

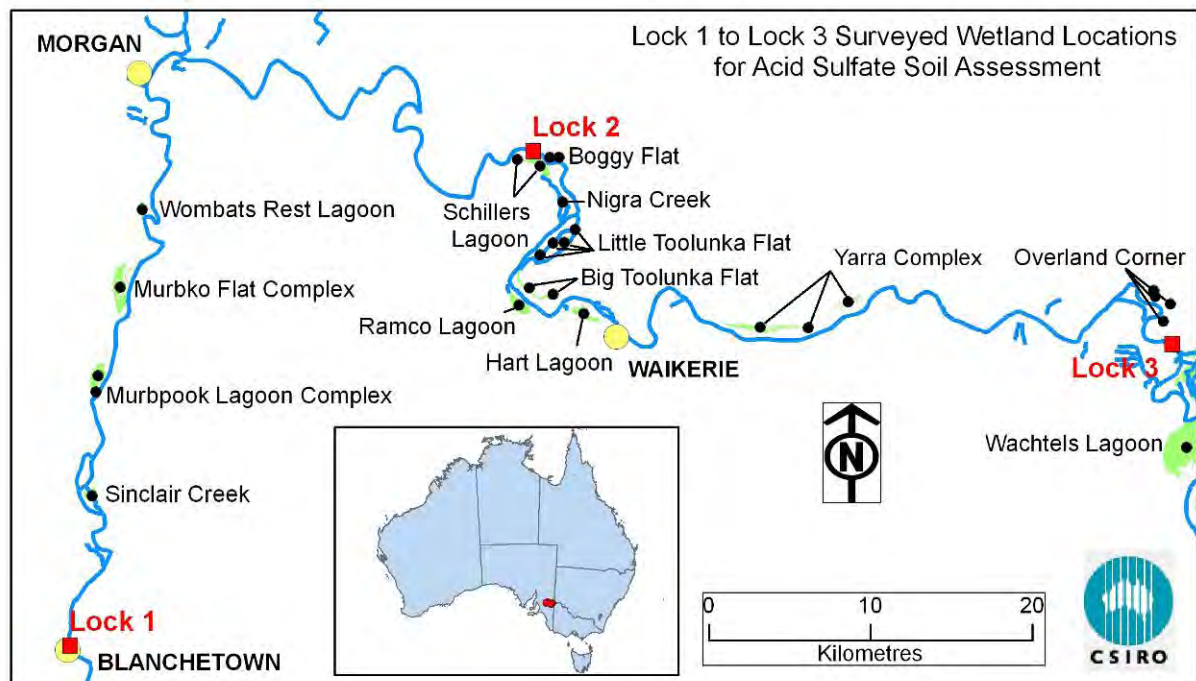
## APPENDIX B2

### DESCRIPTIONS FOR ASSESSED WETLANDS BETWEEN LOCK 2 AND LOCK 3

#### Table of Contents

1. Little Toolunka Flat (Wetland ID. 12209)	197
2. Little Toolunka Flat (Wetland ID. 12211)	209
3. Little Toolunka Flat (Wetland ID. 12212)	220
4. Little Toolunka Flat (Wetland ID. 12214)	235
5. Big Toolunka Flat (Wetland ID. 12063)	248
6. Big Toolunka Flat (Wetland ID. 12064)	257
7. Ramco Lagoon (Wetland ID. 12046)	271
8. Hart Lagoon (Wetland ID. 12006)	286
9. Yarra Complex (Wetland ID. 12605)	301
10. Yarra Complex (Wetland ID. 12606)	317
11. Yarra Complex Wetland (ID. 12608)	327
12. Overland Corner (Wetland ID. 12132)	339
13. Overland Corner (Wetland ID. 12133)	346
14. Overland Corner (Wetland ID. 12265)	354
15. Overland Corner (Wetland ID. 12272)	361

#### MAP SHOWING LOCATION OF WETLANDS BETWEEN LOCK 1 AND LOCK 3



# 1. LITTLE TOOLUNKA FLAT (WETLAND ID. 12209)

## 1.1. Location and setting description

Little Toolunka Flat (Wetland ID. 12209) is situated on the eastern side of the River Murray about 10 kilometres down river from the town of Waikerie, located in the Toolunka Complex area. The wetland is linear in shape forming part of a disconnected creek line occurring on the inside of a bend in the river. It is about 700 metres in length and about 50 metres at its widest, with a total surface area of 2 hectares. The wetland is bounded by a raised floodplain that separates the wetland from the river to the northwest and other wetlands in the complex. The other associated wetlands the Little Toolunka Flat Wetland Complex that were surveyed are wetlands ID. 12211, 12212, and 12214.

The wetland is not connected to the river. At the time when the soil survey was conducted in March 2010 the wetland had shallow surface water in the centre over a thick salt crust surface. The wetland is not managed. It has not received water since the 1990's. Sedgeland and grassland were growing along the wetland margins, with open woodland and shrubland on the surrounding higher floodplain. Three sites were sampled as shown in Figure 1-1.

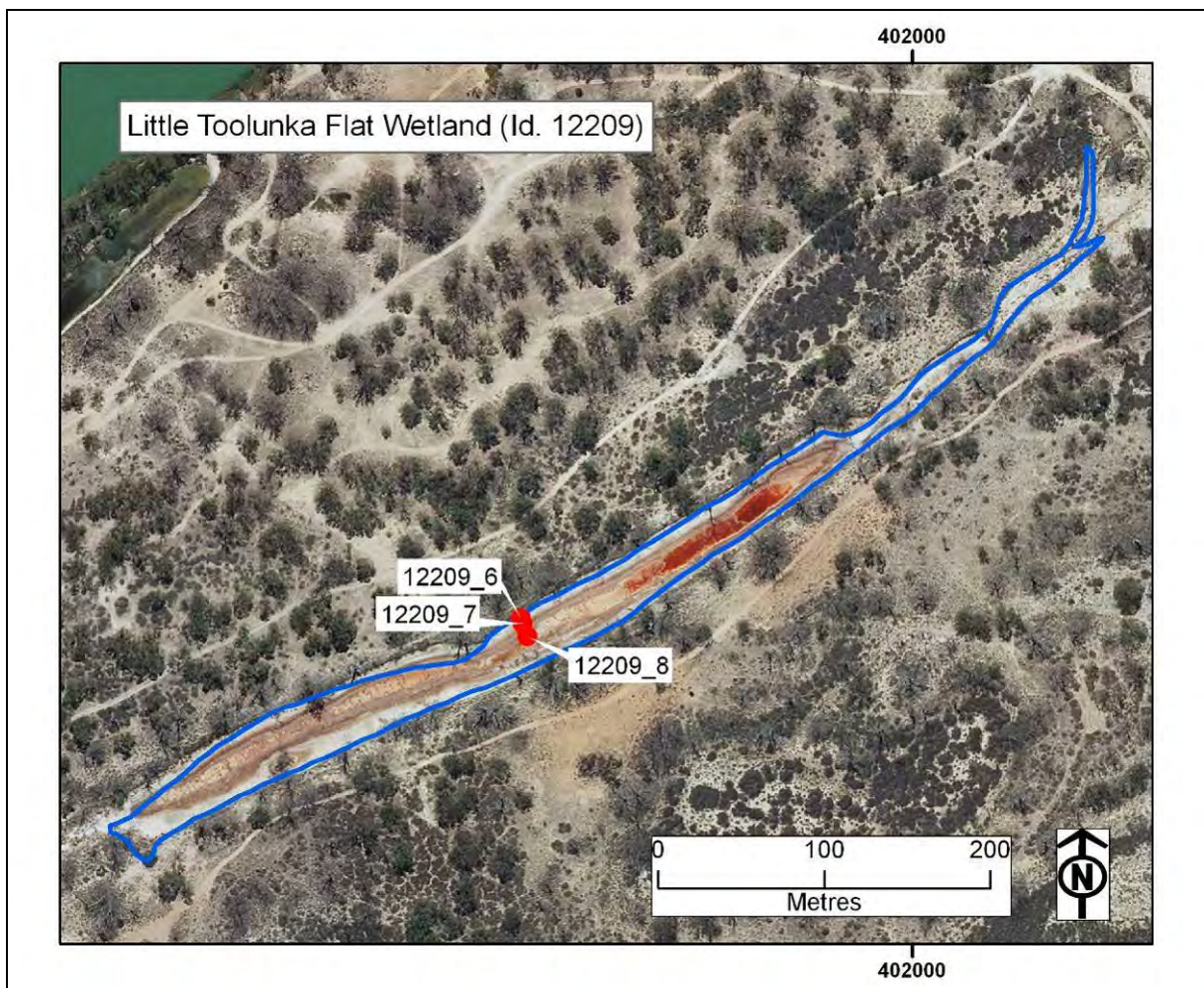


Figure 1-1. Little Toolunka Flat (Wetland ID. 12209) and sample site locations.

## 1.2. Soil profile description and distribution

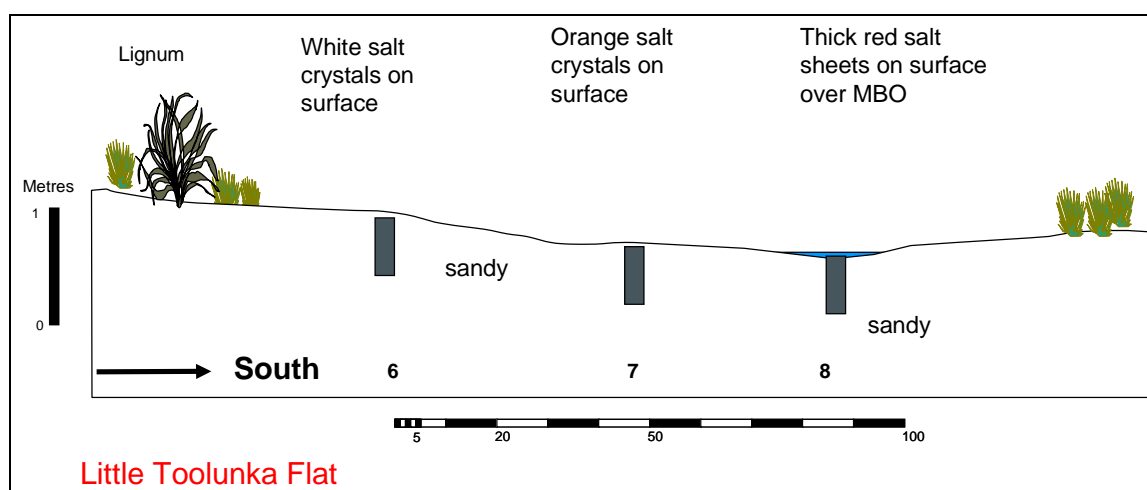
Three sites were described and sampled. The soil subtypes and general location descriptions are presented in Table 1-1. Sites were distributed along one transect across the wetland from the margin to the centre to provide a cross-section (Sites 6, 7 and 8) of the wetland. The site and soil profile descriptions are presented in Table 1-2 and Table 1-3, and a conceptual cross-section diagram in Figure 1-2.

### Centre transect

Site 6 (Figure 1-3) occurred on the wetland margin above the water level with a salt crust surface, and the soil consisted of a light grey, weak, sand, over a greenish grey, firm sand. Site 7 (Figure 1-4) occurred adjacent to the shoreline above the water level, with the water table in the pit at about 30 cm depth, and below the orange brown salt crusted surface was a thick black monosulfidic material, over an olive grey, very firm, sandy clay loam. Site 8 (Figure 1-5) occurred in the centre of the wetland in very shallow surface water (0 to 1 cm deep), and the soil consisted of a dark red salt crust, over a thick very weak black monosulfidic material, over an olive grey, firm, loamy sand.

**Table 1-1. Soil identification, subtype and general location description for Little Toolunka Flat (Wetland ID. 12209).**

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12209_6	401764	6222292	Other Soil (sandy)	high elevation, 4m to bank, salt crust surface
12209_7	401765	6222289	Hypersulfidic Soil (loamy)	mid elevation, next to shoreline, salt crust
12209_8	401768	6222281	Other Soil (sandy)	mid creek, low elevation, thick salt



**Figure 1-2. Conceptual cross-section diagram, showing location of Sites 6, 7 and 8.**



**Figure 1-3. Photographs of Site 6, showing the site location on the wetland margin looking across the wetland, the soil surface with white salt, and the soil profile.**



**Figure 1-4. Photographs of Site 7, showing the site location between the wet salt area to the right and the wetland margin, the soil surface was orange brown, and the soil profile.**

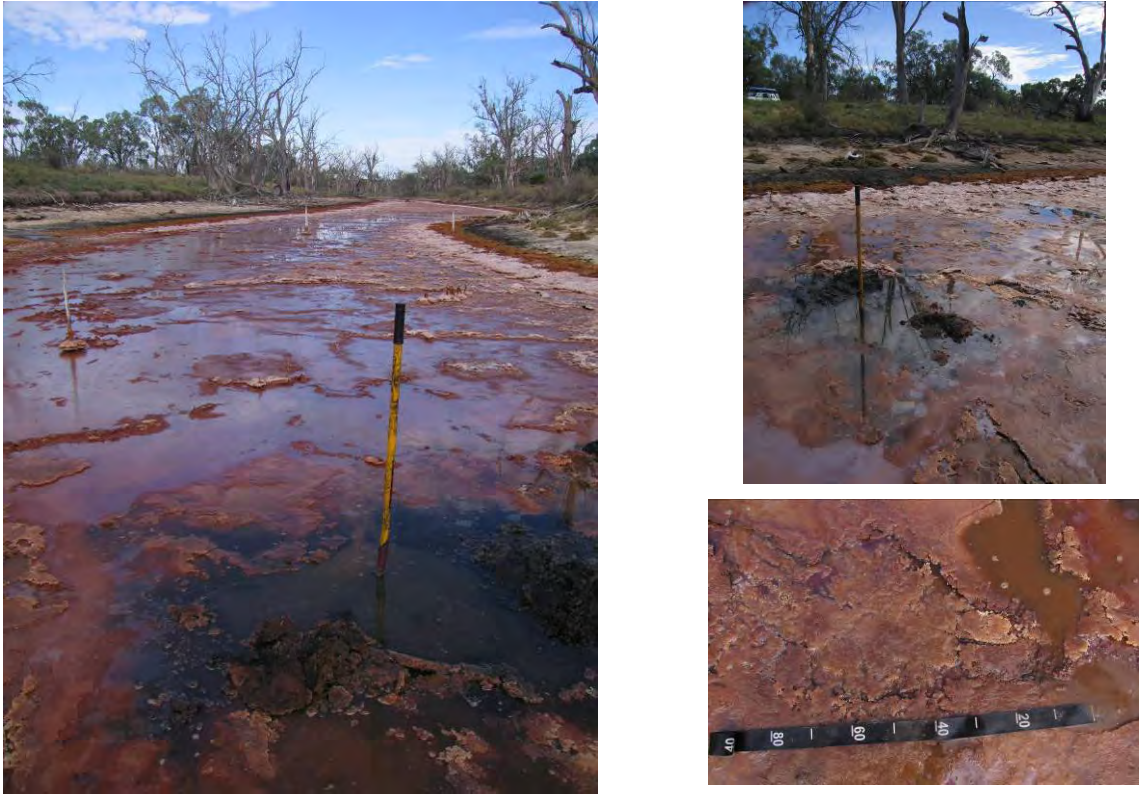


Figure 1-5. Photographs of Site 8, showing the site location placed in the centre of the wetland with shallow surface water, a view across the wetland width, and the thick reddish salt crust surface.

### 1.3. Laboratory data assessment

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

The pH data are provided in Table 1-4 and pH profiles are presented in Figure 1-6. The  $pH_W$  data ranged from 6.10 to 8.32 and sulfuric materials with a  $pH_W < 4$  were not identified. The  $pH_{OX}$  data ranged from 1.80 to 8.05 and identified that one sample in Profile 7 was below the critical value of  $pH_{OX} < 2.5$ , the threshold value normally used to indicate a high likelihood of sulfuric material forming. The  $pH_{INC}$  data ranged from 2.97 to 8.21 and identified that one soil sample in Profile 7 (the same sample with a critical  $pH_{OX}$  value) on incubation declined below the critical values of  $pH < 4$ , indicating that sulfuric material could potentially form on oxidation.

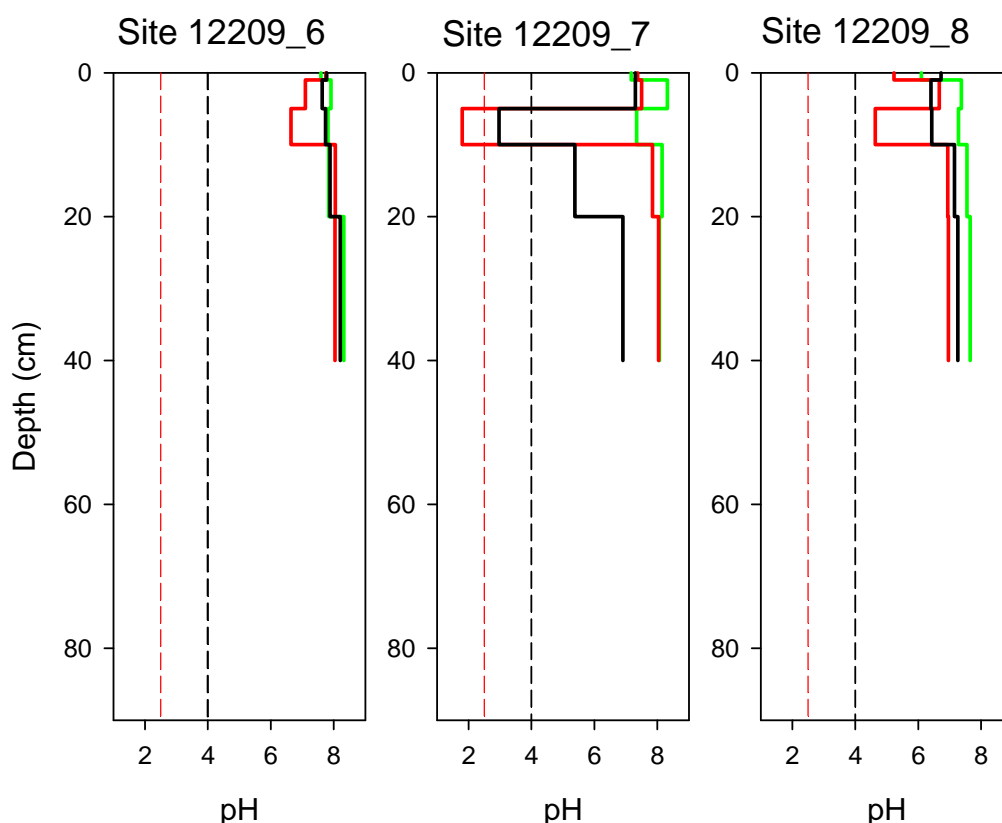


Figure 1-6. Depth profiles of soil pH for Little Toolunka Flat (Wetland ID. 12209), showing soil pH ( $pH_W$  as green line), peroxide treated pH ( $pH_{OX}$  as red line) and incubation pH ( $pH_{INC}$  after 8 weeks as black line). Critical  $pH_W$  and  $pH_{INC}$  value of 4 (black dashed line) and 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 1-7.

#### Chromium reducible sulfur

Chromium reducible sulfur values ranged from 0.01 to 0.37 % $S_{CR}$ , and sulfidic materials were detected in all soil layers except a subsoil layer in Profile 6.

#### Titrateable actual acidity

Titrateable actual acidity values were not detected in any of the samples.

#### Retained acidity

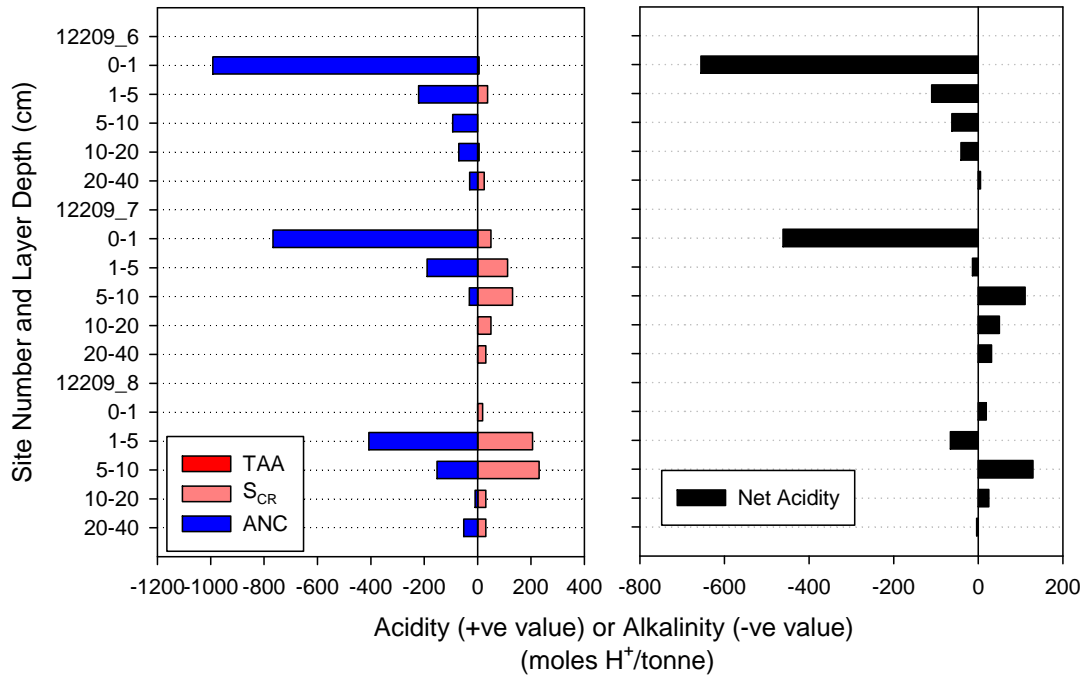
Retained acidity was not measured in any of the layers as all samples had a  $pH_{KCl}$  of greater than 4.5.

#### Acid neutralising capacity

Acid neutralising capacity values ranged from 0 to 4.97 % $CaCO_3$ , and were measured in nearly all samples.

#### Net acidity

Net acidity values ranged from -655 to 130 mole  $H^+$ /tonne. Profiles tended to have negative values for the surface samples and positive values in the subsoil. Moderate to high net acidity values occurred in the subsoils of Profiles 7 and 8.



**Figure 1-7. Acid base accounting depth profiles for Little Toolunka Flat (Wetland ID. 12209). 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.**

### 1.3.3. Water soluble sulfate

Water soluble sulfate data values shown in Table 1-4 identified that all surface layers were higher than the criterion trigger value of 100mg/kg  $SO_4$ .

### 1.3.4. Acid volatile sulfur

Monosulfidic materials were observed in Profile 8 and sampled for analysis. The values shown in Table 1-4 were above  $S_{AV} \geq 0.01\%$  S, the criteria value for identifying monosulfidic material.

### 1.3.5. Hydrochemistry

A single pit water sample was collected from this small wetland which had extensive precipitates of salt and Fe oxyhydroxide. The water was below a thin surface layer of salt, resting on thick halite. Field parameters are shown in Table 1-5. The surface water was moderately acidic and very saline. Dissolved oxygen was low, and turbidity moderate but this may be due to disturbance during sampling. Bicarbonate alkalinity was zero.

The surface water was of a very unusual type: Mg-Cl type water (Table 1-6, Figure 1-8). Sulfate concentrations in the surface water were high at  $500 \text{ mg l}^{-1}$ . The  $\text{SO}_4/\text{Cl}$  ratio in the water was very low (0.002) in comparison with seawater (0.142). Nitrate was moderately high, and  $\text{NH}_4$  and  $\text{PO}_4$  were much higher than ANZECC Guideline values. Iron was below detection limit (but the detection limit was high due to the dilution required due to the very high salinity) and Mn was extremely high. Detection limits were high for most metals, but elevated concentrations of Co, Ni and Zn were noted. Dissolved organic carbon concentration was very high.

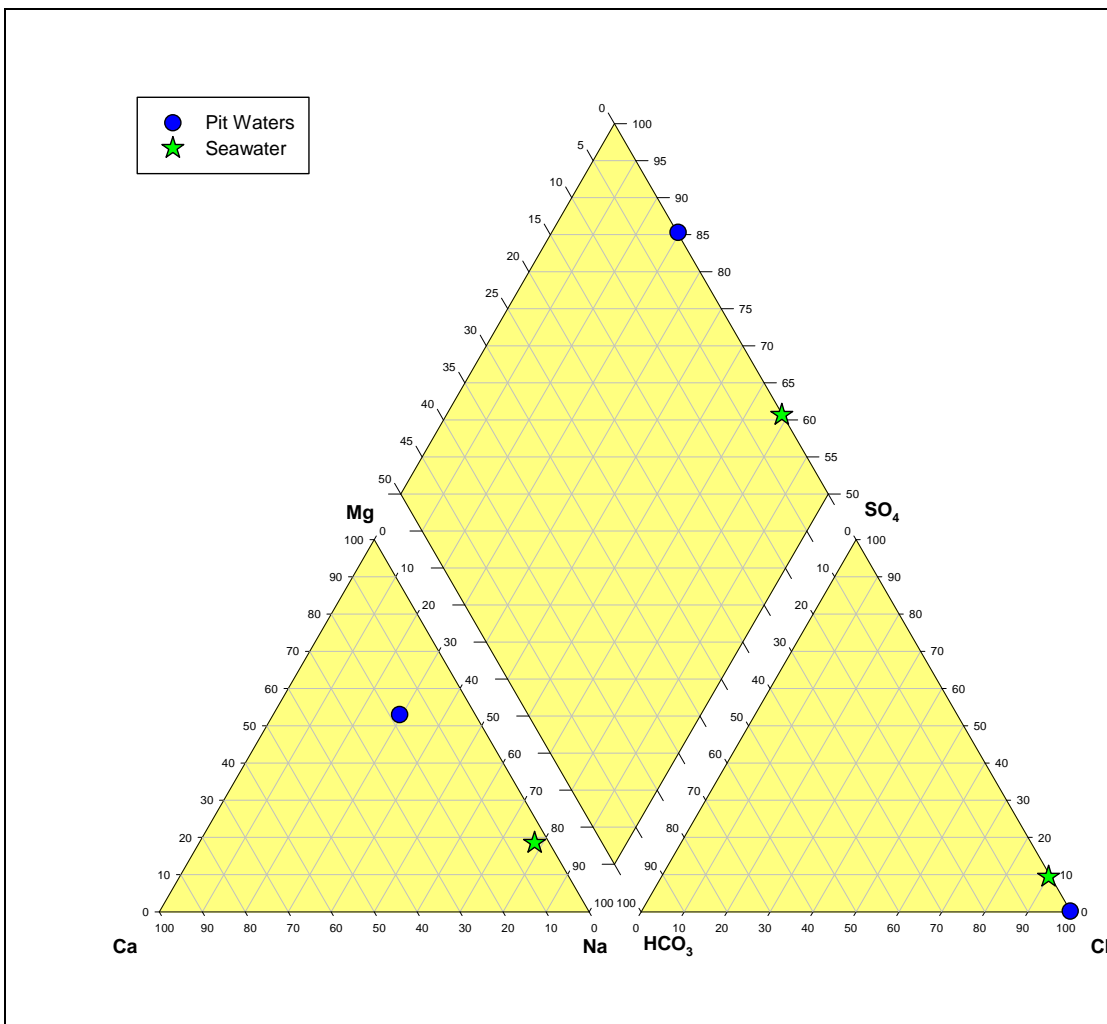


Figure 1-8. Piper diagram of hydrochemical data for Little Toolunka Flat (Wetland ID. 12209).



## 1.4. Discussion

Acid sulfate soil materials at Little Toolunka Flat (Wetland ID. 12209) were identified as hypersulfidic or hyposulfidic. The acid sulfate soil subtype classes identified were Hypersulfidic Soil (loamy) that occurred along the edge of the wetland adjacent to the thick salt crust, soils in the wetland below the salt crust and on the wetland margins were identified as Other Soil (sandy).

The soils throughout the wetland were loamy textured and in some areas the subsoils were clayey at depth. There was a very thick salt crust in the centre of the wetland, and black monosulfidic material occurred below the salt crust.

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

The potential hazards posed by acid sulfate soil materials at Little Toolunka Flat (Wetland ID. 12209) are:

- Acidification hazard: The data identified moderate or high net acidity values in the subsoils and pH data identified one sample with values that indicated a potential acidification hazard due to oxidation. There is a medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data and observed monosulfidic material indicated that there is potential for monosulfidic materials to form in the surface layers of soils. There is a high level of concern.
- Metal mobilisation: The medium acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

### Summary of key findings Little Toolunka Flat (Wetland ID. 12209):

<b>Soil materials:</b>	The soil layers throughout the wetland were generally hyposulfidic, with a hypersulfidic layer identified in one profile. Soils were loamy textured throughout the profile. Moderate or high net acidity values occurred in some of the subsoil layers and pH data identified samples that indicated a potential for acidification due to oxidation.
<b>Acid sulfate soil identification:</b>	<ul style="list-style-type: none"> <li>• Hypersulfidic Soil (loamy) – occurring parallel to the thick salt crust above the water level and below the wetland margin. Minor (&lt;25%) in extent.</li> <li>• Other Soil (sandy) – occurring on the margins of the wetland and in the centre of the wetland. Dominant (&gt;50%) in extent.</li> </ul>
<b>Hazard assessment</b>	<ul style="list-style-type: none"> <li>• Acidification hazard – medium level of concern</li> <li>• De-oxygenation hazard – high level of concern</li> <li>• Metal mobilisation hazard – medium level of concern</li> </ul>

**Table 1-2. Site description data for Little Toolunka Flat (Wetland ID. 12209).**

<b>Site Number</b>	<b>Sample Date</b>	<b>Easting m Zone 54H</b>	<b>Northing m Zone 54H</b>	<b>Water depth (+ve) Water table (-ve)</b>	<b>Surface condition</b>	<b>Earth cover (vegetation)</b>	<b>Location Notes</b>
6	27/03/2010	401764	6222292	not reached	firm, salt crust	bare	high elevation, 4m to bank, salt crust surface
7	27/03/2010	401765	6222289	-30	salt crust	bare	mid elevation, next to shoreline, salt crust
8	27/03/2010	401768	6222281	0	thick salt	bare	mid creek, low elevation, thick salt

**Table 1-3. Soil profile description data for Little Toolunka Flat (Wetland ID. 12209).**

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_0	0 - 0.5	surface salt scrap		salt			crystalline	weak	white salt crystals
6_1	0 - 1	small pit	light grey (10YR7/2)	sand	dry		massive	weak	
6_2	1 - 5	small pit	light grey (10YR7/2)	sand	dry	5% dark brown In the matrix	massive	firm	
6_3	5 - 10	small pit	grey (5Y6/1)	sand	dry		massive	firm	
6_4	10 - 20	small pit	greenish gray (10Y6/1)	sand	dry		massive	firm	
6_5	20 - 40	small pit	greenish gray (10Y6/1)	sand	dry		massive	very firm	
7_0	0 - 0.5	surface salt scrap		salt			crystalline	weak	orange crystals from pit possibly gypsum
7_0	0 - 0.5	surface salt scrap		salt			crystalline	weak	bright red crystals adjacent to pit, possibly akaganeite
7_1	0 - 1	small pit	reddish brown (2.5YR4/4)	salt	dry		crystalline	weak	
7_2	1 - 5	small pit	black (2.5Y2/0)	monosulfidic black ooze	moist		massive	firm	
7_3	5 - 10	small pit	dark greyish brown (2.5Y4/2)	loamy sand	moist		massive	firm	
7_4	10 - 20	small pit	olive grey (5Y5/2)	sandy loam	moist		massive	firm	
7_5	20 - 40	small pit	olive grey (5Y5/2)	sandy clay loam	moist		massive	very firm	too hard to dig and auger below this
8_0	0 - 0.5	surface salt scrap		salt			crystalline	weak	white salt crystals
8_0	0 - 0.5	surface salt scrap		salt			crystalline	weak	red platy salt crystals
8_1	0 - 1	small pit	dark red (2.5YR3/6)	salt	dry		platy	weak	probably halite
8_2	1 - 5	small pit	black (2.5Y2/0)	monosulfidic black ooze	wet		gel	weak	
8_3	5 - 10	small pit	very dark greyish brown (2.5Y3/2)	monosulfidic black ooze	wet		gel	weak	
8_4	10 - 20	small pit	olive grey (5Y5/2)	loamy sand	wet		massive	weak	
8_5	20 - 40	small pit	olive grey (5Y5/2)	loamy sand	wet		massive	weak	too much water and difficult to recover sample
8_W1	-	pit water							water sampled

**Table 1-4. Laboratory data for acid sulfate soil assessment of Little Toolunka Flat (Wetland ID. 12209).**

(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 <sub>4</sub> /kg)	pH KCl	Titrateable Actual Acidity (mole H <sup>+</sup> /tonne)	Chromium Reducible Sulfur (%S <sub>CR</sub> )	Acid Neutralising Capacity (%CaCO <sub>3</sub> )	Net Acidity (mole H <sup>+</sup> /tonne)	Acid Volatile Sulfur (%S <sub>av</sub> )	Acid Sulfate Soil Material Classification
6.0	0-0.5	..	..	..	..	..	..	..	..	..	..	..	..	..	salt crust
6.1	0-1	Medium	11,590	7.59	7.75	7.74	7.77	2,700	8.56	0.00	0.01	4.97	-655	..	hyposulfidic (S <sub>CR</sub> <0.10%)
6.2	1-5	Medium	4,290	7.91	7.10	7.75	7.63	140	9.21	0.00	0.06	1.11	-110	..	hyposulfidic (S <sub>CR</sub> <0.10%)
6.3	5-10	Medium	6,610	7.81	6.64	7.79	7.74	190	9.01	0.00	<0.01	0.47	-62	..	other soil material
6.4	10-20	Medium	4,970	7.84	8.05	7.90	7.88	170	8.71	0.00	0.01	0.35	-41	..	hyposulfidic (S <sub>CR</sub> <0.10%)
6.5	20-40	Medium	3,360	8.32	8.04	8.21	8.21	130	8.11	0.00	0.04	0.15	5	..	hyposulfidic (S <sub>CR</sub> <0.10%)
7.0	0-0.5	..	..	..	..	..	..	..	..	..	..	..	..	..	salt crust
7.0	0-0.5	..	..	..	..	..	..	..	..	..	..	..	..	..	salt crust
7.1	0-1	Coarse	41,600	7.17	7.37	7.04	7.30	4,200	7.88	0.00	0.08	3.84	-461	..	hyposulfidic (S <sub>CR</sub> <0.10%)
7.2	1-5	Medium	8,750	8.32	7.50	7.76	7.30	2,200	8.32	0.00	0.18	0.95	-14	..	hyposulfidic (S <sub>CR</sub> ≥0.10%)
7.3	5-10	Medium	8,230	7.34	1.80	7.37	2.97	330	8.34	0.00	0.21	0.15	111	..	hypersulfidic
7.4	10-20	Medium	5,070	8.15	7.85	7.61	5.38	180	7.79	0.00	0.08	0.00	50	..	hyposulfidic (S <sub>CR</sub> <0.10%)
7.5	20-40	Medium	4,200	8.06	8.04	7.22	6.91	260	7.60	0.00	0.05	0.00	31	..	hyposulfidic (S <sub>CR</sub> <0.10%)
8.0	0-0.1	..	..	..	..	..	..	..	..	..	..	..	..	..	salt crust
8.0	0.1-0.5	..	..	..	..	..	..	..	..	..	..	..	..	..	salt crust
8.1	0-1	salt	185,000	6.10	5.23	7.14	6.73	380	7.12	0.00	0.03	0.00	19	..	hyposulfidic (S <sub>CR</sub> <0.10%)
8.2	1-5	Medium	18,170	7.37	6.67	6.13	6.41	2,800	7.20	0.00	0.33	2.04	-66	0.25	hyposulfidic (S <sub>CR</sub> ≥0.10%)
8.3	5-10	Fine	42,700	7.28	4.64	6.20	6.43	3,300	7.74	0.00	0.37	0.76	130	0.23	hyposulfidic (S <sub>CR</sub> ≥0.10%)
8.4	10-20	Medium	13,130	7.55	6.94	6.76	7.15	320	7.22	0.00	0.05	0.04	25	..	hyposulfidic (S <sub>CR</sub> <0.10%)
8.5	20-40	Fine	11,730	7.65	6.96	6.45	7.26	280	6.97	0.00	0.05	0.26	-4	..	hyposulfidic (S <sub>CR</sub> <0.10%)
8.W1	-	..	..	..	..	..	..	..	..	..	..	..	..	..	pit water

**Table 1-5. Summary of hydrochemical field measurements for Little Toolunka Flat (Wetland ID. 12209).**

	pH	SEC µS cm <sup>-1</sup>	DO mg l <sup>-1</sup>	Eh mV	Turbidity NTU	Alkalinity as HCO <sub>3</sub>
Pit waters (n=1)	5.59	165184	0.26	208	25	0

**Table 1-6. Hydrochemical data for Little Toolunka Flat (Wetland ID. 12209).**

Parameter	units	ANZECC Guidelines	Site 8 (PW)
Na	mg l <sup>-1</sup>		36200
K	mg l <sup>-1</sup>		634
Ca	mg l <sup>-1</sup>		19100
Mg	mg l <sup>-1</sup>		34900
Si	mg l <sup>-1</sup>		<25
Br	mg l <sup>-1</sup>		1200.0
Cl	mg l <sup>-1</sup>		210000
NO <sub>3</sub>	mg l <sup>-1</sup>	0.7	0.531
NH <sub>4</sub> -N <sup>K</sup>	mg l <sup>-1</sup>	0.01	<b>7.00</b>
PO <sub>4</sub> -P <sup>E</sup>	mg l <sup>-1</sup>	0.005	<b>0.368</b>
SO <sub>4</sub>	mg l <sup>-1</sup>		500
Ag	µg l <sup>-1</sup>	0.05	<0.4
Al <sup>A</sup>	µg l <sup>-1</sup>	55	<1000
As <sup>B</sup>	µg l <sup>-1</sup>	13	<20
Cd	µg l <sup>-1</sup>	0.2	<1
Co	µg l <sup>-1</sup>	2.8	<b>3.6</b>
Cr <sup>C</sup>	µg l <sup>-1</sup>	1	<5
Cu <sup>H</sup>	µg l <sup>-1</sup>	1.4	<20
Fe	µg l <sup>-1</sup>	300	<50000
Mn	µg l <sup>-1</sup>	1700	<b>673000</b>
Ni <sup>H</sup>	µg l <sup>-1</sup>	11	<b>30.0</b>
Pb <sup>H</sup>	µg l <sup>-1</sup>	3.4	<10
Se	µg l <sup>-1</sup>	11	<8
Zn <sup>H</sup>	µg l <sup>-1</sup>	8	<b>200</b>
DOC	mg l <sup>-1</sup>		180

**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<sub>4</sub> and PO<sub>4</sub>, 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.

<sup>A</sup> Trigger value for Aluminium in freshwater where pH > 6.5.

<sup>B</sup> Trigger value assumes As in solution as Arsenic (AsV).

<sup>C</sup> Trigger value for Chromium is applicable to Chromium (CrVI) only.

<sup>E</sup> Guideline is for filterable reactive phosphorous (FRP).

<sup>H</sup> Hardness affected (refer to Guidelines).

<sup>K</sup> Guideline for South-east Australia-Freshwater Lakes and reservoirs.

## 2. LITTLE TOOLUNKA FLAT (WETLAND ID. 12211)

### 2.1. Location and setting description

Little Toolunka Flat (Wetland ID. 12211) is situated on the eastern side of the River Murray about 10 kilometres down river from the town of Waikerie, located in the Toolunka Complex area. The wetland is irregular in shape forming part of a wetland complex that occurs on the inside of a bend in the river. It is about 1.5 kilometres in length and about 200 metres at its widest, with a total surface area of 15 hectares. The wetland is bounded by a raised floodplain that separates the wetland from the river to the northwest and other wetlands in the complex. The other associated wetlands in the Little Toolunka Flat Complex that were surveyed are wetland IDs. 12209, 12212, and 12214.

The wetland is not connected to the river. At the time when the soil survey was conducted in March 2010 the wetland had no surface water. The wetland is not managed. It probably has not received river water since the 1990's. Sedgeland and grassland was growing along the wetland margins, with open woodland and shrubland on the surrounding higher floodplain. Three sites were sampled as shown in Figure 2-1.

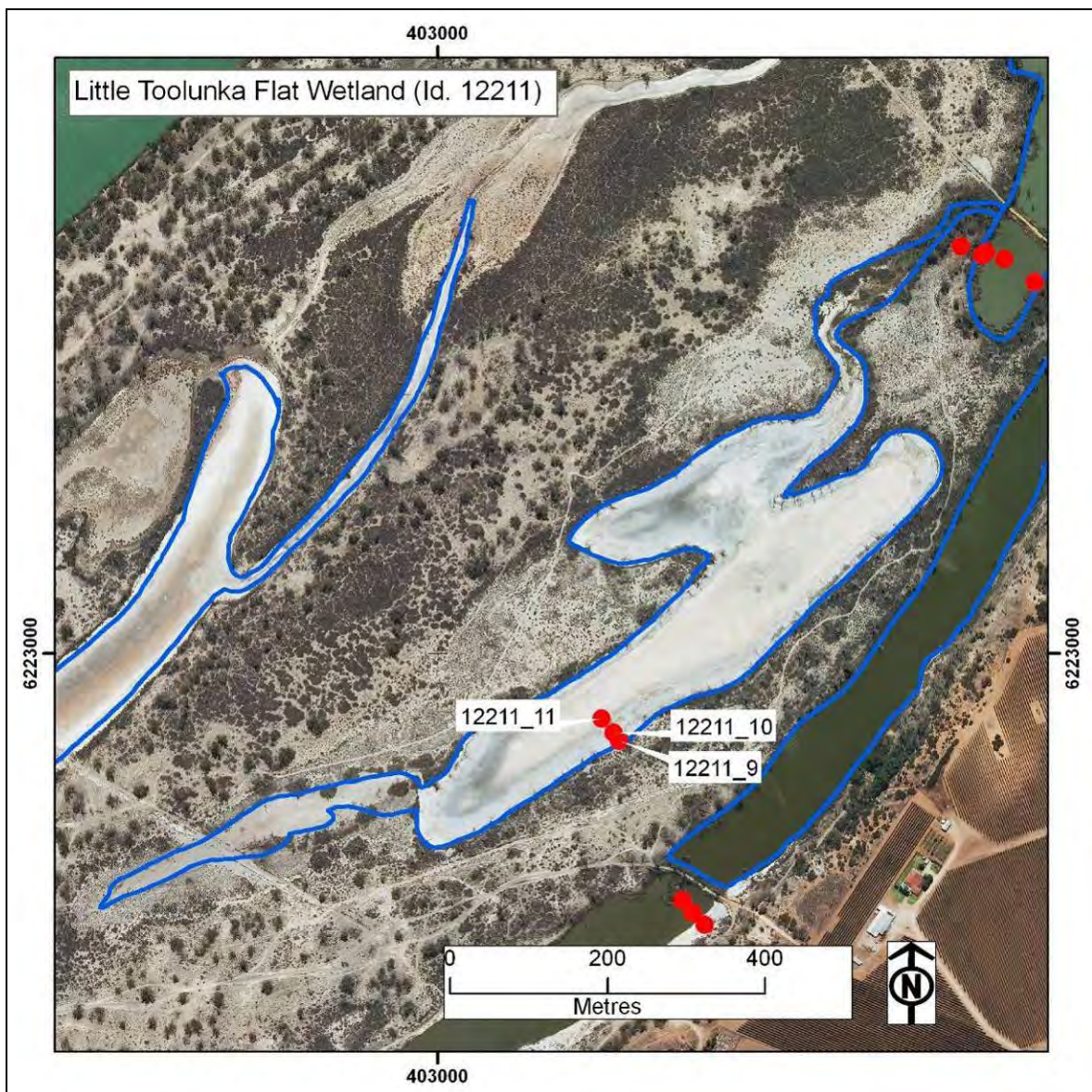


Figure 2-1. Little Toolunka Flat (Wetland ID. 12211) and sample site locations.

## 2.2. Soil profile description and distribution

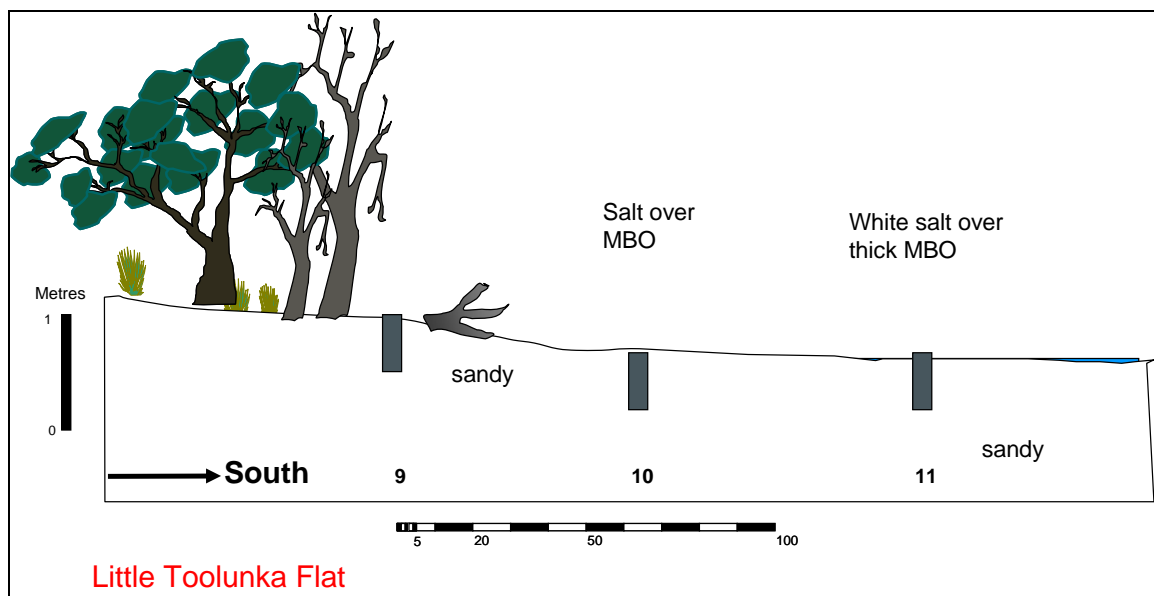
Three sites were described and sampled. The soil subtypes and general location descriptions are presented in Table 2-1. Sites were distributed from the margin to the middle of the wetland to provide a cross-section, with one transect placed near the centre of the wetland (Sites 9, 10 and 11). The site and soil profile descriptions are presented in Table 2-2 and Table 2-3, and a conceptual cross-section diagram in Figure 2-2.

### Centre transect

Site 9 (Figure 2-3) occurred on the wetland margin above the water level where there was a salt crust surface, with the water table at about 60 cm depth, over a dark grey, firm, loamy sand to sandy loam in the subsoil. Site 10 (Figure 2-4) occurred adjacent to the shoreline above the water level, with the water table in the pit at about 30 cm depth, and the soil consisted of a salt crust over a thick, very weak, black monosulfidic material, over a dark grey, weak, clay. Site 11 (Figure 2-5) occurred in the centre of the wetland, with the water table in the pit at about 3 cm depth, and the soil consisted of a thick white salt crust, over a very weak, very thick black monosulfidic material, over a dark grey, firm, sandy clay loam.

**Table 2-1. Soil identification, subtype and general location description for Little Toolunka Flat (Wetland ID. 12211).**

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12211_9	403231	6222889	Other Soil (sandy)	high elevation, shoreline, with surface salt crust
12211_10	403224	6222899	Other Soil (clayey)	mid elevation, shoreline and before main salt crust
12211_11	403209	6222917	Other Soil (loamy)	low elevation, mid point



**Figure 2-2. Conceptual cross-section diagram, showing locations of Sites 9, 10 and 11.**



**Figure 2-3. Photographs of Site 9, showing the site location on the wetland margin, and the soil profile.**



**Figure 2-4. Photographs of Site 10, showing the site location in the wetland with a salt crust on the surface, the soil surface photo shows very weak upper layers that cannot support a person.**



**Figure 2-5. Photographs of Site 11, showing the site location placed in the centre of the wetland, the surface is a thick salt crust, the photograph on the right shows the very weak black monosulfide material that occurs under the salt crust appearing in areas that were disturbed by walking.**



## 2.3. Laboratory data assessment

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

The pH data are provided in Table 2-4 and pH profiles are presented in Figure 2-6. The  $pH_W$  data ranged from 7.02 to 8.63 and sulfuric materials with a  $pH_W < 4$  were not identified. The  $pH_{OX}$  data ranged from 2.04 to 7.86 and identified that one subsurface sample in Profile 10 was below the critical value of  $pH_{OX} < 2.5$ , the threshold value normally used to indicate a high likelihood of sulfuric material forming. The  $pH_{INC}$  data ranged from 6.42 to 7.87 and identified no samples on incubation declined below the critical values of  $pH < 4$ .

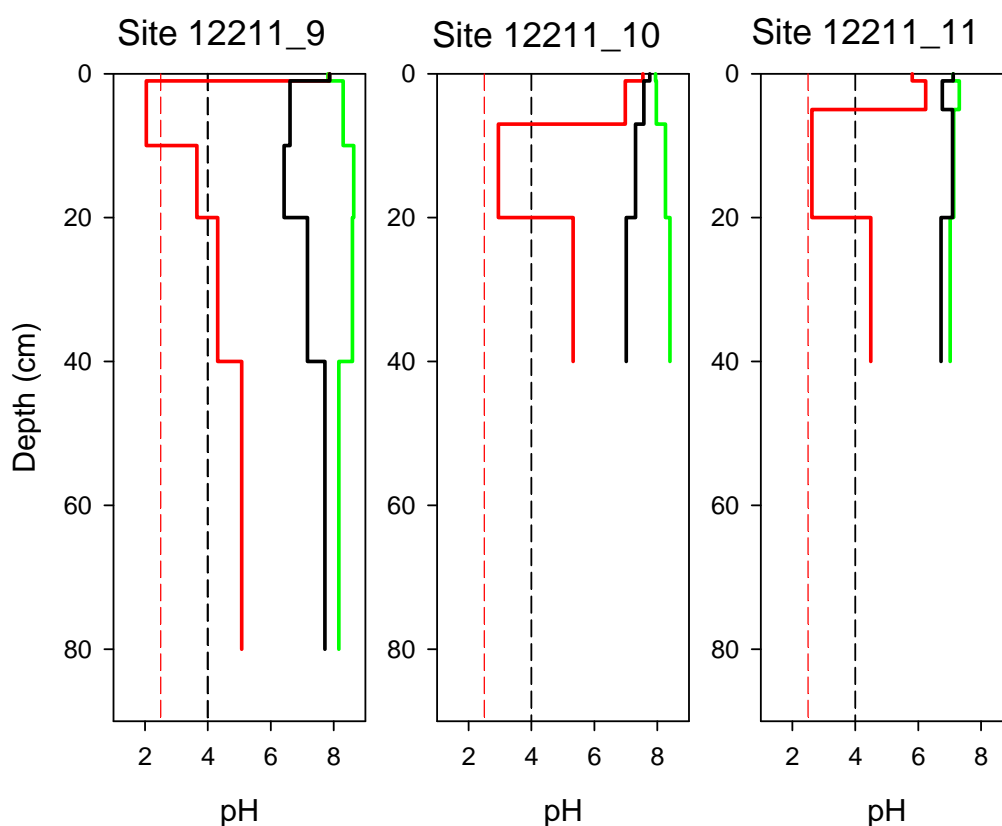


Figure 2-6. Depth profiles of soil pH for Little Toolunka Flat (Wetland ID. 12211), showing soil pH ( $pH_W$  as green line), peroxide treated pH ( $pH_{OX}$  as red line) and incubation pH ( $pH_{INC}$  after 8 weeks as black line). Critical  $pH_W$  and  $pH_{INC}$  value of 4 (black dashed line) and 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 2-4 and summarised in Figure 2-7.

#### Chromium reducible sulfur

Chromium reducible sulfur values ranged from 0.02 to 1.92 % $S_{CR}$  and sulfidic materials were detected in all soil layers.

#### Titrateable actual acidity

Titrateable actual acidity was not detected in any of the layers sampled.

#### Retained acidity

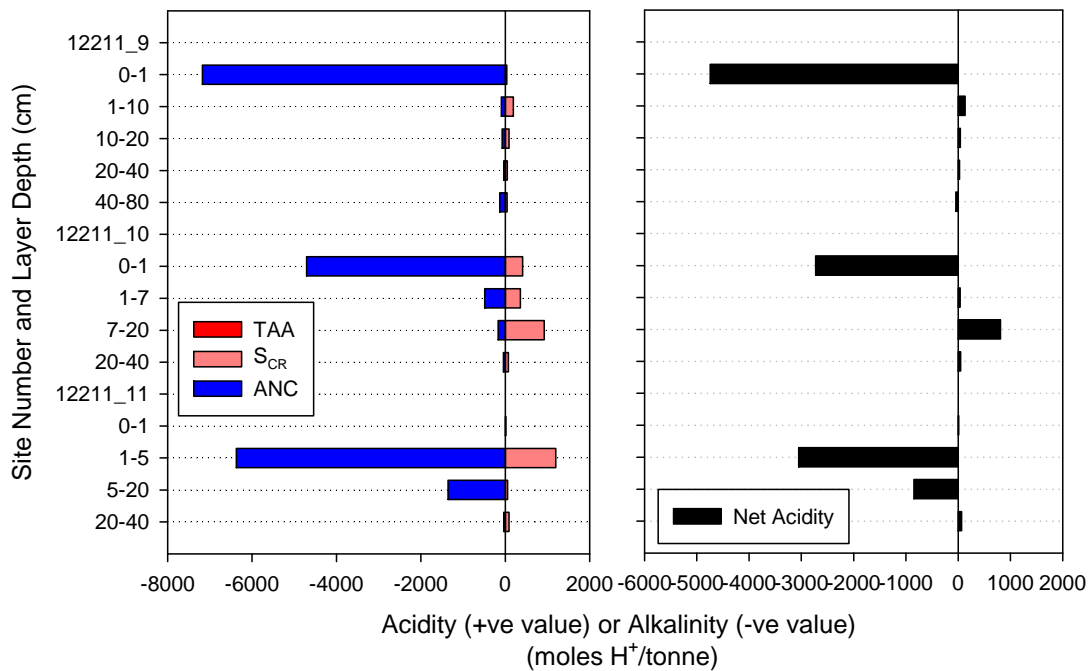
Retained acidity was not measured in any of the layers as all samples had a  $pH_{KCl}$  of greater than 4.5.

### Acid neutralising capacity

Acid neutralising capacity values ranged from 0 to 35.90 %CaCO<sub>3</sub> and were measured in nearly all samples.

### Net acidity

Net acidity values ranged from -4745 to 809 mole H<sup>+</sup>/tonne. Profiles tended to have negative values for the surface layers and moderate or high values in the subsoil.



**Figure 2-7. Acid base accounting depth profiles for Little Toolunka Flat (Wetland ID. 12211).** Left side shows the components: Titratable actual acidity (TAA - red bar), acid generating potential (AGP as S<sub>CR</sub> - 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 that surface layers for all three profiles were above the criterion trigger value of 100 mg/kg SO<sub>4</sub>.

### 2.3.4. Acid volatile sulfur

Monosulfidic materials were observed in the upper layers of Profiles 10 and 11 and sampled for analysis. The values shown in Table 2-4 were all above S<sub>AV</sub> ≥0.01% S, the criteria value for identifying monosulfidic material.

### 2.3.5. Hydrochemistry

A surface water and a pit water sample were collected from the transect. Field parameters are shown in Table 2-5. The surface water had circumneutral pH (7.16) and was hypersaline. The water was relatively low in dissolved oxygen and turbidity whilst alkalinity was high.

The SEC for the pit water was slightly higher than in the surface water. The pH was slightly acidic, and DO and Eh were low (but have likely been modified by contact with the atmosphere). Alkalinity was high, but slightly lower than the surface water.

All water samples were of Na-Cl type (Table 2-6, Figure 2-8). Sulfate concentration in the surface water was 13000 mg l<sup>-1</sup>, and for the pit water 250000 mg l<sup>-1</sup>. The SO<sub>4</sub>/Cl ratio in the surface water was 0.07, and in the pit water 0.04, much lower than seawater (0.142). Nitrate concentrations were low, and NH<sub>4</sub> and PO<sub>4</sub> concentrations were high. Iron was below the detection limit, but this was very high due to dilutions required for analysis, and Mn was very high. The detection limits for metals was high due to the need for sample dilution, however elevated concentrations of Zn were still noted. Dissolved organic carbon concentrations were very high in both samples.

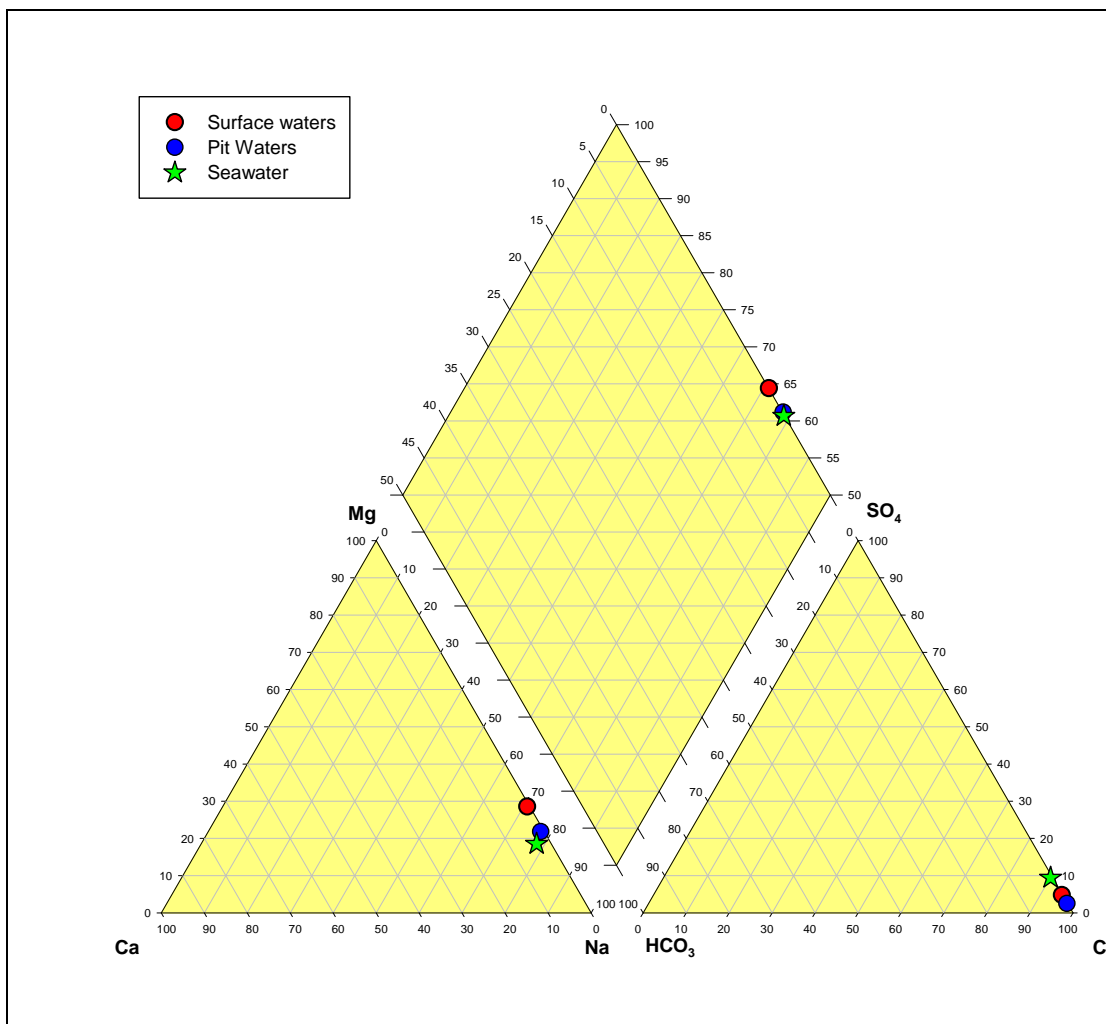


Figure 2-8. Piper diagram of hydrochemical data for Little Toolunka Flat (Wetland ID. 12211).

## 2.4. Discussion

Acid sulfate soil materials at Little Toolunka Flat (Wetland ID. 12211) were identified as hyposulfidic. The acid sulfate soil subtype class identified was Other Soil (clayey or loamy or sandy)

The soils throughout the wetland were clayey textured. There was a very thick salt crust in the centre of the wetland, and black monosulfidic material occurred below the salt crust. The soil electrical conductivity was very high throughout the soil profiles.

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

The potential hazards posed by acid sulfate soil materials at Little Toolunka Flat (Wetland ID. 12211) are:

- Acidification hazard: The data identified moderate or high net acidity values in the subsoil layers, 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 and the observed thick black monosulfidic material indicated that there is potential for monosulfidic materials to form in the surface layers of soils. There is a high level of concern.
- Metal mobilisation: The medium acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

### Summary of key findings Little Toolunka Flat (Wetland ID. 12211):

<b>Soil materials:</b>	The soil layers throughout the wetland were hyposulfidic. There was a salt crust on the surface becoming thicker towards the wetland centre, and soils were clayey textured. Profiles had a moderate or high net acidity values in the subsoil layers and pH data did not indicate a potential for acidification due to oxidation.
<b>Acid sulfate soil identification:</b>	<ul style="list-style-type: none"> <li>• Other Soil (clayey or loamy or sandy) – occurring throughout the wetland. Dominant (&gt;50%) in extent.</li> </ul>
<b>Hazard assessment</b>	<ul style="list-style-type: none"> <li>• Acidification hazard – medium level of concern</li> <li>• De-oxygenation hazard – high level of concern</li> <li>• Metal mobilisation hazard – medium level of concern</li> </ul>

**Table 2-2. Site description data for Little Toolunka Flat (Wetland ID. 12211).**

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	27/03/2010	403231	6222889	-60	salt crust	dead trees	high elevation, shoreline, with surface salt crust
10	27/03/2010	403224	6222899	-30	salt crust, water, soft	bare	mid elevation, shoreline and before main salt crust
11	27/03/2010	403209	6222917	-3	crusted, weak	bare	low elevation, mid point

**Table 2-3. Soil profile description data for Little Toolunka Flat (Wetland ID. 12211).**

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_0	0 - 0.5	surface salt scrap		salt			crystalline	weak	white salt crystals collected from sheltered area adjacent to dead tree
9_1	0 - 1	small pit	white (10YR8/1)	salt	dry		crystalline	very weak	white salt crystals
9_2	1 - 10	small pit	dark greyish brown (10YR4/2)	sandy loam	moist	25% dark brown in the matrix	massive	firm	possible jarosite present
9_3	10 - 20	small pit	dark grey (5Y4/1)	loamy sand	moist		massive	firm	
9_4	20 - 40	small pit	dark grey (5Y4/1)	loamy sand	moist		massive	firm	
9_5	40 - 80	small pit	dark grey (5Y4/1)	sandy loam	wet		massive	firm	
10_0	0 - 0.2	surface salt scrap		salt			crystalline	weak	white salt crust
10_1	0 - 1	small pit	white (10YR8/1)	salt	moist		crystalline	very weak	
10_2	1 - 7	small pit	dark grey (5Y4/1)	monosulfidic black ooze	moist		massive	very weak	
10_3	7 - 20	small pit	dark grey (5Y4/1)	clay	moist		massive	very weak	
10_4	20 - 40	small pit	dark grey (5Y4/1)	clay	wet		massive	weak	too difficult to auger and too dangerous to safely stay at site
11_W1	0 - 0	surface water							surface water discharge area, water sampled
11_W2	-	pit water							water sampled
11_0	0 - 0.5	surface salt scrap		salt			crystalline	weak	white salts at surface
11_1	0 - 1	small pit	pinkish grey (7.5YR6/2)	salt	moist		crystalline	weak	white salts at surface
11_2	1 - 5	small pit	black (2.5Y2/0)	monosulfidic black ooze	wet		gel	very weak	contains some salt crystals
11_3	5 - 20	small pit	very dark grey (5Y3/1)	monosulfidic black ooze	wet		gel	very weak	
11_4	20 - 40	push tube	very dark grey (5Y3/1)	sandy clay loam	wet		massive	firm	

**Table 2-4. Laboratory data for acid sulfate soil assessment of Little Toolunka Flat (Wetland ID. 12211).**

(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 <sub>4</sub> /kg)	pH KCl	Titrateable Actual Acidity (mole H <sup>+</sup> /tonne)	Chromium Reducible Sulfur (%S <sub>CR</sub> )	Acid Neutralising Capacity (%CaCO <sub>3</sub> )	Net Acidity (mole H <sup>+</sup> /tonne)	Acid Volatile Sulfur (%Sav)	Acid Sulfate Soil Material Classification
9.0	0-0.5	..	..	..	..	7.68	7.70	..	..	..	..	..	..	..	salt crust
9.1	0-1	Medium	31,600	7.81	7.86	7.54	7.87	6,200	8.77	0.00	0.06	35.90	-4745	..	hyposulfidic (S <sub>CR</sub> <0.10%)
9.2	1-10	Fine	13,270	8.30	2.04	7.01	6.61	520	8.02	0.00	0.31	0.46	133	..	hyposulfidic (S <sub>CR</sub> ≥0.10%)
9.3	10-20	Fine	3,820	8.63	3.65	7.63	6.42	260	7.79	0.00	0.14	0.36	40	..	hyposulfidic (S <sub>CR</sub> ≥0.10%)
9.4	20-40	Fine	3,250	8.59	4.31	7.84	7.16	230	7.48	0.00	0.08	0.18	26	..	hyposulfidic (S <sub>CR</sub> <0.10%)
9.5	40-80	Fine	4,340	8.16	5.07	7.44	7.72	300	7.73	0.00	0.07	0.65	-43	..	hyposulfidic (S <sub>CR</sub> <0.10%)
10.0	0-0.2	..	..	..	..	7.72	7.56	..	..	..	..	..	..	..	salt crust
10.1	0-1	Fine	13,350	7.94	7.54	7.46	7.76	3,400	8.19	0.00	0.66	23.55	-2725	..	hyposulfidic (S <sub>CR</sub> ≥0.10%)
10.2	1-7	Fine	10,070	7.97	6.98	7.23	7.57	2,300	7.97	0.00	0.58	2.42	39	0.14	hyposulfidic (S <sub>CR</sub> ≥0.10%)
10.3	7-20	Fine	5,630	8.26	2.95	7.63	7.31	400	7.62	0.00	1.48	0.85	809	..	hyposulfidic (S <sub>CR</sub> ≥0.10%)
10.4	20-40	Fine	3,670	8.40	5.32	7.58	7.01	320	7.57	0.00	0.12	0.20	48	..	hyposulfidic (S <sub>CR</sub> ≥0.10%)
11.0	0-0.5	..	..	..	..	7.63	7.31	..	..	..	..	..	..	..	salt crust
11.1	0-1	salt	OVER	7.11	5.81	7.53	7.11	2,200	7.72	0.00	0.02	0.00	12	..	hyposulfidic (S <sub>CR</sub> <0.10%)
11.2	1-5	Fine	95,800	7.31	6.24	6.35	6.77	6,800	8.01	0.00	1.92	31.90	-3052	0.06	hyposulfidic (S <sub>CR</sub> ≥0.10%)
11.3	5-20	Fine	11,920	7.13	2.62	6.25	7.09	2,100	9.10	0.00	0.09	6.79	-848	0.04	hyposulfidic (S <sub>CR</sub> <0.10%)
11.4	20-40	Fine	28,000	7.02	4.49	5.99	6.73	1,900	7.25	0.00	0.14	0.18	63	..	hyposulfidic (S <sub>CR</sub> ≥0.10%)
11.W1	-	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
11.W2	-	..	..	..	..	..	..	..	..	..	..	..	..	..	pit water

**Table 2-5. Summary of hydrochemical field measurements for Little Toolunka Flat (Wetland ID. 12211).**

	pH	SEC µS cm <sup>-1</sup>	DO mg l <sup>-1</sup>	Eh mV	Turbidity NTU	Alkalinity as HCO <sub>3</sub>
Surface waters (n=1)	7.16	201218	1.74	230	22	367
Pit waters (n = 1)	6.73	206114	0.6	123		270

**Table 2-6. Hydrochemical data for Little Toolunka Flat (Wetland ID. 12211).**

Parameter	units	ANZECC Guidelines	Site 11 (SW)	Site 11 (PW)
Na	mg l <sup>-1</sup>		83200	82200
K	mg l <sup>-1</sup>		538.0	248.0
Ca	mg l <sup>-1</sup>		617	760
Mg	mg l <sup>-1</sup>		17800	12300
Si	mg l <sup>-1</sup>		<25	<25
Br	mg l <sup>-1</sup>		790.0	520.0
Cl	mg l <sup>-1</sup>		190000	250000
NO <sub>3</sub>	mg l <sup>-1</sup>	0.7	<0.022	0.075
NH <sub>4</sub> -N <sup>K</sup>	mg l <sup>-1</sup>	0.01	<b>0.26</b>	<b>0.650</b>
PO <sub>4</sub> -P <sup>E</sup>	mg l <sup>-1</sup>	0.005	<b>0.368</b>	<b>0.187</b>
SO <sub>4</sub>	mg l <sup>-1</sup>		13000	8800
Ag	µg l <sup>-1</sup>	0.05	<0.6	<0.6
Al <sup>A</sup>	µg l <sup>-1</sup>	55	<2000	<2000
As <sup>B</sup>	µg l <sup>-1</sup>	13	<30	<30
Cd	µg l <sup>-1</sup>	0.2	<2	<2
Co	µg l <sup>-1</sup>	2.8	<1	<b>6</b>
Cr <sup>C</sup>	µg l <sup>-1</sup>	1	<8	<8
Cu <sup>H</sup>	µg l <sup>-1</sup>	1.4	<30	<30
Fe	µg l <sup>-1</sup>	300	<50000	<50000
Mn	µg l <sup>-1</sup>	1700	<b>11560</b>	<b>15700</b>
Ni <sup>H</sup>	µg l <sup>-1</sup>	11	<20	<20
Pb <sup>H</sup>	µg l <sup>-1</sup>	3.4	<10	<10
Se	µg l <sup>-1</sup>	11	<10	<10
Zn <sup>H</sup>	µg l <sup>-1</sup>	8	<b>240</b>	<b>510</b>
DOC	mg l <sup>-1</sup>		274	174

**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<sub>4</sub> and PO<sub>4</sub>, 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.

<sup>A</sup> Trigger value for Aluminium in freshwater where pH > 6.5.

<sup>B</sup> Trigger value assumes As in solution as Arsenic (AsV).

<sup>C</sup> Trigger value for Chromium is applicable to Chromium (CrVI) only.

<sup>E</sup> Guideline is for filterable reactive phosphorous (FRP).

<sup>H</sup> Hardness affected (refer to Guidelines).

<sup>K</sup> Guideline for South-east Australia-Freshwater Lakes and reservoirs.



### 3. LITTLE TOOLUNKA FLAT (WETLAND ID. 12212)

#### 3.1. Location and setting description

Little Toolunka Flat (Wetland ID. 12212) is situated on the eastern side of the River Murray about 11 kilometres down river from the town of Waikerie, located in the Toolunka Complex area. The wetland is irregular to linear in shape forming part of a wetland complex that occurs on the inside of a bend in the river. It is about 2.2 kilometres in length and about 300 metres at its widest, with a total surface area of 38 hectares. The wetland is bounded by a raised floodplain that separates the wetland from the river and other wetlands to the north and west and there is a hill slopes to the southeast. The other associated wetlands in the Little Toolunka Flat Complex that were surveyed are wetland IDs. 12209, 12211, and 12214.

The wetland is connected to the river at the northern end. At the time when the soil survey was conducted in March 2010 the wetland had surface water. The wetland is not managed. Sedgeland and grassland was growing along the wetland margins, with open woodland and shrubland on the surrounding higher floodplain. Eight sites were sampled as shown in Figure 3-1.

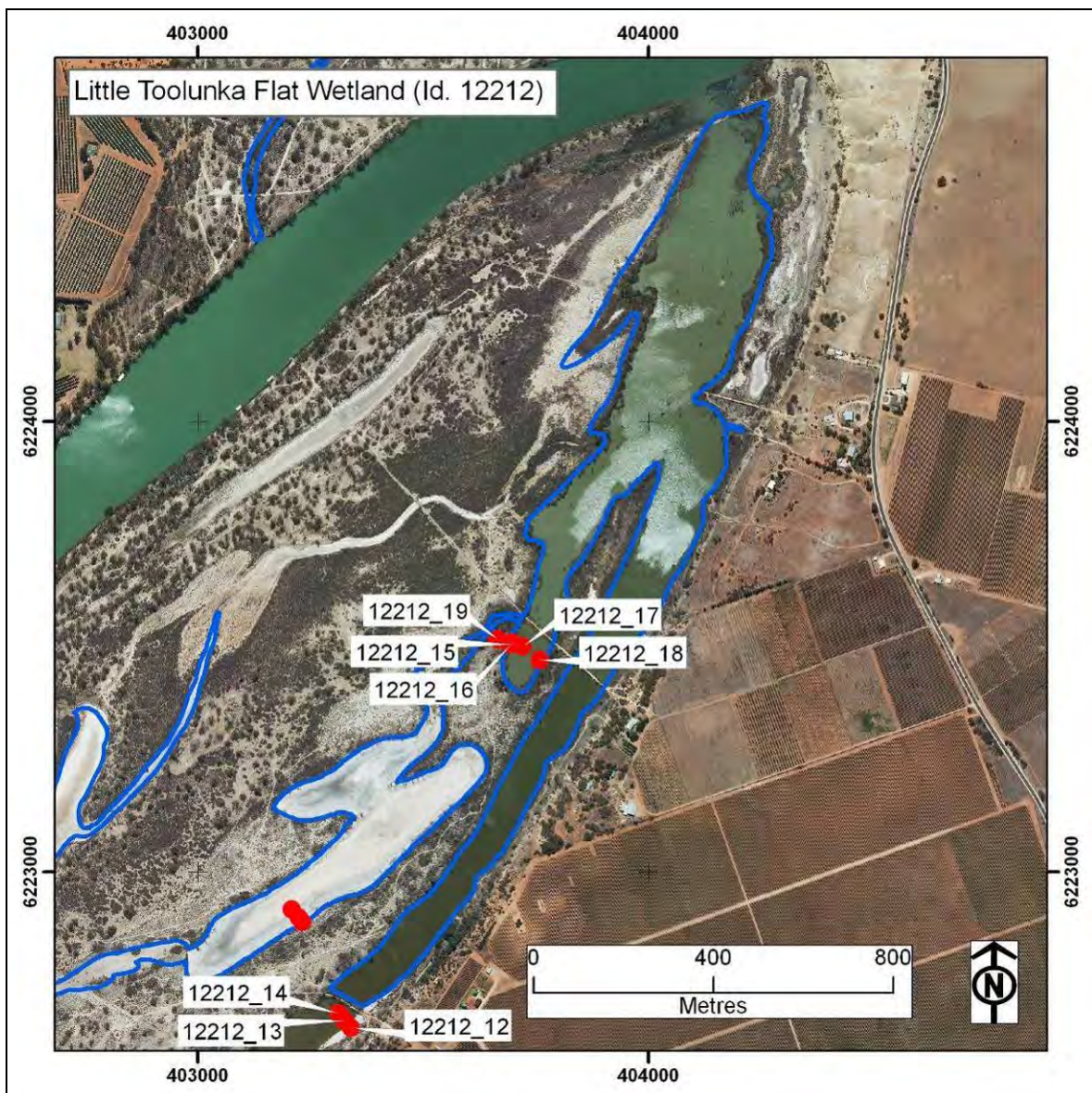


Figure 3-1. Little Toolunka Flat (Wetland ID. 12212) and sample site locations.

### 3.2. Soil profile description and distribution

Eight sites were described and sampled. The soil subtypes and general location descriptions are presented in Table 3-1. Sites were distributed along two transects across the wetland to provide a cross-sections, with transects placed at the southern end (Sites 12, 13, and 14), and near the centre of the wetland (Sites 15, 16, 17, 18 and 19). The site and soil profile description are presented in Table 3-2 and Table 3-3, and a conceptual cross-section diagram in Figure 3-2.

#### Southern transect

Site 12 (Figure 3-3) occurred on the wetland margin above the water level where there was a salt crust surface, and the soil consisted of a very dark grey, firm, sandy loam at the surface to sandy clay loam in the subsoil. Site 13 (Figure 3-4) occurred in open water (50 cm deep), and the soil consisted of a very dark grey, very weak at the surface to very firm in the subsoil, clay. Site 14 (Figure 3-5) occurred in water (60 cm deep) next to Phragmites, and the soil consisted of an olive grey, very weak, clay with sulfurous odour, over a grey, firm, clay.

#### Centre transect

Site 15 (Figure 3-6) occurred in water (30 cm deep) surrounded by Typha, and the soil consisted of an olive grey, very weak, mucky clay over clay. Site 16 (Figure 3-7) occurred in water (30 cm deep) amongst Typha, and the soil consisted of dark grey, very weak, gel like mucky clay over a very dark grey, very firm clay. Site 17 (Figure 3-8) occurred in open water (60 cm deep), and the soil consisted of an olive grey very weak, mucky clay, over a dark grey, very firm clay. Site 18 (Figure 3-9) occurred adjacent to Typha on the open water side (40 cm deep), and the soil consisted of an olive grey, very weak, mucky clay with sulfurous odour, over a dark grey, very firm, clay. Site 19 (Figure 3-10) occurred on the wetland margin high up next to the floodplain area, and the soil consisted of a very dark grey, very firm, blocky structured, clay.

**Table 3-1. Soil identification, subtype and general location description for Little Toolunka Flat (Wetland ID. 12212).**

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12212_12	403340	6222655	Other Soil (loamy)	high elevation, on margins
12212_13	403325	6222670	Subaqueous Soil (clayey)	low elevation, centre of wetland in water
12212_14	403312	6222686	Subaqueous Soil (clayey)	in water adjacent to phragmites
12212_15	403693	6223506	Subaqueous Soil (clayey)	in water, amongst reed on margin
12212_16	403698	6223509	Subaqueous Soil (clayey)	mid elevation, in water, amongst Typha
12212_17	403721	6223501	Subaqueous Soil (clayey)	low elevation, middle of channel, in open water
12212_18	403760	6223471	Subaqueous Soil (clayey)	near margin, in water next to Typha
12212_19	403666	6223517	Other Soil (clayey)	high elevation on floodplain

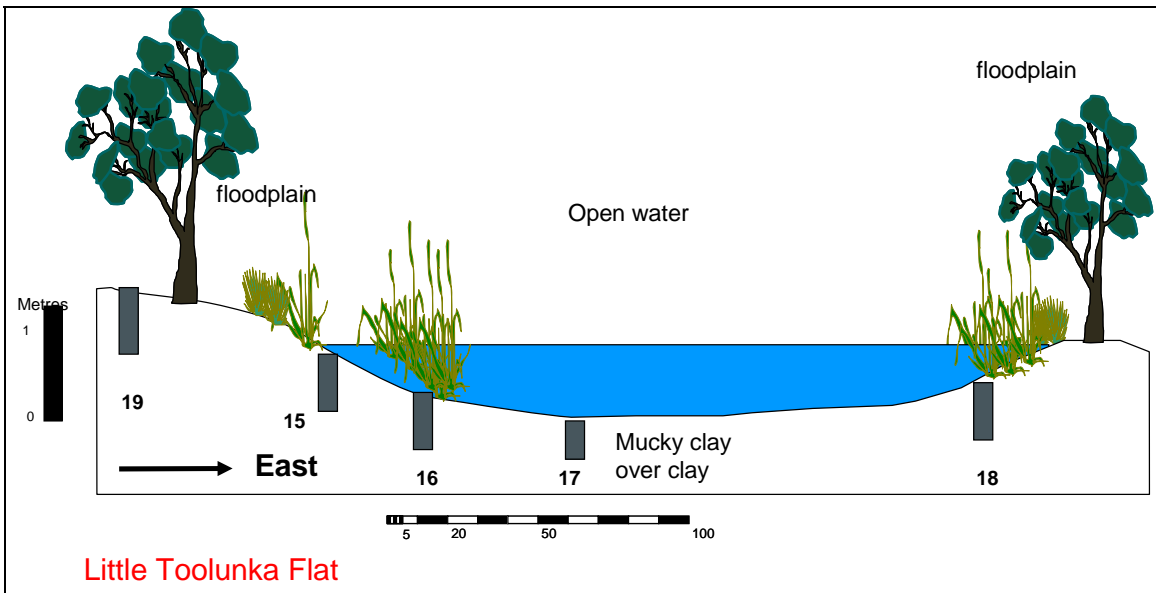


Figure 3-2. Conceptual cross-section diagram, showing locations of Sites 15 to 19.



Figure 3-3. Photograph of Site 12, showing the soil profile on the wetland margin.



Figure 3-4. Photograph of Site 13, showing the site location in the middle of the wetland in open water.



Figure 3-5. Photograph of Site 14, showing the site location in water adjacent to the Phragmites on the opposite side of the wetland from Site 12.



Figure 3-6. Photograph of Site 15, showing the site location placed in a water area surrounded by reeds.



**Figure 3-7. Photograph of Site 16, showing the site location in water and amongst reeds**



**Figure 3-8. Photograph of Site 17, showing the site location in the centre of the wetland in open water.**



**Figure 3-9. Photograph of Site 18, showing the site location on the margin in water adjacent to Phragmites, this site is on the side opposite of the wetland from Site 15.**

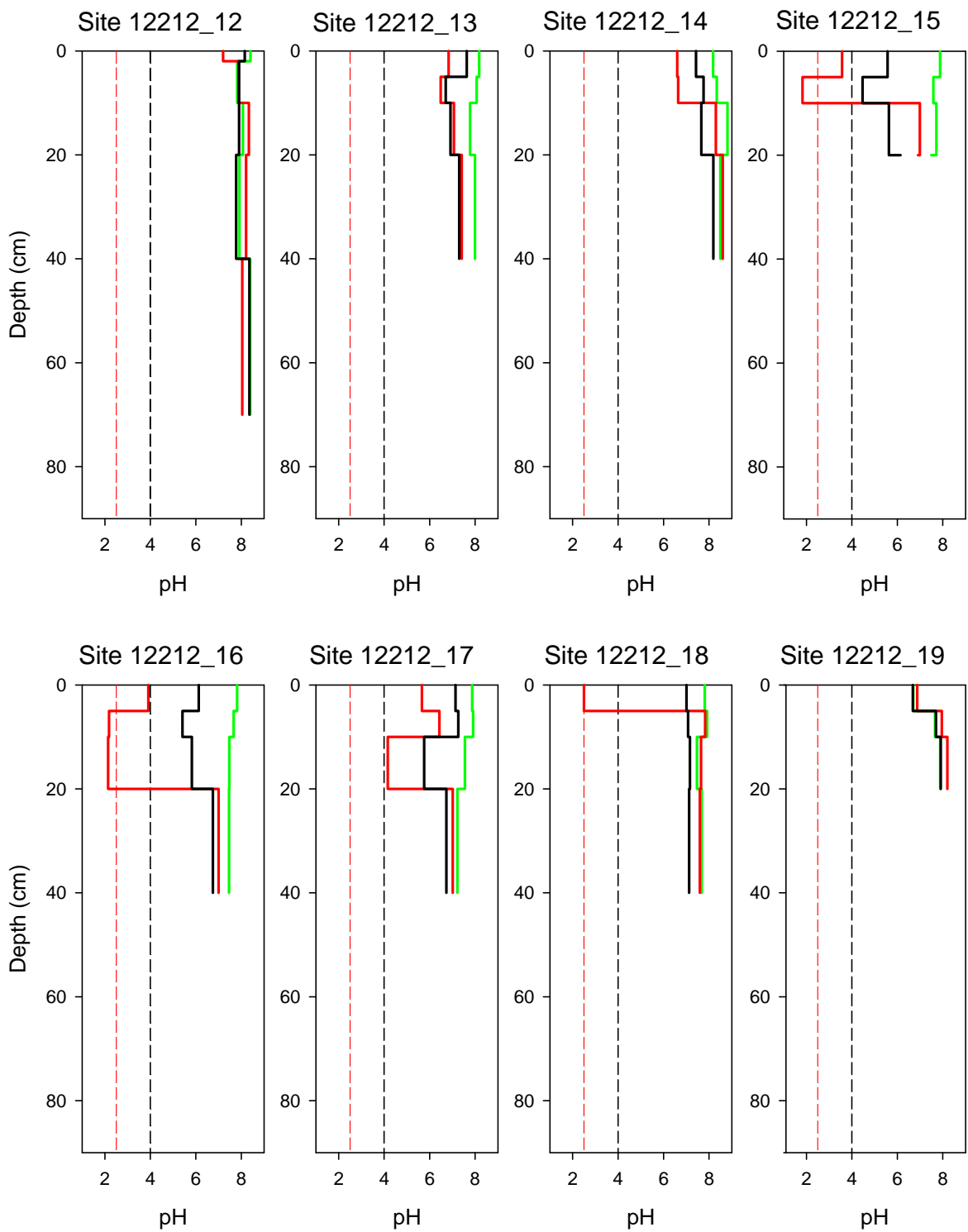


**Figure 3-10. Photograph of Site 19, showing the site location and soil profile placed on the wetland margin and floodplain area.**

### **3.3. Laboratory data assessment**

#### **3.3.1. Soil pH testing ( $pH_W$ , $pH_{OX}$ , $pH_{INC}$ )**

The  $pH$  data are provided in Table 3-4 and  $pH$  profiles are presented in Figure 3-11. The  $pH_W$  data ranged from 6.70 to 8.50 and sulfuric materials with a  $pH_W < 4$  were not identified. The  $pH_{OX}$  data ranged from 1.83 to 8.60 and identified that subsurface layers in Profile 15 and 16 were below the critical value of  $pH_{OX} < 2.5$  the threshold value normally used to indicate a high likelihood of sulfuric material forming. The  $pH_{INC}$  data ranged from 4.47 to 8.35 and identified no samples on incubation that declined below the critical values of  $pH < 4$ .



**Figure 3-11. Depth profiles of soil pH for Little Toolunka Flat (Wetland ID. 12212), showing soil pH (pH<sub>W</sub> as green line), peroxide treated pH (pH<sub>OX</sub> as red line) and incubation pH (pH<sub>INC</sub> after 8 weeks as black line). Critical pH<sub>W</sub> and pH<sub>INC</sub> value of 4 (black dashed line) and critical pH<sub>OX</sub> value of 2.5 (red dashed line).**

### **3.3.2. Acid base accounting**

The acid base accounting data is provided in Table 3-4 and summarised in Figure 3-12.

#### **Chromium reducible sulfur**

Chromium reducible sulfur values ranged from 0.0 to 0.92 %S<sub>CR</sub> and sulfidic materials were detected in all soil layers except for Profile 19 that was located high up on the wetland margin above the water.

#### **Titrateable actual acidity**

Titrateable actual acidity was not detected in any of the layers sampled.

#### **Retained acidity**

Retained acidity was not measured in any of the layers as all samples had a pH<sub>KCl</sub> of greater than 4.5.

#### **Acid neutralising capacity**

Acid neutralising capacity values ranged from 0.32 to 5.05 %CaCO<sub>3</sub> and was measured in all samples.

#### **Net acidity**

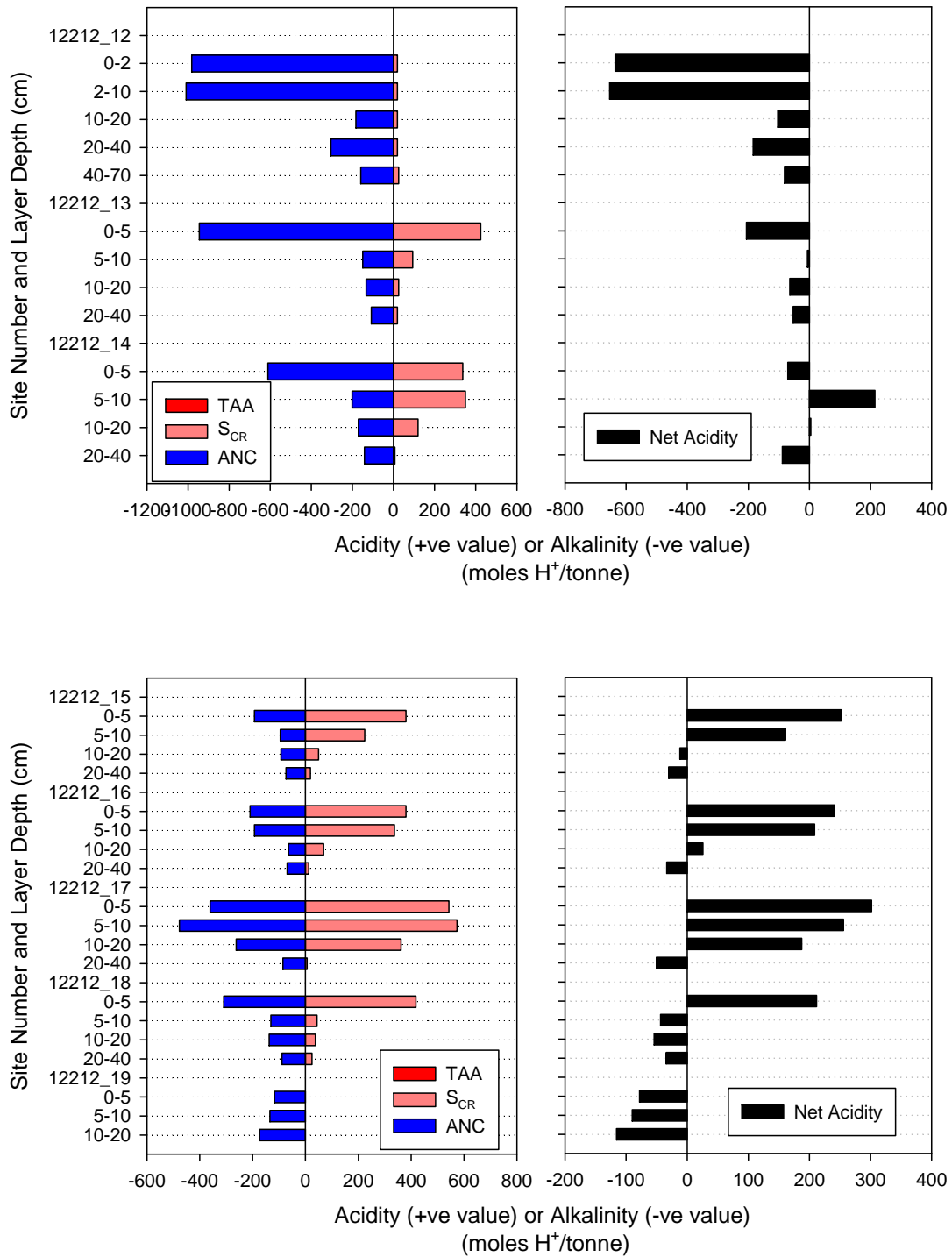
Net acidity values ranged from -654 to 302 mole H<sup>+</sup>/tonne. Profiles 12, 13 and 19 had negative values for all layers, and the other profiles that occurred below water generally had high values for the surface layers and for the lower subsoil layers they were negative values.

### **3.3.3. Water soluble sulfate**

Water soluble sulfate data values shown in Table 3-4 identified that surface layers for all profiles were above the criteria value of 100 mg/kg SO<sub>4</sub>.

### **3.3.4. Acid volatile sulfur**

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



**Figure 3-12. Acid base accounting depth profiles for Little Toolunka Flat (Wetland ID. 12212). Left side shows the components: Titratable actual acidity (TAA - red bar), acid generating potential (AGP as S<sub>CR</sub> - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.**

### 3.3.5. Hydrochemistry

Two surface waters were collected from the sampled transects. Field parameters are shown in Table 3-5. The surface waters were alkaline with moderately high SEC. The waters were saturated with dissolved oxygen and turbidity was relatively low whilst alkalinity was high.

All waters were of Na-Cl type (Table 3-6, Figure 3-13). Sulfate concentrations in the surface water varied from 290 to 460 mg l<sup>-1</sup>. The SO<sub>4</sub>/Cl ratios ranged from 0.145 to 0.177, similar to seawater (0.142). Nitrate concentrations were below detection limit, and NH<sub>4</sub> and PO<sub>4</sub> concentrations were slightly elevated. Most metals were present at low concentrations, although Zn was slightly elevated above ANZECC Guideline values.

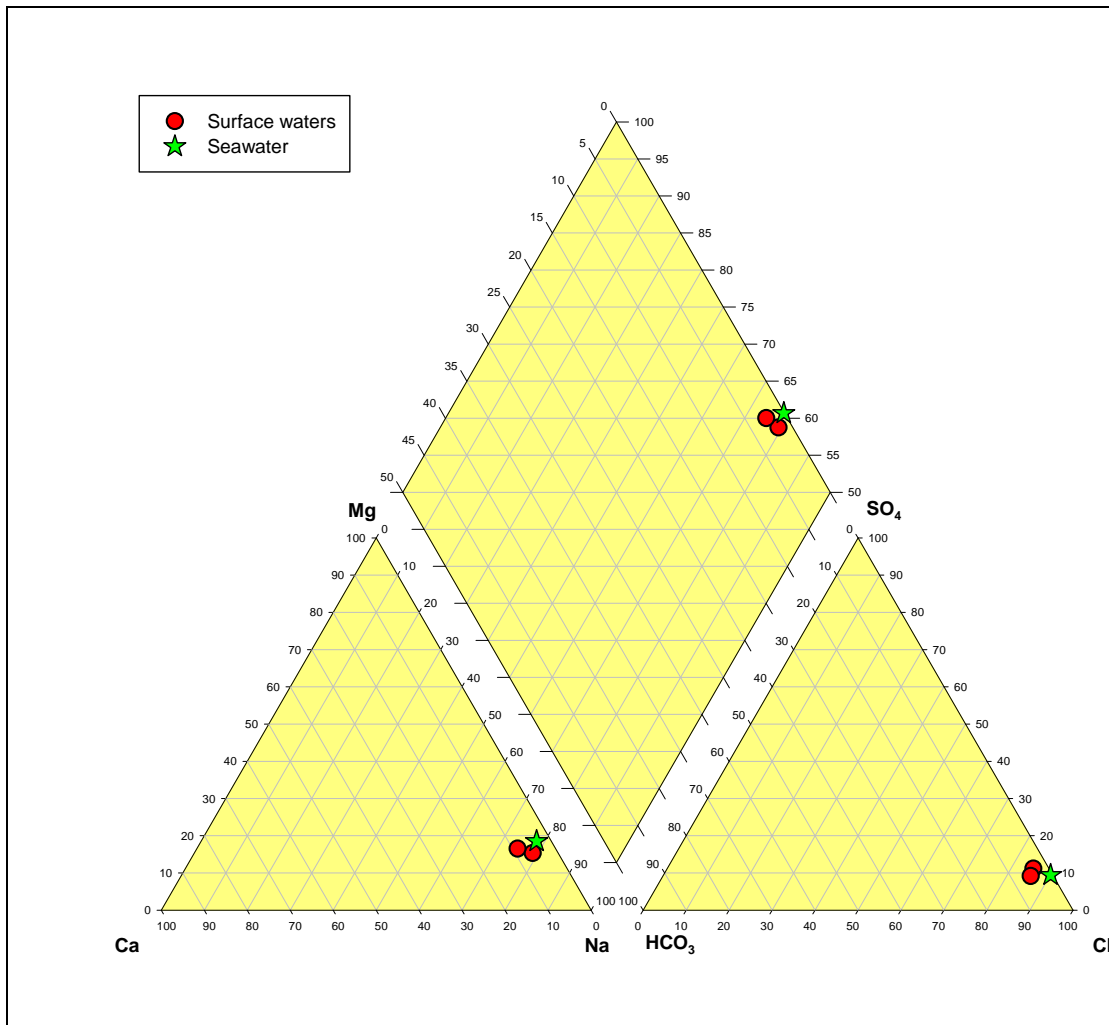


Figure 3-13. Piper diagram of hydrochemical data for Little Toolunka Flat (Wetland ID. 12212).



### 3.4. Discussion

Acid sulfate soil materials at Little Toolunka Flat (Wetland ID. 12212) were identified as hyposulfidic that occurred throughout the wetland. The acid sulfate soil subtype classes identified were Subaqueous Soil (clayey) and Other Soil (clayey or loamy).

The soils throughout the wetland were clayey textured. The soil electrical conductivity was very high in the surface layers that occurred in profiles on dry land.

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

The potential hazards posed by acid sulfate soil materials at Little Toolunka Flat (Wetland ID. 12212) are:

- Acidification hazard: The data identified high net acidity values in 5 of the 8 upper layers of profiles that occurred below water, 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, monosulfidic material was not observed. There is a medium level of concern.
- Metal mobilisation: The medium acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

#### Summary of key findings Little Toolunka Flat (Wetland ID. 12212):

<b>Soil materials:</b>	The soil layers throughout the wetland were hyposulfidic. Soils were clayey textured throughout the wetland. Soils had high net acidity values in the upper layers of profiles below water and negative values elsewhere and pH data did not indicate a potential for acidification due to oxidation.
<b>Acid sulfate soil identification:</b>	<ul style="list-style-type: none"> <li>• Subaqueous Soil (clayey) – occurring throughout the wetland below water. Dominant (&gt;50%) in extent.</li> <li>• Other Soil (clayey or loamy) – occurring on the wetland. Isolated (&lt;10%) in extent.</li> </ul>
<b>Hazard assessment</b>	<ul style="list-style-type: none"> <li>• Acidification hazard – medium level of concern</li> <li>• De-oxygenation hazard – medium level of concern</li> <li>• Metal mobilisation hazard – medium level of concern</li> </ul>

**Table 3-2. Site description data for Little Toolunka Flat (Wetland ID. 12212).**

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
12	27/03/2010	403340	6222655	not reached	salt crust	bare	high elevation, on margins
13	27/03/2010	403325	6222670	50	soft	water, bare	low elevation, centre of wetland in water
14	27/03/2010	403312	6222686	60	water, soft	Typha	in water adjacent to phragmites
15	27/03/2010	403693	6223506	30	water, soft	between Typha	in water, amongst reed on margin
16	27/03/2010	403698	6223509	30	water, soft	Typha	mid elevation, in water, amongst Typha
17	27/03/2010	403721	6223501	60	water, soft	bare	low elevation, middle of channel, in open water
18	27/03/2010	403760	6223471	40	water	Typha	near margin, in water next to Typha
19	27/03/2010	403666	6223517	not reached	salt crystals, sealed surface	small phragmites	high elevation on floodplain

**Table 3-3. Soil profile description data for Little Toolunka Flat (Wetland ID. 12212).**

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_0	0 - 0.5	surface salt scrap		salt			crystalline	weak	
12_1	0 - 2	small pit	very dark grey (5Y3/1)	sand	dry		massive	firm	
12_2	2 - 10	small pit	very dark grey (5Y3/1)	sandy loam	moist	2% dark brown In the matrix	massive	firm	
12_3	10 - 20	small pit	very dark grey (5Y3/1)	sandy loam	moist	5% brown In the matrix	massive	firm	
12_4	20 - 40	small pit	very dark grey (5Y3/1)	sandy clay loam	moist	2% brown In the matrix	massive	firm	
12_4DUP	20 - 40	small pit	very dark grey (5Y3/1)	sandy clay loam	moist	2% brown In the matrix	massive	very firm	
12_5	40 - 70	push tube	very dark grey (5Y3/1)	sandy clay loam	moist		massive	very firm	
13_W1	50 - 0	surface water							water sampled
13_1	0 - 5	small pit	very dark grey (5Y3/1)	clay	wet		gel	very weak	
13_2	5 - 10	small pit	very dark grey (5Y3/1)	clay	wet		massive	very weak	
13_3	10 - 20	push tube	very dark grey (5Y3/1)	clay	wet		massive	firm	
13_4	20 - 40	push tube	very dark grey (5Y3/1)	clay	wet		massive	very firm	too hard to auger below
14_W	60 - 0	water							
14_1	0 - 5	small pit	olive grey (5Y4/2)	clay	wet		gel	very weak	strong sulfurous odour
14_2	5 - 10	small pit	grey (5Y5/1)	clay	wet		gel	very weak	strong sulfurous odour
14_3	10 - 20	push tube	grey (5Y5/1)	clay	moist		massive	firm	
14_4	20 - 40	push tube	grey (5Y5/1)	clay	moist		massive	firm	
15_W	30 - 0	water							
15_1	0 - 5	small pit	olive grey (5Y4/2)	mucky clay	wet		gel	very weak	strong sulfurous odour
15_2	5 - 10	small pit	dark grey (5Y4/1)	mucky clay	wet		gel	very weak	strong sulfurous odour
15_3	10 - 20	small pit	dark grey (5Y4/1)	clay	moist		massive	firm	
15_4	20 - 40	push tube	olive grey (5Y4/2)	clay	moist		massive	very firm	too clayey to auger below
16_W	30 - 0	water							
16_1	0 - 5	small pit	dark grey (5Y4/1)	mucky clay	wet		gel	very weak	strong sulfurous odour
16_2	5 - 10	small pit	dark grey (5Y4/1)	mucky clay	wet		gel	very weak	strong sulfurous odour
16_3	10 - 20	small pit	dark grey (5Y4/1)	clay	moist		angular blocky	weak	
16_4	20 - 40	push tube	very dark grey (5Y3/1)	clay	moist		massive	very firm	too clayey to auger below

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
17_W1	60 - 0	surface water							water sampled
17_1	0 - 5	small pit	olive grey (5Y4/2)	mucky clay	wet		gel	very weak	strong sulfurous odour
17_2	5 - 10	small pit	dark grey (5Y4/1)	mucky clay	wet		gel	very weak	strong sulfurous odour
17_3	10 - 20	small pit	dark grey (5Y4/1)	mucky clay	moist		gel	very weak	sulfurous odour
17_4	20 - 40	push tube	dark grey (5Y4/1)	clay	moist		massive	very firm	too firm to dig below
18_W	40 - 0	water							
18_1	0 - 5	small pit	olive grey (5Y4/2)	mucky clay	wet		gel	very weak	strong sulfurous odour
18_2	5 - 10	small pit	dark grey (5Y4/1)	mucky clay	wet		angular blocky	weak	
18_3	10 - 20	small pit	dark grey (5Y4/1)	clay	moist		massive	firm	
18_4	20 - 40	push tube	dark grey (5Y4/1)	clay	moist		massive	very firm	
19_0	0 - 0.5	surface salt scrap		salt	dry		crystalline	very weak	
19_1	0 - 5	small pit	very dark greyish brown (10YR3/2)	clay	moist		angular blocky	very firm	
19_2	5 - 10	small pit	very dark grey (10YR3/1)	clay	moist		angular blocky	very firm	
19_3	10 - 20	small pit	very dark grey (10YR3/1)	clay	moist		angular blocky	very firm	slickensides visible. Too clayey to auger below

**Table 3-4. Laboratory data for acid sulfate soil assessment of Little Toolunka Flat (Wetland ID. 12212).**

(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 <sub>4</sub> /kg)	pH KCl	Titrateable Actual Acidity (mole H <sup>+</sup> /tonne)	Chromium Reducible Sulfur (%S <sub>CR</sub> )	Retained Acidity (mole H <sup>+</sup> /tonne)	Acid Neutralising Capacity (%CaCO <sub>3</sub> )	Net Acidity (mole H <sup>+</sup> /tonne)	Acid Sulfate Soil Material Classification
12.0	0-0.5	..	..	..	..	8.05	7.87	..	..	..	..	..	..	..	salt crust
12.1	0-2	Coarse	18,920	8.40	7.20	8.01	8.15	3,000	8.96	0.00	0.03	..	4.91	-636	hyposulfidic (S <sub>CR</sub> <0.10%)
12.2	2-10	Fine	12,600	7.82	7.87	7.65	7.90	430	8.79	0.00	0.03	..	5.05	-654	hyposulfidic (S <sub>CR</sub> <0.10%)
12.3	10-20	Fine	5,740	8.07	8.33	7.71	7.90	360	8.05	0.00	0.03	..	0.92	-103	hyposulfidic (S <sub>CR</sub> <0.10%)
12.4	20-40	Fine	4,380	7.92	8.21	7.65	7.77	380	8.12	0.00	0.03	..	1.52	-184	hyposulfidic (S <sub>CR</sub> <0.10%)
12.5	40-70	Fine	4,170	8.39	8.04	7.68	8.35	370	7.54	0.00	0.04	..	0.80	-82	hyposulfidic (S <sub>CR</sub> <0.10%)
13.W1	50-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
13.1	0-5	Fine	1,607	8.18	6.84	7.22	7.63	210	7.97	0.00	0.68	..	4.73	-206	hyposulfidic (S <sub>CR</sub> ≥0.10%)
13.2	5-10	Fine	851	8.07	6.49	7.21	6.71	64	7.58	0.00	0.15	..	0.75	-6	hyposulfidic (S <sub>CR</sub> ≥0.10%)
13.3	10-20	Fine	968	7.78	7.07	7.19	6.92	59	7.09	0.00	0.04	..	0.67	-64	hyposulfidic (S <sub>CR</sub> <0.10%)
13.4	20-40	Fine	794	7.99	7.41	7.45	7.30	48	7.10	0.00	0.03	..	0.54	-53	hyposulfidic (S <sub>CR</sub> <0.10%)
14.W1	60-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
14.1	0-5	Fine	1,491	8.18	6.60	7.97	7.43	250	7.89	0.00	0.54	..	3.06	-71	hyposulfidic (S <sub>CR</sub> ≥0.10%)
14.2	5-10	Fine	1,672	8.34	6.64	7.40	7.76	300	7.98	0.00	0.56	..	1.01	215	hyposulfidic (S <sub>CR</sub> ≥0.10%)
14.3	10-20	Fine	1,090	8.81	8.30	7.09	7.66	140	7.57	0.00	0.19	..	0.85	5	hyposulfidic (S <sub>CR</sub> ≥0.10%)
14.4	20-40	Fine	970	8.50	8.60	7.42	8.19	75	7.15	0.00	0.01	..	0.71	-88	hyposulfidic (S <sub>CR</sub> <0.10%)
15.W1	60-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
15.1	0-5	Fine	1,312	7.88	3.57	6.81	5.57	120	7.15	0.00	0.61	..	0.96	252	hyposulfidic (S <sub>CR</sub> ≥0.10%)
15.2	5-10	Fine	1,380	7.58	1.83	6.56	4.47	230	6.97	0.00	0.36	..	0.48	161	hyposulfidic (S <sub>CR</sub> ≥0.10%)
15.3	10-20	Fine	749	7.72	6.99	6.50	5.63	62	6.84	0.00	0.08	..	0.46	-12	hyposulfidic (S <sub>CR</sub> <0.10%)
15.4	20-40	Fine	493	7.49	6.91	6.58	6.14	46	6.68	0.00	0.03	..	0.37	-30	hyposulfidic (S <sub>CR</sub> <0.10%)
16.W1	30-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
16.1	0-5	Fine	1,576	7.81	3.91	6.66	6.13	130	7.03	0.00	0.61	..	1.05	241	hyposulfidic (S <sub>CR</sub> ≥0.10%)
16.2	5-10	Fine	2,070	7.66	2.18	6.58	5.41	230	7.16	0.00	0.54	..	0.96	208	hyposulfidic (S <sub>CR</sub> ≥0.10%)
16.3	10-20	Fine	1,408	7.47	2.14	6.51	5.83	92	6.89	0.00	0.11	..	0.32	26	hyposulfidic (S <sub>CR</sub> ≥0.10%)
16.4	20-40	Fine	203	7.46	7.00	6.59	6.75	35	6.54	0.00	0.02	..	0.35	-34	hyposulfidic (S <sub>CR</sub> <0.10%)
17.W1	60-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
17.1	0-5	Fine	1,284	7.87	5.66	6.52	7.14	140	7.35	0.00	0.87	..	1.81	302	hyposulfidic (S <sub>CR</sub> ≥0.10%)
17.2	5-10	Fine	1,245	7.91	6.43	6.55	7.26	100	7.53	0.00	0.92	..	2.39	256	hyposulfidic (S <sub>CR</sub> ≥0.10%)
17.3	10-20	Fine	689	7.55	4.16	6.49	5.76	97	7.41	0.00	0.58	..	1.31	187	hyposulfidic (S <sub>CR</sub> ≥0.10%)
17.4	20-40	Fine	314	7.22	7.02	6.56	6.74	28	6.82	0.00	0.01	..	0.42	-50	hyposulfidic (S <sub>CR</sub> <0.10%)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC ( $\mu\text{S}/\text{cm}$ )	pH water	pH peroxide	pH incubation week 0	pH incubation week 8	Sulfate ( $\text{mg SO}_4/\text{kg}$ )	pH KCl	Titrateable Actual Acidity (mole $\text{H}^+$ /tonne)	Chromium Reducible Sulfur ( $\%\text{S}_{\text{CR}}$ )	Retained Acidity (mole $\text{H}^+$ /tonne)	Acid Neutralising Capacity ( $\%\text{CaCO}_3$ )	Net Acidity (mole $\text{H}^+$ /tonne)	Acid Sulfate Soil Material Classification
18.W1	40-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
18.1	0-5	Fine	1,246	7.81	2.50	6.58	7.01	32	7.23	0.00	0.67	..	1.55	212	hyposulfidic ( $\text{S}_{\text{CR}} \geq 0.10\%$ )
18.2	5-10	Fine	1,160	7.92	7.83	6.77	7.08	260	6.66	0.00	0.07	..	0.65	-43	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
18.3	10-20	Fine	905	7.47	7.65	6.46	7.16	84	6.61	0.00	0.06	..	0.69	-54	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
18.4	20-40	Fine	684	7.68	7.60	6.58	7.13	45	6.54	0.00	0.04	..	0.44	-34	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
19.0	0-0.5	..	..	..	..	6.61	6.57	..	..	..	..	..	..	..	salt crust
19.1	0-5	Fine	17,440	6.70	6.87	7.33	6.68	4,400	6.53	0.00	<0.01	..	0.58	-78	other soil material
19.2	5-10	Fine	15,320	7.66	7.96	7.76	7.70	3,100	6.96	0.00	<0.01	..	0.67	-90	other soil material
19.3	10-20	Fine	8,530	7.89	8.20	6.35	7.91	670	7.15	0.00	<0.01	..	0.87	-116	other soil material

**Table 3-5. Summary of hydrochemical field measurements for Little Toolunka Flat (Wetland ID. 12212).**

	pH	SEC $\mu\text{S cm}^{-1}$	DO $\text{mg l}^{-1}$	Eh mV	Turbidity NTU	Alkalinity as $\text{HCO}_3$
Surface waters (n=2)	8.34-8.60	6200-7932	12.2-13.7	34-150	27-38	187-207

**Table 3-6. Hydrochemical data for Little Toolunka Flat (Wetland ID. 12212).**

Parameter	units	ANZECC Guidelines	Site 13 (SW)	Site 17 (SW)
Na	mg l <sup>-1</sup>		1370	1000
K	mg l <sup>-1</sup>		11.1	9.6
Ca	mg l <sup>-1</sup>		90.4	104
Mg	mg l <sup>-1</sup>		142	118
Si	mg l <sup>-1</sup>		1.2	0.294
Br	mg l <sup>-1</sup>		5.9	3.9
Cl	mg l <sup>-1</sup>		2600	2000
NO <sub>3</sub>	mg l <sup>-1</sup>	0.7	<0.022	<0.022
NH <sub>4</sub> -N <sup>K</sup>	mg l <sup>-1</sup>	0.01	<b>0.02</b>	<b>0.019</b>
PO <sub>4</sub> -P <sup>E</sup>	mg l <sup>-1</sup>	0.005	<b>0.034</b>	<b>0.030</b>
SO <sub>4</sub>	mg l <sup>-1</sup>		460	290
Ag	µg l <sup>-1</sup>	0.05	<0.04	<0.04
Al <sup>A</sup>	µg l <sup>-1</sup>	55	<100	<100
As <sup>B</sup>	µg l <sup>-1</sup>	13	2	4
Cd	µg l <sup>-1</sup>	0.2	<0.1	<0.1
Co	µg l <sup>-1</sup>	2.8	0.24	0.4
Cr <sup>C</sup>	µg l <sup>-1</sup>	1	<0.5	<0.5
Cu <sup>H</sup>	µg l <sup>-1</sup>	1.4	<2	<2
Fe	µg l <sup>-1</sup>	300	<500	<500
Mn	µg l <sup>-1</sup>	1700	21	177.6
Ni <sup>H</sup>	µg l <sup>-1</sup>	11	<1	<1
Pb <sup>H</sup>	µg l <sup>-1</sup>	3.4	<1	<1
Se	µg l <sup>-1</sup>	11	<0.8	<0.8
Zn <sup>H</sup>	µg l <sup>-1</sup>	8	<b>36</b>	<b>22</b>
DOC	mg l <sup>-1</sup>		21.1	23.6

**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<sub>4</sub> and PO<sub>4</sub>, 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.

<sup>A</sup> Trigger value for Aluminium in freshwater where pH > 6.5.

<sup>B</sup> Trigger value assumes As in solution as Arsenic (AsV).

<sup>C</sup> Trigger value for Chromium is applicable to Chromium (CrVI) only.

<sup>E</sup> Guideline is for filterable reactive phosphorous (FRP).

<sup>H</sup> Hardness affected (refer to Guidelines).

<sup>K</sup> Guideline for South-east Australia-Freshwater Lakes and reservoirs.

## 4. LITTLE TOOLUNKA FLAT (WETLAND ID. 12214)

### 4.1. Location and setting description

Little Toolunka Flat (Wetland ID. 12214) is situated on the eastern side of the River Murray about 11 kilometres down river from the town of Waikerie, located in the Toolunka Complex area. The wetland is somewhat linear in shape forming part of a wetland complex that occurs on the inside of a bend in the river. It is about 1 kilometre in length and about 100 metres at its widest, with a total surface area of 8 hectares. The wetland is bounded by a raised floodplain that separates the wetland from the river and other wetlands. The other associated wetlands in the Little Toolunka Flat Wetland complex that were surveyed are wetland 12209, 12211 and 12212.

The wetland is not connected to the river. At the time when the soil survey was conducted in March 2010 the wetland did not have surface water, except for an isolated pool backed up against a causeway, the soil surface was bare with a thick salt crust. The wetland is not managed. Sedgeland and grassland was growing along the wetland margins, with open woodland and shrubland on the surrounding higher floodplain. Five sites were sampled as shown in Figure 4-1.

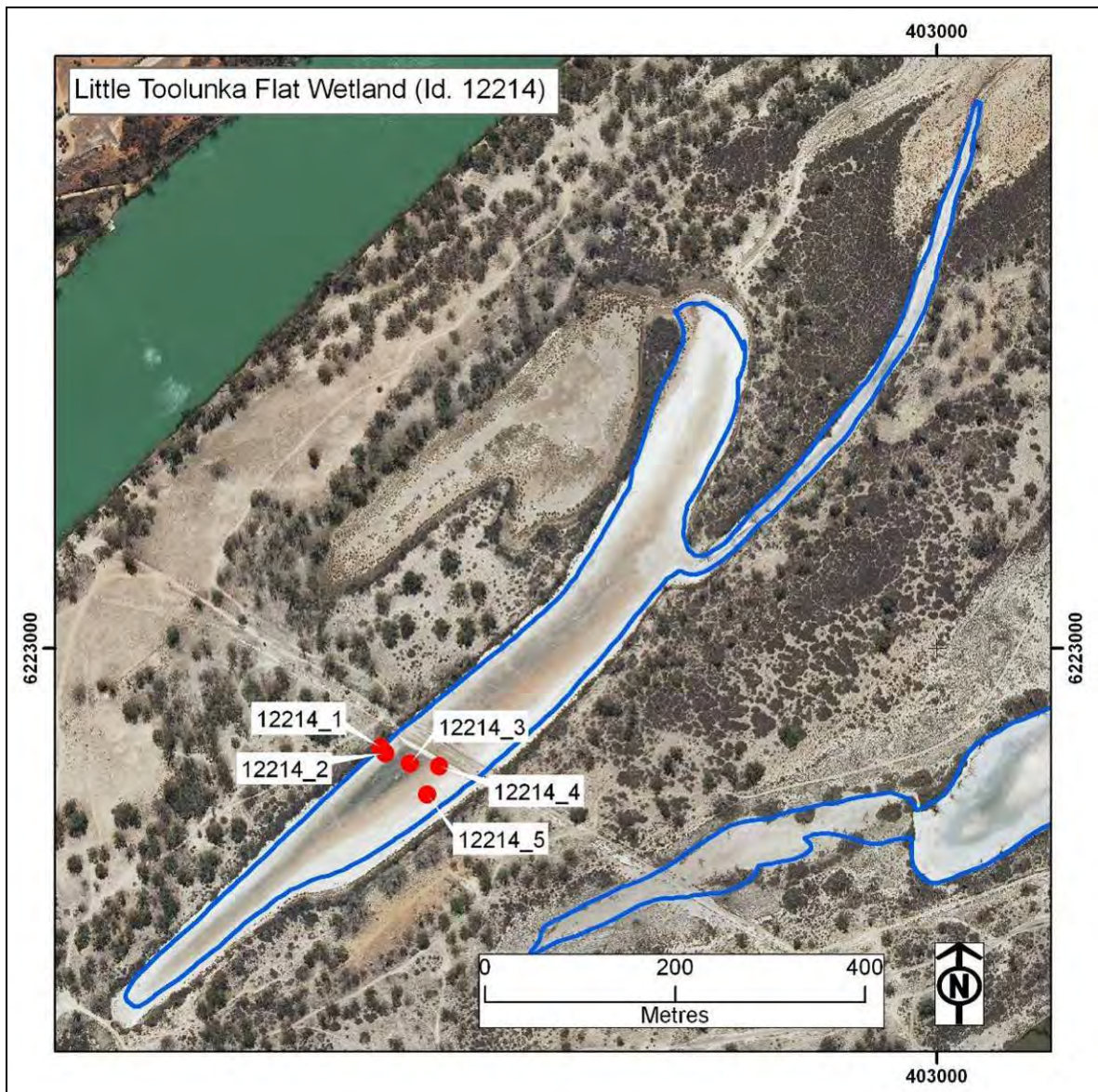


Figure 4-1. Little Toolunka Flat (Wetland ID. 12214) and sample site locations.



## 4.2. Soil profile description and distribution

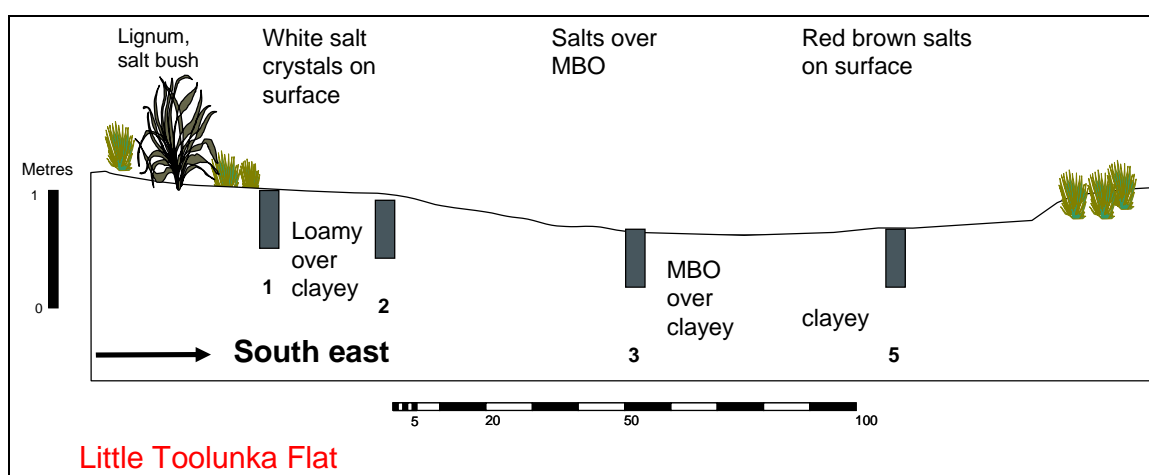
Five sites were described and sampled. The soil subtypes and general location descriptions are presented in Table 4-1. Sites were distributed along one transect across the wetland to provide a cross-section. The transect was located near the centre of the wetland (Sites 1, 2, 3, 4 and 5). The site and soil profile descriptions are presented in Table 4-2 and Table 4-3, and a conceptual cross-section diagram in Figure 4-2.

### Centre transect

Site 1 (Figure 4-3) occurred on the wetland margin above the water level where there was a salt crust surface, and the soil consisted of a salt crust, over a grey, firm, sandy loam. Site 2 (Figure 4-4) occurred on the side slope of the wetland, with the water table in the pit at about 50 cm depth, and the soil consisted of a salt crust, over a very dark grey, firm, sandy clay loam, containing patches of dry black monosulfidic material in the surface layer. Site 3 (Figure 4-5) occurred in the centre of the wetland, with the water table in the pit at about 15 cm depth, and the soil consisted of a salt crust, over a thick black, very weak, monosulfidic material, over a dark grey, firm, clay. Site 4 (Figure 4-6) occurred adjacent to a channel next to the causeway, with the water level at the surface, and the soil consisted a thick salt crust, over a thick layer of very weak black monosulfidic material. Site 5 (Figure 4-7) occurred on the side of the wetland where the surface was a reddish brown salt crust, with the water table in the pit at about 10 cm depth, and the soil consisted of a dark grey, very firm, clay.

**Table 4-1. Soil identification, subtype and general location description for Little Toolunka Flat (Wetland ID. 12214).**

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12214_1	402415	6222896	Other Soil (loamy)	high elevation, next to margin, salt crust surface and lignum growing nearby
12214_2	402420	6222890	Other Soil (loamy)	mid elevation, crusted surface, no vegetation
12214_3	402446	6222879	Other Soil (clayey)	mid location, low elevation, platy salt crust, no vegetation
12214_4	402477	6222876	Other Soil (clayey)	thick salt crust, adjacent to causeway
12214_5	402464	6222846	Other Soil (clayey)	low elevation, salt crust



**Figure 4-2. Conceptual cross-section diagram.**



**Figure 4-3. Photographs of Site 1, showing the site location on the wetland margin, and the soil profile with a salt crust on the soil surface.**



**Figure 4-4. Photographs of Site 2, showing the site location on the side of the wetland and the soil profile.**



**Figure 4-5. Photograph of Site 3, showing the site location and soil pit with shallow water table and a thick white salt crust on the surface over black monosulfidic material.**

**Figure 4-6. Photograph of Site 4, showing the site location and soil pit in a drain next to the causeway. The drain had a thick salt crust surface over water over black monosulfidic material.**



**Figure 4-7. Photograph of Site 5, showing the site location on the side of the wetland where there was brown salt crust.**

### **4.3. Laboratory data assessment**

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

The pH data are provided in Table 4-4 and pH profiles are presented in Figure 4-8. The  $pH_W$  data ranged from 5.74 to 8.35 and sulfuric materials with a  $pH_W < 4$  were not identified. The  $pH_{OX}$  data ranged from 3.28 to 8.32 and identified that no samples were below the critical value of  $pH_{OX} < 2.5$ . The  $pH_{INC}$  data ranged from 5.22 to 7.64 and identified no samples on incubation declined below the critical values of  $pH < 4$ .

#### **4.3.2. Acid base accounting**

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

##### **Chromium reducible sulfur**

Chromium reducible sulfur values ranged from 0.0 to 0.33 % $S_{CR}$  and sulfidic materials were detected in all soil layers except for Profile 1 that was located high up on the wetland margin.

##### **Titrateable actual acidity**

Titrateable actual acidity values ranged from 0 to 5.75 mole  $H^+$ /tonne and were detected in some layers of Profiles 2, 3 and 5.

##### **Retained acidity**

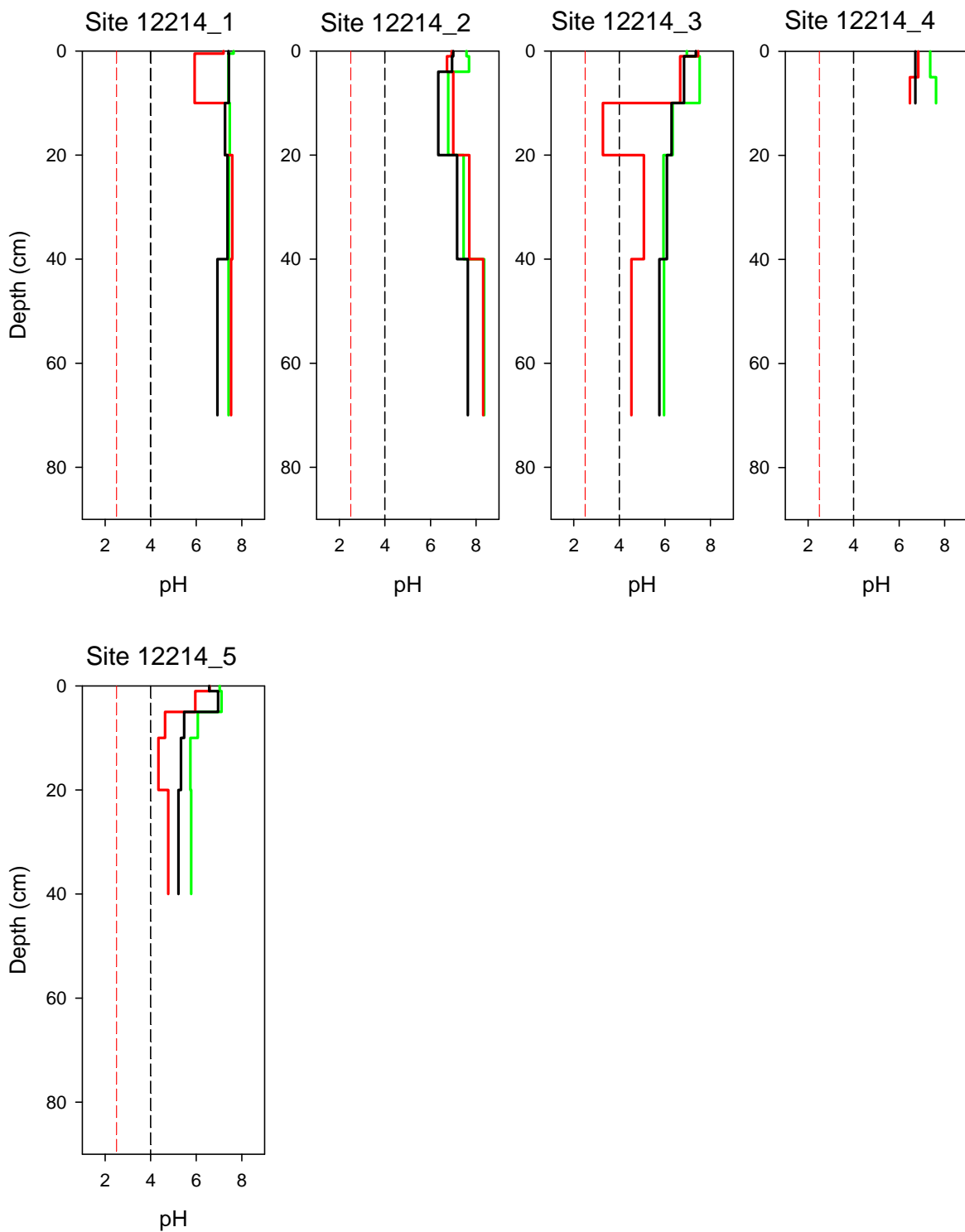
Retained acidity was not measured in any of the layers as all samples had a  $pH_{KCl}$  of greater than 4.5.

##### **Acid neutralising capacity**

Acid neutralising capacity values ranged from 0 to 2.90 % $CaCO_3$  and were measured in nearly all samples.

##### **Net acidity**

Net acidity values ranged from -245 to 21 mole  $H^+$ /tonne. Generally samples were negative values except for the lower subsoil layers of Profiles 3, 4 and 5 that had low or moderate values.



**Figure 4-8. Depth profiles of soil pH for Little Toolunka Flat (Wetland ID. 12214), 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).**

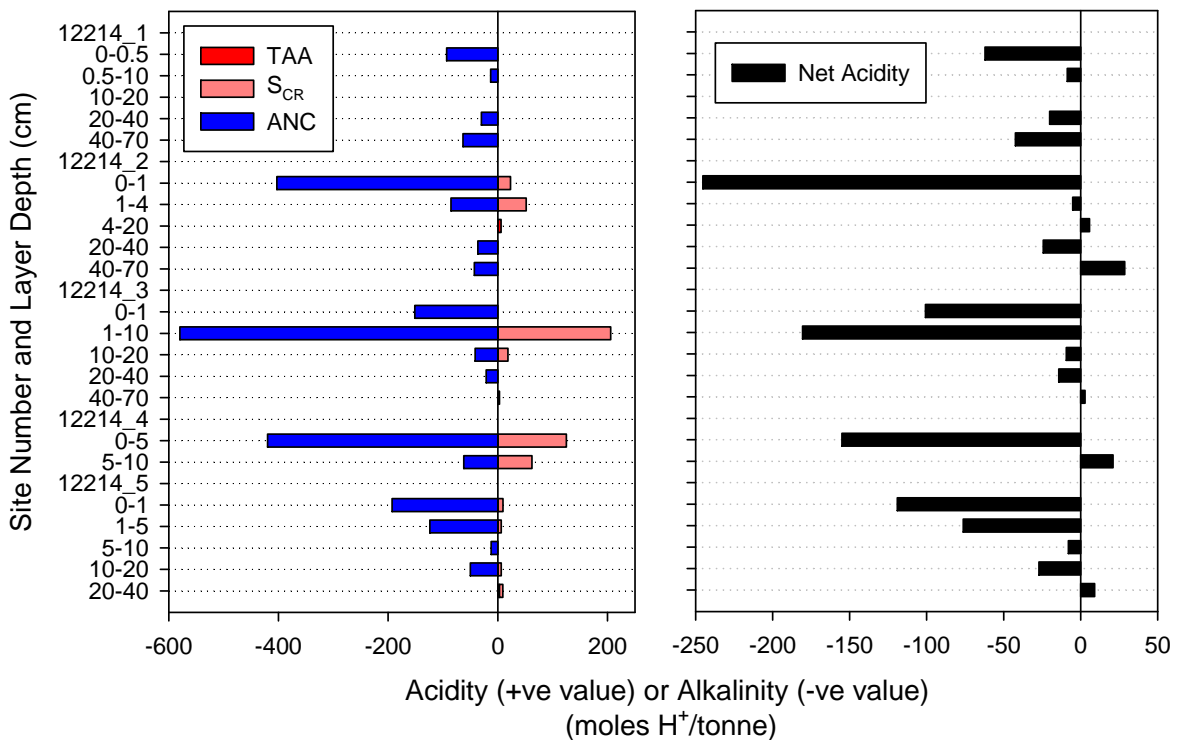


Figure 4-9. Acid base accounting depth profiles for Little Toolunka Flat (Wetland ID. 12214). Left side shows the components: Titratable actual acidity (TAA - red bar), acid generating potential (AGP as  $S_{CR}$  - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

#### 4.3.3. Water soluble sulfate

Water soluble sulfate data values Table 4-4 that surface layers for all profiles were above the criteria value of 100 mg/kg  $SO_4$ .

#### 4.3.4. Acid volatile sulfur

Monosulfidic materials were observed in the upper layers of Profiles 3 and 4 and sampled for analysis. The values shown in Table 4-4 were all above  $S_{AV} \geq 0.01\%$  S, the criteria value for identifying monosulfidic material.

### 4.3.5. Hydrochemistry

Two pit water samples were collected from the wetland, whilst no surface water samples were collected as the wetland was dry. Field parameters are shown in Table 4-5. The pH of the pit waters varied from acidic to slightly acidic. Dissolved oxygen was low and its presence may be related to contact with the atmosphere. Alkalinity was less than the detection limit in both pit water samples.

The pit waters were of Na-Cl type, with relatively high Mg and SO<sub>4</sub> relative to seawater composition (Table 4-6, Figure 4-10). Sulfate concentrations in the pit water samples were high varying between 1200 and 1600 mg l<sup>-1</sup>. The SO<sub>4</sub>/Cl ratio in the surface water samples (0.006 – 0.01) were much lower than seawater (0.142). For the nutrients, NH<sub>4</sub> and PO<sub>4</sub> concentrations were significantly above ANZECC Guideline values. Although the detection limits were high for some trace metals, high concentrations of Co, Mn, Pb and Zn are noteworthy. Dissolved organic carbon concentrations were very high in all samples.

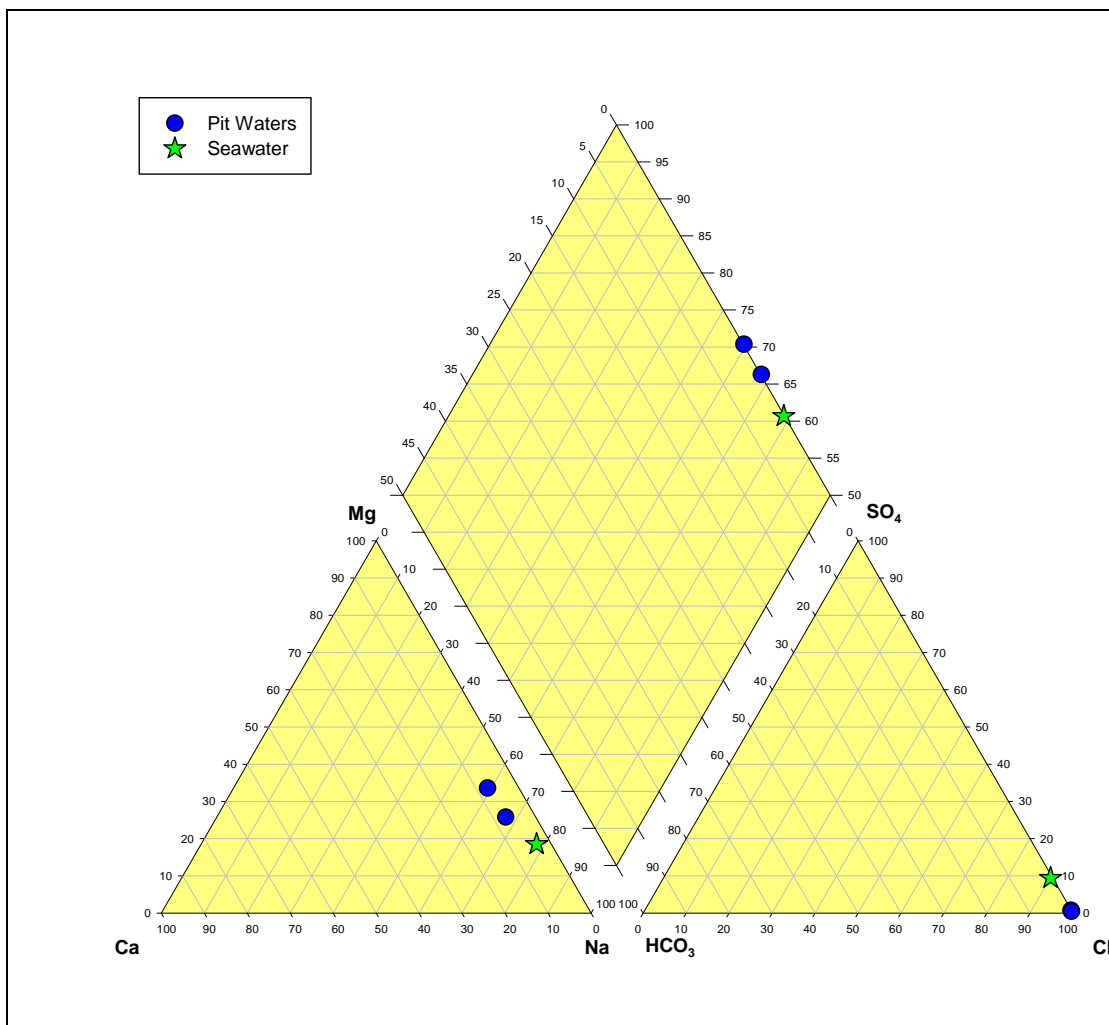


Figure 4-10. Piper diagram of hydrochemical data for Little Toolunka Flat (Wetland ID. 12214).

## 4.4. Discussion

Acid sulfate soil materials at Little Toolunka Flat (Wetland ID. 12214) were identified as hyposulfidic, and the remaining samples were characterised as other soil materials. The acid sulfate soil subtype class identified was Other Soil (clayey or loamy).

The soils throughout the wetland were clayey and for the sites on the margins loamy textured. The soil electrical conductivity was very high in the surface layers and observed by the thick salt crusts on the surface.

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

The potential hazards posed by acid sulfate soil materials at Little Toolunka Flat (Wetland ID. 12214) are:

- Acidification hazard: The data identified negative net acidity values in most soil layers 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 and supported by the observation of thick black monosulfidic material in the profiles. There is a 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 Little Toolunka Flat (Wetland ID. 12214):

<b>Soil materials:</b>	The soil layers throughout the wetland were hyposulfidic or other soil materials. Soils were generally clayey textured. Soils samples generally had negative net acidity values and pH data did not identify a potential for acidification due to oxidation. There was a salt crust on the surface throughout the wetland and in some areas a thick, very weak black monosulfidic material was observed below the salt crust.
<b>Acid sulfate soil identification:</b>	<ul style="list-style-type: none"> <li>• Other Soil (clayey or loamy) – occurring throughout the wetland. Dominant (&gt;50%) in extent.</li> </ul>
<b>Hazard assessment</b>	<ul style="list-style-type: none"> <li>• Acidification hazard – low level of concern</li> <li>• De-oxygenation hazard – high level of concern</li> <li>• Metal mobilisation hazard – low level of concern</li> </ul>

**Table 4-2. Site description data for Little Toolunka Flat (Wetland ID. 12214).**

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	26/03/2010	402415	6222896	not reached	salt crust	bare, lignum nearby	high elevation, next to margin, salt crust surface and lignum growing nearby
2	26/03/2010	402420	6222890	-50	crusted	bare	mid elevation, crusted surface, no vegetation
3	26/03/2010	402446	6222879	-15	salt crust, platy	bare	mid location, low elevation, platy salt crust, no vegetation
4	26/03/2010	402477	6222876	0	salt crust, thick	bare	thick salt crust
5	26/03/2010	402464	6222846	-10	salt crust	bare	low elevation, salt crust

**Table 4-3. Soil profile description data for Little Toolunka Flat (Wetland ID. 12214).**

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_0	0 - 0.5	surface salt scrap		salt	dry		crystalline	very weak	salt crystals
1_1	0 - 0.5	small pit	very dark grey (10YR3/1)	salt	dry		crystalline	weak	salt crust
1_2	0.5 - 10	small pit	dark grey (10YR4/1)	sandy loam	dry		massive	firm	
1_3	10 - 20	push tube	grey (5Y5/1)	sandy loam	moist		massive	firm	
1_4	20 - 40	push tube	grey (5Y5/1)	sandy loam	moist		massive	firm	
1_5	40 - 70	push tube	grey (5Y5/1)	clay	moist		massive	very firm	
2_0	0 - 0.5	surface salt scrap		salt	dry		crystalline	very weak	salt crystals
2_1	0 - 1	small pit	very dark grey (10YR3/1)	salt	dry		platy	very weak	salt crust
2_2	1 - 4	small pit	very dark grey (10YR3/1)	clay	moist		massive	very weak	contains dry monosulfidic material
2_3	4 - 20	small pit	dark grey (5Y4/1)	sandy clay loam	moist	10% dark brown infused into the matrix adjacent to pores	subangular blocky	firm	
2_4	20 - 40	small pit	dark grey (5Y4/1)	sandy clay loam	moist	5% dark brown infused into the matrix adjacent to pores	massive	firm	
2_5	40 - 70	push tube	grey (5Y6/1)	sandy clay loam	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_0	0 - 0.5	surface salt scrap		salt	dry		crystalline	very weak	salt crystals
3_1	0 - 1	small pit	white (10YR8/1)	salt	dry		platy	very weak	salt crust
3_2	1 - 10	small pit	black (N2.5/0)	monosulfidic black ooze	moist		massive	very weak	
3_3	10 - 20	small pit	dark grey (5Y4/1)	sandy clay loam	moist		massive	firm	
3_4	20 - 40	small pit	dark grey (5Y4/1)	clay	moist		massive	firm	
3_5	40 - 70	push tube	dark grey (5Y4/1)	clay	moist		massive	very firm	
3_W1	-	pit water							water sampled
4_0	0 - 0.5	surface salt scrap		salt	dry		crystalline	very weak	thick salt crust of halite
4_1	0 - 5	small pit	very dark grey (10YR3/1)	monosulfidic black ooze	moist		massive	very weak	
4_2	5 - 10	small pit	grey (10YR5/1)	monosulfidic black ooze	moist		massive	very weak	
4_W1	-	pit water							water sampled
5_0	0 - 0.2	surface salt scrap		salt	dry		crystalline	weak	salt crystals
5_1	0 - 1	small pit	reddish brown (2.5YR5/3)	salt	dry		platy	weak	salt crust
5_2	1 - 5	small pit	dark grey (5Y4/1)	clay	wet		massive	firm	
5_3	5 - 10	small pit	dark grey (5Y4/1)	clay	moist	20% reddish brown infused into the matrix along faces of peds	subangular blocky	very firm	
5_4	10 - 20	small pit	dark grey (5Y4/1)	clay	moist	5% reddish brown infused into the matrix adjacent to pores	subangular blocky	very firm	very sticky
5_5	20 - 40	small pit	dark grey (5Y4/1)	clay	moist		massive	very firm	very sticky

**Table 4-4. Laboratory data for acid sulfate soil assessment of Little Toolunka Flat (Wetland ID. 12214).**

(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 <sub>4</sub> /kg)	pH KCl	Titrateable Actual Acidity (mole H <sup>+</sup> /tonne)	Chromium Reducible Sulfur (%S <sub>CR</sub> )	Acid Neutralising Capacity (%CaCO <sub>3</sub> )	Net Acidity (mole H <sup>+</sup> /tonne)	Acid Volatile Sulfur (%S <sub>av</sub> )	Acid Sulfate Soil Material Classification
1.0	0-0.5	..	..	..	..	6.29	7.28	..	..	..	..	..	..	..	salt crust
1.1	0-0.5	Medium	28,700	7.64	7.20	7.25	7.41	6,200	8.50	0.00	<0.01	0.47	-62	..	other soil material
1.2	0.5-10	Medium	15,660	7.41	5.93	7.06	7.43	230	8.36	0.00	<0.01	0.06	-9	..	other soil material
1.3	10-20	Fine	5,940	7.47	7.26	7.31	7.26	120	7.85	0.00	<0.01	0.00	0	..	other soil material
1.4	20-40	Fine	2,990	7.43	7.58	7.44	7.37	120	7.32	0.00	<0.01	0.15	-20	..	other soil material
1.5	40-70	Fine	1,850	7.42	7.53	7.00	6.93	100	7.00	0.00	<0.01	0.32	-42	..	other soil material
2.0	0-0.5	..	..	..	..	6.86	7.31	..	..	..	..	..	..	..	salt crust
2.1	0-1	Medium	53,300	7.58	6.93	6.74	7.00	6,500	7.84	0.00	0.04	2.01	-245	..	hyposulfidic (S <sub>CR</sub> <0.10%)
2.2	1-4	Fine	24,700	7.69	6.73	6.68	6.95	4,400	8.01	0.00	0.08	0.43	-5	..	hyposulfidic (S <sub>CR</sub> <0.10%)
2.3	4-20	Fine	21,110	6.78	7.00	6.30	6.34	130	6.18	5.75	<0.01	0.00	6	..	other soil material
2.4	20-40	Fine	9,510	7.45	7.70	6.65	7.17	530	6.75	0.00	<0.01	0.18	-24	..	other soil material
2.5	40-70	Fine	4,150	8.35	8.31	8.13	7.64	180	6.95	0.00	<0.01	0.21	-29	..	other soil material
3.0	0-0.5	..	..	..	..	6.84	7.36	..	..	..	..	..	..	..	salt crust
3.1	0-1	Course	158,400	6.96	7.46	6.93	7.36	8,600	7.45	0.00	<0.01	0.76	-101	..	other soil material
3.2	1-10	Fine	49,200	7.53	6.67	6.24	6.84	5,500	8.05	0.00	0.33	2.90	-180	0.25	hyposulfidic (S <sub>CR</sub> ≥0.10%)
3.3	10-20	Fine	35,400	6.34	3.28	5.48	6.29	2,400	7.37	0.00	0.03	0.21	-9	..	hyposulfidic (S <sub>CR</sub> <0.10%)
3.4	20-40	Fine	24,300	5.94	5.08	5.62	6.09	460	7.03	0.00	<0.01	0.11	-14	..	other soil material
3.5	40-70	Fine	19,950	5.96	4.53	5.66	5.76	210	6.42	2.88	<0.01	0.00	3	..	other soil material
3.W1	-	..	..	..	..	..	..	..	..	..	..	..	..	..	pit water
4.0	0-0.2	..	..	..	..	6.52	6.72	..	..	..	..	..	..	..	salt crust
4.0	0-0.5	..	..	..	..	6.49	6.67	..	..	..	..	..	..	..	salt crust
4.1	0-5	Fine	74,100	7.36	6.84	6.33	6.71	0	6.95	0.00	0.20	2.10	-155	0.17	hyposulfidic (S <sub>CR</sub> ≥0.10%)
4.2	5-10	Fine	60,500	7.62	6.47	5.80	6.71	4,200	7.28	0.00	0.10	0.31	21	0.05	hyposulfidic (S <sub>CR</sub> ≥0.10%)
4.W1	-	..	..	..	..	..	..	..	..	..	..	..	..	..	pit water
5.1	0-1	Fine	55,200	7.03	6.59	6.29	6.57	6,600	7.01	0.00	0.02	0.96	-119	..	hyposulfidic (S <sub>CR</sub> <0.10%)
5.2	1-5	Fine	25,800	7.11	5.96	6.14	6.96	6,000	7.08	0.00	0.01	0.62	-76	..	hyposulfidic (S <sub>CR</sub> <0.10%)
5.3	5-10	Fine	21,630	6.07	4.63	5.61	5.47	590	7.03	0.00	<0.01	0.06	-8	..	other soil material
5.4	10-20	Fine	15,920	5.74	4.34	5.32	5.33	250	6.73	0.00	0.01	0.25	-27	..	hyposulfidic (S <sub>CR</sub> <0.10%)
5.5	20-40	Fine	15,650	5.78	4.77	5.58	5.22	780	6.48	2.88	0.01	0.00	9	..	hyposulfidic (S <sub>CR</sub> <0.10%)

**Table 4-5. Summary of hydrochemical field measurements for Little Toolunka Flat (Wetland ID. 12214).**

	<b>pH</b>	<b>SEC</b> $\mu\text{S cm}^{-1}$	<b>DO</b> $\text{mg l}^{-1}$	<b>Eh</b> mV	<b>Turbidity</b> NTU	<b>Alkalinity</b> as $\text{HCO}_3$
Pit waters (n=2)	5.21-6.75	201309-203471	0.2-1.0	146-193		0

**Table 4-6. Hydrochemical data for Little Toolunka Flat (Wetland ID. 12214).**

Parameter	units	ANZECC Guidelines	Site 3 (PW)	Site 4 (PW)
Na	mg l <sup>-1</sup>		63000	69600
K	mg l <sup>-1</sup>		66.1	294.0
Ca	mg l <sup>-1</sup>		5690	7500
Mg	mg l <sup>-1</sup>		12800	21000
Si	mg l <sup>-1</sup>		<25	<25
Br	mg l <sup>-1</sup>		410.0	700.0
Cl	mg l <sup>-1</sup>		160000	190000
NO <sub>3</sub>	mg l <sup>-1</sup>	0.7	<0.022	<0.022
NH <sub>4</sub> -N <sup>K</sup>	mg l <sup>-1</sup>	0.01	<b>18.00</b>	<b>0.410</b>
PO <sub>4</sub> -P <sup>E</sup>	mg l <sup>-1</sup>	0.005	<b>0.705</b>	<b>0.368</b>
SO <sub>4</sub>	mg l <sup>-1</sup>		1600	1200
Ag	µg l <sup>-1</sup>	0.05	<0.6	<0.6
Al <sup>A</sup>	µg l <sup>-1</sup>	55	<2000	<2000
As <sup>B</sup>	µg l <sup>-1</sup>	13	<30	30
Cd	µg l <sup>-1</sup>	0.2	<2	<2
Co	µg l <sup>-1</sup>	2.8	<b>382</b>	<b>12</b>
Cr <sup>C</sup>	µg l <sup>-1</sup>	1	<8	<8
Cu <sup>H</sup>	µg l <sup>-1</sup>	1.4	<30	<30
Fe	µg l <sup>-1</sup>	300	<50000	<50000
Mn	µg l <sup>-1</sup>	1700	<b>151000</b>	<b>88100</b>
Ni <sup>H</sup>	µg l <sup>-1</sup>	11	<b>180.0</b>	<20
Pb <sup>H</sup>	µg l <sup>-1</sup>	3.4	<b>480</b>	<10
Se	µg l <sup>-1</sup>	11	<10	<10
Zn <sup>H</sup>	µg l <sup>-1</sup>	8	<b>630</b>	<b>510</b>
DOC	mg l <sup>-1</sup>		93.6	241.2

**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<sub>4</sub> and PO<sub>4</sub>, 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.

<sup>A</sup> Trigger value for Aluminium in freshwater where pH > 6.5.

<sup>B</sup> Trigger value assumes As in solution as Arsenic (AsV).

<sup>C</sup> Trigger value for Chromium is applicable to Chromium (CrVI) only.

<sup>E</sup> Guideline is for filterable reactive phosphorous (FRP).

<sup>H</sup> Hardness affected (refer to Guidelines).

<sup>K</sup> Guideline for South-east Australia-Freshwater Lakes and reservoirs.

## 5. BIG TOOLUNKA FLAT (WETLAND ID. 12063)

### 5.1. Location and setting description

Big Toolunka Flat (Wetland ID. 12063) is situated on the northern side of the River Murray about 4.5 kilometres down river from the town of Waikerie, located in the Toolunka Complex area. The wetland is a creek that is linear in shape that occurs on the inside of a bend in the river. It is about 1 kilometre in length and about 10 to 30 metres wide, with a total surface area of 4 hectares. The wetland is bounded by a raised floodplain that separates the wetland from the river to the north and east, and a hillside to the south. The other associated wetland in the Big Toolunka Flat Complex that was surveyed is wetland ID. 12064.

The wetland is connected to the river at the southeast end. At the time when the soil survey was conducted in March 2010 it contained surface water. The wetland is not managed. It is permanently connected to the river and was probably last dry in the 1920's before the Locks were installed. 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 5-1.

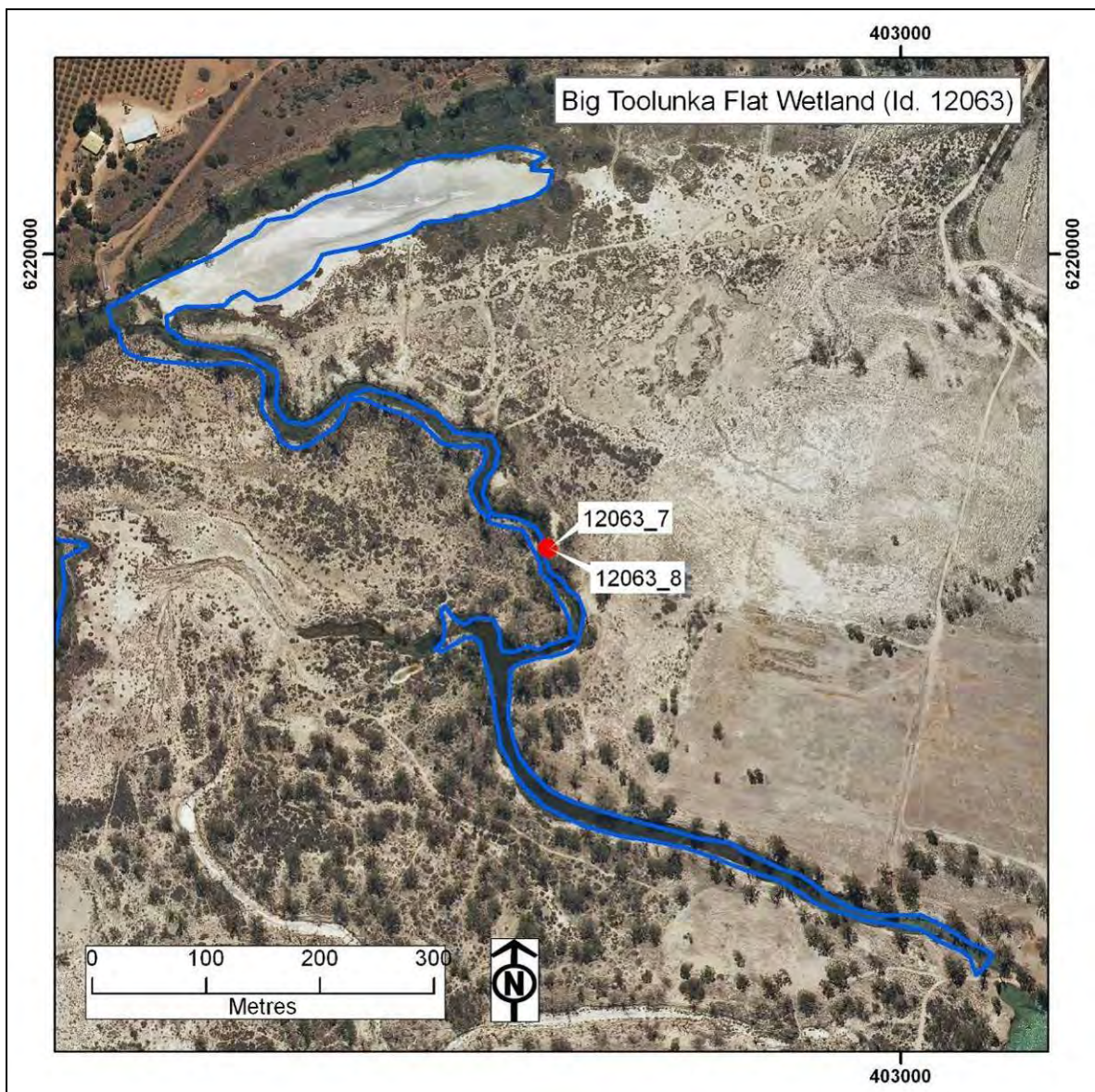


Figure 5-1. Big Toolunka Flat (Wetland ID. 12063) and sample site locations.

## 5.2. Soil profile description and distribution

Two sites were described and sampled. The soil subtypes and general location descriptions are presented in Table 5-1. Sites were distributed as a pair to describe the wetland margin and into the water (Sites 7 and 8). 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.

Site 7 (Figure 5-3) occurred adjacent to the bank in water (90 cm deep), the soil consisted of a very dark grey, very weak sand, over a dark grey, firm, sand. Site 8 (Figure 5-4) occurred in open water (130 cm deep), and the soil consisted of a very dark grey, weak, sand.

**Table 5-1. Soil identification, subtype and general location description for Big Toolunka Flat (Wetland ID. 12063).**

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12063_7	402691	6219741	Subaqueous Soil (sandy)	next to bank, in water, amongst Typha
12063_8	402690	6219742	Subaqueous Soil (sandy)	mid creek, open water

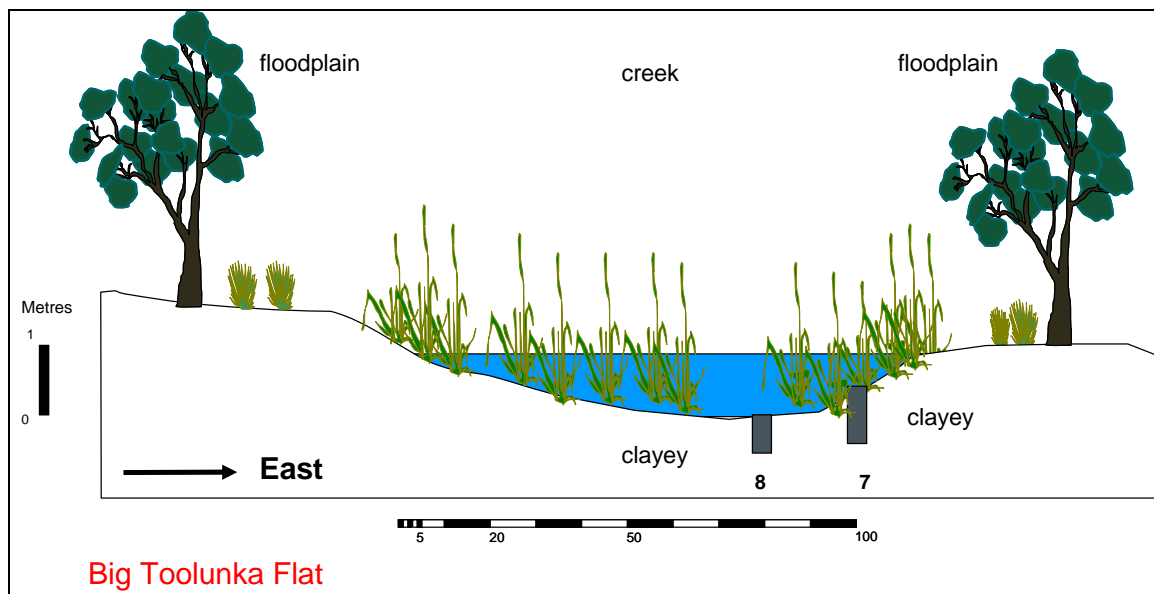


Figure 5-2. Conceptual cross-section diagram, showing locations for Sites 7 and 8.



**Figure 5-3: Photograph of Site 7, showing the site location in reeds adjacent to the bank.**



**Figure 5-4. Photograph of Site 8, showing the site location in open water, amongst reeds in the middle of the creek.**

### **5.3. Laboratory data assessment**

#### **5.3.1. Soil pH testing (pH<sub>W</sub>, pH<sub>OX</sub>, pH<sub>INC</sub>)**

The pH data are provided in Table 5-4 and pH profiles are presented in Figure 5-5. The pH<sub>W</sub> data ranged from 6.61 to 7.14 and sulfuric materials with a pH<sub>W</sub> <4 were not identified. The pH<sub>OX</sub> data ranged from 1.83 to 2.14 and identified that all sample declined below the critical value of pH<sub>OX</sub> <2.5, the threshold value normally used to indicate a high likelihood of sulfuric materials forming. The pH<sub>INC</sub> data ranged from 4.06 to 4.65 and identified that no soil samples on incubation declined below the critical values of pH<4, but all were less than pH 5.5, where trace elements such as Aluminium can be mobilised to values of concern.

#### **5.3.2. Acid base accounting**

The acid base accounting data is provided in Table 5-4 and summarised in Figure 5-6.

##### **Chromium reducible sulfur**

Chromium reducible sulfur values ranged from 0.02 to 0.16 %S<sub>CR</sub>, and sulfidic materials were detected in all soil layers.

##### **Titrateable actual acidity**

Titrateable actual acidity values ranged from 0 to 9.32 mole H<sup>+</sup>/tonne.

##### **Retained acidity**

Retained acidity was not measured in any of the layers as all samples had a pH<sub>KCl</sub> of greater than 4.5.

##### **Acid neutralising capacity**

Acid neutralising capacity values ranged were 0 %CaCO<sub>3</sub> for all samples except for the surface layer of Profile 7 that was 0.19 %CaCO<sub>3</sub>.

##### **Net acidity**

Net acidity values ranged from 12 to 103 mole H<sup>+</sup>/tonne. Profile 7 had low and moderate values and Profile 8 had high and moderate values.

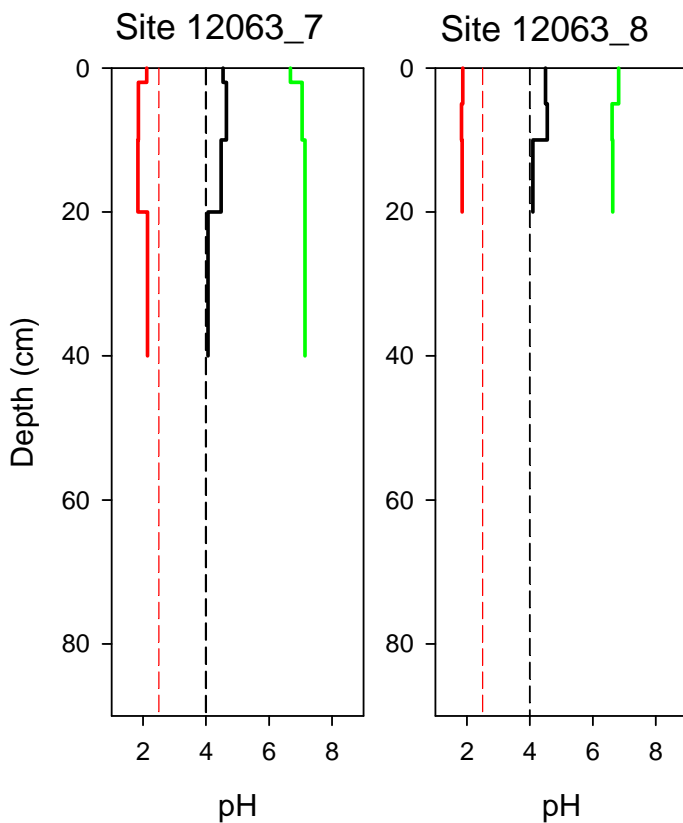


Figure 5-5. Depth profiles of soil pH for Big Toolunka Flat (Wetland ID. 12063), showing soil pH ( $pH_W$  as green line), peroxide treated pH ( $pH_{OX}$  as red line) and incubation pH ( $pH_{INC}$  after 8 weeks as black line). Critical  $pH_W$  and  $pH_{INC}$  value of 4 (black dashed line) and critical  $pH_{OX}$  value of 2.5 (red dashed line).

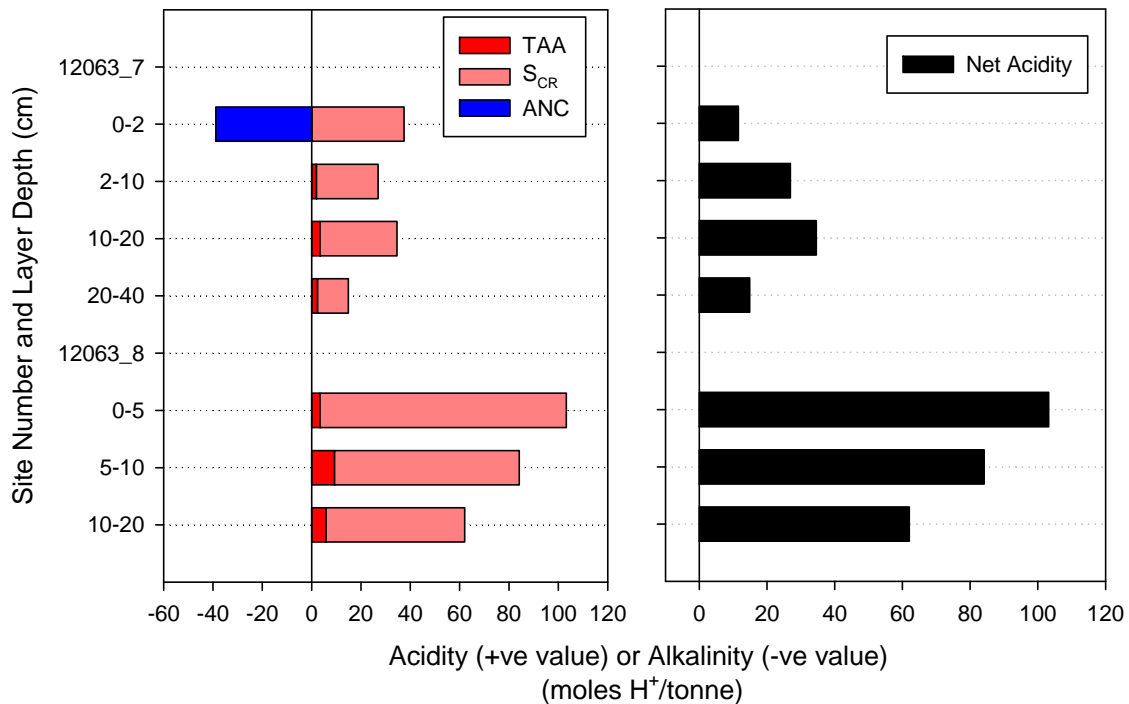


Figure 5-6. Acid base accounting depth profiles for Big Toolunka Flat (Wetland ID. 12063). Left side shows the components: Titratable actual acidity (TAA - red bar), acid generating potential (AGP as  $S_{CR}$  - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.



### 5.3.3. Water soluble sulfate

Water soluble sulfate data values shown in Table 5-4 identified that surface layers were below the criterion trigger value of 100 mg/kg SO<sub>4</sub>.

### 5.3.4. Acid volatile sulfur

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

### 5.3.5. Hydrochemistry

One surface water sample was collected from this small narrow wetland. Field parameters are shown in Table 5-5. The surface water had a circumneutral pH and was very fresh. The water had relatively low dissolved oxygen and turbidity was very high. Alkalinity was present, although at concentrations of the same magnitude as river water.

The water was of Na-Cl type, but there was a strong relative enrichment in HCO<sub>3</sub> relative to seawater composition (Table 5-6, Figure 5-7). Sulfate concentration in the surface water was low at 6.6 mg l<sup>-1</sup>. The SO<sub>4</sub>/Cl ratio in the surface waters (0.19) was slightly higher than seawater (0.142). Nitrate concentrations were below detection limit, and NH<sub>4</sub> and PO<sub>4</sub> were elevated above ANZECC Guideline values. Iron and Al were relatively high possibly due to the presence of colloidal material with the high turbidity. The concentrations of other trace metals were low.

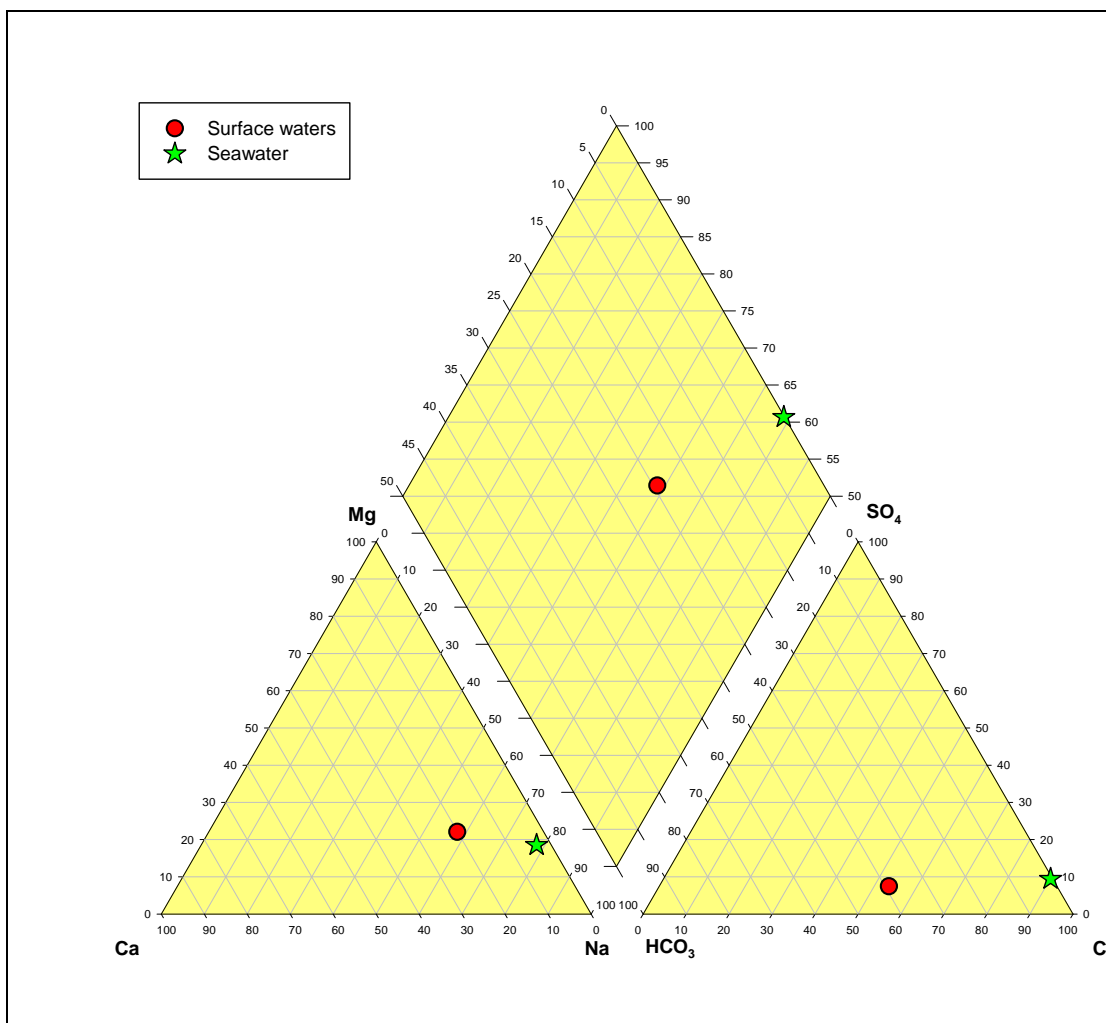


Figure 5-7. Piper diagram of hydrochemical data for Big Toolunka Flat (Wetland ID. 12063).

## 5.4. Discussion

Acid sulfate soil materials at Big Toolunka Flat (Wetland ID. 12063) were identified as hyposulfidic. The acid sulfate soil subtype class identified was Subaqueous Soil (sandy) that occurred throughout the wetland in areas below the water level.

The soils throughout the wetland below the water level were clays and near the creek bank they were loamier textured.

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 Big Toolunka Flat (Wetland ID. 12063) are:

- Acidification hazard: The data identified moderate and high values for both profiles and pH<sub>OX</sub> data identified samples with values that indicated potential acidification hazard due to oxidation. There is a medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated there is limited potential for monosulfidic materials to form in the surface layers of soils, monosulfidic material was not observed. There is a low 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 Big Toolunka Flat (Wetland ID. 12063):

<b>Soil materials:</b>	The soil layers throughout the wetland were hyposulfidic. The soils were clayey textured. Both profiles had moderate and high net acidity values and pH <sub>OX</sub> data indicated a potential for acidification due to oxidation.
<b>Acid sulfate soil identification:</b>	<ul style="list-style-type: none"> <li>• Subaqueous Soil (sandy) – occurring throughout the wetland below water. Dominant (&gt;50%) in extent.</li> </ul>
<b>Hazard assessment</b>	<ul style="list-style-type: none"> <li>• Acidification hazard – medium level of concern</li> <li>• De-oxygenation hazard – low level of concern</li> <li>• Metal mobilisation hazard – medium level of concern</li> </ul>

**Table 5-2. Site description data for Big Toolunka Flat (Wetland ID. 12063).**

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
7	26/03/2010	402691	6219741	90	soft	Typha	next to bank, in water, amongst Typha
8	26/03/2010	402690	6219742	130	soft	water	mid creek, open water

**Table 5-3. Soil profile description data for Big Toolunka Flat (Wetland ID. 12063)**

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
7_W	90 - 0	water							
7_1	0 - 2	small pit	very dark grey (10YR3/1)	sand	wet		gel	very weak	
7_2	2 - 10	small pit	very dark grey (10YR3/1)	sand	moist		massive	firm	
7_3	10 - 20	push tube	dark grey (5Y4/1)	sand	moist		single grain	firm	
7_4	20 - 40	push tube	dark grey (5Y4/1)	sand	moist		single grain	firm	
8_W1	130 - 0	surface water							water sampled
8_1	0 - 5	small pit	dark grey (5Y4/1)	peaty clay	wet		gel	very weak	
8_2	5 - 10	small pit	dark grey (5Y4/1)	sand	moist		massive	very weak	
8_3	10 - 20	push tube	dark greenish gray (10Y4/1)	sand	moist		massive	very weak	

**Table 5-4. Laboratory data for acid sulfate soil assessment of Big Toolunka Flat (Wetland ID. 12063).**

(red printed values indicates data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC ( $\mu\text{S}/\text{cm}$ )	pH water	pH peroxide	pH incubation week 0	pH incubation week 8	Sulfate (mg $\text{SO}_4/\text{kg}$ )	pH KCl	Titrateable Actual Acidity (mole $\text{H}^+$ /tonne)	Chromium Reducible Sulfur (% $\text{S}_{\text{CR}}$ )	Retained Acidity (mole $\text{H}^+$ /tonne)	Acid Neutralising Capacity (% $\text{CaCO}_3$ )	Net Acidity (mole $\text{H}^+$ /tonne)	Acid Sulfate Soil Material Classification
7.1	0-2	Medium	59	6.68	2.12	6.35	4.54	39	6.53	0.00	0.06	..	0.19	12	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
7.2	2-10	Medium	61	7.05	1.85	6.46	4.65	38	6.32	1.96	0.04	..	0.00	27	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
7.3	10-20	Medium	55	7.14	1.84	6.64	4.48	42	6.12	3.43	0.05	..	0.00	35	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
7.4	20-40	Medium	49	7.14	2.14	6.87	4.06	29	6.16	2.45	0.02	..	0.00	15	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
8.W1	130-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
8.1	0-5	Fine	126	6.82	1.87	6.33	4.50	49	6.40	3.43	0.16	..	0.00	103	hyposulfidic ( $\text{S}_{\text{CR}} \geq 0.10\%$ )
8.2	5-10	Fine	130	6.61	1.83	6.46	4.55	52	5.86	9.32	0.12	..	..	84	hyposulfidic ( $\text{S}_{\text{CR}} \geq 0.10\%$ )
8.3	10-20	Fine	131	6.63	1.85	6.31	4.10	68	5.78	5.89	0.09	..	..	62	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )

**Table 5-5. Summary of hydrochemical field measurements for Big Toolunka Flat (Wetland ID. 12063).**

	pH	SEC $\mu\text{S cm}^{-1}$	DO $\text{mg l}^{-1}$	Eh mV	Turbidity NTU	Alkalinity as $\text{HCO}_3$
Surface waters (n=1)	7.44	236	2.25	187	175	44

**Table 5-6. Hydrochemical data for Big Toolunka Flat (Wetland ID. 12063).**

Parameter	units	ANZECC Guidelines	Site 3 (SW)
Na	mg l <sup>-1</sup>		26.3
K	mg l <sup>-1</sup>		3.6
Ca	mg l <sup>-1</sup>		8.63
Mg	mg l <sup>-1</sup>		5.73
Si	mg l <sup>-1</sup>		3.44
Br	mg l <sup>-1</sup>		0.1
Cl	mg l <sup>-1</sup>		35
NO <sub>3</sub>	mg l <sup>-1</sup>	0.7	<0.022
NH <sub>4</sub> -N <sup>K</sup>	mg l <sup>-1</sup>	0.01	<b>0.12</b>
PO <sub>4</sub> -P <sup>E</sup>	mg l <sup>-1</sup>	0.005	<b>0.101</b>
SO <sub>4</sub>	mg l <sup>-1</sup>		6.6
Ag	µg l <sup>-1</sup>	0.05	0.02
Al <sup>A</sup>	µg l <sup>-1</sup>	55	<b>220</b>
As <sup>B</sup>	µg l <sup>-1</sup>	13	1
Cd	µg l <sup>-1</sup>	0.2	0.06
Co	µg l <sup>-1</sup>	2.8	0.17
Cr <sup>C</sup>	µg l <sup>-1</sup>	1	0.3
Cu <sup>H</sup>	µg l <sup>-1</sup>	1.4	<b>1.6</b>
Fe	µg l <sup>-1</sup>	300	<b>461</b>
Mn	µg l <sup>-1</sup>	1700	21
Ni <sup>H</sup>	µg l <sup>-1</sup>	11	1.1
Pb <sup>H</sup>	µg l <sup>-1</sup>	3.4	0.4
Se	µg l <sup>-1</sup>	11	<0.08
Zn <sup>H</sup>	µg l <sup>-1</sup>	8	<b>285</b>
DOC	mg l <sup>-1</sup>		6.8

**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<sub>4</sub> and PO<sub>4</sub>, 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.

<sup>A</sup> Trigger value for Aluminium in freshwater where pH > 6.5.

<sup>B</sup> Trigger value assumes As in solution as Arsenic (AsV).

<sup>C</sup> Trigger value for Chromium is applicable to Chromium (CrVI) only.

<sup>E</sup> Guideline is for filterable reactive phosphorous (FRP).

<sup>H</sup> Hardness affected (refer to Guidelines).

<sup>K</sup> Guideline for South-east Australia-Freshwater Lakes and reservoirs.

## 6. BIG TOOLUNKA FLAT (WETLAND ID. 12064)

### 6.1. Location and setting description

Big Toolunka Flat (Wetland ID. 12064) is situated on the northern side of the River Murray about 5 kilometres down river from the town of Waikerie, located in the Toolunka Complex area. The wetland is linear in shape that occurs on the inside of a bend in the river. It is about 3 kilometres in length and about 150 metres at its widest, with a total surface area of 37 hectares. The wetland is bounded by a raised floodplain that separates the wetland from the river to the south and hillside to the northeast. The other associate wetland in the Big Toolunka Flat complex is wetland ID. 12063 that occurs at the southeast end of the wetland.

The wetland is connected to the river by a permanent inlet to the northwest end of the wetland, and at the east end it is connected by the creek (Wetland ID. 12064) to the river. 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 to the river and was probably last dry in the 1920's before the Locks were installed. 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.

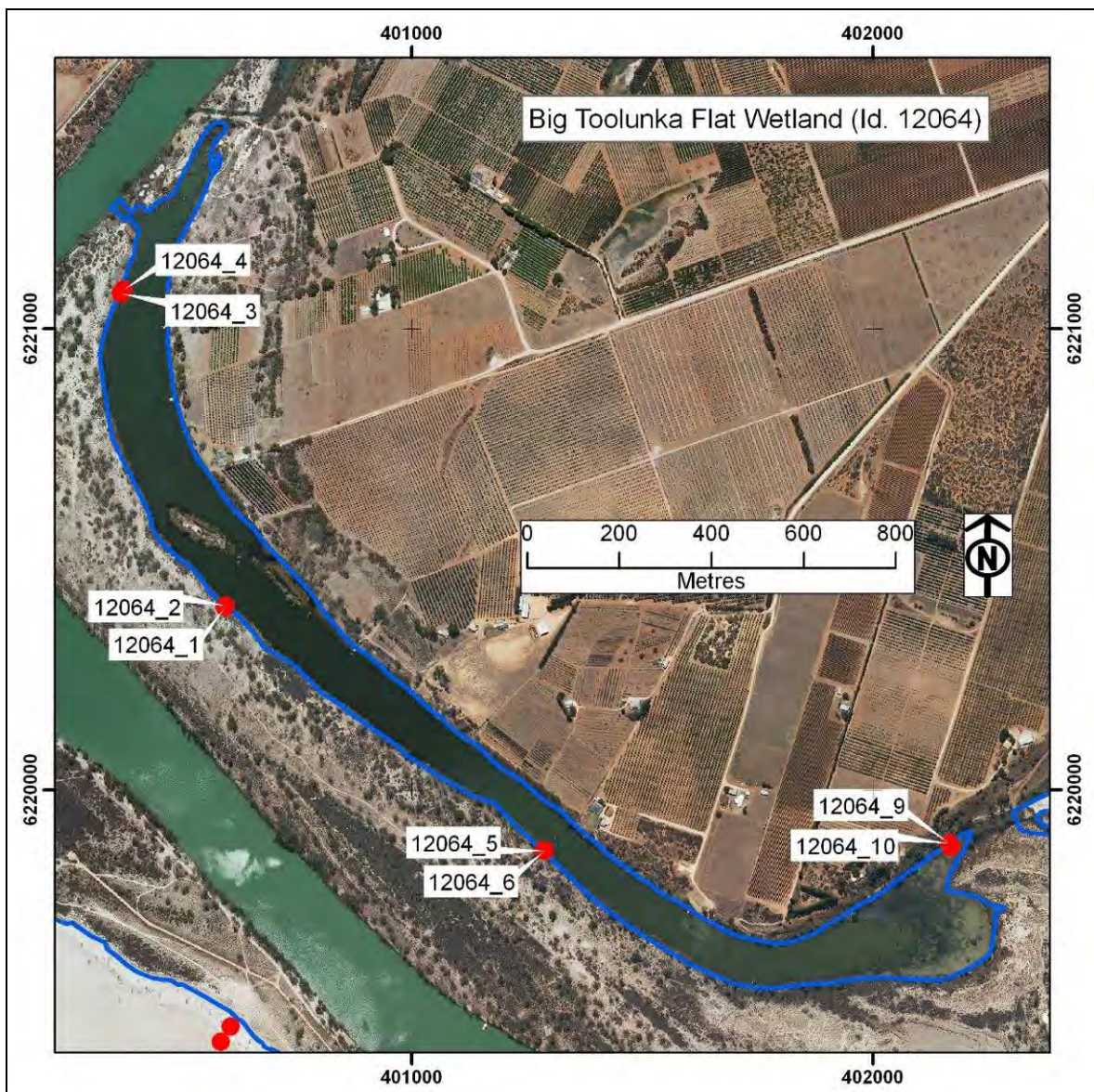


Figure 6-1. Big Toolunka Flat (Wetland ID. 12064) and sample site locations.

## 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 as pairs along the length of the wetland, with one site placed near the bank and the other in the open water, with pairs placed in the northwestern (Sites 1 and 2), western (Sites 3 and 4), southern (Sites 5 and 6), and eastern sides (Sites 9 and 10) of the wetland. The site and profile descriptions are presented in Table 6-2 and Table 6-3, and a conceptual cross-section diagram in Figure 6-2.

### Northwestern transect

Site 1 (Figure 6-3) occurred adjacent to the bank amongst Typha in water (60 cm deep), the soil consisted of a grey, firm, clay. Site 2 (Figure 6-4) occurred in open water (85 cm deep), and the soil consisted of a black, very weak, clay surface layer over a grey, weak, sandy clay loam subsoil layers.

### Western transect

Site 3 (Figure 6-5) occurred adjacent to the bank in water (85 cm deep), and the soil consisted of a black, very weak, mucky clay surface layer over a grey, very firm, gritty clay. Site 4 (Figure 6-6) occurred in water (120 cm deep), and the soil consisted of a grey, firm, gritty clay.

### Southern transect

Site 5 (Figure 6-7) occurred adjacent to bank, amongst Typha in water (80 cm deep), and the soil consisted of a very dark grey, very weak, peaty and gritty clay, with a strong sulfurous odour. Site 6 (Figure 6-7) occurred on the edge of Typha and open water (120 cm deep), and the soil consisted of a grey, very firm, gritty sandy clay loam.

### Eastern transect

Site 9 (Figure 6-8) occurred adjacent to the bank where lignum was growing and in water (50 cm deep), and the soil consisted of a dark greyish brown, weak sand over firm clay. Site 10 (Figure 6-9) occurred in open water (40 cm deep), and the soil consisted of very dark grey, very weak peaty clay surface over a dark greyish brown, firm, clay.

**Table 6-1. Soil identification, subtype and general location description for Big Toolunka Flat (Wetland ID. 12064).**

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12064_1	400594	6220396	Subaqueous Soil (clayey)	next to bank, in water, amongst Typha
12064_2	400596	6220400	Subaqueous Soil (clayey)	low elevation, in open water
12064_3	400370	6221077	Subaqueous Soil (clayey)	mid elevation, next to bank, in water amongst Typha
12064_4	400376	6221085	Subaqueous Soil (clayey)	low elevation, 10m from bank, in water
12064_5	401288	6219868	Hypersulfidic Subaqueous Soil (clayey)	mid elevation, next to bank, in water and amongst Typha
12064_6	401286	6219868	Subaqueous Soil (clayey)	low, edge Typha, water drops steeply into open water
12064_9	402166	6219884	Subaqueous Soil (clayey)	edge next to bank, in water amongst lignum
12064_10	402170	6219877	Hypersulfidic Subaqueous Soil (clayey)	low, elevation mid point of creek from lagoon

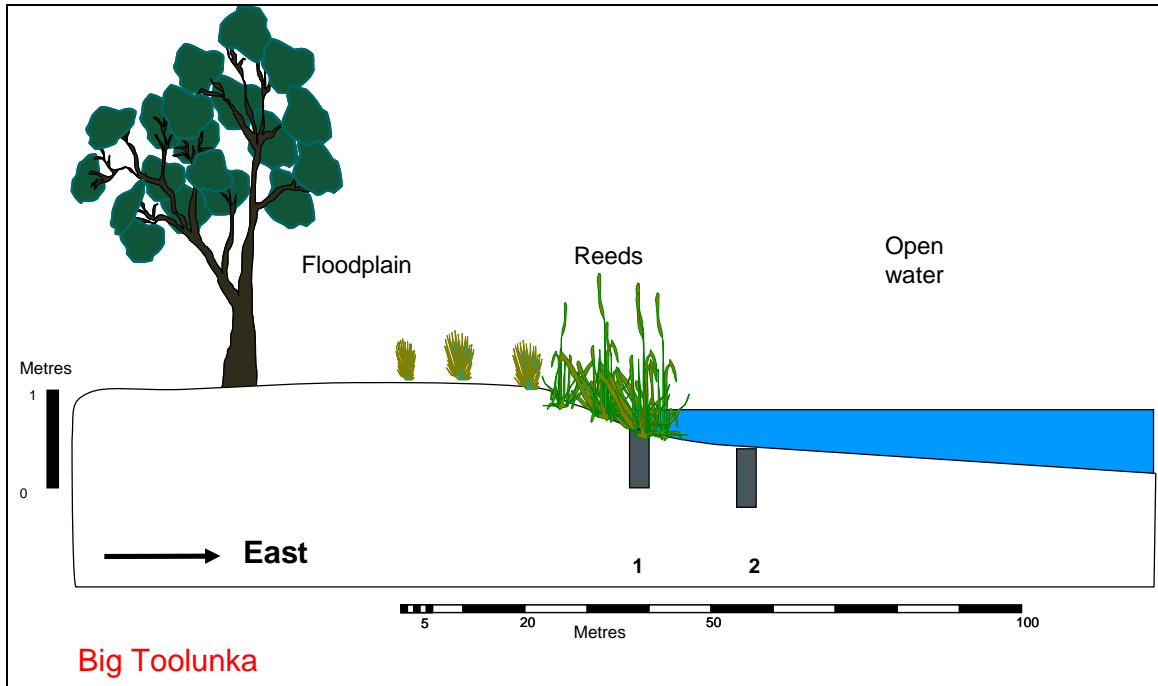


Figure 6-2. Conceptual cross-section diagram, showing locations of Sites 1 and 2.



Figure 6-3: Photograph of Site 1, showing the site location adjacent 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 near the bank in reeds.**



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



**Figure 6-7. Photograph of Site 5 and Site 6, showing the site locations in reeds (Site 5) and open water with (Site 6) in the background.**



**Figure 6-8. Photograph of Site 9, showing the site location adjacent to the bank in water.**



**Figure 6-9. Photograph of Site 10, showing the site location in open water.**

## 6.3. Laboratory data assessment

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

The pH data are provided in Table 6-4 and pH profiles are presented in Figure 6-10. The  $pH_W$  data ranged from 6.06 to 9.53 and sulfuric materials with  $pH_W < 4$  were not identified. The  $pH_{OX}$  data ranged from 1.68 to 9.09 and identified that the surface samples for Profiles 2, 5, 9 and 10 were below the critical value of  $pH_{OX} < 2.5$ , the threshold value normally used to indicate a high likelihood of sulfuric material forming. The  $pH_{INC}$  data ranged from 2.83 to 8.39 and identified that the surface layers of Profiles 5 and 10 were below the critical values of  $pH < 4$ , indicating that these soils potentially would form sulfuric material on oxidation.

### 6.3.2. Acid base accounting

The acid base accounting data is provided in Table 6-4 and summarised in Figure 6-11.

#### Chromium reducible sulfur

Chromium reducible sulfur values ranged from 0 to 0.62 % $S_{CR}$  sulfidic materials were detected in nearly all soil layers.

#### Titrateable actual acidity

Titrateable actual acidity was not measured in most soil samples, except for soil layers in Profile 10 that ranged from 4.79 to 16.30 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 8.81 % $CaCO_3$  and were measured in nearly all samples.

#### Net acidity

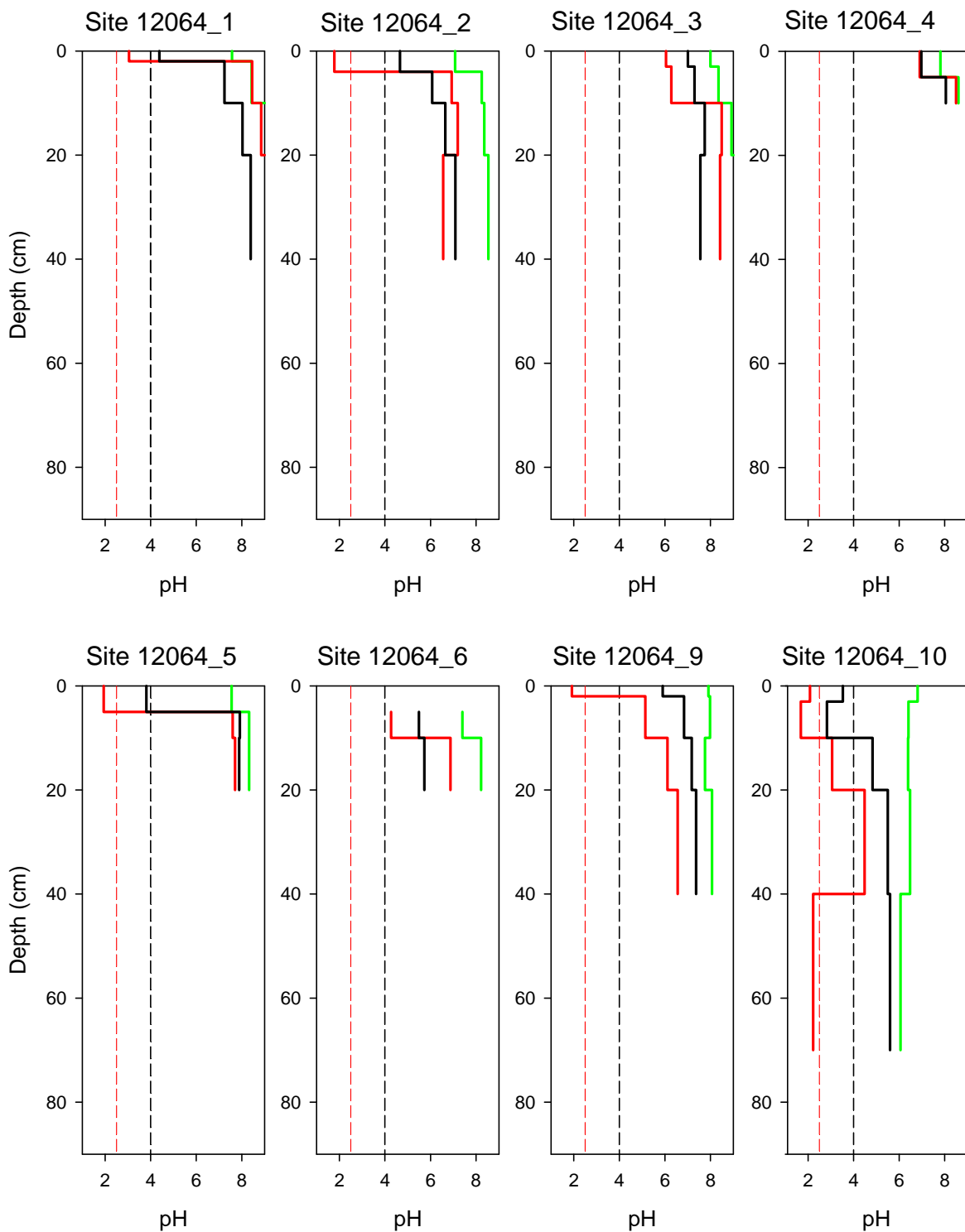
Net acidity values ranged from -1143 to 89 mole  $H^+$ /tonne. All layers in Profiles 3, 4, and 5 were negative values. The remaining profiles had negative values and at least one layer with a moderate net acidity value.

### 6.3.3. Water soluble sulfate

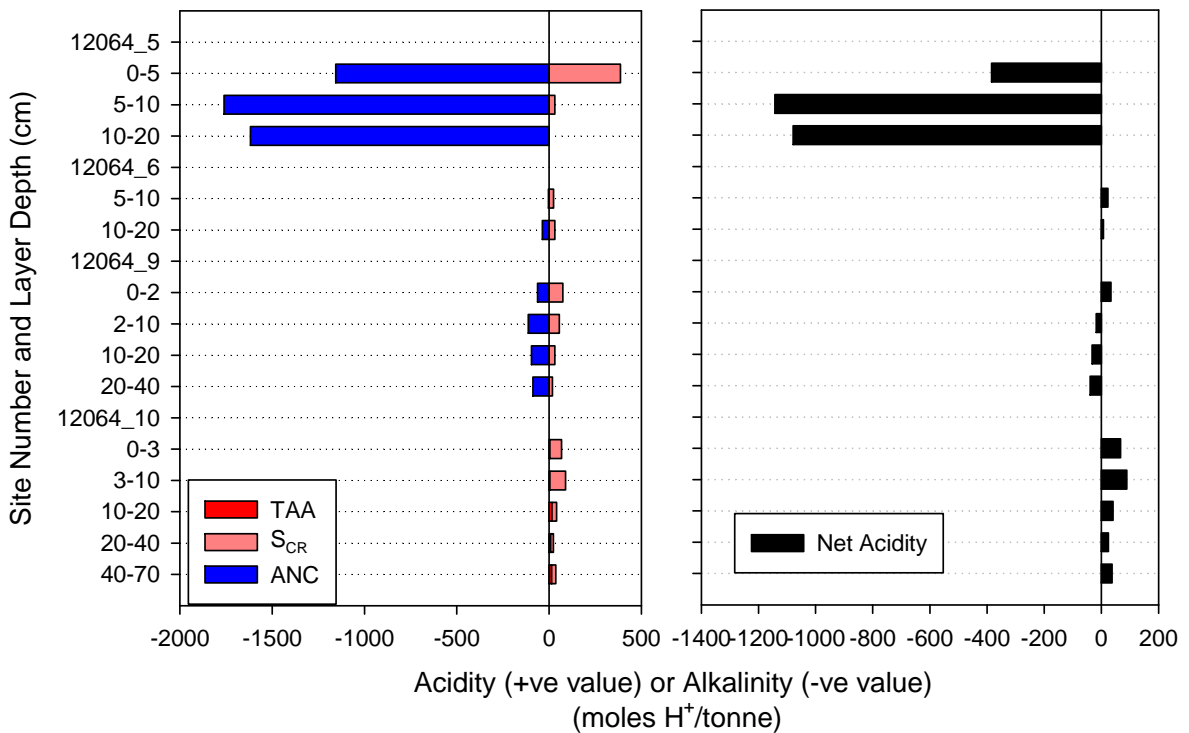
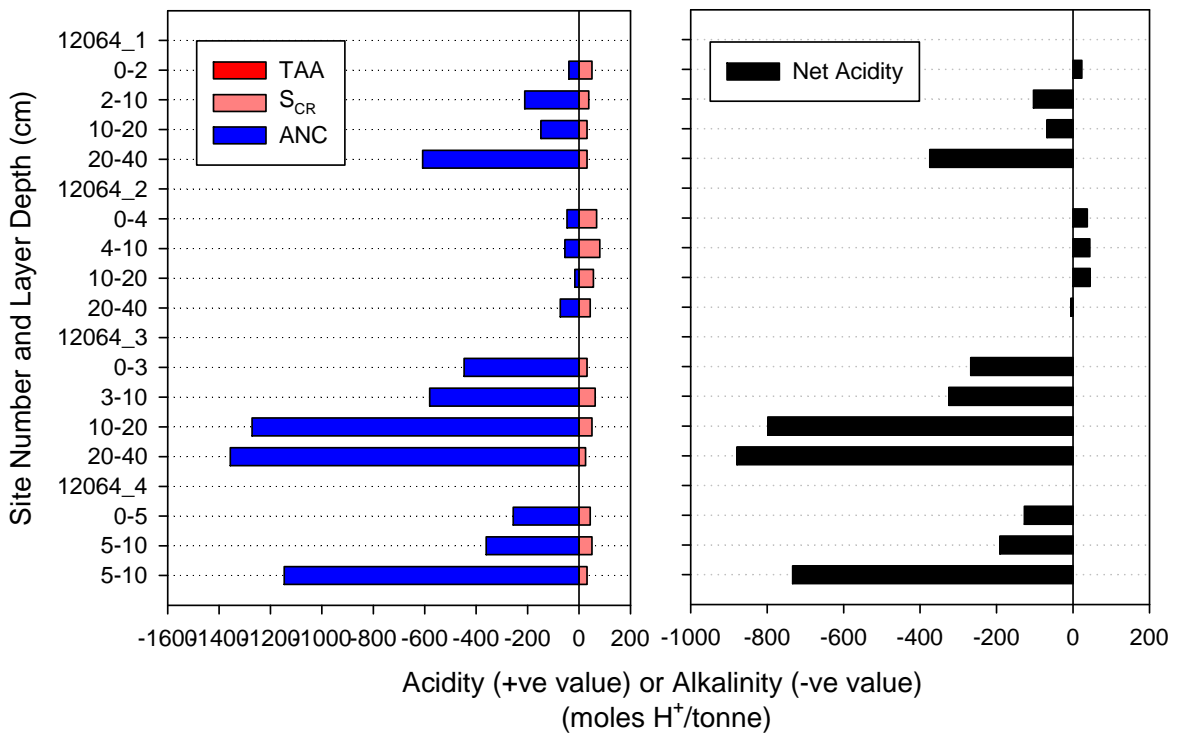
Water soluble sulfate data values shown in Table 6-4 identified that surface layers at Sites 1, 3 and 5 were above the criterion trigger value of 100 mg/kg  $SO_4$ .

### 6.3.4. Acid volatile sulfur

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



**Figure 6-10. Depth profiles of soil pH for Big Toolunka Flat (Wetland ID. 12064), showing soil pH (pH<sub>W</sub> as green line), peroxide treated pH (pH<sub>OX</sub> as red line) and incubation pH (pH<sub>INC</sub> after 8 weeks as black line). Critical pH<sub>W</sub> and pH<sub>INC</sub> value of 4 (black dashed line) and critical pH<sub>OX</sub> value of 2.5 (red dashed line).**



**Figure 6-11. Acid base accounting depth profiles for Big Toolunka Flat (Wetland ID. 12064). Left side shows the components: Titratable actual acidity (TAA - red bar), acid generating potential (AGP as S<sub>CR</sub> - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.**

### 6.3.5. Hydrochemistry

Four surface water samples were collected from this wetland. Field parameters are shown in Table 6-5. The surface water had a circumneutral pH and was moderately fresh. The water was slightly undersaturated with dissolved oxygen and turbidity was moderately low. Alkalinity was present at concentrations similar to that expected for river water.

The waters were of Na-Cl type, with a slight relative enrichment in Ca and  $\text{HCO}_3$  relative to seawater composition (Table 6-6, Figure 6-12). Sulfate concentrations in the surface waters varied from 13 to 30  $\text{mg l}^{-1}$ . The  $\text{SO}_4/\text{Cl}$  ratio in the surface waters (0.131 to 0.144) was similar to seawater (0.142). Nitrate concentrations were below detection limit and  $\text{PO}_4$  and to a lesser degree  $\text{NH}_4$  were elevated above ANZECC Guideline values. The concentrations of most trace metals were low.

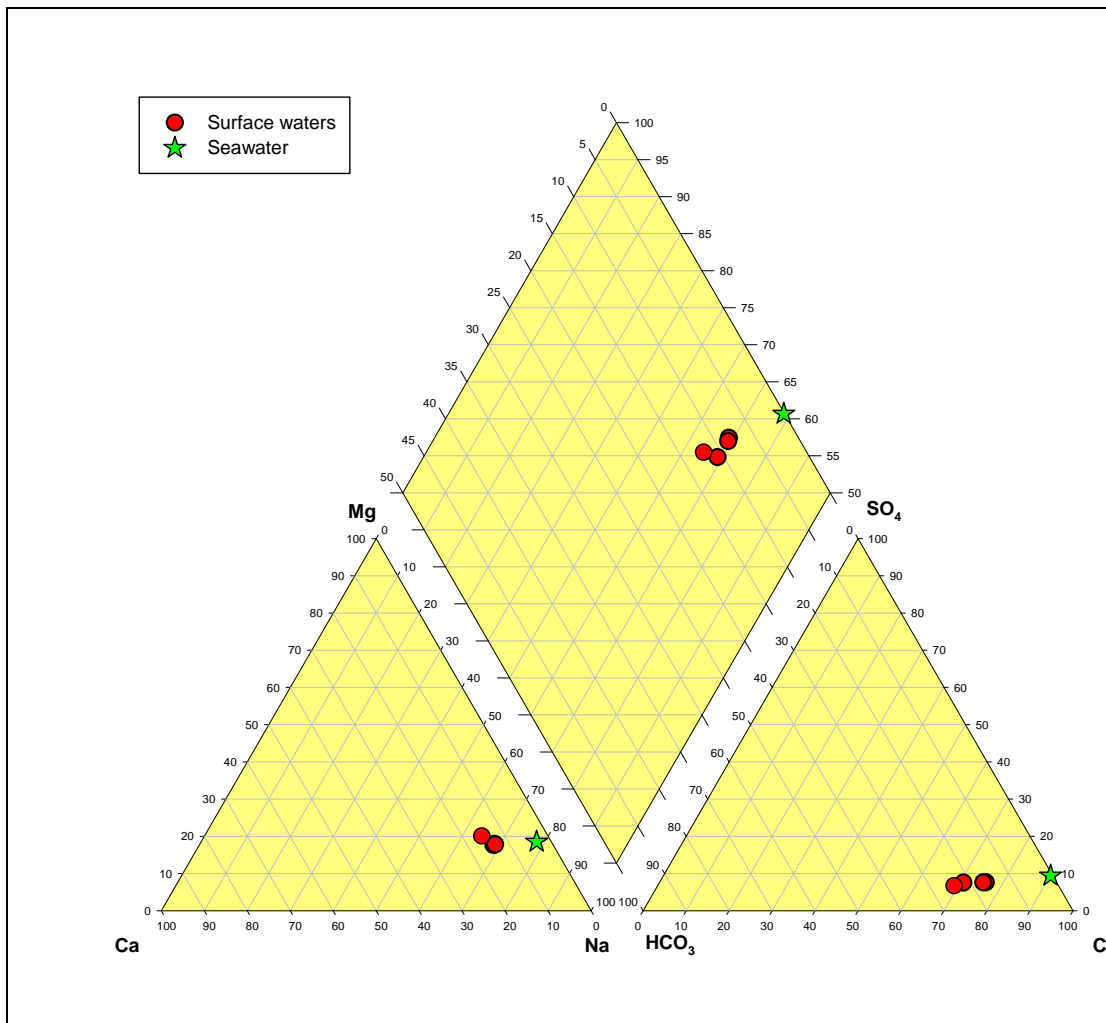


Figure 6-12. Piper diagram of hydrochemical data for Big Toolunka Flat (Wetland ID. 12064).

## 6.4. Discussion

Acid sulfate soil materials at Big Toolunka Flat (Wetland ID. 12064) were identified as hypersulfidic in the surface layers of Profiles 5 and 10 or hyposulfidic for the other samples. The acid sulfate soil subtype classes identified were Subaqueous Soil (clayey) that occurred throughout the wetland and Hypersulfidic Subaqueous Soil (clayey) that tended to occur in open water at the eastern end of the wetland.

The soils throughout the wetland below the water level were clay and loam textures in the surface layers and the in the subsoil became firm clays.

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

The potential hazards posed by acid sulfate soil materials at Big Toolunka Flat (Wetland ID. 12064) are:

- Acidification hazard: The data identified moderate net acidity values in 5 of the 8 profiles and  $pH_{OX}$  and  $pH_{INC}$  data in the surface layers with values that indicated a potential acidification hazard due to oxidation. There is a medium to high level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there were a three profiles with potential for monosulfidic materials to form in the surface layers of soils, monosulfidic material was not observed. There is a low to 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 Big Toolunka Flat (Wetland ID. 12064):

<b>Soil materials:</b>	The surface soil layers throughout the wetland were generally hyposulfidic and in some areas hypersulfidic. The subsoil layers were all hyposulfidic. Surface layers were clayey or loamy textured and subsoil layers were clayey textured. Net acidity in samples varied from negative to moderate values and pH data in some samples indicated potential acidification due to oxidation.
<b>Acid sulfate soil identification:</b>	<ul style="list-style-type: none"> <li>• Subaqueous Soil (clayey) – occurring throughout the wetland. Dominant (&gt;50%) in extent.</li> <li>• Hypersulfidic Subaqueous Soil (clayey) – occurring in open water at the eastern end of the wetland. Minor (&lt;25%) in extent.</li> </ul>
<b>Hazard assessment</b>	<ul style="list-style-type: none"> <li>• Acidification hazard – medium to high level of concern</li> <li>• De-oxygenation hazard – low to medium level of concern</li> <li>• Metal mobilisation hazard – medium level of concern</li> </ul>

**Table 6-2. Site description data for Big Toolunka Flat (Wetland ID. 12064).**

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	26/03/2010	400594	6220396	60	water	Typha	next to bank, in water, amongst Typha
2	26/03/2010	400596	6220400	85	soft	water	low elevation, in open water
3	26/03/2010	400370	6221077	85	soft	Typha	mid elevation, next to bank, in water amongst Typha
4	26/03/2010	400376	6221085	120	firm, tree logs, dredged	water	low elevation, 10m from bank, in water
5	26/03/2010	401288	6219868	80	soft, water	Typha	mid elevation, next to bank, in water and amongst Typha
6	26/03/2010	401286	6219868	120	water, roots	Typha	low, edge Typha, water drops steeply into open water
9	26/03/2010	402166	6219884	50		lignum on banks	edge next to bank, in water amongst lignum
10	26/03/2010	402170	6219877	40	water, soft	bare	low, elevation mid point of creek from lagoon

**Table 6-3. Soil profile description data for Big Toolunka Flat (Wetland ID. 12064).**

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	#N/A							
1_1	0 - 2	small pit	dark grey (10YR4/1)	clay	wet		gel	very weak	stringy sulfidic odour
1_2	2 - 10	small pit	grey (5Y5/1)	clay	wet		massive	firm	
1_3	10 - 20	small pit	grey (5Y5/1)	sandy loam	moist		massive	firm	
1_4	20 - 40	push tube	grey (5Y5/1)	clay	moist		massive	firm	
2_W1	85 - 0	surface water							water sampled
2_1	0 - 4	small pit	black (10YR2/1)	clay	wet		gel	very weak	stringy sulfidic odour
2_2	4 - 10	small pit	dark grey (5Y4/1)	clay	wet		massive	weak	
2_3	10 - 20	small pit	grey (5Y5/1)	clay	moist		massive	weak	
2_4	20 - 40	push tube	grey (5Y5/1)	sandy clay loam	moist		massive	weak	

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_W	85 - 0	water							
3_1	0 - 3	small pit	black (10YR2/1)	mucky clay	wet		gel	very weak	
3_2	3 - 10	small pit	greyish brown (2.5Y5/2)	gritty clay	wet		massive	firm	
3_3	10 - 20	small pit	grey (5Y5/1)	gritty clay	wet		massive	firm	
3_4	20 - 40	push tube	grey (5Y5/1)	clay	moist		massive	very firm	contains carbonate fragments
4_W1	120 - 0	surface water							water sampled
4_1	0 - 5	small pit	grey (5Y5/1)	gritty clay	wet		massive	firm	
4_2	5 - 10	small pit	grey (5Y5/1)	gritty clay	wet		massive	very firm	
4_2 DUP	5 - 10	small pit	grey (5Y5/1)	gritty clay	wet		massive	very firm	
5_W	80 - 0	water							
5_1	0 - 5	small pit	very dark grey (10YR3/1)	peaty clay	wet		gel	very weak	strong sulfide odour
5_2	5 - 10	small pit	grey (5Y5/1)	gritty clay	moist		massive	very firm	contains carbonate fragments
5_3	10 - 20	push tube	grey (5Y5/1)	gritty clay	moist		massive	very firm	contains carbonate fragments
6_W1	120 - 0	surface water							water sampled
6_1	0 - 5	push tube	grey (5Y5/1)	clay	wet		gel	very weak	contains many plant roots
6_2	5 - 10	push tube	grey (5Y5/1)	gritty sandy clay loam	moist		massive	very firm	
6_3	10 - 20	push tube	grey (5Y5/1)	gritty sandy clay loam	moist		massive	very firm	contains carbonate fragments
9_W	50 - 0	water							
9_1	0 - 2	small pit	very dark grey (10YR3/1)	peaty clay	wet		gel	very weak	
9_2	2 - 10	small pit	dark greyish brown (2.5Y4/2)	sand	moist		massive	weak	
9_3	10 - 20	push tube	dark greyish brown (2.5Y4/2)	sand	moist		massive	firm	
9_4	20 - 40	push tube	dark greyish brown (2.5Y4/2)	clay	moist		massive	firm	contains carbonate fragments
10_W1	40 - 0	surface water							water sampled
10_1	0 - 3	small pit	very dark grey (10YR3/1)	peaty clay	wet		gel	very weak	
10_2	3 - 10	small pit	very dark grey (10YR3/1)	sand	wet		massive	very weak	
10_3	10 - 20	push tube	dark greyish brown (2.5Y4/2)	sand	moist		massive	weak	
10_4	20 - 40	push tube	dark greyish brown (2.5Y4/2)	clay	moist		massive	firm	
10_5	40 - 70	push tube	dark greyish brown (2.5Y4/2)	clay	moist		massive	firm	



**Table 6-4. Laboratory data for acid sulfate soil assessment of Big Toolunka Flat (Wetland ID. 12064).**

(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 <sub>4</sub> /kg)	pH KCl	Titrateable Actual Acidity (mole H <sup>+</sup> /tonne)	Chromium Reducible Sulfur (%S <sub>CR</sub> )	Retained Acidity (mole H <sup>+</sup> /tonne)	Acid Neutralising Capacity (%CaCO <sub>3</sub> )	Net Acidity (mole H <sup>+</sup> /tonne)	Acid Sulfate Soil Material Classification
1.W	60-0														water
1.1	0-2	Medium	231	7.57	3.05	6.61	4.38	98	6.61	0.00	0.08	..	0.20	23	hyposulfidic (S <sub>CR</sub> <0.10%)
1.2	2-10	Fine	1,917	8.43	8.45	7.29	7.24	110	7.70	0.00	0.06	..	1.06	-103	hyposulfidic (S <sub>CR</sub> <0.10%)
1.3	10-20	Fine	167	9.17	8.85	8.56	8.03	43	7.97	0.00	0.05	..	0.74	-68	hyposulfidic (S <sub>CR</sub> <0.10%)
1.4	20-40	Fine	237	9.53	9.09	8.87	8.39	42	8.30	0.00	0.05	..	3.04	-374	hyposulfidic (S <sub>CR</sub> <0.10%)
2.W1	85-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
2.1	0-4	Medium	149	7.08	1.78	6.63	4.66	86	7.38	0.00	0.11	..	0.23	37	hyposulfidic (S <sub>CR</sub> ≥0.10%)
2.2	4-10	Fine	227	8.25	6.93	7.67	6.07	100	6.84	0.00	0.13	..	0.28	44	hyposulfidic (S <sub>CR</sub> ≥0.10%)
2.3	10-20	Fine	161	8.36	7.20	7.81	6.65	72	7.51	0.00	0.09	..	0.08	45	hyposulfidic (S <sub>CR</sub> <0.10%)
2.4	20-40	Fine	143	8.54	6.56	7.53	7.09	61	7.31	0.00	0.07	..	0.36	-5	hyposulfidic (S <sub>CR</sub> <0.10%)
3.W	85-0														water
3.1	0-3	Fine	171	8.00	6.05	6.99	7.01	140	8.25	0.00	0.05	..	2.24	-267	hyposulfidic (S <sub>CR</sub> <0.10%)
3.2	3-10	Fine	248	8.35	6.28	7.01	7.30	180	8.19	0.00	0.10	..	2.90	-325	hyposulfidic (S <sub>CR</sub> ≥0.10%)
3.3	10-20	Fine	242	8.92	8.49	7.68	7.75	54	8.25	0.00	0.08	..	6.37	-798	hyposulfidic (S <sub>CR</sub> <0.10%)
3.4	20-40	Fine	179	9.12	8.42	7.50	7.56	30	7.77	0.00	0.04	..	6.79	-879	hyposulfidic (S <sub>CR</sub> <0.10%)
4.W1	120-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
4.1	0-5	Medium	220	7.81	6.90	6.98	6.97	95	8.17	0.00	0.07	..	1.28	-127	hyposulfidic (S <sub>CR</sub> <0.10%)
4.2	5-10	Medium	217	7.81	7.02	6.94	7.26	96	8.37	0.00	0.08	..	1.81	-191	hyposulfidic (S <sub>CR</sub> <0.10%)
4.2DUP	5-10	Fine	148	8.60	8.50	8.06	8.05	38	8.28	0.00	0.05	..	5.74	-733	hyposulfidic (S <sub>CR</sub> <0.10%)
5.W	80-0														water
5.1	0-5	Medium	306	7.55	1.94	6.70	3.81	190	7.68	0.00	0.62	..	5.78	-384	hypersulfidic
5.2	5-10	Fine	197	8.32	7.60	7.00	7.91	61	8.42	0.00	0.05	..	8.81	-1143	hyposulfidic (S <sub>CR</sub> <0.10%)
5.3	10-20	Fine	218	8.32	7.70	7.52	7.88	30	8.20	0.00	<0.01	..	8.10	-1078	other soil material
6.W1	120-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
6.1	0-5	..	..	..	..	..	..	..	..	..	..	..	..	..	Not assessed
6.2	5-10	Fine	136	7.40	4.27	6.67	5.49	60	7.34	0.00	0.04	..	0.02	23	hyposulfidic (S <sub>CR</sub> <0.10%)
6.3	10-20	Fine	180	8.22	6.88	6.40	5.73	63	7.09	0.00	0.05	..	0.18	7	hyposulfidic (S <sub>CR</sub> <0.10%)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC ( $\mu\text{S}/\text{cm}$ )	pH water	pH peroxide	pH incubation week 0	pH incubation week 8	Sulfate ( $\text{mg SO}_4/\text{kg}$ )	pH KCl	Titrateable Actual Acidity ( $\text{mole H}^+/\text{tonne}$ )	Chromium Reducible Sulfur ( $\%S_{\text{CR}}$ )	Retained Acidity ( $\text{mole H}^+/\text{tonne}$ )	Acid Neutralising Capacity ( $\%\text{CaCO}_3$ )	Net Acidity ( $\text{mole H}^+/\text{tonne}$ )	Acid Sulfate Soil Material Classification
9.W	50-0														water
9.1	0-2	Medium	314	7.91	1.92	7.02	5.90	92	6.52	0.00	0.12	..	0.31	34	hyposulfidic ( $S_{\text{CR}} \geq 0.10\%$ )
9.2	2-10	Fine	544	7.98	5.14	7.48	6.84	63	6.66	0.00	0.09	..	0.56	-18	hyposulfidic ( $S_{\text{CR}} < 0.10\%$ )
9.3	10-20	Fine	609	7.76	6.11	7.49	7.18	66	6.69	0.00	0.05	..	0.48	-32	hyposulfidic ( $S_{\text{CR}} < 0.10\%$ )
9.4	20-40	Fine	823	8.07	6.56	6.96	7.37	42	6.67	0.00	0.03	..	0.44	-40	hyposulfidic ( $S_{\text{CR}} < 0.10\%$ )
10.W1	40-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
10.1	0-3	Medium	176	6.81	2.08	6.69	3.53	72	6.18	4.90	0.10	..	0.00	67	hypersulfidic
10.2	3-10	Medium	258	6.41	1.68	6.44	2.83	83	6.27	4.79	0.13	..	0.00	89	hypersulfidic
10.3	10-20	Fine	407	6.39	3.06	6.26	4.83	21	5.67	16.30	0.04	..	..	41	hyposulfidic ( $S_{\text{CR}} < 0.10\%$ )
10.4	20-40	Fine	476	6.48	4.48	6.28	5.50	37	5.98	8.63	0.03	..	..	24	hyposulfidic ( $S_{\text{CR}} < 0.10\%$ )
10.5	40-70	Fine	338	6.06	2.23	6.28	5.60	44	5.63	14.38	0.04	..	..	37	hyposulfidic ( $S_{\text{CR}} < 0.10\%$ )

**Table 6-5. Summary of hydrochemical field measurements for Big Toolunka Flat (Wetland ID. 12064).**

	pH	SEC $\mu\text{S cm}^{-1}$	DO $\text{mg l}^{-1}$	Eh mV	Turbidity NTU	Alkalinity as $\text{HCO}_3$
Surface waters (n=4)	7.12-7.45	441-870	4.29-6.26	179-225	20-76	60-85

**Table 6-6. Hydrochemical data for Big Toolunka Flat (Wetland ID. 12064).**

Parameter	units	ANZECC Guidelines	Site 2 (SW)	Site 4 (SW)	Site 6 (SW)	Site 10 (SW)
Na	mg l <sup>-1</sup>		116	95.7	122	56.3
K	mg l <sup>-1</sup>		3.9	3.9	3.9	3.1
Ca	mg l <sup>-1</sup>		20.4	17.3	21.2	12.1
Mg	mg l <sup>-1</sup>		16.4	13.4	17	9.56
Si	mg l <sup>-1</sup>		1.74	2.23	1.63	2.35
Br	mg l <sup>-1</sup>		0.5	0.3	0.5	0.2
Cl	mg l <sup>-1</sup>		220	160	220	99
NO <sub>3</sub>	mg l <sup>-1</sup>	0.7	<0.022	<0.022	<0.022	<0.022
NH <sub>4</sub> -N <sup>K</sup>	mg l <sup>-1</sup>	0.01	<b>0.017</b>	<b>0.012</b>	<b>0.020</b>	<b>0.013</b>
PO <sub>4</sub> -P <sup>E</sup>	mg l <sup>-1</sup>	0.005	<b>0.034</b>	<b>0.083</b>	<b>0.025</b>	<b>0.034</b>
SO <sub>4</sub>	mg l <sup>-1</sup>		30	23	30	13
Ag	µg l <sup>-1</sup>	0.05	<0.01	0.01	<0.01	<0.01
Al <sup>A</sup>	µg l <sup>-1</sup>	55	30	<b>90</b>	<10	<b>80</b>
As <sup>B</sup>	µg l <sup>-1</sup>	13	0.8	0.8	0.8	1
Cd	µg l <sup>-1</sup>	0.2	0.02	0.03	0.03	0.06
Co	µg l <sup>-1</sup>	2.8	0.08	0.08	0.04	0.09
Cr <sup>C</sup>	µg l <sup>-1</sup>	1	0.05	0.1	<0.05	0.1
Cu <sup>H</sup>	µg l <sup>-1</sup>	1.4	0.4	0.6	0.4	0.6
Fe	µg l <sup>-1</sup>	300	<100	155	<100	182
Mn	µg l <sup>-1</sup>	1700	12	4.86	4.14	38.34
Ni <sup>H</sup>	µg l <sup>-1</sup>	11	0.9	0.9	0.8	0.9
Pb <sup>H</sup>	µg l <sup>-1</sup>	3.4	<0.1	0.1	<0.1	0.2
Se	µg l <sup>-1</sup>	11	<0.08	<0.08	<0.08	<0.08
Zn <sup>H</sup>	µg l <sup>-1</sup>	8	<b>31.8</b>	<b>51</b>	<b>64.6</b>	<b>170</b>
DOC	mg l <sup>-1</sup>		6.4	5.8	6.2	5.6

**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<sub>4</sub> and PO<sub>4</sub>, 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.

- <sup>A</sup> Trigger value for Aluminium in freshwater where pH > 6.5.  
<sup>B</sup> Trigger value assumes As in solution as Arsenic (AsV).  
<sup>C</sup> Trigger value for Chromium is applicable to Chromium (CrVI) only.  
<sup>E</sup> Guideline is for filterable reactive phosphorous (FRP).  
<sup>H</sup> Hardness affected (refer to Guidelines).  
<sup>K</sup> Guideline for South-east Australia-Freshwater Lakes and reservoirs.

## 7. RAMCO LAGOON (WETLAND ID. 12046)

### 7.1. Location and setting description

Ramco Lagoon (Wetland ID. 12046) is situated on the southern side of the River Murray about 6 kilometres down river from the town of Waikerie. The wetland is droplet in shape that occurs on the inside of a bend in the river. It is about 1.7 kilometres in length and about 800 metres at it's widest, with a total surface area of 93 hectares. The wetland is bounded by a raised floodplain that separates the wetland from the river to the northeast and there is a steep hillside to the southwest.

The wetland is connected to the river with an inlet to the up river end of the wetland (when the river flows at about 50,000 ML/day) and at the down river end (when the river flows at pool level). At the time when the soil survey was conducted in March 2010 the wetland contained isolated pools of surface water. The wetland is managed and there are structures installed. Monitoring is conducted by Ramco Wetland Management Group with assistance from the South Australian Murray-Darling Basin Natural Resources Management Board (SA MDB NRM Board) and RWLAP. Sedgeland and shrublands were growing around the wetland margins, with open woodland and shrubland on the surrounding higher floodplain. Eight sites were sampled as shown in Figure 7-1.

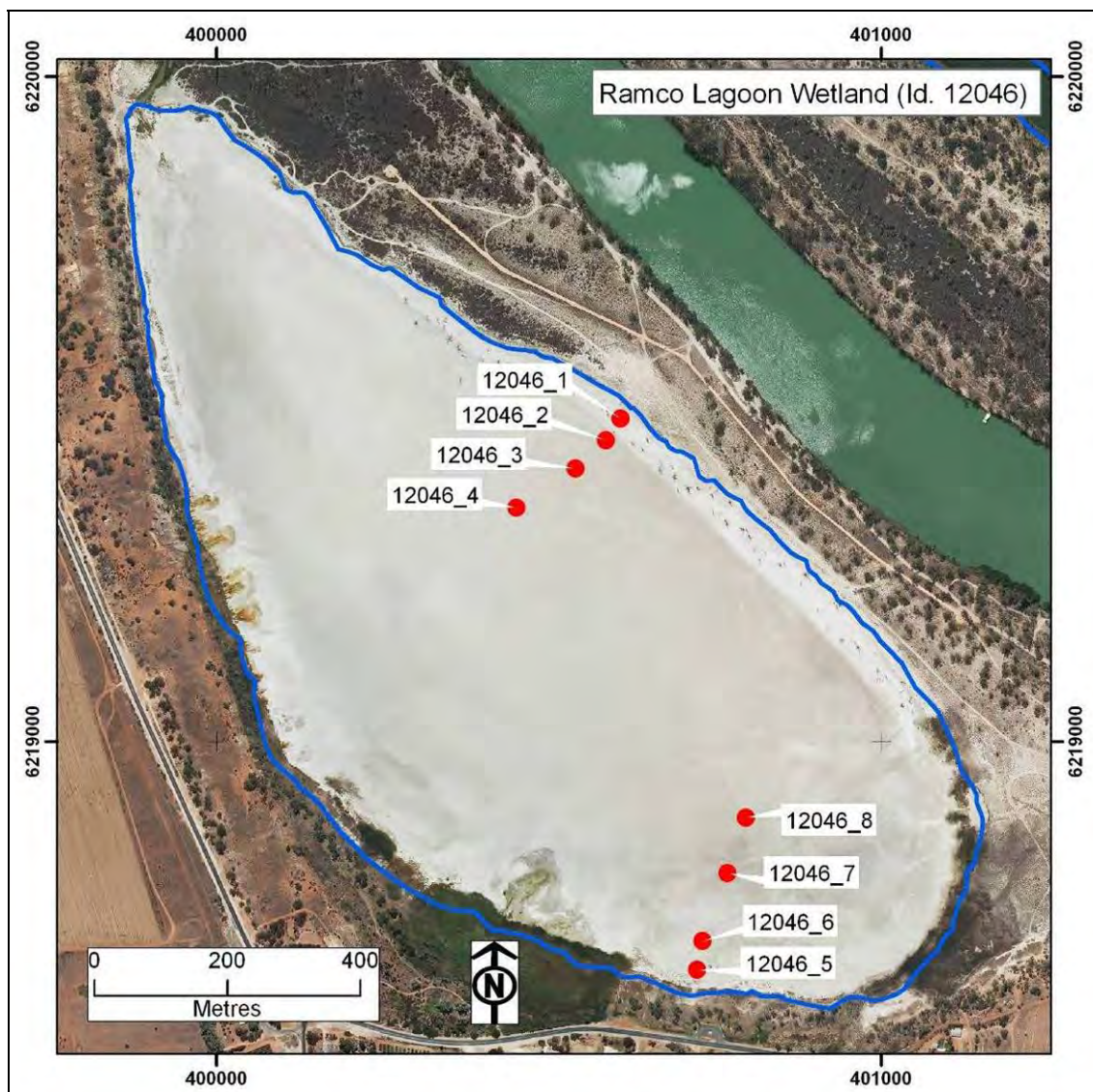


Figure 7-1. Ramco Lagoon (Wetland ID. 12046) and sample site locations.

## 7.2. Soil profile description and distribution

Eight 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 centre along two transects to provide cross-sections, with transects in the northeastern (Sites 1, 2, 3 and 4), and southern sides (Sites 5, 6, 7 and 8) of the wetland. The site and soil profile descriptions are presented in Table 7-2 and Table 7-3, and a cross-section diagram in Figure 7-2.

### Northeastern transect

Site 1 (Figure 7-3) occurred high up on the wetland margin, the soil consisted of a dark grey, firm, angular block structured, clay at the surface, to a greenish grey, very firm, clay subsoil. Site 2 (Figure 7-4) occurred at mid to low elevation on a cracking clay surface, and the soil consisted of a greyish brown, weak, angular block structured, clay at the surface, to greenish grey, very firm, clay subsoil. Site 3 (Figure 7-5) occurred low elevation near the centre of the wetland where the surface was cracking, with the water table in the pit at about 30 cm depth, and the soil consisted of an olive grey, firm, angular blocky structured, clay surface, to a light greenish grey, very firm, clay. Site 4 (Figure 7-6) occurred towards the wetland centre, with the water table in the pit at about 10 cm depth, and the soil consisted of a dark greenish grey, firm, angular block structured, clay surface layers over a dark greenish grey, very firm, clay.

### Southern transect

Site 5 (Figure 7-7) occurred at high elevation on the wetland margin where the surface was crusted, and the soil consisted of an olive grey, firm, platy and blocky structured surface layers, over a greenish grey, weak, clay. Site 6 (Figure 7-8) occurred on the dried up shoreline with a crusted surface, and the soil consisted of a dark grey, platy and angular block structured, firm, clay surface layers, over a dark grey, firm, clay. Site 7 (Figure 7-9) occurred towards the wetland centre, and the soil consisted of an olive grey, weak, clay surface layers over a dark grey, very firm, clay. Site 8 (Figure 7-10) occurred towards the wetland centre where the surface was cracking, with the water table at about 50 cm depth, and the soil consisted of an olive grey, very weak, blocky structured, clay surface layers, over grey, very firm, clay.

**Table 7-1. Soil identification, subtype and general location description for Ramco Lagoon (Wetland ID. 12046).**

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12046_1	400608	6219486	Other Soil (clayey)	high elevation, in line with dead trees, with salt crust surface seal
12046_2	400586	6219453	Other Soil (clayey)	mid to low elevation 50m from side on cracking surface
12046_3	400540	6219411	Other Soil (clayey)	low elevation, centre of wetland, cracking surface
12046_4	400451	6219352	Other Soil (clayey)	low elevation, centre of wetland, cracking surface
12046_5	400723	6218657	Other Soil (clayey)	high, edge of wetland, 20m from old shoreline, crusted surface
12046_6	400731	6218701	Other Soil (clayey)	low elevation, 100m from shoreline, crusted surface
12046_7	400769	6218803	Other Soil (clayey)	low elevation, near centre of wetland, sealed surface
12046_8	400797	6218886	Other Soil (clayey)	low elevation, centre of wetland, cracking surface

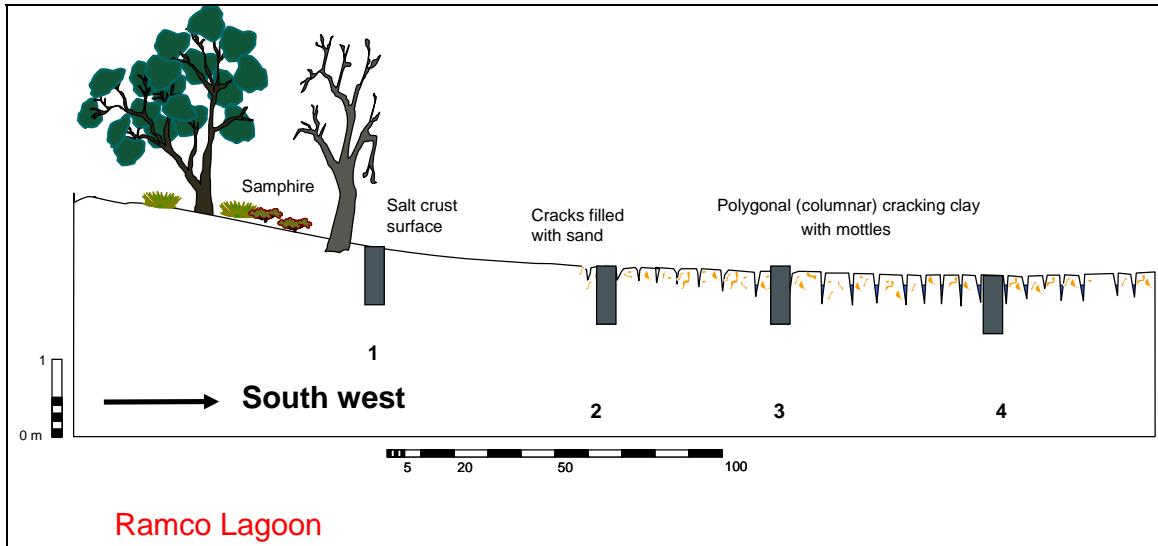


Figure 7-2. Conceptual cross-section diagram, showing locations for Sites 1 to 4.



Figure 7-3: Photographs of Site 1, showing the site location near the wetland margin and the soil profile.



**Figure 7-4. Photographs of Site 2, showing the site location looking towards the wetland centre, the surface cracks now in-filled with sediment, and the soil profile.**



**Figure 7-5. Photograph of Site 3, looking back along the transect to the wetland margin showing that the surface cracks are not as in-filled as those at Site 2.**



**Figure 7-6. Photograph of Site 4, showing the site location and the cracking soil surface.**



**Figure 7-7. Photograph of Site 5, showing the site location at the wetland margin.**



**Figure 7-8. Photograph of Site 6, showing the site location.**



**Figure 7-9. Photograph of Site 7, showing the soil profile.**



**Figure 7-10. Photograph of Site 8, showing the site location near the centre of the wetland where the surface was cracking.**

## **7.3. Laboratory data assessment**

### **7.3.1. Soil pH testing ( $pH_W$ , $pH_{OX}$ , $pH_{INC}$ )**

The pH data are provided in Table 7-4 and pH profiles are presented in Figure 7-11. The  $pH_W$  data ranged from 5.76 to 8.65 and sulfuric materials with a  $pH_W < 4$  were not identified. The  $pH_{OX}$  data ranged from 3.15 to 8.50 and identified that no sample declined below the critical value of  $pH_{OX} < 2.5$ . The  $pH_{INC}$  data ranged from 5.27 to 8.26 and identified that no soil samples on incubation declined below the critical value of  $pH < 4$ .

### **7.3.2. Acid base accounting**

The acid base accounting data is provided in Table 7-4 and summarised in Figure 7-12.

#### **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 values declined with depth in the subsoil layers.

#### **Titrateable actual acidity**

Titrateable actual acidity was not measured in any of the layers sampled.

#### **Retained acidity**

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

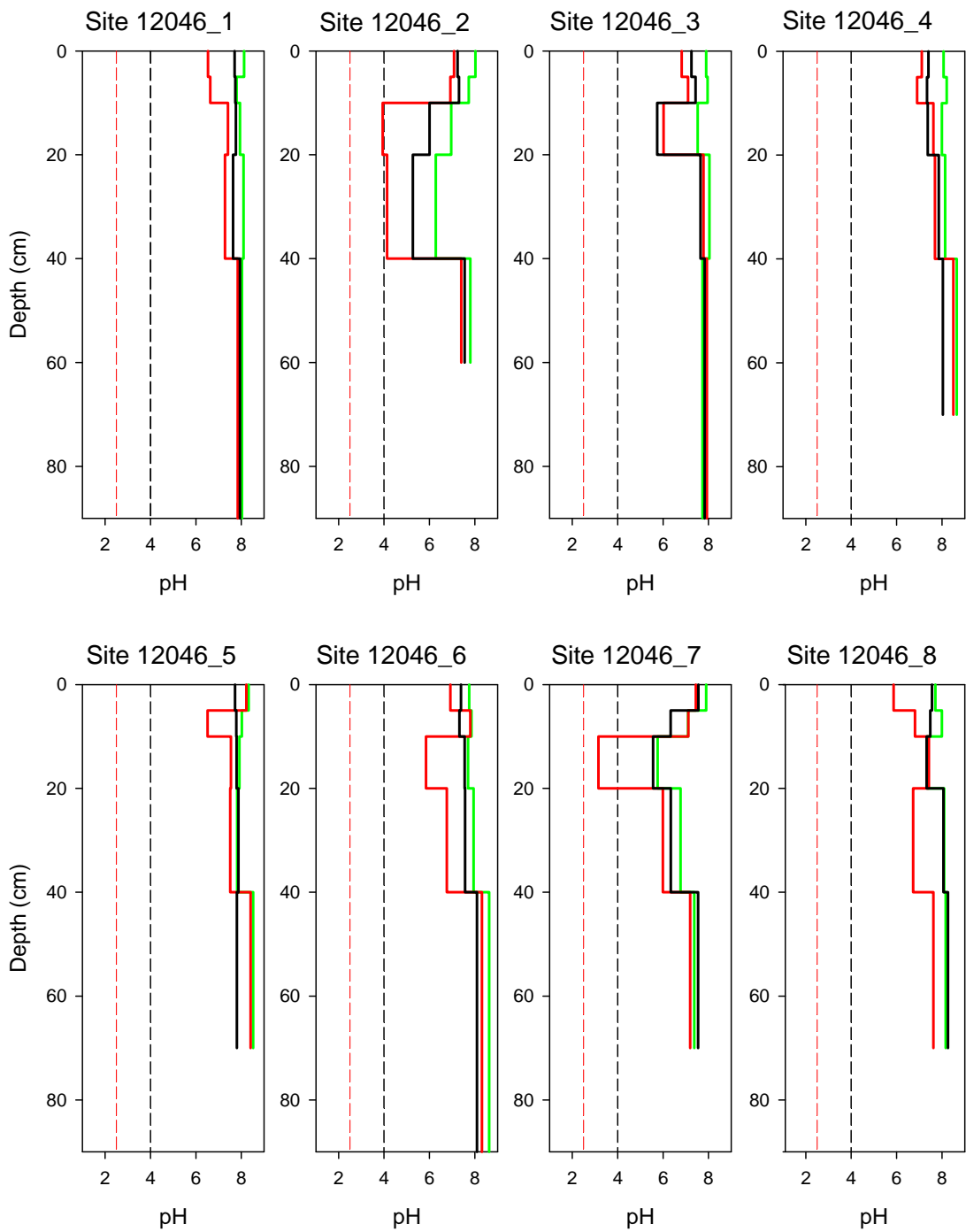
#### **Acid neutralising capacity**

Acid neutralising capacity values ranged from 0 to 17.22 % $CaCO_3$  and were measured in nearly all samples.

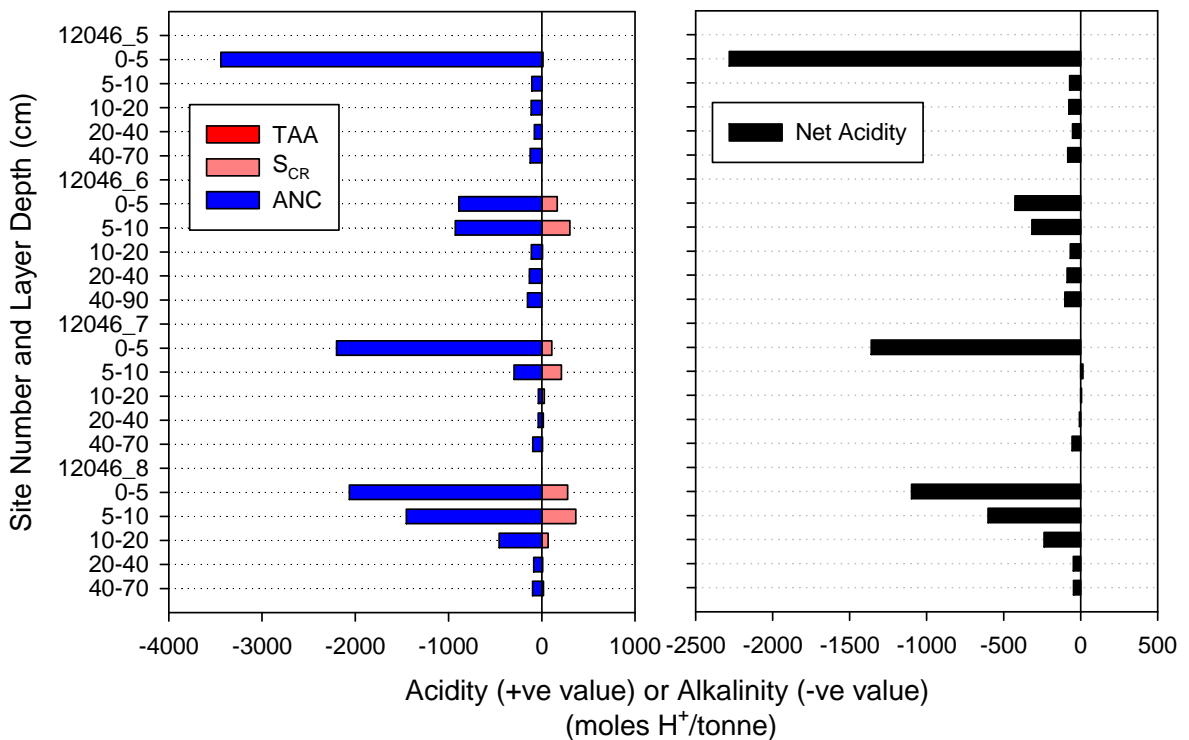
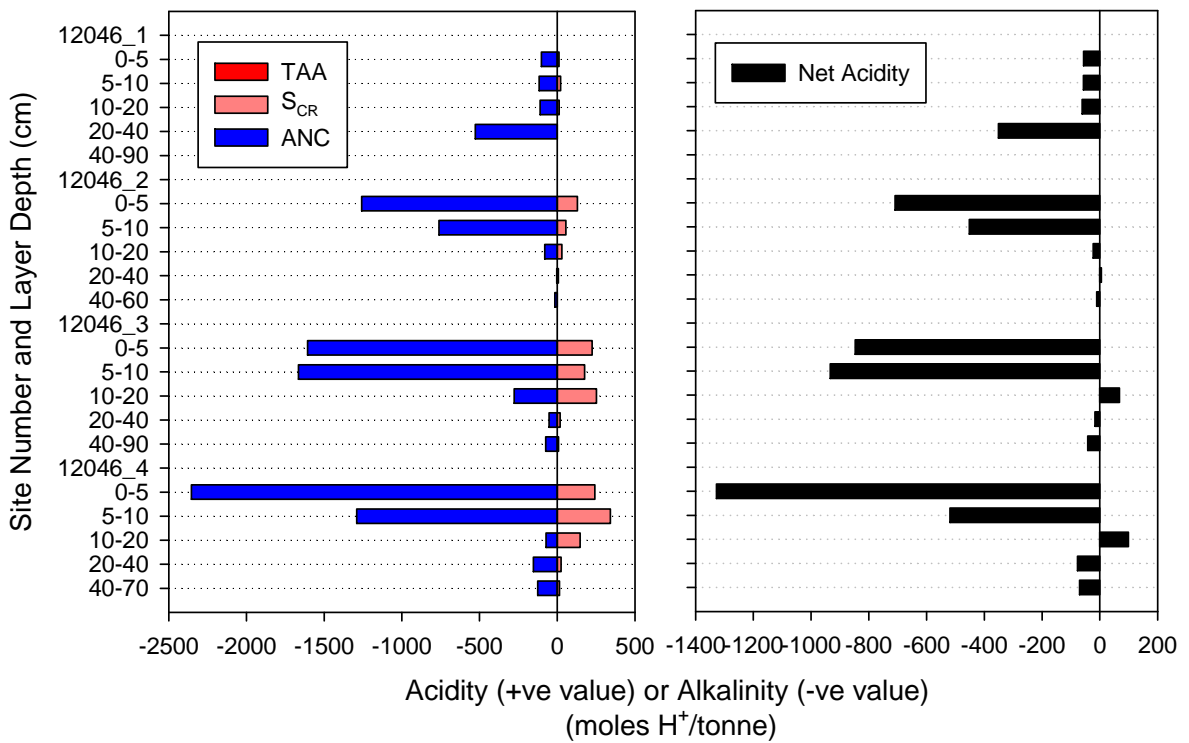
#### **Net acidity**

Net acidity values ranged from -2280 to 99 mole  $H^+$ /tonne. Generally all samples were negative except for Profiles 2, 3, 4 and 7 that had a subsoil layer with a low or moderate value.





**Figure 7-11. Depth profiles of soil pH for Ramco Lagoon Wetland, 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 7-12. Acid base accounting depth profiles for Ramco Lagoon Wetland. Left side shows the components: Titratable actual acidity (TAA - red bar), acid generating potential (AGP as S<sub>CR</sub> - 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 at for all profiles except Profile 8 were above the criterion trigger value of 100 mg/kg SO<sub>4</sub>.

### 7.3.4. Acid volatile sulfur

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

### 7.3.5. Hydrochemistry

Two pit waters were collected from this saline wetland as the surface water was too shallow to sample. Field parameters are shown in Table 7-5. The pit waters had circumneutral pH and were very saline. Dissolved oxygen and Eh were low but may have been affected by contact with atmosphere. Alkalinity was moderately high.

The pit waters are of Na-Cl type, with Na being higher relative to Mg and Ca relative to seawater (Table 7-6, Figure 7-13). Sulfate concentrations in the pit waters were very high (8200-9400 mg l<sup>-1</sup>). The SO<sub>4</sub>/Cl ratio in the pit water samples (0.122-0.127) were slightly lower than seawater (0.142). For the nutrients, NH<sub>4</sub> and PO<sub>4</sub> were moderately high and above ANZECC Guideline values. Manganese concentrations were very high, but detection limits for Fe were too high to determine concentrations due to dilution requirements for analysis. For a number of other trace elements, detection limits were high, although elevated concentrations of Zn and Co (and Ni in one sample) were noted.

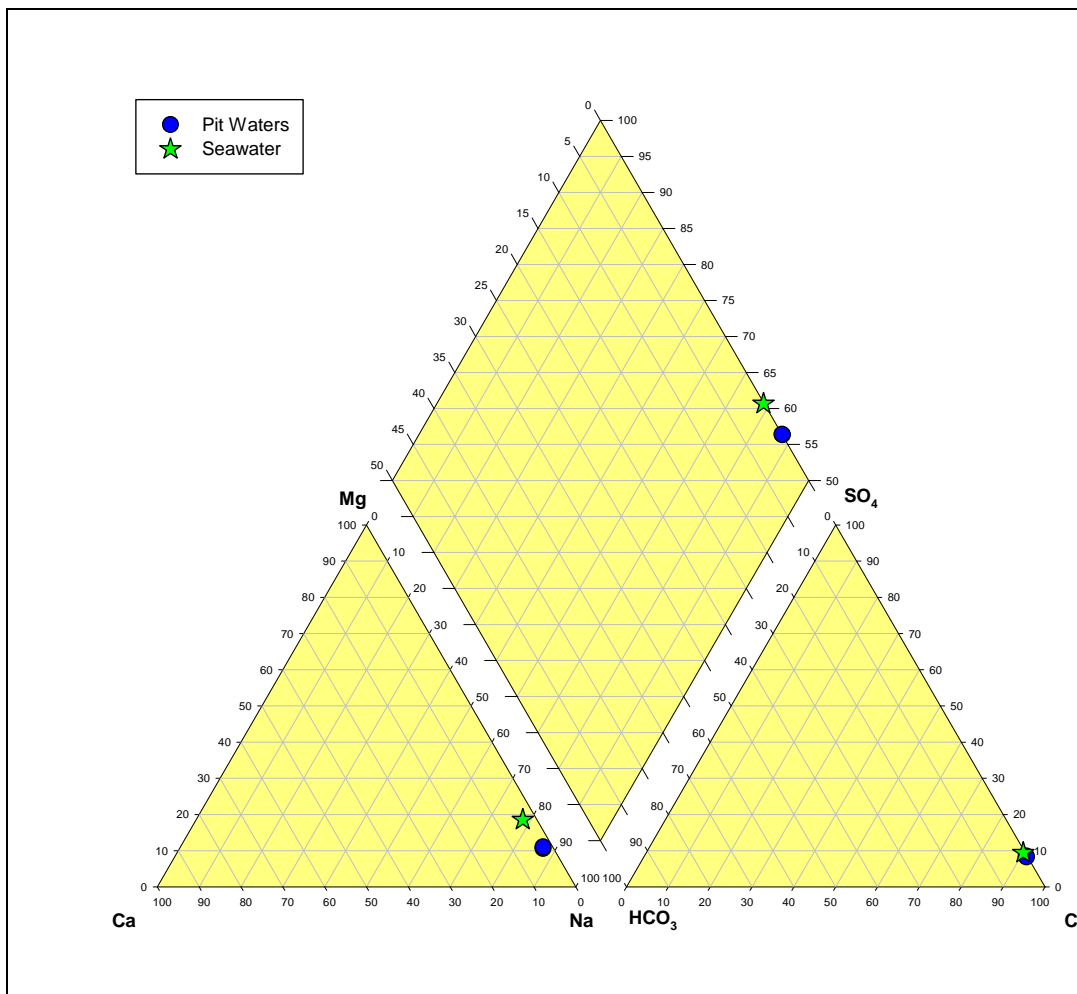


Figure 7-13. Piper diagram of hydrochemical data for Ramco Lagoon Wetland.

## 7.4. Discussion

Acid sulfate soil materials at Ramco Lagoon (Wetland ID. 12046) were identified as hyposulfidic and in some of the subsoil layers as other soil material. The acid sulfate soil subtype class identified was Other Soil (clayey).

The soils throughout the wetland were clays with cracking surfaces, and near the margins the cracks were in-filled with sediment. Surface water was not present except for a few isolated patches in depressions.

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

The potential hazards posed by acid sulfate soil materials at Ramco Lagoon (Wetland ID. 12046) 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. 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 Ramco Lagoon (Wetland ID. 12046):

<b>Soil materials:</b>	The surface soil layers throughout the wetland were generally hyposulfidic and the subsoil layers were hyposulfidic or other soil materials. Soil textures were clayey throughout the wetland. Nearly all samples had a negative net acidity values and pH data did not indicate a potential for acidification due to oxidation.
<b>Acid sulfate soil identification:</b>	<ul style="list-style-type: none"> <li>• Other Soil (clayey) – occurring throughout the wetland. Dominant (&gt;50%) in extent.</li> </ul>
<b>Hazard assessment</b>	<ul style="list-style-type: none"> <li>• Acidification hazard – low level of concern</li> <li>• De-oxygenation hazard – medium to high level of concern</li> <li>• Metal mobilisation hazard – low level of concern</li> </ul>

**Table 7-2. Site description data for Ramco Lagoon (Wetland ID. 12046).**

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	23/03/2010	400608	6219486	not reached	sealed, salt crust	bare	high elevation, in line with dead trees, surface sealed with salt crust
2	23/03/2010	400586	6219453	not reached	cracking, infilled, sealed		mid to low elevation 50m from side on cracking surface
3	23/03/2010	400540	6219411	-30	cracking, infilled, sealed		low elevation, centre of wetland, cracking surface
4	23/03/2010	400451	6219352	-10	cracking, infilled	bare	low elevation, centre of wetland, cracking surface
5	23/03/2010	400723	6218657	not reached	crusted	bare	high, edge of wetland, 20m from old shoreline, crusted surface
6	23/03/2010	400731	6218701	not reached	crusted	bare	low elevation, 100m from shoreline, crusted surface
7	23/03/2010	400769	6218803	not reached	sealed, slippery	bare	low elevation, near centre of wetland, sealed surface
8	23/03/2010	400797	6218886	-50	cracked, infilled, degraded	bare	low elevation, centre of wetland, cracking surface

**Table 7-3. Soil profile description data for Ramco Lagoon (Wetland ID. 12046).**

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	greyish brown (2.5Y5/2)	clay	moist	10% brown infused into the matrix adjacent to pores	massive	firm	
1_2	5 - 10	small pit	dark grey (5Y4/1)	clay	moist	15% dark brown infused into the matrix along faces of peds	angular blocky	firm	
1_3	10 - 20	small pit	dark grey (5Y4/1)	clay	moist		angular blocky	firm	
1_4	20 - 40	small pit	dark greenish gray (10Y4/1)	clay	moist		massive	firm	
1_5	40 - 90	push tube	greenish gray (10Y6/1)	clay	moist		massive	very firm	
2_1	0 - 5	small pit	greyish brown (2.5Y5/2)	clay	moist		angular blocky	weak	
2_2	5 - 10	small pit	greyish brown (2.5Y5/2)	clay	moist		angular blocky	weak	very sticky
2_3	10 - 20	small pit	grey (5Y5/1)	clay	moist		angular blocky	firm	very sticky
2_4	20 - 40	small pit	grey (5Y5/1)	clay	moist		massive	firm	very sticky
2_5	40 - 60	push tube	greenish gray (10Y6/1)	clay	moist		massive	very firm	
3_1	0 - 5	small pit	olive grey (5Y4/2)	clay	moist		angular blocky	weak	very sticky, contains patches of light grey infill
3_2	5 - 10	small pit	olive grey (5Y4/2)	clay	moist	10% reddish brown infused into the matrix along faces of peds	angular blocky	firm	very sticky
3_3	10 - 20	small pit	olive grey (5Y4/2)	clay	moist	10% yellowish brown infused into the matrix along faces of peds	angular blocky	firm	very sticky
3_4	20 - 40	small pit	light greenish gray (10Y7/1)	clay	moist		massive	firm	very sticky
3_5	40 - 90	push tube	light greenish gray (10Y7/1)	clay	moist		massive	very firm	very sticky
4_W1	-	pit water							water sampled
4_1	0 - 5	small pit	dark greenish gray (10Y4/1)	clay	wet		angular blocky	firm	very sticky
4_2	5 - 10	small pit	dark greenish gray (10Y4/1)	clay	wet	10% reddish brown infused into the matrix along faces of peds	angular blocky	firm	very sticky
4_3	10 - 20	small pit	dark greenish gray (10Y4/1)	clay	wet		angular blocky	firm	
4_4	20 - 40	small pit	dark greenish gray (10Y4/1)	clay	moist		massive	very firm	
4_5	40 - 70	push tube	dark greenish gray (10Y4/1)	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
5_1	0 - 5	small pit	light brownish grey (2.5Y6/2)	clay	dry		platy	firm	
5_2	5 - 10	small pit	olive grey (5Y4/2)	clay	moist	3% brown In the matrix	angular blocky	firm	very sticky
5_3	10 - 20	small pit	dark grey (5Y4/1)	clay	moist	3% yellowish brown In the matrix	massive	firm	very sticky
5_4	20 - 40	small pit	dark grey (5Y4/1)	clay	moist		massive	weak	very sticky
5_5	40 - 70	push tube	greenish gray (10Y6/1)	clay	moist		massive	weak	
6_1	0 - 5	small pit	dark grey (10YR4/1)	clay	dry		platy	firm	
6_2	5 - 10	small pit	very dark grey (10YR3/1)	clay	moist	20% yellowish brown In the matrix	angular blocky	firm	very sticky
6_3	10 - 20	small pit	dark grey (5Y4/1)	clay	moist	20% yellowish brown In the matrix	angular blocky	firm	very sticky
6_4	20 - 40	small pit	dark grey (5Y4/1)	clay	moist		massive	firm	very sticky
6_5	40 - 90	push tube	dark grey (5Y4/1)	clay	moist		massive	firm	
7_1	0 - 5	small pit	olive grey (5Y5/2)	clay	moist	20% greenish grey In the matrix	massive	weak	20% grey infill inclusions
7_2	5 - 10	small pit	olive grey (5Y5/2)	clay	moist	20% yellowish brown In the matrix	angular blocky	firm	very sticky
7_3	10 - 20	small pit	dark grey (5Y4/1)	clay	moist	10% yellowish brown In the matrix	angular blocky	very firm	very sticky
7_4	20 - 40	small pit	dark grey (5Y4/1)	clay	moist	5% yellowish brown In the matrix	massive	very firm	
7_5	40 - 70	push tube	dark grey (5Y4/1)	clay	moist		massive	very firm	
8_1	0 - 5	small pit	olive grey (5Y5/2)	clay	moist		subangular blocky	weak	
8_2	5 - 10	small pit	olive grey (5Y5/2)	clay	wet	10% reddish brown In the matrix	angular blocky	firm	
8_3	10 - 20	small pit	olive grey (5Y5/2)	clay	moist	10% yellowish brown In the matrix	angular blocky	very firm	
8_4	20 - 40	small pit	grey (5Y5/1)	clay	moist		massive	very firm	
8_5	40 - 70	push tube	grey (5Y5/1)	clay	moist		massive	very firm	
8_W1	-	pit water							water sampled

**Table 7-4. Laboratory data for acid sulfate soil assessment of Ramco Lagoon (Wetland ID. 12046).**

(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 <sub>4</sub> /kg)	pH KCl	Titrateable Actual Acidity (mole H <sup>+</sup> /tonne)	Chromium Reducible Sulfur (%S <sub>CR</sub> )	Retained Acidity (mole H <sup>+</sup> /tonne)	Acid Neutralising Capacity (%CaCO <sub>3</sub> )	Net Acidity (mole H <sup>+</sup> /tonne)	Acid Sulfate Soil Material Classification
1.1	0-5	Medium	20,800	8.12	6.53	7.70	7.70	1,400	9.11	0.00	0.02	..	0.51	-56	hyposulfidic (S <sub>CR</sub> <0.10%)
1.2	5-10	Fine	9,800	7.79	6.63	7.69	7.74	170	7.93	0.00	0.03	..	0.59	-57	hyposulfidic (S <sub>CR</sub> <0.10%)
1.3	10-20	Fine	6,540	7.94	7.41	7.80	7.76	220	7.40	0.00	0.02	..	0.55	-61	hyposulfidic (S <sub>CR</sub> <0.10%)
1.4	20-40	Fine	3,370	8.10	7.28	7.95	7.63	150	8.45	0.00	<0.01	..	2.64	-352	other soil material
1.5	40-90	Fine	2,730	8.03	7.84	7.81	7.94	120	7.49	0.00	<0.01	..	0.00	0	other soil material
2.1	0-5	Fine	58,400	8.02	7.08	7.25	7.24	7,400	8.15	0.00	0.21	..	6.29	-709	hyposulfidic (S <sub>CR</sub> ≥0.10%)
2.2	5-10	Fine	44,700	7.73	6.92	7.09	7.30	6,700	8.27	0.00	0.09	..	3.81	-452	hyposulfidic (S <sub>CR</sub> <0.10%)
2.3	10-20	Fine	18,250	6.96	3.94	5.97	6.01	920	7.44	0.00	0.05	..	0.40	-23	hyposulfidic (S <sub>CR</sub> <0.10%)
2.4	20-40	Fine	10,540	6.28	4.14	4.75	5.27	730	7.03	0.00	0.01	..	0.02	5	hyposulfidic (S <sub>CR</sub> <0.10%)
2.5	40-60	Fine	11,130	7.80	7.40	6.98	7.55	690	6.94	0.00	<0.01	..	0.08	-11	other soil material
3.1	0-5	Fine	51,600	7.90	6.82	7.63	7.25	6,400	8.37	0.00	0.36	..	8.04	-847	hyposulfidic (S <sub>CR</sub> ≥0.10%)
3.2	5-10	Fine	21,720	7.96	7.10	7.33	7.43	5,100	8.47	0.00	0.28	..	8.33	-934	hyposulfidic (S <sub>CR</sub> ≥0.10%)
3.3	10-20	Fine	16,090	7.52	6.02	6.41	5.74	940	8.34	0.00	0.40	..	1.39	68	hyposulfidic (S <sub>CR</sub> ≥0.10%)
3.4	20-40	Fine	4,410	8.04	7.78	7.45	7.65	140	7.82	0.00	0.03	..	0.27	-17	hyposulfidic (S <sub>CR</sub> <0.10%)
3.5	40-90	Fine	3,170	7.74	7.93	6.91	7.83	140	7.47	0.00	0.01	..	0.37	-42	hyposulfidic (S <sub>CR</sub> <0.10%)
4.1	0-5	Fine	76,100	8.07	7.11	6.84	7.40	8,400	8.34	0.00	0.39	..	11.78	-1328	hyposulfidic (S <sub>CR</sub> ≥0.10%)
4.2	5-10	Fine	52,600	8.21	6.90	7.15	7.34	3,900	8.26	0.00	0.55	..	6.46	-519	hyposulfidic (S <sub>CR</sub> ≥0.10%)
4.3	10-20	Fine	9,120	7.99	7.62	6.82	7.37	790	7.86	0.00	0.24	..	0.36	99	hyposulfidic (S <sub>CR</sub> ≥0.10%)
4.4	20-40	Fine	7,660	8.14	7.69	7.39	7.86	710	7.92	0.00	0.04	..	0.77	-78	hyposulfidic (S <sub>CR</sub> <0.10%)
4.5	40-70	Fine	2,750	8.65	8.50	7.26	8.04	290	7.56	0.00	0.02	..	0.63	-70	hyposulfidic (S <sub>CR</sub> <0.10%)
4.W1	-	..	..	..	..	..	..	..	..	..	..	..	..	..	pit water
5.1	0-5	Medium	17,520	8.32	8.22	7.38	7.72	6,500	8.65	0.00	0.02	..	17.22	-2280	hyposulfidic (S <sub>CR</sub> <0.10%)
5.2	5-10	Fine	8,270	8.02	6.51	7.54	7.78	630	8.21	0.00	<0.01	..	0.53	-71	other soil material
5.3	10-20	Fine	6,550	7.92	7.54	7.44	7.79	530	7.61	0.00	<0.01	..	0.57	-76	other soil material
5.4	20-40	Fine	5,540	7.81	7.51	7.47	7.87	410	7.26	0.00	<0.01	..	0.40	-53	other soil material
5.5	40-70	Fine	2,730	8.52	8.41	7.62	7.80	330	7.77	0.00	<0.01	..	0.62	-82	other soil material
6.1	0-5	Fine	52,900	7.75	6.92	7.21	7.39	8,300	8.16	0.00	0.27	..	4.45	-426	hyposulfidic (S <sub>CR</sub> ≥0.10%)
6.2	5-10	Fine	21,590	7.85	7.80	6.94	7.32	2,500	8.51	0.00	0.48	..	4.64	-316	hyposulfidic (S <sub>CR</sub> ≥0.10%)
6.3	10-20	Fine	10,080	7.70	5.85	7.26	7.55	840	7.68	0.00	0.01	..	0.56	-66	hyposulfidic (S <sub>CR</sub> <0.10%)
6.4	20-40	Fine	5,870	7.94	6.77	7.45	7.57	390	7.41	0.00	<0.01	..	0.66	-88	other soil material
6.5	40-90	Fine	2,240	8.63	8.31	7.19	8.09	150	7.67	0.00	<0.01	..	0.76	-102	other soil material



Site and Layer ID.	Depth Range (cm)	Soil Texture	EC ( $\mu\text{S}/\text{cm}$ )	pH water	pH peroxide	pH incubation week 0	pH incubation week 8	Sulfate ( $\text{mg SO}_4/\text{kg}$ )	pH KCl	Titrateable Actual Acidity ( $\text{mole H}^+/\text{tonne}$ )	Chromium Reducible Sulfur ( $\%\text{S}_{\text{CR}}$ )	Retained Acidity ( $\text{mole H}^+/\text{tonne}$ )	Acid Neutralising Capacity ( $\%\text{CaCO}_3$ )	Net Acidity ( $\text{mole H}^+/\text{tonne}$ )	Acid Sulfate Soil Material Classification
7.1	0-5	Fine	5,120	7.90	7.44	6.94	7.55	7,900	8.42	0.00	0.17	..	11.02	-1360	hyposulfidic ( $\text{S}_{\text{CR}} \geq 0.10\%$ )
7.2	5-10	Fine	8,820	7.10	7.11	5.79	6.33	5,300	8.44	0.00	0.34	..	1.48	15	hyposulfidic ( $\text{S}_{\text{CR}} \geq 0.10\%$ )
7.3	10-20	Fine	15,220	5.76	3.15	5.79	5.56	1,400	7.34	0.00	0.05	..	0.17	6	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
7.4	20-40	Fine	13,210	6.77	5.99	6.21	6.34	850	7.14	0.00	0.03	..	0.18	-7	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
7.5	40-70	Fine	11,010	7.37	7.19	6.81	7.54	890	7.05	0.00	0.01	..	0.48	-55	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
8.1	0-5	Fine	182	7.71	5.87	7.11	7.56	56	8.55	0.00	0.45	..	10.32	-1097	hyposulfidic ( $\text{S}_{\text{CR}} \geq 0.10\%$ )
8.2	5-10	Fine	13,660	7.99	6.81	6.91	7.48	1,600	8.57	0.00	0.59	..	7.26	-600	hyposulfidic ( $\text{S}_{\text{CR}} \geq 0.10\%$ )
8.3	10-20	Fine	14,800	7.34	7.42	6.62	7.32	1,300	7.39	0.00	0.11	..	2.29	-237	hyposulfidic ( $\text{S}_{\text{CR}} \geq 0.10\%$ )
8.4	20-40	Fine	5,730	8.09	6.73	7.09	8.06	410	7.49	0.00	0.02	..	0.44	-47	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
8.5	40-70	Fine	3,410	8.16	7.62	7.59	8.26	250	7.65	0.00	0.03	..	0.48	-45	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
8.W1	-	..	..	..	..	..	..	..	..	..	..	..	..	..	pit water

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

	pH	SEC $\mu\text{S cm}^{-1}$	DO $\text{mg l}^{-1}$	Eh mV	Turbidity NTU	Alkalinity as $\text{HCO}_3$
Pit waters (n=2)	6.81-6.96	131884-134787	0.28-0.34	202-287		235-296

**Table 7-6. Hydrochemical data for Ramco Lagoon (Wetland ID. 12046).**

Parameter	units	ANZECC Guidelines	Site 4 (PW)	Site 8 (PW)
Na	mg l <sup>-1</sup>		40800	37400
K	mg l <sup>-1</sup>		243.0	258.0
Ca	mg l <sup>-1</sup>		1040	878
Mg	mg l <sup>-1</sup>		2640	2530
Si	mg l <sup>-1</sup>		<10	<10
Br	mg l <sup>-1</sup>		190.0	160.0
Cl	mg l <sup>-1</sup>		74000	67000
NO <sub>3</sub>	mg l <sup>-1</sup>	0.7	0.097	<0.022
NH <sub>4</sub> -N <sup>K</sup>	mg l <sup>-1</sup>	0.01	<b>4.30</b>	<b>2.40</b>
PO <sub>4</sub> <sup>E</sup>	mg l <sup>-1</sup>	0.02	<b>0.705</b>	<b>0.583</b>
SO <sub>4</sub>	mg l <sup>-1</sup>		9400	8200
Ag	µg l <sup>-1</sup>	0.05	<b>0.4</b>	<0.4
Al <sup>A</sup>	µg l <sup>-1</sup>	55	<1000	<1000
As <sup>B</sup>	µg l <sup>-1</sup>	13	<20	<20
Cd	µg l <sup>-1</sup>	0.2	<1	<1
Co	µg l <sup>-1</sup>	2.8	<b>7.2</b>	<b>11.2</b>
Cr <sup>C</sup>	µg l <sup>-1</sup>	1	<5	<5
Cu <sup>H</sup>	µg l <sup>-1</sup>	1.4	<20	<20
Fe	µg l <sup>-1</sup>	300	<20000	<20000
Mn	µg l <sup>-1</sup>	1700	<b>8136</b>	<b>10200</b>
Ni <sup>H</sup>	µg l <sup>-1</sup>	11	<10	20.0
Pb <sup>H</sup>	µg l <sup>-1</sup>	3.4	<10	<10
Se	µg l <sup>-1</sup>	11	<8	<8
Zn <sup>H</sup>	µg l <sup>-1</sup>	8	<b>80</b>	<b>140</b>
DOC	mg l <sup>-1</sup>		39.6	34.6

**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<sub>4</sub> and PO<sub>4</sub>, 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.

<sup>A</sup> Trigger value for Aluminium in freshwater where pH > 6.5.

<sup>B</sup> Trigger value assumes As in solution as Arsenic (AsV).

<sup>C</sup> Trigger value for Chromium is applicable to Chromium (CrVI) only.

<sup>E</sup> Guideline is for filterable reactive phosphorous (FRP).

<sup>H</sup> Hardness affected (refer to Guidelines).

<sup>K</sup> Guideline for South-east Australia-Freshwater Lakes and reservoirs.

## 8. HART LAGOON (WETLAND ID. 12006)

### 8.1. Location and setting description

Hart Lagoon (Wetland ID. 12006) is situated on the southern side of the River Murray about 1.5 kilometres down river from the town of Waikerie. The wetland is irregular in shape that occurs on the inside of a bend in the river. It is about 2.3 kilometres in length and about 500 metres at its widest, with a total surface area of 73 hectares. The wetland is bounded by a raised floodplain that separates the wetland from the river to the north and there is a steep hillside to the south.

The wetland is connected to the river with an inlet to the northwest end of the wetland and at the up river eastern end the temporary connection is inundated when river flow exceeds 25,000 ML/day. At the time when the soil survey was conducted in March 2010 the wetland was dry and contained no surface water. The wetland has been managed by Hart Lagoon Wetland Group since 2004 with assistance from the South Australian Murray-Darling Basin Natural Resources Management Board (SA MDB NRM Board) and RWLAP. The inlets were closed in October 2006, opened in March 2009, and then closed again in September 2009. The wetland has had frequent wetting and drying since 2000 as the inlet has silted up due to lack of flooding. The wetland area has salt bush with samphire on the margins, there are also isolated reeds and sedgeland along the wetland margins, with open woodland and shrubland on the surrounding higher floodplain. Eight sites were sampled as shown in Figure 8-1.

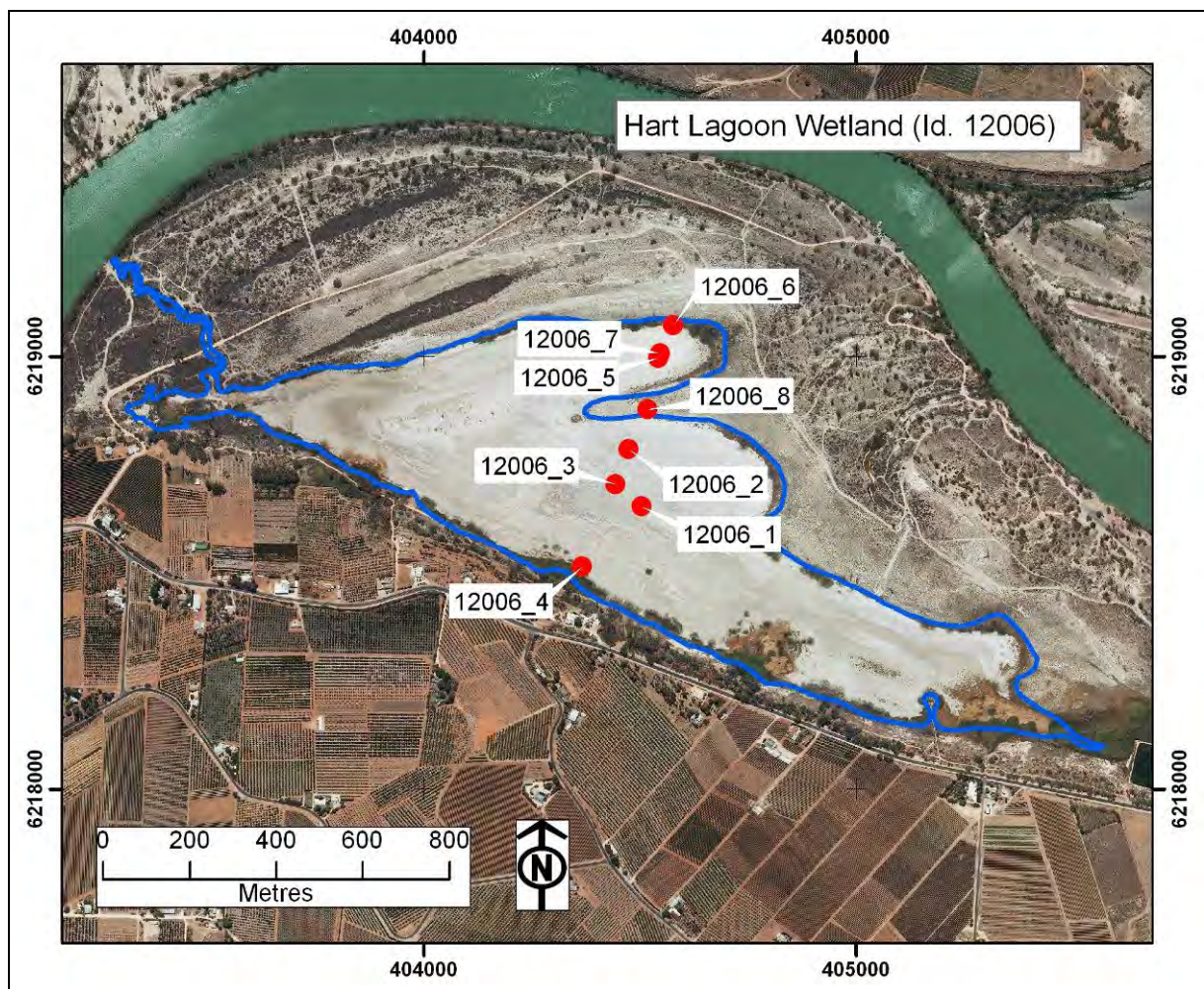


Figure 8-1. Hart Lagoon (Wetland ID. 12006) and sample site locations.

## 8.2. Soil profile description and distribution

Eight sites were described and sampled. The soil subtypes and general location descriptions are presented in Table 8-1. Sites were distributed in one transect across the wetland at the widest part of the wetland. The site and soil profile descriptions are presented in Table 8-2 and Table 8-3, and a conceptual cross-section diagram in Figure 8-2.

Site 1 (Figure 8-3) occurred on the wetland margin of the spit, the soil consisted of an olive grey at the surface to dark grey in the subsoil, firm, clay. Site 2 (Figure 8-4) occurred mid elevation, with the water table in the pit at about 10 cm depth, and the soil consisted of a thin surface layer of very weak, black monosulfide material, over a dark grey, weak to firm with depth, clay. Site 3 (Figure 8-5) occurred in the wetland centre, with the water table in the pit at about 35 cm depth, and the soil consisted of isolated black monosulfide material, over an olive grey, firm, clay. Site 4 (Figure 8-6) occurred on the wetland margin amongst reeds, and the soil consisted of a brown, firm, angular blocky structured, clay, over a very dark grey, very firm, clay. Site 5 (Figure 8-7) occurred at low elevation where salt crusts were on the surface, and the soil consisted of a grey, firm, angular blocky structured, clay, with evidence of jarosite. Site 6 (Figure 8-8) occurred on the wetland margin amongst reeds, and the soil consisted of a grey, weak, sandy clay loam, over a grey, firm, clay. Site 7 (Figure 8-9) occurred in the wetland adjacent to an old tree stump where there was salt crystals on the surface, and the soil consisted of a dark greyish brown, firm, clay. Site 8 (Figure 8-10) occurred on the spit protruding into the wetland, and the soil consisted of a dark grey, firm, blocky structured, clay with slickensides on the soil ped faces.

**Table 8-1. Soil identification, subtype and general location description for Hart Lagoon (Wetland ID. 12006).**

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12006_1	404504	6218653	Other Soil (clayey)	mid to high elevation, centre wetland, sealed surface and samphire vegetation
12006_2	404474	6218785	Other Soil (clayey)	mid elevation, soft and bare surface
12006_3	404443	6218704	Other Soil (clayey)	low elevation, centre wetland
12006_4	404366	6218514	Other Soil (clayey)	high on margin, in reeds
12006_5	404542	6218996	Other Soil (clayey)	low elevation, mid way between reeds/spit, salt crust surface
12006_6	404577	6219072	Other Soil (clayey)	high elevation, on margin in reeds and samphire
12006_7	404546	6219007	Other Soil (clayey)	low elevation, mid way next to tree stump, sealed salt crust surface
12006_8	404517	6218878	Other Soil (clayey)	high elevation, on spit, sealed salt crust surface

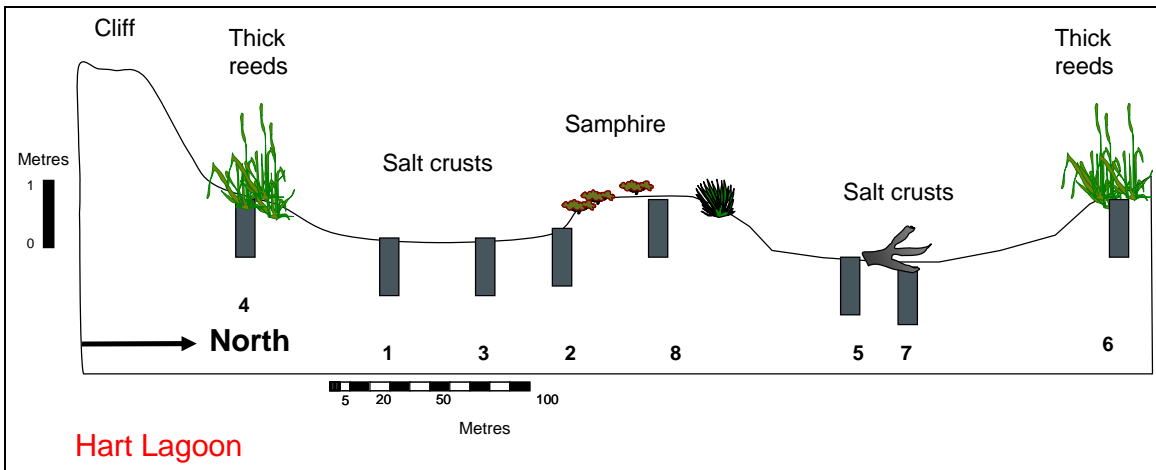


Figure 8-2. Conceptual cross-section diagram, showing locations of Sites 1 to 8.



Figure 8-3: Photograph of Site 1, showing the site location on the wetland margin.



Figure 8-4: Photograph of Site 2, showing the site location in the wetland with a shallow water table in the soil pit.



Figure 8-5: Photograph of Site 3, showing the soil profile where the site is a bare surface.



Figure 8-6: Photograph of Site 4, showing the soil pit located on the wetland margin.



Figure 8-7. Photograph of Site 5, showing the site soil pit.

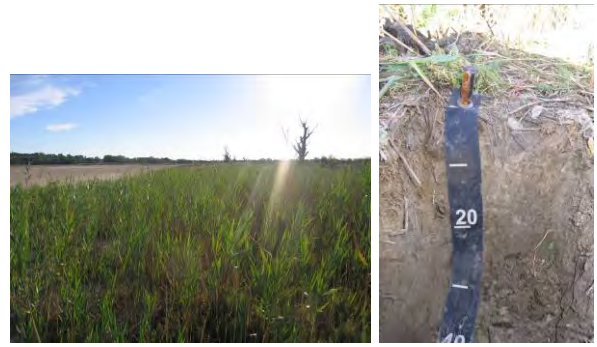


Figure 8-8. Photograph of Site 6, showing the site location on the wetland margin amongst reeds, and the soil profile.



Figure 8-9. Photographs of Site 7, showing the site location next to a dead tree stump and the soil pit with salt crust on the soil surface.

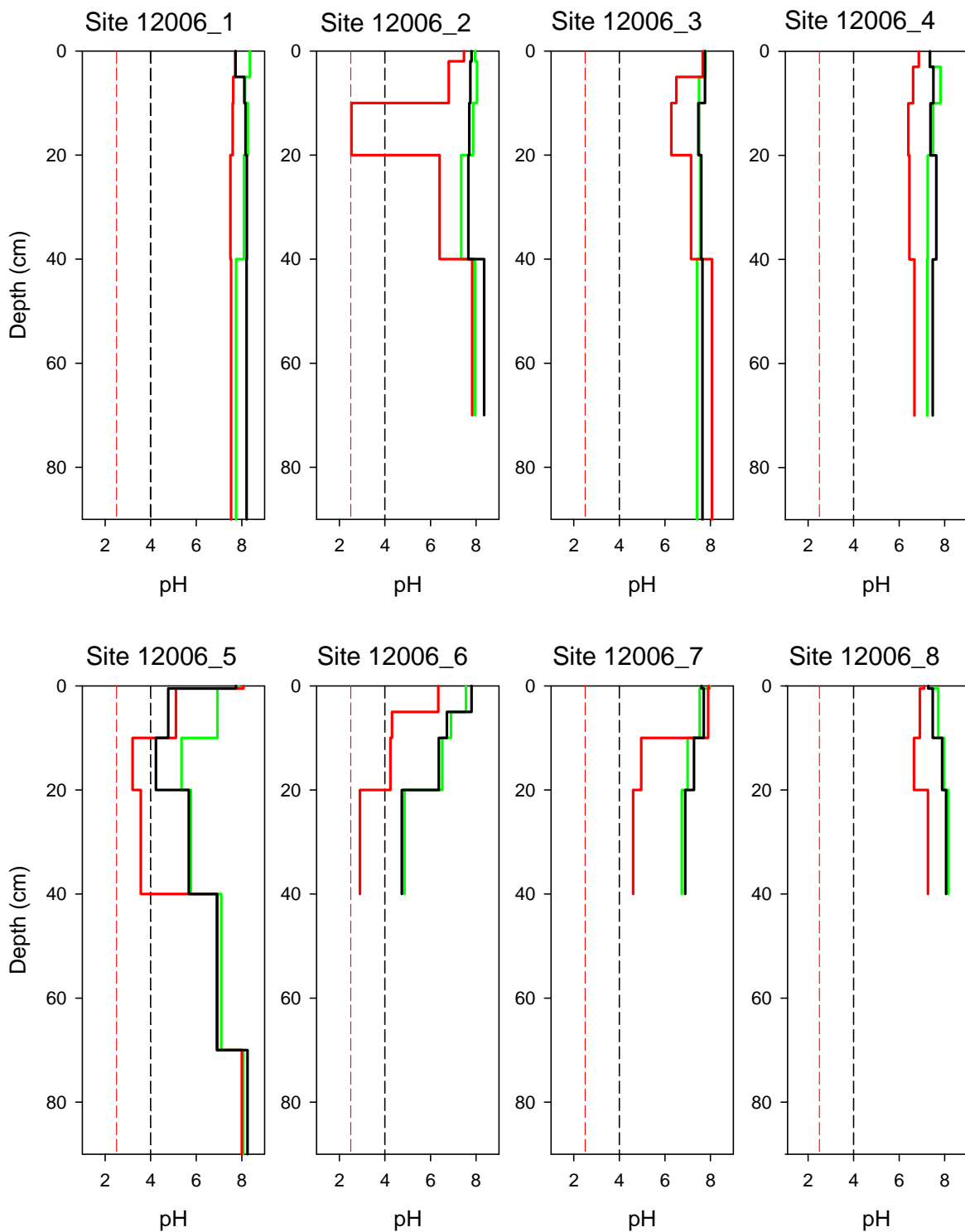


Figure 8-10. Photograph of Site 8, showing the site location on the wetland margin of the raised spit area.

### 8.3. Laboratory data assessment

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

The  $pH$  data are provided in Table 8-4 and  $pH$  profiles are presented in Figure 8-11. The  $pH_W$  data ranged from 4.86 to 8.35 and sulfuric materials with a  $pH_W < 4$  were not identified. The  $pH_{OX}$  data ranged from 2.53 to 8.07 and identified that no sample declined below the critical value of  $pH_{OX} < 2.5$ . The  $pH_{INC}$  data ranged from 4.23 to 8.35 and identified that no soil samples on incubation declined below the critical values of  $pH < 4$ .



**Figure 8-11. Depth profiles of soil pH for Hart Lagoon (Wetland ID. 12006), 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 8-12.

#### **Chromium reducible sulfur**

Chromium reducible sulfur values ranged from 0 to 0.33 %S<sub>CR</sub> and sulfidic materials were generally detected in the surface soil layers and not detected in the deeper subsoil layers.

#### **Titrateable actual acidity**

Titrateable actual acidity values ranged from 0 to 24.92 mole H<sup>+</sup>/tonne and were measured in Profiles 5 and 6.

#### **Retained acidity**

Retained acidity was not measured in any of the layers as all samples had a pH<sub>KCl</sub> of greater than 4.5.

#### **Acid neutralising capacity**

Acid neutralising capacity values ranged from 0 to 10.70 %CaCO<sub>3</sub> and were measured in all samples.

#### **Net acidity**

Net acidity values ranged from -1350 to 25 mole H<sup>+</sup>/tonne. All samples had negative values except for subsoil layers in Profiles 5 and 6 that were low or moderate values.

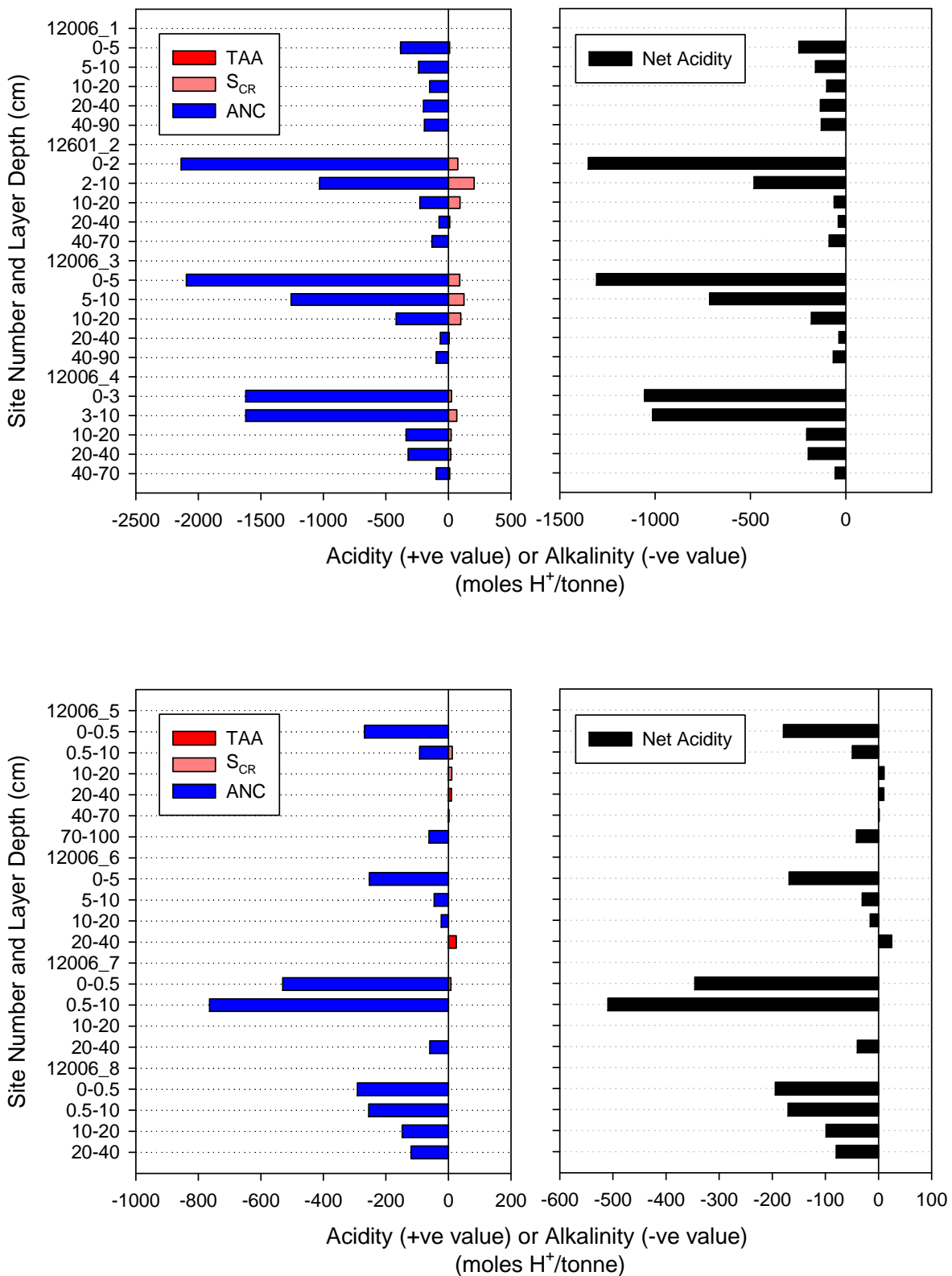
### **8.3.3. Water soluble sulfate**

Water soluble sulfate data values shown in Table 8-4 identified that surface layers for all Sites were above the criterion trigger value of 100 mg/kg SO<sub>4</sub>.

### **8.3.4. Acid volatile sulfur**

Monosulfidic materials were observed in the upper layer of Profile 2 and sampled for analysis. The values shown in Table 8-4 was above S<sub>AV</sub> ≥0.01% S, the criteria value for identifying monosulfidic material.





**Figure 8-12. Acid base accounting depth profiles for Hart Lagoon (Wetland ID. 12006). 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.**

### 8.3.5. Hydrochemistry

One pit water sample was collected from this saline wetland as no surface water was present. Field parameters are shown in Table 8-5. The pit water had slightly acidic pH and was saline. Dissolved oxygen and Eh were low but may have been affected by contact with atmosphere. Alkalinity was moderately high.

The pit waters are of Na-Cl type (Table 8-6, Figure 8-13). Sulfate concentrations in the pit water were very high ( $4100 \text{ mg l}^{-1}$ ). The  $\text{SO}_4/\text{Cl}$  ratio in the pit waters (0.178) was slightly higher than seawater (0.142). For the nutrients,  $\text{NH}_4$  and  $\text{PO}_4$  were high and above ANZECC Guideline values. Manganese concentrations were very high, but detection limits for Fe were too high to determine concentrations due to dilution requirements for analysis. For a number of other trace elements, detection limits were relatively high, although elevated concentrations of Ni, Co and Cd were noted.

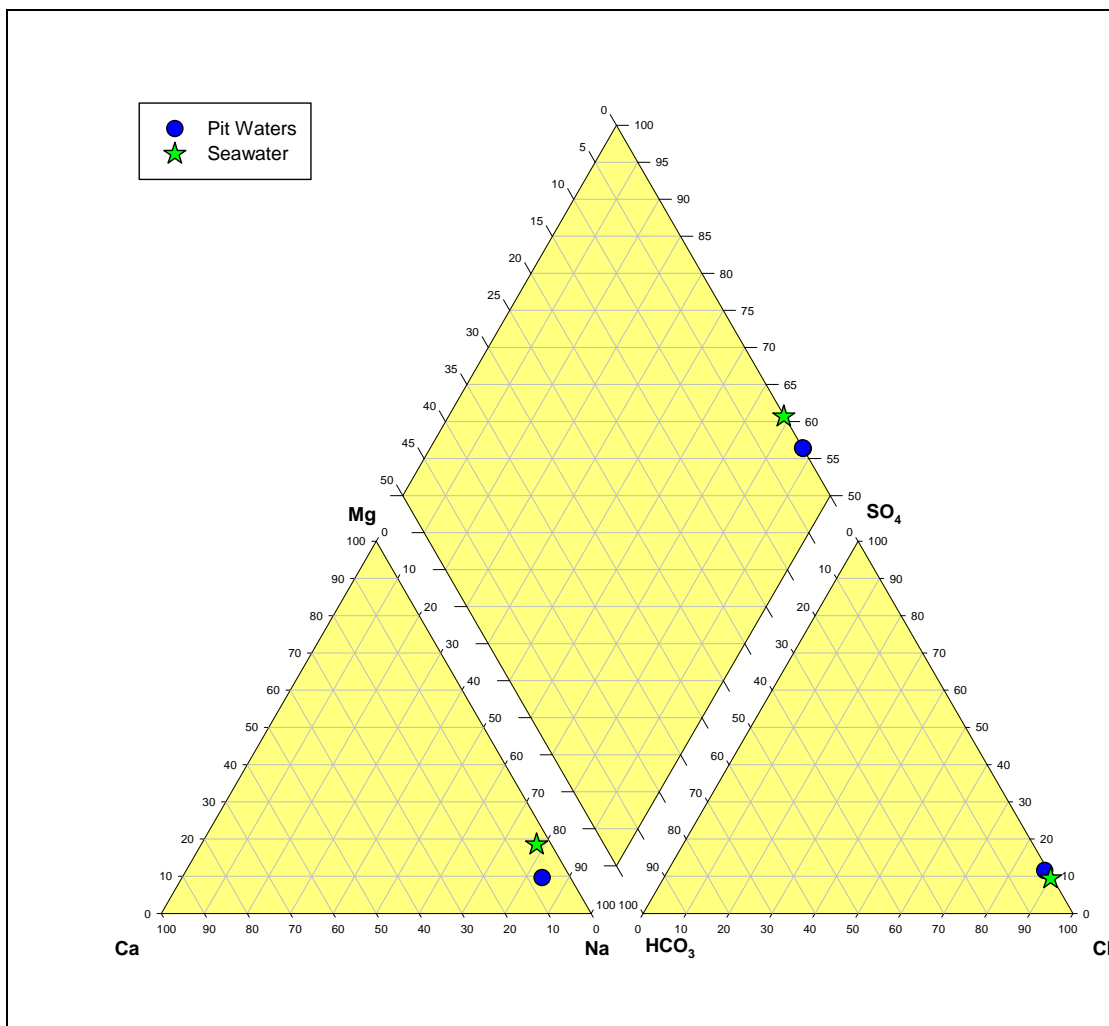


Figure 8-13. Piper diagram of hydrochemical data for Hart Lagoon (Wetland ID. 12006).

## 8.4. Discussion

Acid sulfate soil materials at Hart Lagoon (Wetland ID. 12006) were identified as hyposulfidic and in some areas on the wetland margins the soil material was characterised as other soil material. The acid sulfate soil subtype class identified was Other Soil (clayey)

The soils throughout the wetland were clay and loam textured in the surface layers and in the subsoils became firm clays. There was no surface water present in the wetland, the soil surface was cracking and in some areas salt crusts formed.

Monosulfidic material was observed and water soluble sulfate data identified that surface layers for 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 Hart Lagoon (Wetland ID. 12006) are:

- Acidification hazard: The data identified negative net acidity values for nearly all profiles 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 all soils, and black monosulfidic material was observed. There is a high level of concern.
- Metal mobilisation: The low acidification hazard indicates that soil acidification potential is not likely increase the solubility of metals. There is a low level of concern.

### Summary of key findings Hart Lagoon (Wetland ID. 12006):

<b>Soil materials:</b>	The soil layers throughout the wetland were hyposulfidic or other soil materials. Soils were clayey or loamy textured in the surface layers and clayey in the subsoil. Nearly all soil layers had a negative net acidity values and pH data did not indicate a potential for acidification due to oxidation.
<b>Acid sulfate soil identification:</b>	<ul style="list-style-type: none"> <li>• Other Soil (clayey) – occurring throughout the wetland. Dominant (&gt;50%) in extent.</li> </ul>
<b>Hazard assessment</b>	<ul style="list-style-type: none"> <li>• Acidification hazard – low level of concern</li> <li>• De-oxygenation hazard – high level of concern</li> <li>• Metal mobilisation hazard – low level of concern</li> </ul>

**Table 8-2. Site description data for Hart Lagoon (Wetland ID. 12006).**

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	404504	6218653	not reached	sealed	samphire	mid to high elevation, centre wetland, sealed surface and samphire vegetation
2	25/03/2010	404474	6218785	-10	soft, old grass algae mat	bare	mid elevation, soft and bare surface
3	25/03/2010	404443	6218704	-35	algae/sealed, soft	bare	low elevation, centre wetland
4	25/03/2010	404366	6218514	not reached	plant material, firm	reeds	high on margin, in reeds
5	25/03/2010	404542	6218996	not reached	white salt crust	bare	low elevation, mid way between reeds/spit, salt crust surface
6	25/03/2010	404577	6219072	not reached	firm, plant material	reeds, samphire	high elevation, on margin in reeds and samphire
7	25/03/2010	404546	6219007	not reached	salt crust, sealed	bare	low elevation, mid way next to tree stump, sealed salt crust surface
8	25/03/2010	404517	6218878	not reached	sealed, salt crust	samphire	high elevation, on spit, sealed salt crust surface

**Table 8-3. Soil profile description data for Hart Lagoon (Wetland ID. 12006).**

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	olive grey (5Y4/2)	clay	moist		massive	firm	
1_2	5 - 10	small pit	dark grey (5Y4/1)	clay	moist	5% olive brown In the matrix	massive	firm	contains thin inclusions of monosulfidic material
1_3	10 - 20	small pit	dark grey (5Y4/1)	clay	moist		massive	firm	
1_4	20 - 40	small pit	dark grey (5Y4/1)	clay	moist		massive	firm	
1_5	40 - 90	push tube	dark grey (5Y4/1)	clay	moist		massive	very firm	
2_1	0 - 2	small pit	black (2.5Y2/0)	monosulfidic black ooze	wet		gel	very weak	
2_2	2 - 10	small pit	dark grey (5Y4/1)	clay	wet	5% reddish brown In the matrix	angular blocky	weak	
2_3	10 - 20	small pit	dark grey (5Y4/1)	clay	wet		massive	weak	very sticky
2_4	20 - 40	small pit	dark grey (5Y4/1)	clay	moist		massive	firm	very sticky
2_5	40 - 70	push tube	dark grey (5Y4/1)	clay	moist		massive	very firm	
3_1	0 - 5	small pit	very dark grey (10YR3/1)	clay	moist		massive	very weak	contains isolated inclusions of monosulfidic material
3_2	5 - 10	small pit	olive grey (5Y4/2)	clay	moist		angular blocky	very firm	very sticky
3_3	10 - 20	small pit	olive grey (5Y4/2)	clay	moist		angular blocky	firm	very sticky
3_4	20 - 40	small pit	olive grey (5Y4/2)	clay	wet		massive	firm	
3_5	40 - 90	push tube	very dark grey (5Y3/1)	clay	moist		massive	firm	
3_W1	-	pit water							water sampled
4_1	0 - 3	small pit	brown (10YR5/3)	clay	dry		angular blocky	firm	includes an organic mat
4_2	3 - 10	small pit	greyish brown (2.5Y5/3)	clay	moist	10% reddish brown In the matrix	angular blocky	firm	
4_3	10 - 20	small pit	greyish brown (2.5Y5/3)	clay	moist		angular blocky	firm	contains sheel fragments, and crystals in matrix
4_4	20 - 40	small pit	olive grey (5Y4/2)	clay	moist		massive	firm	
4_5	40 - 70	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
5_1	0 - 0.5	small pit	dark yellowish brown (10YR3/6)	salt	dry		crystalline	weak	salt crust
5_2	0.5 - 10	small pit	grey (5Y5/1)	clay	moist	20% yellowish brown In the matrix	angular blocky	firm	contains 5% jarosite
5_3	10 - 20	small pit	grey (5Y5/1)	clay	moist	20% yellowish brown In the matrix	angular blocky	firm	contains 15% jarosite
5_4	20 - 40	small pit	grey (5Y5/1)	clay	moist	10% yellowish brown In the matrix	angular blocky	firm	contains 5% jarosite
5_5	40 - 70	push tube	grey (5Y5/1)	clay	moist		massive	firm	
5_6	70 - 100	push tube	grey (5Y5/1)	clay	moist		massive	very firm	
6_1	0 - 5	small pit	light brownish grey (2.5Y6/2)	sandy clay loam	dry	5% reddish brown In the matrix	subangular blocky	weak	
6_2	5 - 10	small pit	grey (5Y5/1)	sandy clay loam	dry	10% reddish brown infused into the matrix adjacent to pores	subangular blocky	weak	
6_3	10 - 20	small pit	grey (5Y5/1)	clay	moist	5% reddish brown infused into the matrix adjacent to pores	massive	firm	
6_4	20 - 40	push tube	grey (5Y5/1)	clay	moist		massive	firm	
7_1	0 - 0.5	small pit	dark greyish brown (2.5Y4/2)	salt	dry		platy	weak	surface salt crystals
7_2	0.5 - 10	small pit	black (2.5Y2/0)	clay	moist		angular blocky	firm	contains dry black monosulfidic material
7_3	10 - 20	small pit	dark greyish brown (2.5Y4/2)	clay	moist	15% reddish brown In the matrix	massive	firm	
7_4	20 - 40	push tube	dark greyish brown (2.5Y4/2)	clay	moist		massive	very firm	contains shell fragments
8_1	0 - 0.5	small pit	dark grey (10YR4/1)	sandy clay loam	dry		platy	weak	a thin white salt crust over black
8_2	0.5 - 10	small pit	dark grey (10YR4/1)	clay	moist		subangular blocky	firm	
8_3	10 - 20	small pit	dark grey (10YR4/1)	clay	moist		subangular blocky	firm	slickensides
8_4	20 - 40	push tube	grey (10YR5/1)	clay	moist		subangular blocky	very firm	slickensides

**Table 8-4. Laboratory data for acid sulfate soil assessment of Hart Lagoon (Wetland ID. 12006).**

(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 <sub>4</sub> /kg)	pH KCl	Titrateable Actual Acidity (mole H <sup>+</sup> /tonne)	Chromium Reducible Sulfur (%S <sub>CR</sub> )	Acid Neutralising Capacity (%CaCO <sub>3</sub> )	Net Acidity (mole H <sup>+</sup> /tonne)	Acid Volatile Sulfur (%Sav)	Acid Sulfate Soil Material Classification
1.1	0-5	Fine	22,770	8.35	7.72	7.14	7.72	2,000	8.40	0.00	0.02	1.92	-246		hyposulfidic (S <sub>CR</sub> <0.10%)
1.2	5-10	Fine	11,570	8.14	7.62	7.32	8.11	370	7.94	0.00	<0.01	1.20	-159		other soil material
1.3	10-20	Fine	7,220	8.26	7.60	7.68	8.16	220	7.42	0.00	<0.01	0.76	-101		other soil material
1.4	20-40	Fine	5,480	8.09	7.50	7.61	8.22	200	7.05	0.00	<0.01	1.00	-133		other soil material
1.5	40-90	Fine	4,090	7.75	7.53	7.10	8.21	160	6.94	0.00	<0.01	0.96	-129		other soil material
2.1	0-2	Fine	5,000	7.96	7.47	7.17	7.80	9,900	8.63	0.00	0.12	10.70	-1350	0.04	hyposulfidic (S <sub>CR</sub> ≥0.10%) monosulfidic
2.2	2-10	Fine	15,150	8.04	6.80	7.34	7.75	1,500	7.82	0.00	0.33	5.16	-481		hyposulfidic (S <sub>CR</sub> ≥0.10%)
2.3	10-20	Fine	11,610	7.87	2.53	7.09	7.70	1,100	7.98	0.00	0.15	1.15	-61		hyposulfidic (S <sub>CR</sub> ≥0.10%)
2.4	20-40	Fine	4,960	7.35	6.40	7.03	7.66	340	7.46	0.00	0.02	0.38	-39		hyposulfidic (S <sub>CR</sub> <0.10%)
2.5	40-70	Fine	3,490	7.95	7.83	7.02	8.35	250	7.07	0.00	<0.01	0.66	-88		other soil material
3.1	0-5	Fine	32,800	7.78	7.66	7.10	7.76	6,800	8.17	0.00	0.15	10.49	-1307		hyposulfidic (S <sub>CR</sub> ≥0.10%)
3.2	5-10	Fine	11,280	7.50	6.50	6.84	7.76	3,300	8.22	0.00	0.20	6.30	-714		hyposulfidic (S <sub>CR</sub> ≥0.10%)
3.3	10-20	Fine	15,690	7.51	6.28	6.75	7.47	3,600	7.97	0.00	0.16	2.10	-180		hyposulfidic (S <sub>CR</sub> ≥0.10%)
3.4	20-40	Fine	15,950	7.55	7.15	6.80	7.60	3,400	7.77	0.00	0.01	0.32	-36		hyposulfidic (S <sub>CR</sub> <0.10%)
3.5	40-90	Fine	6,270	7.41	8.07	6.73	7.65	760	7.58	0.00	<0.01	0.49	-65		other soil material
3.W1	-	..	..	..	..	..	..	..	..	..	..	..	..	..	pit water
4.1	0-3	Medium	29,900	7.34	6.86	7.31	7.35	5,900	7.92	0.00	0.04	8.11	-1056		hyposulfidic (S <sub>CR</sub> <0.10%)
4.2	3-10	Fine	11,370	7.82	6.61	7.36	7.50	3,600	7.65	0.00	0.11	8.11	-1013		hyposulfidic (S <sub>CR</sub> ≥0.10%)
4.3	10-20	Fine	10,930	7.49	6.40	7.26	7.37	3,100	7.62	0.00	0.03	1.70	-205		hyposulfidic (S <sub>CR</sub> <0.10%)
4.4	20-40	Fine	9,210	7.25	6.45	6.88	7.63	3,700	7.73	0.00	0.03	1.62	-197		hyposulfidic (S <sub>CR</sub> <0.10%)
4.5	40-70	Fine	6,290	7.23	6.67	6.55	7.47	890	7.42	0.00	0.02	0.49	-55		hyposulfidic (S <sub>CR</sub> <0.10%)
5.1	0-0.5	Medium	37,400	7.88	8.07	7.07	7.74	11,000	8.31	0.00	<0.01	1.34	-179		other soil material
5.2	0.5-10	Fine	20,890	6.93	5.11	5.49	4.77	4,400	8.24	0.00	0.02	0.46	-49		hyposulfidic (S <sub>CR</sub> <0.10%)
5.3	10-20	Fine	10,130	5.35	3.21	4.60	4.23	2,600	6.75	0.00	0.02	0.00	11		hyposulfidic (S <sub>CR</sub> <0.10%)
5.4	20-40	Fine	6,870	5.77	3.57	4.95	5.67	750	6.05	10.06	<0.01	0.00	10		other acidic
5.5	40-70	Fine	4,220	7.10	6.93	6.51	6.91	240	6.44	1.44	<0.01	0.00	1		other soil material
5.6	70-100	Fine	2,470	8.05	8.00	7.03	8.25	150	6.52	0.00	<0.01	0.31	-41		other soil material
6.1	0-5	Medium	15,510	7.56	6.34	7.18	7.80	2,400	7.78	0.00	<0.01	1.26	-168		other soil material
6.2	5-10	Medium	8,870	6.90	4.31	5.96	6.72	1,000	7.66	0.00	<0.01	0.23	-31		other soil material
6.3	10-20	Fine	7,820	6.52	4.24	6.05	6.36	810	6.87	0.00	<0.01	0.12	-15		other soil material
6.4	20-40	Fine	7,230	4.86	2.90	4.22	4.74	1,900	4.90	24.92	<0.01	..	25		other acidic

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC ( $\mu\text{S}/\text{cm}$ )	pH water	pH peroxide	pH incubation week 0	pH incubation week 8	Sulfate ( $\text{mg SO}_4/\text{kg}$ )	pH KCl	Titrateable Actual Acidity ( $\text{mole H}^+/\text{tonne}$ )	Chromium Reducible Sulfur ( $\%S_{\text{CR}}$ )	Acid Neutralising Capacity ( $\%\text{CaCO}_3$ )	Net Acidity ( $\text{mole H}^+/\text{tonne}$ )	Acid Volatile Sulfur ( $\%\text{Sav}$ )	Acid Sulfate Soil Material Classification
7.1	0-0.5	Medium	58,200	7.97	7.92	7.29	7.61	19,000	8.42	0.00	0.01	2.65	-346		hyposulfidic ( $S_{\text{CR}} < 0.10\%$ )
7.2	0.5-10	Fine	18,730	7.53	7.90	6.92	7.71	3,600	8.65	0.00	<0.01	3.82	-509		other soil material
7.3	10-20	Fine	8,240	7.00	4.96	6.31	7.28	1,300	7.86	0.00	<0.01	0.00	0		other soil material
7.4	20-40	Fine	4,360	6.74	4.61	6.12	6.89	400	7.20	0.00	<0.01	0.30	-40		other soil material
8.1	0-0.5	Fine	29,550	7.27	7.09	6.79	7.28	6,900	7.54	0.00	<0.01	1.46	-194		other soil material
8.2	0.5-10	Fine	15,580	7.72	6.91	7.07	7.47	500	7.77	0.00	<0.01	1.28	-170		other soil material
8.3	10-20	Fine	7,850	7.97	6.65	7.66	7.89	220	7.64	0.00	<0.01	0.74	-99		other soil material
8.4	20-40	Fine	3,920	8.16	7.26	7.93	8.06	100	7.51	0.00	<0.01	0.60	-80		other soil material

**Table 8-5. Summary of hydrochemical field measurements for Hart Lagoon (Wetland ID. 12006).**

	pH	SEC $\mu\text{S cm}^{-1}$	DO $\text{mg l}^{-1}$	Eh mV	Turbidity NTU	Alkalinity as $\text{HCO}_3$
Pit waters (n=1)	6.56	62071	1.74	182		327



**Table 8-6. Hydrochemical data for Hart Lagoon (Wetland ID. 12006).**

Parameter	units	ANZECC Guidelines	Site 3 (PW)
Na	mg l <sup>-1</sup>		12900
K	mg l <sup>-1</sup>		49.0
Ca	mg l <sup>-1</sup>		886
Mg	mg l <sup>-1</sup>		785
Si	mg l <sup>-1</sup>		14.8
Br	mg l <sup>-1</sup>		52.0
Cl	mg l <sup>-1</sup>		23000
NO <sub>3</sub>	mg l <sup>-1</sup>	0.7	0.323
NH <sub>4</sub> -N <sup>K</sup>	mg l <sup>-1</sup>	0.01	<b>1.50</b>
PO <sub>4</sub> -P <sup>E</sup>	mg l <sup>-1</sup>	0.005	<b>0.521</b>
SO <sub>4</sub>	mg l <sup>-1</sup>		4100
Ag	µg l <sup>-1</sup>	0.05	<0.2
Al <sup>A</sup>	µg l <sup>-1</sup>	55	<500
As <sup>B</sup>	µg l <sup>-1</sup>	13	<10
Cd	µg l <sup>-1</sup>	0.2	<b>1.50</b>
Co	µg l <sup>-1</sup>	2.8	<b>21.2</b>
Cr <sup>C</sup>	µg l <sup>-1</sup>	1	<3
Cu <sup>H</sup>	µg l <sup>-1</sup>	1.4	<10
Fe	µg l <sup>-1</sup>	300	<5000
Mn	µg l <sup>-1</sup>	1700	<b>6950</b>
Ni <sup>H</sup>	µg l <sup>-1</sup>	11	<b>20.0</b>
Pb <sup>H</sup>	µg l <sup>-1</sup>	3.4	<5
Se	µg l <sup>-1</sup>	11	<4
Zn <sup>H</sup>	µg l <sup>-1</sup>	8	<b>190</b>
DOC	mg l <sup>-1</sup>		23.3

**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<sub>4</sub> and PO<sub>4</sub>, 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.

<sup>A</sup> Trigger value for Aluminium in freshwater where pH > 6.5.

<sup>B</sup> Trigger value assumes As in solution as Arsenic (AsV).

<sup>C</sup> Trigger value for Chromium is applicable to Chromium (CrVI) only.

<sup>E</sup> Guideline is for filterable reactive phosphorous (FRP).

<sup>H</sup> Hardness affected (refer to Guidelines).

<sup>K</sup> Guideline for South-east Australia-Freshwater Lakes and reservoirs.

## 9. YARRA COMPLEX (WETLAND ID. 12605)

### 9.1. Location and setting description

Yarra Complex (Wetland ID. 12605) is situated on the northern side of the River Murray, about 10 kilometres up river from the town of Waikerie, located in the Yarra Complex area. The wetland is irregular to linear in shape forming part of a wetland complex that occurs on the inside of a bend in the river. It is about 5 kilometres in length and about 500 metres at its widest, with a total surface area of 86 hectares. The wetland is bounded by a raised floodplain that separates the wetland from the river to the south and steep hill slopes to the north. The other associated wetlands in the Yarra Complex are Wetland IDs. 12606 and 12608.

The wetland is permanently connected to the river at the down river, western end by a wide inlet. At the time when the soil survey was conducted in March 2010 the wetland had surface water. The wetland is not managed. It was probably last dry in the 1920's before the Locks were installed. Sedgeland and grassland was growing along the wetland margins, with open woodland and shrubland on the surrounding higher floodplain. Ten sites were sampled as shown in Figure 9-1.

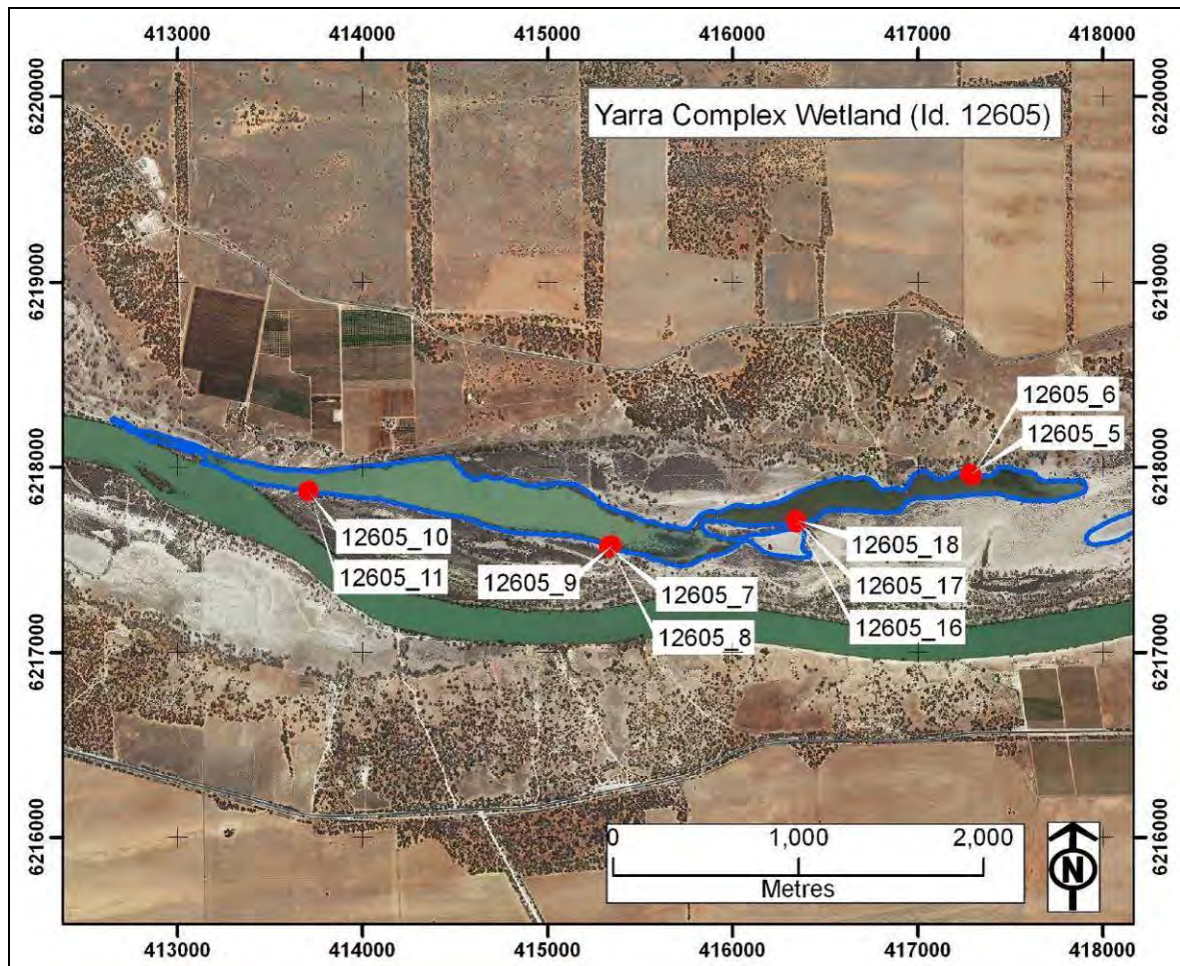


Figure 9-1. Yarra Complex (Wetland ID. 12605) and sample site locations.

## 9.2. Soil profile description and distribution

Ten sites were described and sampled. The soil subtypes and general location descriptions are presented in Table 9-1. Sites were distributed along four transects distributed along the wetland where sites were placed on the margin and as far as possible into the open water to provide cross-sections, with sites placed on the eastern transect (Sites 5 and 6), southwestern transect (Sites 7, 8 and 9), western transect (Sites 10 and 11) and southeastern transect (Sites 16, 17 and 18) of the wetland. The site and soil profile descriptions are presented in Table 9-2 and Table 9-3, and a conceptual cross-section diagram in Figure 9-2.

### Eastern transect

Site 5 (Figure 9-3) occurred on the wetland margin adjacent to the bank amongst reeds in water (30 cm deep), and the soil consisted of a black, firm, peat, over a light olive grey, very firm, gritty clay. Site 6 (Figure 9-4) occurred in open water (100 cm deep), and the soil consisted of an olive grey, firm, loamy sand.

### Southwestern transect

Site 7 (Figure 9-5) occurred adjacent to the bank, amongst Phragmites, in water (30 cm deep), and the soil consisted of a greyish brown, weak, peat, over a grey, firm to very firm clay. Site 8 (Figure 9-6) occurred amongst Typha in water (50 cm deep), and the soil consisted of a yellowish brown, weak, peat, over grey to greenish grey with depth, very firm, clay. Site 9 (Figure 9-7) occurred adjacent to reeds in open water (80 cm deep), and the soil consisted of a grey, firm to very firm with depth, clay.

### Western transect

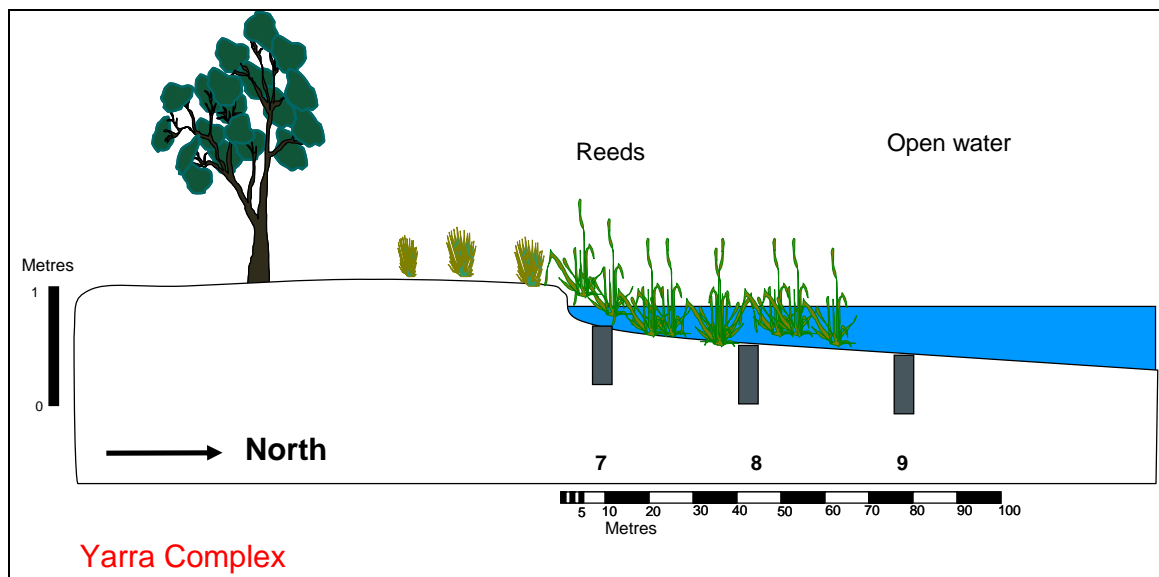
Site 10 (Figure 9-8) occurred adjacent to the bank, amongst Phragmites, in water (20 cm deep), and the soil consisted of a light yellowish brown, weak, peat and roots, over a grey, very firm, clay to sandy clay loam. Site 11 (Figure 9-9) occurred in open water (100 cm deep), and the soil consisted of a light olive grey, very weak, mucky clay, over a grey, very firm, clay.

### Southeastern transect

Site 16 (Figure 9-10) occurred amongst Typha in water (25 cm deep), and the soil consisted of a greyish brown, firm, peat, over an olive grey, firm, sandy clay loam. Site 17 (Figure 9-11) occurred amongst thick reeds in water (40 cm deep), and the soil consisted of a yellowish brown, peat, over olive grey, weak sand to sandy clay loam with depth. Site 18 (Figure 9-12) occurred in open water (120 cm deep), and the soil consisted of a yellowish brown, very weak, mucky clay, over a dark grey, firm, clay loam.

**Table 9-1. Soil identification, subtype and general location description for Yarra Complex (Wetland ID. 12605).**

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12605_5	417286	6217963	Subaqueous Soil (clayey)	mid, next to shoreline, amongst reeds
12605_6	417295	6217953	Subaqueous Soil (loamy)	mid/low, 20m from shore water
12605_7	415331	6217566	Hypersulfidic Subaqueous Soil (clayey)	mid elevation, next to bank and Phragmites, in water
12605_8	415335	6217576	Hypersulfidic Subaqueous Soil (clayey)	mid elevation, in water, amongst Typha
12605_9	415349	6217579	Subaqueous Soil (clayey)	mid/low elevation towards edge where Typha grows, in water
12605_10	413707	6217867	Subaqueous Soil (loamy)	next to bank, in water, amongst Phragmites
12605_11	413710	6217872	Subaqueous Soil (loamy)	low elevation, in open water
12605_16	416348	6217697	Subaqueous Soil (loamy)	mid/low elevation, margin of water, in water amongst Typha
12605_17	416347	6217706	Subaqueous Soil (clayey)	mid elevation in reeds, in water
12605_18	416344	6217712	Subaqueous Soil (clayey)	low elevation in open water



**Figure 9-2. Conceptual cross-section diagram.**



**Figure 9-3. Photograph of Site 5, showing the site location in water amongst reeds in water.**



**Figure 9-4. Photograph of Site 6, showing the site location in open water.**



**Figure 9-5. Photograph of Site 7, showing the site location in water adjacent to the bank and amongst Phragmites.**



**Figure 9-6. Photograph of Site 8, showing the site location placed in water surrounded by Phragmites.**



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



**Figure 9-8. Photograph of Site 10, showing the site location in the foreground (auger handle), next to the bank in water and amongst Phragmites. Site 11 is identified by the yellow shovel handle in the background.**



**Figure 9-9. Photograph of Site 11, showing the site location in open water.**



**Figure 9-10. Photograph of Site 16, showing the site location near the bank in water amongst Phragmites.**



**Figure 9-11. Photograph of Site 17, showing the site location in water amongst thick reeds.**

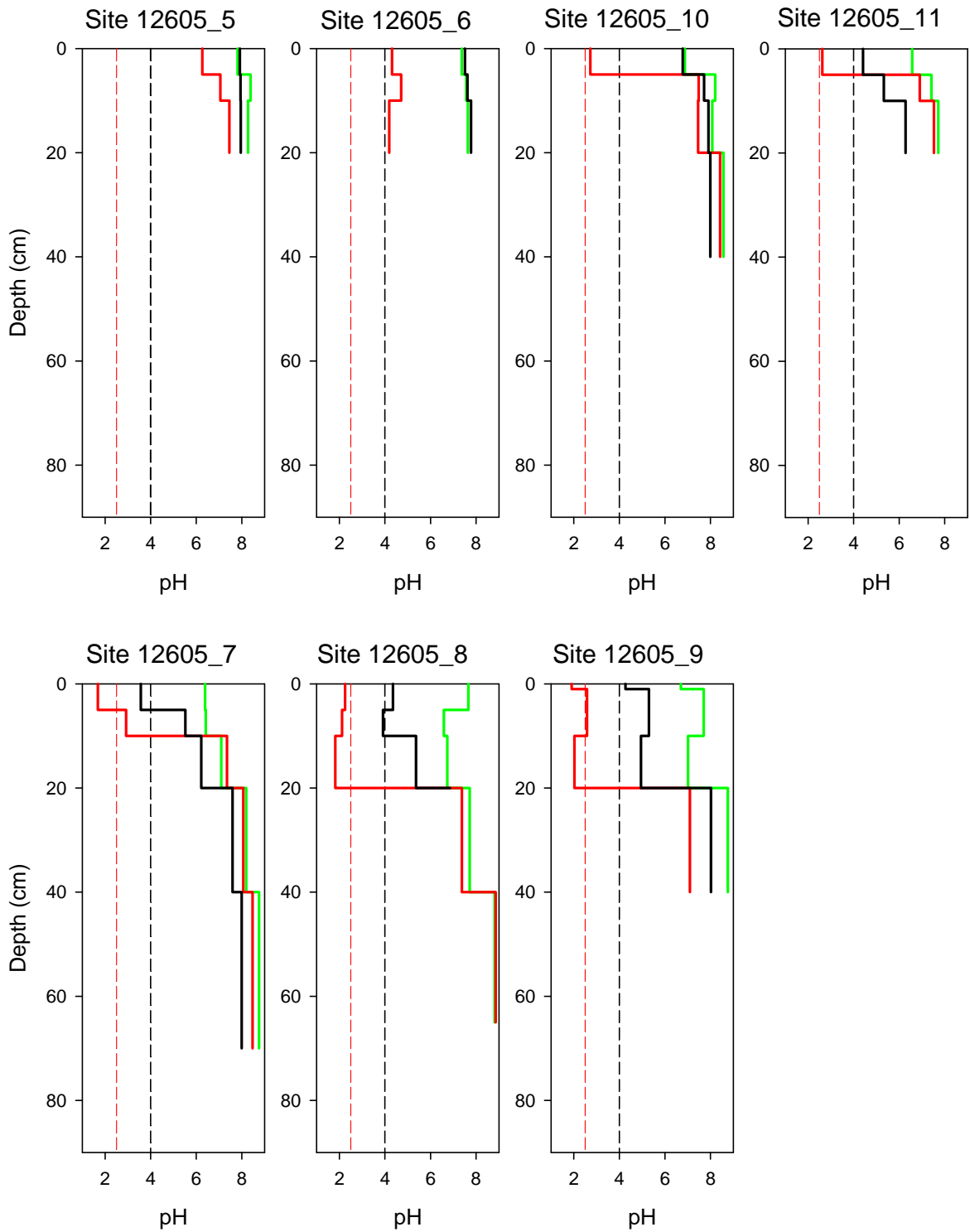


**Figure 9-12. Photograph of Site 18, showing the site location in open water at the edge of the reeds to open water.**

### **9.3. Laboratory data assessment**

#### **9.3.1. Soil pH testing ( $pH_W$ , $pH_{OX}$ , $pH_{INC}$ )**

The pH data are provided in Table 9-4 and pH profiles are presented in Figure 9-13. The  $pH_W$  data ranged from 4.65 to 9.04 and sulfuric materials with a  $pH_W < 4$  were not identified. The  $pH_{OX}$  data ranged from 1.68 to 9.09 and identified that samples in the upper layers of Profiles 7, 8, 9 and 18 were below the critical value of  $pH_{OX} < 2.5$ , the threshold value normally used to indicate a high likelihood of sulfuric material forming. The  $pH_{INC}$  data ranged from 3.57 to 8.73 and identified samples in Profiles 7 and 8 on incubation declined below the critical values of  $pH < 4$ , indicating that the soils would be sulfuric if oxidised.



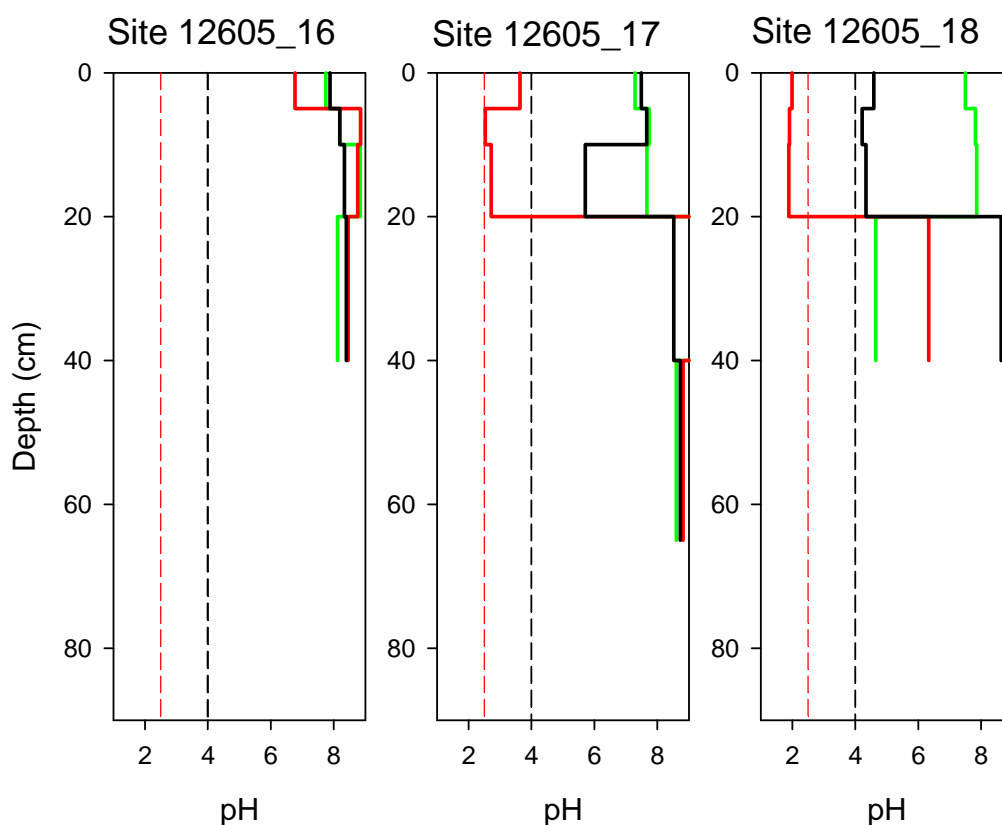


Figure 9-13. Depth profiles of soil pH for Yarra Complex (Wetland ID. 12605), showing soil pH ( $pH_W$  as green line), peroxide treated pH ( $pH_{OX}$  as red line) and incubation pH ( $pH_{INC}$  after 8 weeks as black line). Critical  $pH_W$  and  $pH_{INC}$  value of 4 (black dashed line) and critical  $pH_{OX}$  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 9-14.

#### Chromium reducible sulfur

Chromium reducible sulfur values ranged from 0.01 to 0.57 % $S_{CR}$  and sulfidic materials were detected in all soil layers.

#### Titratable actual acidity

Titratable actual acidity values ranged from 0 to 16.19 mole  $H^+$ /tonne and were detected in samples of Profiles 7, 8, 9, 10 and 11.

#### Retained acidity

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

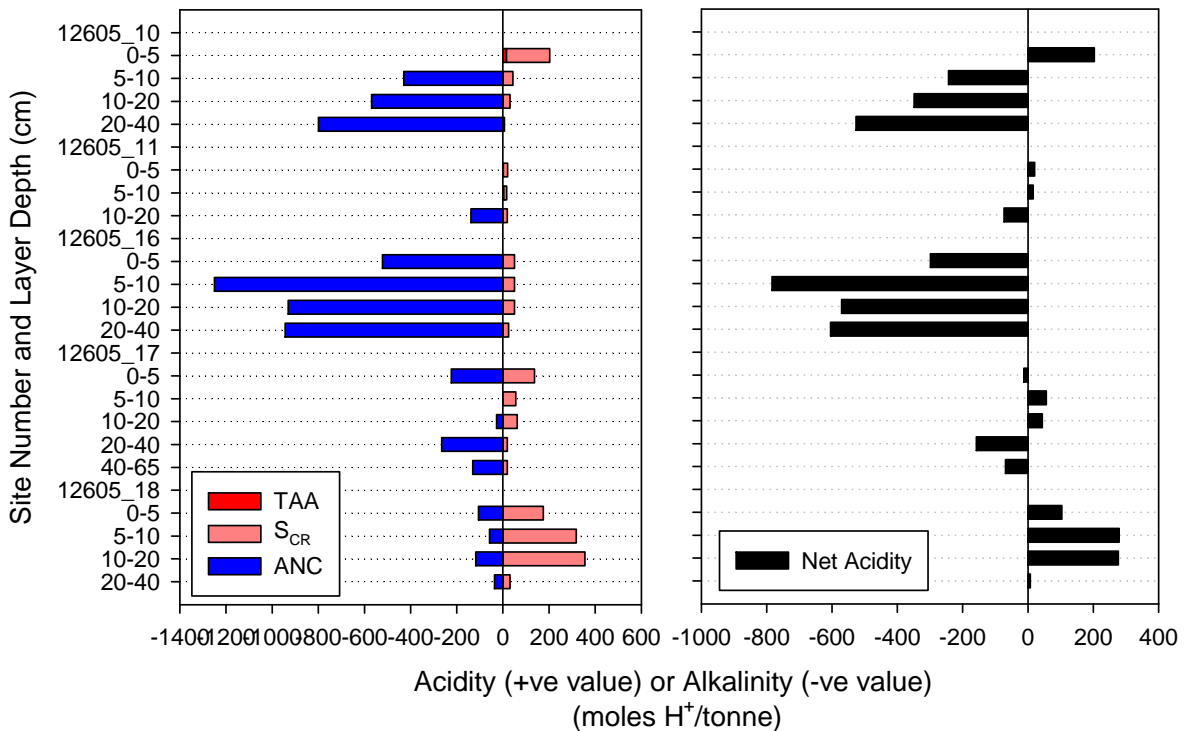
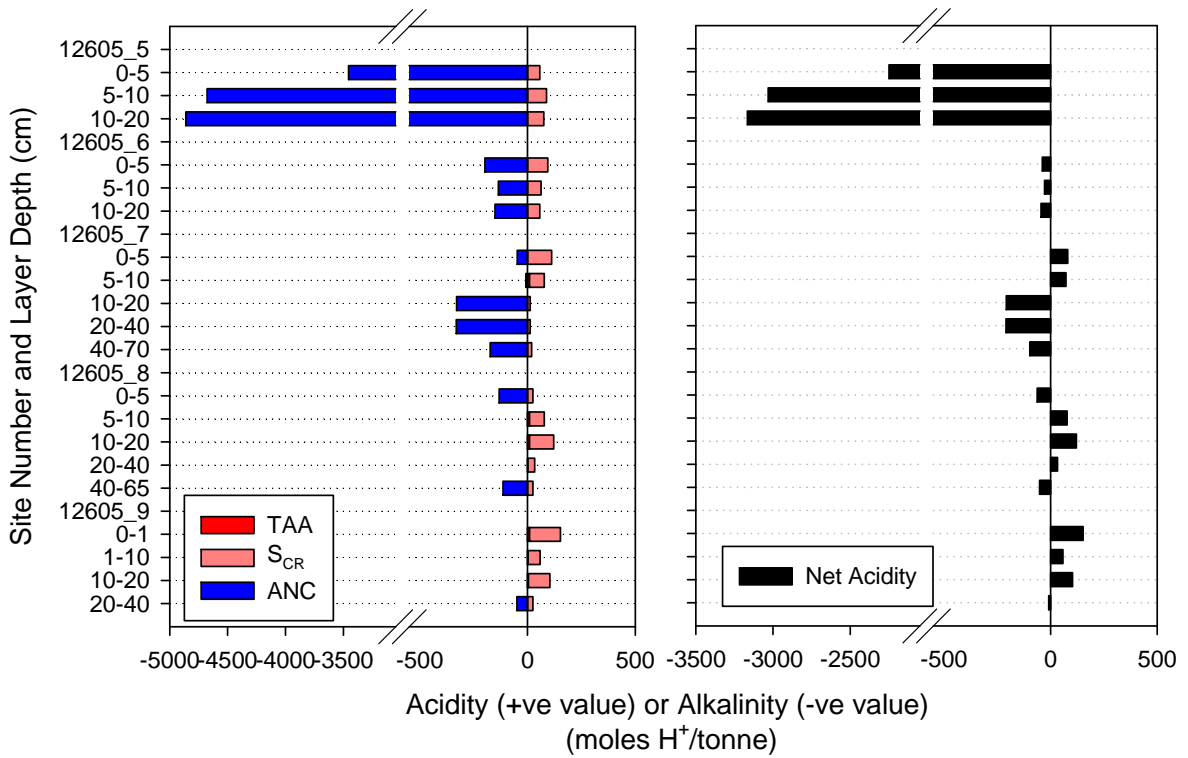
#### Acid neutralising capacity

Acid neutralising capacity values ranged from 0 to 24.33 % $CaCO_3$  and were measured in nearly all samples.

#### Net acidity

Net acidity values ranged from -3166 to 279 mole  $H^+$ /tonne. Samples in profiles tended to be moderate or high values in the surface layers declining to negative values in the subsoil layers, and for Profiles 5, 6 and 16 the values were negative in all layers.





**Figure 9-14. Acid base accounting depth profiles for Yarra Complex (Wetland ID. 12605). 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 Profiles 5, 7, 8, 10, 17 and subsurface layer of Profile 18 were above the criteria value of 100 mg/kg SO<sub>4</sub>.

### 9.3.4. Acid volatile sulfur

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

### 9.3.5. Hydrochemistry

Four surface water samples were collected from this wetland. Field parameters are shown in Table 9-5. The surface water had circumneutral to slightly alkaline pH with a range of salinities from fresh to moderately high SEC. Dissolved oxygen, turbidity and alkalinity were variable.

The surface waters were of Na-Cl type, with elevated HCO<sub>3</sub> compared to seawater composition (Table 9-6, Figure 9-15). Sulfate concentrations in the surface waters varied from 13 to 56 mg l<sup>-1</sup>. The SO<sub>4</sub>/Cl ratio in the surface waters varied from 0.100 to 0.167, similar to seawater (0.142). For the nutrients, NH<sub>4</sub> and PO<sub>4</sub> were slightly elevated above ANZECC Guideline values in some samples. Of the metals, Al and Zn were elevated above ANZECC Guideline values, although this may be partly due the high turbidity in some samples with colloidal material present.

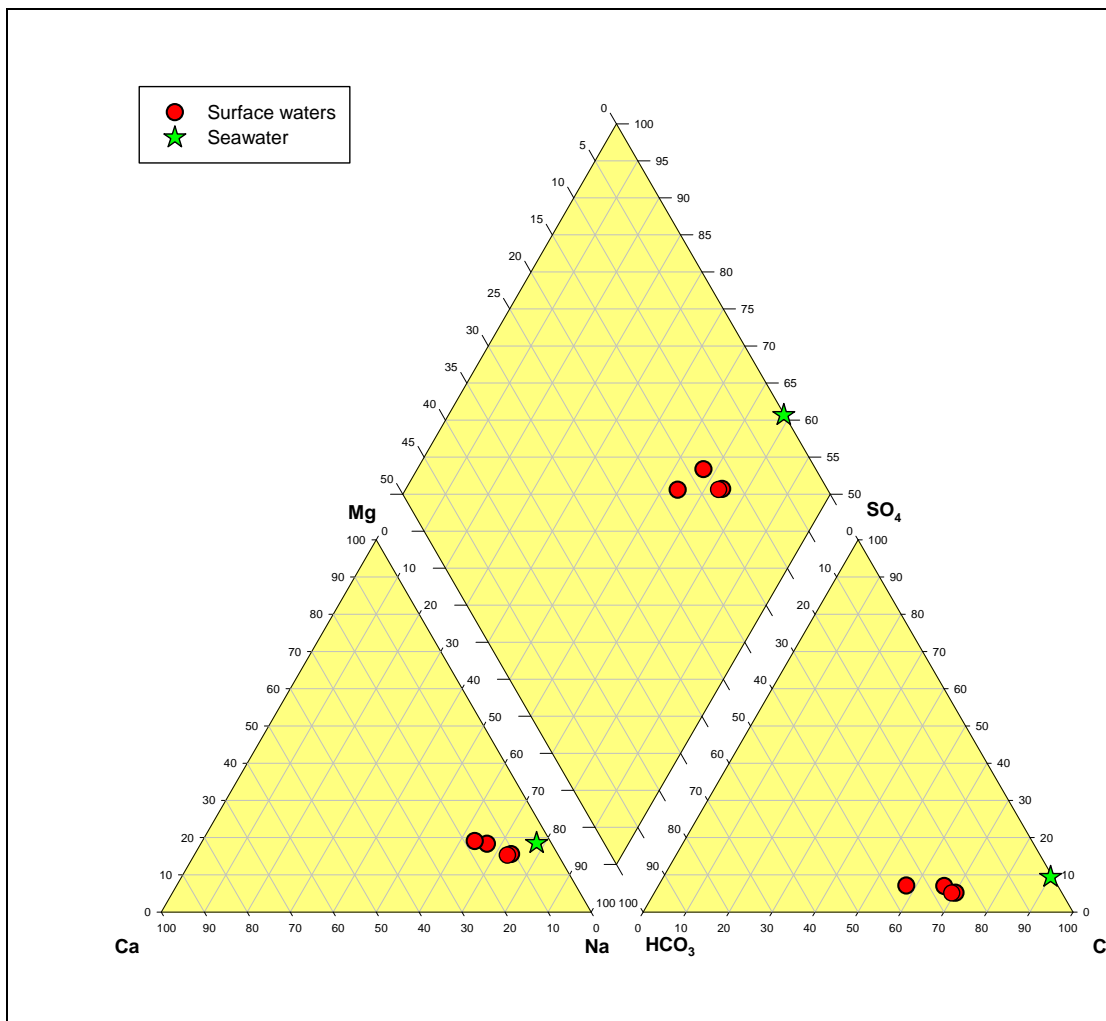


Figure 9-15. Piper diagram of hydrochemical data for Yarra Complex (Wetland ID. 12605).

## 9.4. Discussion

Acid sulfate soil materials at Yarra Complex (Wetland ID. 12605) were identified as hypersulfidic occurring in the upper layers of Sites 7 and 8 on the southern side of the wetland, other samples were characterised as hyposulfidic. The acid sulfate soil subtype classes identified were Hypersulfidic Subaqueous Soil (clayey) and Subaqueous Soil (clayey or loamy).

The soils throughout the wetland were loamy or peaty on the surface and in the subsoils dominantly clayey.

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

The potential hazards posed by acid sulfate soil materials at Yarra Complex (Wetland ID. 12605) are:

- Acidification hazard: The data identified moderate or high net acidity values in the surface and subsoil layers in 7 of the 10 profiles and pH data identified a few samples with values that indicated a potential acidification hazard due to oxidation. There is a medium to high level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there 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 acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

### Summary of key findings Yarra Complex (Wetland ID. 12605):

<b>Soil materials:</b>	The soil layers throughout the wetland were hyposulfidic and in a few areas the surface layers were hypersulfidic. Soils were peaty or loamy textured at the surface and in the subsoils clayey textured. Most profiles contained some layers with a moderate or high net acidity values and pH data for some samples indicated a potential for acidification due to oxidation.
<b>Acid sulfate soil identification:</b>	<ul style="list-style-type: none"> <li>• Hypersulfidic Subaqueous Soil (clayey) – occurring in some areas on the south side of the wetland. Minor (&lt;25%) in extent.</li> <li>• Subaqueous Soil (clayey or loamy) – occurring throughout the wetland. Dominant (&gt;50%) in extent.</li> </ul>
<b>Hazard assessment</b>	<ul style="list-style-type: none"> <li>• Acidification hazard – medium to high level of concern</li> <li>• De-oxygenation hazard – medium level of concern</li> <li>• Metal mobilisation hazard – medium level of concern</li> </ul>

**Table 9-2. Site description data for Yarra Complex (Wetland ID. 12605).**

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	28/03/2010	417286	6217963	30	firm, phragmites	Typha	mid, next to shoreline, amongst reeds
6	28/03/2010	417295	6217953	100	firm	bare, water	mid/low, 20m from shore in water
7	28/03/2010	415331	6217566	30	water, firm	Phragmites	mid elevation, next to bank and Phragmites, in water
8	28/03/2010	415335	6217576	50	water, plant roots	Typha	mid elevation, in water, amongst Typha
9	28/03/2010	415349	6217579	80	gel	water	mid/low elevation towards edge where Typha grows, in water
10	28/03/2010	413707	6217867	20	plant roots, firm	Phragmites	next to bank, in water, amongst Phragmites
11	28/03/2010	413710	6217872	100	water, firm	bare, water	low elevation, in open water

**Table 9-3. Soil profile description data for Yarra Complex (Wetland ID. 12605).**

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_W	30 - 0	water							
5_1	0 - 5	small pit	black (2.5Y2/0)	peat	wet		massive	firm	
5_2	5 - 10	small pit	light olive grey (5Y6/2)	gritty clay	wet		massive	firm	many coarse gravels, possible jarosite visible
5_3	10 - 20	small pit	light olive grey (5Y6/2)	gritty clay	wet		massive	very firm	10% carbonate fragments
6_W1	100 - 0	surface water							water sampled
6_1	0 - 5	small pit	olive grey (5Y5/2)	sand	wet		massive	firm	
6_2	5 - 10	small pit	olive grey (5Y5/2)	loamy sand	wet		massive	firm	
6_3	10 - 20	small pit	olive grey (5Y5/2)	loamy sand	moist		massive	very firm	10% carbonate fragments
7_W	30 - 0	water							
7_1	0 - 5	small pit	greyish brown (10YR5/2)	peat	wet		massive	weak	
7_2	5 - 10	small pit	grey (5Y6/1)	gritty clay	wet		massive	firm	
7_3	10 - 20	small pit	grey (5Y6/1)	clay	wet		massive	firm	
7_4	20 - 40	small pit	grey (5Y6/1)	clay	moist		massive	firm	
7_5	40 - 70	push tube	greenish grey (5GY6/1)	clay	moist		massive	very firm	
8_W	50 - 0	water							
8_1	0 - 5	small pit	yellowish brown (10YR5/4)	peat	wet		massive	weak	50% plant root material
8_2	5 - 10	small pit	grey (5Y6/1)	clay	wet		massive	firm	
8_3	10 - 20	small pit	grey (5Y6/1)	clay	moist		massive	firm	
8_4	20 - 40	small pit	greenish grey (5GY6/1)	clay	moist		massive	very firm	
8_5	40 - 65	push tube	greenish grey (5GY6/1)	clay	moist		massive	very firm	
9_W1	80 - 0	surface water							water sampled
9_1	0 - 1	small pit	grey (5Y5/1)	clay	wet		gel	very weak	
9_2	1 - 10	small pit	grey (5Y5/1)	clay	wet		massive	firm	
9_3	10 - 20	small pit	grey (10YR6/1)	clay	moist		massive	firm	
9_4	20 - 40	push tube	greenish gray (10Y6/1)	clay	moist		massive	very firm	too hard to auger below
9_5	40 - 50	push tube							

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
10_W	20 - 0	water							
10_1	0 - 5	small pit	light yellowish brown (10YR6/4)	peat	wet		massive	weak	mainly root material
10_2	5 - 10	small pit	grey (5Y6/1)	clay	wet		massive	firm	10% carbonate fragments
10_3	10 - 20	small pit	grey (5Y6/1)	clay	wet		massive	firm	15% carbonate fragments
10_4	20 - 40	push tube	grey (5Y6/1)	sandy clay loam	moist		massive	very firm	35% carbonate fragments
11_W1	100 - 0	surface water							water sampled
11_1	0 - 5	small pit	light olive grey (5Y6/2)	mucky clay	wet		massive	very weak	
11_2	5 - 10	small pit	light olive grey (5Y6/2)	clay	moist		massive	very firm	15% carbonate fragments
11_3	10 - 20	small pit	grey (5Y6/1)	clay	moist		massive	very firm	15% carbonate fragments
16_W	25 - 0	water							
16_1	0 - 5	small pit	greyish brown (2.5Y5/2)	peat	wet		massive	firm	
16_2	5 - 10	small pit	olive grey (5Y5/2)	sandy clay loam	wet		angular blocky	firm	10% carbonate fragments
16_3	10 - 20	small pit	olive grey (5Y5/2)	sandy clay loam	wet		angular blocky	firm	15% carbonate fragments
16_4	20 - 40	push tube	olive grey (5Y5/2)	clay loam sandy	moist		massive	very firm	
17_W	40 - 0	water							
17_1	0 - 5	small pit	yellowish brown (10YR5/6)	peat	wet		massive	firm	
17_2	5 - 10	small pit	light olive grey (5Y6/2)	sand	wet		single grain	weak	
17_3	10 - 20	small pit	olive grey (5Y5/2)	loamy sand	wet		single grain	weak	
17_4	20 - 40	small pit	olive grey (5Y5/2)	sandy clay loam	wet		massive	firm	
17_5	40 - 65	push tube	olive grey (5Y5/2)	clay loam sandy	moist		massive	firm	
18_W1	120 - 0	surface water							water sampled
18_1	0 - 5	small pit	dark greyish brown (2.5Y4/2)	mucky clay	wet		gel	very weak	
18_2	5 - 10	small pit	olive grey (5Y4/2)	mucky clay	wet		gel	very weak	
18_3	10 - 20	small pit	dark grey (5Y4/1)	clay	wet		gel	very weak	
18_4	20 - 40	push tube	dark grey (5Y4/1)	clay loam sandy	moist		massive	firm	

**Table 9-4. Laboratory data for acid sulfate soil assessment of Yarra Complex (Wetland ID. 12605).**

(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 <sub>4</sub> /kg)	pH KCl	Titrateable Actual Acidity (mole H <sup>+</sup> /tonne)	Chromium Reducible Sulfur (%S <sub>CR</sub> )	Retained Acidity (mole H <sup>+</sup> /tonne)	Acid Neutralising Capacity (%CaCO <sub>3</sub> )	Net Acidity (mole H <sup>+</sup> /tonne)	Acid Sulfate Soil Material Classification
5.W1	30-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
5.1	0-5	Medium	725	7.81	6.27	8.18	7.91	210	8.82	0.00	0.09	..	17.30	-2248	hyposulfidic (S <sub>CR</sub> <0.10%)
5.2	5-10	Fine	595	8.38	7.06	7.72	7.94	98	9.16	0.00	0.14	..	23.41	-3031	hyposulfidic (S <sub>CR</sub> ≥0.10%)
5.3	10-20	Fine	672	8.27	7.45	7.41	7.95	110	9.19	0.00	0.12	..	24.33	-3166	hyposulfidic (S <sub>CR</sub> ≥0.10%)
6.W1	100-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
6.1	0-5	Fine	425	7.37	4.31	6.82	7.51	69	8.65	0.00	0.15	..	0.99	-38	hyposulfidic (S <sub>CR</sub> ≥0.10%)
6.2	5-10	Fine	401	7.57	4.71	7.27	7.62	57	8.97	0.00	0.10	..	0.68	-28	hyposulfidic (S <sub>CR</sub> ≥0.10%)
6.3	10-20	Medium	336	7.64	4.19	7.27	7.78	53	9.00	0.00	0.09	..	0.76	-45	hyposulfidic (S <sub>CR</sub> <0.10%)
7.W1	30-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
7.1	0-5	Medium	217	6.39	1.68	6.96	3.57	130	6.80	0.00	0.18	..	0.24	80	hypersulfidic
7.2	5-10	Fine	175	6.42	2.92	6.46	5.52	28	5.66	8.90	0.11	..	0.04	72	hyposulfidic (S <sub>CR</sub> ≥0.10%)
7.3	10-20	Fine	285	7.10	7.35	6.59	6.22	19	7.94	0.00	0.02	..	1.65	-207	hyposulfidic (S <sub>CR</sub> <0.10%)
7.4	20-40	Fine	199	8.19	8.06	6.84	7.59	24	8.09	0.00	0.02	..	1.66	-209	hyposulfidic (S <sub>CR</sub> <0.10%)
7.5	40-70	Fine	147	8.76	8.47	7.89	7.99	26	8.08	0.00	0.03	..	0.87	-97	hyposulfidic (S <sub>CR</sub> <0.10%)
8.W1	50-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
8.1	0-5	Medium	175	7.66	2.25	6.66	4.35	160	6.82	0.00	0.04	..	0.66	-63	hyposulfidic (S <sub>CR</sub> <0.10%)
8.2	5-10	Fine	184	6.59	2.12	6.34	3.92	57	5.83	8.83	0.11	..	..	77	hypersulfidic
8.3	10-20	Fine	160	6.74	1.82	6.43	5.36	73	5.76	8.83	0.18	..	..	121	hyposulfidic (S <sub>CR</sub> ≥0.10%)
8.4	20-40	Fine	181	7.72	7.38	6.84	6.86	43	6.47	1.47	0.05	..	0.00	33	hyposulfidic (S <sub>CR</sub> <0.10%)
8.5	40-65	Fine	210	8.81	8.86	7.22	..	18	6.76	0.00	0.04	..	0.57	-51	hyposulfidic (S <sub>CR</sub> <0.10%)
9.W1	80-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
9.1	0-1	Fine	135	6.70	1.91	6.84	4.27	61	5.75	9.32	0.23	..	..	153	hyposulfidic (S <sub>CR</sub> ≥0.10%)
9.2	1-10	Fine	127	7.70	2.58	7.14	5.30	61	6.41	1.96	0.09	..	0.00	58	hyposulfidic (S <sub>CR</sub> <0.10%)
9.3	10-20	Fine	154	7.02	2.03	6.57	4.95	51	6.22	3.43	0.16	..	0.00	103	hyposulfidic (S <sub>CR</sub> ≥0.10%)
9.4	20-40	Fine	150	8.76	7.10	7.48	8.02	18	6.75	0.00	0.04	..	0.25	-8	hyposulfidic (S <sub>CR</sub> <0.10%)
9.NS	40-50	..	..	..	..	..	..	..	..	..	..	..	..	..	not sampled
10.W1	20-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
10.1	0-5	Medium	183	6.87	2.73	6.80	6.78	960	5.99	16.19	0.30	..	..	203	hyposulfidic (S <sub>CR</sub> ≥0.10%)
10.2	5-10	Fine	166	8.21	7.48	7.21	7.72	100	7.78	0.00	0.07	..	2.15	-243	hyposulfidic (S <sub>CR</sub> <0.10%)
10.3	10-20	Fine	196	8.08	7.46	7.30	7.91	87	8.45	0.00	0.05	..	2.85	-348	hyposulfidic (S <sub>CR</sub> <0.10%)
10.4	20-40	Fine	162	8.57	8.42	7.20	7.99	17	8.70	0.00	0.01	..	4.00	-527	hyposulfidic (S <sub>CR</sub> <0.10%)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC ( $\mu\text{S}/\text{cm}$ )	pH water	pH peroxide	pH incubation week 0	pH incubation week 8	Sulfate ( $\text{mg SO}_4/\text{kg}$ )	pH KCl	Titrateable Actual Acidity ( $\text{mole H}^+/\text{tonne}$ )	Chromium Reducible Sulfur ( $\%\text{S}_{\text{CR}}$ )	Retained Acidity ( $\text{mole H}^+/\text{tonne}$ )	Acid Neutralising Capacity ( $\%\text{CaCO}_3$ )	Net Acidity ( $\text{mole H}^+/\text{tonne}$ )	Acid Sulfate Soil Material Classification
11.W1	100-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
11.1	0-5	Fine	64	6.57	2.63	6.80	4.41	43	6.27	1.96	0.03	..	0.00	21	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
11.2	5-10	Fine	194	7.41	6.90	6.76	5.33	38	6.24	3.93	0.02	..	0.00	16	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
11.3	10-20	Fine	214	7.72	7.52	6.93	6.28	46	7.86	0.00	0.03	..	0.69	-73	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
16.W1	25-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
16.1	0-5	Medium	386	7.75	6.77	7.42	7.88	52	8.89	0.00	0.08	..	2.61	-298	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
16.2	5-10	Fine	432	8.19	8.85	7.05	8.19	45	8.50	0.00	0.08	..	6.26	-783	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
16.3	10-20	Fine	378	8.84	8.76	7.16	8.34	48	8.46	0.00	0.08	..	4.66	-570	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
16.4	20-40	Fine	1,240	8.12	8.46	7.04	8.40	47	8.64	0.00	0.04	..	4.72	-604	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
17.W1	40-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
17.1	0-5	Medium	649	7.29	3.63	6.91	7.49	640	7.78	0.00	0.22	..	1.12	-12	hyposulfidic ( $\text{S}_{\text{CR}} \geq 0.10\%$ )
17.2	5-10	Medium	346	7.74	2.53	6.84	7.66	31	7.45	0.00	0.09	..	0.00	56	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
17.3	10-20	Coarse	321	7.67	2.72	7.03	5.71	29	7.00	0.00	0.10	..	0.14	44	hyposulfidic ( $\text{S}_{\text{CR}} \geq 0.10\%$ )
17.4	20-40	Fine	416	9.04	9.09	7.01	8.52	16	7.92	0.00	0.03	..	1.33	-158	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
17.5	40-65	Fine	566	8.60	8.82	7.12	8.73	16	7.90	0.00	0.03	..	0.65	-68	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
18.W1	120-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
18.1	0-5	Fine	448	7.50	1.99	6.24	4.59	50	7.32	0.00	0.28	..	0.53	104	hyposulfidic ( $\text{S}_{\text{CR}} \geq 0.10\%$ )
18.2	5-10	Fine	316	7.82	1.91	6.21	4.22	160	6.95	0.00	0.51	..	0.29	279	hyposulfidic ( $\text{S}_{\text{CR}} \geq 0.10\%$ )
18.3	10-20	Fine	314	7.86	1.89	6.21	4.34	130	6.72	0.00	0.57	..	0.59	277	hyposulfidic ( $\text{S}_{\text{CR}} \geq 0.10\%$ )
18.4	20-40	Fine	327	4.65	6.33	7.26	8.64	57	6.79	0.00	0.05	..	0.18	7	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )

**Table 9-5. Summary of hydrochemical field measurements for Yarra Complex (Wetland ID. 12605).**

	pH	SEC $\mu\text{S cm}^{-1}$	DO $\text{mg l}^{-1}$	Eh mV	Turbidity NTU	Alkalinity as $\text{HCO}_3$
Surface waters (n=4)	7.60-8.19	540-2176	2.83-8.35	181-209	32-105	82-339



**Table 9-6. Hydrochemical data for Yarra Complex (Wetland ID. 12605).**

Parameter	units	ANZECC Guidelines	Site 6 (SW)	Site 9 (SW)	Site 11 (SW)	Site 18 (SW)
Na	mg l <sup>-1</sup>		386	73.4	47.7	300
K	mg l <sup>-1</sup>		11.7	3.8	3.5	10.2
Ca	mg l <sup>-1</sup>		50.4	14.9	12	43.4
Mg	mg l <sup>-1</sup>		43.9	11	7.91	33.9
Si	mg l <sup>-1</sup>		6.21	1.95	2.43	5.56
Br	mg l <sup>-1</sup>		0.9	0.2	0.1	0.7
Cl	mg l <sup>-1</sup>		560	120	78	490
NO <sub>3</sub>	mg l <sup>-1</sup>	0.7	<0.022	<0.022	0.032	<0.022
NH <sub>4</sub> -N <sup>K</sup>	mg l <sup>-1</sup>	0.01	<b>0.03</b>	<b>0.047</b>	<b>0.019</b>	<b>0.018</b>
PO <sub>4</sub> -P <sup>E</sup>	mg l <sup>-1</sup>	0.005	<b>0.018</b>	<b>0.012</b>	<b>0.018</b>	<b>0.013</b>
SO <sub>4</sub>	mg l <sup>-1</sup>		56	17	13	49
Ag	µg l <sup>-1</sup>	0.05	<0.01	<0.01	<0.01	<0.01
Al <sup>A</sup>	µg l <sup>-1</sup>	55	<b>100</b>	<b>90</b>	<b>220</b>	<b>120</b>
As <sup>B</sup>	µg l <sup>-1</sup>	13	5.6	1.4	0.8	4
Cd	µg l <sup>-1</sup>	0.2	<0.02	0.04	0.03	0.04
Co	µg l <sup>-1</sup>	2.8	0.22	0.09	0.08	0.2
Cr <sup>C</sup>	µg l <sup>-1</sup>	1	0.1	0.1	0.2	0.1
Cu <sup>H</sup>	µg l <sup>-1</sup>	1.4	0.8	0.6	1	<b>1.6</b>
Fe	µg l <sup>-1</sup>	300	<100	<100	111	<100
Mn	µg l <sup>-1</sup>	1700	5.7	27.54	4.98	7.3
Ni <sup>H</sup>	µg l <sup>-1</sup>	11	1.0	0.6	0.8	1.4
Pb <sup>H</sup>	µg l <sup>-1</sup>	3.4	<0.2	<0.1	0.1	<0.2
Se	µg l <sup>-1</sup>	11	<0.2	<0.08	<0.08	<0.2
Zn <sup>H</sup>	µg l <sup>-1</sup>	8	<b>54.8</b>	<b>85.8</b>	<b>96</b>	<b>120.4</b>
DOC	mg l <sup>-1</sup>		23.9	7.1	5.4	21.7

**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<sub>4</sub> and PO<sub>4</sub>, 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.

- <sup>A</sup> Trigger value for Aluminium in freshwater where pH > 6.5.
- <sup>B</sup> Trigger value assumes As in solution as Arsenic (AsV).
- <sup>C</sup> Trigger value for Chromium is applicable to Chromium (CrVI) only.
- <sup>E</sup> Guideline is for filterable reactive phosphorous (FRP).
- <sup>H</sup> Hardness affected (refer to Guidelines).
- <sup>K</sup> Guideline for South-east Australia-Freshwater Lakes and reservoirs.

## 10. YARRA COMPLEX (WETLAND ID. 12606)

### 10.1. Location and setting description

Yarra Complex (Wetland ID. 12606) is situated on the northern side of the River Murray, about 15 kilometres up river from the town of Waikerie, located in the Yarra Complex area. The wetland is weakly triangular in shape forming part of a wetland complex that occurs on the inside of a bend in the river. It is about 900 metres in length and about 200 metres at its widest, with a total surface area of 12 hectares. The wetland is bounded by a raised floodplain that separates the wetland from the river to the south and wetlands to the northwest. The other associated wetlands in the Yarra Complex are Wetland IDs. 12605 and 12608.

The wetland is permanently disconnected from the river, and generally permanently dry. At the time when the soil survey was conducted in March 2010 the wetland had no surface water and had sparse vegetation on it. The wetland is not managed. Sedgeland and grassland was growing along the wetland margins and samphire in the wetland area, with open woodland and shrubland on the surrounding higher floodplain. Four sites were sampled as shown in Figure 10-1.

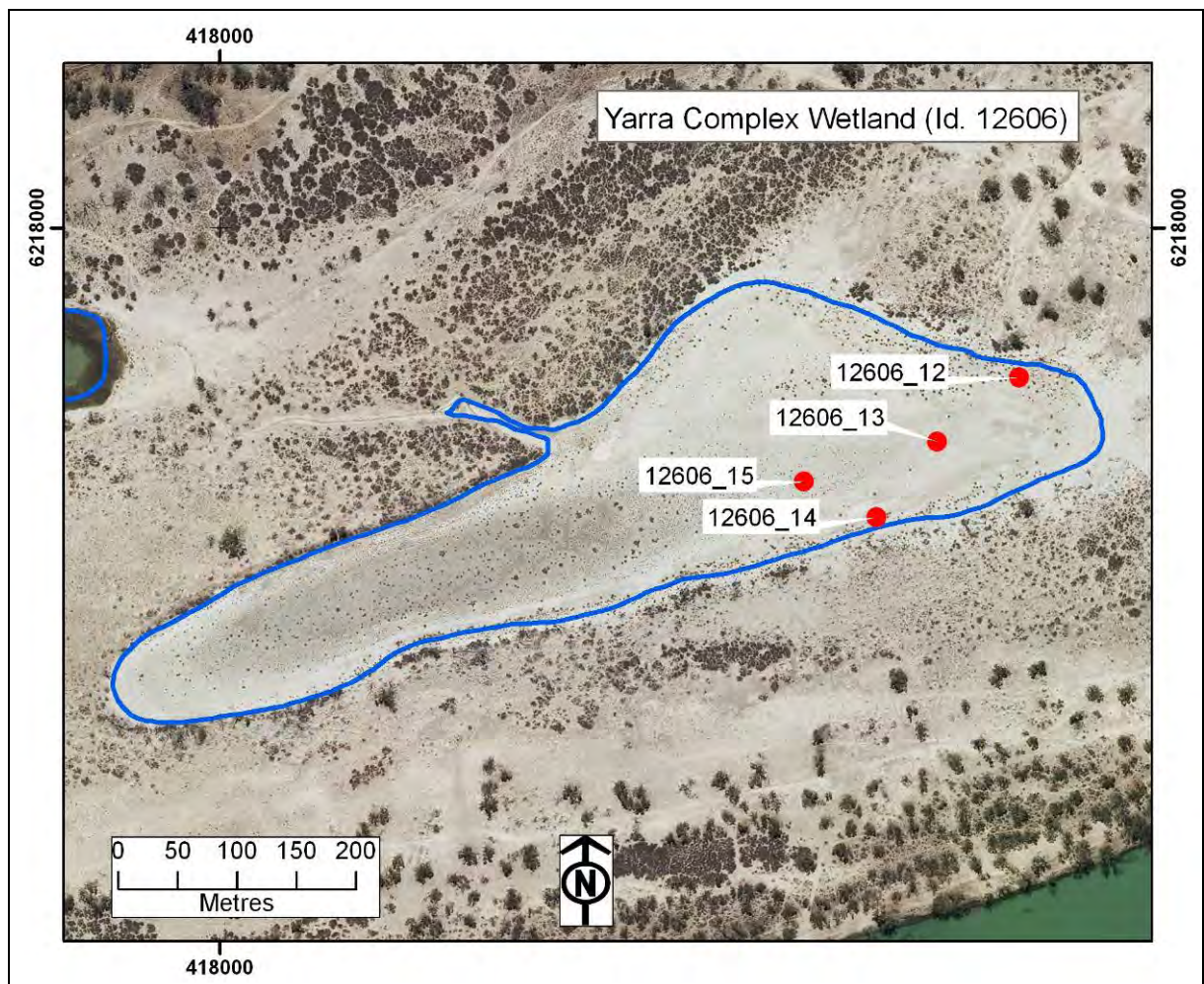


Figure 10-1. Yarra Complex (Wetland ID. 12606) and sample site locations.

## 10.2. Soil profile description and distribution

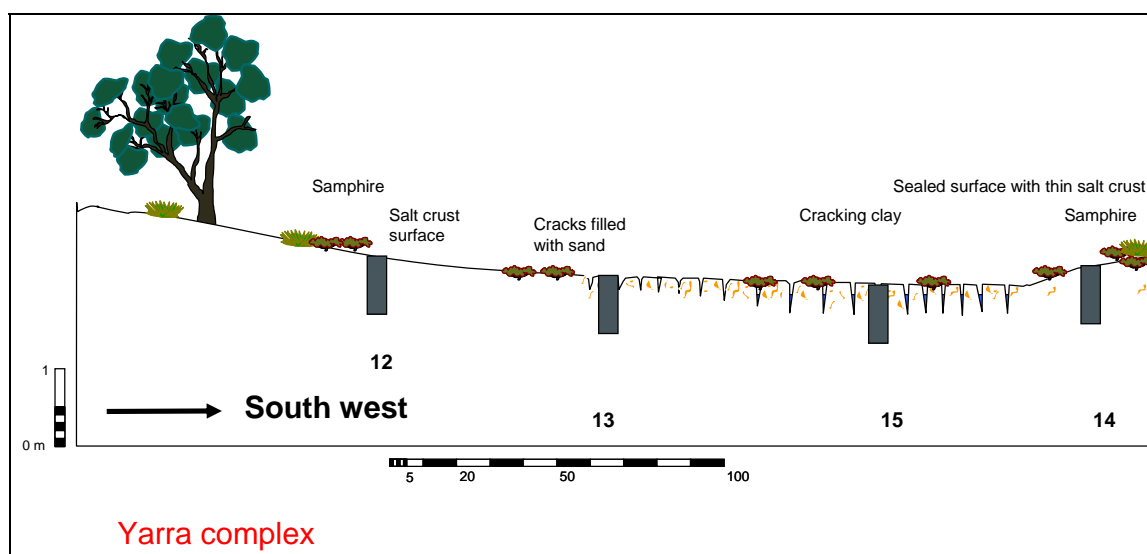
Four sites were described and sampled. The soil subtypes and general location descriptions are presented in Table 10-1. Sites were distributed along one transect where sites were placed from the margin into the centre and located as the soil surface and vegetation changed across the wetland. The site and soil profile descriptions are presented in Table 10-2 and Table 10-3, and a conceptual cross-section in Figure 10-2.

### Transect

Site 12 (Figure 10-3) occurred on the wetland margin where samphire was growing, and the soil consisted of a greyish brown, very weak, granular structured clay loam, over a light brownish grey, firm, angular blocky structured, clay. Site 13 (Figure 10-4) occurred where the surface was cracking, and the soil consisted of a greyish brown, weak, blocky structure, clay loam, over a greyish brown, firm, clay. Site 14 (Figure 10-5) occurred where the soil surface was sealed, and the soil consisted of an olive grey, weak, angular block structured, clay loam, over an olive grey, very firm, clay. Site 15 (Figure 10-6) occurred where the surface was cracking, and the soil consisted of a grey, firm, angular blocky structured, clay, over an olive grey, very firm, blocky structured, clay.

**Table 10-1. Soil identification, subtype and general location description for Yarra Complex (Wetland ID. 12606).**

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12606_12	418673	6217874	Other Soil (clayey)	high elevation margins, samphire growing
12606_13	418604	6217820	Cracking Clay Soil	low elevation, mid wetland, cracking surface and samphire growing
12606_14	418553	6217756	Other Soil (clayey)	mid elevation on margins, sealed surface and samphire growing
12606_15	418492	6217786	Cracking Clay Soil	low elevation, mid wetland, cracking surface and samphire growing



**Figure 10-2. Conceptual cross-section diagram, showing locations of Sites 12 to 15.**



**Figure 10-3. Photographs of Site 12, showing the site location on the edge of the wetland, the sealed soil surface and the soil profile.**



**Figure 10-4. Photographs of Site 13, showing the site location in an open area with cracking clay surface, and the soil profile.**



Figure 10-5. Photograph of Site 14, showing the site location on the wetland margin with the soil surface sealed and a thin salt crust.

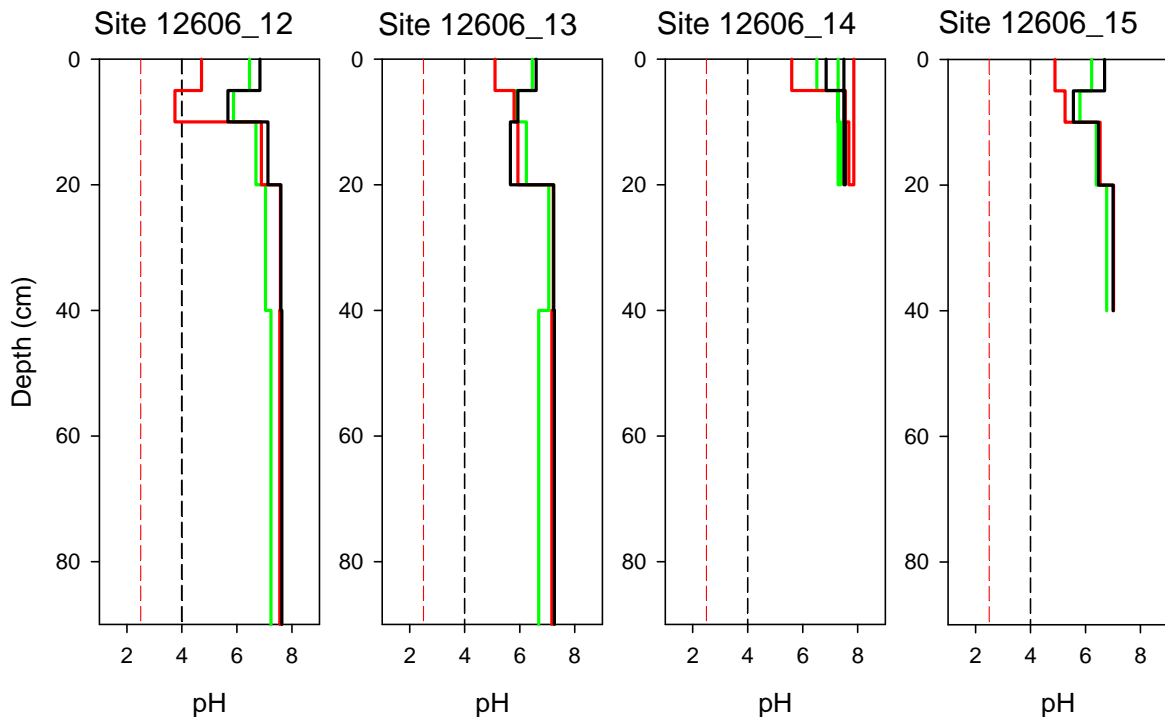


Figure 10-6. Photographs of Site 15, showing the site location, cracking clay surface and soil profile.

### 10.3. Laboratory data assessment

#### 10.3.1. Soil pH testing ( $\text{pH}_W$ , $\text{pH}_{OX}$ , $\text{pH}_{INC}$ )

The pH data are provided in Table 10-4 and pH profiles are presented in Figure 10-7. The  $\text{pH}_W$  data ranged from 5.80 to 7.38 and sulfuric materials with a  $\text{pH}_W < 4$  were not identified. The  $\text{pH}_{OX}$  data ranged from 3.75 to 7.86 and identified that there were no samples below the critical value of  $\text{pH}_{OX} < 2.5$ . The  $\text{pH}_{INC}$  data ranged from 5.56 to 7.63 and identified that no samples on incubation declined below the critical values of  $\text{pH} < 4$ .



**Figure 10-7. Depth profiles of soil pH for Yarra Complex (Wetland ID. 12606), 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 0.00 to 0.04 % $S_{CR}$  and sulfidic materials were detected in all layers except the subsurface layer of Profile 15.

#### Titratable actual acidity

Titratable actual acidity values ranged from 0 to 5.76 mole  $H^+$ /tonne and were detected in some of the samples.

#### Retained acidity

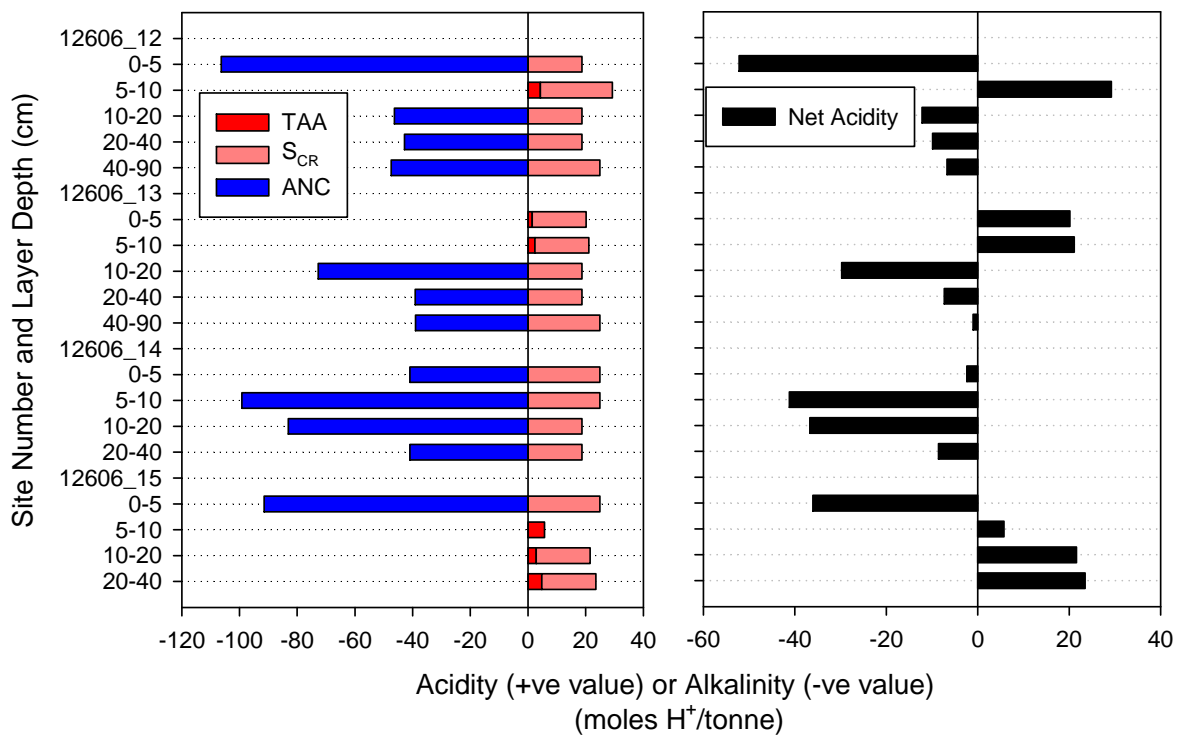
Retained acidity was not measured in any of the layers as all samples had a  $pH_{KCl}$  of greater than 4.5.

#### Acid neutralising capacity

Acid neutralising capacity values ranged from 0 to 0.53 % $CaCO_3$  and were measured in nearly all samples.

#### Net acidity

Net acidity values ranged from -52 to 29 mole  $H^+$ /tonne. Generally samples were negative values with low or moderate values identified for subsurface layers in Profiles 12, 13 and 15.



**Figure 10-8. Acid base accounting depth profiles for Yarra Complex (Wetland ID. 12606). Left side shows the components: Titratable actual acidity (TAA - red bar), acid generating potential (AGP as S<sub>CR</sub> - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.**

### 10.3.3. Water soluble sulfate

Water soluble sulfate data values shown in Table 10-4 identified that surface layers for all profiles were above the criterion trigger value of 100 mg/kg SO<sub>4</sub>.

### 10.3.4. Acid volatile sulfur

Monosulfidic materials were not observed for sampling within this wetland.

### 10.3.5. Hydrochemistry

Water samples were not collected from this wetland as the surface was dry and water was not observed in the soil pits.

## 10.4. Discussion

Acid sulfate soil materials at Yarra Complex (Wetland ID. 12606) were identified as hyposulfidic. The acid sulfate soil subtype classes identified were Cracking Clay Soil and Other Soil (clayey).

The surface layers were loamy near the margins and clayey throughout the main part of the wetland and the subsoils were dominantly clayey.

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

The potential hazards posed by acid sulfate soil materials at Yarra Complex (Wetland ID. 12606) are:

- Acidification hazard: The data identified negative net acidity values for most samples and in some samples there were low or moderate 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 of soils, monosulfidic material was not observed. There is a medium level of concern.
- Metal mobilisation: The low acidification hazard indicates that soil acidification potential is not likely to increase the solubility of metals. There is a low level of concern.

### Summary of key findings Yarra Complex (Wetland ID. 12606):

<b>Soil materials:</b>	The soil layers throughout the wetland were hyposulfidic. The soils were loamy or clayey at the surface and in the subsoils clayey textured. Most samples had negative net acidity values and pH data did not indicate a potential for acidification due to oxidation.
<b>Acid sulfate soil identification:</b>	<ul style="list-style-type: none"> <li>• Other Soil (clayey) – occurring on the margins of the wetland. Minor (&lt;25%) in extent.</li> <li>• Cracking Clay Soil – occurring throughout the lower parts of the wetland. Dominant (&gt;50%) in extent.</li> </ul>
<b>Hazard assessment</b>	<ul style="list-style-type: none"> <li>• Acidification hazard – low to medium level of concern</li> <li>• De-oxygenation hazard – medium level of concern</li> <li>• Metal mobilisation hazard – low level of concern</li> </ul>



**Table 10-2. Site description data for Yarra Complex (Wetland ID. 12606).**

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
12	31/03/2010	418673	6217874	not reached	soft, fluffy	samphire	high elevation margins, samphire growing
13	31/03/2010	418604	6217820	not reached	cracking	isolated samphire	low elevation, mid wetland, cracking surface and samphire growing
14	31/03/2010	418553	6217756	not reached	sealed	samphire	mid elevation on margins, sealed surface and samphire growing
15	31/03/2010	418492	6217786	not reached	cracking	samphire, isolated	low elevation, mid wetland, cracking surface and samphire growing

**Table 10-3. Soil profile description data for Yarra Complex (Wetland ID. 12606).**

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	greyish brown (10YR5/2)	clay loam	dry		granular	very weak	
12_2	5 - 10	small pit	greyish brown (10YR5/2)	clay	moist	15% yellowish brown In the matrix	angular blocky	firm	contains carbonate fragments
12_3	10 - 20	small pit	greyish brown (10YR5/2)	clay	moist	10% yellowish brown In the matrix	angular blocky	firm	
12_4	20 - 40	small pit	light brownish grey (10YR6/2)	clay	moist		angular blocky	firm	
12_5	40 - 90	push tube	light brownish grey (10YR6/2)	clay	moist		angular blocky	firm	
13_1	0 - 5	small pit	greyish brown (2.5Y5/2)	clay loam	dry		subangular blocky	weak	
13_2	5 - 10	small pit	greyish brown (2.5Y5/2)	clay	moist	5% olive In the matrix	angular blocky	firm	
13_3	10 - 20	small pit	greyish brown (2.5Y5/2)	clay	moist	10% olive In the matrix	angular blocky	firm	
13_4	20 - 40	small pit	greyish brown (2.5Y5/2)	clay	moist	10% olive In the matrix	angular blocky	firm	
13_5	40 - 90	push tube	greyish brown (2.5Y5/2)	clay	moist	2% olive In the matrix	massive	firm	
14_1	0 - 5	small pit	olive grey (5Y4/2)	clay loam	dry		angular blocky	weak	
14_2	5 - 10	small pit	olive grey (5Y4/2)	clay	moist	5% olive brown In the matrix	subangular blocky	firm	10% carbonate segregations
14_3	10 - 20	small pit	olive grey (5Y4/2)	clay	moist	10% olive brown In the matrix	subangular blocky	firm	10% carbonate segregations
14_4	20 - 40	small pit	olive grey (5Y4/2)	clay	moist	5% olive brown In the matrix	subangular blocky	very firm	10% carbonate segregations
15_1	0 - 5	small pit	grey (5Y5/1)	clay	dry		angular blocky	firm	few white salts on ped faces
15_2	5 - 10	small pit	olive grey (5Y4/2)	clay	moist	10% dark brown infused into the matrix along faces of peds	angular blocky	firm	
15_3	10 - 20	small pit	olive grey (5Y4/2)	clay	moist	20% yellowish brown infused into the matrix along faces of peds	angular blocky	firm	
15_4	20 - 40	small pit	olive grey (5Y4/2)	clay	moist	10% reddish brown infused into the matrix along faces of peds	angular blocky	very firm	

**Table 10-4. Laboratory data for acid sulfate soil assessment of Yarra Complex (Wetland ID. 12606).**

(red printed values indicates data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC ( $\mu\text{S}/\text{cm}$ )	pH water	pH peroxide	pH incubation week 0	pH incubation week 8	Sulfate (mg $\text{SO}_4/\text{kg}$ )	pH KCl	Titrateable Actual Acidity (mole $\text{H}^+/\text{tonne}$ )	Chromium Reducible Sulfur ( $\%\text{S}_{\text{CR}}$ )	Retained Acidity (mole $\text{H}^+/\text{tonne}$ )	Acid Neutralising Capacity ( $\%\text{CaCO}_3$ )	Net Acidity (mole $\text{H}^+/\text{tonne}$ )	Acid Sulfate Soil Material Classification
12.1	0-5	Medium	19,930	6.46	4.71	6.04	6.84	3,500	7.16	0.00	0.03	..	0.53	-52	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
12.2	5-10	Medium	8,380	5.88	3.75	5.24	5.67	620	6.30	4.32	0.04	..	0.00	29	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
12.3	10-20	Fine	7,600	6.69	6.89	6.77	7.13	210	6.53	0.00	0.03	..	0.23	-12	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
12.4	20-40	Fine	5,380	7.04	7.58	7.26	7.60	190	6.54	0.00	0.03	..	0.21	-10	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
12.5	40-90	Fine	5,420	7.24	7.56	7.11	7.63	290	6.61	0.00	0.04	..	0.24	-7	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
13.1	0-5	Medium	14,160	6.46	5.10	6.34	6.60	1,100	6.43	1.44	0.03	..	0.00	20	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
13.2	5-10	Fine	12,460	5.84	5.79	5.76	5.93	1,100	6.42	2.40	0.03	..	0.00	21	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
13.3	10-20	Fine	8,300	6.24	5.93	5.35	5.66	170	7.49	0.00	0.03	..	0.36	-30	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
13.4	20-40	Fine	6,910	7.06	7.22	6.89	7.24	180	7.08	0.00	0.03	..	0.20	-7	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
13.5	40-90	Fine	6,450	6.69	7.17	6.85	7.26	330	6.64	0.00	0.04	..	0.19	-1	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
14.1	0-5	Fine	20,570	6.51	5.60	6.41	6.85	3,000	7.33	0.00	0.04	..	0.20	-2	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
14.2	5-10	Fine	11,100	7.28	7.55	7.10	7.52	240	7.45	0.00	0.04	..	0.50	-41	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
14.3	10-20	Fine	10,240	7.38	7.68	7.23	7.55	220	7.15	0.00	0.03	..	0.42	-37	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
14.4	20-40	Fine	5,920	7.29	7.86	7.13	7.50	190	6.91	0.00	0.03	..	0.20	-9	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
15.1	0-5	Fine	16,450	6.22	4.89	6.41	6.69	1,000	6.75	0.00	0.04	..	0.46	-36	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
15.2	5-10	Fine	8,810	5.80	5.26	5.39	5.56	300	6.18	5.76	<0.01	..	0.00	6	other acidic
15.3	10-20	Fine	5,820	6.39	6.53	6.13	6.47	150	6.36	2.88	0.03	..	0.00	22	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
15.4	20-40	Fine	5,280	6.77	7.02	6.55	7.00	140	6.30	4.80	0.03	..	0.00	24	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )

## 11. YARRA COMPLEX WETLAND (ID. 12608)

### 11.1. Location and setting description

Yarra Complex Wetland (ID. 12608) is situated on the northern side of the River Murray, about 14 kilometres up river from the town of Waikerie, located in the Yarra Complex area. The wetland is somewhat linear in shape forming part of a wetland complex that occurs on the inside of a bend in the river. It is about 2 kilometres in length and about 100 metres at its widest, with a total surface area of 18 hectares. The wetland is bounded by a raised floodplain that separates the wetland from the river to the south and steep hill slopes to the north. The other associated wetlands in the Yarra Complex are wetland IDs. 12605 and 12606.

The wetland is not connected to the river. At the time when the soil survey was conducted in March 2010 the wetland had surface water along the lowest depression part of the wetland. 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 11-1.

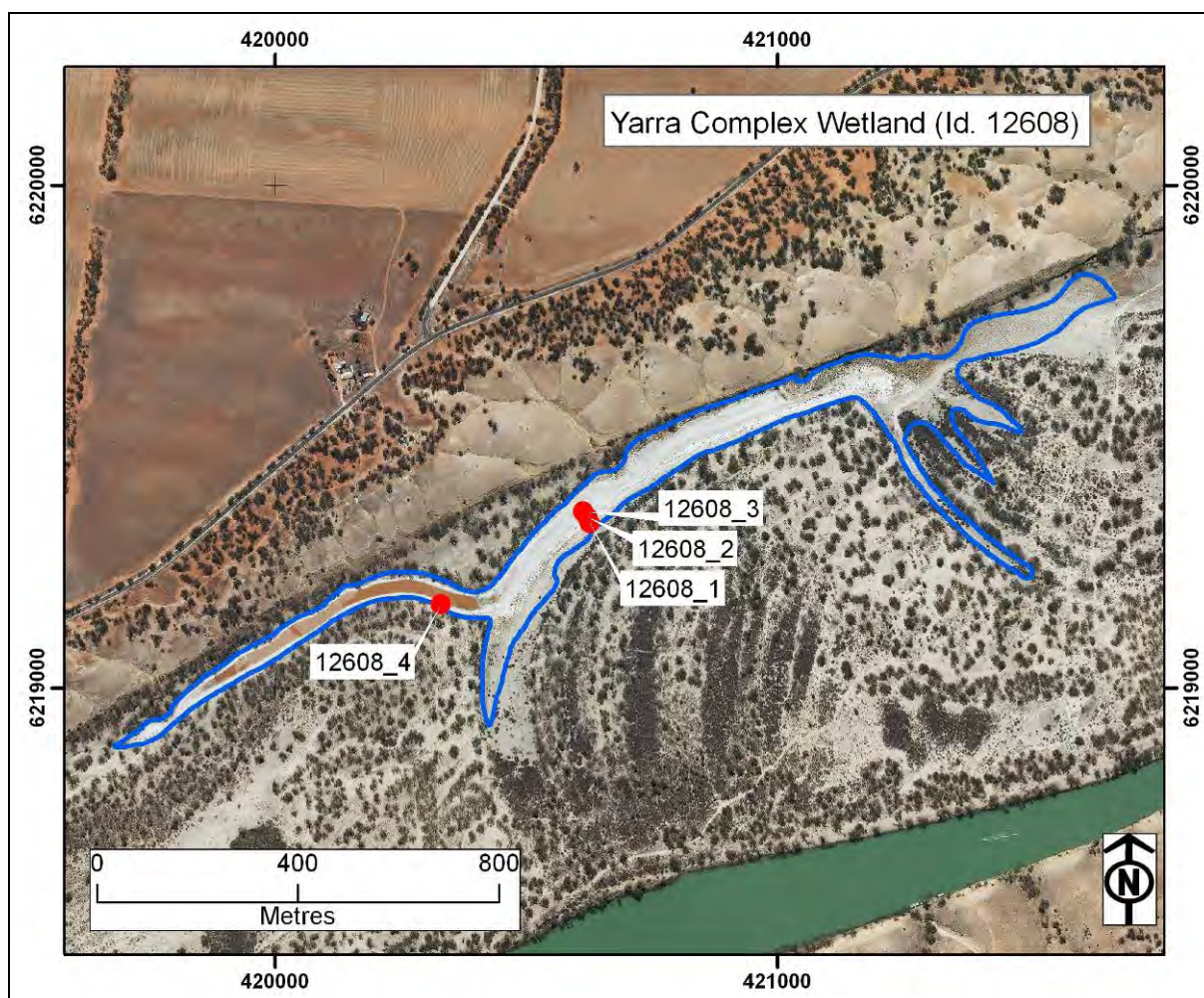


Figure 11-1. Yarra Complex Wetland (ID. 12608) and sample site locations.

## 11.2. Soil profile description and distribution

Four sites were described and sampled. The soil subtypes and general location descriptions are presented in Table 11-1. Sites were distributed along one transect near the centre of the wetland (Sites 1, 2 and 3), and one site in the deeper surface water area. The site and soil profile descriptions are presented in Table 11-2 and Table 11-3, and a conceptual cross-section in Figure 11-2.

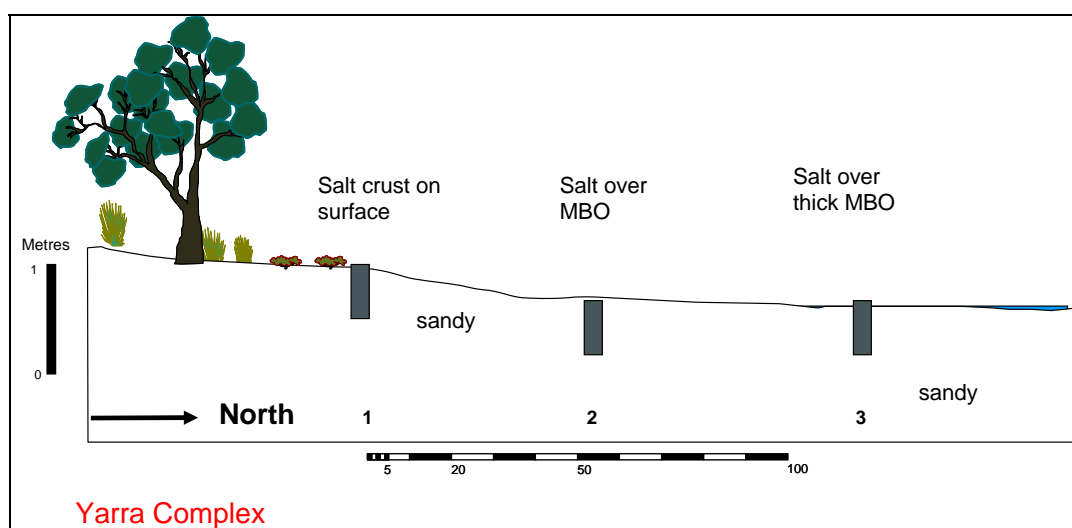
### Centre transect

Site 1 (Figure 11-3) occurred on the wetland margin, and the soil consisted of a white surface salt crust over greyish brown, firm, sandy clay loam, over a grey, very firm, sandy loam. Site 2 (Figure 11-4) occurred where there was a salt crust over very weak monosulfidic material, with the water table in the pit at about 35 cm depth, and the soil consisted of black, very weak, monosulfidic material, over dark grey, very weak to firm, sandy clay loam. Site 3 (Figure 11-5) occurred near the centre of the wetland at a low elevation, with the water table in the pit at about 3 cm depth, and the soil consisted of a pale brown salt crust, over black, very weak, monosulfidic material, over grey, very firm, clay loam.

Site 4 (Figure 11-6) occurred in water (20 cm deep), and the soil consisted of a black, very weak monosulfidic material, over an olive grey, very weak, clay with a strong sulfurous odour.

**Table 11-1. Soil identification, subtype and general location description for Yarra Complex Wetland (ID. 12608).**

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12608_1	420627	6219328	Other Soil (loamy)	high elevation and on margins, where there is a salt crust and samphire
12608_2	420622	6219339	Hypersulfidic Soil (loamy) with monosulfidic material	mid elevation, where there is a salt crust and no vegetation
12608_3	420614	6219350	Other Soil (loamy) with monosulfidic material	low elevation, centre of wetland, and salt crust
12608_4	420330	6219166	Subaqueous Soil (clayey) with monosulfidic material	mid/low elevation, surface water



**Figure 11-2. Conceptual cross-section diagram, showing locations of Sites 1, 2 and 3.**



**Figure 11-3. Photographs of Site 1, showing the site location on the wetland margin looking towards the wetland centre, and the soil profile with a salt crust on the surface.**



**Figure 11-4. Photographs of Site 2, showing the site location and soil profile in an area that is very weak with a salt crust over black monosulfidic material.**



**Figure 11-5. Photograph of Site 3, showing the site location near the centre of the wetland where there was a salt crust over black monosulfidic material and water in the soil pit.**

**Figure 11-6. Photograph of Site 4, showing the site location placed in deep water (marked by the shovel handle in the water next to the log) where the monosulfidic material is thick.**

## 11.3. Laboratory data assessment

### 11.3.1. Soil pH testing ( $pH_W$ , $pH_{OX}$ , $pH_{INC}$ )

The pH data are provided in Table 11-4 and pH profiles are presented in Figure 11-7. The  $pH_W$  data ranged from 7.42 to 8.91 and sulfuric materials with a  $pH_W < 4$  were not identified. The  $pH_{OX}$  data ranged from 2.16 to 6.87 and identified that samples in the deepest layers of Profiles 1 and 2 were below the critical value of  $pH_{OX} < 2.5$ , the threshold value normally used to indicate a high likelihood of sulfuric metameral forming. The  $pH_{INC}$  data ranged from 3.69 to 8.15 and identified one sample in Profile 2 on incubation declined below the critical values of  $pH < 4$  indicating that the sample would be sulfuric if oxidised.

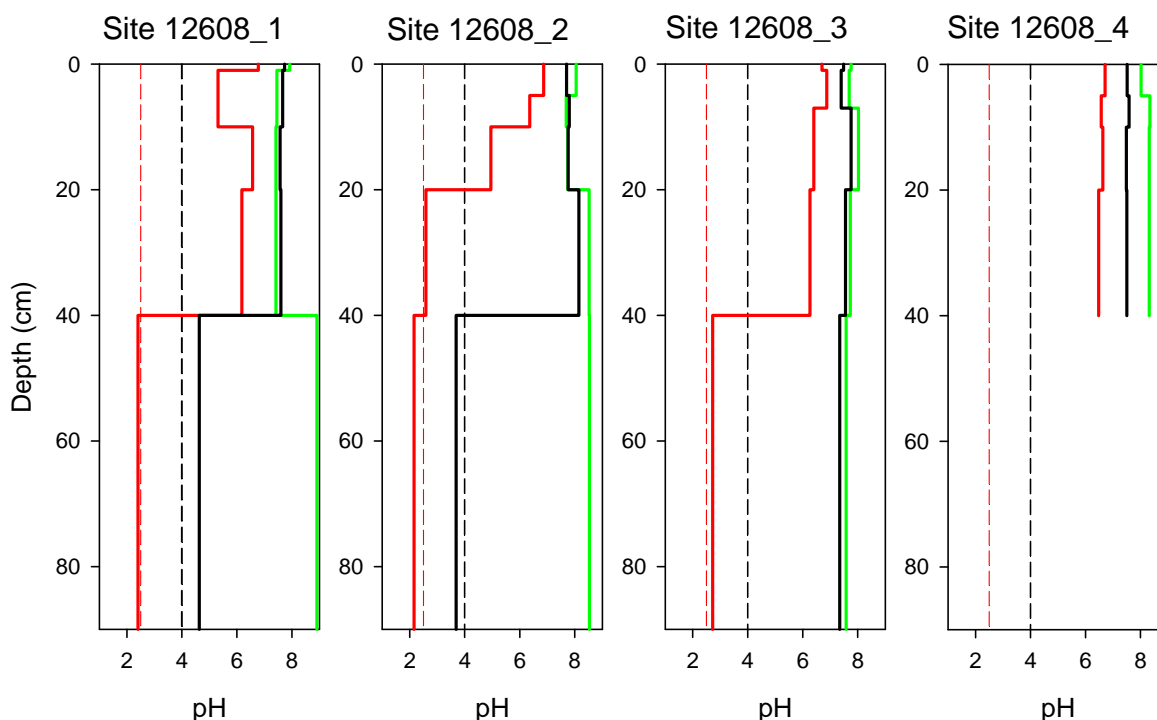


Figure 11-7. Depth profiles of soil pH for Yarra Complex Wetland (ID. 12608), showing soil pH ( $pH_W$  as green line), peroxide treated pH ( $pH_{OX}$  as red line) and incubation pH ( $pH_{INC}$  after 8 weeks as black line). Critical  $pH_W$  and  $pH_{INC}$  value of 4 (black dashed line) and critical  $pH_{OX}$  value of 2.5 (red dashed line).

### 11.3.2. Acid base accounting

The acid base accounting data is provided in Table 11-4 and summarised in Figure 11-8.

#### Chromium reducible sulfur

Chromium reducible sulfur values ranged from 0.0 to 0.57 % $S_{CR}$  and sulfidic materials were detected in all soil profiles.

#### Titrateable actual acidity

Titrateable actual acidity was not detected in any of the 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 0.08 to 13.96 % $CaCO_3$  and were measured in all samples.

## Net acidity

Net acidity values ranged from -1660 to 271 mole H<sup>+</sup>/tonne. Profiles tended to have negative values for most layers except for the deepest subsoil layers of Profiles 2 and 3 where the values were moderate or high and the deepest subsoil layers of Profiles 1 and 4 where the values were low.

### 11.3.3. Water soluble sulfate

Water soluble sulfate data values shown in Table 11-4 identified that surface layers for all Profiles were above the criterion trigger value of 100 mg/kg SO<sub>4</sub>.

### 11.3.4. Acid volatile sulfur

Monosulfidic materials were observed in the upper layers of Profiles 1, 2 and 3 and sampled for analysis. The values shown in Table 11-4 were all above S<sub>AV</sub> ≥ 0.01% S, the criteria value for identifying monosulfidic material.

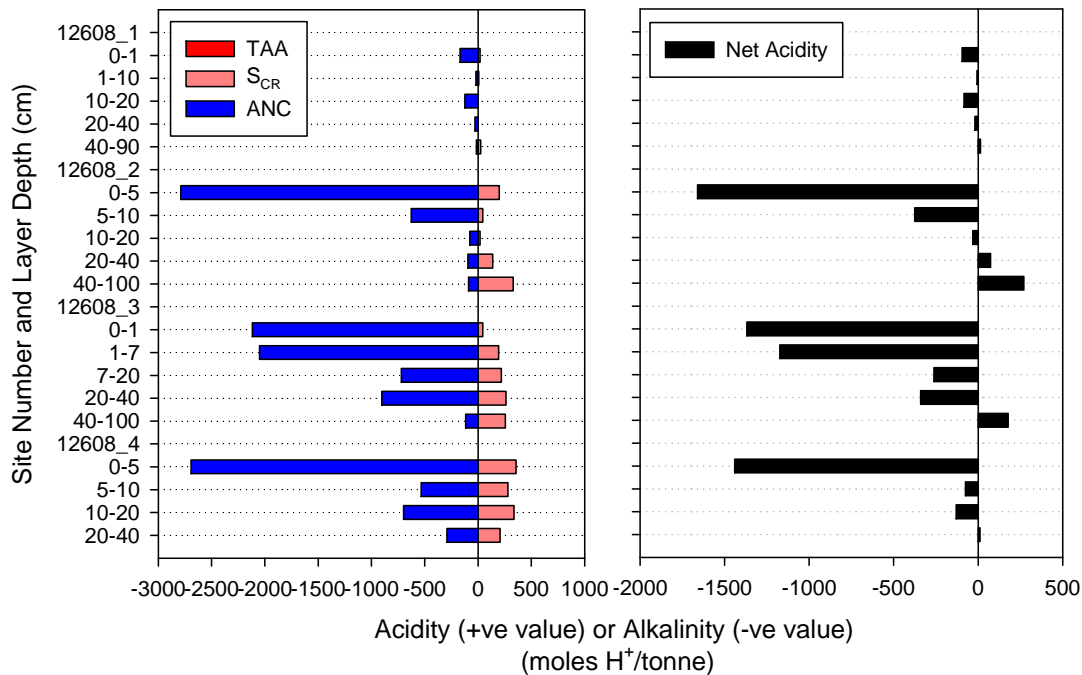


Figure 11-8. Acid base accounting depth profiles for Yarra Complex Wetland (ID. 12608). Left side shows the components: Titratable actual acidity (TAA - red bar), acid generating potential (AGP as S<sub>CR</sub> - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.



### 11.3.5. Hydrochemistry

One surface water sample and one pit water sample were collected from this wetland. Field parameters are shown in Table 11-5. The surface water had a slightly alkaline pH and was hypersaline. Dissolved oxygen was low and alkalinity moderately high. The pit water was slightly acidic, but with very high alkalinity.

The surface water and pit water were both of Na-Cl type (Table 11-6, ). Sulfate concentration in the surface water and pit water were both very high, 18000 and 10000 mg l<sup>-1</sup> respectively. The SO<sub>4</sub>/Cl ratios were 0.111 and 0.113 in the surface water and pit water respectively, slightly lower than seawater (0.142). For the nutrients, NH<sub>4</sub> was high in both samples, with PO<sub>4</sub> particularly high in the pit water, with both above ANZECC Guideline values. Of the metals, Zn and Mn were elevated significantly above ANZECC Guideline values. Of note also is the high As in the pit water. For some elements the detection limits were very high due to the required dilution prior to analysis. Organic C concentrations were very high in all samples.

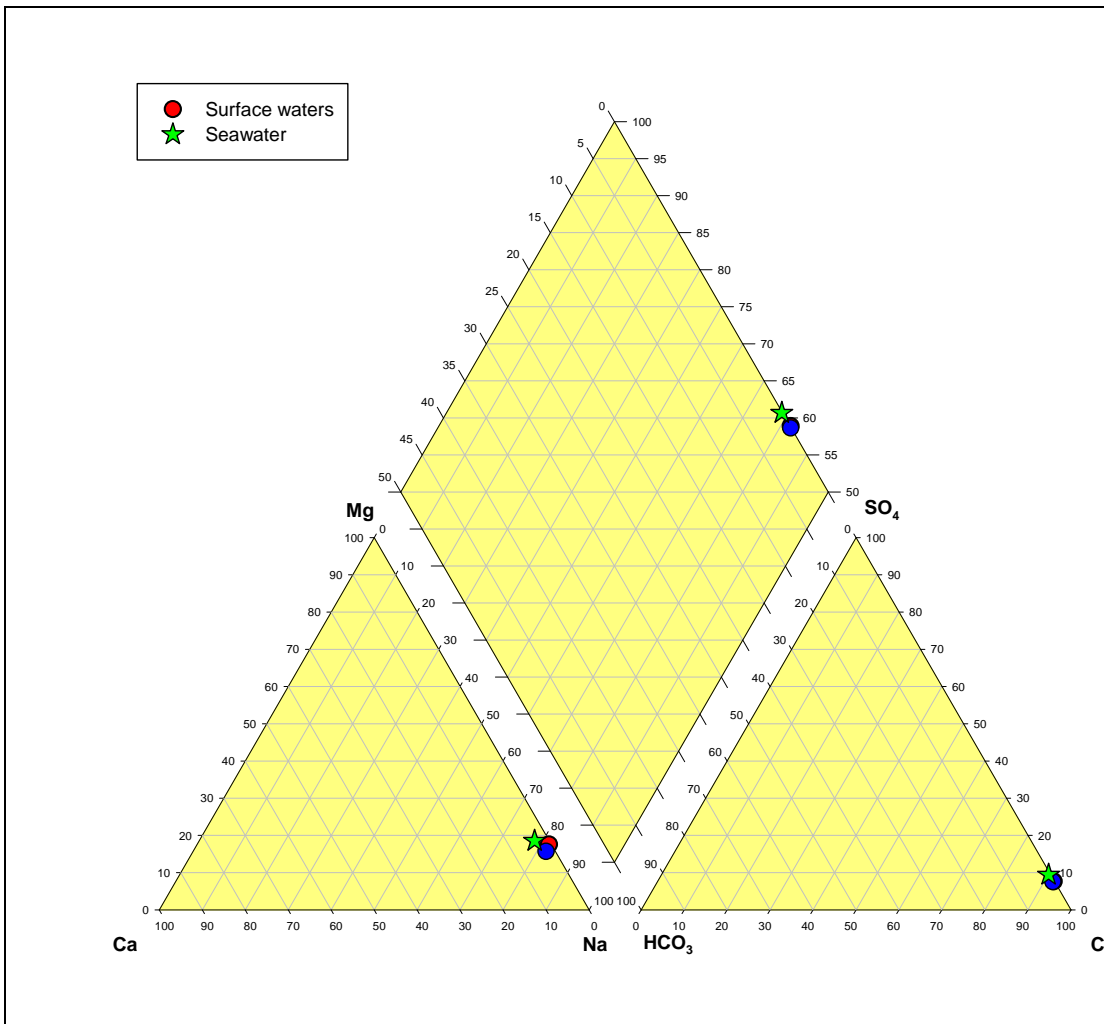


Figure 11-9. Piper diagram of hydrochemical data for Yarra Complex Wetland (ID. 12608).

## 11.4. Discussion

Acid sulfate soil materials at Yarra Complex Wetland (ID. 12608) were identified as hypersulfidic occurring in the subsoil layer of Site 2 and hyposulfidic occurring in most of the samples. The acid sulfate soil subtype classes identified were Hypersulfidic Soil (loamy) with monosulfidic material, Subaqueous Soil (clayey) with monosulfidic material, Other Soil (loamy) with monosulfidic material and Other Soil (loamy).

The soils throughout the wetland were dominantly clayey and in the mid to low elevation areas near the wetland centre the soil surface either had a salt crust or surface water over a very weak monosulfidic material.

Monosulfidic material was observed in the surface layers of Sites 2, 3, and 4 and water soluble sulfate data identified that surface layers for 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 Yarra Complex Wetland (ID. 12608) are:

- Acidification hazard: The data identified negative net acidity values throughout the profiles except for the deepest subsoil layers that were moderate or high values and pH data indicated for the same deep subsoil samples with values that indicated 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, and monosulfidic material was observed. There is a high level of concern.
- Metal mobilisation: The medium acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

### Summary of key findings Yarra Complex Wetland (ID. 12608):

<b>Soil materials:</b>	The soil layers throughout the wetland were generally hyposulfidic and in the surface soil layers where water accumulated they were monosulfidic. Soils were generally clayey textured and often very weak in the upper soil layers. Profiles generally had a negative net acidity values and in the deepest layers they were positive values, pH data indicated a potential for acidification in the subsoil layers.
<b>Acid sulfate soil identification:</b>	<ul style="list-style-type: none"> <li>• Hypersulfidic Soil (loamy) with monosulfidic material – occurring at the mid to high elevated areas. Minor (&lt;25%) in extent.</li> <li>• Subaqueous Soil (clayey) with monosulfidic material – occurring where there was surface water. Co dominant (&gt;25%) in extent.</li> <li>• Other Soil (loamy) with monosulfidic material – occurring adjacent to surface water. Co dominant (&gt;25%) in extent.</li> <li>• Other Soil (loamy) – occurring on the wetland margins. Minor (&lt;25%) in extent.</li> </ul>
<b>Hazard assessment</b>	<ul style="list-style-type: none"> <li>• Acidification hazard – medium level of concern</li> <li>• De-oxygenation hazard – high level of concern</li> <li>• Metal mobilisation hazard – medium level of concern</li> </ul>

**Table 11-2. Site description data for Yarra Complex Wetland (ID. 12608).**

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	28/03/2010	420627	6219328	not reached	salt crust	samphire	high elevation and on margins, where there is a salt crust and samphire
2	28/03/2010	420622	6219339	-35	salt crust	dead, bare	mid elevation, where there is a salt crust and no vegetation
3	28/03/2010	420614	6219350	-3	salt crust	bare	low elevation, centre of wetland, and salt crust
4	28/03/2010	420330	6219166	20	water, soft	bare, water	mid/low elevation, surface water

**Table 11-3. Soil profile description data for Yarra Complex Wetland (ID. 12608).**

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_0	0 - 0.5	surface salt scrap		salt			crystalline	weak	salt crystals
1_1	0 - 1	small pit	white (10YR8/1)	sandy loam	moist		massive	firm	salt crust
1_2	1 - 10	small pit	greyish brown (2.5Y5/2)	sandy clay loam	moist	5% yellowish brown In the matrix	massive	firm	
1_3	10 - 20	small pit	greyish brown (2.5Y5/2)	sandy clay loam	moist	10% olive In the matrix	massive	firm	
1_4	20 - 40	small pit	grey (5Y6/1)	sandy clay loam	moist		massive	firm	
1_5	40 - 90	push tube	grey (5Y6/1)	sandy loam	moist		massive	very firm	
2_0	0 - 0.5	surface salt scrap		salt	dry		crystalline	very weak	thin brown salt crust layer
2_1	0 - 5	small pit	olive grey (5Y4/2)	monosulfidic black ooze	moist		massive	weak	
2_2	5 - 10	small pit	olive grey (5Y4/2)	clay	moist	15% dark brown infused into the matrix along faces of peds	angular blocky	very weak	
2_3	10 - 20	small pit	dark grey (5Y4/1)	sandy clay loam	moist	15% reddish brown infused into the matrix along faces of peds	angular blocky	very weak	possible jarosite visible
2_4	20 - 40	small pit	dark grey (5Y4/1)	sandy clay loam	moist		massive	very weak	
2_5	40 - 100	push tube	dark grey (5Y4/1)	sandy loam	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
3_0	0 - 1	surface salt scrap		salt	dry		crystalline	weak	white salt
3_0	0 - 0.5	surface salt scrap		salt	dry		crystalline	weak	red brown salt
3_1	0 - 1	small pit	pale brown (10YR6/3)	salt	dry		crystalline	weak	a thin layer
3_2	1 - 7	small pit	black (2.5Y2/0)	monosulfidic black ooze	wet		gel	very weak	
3_3	7 - 20	small pit	grey (5Y5/1)	clay	wet	10% dark brown infused into the matrix along faces of peds	angular blocky	firm	
3_4	20 - 40	small pit	grey (5Y5/1)	sandy clay loam	moist	10% dark brown infused into the matrix along faces of peds	angular blocky	firm	
3_5	40 - 100	small pit	grey (5Y6/1)	clay loam	moist		massive	very firm	
3_W1	-	pit water							water sampled
4_W1	20 - 0	surface water							water sampled
4_1	0 - 5	small pit	black (2.5Y2/0)	monosulfidic black ooze	wet		gel	very weak	strong sulfurous odour
4_2	5 - 10	small pit	olive grey (5Y5/2)	clay	wet		gel	very weak	strong sulfurous odour
4_3	10 - 20	small pit	olive grey (5Y5/2)	clay	wet		gel	very weak	strong sulfurous odour
4_4	20 - 40	small pit	olive grey (5Y5/2)	clay	wet		gel	very weak	strong sulfurous odour
4_NS	40 - 110	push tube	olive grey (5Y5/2)	clay	wet		gel	very weak	strong sulfurous odour

**Table 11-4. Laboratory data for acid sulfate soil assessment of Yarra Complex Wetland (ID. 12608).**

(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 <sub>4</sub> /kg)	pH KCl	Titrateable Actual Acidity (mole H <sup>+</sup> /tonne)	Chromium Reducible Sulfur (%S <sub>CR</sub> )	Acid Neutralising Capacity (%CaCO <sub>3</sub> )	Net Acidity (mole H <sup>+</sup> /tonne)	Acid Volatile Sulfur (%Sav)	Acid Sulfate Soil Material Classification
1.0	0-0.5	..	..	..	..	7.90	7.64	..	..	..	..	..	..	..	salt crust
1.1	0-1	Fine	22,810	7.92	6.78	7.27	7.73	4,000	9.05	0.00	0.03	0.85	-95	..	hyposulfidic (S <sub>CR</sub> <0.10%)
1.2	1-10	Medium	11,260	7.45	5.31	7.65	7.66	280	8.01	0.00	0.01	0.10	-7	..	hyposulfidic (S <sub>CR</sub> <0.10%)
1.3	10-20	Fine	3,700	7.42	6.57	7.41	7.57	130	7.55	0.00	<0.01	0.62	-83	..	other soil material
1.4	20-40	Fine	2,880	7.42	6.18	7.32	7.60	86	7.40	0.00	<0.01	0.14	-19	..	other soil material
1.5	40-90	Fine	1,817	8.91	2.40	8.55	4.63	140	7.72	0.00	0.04	0.08	14	..	hyposulfidic (S <sub>CR</sub> <0.10%)
2.0	0-0.5	..	..	..	..	7.67	7.74	..	..	..	..	..	..	..	salt crust
2.1	0-5	Fine	38,400	8.05	6.87	7.35	7.70	3,000	8.61	0.00	0.32	13.96	-1660	0.208	hyposulfidic (S <sub>CR</sub> ≥0.10%) monosulfidic
2.2	5-10	Fine	6,720	7.69	6.36	7.30	7.80	360	8.81	0.00	0.07	3.14	-375	..	hyposulfidic (S <sub>CR</sub> <0.10%)
2.3	10-20	Fine	3,420	7.75	4.95	7.10	7.76	190	7.73	0.00	0.03	0.38	-32	..	hyposulfidic (S <sub>CR</sub> <0.10%)
2.4	20-40	Fine	2,900	8.52	2.59	7.89	8.15	330	7.91	0.00	0.22	0.48	73	..	hyposulfidic (S <sub>CR</sub> ≥0.10%)
2.5	40-100	Fine	2,880	8.53	2.16	7.96	3.69	420	7.62	0.00	0.53	0.45	271	..	hypersulfidic
3.0	0-1	..	..	..	..	7.47	7.80	..	..	..	..	..	..	..	salt crust
3.0	0-0.5	..	..	..	..	7.53	7.35	..	..	..	..	..	..	..	salt crust
3.1	0-1	Medium	85,900	7.76	6.70	7.29	7.49	7,700	9.02	0.00	0.07	10.60	-1368	..	hyposulfidic (S <sub>CR</sub> <0.10%)
3.2	1-7	Fine	64,900	7.69	6.87	6.79	7.40	7,100	8.92	0.00	0.31	10.26	-1173	0.122	hyposulfidic (S <sub>CR</sub> ≥0.10%) monosulfidic
3.3	7-20	Fine	18,830	8.03	6.40	7.09	7.76	3,600	8.43	0.00	0.35	3.60	-261	..	hyposulfidic (S <sub>CR</sub> ≥0.10%)
3.4	20-40	Fine	22,810	7.73	6.26	6.68	7.56	3,400	8.40	0.00	0.42	4.52	-340	..	hyposulfidic (S <sub>CR</sub> ≥0.10%)
3.5	40-100	Fine	18,190	7.58	2.73	6.93	7.35	2,000	7.21	0.00	0.41	0.58	178	..	hyposulfidic (S <sub>CR</sub> ≥0.10%)
3.W1	-	..	..	..	..	..	..	..	..	..	..	..	..	..	pit water
4.W1	20-0	..	..	..	..	..	..	..	..	..	..	..	..	..	surface water
4.1	0-5	Fine	63,700	8.02	6.71	6.86	7.51	4,100	8.69	0.00	0.57	13.48	-1440	0.069	hyposulfidic (S <sub>CR</sub> ≥0.10%) monosulfidic
4.2	5-10	Fine	16,610	8.34	6.57	7.06	7.58	1,200	8.63	0.00	0.45	2.67	-75	..	hyposulfidic (S <sub>CR</sub> ≥0.10%)
4.3	10-20	Fine	16,820	8.32	6.63	7.09	7.48	1,300	8.51	0.00	0.54	3.50	-129	..	hyposulfidic (S <sub>CR</sub> ≥0.10%)
4.4	20-40	Fine	18,440	8.32	6.48	7.27	7.50	1,400	8.67	0.00	0.33	1.46	11	..	hyposulfidic (S <sub>CR</sub> ≥0.10%)

**Table 11-5. Summary of hydrochemical field measurements for Yarra Complex Wetland (ID. 12608).**

	<b>pH</b>	<b>SEC</b> $\mu\text{S cm}^{-1}$	<b>DO</b> $\text{mg l}^{-1}$	<b>Eh</b> mV	<b>Turbidity</b> NTU	<b>Alkalinity</b> as $\text{HCO}_3$
Surface waters (n=1)	7.78	204297	1.81	100		266
Pit waters (n=1)	6.33	162750	0.23	73		612

**Table 11-6. Summary of hydrochemical field measurements for Yarra Complex Wetland (ID. 12608).**

Parameter	units	ANZECC Guidelines	Site 3 (PW)	Site 4 (SW)
Na	mg l <sup>-1</sup>		50300	84800
K	mg l <sup>-1</sup>		309	580
Ca	mg l <sup>-1</sup>		1160	502
Mg	mg l <sup>-1</sup>		5110	9670
Si	mg l <sup>-1</sup>		<25	<25
Br	mg l <sup>-1</sup>		220.0	360.0
Cl	mg l <sup>-1</sup>		90000	160000
NO <sub>3</sub>	mg l <sup>-1</sup>	0.7	0.120	<0.022
NH <sub>4</sub> -N <sup>K</sup>	mg l <sup>-1</sup>	0.01	<b>18.00</b>	<b>2.000</b>
PO <sub>4</sub> -P <sup>E</sup>	mg l <sup>-1</sup>	0.005	<b>0.830</b>	<b>0.021</b>
SO <sub>4</sub>	mg l <sup>-1</sup>		10000	18000
Ag	µg l <sup>-1</sup>	0.05	<0.6	<0.4
Al <sup>A</sup>	µg l <sup>-1</sup>	55	<2000	<1000
As <sup>B</sup>	µg l <sup>-1</sup>	13	<b>60</b>	<20
Cd	µg l <sup>-1</sup>	0.2	<2	<1
Co	µg l <sup>-1</sup>	2.8	<1	<0.8
Cr <sup>C</sup>	µg l <sup>-1</sup>	1	<8	<5
Cu <sup>H</sup>	µg l <sup>-1</sup>	1.4	<30	<20
Fe	µg l <sup>-1</sup>	300	<50000	<50000
Mn	µg l <sup>-1</sup>	1700	740	<b>8580</b>
Ni <sup>H</sup>	µg l <sup>-1</sup>	11	<20	<10
Pb <sup>H</sup>	µg l <sup>-1</sup>	3.4	<10	<10
Se	µg l <sup>-1</sup>	11	<10	<8
Zn <sup>H</sup>	µg l <sup>-1</sup>	8	<b>210</b>	<b>380</b>
DOC	mg l <sup>-1</sup>		108	340

**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<sub>4</sub> and PO<sub>4</sub>, 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.

- <sup>A</sup> Trigger value for Aluminium in freshwater where pH > 6.5.
- <sup>B</sup> Trigger value assumes As in solution as Arsenic (AsV).
- <sup>C</sup> Trigger value for Chromium is applicable to Chromium (CrVI) only.
- <sup>E</sup> Guideline is for filterable reactive phosphorous (FRP).
- <sup>H</sup> Hardness affected (refer to Guidelines).
- <sup>K</sup> Guideline for South-east Australia-Freshwater Lakes and reservoirs.

## 12. OVERLAND CORNER (WETLAND ID. 12132)

### 12.1. Location and setting description

Overland Corner (Wetland ID. 12132) is situated on the north eastern side of the River Murray, adjacent to the settlement of Overland Corner and about 4 kilometres down river from Lock 3, located in the Overland Corner Complex area. The wetland is linear in shape. It is about 300 metres in length and about 50 metres at its widest, with a total surface area of 1 hectare. The wetland is bounded to the west by a raised floodplain that separates it from other wetlands and the river and to the east by a steep hill slope that separates it from farm land. The other associated wetlands in the Overland Corner Complex that were surveyed are wetland IDs. 12265, 12133 and 12272.

The wetland is not connected to the river, but may connect up via a channel to the south if there is sufficient water flow. At the time when the soil survey was conducted in May 2010 the wetland did not have surface water and was covered with grasses. The wetland has been managed by the National Trust of SA and private landholders with the assistance of the South Australian Murray-Darling Basin Natural Resources Management Board (SA MDB NRM Board) and BBLAP since 2003. Grasses were growing on the margins of the wetland, with open woodland and shrubland on the surrounding higher floodplain. Two sites were sampled as shown in Figure 12-1.

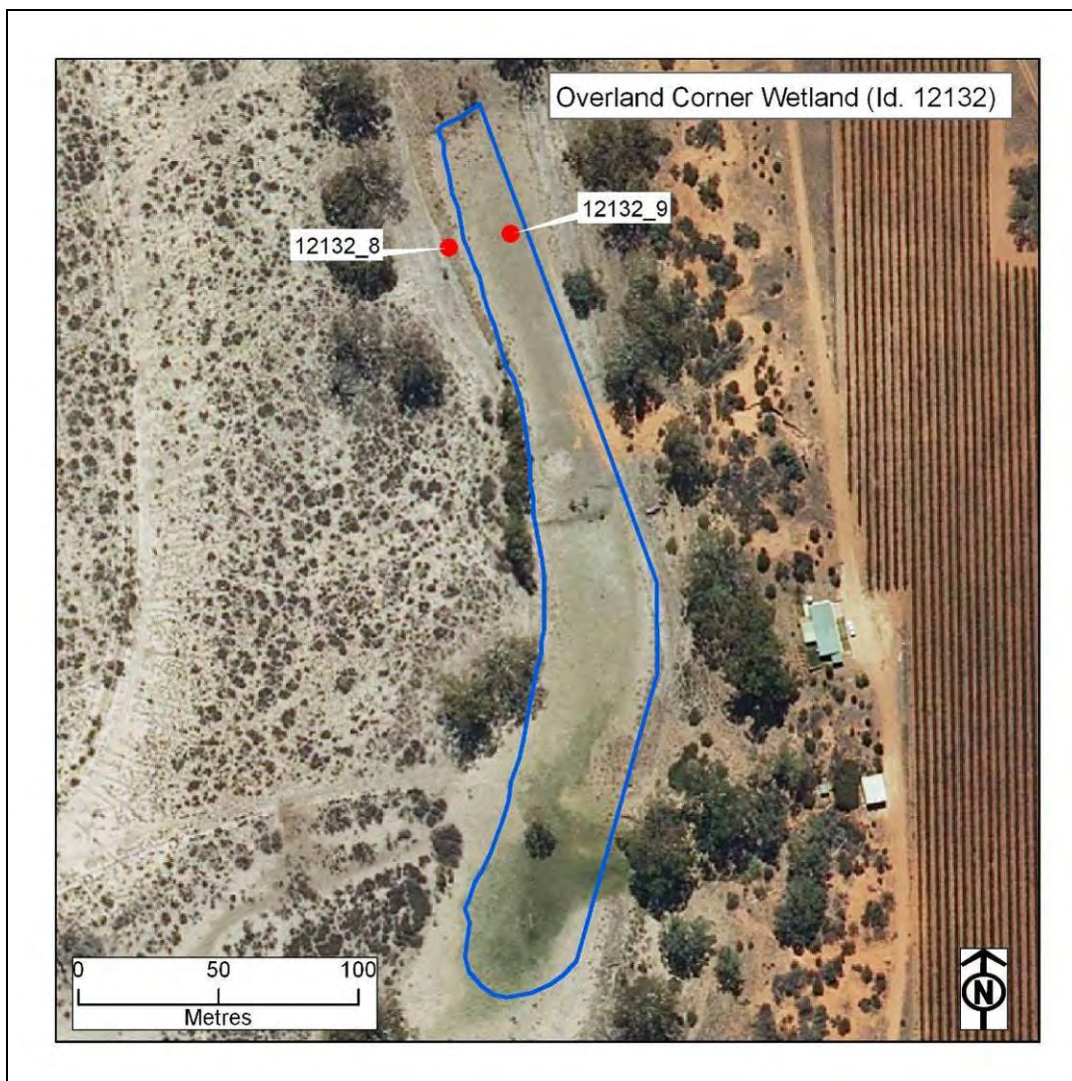


Figure 12-1. Overland Corner (Wetland ID. 12132) and sample site locations.



## 12.2. Soil profile description and distribution

Two sites were described and sampled. The soil subtypes and general location descriptions are presented in Table 12-1. Sites were located at the northern end of the wetland (Sites 8 and 9) of the wetland. The site and soil profile descriptions are presented in Table 12-2 and Table 12-3.

Northern transect

Site 8 (Figure 12-2) occurred on the wetland margin, and the soil consisted of a greyish brown, rigid, clay, over a grey, rigid, clay. Site 9 (Figure 12-3) occurred at low elevation in the middle of the wetland, and the soil consisted of a brown, rigid, clay, over a dark grey, rigid, clay.

**Table 12-1. Soil identification, subtype and general location description for Overland Corner (Wetland ID. 12132).**

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12132_8	440717	6219382	Other Soil (clayey)	high elevation, on wetland margin
12132_9	440739	6219387	Other Soil (clayey)	low elevation, middle of wetland



**Figure 12-2. Photographs of Site 8, showing the site location on the margin where grasses were growing, and the soil profile of rigid clay.**



**Figure 12-3. Photographs of Site 9, showing the site location at low elevation in the middle of the wetland, and the soil profile.**

## **12.3. Laboratory data assessment**

### **12.3.1. Soil pH testing (pH<sub>W</sub>, pH<sub>OX</sub>, pH<sub>INC</sub>)**

The pH data are provided in Table 12-4 and pH profiles are presented in Figure 12-4. The pH<sub>W</sub> data ranged from 5.61 to 7.89 and sulfuric materials with a pH<sub>W</sub> <4 were not identified. The pH<sub>OX</sub> data ranged from 2.77 to 8.01 and identified that no samples were below the critical value of pH<sub>OX</sub> <2.5. The pH<sub>INC</sub> data ranged from 5.74 to 7.71 and identified that no samples on incubation declined below the critical values of pH <4.

### **12.3.2. Acid base accounting**

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

#### **Chromium reducible sulfur**

Chromium reducible sulfur values ranged from 0.0 to 0.04 %S<sub>CR</sub> and sulfidic materials were detected in all profiles at the limits of detection.

#### **Titrateable actual acidity**

Titrateable actual acidity values ranged from 0.00 to 16.10 mole H<sup>+</sup>/tonne and were detected in Profile 8 that occurred on the margin and not detected in Profile 9 that occurred at low elevation in the wetland.

#### **Retained acidity**

Retained acidity was not measured in any of the layers as all samples had a pH<sub>KCl</sub> of greater than 4.5.

#### **Acid neutralising capacity**

Acid neutralising capacity values ranged from 0 to 4.90 %CaCO<sub>3</sub> and were measured in only Profile 9.

#### **Net acidity**

Net acidity values ranged from -653 to 31 mole H<sup>+</sup>/tonne. Profile 8 on the margin had low or moderate values and Profile 9 in the low elevation middle part of the wetland had negative values.

### **12.3.3. Water soluble sulfate**

Water soluble sulfate data values shown in Table 12-4 identified no surface layers that were above the criterion trigger value of 100 mg/kg SO<sub>4</sub>.

### **12.3.4. Acid volatile sulfur**

Monosulfidic material was not observed and no samples were collected for analysis.

### **12.3.5. Hydrochemistry**

Water was not observed on the surface or in the soil pits and water samples were not collected.

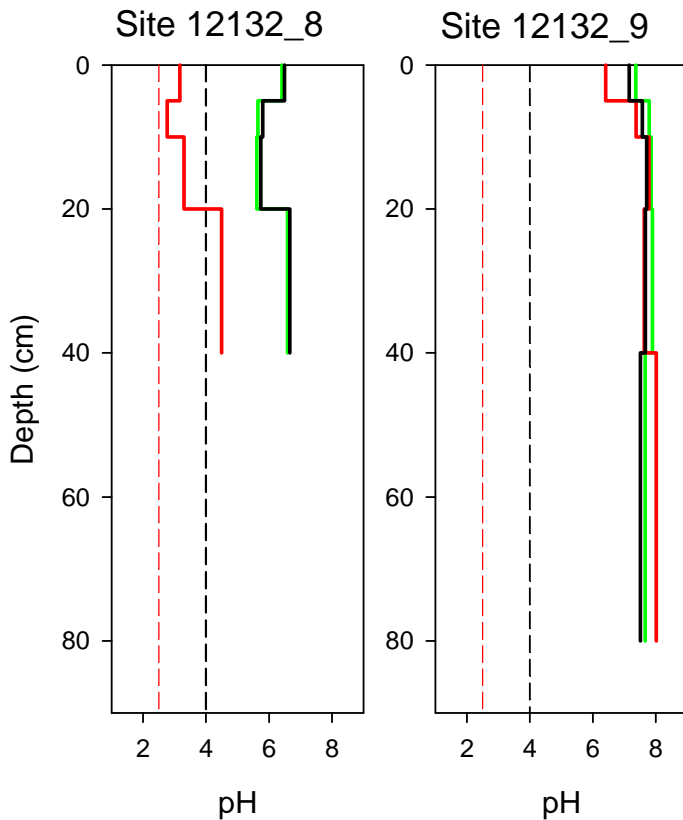


Figure 12-4. Depth profiles of soil pH for Overland Corner (Wetland ID. 12132), showing soil pH ( $pH_W$  as green line), peroxide treated pH ( $pH_{OX}$  as red line) and incubation pH ( $pH_{INC}$  after 8 weeks as black line). Critical  $pH_W$  and  $pH_{INC}$  value of 4 (black dashed line) and critical  $pH_{OX}$  value of 2.5 (red dashed line).

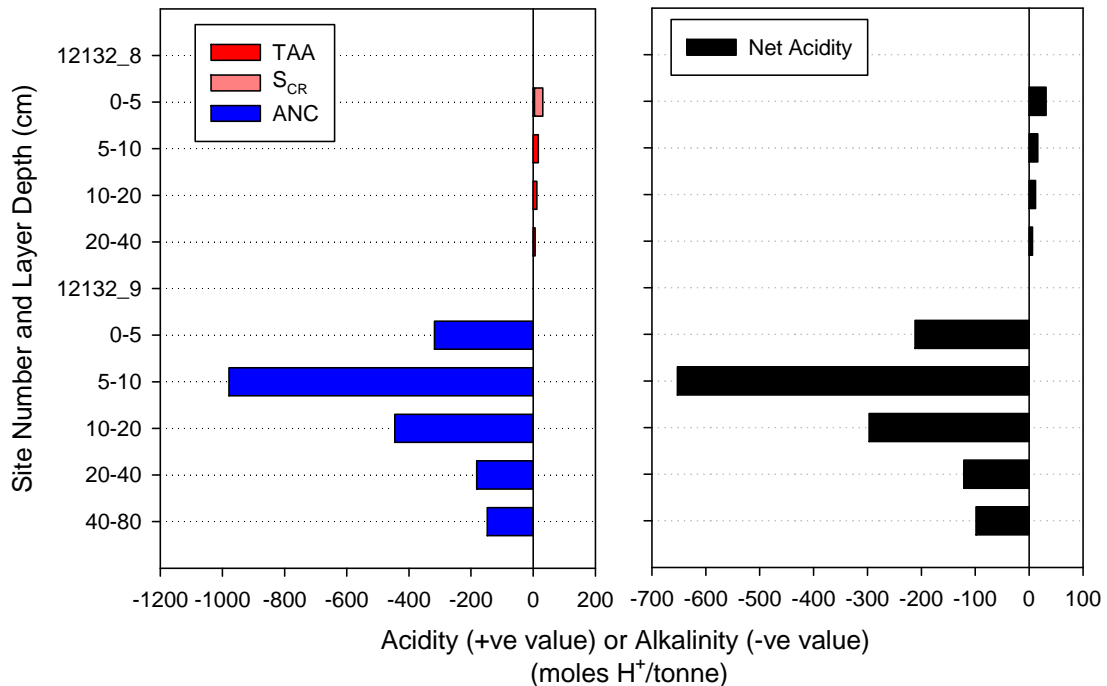


Figure 12-5. Acid base accounting depth profiles for Overland Corner (Wetland ID. 12132). Left side shows the components: Titratable actual acidity (TAA - red bar), acid generating potential (AGP as  $S_{CR}$  - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

## 12.4. Discussion

Acid sulfate soil materials at Overland Corner (Wetland ID. 12132) were identified as hyposulfidic occurring in surface and subsoil layers and the remaining samples were characterised as other soil materials. The acid sulfate soil subtype class identified was Other Soil (clayey).

The soils throughout the wetland were clayey textured in the surface layers. The subsoils were clayey textured with a rigid consistence.

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

The potential hazards posed by acid sulfate soil materials at Overland Corner (Wetland ID. 12132) are:

- Acidification hazard: The data identified low or moderate net acidity values for samples located in the profile on the wetland margin and negative values for the profile located on the low elevated middle part of the wetland area, 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 was no potential for monosulfidic materials to form in the surface layers of all soils, monosulfidic material was not observed. 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 Overland Corner (Wetland ID. 12132):

<b>Soil materials:</b>	The soil profiles contained at least one layer of hyposulfidic soil material. The soils were clayey textured at the surface and clayey textured in the subsoil. Layers in the profile on the margin had low or moderate net acidity values, pH data did not indicate a potential for acidification due to oxidation.
<b>Acid sulfate soil identification:</b>	<ul style="list-style-type: none"> <li>• Other Soil (clayey) – occurring throughout the wetland. Dominant (&gt;50%) in extent.</li> </ul>
<b>Hazard assessment</b>	<ul style="list-style-type: none"> <li>• Acidification hazard – low level of concern</li> <li>• De-oxygenation hazard – low level of concern</li> <li>• Metal mobilisation hazard – low level of concern</li> </ul>

**Table 12-2. Site description data for Overland Corner (Wetland ID. 12132).**

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
8	4/05/2010	440717	6219382	not reached	cracking, rigid	reed grass	high elevation, on wetland margin
9	4/05/2010	440739	6219387	not reached	cracking, rigid	grasses	low elevation, middle of wetland

**Table 12-3. Soil profile description data for Overland Corner (Wetland ID. 12132).**

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_1	0 - 5	small pit	greyish brown (10YR5/2)	clay	dry	5% brownish yellow infused into the matrix adjacent to pores	angular blocky	rigid	
8_2	5 - 10	small pit	greyish brown (10YR5/2)	clay	dry	5% brownish yellow infused into the matrix adjacent to pores	angular blocky	rigid	
8_3	10 - 20	small pit	light brownish grey (10YR6/2)	clay	dry	15% brownish yellow infused into the matrix adjacent to pores	columnar	rigid	
8_4	20 - 40	small pit	grey (10YR5/1)	clay	dry	15% brownish yellow In the matrix	columnar	rigid	
9_1	0 - 5	small pit	brown (10YR5/3)	clay	dry		subangular blocky	rigid	
9_2	5 - 10	small pit	dark greyish brown (10YR4/2)	clay	dry		subangular blocky	rigid	
9_3	10 - 20	small pit	dark grey (10YR4/1)	clay	dry		columnar	rigid	
9_4	20 - 40	small pit	dark grey (10YR4/1)	clay	moist		columnar	rigid	
9_5	40 - 80	push tube	dark grey (10YR4/1)	clay	moist	10% dark reddish brown In the matrix	massive	very firm	

**Table 12-4. Laboratory data for acid sulfate soil assessment of Overland Corner (Wetland ID. 12132).**

(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 <sub>4</sub> /kg)	pH KCl	Titrateable Actual Acidity (mole H <sup>+</sup> /tonne)	Chromium Reducible Sulfur (%S <sub>CR</sub> )	Retained Acidity (mole H <sup>+</sup> /tonne)	Acid Neutralising Capacity (%CaCO <sub>3</sub> )	Net Acidity (mole H <sup>+</sup> /tonne)	Acid Sulfate Soil Material Classification
8.1	0-5	Fine	639	6.41	3.17	6.58	6.49	47	6.29	4.26	0.04	..	0.00	31	hyposulfidic (S <sub>CR</sub> <0.10%)
8.2	5-10	Fine	251	5.65	2.77	5.82	5.80	26	5.27	16.10	<0.01	..	..	16	other soil material
8.3	10-20	Fine	105	5.61	3.30	6.04	5.74	9	5.20	11.84	<0.01	..	..	12	other soil material
8.4	20-40	Fine	106	6.59	4.49	6.57	6.66	6	5.99	6.16	<0.01	..	..	6	other soil material
9.1	0-5	Fine	583	7.36	6.41	7.15	7.15	52	7.63	0.00	<0.01	..	1.59	-213	other soil material
9.2	5-10	Fine	525	7.79	7.37	7.70	7.57	22	7.98	0.00	<0.01	..	4.90	-653	other soil material
9.3	10-20	Fine	393	7.85	7.78	7.50	7.71	15	7.88	0.00	<0.01	..	2.23	-297	other soil material
9.4	20-40	Fine	833	7.89	7.63	7.45	7.67	48	7.28	0.00	<0.01	..	0.91	-121	other soil material
9.5	40-80	Fine	1941	7.66	8.01	7.14	7.51	150	6.90	0.00	<0.01	..	0.74	-99	other soil material

## 13. OVERLAND CORNER (WETLAND ID. 12133)

### 13.1. Location and setting description

Overland Corner (Wetland ID. 12133) is situated on the north eastern side of the River Murray, near to the settlement of Overland Corner and about 1.5 kilometres down river from Lock 3, located in the Overland Corner Complex area. The wetland is somewhat rectangular in shape. It is about 700 metres in length and about 200 metres at its widest, with a total surface area of 13 hectares. The wetland is bounded to the west by a raised floodplain that separates it from other wetlands and the river and to the east by a steep hill slope that separates it from farmland. The other associated wetlands in the Overland Corner Complex that were surveyed are wetland IDs. 12132, 12265 and 12272.

The wetland is not connected to the river. At the time when the soil survey was conducted in May 2010 the wetland did not have surface water. The wetland is managed by the National Trust of SA and private landholders with the assistance of the South Australian Murray-Darling Basin Natural Resources Management Board (SA MDB NRM Board) and BBLAP since 2003. Reeds were on the margin and lignum was growing throughout the wetland, with open woodland and shrubland on the surrounding higher floodplain. Three sites were sampled as shown in Figure 13-1.

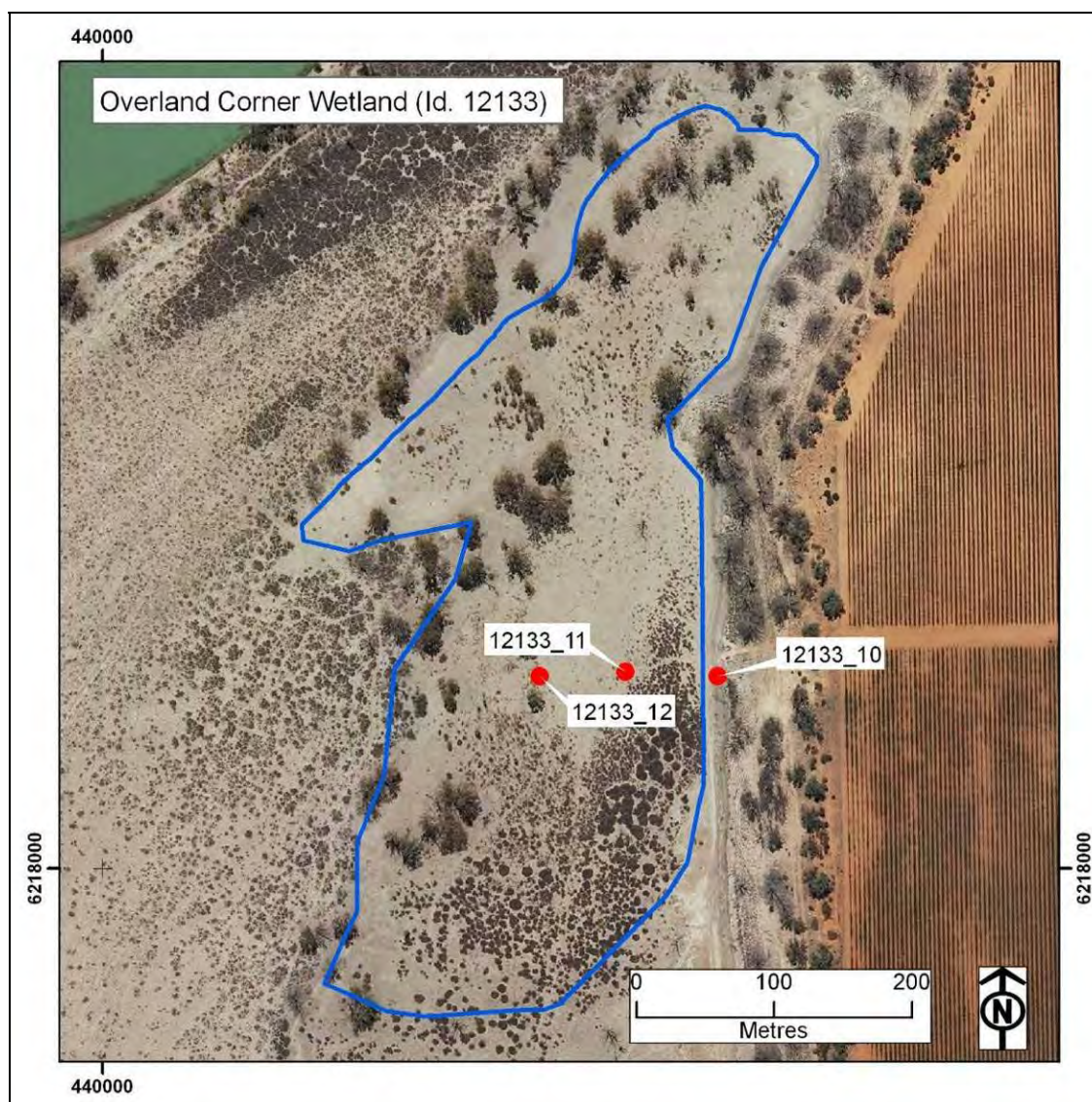


Figure 13-1. Overland Corner (Wetland ID. 12133) and sample site locations.

## 13.2. Soil profile description and distribution

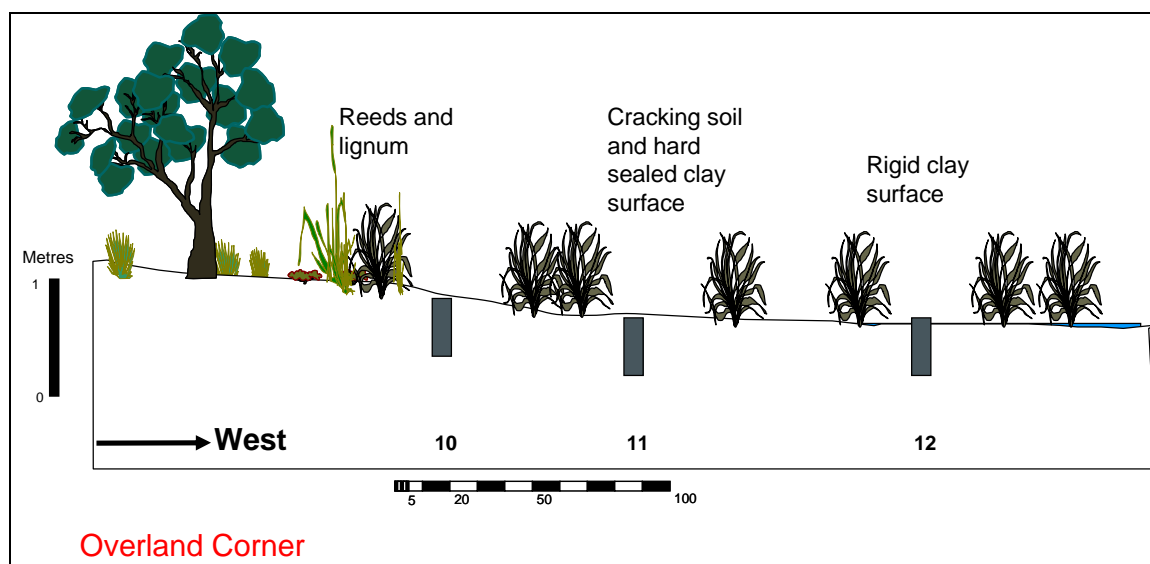
Three sites were described and sampled. The soil subtypes and general location descriptions are presented in Table 13-1. Sites were distributed along one transect near the centre (Sites 10, 11 and 12) of the wetland. The site and soil profile descriptions are presented in Table 13-2 and Table 13-3, and a conceptual cross-section in Figure 13-2.

Centre transect

Site 10 (Figure 13-3) occurred on the margin where reeds and lignum was growing, and the soil consisted of a light brownish grey, rigid, clay. Site 11 (Figure 13-4) occurred in the wetland amongst lignum, and the soil consisted of a light brownish grey, rigid, clay, over a dark grey, rigid, clay. Site 12 (Figure 13-5) occurred in lignum at low to mid elevation, and the soil consisted of a light brownish grey, rigid, clay.

**Table 13-1. Soil identification, subtype and general location description for Overland Corner (Wetland ID. 12133).**

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12133_10	440446	6218139	Other Soil (clayey)	high elevation, on wetland margin
12133_11	440379	6218142	Other Soil (clayey)	low elevation, middle of wetland
12133_12	440317	6218139	Other Soil (clayey)	low to mid elevation, wetland edge



**Figure 13-2. Conceptual cross-section diagram, showing locations of Sites 1, 2 and 3.**





**Figure 13-3. Photographs of Site 10, showing the site location on the wetland margin, and the soil profile.**



**Figure 13-4. Photographs of Site 11, showing the site location in thick lignum, the cracking sealed clay surface, and the soil profile of rigid clay.**



Figure 13-5. Photographs of Site 12, showing the site location and viewed across the wetland to the hill slope, and the soil profile of rigid clay.

### 13.3. Laboratory data assessment

#### 13.3.1. Soil pH testing ( $pH_W$ , $pH_{OX}$ , $pH_{INC}$ )

The pH data are provided in Table 14-4 and pH profiles are presented in Figure 13-6. The  $pH_W$  data ranged from 5.28 to 6.20 and sulfuric materials with a  $pH_W < 4$  were not identified. The  $pH_{OX}$  data ranged from 2.84 to 4.34 and identified that no samples were below the critical value of  $pH_{OX} < 2.5$ . The  $pH_{INC}$  data ranged from 5.33 to 6.34 and identified that no samples on incubation declined below the critical values of  $pH < 4$ .

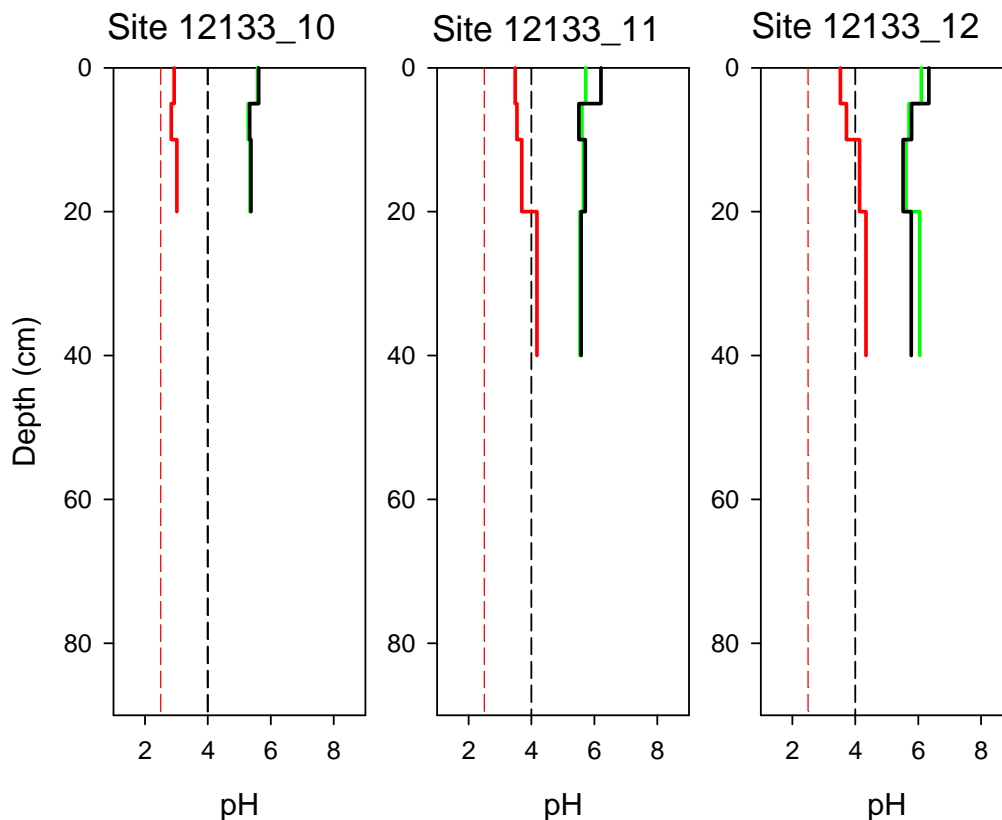


Figure 13-6. Depth profiles of soil pH for Overland Corner (Wetland ID. 12133), showing soil pH ( $pH_W$  as green line), peroxide treated pH ( $pH_{OX}$  as red line) and incubation pH ( $pH_{INC}$  after 8 weeks as black line). Critical  $pH_W$  and  $pH_{INC}$  value of 4 (black dashed line) and critical  $pH_{OX}$  value of 2.5 (red dashed line).

### 13.3.2. Acid base accounting

The acid base accounting data is provided in Table 14-4 and summarised in Figure 13-7.

#### Chromium reducible sulfur

Chromium reducible sulfur values ranged from 0.0 to 0.01 %S<sub>CR</sub> and sulfidic materials were detected in all profiles at the limits of detection.

#### Titratable actual acidity

Titratable actual acidity values ranged from 14.21 to 24.15 mole H<sup>+</sup>/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<sub>KCl</sub> of greater than 4.5.

#### Acid neutralising capacity

Acid neutralising capacity values were 0.00 %CaCO<sub>3</sub> and were not measured in any of the samples..

#### Net acidity

Net acidity values ranged from 14 to 24 mole H<sup>+</sup>/tonne. All samples had a low or moderate net acidity value.

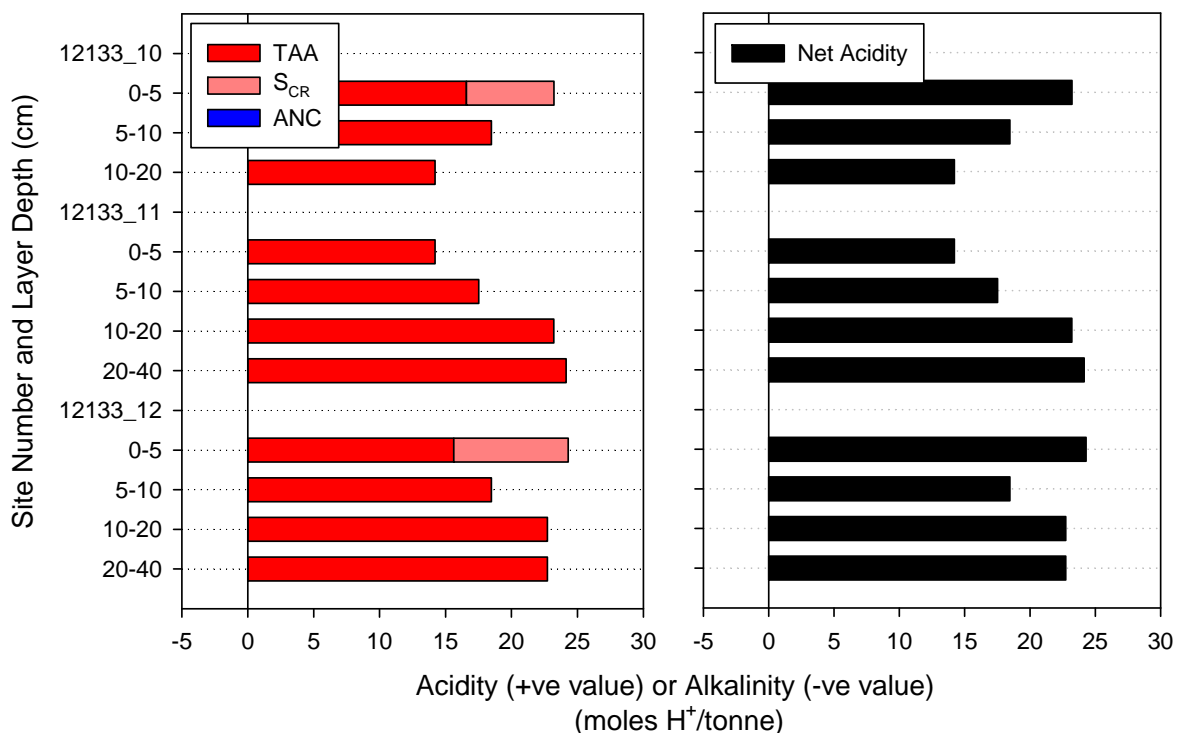


Figure 13-7. Acid base accounting depth profiles for Overland Corner (Wetland ID. 12133). Left side shows the components: Titratable actual acidity (TAA - red bar), acid generating potential (AGP as S<sub>CR</sub> - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

### 13.3.3. Water soluble sulfate

Water soluble sulfate data values shown in Table 14-4 identified no surface layers that were above the criterion trigger value of 100 mg/kg SO<sub>4</sub>.

### 13.3.4. Acid volatile sulfur

Monosulfidic material was not observed and no samples were collected for analysis.

### 13.3.5. Hydrochemistry

Water was not observed on the surface or in the soil pits and no samples were collected for analysis.

## 13.4. Discussion

Acid sulfate soil materials at Overland Corner (Wetland ID. 12133) were identified as hyposulfidic occurring in different layers of all profiles and the remaining samples were characterised as other soil materials. The acid sulfate soil subtype class identified was Other Soil (clayey).

The soils throughout the wetland were clayey textured in the surface layers. The subsoils were clayey textured with a rigid consistence.

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 Overland Corner (Wetland ID. 12133) are:

- Acidification hazard: The data identified low or moderate net acidity values in all samples but 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 was no potential for monosulfidic materials to form in the surface layers of all soils, monosulfidic material was not observed. There is a low level of concern.
- Metal mobilisation: The low to medium acidification hazard indicates that soil acidification potential is not likely to increase the solubility of metals. There is a low level of concern.

### Summary of key findings Overland Corner (Wetland ID. 12133):

<b>Soil materials:</b>	The soil profiles contained at least one layer of hyposulfidic soil material. Soils were clayey textured at the surface and clayey textured in the subsoil. All layers had a low or moderate net acidity value and pH data did not indicated a potential for acidification due to oxidation.
<b>Acid sulfate soil identification:</b>	<ul style="list-style-type: none"><li>• Other Soil (clayey) – occurring throughout the wetland. Dominant (&gt;50%) in extent.</li></ul>
<b>Hazard assessment</b>	<ul style="list-style-type: none"><li>• Acidification hazard – low to medium level of concern</li><li>• De-oxygenation hazard – low level of concern</li><li>• Metal mobilisation hazard – low level of concern</li></ul>

**Table 13-2. Site description data for Overland Corner (Wetland ID. 12133).**

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
10	4/05/2010	440446	6218139	not reached	sealed, rigid	reeds, lignum	high elevation, on wetland margin
11	4/05/2010	440379	6218142	not reached	cracking, rigid	lignum	low elevation, middle of wetland
12	4/05/2010	440317	6218139	not reached	cracking, rigid	lignum and gums	low to mid elevation, wetland edge

**Table 13-3. Soil profile description data for Overland Corner (Wetland ID. 12133).**

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
10_1	0 - 5	small pit	light brownish grey (10YR6/2)	clay	dry	5% brownish yellow In the matrix	subangular blocky	rigid	
10_2	5 - 10	small pit	light brownish grey (10YR6/2)	clay	dry	15% brownish yellow In the matrix	subangular blocky	rigid	
10_3	10 - 20	small pit	light brownish grey (10YR6/2)	clay	dry	15% brownish yellow In the matrix	subangular blocky	rigid	
11_1DUP	0 - 5	small pit	light brownish grey (10YR6/2)	clay	dry	10% brownish yellow infused into the matrix adjacent to pores	angular blocky	rigid	
11_1	0 - 5	small pit	light brownish grey (10YR6/2)	clay	dry	10% brownish yellow infused into the matrix adjacent to pores	angular blocky	rigid	
11_2	5 - 10	small pit	light brownish grey (10YR6/2)	clay	dry	10% brownish yellow In the matrix	angular blocky	rigid	
11_3	10 - 20	small pit	dark grey (10YR4/1)	clay	dry	10% brownish yellow In the matrix	columnar	rigid	
11_4	20 - 40	small pit	dark grey (10YR4/1)	clay	dry		columnar	rigid	too rigid to dig below
12_1	0 - 5	small pit	light brownish grey (10YR6/2)	clay	dry	20% yellowish brown In the matrix	angular blocky	rigid	
12_2	5 - 10	small pit	light brownish grey (10YR6/2)	clay	dry	15% yellowish brown In the matrix	angular blocky	rigid	
12_3	10 - 20	small pit	light brownish grey (10YR6/2)	clay	dry	5% yellowish brown In the matrix	columnar	rigid	
12_4	20 - 40	small pit	dark grey (10YR4/1)	clay	dry	5% yellowish brown In the matrix	columnar	rigid	too rigid to dig below

**Table 13-4. Laboratory data for acid sulfate soil assessment of Overland Corner (Wetland ID. 12133).**

(red printed values indicates data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC ( $\mu\text{S}/\text{cm}$ )	pH water	pH peroxide	pH incubation week 0	pH incubation week 8	Sulfate (mg $\text{SO}_4/\text{kg}$ )	pH KCl	Titrateable Actual Acidity (mole $\text{H}^+/\text{tonne}$ )	Chromium Reducible Sulfur ( $\%\text{S}_{\text{CR}}$ )	Retained Acidity (mole $\text{H}^+/\text{tonne}$ )	Acid Neutralising Capacity ( $\%\text{CaCO}_3$ )	Net Acidity (mole $\text{H}^+/\text{tonne}$ )	Acid Sulfate Soil Material Classification
10.1	0-5	Fine	447	5.58	2.93	5.59	5.61	18	5.50	16.58	0.01	..	..	23	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
10.2	5-10	Fine	256	5.28	2.84	5.82	5.33	15	5.12	18.47	<0.01	..	..	18	other soil material
10.3	10-20	Fine	120	5.34	3.02	5.84	5.37	6	5.08	14.21	<0.01	..	..	14	other soil material
11.1DUP	0-5	Fine	281	5.85	3.60	6.29	6.03	17	5.57	16.58	<0.01	..	..	17	other soil material
11.1	0-5	Fine	510	5.72	3.48	6.57	6.21	26	5.42	14.21	<0.01	..	..	14	other soil material
11.2	5-10	Fine	385	5.60	3.54	5.56	5.51	17	5.28	17.52	<0.01	..	..	18	other soil material
11.3	10-20	Fine	209	5.65	3.69	6.33	5.71	9	5.06	23.21	<0.01	..	..	23	other soil material
11.4	20-40	Fine	210	5.54	4.17	6.03	5.58	12	4.98	24.15	<0.01	..	..	24	other soil material
12.1	0-5	Fine	466	6.10	3.53	6.73	6.34	21	5.71	15.63	0.01	..	..	24	hyposulfidic ( $\text{S}_{\text{CR}} < 0.10\%$ )
12.2	5-10	Fine	438	5.71	3.72	5.87	5.79	15	5.49	18.47	<0.01	..	..	18	other soil material
12.3	10-20	Fine	250	5.61	4.14	5.63	5.52	8	5.13	22.73	<0.01	..	..	23	other soil material
12.4	20-40	Fine	111	6.05	4.34	6.44	5.78	4	5.08	22.73	<0.01	..	..	23	other soil material

## 14. OVERLAND CORNER (WETLAND ID. 12265)

### 14.1. Location and setting description

Overland Corner (Wetland ID. 12265) is situated on the north eastern side of the River Murray, adjacent to the settlement of Overland Corner and about 4 kilometres down river from Lock 3, located in the Overland Corner Complex area. The wetland is somewhat rectangular in shape. It is about 600 metres in length and about 200 metres at its widest, with a total surface area of 11 hectares. The wetland is bounded by a raised floodplain that separates it from other wetlands and the river. The other associated wetlands in the Overland Corner Complex that were surveyed are wetland IDs. 12132, 12133 and 12272.

The wetland is not connected to the river. At the time when the soil survey was conducted in May 2010 the wetland did not have surface water and was covered with thick lignum. The wetland is managed by the National Trust of SA and private landholders with the assistance of the South Australian Murray-Darling Basin Natural Resources Management Board (SA MDB NRM Board) and BBLAP since 2003. Lignum was growing throughout the wetland, with open woodland and shrubland on the surrounding higher floodplain. Three sites were sampled as shown in Figure 14-1.

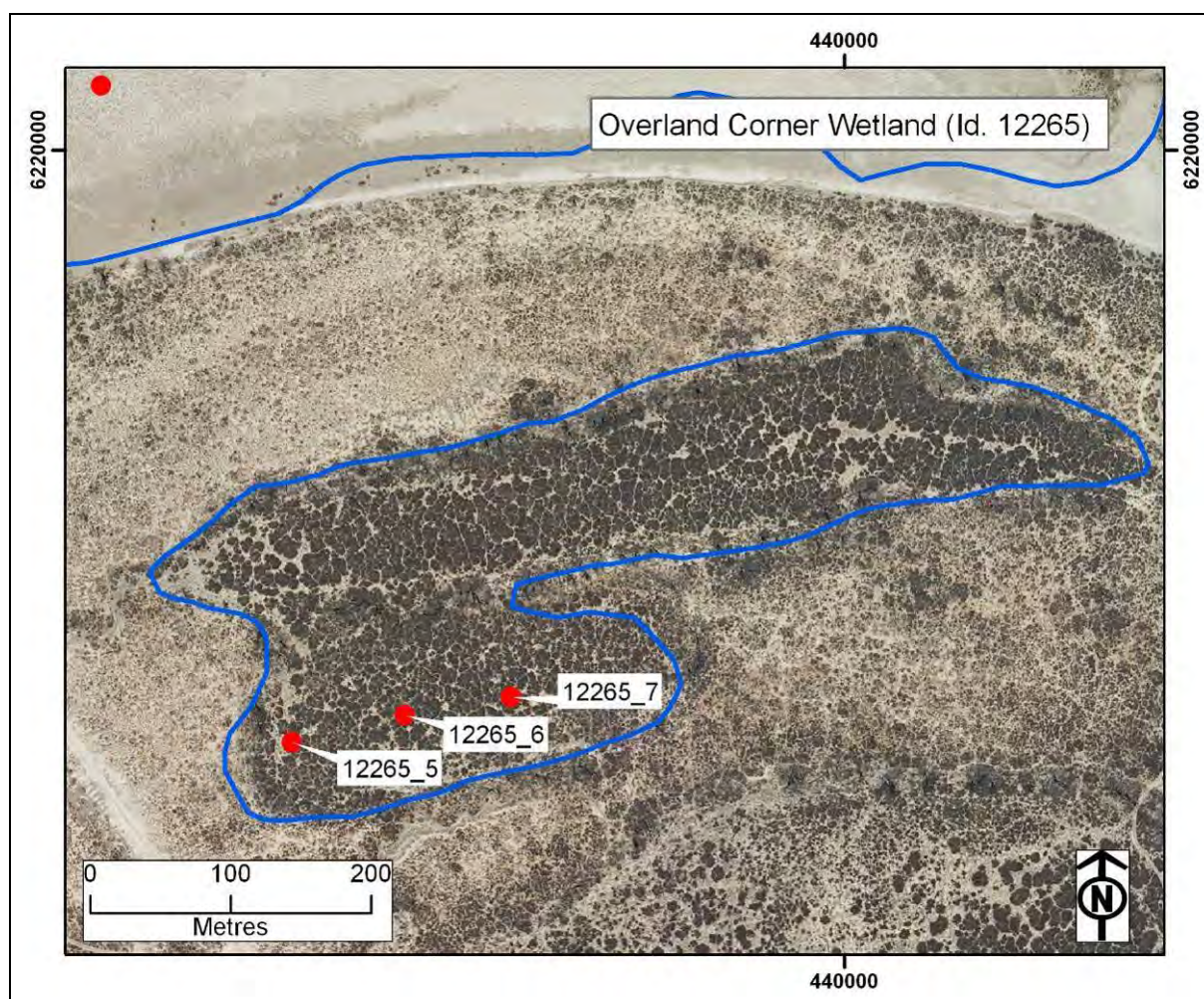


Figure 14-1. Overland Corner (Wetland ID. 12265) and sample site locations.

## 14.2. Soil profile description and distribution

Three sites were described and sampled. The soil subtypes and general location descriptions are presented in Table 14-1. Sites were distributed along one transect at the southern end (Sites 5, 6 and 7) of the wetland. The site and soil profile descriptions are presented in Table 14-2 and Table 14-3.

Southern transect

Site 5 (Figure 14-2) occurred in the wetland amongst lignum, and the soil consisted of a light brownish grey, rigid, clay. Site 6 (Figure 14-3) occurred in the wetland amongst lignum, and the soil consisted of a greyish brown, rigid, clay, over a grey, rigid, clay. Site 7 (Figure 14-4) occurred at the edge of lignum, and the soil consisted of a greyish brown, rigid, clay.

**Table 14-1. Soil identification, subtype and general location description for Overland Corner (Wetland ID. 12265).**

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12265_5	439607	6219579	Other Soil (clayey)	mid elevation, near margin
12265_6	439687	6215598	Other Soil (clayey)	low elevation
12265_7	439763	6219611	Other Soil (clayey)	low elevation



**Figure 14-2. Photographs of Site 5, showing the site location in thick lignum, and the soil profile.**



**Figure 14-3. Photographs of Site 6, showing the site location in thick lignum, and the soil profile of rigid clay.**





Figure 14-4. Photographs of Site 7, showing the site location adjacent to lignum, and the soil profile of rigid clay.

### 14.3. Laboratory data assessment

#### 14.3.1. Soil pH testing ( $pH_W$ , $pH_{OX}$ , $pH_{INC}$ )

The pH data are provided in Table 14-4 and pH profiles are presented in Figure 14-5. The  $pH_W$  data ranged from 4.57 to 5.64 and sulfuric materials with a  $pH_W < 4$  were not identified. The  $pH_{OX}$  data ranged from 2.84 to 5.95 and identified that no samples were below the critical value of  $pH_{OX} < 2.5$ . The  $pH_{INC}$  data ranged from 4.46 to 5.54 and identified that no samples on incubation declined below the critical values of  $pH < 4$ .

#### 14.3.2. Acid base accounting

The acid base accounting data is provided in Table 14-4 and summarised in Figure 14-6.

##### Chromium reducible sulfur

Chromium reducible sulfur values ranged from 0.0 to 0.01 % $S_{CR}$  and sulfidic materials were detected in all profiles at the limits of detection.

##### Titrateable actual acidity

Titrateable actual acidity values ranged from 15.63 to 32.20 mole  $H^+$ /tonne and were detected in all profiles.

##### Retained acidity

Retained acidity was measured in the subsurface layer of Profile 5 as 1.40 mole  $H^+$ /tonne and for the remaining layers it was not measured as all samples had a  $pH_{KCl}$  of greater than 4.5.

##### Acid neutralising capacity

Acid neutralising capacity values were not measured in any of the samples, as none of the samples had a  $pH_{KCl}$  higher than 6.5.

##### Net acidity

Net acidity values ranged from 16 to 37 mole  $H^+$ /tonne. All samples had moderate or low net acidity values.

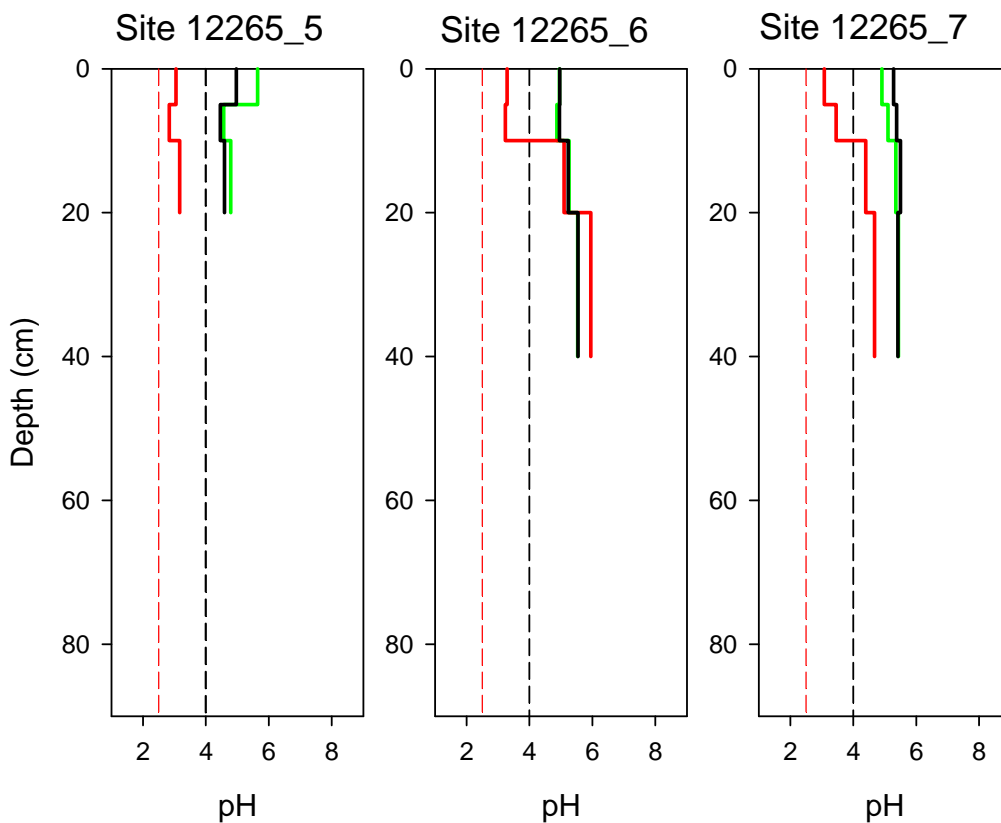


Figure 14-5. Depth profiles of soil pH for Overland Corner (Wetland ID. 12265), showing soil pH ( $pH_W$  as green line), peroxide treated pH ( $pH_{OX}$  as red line) and incubation pH ( $pH_{INC}$  after 8 weeks as black line). Critical  $pH_W$  and  $pH_{INC}$  value of 4 (black dashed line) and critical  $pH_{OX}$  value of 2.5 (red dashed line).

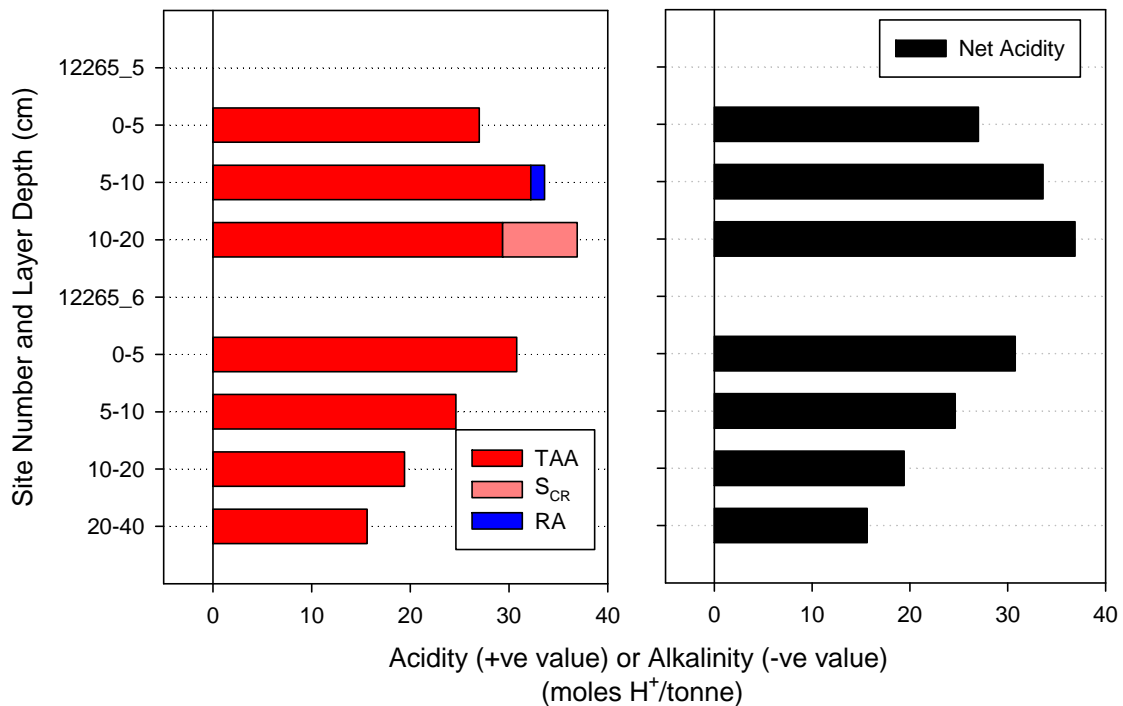


Figure 14-6. Acid base accounting depth profiles for Overland Corner (Wetland ID. 12265). Left side shows the components: Titratable actual acidity (TAA - red bar), acid generating potential (AGP as  $S_{CR}$  - pink bar), and retained acidity (RA - blue bar), and right side shows net acidity.

### 14.3.3. Water soluble sulfate

Water soluble sulfate data values shown in Table 14-4 identified no surface layers that were above the criterion trigger value of 100 mg/kg SO<sub>4</sub>.

### 14.3.4. Acid volatile sulfur

Monosulfidic material was not observed and no samples were collected for analysis.

### 14.3.5. Hydrochemistry

Water was not observed on the surface or in the soil pits and no samples were collected for analysis.

## 14.4. Discussion

Acid sulfate soil materials at Overland Corner (Wetland ID. 12265) were identified as hyposulfidic occurring in different layers for all profiles and the remaining samples were characterised as either other soil materials or other acidic. The acid sulfate soil subtype class identified was Other Soil (clayey).

The soils throughout the wetland were clayey textured in the surface layers. The subsoils were clayey textured with a rigid consistence.

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

The potential hazards posed by acid sulfate soil materials at Overland Corner (Wetland ID. 12265) are:

- Acidification hazard: The data identified moderate or low net acidity values in all samples but 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 was no potential for monosulfidic materials to form in the surface layers of all soils, monosulfidic material was not observed. There is a low level of concern.
- Metal mobilisation: The low to medium acidification hazard indicates that soil acidification potential is not likely to increase the solubility of metals. There is a low level of concern.

### Summary of key findings Overland Corner (Wetland ID. 12265):

<b>Soil materials:</b>	The soil profiles contained at least one layer of hyposulfidic soil material. Soils were clayey textured at the surface and clayey textured in the subsoil. All layers had moderate or low net acidity values and pH values did not indicated a potential for acidification due to oxidation.
<b>Acid sulfate soil identification:</b>	<ul style="list-style-type: none"><li>• Other Soil (clayey) – occurring throughout the wetland. Dominant (&gt;50%) in extent.</li></ul>
<b>Hazard assessment</b>	<ul style="list-style-type: none"><li>• Acidification hazard – low to medium level of concern</li><li>• De-oxygenation hazard – low level of concern</li><li>• Metal mobilisation hazard – low level of concern</li></ul>

**Table 14-2. Site description data for Overland Corner (Wetland ID. 12265).**

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	439607	6219579	not reached	cracking, rigid	lignum	mid elevation, near margin
6	4/05/2010	439687	6215598	not reached	sealed, rigid	lignum	low elevation
7	4/05/2010	439763	6219611	not reached	sealed, rigid	lignum	low elevation

**Table 14-3. Soil profile description data for Overland Corner (Wetland ID. 12265).**

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	light brownish grey (10YR6/2)	clay	dry		subangular blocky	rigid	
5_2	5 - 10	small pit	light brownish grey (10YR6/2)	clay	dry	5% brownish yellow infused into the matrix adjacent to pores	subangular blocky	rigid	
5_3	10 - 20	small pit	light brownish grey (10YR6/2)	clay	dry	5% brownish yellow infused into the matrix adjacent to pores	columnar	rigid	too rigid to dig below
6_1	0 - 5	small pit	greyish brown (10YR5/2)	clay	dry		angular blocky	rigid	
6_2	5 - 10	small pit	greyish brown (10YR5/2)	clay	dry		angular blocky	rigid	
6_3	10 - 20	small pit	grey (10YR5/1)	clay	dry	5% brownish yellow infused into the matrix adjacent to pores	columnar	rigid	
6_4	20 - 40	small pit	grey (10YR5/1)	clay	dry	5% brownish yellow infused into the matrix adjacent to pores	columnar	rigid	too rigid to dig below
7_1	0 - 5	small pit	greyish brown (10YR5/2)	clay	dry		angular blocky	rigid	
7_2	5 - 10	small pit	greyish brown (10YR5/2)	clay	dry		angular blocky	rigid	
7_3	10 - 20	small pit	greyish brown (10YR5/2)	clay	dry	5% strong brown In the matrix	columnar	rigid	
7_4	20 - 40	small pit	greyish brown (10YR5/2)	clay	moist	5% strong brown In the matrix	columnar	rigid	too rigid to dig below

**Table 14-4. Laboratory data for acid sulfate soil assessment of Overland Corner (Wetland ID. 12265).**

(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 <sub>4</sub> /kg)	pH KCl	Titrateable Actual Acidity (mole H <sup>+</sup> /tonne)	Chromium Reducible Sulfur (%S <sub>CR</sub> )	Retained Acidity (mole H <sup>+</sup> /tonne)	Acid Neutralising Capacity (%CaCO <sub>3</sub> )	Net Acidity (mole H <sup>+</sup> /tonne)	Acid Sulfate Soil Material Classification
5.1	0-5	Fine	685	5.64	3.05	6.30	4.97	44	5.31	27.00	<0.01	..	..	27	other acidic incubation
5.2	5-10	Fine	592	4.57	2.84	4.92	4.46	24	4.36	32.20	<0.01	1.40	..	34	other acidic
5.3	10-20	Fine	745	4.79	3.17	5.19	4.59	30	4.68	29.36	0.01	..	..	37	hyposulfidic (S <sub>CR</sub> <0.10%)
6.1	0-5	Fine	441	4.95	3.29	5.20	4.96	13	4.74	30.78	<0.01	..	..	31	other acidic
6.2	5-10	Fine	587	4.87	3.23	5.45	4.95	15	4.64	24.63	<0.01	..	..	25	other acidic
6.3	10-20	Fine	717	5.26	5.10	5.85	5.23	27	4.95	19.42	<0.01	..	..	19	other acidic incubation
6.4	20-40	Fine	2121	5.53	5.95	5.94	5.54	37	5.23	15.63	<0.01	..	..	16	other soil material
7.1	0-5	Fine	1771	4.91	3.08	5.85	5.28	65	4.95	23.68	<0.01	..	..	24	other acidic incubation
7.2	5-10	Fine	1050	5.10	3.46	5.86	5.38	30	4.88	22.73	<0.01	..	..	23	other soil material
7.3	10-20	Fine	678	5.35	4.40	6.54	5.50	13	5.02	18.47	<0.01	..	..	18	other soil material
7.4	20-40	Fine	1134	5.43	4.68	5.97	5.42	15	5.17	15.63	<0.01	..	..	16	other acidic incubation

## 15. OVERLAND CORNER (WETLAND ID. 12272)

### 15.1. Location and setting description

Overland Corner (Wetland ID. 12272) is situated on the north eastern side of the River Murray, adjacent to the settlement of Overland Corner and about 4 kilometres down river from Lock 3, located in the Overland Corner Complex area. The wetland is somewhat rectangular in shape. It is about 1 kilometre in length and about 250 metres at it's widest, with a total surface area of 19 hectares. The wetland is bounded by a raised floodplain that separates it from other wetlands and the river and to the north a steep hill slope separates it from farmland. The other associated wetlands in the Overland Corner Complex that were surveyed are Wetland IDs. 12132, 12133 and 12265..

The wetland is temporarily connected to the river and only receives water when pumped. Pumping events were in 2006, 2009 and 2010 to bank full. At the time when the soil survey was conducted in May 2010 the wetland did not have surface water. The wetland is managed by the National Trust of SA and private landholders with the assistance of the South Australian Murray-Darling Basin Natural Resources Management Board (SA MDB NRM Board) and BBLAP since 2003. Salt bush was growing along and in parts of the wetland, with open woodland and shrubland on the surrounding higher floodplain. Four sites were sampled as shown in Figure 15-1.

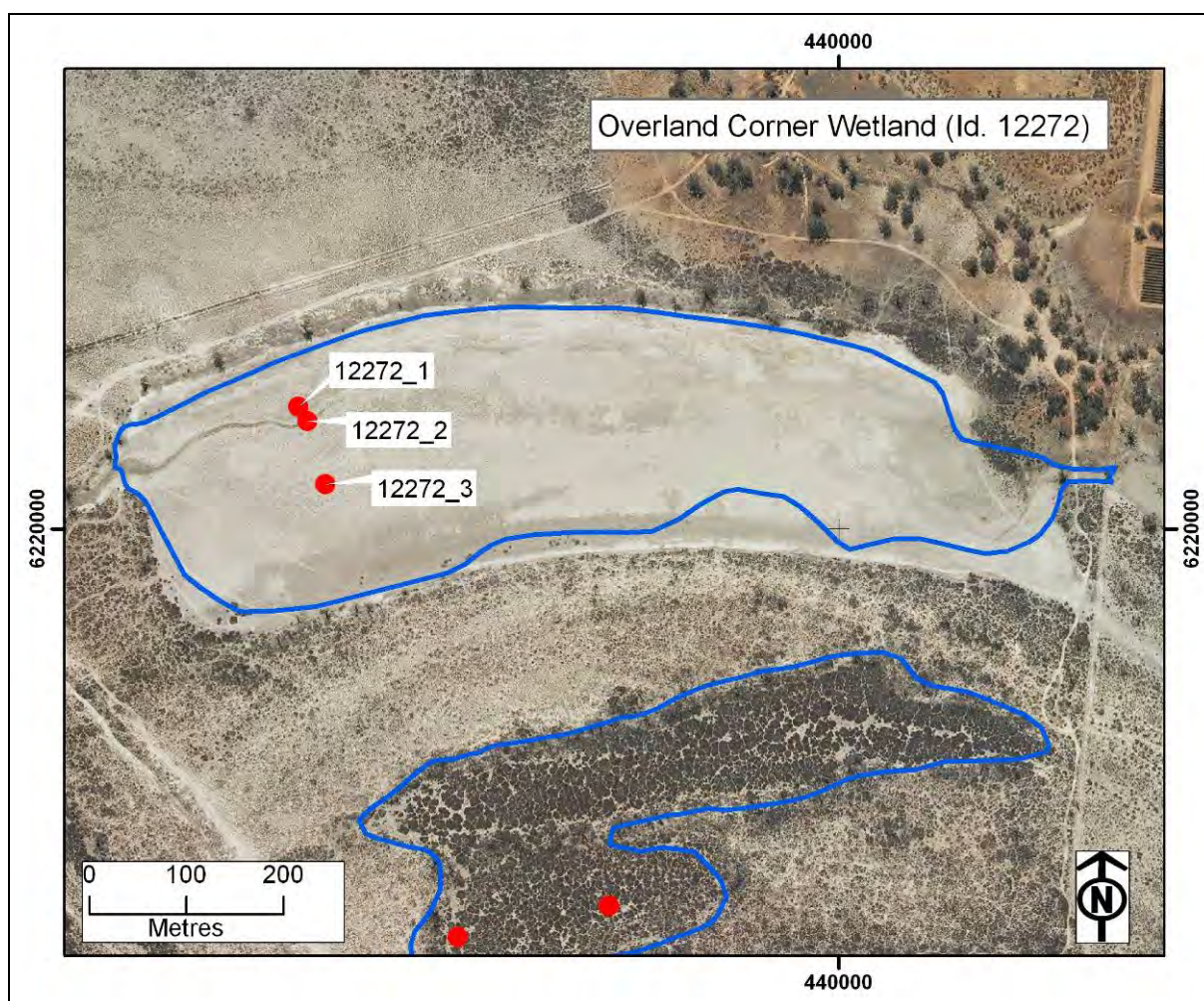


Figure 15-1. Overland Corner (Wetland ID. 12272) and sample site locations.

## 15.2. Soil profile description and distribution

Four sites were described and sampled. The soil subtypes and general location descriptions are presented in Table 15-1. Sites were distributed along one transect at the western end with sites located based on change in soil surface condition (Sites 1, 2 and 3), and a single site placed into the channel at the western end of the wetland where there was water back up behind the control structure. The site and soil profile descriptions are presented in Table 15-2 and Table 15-3, and a conceptual cross-section diagram in Figure 15-2.

### Western transect

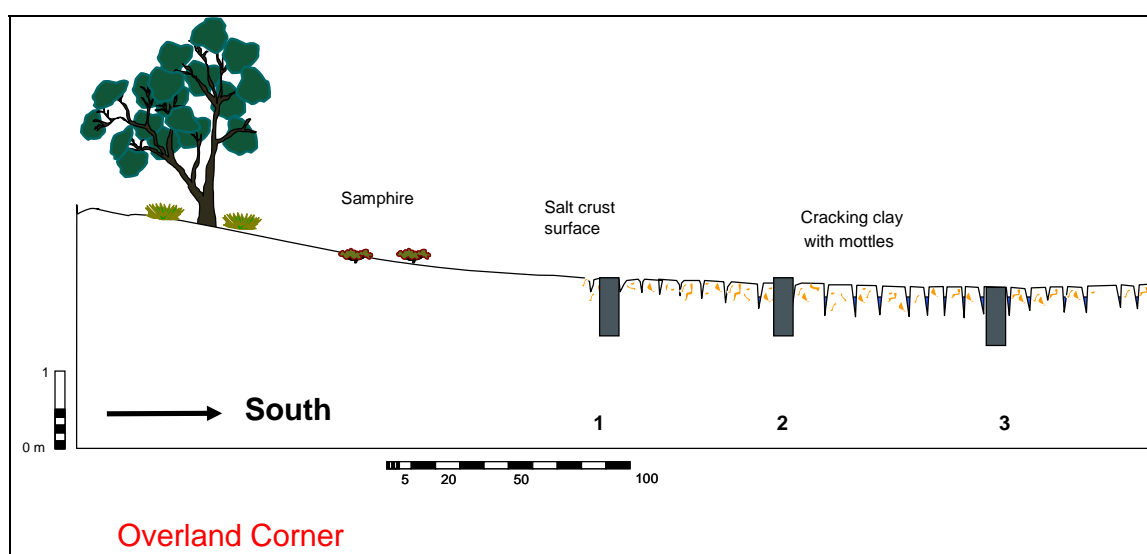
Site 1 (Figure 15-3) occurred on the margin where the surface was cracking, and the soil consisted of a light brownish grey, rigid, clay. Site 2 (Figure 15-4) occurred at low elevation near in a shallow dry channel, and the soil consisted of a light brownish grey, very firm, clay over a dark grey, very firm, clay. Site 3 (Figure 15-5) occurred where there was plant material on the cracking clay surface, and the soil consisted of a light brownish grey, rigid, clay.

### Channel site

Site 4 (Figure 15-6) occurred in the channel where there was a structure on the inlet to the river where there was surface water back up (10 cm deep), and the soil consisted of a black, very weak, mucky clay with monosulfidic material, over a grey, very firm, clay.

**Table 15-1. Soil identification, subtype and general location description for Overland Corner (Wetland ID. 12272).**

Wetland and Site ID	Easting zone 54H	Northing zone 54H	Acid sulfate soil subtype class	General location description
12272_1	439443	6220126	Other Soil (clayey)	mid elevation, side of wetland
12272_2	439452	6220111	Other Soil (clayey)	low elevation, in shallow dry channel
12272_3	439471	6220046	Other Soil (clayey)	mid elevation
12272_4	439173	6220019	Subaqueous Soil (clayey)	in channel, 1 m from shoreline



**Figure 15-2. Conceptual cross-section diagram, showing locations for Sites 1, 2 and 3.**



**Figure 15-3. Photographs of Site 1, showing the site location on the margin, and the soil profile with salt on the surface and cracking.**



**Figure 15-4. Photographs of Site 2, showing the site location where the surface is cracking, and the soil profile with salt efflorescences coating the surface aggregates.**



**Figure 15-5. Photographs of Site 3, showing the site location near the wetland centre, and the soil profile with cracking soil.**





Figure 15-6. Photographs of Site 4, showing the site location in on the side of the channel where water is backed up behind the structure.

### 15.3. Laboratory data assessment

#### 15.3.1. Soil pH testing ( $pH_W$ , $pH_{OX}$ , $pH_{INC}$ )

The pH data are provided in Table 15-4 and pH profiles are presented in Figure 15-7. The  $pH_W$  data ranged from 5.60 to 8.53 and sulfuric materials with a  $pH_W < 4$  were not identified. The  $pH_{OX}$  data ranged from 3.41 to 8.29 and identified that no samples were below the critical value of  $pH_{OX} < 2.5$ . The  $pH_{INC}$  data ranged from 5.46 to 7.86 and identified that no samples on incubation declined below the critical values of  $pH < 4$ .

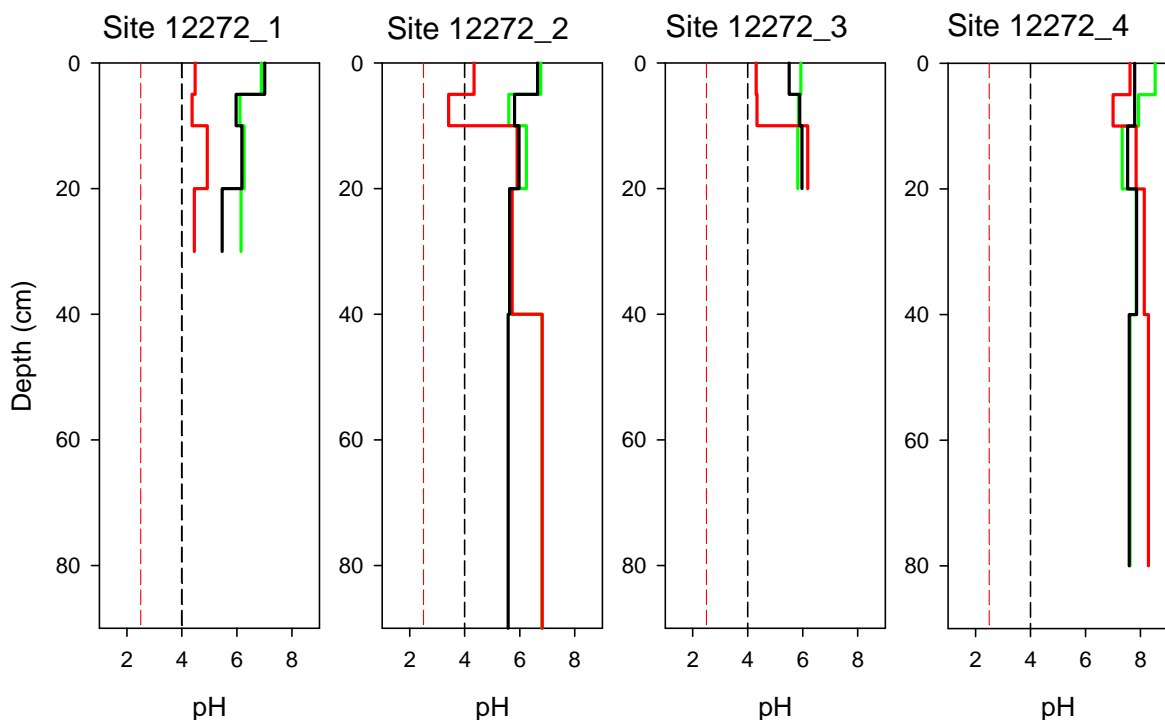


Figure 15-7. Depth profiles of soil pH for Overland Corner (Wetland ID. 12272), showing soil pH ( $pH_W$  as green line), peroxide treated pH ( $pH_{OX}$  as red line) and incubation pH ( $pH_{INC}$  after 8 weeks as black line). Critical  $pH_W$  and  $pH_{INC}$  value of 4 (black dashed line) and critical  $pH_{OX}$  value of 2.5 (red dashed line).

### 15.3.2. Acid base accounting

The acid base accounting data is provided in Table 15-4 and summarised in Figure 15-8.

#### Chromium reducible sulfur

Chromium reducible sulfur values ranged from 0.0 to 0.07 %S<sub>CR</sub> and sulfidic materials were detected in all profiles.

#### Titratable actual acidity

Titratable actual acidity values ranged from 0.00 to 18 mole H<sup>+</sup>/tonne and were detected in Profiles 1, 2 and 4.

#### Retained acidity

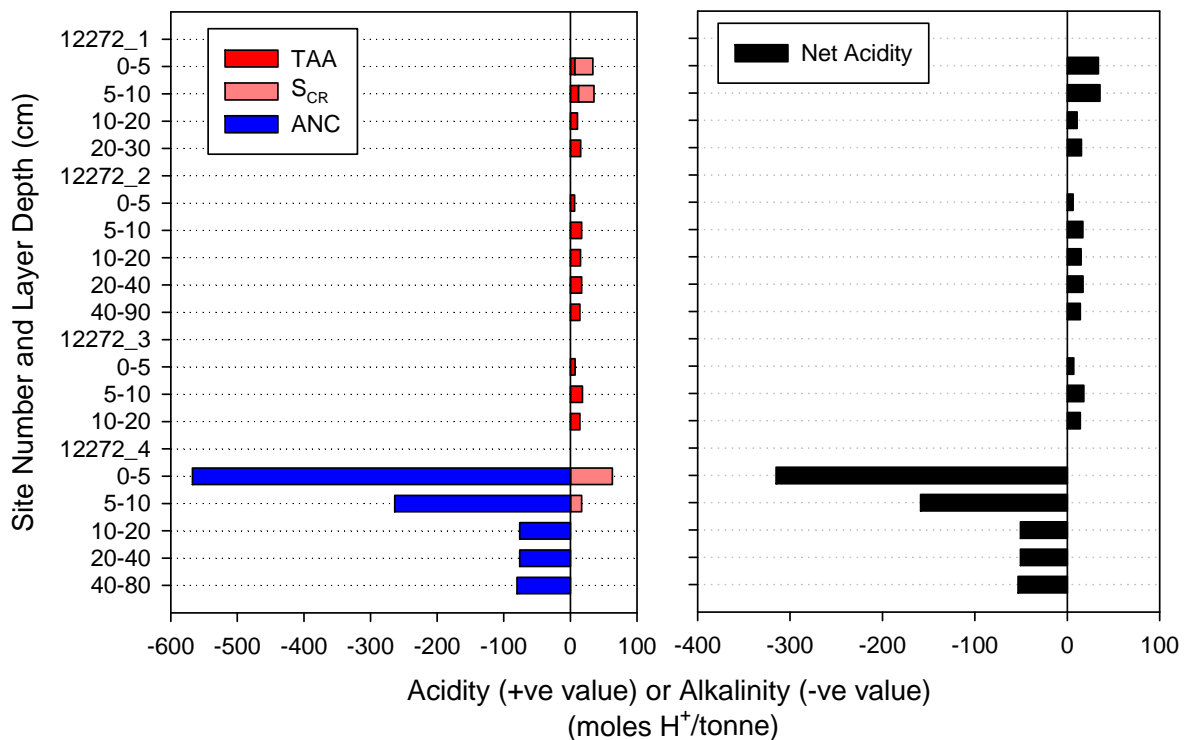
Retained acidity was not measured in any of the layers as all samples had a pH<sub>KCl</sub> of greater than 4.5.

#### Acid neutralising capacity

Acid neutralising capacity values ranged from 0.00 to 2.84 %CaCO<sub>3</sub> and were measured in all layers of Profile 4.

#### Net acidity

Net acidity values ranged from -315 to 35 mole H<sup>+</sup>/tonne. Profiles 1, 2 and 3 had low or moderate values and Profile 4 had negative values in all layers.



**Figure 15-8. Acid base accounting depth profiles for Overland Corner (Wetland ID. 12272). Left side shows the components: Titratable actual acidity (TAA - red bar), acid generating potential (AGP as S<sub>CR</sub> - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.**

### 15.3.3. Water soluble sulfate

Water soluble sulfate data values shown in Table 15-4 identified Profile 2 surface layers that were above the criterion trigger value of 100 mg/kg SO<sub>4</sub>.

### 15.3.4. Acid volatile sulfur

Monosulfidic materials were observed in the upper layer of Profiles 4 and sampled for analysis. The values shown in Table 15-4 were all above S<sub>AV</sub> ≥0.01% S, the criteria value for identifying monosulfidic material.

### 15.3.5. Hydrochemistry

One surface water was collected from a narrow channel close to the river in an area where monosulfidic materials were present. Field parameters are shown in Table 15-5. The water had moderately alkaline pH and was relatively saline. Dissolved oxygen was present and the waters had very high turbidity. It was noted at the time of sampling that a green algae was present on the soil and that the water had a green tinge. Alkalinity was high.

The surface water was of Na-Cl type (Table 15-6, Figure 15-9). Sulfate concentration in the surface water was high at 120 mg l<sup>-1</sup>. The SO<sub>4</sub>/Cl ratio in the surface water (0.018) was much lower than seawater (0.142). For the nutrients, NH<sub>4</sub> and PO<sub>4</sub> concentrations were significantly above ANZECC Guideline values. For the trace metals, Al, Co, Cu, Ni and Zn were elevated. Arsenic concentrations were particularly high at 160 µg l<sup>-1</sup>. Organic C concentrations was also very high.

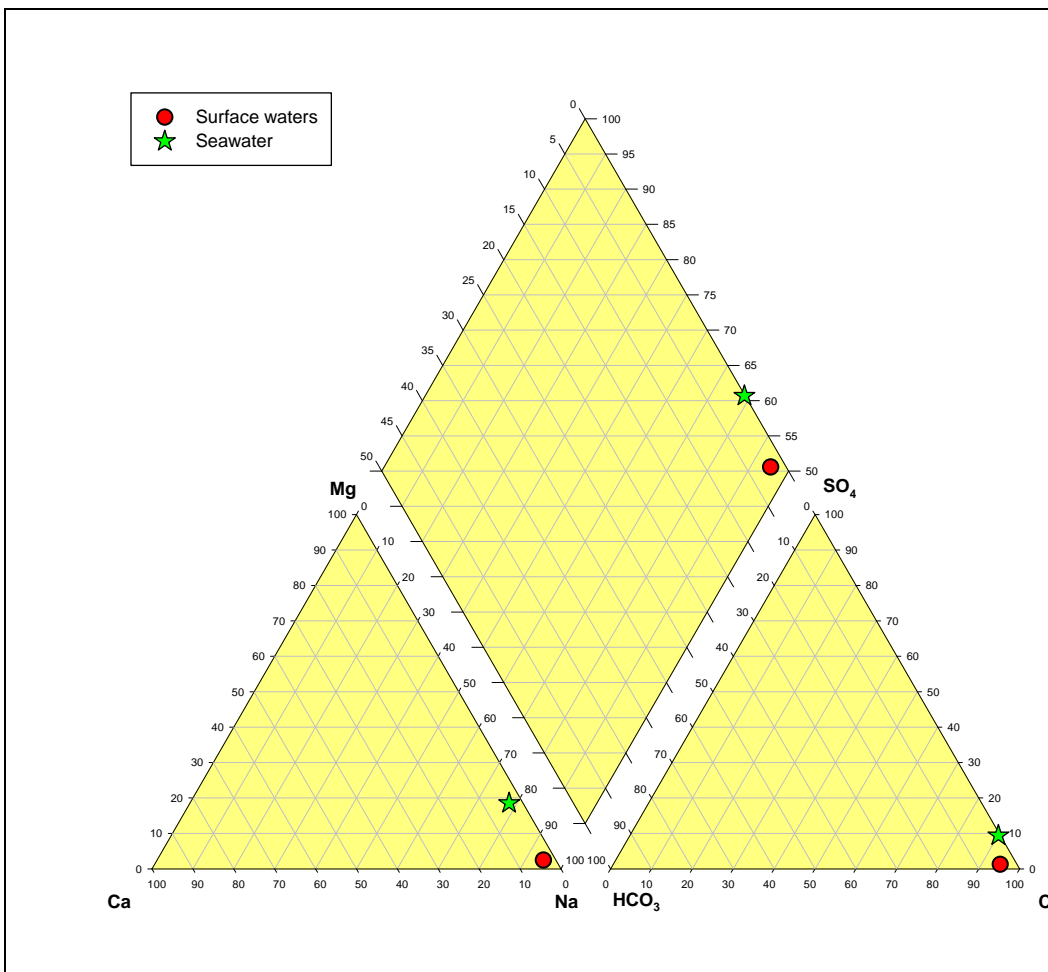


Figure 15-9. Piper diagram of hydrochemical data for Overland Corner (Wetland ID. 12272).

## 15.4. Discussion

Acid sulfate soil materials at Overland Corner (Wetland ID. 12272) were identified as hyposulfidic in the surface soil layers and the remaining samples were characterised as other soil materials. The acid sulfate soil subtype classes identified were Subaqueous Soil (clayey) that occurred at the inlet channel where surface water had accumulated and Other Soil (clayey) that occurred throughout the wetland.

The soils throughout the wetland were dominantly clayey textured in the surface layers. The subsoils were clayey with a rigid consistence.

Monosulfidic material was observed in Profile 4 and except for this profile the water soluble sulfate data identified that surface layers elsewhere were not in excess of the 100mg/L trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials at Overland Corner (Wetland ID. 12272) are:

- Acidification hazard: The data identified low or moderate net acidity values in 3 of the 4 profiles but 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 was one profile with potential for monosulfidic materials to form in the surface layers of all soils, monosulfidic material was observed for an isolated area. There is a medium level of concern.
- Metal mobilisation: The low to medium acidification hazard indicates that soil acidification potential is not likely to increase the solubility of metals. There is a low level of concern.

### Summary of key findings Overland Corner (Wetland ID. 12272):

<b>Soil materials:</b>	The soil surface layers were hyposulfidic and the subsoil layers generally were characterised as other soil materials. Soils were clayey textured at the surface and clayey textured in the subsoil. Subsoil layers had low or moderate net acidity values and pH values did not indicated a potential for acidification due to oxidation.
<b>Acid sulfate soil identification:</b>	<ul style="list-style-type: none"> <li>• Subaqueous Soil (clayey) – occurring where there was accumulated water in the inlet channel. Isolated (&lt;10%) in extent.</li> <li>• Other Soil (clayey) – occurring throughout the wetland. Dominant (&gt;50%) in extent.</li> </ul>
<b>Hazard assessment</b>	<ul style="list-style-type: none"> <li>• Acidification hazard – low to medium level of concern</li> <li>• De-oxygenation hazard – medium level of concern</li> <li>• Metal mobilisation hazard – low level of concern</li> </ul>

**Table 15-2. Site description data for Overland Corner (Wetland ID. 12272).**

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	439443	6220126	not reached	cracking, rigid	dead plant material	mid elevation, side of wetland
2	4/05/2010	439452	6220111	not reached	cracking	bare	low elevation, in shallow dry channel
3	4/05/2010	439471	6220046	not reached	cracking, rigid	dead plant material	mid elevation
4	4/05/2010	439173	6220019	10	soft	water	in channel, 1 m from shoreline

**Table 15-3. Soil profile description data for Overland Corner (Wetland ID. 12272).**

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	light brownish grey (10YR6/2)	clay	dry		angular blocky	rigid	
1_2	5 - 10	small pit	light brownish grey (10YR6/2)	clay	dry	3% red infused into the matrix adjacent to pores	angular blocky	rigid	
1_3	10 - 20	small pit	light brownish grey (10YR6/2)	clay	dry	5% red infused into the matrix adjacent to pores	angular blocky	rigid	
1_4	20 - 30	small pit	light brownish grey (10YR6/2)	clay	dry		angular blocky	rigid	too rigid to auger below
2_1	0 - 5	small pit	light brownish grey (10YR6/2)	clay	dry		angular blocky	very firm	
2_2	5 - 10	small pit	greyish brown (10YR5/2)	clay	dry	5% red infused into the matrix adjacent to pores	subangular blocky	rigid	
2_3	10 - 20	small pit	greyish brown (10YR5/2)	clay	dry	10% red infused into the matrix adjacent to pores	subangular blocky	very firm	
2_4	20 - 40	small pit	dark grey (10YR4/1)	clay	dry	20% red infused into the matrix adjacent to pores	subangular blocky	very firm	
2_5	40 - 90	push tube	olive grey (5Y5/2)	clay	dry		massive	very firm	
3_1	0 - 5	small pit	light brownish grey (10YR6/2)	clay	dry		angular blocky	rigid	few salts on ped faces
3_2	5 - 10	small pit	light brownish grey (10YR6/2)	clay	dry		subangular blocky	rigid	
3_3	10 - 20	small pit	light brownish grey (10YR6/2)	clay	dry		columnar	rigid	too rigid to dig below
4_W1	10 - 0	surface water							water sampled
4_1	0 - 5	small pit	black (2.5Y2/0)	mucky clay	wet		gel	very weak	
4_2	5 - 10	small pit	black (2.5Y2/0)	clay	wet		gel	very weak	
4_3	10 - 20	small pit	grey (5Y5/1)	clay	wet		massive	firm	
4_4	20 - 40	push tube	grey (5Y5/1)	clay	moist	5% yellowish brown In the matrix	massive	firm	
4_5	40 - 80	push tube	grey (5Y5/1)	clay	moist	5% yellowish brown In the matrix	massive	very firm	

**Table 15-4. Laboratory data for acid sulfate soil assessment of Overland Corner (Wetland ID. 12272).**

(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 <sub>4</sub> /kg)	pH KCl	Titrateable Actual Acidity (mole H <sup>+</sup> /tonne)	Chromium Reducible Sulfur (%S <sub>CR</sub> )	Acid Neutralising Capacity (%CaCO <sub>3</sub> )	Net Acidity (mole H <sup>+</sup> /tonne)	Acid Volatile Sulfur (%Sav)	Acid Sulfate Soil Material Classification
1.1	0-5	Fine	484	6.89	4.48	7.05	7.01	40	6.11	6.77	0.04	0.00	34	..	hyposulfidic (S <sub>CR</sub> <0.10%)
1.2	5-10	Fine	1764	6.11	4.37	6.12	5.97	50	5.70	12.58	0.04	..	35	..	hyposulfidic (S <sub>CR</sub> <0.10%)
1.3	10-20	Fine	1546	6.26	4.92	6.24	6.18	50	5.82	10.65	<0.01	..	11	..	other soil material
1.4	20-30	Fine	1570	6.15	4.45	5.86	5.46	48	5.52	15.49	<0.01	..	15	..	other soil material
2.1	0-5	Fine	1991	6.77	4.34	6.94	6.65	170	6.28	6.29	<0.01	0.00	6	..	other soil material
2.2	5-10	Fine	1102	5.60	3.41	6.10	5.81	100	5.44	16.94	<0.01	..	17	..	other soil material
2.3	10-20	Fine	1497	6.24	5.90	5.81	5.97	210	5.57	15.16	<0.01	..	15	..	other soil material
2.4	20-40	Fine	28200	5.68	5.72	5.78	5.63	1300	5.26	17.05	<0.01	..	17	..	other soil material
2.5	40-90	Fine	6950	6.81	6.82	6.06	5.58	570	5.32	14.21	<0.01	..	14	..	other soil material
3.1	0-5	Fine	1118	5.93	4.31	6.21	5.51	43	6.28	7.10	<0.01	0.00	6	..	other soil material
3.2	5-10	Fine	954	5.85	4.34	6.06	5.89	27	5.61	18.00	<0.01	..	18	..	other soil material
3.3	10-20	Fine	1613	5.82	6.18	6.09	5.97	72	5.68	14.21	<0.01	..	14	..	other soil material
4.W1	10-0														
4.1	0-5	Fine	3150	8.53	7.62	7.56	7.79	72	8.10	0.00	0.10	2.84	-315	0.03	hyposulfidic (S <sub>CR</sub> ≥0.10% monosulfidic
4.2	5-10	Fine	1976	7.93	7.00	7.52	7.79	72	7.70	0.00	0.03	1.32	-159	..	hyposulfidic (S <sub>CR</sub> <0.10%)
4.3	10-20	Fine	931	7.33	7.84	8.05	7.53	23	7.39	0.00	<0.01	0.38	-51	..	other soil material
4.4	20-40	Fine	866	7.84	8.14	8.15	7.86	67	7.07	0.00	<0.01	0.38	-51	..	other soil material
4.5	40-80	Fine	1068	7.62	8.29	7.96	7.59	93	6.73	0.00	<0.01	0.40	-53	..	other soil material

**Table 15-5. Summary of hydrochemical field measurements for Overland Corner (Wetland ID. 12272).**

	pH	SEC µS cm <sup>-1</sup>	DO mg l <sup>-1</sup>	Eh mV	Turbidity NTU	Alkalinity as HCO <sub>3</sub>
Surface waters (n=1)	8.44	19466	5.26	-53	533	491

**Table 15-6. Summary of hydrochemical field measurements for Overland Corner (Wetland ID. 12272).**

Parameter	units	ANZECC Guidelines	Site 4 (SW)
Na	mg l <sup>-1</sup>		3590
K	mg l <sup>-1</sup>		8.7
Ca	mg l <sup>-1</sup>		102
Mg	mg l <sup>-1</sup>		49.5
Si	mg l <sup>-1</sup>		3.74
Br	mg l <sup>-1</sup>		24.0
Cl	mg l <sup>-1</sup>		6700
NO <sub>3</sub>	mg l <sup>-1</sup>	0.7	<0.022
NH <sub>4</sub> -N <sup>K</sup>	mg l <sup>-1</sup>	0.01	<b>0.31</b>
PO <sub>4</sub> -P <sup>E</sup>	mg l <sup>-1</sup>	0.005	<b>2.63</b>
SO <sub>4</sub>	mg l <sup>-1</sup>		120
Ag	µg l <sup>-1</sup>	0.05	0.01
Al <sup>A</sup>	µg l <sup>-1</sup>	55	<b>460</b>
As <sup>B</sup>	µg l <sup>-1</sup>	13	<b>160</b>
Cd	µg l <sup>-1</sup>	0.2	0.04
Co	µg l <sup>-1</sup>	2.8	<b>3.98</b>
Cr <sup>C</sup>	µg l <sup>-1</sup>	1	0.6
Cu <sup>H</sup>	µg l <sup>-1</sup>	1.4	<b>4.8</b>
Fe	µg l <sup>-1</sup>	300	<100
Mn	µg l <sup>-1</sup>	1700	102.2
Ni <sup>H</sup>	µg l <sup>-1</sup>	11	<b>29.6</b>
Pb <sup>H</sup>	µg l <sup>-1</sup>	3.4	0.4
Se	µg l <sup>-1</sup>	11	1.8
Zn <sup>H</sup>	µg l <sup>-1</sup>	8	<b>34</b>
DOC	mg l <sup>-1</sup>		646

**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<sub>4</sub> and PO<sub>4</sub>, 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.

- <sup>A</sup> Trigger value for Aluminium in freshwater where pH > 6.5.
- <sup>B</sup> Trigger value assumes As in solution as Arsenic (AsV).
- <sup>C</sup> Trigger value for Chromium is applicable to Chromium (CrVI) only.
- <sup>E</sup> Guideline is for filterable reactive phosphorous (FRP).
- <sup>H</sup> Hardness affected (refer to Guidelines).
- <sup>K</sup> Guideline for South-east Australia-Freshwater Lakes and reservoirs.