8.3. Yallakool Creek

8.3.1. Location and setting description

Yallakool Creek diverges from the Edward River ~21 km downstream of Deniliquin, and just 1 km upstream of the diffluence of Colligen Creek from the Edward (Figure 8-53). Yallakool Creek begins by flowing back 'upstream' along a reach of the palaeo-Edward, before leaving this meander belt and heading in a westerly direction, and incising into an older Shepparton surface. Approximately 19 km downstream, the Yallakool is joined by tributaries from the north, and flows across a more recent surface, with some forested areas, before, ~34 km from the start, joining the Wakool, with which it has gradually converged over its course.

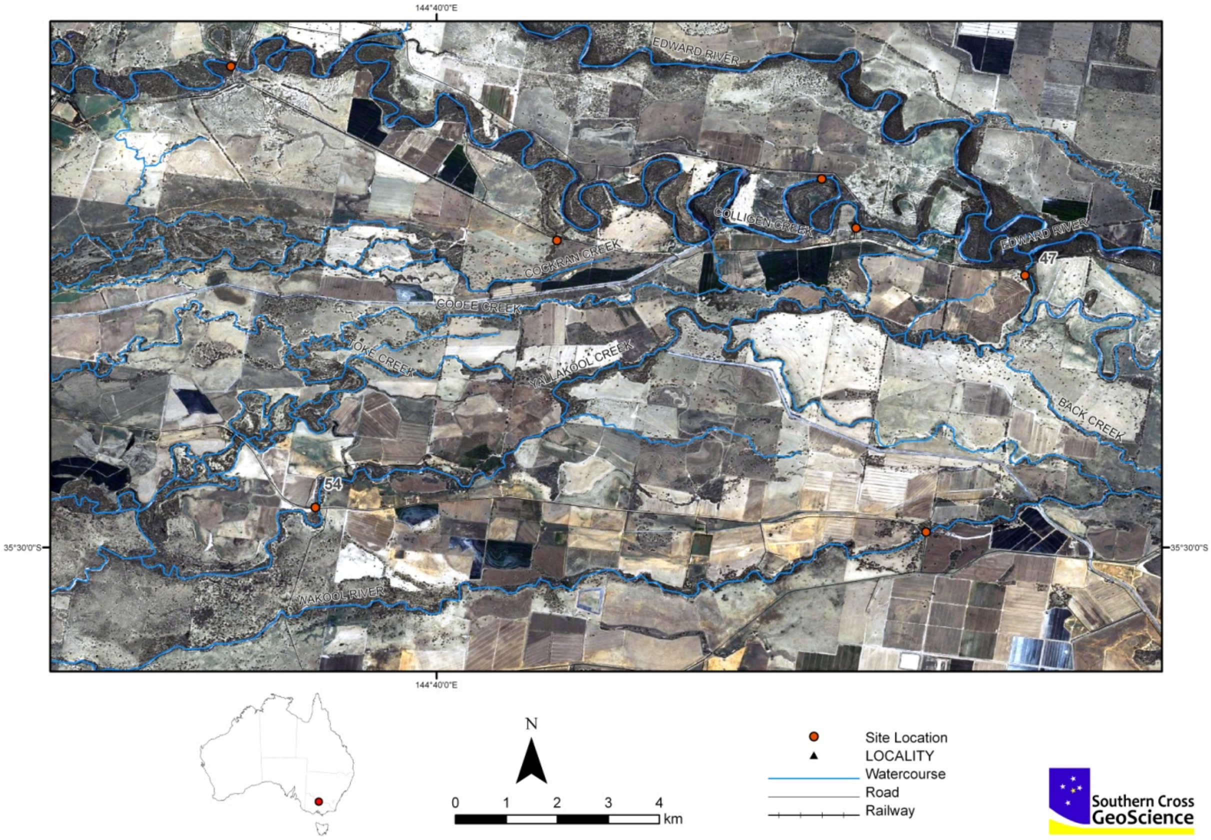

Figure 8-53. Yallakool Creek and sample site locations.

8.3.2. Soil profile description and distribution

Two sites were described and sampled in Yallakool Creek. The soil subtype and general location description are presented in Table 8-9. Profile description data are presented in Table 8-12.

Table 8-9. Soil identification, subtype and general location description for sites sampled in Yallakool Creek.

Site ID	Easting UTM Zone 55H	Northing UTM Zone 55H	Acid sulfate soil subtype class
WC_47	287661	6074545	Subaqueous Soil
WC_54	286405	6069740	Subaqueous Soil

Figure 8-54. Photographs of site WC_47 Yallakool Creek, showing the site and the soil profile.

Figure 8-55. Photographs of site WC_54 Yallakool Creek, showing the site and the soil core.

8.3.3. Laboratory data assessment

Soil pH testing (pH_W, pH_{FOX}, pH_{KCl}, $pH_{INCUBATION}$)

The pH data are provided in Table 8-10 and depth profiles of soil pH for both sites sampled are presented in Figure 8-56. The pH_W values ranged between 4.98 and 6.67. The pH_{FOX} values ranged between 1.88 and 4.19. The pH_{FOX} results indicate that all except one of the surface soils may have the potential to acidify to pH < 4 as a result of sulfide oxidation. One soil material had a pH_{FOX} < 2.5 suggesting that soil acidity problems will emerge when this soil is exposed to air. The S_{CR} data shows none of the eight layers examined contained detectable sulfide (i.e. S_{CR} ≥ 0.01% S). The pH_{KCl} values ranged between 4.44 and 7.38. Other acidic soil materials were identified throughout the profile at both sites, indicating acidity in the soil profile at levels where aluminium may mobilise.

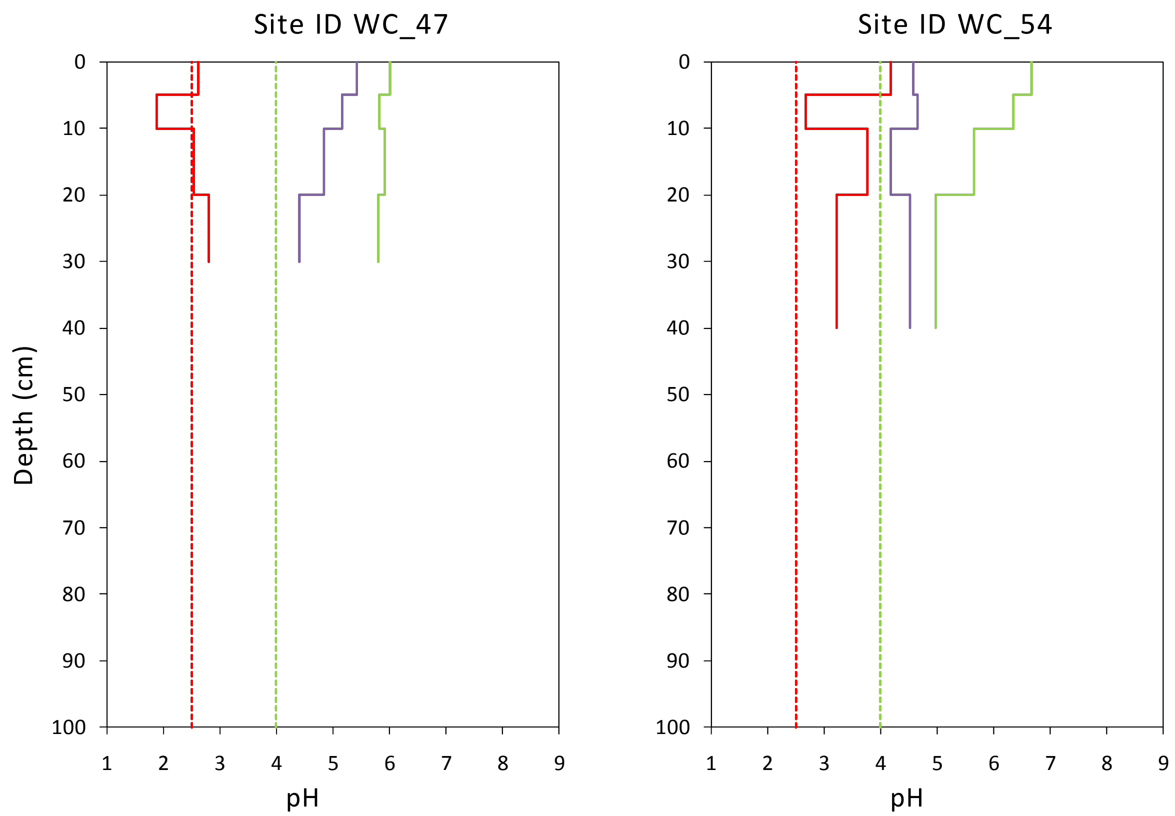

Figure 8-56. Depth profiles of soil pH for sites in Yallakool Creek, showing soil pH (pH_W as green line), peroxide treated pH (pH_{FOX} as red line) and ageing pH ($pH_{incubation}$ after at least 8 weeks as purple line). Critical pH_W and $pH_{incubation}$ value of 4 (green dashed line) and critical pH_{FOX} value of 2.5 (red dashed line).

Acid-base accounting

The acid-base accounting data is provided in Table 8-10 and summarised in Figure 8-57.

Chromium reducible sulfur

Sulfidic soil materials (i.e. S_{CR} ≥ 0.01% S) were not found within Yallakool Creek.

Acid volatile sulfide

Monosulfidic soil materials (i.e. S_{AV} ≥ 0.01% S) were not found within Yallakool Creek.

Acid neutralising capacity

All soil materials had no acid neutralising capacity (ANC) except for one surface layer (WC_54) with 1.35% $CaCO_3$.

Titratable actual acidity

The titratable actual acidity (TAA) ranged between zero and 12 mole H^+/tonne. A slight increase in the TAA with depth was observed at both sites.

Retained acidity

All soil materials had no retained acidity.

Net acidity

Net acidity ranged between -179 and 12 mole H^+/tonne.

Water Soluble Sulfate

The water soluble sulfate in the surface soils (i.e. 0-20 cm) ranged between 30 and 100 mg SO_4/kg. A surface soil layer at one of the sites (i.e. WC_54) had a soluble sulfate content equal to the 100 mg/kg trigger value for MBO formation potential.

Water Data

The surface water data measured in the field are presented in Table 8-11. The field pH of the surface waters collected was 6.7 and 6.8, with neither site being outside the most relevant ANZECC/ARMCANZ (2000) trigger values for aquatic ecosystems of 6.5 and 8.0. The water data indicates that the surface water has not been affected by acidification. Dissolved oxygen and turbidity values were found to be outside the most relevant ANZECC/ARMCANZ (2000) guideline value.

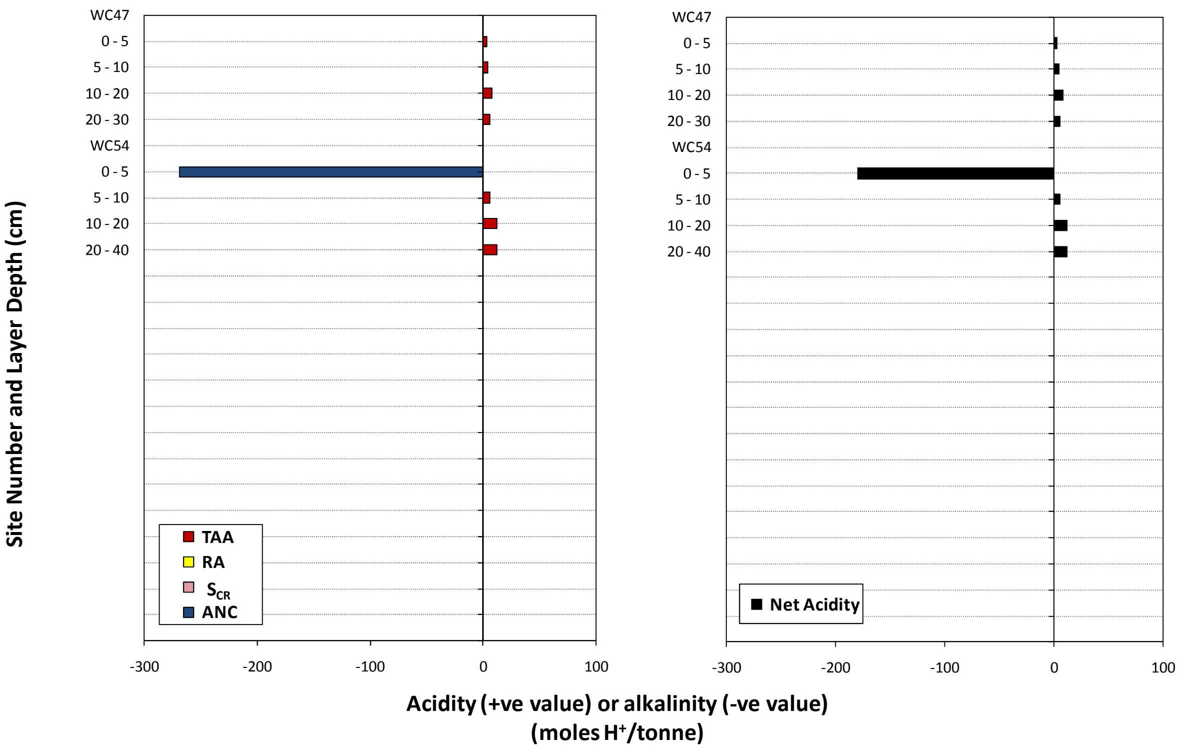

Figure 8-57. Acid-base accounting depth profiles for sites in Yallakool Creek. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), acid neutralising capacity (ANC - blue bar), retained acidity (RA - yellow bar), and right side shows net acidity.

8.3.4. Discussion

Acid sulfate soil materials were not found at either of the two sites sampled in Yallakool Creek. The two sites were classified as other acidic soils. A surficial soil material at one of the sites contained soluble sulfate equal to the 100 mg/kg trigger value for MBO formation potential.

Based on the priority ranking criteria adopted by the Scientific Reference Panel of the Murray-Darling Basin Acid Sulfate Soil Risk Assessment Project, one sampling site had a high priority ranking for Phase 2 detailed assessment based on MBO formation hazard.

The potential hazards posed by acid sulfate soil materials in Yallakool Creek are:

- Acidification hazard: The data indicate that with no sulfuric or sulfidic materials that the degree of acidification hazard is low.

- Deoxygenation hazard: The soluble sulfate content of a surface soil material at one site was equal to the trigger value for MBO formation indicating the possible development of a high deoxygenation hazard at that location after prolonged wet conditions.

- Metal mobilisation: The low acidification hazard indicates that soil acidification is not likely to increase the solubility of metals. However, the potential for MBO formation identified at one site in this creek may result in a low to moderate metal release hazard depending on factors such as the potential for MBO formation and the metal loading in this creek. Soil acidity may be sufficient for mobilisation of aluminium at both sites.

Summary of key findings for Yallakool Creek:

Soil materials:	Sulfuric and sulfidic materials were not observed within this creek. Other acidic soil materials observed at both sites. Low net acidities were observed within creek.
Acid sulfate soil identification:	• No acid sulfate soil materials were recorded. Both sites were subaqueous.
Hazard assessment	• Acidification hazard - low level of concern • Deoxygenation hazard - high level of concern • Metal mobilisation hazard – low to moderate level of concern

Table 8-10. Laboratory analytical data for acid sulfate soil assessment of Yallakool Creek sites.
(red printed values indicate data results of potential concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4 / kg)	pH KCl	Titratable Actual Acidity (mole H^+/t)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H^+/t)	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/t)	Acid Volatile Sulfide (%S_{AV})	Acid Sulfate Soil Material Classification
47.1	0-5		6.01	2.62	5.43*	42.00	5.14	3.17	0.00	0.00	0.00	3.17	0.00	Other Acid Soils
47.2	5-10		5.82	1.88	5.16*	39.30	4.86	4.39	0.00	0.00	0.00	4.39	0.00	Other Acid Soils
47.3	10-20		5.92	2.54	4.85*	30.45	4.44	8.06	0.00	0.00	0.00	8.06	0.00	Other Acid Soils
47.4	20-30		5.81	2.80	4.40*	30.15	4.57	5.61	0.00	0.00	0.00	5.61	0.00	Other Acid Soils
54.1	0-5		6.67	4.19	4.58*	79.80	7.38	0.00	0.00	0.00	1.35	-179.42	0.00	Other Acid Soils
54.2	5-10		6.35	2.68	4.65*	100.05	6.35	5.68	0.00	0.00	0.00	5.68	0.00	Other Acid Soils
54.3	10-20		5.66	3.77	4.18*	39.90	4.87	11.90	0.00	0.00	0.00	11.90	0.00	Other Acid Soils
54.4	20-40		4.98	3.22	4.52*	35.85	4.54	12.12	0.00	0.00	0.00	12.12	0.00	Other Acid Soils

* Indicates that a stable pH has not yet been reached for this sample (after at least 15 weeks).

Table 8-11. Field hydrochemistry data for acid sulfate soil assessment of Yallakool Creek sites.

Site and Layer ID.	Temperature (Deg C)	Specific Electrical Conductivity (µS/cm)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	ORP (mV)	Redox potential (mV)	Turbidity (NTU)	Comment
*Lowland River**		*125-2,220*	*85-110*		*6.5-8.0*			*6-50*	
WC_47	11.4	30.3	3.1	0.34	6.70	316		557	
WC_54	11.0	37.8	68.7	7.62	6.80	287		97	

* ANZECC water quality guidelines for lowland rivers in South-east Australia are provided for relevant parameters (ANZECC/ARMCANZ, 2000).
Surface water values outside the ranges defined in the ANZECC guidelines are indicated with red text.

Table 8-12. Profile description data for acid sulfate soil assessment of the Yallakool Creek sites.

Site and Sample No.	Horizon Depth Range (cm)	Soil Colour – moist [1]	Texture Class [1]	Texture Modifiers[1]	Moisture State[1]	Redoximorphic Features Abundance (%) [2]	Redoximorphic Features – Kind [2]	Redoximorphic Features - Colour [2]	Redoximorphic Features - Location [2]	Structure - Type[1]	Structure - Grade[1]	Consistency (moist or dry) - Rupture Resistance[1]	pH (field measurement)	Comments (odour, fragments, minerals, plant material, inclusions, other)
47.1	0-5	10YR 5/3	S		W					SG	0		6.80	Fine quartz gravels common
47.2	5-10	10YR 4/4	S		W					SG	0		7.30	Fine quartz gravels common
47.3	10-20	10YR 5/1	CS		W					SG	0		7.30	Fine quartz gravels common
47.4	20-30	10YR 5/1	CS		W					SG	0		7.10	Fine quartz gravels common
54.1	0-5	5Y 4/1	SL							MA	0		7.10	
54.2	5-10	5Y 5/1	ZL							MA	0		7.10	
54.3	10-20	5Y 5/1	ZC							MA	0		7.20	
54.4	20-40	5Y 5/1	C	S						MA	0		7.30	

[1] See National Committee on Soil and Terrain (2009) for abbreviation definitions and further details.

[2] See Schoeneberger *et al.* (2002) for abbreviation definitions and further details.

8.4. Jimaringle – Cockran Creek

8.4.1. Location and setting description

The commencement of Jimaringle Creek is marked by its departure from the ancestral stream channel of Cockran Creek. Jimaringle Creek flows in a generally north-westerly direction through an older Shepparton land surface for ~27 km before joining the Niemur River (Figure 8-58). Cockran Creek diverges from Colligen Creek at a point where the Colligen departs from a broad, low sinuosity ancestral channel and turns generally to the north-west. Cockran Creek remains within this ancestral channel, and is the name given to the most obvious of the modern channels, usually dry, in a braided system occupying the breadth of this ancestral belt, which heads in a generally westerly direction for ~24 km. This ancestral channel then turns towards the north and north-west, and ~10 km later, is joined by a tributary from the east, as the dominant modern channel leaves the ancestral channel and turns to the west, in the process changing its form to the low sinuosity single channel of Jimaringle Creek.

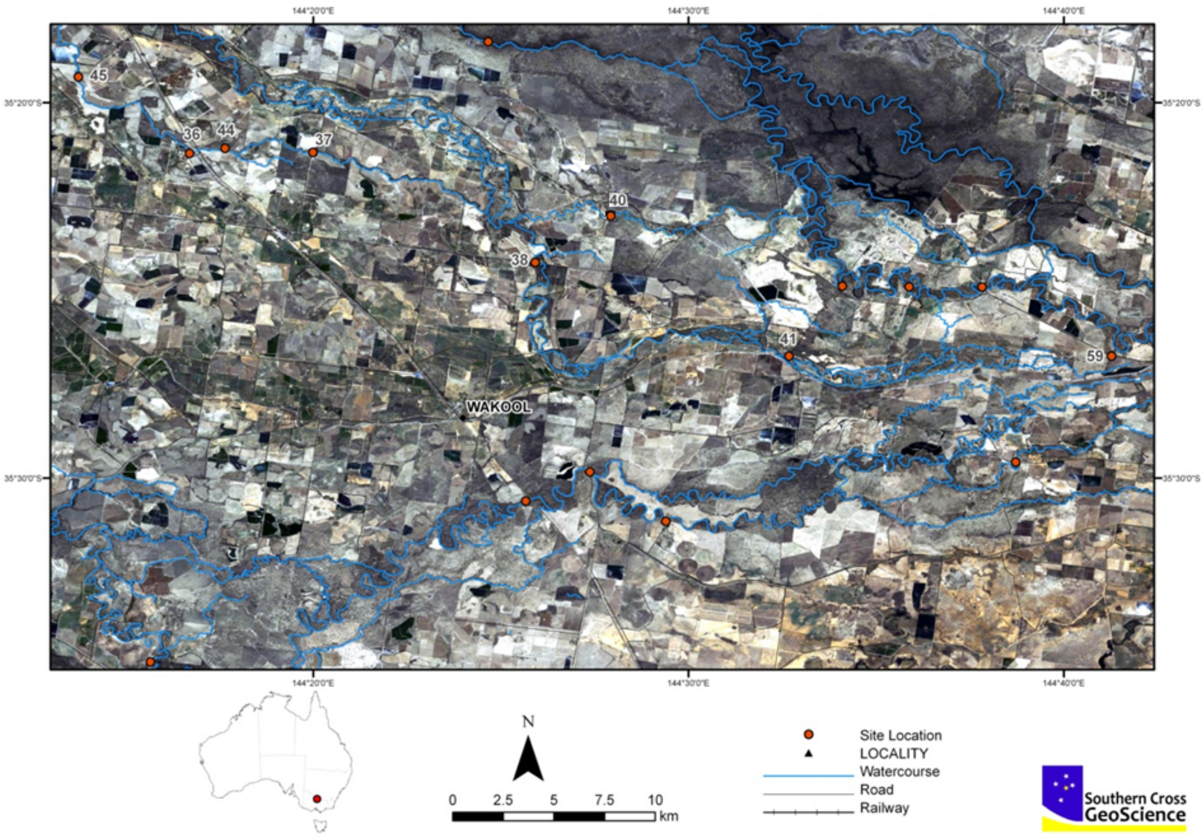

Figure 8-58. Jimaringle – Cockran Creek and sample site locations.

8.4.2. Soil profile description and distribution

Eight sites were described and sampled in Jimaringle – Cockran Creek. The soil subtype and general location description are presented in Table 8-13. Profile description data are presented in Table 8-16.

Table 8-13. Soil identification, subtype and general location description for sites sampled in Jimaringle – Cockran Creek.

Site ID	Easting UTM Zone 55H	Northing UTM Zone 55H	Acid sulfate soil subtype class
WC_36	252688	6084092	Hypersulfidic Subaqueous Soil with Monosulfides
WC_37	257674	6084280	Hypersulfidic Soil
WC_38	266785	6079092	Hydrosol
WC_40	269760	6074232	Subaqueous Soil
WC_41	277143	6074744	Hydrosol
WC_44	254118	6084386	Hypersulfidic Subaqueous Soil
WC_45	248099	6087742	Subaqueous Soil
WC_59	290150	6075056	Hydrosol

Figure 8-59. Photographs of site WC_36 Jimaringle Creek, showing the site and the soil core.

Figure 8-60. Photographs of site WC_37 Jimaringle Creek, showing the site and the soil core.

Figure 8-61. Photographs of site WC_38 Jimaringle Creek, showing the site and the soil profile.

Figure 8-62. Photographs of site WC_40 Cockran Creek, showing the site and the soil profile.

Figure 8-63. Photographs of site WC_41 Cockran Creek, showing the site and the soil profile.

Figure 8-64. Photographs of site WC_44 Jimaringle Creek, showing the site and the soil profile.

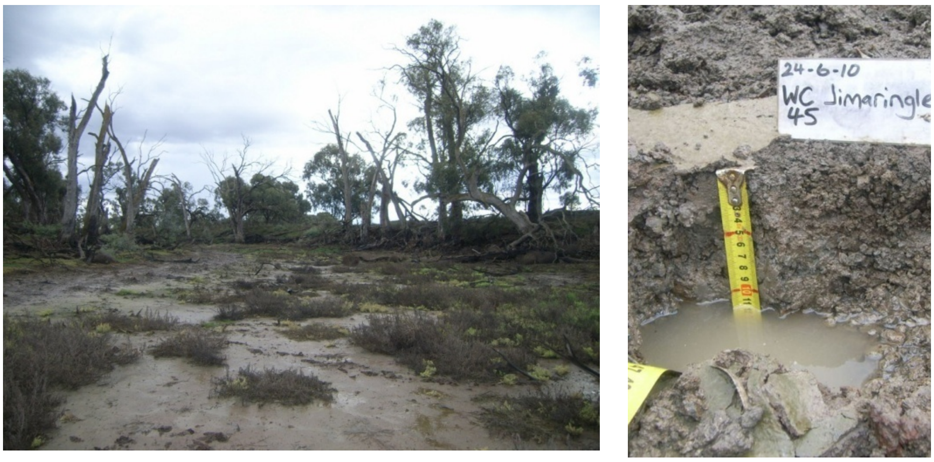

Figure 8-65. Photographs of site WC_45 Jimaringle Creek, showing the site and the soil profile.

Figure 8-66. Photographs of site WC_59 Cockran Creek, showing the site and the soil profile.

8.4.3. Laboratory data assessment

Soil pH testing (pH_W, pH_{FOX}, pH_{KCl}, $pH_{INCUBATION}$)

The pH data is provided in Table 8-14 and depth profiles of soil pH for all the sites sampled are presented in Figures 8-67 and 8-68. The pH_W values ranged between 3.64 and 6.55. Two soil materials at sites WC_40 and WC_59 in Cockran Creek had pH_W values of less than four, however, field pH values and limited pedological evidence of sulfide oxidation (i.e. no mottles and/or coatings with accumulations of jarosite, and no underlying sulfidic materials) indicate that these soils are not sulfuric materials. The pH_{FOX} values ranged between 2.10 and 5.84. The pH_{FOX} results indicate that many of the surface soils may have the potential to acidify to pH < 4 as a result of sulfide oxidation. Four soil materials had a pH_{FOX} < 2.5 suggesting that soil acidity problems will emerge when these soils are exposed to air. The S_{CR} data shows nine of the 35 layers examined contained detectable sulfide (i.e. S_{CR} ≥ 0.01% S). The pH_{KCl} values ranged between 3.58 and 7.53. Three of the sulfidic soil materials (i.e. S_{CR} ≥ 0.01% S) acidified to pH < 4 after at least 8 weeks of incubation. Other acidic soil materials were identified at seven of the eight sites examined, indicating acidity in the soil profile at levels where aluminium may mobilise.

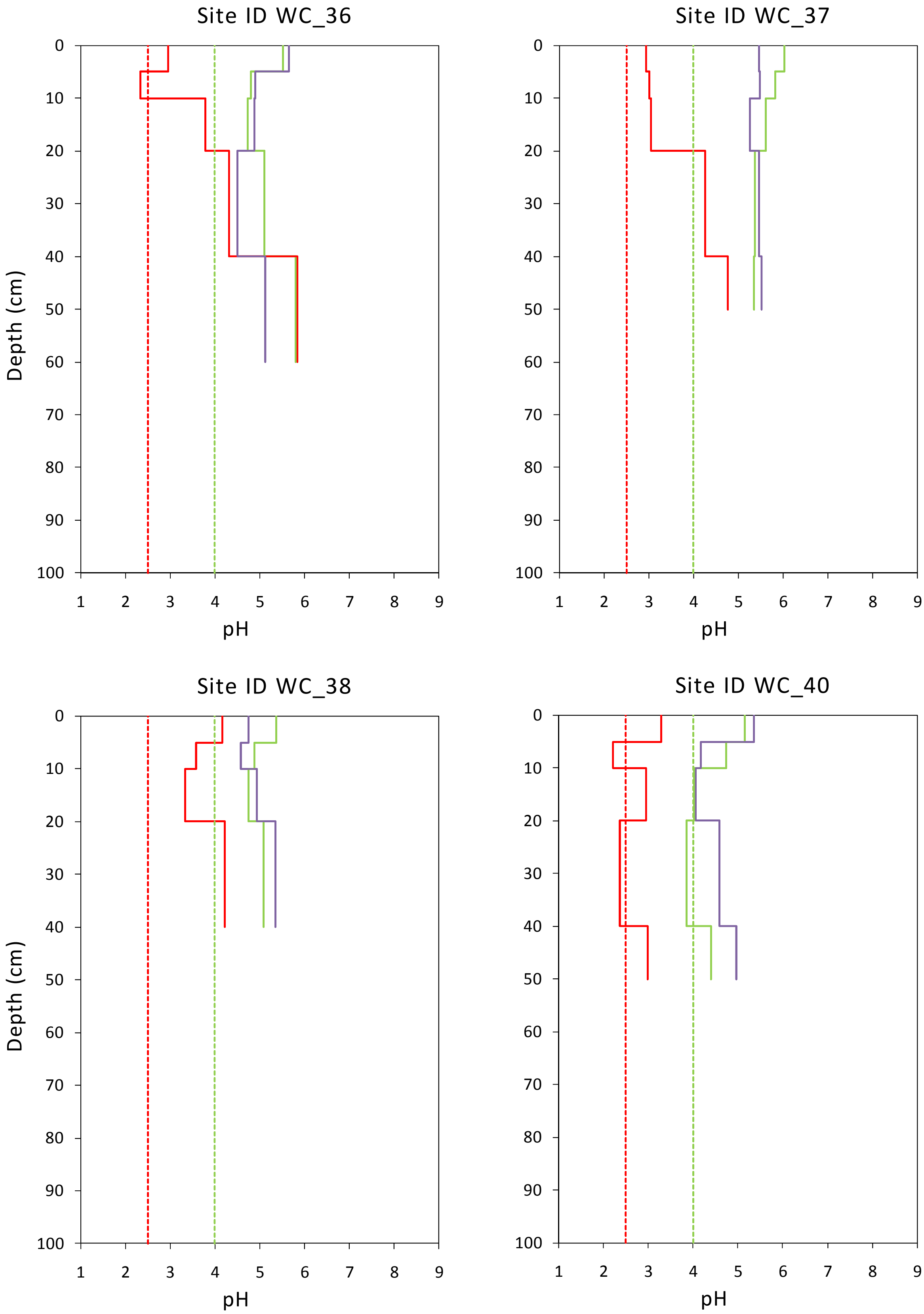

Figure 8-67. Depth profiles of soil pH for sites in Jimaringle – Cockran Creek (sites 36, 37, 38 and 40), showing soil pH (pH_W as green line), peroxide treated pH (pH_{FOX} as red line) and ageing pH ($pH_{incubation}$ after at least 8 weeks as purple line). Critical pH_W and $pH_{incubation}$ value of 4 (green dashed line) and critical pH_{FOX} value of 2.5 (red dashed line).

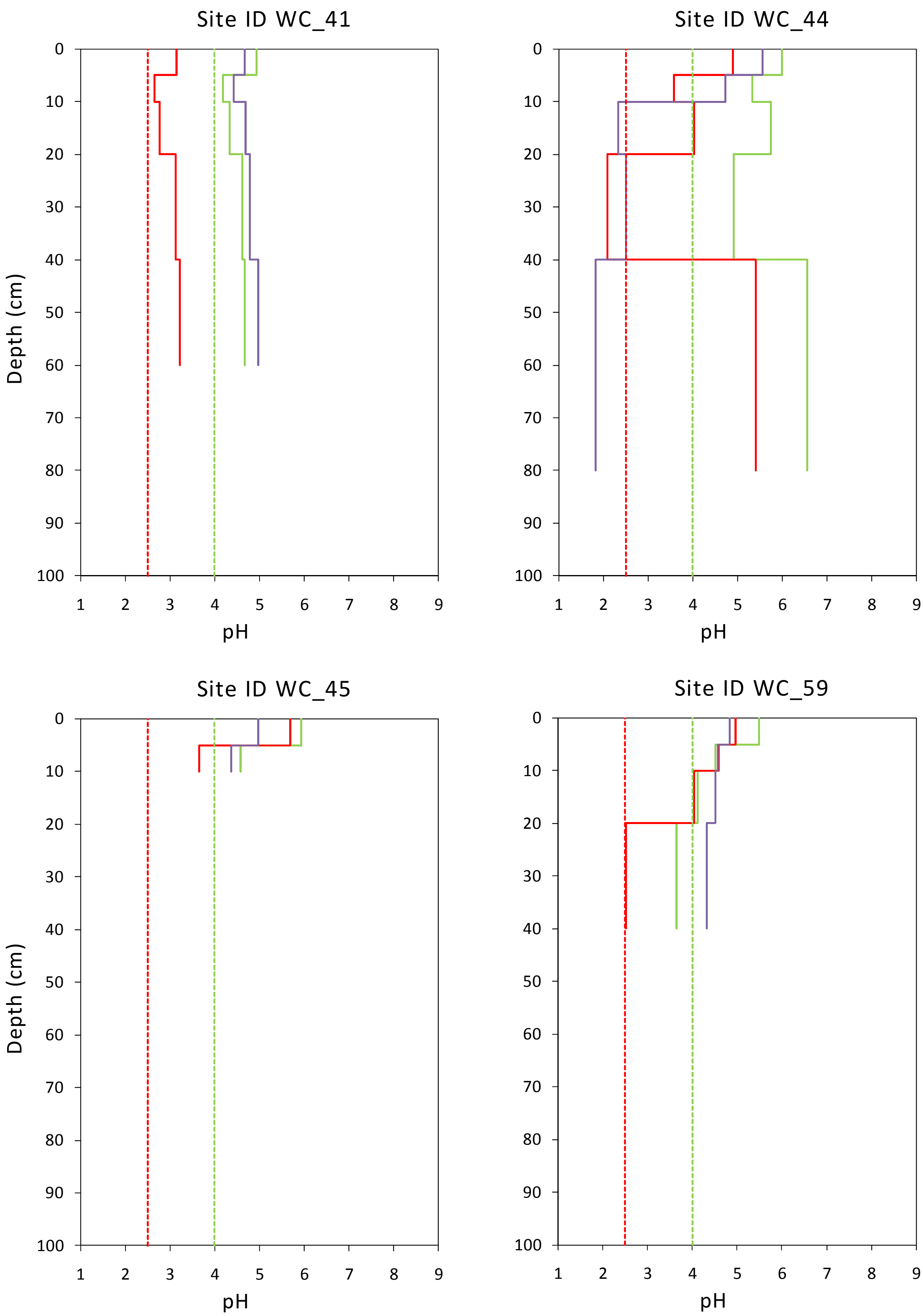

Figure 8-68. Depth profiles of soil pH for sites in Jimaringle – Cockran Creek (sites 41, 44, 45 and 59), showing soil pH (pH_W as green line), peroxide treated pH (pH_{FOX} as red line) and ageing pH ($pH_{incubation}$ after at least 8 weeks as purple line). Critical pH_W and $pH_{incubation}$ value of 4 (green dashed line) and critical pH_{FOX} value of 2.5 (red dashed line).

Acid-base accounting

The acid-base accounting data is provided in Table 8-14 and summarised in Figures 8-69 and 8-70.

Chromium reducible sulfur

Chromium reducible sulfur (S_{CR}) values ranged between < 0.01 and 0.49% S_{CR}. Sulfidic soil materials (i.e. S_{CR} ≥ 0.01% S) were identified at three of the eight sites (i.e. sites WC_36, WC_37 and WC_44), with only nine materials of the 35 samples collected equal to or greater than the sulfidic criterion.

Acid volatile sulfide

The acid volatile sulfide (S_{AV}) values ranged between < 0.01 and 0.12% S_{AV}. Only one monosulfidic soil material (i.e. S_{AV} ≥ 0.01% S) was identified at the eight sites examined.

Acid neutralising capacity

The acid neutralising capacity (ANC) ranged between zero and 5.22% $CaCO_3$.

Titratable actual acidity

The titratable actual acidity (TAA) ranged between zero and 48 mole H^+/tonne. An increase in the TAA with depth was often observed.

Retained acidity

Retained acidity was only detected in two layers from site WC_40, and ranged between zero and 63 mole H^+/tonne.

Net acidity

Net acidity ranged between -391 and 297 mole H^+/tonne. The seven hypersulfidic soils had low to high net acidities ranging between 16 and 297 mole H^+/tonne.

Water Soluble Sulfate

The water soluble sulfate in the surface soils (i.e. 0-20 cm) ranged between 97 and 24,150 mg SO_4/kg. The surface soil layers at the eight sites examined had a soluble sulfate content exceeding the 100 mg/kg trigger value for MBO formation potential.

Water Data

The surface water data measured in the field are presented in Table 8-15. Five of the eight sites examined were dry at the time of sampling. The field pH where surface waters were collected ranged between 3.3 and 5.9, with all sites being below the most relevant ANZECC/ARMCANZ (2000) trigger value for aquatic ecosystems of 6.5. The water data indicates that the surface water has been affected by acidification. Dissolved oxygen, SEC and turbidity values were often found to be outside the most relevant ANZECC/ARMCANZ (2000) guideline value.

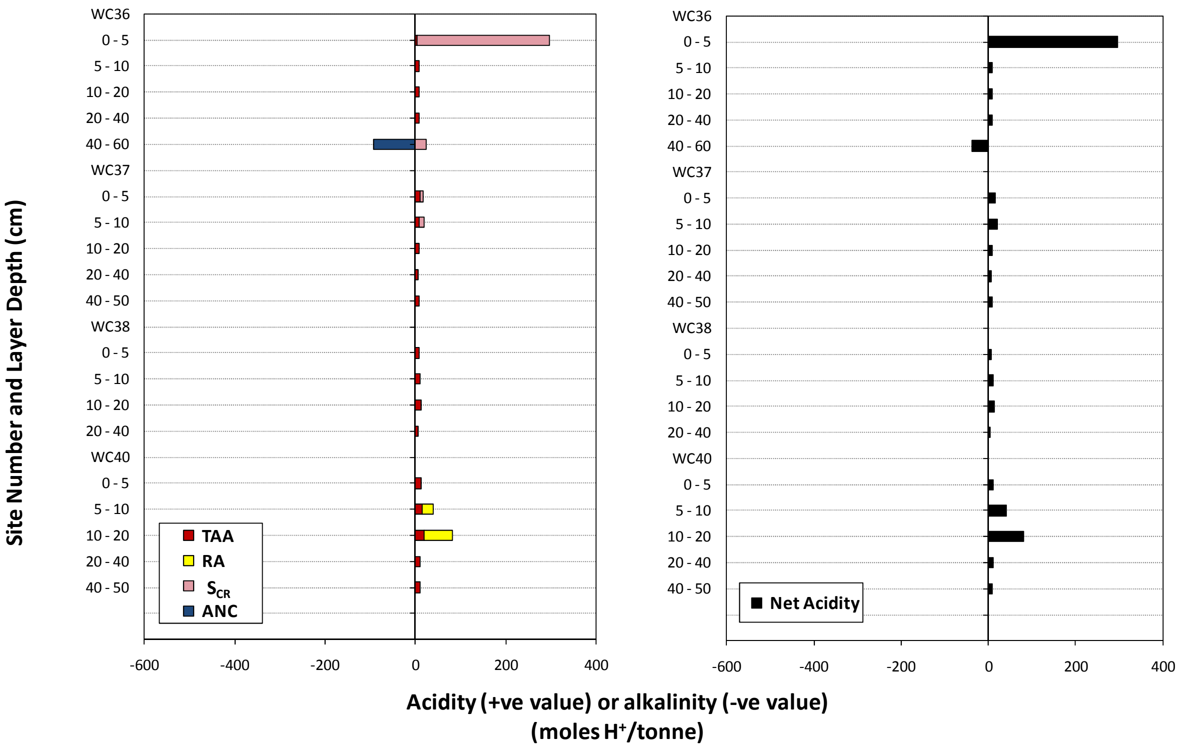

Figure 8-69. Acid-base accounting depth profiles for sites in Jimaringle – Cockran Creek (sites 36, 37, 38 and 40). Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), acid neutralising capacity (ANC - blue bar), retained acidity (RA - yellow bar), and right side shows net acidity.

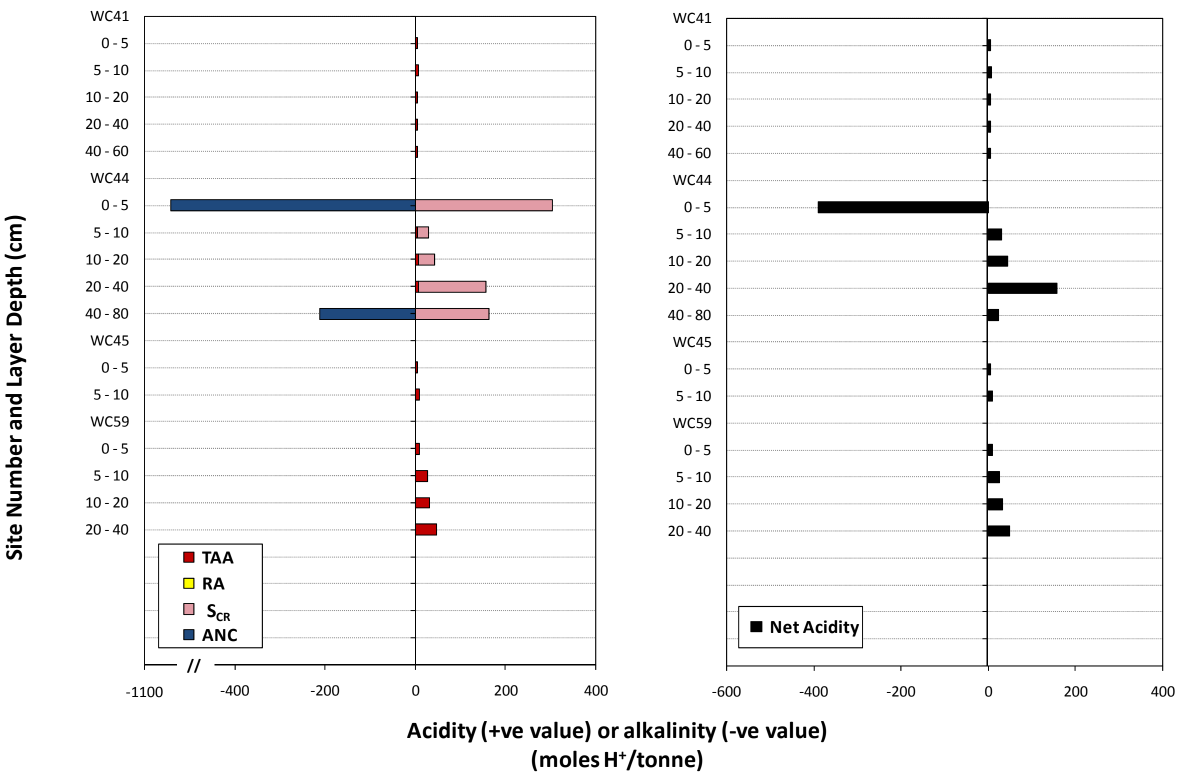

Figure 8-70. Acid-base accounting depth profiles for sites in Jimaringle – Cockran Creek (sites 41, 44, 45 and 59). Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), acid neutralising capacity (ANC - blue bar), retained acidity (RA - yellow bar), and right side shows net acidity.

8.4.4. Discussion

Acid sulfate soils occurred at three sites in Jimaringle – Cockran Creek (i.e. WC_36, WC_37 and WC_44). The presence of reduced inorganic sulfur was identified at three sites, with a S_{CR} of up to 0.49% S. Hypersulfidic soil materials with low to high net acidities (i.e. 16 - 297 mole H^+/tonne) were present in the three soil profiles. The profiles at sites WC_36 and WC_44 also contained a hyposulfidic material. A monosulfidic soil material was observed in the upper 0-5 cm layer at site WC_36, with an S_{AV} content of 0.12% S. These results indicate that acidity would be produced upon oxidation of the sulfidic materials. The surficial soil materials at all sites contained soluble sulfate exceeding the 100 mg/kg trigger value for MBO formation potential. Other acidic soil materials were also observed at the seven sites.

Based on the priority ranking criteria adopted by the Scientific Reference Panel of the Murray-Darling Basin Acid Sulfate Soil Risk Assessment Project, there were three high priority sites based on hypersulfidic material, one high priority site based on hyposulfidic material (S_{CR} ≥ 0.10%) and one high priority site based on monosulfidic material. There was also one moderate priority site based on the presence of hyposulfidic material with S_{CR} < 0.10%. All eight sampling sites had a high priority ranking for Phase 2 detailed assessment based on MBO formation hazard.

The potential hazards posed by acid sulfate soil materials in Jimaringle – Cockran Creek are:

- Acidification hazard: While low-moderate net acidities were dominant in this creek, two hypersulfidic materials had high net acidities (i.e. 6% of layers), indicating that the overall degree of acidification hazard is high.

- Deoxygenation hazard: A high monosulfide concentration (S_{AV} = 0.12% S) in upper 0-5 cm layer at one site represents a high deoxygenation hazard. In addition, the soluble sulfate content of surface soil materials at all eight sites were over the trigger value for MBO formation indicating the possible development of a high deoxygenation hazard at those locations.

- Metal mobilisation: The high acidification hazard indicates that soil acidification may increase the solubility of metals. The presence of a monosulfidic material in an upper soil layer and the potential for MBO formation identified in this creek may also result in a high metal release hazard. This would depend on factors such as the potential for MBO formation and the metal loading in the creek. Soil acidity may be sufficient for mobilisation of aluminium.

Summary of key findings for Jimaringle – Cockran Creek:

Soil materials:	Sulfuric materials were not observed. Sulfidic soil materials identified included: hypersulfidic (3 sites), monosulfidic (1 site), hyposulfidic ≥ 0.10% (1 site) and hyposulfidic < 0.10% (1 site). Low-moderate net acidities dominant within the creek, although 2 hypersulfidic soil materials had high net acidities.
Acid sulfate soil identification:	• Sulfidic materials occurred in surface layers at two sites, and throughout the depth profile at a third site. Only one monosulfidic material was recorded, in the surface layer of a subaqueous site. Both subaqueous (3) and dry (5) sites were present.
Hazard assessment	• Acidification hazard - high level of concern • Deoxygenation hazard - high level of concern • Metal mobilisation hazard - high level of concern

Table 8-14. Laboratory analytical data for acid sulfate soil assessment of Jimaringle – Cockran Creek sites.
(red printed values indicate data results of potential concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4 / kg)	pH KCl	Titratable Actual Acidity (mole H^+/t)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H^+/t)	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/t)	Acid Volatile Sulfide (%S_{AV})	Acid Sulfate Soil Material Classification
36.1	0-5		5.51	2.95	5.65*	20400.00	5.58	4.21	0.47	0.00	0.00	296.56	0.12	Hypermonosulfidic#
36.2	5-10		4.81	2.34	4.89*	7935.00	5.14	7.91	0.00	0.00	0.00	7.91	0.00	Other Acid Soils
36.3	10-20		4.73	3.78	4.88*	11790.00	5.13	8.13	0.00	0.00	0.00	8.13	0.00	Other Acid Soils
36.4	20-40		5.11	4.31	4.51	3735.00	5.56	8.95	0.00	0.00	0.00	8.95	0.00	Other Acid Soils
36.5	40-60		5.80	5.84	5.12*	1515.00	6.65	0.00	0.04	0.00	0.46	-37.70	0.00	Hyposulfidic
37.1	0-5		6.02	2.94	5.47*	358.50	5.06	9.37	0.01	0.00	0.00	16.04	0.00	Hypersulfidic#
37.2	5-10		5.82	3.01	5.48	229.50	5.02	9.08	0.02	0.00	0.00	20.27	0.00	Hypersulfidic#
37.3	10-20		5.62	3.05	5.25*	244.50	4.79	7.91	0.00	0.00	0.00	7.91	0.00	Other Soil Materials
37.4	20-40		5.37	4.25	5.46	153.00	4.81	6.87	0.00	0.00	0.00	6.87	0.00	Other Acid Soils
37.5	40-50		5.35	4.77	5.52	113.85	4.88	7.90	0.00	0.00	0.00	7.90	0.00	Other Acid Soils
38.1	0-5		5.37	4.17	4.75	411.00	4.95	7.17	0.00	0.00	0.00	7.17	0.00	Other Acid Soils
38.2	5-10		4.88	3.57	4.58	520.50	4.52	11.37	0.00	0.00	0.00	11.37	0.00	Other Acid Soils
38.3	10-20		4.75	3.33	4.94	346.50	4.60	12.60	0.00	0.00	0.00	12.60	0.00	Other Acid Soils
38.4	20-40		5.09	4.21	5.35*	75.15	4.92	4.91	0.00	0.00	0.00	4.91	0.00	Other Acid Soils
40.1	0-5		5.15	3.29	5.36*	22050.00	5.16	12.15	0.00	0.00	0.00	12.15	0.00	Other Acid Soils
40.2	5-10		4.74	2.21	4.17*	4680.00	4.28	15.35	0.00	25.00	0.00	40.35	0.00	Other Acid Soils
40.3	10-20		4.03	2.95	4.06*	11055.00	4.10	18.34	0.00	63.00	0.00	81.34	0.00	Other Acid Soils
40.4	20-40		3.85	2.36	4.59	1800.00	4.48	10.66	0.00	0.00	0.00	10.66	0.00	Other Acid Soils^
40.5	40-50		4.39	2.99	4.97*	1245.00	4.80	10.18	0.00	0.00	0.00	10.18	0.00	Other Acid Soils
41.1	0-5		4.93	3.15	4.67*	1341.00	5.40	4.45	0.00	0.00	0.00	4.45	0.00	Other Acid Soils
41.2	5-10		4.19	2.66	4.42	235.50	4.67	8.10	0.00	0.00	0.00	8.10	0.00	Other Acid Soils
41.3	10-20		4.34	2.76	4.69	117.75	5.03	5.58	0.00	0.00	0.00	5.58	0.00	Other Acid Soils
41.4	20-40		4.62	3.12	4.78*	67.20	5.28	4.43	0.00	0.00	0.00	4.43	0.00	Other Acid Soils
41.5	40-60		4.68	3.22	4.98*	70.95	5.53	4.61	0.00	0.00	0.00	4.61	0.00	Other Acid Soils
44.1	0-5		5.99	4.89	5.56	1264.50	7.53	0.00	0.49	0.00	5.22	-390.75	0.00	Hyposulfidic
44.2	5-10		5.33	3.58	4.72*	23400.00	5.88	5.41	0.04	0.00	0.00	30.33	0.00	Hypersulfidic#
44.3	10-20		5.74	4.03	2.33*	24150.00	5.31	7.56	0.06	0.00	0.00	43.35	0.00	Hypersulfidic
44.4	20-40		4.92	2.10	2.51*	8250.00	5.13	7.10	0.24	0.00	0.00	156.76	0.00	Hypersulfidic
44.5	40-80		6.55	5.41	1.82*	5040.00	7.16	0.00	0.26	0.00	1.06	22.73	0.00	Hypersulfidic

* Indicates that a stable pH has not yet been reached for this sample (after at least 15 weeks). # Classified as hypermonosulfidic/hypersulfidic based on positive net acidity.

Table 8-14 (continued). Laboratory analytical data for acid sulfate soil assessment of Jimaringle – Cockran Creek sites.
(red printed values indicate data results of potential concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4 / kg)	pH KCl	Titratable Actual Acidity (mole H^+/t)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H^+/t)	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/t)	Acid Volatile Sulfide (%S_{AV})	Acid Sulfate Soil Material Classification
45.1	0-5		5.93	5.68	4.98*	14520.00	6.14	5.78	0.00	0.00	0.00	5.78	0.00	Other Acid Soils
45.2	5-10		4.58	3.66	4.37*	1198.50	4.83	8.79	0.00	0.00	0.00	8.79	0.00	Other Acid Soils
59.1	0-5		5.50	4.96	4.84	99.45	5.15	9.82	0.00	0.00	0.00	9.82	0.00	Other Acid Soils
59.2	5-10		4.52	4.59	4.57*	115.35	4.22	27.01	0.00	0.00	0.00	27.01	0.00	Other Acid Soils
59.3	10-20		4.11	4.04	4.51*	96.75	4.06	32.20	0.00	0.00	0.00	32.20	0.00	Other Acid Soils
59.4	20-40		3.64	2.51	4.33	59.10	3.58	48.18	0.00	0.00	0.00	48.18	0.00	Other Acid Soils^

* Indicates that a stable pH has not yet been reached for this sample (after at least 15 weeks).

Table 8-15. Field hydrochemistry data for acid sulfate soil assessment of Jimaringle – Cockran Creek sites.

Site ID.	Temperature (Deg C)	Specific Electrical Conductivity (µS/cm)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	ORP (mV)	Redox potential (mV)	Turbidity (NTU)	Comment
*Lowland River**		*125-2,220*	*85-110*		*6.5-8.0*			*6-50*	
WC_36	13.2	15,060	111.3	11.61	5.90	263		12	
WC_37									Site dry at the time of sampling
WC_38									Site dry at the time of sampling
WC_40									Site dry at the time of sampling
WC_41									Site dry at the time of sampling
WC_44	12.1	15,610	153.6	16.54	3.30	467		9	
WC_45	11.1	21,700	26.4	2.92	5.01	389		575	
WC_59									Site dry at the time of sampling

* ANZECC water quality guidelines for lowland rivers in South-east Australia are provided for relevant parameters (ANZECC/ARMCANZ, 2000).
Surface water values outside the ranges defined in the ANZECC guidelines are indicated with red text.

Table 8-16. Profile description data for acid sulfate soil assessment of Jimaringle – Cockran Creek sites.

Site and Sample No.	Horizon Depth Range (cm)	Soil Colour – moist [1]	Texture Class [1]	Texture Modifiers[1]	Moisture State[1]	Redoximorphic Features Abundance (%) [2]	Redoximorphic Features – Kind [2]	Redoximorphic Features - Colour [2]	Redoximorphic Features - Location [2]	Structure - Type[1]	Structure - Grade[1]	Consistency (moist or dry) - Rupture Resistance[1]	pH (field measurement)	Comments (odour, fragments, minerals, plant material, inclusions, other)
36.1	0-5	5YR 4/2	ZC		W	20	FM			SB	2		6.50	Patches of MBO?
36.2	5-10	5YR 4/2	ZC		W	20	FM			SB	2		6.40	Patches of MBO?
36.3	10-20	7.5YR 4/2	ZC		W	50	FM			SB	3		5.70	Patches of MBO?
36.4	20-40	10YR 5/2	ZC		W					MA	0		5.60	
36.5	40-60	10YR 5/2	ZC		W					MA	0		5.90	
37.1	0-5	5YR 3/2		PT	T					n.r.			7.00	Peat
37.2	5-10	5YR 3/2		PT	T					n.r.			6.70	Peat
37.3	10-20	5YR 4/1	ZC	PT	T	10	FM			n.r.	1		6.70	Peaty clay
37.4	20-40	10YR 4/1	C		T	20	FM			n.r.	1		6.70	
37.5	40-50	7.5YR 5/1	C		T	50	FM			n.r.	1		6.60	
38.1	0-5	7.5YR 3/1	ZCL		T					SB	3		6.70	
38.2	5-10	7.5YR 4/2	ZC		D	10	FM			PO	3		6.40	
38.3	10-20	7.5YR 4/2	ZC		D	10	FM			PO	3		6.00	
38.4	20-40	7.5YR 4/1	ZC		M	20	FM			AB	2		6.90	
40.1	0-5	7.5YR 3/2	CL	S		20	FM			GR	1		5.90	
40.2	5-10	7.5YR 4/3	ZC			50	FM			SB	1		5.50	
40.3	10-20	7.5YR 4/1	ZC			20	FM			SB	1		5.20	
40.4	20-40	7.5YR 4/1	ZC			20	FM			SB	1		5.20	
40.5	40-50	7.5YR 5/1	ZC			2	FM			SB	1		5.40	
41.1	0-5	10YR 4/1	CL	S	D					SB	1		5.70	
41.2	5-10	10YR 5/2	ZC		D	10	FM			MA	0		5.40	
41.3	10-20	10YR 5/2	SCL		D	20	FM			MA	0		5.40	
41.4	20-40	10YR 6/2	SCL		D	20	FM			MA	0		5.50	
41.5	40-60	10YR 7/2	SCL		D	50	FM			MA	0		5.50	

Table 8-16 (continued). Profile description data for acid sulfate soil assessment of Jimaringle – Cockran Creek sites.

Site and Sample No.	Horizon Depth Range (cm)	Soil Colour – moist [1]	Texture Class [1]	Texture Modifiers[1]	Moisture State[1]	Redoximorphic Features Abundance (%) [2]	Redoximorphic Features – Kind [2]	Redoximorphic Features - Colour [2]	Redoximorphic Features - Location [2]	Structure - Type[1]	Structure - Grade[1]	Consistency (moist or dry) - Rupture Resistance[1]	pH (field measurement)	Comments (odour, fragments, minerals, plant material, inclusions, other)
44.1	0-5	10YR 3/2	ZC		W					MA	0		6.10	Schwertmannite veneer; MBO
44.2	5-10	2.5Y 3/2	C		W					MA	0		6.20	Schwertmannite
44.3	10-20	2.5Y 3/2	C		W					MA	0		5.90	
44.4	20-40	2.5Y 2/1	C		W					MA	0		5.90	
44.5	40-80	2.5Y 3/2	C		W					MA	0		6.50	
45.1	0-5	2.5Y 3/2	C		W	10	FM			SB	1		6.10	Schwertmannite veneer; abandoned due to rain
45.2	5-10	10YR 3/2	C		W	20	FM			AB	2		6.10	
59.1	0-5	10YR 3/2	SCL		M					GR	1		7.10	
59.2	5-10	10YR 4/4	SCL		M					PO	1		6.80	
59.3	10-20	10YR 5/3	C	S	M	10	FM			PO	1		6.50	
59.4	20-40	10YR 5/4	C	S	M	10	FM			PO	2		6.20	

[1] See National Committee on Soil and Terrain (2009) for abbreviation definitions and further details.

[2] See Schoeneberger *et al.* (2002) for abbreviation definitions and further details.

8.5. Barbers Creek

8.5.1. Location and setting description

Barbers Creek emerges as the dominant channel of a large area of interconnected drainage from the Koondrook-Perricoota forest (Figure 8-71). Shortly before leaving the forest, Barbers Creek is joined by Cow Creek, also coming from the forest, and then flows past Pollack Swamp, north of Barham. The creek continues to meander in a generally north-westerly direction across a broad ~14 km wide alluvial distributary belt including the Wakool River, Barbers Creek, an upper reach of Merran Creek, the Little Murray River, and the Murray itself. Barbers Creek flows into the Wakool some ~30 km downstream of Barham Road.

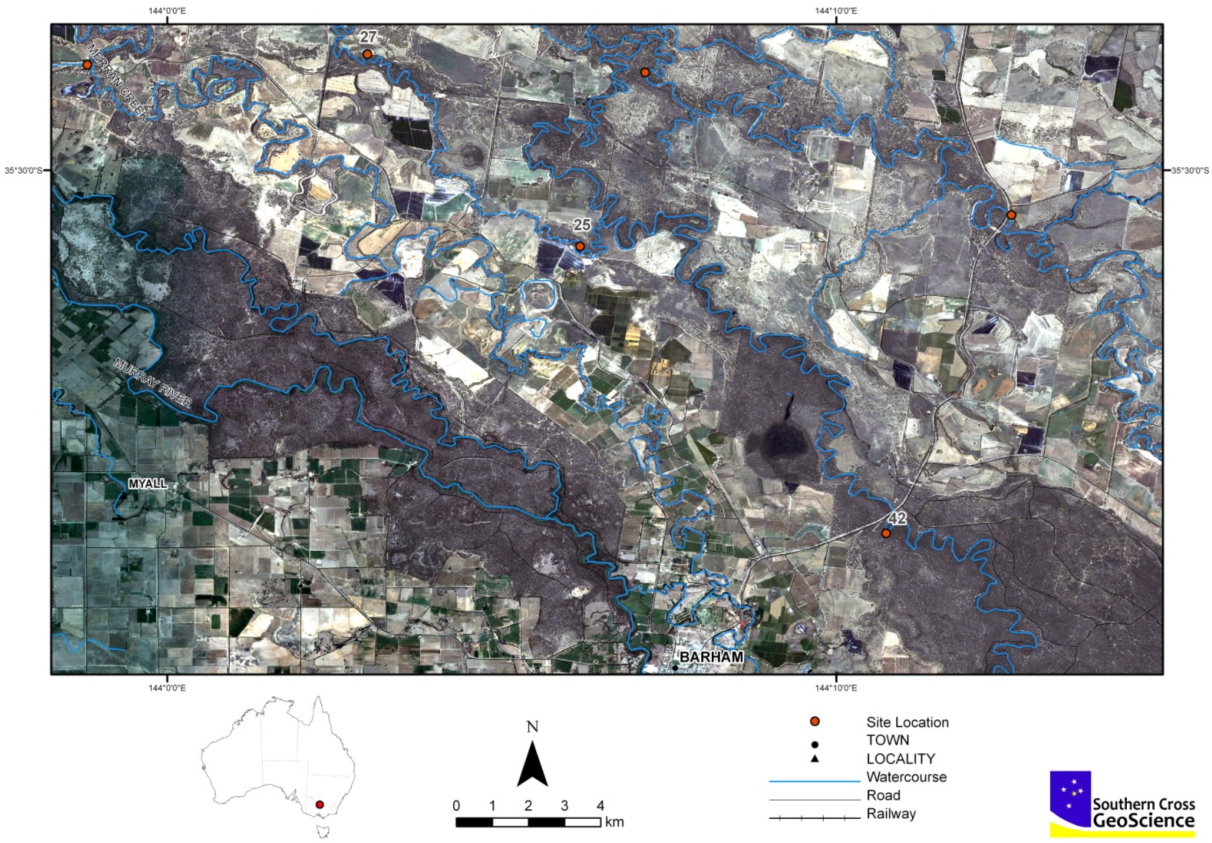

Figure 8-71. Barbers Creek and sample site locations.

8.5.2. Soil profile description and distribution

Three sites were described and sampled in Barbers Creek. The soil subtype and general location description are presented in Table 8-17. Profile description data are presented in Table 8-20.

Table 8-17. Soil identification, subtype and general location description for sites sampled in Barbers Creek.

Site ID	Easting UTM Zone 55H	Northing UTM Zone 55H	Acid sulfate soil subtype class
WC_25	237273	6065545	Hypersulfidic Subaqueous Soil with Monosulfides
WC_27	232306	6070711	Subaqueous Soil
WC_42	244413	6057817	Sulfuric Subaqueous Soil with Monosulfides

Figure 8-72. Photographs of site WC_25 Barbers Creek, showing the site and the soil core.

Figure 8-73. Photographs of site WC_27 Barbers Creek, showing the site and the soil core.

 

Figure 8-74. Photographs of site WC_42 Barbers Creek, showing the site and the soil profile.

8.5.3. Laboratory data assessment

Soil pH testing (pH_W, pH_{FOX}, pH_{KCl}, $pH_{INCUBATION}$)

The pH data is provided in Table 8-18 and depth profiles of soil pH for all the sites sampled are presented in Figure 8-75. The pH_W values ranged between 3.35 and 6.82. Sulfuric materials (i.e. $pH_W < 4$) were present at sites WC_42. The pH_{FOX} values ranged between 1.96 and 4.96. The pH_{FOX} results indicate that all except one of the surface soils have the potential to acidify to pH < 4 as a result of sulfide oxidation. Five soil materials had a $pH_{FOX} < 2.5$ suggesting that soil acidity problems will emerge when these soils are exposed to air. The S_{CR} data shows six of the 13 layers examined contained detectable sulfide (i.e. $S_{CR} \geq 0.01\%$ S). The pH_{KCl} values ranged between 3.63 and 4.84. Three of the sulfidic soil materials (i.e. $S_{CR} \geq 0.01\%$ S) acidified to pH < 4 after at least 8 weeks of incubation. Other acidic soil materials were identified at two of the sites examined, indicating acidity in the soil profile at levels where aluminium may mobilise.

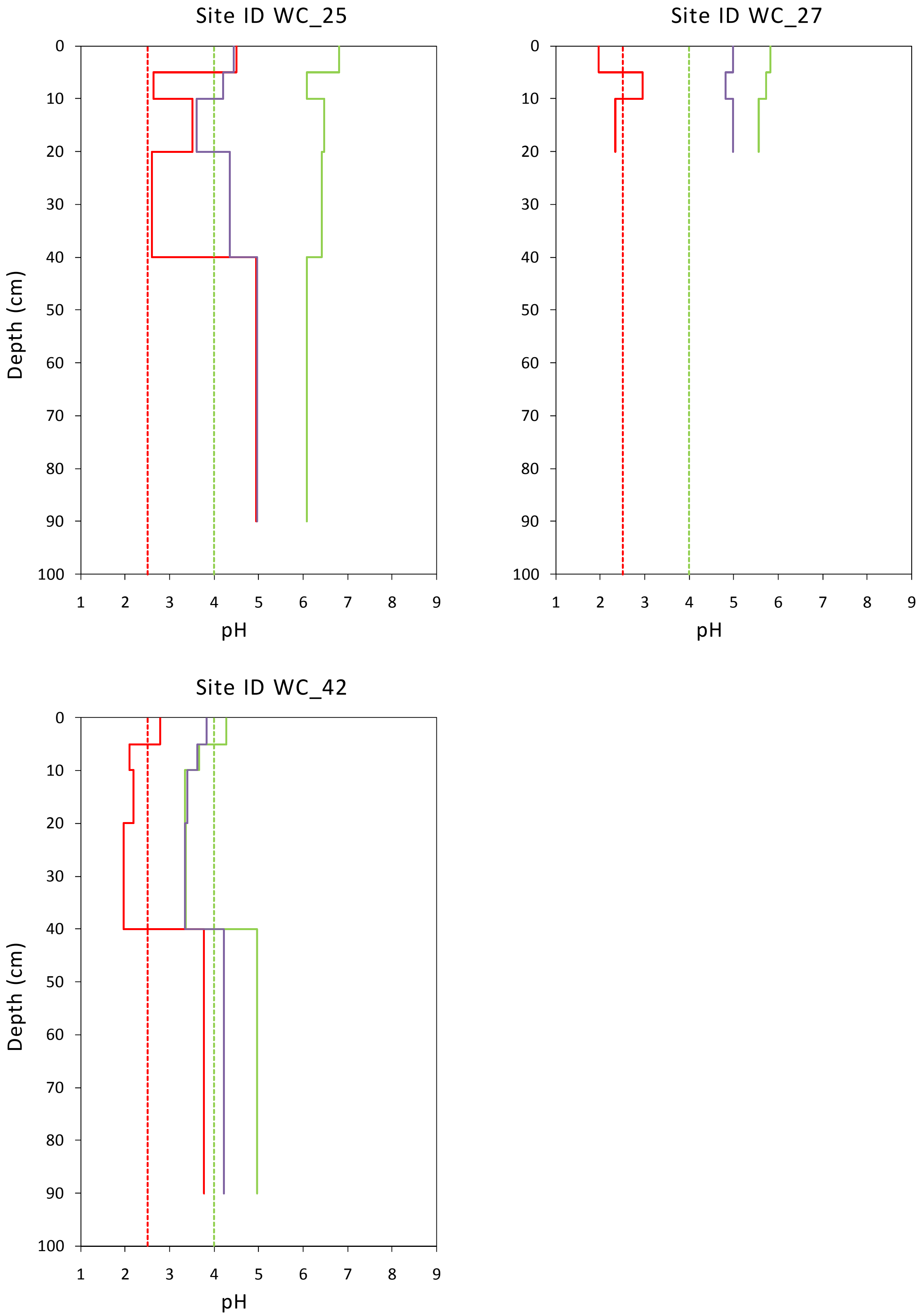

Figure 8-75. Depth profiles of soil pH for sites in Barbers Creek, showing soil pH (pH_W as green line), peroxide treated pH (pH_{FOX} as red line) and ageing pH ($pH_{incubation}$ after at least 8 weeks as purple line). Critical pH_W and $pH_{incubation}$ value of 4 (green dashed line) and critical pH_{FOX} value of 2.5 (red dashed line).

Acid-base accounting

The acid-base accounting data is provided in Table 8-18 and summarised in Figure 8-76.

Chromium reducible sulfur

Chromium reducible sulfur (S_{CR}) values ranged between < 0.01 and 0.08% S_{CR}. Sulfidic soil materials (i.e. S_{CR} ≥ 0.01% S) were identified at two of the three sampling sites (i.e. sites WC_25 and WC_42), with six materials of the 13 samples collected equal to or greater than the sulfidic criterion.

Acid volatile sulfide

The acid volatile sulfide (S_{AV}) values ranged between < 0.01 and 0.04% S_{AV}. A total of four monosulfidic soil materials (i.e. S_{AV} ≥ 0.01% S) were found at two sites (i.e. sites WC_25 and WC_42).

Acid neutralising capacity

All soil materials had no acid neutralising capacity (ANC).

Titratable actual acidity

The titratable actual acidity (TAA) ranged between 4 and 52 mole H^+/tonne. A decrease in the TAA with depth was observed at the three sites examined.

Retained acidity

Retained acidity was only detected in three layers from site WC_42, ranging between zero and 201 mole H^+/tonne.

Net acidity

Net acidity ranged between 4 and 291 mole H^+/tonne. The five hypersulfidic soils had moderate to high net acidities ranging between 25 and 291 mole H^+/tonne. The three sulfuric soils had moderate net acidities of between 54 and 58 mole H^+/tonne.

Water Soluble Sulfate

The water soluble sulfate in the surface soils (i.e. 0-20 cm) ranged between 20 and 9,375 mg SO_4/kg. The surface soil layers at two of the three sites examined had a soluble sulfate content exceeding the 100 mg/kg trigger value for MBO formation potential.

Water Data

The surface water data measured in the field are presented in Table 8-19. The field pH of the surface waters collected ranged between 3.6 and 7.8, with one site being below the most relevant ANZECC/ARMCANZ (2000) trigger value for aquatic ecosystems of 6.5. The water data indicates that the surface water has been affected by acidification at one of the sites (i.e. WC_42). Dissolved oxygen, SEC and turbidity values were sometimes found to be outside the most relevant ANZECC/ARMCANZ (2000) guideline value.

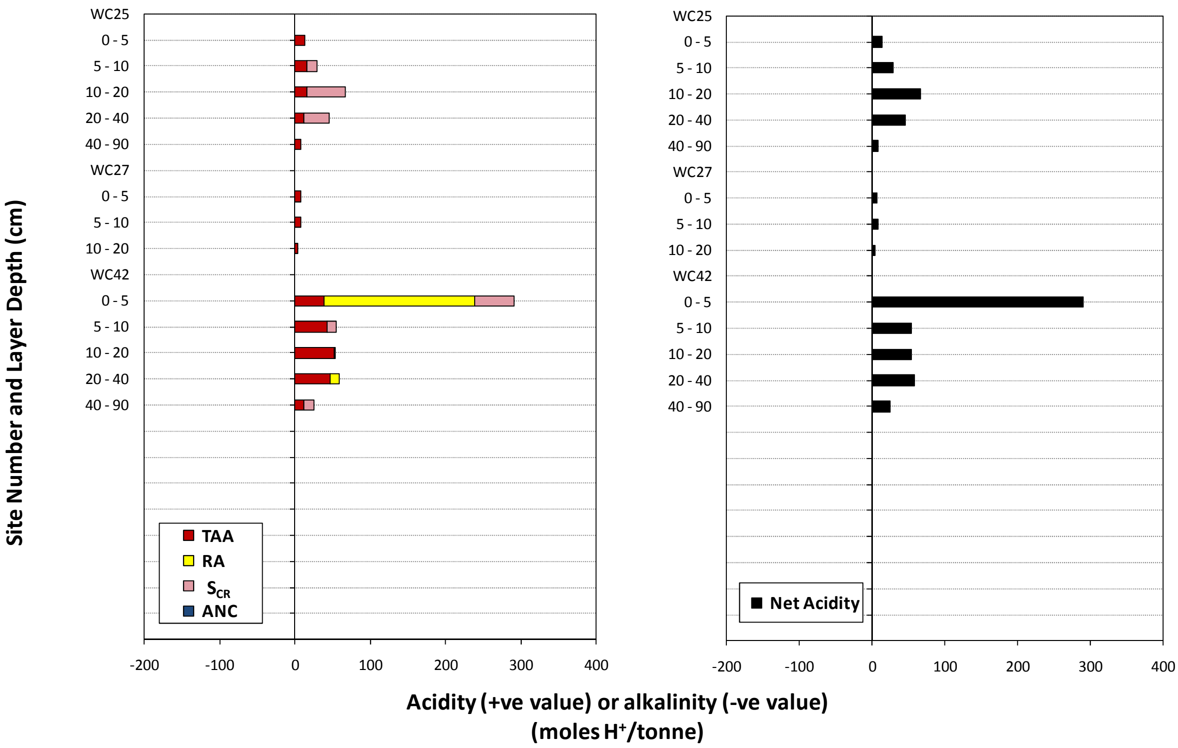

Figure 8-76. Acid-base accounting depth profiles for sites in Barbers Creek. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), acid neutralising capacity (ANC - blue bar), retained acidity (RA - yellow bar), and right side shows net acidity.

8.5.4. Discussion

Acid sulfate soils occurred at two of the three sites examined in Barbers Creek. Sulfuric materials with moderate net acidities (i.e. 54 - 58 mole H^+/tonne) were observed at site WC_42. The presence of reduced inorganic sulfur was identified at two sites (i.e. sites WC_25 and WC_42), with a S_{CR} of up to 0.08% S. Hypersulfidic soil materials with moderate to high net acidities (i.e. 25 - 291 mole H^+/tonne) were present in the two soil profiles. Monosulfidic soil materials were also observed at the two sulfidic sites, with S_{AV} contents of up to 0.04% S. Monosulfidic soil materials ($S_{AV} \leq 0.02\%$ S) were observed in the upper 0-10 cm layers at both sites. These results indicate that acidity would be produced upon oxidation of the sulfidic materials. The surficial soil materials at two sites contained soluble sulfate exceeding the 100 mg/kg trigger value for MBO formation potential. Other acidic soil materials were also observed at two sites.

Based on the priority ranking criteria adopted by the Scientific Reference Panel of the Murray-Darling Basin Acid Sulfate Soil Risk Assessment Project, there was one high priority site based on sulfuric material, two high priority sites based on hypersulfidic material and two high priority sites based on monosulfidic material. Two sampling sites had a high priority ranking for Phase 2 detailed assessment based on MBO formation hazard.

The potential hazards posed by acid sulfate soil materials in Barbers Creek are:

- Acidification hazard: Low-moderate net acidities were dominant in this creek, including three sulfuric and four hypersulfidic materials with moderate net acidities (i.e. 54% of layers), indicating that the overall degree of acidification hazard is moderate. One hypersulfidic soil material had a high net acidity, largely due to the presence of retained acidity.

- Deoxygenation hazard: Monosulfidic soil materials (S_{AV} ≤ 0.02% S) observed in the upper 0-10 cm layers at two sites represent a high deoxygenation hazard. In addition, the soluble sulfate content of surface soil materials at two sites were over the trigger value for MBO formation indicating the possible development of a high deoxygenation hazard at those locations after prolonged wet conditions.

- Metal mobilisation: The moderate acidification hazard indicates that soil acidification may increase the solubility of metals. The presence of monosulfidic materials in upper soil layers and the potential for MBO formation identified in parts of this channel creek may also result in a high metal release hazard. This would depend on factors such as the potential for MBO formation and the metal loading in the creek. Soil acidity may be sufficient for mobilisation of aluminium.

Summary of key findings for Barbers Creek:

Soil materials:	Sulfuric materials were observed at one site. Sulfidic soil materials identified included: sulfuric (1 site), hypersulfidic (2 sites) and monosulfidic (2 sites). Moderate net acidities dominant within creek, although one hypermonosulfidic soil material had a high net acidity.
Acid sulfate soil identification:	• Sulfuric materials occurred at depths of 5-40cm. Sulfidic materials and monosulfides occurred in both surface and subsurface layers. All sites were subaqueous.
Hazard assessment	• Acidification hazard - moderate level of concern • Deoxygenation hazard - high level of concern • Metal mobilisation hazard - high level of concern

Table 8-18. Laboratory analytical data for acid sulfate soil assessment of Barbers Creek sites.
(red printed values indicate data results of potential concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4 / kg)	pH KCl	Titratable Actual Acidity (mole H^+/t)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H^+/t)	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/t)	Acid Volatile Sulfide (%S_{AV})	Acid Sulfate Soil Material Classification
25.1	0-5		6.82	4.50	4.45*	175.50	4.31	13.62	0.00	0.00	0.00	13.62	0.00	Other Acid Soils
25.2	5-10		6.09	2.64	4.21*	204.00	4.14	16.34	0.02	0.00	0.00	28.78	0.02	Hypermonosulfidic#
25.3	10-20		6.47	3.51	3.61*	442.50	4.32	15.85	0.08	0.00	0.00	66.13	0.04	Hypermonosulfidic
25.4	20-40		6.43	2.61	4.36*	300.00	4.52	12.22	0.05	0.00	0.00	45.29	0.03	Hypermonosulfidic#
25.5	40-51		6.08	4.96	4.96	94.95	4.73	7.66	0.00	0.00	0.00	7.66	0.00	Other Acid Soils
27.1	0-5		5.82	1.96	4.99*	31.50	4.52	7.06	0.00	0.00	0.00	7.06	0.00	Other Acid Soils
27.2	5-10		5.74	2.95	4.82*	40.05	4.56	7.81	0.00	0.00	0.00	7.81	0.00	Other Acid Soils
27.3	10-20		5.56	2.34	4.99	19.95	4.71	4.20	0.00	0.00	0.00	4.20	0.00	Other Acid Soils
42.1	0-5		4.28	2.78	3.83*	9375.00	4.27	38.22	0.08	201.00	0.00	291.03	0.02	Hypermonosulfidic
42.2	5-10		3.66	2.10	3.62*	2940.00	3.97	42.63	0.02	0.00	0.00	54.06	0.00	Sulfuric Soil
42.3	10-20		3.35	2.19	3.40*	1057.50	3.63	51.79	0.00	2.00	0.00	53.79	0.00	Sulfuric Soil
42.4	20-40		3.36	1.97	3.34*	1249.50	3.69	46.31	0.00	12.00	0.00	58.31	0.00	Sulfuric Soil
42.5	40-90		4.97	3.77	4.23*	1171.50	4.84	11.12	0.02	0.00	0.00	24.65	0.00	Hypersulfidic#

* Indicates that a stable pH has not yet been reached for this sample (after at least 15 weeks). # Classified as hypermonosulfidic/hypersulfidic based on positive net acidity.

Table 8-19. Field hydrochemistry data for acid sulfate soil assessment of Barbers Creek sites.

Site ID.	Temperature (Deg C)	Specific Electrical Conductivity (µS/cm)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	ORP (mV)	Redox potential (mV)	Turbidity (NTU)	Comment
*Lowland River**		*125-2,220*	*85-110*		*6.5-8.0*			*6-50*	
WC_25	11.3	55.0	86.5	9.63	7.76	334		80	pH determined with stick meter
WC_27	9.3	36.2	57.3	6.48	6.80	351		14	pH determined with stick meter
WC_42	7.3	10,010	52.8	6.49	3.64	339		246	

* ANZECC water quality guidelines for lowland rivers in South-east Australia are provided for relevant parameters (ANZECC/ARMCANZ, 2000).
Surface water values outside the ranges defined in the ANZECC guidelines are indicated with red text.

Table 8-20. Profile description data for acid sulfate soil assessment of Barbers Creek sites.

Site and Sample No.	Horizon Depth Range (cm)	Soil Colour – moist [1]	Texture Class [1]	Texture Modifiers[1]	Moisture State[1]	Redoximorphic Features Abundance (%) [2]	Redoximorphic Features – Kind [2]	Redoximorphic Features - Colour [2]	Redoximorphic Features - Location [2]	Structure - Type[1]	Structure - Grade[1]	Consistency (moist or dry) - Rupture Resistance[1]	pH (field measurement)	Comments (odour, fragments, minerals, plant material, inclusions, other)
25.1	0-5	10Y 4/1	ZL		W					MA	0		7.30	iron floc veneer
25.2	5-10	10Y 4/1	ZL		W	2	FM			MA	0		6.90	
25.3	10-20	10Y 3/1	ZL		W	10	FM			MA	0		6.80	
25.4	20-40	2.5Y 2.5/1	ZL		W					MA	0		7.20	
25.5	40-90	10Y 5/1	ZCL		W					MA	0		7.30	
27.1	0-5	2.5Y 5/2	LS		W					MA	0		7.20	pH measured with stick meter
27.2	5-10	2.5Y 5/2	LS		W					MA	0		7.10	pH measured with stick meter
27.3	10-20	2.5Y 5/3	LS		W					MA	0		6.80	pH measured with stick meter
42.1	0-5	10YR 3/2	C		W	50	FM			MA	0		4.60	
42.2	5-10	10YR 4/3	C		W	10	FM			SB	1		4.70	
42.3	10-20	10YR 4/3	C		W	50	FM			SB	2		4.20	
42.4	20-40	10YR 5/3	C		W	20	FM			AB	2		4.30	
42.5	40-90	5YR 4/1	C		W	2	FM			MA	0		5.50	

[1] See National Committee on Soil and Terrain (2009) for abbreviation definitions and further details.

[2] See Schoeneberger *et al.* (2002) for abbreviation definitions and further details.

8.6. Mallan Mallan Creek

8.6.1. Location and setting description

Mallan Mallan Creek is the lowest ~12 km of the palaeo-Niemur River. Mallan Mallan Creek is an incised, overfit, partially abandoned channel that flows through a Shepparton land surface into the Wakool, the resulting arrangement of channels forming Coobool Island (Figure 8-77).

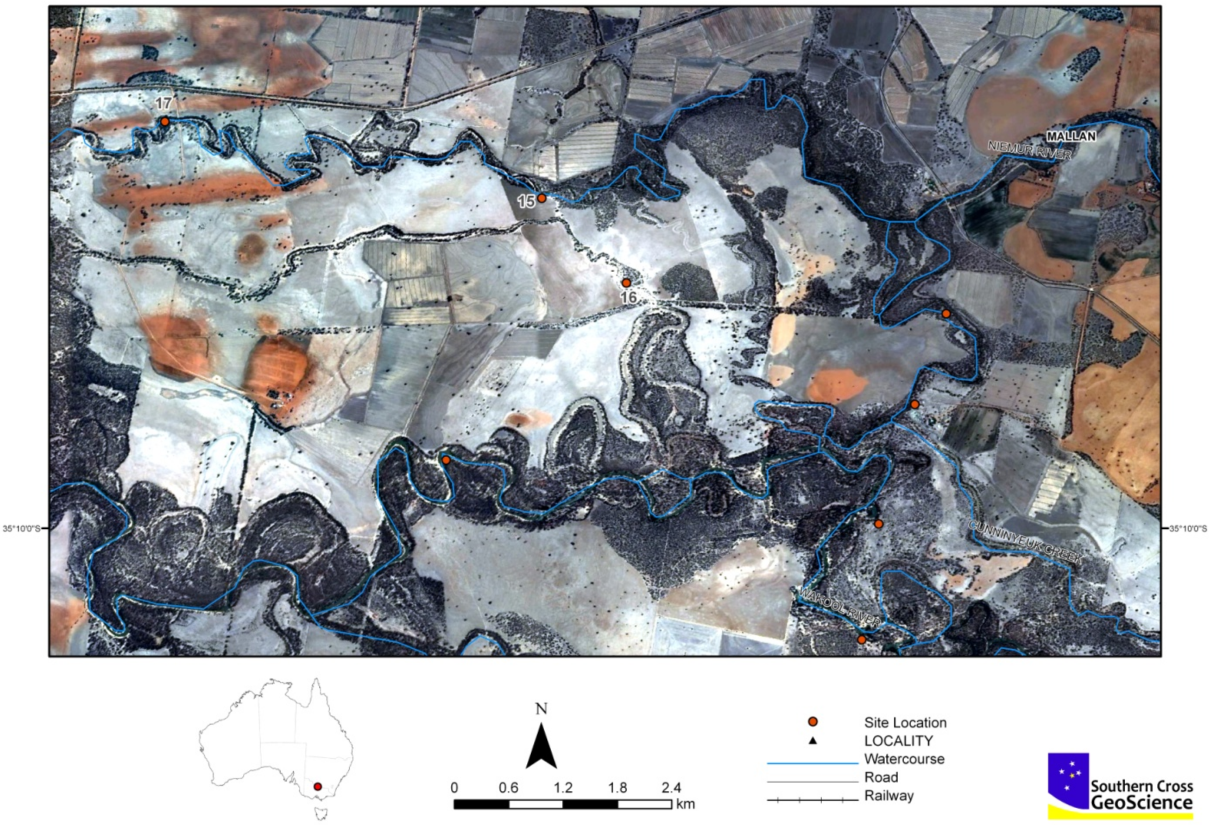

Figure 8-77. Mallan Mallan Creek and sample site locations.

8.6.2. Soil profile description and distribution

Two sites were described and sampled in Mallan Mallan Creek. The soil subtype and general location description are presented in Table 8-21. Profile description data are presented in Table 8-24.

Table 8-21. Soil identification, subtype and general location description for sites sampled in Mallan Mallan Creek.

Site ID	Easting UTM Zone 54H	Northing UTM Zone 54H	Acid sulfate soil subtype class
WC_15	751415	6108620	Hypersulfidic Subaqueous Soil with Monosulfides
WC_17	748030	6109556	Hyposulfidic Subaqueous Soil with Monosulfides

Figure 8-78. Photographs of site WC_15 Mallan Mallan Creek, showing the site and the soil profile.

Figure 8-79. Photographs of site WC_17 Mallan Mallan Creek, showing the site and the soil core.

8.6.3. Laboratory data assessment

Soil pH testing (pH_W, pH_{FOX}, pH_{KCl}, $pH_{INCUBATION}$)

The pH data is provided in Table 8-22 and depth profiles of soil pH for all the sites sampled are presented in Figure 8-80. The pH_W values ranged between 6.23 and 7.40. Sulfuric materials (i.e. $pH_W < 4$) were not present. The pH_{FOX} values ranged between 3.34 and 7.27. The pH_{FOX} results indicate that none of the surface soils may have the potential to acidify to pH < 4 as a result of sulfide oxidation. The S_{CR} data shows all nine layers examined contained detectable sulfide (i.e. $S_{CR} \geq 0.01\%$ S). The pH_{KCl} values ranged between 6.71 and 8.93. None of the sulfidic soil materials (i.e. $S_{CR} \geq 0.01\%$ S) acidified to pH < 4 after at least 8 weeks of incubation.

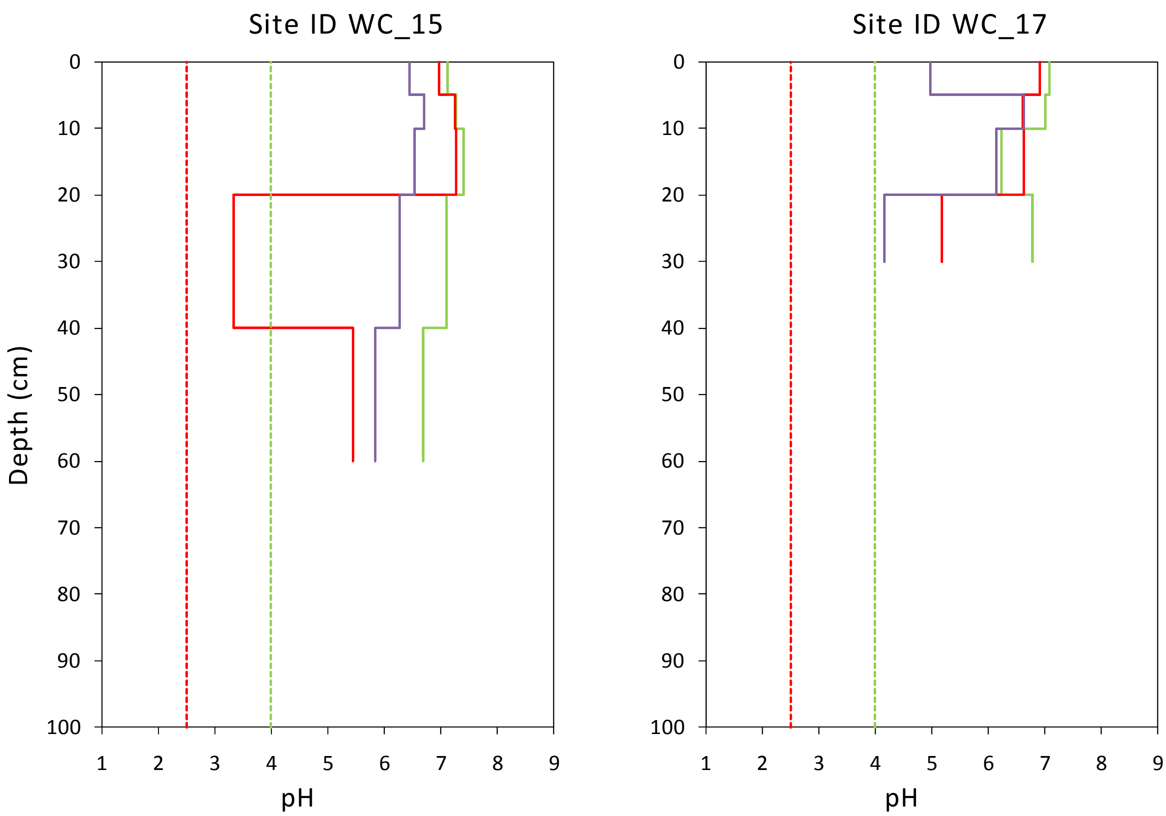

Figure 8-80. Depth profiles of soil pH for sites in Mallan Mallan Creek, showing soil pH (pH_W as green line), peroxide treated pH (pH_{FOX} as red line) and ageing pH ($pH_{incubation}$ after at least 8 weeks as purple line). Critical pH_W and $pH_{incubation}$ value of 4 (green dashed line) and critical pH_{FOX} value of 2.5 (red dashed line).

Acid-base accounting

The acid-base accounting data is provided in Table 8-22 and summarised in Figure 8-81.

Chromium reducible sulfur

Chromium reducible sulfur (S_{CR}) values ranged between 0.01 and 0.27% S_{CR}. Sulfidic soil materials (i.e. S_{CR} ≥ 0.01% S) were identified throughout the profile at both sampling sites (i.e. sites WC_15 and WC_17), with all nine materials collected equal to or greater than the sulfidic criterion.

Acid volatile sulfide

The acid volatile sulfide (S_{AV}) values ranged between < 0.01 and 0.20% S_{AV}. A total of eight monosulfidic soil materials (i.e. S_{AV} ≥ 0.01% S) were found at the two sites examined.

Acid neutralising capacity

The acid neutralising capacity (ANC) ranged between 0.25 and 1.78% $CaCO_3$.

Titratable actual acidity

All soil materials had no titratable actual acidity (TAA).

Retained acidity

All soil materials had no retained acidity.

Net acidity

Net acidity ranged between -78 and 101 mole H^+/tonne. The single hypersulfidic soil had a high net acidity of 101 mole H^+/tonne.

Water Soluble Sulfate

The water soluble sulfate in the surface soils (i.e. 0-20 cm) ranged between 1,464 and 6,105 mg SO_4/kg. All of the surface soil layers examined had a soluble sulfate content exceeding the 100 mg/kg trigger value for MBO formation potential.

Water Data

The surface water data measured in the field are presented in Table 8-23. A field pH of 4.6 was only recorded at site WC_17 and was below the most relevant ANZECC/ARMCANZ (2000) trigger value for aquatic ecosystems of 6.5. The water data indicates that the surface water has been affected by acidification. Dissolved oxygen, SEC and turbidity values were sometimes found to exceed the most relevant ANZECC/ARMCANZ (2000) guideline value.

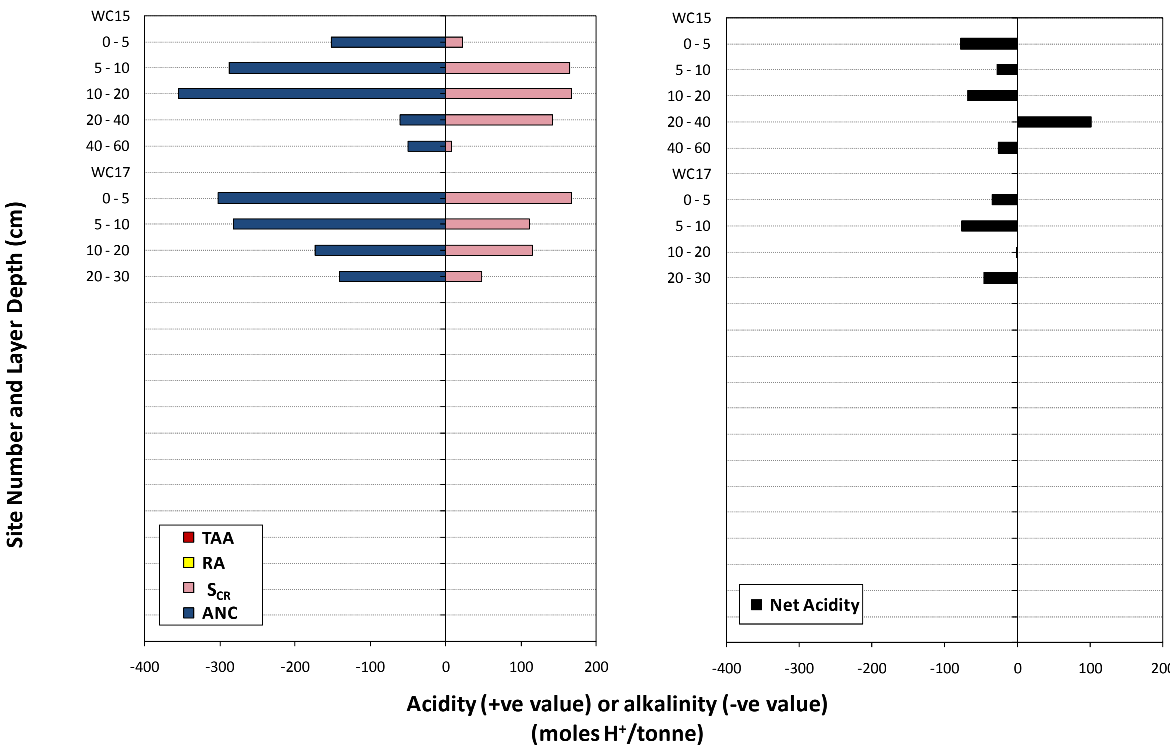

Figure 8-81. Acid-base accounting depth profiles for sites in Mallan Mallan Creek. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), acid neutralising capacity (ANC - blue bar), retained acidity (RA - yellow bar), and right side shows net acidity.

8.6.4. Discussion

Acid sulfate soils occurred at the both sites examined in Mallan Mallan Creek (i.e. sites WC_15 and WC_17). The presence of reduced inorganic sulfur was identified throughout the profile at the two sites, with a S_{CR} of up to 0.27% S. A single hypersulfidic soil material with a high net acidity (i.e. 101 mole H^+/tonne) was present at site WC_15. All other sulfidic soils were hyposulfidic soil materials. Monosulfidic soil materials were also observed in the surface soils and subsoils at the two sites, with S_{AV} contents of up to 0.20% S. These results indicate that acidity would be produced upon oxidation of the sulfidic materials. All surficial soil materials contained soluble sulfate either equal to or exceeding the 100 mg/kg trigger value for MBO formation potential.

Based on the priority ranking criteria adopted by the Scientific Reference Panel of the Murray-Darling Basin Acid Sulfate Soil Risk Assessment Project, there was one high priority site based on hypersulfidic material, two high priority sites based on hyposulfidic material (S_{CR} ≥ 0.10%) and two high priority sites based on monosulfidic material. Both sampling sites had a high priority ranking for Phase 2 detailed assessment based on MBO formation hazard.

The potential hazards posed by acid sulfate soil materials in Mallan Mallan Creek are:

- Acidification hazard: While low net acidities were dominant in this creek, one hypersulfidic material had a high net acidity (i.e. 11% of layers), indicating that the overall degree of acidification hazard is high.
- Deoxygenation hazard: Monosulfidic soil materials (S_{AV} ≤ 0.20% S) observed in the upper 0-10 cm layers at two sites represent a high deoxygenation hazard. In addition, the soluble sulfate content of surface soil materials at both sites were over the trigger value for MBO formation indicating the possible development of a high deoxygenation hazard at those locations after prolonged wet conditions.
- Metal mobilisation: The high acidification hazard indicates that soil acidification may increase the solubility of metals. The presence of monosulfidic materials in upper soil layers and the potential for MBO formation identified in this creek may also result in a high metal release hazard. This would depend on factors such as the potential for MBO formation and the metal loading in the creek.

Summary of key findings for Mallan Mallan Creek:

Soil materials:	Sulfuric materials were not observed. Sulfidic soil materials identified included: hypersulfidic (1 site) and monosulfidic (2 sites), hyposulfidic ≥ 0.10% (2 sites) and hyposulfidic < 0.10% (2 sites). Low net acidities dominant within creek, although a hypermonosulfidic soil material had a high net acidity.
Acid sulfate soil identification:	• Hyposulfidic materials occurred at all depths. Hypersulfidic materials were recorded at one site, at a depth of 20-40cm. Both sites were subaqueous.
Hazard assessment	• Acidification hazard - high level of concern • Deoxygenation hazard - high level of concern • Metal mobilisation hazard - high level of concern

Table 8-22. Laboratory analytical data for acid sulfate soil assessment of Mallan Mallan Creek sites.
(red printed values indicate data results of potential concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4 / kg)	pH KCl	Titratable Actual Acidity (mole H^+/t)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H^+/t)	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/t)	Acid Volatile Sulfide (%S_{AV})	Acid Sulfate Soil Material Classification
15.1	0-5		7.12	6.96	6.44	2175.00	8.25	0.00	0.04	0.00	0.76	-77.79	0.02	Hypomonosulfidic
15.2	5-10		7.27	7.25	6.70*	6105.00	8.90	0.00	0.26	0.00	1.44	-27.29	0.17	Hypomonosulfidic
15.3	10-20		7.40	7.27	6.53*	3345.00	8.93	0.00	0.27	0.00	1.78	-68.38	0.18	Hypomonosulfidic
15.4	20-40		7.11	3.34	6.28*	780.00	8.78	0.00	0.23	0.00	0.31	101.29	0.03	Hypermonosulfidic#
15.5	40-60		6.68	5.45	5.83*	507.00	8.56	0.00	0.01	0.00	0.25	-26.07	0.01	Hypomonosulfidic
17.1	0-5		7.08	6.92	4.97*	1467.00	8.67	0.00	0.27	0.00	1.52	-34.71	0.20	Hypomonosulfidic
17.2	5-10		7.00	6.61	6.63*	1590.00	8.69	0.00	0.18	0.00	1.41	-76.83	0.11	Hypomonosulfidic
17.3	10-20		6.23	6.64	6.14	1464.00	8.31	0.00	0.19	0.00	0.87	-0.37	0.10	Hypomonosulfidic
17.4	20-30		6.78	5.19	4.16*	645.00	6.71	0.00	0.08	0.00	0.71	-45.91	0.00	Hyposulfidic

* Indicates that a stable pH has not yet been reached for this sample (after at least 15 weeks). # Classified as hypermonosulfidic based on positive net acidity.

Table 8-23. Field hydrochemistry data for acid sulfate soil assessment of Mallan Mallan Creek sites.

Site ID.	Temperature (Deg C)	Specific Electrical Conductivity (µS/cm)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	ORP (mV)	Redox potential (mV)	Turbidity (NTU)	Comment
*Lowland River**		*125-2,220*	*85-110*		*6.5-8.0*			*6-50*	
WC_15	19.5	85.2	113.8	10.65	n.a.	290		80	
WC_17	9.5	14,860	127.7	14.57	4.62	237		11	

* ANZECC water quality guidelines for lowland rivers in South-east Australia are provided for relevant parameters (ANZECC/ARMCANZ, 2000).
Surface water values outside the ranges defined in the ANZECC guidelines are indicated with red text.

Table 8-24. Profile description data for acid sulfate soil assessment of Mallan Mallan Creek sites.

Site and Sample No.	Horizon Depth Range (cm)	Soil Colour – moist [1]	Texture Class [1]	Texture Modifiers[1]	Moisture State[1]	Redoximorphic Features Abundance (%) [2]	Redoximorphic Features – Kind [2]	Redoximorphic Features - Colour [2]	Redoximorphic Features - Location [2]	Structure - Type[1]	Structure - Grade[1]	Consistency (moist or dry) - Rupture Resistance[1]	pH (field measurement)	Comments (odour, fragments, minerals, plant material, inclusions, other)
15.1	0-5	7.5YR 5/6	Muck		W								6.50	Iron floc
15.2	5-10	10YR 2/1	Muck		W								6.00	
15.3	10-20	10YR 2/1	Muck		W								6.00	
15.4	20-40	2.5Y 3/1	CS		W								5.90	
15.5	40-60	2.5Y 5/1	LS		W								5.70	
17.1	0-5	N2.5	Muck		W					MA	0		4.33	
17.2	5-10	2.5Y 5/2	Muck		W					MA	0		4.13	
17.3	10-20	2.5Y 5/1	Muck		W					MA	0		3.95	
17.4	20-30	5Y 4/1	ZCL		W					MA	0		4.22	

[1] See National Committee on Soil and Terrain (2009) for abbreviation definitions and further details.

[2] See Schoeneberger *et al.* (2002) for abbreviation definitions and further details.

8.7. Merran Creek

8.7.1. Location and setting description

Merran Creek is connected in its upper reaches to Eagle Creek, which originates in the area to the immediate east of Barham (Figure 8-82). Eagle Creek is supplemented by an off take canal from the Murray River at Barham, and then meanders in a generally north-westerly direction. Approximately 10 km north-west of Barham, artificial canals off take from the Murray and deliver water to Eagle Creek, from which it can be delivered into Barbers Creek to the north, via a small natural connecting channel, at a point where the two creeks come to within 570 m of each other. Downstream of this point, the system is known as Merran Creek, which continues to meander in a generally north-westerly direction, with a number of major meander cut offs. Merran Creek is connected to the Wakool via natural channels along this section, at one point coming within 1 km of the river. This section of the system is fluvially complex and anastomosing, and ~34 km north-west of Barham, the creek diverges, the northern channel being Coobool Creek. Approximately 45 km north-west of Barham, and ~23 km east of Swan Hill, Merran Creek redirects towards the west into an area marked by sand dunes, deflation basins and lunettes. After being joined by Waddy Creek from the south, the Merran rounds the southern end and flows along the western side of a major lunette remnant, before flowing through a break in this lunette remnant and across the floor of a more recent lake/deflation basin, Lake Tooim. After leaving the bed of this lake, Merran Creek flows in a generally north-westerly direction across the bed of another, larger basin, before turning to the north and incising into an older Shepparton surface before finally flowing into the Wakool at Stony Crossing, itself flowing through a large basin in this area.

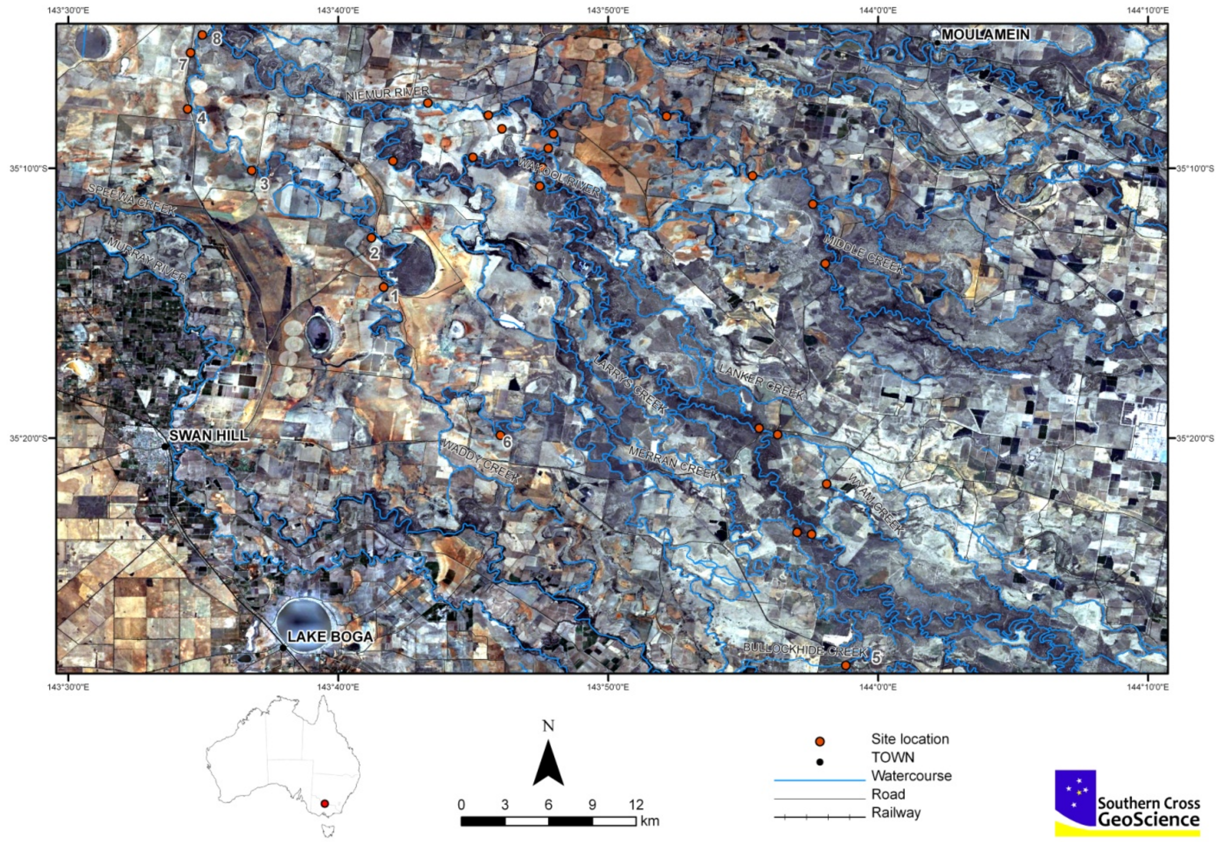

Figure 8-82. Merran Creek and sample site locations.

8.7.2. Soil profile description and distribution

Eight sites were described and sampled in Merran Creek. The soil subtype and general location description are presented in Table 8-25. Profile description data are presented in Table 8-28.

Table 8-25. Soil identification, subtype and general location description for sites sampled in Merran Creek.

Site ID	Easting UTM Zone 54H	Northing UTM Zone 54H	Acid sulfate soil subtype class
WC_1	745200	6097000	Subaqueous Soil
WC_2	744600	6100400	Hypersulfidic Subaqueous Soil
WC_3	738000	6105200	Hypersulfidic Subaqueous Soil with Monosulfides
WC_4	734500	6109500	Hypersulfidic Subaqueous Soil with Monosulfides
WC_5	770400	6070339	Subaqueous Soil
WC_6	751479	6086667	Hypersulfidic Subaqueous Soil
WC_7	734767	6113357	Hypersulfidic Subaqueous Soil with Monosulfides
WC_8	735457	6114554	Hypersulfidic Subaqueous Soil with Monosulfides

Figure 8-83. Photographs of site WC_1 Merran Creek, showing the site and the soil profile.

Figure 8-84. Photographs of site WC_2 Merran Creek, showing the site and the soil profile.

Figure 8-85. Photographs of site WC_3 Merran Creek, showing the site and the soil profile.

Figure 8-86. Photographs of site WC_4 Merran Creek, showing the site and the soil profile.

Figure 8-87. Photographs of site WC_5 Merran Creek, showing the site and the soil profile.

Figure 8-88. Photographs of site WC_6 Merran Creek, showing the site and the soil profile.

Figure 8-89. Photographs of site WC_7 Merran Creek, showing the site and the soil profile.

Figure 8-90. Photographs of site WC_8 Merran Creek, showing the site and the soil profile.

8.7.3. Laboratory data assessment

Soil pH testing (pH_W, pH_{FOX}, pH_{KCl}, $pH_{INCUBATION}$)

The pH data is provided in Table 8-26 and depth profiles of soil pH for all the sites sampled are presented in Figure 8-91. The pH_W values ranged between 5.49 and 7.63. Sulfuric materials (i.e. $pH_W < 4$) were not present. The pH_{FOX} values ranged between 1.72 and 6.97. The pH_{FOX} results indicate that many of the surface soils may have the potential to acidify to pH < 4 as a result of sulfide oxidation. Eighteen soil materials had a $pH_{FOX} < 2.5$ suggesting that soil acidity problems will emerge when these soils are exposed to air. The S_{CR} data shows 19 of the 39 layers examined contained detectable sulfide (i.e. $S_{CR} \geq 0.01\%$ S). The pH_{KCl} values ranged between 3.97 and 7.96. Seven of the sulfidic soil materials (i.e. $S_{CR} \geq 0.01\%$ S) acidified to pH < 4 after at least 8 weeks of incubation. Other acidic soil materials were identified at seven of the eight sites examined, indicating acidity in the soil profile at levels where aluminium may mobilise.

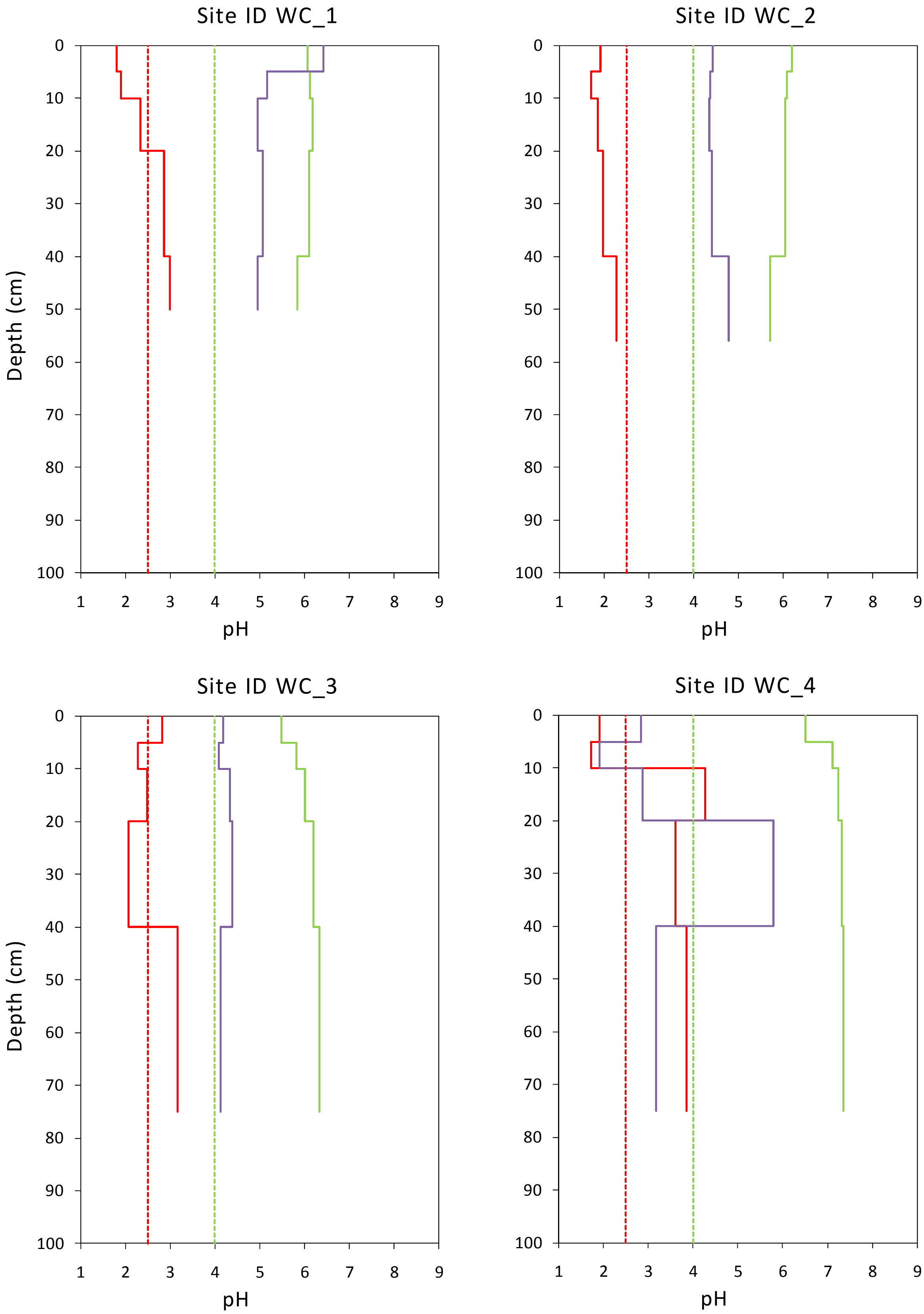

Figure 8-91. Depth profiles of soil pH for sites in Merran Creek, showing soil pH (pH_W as green line), peroxide treated pH (pH_{FOX} as red line) and ageing pH ($pH_{incubation}$ after at least 8 weeks as purple line). Critical pH_W and $pH_{incubation}$ value of 4 (green dashed line) and critical pH_{FOX} value of 2.5 (red dashed line).

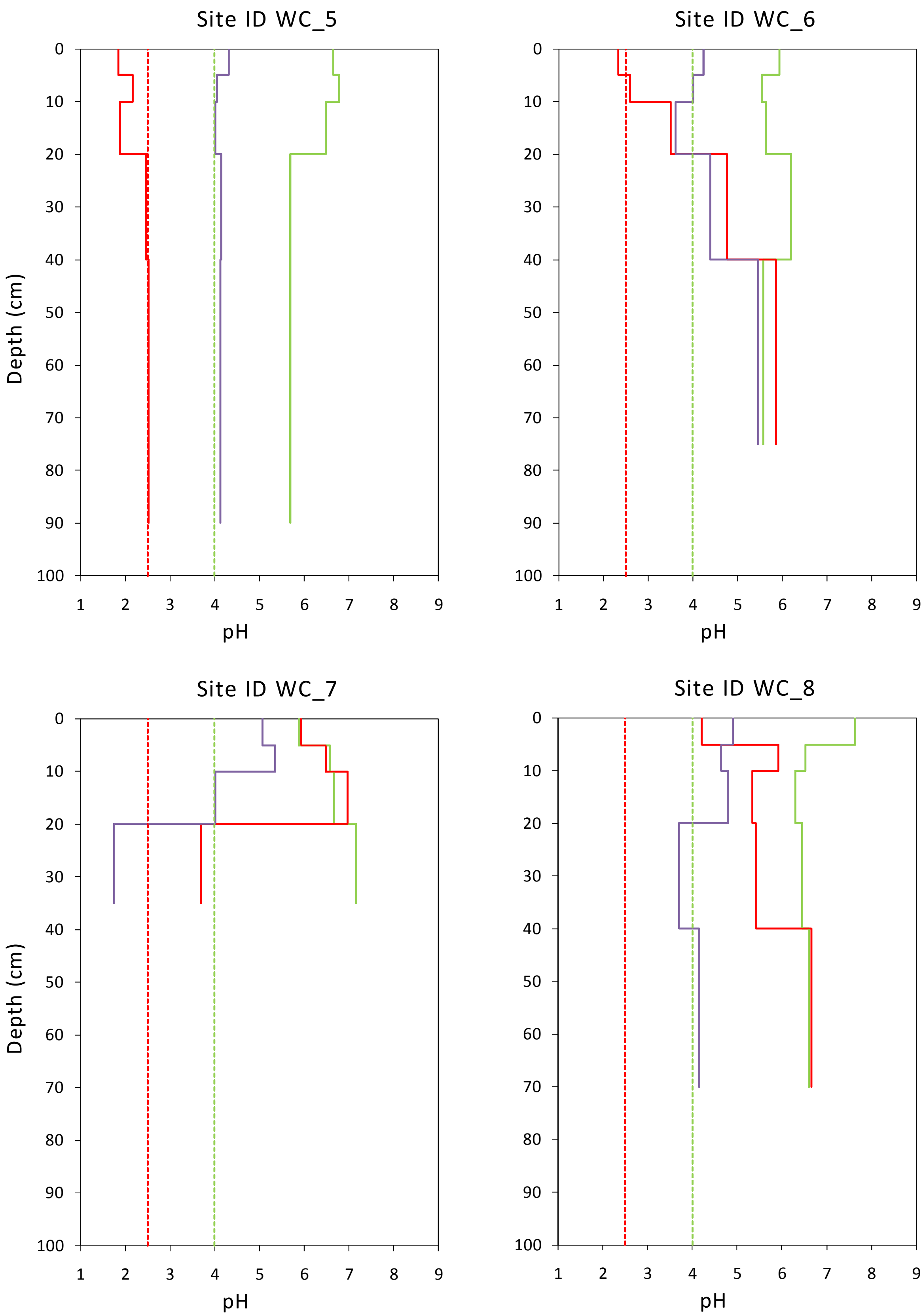

Figure 8-92. Depth profiles of soil pH for sites in Merran Creek, showing soil pH (pH_W as green line), peroxide treated pH (pH_{FOX} as red line) and ageing pH ($pH_{incubation}$ after at least 8 weeks as purple line). Critical pH_W and $pH_{incubation}$ value of 4 (green dashed line) and critical pH_{FOX} value of 2.5 (red dashed line).

Acid-base accounting

The acid-base accounting data is provided in Table 8-26 and summarised in Figure 8-93.

Chromium reducible sulfur

Chromium reducible sulfur (S_{CR}) values ranged between < 0.01 and 1.16% S_{CR}. Sulfidic soil materials (i.e. S_{CR} ≥ 0.01% S) were identified at six of the eight sampling sites (i.e. sites WC_2, WC_3, WC_4, WC_6, WC_7 and WC_8), with 19 materials of the 39 samples collected equal to or greater than the sulfidic criterion.

Acid volatile sulfide

The acid volatile sulfide (S_{AV}) values ranged between < 0.01 and 0.31% S_{AV}. A total of four monosulfidic soil materials (i.e. S_{AV} ≥ 0.01% S) were found at four sites (i.e. sites WC_3, WC_4, WC_7 and WC_8).

Acid neutralising capacity

The acid neutralising capacity (ANC) ranged between zero and 1.05% $CaCO_3$.

Titratable actual acidity

The titratable actual acidity (TAA) ranged between zero and 46 mole H^+/tonne.

Retained acidity

Retained acidity was only detected in two layers and ranged between zero and 2 mole H^+/tonne.

Net acidity

Net acidity ranged between -5 and 602 mole H^+/tonne. The 18 hypersulfidic soils had low to high net acidities ranging between 11 and 602 mole H^+/tonne.

Water Soluble Sulfate

The water soluble sulfate in the surface soils (i.e. 0-20 cm) ranged between 45 and 2,850 mg SO_4/kg. The surface soil layers at seven of the eight sites examined had a soluble sulfate content exceeding the 100 mg/kg trigger value for MBO formation potential.

Water Data

The surface water data measured in the field are presented in Table 8-27. The field pH of the surface waters collected ranged between 6.7 and 7.9, with none of the sites being outside the most relevant ANZECC/ARMCANZ (2000) trigger values for aquatic ecosystems of 6.5 and 8.0. The water data indicates that the surface water has not been affected by acidification. Dissolved oxygen and turbidity values were found to be outside the most relevant ANZECC/ARMCANZ (2000) guideline value at some sites.

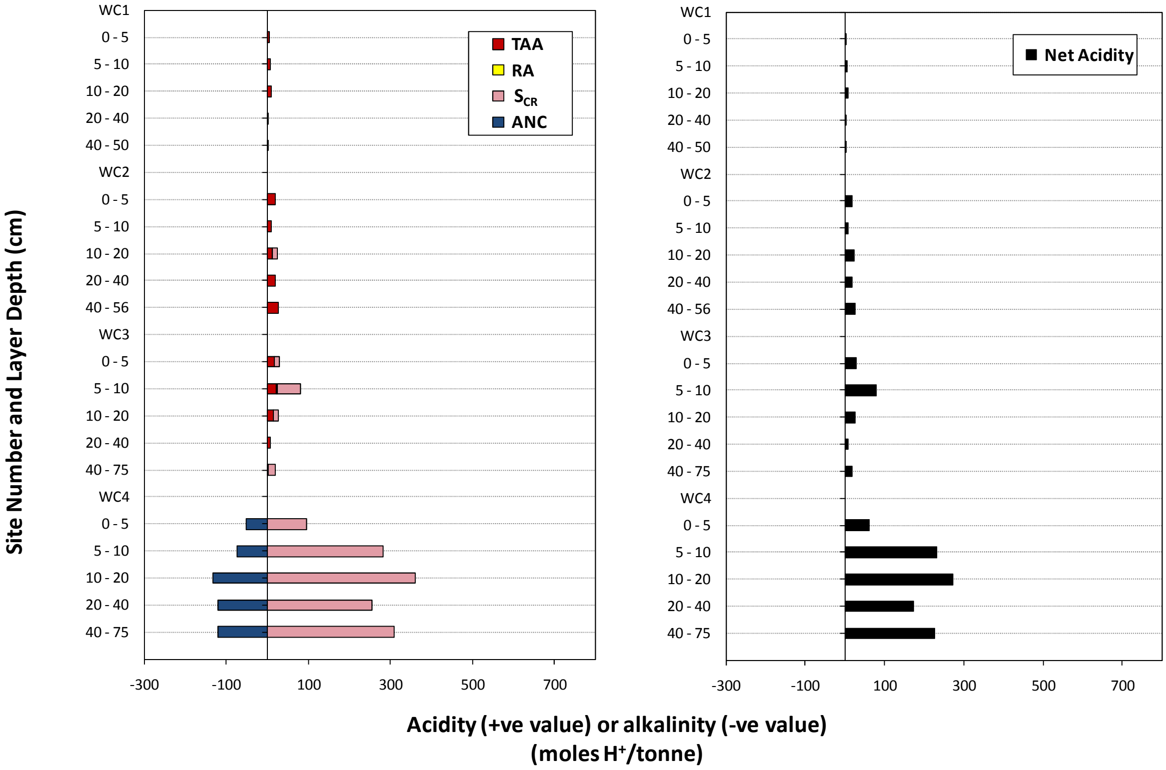

Figure 8-93. Acid-base accounting depth profiles for sites in Merran Creek. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), acid neutralising capacity (ANC - blue bar), retained acidity (RA - yellow bar), and right side shows net acidity.

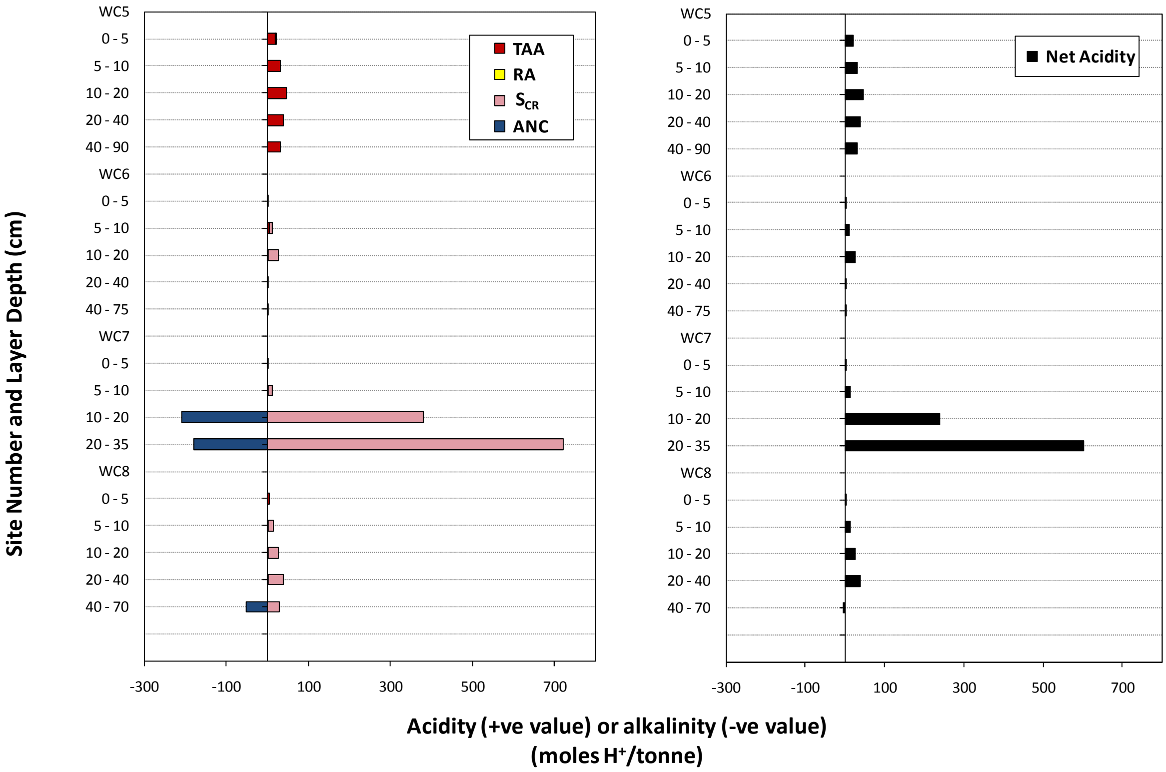

Figure 8-94. Acid-base accounting depth profiles for sites in Merran Creek. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), acid neutralising capacity (ANC - blue bar), retained acidity (RA - yellow bar), and right side shows net acidity.

8.7.4. Discussion

Acid sulfate soils occurred at six sites in Merran Creek (i.e. sites WC_2, WC_3, WC_4, WC_6, WC_7 and WC_8). The presence of reduced inorganic sulfur was identified at six sites, with a S_{CR} of up to 1.16% S. Hypersulfidic soil materials with low to high net acidities (i.e. 11 - 602 mole H^+/tonne) were present in the six soil profiles (one profile also contained a hyposulfidic material). Monosulfidic soil materials were also observed in the surface soils/subsoils at four of the sites, with S_{AV} contents of up to 0.31% S. Monosulfidic soil materials (S_{AV} ≤ 0.04% S) were observed in the upper 0-10 cm layers at two sites. These results indicate that acidity would be produced upon oxidation of the sulfidic materials. The surficial soil materials at seven sites contained soluble sulfate exceeding the 100 mg/kg trigger value for MBO formation potential. Other acidic soil materials were also observed at seven sites.

Based on the priority ranking criteria adopted by the Scientific Reference Panel of the Murray-Darling Basin Acid Sulfate Soil Risk Assessment Project, there were six high priority sites based on hypersulfidic material and four high priority sites based on monosulfidic material. There was also one moderate priority site based on the presence of hyposulfidic material with S_{CR} < 0.10%. Seven sampling sites had a high priority ranking for Phase 2 detailed assessment based on MBO formation hazard.

The potential hazards posed by acid sulfate soil materials in Merran Creek are:

- Acidification hazard: While low-moderate net acidities were dominant in this creek, six hypersulfidic materials had high net acidities (i.e. 15% of layers), indicating that the overall degree of acidification hazard is high.

- Deoxygenation hazard: Monosulfidic soil materials (S_{AV} ≤ 0.04% S) observed in the upper 0-10 cm layers at two sites represent a high deoxygenation hazard. In addition, the soluble sulfate content of surface soil materials at seven sites were over the trigger value for MBO formation indicating the possible development of a high deoxygenation hazard at those locations after prolonged wet conditions.

- Metal mobilisation: The high acidification hazard indicates that soil acidification may increase the solubility of metals. The presence of monosulfidic materials in upper soil layers and the potential for MBO formation identified in parts of this creek may also result in a high metal release hazard. This would depend on factors such as the potential for MBO formation and the metal loading in the creek. Soil acidity may be sufficient for mobilisation of aluminium.

Summary of key findings for Merran Creek:

Soil materials:	Sulfuric materials were not observed. Sulfidic soil materials identified included: hypersulfidic (6 sites), monosulfidic (4 sites) and hyposulfidic < 0.10% (1 site). Low-moderate net acidities dominant within creek, although 6 hypersulfidic soil materials had high net acidities.
Acid sulfate soil identification:	• Sulfidic materials occurred across the range of depths, and at some sites were prevalent throughout most or all of the depth profile. Monosulfides were recorded at depths below 5cm. All sites were subaqueous.
Hazard assessment	• Acidification hazard - high level of concern • Deoxygenation hazard - high level of concern • Metal mobilisation hazard - high level of concern

Table 8-26. Laboratory analytical data for acid sulfate soil assessment of Merran Creek sites.
(red printed values indicate data results of potential concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4 / kg)	pH KCl	Titratable Actual Acidity (mole H^+/t)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H^+/t)	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/t)	Acid Volatile Sulfide (%S_{AV})	Acid Sulfate Soil Material Classification
1.1	0-5		6.07	1.81	6.43	97.65	4.89	3.93	0.00	0.00	0.00	3.93	0.00	Other Soil Materials
1.2	5-10		6.12	1.90	5.16*	75.60	4.56	6.18	0.00	0.00	0.00	6.18	0.00	Other Acid Soils
1.3	10-20		6.17	2.33	4.95*	85.95	4.51	8.91	0.00	0.00	0.00	8.91	0.00	Other Acid Soils
1.4	20-40		6.10	2.86	5.06*	35.55	5.03	2.91	0.00	0.00	0.00	2.91	0.00	Other Acid Soils
1.5	40-50		5.84	2.99	4.96*	28.65	5.09	2.68	0.00	0.00	0.00	2.68	0.00	Other Acid Soils
2.1	0-5		6.19	1.93	4.42*	83.70	4.19	18.13	0.00	0.00	0.00	18.13	0.00	Other Acid Soils
2.2	5-10		6.09	1.72	4.38*	81.45	4.41	9.23	0.00	0.00	0.00	9.23	0.00	Other Acid Soils
2.3	10-20		6.04	1.87	4.36*	135.00	4.34	10.63	0.02	0.00	0.00	24.00	0.00	Hypersulfidic#
2.4	20-40		6.04	1.97	4.40*	120.60	4.27	19.35	0.00	0.00	0.00	19.35	0.00	Other Acid Soils
2.5	40-56		5.70	2.29	4.78*	82.35	4.33	25.24	0.00	0.00	0.00	25.24	0.00	Other Acid Soils
3.1	0-5		5.49	2.82	4.18*	177.00	4.26	16.09	0.02	0.00	0.00	28.35	0.00	Hypersulfidic#
3.2	5-10		5.82	2.27	4.09*	444.00	4.30	21.45	0.09	2.00	0.00	79.91	0.04	Hypermonosulfidic#
3.3	10-20		6.01	2.48	4.33*	131.10	4.39	15.23	0.02	0.00	0.00	26.92	0.00	Hypersulfidic#
3.4	20-40		6.20	2.07	4.38*	103.05	4.82	7.34	0.00	0.00	0.00	7.34	0.00	Other Acid Soils
3.5	40-75		6.32	3.17	4.13*	313.50	6.39	2.43	0.03	0.00	0.00	19.01	0.00	Hypersulfidic#
4.1	0-5		6.50	1.92	2.84*	1347.00	7.00	0.00	0.15	0.00	0.27	60.75	0.00	Hypersulfidic
4.2	5-10		7.11	1.73	1.92*	1665.00	7.48	0.00	0.45	0.00	0.37	232.67	0.03	Hypermonosulfidic
4.3	10-20		7.25	4.26	2.87*	2850.00	7.44	0.00	0.58	0.00	0.66	273.33	0.00	Hypersulfidic
4.4	20-40		7.32	3.60	5.80*	2595.00	6.94	0.00	0.41	0.00	0.60	174.55	0.00	Hypersulfidic#
4.5	40-75		7.36	3.86	3.17*	3810.00	7.04	0.00	0.49	0.00	0.60	227.46	0.00	Hypersulfidic
5.1	0-5		6.65	1.84	4.32*	118.95	4.49	18.02	0.00	2.00	0.00	20.02	0.00	Other Acid Soils
5.2	5-10		6.79	2.17	4.05*	117.75	4.13	31.67	0.00	0.00	0.00	31.67	0.00	Other Acid Soils
5.3	10-20		6.47	1.89	4.01*	141.00	3.97	45.75	0.00	0.00	0.00	45.75	0.00	Other Acid Soils
5.4	20-40		5.69	2.47	4.14*	137.85	4.17	38.29	0.00	0.00	0.00	38.29	0.00	Other Acid Soils
5.5	40-90		5.68	2.53	4.12*	118.80	4.32	32.27	0.00	0.00	0.00	32.27	0.00	Other Acid Soils

* Indicates that a stable pH has not yet been reached for this sample (after at least 15 weeks). # Classified as hypermonosulfidic/hypersulfidic based on positive net acidity.

Table 8-26 (continued). Laboratory analytical data for acid sulfate soil assessment of Merran Creek sites.

(red printed values indicate data results of potential concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4 / kg)	pH KCl	Titratable Actual Acidity (mole H^+/t)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H^+/t)	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/t)	Acid Volatile Sulfide (%S_{AV})	Acid Sulfate Soil Material Classification
6.1	0-5		5.93	2.33	4.23*	44.55	4.85	2.94	0.00	0.00	0.00	2.94	0.00	Other Acid Soils
6.2	5-10		5.53	2.60	4.01*	57.90	4.98	3.21	0.01	0.00	0.00	11.18	0.00	Hypersulfidic#
6.3	10-20		5.64	3.51	3.62*	213.00	5.38	2.55	0.04	0.00	0.00	26.30	0.00	Hypersulfidic
6.4	20-40		6.19	4.76	4.39*	552.00	5.92	2.82	0.00	0.00	0.00	2.82	0.00	Other Acid Soils
6.5	40-75		5.58	5.86	5.47*	874.50	6.38	1.13	0.00	0.00	0.00	1.13	0.00	Other Soil Materials
7.1	0-5		5.88	5.93	5.07*	166.50	6.24	2.98	0.00	0.00	0.00	2.98	0.00	Other Acid Soils
7.2	5-10		6.58	6.48	5.34*	166.50	6.12	2.96	0.02	0.00	0.00	12.81	0.00	Hypersulfidic#
7.3	10-20		6.66	6.97	4.01*	1410.00	7.96	0.00	0.61	0.00	1.05	239.70	0.31	Hypermonosulfidic#
7.4	20-35		7.16	3.69	1.76*	1935.00	7.57	0.00	1.16	0.00	0.90	601.66	0.00	Hypersulfidic
8.1	0-5		7.63	4.22	4.91*	312.00	5.66	3.15	0.00	0.00	0.00	3.15	0.00	Other Acid Soils
8.2	5-10		6.53	5.93	4.65*	555.00	5.94	2.81	0.02	0.00	0.00	14.21	0.00	Hypersulfidic#
8.3	10-20		6.30	5.34	4.80*	652.50	5.83	2.63	0.04	0.00	0.00	26.37	0.00	Hypersulfidic#
8.4	20-40		6.46	5.41	3.70*	850.50	6.28	2.81	0.06	0.00	0.00	38.45	0.02	Hypermonosulfidic
8.5	40-70		6.60	6.66	4.15*	594.00	6.76	0.00	0.05	0.00	0.26	-4.71	0.00	Hyposulfidic

* Indicates that a stable pH has not yet been reached for this sample (after 19 weeks). # Classified as hypermonosulfidic/hypersulfidic based on positive net acidity.

Table 8-27. Field hydrochemistry data for acid sulfate soil assessment of Merran Creek sites.

Site ID.	Temperature (Deg C)	Specific Electrical Conductivity (µS/cm)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	ORP (mV)	Redox potential (mV)	Turbidity (NTU)	Comment
*Lowland River**		*125-2,220*	*85-110*		*6.5-8.0*			*6-50*	
WC_1	12.4	118		7.54	6.93	351		n.a.	
WC_2	12.7	92.5		6.23	7.03	345		80	
WC_3	13.5	84.0		7.30	6.90	358		80	
WC_4	14.1	297		9.70	7.07	369		150	
WC_5	12.5	52.8	71.4	7.64	7.09	299		60	
WC_6	13.2	154	1.8	0.19	6.71	332		60	
WC_7	15.8	386	109.8	11.01	7.86	42		n.a.	
WC_8	14.7	633	2.2	0.22	7.27	-30		200	

* ANZECC water quality guidelines for lowland rivers in South-east Australia are provided for relevant parameters (ANZECC/ARMCANZ, 2000).
Surface water values outside the ranges defined in the ANZECC guidelines are indicated with red text.

Table 8-28. Profile description data for acid sulfate soil assessment of Merran Creek sites.

Site and Sample No.	Horizon Depth Range (cm)	Soil Colour – moist [1]	Texture Class [1]	Texture Modifiers[1]	Moisture State[1]	Redoximorphic Features Abundance (%) [2]	Redoximorphic Features – Kind [2]	Redoximorphic Features - Colour [2]	Redoximorphic Features - Location [2]	Structure - Type[1]	Structure - Grade[1]	Consistency (moist or dry) - Rupture Resistance[1]	pH (field measurement)	Comments (odour, fragments, minerals, plant material, inclusions, other)
1.1	0-5	2.5Y 5/1	ZCL		W					MA	0		6.93	
1.2	5-10	2.5Y 5/1	ZCL		W					MA	0		7.04	
1.3	10-20	2.5Y 5/1	C	S	W					MA	0		7.04	
1.4	20-40	2.5Y 5/1	LS		W					SG	0		7.25	
1.5	40-50	2.5Y 5/1	LS		W					SG	0		7.40	
2.1	0-5	2.5Y 5/1	ZCL		W					MA	0		7.58	
2.2	5-10	2.5Y 5/1	ZCL		W					MA	0		7.46	
2.3	10-20	2.5Y 5/1	SCL		W					MA	0		7.56	
2.4	20-40	2.5Y 5/1	SCL		W					MA	0		7.18	
2.5	40-56	2.5Y 5/1	ZC		W					MA	0		7.06	
3.1	0-5	2.5Y 5/1	ZCL		W					MA	0		6.98	
3.2	5-10	2.5Y 5/1	ZCL		W					MA	0		7.17	
3.3	10-20	2.5Y 5/1	ZCL		W					MA	0		6.98	
3.4	20-40	2.5Y 5/1	ZCL		W					MA	0		7.04	
3.5	40-75	2.5Y 5/1	ZCL		W					MA	0		6.90	
4.1	0-5	5Y 2/1	CLS		W					MA	0		8.00	Schwertmannite around water
4.2	5-10	5Y 3/1	CLS		W					MA	0		7.81	
4.3	10-20	5Y 4/1	ZC		W					MA	0		7.50	
4.4	20-40	5Y 5/1	ZC		W					MA	0		7.44	
4.5	40-75	5Y 5/1	ZC		W					MA	0		7.25	

Table 8-28 (continued). Profile description data for acid sulfate soil assessment for Merran Creek sites.

Site and Sample No.	Horizon Depth Range (cm)	Soil Colour – moist [1]	Texture Class [1]	Texture Modifiers[1]	Moisture State[1]	Redoximorphic Features Abundance (%) [2]	Redoximorphic Features – Kind [2]	Redoximorphic Features - Colour [2]	Redoximorphic Features - Location [2]	Structure - Type[1]	Structure - Grade[1]	Consistency (moist or dry) - Rupture Resistance[1]	pH (field measurement)	Comments (odour, fragments, minerals, plant material, inclusions, other)
5.1	0-5	10YR 5/1	ZC		W					MA	0		6.97	
5.2	5-10	10YR 5/1	ZC		W					MA	0		7.22	
5.3	10-20	10YR 5/1	ZC		W					MA	0		7.13	
5.4	20-40	10YR 5/1	ZC		W					MA	0		6.99	
5.5	40-90	10YR 5/1	ZC		W					MA	0		7.42	
6.1	0-5	10YR 5/2	CS		W					SG	0		7.08	
6.2	5-10	10YR 6/2	LS		W					SG	0		6.80	
6.3	10-20	2.5Y 4/2	SCL		W					MA	0		6.11	
6.4	20-40	2.5Y 4/2	CS		W					MA	0		6.76	
6.5	40-75	5GY 4/2	CS		W					MA	0		6.84	Bluish grey mottles - fougerite?
7.1	0-5	10Y 5/2	CL		W					MA	0		7.26	
7.2	5-10	10Y 4/1	CL		W					MA	0		7.58	
7.3	10-20	10YR 2/1	CL		W					MA	0		7.79	
7.4	20-35	10YR 4/1	CL		W					MA	0		8.05	
8.1	0-5	10YR 5/4	CS		W	50	FM			MA	0		7.06	
8.2	5-10	10YR 5/2	C	S	W					MA	0		6.93	Ironstone nodules common
8.3	10-20	10YR 5/3	C		W					MA	0		7.03	Ironstone nodules common
8.4	20-40	10YR 4/1	C		W					MA	0		7.23	
8.5	40-70	10Y 4/1	C		W					MA	0		7.43	

[1] See National Committee on Soil and Terrain (2009) for abbreviation definitions and further details.

[2] See Schoeneberger *et al.* (2002) for abbreviation definitions and further details.

8.8. Yarrein Creek

8.8.1. Location and setting description

The upper reaches of Yarrein Creek receive flow from the Edward River, ~10 km and ~14 km upstream of Moulamein, at two points where a major Yanco Phase channel approaches the Edward from the south. Shortly downstream, a connecting channel diverts some flow to the Niemur River, with Yarrein Creek meandering in a generally north-westerly direction within the ~1.5 km wide Yanco Phase channel. Yarrein Creek continues for another ~55 km, confined within the Yanco channel, until its confluence with the Wakool River, 15 km upstream of Kyalite.

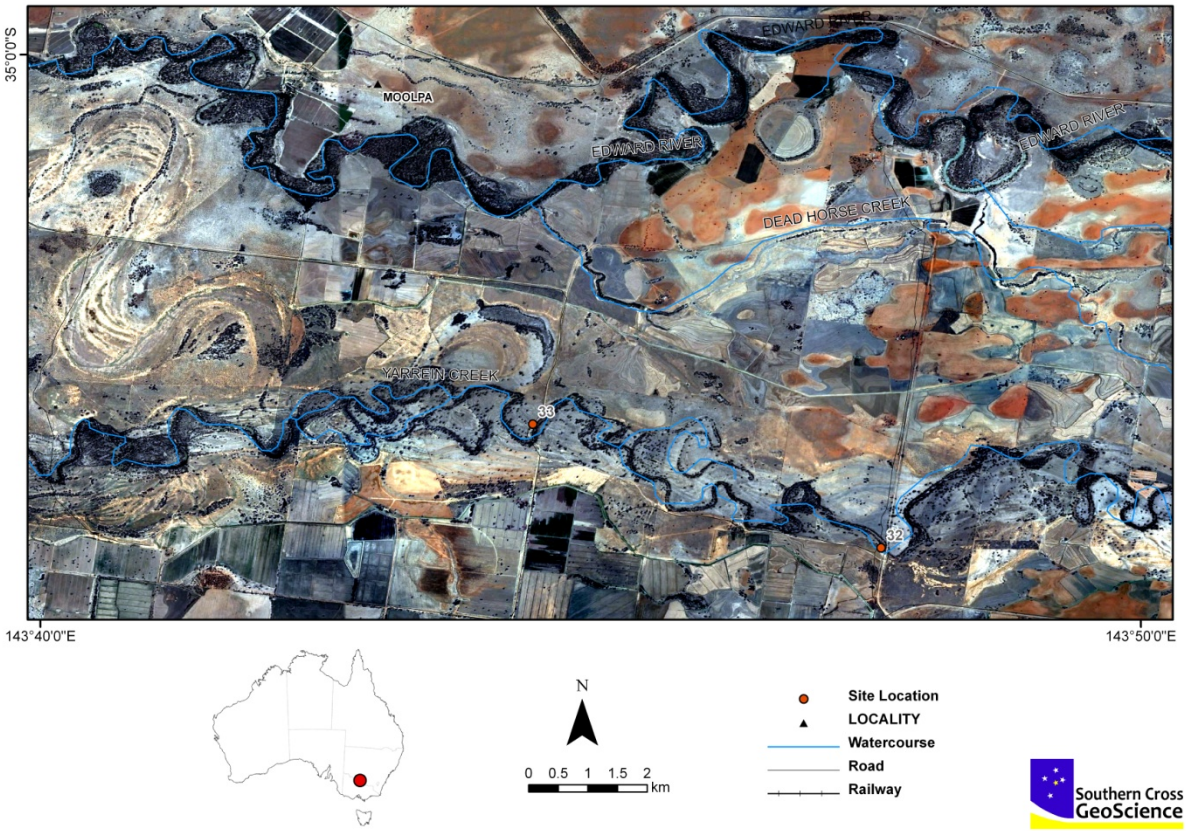

Figure 8-95. Yarrein Creek and sample site locations.

8.8.2. Soil profile description and distribution

Two sites were described and sampled in Yarrein Creek. The soil subtype and general location description are presented in Table 8-29. Profile description data are presented in Table 8-32.

Table 8-29. Soil identification, subtype and general location description for sites sampled in Yarrein Creek.

Site ID	Easting UTM Zone 54H	Northing UTM Zone 54H	Acid sulfate soil subtype class
WC_32	754718	6114930	Hypersulfidic Subaqueous Soil with Monosulfides
WC_33	749985	6007278	Hydrosol

Figure 8-96. Photographs of site WC_32 Yarrein Creek, showing the site and the soil core.

Figure 8-97. Photographs of site WC_33 Yarrein Creek, showing the site and the soil profile.

8.8.3. Laboratory data assessment

Soil pH testing (pH_W, pH_{FOX}, pH_{KCl}, $pH_{INCUBATION}$)

The pH data is provided in Table 8-30 and depth profiles of soil pH for all the sites sampled are presented in Figure 8-98. The pH_W values ranged between 4.42 and 6.42. No sulfuric materials (i.e. pH_W < 4) were present. The pH_{FOX} values ranged between 3.41 and 6.71. The pH_{FOX} results indicate that one of the surface soils may have the potential to acidify to pH < 4 as a result of sulfide oxidation. The S_{CR} data shows only one of the ten layers examined contained detectable sulfide (i.e. S_{CR} ≥ 0.01% S). The pH_{KCl} values ranged between 5.02 and 8.35. The sulfidic soil material (i.e. S_{CR} ≥ 0.01% S) did not acidify to pH < 4 after at least 8 weeks of incubation. Other acidic soil materials were identified at both sites examined, indicating acidity in the soil profile at levels where aluminium may mobilise. One of the other acidic soils acidified to pH < 4 after at least 8 weeks of incubation.

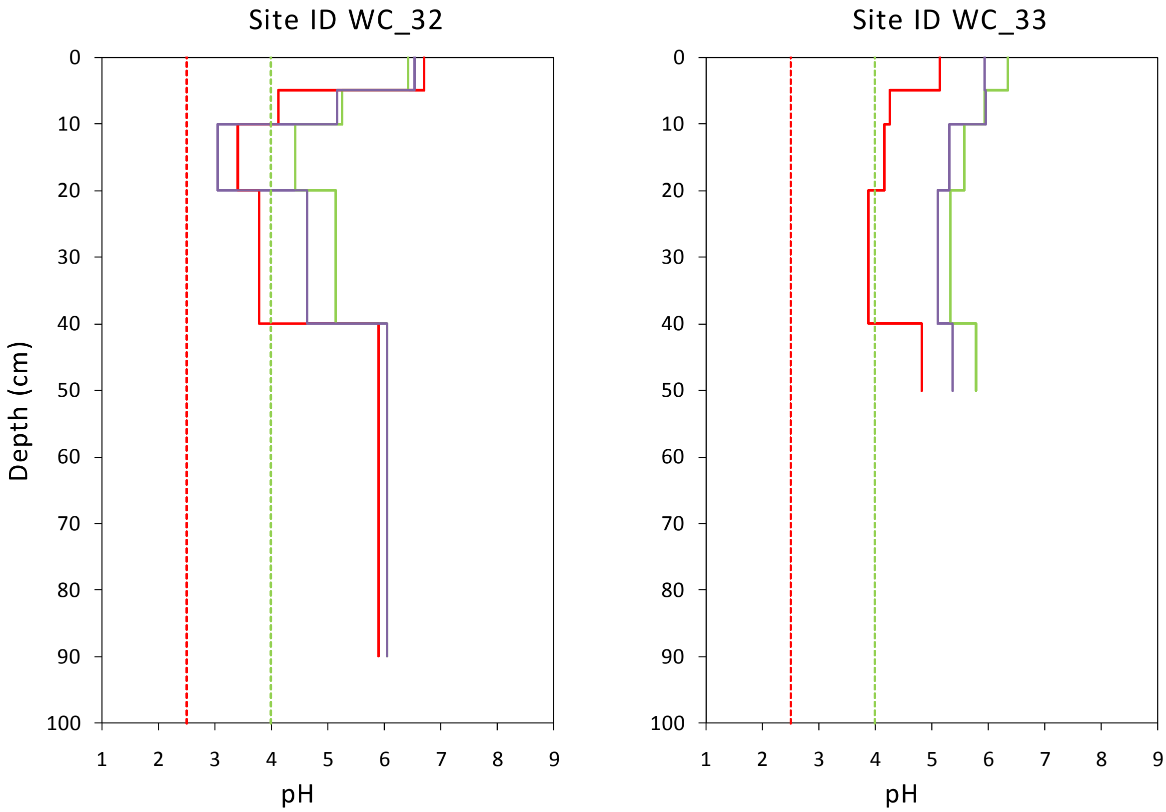

Figure 8-98. Depth profiles of soil pH for sites in Yarrein Creek, showing soil pH (pH_W as green line), peroxide treated pH (pH_{FOX} as red line) and ageing pH ($pH_{incubation}$ after at least 8 weeks as purple line). Critical pH_W and $pH_{incubation}$ value of 4 (green dashed line) and critical pH_{FOX} value of 2.5 (red dashed line).

Acid-base accounting

The acid-base accounting data is provided in Table 8-30 and summarised in Figure 8-99.

Chromium reducible sulfur

Chromium reducible sulfur (S_{CR}) values ranged between < 0.01 and 0.09% S_{CR}. A sulfidic soil material (i.e. S_{CR} ≥ 0.01% S) was identified at one of the two sampling sites (i.e. site WC_32), with only one material of the ten samples collected equal to or greater than the sulfidic criterion.

Acid volatile sulfide

The acid volatile sulfide (S_{AV}) values ranged between < 0.01 and 0.05% S_{AV}. A single monosulfidic soil material (i.e. S_{AV} ≥ 0.01% S) was found at Site WC_32 (40-90 cm).

Acid neutralising capacity

The acid neutralising capacity (ANC) ranged between zero and 1.45% $CaCO_3$.

Titratable actual acidity

The titratable actual acidity (TAA) ranged between zero and 9 mole H^+/tonne.

Retained acidity

All soil materials had no retained acidity.

Net acidity

All soil materials had low net acidities, ranging between -193 and 9 mole H^+/tonne.

Water Soluble Sulfate

The water soluble sulfate in the surface soils (i.e. 0-20 cm) ranged between 164 and 16,350 mg SO_4/kg. All of the surface soil layers examined had a soluble sulfate content exceeding the 100 mg/kg trigger value for MBO formation potential.

Water Data

Surface water data was only collected at site WC_32 as site WC_33 was dry at the time of sampling (Table 8-31). The field pH of the surface water collected was 5.8 and was below the most relevant ANZECC/ARMCANZ (2000) trigger value for aquatic ecosystems of 6.5. The water data indicates that the surface water has been affected by acidification. SEC was found to exceed the most relevant ANZECC/ARMCANZ (2000) guideline value.

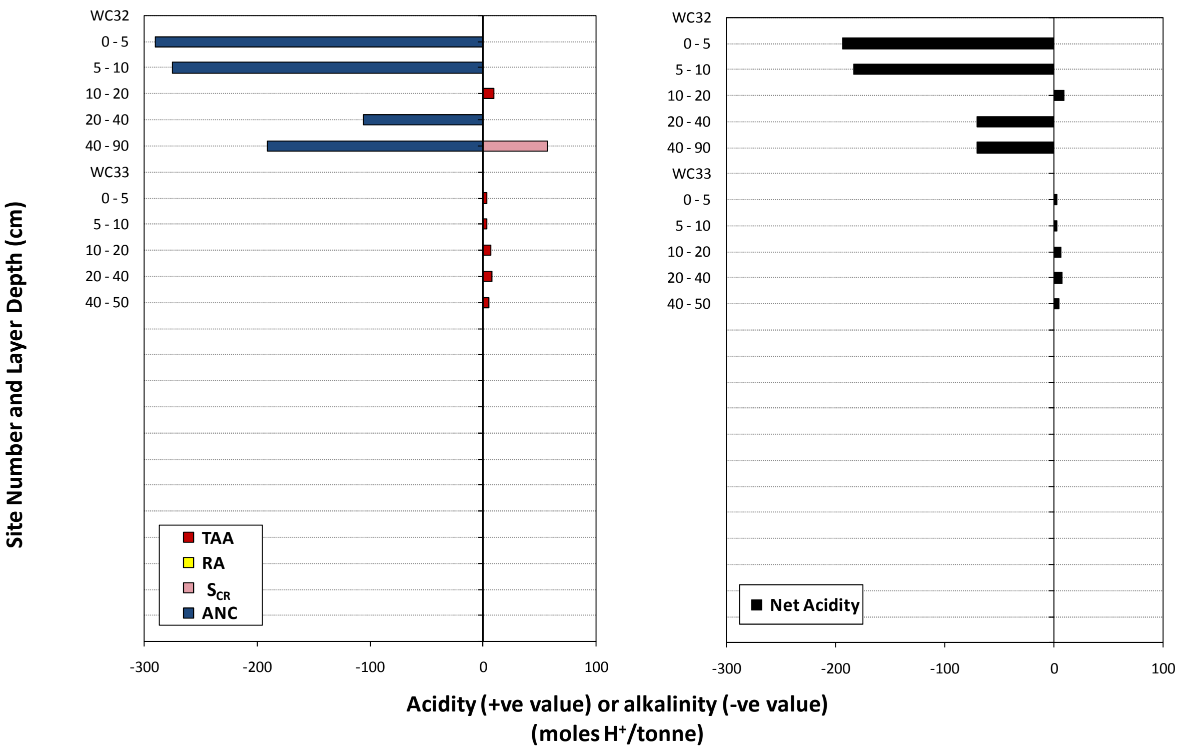

Figure 8-99. Acid-base accounting depth profiles for sites in Yarrein Creek. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), acid neutralising capacity (ANC - blue bar), retained acidity (RA - yellow bar), and right side shows net acidity.

8.8.4. Discussion

Acid sulfate soils occurred at one site in Yarrein Creek (i.e. site WC_32). Sulfuric materials were not observed at Yarrein Creek. The presence of reduced inorganic sulfur was identified at one site (i.e. site WC_32), with a S_{CR} of 0.09% S. The single hyposulfidic soil material had a net acidity of -70 mole H^+/tonne. A monosulfidic soil material was also observed in the subsoil (i.e. at a depth of 40-90 cm) at site WC_32, with S_{AV} content of 0.05% S. These results indicate that acidity would be produced upon oxidation of the sulfidic materials. All surficial soil materials contained soluble sulfate exceeding the 100 mg/kg trigger value for MBO formation potential. Other acidic soil materials were also observed at the two sites.

Based on the priority ranking criteria adopted by the Scientific Reference Panel of the Murray-Darling Basin Acid Sulfate Soil Risk Assessment Project, there was one high priority site based on monosulfidic material and one moderate priority site based on the presence of a hyposulfidic material with S_{CR} < 0.10%. Both sampling sites had a high priority ranking for Phase 2 detailed assessment based on MBO formation hazard.

The potential hazards posed by acid sulfate soil materials in Yarrein Creek are:

- Acidification hazard: The data indicate that with low net acidities, and no sulfuric or hypersulfidic materials, that the degree of acidification hazard is low.

- Deoxygenation hazard: A monosulfidic soil material (S_{AV} = 0.05% S) was observed at a depth of greater than 40 cm and therefore represents a low deoxygenation hazard. However, the soluble sulfate content of surface soil materials at both sites were over the trigger value for MBO formation indicating the possible development of a high deoxygenation hazard at those locations after prolonged wet conditions.

- Metal mobilisation: The low acidification hazard indicates that soil acidification is not likely to increase the solubility of metals. However, the potential for MBO formation identified in this creek may result in a low to moderate metal release hazard depending on factors such as the potential for MBO formation and the metal loading in this creek. Soil acidity may be sufficient for mobilisation of aluminium.

Summary of key findings for Yarrein Creek:

Soil materials:	Sulfuric materials were not observed. Sulfidic soil materials identified included: monosulfidic (1 site) and hyposulfidic < 0.10% (1 site). Low net acidities observed within creek.
Acid sulfate soil identification:	• One hypomonosulfidic material was observed, at a depth of 40-90cm at a subaqueous site. This site also contained a layer that dropped to a pH of 3.06 during incubation, but contained no detectable sulfides. The second site was dry.
Hazard assessment	• Acidification hazard - low level of concern • Deoxygenation hazard - high level of concern • Metal mobilisation hazard – low to moderate level of concern

Table 8-30. Laboratory analytical data for acid sulfate soil assessment of Yarrein Creek sites.
(red printed values indicate data results of potential concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4 / kg)	pH KCl	Titratable Actual Acidity (mole H^+/t)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H^+/t)	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/t)	Acid Volatile Sulfide (%S_{AV})	Acid Sulfate Soil Material Classification
32.1	0-5		6.42	6.71	6.53*	16350.00	8.34	0.00	0.00	0.00	1.45	-193.62	0.00	Other Soil Materials
32.2	5-10		5.25	4.13	5.16	14940.00	8.35	0.00	0.00	0.00	1.38	-183.72	0.00	Other Acid Soils
32.3	10-20		4.42	3.41	3.06*	3885.00	5.12	9.43	0.00	0.00	0.00	9.43	0.00	Other Acid Soils
32.4	20-40		5.15	3.79	4.64	1335.00	6.72	0.00	0.00	0.00	0.53	-70.48	0.00	Other Acid Soils
32.5	40-90		6.05	5.89	6.05*	1294.50	7.88	0.00	0.09	0.00	0.95	-70.14	0.05	Hypomonosulfidic
33.1	0-5		6.35	5.15	5.94*	163.50	5.86	2.85	0.00	0.00	0.00	2.85	0.00	Other Soil Materials
33.2	5-10		5.93	4.26	5.96*	385.50	5.57	2.95	0.00	0.00	0.00	2.95	0.00	Other Soil Materials
33.3	10-20		5.58	4.16	5.32*	364.50	5.33	6.60	0.00	0.00	0.00	6.60	0.00	Other Soil Materials
33.4	20-40		5.34	3.88	5.11*	291.00	5.02	7.64	0.00	0.00	0.00	7.64	0.00	Other Acid Soils
33.5	40-50		5.78	4.83	5.37	120.90	5.28	4.91	0.00	0.00	0.00	4.91	0.00	Other Soil Materials

* Indicates that a stable pH has not yet been reached for this sample (after at least 15 weeks).

Table 8-31. Field hydrochemistry data for acid sulfate soil assessment of Yarrein Creek sites.

Site ID.	Temperature (Deg C)	Specific Electrical Conductivity (µS/cm)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	ORP (mV)	Redox potential (mV)	Turbidity (NTU)	Comment
*Lowland River**		*125-2,220*	*85-110*		*6.5-8.0*			*6-50*	
WC_32	10.7	20,090	105.3	11.83	5.80	232		10	
WC_33									Site dry at the time of sampling

* ANZECC water quality guidelines for lowland rivers in South-east Australia are provided for relevant parameters (ANZECC/ARMCANZ, 2000).
Surface water values outside the ranges defined in the ANZECC guidelines are indicated with red text.

Table 8-32. Profile description data for acid sulfate soil assessment of Yarrein Creek sites.

Site and Sample No.	Horizon Depth Range (cm)	Soil Colour – moist [1]	Texture Class [1]	Texture Modifiers[1]	Moisture State[1]	Redoximorphic Features Abundance (%) [2]	Redoximorphic Features – Kind [2]	Redoximorphic Features - Colour [2]	Redoximorphic Features - Location [2]	Structure - Type[1]	Structure - Grade[1]	Consistency (moist or dry) - Rupture Resistance[1]	pH (field measurement)	Comments (odour, fragments, minerals, plant material, inclusions, other)
32.1	0-5	7.5YR 5/4	ZC		W	50	FM			n.r.			6.10	
32.2	5-10	7.5YR 5/6	ZC		W	50	FM			n.r.			5.80	
32.3	10-20	7.5YR 5/6	ZC		W	50	FM			n.r.			5.50	
32.4	20-40	2.5YR 4/1	ZC		W	50	FM			n.r.			5.70	Possibly MBO mottles
32.5	40-90	2.5YR 4/1	ZC		W	50	FM			n.r.			6.10	Possibly MBO mottles
33.1	0-5	7.5YR 3/2	ZCL		T					GR	2		6.80	
33.2	5-10	7.5YR 4/1	ZCL		T					SB	2		6.30	
33.3	10-20	10YR 4/2	ZC		T	50	FM			PO	3		6.70	
33.4	20-40	10YR 4/1	ZC		T	50	FM			PO	3		6.40	
33.5	40-50	10YR 4/1	ZC		T	50	FM			AB	3		6.50	

[1] See National Committee on Soil and Terrain (2009) for abbreviation definitions and further details.

[2] See Schoeneberger *et al.* (2002) for abbreviation definitions and further details.

8.9. Wyam Creek

8.9.1. Location and setting description

Wyam Creek is an anabranch channel with several off takes from the Wakool in its middle reaches, the main channel being ~21 km north of Barham. The creek flows for another ~22 km in a generally north-westerly direction, in an anastomosing pattern with many tributaries and distributaries, part of the way adopting an almost braided pattern within a Yanco Phase channel before incising into an older land surface and joining the Wakool River near Gee Gee Bridge (Figure 8-100).

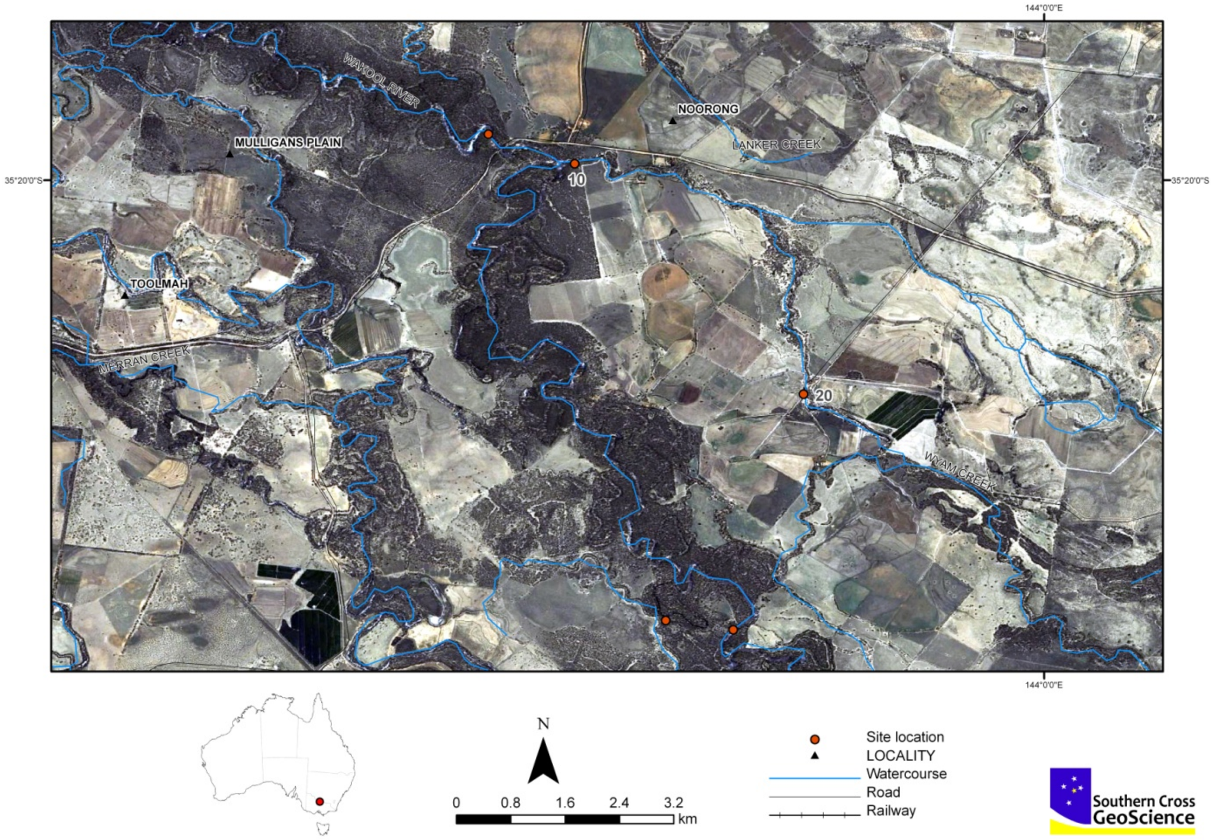

Figure 8-100. Wyam Creek and sample site locations.

8.9.2. Soil profile description and distribution

Two sites were described and sampled in Wyam Creek. The soil subtype and general location description are presented in Table 8-33. Profile description data are presented in Table 8-36.

Table 8-33. Soil identification, subtype and general location description for sites sampled in Wyam Creek.

Site ID	Easting UTM Zone 54H	Northing UTM Zone 54H	Acid sulfate soil subtype class
WC_10	767042	6086271	Sulfuric Subaqueous Soil with Monosulfides
WC_20	769693	6082806	Hypersulfidic Subaqueous Soil with Monosulfides

Figure 8-101. Photographs of site WC_10 Wyam Creek, showing the site and the soil profile.

Figure 8-102. Photographs of site WC_20 Wyam Creek, showing the site and the soil core.

8.9.3. Laboratory data assessment

Soil pH testing (pH_W, pH_{FOX}, pH_{KCl}, $pH_{INCUBATION}$)

The pH data is provided in Table 8-34 and depth profiles of soil pH for all the sites sampled are presented in Figure 8-103. The pH_W values ranged between 3.19 and 7.01. Sulfuric materials (i.e. $pH_W < 4$) were present at site WC_10 (0-10 cm). The pH_{FOX} values ranged between 1.51 and 7.14. The pH_{FOX} results indicate the surface soils in one of the profiles may have the potential to acidify to pH < 4 as a result of sulfide oxidation. One soil material had a $pH_{FOX} < 2.5$ suggesting that soil acidity problems will emerge when this soil is exposed to air. The S_{CR} data shows nine of the 10 layers examined contained detectable sulfide (i.e. $S_{CR} \geq 0.01\%$ S). The pH_{KCl} values ranged between 3.64 and 8.76. Three of the sulfidic soil materials (i.e. $S_{CR} \geq 0.01\%$ S) acidified to pH < 4 after at least 8 weeks of incubation.

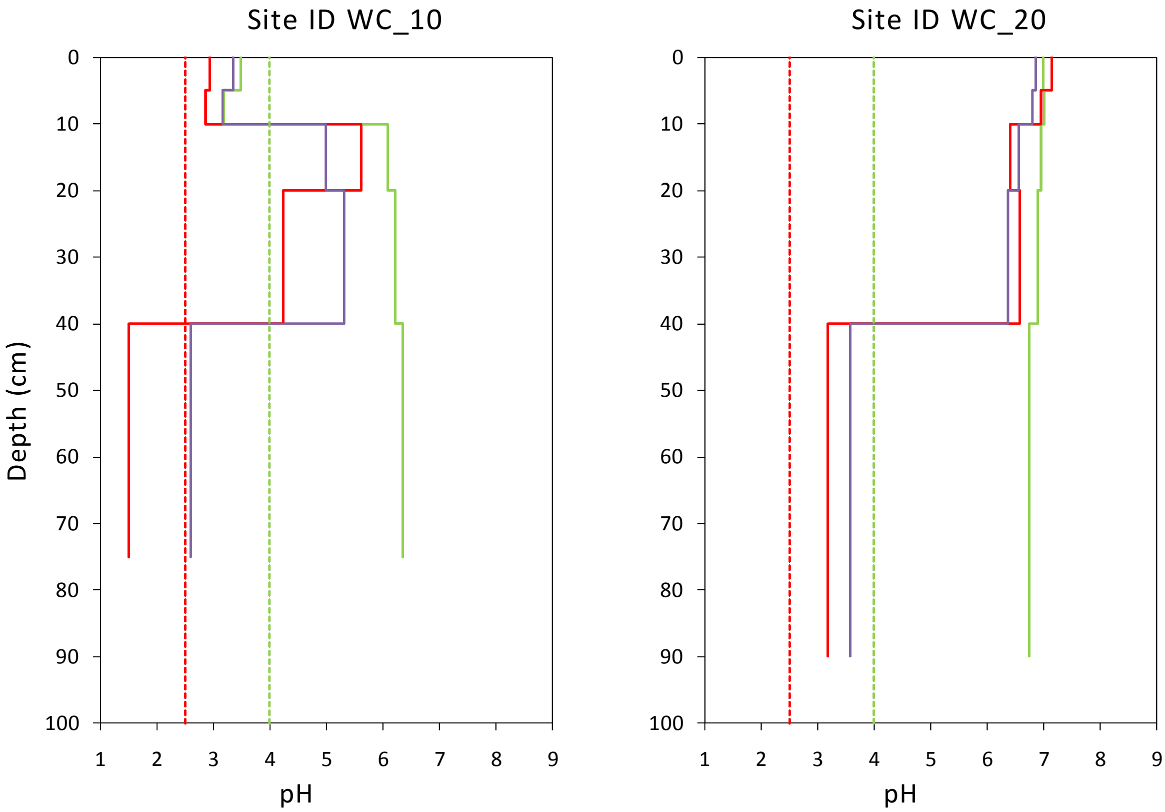

Figure 8-103. Depth profiles of soil pH for sites in Wyam Creek, showing soil pH (pH_W as green line), peroxide treated pH (pH_{FOX} as red line) and ageing pH ($pH_{incubation}$ after at least 8 weeks as purple line). Critical pH_W and $pH_{incubation}$ value of 4 (green dashed line) and critical pH_{FOX} value of 2.5 (red dashed line).

Acid-base accounting

The acid-base accounting data is provided in Table 8-34 and summarised in Figure 8-104.

Chromium reducible sulfur

Chromium reducible sulfur (S_{CR}) values ranged between < 0.01 and 0.85% S_{CR}. Sulfidic soil materials (i.e. S_{CR} ≥ 0.01% S) were identified at both of the sampling sites examined (i.e. sites WC_10 and WC_20), with nine materials of the ten samples collected equal to or greater than the sulfidic criterion.

Acid volatile sulfide

The acid volatile sulfide (S_{AV}) values ranged between < 0.01 and 0.54% S_{AV}. A total of eight monosulfidic soil materials (i.e. S_{AV} ≥ 0.01% S) were found at the two sites examined.

Acid neutralising capacity

The acid neutralising capacity (ANC) ranged between zero and 2.60% $CaCO_3$.

Titratable actual acidity

The titratable actual acidity (TAA) ranged between zero and 41 mole H^+/tonne. At the site with TAA present (i.e.WC_10) a decrease with depth was observed

Retained acidity

Retained acidity was only detected in two layers from site WC_10 (0-10 cm), ranging between zero and 70 mole H^+/tonne.

Net acidity

Net acidity ranged between -165 and 547 mole H^+/tonne. The seven hypersulfidic soils had low to high net acidities ranging between 10 and 547 mole H^+/tonne. The two sulfuric soils had moderate net acidities of 64 and 94 mole H^+/tonne.

Water Soluble Sulfate

The water soluble sulfate in the surface soils (i.e. 0-20 cm) ranged between 1,500 and 9,915 mg SO_4/kg. All of the surface soil layers examined had a soluble sulfate content either equal to or exceeding the 100 mg/kg trigger value for MBO formation potential.

Water Data

The surface water data measured in the field are presented in Table 8-35. The field pH of the surface waters collected were 3.8 and 4.5, with both sites being below the most relevant ANZECC/ARMCANZ (2000) trigger value for aquatic ecosystems of 6.5. The water data therefore indicates that the surface water has been affected by acidification. Dissolved oxygen and SEC values were also found to be outside the most relevant ANZECC/ARMCANZ (2000) guideline value.

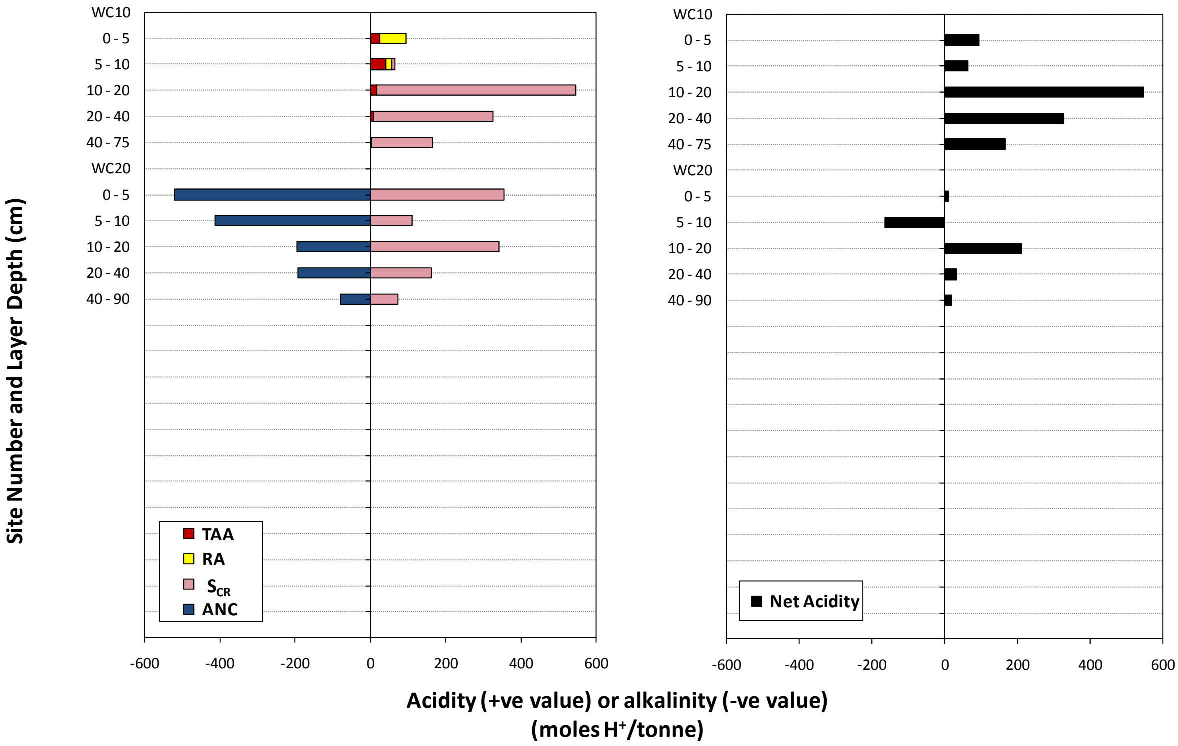

Figure 8-104. Acid-base accounting depth profiles for sites in Wyam Creek. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), acid neutralising capacity (ANC - blue bar), retained acidity (RA - yellow bar), and right side shows net acidity.

8.9.4. Discussion

Acid sulfate soils occurred at both sites examined in Wyam Creek (i.e. sites WC_10 and WC_20). Sulfuric materials with moderate net acidities (i.e. 64 - 94 mole H^+/tonne) were observed in the surface layers (i.e. 0-10 cm) at site WC_10. The presence of reduced inorganic sulfur was identified in all except one layer at the two sites examined, with a S_{CR} of up to 0.85% S. Hypersulfidic soil materials with low to high net acidities (i.e. 10 - 547 mole H^+/tonne) were present (the profile at site WC_20 also contained a hyposulfidic material). Monosulfidic soil materials were also observed at both sulfidic sites, with S_{AV} contents of up to 0.54% S. Monosulfidic soil materials (S_{AV} ≤ 0.20% S) were observed in the upper 0-10 cm layers at site WC_20. These results indicate that acidity would be produced upon oxidation of the sulfidic materials. All surficial soil materials contained soluble sulfate exceeding the 100 mg/kg trigger value for MBO formation potential.

Based on the priority ranking criteria adopted by the Scientific Reference Panel of the Murray-Darling Basin Acid Sulfate Soil Risk Assessment Project, there was one high priority site based on the presence of sulfuric material, two high priority sites based on hypersulfidic material, one high priority site based on hyposulfidic material (S_{CR} ≥ 0.10%) and two high priority sites based on monosulfidic material. Both sampling sites had a high priority ranking for Phase 2 detailed assessment based on MBO formation hazard.

The potential hazards posed by acid sulfate soil materials in Wyam Creek are:

- Acidification hazard: Two sulfuric materials had moderate net acidities (i.e. 20% of layers) and four hypermonosulfidic materials had high net acidities (i.e. 40% of layers), indicating that the overall degree of acidification hazard is high.

- Deoxygenation hazard: The monosulfidic soil materials (S_{AV} ≤ 0.20% S) in the upper 0-10 cm layers at one site represent a high deoxygenation hazard. In addition, the soluble sulfate content of surface soil materials at both sites were over the trigger value for MBO formation indicating the possible development of a high deoxygenation hazard at those locations after prolonged wet conditions.

- Metal mobilisation: The high acidification hazard indicates that soil acidification may increase the solubility of metals. The presence of monosulfidic materials in an upper soil layer and the potential for MBO formation identified in this creek may also result in a high metal release hazard. This would depend on factors such as the potential for MBO formation and the metal loading in the creek. Soil acidity may be sufficient for mobilisation of aluminium.

Summary of key findings for Wyam Creek:

Soil materials:	Sulfuric materials were observed at 1 site. Sulfidic soil materials identified included: hypersulfidic (2 sites), monosulfidic (2 sites) and hyposulfidic ≥ 0.10% (1 site). Moderate-high net acidities dominant within creek.
Acid sulfate soil identification:	• Sulfidic materials were recorded from all materials but two sulfuric surface samples, and monosulfides were found in all but the sulfuric samples. Both sites were subaqueous.
Hazard assessment	• Acidification hazard - high level of concern • Deoxygenation hazard - high level of concern • Metal mobilisation hazard - high level of concern

Table 8-34. Laboratory analytical data for acid sulfate soil assessment of Wyam Creek sites.
(red printed values indicate data results of potential concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4 / kg)	pH KCl	Titratable Actual Acidity (mole H^+/t)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H^+/t)	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/t)	Acid Volatile Sulfide (%S_{AV})	Acid Sulfate Soil Material Classification
10.1	0-5		3.49	2.93	3.35	9915.00	3.83	24.12	0.00	70.00	0.00	94.12	0.00	Sulfuric Soil
10.2	5-10		3.19	2.87	3.17	4410.00	3.64	41.38	0.01	15.00	0.00	63.90	0.00	Sulfuric Soil
10.3	10-20		6.08	5.62	4.99*	9195.00	5.68	16.39	0.85	0.00	0.00	546.98	0.54	Hypermonosulfidic#
10.4	20-40		6.22	4.24	5.31	4905.00	5.91	7.61	0.51	0.00	0.00	327.04	0.46	Hypermonosulfidic#
10.5	40-75		6.35	1.51	2.60*	1545.00	5.39	3.40	0.26	0.00	0.00	165.74	0.02	Hypermonosulfidic
20.1	0-5		6.98	7.14	6.85*	1605.00	8.76	0.00	0.57	0.00	2.60	10.41	0.20	Hypermonosulfidic#
20.2	5-10		7.01	6.95	6.81*	1995.00	8.54	0.00	0.18	0.00	2.06	-164.62	0.15	Hypomonosulfidic
20.3	10-20		6.95	6.40	6.55*	1500.00	8.23	0.00	0.55	0.00	0.97	212.29	0.19	Hypermonosulfidic#
20.4	20-40		6.90	6.58	6.37*	361.50	8.33	0.00	0.26	0.00	0.96	34.90	0.16	Hypermonosulfidic#
20.5	40-90		6.75	3.18	3.58*	312.00	6.85	0.00	0.12	0.00	0.40	19.48	0.04	Hypermonosulfidic

* Indicates that a stable pH has not yet been reached for this sample (after at least 15 weeks). # Classified as hypermonosulfidic based on positive net acidity.

Table 8-35. Field hydrochemistry data for acid sulfate soil assessment of Wyam Creek sites.

Site ID.	Temperature (Deg C)	Specific Electrical Conductivity (µS/cm)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	ORP (mV)	Redox potential (mV)	Turbidity (NTU)	Comment
*Lowland River**		*125-2,200*	*85-110*		*6.5-8.0*			*6-50*	
WC_10	9.9	3,710	64.7	7.38	3.80	381		23	
WC_20	18.6	89.9	3.3	0.30	4.50	209		10	

* ANZECC water quality guidelines for lowland rivers in South-east Australia are provided for relevant parameters (ANZECC/ARMCANZ, 2000).
Surface water values outside the ranges defined in the ANZECC guidelines are indicated with red text.

Table 8-36. Profile description data for acid sulfate soil assessment of Wyam Creek sites.

Site and Sample No.	Horizon Depth Range (cm)	Soil Colour – moist [1]	Texture Class [1]	Texture Modifiers[1]	Moisture State[1]	Redoximorphic Features Abundance (%) [2]	Redoximorphic Features – Kind [2]	Redoximorphic Features - Colour [2]	Redoximorphic Features - Location [2]	Structure - Type[1]	Structure - Grade[1]	Consistency (moist or dry) - Rupture Resistance[1]	pH (field measurement)	Comments (odour, fragments, minerals, plant material, inclusions, other)
10.1	0-5	10YR 6/4	CL		W	10	FM			MA	0		3.98	Iron floc
10.2	5-10	10YR 5/3	C		W	50	FM			PO	3		3.83	
10.3	10-20	10YR 2/1	CL		W	2	FM			MA	0		6.34	
10.4	20-40	10YR 2/1	CL		W					MA	0		6.56	
10.5	40-75	10YR 4/1	CS		W					SG	0		7.01	
20.1	0-5	2.5Y 5/1	Muck		W					MA	0		4.30	pH possibly inaccurate; MBO: gypsum on shoreline surface
20.2	5-10	N2.5	Muck		W					MA	0		4.20	pH possibly inaccurate; MBO
20.3	10-20	10Y 3/1	ZCL		W					MA	0		3.57	pH possibly inaccurate; MBO?
20.4	20-40	10Y 3/1	ZCL		W					MA	0		3.43	pH possibly inaccurate
20.5	40-90	10YR 5/1	S		W					MA	0		3.58	pH possibly inaccurate

[1] See National Committee on Soil and Terrain (2009) for abbreviation definitions and further details.

[2] See Schoeneberger *et al.* (2002) for abbreviation definitions and further details.

8.10. Pissen Creek

8.10.1. Location and setting description

Pissen Creek is a short, ~6.5 km long, but apparently highly polygenetic channel that flows across Coobool Island (Figure 8-105). It appears to receive overflows at a point at which it comes close to Mallan Mallan Creek, ~1.5 km from the easternmost end of Pissen Creek. From this point, the creek channel increases in width as it flows in a south-easterly direction across a deflation basin in the eastern part of Coobool Island to connect with an abandoned ox-bow of the Wakool on the southern side of Coobool Island. The western part of Pissen Creek connects with the Wakool ~2.7 km above Mallan Mallan Creek. Pissen Creek has fluvial features suggestive of flow in both directions, flow direction possibly having reversed when direct connection with the main river at the upstream end was cut off by ox bow formation.

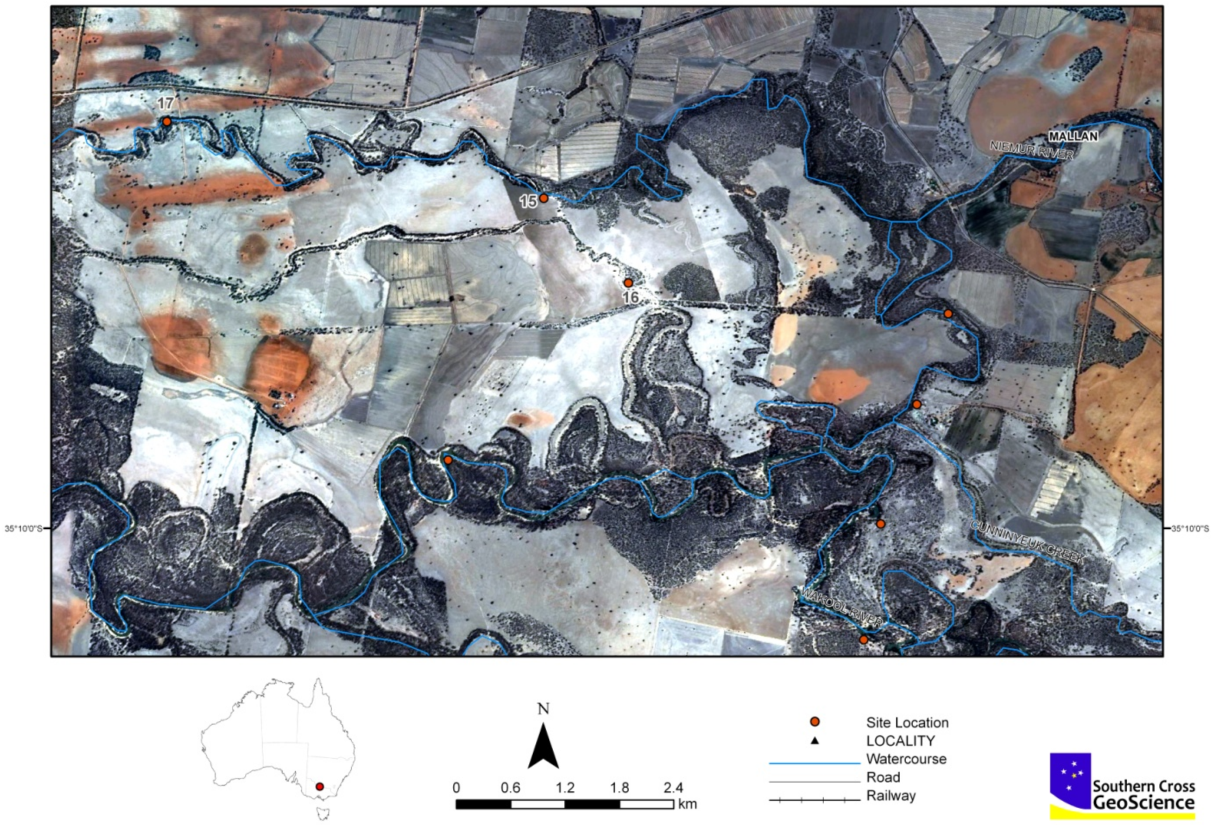

Figure 8-105. Pissen Creek and sample site location.

8.10.2. Soil profile description and distribution

One site was described and sampled in Pissen Creek. The soil subtype and general location description is presented in Table 8-37. Profile description data are presented in Table 8-40.

Table 8-37. Soil identification, subtype and general location description for the site sampled in Pissen Creek.

Site ID	Easting UTM Zone 54H	Northing UTM Zone 54H	Acid sulfate soil subtype class
WC_16	752154	6107665	Subaqueous Soil

Figure 8-106. Photographs of site WC_16 Pissen Creek, showing the site and the soil profile.

8.10.3. Laboratory data assessment

Soil pH testing (pH_W, pH_{FOX}, pH_{KCl}, $pH_{INCUBATION}$)

The pH data is provided in Table 8-38 and depth profiles of soil pH for all the sites sampled are presented in Figure 8-107. The pH_W values ranged between 5.09 and 5.98. Sulfuric materials (i.e. pH_W < 4) were not present. The pH_{FOX} values ranged between 4.29 and 5.39. The pH_{FOX} results indicate that none of the surface soils have the potential to acidify to pH < 4 as a result of sulfide oxidation. The S_{CR} data also shows none of the layers examined contained detectable sulfide (i.e. S_{CR} ≥ 0.01% S). The pH_{KCl} values ranged between 4.72 and 5.14. Other acidic soil materials were identified at the site examined, indicating acidity in the soil profile at levels where aluminium may mobilise. None the other acidic soils acidified to pH < 4 after at least 8 weeks of incubation.

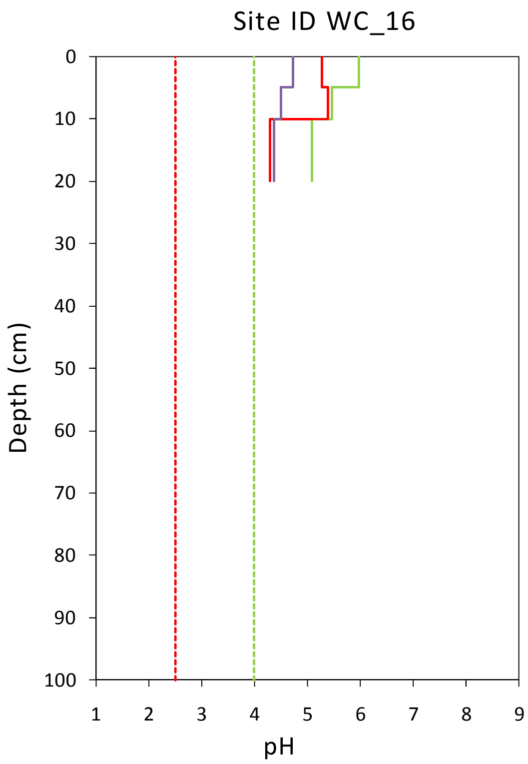

Figure 8-107. Depth profiles of soil pH for the site in Pissen Creek, showing soil pH (pH_W as green line), peroxide treated pH (pH_{FOX} as red line) and ageing pH ($pH_{incubation}$ after at least 8 weeks as purple line). Critical pH_W and $pH_{incubation}$ value of 4 (green dashed line) and critical pH_{FOX} value of 2.5 (red dashed line).

Acid-base accounting

The acid-base accounting data is provided in Table 8-38 and summarised in Figure 8-108.

Chromium reducible sulfur

Sulfidic soil materials (i.e. S_{CR} ≥ 0.01% S) were not found within the single profile examined at Pissen Creek.

Acid volatile sulfide

Monosulfidic soil materials (i.e. S_{AV} ≥ 0.01% S) were not found within Pissen Creek.

Acid neutralising capacity

All soil materials had no acid neutralising capacity (ANC).

Titratable actual acidity

The titratable actual acidity (TAA) ranged between 4 and 9 mole H^+/tonne. A slight increase in the TAA with depth was observed at the site sampled.

Retained acidity

All soil materials had no retained acidity.

Net acidity

All soil materials had a low net acidity, ranging between 5 and 9 mole H^+/tonne.

Water Soluble Sulfate

The water soluble sulfate in the surface soils (i.e. 0-20 cm) ranged between 43 and 99 mg SO_4/kg. All of the surface soil layers examined had soluble sulfate contents below the 100 mg/kg trigger value for MBO formation potential.

Water Data

The surface water data measured in the field are presented in Table 8-39. The field pH of the surface water collected was 5.2 and was below the most relevant ANZECC/ARMCANZ (2000) trigger value for aquatic ecosystems of 6.5. The water data indicates that the surface water has been affected by acidification. The turbidity was found to exceed the most relevant ANZECC/ARMCANZ (2000) guideline value.

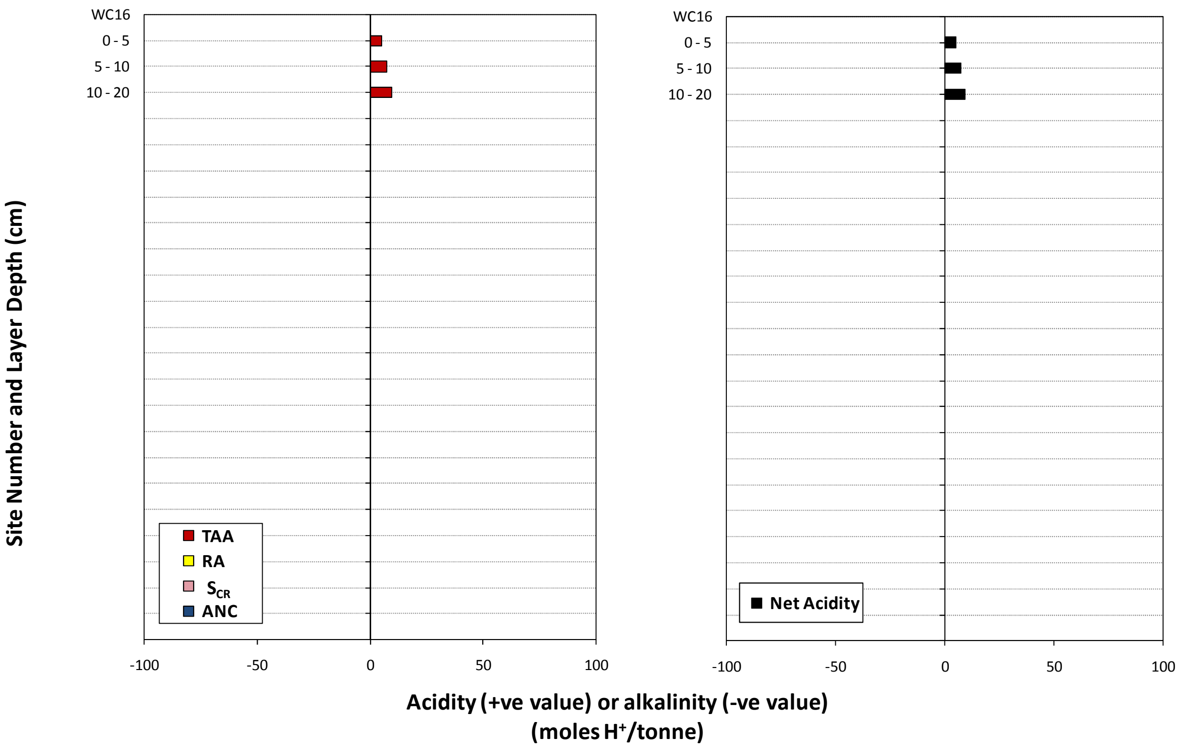

Figure 8-108. Acid-base accounting depth profiles for the site in Pissen Creek. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), acid neutralising capacity (ANC - blue bar), retained acidity (RA - yellow bar), and right side shows net acidity.

8.10.4. Discussion

Acid sulfate soil materials were not found at the site sampled in Pissen Creek. The site examined was classified as an other acidic soil. Surficial soil materials contained soluble sulfate below the 100 mg/kg trigger value for MBO formation potential.

Based on the priority ranking criteria adopted by the Scientific Reference Panel of the Murray-Darling Basin Acid Sulfate Soil Risk Assessment Project, no further assessment is required.

The potential hazards posed by acid sulfate soil materials in Pissen Creek are:

- Acidification hazard: The data indicate that with low net acidities, and no sulfuric or sulfidic materials, that the degree of acidification hazard is low.

- Deoxygenation hazard: The data indicate that with low soluble sulfate contents, and no monosulfidic materials, that the degree of deoxygenation hazard is low.

- Metal mobilisation: The low acidification hazard indicates that soil acidification is not likely to increase the solubility of metals. Soil acidity may be sufficient for mobilisation of aluminium.

Summary of key findings for Pissen Creek:

Soil materials:	Sulfuric and sulfidic materials were not observed within this creek. Other acidic soil materials observed. Low net acidities observed within creek.
Acid sulfate soil identification:	• No acid sulfate soil materials were recorded at this subaqueous site.
Hazard assessment	• Acidification hazard - low level of concern • Deoxygenation hazard - low level of concern • Metal mobilisation hazard – low level of concern

Table 8-38. Laboratory analytical data for acid sulfate soil assessment of Pissen Creek site.
(red printed values indicate data results of potential concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4 / kg)	pH KCl	Titratable Actual Acidity (mole H^+/t)	Chromium Reducible Sulfur (%S_{CR})	Retained Acidity (mole H^+/t)	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/t)	Acid Volatile Sulfide (%S_{AV})	Acid Sulfate Soil Material Classification
16.1	0-5		5.98	5.28	4.73	43.05	5.14	4.93	0.00	0.00	0.00	4.93	0.00	Other Acid Soils
16.2	5-10		5.47	5.39	4.51*	69.60	4.88	7.40	0.00	0.00	0.00	7.40	0.00	Other Acid Soils
16.3	10-20		5.09	4.29	4.37	99.00	4.72	9.31	0.00	0.00	0.00	9.31	0.00	Other Acid Soils

* Indicates that a stable pH has not yet been reached for this sample (after 16 weeks).

Table 8-39. Field hydrochemistry data for acid sulfate soil assessment of Pissen Creek site.

Site ID.	Temperature (Deg C)	Specific Electrical Conductivity (µS/cm)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH	ORP (mV)	Redox potential (mV)	Turbidity (NTU)	Comment
*Lowland River**		*125-2,220*	*85-110*		*6.5-8.0*			*6-50*	
WC_16	14.1	93.1	105.2	10.68	5.18	284.8		300	

* ANZECC water quality guidelines for lowland rivers in South-east Australia are provided for relevant parameters (ANZECC/ARMCANZ, 2000).
Surface water values outside the ranges defined in the ANZECC guidelines are indicated with red text.

Table 8-40. Profile description data for acid sulfate soil assessment of Pissen Creek site.

Site and Sample No.	Horizon Depth Range (cm)	Soil Colour – moist [1]	Texture Class [1]	Texture Modifiers[1]	Moisture State[1]	Redoximorphic Features Abundance (%) [2]	Redoximorphic Features – Kind [2]	Redoximorphic Features - Colour [2]	Redoximorphic Features - Location [2]	Structure - Type[1]	Structure - Grade[1]	Consistency (moist or dry) - Rupture Resistance[1]	pH (field measurement)	Comments (odour, fragments, minerals, plant material, inclusions, other)
16.1	0-5	10YR 5/2	Muck		W								4.20	
16.2	5-10	10YR 5/2	C		T	50	FM			AB	3		3.60	
16.3	10-20	10YR 4/2	C		T	50	FM			AB	3		3.50	

[1] See National Committee on Soil and Terrain (2009) for abbreviation definitions and further details.

[2] See Schoeneberger *et al.* (2002) for abbreviation definitions and further details.