CANADA – BRITISH COLUMBIA
WATER QUALITY MONITORING AGREEMENT

WATER QUALITY ASSESSMENT OF MYERS CREEK AT THE INTERNATIONAL BOUNDARY (1998 – 2002)

Pommen Water Quality Consulting

November 2003

Environment Canada **Environnement Canada**

BRITISH COLUMBIA Ministry of Environment

Executive Summary

The Myers Creek watershed is located in northern Washington State and south-central British Columbia near Midway, B.C. The headwaters of Myers Creek are in Washington State, flowing north into B.C. about 6 km south from Rock Creek, and then turning east to flow into the Kettle River about 6 km upstream from Midway. Myers Creek is a transboundary stream, draining 207 km^2 in Washington state into B.C. Water quality monitoring began in 1998 due to concerns that a proposed mine in Washington might affect Myers Creek in B.C. The water quality sampling station on Myers Creek at International Boundary is located at the Canada-U.S. border, which is about 12 km upstream from its confluence with the Kettle River. This assessment is based on up to four years of water quality data during 1998-2002.

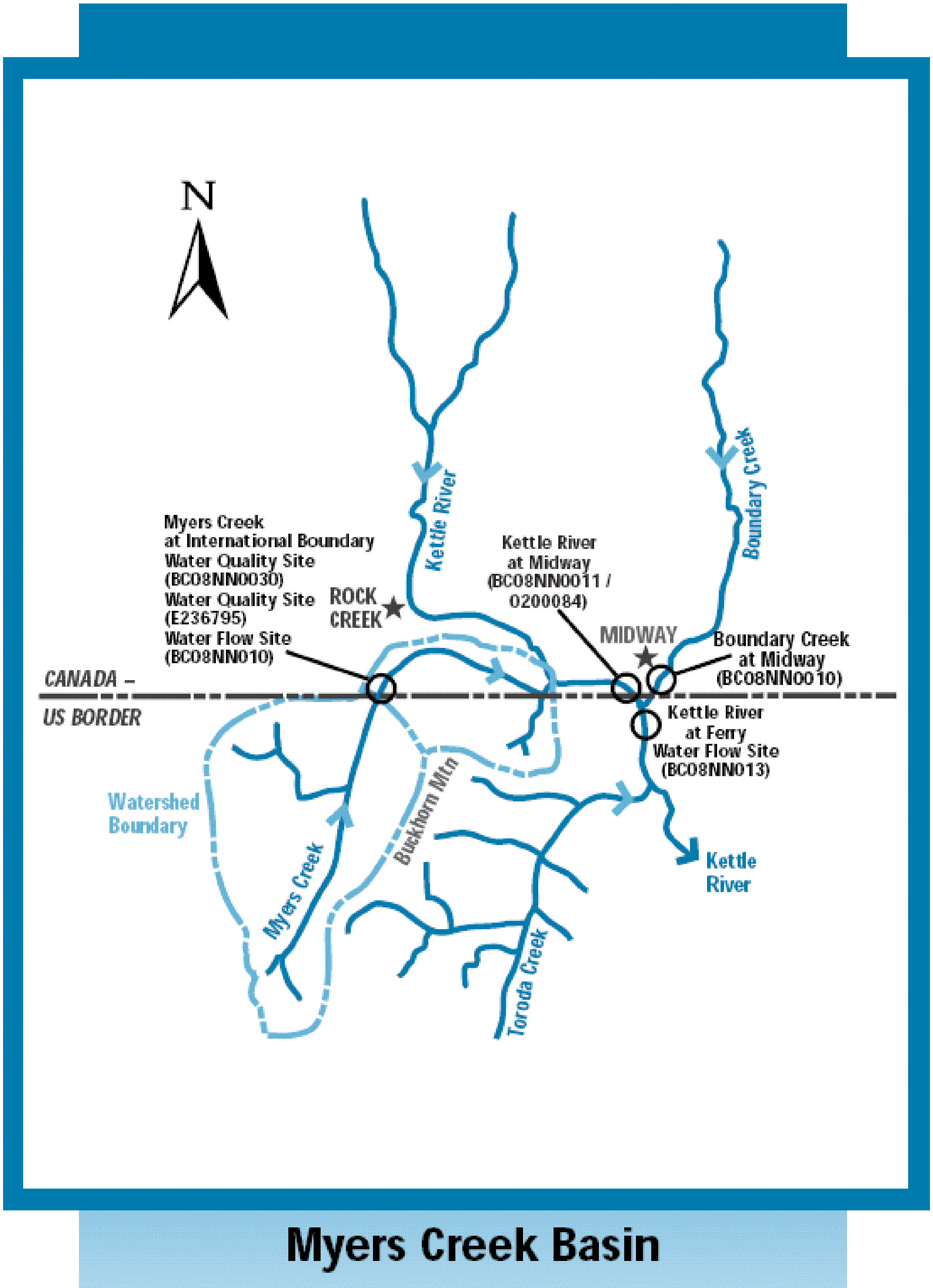
Conclusions

- There was probably no change in water quality during 1998-2002, although the record is too short for trend assessment. Apparent declining trends in turbidity and water quality indicators influenced by turbidity (metals, phosphorus) were likely due to decreases in stream flows during the last two years of record.
- Turbidity was high during spring freshet, exceeding the recreation guidelines, and causing levels of metals (Al, C, Cr, Co, Cu, Fe, Pb, Mn and Zn) and phosphorus to peak, and the metals to exceed various water quality guidelines. Since the metals were associated with suspended sediment, they are unlikely to be bio-available and would be reduced by the water treatment needed before use for drinking water.
- Myers Creek water was of poor quality as a raw drinking water source. Complete water treatment and disinfection would be needed to remove turbidity, iron, manganese and fecal contamination. The high levels of true colour and dissolved organic carbon during spring freshet would reduce the aesthetic desirability of the water, and could lead to the formation of harmful disinfection by-products if the water was chlorinated. Hardness often exceeded the poor but tolerable level, and water temperature exceeded the aesthetic guideline in summer.
- Fecal coliform levels suggest that guidelines for water-contact recreation (e.g., swimming) and the irrigation of crops eaten raw (e.g., garden irrigation) may have been exceeded, but more frequent monitoring would be required to confirm this.
- Fluoride levels exceeded aquatic life guidelines, but elevated fluoride levels appear to be a natural occurrence in the Kettle River basin.
- Selenium slightly exceeded aquatic life guidelines during winter low flows.
- Sulphate levels often exceeded the alert level for monitoring the health of aquatic mosses. There is a possible trend of increasing sulphate concentrations, but this is likely due to decreasing flows during 2001 and 2002.
- An adequate water quality baseline (5.25 years in May 2003) has been collected for impact assessment and setting water quality objectives, if needed.
- The withdrawal of the proposal for an open pit mine on Buckhorn Mountain in favour of an underground mine may reduce the potential hydrological effects on Myers Creek.

Recommendations

- Flow measurement should be implemented if water quality continues to be monitored. Flow is required for an adequate assessment of trends in water quality indicators, and flow reduction is the main potential impact on Myers Creek of the mining proposal on Buckhorn Mountain.
- Reduce the detection limit for cadmium when the technology becomes available.
- The health of aquatic mosses should be documented with respect to elevated sulphate levels.
- Measure trivalent and hexavalent chromium species when suitable technology becomes available.
- Levels of bromide should be measured at a suitably low detection limit if the water is to be treated by ozonation.
- A decision to suspend or continue the Myers Creek station should be based on the potential for the proposed underground mine to affect Myers Creek. If the mine has the potential to significantly affect Myers Creek, monitoring should continue (adding flow) to maintain an unbroken time series for maximum trend and impact detection capability. If the mine has limited potential to affect Myers Creek, then monitoring should be suspended.

Figure 1 Map of the Myers Creek Basin



Acknowledgements

Thanks are due to Ms. Liz Bryan, the water sample collector for the Myers Creek station, whose diligence over the years has made this assessment possible, and to Mr. Vic Jensen, RPBio and Mr. Les Swain, PEng for helpful review comments.

Table of Contents

List of Figures

1. Introduction

The Myers Creek at International Boundary water quality monitoring station is located 6 km south from Rock Creek, B.C., 18 km east from Midway, B.C., and 23 m north from the Canada-U.S. border (Figure 1). The drainage area of the creek is 207 km^2 at the border, and it drains an additional 90 km^2 in Washington State and B.C. before joining the Kettle River about 6 km upstream from the Kettle River at Midway water quality monitoring station (ENVRODAT BC08NN0011; EMS 0200084). Myers Creek represents about 6% of the drainage area of the Kettle River at the Midway water quality station. The water in Myers Creek in B.C. is licensed for domestic use (e.g., drinking water, livestock water, garden irrigation), irrigation and storage (Table 2). Myers Creek has healthy populations of Eastern brook and rainbow trout (Okanogan Highlands Alliance, undated).

Forestry, agriculture and mining in Washington State are potential influences on the water quality of Myers Creek at the border. In the early 1990’s, Battle Mountain Gold Co. proposed the Crown Jewel Project, an open pit gold mine on the eastern side of Buckhorn Mountain in Washington, which threatened to divert water from Myers Creek. The Crown Jewel open pit proposal has now been withdrawn and replaced by Crown Resources’ Buckhorn Mountain Project, an underground mining proposal (Okanogan Highlands Alliance, April 2003).

Environment Canada monitored flow in Myers Creek at International Boundary intermittently during April-November between 1923 and 1995. During 1923-95, Myers Creek experienced flow peaks in May-June due to snowmelt freshet, and very low flows in July-September. The flow is regulated in Washington State. The flow data are stored on the Water Survey of Canada database under station number BC08NN010. Flow was not measured during the period when water quality was monitored. During the drought in the late 1920’s and early 1930’s, Myers Creek dried up and the Canadian senior water rights holders were denied their water. To remedy this situation, the International Joint Commission adjudicated the Myers Creek basin in 1932, listing water rights in order of priority (Okanogan Highlands Alliance, undated).

Canada and B.C. began collecting water quality data at Myers Creek at International Boundary in February 1998 and the data are stored on B.C.’s Environmental Monitoring System (EMS) under site number E236795 and on Environment Canada’s ENVIRODAT database under station number BC08NN0030. Water quality data have been collected every two weeks since 1998 and monitoring is continuing at present. Four years (Feb 1998- Mar 2002) of water quality data were used in this report. The data for the suite of water quality indicators are plotted in Figures 2 to 66.

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 and working water quality guidelines (Ministry of Water, Land and Air Protection, 2001a & 2001b) and CCME guidelines (CCME 2002). 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 that were plotted but not discussed because they easily met all water quality guidelines and showed no harmful trends were: total alkalinity, total arsenic, total and extractable barium, total and extractable beryllium, extractable boron, extractable calcium, dissolved inorganic carbon, conductance, total and weak-acid dissociable cyanide, extractable gallium, extractable lanthanum, total and extractable lithium, extractable magnesium, total and extractable nickel, nitrate, nitrite and total dissolved nitrogen, pH, extractable potassium, extractable rubidium, dissolved silica, extractable silicon, extractable sodium, total and extractable strontium, air temperature, extractable thallium, extractable uranium, and total and extractable vanadium.

Trace elements at this station were measured by total and extractable methods. Total and extractable samples are both acidified in the field with nitric acid to about pH 2. Extractable samples are then analysed in the laboratory without further treatment, while total samples have additional nitric and hydrochloric acid added and are boiled to dryness before analysis. The additional extraction step for total metals has the potential to extract trace elements that are strongly bound to particulate matter and unlikely to be bio-available.

The water quality data for 1998-2000 were reviewed previously in a data approval report (Pommen Water Quality Consulting, 2002). The recommendations of the data approval report had not yet been implemented for the raw data received from ENVIRODAT for this assessment. Thus, prior to this assessment, the recommendations were applied to the data in terms of corrections, calculation of missing hardness values, and deletion of errors, probable errors and possible errors. Suspect values in the 2001-02 data that were removed prior to assessment are contained in Table 1.

Aluminum, total (Figure 3) exceeded the 5 mg/L guideline for wildlife, livestock and irrigation four times during spring freshet when turbidity was high (64-190 NTU). This is a common occurrence due to the high aluminum content of suspended sediment, and it is unlikely that the aluminum was in a bio-available form. There is an apparent declining trend during 1998-2002, but this is due to a declining trend in turbidity, which might have been due to lower peak flows in 2000-01.

Bromide, dissolved (Figure 10) had three values above the 0.05 mg/L minimum detectable limit (MDL) and guideline for drinking water that will be ozonated. The values may well be false positives at 2-5 times MDL, and a MDL of at least 0.005 mg/L should be used if it is necessary to evaluate the use of the water as an ozonated drinking water supply.

Cadmium, extractable (Figure 11) shows 18 values above the 0.03-0.06 μg/L aquatic life guidelines, but when hardness is considered, only eight values (7% of values) exceeded the hardness-dependent guideline. All eight exceedances occurred in the April-June spring freshet, when turbidity was elevated (24-190 NTU), when there was increased suspended sediment, from which particulate-bound cadmium was extracted at pH 2. At 0.005 μg/L, the MDL is only four times below the lowest applicable guideline (0.02 μg/L at hardness=60 mg/L), and should be lowered to at least 0.002 μg/L, when the technology becomes available.

Cadmium, total (Figure 12) had an MDL (0.0001 mg/L) that was higher than the guidelines, and thus the data are not reliable for assessing their attainment. Extractable cadmium (above) should be used for interpretations.

Carbon, dissolved organic (Figure 15) exceeded the 4 mg/L guideline for drinking water (that will be disinfected with chlorine) 20 times (17% of values), mainly during spring freshet. Chlorinating this water would have the potential to form harmful disinfection by-products such as trihalomethanes.

Chromium, extractable (Figure 17) was monitored during 1998-2002, but the values prior to July 1, 2000 were deleted due to instrument interferences at the Burlington laboratory (Pommen 2002). During July 2000-March 2002, the 1 μg/L aquatic life guideline for hexavalent chromium was exceeded three times (6% of values). The exceedances occurred when turbidity was low (1-2 NTU), indicating that elevated suspended sediment was not the cause. Two of the exceedances compare well with the corresponding total chromium values, but the highest value on 4-Mar-02 does not (2.2 μg/L Cr-E vs. 0.3 μg/L Cr-T), and may be an error. Measurement of hexavalent and trivalent chromium should be implemented when the technology with a MDL of at least 0.1 μg/L becomes available.

Chromium, total (Figure 18) exceeded the 0.005 mg/L irrigation guideline for trivalent chromium 10 times (8% of values) during freshet when turbidity was elevated, and thus it is unlikely that the chromium was bio-available. The 0.001 mg/L aquatic life guideline was exceeded 33 times (28% of values), mainly during freshet when turbidity was elevated, but also occasionally at other times of the year when turbidity was low. Total chromium suffers from a harsh digestion, which probably overestimates the bio-available fraction, and a MDL (0.0002 mg/L) that is only five times above the lowest guideline, and thus the results may not be reliable. Extractable chromium should be used for interpretations. The apparent declining trend is due to the declining trend in turbidity.

Cobalt, extractable and total (Figures 19 & 20) were very similar with 11 and 13 exceedances of the 0.9 μg/L aquatic life guideline, respectively. All of the exceedances occurred during spring freshet when turbidity was elevated, which is common due to the cobalt that can be extracted from the suspended sediment.

Coliforms, fecal (Figure 21) were monitored during Feb 2000-March 2002. The 10/100 mL drinking water guideline was almost always exceeded, and the 100/100 mL drinking water guideline was often exceeded, suggesting that complete water treatment plus disinfection would be needed before drinking water use. The guideline of 200/100 mL for water-contact recreation and irrigation of crops eaten raw was exceeded on four occasions (6% of values), but monitoring was too infrequent to permit the calculation of the 30-day geometric mean for a rigorous comparison.

Colour, true (Figure 22) exceeded the aesthetic objective for drinking water during each spring freshet (19% of values), indicating that the water would not be aesthetically desirable during these times.

Copper, extractable (Figure 24) exceeded the aquatic life guidelines five times when the hardness of each sample is considered. All occurred during the April-June spring freshet when turbidity was elevated (62-190 NTU), indicating that particulate-bound copper was the cause. The apparent declining trends in extractable and total copper are due to the declining trend in turbidity.

Copper, total (Figure 25) was quite similar to extractable copper with exceedances of the aquatic life guidelines during freshet when turbidity was high. Since total copper involves a harsh digestion that probably overestimates the bio-available copper, extractable copper results are preferred for interpretations.

Fluoride, dissolved (Figure 27) always exceeded the 2002 CCME interim aquatic life guideline (0.12 mg/L), while the B.C. aquatic life guideline (0.3 mg/L, hardness >50 mg/L) was exceeded in about one-half of the samples. Elevated fluoride appears to be a natural occurrence in this area, since the Kettle River at Midway and Boundary Creek stations also exceeded the guidelines (Ministry of Environment, Lands and Parks and Environment Canada, 2000).

Hardness (Figure 29) often exceeded 200 mg/L, which is the poor, but tolerable, aesthetic guideline for drinking water.

Iron, total (Figure 30) exceeded the 5 mg/L guideline for irrigation (maximum of 12.7 mg/L) six times during spring freshet when turbidity was high. Iron is the fourth most abundant element in the Earth's crust and the large amount of suspended sediment present during freshet accounts for the high total iron levels. The 0.3 mg/L guideline for drinking water and aquatic life was exceeded on numerous occasions whenever turbidity was elevated due to the particulate-bound iron in the suspended sediment. Particulate-bound iron is unlikely to be bio-available and would be reduced by the water treatment needed to remove turbidity prior to use as drinking water. The apparent declining trend is likely due to the declining trend in turbidity.

Lead, total (Figure 33) exceeded the hardness-dependent aquatic life guideline three times during freshet when turbidity was elevated (100-190 NTU), indicating that particulate-bound lead in the suspended sediment was the cause. **Extractable lead** (Figure 32)**,** with a less harsh extraction, did not exceed the guidelines, and is preferred for interpretations. The apparent declining trend is likely due to the declining trend in turbidity.

Manganese, extractable and total (Figures 37 & 38)) were quite similar and exceeded the aesthetic drinking water guideline (50 µg/L or 0.05 mg/L) during spring freshet when turbidity was high. The manganese is probably particulate-bound and would be removed by the water treatment needed before use for drinking water. The apparent declining trend is due to the declining trend in turbidity.

Molybdenum, total (Figure 39) exceeded the lowest irrigation guideline once (<1% of values) during winter, when irrigation would not occur, and is thus not of concern.

Phosphorus, total and total dissolved (Figure 46 & 47) showed high levels of total phosphorus during spring freshet, when turbidity was high. The phosphorus was particulate-bound, as shown by the lower levels for total dissolved phosphorus, which better reflects the fraction available for algal growth. The apparent declining trend in total phosphorus was due to the declining trend in turbidity. Total dissolved phosphorus (Figure 47) showed a declining step trend in April 2001, but the record is too short to judge the persistence of the trend.

Selenium, total (Figure 50) exceeded the CCME aquatic life guideline (0.001 mg/L) in about one-half of the samples, whereas the more recent B.C. guideline (0.002 mg/L) was exceeded only four times during winter low flow, with a maximum of 0.0023 mg/L.

Silver, extractable (Figure 52) was well below guidelines, while **total silver** (Figure 53) had a MDL (0.0001 mg/L) that was above the aquatic life guideline (0.00005 mg/L), and had three detectable values in 2001 that exceeded in the guideline. The extractable silver values were very low on these three dates, and thus the total silver values are most likely false-positive errors.

Sulphate (Figure 57) did not exceed the 100 mg/L guideline for aquatic life, but exceeded the 50 mg/L alert level for aquatic life in 57% of the samples. The guidelines recommend occasional monitoring of the health of aquatic mosses when the alert level is exceeded. There was an apparent increasing trend in sulphate, probably due to lower flows in 2001-02.

Temperature, water (Figure 59) met the guideline for freshwater aquatic life (maximum of 19 degrees C). Water temperatures exceeded 15 degrees C during summer, which is the aesthetic guideline for drinking water, and the lower limit for swimming.

Turbidity (Figure 61) is an optical measure of the amount of suspended sediment in water. All of the peak values (e.g., >50 NTU) occurred during the spring snowmelt freshet in April-June. The recreation guideline of 50 NTU was exceeded during three of the four freshets monitored, and the drinking water guidelines of 1-5 NTU were often exceeded, indicating that water treatment to remove turbidity (e.g., filtration) would be needed before using the creek for drinking water. There was an apparent decreasing trend over time, but this was probably due to lower peak flows in the 2000-01 freshets. Several other water quality indicators that are dependent on turbidity exhibited the same decreasing trend. This illustrates the importance of measuring flow at stations used for trend assessment. Flow measurement should be implemented if this station continues to be monitored.

Zinc, extractable and total (Figures 65 and 66) were quite similar, with peak levels during spring freshet when turbidity was high. When the hardness of the individual values is considered, one extractable zinc and three total zinc values exceeded the aquatic life guideline during the spring freshet of 1999, when turbidity was high (64-190 NTU). There were apparent declining trends in both forms of zinc due to the declining trend in turbidity.

References

Canadian Council of Ministers of the Environment (CCME). 2002. Canadian Environmental Quality Guidelines.

Ministry of Environment, Lands and Parks and Environment Canada. 2000. Water Quality Trends in Selected British Columbia Waterbodies.

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

Ministry of Water, Land and Air Protection. 2001b. A Compendium of Working Water Quality Guidelines for British Columbia. 1998 Edition updated August 23, 2001.

Okanogan Highlands Alliance (undated): www.telvar.com/~kliegoha/water.html

Okanogan Highlands Alliance, April 2003: www.telvar.com/~kliegoha/April2003.html

Pommen Water Quality Consulting. 2002. Water Quality Data Approval, Myers Creek at International Boundary 1998-2000.

Figure 2 Alkalinity , Total

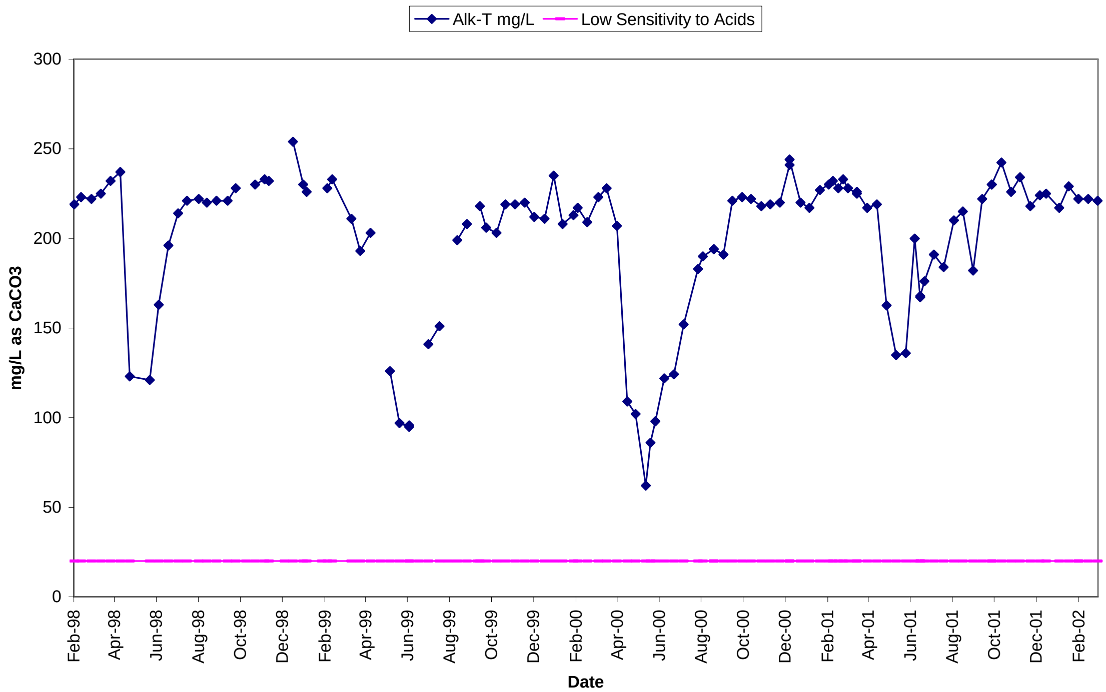


Figure 3 Aluminum, Total

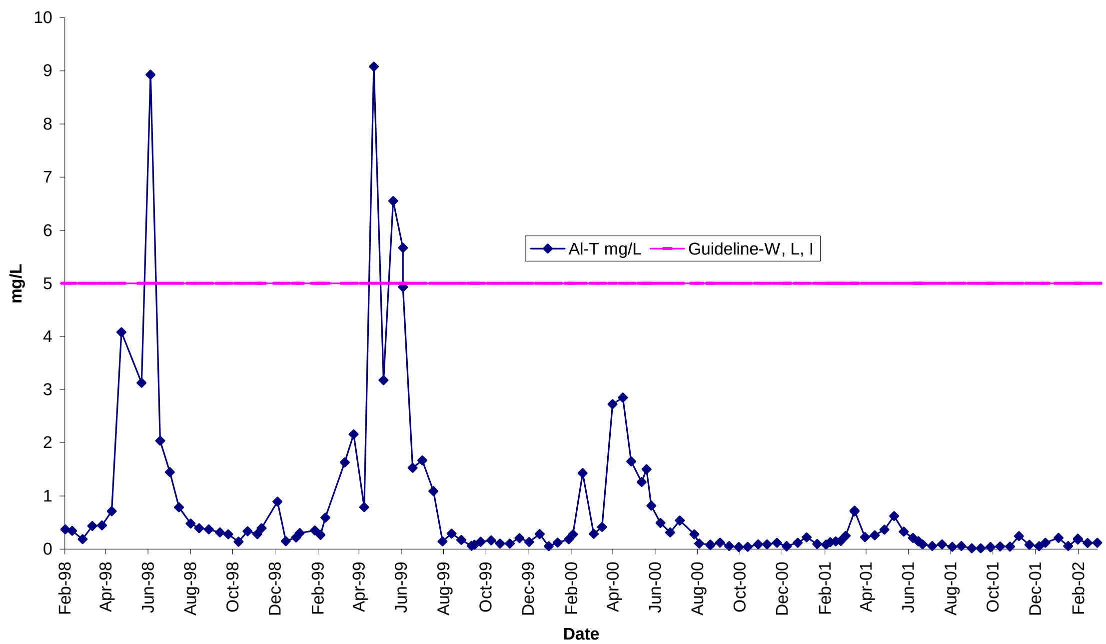


Figure 4 Arsenic, Total

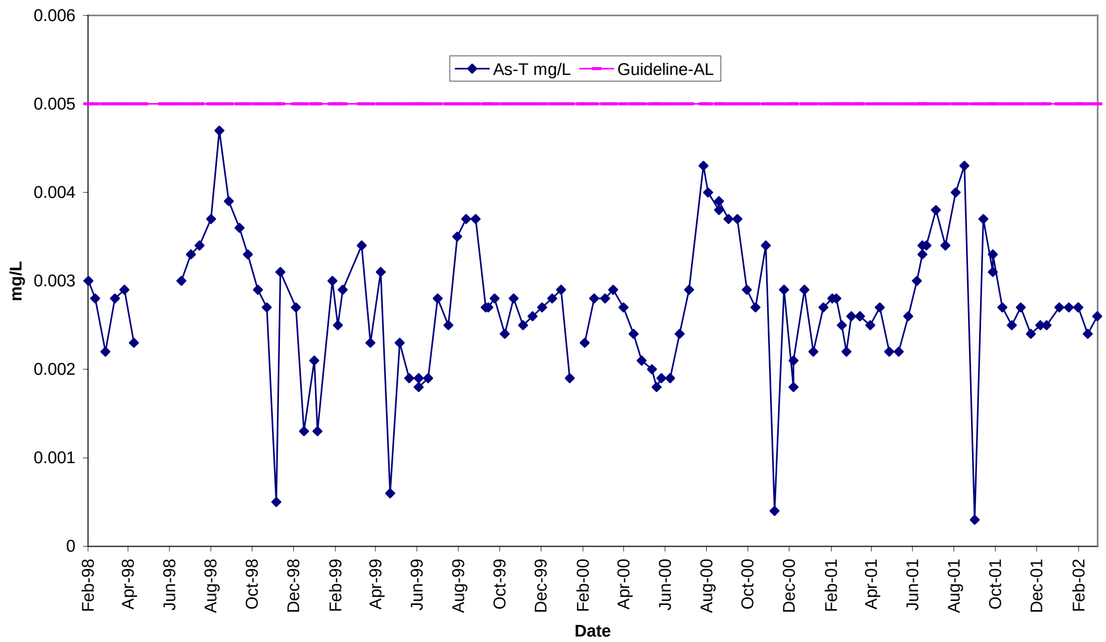


Figure 5 Barium, Extractable

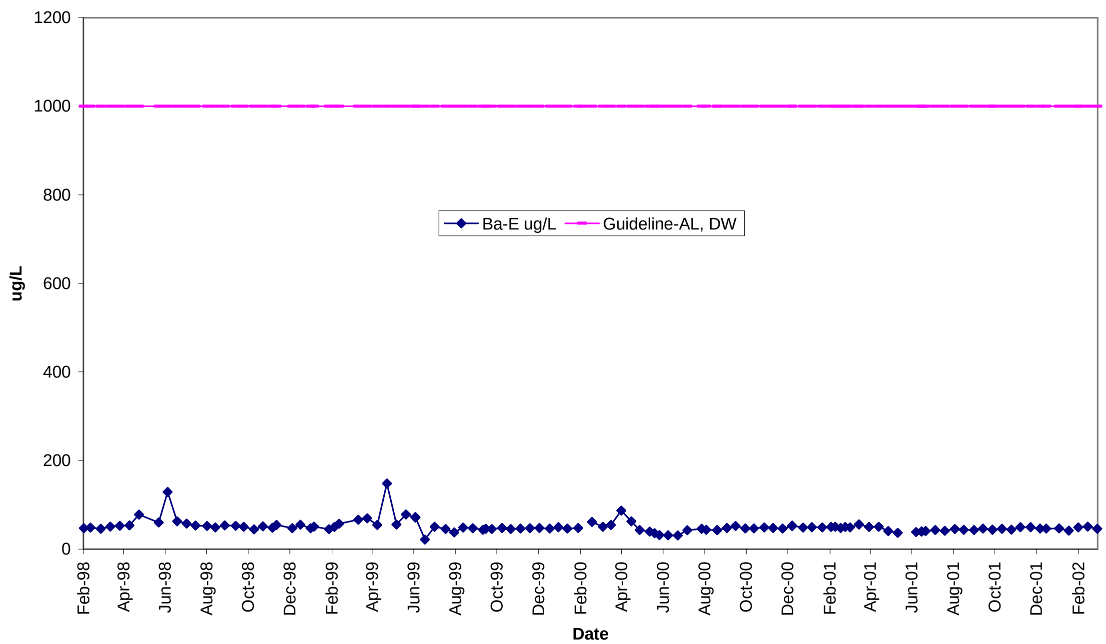


Figure 6 Barium, Total

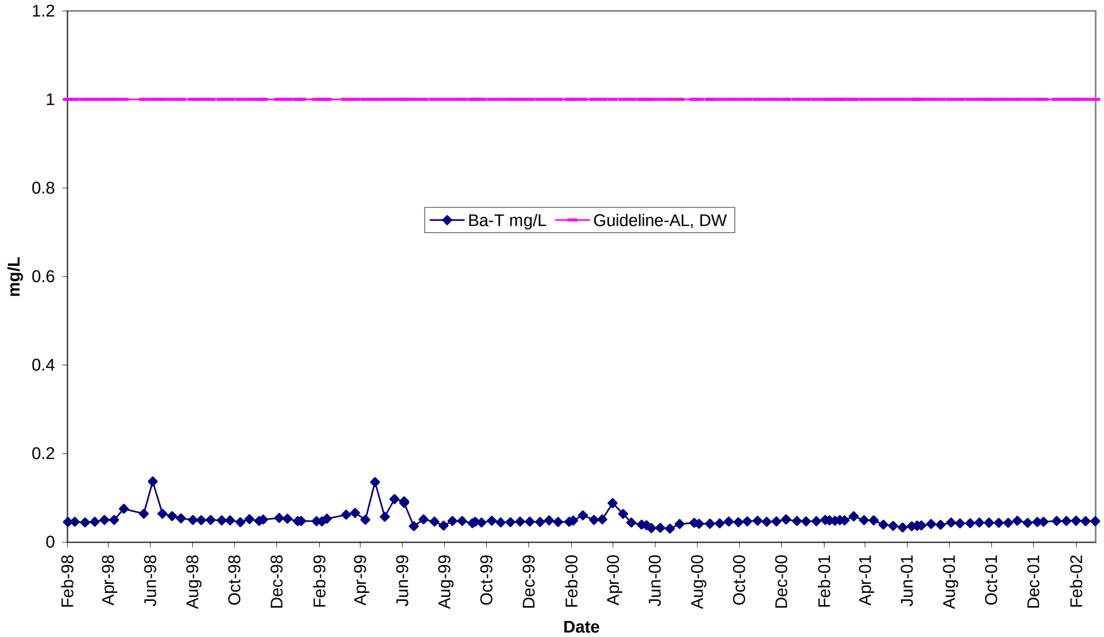


Fig 7 Beryllium, Extractable

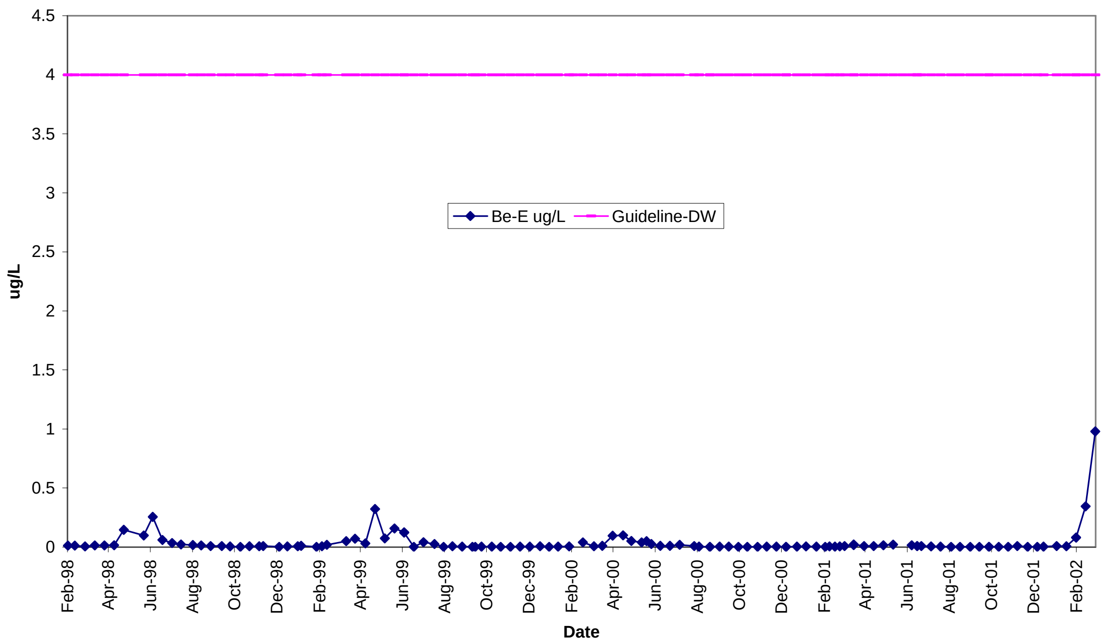


Figure 8 Beryllium, Total

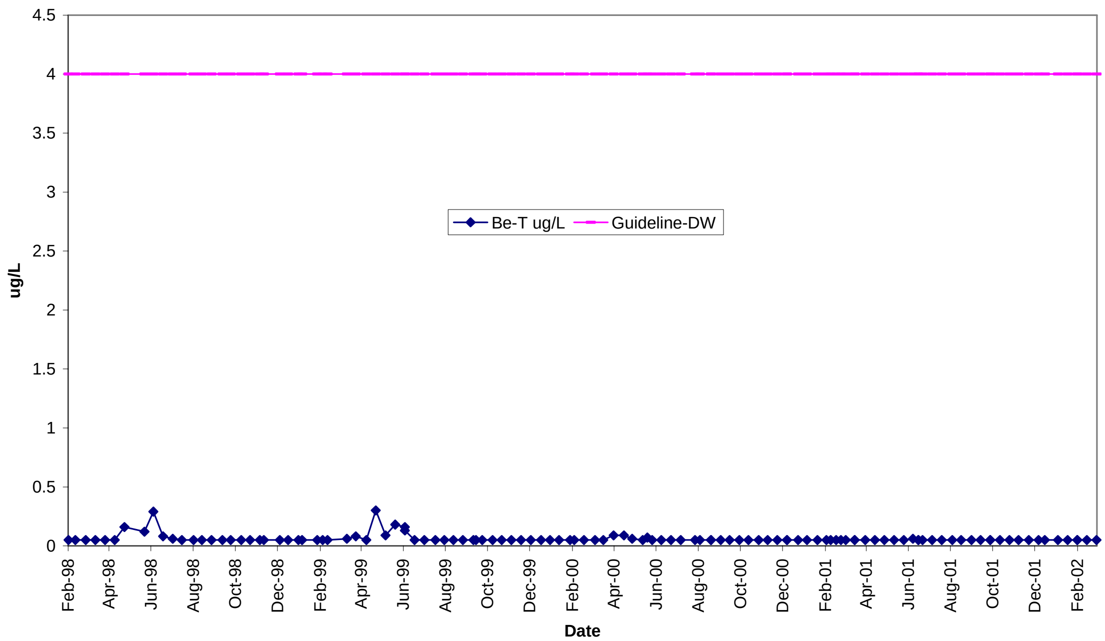


Figure 9 Boron, Extractable

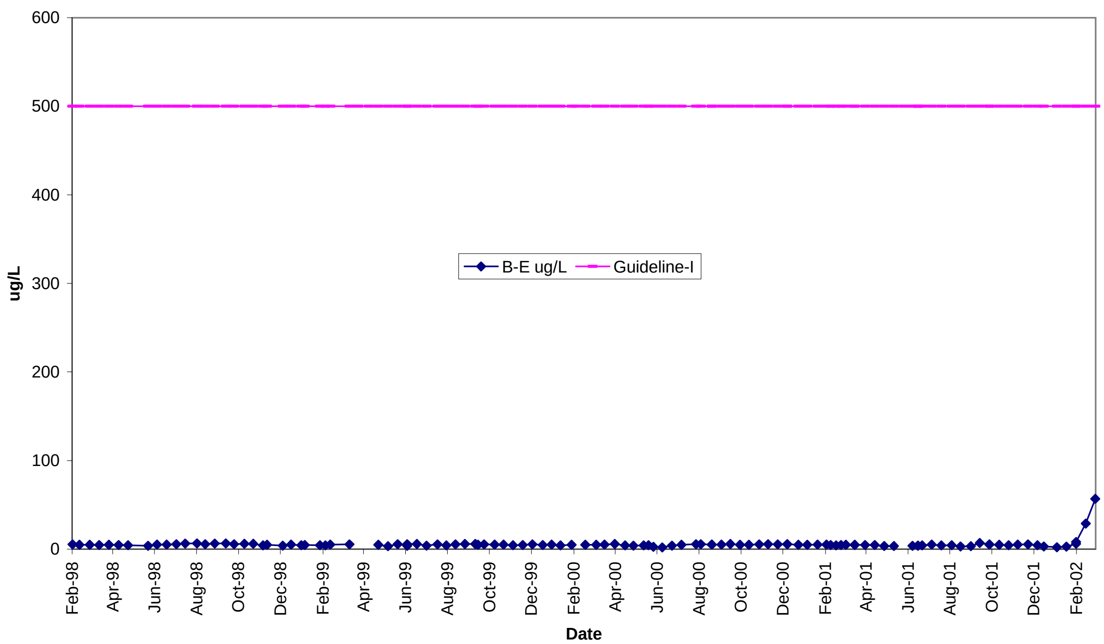


Fig 10 Bromide, Dissolved

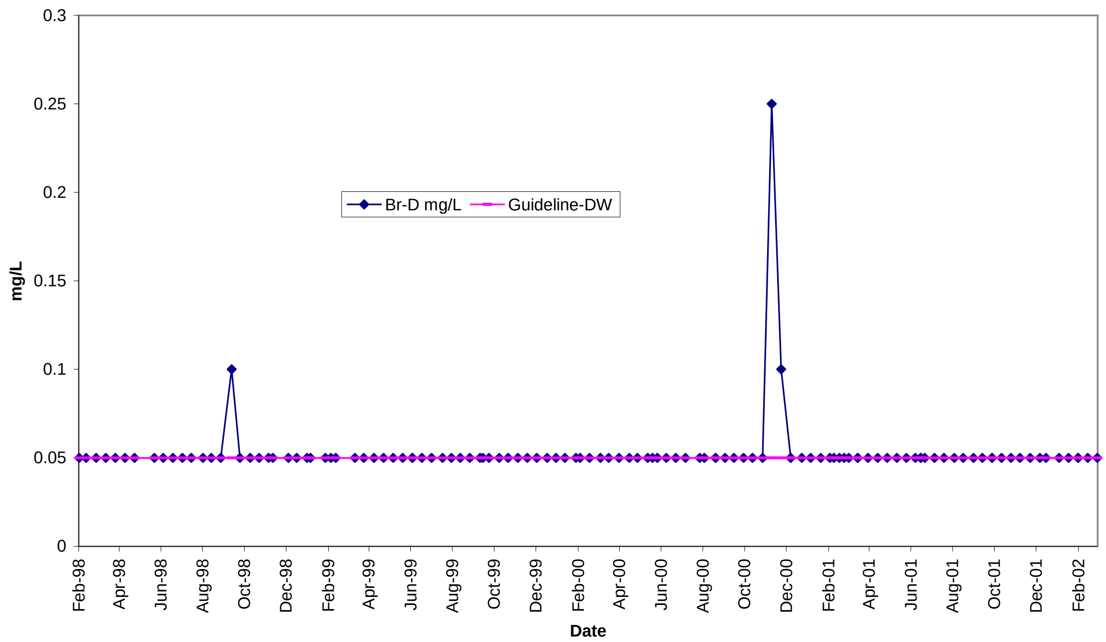


Figure 11 Cadmium, Extractable

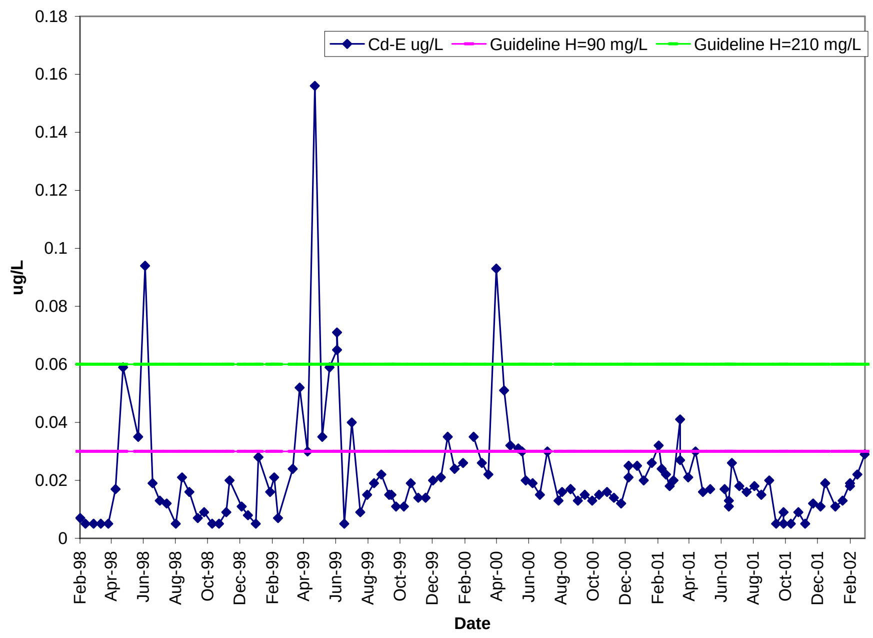


Figure 12 Cadmium, Total

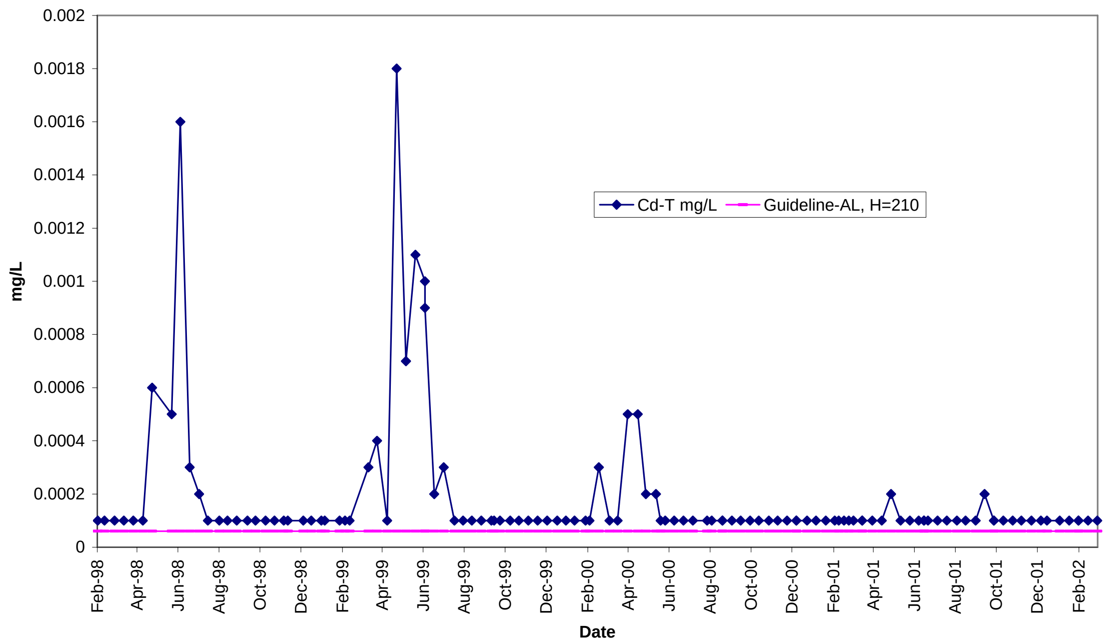


Figure 13 Calcium, Extractable

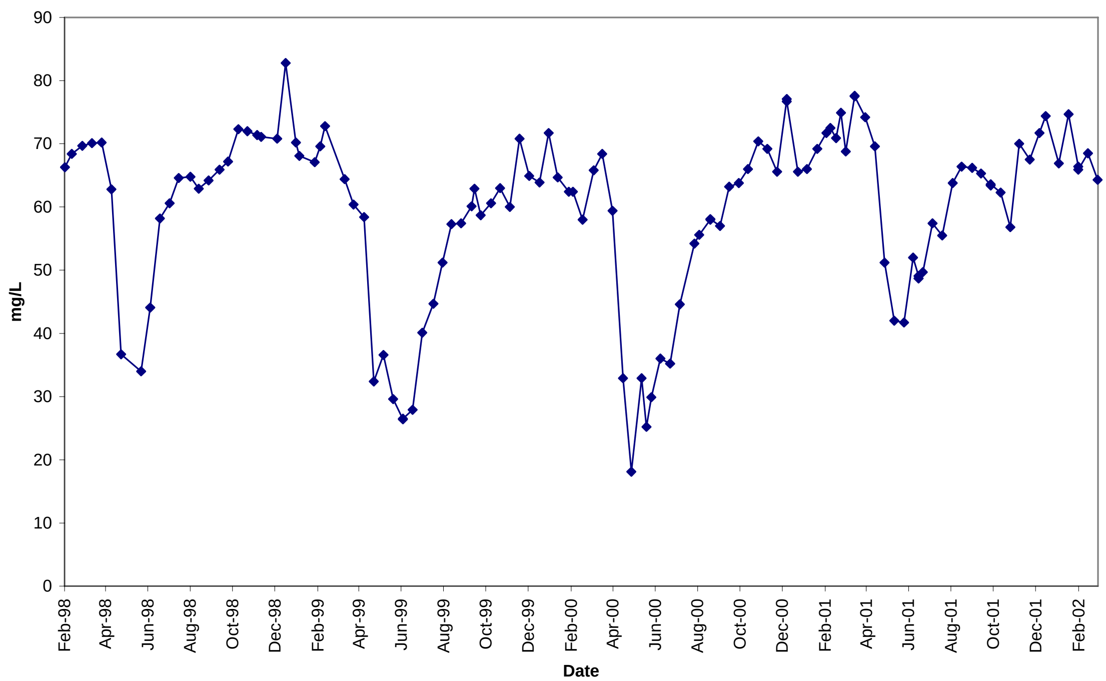


Figure 14 Carbon, Dissolved Inorganic

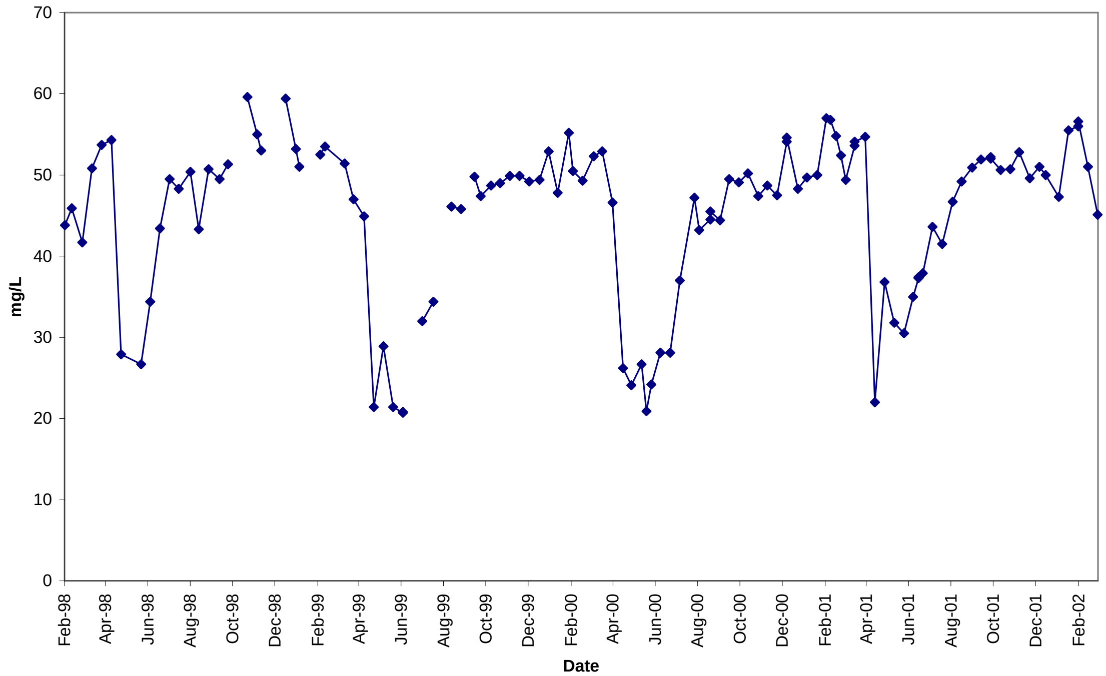


Figure 15 Carbon, Dissolved Organic

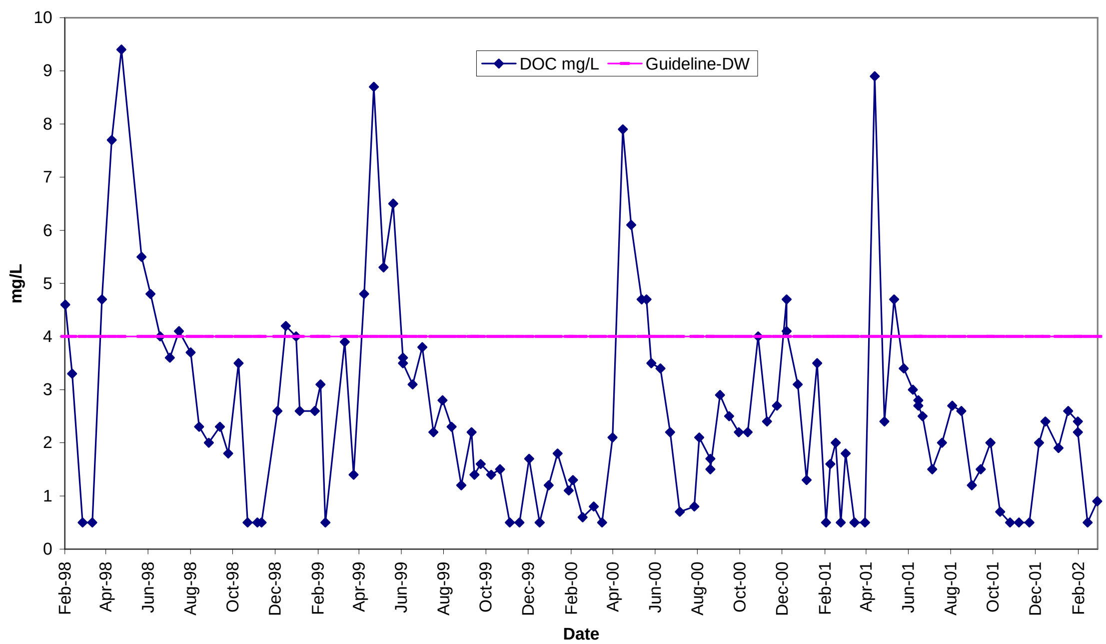


Figure 16 Chloride, Dissolved

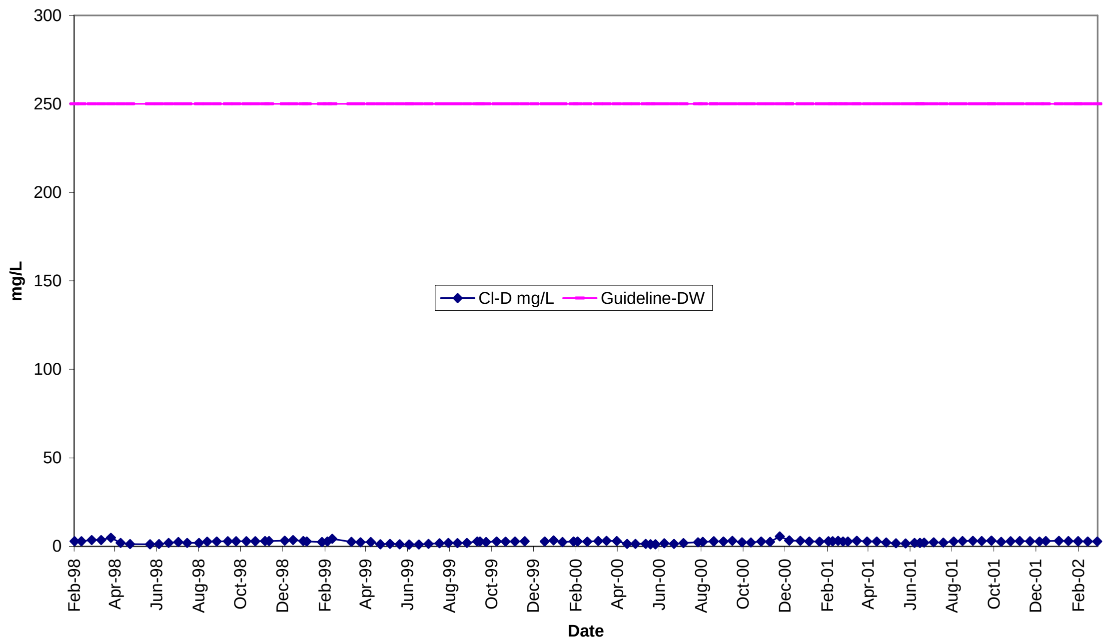


Figure 17 Chromium, Extractable

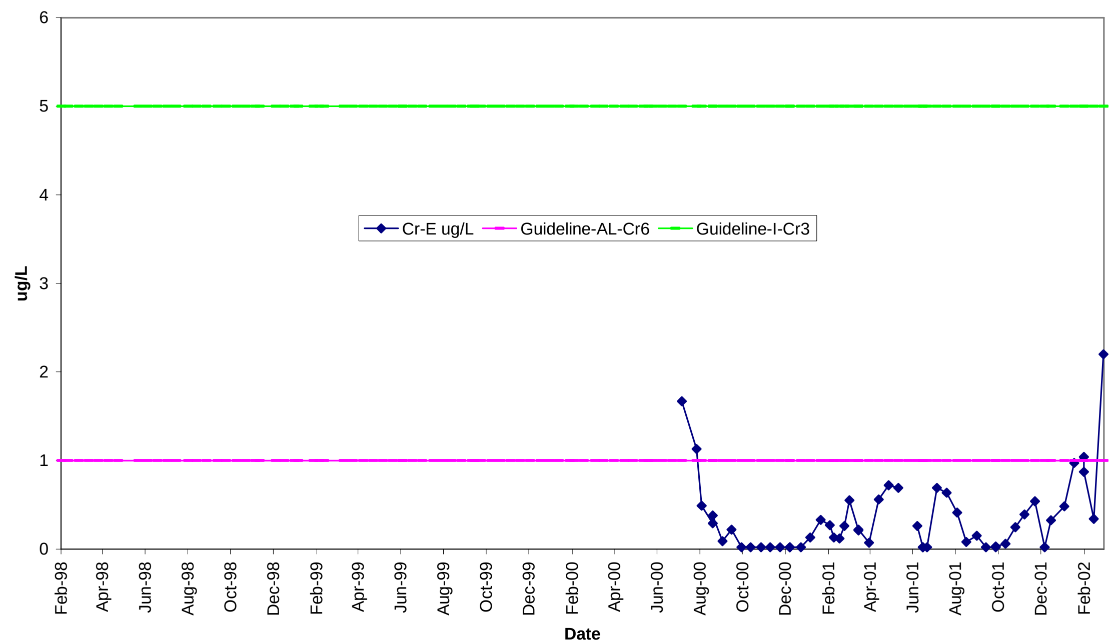


Figure 18 Chromium, Total

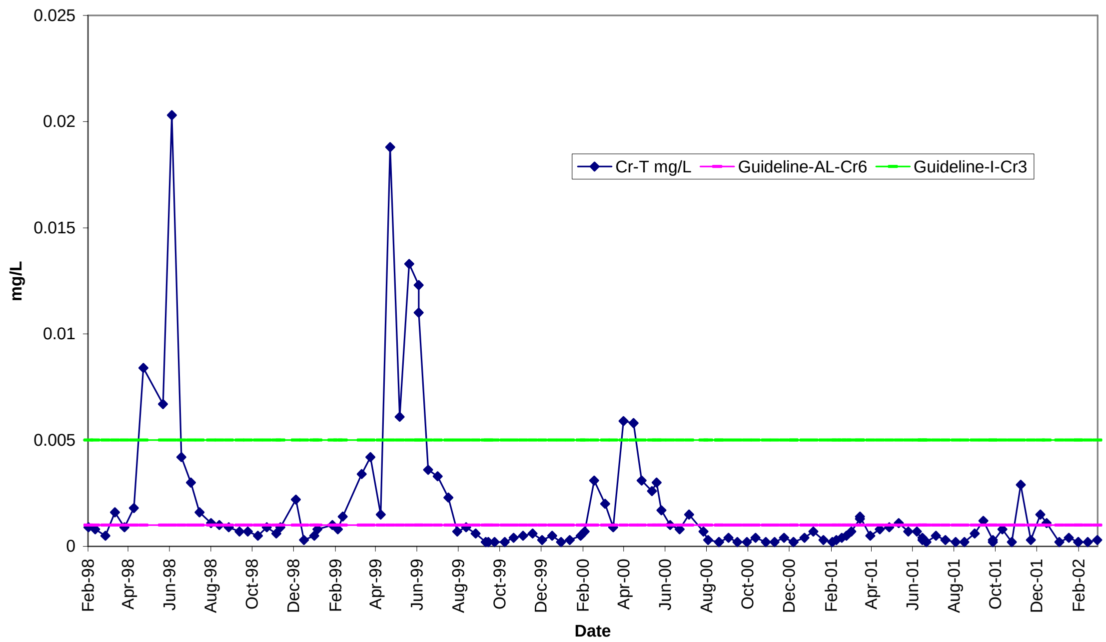


Figure 19 Cobalt, Extractable

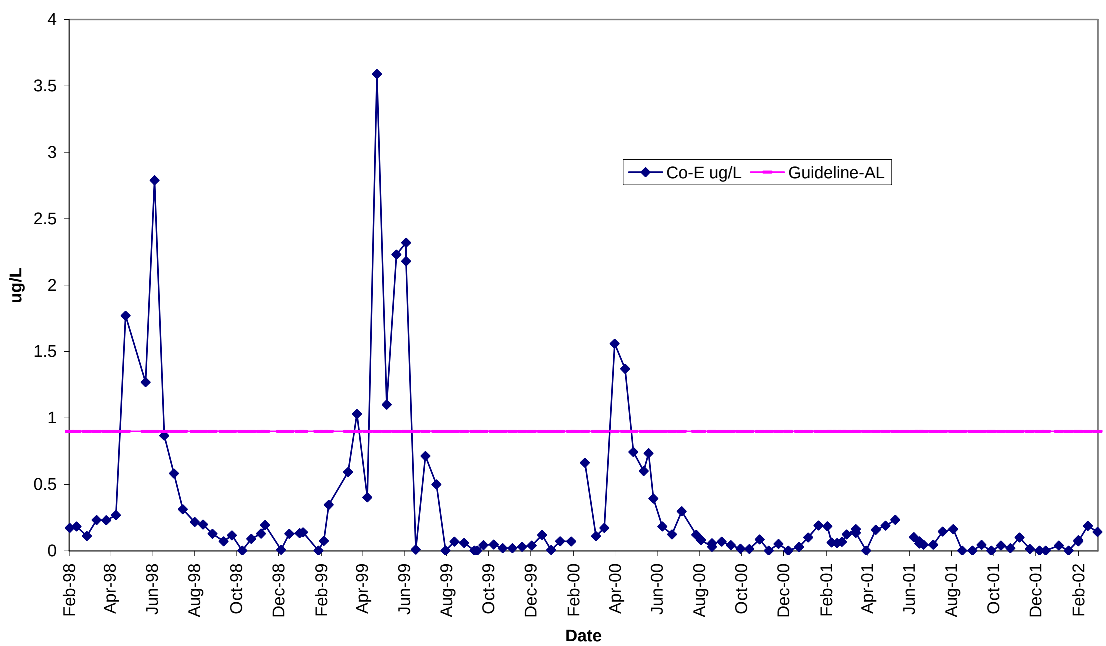


Figure 20 Cobalt, Total

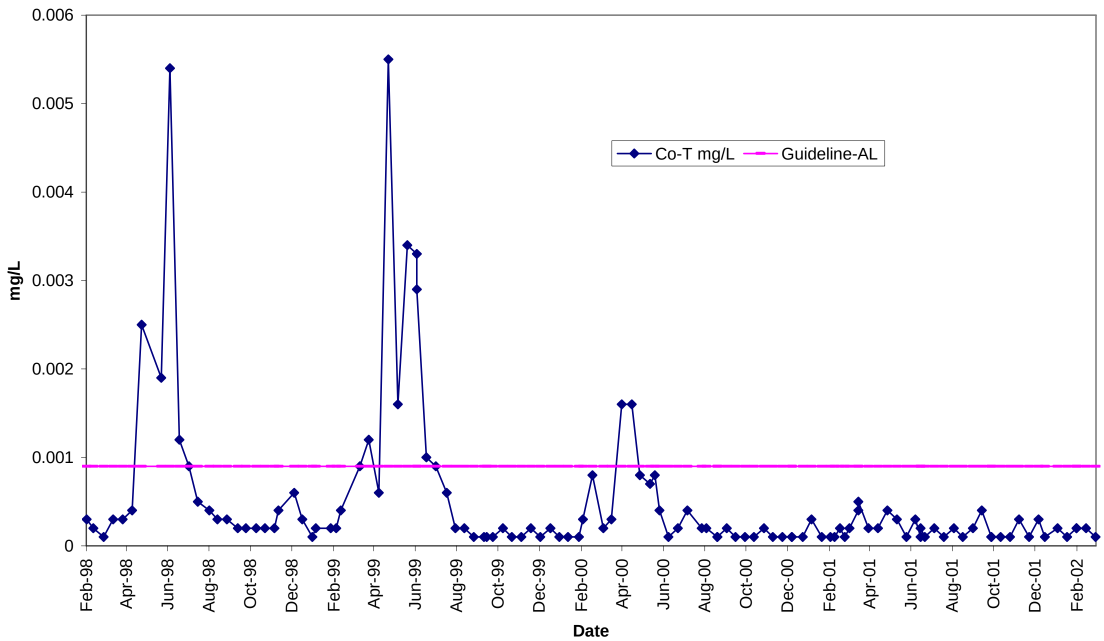


Figure 21 Coliforms, Fecal

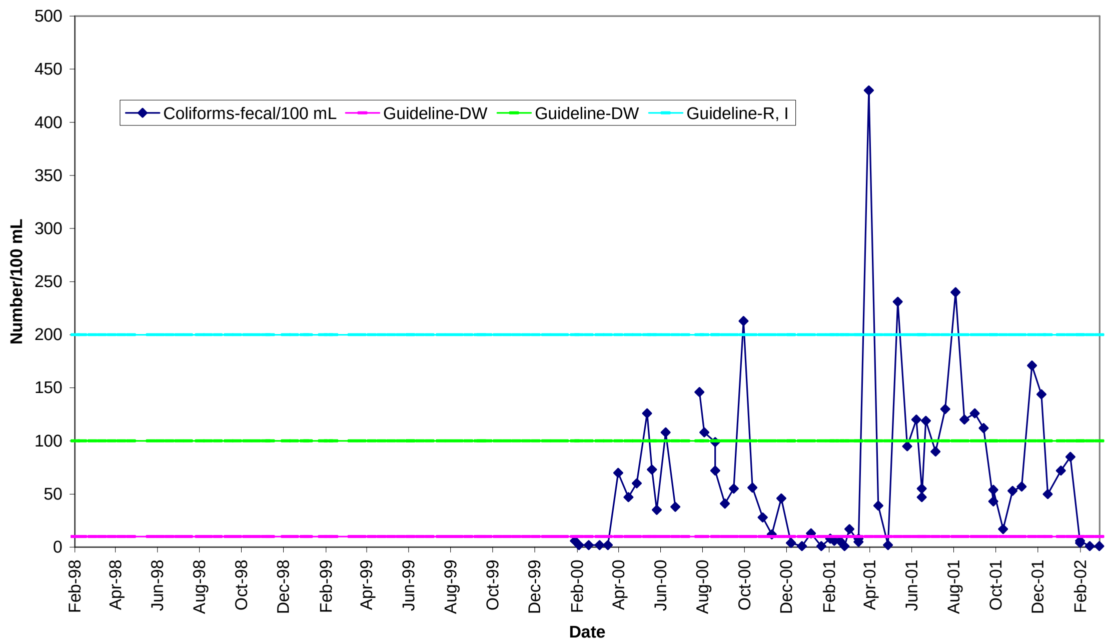


Figure 22 Colour, True

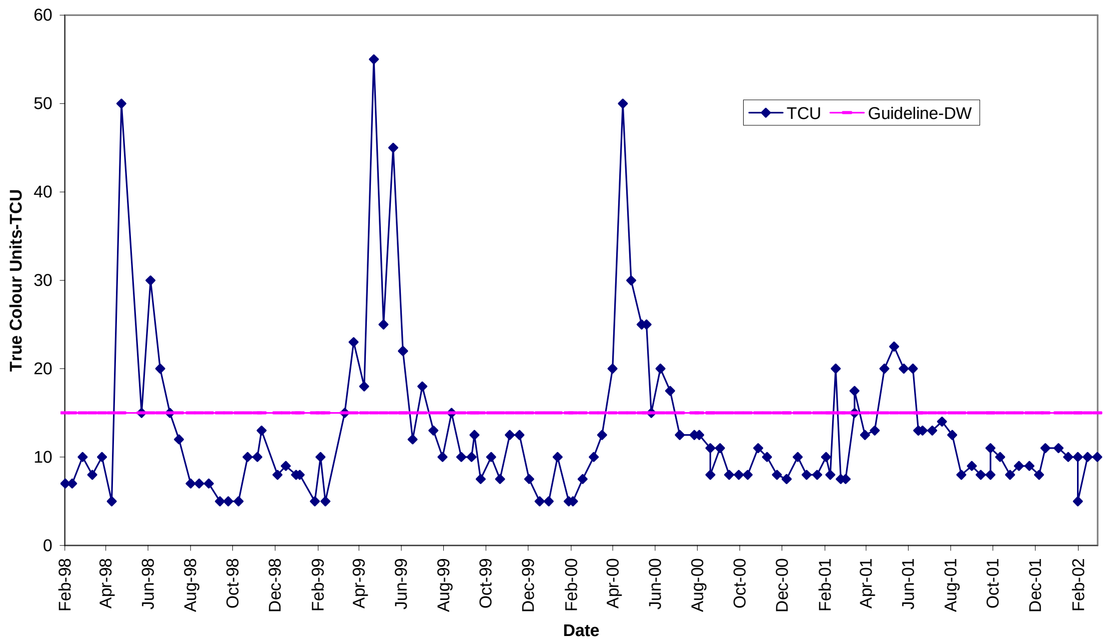


Figure 23 Conductivity, Specific

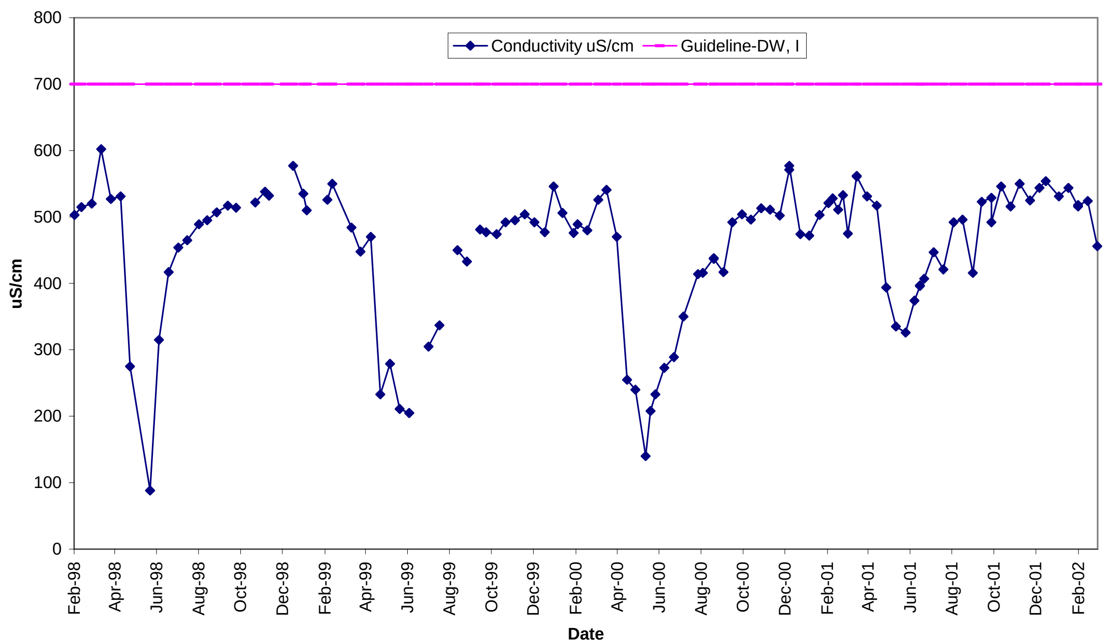


Figure 24 Copper, Extractable

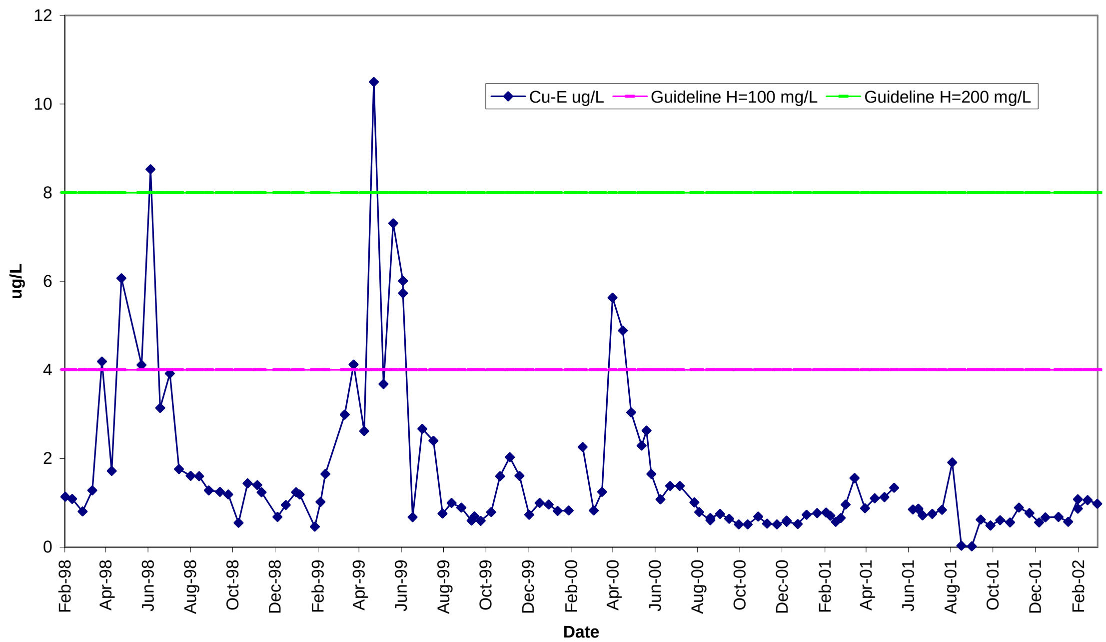


Figure 25 Copper, Total

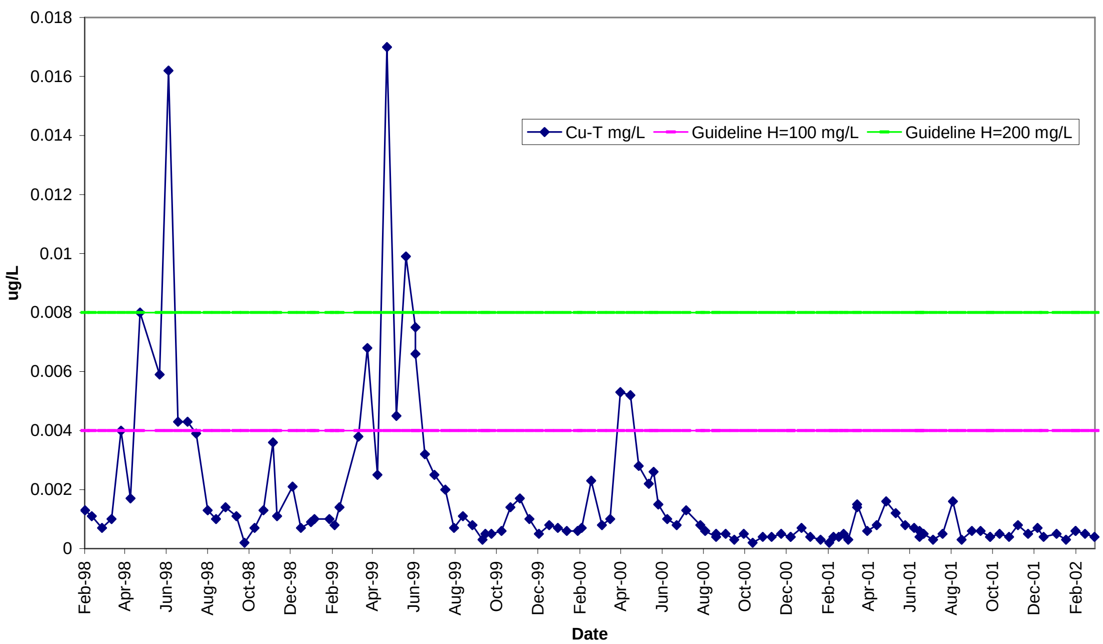


Figure 26 Cyanide

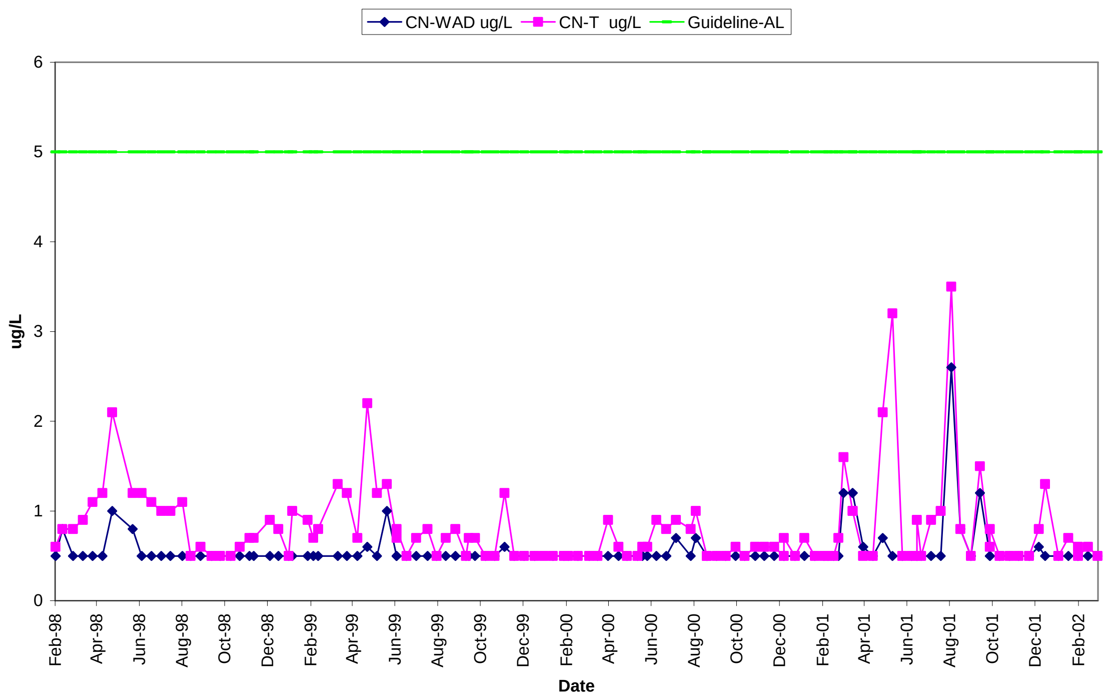


Figure 27 Fluoride, Dissolved

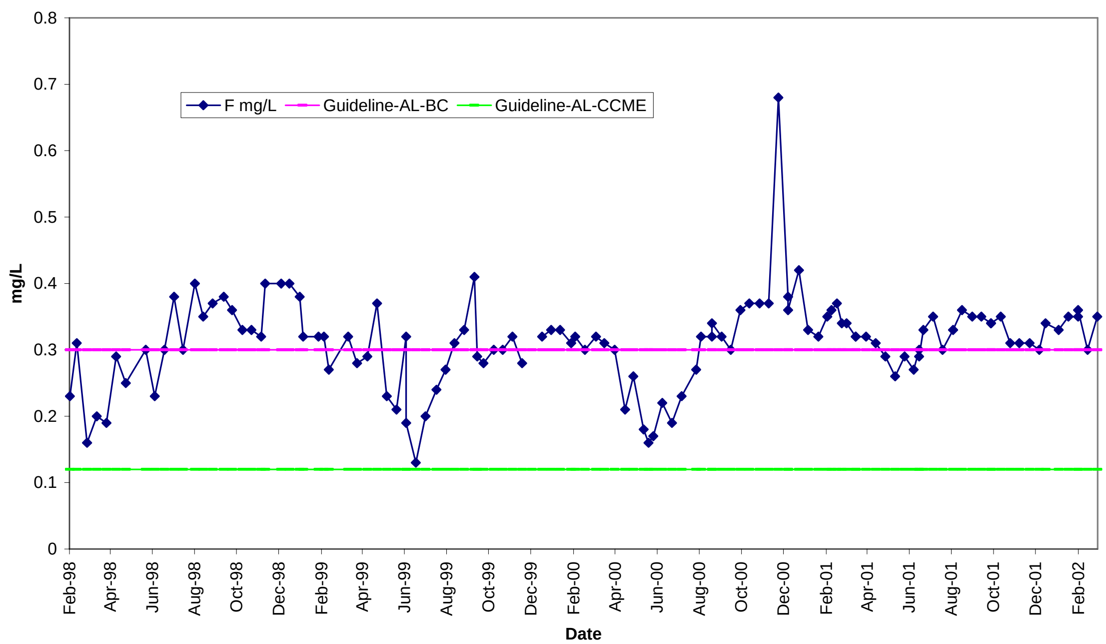


Figure 28 Gallium, Extractable

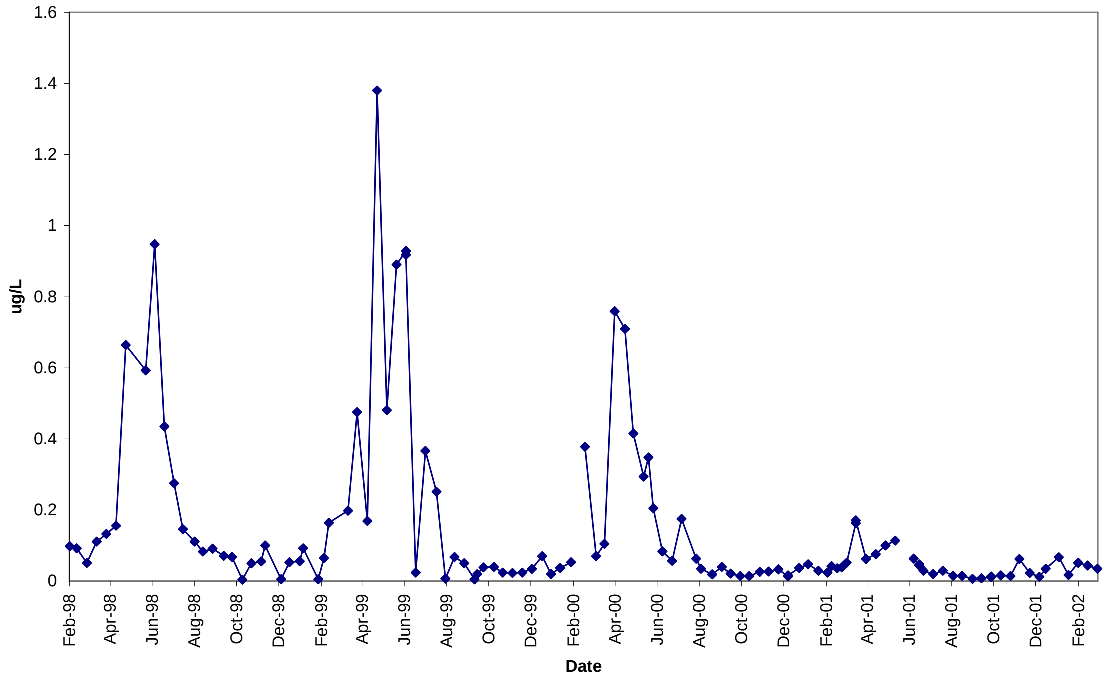


Figure 29 Hardness

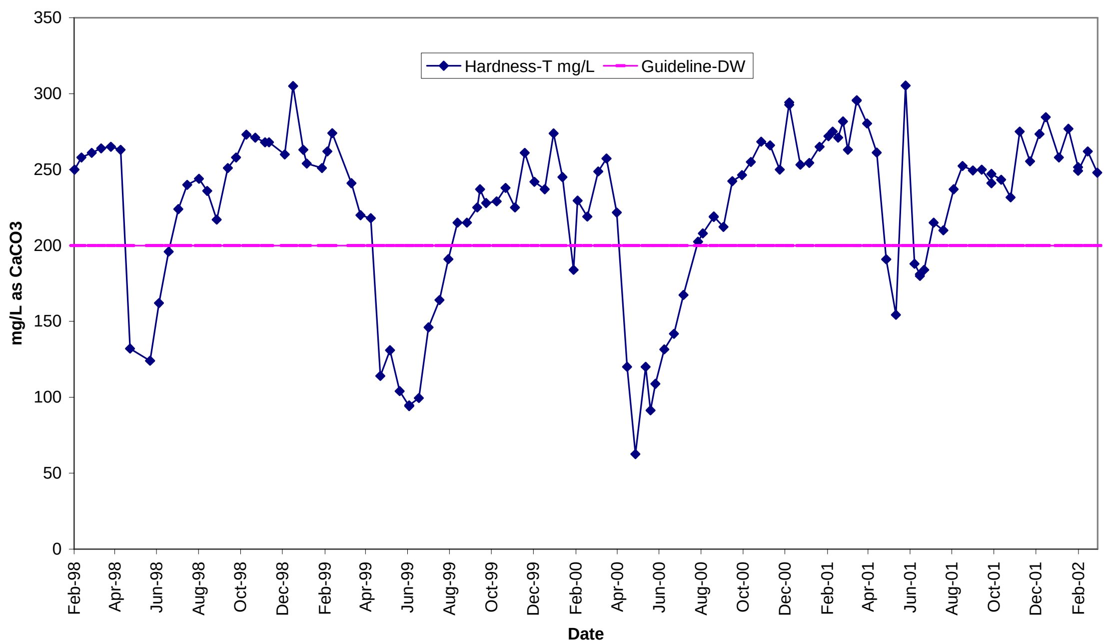


Figure 30 Iron, Total

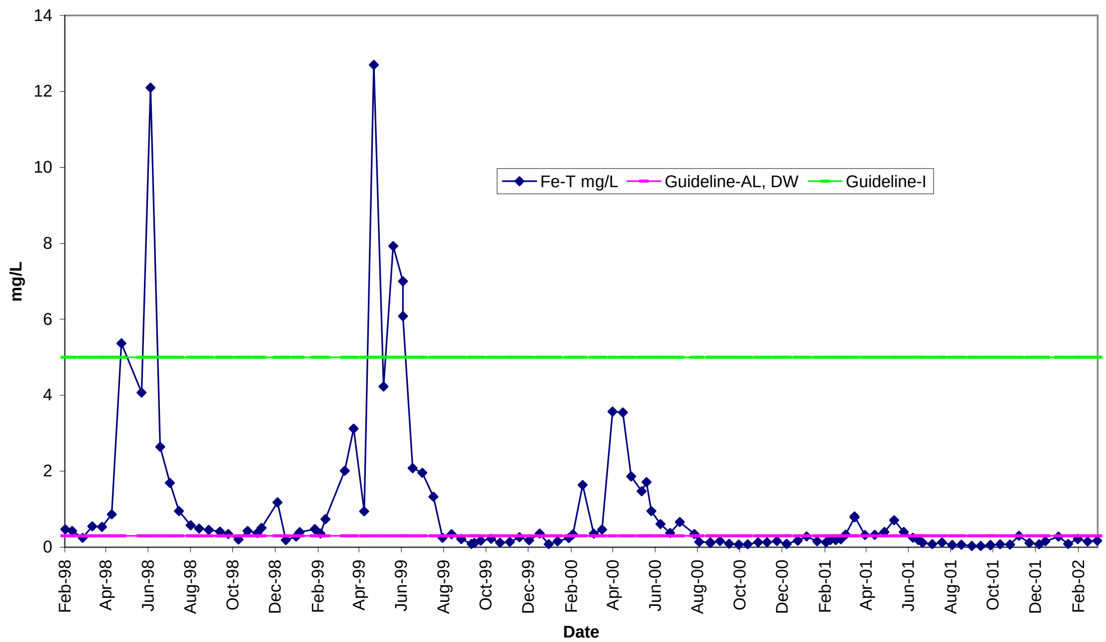


Figure 31 Lanthanum, Extractable

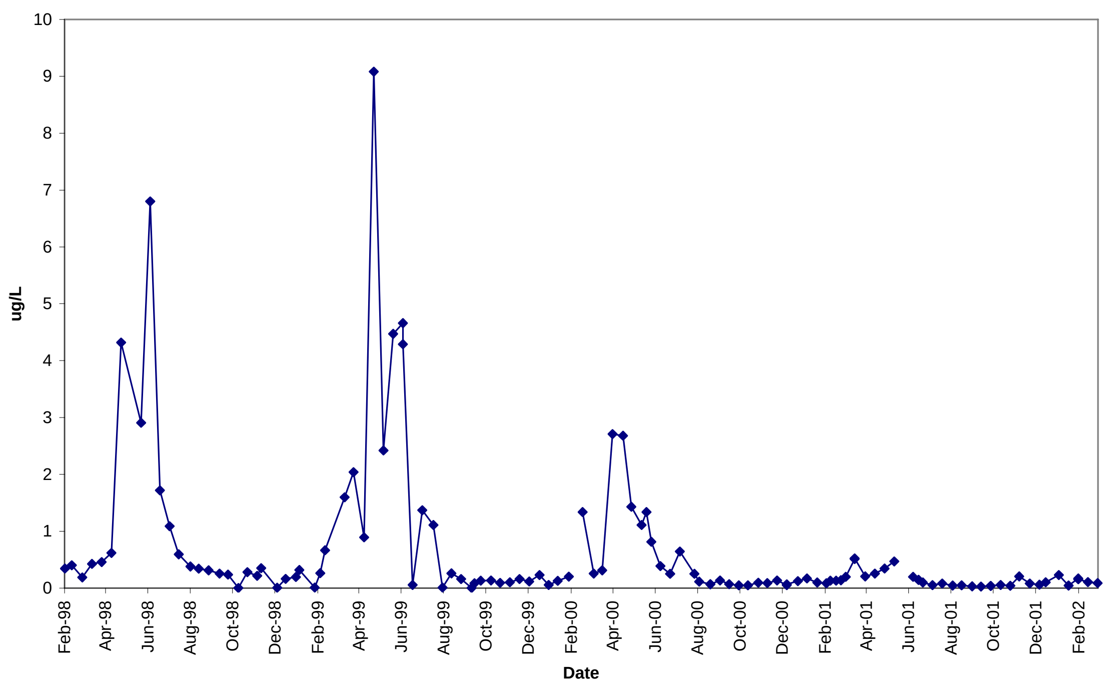


Figure 32 Lead, Extractable

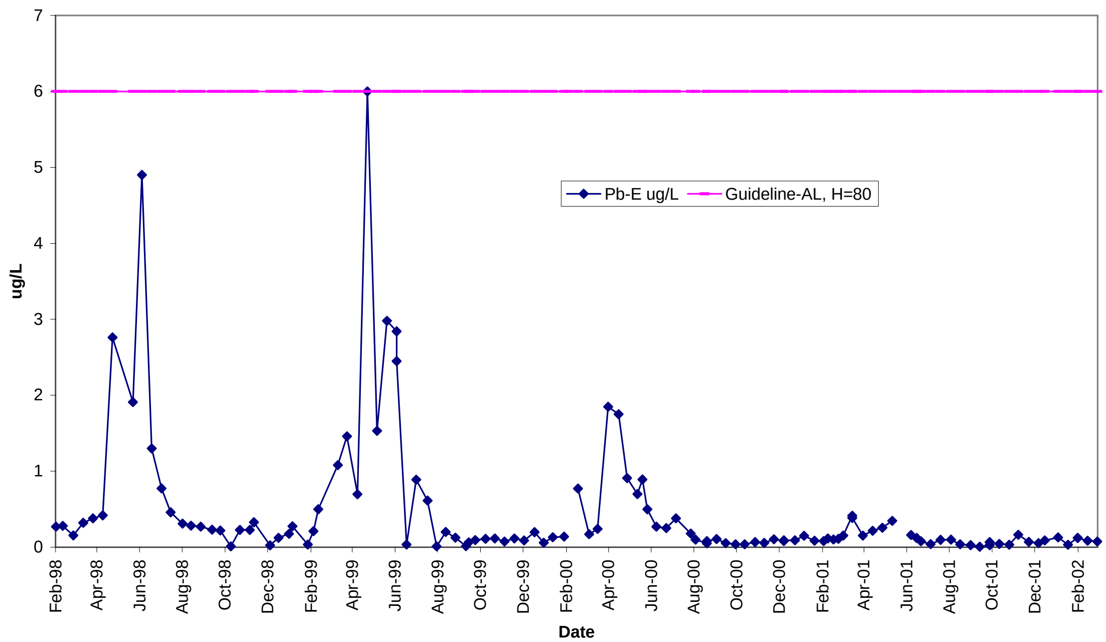


Figure 33 Lead, Total

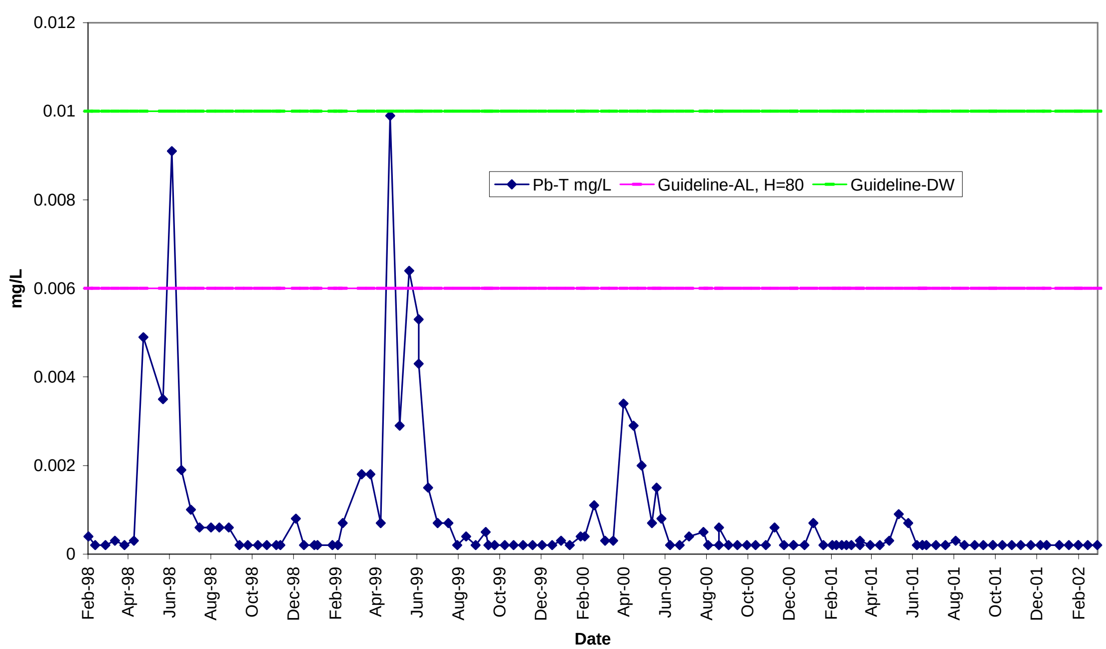


Figure 34 Lithium, Extractable

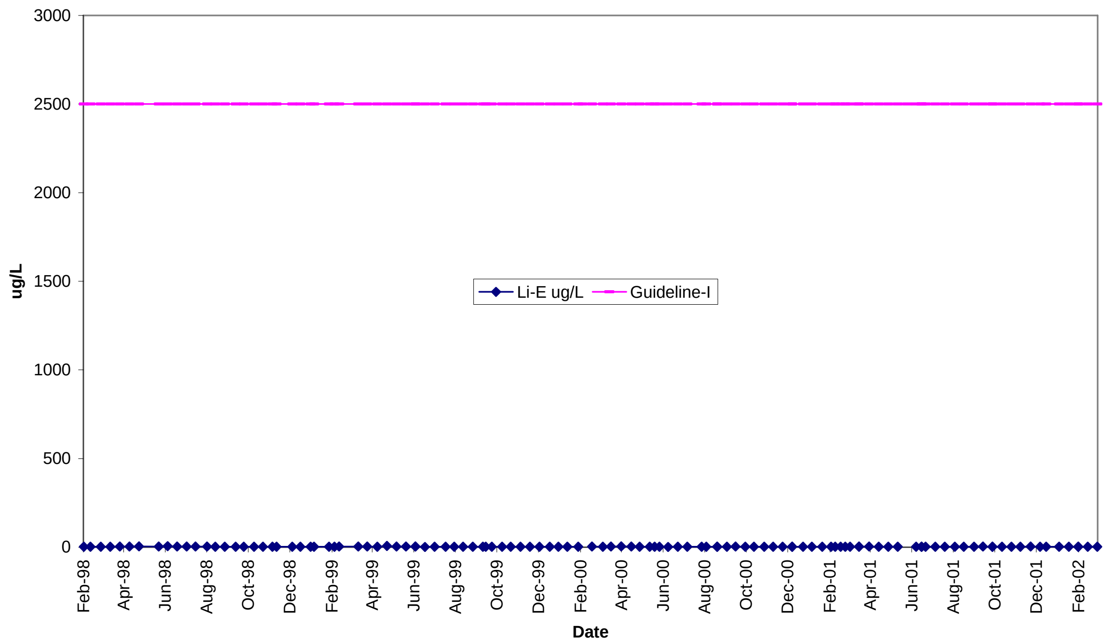


Figure 35 Lithium, Total

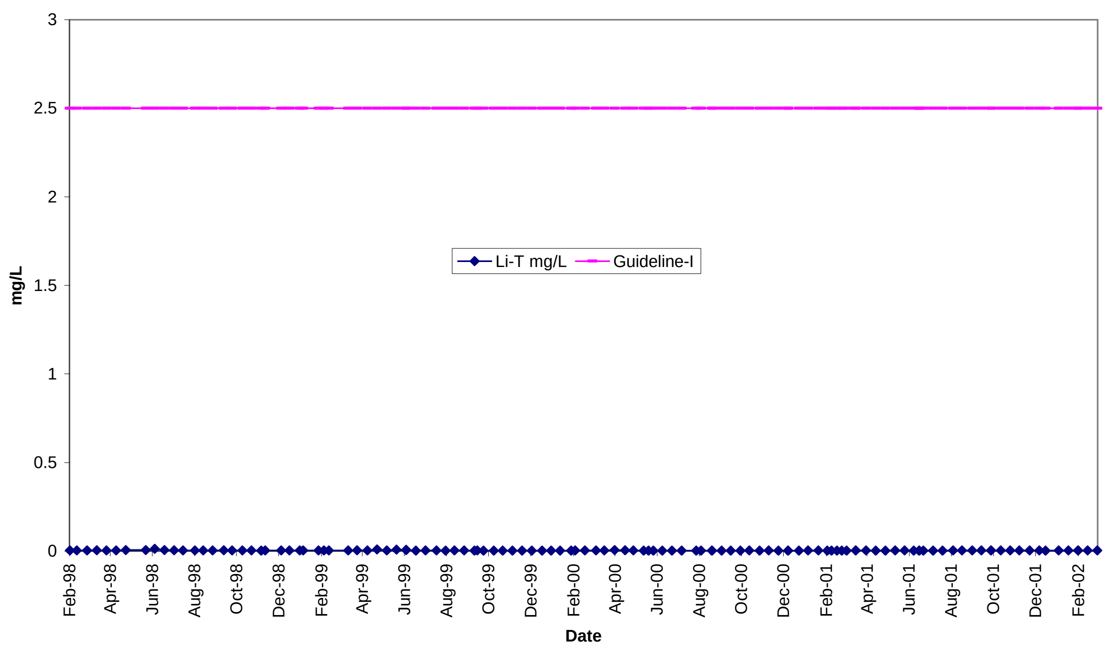


Figure 36 Magnesium, Extractable

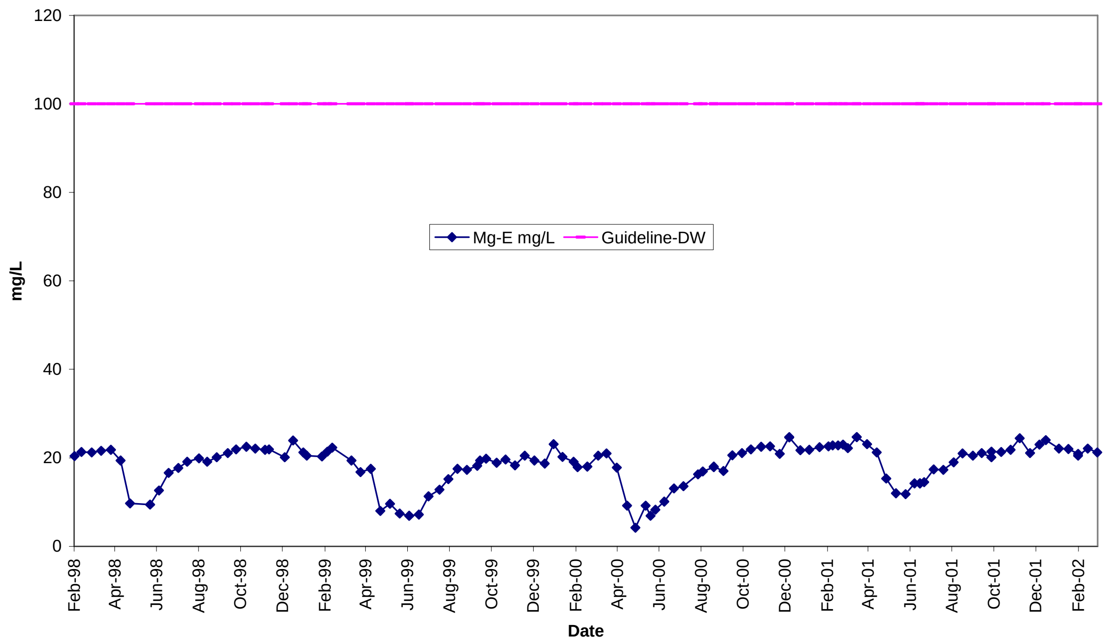


Figure 37 Manganese, Extractable

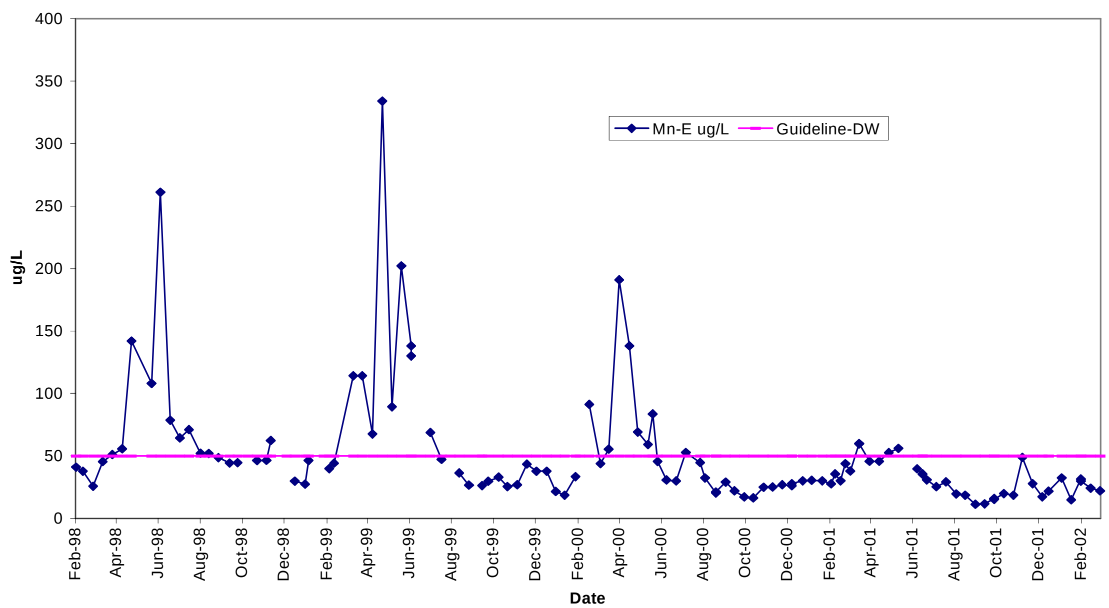


Figure 38 Manganese, Total

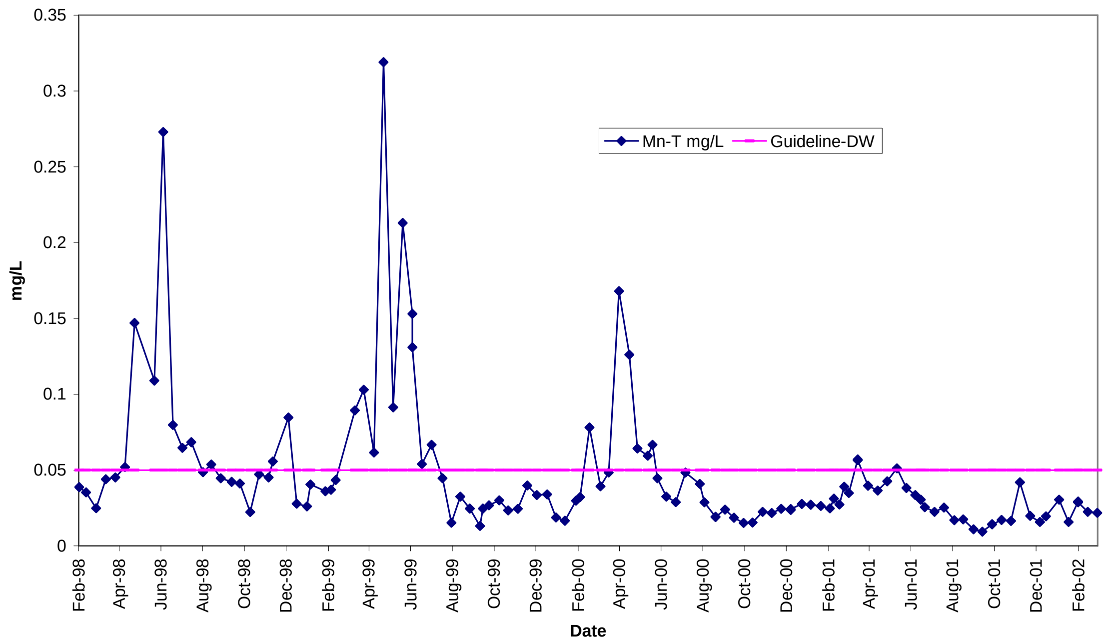


Figure 39 Molybdenum, Total

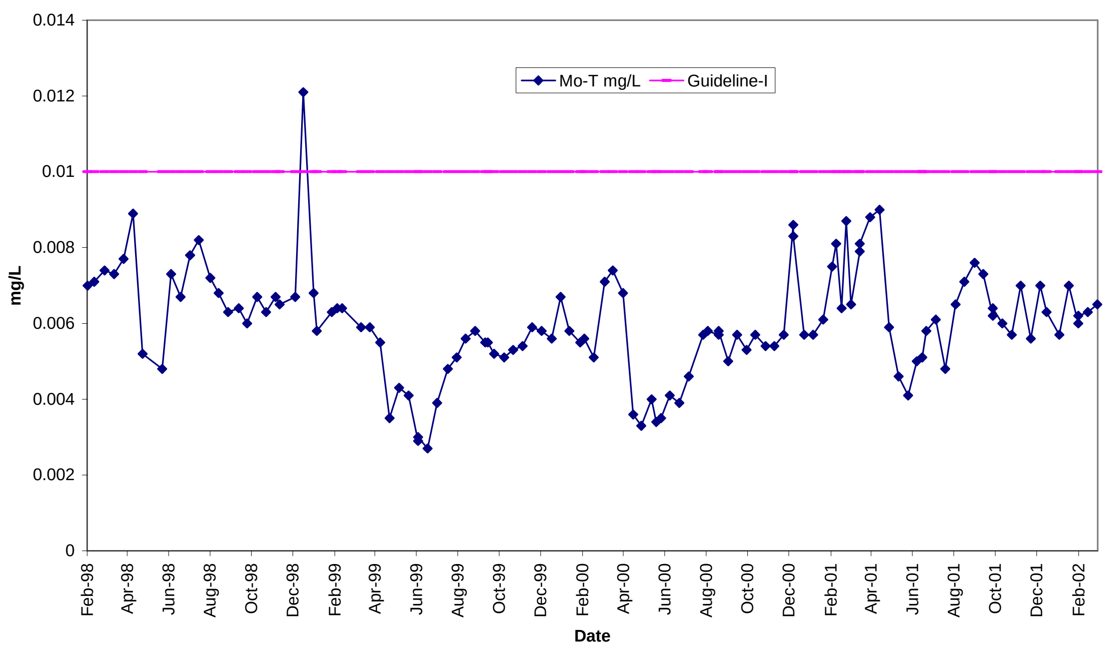


Figure 40 Nickel, Extractable

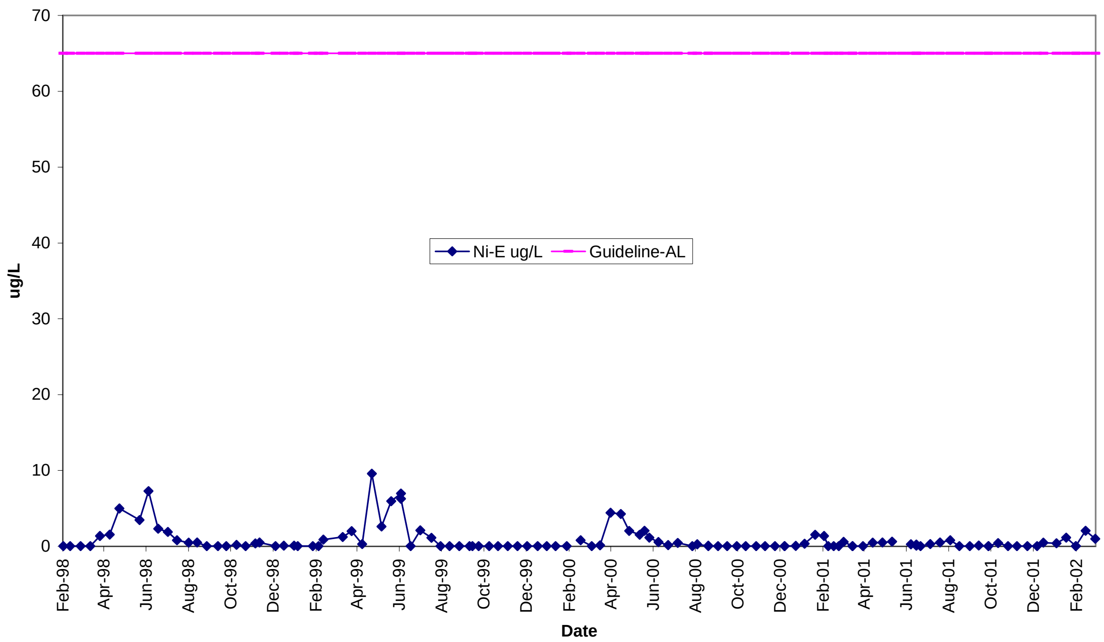


Figure 41 Nickel, Total

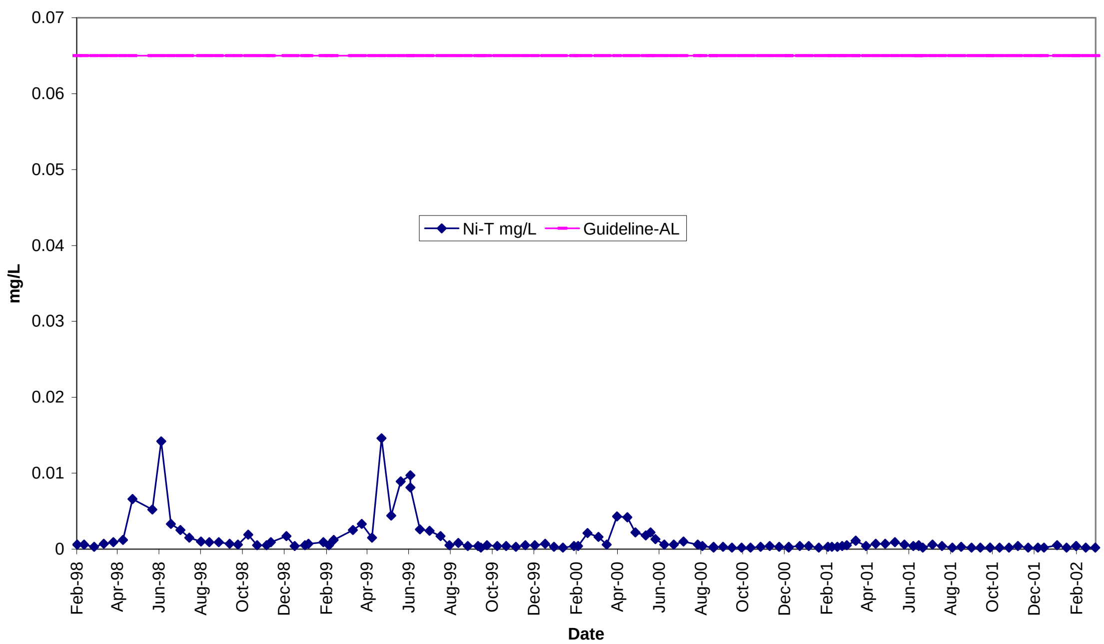


Figure 42 Nitrogen, Nitrate

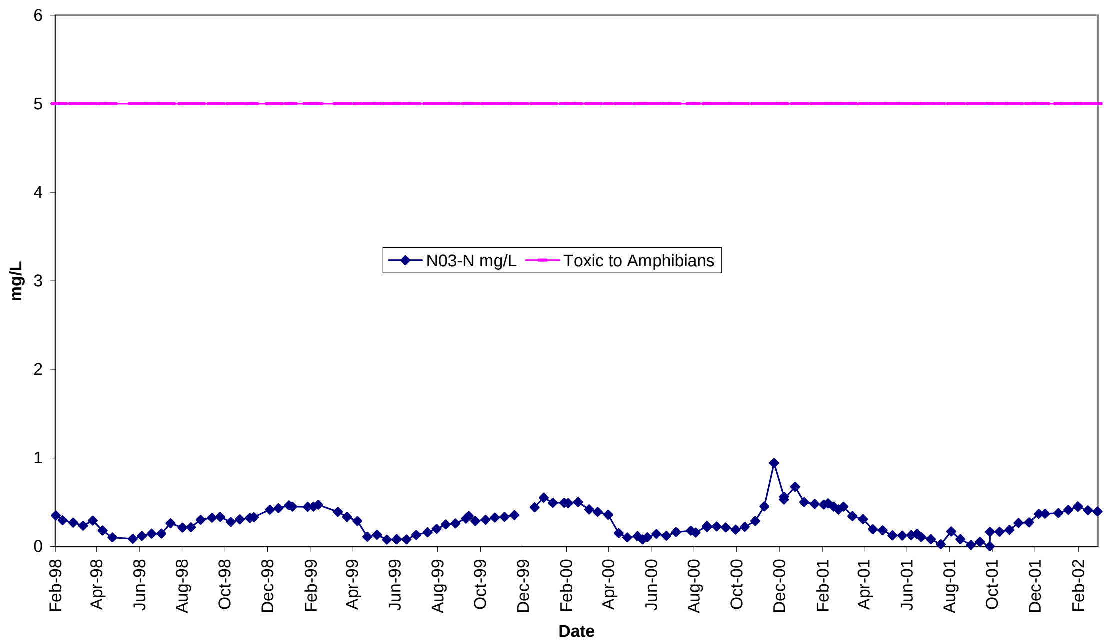


Figure 43 Nitrogen, Nitrite

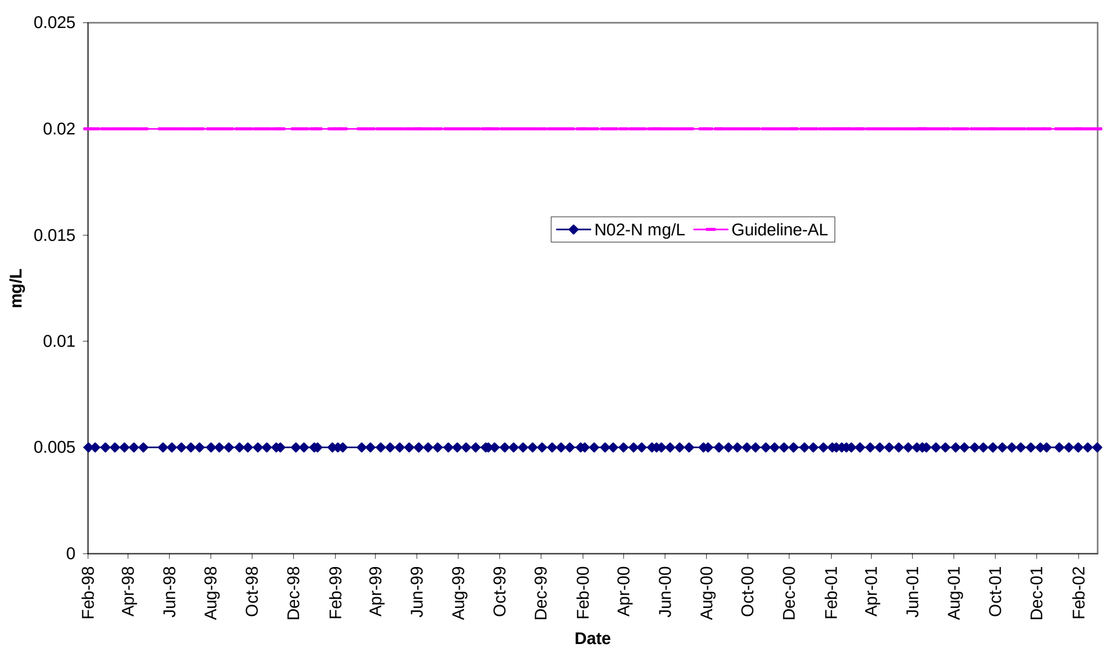


Figure 44 Nitrogen, Total Dissolved

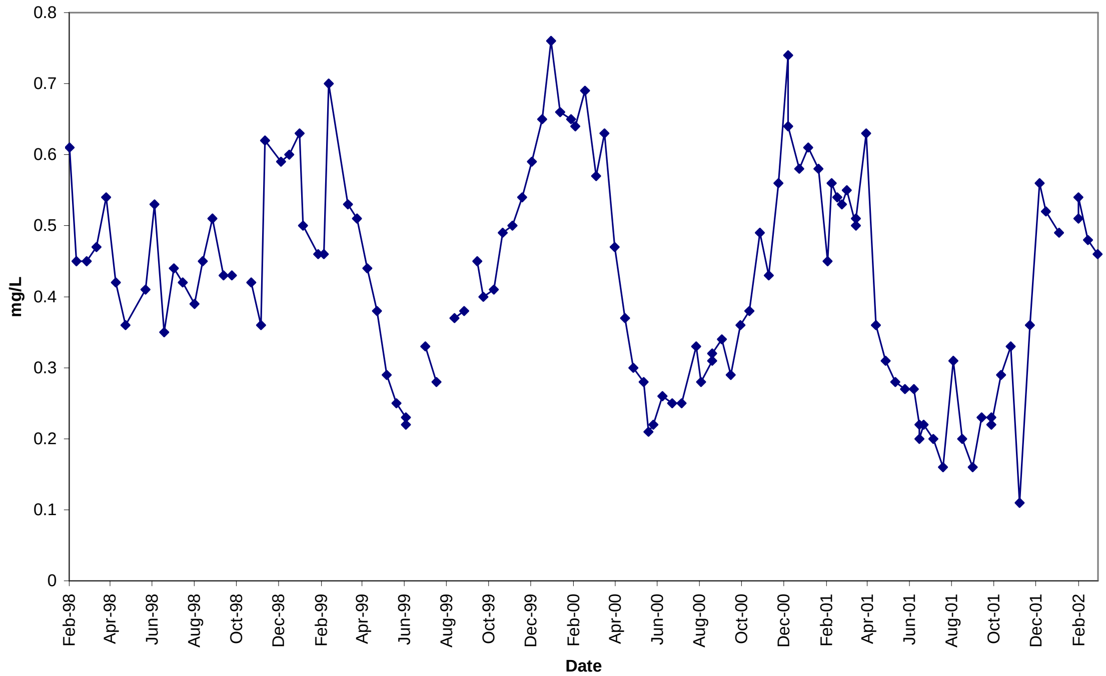


Figure 45 pH

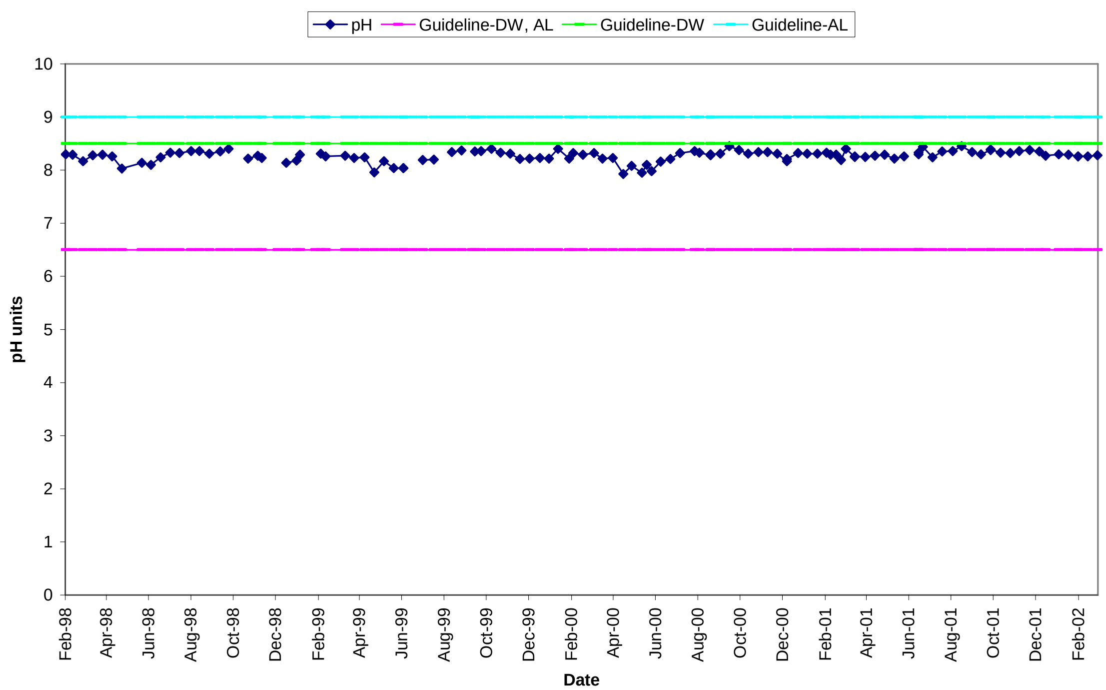


Figure 46 Phosphorus

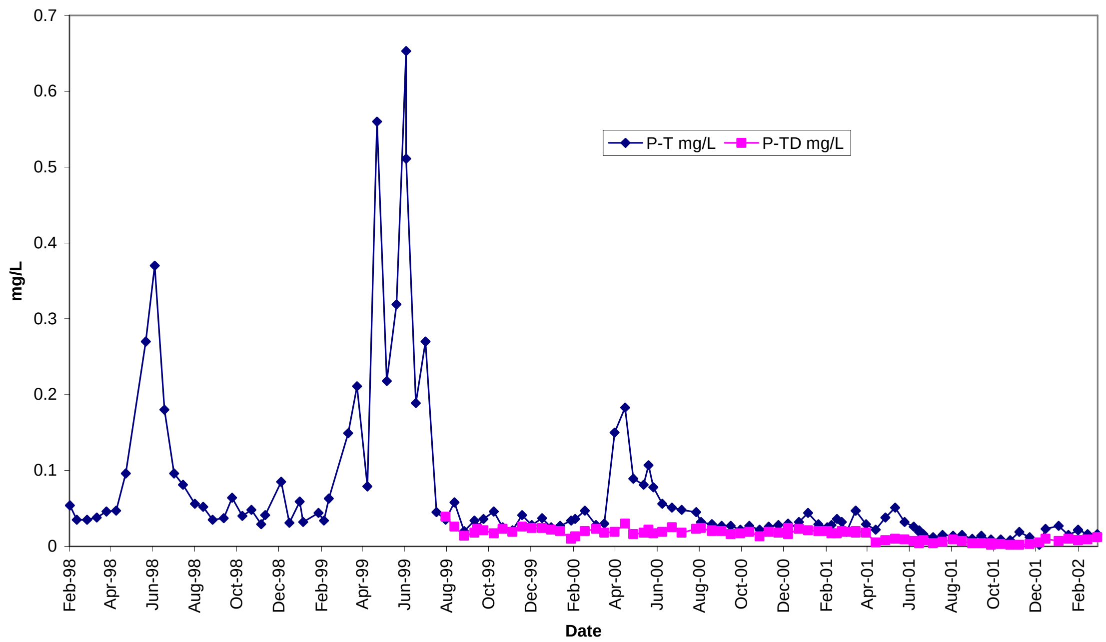


Figure 47 Phosphorus, Total Dissolved

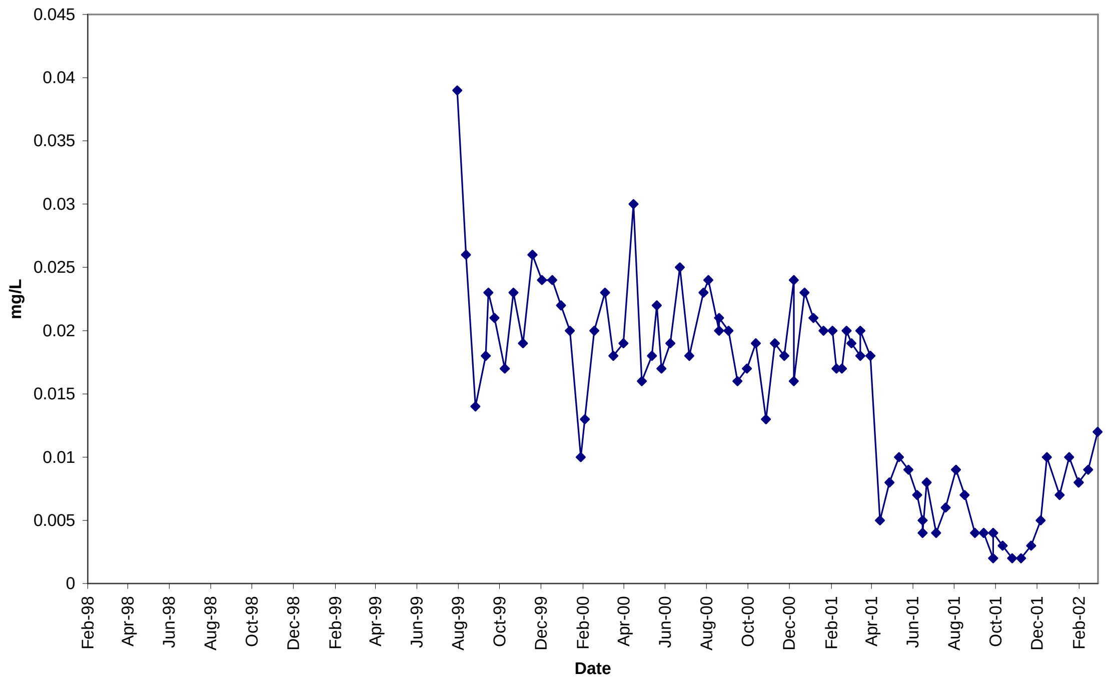


Figure 48 Potassium, Extractable

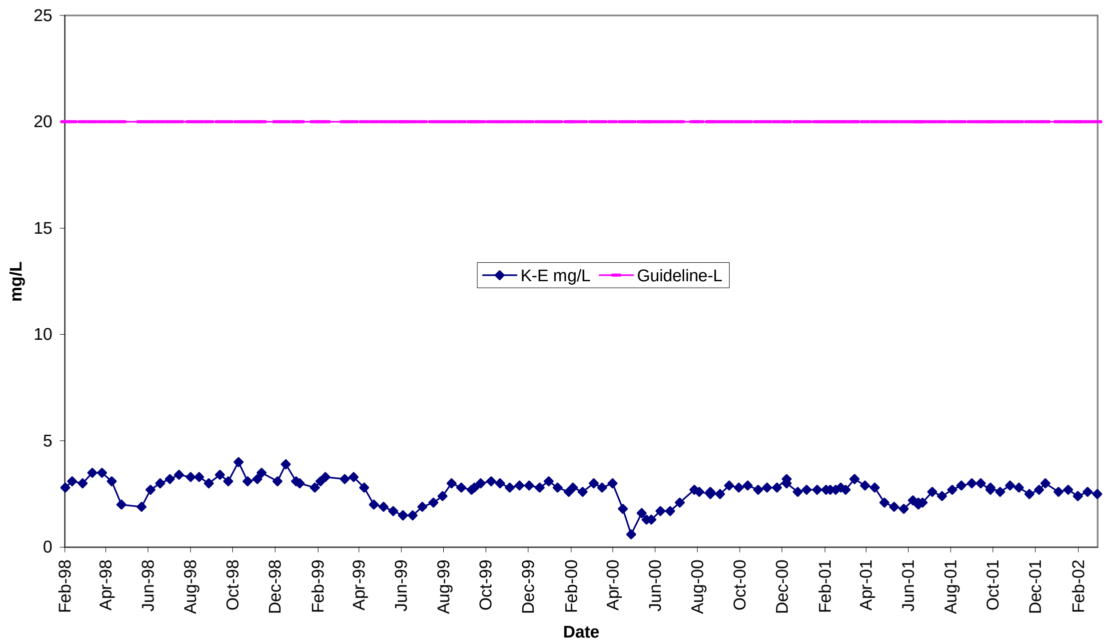


Figure 49 Rubidium, Extractable

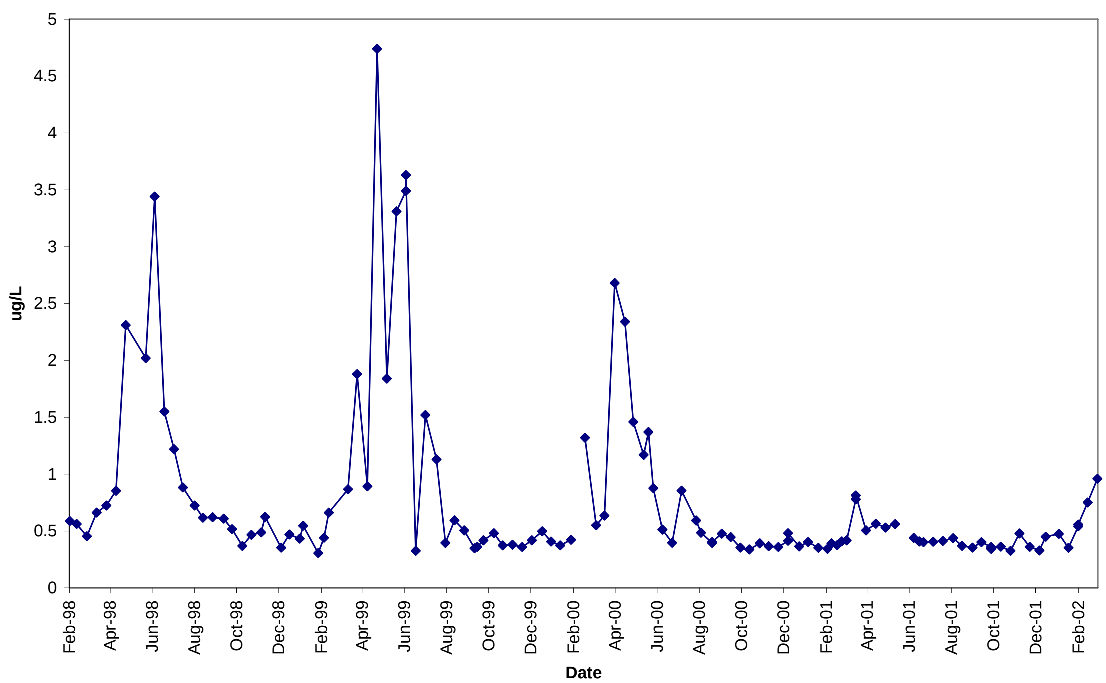


Figure 50 Selenium, Total

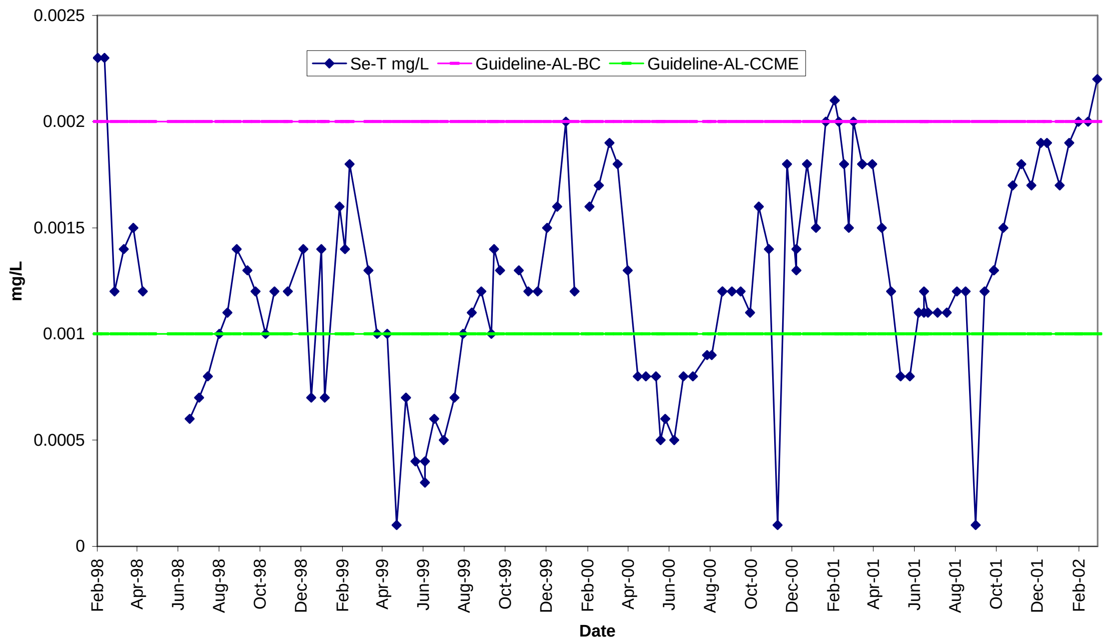


Figure 51 Silicon

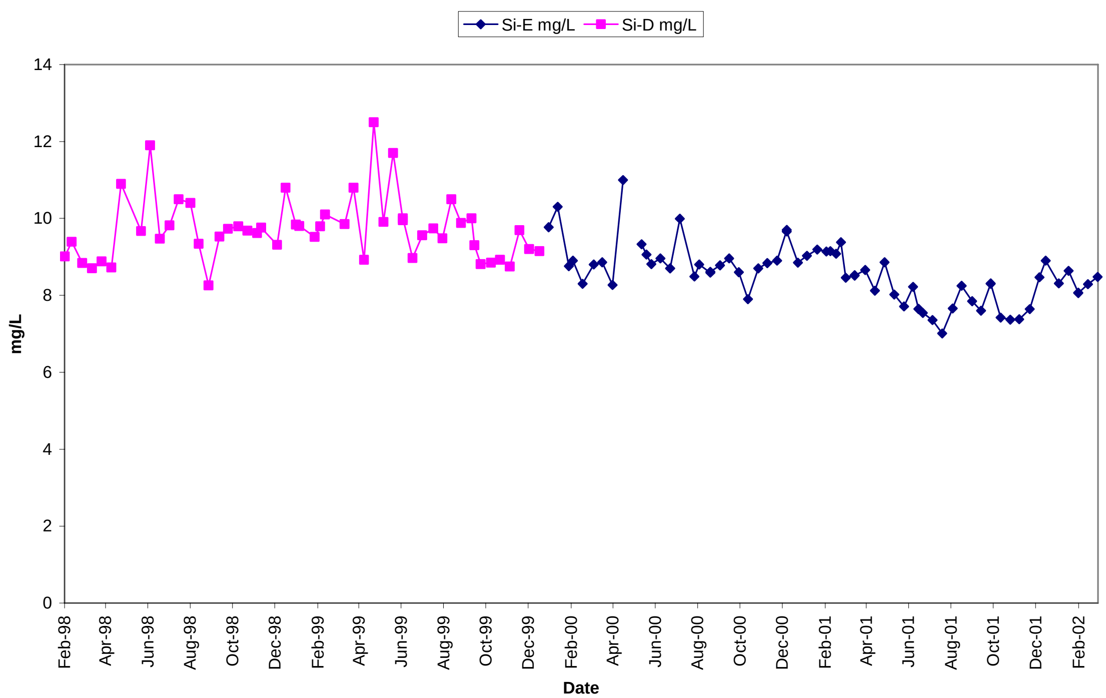


Figure 52 Silver, Extractable

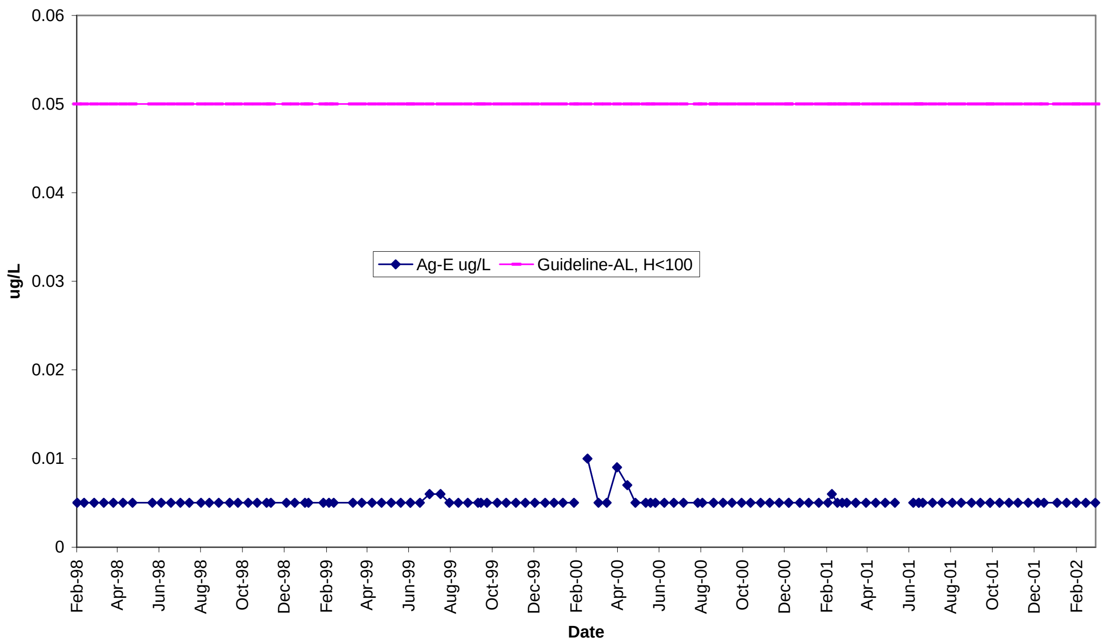


Figure 53 Silver, Total

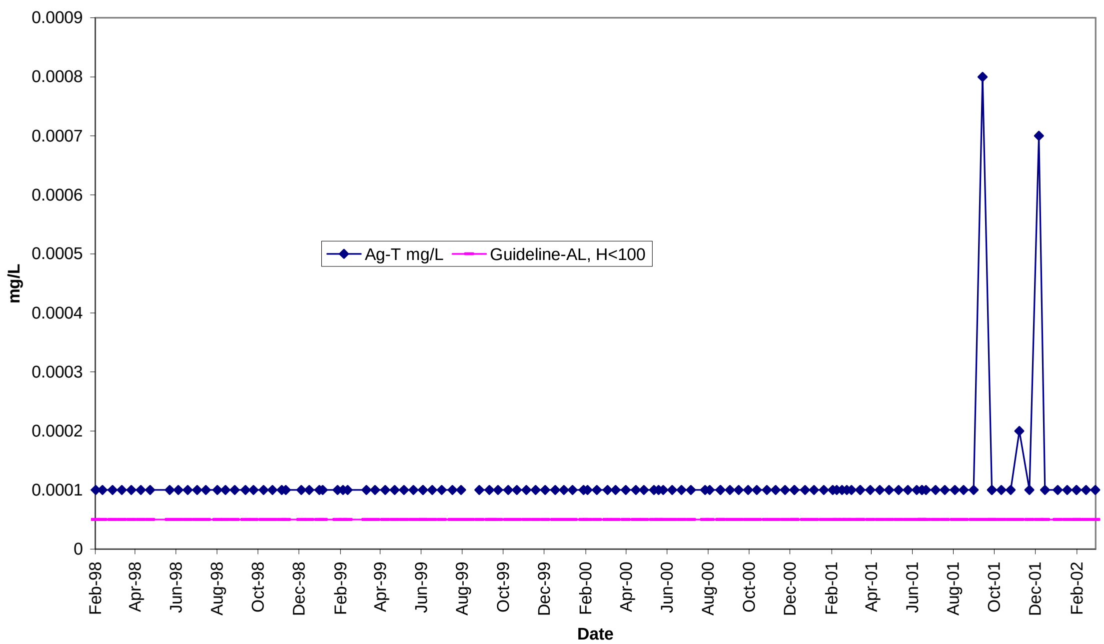


Figure 54 Sodium, Extractable

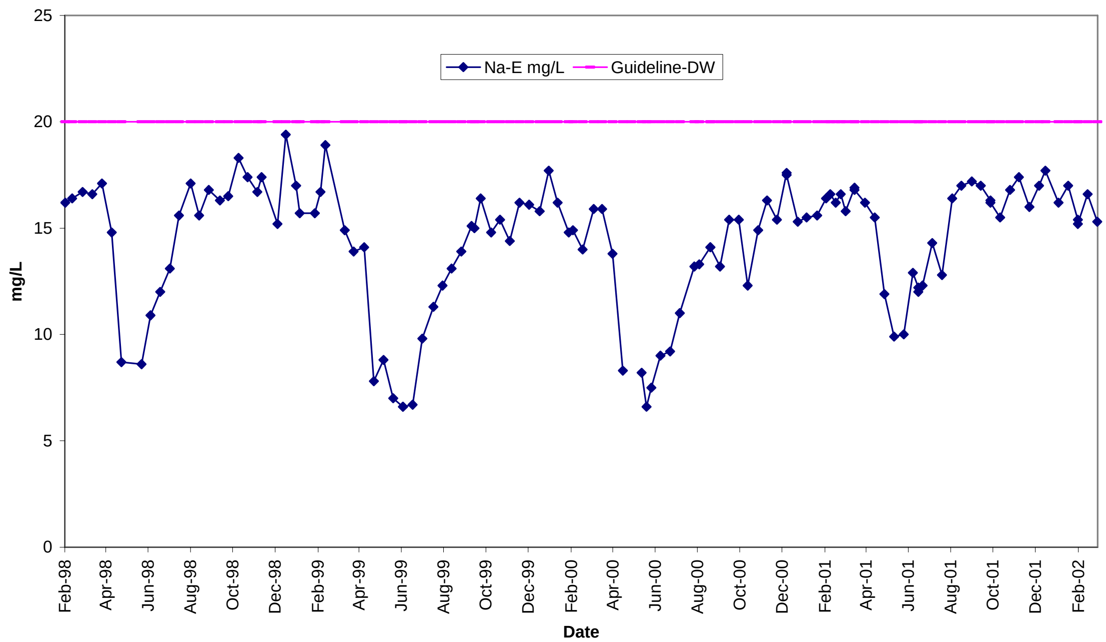


Figure 55 Strontium, Extractable

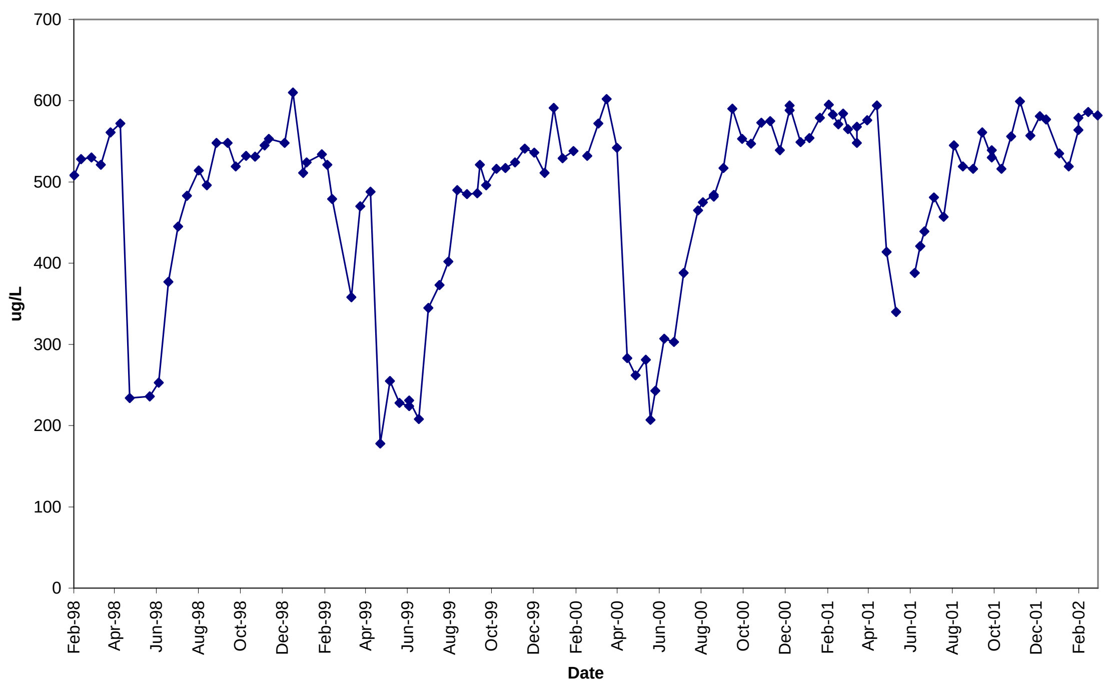


Figure 56 Strontium, Total

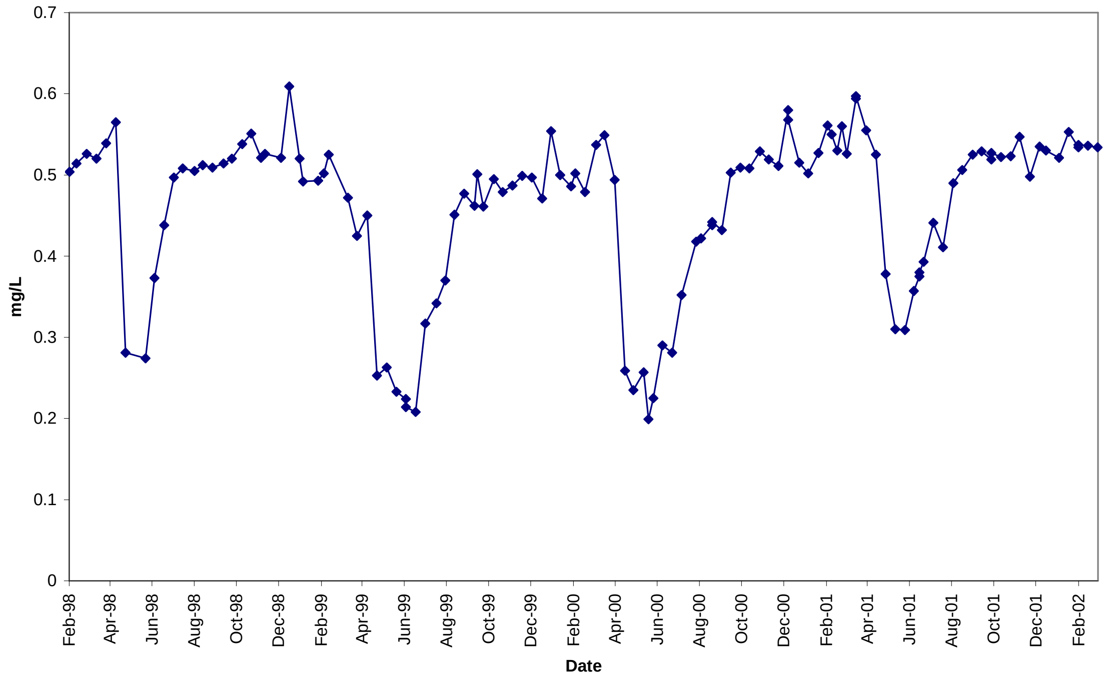


Figure 57 Sulphate

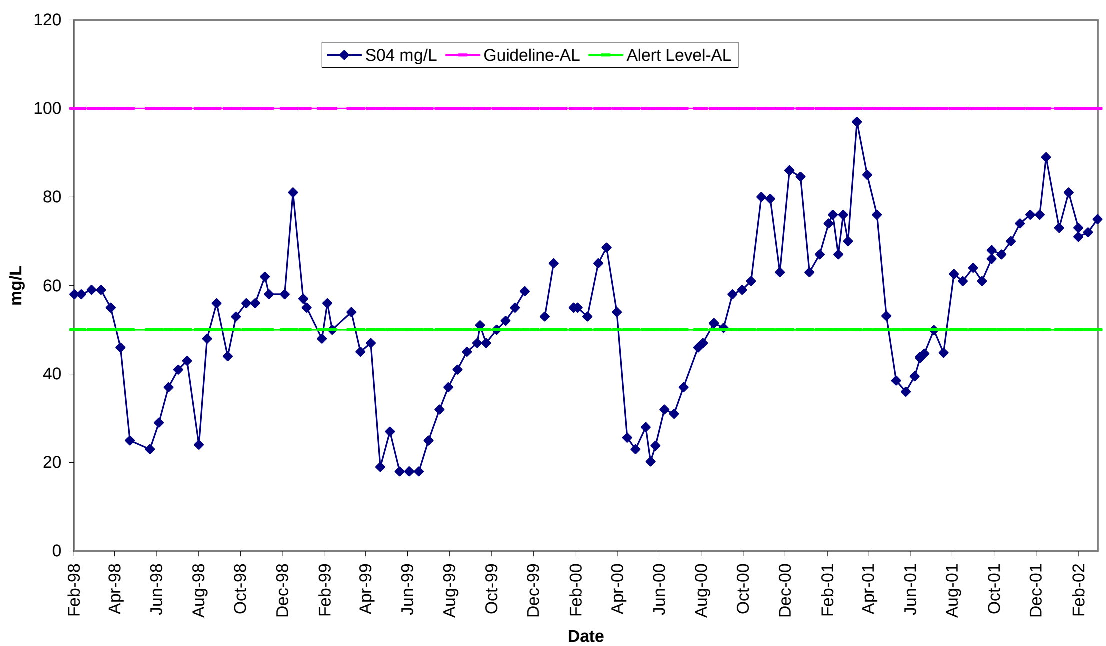


Figure 58 Temperature, Air

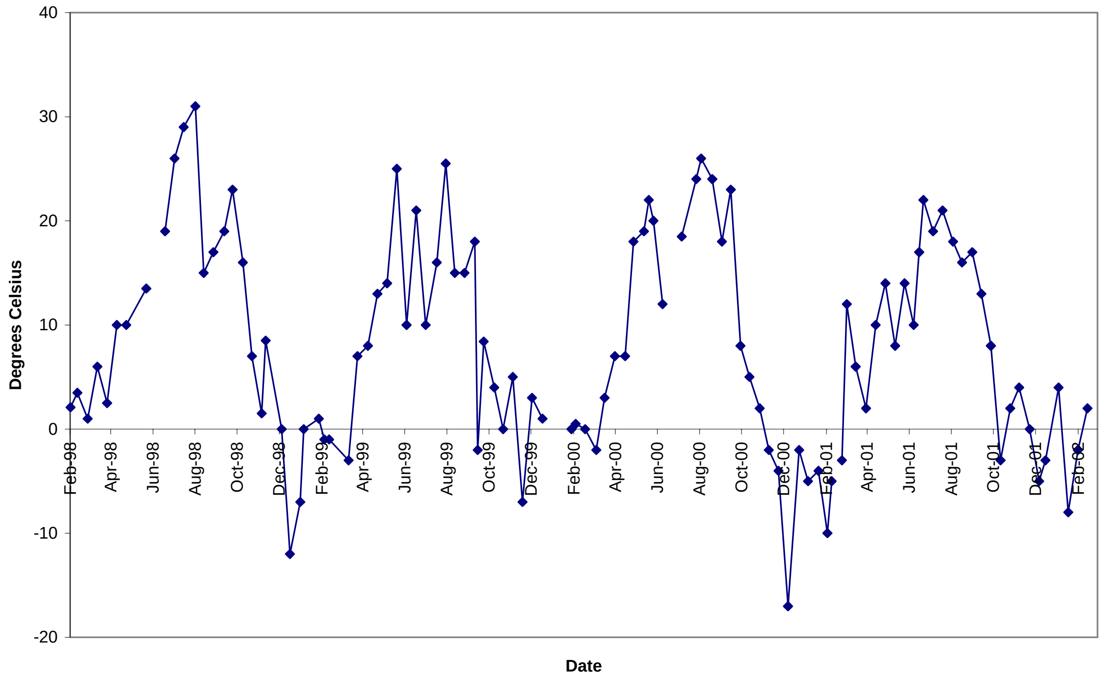


Figure 59 Temperature, Water

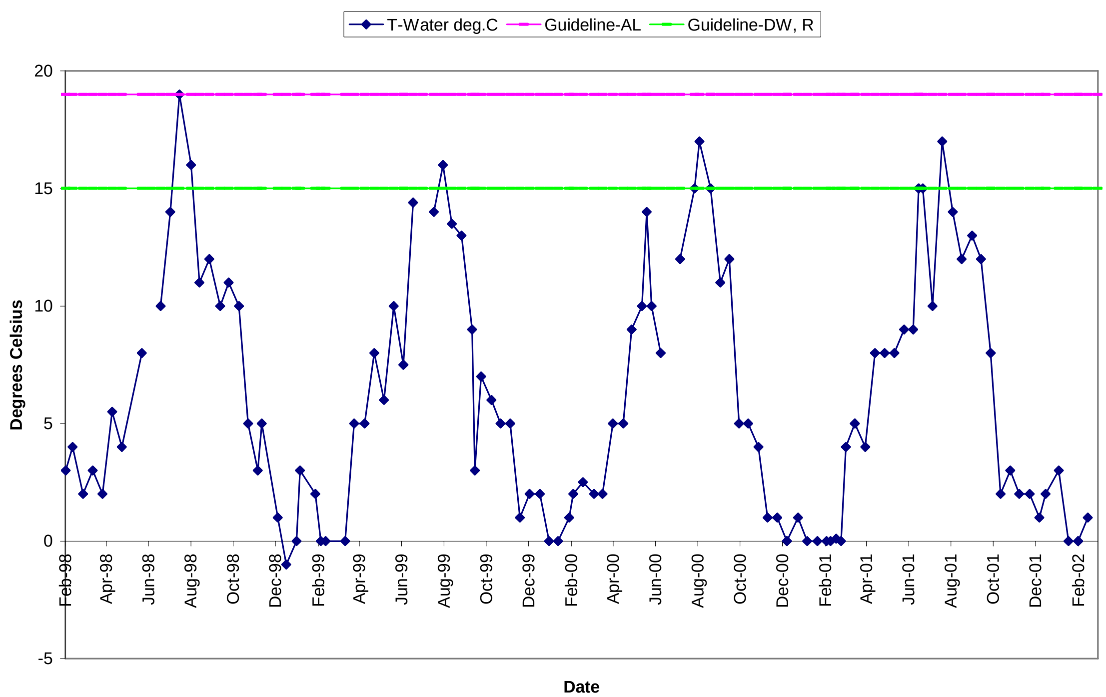


Figure 60 Thallium, Extractable

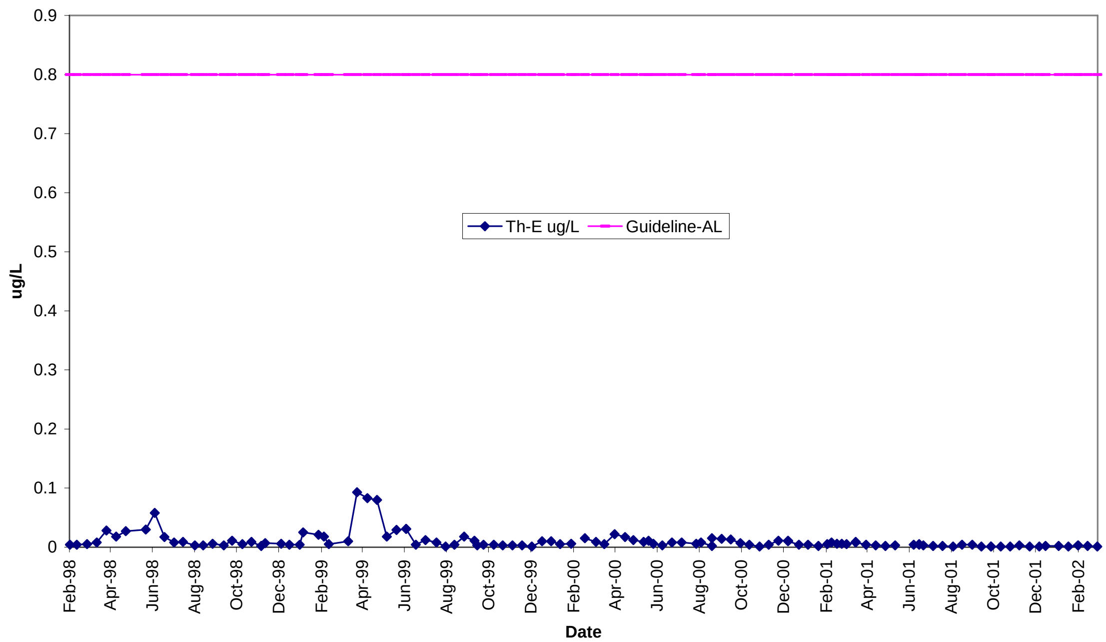


Figure 61 Turbidity

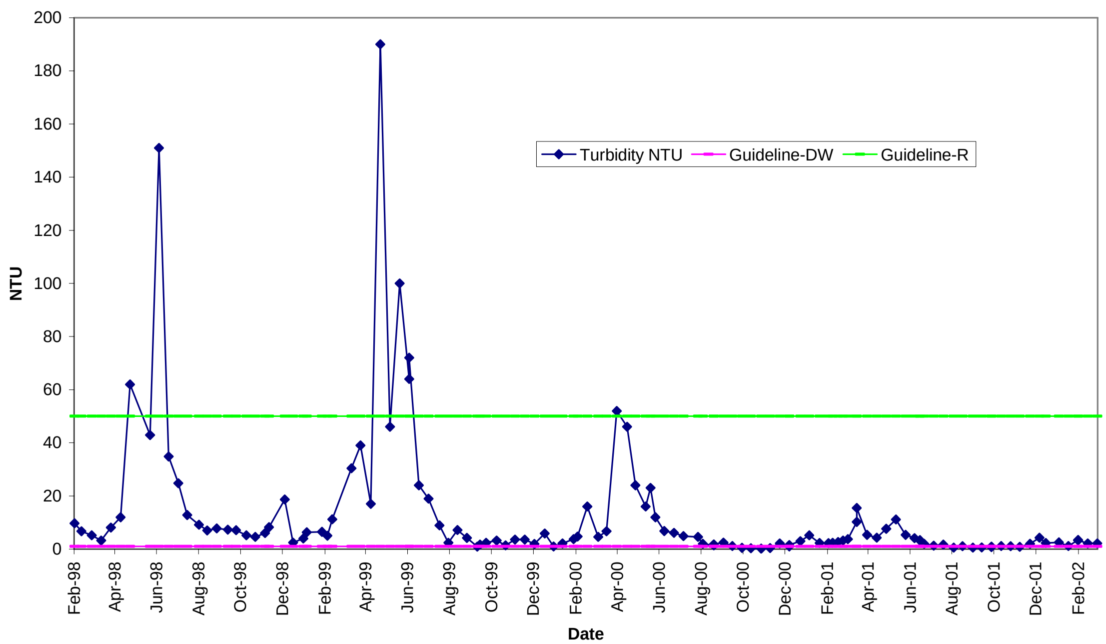


Figure 62 Uranium, Extractable

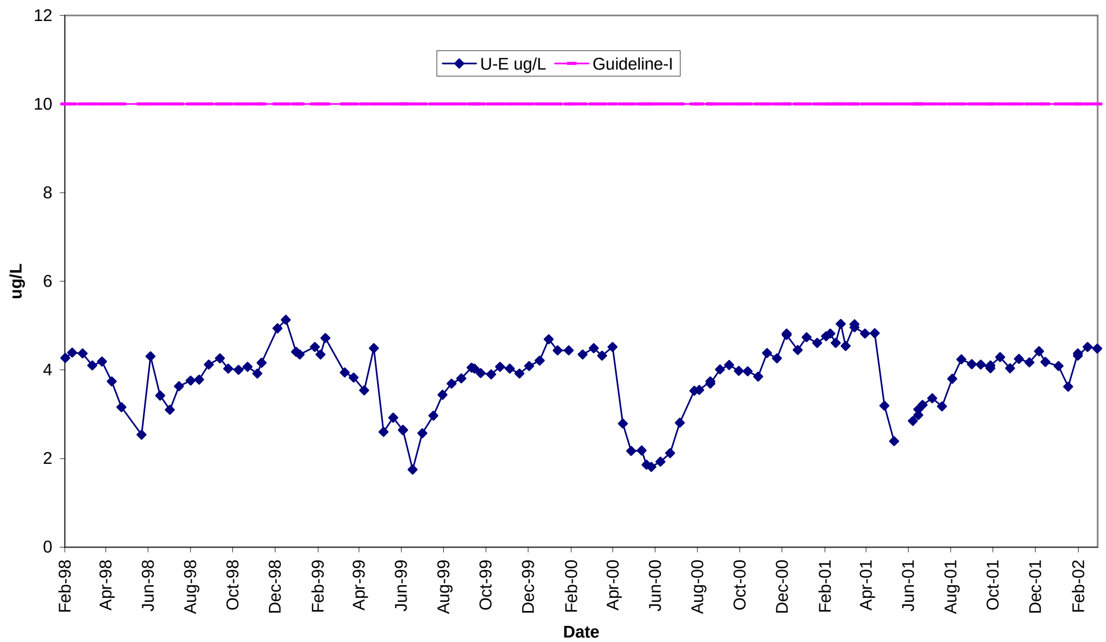


Figure 63 Vanadium, Extractable

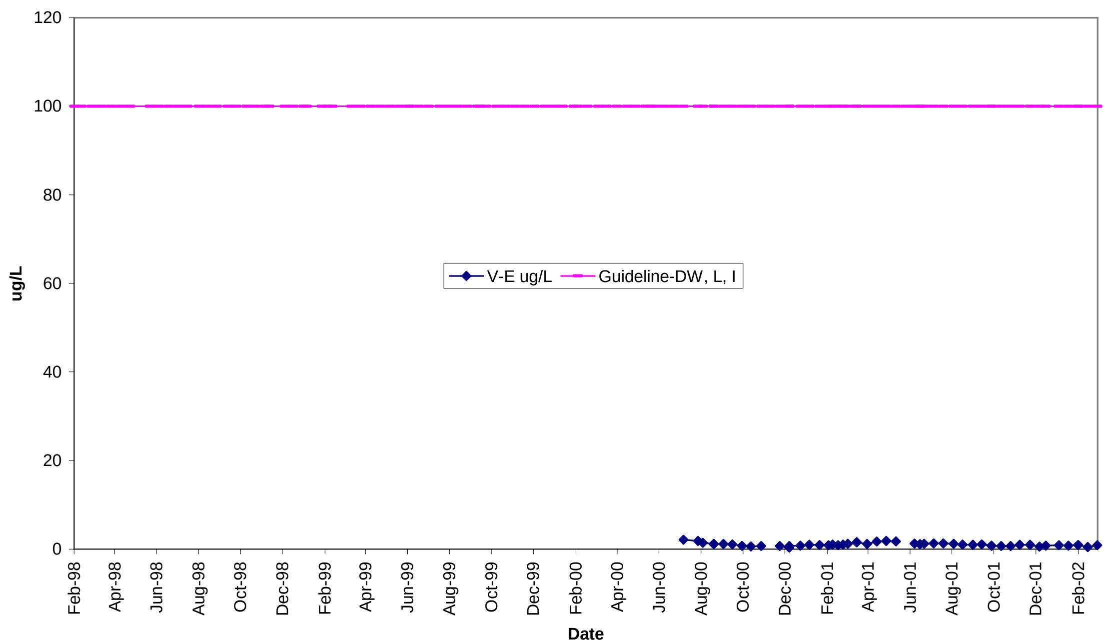


Figure 64 Vanadium, Total

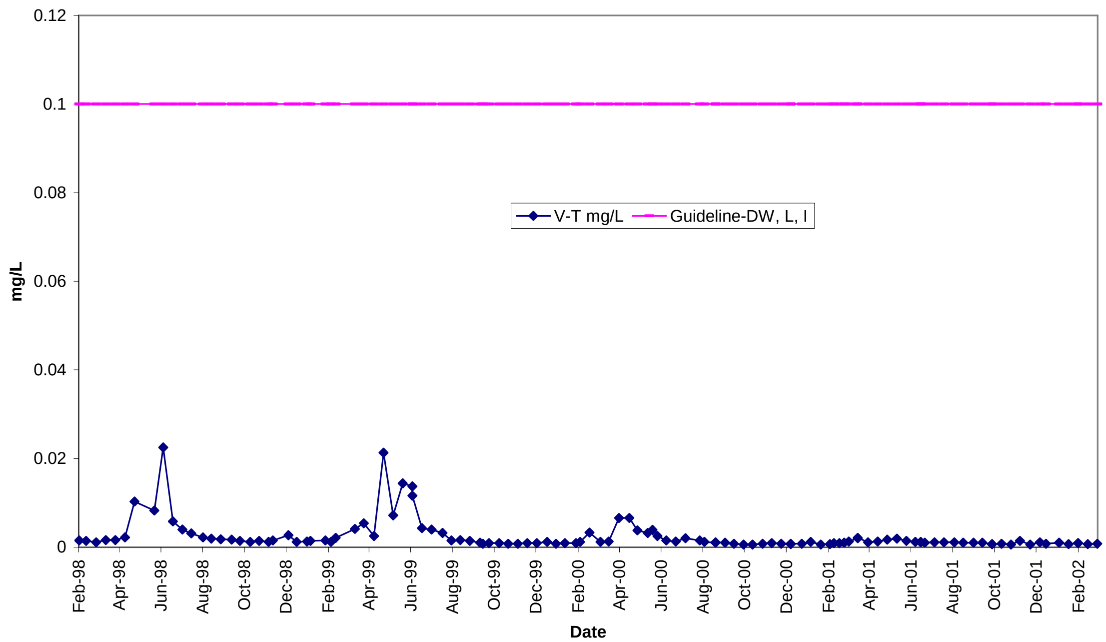


Figure 65 Zinc, Extractable

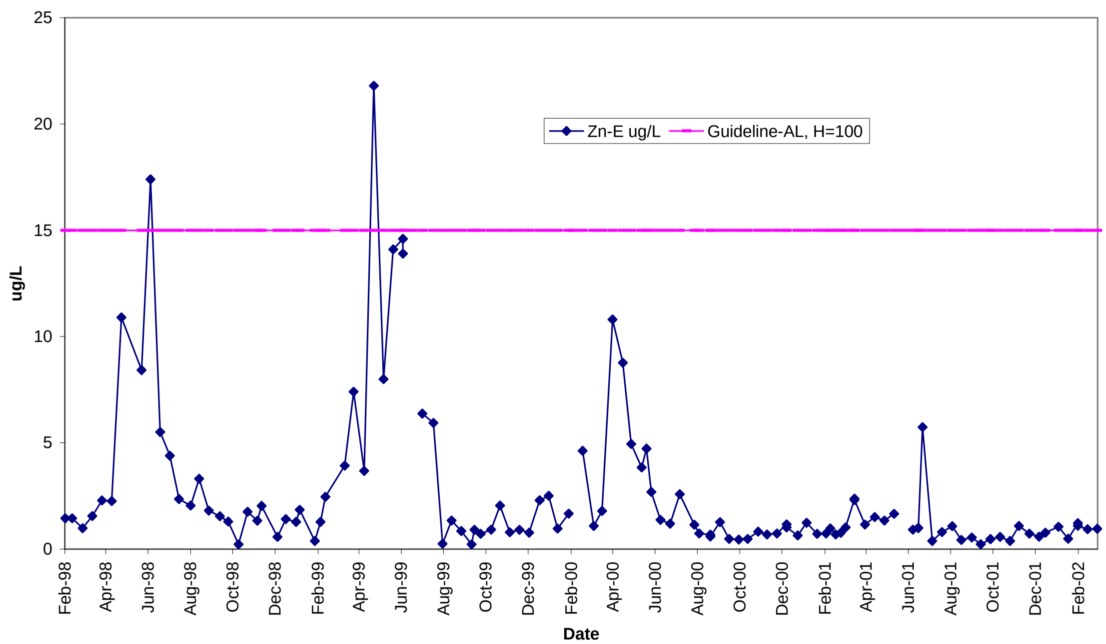


Figure 66 Zinc, Total