CANADA – BRITISH COLUMBIA
WATER QUALITY MONITORING AGREEMENT

WATER QUALITY ASSESSMENT OF KOKSILAH RIVER AT HIGHWAY 1 BRIDGE (1971 – 2003)

Pommen Water Quality Consulting

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Environment Canada Environnement Canada

BRITISH COLUMBIA Ministry of Environment

Executive Summary

The Koksilah 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, and the river flows east and north to join the Cowichan River one kilometre upstream from the Cowichan Bay estuary. The water quality sampling station on the Koksilah River at Highway 1 is located two kilometres upstream from the Cowichan River. The river provides habitat for sport and commercial fish species, and is used for recreation and domestic, irrigation, and industrial water supplies. The main human activities in the Koksilah River watershed are forestry, agriculture, and residential and commercial development. This assessment is based on up to 33 years of water quality data during 1971-2003. The water quality trends identified below have not yet been confirmed by statistical analysis.

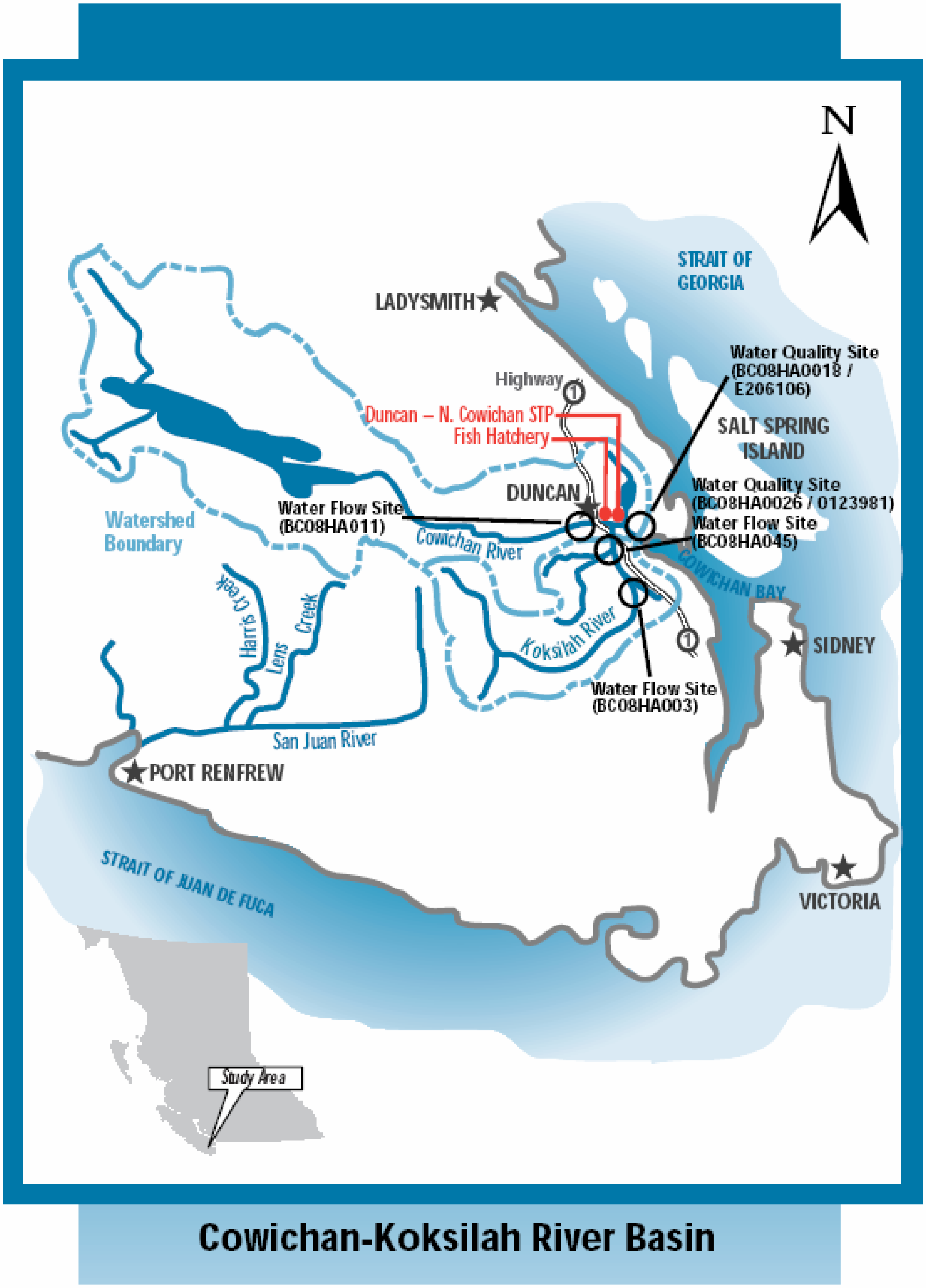
Conclusions

- The water was soft with respect to hardness, but had a low sensitivity to acids.
- The water quality objectives for ammonia, lead, and zinc were attained.
- Water quality indicators of fecal contamination were often exceeded, but the objectives may be too stringent for the water uses in the river. The objectives appear unrealistically low because the turbidity in the river would require partial treatment (e.g., filtration) plus disinfection before drinking, thereby allowing a higher objective for the water.
- Periphyton algal growth exceeded the recreation and aquatic life guidelines in 1990, but not in 1988. A 1998 survey found large quantities of algal growth throughout the lower river wherever the river was not heavily shaded. There was ample nitrogen and phosphorus to support algal growth.
- Colour exceeded the aesthetic drinking water guideline during winter high flow.
- Total copper exceeded the objectives during 1998-2003, although dissolved copper met the objectives.
- Iron occasionally exceeded the guideline for drinking water aesthetics and aquatic life, especially during winter high flows.
- Water quality objectives for dissolved oxygen were often not attained.
- Water temperatures were suitable for cold-water fish species, but the aesthetic drinking water guideline was exceeded in the summer, when the water was warm enough for swimming.
- Turbidity often exceeded the drinking water guideline for health, and partial treatment plus disinfection is needed before drinking water use.
- There was an increasing (deteriorating) trend in manganese during summer low flow due to very low flows in 2002-03. The aesthetic drinking water guideline was exceeded during the late summer in 1998 and 2002-3.
- Other water quality indicators had apparent increasing and decreasing trends, but they were attributed to decreasing minimum detectable limits over time or increased sampling frequency during 2000-03.

Recommendations

- Reconsider the objectives for indicators of fecal contamination.
- 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 Koksilah 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, and the river flows east and north to join the Cowichan River one kilometre upstream from the Cowichan Bay estuary.

The Koksilah River at Highway 1 water quality monitoring station is located south from Duncan, B.C. at the Highway 1 bridge crossing of the Koksilah River, two kilometres upstream from its confluence with the Cowichan River (Figure 1). The drainage area of the river at the station is 282 km^2 (Water Survey of Canada hydrometric station BC08HA045). 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 is used for domestic and industrial water supplies, recreation, and irrigation. The potential influences on water quality include non-point agricultural and urban runoff and runoff from gravel washing and a landfill/incinerator [1, 2], as well as runoff from forestry operations in the headwaters.

Flow in the Koksilah River at Cowichan Station (209 km^2) was monitored year-round during 1960-2003. The flow data are stored on the Water Survey of Canada database under station number BC08HA003. Thirty-three years (1971-2003) of flow data are plotted in Figure 2a, and Figure 2b shows 1999-2003 to provide more detail for recent years. The Province began collecting water quality data in 1971 and the data are stored on the Environmental Monitoring System (EMS) under site number 0123981. 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 BC08HA0026 and on EMS under site number 0123981. Up to 33 years (1971-2003) of water quality data were used in this report. The data for the water quality indicators are plotted in Figures 3 to 19.

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 Koksilah 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 and total organic, chloride, chromium, cobalt, fluoride, lithium, mercury, potassium, magnesium, nickel, 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) had a low sensitivity to acids (>20 mg/L).

Aluminum – Figure 3 – had higher values during winter when flow and non-filterable residue 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 well below the average water quality objectives[1].

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, but all values above the guideline were below their detection limits. 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 two occasions (1988 and 1990). The water quality guidelines of an average of 50 and 100 mg/m^2 (0.05 and 0.1 g/m^2) for recreation and aquatic life were exceeded in 1990. A 1998 survey of the river "found large quantities of algal growth throughout the lower Koksilah whenever the river was not heavily shaded. Fortunately, much of the lower Koksilah is heavily shaded, protecting the river from the impacts of excessive nutrient input [9]. There was ample nitrogen and phosphorus in the river to support algal growth.

Coliforms, fecal, E. Coli, and Enterococci – Figure 5

The water quality objectives [1] for the Koksilah River were exceeded by 80% of the results for fecal coliforms, 88% of the results for *E. Coli*, and 77% of the results for enterococci. The 1996 Water Quality Status Report [2] rated the 1988-93 water quality as fair due to coliforms and dissolved oxygen not meeting the objectives at times. The objectives are based on the use of the water for drinking after disinfection. The objectives appear unrealistically low because the turbidity in the river would require partial treatment (e.g., filtration) plus disinfection before drinking, and given the relatively high levels of fecal contamination in the river. An objective of 100/100 mL for fecal coliforms and *E. Coli*, and 25/100 mL for enterococci would be consistent with the need for partial treatment plus disinfection, and would also protect recreation and irrigation use. There is a suggestion of an increasing (deteriorating) trend over time for fecal coliforms due to higher values in 2000-03, 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 (149 results, averaging 37/year) compared to 1971-98 (89 results, averaging 3/year), which gave a greater probability of sampling episodes of elevated fecal contamination.

Colour, true (no figure) had four of 49 (8%) values above the aesthetic drinking water guideline of 15 units during winter rains and higher flows, which is normal.

Conductance, specific – Figure 6 – had an apparent minor increase (deterioration) over time, but the levels were well below the lowest water quality guideline of 700 µS/cm, and thus the trend is of no concern at this time. The trend could have been caused by differences in the sampling frequency of low flows, which have a higher proportion of groundwater, and thus a higher conductance, but the levels were too low to warrant more detailed analysis.

Copper - **Figure 7 –** had high MDLs (0.001 and 0.01 mg/L) during 1971-93, resulting in 23 of 74 (31%) total copper measurements exceeding the average water quality objective[2] of 0.002 mg/L at hardness ≤50 mg/L. The three highest values were identified as possible or probable false positive errors and removed [7]. During 1998-2003, lower MDLs were used, resulting in lower levels, but four of 19 values (21%) exceeded the objective, although dissolved copper did not. Dissolved copper levels exceeded the objective for two of 50 results (4%), when the MDL (0.001 mg/L) was high. There was an apparent decline (improvement) in total copper levels over time, but this was likely due to the decline in MDLs over time.

Hardness –Figure 8 – indicated that the water was soft (0-75 mg/L) and no changes over time are apparent.

Iron– Figure 9 - had 20% (15 of 75) of the total iron values exceed the drinking water and aquatic life guidelines of 0.3 mg/L, mainly during winter, when flow was high. This suggests that the iron probably would have been associated with suspended sediment and not biologically available. However, the few non-filterable residue or turbidity values collected when iron was high were low. Dissolved iron exceeded the guideline for two of 25 values (8%). Total iron values declined over time, but the paucity of data after 1990 precludes the confirmation of a trend.

Lead – Figure 10 – had high outliers during 1971-93 due to the use of high MDLs. Fourteen values exceeded the average water quality objective [2] of 0.003 mg/L, and these values were reviewed with one identified as an error, eight as possible errors, and five were validated [7]. The error and possible errors were removed from the figure. Once lower MDLs were used in 1998-2003, the objective was always met. The apparent decreasing trend in lead over time is due to decreasing MDLs.

Manganese – **Figure 11a** – had eight of 71 total manganese values (11%) and five of 41 dissolved manganese values (12%) exceed the drinking water aesthetic guideline during August-September 1998-2003, when flow, non-filterable residue, and turbidity are typically very low. There appears to have been an increasing (deteriorating) trend over time, due to lower than normal flows in 2002-03. The August-September low flow period was sampled in nine of the 18 years during 1986-2003 with one to five samples during each year (1986:two, 1987:two, 1988:two, 1989:five, 1990:one, 1993:five, 1998:one, 2002:four, 2003:five), and thus the trend does not appear to be due to the greater sampling frequency during 2002-03. **Figures 11b** and **11c** show that the manganese concentration was inversely proportional to flow, and that the flow was lowest in 2002-03. As flow declined, the proportion of groundwater bearing higher concentrations of manganese increased in the river, giving rise to increased manganese concentrations in the river.

Molybdenum – Figure 12 – a high MDL of 0.01 mg/L was used during 1982-88, resulting in seven high detectable values at the 0.01 mg/L irrigation guideline. In contrast, 1998-2003 values measured with an MDL of <0.00005 mg/L, had a maximum of 0.00016 mg/L, which is 62 times lower. The seven high detectable values were identified as probable false positive errors [7]. The apparent declining trend in Figure 10 is due to the decline in MDLs.

Nitrogen – Figure 13 – had no apparent trends and the levels were well below water quality guidelines.

Oxygen, dissolved – Figure 14 – had 39 of 43 (91%) of the June to September values fail to attain the water quality objective [1] of 8 mg/L. Dissolved oxygen was measured less frequently during October to May, but eight of the 12 (67%) measurements failed to attain the objective of 11.2 mg/L. The 1996 Water Quality Status Report [2] rated the 1988-93 water quality as fair due to coliforms and dissolved oxygen not meeting the objectives at times. The Koksilah may have natural conditions making it difficult to attain the objectives (e.g., low flow and velocity during August-September), but human influence may have exacerbated these conditions (e.g., irrigation water withdrawal, agricultural nutrient loading, and excessive periphyton growth) [8]. There is an apparent declining (deteriorating) trend in the figure, but the sparse, sporadic nature of the data precludes any judgment of the validity of the trend.

pH – Figure 15 - had all values in the drinking water guideline range of 6.5-8.5. There was no apparent change in pH over time.

Phosphorus – **Figure 16 –** had higher total phosphorus levels, mainly during winter when flows are typically higher, although non-filterable and turbidity were relatively low on most dates. The phosphorus levels were relatively high and could support abundant algal growth. There was no apparent change in phosphorus levels over time.

Temperature, water – Figure 17 - had no values above the aquatic life guideline of 19 degrees C, although 31 of 158 (31%) values exceeded the aesthetic drinking water guideline (15 C) during June-August, when the water was warm enough for water-contact recreation.

Turbidity and Residue, non-filterable – **Figure 18 –** shows higher values for non-filterable residue and turbidity during fall-winter high flows, which is normal. Turbidity had 38% (62 of 165) values above the drinking water health guideline of 1 NTU, indicating that partial treatment (e.g., filtration) plus disinfection would be needed before drinking water use. There is an apparent increasing trend over time, but this is due to differences in sampling frequency during 1971-99 (average of <3 samples/year) and 2000-03 (average of 32 samples/year). Twenty-eight winter (October-March) results were collected during 1971-99, compared to 71 winter results during 2000-03. The regular (biweekly) and more frequent sampling during 2000-03 resulted in the sampling of more of the winter high flow events, which have high non-filterable residue and turbidity.

Zinc – Figure 19 – had high MDLs (0.01 and 0.005 mg/L) during 1971-90, resulting in ten detectable total zinc values above the 0.0075 mg/L average aquatic life guideline (the newer zinc guidelines should supersede the 1989 objectives [1]), ranging from 0.01 to 0.03 mg/L. In contrast, the maximum value during 1998-2003 measured at a lower MDL (0.0001 mg/L) was 0.0049 mg/L when non-filterable residue and turbidity were high. The 1971-90 values were identified as possible or probable errors because they had high MDLs, and were two to six times higher than the highest value measured with low-level methods in 1998-2003 [7],and were removed from the figure. The apparent decreasing trend in zinc is due to declining MDLs.

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1. BC Ministry of Environment. 1989. Cowichan-Koksilah Rivers Water Quality Assessment and Objectives. Water Management Branch, Victoria, B.C.
2. Ministry of Environment, Lands and Parks. 1996. British Columbia Water Quality Status Report. Victoria, B.C.
3. BC Ministry of Water, Land and Air Protection. 2001. British Columbia Approved Water Quality Guidelines (Criteria).
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8. Deniseger, J. 2004. Personal Communication. Environmental Quality Section, Ministry of Water, Land and Air Protection, Nanaimo, B.C.
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 2a Flow in the Koksilah River at Cowichan Station, 1971-2003

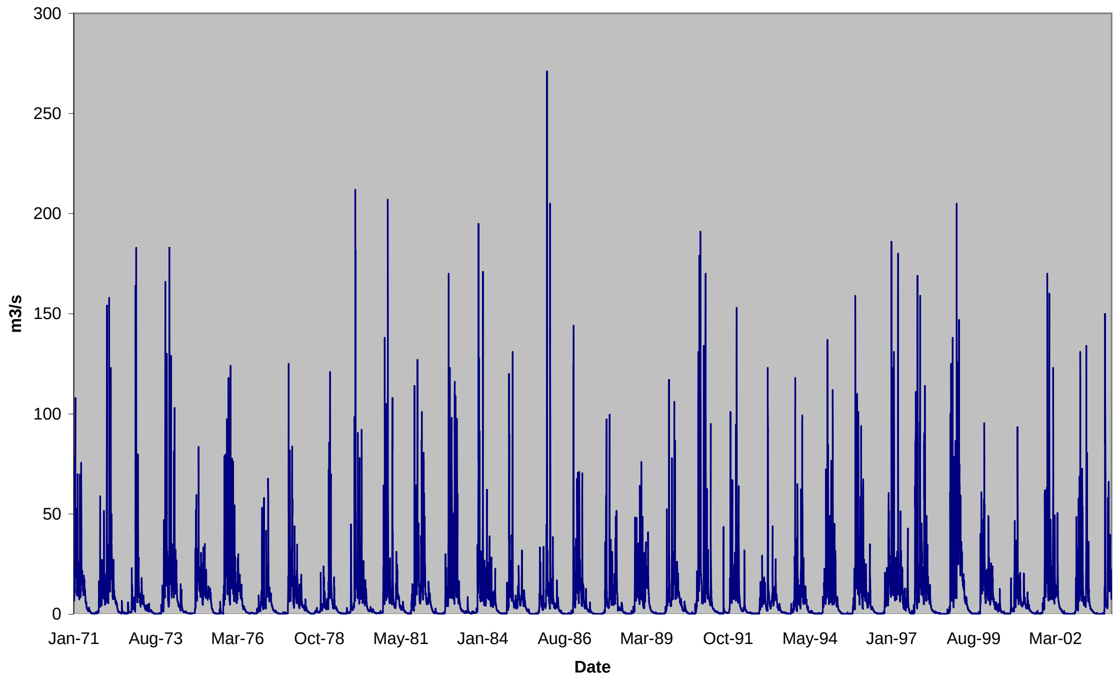


Figure 2b Flow in the Koksilah River at Cowichan Station, 1999-2003

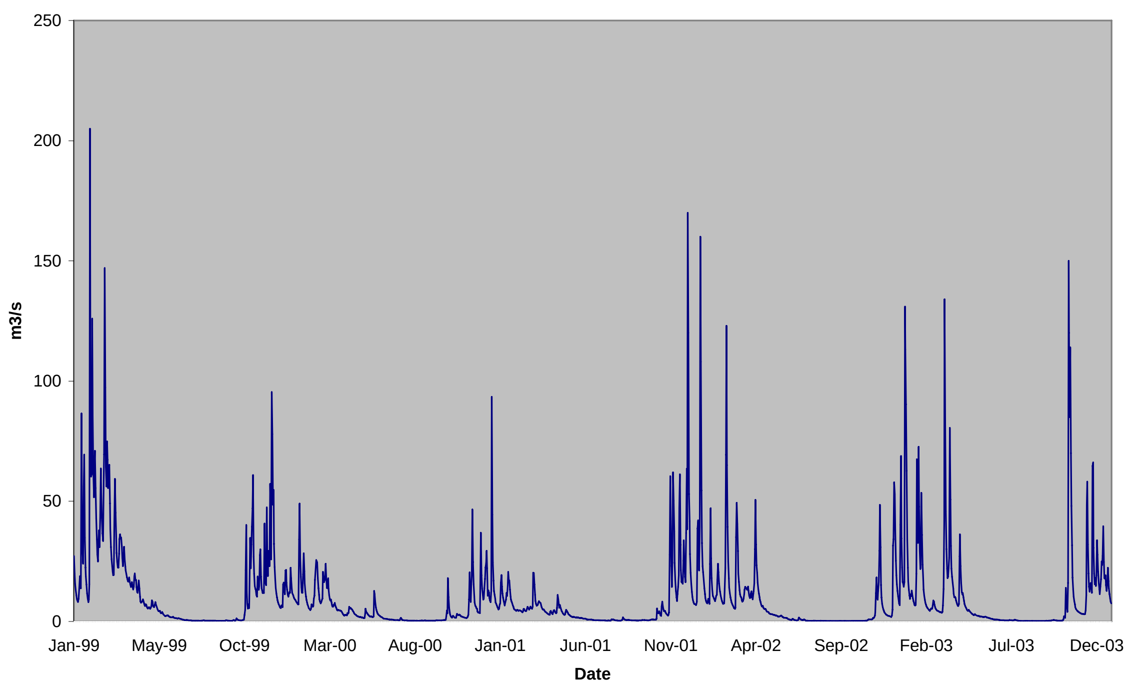


Figure 3 Aluminum

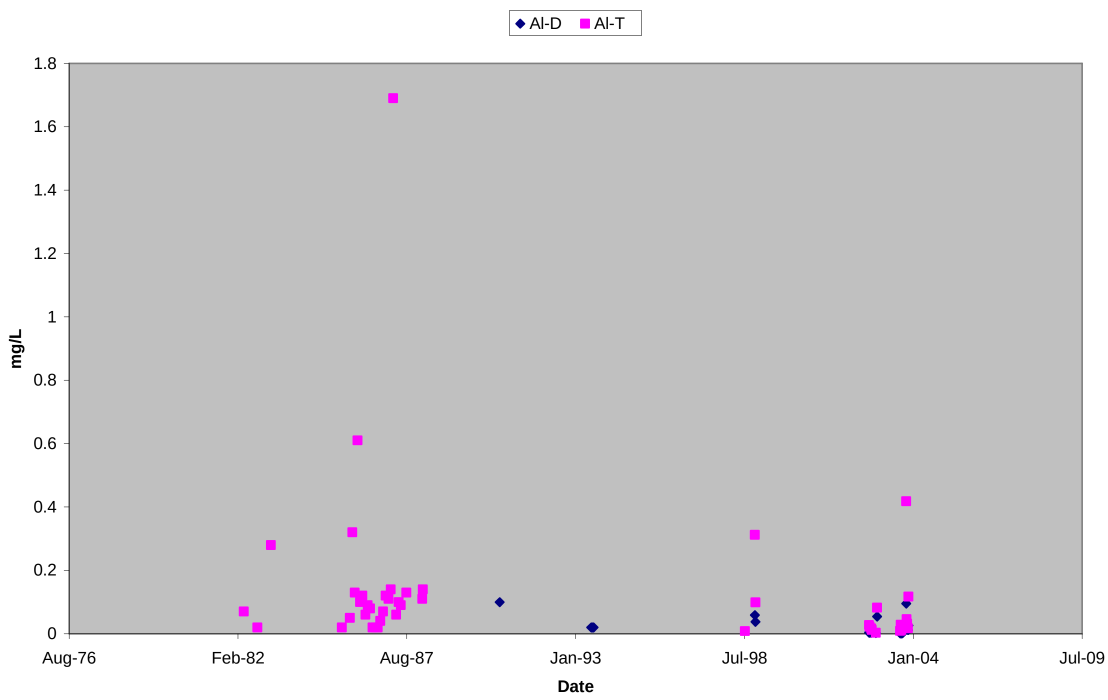


Figure 4 Ammonia-N

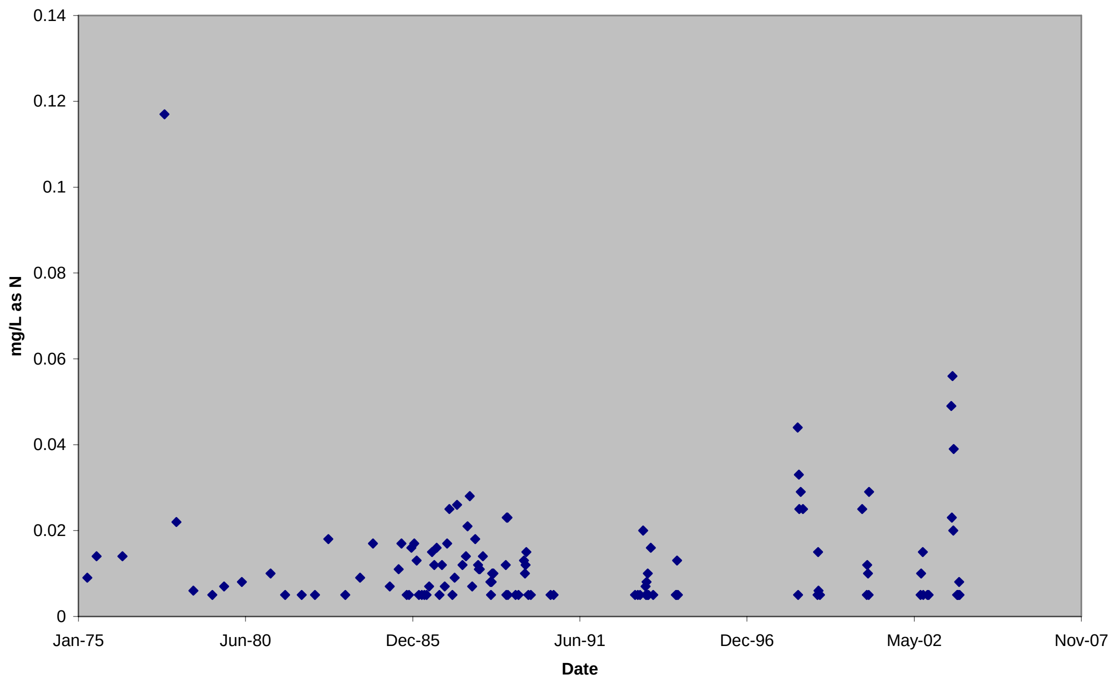


Figure 5 Coliforms

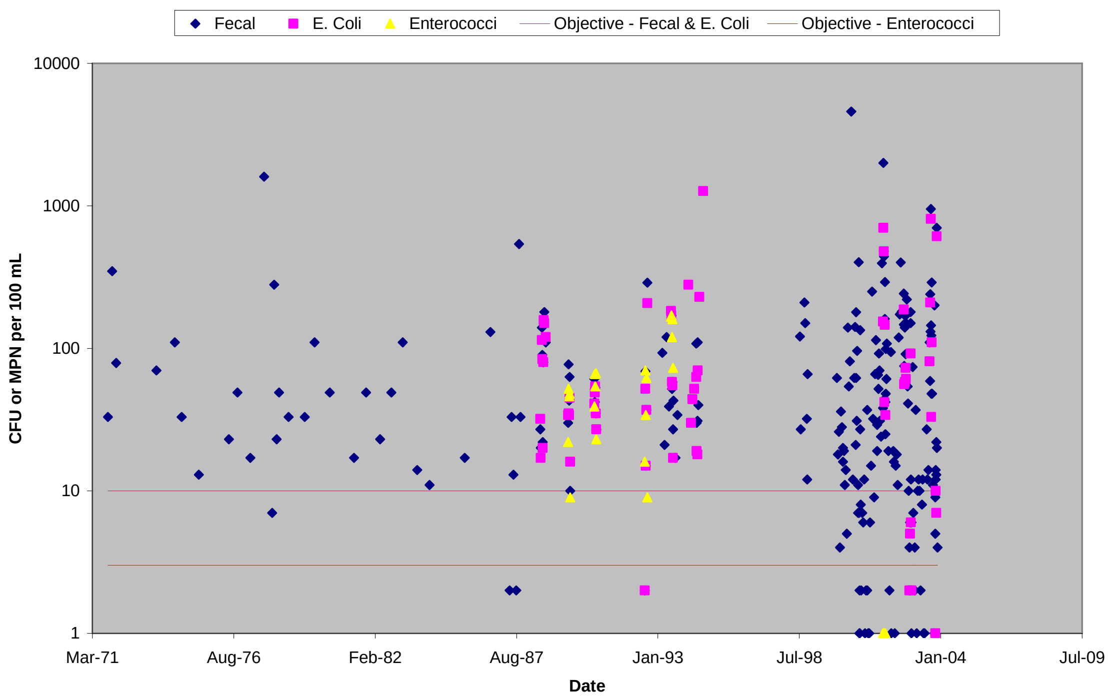
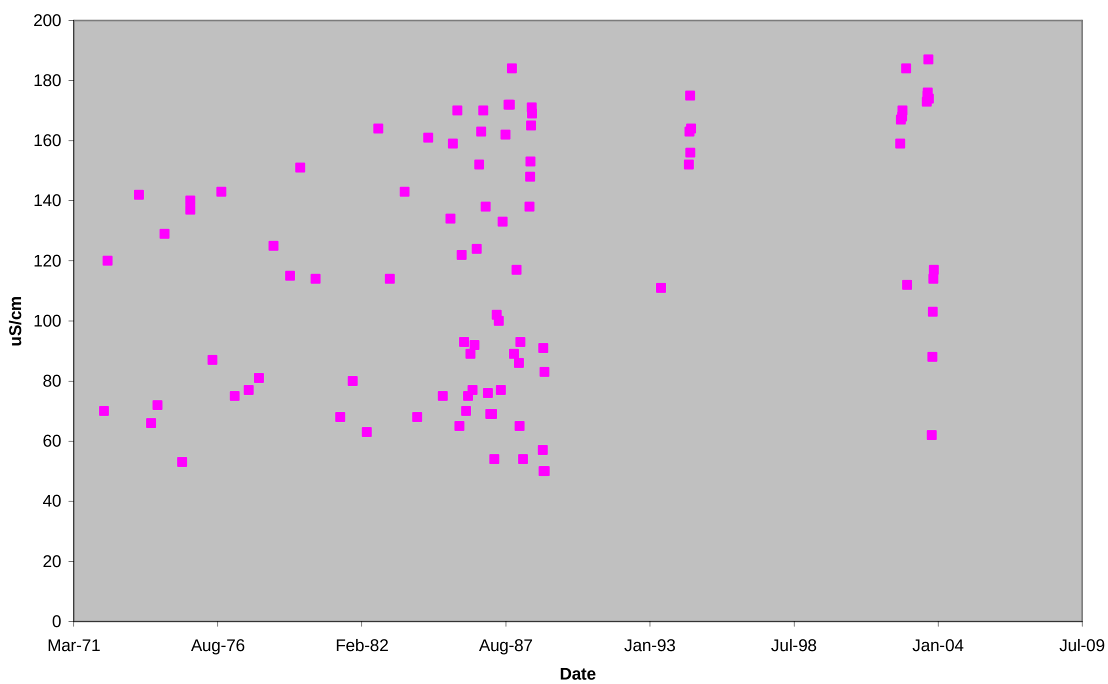


Figure 6 Conductance, Specific



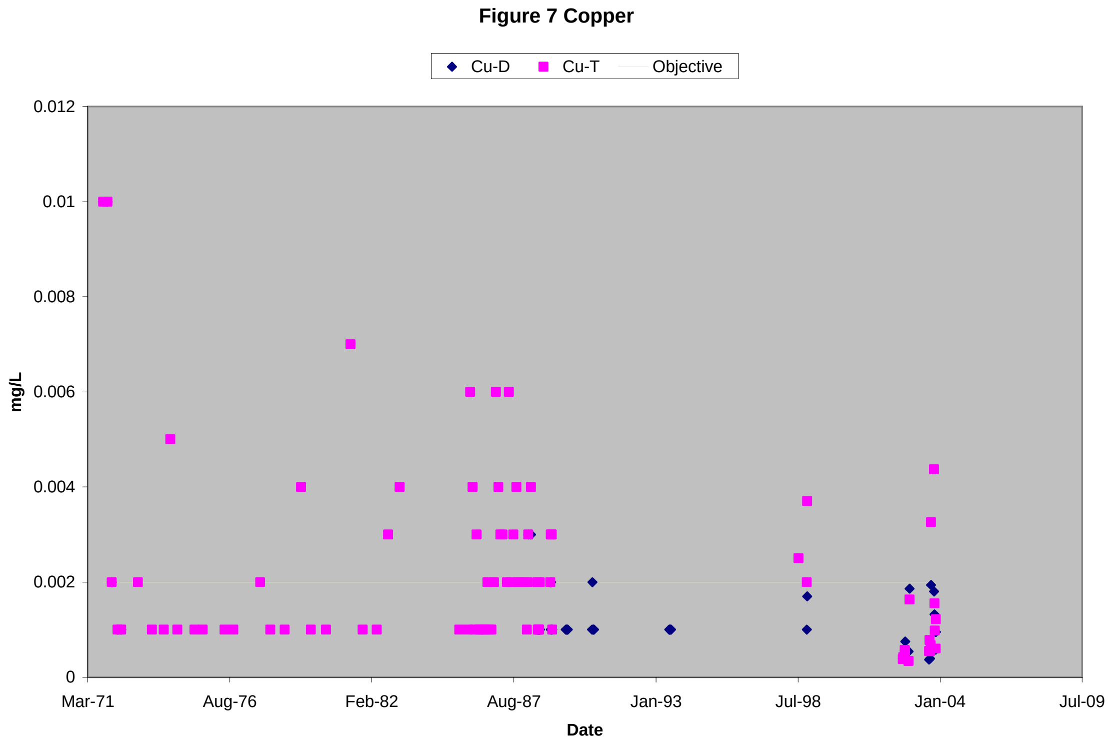


Figure 7 Copper
Cu-D
Cu-T
Objective
0.012
0.01
0.008
0.006
0.004
0.002
0
mg/L
Mar-71
Aug-76
Feb-82
Aug-87
Jan-93
Jul-98
Jan-04
Jul-09
Date

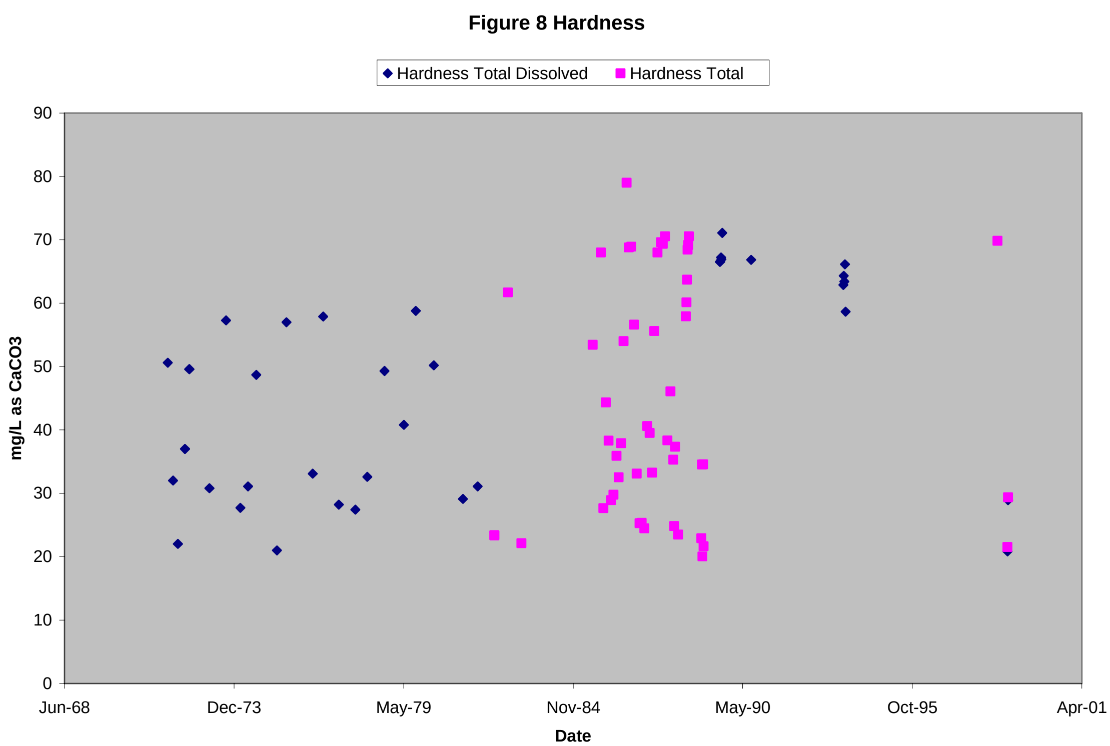


Figure 8 Hardness
Hardness Total Dissolved
Hardness Total
90
80
70
60
50
40
30
20
10
0
mg/L as CaCO3
Jun-68
Dec-73
May-79
Nov-84
May-90
Oct-95
Apr-01
Date

Figure 9 Iron

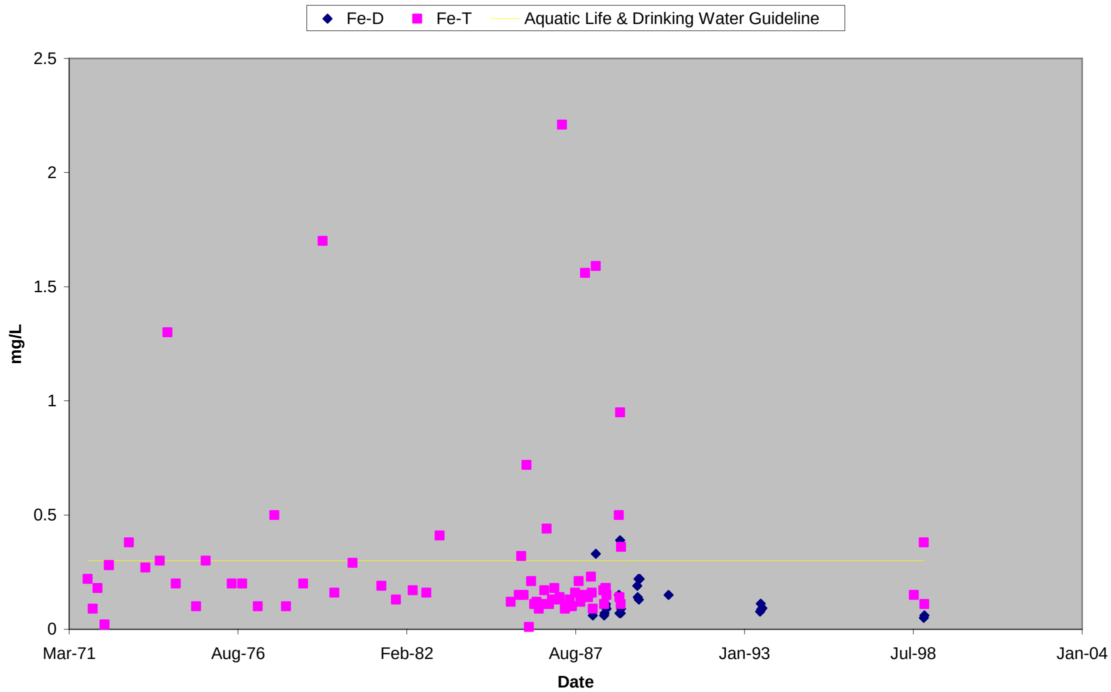


Figure 10 Lead

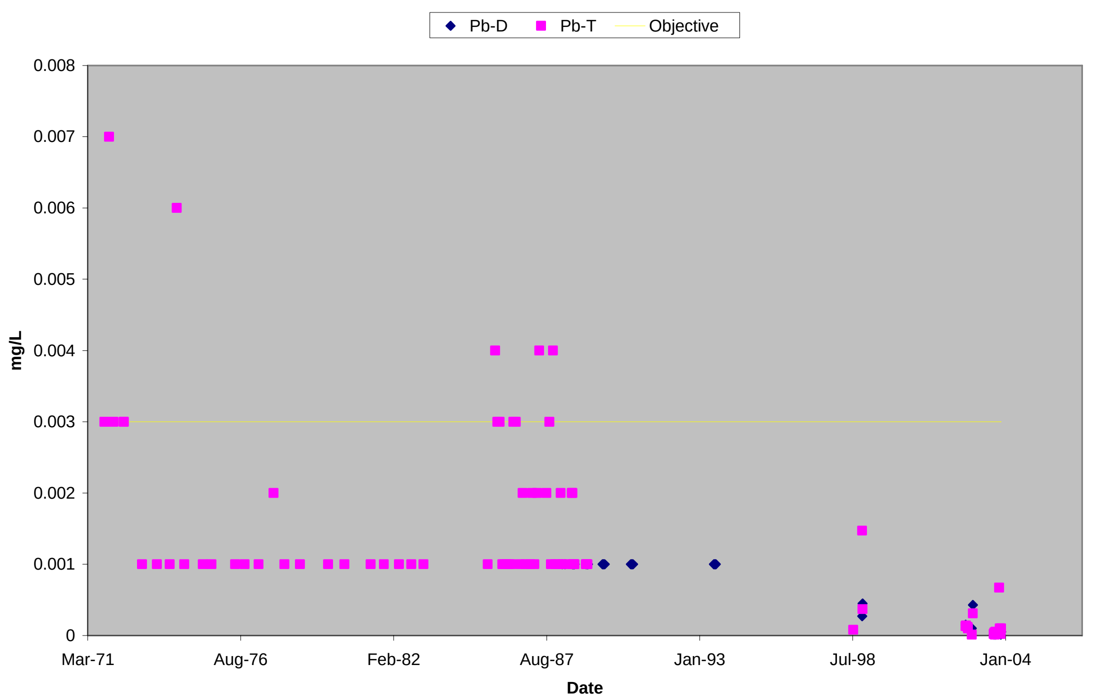


Figure 11 Manganese

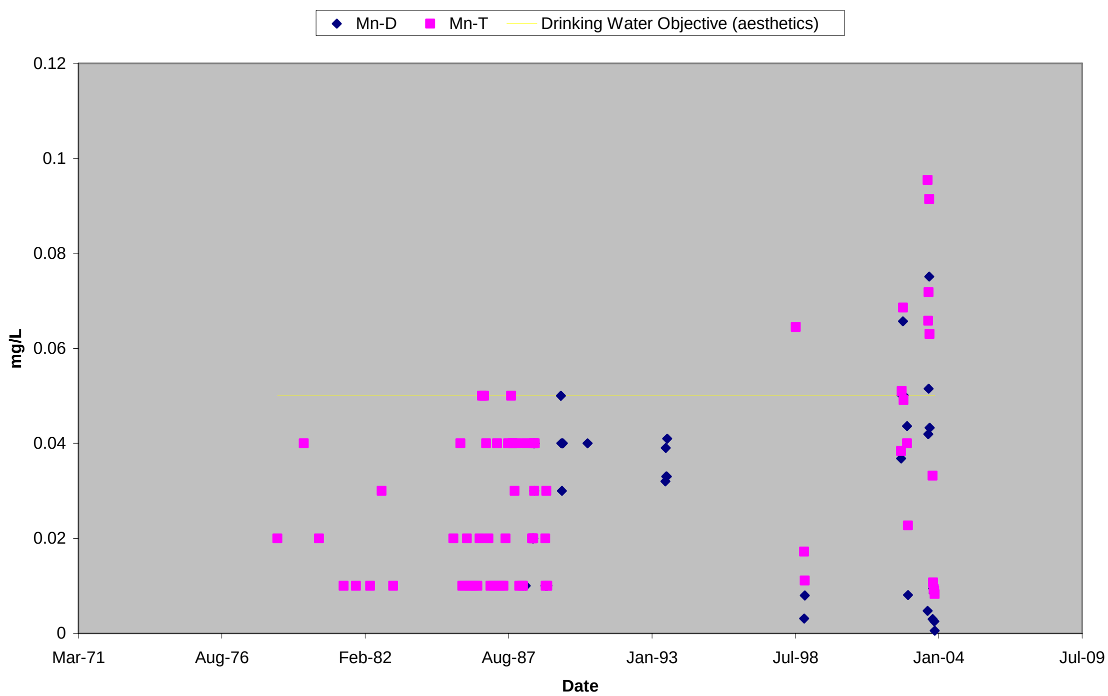
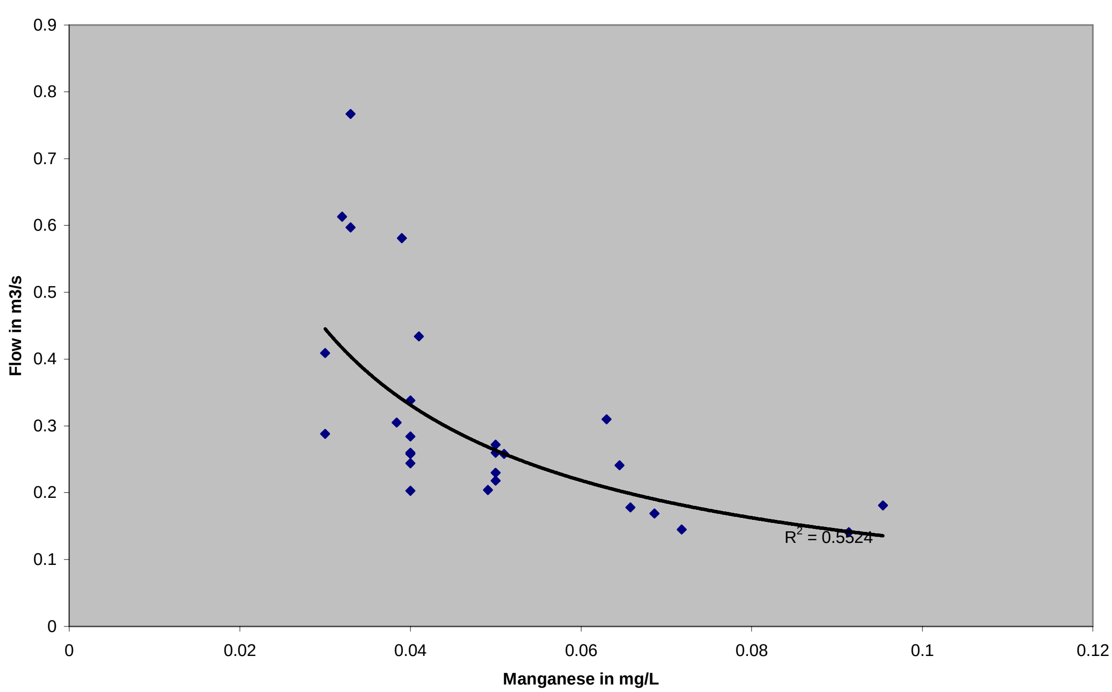


Figure 11b Manganese versus Flow, August-September



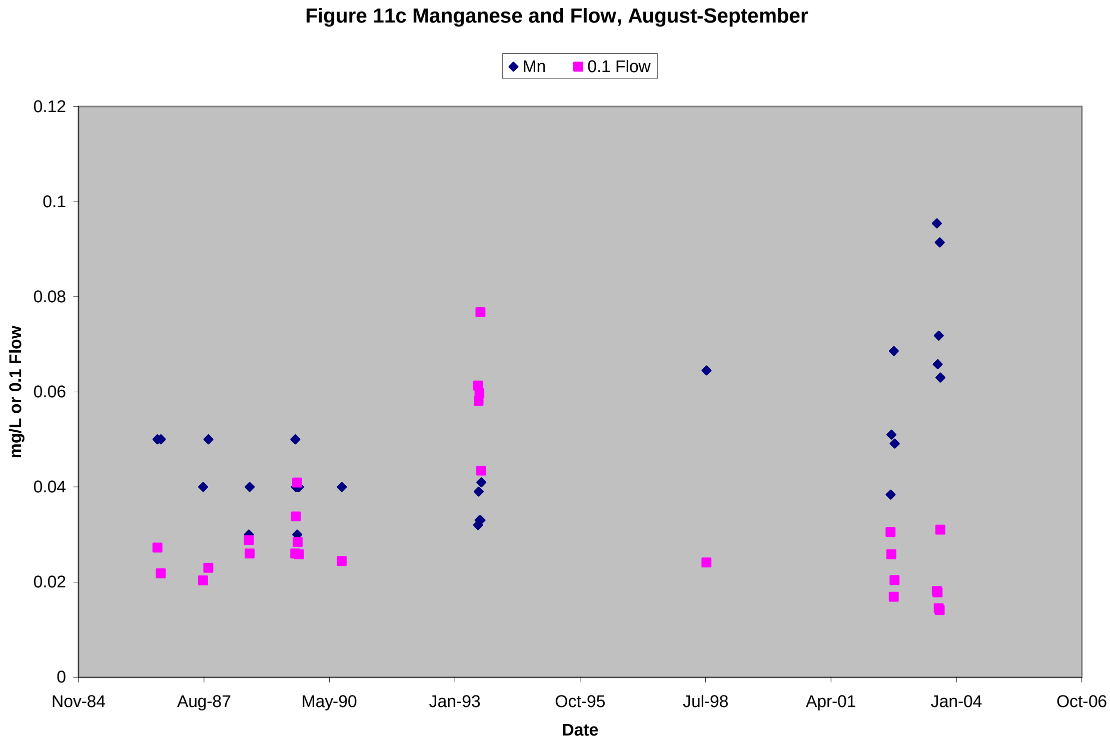


Figure 11c Manganese and Flow, August-September
Mn
0.1 Flow
mg/L or 0.1 Flow
0.12
0.1
0.08
0.06
0.04
0.02
0
Nov-84
Aug-87
May-90
Jan-93
Oct-95
Jul-98
Apr-01
Jan-04
Oct-06
Date

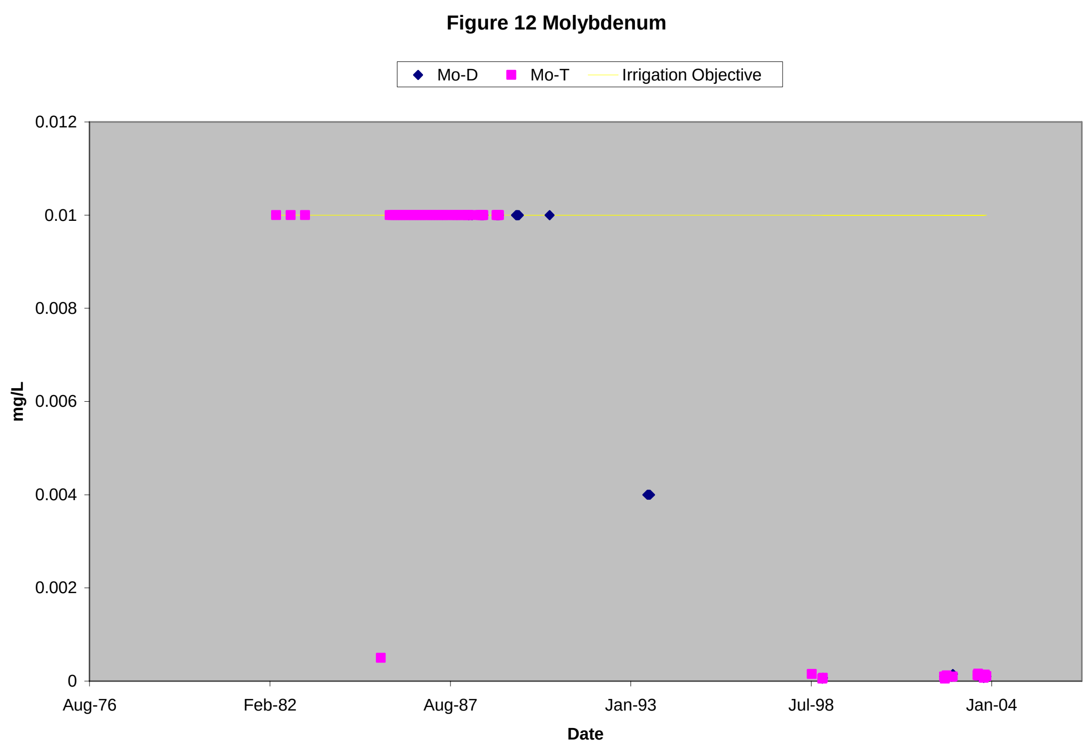


Figure 12 Molybdenum
Mo-D
Mo-T
Irrigation Objective
mg/L
0.012
0.01
0.008
0.006
0.004
0.002
0
Aug-76
Feb-82
Aug-87
Jan-93
Jul-98
Jan-04
Date

Figure 13 Nitrogen

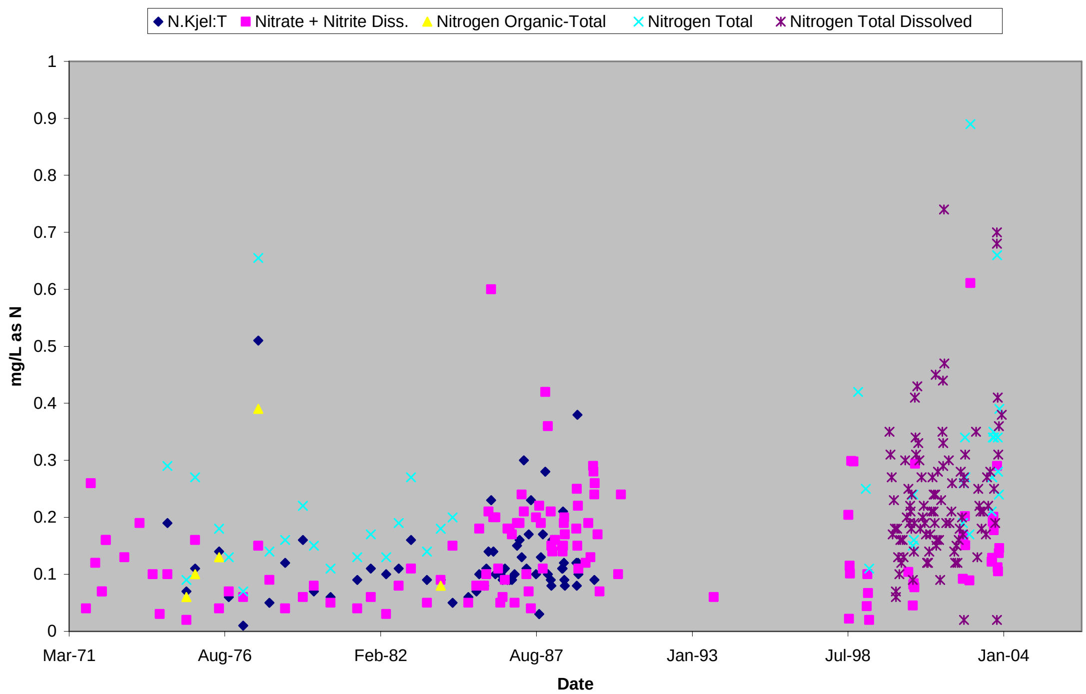


Figure 14 Oxygen, Dissolved

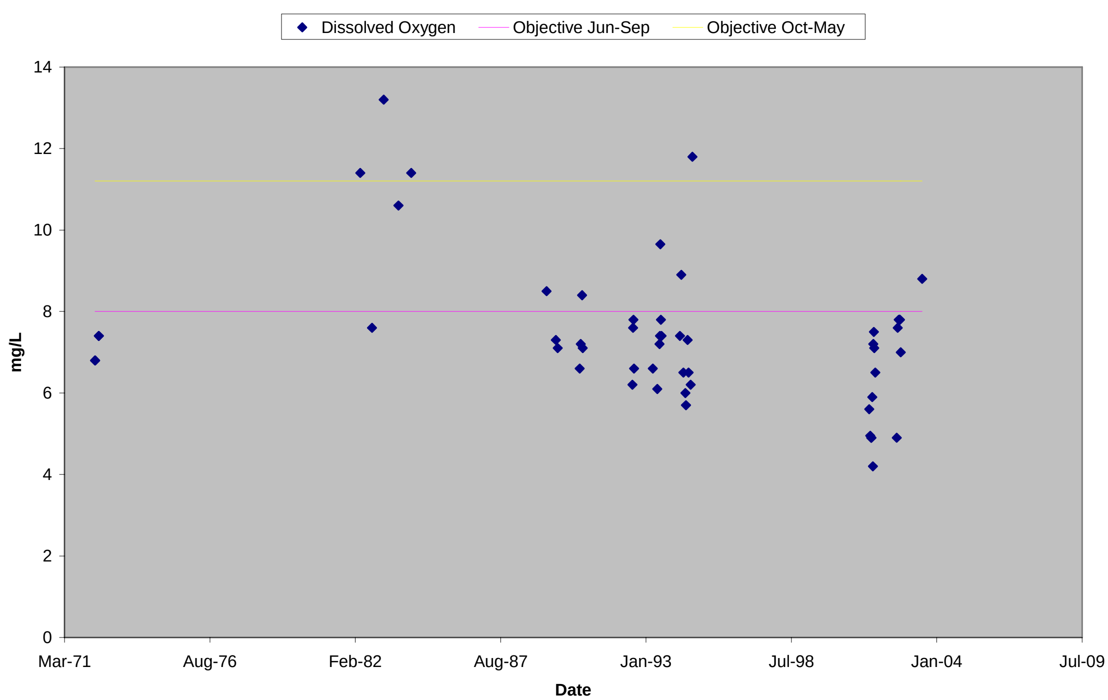


Figure 15 pH

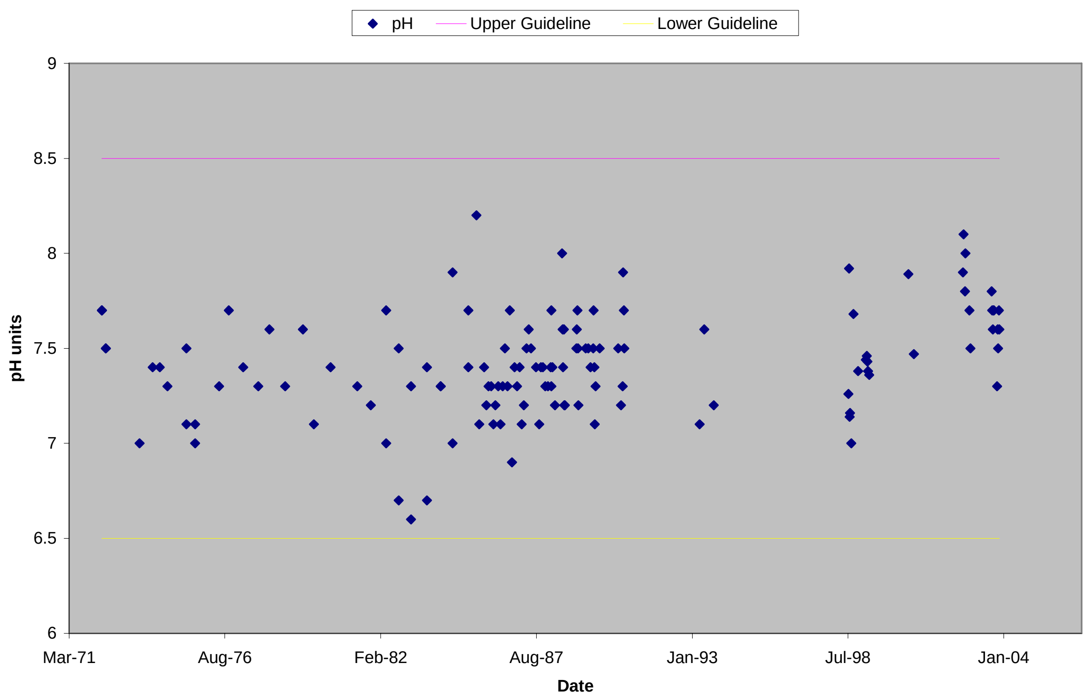


Figure 16 Phosphorus

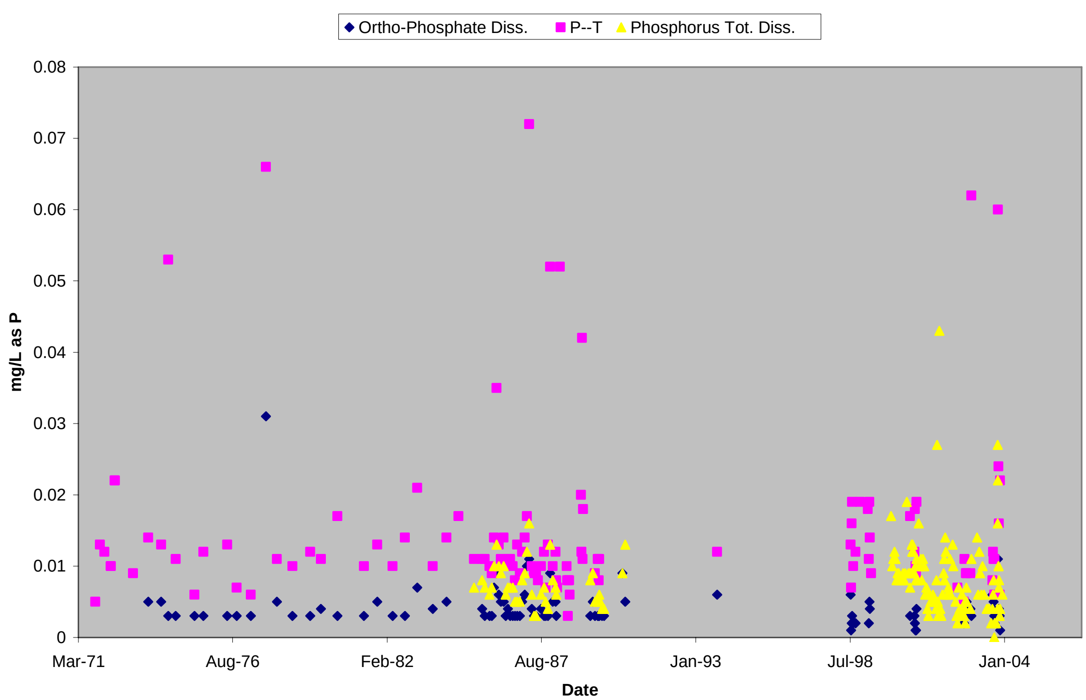


Figure 17 Temperature, Water

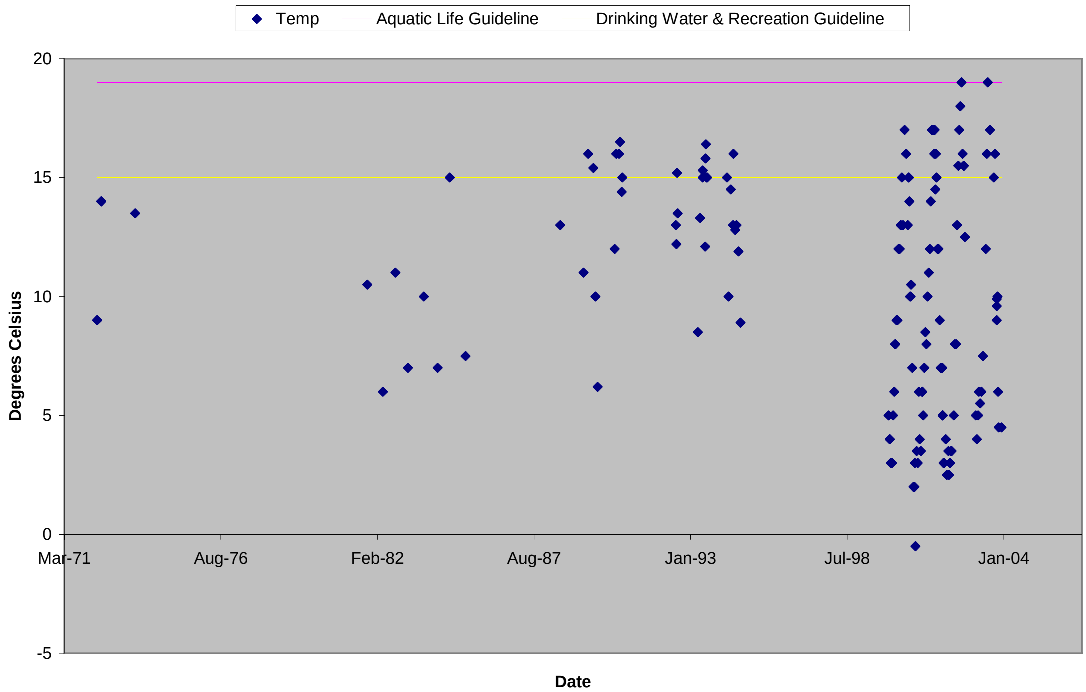


Figure 14 Turbidity and Residue, Non-filterable

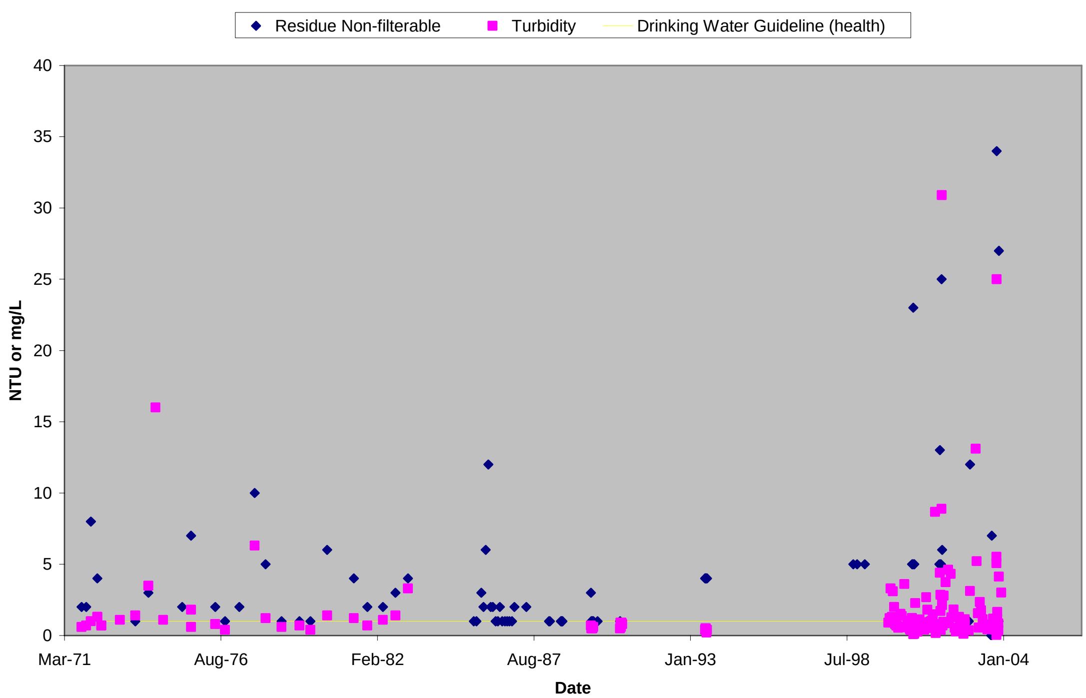


Figure 19 Zinc