MWH

BUILDING A BETTER WORLD

ANNUAL REPORT

Cape Peron Surface Water Study

Prepared for Strategen

April 2011

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Annual Report

Strategen

Cape Peron Surface Water Study

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REVISION SCHEDULE

REV. NO.	DATE	DESCRIPTION	PREPARED BY	REVIEWED BY	APPROVED BY
1.0	7/9/2010	Draft Report	K Amor / C Jones	G Clark	G Clark
2.0	14/1/2011	Draft Report (Update)	K Amor / C Jones	G Clark	G Clark
3.0	28/3/2011	Draft Annual Report	K Amor / C Jones	G Clark	J Campbell
4.0	13/4/2011	Final Report	C Jones	G Clark	J Campbell

1 Introduction

The Mangles Bay area of Cape Peron, Rockingham (approximately 47 km south of Perth), is the focus of the proposed development for a marina-based tourist precinct. The concept is a tourist based marina which will accommodate more than 500 boats and will incorporate local boating clubs and commercial areas. The surrounding land use will be 'mixed-use', with recreational, commercial and residential components, if the development occurs.

Lake Richmond (the Lake) is located to the south east of the proposed development and is separated from the development area by Safety Bay Road. The Lake has national conservation significance and supports many biological and social values. Potential risks and impacts that may occur from the proposed development need to be understood to allow appropriate mitigation measures to be put in place to protect the Lake's integrity. Some of the potential risks that have been identified are:

- lowering of the Lake's water levels,
- saltwater intrusion into the Lake, and
- an increase of nutrient levels in the Lake.

All land within the proposed development area south of Point Peron Road, including the Lake is within a Bush Forever Protection Area (BFPA 355) and Rockingham Lakes Regional Park.

1.1 Project Scope

The aim of the Project is to review previous studies and reports completed and implement a surface water monitoring program to provide further information on the hydrologic nature of the Lake.

The Project's monitoring phase began in January 2010 and is still underway and has been extended until September 2011. This Report presents data collected during the period January 2010 to March 2011.

The Project scope to date includes:

- Desktop investigation:
  - review of surface and stormwater information related to the Lake;
- Monitoring and Data Analysis:
  - development of a surface water quality monitoring program for the Lake;
  - installation of a water level logger; and
  - undertake two sample sets of water quality monitoring.
- Reporting:
  - a report providing the outcomes of the desktop analysis and water level and water quality monitoring program.

2 Background Information

2.1 Study Area

The Lake is an urban wetland located to the south east of the proposed development and is separated from the development area by Safety Bay Road. Residential development bounds the Lake, except for a section on the north western boundary which is bushland (Figure 2-1). The Lake is a perennial freshwater lake covering approximately 40 ha that is approximately one metre above sea level and is up to 15 m deep (CALM 2003).

The Lake evolved from a marine embayment and historically (prior to the 1960's) contained saline water (English et al. 2003). Cape Peron was once an island that became connected to the mainland as sand accumulated on the leeward side. The Lake was cut off from the marine environment by this process (CALM 2005).

In the 1960's, urban storm water drains were installed that discharged into the Lake and thus reduced the salinity concentration of the Lake. Currently, there are three drains into the Lake and one outlet that discharges to Mangles Bay (Figure 2-1).

The Lake Richmond reserve is about 77 ha in area and is one of the largest freshwater lakes occurring in close proximity to the ocean supporting many biological and social values. The Lake is part of the Rockingham Lakes Regional Park and a Bush Forever Protection Area. It is classified as a Conservation Category wetland and is recognised in the *Environmental Protection (Swan Coastal Plain Lakes) Policy 1992*.

The Lake is significant as a habitat for two critically endangered threatened ecological communities (TEC) which are protected under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The two TECs within the reserve are:

- the thrombolite community known as the Richmond Microbial Community; and
- the vegetation community known as Sedgelands in Holocene Dune Swales.

The Water Corporation Point Peron Wastewater Treatment Plant is located to the west of the Garden Island Causeway and a Water Corporation drain dissects the landscape from the Lake to Mangles Bay.


378,750 mE
379,000 mE
379,250 mE
N
6,427,500 mN
6,427,250 mN
6,427,000 mN
6,426,750 mN
Storm Water Outlet
Storm Water Inlet
Storm Water Inlet
Storm Water Inlet
0.1
0
0.1
0.2
0.3
Kilometers
Data Conditions
Considerable care has been taken to avoid errors and omissions and the latest information has been sought out and included. MWH does not accept any responsibility for any errors,omissions or inaccurracies.
To ensure formatting consistency this map should only be viewed using Adobe Viewer 7.0 or later.
Legend
Storm Water Inlets
Storm Water Outlet
Aerial image is not current and may not represent actual water levels
MWH
Lake Richmond Monitoring
Author: CJ & VC
Date: 03/09/2010
Revised:
Project No.: A1235400
Projection:MGA Z50 (GDA94)
Scale: As shown

2.2 Topography

The Lake Richmond reserve is gently undulating reaching an elevation of about five metres above sea level. The Lake is marine relic which was once part of the Cockburn Sound, but was separated from the ocean about 4000 years ago by the seaward advancement of the coastline. This movement is marked by the series of dune ridges (Kenneally et al, 1997). Evidence of these older dune formations are rare within the area due to levelling design of urban development (Ecoscape, 2009).

2.3 Geology and Soils

The Lake is located on the Quindalup Dune system, the youngest and most westerly soil system often referred to as the Safety Bay Sands. It overlies the Spearwood Dune system which was formed over the last 10,000 years when the sea level began to rise. The Safety Bay Sands are made up of calcareous sands of Aelion origin (Ecoscape, 2009).

A summary of soils that have previously been mapped at the site is provided in Table 2-1 (DAFWA, 2007).

Table 2-1: Mapped soil types at Lake Richmond

Soil Unit	Description	Location
211Qu_Qf2	Relcit fordunes and gently undulating beach ridge plain, deep uniform calcareous sands. Associated vegetation coastal health and peppermint scrub.	Upland areas – coastal shrublands and woodlands
211Va_V4a	Lake fringe, deep calcareous sands, black loams over brown/grey silty clay and muddy sands.	Around the lake edge- sedgeland
211VaW_SWAMP	Swamp, wet soils and water.	Lake

The lowest portions of the Lake Richmond Reserve are identified as having a high risk of actual acid sulfate soils (AASS) and potential acid sulfate soils (PASS) at less than three metres from the surface (WAPC, 2003b).

2.4 Hydrogeology

The Lake is a through flow lake receiving groundwater discharge from the Safety Bay aquifer in a southerly arc spanning the Lake from east to west. The Lake leaks water to the north where it becomes part of the groundwater flow system that eventually discharges into Cockburn Sound (English et al. 2003).

A saltwater-groundwater (freshwater) interface currently intrudes approximately 150 metres inland to the base of the Safety Bay aquifer at a depth of approximately 65 m beneath the Lake (English et al. 2003).

The aquifers recognised in the Cape Peron region, in order of increasing depth, are:

- Superficial aquifer;
- Rockingham Sand aquifer;
- Leederville aquifer; and
- Yarragadee aquifer.

The Lake is located in the Warnbro groundwater subarea. Warnbro has been identified as having 95 percent of licences allocated to the Superficial aquifer and the remainder to the Leederville aquifer. The Superficial aquifer is unconfined and up to 30 metres deep and recharge is through infiltration and rainfall. It discharges into the Lake as well as the ocean and into the Rockingham Sand aquifer through downward leakage (DoW, 2007).

From the period between 1975-2005, data from the monitoring bores in the Superficial aquifer show seasonal variations in groundwater levels. In the Warnbro subarea, winter levels are relatively stable and summer levels show a decline of up to half a metre. Salinity ranges from 367-560 mg/L (total dissolved solids (TDS)) which is fresh to marginal (DoW, 2007). Water is fresh to marginal if it is <1000 mg/L, brackish at 1000-3000 mg/L, saline at >3000 mg/L and seawater is about 35000 mg/L (Strategen, 2006).

An average aquifer transmissivity (T) for the superficial aquifer has been estimated at approximately 600 m²/d with a saturated thickness of 20 meters. Hydraulic conductivity (k) values are estimated in the range of 100-1000 m/d for the Tamala Limestone and 50 m/d for the Safety Bay sand (Davidson, 1995).

2.5 Hydrology

The Lake is approximately 1000 m by 600 m and up to 15 m deep but much shallower near the edges. Historically, the Lake was saline as it was once connected to the marine environment. Water levels vary seasonally, ranging from 0.2 to 1.2 m AHD with a long term average water level of 0.74 m AHD.

The Lake was included to be a part of the Rockingham urban drainage scheme in the 1960's. Three inlet drains were constructed into the Lake and one outlet drain in 1968 by the Water Board (Water Corporation). Subsequently the Lake receives stormwater from Rockingham, Shoalwater and Safety Bay. The location of the inlet and outlet drains is shown in Figure 2-1.

The main inlet drain discharging into the south east area of the Lake extends east to the Rockingham City Shopping Centre. The inlet drain discharging into the north east corner of the Lake, extends north of Rockingham Senior High School. The inlet drain discharging into the south west corner of the Lake, extends south west towards the coastline. The outlet drain traverses the Lake and discharges to Mangles Bay from the north west corner of the Lake Richmond Reserve.

Due to the constructed drainage system the water levels in the Lake have remained relatively stable and the water quality is fresh to marginal. Nonetheless, there has been an increase in nutrients, rubbish and other pollutants in the Lake as a result of increased urban development in the catchment (Ecoscape, 2009). During the warmer months water in the drains can become stagnate, increasing the risk of algal blooms and mosquito breeding.

2.6 Historic Water Level and Quality Monitoring

A summary of surface water monitoring that has previously been undertaken within the Lake Richmond Reserve, including monitoring within the inlet and outlet drains, is provided in Table 2-2. More details of the monitoring sites, including a location map, is provided in Appendix A.

Table 2-2: Lake Richmond previous surface water monitoring

Site ID	Site Name	Type of Monitoring	Date	Number of Readings
13662	Lake Richmond	Water Level	1945 – current	330[2]
13662	Lake Richmond	WQ[1]	1970 – 1986	35
23002414	Lake Richmond Outlet	Water Level	2002-2003	10
23002414	Lake Richmond Outlet	WQ	2002-2003	10
23015714	Mangles Bay Drain	WQ	2003	20[3]
23015717	Rockingham North Drain	WQ	2003	2[3]
23015718	Rockingham Central Drain	WQ	2003	5[3]
23015720	Lake Richmond	WQ	2003	1
23015721	Lake Richmond	WQ	2003	1
23018873	Safety Bay SW Drain	WQ	2005	9[3]

1 Water Quality (WQ)
2 Water levels have been recorded consistently since 1978
3 Variable number of readings have been collected for different parameters. Maximum number of readings shown in table.

2.6.1 Water Levels

The Lake (13662) is one of three wetlands in the Rockingham Groundwater Area that have been monitored by the Department of Water (DoW) prior to the 1970s. Nonetheless, water levels in Lake Richmond have been consistently recorded since 1978. The long term water levels are displayed in Figure 2-2.

Water levels vary seasonally, ranging from 0.2 to 1.2 m AHD with a long term average water level of 0.74 m AHD. Historically, Lake levels are the lowest during late summer due to low rainfall and stormwater runoff.

For the period of 1945-1975 the Lake declined up to 0.5 metres but has been stable from 1975 to 2005 which is probably attributable to the construction of an outlet drain by the Water Board (Water Corporation) in 1968 (Ecoscape, 2009).

Occasionally since the late 1980s water levels have been below the staff gauges in all wetlands, which makes it difficult to determine trends (Ecoscape, 2009).

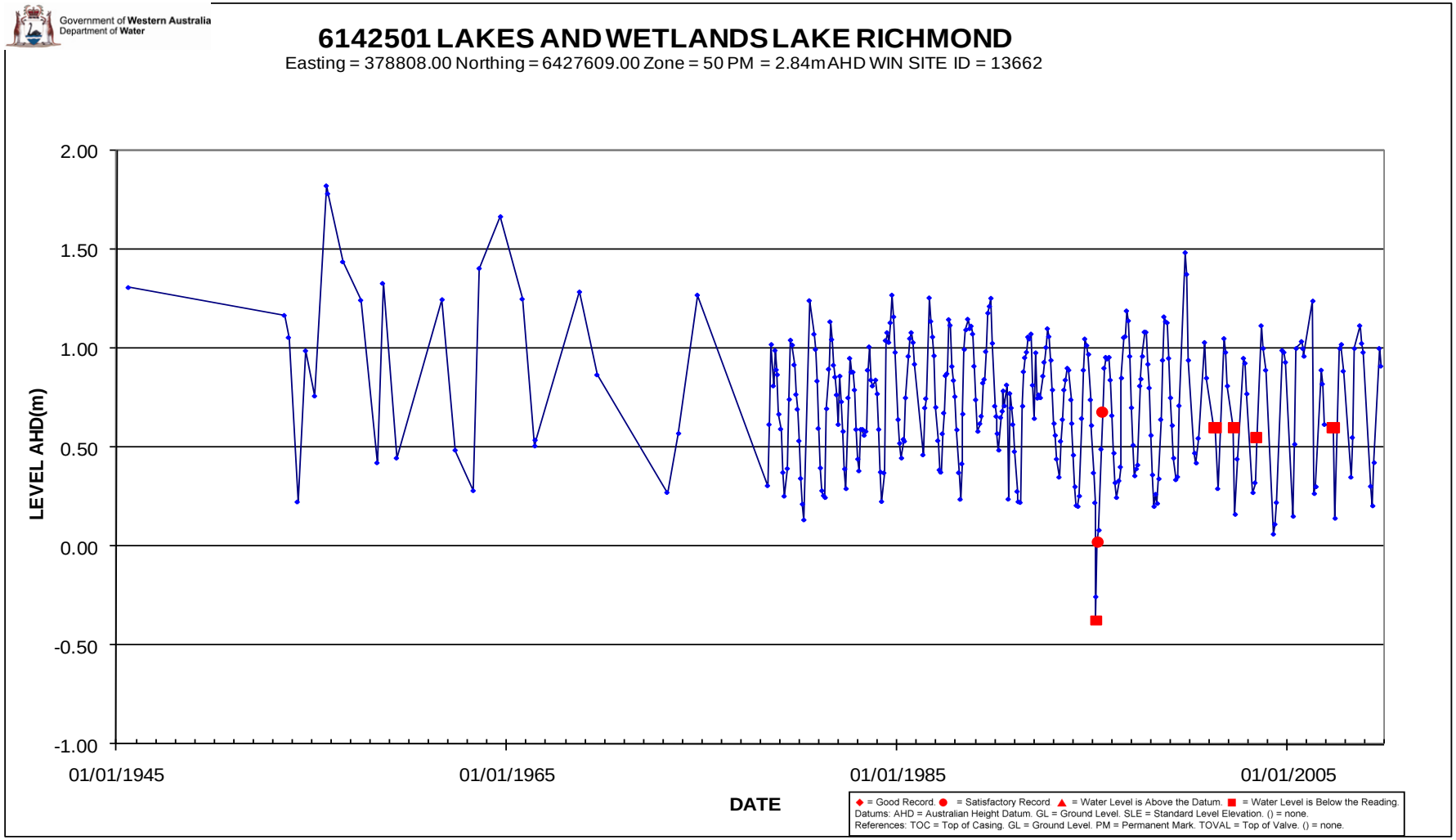


Figure 2-2: Lake Richmond (13662) historical water levels.

2.6.2 Water Quality

At present the DoW, Water Corporation and the City of Rockingham do not conduct water quality monitoring for the Lake. The Water Corporation undertook regular monitoring of water quality up to twice a year between 1970-1986 as detailed in Table 2-3. Water quality was also undertaken in 2003 and 2005 (Table 2-3).

The water quality at the Lake is used as one of the environmental indicators of the health of inland waters within the City of Rockingham, thus the 2003 monitoring has been utilised for this purpose. The water quality of the Lake recorded in 2003 is detailed in Table 2-3 along with the ANZECC Guidelines for comparison. As seen in Table 2-3, the nutrient levels recorded in 2003 exceed the ANZECC guidelines for freshwater lakes, nonetheless, the recorded levels are under guidelines for slightly disturbed ecosystems.

Table 2-3: Lake Richmond water quality in 2003 (CoR, 2005)

Water Quality Parameter	Results	ANZECC Guidelines	
		Fresh water lake	Wetlands in slightly disturbed ecosystems
TN – total nitrogen (μL^{-1})	650 – 840	350	1500
NOx Reactive Nitrogen (μL^{-1})	12 to 25	10	100
TP – total phosphorus (μL^{-1})	12 to 30	10	60
FRP – filterable reactive phosphorus (μL^{-1})	7 to 12	5	30

Prior to the 1960s and construction of the stormwater drains the Lake was saline with salinity ranging from 2000 to 3500 mg/L TDS (Ecoscape, 2009). After installation of the drains, salinity reduced to 300– 400 mg/L TDS (Strategen, 2006).

The Naragebup Natural Resource Management (NRM) office conducted a study of the water quality of the outlet drain at the Lake to determine the level of nutrients entering into Mangles Bay and Cockburn Sound. Monitoring was conducted over a three month period after the winter months in 2002. Results indicated that (Ecoscape, 2009):

- pH was between 8.26 and 8.79 which is alkaline but expected due to the limestone geology of the catchment;
- dissolved oxygen (DO) was above recommended levels for lowland rivers;
- all nitrogen samples were above recommended levels for freshwater lakes;
- total phosphorus was above recommended levels for freshwater lakes and lowland rivers;
- toxicants such as heavy metals, oils and pesticides were below recommended levels for freshwater ecosystems except for zinc; and
- algal blooms were obvious during the survey in September 2002, with high levels of toxic blue-green algae (Microcystis cyanobacteria). There was no evidence of the algal bloom during a follow up survey about a month later in October 2002.

3 Monitoring Program

The Lake Richmond monitoring program is currently being undertaken by MWH. The program started in January 2010 and will be completed in September 2011. This Report provides a summary of the data collected from January 2010 to March 2011. The field program consisted of an initial site visit to identify the Lake's physical characteristics (i.e. inlet / outlet points) and the installation of a water level logger. The monitoring program then followed and consisted of:

- water level monitoring;
- water sampling;
- stratification monitoring; and
- depth transects.

The monitoring program is conducted on a monthly basis, to ensure any seasonal trends are adequately recorded, at three sites (Lake Richmond 1, Lake Richmond 2 and Lake Richmond 3) on the Lake, as shown in Figure 3-1. The monitoring program, adheres to DoW's Field Sampling Guidelines (DoW, 2009), and is summarised below with the results included in the subsequent sections.

Water level monitoring

Water level monitoring is undertaken through the installation, and subsequent data download, of a Level TROLL 300 water level logger to gather accurate water level data. In addition, a manual water level reading is recorded from the DoW stadia (site no. 6142501) located in the Lake. The data logger is installed on the DoW stadia. The location of the stadia is provided in Table 3-1 and illustrated in Figure 3-1 and Appendix B.

Water sampling

Water samples are collected at two of the three sites on the Lake, Lake Richmond 1 and Lake Richmond 2 (Table 3-1 and Figure 3-1). In addition, the stormwater outlet (Figure 2-1) discharge was sampled on one occasion in September 2010. *SGS Pty. Ltd. Australia* conducts the laboratory analysis of the water samples in addition to providing the bottles and preservatives.

Water samples are collected from approximately 0.2 m below the water's surface before being stored in an esky and transported to *SGS Pty. Ltd. Australia* for analysis as soon as possible after sampling.

Each sample is analysed for standard water quality (pH, EC, TDS, Na, K, Ca, Mg, Fe, Cl, SO4, NO3, HCO3 and CO3), TSS, DO, total nitrogen, total phosphorus, nitrite, FRP (subsequent anions), eight standard metals (As, Cd, Cu, Cr, Hg, Pb, Ni, Zn), hydrocarbons (TRH C6 – C36), turbidity (NTU) and colour.

Stratification monitoring

Stratification monitoring is conducted at all three sites on the Lake (Table 3-1 and Figure 3-1). This involves the recording of EC, pH, DO, redox and temperature at depths of one metre intervals. A *Quanta.G Water Quality Monitoring System* is used to measure the above parameters with depth.

Depth transects

Six depth transects of the Lake were completed on 18 January 2010. The location of the transects is shown in Figure 3-1.

Table 3-1: Monitoring and equipment locations

Location	Monitoring	Easting	Northing
Lake Richmond 1	• Water quality • Stratification	378787	6427116
Lake Richmond 2	• Water quality • Stratification	379059	6427057
Lake Richmond 3	• Stratification	378919	6427396
Installed Data Logger DoW Stadia Site No. 6142501	• Water Level	378808	6427609

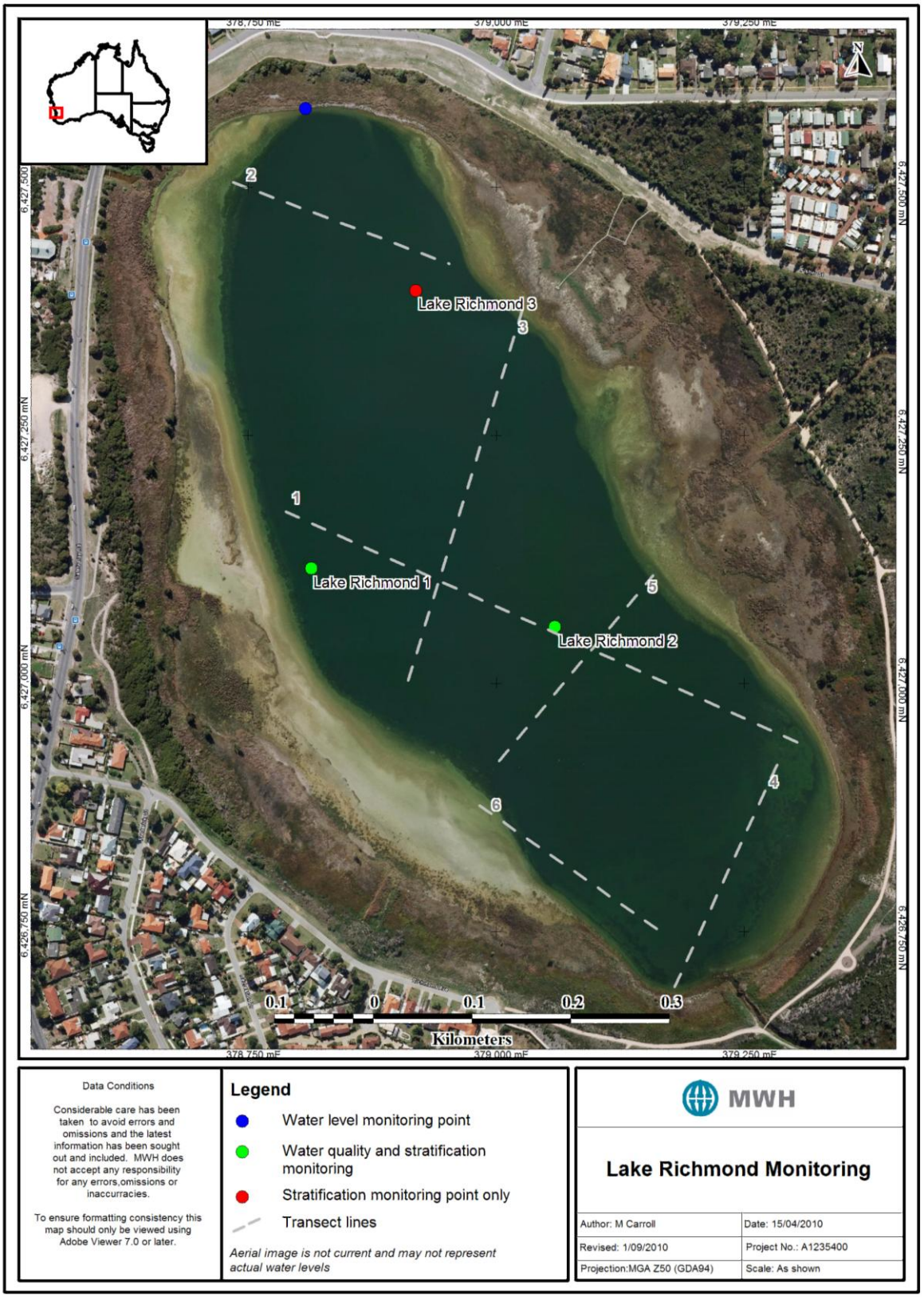


Figure 3-1: Location of Lake Richmond monitoring

4 Monitoring Results

4.1 Water Level Monitoring

Hydrographs generated from the water level data retrieved from the data logger are provided in Figures 4-2 to 4-5 (raw data are provided in Appendix C). The water level data collected in the data logger has been corrected for barometric pressure using barometric pressure data collected from an *Insitu Baro Troll 500* data logger located in a nearby groundwater monitoring bore, and, the stadia readings. As a result, the water level data is displayed in metres AHD.

The water level data has been plotted against rainfall (Bureau of Meteorology (BoM) station number 9256 (BoM, 2011)), temperature (data recorded in the data logger) and tidal movements for the Cape Peron area. The stadia water level readings are also plotted in the hydrographs.

It should be noted that the DoW stadia and the data logger were above the Lake's water level in March 2011 (Figure 4-1). The data logger data indicates that the water level fell below the DoW stadia on 13 March 2011. The DoW stadia has a minimum water level of 0 m AHD.

Figure 4-1: Photo showing Lake Richmond's water level below DoW stadia post.

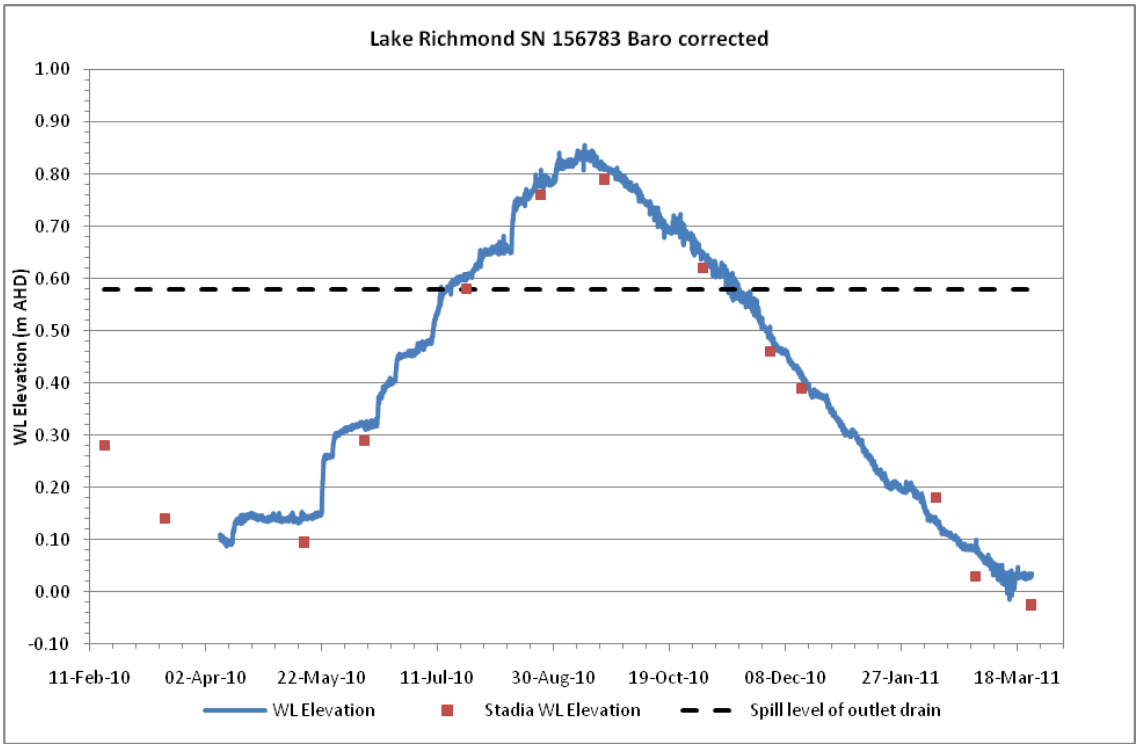


Figure 4-2: Lake Richmond hydrograph

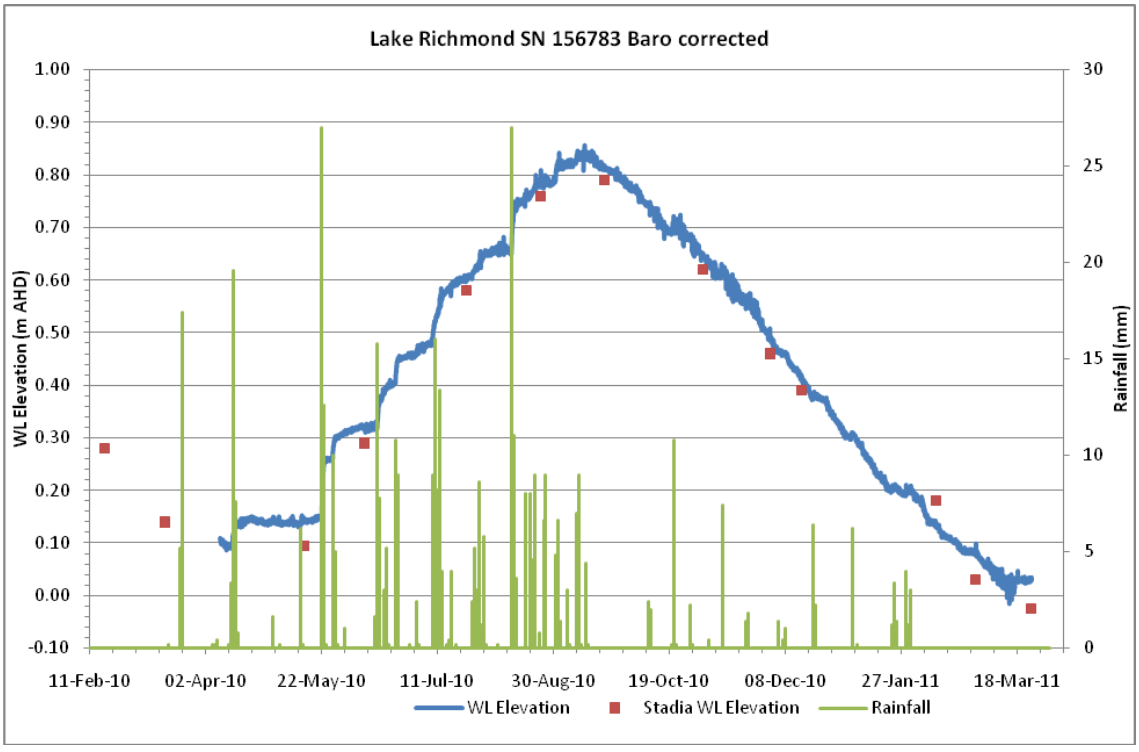


Figure 4-3: Lake Richmond hydrograph with rainfall

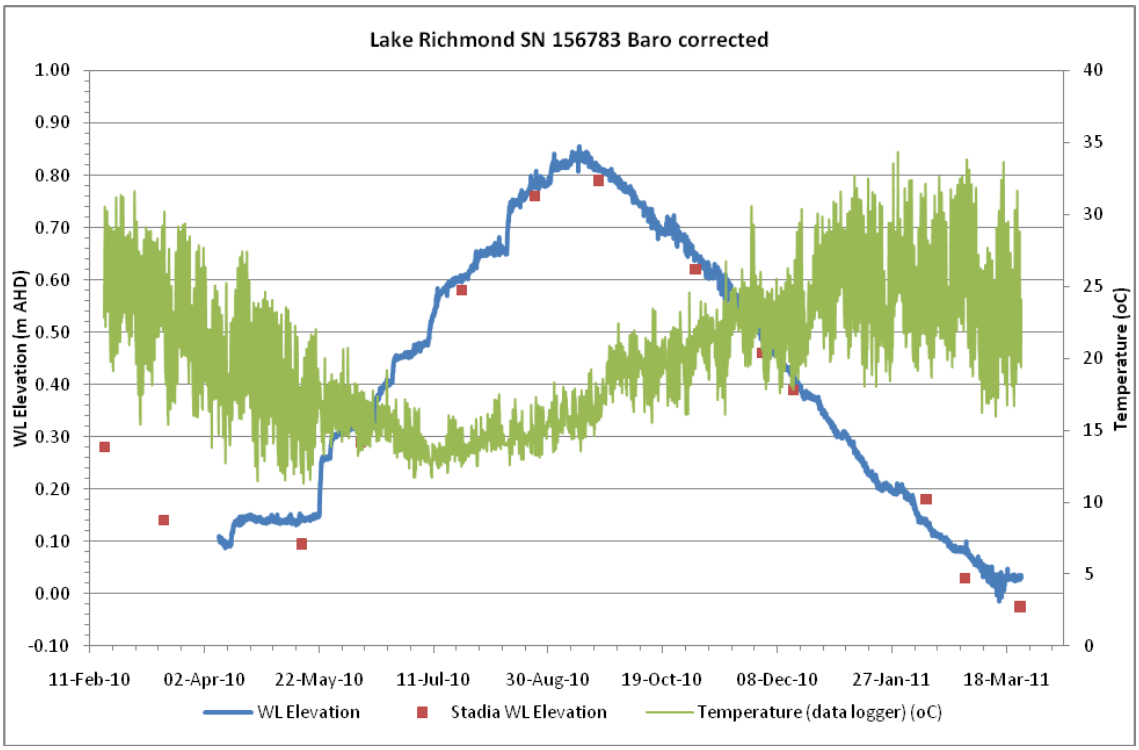


Figure 4-4: Lake Richmond hydrograph with temperature

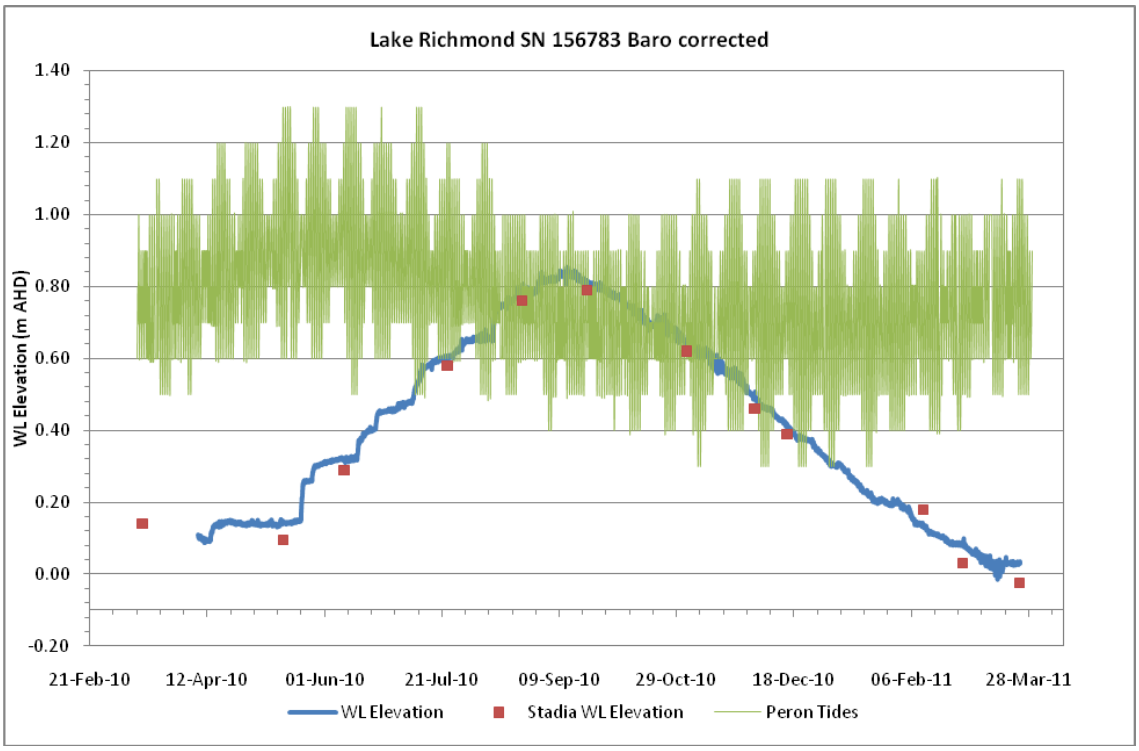


Figure 4-5: Lake Richmond hydrograph with tidal data[1]

1 Peron tidal data obtained by converting the tide forecasts provided by Australian Bureau of Meteorology for standard ports and data from the Australian National tide Tables (willyweather)

4.2 Water Quality Monitoring

The results of the water quality analysis are presented in Tables 4-1 to 4-3 with the laboratory analytical reports provided in Appendix D. Laboratory analysis methods and reporting limits have been specified where analytes of similar names have been reported.

Table 4-1: Water quality analysis for Lake Richmond 1

Analyte	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Mean	Median	Min - Max
Date Sampled	-	18/1/10	17/2/10	15/3/10	19/4/10	14/5/10	9/6/10	23/7/10	23/8/10	21/9/10	2/11/10	1/12/10	15/12/10	11/2/11	28/2/11	24/3/11	-	-	-
pH	pH units	8.6	8.8	8.6	8.7	8.7	8.6	8.7	8.0	8.60	8.80	8.90	8.90	9.00	8.90	8.8	8.71	8.7	8 - 9
Conductivity @ 25degC	µS/cm	830	900	890	850	900	980	990	960	990	980	970	960	1000	1000	1100	953	970	830 - 1100
Total Dissolved Solids @ 180degC	mg/L	520	530	560	540	560	580	560	540	540	580	560	580	660	600	620	568	560	520 - 660
Soluble Iron, Fe	mg/L	<0.02	<0.02	0.03	0.03	<0.02	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	0.02	<0.02 – 0.03
Sodium, Na	mg/L	85	93	97	100	120	100	110	91	95	98	100	99	110	110	110	101	100	85 - 120
Potassium, K	mg/L	4.9	5.6	5.5	5.9	7.0	6.0	6.3	6.1	5.9	6.0	7.0	6.0	6.3	6.4	7.1	6.1	6	4.9 – 7.1
Calcium, Ca	mg/L	26	28	27	28	30	28	32	28	29	26	27	24	24	23	24	26.9	27	23 - 32
Magnesium, Mg	mg/L	42	49	47	50	53	49	53	46	50	50	56	50	56	55	58	50.9	50	42 - 58
Chloride, Cl	mg/L	160	170	170	170	210	170	170	170	180	170	190	180	190	190	200	179.3	170	160 - 210
Carbonate, CO3	mg/L	14	12	11	17	9	7	11	11	12	19	19	14	24	18	12	14	12	7 - 24

Analyte	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Mean	Median	Min - Max
Bicarbonate, HCO3	mg/L	220	210	230	200	230	240	240	230	220	210	210	230	200	210	240	221.3	220	200 - 240
Sulphate, SO4	mg/L	57	79	68	64	66	65	64	63	71	62	64	65	71	79	72	67.3	65	57 - 79
Nitrate, NO3 (method AN258, reporting limit = <0.2 mg/L)	mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.2	<0.2	<0.2 - <0.2
Nitrate, NO3 as NO3 (method AN258, reporting limit = 0.05 mg/L)	mg/L	NA	NA	NA	NA	NA	NA	0.14	0.17	0.95	<0.05	<0.05	<0.05	<0.05	2.4	0.18	1.29	1.29	0.18 – 2.4
Fluoride, F	mg/L	0.7	0.9	<0.1	0.9	1	0.9	0.9	0.8	1.0	0.8	0.9	1.0	0.9	0.7	0.9	0.88	0.9	0.7 – 1.0
Soluble Manganese, Mn	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005 - <0.005
Soluble Silica, SiO2	mg/L	11	13	13	15	14	14	13	13	12	13	15	14	16	15	16	13.8	14	11 - 16
Cation / Anion balance	%	-6.9	-3.5	-3.5	0.8	0.8	-1.4	2	-5	-3	-2	0	-4	-1	-2	-2	-2.05	-2	-6.9 – 2.0

Analyte	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Mean	Median	Min - Max
Sum of Ions (calc.)	mg/L	612	650	655	635	722	663	643	615	634	619	656	635	654	661	680	649	650	612 - 722
Total Suspended Solids @103degC	mg/L	6	8	8	<5	<5	5	7	8	<5	8	<5	<5	<5	<5	6	6.1	5	<5 - 8
Dissolved Oxygen	mg/L	5.9	10.3	5.3	8.8	8.3	9.2	8.3	9.0	9.5	8.1	7.7	8.6	8.3	7.6	9.8	8.3	8.3	5.3 – 10.3
Soluble Arsenic, As (method AN322)	mg/L	0.006	0.005	0.003	0.006	0.005	0.004	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	NA	0.01	0.02	0.003 – 0.02
Soluble Arsenic, As (method AN318)	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4	4	4	4 - 4
Soluble Cadmium, Cd (method AN321)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005	<0.001	<0.001	NA	0.002	0.001	0.001 – 0.005
Soluble Cadmium, Cd (method AN318)	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.1	<0.1	<0.1	<0.1 - <0.1
Soluble Chromium, Cr (method AN321)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NA	<0.005	<0.005	<0.005 - <0.005

Analyte	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Mean	Median	Min - Max
Soluble Chromium, Cr (method AN318)	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1 - <1
Soluble Copper, Cu (method AN321)	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NA	<0.005	<0.005	<0.005 – 0.005
Soluble Copper, Cu (method AN318)	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1 - <1
Soluble Lead, Pb (method AN322)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NA	<0.005	<0.005	<0.005 - <0.005
Soluble Lead, Pb (method AN318)	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1 - <1
Soluble Mercury, Hg	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0001	<0.0001	<0.0001	<0.00005	<0.0001	<0.0001	<0.00005	<0.00005	<0.00005	0.0002	0.0001	<0.00005 - <0.0001
Soluble Nickel, Ni (method AN321)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.01	<0.005	NA	0.006	0.005	0.005 – 0.012

Analyte	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Mean	Median	Min - Max
Soluble Nickel, Ni (method AN318)	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	1	1	1 - 1
Soluble Zinc, Zn (method AN321)	mg/L	0.052	0.16	0.027	0.022	<0.010	0.039	<0.005	0.007	0.04	0.02	<0.01	0.02	0.10	0.03	NA	0.039	0.025	0.005 – 0.16
Soluble Zinc, Zn (method AN318)	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	55	55	55	55 - 55
Turbidity	NTU	<1	<1	1	1	<1	1	0.8	0.8	0.9	2.1	2.4	3.8	0.5	0.6	1	1.3	1	0.5 – 3.8
Colour (Apparent)	PCU	14	10	8	9	11	8	6	9	6	10	7	4	6	8	8	8.3	8	4 - 14
Total Nitrogen (method AN209)	mg/L	0.83	1.90	0.76	0.61	0.71	0.59	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.900	0.735	0.59 – 1.9
Total Nitrogen (method AN268)	mg/L	NA	NA	NA	NA	NA	NA	0.66	0.83	1.00	0.85	0.80	0.62	NA	NA	NA	0.793	0.815	0.62 - 1
Total Nitrogen (method AN281/292)	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.71	1.50	1.2	1.137	1.200	0.71 – 1.5

Analyte	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Mean	Median	Min - Max
Total Kjeldahl Nitrogen (method AN281/292)	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.96	1.2	1.08	1.08	0.96 – 1.2
Total Phosphorus	mg/L	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.01	0.01	0.02	0.03	0.02	0.02	0.02	0.01 – 0.03
Ammonia Nitrogen NH3-N	mg/L	0.02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.02	0.02	0.02 – 0.02
Ortho Phosphorus, PO4-P	mg/L	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.002	0.003	0.003	<0.002	<0.002	0.01	0.003	<0.002	0.003	0.0029	0.003	<0.002 – 0.01
Nitrite, NO2 (method AN258)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	<0.05 - <0.05
TRH C6-C9 (reporting limit = <0.04 mg/L)	mg/L	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.04	<0.04	<0.04 - <0.04
TRH C10-C14 (reporting limit = <0.04 mg/L)	mg/L	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.04	<0.04	<0.04 - <0.04
TRH C15-C28 (reporting limit = <0.2 mg/L)	mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.2	<0.2	<0.2 - <0.2

Analyte	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Mean	Median	Min - Max
TRH C29-C36 (reporting limit = <0.2 mg/L)	mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.2	<0.2	<0.2 - <0.2
TRH C6-C9 (reporting limit = <40 mg/L)	µg/L	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40 - <40
TRH C10-C14 (reporting limit = <40 mg/L)	µg/L	<40	<40	<40	<40	<40	<40	<50	<50	<50	<50	<50	<50	<40	<50	<50	45.3	50	<40 - <50
TRH C15-C28 (reporting limit = <200 mg/L)	µg/L	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	300	<200	300	300	<200 - 300
TRH C29-C36 (reporting limit = <200 mg/L)	µg/L	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200 - <200
TRH Surrogate	%	23	26	27	61	55	34	23	27	57	50	48	60	68	72	81	47.3	51.5	23 - 81

Notes:
NA = data not available

Table 4-2: Water quality analysis for Lake Richmond 2

Analyte	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Mean	Median	Min - Max
Date Sampled	-	18/1/10	17/2/10	15/3/10	19/4/10	14/5/10	9/6/10	23/7/10	23/8/10	21/9/10	2/11/10	1/12/10	15/12/10	11/2/11	28/2/11	24/3/11	-	-	-
pH	pH units	8.7	8.8	8.7	8.8	8.7	8.6	8.7	8.6	8.7	9	9	8.9	9	8.9	7.6	8.72	8.7	7.6 – 9
Conductivity @25degC	µS/cm	830	910	880	850	920	980	1000	980	990	980	980	950	1000	1000	1300	970	980	830 – 1300
Total Dissolved Solids @ 180degC	mg/L	520	520	580	530	560	580	540	540	540	570	560	590	660	600	620	567.3	560	520 - 660
Soluble Iron, Fe	mg/L	<0.02	<0.02	0.04	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.022	0.02	0.02 – 0.04
Sodium, Na	mg/L	86	94	97	100	100	100	130	90	97	99	100	100	110	110	110	101.5	100	86 - 130
Potassium, K	mg/L	4.9	5.4	5.5	6.1	6.2	6	6.4	6.1	5.7	6.3	6.8	6.2	6.3	6.4	6.8	6.1	6.2	4.9 – 6.8
Calcium, Ca	mg/L	27	27	26	28	29	29	34	28	36	26	27	27	24	23	24	27.6	27	23 - 36

Analyte	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Mean	Median	Min - Max
Magnesium, Mg	mg/L	42	46	47	51	51	50	55	46	52	50	55	52	56	55	58	50.9	51	42 - 58
Chloride, Cl	mg/L	160	170	170	170	180	170	170	170	170	170	180	180	190	190	200	176	170	160 - 200
Carbonate, CO3	mg/L	16	12	13	17	9	9	13	11	7	19	19	18	24	18	<1	13.5	13	1 - 22
Bicarbonate, HCO3	mg/L	210	210	230	190	220	240	240	230	210	230	220	220	200	210	260	222	220	190 - 260
Sulphate, SO4	mg/L	55	65	68	65	65	64	63	63	65	63	65	65	71	79	71	65.2	65	55 - 72
Nitrate, NO3 (method AN258, reporting limit = <0.2 mg/L)	mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.2	<0.2	<0.2 - <0.2
Nitrate, NO3 as NO3 (method AN258, reporting limit = 0.05 mg/L)	mg/L	NA	NA	NA	NA	NA	NA	0.17	0.18	1.5	0.14	<0.05	<0.05	<0.05	2.4	0.21	0.08	0.05	0.05 – 0.21

Analyte	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Mean	Median	Min - Max
Fluoride, F	mg/L	0.7	0.9	<0.1	0.8	1	0.8	0.8	0.8	0.9	0.8	0.9	1	0.9	0.7	0.9	0.8	0.8	0.1 - 1
Soluble Manganese, Mn	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005 - <0.005
Soluble Silica, SiO2	mg/L	11	13	13	15	14	14	13	13	12	13	15	14	16	15	16	13.8	14	11 - 16
Cation / Anion balance	%	-6.1	-3.4	-4.4	1.7	-0.2	-1.2	6	-5	-3	-3	-1	-2	-1	-2	-2	-1.84	-2	-6.1 - 6
Sum of Ions (calc.)	mg/L	608	628	657	639	663	667	667	613	649	634	648	640	654	661	678	646.1	649.5	608 - 678
Total Suspended Solids @103degC	mg/L	6	7	<5	<5	5	<5	<5	7	10	9	<5	5	<5	<5	7	6.14	5	5 - 10
Dissolved Oxygen	mg/L	5.8	10.7	4.9	8.9	8.8	6.4	9.2	9.2	10.7	8.3	7.9	8.5	8.3	7.6	9.6	8.37	8.8	4.9 – 10.7
Soluble Arsenic, As (method AN322)	mg/L	0.006	0.004	0.004	0.007	0.006	0.005	<0.02	<0.02	0.021	<0.02	<0.02	<0.02	<0.02	<0.02		0.014	0.02	0.004 – 0.021

Analyte	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Mean	Median	Min - Max
Soluble Arsenic, As (method AN318)	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4	4	4 - 4
Soluble Cadmium, Cd (method AN321)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005	<0.001	<0.001	4	0.002	0.001	0.001 – 0.005
Soluble Cadmium, Cd (method AN318)	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.1	<0.1	<0.1	<0.1 - <0.1
Soluble Chromium, Cr (method AN321)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NA	<0.005	<0.005	<0.005 - <0.005
Soluble Chromium, Cr (method AN318)	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1 - <1
Soluble Copper, Cu (method AN321)	mg/L	0.053	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.044	<0.005	<0.005	<0.005	<0.005	NA	0.011	0.005	0.005 – 0.053
Soluble Copper, Cu (method AN318)	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1 - <1

Analyte	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Mean	Median	Min - Max
Soluble Lead, Pb (method AN322)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NA	<0.005	<0.005	<0.005 - <0.005
Soluble Lead, Pb (method AN318)	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1 - <1
Soluble Mercury, Hg	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0001	<0.0001	<0.0001	<0.00005	<0.0001	<0.0001	<0.00005	<0.00005	<0.00005	0.00025	0.0001	0.000005 – 0.0005
Soluble Nickel, Ni (method AN321)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NA	<0.005	<0.005	<0.005 - <0.005
Soluble Nickel, Ni (method AN318)	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1 - <1
Soluble Zinc, Zn (method AN321)	mg/L	0.051	0.091	0.03	0.03	<0.010	0.039	0.006	0.007	0.035	0.09	<0.01	0.04	0.10	0.03	NA	0.038	0.030	0.006 – 0.091
Soluble Zinc, Zn (method AN318)	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	28	28	28	28 - 28

Analyte	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Mean	Median	Min - Max
Turbidity	NTU	1	<1	1	1	<1	1	0.9	0.8	2	2.2	1.9	2	0.5	0.6	1.0	1.19	1	0.4 – 2.2
Colour (Apparent)	PCU	13	9	7	10	11	10	7	7	7	10	8	4	6	8	8	8.57	8	6 - 13
Total Nitrogen (method AN209)	mg/L	0.64	1.8	0.73	0.61	0.76	0.61	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.86	0.69	0.61 – 1.8
Total Nitrogen (method AN268)	mg/L	NA	NA	NA	NA	NA	NA	0.66	0.83	1.30	0.87	0.80	0.66	NA	NA	NA	0.85	0.82	0.66 – 1.3
Total Nitrogen (method AN281/292)	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.71	1.50	1.5	0.99	0.78	0.68 – 1.5
Total Kjeldahl Nitrogen (method AN281/292)	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.76	1.4	1.08	1.08	0.76 – 1.4
Total Phosphorus	mg/L	0.02	0.02	0.02	0.01	0.02	0.01	NA	0.01	0.03	0.01	0.01	0.02	0.02	0.03	0.02	0.02	0.02	0.01 – 0.1

Analyte	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Mean	Median	Min - Max
Ammonia Nitrogen NH3-N	mg/L	0.02	NA	NA	NA	NA	NA	<0.01	NA	NA	NA	NA	NA	NA	NA	NA	0.02	0.02	0.01 – 0.02
Ortho Phosphorus, PO4-P	mg/L	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.002	0.003	0.003	<0.002	<0.002	<0.002	0.003	<0.002	<0.002	0.0026	0.003	0.002 – 0.003
Nitrite, NO2 (method AN258)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	1.30	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.13	0.05	0.05 – 1.3
TRH C6-C9 (reporting limit = <0.04 mg/L)	mg/L	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.04	<0.04	<0.04 - <0.04
TRH C10-C14 (reporting limit = <0.04 mg/L)	mg/L	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.04	<0.04	<0.04 - <0.04
TRH C15-C28 (reporting limit = <0.2 mg/L)	mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.2	<0.2	<0.2 - <0.2
TRH C29-C36 (reporting limit = <0.2 mg/L)	mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.2	<0.2	<0.2 - <0.2

Analyte	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Mean	Median	Min - Max
TRH C6-C9 (reporting limit = <40 mg/L)	µg/L	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40 - <40
TRH C10-C14 (reporting limit = <40 mg/L)	µg/L	<40	<40	<40	<40	<40	<40	<50	<50	<50	<50	<50	100	<40	<50	<50	48.67	50	40 - 100
TRH C15-C28 (reporting limit = <200 mg/L)	µg/L	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	1300	<200	230	<200	275.3	200	200 - 1300
TRH C29-C36 (reporting limit = <200 mg/L)	µg/L	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200 - <200
TRH Surrogate	%	31	32	39	38	53	38	34	23	58	50	77	68	68	72	79	49.4	50	23 - 79

Notes:

NA = data not available

Table 4-3: Water quality analysis for Lake Richmond Stormwater Outlet

Analyte	Units	Sept
Date Sampled	-	21/9/10
pH	pH Units	8.1
Conductivity@25degC	µS/cm	1000
Total Dissolved Solids @ 180degC	mg/L	570
Soluble Iron, Fe	mg/L	<0.02
Sodium, Na	mg/L	97
Potassium, K	mg/L	5.7
Calcium, Ca	mg/L	29
Magnesium, Mg	mg/L	51
Chloride, Cl	mg/L	170
Carbonate, CO3	mg/L	35
Bicarbonate, HCO3	mg/L	200
Sulphate, SO4	mg/L	65
Nitrate, NO3	mg/L	<0.05
Fluoride, F	mg/L	0.9
Soluble Manganese, Mn	mg/L	<0.005
Soluble Silica, SiO2 *	mg/L	10
Cation/Anion balance	%	-2
Sum of Ions (calc.)	mg/L	636
Total Suspended Solids @103degC	mg/L	<5
Dissolved Oxygen	mg/L	8.4
Soluble Arsenic, As	mg/L	<0.02
Soluble Cadmium, Cd	mg/L	<0.001

Analyte	Units	Sept
Soluble Chromium, Cr	mg/L	<0.005
Soluble Copper, Cu	mg/L	<0.005
Soluble Lead, Pb	mg/L	<0.005
Soluble Mercury, Hg	mg/L	<0.0001
Soluble Nickel,Ni	mg/L	<0.005
Soluble Zinc, Zn	mg/L	<0.005
Turbidity	NTU	1.7
Colour (Apparent)	PCU	19
Total Nitrogen	mg/L	0.75
Total Phosphorus	mg/L	0.03
Ammonia Nitrogen NH3-N	mg/L	NA
Ortho Phosphorus, PO4-P	mg/L	0
Nitrite, NO2	mg/L	<0.05
TRH C6-C9	mg/L	NA
TRH C10-C14	mg/L	NA
TRH C15-C28	mg/L	NA
TRH C29-C36	mg/L	NA
TRH C6-C9	µg/L	<40
TRH C10-C14	µg/L	<50
TRH C15-C28	µg/L	<200
TRH C29-C36	µg/L	<200
TRH Surrogate	%	32

4.3 Stratification Data

The stratification data collected at all three sites in the Lake during the review period are illustrated in Figures 4-6 to 4-20. Depths are provided in m AHD which are based on the DoW stadia water level readings.

Lake Richmond 1 Stratification Data

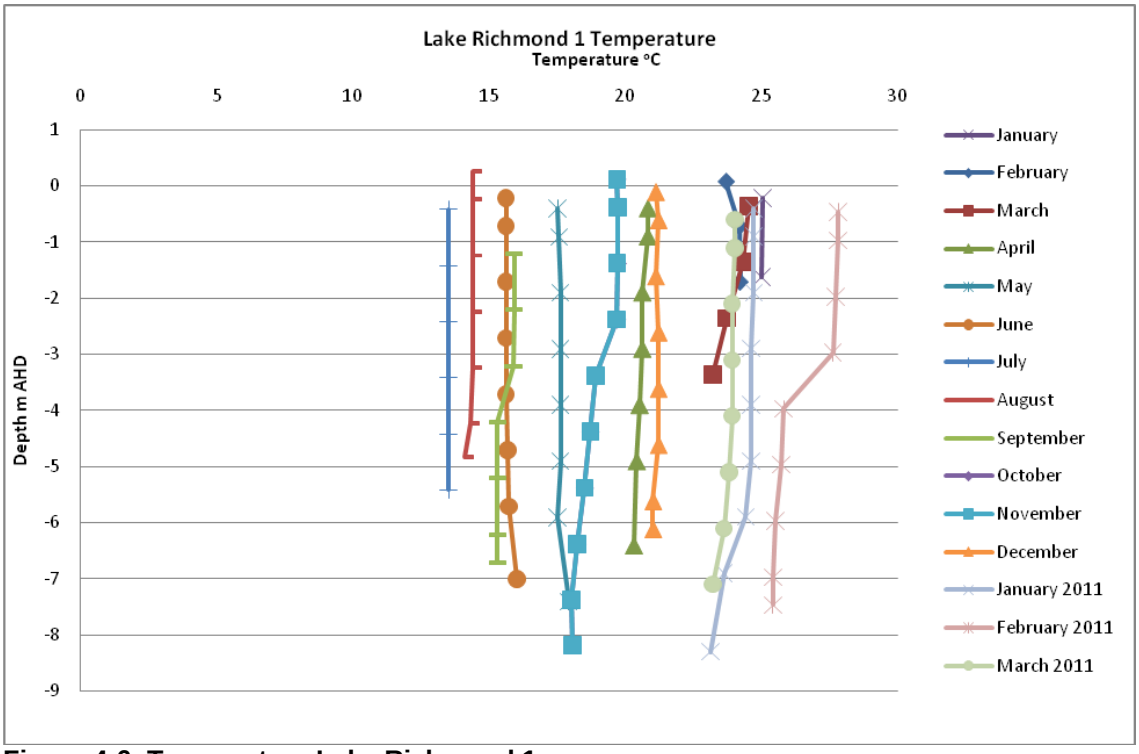


Figure 4-6: Temperature Lake Richmond 1

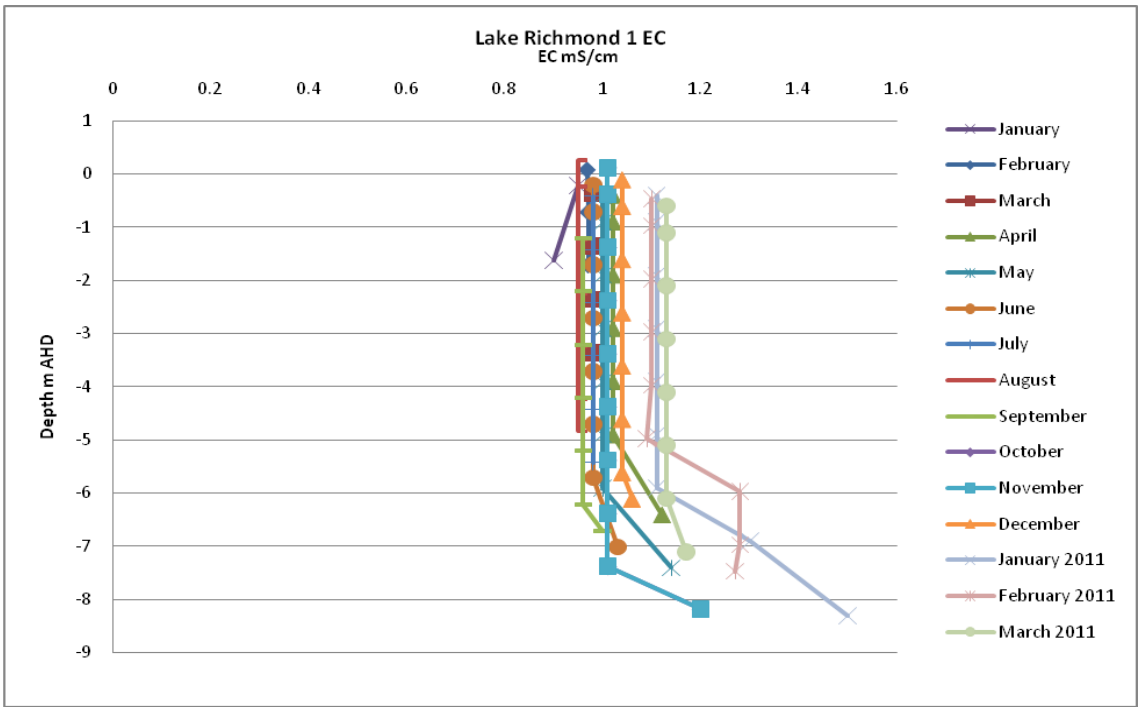


Figure 4-7: EC Lake Richmond 1

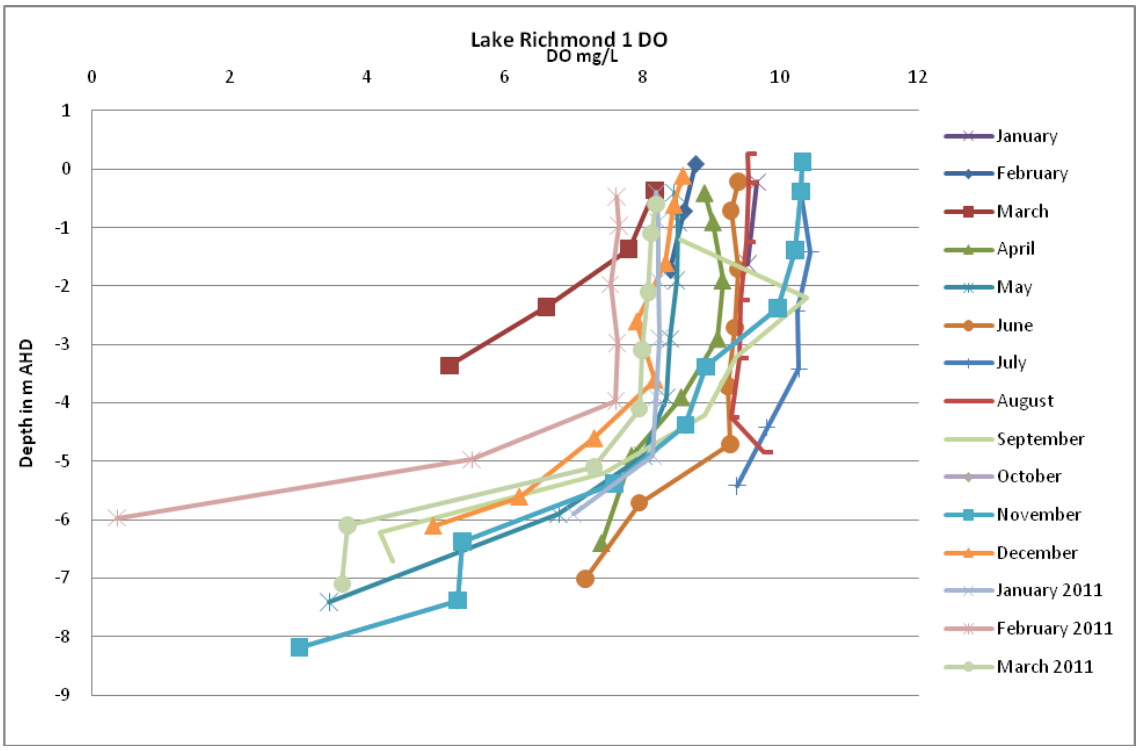


Figure 4-8: DO Lake Richmond 1

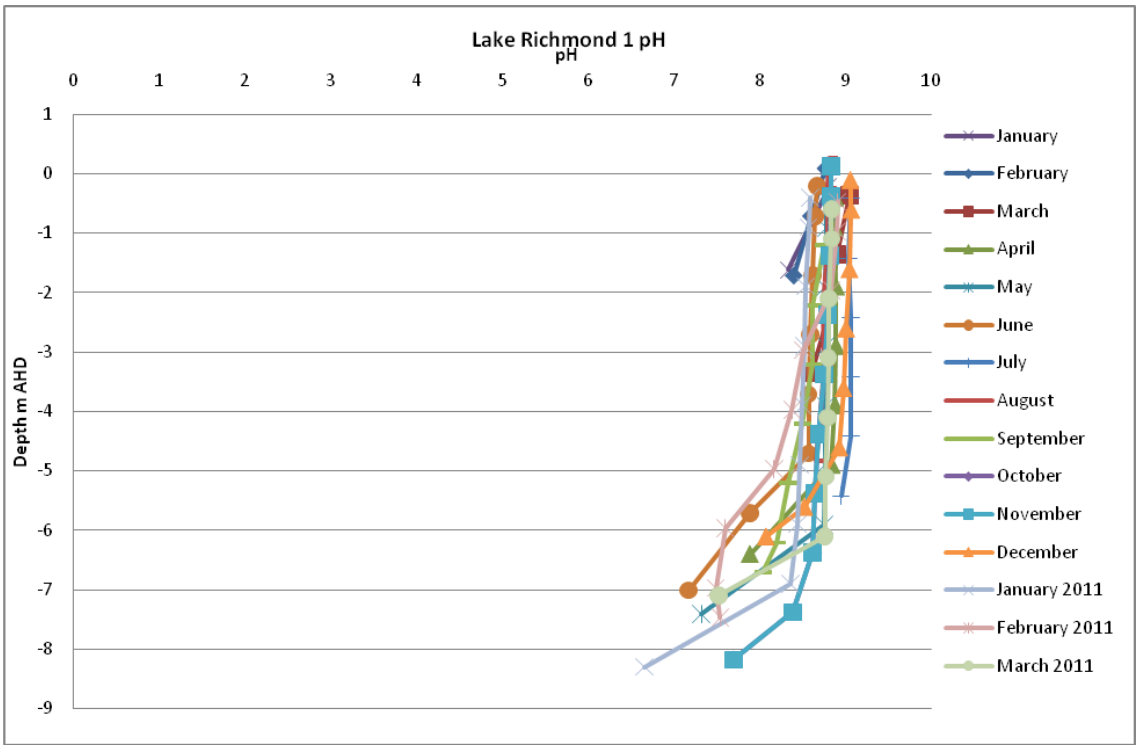


Figure 4-9: pH Lake Richmond 1

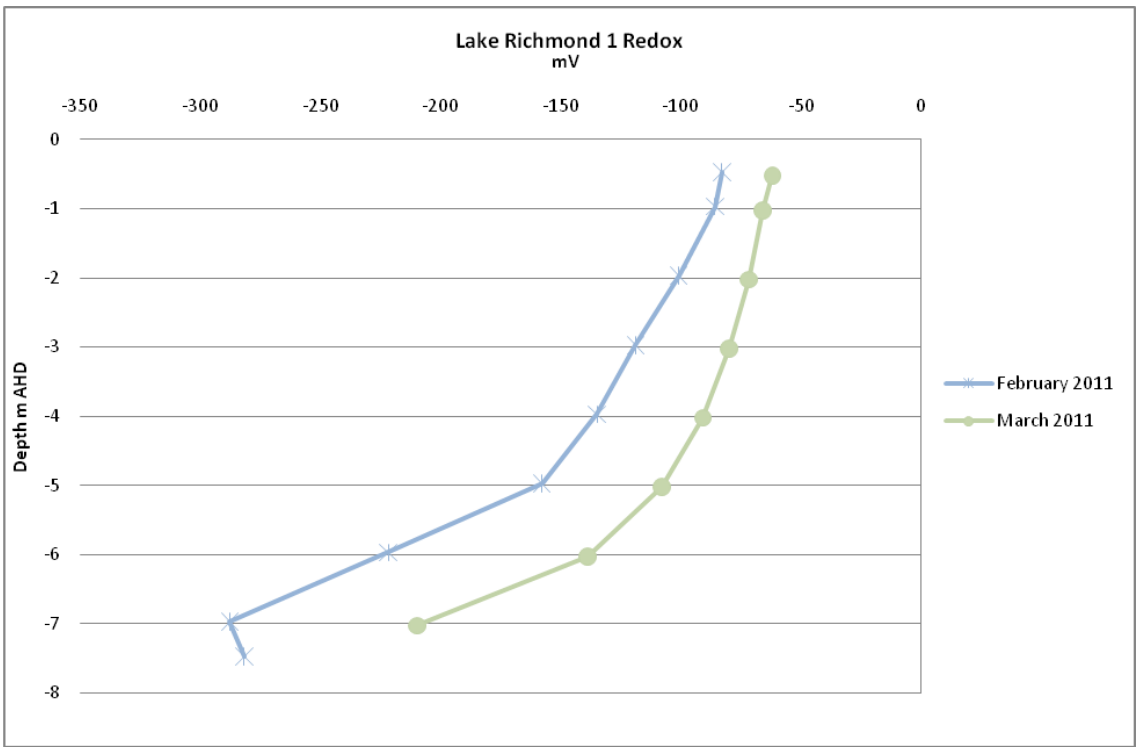


Figure 4-10: Redox Lake Richmond 1

Lake Richmond 2 Stratification Data

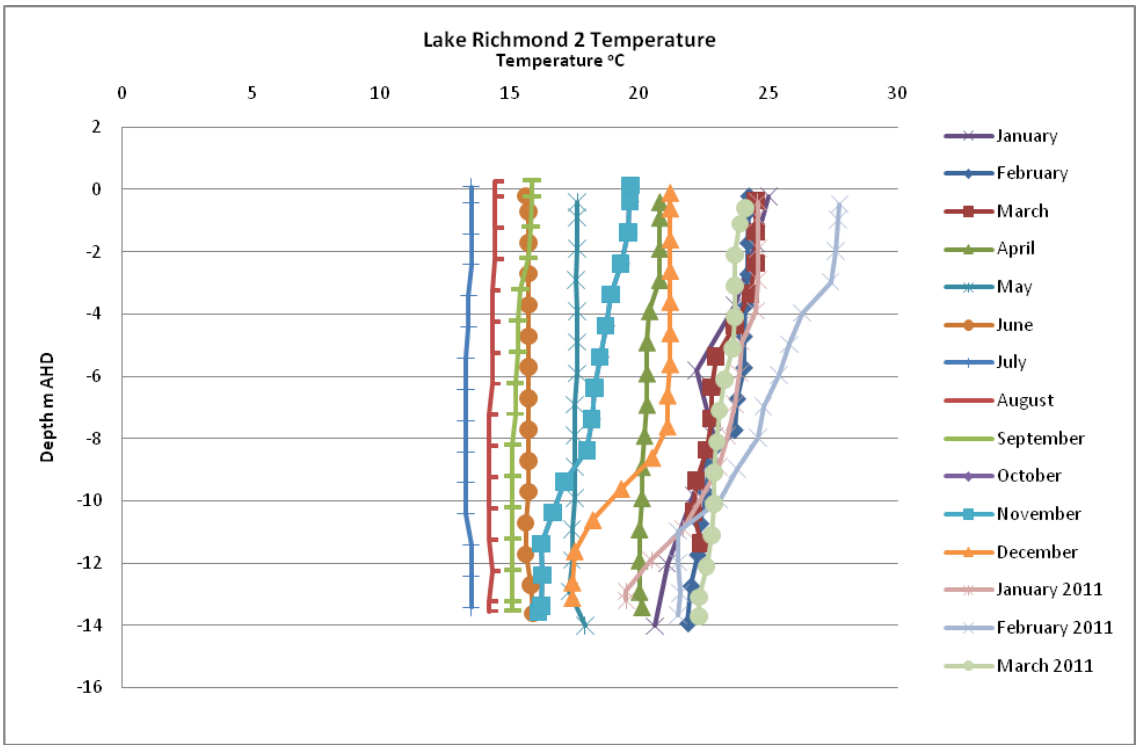


Figure 4-11: Temperature Lake Richmond 2

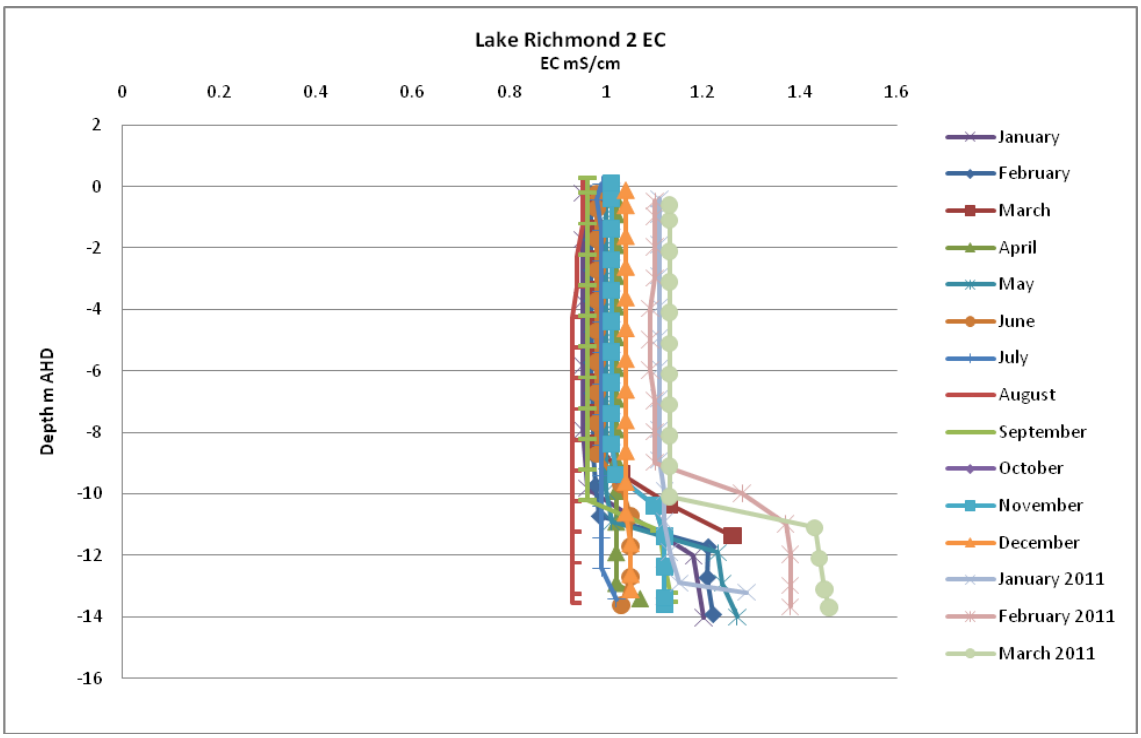


Figure 4-12: EC Lake Richmond 2

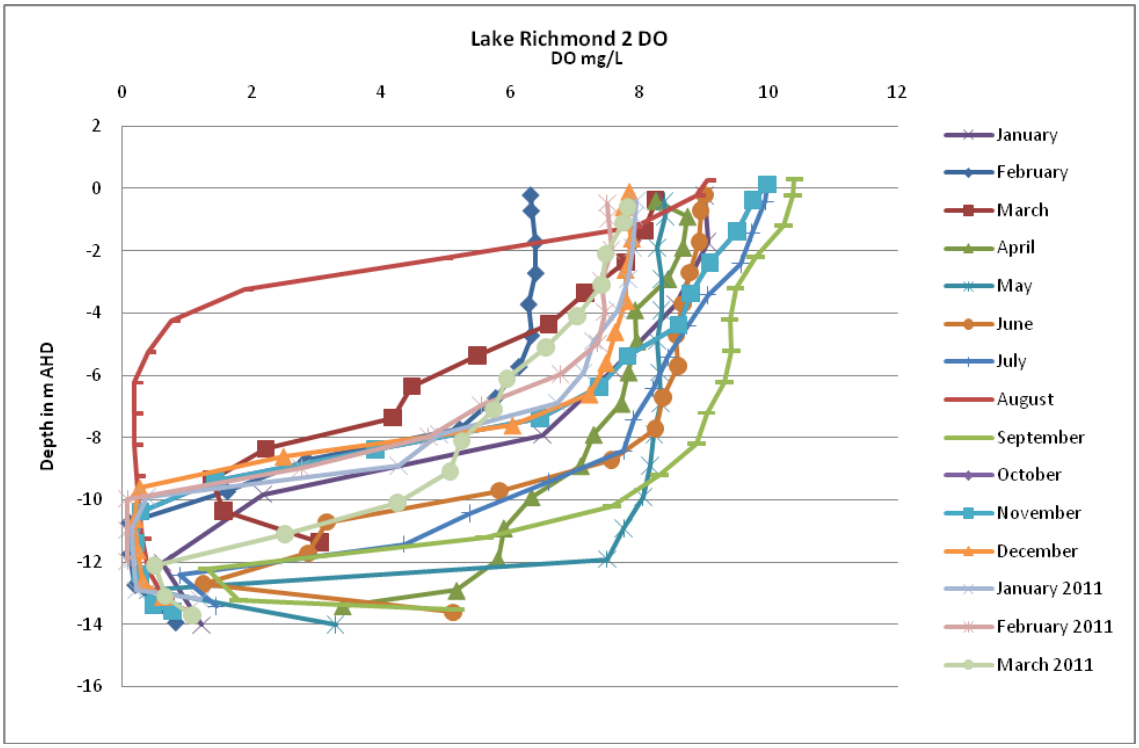


Figure 4-13: DO Lake Richmond 2

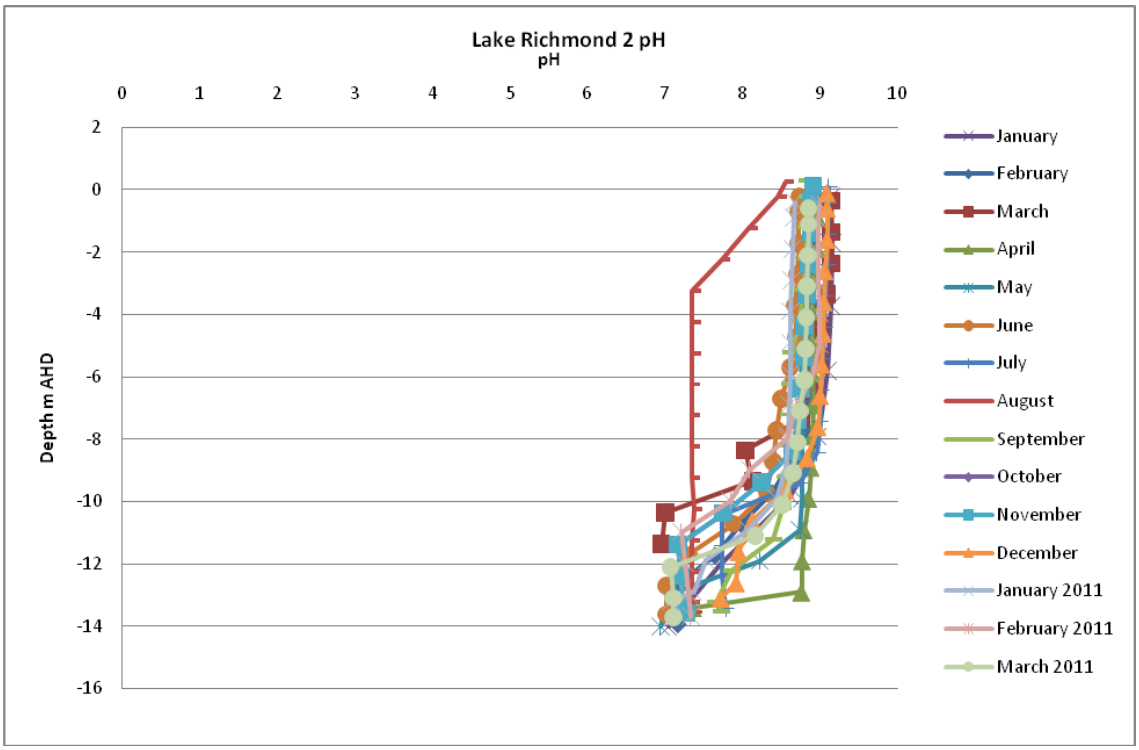


Figure 4-14: pH Lake Richmond 2

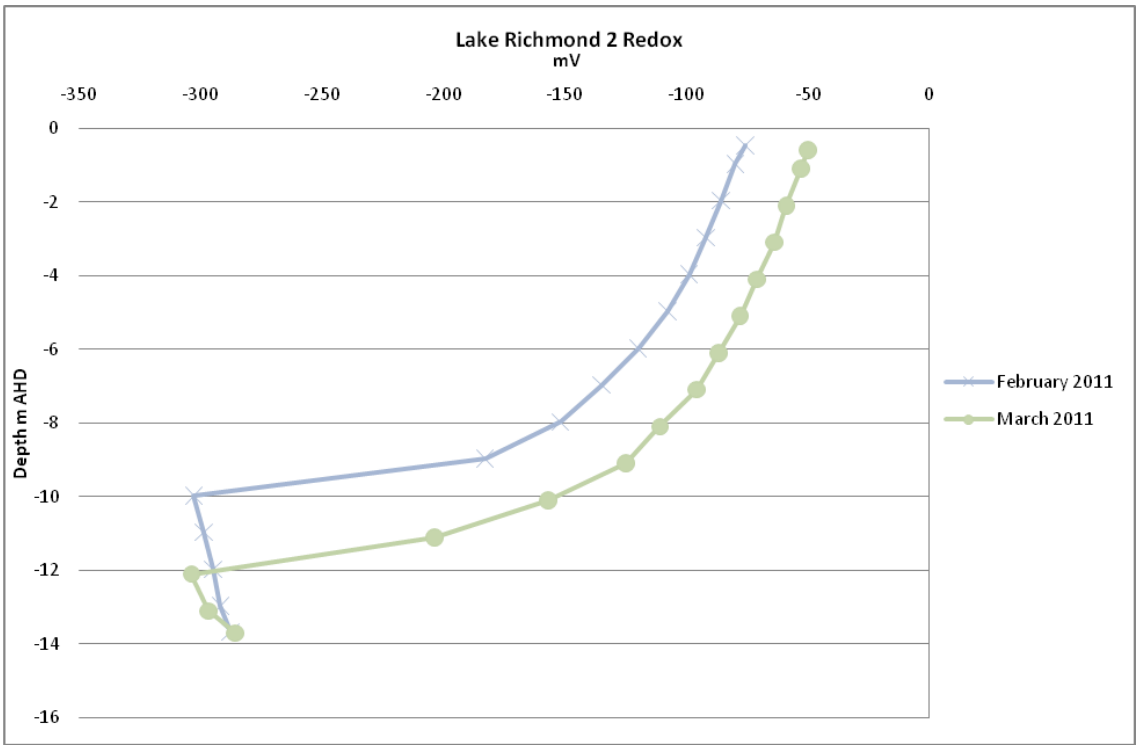


Figure 4-15: Redox Lake Richmond 2

Lake Richmond 3 Stratification Data

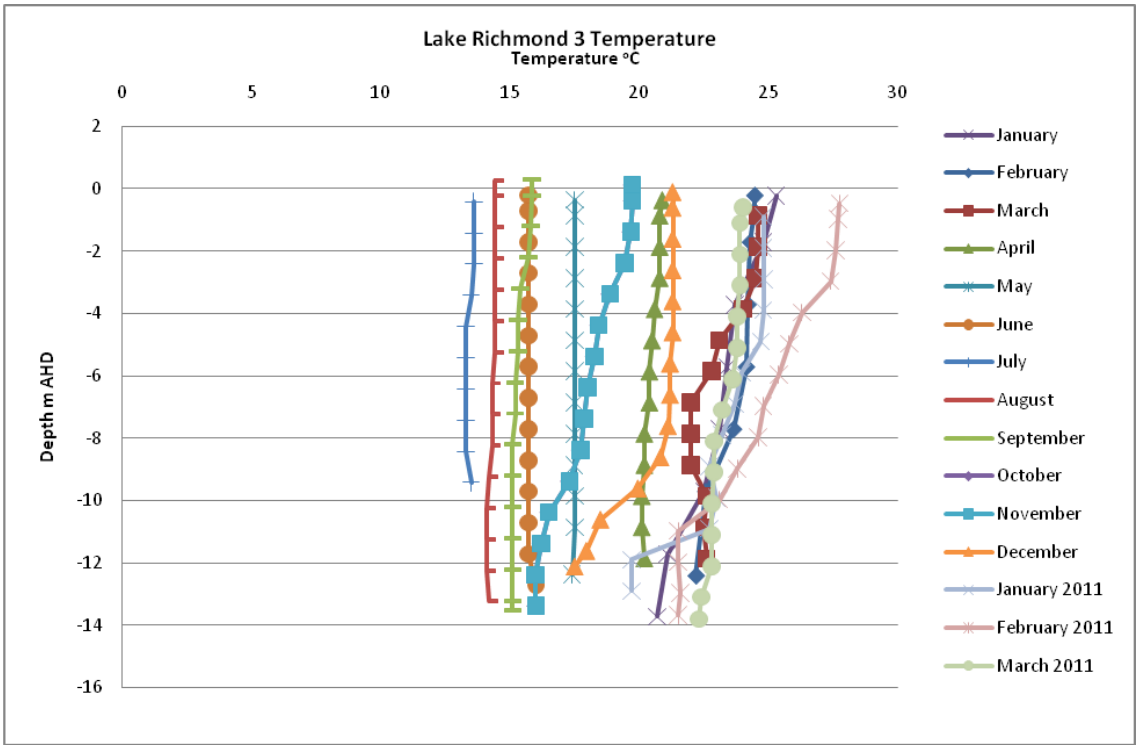


Figure 4-16: Temperature Lake Richmond 3

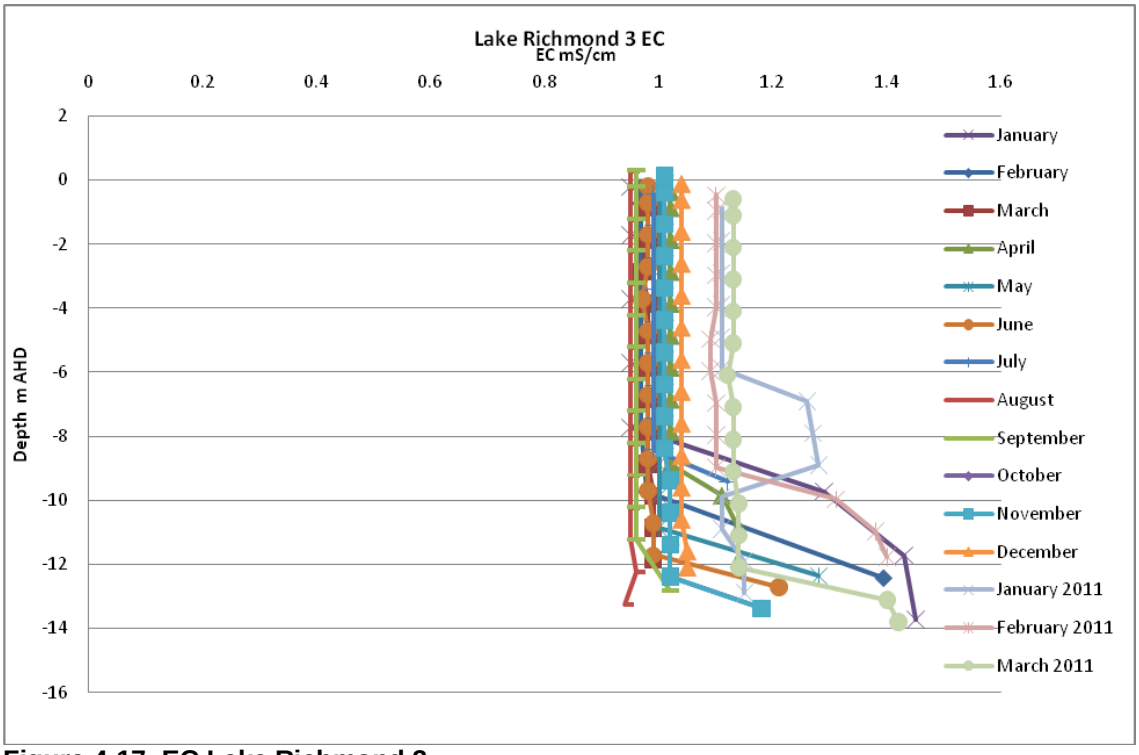


Figure 4-17: EC Lake Richmond 3

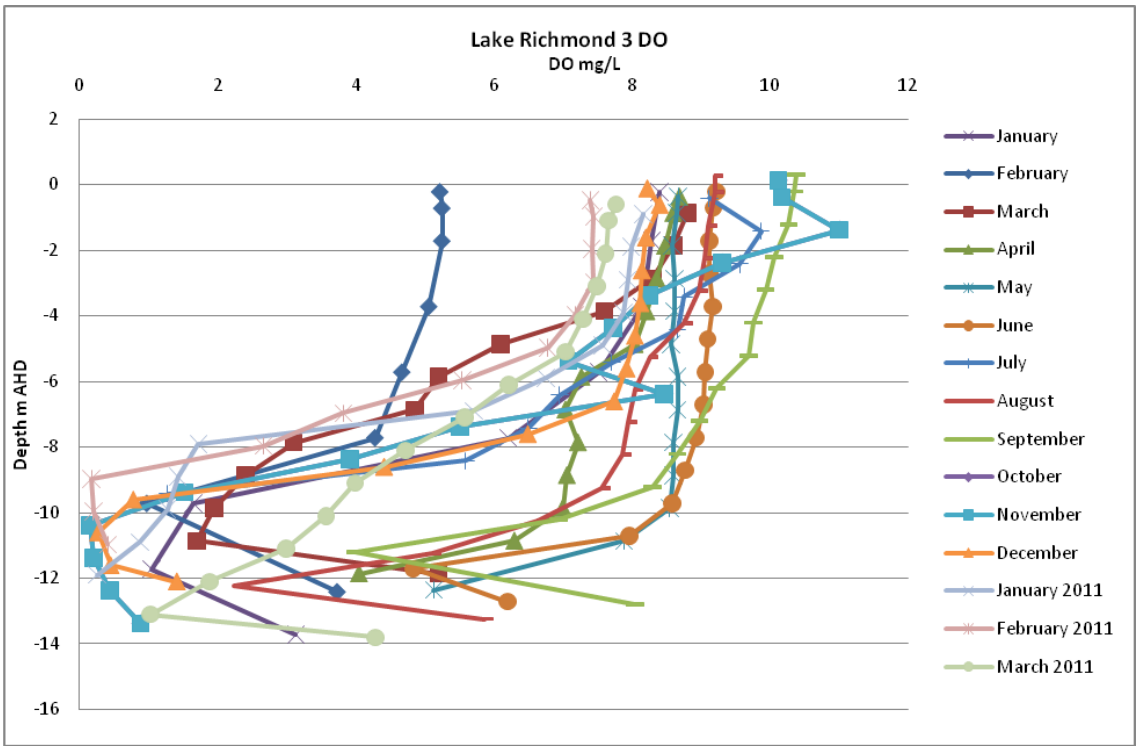


Figure 4-18: DO Lake Richmond 3

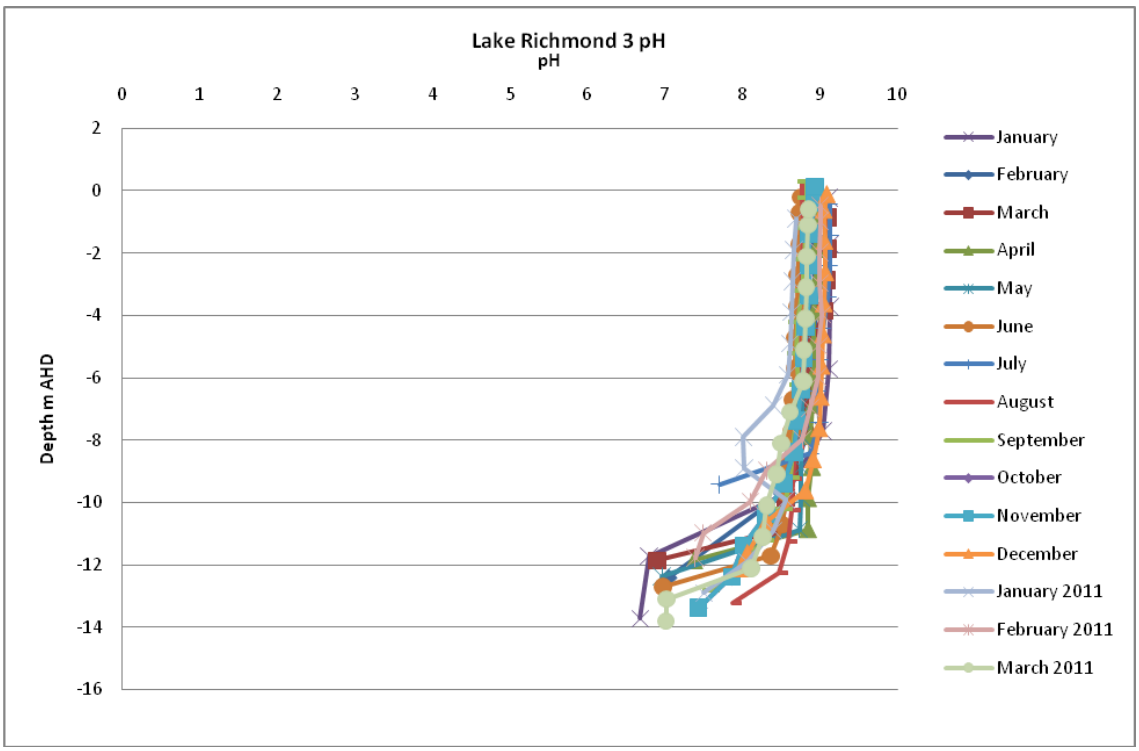


Figure 4-19: pH Lake Richmond 3

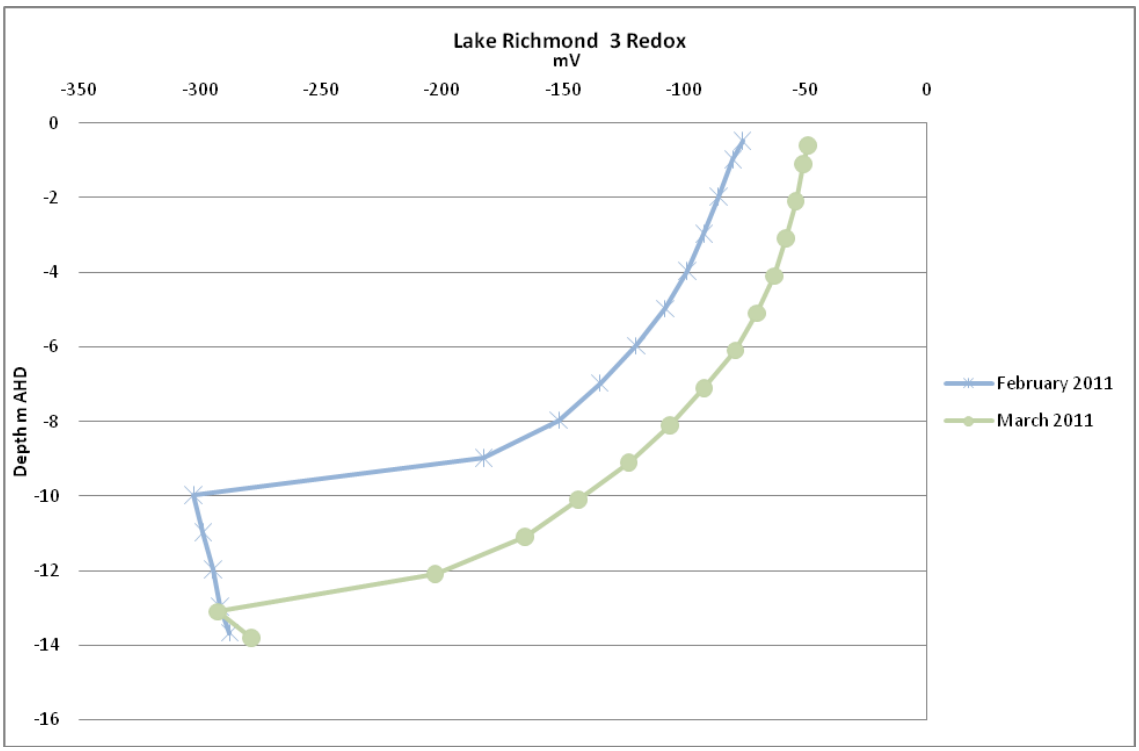


Figure 4-20: Redox Lake Richmond 3

4.4 Depth Transects

The six depth transects of the Lake completed on 18 January 2010 are illustrated in Figures 4-21 to 4-26. The location of the transects are shown in Figure 3-1. All levels relate to the Lake's surface water level on 18 January 2010 (stadia level = 0.28 m AHD).

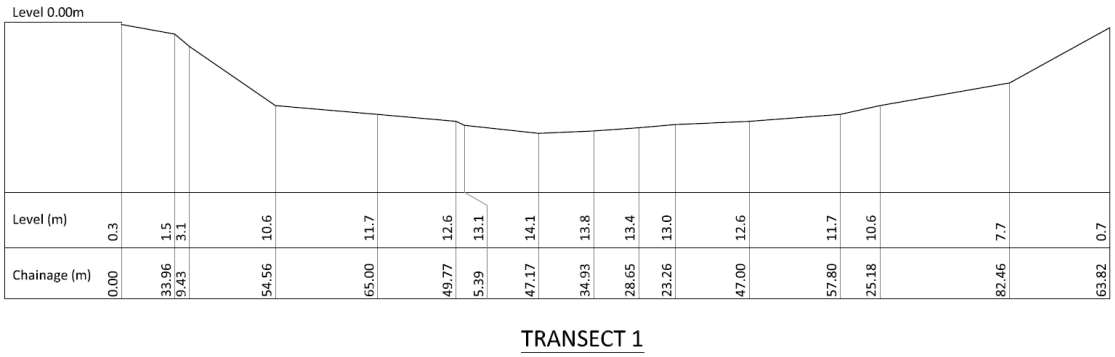


Figure 4-21: Depth transect 1

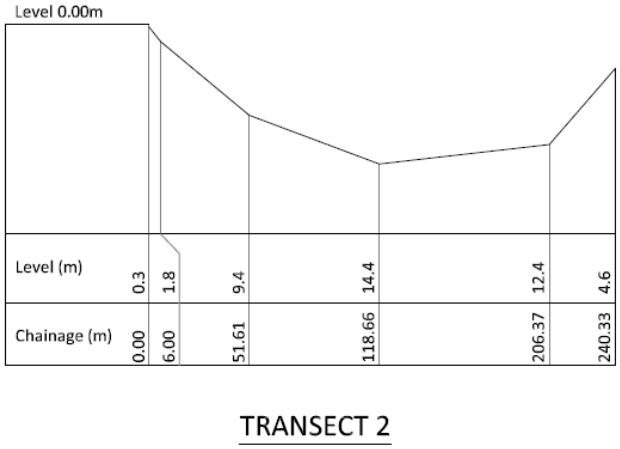


Figure 4-22: Depth transect 2

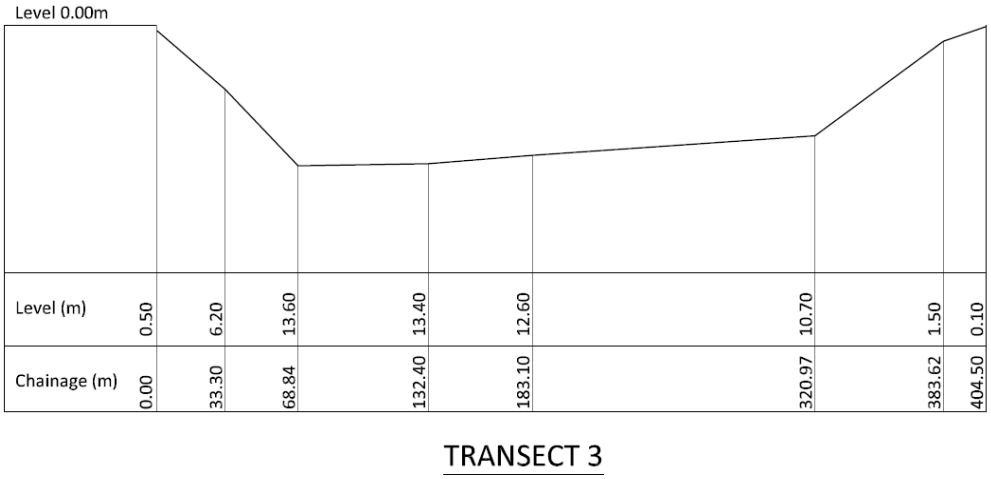
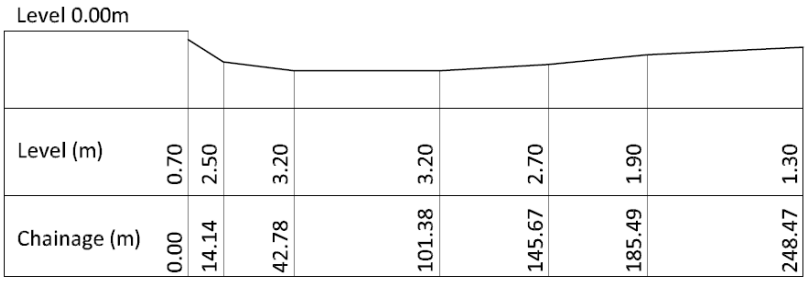
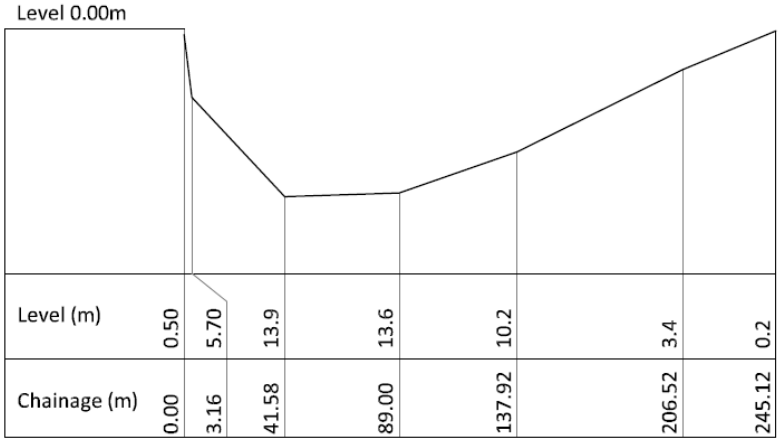


Figure 4-23: Depth transect 3



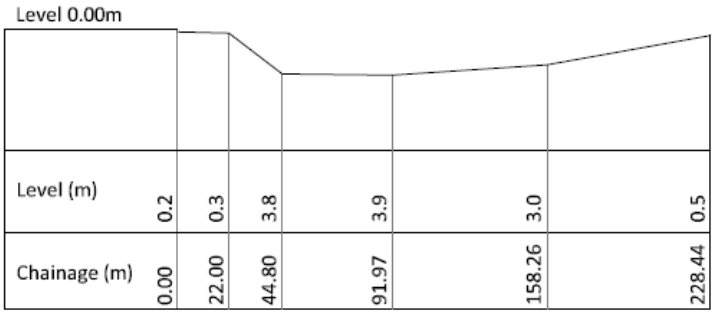
TRANSECT 4

Figure 4-24: Depth transect 4



TRANSECT 5

Figure 4-25: Depth transect 5



TRANSECT 6

Figure 4-26: Depth transect 6

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Appendix A Historic Monitoring Details for Lake Richmond

Table A-1: Site Details of Monitoring Sites within Lake Richmond Reserve (DoW, 2009)

WIN Site Id	AWRC Reference	AWRC Context Name	AWRC Name	Easting	Northing	Commenced	Owning Authority
13662	6142501	LAKES AND WETLANDS	LAKE RICHMOND	378808	6427609	15/08/1945	Department of Water
23002414	6141692	LAKE RICHMOND	OUTLET	378517	6427522	01/06/2002	Department of Water
23015714	6140792	MANGLES BAY DRAIN	MANGLES BAY DRAIN	378617	6427521	14/11/2003	Cockburn Sound Management Council
23015717	6140794	ROCKINGHAM NORTH DRAIN	ROCKINGHAM NORTH DRAIN	379496	6427310	14/11/2003	Cockburn Sound Management Council
23015718	6140795	ROCKINGHAM CENTRAL DRAIN	ROCKINGHAM CENTRAL DRAIN	379268	6426664	14/11/2003	Cockburn Sound Management Council
23015720	6140796	LAKE RICHMOND	LAKE RICHMOND CENTRAL	379045	6427227	14/11/2003	Cockburn Sound Management Council
23015721	6140797	LAKE RICHMOND	LAKE RICHMOND NORTH	378808	6427335	14/11/2003	Cockburn Sound Management Council
23018873	6140774	SAFETY BAY STORMWATER DRAINAGE	NORTH OF BENT STREET	379526	6427014	26/08/2004	Department of Water

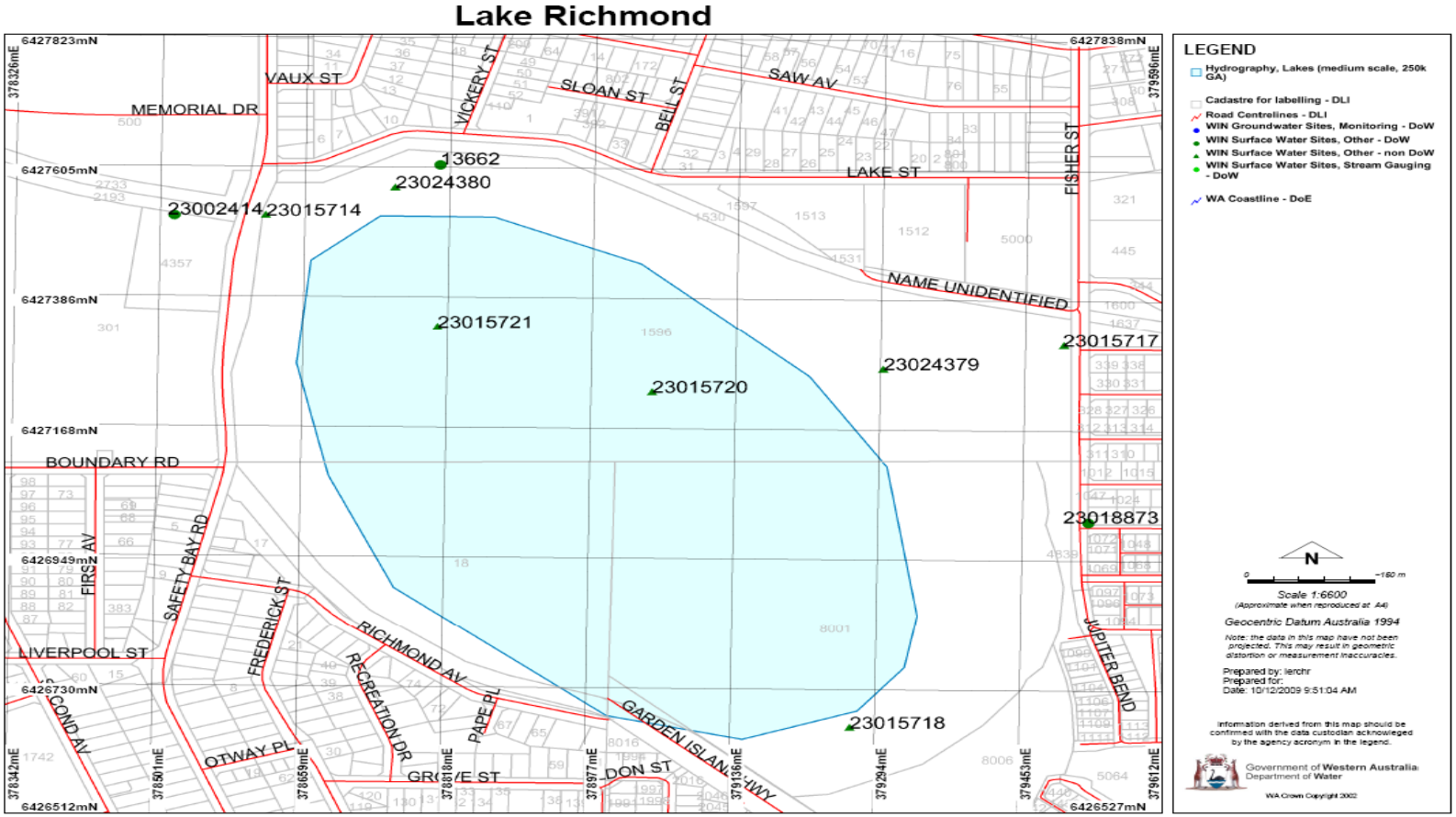

Figure A-1: Location of Monitoring Sites within the Lake Richmond Reserve (DoW, 2009)

Appendix B Monitoring Program Photographs

Photo A-1: Installation of Level TROLL 300 at DoW Stadia Site No 6142501

Photo A-2: Location of DoW stadia (site number 6141692) located at Lake Richmond outlet drain approximately 10 m west of Safety Bay Road.

Appendix C Data Logger Raw Data

(REFER TO CD)

Appendix D Water Quality Analysis

(REFER TO CD)