CANADA – BRITISH COLUMBIA
WATER QUALITY MONITORING AGREEMENT

WATER QUALITY ASSESSMENT OF FLATHEAD RIVER AT INTERNATIONAL BORDER (1980 – 2004)

Prepared by:
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Prepared for:
B.C. Ministry of Environment
and
Environment Canada

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Environment Canada Environnement Canada

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Executive Summary

The Flathead River watershed is located in the extreme southeast corner of British Columbia. Its headwaters are in the Rocky Mountains southeast from Fernie, and the river flows south into Montana, where it forms the western boundary of Glacier National Park. The water quality sampling station is located at the Canada-US border. This assessment is based on up to 18 years of water quality data collected during 1980-2004. The main human influences on water quality in the Flathead River watershed were timber harvesting, coal mine exploration, and road building. The water quality trends identified below have not yet been confirmed by statistical analysis.

Conclusions

- The water was moderately hard and had a low sensitivity to acids.

- Numerous water quality indicators had apparent declining trends from 1980-95 to 2002-04, but they were not real, being attributable to declining minimum detection limits, artificial contamination in 1986-90, or the low turbidity measured in 2002-04.

- Water temperature met the aquatic life guideline, although summer temperatures occasionally exceeded the aesthetic drinking water guideline, when the water was warm enough for swimming.

- Turbidity and non-filterable residue (suspended solids) were elevated during the high flows of spring freshet, when the recreation guideline was often exceeded and drinking water would need partial treatment, such as filtration, plus disinfection before consumption.

- Metals such as chromium, copper, iron, manganese, and zinc occasionally exceeded water quality guidelines due to high turbidity during spring freshet. The

metals were associated with the suspended sediment, were probably not bio-available, and would be removed by treatment needed to remove turbidity before drinking water consumption.

Recommendations

- The water quality of the Flathead River at the International Border was excellent, there were no apparent deteriorating trends during 1980-2004, and water quality has remained relatively stable over this time period. The data collected to date is sufficient to characterize baseline water quality, and it is recommended that routine monitoring be suspended for another 5-10 years, or until reactivation is warranted by proposed developments.

- Use the same monitoring frequency when reactivating an old monitoring station.

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1. Introduction

The Flathead River watershed is located in the extreme southeast corner of British Columbia. Its headwaters are in the Rocky Mountains southeast from Fernie, and the river flows south into Montana, where it forms the western boundary of Glacier National Park.

The Flathead River at the International Border water quality monitoring station is located 0.3 km upstream from the Canada-US border (Figure 1). The drainage area of the river at the water quality station is 1110 km^2. The river supports a diversity of fish species, including westslope cutthroat trout, mountain whitefish, bull trout, and kokanee. The main human influences on water quality in the Flathead River watershed were timber harvesting, coal mine exploration, and road building [1].

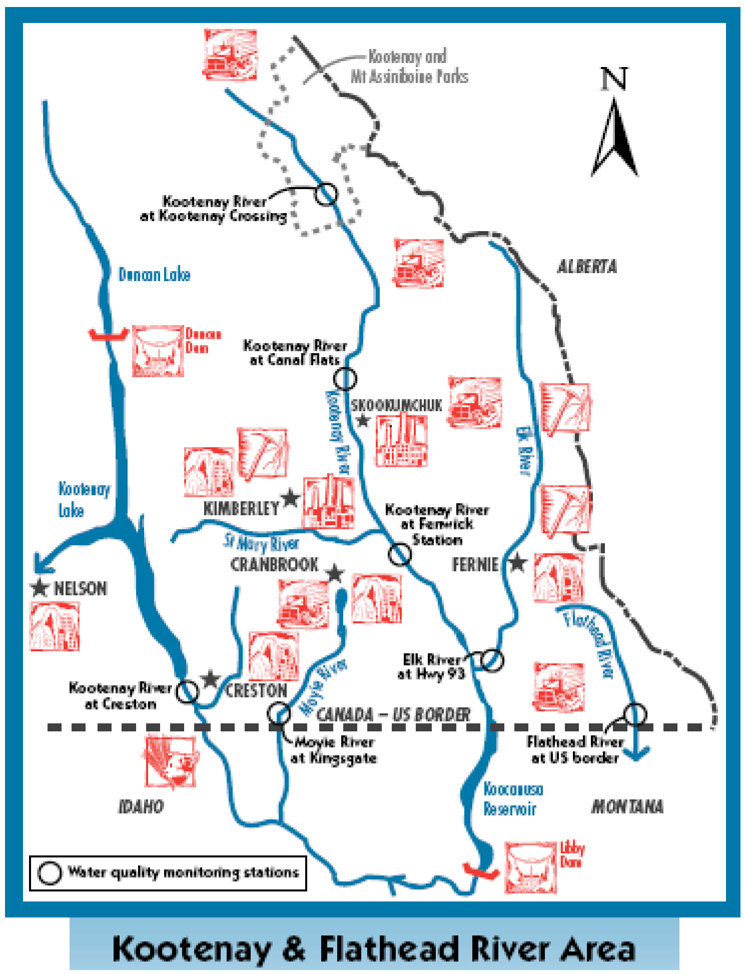


Figure 1 Map of the Flathead River Basin

Flow was monitored on the Flathead River at Flathead on the Canada-US border (Water Survey of Canada station BC08NP001) during 1980-95 and by the US Geological Survey (station 12355000) during 1999-2004, and these data are plotted in Figures 2a and 2b. Figure 2b shows the 2002-04 water quality sampling dates in relation to flow.

Environment Canada collected water quality data at the Flathead weekly or biweekly during mid 1979-95 and the data are stored on ENVIRODAT (BC08NP0003), and were copied to the B.C. Environmental Monitoring System (EMS, site number 0200047) for 1980-95. Water quality monitoring at the station was suspended in 1995, and then reactivated in 2002-04 as a federal-provincial water quality monitoring station with joint operation by Canada and B.C. Water quality data were collected monthly during November 2002 - October 2004. Up to 18 years of water quality data during 1980-2004 were used in this report.

2. Water Quality Assessment

The status and trends of water quality were assessed by plotting water quality measurements for the Flathead River at the International Boundary on a graph over time, along with the relevant approved [2] and working [3] water quality guidelines or the Canadian water quality guidelines [4]. (There are no site-specific water quality objectives for the Flathead River.) The data are plotted in Figures 3 to 31. (Note: For this assessment, 1980-95 data came from EMS 0200047 and 2002-04 data came from ENVIRODAT BC08NP0003). The graphs were inspected for "environmentally significant" trends - where the measurements are increasing or decreasing over time and the levels are close to the objectives or guidelines, or are otherwise judged to represent an important change in water quality. These trends are further evaluated to ensure that they were not caused by measurement errors, to identify their causes, and to determine whether they are statistically significant. A confidence level of 95% or better is used to define statistical significance, unless noted otherwise.

When concentrations of a substance cannot be detected, we have plotted the concentration at the level of detection. We believe this to be a conservative approach to assessing possible trends. As well, there are times when measurements were not taken for some reason. In these cases, straight lines will join the two consecutive points and may give the illusion on the graph of a trend that does not exist.

In some cases, testing for the presence of a variable has been terminated after a certain period. In general, this has been because a previous data assessment and review has indicated that collections of these data are not warranted for this station. For other variables, concerns about concentrations may have only arisen in recent years.

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 reviewed but not discussed because they easily met all water quality guidelines and showed no harmful trends were: antimony, barium, bismuth, boron, bromide, dissolved organic carbon, chloride, fecal coliforms, true colour, specific conductivity, gallium, lanthanum, lithium, molybdenum, potassium, rubidium, selenium, silver, sodium, strontium, sulphate, air temperature, thallium, uranium, and vanadium.

The data for 1980-95 were reviewed previously, and no environmentally significant changes over time were found [1]. During 1986-1990, contamination from the preservative vial cap liners impacted a number of metals (primarily chromium, copper, lead and zinc). This contaminated data has been copied to EMS from ENVIRODAT, and should be removed by deleting these metals records from EMS and replacing them with a copy from ENVIRODAT that excludes contaminated data.

Before the data were assessed, the data were reviewed and the errors found on EMS were complied for later correction, and outliers were removed.

Aluminum (Al) (Figure 3) had values that were below all water quality guidelines for total aluminum (dissolved aluminum was measured three times in 2003-04 and was well below all guidelines) with the peak levels occurring during freshet due to elevated turbidity. The apparent decline over time was due to the low turbidity in 2002-04.

Arsenic (As) (Figure 4) had levels below all water quality guidelines, with the peak levels occurring during freshet when turbidity was elevated. The apparent decline over time was due to the low turbidity in 2002-04.

Beryllium (Be) (Figure 6) had levels well below all water quality guidelines, with the peak levels occurring during freshet when turbidity was elevated. The apparent decline over time was due to declining minimum detection limits (MDL).

Cadmium (Cd) (Figures 7a and 7b) had MDL that were above the aquatic life guidelines during 1981-95, and these data are unreliable for comparison to the guidelines. The apparent decline over time in Figure 7a is due to declining MDL. **Figure 7b** shows that low-level cadmium met the aquatic life guidelines in 2002-04.

Calcium (Ca), Hardness, and Magnesium (Mg) (Figure 8) showed that the water had a low sensitivity to acids (calcium > 8 mg/L), and was moderately hard with respect to hardness. There were no significant changes over time.

Chromium (Cr) (Figure 9) often had values above the aquatic life and irrigation guidelines during 1987-94 because of MDL's that were too high, artificial contamination during 1987-90, and turbidity peaks. High chromium concentrations during turbidity peaks are not likely biologically available and thus are not of concern. The 2002-04 low-level chromium results met the guidelines. There was a declining trend over time due to declining MDL and the artificial contamination during 1987-90. Values flagged as contaminated in ENVIRODAT should be removed from EMS.

Cobalt (Co) (Figure 10) had levels that were well below all water quality guidelines. There was a declining trend over time due to declining MDL.

Copper (Cu) (Figure 12a) often exceeded the aquatic life guideline during 1986-90, but the data are suspect due to artificial contamination. **Figure 12b** has the 1986-90 values removed, and shows a few exceedances of the guidelines, mainly due to high MDL and high turbidity during freshet. High copper concentrations during turbidity peaks are not likely biologically available and thus are not of concern. The 2002-04 results obtained with low-level methods were well below the guidelines. The apparent declining trend over time is due to declining MDL and the low turbidity in 2002-04. Values flagged as contaminated in ENVIRODAT should be removed from EMS.

Fluoride (F) (Figure 13) had three values above the aquatic life guideline during 1980-95, which may be errors, but all 2002-04 values were below the guideline. There was no apparent change over time.

Iron (Fe) (Figure 14) shows that the aquatic life and aesthetic drinking water guideline (0.3 mg/L) was often exceeded and that the irrigation guideline (5 mg/L) was rarely exceeded during spring freshet, when turbidity was elevated. High iron concentrations during turbidity peaks are not likely biologically available and thus are not of concern. As well, irrigation is unlikely to take place during spring freshet. There was an apparent declining trend over time, but this was due to the low turbidity in 2002-04.

Lead (Pb) (Figure 15) shows that levels occasionally exceeded the drinking water and aquatic life guidelines during 1986-88, probably due to the artificial contamination during 1986-90. The 2002-04 results obtained with low-level methods were well below the guidelines. The apparent declining trend over time is due to declining MDL and the contaminated 1986-90 results. Values flagged as contaminated in ENVIRODAT should be removed from EMS.

Manganese (Mn) (Figure 17) shows that some values exceeded the aesthetic drinking water guideline (50 µg/L) during spring freshet, when turbidity was elevated. Water withdrawn for drinking should receive partial treatment such as filtration, which should remove the particulate manganese. The apparent declining trend was due declining MDL and the low turbidity during 2002-04.

Nickel (Ni) (Figure 19) had all values well below the aquatic life guideline (65 µg/L), with peak levels due to elevated turbidity during spring freshet. The apparent declining trend was due to declining MDL and the low turbidity in 2002-04.

Nitrogen (N) (Figure 20) exceeded the aquatic life guideline for nitrate once during freshet in 1991**,** and showed a declining (improving) trend in some nitrogen forms over time. This is probably due in part to the small 2002-04 dataset, which was too sparse to sample any extreme events that could cause higher nitrogen. There were no known nitrogen sources in the watershed. In any case, the levels are not environmentally significant with respect to water quality guidelines.

pH (Figure 21) shows that all but two values were within the aquatic life and drinking water guidelines. The lower values during 1986-89 were due to a loss of analytical control in the laboratory. There was no apparent change over time.

Phosphorus (P) (**Figure 22)** peaked during freshet when turbidity was elevated. There was an apparent declining (improving) trend over time due to the lower turbidity in 2002-04.

Silica and silicon (Si) (Figure 24) shows an apparent declining trend, but the chemical forms that were reported caused this anomaly with silica being expressed as SiO2 and silicon being expressed as Si, thus causing an apparent two-fold difference. There was no real change in silica/silicon over time, and there are no guidelines for them.

Temperature, water (T) (Figure 27) met the aquatic life guideline of 19 degrees C, and occasionally exceeded the aesthetic drinking water guideline in summer, when the water was just warm enough for water-contact recreation (e.g., swimming). There was no apparent change over time.

Turbidity and non-filterable residue (Figure 29) peaked during the high flows of spring freshet, when the recreation guideline for turbidity was often exceeded. The drinking water guideline of 1 NTU was often exceeded, indicating that partial treatment (e.g., filtration) plus disinfection was needed before consumption. There was an apparent decline over time, but this was probably due to lower flows during the 2003-04 freshets (Figure 2a) and the fact that the less frequent monitoring in 2002-04 (monthly) missed the peak flows in 2002-2004 that would have higher turbidity (Figure 2b). When reactivating an old monitoring station, it would be desirable to use the same sampling frequency as previously used to have a similar probability of sampling peak events.

Zinc (Zn) (Figure 31a) shows high levels during 1984 due to a non-freshet outlier and in 1986-90 due to artificial contamination. These values were removed in **Figure 31b**, which shows several values above the lowest aquatic life guideline at 90 mg/L hardness, mainly during spring freshet, when turbidity was elevated. However, when the actual hardness is considered, only three values exceeded the guideline, all during freshet, in 1983 and 1991. There was an apparent declining trend over time, but this was due to declining MDL and the low turbidity in 2002-04.

References

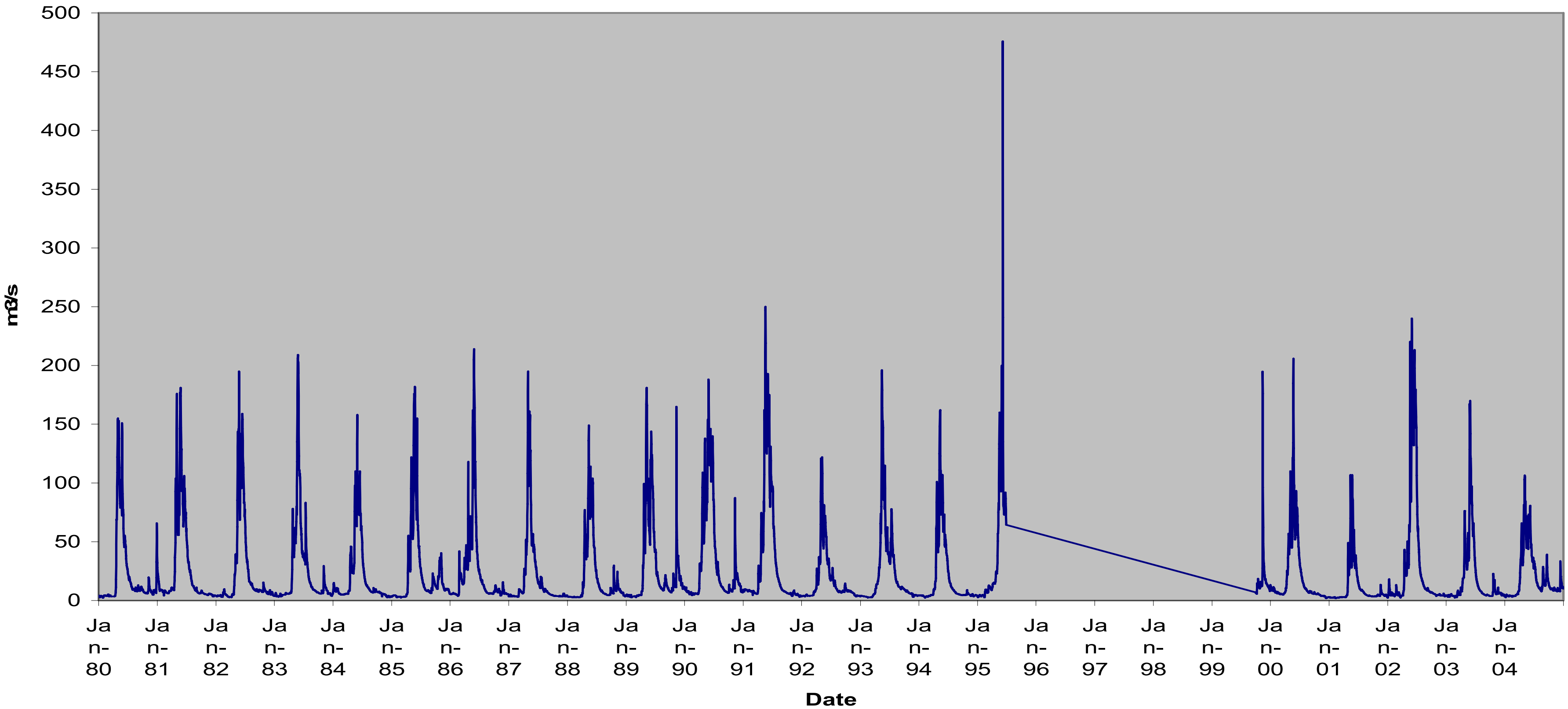
1. B.C. Ministry of Environment, Lands and Parks and Environment Canada. 2000. Water Quality Trends in Selected British Columbia Waterbodies.

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

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

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

Figure 2a Flow in Flathead River at Flathead 1980-2004



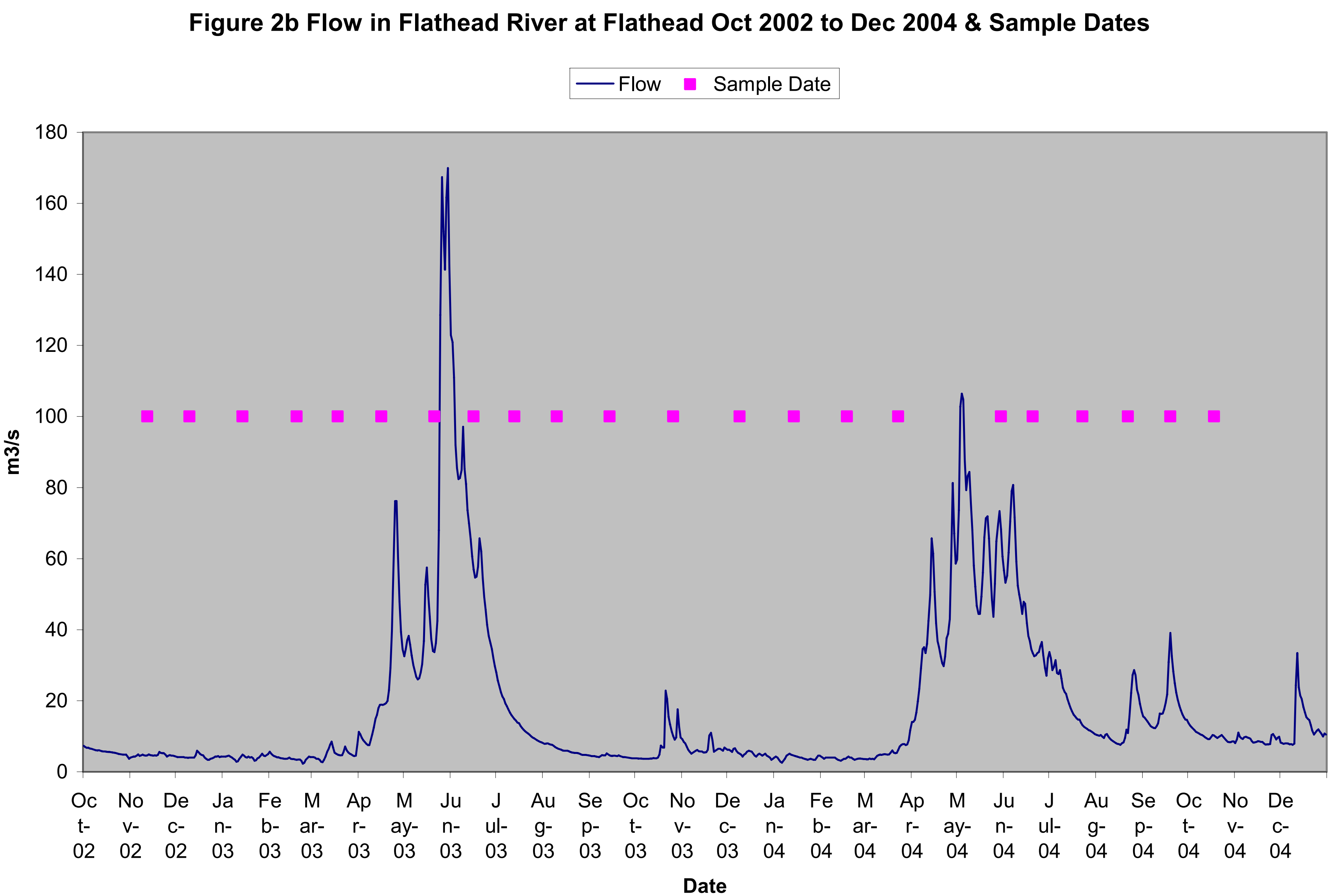


Figure 2b Flow in Flathead River at Flathead Oct 2002 to Dec 2004 & Sample Dates
Flow
Sample Date
180
160
140
120
100
80
60
40
20
0
m3/s
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04
Oct-04
Nov-04
Dec-04
Date

Figure 3 Aluminum

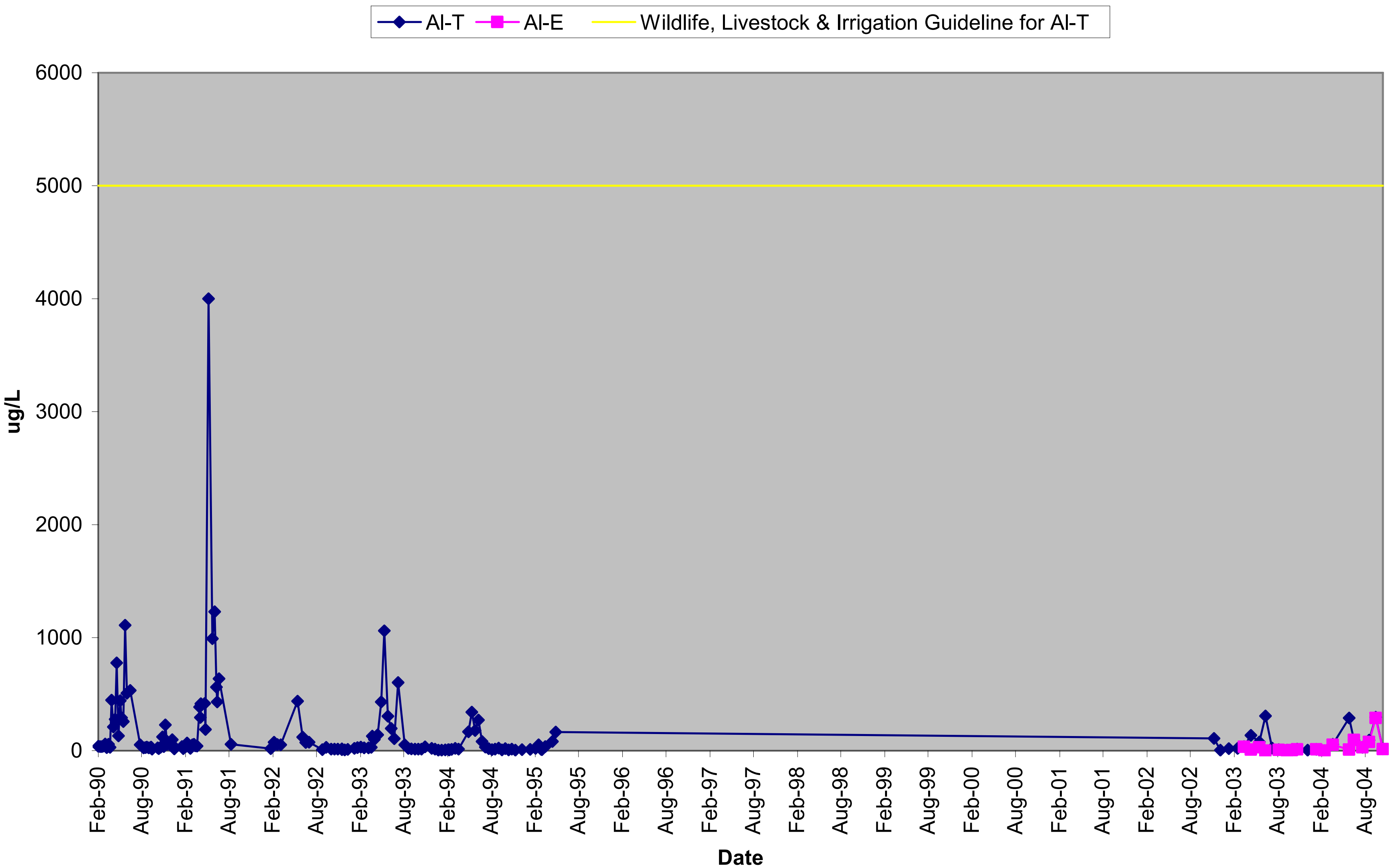


Figure 4 Arsenic

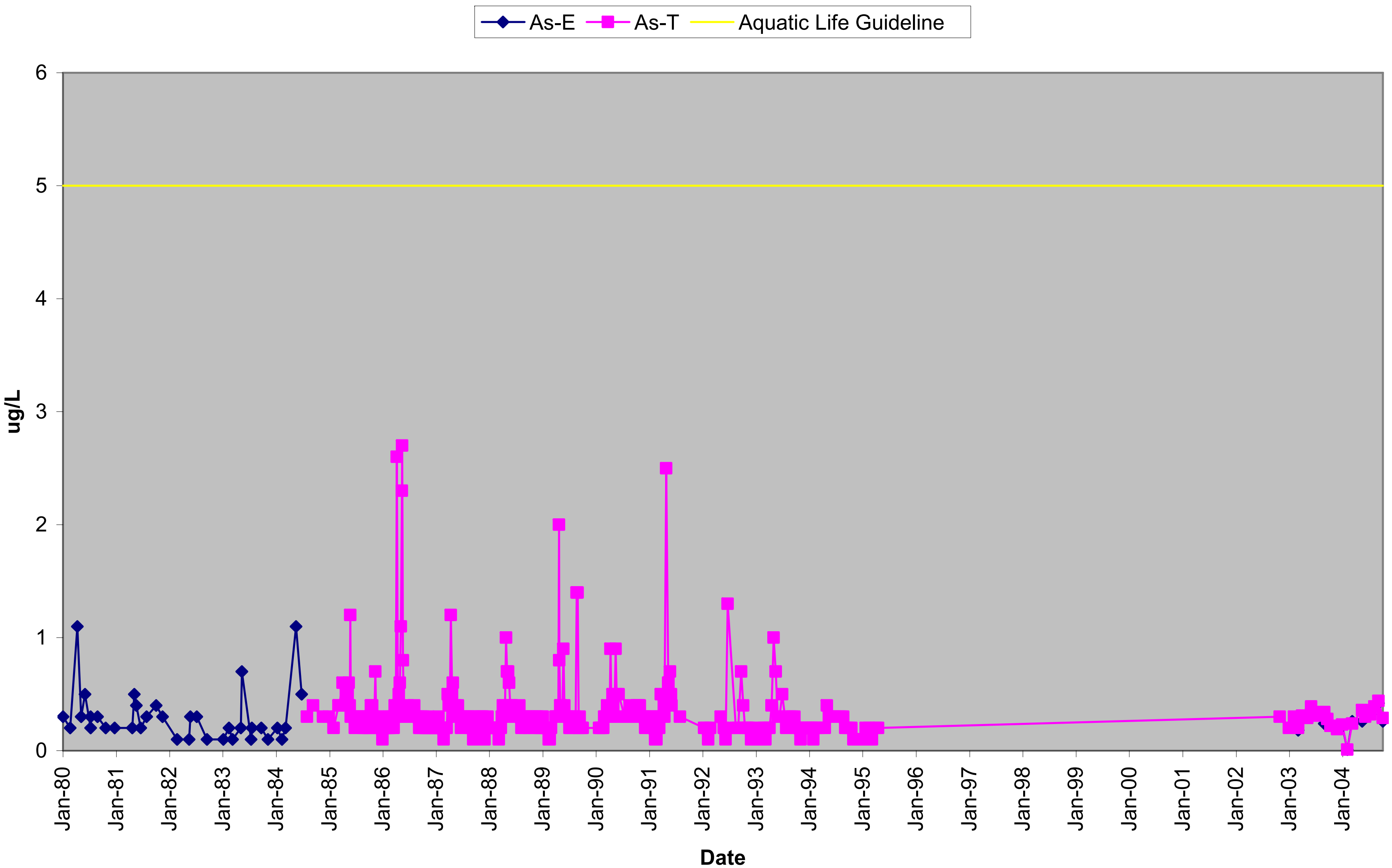


Figure 5 Barium

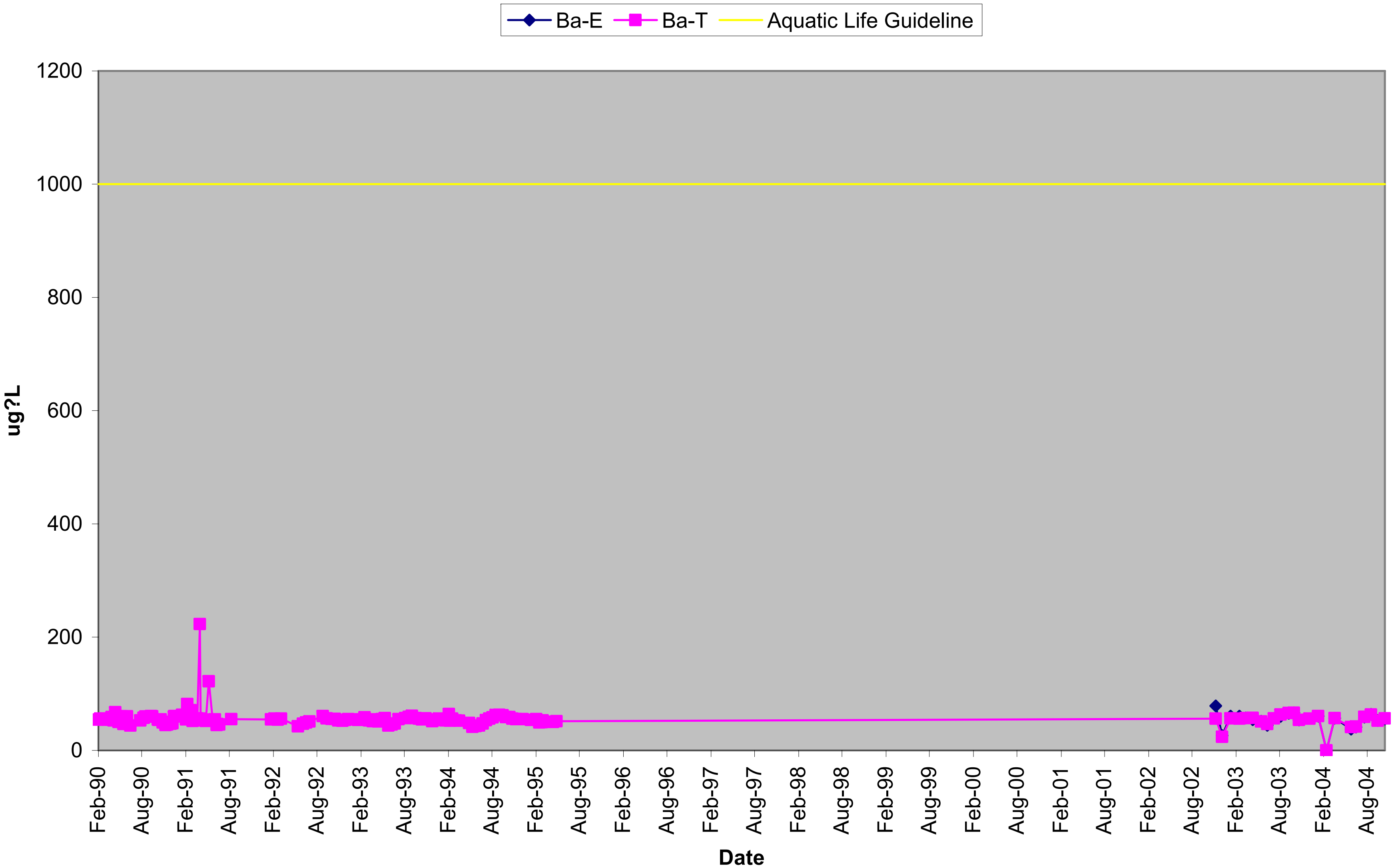


Figure 6 Beryllium (lowest guideline is 4 ug/L)

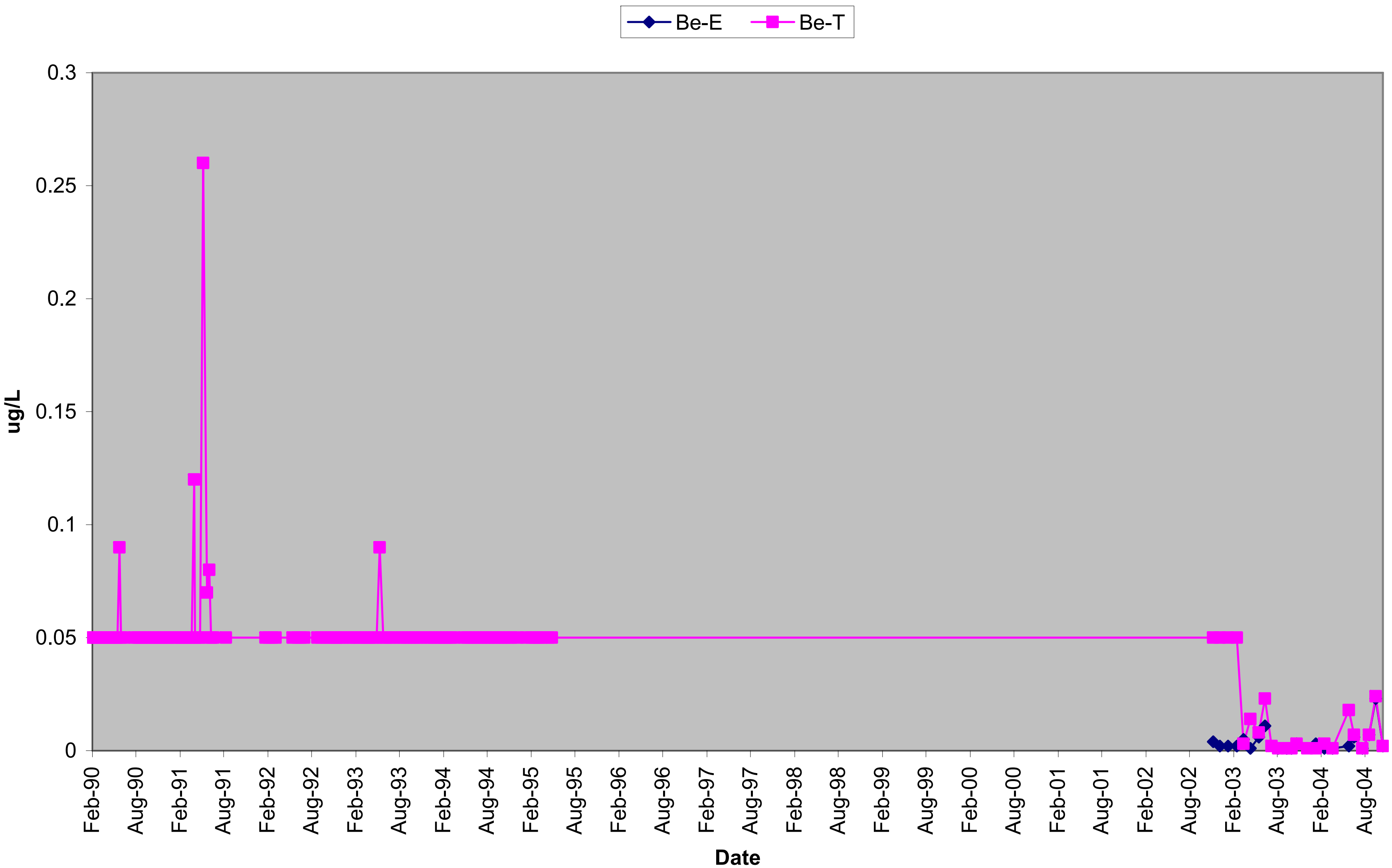


Figure 7a Cadmium

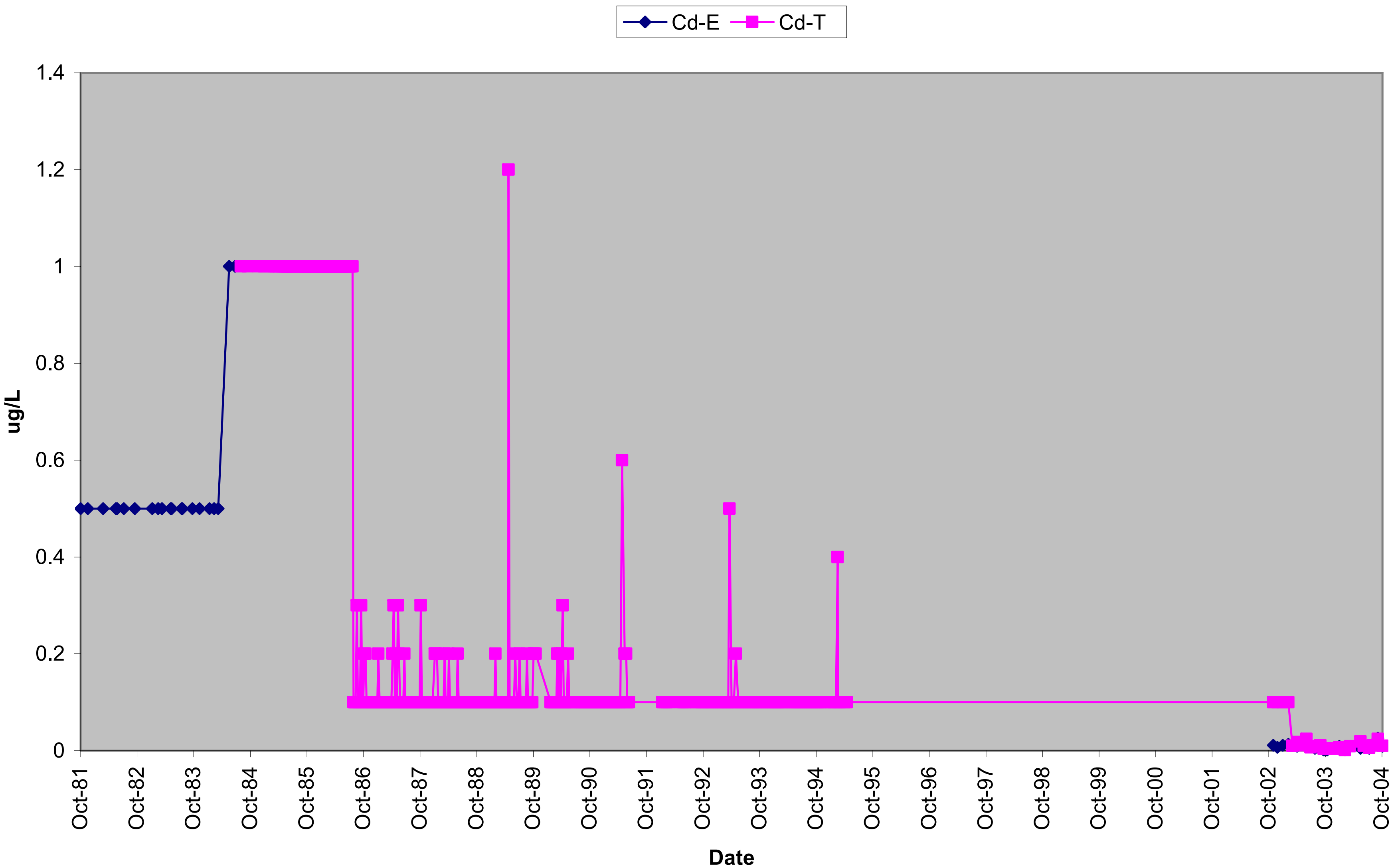


Figure 7b Cadmium 2002-04

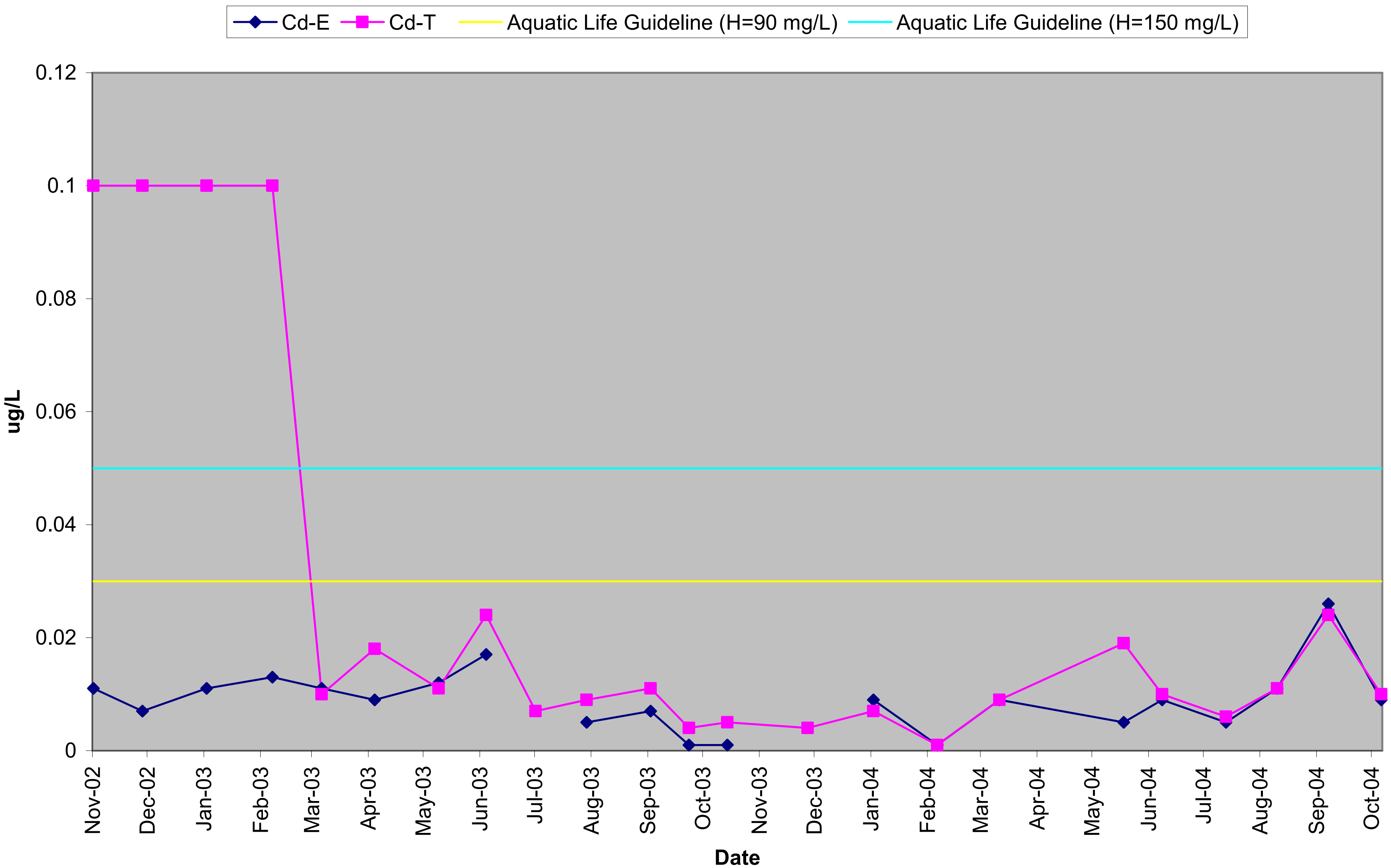


Figure 8 Calcium, Hardness & Magnesium

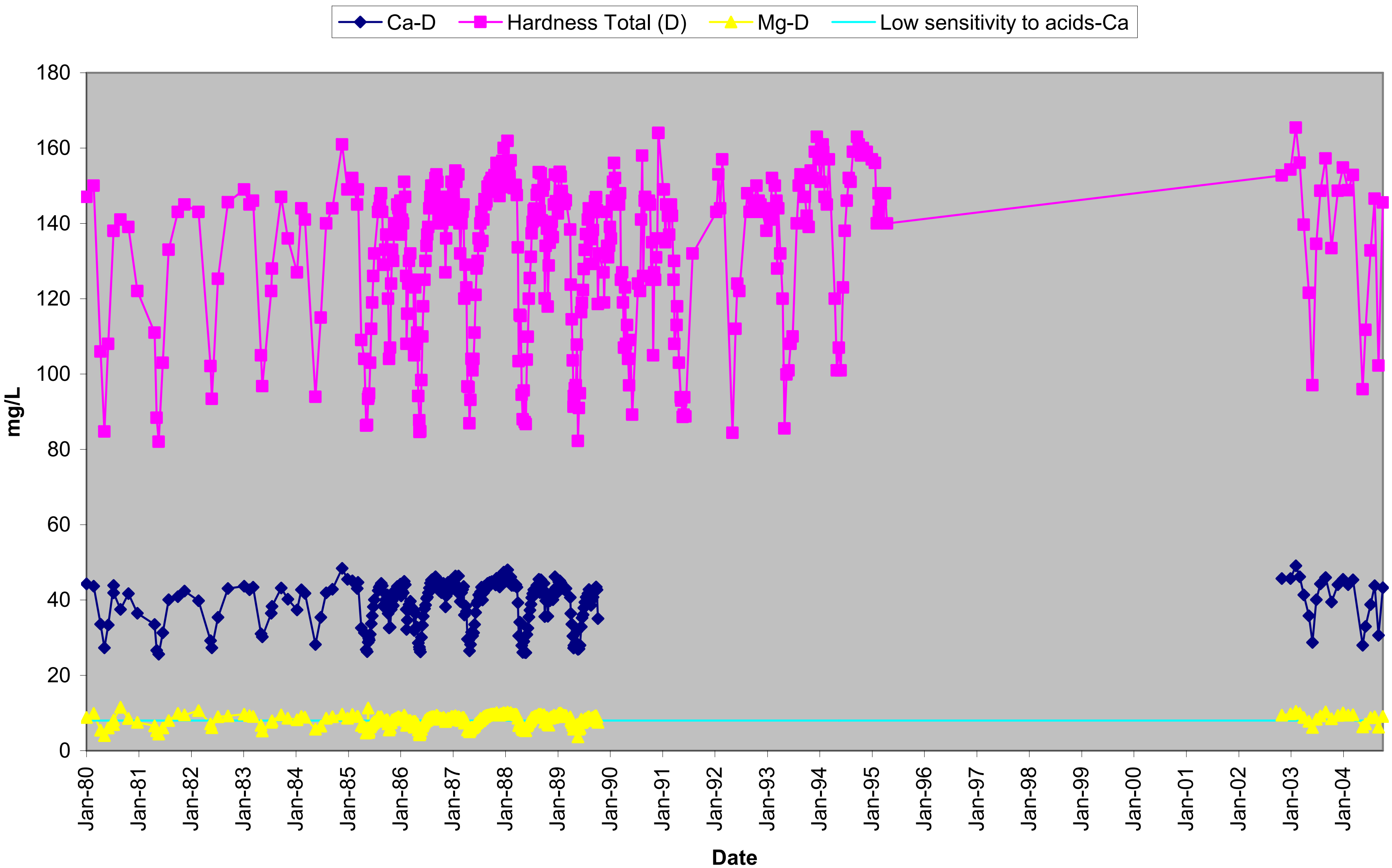
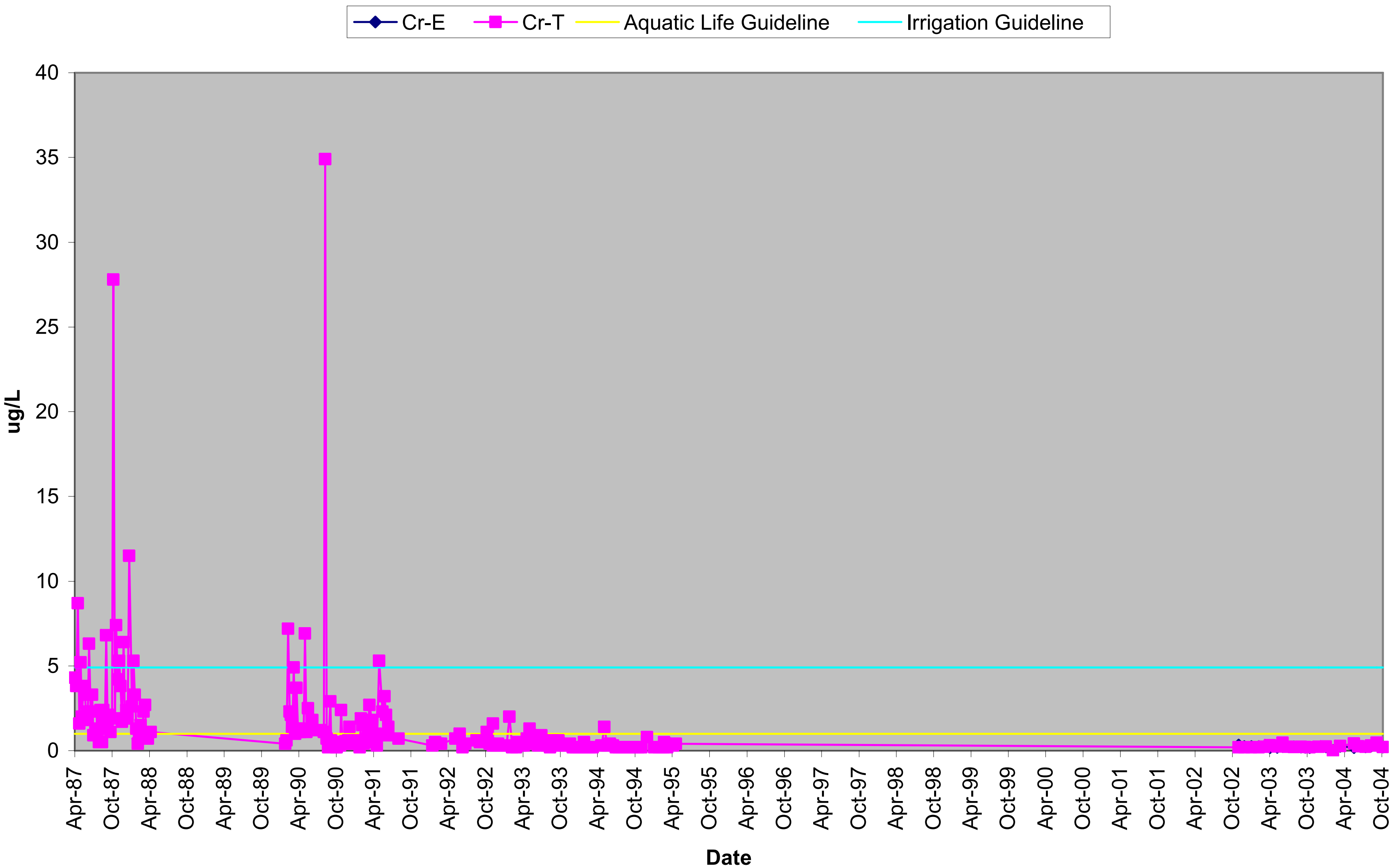


Figure 9 Chromium



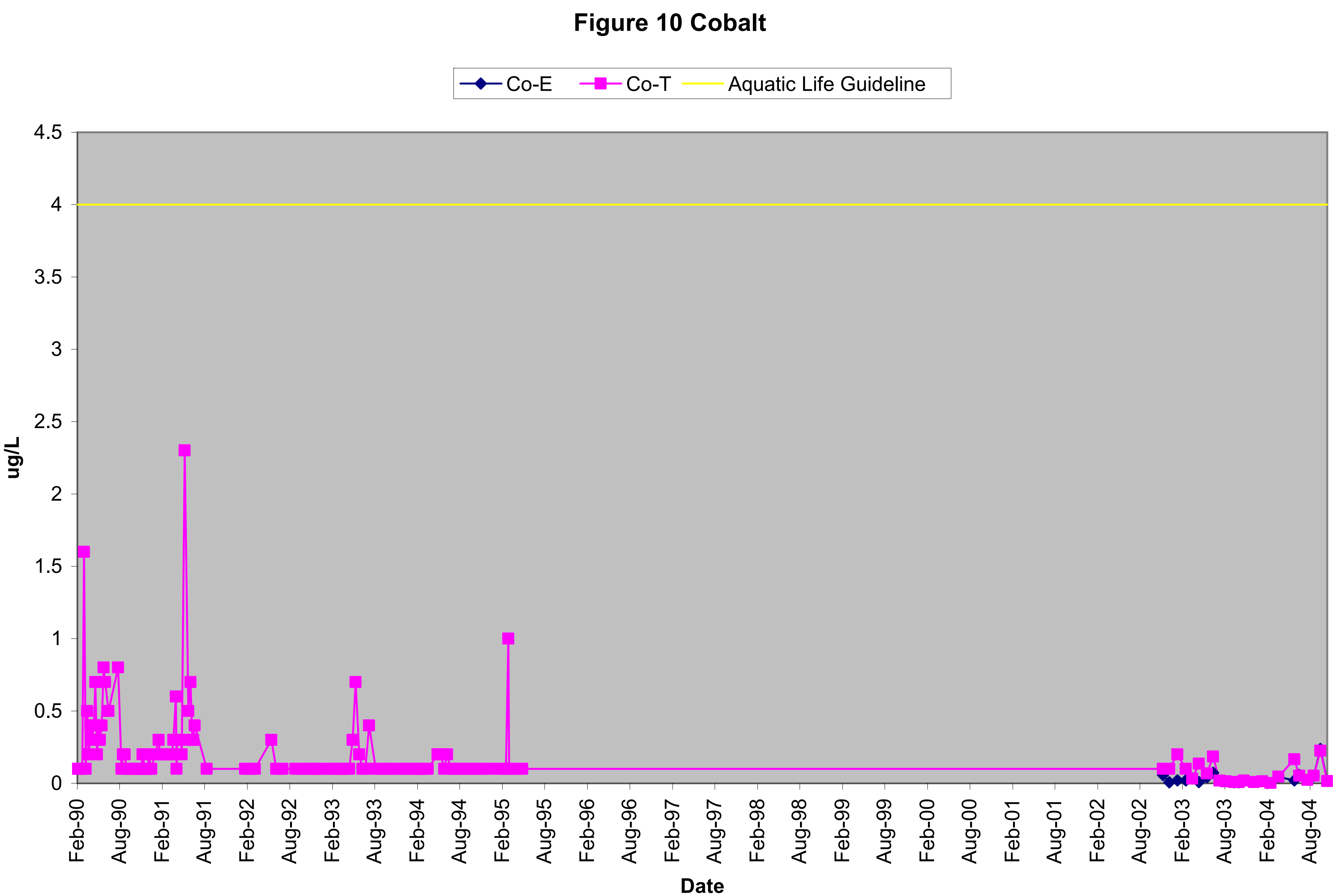
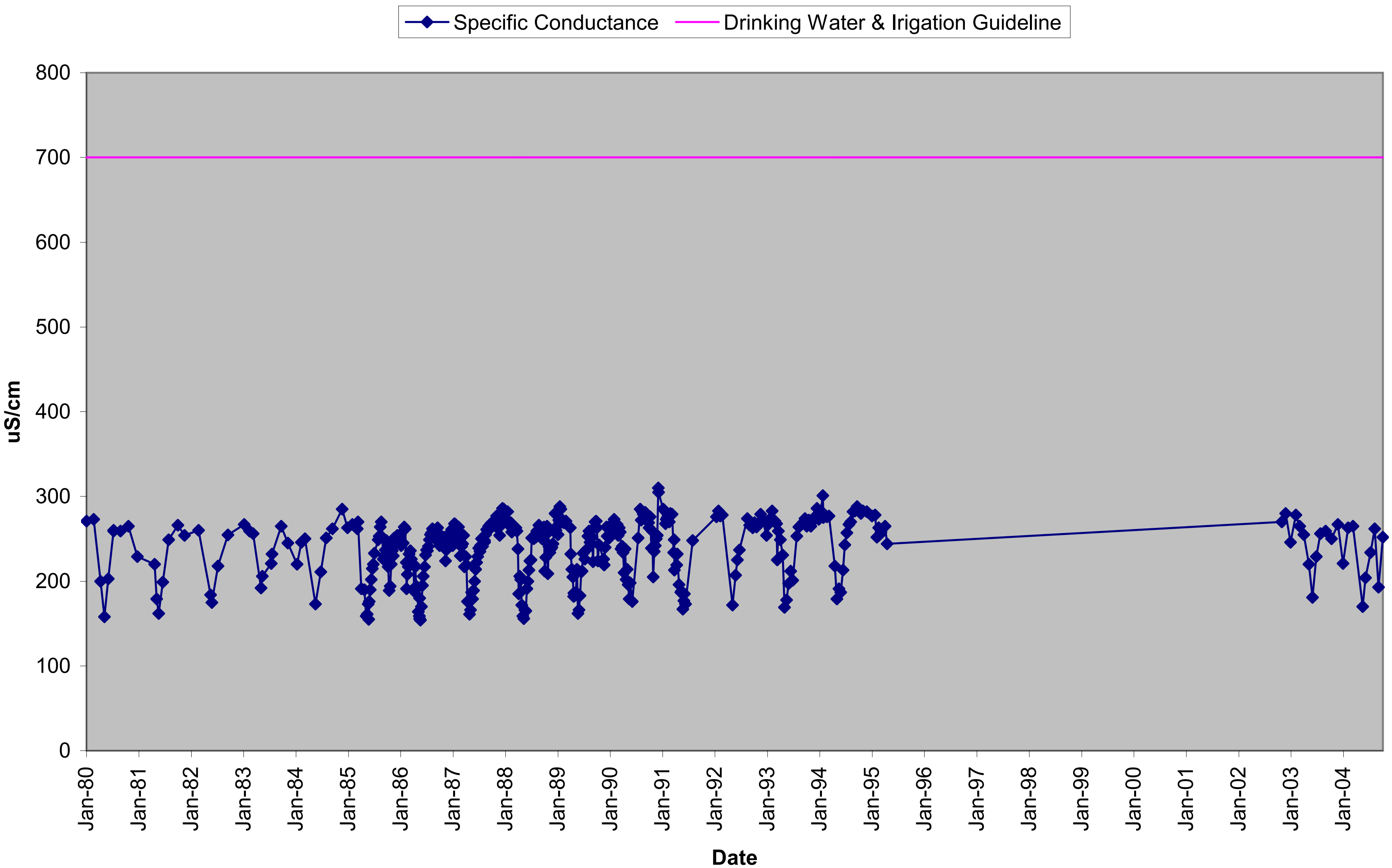


Figure 10 Cobalt
Co-E
Co-T
Aquatic Life Guideline
ug/L
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Feb-90
Aug-90
Feb-91
Aug-91
Feb-92
Aug-92
Feb-93
Aug-93
Feb-94
Aug-94
Feb-95
Aug-95
Feb-96
Aug-96
Feb-97
Aug-97
Feb-98
Aug-98
Feb-99
Aug-99
Feb-00
Aug-00
Feb-01
Aug-01
Feb-02
Aug-02
Feb-03
Aug-03
Feb-04
Aug-04
Date

Figure 11 Conductance, Specific



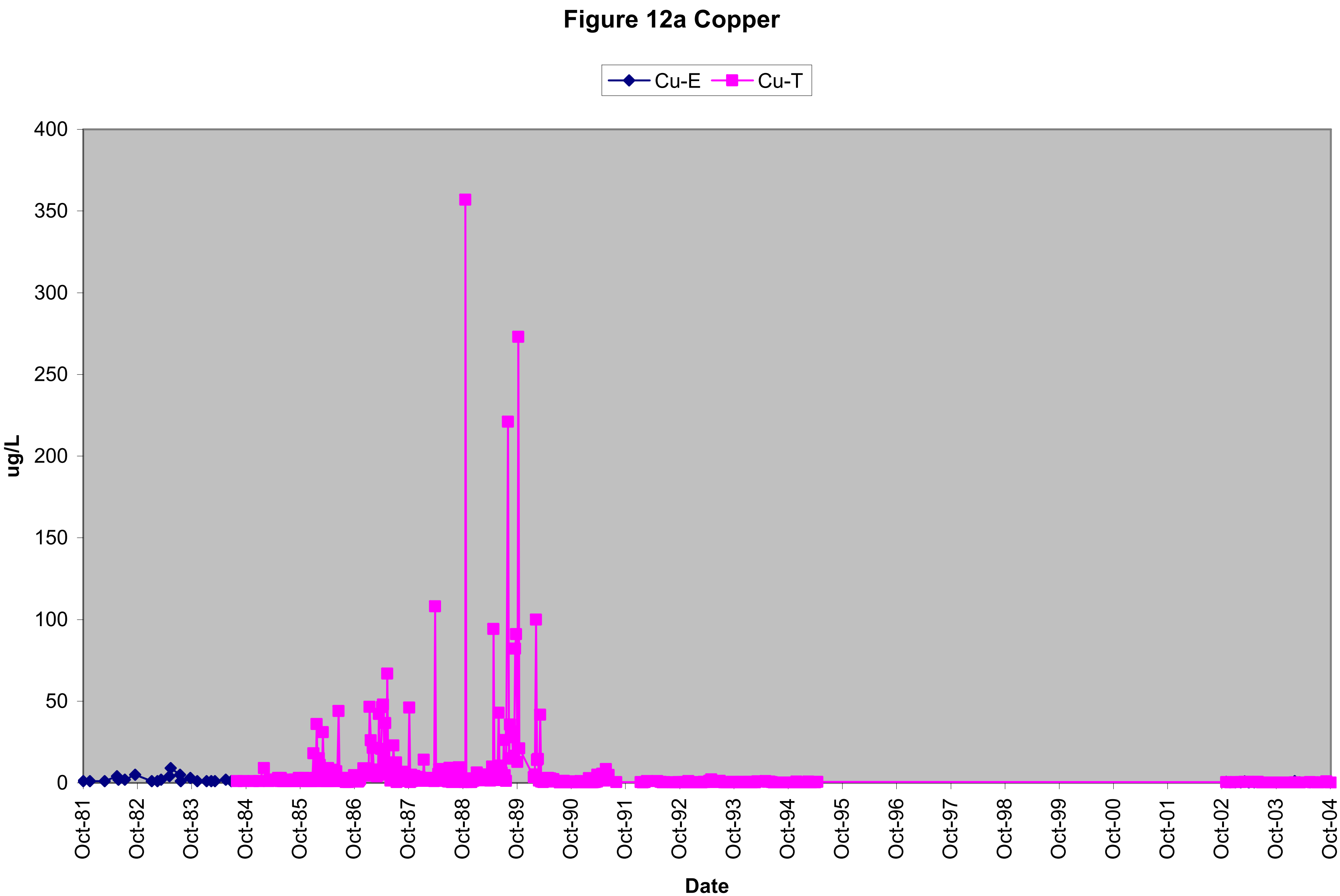


Figure 12a Copper
Cu-E
Cu-T
400
350
300
250
200
150
100
50
0
ug/L
Oct-81
Oct-82
Oct-83
Oct-84
Oct-85
Oct-86
Oct-87
Oct-88
Oct-89
Oct-90
Oct-91
Oct-92
Oct-93
Oct-94
Oct-95
Oct-96
Oct-97
Oct-98
Oct-99
Oct-00
Oct-01
Oct-02
Oct-03
Oct-04
Date

Figure 12b Copper with Errors Removed

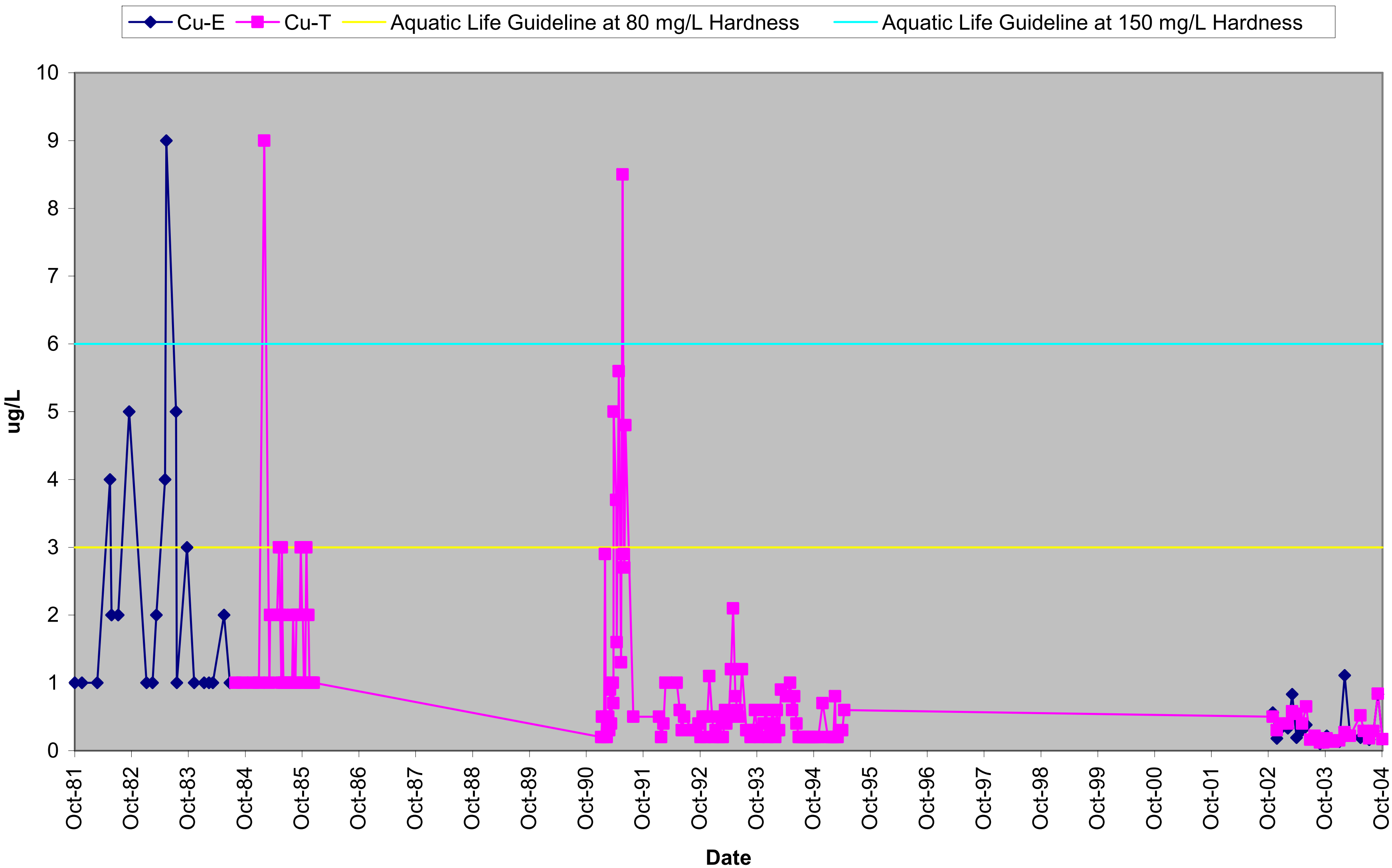


Figure 13 Fluoride

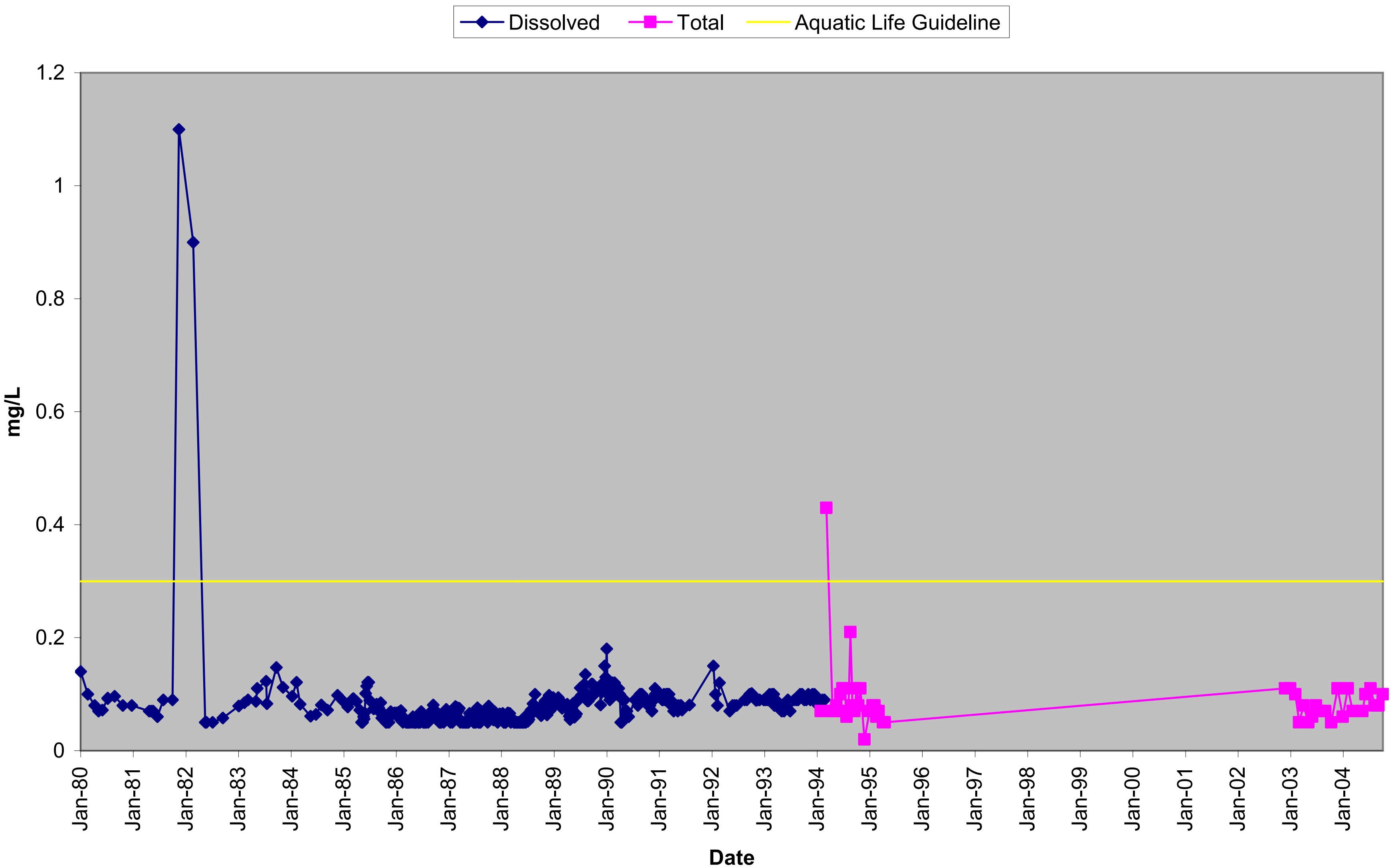


Figure 14 Iron (Fe)

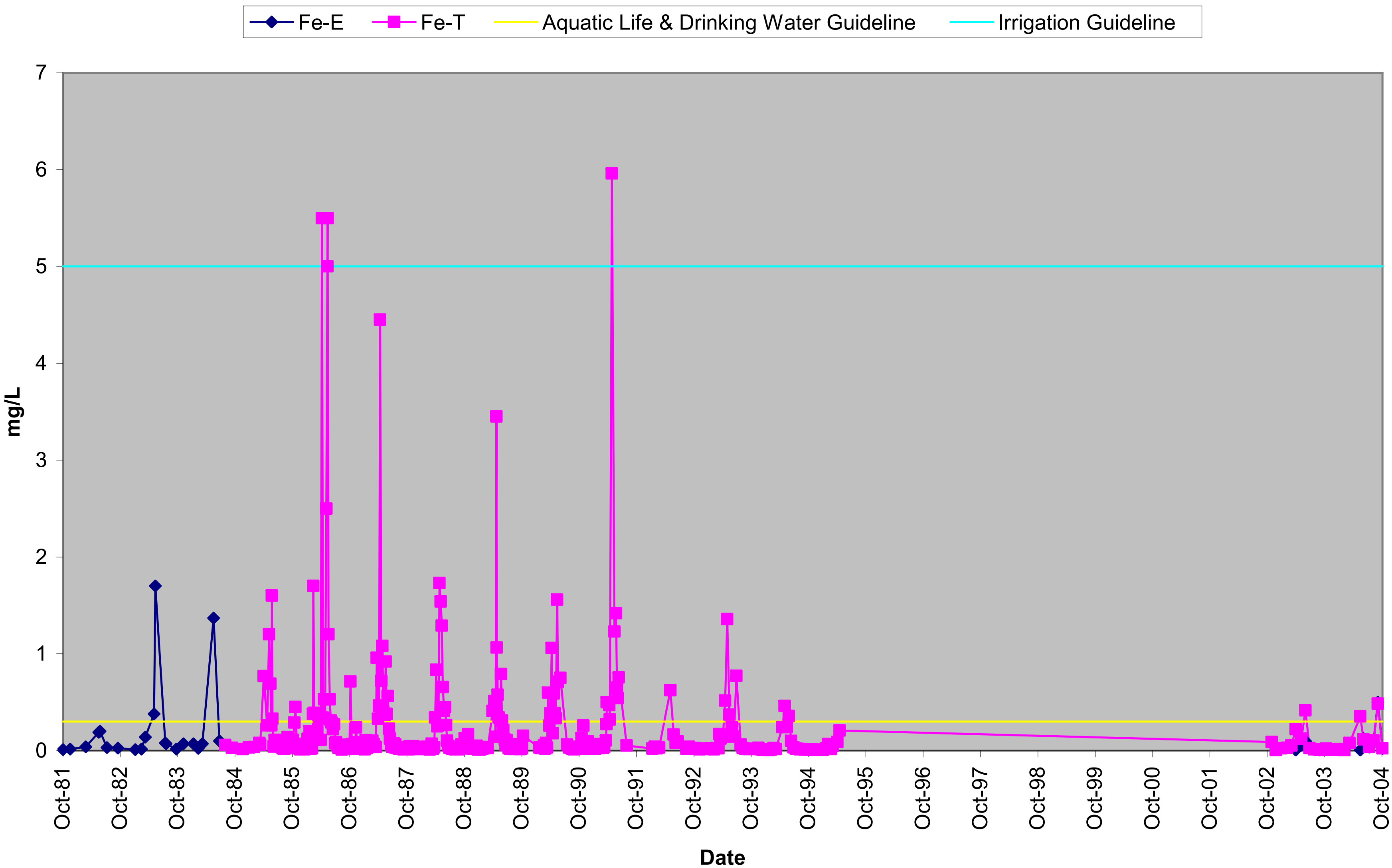


Figure 15 Lead (Pb)

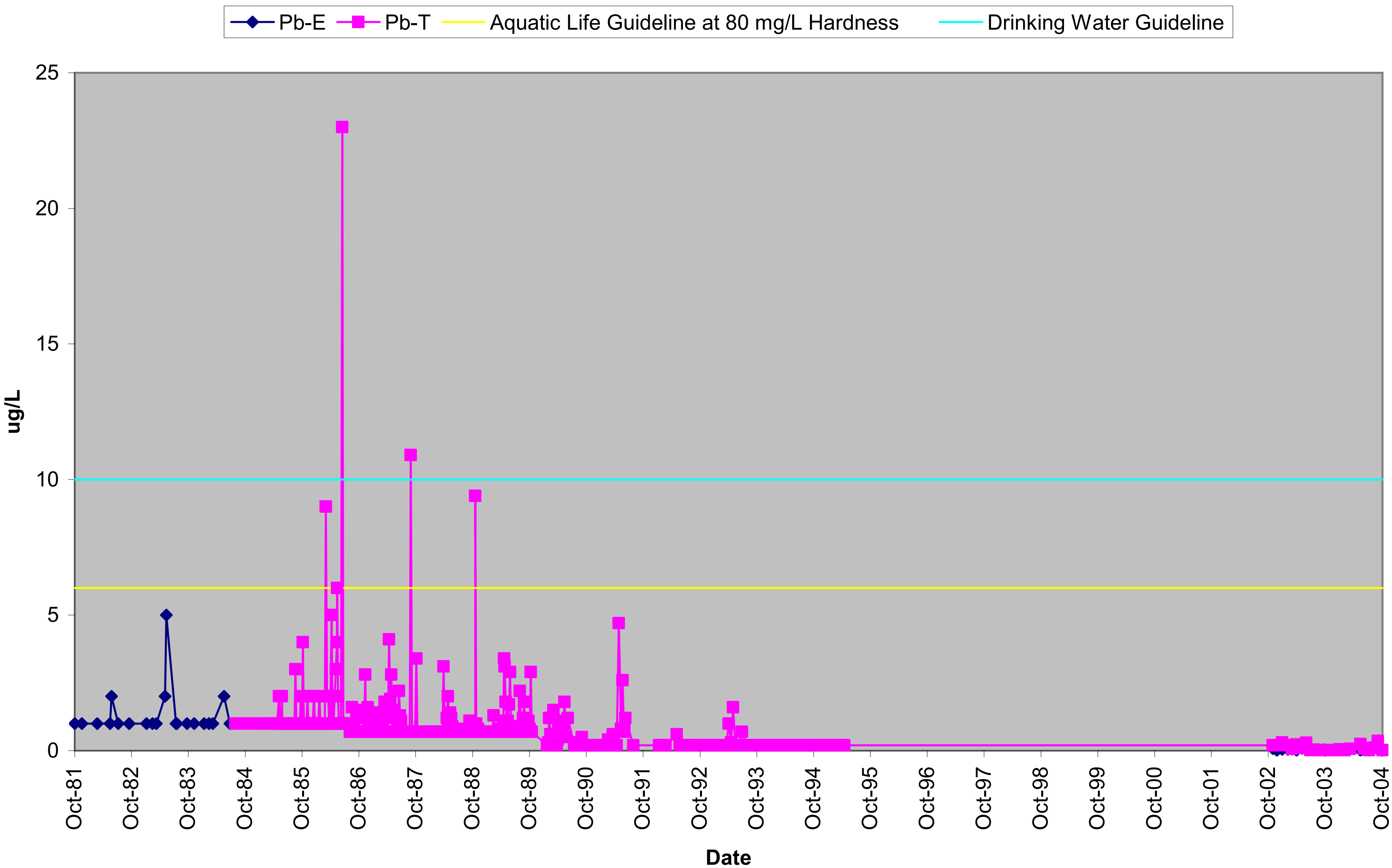
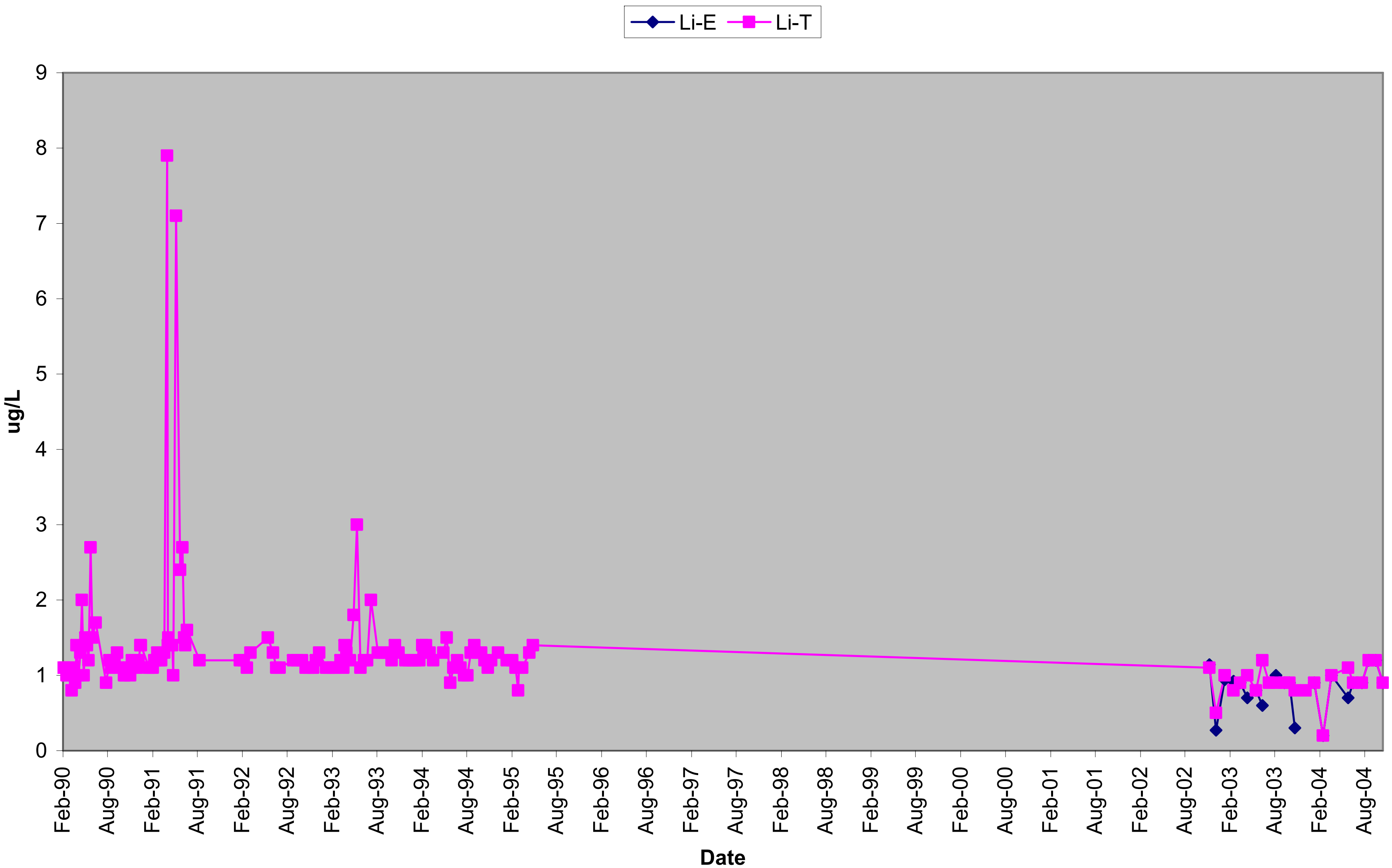


Figure 16 Lithium (lowest guideline is 1000 ug/L)



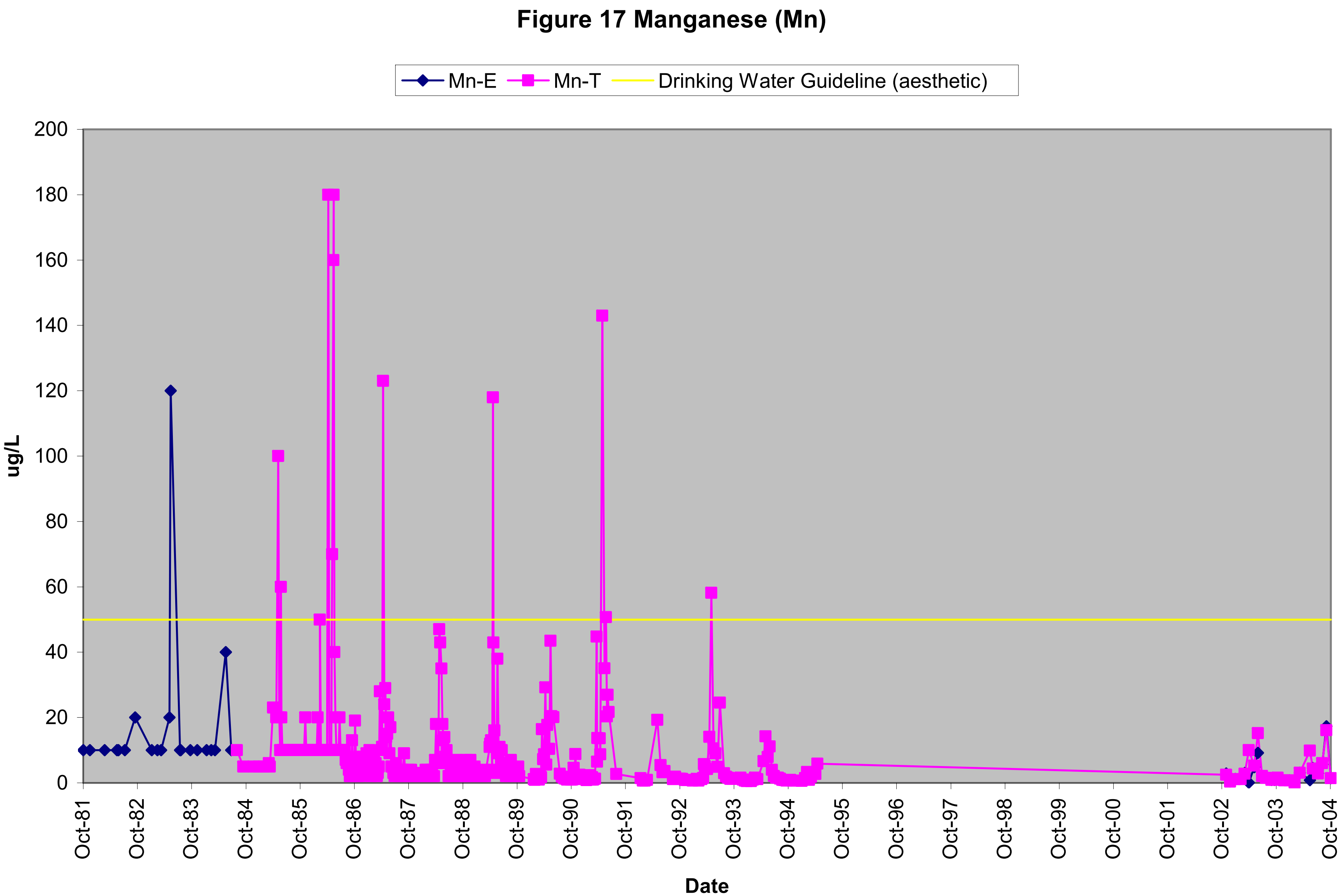


Figure 17 Manganese (Mn)
Mn-E
Mn-T
Drinking Water Guideline (aesthetic)
ug/L
200
180
160
140
120
100
80
60
40
20
0
Oct-81
Oct-82
Oct-83
Oct-84
Oct-85
Oct-86
Oct-87
Oct-88
Oct-89
Oct-90
Oct-91
Oct-92
Oct-93
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Oct-96
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Oct-98
Oct-99
Oct-00
Oct-01
Oct-02
Oct-03
Oct-04
Date

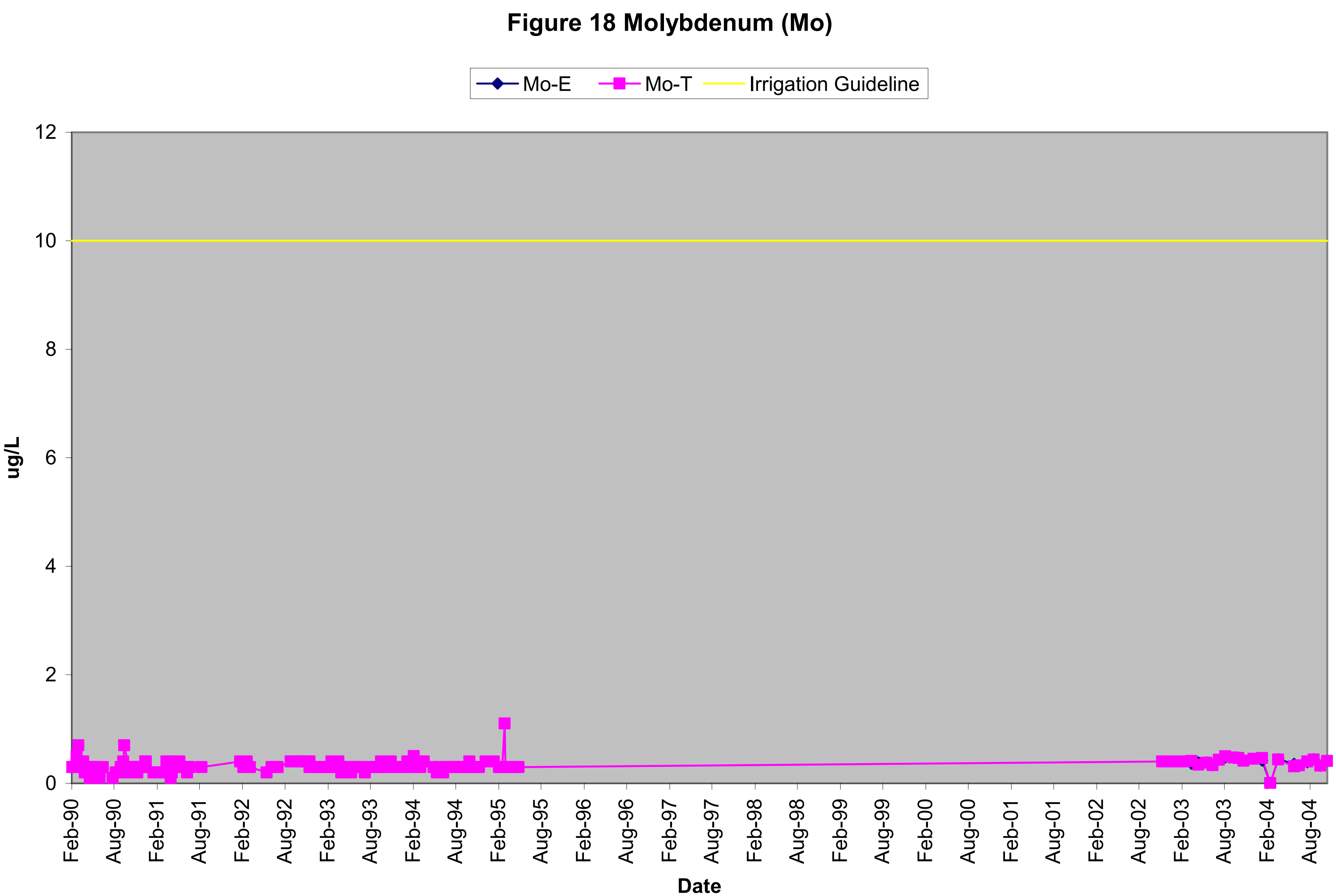


Figure 18 Molybdenum (Mo)
Mo-E
Mo-T
Irrigation Guideline
ug/L
12
10
8
6
4
2
0
Feb-90
Aug-90
Feb-91
Aug-91
Feb-92
Aug-92
Feb-93
Aug-93
Feb-94
Aug-94
Feb-95
Aug-95
Feb-96
Aug-96
Feb-97
Aug-97
Feb-98
Aug-98
Feb-99
Aug-99
Feb-00
Aug-00
Feb-01
Aug-01
Feb-02
Aug-02
Feb-03
Aug-03
Feb-04
Aug-04
Date

Figure 19 Nickel (NI) (lowest guideline is 65 ug/L)

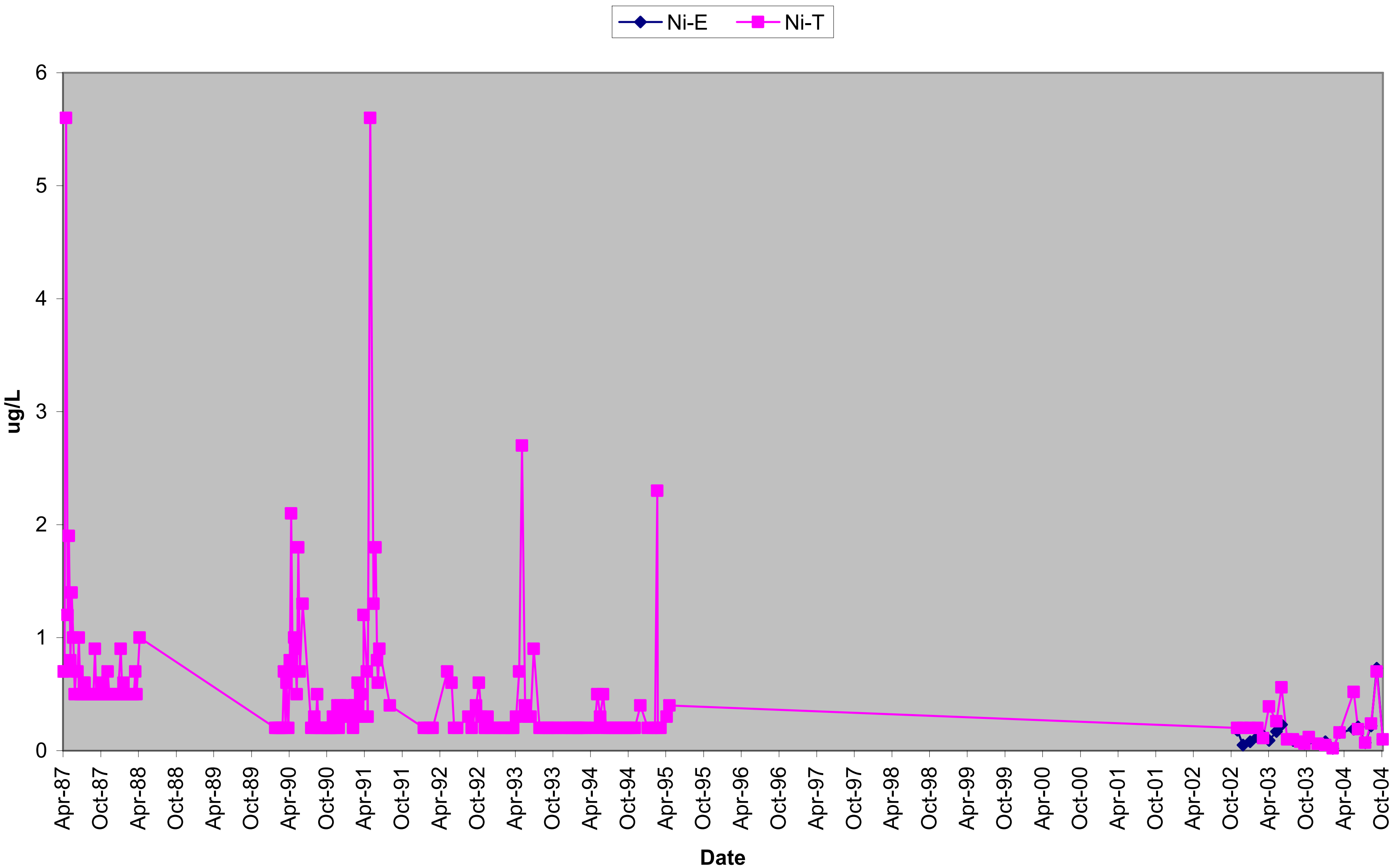
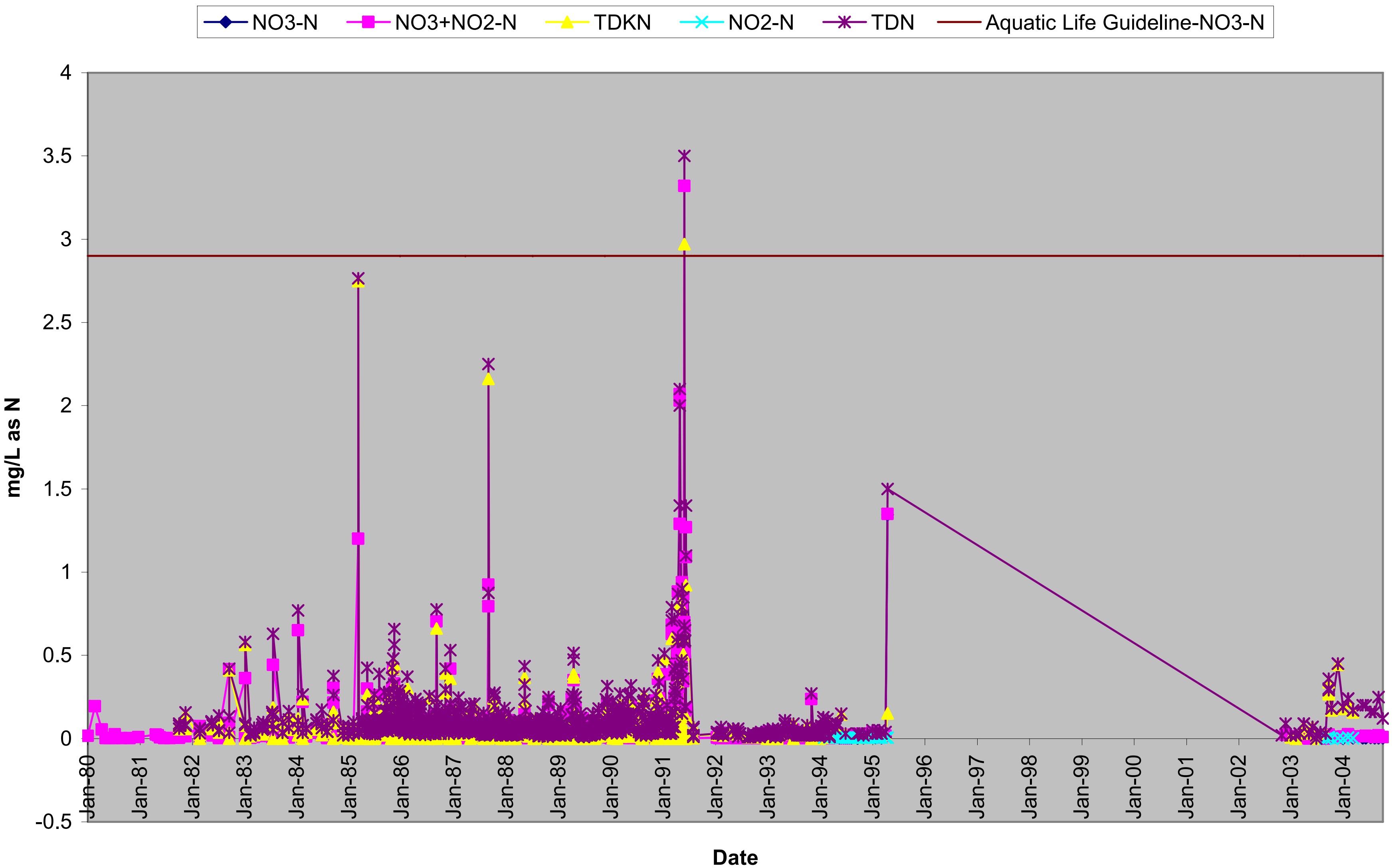


Figure 20 Nitrogen



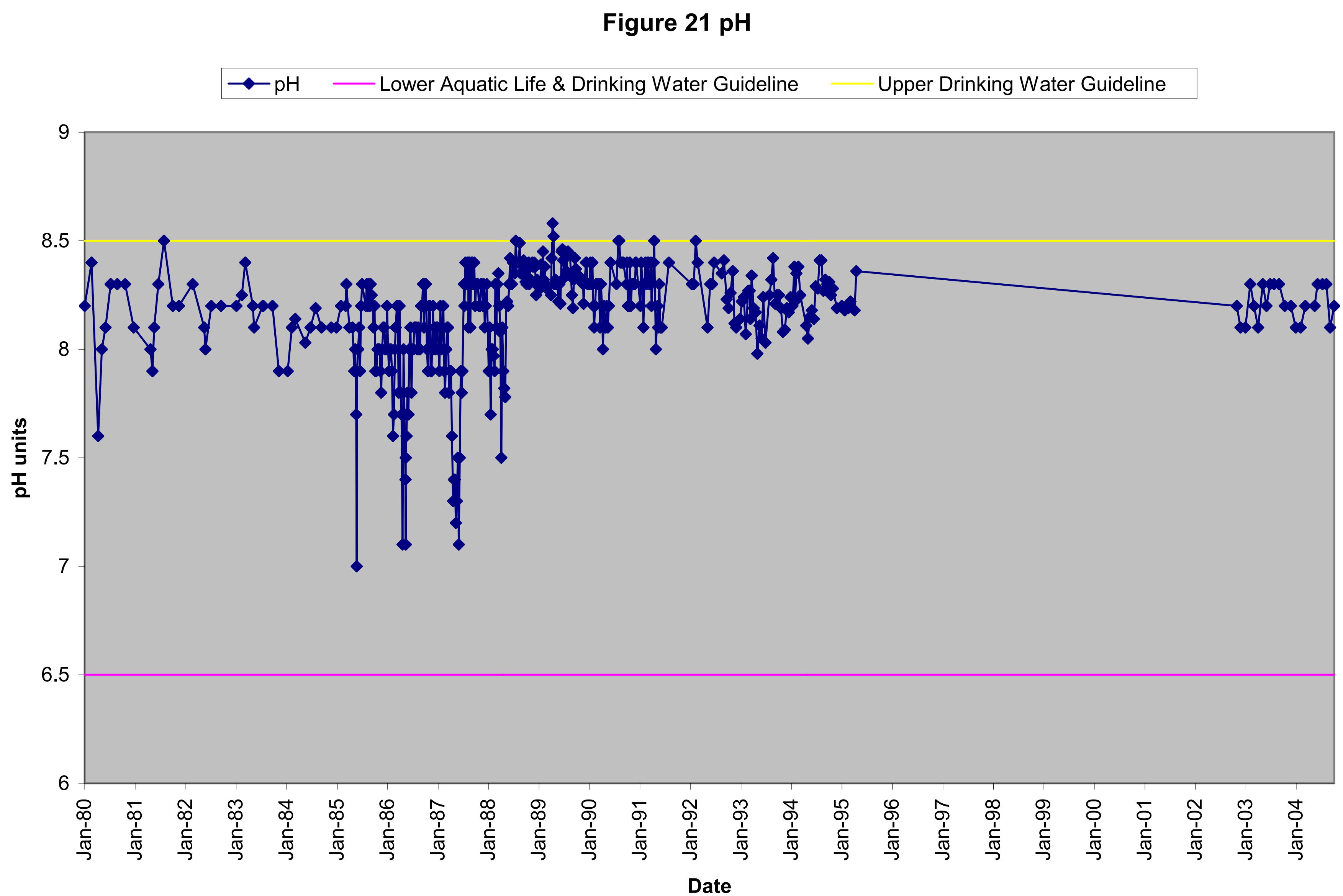


Figure 21 pH
pH
Lower Aquatic Life & Drinking Water Guideline
Upper Drinking Water Guideline
9
8.5
8
7.5
7
6.5
6
pH units
Jan-80
Jan-81
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Date

Figure 22 Phosphorus

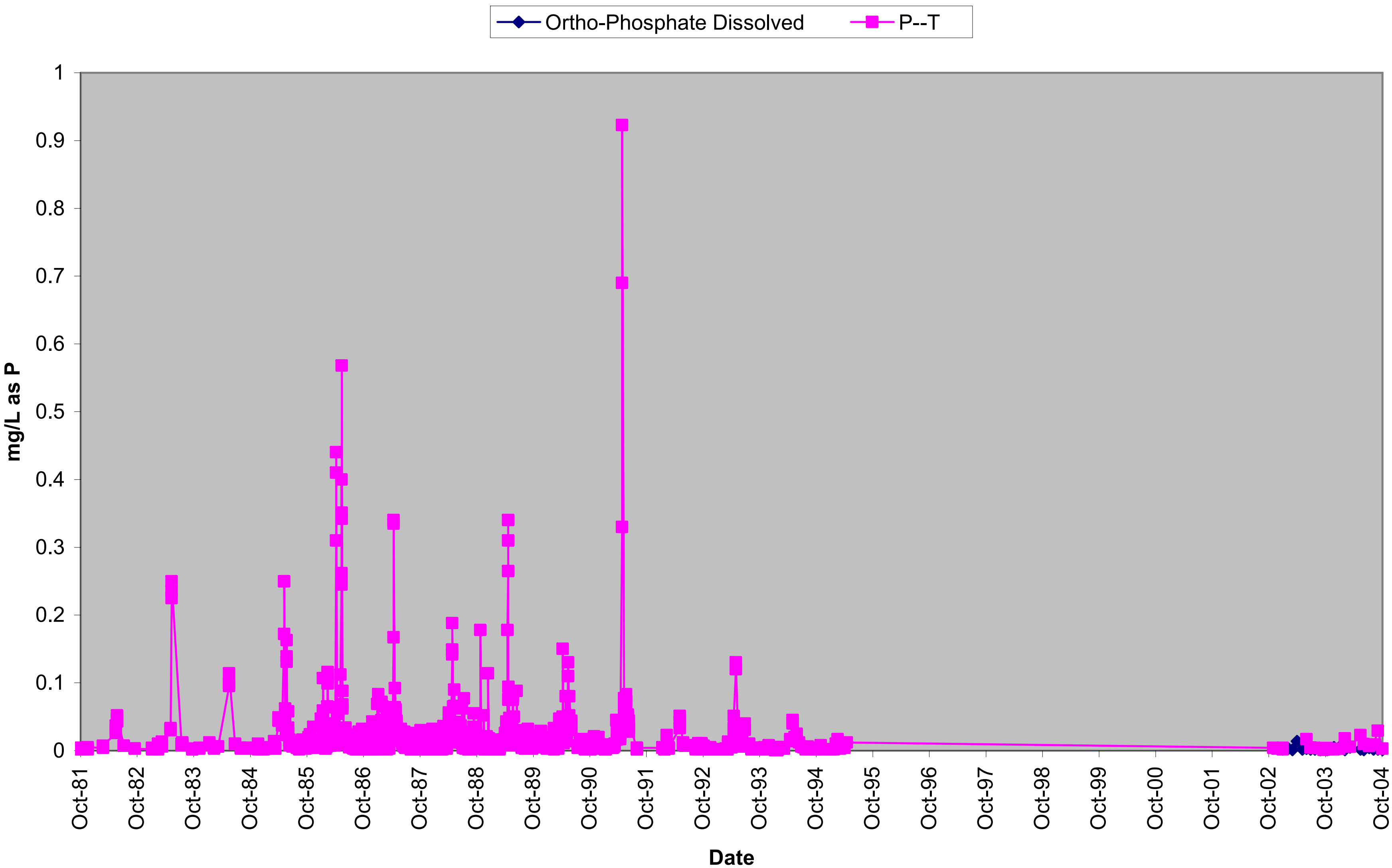


Figure 23 Selenium (Se)

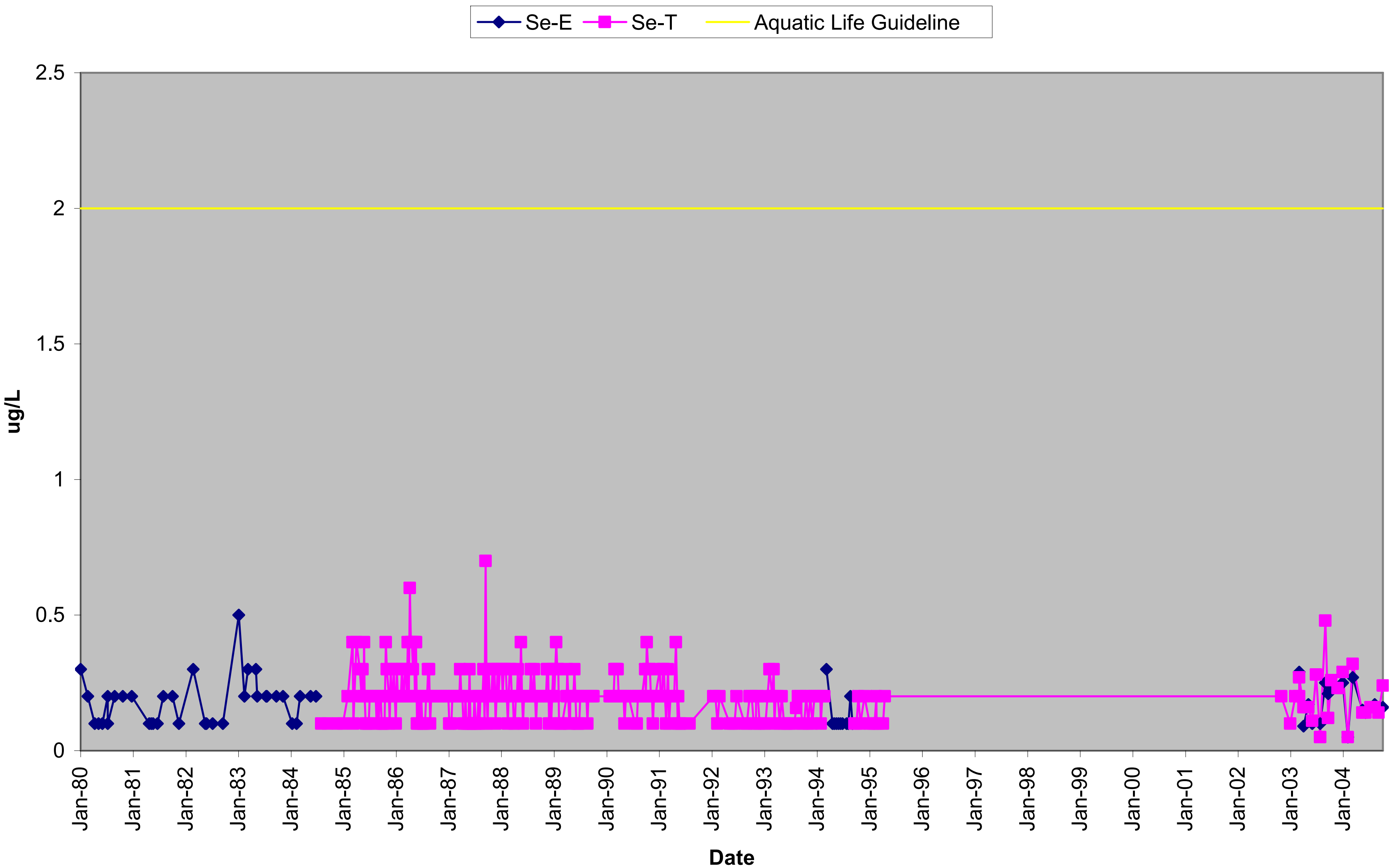


Figure 24 Silicon (Si)

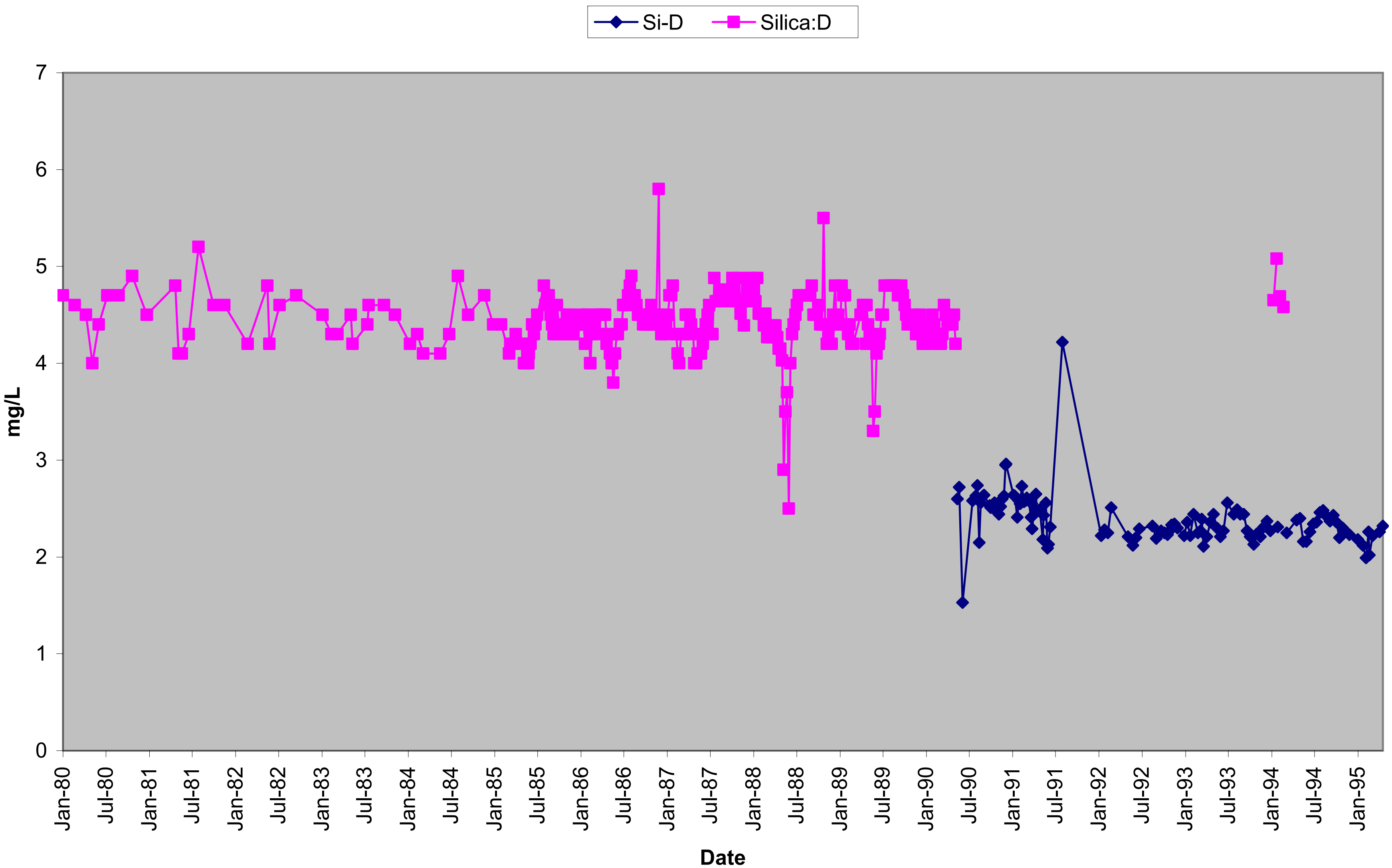
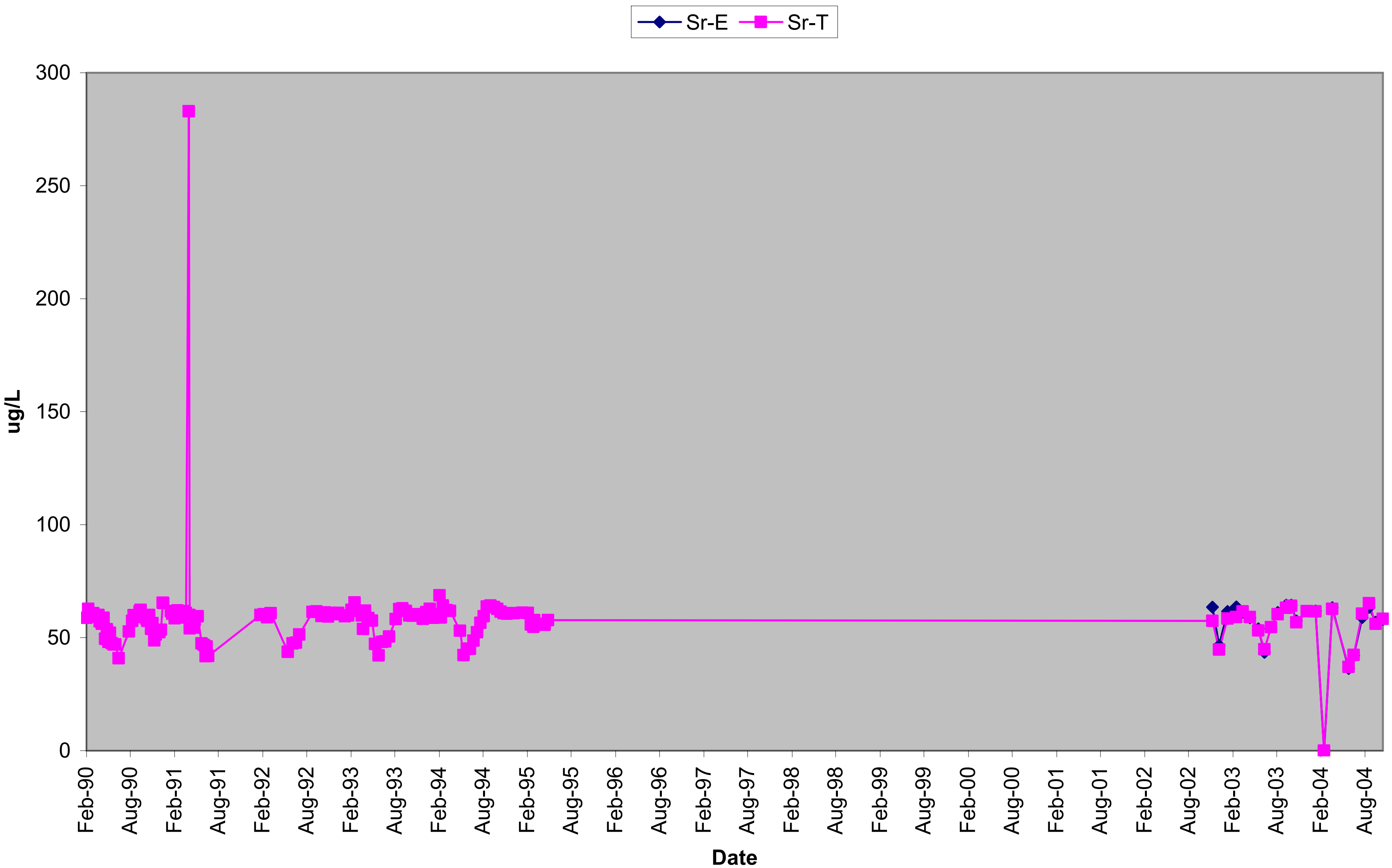


Figure 25 Strontium (Sr) (no guidelines)



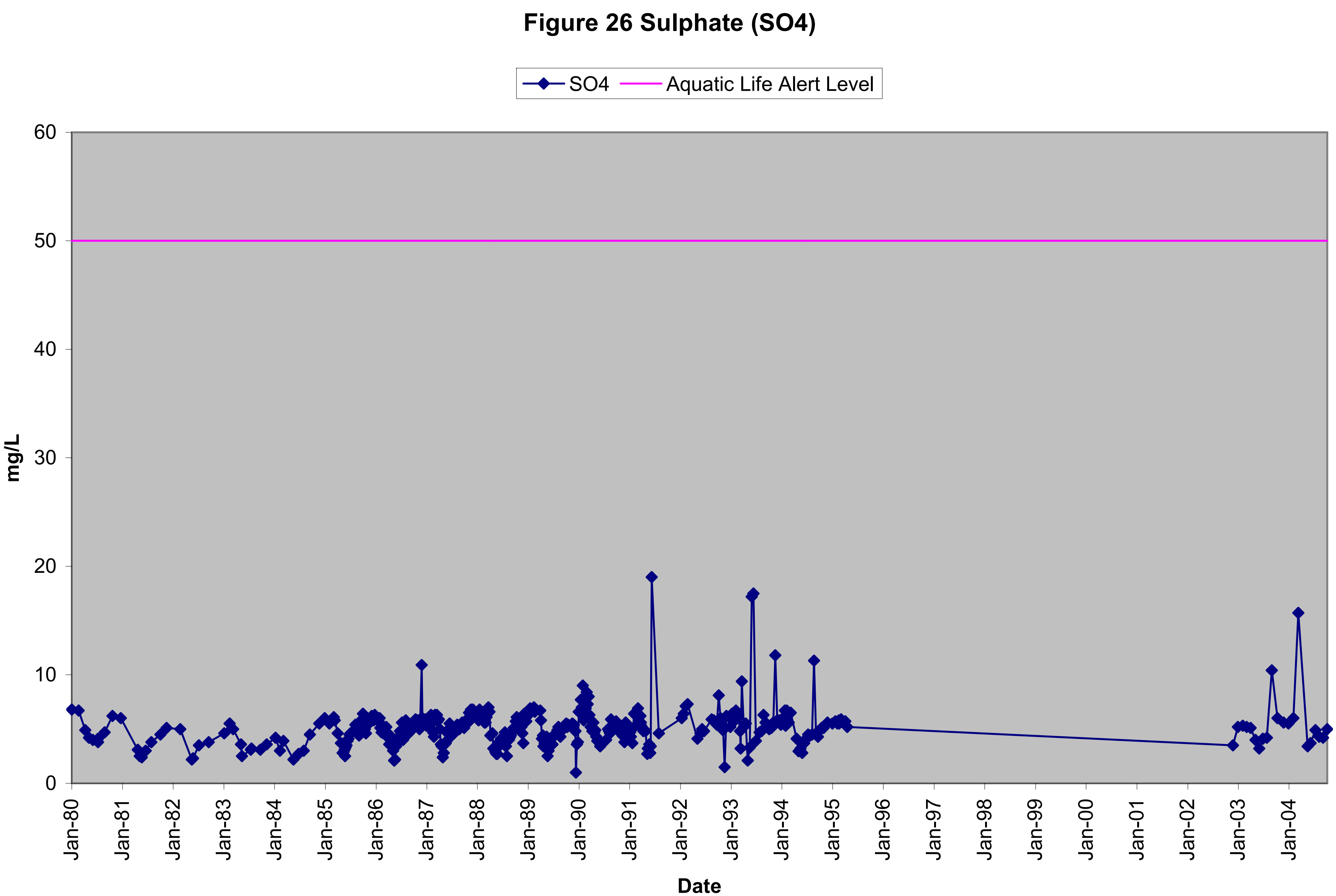


Figure 26 Sulphate (SO4)
SO4
Aquatic Life Alert Level
60
50
40
30
20
10
0
mg/L
Jan-80
Jan-81
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Date

Figure 27 Temperature, Water

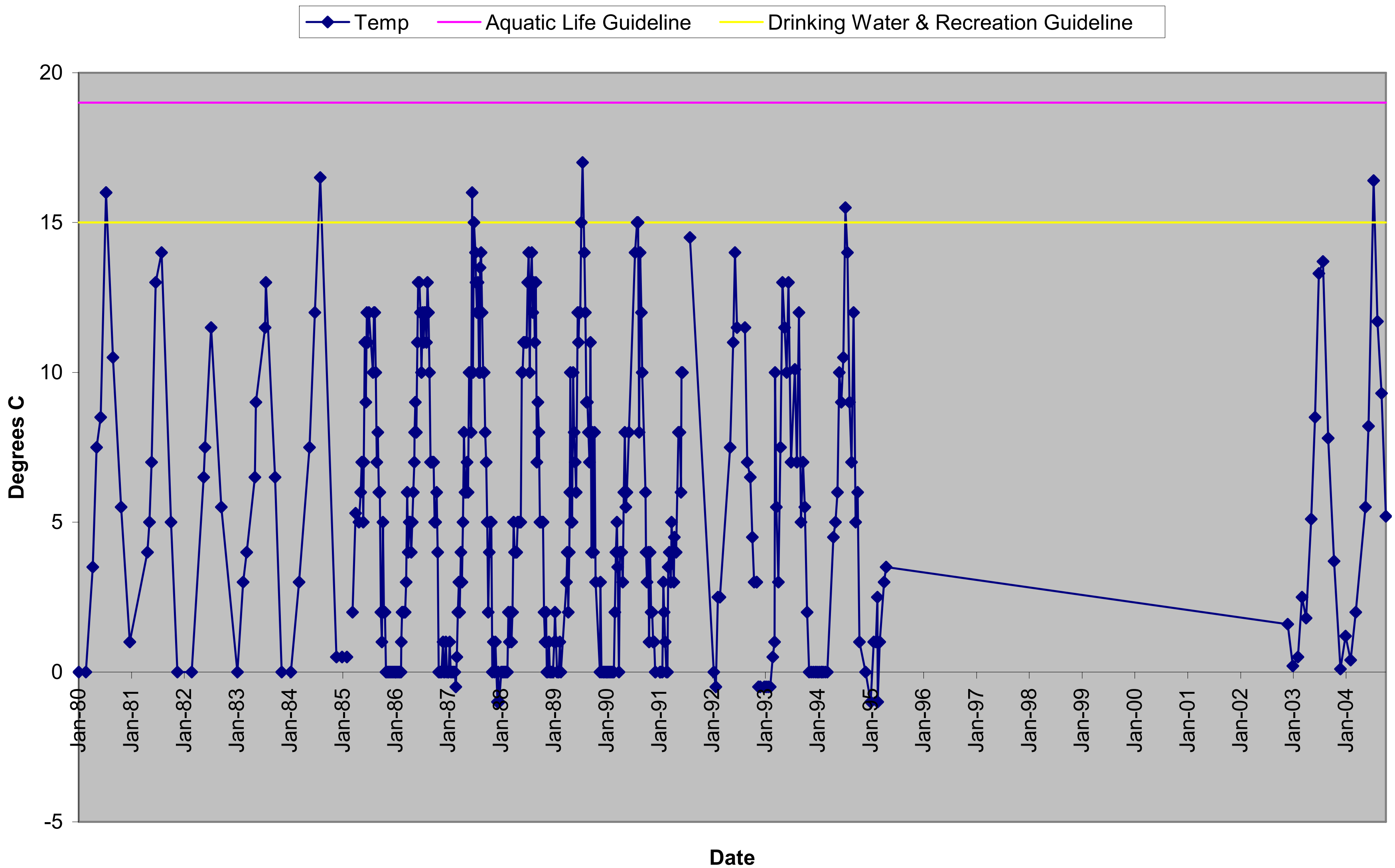
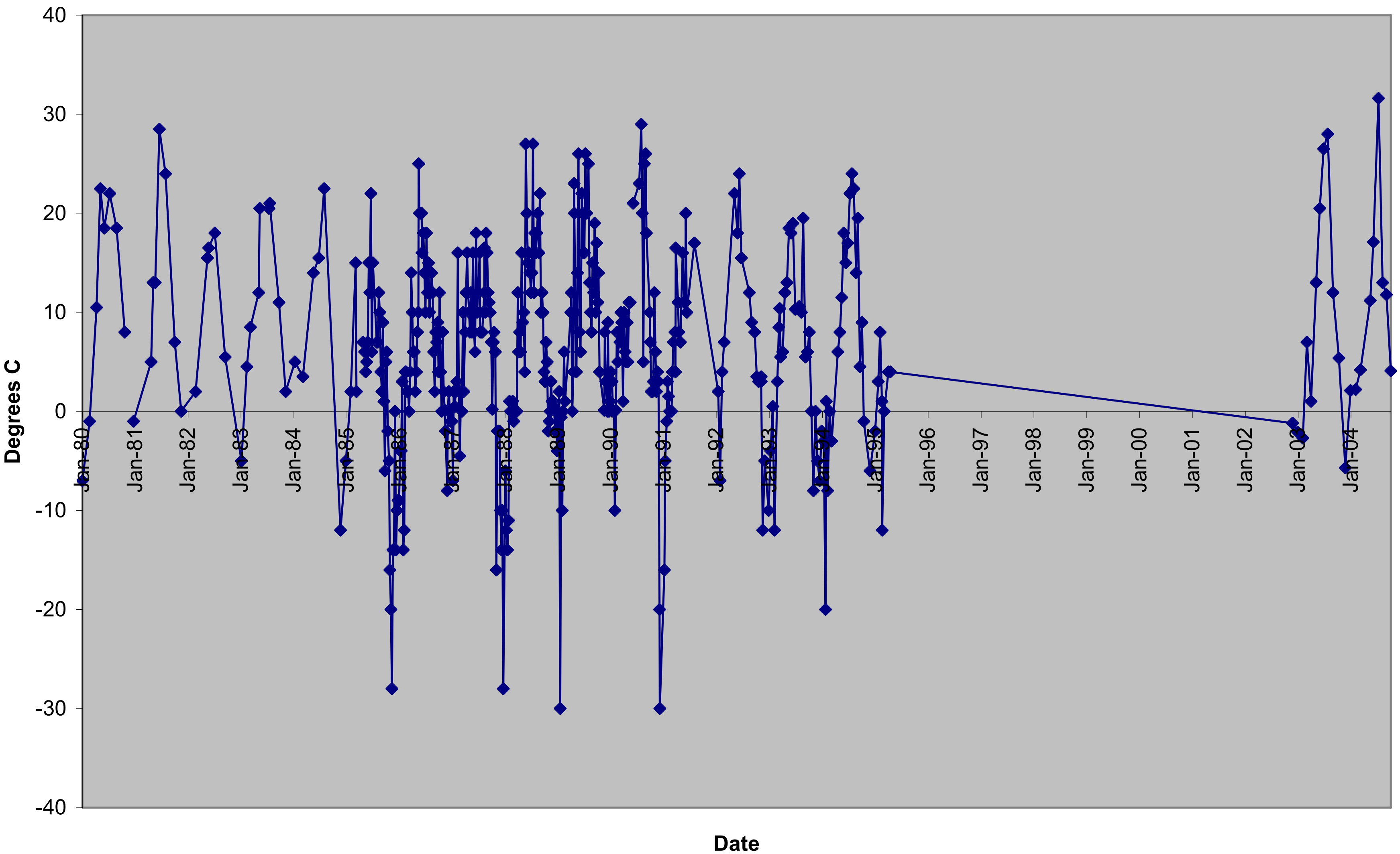


Figure 28 Temperature, Air



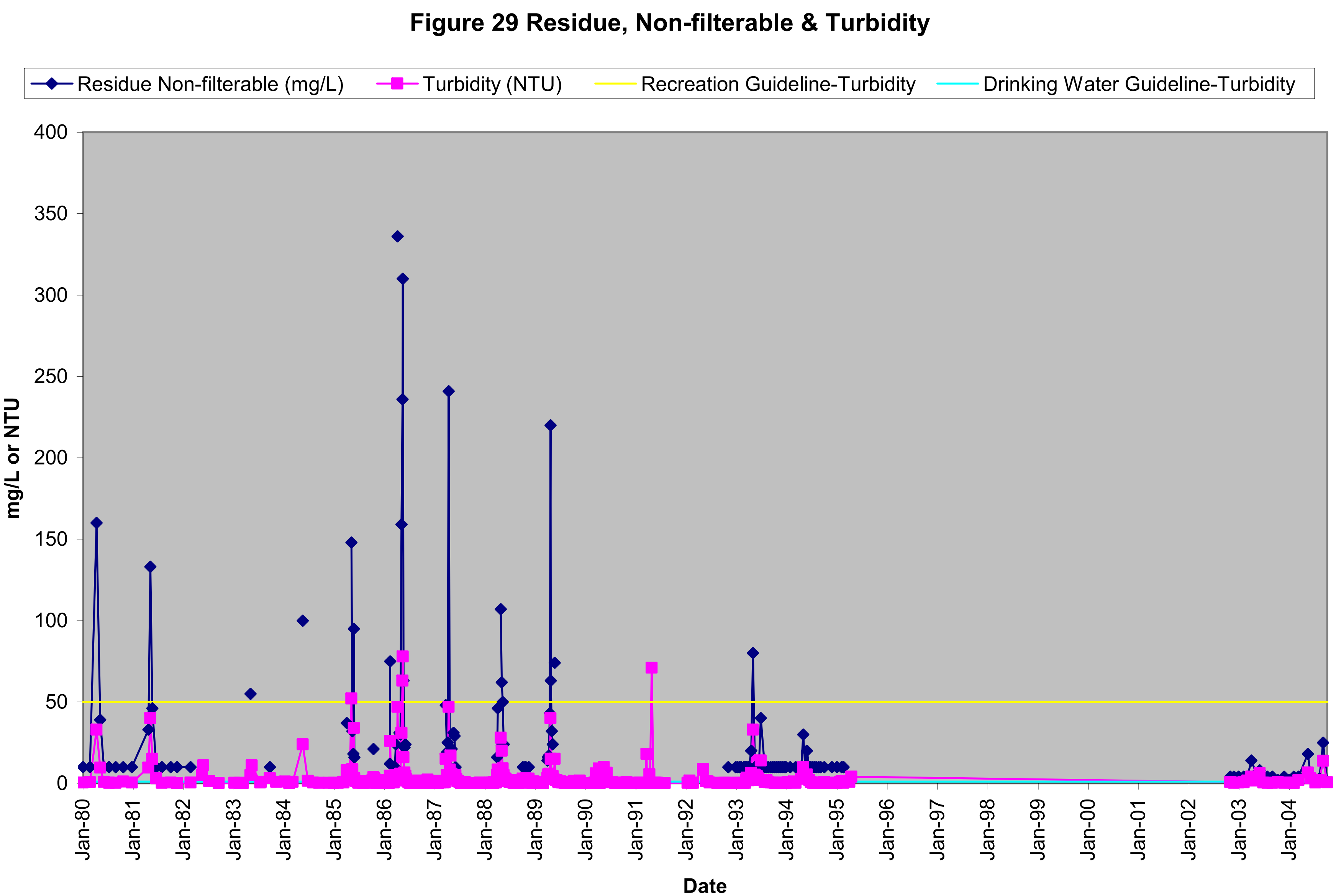
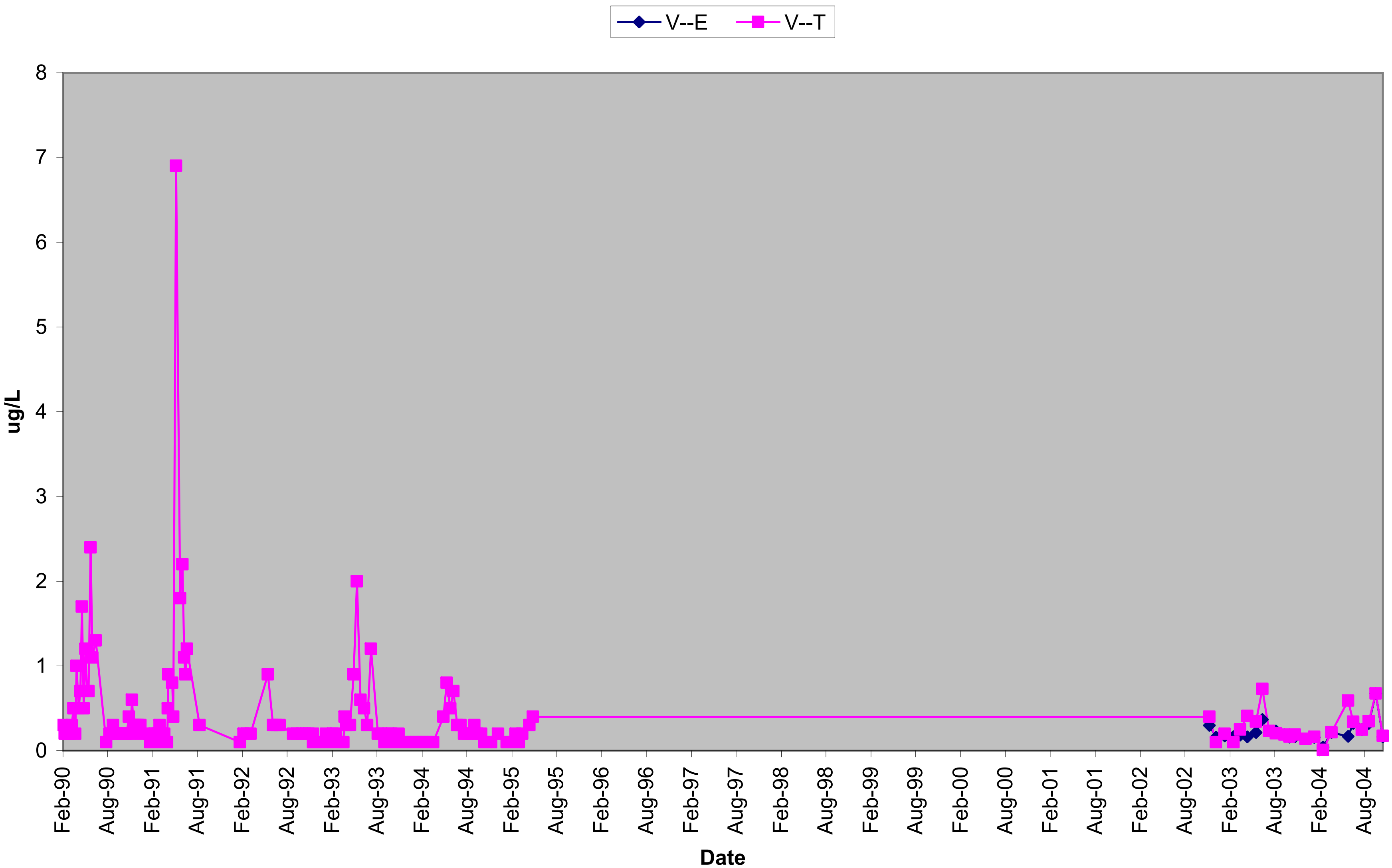


Figure 29 Residue, Non-filterable & Turbidity
Residue Non-filterable (mg/L)
Turbidity (NTU)
Recreation Guideline-Turbidity
Drinking Water Guideline-Turbidity
mg/L or NTU
400
350
300
250
200
150
100
50
0
Jan-80
Jan-81
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Date

Figure 30 Vanadaium (V) (lowest guideline is 100 ug/L)



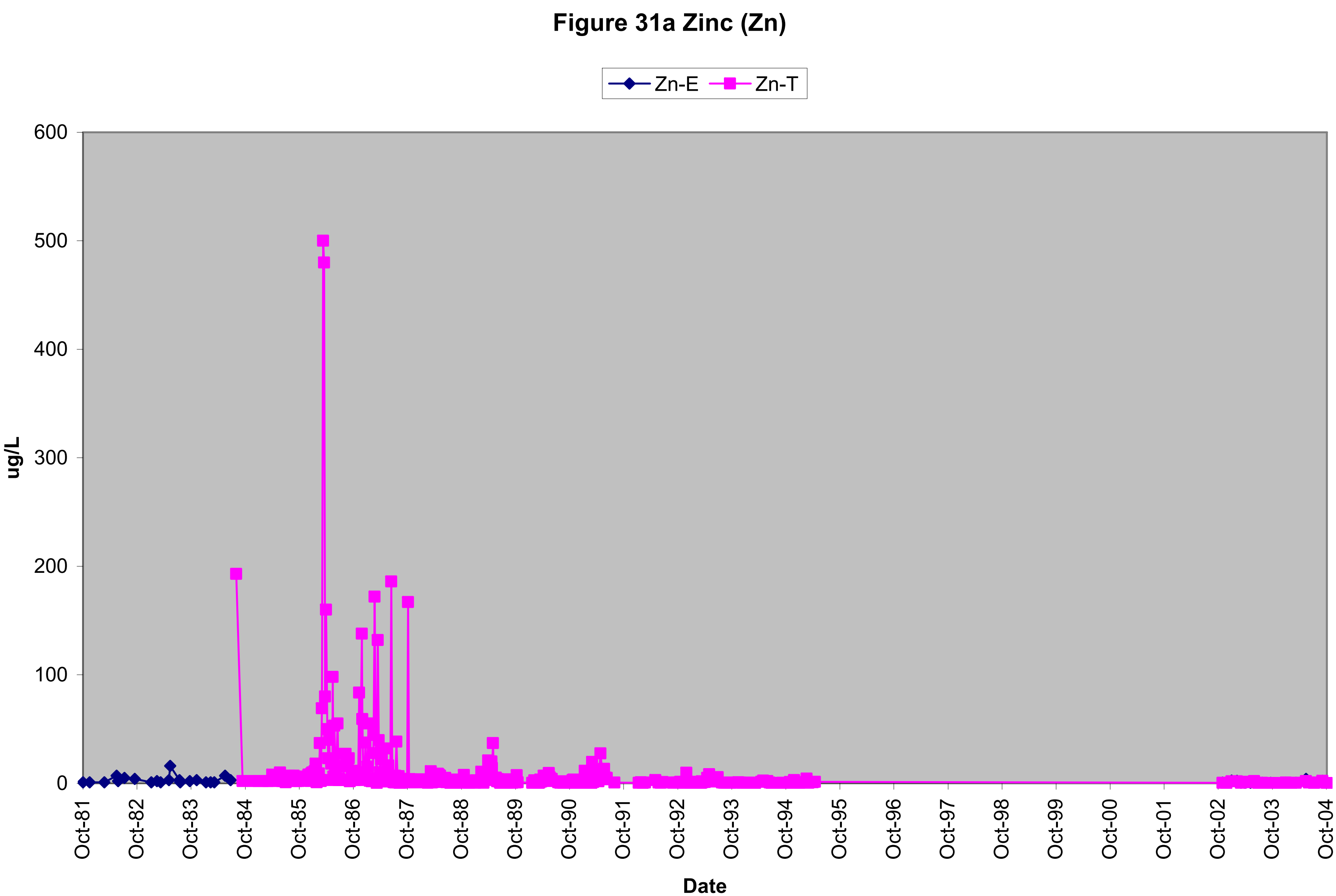


Figure 31a Zinc (Zn)
Zn-E
Zn-T
600
500
400
300
200
100
0
ug/L
Oct-81
Oct-82
Oct-83
Oct-84
Oct-85
Oct-86
Oct-87
Oct-88
Oct-89
Oct-90
Oct-91
Oct-92
Oct-93
Oct-94
Oct-95
Oct-96
Oct-97
Oct-98
Oct-99
Oct-00
Oct-01
Oct-02
Oct-03
Oct-04
Date

Figure 31b zinc (Zn) with Errors Removed