

CANADA – BRITISH COLUMBIA

WATER QUALITY MONITORING AGREEMENT

WATER QUALITY ASSESSMENT OF Elk River AT HIGHWAY 93 NEAR ELKO (1968 – 2005)



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Prepared for:
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Ministry of
Environment

EXECUTIVE SUMMARY

The Elk River watershed is located in the southeast corner of British Columbia, and drains 4450 km² of the Rocky Mountains to the Kootenay River/Lake Koocanusa about 20 km upstream from the border with the United States. The downstream water quality sampling station on the Elk River is located just upstream from the confluence with the Kootenay River/Lake Koocanusa at Highway 93. This assessment is based on up to 38 years of water quality data during 1968-2005. A second station is located upstream at Sparwood.

The main human activities in the Elk River watershed are open pit coal mining, forestry, outdoor tourism, and residential and commercial development. The water quality trends identified below have not yet been confirmed by statistical analysis.

CONCLUSIONS

- Selenium concentrations continue to show an increasing trend to higher concentrations and generally always exceeded both CCME and B.C. guidelines for the protection of aquatic life. Work is underway to determine whether these high levels are impacting aquatic life in the Elk River. These high values are associated with surface runoff from open pit coal mining.
- Fecal coliform concentrations exceeded source water protection guidelines for use of the water with disinfection only. This means that the water should have partial treatment to remove both turbidity and improve the removal of bacteria.
- Otherwise, water quality was generally good with only occasional values exceeding guidelines for pH, temperature, phosphorus, several metals, dissolved organic carbon, and true colour. In cases where total metal concentrations exceeded guideline values, these were generally correlated with higher turbidity concentrations, meaning that the metals were likely in particulate form and not biologically available

RECOMMENDATIONS

We recommend monitoring be continued for the Elk River near Elko since selenium continues to increase and the success of any management steps undertaken can be tracked at this site.

Water quality indicators that are important for future monitoring are:

- flow, water temperature, specific conductivity, pH, turbidity, nutrients, and dissolved oxygen,
- appropriate forms of metals for comparison to their respective guidelines, and
- other variables related to drinking water such as colour.

ACKNOWLEDGEMENTS

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INTRODUCTION

Since 1985, B.C. Ministry of Environment and Environment Canada have been cooperatively measuring water quality at a number of locations in British Columbia. The express purposes of this joint monitoring program have been to define the quality of the water and to determine whether there are any trends in water quality. This assessment is based on up to 38 years of water quality data during 1968-2005.

The Elk River watershed is located in the southeast corner of British Columbia, and drains 4450 km² of the Rocky Mountains to the Kootenay River/Lake Kooconusa about 20 km upstream from the border with the United States. It is the most heavily-fished river in the Kootenays, with large populations of westslope cutthroat trout, bull trout and whitefish.

The main human activities in the Elk River watershed are open pit coal mining, forestry, outdoor tourism, agriculture, transportation, and residential and commercial development. Large scale coal mining began in the Elk River Valley in 1970 and has since expanded to five major coal mining operations producing over 25 million metric tons of coal each year. The Valley presently contains the largest producing coalfield in British Columbia.

Water quality measurements for the Elk River at Highway 93 near Elko were plotted on a graph over time, along with the relevant water quality objectives or guidelines. The graphs were inspected for "environmentally significant" trends determined 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.

The water quality sampling station on the Elk River is located just upstream from the confluence with the Kootenay River/Lake Koocanusa at Highway 93.

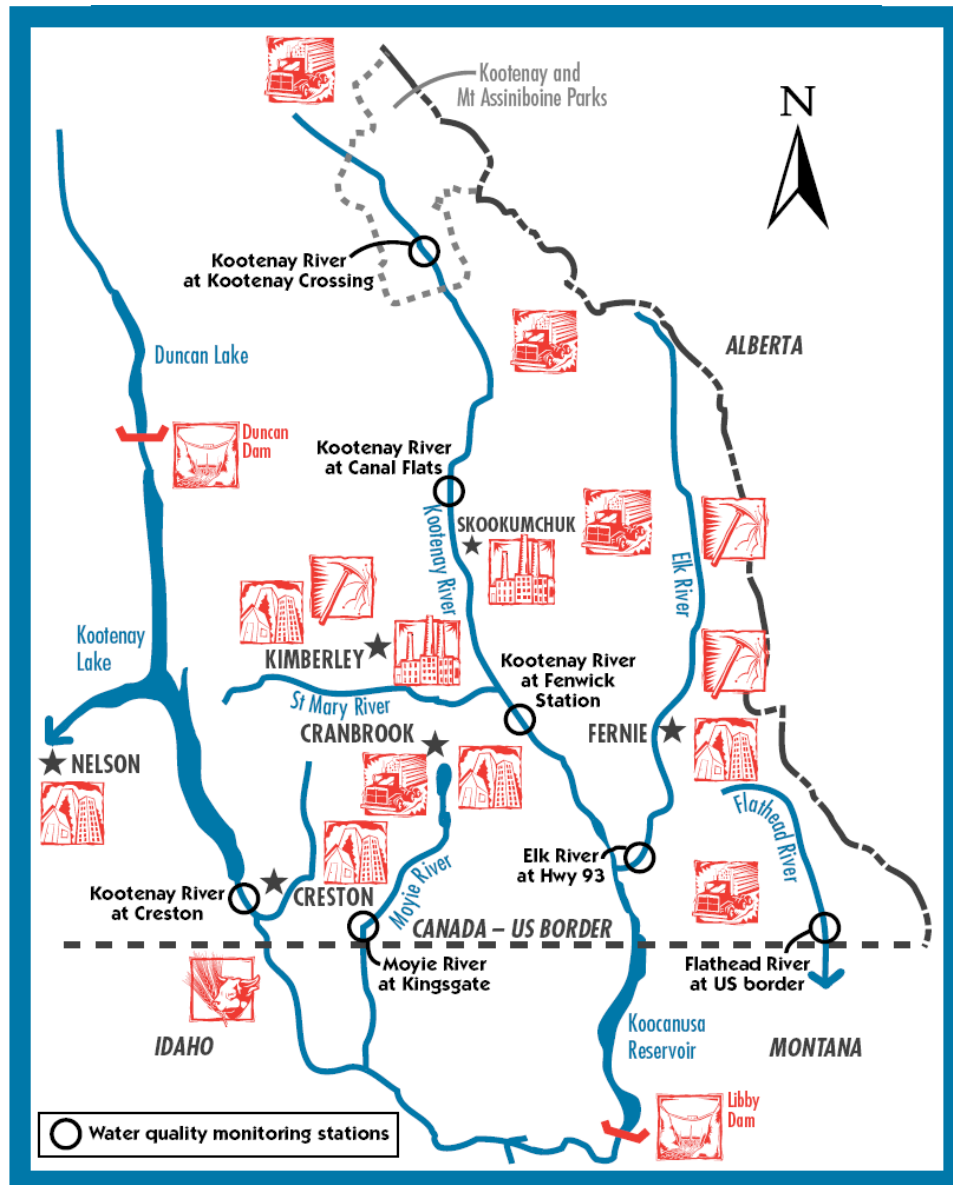


FIGURE 1: ELK RIVER NEAR ELKO

WATER QUALITY ASSESSMENT

The state of the water quality was assessed by comparing the values to the B.C.'s approved and working guidelines (if guidelines exist for the variable) for water quality

(B.C. Ministry of Environment, 2006a and b), and by looking for any obvious trends in the data. Any levels or apparent trends that were found to be deleterious or potentially deleterious to sensitive water uses, including drinking water, aquatic life, wildlife, recreation, irrigation, and livestock watering were noted in the following variable-by-variable discussion described below in alphabetical order.

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. We have normally plotted each variable against either turbidity levels or specific conductivity, whichever we believe from experience may be correlated with the particular variable. Sometimes, we have plotted the same variable for two or three different periods of time, usually to highlight periods of time when analytical detection limits may have improved. In such cases, one plot will include the entire period of record for the variable. 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 cases where we have used statistical techniques such as linear regression analysis to estimate if a trend is possibly present, a more thorough statistical analysis of the trend is necessary for verification of the trend.

Data for the Elk River near Elko have been collected on a frequency of about once every two weeks. As well, twice per year, two additional samples are collected in order to ensure that there are two periods when weekly samples are collected during five consecutive weeks. In addition, quality assurance samples (blanks and replicates) are collected three times per year. These results for each variable were used in this assessment to identify potential outliers that should be removed from consideration of trends, and to “flag” questionable data in the database (www.waterquality.ec.gc.ca) as to possible or likely errors.

Water Quality Assessment of the Elk River at Highway 93 near Elko 1984-2005

The following water quality indicators were not discussed as they met all water quality guidelines (if guidelines exist) and showed no clearly visible trends: ammonia, bromide, potassium, silica, silicon, and tin.

The following water quality indicators seemed to fluctuate through the year according to turbidity concentrations, but were below guideline values (if guidelines exist) and had no other trends: antimony, beryllium, bismuth, apparent colour, gallium, lanthanum, manganese, nickel, fixed non-filterable residue, non-filterable residue, total rubidium, strontium, thallium, and vanadium.

Other water quality indicators seemed to fluctuate through the year according to the specific conductivity of the water. For dissolved forms of many of these indicators, they would be a part of the measured conductivity, and this correlation is to be expected.

These types of indicators that were not measured above guideline values (if guidelines exist) included alkalinity, barium, boron, calcium, dissolved inorganic carbon, chloride, fluoride, lithium, magnesium, molybdenum, dissolved nitrate plus nitrite, dissolved nitrogen, sodium, hardness, dissolved sulphate, and uranium.

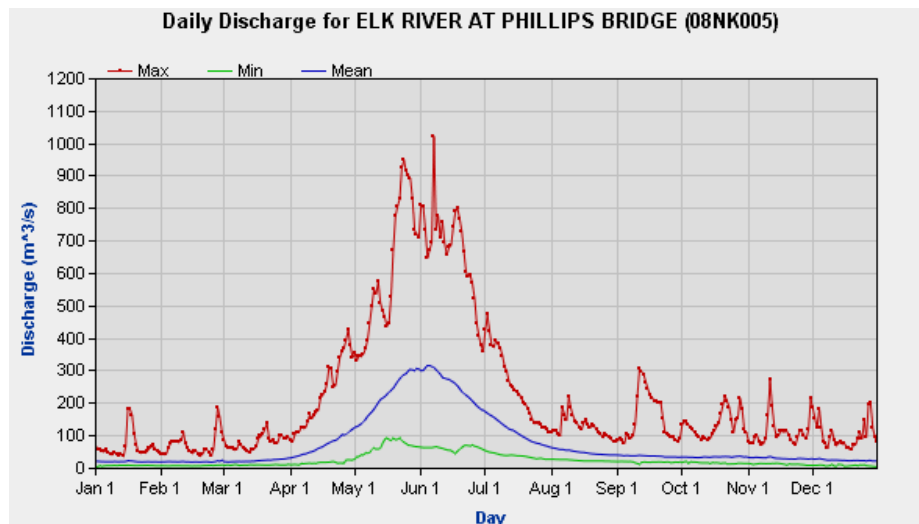


FIGURE 2: WATER SURVEY OF CANADA FLOW DATA FOR ELK RIVER AT PHILLIPS BRIDGE (1924-1996)

Flow (Figure 2) values showed fairly typical patterns characteristic of interior river systems, with peak flows in May through June and low flows during August through March, generally declining through that period of time.

Aluminum (Figures 4 and 5) values (dissolved) met the guideline except on one occasion. Although total values often exceeded the guideline for dissolved aluminum, these values were correlated with turbidity and were likely in particulate form, making them not biologically available.

Arsenic (Figures 8 and 9) values were generally below the source water guideline for drinking water supplies of 5 µg/L; however one dissolved value (omitting the outlier) did exceed the guideline. Considering the fact that no other total or dissolved values have exceeded 3.5 µg/L since 1984, this one high value is questionable.

Cadmium (Figures 17 and 18) values occasionally exceeded the guideline to protect aquatic life that is based on water hardness. Most values that exceeded the guideline were total cadmium values, which were correlated with turbidity, where the cadmium would be in particulate form and not biologically available.

Dissolved Organic Carbon (Figures 20 and 21) values usually met the guideline for total organic carbon of 4 mg/L to protect source waters used for drinking water supplies. The guideline was exceeded by only one DOC value in 2002.

Chromium (Figures 23 and 24) values should be measured in hexavalent and trivalent forms for direct comparison to guidelines; however, these tests are not available. Total chromium, which is correlated with turbidity concentrations, occasionally exceeded both the trivalent and hexavalent guidelines; however, the chromium would be in particulate form and would not be biologically available. Virtually all extractable and dissolved chromium values met both guidelines all the time.

Cobalt (Figures 25 and 26) values (individual total) occasionally exceeded the guideline for the 30-day mean concentration but were correlated with turbidity concentrations, would be in particulate form and likely would not be biologically available.

True colour (Figure 27) values generally met the guideline for source waters used for drinking although there were some occasions when the guideline was exceeded. The guideline is based on aesthetics of the water supply, not health considerations.

Copper (Figures 29 and 30) concentrations were correlated with turbidity values and total values sometimes exceeded the B.C. guideline for maximum concentrations. This means that the copper was in particulate form and not likely biologically available. Between 2003 and 2005 all values (except one) were well below the 30-day mean B.C. guideline.

Fecal Coliforms (Figure 31) were often above the guideline for source waters used for drinking that apply disinfection only. This means that some form of partial treatment of the water supplies should also be applied for effective disinfection to occur.

Hardness (Figure 35) values exceeded the guideline for source waters, meaning that the water from the river should be softened for aesthetic considerations in households. Hardness values may have been increasing during the period of record.

Iron (Figures 36 and 37) values often exceeded the guidelines for protection of aquatic life and source waters used for drinking. Iron is an aesthetic concern related to drinking water supplies, while total iron concentrations were correlated with turbidity and would not likely be biologically available.

Lead (Figures 40 and 41) values generally appear to have met the guidelines since 2003 when lower detection limits were instituted. Prior to that time, some total concentrations

exceeded the guidelines; however, these values were correlated with high turbidity and would not likely be biologically available.

pH (Figure 56) values in the mid-1990's occasionally exceeded the upper limit of 9.0 to protect aquatic life; however, these values which were at least one pH unit greater than the normal range and if these were real, would represent a ten-fold increase in the amount of basic material in the river, a highly unlikely event. Thus, the pH excursions seem like random events and may have actually been a contaminated sample or a poorly calibrated probe.

Phosphorus (Figure 57) often exceeds the source water for drinking water guideline of 0.01 mg/L, likely due to it being associated with higher turbidity concentrations. Drinking water supplies would need some form of treatment prior to the use of this water as a supply.

Selenium (Figure 67) values regularly exceeded the CCME guideline of 1.0 µg/L and the B.C. 30-day mean guideline of 2 µg/L. Values have increased considerably since 1984 but this increase appears to have slowed but continues to the end of 2005. This needs to be verified statistically.

Silver (Figures 70 and 71) exceeded the 30-day average guideline until 2003 when lower analytical detection limits became available. After that time, the guideline has not been exceeded. The values in excess of the guideline which was also the detection limit were “noise” associated and typical of what is encountered near the detection limit. Silver is not expected to be a concern.

Temperature (Figure 76) maxima occasionally exceeded the guideline for the maximum temperature for streams with unknown species distribution. These values were higher than recorded at the upstream site at Sparwood during comparable periods. Stream bank

remediation and planting of shade trees may be a needed management step between these two sites in order to reduce peak summer temperatures.

Turbidity (Figure 80) values often exceeded the guideline for source waters used for drinking. This means that a minimum of partial treatment is required before this water can be used as a reliable source water for drinking.

Zinc (Figure 86-86a) values sometimes exceeded guidelines when detection limits were higher but in recent years when detection limits were lowered, this problem seems to have been eliminated. This is likely related to difficulty in obtaining quantitation within five times the detection limit. Zinc values were correlated to turbidity, so that high zinc concentrations are likely associated with particulate matter and would not be biologically available.

REFERENCES

Ministry of Environment. 2006a. British Columbia Approved Water Quality Guidelines (Criteria). Ministry of Environment, Victoria, B.C.

Ministry of Environment. 2006b. A Compendium of Working Water Quality Guidelines for British Columbia. Ministry of Environment, Victoria, B.C.

Figure 3
Elk River at Hwy93 near Elko
Alkalinity Total CaCO3 (mg/L)

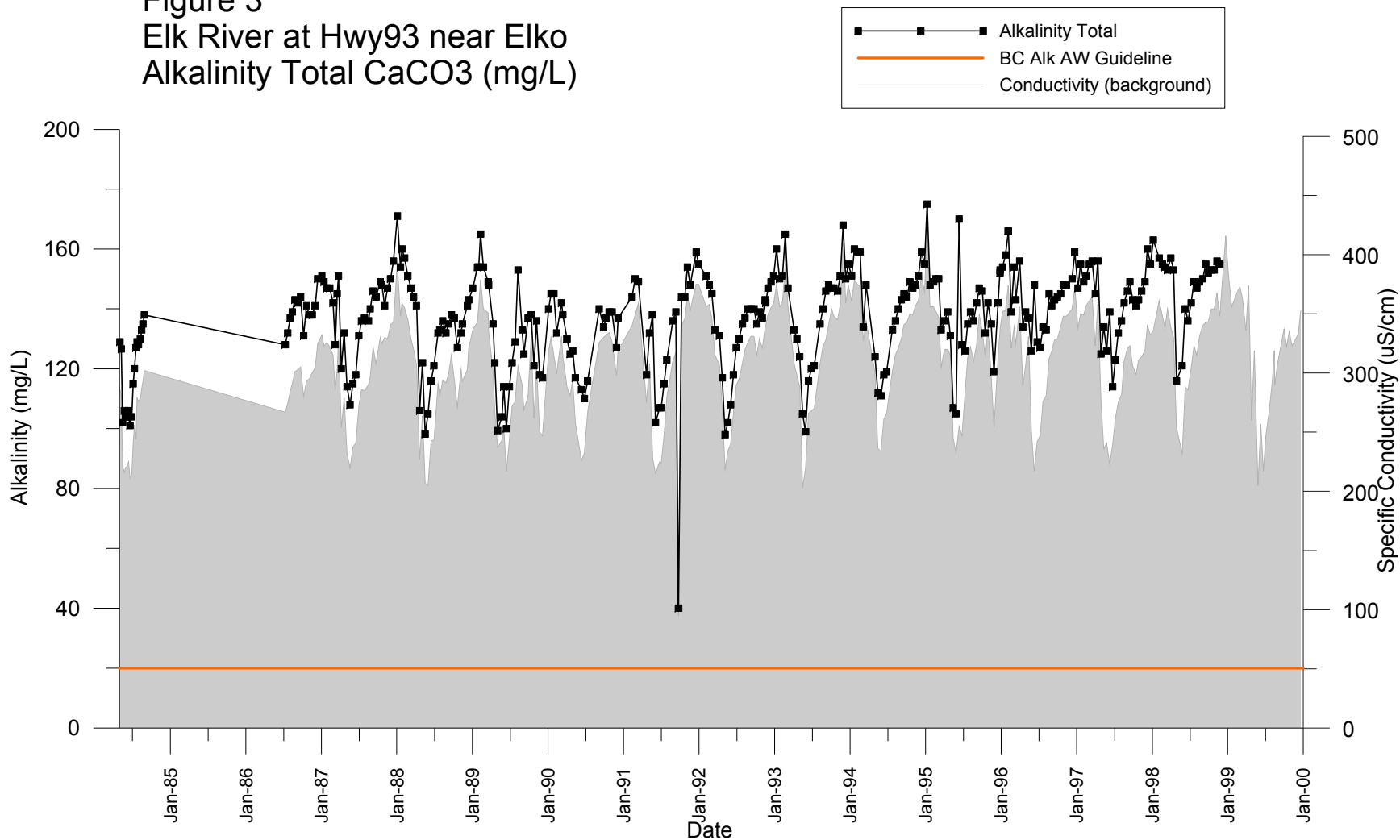


Figure 4
 Elk River at Hwy93 near Elko
 Aluminum Total, Dissolved and Extractable (ug/L)
 1990 - 2005

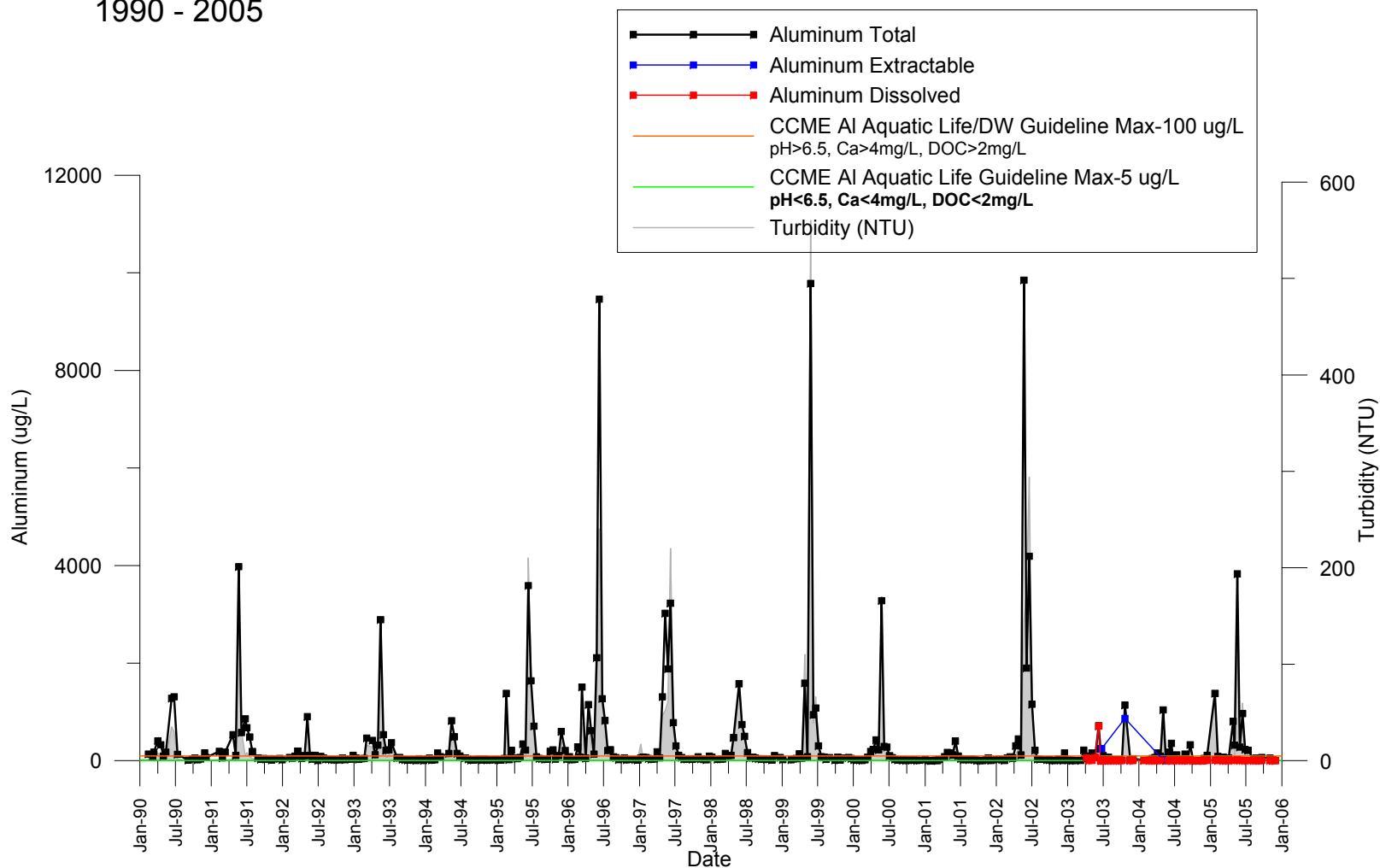


Figure 5
 Elk River at Hwy93 near Elko
 Aluminum Total, Dissolved and Extractable (ug/L)
 2003 - 2005

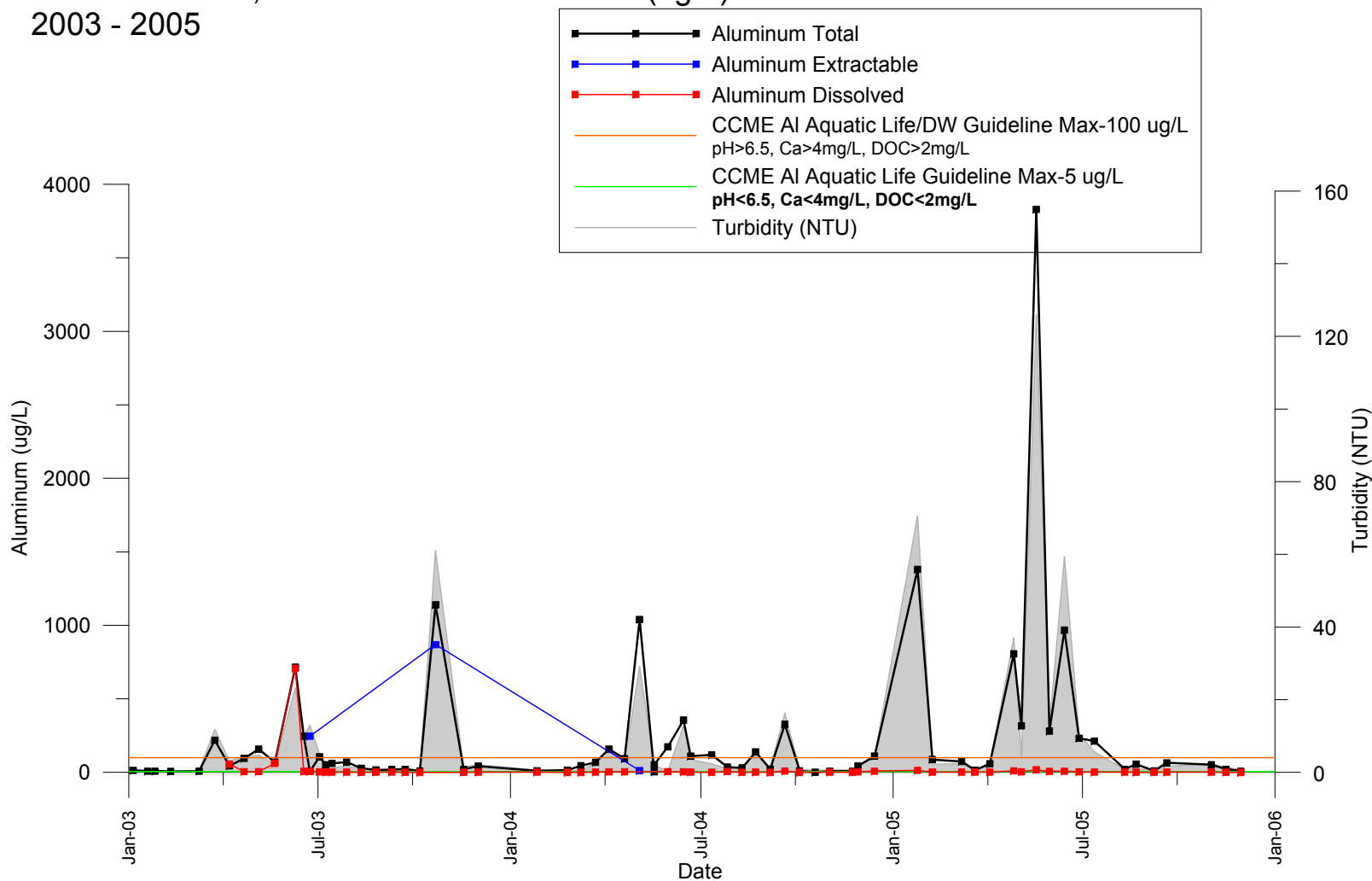


Figure 6
Elk River at Hwy93 near Elko
Ammonia Dissolved (ug/L)

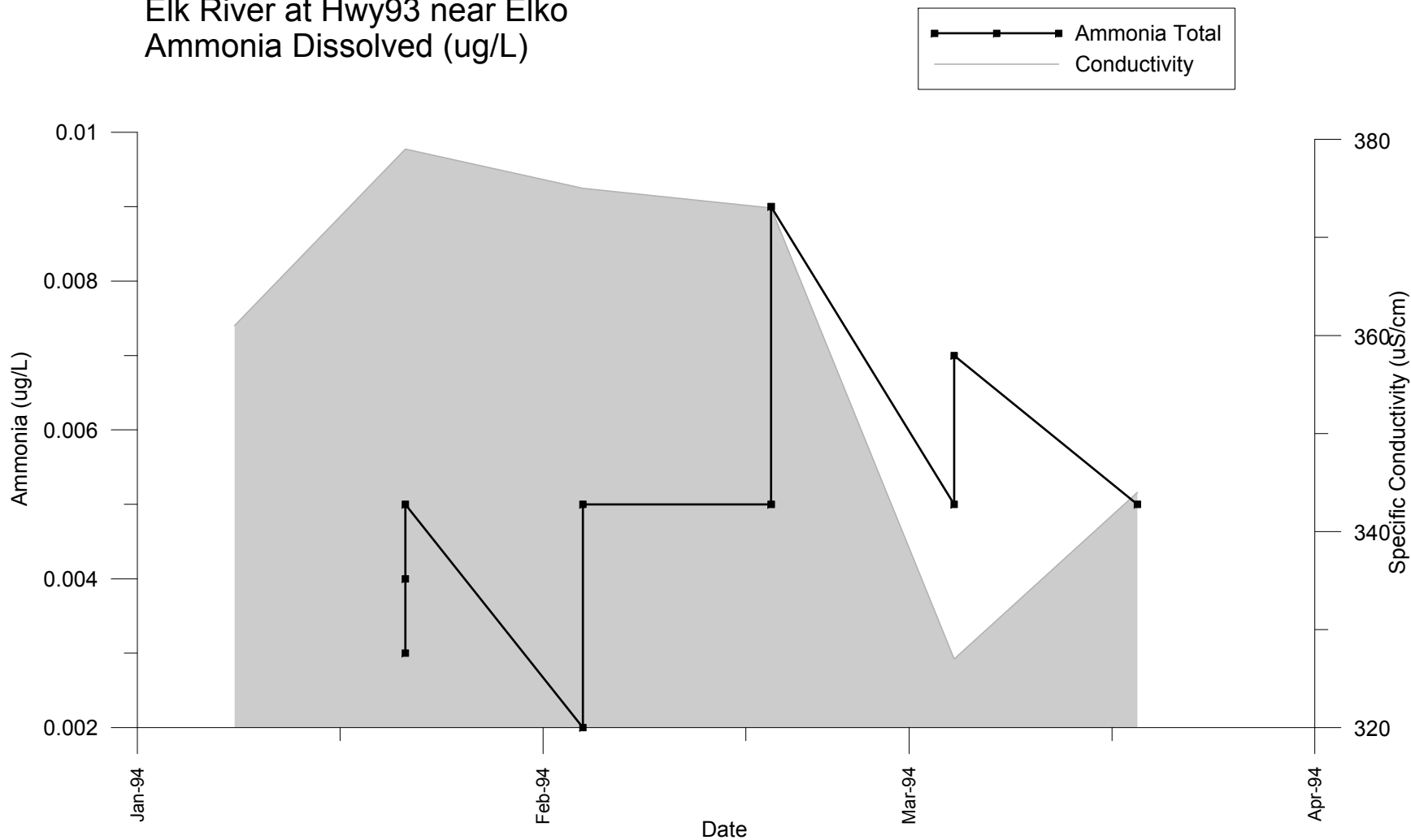


Figure 7
 Elk River at Hwy93 near Elko
 Antimony Total and Extractable(ug/L)

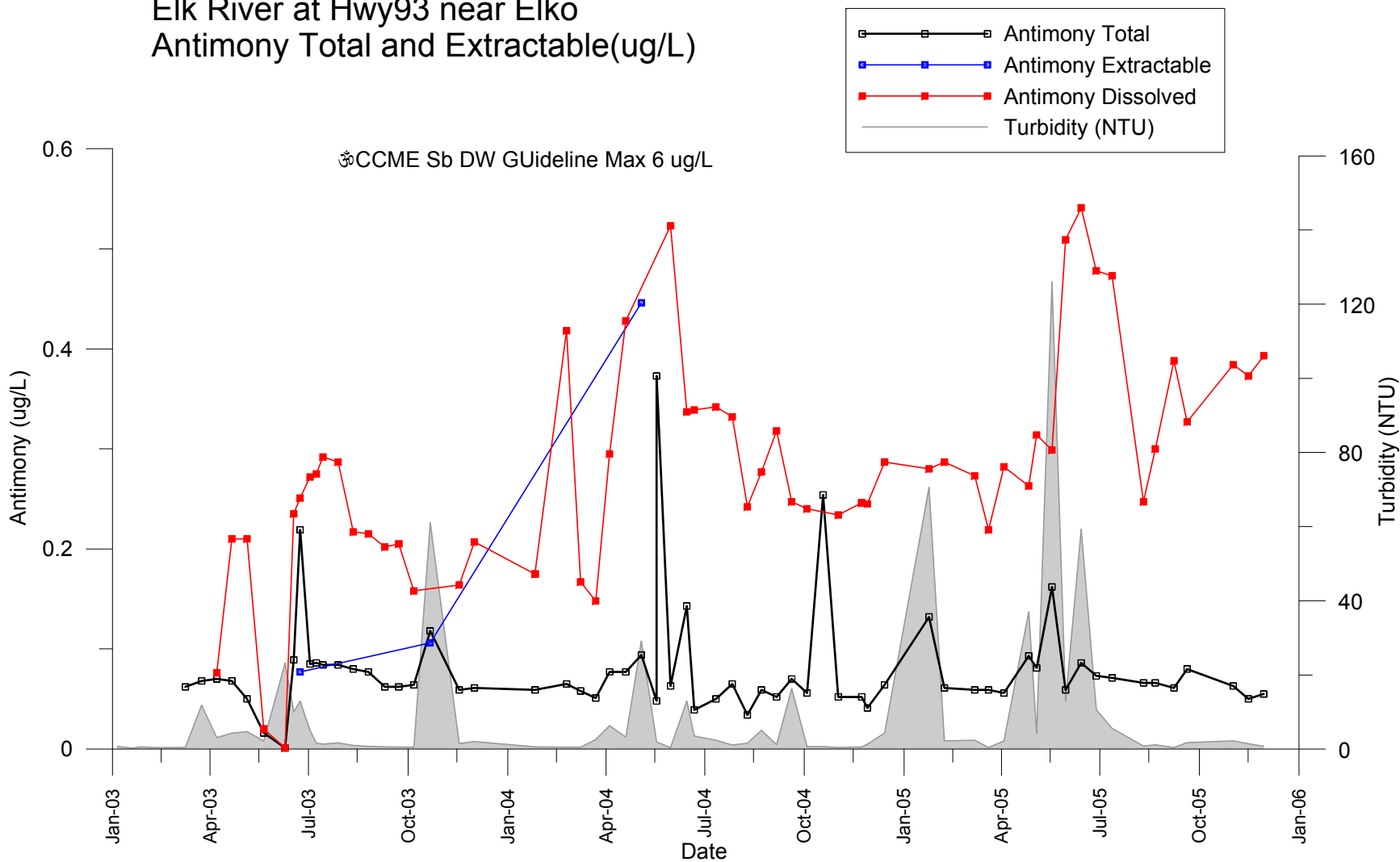


Figure 8
Elk River at Hwy93 near Elko
Arsenic Total (ug/L)
1984 - 2004

☞ CCME/B.C. Max DW guideline-25 ug/L
☞ CCME/B.C. Max Aquatic Life guideline-5 ug/L

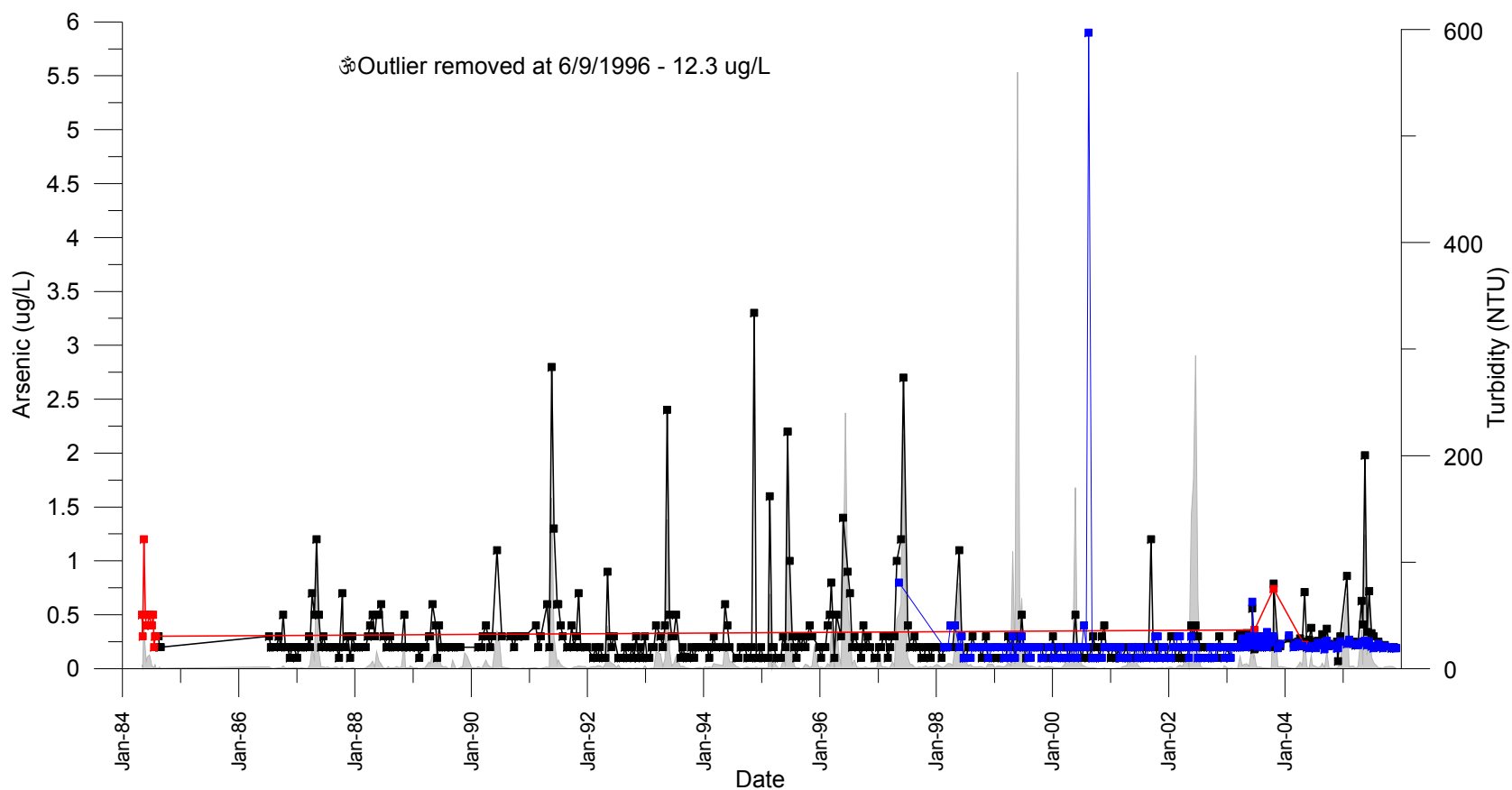
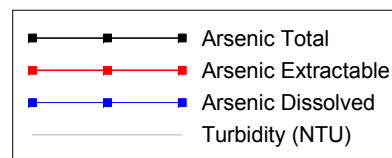


Figure 9
 Elk River at Hwy93 near Elko
 Arsenic Total, Dissolved and Extractable (ug/L)
 1997 - 2006

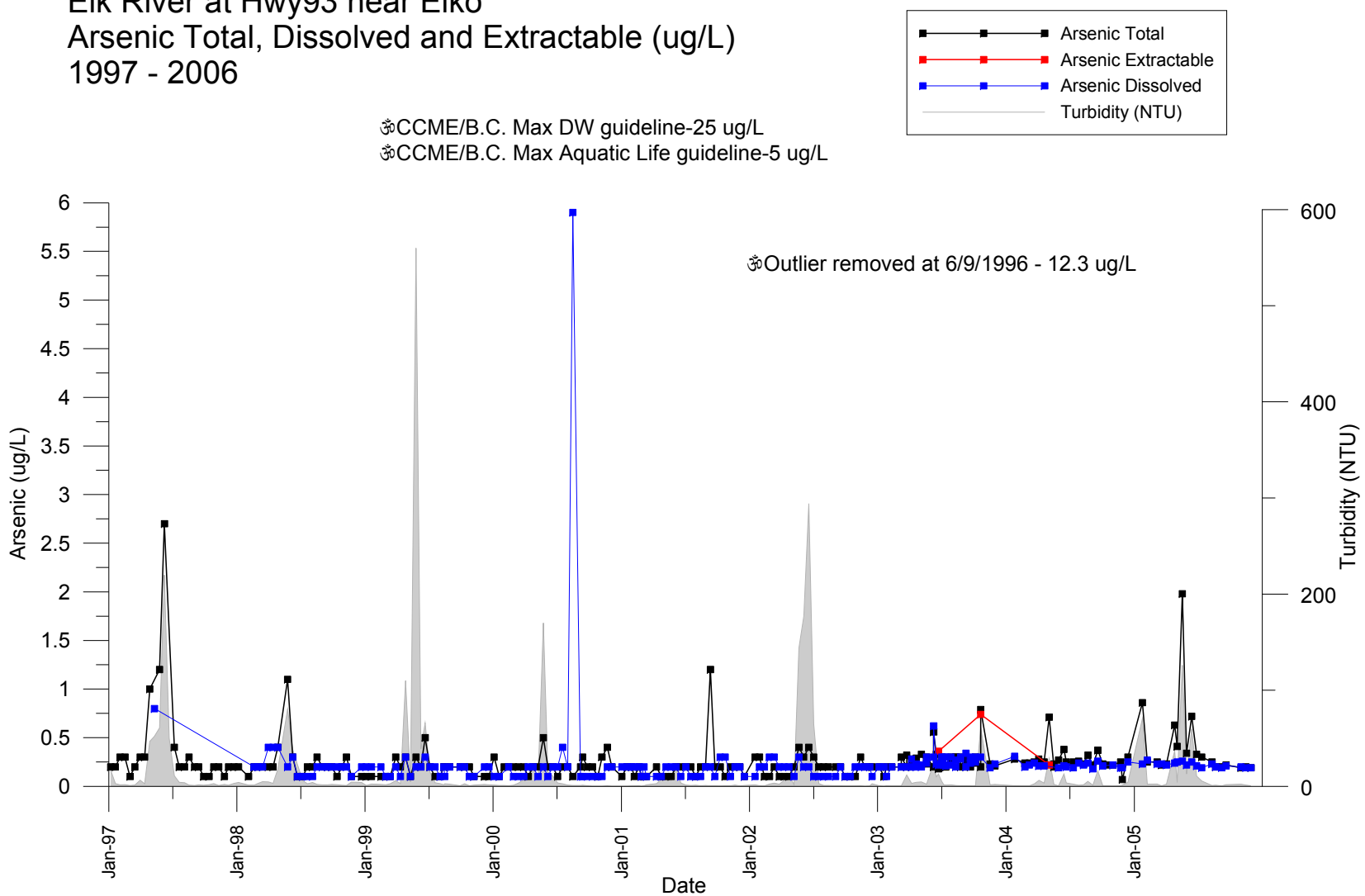


Figure 10
 Elk River at Hwy93 near Elko
 Barium Total, Dissolved and Extractable(ug/L)
 1990 - 2006

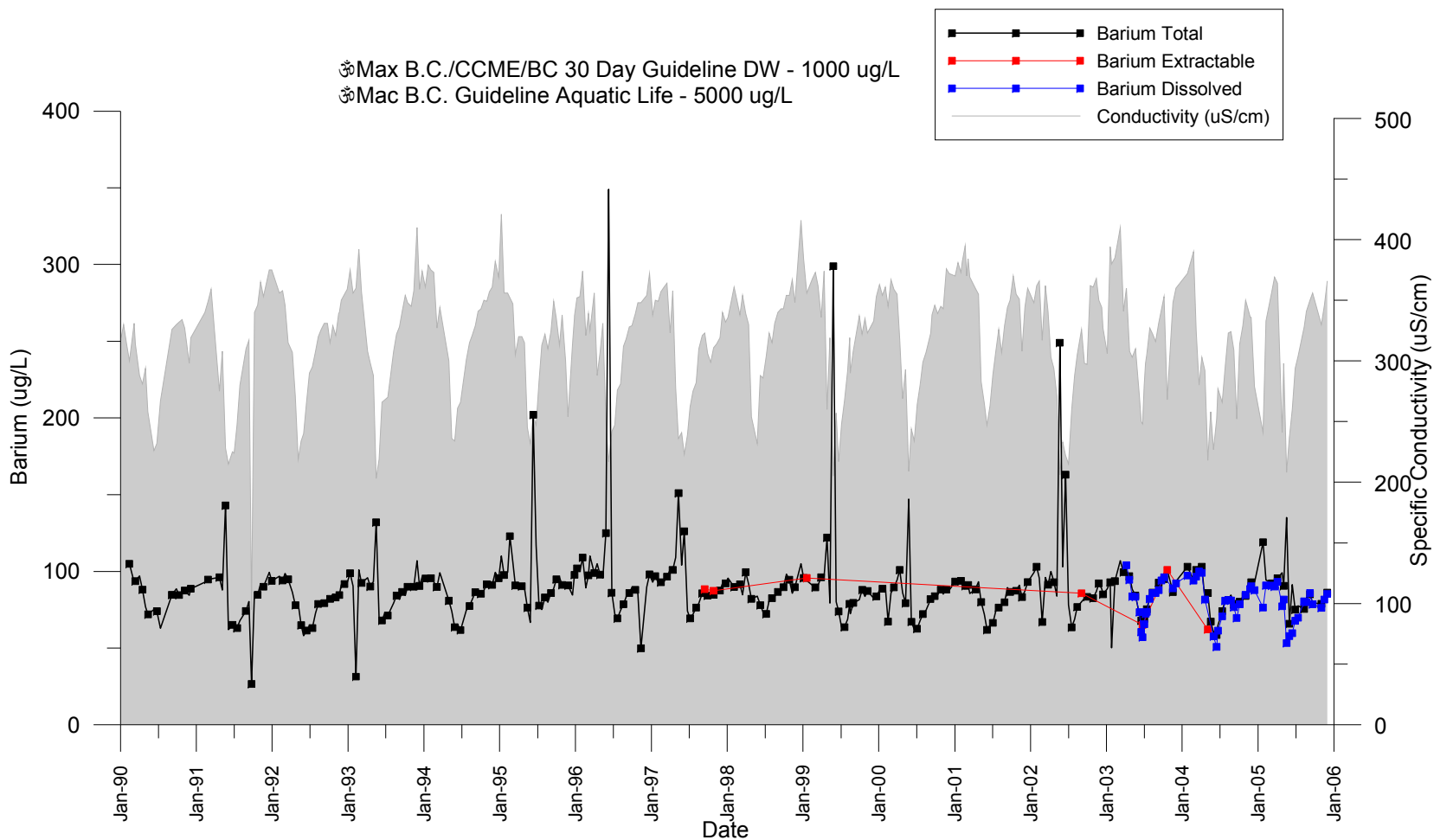


Figure 10 (A)
 Elk River at Hwy93 near Elko
 Barium Total, Dissolved and Extractable(ug/L)
 2003 - 2006

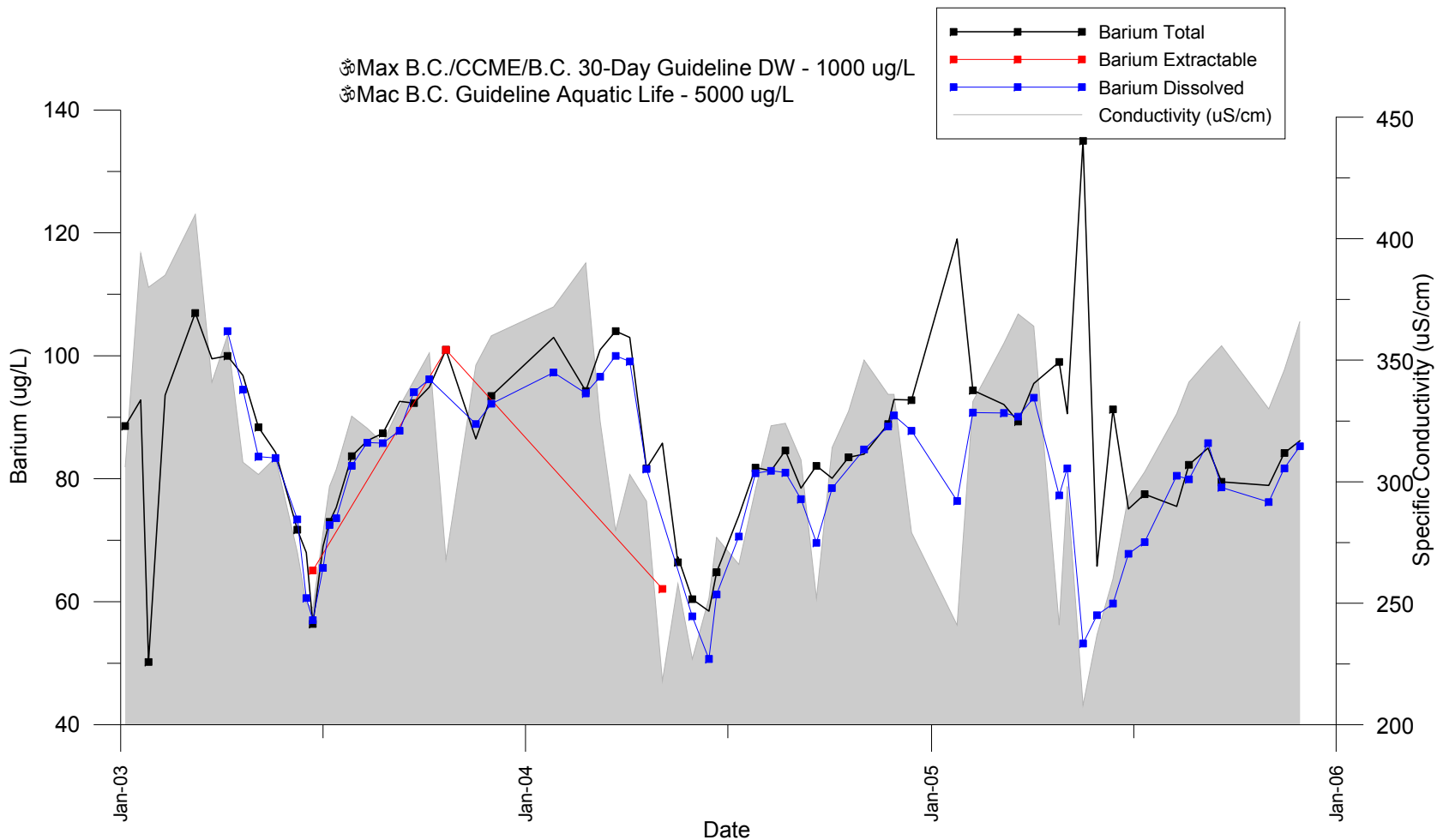


Figure 11
 Elk River at Hwy93 near Elko
 Beryllium Total, Dissolved and Extractable(ug/L)
 1990 - 2005

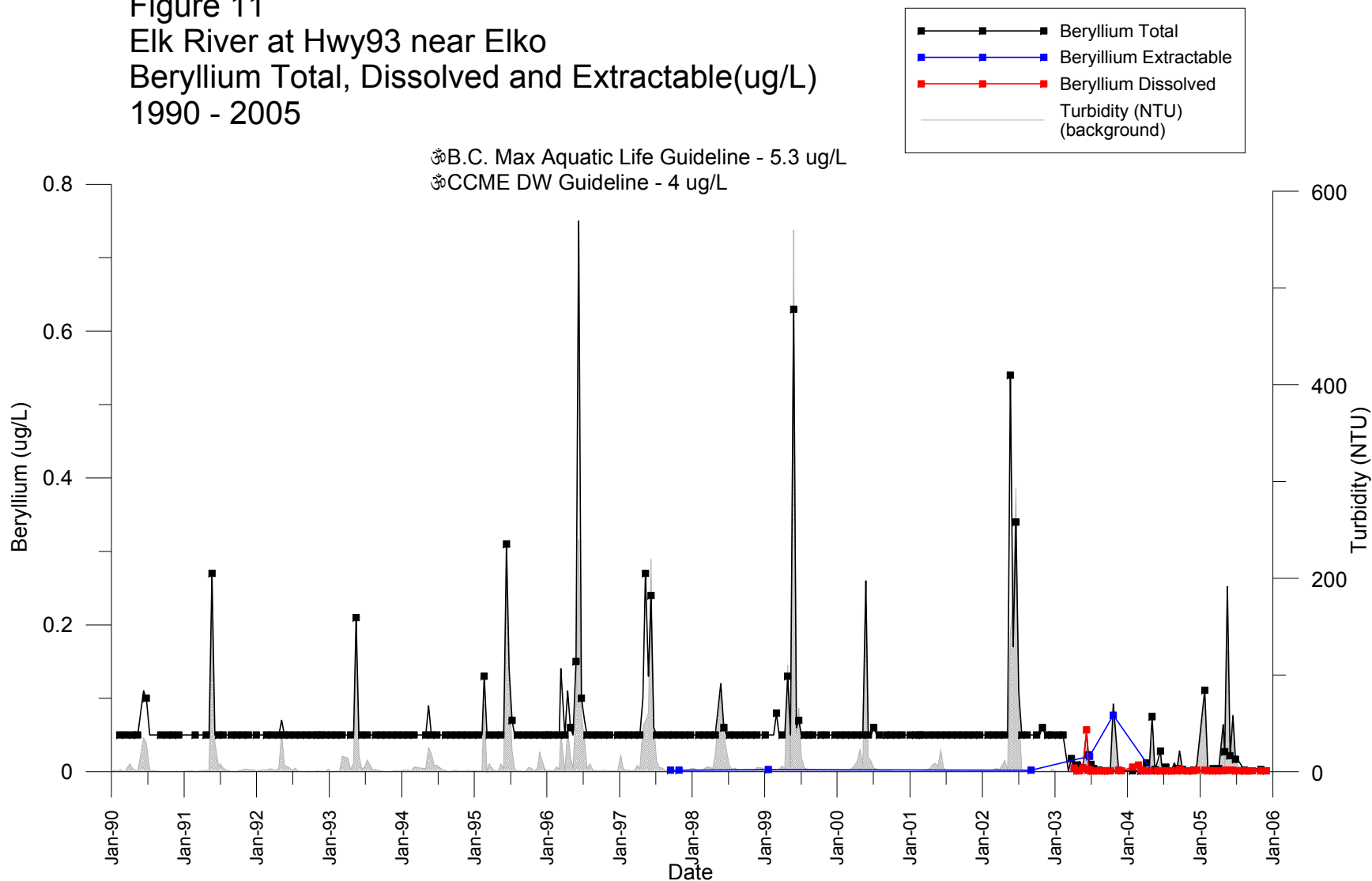


Figure 12
 Elk River at Hwy93 near Elko
 Beryllium Total, Dissolved and Extractable(ug/L)
 2003 - 2005

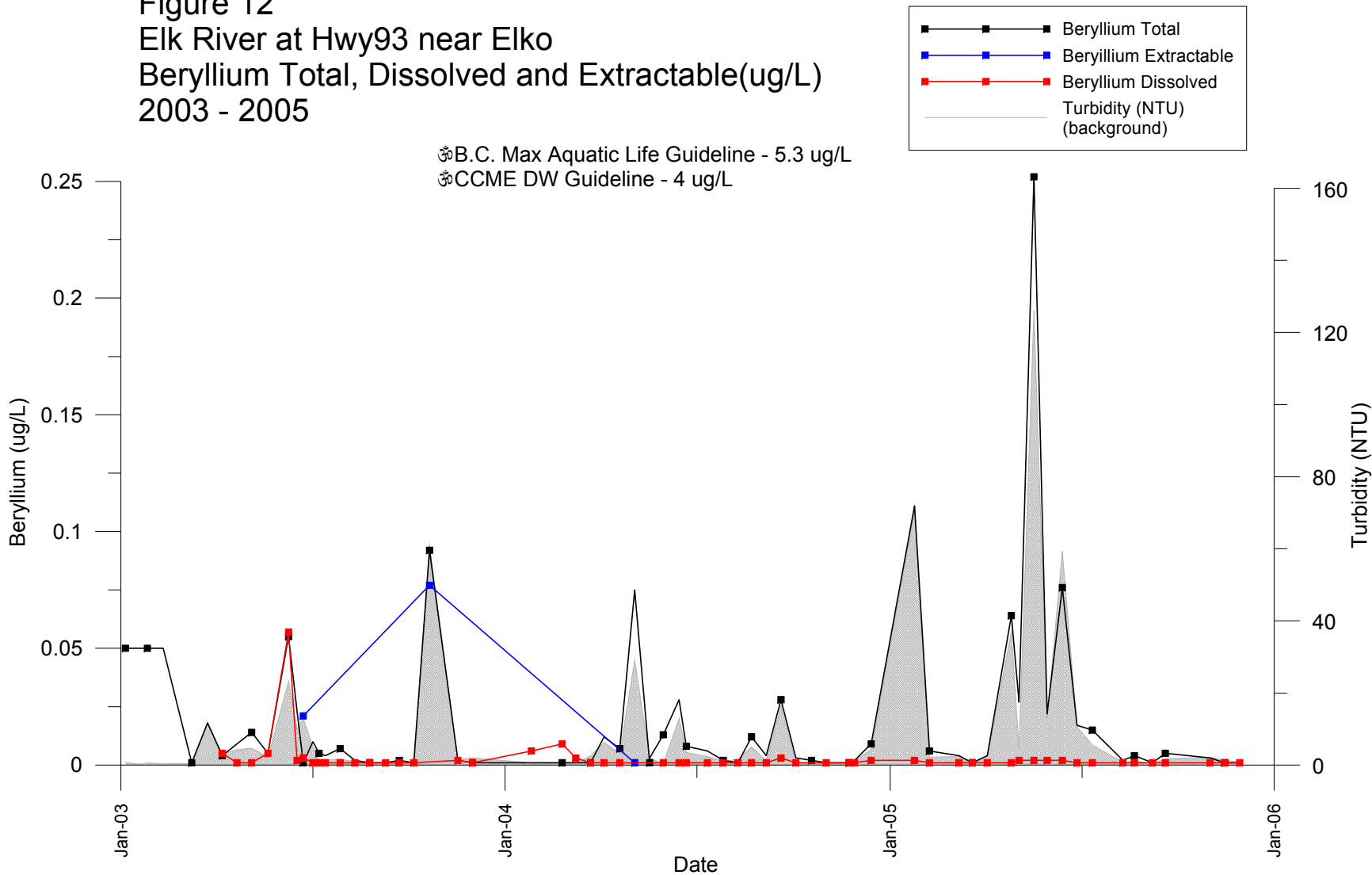


Figure 13
 Elk River at Hwy93 near Elko
 Bismuth Total, Dissolved and Extractable (ug/L)

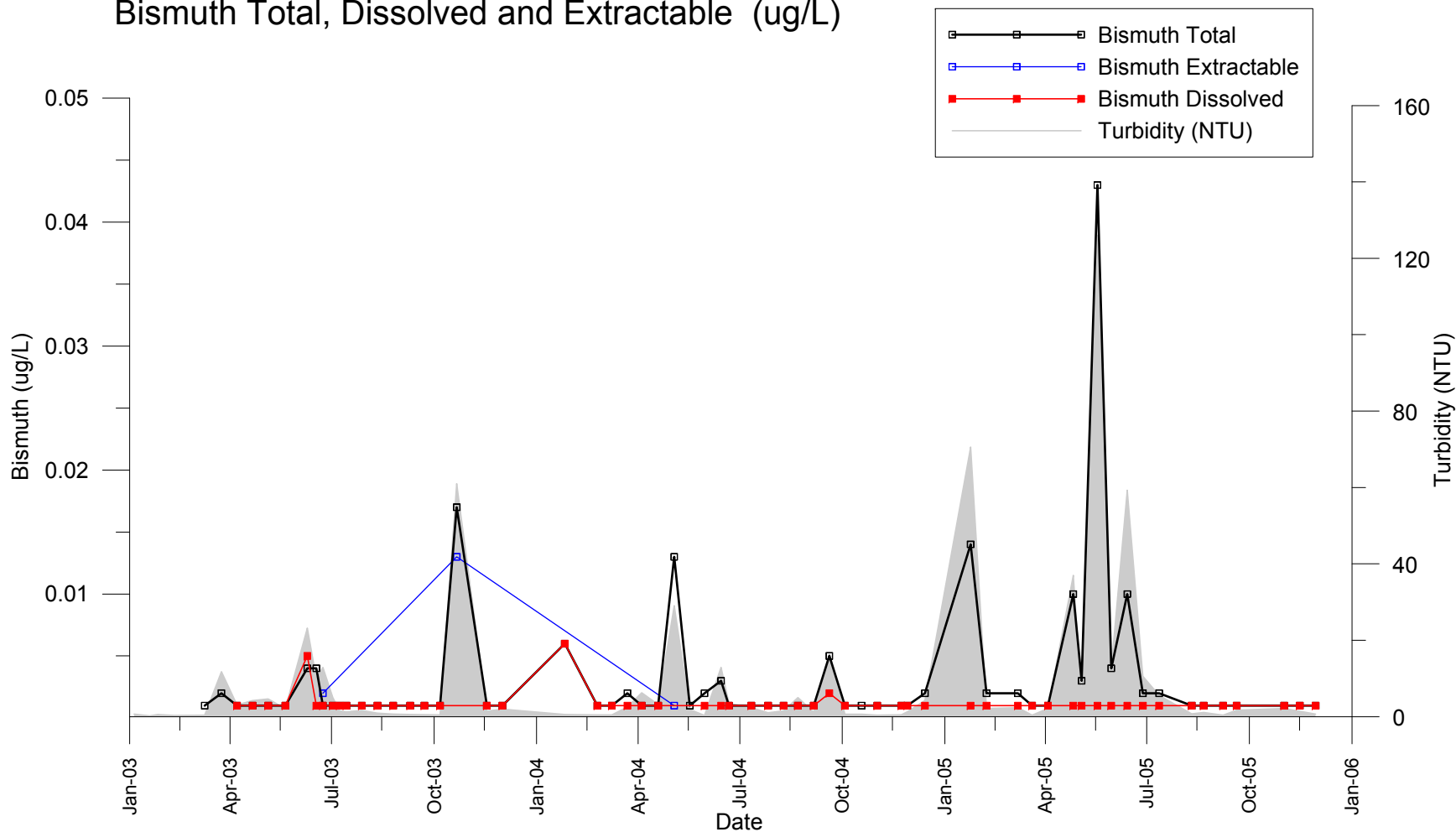


Figure 14
Elk River at Hwy93 near Elko
Boron Total, Dissolved and Extractable (ug/L)
1997 - 2006

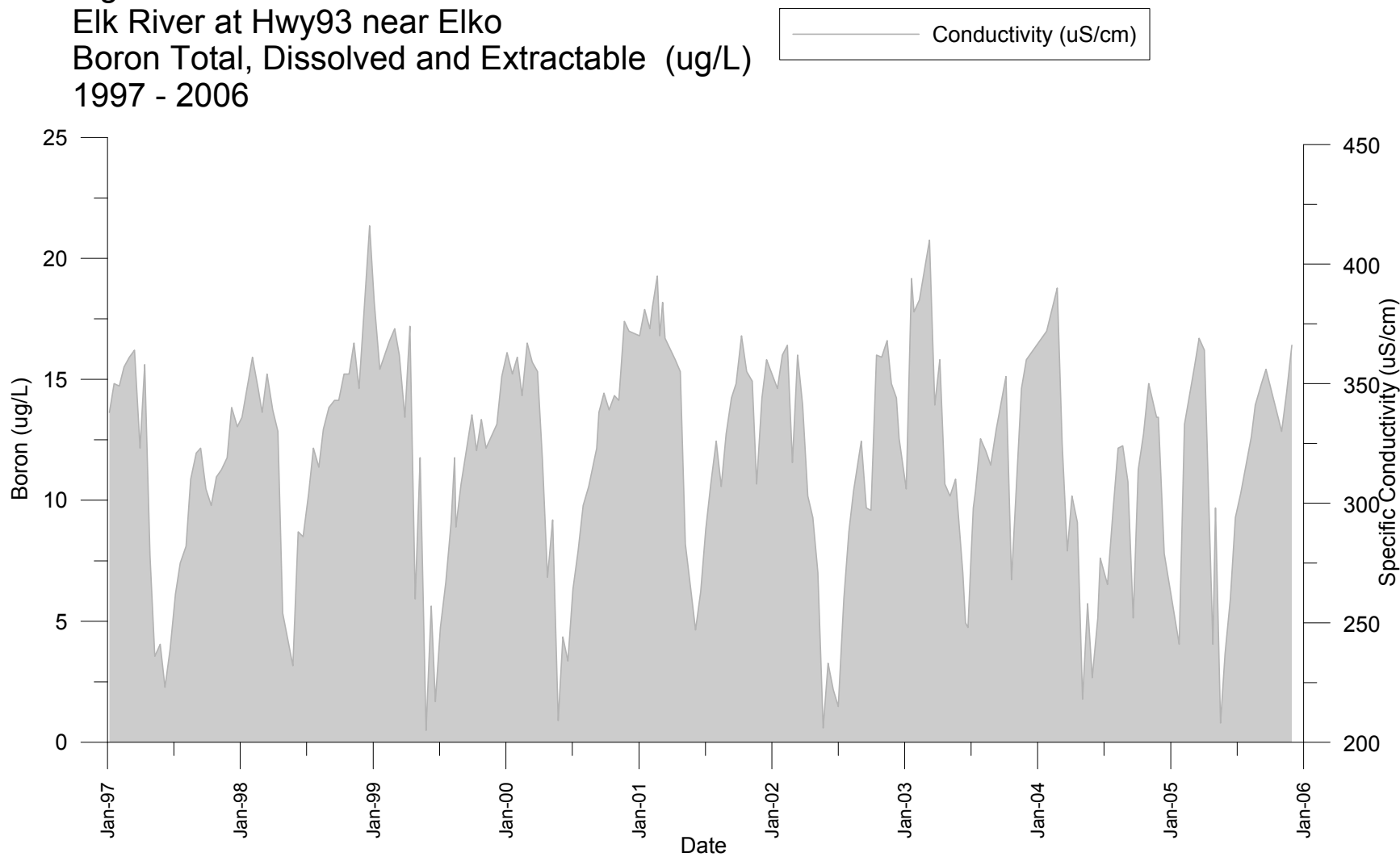


Figure 15
 Elk River at Hwy93 near Elko
 Boron Total, Dissolved and Extractable (ug/L)
 2003 - 2006

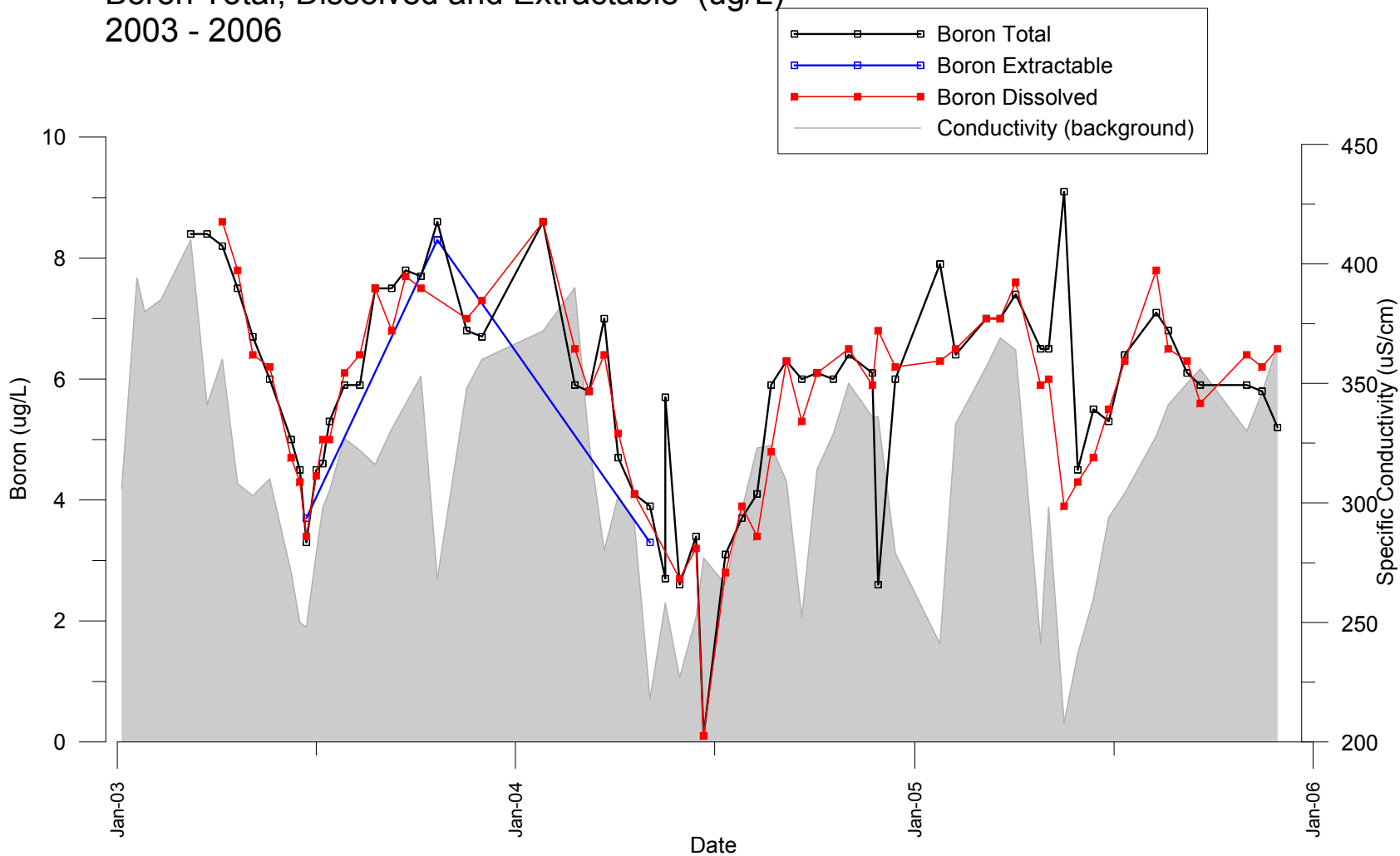


Figure 16
Elk River at Hwy93 near Elko
Bromide Dissolved (ug/L)

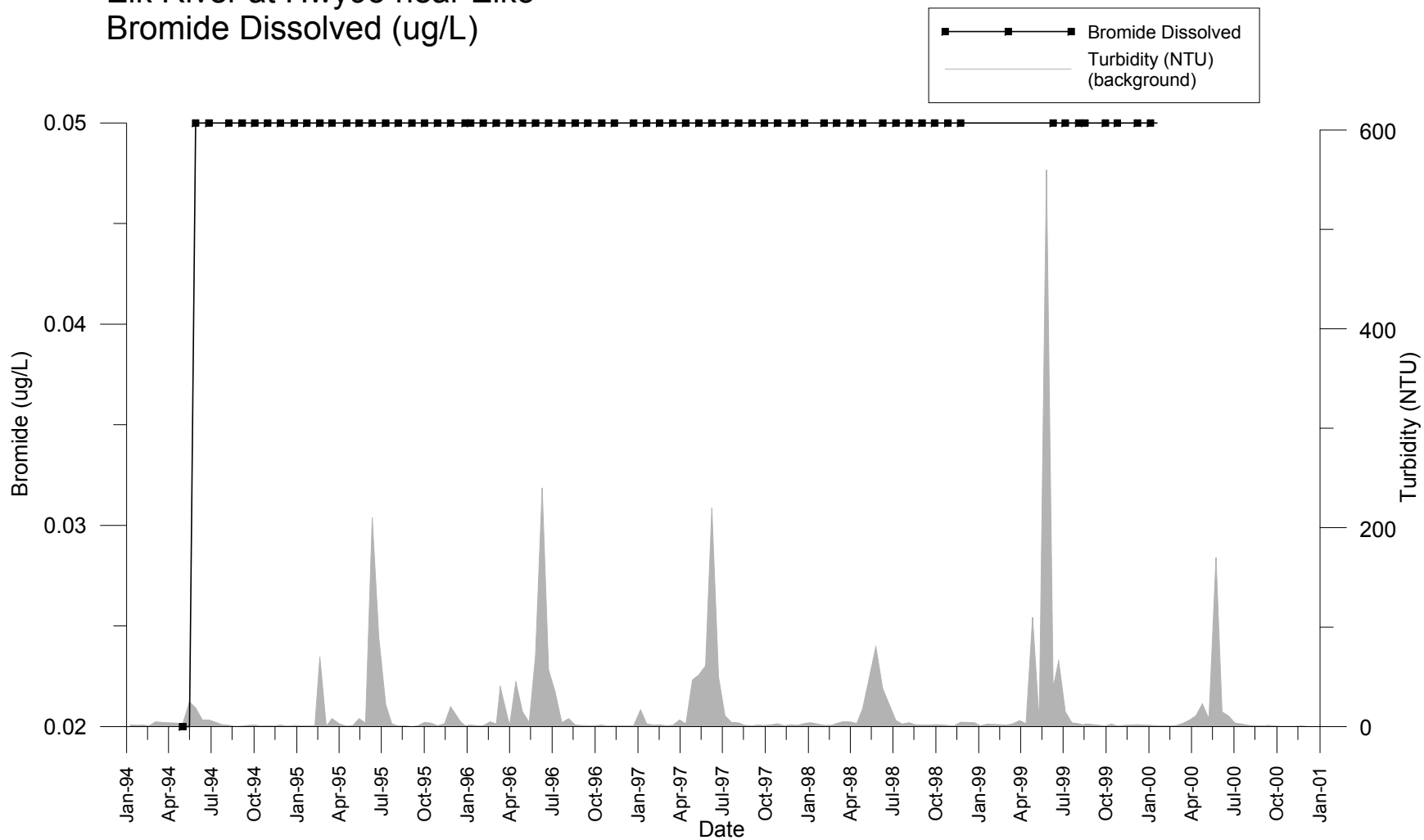


Figure 17
 Elk River at Hwy93 near Elko
 Cadmium Total, Dissolved and Extractable (ug/L)
 1984 - 2005

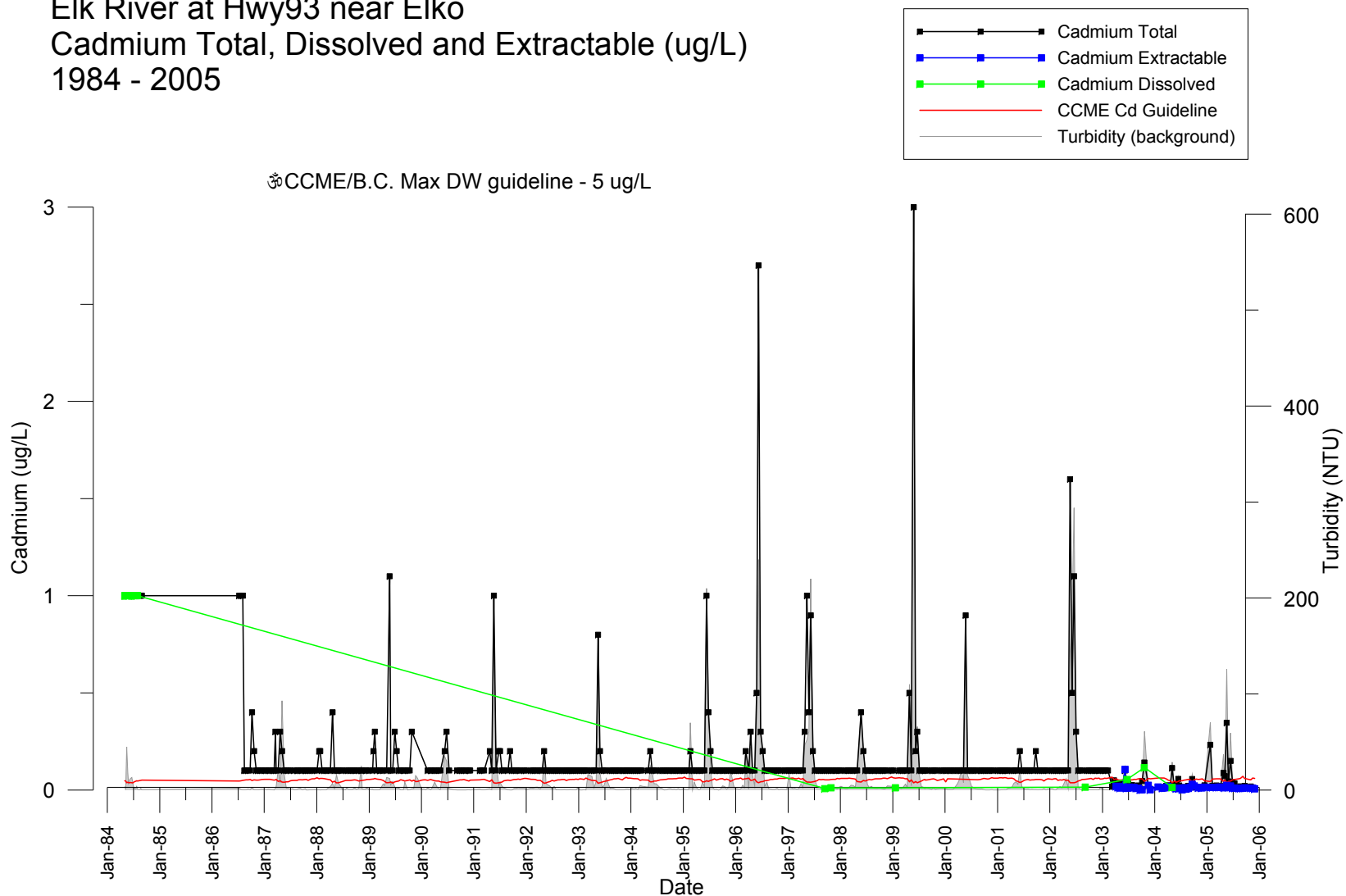


Figure 18
 Elk River at Hwy93 near Elko
 Cadmium Total, Dissolved and Extractable (ug/L)
 2003 - 2006

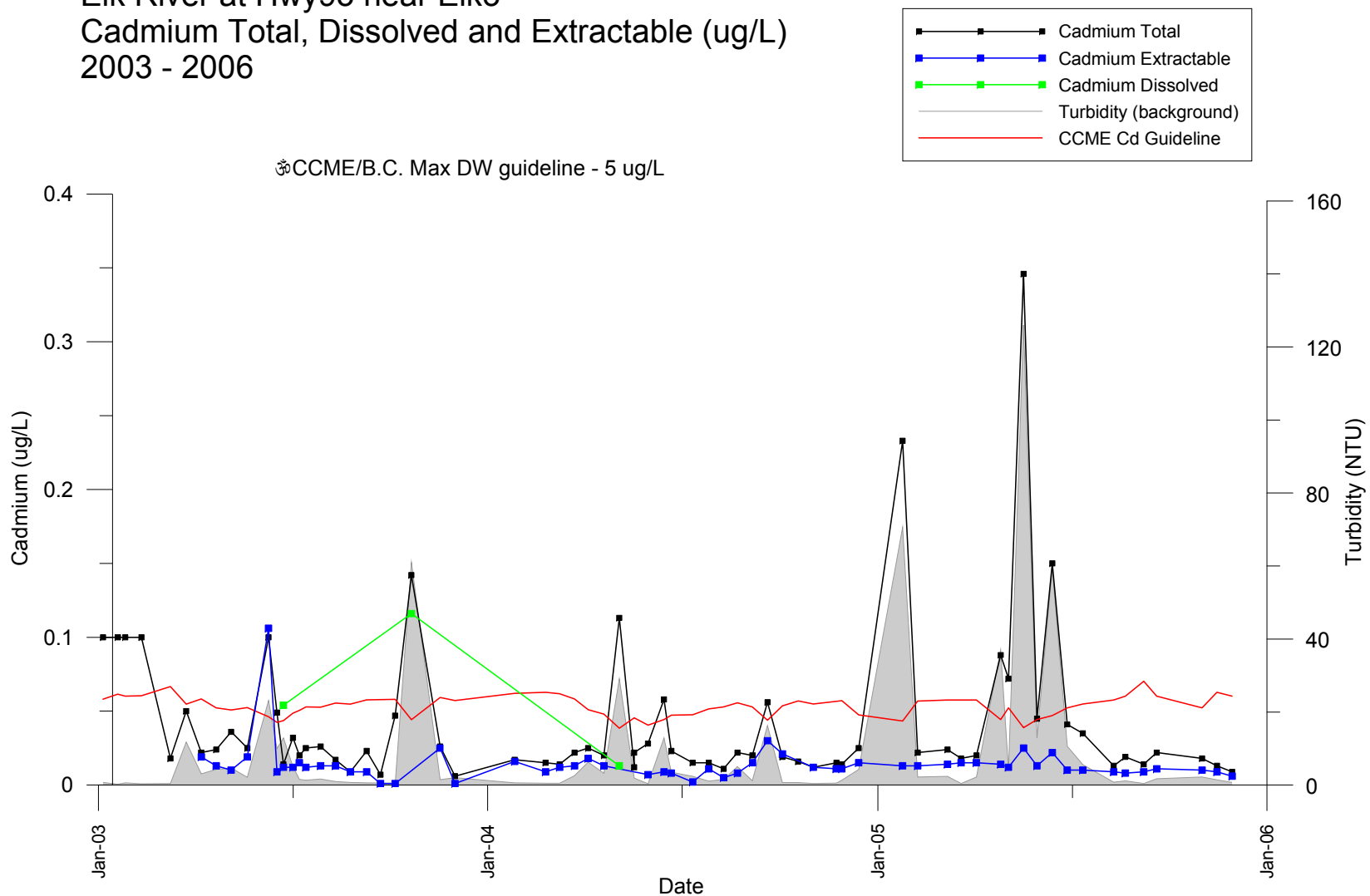


Figure 19
Elk River at Hwy93 near Elko
Calcium Dissolved and Extractable (mg/L)

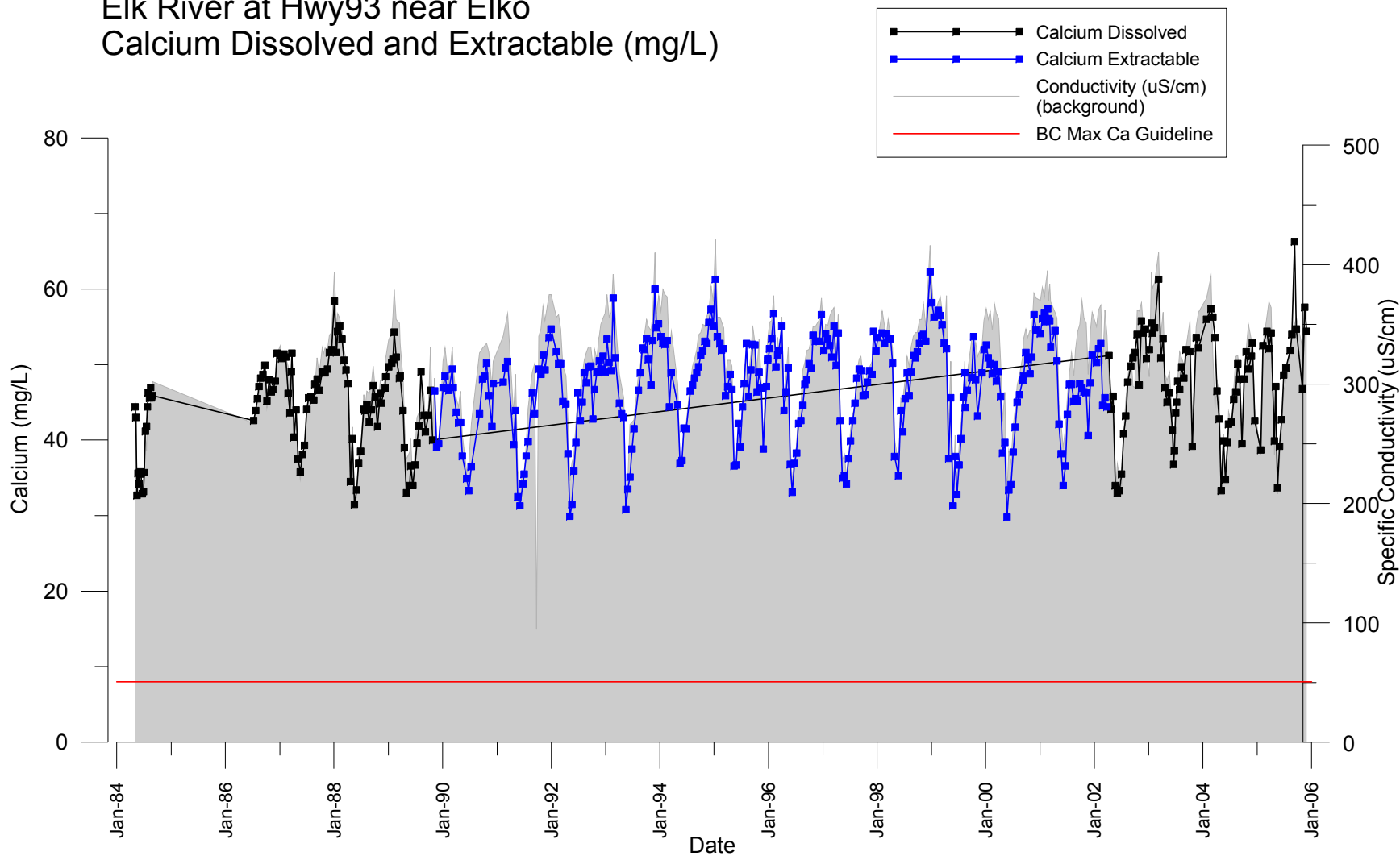


Figure 20
Elk River at Hwy93 near Elko
Carbon Dissolved Inorganic and Organic(mg/L)
1997 - 2005

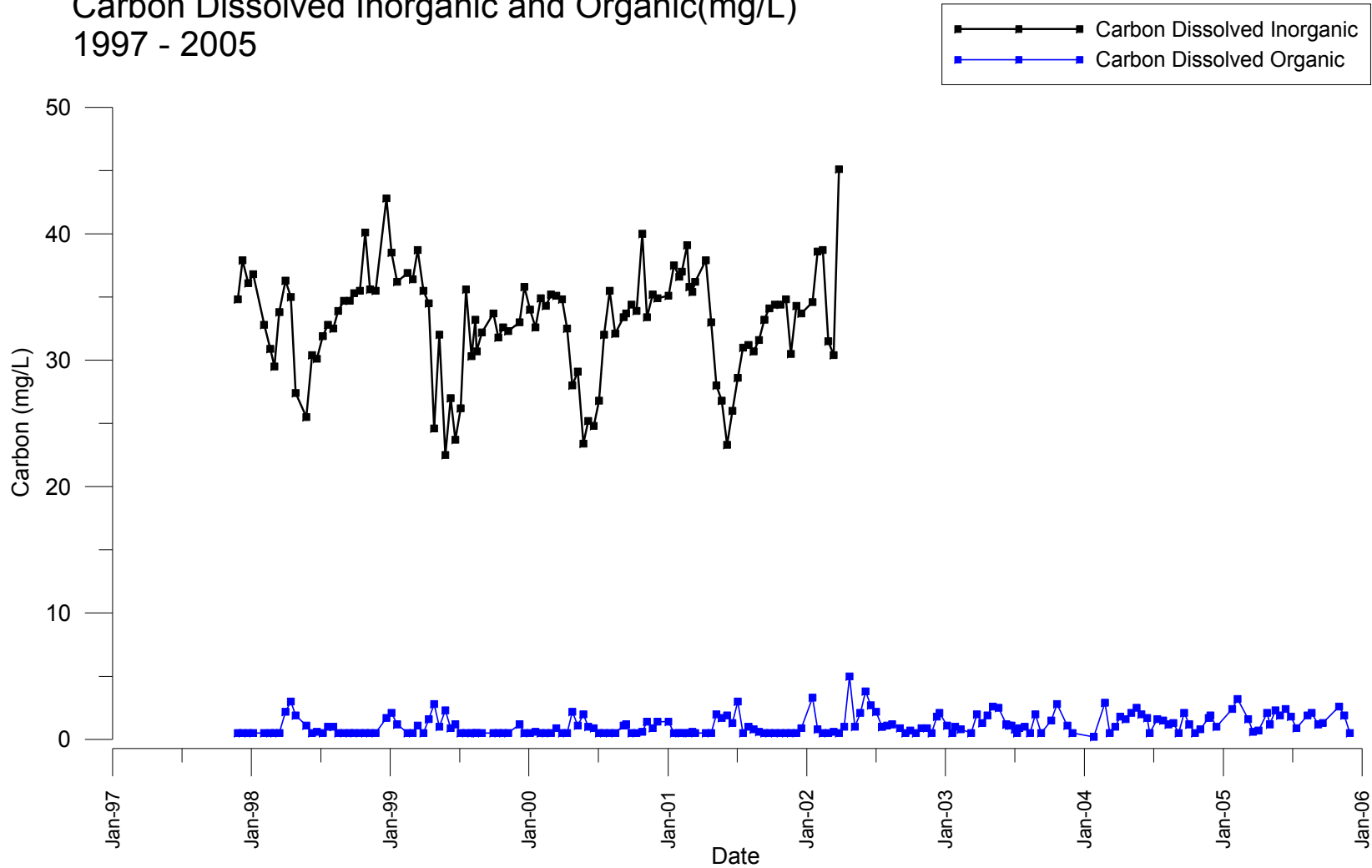


Figure 21 (A)
 Elk River at Hwy93 near Elko
 Carbon Dissolved Organic (mg/L)
 1997 - 2005

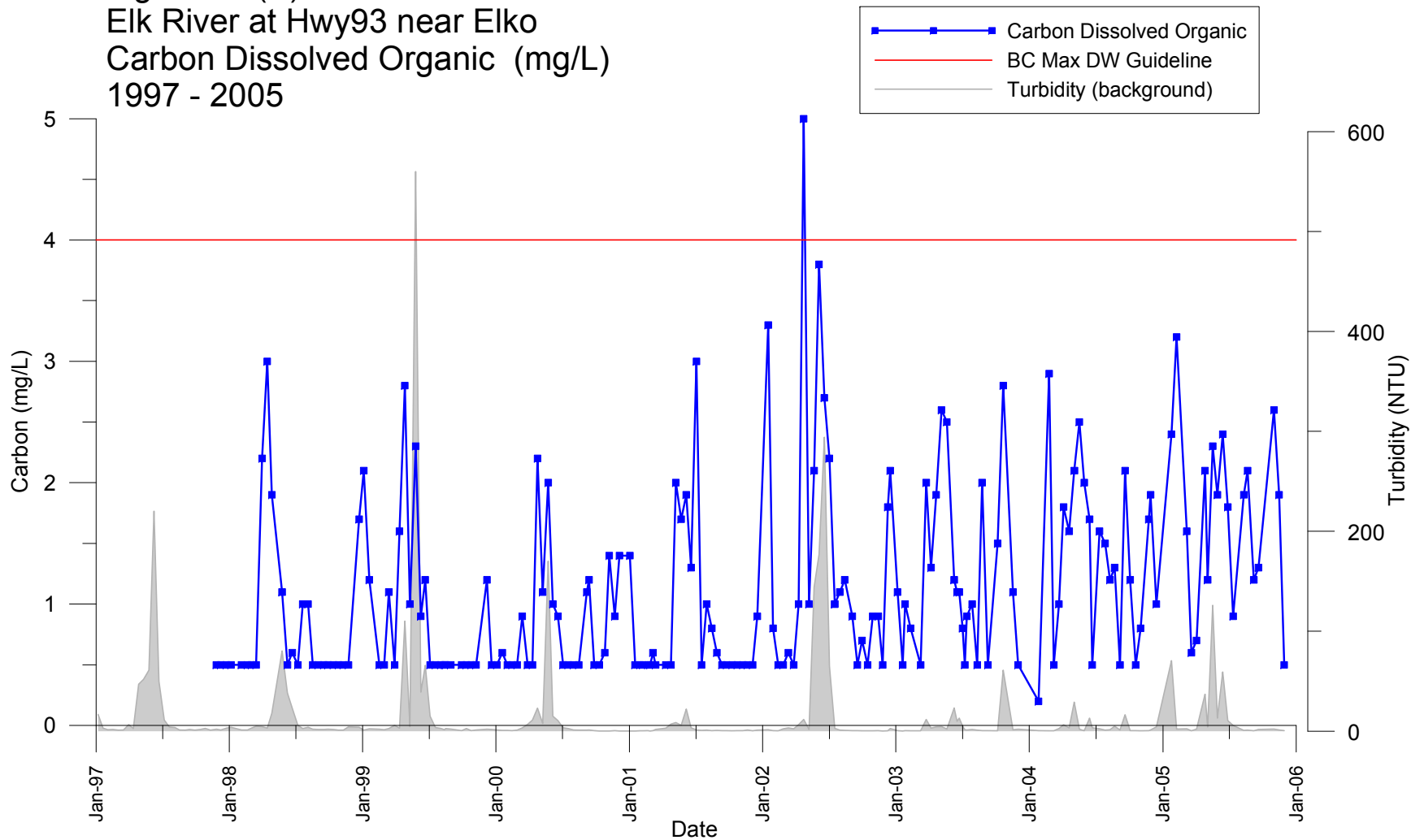


Figure 21 (B)
Elk River at Hwy93 near Elko
Carbon Dissolved Inorganic (mg/L)
1997 - 2005

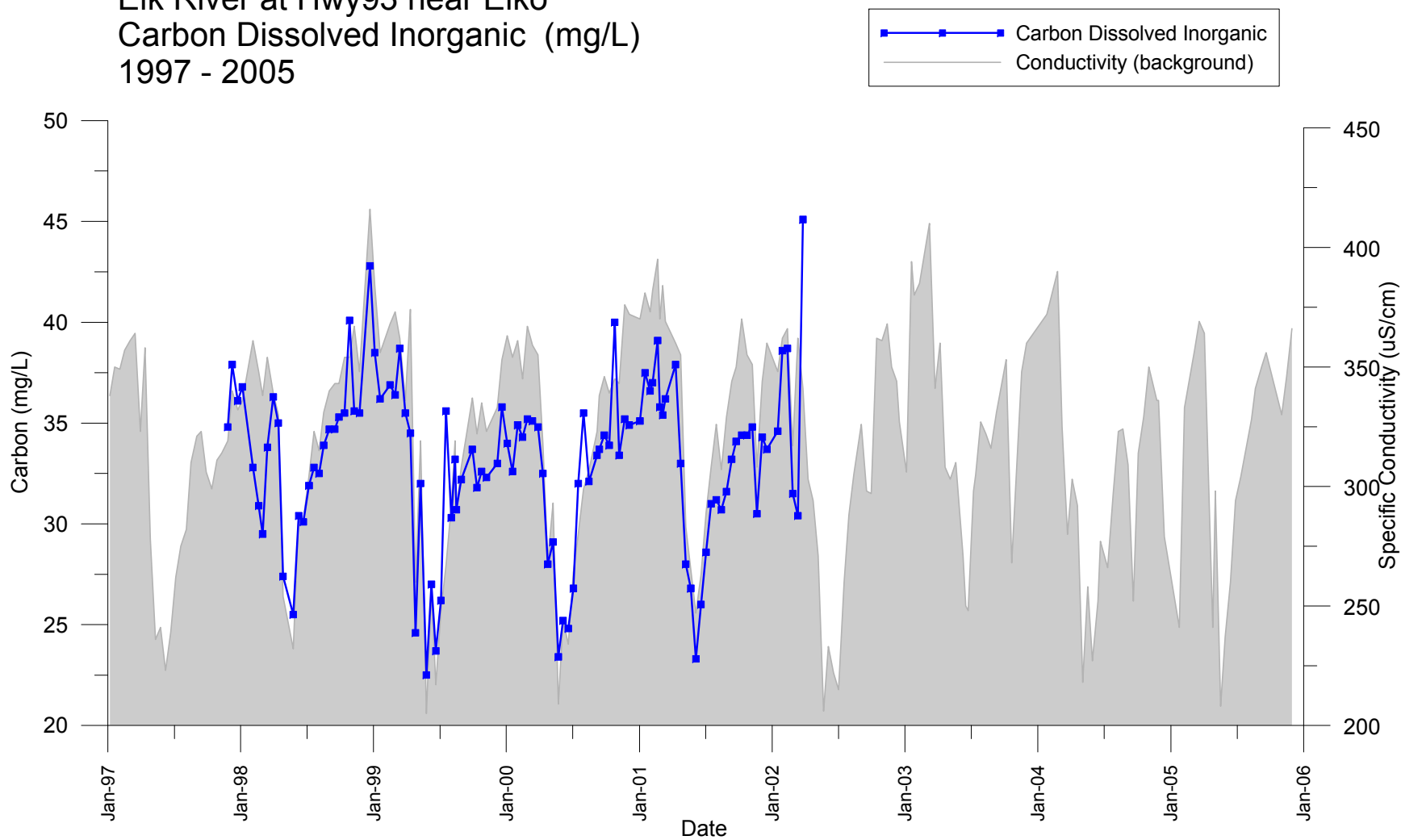


Figure 22
Elk River at Hwy93 near Elko
Chloride Dissolved (mg/L)

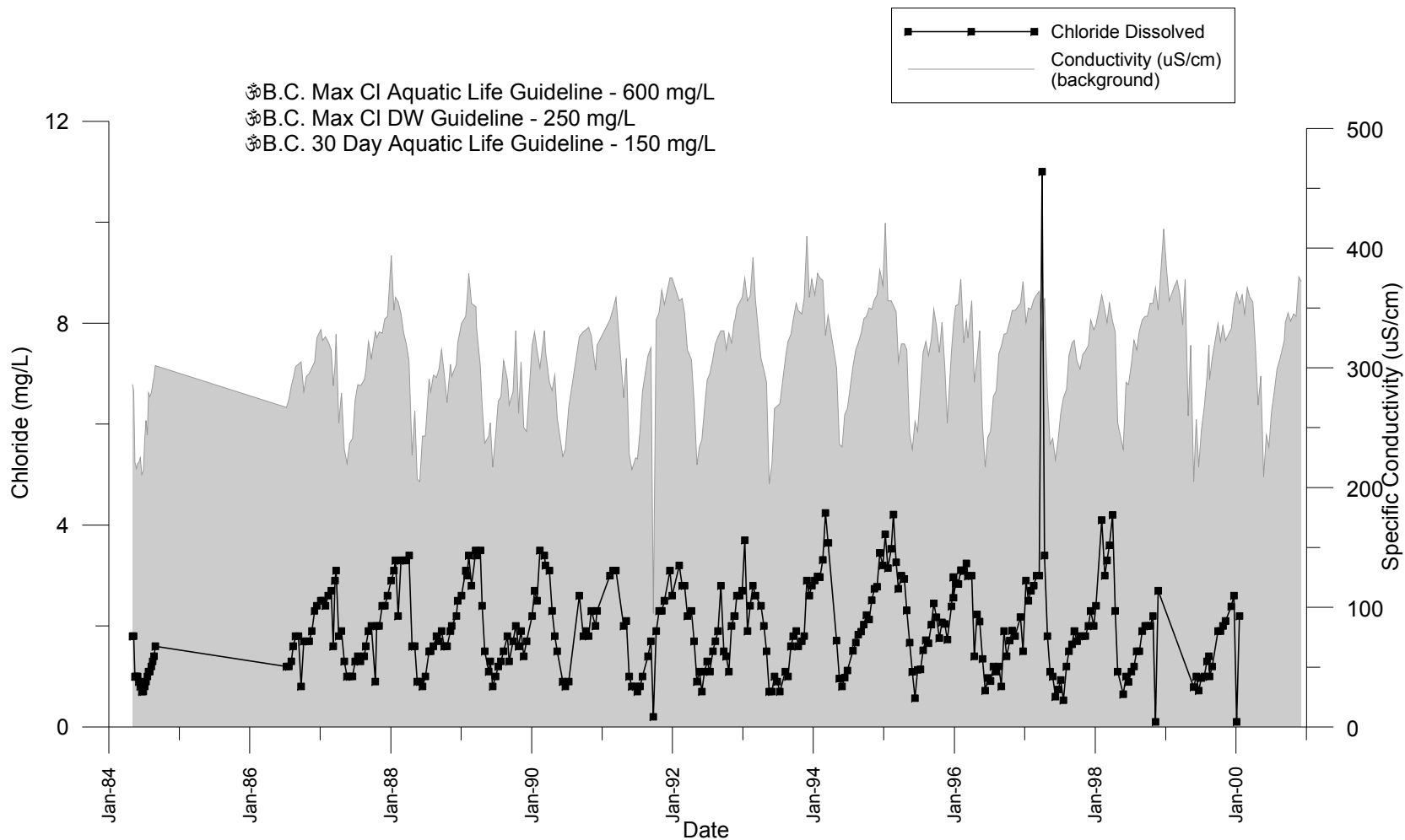


Figure 23
 Elk River at Hwy93 near Elko
 Chromium Total, Dissolved and Extractable (ug/L)
 1987 - 2006

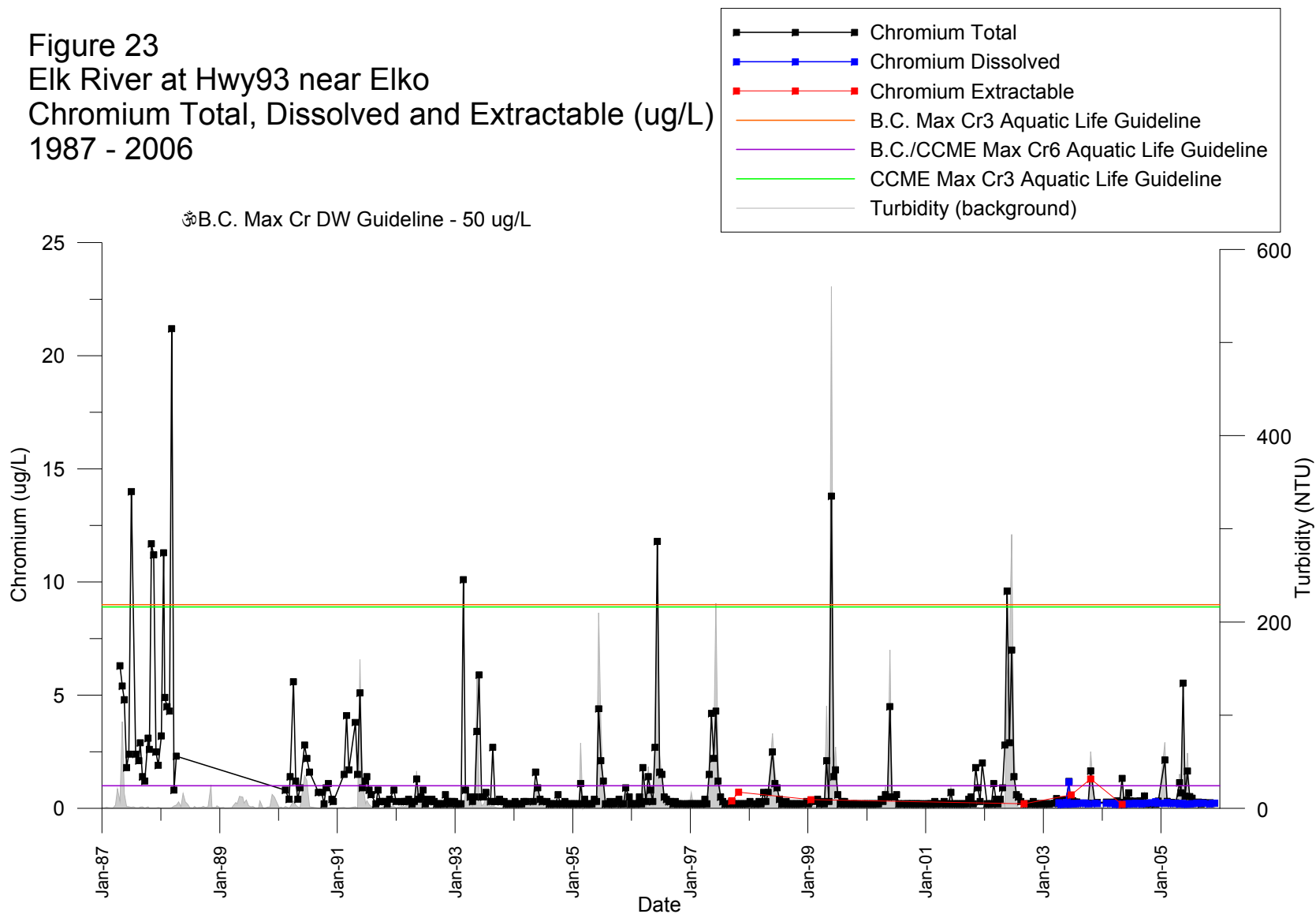


Figure 24
 Elk River at Hwy93 near Elko
 Chromium Total, Dissolved and Extractable (ug/L)
 2003 - 2006

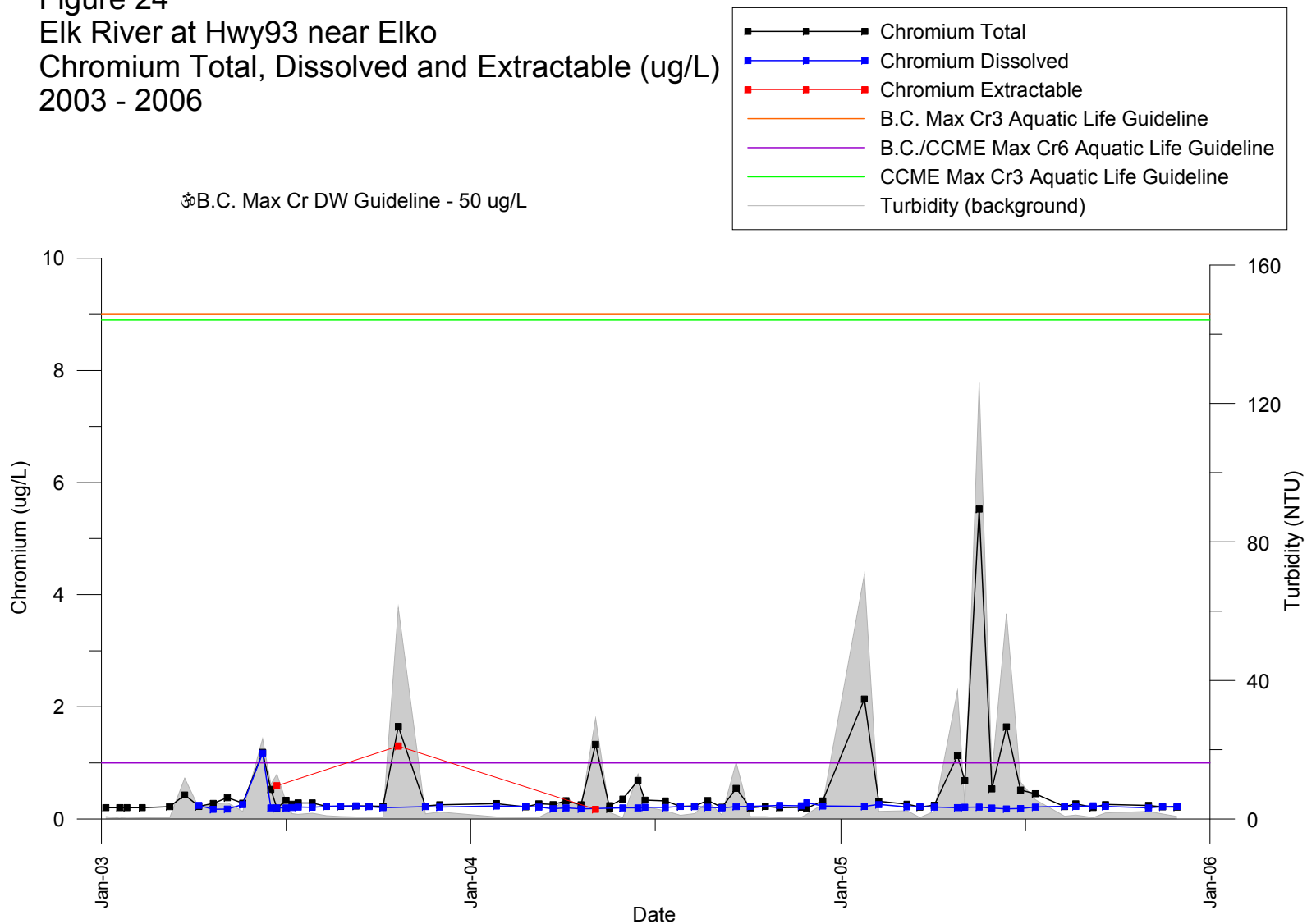


Figure 25
 Elk River at Hwy93 near Elko
 Cobalt Total, Dissolved and Extractable (ug/L)
 1990 - 2005

☞ B.C. Max Co Aquatic Life Guideline - 110 ug/L
 ☞ B.C. 30 Day Co Aquatic Life Guideline - 4 ug/L

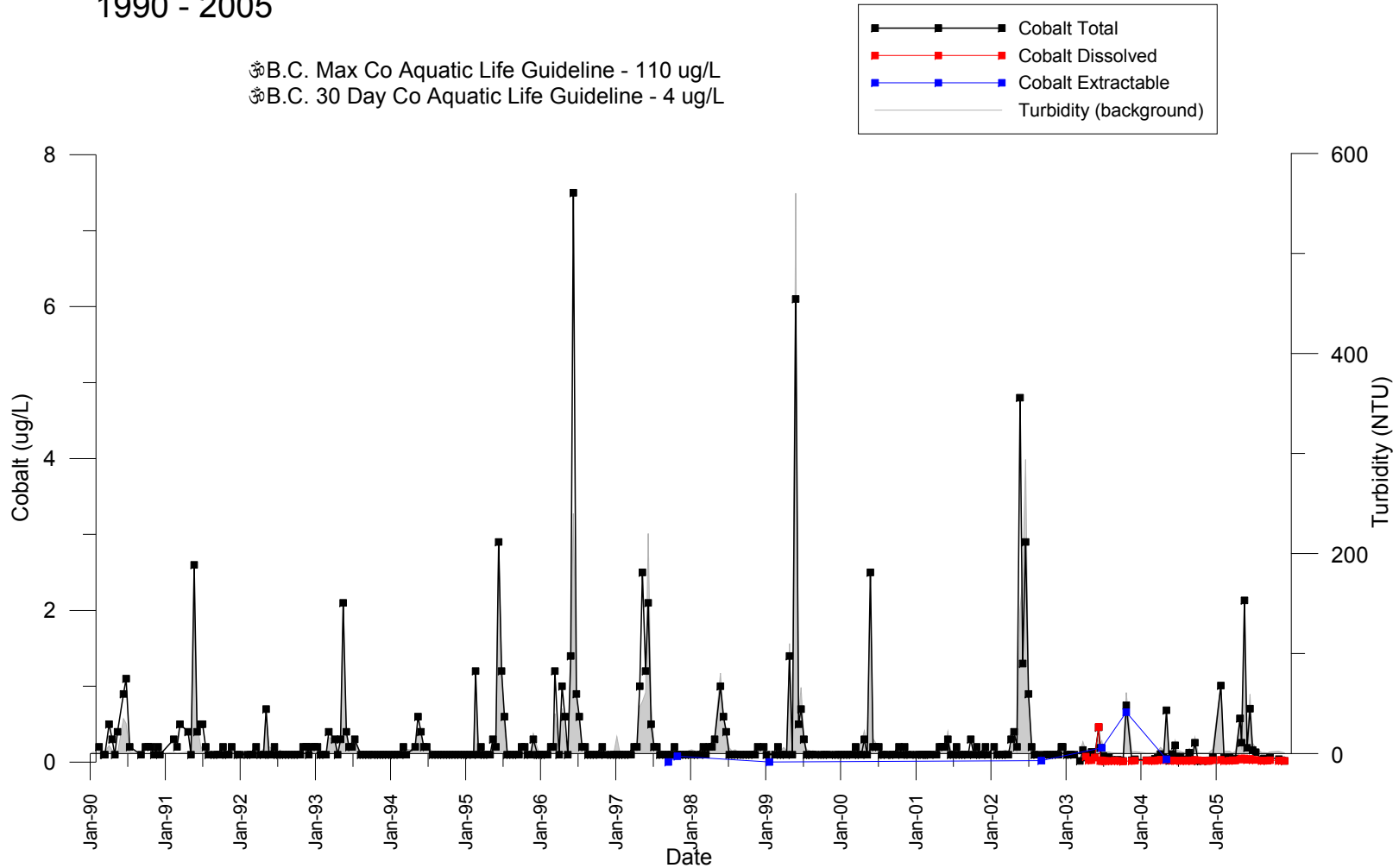


Figure 26
 Elk River at Hwy93 near Elko
 Cobalt Total, Dissolved and Extractable (ug/L)
 2003 - 2005

☞ B.C. Max Co Aquatic Life Guideline - 110 ug/L
 ☞ B.C. 30 Day Co Aquatic Life Guideline - 4 ug/L

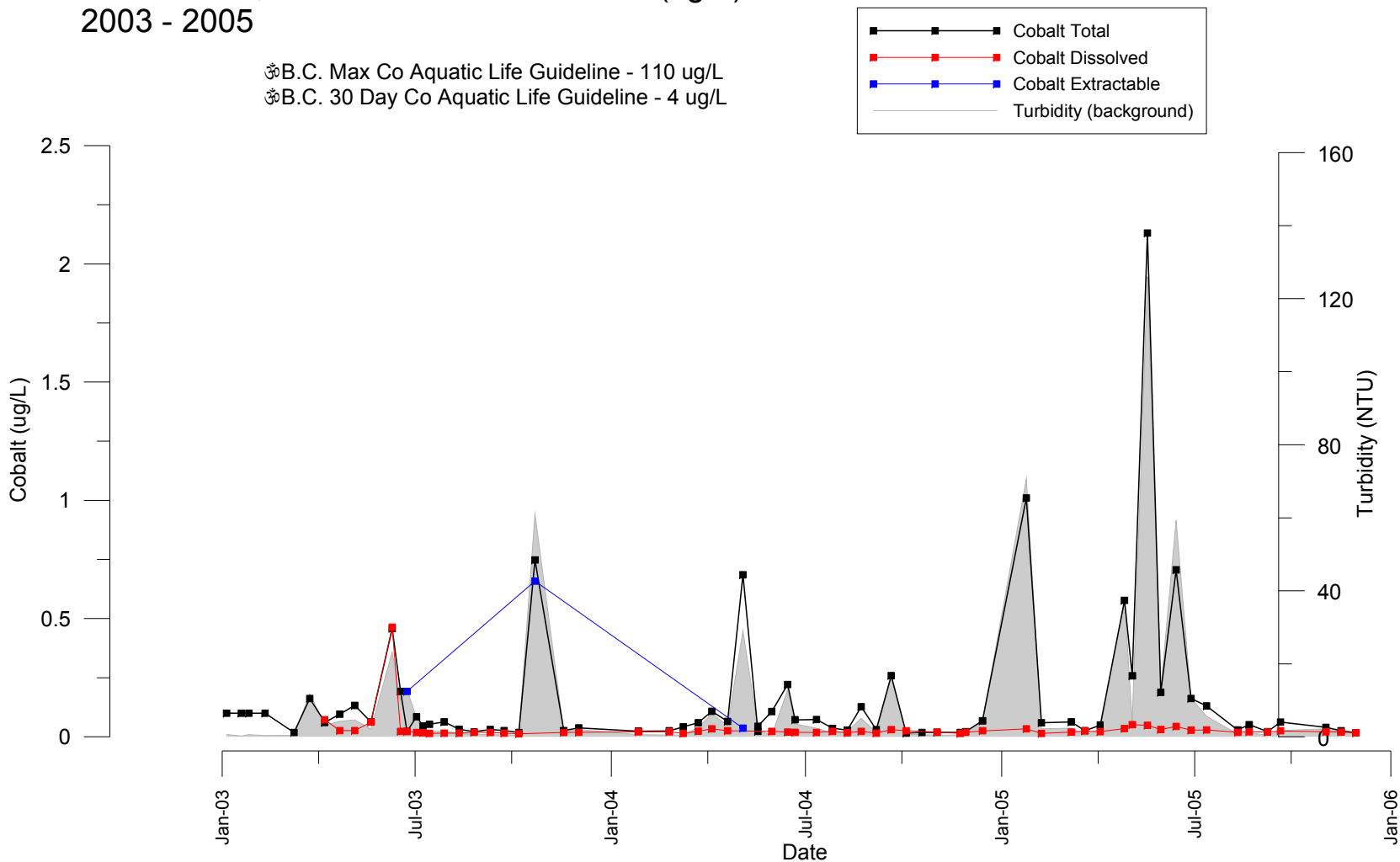


Figure 27
 Elk River at Hwy93 near Elko
 Colour True (Colour Units)

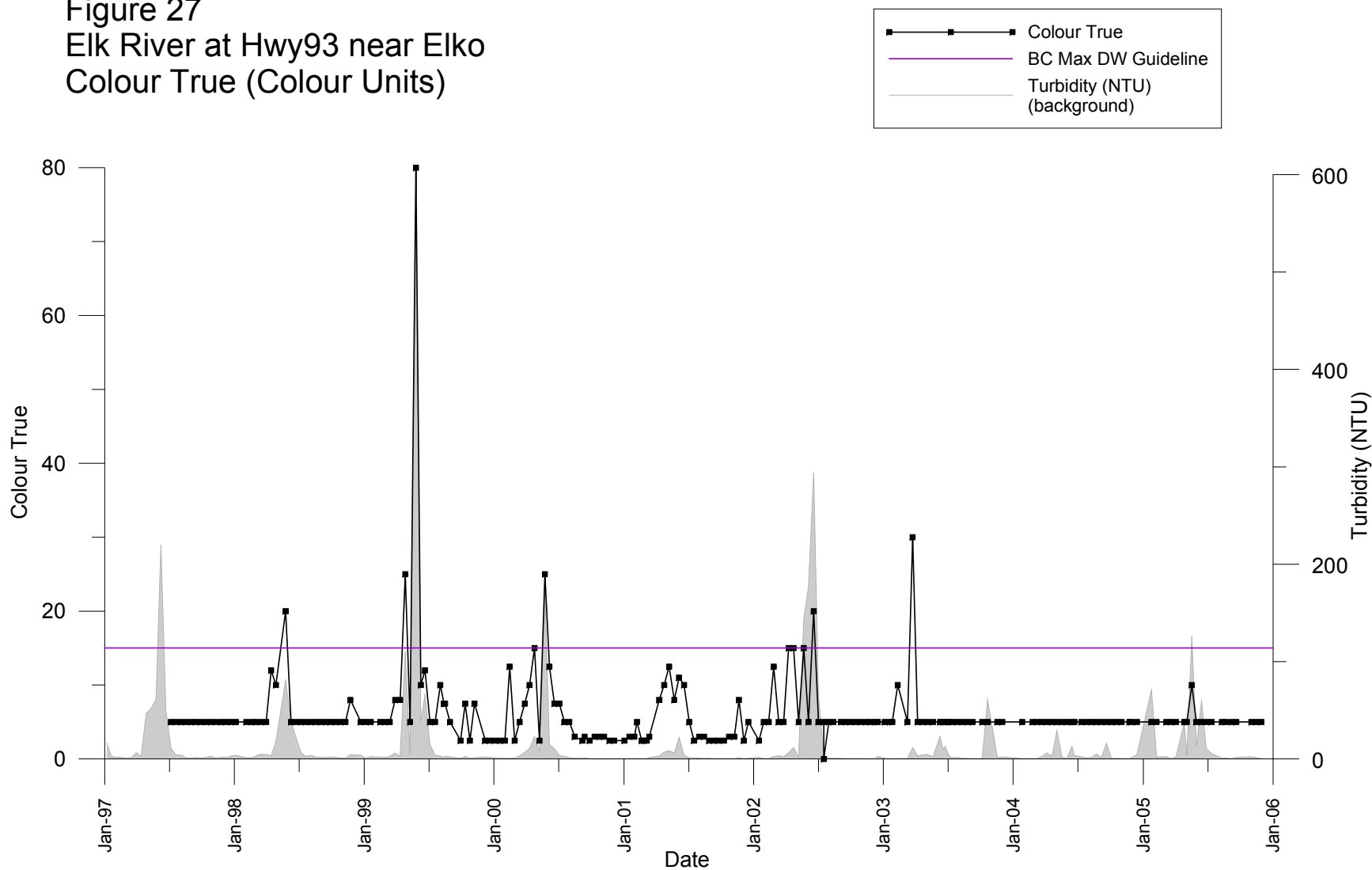


Figure 28
Elk River at Hwy93 near Elko
Colour Apparent (Colour Units)

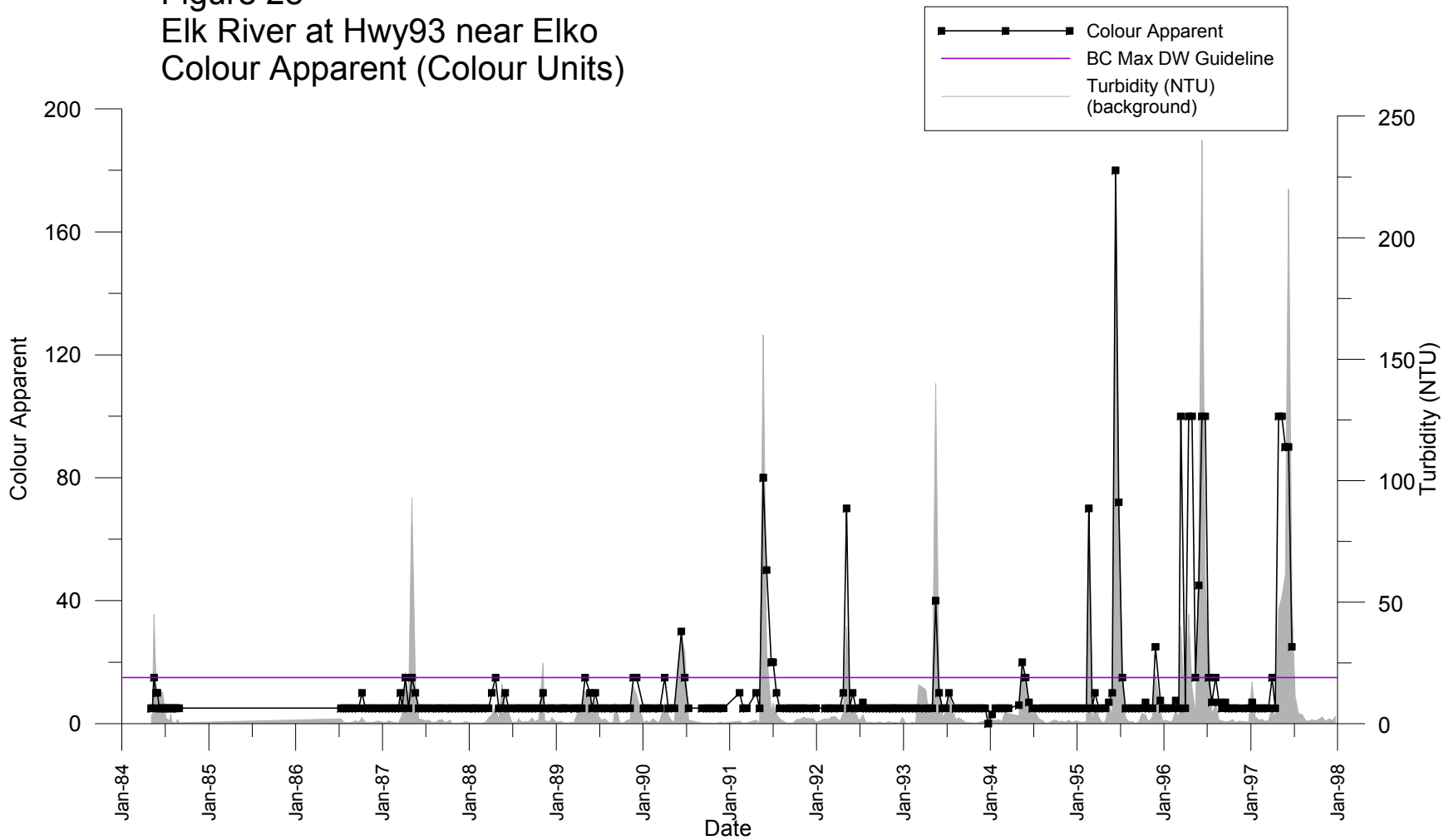


Figure 29
 Elk River at Hwy93 near Elko
 Copper Total, Dissolved and Extractable (ug/L)
 1984 - 2005

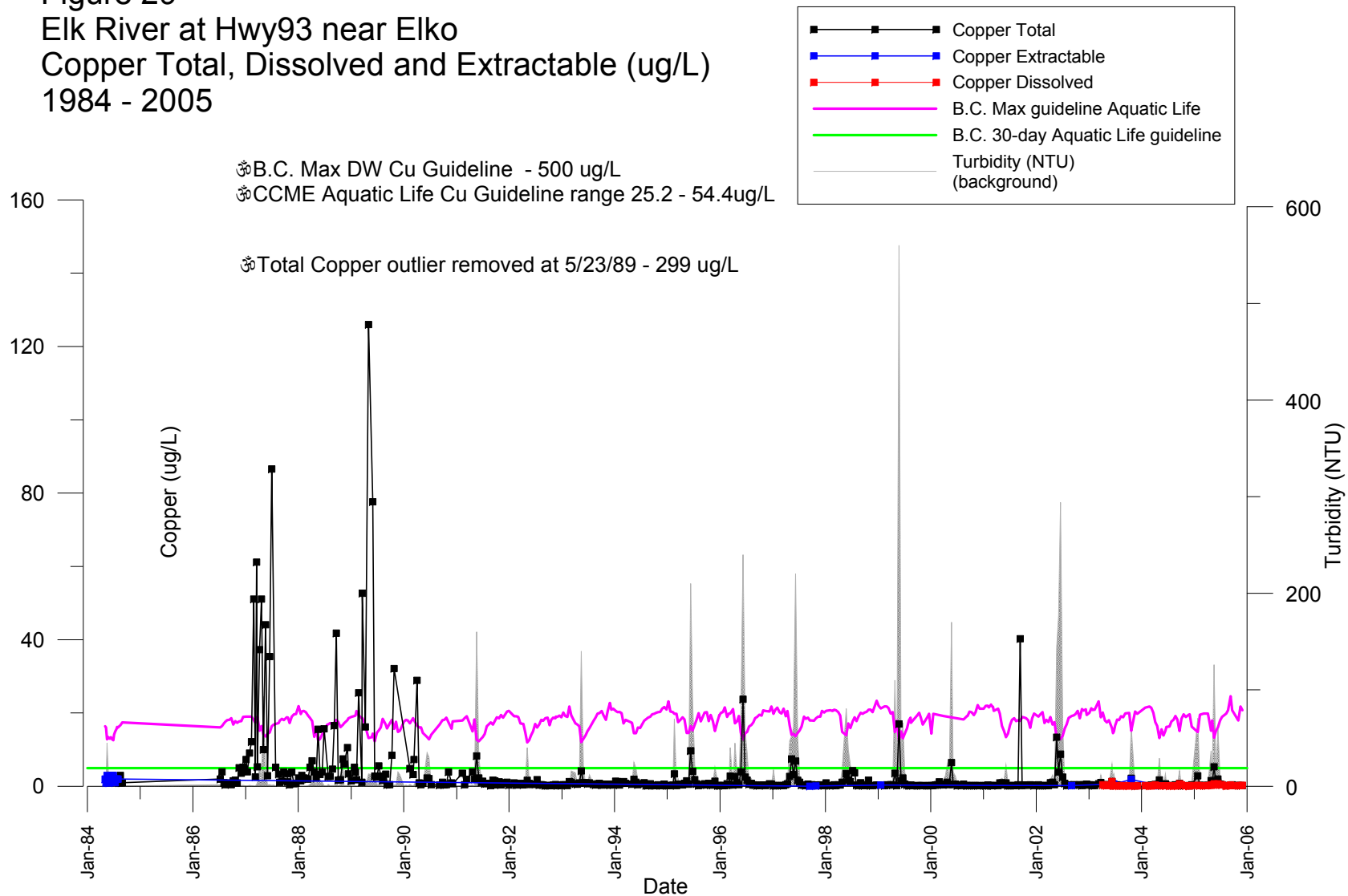


Figure 30
 Elk River at Hwy93 near Elko
 Copper Total, Dissolved and Extractable (ug/L)
 2003 - 2006

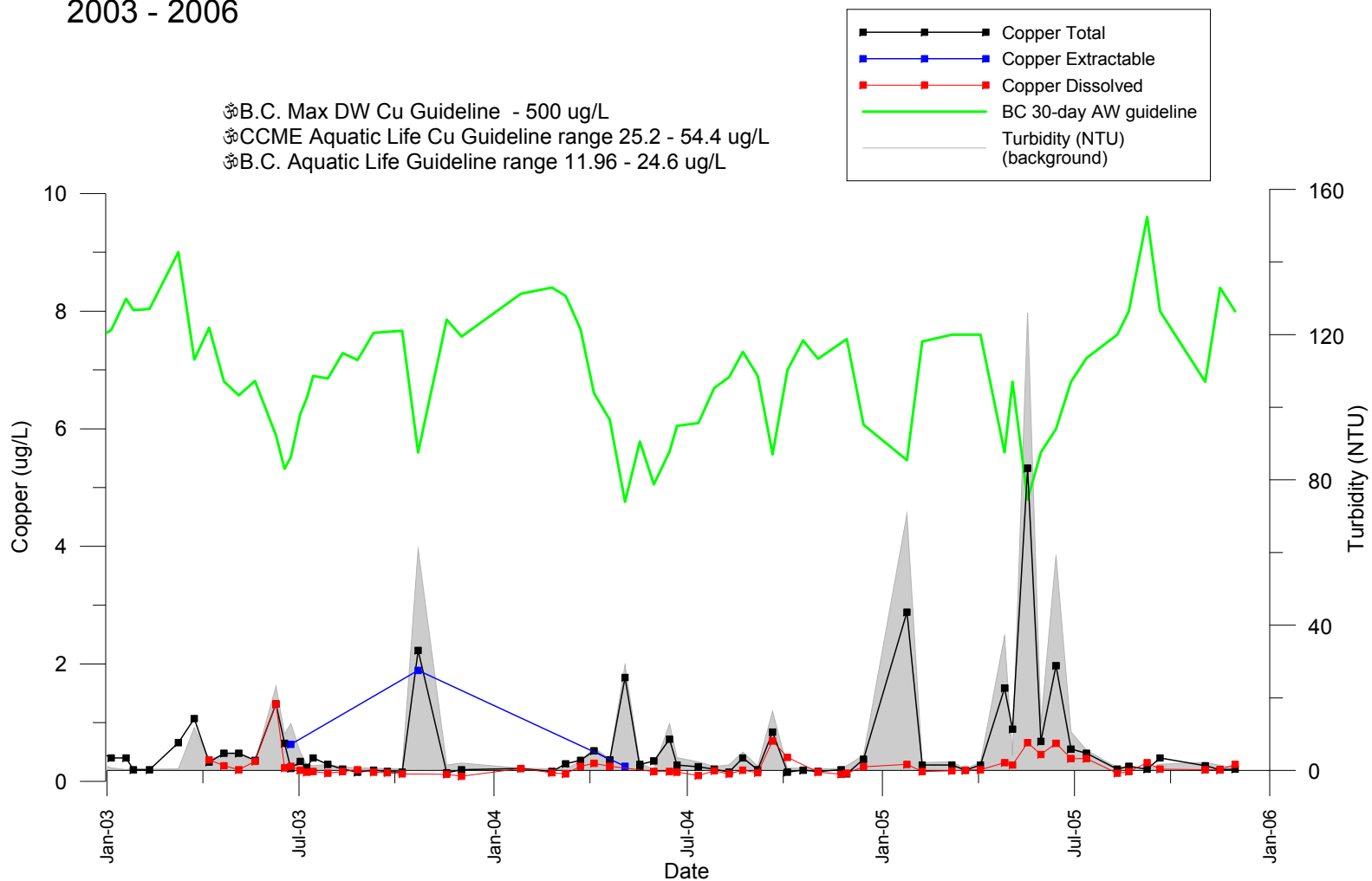


Figure 31
 Elk River at Hwy93 near Elko
 Fecal Coliforms (CFU/100mL)

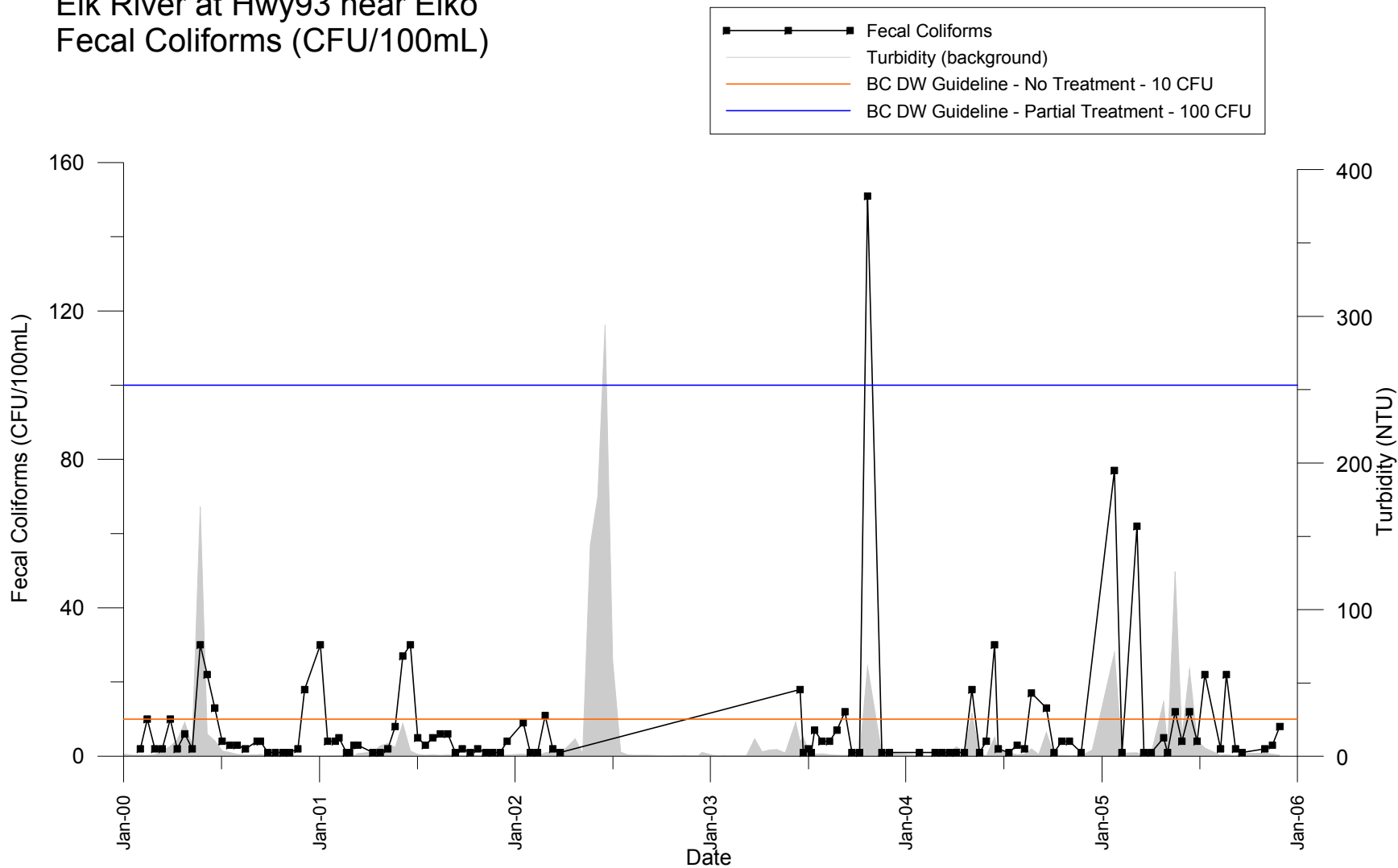


Figure 32
Elk River at Hwy93 near Elko
Fluoride Dissolved and Total (mg/L)

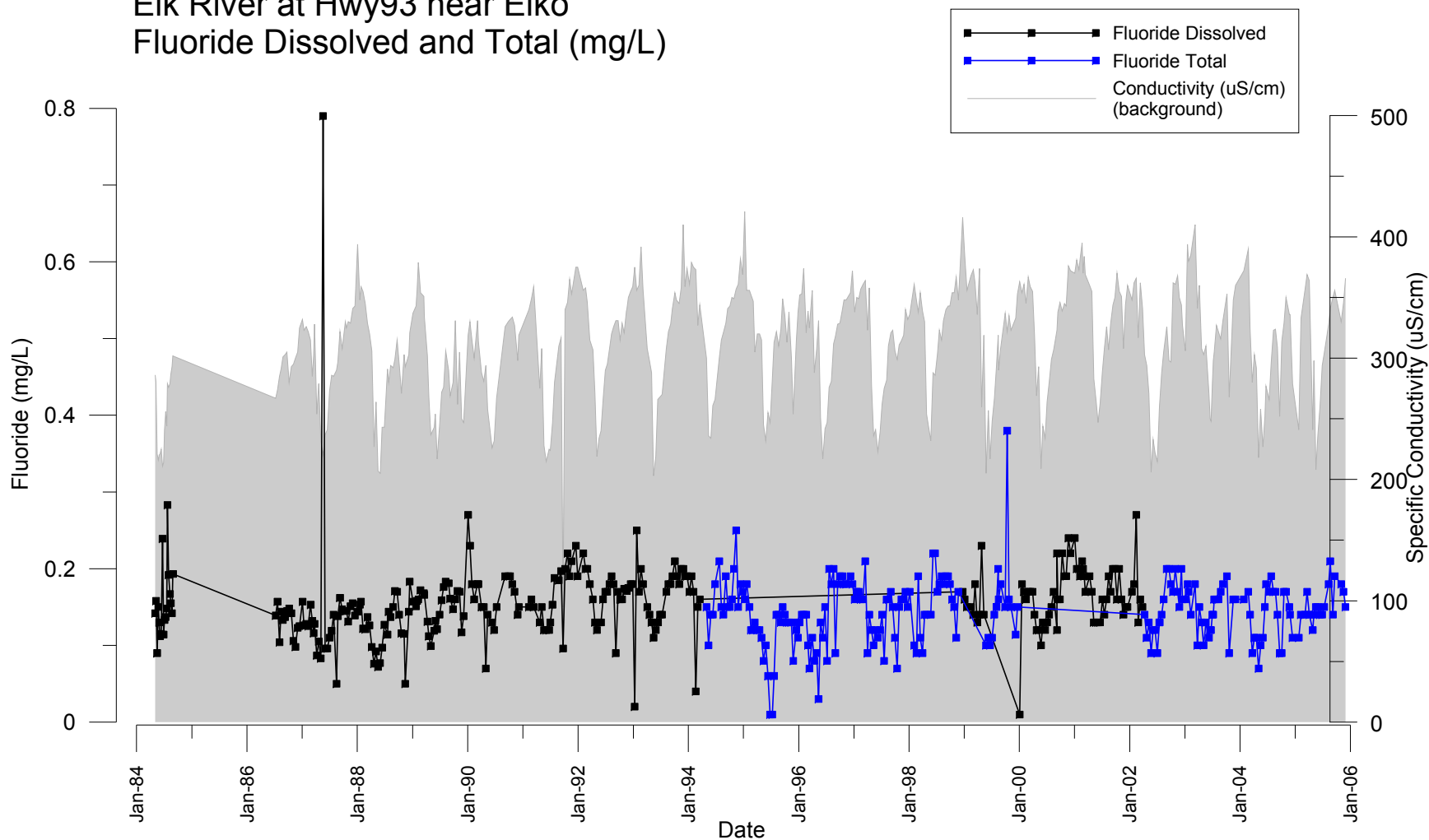


Figure 33
 Elk River at Hwy93 near Elko
 Gallium Total, Extractable and Dissolved(ug/L)
 1997 - 2006

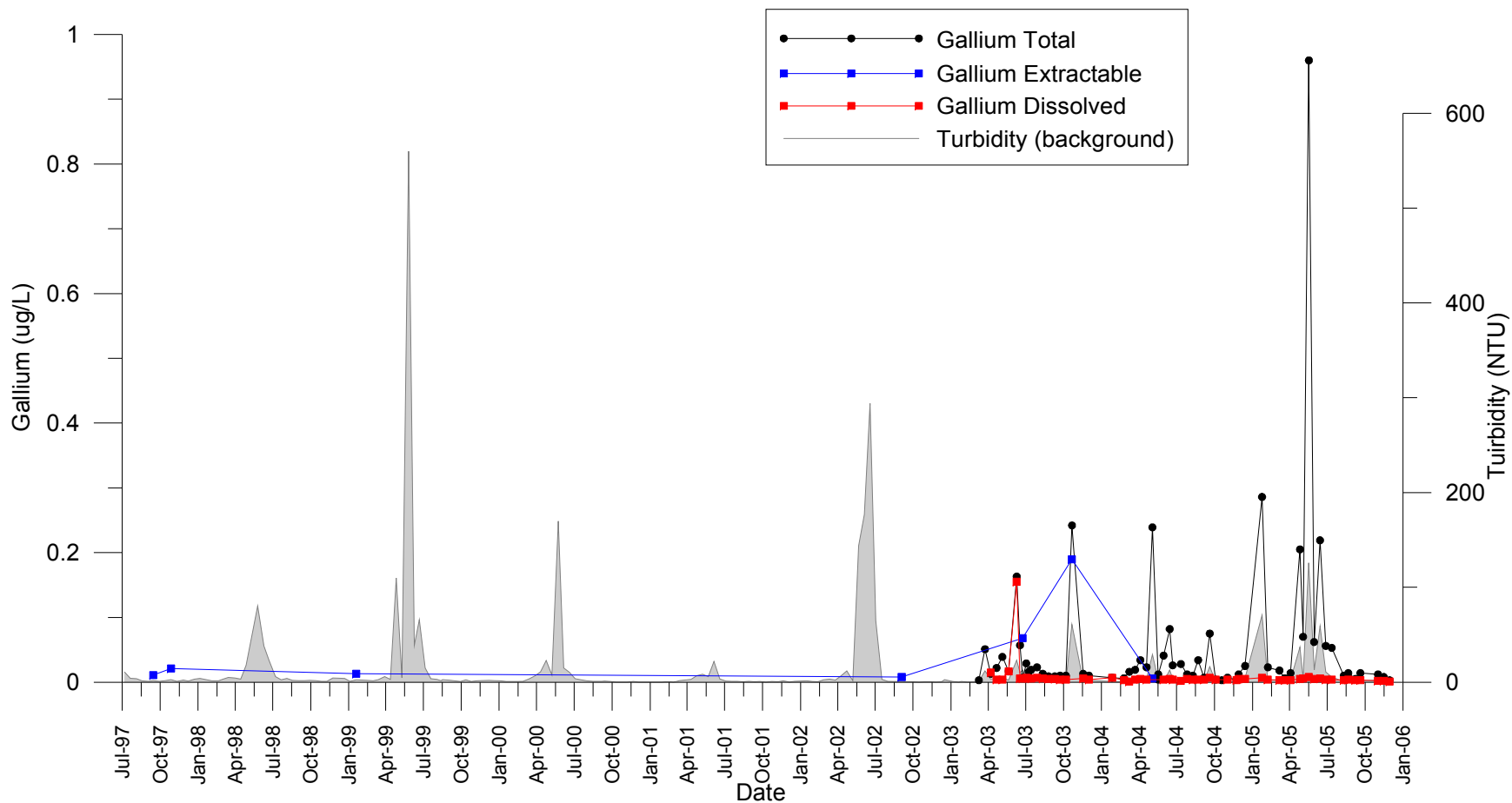


Figure 34
 Elk River at Hwy93 near Elko
 Gallium Total, Extractable and Dissolved(ug/L)
 2003 - 2006

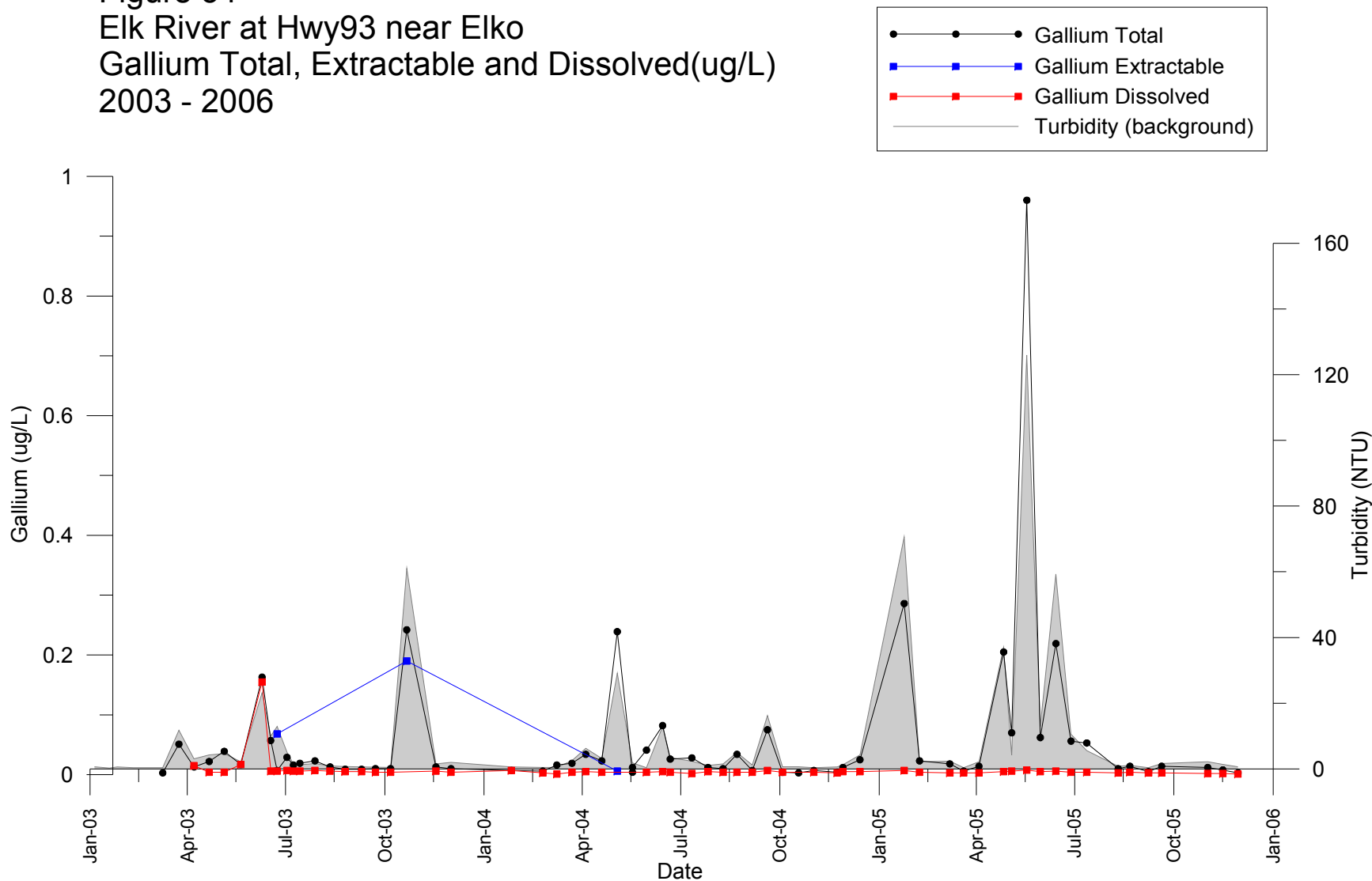


Figure 35
 Elk River at Hwy93 near Elko
 Hardness Total and Total Calcd (CaCO₃)

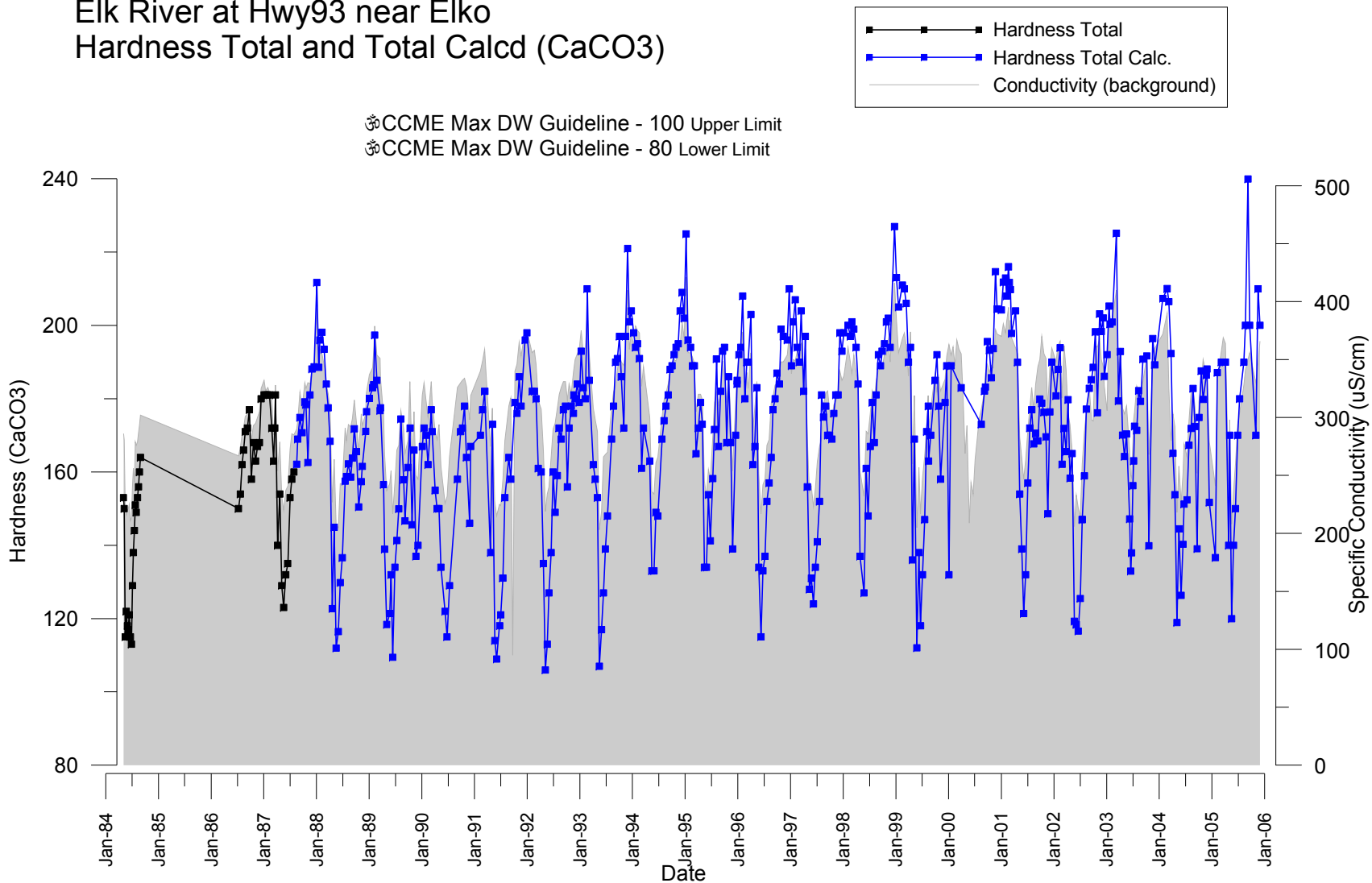


Figure 36
Elk River at Hwy93 near Elko
Iron Total, Extractable and Dissolved (ug/L)
1984 - 2005

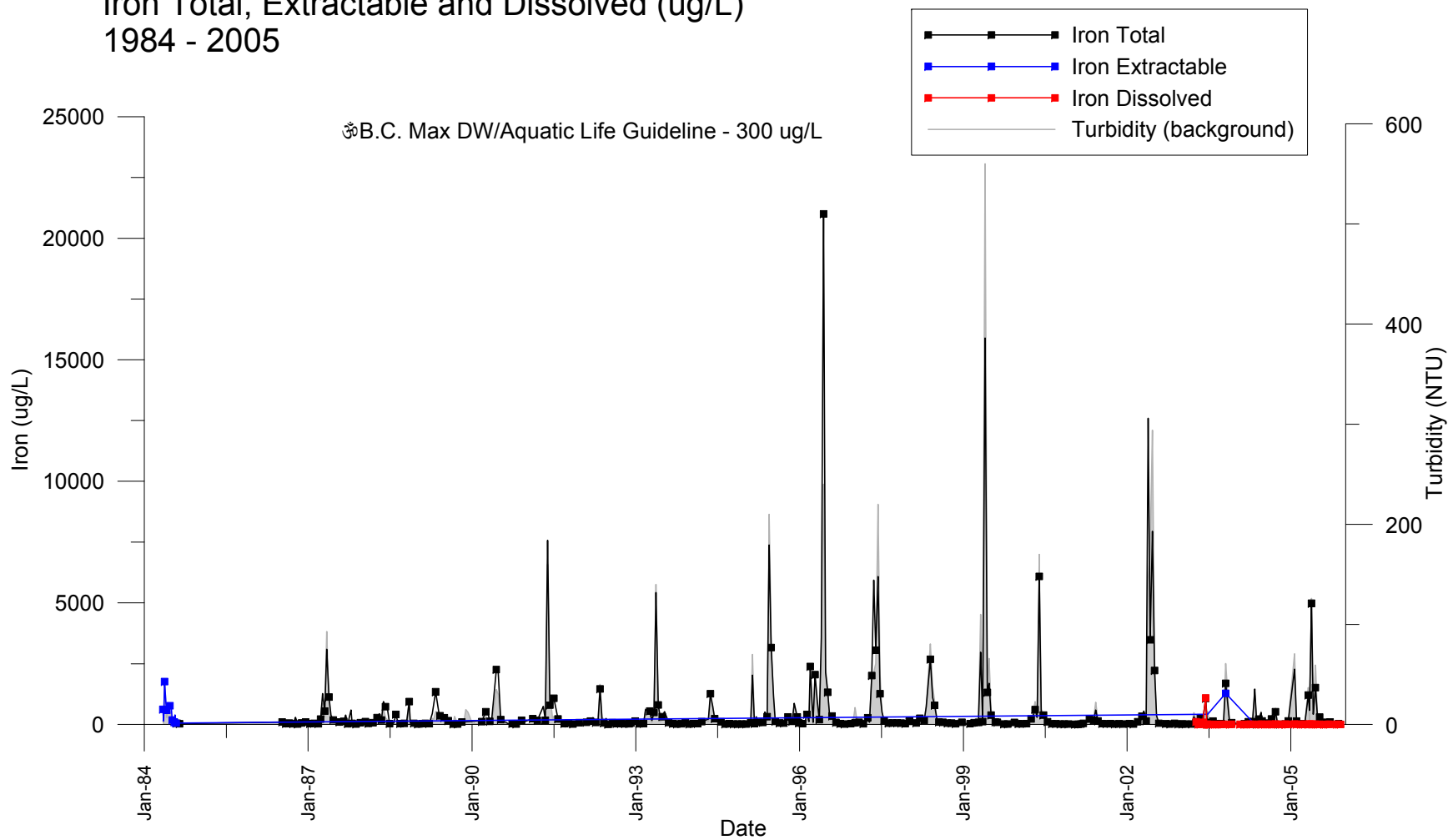


Figure 37
 Elk River at Hwy93 near Elko
 Iron Total, Extractable and Dissolved (ug/L)
 2003 - 2006

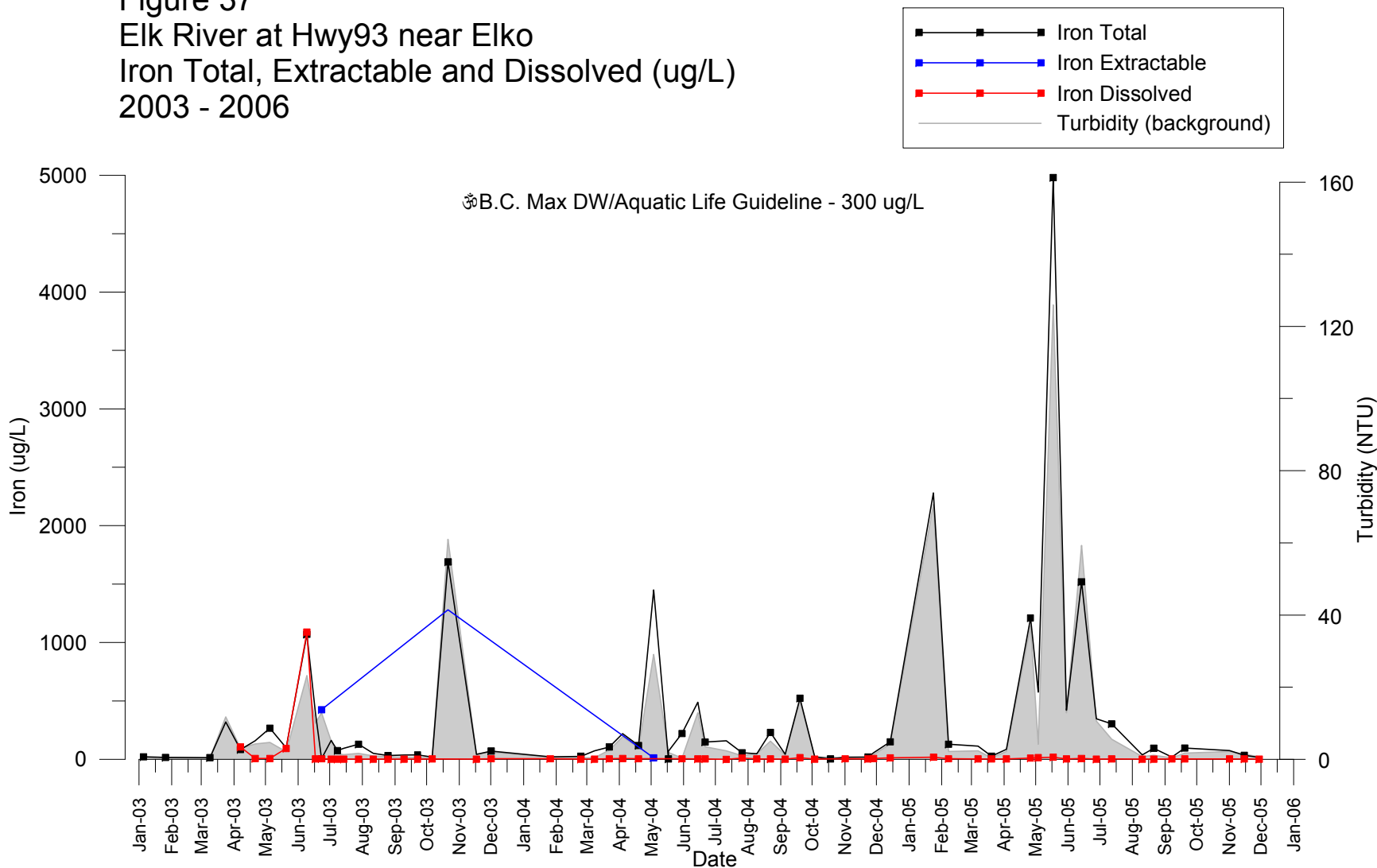


Figure 38
 Elk River at Hwy93 near Elko
 Lanthanum Total, Extractable and Dissolved (ug/L)
 1997 - 2006

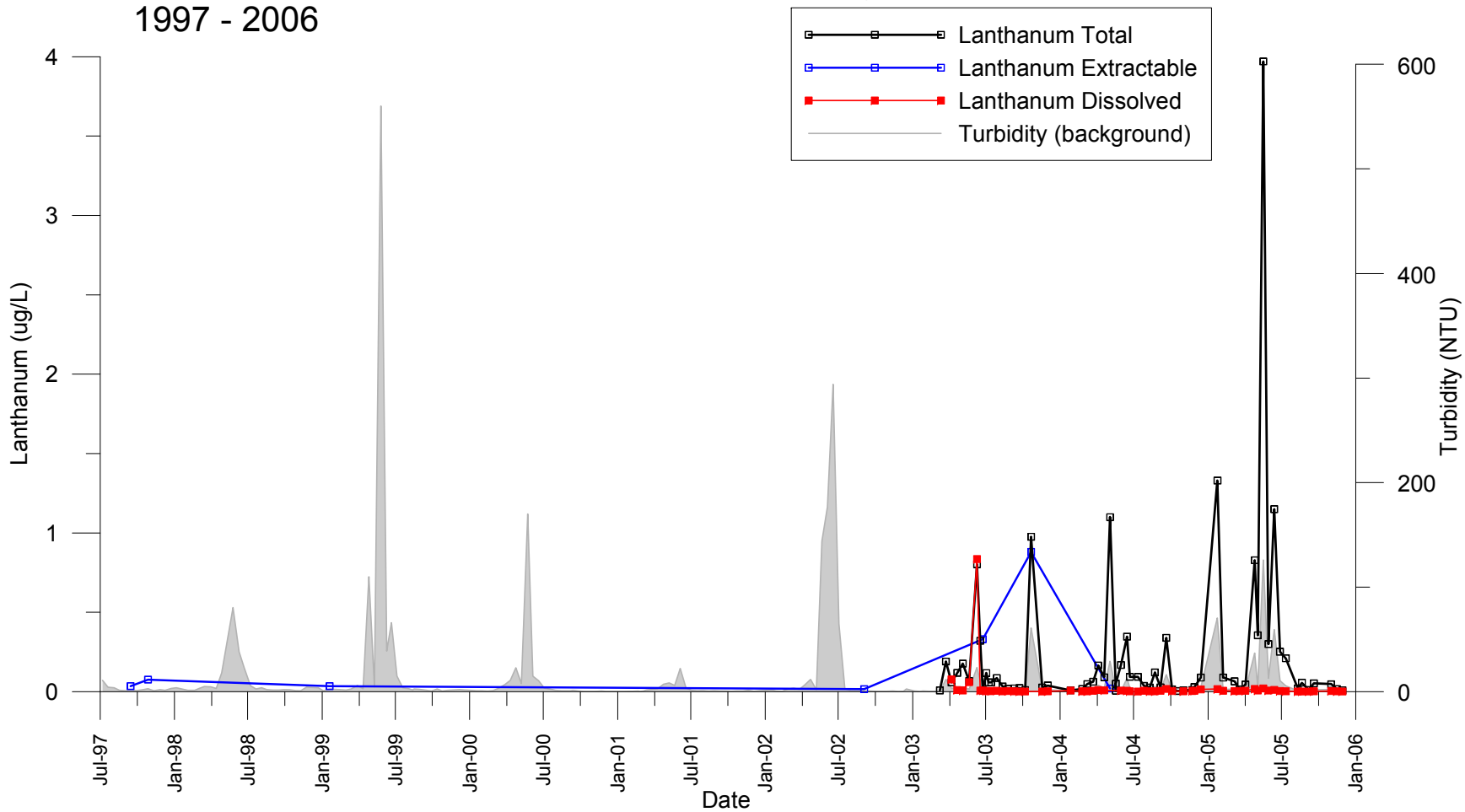


Figure 39
 Elk River at Hwy93 near Elko
 Lanthanum Total, Extractable and Dissolved (ug/L)

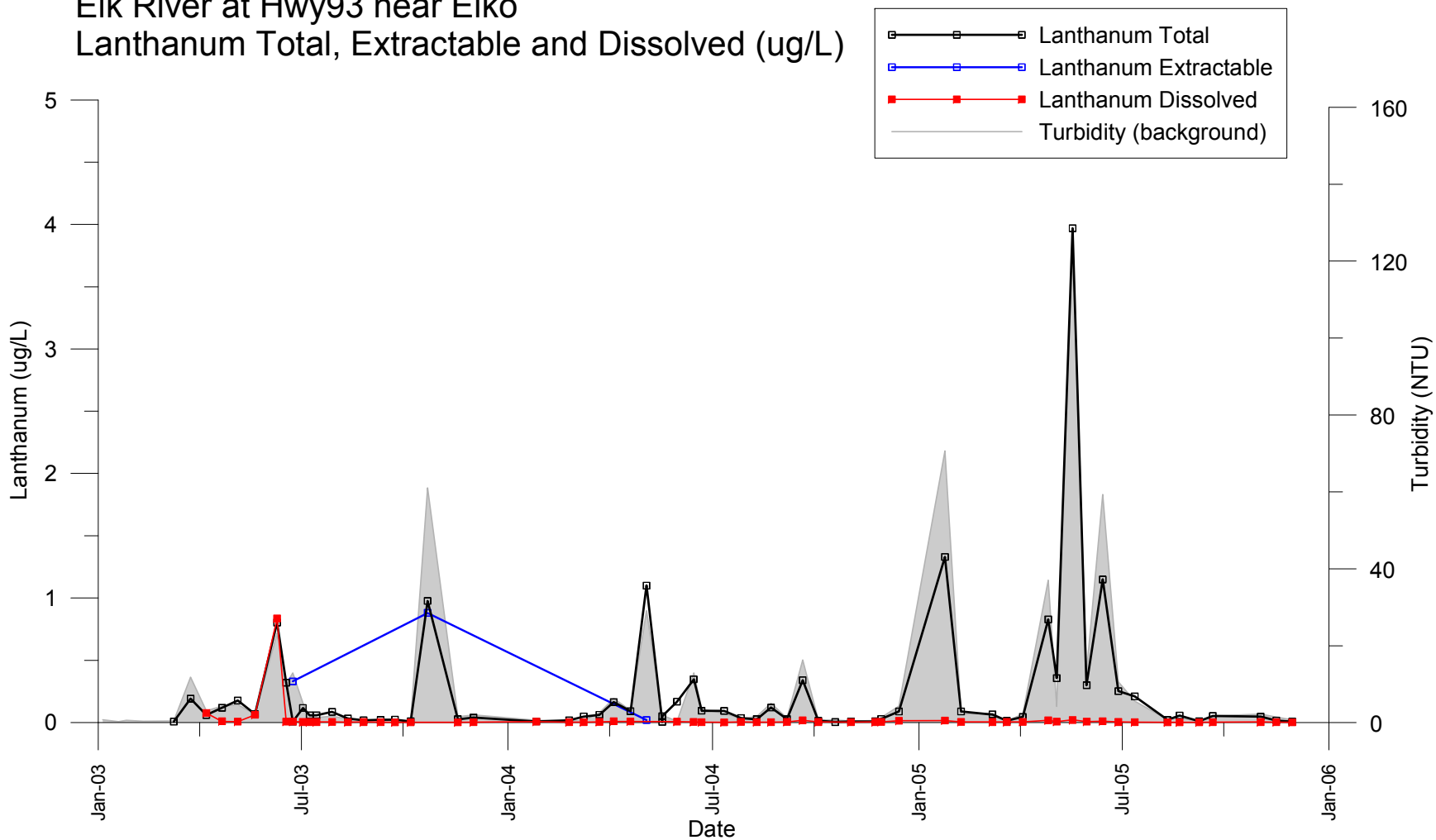


Figure 40
 Elk River at Hwy93 near Elko
 Lead Total, Extractable and Dissolved

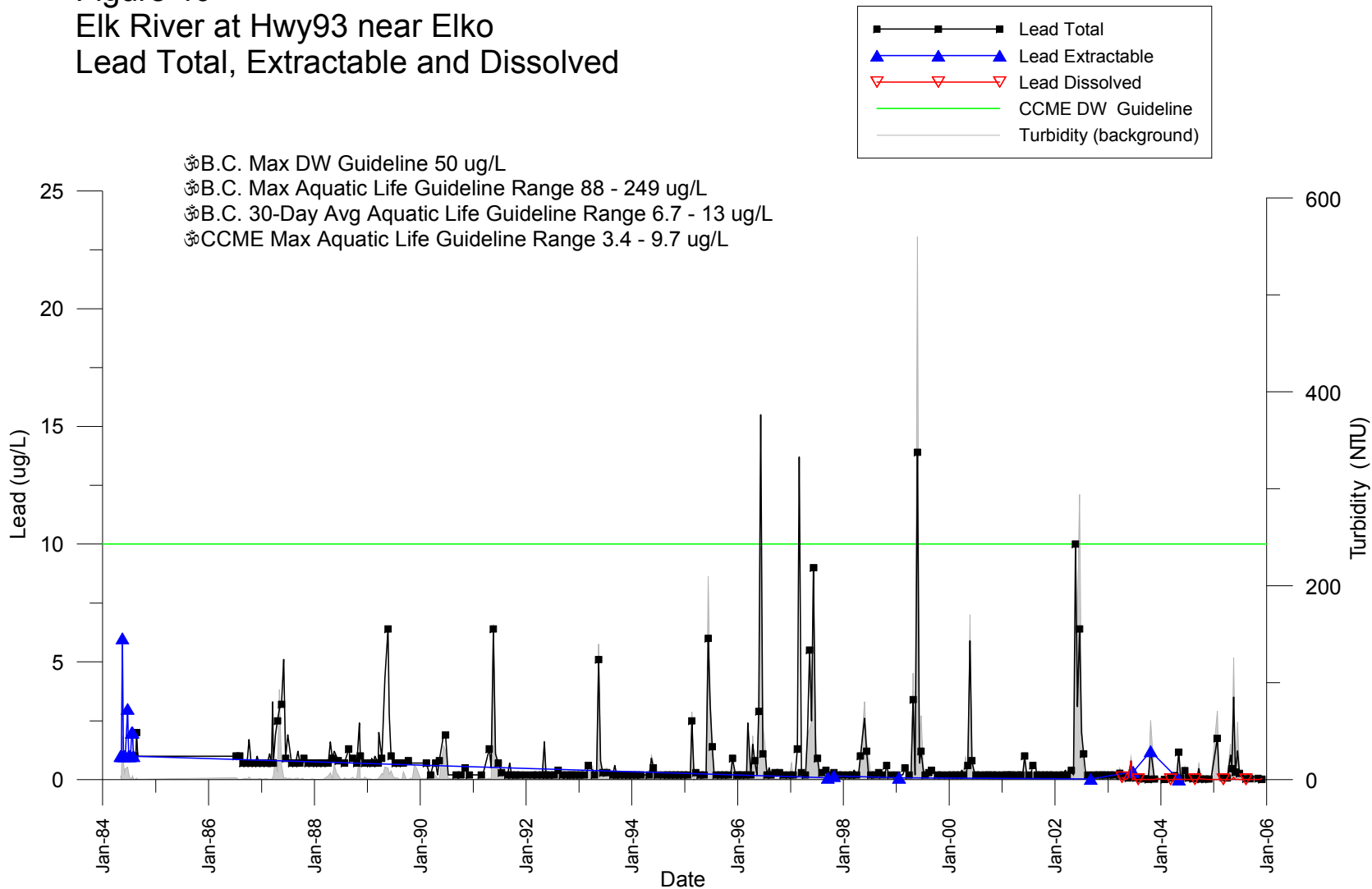


Figure 41
 Elk River at Hwy93 near Elko
 Lead Total, Extractable and Dissolved
 2003 - 2005

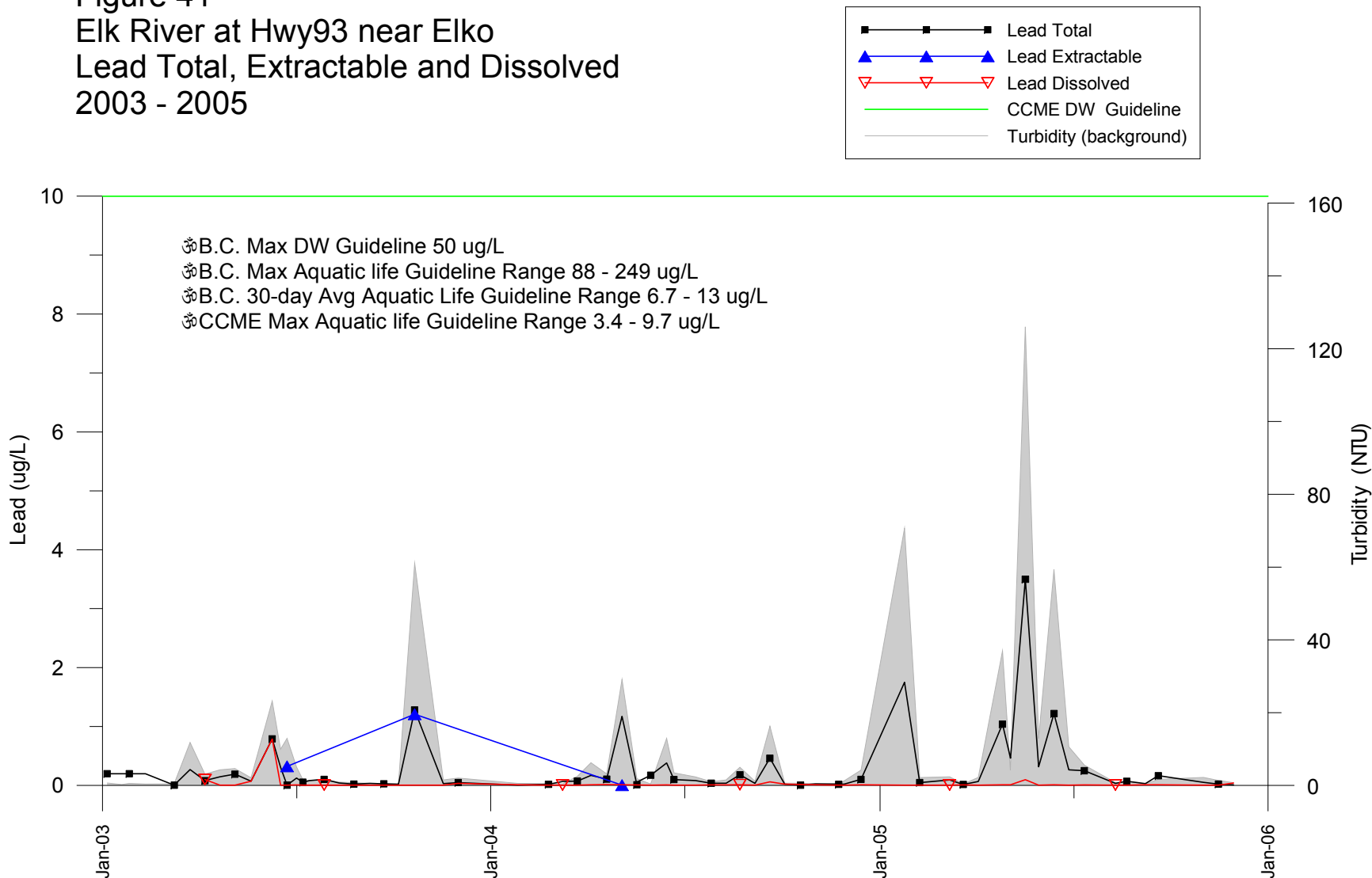


Figure 42
 Elk River at Hwy93 near Elko
 Lithium Total, Extractable and Dissolved

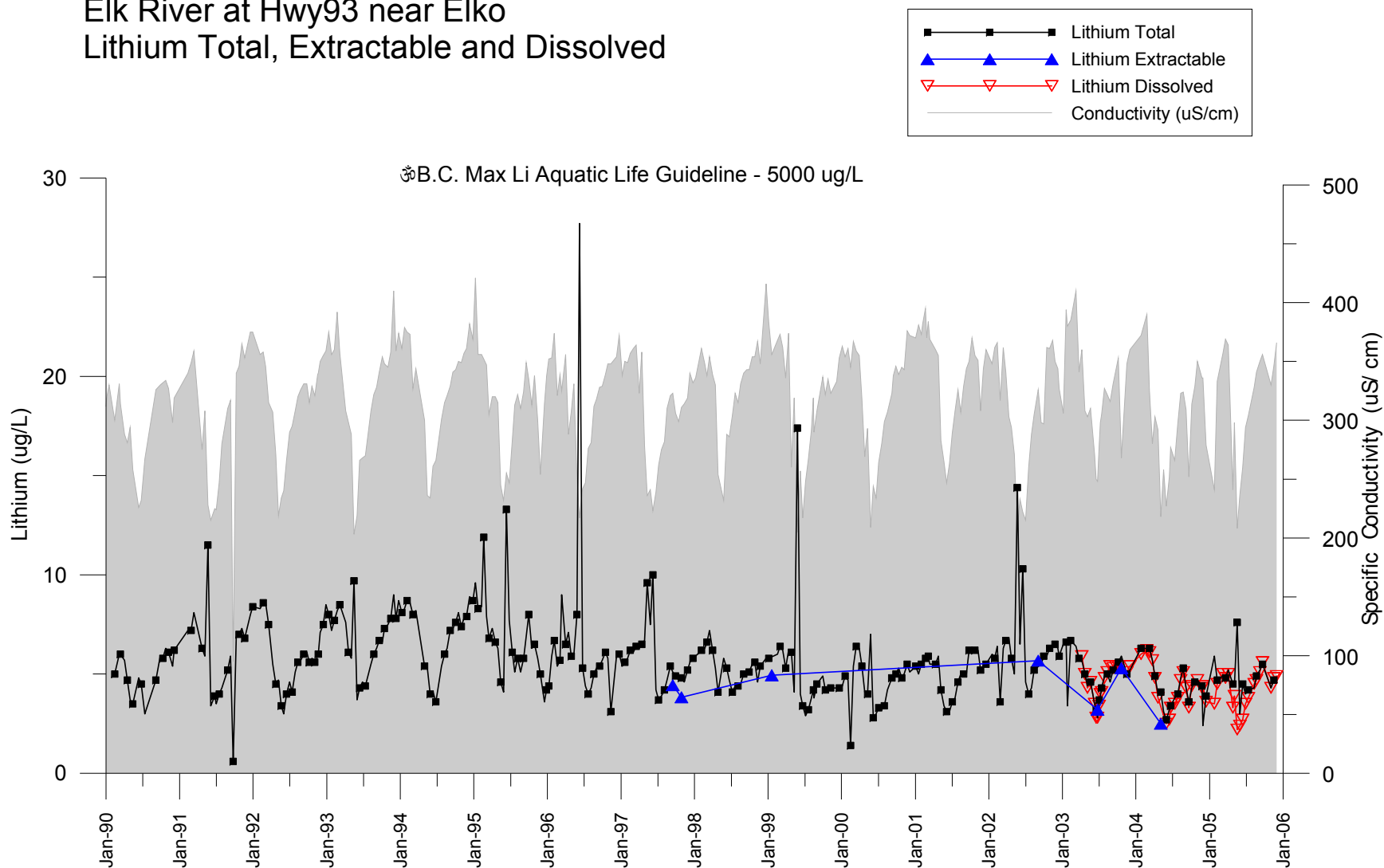


Figure 43
 Elk River at Hwy93 near Elko
 Lithium Total, Extractable and Dissolved

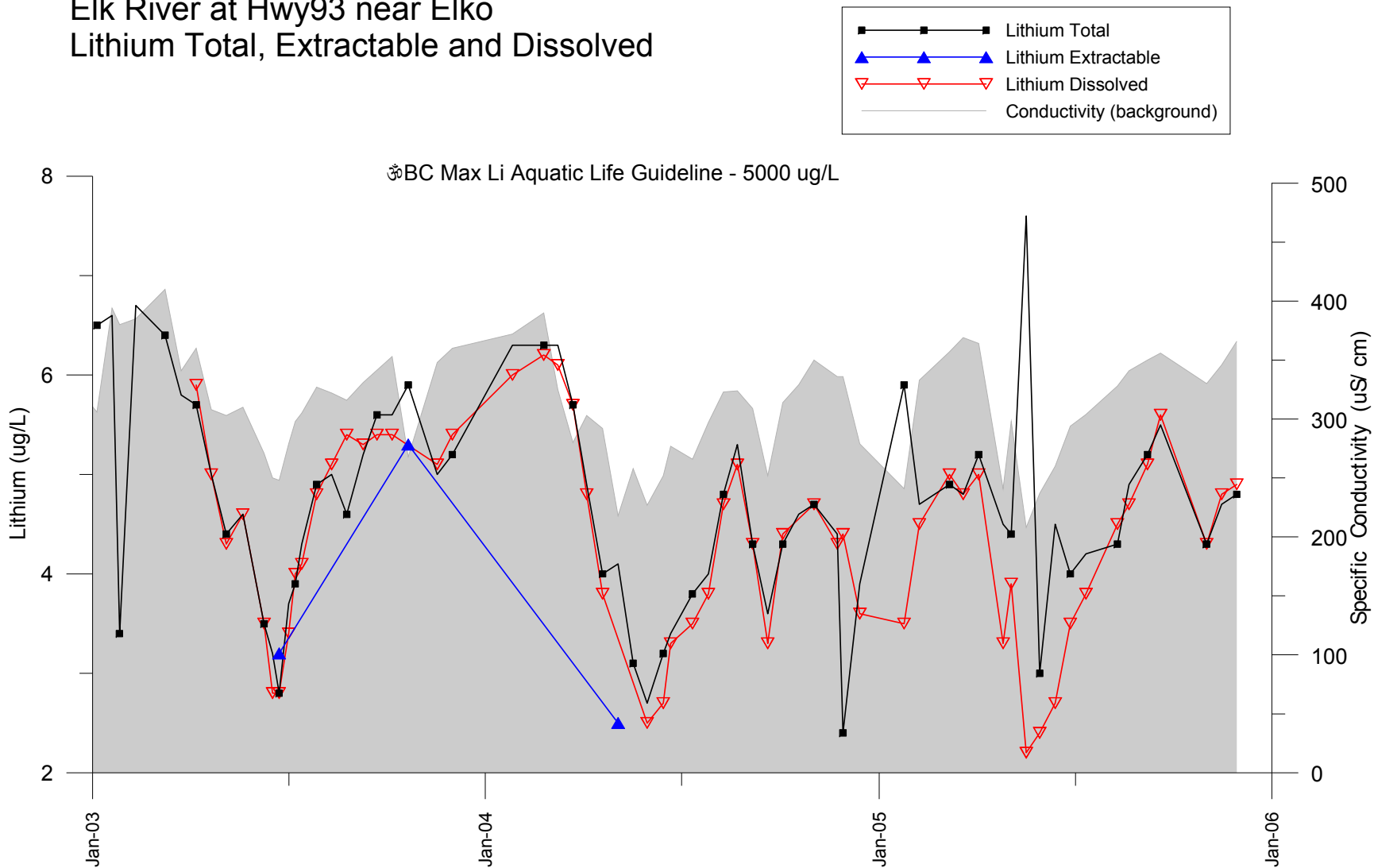


Figure 44
 Elk River at Hwy93 near Elko
 Magnesium Dissolved, Extractable, Dissolved Calcd

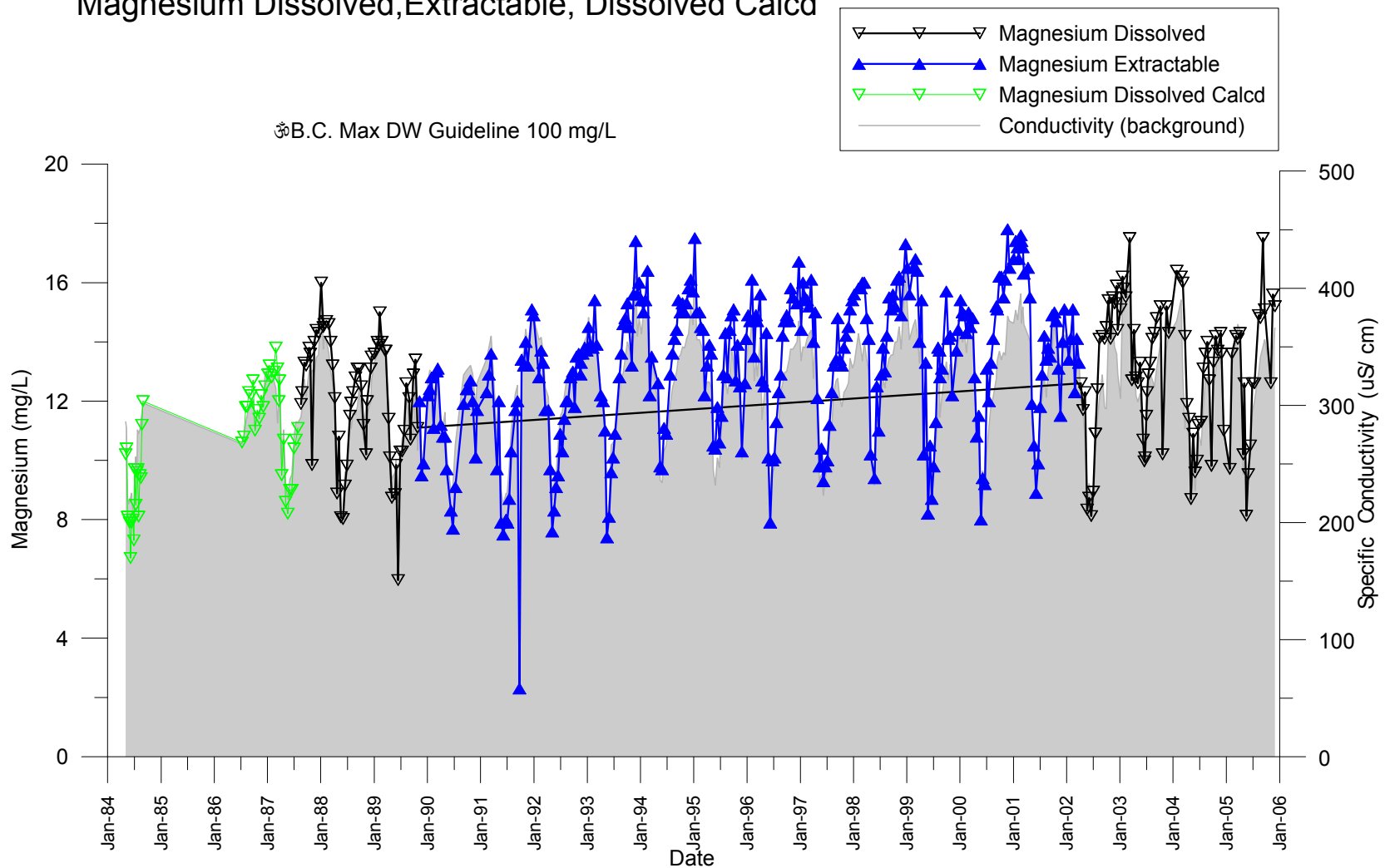


Figure 45
 Elk River at Hwy93 near Elko
 Manganese Total, Extractable and Dissolved

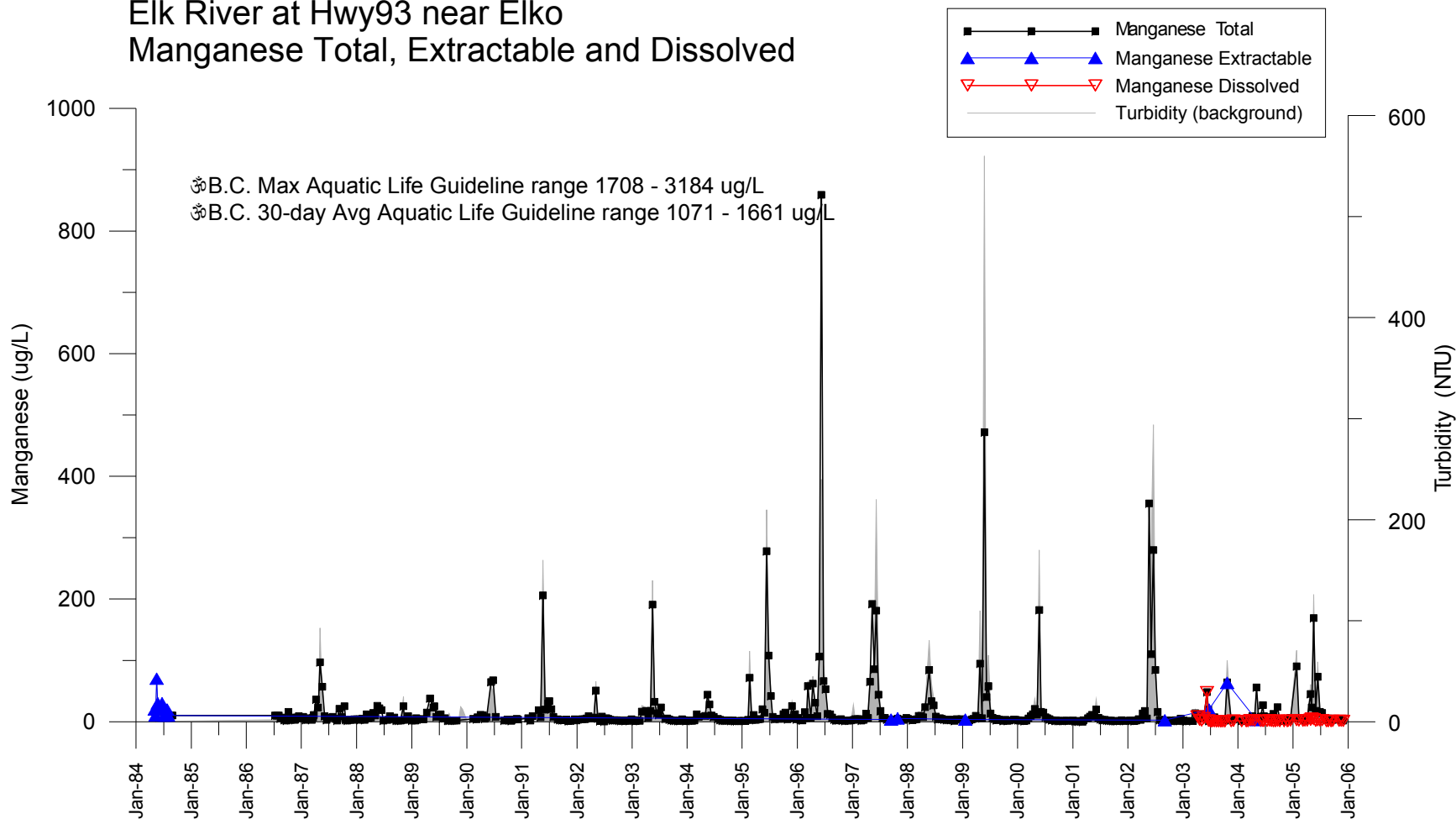


Figure 46
 Elk River at Hwy93 near Elko
 Manganese Total, Extractable and Dissolved

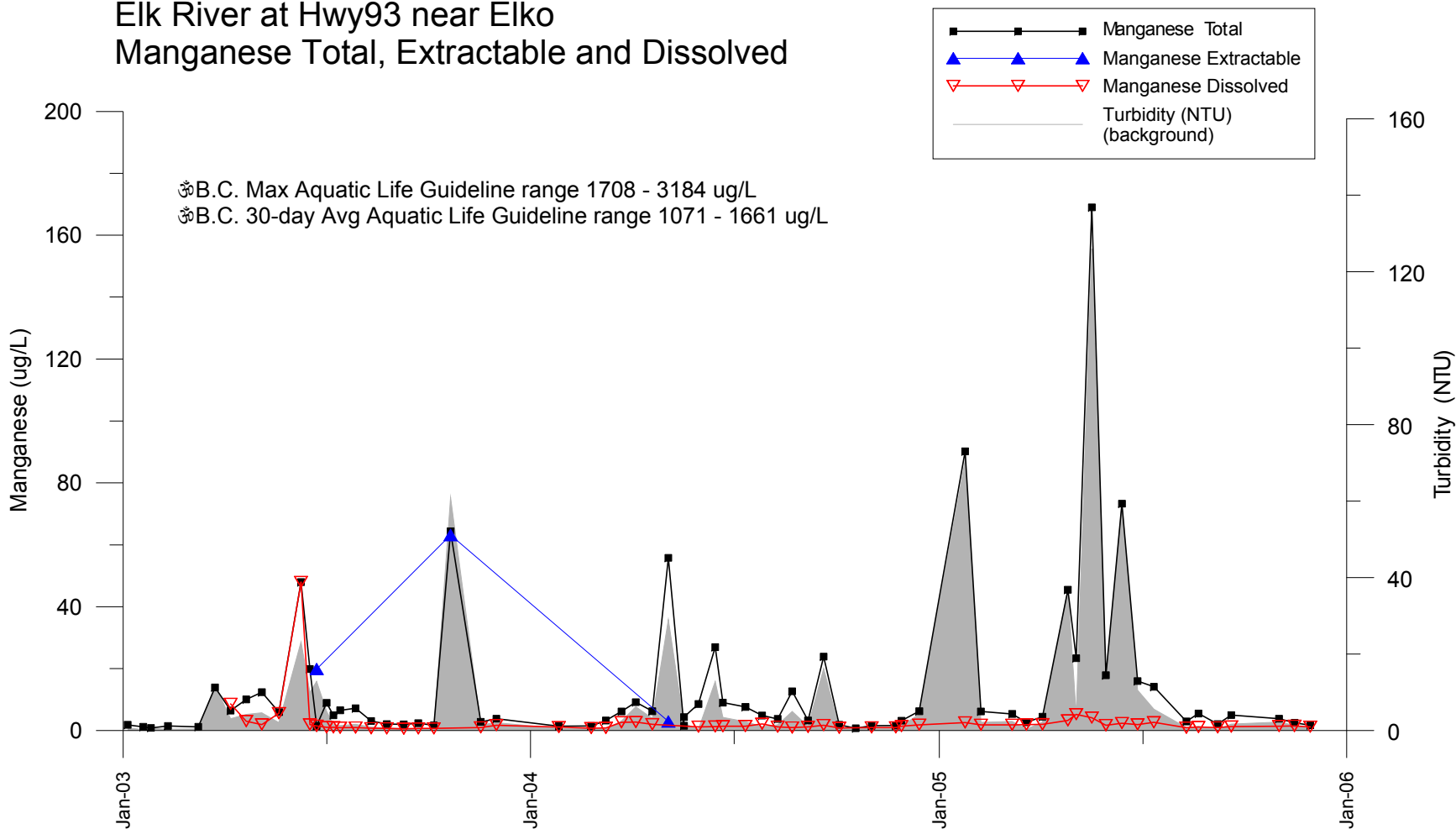


Figure 47
 Elk River at Hwy93 near Elko
 Molybdenum Total, Extractable and Dissolved

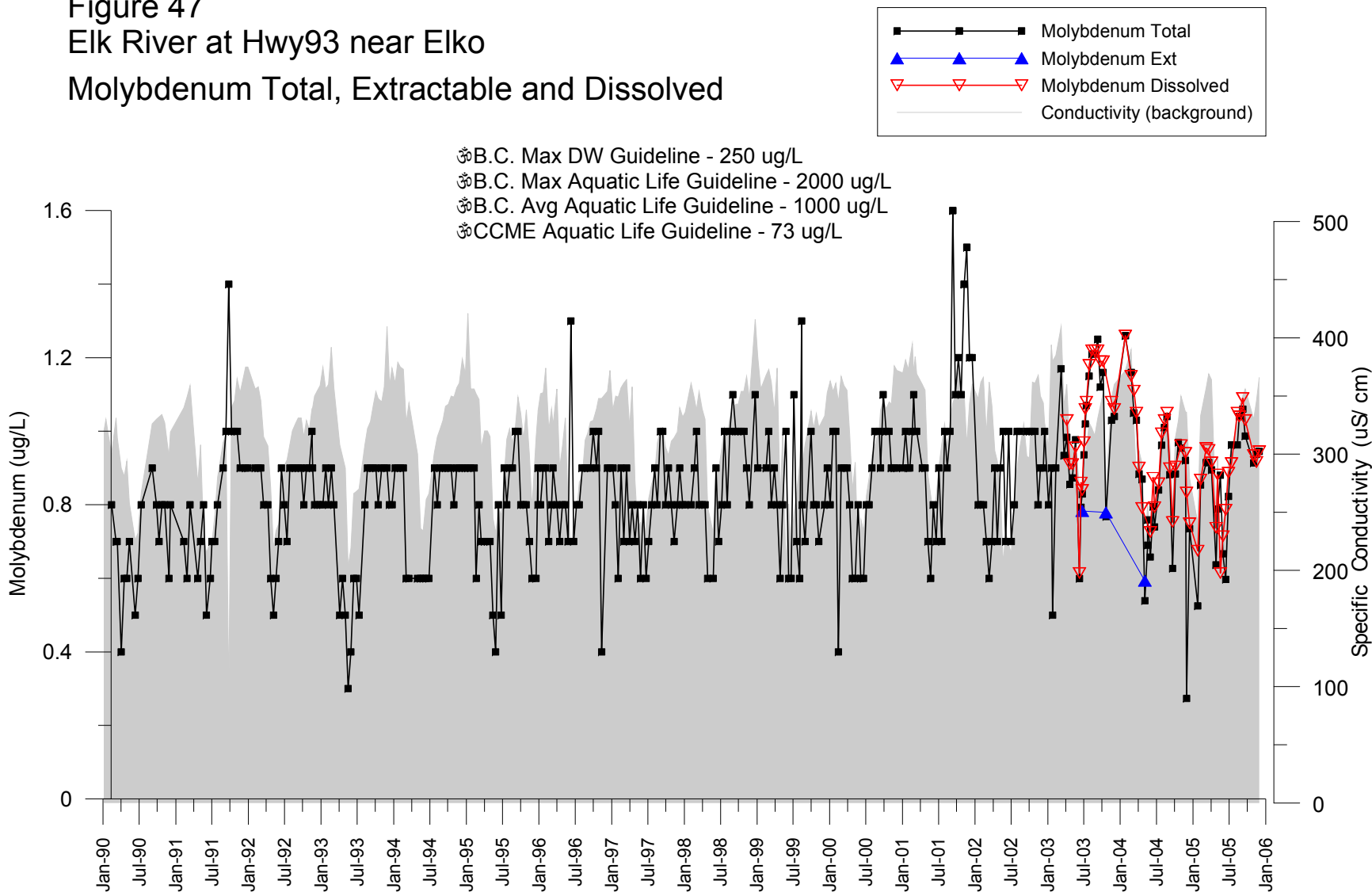


Figure 48
 Elk River at Hwy93 near Elko
 Molybdenum Total, Extractable and Dissolved

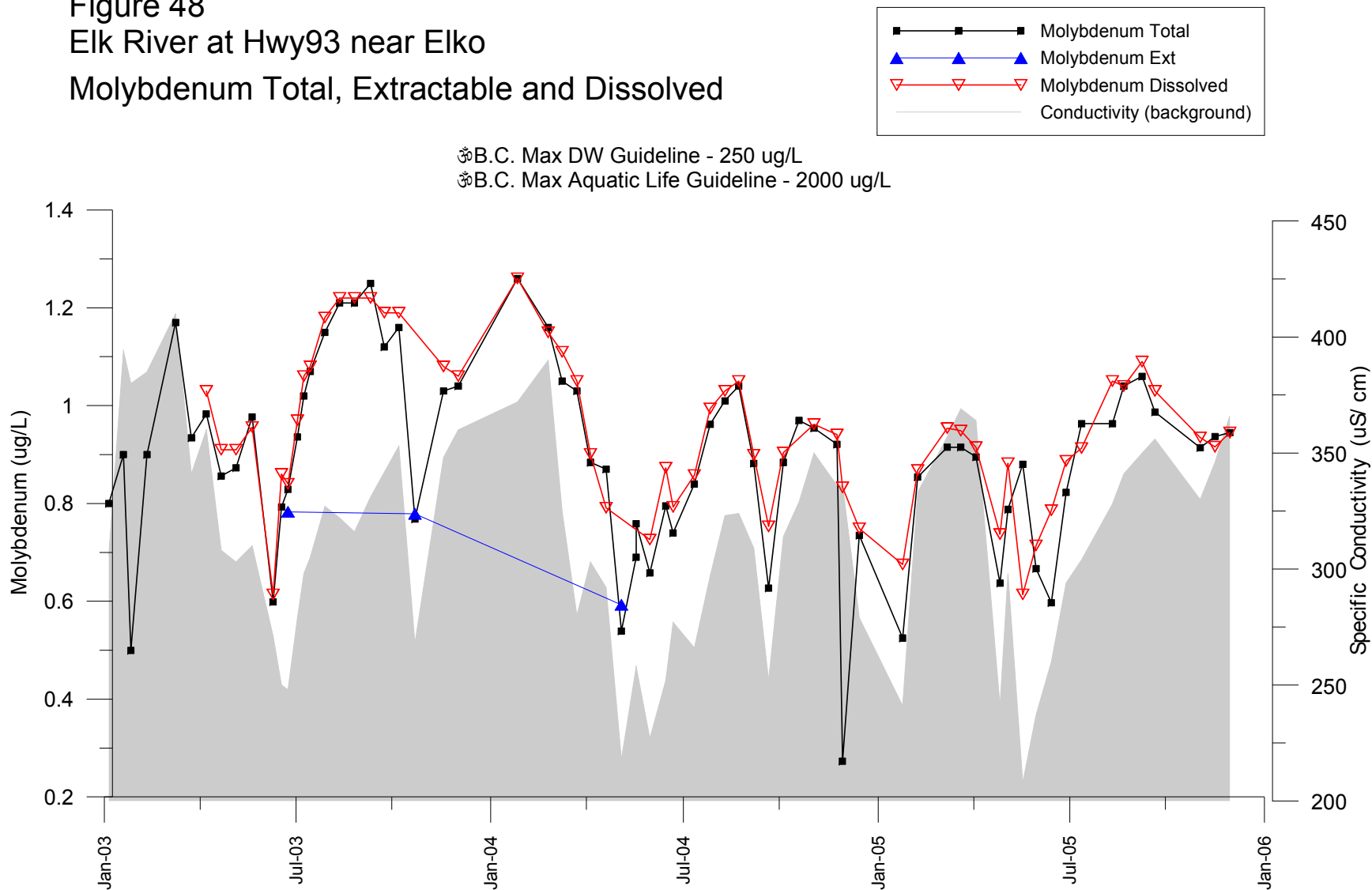


Figure 49
 Elk River at Hwy93 near Elko
 Nickel Total, Extractable and Dissolved

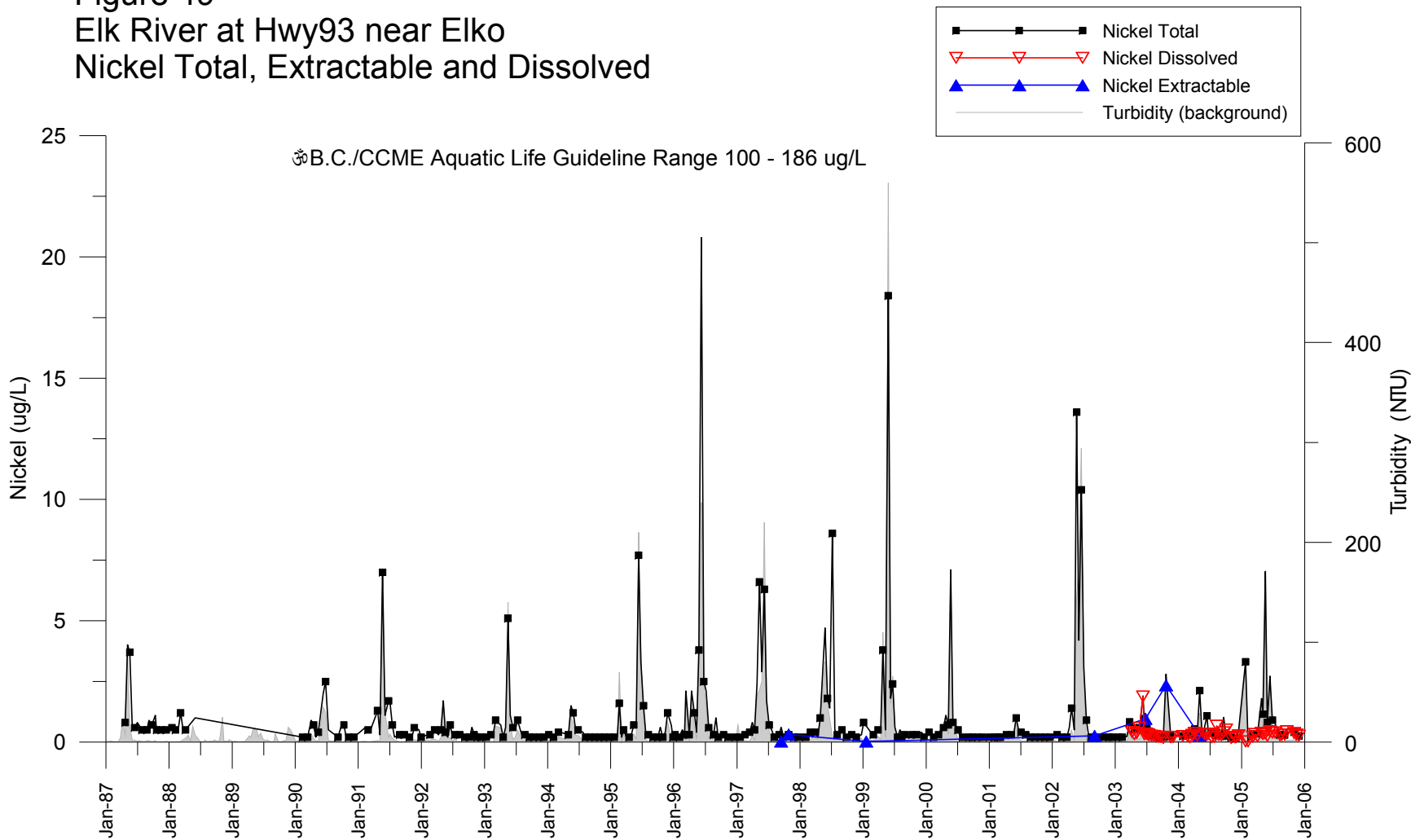


Figure 50
 Elk River at Hwy93 near Elko
 Nickel Total, Extractable and Dissolved

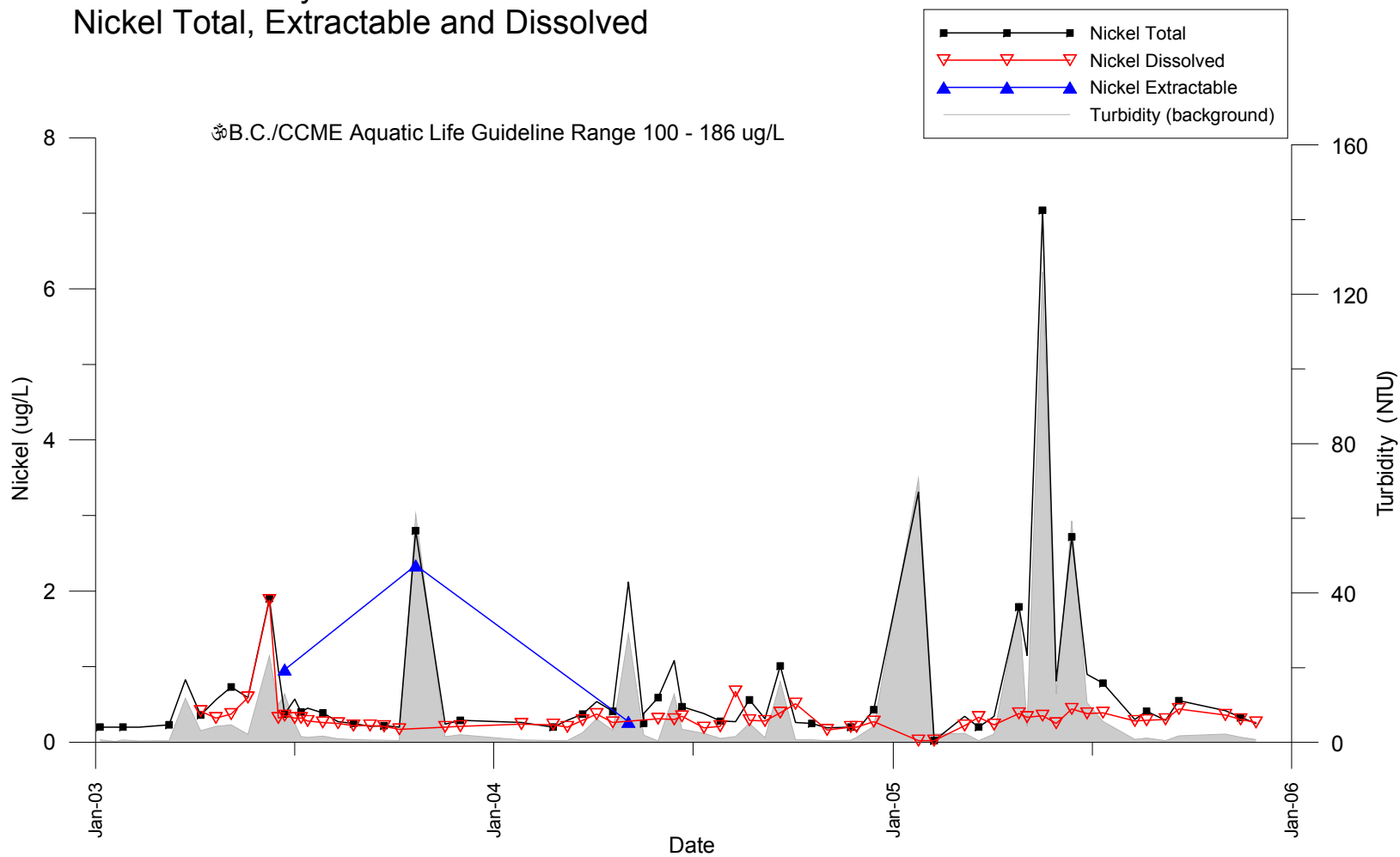


Figure 51
Elk River at Hwy93 near Elko
Nitrogen Dissolved NO3 and NO2

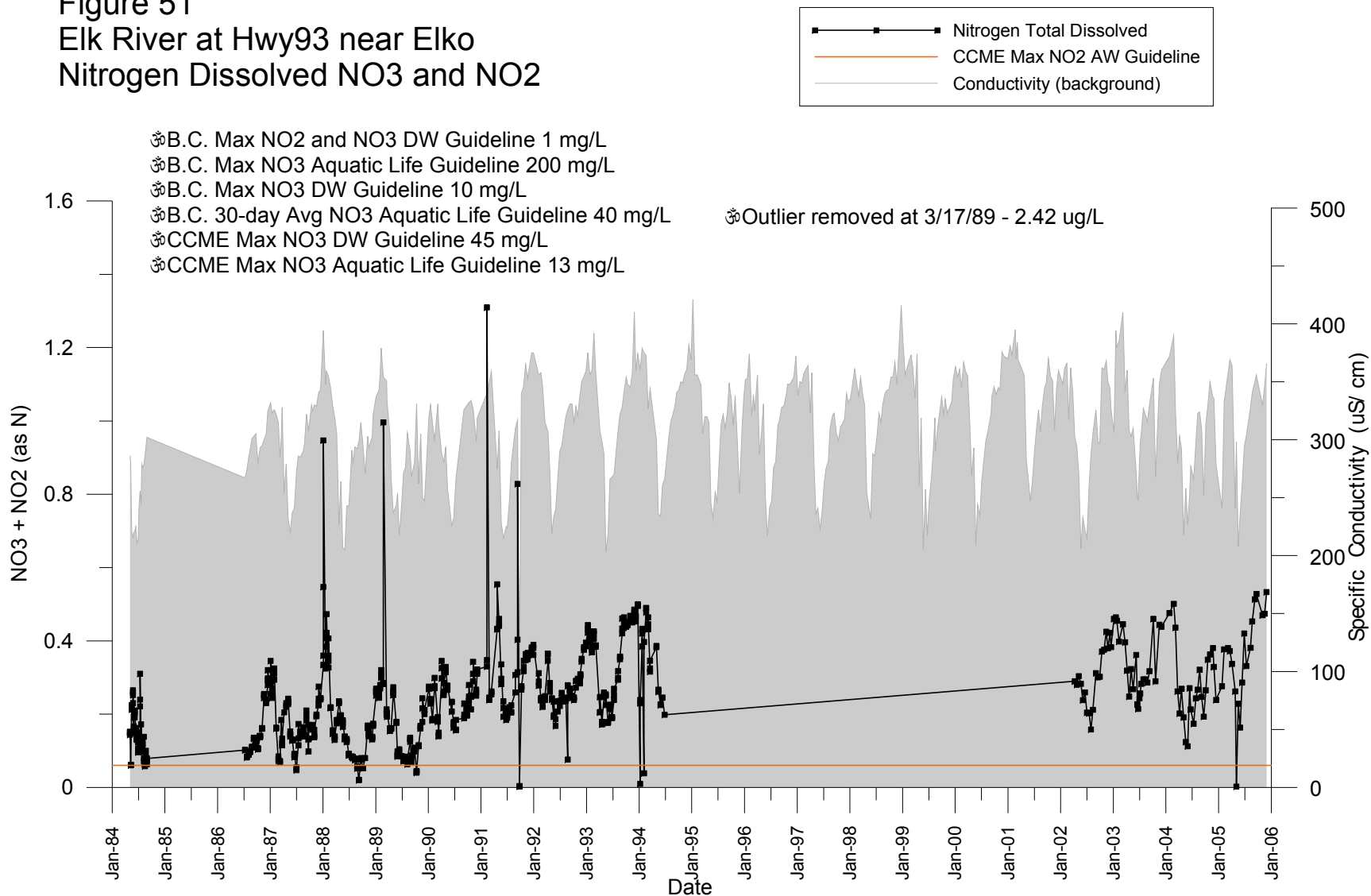


Figure 52
Elk River at Hwy93 near Elko
Nitrogen Dissolved Nitrate

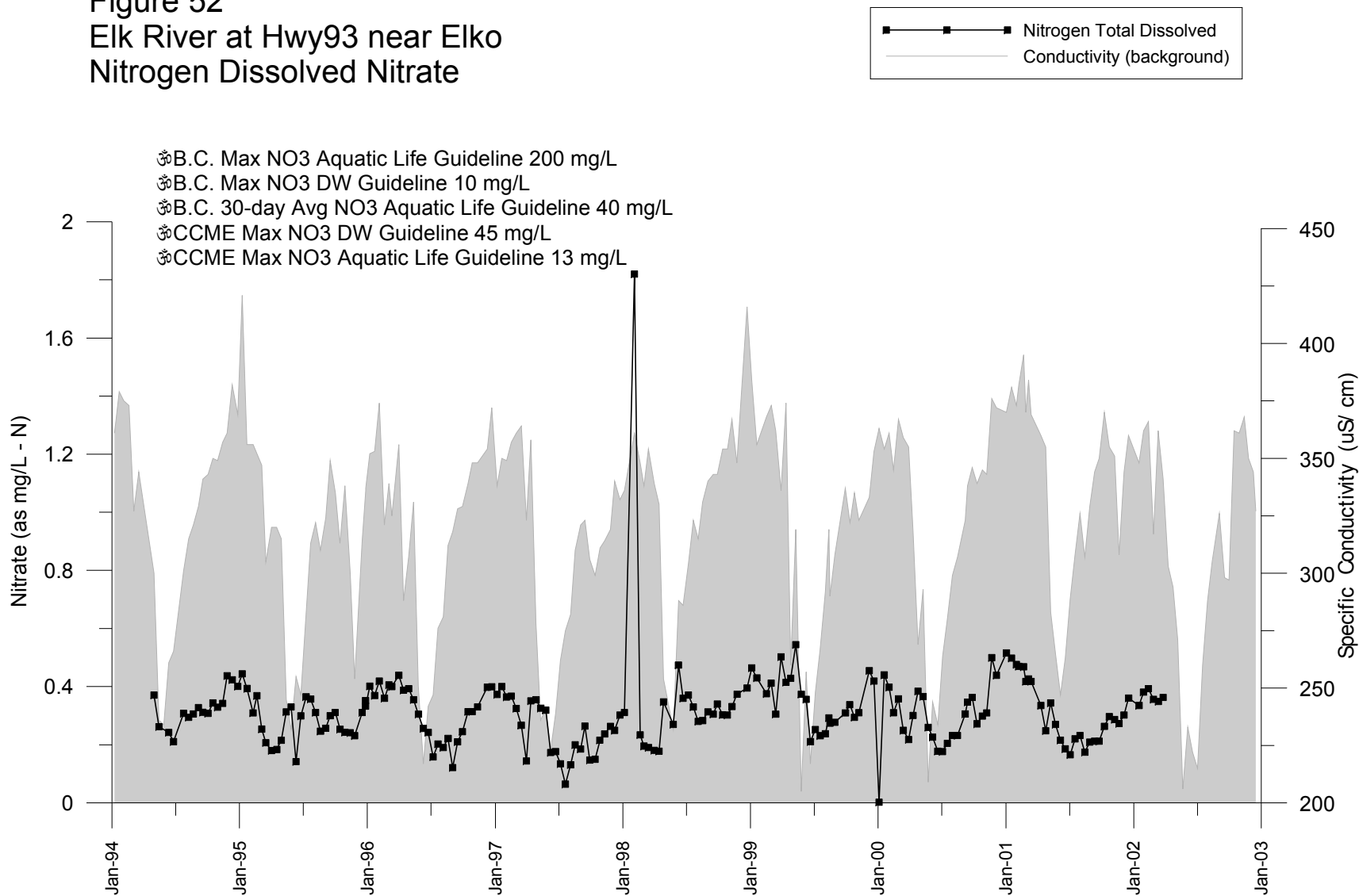


Figure 53
Elk River at Hwy 93 near Elko
Nitrogen Nitrite

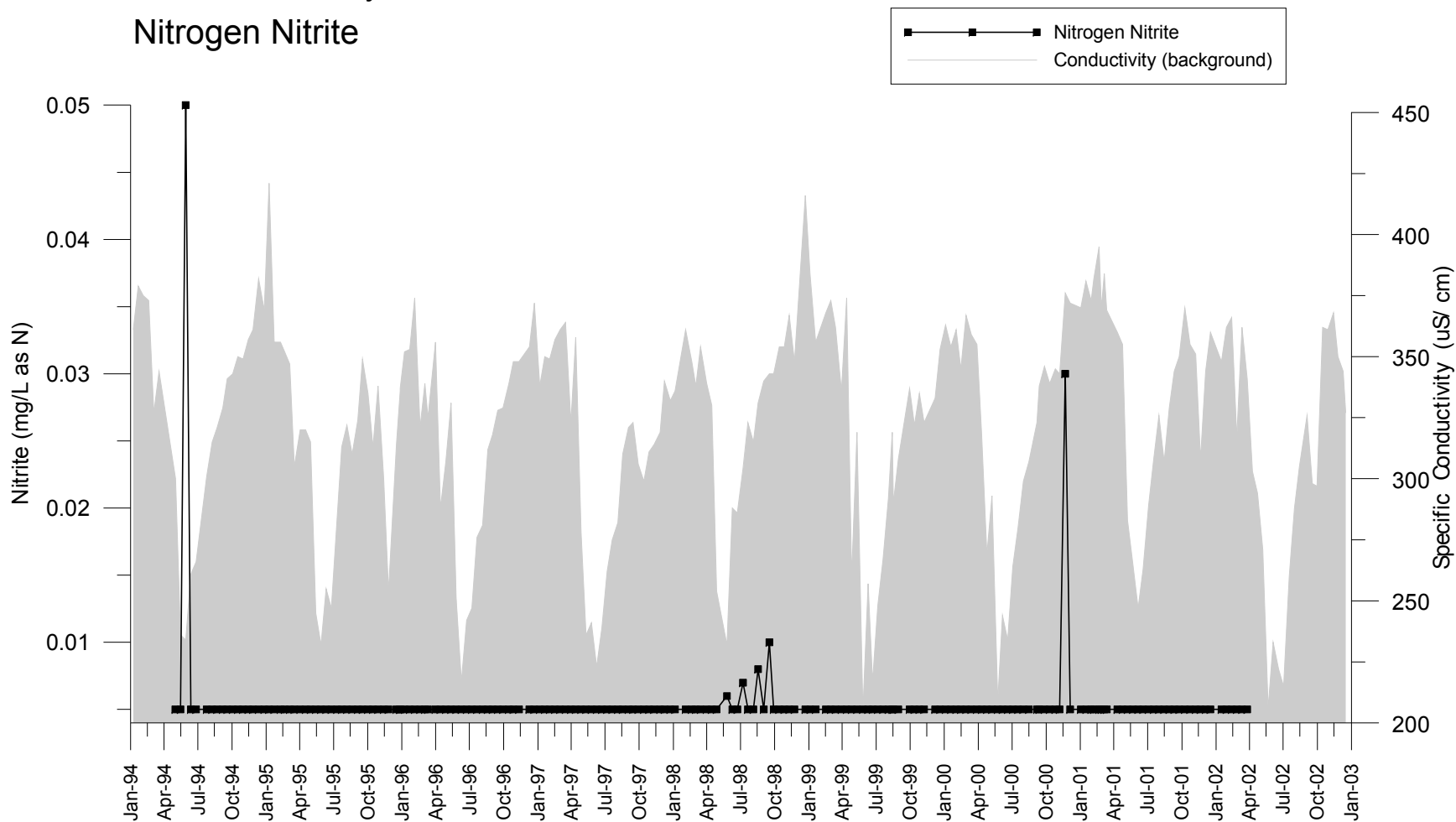


Figure 54
Elk River at Hwy 93 near Elko
Nitrogen Total

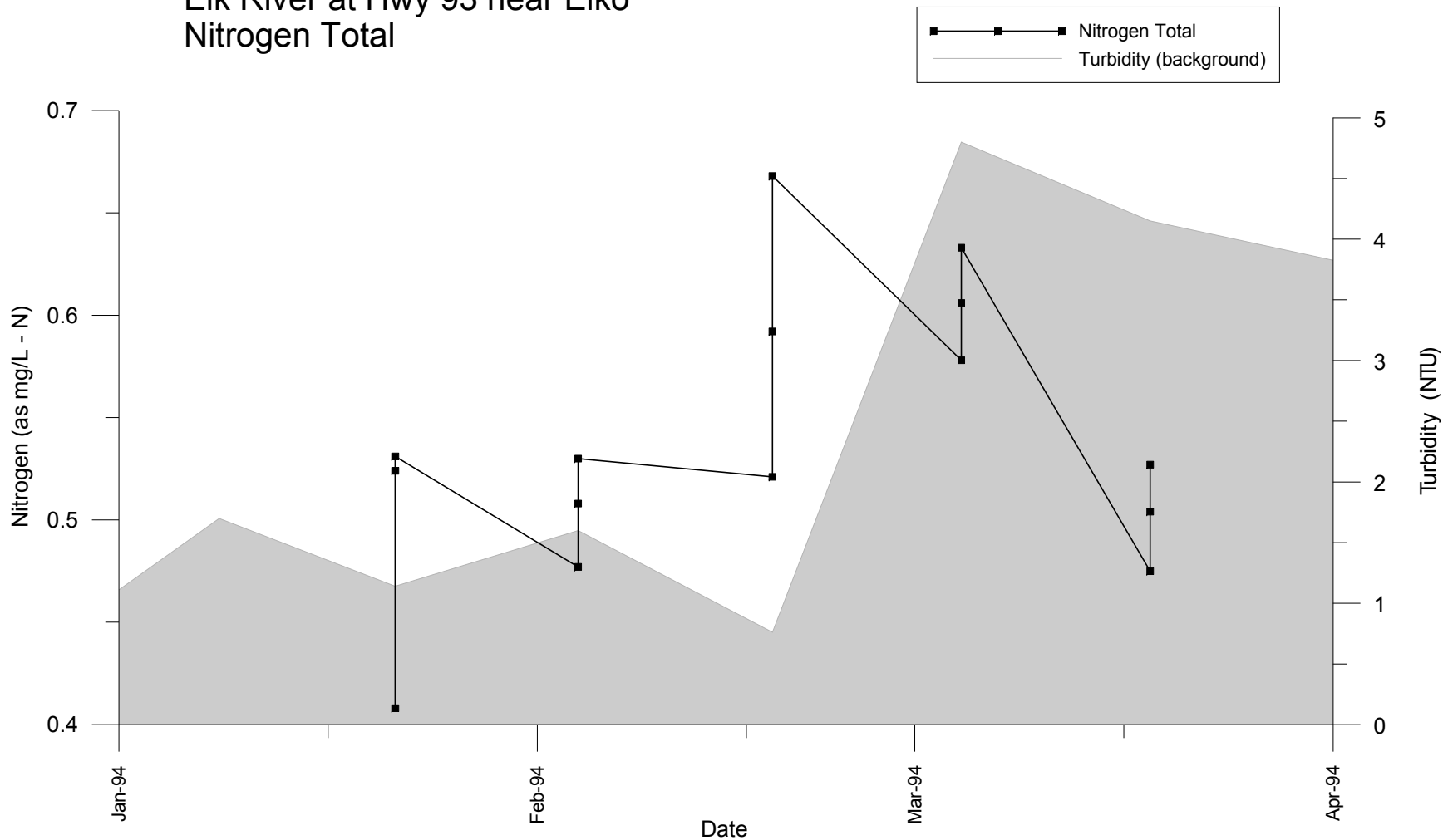


Figure 55
Elk River at Hwy93 near Elko
Nitrogen Total Dissolved

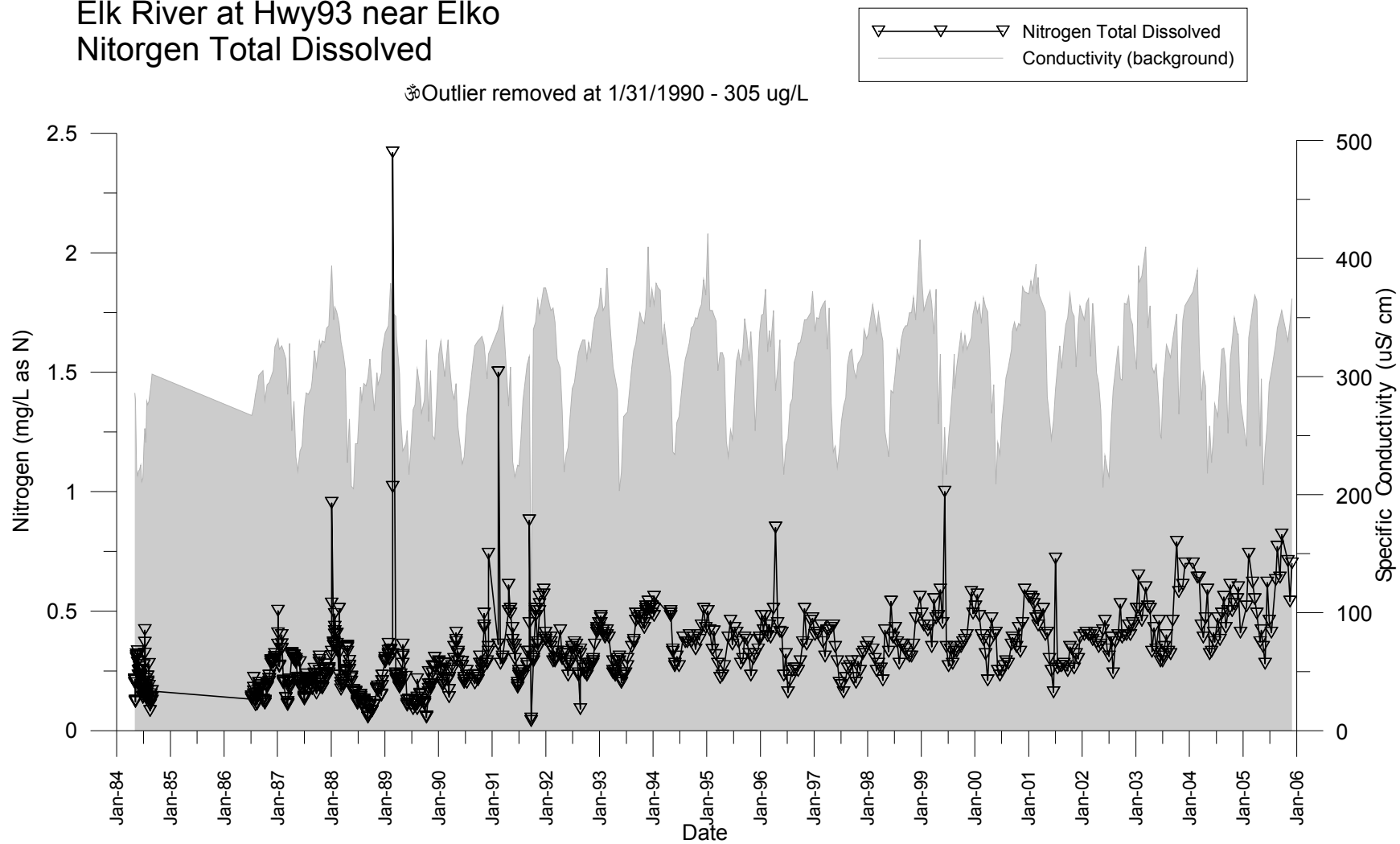


Figure 56
Elk River at Hwy93 near Elko
pH

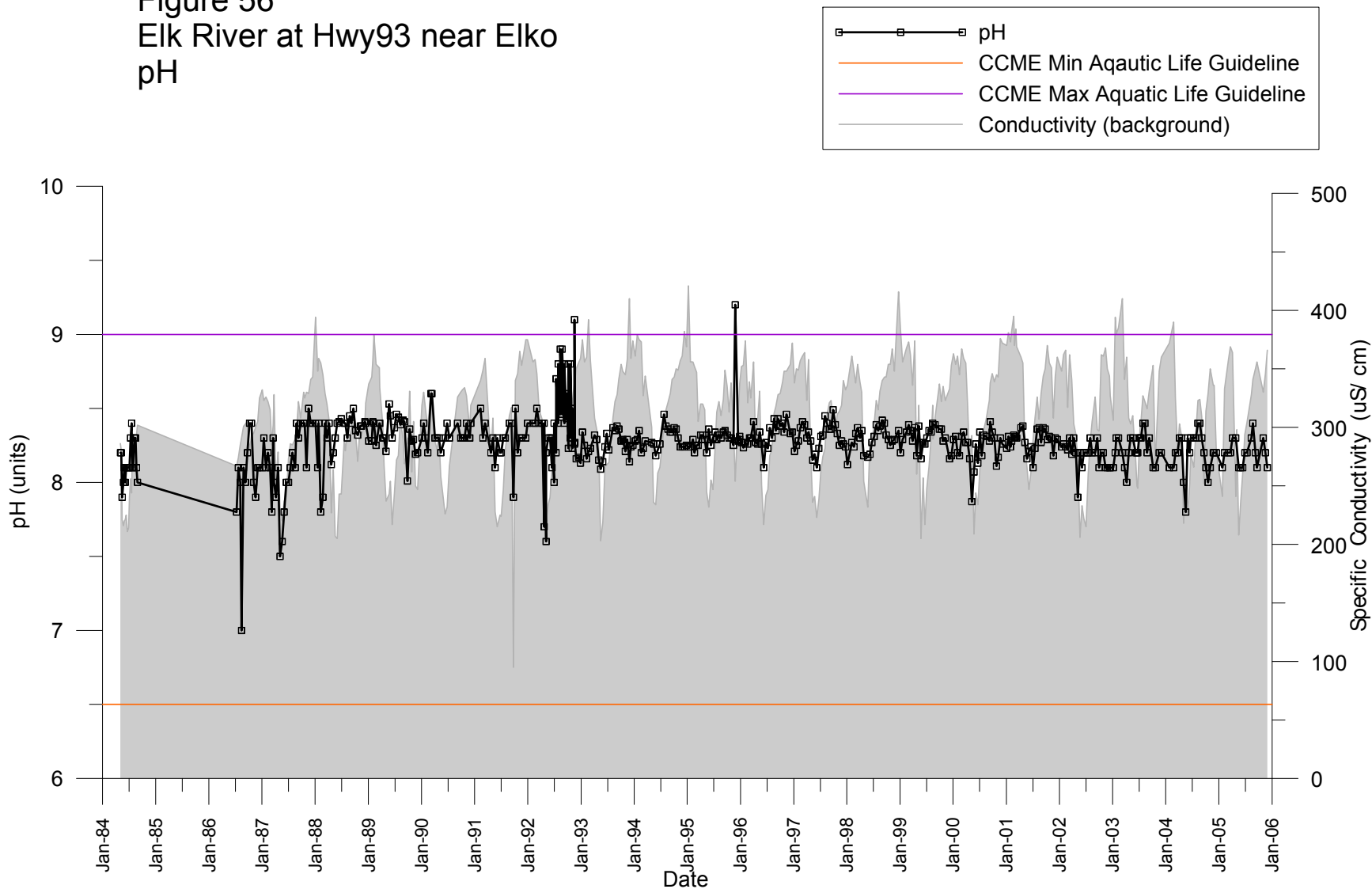


Figure 57
Elk River at Hwy 93 near Elko
Phosphorus Total

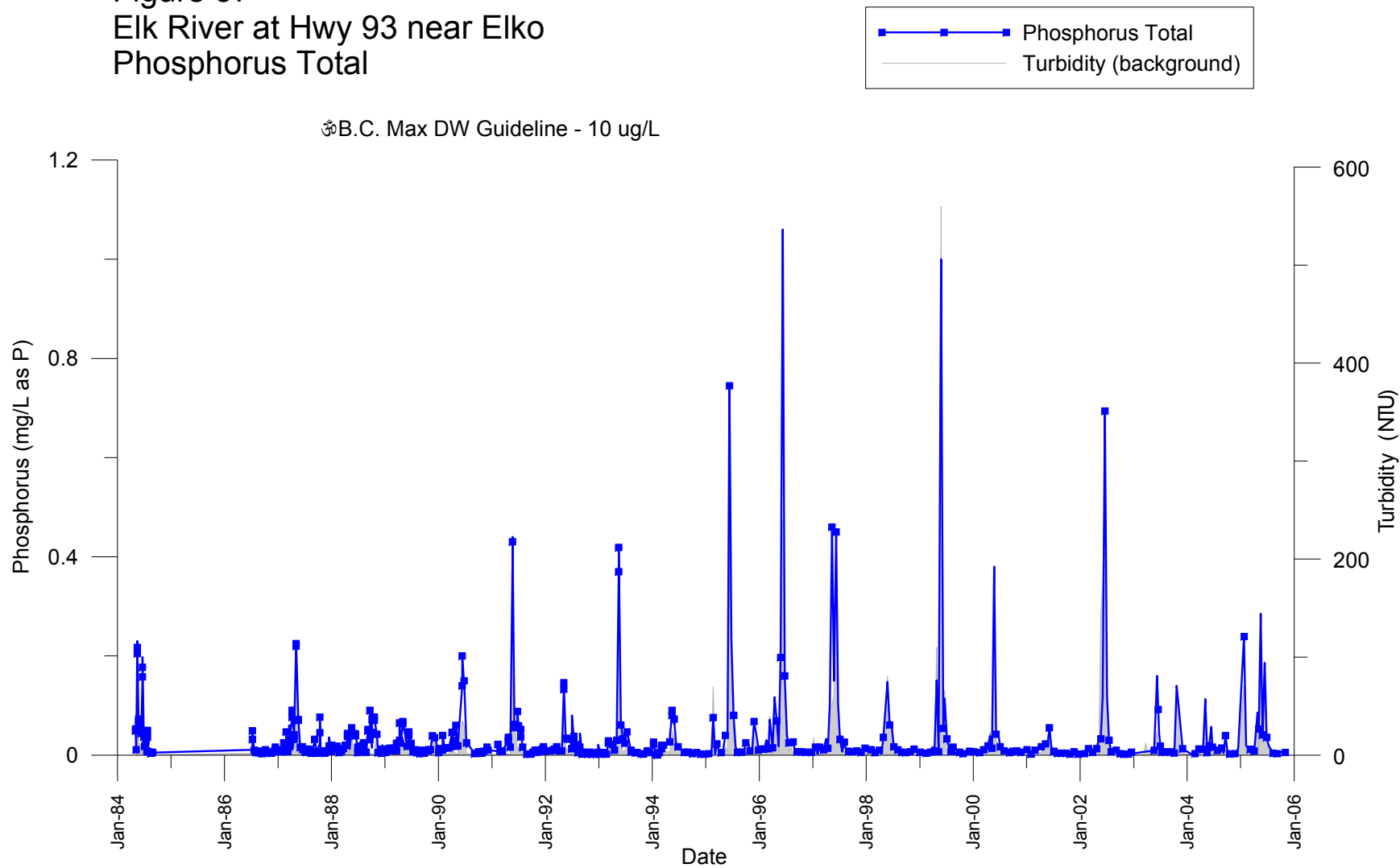


Figure 58
 Elk River at Hwy93 near Elko
 Phosphate Dissolved Ortho

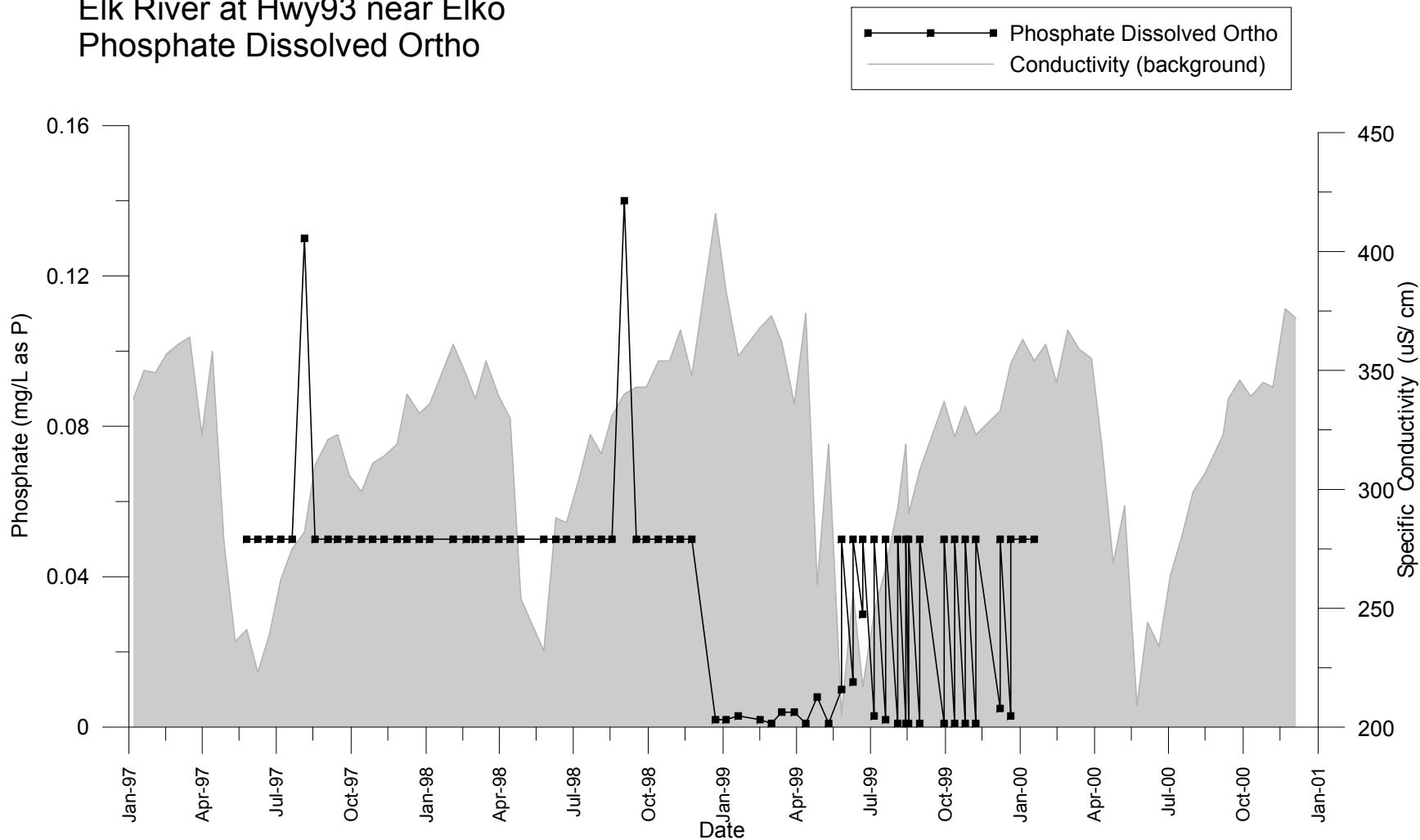


Figure 59
Elk River at Hwy93 near Elko
Phosphorus Dissolved Ortho

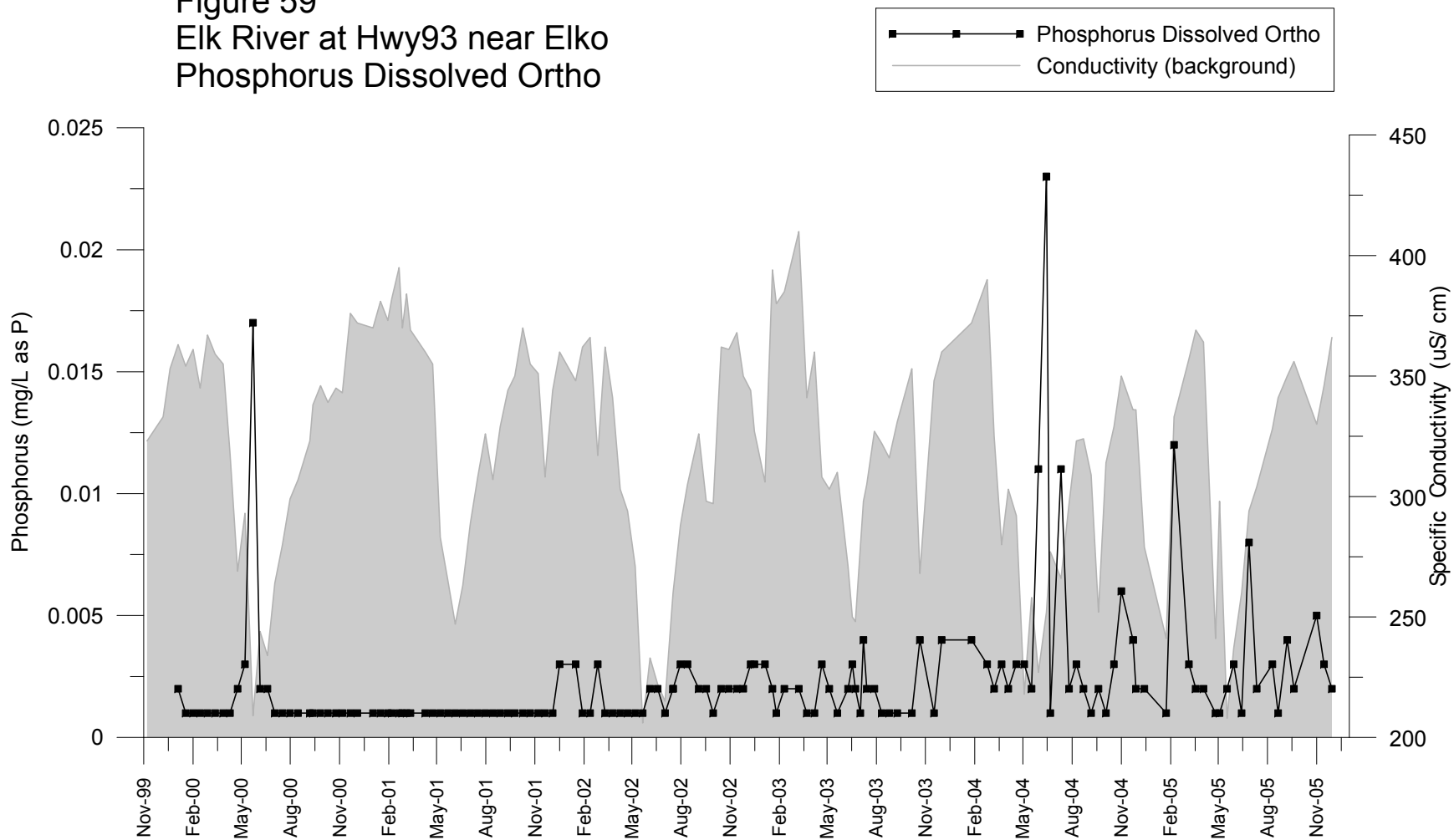


Figure 60
Elk River at Hwy93 near Elko
Potassium Dissolved and Extractable (mg/L)

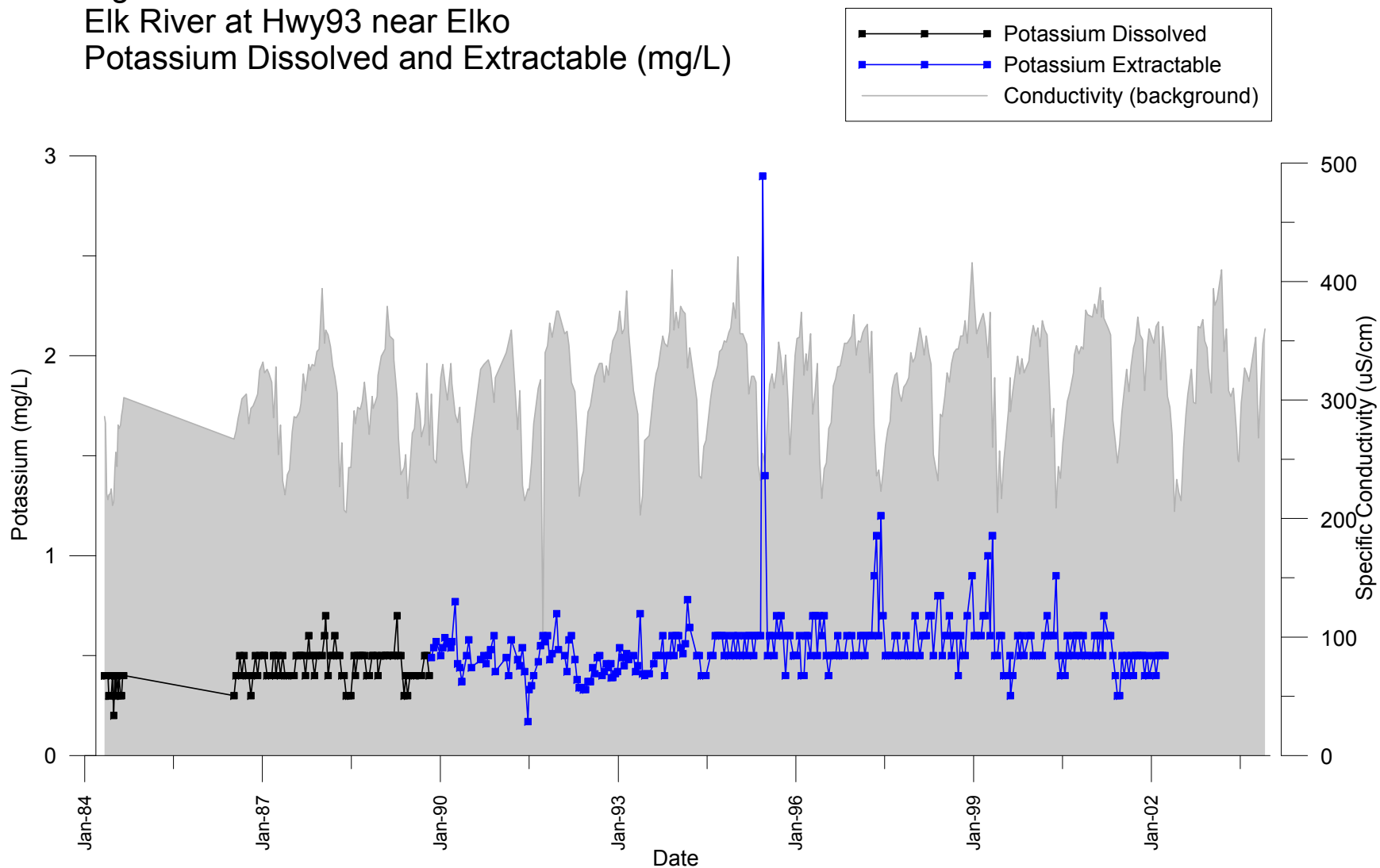


Figure 61
Elk River at Hwy 93 near Elko
Residue Filterable

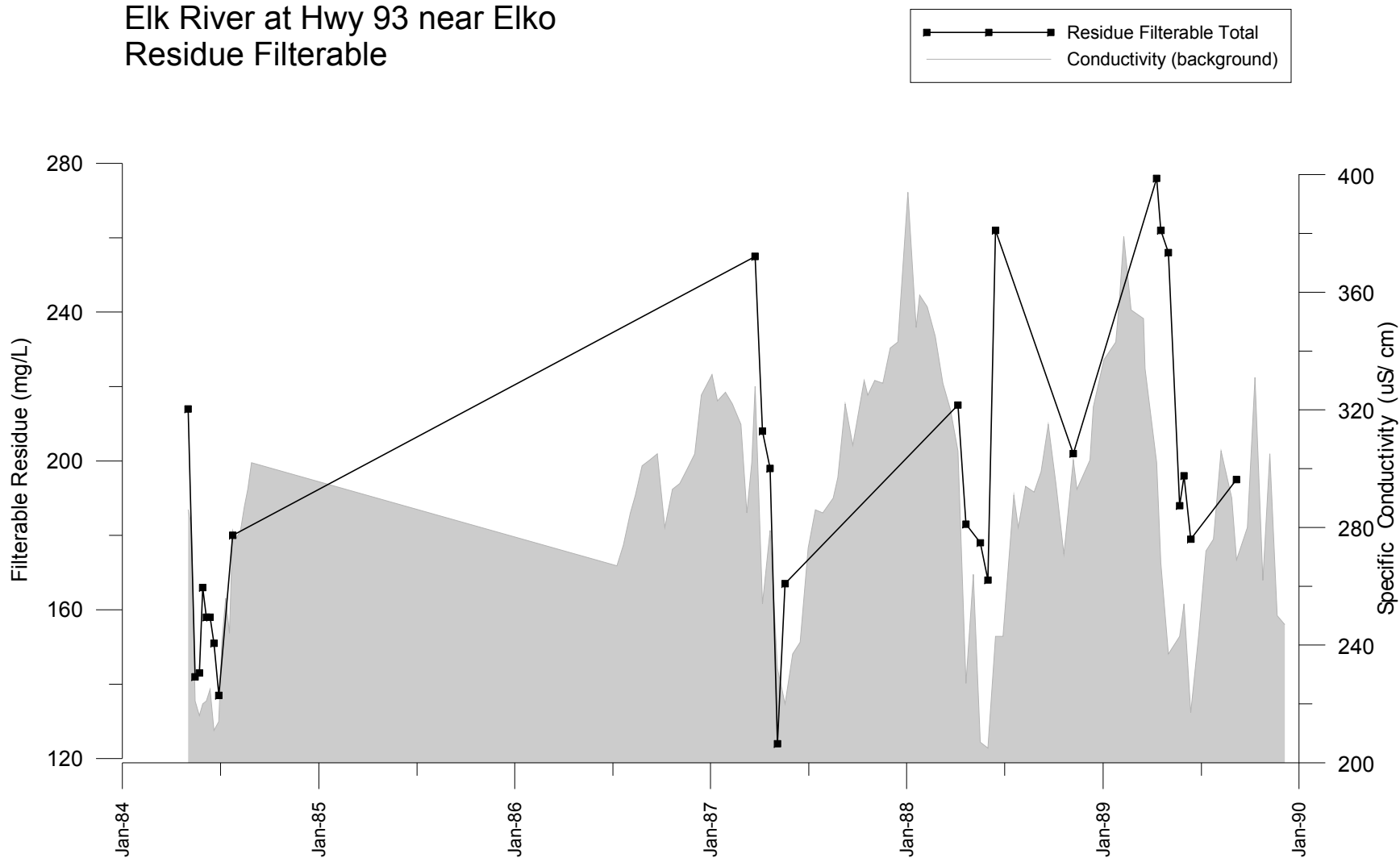


Figure 62
Elk River at Hwy93 near Elko
Residue Fixed Filterable

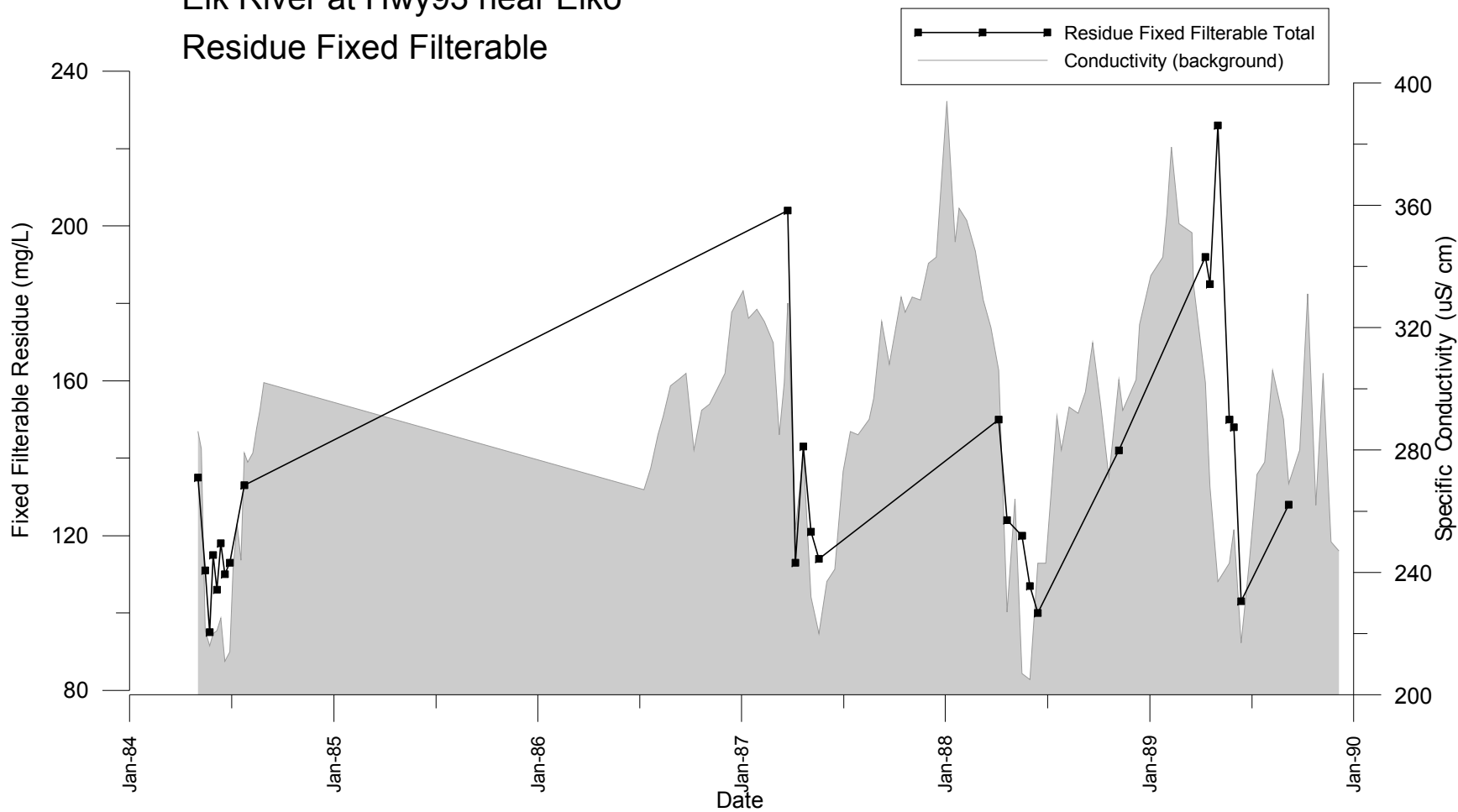


Figure 63
Elk River at Hwy 93 near Elko
Residue Fixed non-Filterable

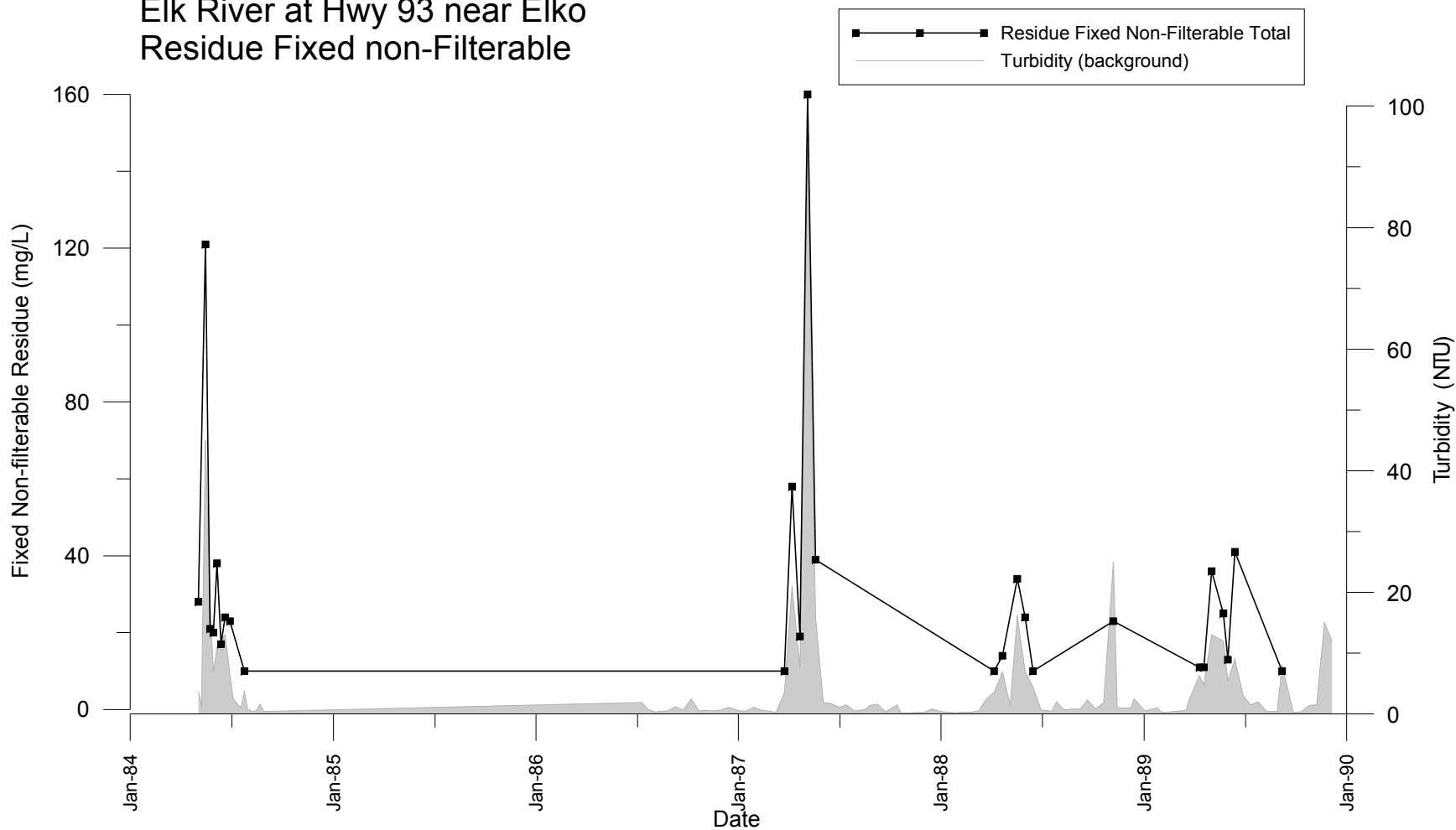


Figure 64
Elk River at Hwy93 near Elko
Residue non-Filterable

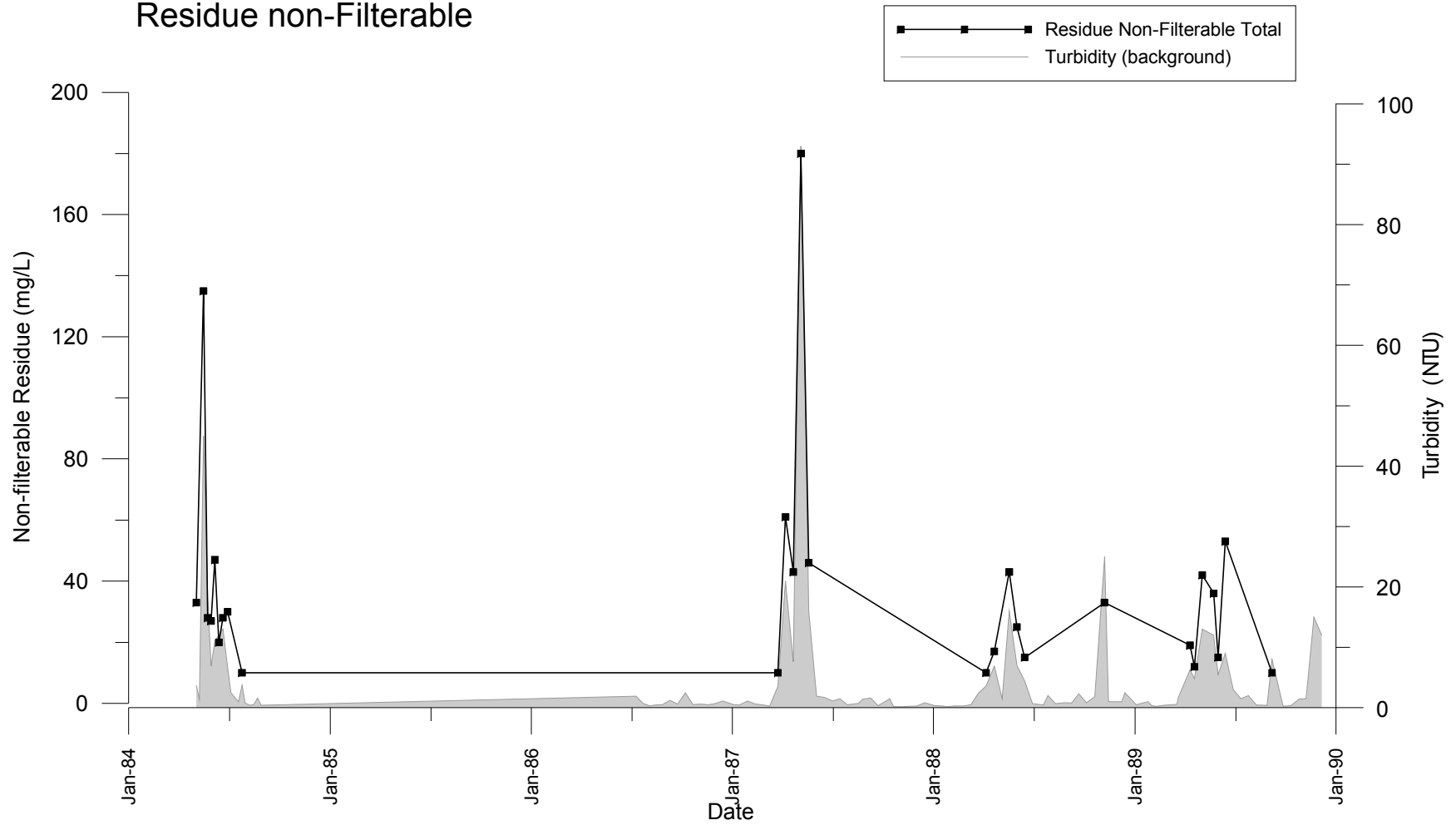


Figure 65
Elk River at Hwy93 near Elko
Rubidium Total, Dissolved and Extractable

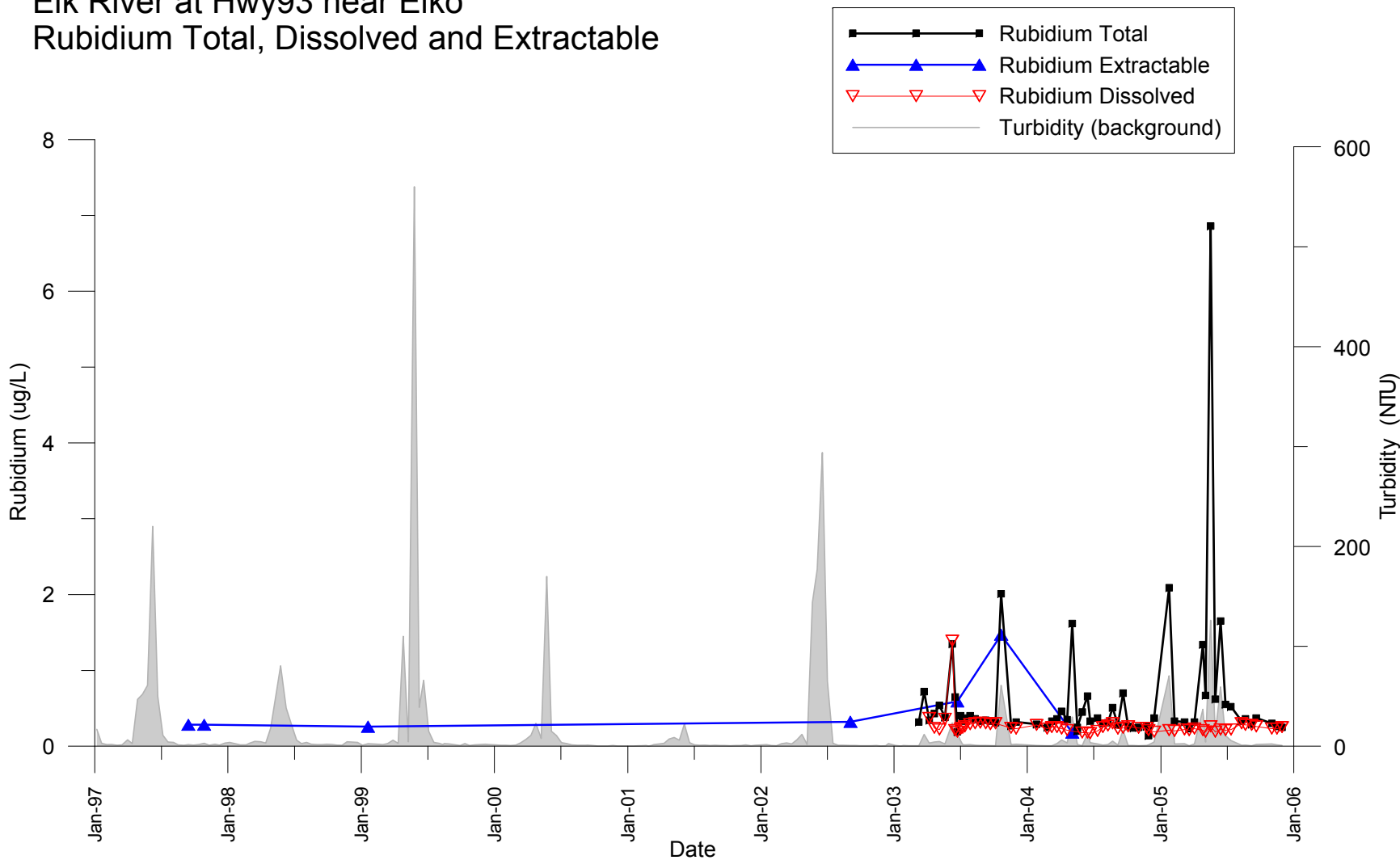


Figure 66
 Elk River at Hwy93 near Elko
 Rubidium Total, Dissolved and Extractable

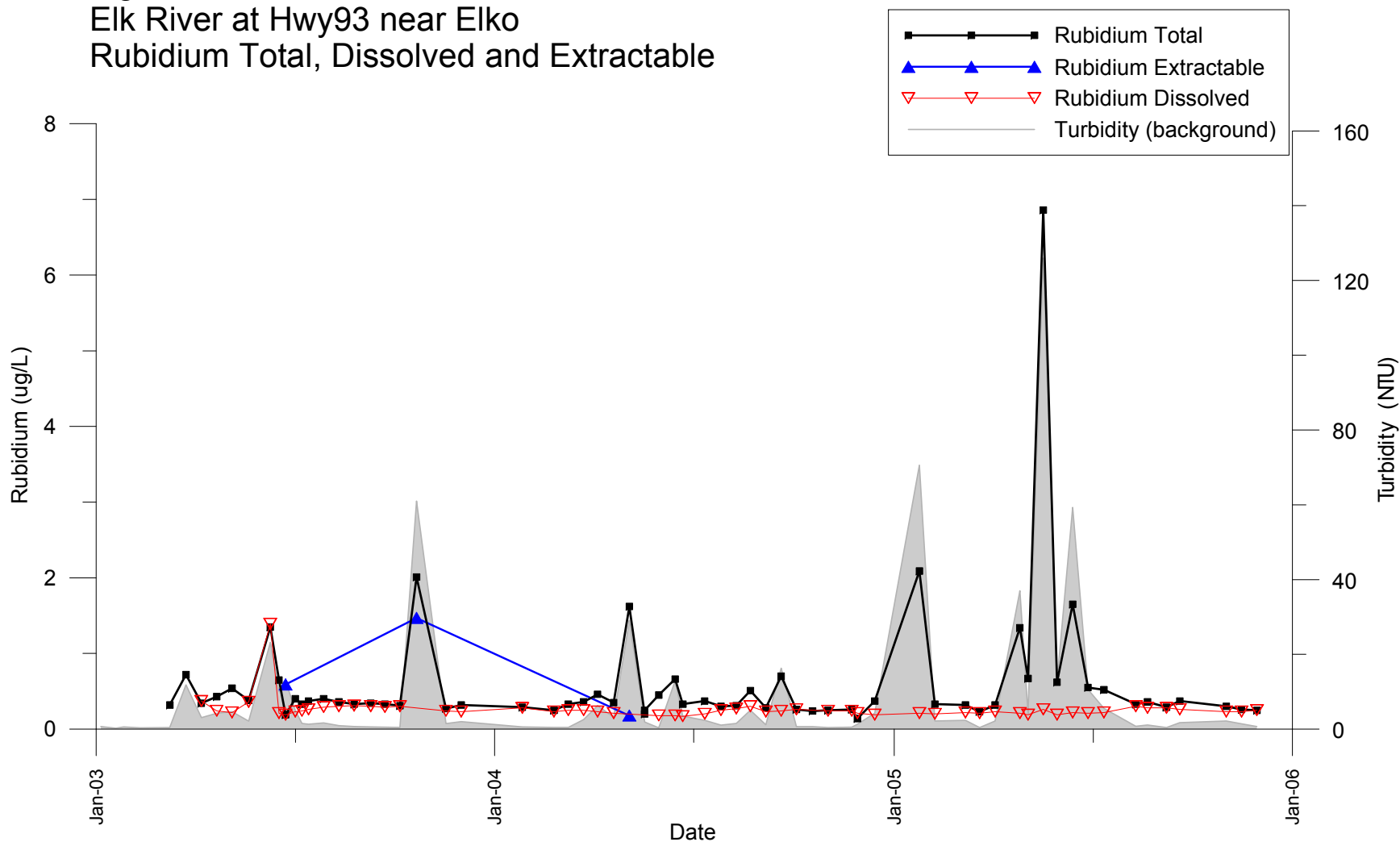


Figure 67
 Elk River at Hwy93 near Elko
 Selenium Total, Dissolved and Extractable

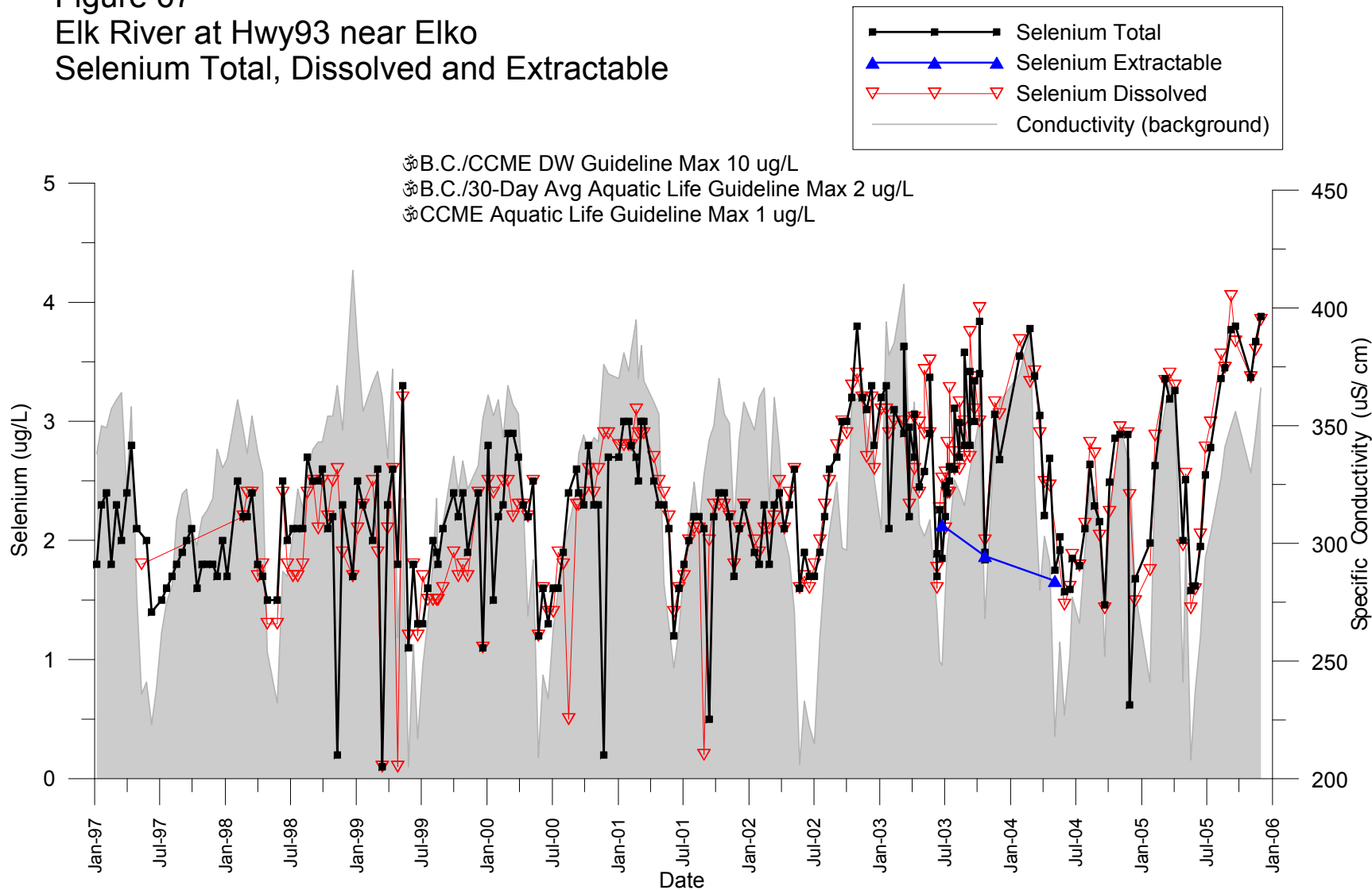


Figure 68
Elk River at Hwy93 near Elko
Silica Reactive and Dissolved

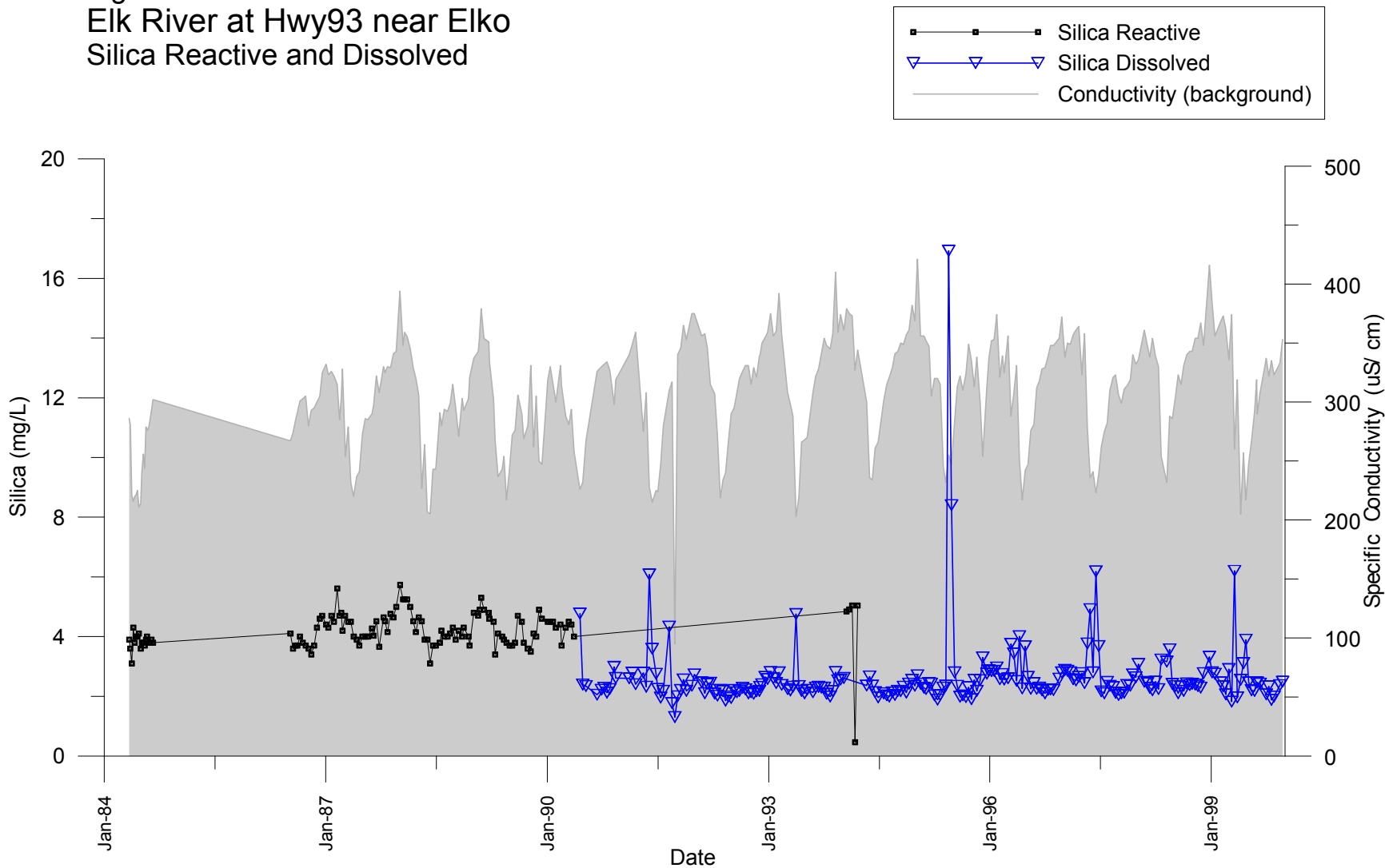


Figure 69
Elk River at Hwy93 near Elko
Silicon Extractable

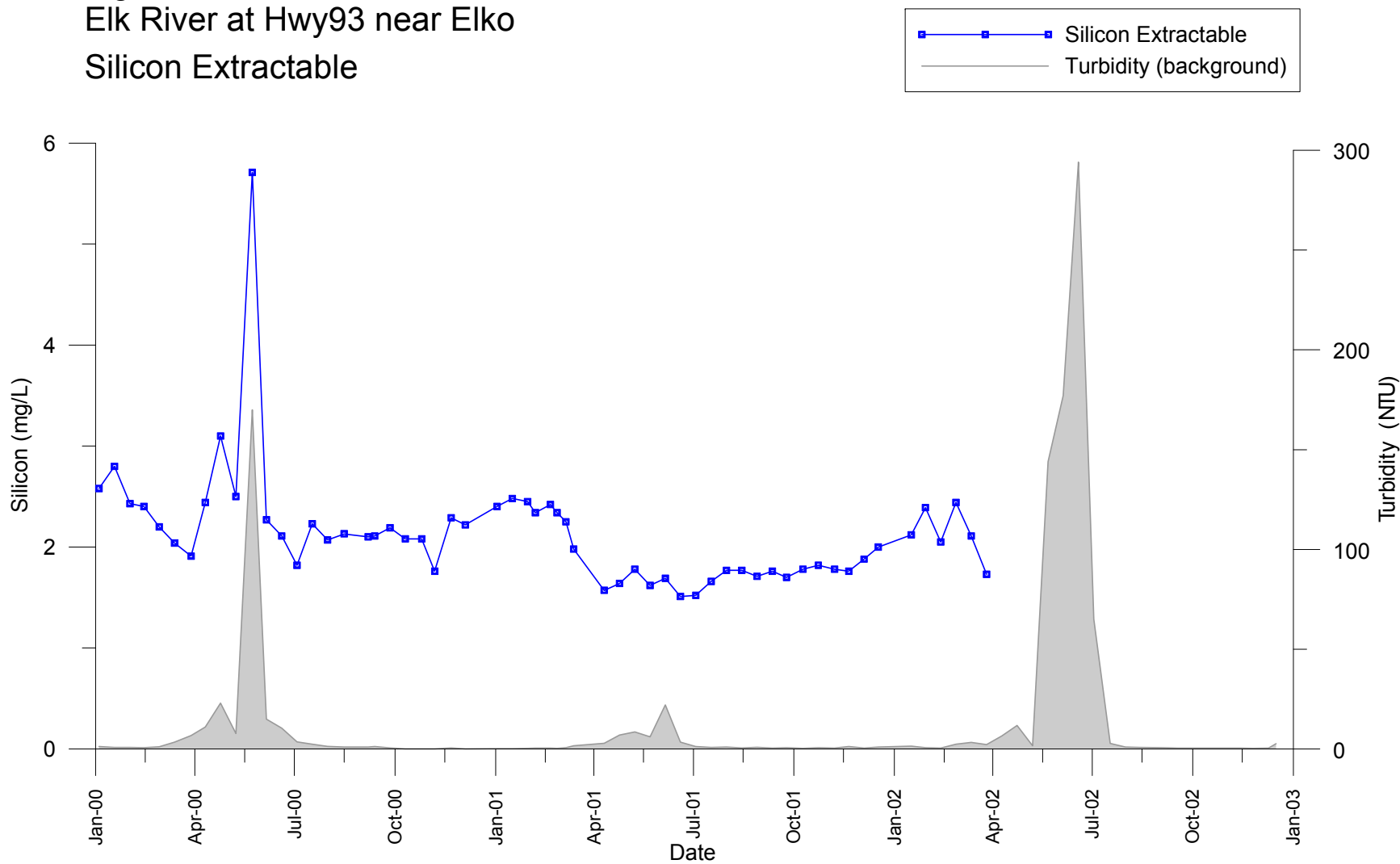


Figure 70
 Elk River at Hwy93 near Elko
 Silver Total, Dissolved and Extractable

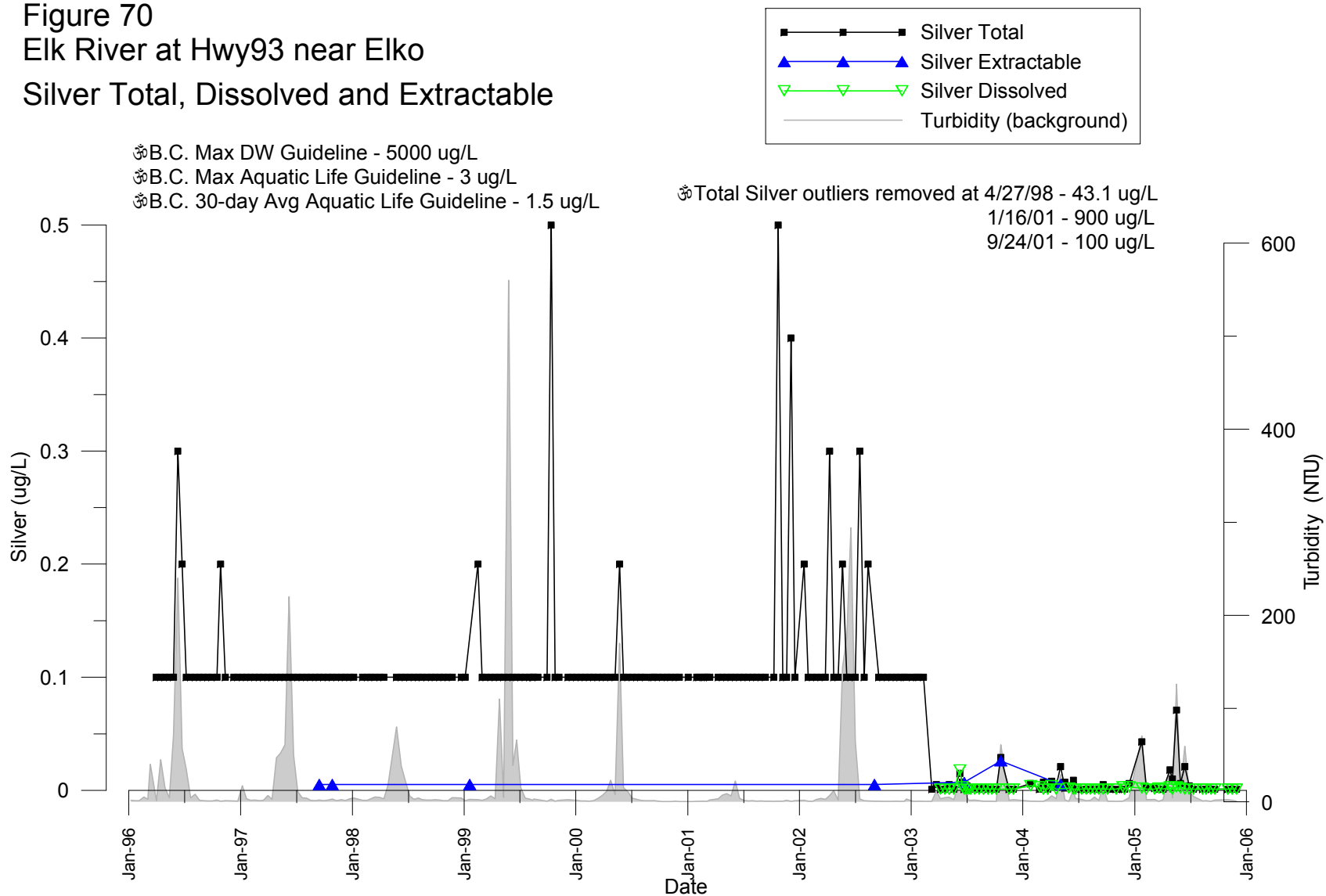


Figure 71
 Elk River at Hwy93 near Elko
 Silver Total, Dissolved and Extractable

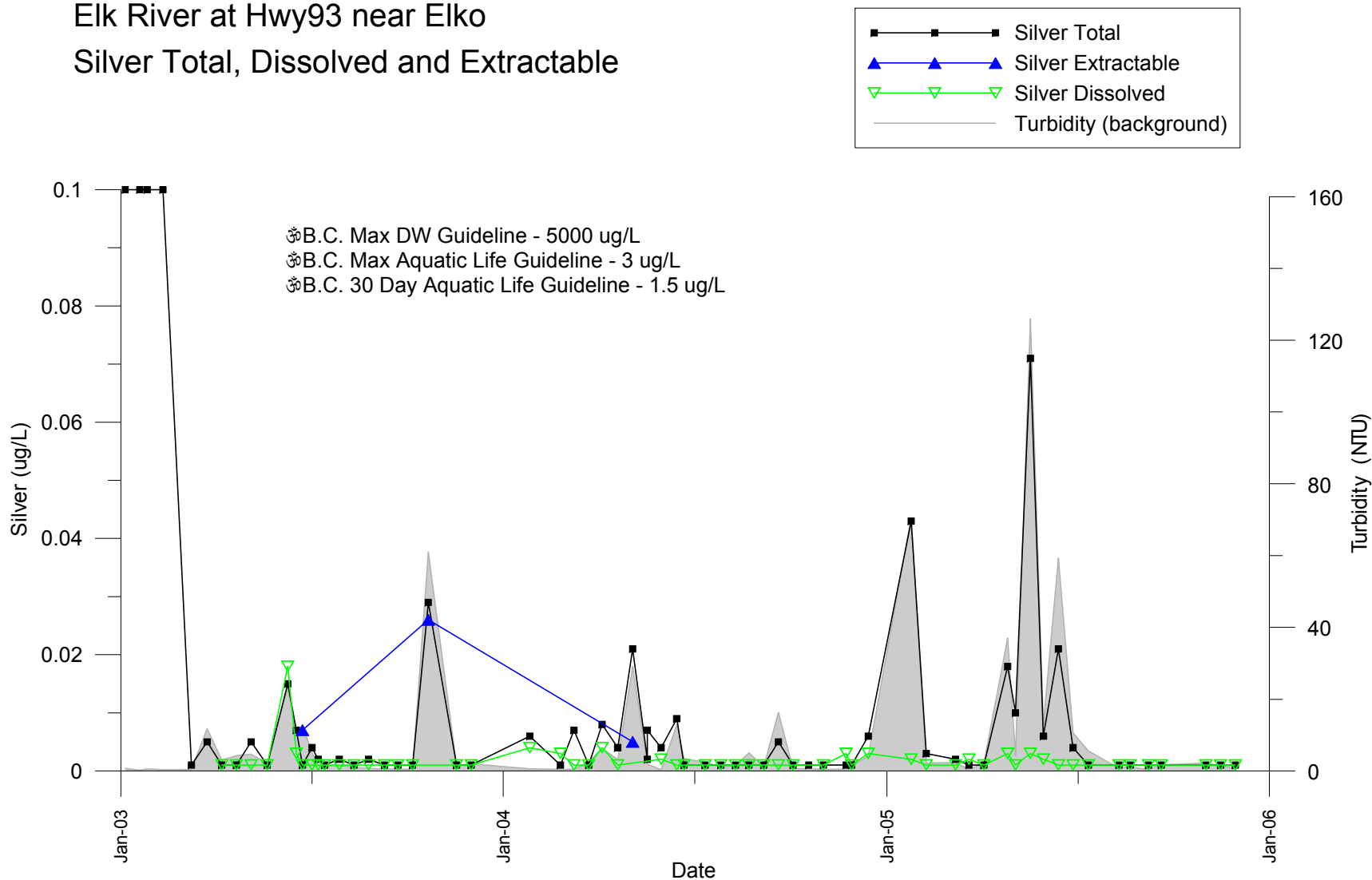


Figure 72
 Elk River at Hwy93 near Elko
 Sodium Dissolved and Extractable

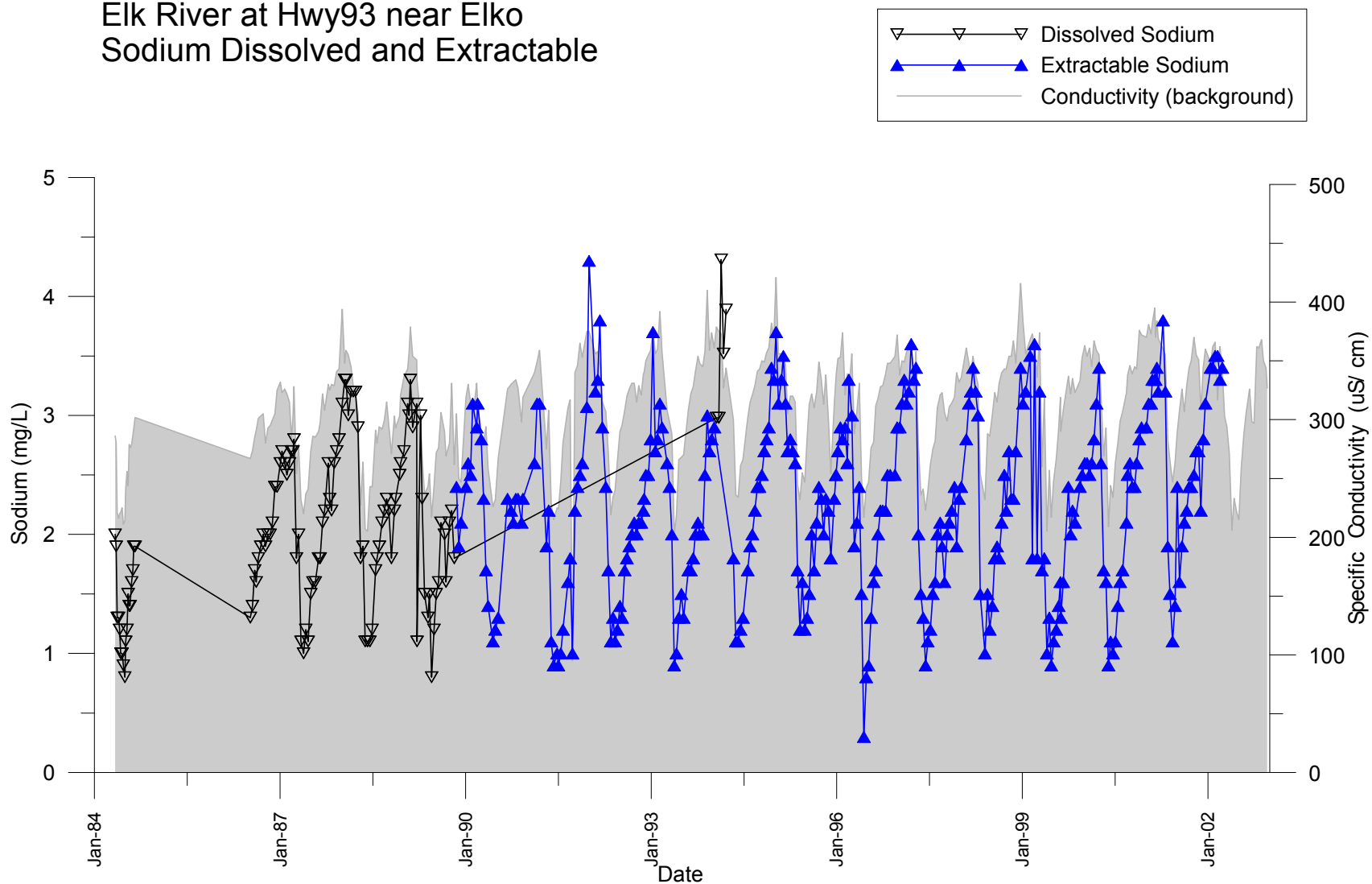


Figure 73
Elk River at Hwy93 near Elko
Specific Conductivity

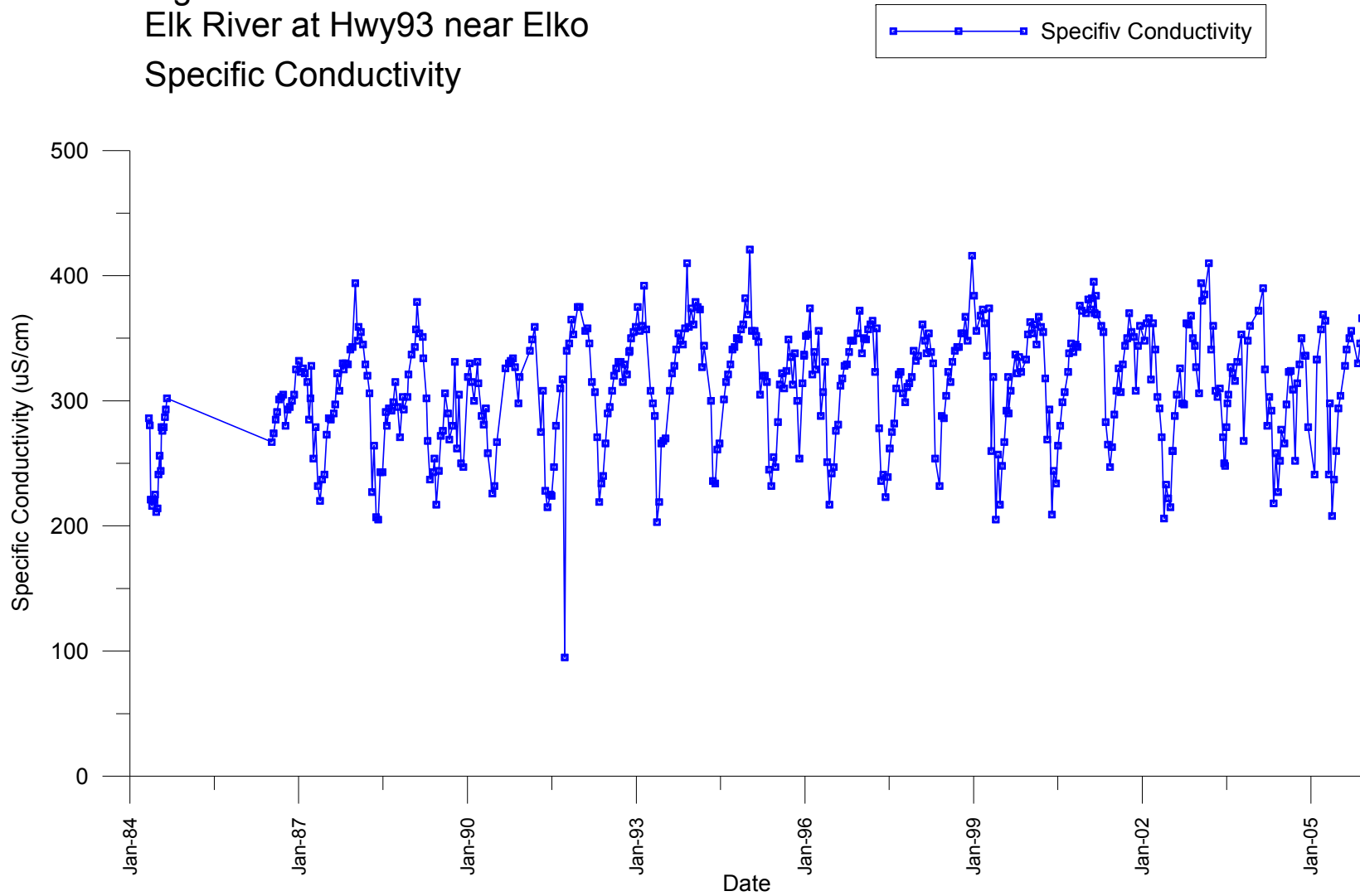


Figure 74
Elk River at Hwy93 near Elko
Strontium Total and Extractable

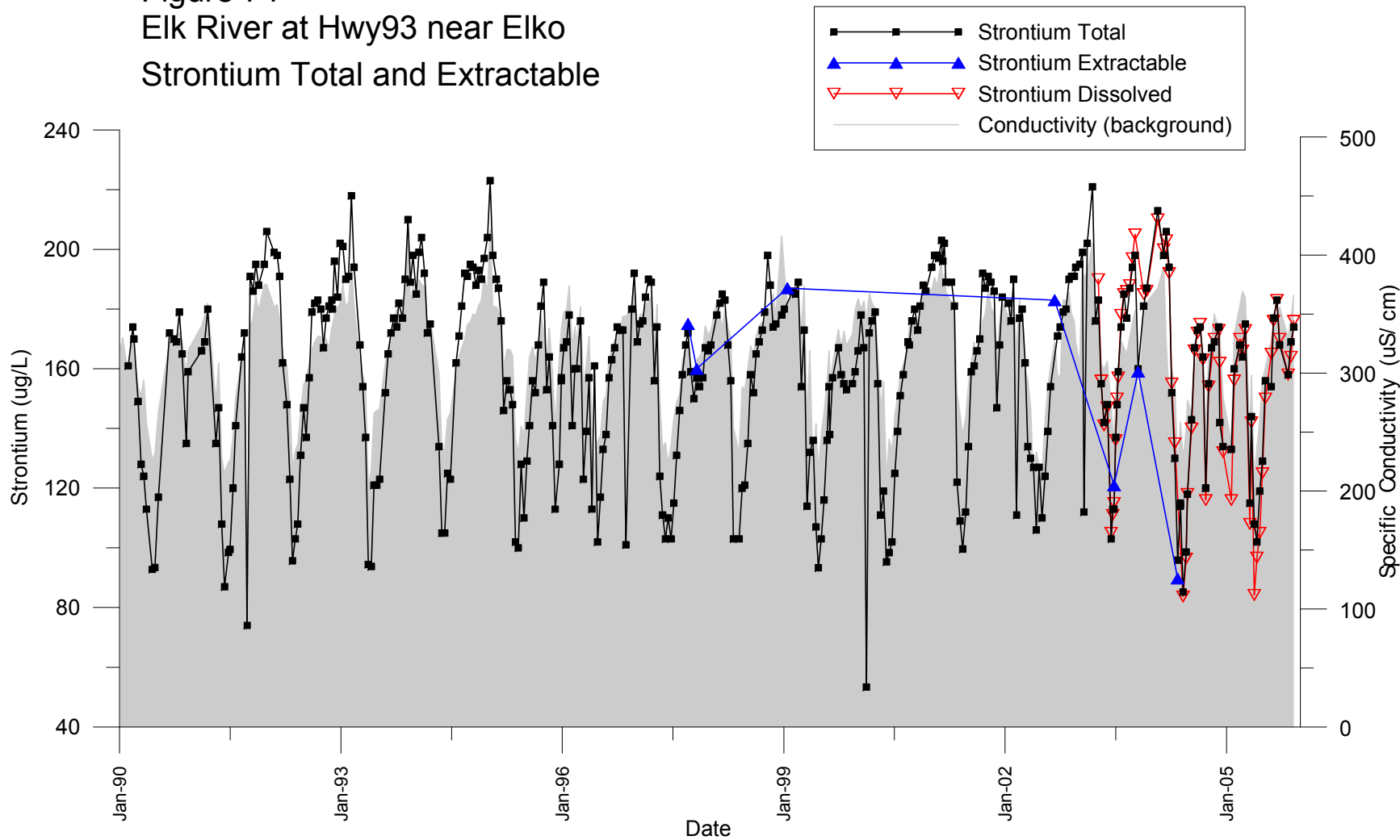


Figure 75
 Elk River at Hwy93 near Elko
 Sulphate Dissolved

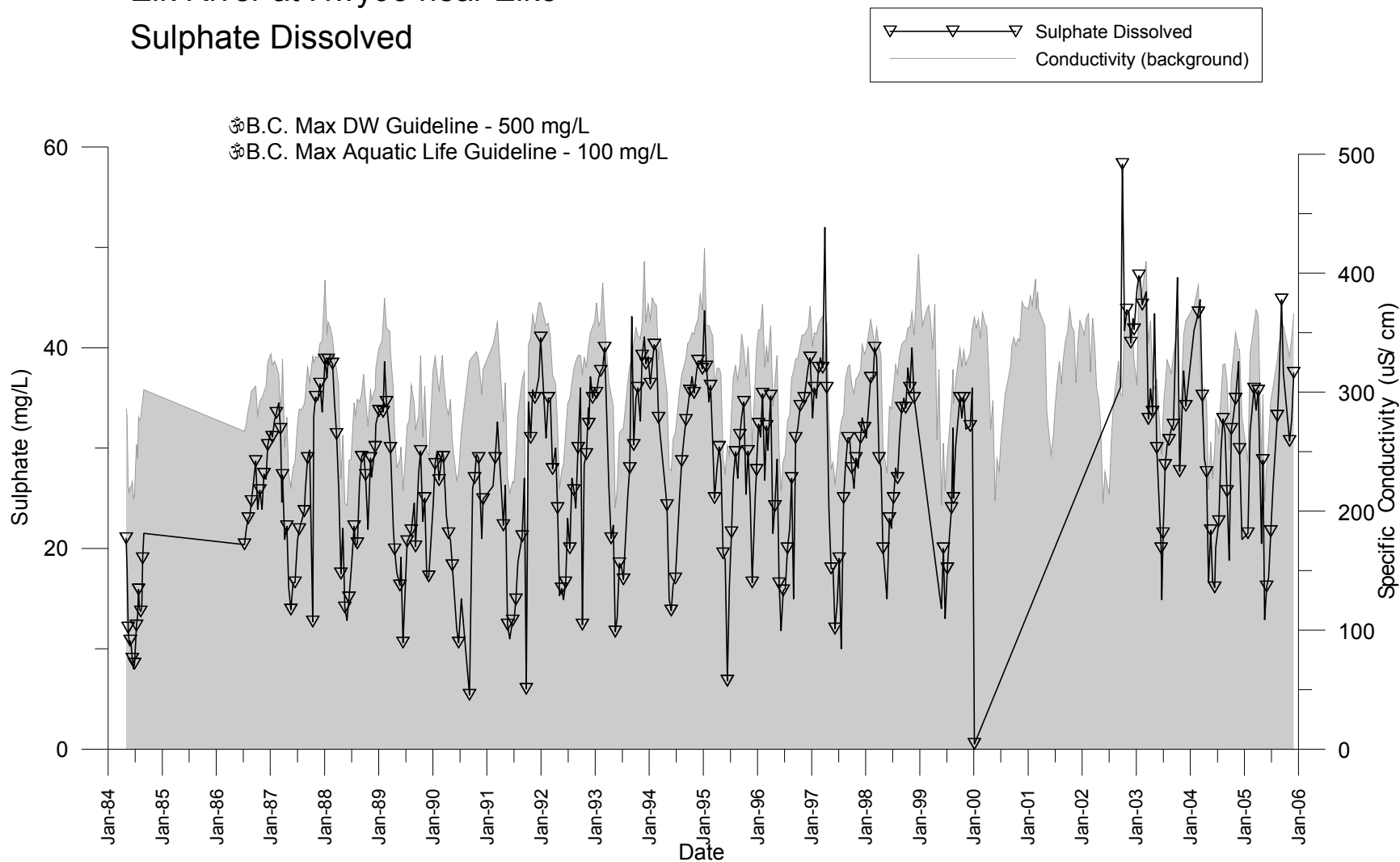


Figure 76
Elk River at Hwy93 near Elko
Temperature Air and Water

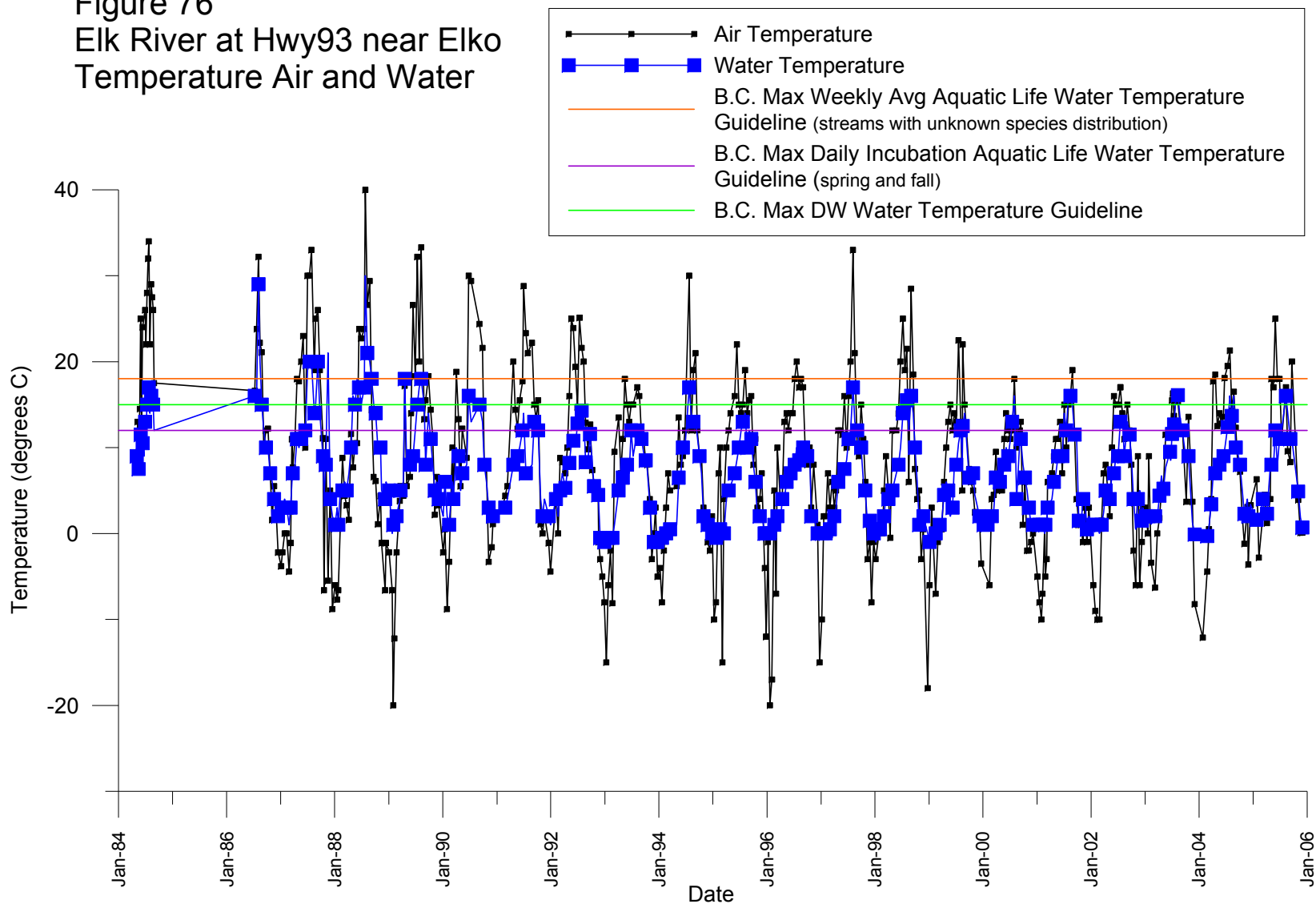


Figure 77
 Elk River at Hwy93 near Elko
 Thallium Total, Dissolved and Extractable

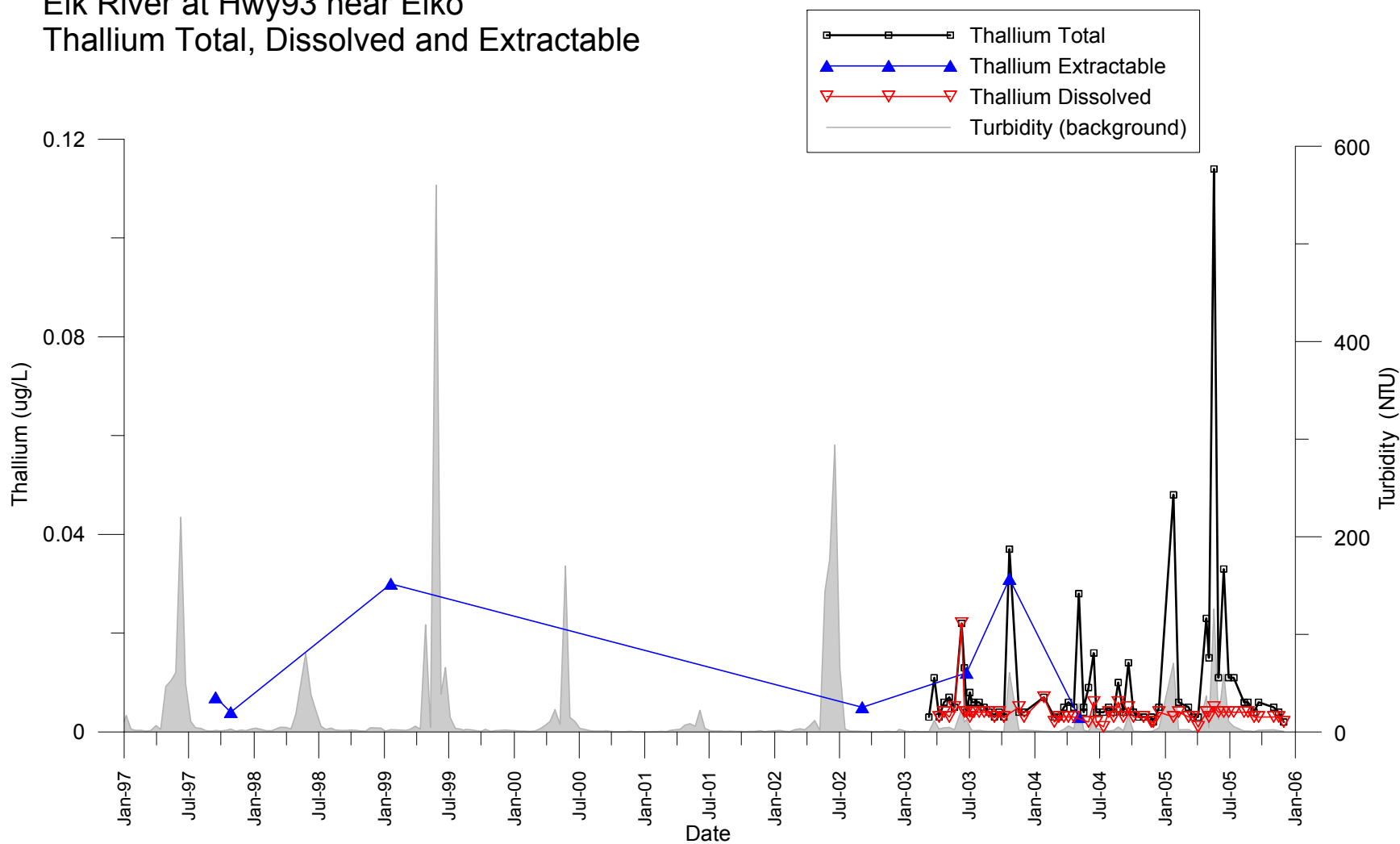


Figure 78
 Elk River at Hwy93 near Elko
 Thallium Total, Dissolved and Extractable

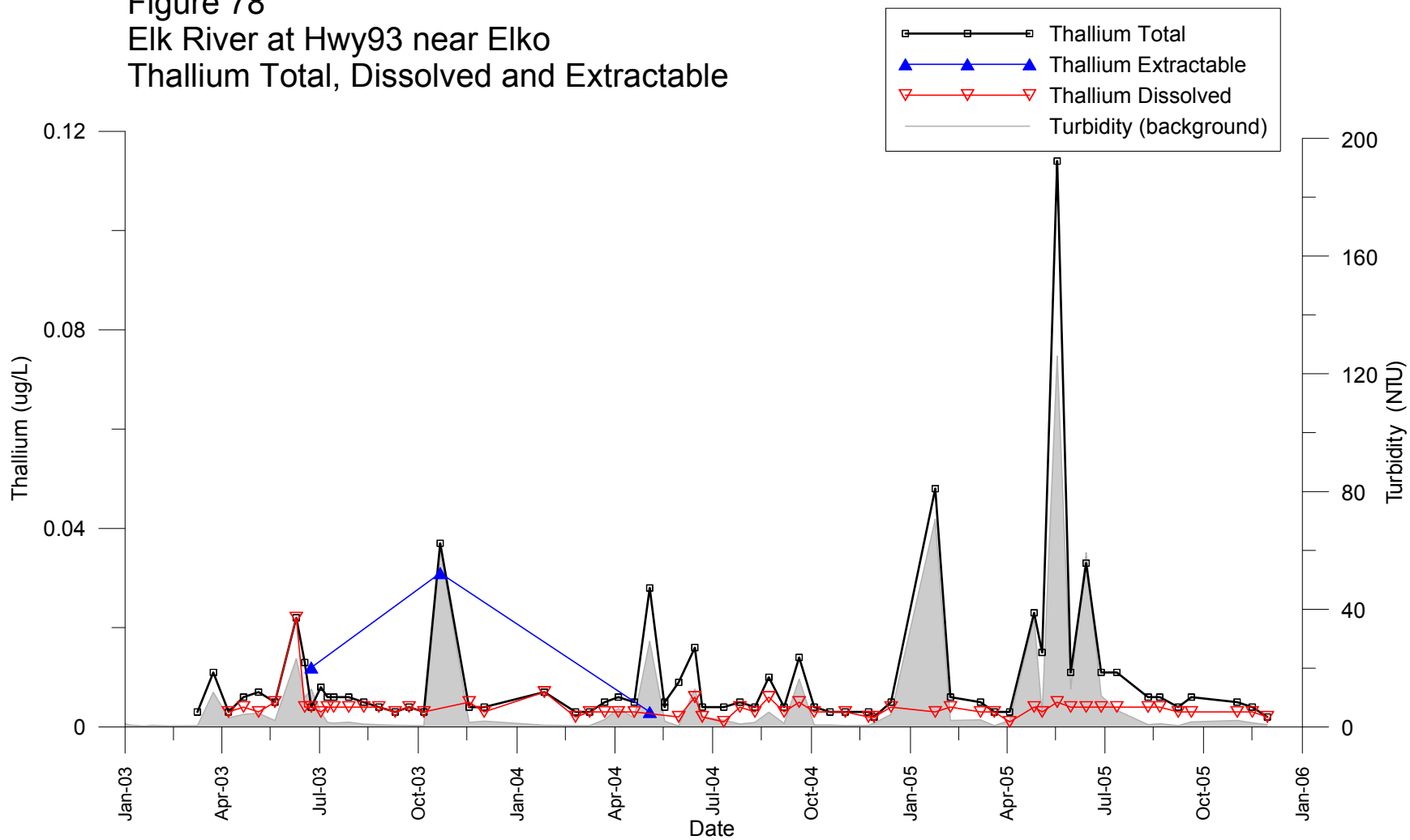


Figure 79
 Elk River at Hwy93 near Elko
 Tin Total and Extractable

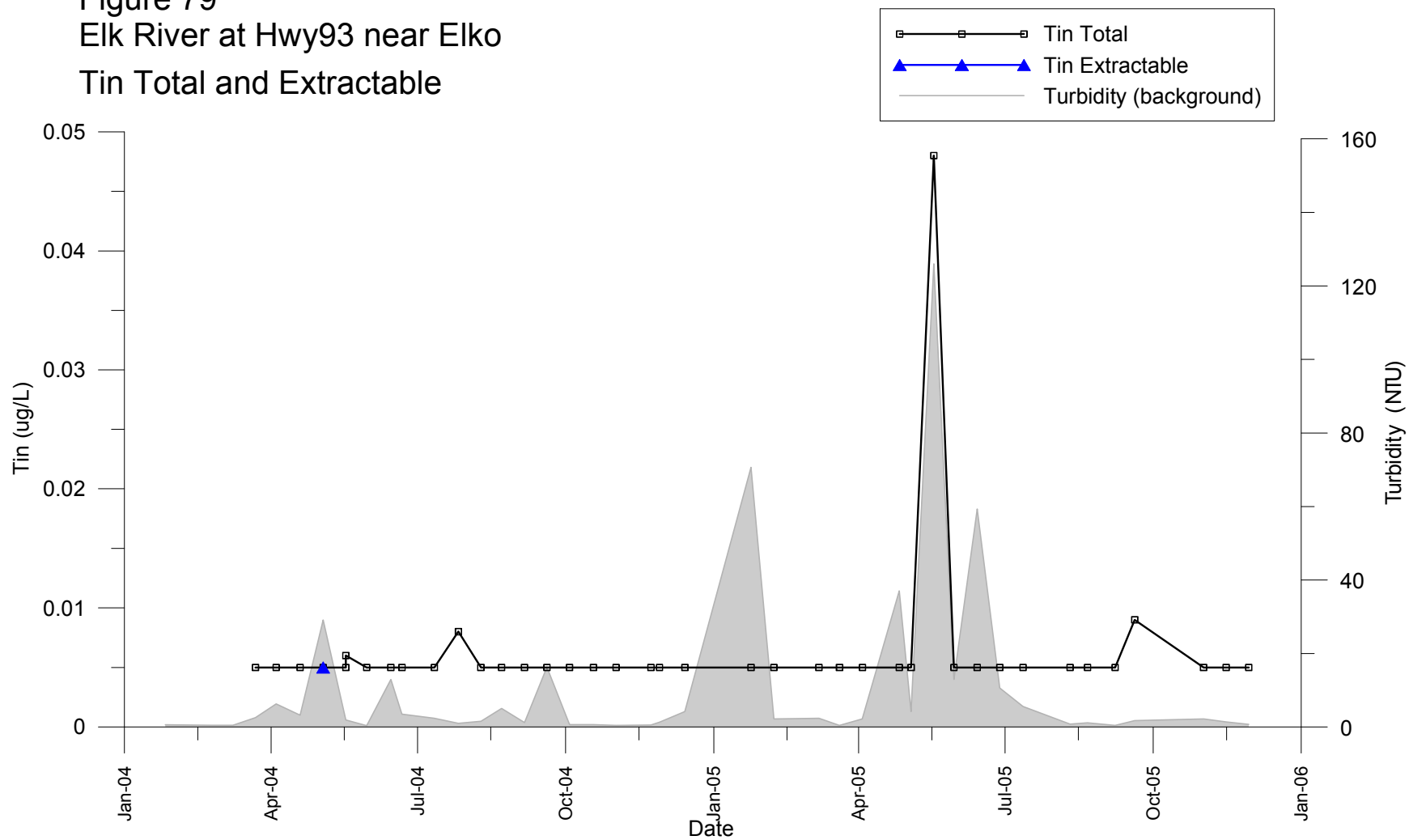


Figure 80
Elk River at Hwy93 near Elko
Turbidity

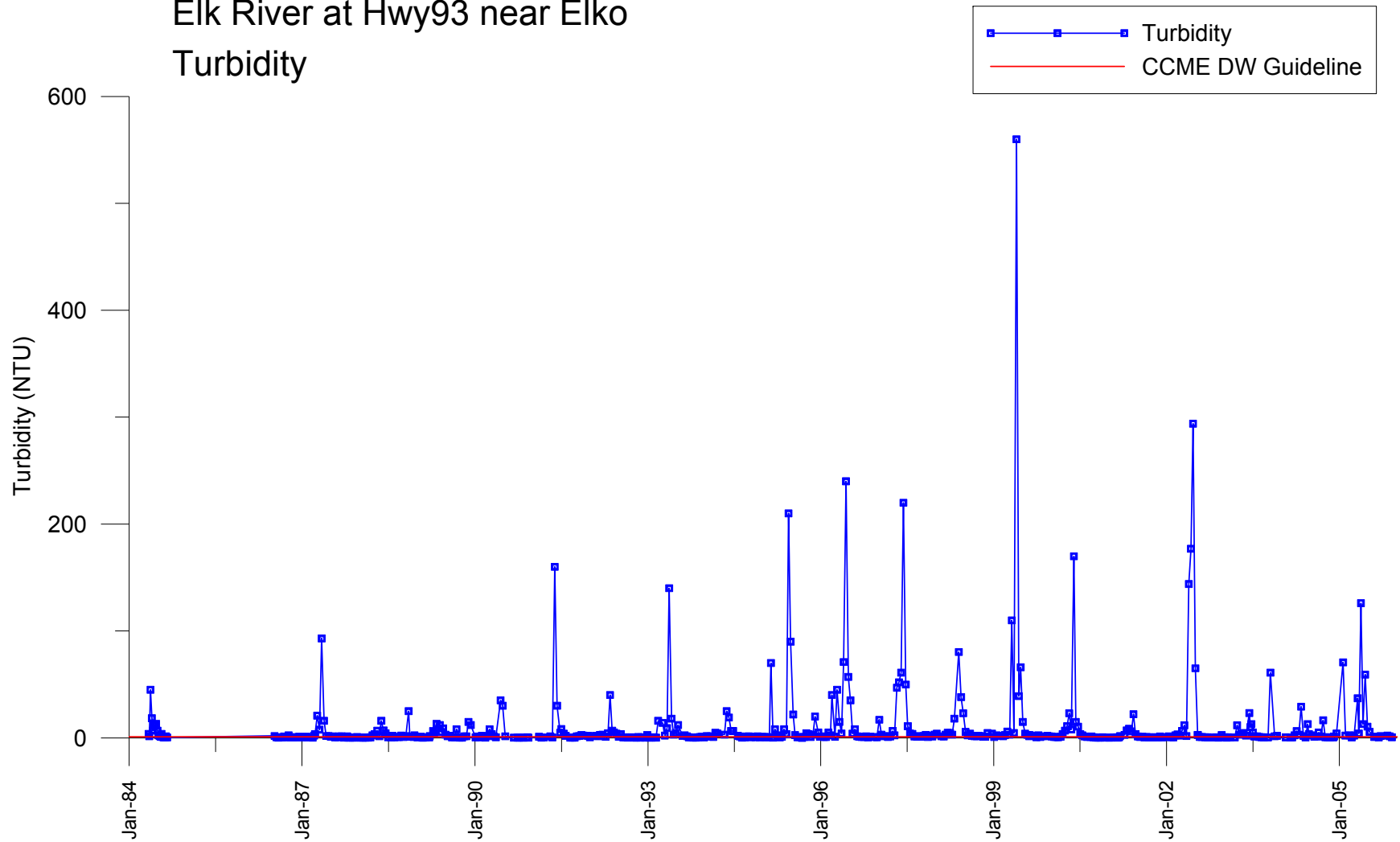


Figure 81
 Elk River at Hwy93 near Elko
 Uranium Total, Dissolved and Extractable

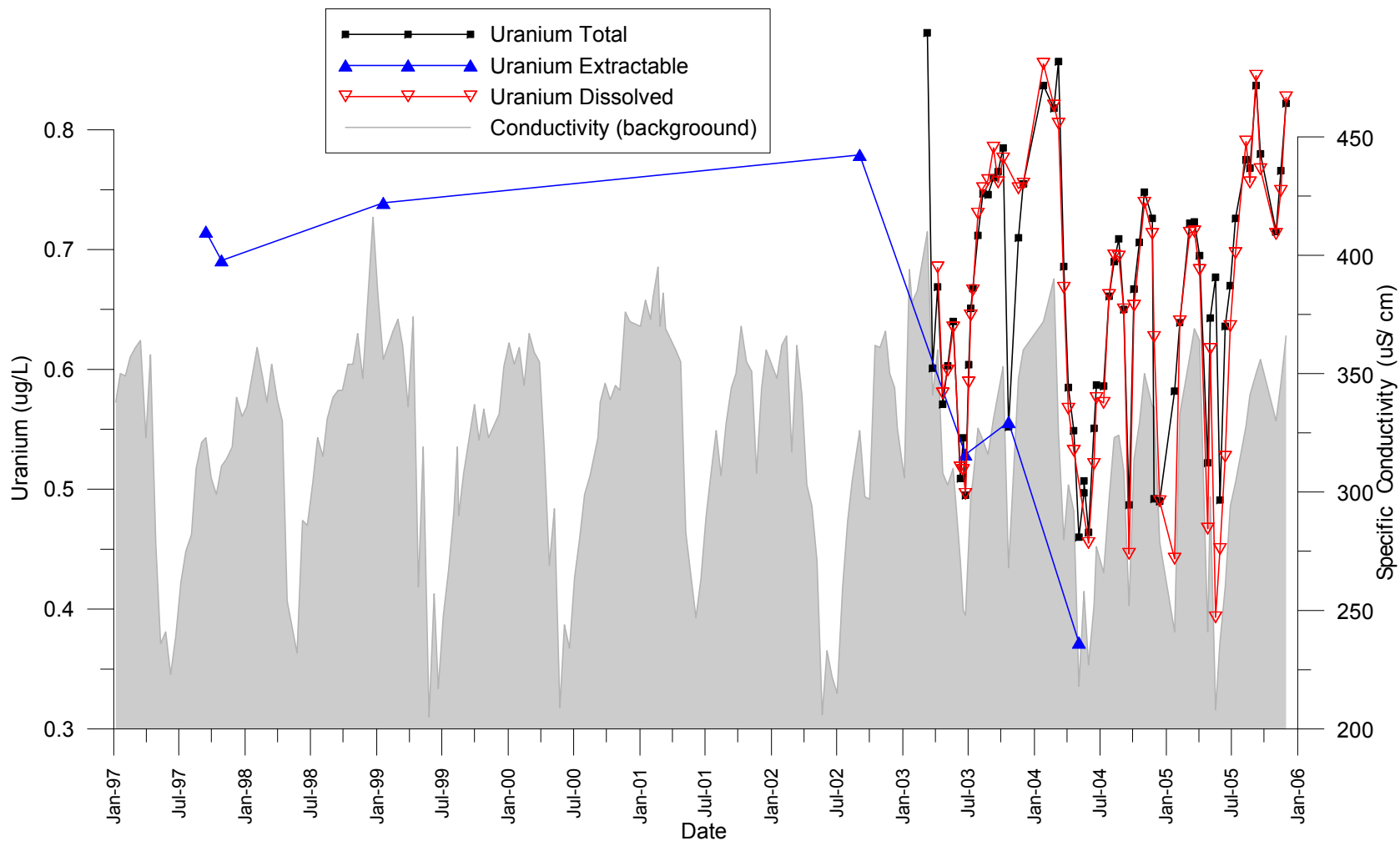


Figure 82
 Elk River at Hwy93 near Elko
 Uranium Total, Dissolved and Extractable

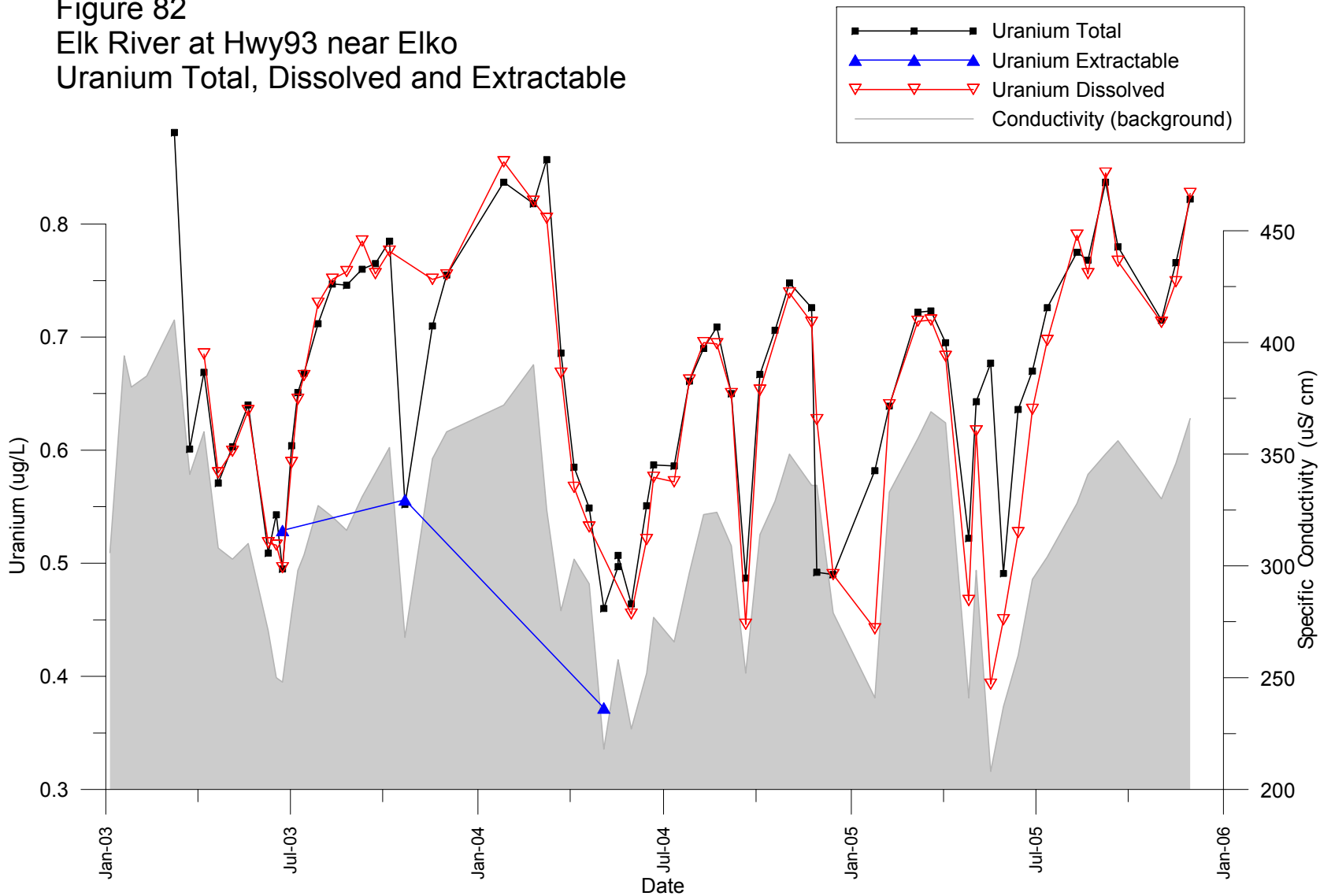


Figure 83
Elk River at Hwy93 near Elko
Vanadium Total, Dissolved and Extractable

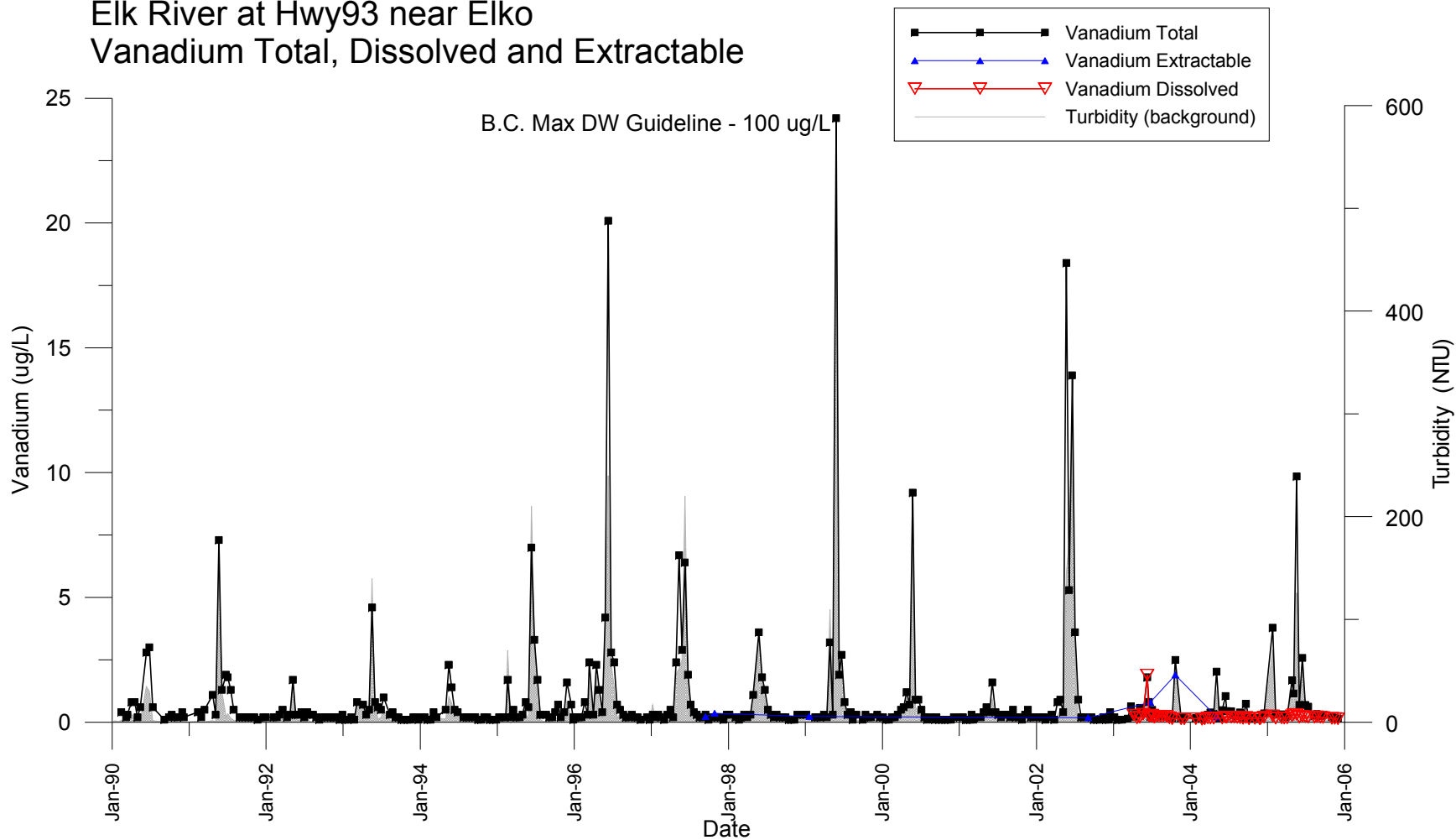


Figure 84
 Elk River at Hwy93 near Elko
 Vanadium Total, Dissolved and Extractable

B.C. Max DW Guideline - 100 ug/L

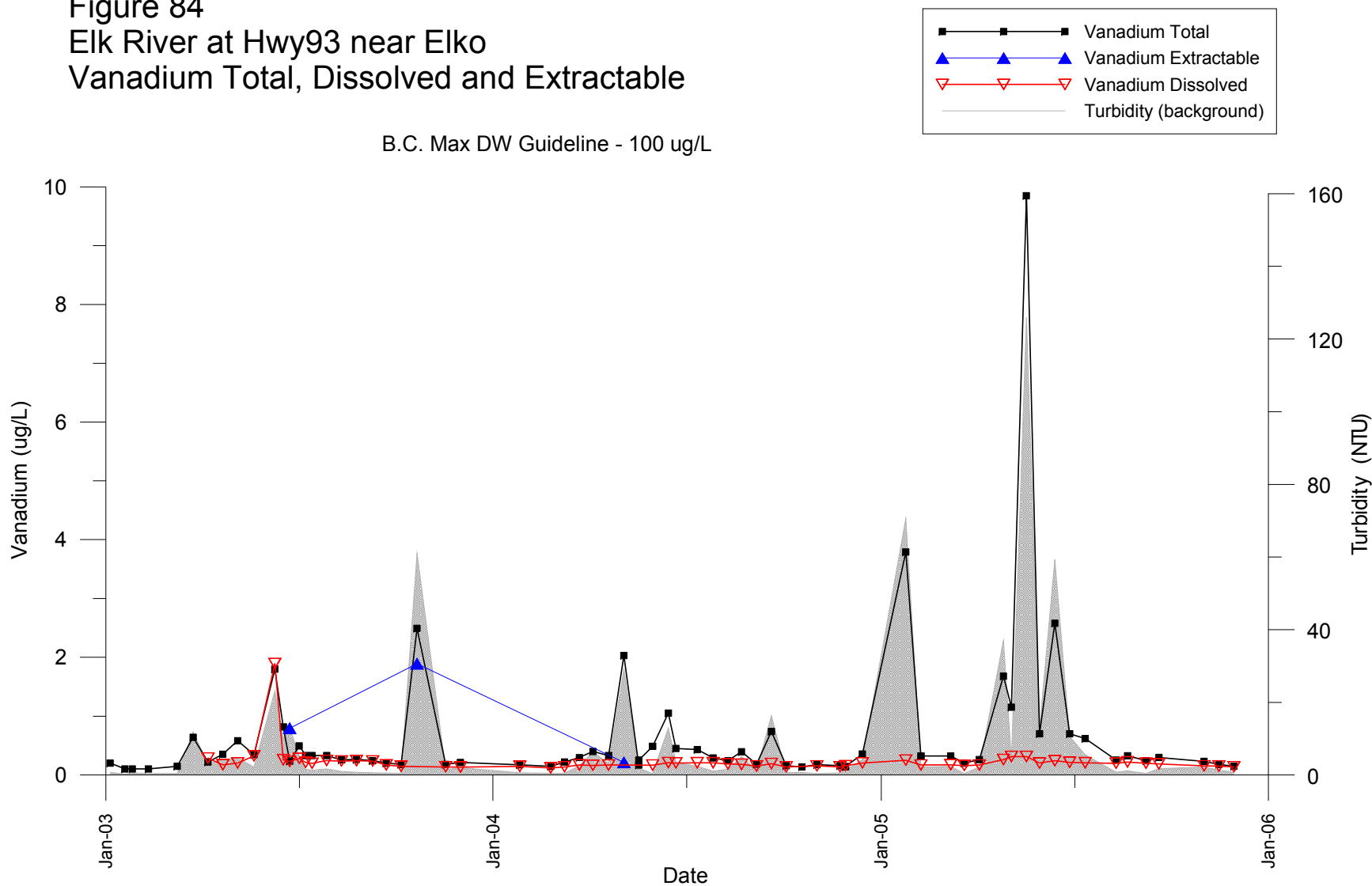


Figure 85
Elk River at Hwy93 near Elko
Zinc Total, Dissolved and Extractable

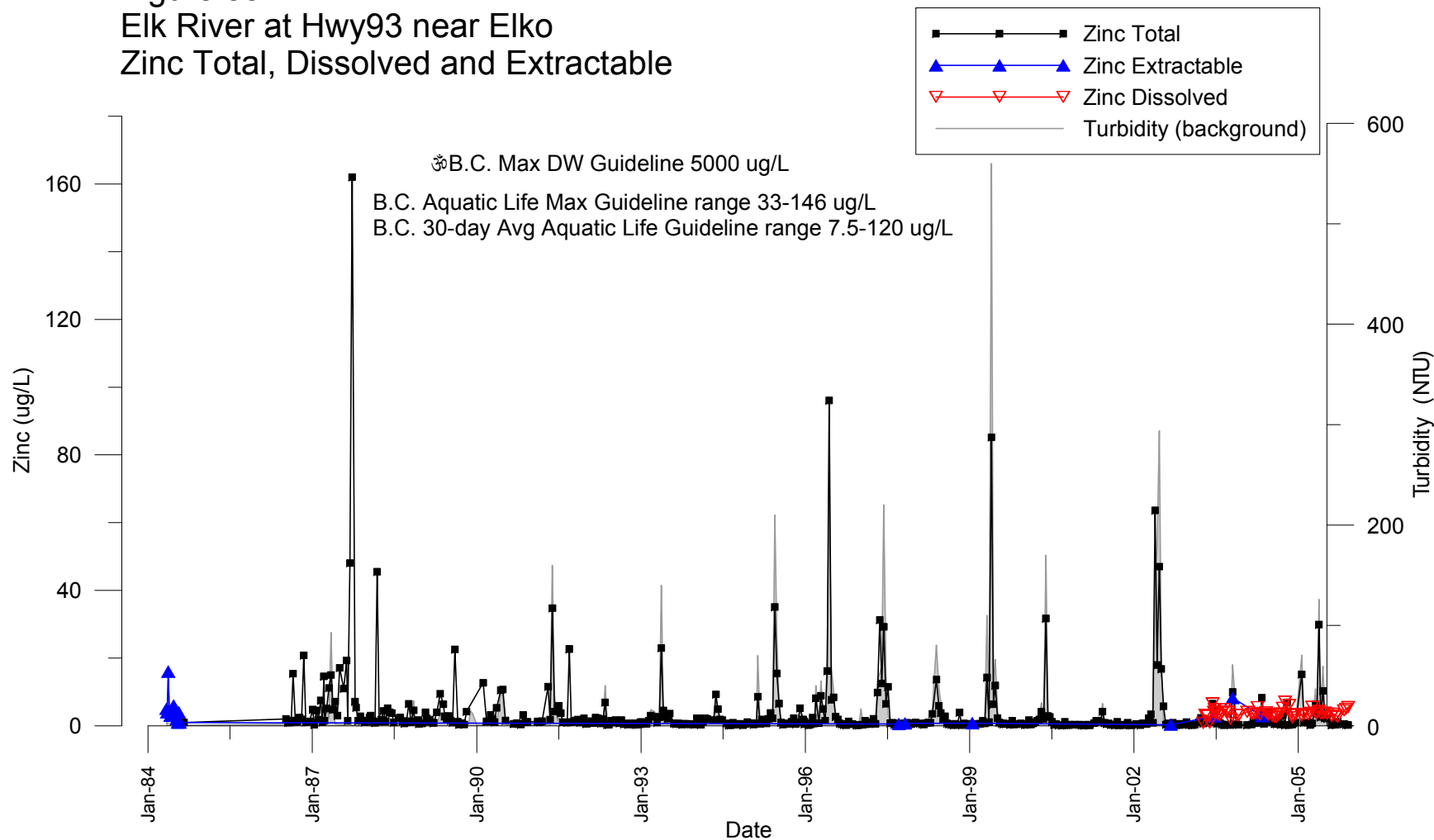


Figure 86
 Elk River at Hwy93 near Elko
 Zinc Total, Dissolved and Extractable
 2003 - 2005

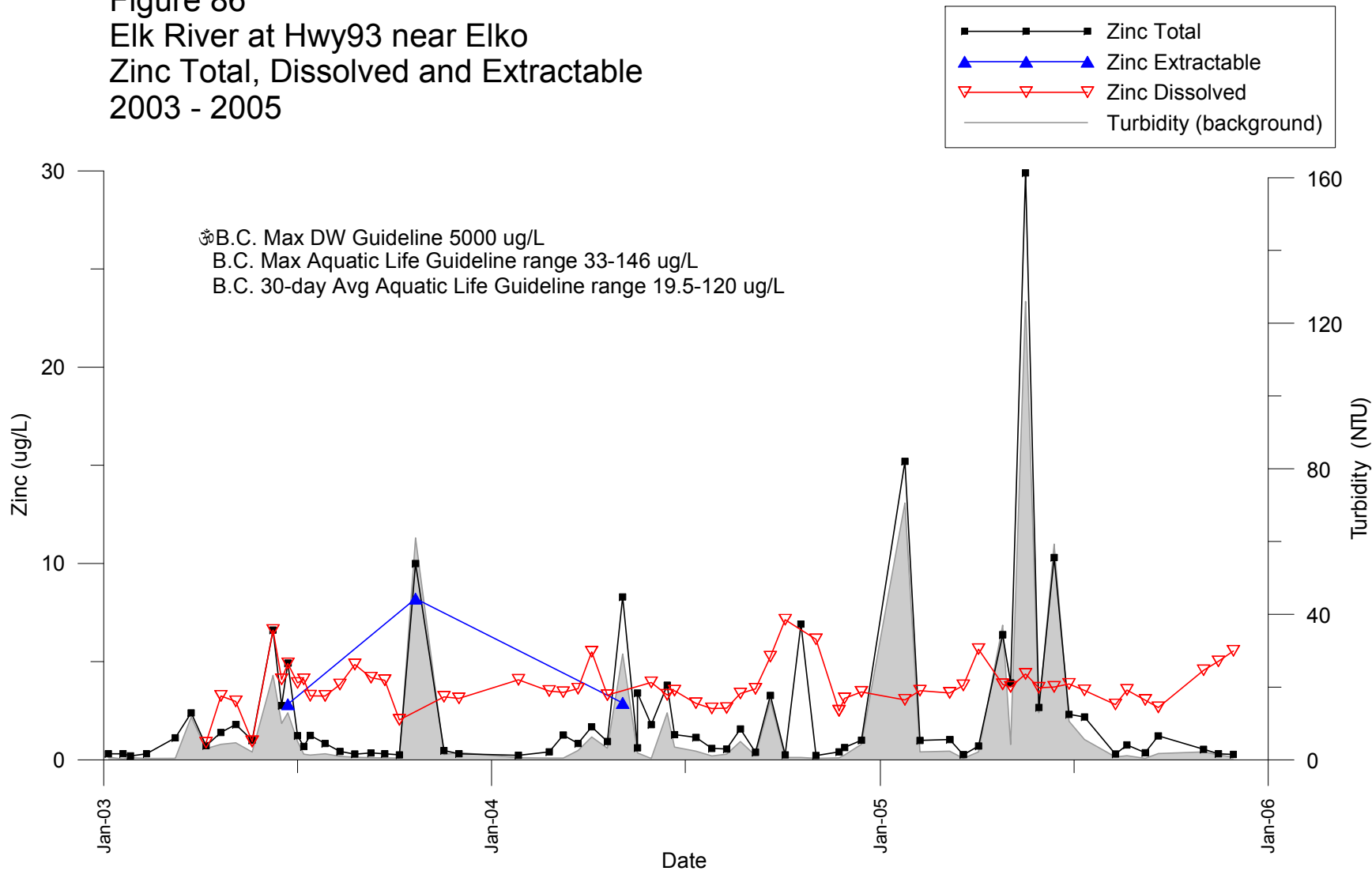


Figure 86 (a)
 Elk River at Hwy93 near Elko
 Zinc Total, Dissolved and Extractable
 2003 - 2005

