PRE2.2	10	25	soil pit	2.5Y 3/1	clay	moist	20	2.5Y 6/6	in matrix adjacent to pores	massive	very soft	
PRE2.3	25	55	soil pit	2.5Y 4/1	clay	moist	10	2.5Y 6/6	in matrix along ped faces	massive	firm	
PRE2.4	55	100	push tube	2.5Y 2.5/1	clay	moist	0			massive	very firm	
PRE2.5	100	105	push tube	2.5Y 4/2	sand	moist	0			massive	loose	

Table 62-4. Laboratory data for acid sulfate soil assessment of Preiss Landing 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
PRE1.1	0 - 10	Coarse	-	5.80	3.75	4.00	256	5.14	6.41	< 0.01	0.00	6	other acidic
PRE1.2	10 - 20	Fine	-	8.20	7.61	6.10	175	6.66	-	< 0.01	0.63	-84	other soil material
PRE1.3	20 - 40	Fine	-	8.24	7.47	6.50	129	6.74	-	< 0.01	0.98	-130	other soil material
PRE1.4	40 - 100	Fine	-	8.84	6.64	6.50	208	7.58	-	0.08	0.92	-71	hyposulfidic (S_{CR}<0.10%)
PRE1.5	100 - 140	Fine	-	8.18	1.85	6.50	676	7.18	-	0.25	1.18	-2	hyposulfidic (S_{CR}≥0.10%)
PRE2.1	0 - 10	Coarse	-	3.37	1.40	4.50	336	4.24	13.81	0.01	0.00	21	sulfuric
PRE2.2	10 - 25	Fine	-	7.34	2.70	5.00	972	5.56	6.42	0.01	0.00	15	hyposulfidic (S_{CR}<0.10%)
PRE2.3	25 - 55	Fine	-	5.78	3.44	4.70	697	5.60	4.44	0.01	0.00	13	hyposulfidic (S_{CR}<0.10%)
PRE2.4	55 - 100	Fine	-	7.10	3.72	5.00	198	5.92	2.77	< 0.01	0.00	3	other acidic
PRE2.5	100 - 105	Coarse	-	-	-	-	-	-	-	-	-	-	-

63 HENLEY PARK WETLAND (WETLAND ID. 12045)

63.1 LOCATION AND SETTING DESCRIPTION

Henley Park Wetland (Wetland ID. 12045) is situated on the south western side of the River Murray. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is an irregular shape, approximately 1.2 kilometres in length and approximately 300 metres at the widest, with a total surface area of 22 hectares. It is bounded to the south by hill slope and on the other sides by a raised terrace 100 to 200 metres wide that separates it from the river. There was one narrow water connection channel with the river at the down-river end. At the time when the soil survey was conducted in August 2008, the wetland was generally dry with water in the deep cracks of some areas. The wetland had bare, cracking clay surfaces with large intact columns throughout, the cracks were filled with encroaching sand towards the wetland edges, and on the wetland margins were isolated areas of *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed) vegetation, and trees on the raised terrace. Two sites were described and sampled and their locations are shown in Figure 63-1.

Figure 63-1. Henley Park Wetland and sample site locations.

63.2 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 63-1. The sites were located to characterise the two main features of the wetland, clay soils with deep cracks at a low elevation near the centre of the wetland (HEN1), and clay soils with cracks filled with sand at the mid to high elevation on the sides of the wetland (HEN2). The site and soil descriptions are presented in Table 63-2 and Table 63-3.

Site HEN1 (Figure 63-2) occurred at low elevation near the middle where the surface was bare and there were many large and deep cracks. The soil consisted of grey, soft clay, over black, firm clay, with sand in cracks.

Site HEN2 (Figure 63-3) occurred at low to mid elevation on the side of the wetland where sand has completely filled the cracks to form a sealed surface. The soil consisted of black, soft clay over grey, firm clay with lenses of sand throughout and in-filling the cracks.

Table 63-1. Soil identification, subtype and general location description of sites for Henley Park Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
HEN1	376254	6167513	Sulfuric cracking clay soil	Low to mid elevation, cracking clay soil areas near the middle
HEN2	376193	6167591	Other acidic soil (cracking clay)	Mid to high elevation, where sand has filled soil cracks

Figure 63-2. Photographs of site HEN1, showing the main wetland area of cracking surface formed by large columns, and the soil profile with deep cracks extending into the subsoil.

Figure 63-3. Photographs of site HEN2, showing the landscape across the wetland from the side where the cracks were filled with sand to the wetland centre where the cracks were not filled with encroaching sand, and the soil profile of clay and sand in the cracks.

63.3 LABORATORY DATA ASSESSMENT

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

The pH data are provided in Table 63-4 and pH profiles are presented in Figure 63-4.

The pH_W data for the thin (2 cm) surface layers of both profiles identified samples as sulfuric materials with a pH_W <4.

The pH_{INC} data for some layers in 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 some 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.

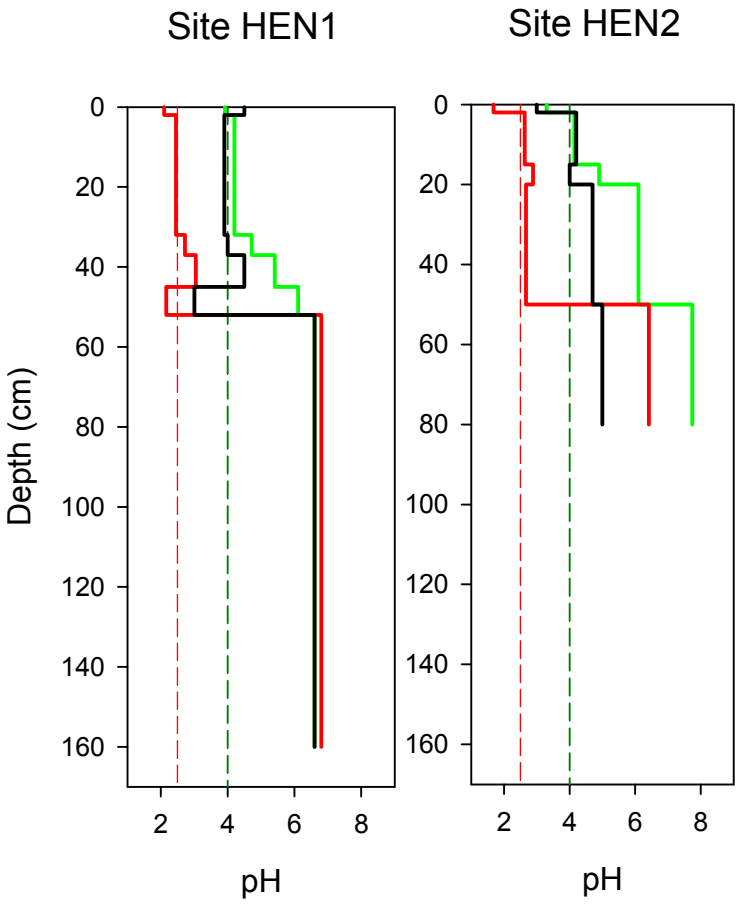

Figure 63-4. Depth profiles of soil pH for Henley Park Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

Acid base accounting data is provided in Table 63-4 and summarised in Figure 63-5.

Chromium reducible sulfur values ranged from below the limit of detection to 0.07 %S_{CR}. Sulfidic materials were identified in the surface layers of profile HEN1 and all layers in HEN2 were below the detection limit.

Titratable actual acidity values ranged from 2.09 to 55.55 mole H^+/tonne. Concentrations were measured in all sampled layers.

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

Acid neutralising capacity was not measured in any of the soil layers.

Net acidity values ranged from 2 to 93 mole H^+/tonne. High net acidity values occurred in surface layers and low values occurred in the subsoils.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 63-4 identified that surface layers were above the trigger value of 100 mg/kg SO_4.

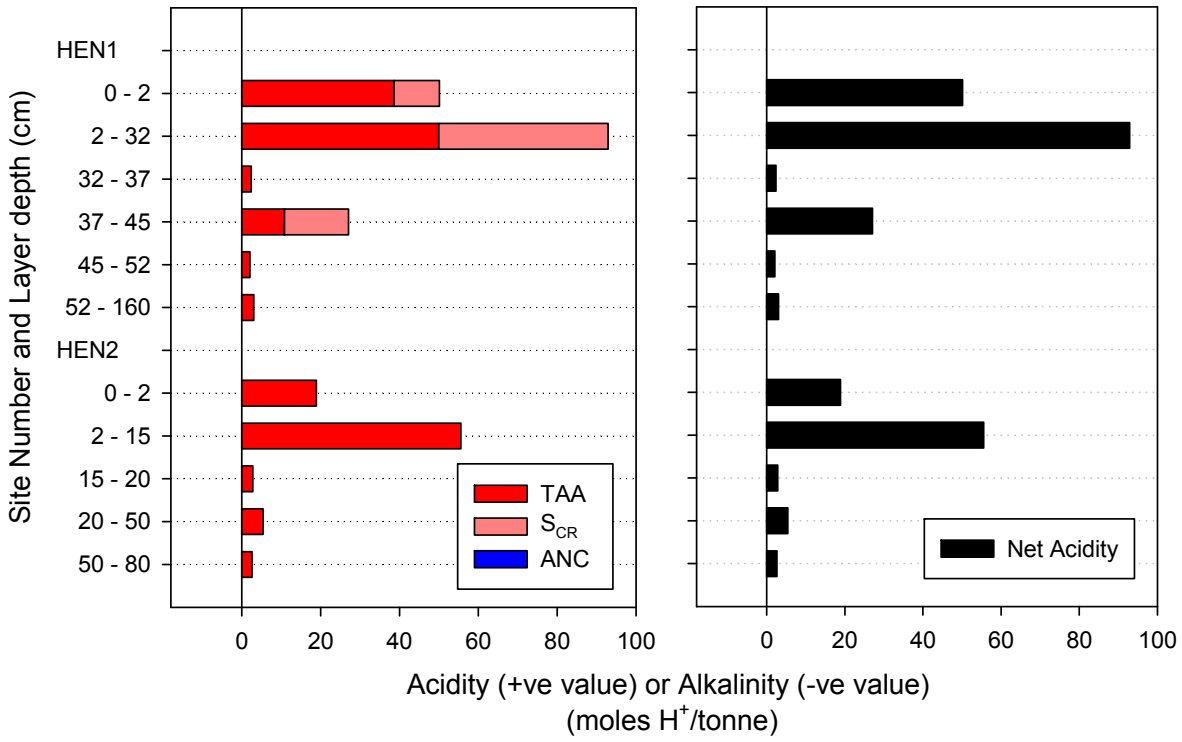

Figure 63-5. Acid base accounting depth profiles for Henley Park Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

63.4 DISCUSSION

Acid sulfate soil materials at Henley Park Wetland were identified as sulfuric that occurred as a thin surface layer. The subsurface and subsoil layers were hyposulfidic near the centre of the wetland and progressed to other acidic materials toward the wetland margins.

The soils were clayey and characterised by very large soil cracks that extended deep into the subsoil. The soil cracks in the centre of the wetland were open, and the cracks became progressively more filled with sand towards the margins. About half way between the wetland centre and the margins the soil cracks were completely filled and the surface was somewhat sealed.

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

- Acidification hazard: The sulfuric layer was thin and the underlying soil was hyposulfidic for the main area of the wetland. There is potential for the sulfuric layer to become thicker if the water table declines allowing the soil to oxidise. There is a 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, although monosulfidic material was not observed. There is a high 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 Henley Park Wetland:

Soil materials:	These soils were characterised by the very large and deep soil cracks that extended into the clay subsoils, the cracks progressively became filled with sand toward the wetland margins. There was a thin (2 cm) surface layer of sulfuric material throughout the wetland. The subsurface and subsoil layers were hyposulfidic near the centre of the wetland and progressed to acidic soil materials toward the wetland margins.
Acid sulfate soil identification:	• Sulfuric Cracking Clay Soil – that occurred throughout the wetland. Dominant (>50%) in extent. • Cracking Clay Soil – that occurred near the margins of the wetland. Subdominant (<50%) in extent.
Hazard assessment	• Acidification hazard – medium level of concern • De-oxygenation hazard – high level of concern • Metal mobilisation hazard – medium level of concern

Table 63-2. Site data for Henley Park 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
HEN1	26-Aug-08	376254	6167513	Sulfuric cracking clay soil	55	cracking	Bare	mid, hard set cap on columns, with 20cm deep cracks
HEN2	26-Aug-08	376193	6167591	Other acidic soil (cracking clay)	not reached	sealed, soft	Bare	low, sand in-fill of cracks and on surface

Table 63-3. Soil description data for Henley Park 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
HEN1.1	0	2	soil pit	10YR 4/1	clay	dry	0			massive	hard	
HEN1.2	2	32	soil pit	10YR 4/2	clay	moist	10	7.5YR 5/8	in matrix	massive	soft	
HEN1.3	32	37	soil pit	10YR 5/3	sand	moist	3	7.5YR 5/8	in matrix	single grain	loose	
HEN1.4	37	45	soil pit	10YR 2/1	clay	moist	15	7.5YR 5/8	in matrix	massive	firm	
HEN1.5	45	52	soil pit	10YR 6/3	sand	moist	0			single grain	loose	
HEN1.6	52	160	push tube	10YR 3/1	clay	wet	0			massive	firm	
HEN2.1	0	2	soil pit	10YR 6/2	sandy clay loam	dry	0			massive	soft	
HEN2.2	2	15	soil pit	10YR 4/1	clay	dry	0			massive	soft	
HEN2.3	15	20	soil pit	10YR 5/3	loamy sand	dry	15	7.5YR 5/8	in matrix along ped faces	single grain	loose	
HEN2.4	20	50	soil pit	10YR 3/1	sandy clay loam	moist	3	7.5YR 5/8	in matrix	massive	firm	
HEN2.5	50	80	push tube	10YR 3/1	clay	moist	0			massive	firm	

Table 63-4. Laboratory data for acid sulfate soil assessment of Henley Park 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
HEN1.1	0 - 2	Fine	-	3.92	2.10	4.50	3989	4.28	38.65	0.02	0.00	50	sulfuric
HEN1.2	2 - 32	Fine	-	4.20	2.45	3.90	5158	4.02	49.96	0.07	0.00	93	hyposulfidic (S_{CR}<0.10%)
HEN1.3	32 - 37	Coarse	-	4.72	2.72	4.00	216	5.33	2.39	< 0.01	0.00	2	other acidic
HEN1.4	37 - 45	Fine	-	5.41	3.05	4.50	1030	5.11	10.84	0.03	0.00	27	hyposulfidic (S_{CR}<0.10%)
HEN1.5	45 - 52	Coarse	-	6.11	2.16	3.00	217	5.85	2.09	< 0.01	0.00	2	other acidic
HEN1.6	52 - 160	Fine	-	6.60	6.80	6.60	365	6.23	3.03	< 0.01	0.00	3	other soil material
HEN2.1	0 - 2	Medium	-	3.30	1.68	3.00	8173	4.23	18.88	< 0.01	0.00	19	sulfuric
HEN2.2	2 - 15	Fine	-	4.14	2.63	4.20	3144	3.85	55.55	< 0.01	0.00	56	other acidic
HEN2.3	15 - 20	Coarse	-	4.90	2.89	4.00	332	5.80	2.81	< 0.01	0.00	3	other acidic
HEN2.4	20 - 50	Medium	-	6.10	2.67	4.70	345	5.48	5.40	< 0.01	0.00	5	other acidic
HEN2.5	50 - 80	Fine	-	7.74	6.42	5.00	104	6.17	2.59	< 0.01	0.00	3	other acidic

64 BIG BEND WETLAND (WETLAND ID. 12328)

64.1 LOCATION AND SETTING DESCRIPTION

Big Bend wetland (Wetland ID. 12328) is situated on the north-western side of the River Murray. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is a linear shape, approximately 2.5 kilometres in length and approximately 250 metres at its widest, with a total surface area of 48 hectares. The wetland is bounded to the west by a cliff and hill slope and to the east by a raised floodplain area up to 100 metres wide that separates it from the river. There is a narrow water connection channel with the river at the southern end. At the time when the soil survey was conducted in September 2008, the wetland was dry and there was no surface water. The wetland had a sealed friable soil surface, and plants grew throughout with areas of *Persicaria lapathifolium* (Pale Knotweed) near the centre, isolated areas of *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed) on the margins and trees on the surrounding floodplain areas. Three sites were described and sampled and their locations are shown in Figure 64-1.

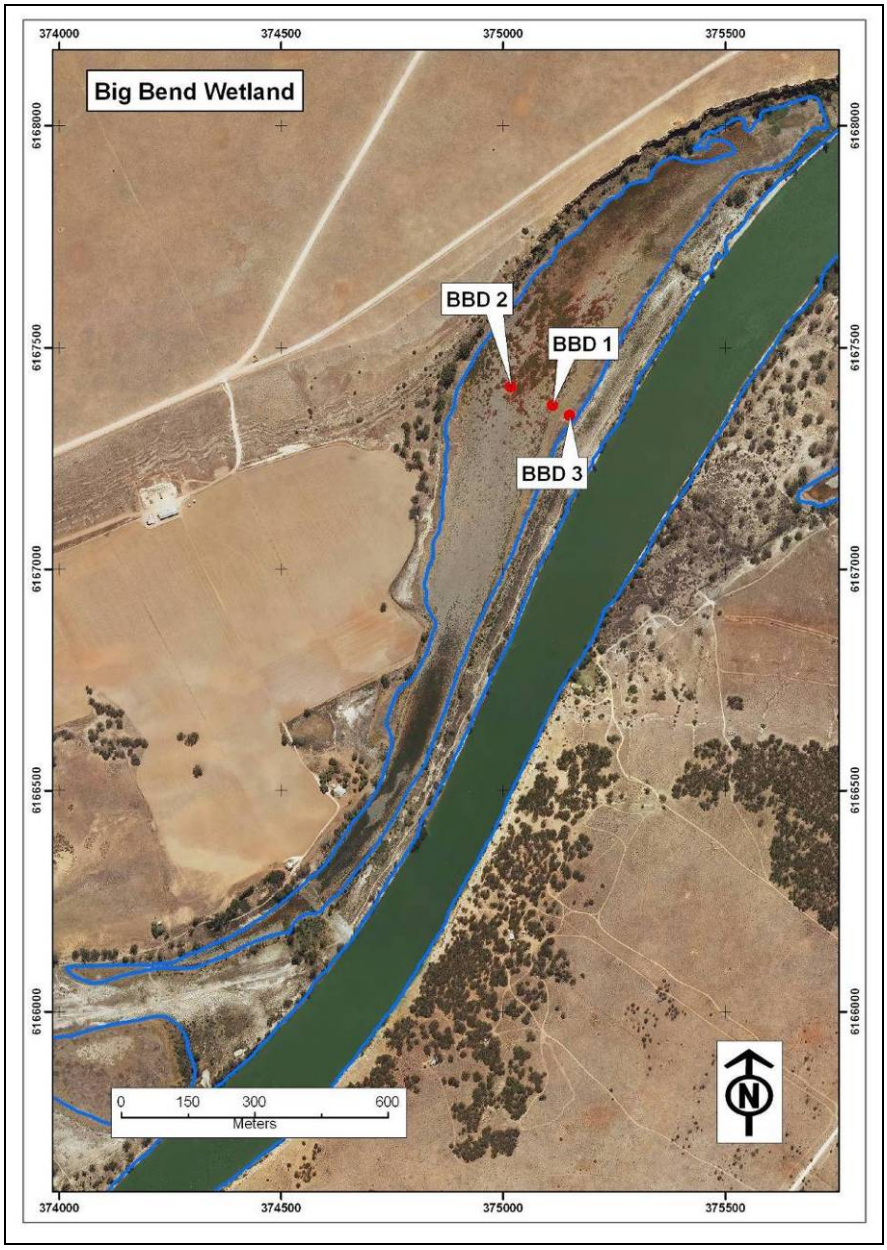

Figure 64-1. Big Bend Wetland and sample site locations.

64.2 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 64-1. The sites were located to form one transect through the wetland, from a mid elevation area near the river side (BBD3), to the main wetland area (BBD1), to the higher elevation margin areas (BBD2). The site and profile descriptions are presented in Table 64-2 and Table 64-3.

Site BBD1 (Figure 64-2) occurred in the main wetland area where a mix of vegetation was growing on what was generally a bare surface. The soil consisted of black, very firm, clay, over black, rigid, clay that became too difficult to dig below 50 centimetres depth.

Site BBD2 (Figure 64-3) occurred on margin area where *Persicaria lapathifolium* (Pale Knotweed) was growing. The soil consisted of black, very firm, clay, over black, rigid, clay that became too difficult to dig below 60 centimetres depth.

Site BBD3 (Figure 64-4) occurred on the wetland margin on the river side of the wetland where *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed) were growing. The soil consisted of brown, firm, clay loam, over dark grey, firm, clay.

Table 64-1. Soil identification, subtype and general location description for Big Bend Wetland.

Site ID	Easting m zone 54H	Northing m zone 54H	Acid sulfate soil subtype class	General location description
BBD1	375112	6167369	Other soil	Low elevation, where surface is sealed
BBD2	375018	6167411	Hyposulfidic soil	Mid elevation
BBD3	375150	6167346	Other soil	Mid elevation

Figure 64-2. Photographs of site BBD1, showing the landscape across the main wetland area with some vegetation growing, and the soil profile of friable, cloddy clay over slightly rigid, blocky, clay.

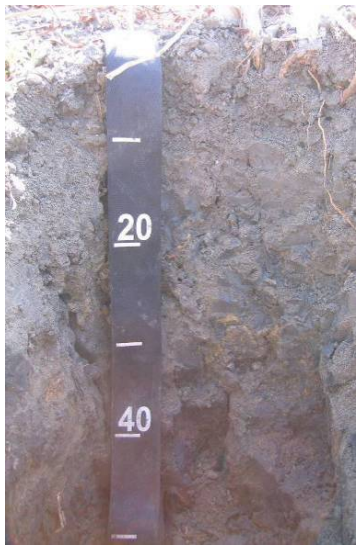

Figure 64-3. Photographs of site BBD2, showing the wetland margin where *Persicaria lapathifolium* (Pale Knotweed)was growing, and the soil profile of slightly rigid, blocky grading to massive clay.

Figure 64-4. Photograph of site BBD3, showing the landscape near the river side margin of the wetland where rushes had fallen over and died.

64.3 LABORATORY DATA ASSESSMENT

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

The pH data are provided in Table 64-4 and pH profiles are presented in Figure 64-5.

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.

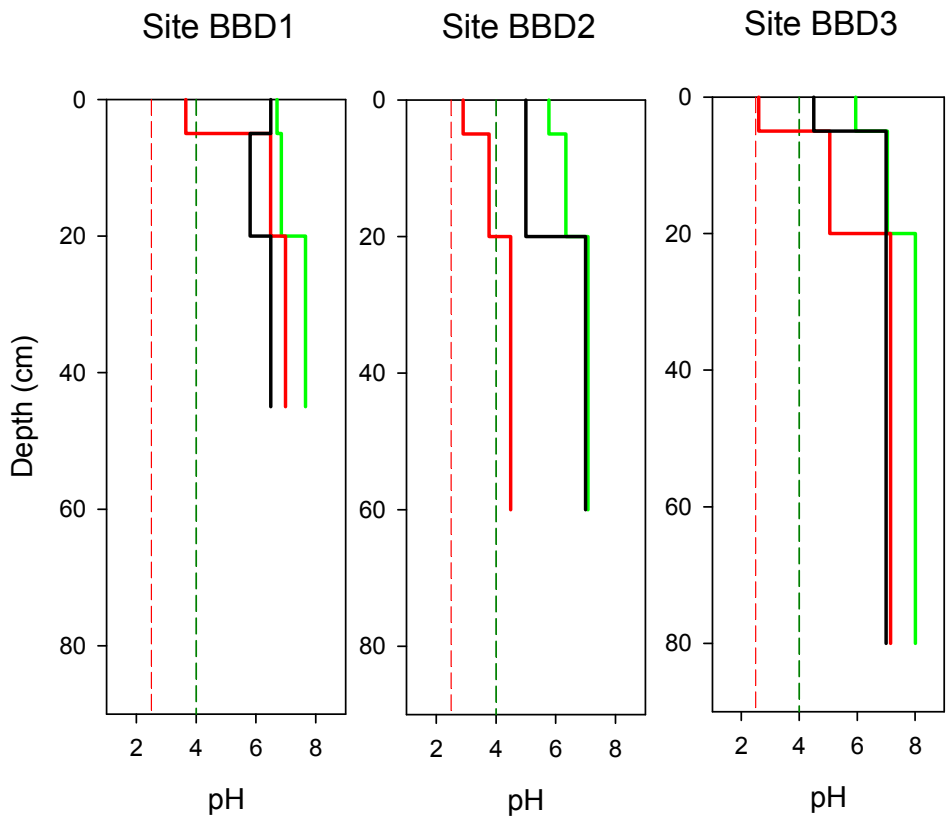

Figure 64-5. Depth profiles of soil pH for Big Bend Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data is provided in Table 64-4 and summarised in Figure 64-6.

Chromium reducible sulfur values ranged from below the limit of detection to 0.01%S_{CR}. Sulfidic materials were detected in the subsoil layer of BBD2.

Titratable actual acidity values ranged from 0 to 11.84 mole H^+/tonne.

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 0 to 1.12 %$CaCO_3$, and were measured in the subsoil layers of profiles BBD1 and BBD3 and the surface layer of BBD1.

Net acidity values ranged from -149 to 15 mole H^+/tonne. Negative or low net acidity values occurred in all layers of the soil profiles.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 64-4 identified that surface layers were above the critical trigger value of 100 mg/kg SO_4.

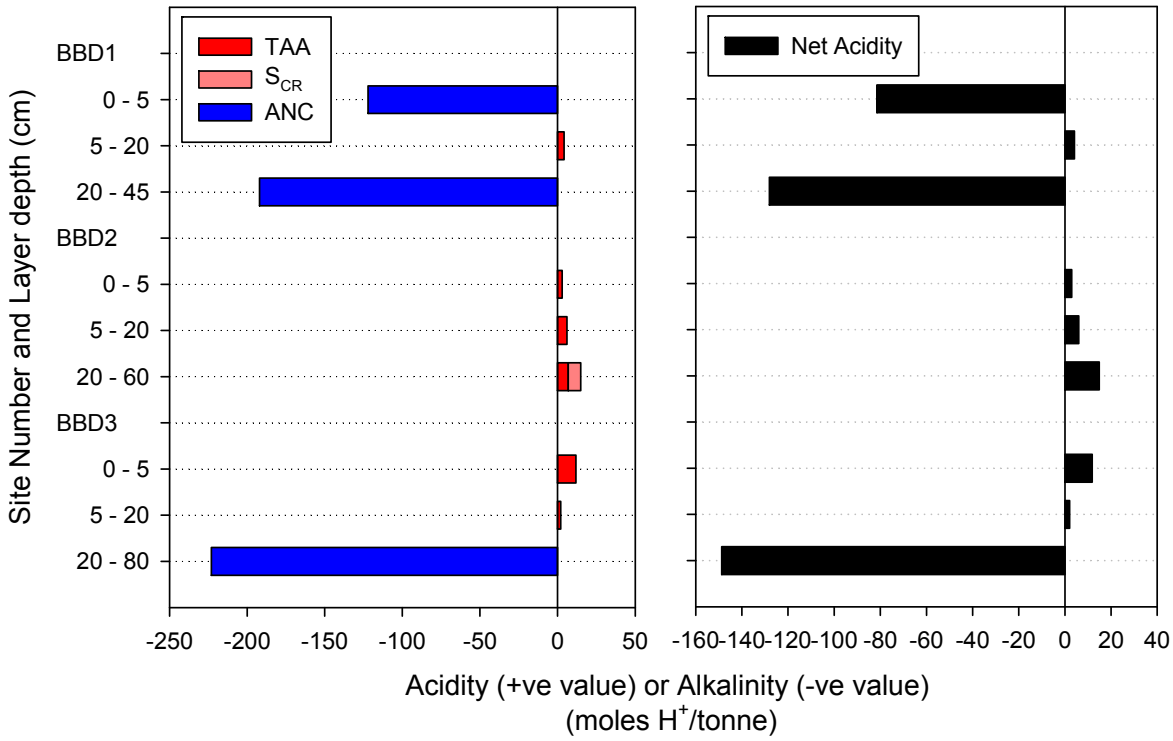

Figure 64-6. Acid base accounting depth profiles for Big Bend Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

64.4 DISCUSSION

Acid sulfate soil materials at Big Bend Wetland were identified as hyposulfidic in the subsoil layer of BBD2, and the rest of the samples were characterised as other acidic or other soil materials. The acid sulfate soil subtype classes identified were Other Soil and Hyposulfidic Soil.

The soils throughout the wetland were generally friable, cloddy, loams in the surface layers over slightly rigid, massive clay.

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 Big Bend Wetland are:

- Acidification hazard: The data identified low or negative net acidity values throughout all profiles, 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 is not likely to increase the solubility of metals. There is a low level of concern.

Summary of key findings for Big Bend Wetland:

Soil materials:	Hyposulfidic soil materials were identified in one subsoil layer, and the remaining soil layers were characterised as other acidic or other soil materials. The soils throughout were generally friable, cloddy, loams in the surface layers over slightly rigid, massive clay. Samples had negative or low net acidity values and pH data did not identify potential acidification due to oxidation.
Acid sulfate soil identification:	• Other Soil – that occurred in the lower elevation main areas of the wetland. Dominant (>50%) in extent. • Hyposulfidic Soil – that occurred on the margins 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 64-2. Site data for Big Bend 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
BBD1	03-Sep-08	375112	6167369	Other soil	Not reached	sealed, friable	mixed	Mid elevation
BBD2	03-Sep-08	375018	6167411	Hyposulfidic soil	Not reached	sealed	*Persicaria lapathifolium* (Pale Knotweed)	Low elevation, where surface is sealed
BBD3	03-Sep-08	375150	6167346	Other soil	Not reached	plant material	Bulrushes	High elevation

Table 64-3. Soil description data for Big Bend 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
BBD1.1	0	5	soil pit	10YR 5/2	clay loam	moist	0			cloddy	friable	
BBD1.2	5	20	soil pit	10YR 2/1	clay	moist	30	10YR 6/8	on ped faces	subangular blocky	very firm	
BBD1.3	20	45	soil pit	10YR 2/1	clay	moist	0			subangular blocky	slightly rigid	too hard to auger below this layer
BBD2.1	0	5	soil pit	10YR 5/2	clay loam	moist	0			cloddy	friable	
BBD2.2	5	20	soil pit	10YR 2/1	clay	moist	30	10YR 6/8	on ped faces	subangular blocky	very firm	
BBD2.3	20	60	soil pit	10YR 2/1	clay	moist	3	10YR 8/1	in matrix	massive	slightly rigid	too hard to auger below this layer; white salts on surface
BBD3.1	0	5	soil pit	5YR 4/2	peat	moist	0			massive	friable	
BBD3.2	5	20	soil pit	10YR 4/2	clay loam	moist	15	10YR 6/8	on ped faces	subangular blocky	very firm	
BBD3.3	20	80	soil pit	10YR 3/1	clay	moist	0			massive	firm	too hard to auger below this layer

Table 64-4. Laboratory data for acid sulfate soil assessment of Big Bend 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
BBD1.1	0 - 5	medium	-	6.71	3.65	6.50	615	6.63	-	< 0.01	0.61	-81	other soil material
BBD1.2	5 - 20	fine	-	6.85	6.49	5.80	271	6.05	4.17	< 0.01	-	4	other soil material
BBD1.3	20 - 45	fine	-	7.66	6.99	6.50	74	6.66	-	< 0.01	0.96	-128	other soil material
BBD2.1	0 - 5	medium	-	5.77	2.90	5.00	1344	6.00	3.00	< 0.01	-	3	other acidic incubation
BBD2.2	5 - 20	fine	-	6.34	3.77	5.00	915	5.79	6.03	< 0.01	-	6	other acidic incubation
BBD2.3	20 - 60	fine	-	7.08	4.49	7.00	418	5.52	6.91	0.01	-	15	hyposulfidic (S_{CR}<0.10%)
BBD3.1	0 - 5	medium	-	5.95	2.60	4.50	1580	5.32	11.84	< 0.01	-	12	other acidic incubation
BBD3.2	5 - 20	medium	-	7.04	5.05	7.00	421	6.41	2.07	< 0.01	-	2	other soil material
BBD3.3	20 - 80	fine	-	8.01	7.15	7.00	261	6.86	-	< 0.01	1.12	-149	other soil material

65 PUNYELROO WETLAND (WETLAND ID. 12044)

65.1 LOCATION AND SETTING DESCRIPTION

Punyelroo Wetland (Wetland ID. 12044) is situated on the western side of the River Murray, up river from Big Bend location on the river. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is somewhat rectangular in shape that follows the curve of the river, approximately 3.5 kilometres in length and up to 500 metres at its widest, with a total surface area of 125 hectares. The wetland is bounded to the west by cliffs and to the east by a floodplain area that is approximately 130 to 200 metres wide. There is a water connection channel with the river at the southern end of the wetland. At the time when the soil survey was conducted in August 2008, the wetland was dry. The wetland had no vegetation growing on it except for a few isolated areas. Two sites were described and sampled and their locations are shown in Figure 65-1.

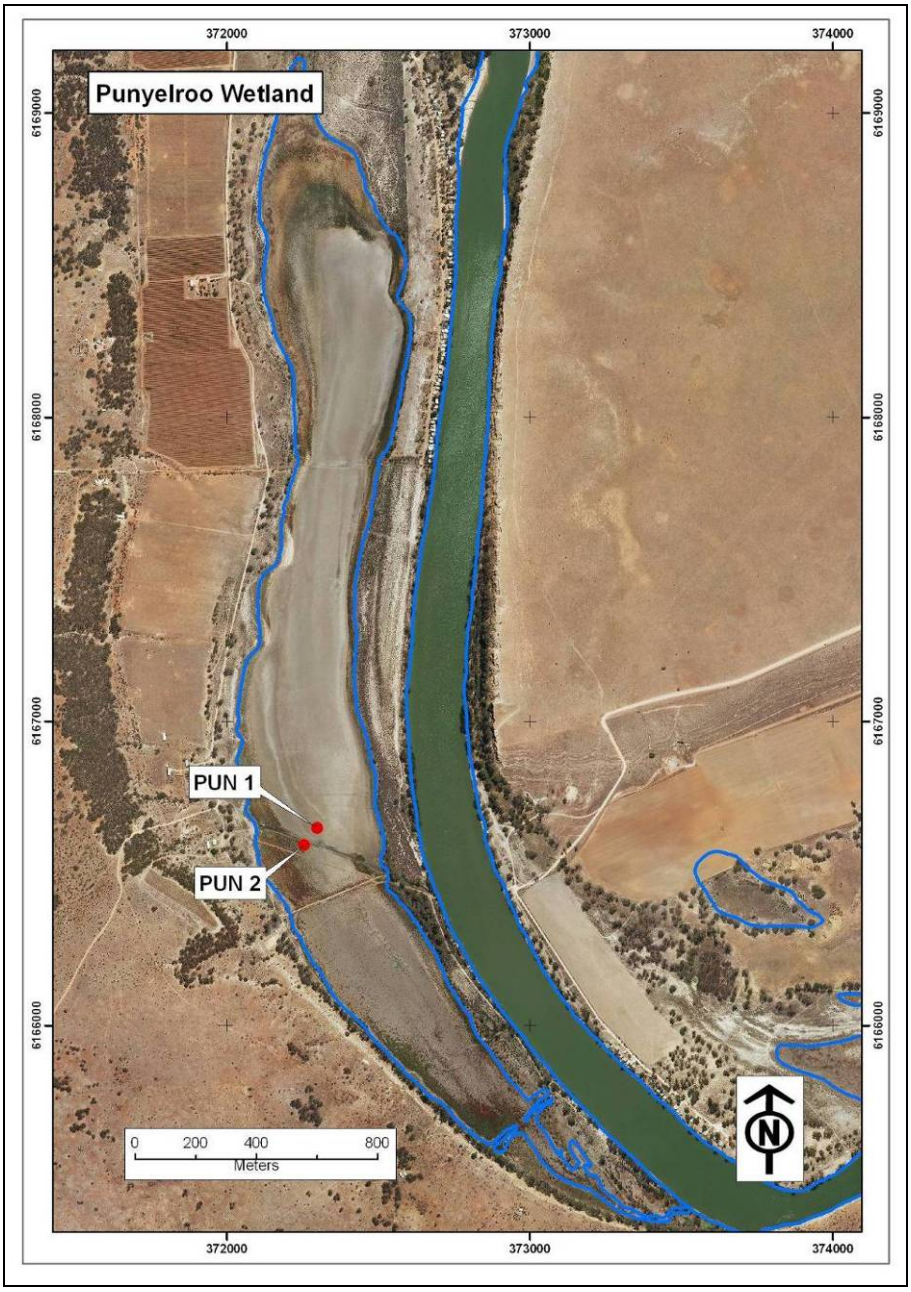

Figure 65-1. Punyelroo Wetland and sample site locations.

65.2 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 65-1. Sites were located to characterise the two main wetland features, where no vegetation was growing in the main area (PUN1) and near the wetland margin where vegetation was growing (PUN2). The site and soil profile descriptions are presented in Table 65-2 and Table 65-3.

Site PUN1 (Figure 65-2) occurred near the middle of the wetland where no vegetation was growing and the surface was firm and sealed. The soil consisted of black, very firm, clay.

Site PUN2 (Figure 65-3) occurred near the side of the wetland where some vegetation was growing. The soil consisted of black, very firm, clay, over black, rigid, clay that became too dry and difficult to dig below 30 centimetres.

Table 65-1. Soil identification, subtype and general location description of sites for Punyelroo Wetland.

Site ID	Easting m zone 54H	Northing m zone 54H	Acid sulfate soil subtype class	General location description
PUN1	372298	6166648	Hyposulfidic soil	Low elevation
PUN2	372256	6166592	Other acidic	Mid elevation, on sealed surface and 20m from bare surface area

Figure 65-2. Photographs of site PUN1, showing the main wetland area where no vegetation was growing on the sealed soil surface, and the soil profile of black, very firm, clay.

Figure 65-3. Photographs of site PUN2, showing the wetland margin where vegetation was growing, and the soil profile of black, very firm, clay that became too hard to dig.

65.3 LABORATORY DATA ASSESSMENT

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

The pH data are provided in Table 65-4 and pH profiles are presented in Figure 65-4.

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.

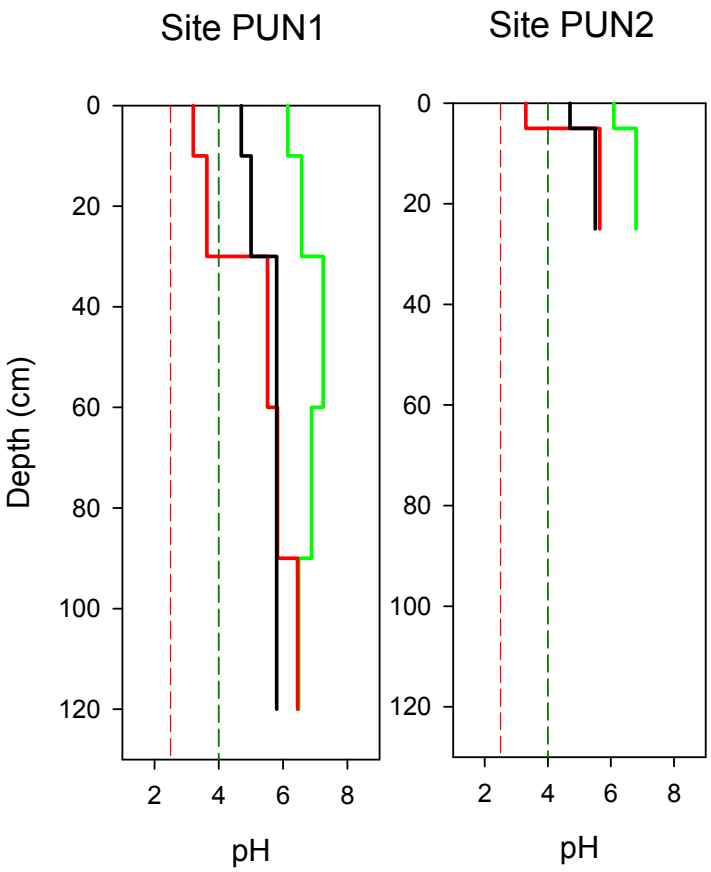

Figure 65-4. Depth profiles of soil pH for Punyelroo Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data is provided in Table 65-4 and summarised in Figure 65-5.

Chromium reducible sulfur values ranged from below the limit of detection to 0.01 $\%S_{CR}$. Sulfidic materials were detected at the limit of detection in the surface layer of profile PUN1 that characterised the main wetland area.

Titratable actual acidity values ranged from 3.09 to 13.81 mole H^+/tonne.

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 was not detected in any of the samples.

Net acidity values ranged from 3 to 22 mole H^+/tonne. Low net acidity values occurred in all layers of both soil profiles with the exception of the surface layer in profile PUN1 which was moderate.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 65-4 identified that surface layers were above the critical trigger value of 100 mg/kg SO_4.

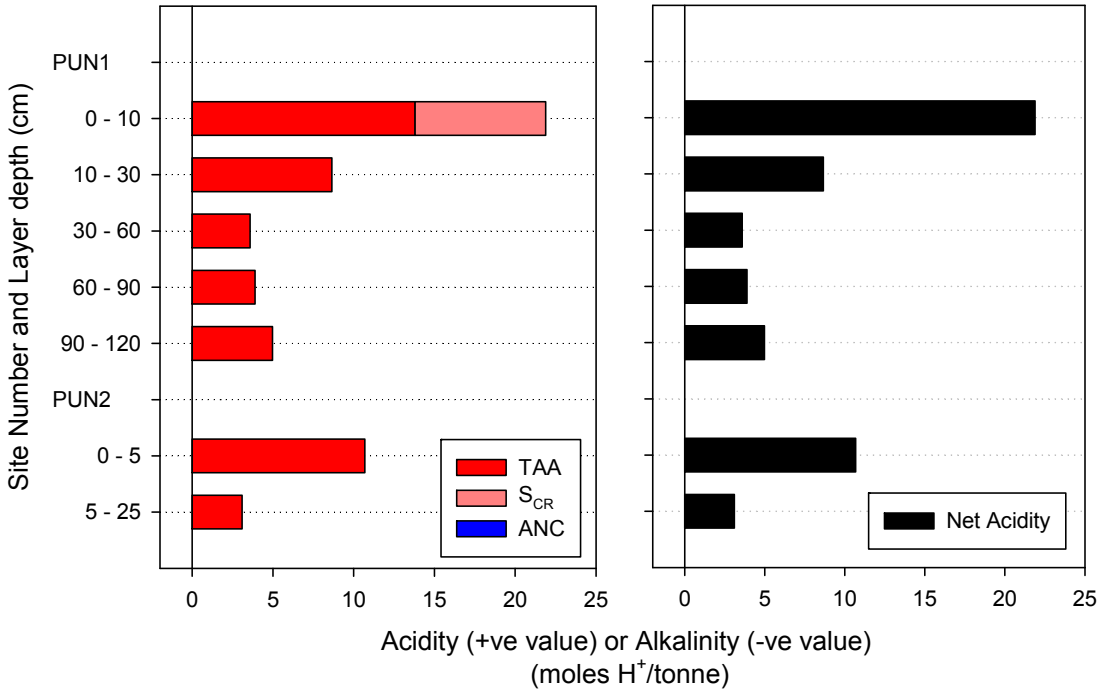

Figure 65-5. Acid base accounting depth profiles for Punyelroo Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

65.4 DISCUSSION

Acid sulfate soil materials at Punyelroo Wetland were identified as hyposulfidic in the surface layer of PUN1, and the rest of the samples were characterised as other acidic or other soil materials. The acid sulfate soil subtype classes identified were Hyposulfidic Soil and Other Soil.

The soils throughout the wetland were generally black, very firm, clayey, and in the main wetland area the surface layer was loamy.

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 Punyelroo Wetland are:

- Acidification hazard: The data identified moderate or low net acidity values throughout both profiles, and pH data did not identify potential acidification due to oxidation. There is a 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, although 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 Punyelroo Wetland:

Soil materials:	Hyposulfidic soil materials were identified in the surface layer for the main wetland area. The soils throughout were generally black, very firm, clayey, and in the main wetland area the surface layer was loamy. All samples had moderate or low net acidity values and pH data not identify potential acidification due to oxidation.
Acid sulfate soil identification:	• Hyposulfidic Soil – 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 – medium level of concern. • De-oxygenation hazard – medium level of concern. • Metal mobilisation hazard – medium level of concern.

Table 65-2. Site data for Punyelroo 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
PUN1	26-Aug-08	372298	6166648	Hyposulfidic soil	Not reached	sealed	Bare	Low elevation
PUN2	26-Aug-08	372256	6166592	Other acidic	Not reached	sealed	grasses, weeds	Mid elevation, on sealed surface and 20m from bare surface area

Table 65-3. Soil description data for Punyelroo 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
PUN1.1	0	10	soil pit	10YR 6/1	sandy clay loam	dry	0			angular blocky	slightly hard	
PUN1.2	10	30	soil pit	10YR 3/1	clay	dry	5	10YR 6/6	in matrix adjacent to pores	subangular blocky	extremely hard	
PUN1.3	30	60	soil pit	10YR 2/1	clay	moist	3	10YR 6/6	in matrix adjacent to pores	subangular blocky	very firm	
PUN1.4	60	90	push tube	10YR 2/1	clay	moist	2	2.5Y 6/6	in matrix adjacent to pores	massive	very firm	
PUN1.5	90	120	push tube	10YR 2/1	clay	moist	0			massive	very firm	
PUN2.1	0	5	soil pit	10YR 6/1	clay	dry	2	2.5YR 5/6	in matrix along ped faces	subangular blocky	slightly hard	
PUN2.2	5	25	soil pit	10YR 2/1	clay	moist	5	10YR 6/6	in matrix along ped faces	subangular blocky	very firm	too hard to dig below this layer

Table 65-4. Laboratory data for acid sulfate soil assessment of Punyelroo 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
PUN1.1	0 - 10	medium	-	6.15	3.21	4.70	1852	4.89	13.81	0.01	-	22	hyposulfidic (S_{CR}<0.10%)
PUN1.2	10 - 30	fine	-	6.58	3.63	5.00	259	5.44	8.65	< 0.01	-	9	other acidic incubation
PUN1.3	30 - 60	fine	-	7.25	5.52	5.80	202	5.82	3.59	< 0.01	-	4	other soil material
PUN1.4	60 - 90	fine	-	6.89	5.83	5.80	311	5.77	3.89	< 0.01	-	4	other soil material
PUN1.5	90 - 120	fine	-	6.48	6.45	5.80	512	5.73	4.98	< 0.01	-	5	other soil material
PUN2.1	0 - 5	fine	-	6.09	3.30	4.70	588	5.01	10.69	< 0.01	-	11	other acidic incubation
PUN2.2	5 - 25	fine	-	6.80	5.65	5.50	462	5.94	3.09	< 0.01	-	3	other soil material

66 MARK'S LANDING WETLAND (WETLAND ID. 12001)

66.1 LOCATION AND SETTING DESCRIPTION

Mark's Landing Wetland (Wetland ID. 12001) is situated on the eastern side of the River Murray, down river and nearly adjacent to the town of Swan Reach. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is formed by two irregular connected shapes, approximately 4 kilometres in length and up to 700 metres at the widest, with a total surface area of 193 hectares. It is bound to the east by a cliff and hill slope and to the west by floodplain up to 300 metres. The northern part of the floodplain has a road and buildings on it. There are three narrow water connection channels with the river. At the time when the soil survey was conducted in October 2008, the wetland was dry. The wetland had a sealed friable surface that was bare, fringing the area were isolated patches of *Phragmites australis* (Common Reed), and trees on the raised terrace. Six sites were described and sampled and their locations are shown in Figure 66-1.

Figure 66-1. Mark's Landing Wetland and sample site locations.

66.2 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 66-1. Two sites were located as a pair in the up-river section to characterise the main wetland area (MLA1) and the upper elevation margin area (MLA2). The down-river section was characterised by a cross-section, with a site at the low elevation in the water (MLG3), adjacent to the water and in the main wetland area (MLG4), main mid elevation (MLG5), and the upper margin of the wetland (MLG6). The site and soil profile descriptions are presented in Table 66-2 and Table 66-3.

Site MLA1 (Figure 66-2) occurred near the middle of the wetland in the up-river area of the wetland where the surface was bare with friable aggregates. The soil consisted of grey, hard clay, over black, firm clay.

Site MLA2 (Figure 66-3) occurred near the wetland edge where *Phragmites australis* (Common Reed) were growing on a slightly elevated area where sand encroachment occurred from the adjacent slopes. The soil consisted of layered, brown and black, loose sand.

Site MLG3 (Figure 66-4) occurred near the middle of the wetland in the up-river area of the wetland where the surface was bare with friable aggregates. The soil consisted of grey, hard clay, over black, firm clay.

Site MLG4 (Figure 66-5) occurred near edge of wetland on a slightly elevated area where sand encroachment from the adjacent slopes covered the soil. The soil consisted of layered, brown and black, loose, sand.

Site MLG5 (Figure 66-6) occurred near the middle of the wetland in the up-river area of the wetland where the surface was bare with friable aggregates. The soil consisted of grey, hard clay, over black, firm clay.

Site MLG6 (Figure 66-7) occurred near edge of wetland on a slightly elevated area where sand encroachment from the adjacent slopes. The soil consisted of layered, brown and black, loose, sand.

Table 66-1. Soil identification, subtype and general location description of sites for Mark's Landing Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
MLA1	370958	6172998	Hyposulfidic cracking clay soil	Low to mid elevation of up-river section of wetland, cracking clay soil areas
MLA2	371061	6172965	Sulfuric soil	High elevation of up-river section of wetland, on the margins of the wetland where sandy encroaches and *Phragmites australis* (Common Reed) and *Typha latifolia* (Bulrush) grow
MLG3	372240	6171352	Hyposulfidic cracking clay soil	Low elevation of down-river section of wetland, where surface water occurs
MLG4	372161	6171369	Hyposulfidic cracking clay soil	Low to mid elevation of down-river section, cracking clay soil areas
MLG5	372062	6171389	Hyposulfidic cracking clay soil	Mid elevation of the down-river section of the wetland
MLG6	372007	6171387	Other acidic soil (clay)	High elevation of the down-river section of the wetland, on the sandy margins

Figure 66-2. Photograph of site MLA1, showing the soil profile of friable surface aggregates and a firm subsoil clay.

Figure 66-3. Photographs of site MLA2, showing the landscape from the margin where sand was encroaching to the cracking clay areas of the wetland in the background, and the soil profile of sand over the clay.

Figure 66-4. Photograph of site MLG3, showing the very soft clay surface adjacent to a water channel.

Figure 66-5. Photograph of site MLG4, showing the soft clay surface that had degraded and filled the soil cracks with the surface aggregates.

Figure 66-6. Photograph of site MLG5, showing the soil profile of the upper soil layers of friable aggregated clay.

Figure 66-7. Photograph of site MLG6, showing the sol profile of the upper soil layers of a thin dry brown sand over grey clay.

66.3 LABORATORY DATA ASSESSMENT

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

The pH data are provided in Table 66-4 and pH profiles are presented in Figure 66-8.

The pH_W data for the surface layer of profile MLA2 identified samples as sulfuric materials with a pH_W <4.

The pH_{INC} data for the surface layers of profiles MLA2 and MLG5 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 layers of profiles MLA1, MLA2 and MLG3 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.

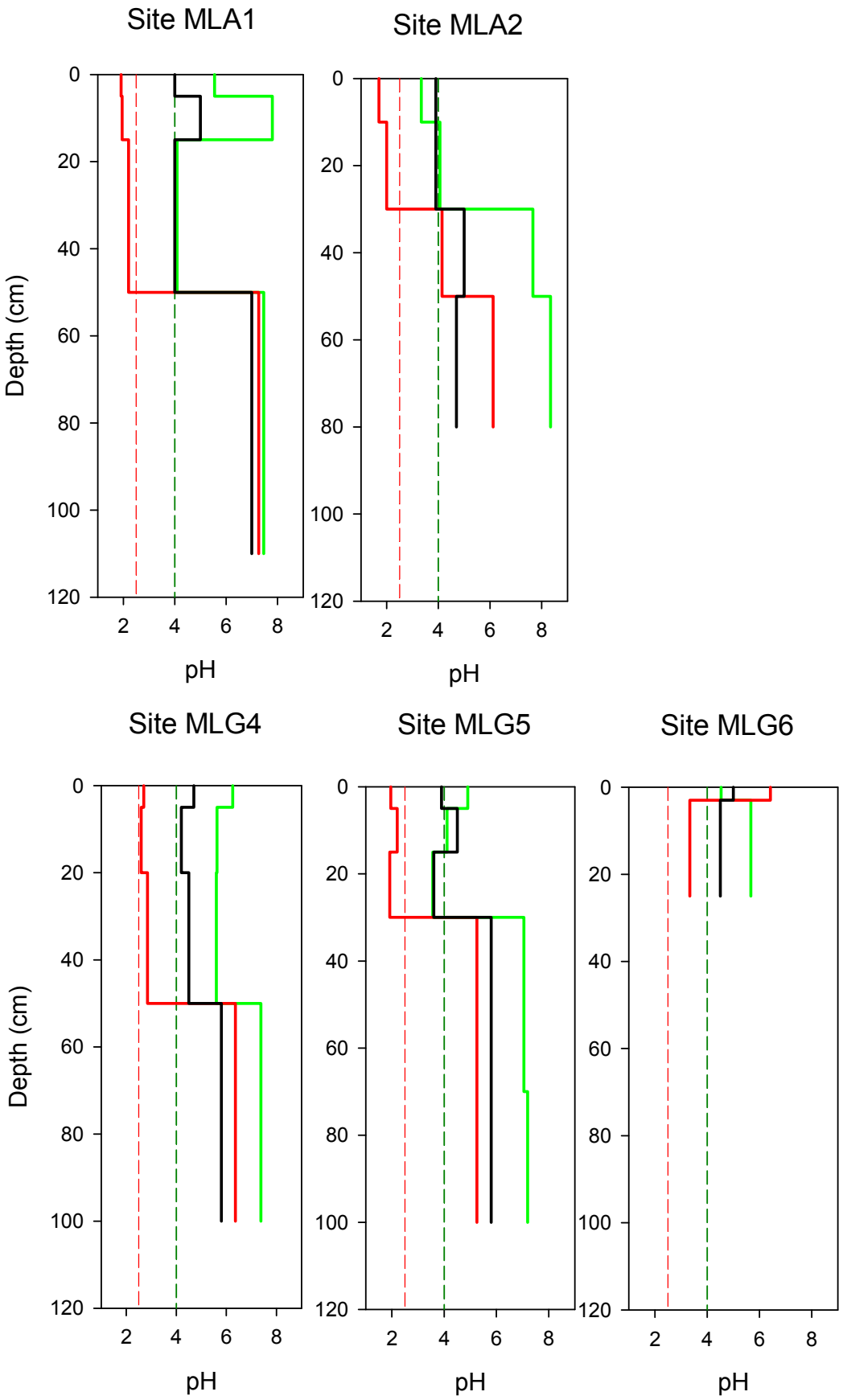

Figure 66-8. Depth profiles of soil pH for Mark's Landing Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

Acid base accounting data is provided in Table 66-4 and summarised in Figure 66-9.

Chromium reducible sulfur values ranged from below the limit of detection to 0.11 $\%S_{CR}$. Sulfidic materials were detected in the upper soil layers for all profiles.

Titratable actual acidity values ranged from 0 to 29.80 mole H^+/tonne. Concentrations were measured in most soil layers.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present in the subsurface layer of profile MLA2 that was below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity values ranged from 0 to 4.76 $\%CaCO_3$, and were measured in the lower subsoil layers of profiles MLA1 and MLA2.

Net acidity values ranged from -634 to 65 mole H^+/tonne. Low or moderate net acidity values occurred in all surface layers and with depth in the soil profile the values tended to decline. For the subsoil layers of MLA1 and MLA2 the values were negative.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 66-4 identified that surface layers were above the trigger value of 100 mg/kg SO_4.

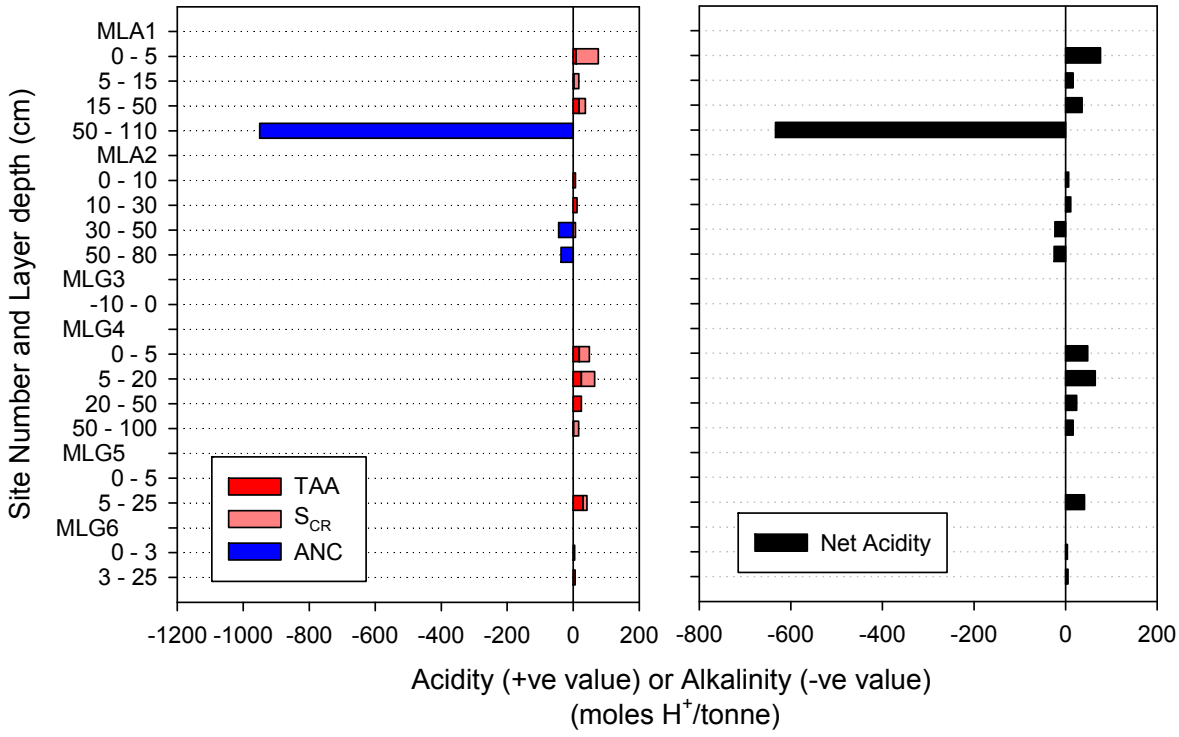

Figure 66-9. Acid base accounting depth profiles for Mark's Landing Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

66.4 DISCUSSION

Acid sulfate soil materials at Mark's Landing Wetland were identified as sulfuric for the surface sandy soils that only occurred in isolated margin areas in the up-river section of the wetland. The remaining soil materials were characterised as hyposulfidic or acidic.

The wetland was in two sections and soils in both were clayey with surface cracks and toward the wetland margins the cracks had filled with wind-blown and encroaching sand to form a sealed surface. It was these areas mainly on the hill-side of the wetland where the sulfuric surface layers occurred. The main area of both wetlands had hyposulfidic surface and subsoil materials. In the down-river section of the wetland there was surface water in an isolated section near the middle, probably from a ground water seep. The soils in this area were cracking and hyposulfidic.

The potential hazards posed by acid sulfate sol materials at the Mark's Landing Wetland are:

- Acidification hazard: The sulfuric acid sulfate soil materials occurred on the wetland margins at a high elevation and are not expected to be inundated until the wetland refilled completely. There is a low to medium level of concern.
- De-oxygenation: 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 high 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 Mark's Landing Wetland:

Soil materials:	The cracking clay surface soil layers throughout the wetland were hyposulfidic. In isolated areas, on the hill-side of the wetland where sand was encroaching the surface layer was sulfuric, and in other isolated areas no acid sulfate soil materials had been identified. The subsoil layers were hyposulfidic or acidic.
Acid sulfate soil identification:	• Hyposulfidic Cracking Clay Soil – that occurred throughout the low to mid elevations of the wetland. Dominant (>50%) in extent. • Sulfuric Cracking Clay Soil – that occurred on the margins where sand had encroached filling soil cracks and covering the clay. 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 66-2. Site data for Mark's Landing 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
MLA1	29-Aug-08	370958	6172998	Hyposulfidic cracking clay soil	45	cracking, crumbling, extremely hard	Bare	mid,
MLA2	29-Aug-08	371061	6172965	Sulfuric soil	not reached	loose, sand	Bare	high,
MLG3	22-Oct-08	372240	6171352	Hyposulfidic cracking clay soil	-10	water	Water	low, in surface water,
MLG4	22-Oct-08	372161	6171369	Hyposulfidic cracking clay soil	2	sealed, soft	Bare	low, centre wetland near water,
MLG5	22-Oct-08	372062	6171389	Hyposulfidic cracking clay soil	not reached	cracking, salts	Bare	mid,
MLG6	22-Oct-08	372007	6171387	Other acidic soil (clay)	not reached	sealed, plant material	*Eucalyptus camaldulensis* (River Red Gum) , weeds	high, in reeds on sandy surface,

Table 66-3. Soil description data for Mark's Landing 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
MLA1.1	0	5	soil pit	2.5Y 5/1	clay	dry	5	2.5Y 6/8	in matrix	cloddy	extremely hard	
MLA1.2	5	15	soil pit	2.5Y 4/1	clay	dry	0			subangular blocky	hard	
MLA1.3	15	50	soil pit	2.5Y 2.5/1	clay	moist	5	2.5YR 5/6	on ped faces	subangular blocky	firm	
MLA1.4	50	110	push tube	2.5Y 3/2	clay	wet	0			massive	firm	
MLA2.1	0	10	soil pit	2.5Y 6/3	sand	dry	0			single grain	loose	
MLA2.2	10	30	soil pit	2.5Y 3/1	CS	moist	0			massive	loose	
MLA2.3	30	50	soil pit	2.5Y 3/1	CS	moist	0			single grain	loose	
MLA2.4	50	80	push tube	2.5Y 4/3	loamy sand	moist	0			single grain	loose	
MLG3.0	-10	0	water	/	water	wet	0	/				water sample collected
MLG4.1	0	5	soil pit	5Y 5/1	clay	wet	0	/		massive	very soft	low bearing strength
MLG4.2	5	20	soil pit	5Y 5/1	clay	wet	0	/		massive	friable	
MLG4.3	20	50	soil pit	5Y 5/1	clay	wet	0	/		massive	very soft	low bearing strength
MLG4.4	50	100	push tube	5Y 4/1	clay	wet	0	/		massive	very soft	low bearing strength
MLG5.1	0	5	soil pit	2.5Y 5/1	clay	dry	0	/		subangular blocky	hard	
MLG5.2	5	25	soil pit	2.5Y 4/1	clay	moist	0	/		columnar	very firm	
MLG6.1	0	3	soil pit	2.5Y 6/2	sand	moist	0	/		single grain	firm	
MLG6.2	3	25	soil pit	2.5Y 2.5/1	clay	moist	15	5YR 6/8	in matrix adjacent to pores	massive	very firm	

Table 66-4. Laboratory data for acid sulfate soil assessment of Mark's Landing 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
MLA1.1	0 - 5	Fine	-	5.55	1.91	4.00	1693	5.41	8.79	0.11	0.00	76	hyposulfidic (S_{CR}≥0.10%)
MLA1.2	5 - 15	Fine	-	7.80	1.95	5.00	4485	5.81	2.76	0.02	0.00	17	hyposulfidic (S_{CR}<0.10%)
MLA1.3	15 - 50	Fine	-	4.09	2.20	4.00	2237	4.83	17.78	0.03	0.00	36	hyposulfidic (S_{CR}<0.10%)
MLA1.4	50 - 110	Fine	-	7.46	7.27	7.00	1338	8.45	-	< 0.01	4.76	-634	other soil material
MLA2.1	0 - 10	Coarse	-	3.34	1.70	3.90	1197	4.63	6.88	< 0.01	0.00	7	sulfuric
MLA2.2	10 - 30	Coarse	-	4.06	2.00	3.90	2626	4.43	11.51	< 0.01	0.00	12	other acidic
MLA2.3	30 - 50	Coarse	-	7.66	4.14	5.00	600	6.84	-	0.01	0.22	-23	hyposulfidic (S_{CR}<0.10%)
MLA2.4	50 - 80	Coarse	-	8.34	6.12	4.70	116	6.80	-	< 0.01	0.19	-25	other acidic
MLG3.0	-10 - 0	Water	-	-	-	-	-	-	-	-	-	-	water
MLG4.1	0 - 5	Fine	530	6.25	2.70	4.70	546	5.10	18.14	0.05	0.00	49	hyposulfidic (S_{CR}<0.10%)
MLG4.2	5 - 20	Fine	740	5.63	2.60	4.20	737	4.83	24.52	0.07	0.00	65	hyposulfidic (S_{CR}<0.10%)
MLG4.3	20 - 50	Fine	2,600	5.60	2.85	4.50	2122	4.81	24.27	< 0.01	0.00	24	other acidic
MLG4.4	50 - 100	Fine	6,360	7.38	6.36	5.80	217	6.48	1.67	0.02	0.00	16	hyposulfidic (S_{CR}<0.10%)
MLG5.1	0 - 5	Fine	-	-	-	-	-	-	-	-	-	-	-
MLG5.2	5 - 25	Fine	9,580	4.22	2.27	3.90	8647	4.62	29.80	0.02	0.00	42	hyposulfidic (S_{CR}<0.10%)
MLG6.1	0 - 3	Coarse	2,540	4.53	6.42	5.00	765	5.36	4.26	< 0.01	0.00	4	other acidic
MLG6.2	3 - 25	Fine	2,430	5.67	3.34	4.50	208	5.72	5.55	< 0.01	0.00	6	other acidic

67 SWAN REACH FERRY WETLAND (WETLAND ID. 12016)

67.1 LOCATION AND SETTING DESCRIPTION

Swan Reach Ferry Wetland (Wetland ID. 12016) is situated on the north-western side of the River Murray, up river from Marks Landing. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is an elongate shape that follows the curve of the river, 1.8 kilometres in length and up to 400 metres at its widest, with a total surface area of 68 hectares. The wetland is bounded to the northwest by a cliff and to the southeast there is floodplain area that separates it from the river. There is a water connection channel with the river at the down-river end of the wetland. At the time when the soil survey was conducted in August 2008, the wetland was dry. The wetland had areas of *Persicaria lapathifolium* (Pale Knotweed) and grass vegetation growing. Three sites were described and sampled and their locations are shown in Figure 67-1.

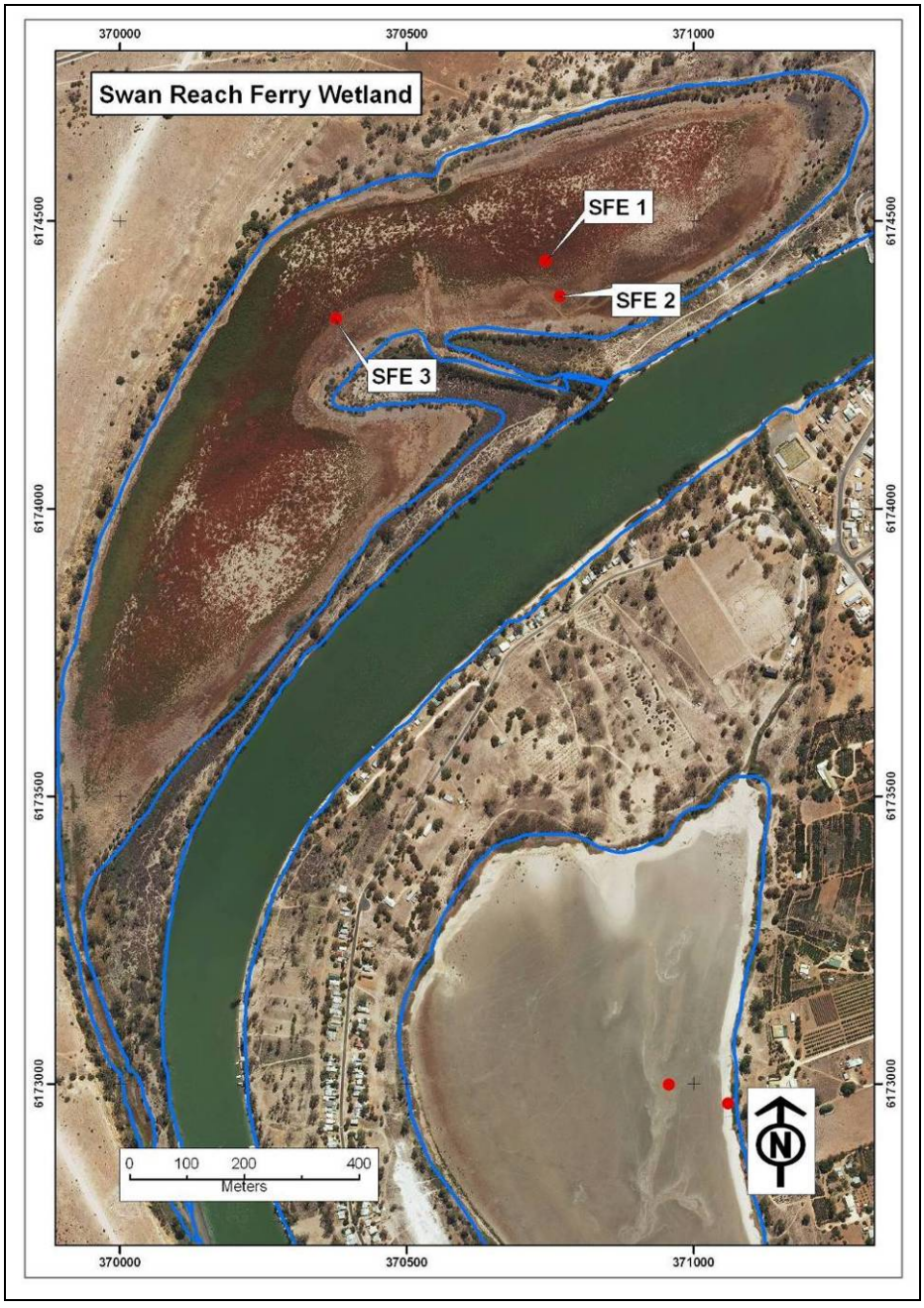

Figure 67-1. Swan Reach Ferry Wetland and sample site locations.

67.2 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 67-1. The sites were distributed to characterise the main wetland surface features, the main wetland area (SFE1), mid elevation where the surface was sandy (SFE2), and mid elevation near the change in vegetation types (SFE3). The site and soil profile descriptions are presented in Table 67-2 and Table 67-3.

Site SFE1 (Figure 67-2) occurred near the middle of the wetland where the surface was hard with dense growth of *Persicaria lapathifolium* (Pale Knotweed). The soil consisted of dark grey, rigid, clay with orange mottles, over black, very firm, clay.

Site SFE2 (Figure 67-3) occurred at mid elevation area where grasses were growing and the surface was sandy and soft. The soil consisted of light grey, soft, fine sandy loam, over dark grey, firm, clay.

Site SFE3 (Figure 67-4) occurred near the margin where *Persicaria lapathifolium* (Pale Knotweed) and grasses were growing. The soil consisted of grey, soft, sandy clay loam with orange mottles, over black, very firm, clay.

Table 67-1. Soil identification, subtype and general location description of sites for Swan Reach Ferry Wetland.

Site ID	Easting m zone 54H	Northing m zone 54H	Acid sulfate soil subtype class	General location description
SFE1	370743	6174430	Hyposulfidic soil	Low elevation
SFE2	370768	6174368	Hyposulfidic soil	Mid elevation
SFE3	370378	6174330	Hyposulfidic soil	High elevation

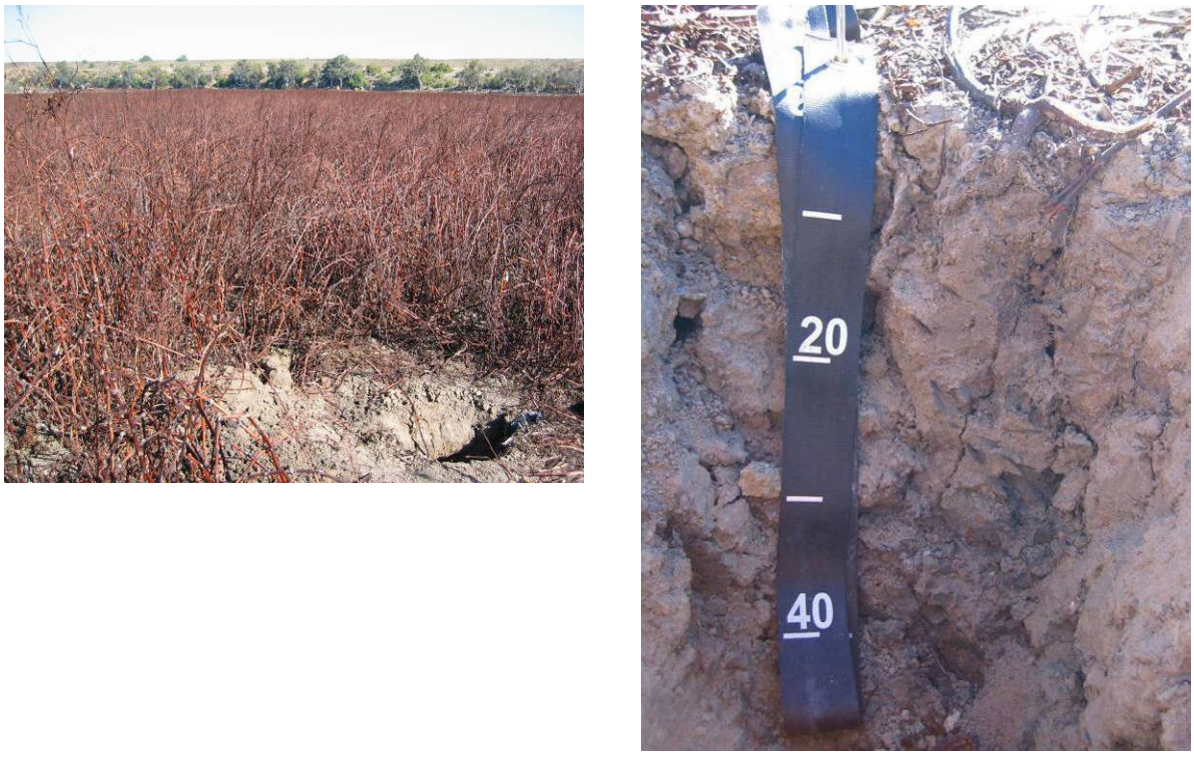

Figure 67-2. Photographs of site SFE1, showing the main wetland area with *Persicaria lapathifolium* (Pale Knotweed) growing, and the soil profile of rigid, massive clay.

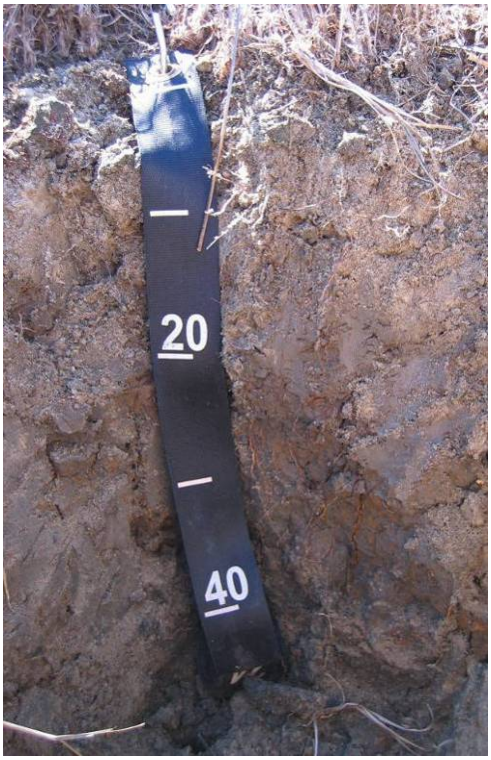

Figure 67-3. Photographs of site SFE2, showing the wetland margin where grasses were growing, and showing the soil profile of friable, sandy loam, over very firm, clay.

Figure 67-4. Photographs of site SFE3, showing the site location on the edge of change in vegetation from the red coloured *Persicaria lapathifolium* (Pale Knotweed) into the grasses, and the soil profile of rigid clay.

67.3 LABORATORY DATA ASSESSMENT

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

The pH data are provided in Table 67-4 and pH profiles are presented in Figure 67-5.

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.

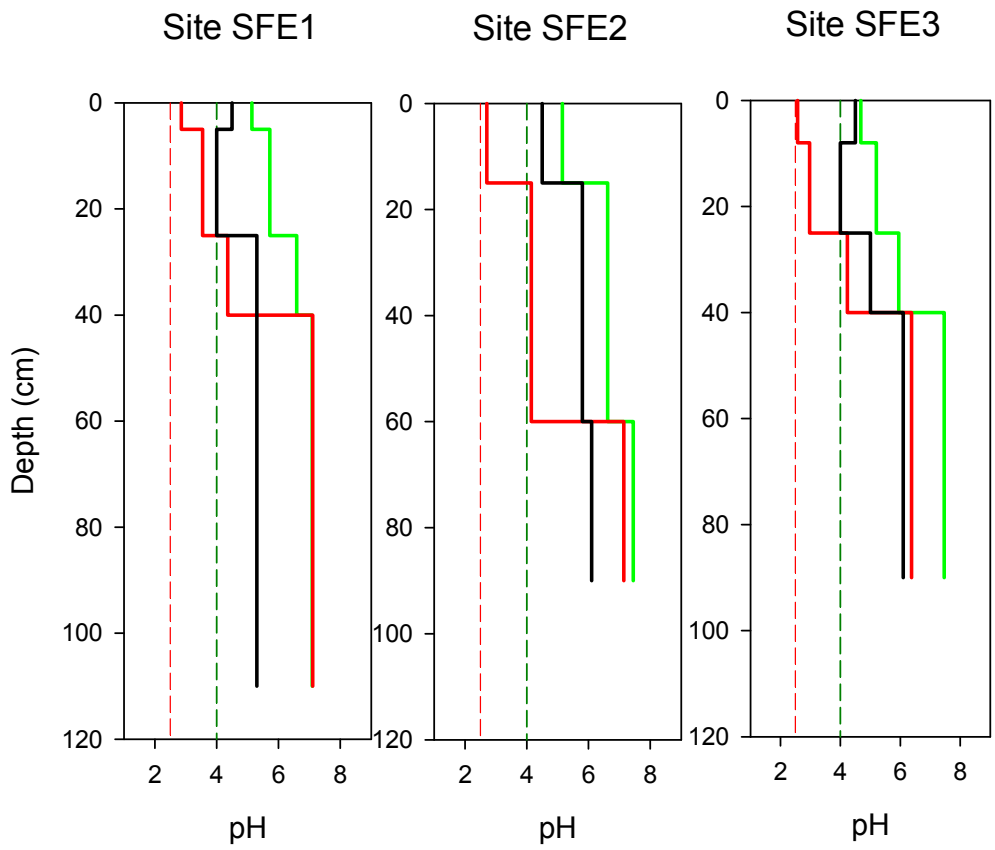

Figure 67-5. Depth profiles of soil pH for Swan Reach Ferry Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data is provided in Table 67-4 and summarised in Figure 67-6.

Chromium reducible sulfur values ranged from below the limit of detection to 0.02 $\%S_{CR}$. Sulfidic materials were detected at the limit of detection in most soil layers of the profiles.

Titratable actual acidity values ranged from 1.04 to 15.29 mole H^+/tonne.

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 was not detected in any of the samples.

Net acidity values ranged from 2 to 26 mole H^+/tonne. Moderate net acidities occurred in the upper layers of profiles SFE1 and SFE3 while all other layers had low net acidities.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 67-4 identified that surface layers were above the critical trigger value of 100 mg/kg SO_4.

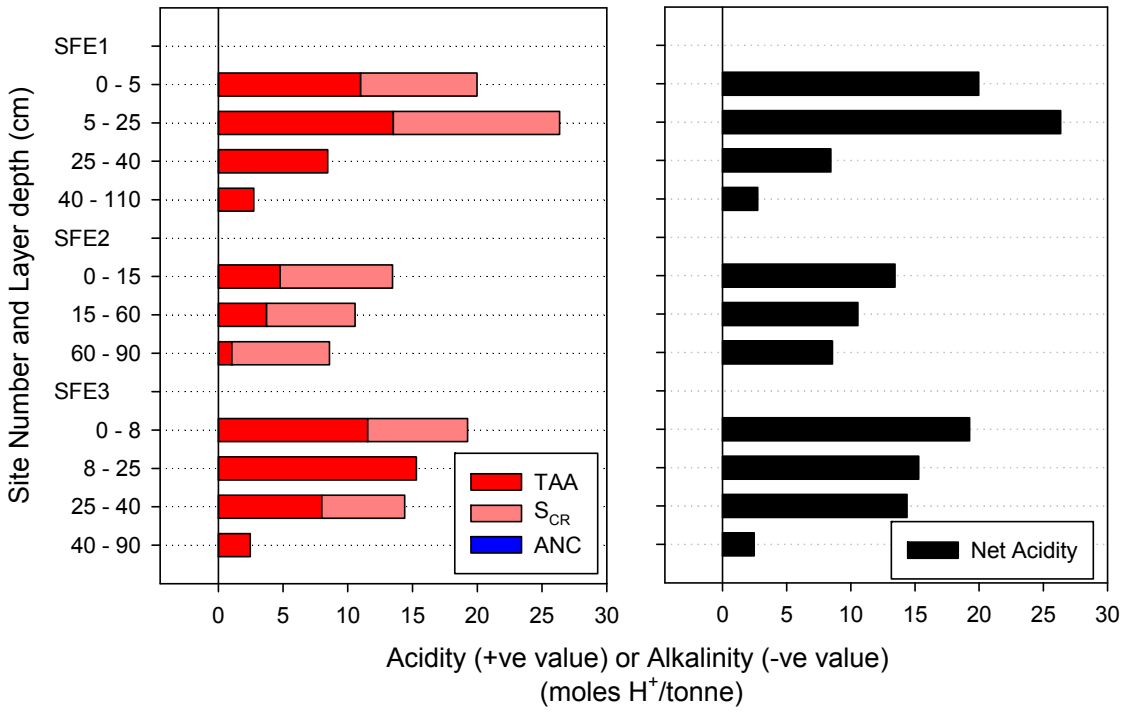

Figure 67-6. Acid base accounting depth profiles for Swan Reach Ferry Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

67.4 DISCUSSION

Acid sulfate soil materials at Swan Reach Ferry Wetland were identified as hyposulfidic in the surface and some subsoil layers for all profiles, subsoil samples in profiles SFE1 and SFE3 were characterised as other acidic or other soil materials. The acid sulfate soil subtype classes identified were Hyposulfidic Soil.

The soils throughout the wetland were generally rigid, clays and near the margins the surface layers were loamy.

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 Swan Reach Ferry Wetland are:

- Acidification hazard: The data identified moderate or low net acidity values throughout all profiles, and pH data did not identify potential acidification due to oxidation. There is a 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, although 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 Swan Reach Ferry Wetland:

Soil materials:	Hyposulfidic soil materials were identified in most soil layers. The soils throughout were generally rigid, clays and near the margin areas the surface layer was loamy. Profiles had samples with moderate or low net acidity values and pH data did not identify potential acidification due to oxidation.
Acid sulfate soil identification:	• Hyposulfidic 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 hazard – medium level of concern.

Table 67-2. Site data for Swan Reach Ferry 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
SFE1	26-Aug-08	370743	6174430	Hyposulfidic soil	Not reached	crumbling, aggregates	*Persicaria lapathifolium* (Pale Knotweed)	Low elevation
SFE2	26-Aug-08	370768	6174368	Hyposulfidic soil	Not reached	plant material	grasses, weeds	Mid elevation
SFE3	26-Aug-08	370378	6174330	Hyposulfidic soil	Not reached	sealed	*Persicaria lapathifolium* (Pale Knotweed)	High elevation

Table 67-3. Soil description data for Swan Reach Ferry 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
SFE1.1	0	5	soil pit	10YR 7/1	clay loam	dry	10	10YR 7/1	in matrix along ped faces	subangular blocky	rigid	white salts on surface
SFE1.2	5	25	soil pit	10YR 5/1	clay	moist	40	10YR 6/8	in matrix adjacent to pores	massive	rigid	
SFE1.3	25	40	soil pit	2.5Y 4/1	clay	moist	20	10YR 6/8	in matrix adjacent to pores	massive	rigid	
SFE1.4	40	110	push tube	2.5Y 4/1	clay	moist	5	10YR 6/8	in matrix adjacent to pores	massive	very firm	
SFE2.1	0	15	soil pit	10YR 5/1	sandy loam	dry	5	10YR 6/8	in matrix adjacent to pores	single grain	friable	
SFE2.2	15	60	soil pit	5Y 2.5/1	clay	moist	25	10YR 6/8	in matrix adjacent to pores	columnar	very firm	
SFE2.3	60	90	push tube	5Y 2.5/1	clay	moist	5	10YR 6/8	in matrix adjacent to pores	massive	very firm	
SFE3.1	0	8	soil pit	10YR 5/1	sandy clay loam	dry	5	10YR 6/8	in matrix adjacent to pores	single grain	rigid	
SFE3.2	8	25	soil pit	10YR 5/2	clay	moist	35	10YR 6/8	in matrix adjacent to pores	columnar	rigid	
SFE3.3	25	40	soil pit	5Y 3/1	clay	moist	30	10YR 6/8	in matrix adjacent to pores	columnar	slightly rigid	
SFE3.4	40	90	push tube	5Y 3/1	clay	moist	0			massive	very firm	

Table 67-4. Laboratory data for acid sulfate soil assessment of Swan Reach Ferry 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
SFE1.1	0 - 5	medium	-	5.14	2.86	4.50	2153	5.11	10.99	0.01	-	20	hyposulfidic (S_{CR}<0.10%)
SFE1.2	5 - 25	fine	-	5.72	3.55	4.00	405	5.04	13.51	0.02	-	26	hyposulfidic (S_{CR}<0.10%)
SFE1.3	25 - 40	fine	-	6.59	4.36	5.30	339	5.41	8.45	< 0.01	-	8	other acidic incubation
SFE1.4	40 - 110	fine	-	7.09	7.11	5.30	481	6.07	2.74	< 0.01	-	3	other acidic incubation
SFE2.1	0 - 15	medium	-	5.15	2.71	4.50	237	5.54	4.78	0.01	-	13	hyposulfidic (S_{CR}<0.10%)
SFE2.2	15 - 60	fine	-	6.62	4.15	5.80	503	5.97	3.74	0.01	-	11	hyposulfidic (S_{CR}<0.10%)
SFE2.3	60 - 90	fine	-	7.45	7.14	6.10	820	6.41	1.04	0.01	-	9	hyposulfidic (S_{CR}<0.10%)
SFE3.1	0 - 8	medium	-	4.68	2.57	4.50	277	4.70	11.53	0.01	-	19	hyposulfidic (S_{CR}<0.10%)
SFE3.2	8 - 25	fine	-	5.20	2.97	4.00	464	4.73	15.29	< 0.01	-	15	other acidic incubation
SFE3.3	25 - 40	fine	-	5.95	4.23	5.00	473	5.23	8.00	0.01	-	14	hyposulfidic (S_{CR}<0.10%)
SFE3.4	40 - 90	fine	-	7.46	6.37	6.10	1216	6.35	2.47	< 0.01	-	2	other soil material

68 MCCAULEY SWAMP WETLAND (WETLAND ID. 12725)

No field survey or assessment conducted at this wetland.

69 SWAN REACH COMPLEX WETLAND (WETLAND ID. 12168, 12169, 12170, 12173, 12194)

69.1 LOCATION AND SETTING DESCRIPTION

Swan Reach Complex Wetland (Wetland ID. 12168, 12169, 12170, 12173, 12194) is situated on the eastern side of the River Murray, up river from the Swan Reach car ferry ramp. The wetland complex is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and consists of eight irregularly shaped wetland areas.In combination they cover approximately 6 kilometres in length and range in width from 50 to 600 metres, with a total surface area of 242 hectares. The wetland is bounded to the northeast by a cliff and hill slope and to the southwest floodplain area that separates it from the river. There are at least two water connection channels with the river at the southern end of the wetland and one connection channel at the northern end. At the time when the soil survey was conducted in August 2008 the wetland was dry with no surface water. The wetlands main areas had sealed friable surfaces that had no vegetation growing, and the wetland margins had isolated areas of *Phragmites australis* (Common Reed), and trees growing on the elevated floodplain areas. Eight sites were described and sampled and their locations are shown in Figure 69-1.

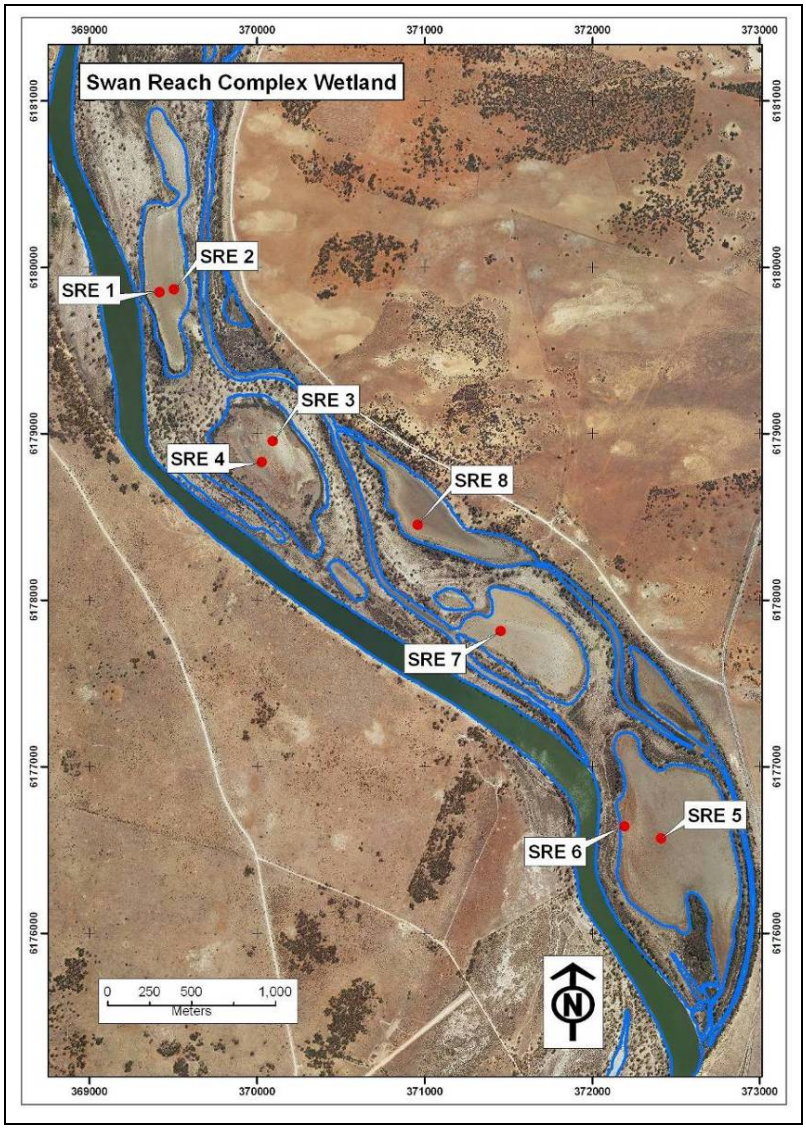

Figure 69-1. Swan Reach Complex Wetland and sample site locations.

69.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTIONS

Eight sites were sampled and described. The acid sulfate soil subtype class and general location description are presented in Table 69-1. The sites were distributed to characterise the main areas for each of the wetland areas. The site and profile descriptions are presented in Table 69-2 and Table 69-3.

Site SRE1 (Figure 69-2) occurred near the middle of the wetland and the surface was friable with no vegetation growing. The soil consisted of dark grey, very firm, clay, over clay that was too dry and hard to dig below 70 centimetres depth.

Site SRE2 (Figure 69-3) occurred near a dry creek channel that crossed the wetland and the surface was friable with no vegetation growing. The soil consisted of dark grey, very firm, clay, over clay that was too hard to dig.

Site SRE3 (Figure 69-4) occurred near the middle of the wetland where the surface was crusted and friable with no vegetation growing. The soil consisted of light grey, hard, clay, over clay too dry and hard to dig below 30 centimetres depth.

Site SRE4 **(**Figure 69-5**)** occurred near the margin of the wetland where there was thick growth of *Typha latifolia* (Bulrush) vegetation and the surface was friable. The soil consisted of black, very firm, clay.

Site SRE5 **(**Figure 69-6) occurred near the middle of the wetland where the surface was breaking down and was cracked. The cracks were backfilling with surface aggregates to leave a sealed friable surface with no vegetation growth. The soil consisted of grey, hard, clay, over clay that was too hard to dig below 45 centimetres.

Site SRE6 **(**Figure 69-7**)** occurred on the side of the wetland where there was *Muehlenbeckia florulenta (*Lignum*)* and Thistle species were growing. The soil consisted of grey, hard, clay, over clay that was too hard to dig below 45 centimetres depth.

Site SRE7 (Figure 69-8) occurred were the surface was loose aggregates that had filled the soil cracks and thistle species grew in isolated areas. The soil consisted of grey, firm to very firm, clay, over clay that was too hard to dig.

Site SRE8 **(**Figure 69-9) occurred near the middle of the wetland where there was a cracking clay surface that had broken down into aggregates. The soil consisted of grey, very firm, clay, over hard, clay that was too difficult to dig.

Table 69-1. Soil identification, subtype and general location description of sites for Swan Reach Complex Wetland.

Site ID	Easting m zone 54H	Northing m zone 54H	Acid sulfate soil subtype class	General location description
SRE1	369418	6179850	Other soil (cracking clay)	Low elevation
SRE2	369507	6179866	Hyposulfidic soil	Low elevation
SRE3	370094	6178955	Other soil (cracking clay)	Low elevation
SRE4	370029	6178829	Other soil (cracking clay)	High elevation
SRE5	372414	6176567	Hyposulfidic soil	Low elevation
SRE6	372194	6176639	Other soil (cracking clay)	High elevation
SRE7	371454	6177814	Hyposulfidic soil	Mid elevation
SRE8	370961	6178452	Hyposulfidic soil	Mid elevation

Figure 69-2. Photographs of site SRE1, showing the main wetland area with angular blocky surface aggregates broken down to fill the soil cracks, and the soil profile of very firm, clay.

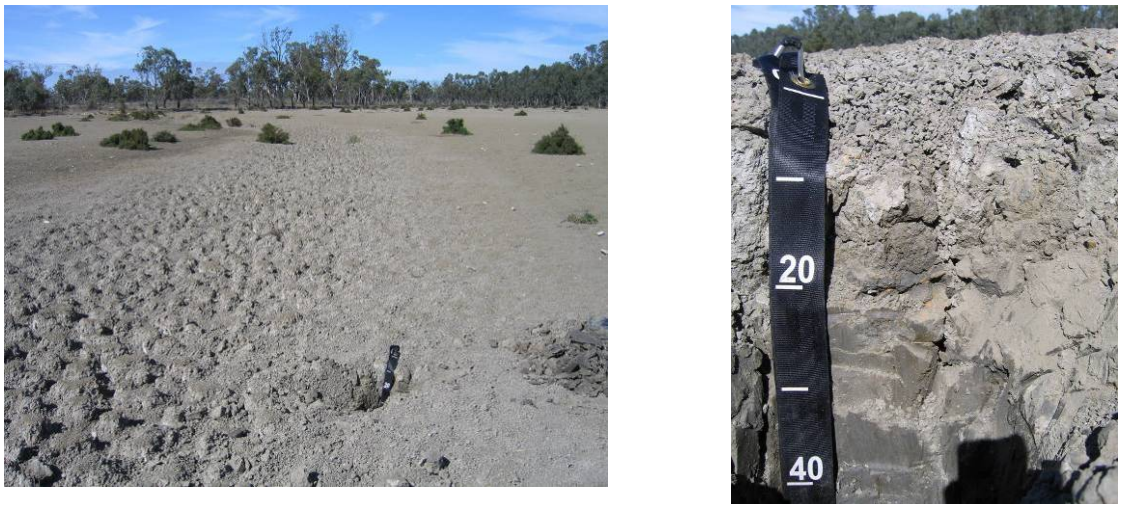

Figure 69-3. Photographs of site SRE2, showing the site location adjacent to a dry creek channel through the wetland, and the soil profile of rigid, blocky structured, clay surface layer over a very firm, massive, clay.

Figure 69-4. Photographs of site SRE3, showing the site location in the main wetland area, and the soil profile of firm, blocky structure, clay.

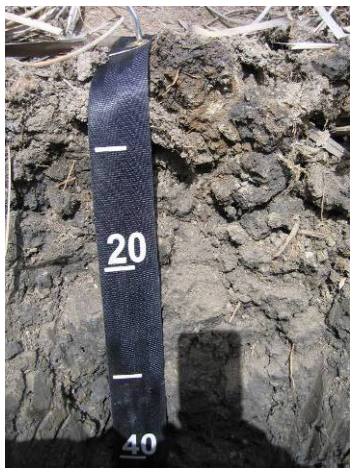

Figure 69-5. Photographs of site SRE4, showing the site location on the wetland margin adjacent to bulrushes, and the soil profile very firm clay.

Figure 69-6. Photographs of site SRE5, showing the site location in the main wetland area, and the soil profile with a cloddy, clay surface layer over rigid, blocky, clay.

Figure 69-7. Photographs of site SRE6, showing the site location in the main wetland area where there was sparse vegetation and the soil profile of friable clay over very firm clay.

Figure 69-8. Photographs of site SRE7, showing the main wetland area where there was isolated areas of vegetation and crumbling aggregates on the surface, and the soil profile of surface aggregates, over firm, clay.

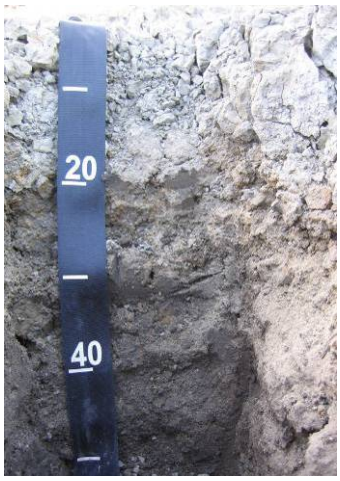

Figure 69-9. Photographs of site SRE8, showing the main wetland area with crumbling surface, and the soil profile of broken down surface aggregates, over firm clay.

69.3 LABORATORY DATA ASSESSMENT

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

The pH data are provided in Table 69-4 and pH profiles are presented in Figure 69-10.

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 for the surface layer of profile SRE8 identified a sample 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 samples were above the critical value.

Acid Base Accounting

The acid base accounting data is provided in Table 69-4 and summarised in Figure 69-11.

Chromium reducible sulfur values ranged from below the limit of detection to 0.06 $\%S_{CR}$. Sulfidic materials were detected generally in the surface layers with values at the level of detection.

Titratable actual acidity values ranged from 2.57 to 27.43 mole H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present in the surface layer of SRE2 that was below the critical value of pH_{KCl} <4.5. All other samples were above the critical value.

Acid neutralising capacity was not detected.

Net acidity values ranged from 3 to 55 mole H^+/tonne. Moderate net acidities occurred in the surface layers of profiles SRE2, SRE7 and SRE8 while all other surfaces had low net acidity values.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 69-4 identified that surface layers in all profiles except for profile SRE3 and SRE6 were above the critical trigger value of 100 mg/kg SO_4.

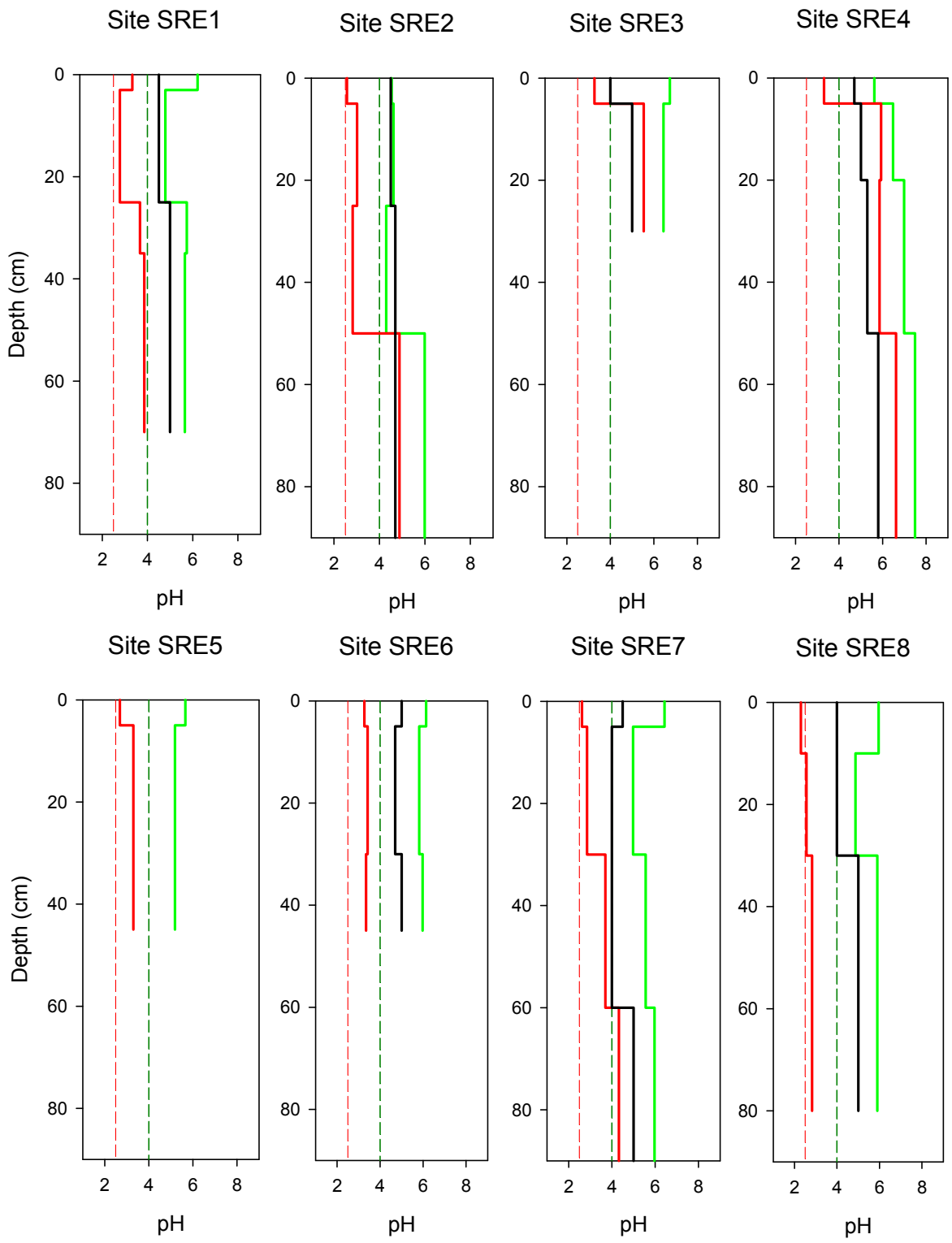

Figure 69-10. Depth profiles of soil pH for Swan Reach Complex Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

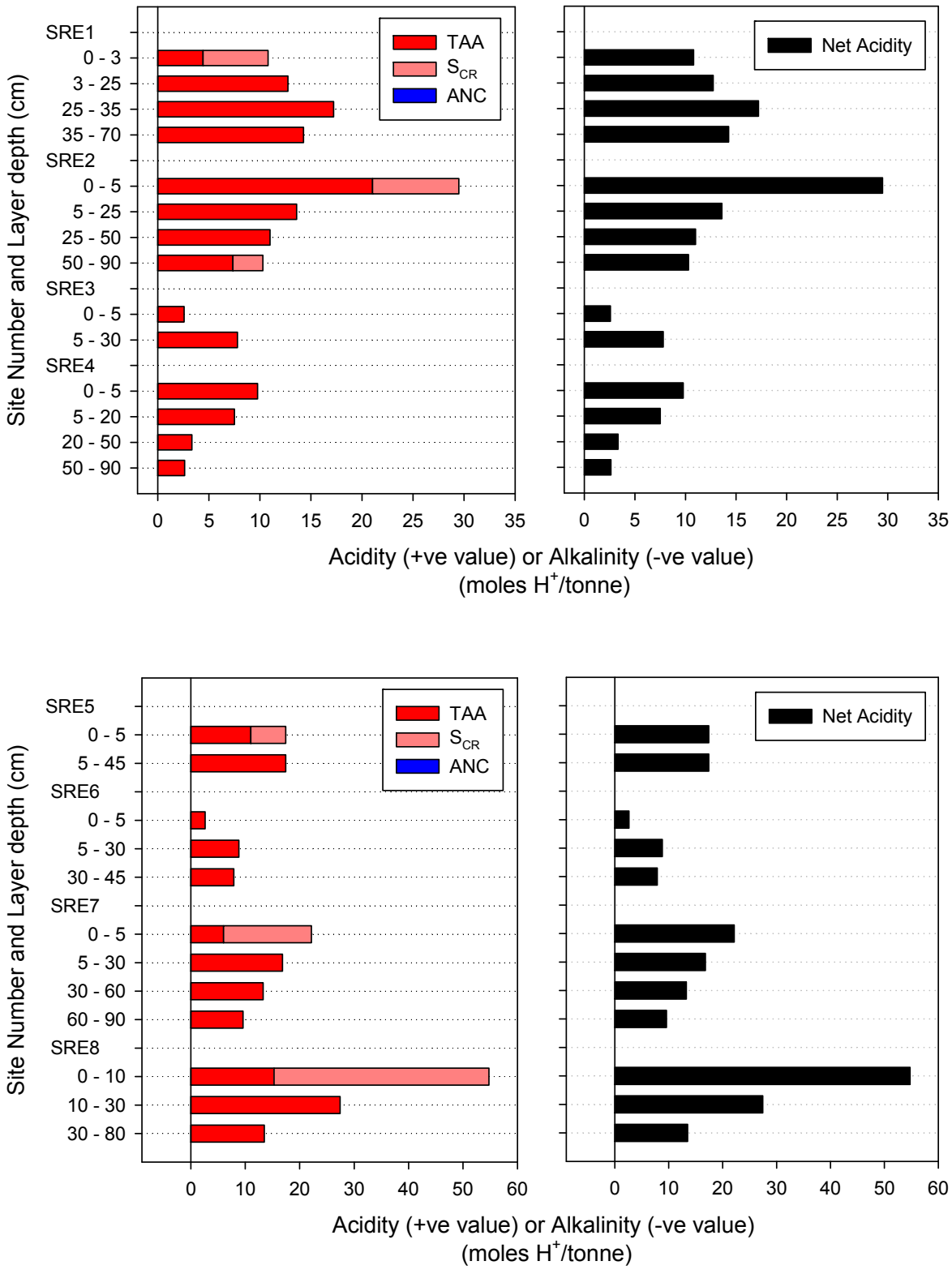

Figure 69-11. Acid base accounting depth profiles for Swan Reach Complex wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

69.4 DISCUSSION

Acid sulfate soil materials at Swan Reach Complex Wetland were identified as hyposulfidic for the surface layers in five of the eight profiles, and the rest of the samples were characterised as other acidic or other soil materials. The acid sulfate soil subtype classes identified were Hyposulfidic Soil or Other Soil (cracking clay).

The soils throughout the wetland were generally friable, blocky structured, clay over very firm, massive clay

Monosulfidic material was not observed but water soluble sulfate data identified that surface layers for the majority of 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 Swan Reach complex Wetland are:

- Acidification hazard: The data identified moderate or low net acidity values throughout both profiles, and pH_{OX} data identified potential acidification due to oxidation for one sample. There is a 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, although 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 Swan Reach Complex Wetland:

Soil materials:	Hyposulfidic soil materials were identified in some of the surface soil layers. The soils throughout were generally friable, blocky clay, over very firm, clay. Profiles had samples with moderate or low net acidity values and generally pH data did not identify potential acidification due to oxidation, except for one sample.
Acid sulfate soil identification:	• Hyposulfidic Soil – 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. 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 69-2. Site data for Swan Reach Complex 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
SRE1	25-Aug-08	369418	6179850	Other soil (cracking clay)	Not reached	cracking	Bare	Low elevation
SRE2	25-Aug-08	369507	6179866	Hyposulfidic soil	Not reached	crumbling	Bare	Low elevation
SRE3	25-Aug-08	370094	6178955	Other soil (cracking clay)	Not reached	crust, crumbling, cracking	Bare	Low elevation
SRE4	25-Aug-08	370029	6178829	Other soil (cracking clay)	Not reached	crust, crumbling, cracking	Bulrushes	High elevation
SRE5	25-Aug-08	372414	6176567	Hyposulfidic soil	Not reached	crust, crumbling	Bare	Low elevation
SRE6	25-Aug-08	372194	6176639	Other soil (cracking clay)	Not reached	cracking	*Muehlenbeckia florulenta (*Lignum*)*	High elevation
SRE7	25-Aug-08	371454	6177814	Hyposulfidic soil	Not reached	crumbling, aggregates	weeds	Mid elevation
SRE8	25-Aug-08	370961	6178452	Hyposulfidic soil	Not reached	crumbling	Bare	Mid elevation

Table 69-3. Soil description data for Swan Reach Complex 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
SRE1.1	0	3	soil pit	10YR 7/1	clay	dry	0			angular blocky	rigid	
SRE1.2	3	25	soil pit	10YR 6/1	clay	dry	20	10YR 5/8	on ped faces	massive	slightly rigid	
SRE1.3	25	35	soil pit	10YR 4/1	clay	moist	20	10YR 5/8	in matrix adjacent to pores	massive	very firm	
SRE1.4	35	70	soil pit	2.5Y 4/2	clay	moist	0			massive	very firm	
SRE2.1	0	5	soil pit	10YR 7/1	clay	dry	20	10YR 5/8		angular blocky	rigid	
SRE2.2	5	25	soil pit	10YR 6/1	clay	moist	30	10YR 5/8		massive	slightly rigid	
SRE2.3	25	50	soil pit	10YR 4/1	clay	moist	20	10YR 5/8		massive	very firm	
SRE2.4	50	90	push tube	2.5Y 4/2	clay	moist	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
SRE3.1	0	5	soil pit	10YR 7/1	clay	dry	15	10YR 5/8	in matrix along ped faces	platy	very firm	
SRE3.2	5	30	soil pit	2.5Y 4/2	clay	moist	25	10YR 5/8	in matrix adjacent to pores	massive	firm	
SRE4.1	0	5	soil pit	2.5Y 3/2	clay	moist	25	10YR 5/8	in matrix adjacent to pores	subangular blocky	firm	
SRE4.2	5	20	soil pit	2.5Y 4/1	clay	moist	5	10YR 5/8	in matrix along ped faces	subangular blocky	firm	
SRE4.3	20	50	soil pit	2.5Y 4/1	clay	moist	0			massive	very firm	
SRE4.4	50	90	push tube	2.5Y 3/2	clay	moist	0			massive	very firm	
SRE5.1	0	5	soil pit	2.5Y 6/1	clay	dry	5	10YR 8/1	in matrix along ped faces	cloddy	loose	white salts on surface
SRE5.2	5	45	soil pit	2.5Y 6/1	clay	moist	35	10YR 5/8	in matrix adjacent to pores	angular blocky	rigid	vertical cracks
SRE6.1	0	5	soil pit	2.5Y 7/1	sandy loam	dry	10	10YR 5/8	in matrix adjacent to pores	angular blocky	friable	
SRE6.2	5	30	soil pit	2.5Y 4/1	clay loam	moist	35	10YR 5/8	in matrix adjacent to pores	subangular blocky	firm	
SRE6.3	30	45	soil pit	2.5Y 4/1	clay	moist	25	10YR 5/8	in matrix adjacent to pores	massive	very firm	
SRE7.1	0	5	soil pit	10YR 7/1	clay	dry	5	10YR 6/6	in matrix along ped faces	subangular blocky	rigid	
SRE7.2	5	30	soil pit	2.5Y 6/1	clay	moist	35	10YR 6/4	in matrix adjacent to pores	massive	firm	
SRE7.3	30	60	soil pit	2.5Y 4/1	clay	moist	5	10YR 6/8	in matrix adjacent to pores	massive	firm	
SRE7.4	60	90	push tube	2.5Y 4/1	clay	moist	3	10YR 6/8	in matrix adjacent to pores	massive	very firm	
SRE8.1	0	10	soil pit	10YR 7/1	clay loam	dry	3	10YR 7/1	in matrix along ped faces	subangular blocky	rigid	white salts on surface
SRE8.2	10	30	soil pit	10YR 5/2	clay	moist	3	10YR 6/8	in matrix adjacent to pores	massive	very firm	
SRE8.3	30	80	soil pit	2.5Y 4/1	clay	moist	3	10YR 6/8	in matrix adjacent to pores	massive	very firm	

Table 69-4. Laboratory data for acid sulfate soil assessment of Swan Reach Complex 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
SRE1.1	0 - 3	fine	-	6.22	3.33	4.50	316	5.61	4.43	0.01	-	11	hyposulfidic (S_{CR}<0.10%)
SRE1.2	3 - 25	fine	-	4.79	2.78	4.50	668	4.73	12.74	< 0.01	-	13	other acidic
SRE1.3	25 - 35	fine	-	5.74	3.67	5.00	245	4.83	17.22	< 0.01	-	17	other acidic incubation
SRE1.4	35 - 70	fine	-	5.65	3.86	5.00	301	4.77	14.27	< 0.01	-	14	other acidic incubation
SRE2.1	0 - 5	fine	-	4.54	2.57	4.50	1980	4.41	21.04	0.01	-	29	hyposulfidic (S_{CR}<0.10%)
SRE2.2	5 - 25	fine	-	4.62	3.02	4.50	429	4.71	13.61	< 0.01	-	14	other acidic
SRE2.3	25 - 50	fine	-	4.30	2.82	4.70	408	4.76	10.99	< 0.01	-	11	other acidic
SRE2.4	50 - 90	fine	-	5.99	4.88	4.70	583	5.01	7.35	0.00	-	10	other acidic incubation
SRE3.1	0 - 5	fine	-	6.73	3.27	4.00	63	5.84	2.57	< 0.01	-	3	other acidic incubation
SRE3.2	5 - 30	fine	-	6.44	5.53	5.00	75	5.29	7.80	< 0.01	-	8	other acidic incubation
SRE4.1	0 - 5	fine	-	5.62	3.31	4.70	264	5.04	9.77	< 0.01	-	10	other acidic incubation
SRE4.2	5 - 20	fine	-	6.48	5.93	5.00	150	5.46	7.50	< 0.01	-	8	other acidic incubation
SRE4.3	20 - 50	fine	-	6.99	5.86	5.30	144	5.77	3.34	< 0.01	-	3	other acidic incubation
SRE4.4	50 - 90	fine	-	7.49	6.62	5.80	150	5.87	2.63	< 0.01	-	3	other soil material
SRE5.1	0 - 5	fine	-	5.66	2.69	4.50	1857	5.34	11.01	0.01	-	17	hyposulfidic (S_{CR}<0.10%)
SRE5.2	5 - 45	fine	-	5.19	3.30	-	379	4.64	17.43	< 0.01	-	17	-
SRE6.1	0 - 5	medium	-	6.14	3.27	5.00	73	5.95	2.64	< 0.01	-	3	other acidic incubation
SRE6.2	5 - 30	medium	-	5.82	3.42	4.70	321	5.17	8.82	< 0.01	-	9	other acidic incubation
SRE6.3	30 - 45	fine	-	5.98	3.35	5.00	180	5.14	7.88	< 0.01	-	8	other acidic incubation
SRE7.1	0 - 5	fine	-	6.43	2.62	4.50	431	5.14	6.01	0.03	-	22	hyposulfidic (S_{CR}<0.10%)
SRE7.2	5 - 30	fine	-	4.98	2.85	4.00	347	4.70	16.82	< 0.01	-	17	other acidic incubation
SRE7.3	30 - 60	fine	-	5.56	3.70	4.00	270	4.83	13.28	< 0.01	-	13	other acidic incubation
SRE7.4	60 - 90	fine	-	5.97	4.32	5.00	312	5.00	9.59	< 0.01	-	10	other acidic incubation
SRE8.1	0 - 10	medium	-	5.96	2.30	4.00	1294	4.72	15.28	0.06	-	55	hyposulfidic (S_{CR}<0.10%)
SRE8.2	10 - 30	fine	-	4.87	2.56	4.00	914	4.55	27.43	< 0.01	-	27	other acidic incubation
SRE8.3	30 - 80	fine	-	5.90	2.83	5.00	353	5.06	13.50	< 0.01	-	14	other acidic incubation

70 YARRAMUNDI CREEK WETLAND (WETLAND ID. 12043)

70.1 LOCATION AND SETTING DESCRIPTION

Yarramundi Creek Wetland (Wetland ID. 12043) is situated on the western side of the River Murray. The wetland is geomorphically categorised as a lentic channel (Pressey 1986) and is a linear shape formed by the creek channel that is parallel with the river, approximately 4.5 kilometres in length and 100 to 150 metres at its widest, with a total surface area of 33 hectares. The wetland is bounded to the west by a cliff and hill slope and to the east by a wide floodplain that separates it from the river. There is a water connection channel with the river at the southern end and at the northern end it joins with South Portee wetland. At the time when the soil survey was conducted in September 2008, the wetland had water in the channel area of the creek. The wetland had sealed friable surface with no vegetation growing on it and on the margins there were isolated areas of *Phragmites australis* (Common Reed), with trees on the surrounding elevated floodplain. Four sites were described and sampled and their locations are shown in Figure 70-1.

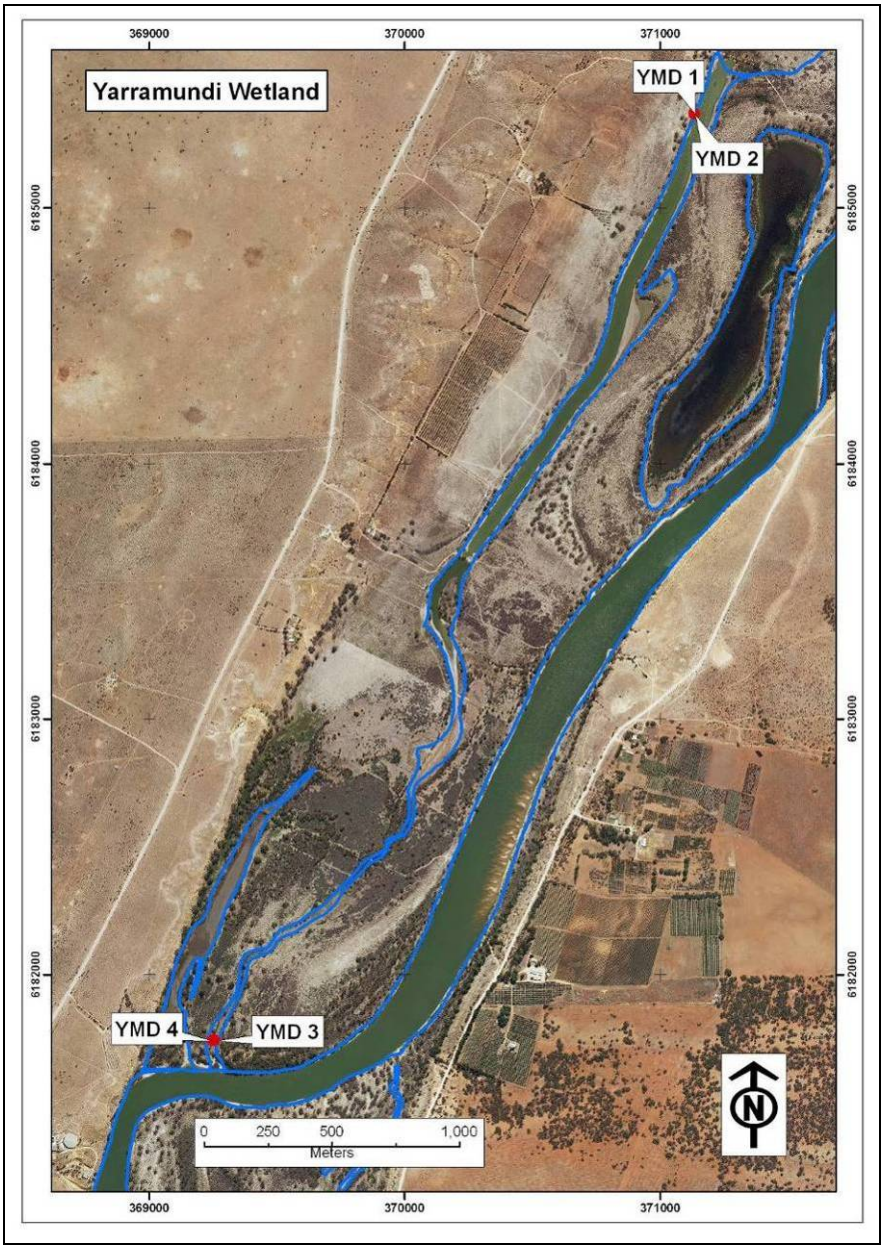

Figure 70-1. Yarramundi Creek Wetland and sample site locations.

70.2 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 70-1. The sites were located in pairs at either end of the wetland, in the north (YMD1 and YMD2) and in the south (YMD3 and YMD4). The site and soil profile descriptions are presented in Table 70-2 and Table 70-3.

Site YMD1 (Figure 70-2) occurred on the elevated side of the creek where *Phragmites australis* (Common Reed) were growing. The soil consisted of dark grey, very firm, sandy clay loam, over olive grey, slightly rigid, clay.

Site YMD2 (Figure 70-3) occurred in the creek where the water was approximately 10 centimetres deep and the very soft sediments prevented wading out any deeper. The soil consisted of grey, firm, sandy loam, over olive grey, very soft, clay.

Site YMD3 (Figure 70-4) occurred near the middle of the creek bed of the wetland that was dry, the surface was cracking with loose aggregates. The soil consisted of dark grey, rigid, clay, over olive grey, firm, clay that became too difficult to dig.

Site YMD4 (Figure 70-5) occurred near the wetland margin where *Eucalyptus camaldulensis* (River Red Gum) seedlings were growing and the surface was cracking and friable, and the soil consisted of grey, very firm, clay.

Table 70-1. Soil identification, subtype and general location description of sites for Yarramundi Creek Wetland.

Site ID	Easting m zone 54H	Northing m zone 54H	Acid sulfate soil subtype class	General location description
YMD1	371136	6185369	Other soil	High elevation
YMD2	371136	6185366	Subaqueous Hyposulfidic soil	Low elevation, in surface water
YMD3	369258	6181742	Hyposulfidic soil (cracking clay)	Low elevation, near centre of dry creek
YMD4	369249	6181743	Other soil (cracking clay)	Upper elevation, adjacent to edge of vegetation

Figure 70-2. Photographs of site YMD1, showing the wetland margin where reeds were growing, and the soil profile of very firm clay.

Figure 70-3. Photographs of site YMD2, showing the surface water where the site was located adjacent to the waters edge, and the wetland landscape.

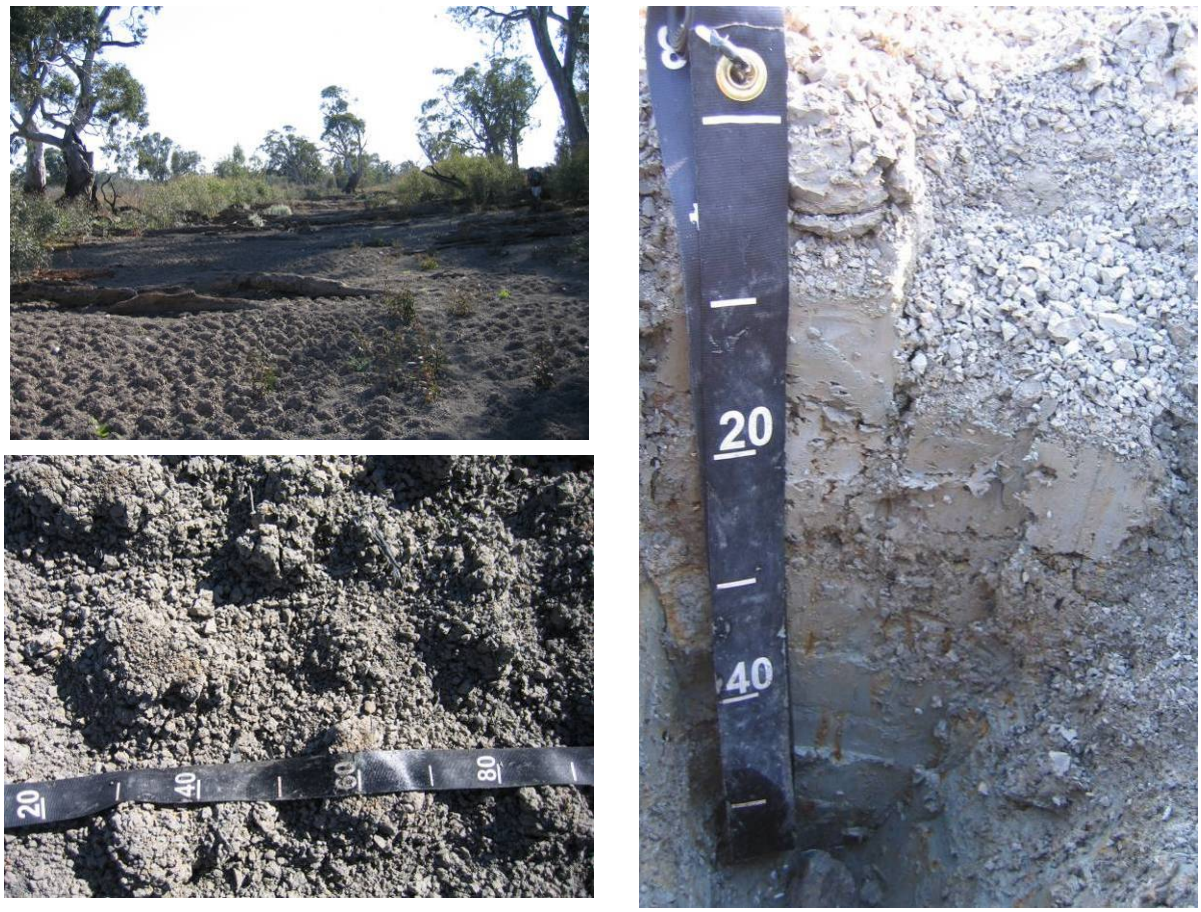

Figure 70-4. Photographs of site YMD3, showing the crumbling aggregates that have filled the surface cracks, and the soil profile very firm clay with orange mottles in the soil matrix.

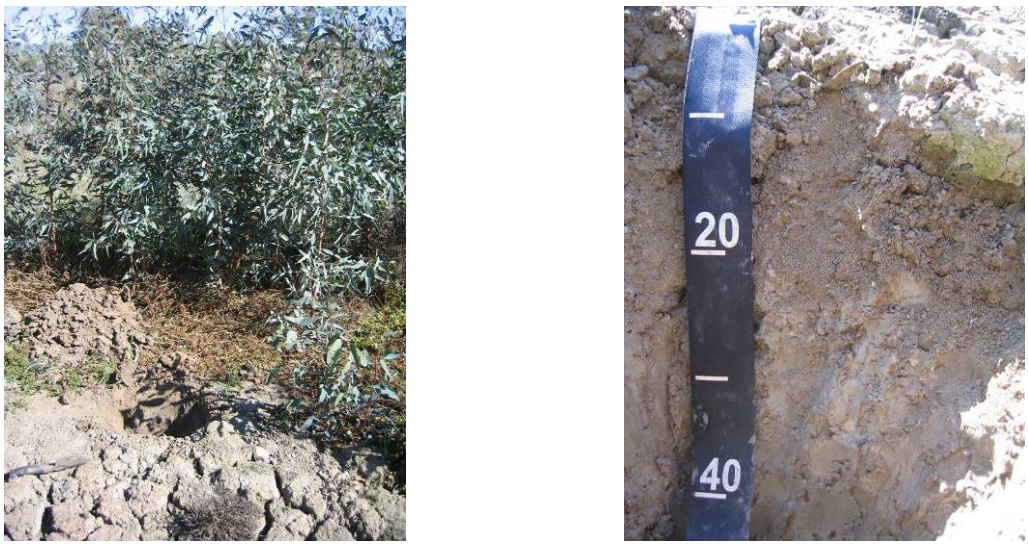

Figure 70-5. Photographs of site YMD4, showing the site location adjacent to *Eucalyptus camaldulensis* (River Red Gum) seedlings growing in a cracking clay surface, and the soil profile of very firm clay.

70.3 LABORATORY DATA ASSESSMENT

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

The pH data are provided in Table 70-4 and pH profiles are presented in Figure 70-6.

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 for the surface layers of YMD2 and YMD4 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. All other samples were below the critical value.

Acid Base Accounting

The acid base accounting data is provided in Table 70-4 and summarised in Figure 70-7.

Chromium reducible sulfur values ranged from below the limit of detection to 0.04 $\%S_{CR}$. Sulfidic materials were detected in the subsoil layers of profile YMD2 and YMD3.

Titratable actual acidity values ranged from 0 to 35.83 mole H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present in upper layers of profiles YMD2 and YMD3 that were below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity values ranged from 0 to 0.44 $\%CaCO_3$, and were measured in the layers of profile YMD2.

Net acidity values ranged from -49 to 34 mole H^+/tonne. Moderate net acidity values occurred in the upper layers of profiles YMD3 and YMD4. All other samples were low with the exception of profile YMD2 which had negative net acidity values.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 70-4 identified that surface layers were above the critical trigger value of 100 mg/kg SO_4.

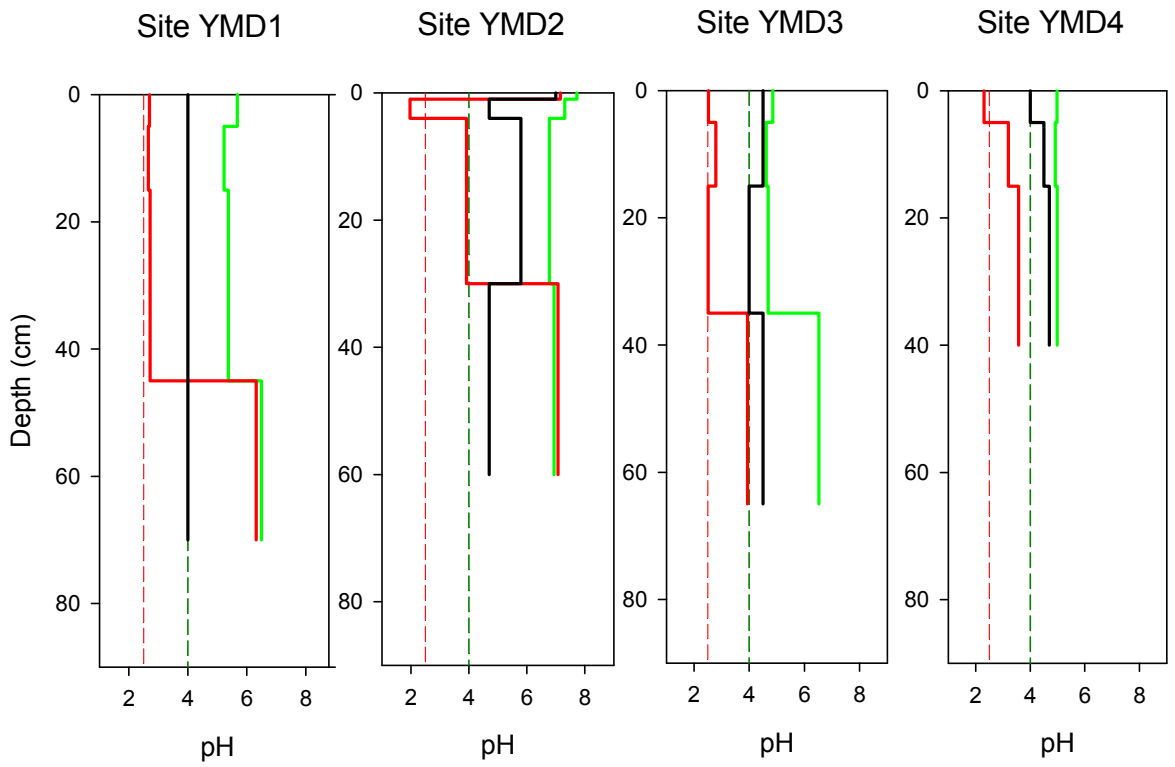

Figure 70-6. Depth profiles of soil pH for Yarramundi Creek Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

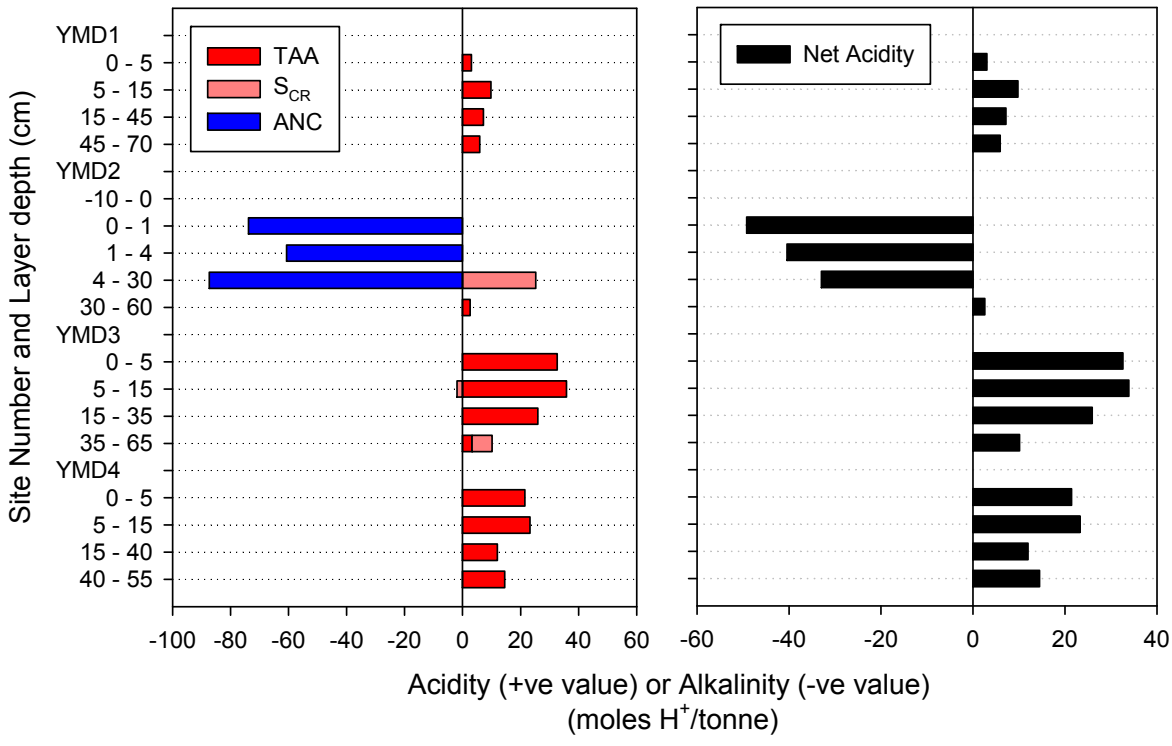

Figure 70-7. Acid base accounting depth profiles for Yarramundi Creek Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

70.4 DISCUSSION

Acid sulfate soil materials at Yarramundi Creek Wetland were identified as hyposulfidic in the subsoil layers of profiles YMD2 and YMD3, the rest of the samples were characterised as other soils or other acidic soil materials. The acid sulfate soil subtype classes identified were Subaqueous Hyposulfidic Soil, Hyposulfidic Soil (cracking clay), Other Soil, and Other Soil (cracking clay).

The soils throughout the wetland were generally very firm and clay textured, and below surface water the subsoil layers were very 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 Yarramundi Creek Wetland are:

- Acidification hazard: The data identified moderate net acidity values in two of the four profiles that occurred at the dry southern end of the wetland, and pH data identified potential acidification due to oxidation in two of the samples. There is a 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, although 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 Yarramundi Creek Wetland:

Soil materials:	Hyposulfidic soil materials were identified in subsoil layers for profiles near the centre of the channel, the rest of the samples were other acidic soil materials. The soils throughout were very firm and clay textured and below surface water the subsoil layers were very soft. Moderate net acidity values occurred in the dry southern end of the wetland and pH data identified potential acidification due to oxidation in two of the samples.
Acid sulfate soil identification:	• Subaqueous Hyposulfidic Soil – that occurred in the lower elevation main areas of the wetland where there was surface water at the northern end. Co-dominant (>25%) in extent. • Hyposulfidic Soil (cracking clay) – that occurred in the main areas of the southern end of the wetland where there was no water. Co-dominant (>25%) in extent. • Other Soil (cracking clay) – that occurred on the margins of the southern end of the wetland. Co-dominant (>25%). • Other Soil – that occurred on the margins of the northern end of the wetland. Isolated (<10%).
Hazard assessment	• Acidification hazard – medium level of concern. • De-oxygenation hazard – medium level of concern. • Metal mobilisation hazard – medium level of concern.

Table 70-2. Site data for Yarramundi 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
YMD1	05-Sep-08	371136	6185369	Other soil	Not reached	soft	*Phragmites australis* (Common Reed)	High elevation
YMD2	05-Sep-08	371136	6185366	Hyposulfidic soil	-10	water	Water	Low elevation, in surface water
YMD3	06-Sep-08	369258	6181742	Hyposulfidic cracking clay soil	60	cracking, crumbling	Bare	Low elevation, near centre of creek
YMD4	06-Sep-08	369249	6181743	Other soil (cracking clay)	Not reached	cracking	eucalypts	Upper elevation, adjacent to edge of vegetation

Table 70-3. Soil description data for Yarramundi 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
YMD1.1	0	5	soil pit	10YR 7/2	sandy clay loam	dry	0			subangular blocky	very firm	
YMD1.2	5	15	soil pit	10YR 4/1	clay	moist	15	5YR 5/8	in matrix	subangular blocky	very firm	
YMD1.3	15	45	soil pit	10YR 4/1	clay	moist	15	5YR 5/8	in matrix	subangular blocky	very firm	
YMD1.4	45	70	push tube	5Y 5/2	clay	moist	30	5YR 5/8	in matrix	massive	slightly rigid	too hard to dig below this layer
YMD2.0	-10	0	water		water	wet	0					water
YMD2.1	0	1	soil pit	10YR 5/2	sandy loam	wet	0			massive	firm	
YMD2.2	1	4	soil pit	10YR 3/1	sandy loam	wet	0			massive	firm	
YMD2.3	4	30	push tube	5Y 6/1	clay	wet	0			massive	very soft	very low bearing strength, very sticky
YMD2.4	30	60	push tube	5Y 5/2	clay	wet	0			massive	very firm	
YMD3.1	0	5	soil pit	5Y 6/1	clay	dry	5	5YR 6/8	in matrix	angular blocky	rigid	
YMD3.2	5	15	soil pit	5Y 4/1	clay	moist	10	10YR 5/8	in matrix	subangular blocky	slightly rigid	
YMD3.3	15	35	soil pit	5Y 4/1	clay	moist	20	5YR 5/8	in matrix	massive	very firm	
YMD3.4	35	65	soil pit	5Y 5/4	clay	moist	15	5YR 5/8	in matrix	massive	firm	too hard to dig below this layer
YMD4.1	0	5	soil pit	5Y 6/1	clay	moist	5	5YR 6/8	in matrix	angular blocky	slightly rigid	
YMD4.2	5	15	soil pit	5Y 4/1	clay	moist	10	10YR 5/8	in matrix	subangular blocky	very firm	
YMD4.3	15	40	soil pit	5Y 4/1	clay	moist	20	5YR 5/8	in matrix	massive	very firm	
YMD4.4	40	55	soil pit	5Y 5/2	clay	moist	5	5YR 5/8	in matrix	massive	very firm	too hard to dig below this layer

Table 70-4. Laboratory data for acid sulfate soil assessment of Yarramundi Creek 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
YMD1.1	0 - 5	medium	-	5.68	2.70	4.00	3725	5.68	3.06	< 0.01	-	3	other acidic incubation
YMD1.2	5 - 15	fine	-	5.23	2.66	4.00	1561	5.13	9.82	< 0.01	-	10	other acidic incubation
YMD1.3	15 - 45	fine	-	5.38	2.72	4.00	1191	5.08	7.19	< 0.01	-	7	other acidic incubation
YMD1.4	45 - 70	fine	-	6.50	6.32	4.00	146	5.25	5.92	< 0.01	-	6	other acidic incubation
YMD2.0	-10 - 0	water	-	-	-	-	-	-	-	-	-	-	-
YMD2.1	0 - 1	medium	-	7.73	7.16	7.00	209	8.92	-	< 0.01	0.37	-49	other soil material
YMD2.2	1 - 4	medium	-	7.31	1.97	4.70	303	7.06	-	< 0.01	0.30	-40	other acidic incubation
YMD2.3	4 - 30	fine	-	6.78	3.92	5.80	283	6.53	-	0.04	0.44	-33	hyposulfidic (S_{CR}<0.10%)
YMD2.4	30 - 60	fine	-	6.94	7.08	4.70	167	6.44	2.57	< 0.01	-	3	other acidic incubation
YMD3.1	0 - 5	fine	-	4.85	2.52	4.50	1278	4.30	32.62	< 0.01	-	33	other acidic
YMD3.2	5 - 15	fine	-	4.62	2.79	4.50	2107	4.25	35.83	0.00	-	34	other acidic
YMD3.3	15 - 35	fine	-	4.69	2.51	4.00	1557	4.59	25.94	< 0.01	-	26	other acidic incubation
YMD3.4	35 - 65	fine	-	6.52	3.94	4.50	242	5.65	3.28	0.01	-	10	hyposulfidic (S_{CR}<0.10%)
YMD4.1	0 - 5	fine	-	4.98	2.31	4.00	1594	4.36	21.44	< 0.01	-	21	other acidic incubation
YMD4.2	5 - 15	fine	-	4.92	3.20	4.50	1078	4.41	23.27	< 0.01	-	23	other acidic
YMD4.3	15 - 40	fine	-	4.99	3.58	4.70	419	4.83	11.99	< 0.01	-	12	other acidic
YMD4.4	40 - 55	fine	-	5.51	3.78	4.00	259	4.67	14.49	< 0.01	-	14	other acidic incubation

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