APPENDIX B1

DESCRIPTIONS FOR ASSESSED WETLANDS BETWEEN LOCK 1 AND LOCK 2

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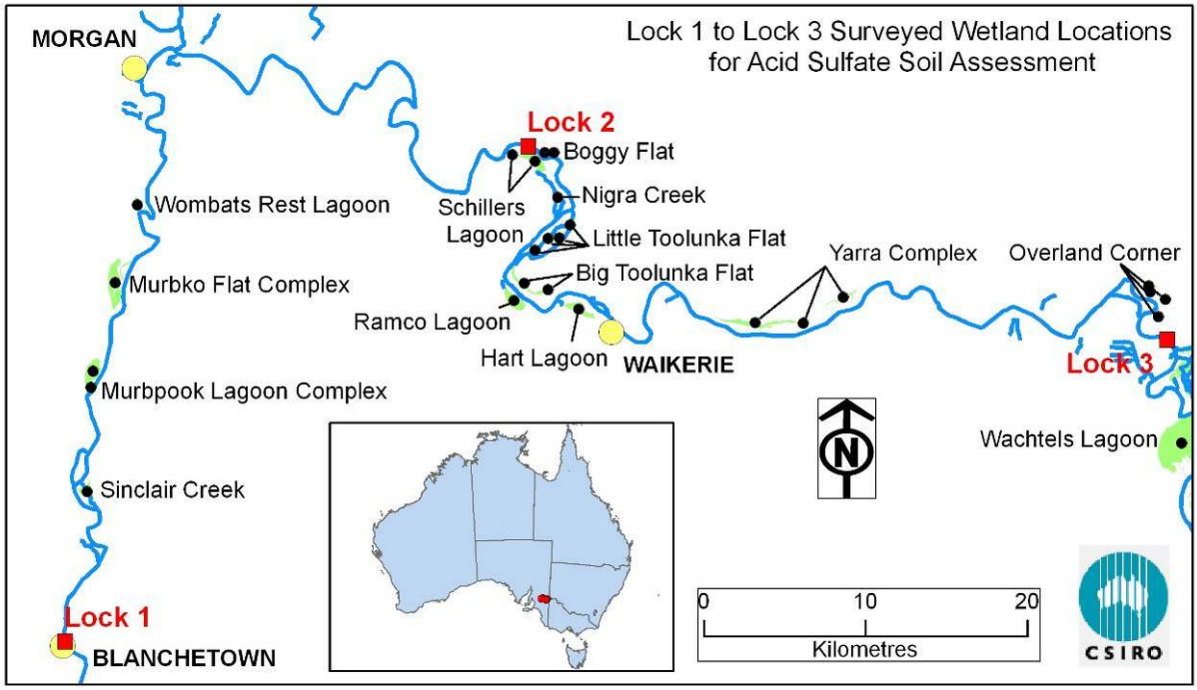
MAP SHOWING LOCATION OF WETLANDS BETWEEN LOCK 1 AND LOCK 3



1. SINCLAIR CREEK (WETLAND ID. 12301)

1.1. Location and setting description

Sinclair Creek (Wetland ID. 12301) is situated on the eastern side of the River Murray about 9 kilometres up river from Lock 1 at Blanchetown. The wetland is somewhat triangular in shape occurring on the inside bend of the river. It is about 1 kilometre in length and approximately 700 metres at the widest point, with a total surface area of 56 hectares. The wetland is bounded by hill slopes to the east and a raised bank/floodplain that separates the wetland from the river to the north and west.

The wetland connected with the river by three narrow permanent water connection channels when the river is at pool level, one in the south and two in the north. At the time when the soil survey was conducted in March 2010, the wetland contained surface water. The wetland is not managed. It is permanently connected and was probably last dry in the 1920s before the Locks were installed. Typha and Phragmites were growing along the wetland margins, with shrubland on the higher floodplain that separated the wetland and river. Eight sites were sampled as shown in Figure 1-1.

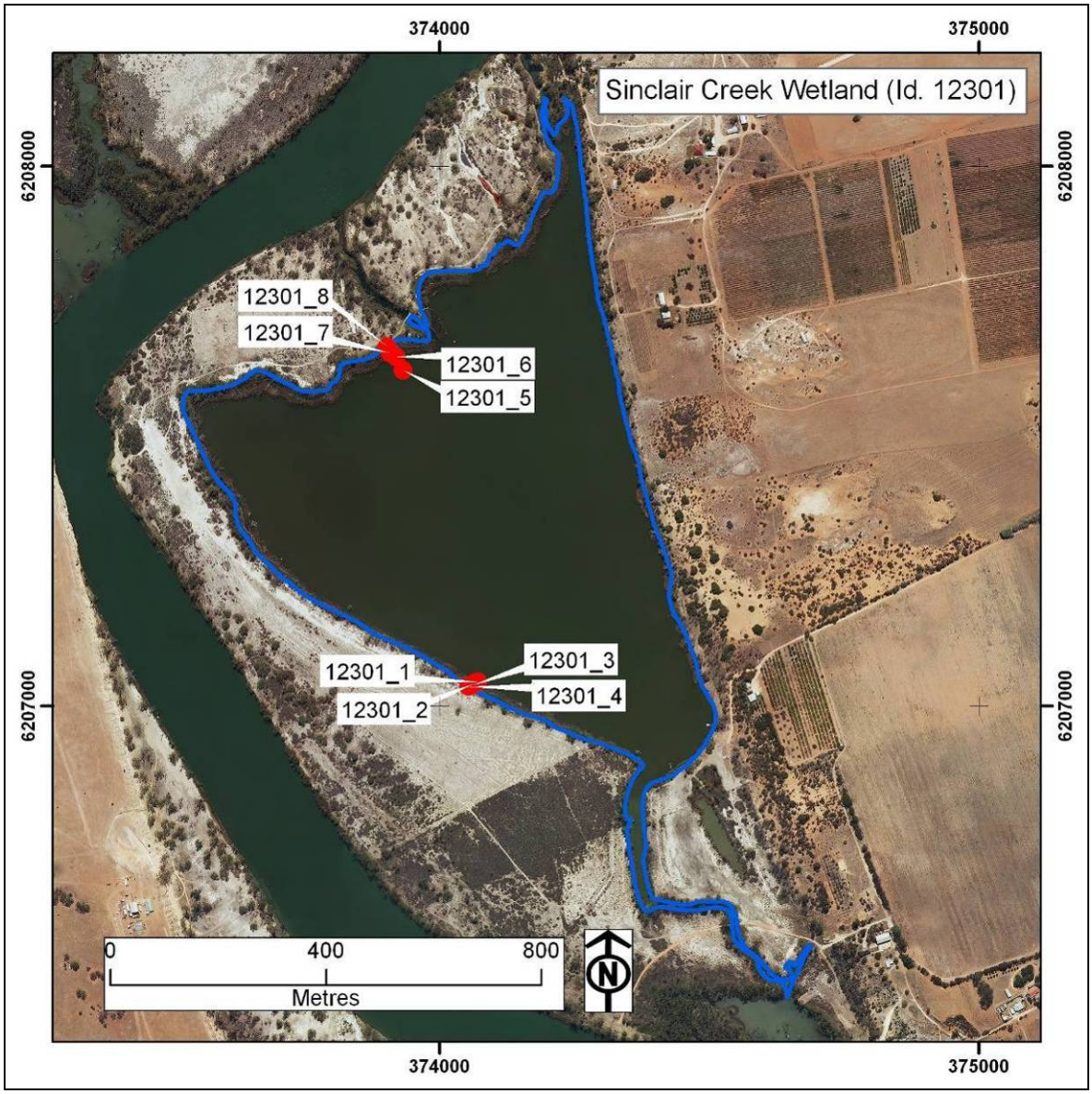


Figure 1-1. Sinclair Creek (Wetland ID. 12301) and sample site locations.

1.2. Soil profile description and distribution

Eight sites were described and sampled. The soil subtypes and general location descriptions are presented in Table 1-1. Sites were distributed from the wetland margin into the water along two transects to provide cross-sections, with transects in the southwestern (Sites 1, 2, 3 and 4) and northern side (Sites 5, 6, 7, and 8) of the wetland. The site and soil profile descriptions are presented in Table 1-2 and Table 1-3, and a conceptual cross-section diagram in Figure 1-2.

Southwestern transect.

Site 1 (Figure 1-3) occurred in open water (80 cm deep), the soil surface was soft, the soil consisted of a grey, very weak clay, that became very firm below 10cm. Site 2 (Figure 1-4) occurred at the edge of the reeds to open water (40 cm deep), and the soil consisted of a greyish brown, very weak clay, over grey, very firm, clay. Site 3 (Figure 1-5) occurred in Phragmites growing in water (40 cm deep), and the soil consisted of a greyish brown, very weak clay over dark grey, firm, clay. Site 4 (Figure 1-6) occurred on the wetland margin, the water table in the pit was at about 10 cm depth, and the soil consisted of a very dark greyish brown, very weak, peat with many plant roots, over a very dark grey, firm, clay.

Northern transect.

Site 5 (Figure 1-7) occurred in open water (85 cm deep), and the soil consisted of a grey, firm, clay, over a grey, firm, sandy loam. Site 6 (Figure 1-8) occurred at the edge of reeds in open water (40 cm deep), and the soil consisted of a grey, sandy loam, that was weak at the surface to very firm at depth. Site 7 (Figure 1-9) occurred in the Phragmites growing in water (20 cm deep), and the soil consisted of light brownish grey, firm sandy loam. Site 8 (Figure 1-10) occurred on the wetland margin, and the soil consisted of many plant roots and sand for the upper 20 cm, over a dark grey, firm loamy sand.

Table 1-1. Soil identification, subtype and general location description for Sinclair Creek Wetland (ID 12301).

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12301_1	374072	6207045	Hypersulfidic Subaqueous Soil (clayey)	Low elevation, in open water 15m from edge of reeds
12301_2	374065	6207042	Subaqueous Soil (clayey)	Low to mid elevation, edge of reeds and the open water
12301_3	374059	6207038	Subaqueous Soil (clayey)	Mid elevation, in open reed with water
12301_4	374054	6207036	Hypersulfidic Soil (clayey)	High elevation, in reeds on margin before bank up to floodplain
12301_5	373933	6207622	Subaqueous Soil (clayey)	Low elevation, in open water 30m from edge of reeds
12301_6	373920	6207647	Hypersulfidic Subaqueous Soil (loamy)	Low to mid elevation, edge of reeds and the open water
12301_7	373909	6207654	Subaqueous Soil (loamy)	Mid elevation, in open reed with water
12301_8	373903	6207666	Hypersulfidic Soil (sandy)	High elevation, 2m from reeds on bank up to floodplain

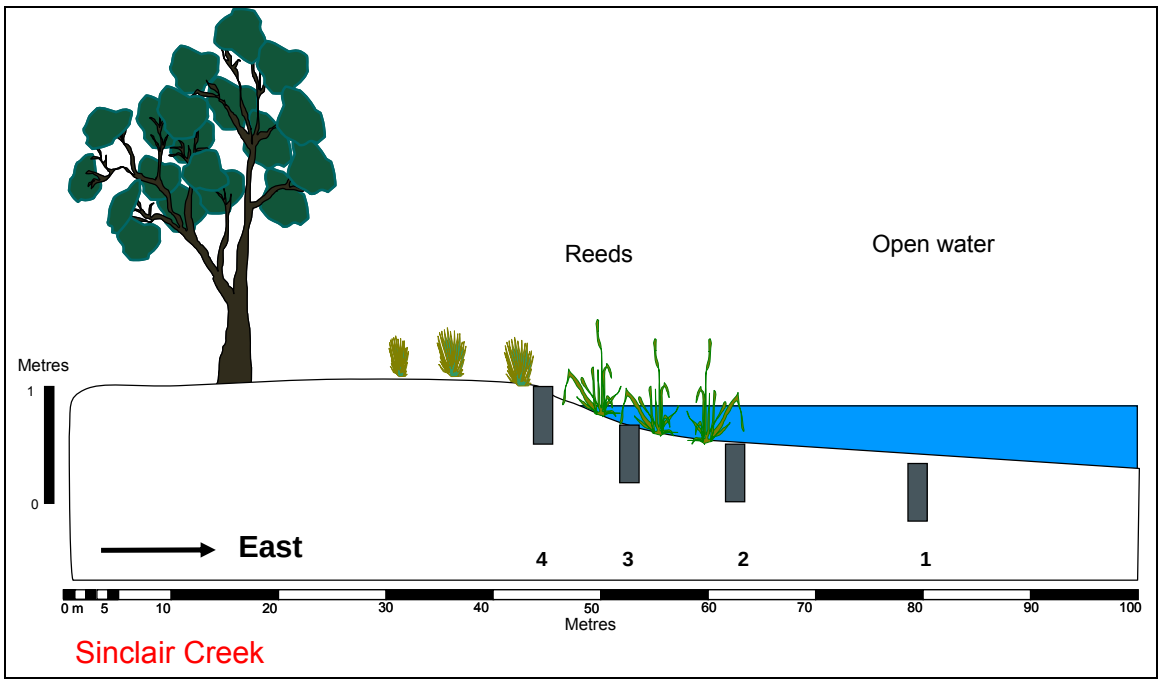


Figure 1-2. Conceptual cross-section diagram, showing the site positions in the wetland.

Figure 1-3: Photograph of Site 12301_1, showing the site location in open water.

Figure 1-4. Photograph of Site 12301_2, showing the site location at the edge of the reeds and open water.

Figure 1-5. Photograph of Site 12301_3, showing the site location where reeds were growing in water.

Figure 1-6. Photograph of Site 12301_4, showing the site location at the edge of the reeds looking up to the floodplain above.

Figure 1-7. Photograph of Site 12301_5, showing the site location in open water.

Figure 1-8. Photograph of Site 12301_6, showing the site location at the edge of the reeds with open water.

Figure 1-9. Photograph of Site 12301_7, showing the site location amongst reeds growing in water.

Figure 1-10. Photographs of Site 12301_8, showing the site location in reeds on the wetland margin, and the soil pit with a shallow water table.

1.3. Laboratory data assessment

1.3.1. Soil pH testing (pH_W, pH_{OX}, $pH_{incubation}$)

The pH data are provided in Table 1-4 and pH profiles are presented in Figure 1-11. The pH_W data ranged from 6.06 to 8.68 and sulfuric materials with a pH_W <4 were not identified. The pH_{OX} data ranged from 1.36 to 8.55 and identified that all eight profiles had at least one or more layers were below the critical value of pH_{OX} <2.5. The $pH_{incubation}$ data ranged from 2.45 to 8.10 and identified soil layers in Profiles 6 and 8 that on incubation declined below the critical value of pH <4.

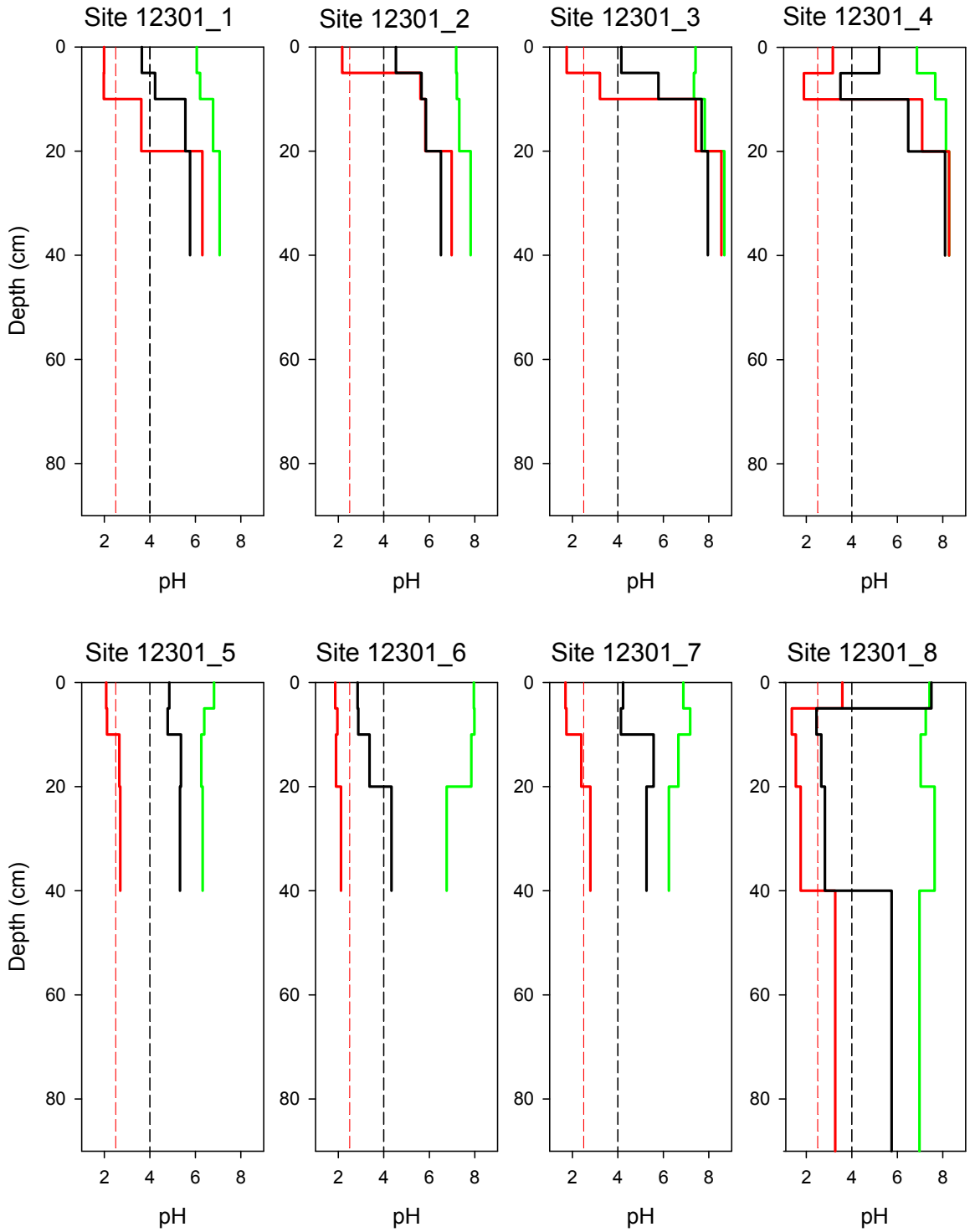


Figure 1-11. Depth profiles of soil pH for Sinclair Creek (Wetland ID. 12301), showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and incubation pH (pH_{INC} after 8 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

1.3.2. Acid base accounting

The acid base accounting data is provided in Table 1-4 and summarised in Figure 1-12.

Chromium reducible sulfur

Chromium reducible sulfur values ranged from 0 to 0.39 % S_{CR} and sulfidic soil materials were detected in nearly all soil layers.

Titratable actual acidity

Titratable actual acidity values ranged from 0 to 22.58 mole H^+/tonne, and were detected in at least one layer for all profiles except for Profile 3.

Retained acidity

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

Acid neutralising capacity

Acid neutralising capacity values ranged from 0 to 4.38 %$CaCO_3$ and were measured in Profiles 1, 3, 4, 5 and 8.

Net acidity

Net acidity values ranged from -572 to 208 mole H^+/tonne. All profile layers were positive, with high net acidity values occurring in the surface and subsurface layers of Profiles 1, 2, 3, and 8 and moderate or low value occurring in the remaining soil layers. Negative net acidity values occurred in the lower subsoil layers of Profiles 3 and 4 and the surface layer of Profile 8.

1.3.3. Water soluble sulfate

Water soluble sulfate data values shown in Table 1-4 identified Profiles 2, 3, 4 and 8 with surface layers that were higher than the criterion trigger value of 100 mg/kg SO_4.

1.3.4. Acid volatile sulfur

Monosulfidic materials were not observed and samples were not collected for analysis.

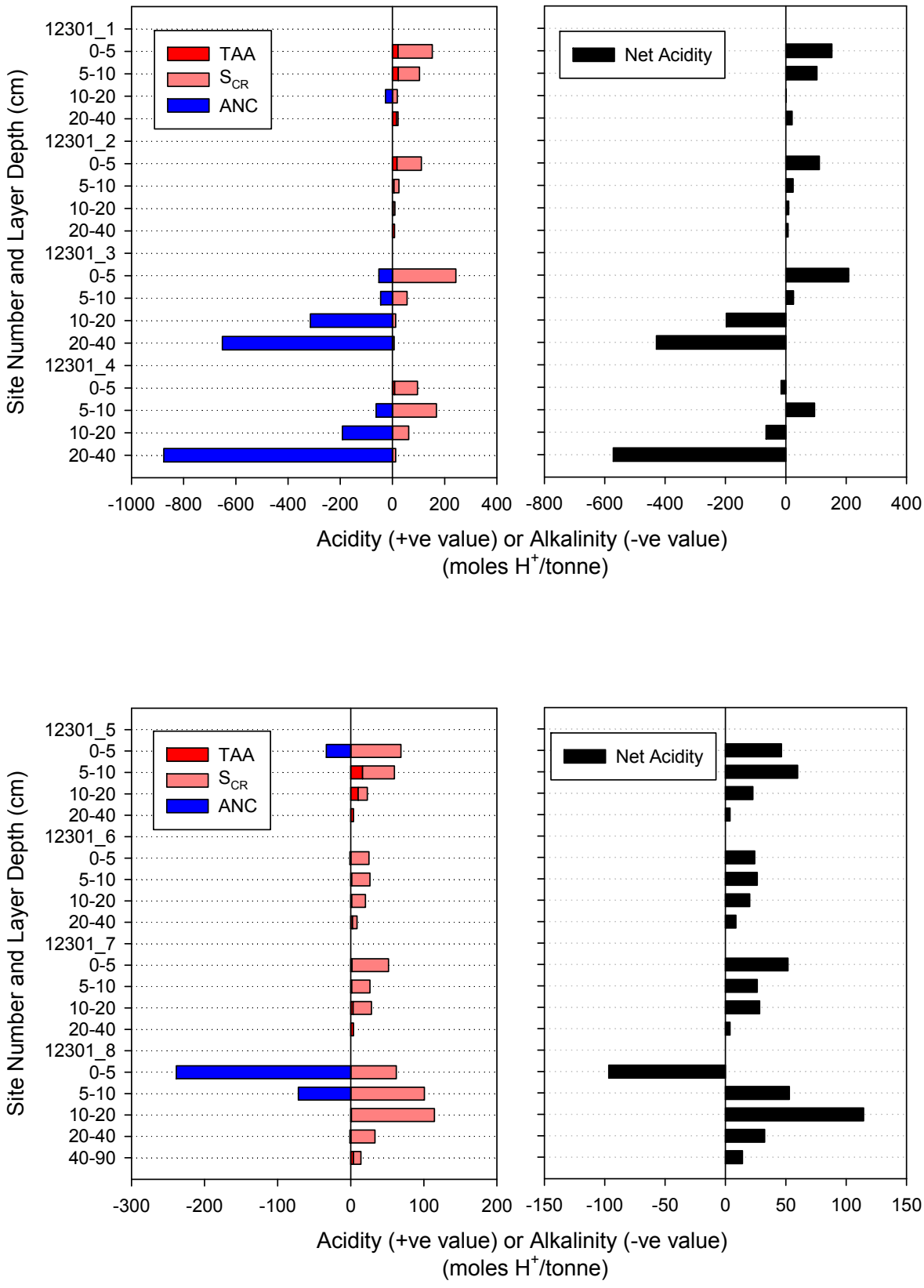


Figure 1-12. Acid base accounting depth profiles for Sinclair Creek (Wetland ID. 12301). Left side graph shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side graph shows net acidity.

1.3.5. Hydrochemistry

A surface water and a pit water were collected from each of the two transects. Field parameters are shown in Table 1-5. The surface waters had a slightly alkaline pH (7.90-8.13) and were relatively fresh (SEC 959-960 µS cm-1). The surface waters were saturated with dissolved oxygen and turbidity was moderate. Alkalinity was moderately high.

The SEC in the pit waters was higher than in the surface water but variable (Table 1-5). The pH was slightly acidic, and DO and Eh were low (but have likely been modified by contact with the atmosphere). Alkalinity was high in both samples.

All waters were of Na-Cl type (Table 1-6, Figure 1-13). Sulfate concentrations in the surface water were 33 mg l^{-1}, and pit waters varied from 6 to 60 mg l^{-1}. The SO_4/Cl ratios in the surface waters (0.15) was similar to seawater (0.142), but were much lower in the reducing pit waters (0.02-0.04). Nitrate concentrations were below detection limit, and NH_4 was present at slightly elevated concentrations, particularly at site 1. Iron and Mn were present, being higher in the pit waters. Elevated Al in waters from the first transect (sites 1 and 4) may be due to colloidal material as a consequence of high turbidity. The concentrations of most metals were low consistent with the circumneutral pH. Of note are slightly elevated concentrations of Zn (up to 200 µg l^{-1} in one pit water).

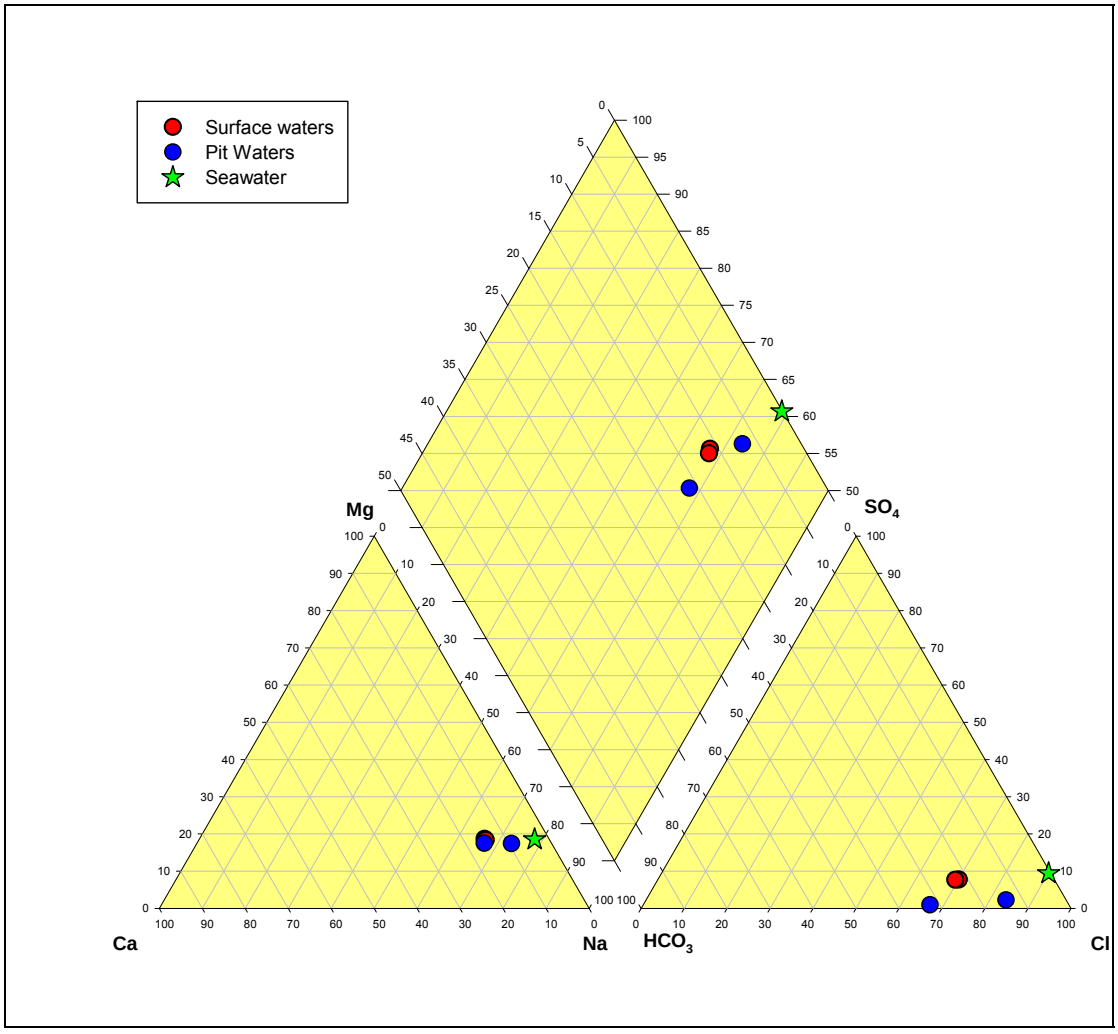


Figure 1-13. Piper diagram showing hydrochemistry for Sinclair Creek (Wetland ID. 12301)

1.4. Discussion

Acid sulfate soil materials in Sinclair Creek (Wetland ID. 12301) were identified as hypersulfidic and these soil materials occurred in one or more soil layers in four of the eight profiles. The other four profiles had soil layers with a positive net acidity. The acid sulfate soil subtype classes identified were Hypersulfidic Subaqueous Soil (clayey or loamy or sandy) that occurred in the low elevated areas below water, Hypersulfidic Soil (clayey) that occurred on the wetland margin, and Subaqueous Soil (clayey or loamy) that occurred throughout the wetland below water.

The soils throughout the main wetland area were clayey textured and in some areas around the margin they were loamy.

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

The potential hazards posed by acid sulfate soil materials at Sinclair Creek (Wetland ID. 12301) are:

- Acidification hazard: The data identified low, moderate or high net acidity values in samples at all profiles. Surface and upper soil layers had pH_{OX} data that indicated there was potentially an acidification hazard due to oxidation. There is a medium to high level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that in some locations there is potential for monosulfidic materials to form. There is a medium level of concern.
- Metal mobilisation: The medium to high acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

Summary of key findings for Sinclair Creek (Wetland ID. 12301):

Soil materials:	The soil layers were characterised as hypersulfidic in some profiles and hyposulfidic in other layers. The soils were generally clayey textured throughout the main wetland area and on the wetland margins they were loamy, and the soils became increasingly firmer with depth. Soils had low, moderate or high net acidity values in most layers and pH_{OX} data indicated a potential for acidification due to oxidation.
Acid sulfate soil identification:	• Hypersulfidic Subaqueous Soil (clayey or loamy or sandy) – occurring throughout the wetland below surface water. Dominant (>50%) in extent • Hypersulfidic Soil (clayey) – occurring on the wetland margins. Minor (<25%) in extent • Subaqueous Soil (clayey or loamy) – occurring throughout the wetland below surface water. Minor (<25%) in extent
Hazard assessment	• Acidification hazard – medium level of concern • De-oxygenation hazard – medium level of concern • Metal mobilisation hazard – low to medium level of concern

Table 1-2. Site description data for Sinclair Creek (Wetland ID. 12301).

Site Number	Sample Date	Easting m Zone 54H	Northing m Zone 54H	Water depth (+ve) Water table (-ve)	Surface condition	Earth cover (vegetation)	Location Notes
1	22/03/2010	374072	6207045	80	soft	water	Low elevation, in open water 15m from edge of reeds
2	22/03/2010	374065	6207042	40	soft	water	Low to mid elevation, edge of reeds and the open water
3	22/03/2010	374059	6207038	40	water	water	Mid elevation, in open reed with water
4	22/03/2010	374054	6207036	-10	soft	reeds	High elevation, in reeds on margin before bank up to floodplain
5	22/03/2010	373933	6207622	85	water	water	Low elevation, in open water 30m from edge of reeds
6	22/03/2010	373920	6207647	40	reeds	water	Low to mid elevation, edge of reeds and the open water
7	22/03/2010	373909	6207654	20	water	water	Mid elevation, In open reed with water
8	22/03/2010	373903	6207666	-25	soft	plant roots	High elevation, 2m from reeds on bank up to floodplain

Table 1-3. Soil profile description data for Sinclair Creek (Wetland ID. 12301).

Site and Sample (number)	Depth Range (cm)	Observation Method (kind)	Soil Colour (name, Munsell notation)	Texture (Class)	Soil Water Status	Redoximorphic Features (%, colour, location)	Structure Type (category)	Consistence (category)	Comments
1_W1	80 - 0	surface water							water sampled
1_W1DUP	80 - 0	surface water							water sampled
1_1	0 - 5	small pit	grey (5Y5/1)	clay	wet		gel	very weak	
1_2	5 - 10	small pit	grey (5Y5/1)	clay	wet		massive	very weak	
1_3	10 - 20	push tube	grey (5Y5/1)	clay	wet		massive	firm	
1_4	20 - 40	push tube	grey (5Y5/1)	clay	moist		massive	very firm	
2_W	40 - 0	water							
2_1	0 - 5	small pit	greyish brown (10YR5/2)	clay	wet		gel	very weak	
2_2	5 - 10	small pit	dark grey (5Y4/1)	clay	wet		massive	very weak	
2_3	10 - 20	push tube	grey (5Y5/1)	clay	wet		massive	firm	
2_4	20 – 40	push tube	grey (5Y5/1)	clay	moist		massive	firm	
3_W	40 - 0	water							
3_1	0 - 5	small pit	greyish brown (10YR5/2)	peaty clay	wet		gel	very weak	odour, many roots
3_2	5 - 10	small pit	dark grey (5Y4/1)	clay	wet		massive	very weak	many roots
3_3	10 - 20	push tube	dark grey (5Y4/1)	clay	moist		massive	firm	
3_4	20 - 40	push tube	very dark grey (5Y3/1)	clay	moist		massive	firm	few fine carbonate segregations

Site and Sample (number)	Depth Range (cm)	Observation Method (kind)	Soil Colour (name, Munsell notation)	Texture (Class)	Soil Water Status	Redoximorphic Features (%, colour, location)	Structure Type (category)	Consistence (category)	Comments
4_1	0 - 5	small pit	very dark greyish brown (10YR3/2)	plant material	wet		massive	very weak	dominantly plant roots
4_2	5 - 10	small pit	very dark greyish brown (10YR3/2)	plant material	wet		massive	very weak	dominantly plant roots
4_3	10 - 20	push tube	very dark grey (5Y3/1)	clay	moist		massive	firm	
4_4	20 - 40	push tube	very dark grey (5Y3/1)	clay	moist		massive	firm	
4_W1	-	pit water							water sampled
5_W1	85 - 0	surface water							water sampled
5_1	0 - 5	small pit	grey (5Y6/1)	clay	wet		massive	very weak	
5_2	5 - 10	small pit	grey (5Y5/1)	clay	wet		massive	firm	
5_3	10 - 20	push tube	grey (5Y5/1)	sandy loam	wet		massive	firm	
5_4	20 - 40	push tube	grey (5Y5/1)	sandy loam	wet		massive	very firm	
6_W	20 - 0	water							
6_1	0 - 5	small pit	grey (5Y6/1)	sandy loam	wet		massive	weak	
6_2	5 - 10	small pit	grey (5Y6/1)	sandy loam	wet		massive	firm	
6_3	10 - 20	push tube	grey (5Y6/1)	sandy loam	wet		massive	firm	
6_4	20 - 40	push tube	grey (5Y6/1)	sandy loam	wet		massive	very firm	
7_W	20 - 0	water							
7_1	0 - 5	small pit	grey (10YR5/1)	sandy loam	wet		massive	firm	
7_2	5 - 10	small pit	light brownish grey (2.5Y6/2)	sandy loam	wet		massive	firm	
7_3	10 - 20	push tube	light brownish grey (2.5Y6/2)	sandy loam	wet		massive	firm	
7_4	20 - 40	push tube	light brownish grey (2.5Y6/2)	sandy loam	wet		massive	firm	
8_1	0 - 5	small pit	very dark greyish brown (10YR3/2)	sandy plant material	moist		massive	very weak	80% plant roots
8_2	5 - 10	small pit	dark grey (10YR4/1)	sandy plant material	moist		massive	very weak	80% plant roots
8_3	10 - 20	push tube	dark grey (10YR4/1)	sandy plant material	wet		massive	very weak	30% plant roots
8_4	20 - 40	push tube	dark grey (5Y4/1)	loamy sand	wet		massive	firm	
8_5	40 - 90	push tube	dark grey (5Y4/1)	clay loam sandy	wet		massive	very firm	
8_W1	-	pit water							water sampled

Table 1-4. Laboratory data for acid sulfate soil assessment of Sinclair Creek (Wetland ID. 12301).

(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 week 0	pH incubation week 8	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+ /tonne)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H+/ tonne)	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
1.W1	80-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
1.1	0-5	Fine	1,235	6.06	1.99	6.24	3.65	88	6.35	21.60	0.21	..	0.00	153	hypersulfidic
1.2	5-10	Fine	1,465	6.21	1.98	6.37	4.23	77	6.08	22.58	0.13	..	0.00	104	hyposulfidic (S_{CR}≥0.10%)
1.3	10-20	Fine	1,338	6.78	3.62	6.49	5.56	17	6.54	0.00	0.03	..	0.13	1	hyposulfidic (S_{CR}<0.10%)
1.4	20-40	Fine	1,090	7.07	6.31	6.34	5.77	15	6.20	15.22	0.01	..	0.00	21	hyposulfidic (S_{CR}<0.10%)
2.W1	40-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
2.1	0-5	Fine	1,773	7.18	2.17	6.66	4.53	110	6.28	17.67	0.15	..	0.00	111	hyposulfidic (S_{CR}≥0.10%)
2.2	5-10	Fine	1,095	7.21	5.61	6.80	5.66	55	6.35	5.89	0.03	..	0.00	25	hyposulfidic (S_{CR}<0.10%)
2.3	10-20	Fine	934	7.32	5.83	6.91	5.85	21	6.40	3.44	0.01	..	0.00	10	hyposulfidic (S_{CR}<0.10%)
2.4	20-40	Fine	960	7.82	6.98	7.06	6.51	14	6.36	7.85	<0.01	..	0.00	8	other soil material
3.W1	40-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
3.1	0-5	Medium	1,975	7.41	1.75	6.66	4.15	130	6.57	0.00	0.39	..	0.26	208	hyposulfidic (S_{CR}≥0.10%)
3.2	5-10	Medium	2,420	7.34	3.21	6.47	5.78	71	6.99	0.00	0.09	..	0.23	26	hyposulfidic (SCR<0.10%)
3.3	10-20	Fine	3,010	7.82	7.42	6.91	7.68	27	7.23	0.00	0.02	..	1.57	-197	hyposulfidic (SCR<0.10%)
3.4	20-40	Fine	1,852	8.68	8.55	7.37	7.95	21	7.06	0.00	0.01	..	3.26	-428	hyposulfidic (S_{CR}<0.10%)
4.1	0-5	Medium	2,720	6.86	3.16	6.81	5.20	330	6.44	8.35	0.14	..	0.00	96	hyposulfidic (S_{CR}≥0.10%)
4.2	5-10	Medium	2,840	7.67	1.89	6.91	3.50	260	6.51	0.00	0.27	..	0.31	127	hypersulfidic
4.3	10-20	Fine	2,960	8.14	7.09	6.62	6.48	180	6.86	0.00	0.10	..	0.96	-65	hyposulfidic (S_{CR}≥0.10%)
4.4	20-40	Fine	406	8.28	8.28	7.54	8.10	23	7.27	0.00	0.02	..	4.38	-572	hyposulfidic (S_{CR}<0.10%)
4.W1	-	..	..	..	..	..	..	..	..	..	..	..	..	..	pit water
5.W1	85-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
5.1	0-5	Fine	165	6.82	2.08	6.44	4.85	38	7.20	0.00	0.11	..	0.17	46	hyposulfidic (S_{CR}≥0.10%)
5.2	5-10	Fine	168	6.39	2.12	6.46	4.78	36	6.03	16.20	0.07	..	0.00	60	hyposulfidic (S_{CR}<0.10%)
5.3	10-20	Medium	92	6.26	2.66	6.29	5.37	14	6.10	10.31	0.02	..	0.00	23	hyposulfidic (S_{CR}<0.10%)
5.4	20-40	Medium	100	6.32	2.70	6.46	5.33	6	6.23	3.93	<0.01	..	0.00	4	other acidic incubation
6.1	0-5	Medium	117	7.96	1.87	7.16	2.85	44	6.67	0.00	0.04	..	0.00	24	hypersulfidic
6.2	5-10	Medium	112	7.98	1.96	7.37	2.88	34	6.33	1.47	0.04	..	0.00	26	hypersulfidic
6.3	10-20	Medium	103	7.85	1.90	6.91	3.37	34	6.42	1.47	0.03	..	0.00	20	hypersulfidic
6.4	20-40	Medium	84	6.76	2.12	6.68	4.34	21	6.21	2.45	0.01	..	0.00	9	hyposulfidic (S_{CR}<0.10%)
6.W1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	pit water

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation week 0	pH incubation week 8	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+ /tonne)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H+/ tonne)	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
7.W1	20-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
7.1	0-5	Medium	175	6.88	1.70	6.28	4.23	51	6.36	1.96	0.08	..	0.00	52	hyposulfidic (S_{CR}<0.10%)
7.2	5-10	Medium	134	7.18	1.74	6.49	4.13	39	6.44	1.47	0.04	..	0.00	26	hyposulfidic (S_{CR}<0.10%)
7.3	10-20	Medium	120	6.66	2.39	6.37	5.57	32	6.05	3.44	0.04	..	0.00	28	hyposulfidic (S_{CR}<0.10%)
7.4	20-40	Medium	132	6.24	2.79	6.39	5.26	6	6.16	3.93	<0.01	..	0.00	4	other acidic incubation
8.1	0-5	Fine	1,352	7.41	3.58	7.29	7.50	120	7.12	0.00	0.10	..	1.19	-97	hyposulfidic (S_{CR}≥0.10%)
8.2	5-10	Medium	710	7.25	1.36	6.52	2.45	130	6.78	0.00	0.16	..	0.36	53	hypersulfidic
8.3	10-20	Medium	1,037	7.03	1.54	6.53	2.66	83	6.41	0.98	0.18	..	0.00	115	hypersulfidic
8.4	20-40	Medium	593	7.64	1.75	7.01	2.82	36	6.97	0.00	0.05	..	0.00	33	hypersulfidic
8.5	40-90	Fine	448	6.97	3.27	6.36	5.75	35	6.46	3.94	0.02	..	0.00	14	hyposulfidic (S_{CR}<0.10%)
8.W1	-	..	..	..	..	..	..	..	..	..	..	..	..	..	pit water

Table 1-5. Summary of hydrochemical field measurements for Sinclair Creek (Wetland ID. 12301).

	pH	SEC	DO	Eh	Turbidity	Alkalinity
		µS cm^{-1}	mg l^{-1}	mV	NTU	as HCO_3
Surface waters (n=2)	7.90 - 8.13	959 - 960	8.6 - 10.1	190 - 499	33 - 41	119 - 126
Pit waters (n = 2)	6.45 - 6.50	1454 - 6404	0.16 - 0.22	29 - 48		257 - 543

Table 1-6. Hydrochemistry data for Sinclair Creek (Wetland ID. 12301)

Parameter	units	ANZECC Guidelines	Site 1 (SW)	Site 4 (PW)	Site 5 (SW)	Site 8 (PW)
Na	mg l^{-1}		133	192	133	969
K	mg l^{-1}		4.9	3.5	4.7	1.8
Ca	mg l^{-1}		26.8	39.6	26.4	108
Mg	mg l^{-1}		20.2	26.9	19.8	122
Si	mg l^{-1}		3.13	4.75	2.82	8.58
Br	mg l^{-1}		0.470	0.660	0.510	2.90
Cl	mg l^{-1}		220	310	220	1900
NO_3	mg l^{-1}	0.7	<0.022	<0.022	<0.022	<0.022
NH_4-N^K	mg l^{-1}	0.01	**0.180**	**0.040**	**0.012**	**0.039**
PO_4^E	mg l^{-1}	0.02	**0.049**	**0.055**	0.020	**0.055**
SO_4	mg l^{-1}		33	6	33	69
Ag	µg l^{-1}	0.05	0.01	<0.01	0.01	<0.04
Al^A	µg l^{-1}	55	**440**	**400**	**70**	<100
As^B	µg l^{-1}	13	2	2.8	1.2	4
Cd	µg l^{-1}	0.2	**0.22**	0.10	0.05	0.10
Co	µg l^{-1}	2.8	0.58	0.38	0.09	0.64
Cr^C	µg l^{-1}	1	0.5	0.5	0.1	<0.5
Cu^H	µg l^{-1}	1.4	1.4	1.2	0.8	<2
Fe	µg l^{-1}	300	**687**	**716**	<100	**2880**
Mn	µg l^{-1}	1700	130	320	2.22	439
Ni^H	µg l^{-1}	11	3.0	1.2	0.90	2.0
Pb^H	µg l^{-1}	3.4	1.6	0.4	<0.1	<1
Se	µg l^{-1}	11	<0.08	<0.2	<0.08	<0.8
Zn^H	µg l^{-1}	8	6.6	**48.4**	**19**	**200**
DOC	mg l^{-1}		11.2	20.0	8.9	66.3

Notes.

The ANZECC guideline values for toxicants refer to the trigger values applicable to 'slightly-moderately disturbed' freshwater systems, as outlined in the Australian Water Quality Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000). For the nutrients NH_4 and PO_4, trigger values are provided for Freshwater Lakes and reservoirs. Surface water values outside the ranges defined in the ANZECC guidelines are indicated with red text. (SW) and (PW) indicate whether the sample was taken from surface water or pit-water (groundwater that entered an excavated pit), respectively.

A *Trigger value for Aluminium in freshwater where pH > 6.5.*

B *Trigger value assumes As in solution as Arsenic (AsV).*

C *Trigger value for Chromium is applicable to Chromium (CrVI) only.*

E *Guideline is for filterable reactive phosphorous (FRP).*

H *Hardness affected (refer to Guidelines).*

K *Guideline for South-east Australia-Freshwater Lakes and reservoirs.*

2. MURBPOOK LAGOON COMPLEX (WETLAND ID. 12158)

2.1. Location and setting description

This wetland in the Murbpook Lagoon Complex (Wetland ID. 12158) is situated on the northern side of the River Murray about 17 kilometres up river from Lock 1 at Blanchetown, located in the Murbpook Lagoon Complex area. The wetland is somewhat oval in shape, about 1.8 kilometres in length parallel to the river and approximately 850 metres at the widest point, with an area of 102 hectares. The wetland is bounded by hill slopes to the west and a raised floodplain that separates it from the wetland to the south and the river. One other wetland in this Complex was surveyed (Wetland Id. 12161).

There are four inlet creeks that occasionally flow. At the time when the soil survey was conducted in March 2010, the wetland had surface water. The wetland complex has been managed by the property manager with the assistance of the South Australian Murray-Darling Basin Natural Resources Management Board (SA MDB NRM Board) and the RWLAP, since 2004. The wetland was closed in October 2006 and water was pumped into it in June 2009. The wetland margins have Typha and sedges growing, with woodland and shrubland on the raised floodplain that separates the wetland and river. Thirteen sites were sampled as shown in Figure 2-1.

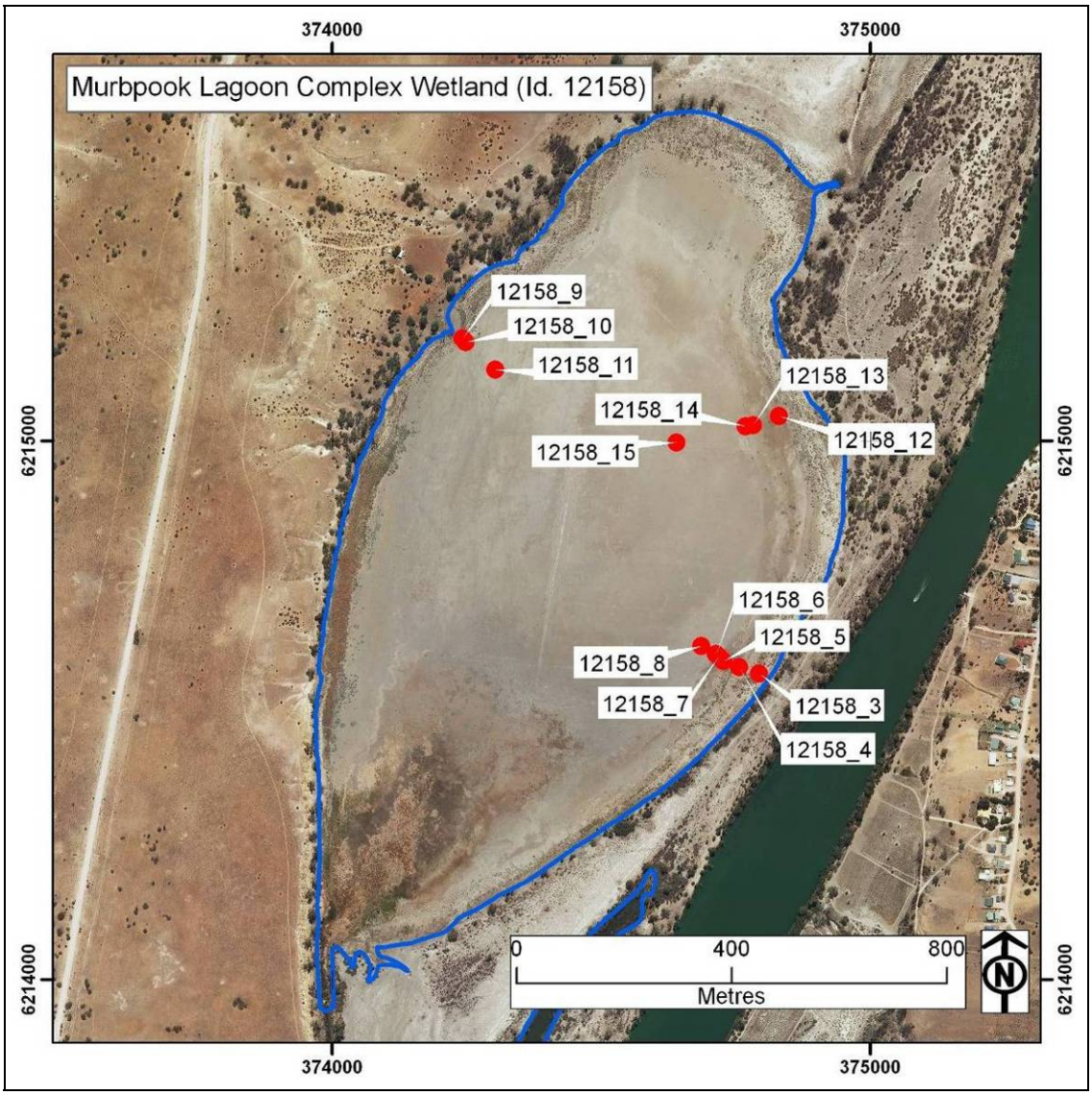


Figure 2-1. Murbpook Lagoon Complex (Wetland ID. 12158) and sample site locations.

2.2. Soil profile description and distribution

Thirteen sites were described and sampled. The soil subtypes and general location descriptions are presented in Table 2-1. Sites were distributed from the wetland margin into the water along three transects to provide cross-sections, from the eastern side (Sites 3, 4, 5, 6, 7, and 8), from the western side (Sites 9, 10, and 11), and from the north eastern side (Sites 12, 13, 14, and 15) of the wetland. The site and soil profile descriptions are presented in Table 2-2 and Table 2-3, and a conceptual cross-section diagram Figure 2-2.

Eastern transect

Site 3 (Figure 2-3) occurred on the wetland margin, and the soil consisted of a greyish brown, weak to firm, sand over a light olive grey, very firm, clay. Site 4 (Figure 2-4) occurred at the edge of water, and the soil consisted of a dark greyish brown, firm, clay. Site 5 (Figure 2-5) occurred at the shoreline edge in the water (20 cm deep), and the soil consisted of a dark greyish brown, weak, blocky, clay over a dark grey, firm, clay. Site 6 occurred in open water (15 cm deep), a water sample was collected and although the soil was not described or sampled, it was similar to Site 7. Site 7 (Figure 2-6) occurred in open water (15 cm deep), and the soil consisted of a thin (3 cm), black, monosulfidic gel, over a grey, firm, clay. Site 8 (Figure 2-7) occurred in open water (20 cm deep), and the soil consisted of a greyish brown, firm, clay.

Western transect

Site 9 (Figure 2-8) occurred on the wetland margin, and the soil consisted of a very dark grey, weak, clay over a dark grey, firm, sandy loam, over a very firm, clay at depth. Site 10 (Figure 2-9) occurred at the edge of water, the water table in the pit was at about 25 cm depth, and the soil consisted of a very dark grey, weak, clay over a dark grey, firm, sandy loam, over a very firm, clay. Site 11 (Figure 2-10) occurred in open water (15 cm deep), and the soil consisted of a dark grey, firm, clay.

North eastern transect

Site 12 (Figure 2-11) occurred on the wetland margin near an old shoreline, and the soil consisted of a dark grey, weak, sandy loam, over an olive grey, firm, sand. Site 13 occurred at the edge of water, the water table in the pit was at about 10 cm depth, and the soil consisted of dark grey, weak, loamy sand, over a dark grey, very firm, clay. Site 14 (Figure 2-12) occurred in the water near shore (3 cm deep), and the soil consisted of a dark grey, firm, sandy clay loam. Site 15 (Figure 2-13) occurred in open water (15 cm deep), and the soil consisted of dark grey, very firm, clay, over a dark greenish grey, very firm, sandy clay loam.

Table 2-1. Soil identification, subtype and general location description for Murbpook Lagoon Complex (Wetland ID. 12158)

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12158_3	374794	6214568	Other Soil (clayey)	high elevation, on margin where surface is sandy
12158_4	374757	6214580	Other Soil (clayey)	mid to high elevation, adjacent to waters edge
12158_5	374728	6214591	Other Soil (clayey)	mid elevation, 20m from waters edge
12158_6	374714	6214604	Subaqueous Soil (clayey)	water sample only
12158_7	374719	6214600	Subaqueous Soil (clayey)	low elevation, in open water
12158_8	374687	6214619	Subaqueous Soil (clayey)	low elevation, in open water
12158_9	374243	6215190	Other Soil (clayey)	high elevation, on wetland margin
12158_10	374249	6215183	Subaqueous Soil (clayey)	mid elevation, 1m above waters edge
12158_11	374304	6215132	Subaqueous Soil (clayey)	low elevation, in open water
12158_12	374831	6215046	Other Soil (sandy)	high elevation, near old shoreline with dead trees
12158_13	374783	6215029	Other Soil (clayey)	mid to high elevation, near waters edge
12158_14	374769	6215027	Subaqueous Soil (loamy)	low elevation, 5m from waters edge
12158_15	374641	6214997	Subaqueous Soil (clayey)	low elevation, in open water

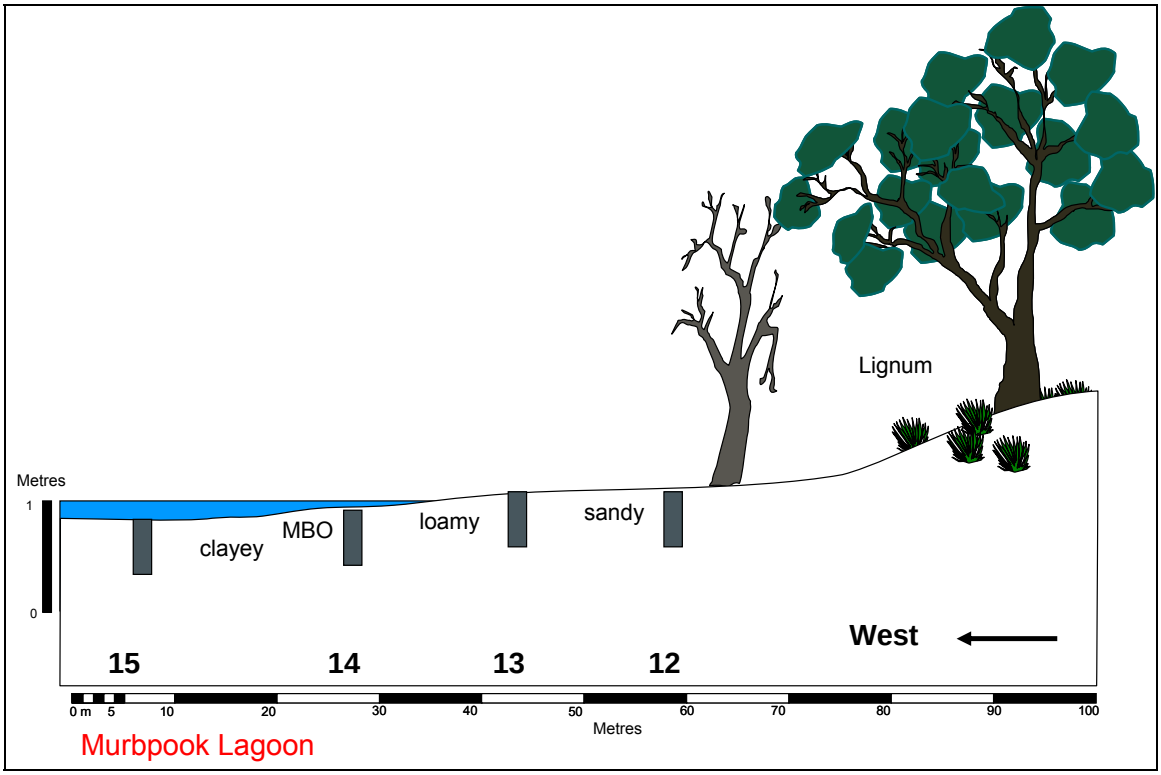


Figure 2-2. Conceptual cross-section diagram, showing position of Sites 12 to 15.

Figure 2-3: Photographs of Site 3, showing the site location on the wetland margin, and the soil profile that is clayey with a sandy surface.

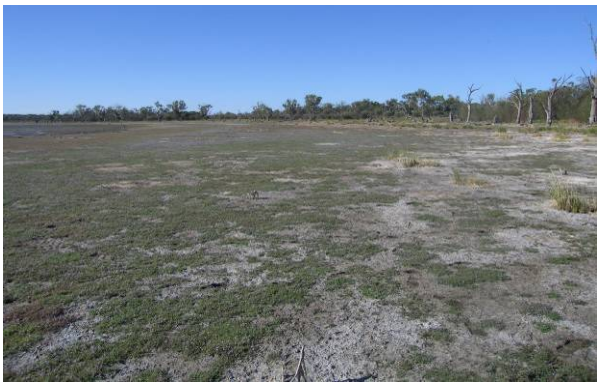


Figure 2-4. Photographs of Site 4, showing the site location between the wetland margin and waters edge, and the soil profile.

Figure 2-5. Photographs of Site 5, showing the site location near the waters edge, and the soil profile that is clayey.

Figure 2-6. Photograph of Site 7, showing the site location at water level.

Figure 2-7. Photograph of Site 8, showing the soil pit in shallow water with algae on the surface.

Figure 2-8. Photograph of Site 9, showing the site location on the wetland margin, and the soil that is clayey.

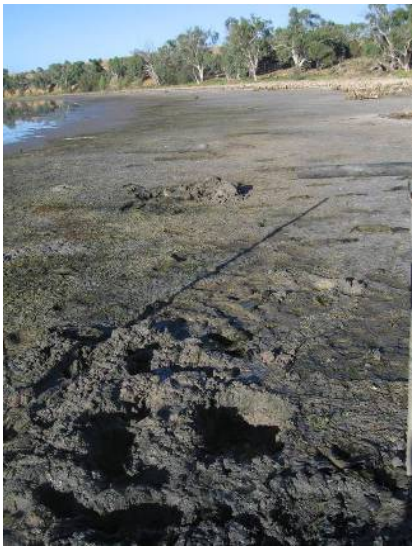


Figure 2-9. Photograph of Site 10, showing the site location adjacent to the water.

Figure 2-10. Photograph of Site 11, showing the site location in open water.

Figure 2-11. Photographs of Site 12, showing the site location high up on the wetland margin where there was an old shoreline, and the soil profile that is clayey.

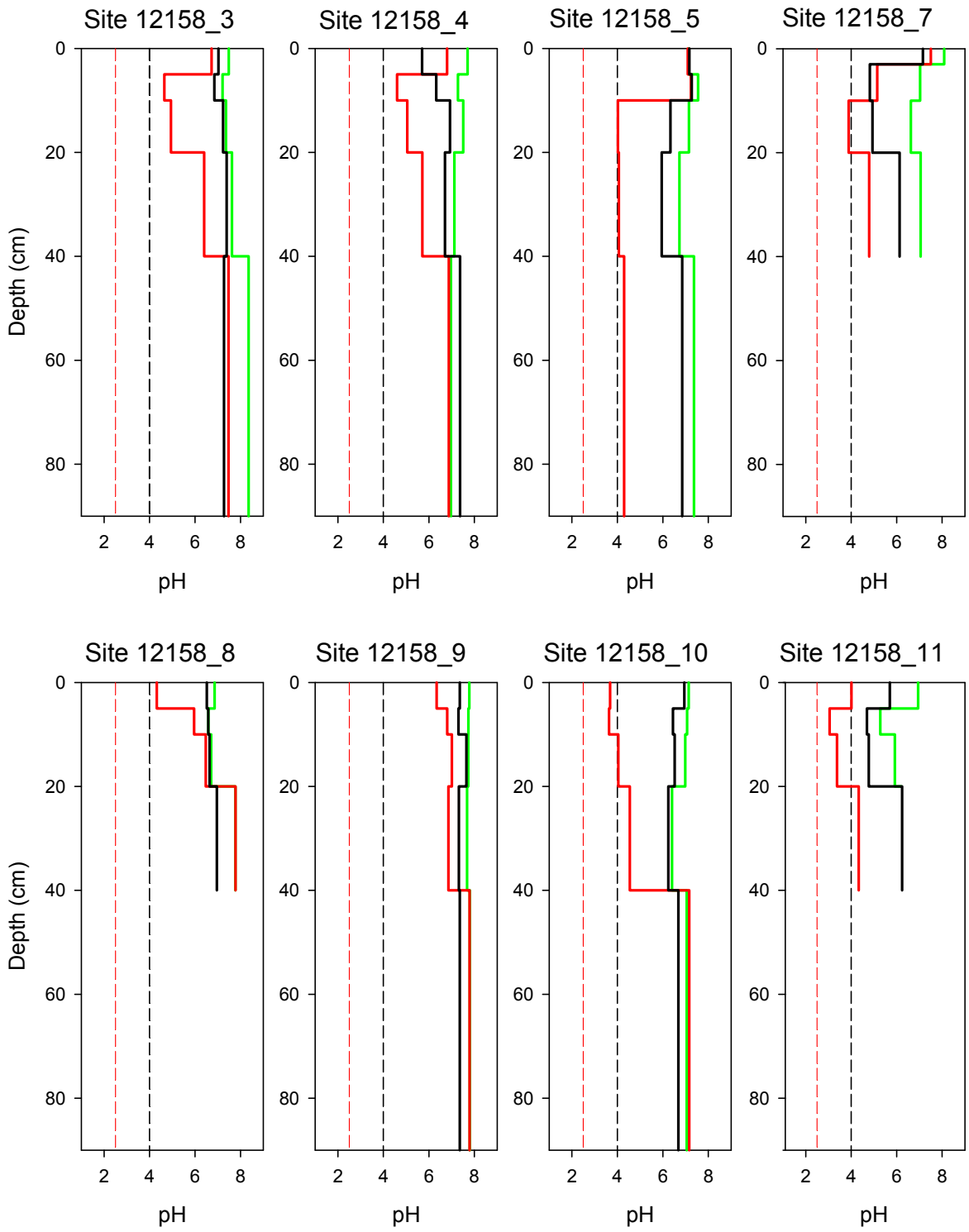
Figure 2-12. Photograph of Site 14, showing the site location in water and black monosulfidic material in the surface layer.

Figure 2-13. Photograph of Site 15, showing the site location in open water.

2.3. Laboratory data assessment

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

The pH data is provided in Table 2-5 and pH profiles are presented in Figure 2-14. The pH_W data ranged from 5.28 to 8.35 and sulfuric materials with a pH_W were not identified. The pH_{OX} data ranged from 3.05 to 7.94, and identified that there were no samples below the critical value of pH_{OX} <2.5. The pH_{INC} data ranged from 4.96 to 7.65, and identified that no samples on incubation declined below the critical value of pH <4.


Site 12158_3
Site 12158_4
Site 12158_5
Site 12158_7
Site 12158_8
Site 12158_9
Site 12158_10
Site 12158_11
Depth (cm)
0
20
40
60
80
2
4
6
8
pH

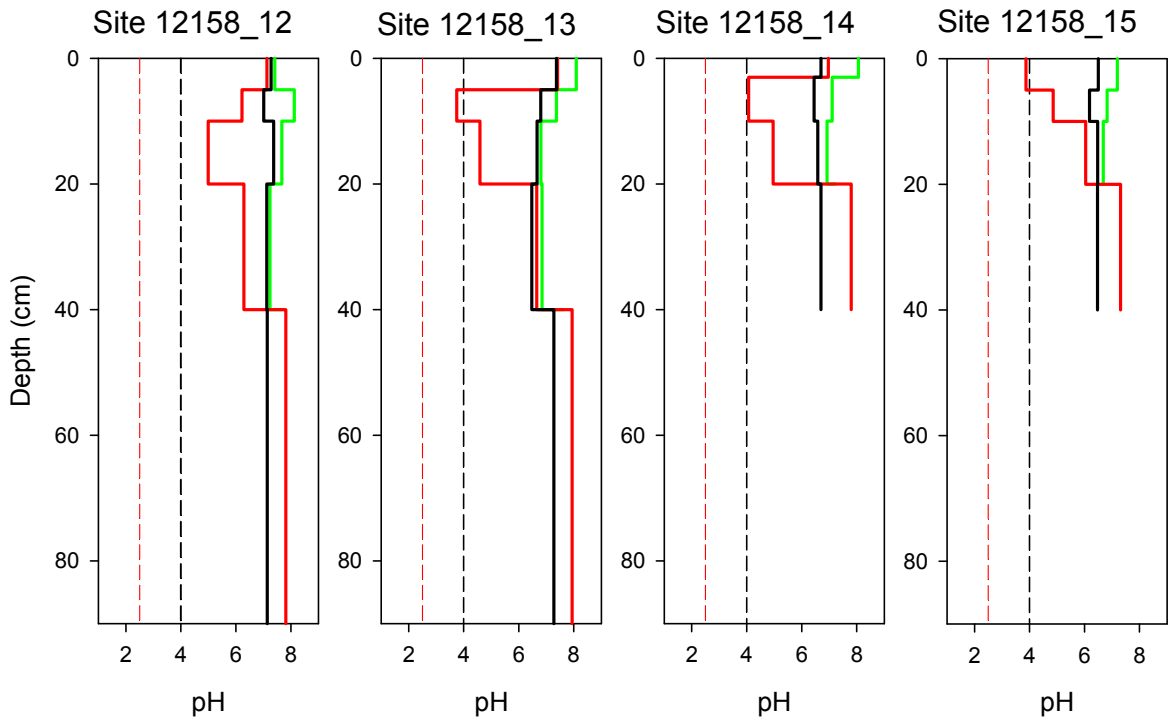


Figure 2-14. Depth profiles of soil pH for Murbpook Lagoon Complex (Wetland ID. 12158), showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and incubation pH (pH_{INC} after 8 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

2.3.2. Acid base accounting

The acid base accounting data is provided in Table 2-6 and summarised in Figure 2-15.

Chromium reducible sulfur

Chromium reducible sulfur values ranged from 0 to 0.43 $\%S_{CR}$ and sulfidic materials were detected in at least one layer of every profile. Generally the lower subsoil layer values were below detection limits.

Titratable actual acidity

Titratable actual acidity values ranged from 0 to 25.60 mole H^+/tonne. Generally for profiles that were not below water, values were at or below detection limits and for profiles occurring below water titratable actual acidity was detected.

Retained acidity

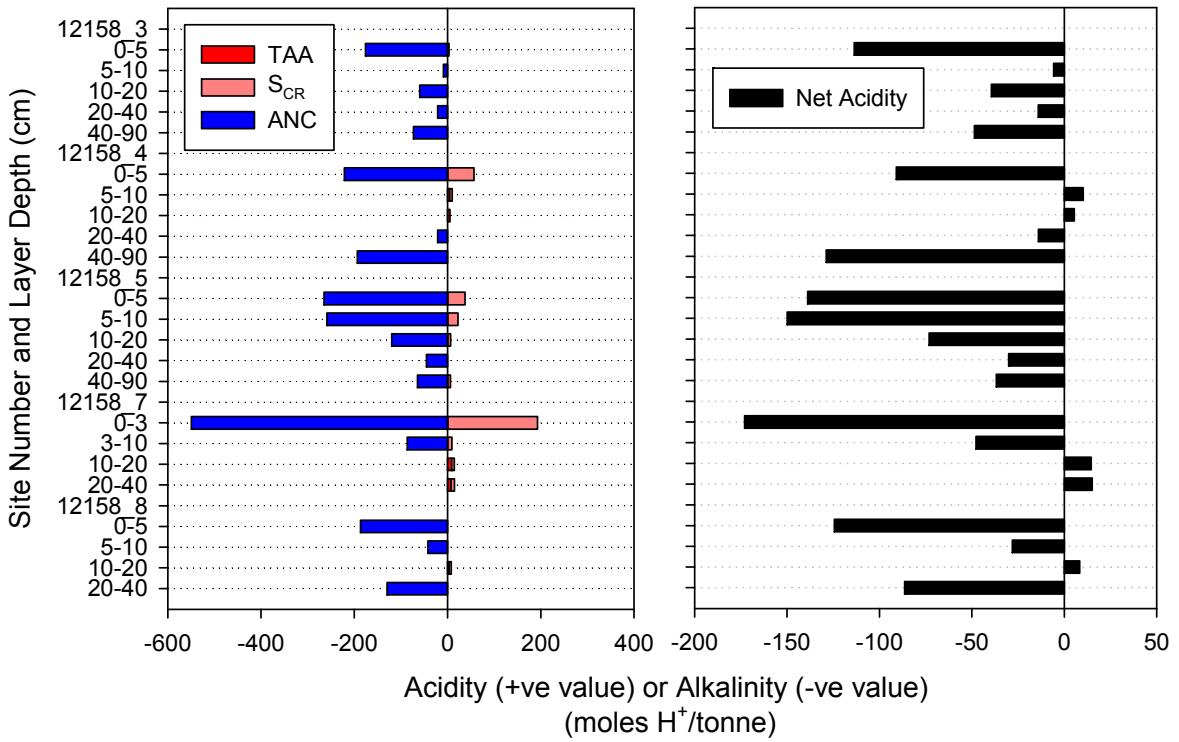
Retained acidity was not measured in any of the layers as all samples had a pH_{KCl} of greater than 4.5.

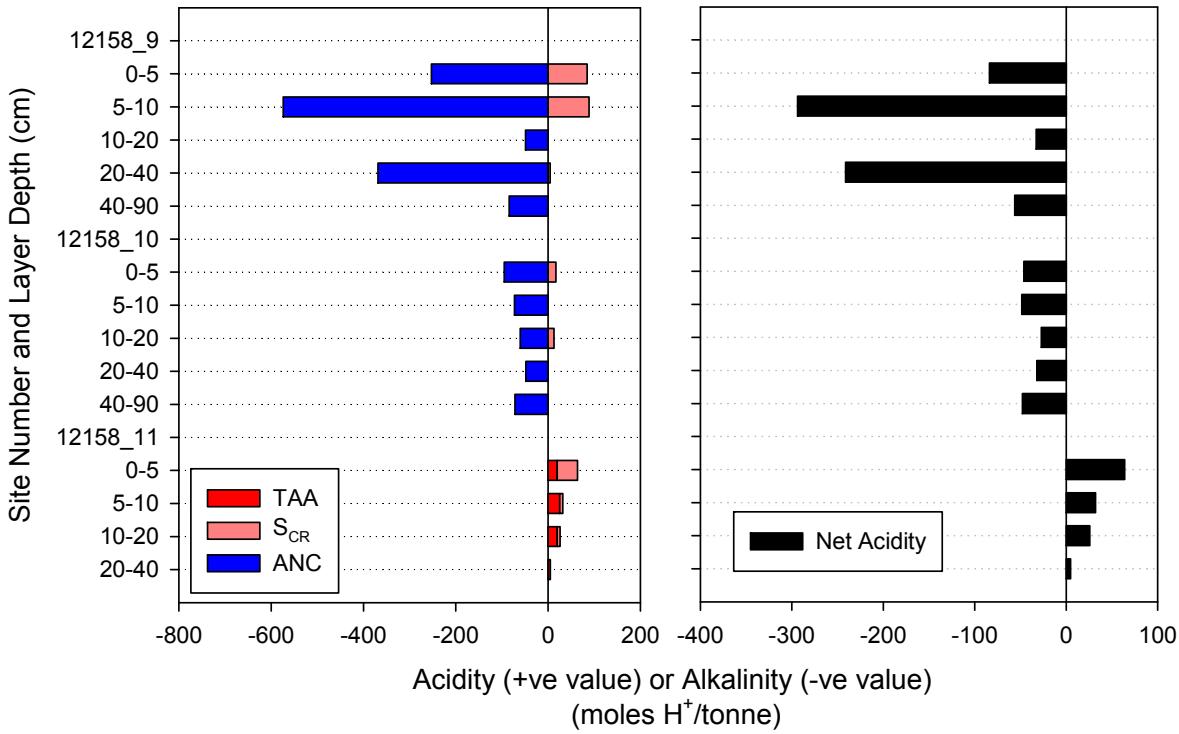
Acid neutralising capacity

Acid neutralising capacity values ranged from 0 to 5.33 % $CaCO_3$ and were measured in at least one layer for each profile.

Net acidity

Net acidity values ranged from -442 to 64 mole H^+/tonne. Generally layers were negative net acidity values or low net acidity values for some profile layers. The exception was Profile 11 that had moderate net acidity values.


12158_3
0-5
5-10
10-20
20-40
40-90
12158_4
0-5
5-10
10-20
20-40
40-90
12158_5
0-5
5-10
10-20
20-40
40-90
12158_7
0-3
3-10
10-20
20-40
12158_8
0-5
5-10
10-20
20-40
TAA
S_CR
ANC
Net Acidity
Site Number and Layer Depth (cm)
-600
-400
-200
0
200
400
-200
-150
-100
-50
0
50
Acidity (+ve value) or Alkalinity (-ve value)
(moles H+/tonne)


12158_9
0-5
5-10
10-20
20-40
40-90
12158_10
0-5
5-10
10-20
20-40
40-90
12158_11
0-5
5-10
10-20
20-40
TAA
S_CR
ANC
Net Acidity
Site Number and Layer Depth (cm)
-800
-600
-400
-200
0
200
-400
-300
-200
-100
0
100
Acidity (+ve value) or Alkalinity (-ve value)
(moles H+/tonne)

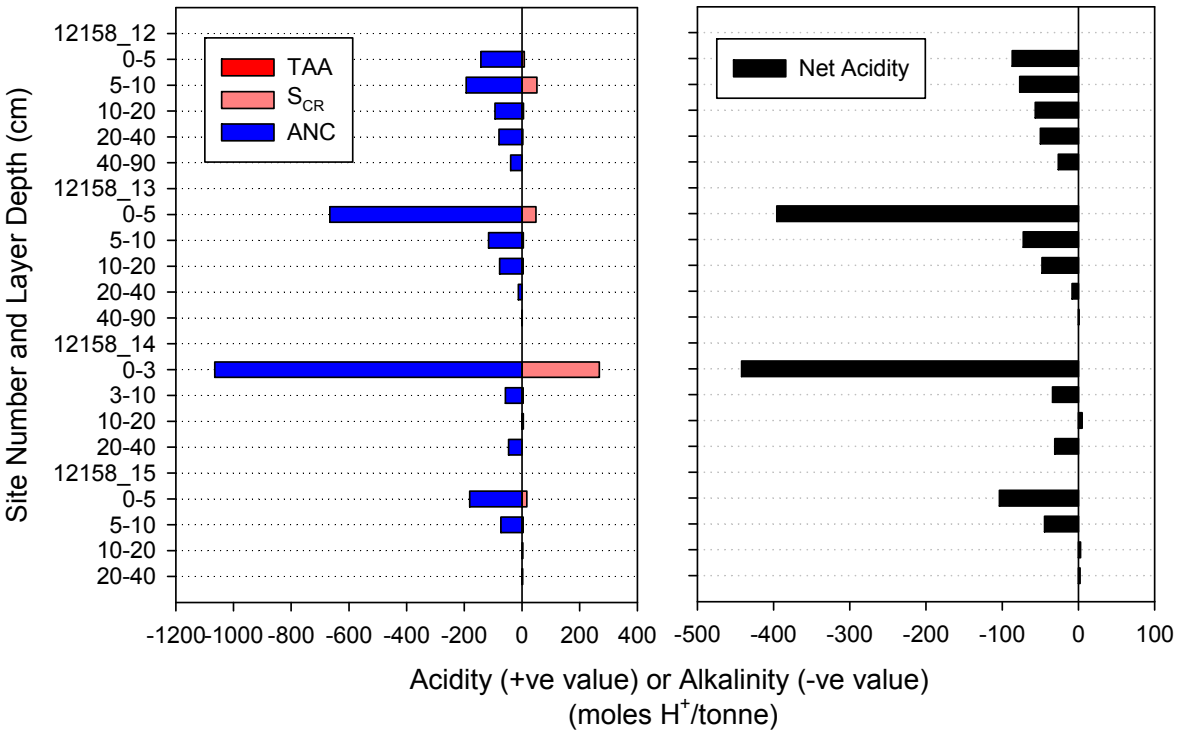


Figure 2-15. Acid base accounting depth profiles for Murbpook Lagoon Complex (Wetland ID. 12158). Left side shows the components: Titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

2.3.3. Water soluble sulfate

Water soluble sulfate data values shown in Table 2-4 identified all profiles with surface layers that were higher than the criterion trigger value of 100 mg/kg SO_4.

2.3.4. Acid volatile sulfur

Monosulfidic materials were observed in the upper layers of Profiles 7 and 14 and sampled for analysis. The values shown in Table 2-4 were all above S_{AV} ≥0.01% S, the criteria value for identifying monosulfidic material.

2.3.5. Hydrochemistry

A surface water and pit water sample was collected from each of the three transects surveyed in the wetland. Surface water was shallow and large areas of the wetland had dried. Field parameters are shown in Table 2-5. The surface waters had neutral to slightly alkaline pH and were relatively saline. The waters were saturated with dissolved oxygen and turbidity was low to moderate. Alkalinity was present in all samples but was variable.

The SEC in the pit waters was lower than in the surface water (Table 2-5). The pH was slightly acidic, and DO and Eh were low (but have likely been modified by contact with the atmosphere). Alkalinity was much higher in the pit water samples compared to surface waters.

All waters were of Na-Cl type, but there were strong enrichments in Ca and SO_4 relative to seawater (Table 2-6, Figure 2-16). Sulfate concentrations in the surface waters varied from 3400 to 4000 mg l^{-1}, and were lower in the pit waters varying from 1500 to 2700 mg l^{-1}. The SO_4/Cl ratio in the surface waters (0.45-0.46) was much higher than seawater (0.142), and slightly higher than those in the reducing pit waters (0.26-0.42). Nitrate concentrations were below detection limit in the surface waters, but present at low concentrations in two of the pit water samples. The concentrations of NH_4, PO_4 and NO_2 were higher in pit waters, with NH_4 in particular being significantly higher than ANZECC Guideline values (Table 2-5). Iron and Mn were present at high concentration in the pit waters. The detection limit for Fe in the surface waters (as well as a number of trace elements) was high due to required dilution prior to analyses. Nevertheless, concentrations of As, Co, Ni and Zn in the pit waters were high, and for Co, Ni and Zn significantly higher than ANZECC Guideline values. Organic carbon concentrations were high in all samples.

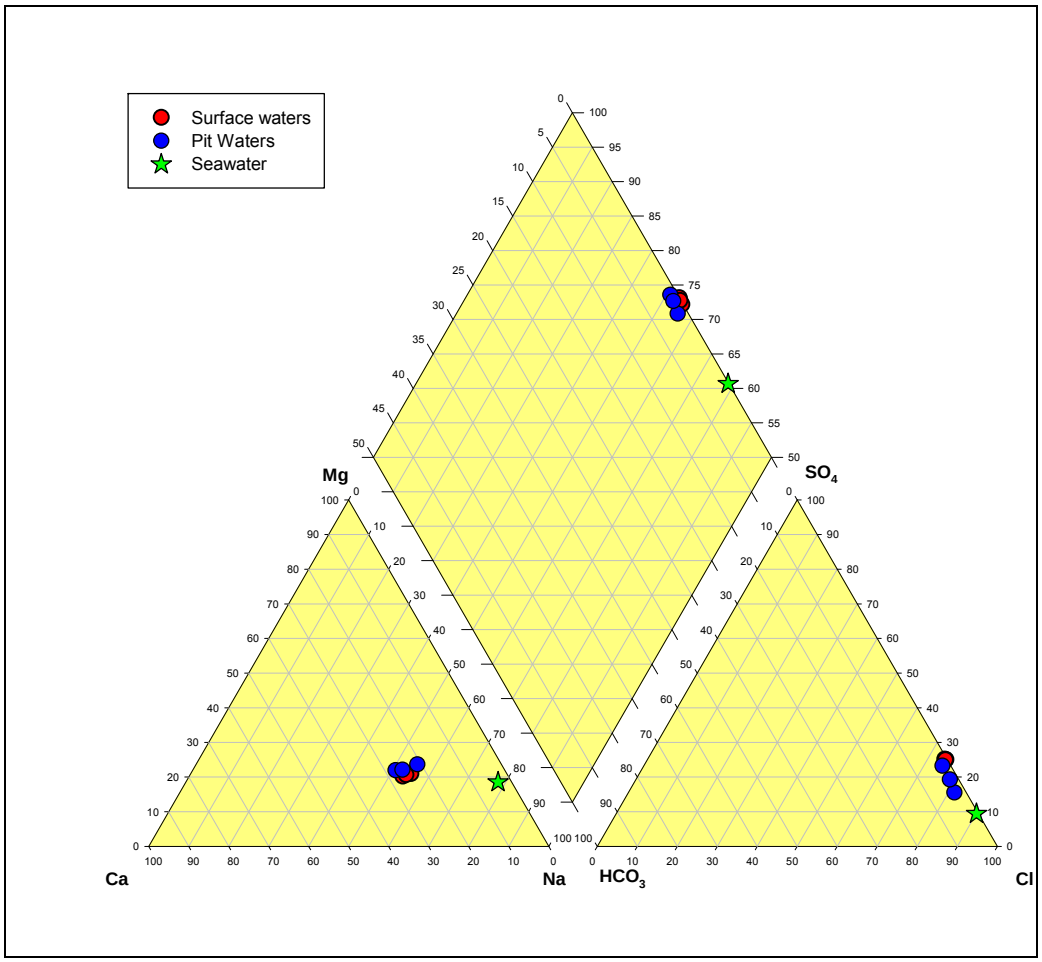


Figure 2-16. Piper diagram for Murbpook Lagoon Complex (Wetland ID. 12158).

2.4. Discussion

Acid sulfate soil materials in Murbpook Lagoon Complex (Wetland ID. 12158) were identified as hyposulfidic that occurred in at least one or more layers for each profile and the remainder of the samples being characterised as other soil materials. Soil subtypes were Subaqueous Soil (clayey or loamy) and Other Soil (clayey or sandy)

The soils throughout the main wetland area were clayey textured and in some areas around the margin loamy or sandy for the surface layer.

Monosulfidic material was observed, and water soluble sulfate data identified that surface layers in all profiles were in excess of the 100mg/L trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials at the Murbpook Lagoon Complex (Wetland ID. 12158) are:

- Acidification hazard: The data identified that generally samples had negative net acidity values, and pH data did not indicate a potential acidification hazard due to oxidation. There is a low to medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there is potential for monosulfidic materials to form in the surface layers at some sites, monosulfidic material was observed at Profile 13. There is a medium to high 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 Murbpook Lagoon Complex (**Wetland ID. 12158):**

Soil materials:	The soil layers were generally hyposulfidic and in some layers the samples were characterised as other soil materials. Soils were generally clayey textured throughout the main wetland area and on the wetland margins the surfaces soils were sandy or loamy. Soils had negative net acidity values and pH data did not indicate a potential for acidification due to oxidation.
Acid sulfate soil identification:	• Subaqueous Soil (clayey or loamy) – occurring throughout the wetland. Dominant (>50%) in extent. • Other Soil (clayey or sandy) – occurring on the wetland margins above the water. Isolated (<10%) in extent.
Hazard assessment	• Acidification hazard – low to medium level of concern • De-oxygenation hazard – medium to high level of concern • Metal mobilisation hazard – low level of concern

Table 2-2. Site description data for Murbpook Lagoon Complex (Wetland ID. 12158).

Site Number	Sample Date	Easting m Zone 54H	Northing m Zone 54H	Water depth (+ve) Water table (-ve)	Surface condition	Earth cover (vegetation)	Location Notes
3	22/03/2010	374794	6214568	not reached	algae mat/crust	grasses	high elevation, on margin where surface is sandy
4	22/03/2010	374757	6214580	not reached			mid to high elevation, adjacent to waters edge
5	22/03/2010	374728	6214591	20	soft	no vegetation	mid elevation, 20m from waters edge
6	22/03/2010	374714	6214604	15	water	water	water sample only
7	22/03/2010	374719	6214600		soft		low elevation, in open water
8	23/03/2010	374687	6214619	20			low elevation, in open water
9	23/03/2010	374243	6215190	not reached			high elevation, on wetland margin
10	23/03/2010	374249	6215183	-25	green algae mat	algae	mid elevation, 1m above waters edge
11	23/03/2010	374304	6215132	15	water	water	low elevation, in open water
12	23/03/2010	374831	6215046		weakly cracking	sandy	high elevation, near old shoreline with dead trees
13	23/03/2010	374783	6215029	-10	soft, sealed by algae	bare	mid to high elevation, above water level
14	23/03/2010	374769	6215027	3	water	algae	low elevation, 5m from waters edge
15	23/03/2010	374641	6214997	15	firm	water, algae	low elevation, in open water

Table 2-3. Soil profile description data for Murbpook Lagoon Complex (Wetland ID. 12158).

Site and Sample (number)	Depth Range (cm)	Observation Method (kind)	Soil Colour (name, Munsell notation)	Texture (Class)	Soil Water Status	Redoximorphic Features (%, colour, location)	Structure Type (category)	Consistence (category)	Comments
3_1	0 - 5	small pit	greyish brown (2.5Y5/2)	sand	moist		single grain	weak	
3_2	5 - 10	small pit	greyish brown (2.5Y5/2)	sand	moist		massive	weak	
3_3	10 - 20	small pit	greyish brown (2.5Y5/2)	sand	moist		massive	firm	
3_4	20 - 40	small pit	greyish brown (2.5Y5/2)	sand	moist		massive	firm	
3_5	40 - 90	push tube	light olive grey (5Y6/2)	clay	moist	15% dark red infused into the matrix along faces of peds	massive	very firm	
4_1	0 - 5	small pit	dark greyish brown (2.5Y4/2)	clay	moist		massive	very weak	faint sulfourous odour
4_2	5 - 10	small pit	dark greyish brown (2.5Y4/2)	clay	moist	10% reddish brown infused into the matrix along faces of peds	massive	firm	
4_3	10 - 20	small pit	dark greyish brown (2.5Y4/2)	clay loam sandy	moist		massive	firm	
4_4	20 - 40	small pit	dark grey (5Y4/1)	clay loam sandy	moist		massive	firm	
4_5	40 - 90	push tube	dark grey (5Y4/1)	clay loam sandy	moist		massive	firm	
5_1	0 - 5	small pit	dark grey (10YR4/1)	clay	moist		massive	very weak	
5_2	5 - 10	small pit	dark greyish brown (10YR4/2)	clay	moist		angular blocky	weak	
5_3	10 - 20	small pit	dark greyish brown (10YR4/2)	clay	moist	5% yellowish brown infused into the matrix adjacent to pores	angular blocky	firm	
5_4	20 - 40	small pit	dark grey (10YR4/1)	clay	moist	5% yellowish brown infused into the matrix adjacent to pores	massive	firm	
5_5	40 - 90	push tube	dark grey (10YR4/1)	clay	moist		massive	firm	
5_W1	-	pit water							water sampled
6_W1	15 - 0	surface water							water sampled, water measurement only at this site
7_W	15 - 0	water							
7_1	0 - 3	small pit	dark greyish brown (2.5Y4/3)	monosulfidic black ooze	wet		gel	very weak	monosulfidic black ooze
7_2	3 - 10	small pit	olive grey (5Y5/2)	clay	wet		massive	very weak	
7_3	10 - 20	small pit	olive grey (5Y5/2)	clay	wet		massive	firm	
7_4	20 - 40	push tube	grey (5Y5/1)	clay	moist		massive	firm	

Site and Sample (number)	Depth Range (cm)	Observation Method (kind)	Soil Colour (name, Munsell notation)	Texture (Class)	Soil Water Status	Redoximorphic Features (%, colour, location)	Structure Type (category)	Consistence (category)	Comments
8_W	20 - 0	water							
8_1	0 - 5	small pit	greyish brown (2.5Y5/2)	clay	wet	20% reddish brown infused into the matrix along faces of peds	massive	weak	
8_2	5 - 10	small pit	greyish brown (2.5Y5/2)	clay	wet	5% reddish brown infused into the matrix along faces of peds	angular blocky	firm	
8_3	10 - 20	small pit	greyish brown (2.5Y5/2)	clay	moist		angular blocky	firm	
8_4	20 - 40	push tube	olive (5Y4/3)	clay	moist		massive	firm	
9_1	0 - 5	small pit	very dark grey (10YR3/1)	clay	moist		massive	weak	
9_2	5 - 10	small pit	very dark grey (10YR3/1)	clay	moist		massive	weak	
9_3	10 - 20	small pit	dark grey (10YR4/1)	sandy loam	moist		massive	weak	
9_4	20 - 40	small pit	dark grey (10YR4/1)	sandy loam	moist		massive	firm	
9_5	40 - 90	push tube	dark grey (5Y4/1)	clay	moist		massive	very firm	
10_1	0 - 5	small pit	dark grey (5Y4/1)	clay	moist		massive	very weak	
10_2	5 - 10	small pit	dark grey (5Y4/1)	clay	moist		massive	weak	
10_3	10 - 20	small pit	dark grey (5Y4/1)	sandy loam	wet		massive	firm	
10_4	20 - 40	small pit	dark grey (5Y4/1)	sandy loam	moist	10% reddish brown infused into the matrix along faces of peds	massive	firm	
10_5	40 - 90	push tube	grey (5Y5/1)	clay	moist		massive	very firm	
10_W1	-	pit water							water sampled
11_W1	15 - 0	surface water							water sampled
11_1	0 - 5	small pit	olive brown (2.5Y4/4)	clay	wet		gel	very weak	
11_2	5 - 10	small pit	dark grey (5Y4/1)	clay	wet		angular blocky	firm	
11_3	10 - 20	small pit	dark grey (5Y4/1)	sandy loam	moist	3% reddish brown infused into the matrix along faces of peds	angular blocky	firm	
11_4	20 - 40	push tube	dark grey (5Y4/1)	clay	moist		massive	very firm	

Site and Sample (number)	Depth Range (cm)	Observation Method (kind)	Soil Colour (name, Munsell notation)	Texture (Class)	Soil Water Status	Redoximorphic Features (%, colour, location)	Structure Type (category)	Consistence (category)	Comments
12_1	0 - 5	small pit	dark grey (10YR4/1)	sandy loam	moist		massive	weak	
12_2	5 - 10	small pit	dark grey (5Y4/1)	clay	moist		massive	very weak	very sticky
12_3	10 - 20	small pit	olive grey (5Y4/2)	sand	moist	5% reddish brown infused into the matrix along faces of peds	massive	firm	
12_4	20 - 40	small pit	olive grey (5Y4/2)	sand	moist		massive	firm	
12_5	40 - 90	push tube	grey (5Y5/1)	sand	moist		massive	firm	
13_1	0 - 5	small pit	very dark grey (10YR3/1)	clay	moist		massive	very weak	
13_2	5 - 10	small pit	dark grey (5Y4/1)	loamy sand	moist		angular blocky	weak	
13_3	10 - 20	small pit	dark grey (5Y4/1)	loamy sand	wet		angular blocky	weak	
13_4	20 - 40	small pit	grey (5Y5/1)	loamy sand	wet		massive	firm	
13_5	40 - 90	push tube	greenish gray (10Y6/1)	clay loam sandy	moist		massive	very firm	
13_W1	-	pit water							water sampled
14_W	3 - 0	water							
14_1	0 - 3	small pit	dark greenish gray (10Y3/1)	monosulfidic black ooze	wet		gel	very weak	
14_2	3 - 10	small pit	dark grey (10YR4/1)	clay	wet		angular blocky	firm	
14_3	10 - 20	small pit	dark grey (5Y4/1)	sandy clay loam	wet	3% reddish brown In the matrix	massive	firm	
14_3DUP	10 - 20	small pit	dark grey (5Y4/1)	sandy clay loam	wet	3% reddish brown In the matrix	massive	firm	
14_4	20 - 40	push tube	dark grey (5Y4/1)	clay loam sandy	moist		massive	very firm	
15_W1	15 - 0	surface water							water sampled
15_1	0 - 5	small pit	dark grey (10YR4/1)	clay	wet		massive	very weak	
15_2	5 - 10	small pit	dark grey (5Y4/1)	clay	wet		angular blocky	very firm	
15_3	10 - 20	small pit	dark greenish gray (10Y4/1)	clay	moist		angular blocky	very firm	
15_4	20 - 40	push tube	dark greenish gray (10Y4/1)	sandy clay loam	moist		angular blocky	very firm	

Table 2-4. Laboratory data for acid sulfate soil assessment of Murbpook Lagoon Complex (Wetland ID. 12158).

(red printed values indicates data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (mS)	pH water	pH peroxide	pH incubation week 0	pH incubation week 8	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 Volatile Sulfur (%Sav)	Acid Sulfate Soil Material Classification
3.1	0-5	Medium	11,670	7.48	6.73	6.07	7.03	230	7.90	0.00	<0.01	0.88	-114		other soil material
3.2	5-10	Medium	2,202	7.21	4.65	6.94	6.85	36	7.26	0.00	<0.01	0.04	-6		other soil material
3.3	10-20	Medium	2,990	7.36	4.94	7.03	7.23	92	7.60	0.00	<0.01	0.30	-39		other soil material
3.4	20-40	Fine	489	7.62	6.40	7.16	7.39	42	6.59	0.00	<0.01	0.11	-14		other soil material
3.5	40-90	Fine	174	8.35	7.47	7.00	7.27	7	6.66	0.00	<0.01	0.36	-49		other soil material
4.1	0-5	Medium	11,290	7.70	6.80	6.63	5.70	600	6.66	0.00	0.09	1.11	-91		hyposulfidic (S_{CR}<0.10%)
4.2	5-10	Fine	2,880	7.28	4.60	6.88	6.32	59	6.45	4.92	<0.01	0.00	10		other soil material
4.3	10-20	Fine	2,189	7.51	5.05	6.94	6.93	44	6.11	5.41	<0.01	0.00	5		other soil material
4.4	20-40	Fine	1,262	7.12	5.71	6.81	6.71	24	6.78	0.00	<0.01	0.10	-14		other soil material
4.5	40-90	Fine	1,551	6.97	6.88	6.95	7.37	36	6.57	0.00	<0.01	0.97	-129		other soil material
5.1	0-5	Fine	6,670	7.14	7.10	6.65	7.17	2,200	6.70	0.00	0.06	1.33	-139		hyposulfidic (S_{CR}<0.10%)
5.2	5-10	Fine	4,010	7.55	7.24	6.61	7.27	2,200	6.74	0.00	0.04	1.29	-150		hyposulfidic (S_{CR}<0.10%)
5.3	10-20	Fine	1,484	7.15	4.02	6.61	6.33	250	6.86	0.00	0.01	0.60	-73		hyposulfidic (S_{CR}<0.10%)
5.4	20-40	Fine	1,374	6.73	4.06	6.05	5.95	350	6.73	0.00	<0.01	0.23	-30		other soil material
5.5	40-90	Fine	997	7.37	4.30	6.93	6.85	120	6.69	0.00	<0.01	0.32	-37		other soil material
5.W1	-	..	..	..	..	..	..	..	..	..	..	..	..		pit water
6.W1	15-0	..	..	..	..	..	..	..	..	..	..	..	..		surface water
7.1	0-3	Fine	8,670	8.09	7.50	7.04	7.15	1,700	7.98	0.00	0.31	2.75	-173	0.14	hyposulfidic (S_{CR}≥0.10%)
7.2	3-10	Fine	2,530	7.03	5.15	6.24	4.82	480	6.56	0.00	0.02	0.43	-48		hyposulfidic (S_{CR}<0.10%)
7.3	10-20	Fine	2,410	6.62	3.89	5.93	4.94	310	6.25	9.35	<0.01	0.00	15		other acidic
7.4	20-40	Fine	1,952	7.05	4.79	6.38	6.13	260	6.24	7.88	0.01	0.00	15		hyposulfidic (S_{CR}<0.10%)
8.W1	20-0	..	..	..	..	..	..	..	..	..	..	..	..		surface water
8.1	0-5	Fine	2,063	6.86	4.32	6.30	6.52	410	6.76	0.00	<0.01	0.93	-124		other soil material
8.2	5-10	Fine	1,760	6.59	5.96	6.45	6.58	210	6.53	0.00	<0.01	0.21	-28		other soil material
8.3	10-20	Fine	1,998	6.71	6.47	6.54	6.64	180	6.44	3.94	<0.01	0.00	8		other soil material
8.4	20-40	Fine	1,773	7.77	7.78	6.88	6.96	120	6.71	0.00	<0.01	0.65	-86		other soil material
9.1	0-5	Fine	5,160	7.78	6.34	7.10	7.36	420	7.12	0.00	0.14	1.26	-84		hyposulfidic (S_{CR}≥0.10%)
9.2	5-10	Fine	2,097	7.74	6.81	7.00	7.30	370	7.55	0.00	0.14	2.87	-294		hyposulfidic (S_{CR}≥0.10%)
9.3	10-20	Medium	1,431	7.73	7.01	7.82	7.65	73	7.54	0.00	<0.01	0.24	-33		other soil material
9.4	20-40	Fine	2,750	7.68	6.86	7.30	7.32	340	7.29	0.00	<0.01	1.85	-241		other soil material

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (mS)	pH water	pH peroxide	pH incubation week 0	pH incubation week 8	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 Volatile Sulfur (%Sav)	Acid Sulfate Soil Material Classification
9.5	40-90	Fine	1,448	7.80	7.79	7.97	7.36	150	7.08	0.00	<0.01	0.42	-56		other soil material
10.1	0-5	Fine	2,072	7.14	3.68	6.71	6.94	400	6.88	0.00	0.03	0.48	-46		hyposulfidic (S_{CR}<0.10%)
10.2	5-10	Fine	2,610	7.07	3.63	6.43	6.44	320	6.77	0.00	<0.01	0.36	-48		other soil material
10.3	10-20	Fine	2,570	6.99	4.04	6.44	6.52	350	6.69	0.00	0.02	0.30	-27		hyposulfidic (S_{CR}<0.10%)
10.4	20-40	Medium	1,356	6.40	4.55	6.56	6.24	210	6.65	0.00	<0.01	0.24	-32		other soil material
10.5	40-90	Fine	2,156	7.05	7.16	6.96	6.68	200	6.52	0.00	<0.01	0.36	-48		other soil material
10.W1	-	..	..	..	..	..	..	..	..	..	..	..	..		pit water
11.W1	15-0	..	..	..	..	..	..	..	..	..	..	..	..		surface water
11.1	0-5	Fine	3,630	6.94	4.01	6.34	5.70	2,600	6.39	19.69	0.07	0.00	64		hyposulfidic (S_{CR}<0.10%)
11.2	5-10	Fine	1,501	5.28	3.05	5.83	4.69	580	6.02	25.60	0.01	0.00	32		hyposulfidic (S_{CR}<0.10%)
11.3	10-20	Fine	2,192	5.92	3.38	5.16	4.77	500	6.07	19.69	<0.01	0.00	26		other acidic
11.4	20-40	Fine	1,356	6.21	4.33	6.65	6.24	210	6.41	4.92	<0.01	0.00	5		other soil material
12.1	0-5	Fine	10,700	7.41	7.13	7.27	7.28	1,800	7.40	0.00	0.01	0.71	-87		hyposulfidic (S_{CR}<0.10%)
12.2	5-10	Fine	1,450	8.12	6.22	7.17	7.01	720	7.29	0.00	0.08	0.97	-77		hyposulfidic (S_{CR}<0.10%)
12.3	10-20	Medium	991	7.67	4.99	7.71	7.37	48	8.22	0.00	<0.01	0.47	-57		other soil material
12.4	20-40	Fine	654	7.24	6.29	7.41	7.12	24	7.17	0.00	<0.01	0.40	-50		other soil material
12.5	40-90	Medium	858	7.68	7.81	7.36	7.14	26	6.78	0.00	<0.01	0.20	-26		other soil material
13.1	0-5	Fine	7,230	8.09	7.41	6.99	7.37	1,900	7.67	0.00	0.08	3.33	-396		hyposulfidic (S_{CR}<0.10%)
13.2	5-10	Fine	1,874	7.37	3.75	6.87	6.80	220	7.40	0.00	<0.01	0.58	-72		other soil material
13.3	10-20	Medium	1,314	6.81	4.59	6.71	6.67	74	6.69	0.00	<0.01	0.39	-48		other soil material
13.4	20-40	Medium	1,464	6.85	6.66	6.68	6.48	45	6.54	0.00	<0.01	0.06	-8		other soil material
13.5	40-90	Fine	1,220	7.64	7.94	6.97	7.28	55	6.48	0.48	<0.01	0.00	0		other soil material
13.W1	-	..	..	..	..	..	..	..	..	..	..	..	..		pit water
14.W1	3-0	..	..	..	..	..	..	..	..	..	..	..	..		surface water
14.1	0-3	Fine	9,210	8.06	6.97	7.06	6.70	2,700	8.13	0.00	0.43	5.33	-442	0.27	hyposulfidic (S_{CR}≥0.10%)
14.2	3-10	Fine	1,625	7.11	4.07	6.72	6.45	160	6.54	0.00	<0.01	0.29	-34		other soil material
14.3	10-20	Fine	1,578	6.92	4.96	6.84	6.58	140	6.43	0.96	<0.01	0.00	5		other soil material
14.4	20-40	Fine	1,082	7.24	7.80	6.84	6.70	79	6.65	0.00	<0.01	0.23	-31		other soil material
15.W1	15-0	..	..	..	..	..	..	..	..	..	..	..	..		surface water
15.1	0-5	Fine	2,740	7.19	3.87	6.53	6.50	430	6.90	0.00	0.03	0.91	-104		hyposulfidic (S_{CR}<0.10%)
15.2	5-10	Fine	1,554	6.82	4.86	6.38	6.18	150	6.61	0.00	0.01	0.37	-44		hyposulfidic (S_{CR}<0.10%)
15.3	10-20	Fine	1,652	6.68	6.04	6.49	6.48	92	6.32	2.89	<0.01	0.00	3		other soil material
15.4	20-40	Fine	1,157	6.73	7.31	6.69	6.47	91	6.40	2.41	<0.01	0.00	2		other soil material

Table 2-5. Summary of hydrochemical field measurements for Murbpook Lagoon Complex Wetland (Id, 12158).

	pH	SEC	DO	Eh	Turbidity	Alkalinity
		µS cm^{-1}	mg l^{-1}	mV	NTU	as HCO_3
Surface waters (n=3)	7.03–8.30	22765-25242	7.2 – 15.6	244-302	2.1-14.5	43-95
Pit waters (n = 3)	5.92–6.31	18460-19666	0.4 – 7.9	103-187		295-354

Table 2-6. Hydrochemical data for Murbpook Lagoon Complex (Wetland ID. 12158).

Parameter	units	ANZECC Guidelines	Site 6 (SW)	Site 5 (PW)	Site 11 (SW)	Site 10 (PW)	Site 15 (SW)	Site 13 (PW)
Na	mg l^{-1}		3760	2330	3580	2600	3270	2550
K	mg l^{-1}		50.2	16.0	51.5	30.0	47.5	27.0
Ca	mg l^{-1}		1630	775	1370	1230	1350	1090
Mg	mg l^{-1}		761	530	730	600	668	573
Si	mg l^{-1}		<0.5	24	<0.5	28.2	<0.5	17
Br	mg l^{-1}		20.0	9.4	17.0	18.0	16.0	15.0
Cl	mg l^{-1}		8800	5800	8500	6400	7500	6300
NO_3	mg l^{-1}	0.7	<0.022	<0.022	<0.022	0.576	<0.022	0.0434
NH_4-N^K	mg l^{-1}	0.01	**7.10**	**0.056**	**3.1**	**0.14**	**4.2**	**0.17**
PO_4^E	mg l^{-1}	0.02	0.020	**0.071**	**0.037**	**0.178**	**0.024**	**0.077**
SO_4	mg l^{-1}		4000	1500	3900	2700	3400	2100
Ag	µg l^{-1}	0.05	<0.1	<0.08	<0.1	<0.08	<0.1	<0.08
Al^A	µg l^{-1}	55	<300	<200	<300	<200	<300	<200
As^B	µg l^{-1}	13	5	**24**	5	**44**	<5	**28**
Cd	µg l^{-1}	0.2	<0.3	<0.2	<0.3	<0.2	<0.3	0.20
Co	µg l^{-1}	2.8	0.6	**155**	1.4	**87.8**	1.4	**97.6**
Cr^C	µg l^{-1}	1	<1	<1	<1	<1	<1	<1
Cu^H	µg l^{-1}	1.4	<5	<4	<5	<4	<5	<4
Fe	µg l^{-1}	300	<1000	**35800**	<1000	**70600**	<1000	**26400**
Mn	µg l^{-1}	1700	28	**61100**	214	**33800**	258	**34200**
Ni^H	µg l^{-1}	11	**12.0**	**92.0**	**18.0**	**56.0**	**12.0**	**60.0**
Pb^H	µg l^{-1}	3.4	<2	<2	<2	<2	<2	<2
Se	µg l^{-1}	11	<2	<2	<2	<2	<2	<2
Zn^H	µg l^{-1}	8	<10	**80**	**50**	**136**	**65**	**132**
DOC	mg l^{-1}		91.9	71.4	94.2	84.4	79.9	58.9

Notes.

The ANZECC guideline values for toxicants refer to the trigger values applicable to 'slightly-moderately disturbed' freshwater systems, as outlined in the Australian Water Quality Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000). For the nutrients NH_4 and PO_4, trigger values are provided for Freshwater Lakes and reservoirs. Surface water values outside the ranges defined in the ANZECC guidelines are indicated with red text. (SW) and (PW) indicate whether the sample was taken from surface water or pit-water (groundwater that entered an excavated pit), respectively.

A *Trigger value for Aluminium in freshwater where pH > 6.5.*

B *Trigger value assumes As in solution as Arsenic (AsV).*

C *Trigger value for Chromium is applicable to Chromium (CrVI) only.*

E *Guideline is for filterable reactive phosphorous (FRP).*

H *Hardness affected (refer to Guidelines).*

K *Guideline for South-east Australia-Freshwater Lakes and reservoirs.*

3. MURBPOOK LAGOON COMPLEX (WETLAND ID. 12161)

3.1. Location and setting description

This wetland in the Murbpook Lagoon Complex (Wetland ID. 12161) is situated on the northern side of the River Murray about 17 kilometres up river from Lock 1 at Blanchetown, located in the Murbpook Lagoon Complex area. The wetland is an anabranch connected to the river that is linear in shape. It is about 1 kilometre in length and about 50 metres at its widest, with a total surface area of 4 hectares in area. The wetland is bounded by a raised floodplain that separates it from the adjacent wetland to the north and from the river. One other wetland in this complex was surveyed (Wetland ID.12158).

There is one connection channel with the river at the southern end of the wetland. At the time when the soil survey was conducted in March 2010, the wetland had surface water. The wetland complex is managed by the property manager with the assistance of the South Australian Murray-Darling Basin Natural Resources Management Board (SA MDB NRM Board) and the RWLAP, since 2004. The wetland margins have Typha and Sedgelands growing, with woodland and shrubland on the surrounding higher floodplain. Two sites were sampled as shown in Figure 3-1.

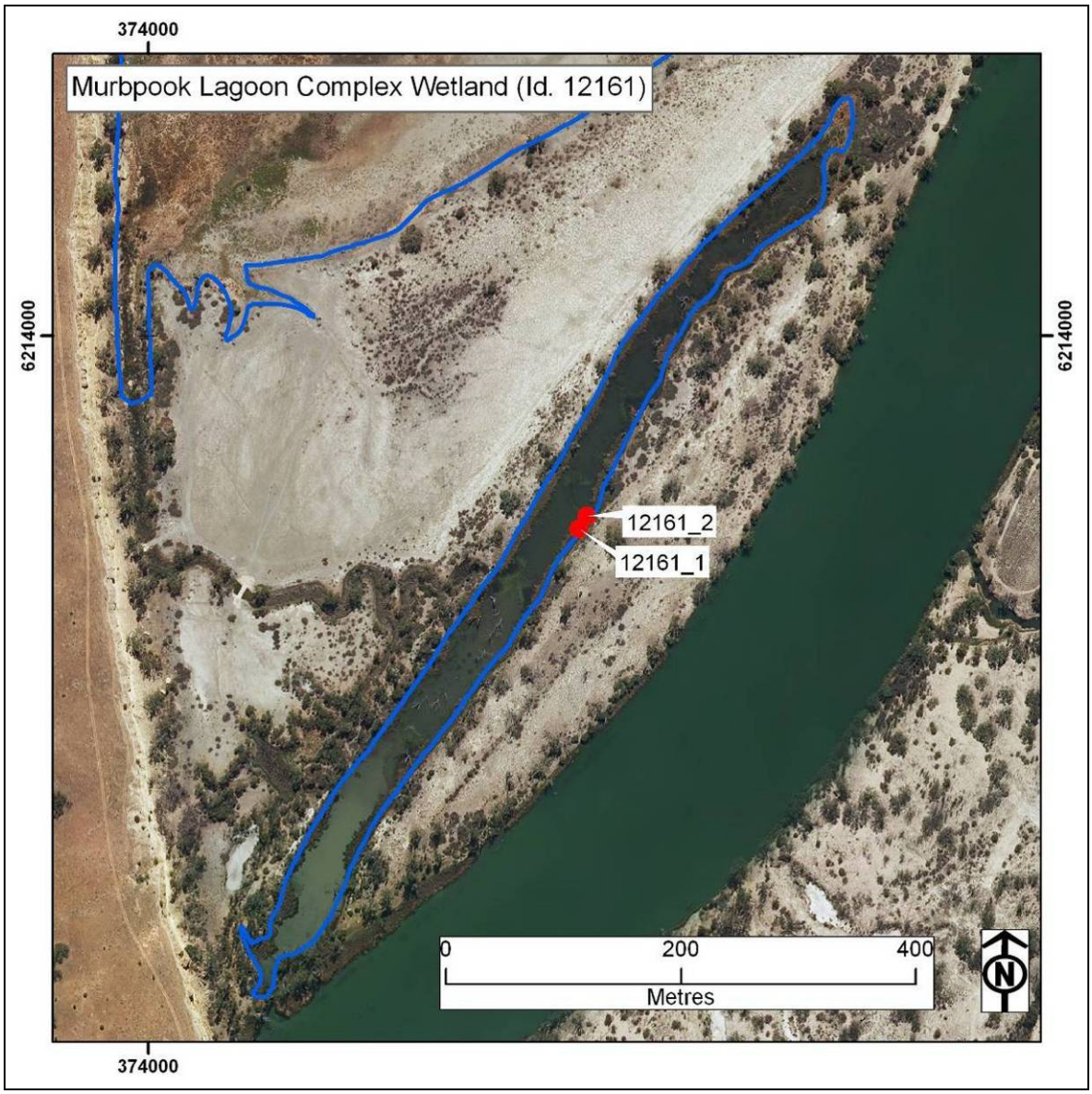


Figure 3-1. Murbpook Lagoon Complex (Wetland ID. 12161) and sample site locations.

3.2. Soil profile description and distribution

Two sites were described and sampled. The soil subtypes and general location descriptions are presented in Table 3-1. Sites were distributed as a pair from the wetland margin into the water (Sites 1, and 2) of the wetland. The site and soil profile descriptions are presented in Table 3-2 and Table 3-3, and a conceptual cross-section diagram in Figure 3-2.

Centre transect

Site 1 (Figure 3-3) occurred adjacent to the bank in water (40 cm deep), and the soil consisted of a brown, very weak, mucky clay, over greyish brown clay. Site 2 (Figure 3-4) occurred in open water (60 cm deep), and the soil consisted of a dark grey, very weak, clay, over olive, firm, clay.

Table 3-1. Soil identification, subtype and general location description for Murbpook Lagoon Complex (Wetland ID. 12161).

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12161_1	374367	6213836	Subaqueous Soil (clayey)	mid elevation 2m from shore next to reeds
12161_2	374374	6213847	Hypersulfidic Subaqueous Soil (clayey)	low elevation,15m from shore in open water

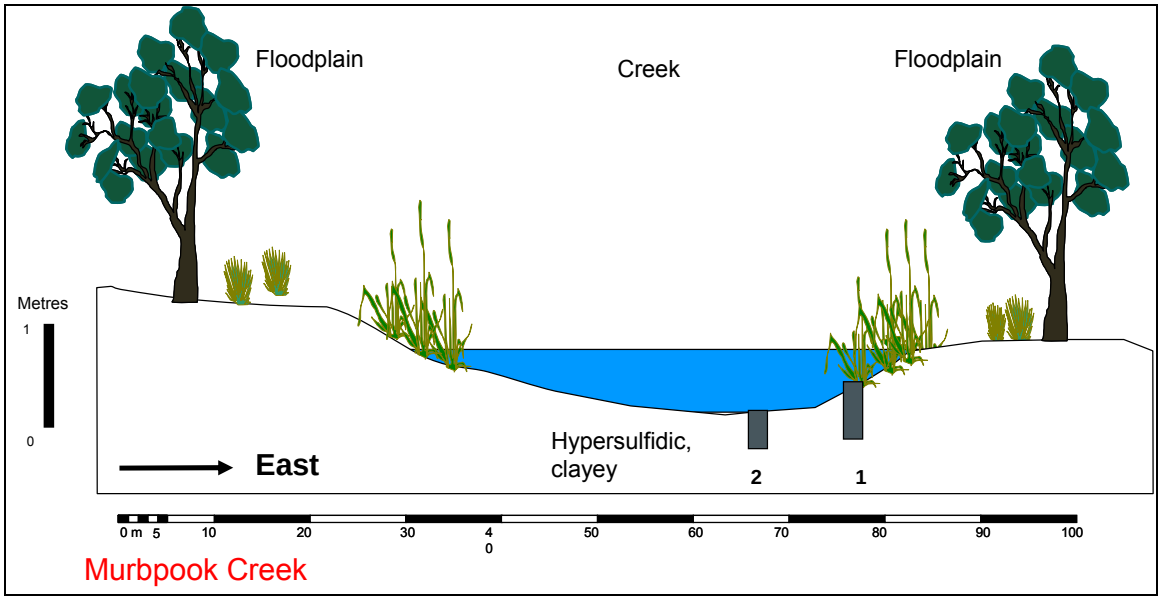


Figure 3-2. Conceptual cross-section diagram, showing position of Sites 1 and 2.

Figure 3-3: Photograph of Site 1, showing the site location adjacent to reeds growing in water.

Figure 3-4. Photograph of Site 2, showing the site location marked by the green shovel handle marking in open water.

3.3. Laboratory data assessment

3.3.1. Soil pH testing (pH_W, pH_{OX}, $pH_{incubation}$)

The pH data is provided in Table 3-4 and pH profiles are presented in Figure 3-5. The pH_W data ranged from 6.28 to 7.29 and sulfuric materials with a pH_W were not identified. The pH_{OX} data ranged from 1.60 to 6.13 and identified that the two profiles had at least one or more layers below the critical value of pH_{OX} <2.5. The $pH_{incubation}$ data ranged from 3.91 to 5,60 and identified soil layers in Profile 2 that on incubation declined below the critical value of pH <4, indicating that sulfuric material may form on oxidation.

3.3.2. Acid base accounting

The acid base accounting data is provided in Table 3-4 and summarised in Figure 3-6.

Chromium reducible sulfur

Chromium reducible sulfur values ranged from <0.01 to 0.23 $\%S_{CR}$ and sulfidic materials were detected in almost every layer of the two profiles. Generally the values declined with depth down the profile.

Titratable actual acidity

Titratable actual acidity values ranged from 7.38 to 35.93 mole H^+/tonne.

Retained acidity

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

Acid neutralising capacity

Acid neutralising capacity values were not measured in either profile.

Net acidity

Net acidity values ranged from 14 to 164 mole H^+/tonne. All layers were positive, with moderate or high values in the surface layers and with depth the values decreased to moderate or low..

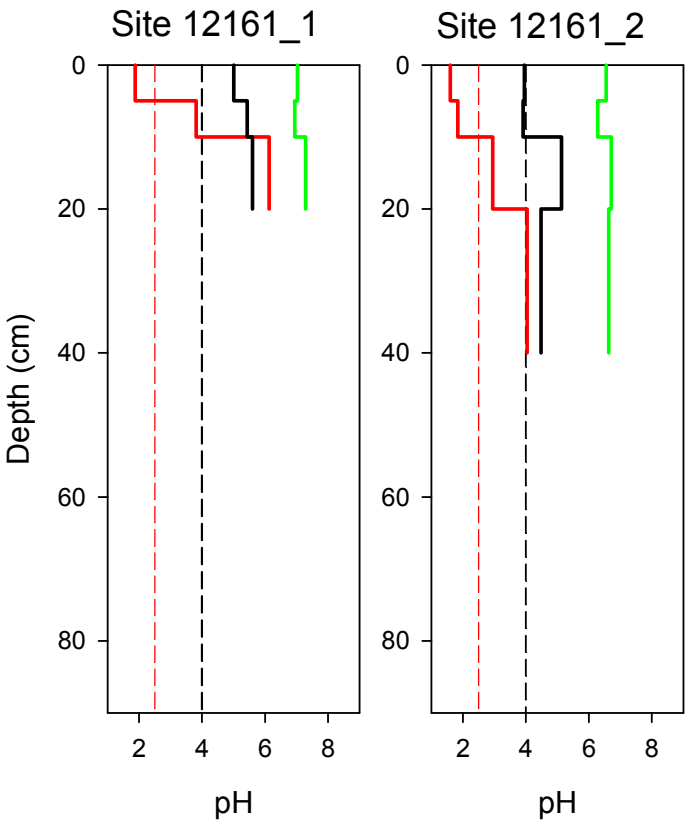


Figure 3-5. Depth profiles of soil pH for Murbpook Lagoon Complex (Wetland ID. 12161), showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and incubation pH (pH_{INC} after 8 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

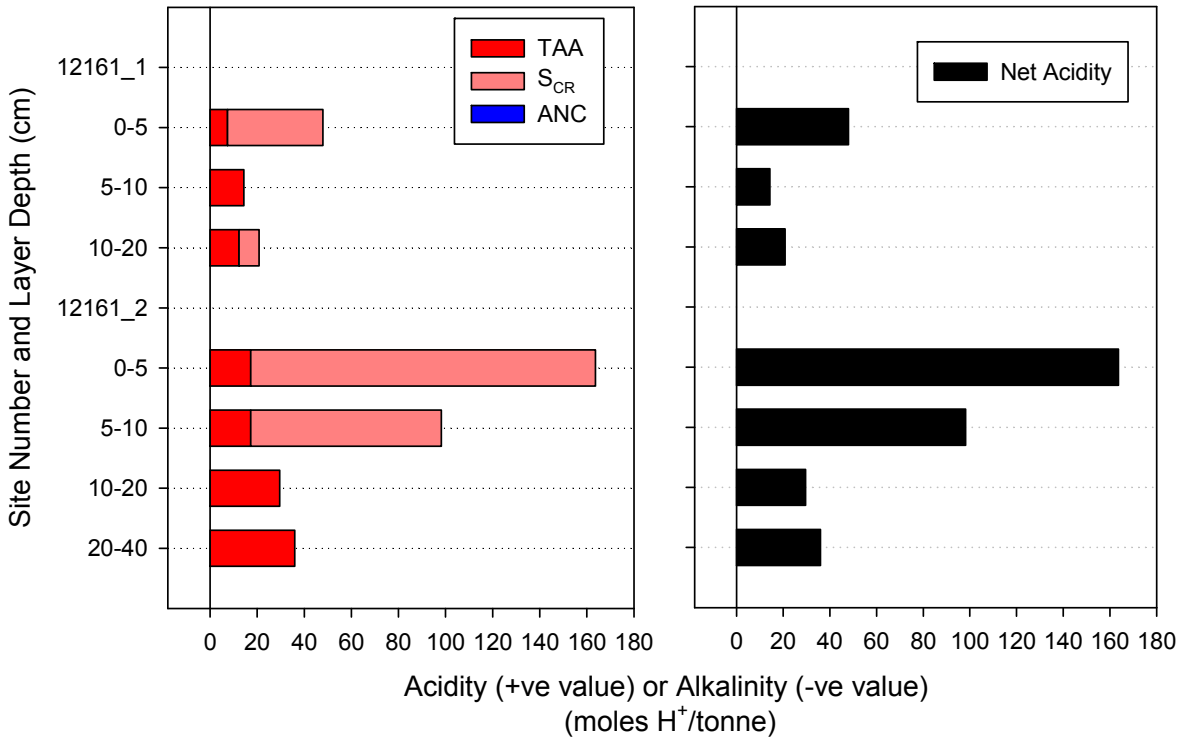


Figure 3-6. Acid base accounting depth profiles for Murbpook Lagoon Complex (Wetland ID. 12161). Left side shows the components: Titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

3.3.3. Water soluble sulfate

Water soluble sulfate data values shown in Table 3-4 identified Profile 2 with surface layers that were higher than the criterion trigger value of 100 mg/kg SO_4.

3.3.4. Acid volatile sulfur

Monosulfidic materials were not observed and samples were not collected for analysis.

3.3.5. Hydrochemistry

A single surface water sample was collected from this small wetland as no marginal areas were dry and, therefore, a pit sample was not available. Field parameters are shown in Table 3-5. The surface water had a neutral pH and was relatively fresh (SEC 559 µS cm^{-1}). The water was saturated with dissolved oxygen, and turbidity was low. Alkalinity was of a similar magnitude to river water.

The surface waters is of Na-Cl type (Table 3-6, Figure 3-7). Sulfate concentrations in the surface water were 8.6 mg l^{-1}. The SO_4/Cl ratio in the surface water (0.07) was significantly lower than seawater (0.142). Nitrate was below detection limit, and NH_4 and NO_2 were present at low concentrations. Iron was below detection limit and Mn was present at low concentration. Slightly elevated Al may be due to colloidal material. The concentrations of most metals were low consistent with the neutral pH.

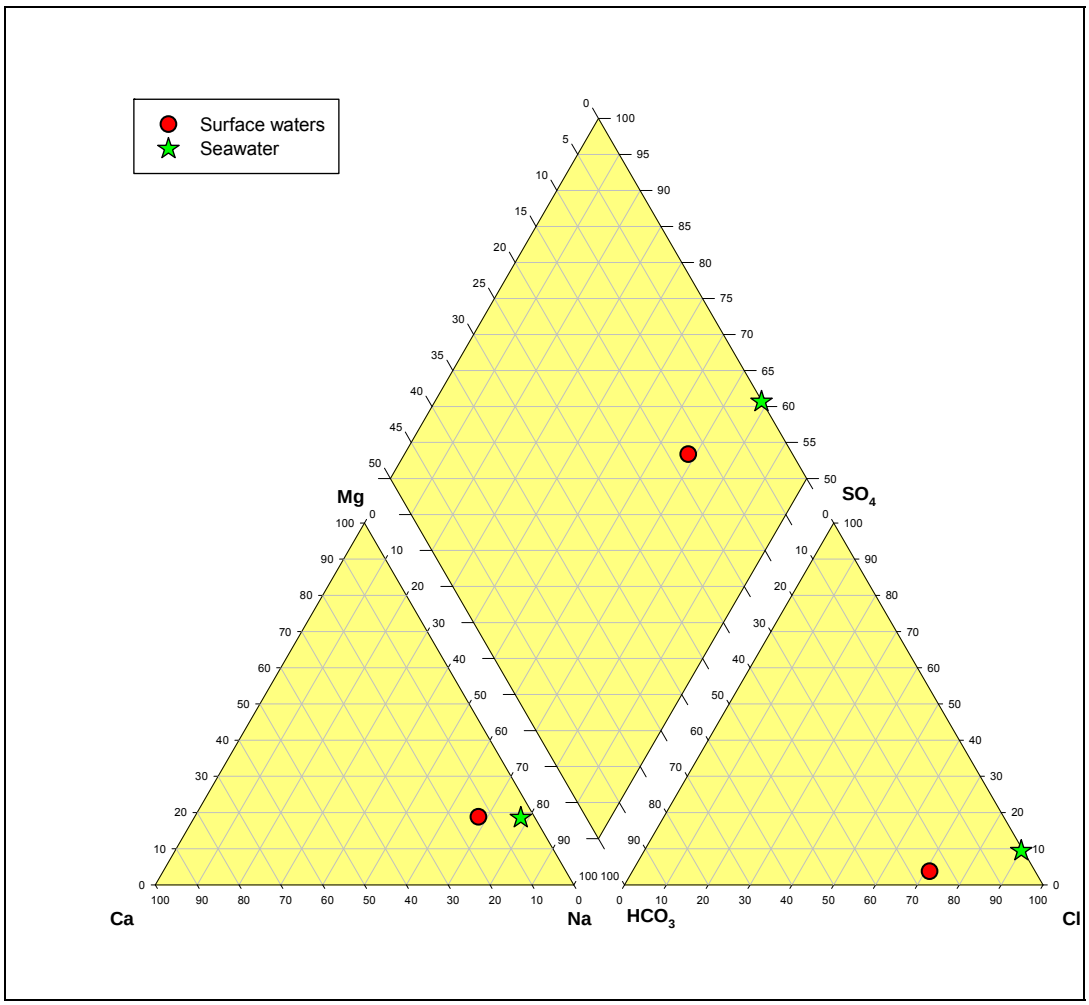


Figure 3-7. Piper diagram for Murbpook Lagoon Complex (Wetland ID. 12161).

3.4. Discussion

Acid sulfate soil materials in Murbpook Lagoon Complex (Wetland ID. 12161) were identified as hypersulfidic or hyposulfidic. The acid sulfate soil subtype classes identified were Hypersulfidic Subaqueous Soil (clayey) or Subaqueous Soil (clayey).

The soils throughout the wetland were clayey textured.

Monosulfidic material was not observed but water soluble sulfate data identified that surface layers in Profile 2 were in excess of the 100mg/L trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials at the Murbpook Lagoon Complex Wetland are:

- Acidification hazard: The data identified low, moderate or high net acidity values in all samples and pH data identified samples with values that were a potential acidification hazard due to oxidation. There is a high level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that surface soils in the wetland have a potential for monosulfidic materials to form. There is a medium level of concern.
- Metal mobilisation: The high acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a high level of concern.

Summary of key findings for Murbpook Lagoon Complex (Wetland ID. 12161):

Soil materials:	Soil samples were characterised as hypersulfidic or hyposulfidic. The soils were generally clayey textured throughout the wetland. Soil samples had low, moderate or high net acidity values and pH data indicated a potential for acidification due to oxidation.
Acid sulfate soil identification:	• Hypersulfidic Subaqueous Soil (clayey) – occurring in the centre areas of the wetland. Dominant (>50%) in extent. • Subaqueous Soil (clayey) – occurring on the wetland edge below water. Minor (<25%) in extent. • Other Soil (clayey) – occurring on the wetland margins above water. Isolated (<10%) in extent. Note this soil type not sampled as part of the survey but would be expected to occur.
Hazard assessment	• Acidification hazard – high level of concern • De-oxygenation hazard – medium level of concern • Metal mobilisation hazard – high level of concern

Table 3-2. Site description data for Murbpook Lagoon Complex (Wetland ID. 12161).

Site Number	Sample Date	Easting m Zone 54H	Northing m Zone 54H	Water depth (+ve) Water table (-ve)	Surface condition	Earth cover (vegetation)	Location Notes
1	22/03/2010	374367	6213836	40	water	water	mid elevation 2m from shore next to reeds
2	22/03/2010	374374	6213847	60	water	water	low elevation,15m from shore

Table 3-3. Soil profile description data for Murbpook Lagoon Complex (Wetland ID. 12161).

Site and Sample (number)	Depth Range (cm)	Observation Method (kind)	Soil Colour (name, Munsell notation)	Texture (Class)	Soil Water Status	Redoximorphic Features (%, colour, location)	Structure Type (category)	Consistence (category)	Comments
1_W	40 - 0	water							
1_1	0 - 5	small pit	brown (10YR4/3)	mucky clay	wet		gel	very weak	plant roots
1_2	5 - 10	small pit	dark grey (10YR4/1)	clay	wet		massive	very firm	
1_3	10 - 20	push tube	greyish brown (2.5Y5/2)	clay	moist		massive	very weak	too hard to auger below this depth
2_W1	60 - 0	surface water							water sampled
2_1	0 - 5	small pit	dark grey (10YR4/1)	mucky clay	wet		gel	very weak	
2_2	5 - 10	small pit	dark grey (5Y4/1)	clay	wet		massive	weak	
2_3	10 - 20	push tube	dark grey (5Y4/1)	clay	moist		massive	firm	
2_4	20 - 40	push tube	olive (5Y4/3)	clay	moist		massive	firm	

Table 3-4. Laboratory data for acid sulfate soil assessment of Murbpook Lagoon Complex (Wetland ID. 12161).

(red printed values indicates data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (mS)	pH water	pH peroxide	pH incubation week 0	pH incubation week 8	Sulfate (mg SO_4/kg)	pH KCl	Titratable actual acidity (mole H^+ /tonne)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H+/ tonne)	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
1.W1	40-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
1.1	0-5	Medium	186	7.03	1.88	6.57	5.01	67	6.05	7.38	0.07	..		48	hyposulfidic (S_{CR}<0.10%)
1.2	5-10	Fine	78	6.94	3.81	6.34	5.43	26	6.31	14.28	<0.01	..		14	other acidic incubation
1.3	10-20	Fine	63	7.29	6.13	6.64	5.60	23	6.00	12.31	0.01	..		21	hyposulfidic (S_{CR}<0.10%)
2.W1	60-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
2.1	0-5	Medium	111	6.55	1.60	6.23	3.95	120	5.85	17.23	0.23	..	..	164	hypersulfidic
2.2	5-10	Medium	107	6.28	1.84	6.13	3.91	110	5.51	17.23	0.13	..	..	98	hypersulfidic
2.3	10-20	Fine	78	6.71	2.95	6.40	5.13	11	5.51	29.53	<0.01	..	..	30	other acidic incubation
2.4	20-40	Fine	82	6.63	4.04	6.03	4.48	8	5.51	35.93	<0.01	..	..	36	other acidic incubation

Table 3-5. Summary of hydrochemical field measurements for Murbpook Lagoon Complex (Wetland ID. 12161).

	pH	SEC	DO	Eh	Turbidity	Alkalinity
		µS cm^{-1}	mg l^{-1}	mV	NTU	as HCO_3
Surface waters (n=1)	6.94	559	8.32	194	16	73

Table 3-6. Hydrochemistry data for Murbpook Lagoon Complex (Wetland ID. 12161).

Parameter	units	ANZECC Guidelines	Site 2 (SW)
Na	mg l^{-1}		76.5
K	mg l^{-1}		4.3
Ca	mg l^{-1}		13.6
Mg	mg l^{-1}		11.6
Si	mg l^{-1}		0.875
Br	mg l^{-1}		0.190
Cl	mg l^{-1}		120
NO_3	mg l^{-1}	0.7	<0.022
NH_4-N^K	mg l^{-1}	0.01	0.014
PO_4^E	mg l^{-1}	0.02	0.021
SO_4	mg l^{-1}		8.6
Ag	µg l^{-1}	0.05	0.01
Al^A	µg l^{-1}	55	80
As^B	µg l^{-1}	13	1.8
Cd	µg l^{-1}	0.2	0.04
Co	µg l^{-1}	2.8	0.05
Cr^C	µg l^{-1}	1	0.1
Cu^H	µg l^{-1}	1.4	0.4
Fe	µg l^{-1}	300	<100
Mn	µg l^{-1}	1700	33.9
Ni^H	µg l^{-1}	11	1.0
Pb^H	µg l^{-1}	3.4	<0.1
Se	µg l^{-1}	11	<0.08
Zn^H	µg l^{-1}	8	38.2
DOC	mg l^{-1}		11.2

Notes.

The ANZECC guideline values for toxicants refer to the trigger values applicable to 'slightly-moderately disturbed' freshwater systems, as outlined in the Australian Water Quality Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000). For the nutrients NH_4 and PO_4, trigger values are provided for Freshwater Lakes and reservoirs. Surface water values outside the ranges defined in the ANZECC guidelines are indicated with red text. (SW) and (PW) indicate whether the sample was taken from surface water or pit-water (groundwater that entered an excavated pit), respectively.

A *Trigger value for Aluminium in freshwater where pH > 6.5.*

B *Trigger value assumes As in solution as Arsenic (AsV).*

C *Trigger value for Chromium is applicable to Chromium (CrVI) only.*

E *Guideline is for filterable reactive phosphorous (FRP).*

H *Hardness affected (refer to Guidelines).*

K *Guideline for South-east Australia-Freshwater Lakes and reservoirs.*

4. MURBKO FLAT COMPLEX (WETLAND ID. 12323)

4.1. Location and setting description

This wetland in the Murbko Flat Complex (Wetland ID. 12323) is situated on the western side of the River Murray about 22 kilometres up river from Lock 1 at Blanchetown. The wetland is somewhat elongated in shape, about 3 kilometres in length and approximately 800 metres at the widest, with a total area of 173 hectares. The wetland is bounded to the west by hill slopes and to the east by a raised floodplain that separates the wetland from the river. This other associated wetlands in the Murbko Flat Complex that were not surveyed as part of this project are wetlands ID. 12324 and 12325.

The wetland is permanently connect to the river by an excavated water channel that to the south of the lagoon. At the time when the soil survey was conducted in March 2010, the wetland had surface water. The wetland is not managed. It is permanently connected and was probably last dry in the 1920's before the Locks were installed. Surrounding on the wetland margins at a slightly higher elevation were Phragmites and Typha, with woodlands and shrubland on the raised floodplain. Eight sites were sampled as shown in Figure 4-1.

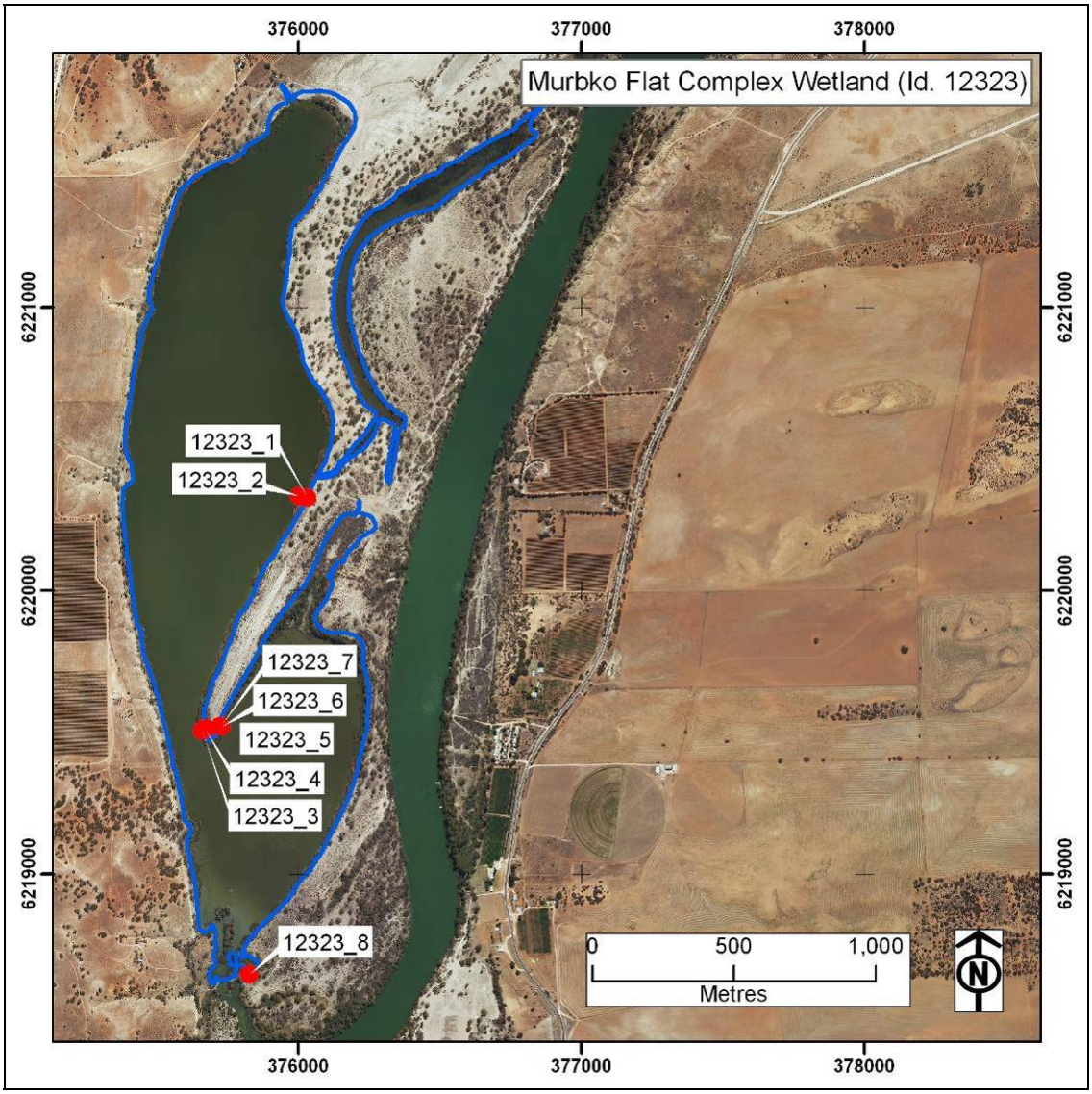


Figure 4-1. Murbko Flat Complex (Wetland ID. 12323) and sample site locations.

4.2. Soil profile description and distribution

Eight sites were described and sampled. The soil subtypes and general location descriptions are presented in Table 4-1. Sites were distributed along two transects, with an eastern transect (Sites 1 and 2), a centre transect either side of a spit into the wetland (Sites 3, 4, 5, 6, and 7), and an isolated site near the southern inlet channel (Site 8) of the wetland. The site and soil profile descriptions are presented in Table 4-2 and Table 4-3 and a conceptual cross-section diagram in Figure 4-2.

Eastern transect

Site 1 (Figure 4-3) occurred at the wetland edge amongst reeds and in water (20 cm deep), and the soil consisted of a grey, very firm, clay. Site 2 (Figure 4-4) occurred in open water (80 cm deep), and the soil consisted of a dark grey, very firm, clay.

Centre transect

Site 3 (Figure 4-5) occurred where there was thick Typha in water (40 cm deep), and the soil consisted of a dark grey, very firm, clay. Site 4 (Figure 4-6) occurred where there was Typha in water (30 cm deep), and the soil consisted of a dark greyish brown, very weak, clay over dark grey, very firm clay. Site 5 (Figure 4-7) occurred adjacent to the bank in water (20 cm deep), and the soil consisted of a dark grey, very weak, clay with many plant roots over a dark grey very firm, clay. Site 6 occurred where Typha was growing in water (20 cm deep), and the soil consisted of a mucky clay over a dark grey, very firm clay. Site 7 (**Error! Reference source not found.**) occurred where Typha was growing in water (30 cm deep), and the soil consisted of a mucky clay over dark grey, very firm clay.

Southern site

Site 8 occurred where Typha was growing in water (60 cm deep) near the inlet channel, and the soil consisted of a dark grey, very weak, mucky clay with plant material and a strong sulfurous odour, over an olive grey, firm, clay.

Table 4-1. Soil identification, subtype and general location description for Murbko Flat Complex (Wetland ID. 12323).

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12323_1	376031	6220328	Subaqueous Soil (clayey)	mid elevation, waters edge in reeds
12323_2	376004	6220333	Hypersulfidic Subaqueous Soil (clayey)	low elevation, in open water 50m from shore
12323_3	375660	6219504	Subaqueous Soil (clayey)	low elevation, west of spit in thick Typha
12323_4	375670	6219512	Subaqueous Soil (clayey)	low elevation, in Typha and water
12323_5	375678	6219511	Subaqueous Soil (clayey)	mid elevation, in Typha next to step up in bank
12323_6	375729	6219520	Subaqueous Soil (clayey)	low elevation, in Typha and water
12323_7	375724	6219522	Subaqueous Soil (clayey)	mid elevation, 2m from bank in water and Typha
12323_8	375828	6218645	Subaqueous Soil (clayey)	low elevation, 4m from bank in Typha and water

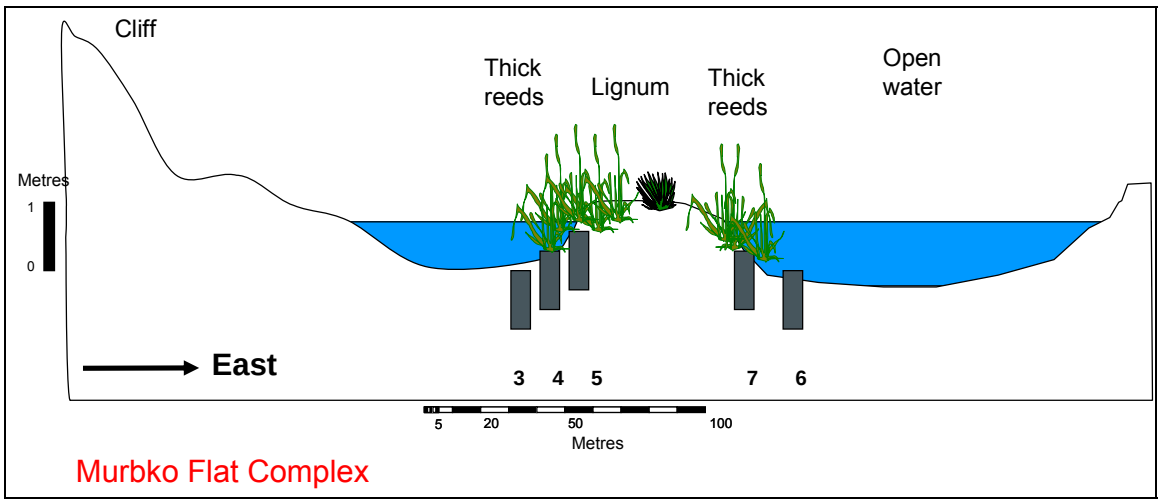


Figure 4-2. Conceptual cross-section diagram.

Figure 4-3: Photograph of Site 1, showing the site location in the water adjacent to reeds.

Figure 4-4: Photograph of Site 2, showing the site location in open water.

Figure 4-5. Photograph of Site 3, showing the site location in thick Typha vegetation.

Figure 4-6. Photograph of Site 4, showing the site location in thick Typha vegetation and surface water.

Figure 4-7. Photograph of Site 5, showing the site location in thick Typha vegetation that is adjacent to the bank.

Figure 4-8. Photograph of Site 7, showing the site location in Typha vegetation and in water.

4.3. Laboratory data assessment

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

The pH data is provided in Table 4-4 and pH profiles are presented in Figure 4-9. The pH_W data ranged from 6.81 to 9.43 and sulfuric materials with a pH_W <4 were not identified. The pH_{OX} data ranged from 1.95 to 9.13 and identified that the Profiles 2, 4, 5, 6, and 7 had at least one or more layers often the surface layer below the critical value of pH_{OX} <2.5. The pH_{INC} data ranged from 2.82 to 8.44 and identified one soil layer in Profile 2 that on incubation declined below the critical value of pH <4, indicating the potential for sulfuric material to form on oxidation.

4.3.2. Acid base accounting

The acid base accounting data is provided in Table 4-4 and summarised in Figure 4-10.

Chromium reducible sulfur

Chromium reducible sulfur values ranged from 0.01 to 0.68 $\%S_{CR}$ and sulfidic materials were detected in all layers for all profiles. Generally the higher values occurred in the surface layer samples and the values became lower with depth in the profiles.

Titratable actual acidity

Titratable actual acidity values ranged from 0 to 7.63 mole H^+/tonne. Titratable actual acidity was measured in some or all layers of Profiles 3, 4, 5, and 6, and not measured in Profiles 1, 2, 7 and 8.

Retained acidity

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

Acid neutralising capacity

Acid neutralising capacity values ranged from 0 to 19.27 $\%CaCO_3$ and were measured in some or all layers of all profiles except Profiles 5.

Net acidity

Net acidity values ranged from -2544 to 425 mole H^+/tonne. The surface layers of Profiles 4, 5, 6, and 7 had high values that tended to decrease in value with depth in the subsoil layers. For Profiles 1, 3 and 8 values for all layers were negative.

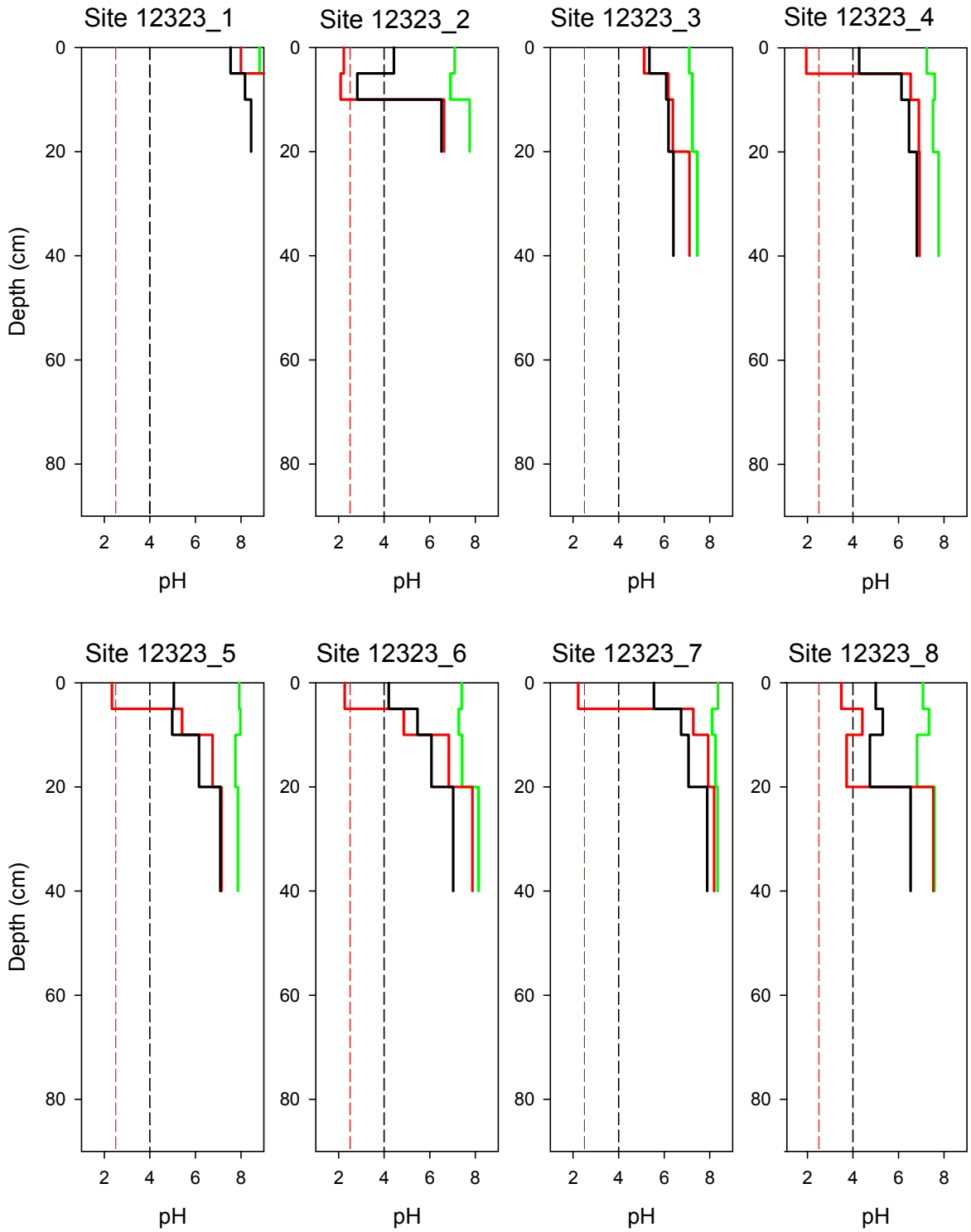
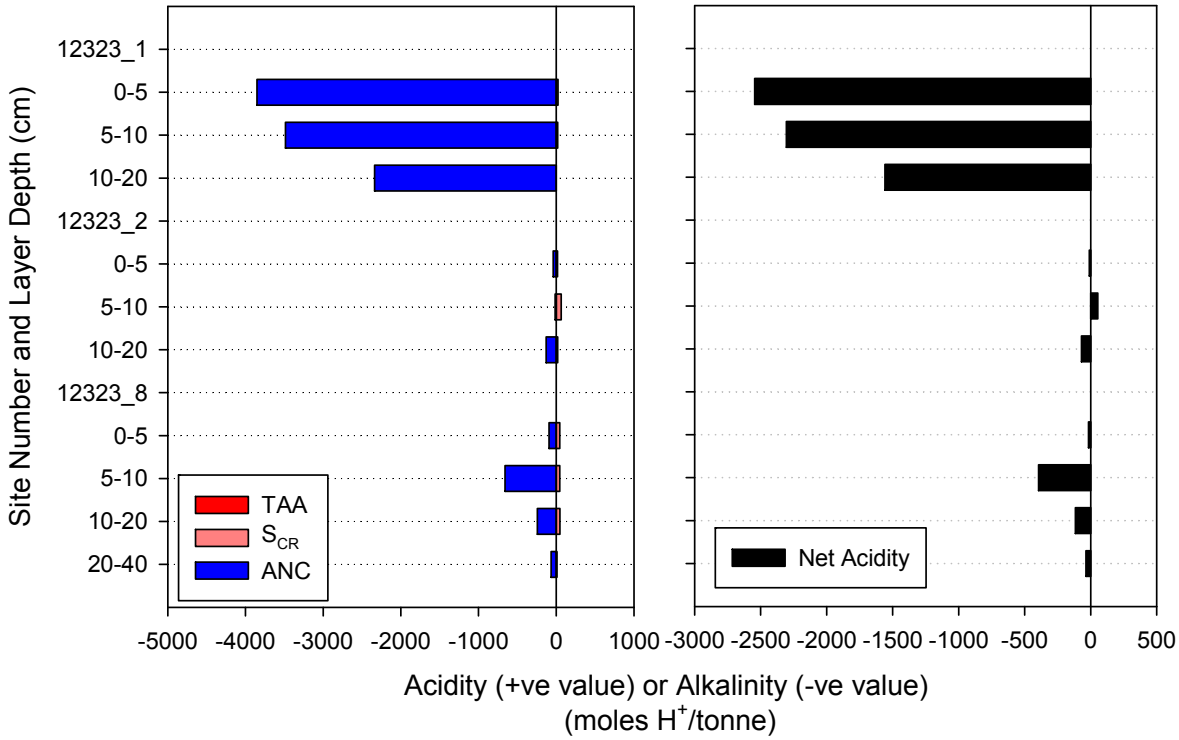


Figure 4-9. Depth profiles of soil pH for Murbko Flat Complex (Wetland ID. 12323), showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and incubation pH (pH_{INC} after 8 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).



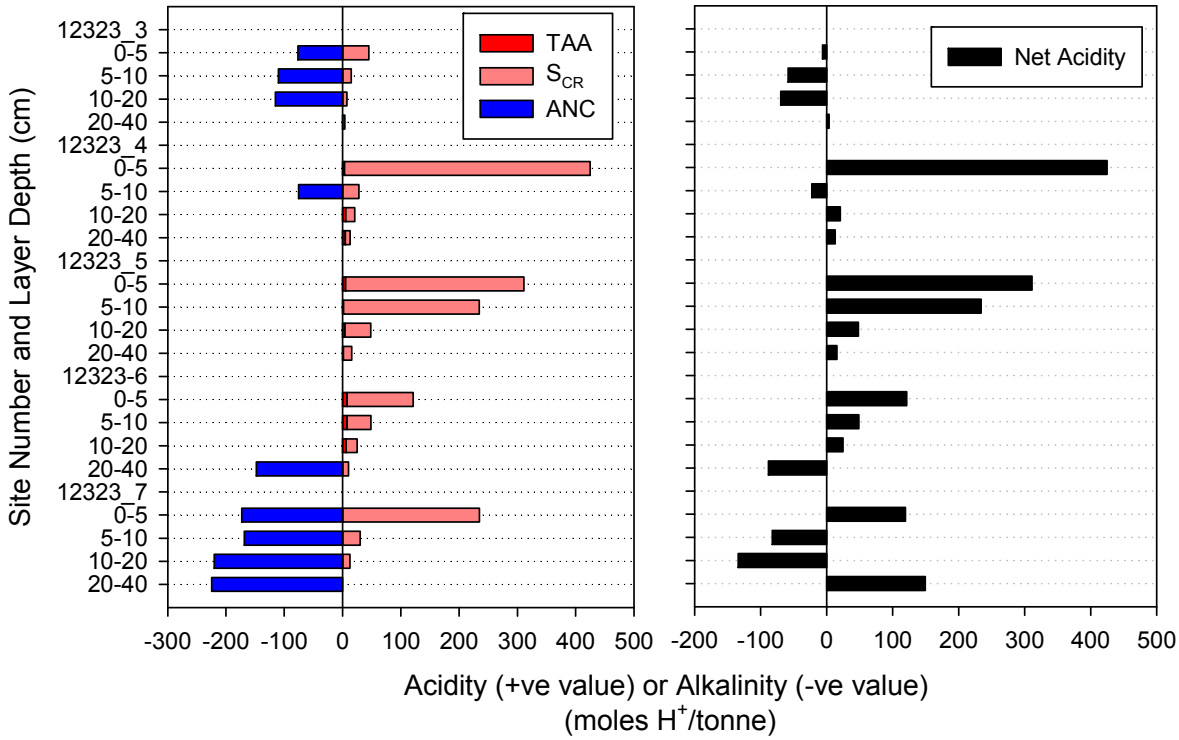


Figure 4-10. Acid base accounting depth profiles for Murbko Flat Complex (Wetland ID. 12323). Left side shows the components: Titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

4.3.3. Water soluble sulfate

Water soluble sulfate data values shown in Table 4-4 identified surface layers in Profiles 4, 5, 6, and 7 were higher than the criterion trigger value of 100 mg/kg SO_4.

4.3.4. Acid volatile sulfur

Monosulfidic materials were not observed and samples were not collected for analysis.

4.3.5. Hydrochemistry

Four surface water samples were collected from the wetland, however no pit water samples were collected as the marginal areas were submerged. Field parameters are shown in Table 4-5. The pit waters had circumneutral pH and were fresh (Site 8) to moderately fresh. Site 8 was close to the river and the low SEC at this site is undoubtedly due to mixing with river water. Dissolved oxygen was variable. Alkalinity was moderately high except for Site 8 (46 mg l^{-1} HCO_3) reflecting river influence.

The surface water samples are of Na-Cl type, with Ca and HCO_3 being higher relative to Na and Cl relative to seawater (Table 4-6, Figure 4-11). Sulfate concentrations in the surface water samples ranged from 8.7 to 41 mg l^{-1}). The SO_4/Cl ratio in the surface water samples (0.146-0.218) was similar or slightly higher than seawater (0.142). For the nutrients, PO_4 concentrations were slightly above ANZECC Guideline values. Manganese concentrations were relatively low, whilst Fe was high at Site 8. Aluminium concentrations were relatively high for the pH's observed, and may be a consequence of colloidal material as the waters were relatively turbid.

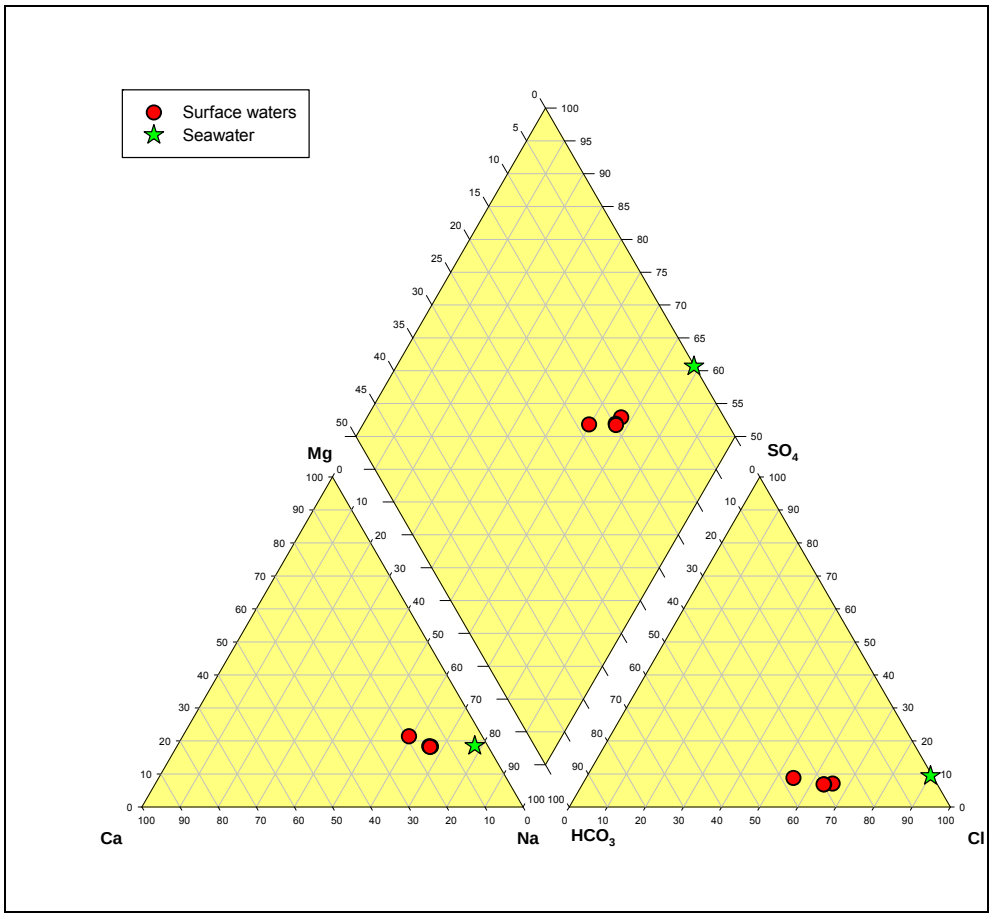


Figure 4-11. Piper diagram of hydrochemical data for Murbko Flat Complex (Wetland ID. 12323).

4.4. Discussion

Acid sulfate soil materials in Murbko Flat Complex Wetland were identified as hyposulfidic that occurred throughout the surface and subsoil layers, and a hypersulfidic layer was identified in the subsurface layer of Profile 2. The soil subtypes were identified as Hypersulfidic Subaqueous Soil (clayey) or Subaqueous Soil (clayey).

The soils throughout the wetland were clayey textured.

Monosulfidic material was not observed but water soluble sulfate data identified that surface layers in all Profiles 4, 5, 6 and 7 were in excess of the 100mg/L trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials at the Murbko Flat Complex (Wetland ID. 12323) are:

- Acidification hazard: The data identified high net acidity values in some soil layers, and pH data identified that some samples had values that indicate a potential acidification hazard due to oxidation. There is a medium level of concern
- De-oxygenation hazard: The water soluble sulfate data indicated there is potential for monosulfidic materials to form in the surface layers in four of the eight profiles, monosulfidic material was not observed. There is a low to 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 Murbko Flat Complex (Wetland ID. 12323):

Soil materials:	Soils were generally identified as hyposulfidic and in one profile there was a hypersulfidic soil material. The soils were generally clayey textured throughout the wetland area. Soil samples had high net acidity values in some soil layers and pH data indicated a potential for acidification due to oxidation to occur in some samples.
Acid sulfate soil identification:	• Subaqueous Soil (clayey) – occurring throughout the wetland below surface water. Dominant (>50%) in extent. • Hypersulfidic Subaqueous Soil (clayey) – occurring in low elevated areas below surface water. Minor (<25%) in extent.
Hazard assessment	• Acidification hazard – medium level of concern • De-oxygenation hazard – low to medium level of concern • Metal mobilisation hazard – medium level of concern

Table 4-2. Site description data for Murbko Flat Complex (Wetland ID. 12323).

Site Number	Sample Date	Easting m Zone 54H	Northing m Zone 54H	Water depth (+ve) Water table (-ve)	Surface condition	Earth cover (vegetation)	Location Notes
1	24/03/2010	376031	6220328	20		bare, water amongst reeds	mid elevation, waters edge in reeds
2	24/03/2010	376004	6220333	80		water	low elevation, in open water 50m from shore
3	24/03/2010	375660	6219504	40	water, soft, roots	Typha, very thick 3m tall	low elevation, west of spit in thick Typha, very tall prevented getting to open water
4	24/03/2010	375670	6219512	30	water, plants, soft	Typha	low elevation, in Typha and water
5	24/03/2010	375678	6219511	20	water, plants, soft	Typha	mid elevation, in Typha next to step up in bank
6	24/03/2010	375729	6219520	30	water, roots	Typha	low elevation, in Typha and water
7	24/03/2010	375724	6219522	30	water, plant roots	Typha	mid elevation, 2m from bank in water and Typha
8	24/03/2010	375828	6218645	60	water	edge of Typha	low elevation, 4m from bank in Typha and water

Table 4-3. Soil profile description data for Murbko Flat Complex (Wetland ID. 12323).

Site and Sample (number)	Depth Range (cm)	Observation Method (kind)	Soil Colour (name, Munsell notation)	Texture (Class)	Soil Water Status	Redoximorphic Features (%, colour, location)	Structure Type (category)	Consistence (category)	Comments
1_W	20 - 0	water							
1_1	0 - 5	small pit	black (5Y2.5/1)	clay	wet		massive	firm	
1_2	5 - 10	small pit	grey (5Y6/1)	gritty clay	wet		massive	very firm	
1_3	10 - 20	push tube	grey (5Y6/1)	gritty clay	wet		massive	very firm	
2_W1	80 - 0	surface water							water sampled
2_1	0 - 5	small pit	dark grey (10YR4/1)	clay	wet		gel	weak	
2_2	5 - 10	small pit	dark grey (10YR4/1)	clay	moist		massive	firm	
2_3	10 - 20	push tube	dark grey (5Y4/1)	clay	moist		massive	very firm	
3_W1	40 - 0	surface water							water sampled
3_1	0 - 5	small pit	dark grey (5Y4/1)	clay	wet		gel	weak	
3_2	5 - 10	small pit	dark grey (5Y4/1)	clay	wet		angular blocky	very firm	
3_3	10 - 20	small pit	dark grey (5Y4/1)	clay	wet		massive	very firm	
3_4	20 - 40	push tube	dark grey (5Y4/1)	clay	wet		massive	very firm	
4_W	30 - 0	water							
4_1	0 - 5	small pit	dark greyish brown (10YR4/2)	clay	wet		gel	very weak	
4_2	5 - 10	small pit	dark grey (5Y4/1)	clay	wet		massive	weak	
4_3	10 - 20	small pit	dark grey (5Y4/1)	clay	wet		massive	very firm	
4_4	20 - 40	push tube	dark grey (5Y4/1)	clay	wet		massive	very firm	
5_W	20 - 0	water							
5_1	0 - 5	small pit	dark grey (10YR4/1)	clay	wet		gel	very weak	many plant roots
5_2	5 - 10	small pit	dark grey (10YR4/1)	clay	wet		massive	weak	
5_3	10 - 20	small pit	dark grey (5Y4/1)	clay	wet		massive	very firm	
5_4	20 - 40	push tube	very dark grey (5Y3/1)	clay	wet		massive	very firm	

Site and Sample (number)	Depth Range (cm)	Observation Method (kind)	Soil Colour (name, Munsell notation)	Texture (Class)	Soil Water Status	Redoximorphic Features (%, colour, location)	Structure Type (category)	Consistence (category)	Comments
6_W1	30 - 0	surface water							water sampled
6_1	0 - 5	small pit	dark brown (10YR3/3)	mucky clay	wet		gel	very weak	
6_2	5 - 10	small pit	dark grey (10YR4/1)	clay	moist		massive	firm	
6_3	10 - 20	small pit	dark grey (5Y4/1)	clay	moist		massive	firm	
6_4	20 - 40	push tube	dark grey (5Y4/1)	clay	moist		massive	very firm	carbonate segregations
7_W	30 - 0	water							
7_1	0 - 5	small pit	dark grey (5Y4/1)	clay	wet		gel	very weak	
7_2	5 - 10	small pit	dark grey (5Y4/1)	mucky clay	moist		massive	firm	
7_3	10 - 20	small pit	dark grey (5Y4/1)	clay	moist		massive	very firm	
7_4	20 - 40	push tube	very dark grey (5Y3/1)	clay	moist		massive	very firm	
8_W1	60 - 0	surface water							water sampled
8_1	0 - 5	small pit	olive grey (5Y5/2)	mucky clay	wet		gel	very weak	contains plant material, strong sulfur odour
8_2	5 - 10	small pit	olive grey (5Y5/2)	clay	wet		angular blocky	firm	
8_3	10 - 20	small pit	olive grey (5Y5/2)	clay	moist		massive	firm	
8_4	20 - 40	push tube	light brownish grey (2.5Y6/2)	clay	moist		massive	very firm	

Table 4-4. Laboratory data for acid sulfate soil assessment of Murbko Flat Complex (Wetland ID. 12323).

(red printed values indicates data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (mS)	pH water	pH peroxide	pH incubation week 0	pH incubation week 8	Sulfate (mg SO_4/kg)	pH KCl	Titratable actual acidity (mole H^+ /tonne)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H+/ tonne))	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+ /tonne)	Acid Sulfate Soil Material Classification
1.W1	20-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
1.1	0-5	Fine	246	8.81	7.99	7.38	7.54	87	8.37	0.00	0.04	..	19.27	-2544	hyposulfidic (S_{CR}<0.10%)
1.2	5-10	Fine	176	9.43	9.13	8.48	8.17	31	8.34	0.00	0.03	..	17.44	-2304	hyposulfidic (S_{CR}<0.10%)
1.3	10-20	Fine	191	9.17	9.08	8.13	8.44	16	8.44	0.00	<0.01	..	11.70	-1558	other soil material
2.W1	80-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
2.1	0-5	Medium	189	7.09	2.23	6.73	4.43	22	8.01	0.00	0.03	..	0.20	-9	hyposulfidic (S_{CR}<0.10%)
2.2	5-10	Fine	147	6.91	2.09	6.63	2.82	79	7.29	0.00	0.10	..	0.07	55	hypersulfidic
2.3	10-20	Fine	133	7.75	6.63	6.83	6.52	16	7.18	0.00	0.03	..	0.65	-68	hyposulfidic (S_{CR}<0.10%)
3.W1	40-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
3.1	0-5	Fine	256	7.10	5.12	6.52	5.35	49	7.69	0.00	0.07	..	0.38	-6	hyposulfidic (S_{CR}<0.10%)
3.2	5-10	Fine	195	7.23	6.18	6.54	6.09	26	6.79	0.00	0.02	..	0.55	-58	hyposulfidic (S_{CR}<0.10%)
3.3	10-20	Fine	199	7.24	6.38	6.52	6.19	21	6.56	0.00	0.01	..	0.58	-69	hyposulfidic (S_{CR}<0.10%)
3.4	20-40	Fine	232	7.45	7.11	6.58	6.40	19	6.42	3.81	<0.01	..	0.00	4	other soil material
4.W1	30-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
4.1	0-5	Medium	224	7.24	1.95	6.79	4.27	130	6.47	3.34	0.68	..	0.00	425	hyposulfidic (S_{CR}≥0.10%)
4.2	5-10	Fine	110	7.59	6.53	6.41	6.13	67	6.65	0.00	0.04	..	0.38	-22	hyposulfidic (S_{CR}<0.10%)
4.3	10-20	Fine	136	7.51	6.89	6.39	6.46	57	6.36	5.72	0.02	..	0.00	21	hyposulfidic (S_{CR}<0.10%)
4.4	20-40	Fine	110	7.76	6.92	6.45	6.80	23	6.37	4.77	0.01	..	0.00	13	hyposulfidic (S_{CR}<0.10%)
5.W1	20-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
5.1	0-5	Medium	330	7.92	2.33	6.61	5.05	250	6.45	5.24	0.49	..	0.00	311	hyposulfidic (S_{CR}≥0.10%)
5.2	5-10	Medium	211	7.97	5.41	6.43	4.98	120	6.44	1.91	0.37	..	0.00	234	hyposulfidic (S_{CR}≥0.10%)
5.3	10-20	Fine	196	7.75	6.75	6.45	6.16	98	6.41	4.29	0.07	..	0.00	48	hyposulfidic (S_{CR}<0.10%)
5.4	20-40	Fine	126	7.86	7.14	6.93	7.09	42	6.49	1.43	0.02	..	0.00	16	hyposulfidic (S_{CR}<0.10%)
6.W1	30-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
6.1	0-5	Medium	164	7.40	2.27	6.52	4.20	270	6.25	7.63	0.18	..	0.00	121	hyposulfidic (S_{CR}≥0.10%)
6.2	5-10	Fine	185	7.27	4.86	6.39	5.46	75	6.22	7.63	0.07	..	0.00	49	hyposulfidic (S_{CR}<0.10%)
6.3	10-20	Fine	127	7.42	6.84	6.43	6.07	53	6.34	6.20	0.03	..	0.00	25	hyposulfidic (S_{CR}<0.10%)
6.4	20-40	Fine	156	8.14	7.87	6.94	7.03	37	6.61	0.00	0.02	..	0.74	-88	hyposulfidic (S_{CR}<0.10%)
		..	..	..	..	..	..	..	..	..	..	..	..	..	

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (mS)	pH water	pH peroxide	pH incubation week 0	pH incubation week 8	Sulfate (mg SO_4/kg)	pH KCl	Titratable actual acidity (mole H^+ /tonne)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H+/ tonne))	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+ /tonne)	Acid Sulfate Soil Material Classification
7.W1	30-0														surface water
7.1	0-5	Medium	171	8.36	2.23	6.47	5.55	270	6.60	0.00	0.38	..	0.87	119	hyposulfidic (S_{CR}≥0.10%)
7.2	5-10	Fine	124	8.10	7.28	6.81	6.74	51	7.34	0.00	0.05	..	0.84	-82	hyposulfidic (S_{CR}<0.10%)
7.3	10-20	Fine	211	8.25	7.93	6.73	7.07	36	7.22	0.00	0.02	..	1.10	-134	hyposulfidic (S_{CR}<0.10%)
7.4	20-40	Fine	152	8.34	8.19	7.69	7.89	26	7.13	0.00	<0.01	..	1.12	-150	other soil material
8.W1	60-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
8.1	0-5	Fine	346	7.07	3.49	6.59	5.00	100	7.01	0.00	0.07	..	0.46	-16	hyposulfidic (S_{CR}<0.10%)
8.2	5-10	Fine	203	7.33	4.41	6.60	5.31	100	7.62	0.00	0.07	..	3.30	-394	hyposulfidic (S_{CR}<0.10%)
8.3	10-20	Fine	113	6.81	3.72	6.54	4.74	70	7.48	0.00	0.08	..	1.21	-115	hyposulfidic (S_{CR}<0.10%)
8.4	20-40	Fine	170	7.57	7.52	6.68	6.53	41	7.54	0.00	0.01	..	0.33	-35	hyposulfidic (S_{CR}<0.10%)

Table 4-5. Summary of hydrochemical field measurements for Murbko Flat Complex (Wetland ID. 12323).

	pH	SEC	DO	Eh	Turbidity	Alkalinity
		µS cm^{-1}	mg l^{-1}	mV	NTU	as HCO_3
Surface waters (n=4)	7.34-8.01	251-1244	1.57-8.4	197-222	71-250	46-200

Table 4-6. Hydrochemical data for Murbko Flat Complex (Wetland ID. 12323).

Parameter	units	ANZECC Guidelines	Site 2 (SW)	Site 3 (SW)	Site 6 (SW)	Site 8 (SW)
Na	mg l^{-1}		180	157	158	29.9
K	mg l^{-1}		7.5	6.7	6.7	3.28
Ca	mg l^{-1}		36.3	32.7	32.5	8.99
Mg	mg l^{-1}		26.7	23.6	23.4	6.06
Si	mg l^{-1}		4.63	4.35	4.23	3.19
Br	mg l^{-1}		0.4	0.3	0.4	0.053
Cl	mg l^{-1}		280	240	240	40
NO_3	mg l^{-1}	0.7	<0.022	0.058	<0.022	0.576
NH_4-N^K	mg l^{-1}	0.01	**0.017**	**0.092**	**0.017**	**0.087**
PO_4^E	mg l^{-1}	0.02	**0.049**	**0.046**	**0.031**	**0.064**
SO_4	mg l^{-1}		41	35	35	8.7
Ag	µg l^{-1}	0.05	<0.01	<0.01	<0.01	0.02
Al^A	µg l^{-1}	55	**420**	**460**	**180**	**613**
As^B	µg l^{-1}	13	1.6	1.2	0.8	0.8
Cd	µg l^{-1}	0.2	0.04	0.04	<0.02	0.03
Co	µg l^{-1}	2.8	0.32	0.24	0.16	0.28
Cr^C	µg l^{-1}	1	0.4	0.5	0.2	**1.1**
Cu^H	µg l^{-1}	1.4	1.2	0.8	0.8	**1.6**
Fe	µg l^{-1}	300	178	135	<100	**606**
Mn	µg l^{-1}	1700	34.6	44.3	39.6	12.54
Ni^H	µg l^{-1}	11	1.2	1.6	1.0	1.2
Pb^H	µg l^{-1}	3.4	0.4	<0.2	<0.2	0.6
Se	µg l^{-1}	11	<0.2	<0.2	<0.2	<0.08
Zn^H	µg l^{-1}	8	32	96.8	62	63
DOC	mg l^{-1}		11.2	11.7	10.6	3.9

Notes.

The ANZECC guideline values for toxicants refer to the trigger values applicable to 'slightly-moderately disturbed' freshwater systems, as outlined in the Australian Water Quality Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000). For the nutrients NH_4 and PO_4, trigger values are provided for Freshwater Lakes and reservoirs. Surface water values outside the ranges defined in the ANZECC guidelines are indicated with red text. (SW) and (PW) indicate whether the sample was taken from surface water or pit-water (groundwater that entered an excavated pit), respectively.

A *Trigger value for Aluminium in freshwater where pH > 6.5.*

B *Trigger value assumes As in solution as Arsenic (AsV).*

C *Trigger value for Chromium is applicable to Chromium (CrVI) only.*

E *Guideline is for filterable reactive phosphorous (FRP).*

H *Hardness affected (refer to Guidelines).*

K *Guideline for South-east Australia-Freshwater Lakes and reservoirs.*

5. WOMBATS REST LAGOON (WETLAND ID. 12032)

5.1. Location and setting description

Wombats Rest Lagoon (Wetland ID. 12032) is situated on the western side of the River Murray about 27 kilometres up river from Lock 1 at Blanchetown and about 8 kilometres down river from Morgan. The wetland is oval in shape and occurs on the outside of a sharp bend in the river. It is about 1.3 kilometres in length and about 350 metres at it's widest, with a total surface area of 7 hectares. The wetland is bounded to the east by raised floodplain that separates the wetland from the river and to the west there is a steep hillside.

The wetland is permanently connected to the river with one main inlet at the southern end of the wetland that is approximately 100 metres wide. At the time when the soil survey was conducted in April 2010, the wetland contained surface water. The wetland is not managed. It was probably last dry in the 1920's before the Locks were installed. Reeds were growing along the wetland margins, with sparse vegetation on the higher floodplain. Eight sites were sampled as shown in Figure 5-1.

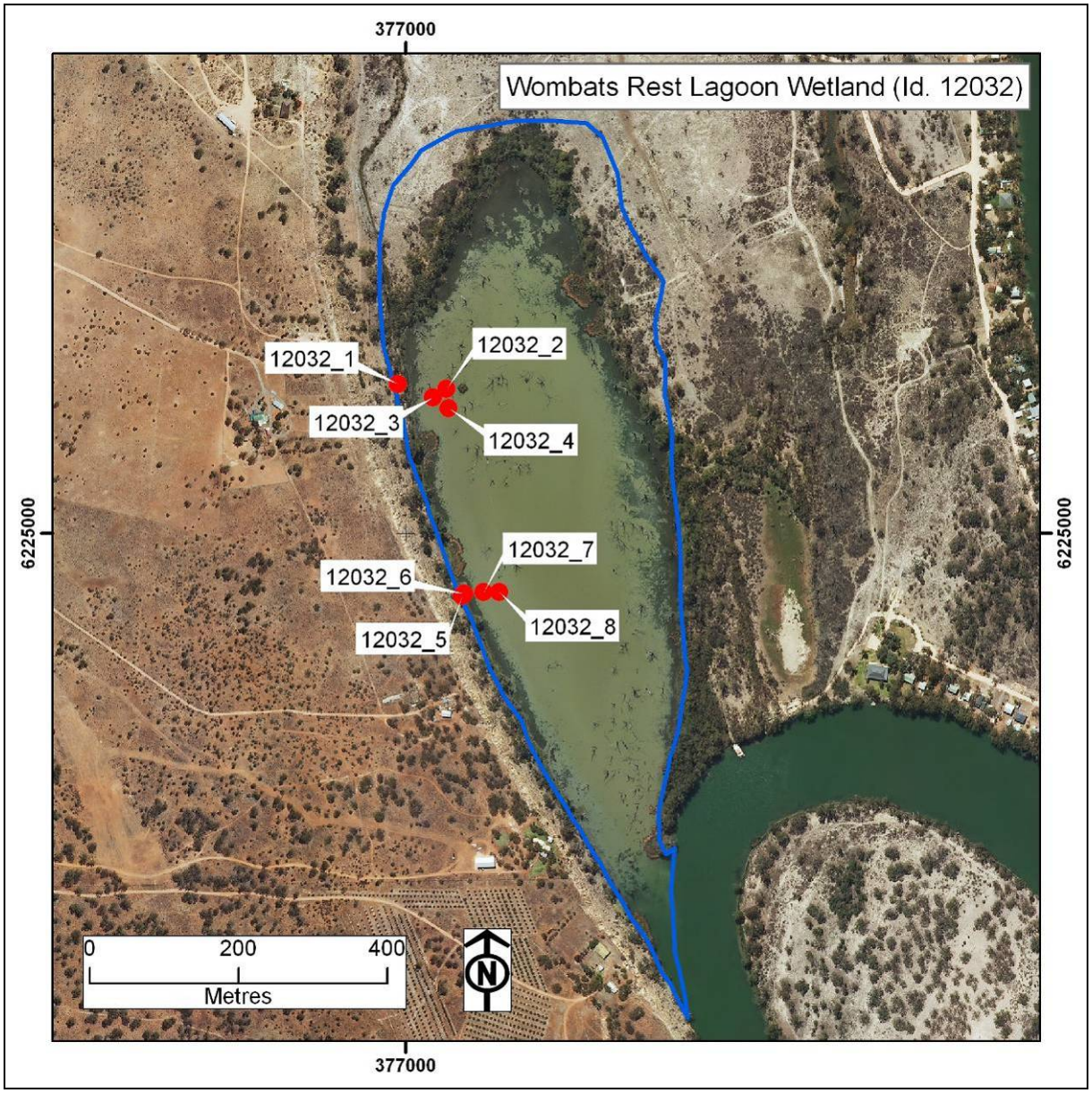


Figure 5-1. Wombats Rest Lagoon (Wetland ID. 12032) and sample site locations.

5.2. Soil profile description and distribution

Eight sites were described and sampled. The soil subtypes and general location descriptions are presented in Table 5-1. Sites were distributed from the wetland margin into the water along two transects to provide cross-sections, with one transect from the northwest (Sites 1, 2, 3, and 4) and the other from the southwest side (Sites 5, 6, 7, and 8) of the wetland. The site and soil profile descriptions are presented in Table 5-2 and Table 5-3, and a conceptual cross-section diagram in Figure 5-2.

Northwest transect.

Site 1 (Figure 5-3) occurred on land amongst reeds on the wetland margin, with the water table in the pit at about 20 cm depth, the soil consisted of a surface layer that was a very dark greyish brown, weak angular block structured, clay loam, with many plant roots, and a dark grey, firm, clay subsoil. Site 2 (Figure 5-4) occurred at the edge of the reeds to open water (20 cm deep), and the soil consisted of a very dark greyish brown, very weak, mucky clay over a very dark grey, very firm, clay. Site 3 (Figure 5-5) occurred in open water (40 cm deep), and the soil consisted of a dark grey, very weak, mucky clay over dark grey, firm, clay. Site 4 (Figure 5-6) occurred in open water (50 cm deep), and the soil consisted of an olive grey, very weak, mucky clay, over a dark grey, firm, clay.

Southwest transect.

Site 5 (Figure 5-7) occurred on land amongst thick reeds on the wetland margin, and the soil consisted of a surface layer that was very dark greyish brown, subangular blocky structure, firm, clay loam, over a very dark grey, firm, clay. Site 6 (Figure 5-8) occurred at the edge of reeds in open water (30 cm deep), and the soil consisted of a dark grey, subangular blocky structure, weak, clay, over a dark grey, very firm, clay. Site 7 (Figure 5-9) occurred in open water (55 cm deep), and the soil consisted of a dark grey, very weak, mucky clay, over grey firm clay. Site 8 (Figure 5-10) occurred in open water (70 cm deep), and the soil consisted of a dark grey, very weak, mucky clay with a few shell fragments, over a dark grey firm clay.

Table 5-1. Soil identification, subtype and general location description for Wombats Rest Lagoon (Wetland ID 12032).

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12032_1	376990	6225200	Other Soil (clayey)	high elevation, in reeds on wetland margin
12032_2	377055	6225194	Subaqueous Soil (clayey)	edge of reeds in water
12032_3	377037	6225182	Subaqueous Soil (clayey)	low elevation, open water 40m from shoreline
12032_4	377058	6225168	Subaqueous Soil (clayey)	low elevation, open water amongst dead trees
12032_5	377076	6224916	Other Soil (clayey)	high elevation, in reeds on wetland margin
12032_6	377079	6224919	Subaqueous Soil (clayey)	mid elevation, edge of reeds in open water
12032_7	377105	6224921	Subaqueous Soil (clayey)	low elevation, open water, 50m from edge
12032_8	377126	6224921	Subaqueous Soil (clayey)	low elevation, open water, near dead trees.

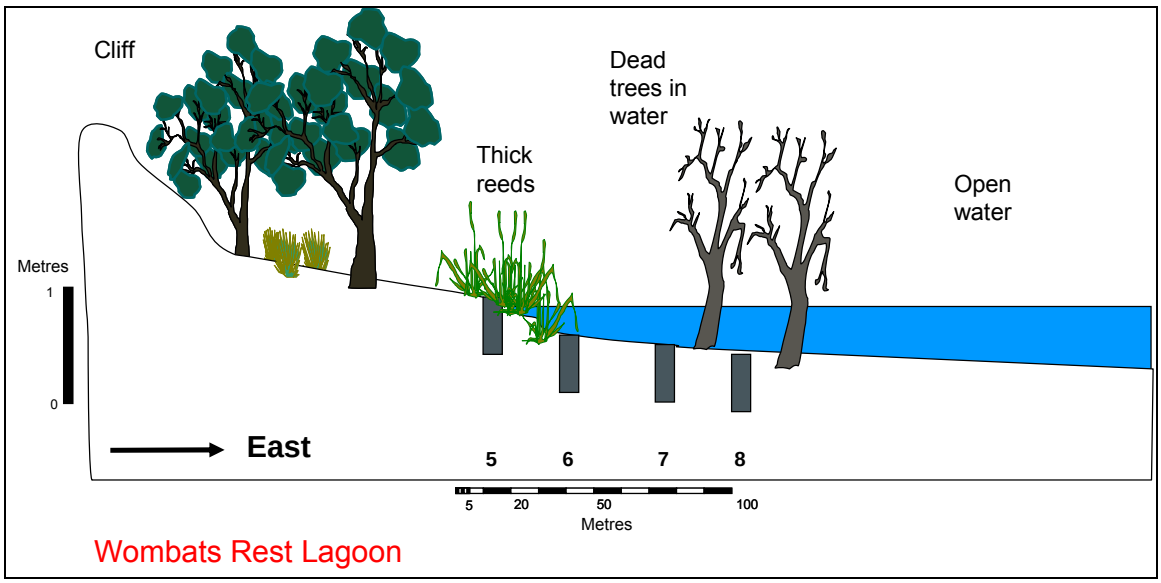


Figure 5-2. Conceptual cross-section diagram, showing the locations of Sites 5 to 8.

Figure 5-3: Photograph of Site 1, showing the site location in reeds on the wetland margin above water.

Figure 5-4. Photograph of Site 2, showing the site location in water adjacent to the reeds growing in the water on the wetland margin.

Figure 5-5. Photograph of Site 3, showing the site location in open water.

Figure 5-6. Photograph of Site 4, showing the site location in open water amongst dead trees.

Figure 5-7. Photograph of Site 5, showing the site location on bank amongst reeds above water.

Figure 5-8. Photograph of Site 6, showing the site location in water adjacent to thick Phragmites growing on the margin.

Figure 5-9. Photograph of Site 7, showing the site location in open water.

Figure 5-10. Photograph of Site 8, showing the site location in open water amongst dead trees.

5.3. Laboratory data assessment

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

The pH data are provided in Table 5-4 and pH profiles are presented in Figure 5-11. The pH_W data ranged from 5.53 to 7.80 and sulfuric materials with a pH_W <4 were not identified. The pH_{OX} data ranged from 2.54 to 7.33 and identified that no soil layers declined below the critical value of pH_{OX} <2.5. The $pH_{incubation}$ data ranged from 4.55 to 7.92 and identified that no soil layers on incubation declined below the critical value of pH <4.

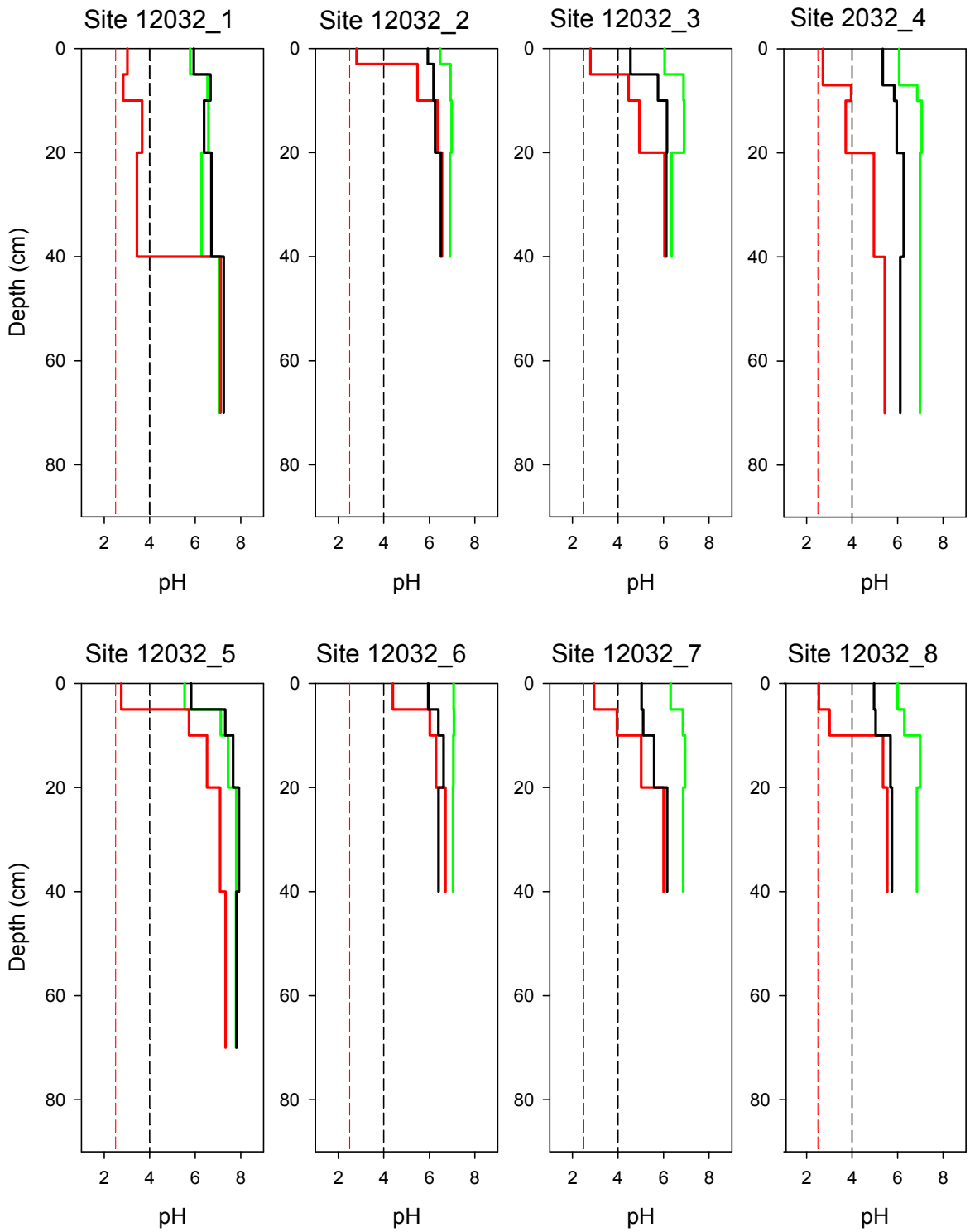


Figure 5-11. Depth profiles of soil pH for Wombats Rest Lagoon (Wetland ID. 12032), showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and incubation pH (pH_{INC} after 8 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

5.3.2. Acid base accounting

The acid base accounting data is provided in Table 5-4 and summarised in Figure 5-12.

Chromium reducible sulfur

Chromium reducible sulfur values ranged from 0 to 0.11 $\%S_{CR}$. and sulfidic materials were detected in nearly every soil layer.

Titratable actual acidity

Titratable actual acidity values ranged from 0 to 35.14 mole H^+/tonne.

Retained acidity

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

Acid neutralising capacity

Acid neutralising capacity values ranged from 0 to 20.41 $\%CaCO_3$, and were measured only in Profile 5.

Net acidity

Net acidity values ranged from -2719 to 95 mole H^+/tonne. Generally high values were recorded in the surface layers and the subsoil layers tended to decrease to moderate and low values with depth, the exception was Profile 5 where negative values occurred in the subsoil layers.

5.3.3. Water soluble sulfate

Water soluble sulfate data values shown in Table 5-4 identified that surface layers at Sites 2 and 5 were above the criterion trigger value of 100 mg/kg SO_4. These sites were near the waters edge.

5.3.4. Acid volatile sulfur

Monosulfidic materials were not observed and samples were not collected for analysis.

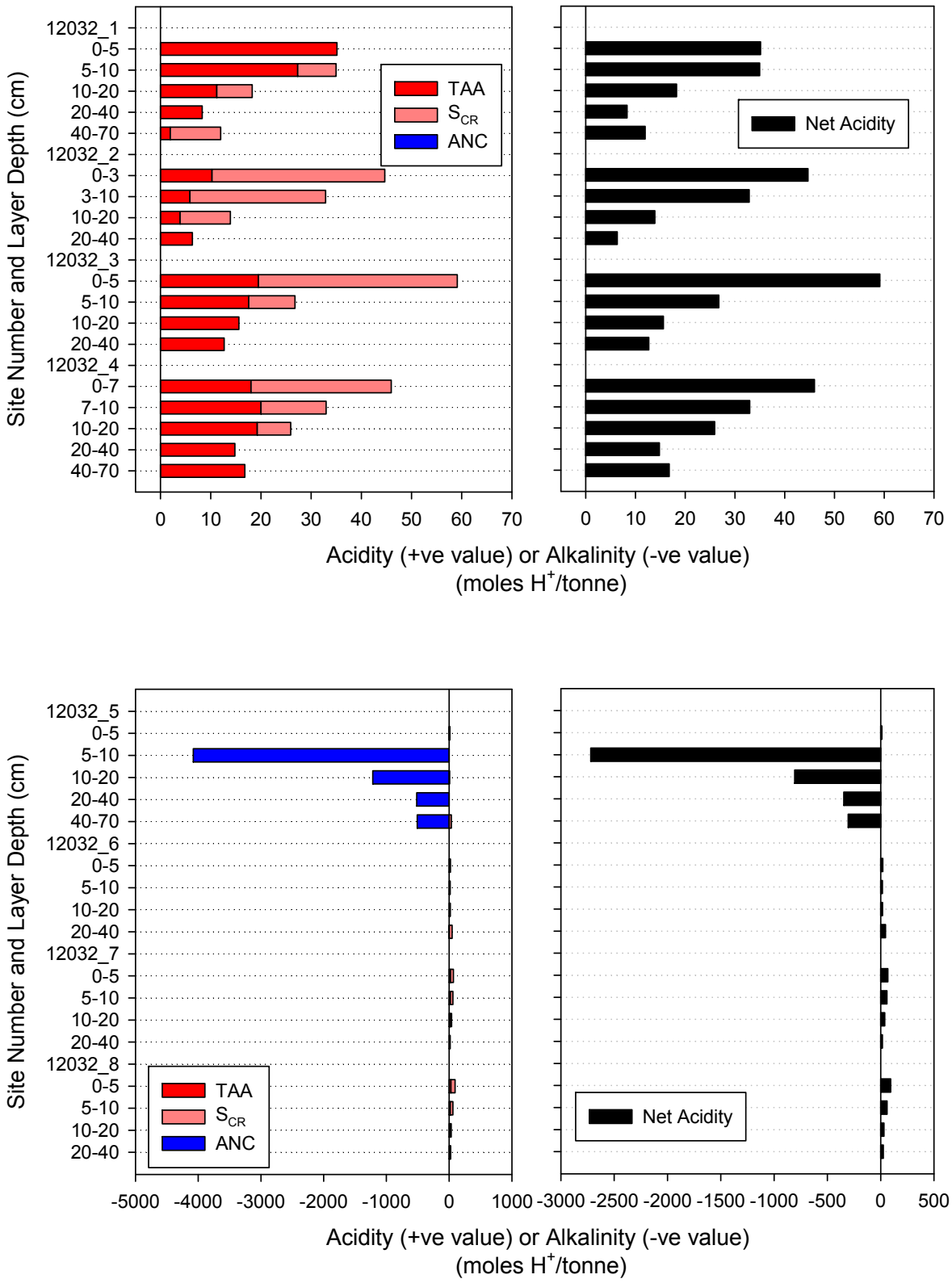


Figure 5-12. Acid base accounting depth profiles for Wombats Rest Lagoon (Wetland ID. 12032). Left side shows the components: Titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

5.3.5. Hydrochemistry

Two surface water samples were collected from this wetland and no pit waters were sampled as none of the marginal areas were dry. Field parameters are shown in Table 5-5. The surface waters had slightly alkaline pH and were relatively fresh. The water was saturated with dissolved oxygen, and turbidity was very high. Alkalinity was of a similar magnitude to river water.

The surface waters were of Na-HCO_3 type (Table 5-6, Figure 5-13). Sulfate concentrations in the surface waters were relatively low (9.8-11 mg l^{-1}). The SO_4/Cl ratio in the surface water (0.216-0.223) was slightly higher than seawater (0.142). Nitrate was below detection limit, and NH_4 and NO_2 were present at low concentrations. Iron was below detection limit and Mn was present at low concentration. Elevated Al may be due to colloidal material due to the high turbidity. The concentrations of most metals were low consistent with the neutral pH.

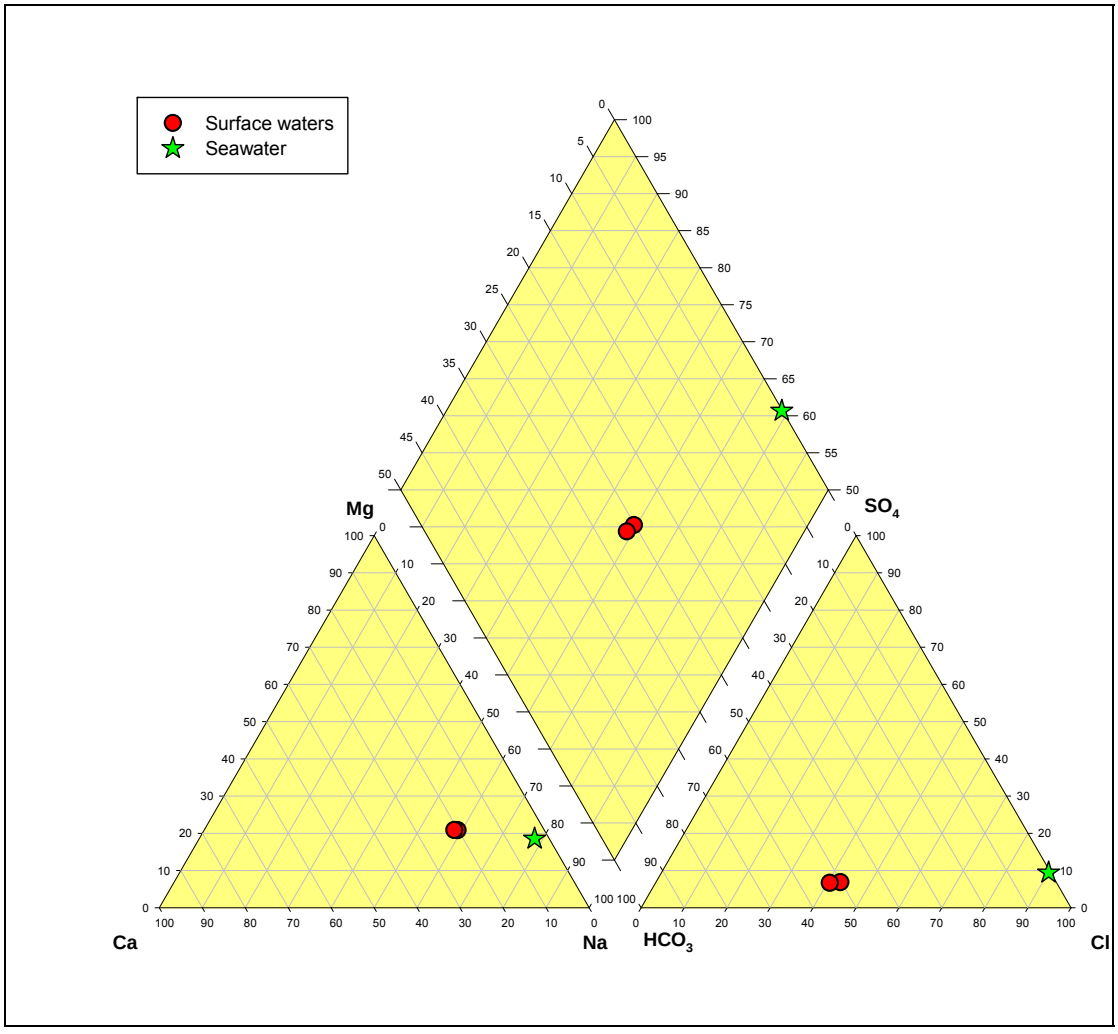


Figure 5-13. Piper diagram of hydrochemical data for Wombats Rest Lagoon (Wetland ID. 12032).

5.4. Discussion

Acid sulfate soil materials at Wombats Rest Lagoon (Wetland ID. 12032) were identified as hyposulfidic and the remaining soil samples were characterised as other acidic. The soil subtype classes identified were Subaqueous Soil (clayey) that occurred throughout the main wetland area and Other Soil (clayey) that occurred in areas above the water level.

The soils throughout the wetland below the water level were mucky clays in the surface layers that were very weak and the soil became firm clays with depth. In areas above the water level on the wetland margin the surface soils were structured and clayey.

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

The potential hazards posed by acid sulfate soil materials at Wombats Rest Lagoon (Wetland ID. 12032) are:

- Acidification hazard: The data identified sol surface layers with high net acidity for 7 of the 8 profiles, but pH data did not indicate a potential acidification hazard due to oxidation. There is a medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there is potential for monosulfidic materials to form in the surface layers of soils below the water level near the shoreline, monosulfidic material was not observed. There is a low to medium level of concern.
- Metal mobilisation: The medium acidification hazard indicates that soil acidification potential is not likely to increase the solubility of metals. There is a medium level of concern.

Summary of key findings Wombats Rest Lagoon (Wetland ID. 12032):

Soil materials:	The surface soil layers throughout the wetland were generally hyposulfidic. Soils were very weak mucky clays at the surface that became firmer with depth. High net acidity values were identified in the soil surface layers and pH data did not indicate a potential for acidification due to oxidation.
Acid sulfate soil identification:	• Subaqueous Soil (clayey) – occurring throughout the wetland below water. Dominant (>50%) in extent. • Other Soil (clayey) – occurring on the margins of the wetland above the water level. Isolated (<10%) in extent.
Hazard assessment	• Acidification hazard – medium level of concern • De-oxygenation hazard – low to medium level of concern • Metal mobilisation hazard – medium level of concern

Table 5-2. Site description data for Wombats Rest Lagoon (Wetland ID. 12032).

Site Number	Sample Date	Easting m Zone 54H	Northing m Zone 54H	Water depth (+ve) Water table (-ve)	Surface condition	Earth cover (vegetation)	Location Notes
1	2/05/2010	376990	6225200	-20	plant material	Phragmites	high elevation, in reeds on wetland margin
2	2/05/2010	377055	6225194	20	water	water, Typha	edge of reeds in water
3	2/05/2010	377037	6225182	40	water	water	low elevation, open water 40m from shoreline
4	2/05/2010	377058	6225168	50	water, soft	water	low elevation, open water amongst dead trees
5	2/05/2010	377076	6224916	not reached	plant material	Phragmites	high elevation, in reeds on wetland margin
6	2/05/2010	377079	6224919	30	water	water, Typha	mid elevation, edge of reeds in open water
7	2/05/2010	377105	6224921	55	water	water	low elevation, open water, 50m from edge
8	2/05/2010	377126	6224921	70	water, very weak	water	low elevation, open water, near dead trees.

Table 5-3. Soil profile description data for Wombats Rest Lagoon (Wetland ID. 12032).

Site and Sample (number)	Depth Range (cm)	Observation Method (kind)	Soil Colour (name, Munsell notation)	Texture (Class)	Soil Water Status	Redoximorphic Features (%, colour, location)	Structure Type (category)	Consistence (category)	Comments
1_1	0 - 5	small pit	very dark greyish brown (10YR3/2)	clay loam	moist		angular blocky	weak	many plant roots
1_2	5 - 10	small pit	dark grey (5Y4/1)	clay	moist		angular blocky	firm	many plant roots
1_3	10 - 20	small pit	dark grey (5Y4/1)	clay	moist		massive	firm	
1_4	20 - 40	push tube	dark grey (5Y4/1)	clay	moist		massive	firm	
1_5	40 - 70	push tube	very dark grey (5Y3/1)	clay	moist		massive	very firm	
2_1	0 - 3	small pit	very dark greyish brown (10YR3/2)	mucky clay	wet		gel	very weak	
2_2	3 - 10	small pit	very dark grey (5Y3/1)	clay	wet		massive	firm	
2_3	10 - 20	small pit	very dark grey (5Y3/1)	clay	moist		massive	very firm	
2_4	20 - 40	push tube	very dark grey (5Y3/1)	clay	moist		massive	very firm	

Site and Sample (number)	Depth Range (cm)	Observation Method (kind)	Soil Colour (name, Munsell notation)	Texture (Class)	Soil Water Status	Redoximorphic Features (%, colour, location)	Structure Type (category)	Consistence (category)	Comments
3_1	0 - 5	small pit	dark grey (10YR4/1)	mucky clay	moist		gel	very weak	
3_2	5 - 10	small pit	dark grey (10YR4/1)	clay	moist		massive	weak	
3_3	10 - 20	small pit	dark grey (5Y4/1)	clay	moist		massive	weak	
3_4	20 - 40	push tube	dark grey (5Y4/1)	clay	moist		massive	very firm	
4_W1	50 - 0	surface water							water sampled
4_1	0 - 7	small pit	olive grey (5Y4/2)	mucky clay	wet		gel	very weak	
4_2	7 - 10	small pit	dark grey (5Y4/1)	clay	wet		massive	weak	
4_3	10 - 20	small pit	dark grey (5Y4/1)	clay	wet		massive	firm	
4_4	20 - 40	push tube	dark grey (5Y4/1)	clay	moist		massive	firm	
4_5	40 - 70	push tube	dark grey (5Y4/1)	clay	moist		massive	very firm	
5_1	0 - 5	small pit	very dark greyish brown (10YR3/2)	clay loam	dry		subangular blocky	firm	many plant roots
5_2	5 - 10	small pit	very dark greyish brown (10YR3/2)	clay loam	moist		subangular blocky	firm	many plant roots
5_3	10 - 20	small pit	dark greyish brown (10YR4/2)	clay	moist		massive	firm	many plant roots
5_4	20 - 40	push tube	very dark grey (5Y3/1)	clay	moist		massive	very firm	
5_5	40 - 70	push tube	black (2.5Y2/0)	clay	moist		massive	very firm	
6_1	0 - 5	small pit	dark grey (5Y4/1)	clay	wet		subangular blocky	weak	
6_2	5 - 10	small pit	dark grey (2.5Y4/0)	clay	wet		subangular blocky	weak	
6_3	10 - 20	small pit	#N/A	clay	moist		massive	firm	
6_4	20 - 40	push tube	#N/A	clay	moist		massive	very firm	
7_1	0 - 5	small pit	dark grey (5Y4/1)	mucky clay	wet		gel	very weak	
7_2	5 - 10	small pit	dark grey (5Y4/1)	mucky clay	wet		gel	very weak	
7_3	10 - 20	small pit	grey (5Y5/1)	clay	moist		massive	firm	
7_4	20 - 40	push tube	grey (5Y5/1)	clay	moist		massive	firm	
8_W1	70 - 0	surface water							water sampled
8_1	0 - 5	small pit	dark grey (5Y4/1)	mucky clay	wet		gel	very weak	contains few shells
8_2	5 - 10	small pit	dark grey (5Y4/1)	clay	wet		gel	very weak	contains few shells
8_3	10 - 20	small pit	dark grey (2.5Y4/0)	clay	moist		massive	firm	
8_4	20 - 40	push tube	dark grey (2.5Y4/0)	clay	moist		massive	firm	

Table 5-4. Laboratory data for acid sulfate soil assessment of Wombats Rest Lagoon (Wetland ID. 12032).

(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 week 0	pH incubation week 8	Sulfate (mg SO_4/kg)	pH KCl	Titratable actual acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H+/ tonne)	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+ /tonne)	Acid Sulfate Soil Material Classification
1.1	0-5	Medium	180	5.78	3.02	4.99	5.94	96	5.83	35.14	<0.01	..	..	35	other acidic
1.2	5-10	Fine	151	6.54	2.83	6.05	6.67	22	5.34	27.33	0.01	..	..	35	hyposulfidic (S_{CR}<0.10%)
1.3	10-20	Fine	121	6.58	3.67	6.51	6.39	26	5.96	11.22	0.01	..	..	18	hyposulfidic (S_{CR}<0.10%)
1.4	20-40	Fine	220	6.28	3.44	6.60	6.71	51	6.10	8.30	<0.01	..	0.00	8	other soil material
1.5	40-70	Fine	411	7.06	7.11	6.92	7.25	12	6.49	1.95	0.02	..	0.00	12	hyposulfidic (S_{CR}<0.10%)
2.1	0-3	Medium	80	6.48	2.80	6.93	5.93	110	6.06	10.25	0.06	..	0.00	45	hyposulfidic (S_{CR}<0.10%)
2.2	3-10	Fine	88	6.93	5.48	7.00	6.18	29	6.04	5.86	0.04	..	0.00	33	hyposulfidic (S_{CR}<0.10%)
2.3	10-20	Fine	95	6.98	6.37	6.79	6.25	16	6.10	3.90	0.02	..	0.00	14	hyposulfidic (S_{CR}<0.10%)
2.4	20-40	Fine	113	6.91	6.56	7.03	6.51	15	6.25	6.34	<0.01	..	0.00	6	other soil material
3.1	0-5	Fine	71	6.05	2.79	6.58	4.55	63	5.40	19.52	0.06	..	..	59	hyposulfidic (S_{CR}<0.10%)
3.2	5-10	Fine	68	6.88	4.47	6.47	5.76	39	5.81	17.57	0.01	..	..	27	hyposulfidic (S_{CR}<0.10%)
3.3	10-20	Fine	90	6.90	4.94	6.55	6.15	15	5.90	15.62	<0.01	..	..	16	other soil material
3.4	20-40	Fine	107	6.35	6.04	6.54	6.12	11	5.85	12.69	<0.01	..	..	13	other soil material
4.W1	50-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
4.1	0-7	Fine	73	6.07	2.72	6.55	5.35	35	5.41	18.06	0.04	..	..	46	hyposulfidic (S_{CR}<0.10%)
4.2	7-10	Fine	105	6.86	3.96	6.87	5.85	18	5.46	20.01	0.02	..	..	33	hyposulfidic (S_{CR}<0.10%)
4.3	10-20	Fine	78	7.06	3.72	6.23	5.96	14	5.53	19.26	0.01	..	..	26	hyposulfidic (S_{CR}<0.10%)
4.4	20-40	Fine	101	6.98	4.96	6.80	6.27	13	5.68	14.82	<0.01	..	..	15	other soil material
4.5	40-70	Fine	96	6.98	5.44	6.71	6.12	13	5.61	16.79	<0.01	..	..	17	other soil material
5.1	0-5	Medium	671	5.53	2.75	5.07	5.82	130	6.49	0.99	0.02	..	0.00	13	hyposulfidic (S_{CR}<0.10%)
5.2	5-10	Medium	1,149	7.12	5.72	6.95	7.32	56	7.66	0.00	<0.01	..	20.41	-2719	other soil material
5.3	10-20	Fine	1,221	7.44	6.52	7.53	7.66	61	7.87	0.00	0.01	..	6.10	-806	hyposulfidic (S_{CR}<0.10%)
5.4	20-40	Fine	578	7.80	7.09	7.78	7.92	21	7.72	0.00	<0.01	..	2.59	-345	other soil material
5.5	40-70	Fine	395	7.79	7.33	7.57	7.81	10	7.58	0.00	0.05	..	2.54	-304	hyposulfidic (S_{CR}<0.10%)
6.1	0-5	Fine	68	7.07	4.40	6.76	5.95	54	6.10	6.92	0.02	..	0.00	22	hyposulfidic (S_{CR}<0.10%)
6.2	5-10	Fine	83	7.08	6.02	7.04	6.40	35	6.10	8.40	0.01	..	0.00	18	hyposulfidic (S_{CR}<0.10%)
6.3	10-20	Fine	89	7.06	6.29	7.21	6.63	32	6.22	7.41	0.02	..	0.00	19	hyposulfidic (S_{CR}<0.10%)
6.4	20-40	Fine	89	7.04	6.71	7.13	6.41	25	6.37	2.47	0.07	..	0.00	46	hyposulfidic (S_{CR}<0.10%)
7.1	0-5	Fine	85	6.31	2.95	6.33	5.04	54	5.40	22.23	0.07	..	..	67	hyposulfidic (S_{CR}<0.10%)
7.2	5-10	Fine	80	6.85	3.95	6.22	5.11	56	5.54	20.25	0.06	..	..	59	hyposulfidic (S_{CR}<0.10%)
7.3	10-20	Fine	112	6.94	5.02	6.49	5.59	68	5.77	16.79	0.04	..	..	39	hyposulfidic (S_{CR}<0.10%)
7.4	20-40	Fine	121	6.86	6.00	6.80	6.16	16	5.72	17.29	<0.01	..	..	17	other soil material

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation week 0	pH incubation week 8	Sulfate (mg SO_4/kg)	pH KCl	Titratable actual acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H+/ tonne)	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+ /tonne)	Acid Sulfate Soil Material Classification
8.W1	70-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
8.1	0-5	Fine	69	6.00	2.54	6.13	4.97	48	5.14	27.17	0.11	..	..	95	hyposulfidic (S_{CR}≥0.10%)
8.2	5-10	Fine	117	6.30	3.01	6.42	5.04	51	5.26	18.77	0.07	..	..	61	hyposulfidic (S_{CR}<0.10%)
8.3	10-20	Fine	127	6.99	5.36	6.60	5.69	23	5.31	23.71	0.01	..	..	31	hyposulfidic (S_{CR}<0.10%)
8.4	20-40	Fine	109	6.85	5.55	6.67	5.75	20	5.30	16.79	0.01	..	..	25	hyposulfidic (S_{CR}<0.10%)

Table 5-5. Summary of hydrochemical field measurements for Wombats Rest Lagoon Wetland.

	pH	SEC	DO	Eh	Turbidity	Alkalinity
		µS cm^{-1}	mg l^{-1}	mV	NTU	as HCO_3
Surface waters (n=2)	8.22-8.31	301-312	13.5-13.6	51-80	150-166	73

Table 5-6. Hydrochemical data for Wombats Rest Lagoon (Wetland ID. 12032).

Parameter	units	ANZECC Guidelines	Site 4 (SW)	Site 8 (SW)
Na	mg l^{-1}		30.9	28.9
K	mg l^{-1}		6.1	6.1
Ca	mg l^{-1}		10.3	10.2
Mg	mg l^{-1}		6.44	6.17
Si	mg l^{-1}		4.31	4.27
Br	mg l^{-1}		0.1	0.1
Cl	mg l^{-1}		51	44
NO_3	mg l^{-1}	0.7	<0.022	<0.022
NH_4-N[K]	mg l^{-1}	0.01	**0.02**	**0.036**
PO_4-P[E]	mg l^{-1}	0.005	**0.058**	**0.095**
SO_4	mg l^{-1}		11	9.8
Ag	µg l^{-1}	0.05	<0.01	<0.01
Al[A]	µg l^{-1}	55	**330**	**390**
As[B]	µg l^{-1}	13	1.2	1.2
Cd	µg l^{-1}	0.2	0.02	0.01
Co	µg l^{-1}	2.8	0.22	0.24
Cr[C]	µg l^{-1}	1	0.4	0.5
Cu[H]	µg l^{-1}	1.4	**2.6**	**2.4**
Fe	µg l^{-1}	300	<1000	<1000
Mn	µg l^{-1}	1700	4.14	5.4
Ni[H]	µg l^{-1}	11	1.4	1.6
Pb[H]	µg l^{-1}	3.4	0.54	0.56
Se	µg l^{-1}	11	0.06	0.06
Zn[H]	µg l^{-1}	8	**37**	**41**
DOC	mg l^{-1}		9.1	8.7

Notes.

The ANZECC guideline values for toxicants refer to the trigger values applicable to 'slightly-moderately disturbed' freshwater systems, as outlined in the Australian Water Quality Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000). For the nutrients NH_4 and PO_4, trigger values are provided for Freshwater Lakes and reservoirs. Surface water values outside the ranges defined in the ANZECC guidelines are indicated with red text. (SW) and (PW) indicate whether the sample was taken from surface water or pit-water (groundwater that entered an excavated pit), respectively.

A *Trigger value for Aluminium in freshwater where pH > 6.5.*

B *Trigger value assumes As in solution as Arsenic (AsV).*

C *Trigger value for Chromium is applicable to Chromium (CrVI) only.*

E *Guideline is for filterable reactive phosphorous (FRP).*

H *Hardness affected (refer to Guidelines).*

K *Guideline for South-east Australia-Freshwater Lakes and reservoirs.*

6. SCHILLERS LAGOON (WETLAND ID. 12259)

6.1. Location and setting description

Schillers Lagoon (Wetland ID. 12259) is situated on the southern side of the River Murray about 18 kilometres down river from Waikerie and adjacent to Lock 2 at Taylorville. The wetland is oval in shape and occurs on the inside of a bend in the river. It is about 2 kilometres in length and about 600 metres at its widest, with a total surface area of 78 hectares. The wetland is bounded to the north and east by a raised floodplain that separates the wetland from the river and to the south there is a hillside. The wetland occurs in a complex with wetland ID. 12266 that connects this wetland with the river.

The wetland is connected to the river by a creek to the northwest (Wetland ID. 12266) and to the south east by Nigra Creek (Wetland ID. 12294). At the time when the soil survey was conducted in March 2010 the wetland contained surface water. The wetland is managed by landholders with assistance from the South Australian Murray-Darling Basin Natural Resources Management Board (SA MDB NRM Board) and RWLAP. It was closed in October 2006, opened in March 2009, closed in September 2009, opened in February 2010. Sedgeland was growing along the wetland margins, with open woodland and shrubland on the surrounding higher floodplain. Eight sites were sampled as shown in Figure 6-1.

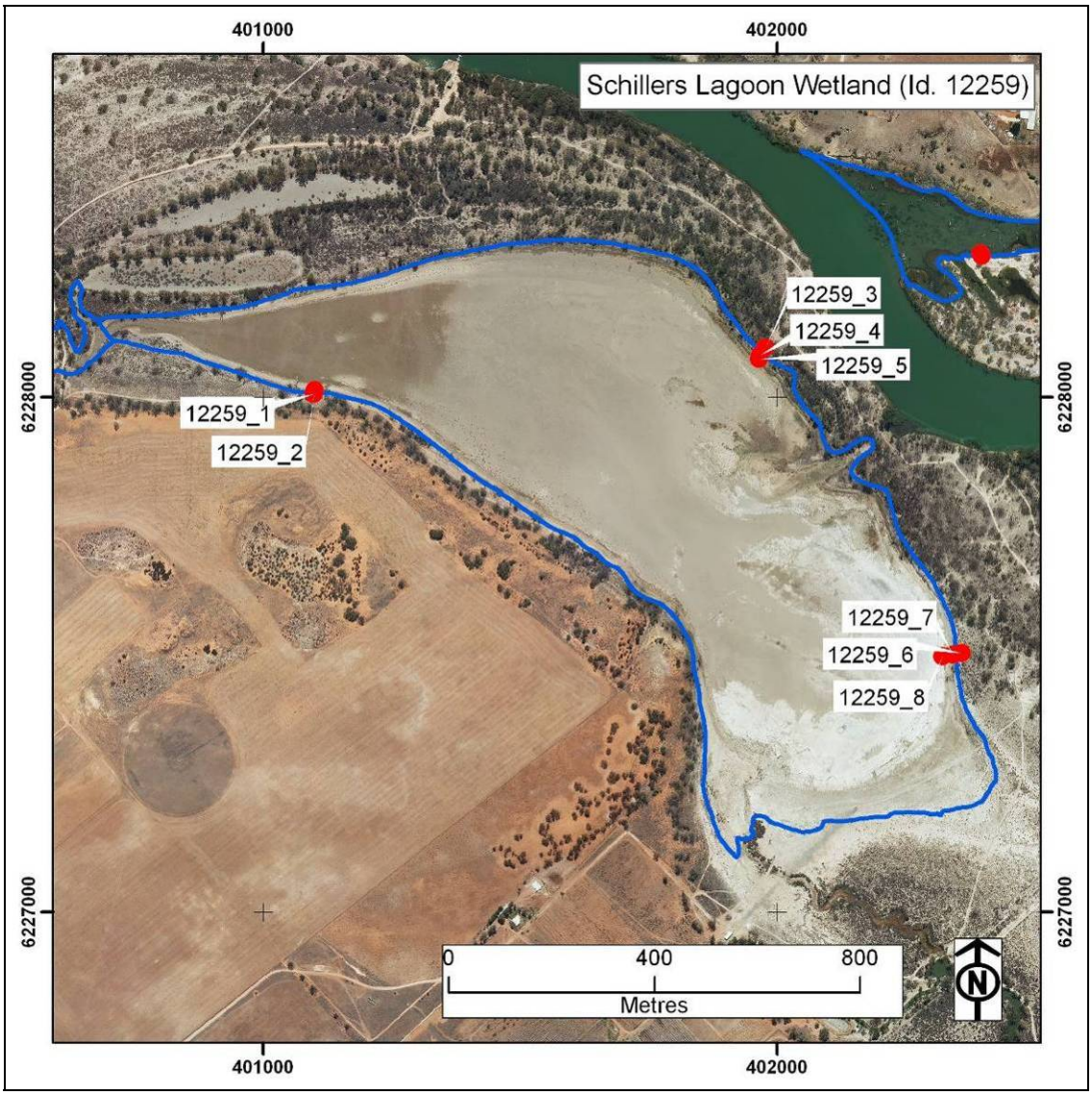


Figure 6-1. Schillers Lagoon (Wetland ID. 12259) and sample site locations.

6.2. Soil profile description and distribution

Eight sites were described and sampled. The soil subtypes and general location descriptions are presented in Table 6-1. Sites were distributed from the wetland margin into the water along three transects to provide cross-sections, with transects from the southwestern (Sites 1 and 2), northern (Sites 3, 4 and 5), and eastern (Sites 6, 7 and 8) sides of the wetland. The site and soil profile descriptions are presented in Table 6-2 and Table 6-3, and a conceptual cross-section in Figure 6-2.

Southwestern transect

Site 1 (Figure 6-3) occurred adjacent to the bank in water (60 cm deep), the soil consisted of a dark grey, very weak clay at the surface, to firm sandy clay loam subsoil. Site 2 (Figure 6-4) occurred in open water (100 cm deep), and the soil consisted of a very dark, very weak clay at the surface, to firm sandy clay loam subsoil.

Northern transect

Site 3 (Figure 6-5) occurred on the wetland margin above the water level where there was salt crust on the surface, with a water table in the pit at about 5 cm depth, and the soil consisted of a grey, firm, loamy sand. Site 4 (Figure 6-6) occurred in open water (50 cm deep), and the soil consisted of a dark greyish brown, weak sand to sandy loam surface layers over a grey, very firm sandy clay loam. Site 5 (Figure 6-7) occurred in open water (90 cm deep), and the soil consisted of a greyish brown, weak, sandy clay loam surface layers over an olive grey, very firm sandy clay loam.

Eastern transect

Site 6 (Figure 6-8) occurred on the wetland margin above the water level and a salt crust surface, and the soil consisted of a very dark grey, angular block structure, firm, clay, over a black to grey, very firm, clay. Site 7 (Figure 6-9) occurred adjacent to the shoreline and in water (2 cm deep), and the soil consisted of a grey, very firm, clay. Site 8 (Figure 6-10) occurred in open water (80 cm deep), and the soil consisted of an olive grey, very weak to rigid, gritty clay.

Table 6-1. Soil identification, subtype and general location description for Schillers Lagoon (Wetland ID. 12259).

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12259_1	401099	6228007	Subaqueous Soil (clayey)	in water adjacent to bank in lignum
12259_2	401101	6228014	Subaqueous Soil (clayey)	15m into open water
12259_3	401978	6228097	Other Soil (sandy)	shoreline above water level in lignum
12259_4	401968	6228083	Subaqueous Soil (loamy)	open water 30m from shoreline
12259_5	401966	6228075	Subaqueous Soil (loamy)	low elevation, 25m from shore
12259_6	402360	6227503	Other Soil (clayey)	high elevation, 20m from shoreline, with salt crust and samphire growing
12259_7	402342	6227500	Other Soil (clayey)	shoreline
12259_8	402322	6227497	Subaqueous Soil (clayey)	open water 30m from shoreline

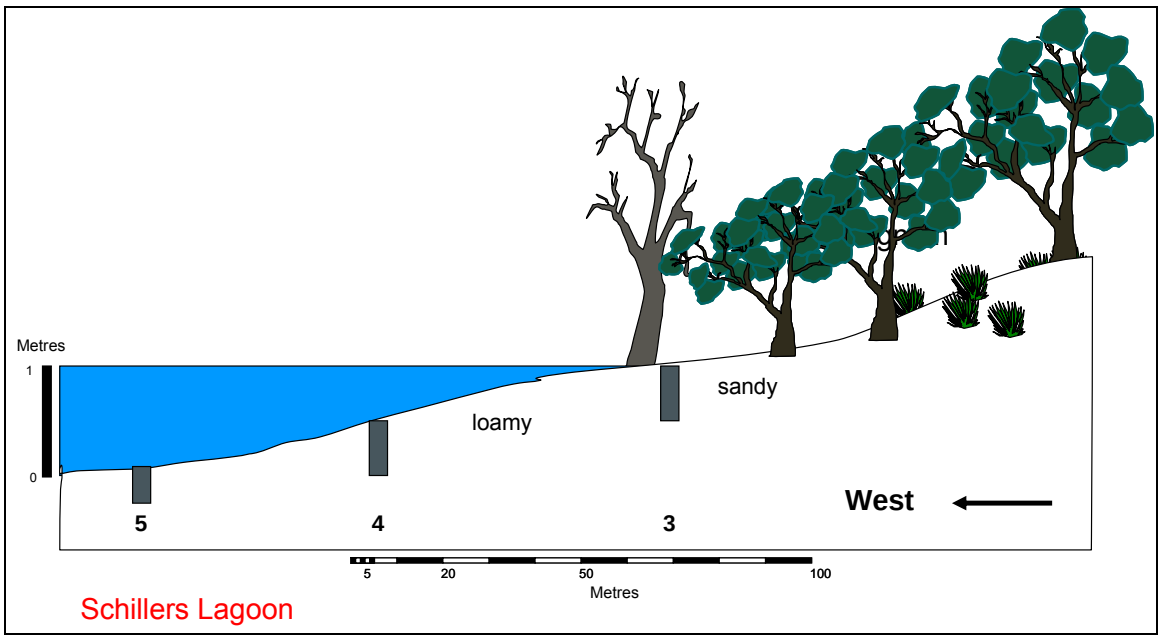


Figure 6-2. Conceptual cross-section diagram, showing the locations of Sites 3, 4 and 5.

Figure 6-3: Photograph of Site 1, showing the site location in water next to reeds.

Figure 6-4. Photograph of Site 2, showing the site location in open water.

Figure 6-5. Photograph of Site 3, showing the site location on the wetland water margin.

Figure 6-6. Photograph of Site 4, showing the site location in water 15m from the shore.

Figure 6-7. Photograph of Site 5, showing the site location in open water.

Figure 6-8. Photographs of Site 6, showing the site location on the wetland margin and the soil profile.

Figure 6-9. Photograph of Site 7, showing the site location next to the water line.

Figure 6-10. Photograph of Site 8, showing the site location in open water amongst dead trees.

6.3. Laboratory data assessment

6.3.1. Soil pH testing (pH_W, pH_{OX}, $pH_{incubation}$)

The pH data are provided in Table 6-4 and pH profiles are presented in Figure 6-11. The pH_W data ranged from 5.88 to 8.97 and sulfuric materials with a pH_W <4 were not identified. The pH_{OX} data ranged from 3.81 to 8.97 and identified that no sample declined below the critical value of pH_{OX} <2.5. The $pH_{incubation}$ data ranged from 5.64 to 9.15 and identified that no soil samples on incubation declined below the critical values of pH<4.

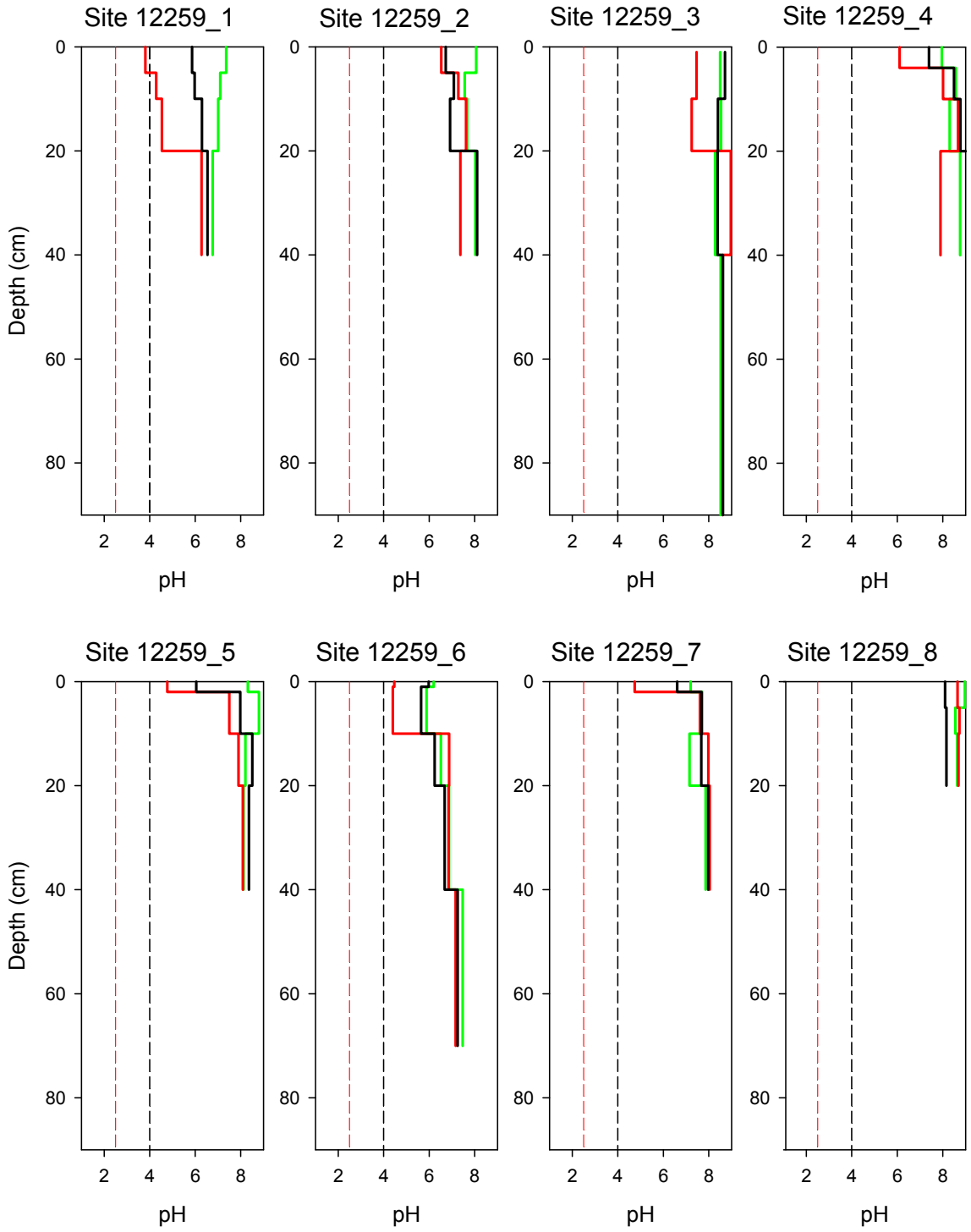


Figure 6-11. Depth profiles of soil pH for Schillers Lagoon (Wetland ID. 12259), showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and incubation pH (pH_{INC} after 8 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

6.3.2. Acid base accounting

The acid base accounting data is provided in Table 6-4 and summarised in Figure 6-12.

Chromium reducible sulfur

Chromium reducible sulfur values ranged from 0 to 0.04 %S_{CR} and sulfidic materials were generally detected in the surface soil layers and not detected in the subsoil layers.

Titratable actual acidity

Titratable actual acidity values ranged from 0 to 4.23 mole H^+/tonne.

Retained acidity

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

Acid neutralising capacity

Acid neutralising capacity values ranged from 0 to 6.72 %$CaCO_3$.and were measured in nearly all samples.

Net acidity

Net acidity values ranged from -891 to 21 mole H^+/tonne. Sample values were generally negative and in some profiles there was a sample with a low or moderate value.

6.3.3. Water soluble sulfate

Water soluble sulfate data values shown in Table 6-4 identified that surface layers at Sites 3, 6, 7 and 8 were above the criterion trigger value of 100 mg/kg SO_4.

6.3.4. Acid volatile sulfur

Monosulfidic materials were not observed and samples were not collected for analysis.

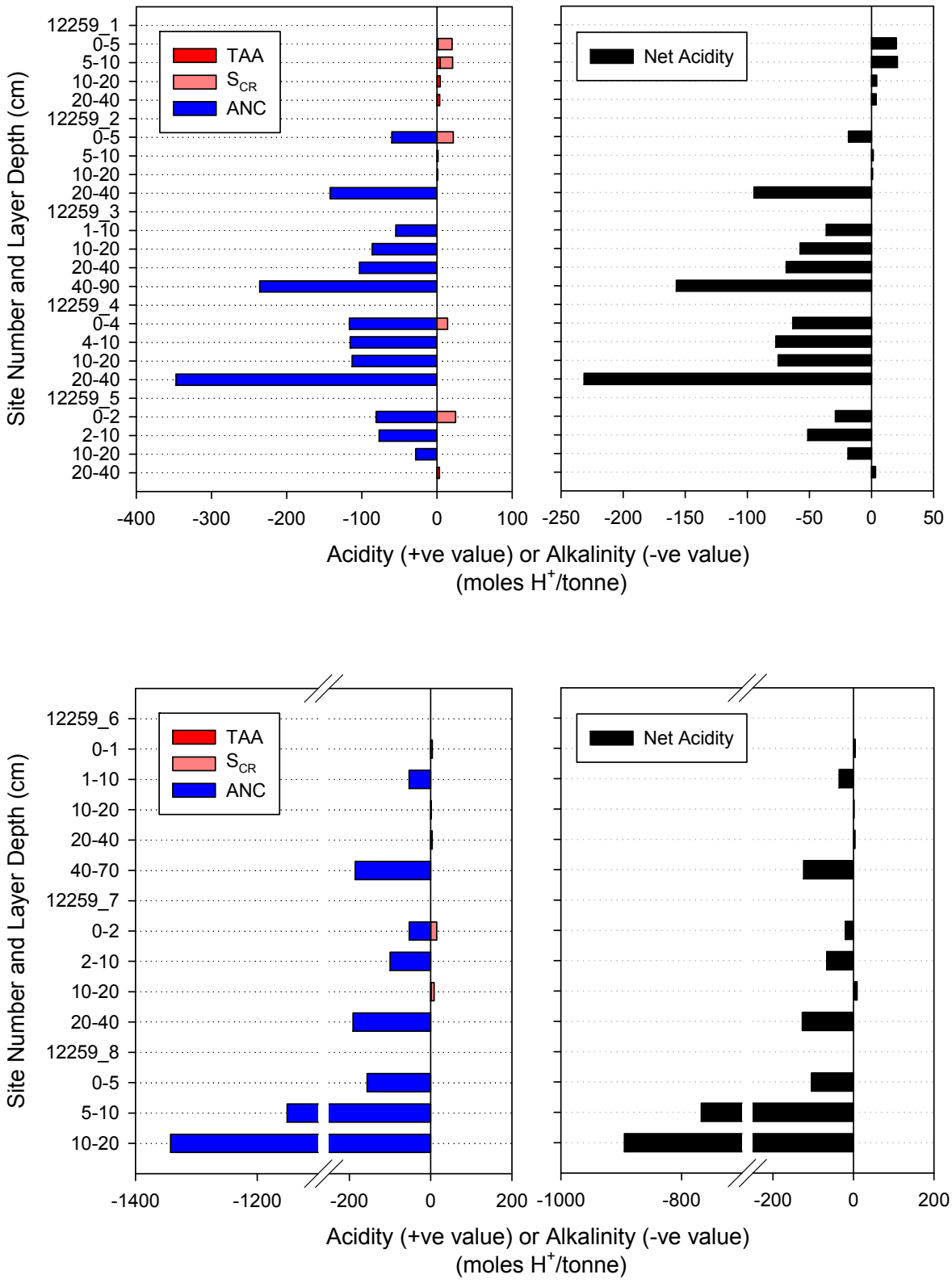


Figure 6-12. Acid base accounting depth profiles for Schillers Lagoon (Wetland ID. 12259). Left side shows the components: Titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

6.3.5. Hydrochemistry

Three surface waters were collected from the wetland and no pit water samples were collected as the marginal areas were covered with surface water. Field parameters are shown in Table 6-5. The surface water samples had neutral pH and were moderately saline. Dissolved oxygen was moderately high and the waters had low turbidity. Alkalinity was slightly higher than expected for the river along this section of the catchment.

The surface waters were of Na-Cl type, with relative proportions of major elements close to seawater (Table 6-6, Figure 6-13). Sulfate concentrations in the surface waters were moderately high varying between 260 and 270 mg l^{-1}. The SO_4/Cl ratio in the surface waters (0.24-0.26) were higher than seawater (0.142). For the nutrients, PO_4 concentrations were significantly above ANZECC Guideline values, and NH_4-N was slightly elevated. Zinc was slightly higher than ANZECC Guideline values, with most other metals being low.

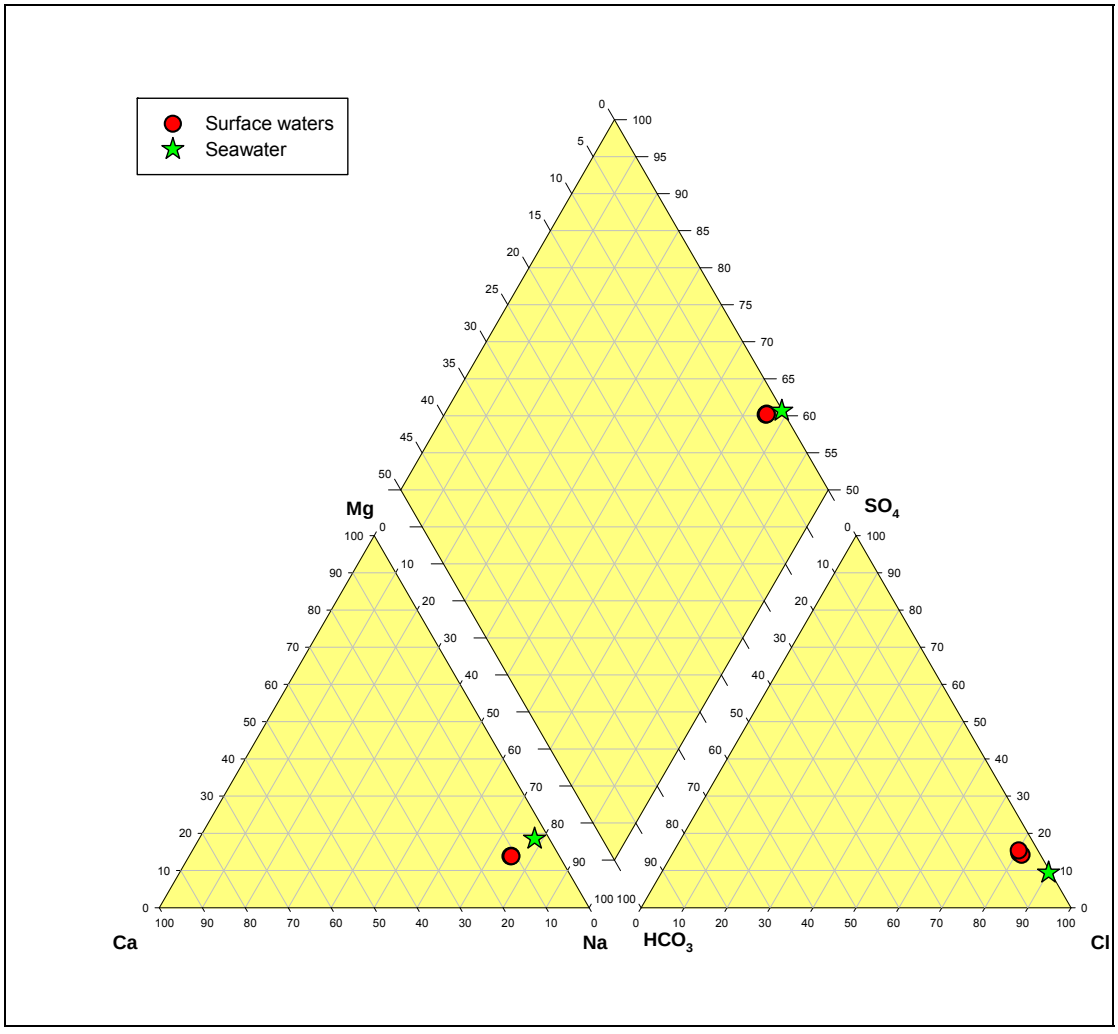


Figure 6-13. Piper diagram of hydrochemical data for Schillers Lagoon (Wetland ID. 12259).

6.4. Discussion

Acid sulfate soil materials at Schillers Lagoon (Wetland ID.12259) were identified as hyposulfidic in the surface layers, and the remaining samples were characterised as other soil materials. The acid sulfate soil subtype classes identified were Subaqueous Soil (clayey or loamy) that occurred throughout the wetland in areas below the water level, and above water they were identified as Other Soil (clayey or loamy).

The soils throughout the wetland below the water level were clays and loam textured in the surface layers and the soil became firm clays with depth. In areas above the water level on the wetland margin the soils were structured clays with a salt crust on the surface.

Monosulfidic material was not observed and water soluble sulfate data identified that surface layers for four of the eight profiles were in excess of the 100mg/L trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials at Schillers Lagoon (Wetland ID. 12259) are:

- Acidification hazard: The data identified negative net acidity values for generally all samples, and pH data did not indicate a potential acidification hazard due to oxidation. There is a low level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there is potential for monosulfidic materials to form in the surface layers of soils in some areas. 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 Schillers Lagoon (Wetland ID. 12259):

Soil materials:	The surface soil layers throughout the wetland were generally hyposulfidic for the surface layers and other soil materials for the subsoil layers. The surface layer textures were clayey or loamy and the subsoil layers were clayey. Generally all samples had negative net acidity values and pH data did not indicate a potential for acidification.
Acid sulfate soil identification:	• Subaqueous Soil (clayey or loamy) – occurring throughout the wetland below water. Dominant (>50%) in extent. • Other Soil (clayey or sandy) – occurring on the margins of the wetland above the water level. 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 6-2. Site description data for Schillers Lagoon (Wetland ID. 12259).

Site Number	Sample Date	Easting m Zone 54H	Northing m Zone 54H	Water depth (+ve) Water table (-ve)	Surface condition	Earth cover (vegetation)	Location Notes
1	25/03/2010	401099	6228007	60	water, soft	water, lignum	adjacent to bank
2	25/03/2010	401101	6228014	100	water	water	15m into water
3	25/03/2010	401978	6228097	-5	firm	lignum	shoreline
4	25/03/2010	401968	6228083	50	soft	water	30m from shoreline
5	25/03/2010	401966	6228075	90	firm	water	low elevation, 25m from shore
6	25/03/2010	402360	6227503	not reached	salt crust	samphire	high elevation, 20m above shoreline
7	25/03/2010	402342	6227500	2	algae mat	water	shoreline, mid
8	25/03/2010	402322	6227497	80	soft	water	30m from shore

Table 6-3. Soil profile description data for Schillers Lagoon (Wetland ID. 12259).

Site and Sample (number)	Depth Range (cm)	Observation Method (kind)	Soil Colour (name, Munsell notation)	Texture (Class)	Soil Water Status	Redoximorphic Features (%, colour, location)	Structure Type (category)	Consistence (category)	Comments
1_W	60 - 0	water							
1_1	0 - 5	small pit	grey (10YR5/1)	clay	wet		gel	very weak	
1_2	5 - 10	small pit	dark grey (5Y4/1)	clay	wet		angular blocky	firm	
1_3	10 - 20	small pit	dark grey (5Y4/1)	sandy clay loam	moist		massive	firm	
1_4	20 - 40	small pit	dark grey (5Y4/1)	sandy clay loam	moist		massive	very firm	
2_W1	100 - 0	surface water							water sampled
2_1	0 - 5	small pit	dark grey (10YR4/1)	clay	wet		gel	very weak	
2_2	5 - 10	small pit	dark grey (5Y4/1)	clay	wet		angular blocky	weak	
2_3	10 - 20	small pit	dark grey (5Y4/1)	sandy loam	moist		massive	firm	
2_4	20 - 40	small pit	olive grey (5Y4/2)	sandy clay loam	moist		massive	firm	
3_1	0 - 1	small pit	greyish brown (2.5Y5/2)	salt	moist		crystalline	firm	
3_2	1 - 10	small pit	greyish brown (2.5Y5/2)	loamy sand	moist		massive	firm	
3_3	10 - 20	small pit	grey (2.5Y5/1)	loamy sand	moist		massive	firm	
3_4	20 - 40	small pit	grey (10YR5/1)	loamy sand	moist		massive	firm	
3_5	40 - 90	push tube	grey (10YR5/1)	clay loam sandy	moist		massive	very firm	

Site and Sample (number)	Depth Range (cm)	Observation Method (kind)	Soil Colour (name, Munsell notation)	Texture (Class)	Soil Water Status	Redoximorphic Features (%, colour, location)	Structure Type (category)	Consistence (category)	Comments
4_W	50 - 0	water							
4_1	0 - 4	small pit	dark greyish brown (2.5Y4/3)	sandy loam	wet		massive	weak	
4_2	4 - 10	small pit	grey (5Y5/1)	sand	wet		massive	firm	
4_3	10 - 20	small pit	grey (5Y5/1)	sand	moist	3% yellowish brown In the matrix	massive	firm	carbonate nodules
4_4	20 - 40	small pit	grey (5Y5/1)	sandy clay loam	moist	2% In the matrix	massive	very firm	
5_W1	90 - 0	surface water							water sampled
5_1	0 - 2	small pit	dark greyish brown (10YR4/2)	sandy clay loam	wet		massive	weak	many plant roots
5_2	2 - 10	small pit	greyish brown (2.5Y5/3)	sandy clay loam	wet		massive	weak	
5_3	10 - 20	small pit	olive grey (5Y5/2)	sandy clay loam	wet	5% yellowish brown In the matrix	massive	firm	
5_4	20 - 40	small pit	olive grey (5Y5/2)	sandy clay loam	moist	3% yellowish brown In the matrix	massive	very firm	
6_1	0 - 1	small pit	light grey (10YR7/1)	salt	dry		crystalline	weak	
6_2	1 - 10	small pit	very dark grey (10YR3/1)	clay	moist		angular blocky	firm	
6_3	10 - 20	small pit	black (10YR2/1)	clay	moist		angular blocky	firm	
6_4	20 - 40	small pit	black (10YR2/1)	clay	moist		massive	firm	
6_5	40 - 70	small pit	grey (10YR5/1)	clay	moist		massive	very firm	
7_W	60 - 0	water							
7_1	0 - 2	small pit	olive brown (2.5Y2/6)	clay	moist		massive	firm	sulfidic?
7_2	2 - 10	small pit	grey (5Y5/1)	clay	moist		massive	firm	
7_3	10 - 20	small pit	grey (5Y5/1)	clay	moist		massive	very firm	
7_4	20 - 40	small pit	grey (5Y5/1)	clay	moist		massive	very firm	
8_W1	80 - 0	surface water							water sampled
8_1	0 - 5	small pit	greyish brown (2.5Y5/2)	clay	wet		massive	very weak	the upper part is a very thin 5mm brown surface layer
8_2	5 - 10	small pit	olive grey (5Y5/2)	clay	moist		massive	weak	
8_3	10 - 20	small pit	olive grey (5Y5/2)	gritty clay	moist		massive	ridged	

Table 6-4. Laboratory data for acid sulfate soil assessment of Schillers Lagoon (Wetland ID. 12259).

(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 week 0	pH incubation week 8	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H+/ tonne)	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+ /tonne)	Acid Sulfate Soil Material Classification
1.W1	60-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
1.1	0-5	Fine	419	7.36	3.81	6.88	5.86	26	6.36	1.41	0.03	..	0.00	20	hyposulfidic (S_{CR}<0.10%)
1.2	5-10	Fine	366	7.10	4.29	6.75	5.97	32	6.31	4.23	0.03	..	0.00	21	hyposulfidic (S_{CR}<0.10%)
1.3	10-20	Fine	301	7.01	4.54	6.59	6.30	27	6.15	4.23	<0.01	..	0.00	4	other soil material
1.4	20-40	Fine	415	6.77	6.28	6.52	6.54	26	6.24	3.76	<0.01	..	0.00	4	other soil material
2.W1	100-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
2.1	0-5	Fine	559	8.06	6.53	7.12	6.73	81	6.80	0.00	0.03	..	0.30	-18	hyposulfidic (S_{CR}<0.10%)
2.2	5-10	Fine	410	7.56	7.28	7.01	7.08	35	6.48	1.41	<0.01	..	0.00	1	other soil material
2.3	10-20	Fine	477	7.67	7.62	6.93	6.92	36	6.45	0.94	<0.01	..	0.00	1	other soil material
2.4	20-40	Fine	646	8.03	7.37	7.86	8.11	43	6.86	0.00	<0.01	..	0.71	-95	other soil material
3.1	0-1		4,820	8.56	7.23	8.37	8.64	570	..	..	..	..	..	..	salt crust
3.2	1-10	Medium	877	8.50	7.46	8.40	8.71	190	8.33	0.00	<0.01	..	0.27	-36	other soil material
3.3	10-20	Medium	1,591	8.54	7.25	8.22	8.40	82	8.65	0.00	<0.01	..	0.43	-57	other soil material
3.4	20-40	Fine	2,520	8.28	8.97	8.19	8.39	170	7.82	0.00	<0.01	..	0.52	-69	other soil material
3.5	40-90	Fine	2,550	8.52	8.60	8.18	8.62	240	8.34	0.00	<0.01	..	1.18	-157	other soil material
4.W1	50-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
4.1	0-4	Medium	415	7.96	6.10	7.31	7.39	29	8.65	0.00	0.02	..	0.58	-63	hyposulfidic (S_{CR}<0.10%)
4.2	4-10	Fine	7	8.57	8.01	7.57	8.49	30	8.05	0.00	<0.01	..	0.58	-77	other soil material
4.3	10-20	Fine	686	8.30	8.67	7.88	8.77	40	7.90	0.00	<0.01	..	0.56	-75	other soil material
4.4	20-40	Fine	718	8.76	7.90	8.15	9.15	28	8.77	0.00	<0.01	..	1.74	-231	other soil material
5.W1	90-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
5.1	0-2	Medium	431	8.31	4.77	7.19	6.05	77	8.36	0.00	0.04	..	0.40	-29	hyposulfidic (S_{CR}<0.10%)
5.2	2-10	Medium	562	8.80	7.50	7.45	7.98	26	9.16	0.00	<0.01	..	0.39	-51	other soil material
5.3	10-20	Medium	974	8.21	7.90	8.07	8.51	40	8.10	0.00	<0.01	..	0.14	-19	other soil material
5.4	20-40	Fine	1,089	8.12	8.09	7.96	8.36	45	6.15	3.29	<0.01	..	0.00	3	other soil material
6.1	0-1	Fine	27,100	6.20	4.47	5.77	5.98	880	6.38	4.23	<0.01	..	0.00	4	other soil material
6.2	1-10	Fine	6,550	5.88	4.40	5.67	5.64	1,400	6.56	0.00	<0.01	..	0.27	-35	other soil material
6.3	10-20	Fine	8,870	6.51	6.88	6.35	6.24	1,100	6.49	1.88	<0.01	..	0.00	2	other soil material
6.4	20-40	Fine	7,560	6.87	6.85	6.70	6.68	710	6.44	3.76	<0.01	..	0.00	4	other soil material
6.5	40-70	Fine	6,540	7.47	7.16	7.17	7.25	600	6.72	0.00	<0.01	..	0.93	-124	other soil material

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation week 0	pH incubation week 8	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H+/ tonne)	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+ /tonne)	Acid Sulfate Soil Material Classification
7.1	0-2	Fine	810	7.20	4.74	6.57	6.61	58	6.61	0.00	0.02	..	0.26	-20	hyposulfidic (S_{CR}<0.10%)
7.2	2-10	Fine	868	7.70	7.61	7.30	7.68	190	6.59	0.00	<0.01	..	0.50	-66	other soil material
7.3	10-20	Fine	2,098	7.15	7.98	7.37	7.67	380	6.48	1.41	0.01	..	0.00	9	hyposulfidic (S_{CR}<0.10%)
7.4	20-40	Fine	2,760	7.86	8.04	7.78	7.97	550	6.64	0.00	<0.01	..	0.96	-124	other soil material
7.W1	-	..	..	..	..	..	..	..	..	..	..	..	..	..	pit water
8.W1	80-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
8.1	0-5	Fine	616	8.97	8.65	7.56	8.10	45	7.88	0.00	<0.01	..	0.78	-104	other soil material
8.2	5-10	Fine	708	8.55	8.73	7.45	8.16	120	7.68	0.00	<0.01	..	5.76	-767	other soil material
8.3	10-20	Fine	1,001	8.64	8.69	7.56	8.16	100	7.91	0.00	<0.01	..	6.72	-895	other soil material

Table 6-5. Summary of hydrochemical field measurements for Schillers Lagoon Wetland.

	pH	SEC	DO	Eh	Turbidity	Alkalinity
		µS cm^{-1}	mg l^{-1}	mV	NTU	as HCO_3
Surface waters (n=3)	7.39-8.22	3628-3792	6.14-10.67	114-250	6-12	94-109

Table 6-6. Hydrochemical data for Schillers Lagoon (Wetland ID. 12259).

Parameter	units	ANZECC Guidelines	Site 2 (SW)	Site 5 (SW)	Site 8 (SW)
Na	mg l^{-1}		613	601	609
K	mg l^{-1}		4.8	4.6	4.6
Ca	mg l^{-1}		81.6	78.5	79.5
Mg	mg l^{-1}		60.1	59.4	59.6
Si	mg l^{-1}		1.42	1.13	1.51
Br	mg l^{-1}		2.1	2.0	2.1
Cl	mg l^{-1}		1100	1100	1000
NO_3	mg l^{-1}	0.7	<0.022	<0.022	<0.022
NH_4-N^K	mg l^{-1}	0.01	**0.014**	**0.019**	**0.013**
PO_4^E	mg l^{-1}	0.02	**0.141**	**0.138**	**0.117**
SO_4	mg l^{-1}		270	260	260
Ag	µg l^{-1}	0.05	<0.02	<0.02	<0.02
Al^A	µg l^{-1}	55	<50	<50	<50
As^B	µg l^{-1}	13	4	4	4
Cd	µg l^{-1}	0.2	<0.05	<0.05	<0.05
Co	µg l^{-1}	2.8	0.36	0.36	0.28
Cr^C	µg l^{-1}	1	<0.3	<0.3	<0.3
Cu^H	µg l^{-1}	1.4	<1	<1	<1
Fe	µg l^{-1}	300	<500	<500	<500
Mn	µg l^{-1}	1700	267.5	290.6	129.4
Ni^H	µg l^{-1}	11	1.0	1.0	1.0
Pb^H	µg l^{-1}	3.4	<0.5	<0.5	<0.5
Se	µg l^{-1}	11	<0.4	<0.4	<0.4
Zn^H	µg l^{-1}	8	**25**	**19**	**17**
DOC	mg l^{-1}		9.1	9.0	8.8

Notes.

The ANZECC guideline values for toxicants refer to the trigger values applicable to 'slightly-moderately disturbed' freshwater systems, as outlined in the Australian Water Quality Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000). For the nutrients NH_4 and PO_4, trigger values are provided for Freshwater Lakes and reservoirs. Surface water values outside the ranges defined in the ANZECC guidelines are indicated with red text. (SW) and (PW) indicate whether the sample was taken from surface water or pit-water (groundwater that entered an excavated pit), respectively.

A *Trigger value for Aluminium in freshwater where pH > 6.5.*

B *Trigger value assumes As in solution as Arsenic (AsV).*

C *Trigger value for Chromium is applicable to Chromium (CrVI) only.*

E *Guideline is for filterable reactive phosphorous (FRP).*

H *Hardness affected (refer to Guidelines).*

K *Guideline for South-east Australia-Freshwater Lakes and reservoirs.*

7. SCHILLERS LAGOON (WETLAND ID. 12266)

7.1. Location and setting description

Schillers Lagoon (Wetland ID. 12266) is situated on the southern side of the River Murray about 20 kilometres down river from Waikerie and about 1.5 kilometres down river from Lock 2 at Taylorville. The wetland is a creek that is linear in shape and occurs on the inside of a bend in the river. It is about 1 kilometre in length and about 30 to 100 metres wide, with a total surface area of 4 hectares. The wetland is bounded to the north by a raised floodplain that separates the wetland from the river and to the south there is a hillside. The wetland occurs in a complex with wetland ID 12259.

The wetland is connected to the river at the northwest end by an inlet and at the south east end to Schillers Lagoon (Wetland ID. 12259). At the time when the soil survey was conducted in March 2010 the wetland contained surface water. The wetland is managed by landholders with assistance from the South Australian Murray-Darling Basin Natural Resources Management Board (SA MDB NRM Board) and RWLAP. It was closed in October 2006, opened in March 2009, closed in September 2009, opened in February 2010. Sedgeland was growing along the wetland margins, with open woodland and shrubland on the surrounding higher floodplain. Two sites were sampled as shown in Figure 7-1.

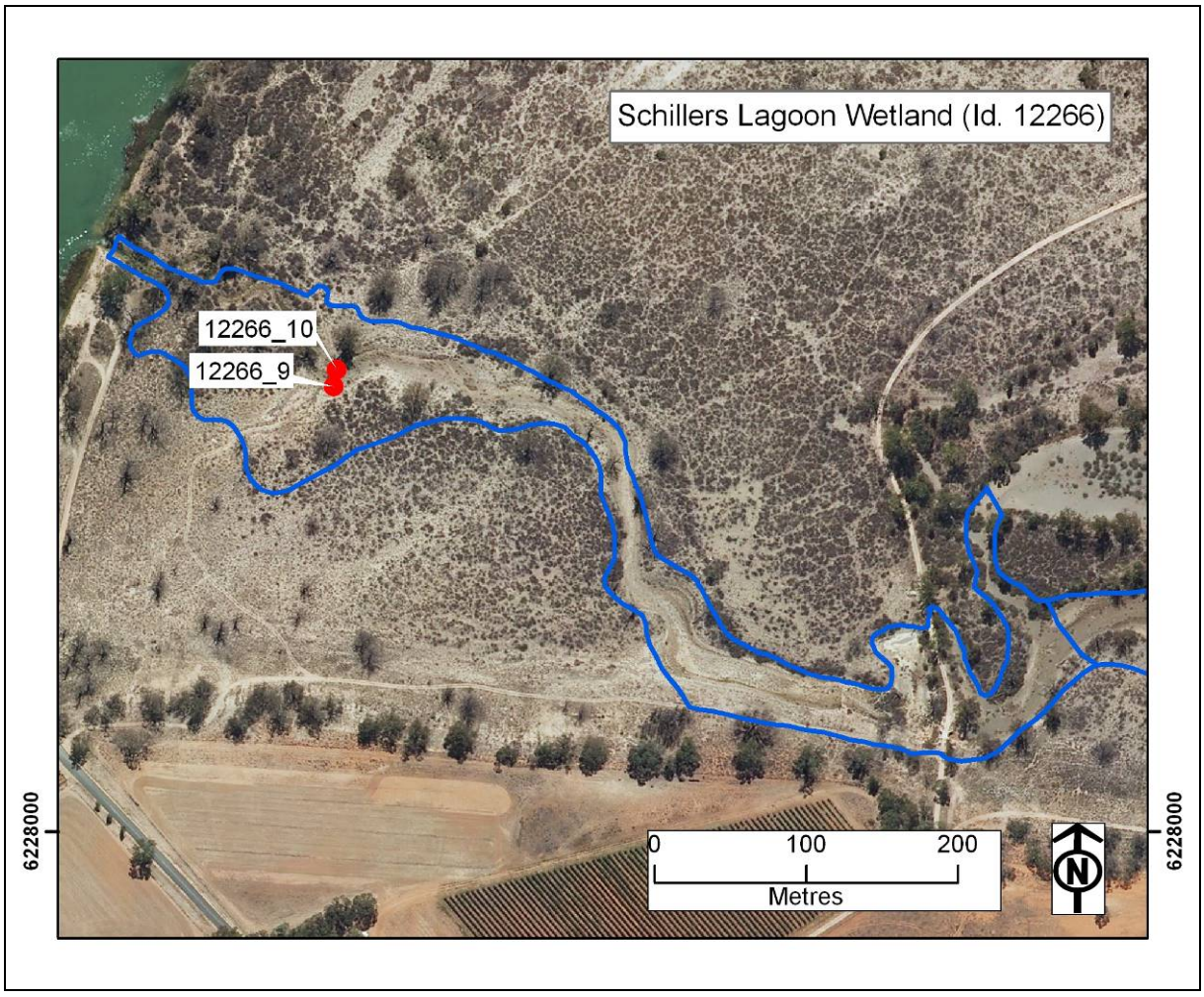


Figure 7-1. Schillers Lagoon (Wetland ID. 12266) and sample site locations.

7.2. Soil profile description and distribution

Two sites were described and sampled. . The soil subtypes and general location descriptions are presented in Table 7-1. Sites were distributed from the wetland margin into the creek water along one transect (Sites 1 and 2). The site and soil profile descriptions are presented in Table 7-2 and Table 7-3. A conceptual cross section is not presented as there was insufficient data to generate the figure.

Site 1 (Figure 7-2) occurred adjacent to the bank in water (2 cm deep), and the soil consisted of a dark greyish brown, firm, clay, over a dark grey, very firm, clay. Site 2 (Figure 7-3) occurred in open water (80 cm deep), and the soil consisted of a dark grey, very weak clay at the surface, to very firm, clay subsoil.

Table 7-1. Soil identification, subtype and general location description for Schillers Lagoon (Wetland ID. 12266).

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12266_9	400208	6228293	Subaqueous Soil (clayey)	on the side of creek
12266_10	400210	6228304	Subaqueous Soil (clayey)	in water, mid creek

Figure 7-2: Photograph of Site 9, showing the site location on the wetland margin above water.

Figure 7-3. Photograph of Site 10, showing the site location in water adjacent to the reeds.

7.3. Laboratory data assessment

7.3.1. Soil pH testing (pH_W, pH_{OX}, $pH_{incubation}$)

The pH data are provided in Table 7-4 and pH profiles are presented in Figure 7-4. The pH_W data ranged from 6.33 to 8.30 and sulfuric materials with a pH_W <4 were not identified. The pH_{OX} data ranged from 4.30 to 7.03 and identified that no sample declined below the critical value of pH_{OX} <2.5. The $pH_{incubation}$ data ranged from 5.98 to 7.71 and identified that no soil samples on incubation declined below the critical values of pH <4.

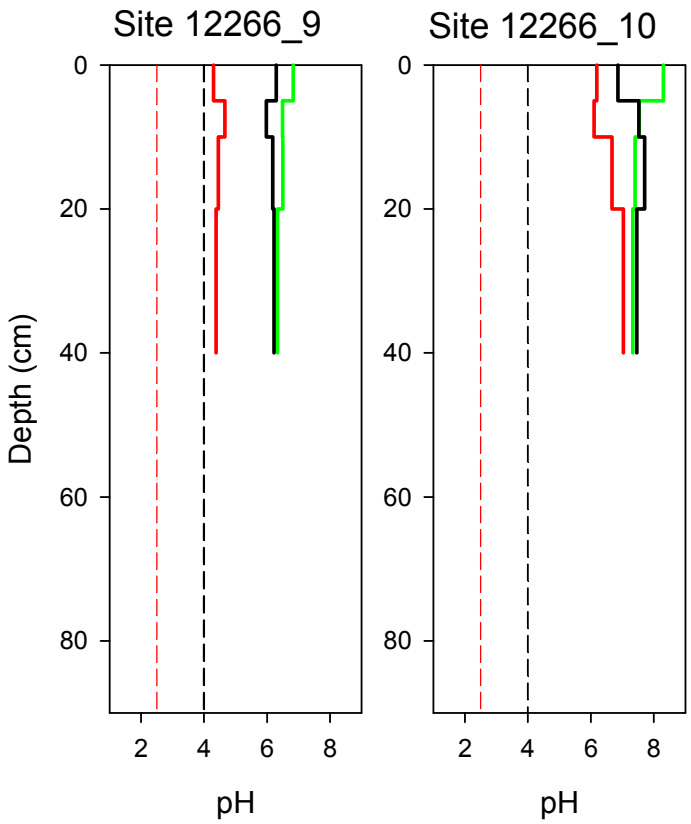


Figure 7-4. Depth profiles of soil pH for Schillers Lagoon (Wetland ID. 12266), showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and incubation pH (pH_{INC} after 8 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

7.3.2. Acid base accounting

The acid base accounting data is provided in Table 7-4 and summarised in Figure 7-5.

Chromium reducible sulfur

Chromium reducible sulfur values ranged from 0 to 0.15 $\%S_{CR}$ and sulfidic materials were detected in the upper soil layers and not detected in the lowest subsoil layers.

Titratable actual acidity

Titratable actual acidity values ranged from 0 to 13.15 mole H^+/tonne.

Retained acidity

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

Acid neutralising capacity

Acid neutralising capacity values ranged from 0 to 2.87 $\%CaCO_3$ and positive values were measured in the surface layers and all layers of Profile 10.

Net acidity

Net acidity values ranged from -292 to 13 mole H^+/tonne. Sample values were generally negative with low positive values measured in the subsoil of Profile 10.

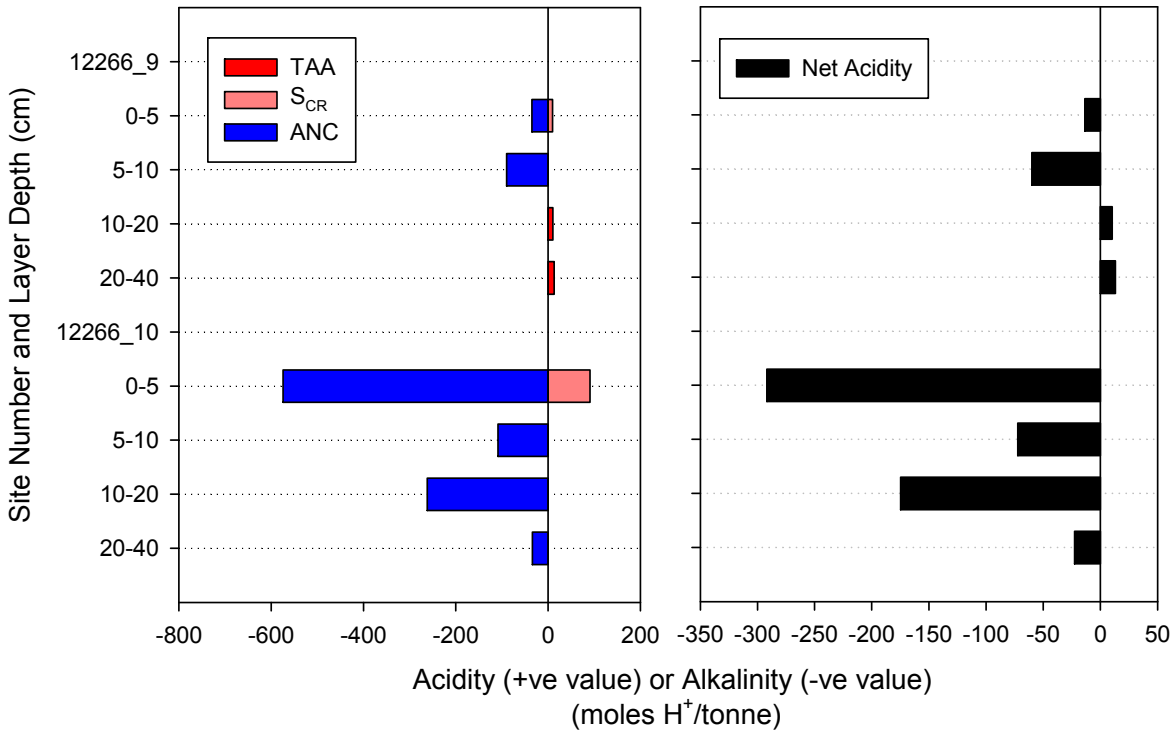


Figure 7-5. Acid base accounting depth profiles for Schillers Lagoon (Wetland ID. 12266). Left side shows the components: Titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

7.3.3. Water soluble sulfate

Water soluble sulfate data values shown in Table 7-4 identified that surface layers were not above the criterion trigger value of 100 mg/kg SO_4.

7.3.4. Acid volatile sulfur

Monosulfidic materials were not observed and samples were not collected for analysis.

7.3.5. Hydrochemistry

One surface water sample was collected from the wetland and no pit water samples were taken as the marginal areas were submerged. Field parameters are shown in Table 7-5. The waters had neutral pH and were moderately saline. Dissolved oxygen was present and the surface water had low turbidity. Alkalinity was slightly higher than expected for the river along this section of the catchment.

The surface water was of Na-Cl type, with relative proportions of major elements close to seawater (Table 7-6, Figure 7-6). Sulfate concentrations in the surface water were high at 490 mg l^{-1}. The SO_4/Cl ratio in the surface water (0.27) was higher than seawater (0.142). For the nutrients, PO_4 concentrations were significantly above ANZECC Guideline values. Zinc was slightly higher than ANZECC Guideline values, with most other metals being low.

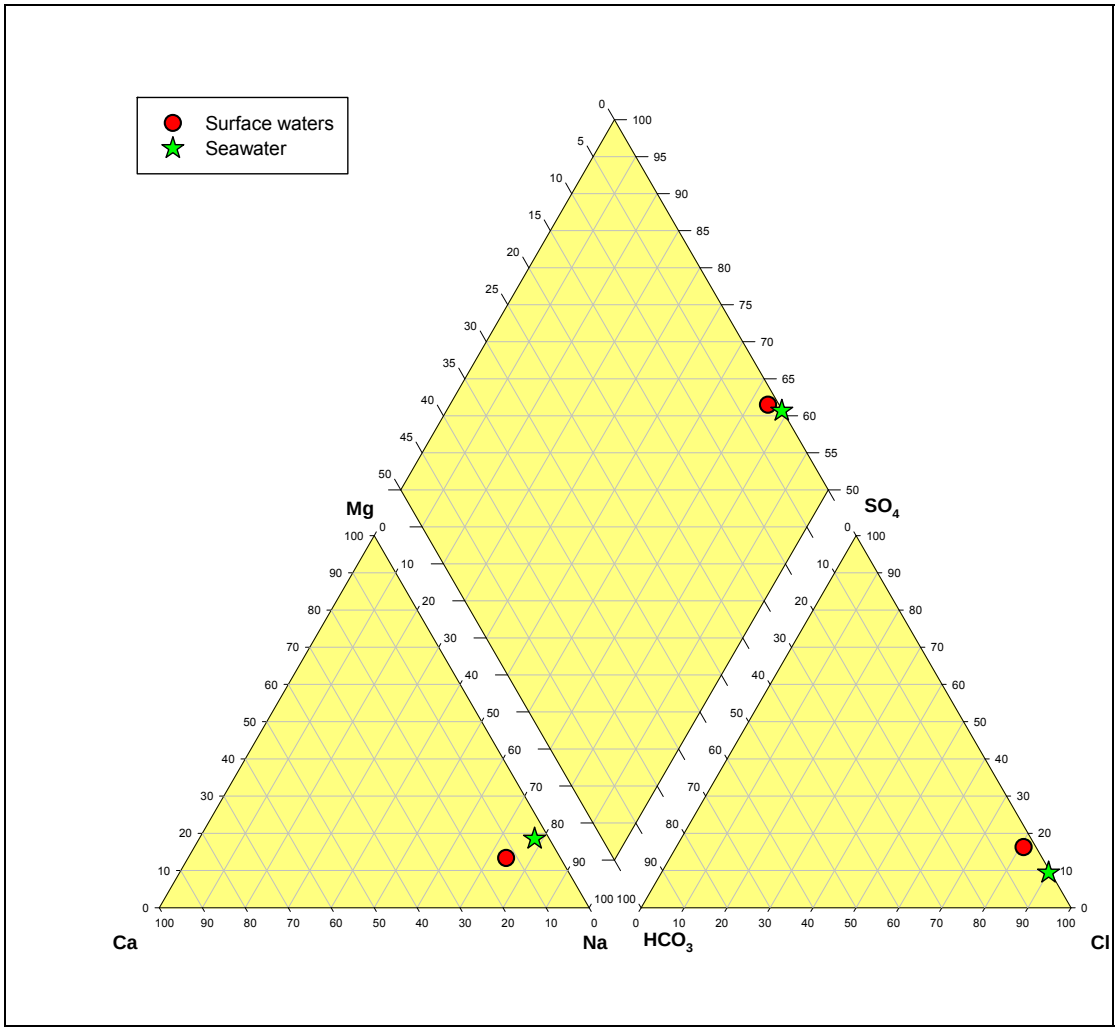


Figure 7-6. Piper diagram of hydrochemical data for Schillers Lagoon (Wetland ID. 12266).

7.4. Discussion

Acid sulfate soil materials at Schillers Lagoon (Wetland ID. 12266) were generally identified as hyposulfidic. The acid sulfate soil subtype class identified was Subaqueous Soil (clayey) that occurred throughout the wetland in areas below the water level while Other Soils (clayey) were identified on wetland margins.

The soils throughout the wetland below the water level were firm, clays.

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

The potential hazards posed by acid sulfate soil materials at Schillers Lagoon (Wetland ID. 12266) are:

- Acidification hazard: The data identified negative net acidity values for nearly all samples and pH data did not indicate a potential acidification hazard due to oxidation. There is a low to medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there is no potential for monosulfidic materials to form in the surface layers of soils. There is a low 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 Schillers Lagoon (Wetland ID. 12266):

Soil materials:	The surface and subsoil layers throughout the wetland were generally hyposulfidic. Soils were clayey textured throughout the wetland. Soil samples generally had negative net acidity values and pH data did not indicate a potential for acidification due to oxidation.
Acid sulfate soil identification:	• Subaqueous Soil (clayey) – occurring throughout the wetland below water. Dominant (>50%) in extent.
Hazard assessment	• Acidification hazard – low to medium level of concern • De-oxygenation hazard – low level of concern • Metal mobilisation hazard – low level of concern

Table 7-2. Site description data for Schillers Lagoon (Wetland ID. 12266).

Site Number	Sample Date	Easting m Zone 54H	Northing m Zone 54H	Water depth (+ve) Water table (-ve)	Surface condition	Earth cover (vegetation)	Location Notes
9	25/03/2010	400208	6228293	2	soft	water	in water on the side of creek
10	25/03/2010	400210	6228304	80	soft	water	in water, mid creek

Table 7-3. Soil profile description data for Schillers Lagoon (Wetland ID. 12266).

Site and Sample (number)	Depth Range (cm)	Observation Method (kind)	Soil Colour (name, Munsell notation)	Texture (Class)	Soil Water Status	Redoximorphic Features (%, colour, location)	Structure Type (category)	Consistence (category)	Comments
9_W	80 - 0	water							
9_1	0 - 5	small pit	dark greyish brown (10YR4/2)	clay	wet		massive	firm	thin brown gel on surface
9_2	5 - 10	small pit	dark greyish brown (10YR4/2)	clay	wet		massive	firm	
9_3	10 - 20	small pit	dark grey (10YR4/1)	clay	moist		massive	very firm	
9_4	20 - 40	small pit	dark grey (10YR4/1)	clay	moist		massive	very firm	
10_W1	80 - 0	surface water							water sampled
10_1	0 - 5	small pit	dark grey (5Y4/1)	clay	wet		massive	very weak	
10_2	5 - 10	small pit	dark grey (5Y4/1)	clay	wet		massive	weak	
10_3	10 - 20	small pit	dark grey (5Y4/1)	clay	moist		massive	firm	
10_4	20 - 40	small pit	dark grey (5Y4/1)	clay	moist		massive	very firm	

Table 7-4. Laboratory data for acid sulfate soil assessment of Schillers Lagoon (Wetland ID. 12266).

(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 week 0	pH incubation week 8	Sulfate (mg SO_4/kg)	pH KCl	Total Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H+/ tonne)	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+ /tonne)	Acid Sulfate Soil Material Classification
9.1	0-5	Fine	796	6.83	4.30	6.41	6.29	49	7.14	0.00	0.02	..	0.18	-14	hyposulfidic (S_{CR}<0.10%)
9.2	5-10	Fine	622	6.49	4.66	6.05	5.98	52	6.76	0.00	<0.01	..	0.45	-60	other soil material
9.3	10-20	Fine	576	6.50	4.45	5.93	6.18	53	6.36	10.33	<0.01	..	0.00	10	other soil material
9.4	20-40	Fine	519	6.33	4.38	5.89	6.22	45	6.20	13.15	<0.01	..	0.00	13	other soil material
9.W1	-	..	..	..	..	..	..	..	..	..	..	..	..	..	pit water
10.W1	80-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
10.1	0-5	Fine	884	8.30	6.19	6.90	6.86	100	7.29	0.00	0.15	..	2.87	-292	hyposulfidic (S_{CR}≥0.10%)
10.2	5-10	Fine	575	7.53	6.10	7.14	7.52	35	7.11	0.00	<0.01	..	0.54	-72	other soil material
10.3	10-20	Fine	765	7.40	6.67	6.82	7.71	58	7.61	0.00	<0.01	..	1.31	-175	other soil material
10.4	20-40	Fine	587	7.33	7.03	6.81	7.46	50	7.17	0.00	<0.01	..	0.17	-23	other soil material

Table 7-5. Summary of hydrochemical field measurements for Schillers Lagoon Wetland.

	pH	SEC	DO	Eh	Turbidity	Alkalinity
		µS cm^{-1}	mg l^{-1}	mV	NTU	as HCO_3
Surface waters (n=1)	7.19	6082	5.30	233	4.8	107

Table 7-6. Hydrochemical data for Schillers Lagoon (Wetland ID. 12266).

Parameter	units	ANZECC Guidelines	Site 10 (SW)
Na	mg l^{-1}		1030
K	mg l^{-1}		7.0
Ca	mg l^{-1}		154
Mg	mg l^{-1}		98.7
Si	mg l^{-1}		0.557
Br	mg l^{-1}		3.6
Cl	mg l^{-1}		1800
NO_3	mg l^{-1}	0.7	<0.022
NH_4-N^K	mg l^{-1}	0.01	**0.021**
PO_4^E	mg l^{-1}	0.02	**0.230**
SO_4	mg l^{-1}		490
Ag	µg l^{-1}	0.05	<0.04
Al^A	µg l^{-1}	55	<100
As^B	µg l^{-1}	13	2
Cd	µg l^{-1}	0.2	<0.1
Co	µg l^{-1}	2.8	0.72
Cr^C	µg l^{-1}	1	<0.5
Cu^H	µg l^{-1}	1.4	<2
Fe	µg l^{-1}	300	<1000
Mn	µg l^{-1}	1700	122
Ni^H	µg l^{-1}	11	1.0
Pb^H	µg l^{-1}	3.4	<1
Se	µg l^{-1}	11	<0.8
Zn^H	µg l^{-1}	8	**30**
DOC	mg l^{-1}		16.9

Notes.

The ANZECC guideline values for toxicants refer to the trigger values applicable to 'slightly-moderately disturbed' freshwater systems, as outlined in the Australian Water Quality Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000). For the nutrients NH_4 and PO_4, trigger values are provided for Freshwater Lakes and reservoirs. Surface water values outside the ranges defined in the ANZECC guidelines are indicated with red text. (SW) and (PW) indicate whether the sample was taken from surface water or pit-water (groundwater that entered an excavated pit), respectively.

A *Trigger value for Aluminium in freshwater where pH > 6.5.*

B *Trigger value assumes As in solution as Arsenic (AsV).*

C *Trigger value for Chromium is applicable to Chromium (CrVI) only.*

E *Guideline is for filterable reactive phosphorous (FRP).*

H *Hardness affected (refer to Guidelines).*

K *Guideline for South-east Australia-Freshwater Lakes and reservoirs.*

8. BOGGY FLAT (WETLAND ID. 12291)

8.1. Location and setting description

Boggy Flat (Wetland ID. 12291) is situated on the northern side of the River Murray, about 1.5 kilometres up river from Lock 1 and near Taylorville. The wetland is irregular in shape forming part of a wetland complex that occurs on the inside of a small bend in the river. It is about 500 metres in length and about 150 metres at its widest, with a total surface area of 10 hectares. The wetland is bounded to the south by raised floodplain that separates the wetland from the river and to the north steep hill slopes. The other associated wetland in the Boggy Flat complex that was surveyed is Wetland ID. 12292.

The wetland is permanently connected to the river at the western end of the wetland, and at the eastern end by a man-made creek to the temporary wetland ID. 12292. At the time when the soil survey was conducted in May 2010 the wetland had surface water, and was probably last dry in the 1920's before the locks were installed. The wetland is not managed. Sedgeland and grassland were growing along the wetland margins, with open woodland and shrubland on the surrounding higher floodplain. Four sites were sampled as shown in Figure 8-1.

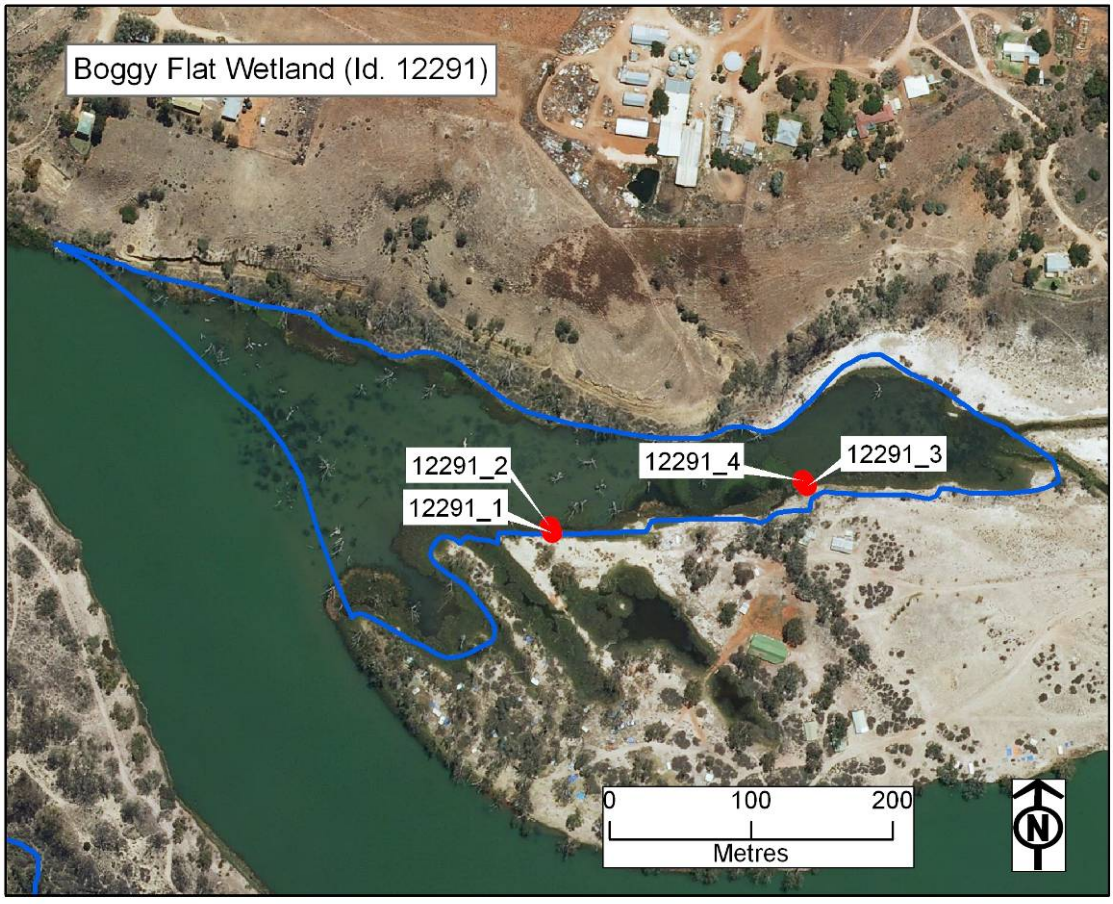


Figure 8-1. Boggy Flat (Wetland ID. 12291) and sample site locations.

8.2. Soil profile description and distribution

Four sites were described and sampled. The soil subtypes and general location descriptions are presented in Table 8-1. Sites were distributed as two transect each with one site adjacent to the bank and the other as far as possible into open water, with transects at the western end (Sites 1 and 2) and eastern end (Sites 3 and 4) of the wetland. The site and soil profile descriptions are presented in Table 8-2 and Table 8-3, and a conceptual cross-section in Figure 8-2.

Western transect

Site 1 (Figure 8-3) occurred on the wetland margin adjacent to the bank in water (30 cm deep), and the soil consisted of a very dark grey, very weak, root material and sandy clay loam, over a dark grey, very firm clay. Site 2 (Figure 8-4) occurred in open water (80 cm deep), and the soil consisted of a dark grey, very weak, mucky sandy clay loam, over a dark grey, firm, clay.

Eastern transect

Site 3 (Figure 8-5) occurred adjacent to the bank in water (35 cm deep), and the soil consisted of a dark grey, very weak, mucky clay, over a dark grey, firm, clay. Site 4 (Figure 8-6) occurred in open water (100 cm deep), and the soil consisted of an olive grey, very weak, mucky clay, over an olive grey, weak, clay.

Table 8-1. Soil identification, subtype and general location description for Boggy Flat (Wetland ID. 12291).

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12291_1	402399	6228276	Subaqueous Soil (clayey)	in water adjacent to bank and in reeds
12291_2	402397	6228280	Hypersulfidic Subaqueous Soil (clayey)	open water 3m from reeds
12291_3	402579	6228309	Subaqueous Soil (clayey)	in water adjacent to bank and in reeds
12291_4	402576	6228313	Hypersulfidic Subaqueous Soil (clayey)	open water, edge of reeds

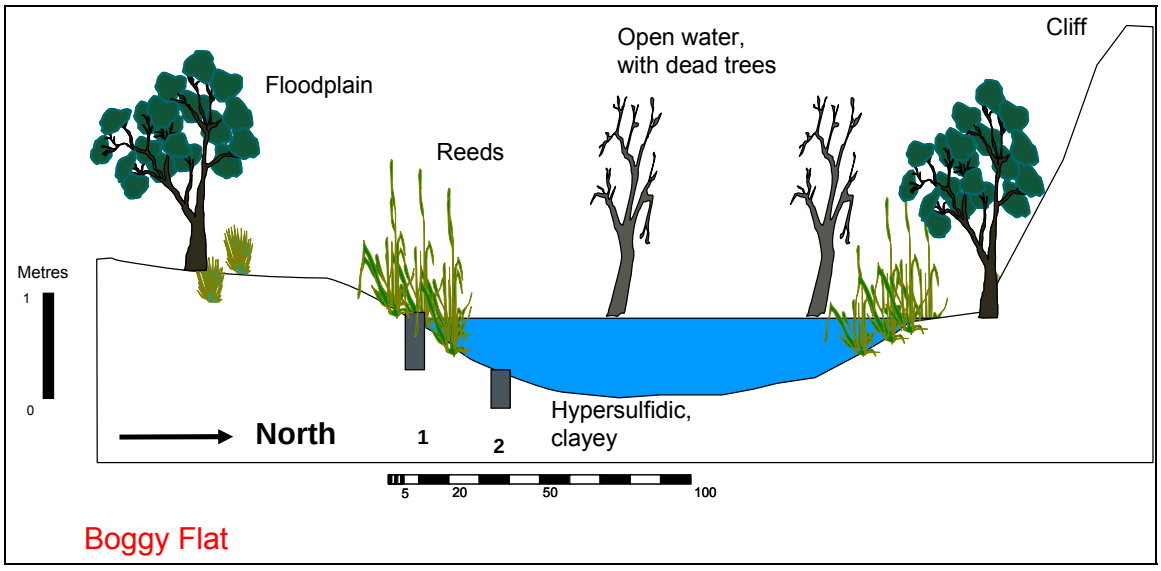


Figure 8-2. Conceptual cross-section diagram, showing locations of Sites 1 and 2.

Figure 8-3. Photograph of Site 1, showing the site location on the wetland margin adjacent to bank and in Phragmites.

Figure 8-4. Photograph of Site 2, showing the site location in open water.

Figure 8-5. Photograph of Site 3, showing the site location adjacent to bank amongst thick Phragmites.

Figure 8-6. Photograph of Site 4, showing the site location on the open water side of the reeds.

8.3. Laboratory data assessment

8.3.1. Soil pH testing (pH_W, pH_{OX}, $pH_{incubation}$)

The pH data are provided in Table 8-4 and pH profiles are presented in Figure 8-7. The pH_W data ranged from 6.21 to 7.72 and sulfuric materials with a pH_W <4 were not identified. The pH_{OX} data ranged from 1.61 to 7.59 and identified that samples in the surface layers of most profiles were below the critical value of pH_{OX} <2.5. The $pH_{incubation}$ data ranged from 3.21 to 6.93 and identified samples in Profiles 2 and 4 that on incubation declined below the critical values of pH <4.

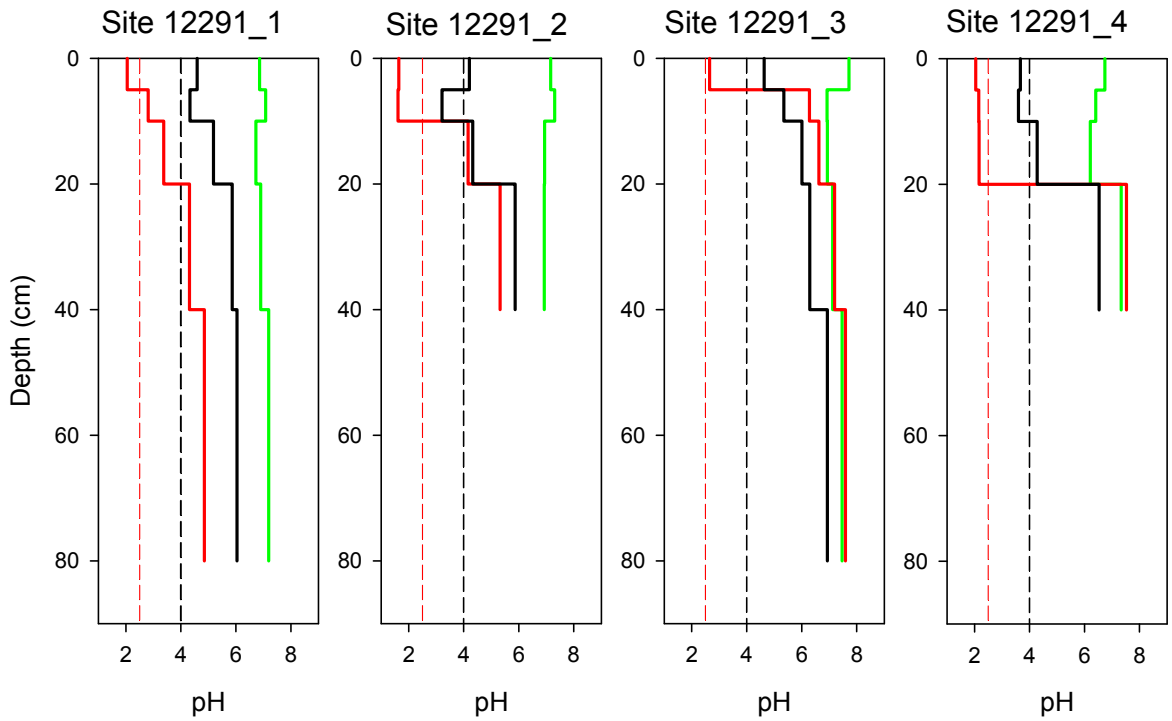


Figure 8-7. Depth profiles of soil pH for Boggy Flat (Wetland ID. 12291), showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and incubation pH (pH_{INC} after 8 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

8.3.2. Acid base accounting

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

Chromium reducible sulfur

Chromium reducible sulfur values ranged from 0.0 to 0.30 $\%S_{CR}$. and sulfidic materials were detected in all soil profiles.

Titratable actual acidity

Titratable actual acidity values ranged from 1.51 to 20.57 mole H^+/tonne and were detected in all samples.

Retained acidity

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

Acid neutralising capacity

Acid neutralising capacity values ranged from 0.0 to 1.15 $\%CaCO_3$ and were measured in some samples.

Net acidity

Net acidity values ranged from 10 to 199 mole H^+/tonne. High values occurred in the upper layers of Profile 3 and 4, moderate values generally occurred in the remaining samples with a low value for the subsoil layer of Profile 4.

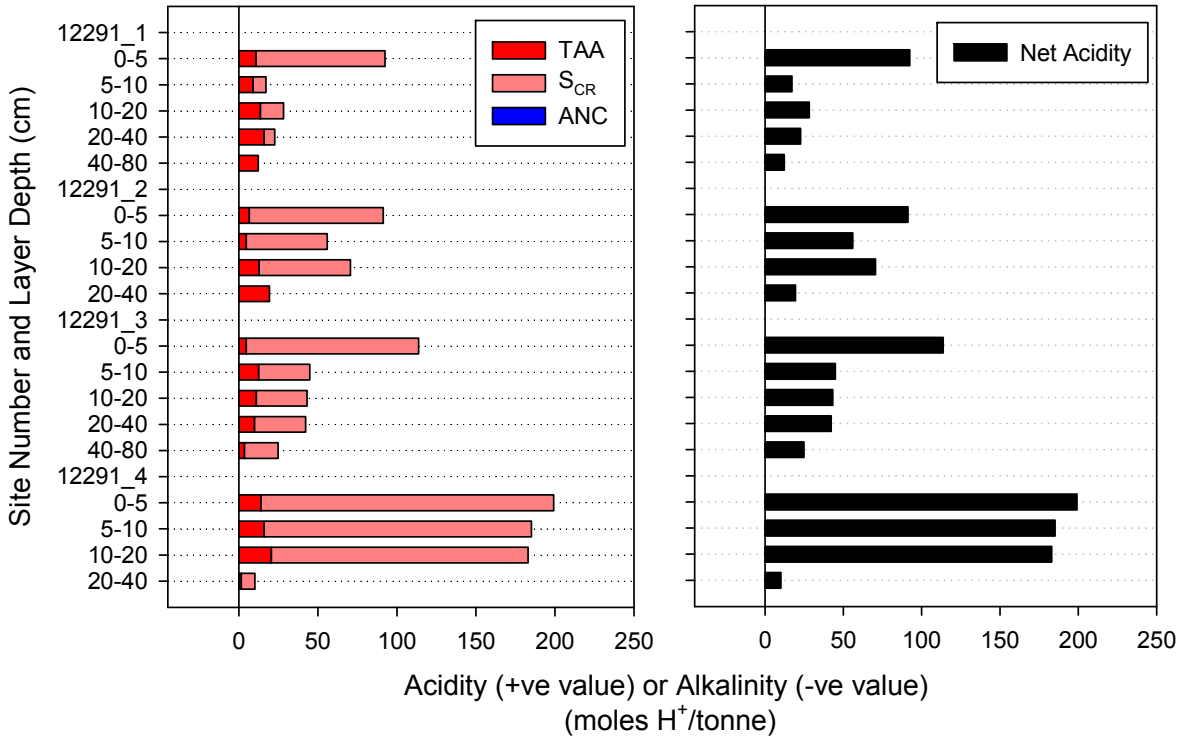


Figure 8-8. Acid base accounting depth profiles for Boggy Flat (Wetland ID. 12291). Left side shows the components: Titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

8.3.3. Water soluble sulfate

Water soluble sulfate data values shown in Table 8-4 identified that surface layers for Profiles 1, 2 and 3 were above the criterion trigger value of 100 mg/kg SO_4.

8.3.4. Acid volatile sulfur

Monosulfidic materials were not observed and no samples were collected for analysis.

8.3.5. Hydrochemistry

One surface water was collected from the wetland. Field parameters are shown in Table 8-5. The water had circumneutral pH and was relatively fresh. Dissolved oxygen was present and the waters had moderately high turbidity. Alkalinity was in the range of expected values for river water.

The surface water was of Na-Cl type, with higher relative HCO_3 compared to seawater (Table 8-6, Figure 8-9). Sulfate concentration in the surface waters was 16 mg l^{-1}. The SO_4/Cl ratio in the surface water (0.198) was slightly higher than seawater (0.142). For the nutrients, NH_4 and PO_4 concentrations were slightly elevated. For the trace metals, Zn was relatively high and the high Al may due to colloidal material as the waters were relatively turbid.

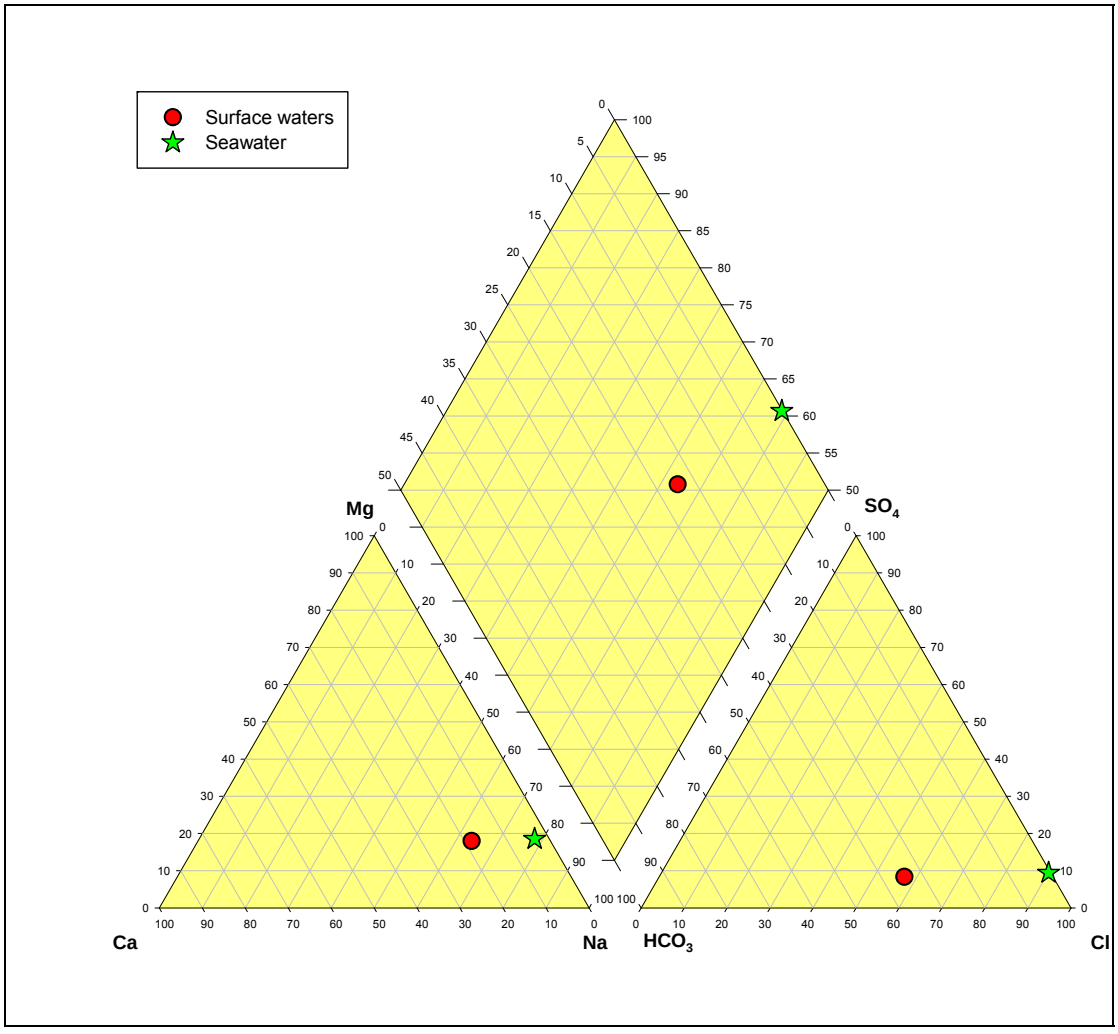


Figure 8-9. Piper diagram of hydrochemical data for Boggy Flat (Wetland ID. 12291).

8.4. Discussion

Acid sulfate soil materials at Boggy Flat (Wetland ID. 12291) were identified as hypersulfidic occurring in the subsoil layer of Site 2 and 4 that were located in open water, the remaining soil materials generally were characterised as hyposulfidic. The acid sulfate soil subtype classes identified were Subaqueous Soil (clayey) that occurred near the bank on the wetland margins and Hypersulfidic Subaqueous Soil (clayey) that occurred in open water areas.

The soils throughout the wetland were dominantly clayey with a mucky clay surface layer that was very weak.

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

The potential hazards posed by acid sulfate soil materials at Boggy Flat (Wetland ID. 12291) are:

- Acidification hazard: The data identified high acidity values in the upper soil layers and pH data identified some samples with values that were potentially an acidification hazard due to oxidation. There is a medium to high level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there is potential for monosulfidic materials to form in the surface layers of soils, monosulfidic material was not observed. There is a medium level of concern.
- Metal mobilisation: The medium to high acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

Summary of key findings Boggy Flat (Wetland ID. 12291):

Soil materials:	The subsoil layers of profiles located in open water in the mid to low elevated areas of the wetland were hypersulfidic and elsewhere throughout the wetland they were hyposulfidic. Soils were generally clayey textured and often very weak in the upper soil layers. Profiles had a high net acidity values in some layers and pH data for some samples indicated a potential for acidification due to oxidation.
Acid sulfate soil identification:	• Subaqueous Soil (clayey) – occurring on the wetland margins. Minor (<25%) in extent. • Hypersulfidic Subaqueous Soil (clayey) – occurring throughout the wetland. Dominant (>50%) in extent.
Hazard assessment	• Acidification hazard – medium to high level of concern • De-oxygenation hazard – medium level of concern • Metal mobilisation hazard – medium level of concern

Table 8-2. Site description data for Boggy Flat (Wetland ID. 12291).

Site Number	Sample Date	Easting m Zone 54H	Northing m Zone 54H	Water depth (+ve) Water table (-ve)	Surface condition	Earth cover (vegetation)	Location Notes
1	4/05/2010	402399	6228276	30	water	Phragmites	in water adjacent to bank and in reeds
2	4/05/2010	402397	6228280	80	water	water	open water 3m from reeds
3	4/05/2010	402579	6228309	35	water, soft	Typha	in water adjacent to bank and in reeds
4	4/05/2010	402576	6228313	100	water, very weak	water	open water, edge of reeds

Table 8-3. Soil profile description data for Boggy Flat (Wetland ID. 12291).

Site and Sample (number)	Depth Range (cm)	Observation Method (kind)	Soil Colour (name, Munsell notation)	Texture (Class)	Soil Water Status	Redoximorphic Features (%, colour, location)	Structure Type (category)	Consistence (category)	Comments
1_W	30 - 0	water							
1_1	0 - 5	small pit	very dark grey (10YR3/1)	plant material	wet		massive	very weak	a plant root mat
1_2	5 - 10	small pit	dark grey (5Y4/1)	sandy clay loam	wet		massive	weak	
1_3	10 - 20	small pit	dark grey (5Y4/1)	sandy clay loam	wet		massive	very firm	
1_4	20 - 40	push tube	dark grey (5Y4/1)	clay	moist		massive	very firm	
1_5	40 - 80	push tube	very dark grey (2.5Y3/0)	clay	moist		massive	very firm	
2_W1	80 - 0	surface water							water sampled
2_1	0 - 5	small pit	dark grey (5Y4/1)	mucky sandy clay loam	wet		gel	very weak	
2_2	5 - 10	small pit	dark grey (5Y4/1)	mucky sandy clay loam	wet		massive	very weak	
2_3	10 - 20	small pit	dark grey (2.5Y4/0)	clay loam	wet		massive	firm	
2_4	20 - 40	push tube	dark grey (2.5Y4/0)	clay	moist		massive	firm	
3_W	35 - 0	water							
3_1	0 - 5	small pit	dark grey (5Y4/1)	mucky clay	wet		gel	very weak	sulfurous odour
3_2	5 - 10	small pit	dark grey (2.5Y4/0)	mucky clay	wet		gel	very weak	sulfurous odour
3_3	10 - 20	small pit	dark grey (2.5Y4/0)	clay loam	moist		massive	firm	
3_4	20 - 40	push tube	dark grey (2.5Y4/0)	clay loam	moist		massive	firm	
3_5	40 - 80	push tube	dark grey (2.5Y4/0)	clay	moist		massive	firm	
4_W	100 - 0	water							
4_1	0 - 5	small pit	olive grey (5Y4/2)	mucky clay	wet		gel	very weak	sulfurous odour
4_2	5 - 10	small pit	olive grey (5Y4/2)	mucky clay	wet		gel	very weak	sulfurous odour
4_3	10 - 20	small pit	olive grey (5Y4/2)	clay	wet		gel	very weak	
4_4	20 - 40	push tube	grey (2.5Y5/0)	clay	moist		massive	weak	
6_W1	10 - 0	surface water							water sampled

Table 8-4. Laboratory data for acid sulfate soil assessment of Boggy Flat (Wetland ID. 12291).

(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 week 0	pH incubation week 8	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+ /tonne)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H+/ tonne)	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+ /tonne)	Acid Sulfate Soil Material Classification
1.1	0-5	Fine	112	6.86	2.05	7.17	4.59	120	6.05	10.89	0.13	..	0	92	hyposulfidic (S_{CR}≥0.10%)
1.2	5-10	Fine	73	7.08	2.81	7.09	4.33	39	5.47	9.00	0.01	..	..	17	hyposulfidic (S_{CR}<0.10%)
1.3	10-20	Fine	77	6.73	3.38	6.94	5.18	28	5.13	13.73	0.02	..	..	28	hyposulfidic (S_{CR}<0.10%)
1.4	20-40	Fine	87	6.90	4.31	7.31	5.87	42	4.98	16.10	0.01	..	..	23	hyposulfidic (S_{CR}<0.10%)
1.5	40-80	Fine	101	7.19	4.85	7.19	6.04	35	5.74	12.31	<0.01	..	..	12	other soil material
2.1	0-5	Fine	122	7.16	1.64	7.45	4.21	140	5.68	6.63	0.14	..	..	91	hyposulfidic (S_{CR}≥0.10%)
2.2	5-10	Fine	119	7.31	1.61	7.56	3.21	130	5.87	4.74	0.08	..	..	56	hypersulfidic
2.3	10-20	Fine	97	6.94	4.16	7.11	4.33	47	5.35	12.79	0.09	..	..	71	hyposulfidic (S_{CR}<0.10%)
2.4	20-40	Fine	91	6.93	5.32	7.41	5.87	10	5.45	19.42	<0.01	..	..	19	other soil material
3.1	0-5	Fine	275	7.72	2.65	6.70	4.64	110	6.18	4.74	0.17	..	0	114	hyposulfidic (S_{CR}≥0.10%)
3.2	5-10	Fine	223	6.92	6.28	7.22	5.35	76	5.77	12.54	0.05	..	..	45	hyposulfidic (S_{CR}<0.10%)
3.3	10-20	Fine	205	6.93	6.62	7.26	6.01	51	6.00	11.04	0.05	..	0	43	hyposulfidic (S_{CR}<0.10%)
3.4	20-40	Fine	217	7.13	7.20	6.92	6.29	25	6.09	10.04	0.05	..	0	42	hyposulfidic (S_{CR}<0.10%)
3.5	40-80	Fine	204	7.47	7.59	7.31	6.93	42	6.37	3.51	0.03	..	0	25	hyposulfidic (S_{CR}<0.10%)
4.1	0-5	Fine	246	6.74	2.04	7.04	3.67	51	5.70	14.05	0.30	..	..	199	hypersulfidic
4.2	5-10	Fine	205	6.41	2.16	7.07	3.60	52	5.57	16.06	0.27	..	..	185	hypersulfidic
4.3	10-20	Fine	189	6.21	2.17	6.72	4.28	52	5.47	20.57	0.26	..	..	183	hyposulfidic (S_{CR}≥0.10%)
4.4	20-40	Fine	139	7.33	7.52	6.98	6.53	52	6.47	1.51	0.01	..	0	10	hyposulfidic (S_{CR}<0.10%)

Table 8-5. Summary of hydrochemical field measurements for Boggy Flat (Wetland ID. 12291).

	pH	SEC µS cm^{-1}	DO mg l^{-1}	Eh mV	Turbidity NTU	Alkalinity as HCO_3
Surface waters (n=1)	7.07	448	4.45	-77	108	84

Table 8-6. Summary of hydrochemical field measurements for Boggy Flat (Wetland ID. 12291).

Parameter	units	ANZECC Guidelines	Site 2 (SW)
Na	mg l^{-1}		57.5
K	mg l^{-1}		5.1
Ca	mg l^{-1}		15.2
Mg	mg l^{-1}		9.04
Si	mg l^{-1}		4.15
Br	mg l^{-1}		0.2
Cl	mg l^{-1}		81
NO_3	mg l^{-1}	0.7	<0.022
NH_4-N^K	mg l^{-1}	0.01	**0.03**
PO_4-P^E	mg l^{-1}	0.005	**0.056**
SO_4	mg l^{-1}		16
Ag	µg l^{-1}	0.05	<0.01
Al^A	µg l^{-1}	55	**430**
As^B	µg l^{-1}	13	2.1
Cd	µg l^{-1}	0.2	0.01
Co	µg l^{-1}	2.8	0.23
Cr^C	µg l^{-1}	1	0.5
Cu^H	µg l^{-1}	1.4	**2.2**
Fe	µg l^{-1}	300	**487**
Mn	µg l^{-1}	1700	20.83
Ni^H	µg l^{-1}	11	1.4
Pb^H	µg l^{-1}	3.4	0.5
Se	µg l^{-1}	11	0.06
Zn^H	µg l^{-1}	8	**67**
DOC	mg l^{-1}		8.7

Notes.

The ANZECC guideline values for toxicants refer to the trigger values applicable to 'slightly-moderately disturbed' freshwater systems, as outlined in the Australian Water Quality Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000). For the nutrients NH_4 and PO_4, trigger values are provided for Freshwater Lakes and reservoirs. Surface water values outside the ranges defined in the ANZECC guidelines are indicated with red text. (SW) and (PW) indicate whether the sample was taken from surface water or pit-water (groundwater that entered an excavated pit), respectively.

A *Trigger value for Aluminium in freshwater where pH > 6.5.*

B *Trigger value assumes As in solution as Arsenic (AsV).*

C *Trigger value for Chromium is applicable to Chromium (CrVI) only.*

E *Guideline is for filterable reactive phosphorous (FRP).*

H *Hardness affected (refer to Guidelines).*

K *Guideline for South-east Australia-Freshwater Lakes and reservoirs.*

9. BOGGY FLAT (WETLAND ID. 12292)

9.1. Location and setting description

Boggy Flat (Wetland ID. 12292) is situated on the northern side of the River Murray, about 1.5 kilometres up river from Lock 1 and near Taylorville. The wetland is somewhat oval in shape forming part of a wetland complex that occurs on the inside of a small bend in the river. It is about 300 metres in length and about 50 metres at its widest, with a total surface area of 3 hectares. The wetland is bounded to the south by raised floodplain that separates the wetland from the river and to the north by steep hill slopes. The other associated wetland in the Boggy Flat complex is wetland ID. 12291.

The wetland is temporarily connected to the river at the western end via a man-made creek to Wetland ID. 12291 that is permanently connected to the river. At the time when the soil survey was conducted in May 2010 the wetland had surface water. The wetland is not managed. Sedgeland and grassland were growing along the wetland margins, with open sparse woodland and shrubland on the surrounding higher floodplain. Two sites were sampled as shown in Figure 8-1.

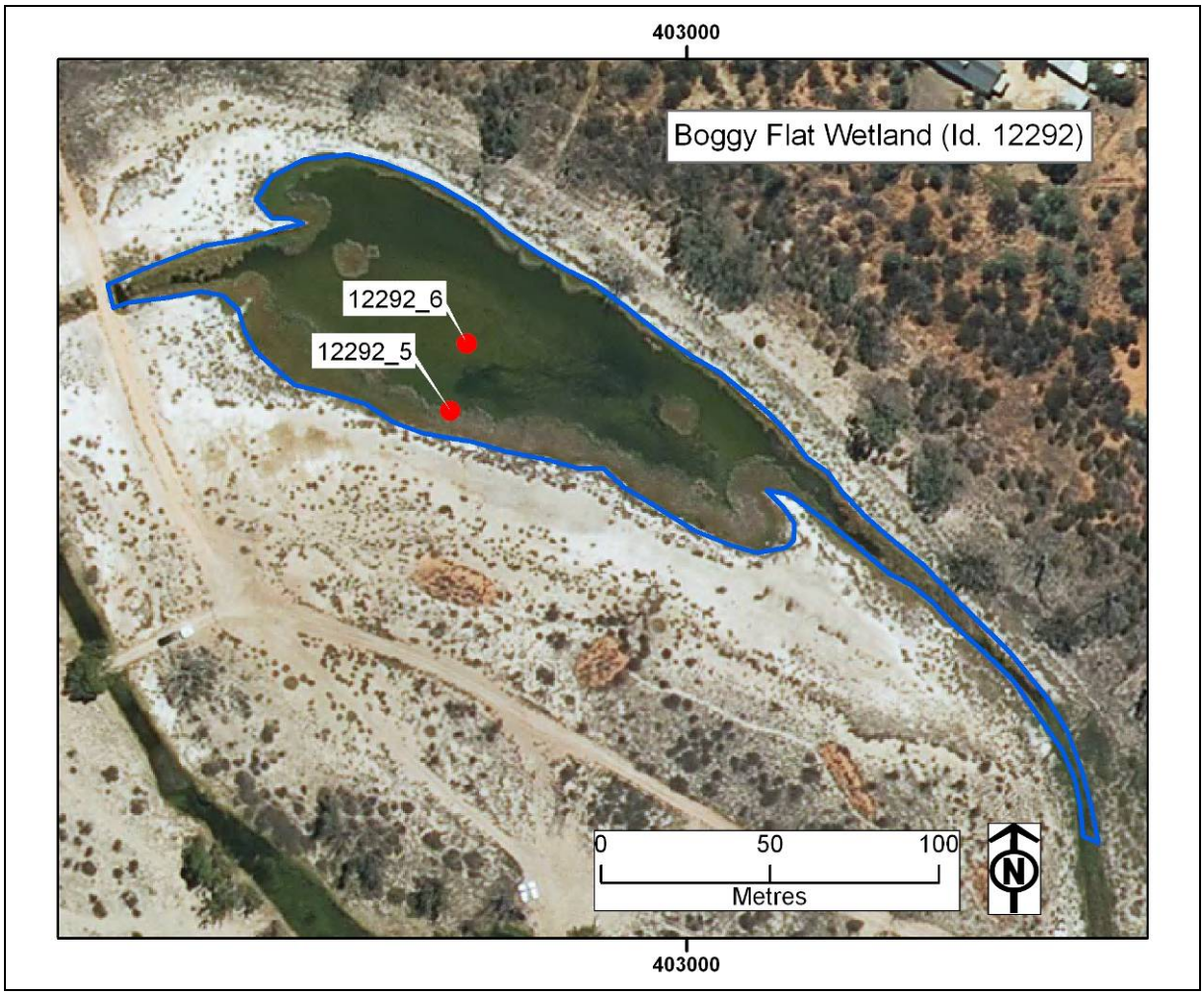


Figure 9-1. Boggy Flat (Wetland ID. 12292) and sample site locations.

9.2. Soil profile description and distribution

Two sites were described and sampled. The soil subtypes and general location descriptions are presented in Table 9-1. Sites were distributed with one placed near the wetland edge in the reeds (Site 5) and the other in open shallow water (Site 6) of the wetland. The site and soil profile descriptions are presented in Table 9-2 and Table 9-3.

Site 5 (Figure 9-2) occurred on the wetland margin adjacent to the bank and Typha in water (10 cm deep), and the soil consisted of a black, weak, sand, with sulfurous odour, over a greyish brown, firm, sandy loam to sandy clay loam with depth. Site 6 (Figure 9-3) occurred in open water (10 cm deep), and the soil consisted of a very dark grey, weak, sand, over a very dark grey, firm, sandy loam to sandy clay loam with depth.

Table 9-1. Soil identification, subtype and general location description for Boggy Flat (Wetland ID. 12292).

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12292_5	402930	6228328	Subaqueous Soil (loamy)	in water adjacent to bank and in reeds
12292_6	402935	6228348	Subaqueous Soil (loamy)	open water, middle of wetland

No cross section diagram

Figure 9-2. Photograph of Site 1, showing the site location on the wetland margin adjacent to bank and in Phragmites.

Figure 9-3. Photograph of Site 2, showing the site location in open water.

9.3. Laboratory data assessment

9.3.1. Soil pH testing (pH_W, pH_{OX}, $pH_{incubation}$)

The pH data are provided in Table 9-4 and pH profiles are presented in Figure 8-7. The pH_W data ranged from 5.43 to 7.35 and sulfuric materials with a pH_W <4 were not identified. The pH_{OX} data ranged from 3.90 to 6.65 and identified that no samples were below the critical value of pH_{OX} <2.5. The $pH_{incubation}$ data ranged from 4.85 to 7.44 and identified no samples that on incubation declined below the critical values of pH <4.

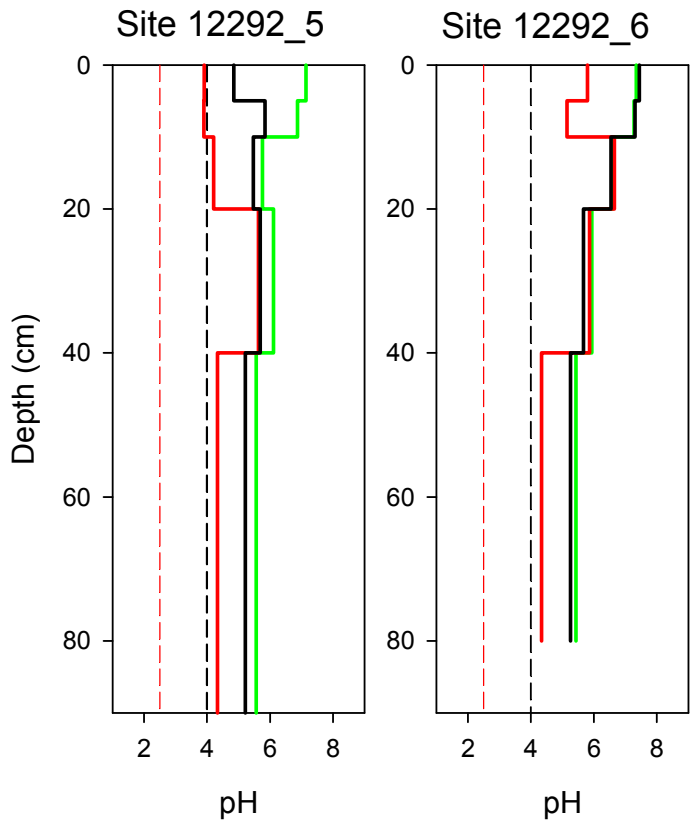


Figure 9-4. Depth profiles of soil pH for Boggy Flat (Wetland ID. 12292), showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and incubation pH (pH_{INC} after 8 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

9.3.2. Acid base accounting

The acid base accounting data is provided in Table 9-4 and summarised in Figure 9-5.

Chromium reducible sulfur

Chromium reducible sulfur values ranged from 0.0 to 0.03 $\%S_{CR}$ and sulfidic materials were detected in both soil profiles.

Titratable actual acidity

Titratable actual acidity values ranged from 0.00 to 19.57 mole H^+/tonne and were detected in most samples.

Retained acidity

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

Acid neutralising capacity

Acid neutralising capacity values ranged from 0.0 to 0.51 $\%CaCO_3$.and were measured in most sample layers.

Net acidity

Net acidity values ranged from -67 to 24 mole H^+/tonne. Profile 5 had moderate net acidity value in the surface layer and declined to low values with depth, and Profile 6 had negative net acidity value in the surface layers and increase to a moderate value with depth.

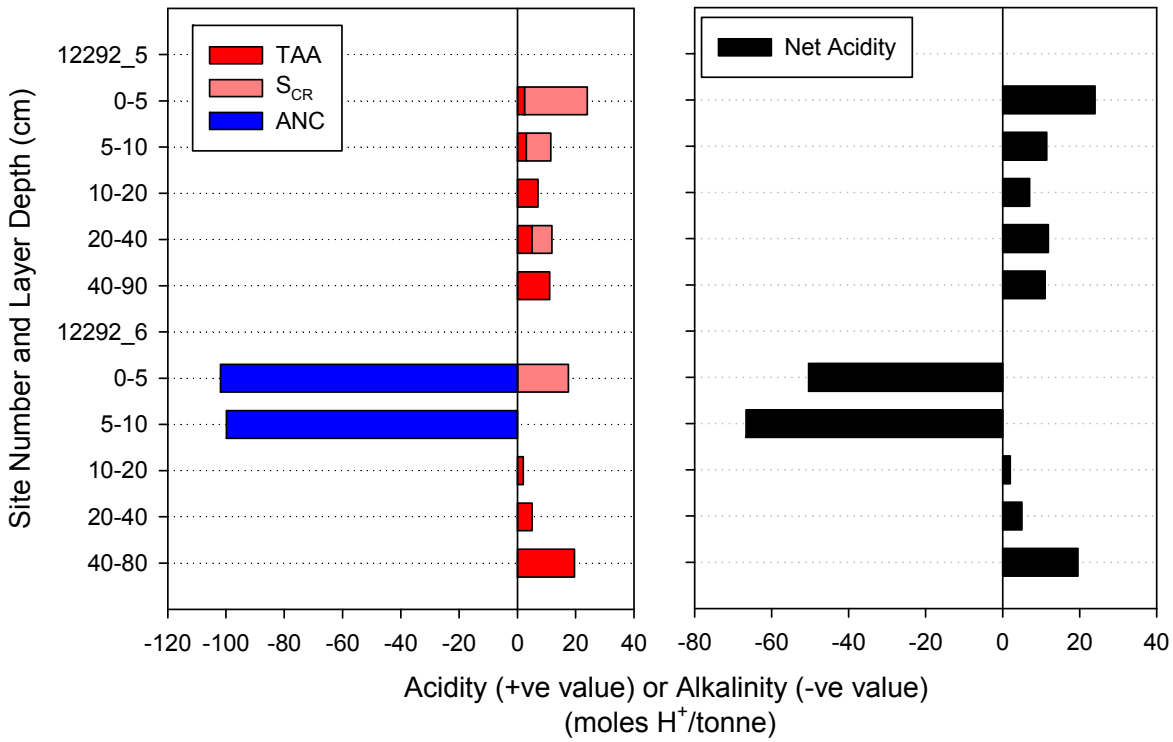


Figure 9-5. Acid base accounting depth profiles for Boggy Flat (Wetland ID. 12292). Left side shows the components: Titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

9.3.3. Water soluble sulfate

Water soluble sulfate data values shown in Table 9-4 identified that surface layers for Profile 5 was above the criterion trigger value of 100 mg/kg SO_4.

9.3.4. Acid volatile sulfur

Monosulfidic materials were not observed and no samples were collected for analysis.

9.3.5. Hydrochemistry

One surface water sample was collected from the wetland. Field parameters are shown in Table 9-5. The water had slightly alkaline pH with a moderate salinity. Dissolved oxygen was at saturation in the water and turbidity was very low. Alkalinity was moderately high.

The surface water was of Na-Cl type (Table 9-6, Figure 9-6). Sulfate concentration in the surface water was high at 270 mg l^{-1}. The SO_4/Cl ratio in the surface water (0.169) was similar to seawater (0.142). For the nutrients, NH_4 and PO_4 concentrations were slightly elevated. For the trace metals, Zn was slightly elevated.

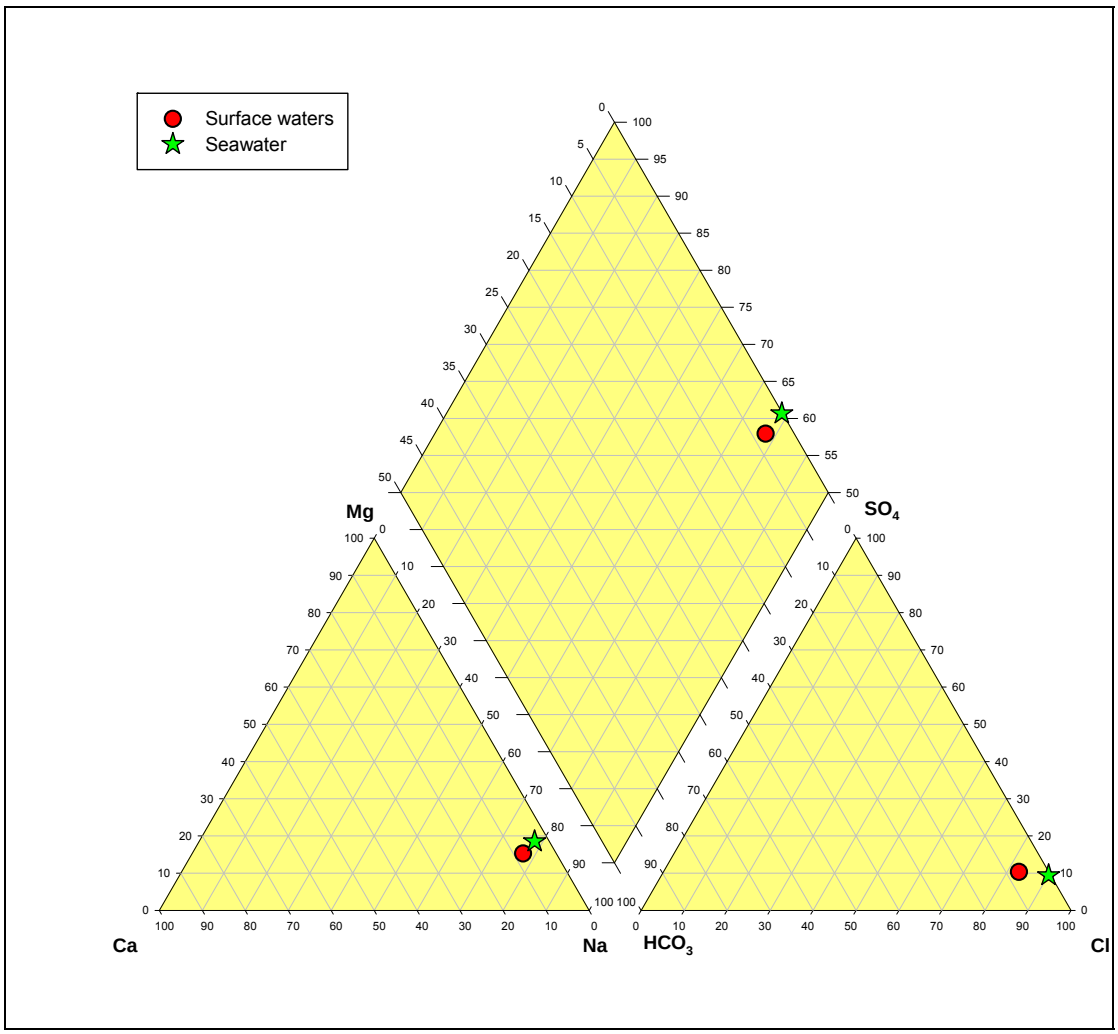


Figure 9-6. Piper diagram of hydrochemical data for Boggy Flat (Wetland ID. 12292).

9.4. Discussion

Acid sulfate soil materials at Boggy Flat (Wetland ID. 12292) were identified as hyposulfidic, and the remaining samples as other acidic soil materials. The acid sulfate soil subtype class identified was Subaqueous Soil (loamy) that occurred throughout the wetland.

The soils throughout the wetland were dominantly sandy at the surface and loamy in the subsoils.

Monosulfidic material was not observed but water soluble sulfate data identified that surface layer for the site adjacent to the bank was in excess of the 100mg/L trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials at Boggy Flat (Wetland ID. 12292) are:

- Acidification hazard: The data identified moderate to low net acidity values in one profile and negative to moderate values in the other profile, and pH data did not indicate a potential acidification hazard due to oxidation. There is a low to medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there is potential for monosulfidic materials to form in the surface layer of soils adjacent to the wetland margin, monosulfidic material was not observed. There is a low to medium level of concern.
- Metal mobilisation: The medium 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 Boggy Flat (Wetland ID. 12292):

Soil materials:	The soil layers were generally hyposulfidic in the upper soil layers and other acidic in the subsoils. Soils were generally loamy textured. Profiles had positive net acidity values in most layers and pH data did not indicate a potential for acidification due to oxidation.
Acid sulfate soil identification:	• Subaqueous Soil (loamy) – occurring throughout the wetland. Dominant (>50%) in extent.
Hazard assessment	• Acidification hazard – low to medium level of concern • De-oxygenation hazard – low to medium level of concern • Metal mobilisation hazard – low level of concern

Table 9-2. Site description data for Boggy Flat (Wetland ID. 12292).

Site Number	Sample Date	Easting m Zone 54H	Northing m Zone 54H	Water depth (+ve) Water table (-ve)	Surface condition	Earth cover (vegetation)	Location Notes
5	4/05/2010	402930	6228328	10	water, firm	water	edge of water adjacent to bank in reeds
6	4/05/2010	402935	6228348	10	water	water	low elevation, middle of wetland

Table 9-3. Soil profile description data for Boggy Flat (Wetland ID. 12292).

Site and Sample (number)	Depth Range (cm)	Observation Method (kind)	Soil Colour (name, Munsell notation)	Texture (Class)	Soil Water Status	Redoximorphic Features (%, colour, location)	Structure Type (category)	Consistence (category)	Comments
5_1	0 - 5	small pit	black (2.5Y2/0)	sand	wet		single grain	weak	sulfurous odour
5_2	5 - 10	small pit	very dark grey (2.5Y3/0)	sand	wet		single grain	weak	
5_3	10 - 20	small pit	greyish brown (2.5Y5/2)	sandy loam	wet		massive	firm	
5_4	20 - 40	small pit	greyish brown (2.5Y5/2)	sandy loam	wet		massive	firm	
5_5	40 - 90	push tube	dark grey (5Y4/1)	sandy clay loam	moist		massive	firm	
6_1	0 - 5	small pit	very dark grey (2.5Y3/0)	sand	wet		single grain	weak	
6_2	5 - 10	small pit	very dark grey (2.5Y3/0)	sand	wet		single grain	weak	
6_3	10 - 20	small pit	greyish brown (2.5Y5/2)	sandy loam	wet		massive	firm	
6_4	20 - 40	small pit	greyish brown (2.5Y5/2)	sandy loam	moist		massive	firm	
6_5	40 - 80	push tube	dark grey (5Y4/1)	sandy clay loam	moist		massive	firm	

Table 9-4. Laboratory data for acid sulfate soil assessment of Boggy Flat (Wetland ID. 12292).

(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 week 0	pH incubation week 8	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+ /tonne)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H+/ tonne)	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
5.W	10-0														water
5.1	0-5	Fine	796	7.14	3.91	6.95	4.85	130	6.34	2.51	0.03	..	0	24	hyposulfidic (S_{CR}≥0.10%)
5.2	5-10	Medium	1352	6.87	3.90	6.90	5.84	130	6.34	3.01	0.01	..	..	11	hyposulfidic (S_{CR}≥0.10%)
5.3	10-20	Fine	2443	5.76	4.21	6.15	5.47	180	5.87	7.02	<0.01	..	0	7	other acidic incubation
5.4	20-40	Fine	1459	6.11	5.63	6.75	5.69	120	6.14	5.02	0.01	..	..	12	hyposulfidic (S_{CR}<0.10%)
5.5	40-90	Fine	1950	5.56	4.33	5.87	5.22	190	5.36	11.04	<0.01	..	0	11	other acidic incubation
6.W	10-0														surface water
6.1	0-5	Medium	710	7.35	5.80	7.28	7.44	73	7.26	0.00	0.03	..	0.51	-50	hyposulfidic (S_{CR}<0.10%)
6.2	5-10	Coarse	934	7.27	5.15	7.36	7.31	79	6.73	0.00	<0.01	..	0.50	-67	other soil material
6.3	10-20	Fine	2405	6.60	6.65	7.17	6.54	310	6.39	2.01	<0.01	..	..	2	other soil material
6.4	20-40	Fine	1914	5.93	5.86	6.35	5.67	190	5.88	5.02	<0.01	..	..	5	other soil material
6.5	40-80	Fine	2245	5.43	4.34	6.68	5.26	310	5.15	19.57	<0.01	..	..	20	other acidic incubation

Table 9-5. Summary of hydrochemical field measurements for Boggy Flat (Wetland ID. 12292).

	pH	SEC	DO	Eh	Turbidity	Alkalinity
		µS cm^{-1}	mg l^{-1}	mV	NTU	as HCO_3
Surface waters (n=1)	8.08	5174	13.82	-24	5	228

Table 9-6. Summary of hydrochemical field measurements for Boggy Flat (Wetland ID. 12292).

Parameter	units	ANZECC Guidelines	Site 6 (SW)
Na	mg l^{-1}		893
K	mg l^{-1}		8.4
Ca	mg l^{-1}		78.6
Mg	mg l^{-1}		94.2
Si	mg l^{-1}		0.809
Br	mg l^{-1}		4.0
Cl	mg l^{-1}		1600
NO_3	mg l^{-1}	0.7	<0.022
NH_4-N^K	mg l^{-1}	0.01	**0.034**
PO_4-P^E	mg l^{-1}	0.005	**0.060**
SO_4	mg l^{-1}		270
Ag	µg l^{-1}	0.05	<0.01
Al^A	µg l^{-1}	55	<4
As^B	µg l^{-1}	13	1.8
Cd	µg l^{-1}	0.2	<0.02
Co	µg l^{-1}	2.8	0.63
Cr^C	µg l^{-1}	1	<0.2
Cu^H	µg l^{-1}	1.4	0.8
Fe	µg l^{-1}	300	<500
Mn	µg l^{-1}	1700	87.8
Ni^H	µg l^{-1}	11	2.4
Pb^H	µg l^{-1}	3.4	0.04
Se	µg l^{-1}	11	<0.1
Zn^H	µg l^{-1}	8	**10**
DOC	mg l^{-1}		22.1

Notes.

The ANZECC guideline values for toxicants refer to the trigger values applicable to 'slightly-moderately disturbed' freshwater systems, as outlined in the Australian Water Quality Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000). For the nutrients NH_4 and PO_4, trigger values are provided for Freshwater Lakes and reservoirs. Surface water values outside the ranges defined in the ANZECC guidelines are indicated with red text. (SW) and (PW) indicate whether the sample was taken from surface water or pit-water (groundwater that entered an excavated pit), respectively.

A *Trigger value for Aluminium in freshwater where pH > 6.5.*

B *Trigger value assumes As in solution as Arsenic (AsV).*

C *Trigger value for Chromium is applicable to Chromium (CrVI) only.*

E *Guideline is for filterable reactive phosphorous (FRP).*

H *Hardness affected (refer to Guidelines).*

K *Guideline for South-east Australia-Freshwater Lakes and reservoirs.*

10. NIGRA CREEK (WETLAND ID. 12294)

10.1. Location and setting description

Nigra Creek (Wetland ID. 12294) is situated on the western side of the River Murray about 2 to 5 kilometres up river from Lock 2 near Taylorville. The wetland is a creek and linear in shape occurring on the inside bend of the river connecting Schillers Lagoon (Wetland ID. 12259) with the river. It is about 1.5 kilometres in length and 20 to 50 metres wide, with a total surface area of 7 hectares. The wetland is bounded by a raised floodplain that separates the wetland from the river and farm land.

The wetland is permanently connected at the southern end to the river and at the northern end to Schillers Lagoon Wetland. At the time when the soil survey was conducted in March 2010, the wetland contained surface water. The wetland is managed by the landholders with assistance from the South Australian Murray-Darling Basin Natural Resources Management Board (SA MDB NRM Board) and RWLAP. It has a structure for management of water and was closed in October 2006, opened in March 2009, closed September 2009, opened February 2010 and is currently open. Sedgeland and woodland were growing along the wetland margins, with shrubland and open woodland on the higher floodplain that separated the wetland and river. Four sites were sampled as shown in Figure 10-1.

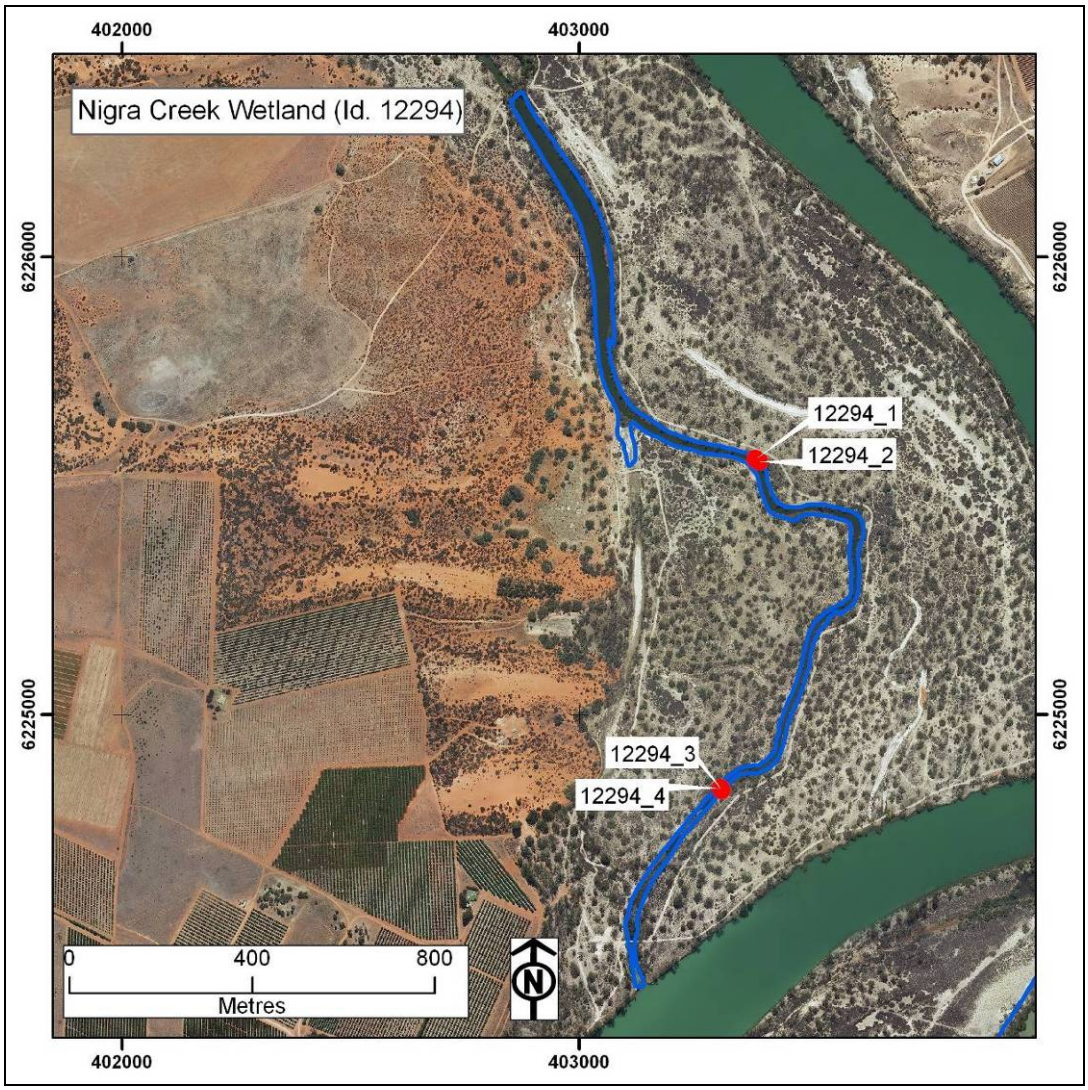


Figure 10-1. Nigra Creek (Wetland ID. 12294) and sample site locations.

10.2. Soil profile description and distribution

Four sites were described and sampled. The soil subtypes and general location descriptions are presented in Table 10-1. Sites were distributed as pairs along two transects where one site was placed in the water near the creek bank and the other was placed as far as possible into the middle of the creek. The site and soil profile descriptions are presented in Table 10-2 and Table 10-3, and a conceptual cross-section in Figure 10-2.

Site 1 (Figure 10-3) occurred in water (60 cm deep), and the soil consisted of a dark greyish brown, very weak, mucky clay, over an olive grey, clay, that became firmer with depth. Site 2 (Figure 10-4) occurred adjacent to the creek bank in water (40 cm deep), and the soil consisted of an olive grey, very weak, mucky clay, over an olive grey, weak, sandy clay loam to firm, clay loam with depth. Site 3 (Figure 10-5) occurred next to the creek bank in water (30 cm deep), and the soil consisted of a dark grey, very weak, mucky clay with a sulfurous odour, over a dark grey, firm, loamy sand. Site 4 (Figure 10-6) occurred mid creek in water (80 cm deep), and the soil consisted of a very dark grey, very weak, mucky clay, over an olive grey, firm, sandy loam.

Table 10-1. Soil identification, subtype and general location description for Nigra Creek Wetland (ID. 12294).

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12294_1	403387	6225558	Hypersulfidic Subaqueous Soil (clayey)	a third into creek
12294_2	403395	6225553	Subaqueous Soil (loamy)	next to creek bank
12294_3	403313	6224834	Hypersulfidic Subaqueous Soil (sandy)	next to bank
12294_4	403310	6224839	Hypersulfidic Subaqueous Soil (sandy)	mid creek, low elevation

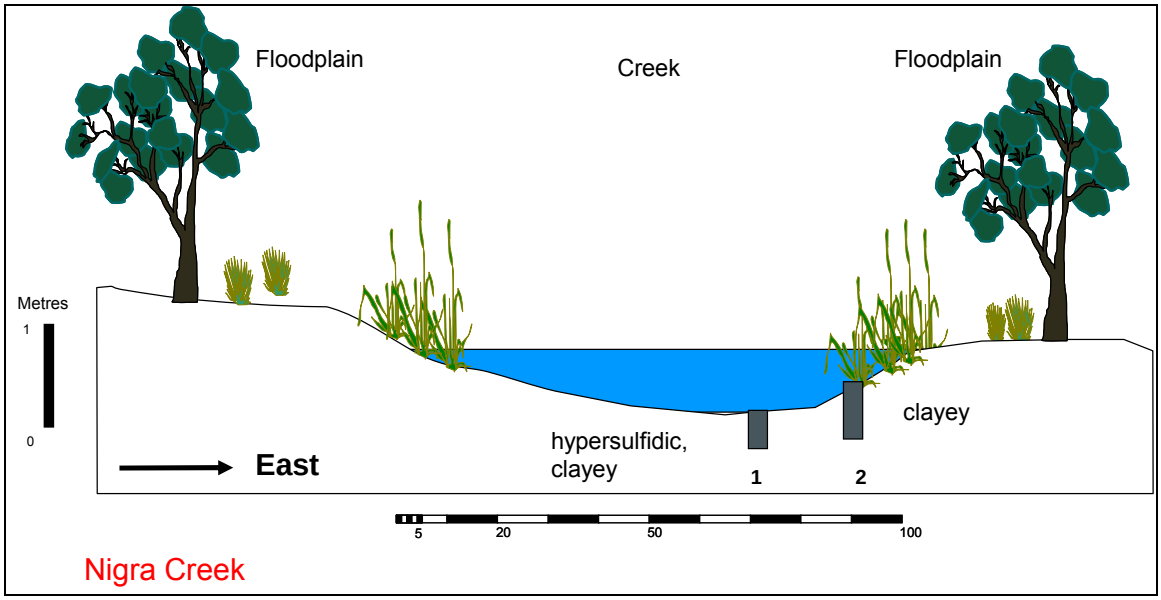


Figure 10-2. Conceptual cross-section diagram, showing locations of Sites 1 and 2.

Figure 10-3: Photograph of Site 1, showing the site location in open water.

Figure 10-4. Photograph of Site 2, showing the site location adjacent to the creek bank where Typha was growing.

Figure 10-5. Photograph of Site 3, showing the site location next to the creek bank where reeds where growing.

Figure 10-6. Photograph of Site 4, showing the site location near the middle of the creek amongst Typha vegetation

10.3. Laboratory data assessment

10.3.1. Soil pH testing (pH_W, pH_{OX}, $pH_{incubation}$)

The pH data are provided in Table 10-4 and pH profiles are presented in Figure 10-7. The pH_W data ranged from 6.16 to 7.62 and sulfuric materials with a pH_W <4 were not identified. The pH_{OX} data ranged from 1.51 to 3.49 and identified that all four profiles had at least one or more layers with a pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming. The $pH_{incubation}$ data ranged from 2.74 to 5.49 and identified soil layers in Profiles 1, 3 and 4 that on incubation declined to pH <4 indicating that the soils would be sulfuric if oxidised.

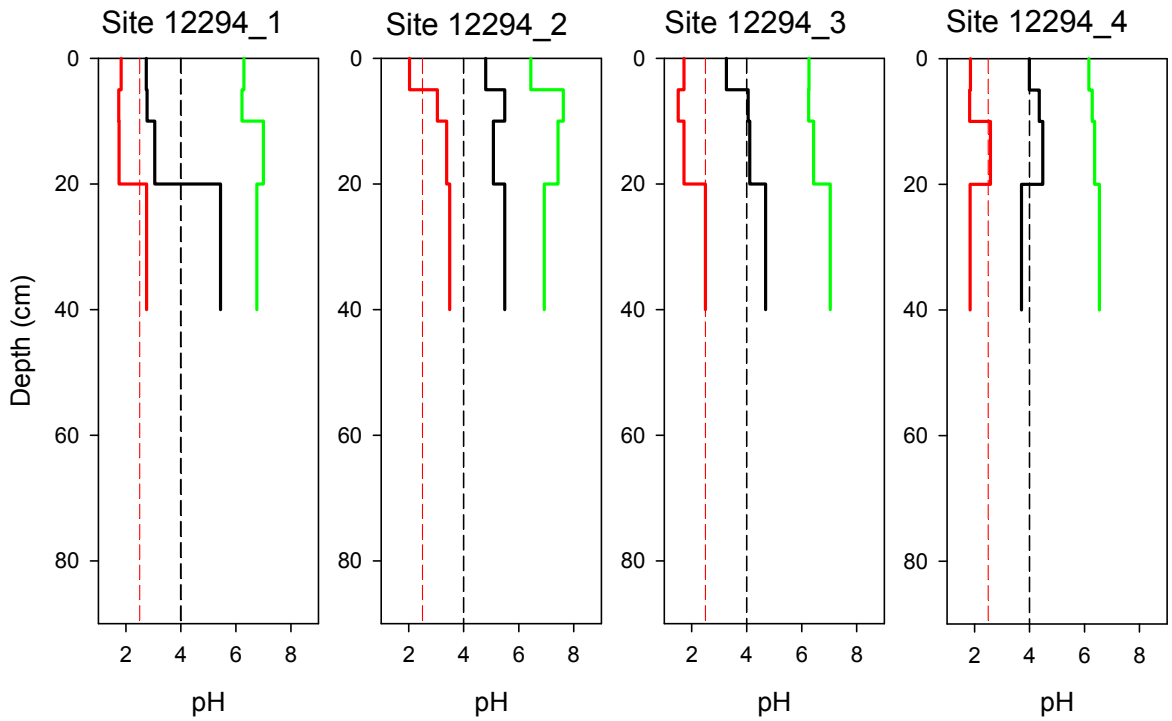


Figure 10-7. Depth profiles of soil pH for Nigra Creek (Wetland ID. 12294), showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and incubation pH (pH_{INC} after 8 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

10.3.2. Acid base accounting

The acid base accounting data is provided in Table 10-4 and summarised in Figure 10-8.

Chromium reducible sulfur

Chromium reducible sulfur values ranged from S_{CR} 0.01 to 0.53 % and sulfidic materials were detected in all layers.

Titratable actual acidity

Titratable actual acidity values ranged from 0.94 to 10.80 mole H^+/tonne and were measured in all samples.

Retained acidity

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

Acid neutralising capacity

Acid neutralising capacity was not measured

Net acidity

Net acidity values ranged from 12 to 339 mole H^+/tonne. Generally samples had moderate net acidity values, with a high value recorded in the subsoil of Profile 1 and low values recorded in the subsoil of Profile 2.

10.3.3. Water soluble sulfate

Water soluble sulfate data values shown in Table 10-4 identified that surface layers were all lower than the criterion trigger value of 100 mg/kg SO_4.

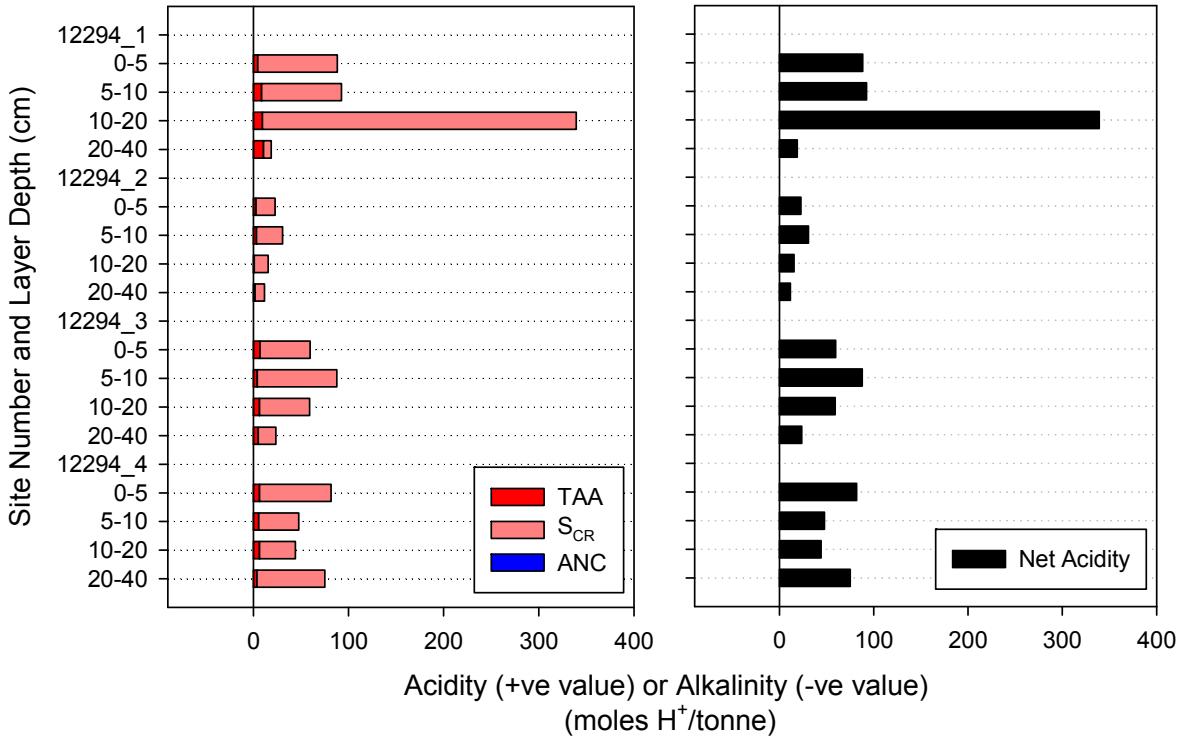


Figure 10-8. Acid base accounting depth profiles for Nigra Creek (Wetland ID. 12294). Left side shows the components: Titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

10.3.4. Hydrochemistry

Two surface waters were collected from the wetland, pit waters were not collected as the marginal areas were covered with surface water. Field parameters are shown in Table 10-5. The surface waters had neutral pH and were fresh. Dissolved oxygen was moderately high and the waters turbid. Alkalinity was slightly higher than expected for the river along this section of the catchment.

The surface waters are of Na-HCO_3 type, with Ca and HCO_3 being higher relative to Na and Cl relative to seawater (Table 10-6, Figure 10-9). Sulfate concentrations in the surface waters were low varying between 4.6 and 7.2 mg l^{-1}. The SO_4/Cl ratio in the surface waters (0.23) were slightly higher than seawater (0.142). For the nutrients, PO_4 and NH_4 concentrations were slightly above ANZECC Guideline values. Iron and Al were high at one of the two sites sampled, and may be a consequence of colloidal material as the waters were relatively turbid. Zinc was slightly elevated above guideline values.

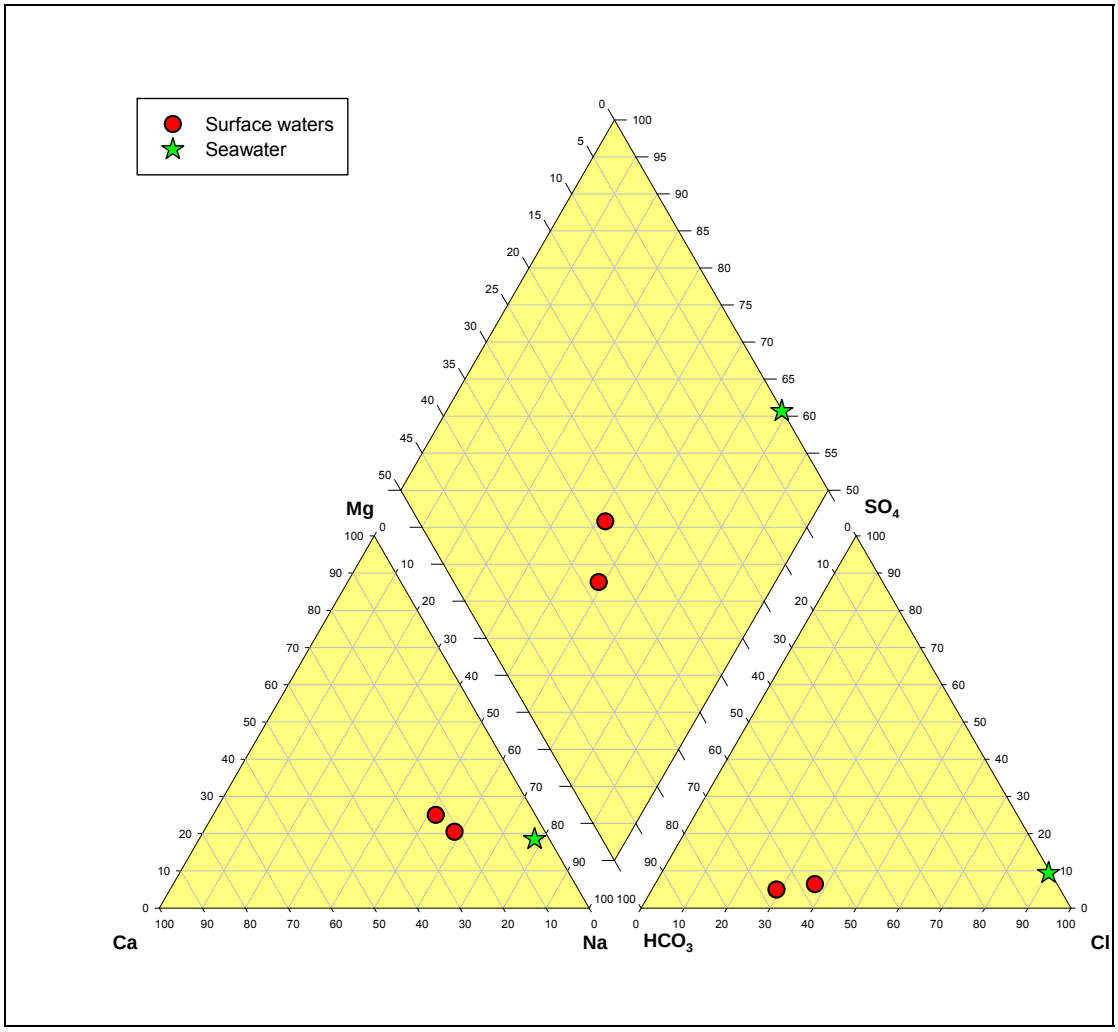


Figure 10-9. Piper diagram of hydrochemical data for Nigra Creek (Wetland ID. 12294).

10.4. Discussion

Acid sulfate soil materials in Nigra Creek (Wetland ID. 12294) were identified as hypersulfidic and these soil materials occurred throughout the wetland but were more common in the soil profiles located in the creek than those profiles adjacent to the creek bank. The acid sulfate soil subtype classes identified were Hypersulfidic Subaqueous Soil (clayey or sandy) that occurred in the low elevated areas below water and Subaqueous Soil (loamy) that occurred on the wetland margin adjacent to the creek bank.

The soils throughout the wetland were clayey textured at depth, with mucky clay on the surface that was very weak. In some areas along the creek bank margins there were sandy soil layers.

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

The potential hazards posed by acid sulfate soil materials at Nigra Creek (Wetland ID. 12294) are:

- Acidification hazard: The data identified moderate net acidity values in all profiles and pH data indicated sample values that there were potential acidification hazards due to oxidation. There is a high level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there is no potential for monosulfidic materials to form in the surface layers, monosulfidic material was not observed. There is a low level of concern.
- Metal mobilisation: The high acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a high level of concern.

Summary of key findings Nigra Creek (Wetland ID. 12294):

Soil materials:	The surface soil layers throughout the wetland were hypersulfidic and the subsoil layers were hypersulfidic or hyposulfidic. Soils were a mucky clayey texture in the surface layers and clayey in the subsoil. Profiles had moderate net acidity values and pH data indicated a potential for acidification due to oxidation.
Acid sulfate soil identification:	• Hypersulfidic Subaqueous Soil (clayey or sandy) – occurring throughout the wetland. Dominant (>50%) in extent. • Subaqueous Soil (loamy) – occurring adjacent to the creek bank. Isolated (<10%) in extent
Hazard assessment	• Acidification hazard – high level of concern • De-oxygenation hazard – low level of concern • Metal mobilisation hazard – high level of concern

Table 10-2. Site description data for Nigra Creek (Wetland ID. 12294).

Site Number	Sample Date	Easting m Zone 54H	Northing m Zone 54H	Water depth (+ve) Water table (-ve)	Surface condition	Earth cover (vegetation)	Location Notes
1	24/03/2010	403387	6225558	60	water	water	a third into creek
2	24/03/2010	403395	6225553	40	water	reeds	next to creek bank
3	24/03/2010	403313	6224834	30	soft gel	water, Typha	next to bank
4	24/03/2010	403310	6224839	80	water, gel, salt	water, Typha	mid creek, low elevation

Table 10-3. Soil profile description data for Nigra Creek (Wetland ID. 12294).

Site and Sample (number)	Depth Range (cm)	Observation Method (kind)	Soil Colour (name, Munsell notation)	Texture (Class)	Moisture State	Redoximorphic Features (%, colour, location)	Structure Type (category)	Consistence (category)	Comments
1_W1	60 - 0	surface water							water sampled
1_1	0 - 5	small pit	dark greyish brown (2.5Y4/2)	mucky clay	wet		gel	very weak	
1_2	5 - 10	small pit	olive grey (5Y4/2)	clay	wet		massive	very weak	
1_3	10 - 20	small pit	olive grey (5Y4/2)	clay	wet		massive	firm	
1_4	20 - 40	push tube	greenish gray (10Y6/1)	clay	moist		massive	very firm	
2_W	40 - 0	water							
2_1	0 - 5	small pit	olive grey (5Y4/2)	mucky clay	wet		gel	very weak	
2_2	5 - 10	small pit	olive grey (5Y4/2)	sandy clay loam	moist		massive	weak	
2_3	10 - 20	small pit	olive grey (5Y4/2)	clay loam sandy	moist		massive	firm	
2_4	20 - 40	push tube	olive grey (5Y5/2)	clay loam	moist		massive	firm	
3_W	30 - 0	water							
3_1	0 - 5	small pit	dark grey (10YR4/1)	mucky clay	wet		gel	very weak	sulfur odour
3_2	5 - 10	small pit	dark grey (10YR4/1)	clay loam sandy	wet		massive	very weak	strong sulfur odour
3_3	10 - 20	small pit	dark grey (10YR4/1)	loamy sand	moist		massive	firm	
3_4	20 - 40	push tube	grey (10YR5/1)	loamy sand	moist		massive	firm	
4_W1	80 - 0	surface water							water sampled
4_1	0 - 5	small pit	very dark grey (10YR3/1)	mucky clay	wet		gel	very weak	
4_2	5 - 10	small pit	olive grey (5Y4/2)	sandy loam	wet		massive	weak	
4_3	10 - 20	small pit	olive grey (5Y4/2)	sandy loam	wet		massive	firm	
4_3DUP	10 - 20	#N/A	olive grey (5Y4/2)	sandy loam	wet		massive	firm	
4_4	20 - 40	push tube	olive grey (5Y4/2)	loamy sand	wet		massive	firm	

Table 10-4. Laboratory data for acid sulfate soil assessment of Nigra Creek (Wetland ID. 12294).

(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 week 0	pH incubation week 8	Sulfate (mg SO_4/kg)	pH KCl	Titratable actual acidity (mole H^+ /tonne)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H+/ tonne)	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
1.W1	60-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
1.1	0-5	Fine	104	6.29	1.83	6.56	2.74	74	6.28	4.77	0.13	..	0.00	88	hypersulfidic
1.2	5-10	Fine	73	6.22	1.74	6.38	2.77	77	5.78	8.58	0.13	..	..	93	hypersulfidic
1.3	10-20	Fine	147	7.00	1.75	6.31	3.05	250	6.14	9.54	0.53	..	0.00	339	hypersulfidic
1.4	20-40	Fine	53	6.76	2.75	6.36	5.44	37	5.55	10.80	0.01	..	..	19	hyposulfidic (S_{CR}<0.10%)
2.W1	40-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
2.1	0-5	Medium	43	6.44	2.03	6.36	4.80	28	6.13	2.82	0.03	..	0.00	23	hyposulfidic (S_{CR}<0.10%)
2.2	5-10	Medium	185	7.62	3.04	6.45	5.49	29	6.09	3.29	0.04	..	0.00	31	hyposulfidic (S_{CR}<0.10%)
2.3	10-20	Fine	89	7.43	3.38	6.59	5.08	46	6.48	0.94	0.02	..	0.00	16	hyposulfidic (S_{CR}<0.10%)
2.4	20-40	Fine	65	6.93	3.49	6.62	5.49	29	6.41	1.88	0.02	..	0.00	12	hyposulfidic (S_{CR}<0.10%)
3.W1	30-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
3.1	0-5	Medium	86	6.26	1.72	6.66	3.26	62	5.94	7.00	0.08	..	..	60	hypersulfidic
3.2	5-10	Fine	67	6.25	1.51	6.32	4.05	83	6.07	4.23	0.13	..	0.00	88	hyposulfidic (S_{CR}≥0.10%)
3.3	10-20	Fine	60	6.43	1.72	6.28	4.11	67	5.61	6.58	0.08	..	..	59	hyposulfidic (S_{CR}<0.10%)
3.4	20-40	Fine	118	7.04	2.50	6.56	4.69	76	6.29	5.17	0.03	..	0.00	24	hyposulfidic (S_{CR}<0.10%)
4.W1	80-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
4.1	0-5	Fine	129	6.16	1.85	6.38	3.99	84	5.94	6.58	0.12	..	..	82	hypersulfidic
4.2	5-10	Fine	109	6.28	1.82	6.13	4.35	60	5.88	5.64	0.07	..	..	48	hyposulfidic (S_{CR}<0.10%)
4.3	10-20	Fine	219	6.37	2.58	6.27	4.48	56	5.87	6.58	0.06	..	..	75	hyposulfidic (S_{CR}<0.10%)

Table 10-5. Summary of hydrochemical field measurements for Nigra Creek Wetland.

	pH	SEC	DO	Eh	Turbidity	Alkalinity
		µS cm^{-1}	mg l^{-1}	mV	NTU	as HCO_3
Surface waters (n=2)	7.08	216-217	5.94-6.98	226	317-322	78-80

Table 10-6. Hydrochemical data for Nigra Creek (Wetland ID. 12294).

Parameter	units	ANZECC Guidelines	Site 1 (SW)	Site 4 (SW)
Na	mg l^{-1}		16.7	16.8
K	mg l^{-1}		3.2	2.9
Ca	mg l^{-1}		7.25	5.82
Mg	mg l^{-1}		4.75	3.43
Si	mg l^{-1}		6.35	2.76
Br	mg l^{-1}		<0.05	<0.05
Cl	mg l^{-1}		31	20
NO_3	mg l^{-1}	0.7	0.328	0.421
NH_4-N^K	mg l^{-1}	0.01	**0.085**	**0.020**
PO_4^E	mg l^{-1}	0.02	**0.147**	**0.043**
SO_4	mg l^{-1}		7.2	4.6
Ag	µg l^{-1}	0.05	0.02	0.01
Al^A	µg l^{-1}	55	**2520**	**60**
As^B	µg l^{-1}	13	1.6	0.6
Cd	µg l^{-1}	0.2	0.02	0.08
Co	µg l^{-1}	2.8	0.8	0.06
Cr^C	µg l^{-1}	1	**1.6**	0.1
Cu^H	µg l^{-1}	1.4	**2.8**	1
Fe	µg l^{-1}	300	**2510**	129
Mn	µg l^{-1}	1700	39.18	4.8
Ni^H	µg l^{-1}	11	2.2	0.6
Pb^H	µg l^{-1}	3.4	2.7	0.1
Se	µg l^{-1}	11	<0.08	<0.08
Zn^H	µg l^{-1}	8	**34.4**	**48.2**
DOC	mg l^{-1}		6.7	3.2

Notes.

The ANZECC guideline values for toxicants refer to the trigger values applicable to 'slightly-moderately disturbed' freshwater systems, as outlined in the Australian Water Quality Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000). For the nutrients NH_4 and PO_4, trigger values are provided for Freshwater Lakes and reservoirs. Surface water values outside the ranges defined in the ANZECC guidelines are indicated with red text. (SW) and (PW) indicate whether the sample was taken from surface water or pit-water (groundwater that entered an excavated pit), respectively.

A *Trigger value for Aluminium in freshwater where pH > 6.5.*

B *Trigger value assumes As in solution as Arsenic (AsV).*

C *Trigger value for Chromium is applicable to Chromium (CrVI) only.*

E *Guideline is for filterable reactive phosphorous (FRP).*

H *Hardness affected (refer to Guidelines).*

K *Guideline for South-east Australia-Freshwater Lakes and reservoirs.*