CANADA – BRITISH COLUMBIA
WATER QUALITY MONITORING AGREEMENT

WATER QUALITY ASSESSMENT OF ST. MARY RIVER AT WYCLIFFE (1973 – 2003)

Prepared by:
Pommen Water Quality Consulting

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Environment Canada **Environnement Canada**

BRITISH COLUMBIA Ministry of Environment

Executive Summary

The St. Mary River watershed is located in the southeast corner of British Columbia. Its headwaters are located in the Purcell Mountains, and the river flows east to join the Kootenay River at Fort Steele (Figure 1). The water quality sampling station is located at Wycliffe, which is 23 km upstream from the Kootenay River and about 9 km downstream from Mark Creek. This assessment is based on up to 31 years of water quality data during 1973-2003. The main human influences on water quality in the St. Mary River watershed were the former Sullivan lead-zinc mine, concentrator and fertilizer plant at Kimberley near Mark Creek, treated sewage from Kimberley, forestry, agriculture, and residential and commercial development. The water quality trends identified below have not been confirmed by statistical analysis.

CONCLUSIONS

- There were dramatic improving trends in the following water quality indicators during the 1970's and 1980's due to waste abatement for the Cominco operation, and for sewage from the City of Kimberley: alkalinity, ammonia, arsenic, cadmium, hardness, chromium, fecal coliforms, copper, cyanide, fluoride, iron, lead, manganese, nitrogen-ammonia and organic, pH, phosphorus, silicon, sulphate, turbidity, and zinc.

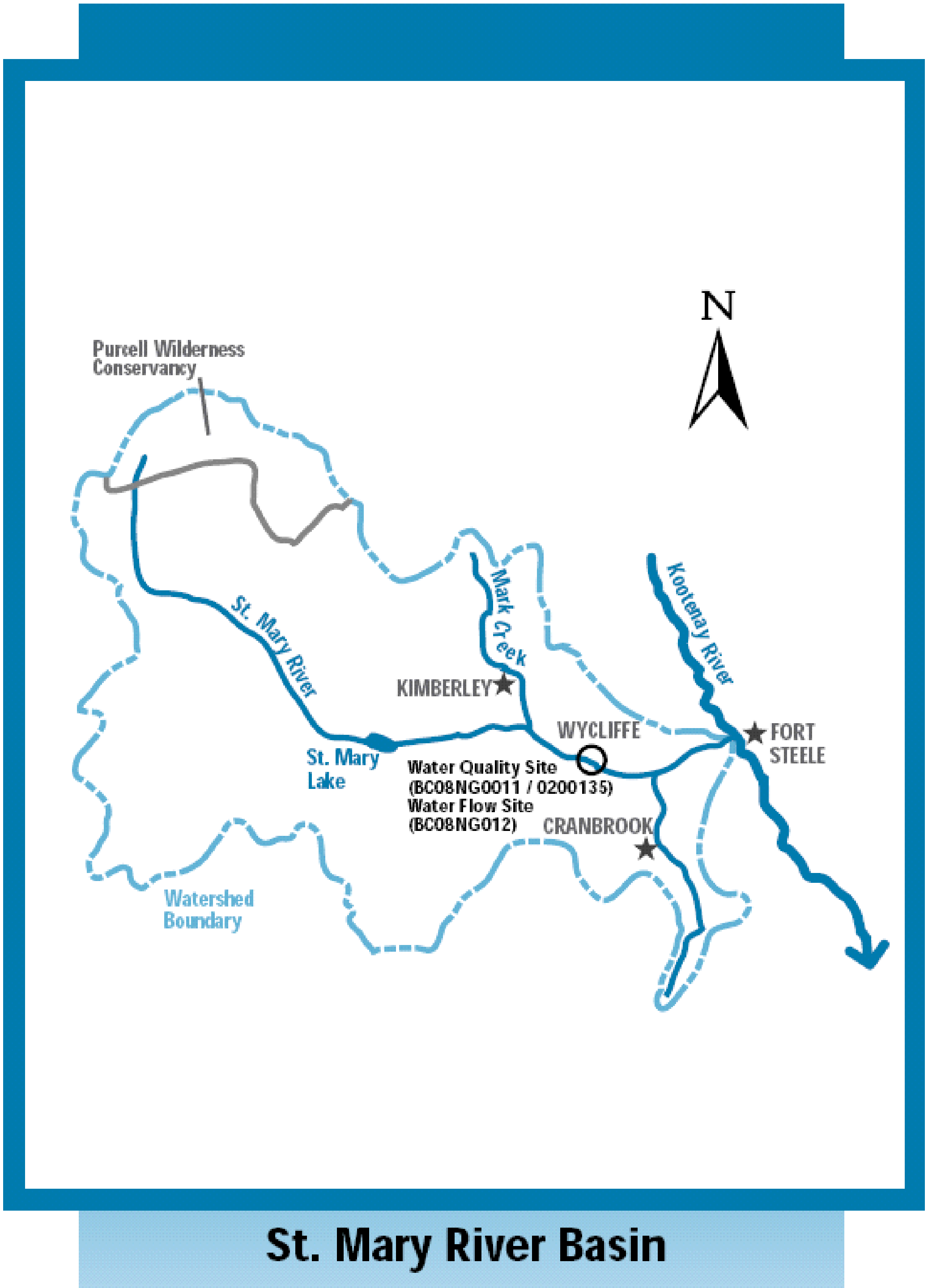
- During 1999-2003, there were no further changes in water quality indicators over time, and the following were observed:

    - Cadmium and zinc often exceeded the aquatic life guidelines.
    - Copper, lead, and manganese occasionally exceeded aquatic life or drinking water (aesthetic) guidelines during higher flows and turbidity.
    - Nitrite exceeded the aquatic life guideline twice during low flow in 2000 and monitoring was stopped in 2001.
    - The water was soft to moderately hard, with a moderate to low sensitivity to acids.
    - Turbidity levels indicate that partial treatment (e.g., filtration) plus disinfection were needed before drinking water consumption.

RECOMMENDATIONS

- Monitoring should continue until water quality guidelines for cadmium and zinc are attained consistently or until it is demonstrated that waste abatement has progressed to the point where there is no detrimental effects on aquatic life in the St. Mary River.
- Nitrite monitoring should be re-implemented along with chloride to determine the appropriate aquatic life guideline for nitrite.

FIGURE 1 MAP OF THE ST. MARY RIVER BASIN



AUTHORS

Pommen, L.W.	Pommen Water Quality Consulting, Victoria, B.C.

CONTRIBUTORS

McDonald, L.E.	Pollution Prevention, Ministry of Water, Land and Air Protection, Cranbrook, B.C.
Ryan, A.	Aquatic Sciences Section, Environmental Conservation Branch, Environment Canada, Vancouver, B.C.
Beatty, J.	Pollution Prevention, Ministry of Water, Land and Air Protection, Nelson, B.C.
Swain, L.G.	Water and Air Monitoring and Reporting Section, Water, Air and Climate Change Branch, Ministry of Water, Land and Air Protection, Victoria, B.C.

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1. INTRODUCTION

The St. Mary River at Wycliffe water quality monitoring station is located just downstream from the Highway 95A bridge, which is about 9 km downstream from Mark Creek and 23 km upstream from the Kootenay River (Figure 1). The drainage area of the river at the water quality station is 2360 km^2. The St. Mary River has 20 water licences or applications, including irrigation, domestic, waterworks, and livestock watering uses. This reach of the river supports significant fisheries (e.g., westslope cutthroat trout, bull trout and whitefish) ??? The former Cominco Ltd. Sullivan lead-zinc mine (closed in 2002), concentrator and fertilizer plant (1953-1987) were located in the St. Mary River watershed at Kimberley and were major influences on the water quality of the river, along with treated sewage from the City of Kimberley. Forestry and agriculture were other potential influences on water quality.

Environment Canada monitored flow on the St. Mary River at Wycliffe (Water Survey of Canada station BC08NG012) during 1914-95. Twenty-three years (1973-95) of flow data are plotted in Figure 2. The Province collected water quality data at Wycliffe during 1973-95 and the data are stored on the Environmental Monitoring System (EMS) under site number 0200135. In 1999, the station became a federal-provincial water quality monitoring station with joint operation by Canada and B.C. Water quality data have been collected every two weeks since 1999 and are stored on the ENVIRODAT database under station number BC08NG0011 and on EMS under site number 0200135. Up to 31 years (1973-2003) of water quality data were used in this report. The data are plotted in Figures 3 to 31.

2. WATER QUALITY ASSESSMENT

The status and trends of water quality were assessed by plotting the water quality indicators over time and comparing the values to the Province's approved [1] and working [2] water quality guidelines or the Canadian water quality guidelines [3], since site-specific water quality objectives have not been established for this waterbody. 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.

Before the data were assessed, the data were corrected as recommended in the data approval reports [4, 5, 6], and the errors and probable errors identified in these reports were removed.

Water quality indicators that were reviewed but not displayed nor discussed because they easily met all water quality guidelines and showed no harmful trends were: antimony, barium, beryllium, boron, bromide, gallium, lanthanum, lithium, molybdenum, nickel, potassium, residue-filterable, rubidium, selenium, sodium, strontium, tellurium, thallium, tin, titanium, uranium, vanadium, and zirconium.

Trace elements at this station were measured by extractable methods during 1999-2003. Extractable samples were acidified in the field with nitric acid to about pH 2 and then analysed in the laboratory without further treatment.

Alkalinity, total (Figure 3) had very low levels in 1973-75 due to acid drainage from the Cominco mine, concentrator, and fertilizer plant at Kimberley, and increased (improved) over time due to waste abatement.

Aluminum (Al) (Figure 4) – had two high values in 1973, which were validated because non-filterable residue and turbidity were high and there was a potential upstream aluminum source from the Cominco operation [4]. Aluminum levels may have declined (improved) during 1973-76 due to waste abatement, but the data are too sparse to confirm it. The decline in dissolved aluminum was also due to declining minimum detection limits (MDL). Water quality guidelines for aluminum were met since 1983.

Ammonia nitrogen (NH3-N) (Figure 5) had high levels in 1973-75 due to the Cominco operation at Kimberley, and declined (improved) over time due to waste abatement. The high values during 1973-75 occurred at low pH (3.6-5), which is below the pH range of the water quality guidelines for ammonia. All other values met the water quality guidelines for aquatic life.

Arsenic, total (As-T) (Figure 6) had levels in excess of aquatic life, drinking water, and livestock watering guidelines during 1973-80 due to discharges from the Cominco operation. There was a declining (improving) trend due to waste abatement at the Cominco operation, and water quality guidelines have been attained since 1980.

Cadmium (Cd) (Figure 7a) had two high outliers in 1974 and 1976 of 0.01 mg/L that might be errors, but were validated because there was a known cadmium source upstream [4]. Twenty-five percent of total and dissolved cadmium values exceeded aquatic life guidelines during 1973-95. There was a declining (improving) trend over time due to waste abatement at the Cominco operation, as well as due to declining MDLs. **Figure 7b** shows that low-level extractable cadmium often exceeded aquatic life guidelines during 1999-2003. There was an apparent declining trend during 1999-2003, although the addition of various trendlines to the plot suggested no change over time.

Calcium (Ca) (Figure 8) had a declining trend over time due to waste abatement at the Cominco operation. The water had a moderate to low sensitivity to acids.

Chlorophyll a, periphyton – (no figure) **–** was measured in 1985 and 1990, and the water quality guidelines for recreation and aquatic life of an average of 50-100 mg/m^2 (0.05-0.1 g/m^2) were met.

Chromium (Cr) – Figure 9a – had high MDLs (e.g., 0.01, 0.005, and 0.002 mg/L), for total and dissolved chromium, which were above the aquatic life guideline (0.001 mg/L), resulting in the high detectable values shown in the figure. The high detectable values might be false positives, but chromium also may have been discharged from the Cominco operation, and thus no flags have been recommended [4]. There was a declining (improving) trend over time, which may have been due to declining MDLs and waste abatement. **Figure 9b** shows that low-level extractable chromium met the aquatic life guideline in 1999-2003 and that there was no change over time.

Cobalt (Co) (Figure 10) shows that low-level extractable cobalt met the aquatic life guideline during 1999-2003 and that there was no change over time. (Cobalt was measured during 1983-95, but all values were less than MDLs, which were at or above the aquatic life guideline, and thus not plotted.)

Coliforms, fecal (Figure 11) were above water quality guidelines for drinking water, livestock water, irrigation, and water-contact recreation at times during 1973-80. There was declining (improving) trend over time due to waste abatement for the Kimberley treated sewage discharge [7, 8]. The data are sparse, but guidelines for all water uses were attained during 1987-93.

Colour (no figure) had low levels during 1973-78 with only two values above the 15-unit true colour aesthetic drinking water guideline.

Conductance, specific (Figure 12) values were below all water quality guidelines, and appeared to decline over time, although the data are sparse after 1978. This is consistent with waste abatement at the Cominco operation.

Copper (Cu) (Figure 13a) often exceeded the aquatic life guidelines during 1973-93 due to discharges from the Cominco operation, but there was a declining (improving) trend over time due to waste abatement at the Cominco operation and declining MDLs. **Figure 13b** shows that low-level extractable copper exceeded the aquatic life guideline on five occasions during 1999-2003, four times during spring freshet, and once in the fall when turbidity was high. There was no change over time.

Cyanide (CN) (Figure 14) was analysed with MDLs above (0.01 mg/L) or at the aquatic life guideline of 0.005 mg/L, and thus the data are not reliable for comparison to the guideline. The detectable values might be false positives, but there was also cyanide discharged from Cominco's operation, and thus no data flags have been recommended [4]. There was an apparent declining trend over time, which may have been due to waste abatement, as well as declining MDLs. Three of 23 weak-acid dissociable cyanide values exceeded the aquatic life guideline in 1988, but the guideline was met in 1995, when the last cyanide results were collected.

Fluoride (F) (Figure 15a) shows that aquatic life guidelines were exceeded frequently during 1973-85, but that there was a declining (improving) trend over time due to waste abatement at the Cominco operation. **Figure 16b** for 1999-2003 shows that only one of 116 results during 1999-2003 slightly exceeded the aquatic life guideline, and there was no change over time.

Hardness (Figure 16) had a declining (improving) trend over time due to waste abatement at the Cominco operation, which can also be seen in the calcium and magnesium plots. The water was soft to moderately hard.

Iron (Fe) (Figure 17a) often exceeded the aquatic life and aesthetic drinking water guideline (0.3 mg/L) and occasionally exceeded the irrigation guideline (5 mg/L), but there was a declining (improving) trend over time due to waste abatement at the Cominco operation. Figure 17b for 1979-99 shows the continuation of the declining trend, and that the aquatic life/drinking water guideline was attained after 1992.

Lead (Pb) (Figure 18a) levels often exceeded the aquatic life guidelines during 1973-79, but there was a declining (improving) trend over time due to waste abatement at the Cominco operation. Aquatic life guidelines were attained during 1980-95. **Figure 18b** shows that low-level extractable lead exceeded the aquatic life guideline on two occasions during spring freshet, when turbidity was elevated, and that there was no change over time.

Magnesium (Mg) (Figure 19) had a declining trend over time due to waste abatement at the Cominco operation.

Manganese (Mn) (Figure 20a) often exceeded the aesthetic drinking water guideline (0.05 mg/L) during 1973-79, but there was a declining trend over time due to waste abatement at the Cominco operation. The guideline was slightly exceeded on only two occasions during 1980-95. **Figure 20b** shows that low-level extractable manganese exceeded the aesthetic drinking water on four occasions during 1999-2003, three during spring freshet and once in the fall, when turbidity was elevated. There was no change over time.

Mercury (Hg) (Figure 21) had 13 detectable values during 1973-79, which could have been due to mercury discharges from the Cominco operation [7, 8], but could also have been due to artificial contamination because ultra-clean techniques were not used [4]. Mercury levels appeared to decline (improve) over time and were not detectable during most of 1978 and 1979.

Nitrogen (Figure 22a) had a declining (improving) trend in total Kjeldahl nitrogen (i.e., ammonia plus organic N) during 1973-80, probably due to waste abatement, as was the case for ammonia. **Figure 22b** shows that nitrate + nitrite levels were well below water quality guidelines, but that there was slight declining trend over time, possibly due to the abatement of explosives residuals at the Cominco operation. **Figure 22c** shows that nitrite exceeded the aquatic life guideline (0.02 mg/L) on two occasions in 2000.

Oxygen, dissolved (DO) (Figure 23) had no change over time, and all the values were above the 8 mg/L minimum aquatic life guideline.

pH (Figure 24) had levels below the lower aquatic life and drinking water guideline of 6.5 during 1973-79 due to acidic discharges from the Cominco operation. There was an increasing (improving) trend over time due to waste abatement at Cominco, and the guideline was attained after mid-1979. Three field pH values exceeded the upper aesthetic drinking water guideline of 8.5 in 1980 and 1983, although the laboratory pH values met the guideline.

Phosphorus (P) (**Figures 25a and b)** shows a decreasing (improving) trend over time due to waste abatement at the Cominco operation.

Silica and silicon (Si) – Figure 26 – had an apparent declining trend over time that cannot be explained totally by the 2.14-fold difference between silica (SiO2) and silicon (Si), and which was probably due to waste abatement at the Cominco operation (e.g., siliceous tailings pond overflow abatement).

Silver, extractable (Ag-E) (Figure 27) shows that the average aquatic life guideline was attained during 1999-2003 and that there was no change over time.

Sulphate (SO4) (Figure 28) had a declining trend over time due to waste abatement at the Cominco operation. During 1973-80, 18 results exceeded the aquatic life guideline (100 mg/L) and 60 results exceeded the aquatic life alert level (50 mg/L), whereas during 1999-2003 only one result exceeded the alert level.

Temperature, water (T) (Figure 29) - had only one date with a result above the aquatic life guideline of 19 degrees C. Water temperatures appeared to be higher in 1999-2003 than in 1973-85, but this is probably due to the more frequent monitoring during 1999-2003 (biweekly) compared to 1973-85 (monthly or less frequently).

Turbidity (Figures 30a and b) showed a decreasing (improving) trend in turbidity during 1973-2003, likely due to waste abatement. **Non-filterable residue** (no figure) showed a similar decline during 1973-80. Figure **30b** for 1999-2003 shows no apparent change in turbidity, and that the drinking water guideline of 1 NTU was often exceeded, indicating that partial treatment (e.g., filtration) plus disinfection was needed before consumption.

Zinc (Zn) (Figure 31a) had almost all of the dissolved and total zinc values above the 0.0075 mg/L aquatic life guideline at hardness ≤90 mg/L during 1973-95 due to discharges from the Cominco operation at Kimberley. However, there was a declining (improving) trend over time due to waste abatement. **Figure 31b** shows that low-level extractable zinc often exceeded the aquatic life guideline during 1999-2003 and that there was no change over time.

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1. Ministry of Water, Land and Air Protection. 2001a. British Columbia Approved Water Quality Guidelines (Criteria). 1998 Edition updated August 24, 2001.

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3. Canadian Council of Ministers of the Environment (CCME). 2003. Canadian Environmental Quality Guidelines.

4. Pommen Water Quality Consulting. 2004. Water Quality Data Approval, St. Mary River at Wycliffe, 1973-2003 (EMS 0200135).

5. Pommen Water Quality Consulting. 2002. Water Quality Data Approval, St. Mary River at Wycliffe, 1999-2000 (ENVIRODAT BC08NG0011).

6. Pommen Water Quality Consulting. 2004. Water Quality Data Approval, St. Mary River at Wycliffe, 2001-2003 (ENVIRODAT BC08NG0011).

7. Department of Environment. 1976. Kootenay Air and Water Quality Study, Phase I. Water Quality in Region 4, The Lower Kootenay River Basin. Victoria, B.C.

8. Ministry of Environment. 1981. Water Quality in the Kootenay River Basin. Kootenay Air and Water Quality Study, Phase II. APD Bulletin 20, Victoria, B.C.

Figure 2 Flow in the St. Mary River at Wycliffe

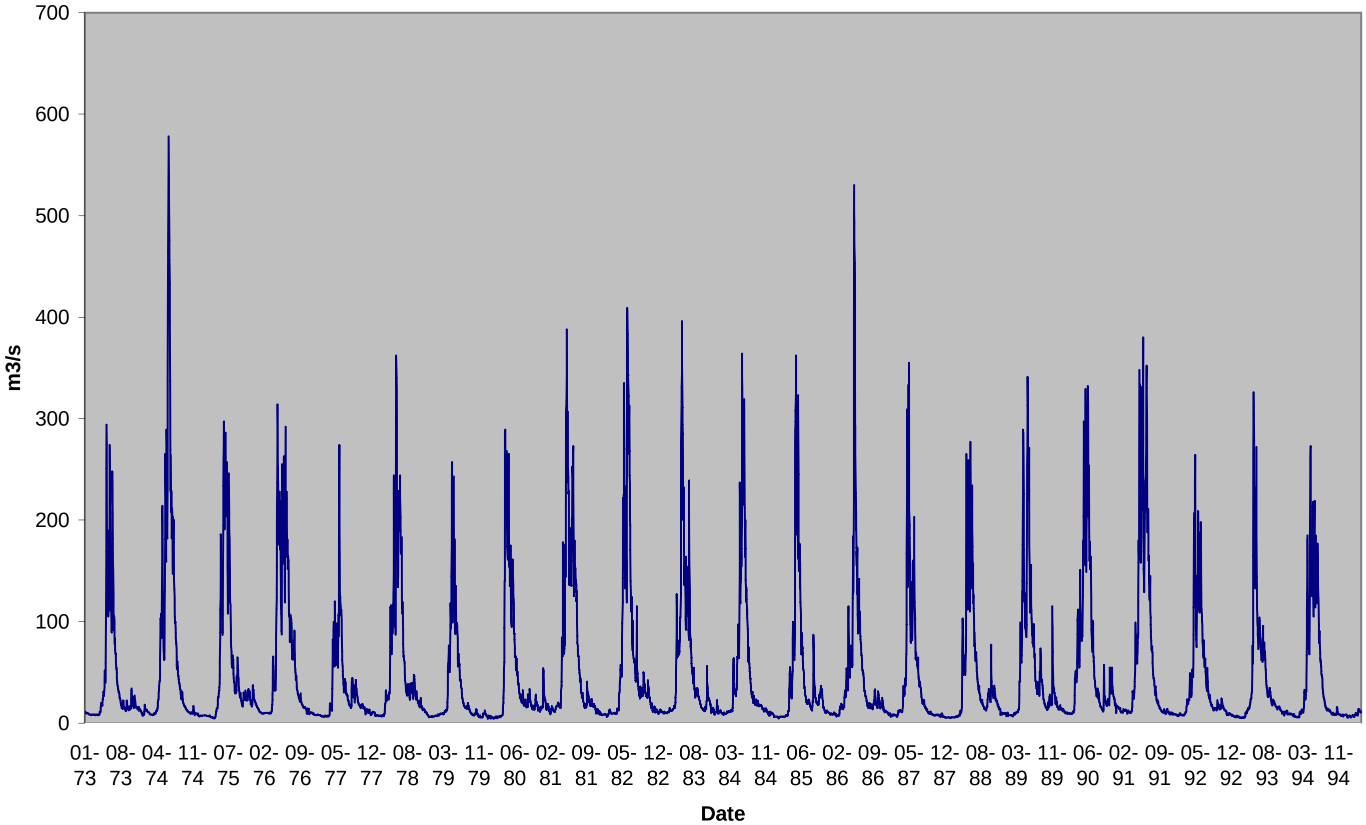


Figure 3 Alkalinity, Total

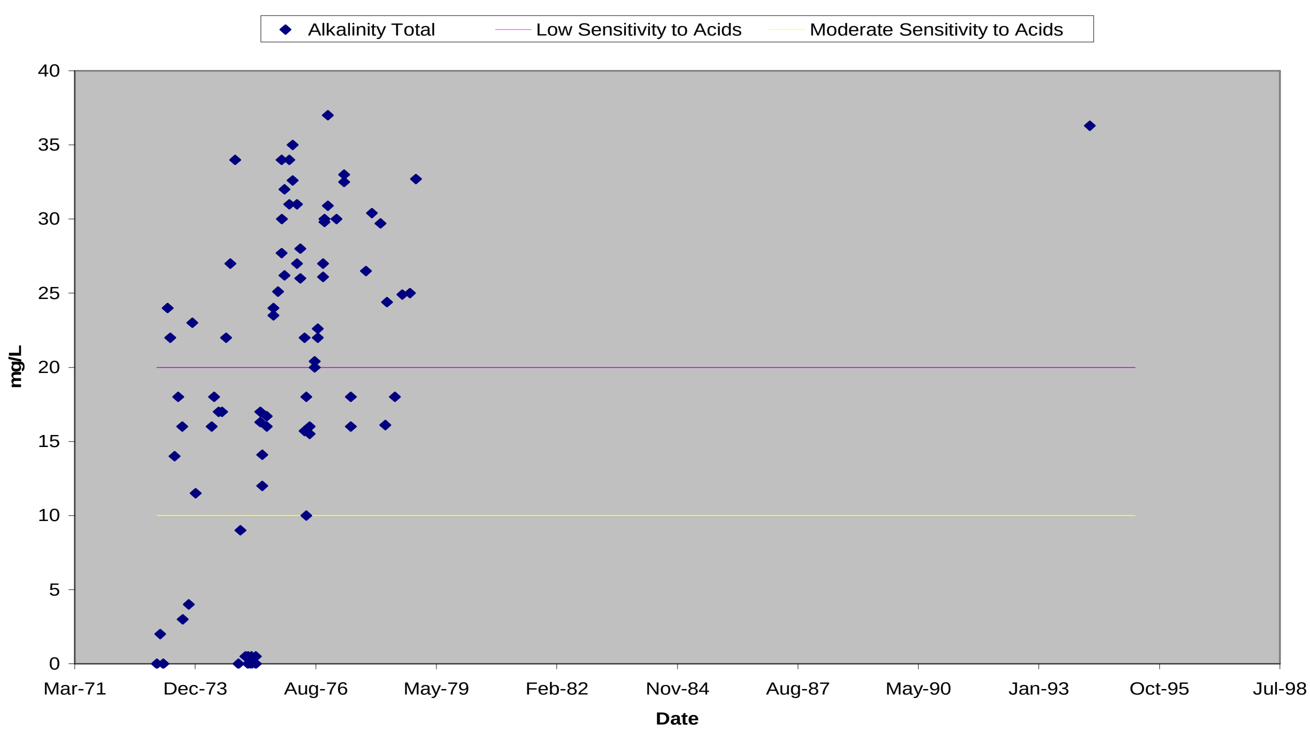


Figure 4 Aluminum

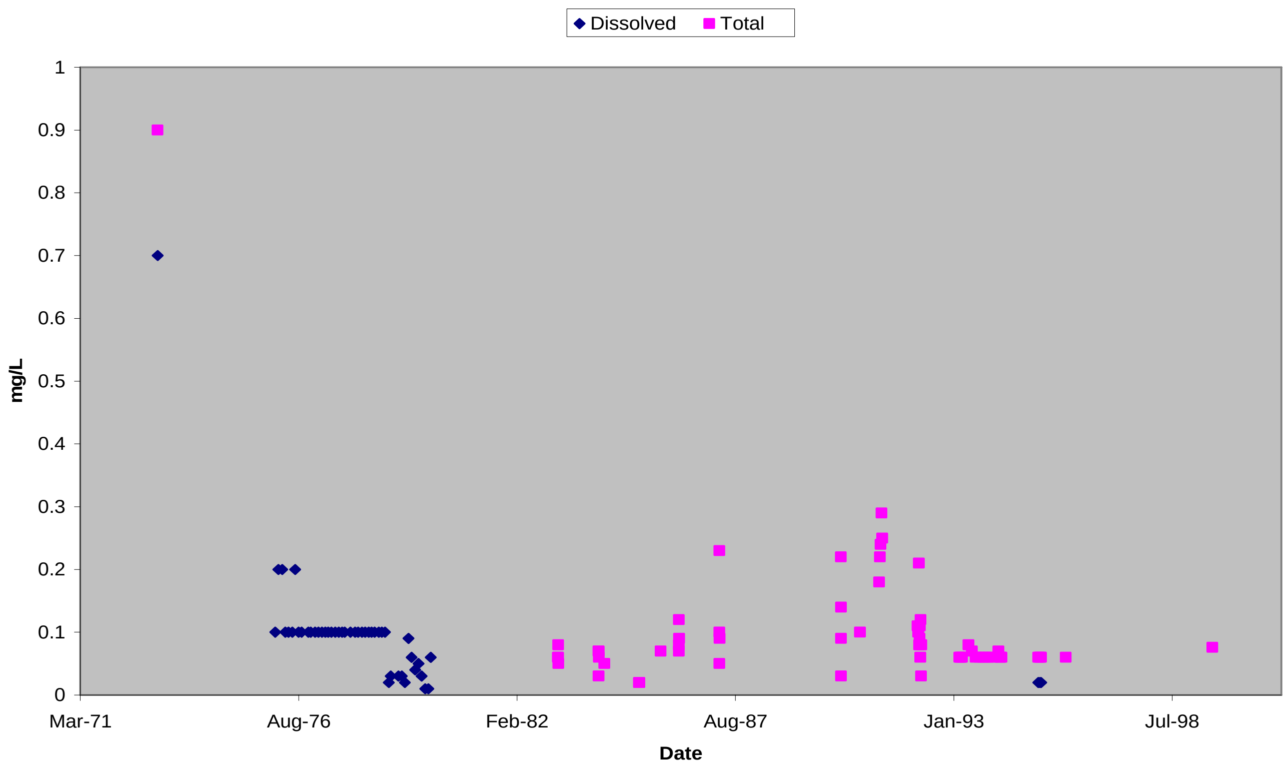


Figure 5 Ammonia Nitrogen

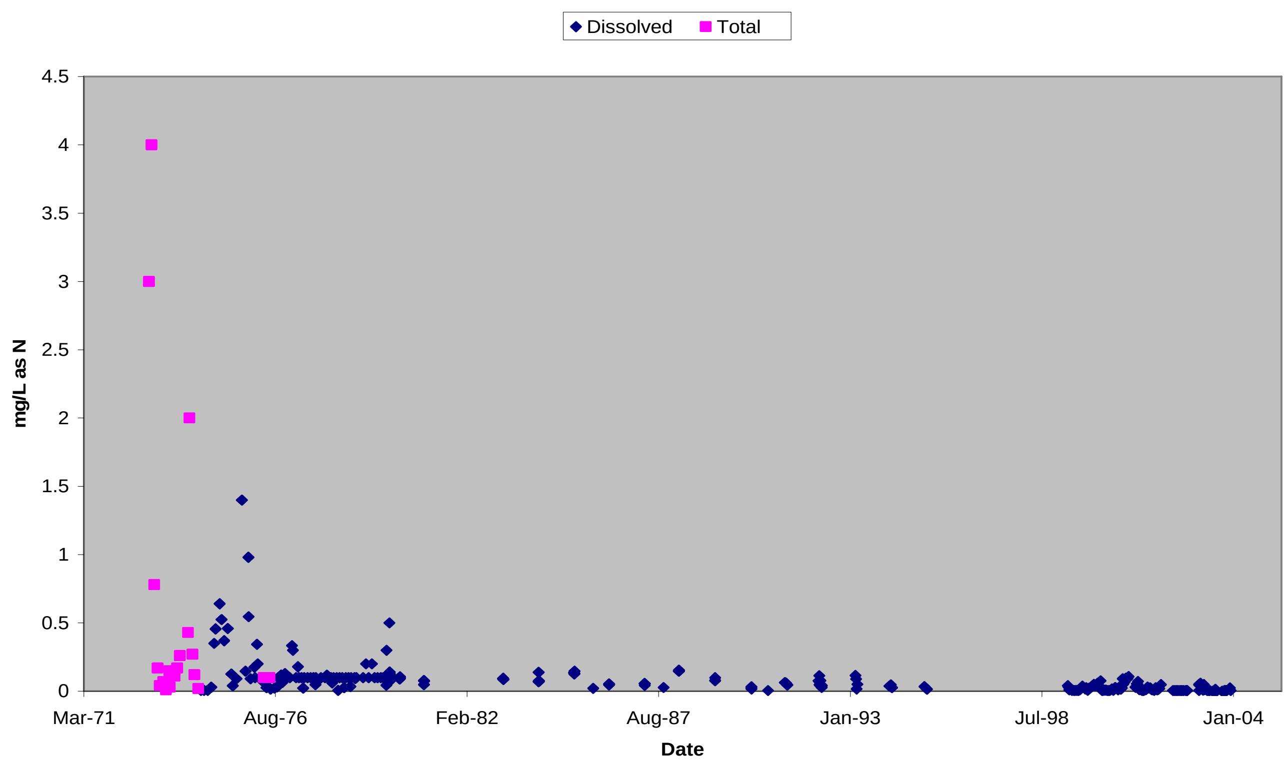


Figure 6 Arsenic

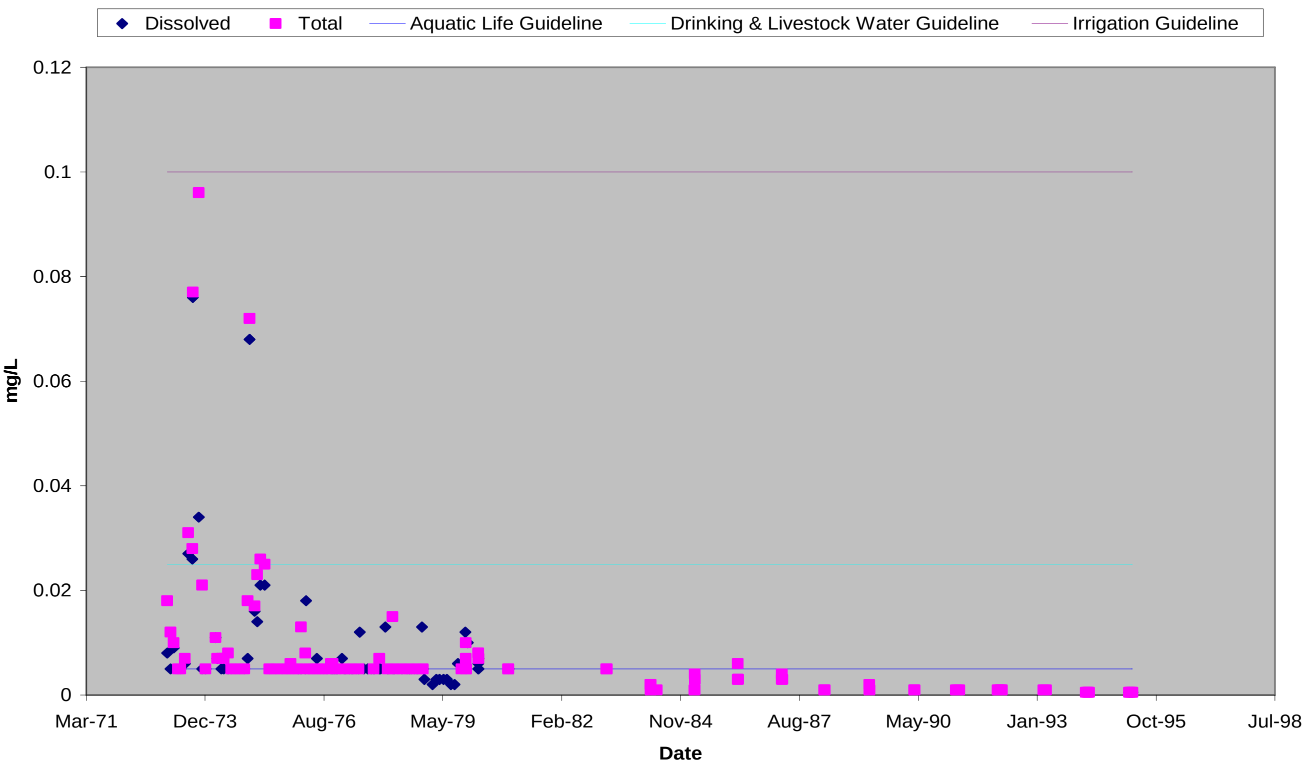


Figure 7a Cadmium

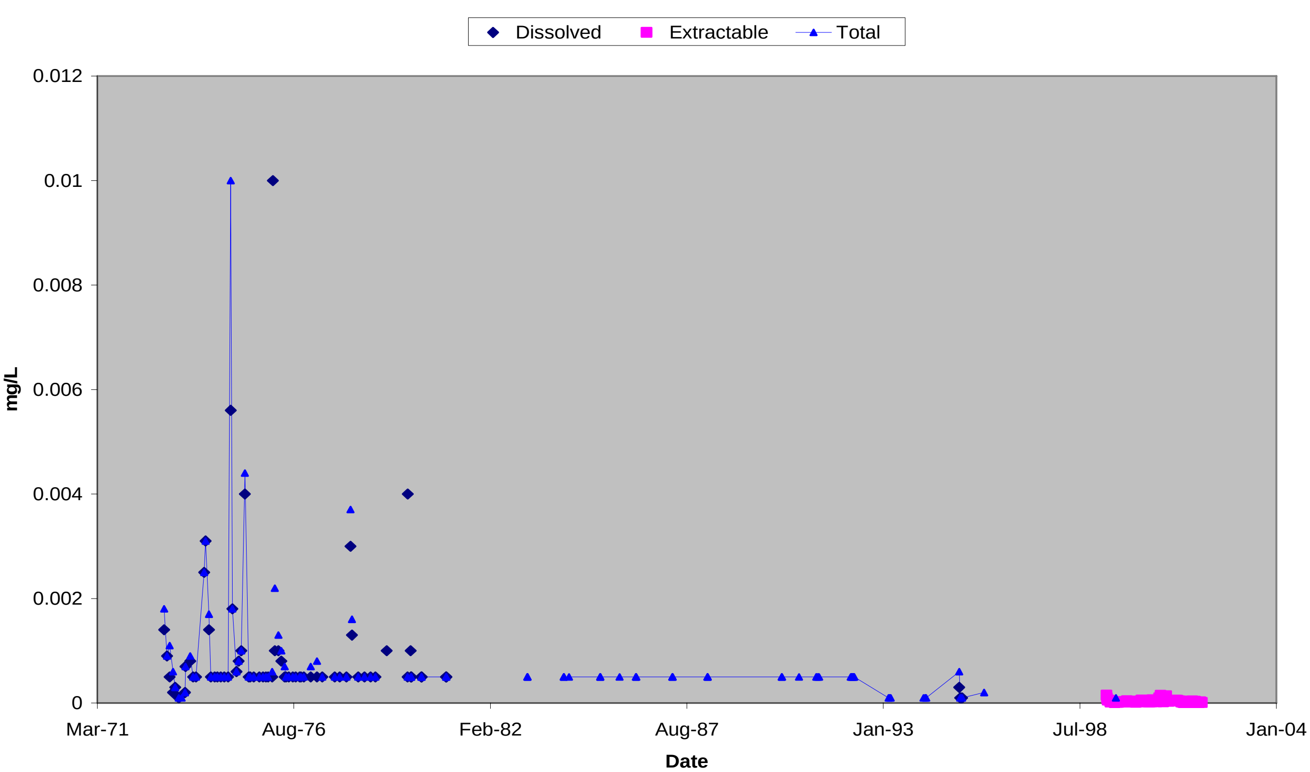


Figure 7b Cadmium, Extractable

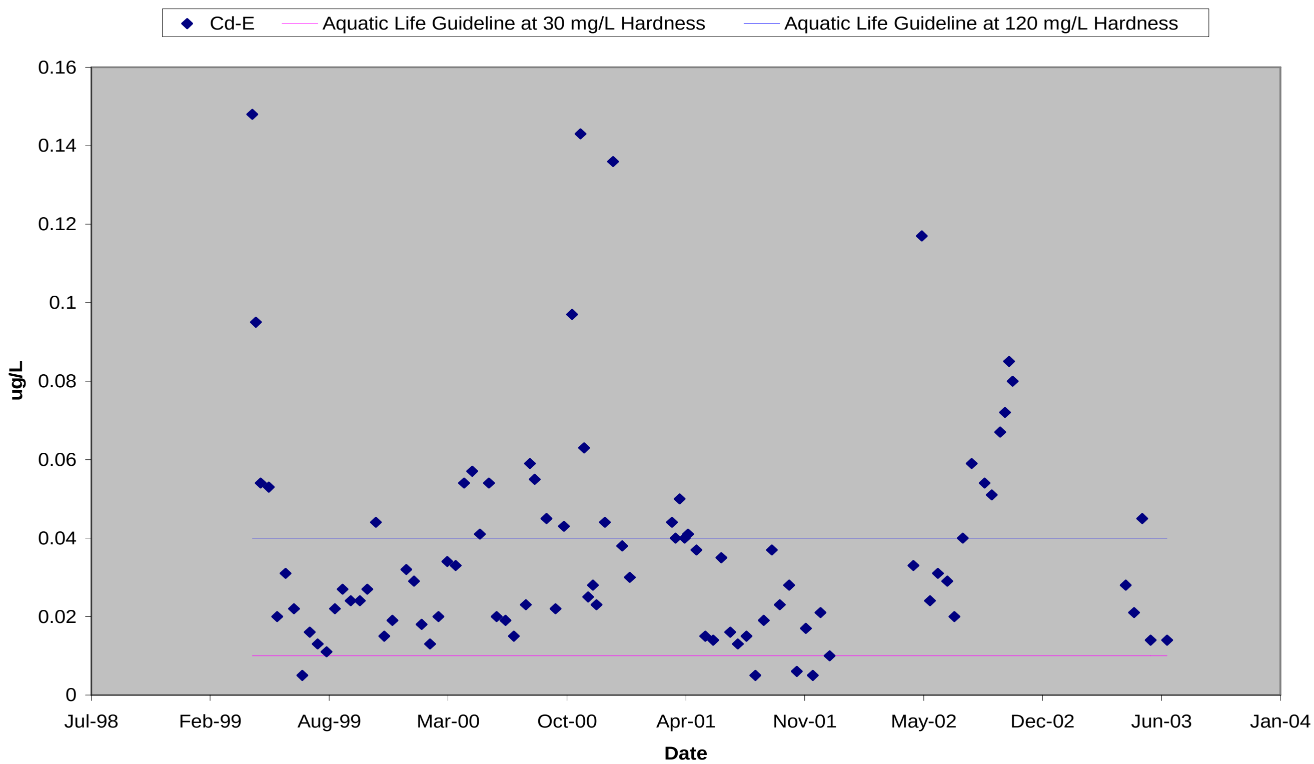


Figure 8 Calcium

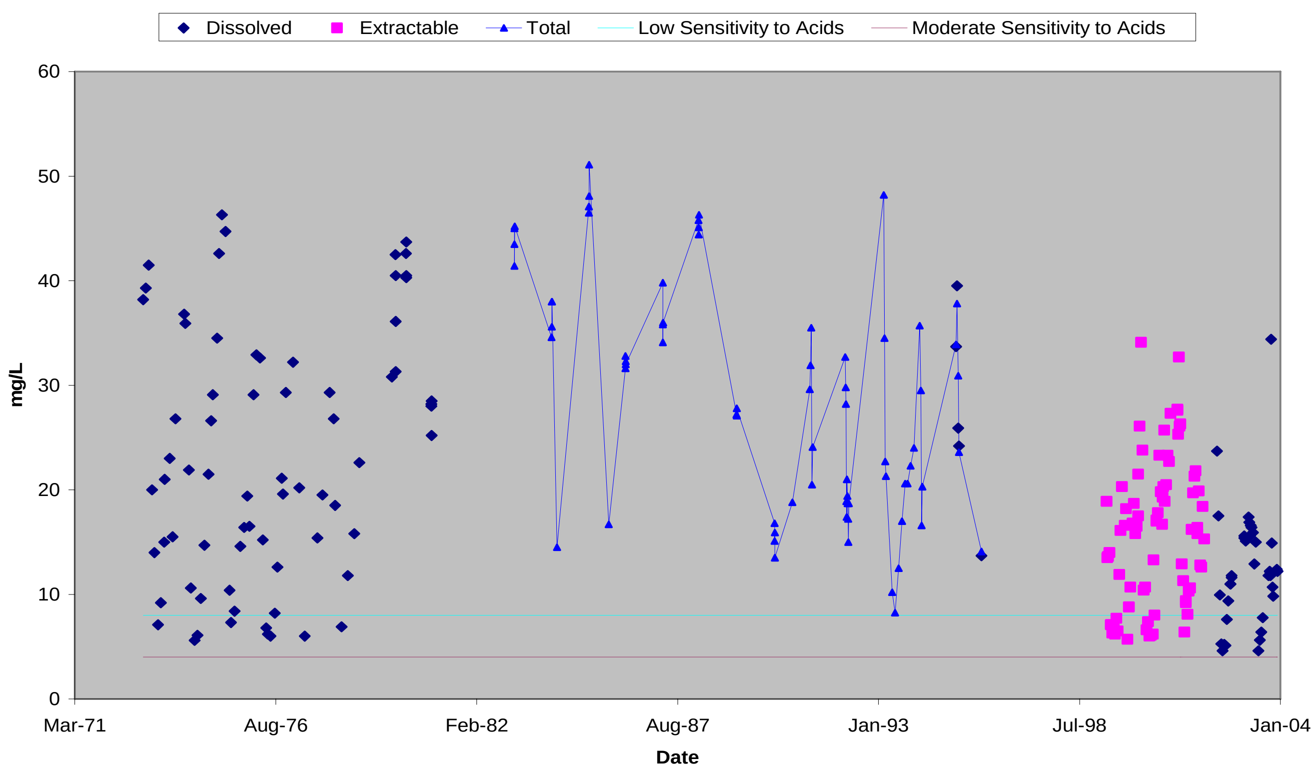


Figure 9a Chromium

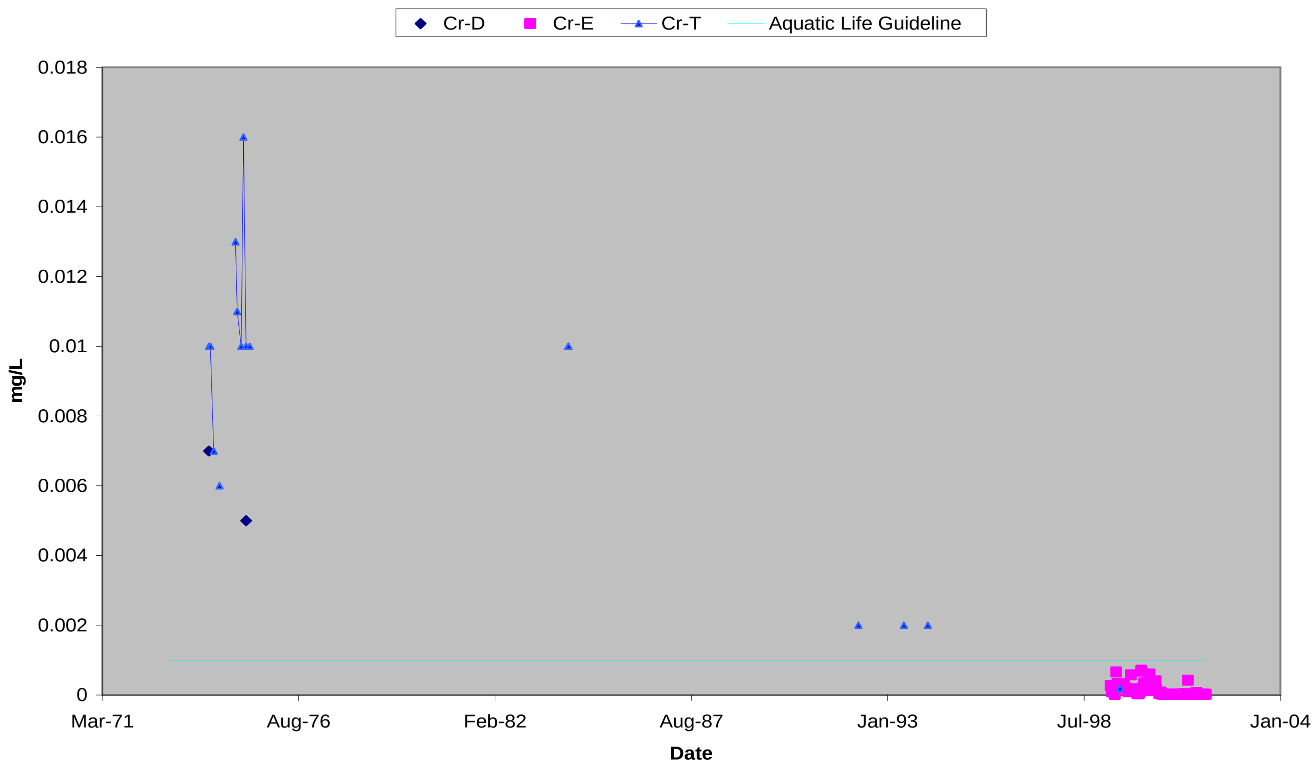


Figure 9b Chromium, Extractable

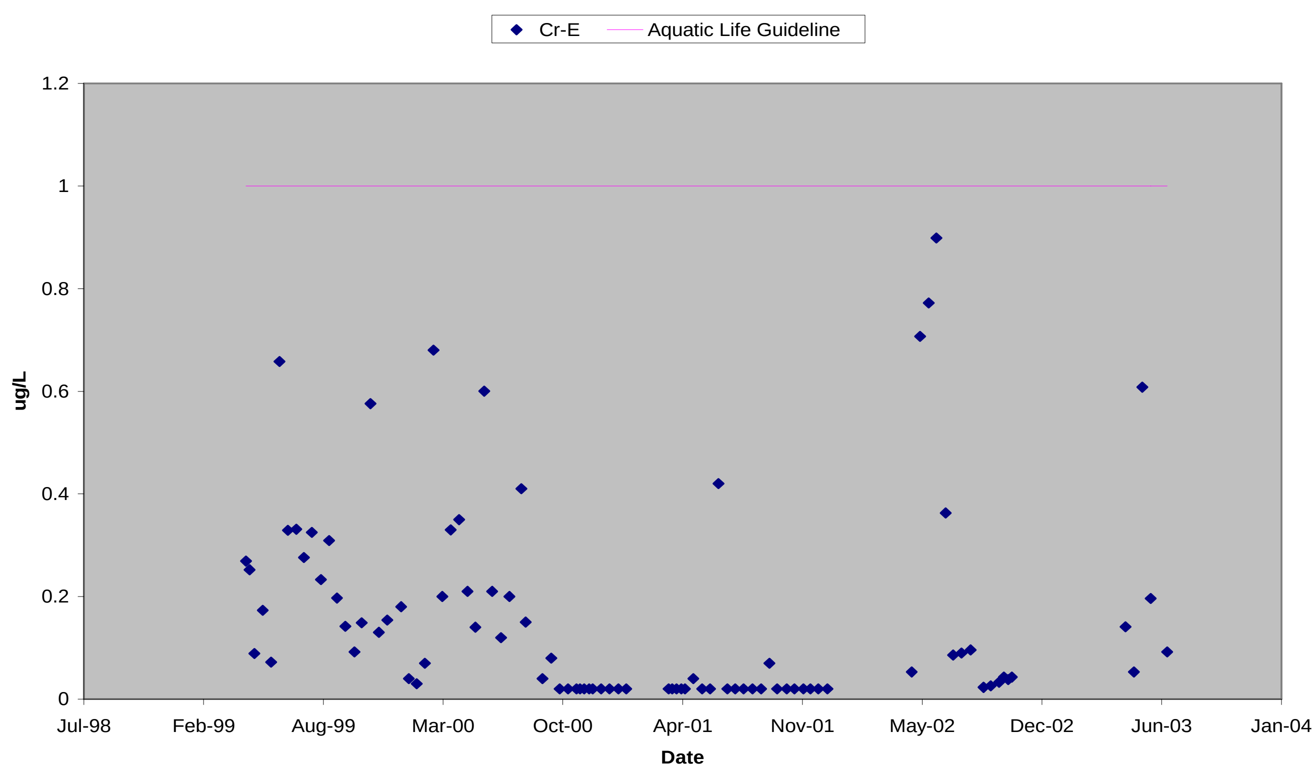


Figure 10 Cobalt, Extractable

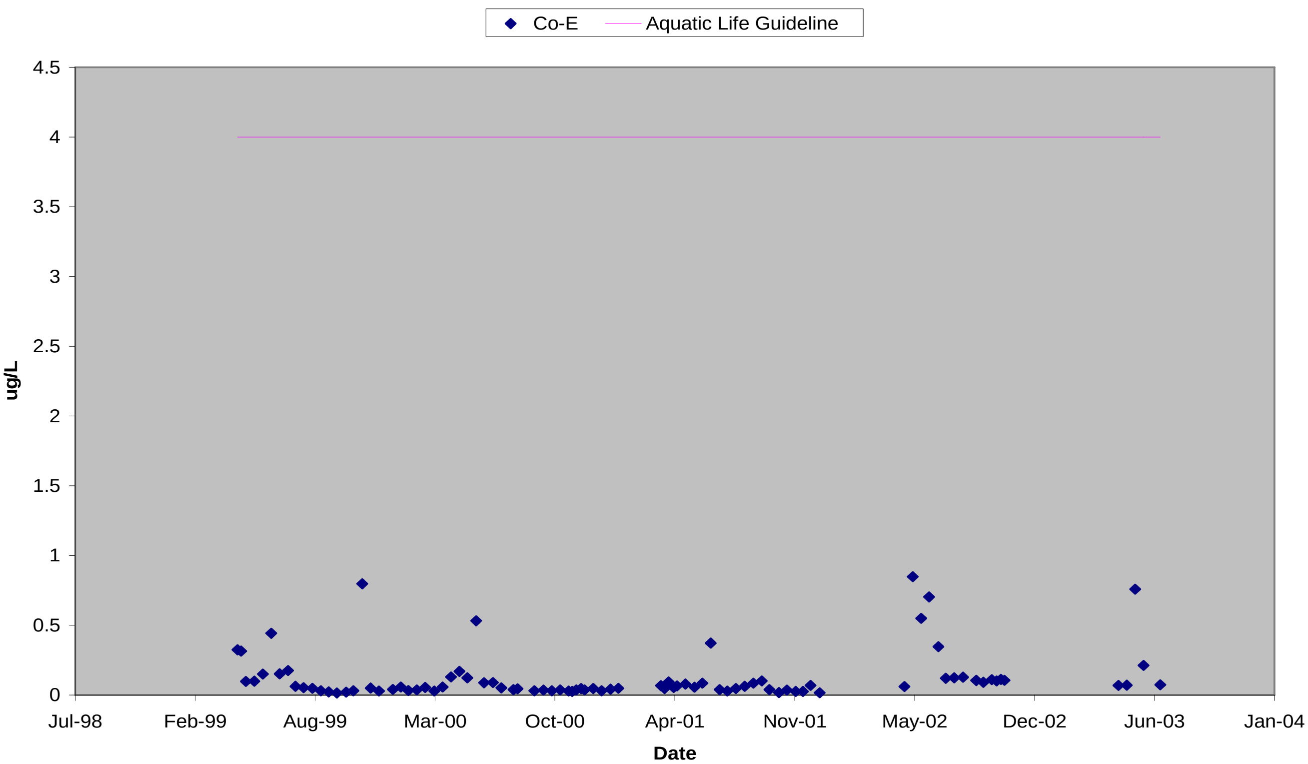


Figure 11 Coliforms, Fecal

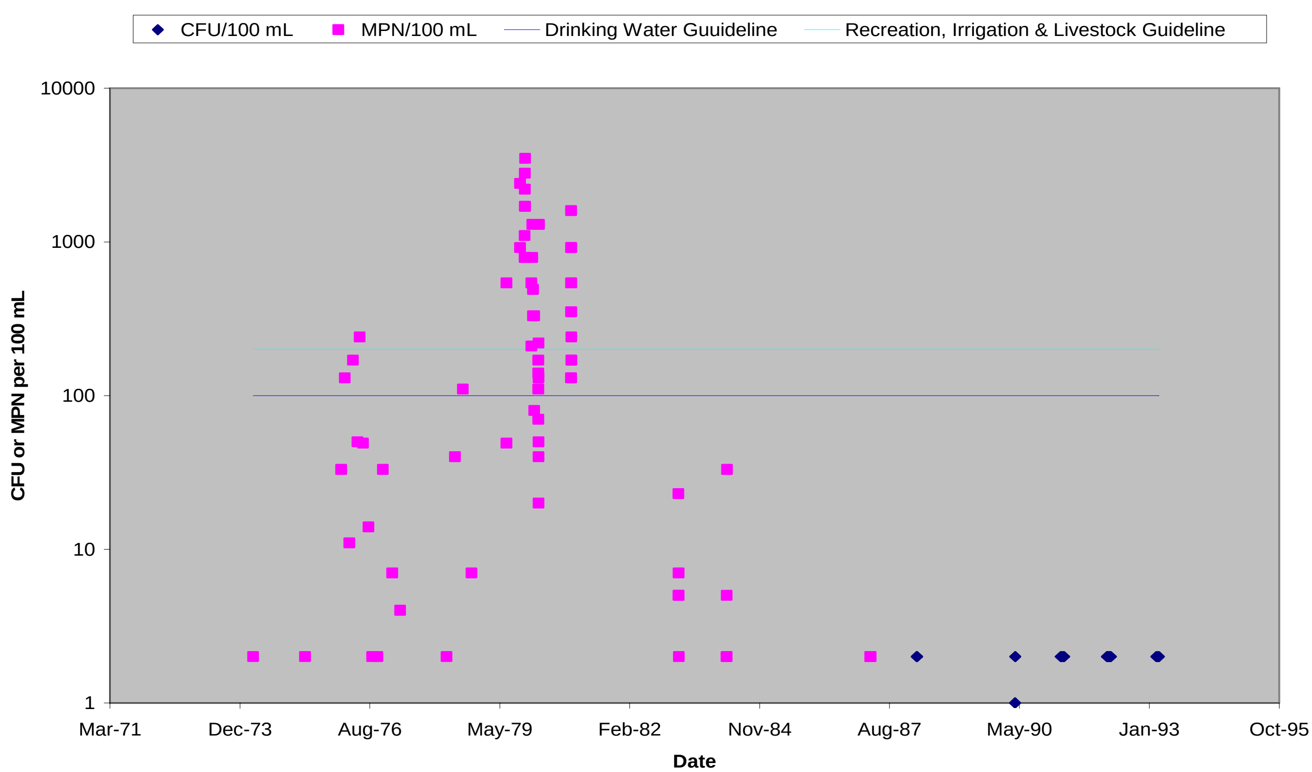


Figure 12 Conductance, Specific

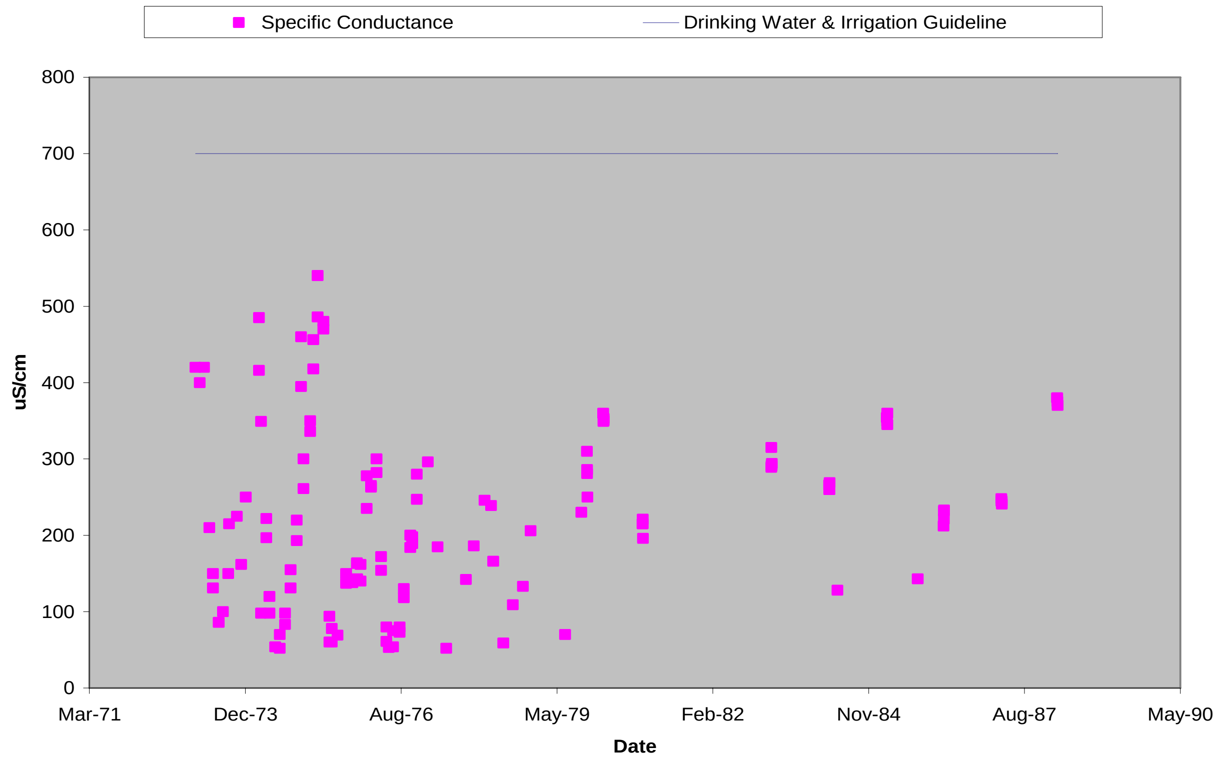


Figure 13a Copper

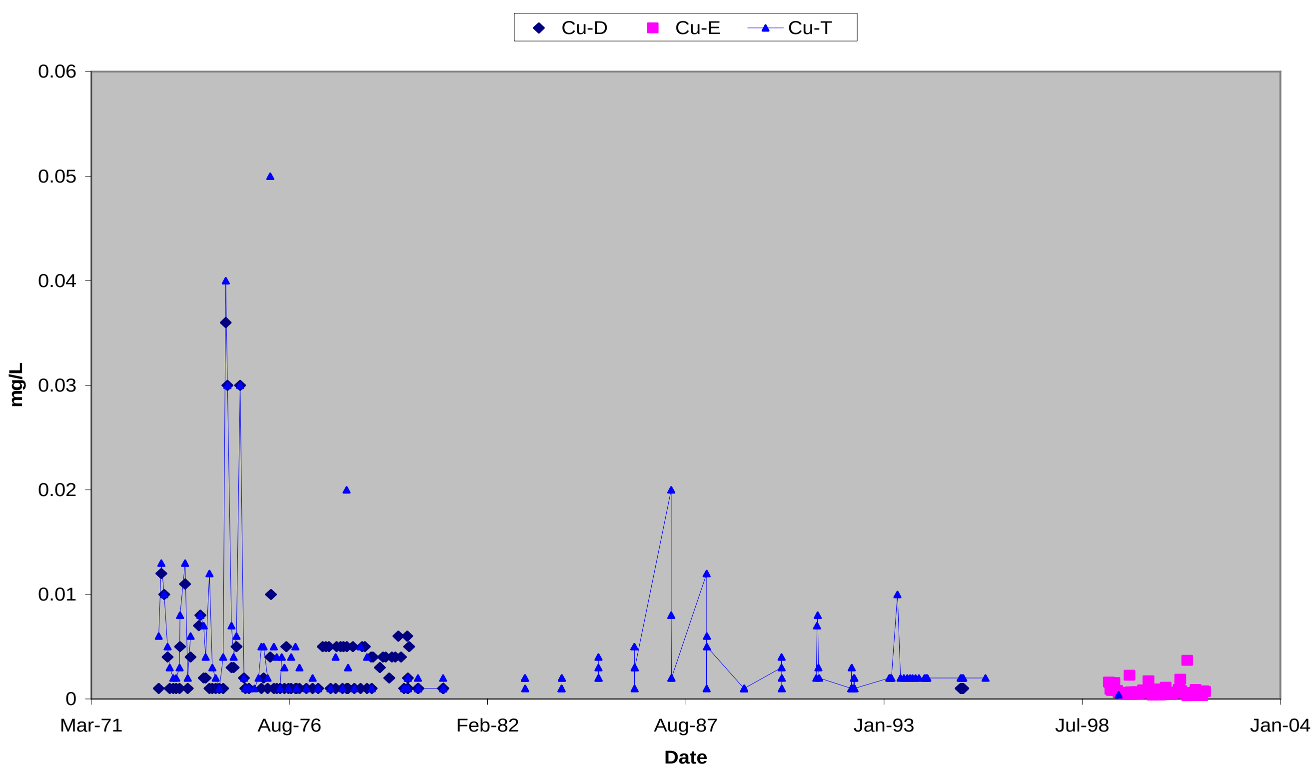


Figure 13b Copper, Extractable

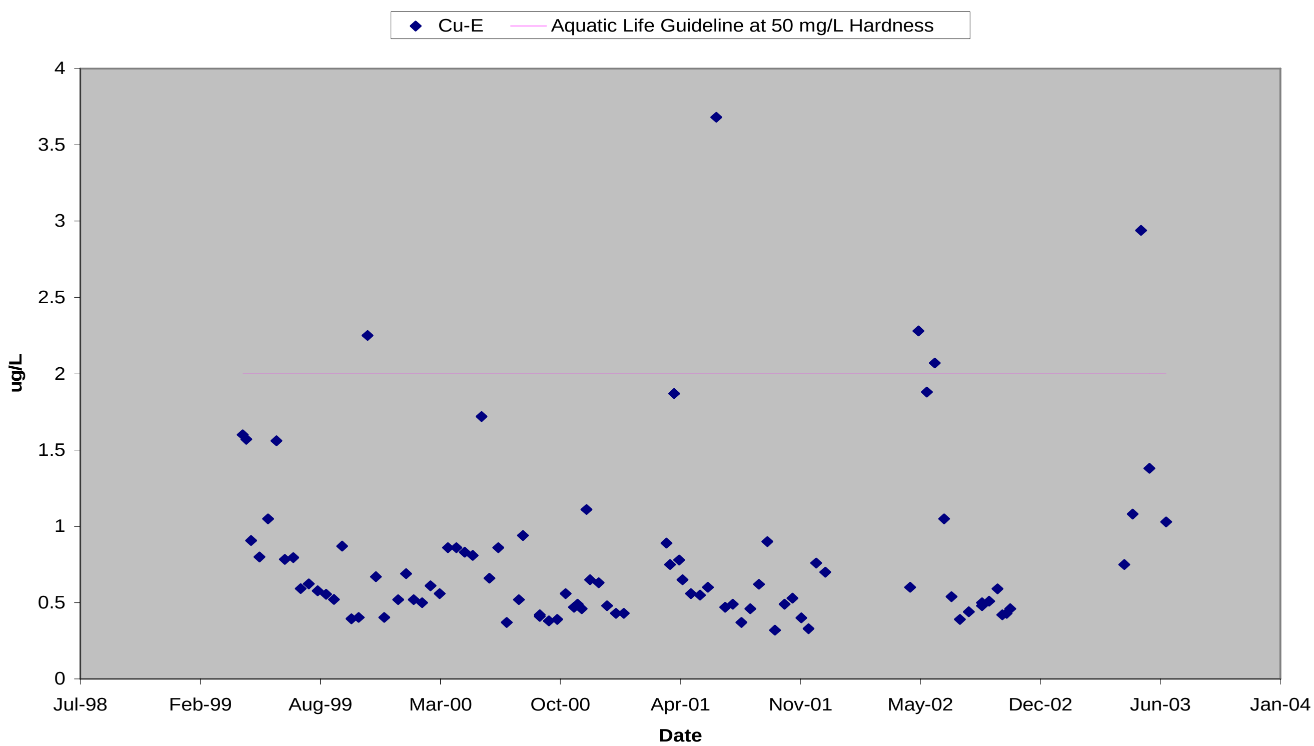


Figure 14 Cyanide

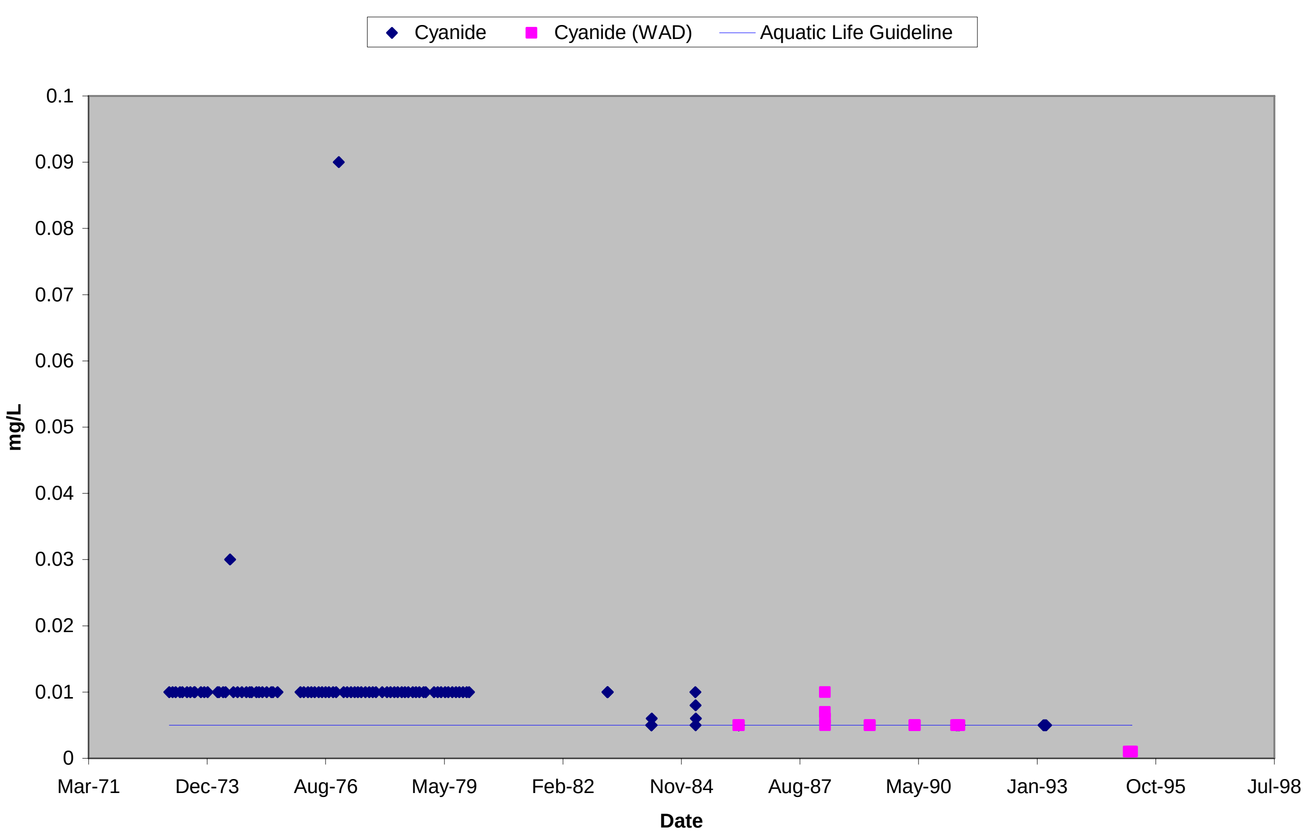


Figure 15a Fluoride

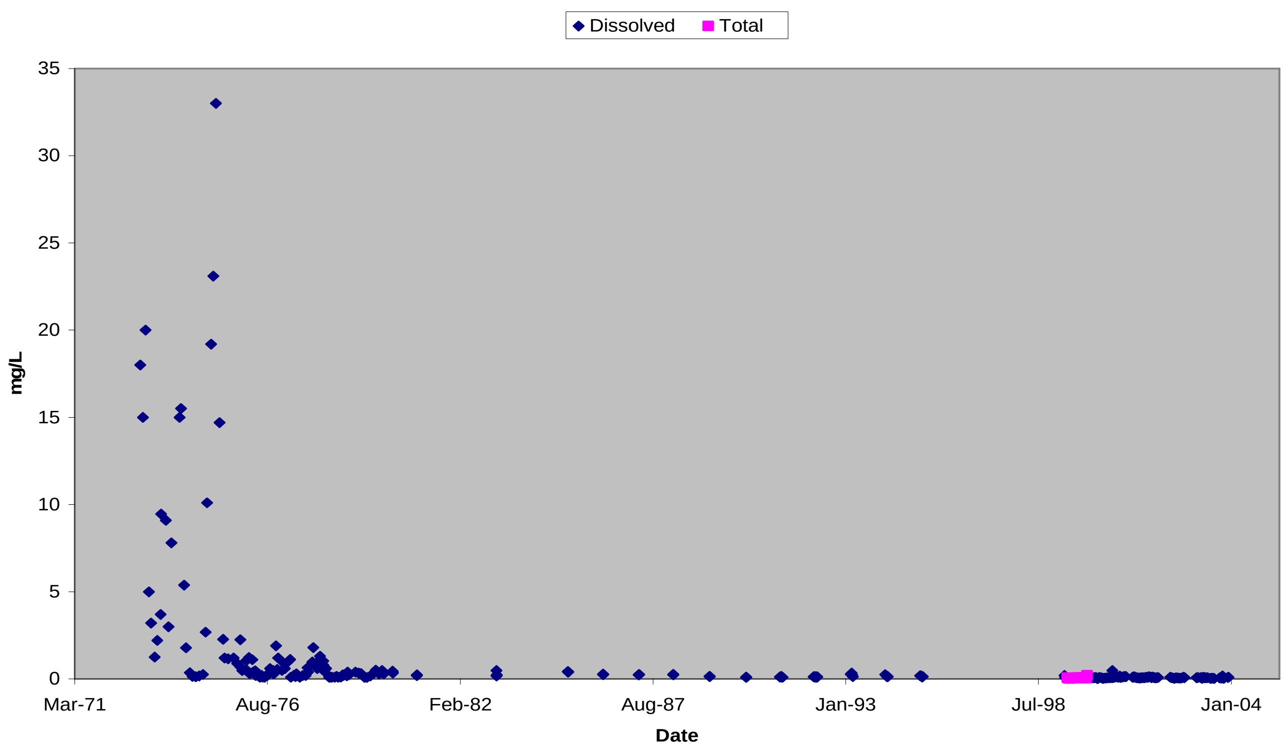


Figure 15b Fluoride 1999-2003

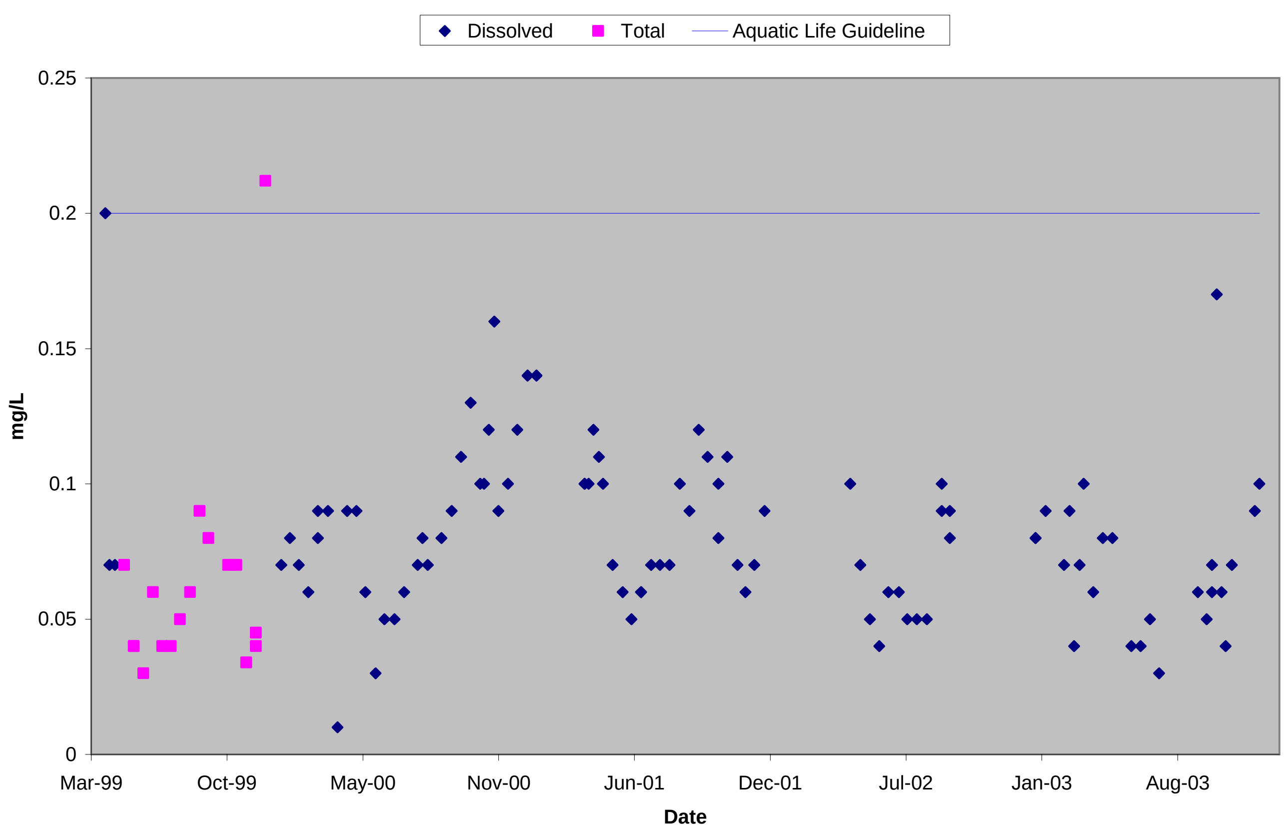


Figure 16 Hardness

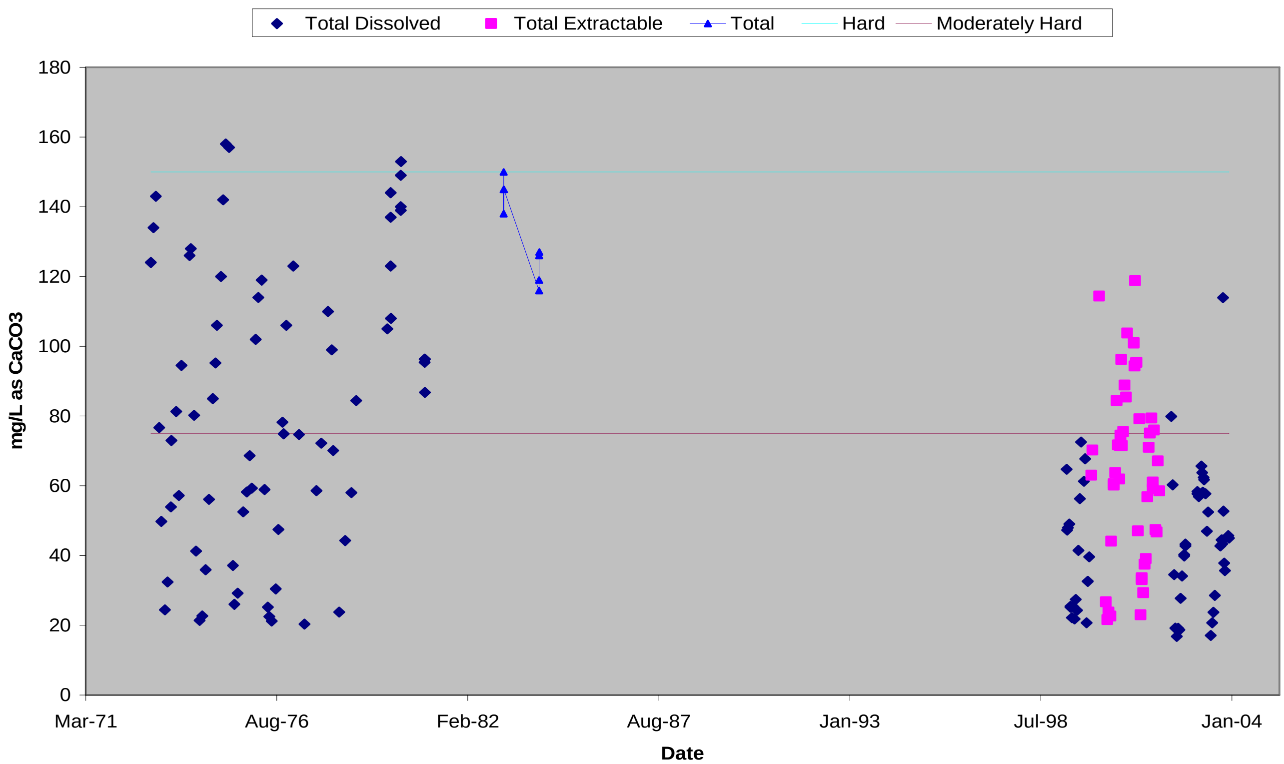
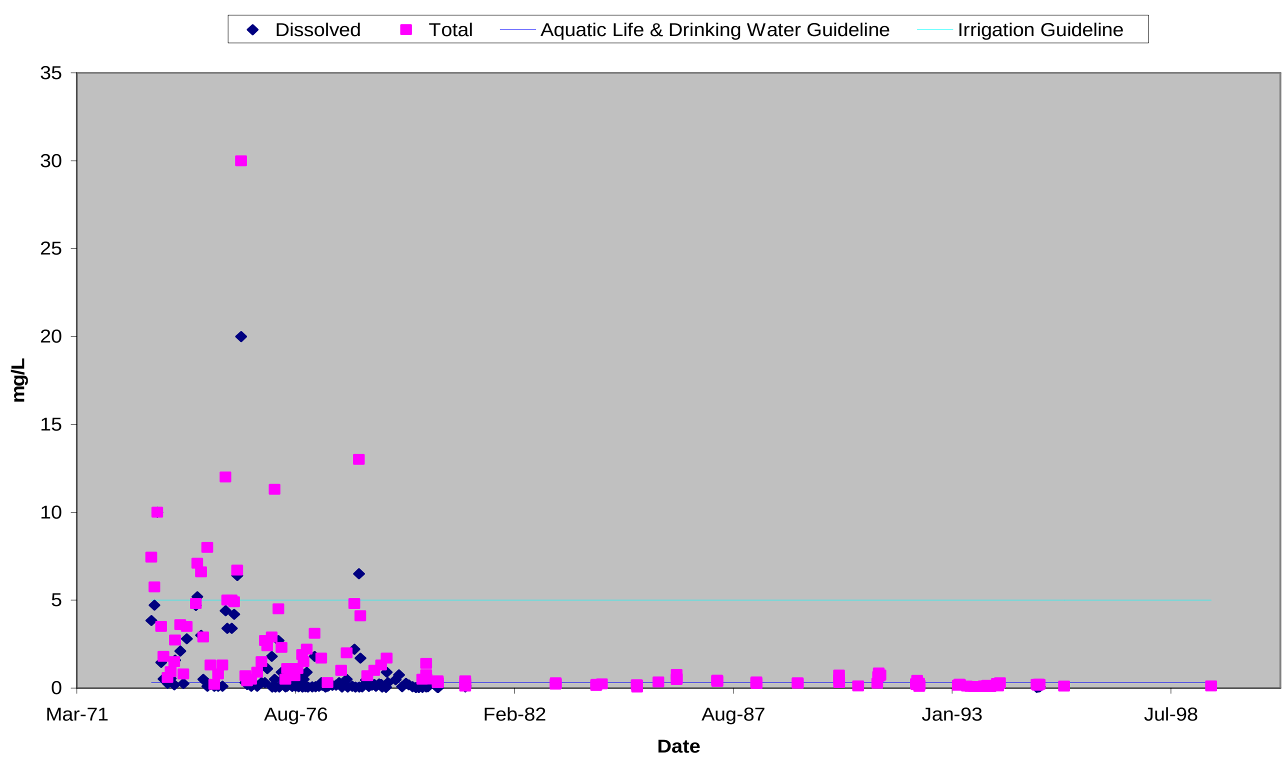


Figure 17a Iron



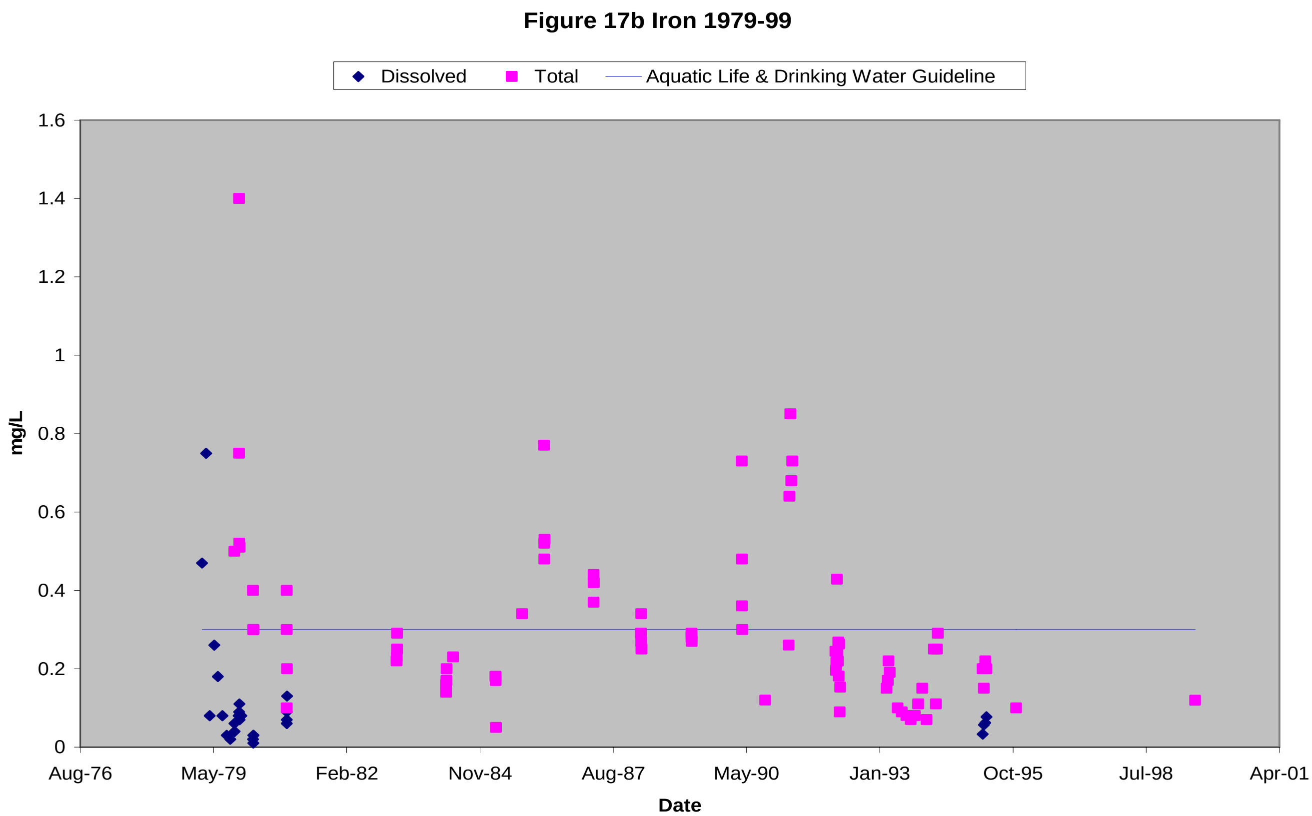


Figure 17b Iron 1979-99
Dissolved
Total
Aquatic Life & Drinking Water Guideline
mg/L
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Aug-76
May-79
Feb-82
Nov-84
Aug-87
May-90
Jan-93
Oct-95
Jul-98
Apr-01
Date

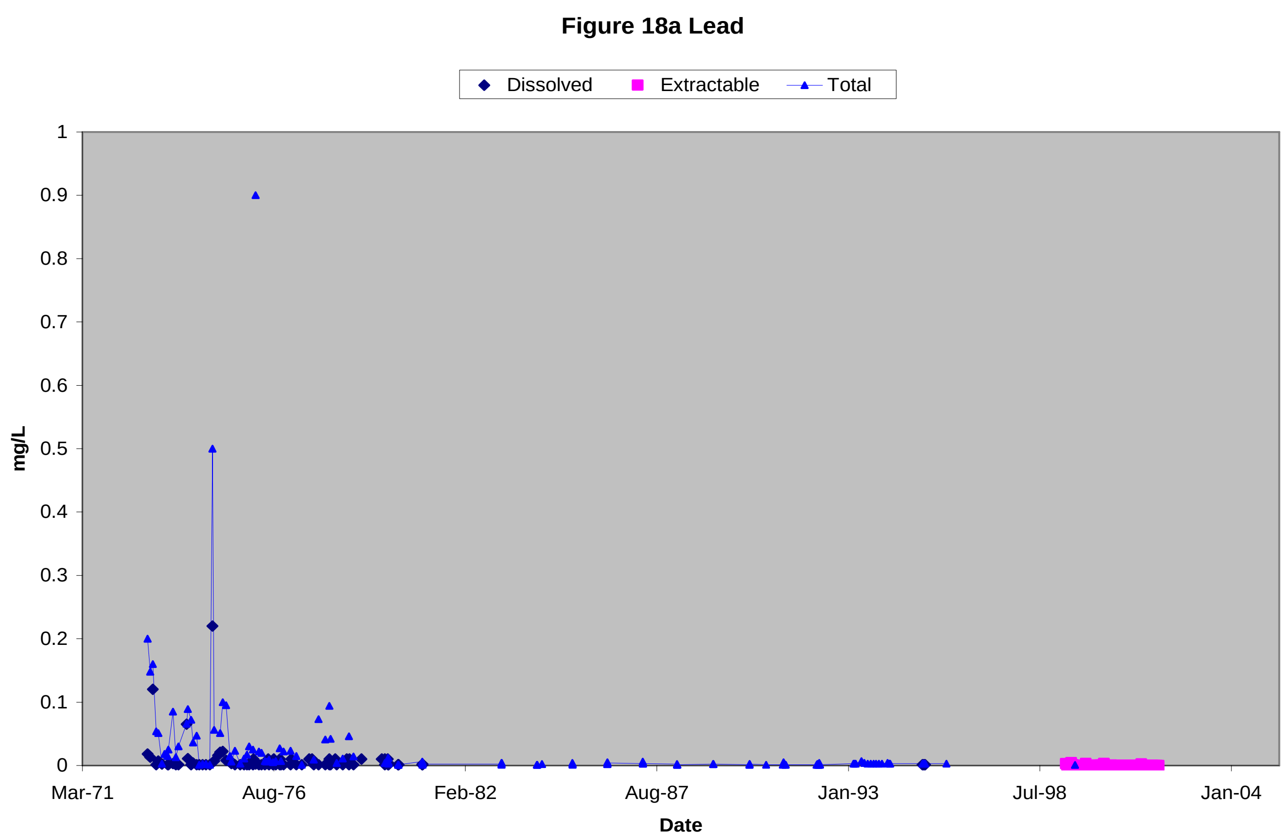


Figure 18a Lead
Dissolved
Extractable
Total
mg/L
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Mar-71
Aug-76
Feb-82
Aug-87
Jan-93
Jul-98
Jan-04
Date

Figure 18b Lead, Extractable

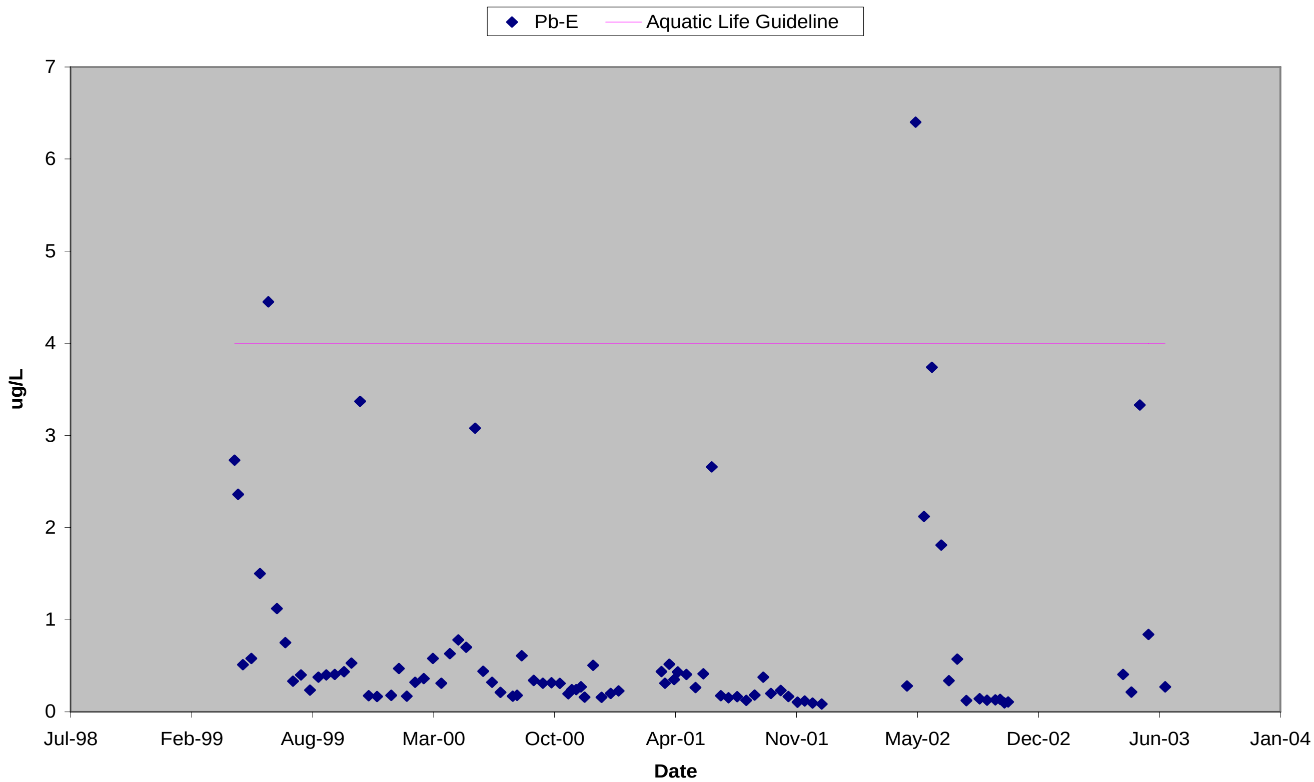


Figure 19 Magnesium

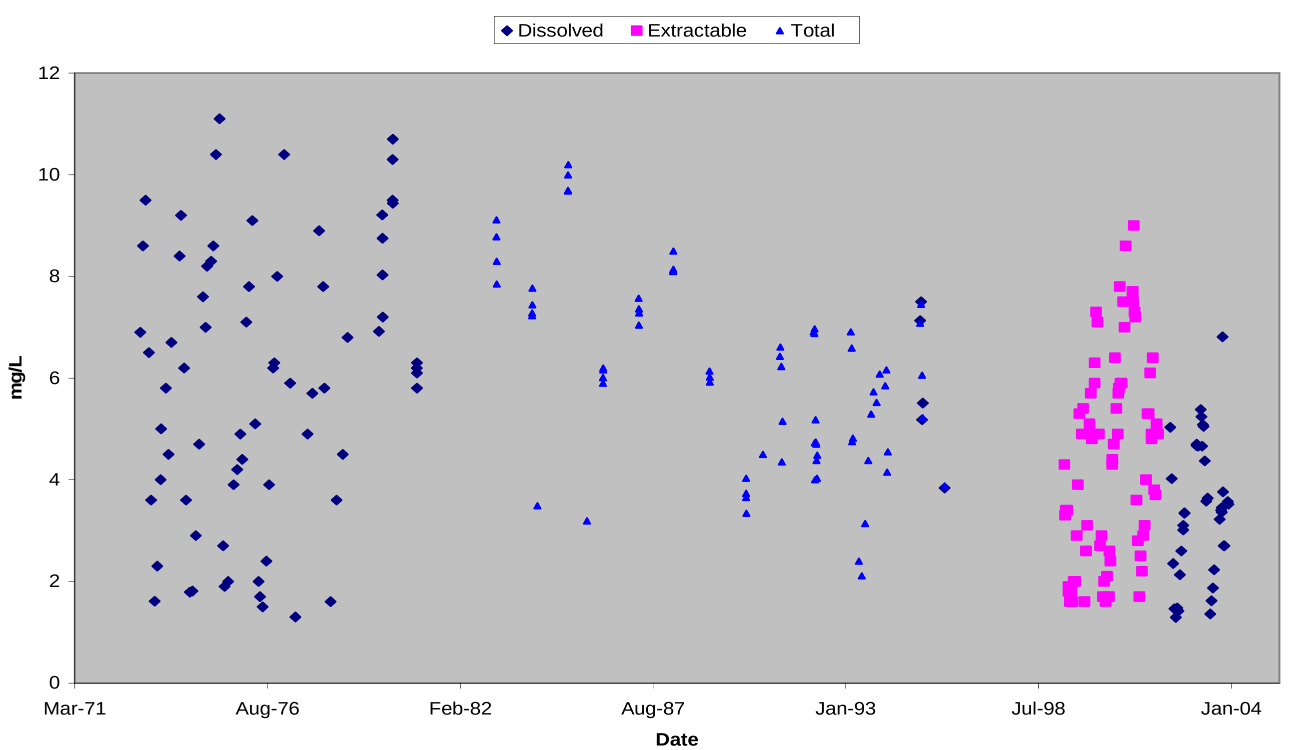


Figure 20a Manganese

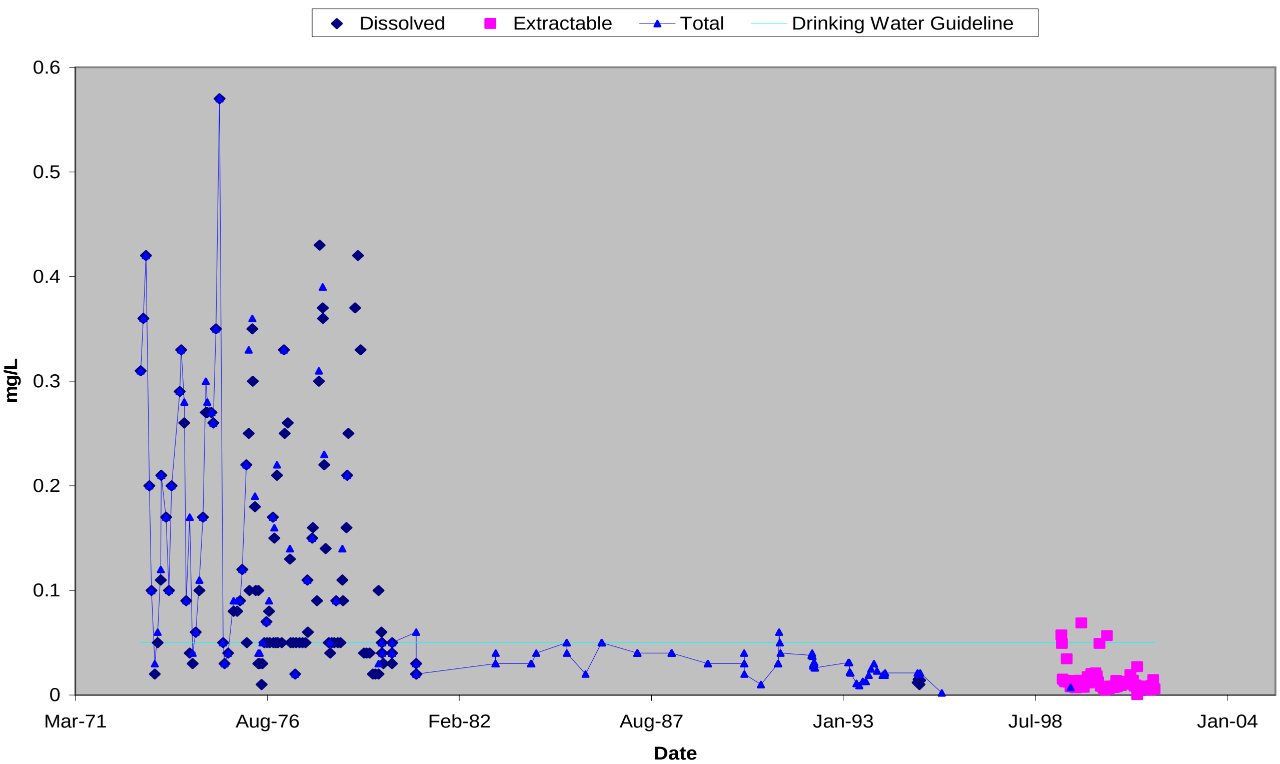


Figure 20b Manganese, Extractable

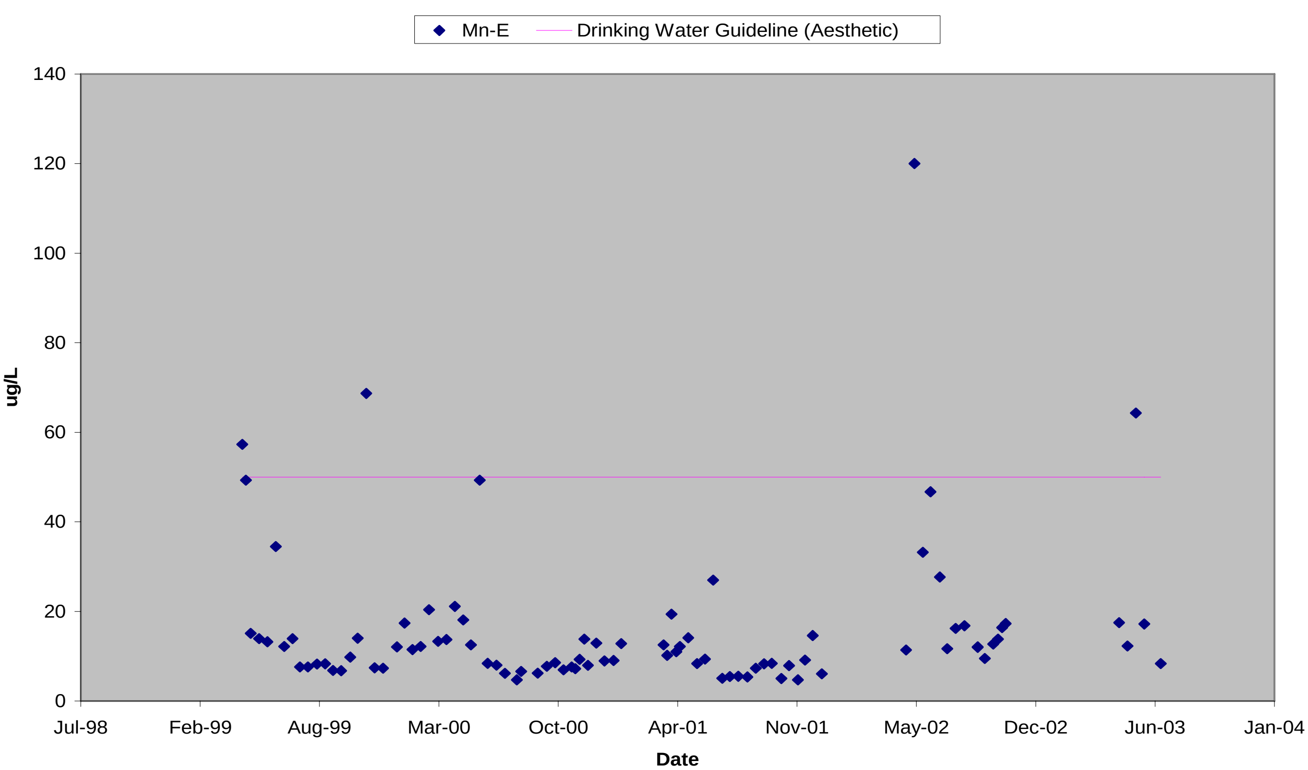


Figure 21 Mercury

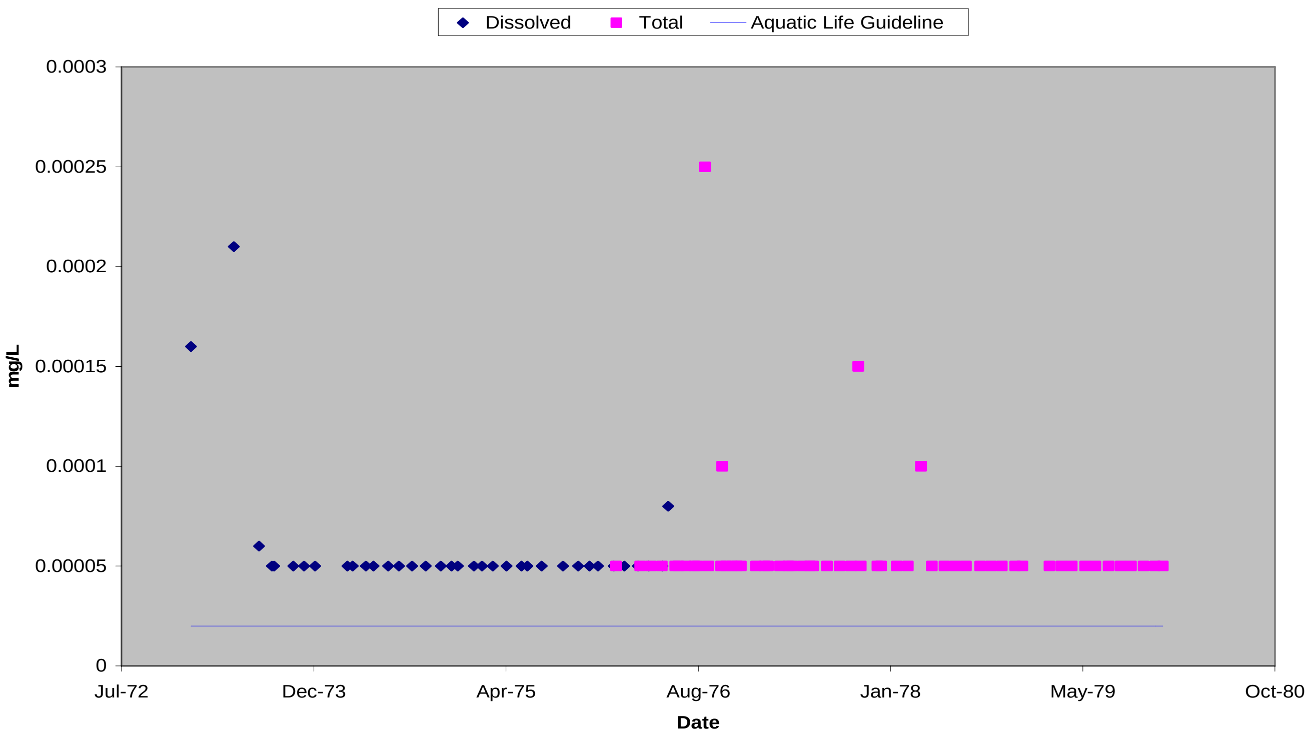


Figure 22a Nitrogen

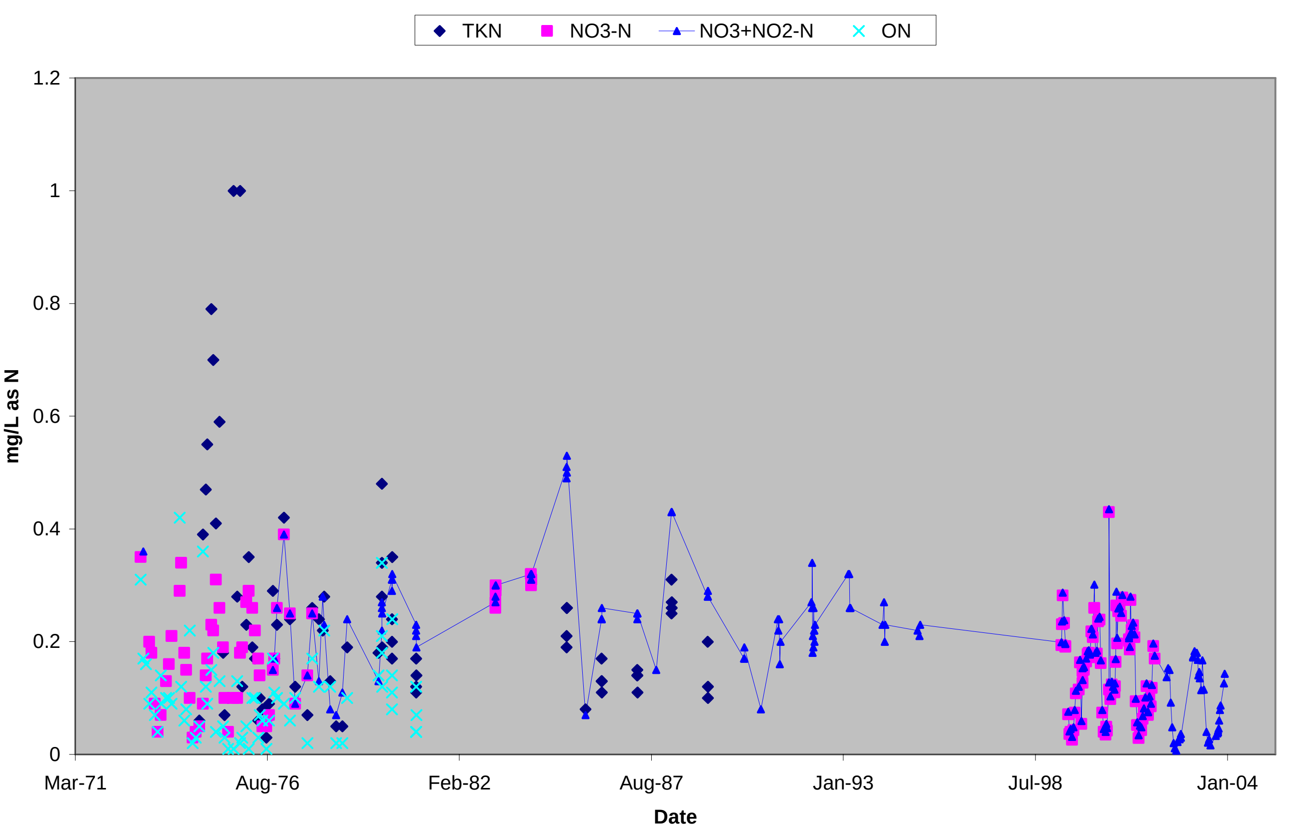


Figure 22b Nitrogen, Nitrate + Nitrite

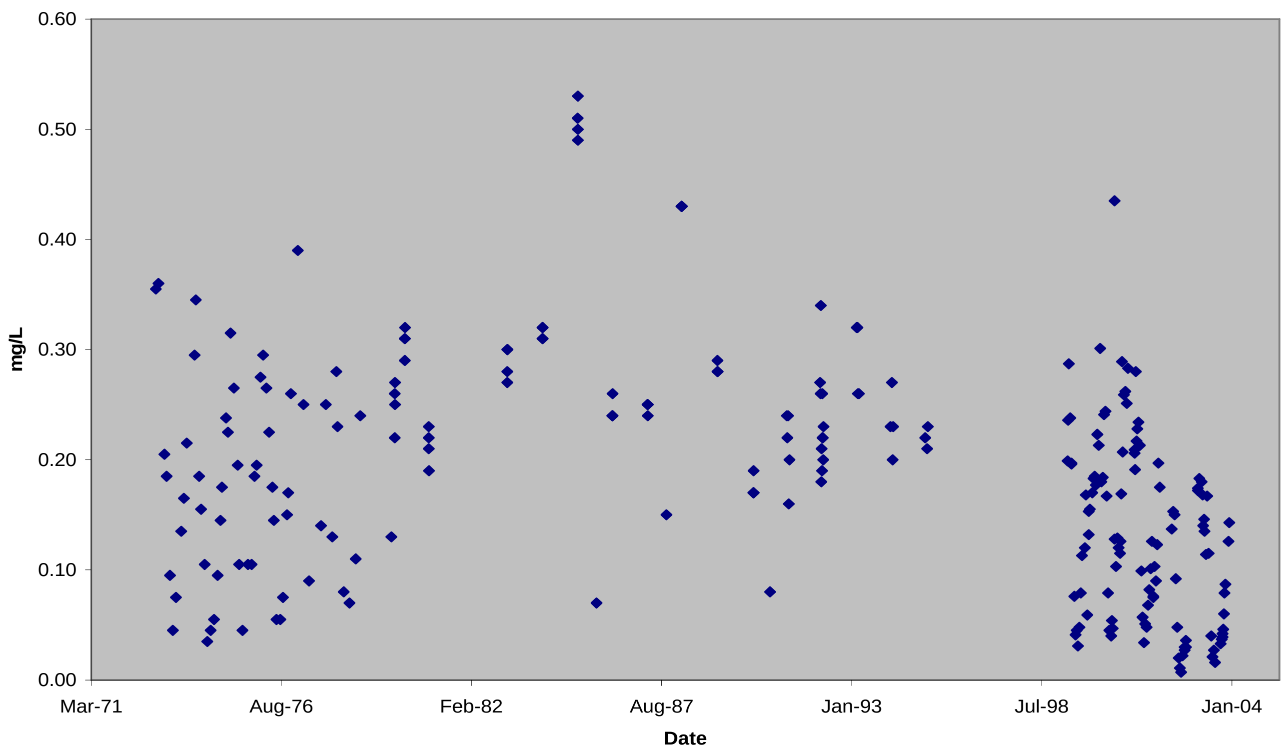


Figure 22c Nitrogen, Nitrite

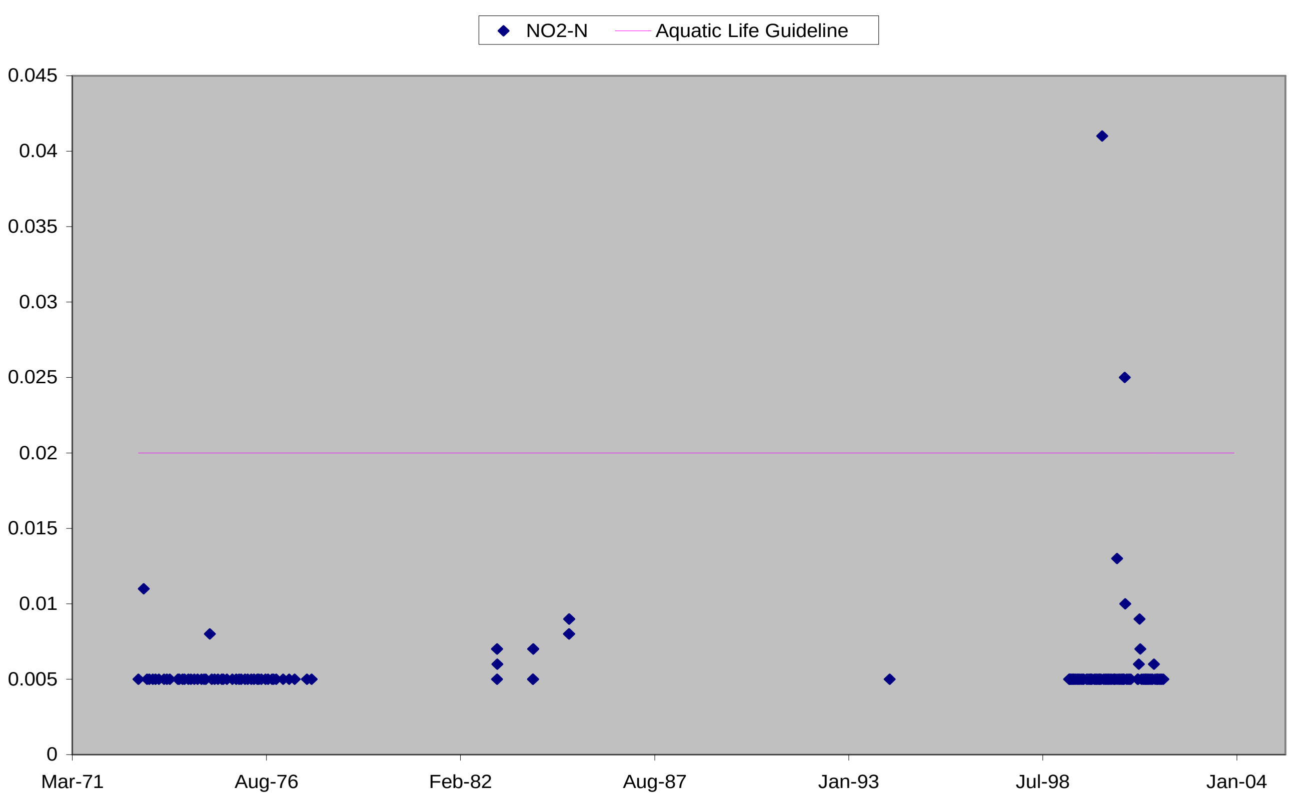


Figure 23 Oxygen, Dissolved

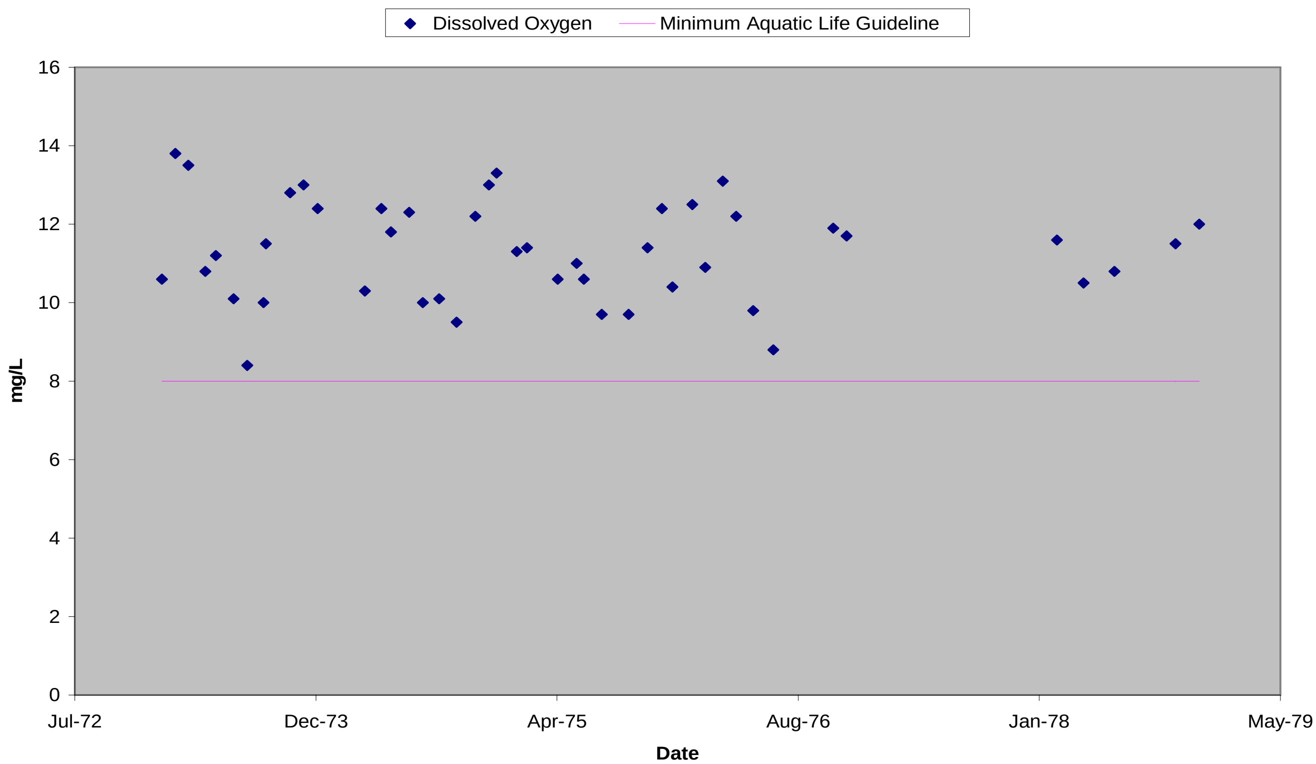


Figure 24 pH

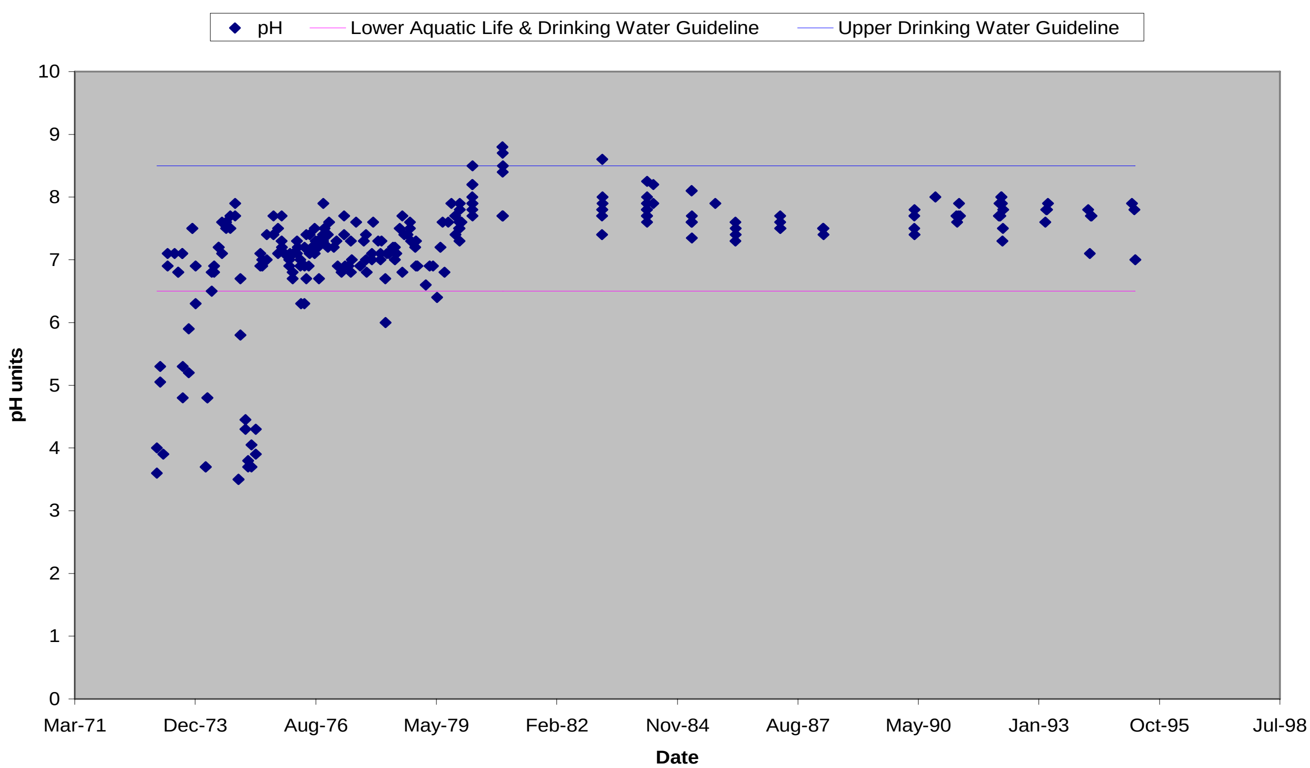


Figure 25a Phosphorus

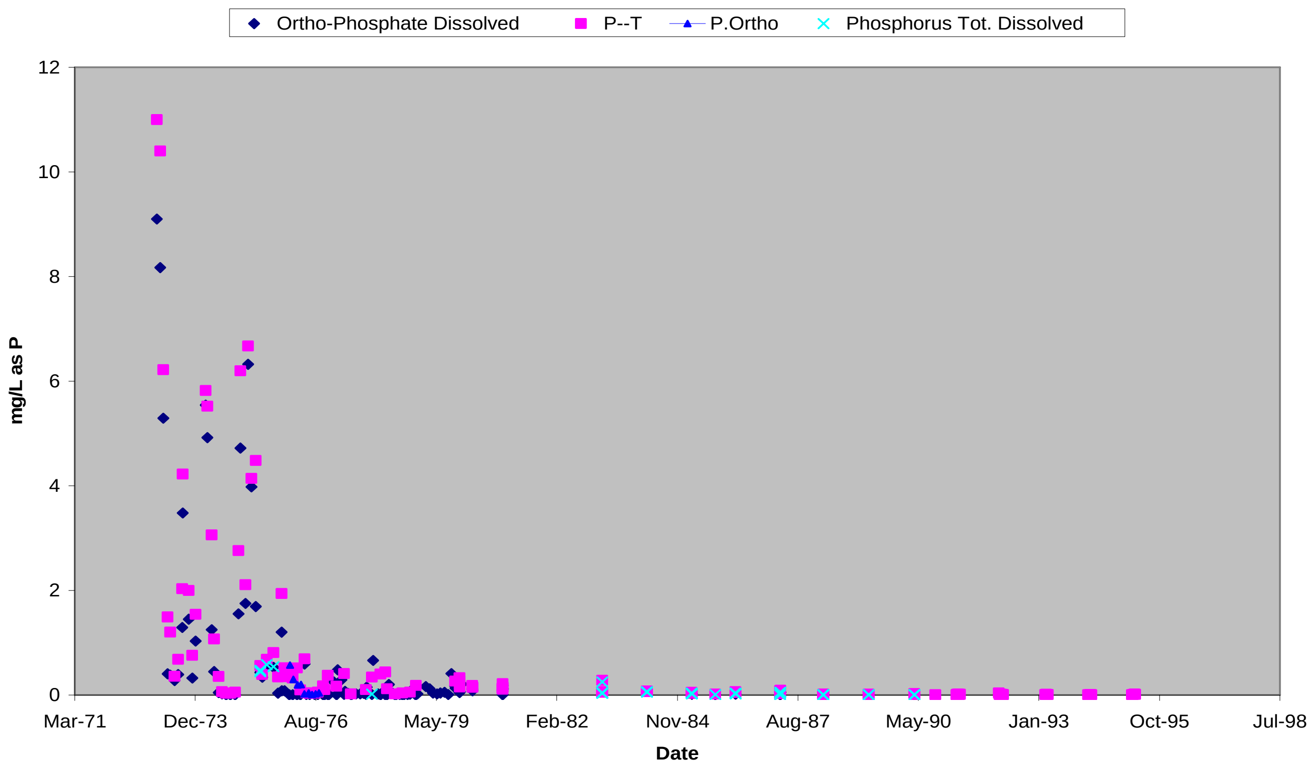


Figure 25b Phosphorus 1980-95

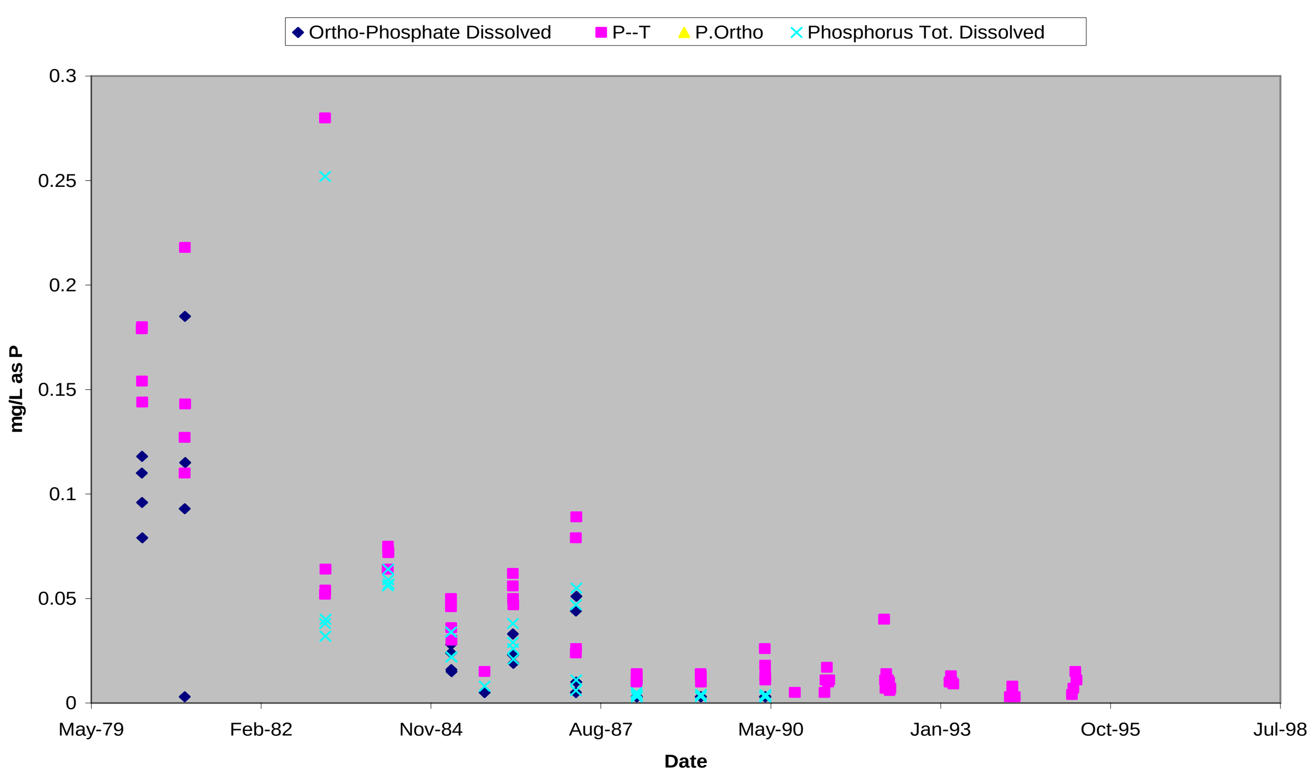


Figure 26 Silica and Silicon

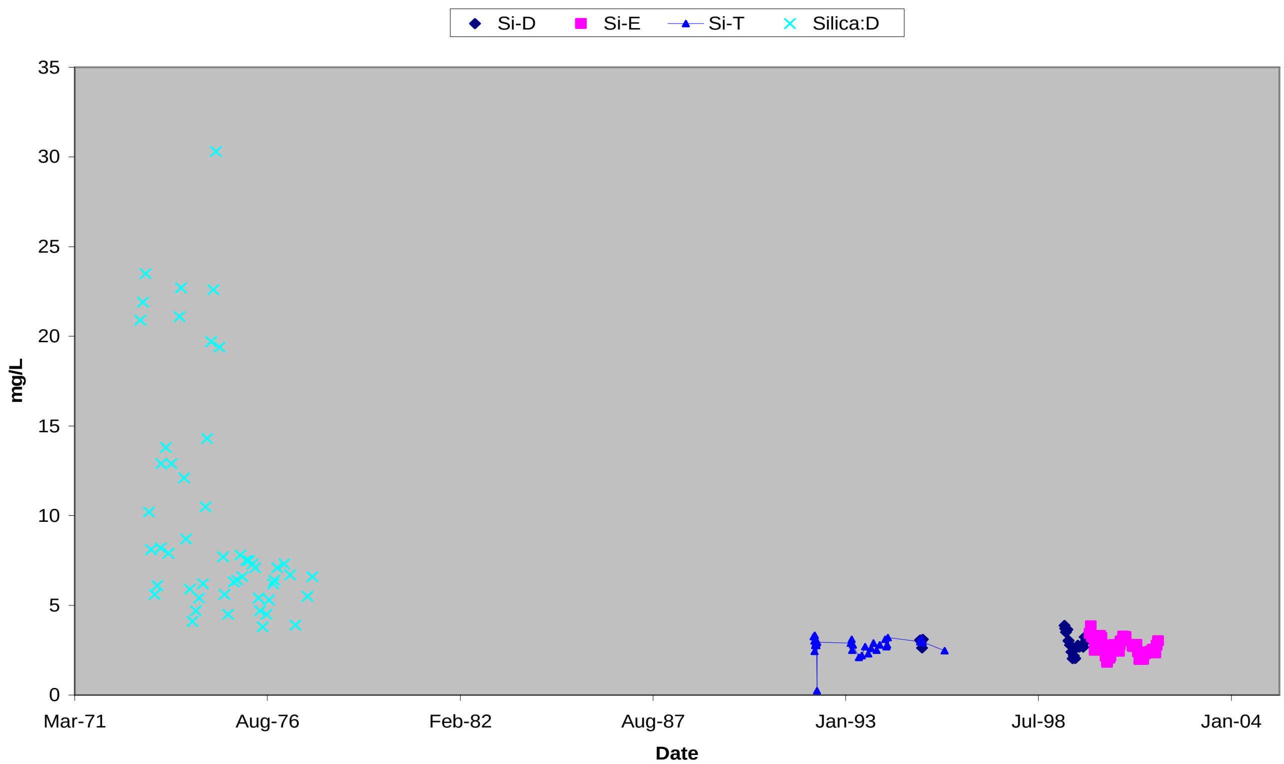


Figure 27 Silver, Extractable

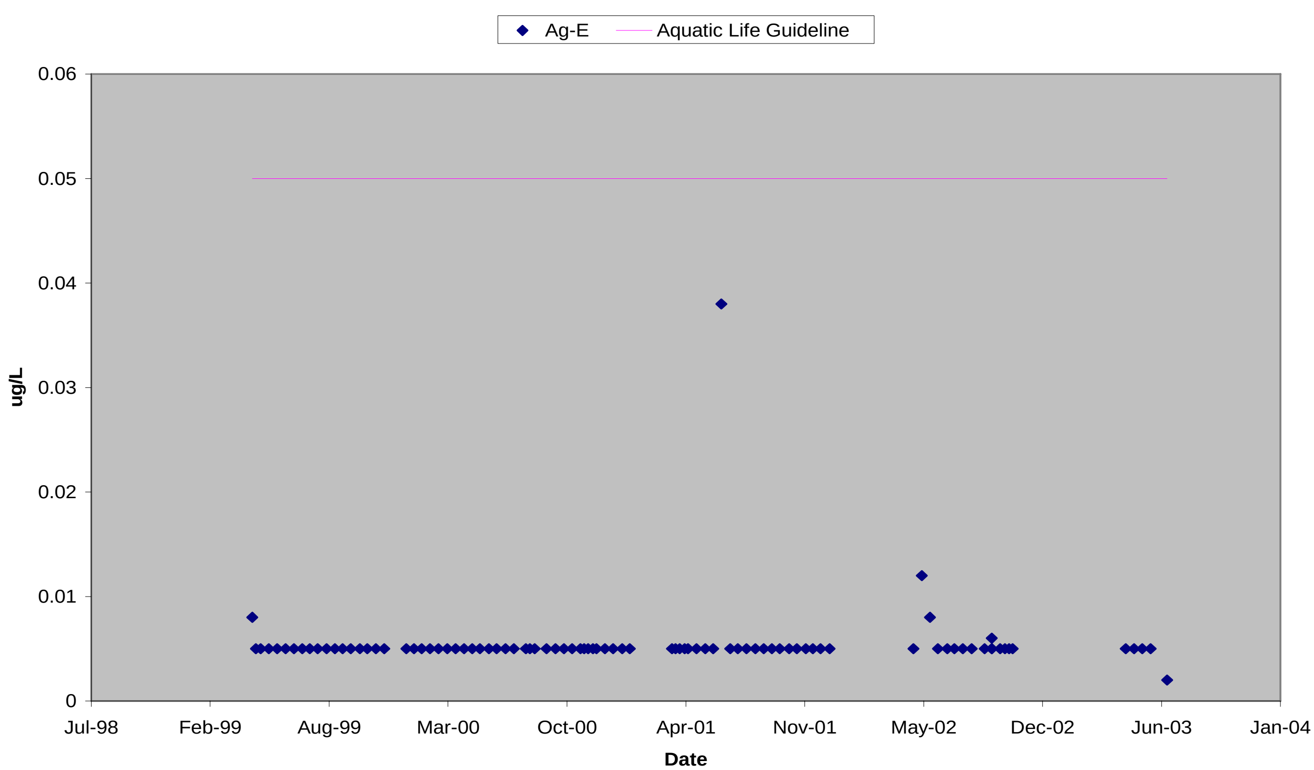


Figure 28 Sulphate

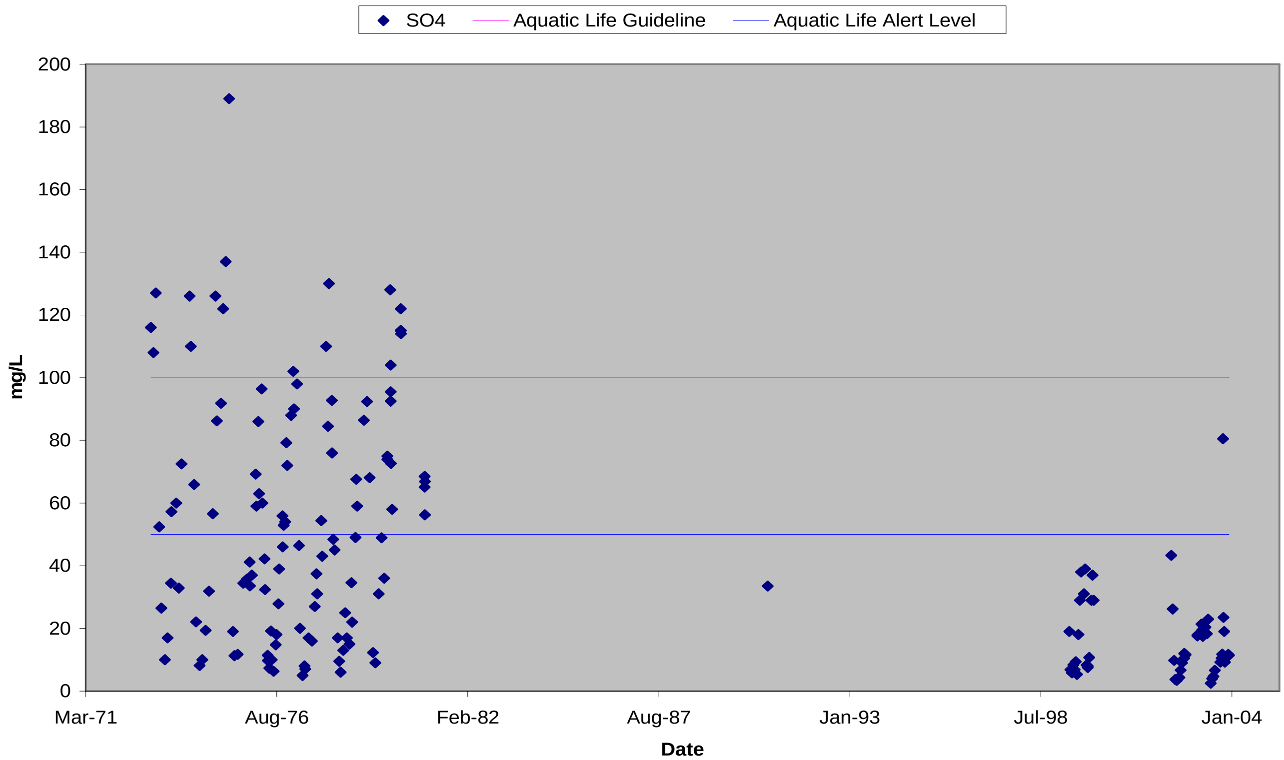


Figure 29 Temperature, Water

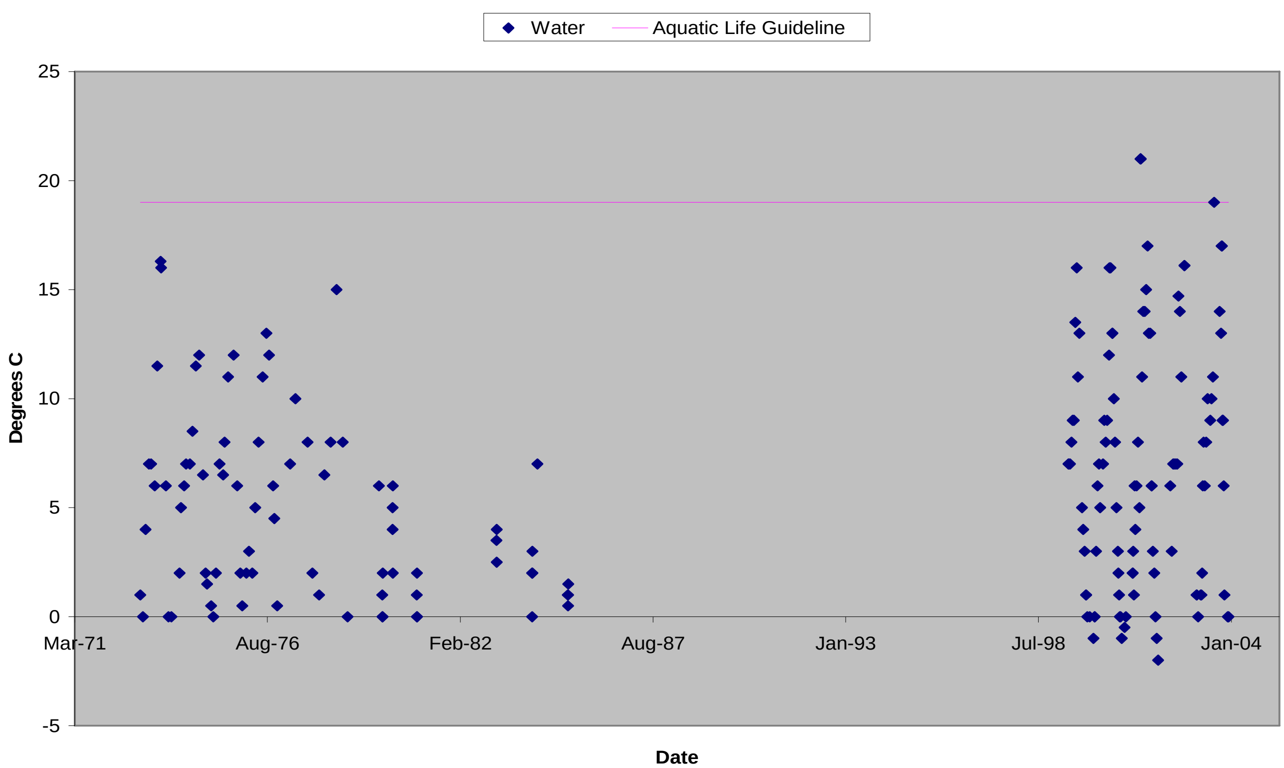


Figure 30a Turbidity 1973-2003

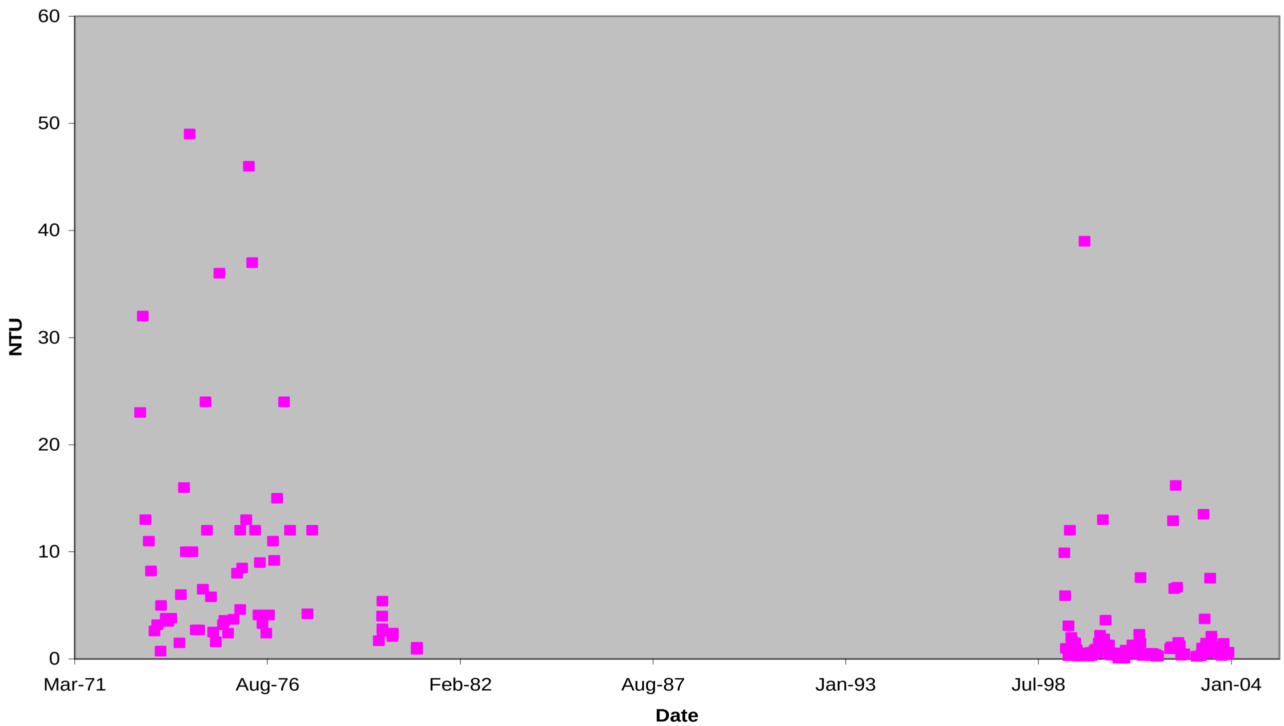


Figure 30b Turbidity 1999-2003

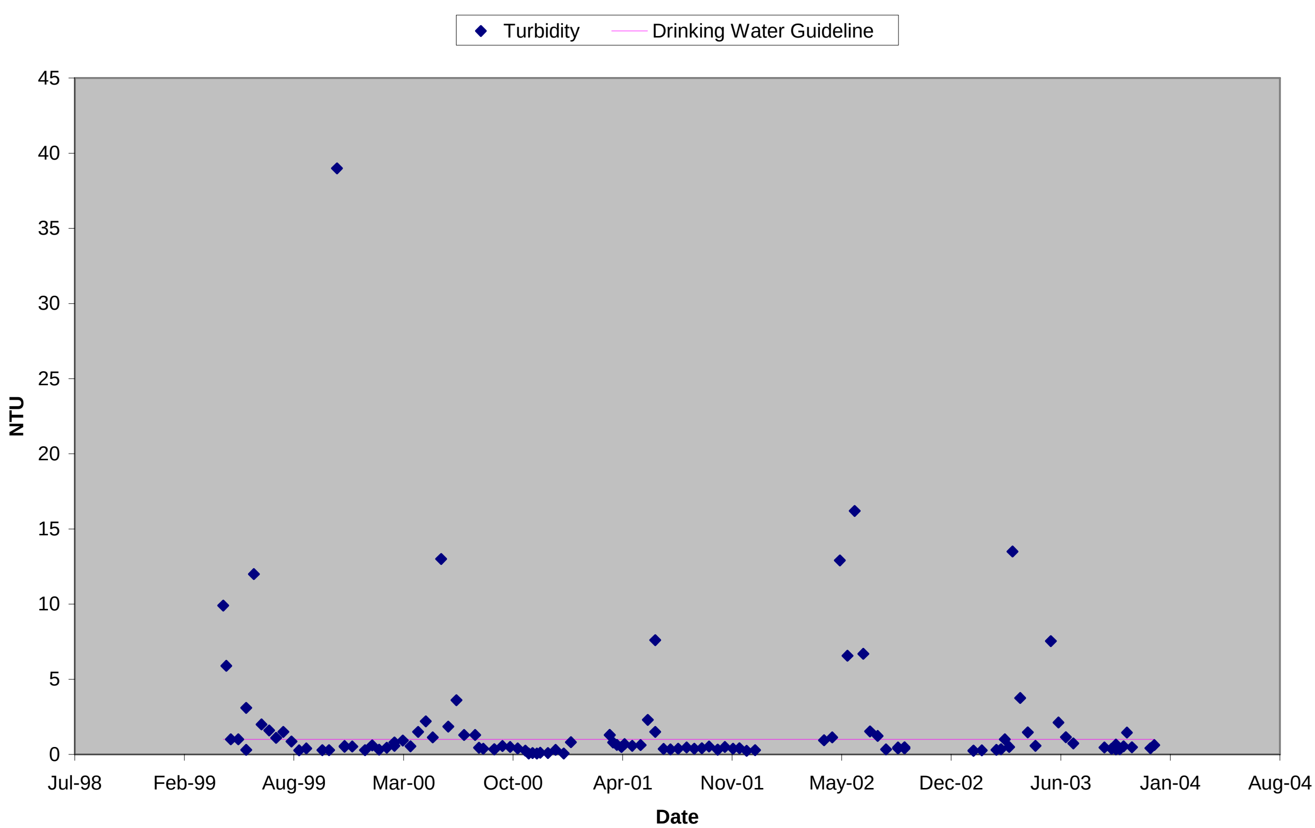


Figure 31a Zinc

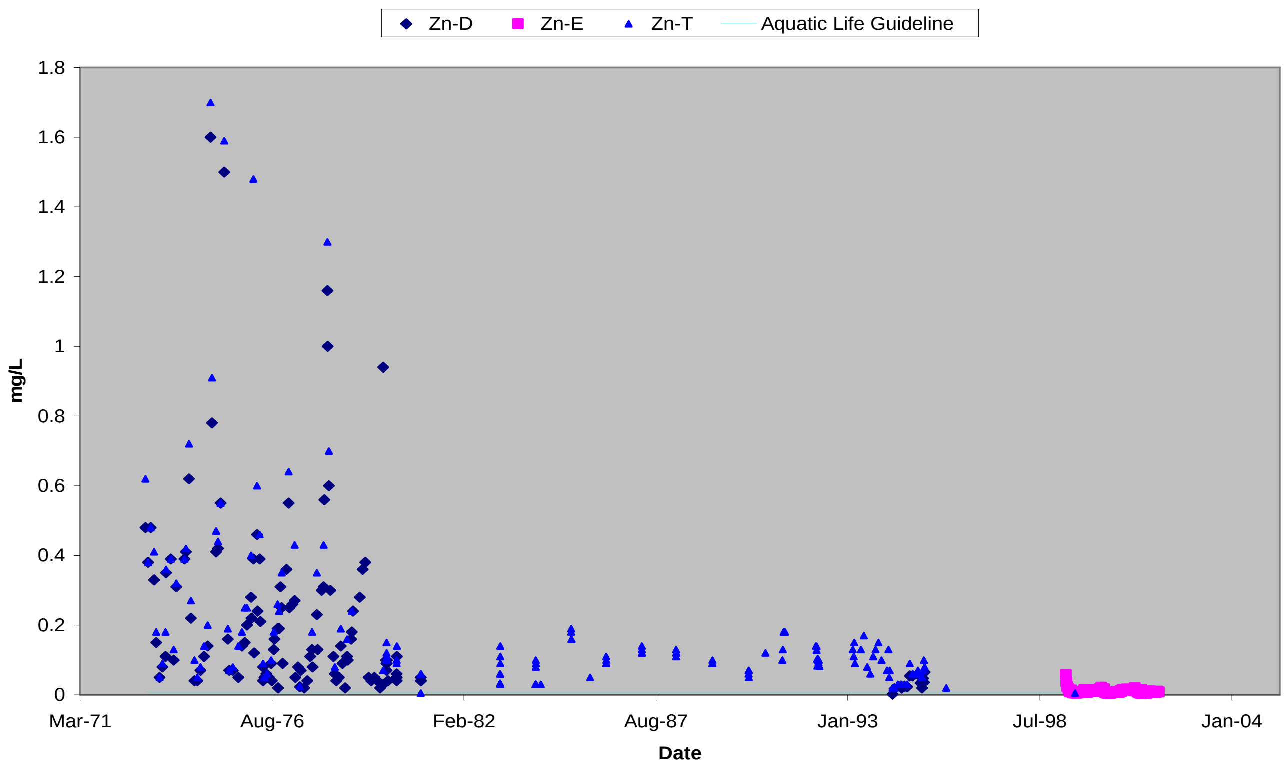


Figure 31b Zinc, Extractable