Lower Lakes and Tributaries

Water Quality Report

Ambient and Event-based Monitoring

Report 23, January 2011

Government of South Australia
Department of Environment and Natural Resources

EPA South Australia

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- ***Water quality continues to improve across the Lower Lakes following substantial inflows of floodwater from the Murray-Darling Basin***
- ***Salinity levels continue to decrease across Lake Alexandrina due to dilution from river inflows and export of salt through the barrages***
- ***Salinity levels still remain elevated in Lake Albert and some embayments on the margins of the Lower Lakes compared to historical values***
- ***pH and alkalinity continue to remain satisfactory at all sites***

Observations at a Glance

Background

The Environment Protection Authority (EPA), Department of Environment and Natural Resources (DENR), and the Department for Water (DFW) are co-ordinating a monitoring program to assess water quality in the Lower Lakes. Previous reports are contained on the EPA website[1].

Water Quality Parameters

A wide range of water quality parameters are monitored with key parameters reported herein being pH, alkalinity, salinity, sulfate:chloride ratio, turbidity, nutrients (total nitrogen and total phosphorus), chlorophyll *a* and metals (aluminium and iron). A brief description of these parameters and typical historical (pre-drought) levels are provided below:

***pH** is an indicator of acidity or alkalinity. Neutral water has a pH of 7, acidic solutions have lower values and alkaline solutions have higher values. The pH in the Lower Lakes region is typically between 8.3 and 8.5.*

***Alkalinity** is a measure of the buffering capacity of water, or the capacity of the water to neutralise acids and resist pH change. Alkalinity within water bodies is consumed as acid is released from acid sulfate soils. Adding limestone contributes alkalinity to waters, helping to neutralise any acid released from the sediments. Historically, alkalinity levels within this region have been between 80 and 250 mg/L as $CaCO_3$.*

***Salinity** is a measure of the amount of dissolved salts in the water. Saline water conducts electricity more readily than freshwater, so electrical conductivity (EC) is routinely used to measure salinity. As salinity increases, it may become toxic to native freshwater organisms. Prior to the 2007–2009 drought conditions, salinity was on average less than 700 µS/cm (EC) in Lake Alexandrina (at Milang) and less than 1600 EC in Lake Albert (at Meningie).*

***Sulfate:chloride** is used to give an indication of any sulfate inputs to the water body from acid sulfate soils. Chloride concentration is largely determined by evaporation and dilution. An increase in the ratio of sulfate:chloride indicates possible external sulfate inputs from acid sulfate soils. This ratio is usually about 0.06 (SO_4:Cl) in the Lower Lakes.*

***Turbidity** is a measure of the cloudiness or haziness in water caused by suspended solids (e.g. sediment, algae). Turbidity is expressed in Nephelometric Turbidity Units (NTU) and is measured using a relationship*

[1] See http://www.epa.sa.gov.au/environmental_info/water_quality/lower_lakes_water_quality_monitoring

of light reflected from a given sample. Turbidity is very variable in the shallow Lower Lakes and influenced primarily by wind events. Prior to the 2007–2009 drought conditions, turbidity was on average about 60 NTU in Lake Alexandrina (at Milang).

Nutrients - total nitrogen (TN) and total phosphorus (TP) are the total amount of nitrogen and phosphorus present in the water body. Nitrogen can be present in different forms (e.g. organic nitrogen in plant material, ammonia, nitrate and nitrite). Phosphorus can also be present in different forms (e.g. organic phosphorus, phosphate). High concentrations of phosphorus and nitrogen can result in excessive growth of aquatic plants such as phytoplankton, cyanobacteria, macrophytes and filamentous algae. Prior to the 2007–2009 drought conditions, TN was on average about 1.2 mg/L in Lake Alexandrina (at Milang) and 1.6 mg/L in Lake Albert (at Meningie) with TP on average about 0.15 mg/L in Lake Alexandrina (at Milang) and in Lake Albert (at Meningie).

Chlorophyll a is the main photosynthetic pigment in green algae. The concentration of chlorophyll a gives an indication of the volume of aquatic plants present in the water column. Levels in excess of 15 µg/L are considered very high ("hyper-eutrophic") and nuisance algae and plant growth can occur. Prior to the 2007–2009 drought conditions, chlorophyll a was on average about 24 µg/L in Lake Alexandrina (at Milang) and 35 µg/L in Lake Albert (at Meningie).

Metals such as iron and aluminium are measured primarily to determine interactions between sediments and the lake water body. During water level declines (i.e. due to evaporation and low inflows during droughts) metal concentrations are expected to increase. Similarly during large wind events total metal levels may also increase as they form part of the suspended solids composition. During floodwater inflows the concentration of metals may be diluted. Additional to this, if exposed acid sulfate sediments acidify and the pH is reduced, metals that were previously bound up within sediment are released. If these exposed sediments are rewet, any subsequent increase in metal concentrations in the water body may indicate acid sulfate soil impacts.

Ambient Water Quality Monitoring

Ambient water quality sampling is undertaken fortnightly at 16 sites in Lake Alexandrina (including Wellington, the Goolwa Channel, Currency Creek and Finniss River tributary regions), and Lake Albert (Figure 1).

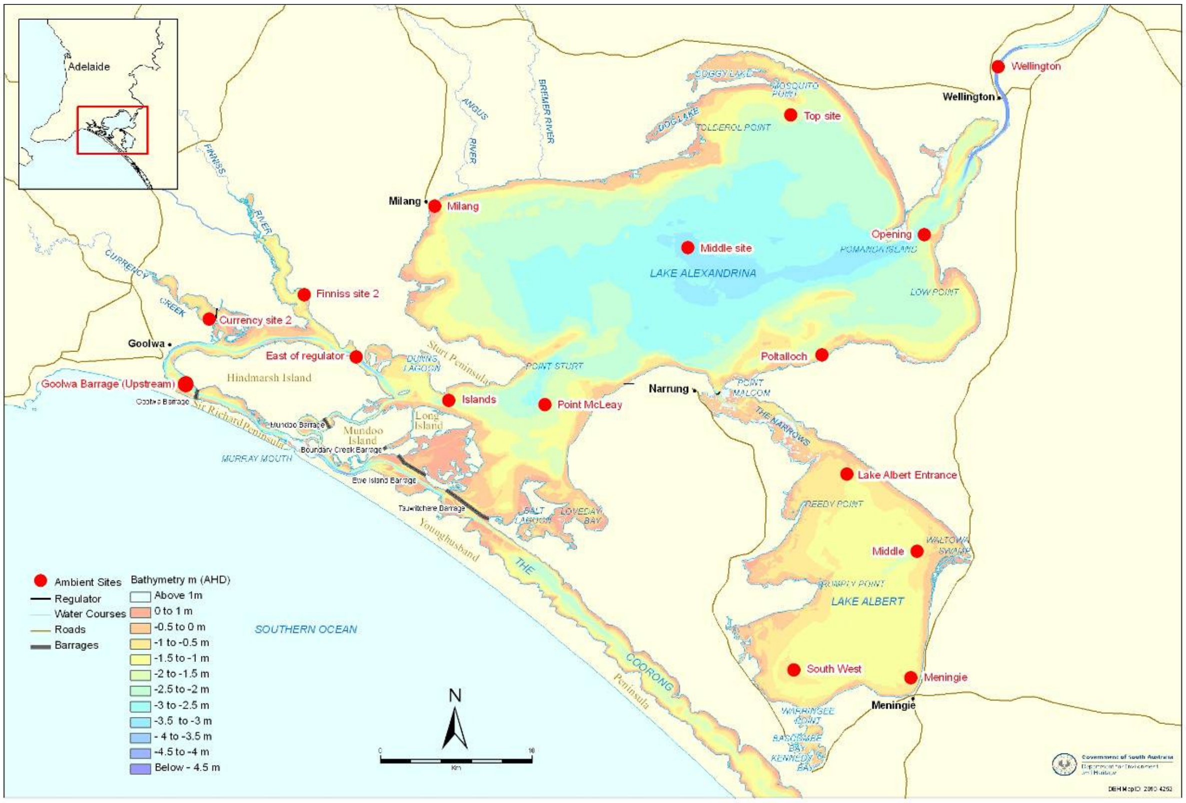

Figure 1 –Lower Lakes and tributaries ambient monitoring sites

Lake Alexandrina

Ambient water quality monitoring results are discussed below for selected sites and parameters in Lake Alexandrina. The five sites selected for reporting have been chosen as they are representative of the water body, incorporating water entering from the river (Wellington) and a transect across Lake Alexandrina from the northern corner (Top) through the centre (Middle) to the southern edge of the lake (Point McLeay) before it enters the Goolwa Channel. The site on the western margin (Poltalloch) provides an indication of the water quality near the entrance to Lake Albert.

pH

- pH levels in Lake Alexandrina (Figure 2) have continued to remain within ANZECC guideline levels (pH 6.5-9.0). The pH within the river channel at Wellington still remains lower than Lake Alexandrina due to the floodwaters, however levels have been stable between December 2010 and January 2011. A general declining trend in pH is still evident across Lake Alexandrina as floodwaters continue to influence water quality.

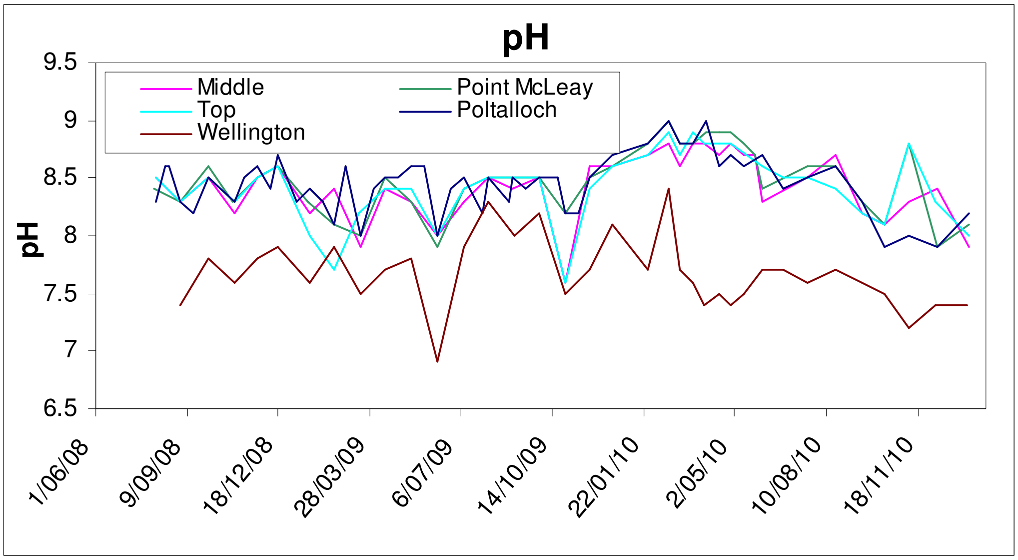

Figure 2 – pH at the Lake Alexandrina ambient monitoring sites

Alkalinity

- Declines in alkalinity continue in the main areas of Lake Alexandrina with the exception of the river channel at Wellington which has recorded an increase in alkalinity since early December 2010 (Figure 3). Alkalinity levels are however tending towards a uniform concentration. The observable decline in alkalinity since May 2010 is consistent with substantial dilution of lake water with lower alkalinity river water (Wellington Site).

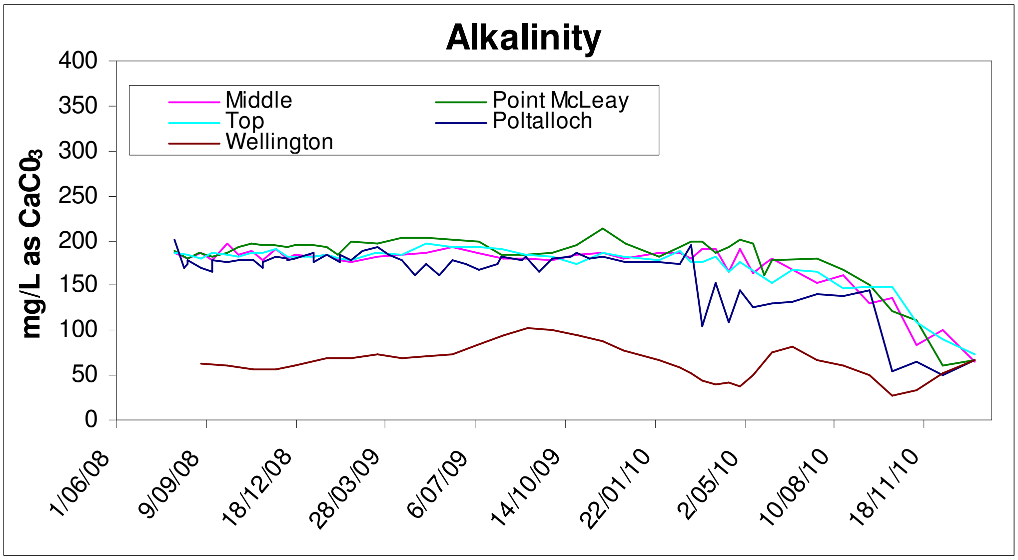

Figure 3 – Alkalinity at the Lake Alexandrina ambient monitoring sites

Sulfate:chloride ratio

- The sulfate:chloride ratio has increased significantly in the main lake water body (Middle, Top, Point McLeay sites) since December 2010 (Figure 4). The increased ratio is likely due to the influx of sulfates from the River Murray (see the Wellington and Poltalloch sites) which are now mixing throughout the rest of the lake. The Wellington and Poltalloch sites, which were previously recording elevated ratios have since declined.

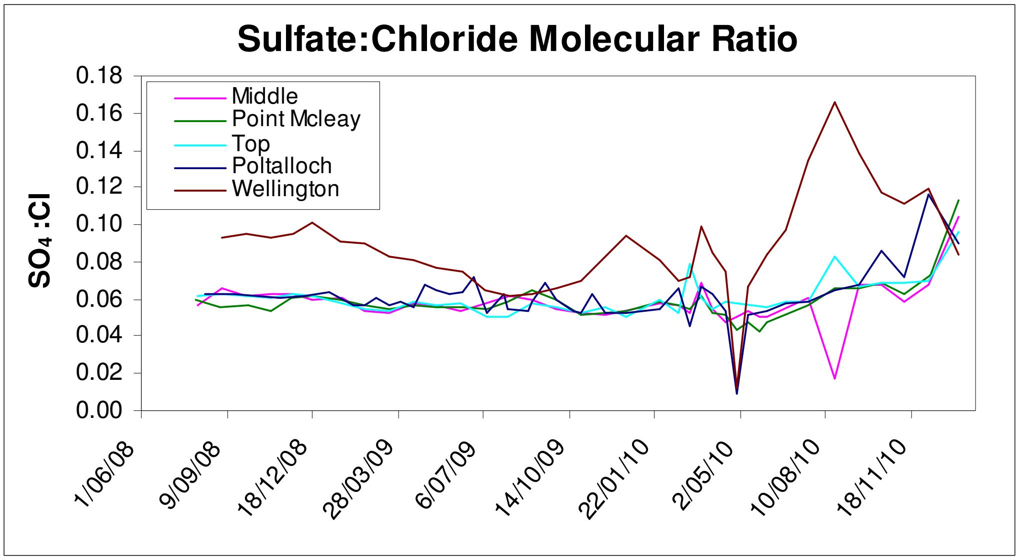

Figure 4 – Sulfate:chloride ratio at the Lake Alexandrina ambient monitoring sites

Salinity (EC)

- Salinity (as measured by electrical conductivity) levels are stabilising across Lake Alexandrina between 1500 and 250 EC (Figure 5), which are below long term averages. The high Murray-Darling Basin inflows and export of accumulated salt through the barrages have contributed to the stabilisation of salinity within the lake.

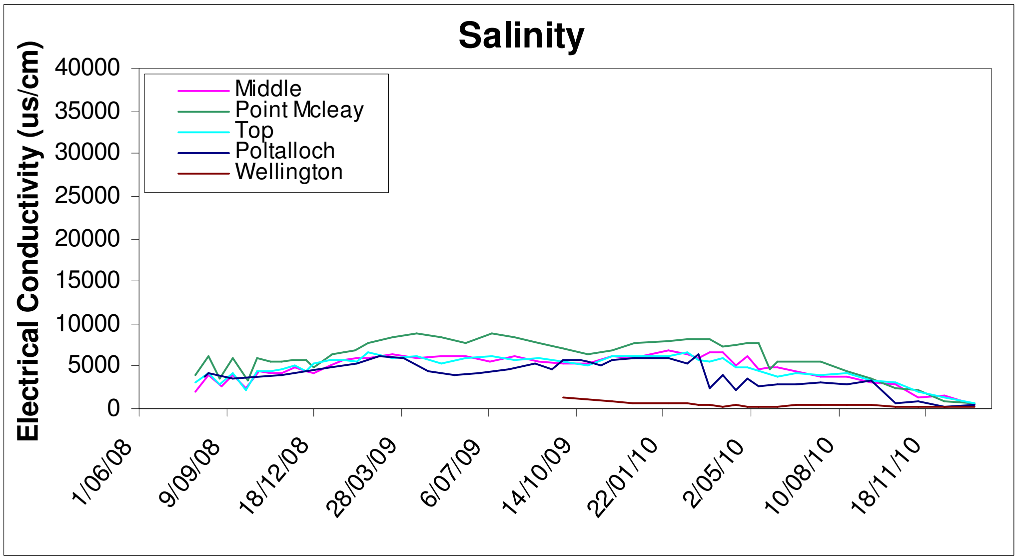

Figure 5 – Salinity at the Lake Alexandrina ambient monitoring sites

Turbidity

- Turbidity levels continue to be variable within Lake Alexandrina and are showing an increasing trend at present (Figure 6). Inflowing flood waters containing high levels of suspended particles, and wind events causing resuspension and redistribution of sediment, are likely responsible for the rise in turbidity.

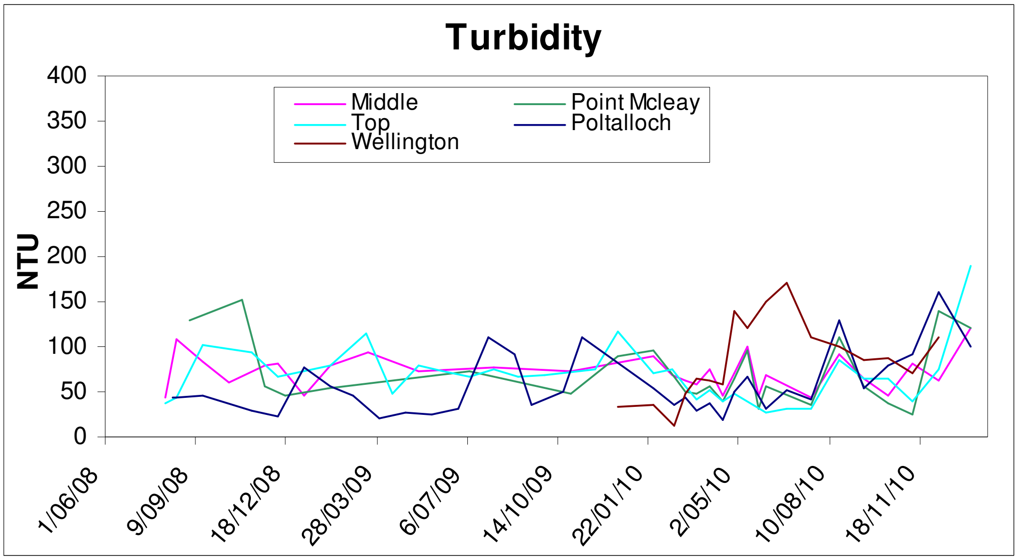

Figure 6 – Turbidity at the Lake Alexandrina ambient monitoring sites

Nutrients (total nitrogen and phosphorus)

- Total nitrogen and phosphorus levels remain relatively stable within Lake Alexandrina (Figures 7 and 8). As the large floodwater inflows dilute and replace the existing lake water, nutrient levels are expected to trend towards that of the river. This is particularly apparent for total nitrogen with most sites recording similar nutrient concentrations to the Wellington site (Figure 7). Total phosphorus levels increased in the river inflows near the end of 2010, likely due to runoff of soil and fertiliser off the wider Murray-Darling Basin catchment. Total phosphorus levels are relatively uniform across all Lake Alexandrina sites (Figure 8). Nutrient levels in the Lower Lakes continue to remain above ANZECC guidelines for freshwater ecosystems (<1mg/L TN, <0.025 mg/L TP).

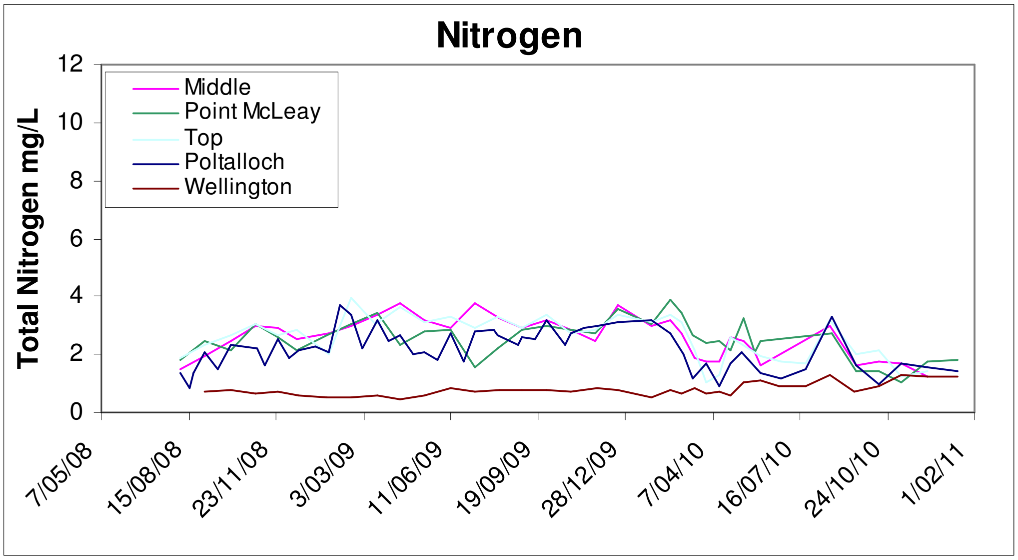

Figure 7 – Total nitrogen at the Lake Alexandrina ambient monitoring sites

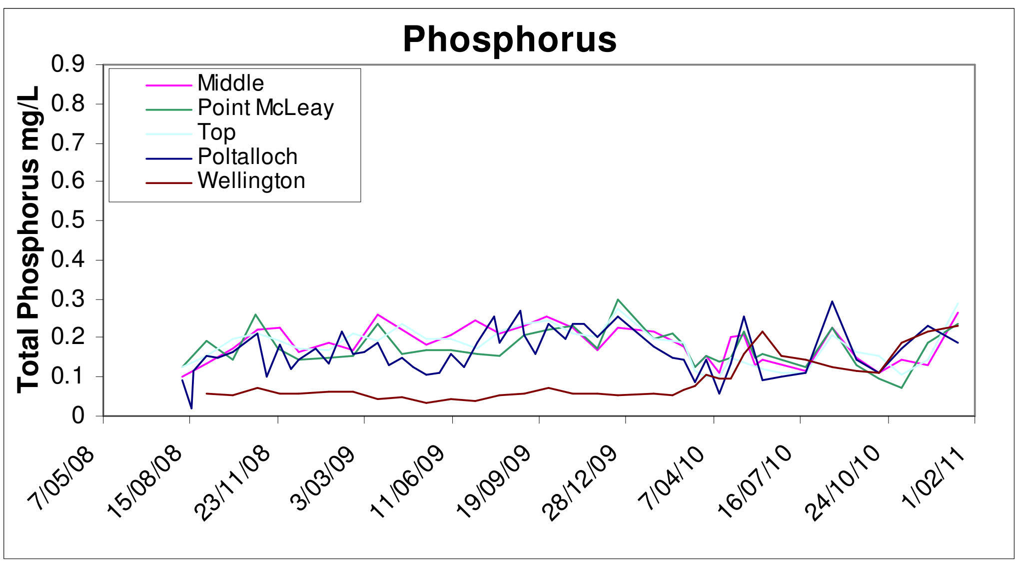

Figure 8 – Total phosphorus at the Lake Alexandrina ambient monitoring sites

Chlorophyll a (algae)

- Chlorophyll *a* continues to remain relatively stable across most Lake Alexandrina sites, however the site Lake Alexandrina 'Top' has seen a considerable increase in concentrations since December 2010 (Figure 9). The system still remains highly nutrient enriched (hyper-eutrophic) and in excess of ANZECC guidelines (<15 µg/L). Chlorophyll levels are much lower in the river inflow (Wellington site) highlighting the increased algal productivity once water enters the Lower Lakes. Although chlorophyll *a* levels in Lake Alexandrina remain high, no potentially toxic blue-green algal blooms are present.

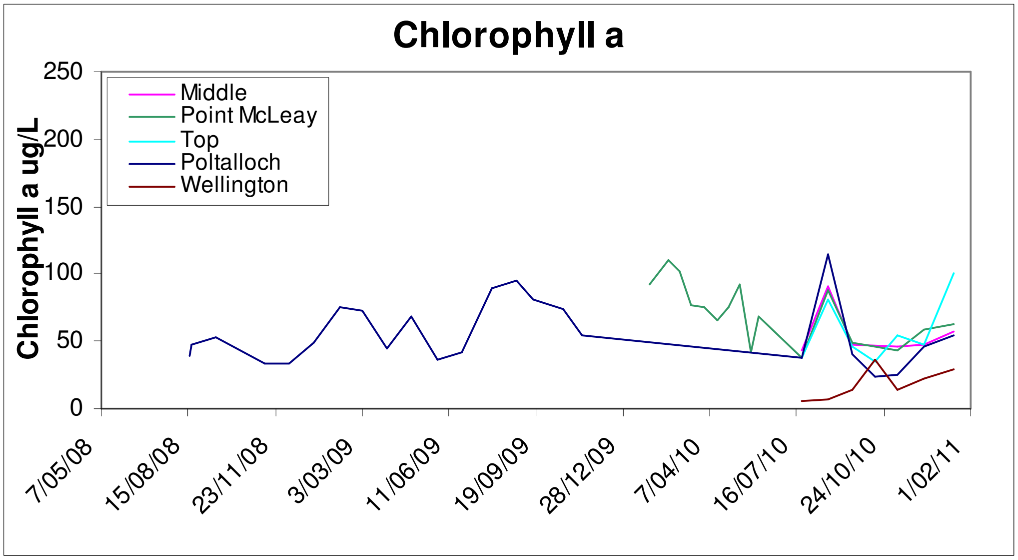

Figure 9 – Chlorophyll *a* at the Lake Alexandrina ambient monitoring sites

Metals

- Total aluminium and total iron within Lake Alexandrina have stabilised at most sites during January, with only the Poltalloch site showing a slight increase (Figure 10 and 11). At present, lake metal concentrations appear to be related to variable floodwater concentrations rather than lake system processes.

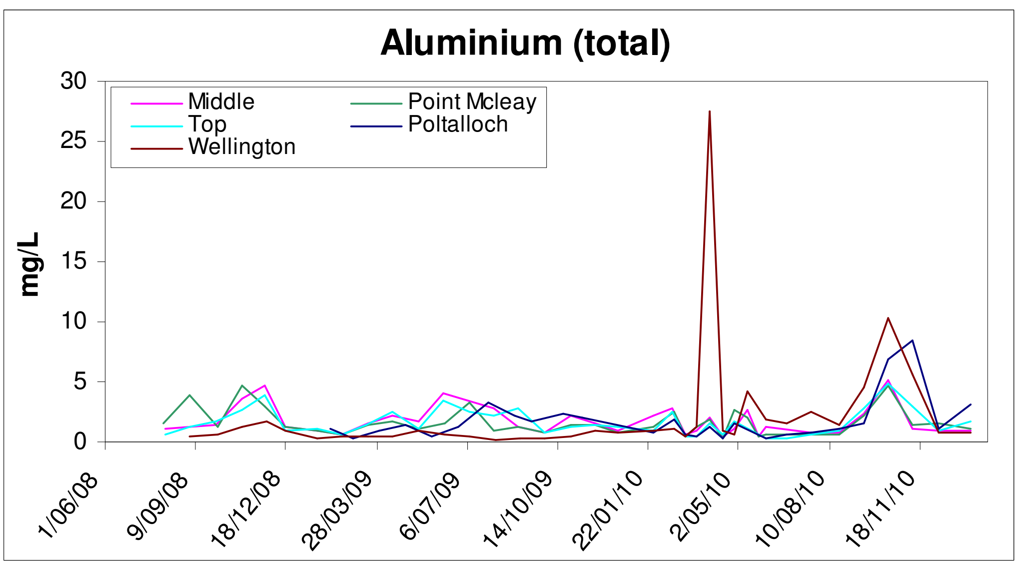

Figure 10 – Total aluminium at the Lake Alexandrina ambient monitoring sites

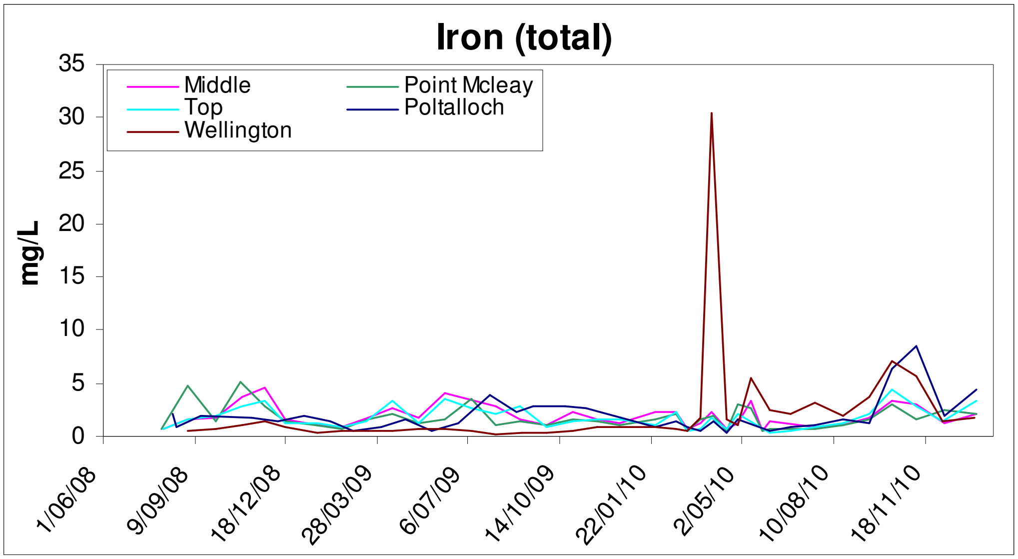

Figure 11 – Total iron at the Lake Alexandrina ambient monitoring sites

Lake Albert Water Quality

Ambient water quality monitoring results are discussed below for selected sites and parameters in Lake Albert. While the Lake Albert Opening site is not part of the ambient program (but rather part of previous event-based monitoring for the Lake Albert Water Level Management Program), it is included at present to assist in interpretation of water quality data in the northern lake region. In mid September (starting 19/9/10), the Narrung bund was partially breached monitoring data after then will reflect changes due to inflows from Lake Alexandrina.

pH

- pH levels in Lake Albert remain stable and within ANZECC guideline levels (pH 6.5-9.0) at all sites (Figure 12).

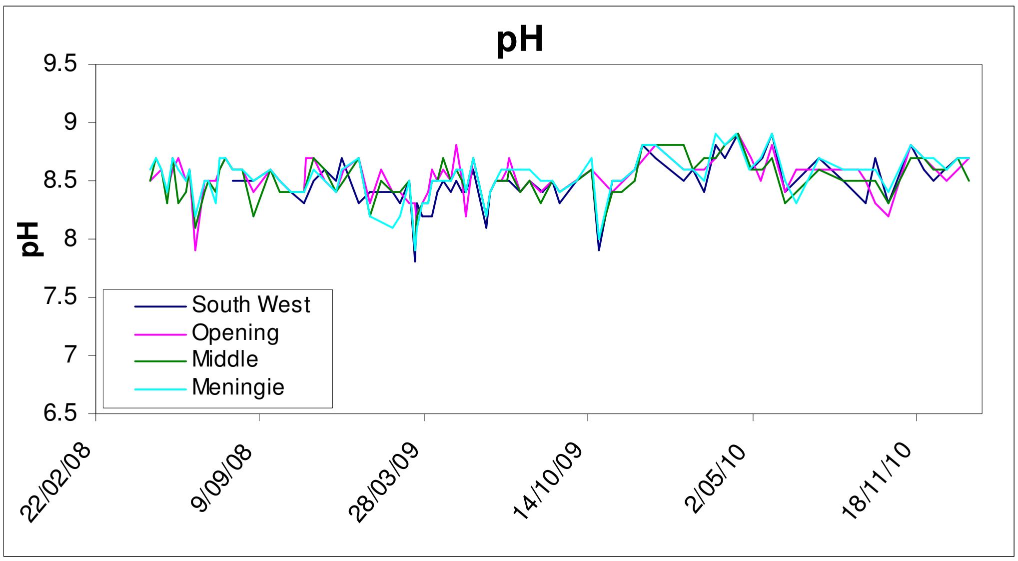

Figure 12 – pH at the Lake Albert ambient monitoring sites

Alkalinity

- Alkalinity within Lake Albert remains uniformly stable at high levels across all sites with the exception of Opening (Figure 13). The alkalinity patterns are similar to lake salinity (see Figure 15), suggesting the trends are influenced by water inputs and mixing patterns. The Opening site is most influenced by inflow of low alkaline water from Lake Alexandrina and thus experiences more variability in concentrations. It is likely that the alkalinity will continue to decline across Lake Albert with further mixing with Lake Alexandrina water.

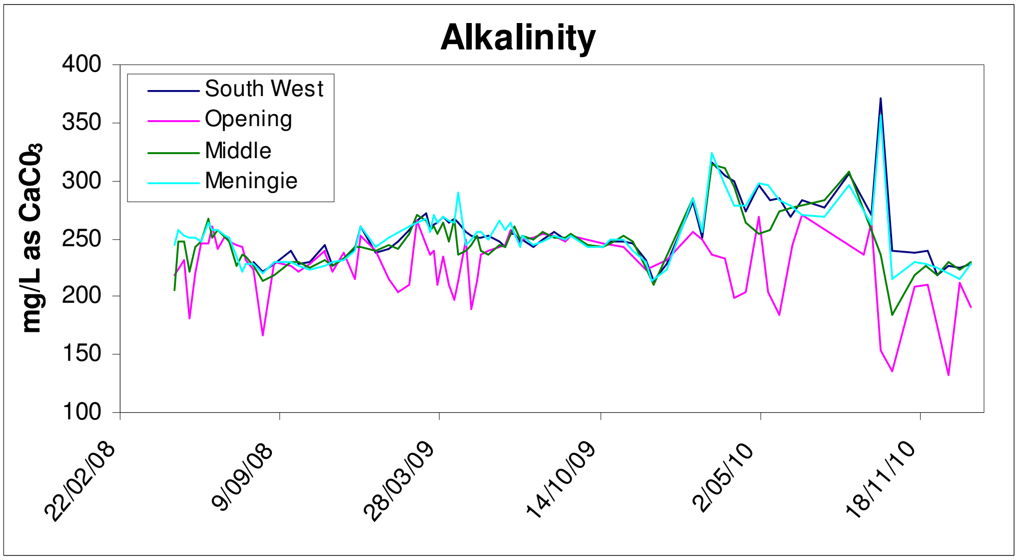

Figure 13 – Alkalinity at the Lake Albert ambient monitoring sites

Sulfate:chloride ratio

- The sulfate:chloride ratio is relatively stable across all Lake Albert sites (Figure 14) with no apparent influences from Lake Alexandrina inflows (higher sulfate:chloride ratio, Figure 4).

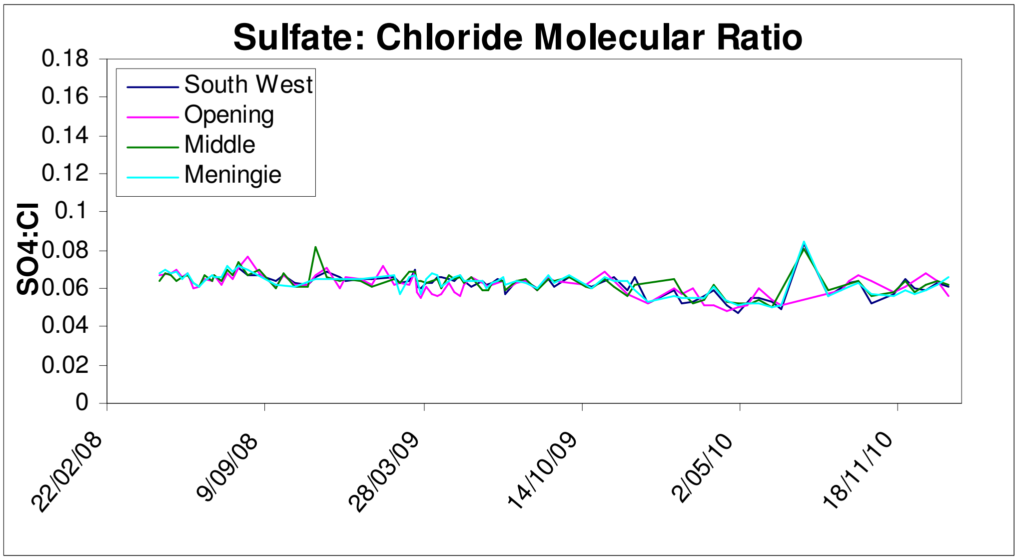

Figure 14 – Sulfate:chloride ratio at the Lake Albert ambient monitoring sites

Salinity (EC)

- Salinity levels have stabilised across most sites but still remain high (between 2900 and 8000 µS/cm) compared to pre-drought levels (Figure 15). The Opening site continues to show variability in salinity levels as it is influenced the most by inflows from Lake Alexandrina and the wind direction at the time of monitoring. Further inflows and mixing of water from Lake Alexandrina are expected to reduce salinities across Lake Albert, however it is unlikely salinities will return to pre drought levels (<1600 µS/cm) for some time due to the limited water exchange between the two lakes.

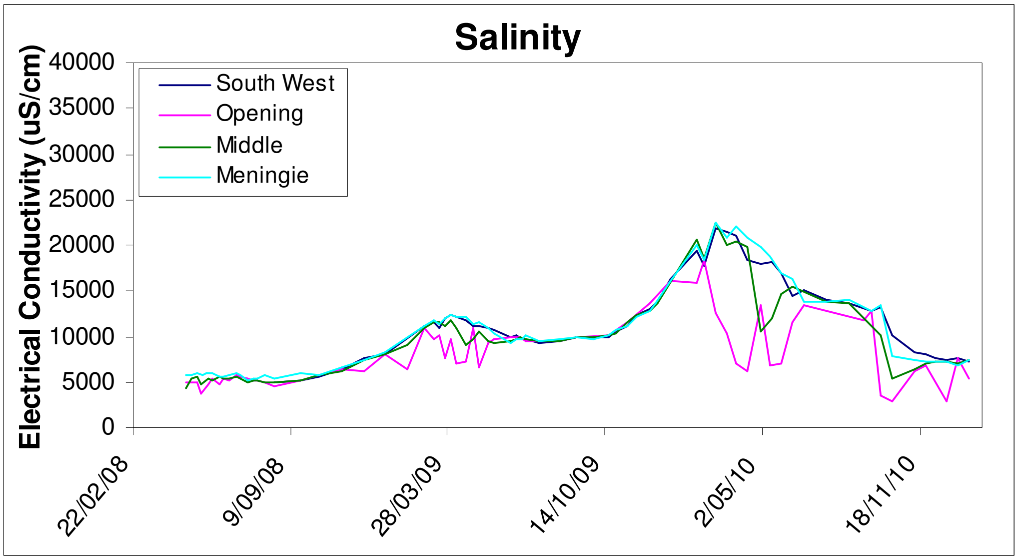

Figure 15 – Salinity at the Lake Albert ambient monitoring sites

Turbidity

- Turbidity in Lake Albert remains variable (Figure 16). Increasing water levels are likely reducing resuspension of sediments during wind events.

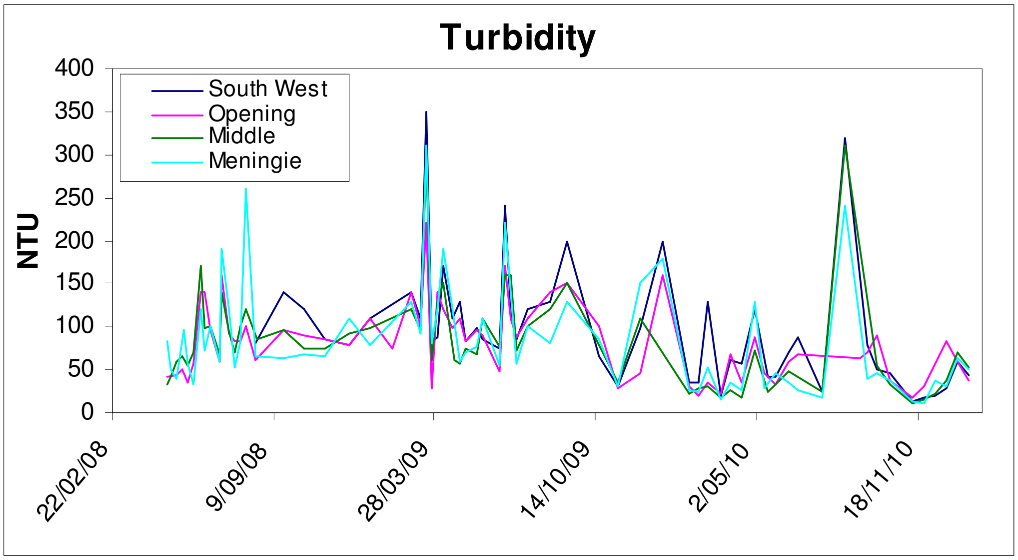

Figure 16 – Turbidity at the Lake Albert ambient monitoring sites

Nutrients (total nitrogen and phosphorus)

- Total nitrogen and total phosphorus levels across all Lake Albert sites declined briefly in early January, however increased again to concentrations that were seen over December 2010. Nutrient levels are comparable to historic data, however continue to be in excess of the ANZECC guidelines for freshwater ecosystems (<1mg/L TN, <0.025 mg/L TP).

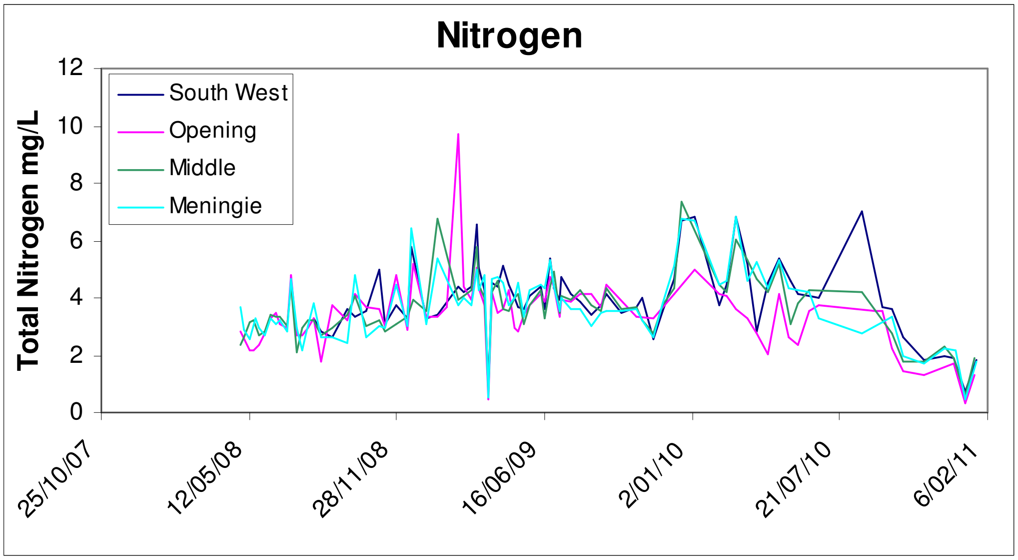

Figure 17 – Total Nitrogen at the Lake Albert ambient monitoring sites

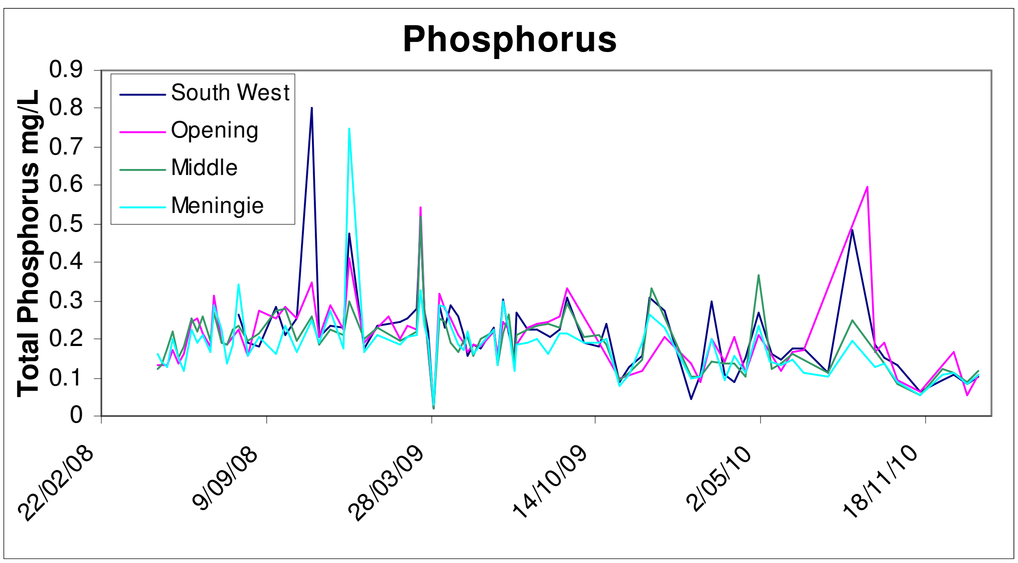

Figure 18 – Total phosphorus at the Lake Albert ambient monitoring sites

Chlorophyll a (algae)

- Chlorophyll *a* levels increased slightly during the beginning of January but declined again over the last month (Figure 19). Levels are comparable to historic data for Lake Albert. These levels do however, continue to be in excess of ANZECC guidelines (>15 µg/L) and indicate a nutrient enriched system. No toxic blue-green algal species have been identified at present.

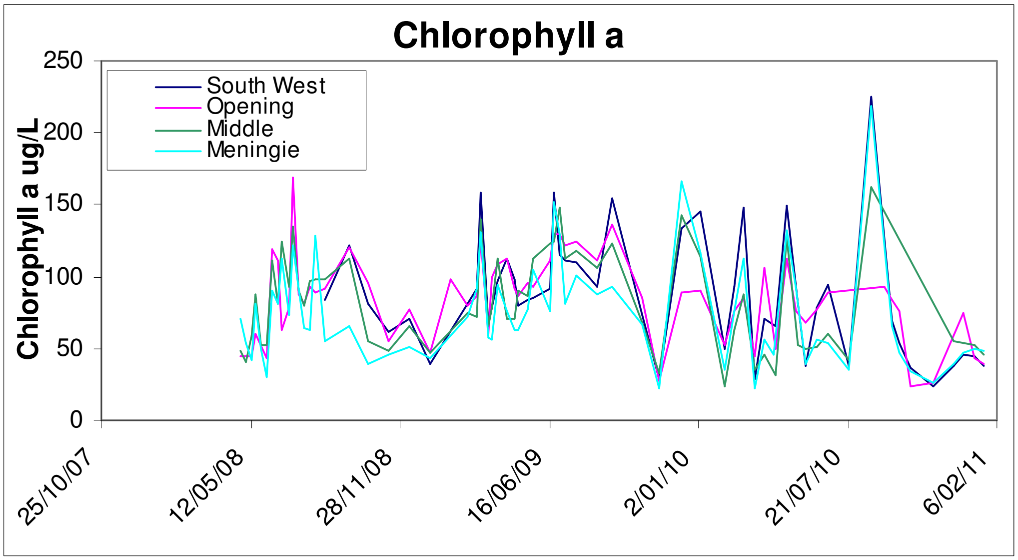

Figure 19 – Chlorophyll *a* at the Lake Albert ambient monitoring sites

Metals

Total aluminium and iron concentrations within Lake Albert (Figures 20 and 21) have remained stable and at low levels since the lake has been maintained at historic pool level. It is likely there has been less resuspension of sediment (containing metals) and lower flux from exposed acidic sediments at these higher water levels. The increase in total iron observed at the Opening site during December has now decreased, and levels are similar to those observed across the remaining sites.

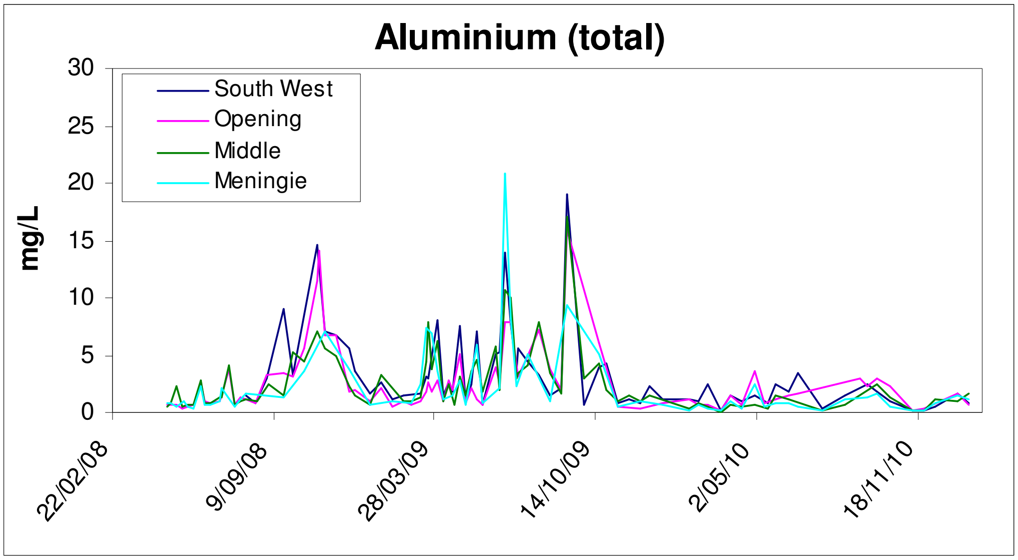

Figure 20 – Total aluminium at the Lake Albert ambient monitoring sites

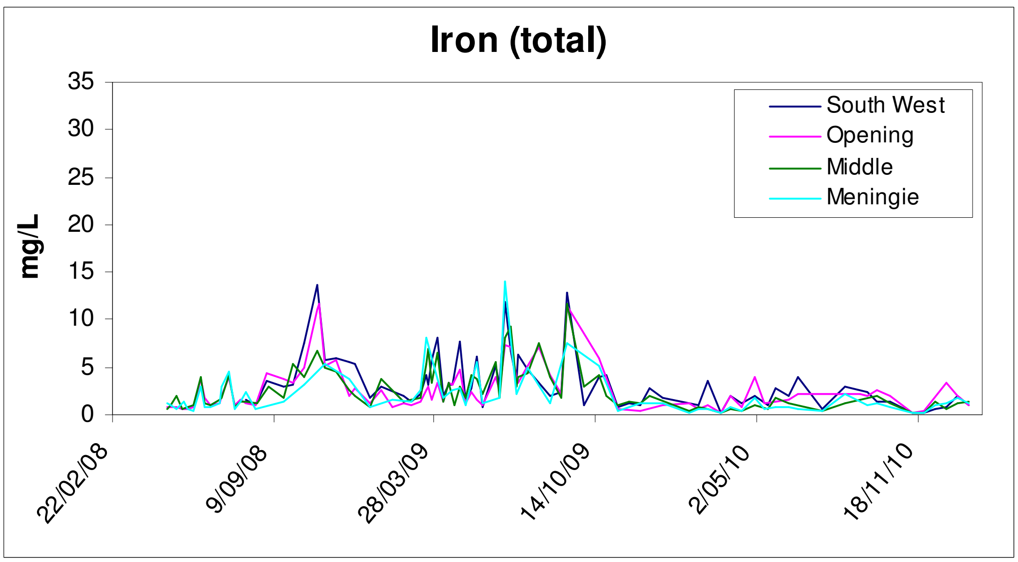

Figure 21 – Total iron at the Lake Albert ambient monitoring sites

Goolwa Channel and Tributaries Water Quality

Ambient and event-based water quality monitoring results are discussed for selected sites and parameters in the Goolwa Channel and Tributaries region (see Figures 1 and 22 for site locations). Due to the nature of the monitoring program both the ambient and event-based sites have been included in this section to compare data collected over the month. In late September (starting 26/9/10), the Goolwa regulator near Clayton was partially breached monitoring data after this will reflect changes due to inflows from Lake Alexandrina.

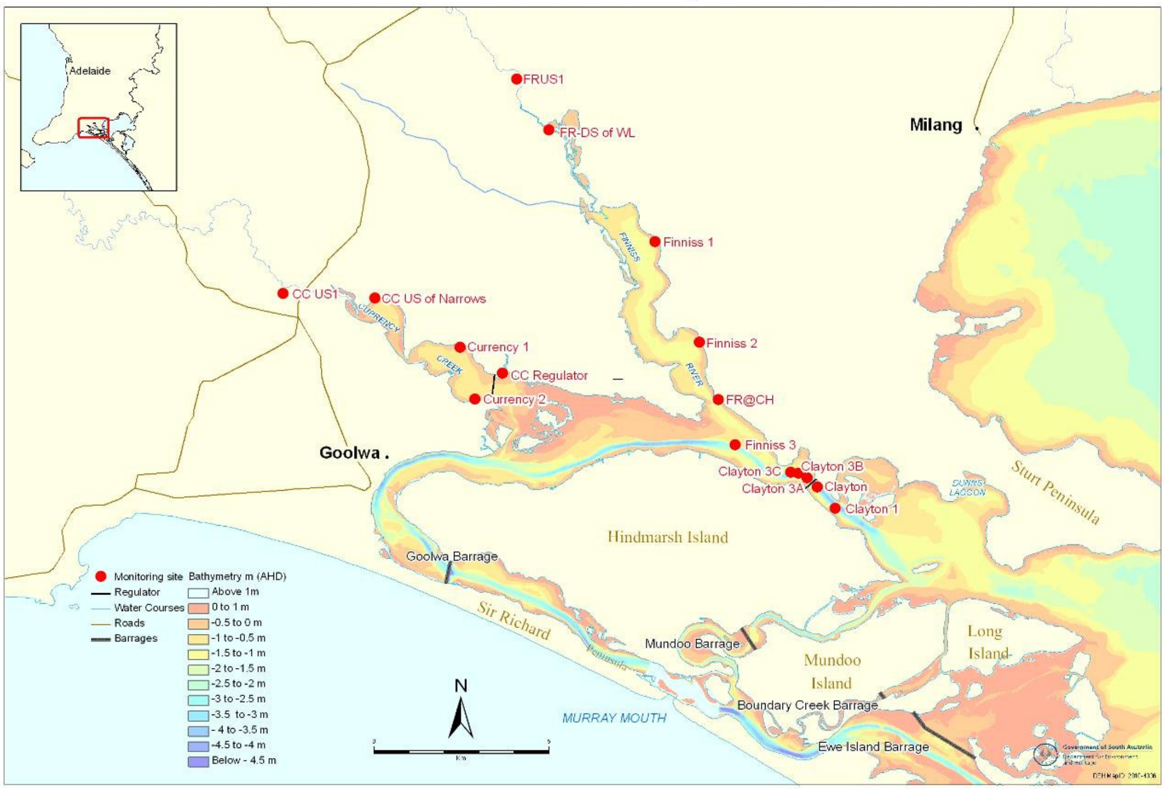

Figure 22 – Goolwa Channel and Tributaries ambient and event-based monitoring sites

pH

- pH levels remain stable and within ANZECC guideline levels (pH 6.5-9.0) at most sites in the Goolwa Channel and Tributaries region (Figure 23). The pH of Currency 2 has declined considerably, however levels are now consistent with those observed at all other sites. This is likely due to inputs from local rainfall diluting water behind the Currency regulator.

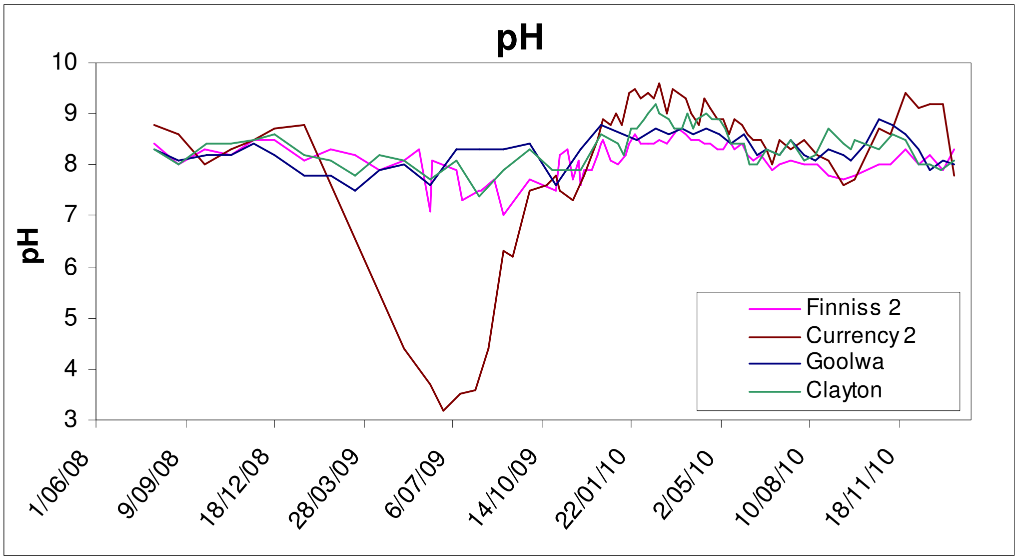

Figure 23 – pH at the Goolwa Channel and Tributaries monitoring sites

Alkalinity

- Alkalinity levels at all of the Goolwa Channel and Tributaries sites are still recording slight decreases (Figure 24). Reconnection with Lake Alexandrina and mixing with the lower alkalinity floodwaters are likely to still be responsible for these declines. As water continues to flow through the Goolwa Channel past the Tributaries to the Murray Mouth, it is expected there will be some further mixing, dilution and reduction of alkalinity.

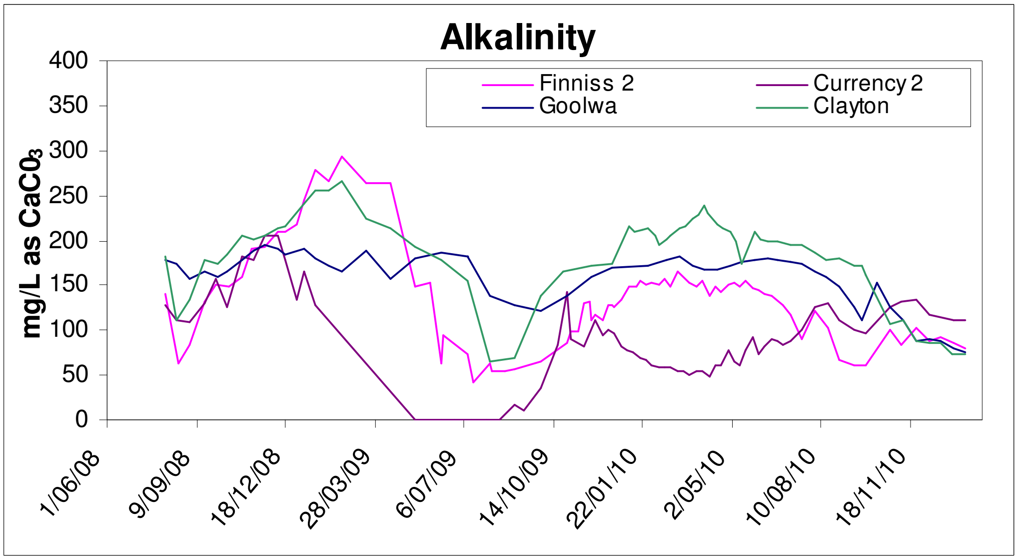

Figure 24 – Alkalinity at the Goolwa Channel and Tributaries monitoring sites

Sulfate:chloride ratio

- The sulfate:chloride ratio remains relatively uniform and stable at most sites (Figure 25). Trends do not indicate any widespread acid sulfate soil inputs.

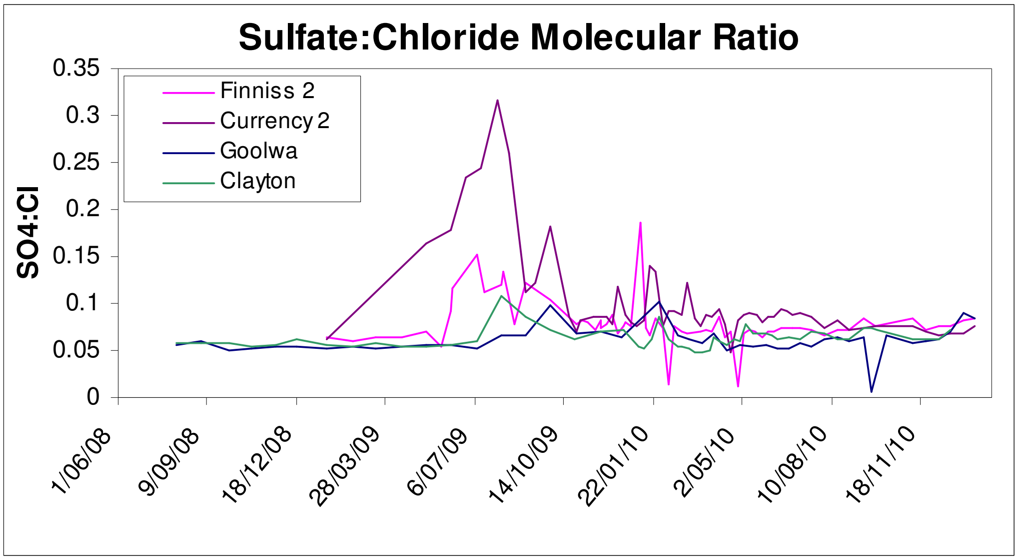

Figure 25 – Sulfate:chloride molecular ratio at the Goolwa Channel and Tributaries monitoring sites

Salinity (EC)

- Salinity levels continue to decrease and remain low at all sites except the Currency 2 site (located on the north western side of the Currency Creek regulator), which is likely due to the Currency Creek regulator restricting mixing with the low saline flood waters. (Figure 26). Salinity is expected to continue to decrease as further water is released through the Goolwa Barrage.

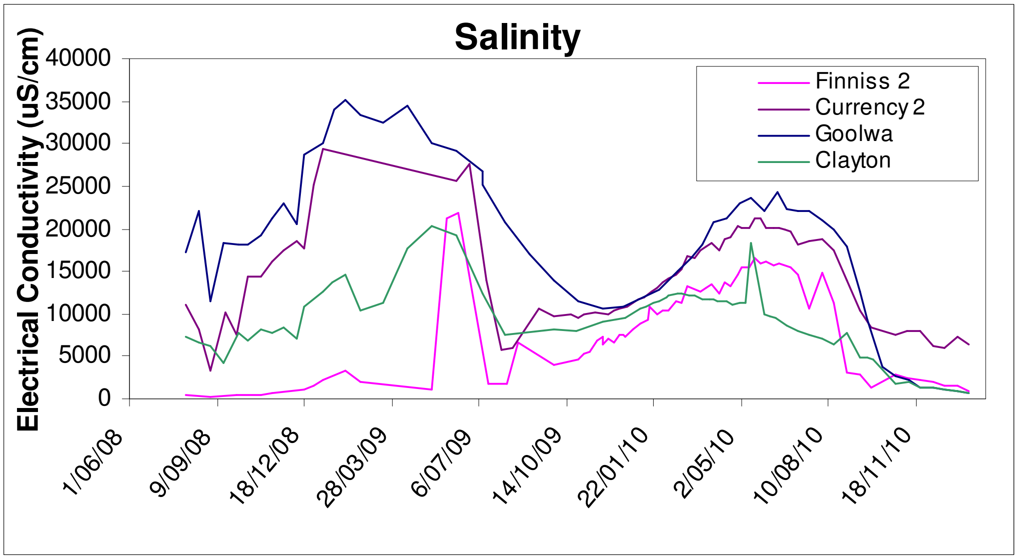

Figure 26 – Salinity at the Goolwa Channel and Tributaries monitoring sites

Turbidity

- Turbidity levels in the Goolwa Channel and Tributaries sites have increased considerably during January (Figure 27) which is consistent with the inflows of highly turbid floodwaters through Lake Alexandrina. The lower turbidity at the Currency 2 site is likely due to the presence of the Currency regulator restricting mixing with the more turbid flood waters.

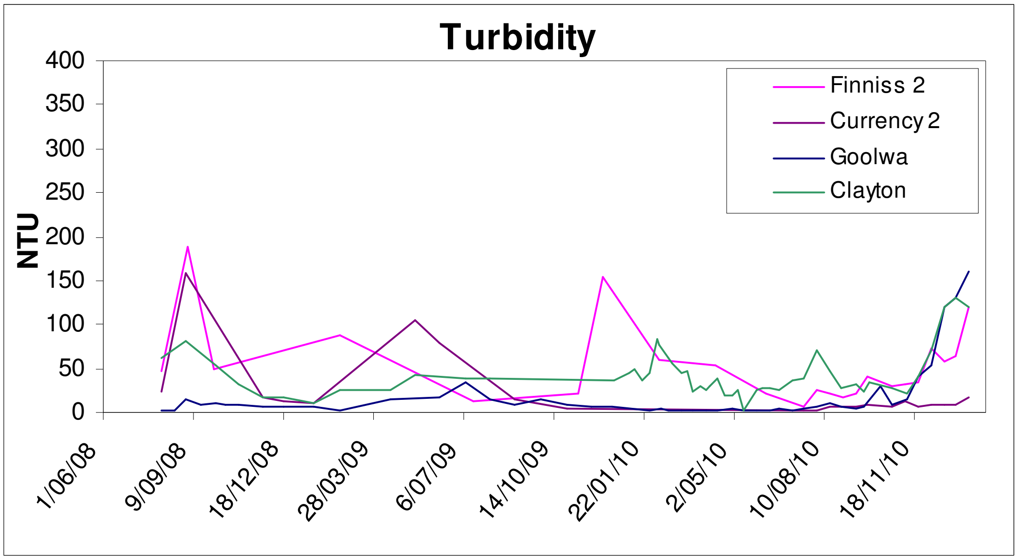

Figure 27 – Turbidity at the Goolwa Channel and Tributaries monitoring sites

Nutrients (total nitrogen and phosphorus)

- Nitrogen levels have remained relatively stable in the Goolwa Channel and Tributaries during January, however phosphorous levels continue to increase across all sites, with the exception of Currency 2 (Figures 28 and 29). Nutrient trends in this region are currently driven by flood water inflow composition and mixing processes in Lake Alexandrina (Figures 7 and 8). Nutrient levels continue to remain above ANZECC guidelines for freshwater ecosystems (<1mg/L TN, <0.025 mg/L TP).

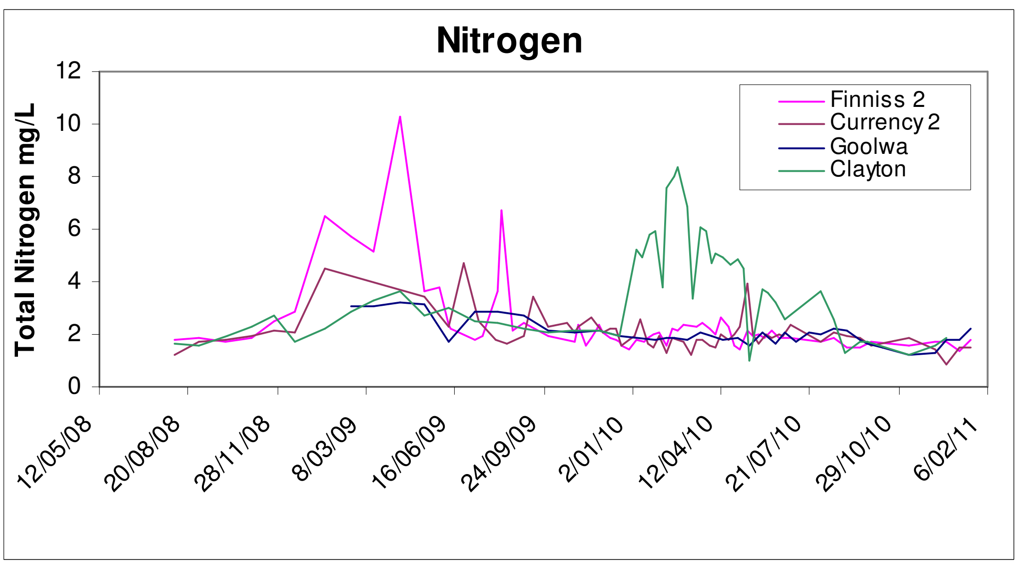

Figure 28 – Total Nitrogen at the Goolwa Channel and Tributaries monitoring sites

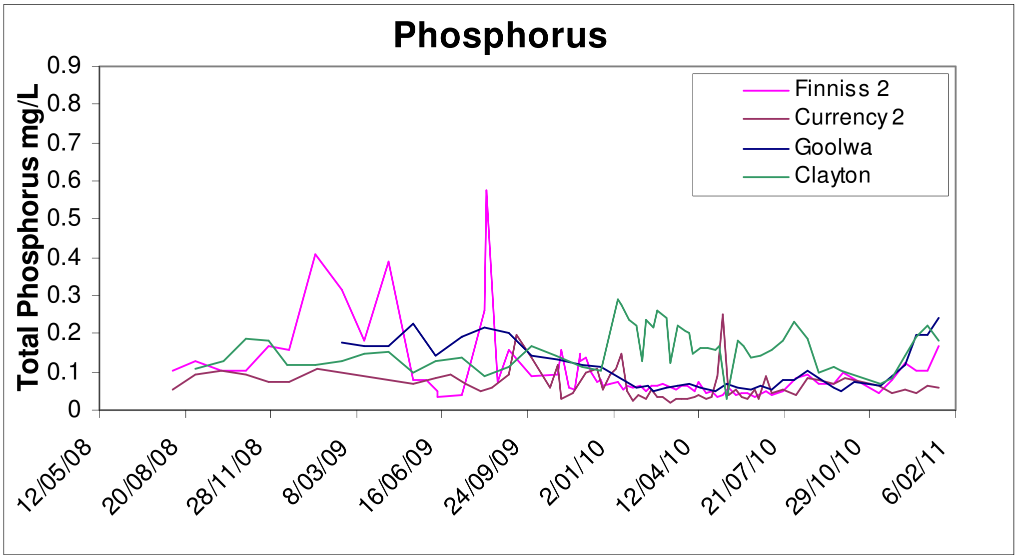

Figure 29 – Total phosphorus at the Goolwa Channel and Tributaries monitoring sites

Chlorophyll (algae)

- Chlorophyll *a* remains variable within the Goolwa Channel and the Tributaries (Figure 30). Higher levels continue to be observed during January in the Goolwa Channel (Clayton and Goolwa sites) attributed to warmer water temperatures and large areas of slow moving shallow water providing ideal conditions for algal growth of the fringing areas surrounding these sites.

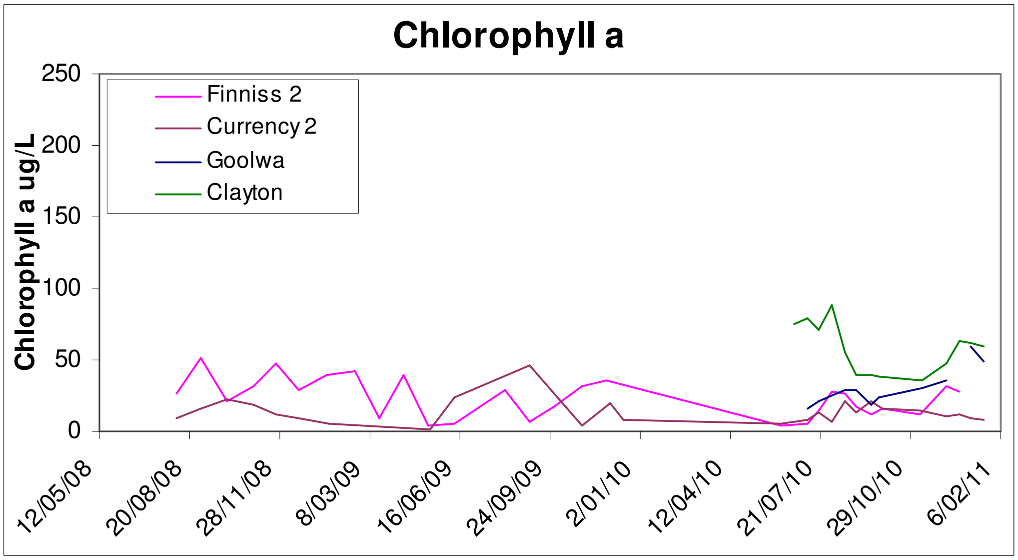

Figure 30 – Chlorophyll *a* at the Goolwa Channel and Tributaries monitoring sites

Metals

- Total aluminium and iron concentrations within the Goolwa channel and Tributaries have increased over the month of January, however remain relatively low compared to the 2008–2009 drought period (Figures 31 and 32). These observed increases are likely due to the increased floodwaters within the system. Currency 2 has recorded lower metals concentrations in comparison, which would be attributed to the presence of the Currency Creek regulator reducing mixing.

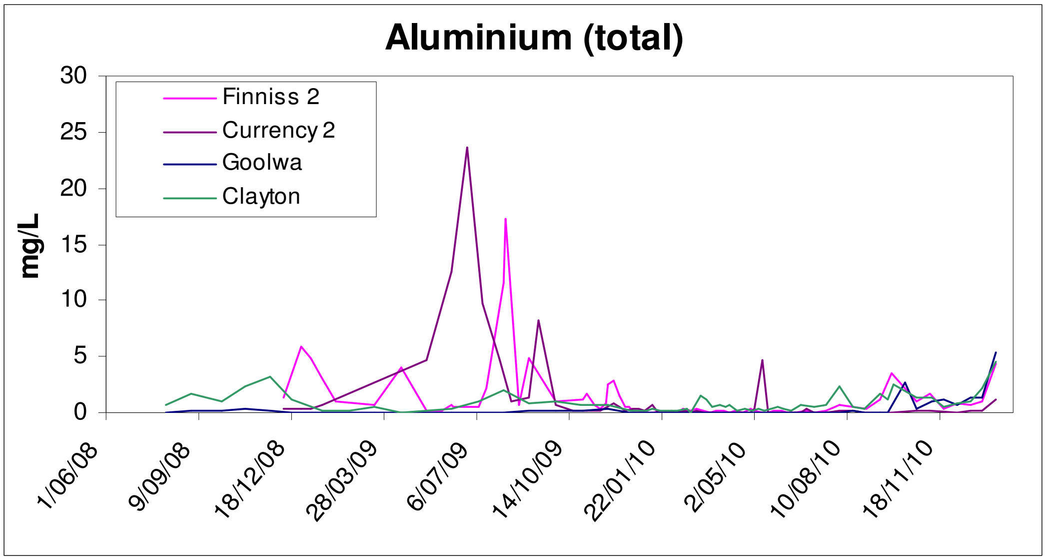

Figure 31 – Total aluminium at the Goolwa Channel and Tributaries monitoring sites

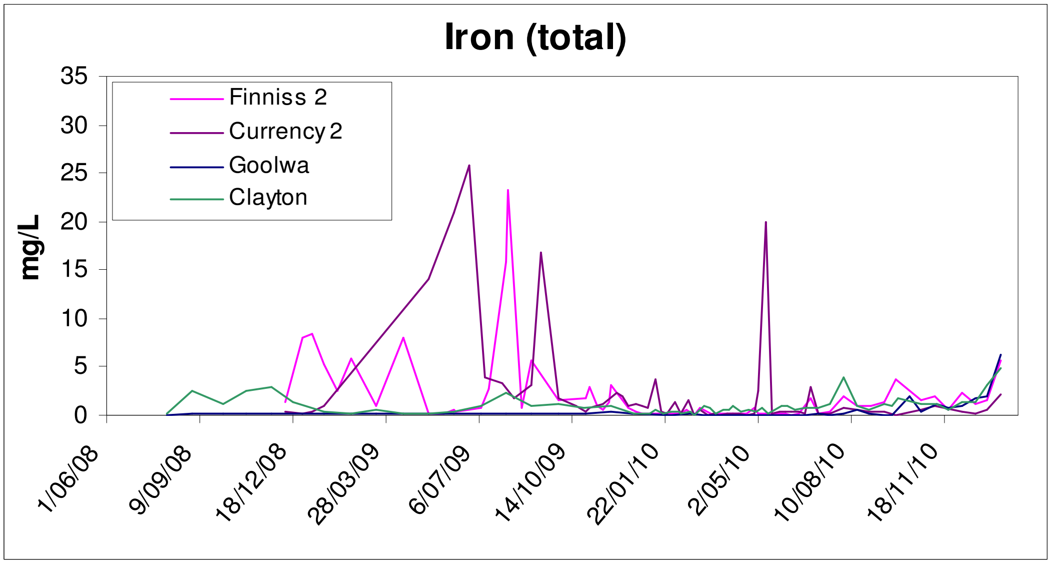

Figure 32 – Total iron at the Goolwa Channel and Tributaries monitoring sites

Event-based monitoring

Event-based water quality sampling is undertaken in regions that have experienced acidification or were at risk of acidification (Figure 33). The selection of sites was based upon previous acid sulfate soil risk assessments, in accordance with available data on the distribution of sulfidic and sulfuric materials and research and modelling into potential acidity fluxes. High risk locations were initially screened to identify the presence and extent of any acidity, and the frequency of further monitoring was determined from these results. Previously this information has been used to determine the need for management actions, such as limestone dosing which occurred in Currency Creek, Finniss River and Boggy Lake, Lake Alexandrina in 2009 and 2010. Limestone dosing reduces the acidity hazard and mitigates further metal release.

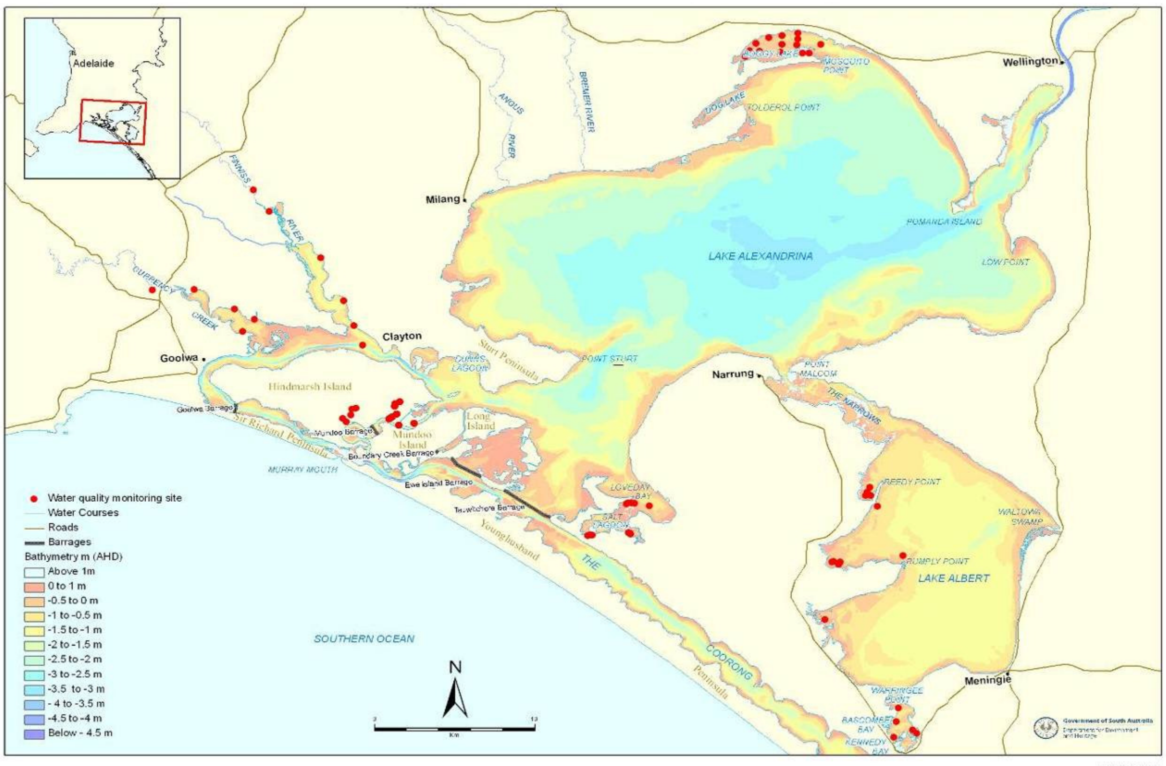

Figure 33 – Event-based water quality monitoring sites

Boggy Lake

Figure 34 shows a map of sampling locations in Boggy Lake with water quality results from selected sites shown in Figure 35. Limestone dosing, and improved water levels from flow into Lake Alexandrina since September 2010 have enabled the pH and alkalinity within Boggy Lake to recover and stabilise to within satisfactory guideline levels and trigger values (Figure 35). pH levels continue to remain stable in Boggy Lake, and despite some variability at sites 10 and 8, alkalinity levels have become consistent across all sites during January. Although salinity levels within Boggy Lake (≈2500 EC) have shown signs of stabilising well above those seen in Lake Alexandrina (between 750 – 1500 EC) there is indication that levels are still declining. This may be attributed to recent rainfall events within the area diluting salinity levels and restricted mixing due to Boggy Lake being a bay. However, it is more likely that increased inflows from floodwaters will promote increased mixing between Boggy Lake and the main water body continuing to drive declines in salinity.

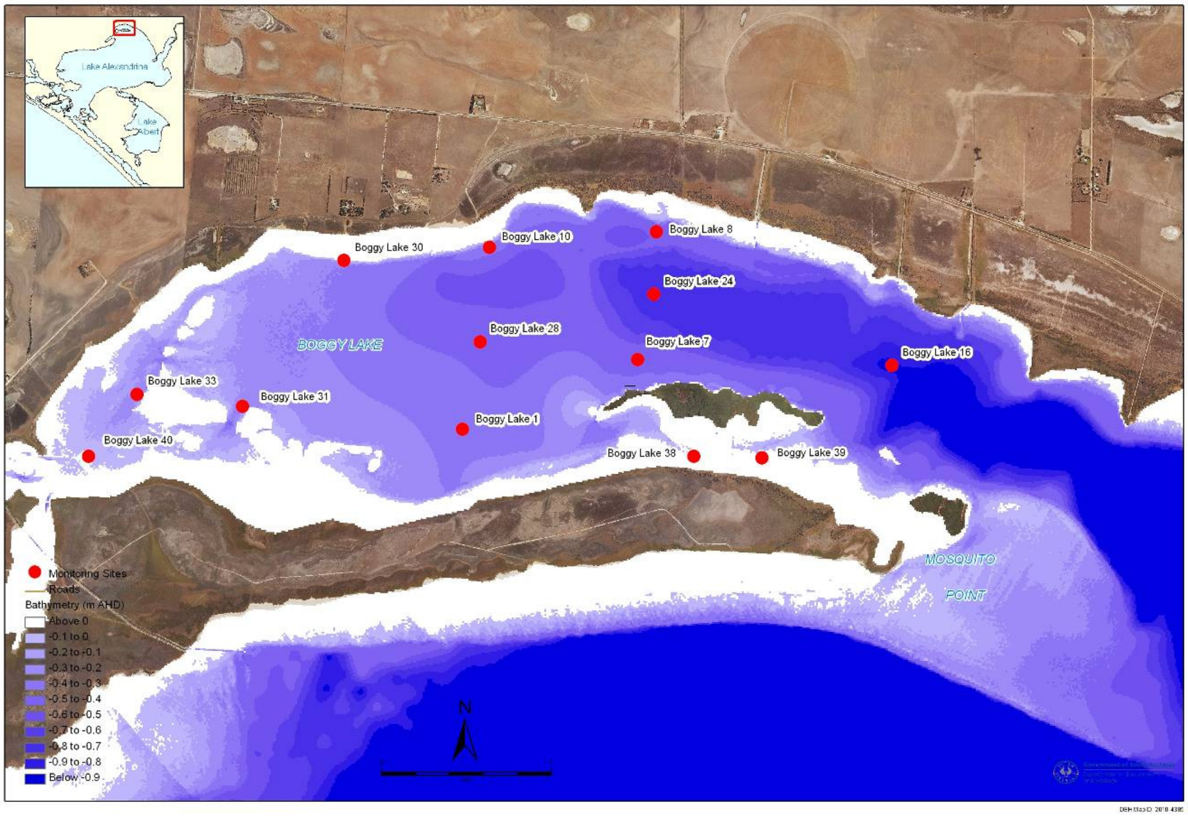

Figure 34 –Boggy Lake monitoring sites

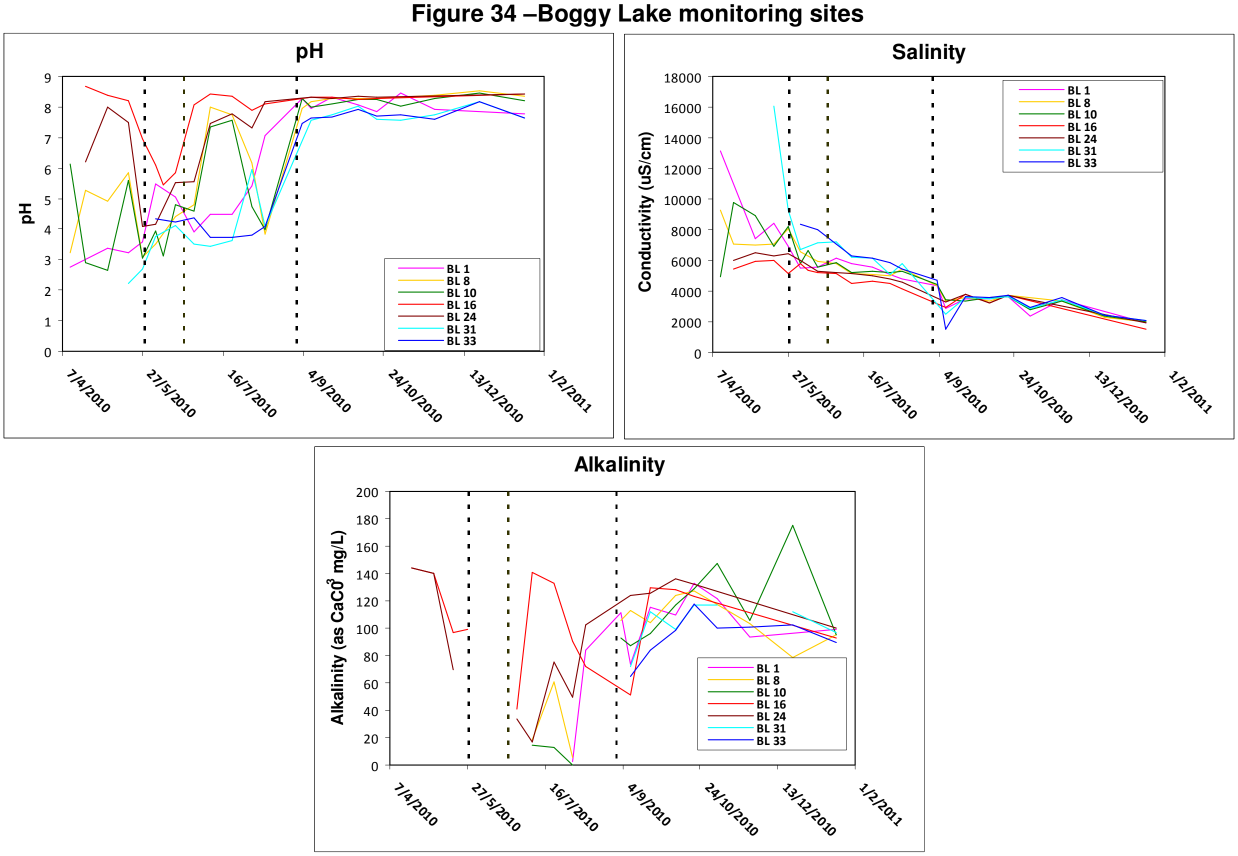

Figure 35 –Boggy Lake water quality results

Narrung Narrows

Figure 36 and 37 show the Narrung Narrows sample sites and water quality results respectively. Sites within the Narrung Narrows have been monitored since the Narrung bund was breached in August 2010. pH has remained relatively stable during January, with levels recovering to those observed prior to the breach. The noticeable decrease in pH immediately after the breach took place can be attributed to the initial inflow and dilution with Lake Alexandrina water. A similar trend was also observed in both the alkalinity and salinity graphs during this time. Current alkalinity and salinity levels within the narrows are still showing similar trends. The majority of sites have remained relatively stable, however sites 16 and 19 (eastern end of the channel) have decreased significantly towards alkalinity and salinity levels observed across the remaining sites. This significant decrease in both parameters is likely due to increasing flows through the narrows as floodwaters enter Lake Alexandrina, coupled with wind driven mixing events.

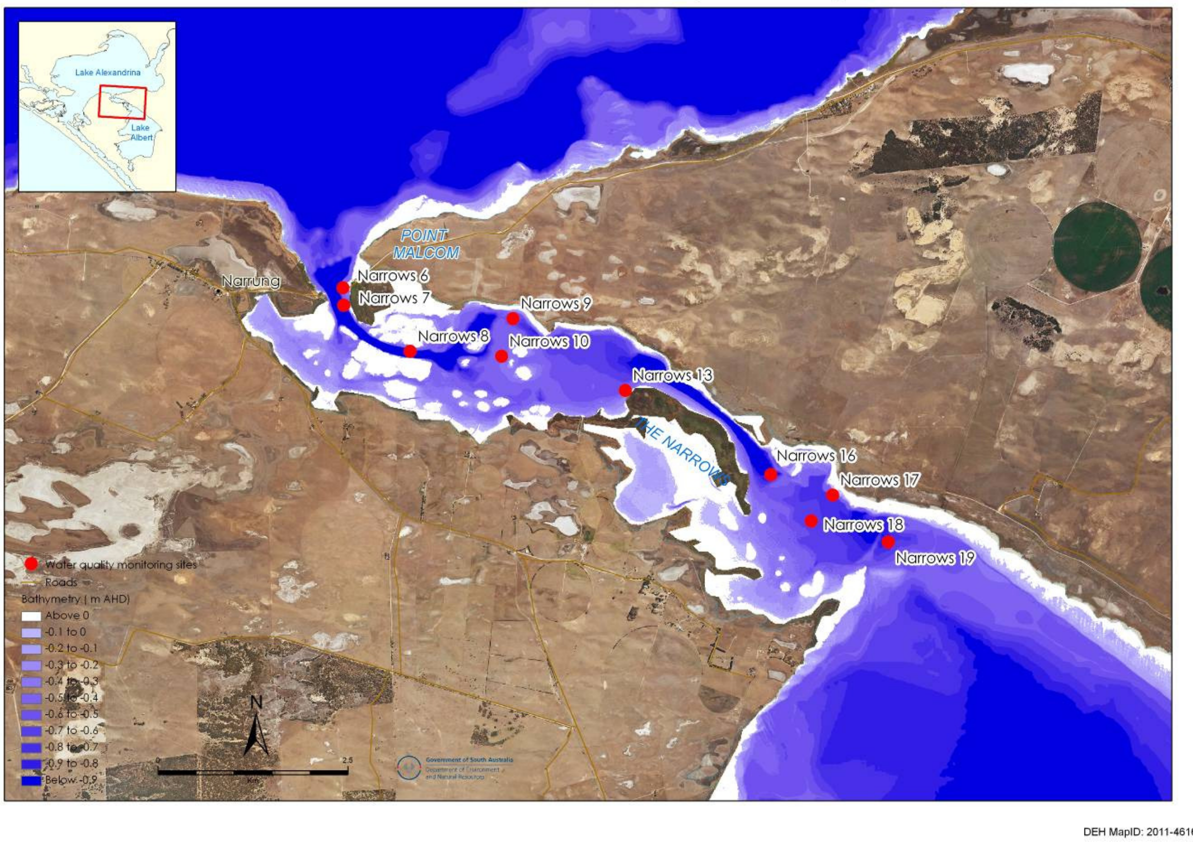

Figure 36 –Narrung Narrows monitoring sites

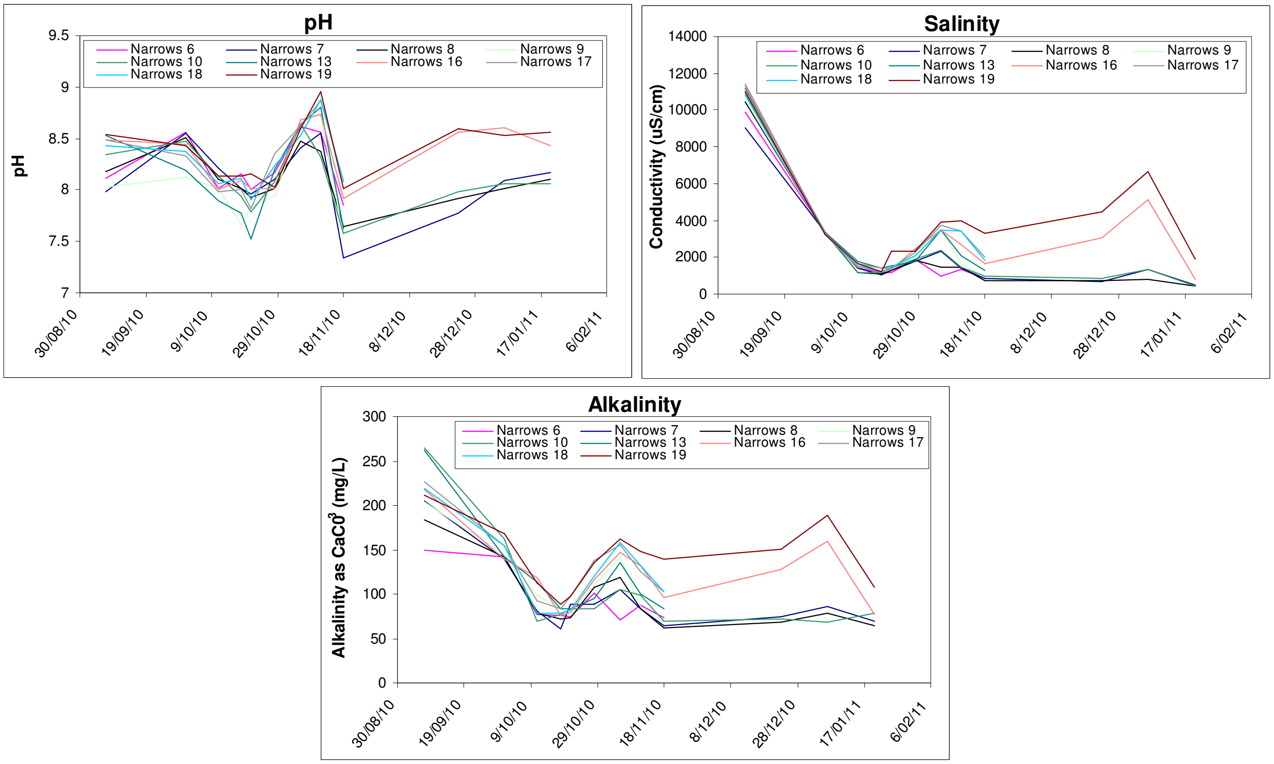

Figure 37 – Narrung Narrows water quality results

Boggy Creek and Hunters Creek

Figure 38 and 40 show the Boggy Creek and Hunters Creek sampling sites and water quality results respectively. pH levels within Boggy Creek began stabilising in early December 2010 (Figure 39), and have remained consistent throughout January 2011 and within ANZECC guidelines. Trends in salinity and alkalinity are showing similar patterns of decline which can be attributed to greater inflows through the Mundoo Channel and into Boggy Creek, resulting from increased floodwaters within Lake Alexandrina. The pH levels within Hunters Creek have remained relatively stable since October 2010 (Figure 41) with the exception of Hunters 5 and 6 which have shown some variability in pH during January. This may be due to these sites proximity to the Mundoo Channel and associated water quality influences with the increased flows. Salinity has remained consistently stable at low levels over the same period. Alkalinity within Hunters Creek remains somewhat variable, however within an overall increasing trend.

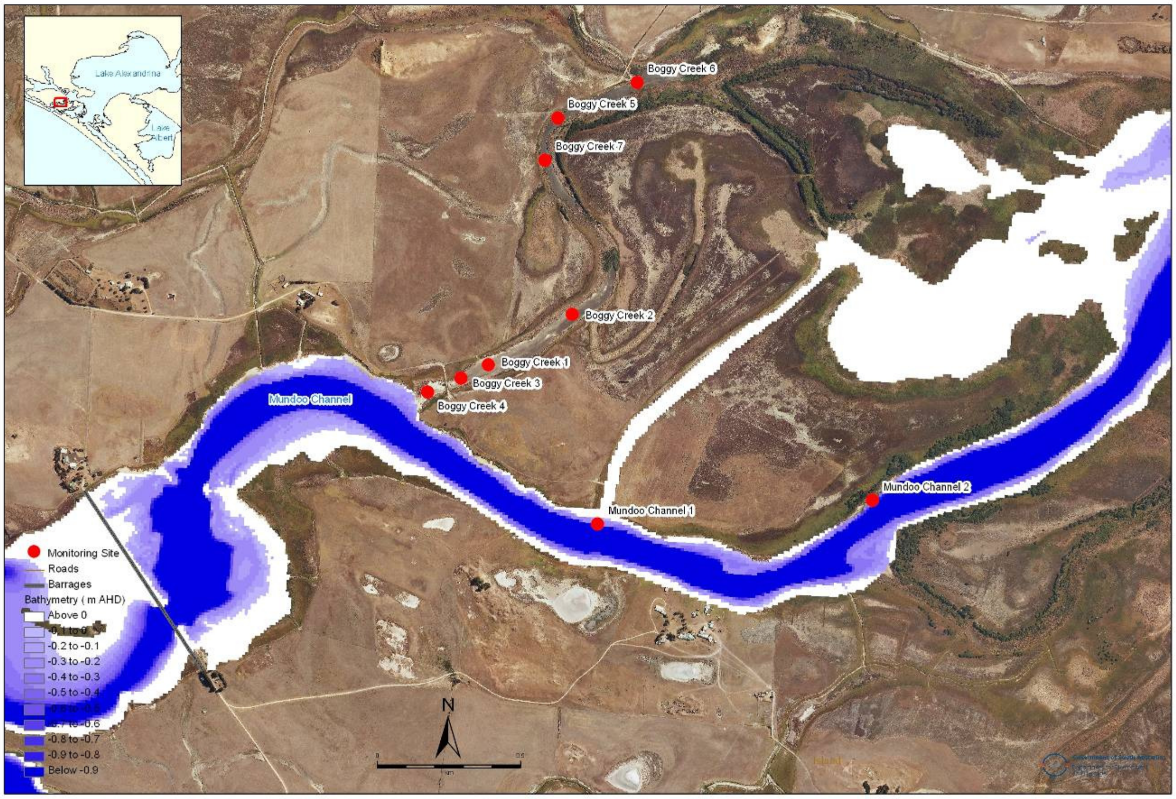

Figure 38 –Boggy Creek sample sites

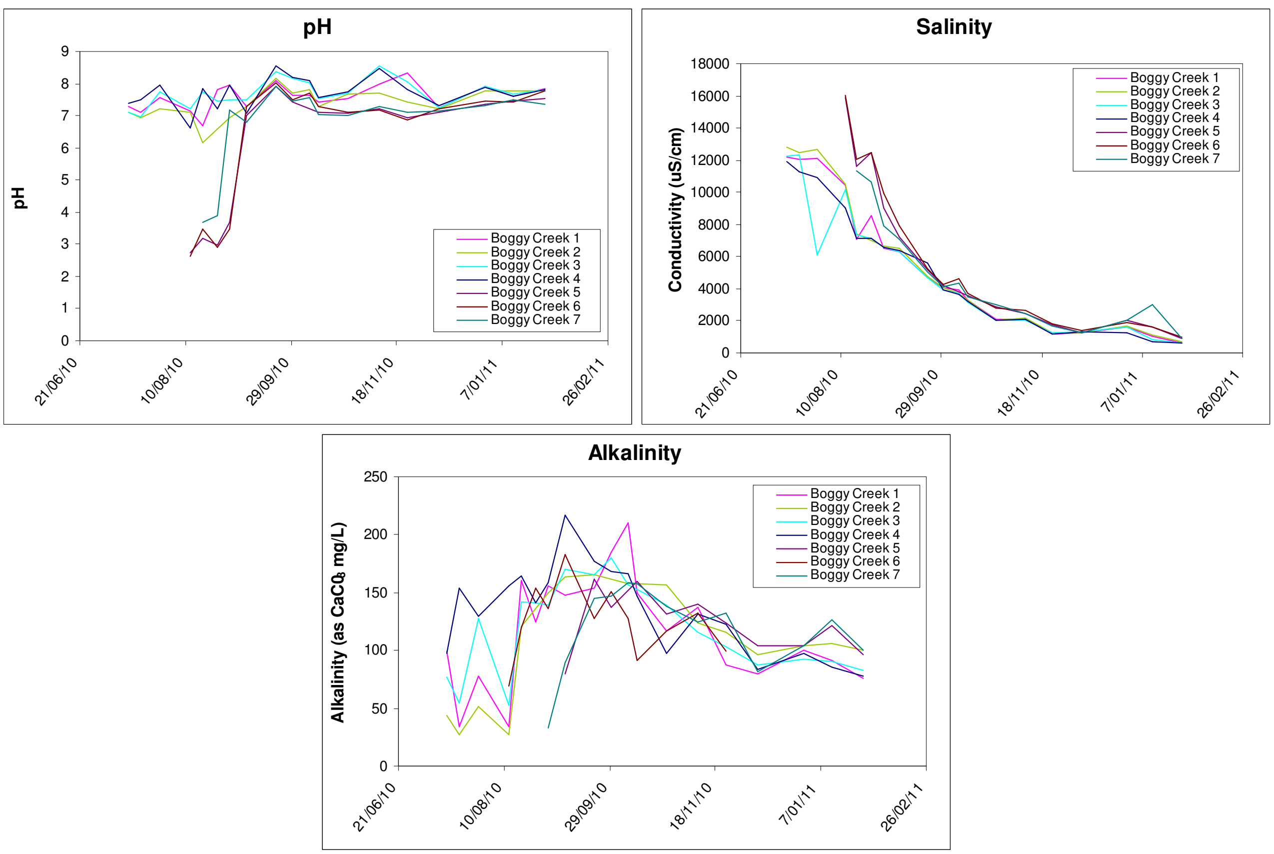

Figure 39 – Boggy Creek water quality results

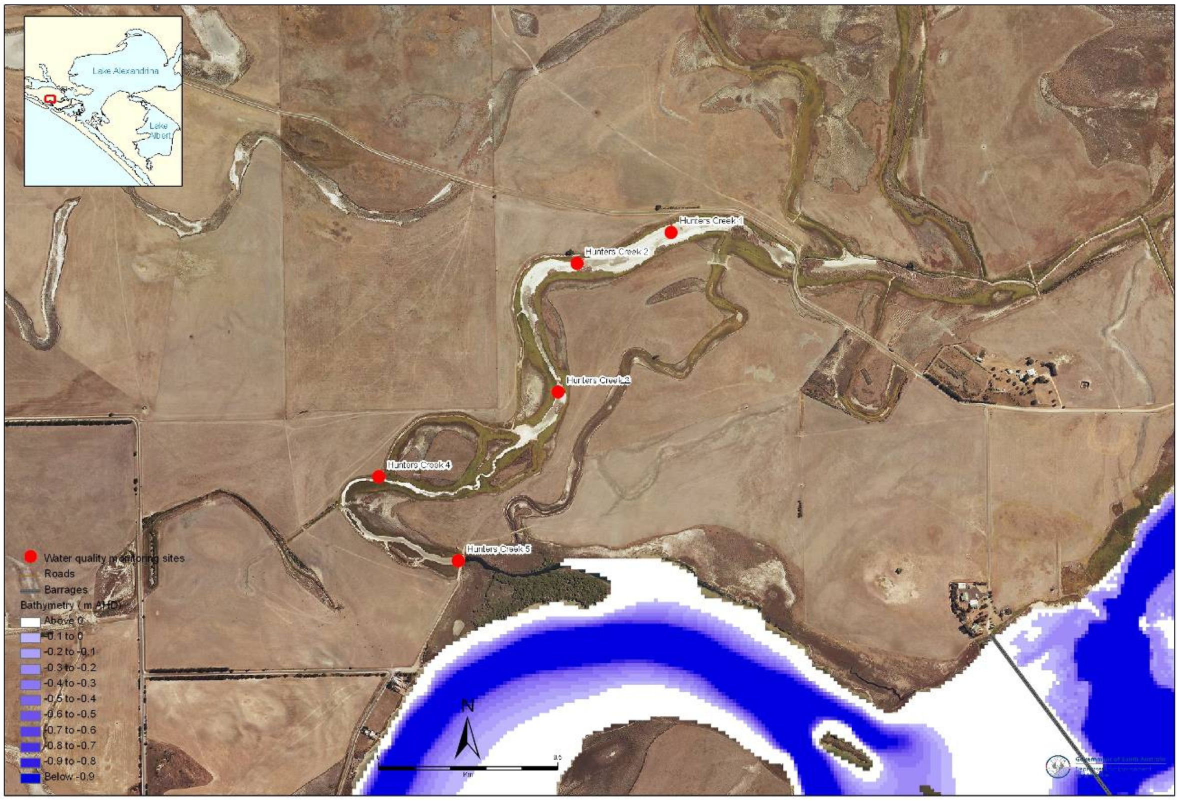

Figure 40 –Hunters Creek monitoring sites

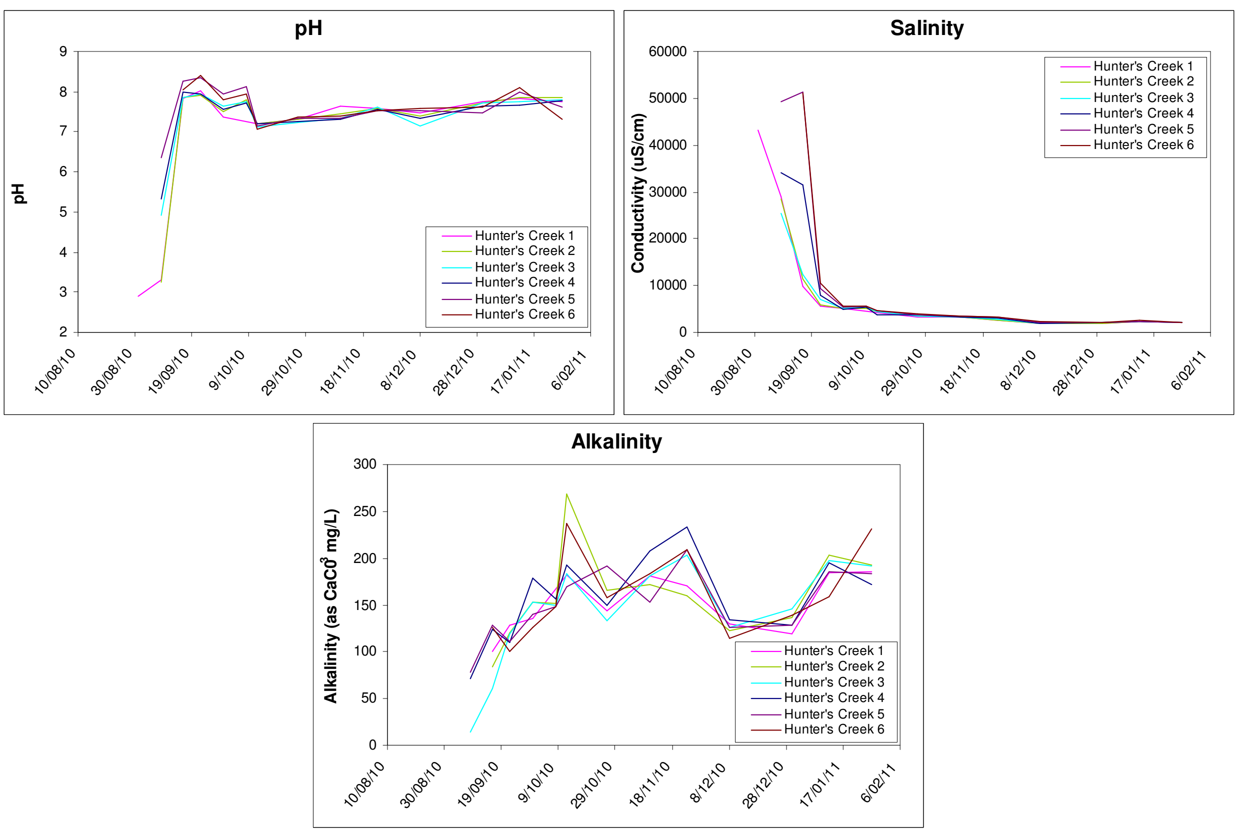

Figure 41 – Hunters Creek water quality results

Tauwitchere

Figure 42 shows a map of the Tauwitchere area and the selected sampling sites. pH levels within the area had remained reasonably stable since November 2010, however during January they have experienced some variability (Figure 43). Salinity has also experienced some variability during January after consistently trending downwards over the latter part of 2010. It is likely that the variability experienced in these two parameters is the result of increased flows through the area as they reach the end of the system and are flushed through the barrages as increasing floodwaters enter the Lower Lakes. Alkalinity across all sites is stabilising, however it is possible that there will be some fluctuations in concentrations as more floodwaters flow through the barrages in the coming months.

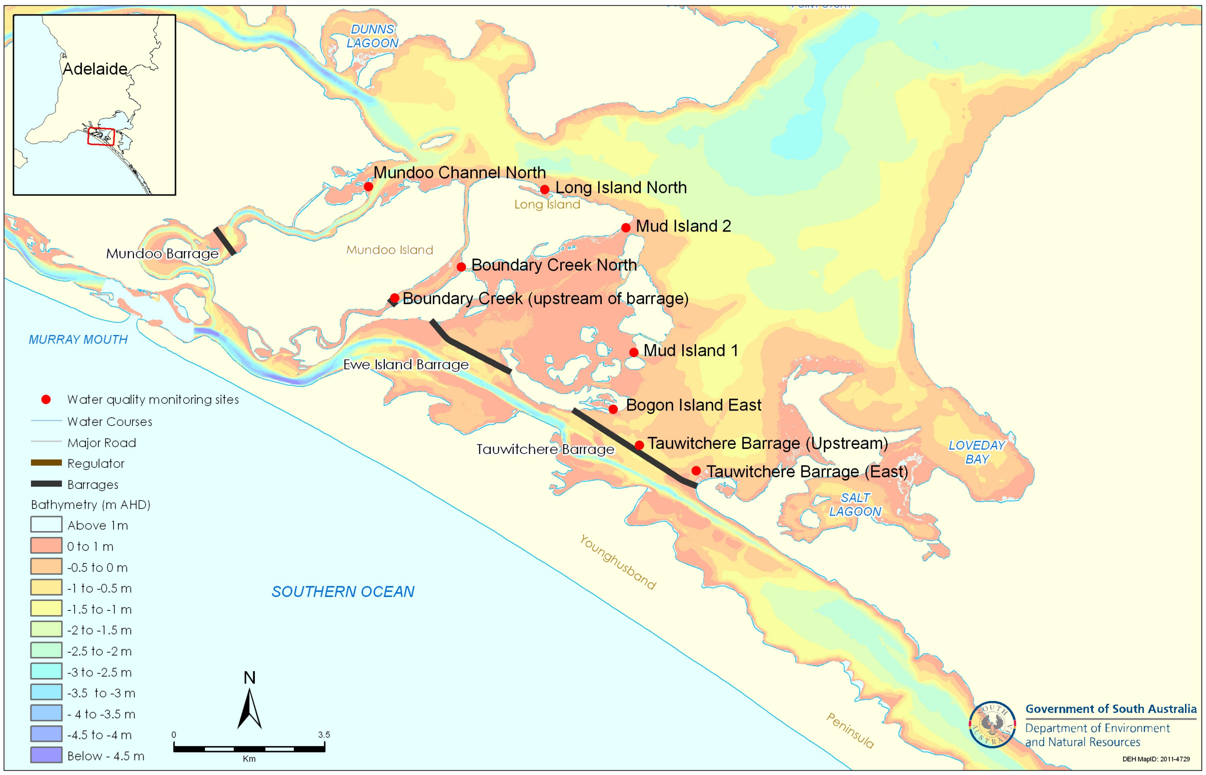

Figure 42 – Tauwitchere monitoring sites

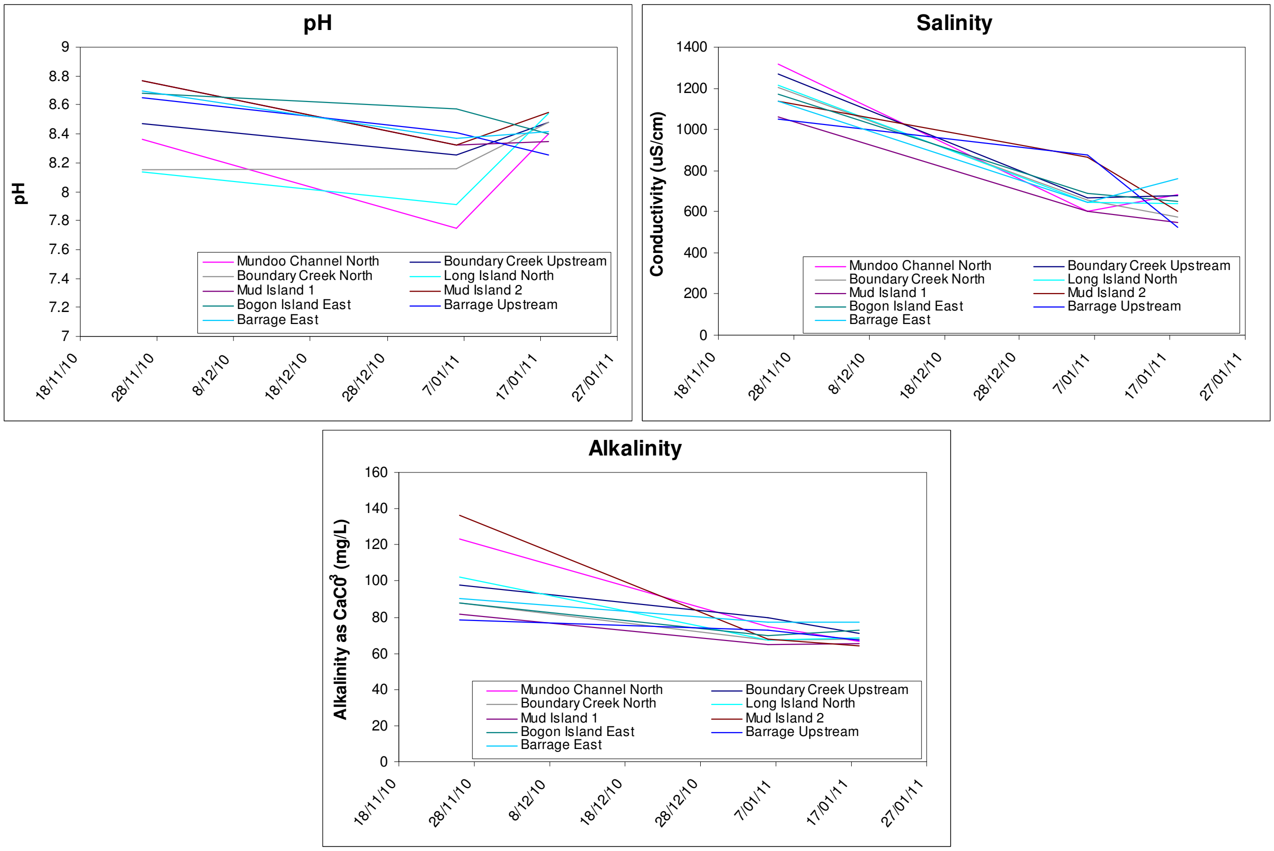

Figure 43 - Tauwitchere water quality results

Further Information

Further information on water quality and quantity, and acid sulfate soils, can be found on the following websites:

- Department of Environment and Natural Resources www.environment.sa.gov.au/cllmm/
- River Murray Data http://data.rivermurray.sa.gov.au/ (real-time data)
- Environment Protection Authority www.epa.sa.gov.au or for specific Lower Lakes data see http://www.epa.sa.gov.au/environmental_info/water_quality/lower_lakes_water_quality_monitoring
- Department for Water www.waterforgood.sa.gov.au/
- South Australian Murray–Darling Basin Natural Resource Management Board www.samdbnrm.sa.gov.au
- Murray–Darling Basin Authority www.mdba.gov.au
- Waterwatch www.waterwatch.org.au
- CSIRO acid sulfate soils www.clw.csiro.au/acidsulfatesoils/murray.html