

Port Curtis and Tributaries

Comparison of Current and Historical Water Quality

October 2011

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Contents

Introduction	1
Dredging history	1
Monitoring data	2
Temperature	3
Salinity	4
Turbidity	5
pH	6
Dissolved oxygen	8
Chlorophyll <i>a</i>	9
Metals and Metalloids	10
Latest monitoring information	11
Attachment 1 Temperature graphs	13
Attachment 2 Salinity graphs	16
Attachment 3 Turbidity graphs	18
Attachment 4 pH graphs	21
Attachment 5 Dissolved oxygen graphs	24
Attachment 6 Chlorophyll <i>a</i> graphs	27
Attachment 7 Biological significance of metal concentrations	29
Attachment 8 Metals and Metalloids graphs	30

Executive Summary

In September 2011, the Department of Employment, Economic Development and Innovation (DEEDI) introduced an emergency disease and quarantine regulation for fisheries in Port Curtis Harbour and surrounding waters which prevented the taking of fish due to fishers reporting increased numbers of diseased fish and health concerns.

One of the claims made was that the increase in fish disease was due to a decline in water quality, with further speculation that the suggested decline in water quality was due to the recent dredging in the harbour and the 2010–11 flooding summer rains.

Changes from what would be considered normal ranges for water quality do have the potential for adverse impacts on fish health.

Therefore, the Department of Environment and Resource Management (DERM) undertook an analysis of the available water quality data to determine if there had been any obvious or unusual deterioration in water quality outside of historical fluctuations in the Port Curtis area. Water quality data was available from DERM, the Gladstone Ports Corporation and the Port Curtis Integrated Monitoring Program (PCIMP).

The water quality indicators analysed included dissolved oxygen, pH, salinity, turbidity, temperature, metals and chlorophyll *a*.

The analysis for the estuaries and the harbour shows natural variation in water quality due to seasons, flooding rains and drought.

For the harbour: Water quality parameters for the February 2010 to August 2011 monitoring period are consistent, with no trend for water quality deterioration. Metal and metalloid concentrations were mostly highest during January, which is consistent with post-flood monitoring throughout the State, and rarely exceed water quality guideline trigger values, except during the January 2011 post-floods sampling.

For the estuaries: Apart from salinity, all other water quality parameters for the 2010–11 period were consistent with historical levels. Salinity was low for an extended period, indicating the impacts from the extensive flooding in December 2010–January 2011.

Overall, water quality in the harbour and the two estuaries, based on available data is consistent with historical trends, apart from the impacts of the recent flooding in January 2011 which was also seen in other parts of the State.

Introduction

In September 2011, DEEDI introduced an emergency disease and quarantine regulation for fisheries in Port Curtis Harbour and surrounding waters. The declaration, which prevented the take of fish in the area, was introduced due to a threat to fisheries from disease and the perception of the threat of illness to persons handling and eating fish. An increase of disease in fish was first reported in the media in late August 2011. First reports of disease were for Barramundi from the Boyne River area with subsequent reports indicating that the disease may be more widespread.

Various causes were suggested for the increased disease outbreak. Among these was a claim that there has been a decline in water quality. It had been further speculated that the suggested decline in water quality may have been due to the recent dredging in the harbour and the 2010–11 flooding summer rains. Recent dredging in the harbour has been ongoing at various intensities since October 2010. More detail of the dredging program in Gladstone Harbour is provided below.

In order to determine if water quality had declined in recent times, DERM undertook an analysis of the readily available water quality data, including historical information. The data analysed included monthly monitoring data collected by DERM in the Boyne and Calliope River estuaries since 1994 to September 2011, data from monitoring undertaken by the Gladstone Ports Corporation in Port Curtis since 2010 to August 2011 and monitoring data from the Port Curtis Integrated Monitoring Program for 2008 and 2010.

The objective of this report is to undertake an analysis of the available water quality data to determine if there has been any obvious or unusual deterioration in water quality outside of historical fluctuations in the Port Curtis area. This analysis in particular will concentrate on those water quality parameters considered to have the potential for adverse impacts on fish health. These indicators include dissolved oxygen, pH, salinity, turbidity, temperature, metals and chlorophyll *a*.

The independent scientific panel, established by the Minister for Main Roads, Fisheries and Marine Infrastructure, to focus on the reasons for poor fish health in the Port Curtis Harbour will be provided with this report together with detailed water quality data on which to make their assessment.

Dredging history

From October 2010 to January 2011, a cutter suction dredge called Wombat removed 343 426 m³ of material from the Queensland Curtis Liquefied Natural Gas construction dock adjacent to Curtis Island. This was disposed of at the Fishermans Landing reclamation area.

In December 2010, 30 000 m³ of material was removed from the RG Tanna coal terminal aggregate dock and disposed of to the RG Tanna mainland reclamation area.

A small amount of material (20 625 m³) was removed from the Australian Pacific Liquefied Natural Gas (APLNG) embarkation dock adjacent to Fishermen's Landing and disposed of to the east bank offshore disposal area in August 2011.

From August to October 2011, 595 000 m³ of material was removed from the APLNG construction dock adjacent to Curtis Island using a backhoe dredge called the Razende Bol and disposed of to the east bank offshore disposal area.

Between August and October 2011, 395 000 m³ of material was removed from Gladstone Liquefied Natural Gas berth pocket by the cutter suction dredge Al Mahaar and disposed to the Western Basin reclamation area.

From August 2011 to the present, 700 000 m³ of material is being removed from the material off-loading facility for Queensland Gas Corporation by bucket dredge Tavos and backhoe dredge Big Boss and disposed to the East Bank offshore disposal area.

Monitoring data

Monthly monitoring data is collected by DERM from the Boyne and Calliope estuaries. This water quality data has been collected monthly since 1994 for the Central Queensland Ambient Monitoring Program. Smaller datasets also exist for the tributaries of these rivers; the Calliope River Anabranch and South Trees Inlet. Samples are taken from the surface (0.2m) and then every two meters to the bottom of the estuary.

In order to highlight any major deviation from historical trends, all the data has been graphed for all sites and all depths since 1994 for the Boyne and Calliope estuaries. Graphs have been prepared for each water quality parameter. This provides a visual representation of water quality changes over time. The graphs include results from this routine monitoring up to August 2011, including the periods of dredging from October 2010 to January 2011 and from May 2011.

Monitoring in the harbour is conducted by Gladstone Ports Corporation. The monitoring is conducted by Vision Environmental Queensland. This data is routinely provided to DERM as part of Gladstone Ports Corporation licence conditions and has been graphed for each water quality parameter (temperature, turbidity, pH and dissolved oxygen). Forty five thousand records of data collected since February 2010 from the Ports Corporation have been assessed.

Monitoring data graphed for the harbour was collected at the sites shown below.

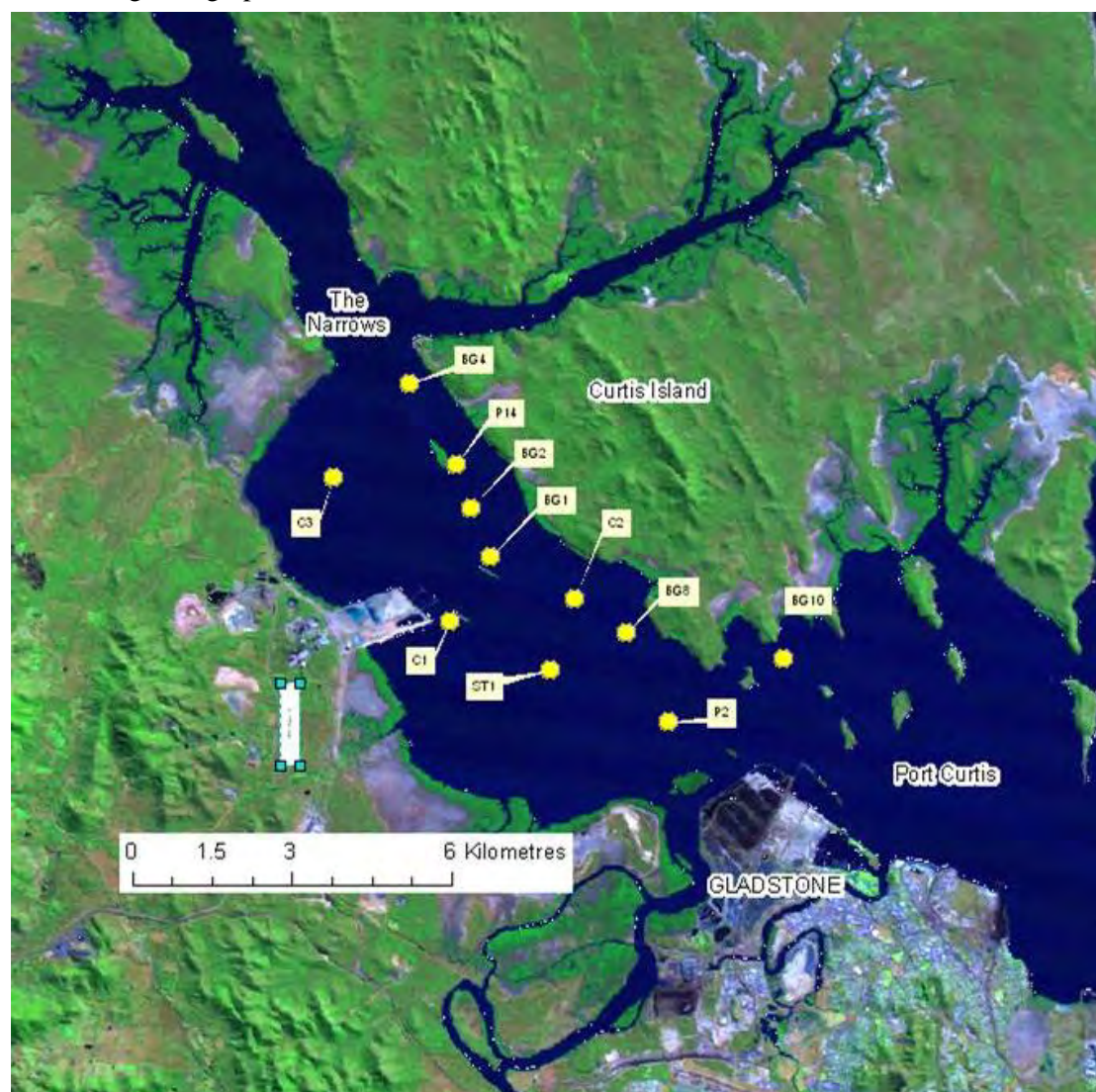


Figure 1 Gladstone Harbour monitoring sites

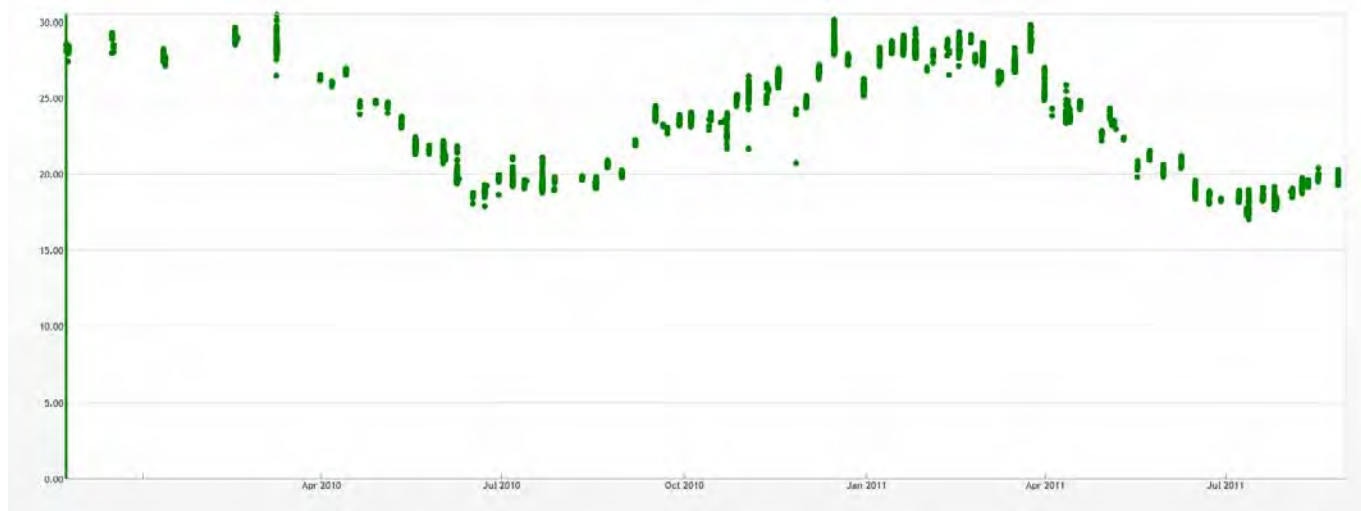
Metals and metalloid monitoring has also been provided by the Port from four dates: October 2010, January 2011, April 2011, and August 2011. Metals were measured as total metal (dissolved and suspended fractions) and 15 metals were measured on all four dates. These metals were aluminium, arsenic, cadmium, chromium-III cobalt, copper, iron, lead, manganese, molybdenum, nickel, selenium, silver, vanadium, and zinc.

Metals have also been monitored in the Port Curtis Integrated Monitoring Program from many sites at three time periods prior to these events: July 2008, January 2010 and July 2010. This data was also assessed for historical comparison.

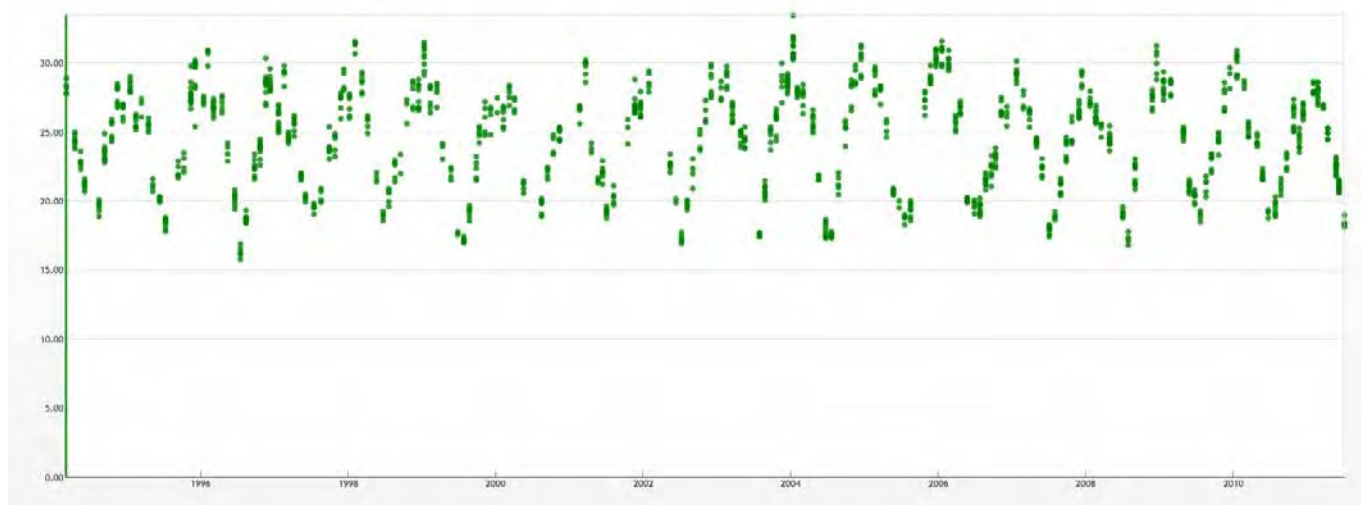
Temperature

Temperature has an impact on fish health. Sudden changes in temperature or an extended, cold winter impacts on fish immune function.

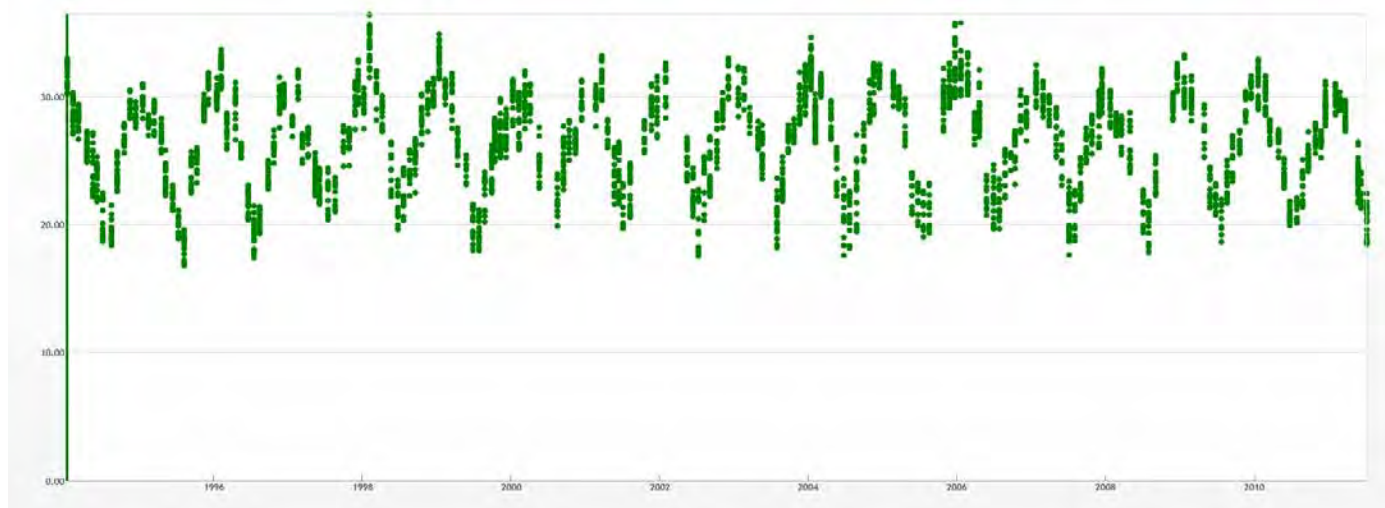
Temperatures in the harbour show variations with the season with a maximum of 30.5 °C and a minimum of 17 °C. In the estuaries, recent water temperatures are consistent with those collected prior to 2010. The graphs show the variation in temperature through summer and winter cycles but this year has not been unusually cold or unusually hot. Summer temperatures for 2010–11 were slightly lower than past summers but the winter temperatures were similar to previous years.



Port Curtis Harbour – All Depths – All Sites – Temperature (°C) – Min: 17 (12/07/2011) Max: 30.5 (09/03/2010)



Boyne River Estuary – All Depths – All Sites – Temperature (°C) Min: 15.8 (17/07/1996) Max: 33.5 (14/01/2004)



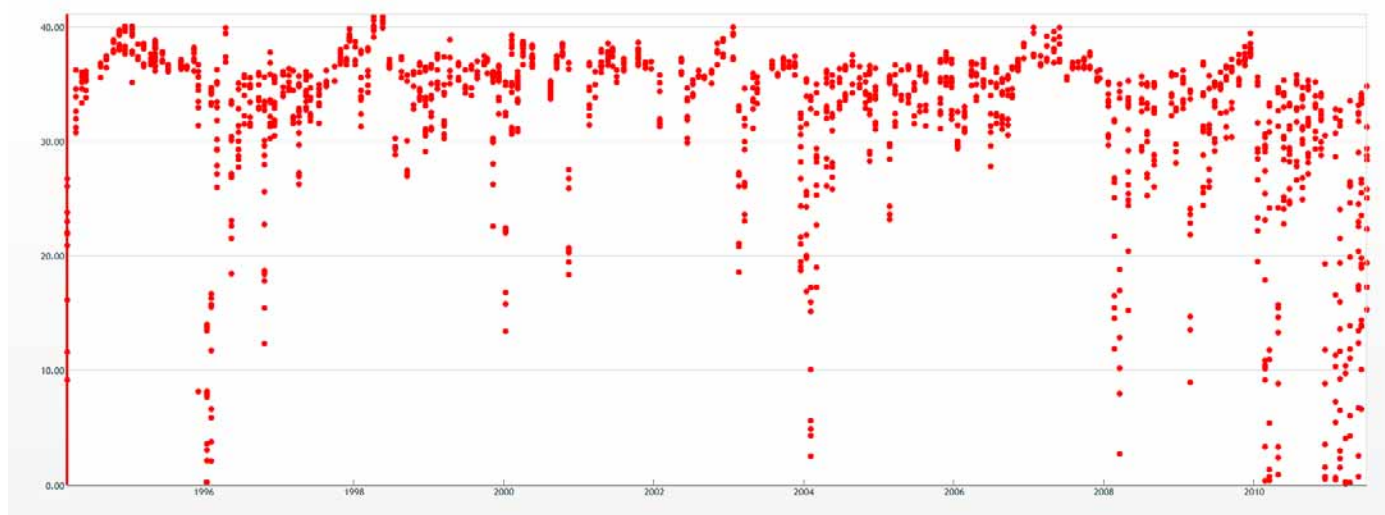
Calliope River Estuary – All Depths – All Sites – Temperature (°C) Min: 16.8 (09/08/1995) Max: 36.4 (05/02/1998)

Enlarged graphs refer to Attachment 1.

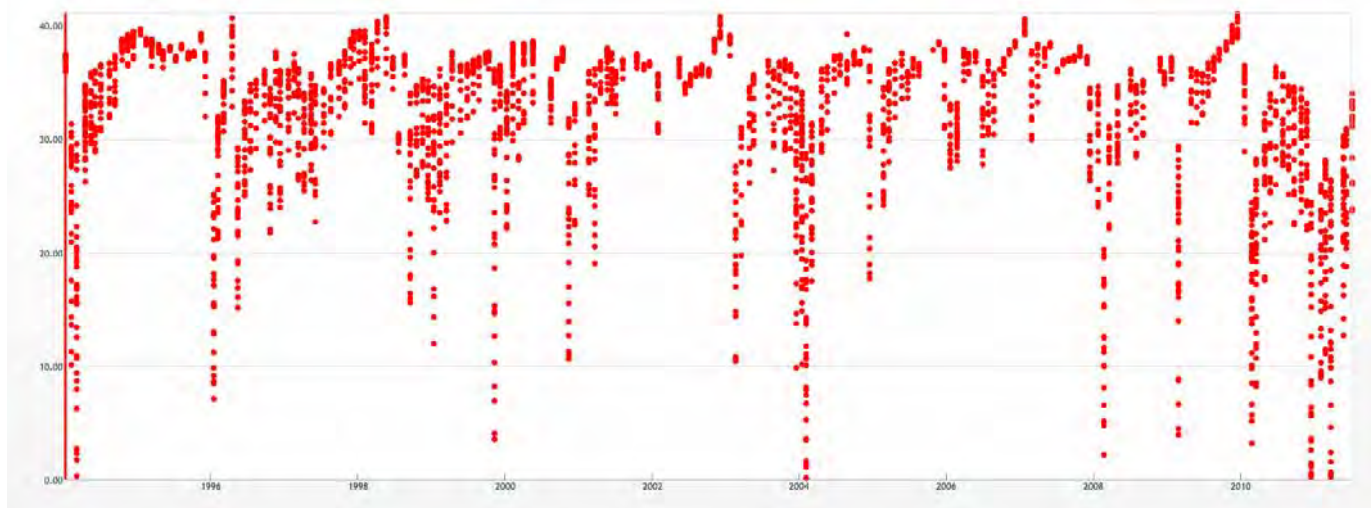
Salinity

Salinity variation arises from varying flows of fresh water into tidal estuaries. This shows the impacts of rainfall and flooding events in the catchment. High salinities (>35) are likely to be due to high evaporation during periods of low freshwater inflows. Salinity has a variable effect on fish species but impacts their ability to maintain cellular integrity through osmoregulation. Estuarine species are generally able to better tolerate changes in salinity and fish are able to move into suitable saline environments.

Salinity during 2011 has been the lowest it has ever been in the Boyne River and the estuary has been fresh for an extended period at lower depths. The Calliope River estuary shows a similar pattern with an extended low salinity period during December 2010 to January 2011.



Boyne River Estuary – All Depths – All Sites – Salinity – Min: 0 (multiple dates) Max: 41 (22/05/1998)



Calliope River Estuary – All Depths – All Sites – Salinity – Min: 0 (multiple dates) Max: 41 (15/12/2009)

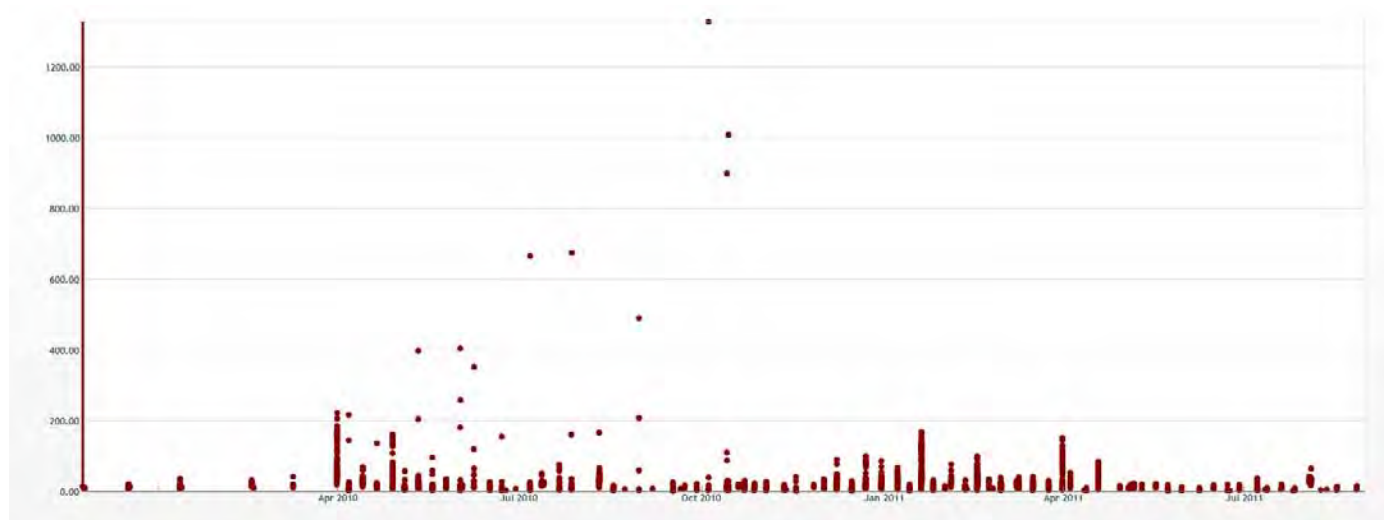
Enlarged graphs refer to Attachment 2.

Turbidity

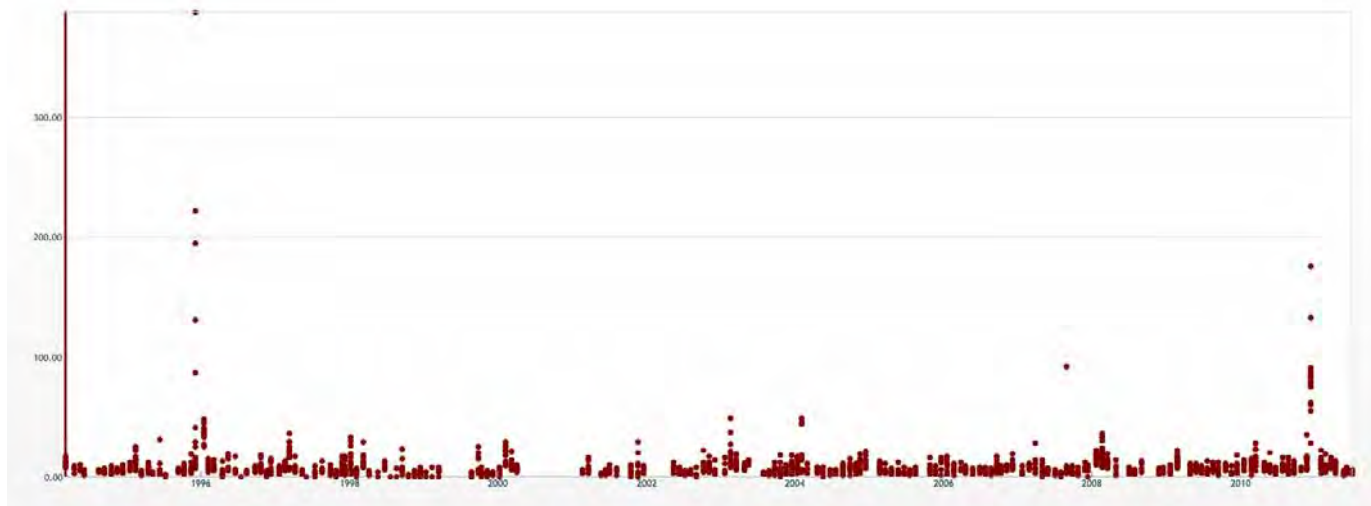
Turbidity provides a measure of sediment in the water column. Sediment in the water column can stress fish because gills become clogged and are less able to absorb oxygen. High turbidity can result from multiple sources including run-off from a catchment during a rainfall event or from activities in the waterway such as boating and dredging.

Data from the harbour show highest levels in May-October 2010. Turbidity in 2011 is not as high as in the previous year.

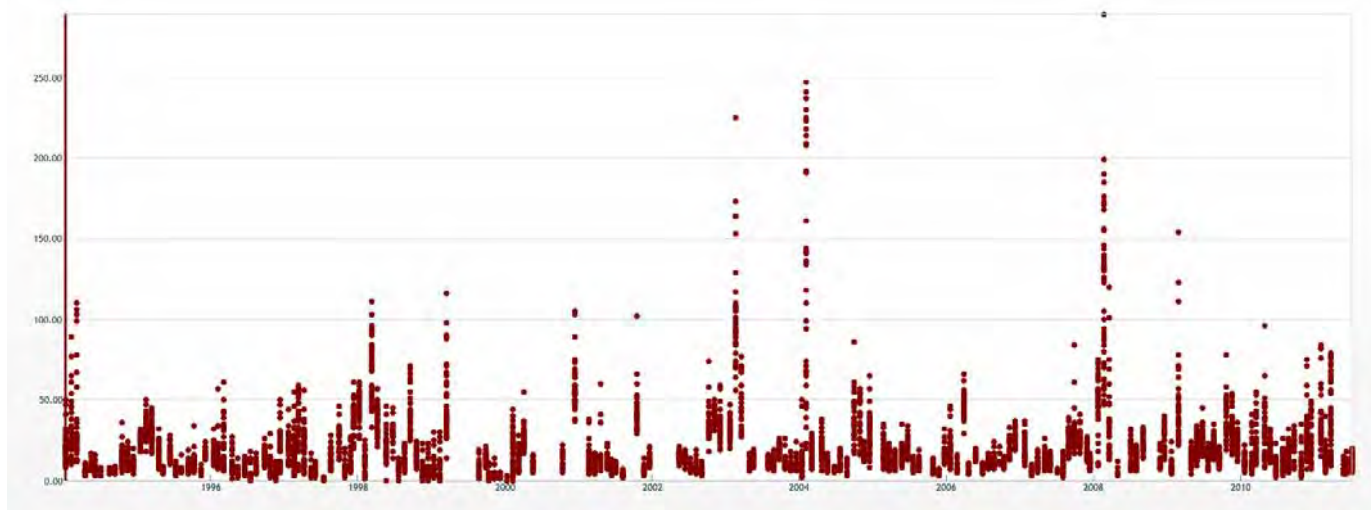
Turbidity in the Boyne estuary was highest in 1995 during a flood event. No subsequent event has produced such high turbidity levels. During the flood in 2011, turbidity was temporarily elevated and all the high values represent sampling from 13/12/2010, at the peak of the flooding. The Calliope is generally a more turbid estuary than the Boyne. The highest turbidity recorded in the Calliope was in February of 2008. This summer has not seen levels that are particularly high.



Port Curtis Harbour – All Depths – All Sites – Turbidity (NTU) Min: 0.1 (multiple dates) Max: 1329.5 (04/10/2010)



Boyne River Estuary – All Depths – All Sites – Turbidity (NTU) Min: 0 (multiple dates) Max: 388 (06/12/1995)



Calliope River Estuary – All Depths – All Sites – Turbidity (NTU)

Enlarged graphs refer to Attachment 3.

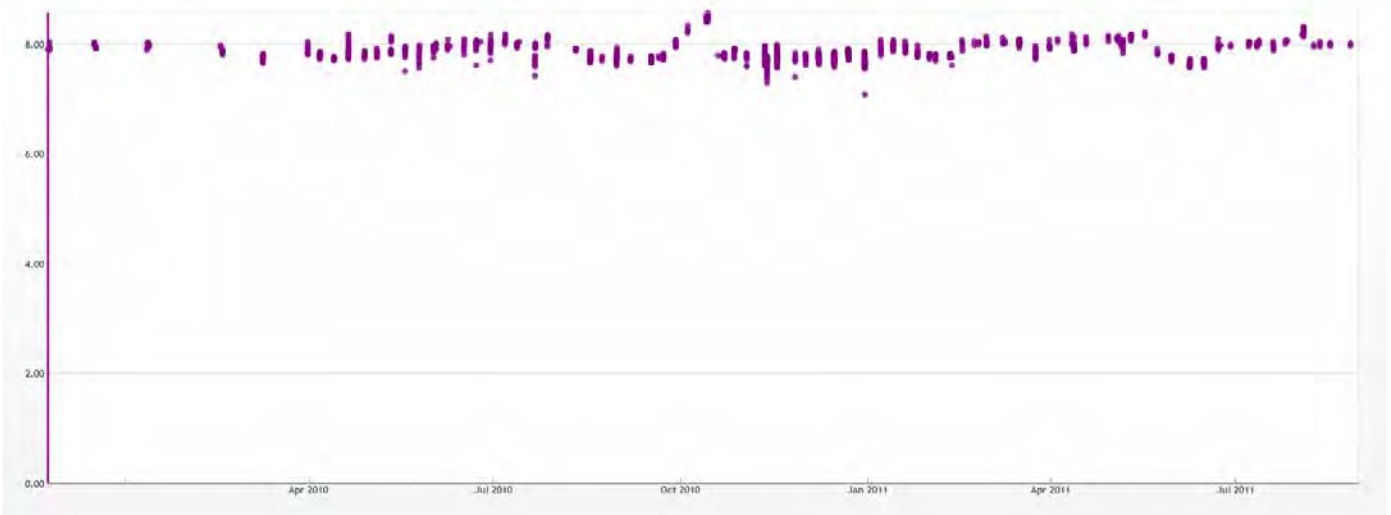
pH

pH is a measure of acidity and alkalinity of the waterway. pH is actually a measure of the hydrogen ion (H⁺) concentration and is a logarithmic scale ranging from 0 (strongly acidic) to 14 (strongly alkaline). Neutral solutions are pH 7. Oceanic waters are alkaline with a pH around 8.2. Estuarine waters can have a lower pH due to the influence of terrestrial inputs. When potentially acid sulphate soils are disturbed or exposed to oxygen they become acidic and this can cause ecological harm to the fauna and flora of the estuary. Acid water affects the health of fish and other aquatic life through damage to the skin and gills. Skin damage increases the susceptibility of fish to fungal and bacterial infections which may lead to disease.

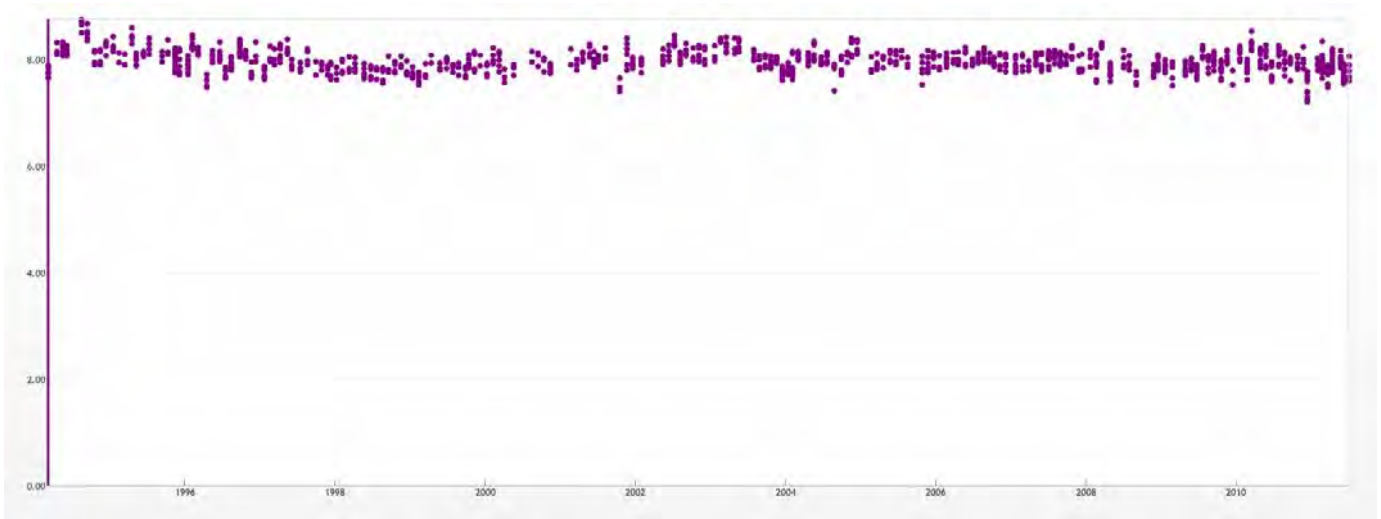
In the harbour, pH is consistently above 7 with a maximum of 8.6 and most samples having a pH around 8, as would be expected in a marine environment.

In the monitoring conducted in the estuary, pH measurement of the water does not show acidic pH levels. The minimum pH measured is not at a level that would impact on fish health. The lowest pH recorded in the Boyne River was still alkaline (7.2) and was recorded in December 2010. Similarly, in the Calliope the lowest pH recorded was also alkaline (7.1) and was recorded in 2004.

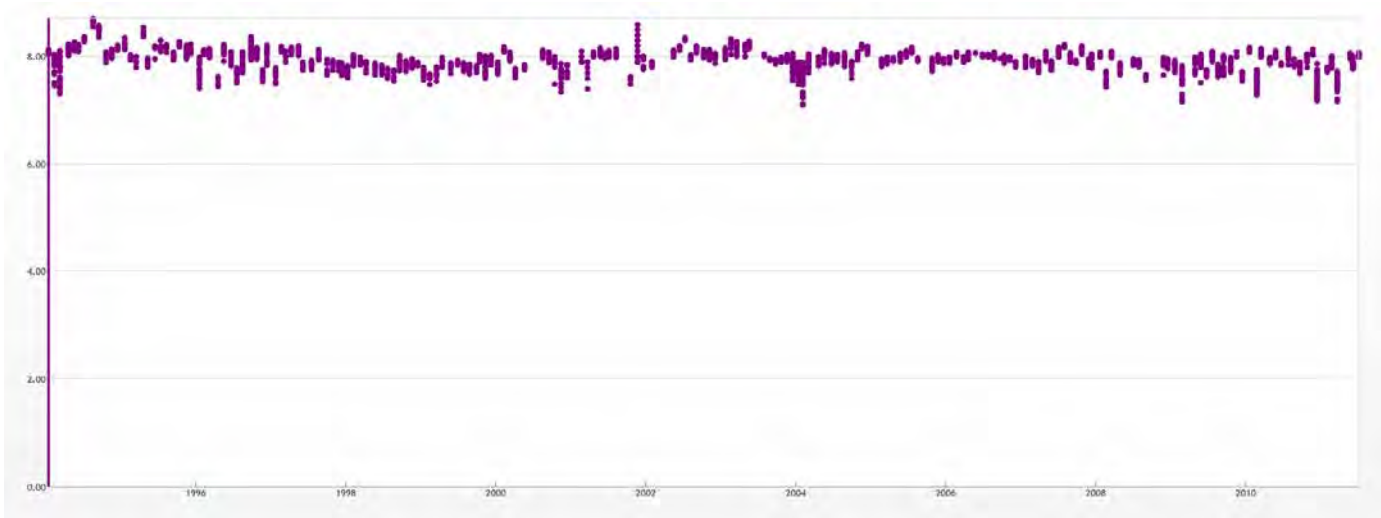
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Port Curtis Harbour – All Depths – All Sites – pH – Min: 7.1 (30/12/2010) Max: 8.6 (14/10/2010)



Boyne River Estuary – All Depths – All Sites – pH – Min: 7.2 (13/12/2010) Max: 8.8 (17/08/1994)



Calliope River Estuary – All Depths – All Sites – pH – Min: 7.1 (04/02/2004) Max: 8.7 (17/08/1994)

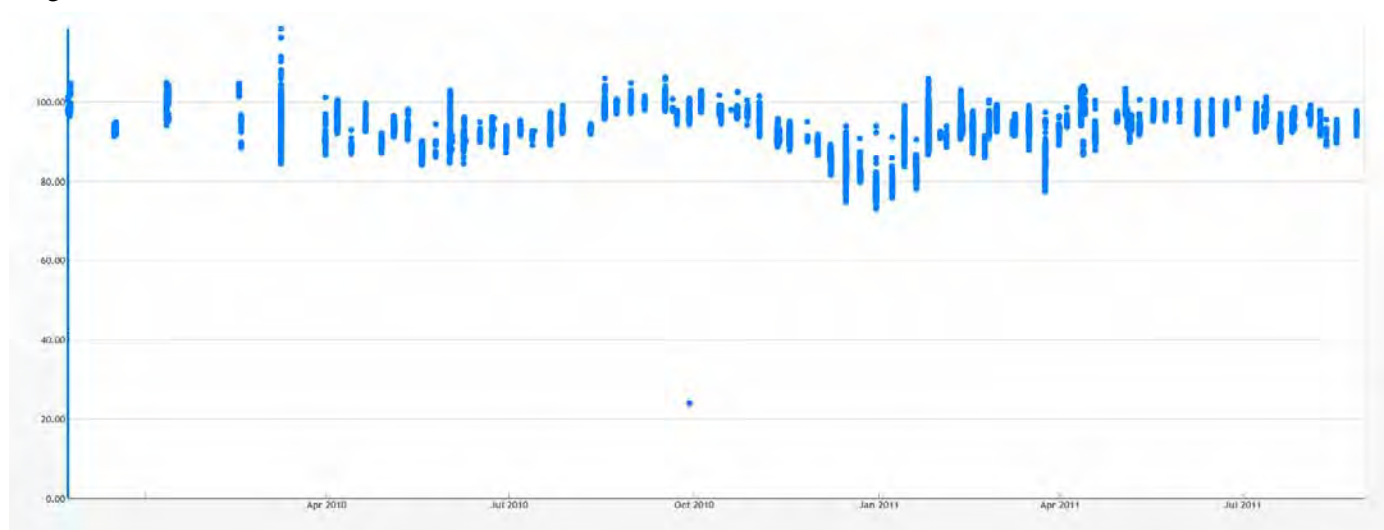
Enlarged graphs refer to Attachment 4.

Dissolved oxygen

Dissolved oxygen is an important measure of the health of a waterway for fish survival because it indicates the available oxygen for fish to respire. Persistent low dissolved oxygen concentrations (< 50% saturation) can result in fish kills but tolerance varies between fish species. The warmer and more saline the water, the less oxygen the water can dissolve. Very high, supersaturated, levels of oxygen (above 100%) generally indicate an algal bloom. Levels often fall during and after flood events due to the aerobic decomposition of high levels of organic matter by microbes in the estuary. Levels also fall in ponds as they warm up and dry out.

Dissolved oxygen in Port Curtis Harbour is variable. A minimum of 24% dissolved oxygen saturation was recorded in the data in 2010 but in a harbour this is unlikely and may be an instrument error. Most records are between 80% and 105% saturation.

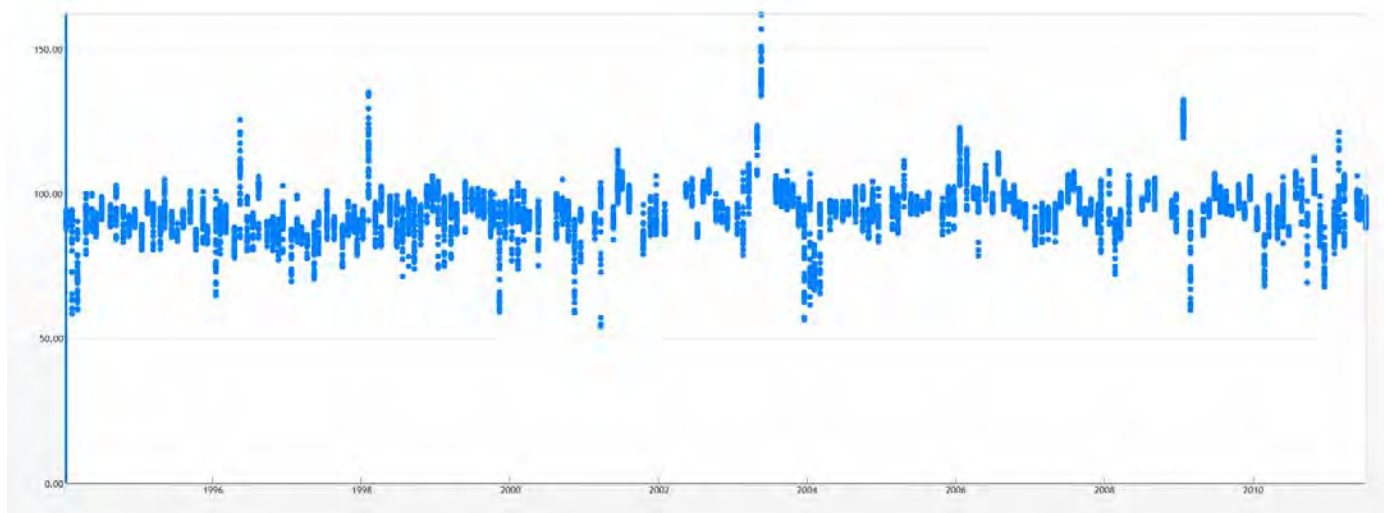
The dissolved oxygen levels in the Boyne River estuary are highly variable but have not declined significantly this year. The lowest level recorded was in 1994. Dissolved oxygen levels in the Calliope were also within usual ranges.



Port Curtis Harbour – All Depths – All Sites – Dissolved Oxygen (%sat) Min: 24 (28/09/2010) Max: 118.5 (09/03/2010)



Boyne River Estuary – All Depths – All Sites – Dissolved Oxygen (%sat) Min: 56 (08/03/1994) Max: 132 (22/02/2006)



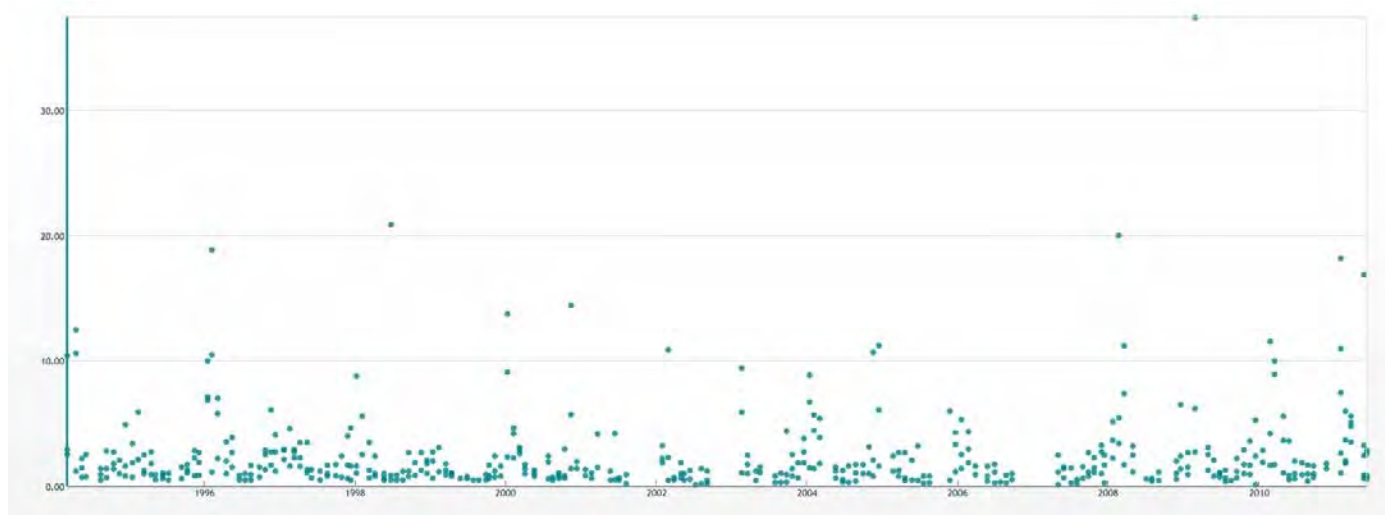
Calliope River Estuary – All Depths – All Sites – Dissolved Oxygen (%sat) Min: 54 (22/03/2001) Max: 162 (19/05/2003) Min: 0 (multiple dates) Max: 289 (21/02/2008)

Enlarged graphs refer to Attachment 5.

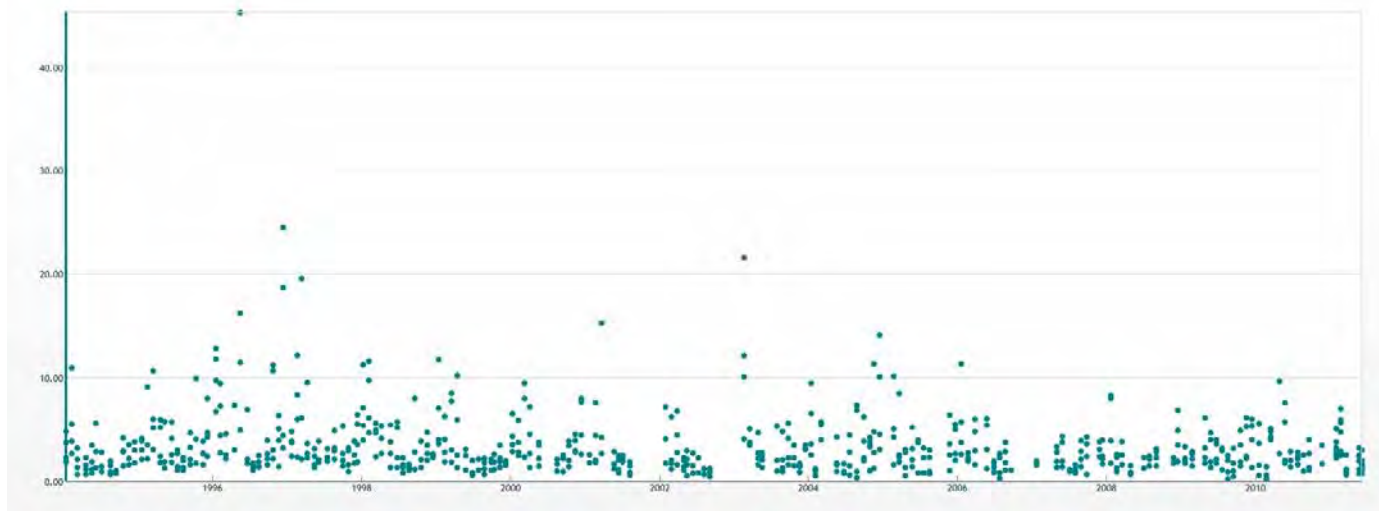
Chlorophyll *a*

Chlorophyll *a* is a measure of algal (phytoplankton) abundance in a waterway. Some species of algae can grow quickly to form high cell concentrations called blooms. The microbial decomposition of these blooms after they die can deplete waterways of dissolved oxygen. Some species may also cause skin irritations to people who come in contact with them. Chlorophyll *a* does not indicate which species of algae is present.

The levels of Chlorophyll *a* found by monitoring since January 2011 in the estuaries are not dissimilar to previous years and do not indicate major algal blooms have occurred. In the Calliope, levels have generally been below 10 µg/L since 2006.



Boyne River Estuary – All Sites – Chlorophyll *a* (ug/L) Min: 0.1 (multiple dates) Max: 37.4 (25/02/2009)



Calliope River Estuary – All Sites – Chlorophyll *a* (ug/L) Min: 0.2 (multiple dates) Max: 45.3 (15/05/1996)

Enlarged graphs refer to Attachment 6.

Metals and Metalloids

Metals and metalloids occur naturally in all waters in Australia. Aluminium, for example, constitutes one of the most common elements in the earth's crust. Metals and metalloids dissolve in water and can also be present as suspended particles. Levels of metals in water tend to peak following heavy rains. Metals and metalloids are toxicants, which, at a high enough level, cause adverse effects to organisms.

Most metal concentrations in this data sample show a common trend, with the highest levels occurring in January 2011. This is consistent with post-flood monitoring results for other parts of the State. Metals returned to pre-flood levels across the region by the next sampling period in April. The highest sites for aluminium, iron, arsenic, manganese and vanadium are BG-1, BG-4 and BG-8 which are all in the harbour south of Curtis Island. Arsenic also had higher levels at C7-1 and in October 2010 at the reference sites in Rodds Bay. Nickel concentration was highest at BG -5 and BG-10 in the January period. Copper concentration was highest at C7-1, BG-1 and BG-10 in the January period.

At site BG5 there was a secondary but lower peak in August 2011 for aluminium, nickel, arsenic and iron.

Silver and chromium III show different patterns. Silver shows the highest levels in October 2010 (however it is below levels of biological concern - see Attachment 7) and has declined in concentration since. Chromium III shows the highest levels in the most recent, August sampling. The highest level was at site BG-8 in August 2011 however again it is below levels of biological concern (see Attachment 7).

Metals data from the Port Curtis Integrated Monitoring Program (PCIMP) was collected from sites in July 2008 and in January and July 2010. All this monitoring occurred prior to the dredging program and prior to the reports of sick fish. The data was monitored from a very large number of sites. Three sites are directly comparable and were monitored for the same metals in both the Gladstone Ports Corporation and PCIMP programs (C7-1, C7-2 and C7-3). This allows a comparison to be made over a longer time period. In all cases, the highest level of the metals monitored occurred during the January 2011 monitoring period, post-flood.

In conclusion, most metals measured in the two monitoring programs displayed their highest concentrations in the January 2011 sampling which is consistent with post-flood monitoring elsewhere in the State.

Latest monitoring information

In addition to the monitoring that has been compared with historical information, DERM conducted monitoring in the week of 26 September 2011 in Port Curtis Harbour. The map of sites monitored is below.

Monitoring for metals has been sent to the laboratories for assessment and results are likely to be returned in late October 2011. The data for physico-chemical measurements is presented below.

It can be seen that at the surface, temperature ranges between 21.87 and 23.4 °C. Dissolved oxygen is high at all sites. Turbidity is variable but is particularly high at BG10. Salinity has returned to normal oceanic levels. The pH ranges from 7.7–8.1 and is 7.9 at BG10 which showed high turbidity, thus the sediment in the waterway is not impacting the pH of the water. Data collected at the lowest depth show similar trends with no low pH measurements and higher turbidity at BG10 and ST1 which are in the mid harbour.

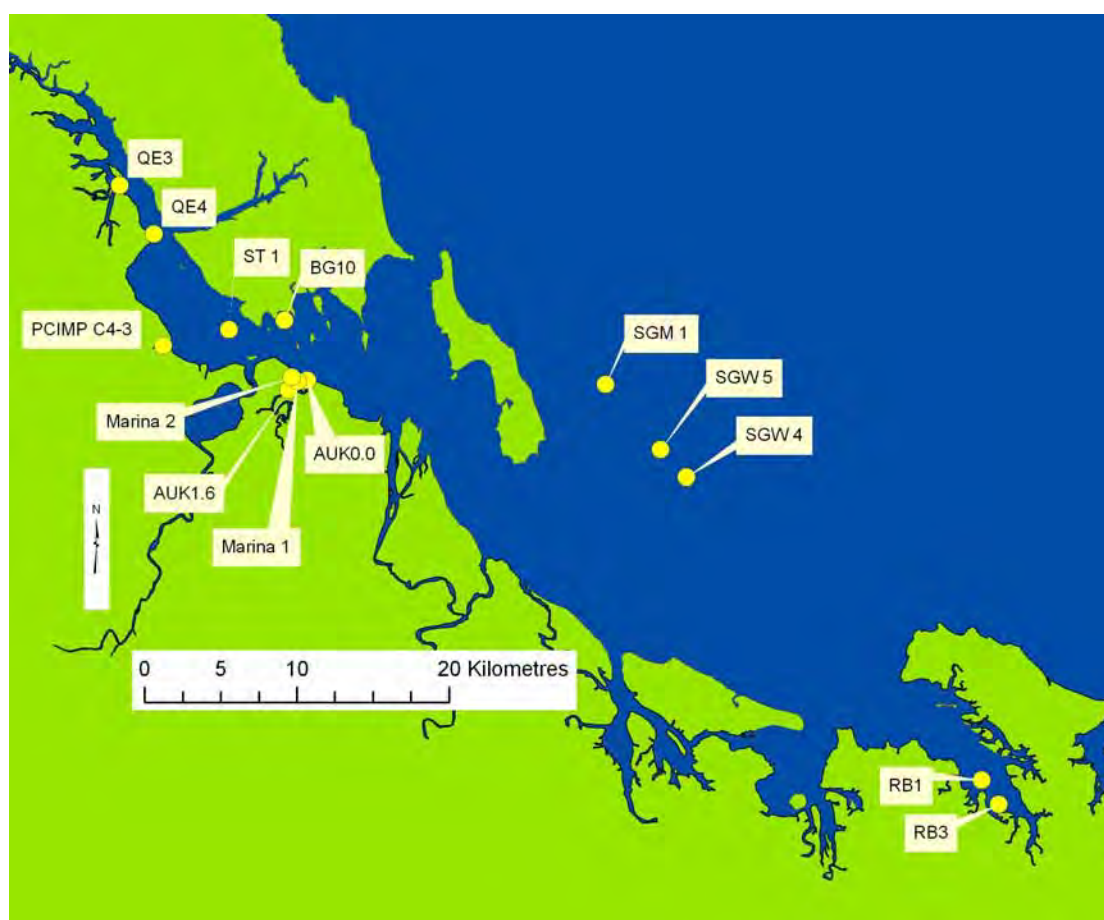


Figure 2 Sites monitored by DERM in the week of 26 September 2011.

Port Curtis and Tributaries: Comparison of Current and Historical Water Quality

Table 1 Data collected by DERM in the week of 26 September 2011 in Port Curtis Harbour and spoil grounds

Sites	Surface Data collected at 0.2m					Depth Data collected approx. 10 cm from bottom				
	Temperature oC	Dissolved oxygen (% sat.)	Turbidity (NTU)	Salinity (PSU)	pH	Temperature oC	Dissolved oxygen (% sat.)	Turbidity (NTU)	Salinity (PSU)	pH
QE 3	22.89	87.1	32	36.3	7.7	22.8	89.9	34	36.4	7.7
QE 4	23.45	92.9	50	36.2	7.8	23.19	89.9	77	36.2	7.8
PCIMP C4-3	21.75	90.9	65	36.2	7.7	21.75	89.9	43	35.8	7.9
AUK 0.0	22.77	97.8	44	35.9	7.9	22.74	95.8	47	35.9	7.9
AUK 1.6	22.69	97	43	35.9	7.9	22.62	95.6	54	35.9	7.9
Marina 1	22.87	97.5	20	35.9	7.9	22.8	96.3	19	35.9	7.9
Marina 2	22.88	97.8	26	36.0	7.9	22.78	96.1	70	35.9	7.9
BG10	22.89	94.8	136	35.9	7.9	22.87	94.2	142	35.9	7.9
ST1	22.94	96	75	35.9	7.9	22.83	94.6	105	35.9	7.9
SGM 1	21.83	101.9	0.5	35.6	8.1	21.74	101.5	0.7	35.6	8.1
SGW 5	21.99	102.1	1	35.6	8.1	21.79	101	4.8	35.6	8.1
SGW 4	22.09	101.9	2.8	35.6	8.1	21.96	100.7	7	35.6	8.1
RB 1 (Rodds Bay - Reference)	22.25	97.6	4	36.2	8.0	21.9	95.8	5	36.3	7.9
RB 3 (Rodds Bay – Reference)	22.2	97.8	3	36.5	7.9	22.1	97.4	3	36.5	7.9

Attachment 1 Temperature graphs



Figure 3 Port Curtis Harbour – All Depths – All Sites – Temperature (°C) – Min: 17 (12/07/2011) Max: 30.5 (09/03/2010)

Port Curtis and Tributaries: Comparison of Current and Historical Water Quality

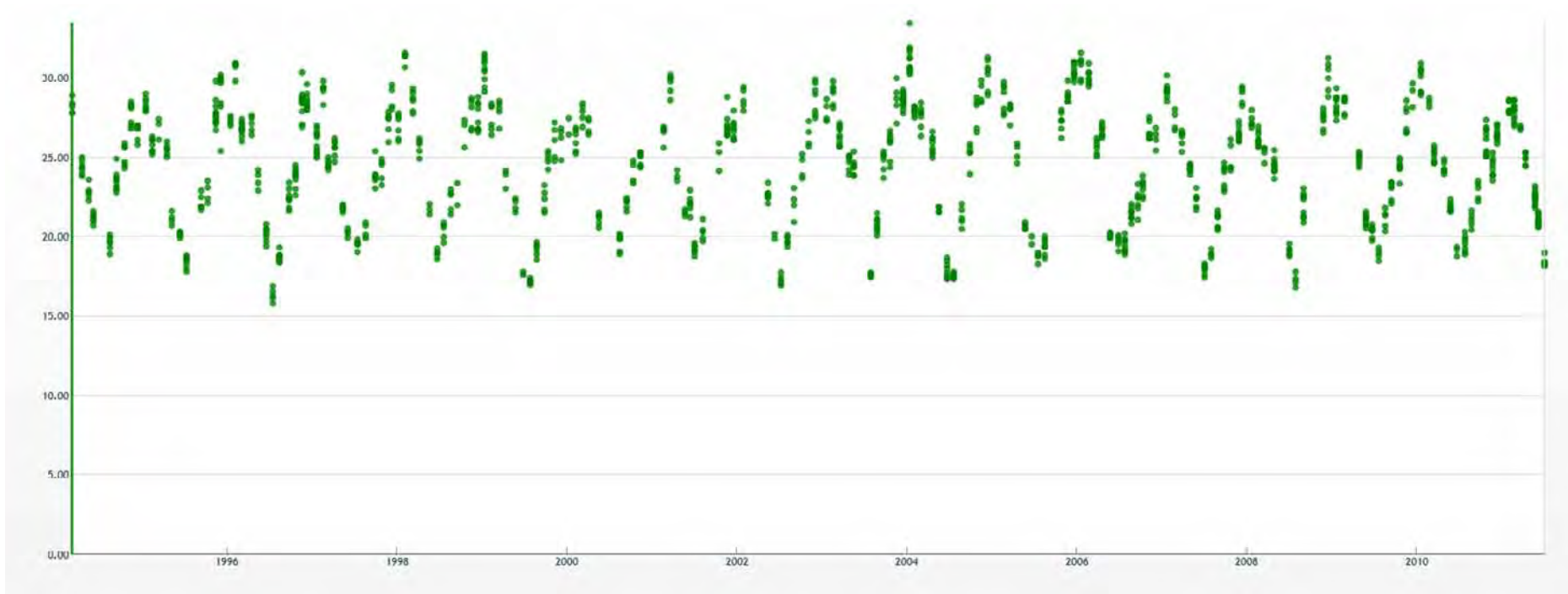


Figure 4 Boyne River Estuary – All Depths – All Sites – Temperature (°C) Min: 15.8 (17/07/1996) Max: 33.5 (14/01/2004)

Port Curtis and Tributaries: Comparison of Current and Historical Water Quality

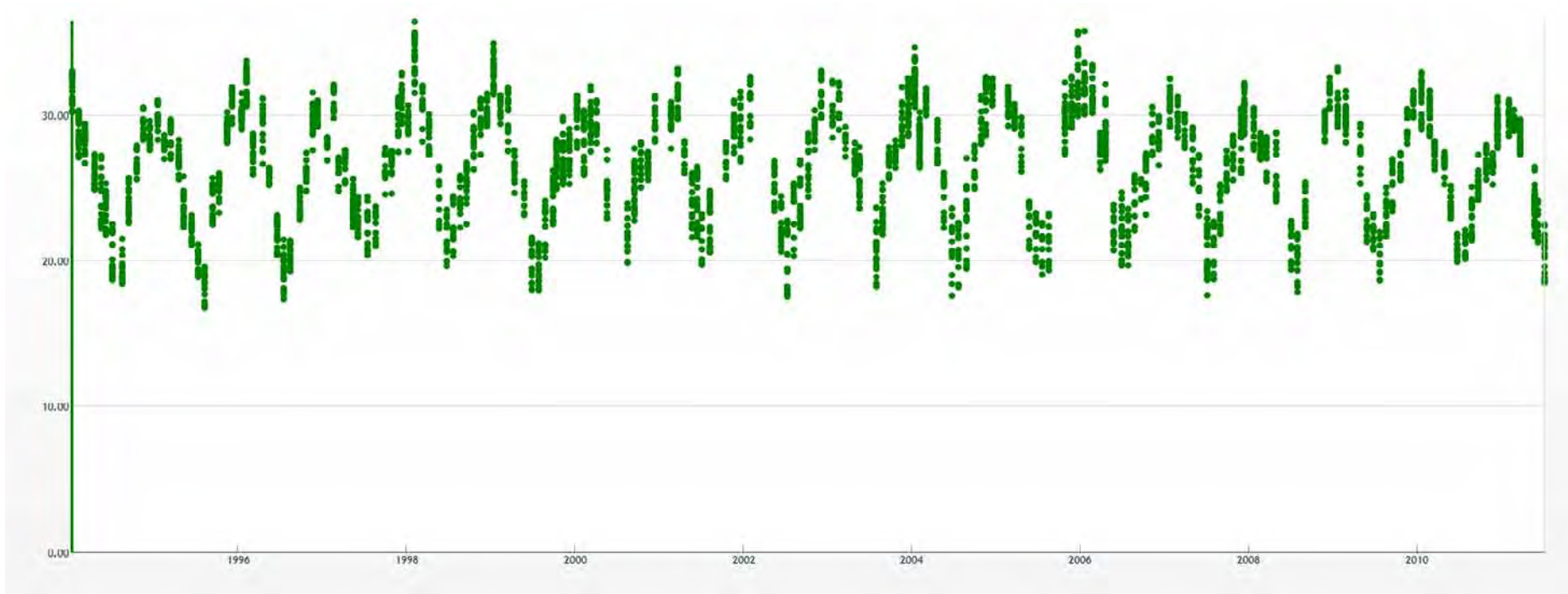


Figure 5 Calliope River Estuary – All Depths – All Sites – Temperature (°C) Min: 16.8 (09/08/1995) Max: 36.4 (05/02/1998)

Attachment 2 Salinity graphs

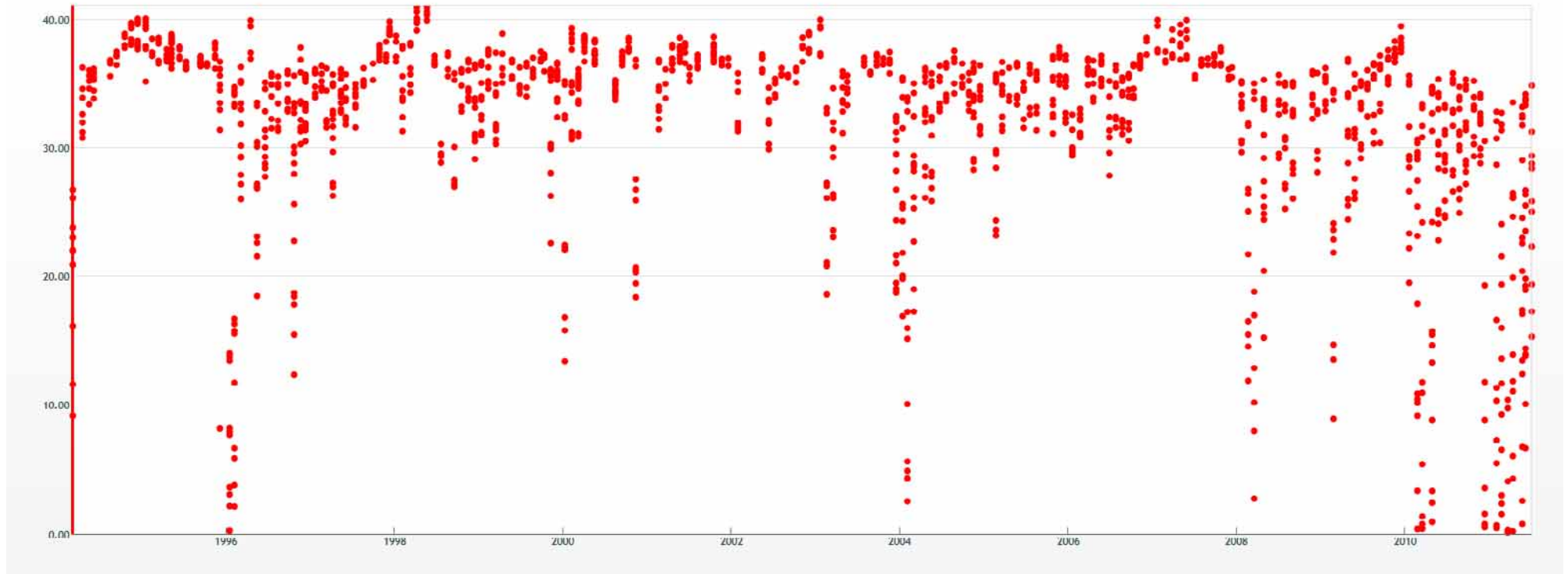


Figure 6 Boyne River Estuary – All Depths – All Sites – Salinity – Min: 0 (multiple dates) Max: 41 (22/05/1998)

Port Curtis and Tributaries: Comparison of Current and Historical Water Quality

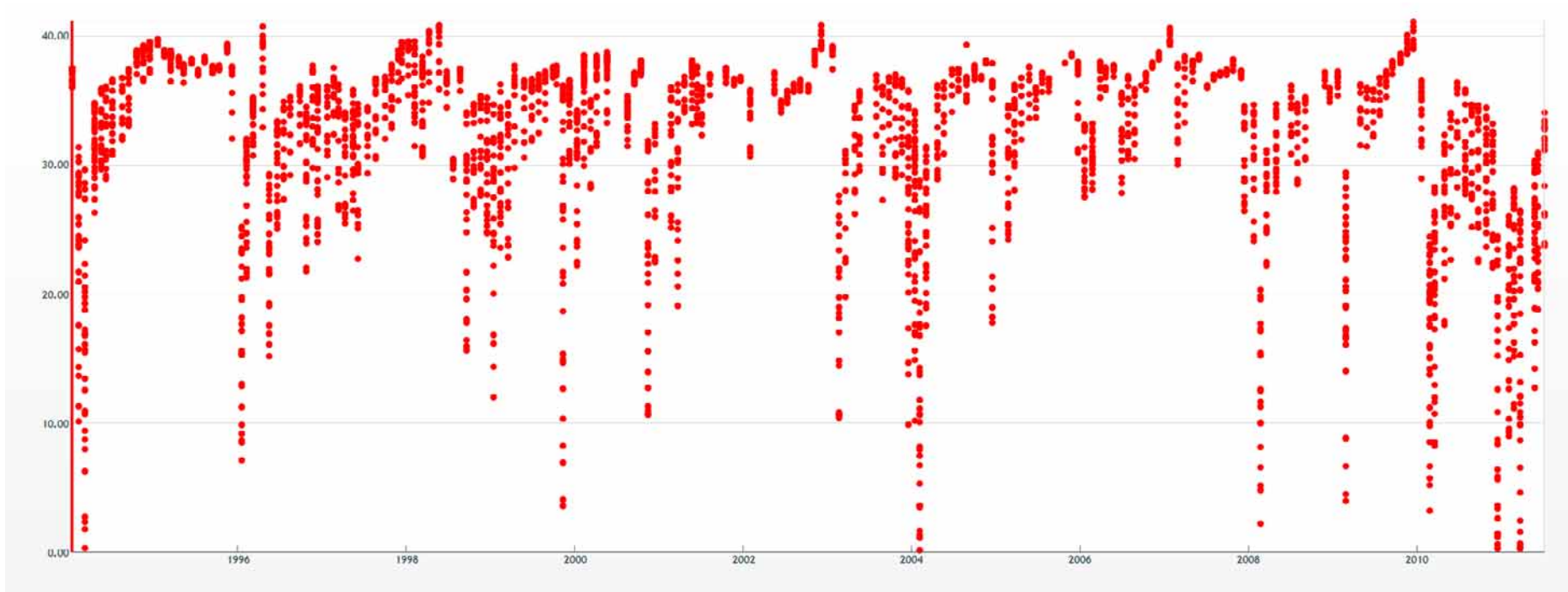


Figure 7 Calliope River Estuary – All Depths – All Sites – Salinity – Min: 0 (multiple dates) Max: 41 (15/12/2009)

Attachment 3 Turbidity graphs

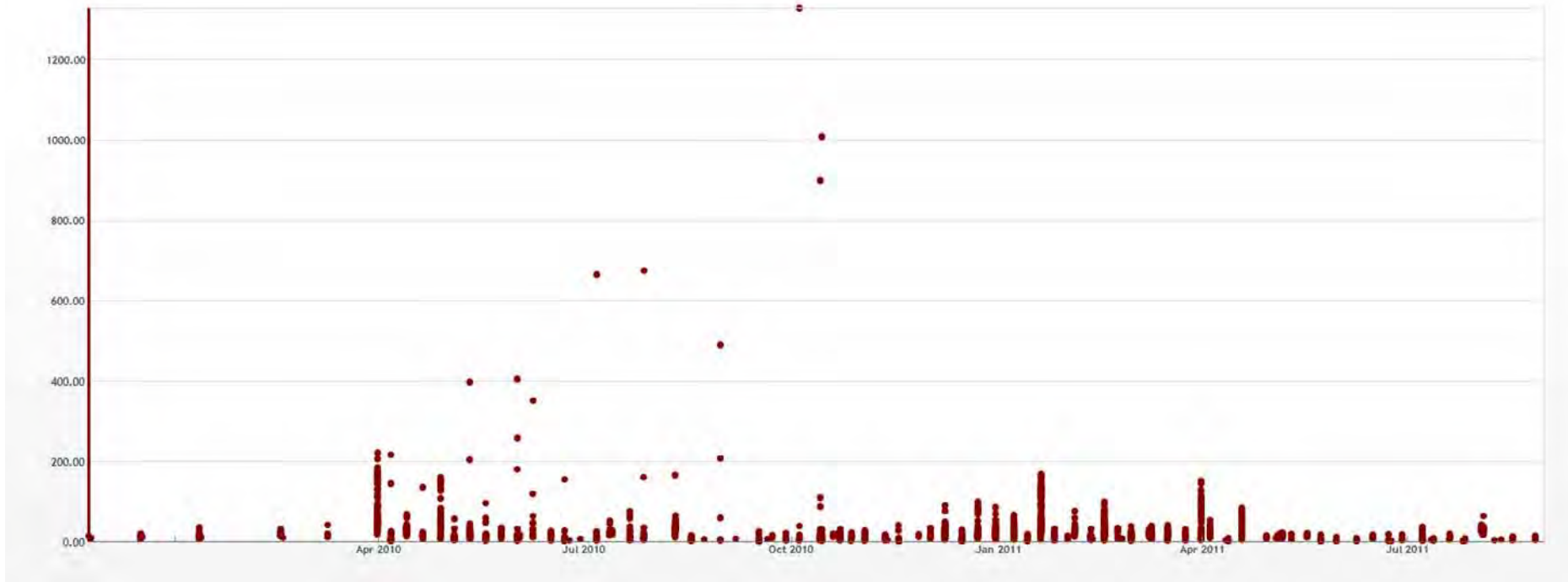


Figure 8 Port Curtis Harbour – All Depths – All Sites – Turbidity (NTU) Min: 0.1 (multiple dates) Max: 1329.5 (04/10/2010)

Port Curtis and Tributaries: Comparison of Current and Historical Water Quality

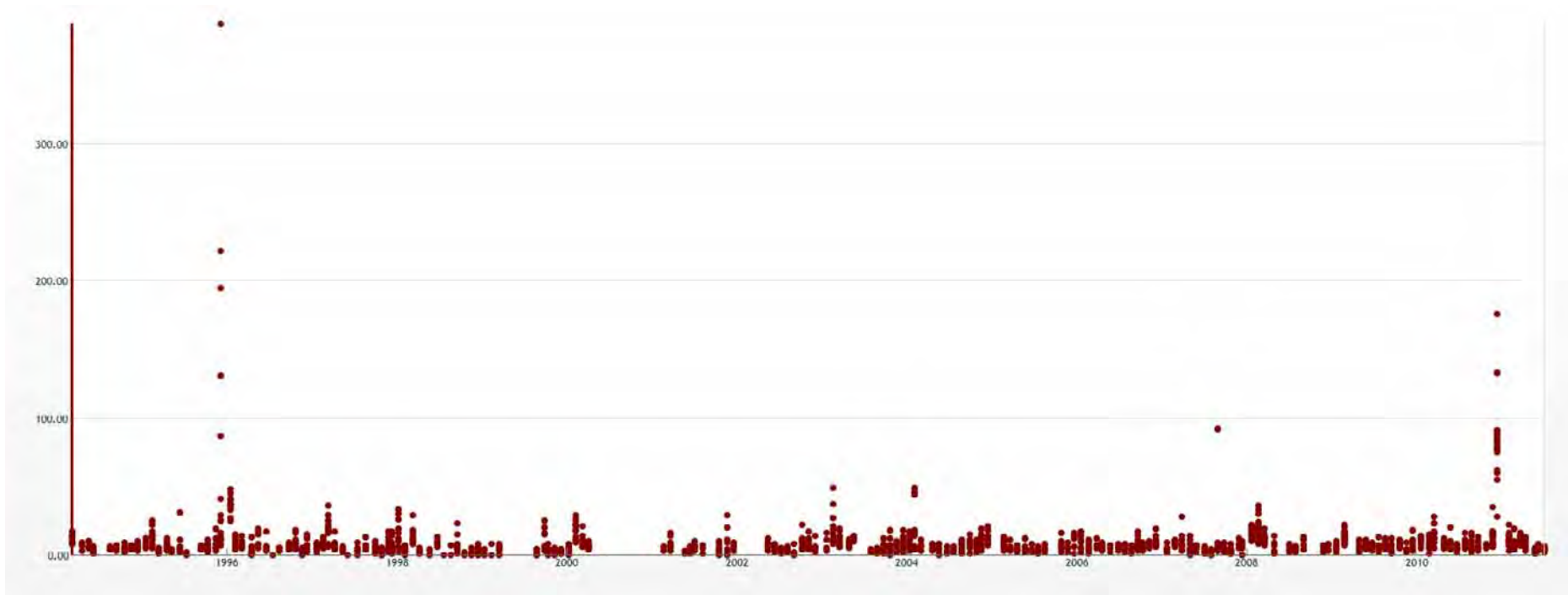


Figure 9 Boyne River Estuary – All Depths – All Sites – Turbidity (NTU) Min: 0 (multiple dates) Max: 388 (06/12/1995)

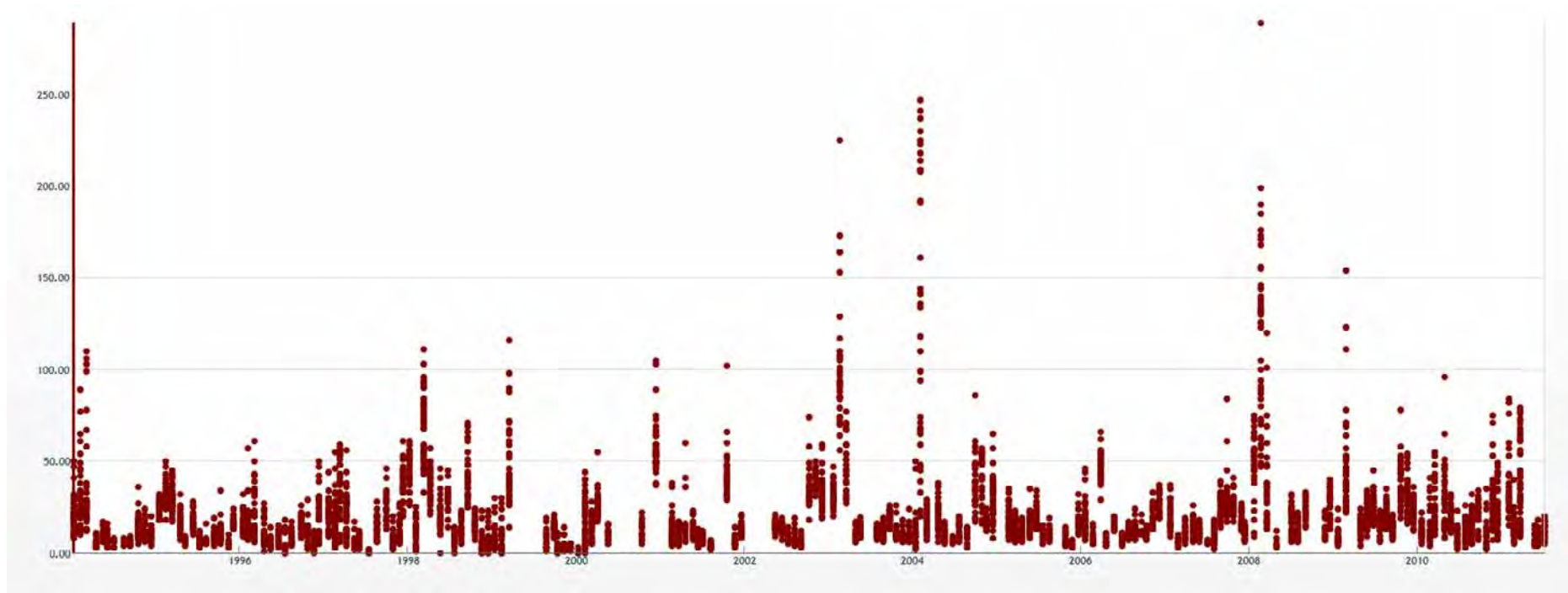


Figure 10 Calliope River Estuary – All Depths – All Sites – Turbidity (NTU)

Attachment 4 pH graphs

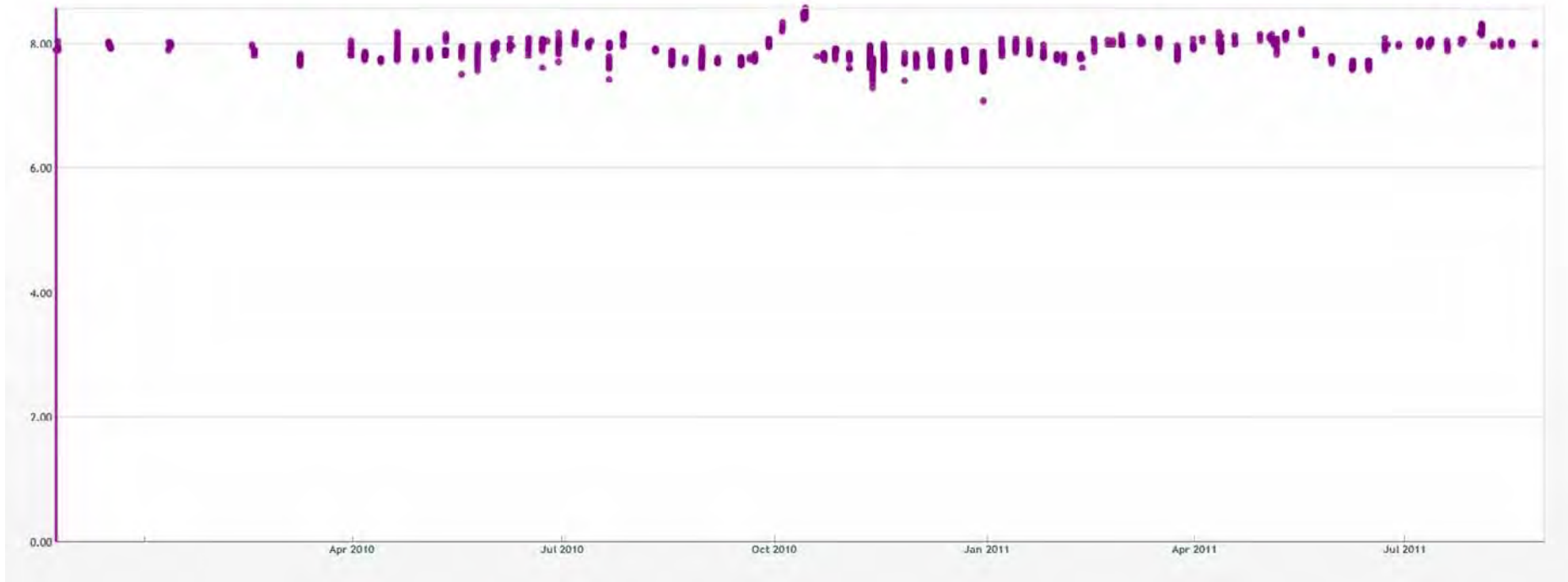


Figure 11 Port Curtis Harbour – All Depths – All Sites – pH – Min: 7.1 (30/12/2010) Max: 8.6 (14/10/2010)

Port Curtis and Tributaries: Comparison of Current and Historical Water Quality

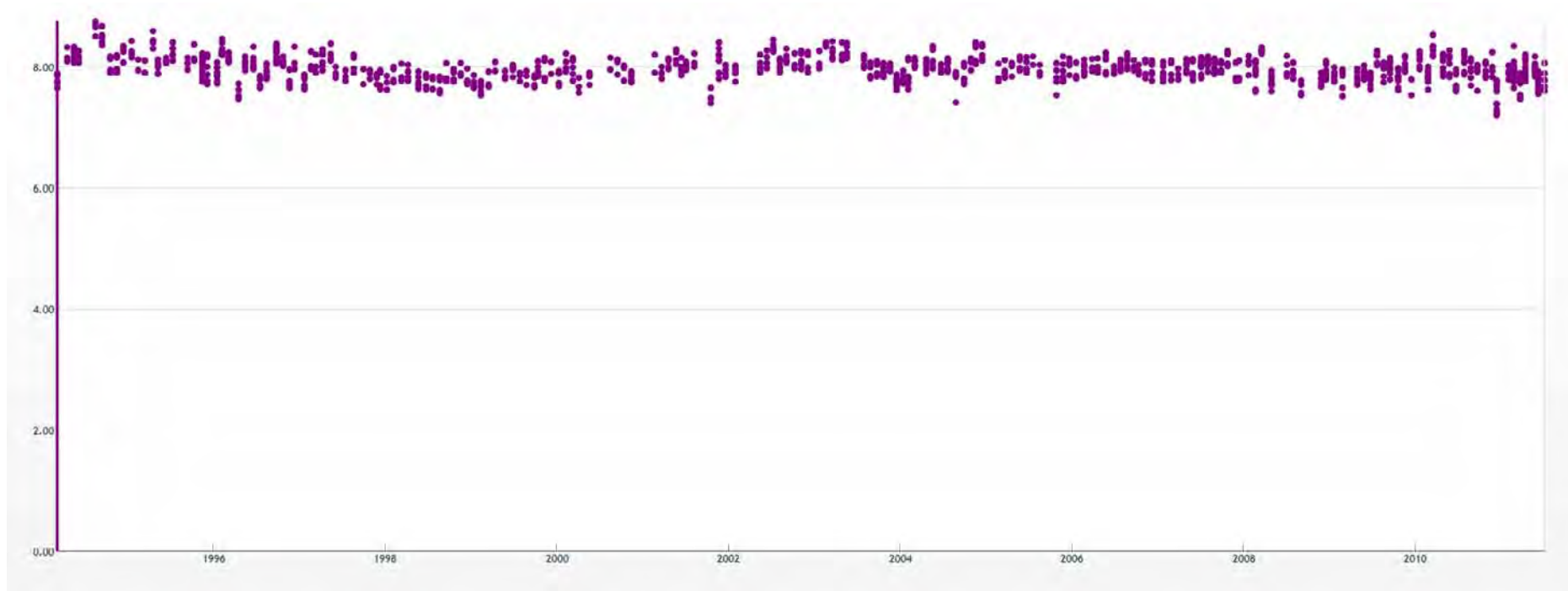


Figure 12 Boyne River Estuary – All Depths – All Sites – pH – Min: 7.2 (13/12/2010) Max: 8.8 (17/08/1994)

Port Curtis and Tributaries: Comparison of Current and Historical Water Quality

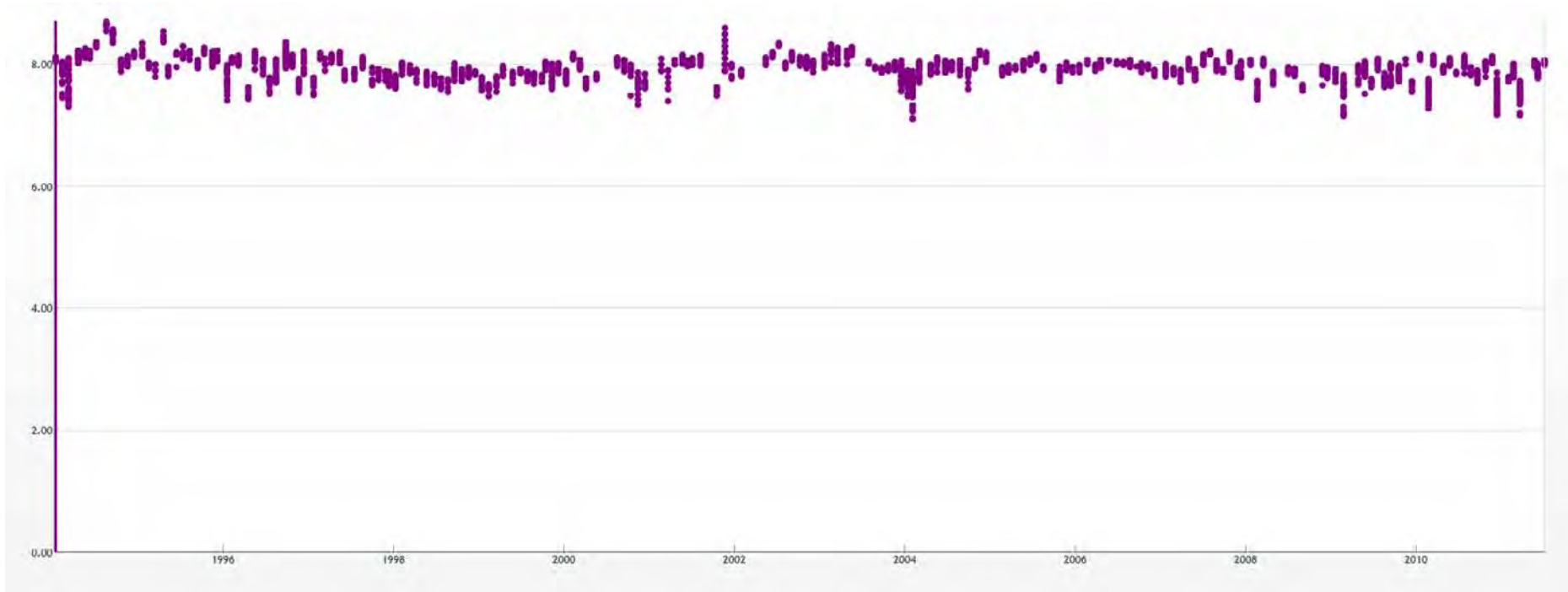


Figure 13 Calliope River Estuary – All Depths – All Sites – pH – Min: 7.1 (04/02/2004) Max: 8.7 (17/08/1994)

Attachment 5 Dissolved oxygen graphs

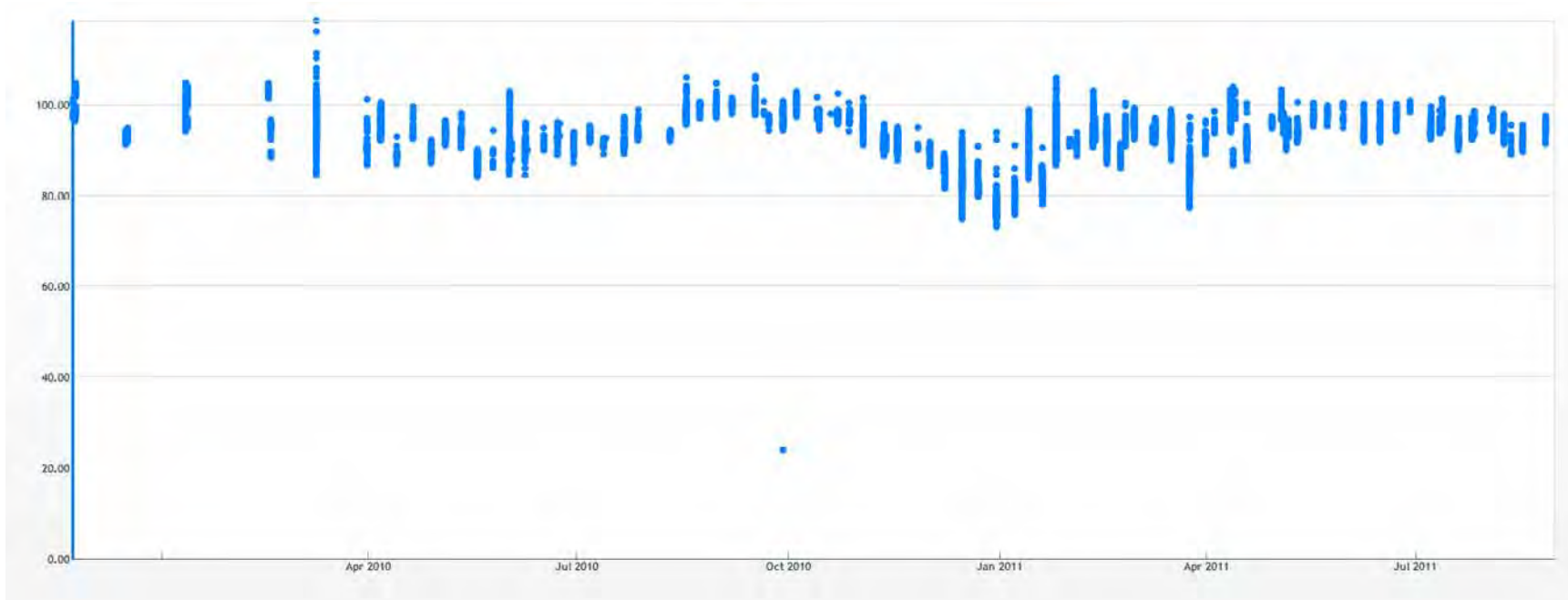


Figure 14 Port Curtis Harbour – All Depths – All Sites – Dissolved Oxygen (%sat) Min: 24 (28/09/2010) Max: 118.5 (09/03/2010)

Port Curtis and Tributaries: Comparison of Current and Historical Water Quality

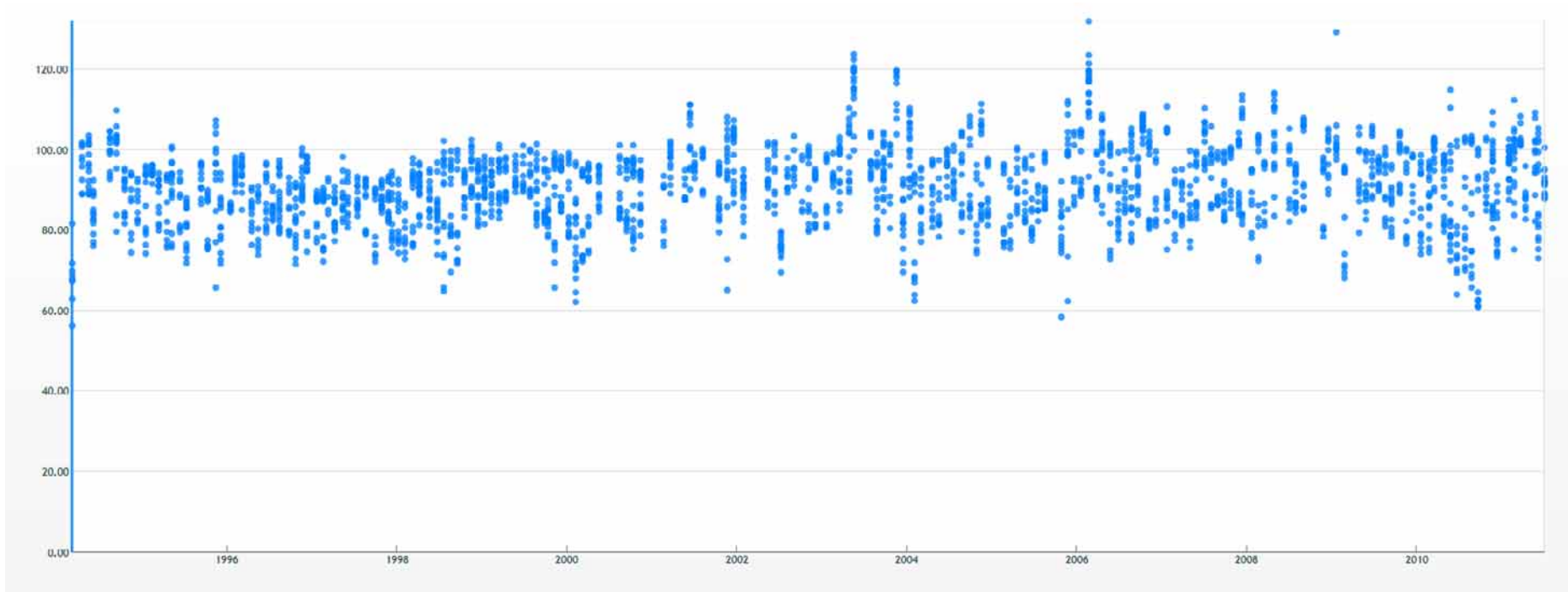


Figure 15 Boyne River Estuary – All Depths – All Sites – Dissolved Oxygen (%sat) Min: 56 (08/03/1994) Max: 132 (22/02/2006)

Port Curtis and Tributaries: Comparison of Current and Historical Water Quality

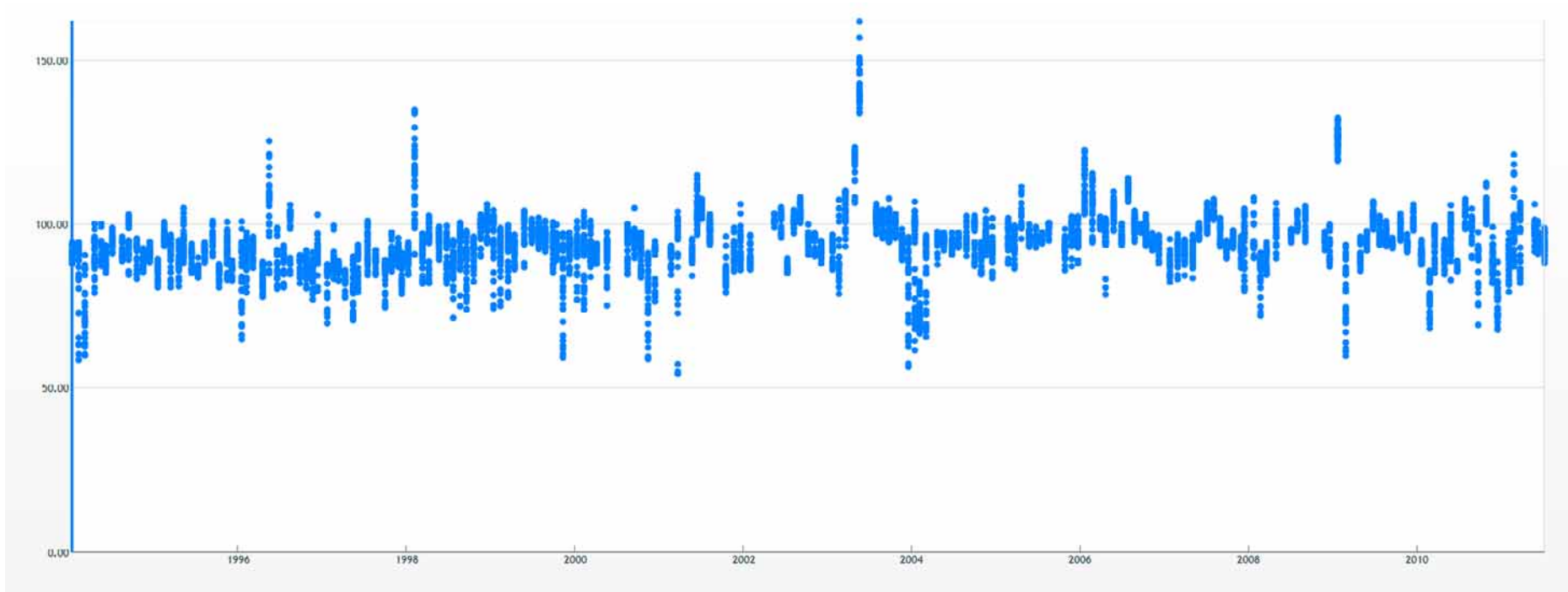


Figure 16 Calliope River Estuary – All Depths – All Sites – Dissolved Oxygen (%sat) Min: 54 (22/03/2001) Max: 162 (19/05/2003) Min: 0 (multiple dates) Max: 289 (21/02/2008)

Attachment 6 Chlorophyll *a* graphs

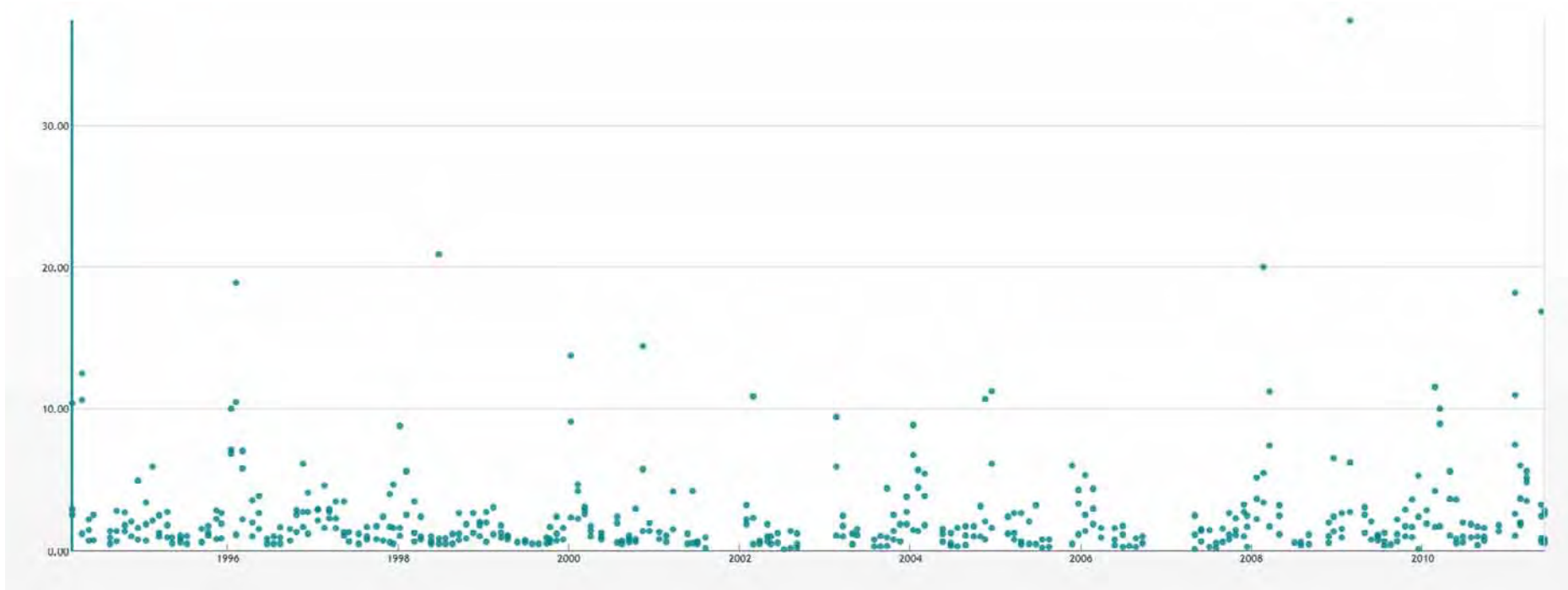


Figure 17 Boyne River Estuary – All Sites – Chlorophyll *a* (ug/L) Min: 0.1 (multiple dates) Max: 37.4 (25/02/2009)

Port Curtis and Tributaries: Comparison of Current and Historical Water Quality

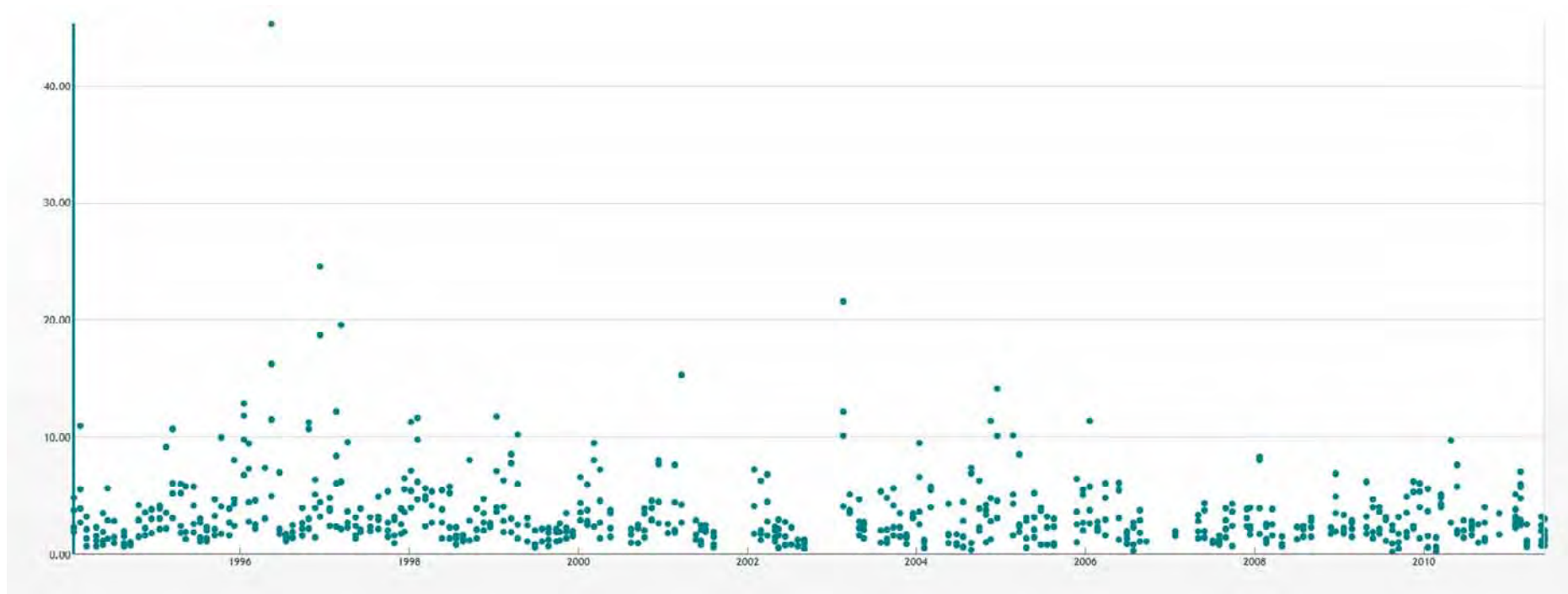


Figure 18 Calliope River Estuary – All Sites – Chlorophyll *a* (ug/L) Min: 0.2 (multiple dates) Max: 45.3 (15/05/1996)

Attachment 7 Biological significance of metal concentrations

Metal and metalloid concentrations are compared with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000). These guidelines include trigger values (TVs) which are calculated based on toxicity testing on a range of species. Trigger values provide the measure of the biological significance of the metal concentration through indicating the likelihood of organisms being impacted. The 95th percentile TV is the standard trigger above which there may be biological effects in slightly to moderately modified waterways – meeting this trigger value means that 95% of species should not experience adverse effects such as reduction in growth rates or reproduction. Water quality in highly disturbed waterways would typically be compared to the 90th or 80th percentile TV.

The toxicity is dependent on how much of the toxicant is biologically available and this is measured as the dissolved fraction of the metal, hence, the trigger values (TVs) are generally applied to dissolved metals. The water quality data assessed as part of this report, however, relates to unfiltered 'total' metals concentrations which includes metals as both dissolved and suspended particulates. The bioavailable fraction of a 'total concentration' can be quite small, therefore using the total concentrations mean that it is more likely that the metal concentration will exceed the TVs, even if the bioavailable fraction is lower than the TV.

The concentration of all total metals except aluminium, arsenic, cobalt, copper, manganese and nickel were less than the 95th percentile TV for marine waters, although there is no TV for iron. The TVs for aluminium and manganese are low reliability TVs.

Total aluminium concentrations are observed to exceed the low reliability 95th percentile TV in all samples assessed. However, aluminium constitutes one of the most common elements in the earth's crust and in Australia the total values often exceed the guidelines. All the reference sites in Rodds Bay also exceeded the 95th percentile TV, indicating that this metal naturally exceeds the TV in the local waterways. Given the results are totals, it is highly likely that the dissolved aluminium concentrations would be significantly lower.

In all cases, total cobalt, manganese and nickel exceedences of the 95% TVs were only observed in the January 2011 sampling, and not during sampling events pre- or post- 2010–11 floods.

During pre- and post- flood monitoring the total copper concentrations were above the 95th percentile but below the 90% percentile TV in all cases. During the flood, however both TVs were exceeded.

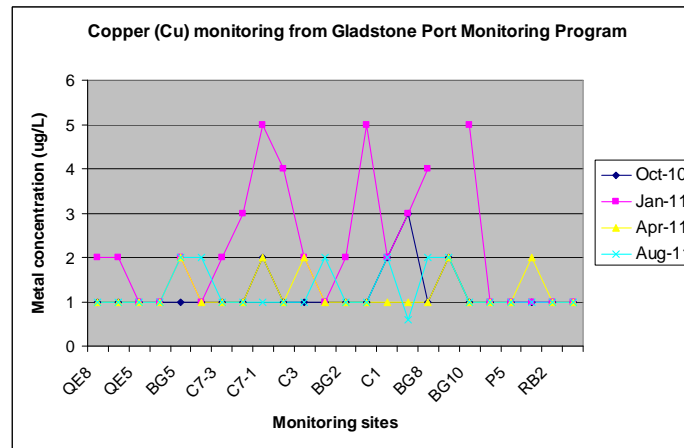
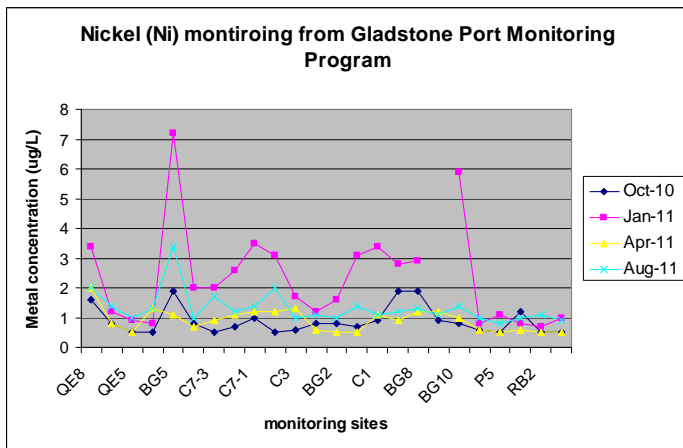
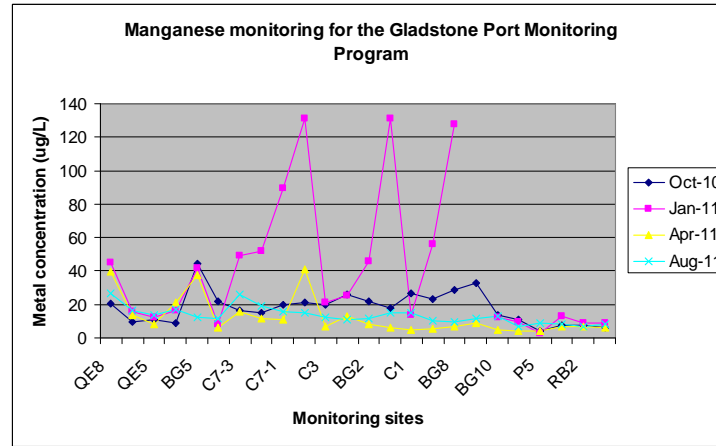
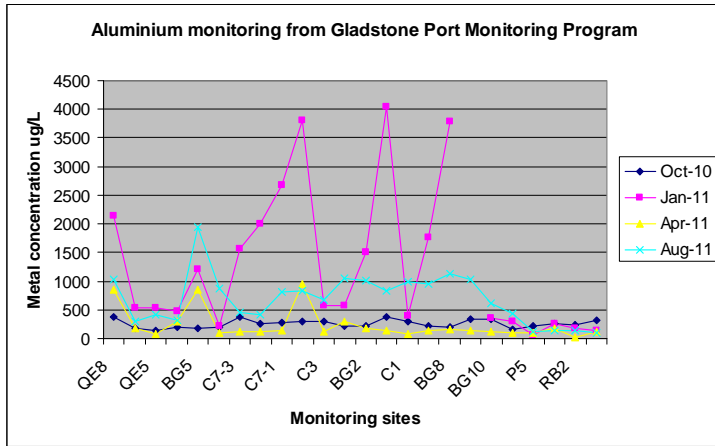
Total silver and chromium III show different patterns. Silver shows the highest levels in October 2010 (however it is below the 95th percentile TV) and has declined in concentration since. Chromium III shows the highest levels in the most recent August 2011 sampling however they are also below the 95th percentile.

PCIMP monitoring data, which were all collected prior to dredging, showed that that all sites exceeded the 95th percentile TVs for total aluminium even prior to dredging activity. In addition, total manganese exceeded the 95th percentile TV at multiple sites in all three monitoring programs. Total aluminium, arsenic, cobalt, copper, molybdenum, selenium and silver exceeded the 95th percentile TVs at some sites in at least one monitoring time. Three sites are directly comparable and were monitored for the same total metals in both the Gladstone Ports Corporation and PCIMP programs (C7-1, C7-2 and C7-3). This allows a comparison to be made over a longer time period. In all cases, the highest level of the metals monitored occurred during the January 2011 monitoring period, post-flood.

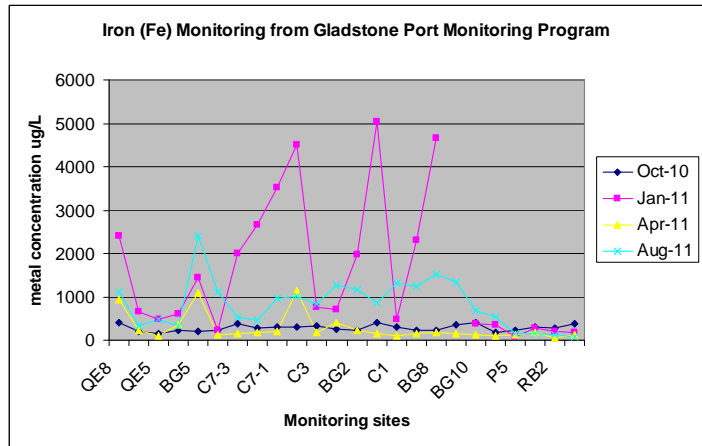
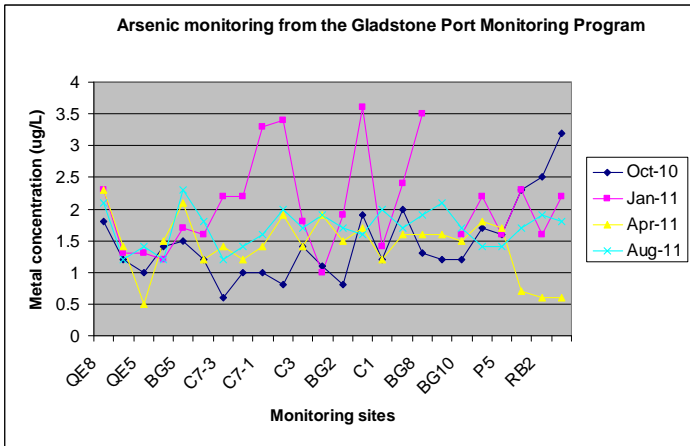
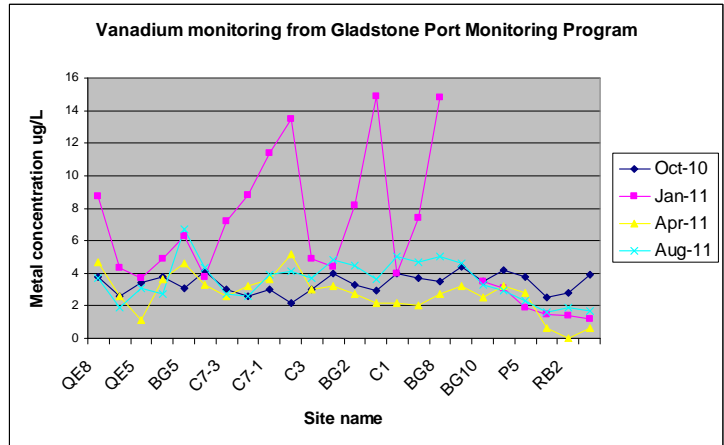
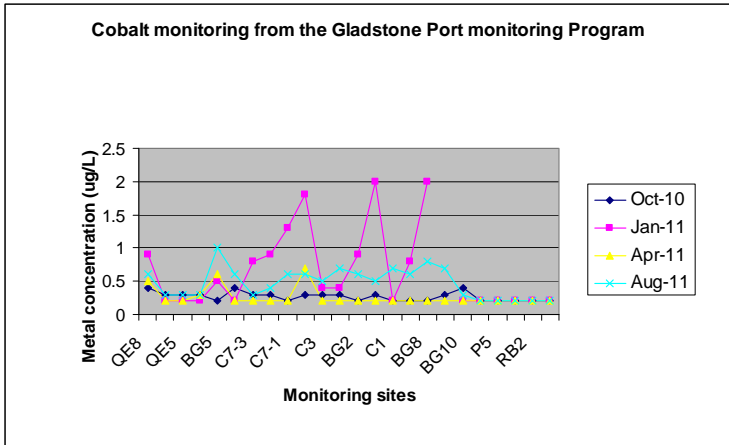
In conclusion, Gladstone metals data assessed is mostly within guidelines. While higher concentrations were observed during the 2010–11 flood period, the metals and metalloids levels in general would be considered to pose a relatively low risk of environmental effects. This is particularly likely given the metals data constitute 'totals' which will overestimate the bioavailable levels in the water. Most metals displayed highest concentrations in the January 2011 post-flood sampling, which is consistent with post-flood monitoring elsewhere in the State.

Attachment 8 Metals and Metalloids graphs

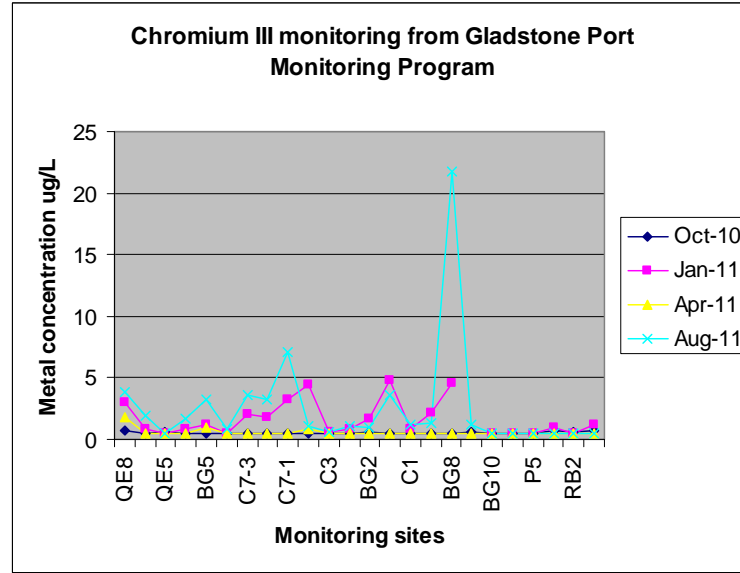
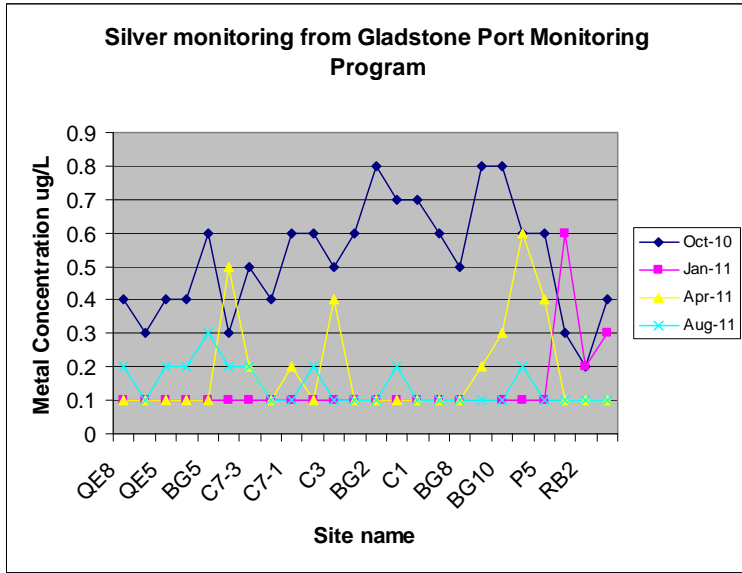
Where detection limits were not exceeded the detection value was used in the graphs below.



Port Curtis and Tributaries: Comparison of Current and Historical Water Quality

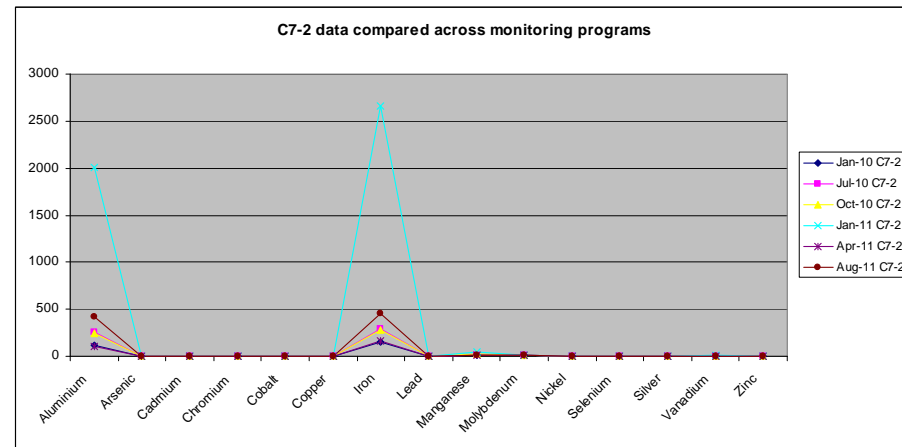
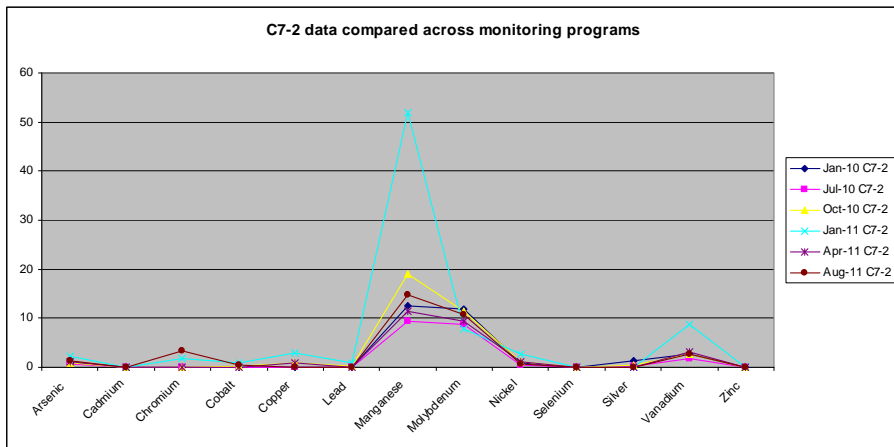
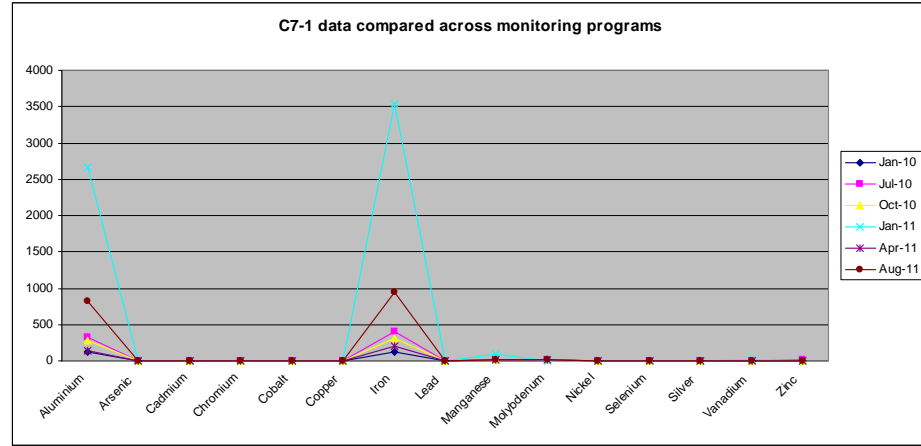
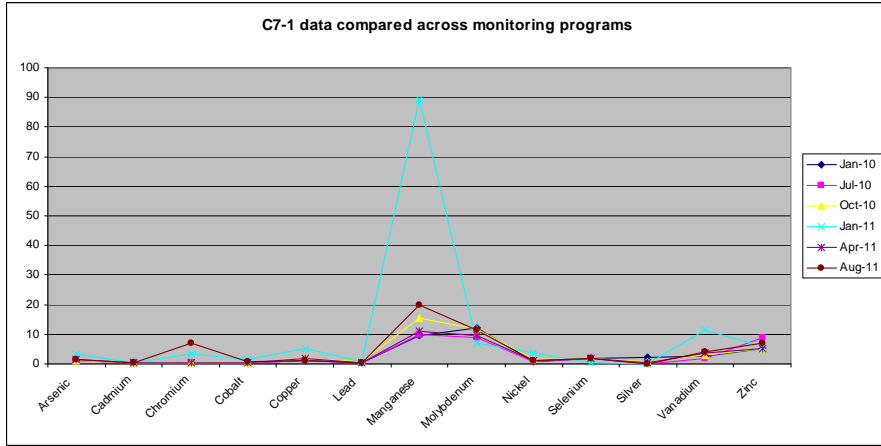


Port Curtis and Tributaries: Comparison of Current and Historical Water Quality



Port Curtis and Tributaries: Comparison of Current and Historical Water Quality

Graphs below refer to the comparison of Monitoring data for common sites among PCIMP and Gladstone Port Monitoring Program.



Port Curtis and Tributaries: Comparison of Current and Historical Water Quality

