CANADA – BRITISH COLUMBIA
WATER QUALITY MONITORING AGREEMENT

WATER QUALITY ASSESSMENT OF KOOTENAY RIVER AT CRESTON (1979 – 2005)

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

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Environment Canada Environnement Canada

British Columbia The Best Place on Earth
Ministry of Environment

EXECUTIVE SUMMARY

The Kootenay River is a transboundary river that flows south from B.C. into Koocanusa Lake, which is the reservoir of the Libby Dam in Montana. After leaving the dam, the river swings northward through Montana and Idaho, re-entering B.C. south from Creston. Just north from Creston, the river enters Kootenay Lake, forming the main inflow to the southern arm of the lake. The Kootenay River near Creston has a drainage area of 36,700 km^2 and is used for irrigation and waterfowl conservation, while Kootenay Lake is an important fishery and recreation area.

The watershed upstream from Creston has been influenced to varying degrees over the years by the following human activities: a hydroelectric development at the Libby Dam, a kraft pulp mill at Skookumchuck, a mine, concentrator and fertilizer complex at Kimberley, coal mines in the Elk River basin, treated sewage discharges, agriculture, and forestry.

CONCLUSIONS

- In an earlier assessment of the data (to 1997), it was determined that there was a subtle trend of decreasing total phosphorus concentrations. This was not deemed a positive thing since fisheries production was declining downstream in Kootenay Lake. From our analysis of data up to the end of 2005, it would appear that this apparent trend no longer exists and the total phosphorus concentrations are stable.
- On the other hand, selenium concentrations in the river at Creston appear to be increasing significantly. No such trend can be observed upstream at Fenwick Station, and it has been documented that the human coal mining operations on the Elk River have increased significantly. Although values in the Kootenay River at Creston are not as high as in the Elk River, concentrations are certainly getting closer to guideline values that indicate possible concern for aquatic life.
- Dissolved sodium concentrations may also be showing an increase through time. A similar trend that is not as strong is also apparent at the Fenwick station.

- All of the apparent trends noted above: stable phosphorus concentrations and increasing selenium and sodium concentrations, need to be confirmed by a statistician.
- Temperature generally exceeds guidelines during warmer summer months.
- Turbidity values generally exceed the guideline for the protection of source water used for drinking, meaning that if suspended solids removal is not used, disinfection of water supplies could be compromised.
- Otherwise, water quality was generally good with only occasional values exceeding guidelines for pH, fecal coliforms, several metals, dissolved organic carbon, and true colour. In cases where total metal concentrations exceeded guideline values, the event 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 Kootenay River at Creston since it is a trans-boundary site and selenium and sodium seem to be increasing.

Water quality indicators that are important for future monitoring are:

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

ACKNOWLEDGEMENTS

The graphs in this report were prepared by Sacha Wassick of Environment Canada. The draft report was reviewed by Alison Stent of BC Environment and Andrea Ryan of Environment Canada. We thank these individuals for their contributions to improving this document. Any errors or omissions are the responsibility of the author.

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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 27years of water quality data during 1979-2005.

The Kootenay River is a transboundary river that flows south from B.C. into Koocanusa Lake, which is the reservoir created by the Libby Dam in Montana. After leaving the dam, the river swings northward through Montana and Idaho, re-entering B.C. south from Creston. Just north from Creston, the river enters Kootenay Lake, forming the main inflow to the southern arm of the lake. The Kootenay River near Creston has a drainage area of 36,700 km^2 and is used for irrigation and waterfowl conservation, while Kootenay Lake is an important fishery and recreation area.

The watershed upstream from Creston has been influenced to varying degrees over the years by hydroelectric development at the Libby Dam, a kraft pulp mill at Skookumchuck, a mine, concentrator and fertilizer complex at Kimberley, coal mines in the Elk River basin, treated sewage discharges, agriculture, and forestry.

Water quality measurements for the Kootenay River at Creston were plotted on a graph over time, along with the relevant water quality objectives or guidelines. 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.

The water quality sampling station on the Kootenay River is located at the highway #3 bridge approximately 5 km. west-northwest from Creston.

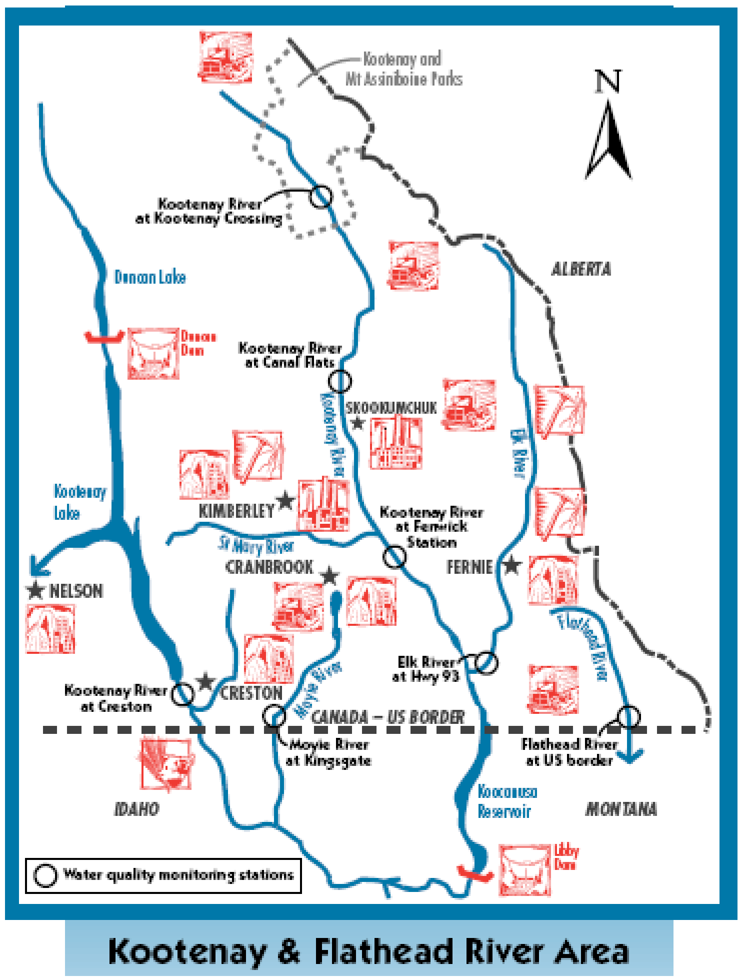

FIGURE 1: KOOTENAY RIVER AT CRESTON

WATER QUALITY ASSESSMENT

The state of the water quality was assessed by comparing results to the B.C. approved and working guidelines (if guidelines exist for that variable) for water quality (B.C. Ministry of Environment, 2006a and b and CCME, 1999), 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. 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.

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.

Data for the Kootenay River at Creston 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 six times per year. 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.

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, arsenic, bromide, gallium, lanthanum, lithium, mercury, molybdenum, nitrate, nitrite, total nitrogen, dissolved ortho phosphorus, dissolved and reactive silica, extractable 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: total antimony, beryllium, bismuth, cobalt, manganese, nickel, non-filterable and fixed non-filterable residue, rubidium, total silver, total thallium, and total vanadium.

Other water quality indicators seemed to fluctuate through the year according to the specific conductivity of the water. The dissolved forms of many of these indicators are components of the measured conductivity, and this trend is to be expected. These types of indicators that were not measured above guideline values (if guidelines exist) included alkalinity, barium, calcium, chloride, fluoride, hardness, magnesium, dissolved nitrogen, potassium, filterable and fixed filterable residue, strontium, sulphate, and uranium.

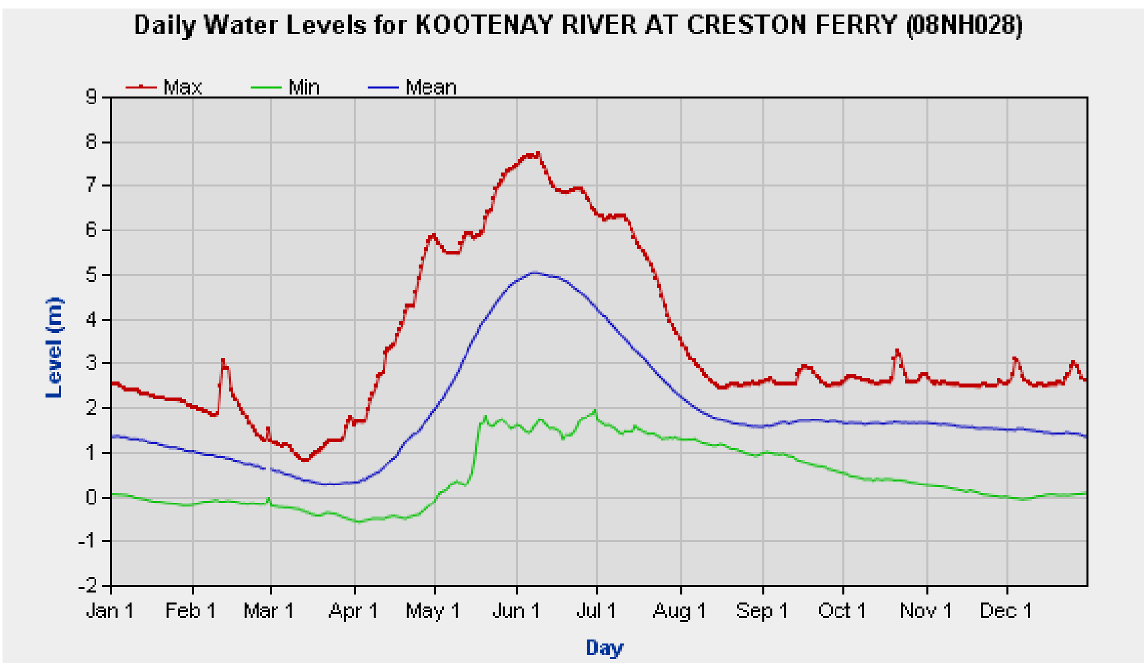

FIGURE 2: WATER SURVEY OF CANADA FLOW DATA FOR KOOTENAY RIVER AT CRESTON

Flow (Figure 2) values showed fairly typical patterns characteristic of an interior river, with freshet taking place between mid-April through July. Average flows through the year are in the order of 1 m^3/s, although low flows in late March just prior to freshet can be as low as 0.3 m^3/s. Average peak flows are about 5 m^3/s.

Aluminum (Figure 4) values (total) were correlated to turbidity levels in the river, with total aluminum concentrations exceeding the B.C. guideline for dissolved aluminum concentrations for protection of aquatic life of 100 µg/L. This in itself is not a concern because the forms of aluminum measured and the guidelines are different. However, since values that exceeded the guidelines were associated with high sediment concentrations, the aluminum was likely in particulate form and not biologically available.

Cadmium (Figures 12-14) values have only been measured since 2003 with detection limits low enough to allow for a meaningful comparison to guidelines. Data from 2003-2005 show that the guidelines are usually met and were only exceeded twice during that period when turbidity levels were elevated. Thus the cadmium would likely be in particulate form and not biologically available.

Carbon (Figures 16 – 18) was measured as dissolved organic and inorganic. The guideline to protect drinking water supplies is a maximum of 4 mg/L as total organic carbon. This level has generally been achieved by measurements of dissolved organic carbon. There appears to be a correlation between turbidity and dissolved organic carbon concentrations.

Chromium (Figures 20 and 21) concentrations when measured as total concentrations occasionally exceeded the guideline for trivalent chromium and regularly exceeded the guideline for hexavalent chromium. These values seem to be correlated to turbidity concentrations.

Fecal Coliforms (Figure 23) have only been measured since 2000, but values often exceed the guideline for source water used for drinking with no treatment other then disinfection, and have twice exceeded the guideline where partial treatment of source water is employed. Concentrations do seem to be correlated with turbidity, meaning that it would be difficult to remove bacteria when disinfecting these higher turbidity waters.

Colour (Figures 24 and 25) has a guideline of 15 units for true colour for protection of aesthetics of source water used for drinking. This guideline has been exceeded only three times since 1997, and is not a significant problem in the river.

Copper (Figures 26 and 27) values generally meet the B.C. guideline for the maximum allowable concentrations, and only occasionally do these individual values exceed the 30-day mean concentration. Copper seems to be correlated with turbidity concentrations and so the higher copper concentrations are likely in particulate form. This means that the copper is not likely biologically available and thus not a concern in the river.

Iron (Figure 31) concentrations frequently exceeded the guidelines; however, these instances were associated with high turbidity values. Thus, the iron was not biologically available and not a concern for aquatic life.

Lead (Figure 32) concentrations seemed to be correlated with turbidity and occasionally exceeded the guideline for the protection of aquatic life. Since higher values were associated with particulate form, there is not likely a concern for aquatic life.

pH (Figure 44) on infrequent occasions was at, or below the lower acceptable range of the guideline for the protection of aquatic life and source water used for drinking. This is not considered to be a concern for the Kootenay River.

Total Phosphorus (Figure 47) values sometimes exceeded the guideline of 10 µg/L that is used for the protection of source water used for drinking. In the *Water Quality Trends 2000* report, it was determined that phosphorus levels in the Kootenay River at Creston for the period up to 1997 had been declining (deemed to be a subtle change with levels in

1995 and 1996 increasing); however, this assessment indicates that phosphorus concentrations appear to be stable over time.

Selenium (Figure 54) appears to be increasing over time, although all values are below but approaching the guidelines at present. A linear regression analysis of total selenium data since 1985 indicated an increasing trend with a R^2 value of 0.25; however, for data collected since 1999, the R^2 value is 0.12. This possible increasing trend should be verified by a statistician. If selenium concentrations in the Kootenay River are increasing, it could be due to the increasing concentrations noted in the Elk River, since the Fenwick station located upstream from the confluence of the Elk River, on the Kootenay River has not shown increasing selenium concentrations.

Sodium (Figure 59) values when measured as dissolved concentrations may be increasing over time. A linear regression analysis of dissolved sodium data since 1979 indicated an increasing trend with a R^2 value of 0.14. Values also seem to possibly be increasing at the upstream Fenwick station but the R^2 value is only about one-half recorded here. Unfortunately, for a period of time from 1989 until 2001, sodium was measured in the extractable form so that a complete record is not available on which to perform trend analyses. This possible increasing trend should be verified by a statistician.

Temperature (Figure 63) values peaked at levels higher than guidelines on a regular basis. Values above the guidelines coincided with high air temperatures at the same time.

Turbidity (Figure 66) values were regularly higher than the guideline for the protection of source water used for drinking. For effective disinfection of this source water, removal of solids will be required as treatment.

Zinc (Figure 69) concentrations (individual) occasionally exceeded the guideline for a monthly mean for the protection of aquatic life. These values were correlated to high turbidity measurements, indicating that the zinc would be in particulate form and not biologically available.

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Canadian Council of Ministers of the Environment (CCME). 1999. Canadian Environmental Quality Guidelines. Winnipeg, Manitoba.

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.

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

Figure 3
Kootenay River at Creston
Alkalinity Total

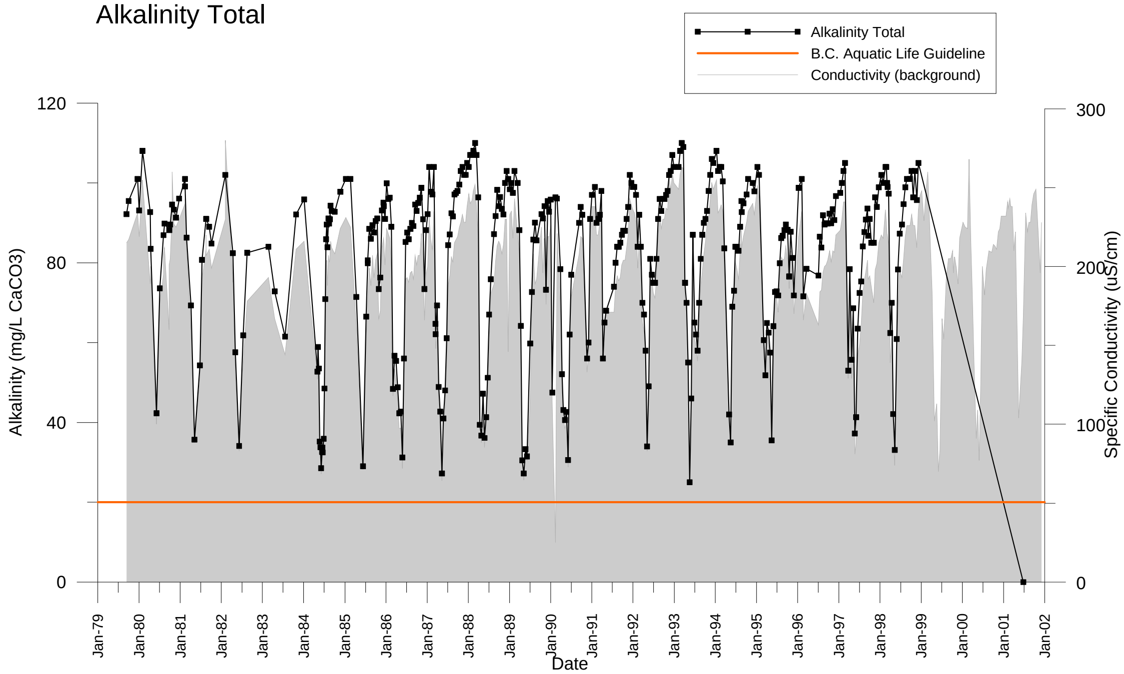

Figure 4
Kootenay River at Creston
Aluminum Total (ug/L)

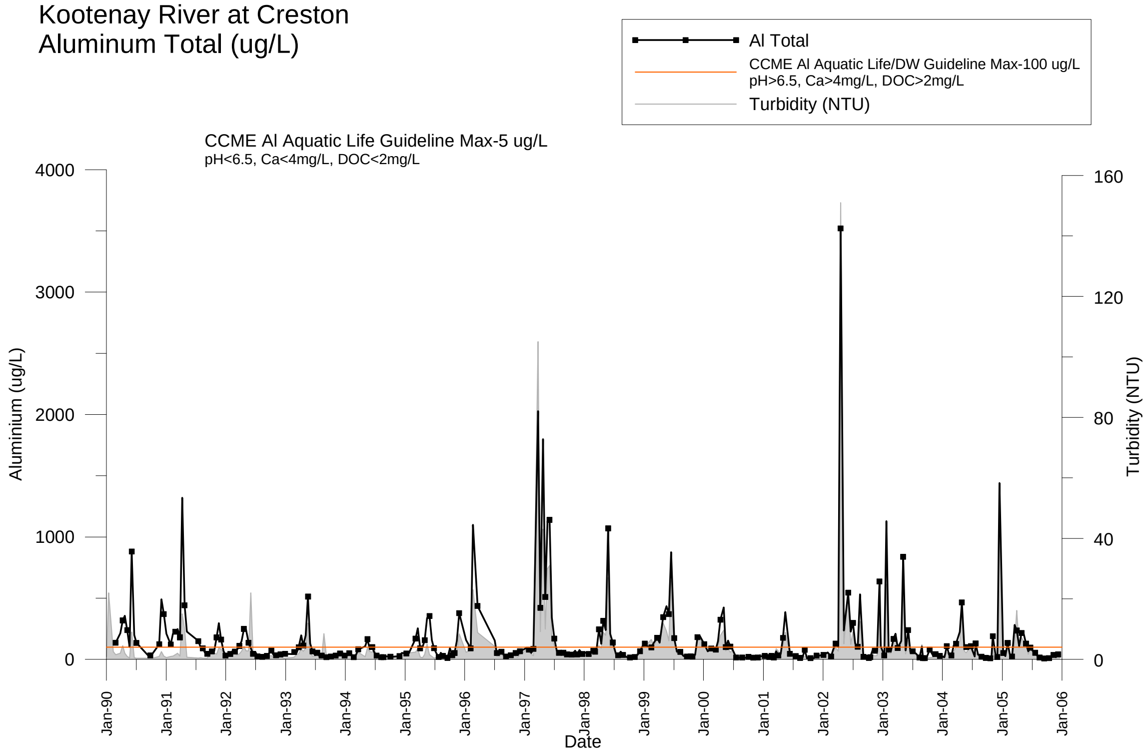

Figure 5
Kootenay River at Creston
Ammonia Dissolved (mg/L)

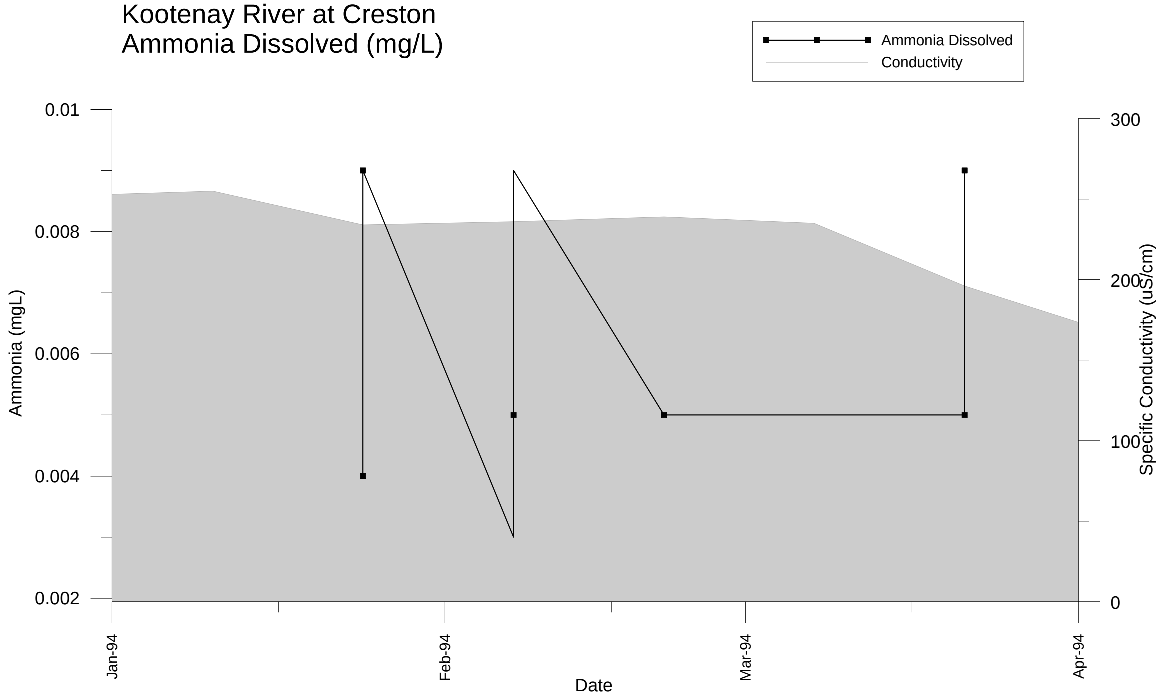

Figure 6
Kootenay River at Creston
Antimony Total (ug/L)

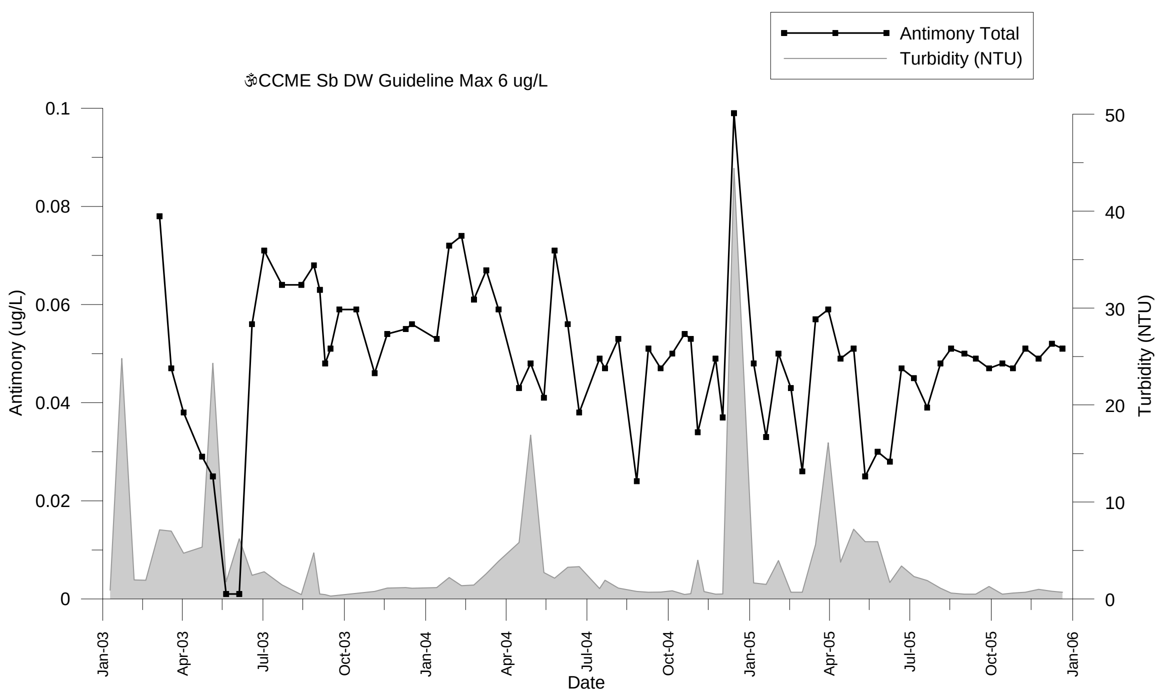

Figure 7
Kootenay River at Creston
Arsenic Total and Extractable (ug/L)

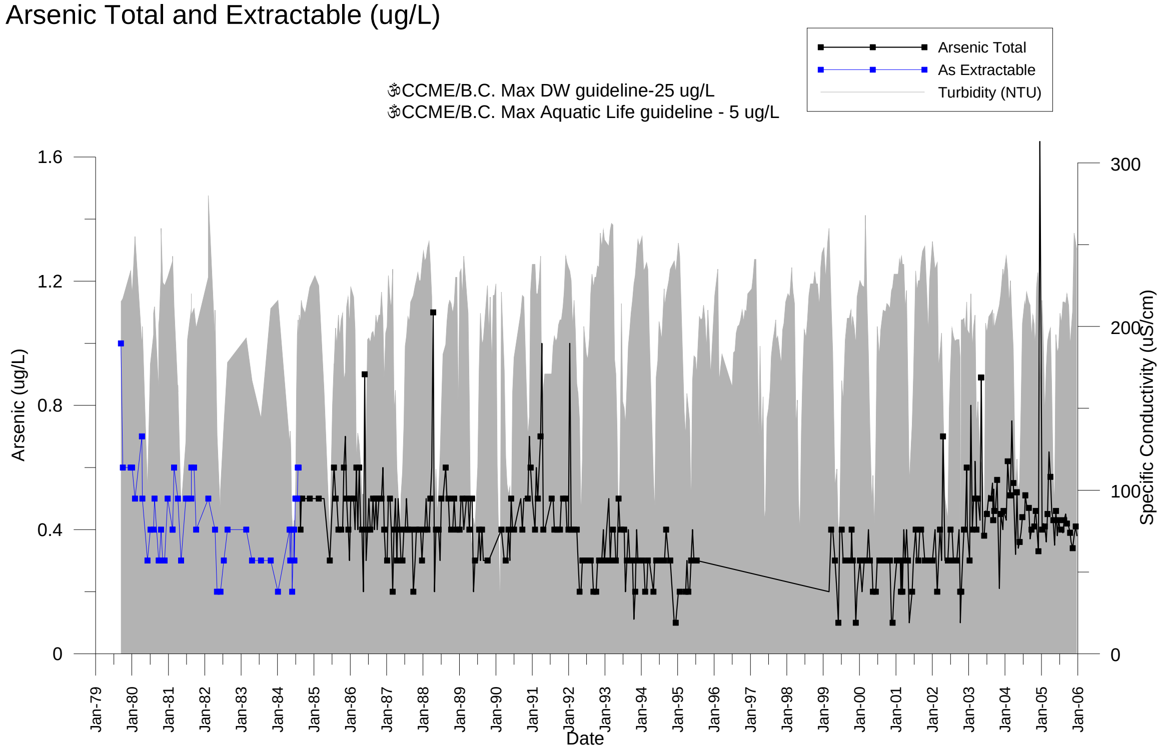

Figure 8
Kootenay River at Creston
Barium Total (ug/L)

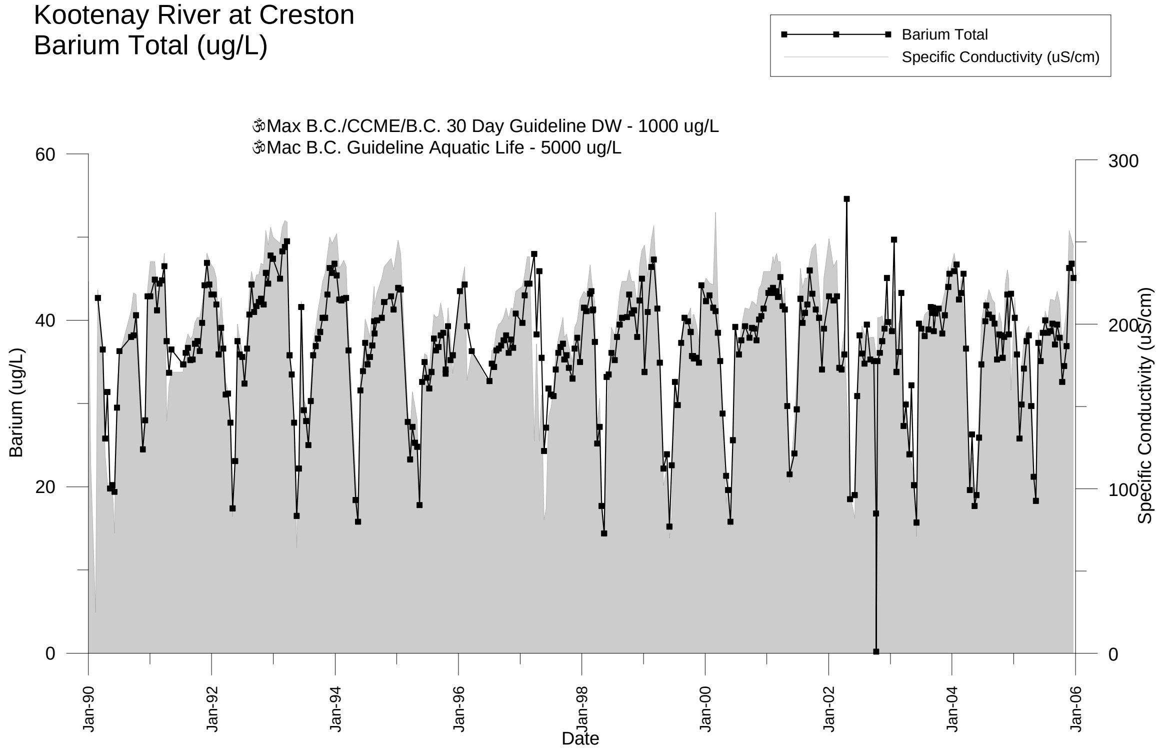

Figure 9
Kootenay River at Creston
Beryllium Total (ug/L)

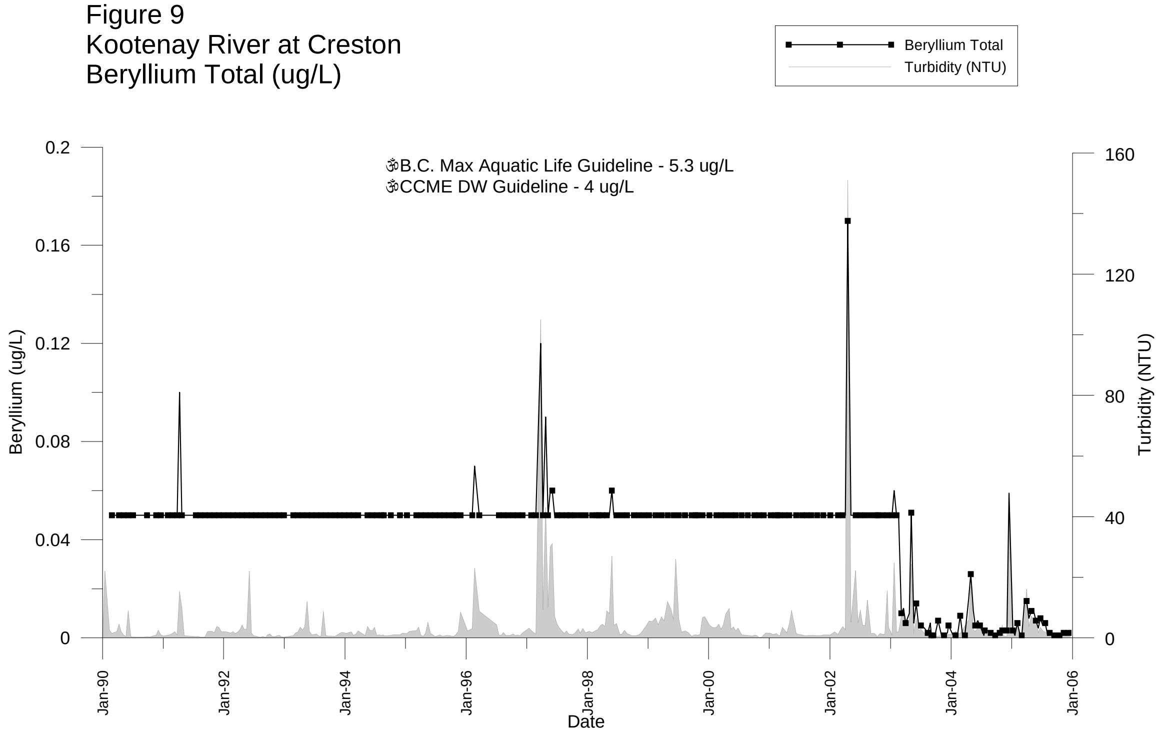

Figure 9 (a)
Kootenay River at Creston
Beryllium Total (2003 - 2005)

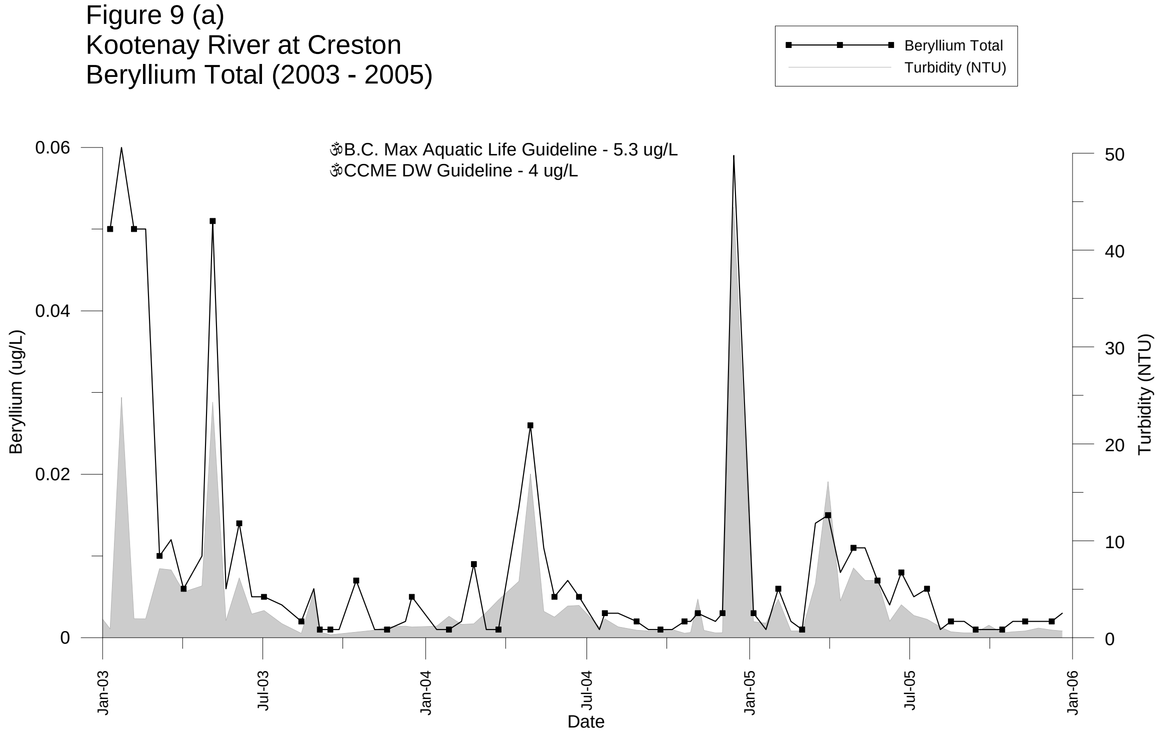

Figure 10
Kootenay River at Creston
BismuthTotal (ug/L)

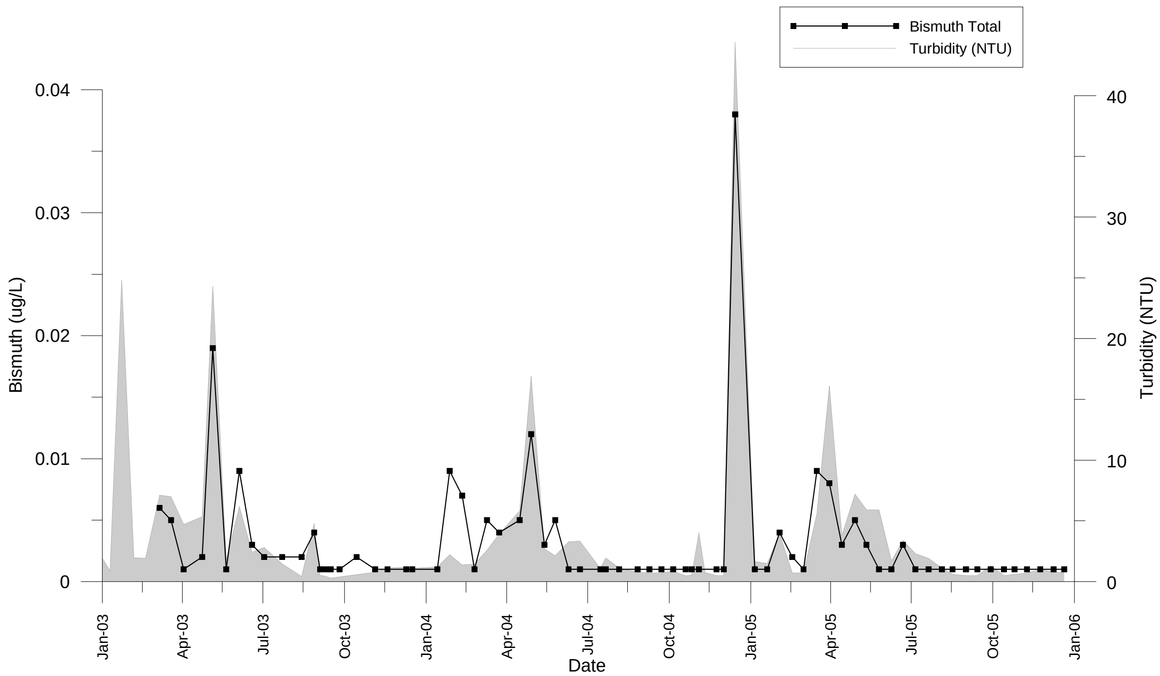

Figure 11
Kootenay River at Creston
Bromide Dissolved (ug/L)

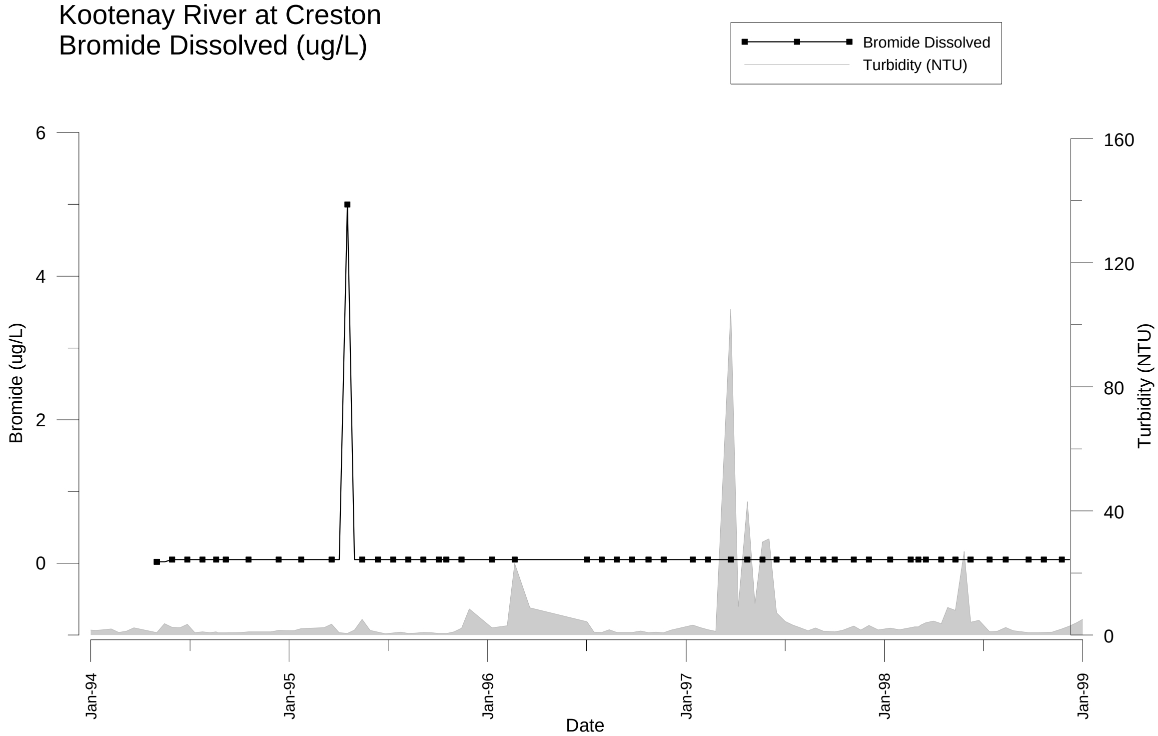

Figure 12
Kootenay River at Creston
Cadmium Total and Extractable (ug/L)
1981-2005

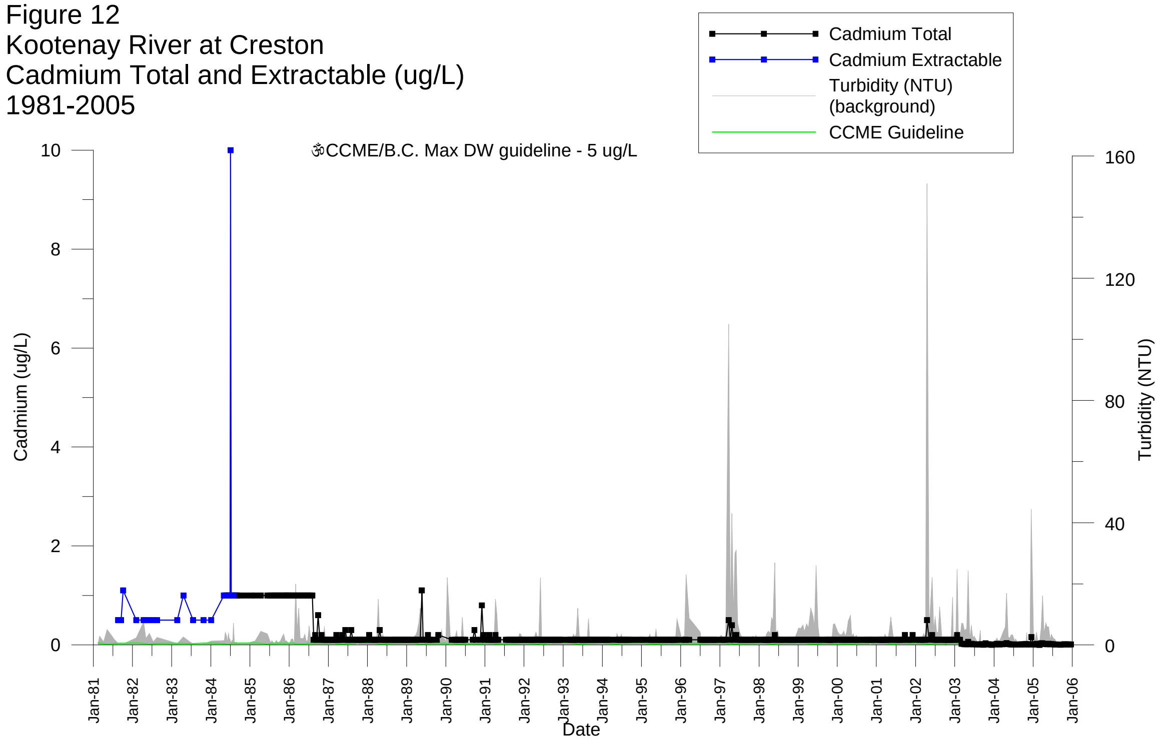

Figure 13
Kootenay River at Creston
Cadmium Total (ug/L)
1987 - 2005

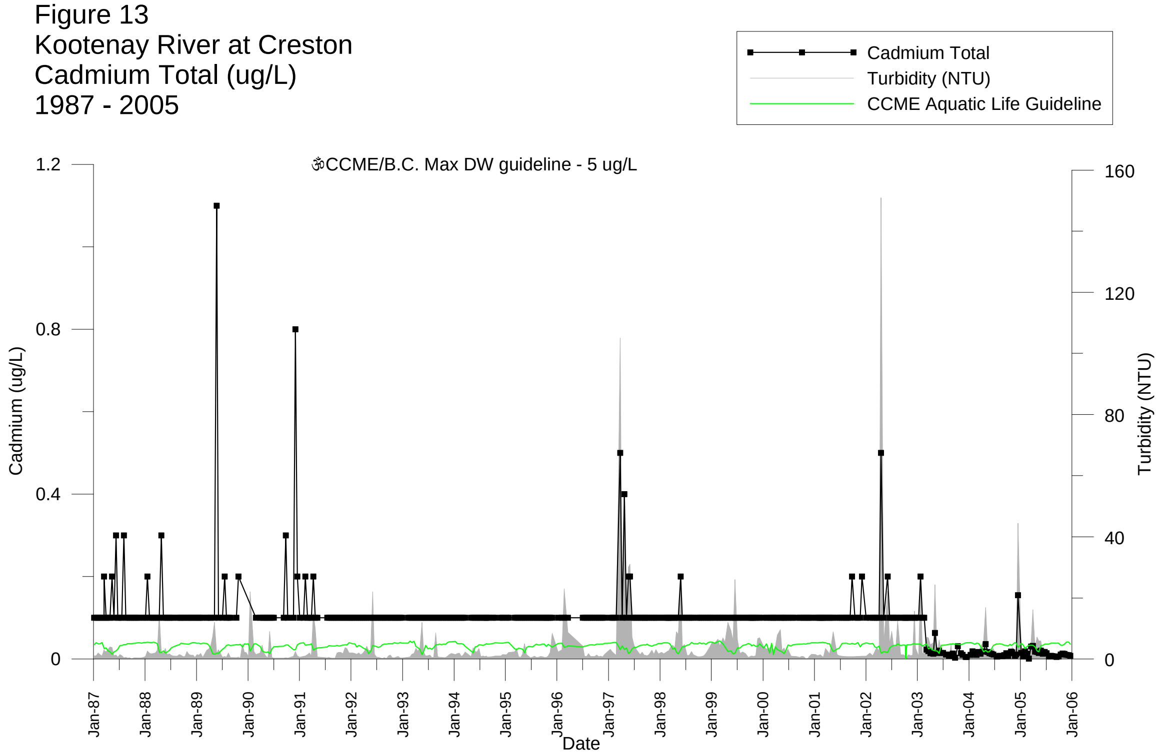

Figure 14
Kootenay River at Creston
Cadmium Total (ug/L)
2003 - 2006

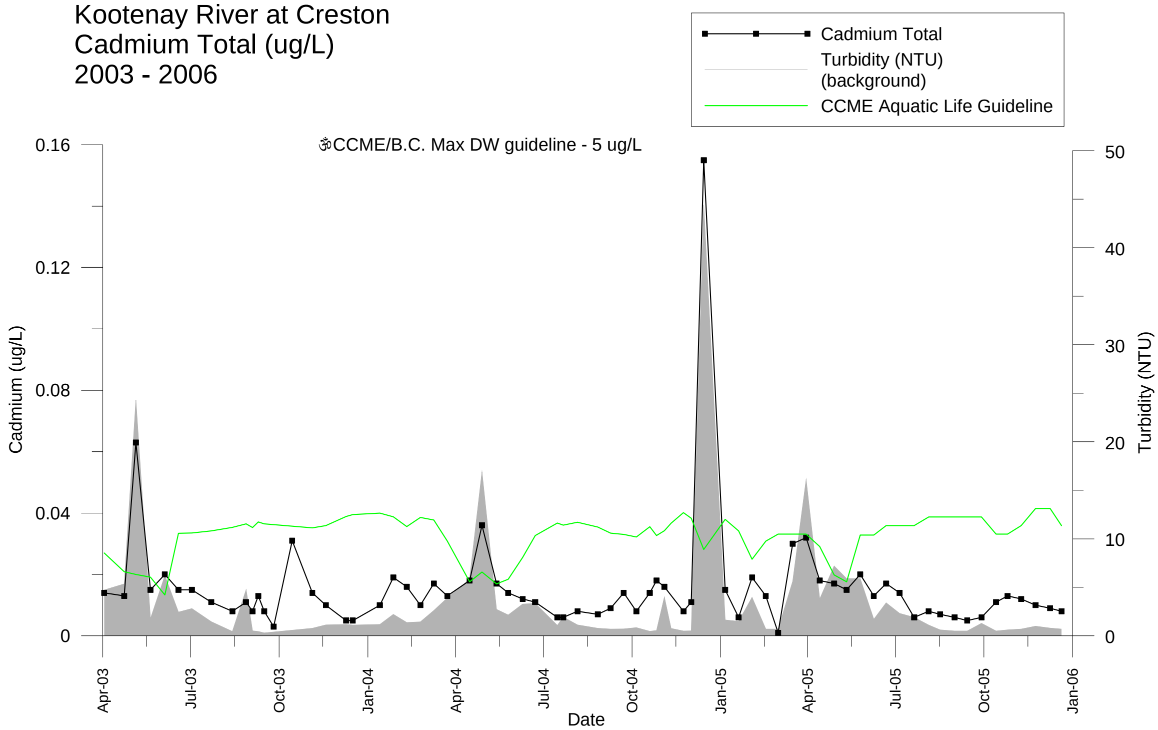

Figure 15
Kootenay River at Creston
Calcium Dissolved and Extractable (mg/L)

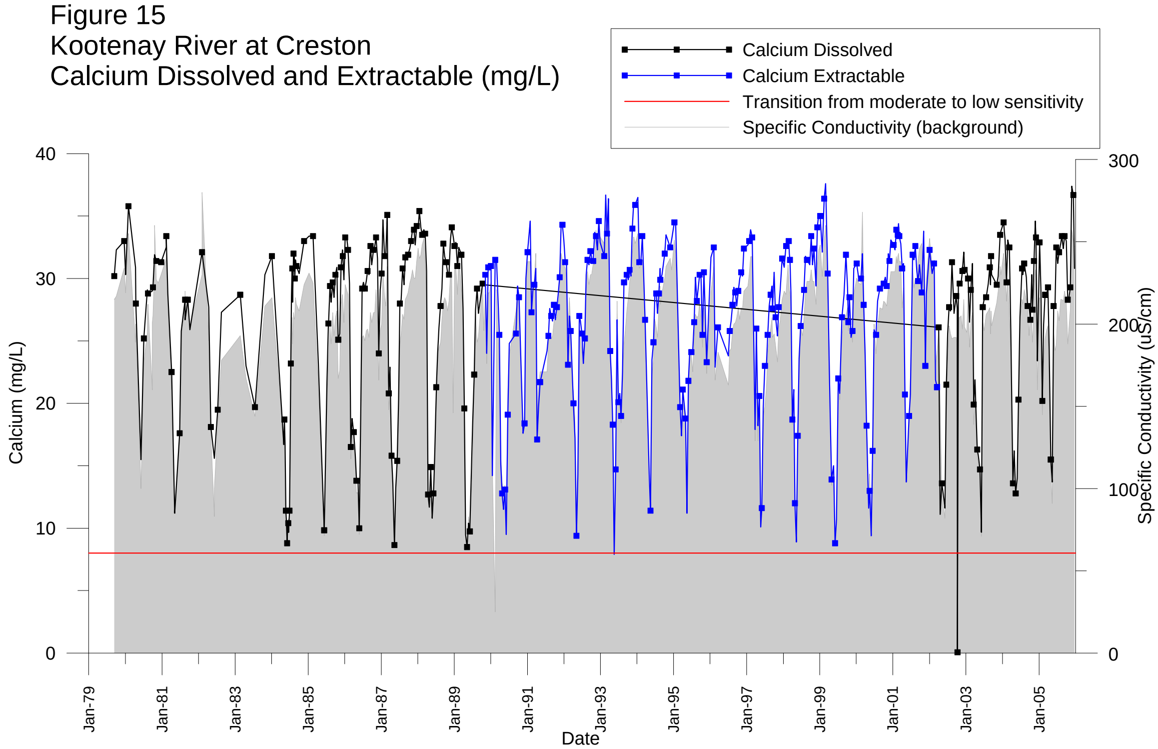

Figure 16
Kootenay River at Creston
Carbon Dissolved Inorganic and Organic (mg/L)

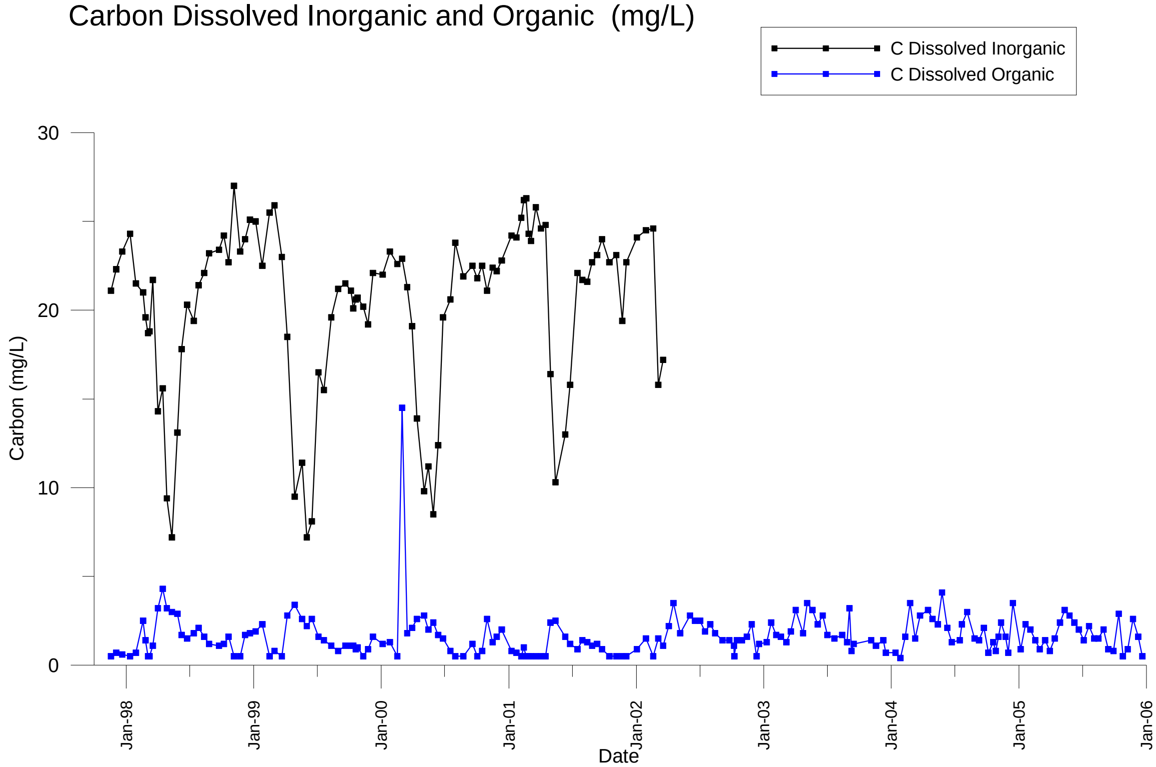

Figure 17
Kootenay River at Creston
Carbon Dissolved Inorganic (mg/L)

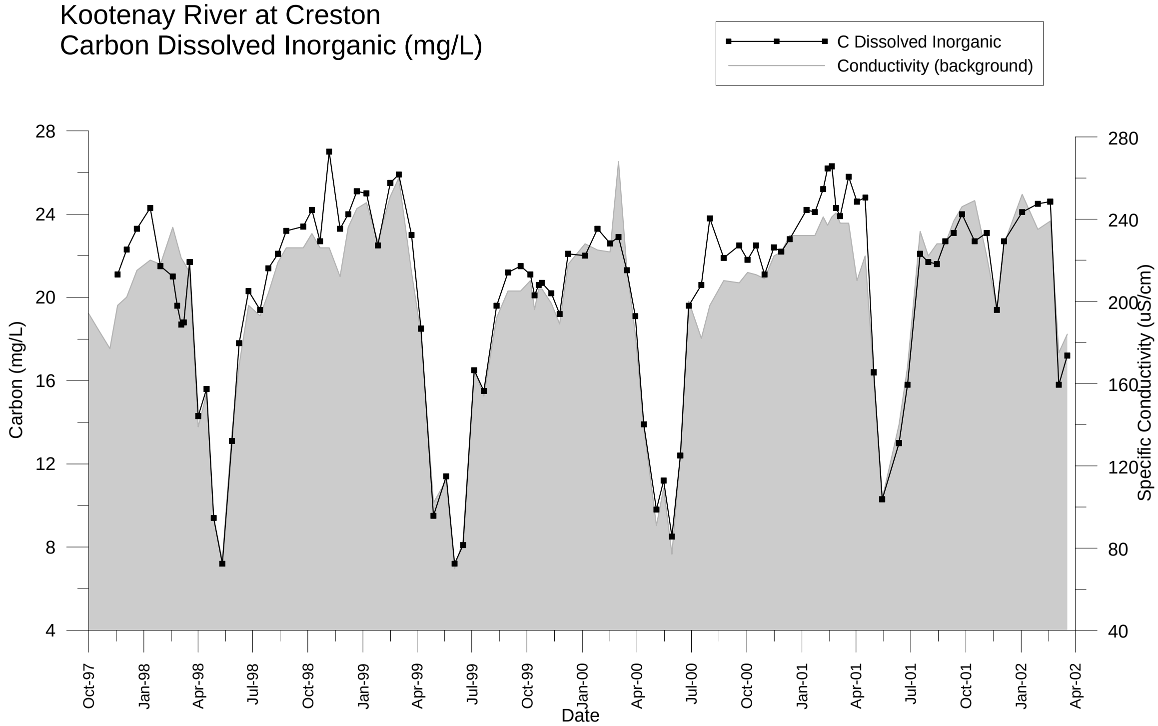

Figure 18
Kootenay River at Creston
Carbon Dissolved Organic (mg/L)

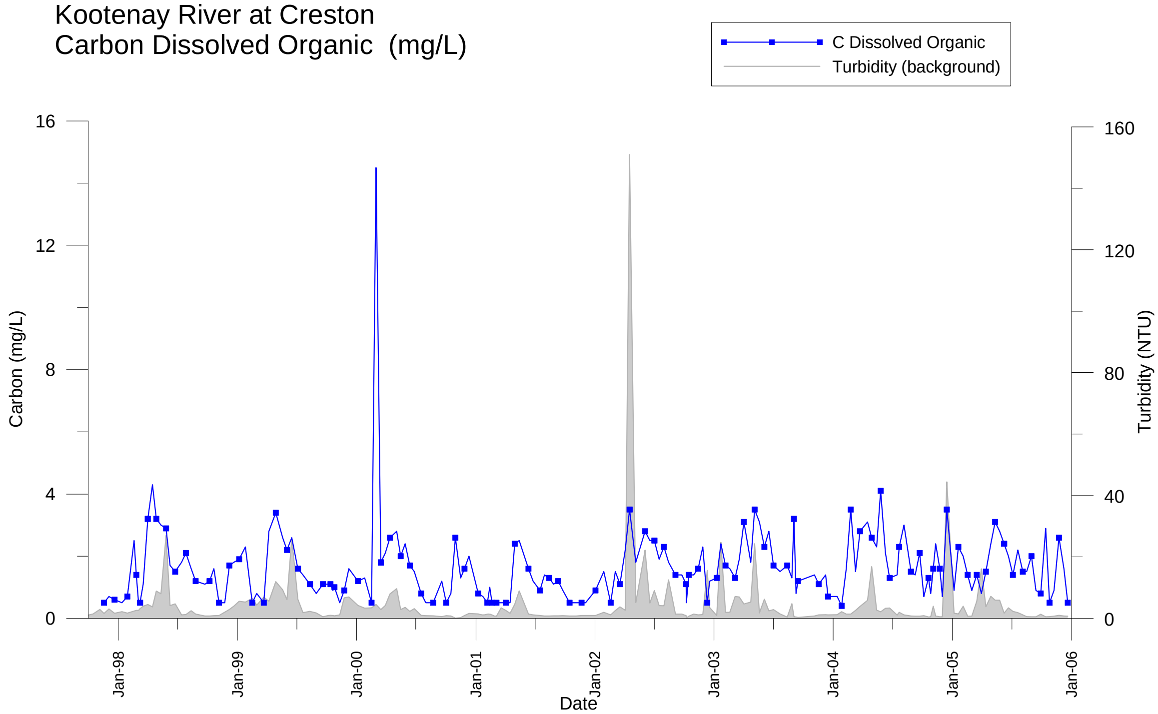

Figure 19
Kootenay River at Creston
Chloride Dissolved (mg/L)

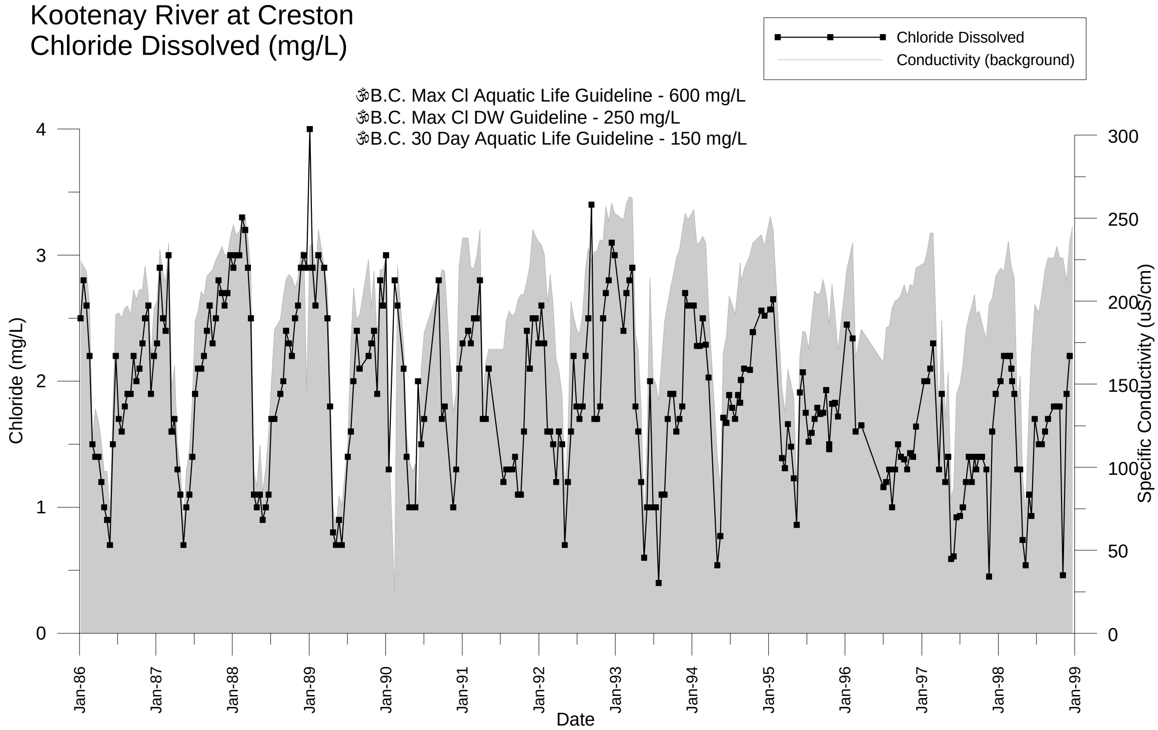

Figure 20
Kootenay River at Creston
Chromium Total (ug/L)

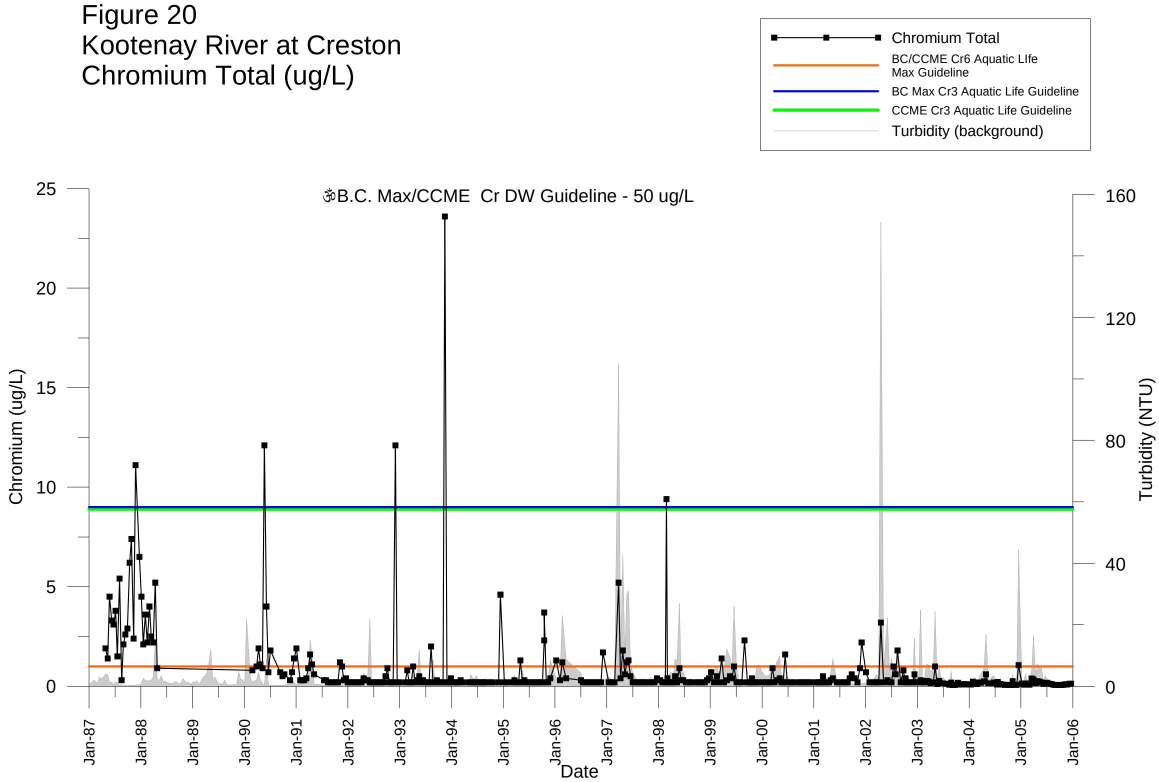

Figure 21
Kootenay River at Creston
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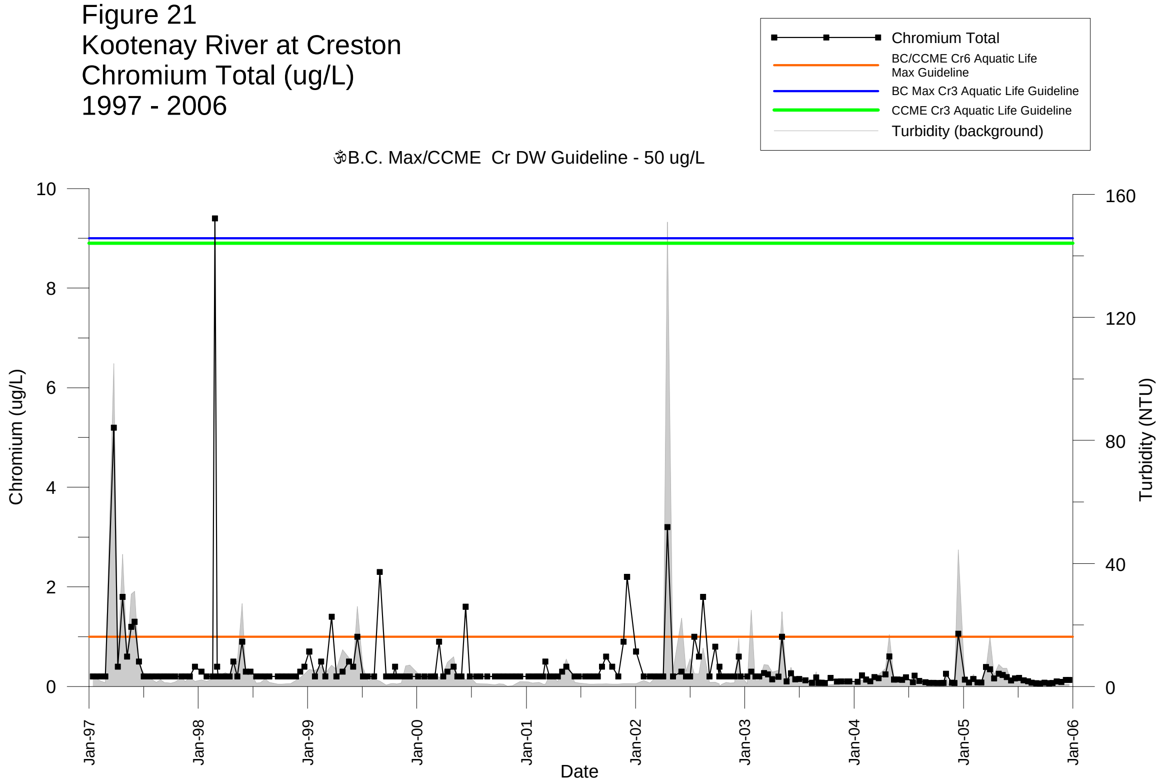

Figure 22
Kootenay River at Creston
Cobalt Total (ug/L)

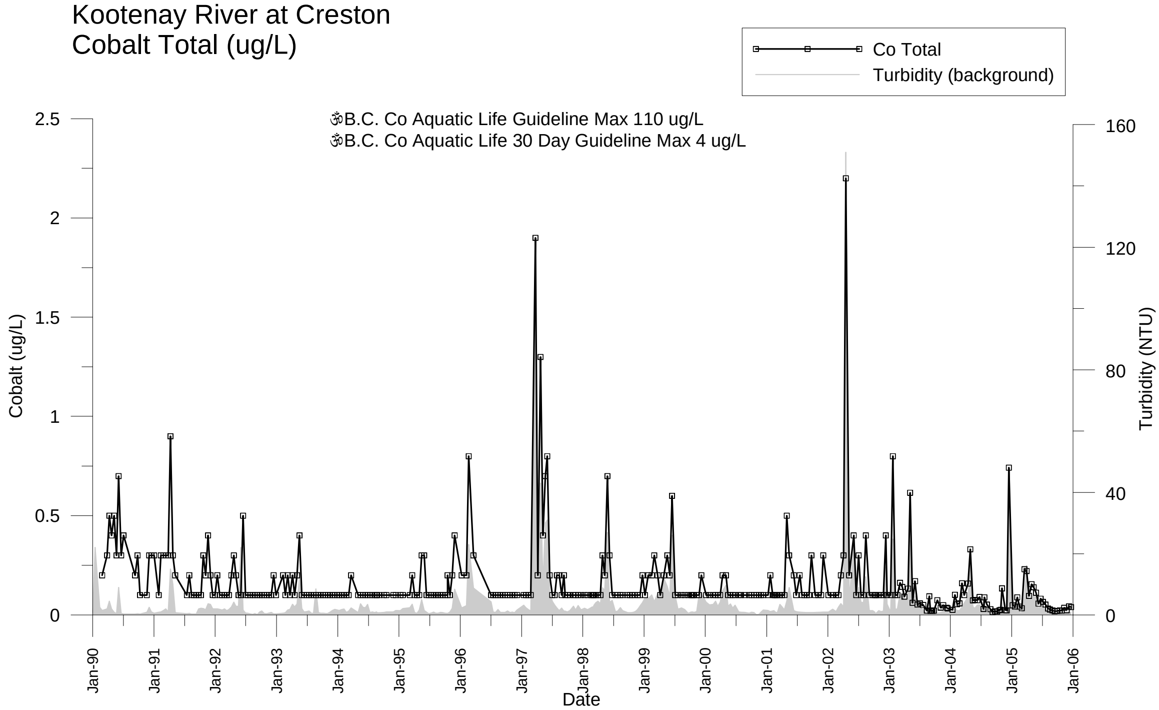

Figure 23
Kootenay River at Creston
Fecal Coliforms

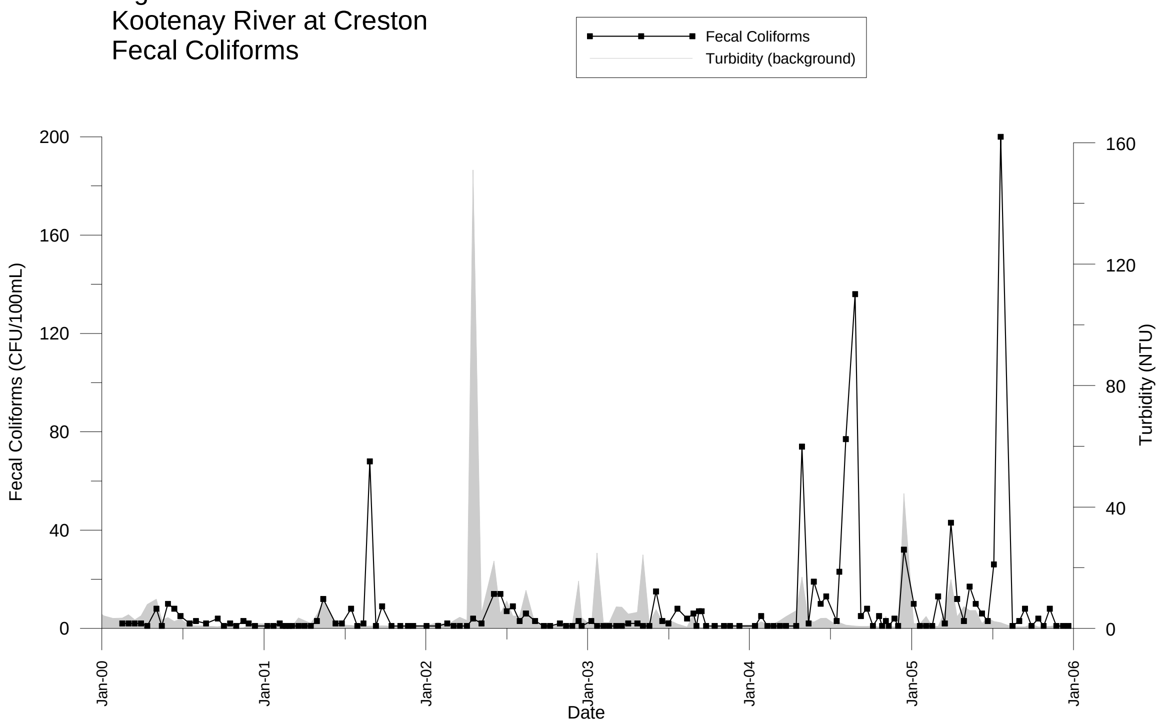

Figure 24
Kootenay River at Creston
Colour Apparent (Colour Units)

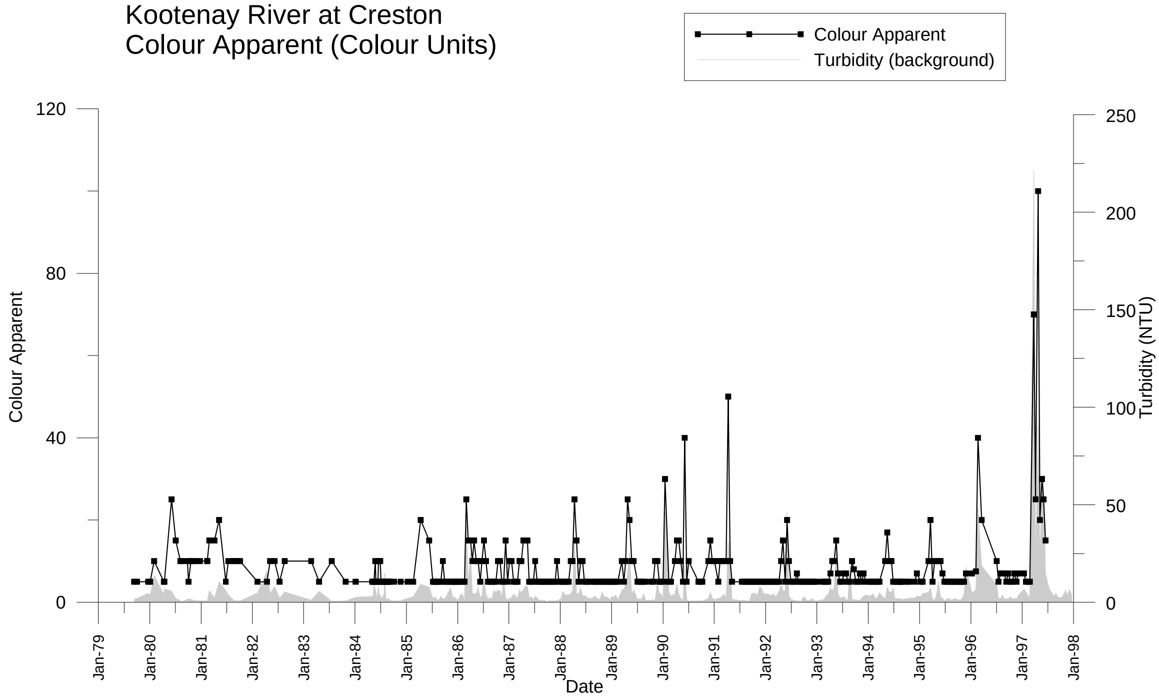

Figure 25
Kootenay River at Creston
Colour True

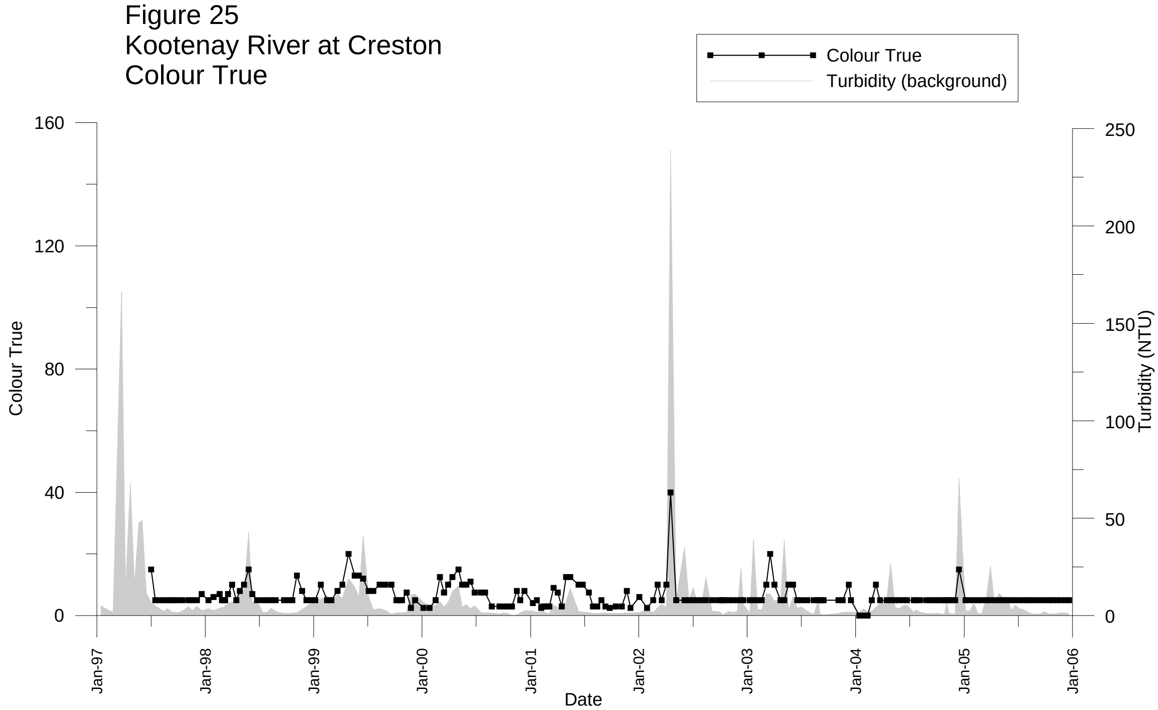

Figure 26
Kootenay River at Creston
Copper Total and Extractable (ug/L)
1981 - 2005

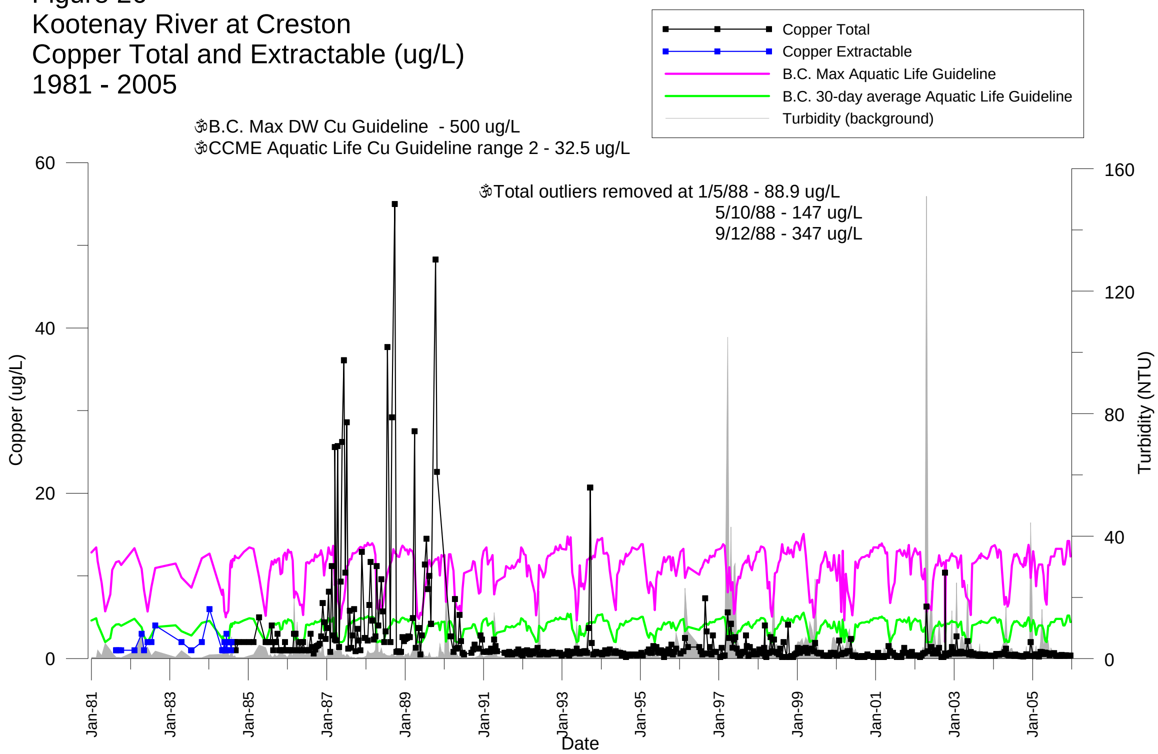

Figure 27
Kootenay River at Creston
Copper Total and Extractable (ug/L)
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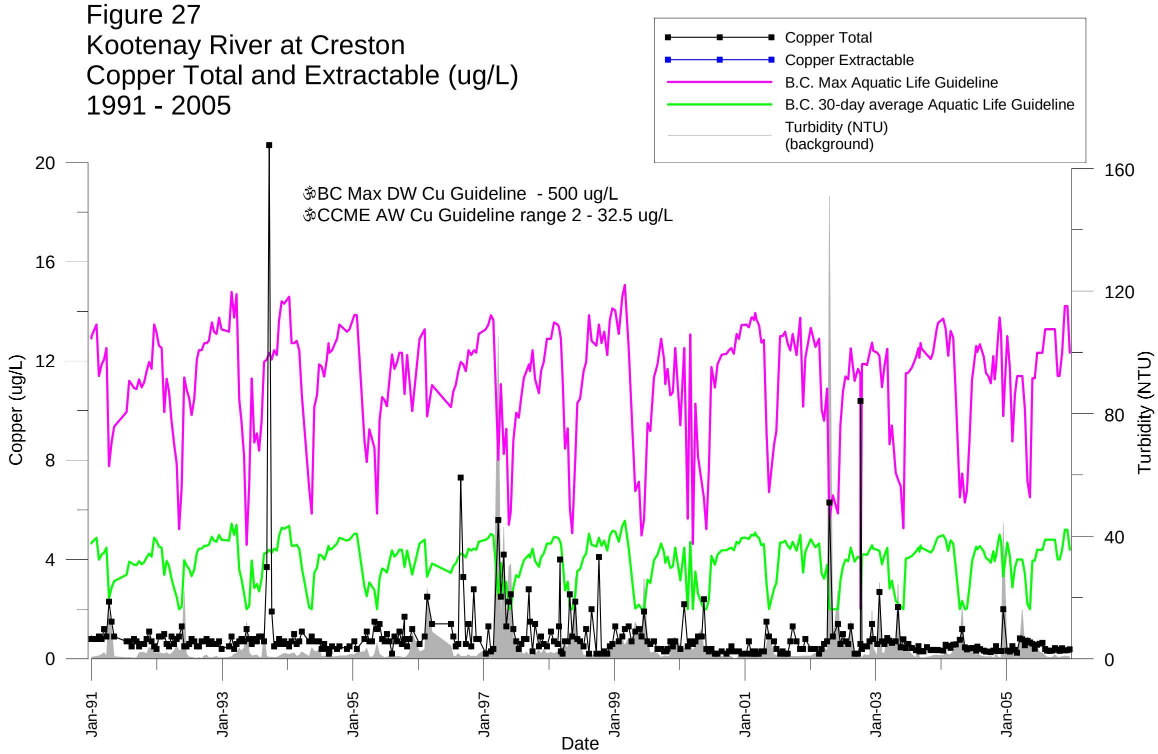

Figure 28
Kootenay River at Creston
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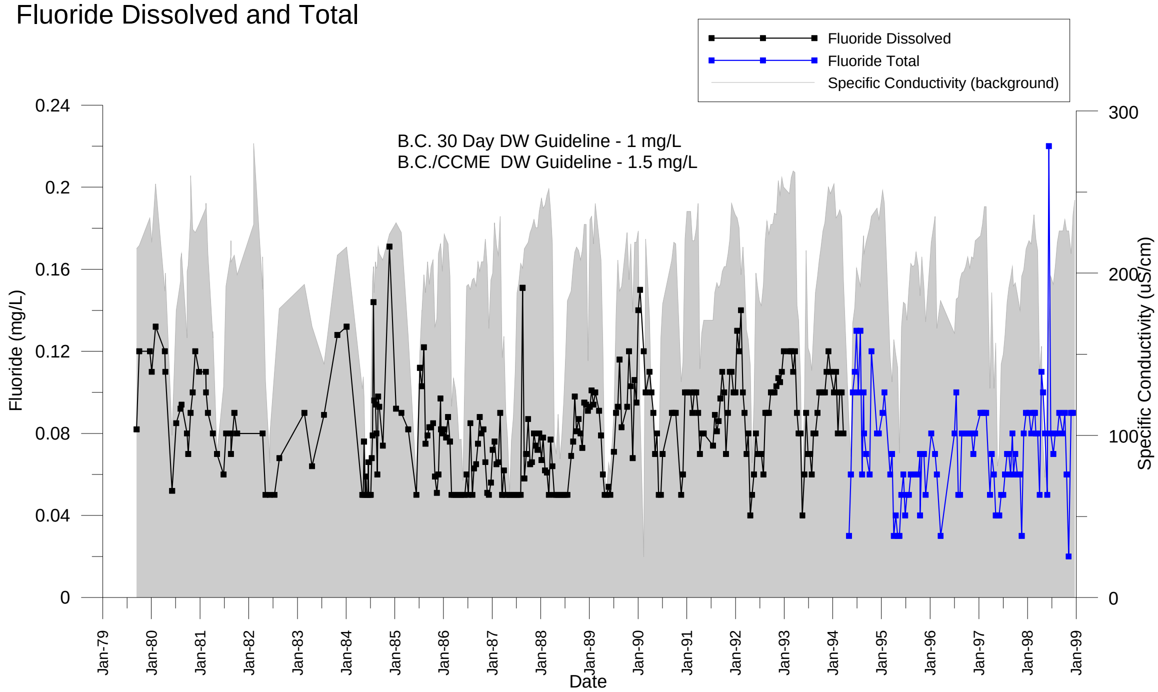


Figure 29
Kootenay River at Creston
Total Gallium (ug/L)

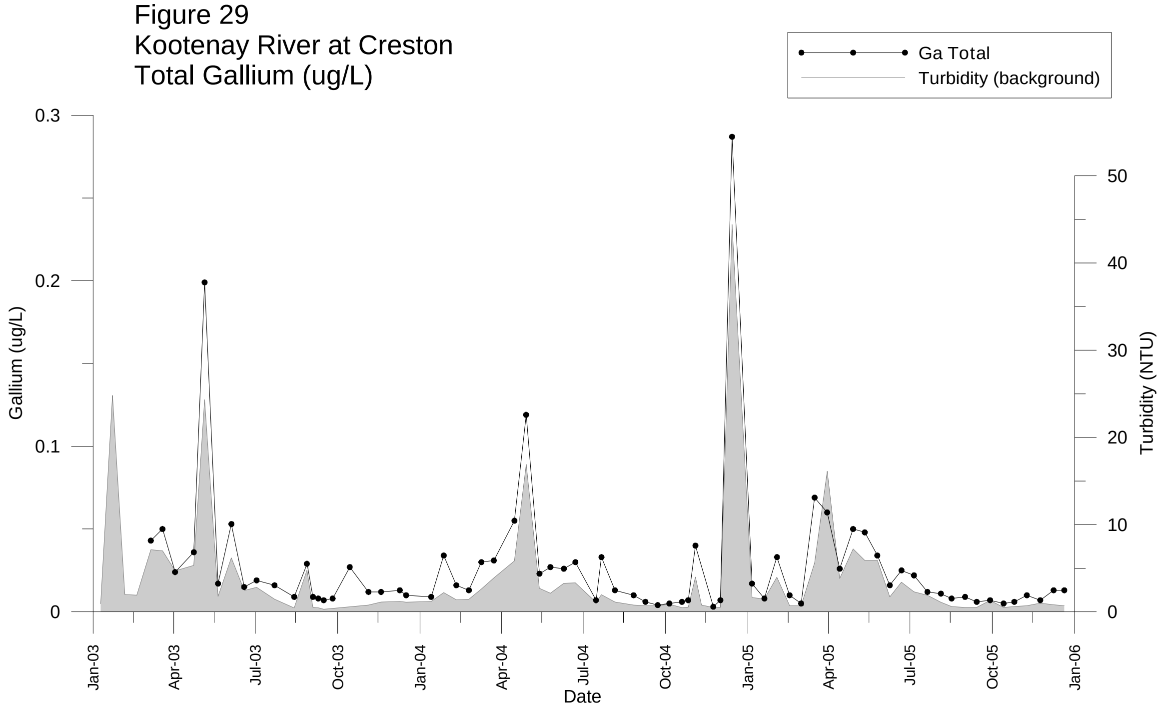


Figure 30
Kootenay River at Creston
Hardness Total

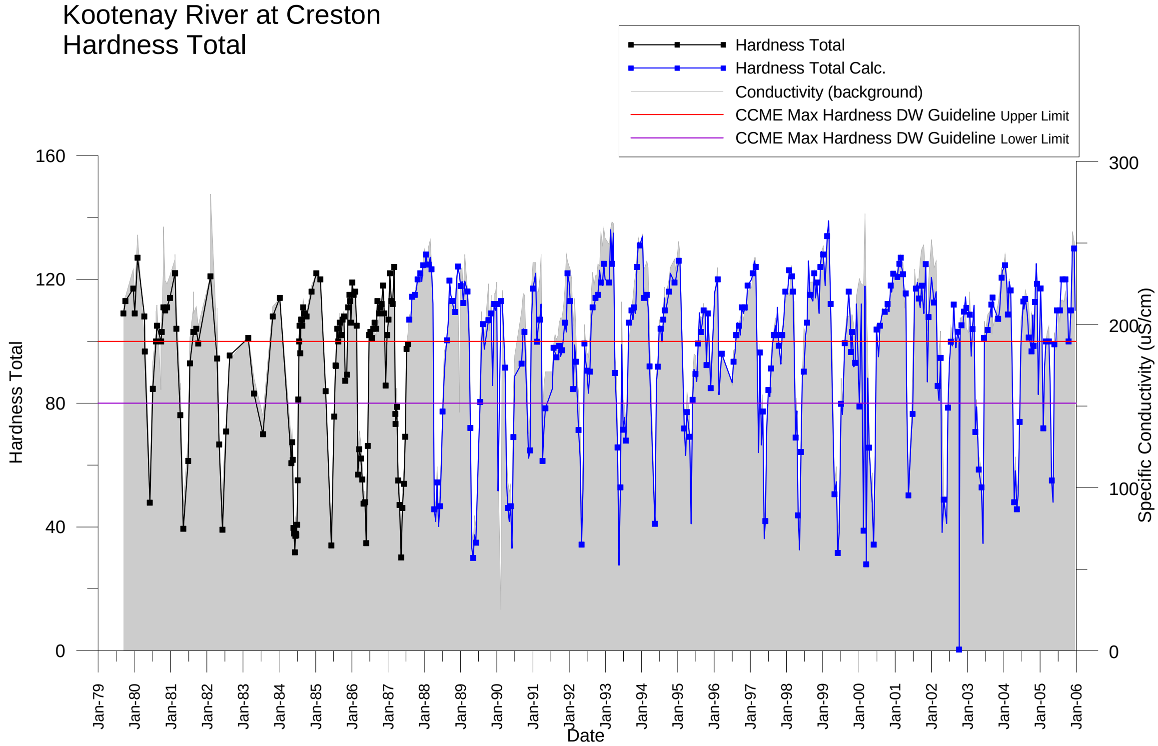


Figure 31
Kootenay River at Creston
Iron Total and Extractable

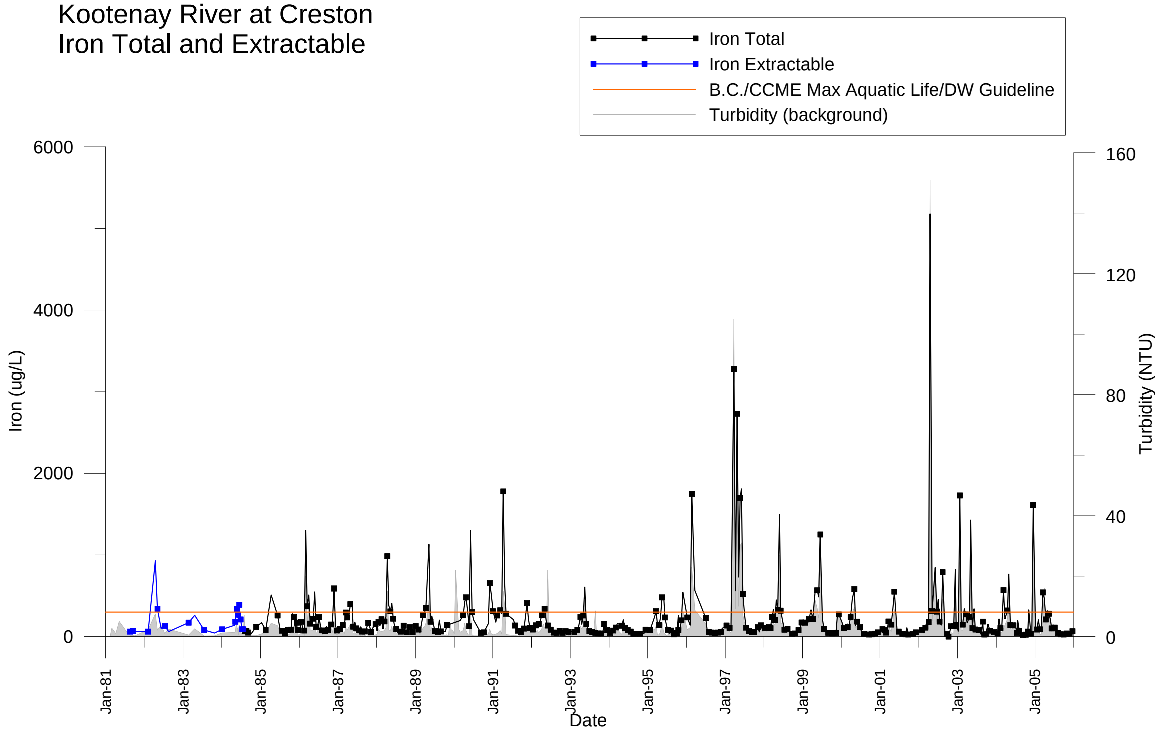


Figure 32
Kootenay River at Creston
Lead Total and Extractable (ug/L)

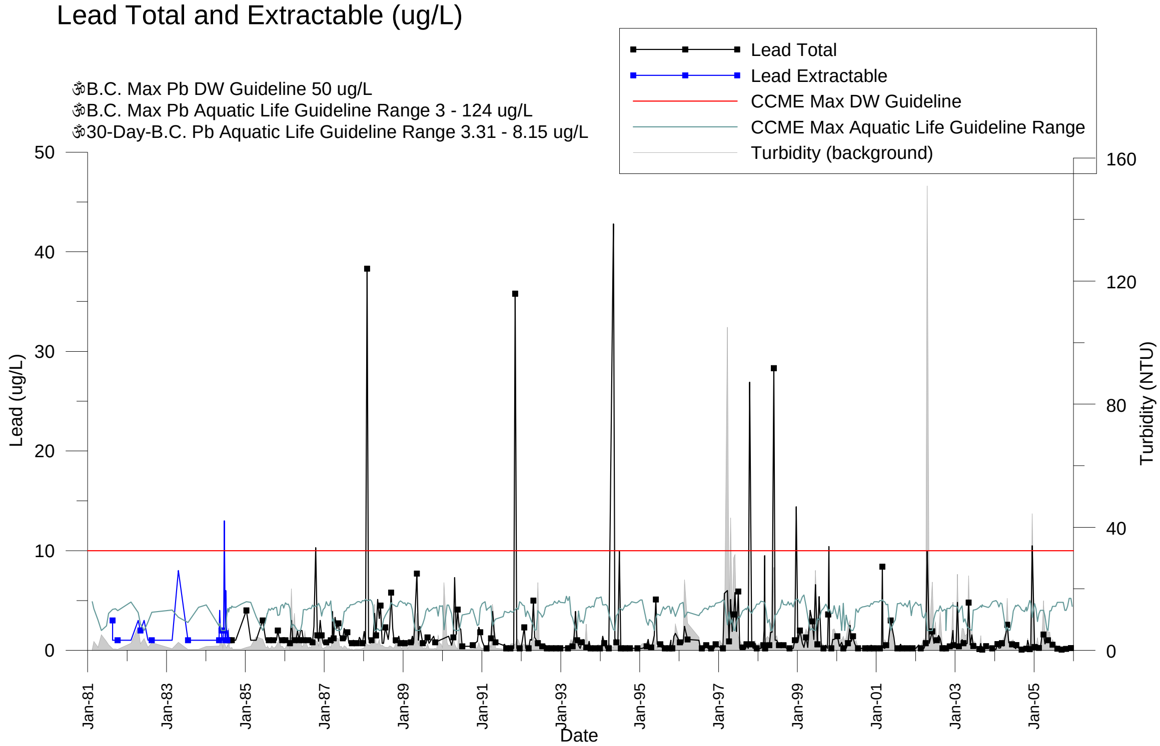


Figure 33
Kootenay River at Creston
Lithium Total

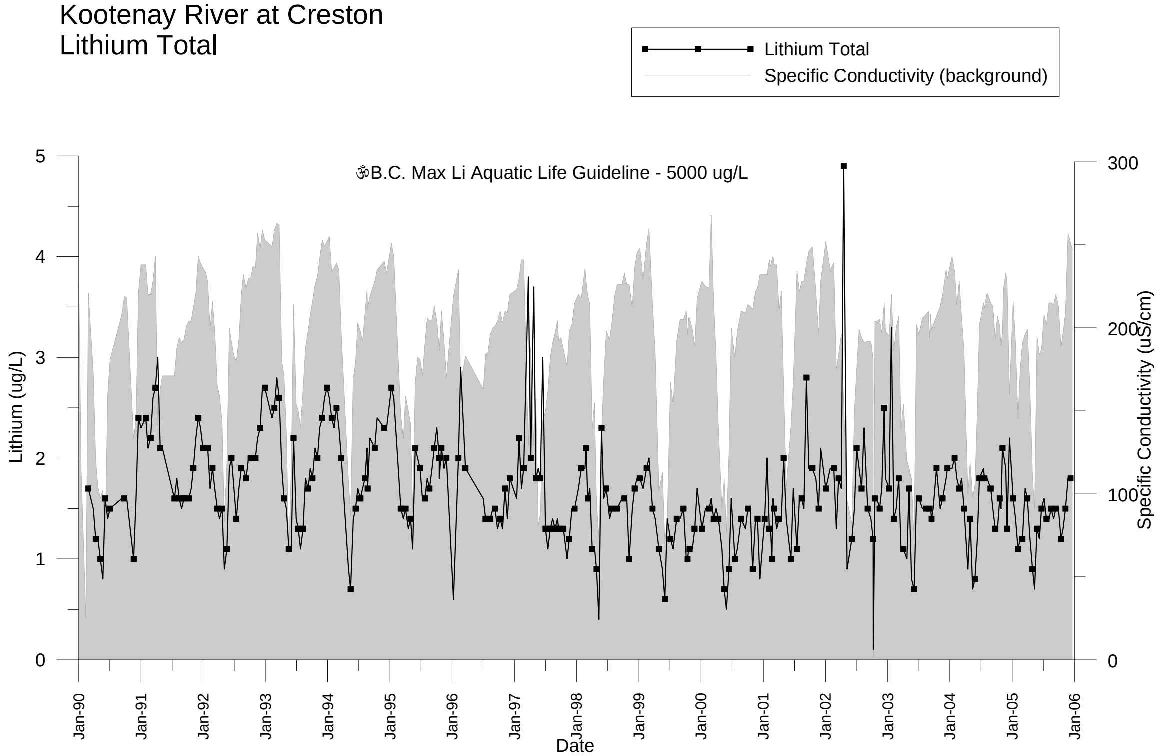


Figure 34
Kootenay River at Creston
Magnesium Dissolved and Extractable

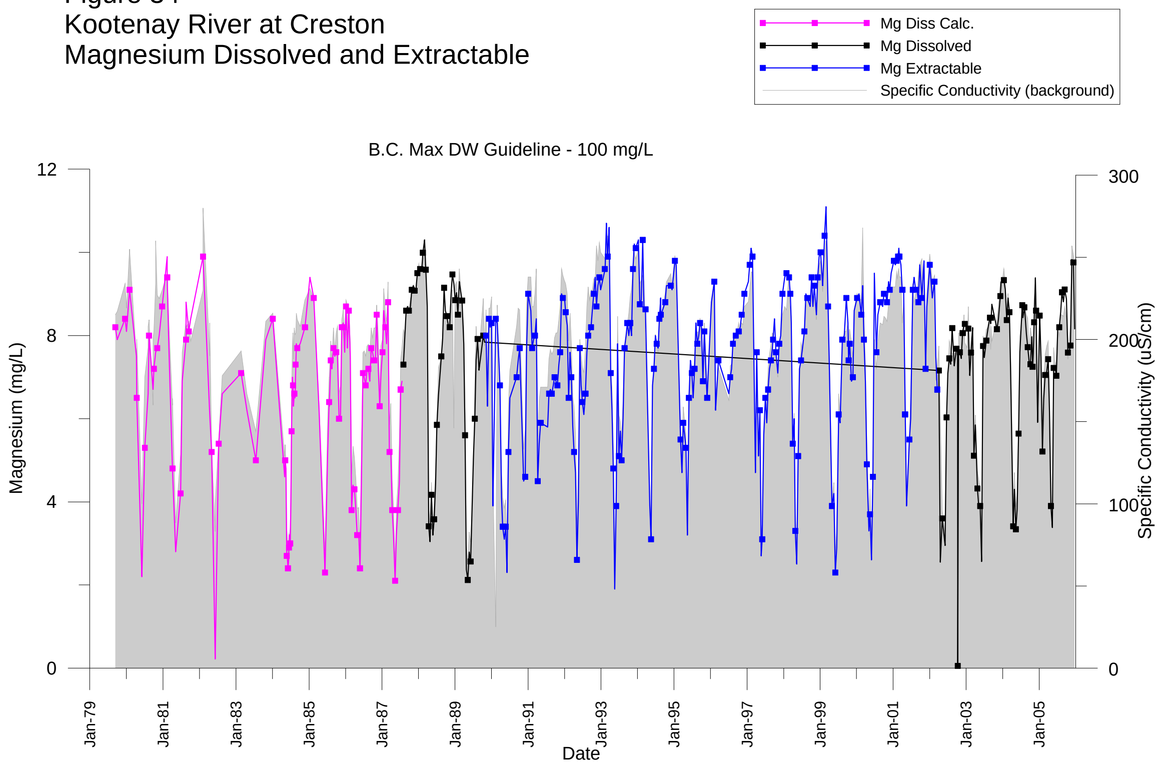


Figure 35
Kootenay River at Creston
Manganese Total and Extractable

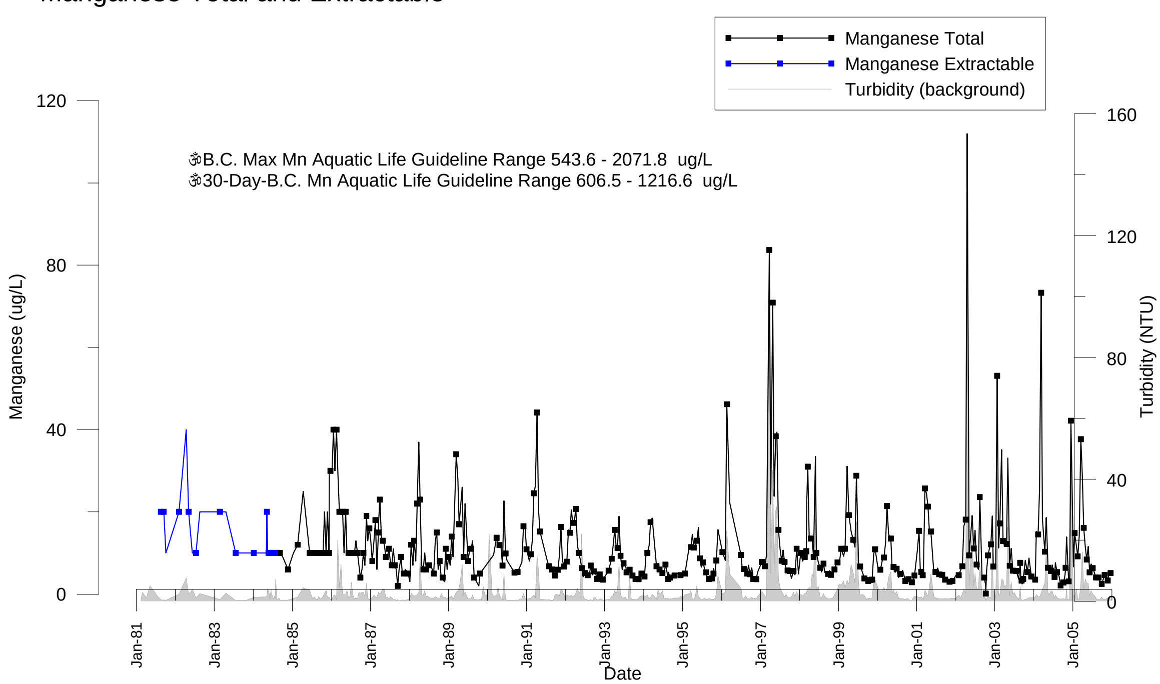


Figure 36
Kootenay River at Creston
Mercury Total and Extractable

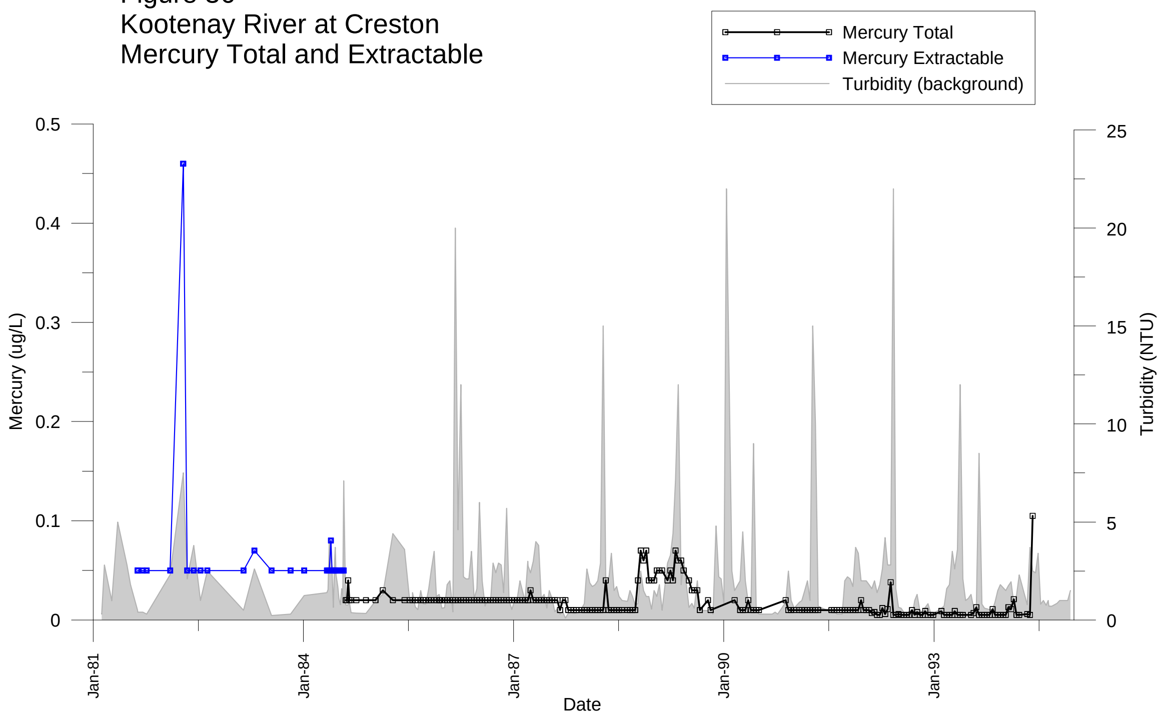


Figure 37
Kootenay River at Creston
Molybdenum Total

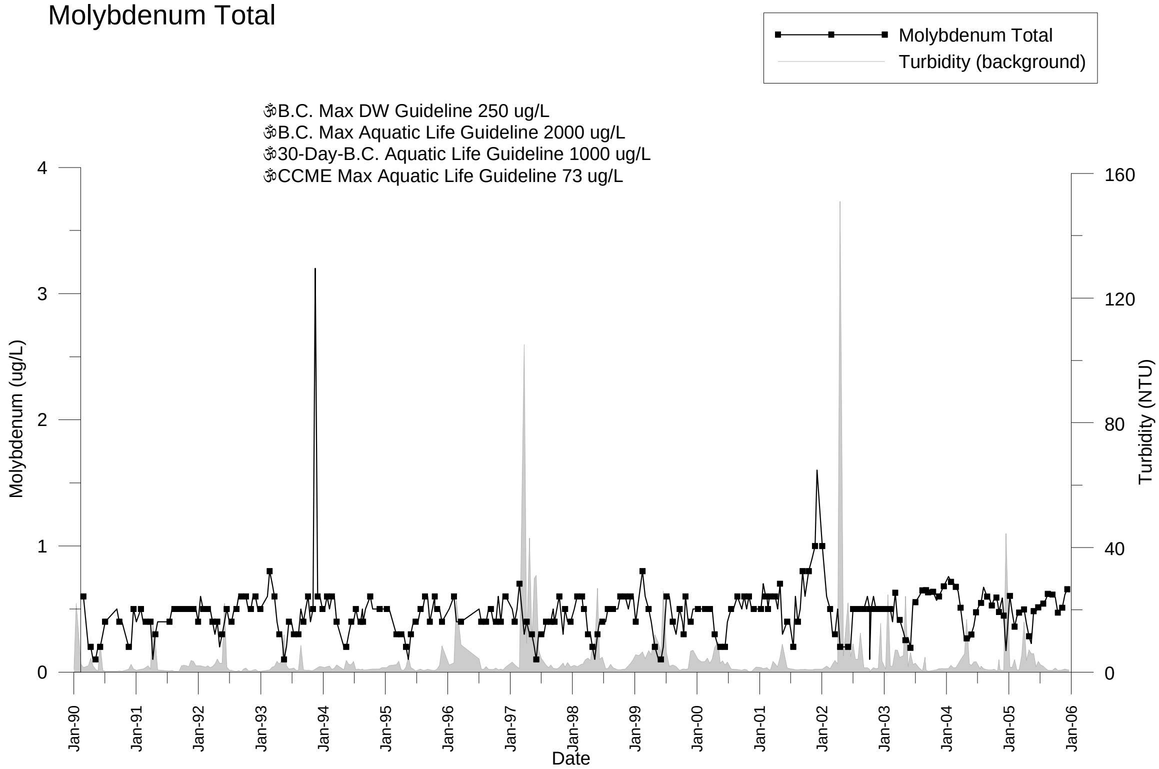


Figure 38
Kootenay River at Creston
Nickel Total (ug/L)

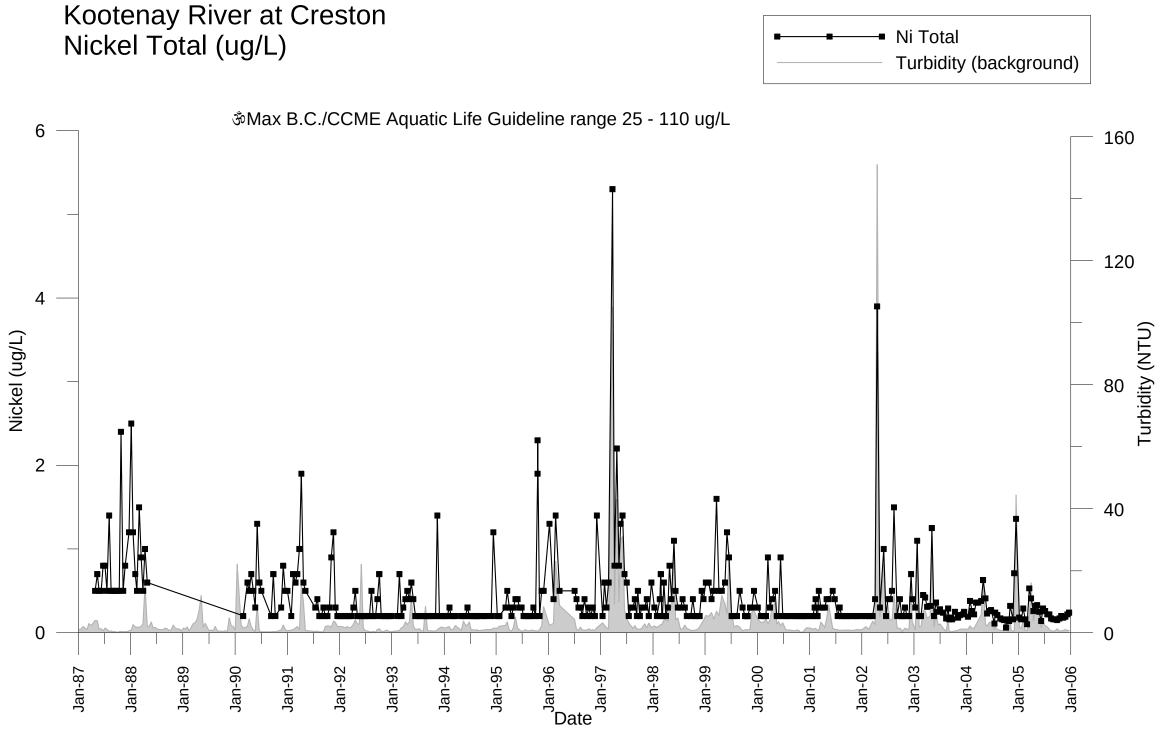


Figure 39
Kootenay River at Creston
Nitrogen Dissolved Nitrate

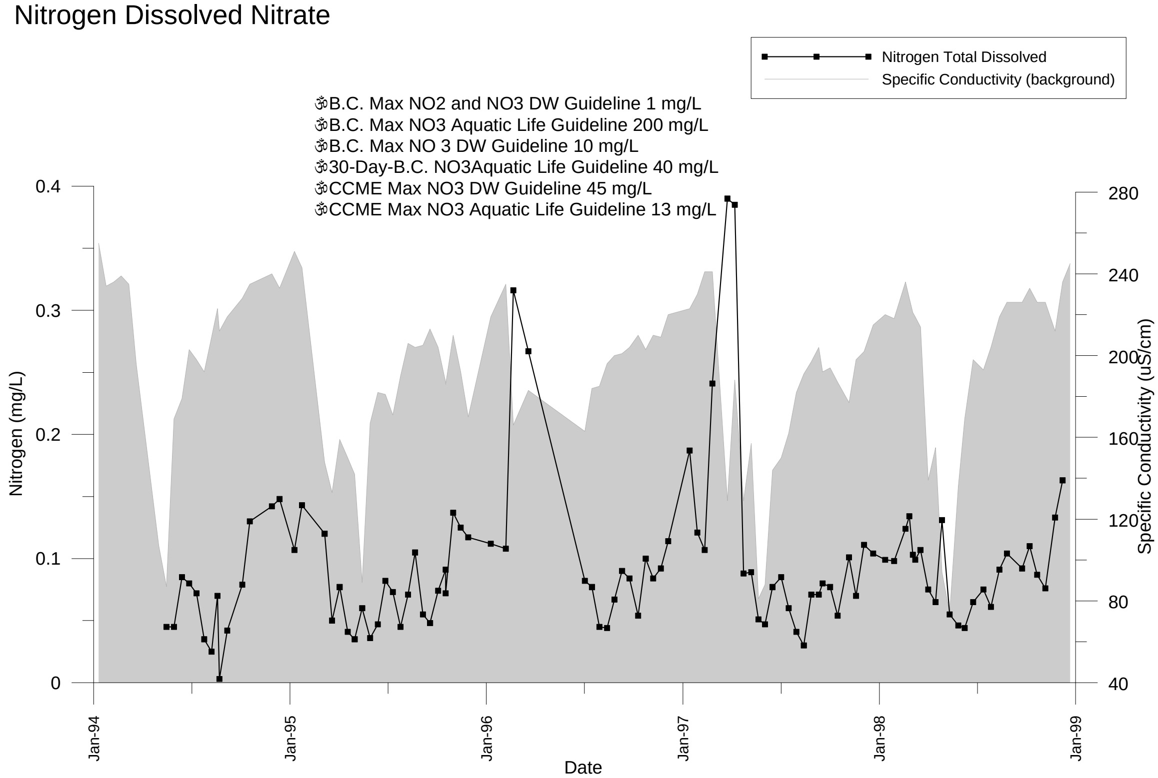


Figure 40
Kootenay River at Creston
Nitrogen Dissolved NO2 and NO3

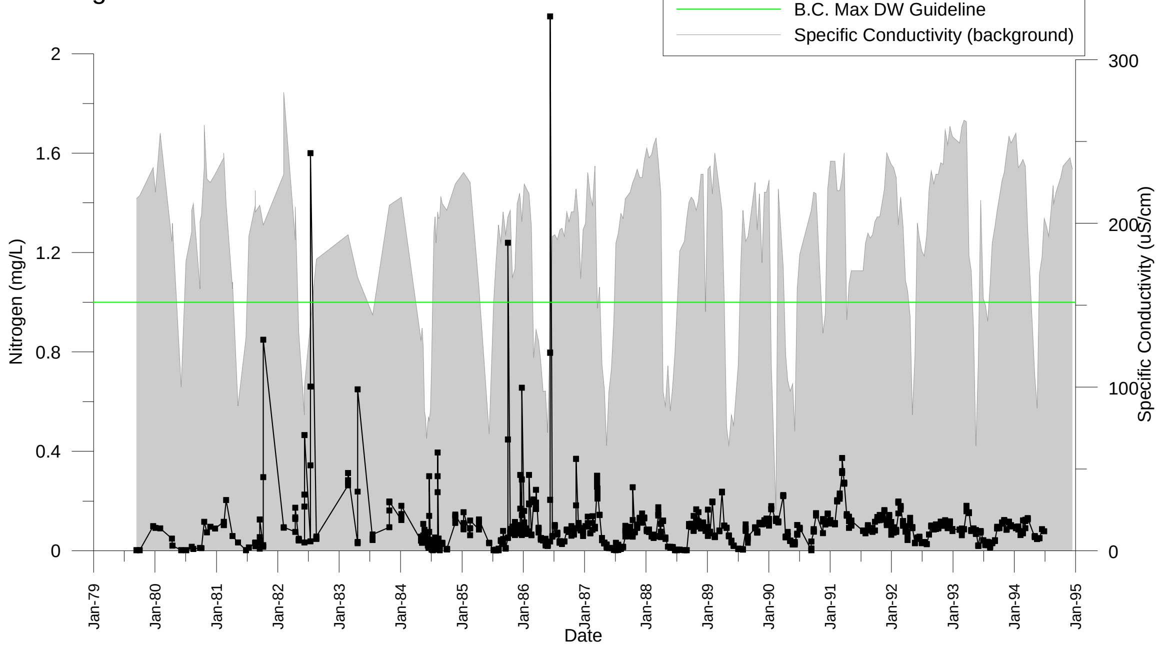


Figure 41
Kootenay River at Creston
Nitrogen Nitrite (mg/L)

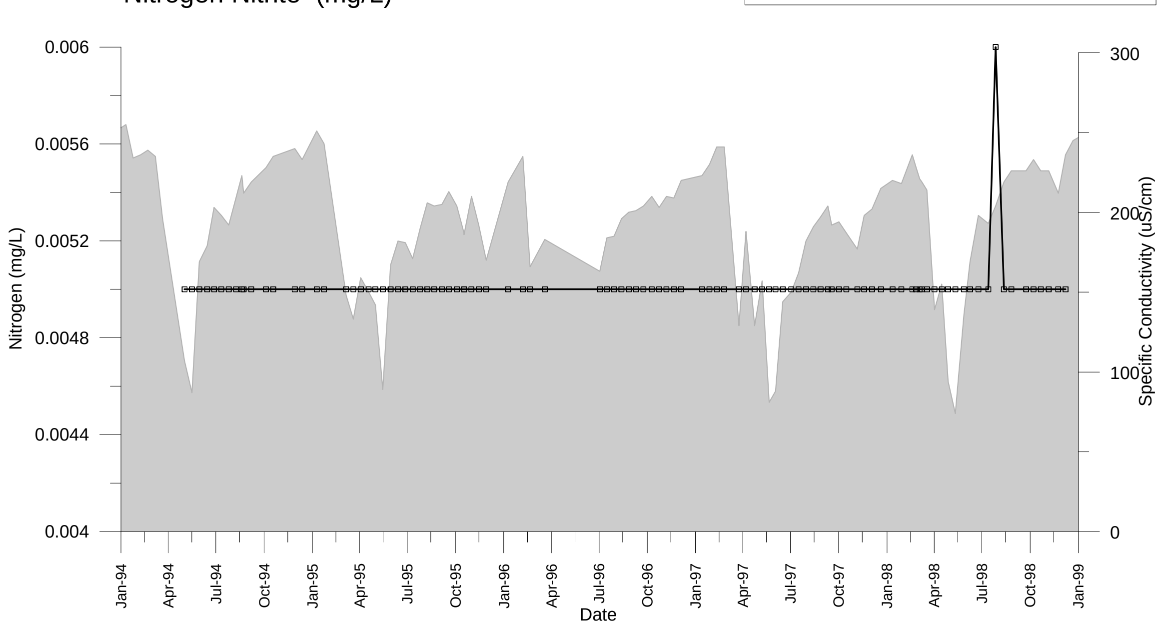


Figure 42
Kootenay River at Creston
Nitrogen Total Dissolved

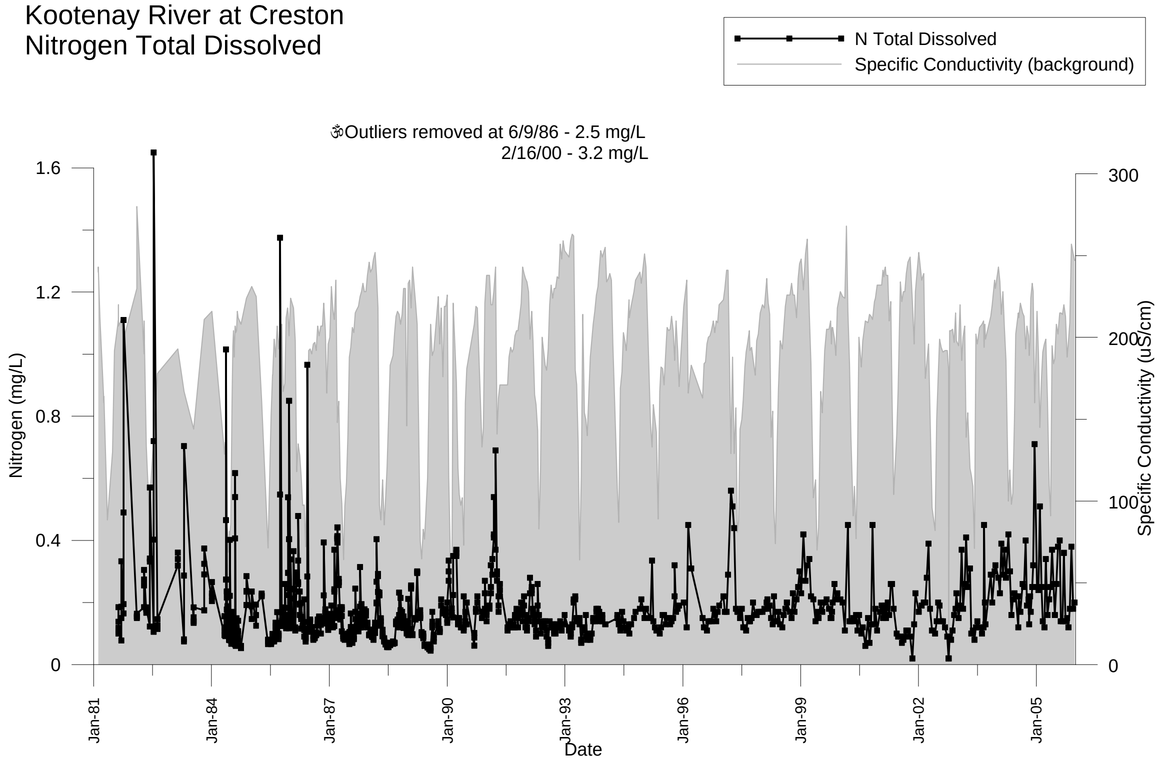


Figure 43
Kootenay River at Creston
Lanthanum Total

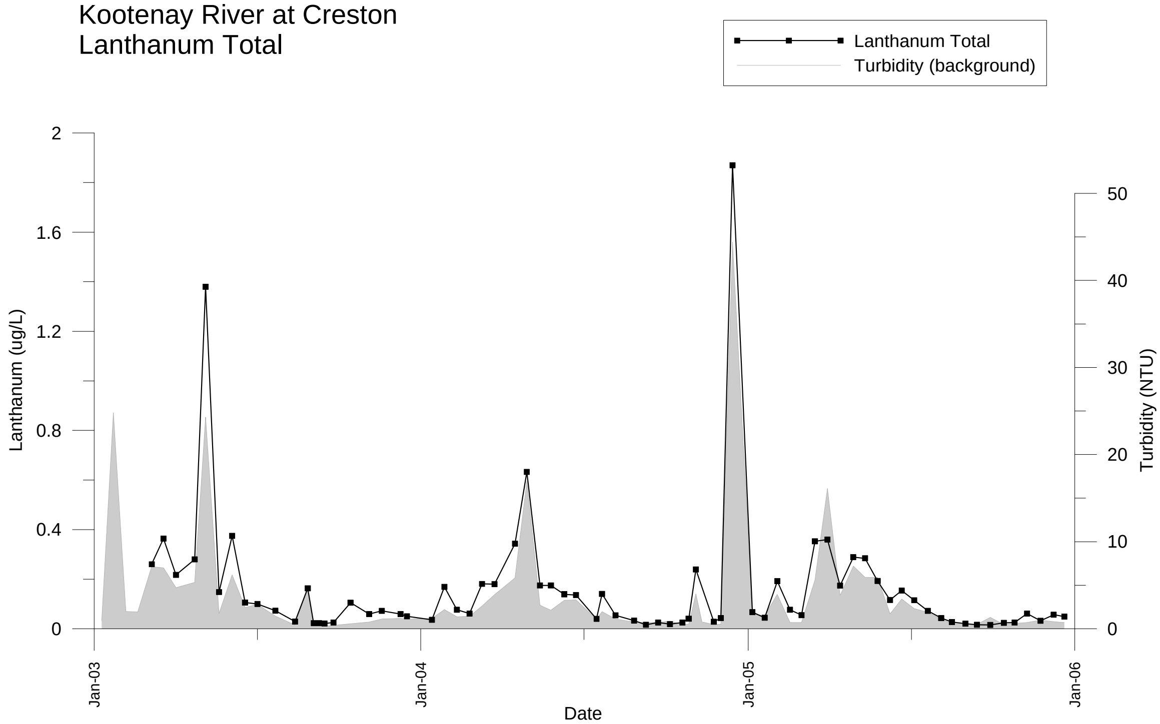


Figure 44
Kootenay River at Creston
pH

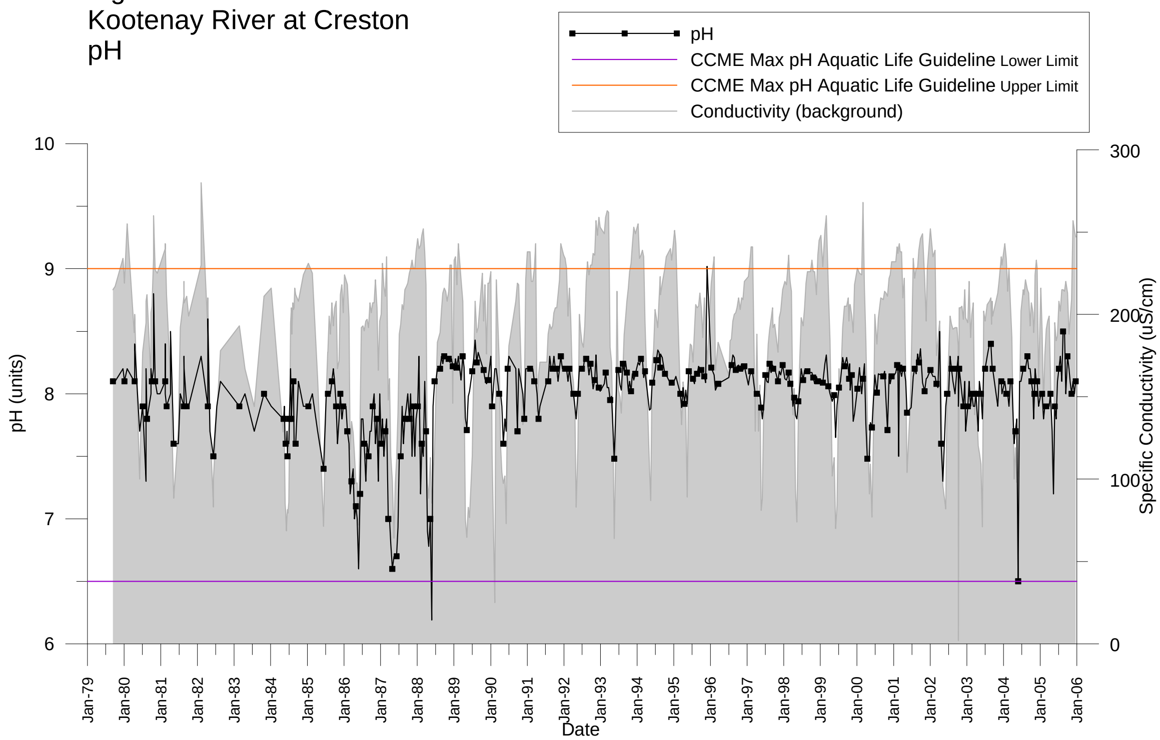


Figure 45
Kootenay River at Creston
Phosphate Dissolved Ortho

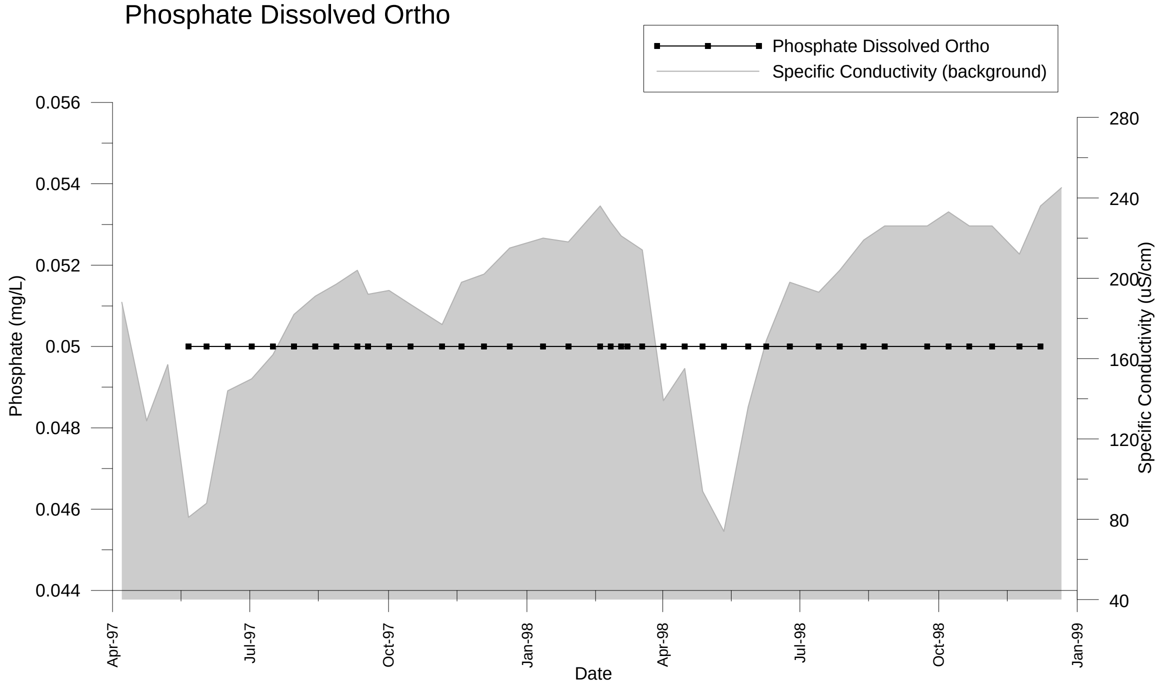


Figure 46
Kootenay River at Creston
Phosphorus Dissolved Ortho

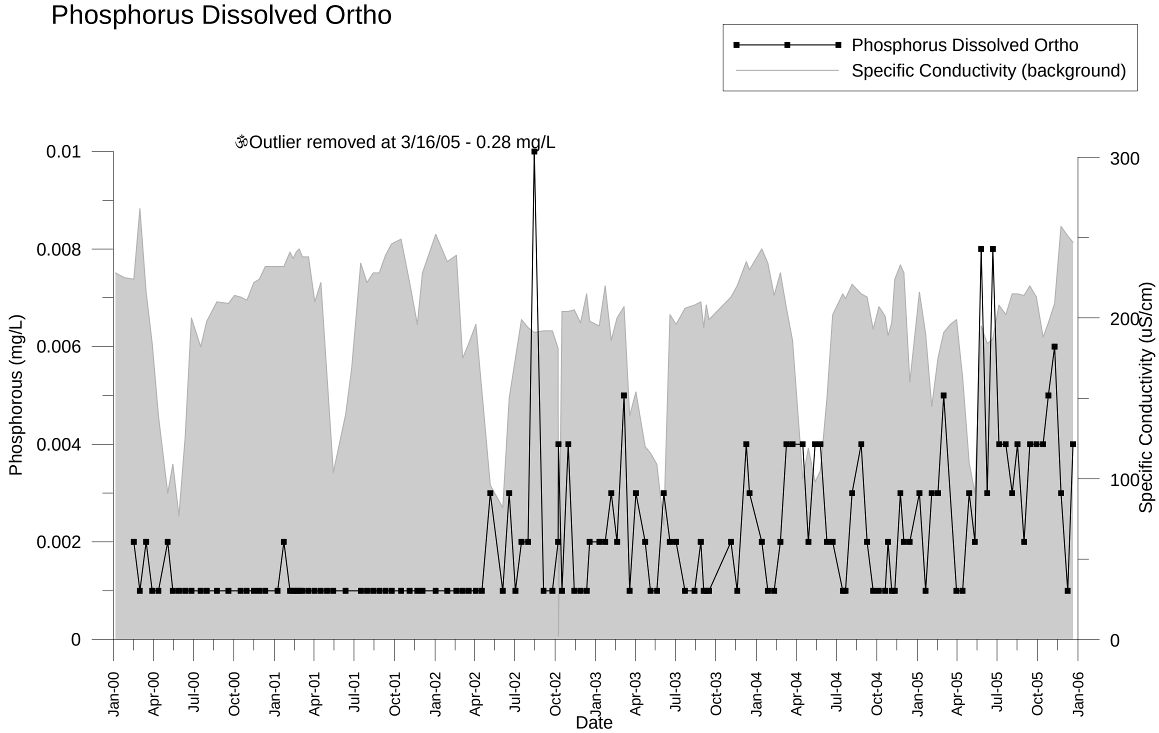


Figure 47
Kootenay River at Creston
Phosphorus Total

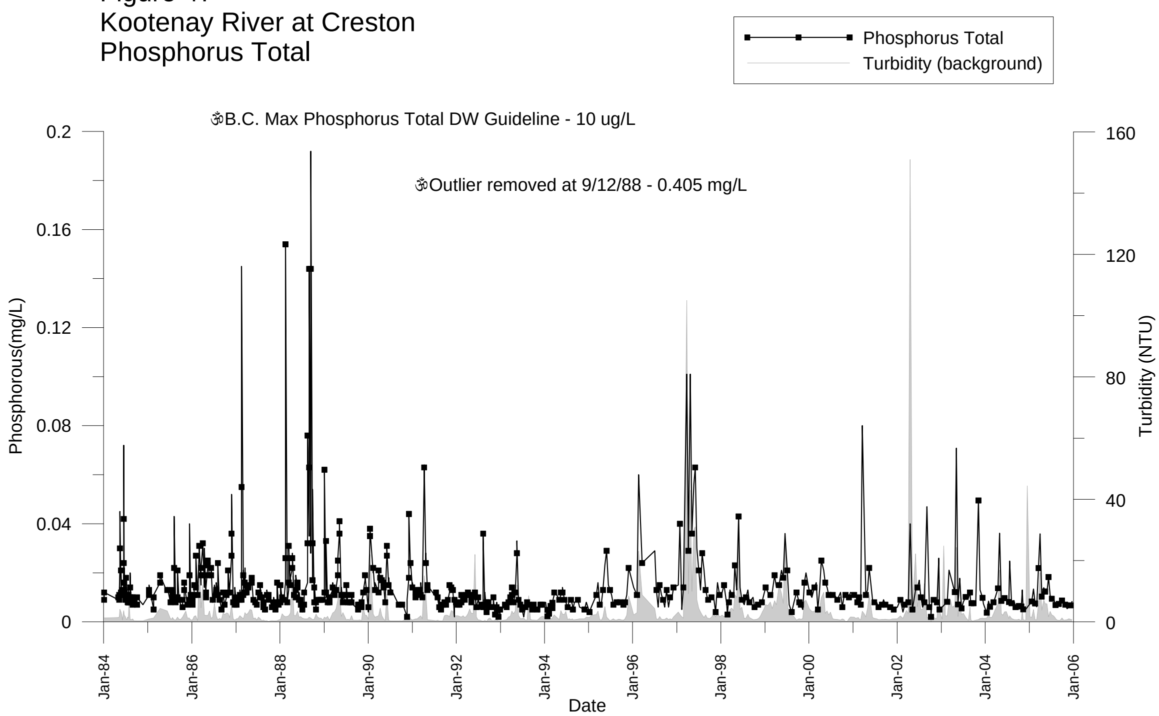


Figure 48
Kootenay River at Creston
Potassium Dissolved and Extractable

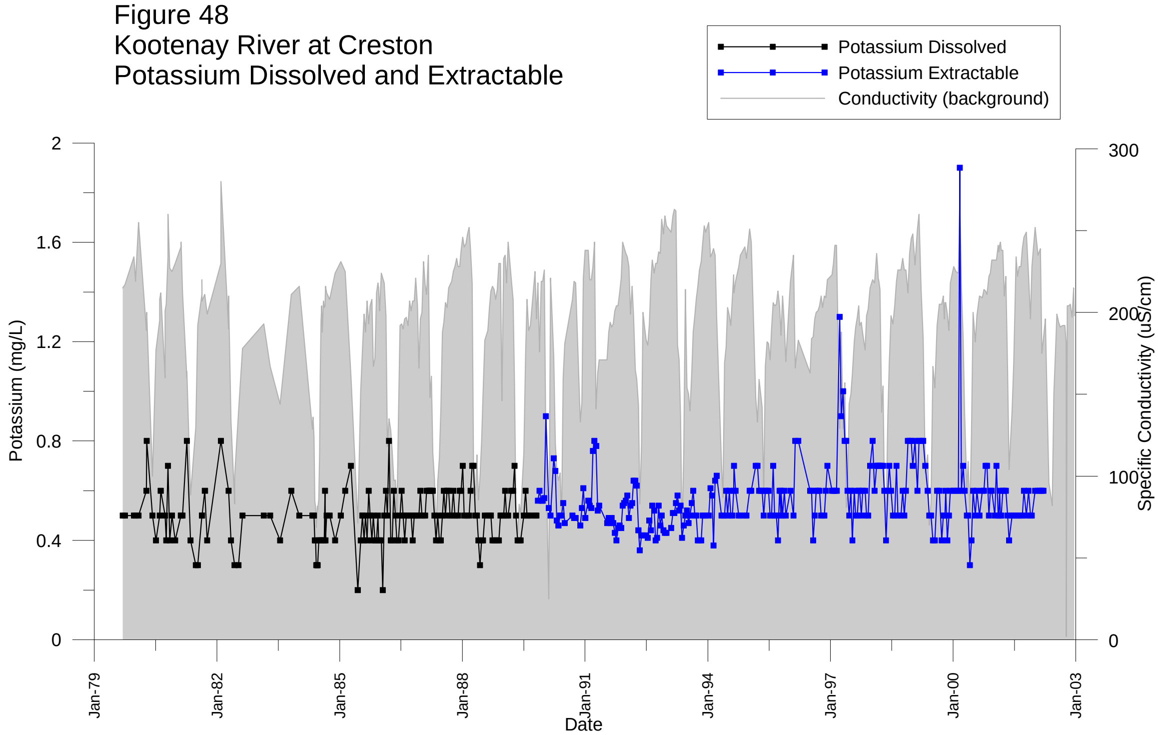
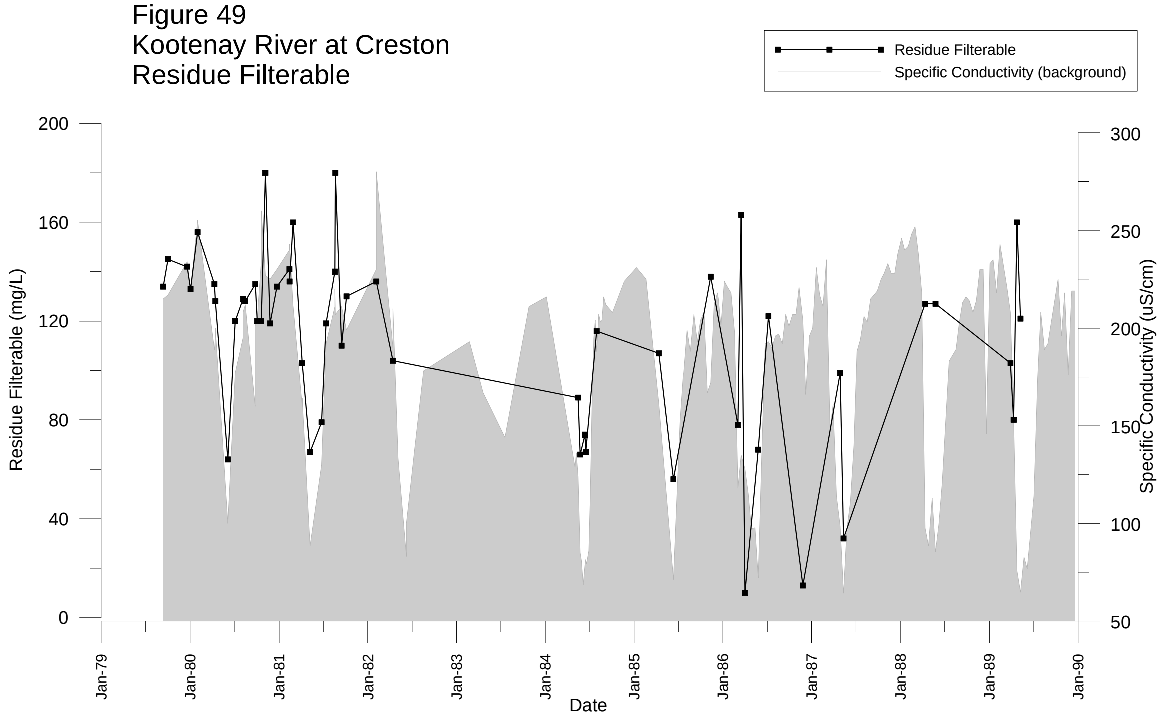


Figure 49
Kootenay River at Creston
Residue Filterable



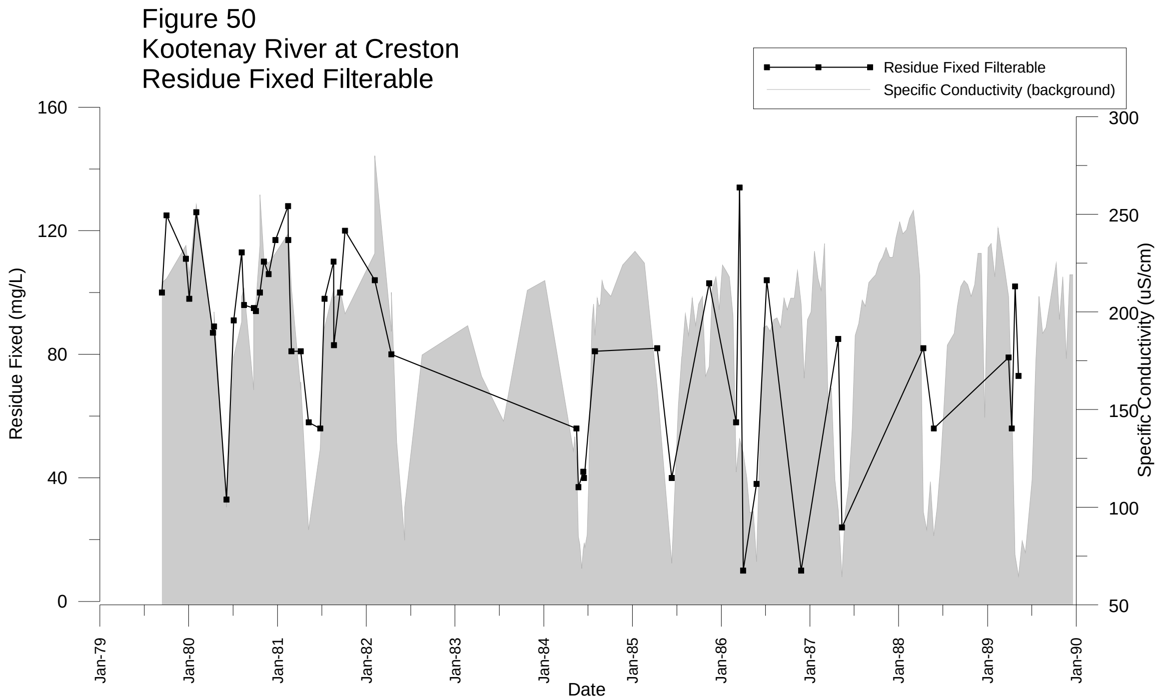


Figure 50
Kootenay River at Creston
Residue Fixed Filterable
Residue Fixed Filterable
Specific Conductivity (background)
Residue Fixed (mg/L)
Specific Conductivity (uS/cm)
0
40
80
120
160
50
100
150
200
250
300
Jan-79
Jan-80
Jan-81
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Date

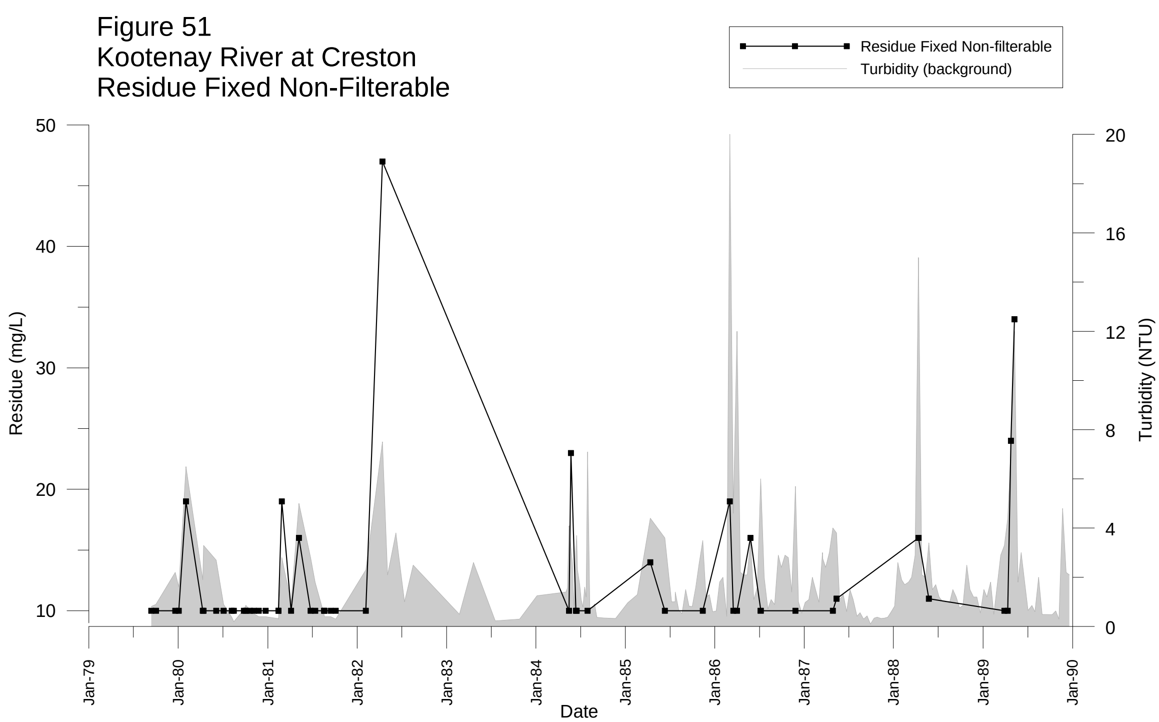


Figure 51
Kootenay River at Creston
Residue Fixed Non-Filterable
Residue Fixed Non-filterable
Turbidity (background)
Residue (mg/L)
Turbidity (NTU)
10
20
30
40
50
0
4
8
12
16
20
Jan-79
Jan-80
Jan-81
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Date

Figure 52
Kootenay River at Creston
Residue Non-filterable

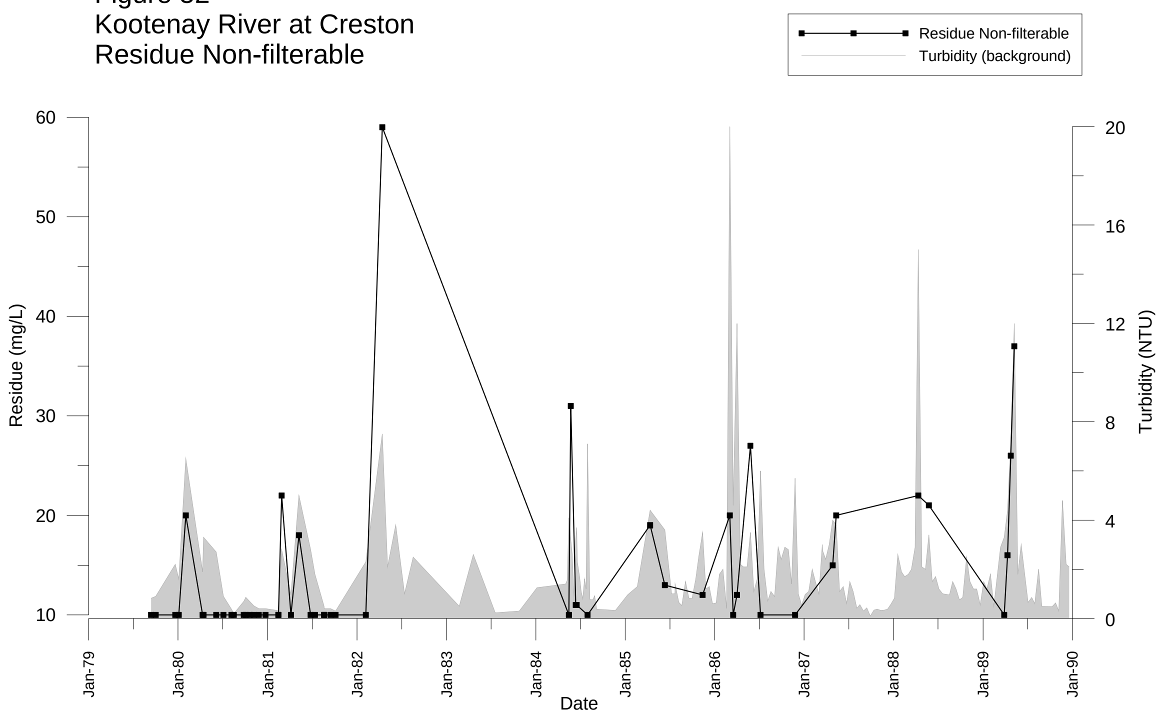


Figure 53
Kootenay River at Creston
Rubidium Total (ug/L)

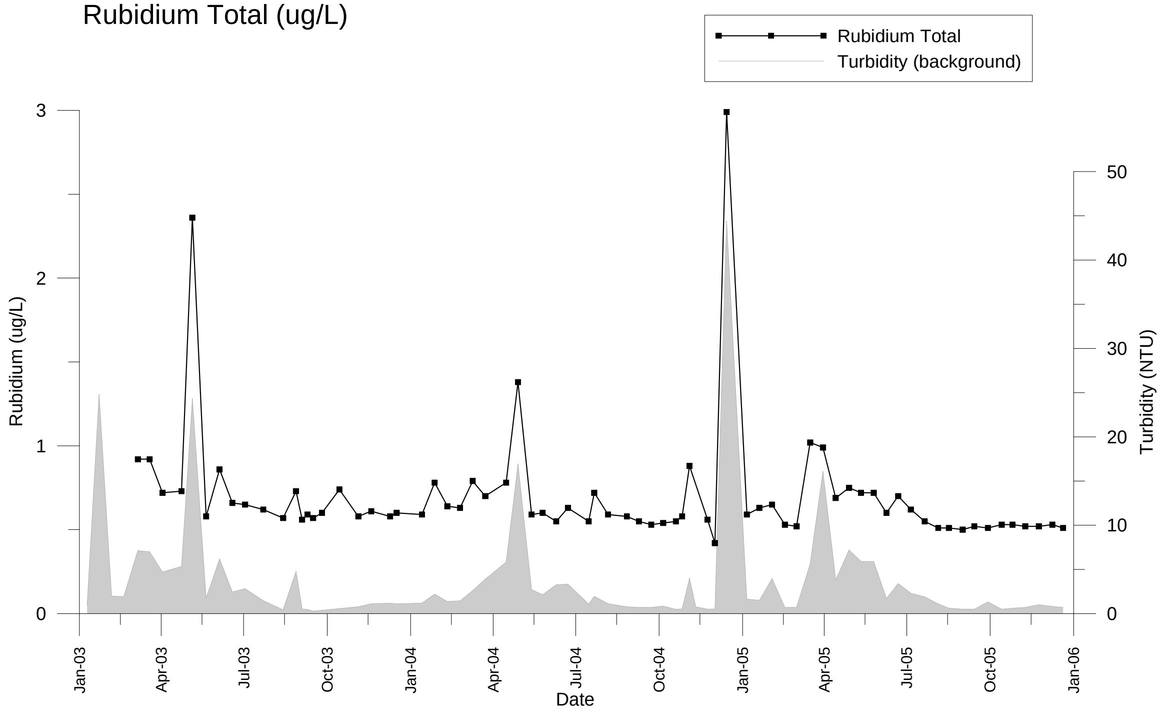


Figure 54
Kootenay River at Creston
Selenium Total and Extractable

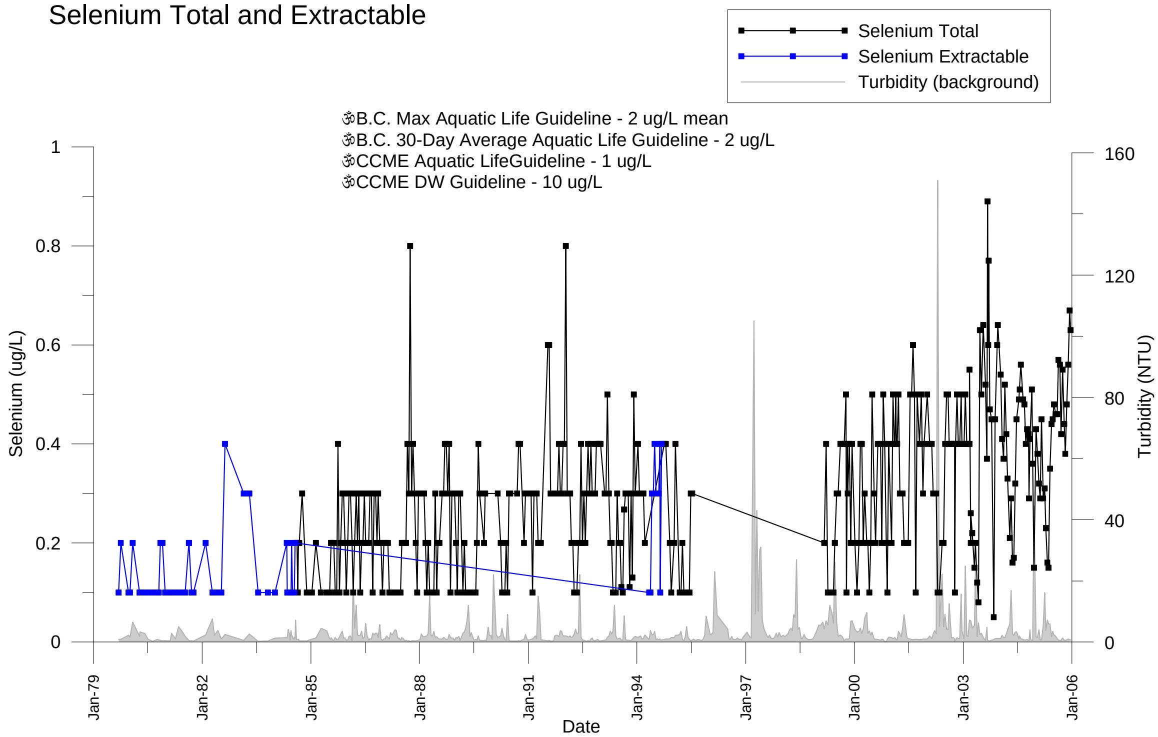


Figure 55
Kootenay River at Creston
Silica Reactive and Dissolved

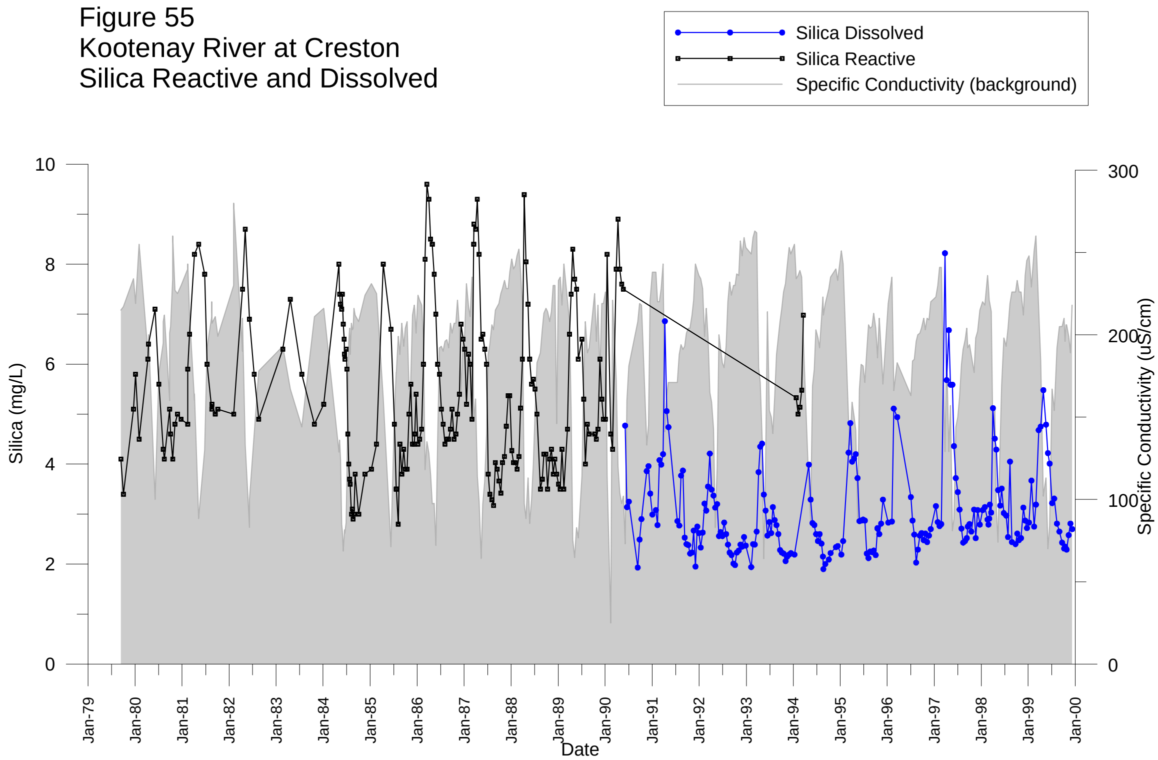


Figure 56
Kootenay River at Creston
Silicon Extractable (mg/L)

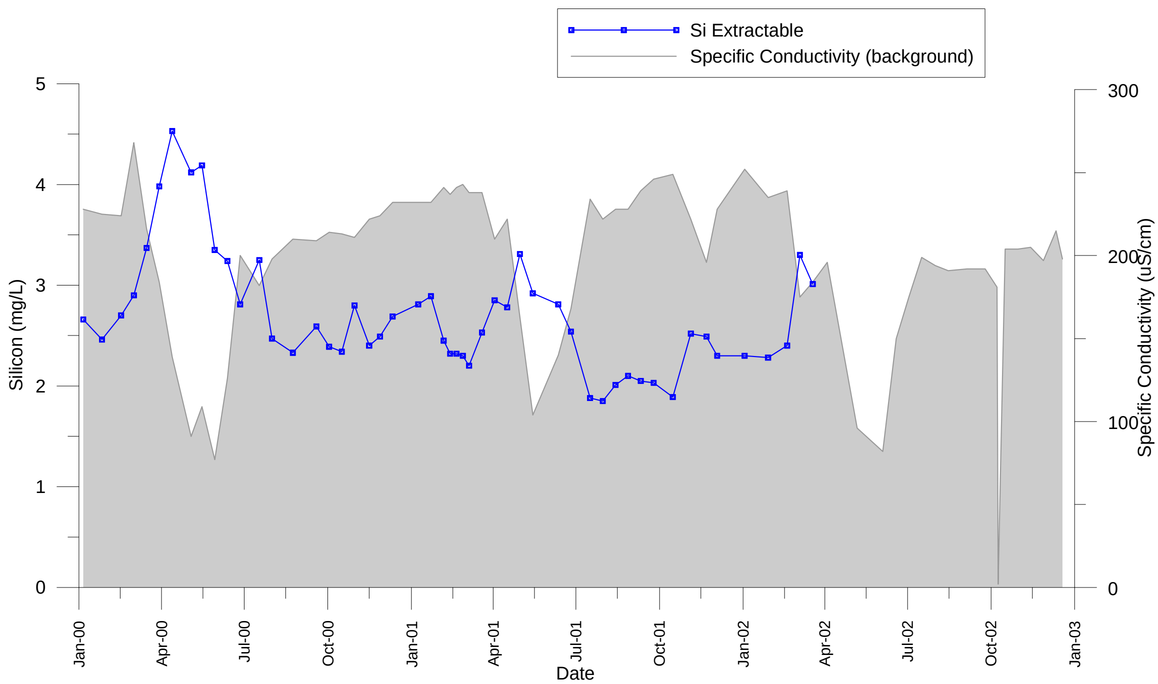
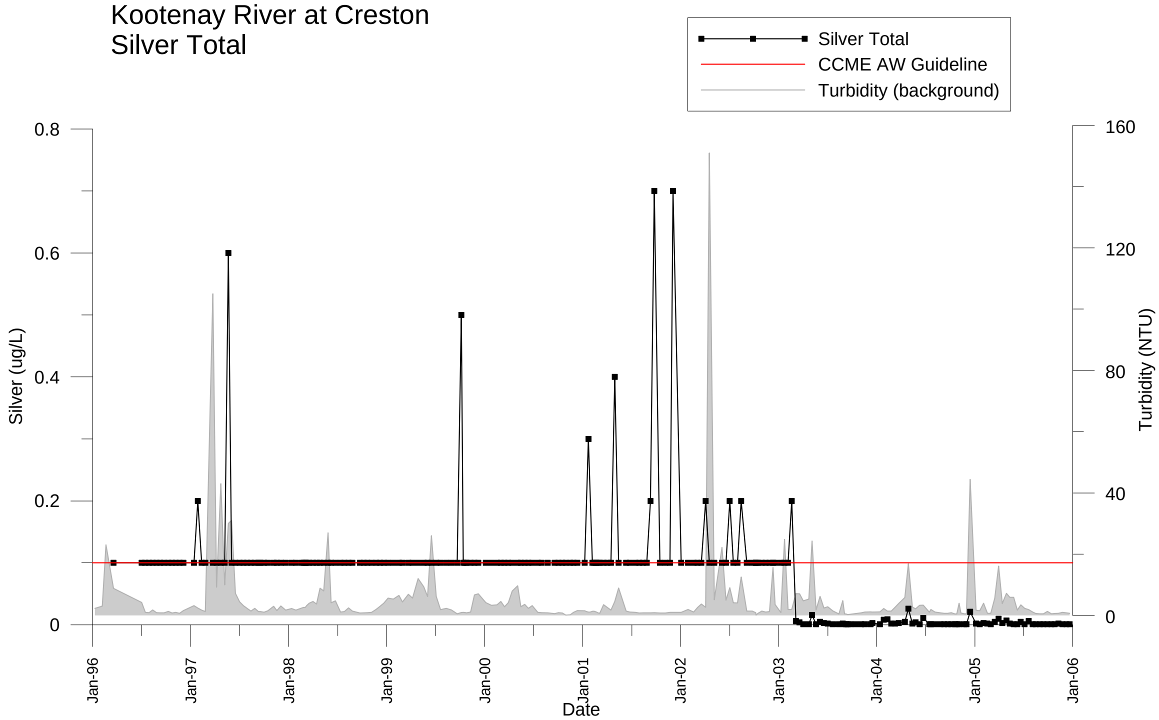


Figure 57
Kootenay River at Creston
Silver Total



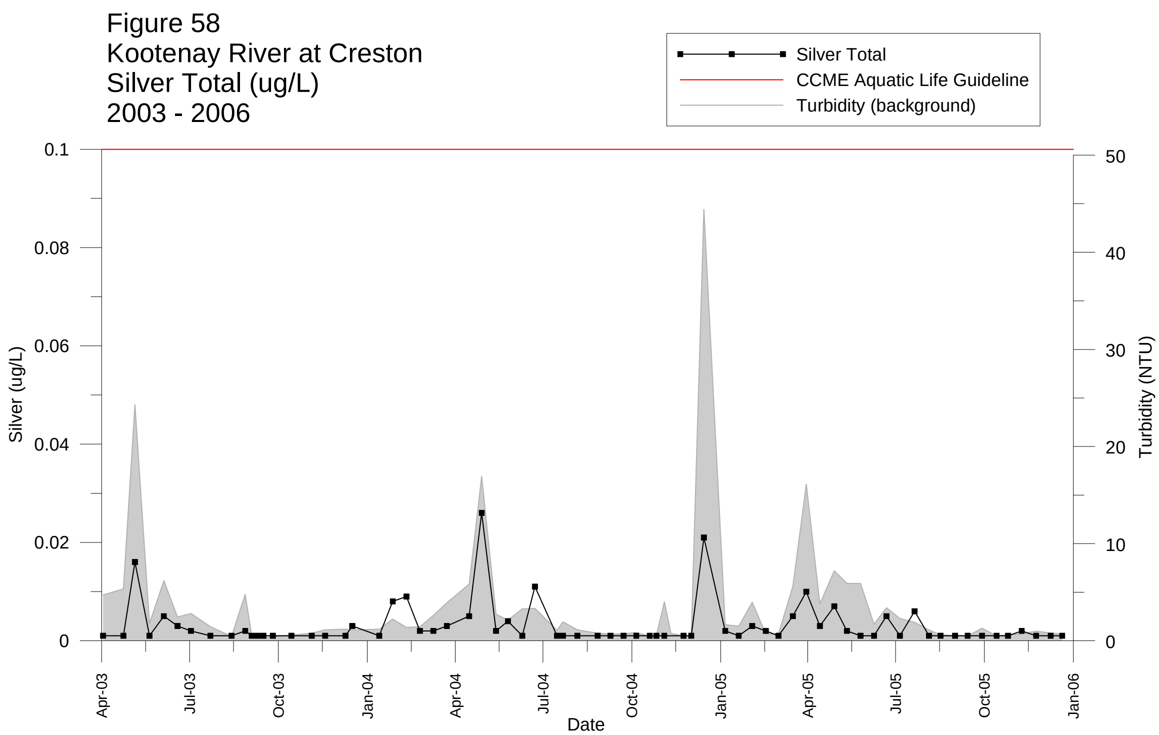


Figure 58
Kootenay River at Creston
Silver Total (ug/L)
2003 - 2006
Silver Total
CCME Aquatic Life Guideline
Turbidity (background)
Silver (ug/L)
Turbidity (NTU)
Date
0.1
0.08
0.06
0.04
0.02
0
50
40
30
20
10
0
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05
Apr-05
Jul-05
Oct-05
Jan-06

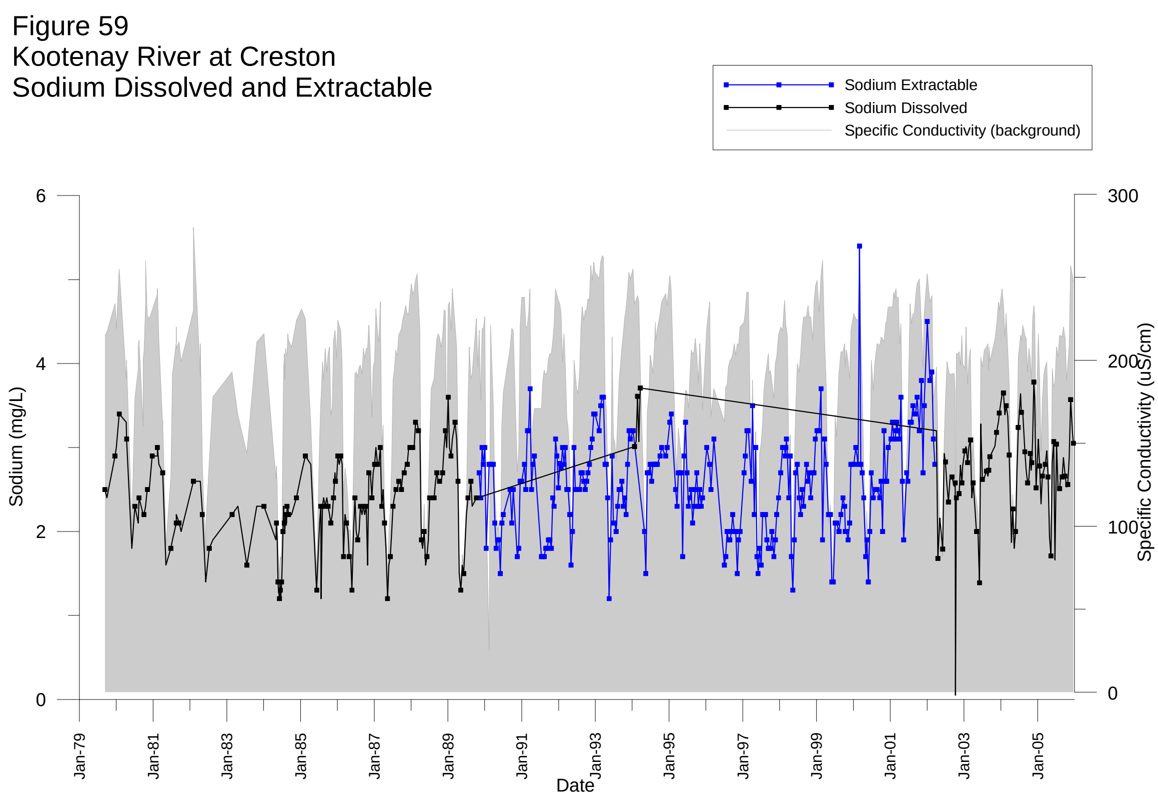


Figure 59
Kootenay River at Creston
Sodium Dissolved and Extractable
Sodium Extractable
Sodium Dissolved
Specific Conductivity (background)
Sodium (mg/L)
Specific Conductivity (uS/cm)
Date
6
4
2
0
300
200
100
0
Jan-79
Jan-81
Jan-83
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Jan-01
Jan-03
Jan-05

Figure 60
Kootenay River at Creston
Specific Conductivity (uS/cm)

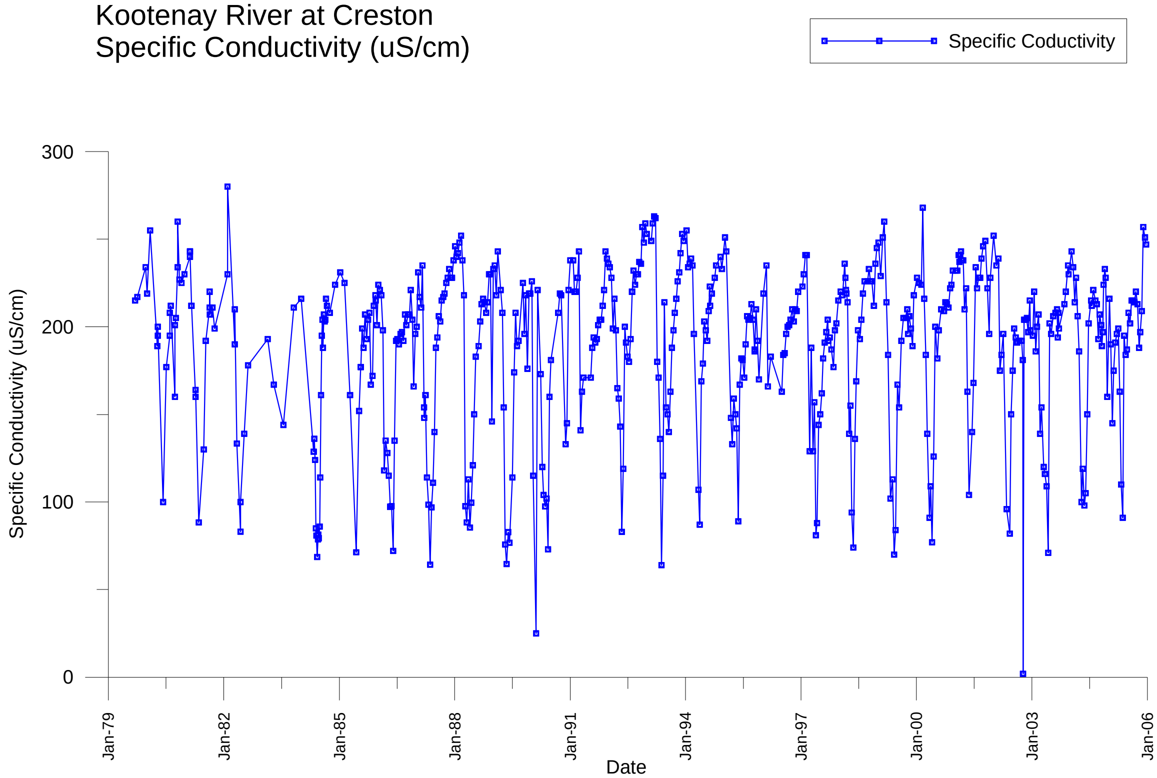


Figure 61
Kootenay River at Creston
Strontium Total

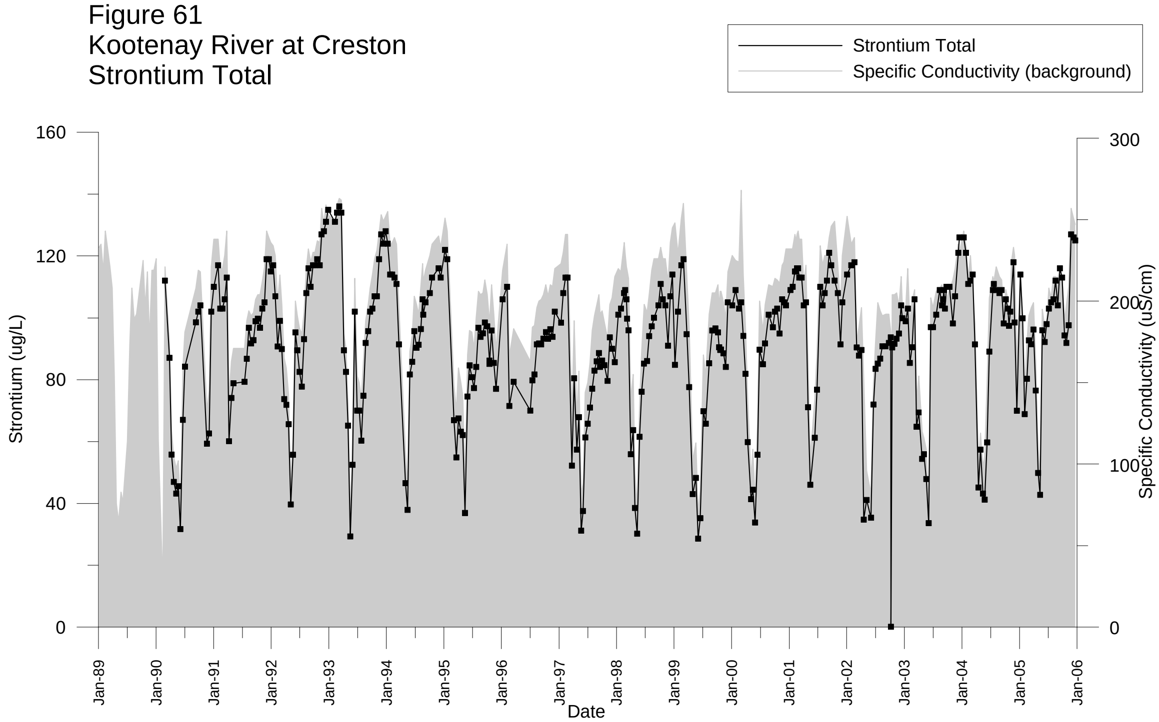


Figure 62
Kootenay River at Creston
Sulphate Dissolved

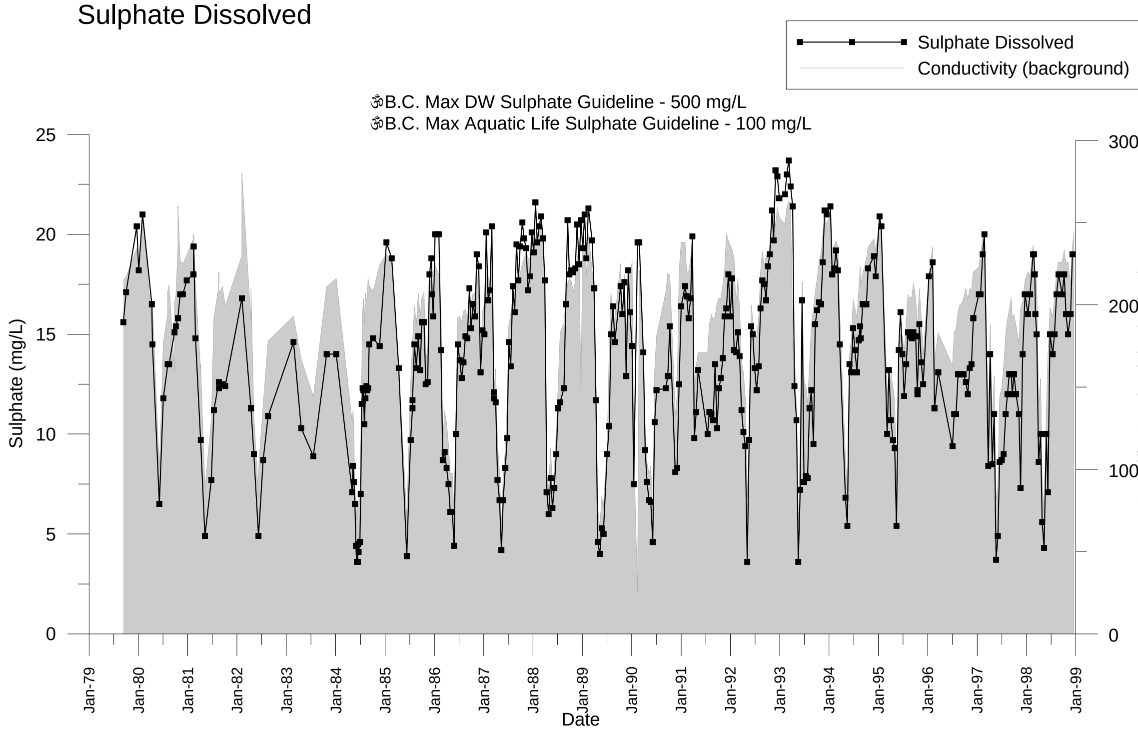


Figure 63
Kootenay River at Creston
Temperature Air and Water (deg C)

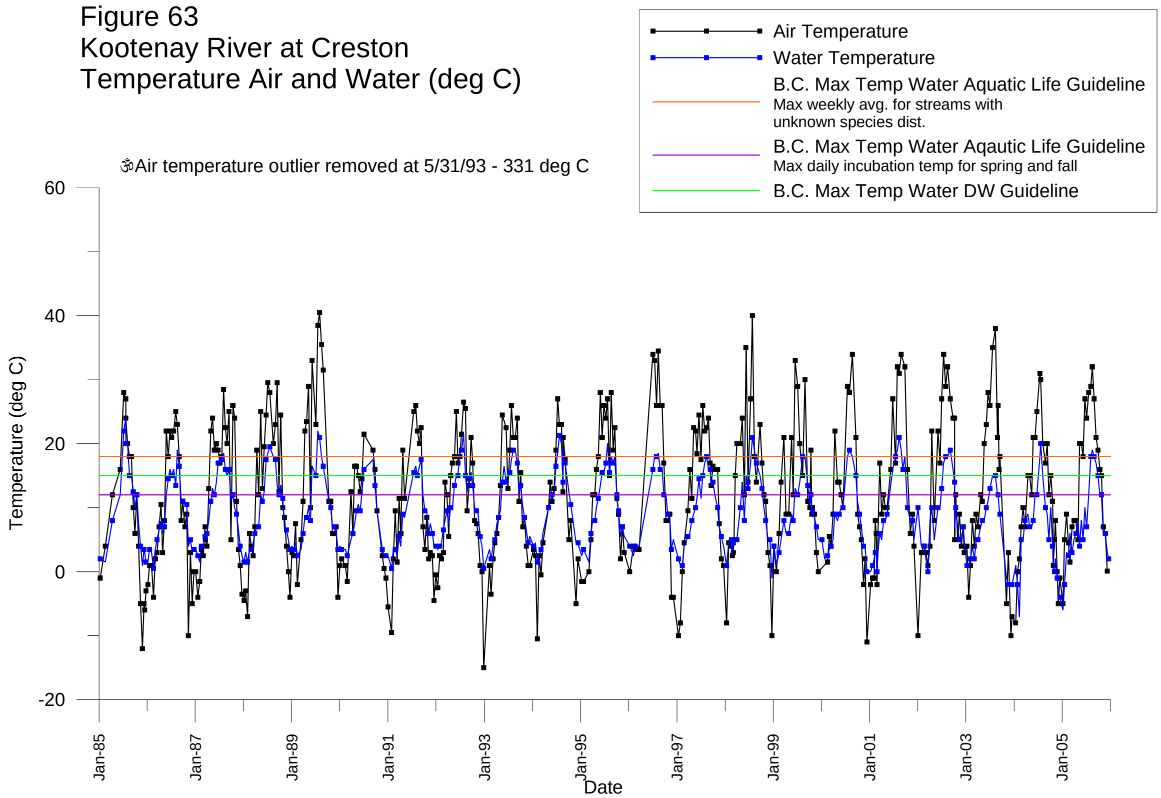


Figure 64
Kootenay River at Creston
Thallium Total

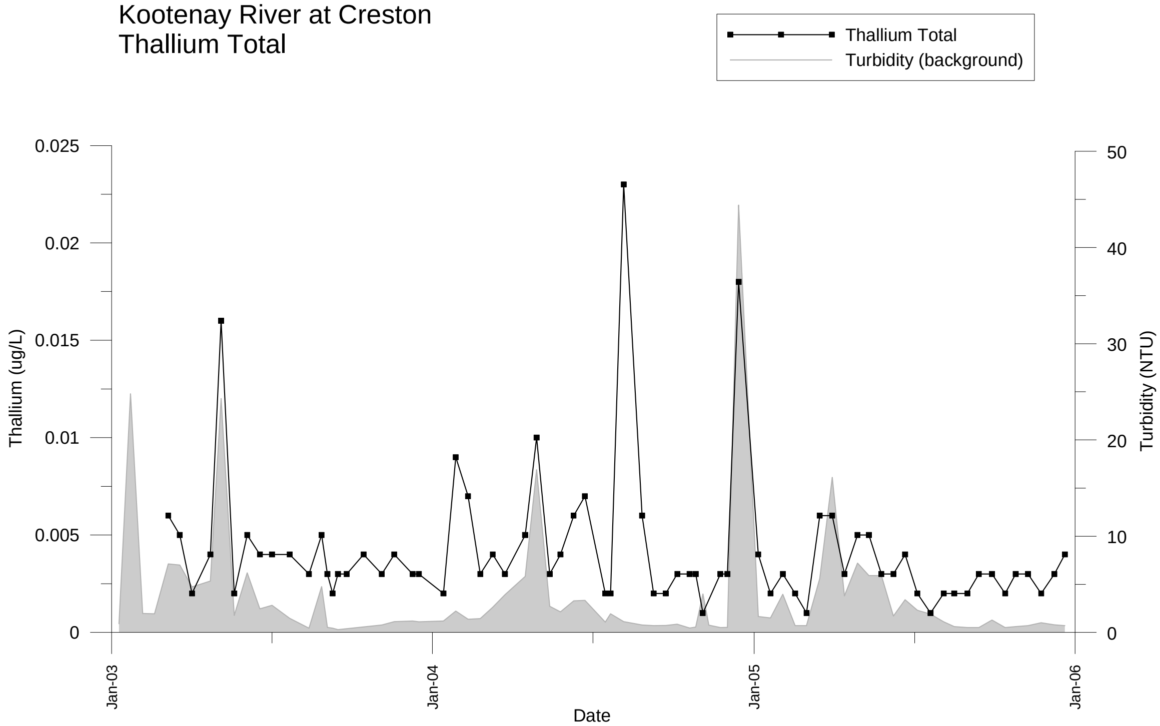
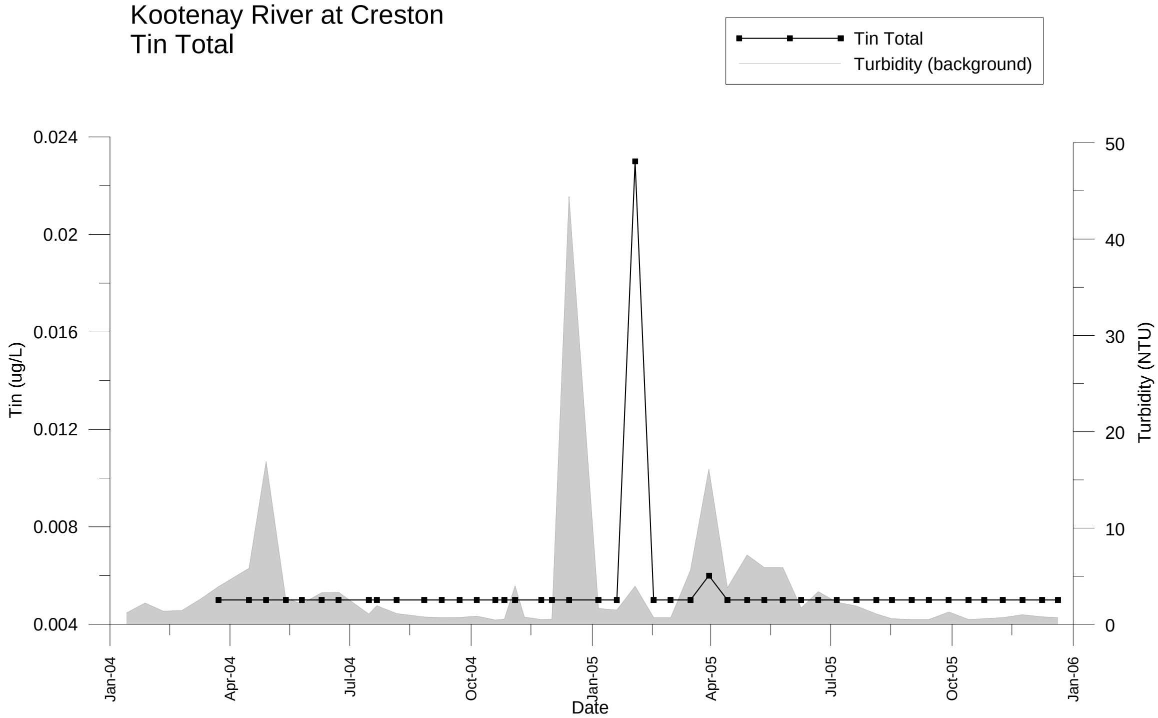


Figure 65
Kootenay River at Creston
Tin Total



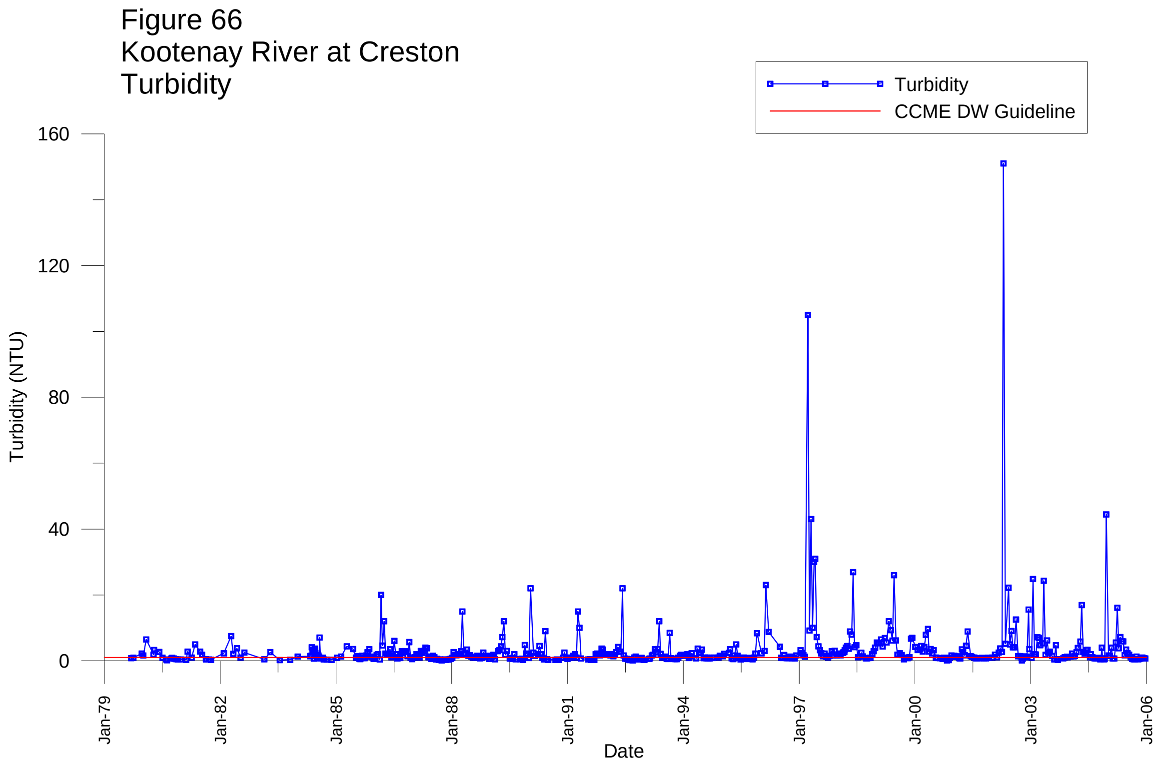


Figure 66
Kootenay River at Creston
Turbidity
Turbidity
CCME DW Guideline
Turbidity (NTU)
160
120
80
40
0
Jan-79
Jan-82
Jan-85
Jan-88
Jan-91
Jan-94
Jan-97
Jan-00
Jan-03
Jan-06
Date

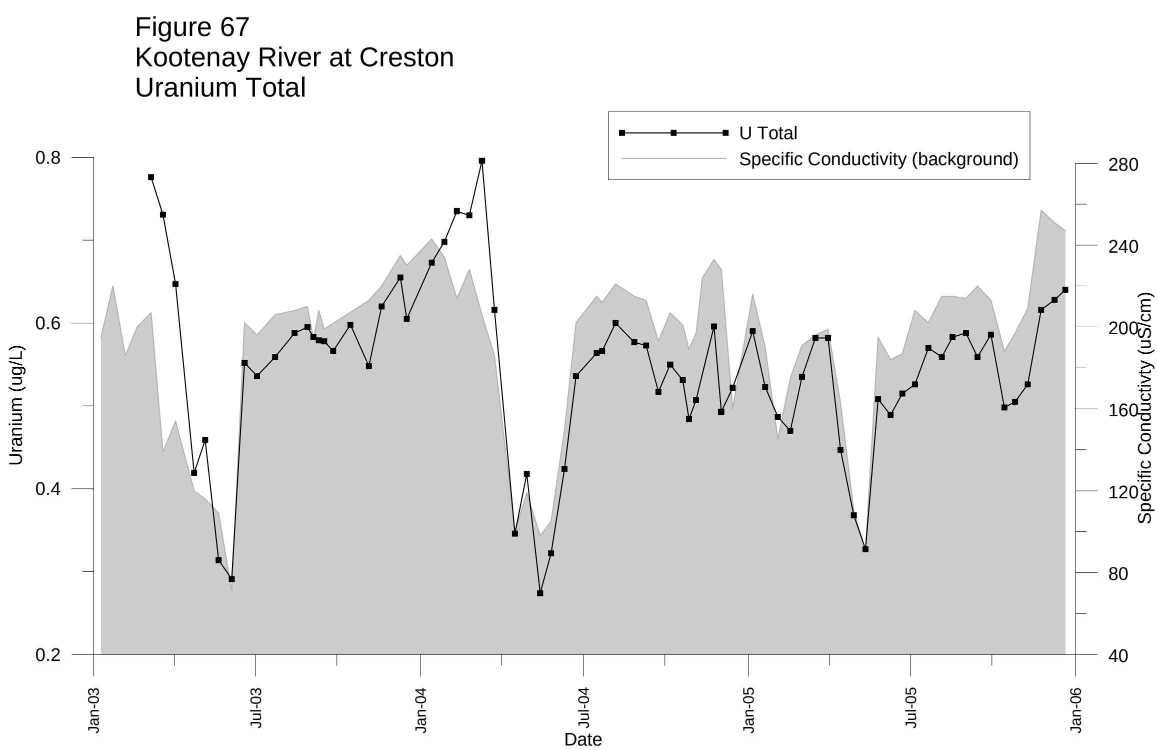


Figure 67
Kootenay River at Creston
Uranium Total
U Total
Specific Conductivity (background)
Uranium (ug/L)
0.8
0.6
0.4
0.2
Specific Conductivty (uS/cm)
280
240
200
160
120
80
40
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Date

Figure 68
Kootenay River at Creston
Vanadium Total

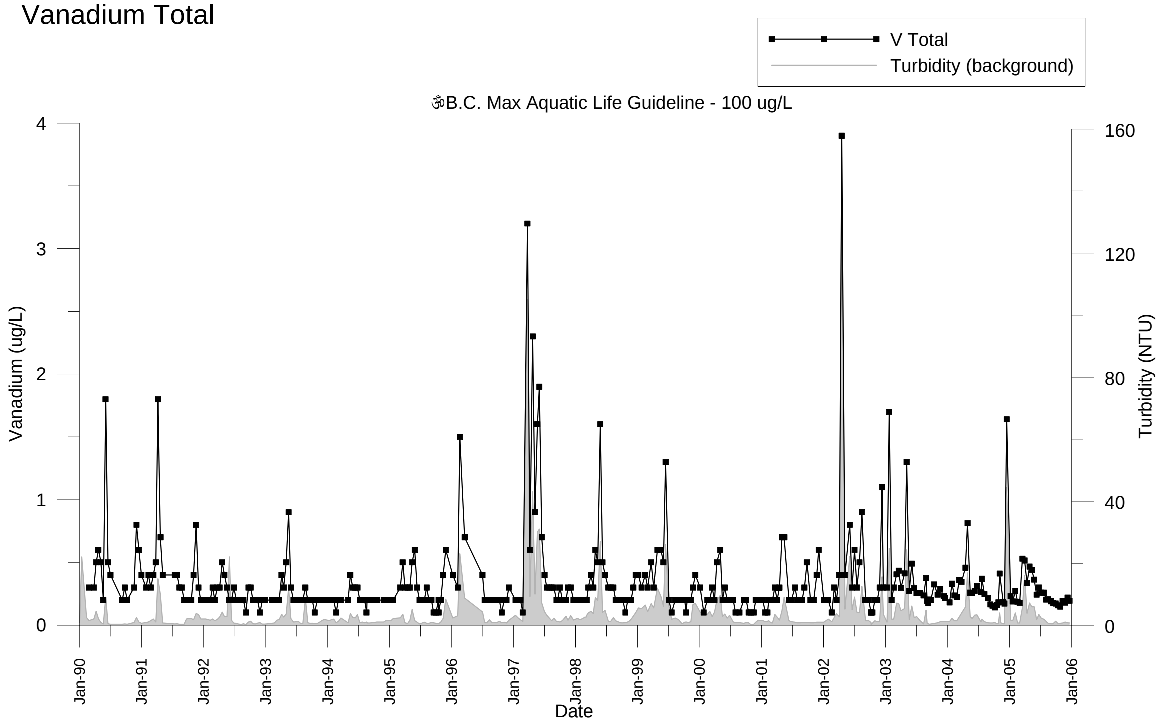


Figure 69
Kootenay River at Creston
Zinc Total and Extractable