CANADA – BRITISH COLUMBIA
WATER QUALITY MONITORING AGREEMENT

WATER QUALITY ASSESSMENT OF COWICHAN RIVER NEAR THE MOUTH (1985 – 2003)

Prepared by:
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Environment Canada   Environnement Canada

British Columbia   Ministry of Environment

Executive Summary

The Cowichan River watershed is located in the southwest corner of British Columbia on the southeast coast of Vancouver Island. The headwaters are located in the Vancouver Island Mountains surrounding Cowichan Lake, and the river flows east to the Cowichan Bay estuary near Duncan. The water quality sampling station on the Cowichan River near the mouth is located two kilometres upstream from the Koksilah River and one kilometre downstream from the Duncan-North Cowichan treated sewage discharge. The river is one of the most important on Vancouver Island for recreational and commercial fish species, and is used for recreation and irrigation near the mouth. The main sources of contamination near the mouth are treated municipal sewage, fish hatchery effluent, agriculture, and urban development. This assessment is based on up to 19 years of water quality data during 1985-2003. The water quality trends identified below have not yet been confirmed by statistical analysis.

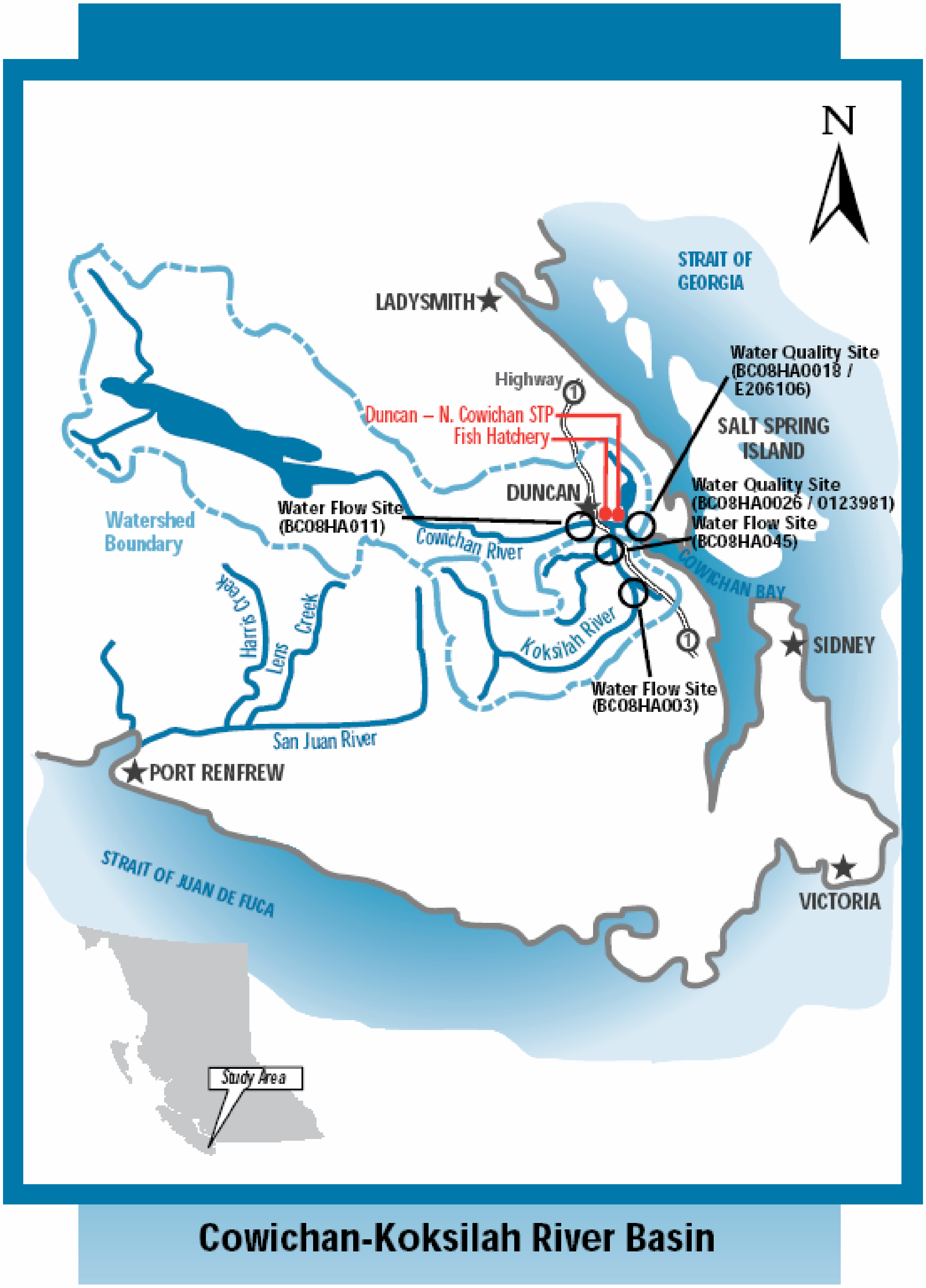
CONCLUSIONS

- The water was very soft with respect to hardness, but had a low sensitivity to acids.
- The water quality objectives for ammonia, fecal contamination, lead, and zinc were attained.
- Periphyton algal growth met the water quality objective on the one occasion when it was measured at the station in 1993, but a 1998 survey of the lower river found that the objective was exceeded downstream from the Duncan-North Cowichan sewage treatment plant outfall. There was ample nitrogen and phosphorus to support algal growth.
- Phosphorus had a declining trend in 2002-03 due to waste abatement at the Duncan-North Cowichan sewage treatment plant.
- Total copper exceeded the objectives occasionally during 1998-2003 due to elevated flow and turbidity, but dissolved copper met the objectives.
- Chromium, cobalt, iron, and manganese occasionally exceeded guidelines for drinking water aesthetics and/or aquatic life, during winter high flows due to elevated turbidity.
- Water quality objectives for dissolved oxygen were often not attained.
- Water temperatures exceeded the guideline for cold-water fish species during the summer, when the water was warm enough for swimming.
- Apparent increasing (deteriorating) trends in fecal coliforms, non-filterable residue, and turbidity were attributed to the increased sampling frequency during 2000-03.
- Apparent decreasing (improving) trends in lead, molybdenum, and zinc were attributed to decreasing minimum detectable limits over time.

RECOMMENDATIONS

- Update the zinc objectives in accordance with the new guidelines for zinc.
- Continue biweekly monitoring and reassess the data for trends in five years, when ten years of consistent, regular data are available.
- Reduce the minimum detection limit for cadmium to at least ten times below the lowest water quality guideline when the technology becomes available.

Figure 1 Map of the Cowichan-Koksilah River Basin



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1. Introduction

The Cowichan River watershed is located in the southwest corner of British Columbia on the southeast coast of Vancouver Island. The headwaters are located in the Vancouver Island Mountains surrounding Cowichan Lake, and the river flows east to the Cowichan Bay estuary near Duncan.

The Cowichan River near the mouth water quality monitoring station is located southeast from Duncan, B.C., two and one-half kilometres downstream from the Highway 1 bridge crossing of the Cowichan River, two kilometres upstream from its confluence with the Koksilah River, three kilometres upstream from Cowichan Bay, and one kilometre downstream from the Duncan-North Cowichan treated sewage discharge (PE 1497) (Figure 1). The drainage area of the river at the station is 826 km^2. The Cowichan/Koksilah watershed supports significant sport (coho and chinook salmon, steelhead, and resident and anadromous trout) and commercial (coho, chinook, and chum salmon) fish species, and the water near the mouth is used for recreation and irrigation. The main influences on water quality include the Duncan-North Cowichan treated sewage effluent, effluent from a fish hatchery two kilometres upstream from the water quality station, and non-point agricultural and urban runoff [1, 2].

Flow in the Cowichan River near Duncan (Water Survey of Canada hydrometric station BC08HA011, 826 km^2) was monitored year-round during 1960-2003. Nineteen years (1985-2003) of flow data are plotted in Figure 2a, and Figure 2b shows 1999-2003 to provide more detail on recent years. The flow has been regulated at the outlet from Cowichan Lake (596 km^2) since 1965 to provide water for the pulp mill at Crofton. The Province began collecting water quality data in 1985 and the data are stored on the Environmental Monitoring System (EMS) under site number E206106. Since June 1999, Environment Canada and B.C. have jointly operated the station as a federal-provincial station. Water quality data have been collected every two weeks since June 1999 and are stored on the ENVIRODAT database under station number BC08HA0018 and on EMS under site number E206106. Up to 19 years (1985-2003) of water quality data were used in this report. The data for the water quality indicators are plotted in Figures 3 to 18.

2. Water Quality Assessment

The status and trends of water quality were assessed by reviewing the data in Excel tables, plotting the important water quality indicators over time, and comparing the values to the Province's water quality objectives for the Cowichan River [1], or to B.C. approved [3] and working [4] water quality guidelines or Canadian water quality guidelines [5] for indicators for which objectives have not been set. Water quality indicators that were plotted include those for which water quality objectives were set, those that were monitored consistently over time, and those that exceeded water quality guidelines at times. Any levels or changes of the indicators over time that may have been harmful to sensitive water uses, such as drinking water, aquatic life, wildlife, recreation, irrigation and livestock, are described below in alphabetical order. Water quality indicators not plotted or discussed met all water quality guidelines and did not change significantly over time. These included: antimony, boron, barium, beryllium, bromide, calcium, carbon-dissolved organic, chloride, colour, fluoride, lithium, mercury, potassium, magnesium, selenium, silicon, sodium, strontium, sulphate, tellurium, tin, titanium, thallium, uranium, vanadium, and zirconium.

Before the assessment was conducted, the corrections recommended by the data approval reports [6, 7] were made, and the errors, possible errors, and probable errors identified by the reports were removed from the dataset.

Alkalinity, total (no figure) – was rarely analysed, but had a low sensitivity to acids (>20 mg/L).

Aluminum – Figure 3 – had the highest total aluminum values during winter high flows when non-filterable residue or turbidity values were elevated. Dissolved and total aluminum values were below water quality guidelines, and no change over time is apparent.

Ammonia nitrogen – Figure 4 – had all values below average aquatic life objectives [1]. There appears to have been an increasing (deteriorating) trend over time, but this impression is solely due to three higher samples in August 2001 during low flow.

Cadmium (no figure) – had high minimum detectable limits (MDL), which were at or above the water quality guideline of 0.00001 mg/L at a hardness of 30 mg/L. There were four values above the water quality guideline, two of which have been identified as an error and possible error [7]. An MDL at least 10 times below the guideline is needed to provide reliable data for comparison to the guideline.

Chlorophyll a, periphyton – (no figure) **–** was measured at the station on one occasion in August 1993, and the water quality objective [1] of an average of 50 mg/m^2 (0.05 g/m^2) was met. In September 1998, the objective was met upstream from the Duncan-North Cowichan sewage treatment plant outfall, but not met 200 m downstream from the outfall. A July 1998 survey of the river found that "large quantities of algal growth dominated much of the river from the outfall to the river mouth" [9].

Chromium (no figure) – had some high MDLs (e.g., 0.01 mg/L), which were above the aquatic life guideline (0.001 mg/L), resulting in one high detectable value, which was identified as a possible false positive error [7]. Only two of 64 total chromium values exceeded the aquatic life guideline, including the possible error above. The other value exceeding the guideline was validated as it occurred when non-filterable residue and flow were high.

Cobalt (no figure) - had one value exceeding the water quality guideline for aquatic life, and it was validated as being due to high flow and non-filterable residue [7]. For this reason, it was unlikely to have been biologically available.

Coliforms, fecal, *E. Coli*, and Enterococci – Figure 5
The water quality objectives [1] for the Cowichan River from Highway #1 to the mouth were met. There is a suggestion of an increasing (deteriorating) trend over time for fecal coliforms due to three higher values in 2001-02, but adding a variety of trendlines to the plot suggested that there was no change over time. The apparent trend is most likely due to the higher sampling frequency in 2000-03 (146 results, averaging 36/year) compared to 1985-94 (60 results, averaging 6/year), which gave a greater probability of sampling episodes of elevated fecal contamination.

Conductance, specific – Figure 6 – had no apparent change over time.

Copper - **Figure 7 –** had high MDLs (0.001 and 0.01 mg/L) during 1985-93, resulting in seven of 63 (11%) total copper measurements exceeding the average water quality objective [1] of 0.002 mg/L at hardness ≤50 mg/L. One of the seven values was validated because flow was high and subsequent measurements made with low MDLs discussed below indicate that comparable levels can occur at high flow when non-filterable residue is high. However, the other six values at moderate-low flows or non-filterable residue were identified as possible or probable false positive errors [7] and were removed. During 1998-2003, lower MDLs were used, resulting in lower levels, except when flow and non-filterable residue were high. At times, copper associated with particulate matter caused concentrations to exceed the objective, but the copper was unlikely to have been biologically available. Dissolved copper levels were always below the objective. There was no apparent change in copper levels over time.

Hardness –Figure 8 – shows that the water was very soft (<32 mg/L) and no changes over time are apparent.

Iron– Figure 9 - had 15% (7 of 47) of the total iron values exceeding the drinking water and aquatic life guidelines of 0.3 mg/L during winter, when flow was high and non-filterable residue or turbidity were elevated. The iron was unlikely to have been biologically available at these times. Dissolved iron always met the guidelines. There was no apparent change in iron over time.

Lead – Figure 10 – had three total lead values that exceeded the average water quality objective [1] of 0.003 mg/L during 1985-87 when the MDL was 0.001 mg/L, despite low non-filterable residue or flow. These values were an order of magnitude higher than the highest values measured during 1998-2003 with low-level methods for samples that contained high levels of non-filterable residue. The three values above the objective have been identified as probable errors [7] and were removed. The apparent decreasing trend in lead over time is due to decreasing MDLs.

Manganese, total – (no figure) – had two of 64 values exceed the drinking water aesthetic guideline when flow and non-filterable residue were high. Dissolved manganese was always less than the guideline.

Molybdenum, total – Figure 11 – had a high MDL of 0.01 mg/L during 1985-90, resulting in two (of 64) high detectable values at or above the 0.01 mg/L irrigation guideline, ranging from 0.01 to 0.03 mg/L. In contrast, 1998-2003 values measured with a MDL of <0.00005 mg/L, had a maximum of 0.00037 mg/L, which is 27-81 times lower. The two high detectable values were identified as probable false positive errors [7] and removed. The apparent declining trend is due to the decline in MDLs.

Nitrogen – Figure 12 – had a suggestion of slightly increasing nitrate + nitrite levels over time, although the levels were well below water quality guidelines.

Oxygen, dissolved – Figure 13 – had 21 of 45 (47%) of the June to September values below the water quality objective [1] of 8 mg/L. Dissolved oxygen was rarely measured during October to May, but three of the four measurements were below the objective of 11.2 mg/L. The water quality was rated fair in 1996, partly because the dissolved oxygen objective was regularly not met in the lower reaches of the river during 1988-93 [2].

pH – **Figure 14 –** had one low outlier in 1997, which was the only value of 124 that was outside of the drinking water guideline range of 6.5-8.5, and it has been identified as a probable error [7] and removed. There was no apparent change in pH over time.

Phosphorus – **Figure 15a –** had phosphorus levels that were relatively high and could support abundant algal growth. There was no obvious change in phosphorus levels over time in Figure 15a, but **Figure 15b** for total dissolved phosphorus for 2000-03 shows that there was an apparent declining trend. The Duncan-North Cowichan sewage treatment plant began alum addition during May through September in 2002 to reduce the phosphorus loading to the Cowichan River [8], and the lower phosphorus concentrations in the river during these periods in 2002-03 are reflected in Figure 15b.

Temperature, water – Figure 16 - had 25 of 148 values (17%) above the aquatic life guideline of 19 degrees C. These high values occurred during June and August, when the water was warm enough for water-contact recreation.

Turbidity and Residue, non-filterable – **Figure 17 –** had high values for non-filterable residue and turbidity during winter high flows, which is normal. There was one high non-filterable residue value during summer low flow, which has been identified as a probable error [7] and removed. There is an apparent increasing trend over time, but this is due to differences in sampling frequency during 1985-93 (1-10 samples/year) and 2000-03 (26-37 samples/year). Sixteen winter (October through March) results were collected during 1985-93, compared to 71 winter results during 1998-2003. The regular (biweekly) and more frequent sampling during 2000-03 resulted in more of the winter high flow events being sampled, which have high non-filterable residue and turbidity.

Zinc – Figure 18 – had three detectable total zinc values above the 0.0075 mg/L average aquatic life guideline (this value should supersede the 1989 objective of 0.03 mg/L average [1]) in 1986-87. These values have been identified as possible errors because they had a high MDL (0.005 mg/L), and were 3-10 times higher than the highest values measured with low-level methods (0.0002 mg/L MDL) in 2000-03 [7] and were removed. The apparent decreasing trend in zinc is due to declining MDLs.

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9. Rideout, Paul *et al.* 2000. A Water Quality Assessment of the Cowichan and Koksilah Rivers and Cowichan Bay. Ministry of Environment, Lands and Parks, Pollution Prevention, Vancouver Island Region.

Figure 2 Flow in the Cowichan River near Duncan, 1985-2003

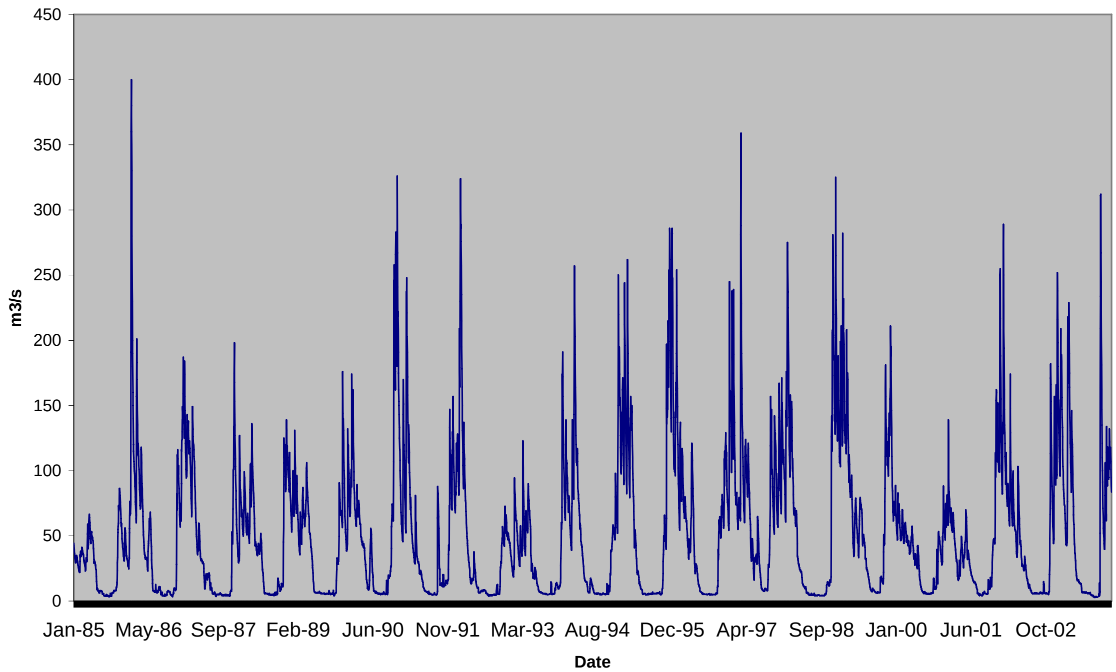
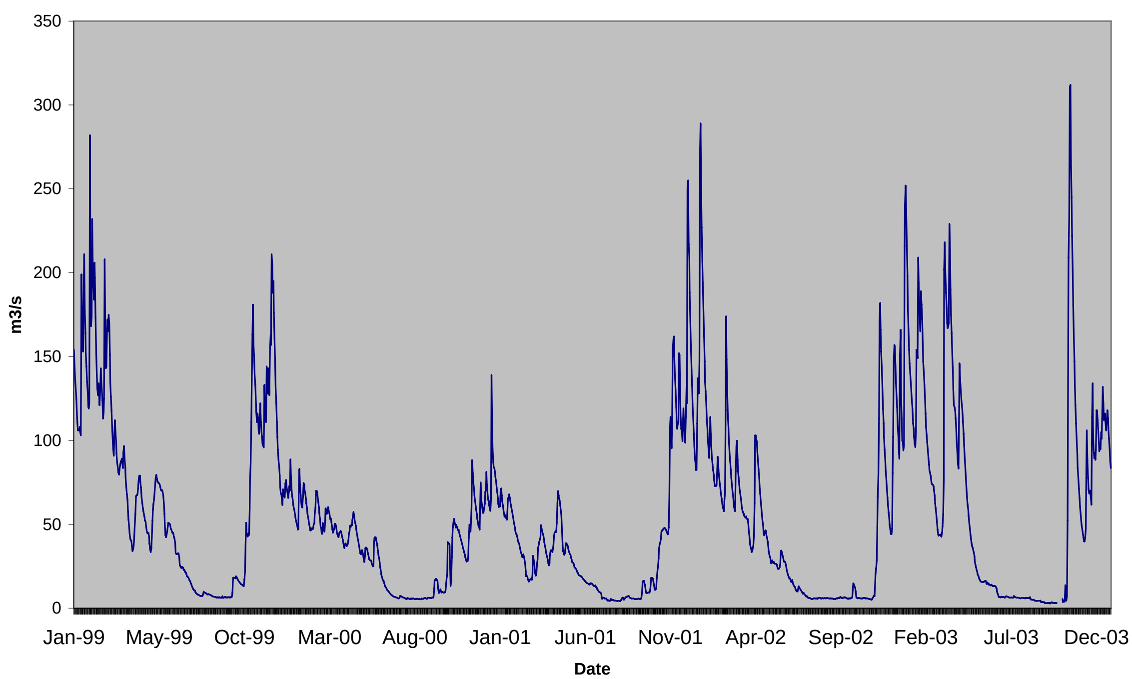


Figure 2b Flow in the Cowichan River near Duncan, 1999-2003



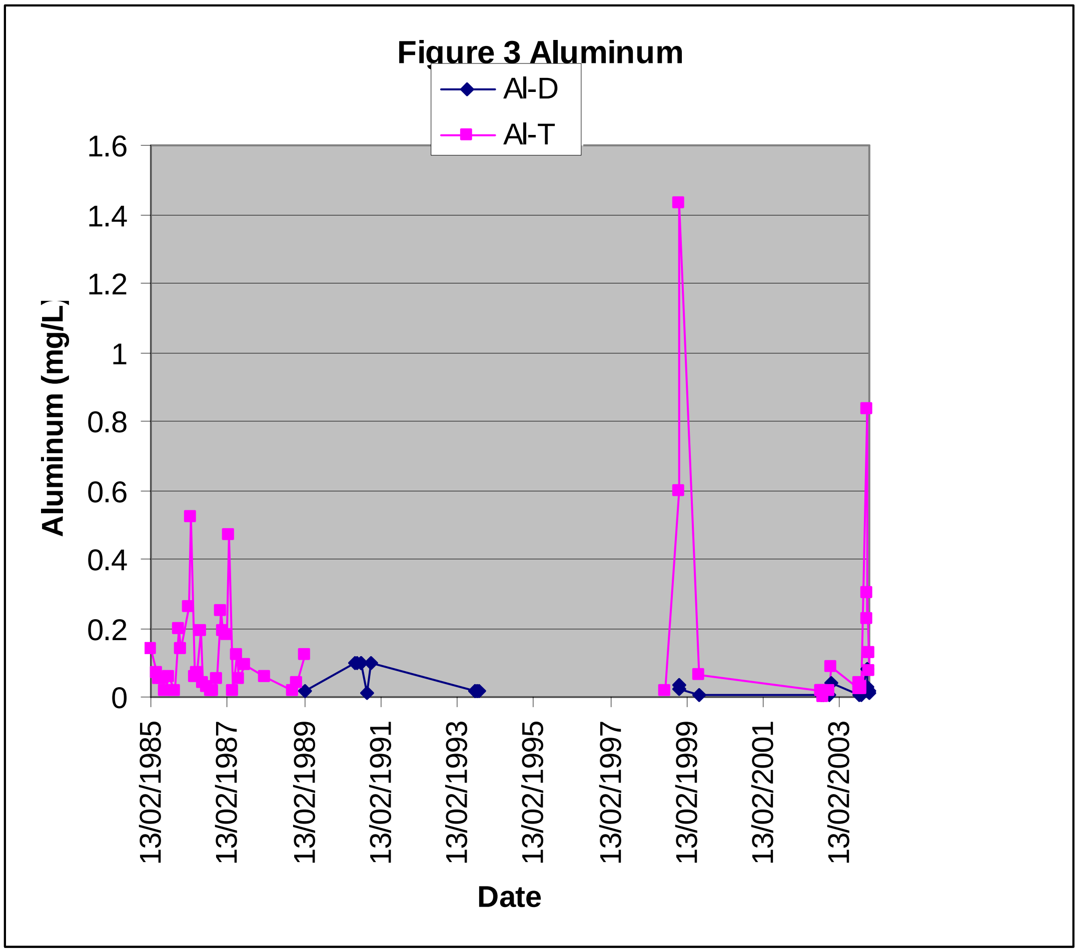


Figure 3 Aluminum
Al-D
Al-T
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Aluminum (mg/L)
13/02/1985
13/02/1987
13/02/1989
13/02/1991
13/02/1993
13/02/1995
13/02/1997
13/02/1999
13/02/2001
13/02/2003
Date

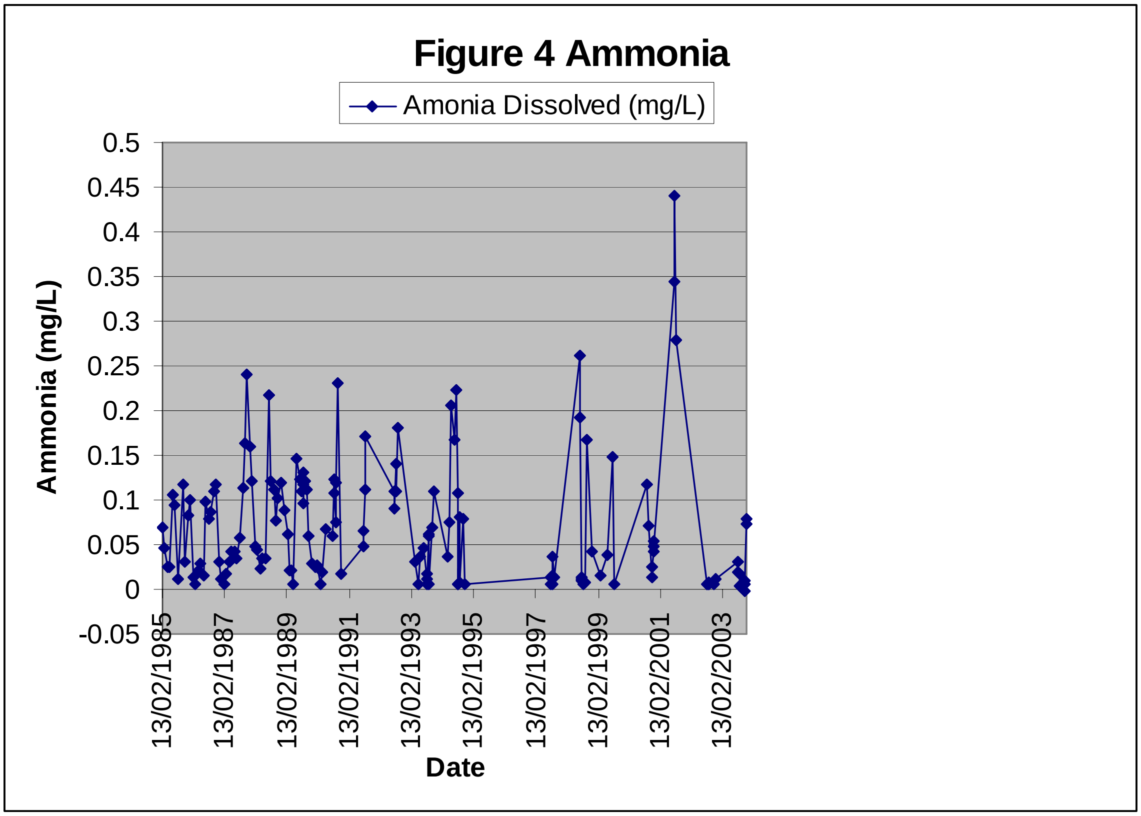


Figure 4 Ammonia
Amonia Dissolved (mg/L)
Ammonia (mg/L)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
13/02/1985
13/02/1987
13/02/1989
13/02/1991
13/02/1993
13/02/1995
13/02/1997
13/02/1999
13/02/2001
13/02/2003
Date

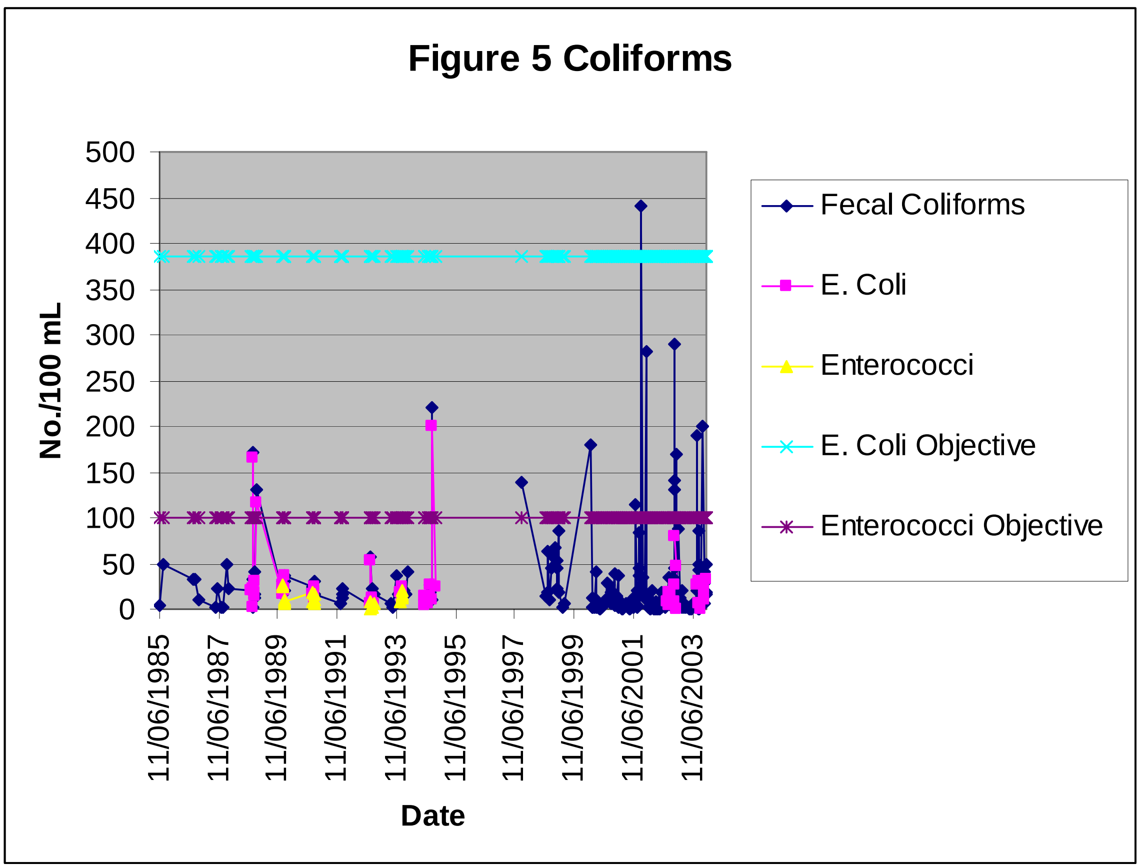


Figure 5 Coliforms
No./100 mL
500
450
400
350
300
250
200
150
100
50
0
11/06/1985
11/06/1987
11/06/1989
11/06/1991
11/06/1993
11/06/1995
11/06/1997
11/06/1999
11/06/2001
11/06/2003
Date
Fecal Coliforms
E. Coli
Enterococci
E. Coli Objective
Enterococci Objective

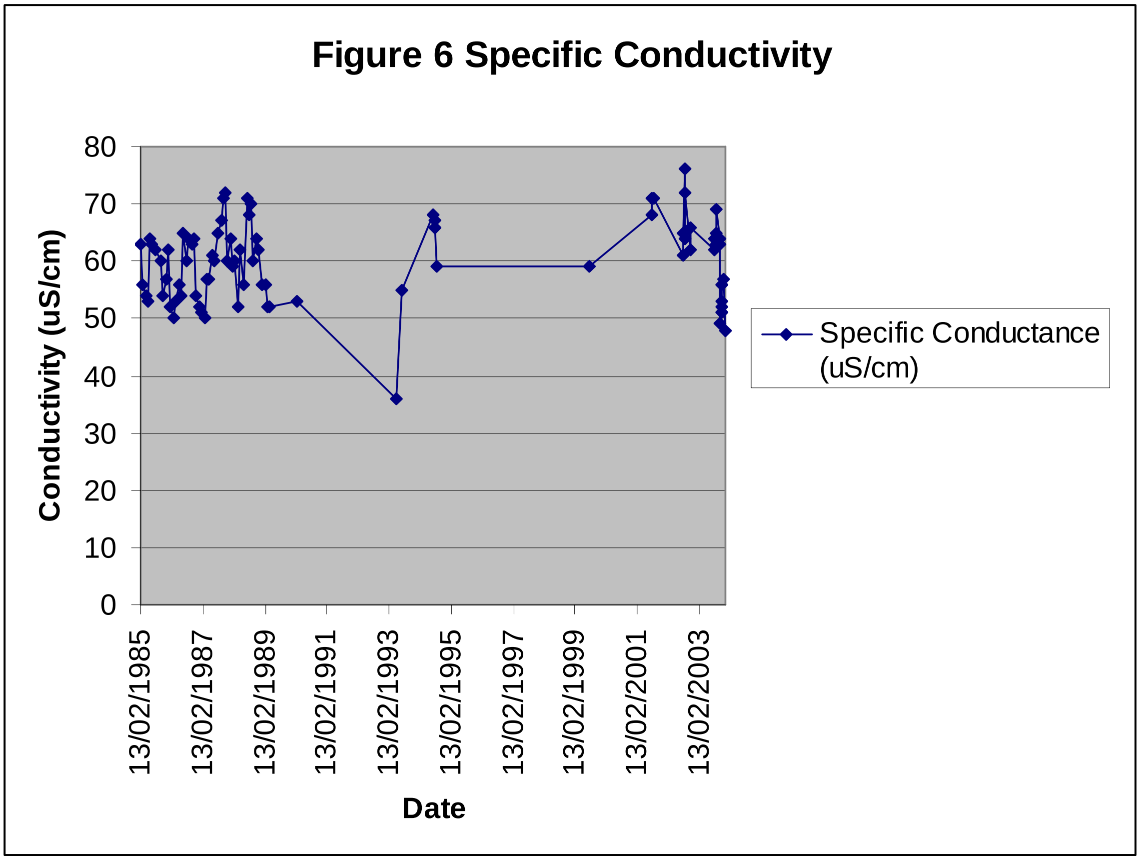


Figure 6 Specific Conductivity
Conductivity (uS/cm)
80
70
60
50
40
30
20
10
0
13/02/1985
13/02/1987
13/02/1989
13/02/1991
13/02/1993
13/02/1995
13/02/1997
13/02/1999
13/02/2001
13/02/2003
Date
Specific Conductance (uS/cm)

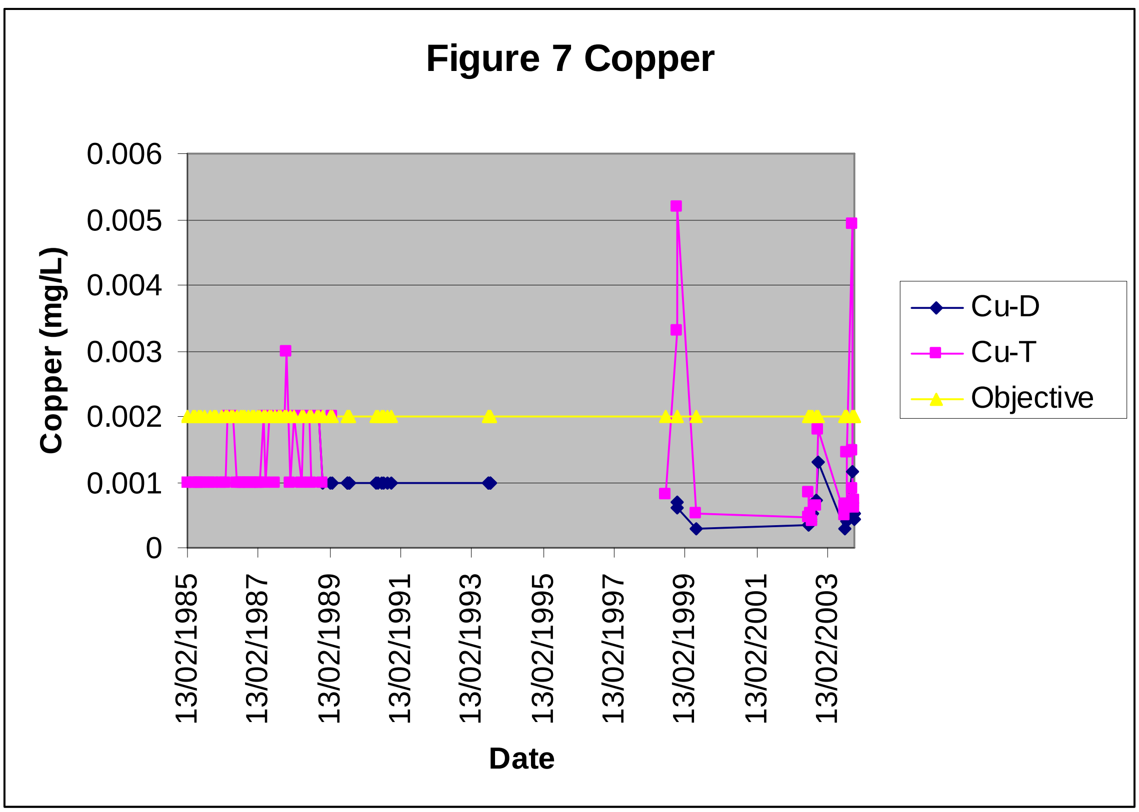


Figure 7 Copper
Copper (mg/L)
0.006
0.005
0.004
0.003
0.002
0.001
0
13/02/1985
13/02/1987
13/02/1989
13/02/1991
13/02/1993
13/02/1995
13/02/1997
13/02/1999
13/02/2001
13/02/2003
Date
Cu-D
Cu-T
Objective

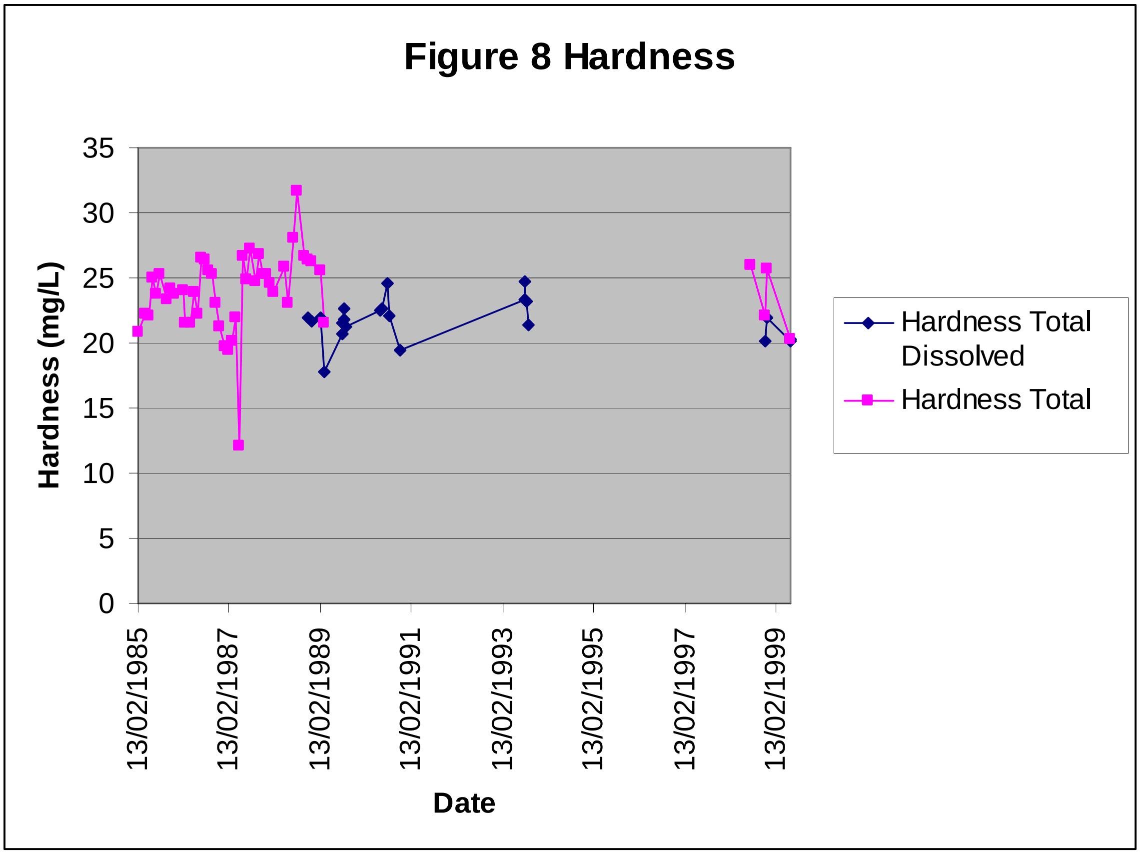


Figure 8 Hardness
Hardness (mg/L)
35
30
25
20
15
10
5
0
13/02/1985
13/02/1987
13/02/1989
13/02/1991
13/02/1993
13/02/1995
13/02/1997
13/02/1999
Date
Hardness Total Dissolved
Hardness Total

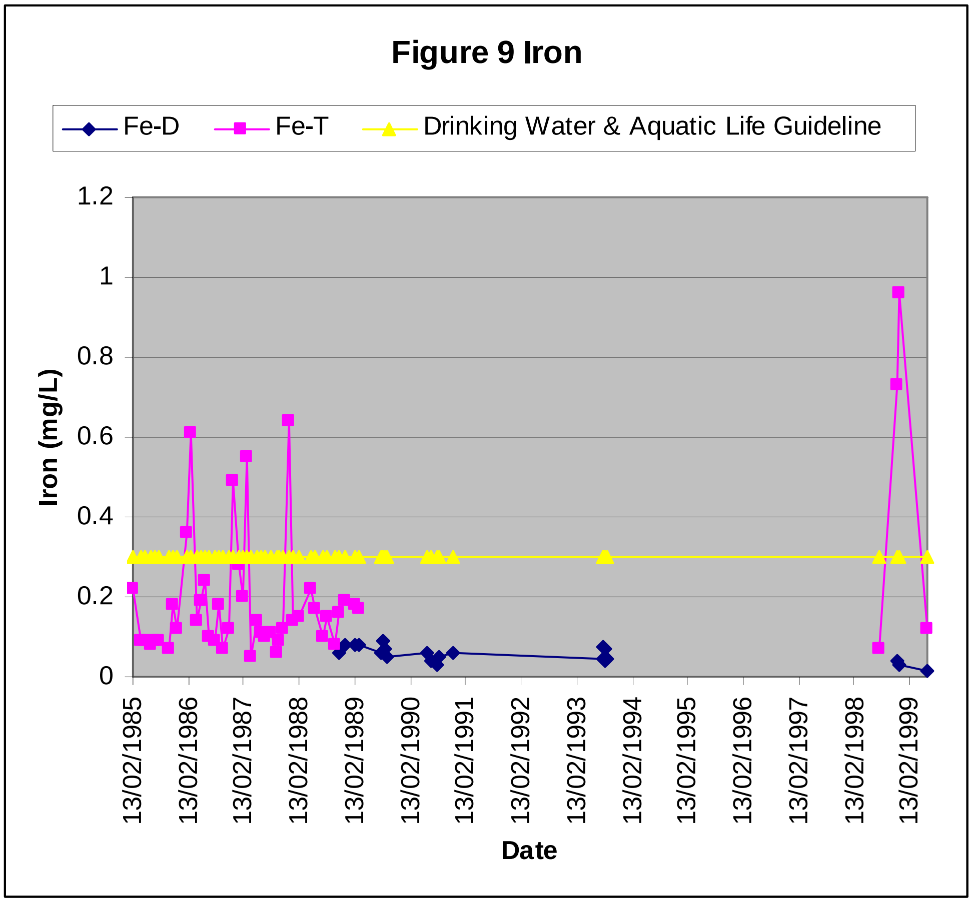


Figure 9 Iron
Fe-D
Fe-T
Drinking Water & Aquatic Life Guideline
Iron (mg/L)
1.2
1
0.8
0.6
0.4
0.2
0
13/02/1985
13/02/1986
13/02/1987
13/02/1988
13/02/1989
13/02/1990
13/02/1991
13/02/1992
13/02/1993
13/02/1994
13/02/1995
13/02/1996
13/02/1997
13/02/1998
13/02/1999
Date

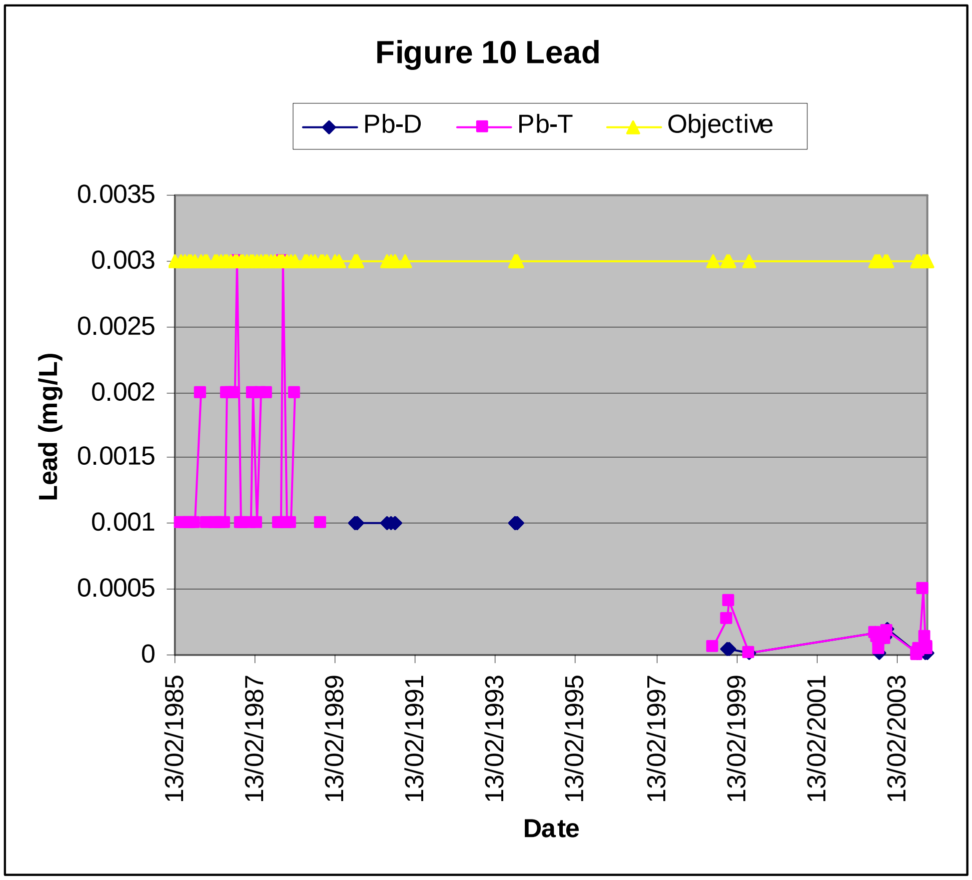


Figure 10 Lead
Pb-D
Pb-T
Objective
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
Lead (mg/L)
13/02/1985
13/02/1987
13/02/1989
13/02/1991
13/02/1993
13/02/1995
13/02/1997
13/02/1999
13/02/2001
13/02/2003
Date

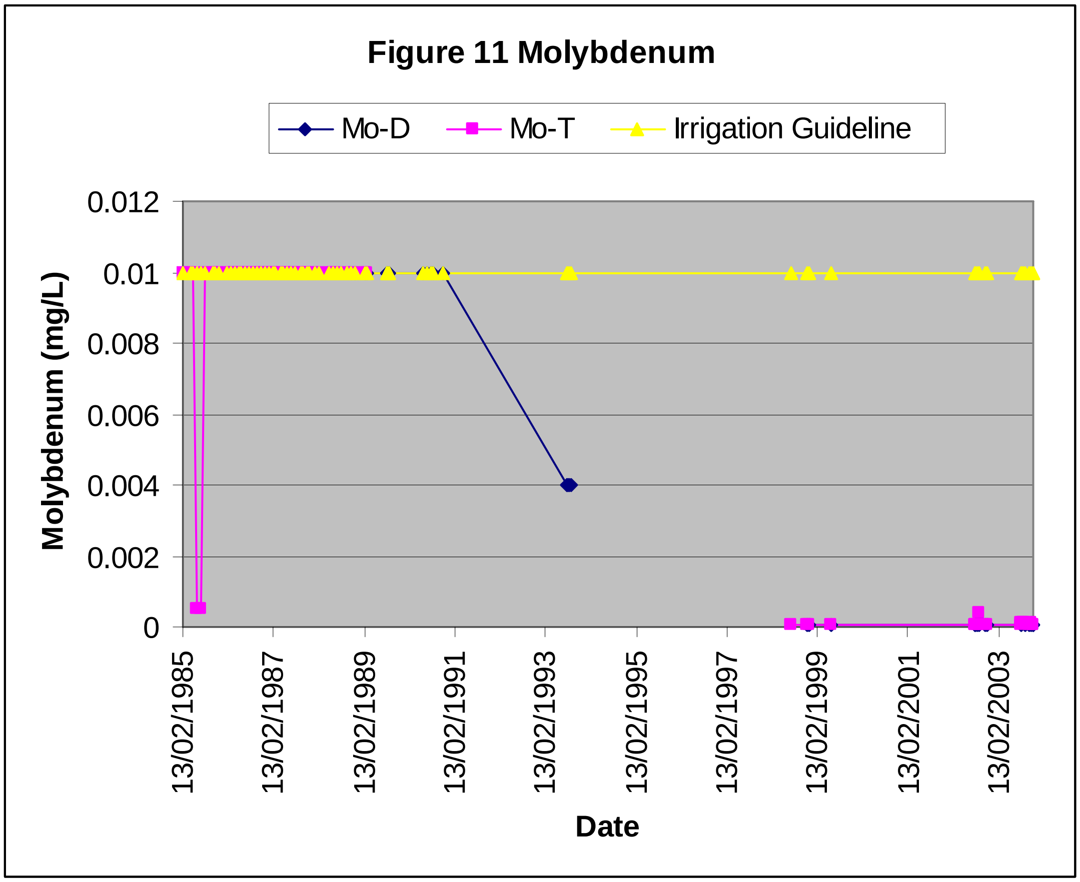


Figure 11 Molybdenum
Mo-D
Mo-T
Irrigation Guideline
Molybdenum (mg/L)
0.012
0.01
0.008
0.006
0.004
0.002
0
13/02/1985
13/02/1987
13/02/1989
13/02/1991
13/02/1993
13/02/1995
13/02/1997
13/02/1999
13/02/2001
13/02/2003
Date

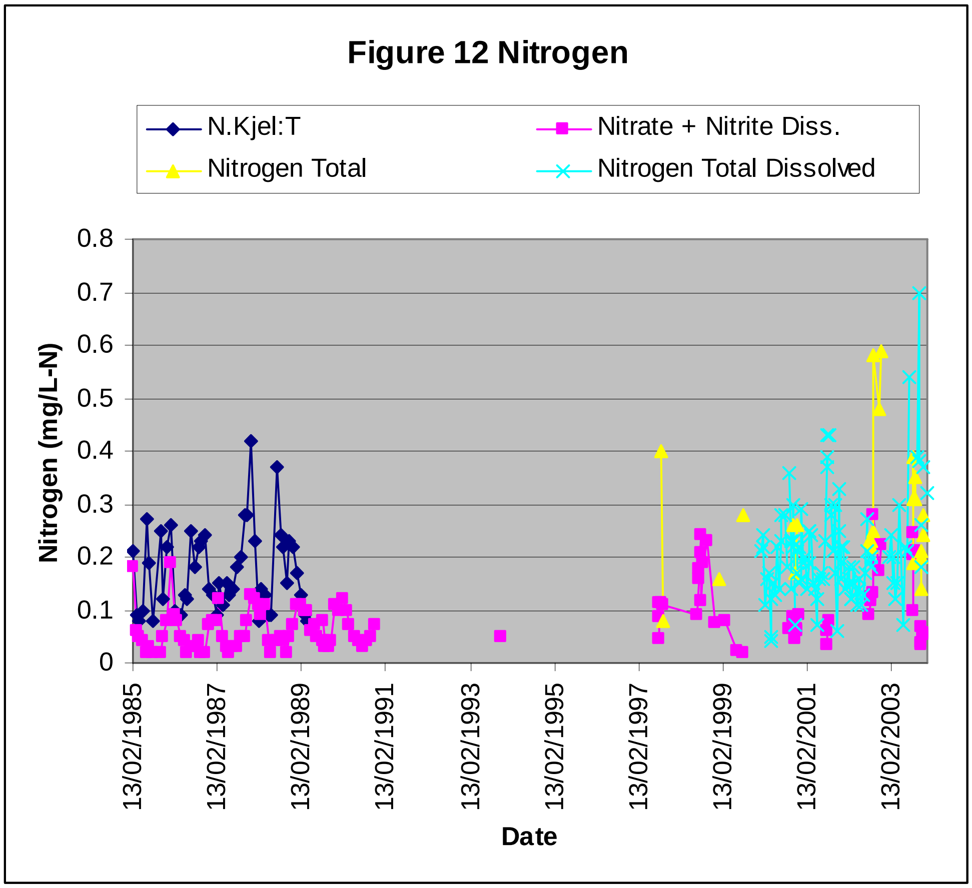


Figure 12 Nitrogen
N.Kjel:T
Nitrate + Nitrite Diss.
Nitrogen Total
Nitrogen Total Dissolved
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Nitrogen (mg/L-N)
13/02/1985
13/02/1987
13/02/1989
13/02/1991
13/02/1993
13/02/1995
13/02/1997
13/02/1999
13/02/2001
13/02/2003
Date

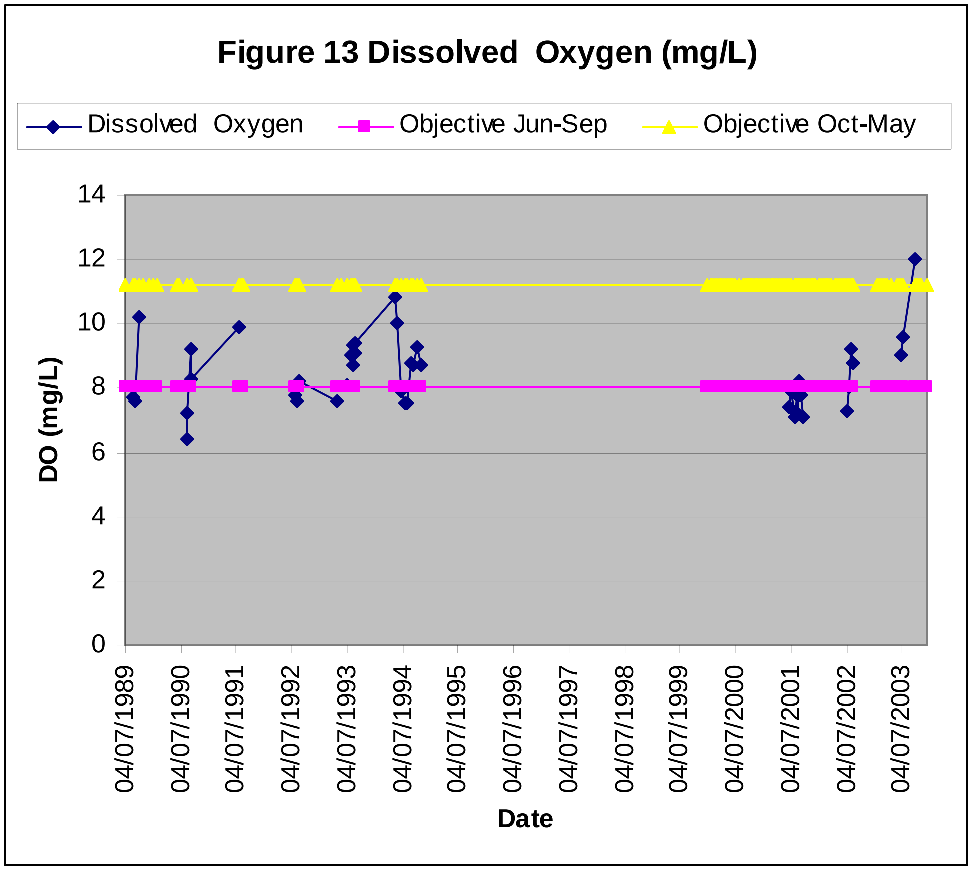


Figure 13 Dissolved Oxygen (mg/L)
Dissolved Oxygen
Objective Jun-Sep
Objective Oct-May
DO (mg/L)
14
12
10
8
6
4
2
0
04/07/1989
04/07/1990
04/07/1991
04/07/1992
04/07/1993
04/07/1994
04/07/1995
04/07/1996
04/07/1997
04/07/1998
04/07/1999
04/07/2000
04/07/2001
04/07/2002
04/07/2003
Date

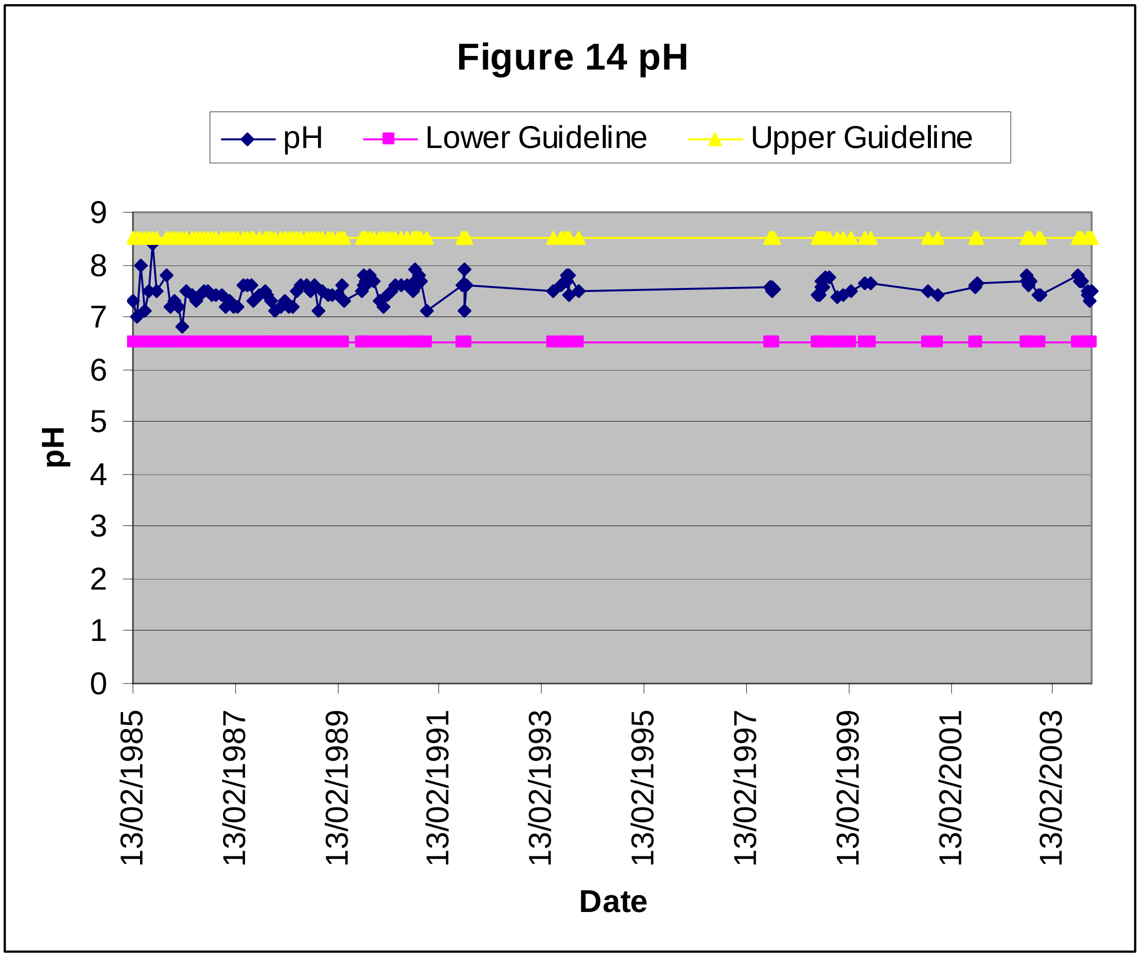


Figure 14 pH
pH
Lower Guideline
Upper Guideline
9
8
7
6
5
4
3
2
1
0
pH
13/02/1985
13/02/1987
13/02/1989
13/02/1991
13/02/1993
13/02/1995
13/02/1997
13/02/1999
13/02/2001
13/02/2003
Date

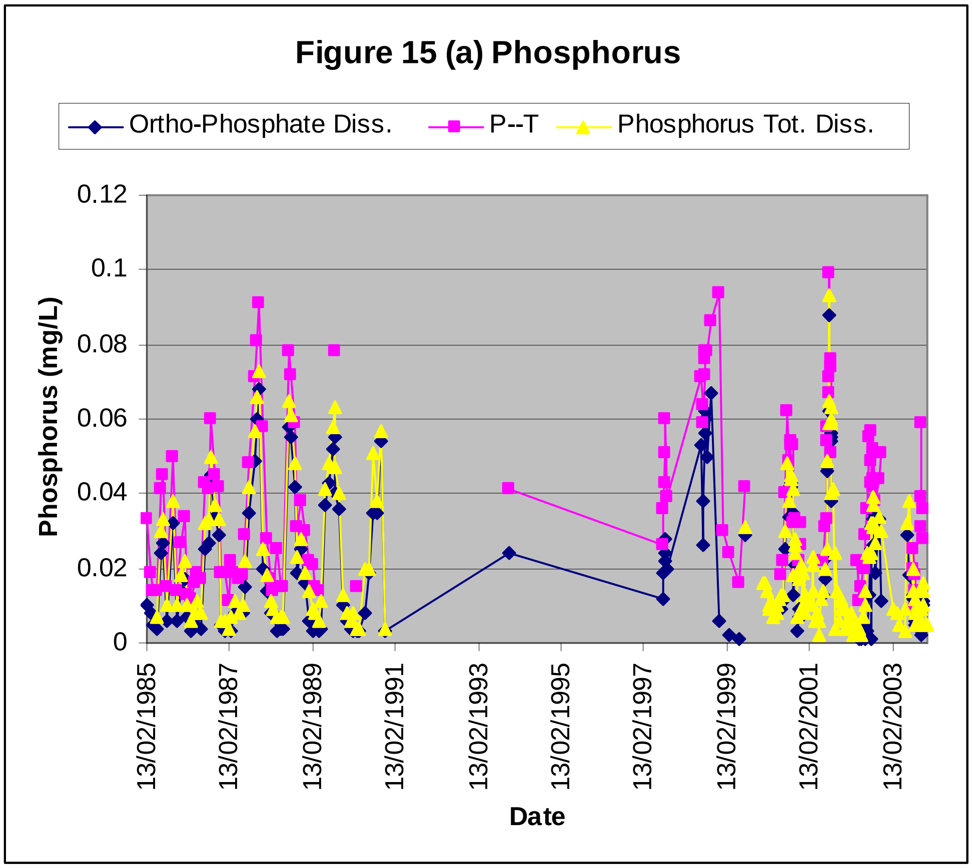


Figure 15 (a) Phosphorus
Ortho-Phosphate Diss.
P--T
Phosphorus Tot. Diss.
0.12
0.1
0.08
0.06
0.04
0.02
0
Phosphorus (mg/L)
13/02/1985
13/02/1987
13/02/1989
13/02/1991
13/02/1993
13/02/1995
13/02/1997
13/02/1999
13/02/2001
13/02/2003
Date

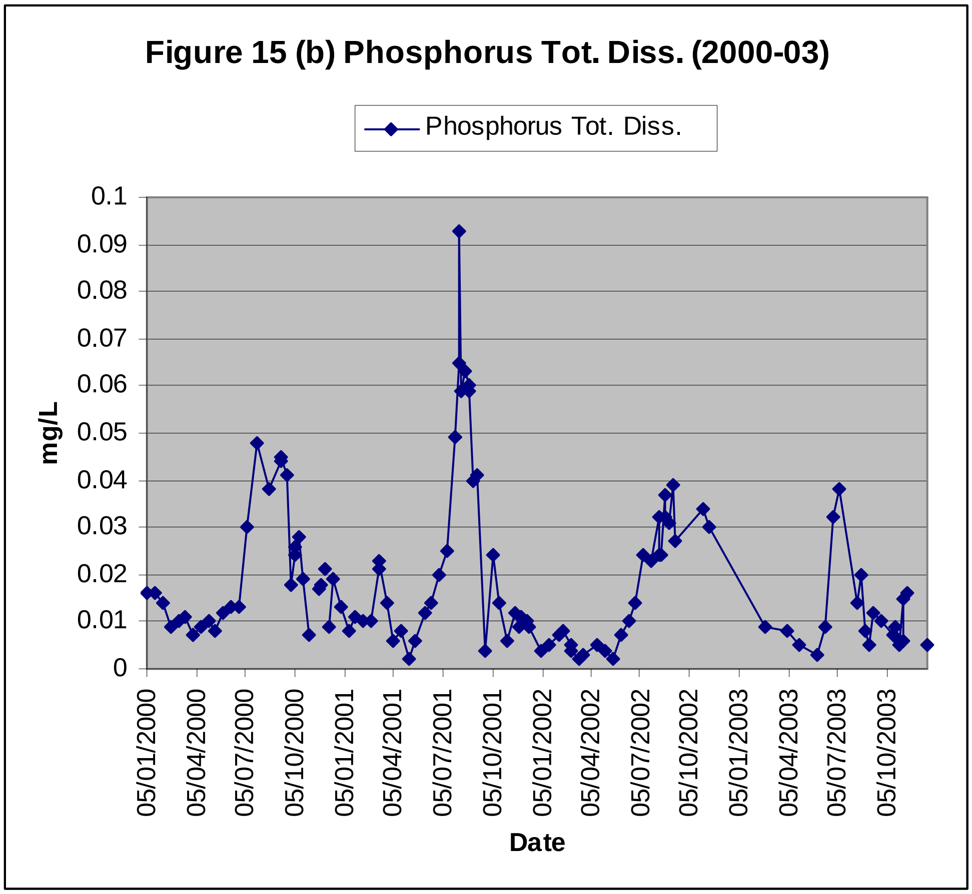


Figure 15 (b) Phosphorus Tot. Diss. (2000-03)
Phosphorus Tot. Diss.
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
mg/L
05/01/2000
05/04/2000
05/07/2000
05/10/2000
05/01/2001
05/04/2001
05/07/2001
05/10/2001
05/01/2002
05/04/2002
05/07/2002
05/10/2002
05/01/2003
05/04/2003
05/07/2003
05/10/2003
Date

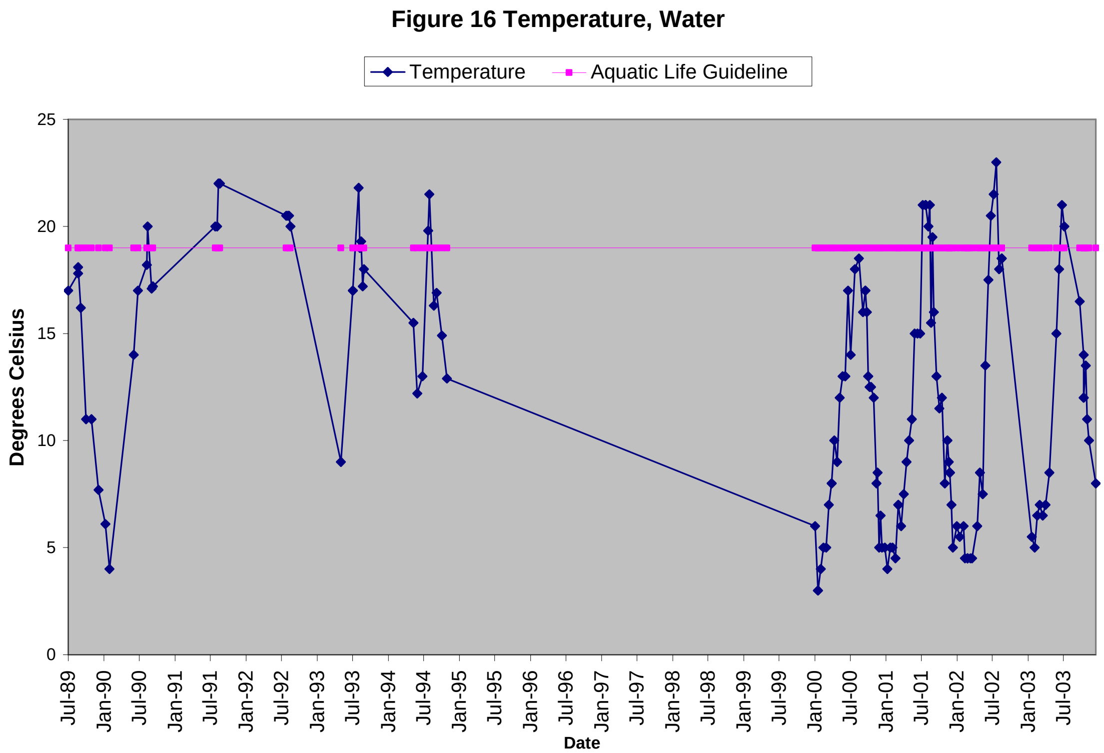


Figure 16 Temperature, Water
Temperature
Aquatic Life Guideline
Degrees Celsius
0
5
10
15
20
25
Jul-89
Jan-90
Jul-90
Jan-91
Jul-91
Jan-92
Jul-92
Jan-93
Jul-93
Jan-94
Jul-94
Jan-95
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Date

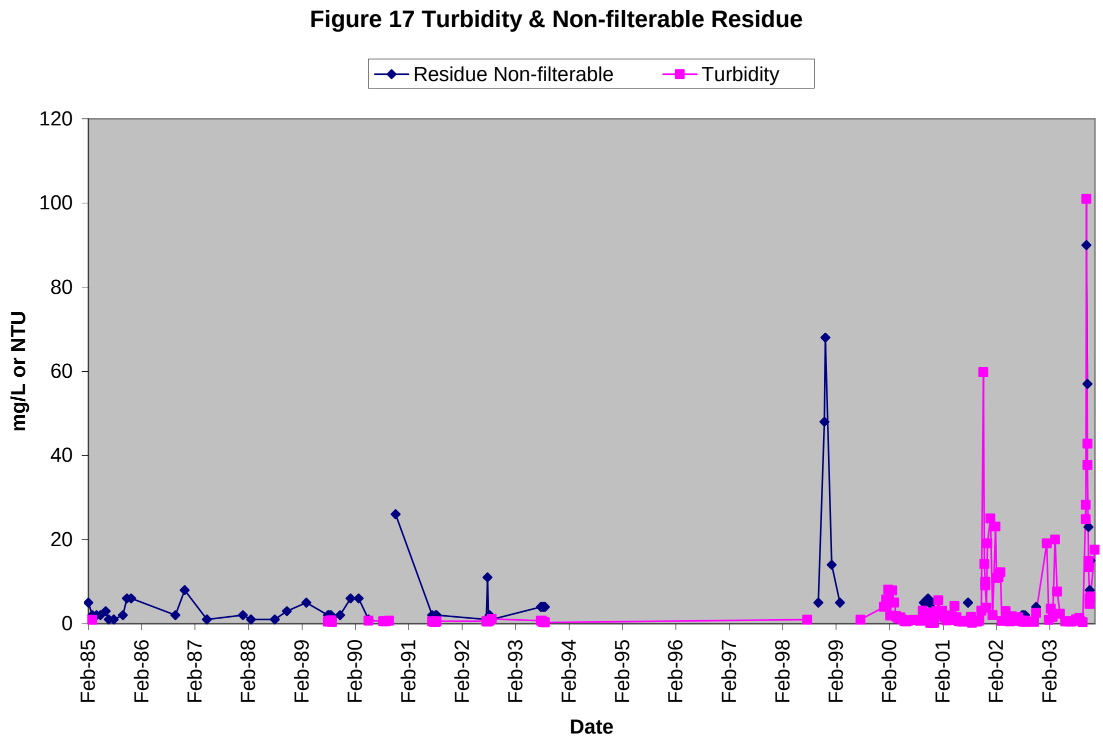


Figure 17 Turbidity & Non-filterable Residue
Residue Non-filterable
Turbidity
mg/L or NTU
0
20
40
60
80
100
120
Feb-85
Feb-86
Feb-87
Feb-88
Feb-89
Feb-90
Feb-91
Feb-92
Feb-93
Feb-94
Feb-95
Feb-96
Feb-97
Feb-98
Feb-99
Feb-00
Feb-01
Feb-02
Feb-03
Date

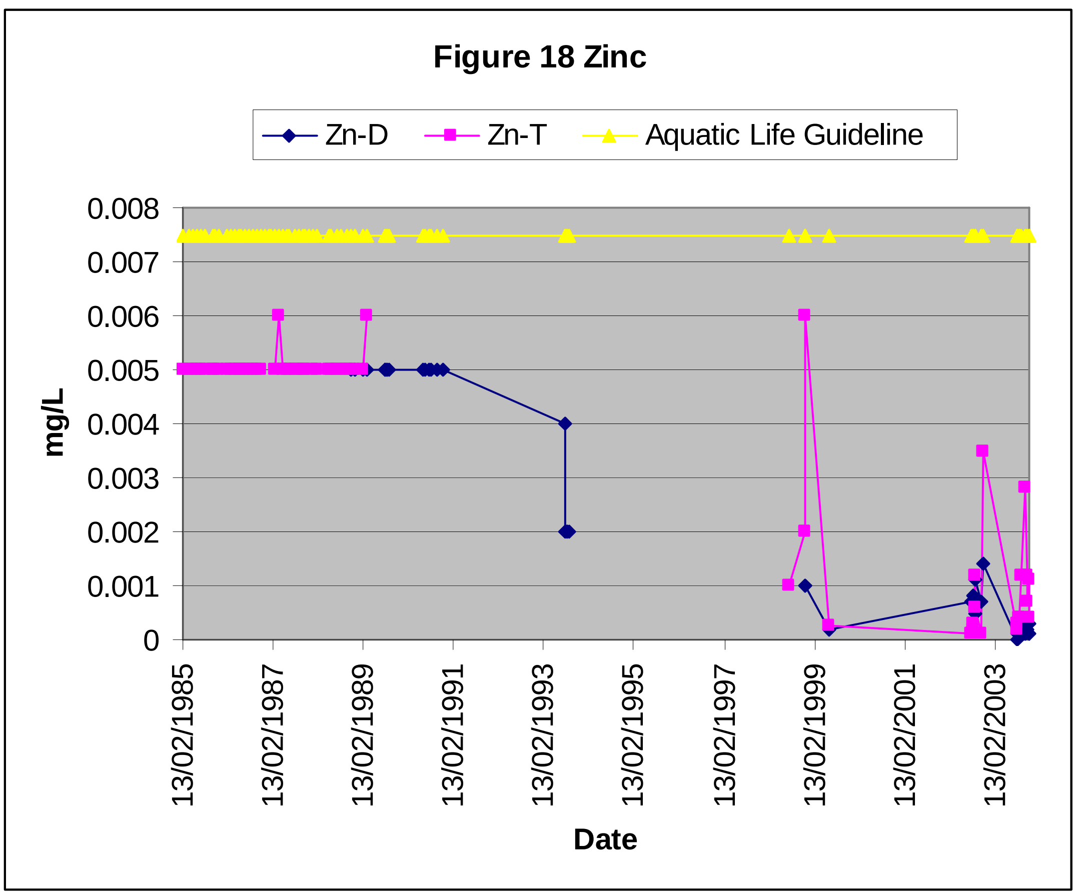


Figure 18 Zinc
Zn-D
Zn-T
Aquatic Life Guideline
mg/L
0
0.001
0.002
0.003
0.004
0.005
0.006
0.007
0.008
13/02/1985
13/02/1987
13/02/1989
13/02/1991
13/02/1993
13/02/1995
13/02/1997
13/02/1999
13/02/2001
13/02/2003
Date