CANADA – BRITISH COLUMBIA
WATER QUALITY MONITORING AGREEMENT

WATER QUALITY ASSESSMENT OF Columbia River AT BIRCHBANK (1983 – 2005)

Prepared by:

Tri-Star Environmental Consulting

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

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British Columbia – The Best Place on Earth – Ministry of Environment

EXECUTIVE SUMMARY

The Columbia River watershed is located in the southeast corner of British Columbia. Water quality measurements for the Columbia River at Birchbank are from samples collected 10 km upstream from Trail, B.C.. The drainage area at this point is 102,852 km^2, with the Rocky Mountains to the east and the Purcell Mountains to the west. The river flows in the Rocky Mountain Trench and is used for drinking water, irrigation and industry and supports populations of cutthroat, rainbow, bull, and eastern trout and whitefish. Cirque glaciers in the high Purcell and Rocky mountains drain to the Columbia River and the glacial silt imparts a gray, muddy colour to the river at times. This is alleviated by the time the water reaches Birchbank due to the settling provided behind the reservoirs created for electricity generation.

The main influences on water quality at the Birchbank site include the Hugh Keenleyside, Mica and Revelstoke dams on the Columbia River upstream from Castlegar and the Libby and Brilliant dams on the Kootenay River. The pulp mill at Castlegar and treated municipal wastewater discharges from the Nelson-Castlegar area may also affect water quality. There are also non-point source discharges from agriculture, urban development, forestry, transportation and stream bank erosion.

CONCLUSIONS

- Several metals that exceeded guidelines on occasion had higher concentrations that correlated with high turbidity levels. At those times, metals were likely in particulate form and not biologically available. Such metals included aluminum, cadmium, chromium, copper, iron, and lead. It should be noted that data for a number of metals (copper, chromium, lead, nickel, zinc) prior to 1991 are questionable due to potential contamination from preservative vials in use at the time. These are included on the graphs for completeness, but where contamination exists it is readily apparent.
- There appear to be a number of declining trends through time in the Columbia River at Birchbank for aluminum, iron, phosphorus and lanthanum. The trends for

aluminum, iron and phosphorus had been noted in an earlier report (Holms and Pommen, 1999), and possibly attributed in part to the sediment trapping effect of upstream dams and reservoirs; another potential reason cited for the decrease in phosphorus was waste abatement. The reasons for the apparent trend in lanthanum are not known at this time. There are also possible increasing trends for dissolved sulphate and total dissolved nitrogen. This latter trend is likely due to known filtration contamination in the laboratory beginning around 2004. All of the other possible trends noted above require statistical testing to confirm these visual assessments.

- Water quality in the Columbia River at Birchbank would be characterized as being good for both the protection of aquatic life and source waters used for drinking. This is likely due in large part to the settling out of particulate matter behind the upstream dams. There are relatively low fecal coliform levels and disinfection of all surface waters is required in British Columbia.

RECOMMENDATIONS

We recommend monitoring be continued for the Columbia River at Birchbank since it serves as an upstream control station for the Columbia River at Waneta which is just above the International Boundary.

Water quality indicators that are important for future monitoring are:

- flow, water temperature, specific conductivity, pH, turbidity, nutrients, total gas pressure and dissolved oxygen,
- 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 Andrea Ryan of Environment Canada. We thank these individuals for their contributions to improving this document. Any errors or omissions are the responsibility of Tri-Star Environmental Consulting.

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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.

The Columbia River watershed is located in the southeast corner of British Columbia. Water quality measurements for the Columbia River at Birchbank are from samples collected 10 km upstream from Trail, B.C. at the Water Survey of Canada site Its (coordinates are 49.177 N and 117.72" W). The drainage area at this point is 102,852 km^2, with the Rocky Mountains to the east and the Purcell Mountains to the west. The river flows in the Rocky Mountain Trench and is used for drinking water, irrigation and industry and supports populations of cutthroat, rainbow, bull, and eastern trout and whitefish. Cirque glaciers in the high Purcell and Rocky mountains drain to the Columbia River and the glacial silt imparts a gray, muddy colour to the river at times. This is alleviated by the time the water reaches Birchbank due to the settling provided behind the reservoirs for electricity generation.

This assessment is based on up to 22 years of water quality data collected during 1983-2005. The data were plotted on a graph over time, along with the relevant water quality 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 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 main influences on water quality include the Hugh Keenleyside, Mica and Revelstoke dams on the Columbia River upstream from Castlegar and the Libby and

Brilliant dams on the Kootenay River. The pulp mill at Castlegar and treated municipal wastewater discharges from the Nelson-Castlegar area may also affect water quality. There are also non-point source discharges from agriculture, urban development, forestry, transportation and stream bank erosion.

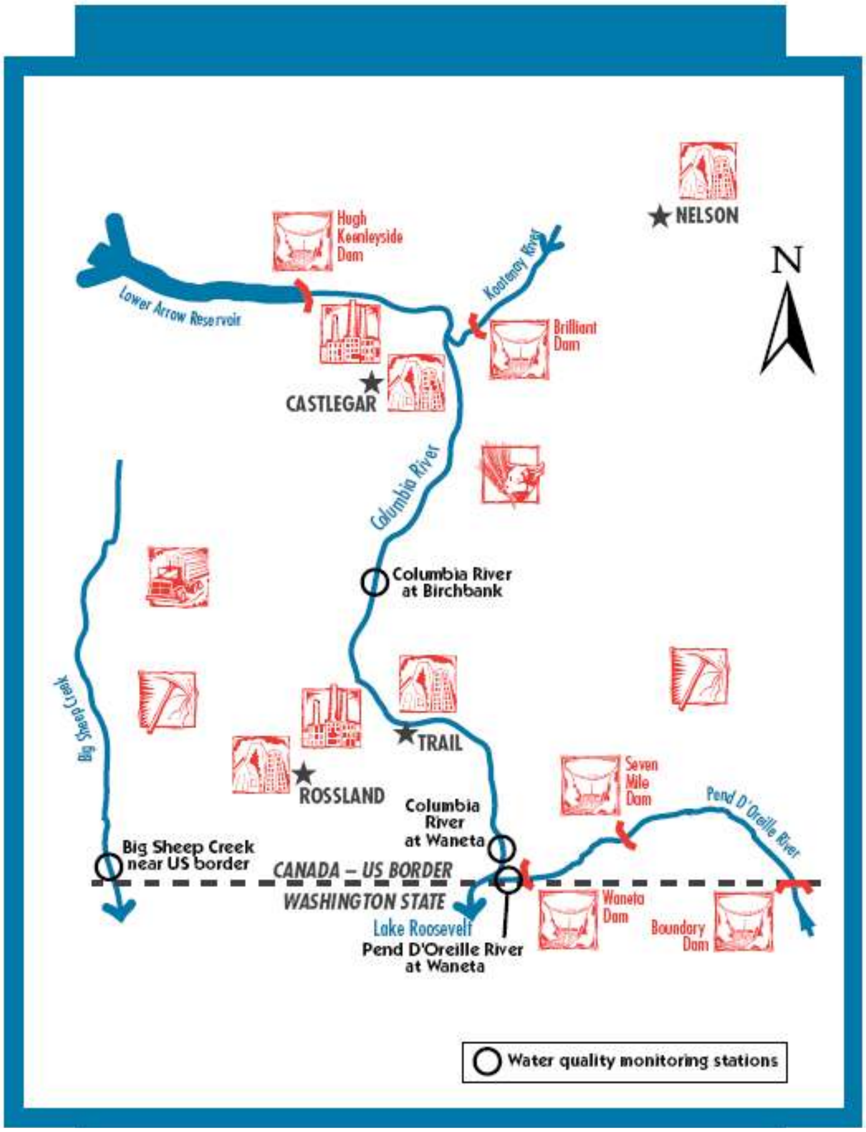


FIGURE 1: COLUMBIA RIVER AT BIRCHBANK

WATER QUALITY ASSESSMENT

Data for the Columbia River at Birchbank have been collected on a frequency of about once every two weeks. As well, once per year, two additional samples are collected in order to ensure that there is one period when weekly samples are collected during five consecutive weeks for evaluation of water quality objectives attainment. 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 for consideration of trends, and to "flag" questionable data in the database (www.waterquality.ec.gc.ca) as to possible or likely errors.

The state of the water quality was assessed by comparing the values to 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 below.

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 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.

The following water quality indicators were not discussed as they met all water quality guidelines (where these exist) and showed no clearly visible trends: ammonia, bromine, apparent colour, true colour, cyanide, nitrite, total nitrogen, dissolved ortho phosphate, silver, thallium, and tin.

The following water quality indicators seemed to fluctuate through the year according to turbidity concentrations, but were assessed to be below guideline values (if available) and exhibited no other trends: arsenic, beryllium, bismuth, calcium, cobalt, gallium, lanthanum, manganese, mercury, nickel, selenium, uranium, vanadium, and zinc.

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 is to be expected. These types of indicators that were not measured above guideline values (if guidelines exist) included: antimony, barium, boron, calcium, dissolved inorganic carbon, chloride, fluoride, lithium, magnesium, molybdenum, niobium, total dissolved nitrogen, potassium, rubidium, silica, silicon, sodium, hardness, strontium, and sulphate.

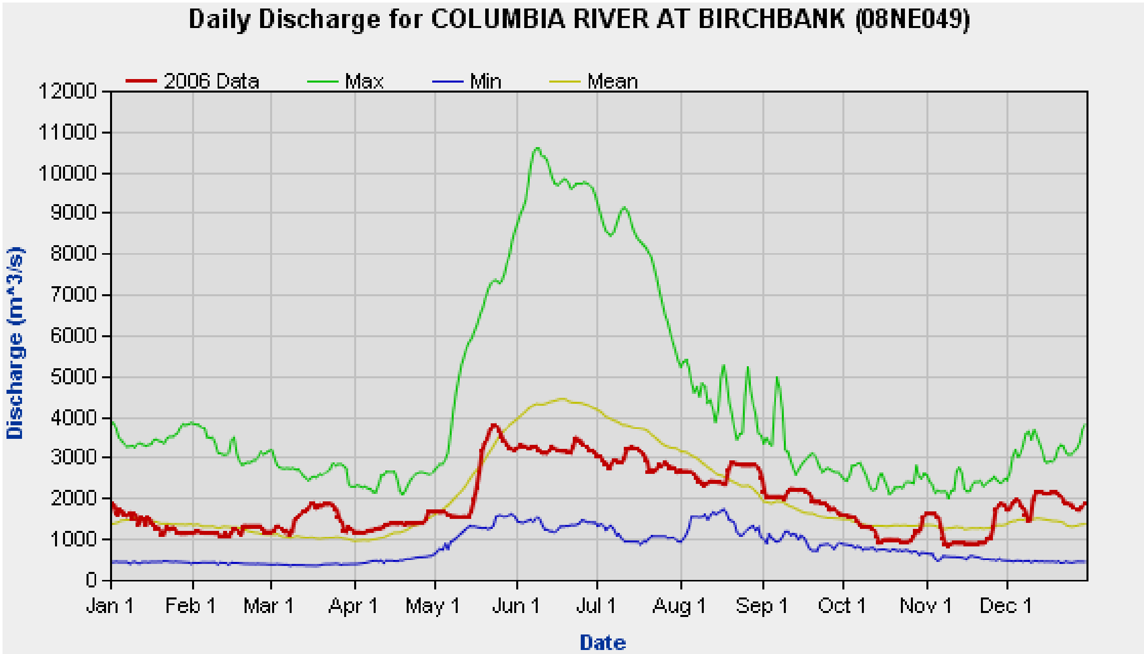


FIGURE 2: WATER SURVEY OF CANADA FLOW DATA FOR COLUMBIA RIVER AT BIRCHBANK

Flow (Figure 2) values are controlled by releases from the dams upstream. Peak flows occur during the months from May through August, with lowest flows being recorded in the November through April period. Maximum flows can exceed 4,500 m^3/s.

Alkalinity (Figure 3) fluctuates throughout the year, with highest concentrations taking place during low flow periods and lowest concentrations during times of high flow.

Aluminum (Figure 4) concentrations are related to turbidity, with highest total and extractable concentrations being measured during periods of higher turbidity. (Turbidity is generally quite low in the river.) Total and extractable concentrations occasionally exceed the guidelines to protect aquatic life; however, these guidelines are expressed as dissolved aluminum. For this reason there is likely no concern regarding aluminum levels in the river. An apparent downward trend in aluminum was noted over time. This had previously been identified and attributed at least in part to the trapping effect of upstream dams and reservoirs (Holms and Pommen, 1999).

Cadmium (figures 17 and 18) occasionally exceeded the CCME guideline for the protection of aquatic life. When this happened, turbidity levels were also higher. This means that the cadmium may have been associated with the turbidity and may not have been biologically available.

Dissolved organic carbon (Figures 21, 21(a) and 23) fluctuated with turbidity and exceeded the guideline for the protection of source waters used for drinking on one occasion since 1997. This is not considered to be a concern.

Chromium (Figures 25 – 27) (total and extractable) has not exceeded the guidelines for the protection of aquatic life (expressed in terms of Cr^{+3} and Cr^{+6}) since lower analytical detection limits were used beginning in 2003. Prior to that time, some values on occasion exceeded the Cr^{+6} guideline; however, these values are questionable since they were quite close to the detection limits.

Fecal Coliforms (Figure 30) occasionally exceeded the guideline to protect source waters used for drinking water supplies by a small amount. Concentrations appear to be correlated with turbidity levels

Copper (Figures 33 – 35) (total and extractable) has not exceeded the guidelines for the protection of aquatic life since lower analytical detection limits were used beginning in 2003. Prior to that time, some values on occasion exceeded the guideline; however, these values are questionable since they were quite close to the detection limits. Copper concentrations appear to be correlated to turbidity levels.

Iron (Figures 41 and 42) concentrations were correlated with turbidity and on occasion in the late 1980’s exceeded the guidelines to protect aquatic life and for source waters used for drinking. Since no values have exceeded guidelines since about 1990, there is no current concern regarding iron levels at the site. An apparent declining trend in iron was noted, and had been identified in a previous report (Holms and Pommen, 1999). At that time the trend was attributed potentially at least in part to the trapping effect of upstream dams.

Lanthanum (Figure 42) shows a potential declining trend in concentrations since 1996. The reason for this is not known at this time. This visually-identified trend needs to be confirmed statistically.

Individual **lead** (Figures 44 (a) to (c)) values occasionally exceeded the B.C. 30-day average concentration to protect aquatic life but this has not occurred since more sensitive analytical techniques have been used. Previous high lead concentrations were correlated with turbidity and so were likely not biologically available if the measure values were in fact accurate.

Nitrate (Figures 54 and 55) concentrations fluctuate with specific conductivity; however all values are less than guidelines.

Total Dissolved Nitrogen (Figure 58) appears to have increased in recent years. However this is likely a result of known filtration contamination in the laboratory, which originated in about 2004. These data are in the process of being flagged in the database.

pH (Figure 59) has on occasion been measured below the lower guideline limit of 6.5 units; however, this only happened in the 1980's and only dropped as low as 6.2. Some lower values (still within the acceptable range for pH) have occurred since about the year 2000. It is not believed that pH is a concern in the river.

Total Phosphorus (Figure 61) and **total dissolved phosphorus** (Figure 62) concentrations fluctuate with turbidity but all have been below the guideline for source waters used for drinking. An apparent declining trend in phosphorus can be seen. This was noted in a previous report, and potentially attributed (at least in part) to the trapping effect of upstream dams, and waste abatement (Holms and Pommen, 1999).

Dissolved Sulphate (Figure 75) may be increasing through time. This needs to be confirmed with statistical testing: it also needs to be confirmed that any changes in concentrations are not the result of changes in analytical techniques.

Water Temperature (Figure 76) occasionally exceeded the guideline for protection of streams with unknown fish species. This occurred as would be expected during the warm summer months; however, the amount above the guideline was minimal and thus not a serious concern to aquatic life.

Turbidity (Figure 81) frequently exceeded the guideline for the protection of source waters used for drinking; however, the level by which the guideline was exceeded was usually less than 2 NTU. This means that drinking water supplies using this water might have problems with providing adequate disinfection during these periods.

References

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

Ministry of Environment. 2006a. British Columbia. A Compendium of Working Water Quality Guidelines for British Columbia. Environmental Protection Division, Ministry of Environment. Victoria, B.C.

Holms, G.B, and L.W. Pommen. 2006. State of Water Quality of Columbia River at Birchbank, 1983-1997. Ministry of Environment, Lands and Parks and Environment Canada.

Figure 3
Columbia River at Birchbank
Alkalinity Total (mg/L CaCO3)

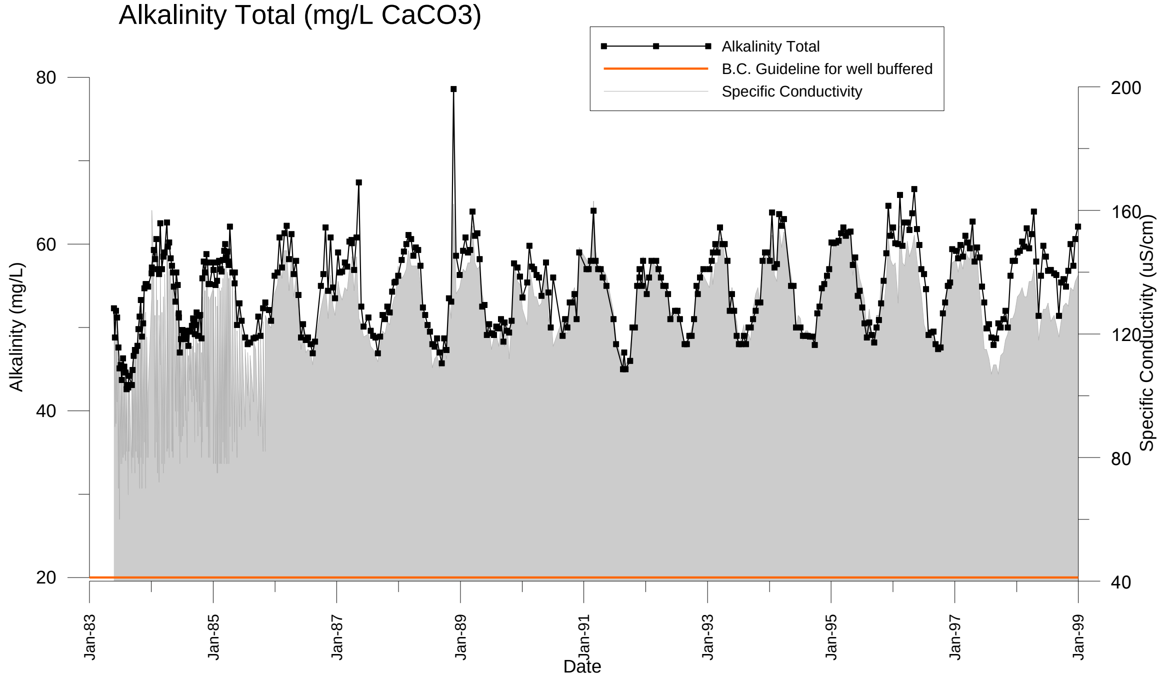


Figure 4
Columbia River at Birchbank
Aluminum (Total and Extractable)

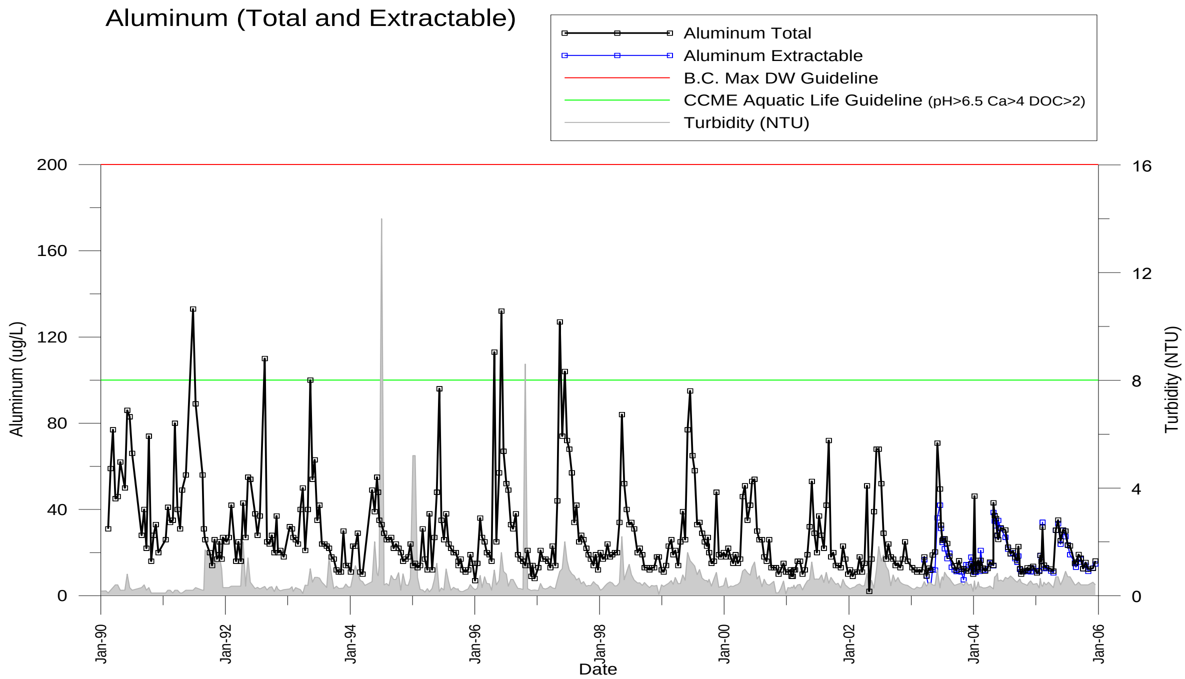


Figure 5
Columbia River at Birchbank
Ammonia Dissolved (mg/L)

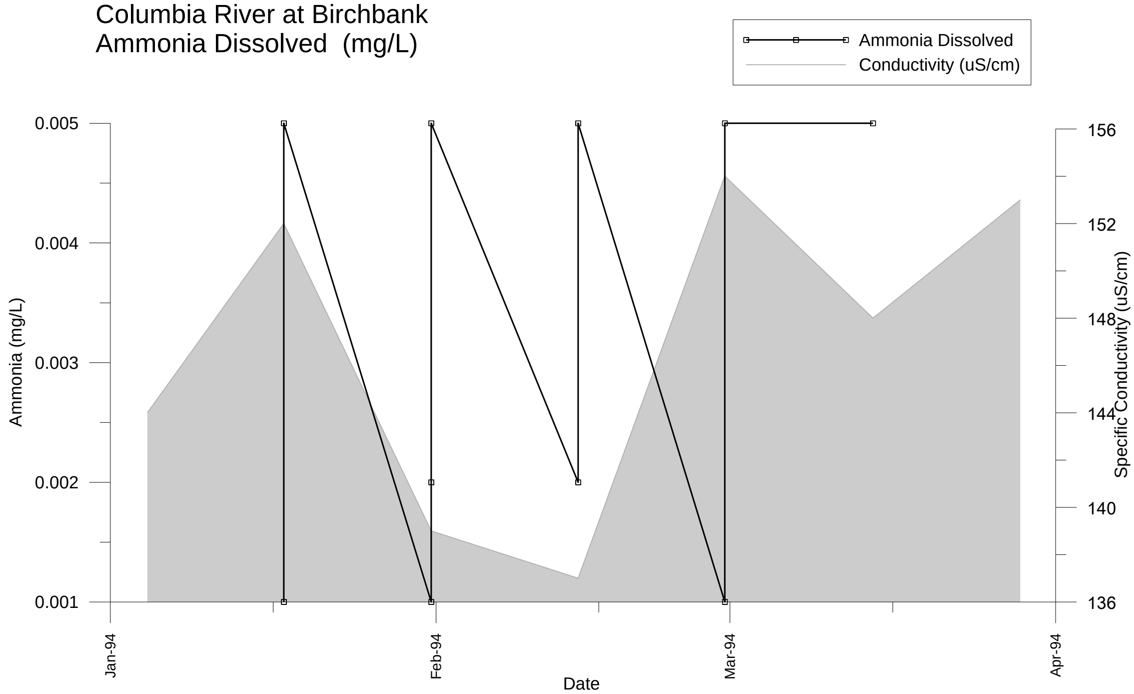


Figure 6
Columbia River at Birchbank
Antimony Total and Extractable (ug/L)

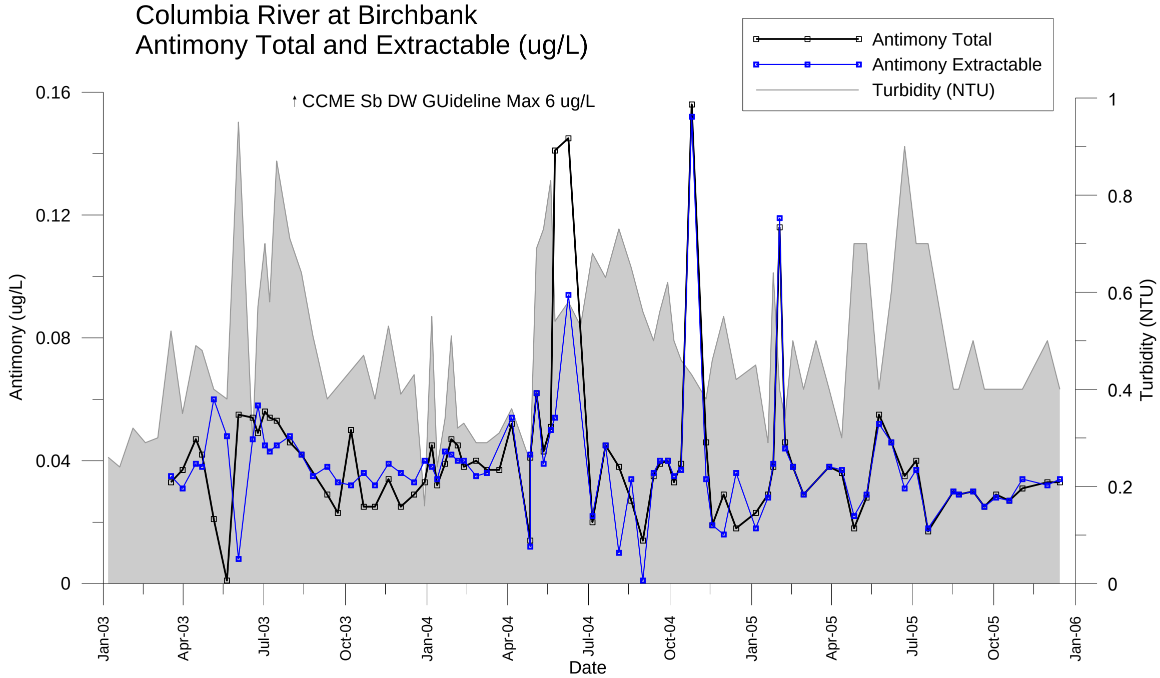


Figure 7
Columbia River at Birchbank
Arsenic Total and Extractable (ug/L)
1983 - 2005

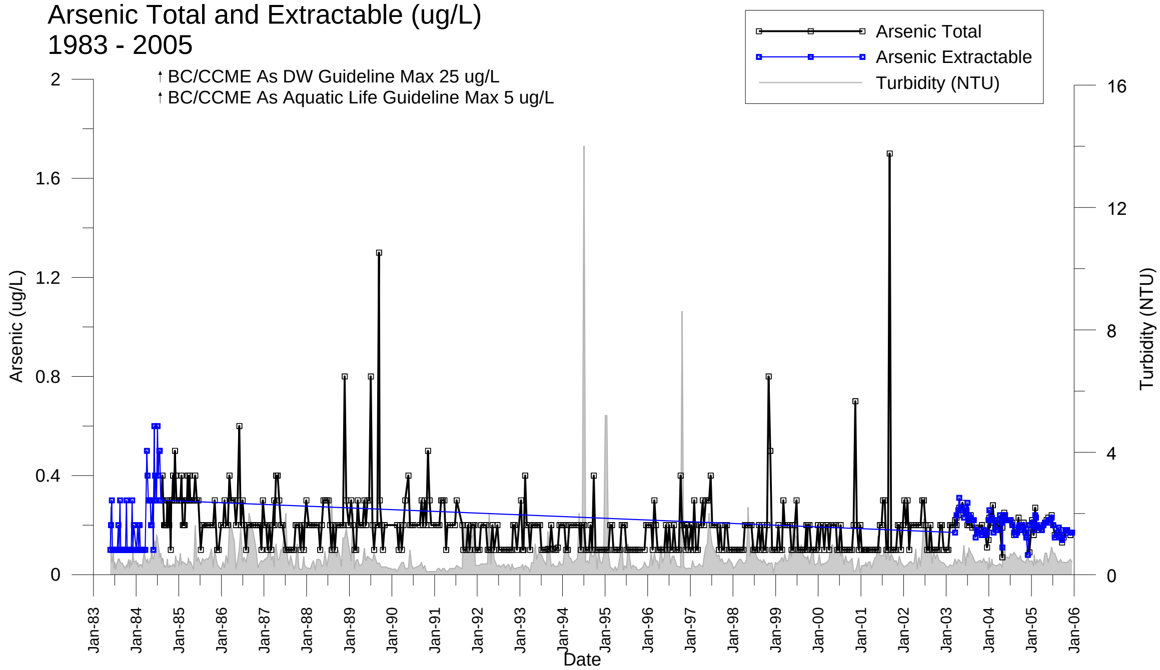
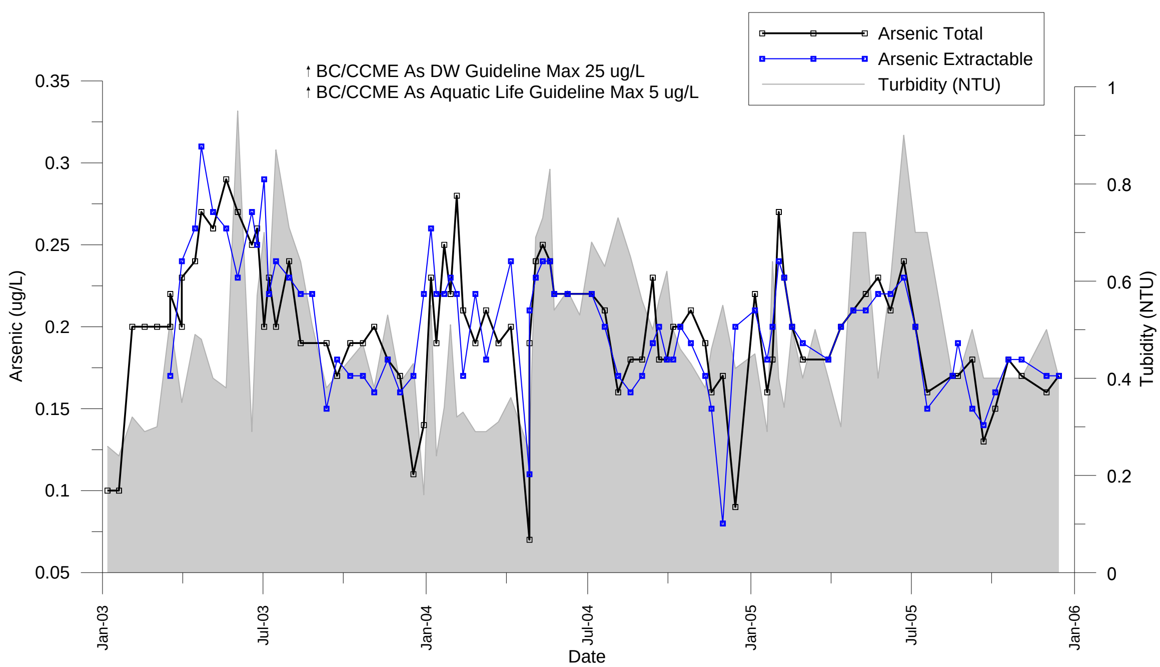


Figure 8
Columbia River at Birchbank
Arsenic Total and Extractable (ug/L)
2003-2005



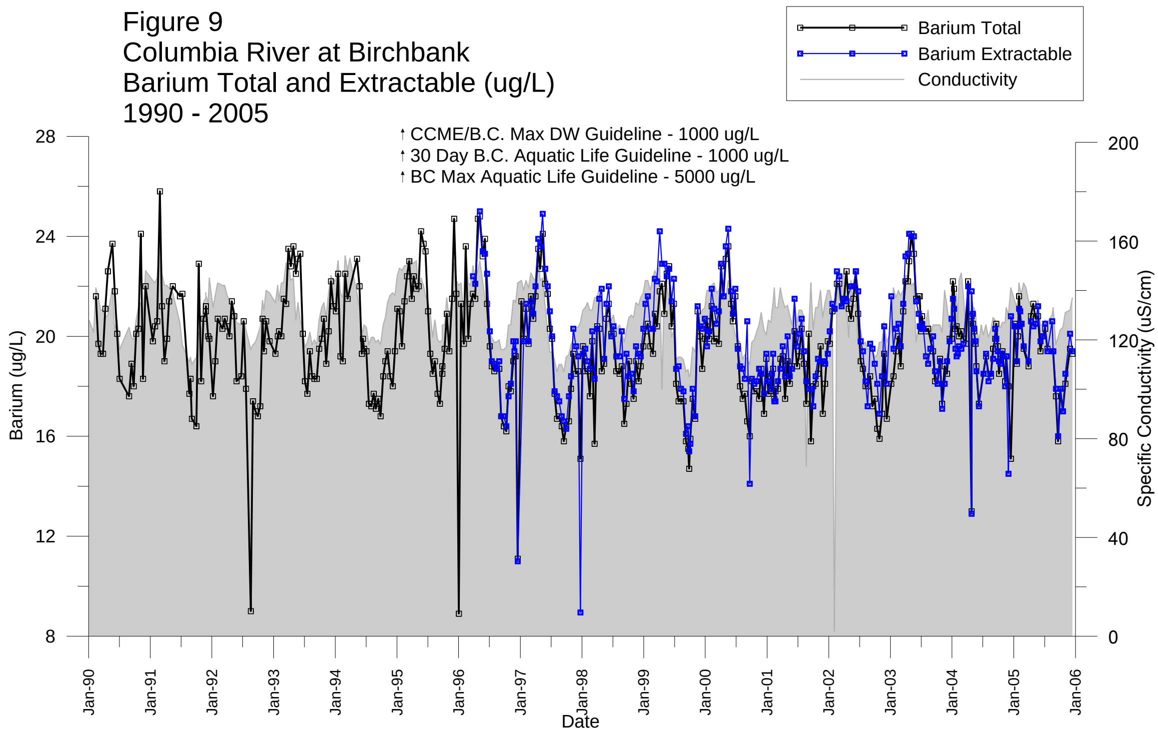


Figure 9
Columbia River at Birchbank
Barium Total and Extractable (ug/L)
1990 - 2005
Barium Total
Barium Extractable
Conductivity
↑ CCME/B.C. Max DW Guideline - 1000 ug/L
↑ 30 Day B.C. Aquatic Life Guideline - 1000 ug/L
↑ BC Max Aquatic Life Guideline - 5000 ug/L
Barium (ug/L)
Specific Conductivity (uS/cm)
Date

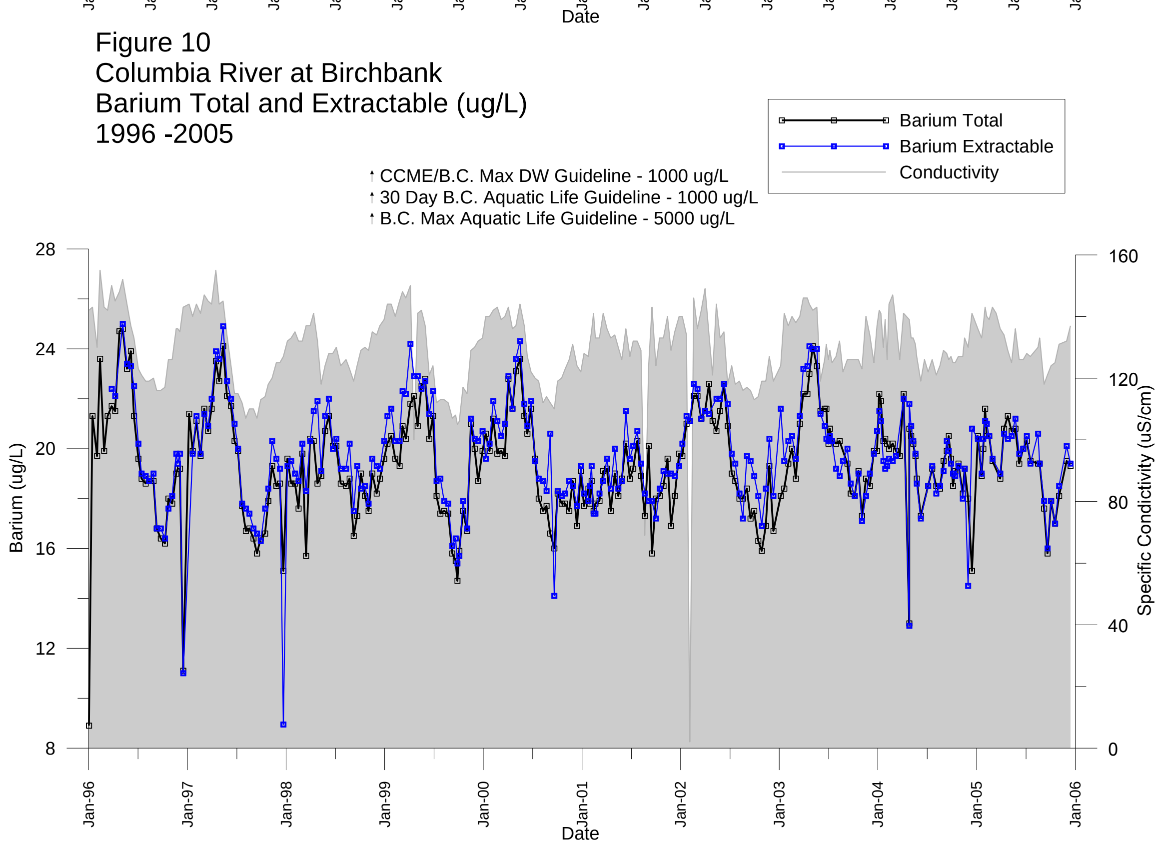
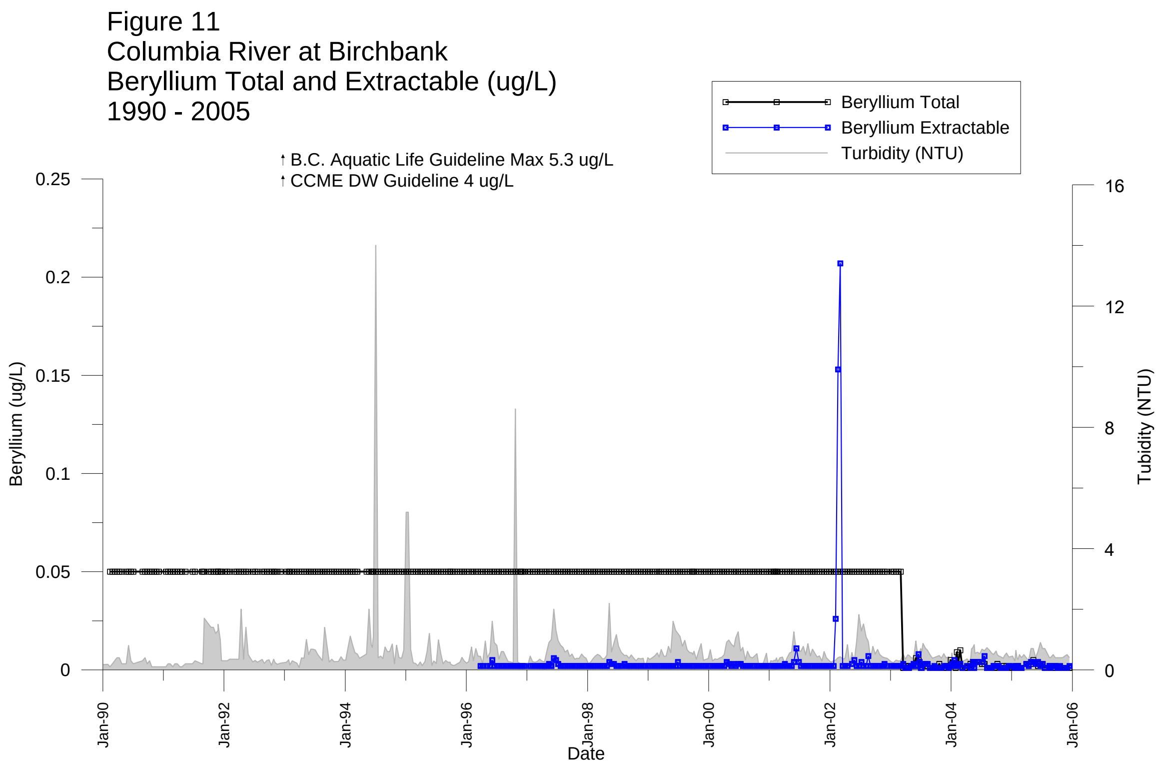


Figure 10
Columbia River at Birchbank
Barium Total and Extractable (ug/L)
1996 -2005
Barium Total
Barium Extractable
Conductivity
↑ CCME/B.C. Max DW Guideline - 1000 ug/L
↑ 30 Day B.C. Aquatic Life Guideline - 1000 ug/L
↑ B.C. Max Aquatic Life Guideline - 5000 ug/L
Barium (ug/L)
Specific Condictivity (uS/cm)
Date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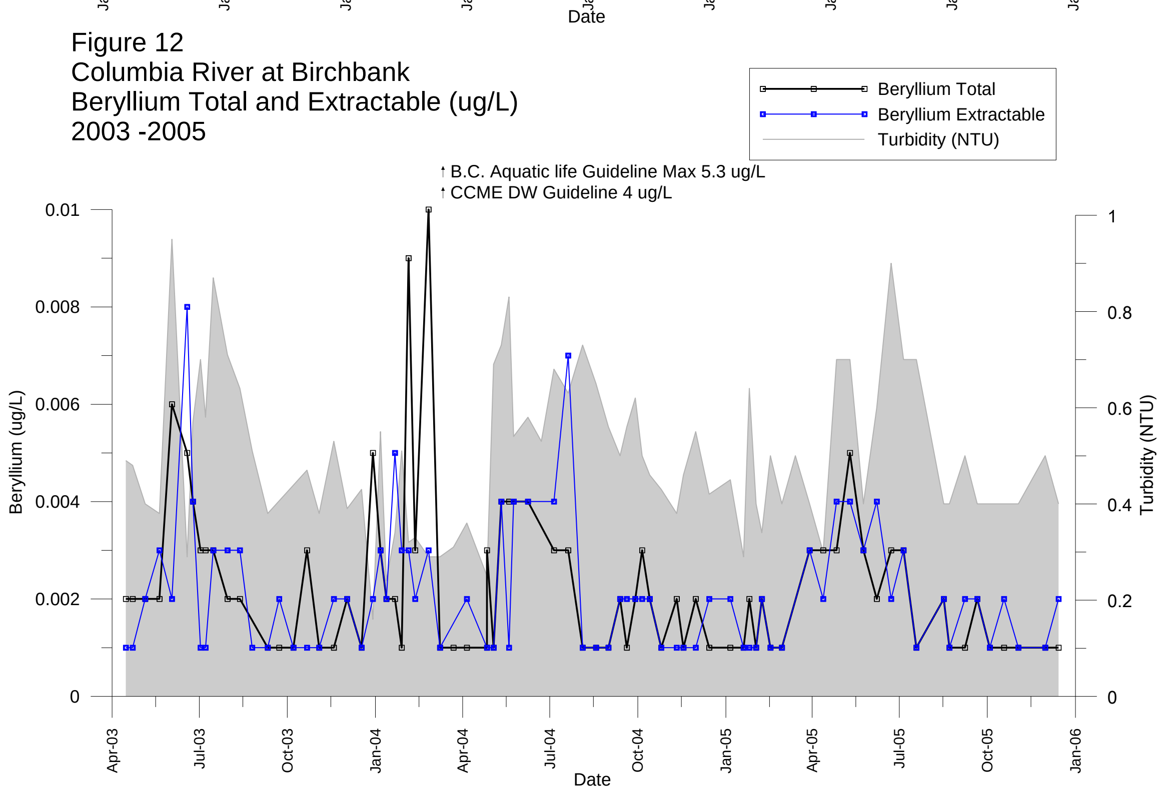
Columbia River at Birchbank
Beryllium Total and Extractable (ug/L)
1990 - 2005
Beryllium Total
Beryllium Extractable
Turbidity (NTU)
B.C. Aquatic Life Guideline Max 5.3 ug/L
CCME DW Guideline 4 ug/L
Beryllium (ug/L)
Turbidity (NTU)
Date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Columbia River at Birchbank
Beryllium Total and Extractable (ug/L)
2003 -2005
Beryllium Total
Beryllium Extractable
Turbidity (NTU)
B.C. Aquatic life Guideline Max 5.3 ug/L
CCME DW Guideline 4 ug/L
Beryllium (ug/L)
Turbidity (NTU)
Date

Figure 13
Columbia River at Birchbank
Bismuth Total and Extractable (ug/L)

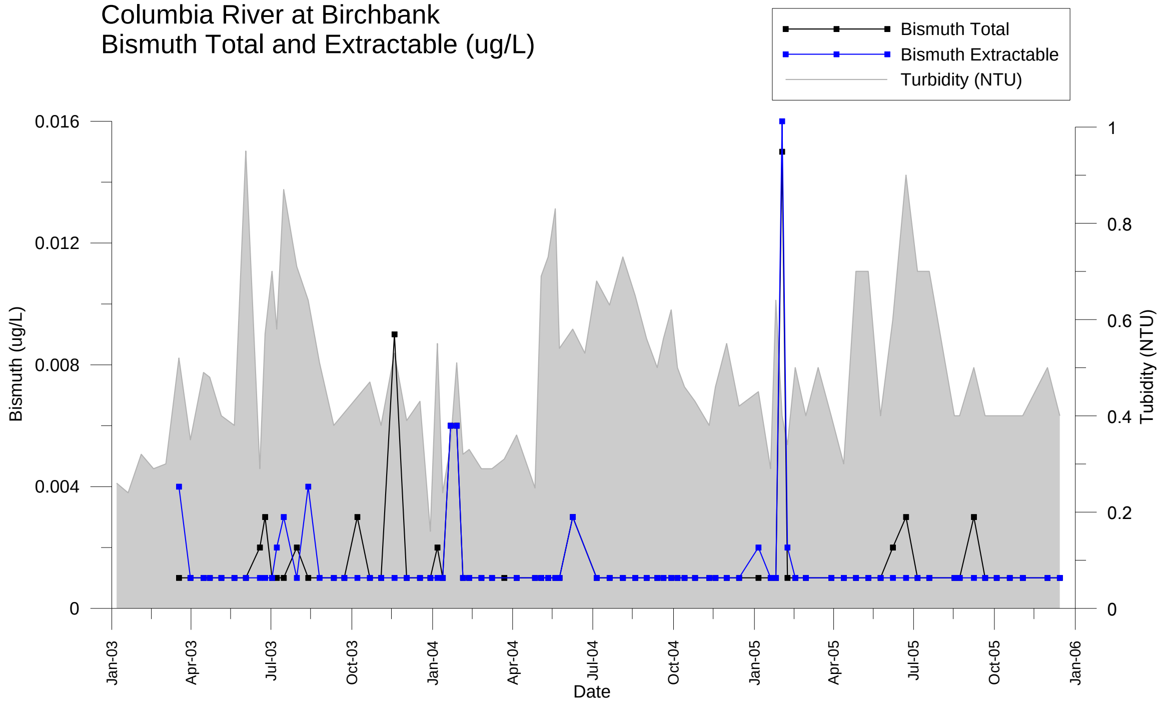

Figure 14
Columbia River at Birchbank
Boron Total and Extractable (ug/L)
1996 - 2005

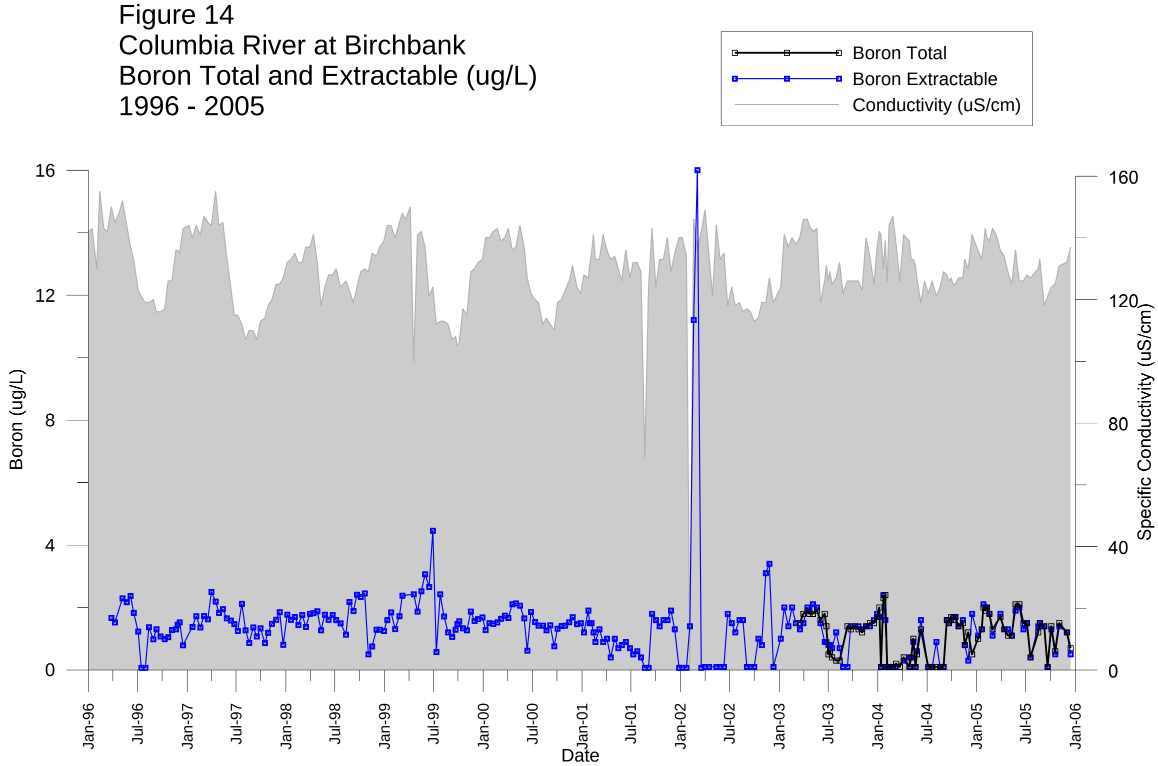

Figure 15
Columbia River at Birchbank
Boron Total and Extractable (ug/L)
2003 - 2005

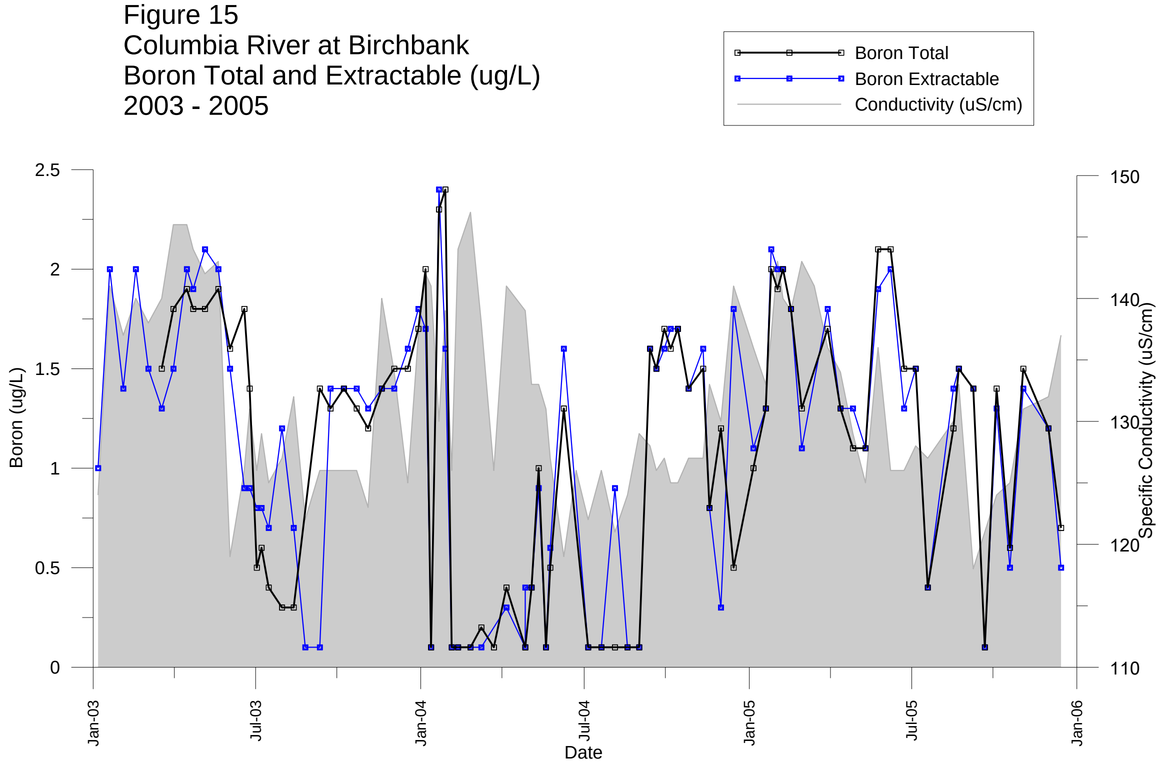

Figure 16
Columbia River at Birchbank
Bromine Dissolved (ug/L)

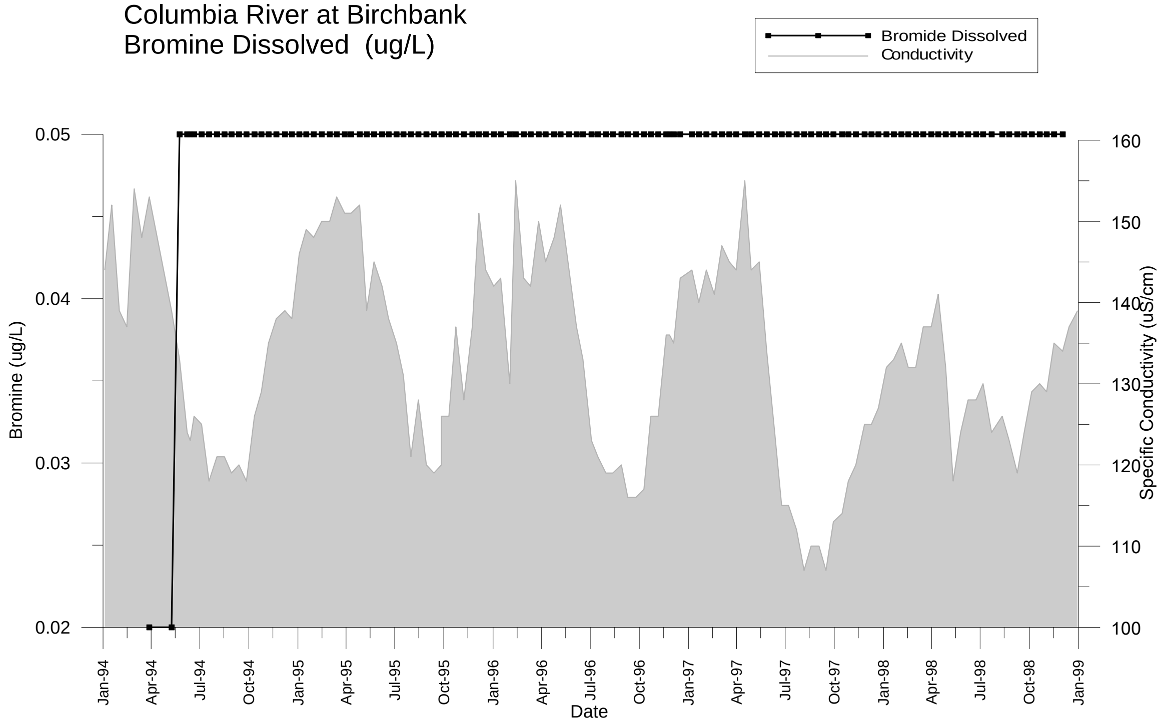

Figure 17
Columbia River at Birchbank
Cadmium Total and Extractable (ug/L)
1983 - 2005

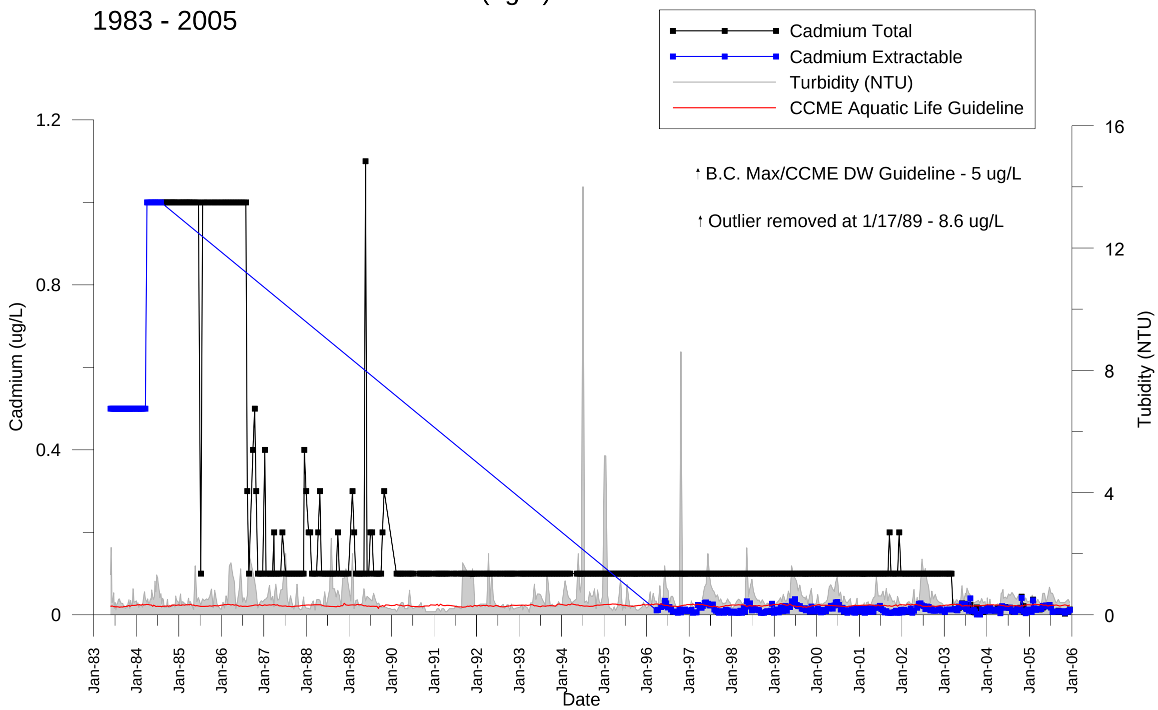

Figure 18
Columbia River at Birchbank
Cadmium Total and Extractable (ug/L)
2003 - 2005

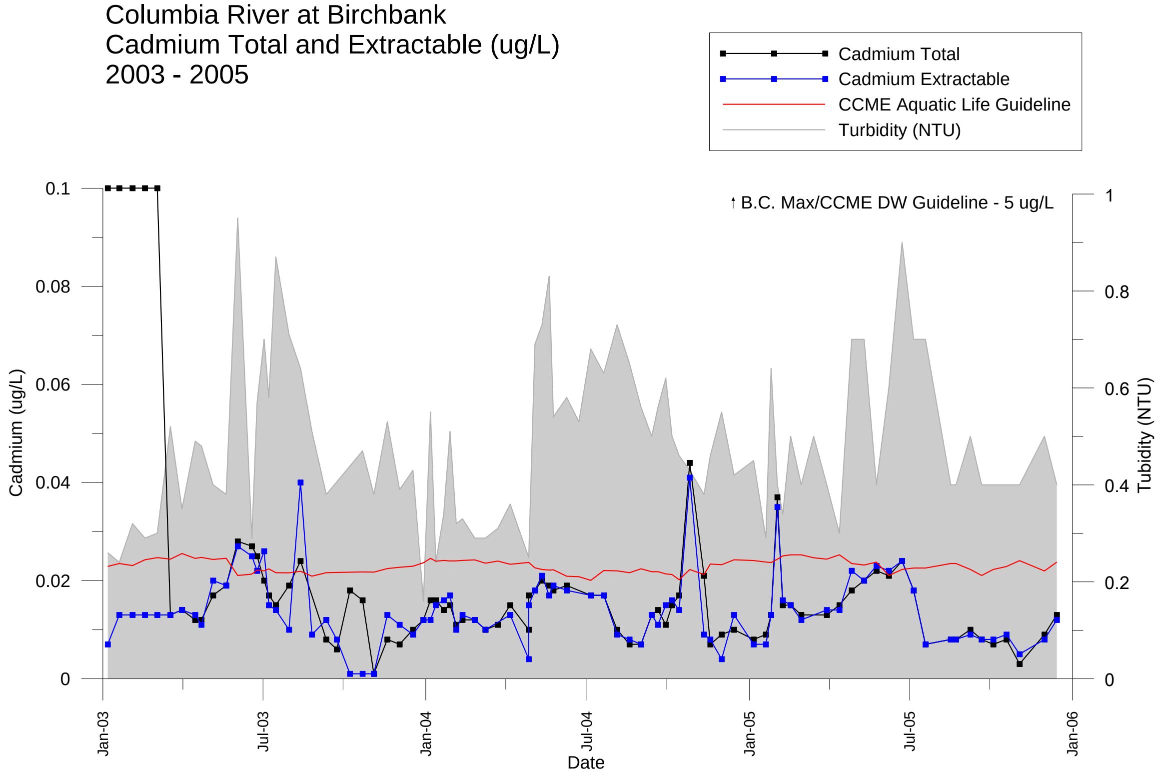

Figure 19
Columbia River at Birchbank
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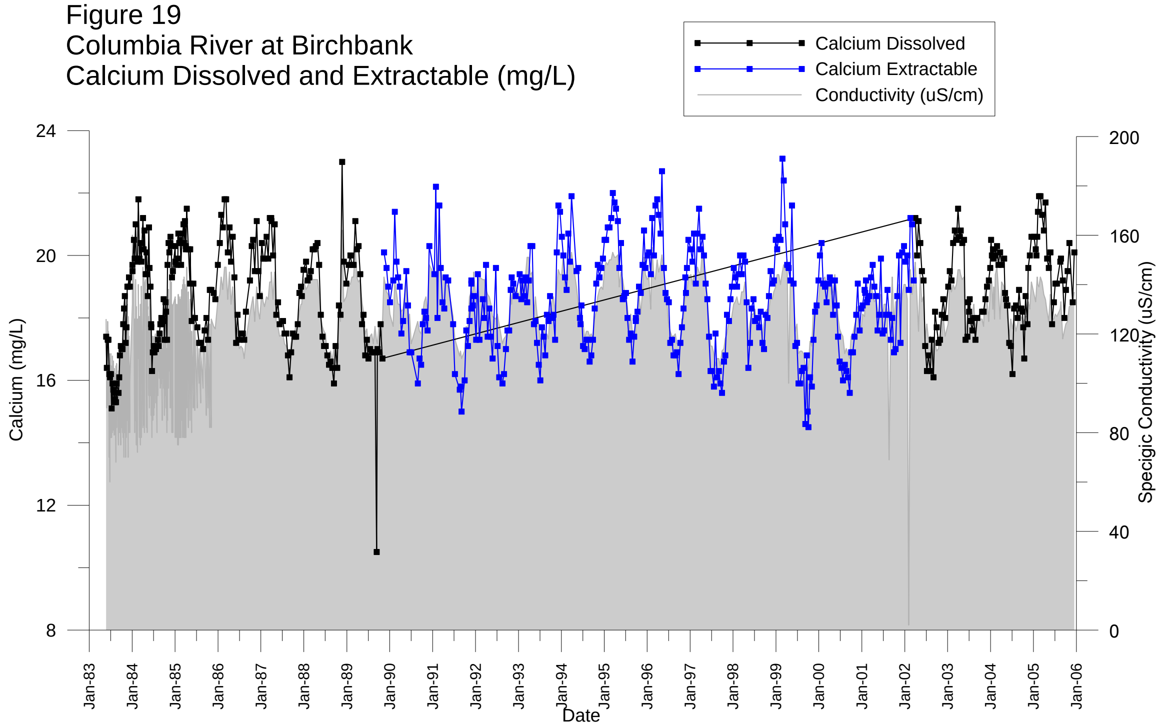


Figure 20
Columbia River at Birchbank
Carbon Dissolved Inorganic (mg/L)
1997 - 2002

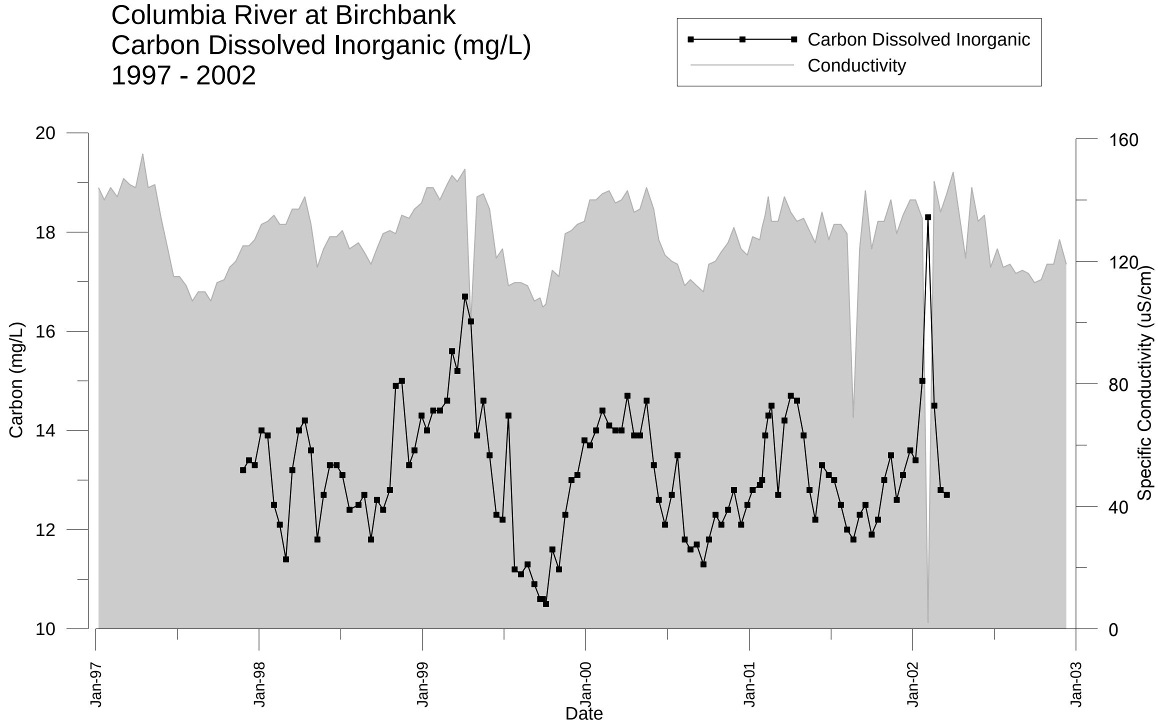


Figure 21
Columbia River at Birchbank
Carbon - Dissolved Organic and Inorganic (mg/L)

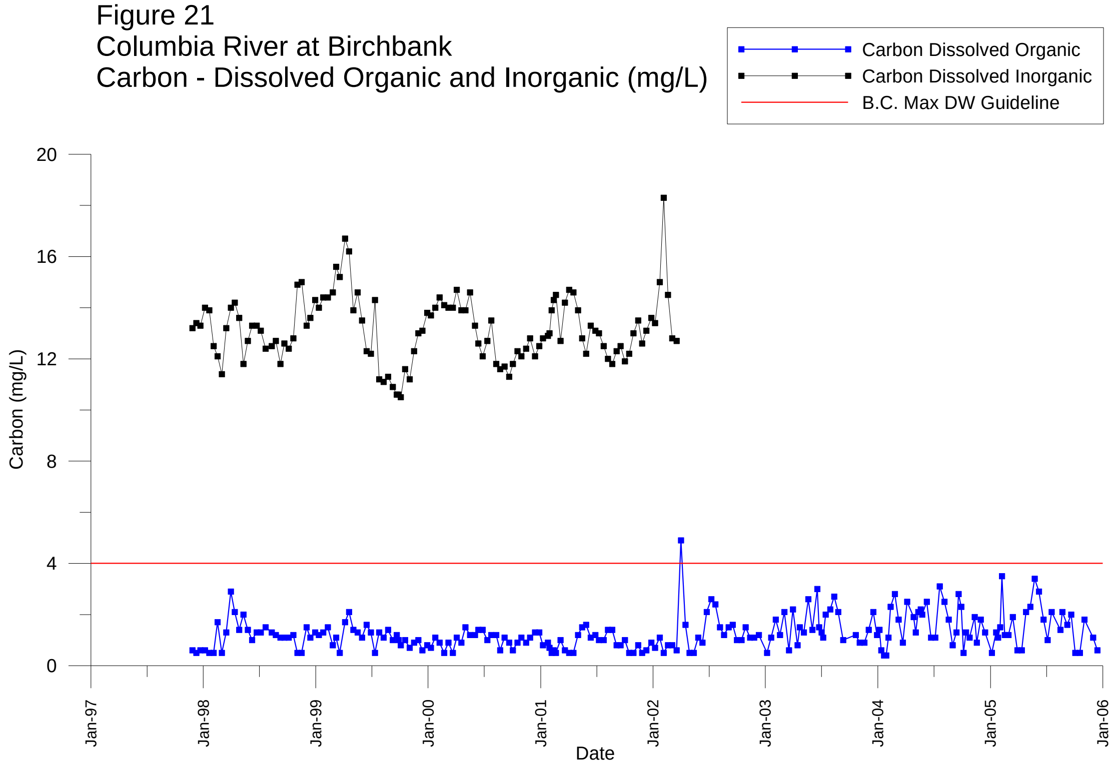


Figure 22
Columbia River at Birchbank
Carbon Total Inorganic (mg/L)

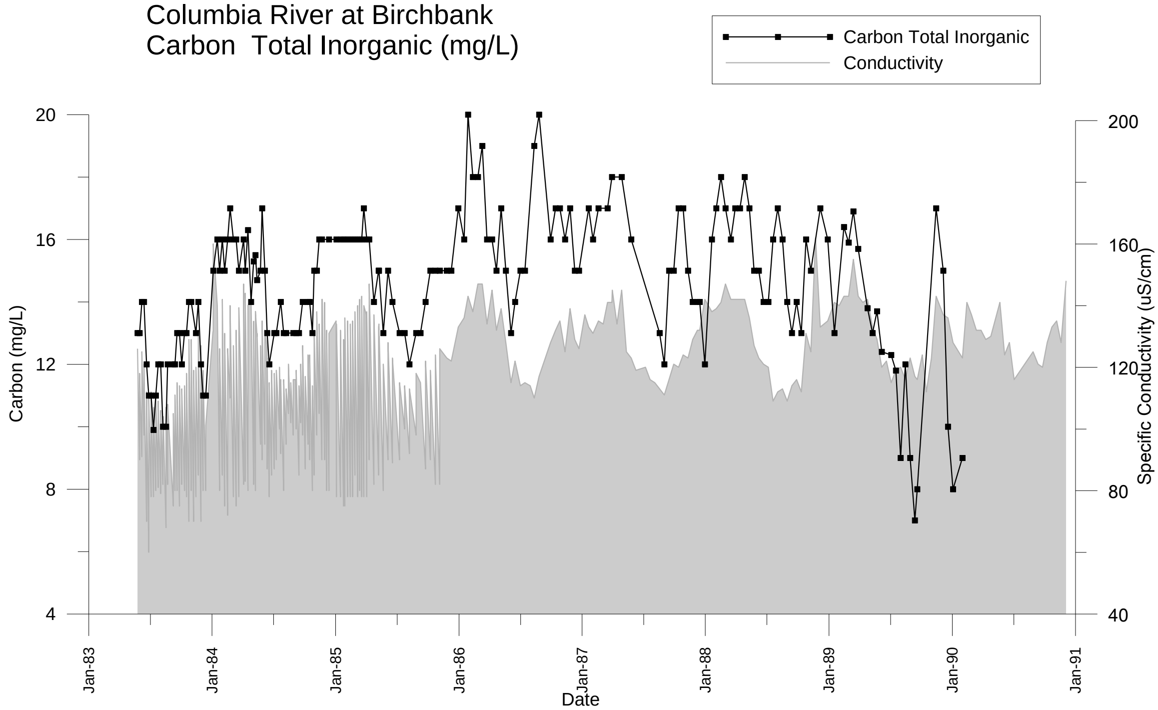


Figure 23
Columbia River at Birchbank
Carbon Total Organic (mg/L)

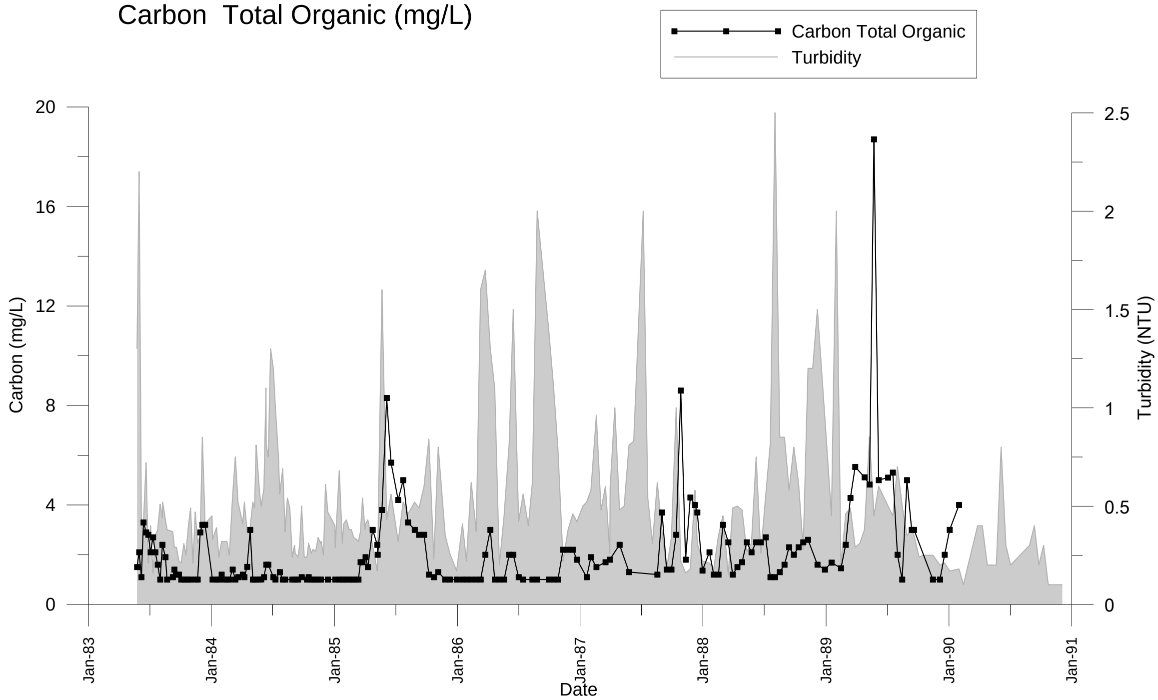
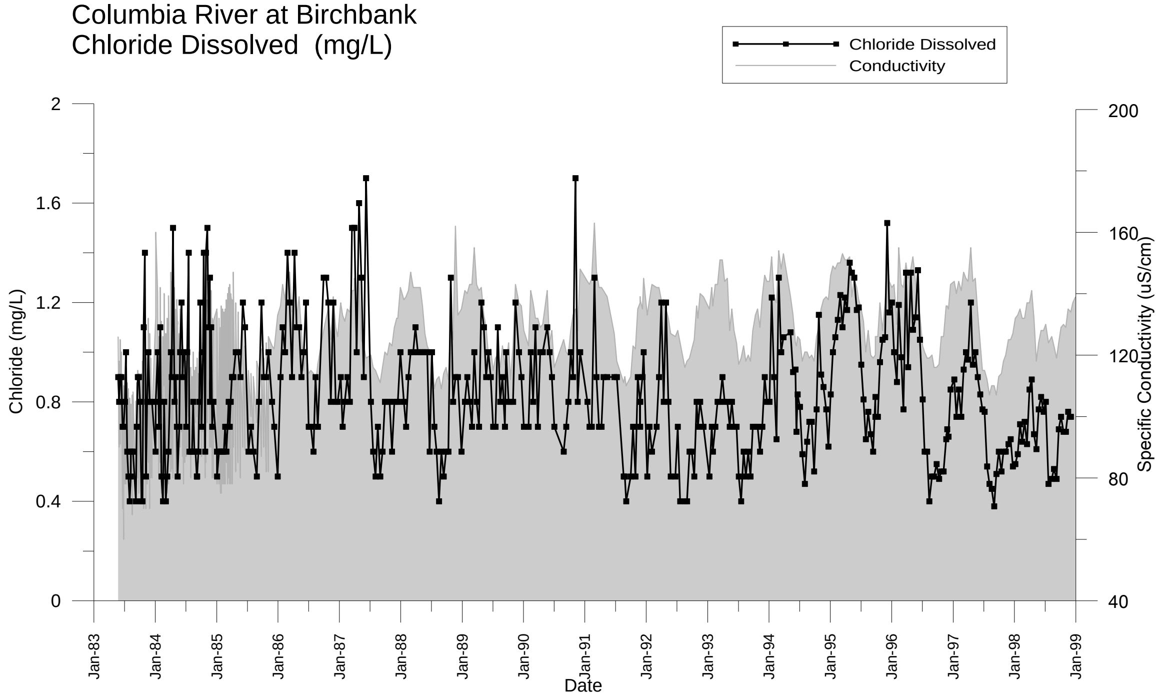


Figure 24
Columbia River at Birchbank
Chloride Dissolved (mg/L)



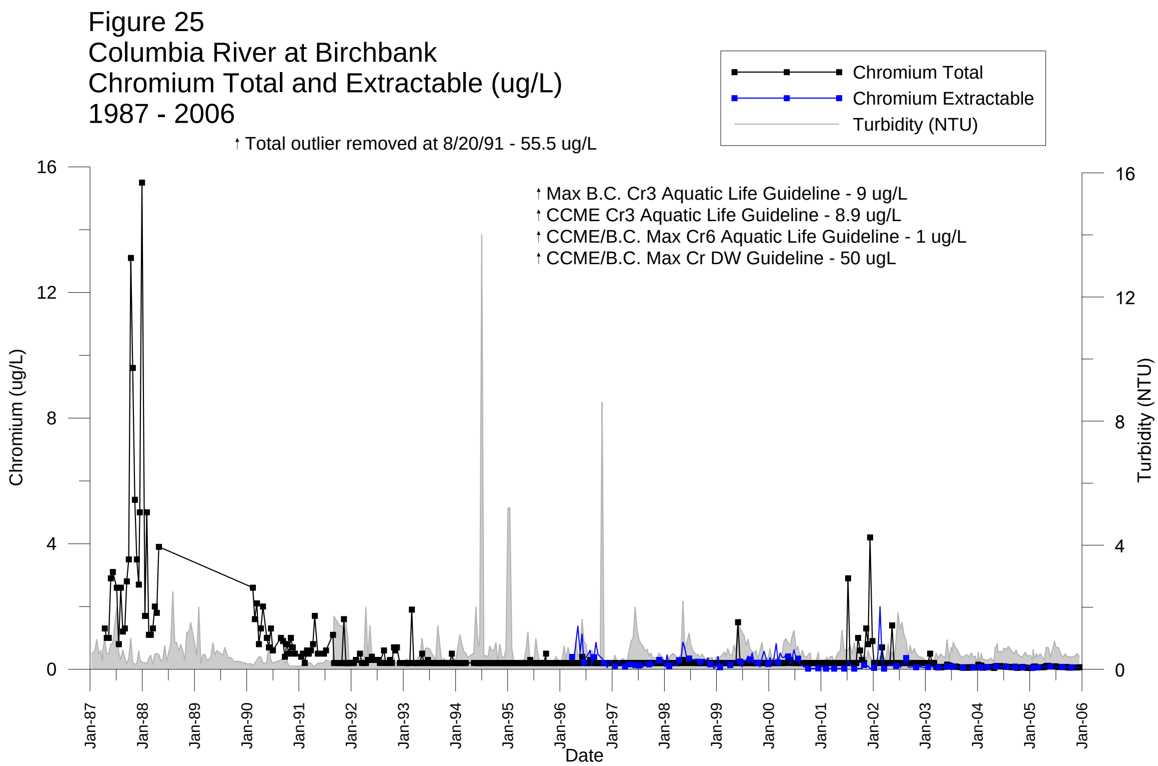


Figure 25
Columbia River at Birchbank
Chromium Total and Extractable (ug/L)
1987 - 2006
Total outlier removed at 8/20/91 - 55.5 ug/L
Chromium Total
Chromium Extractable
Turbidity (NTU)
Max B.C. Cr3 Aquatic Life Guideline - 9 ug/L
CCME Cr3 Aquatic Life Guideline - 8.9 ug/L
CCME/B.C. Max Cr6 Aquatic Life Guideline - 1 ug/L
CCME/B.C. Max Cr DW Guideline - 50 ugL
Chromium (ug/L)
Turbidity (NTU)
Date

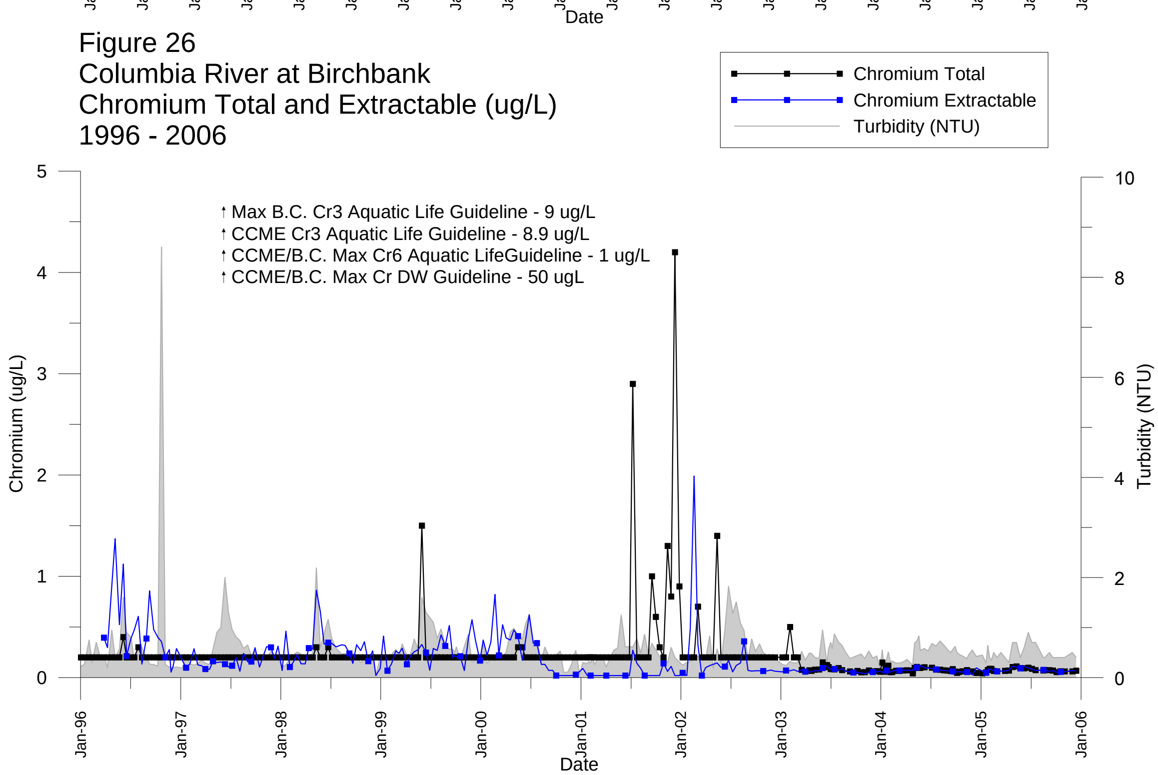


Figure 26
Columbia River at Birchbank
Chromium Total and Extractable (ug/L)
1996 - 2006
Chromium Total
Chromium Extractable
Turbidity (NTU)
Max B.C. Cr3 Aquatic Life Guideline - 9 ug/L
CCME Cr3 Aquatic Life Guideline - 8.9 ug/L
CCME/B.C. Max Cr6 Aquatic LifeGuideline - 1 ug/L
CCME/B.C. Max Cr DW Guideline - 50 ugL
Chromium (ug/L)
Turbidity (NTU)
Date

Figure 27
Columbia River at Birchbank
Chromium Total and Extractable (ug/L)
2003 - 2006

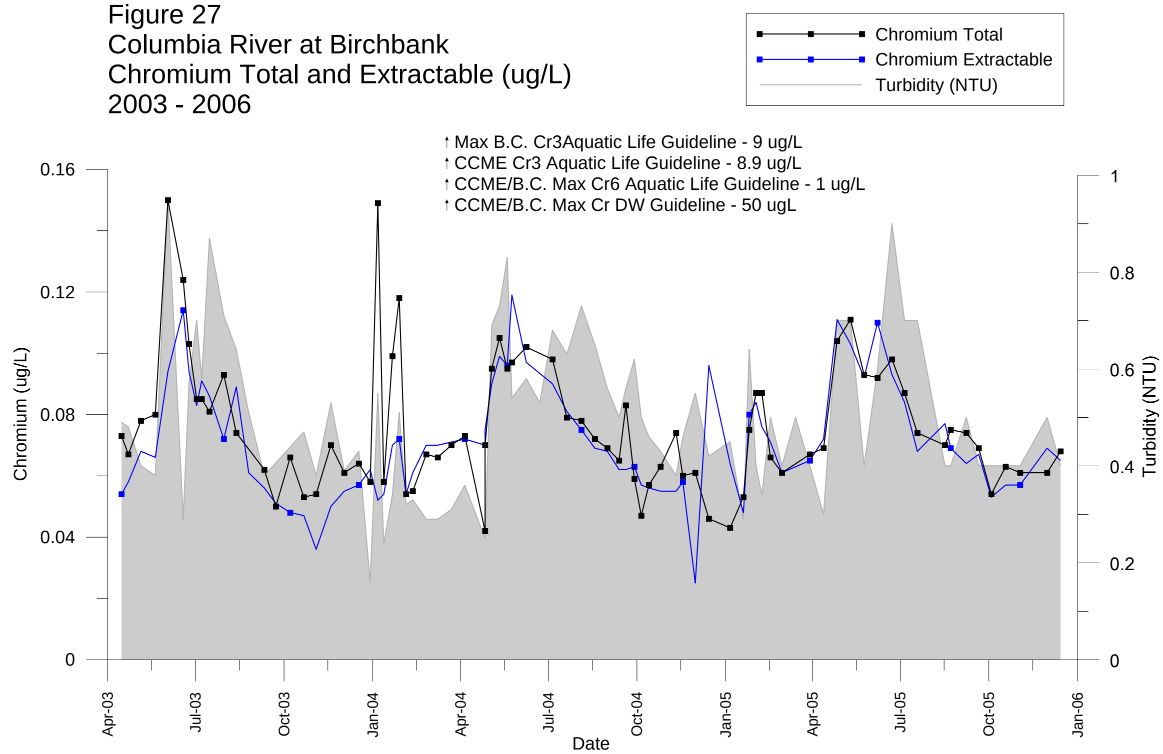


Figure 28
Columbia River at Birchbank
Cobalt Total and Extractable (ug/L)
1990 - 2005

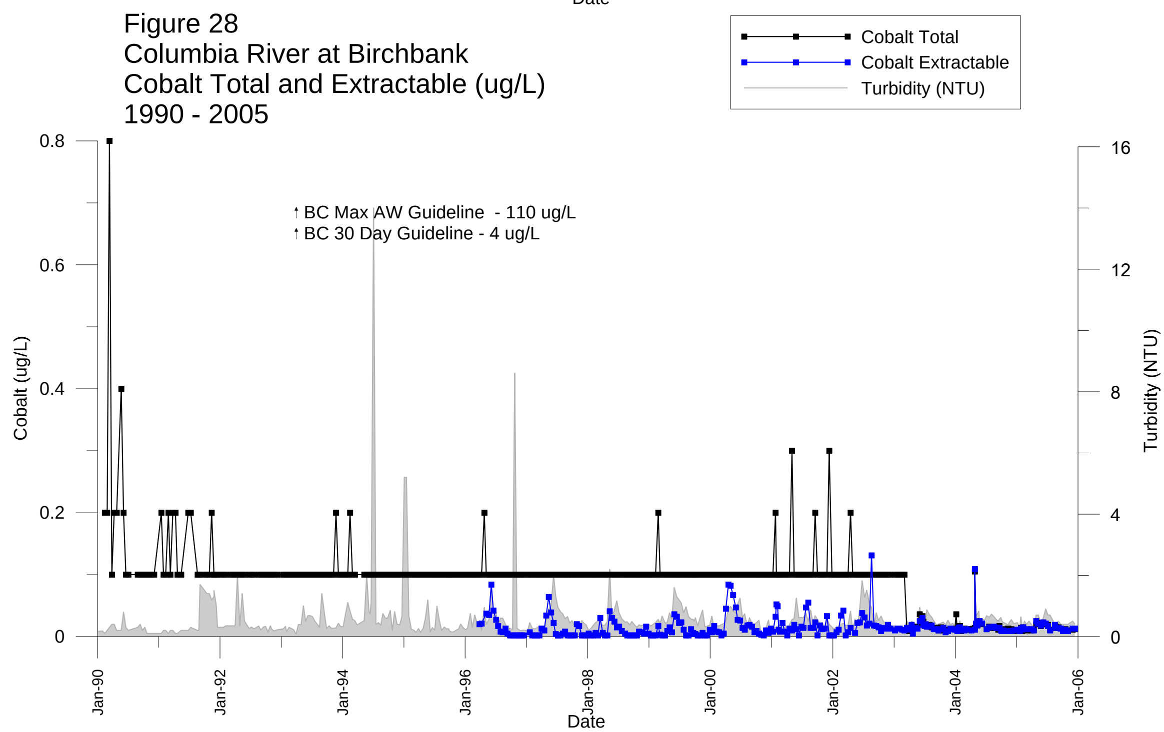


Figure 29
Columbia River at Birchbank
Cobalt Total and Extractable (ug/L)
2003 - 2005

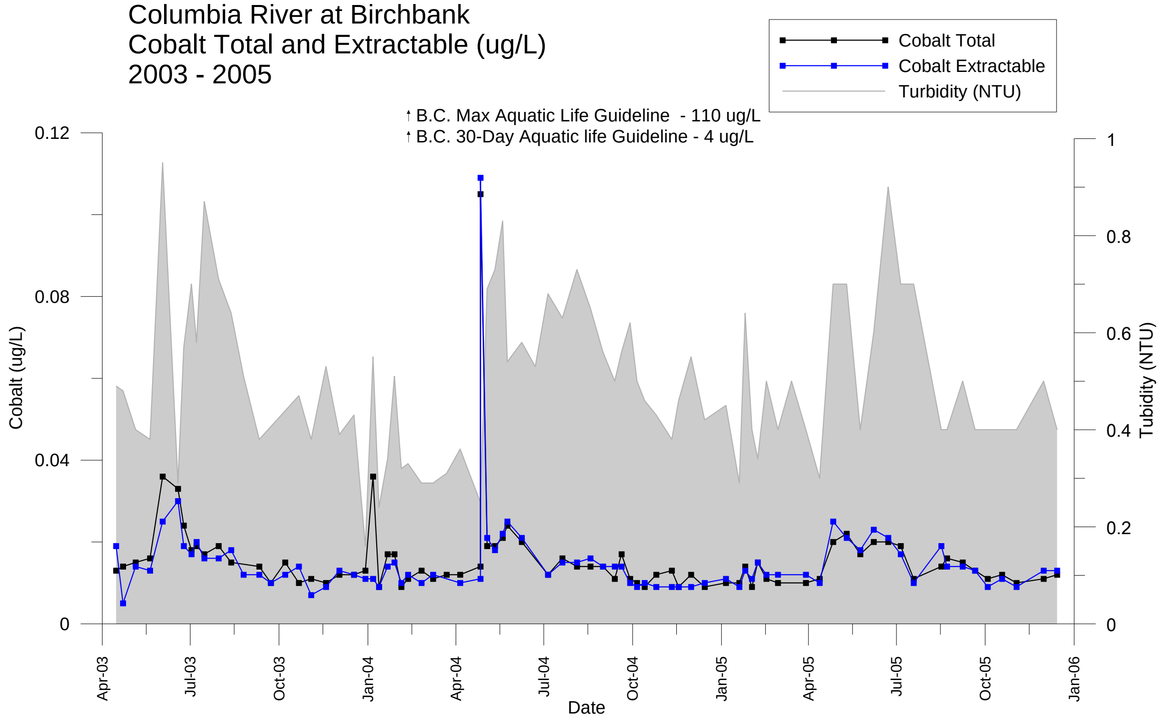
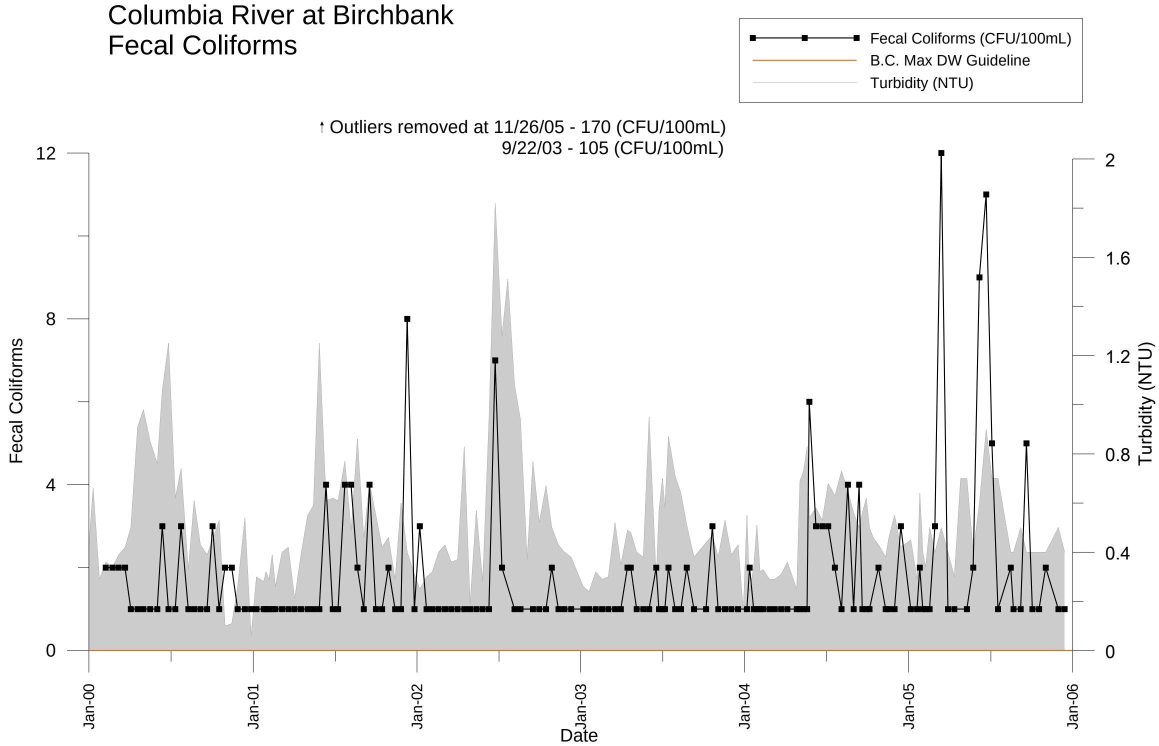


Figure 30
Columbia River at Birchbank
Fecal Coliforms



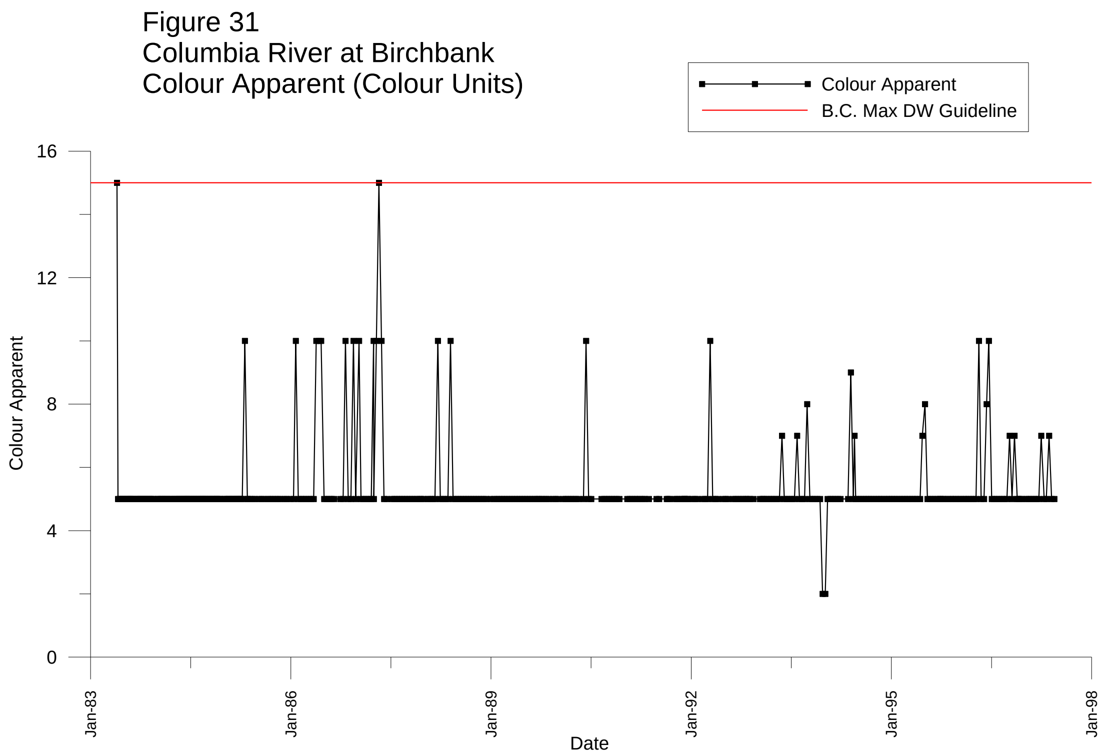


Figure 31
Columbia River at Birchbank
Colour Apparent (Colour Units)
Colour Apparent
B.C. Max DW Guideline
Colour Apparent
16
12
8
4
0
Jan-83
Jan-86
Jan-89
Jan-92
Jan-95
Jan-98
Date

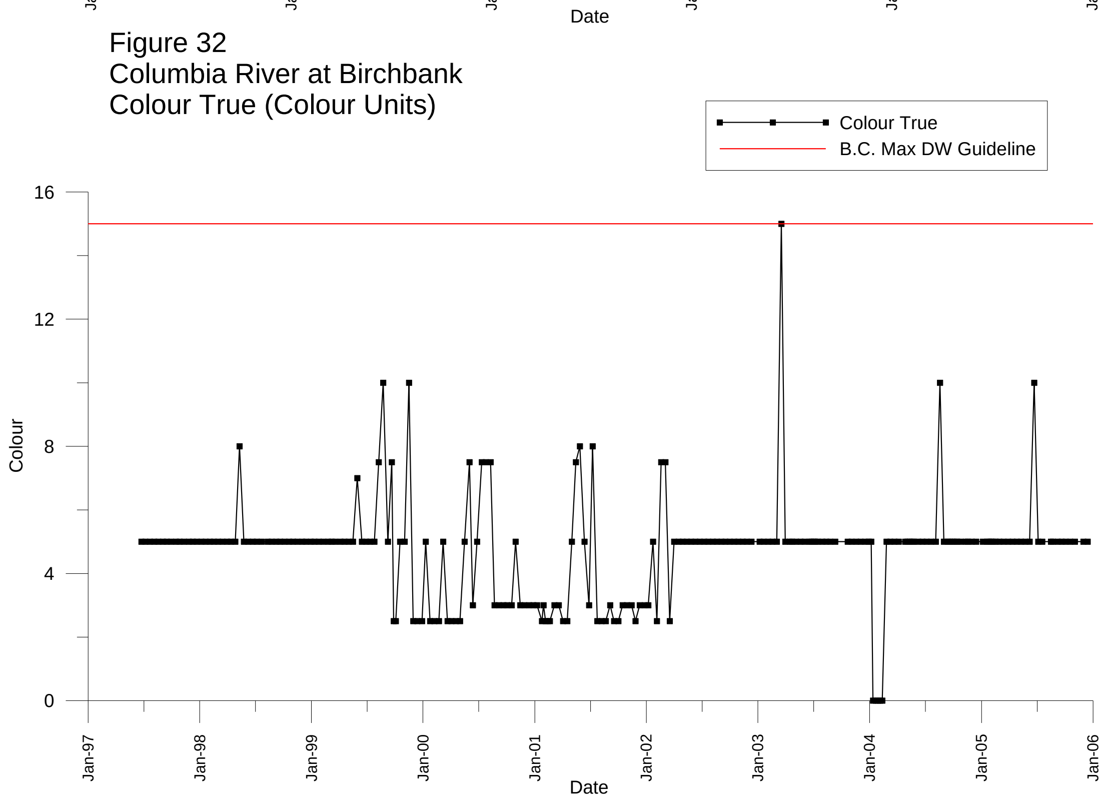


Figure 32
Columbia River at Birchbank
Colour True (Colour Units)
Colour True
B.C. Max DW Guideline
Colour
16
12
8
4
0
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Date

Figure 33
Columbia River at Birchbank
Copper Total and Extractable (ug/L)
1983 - 2004

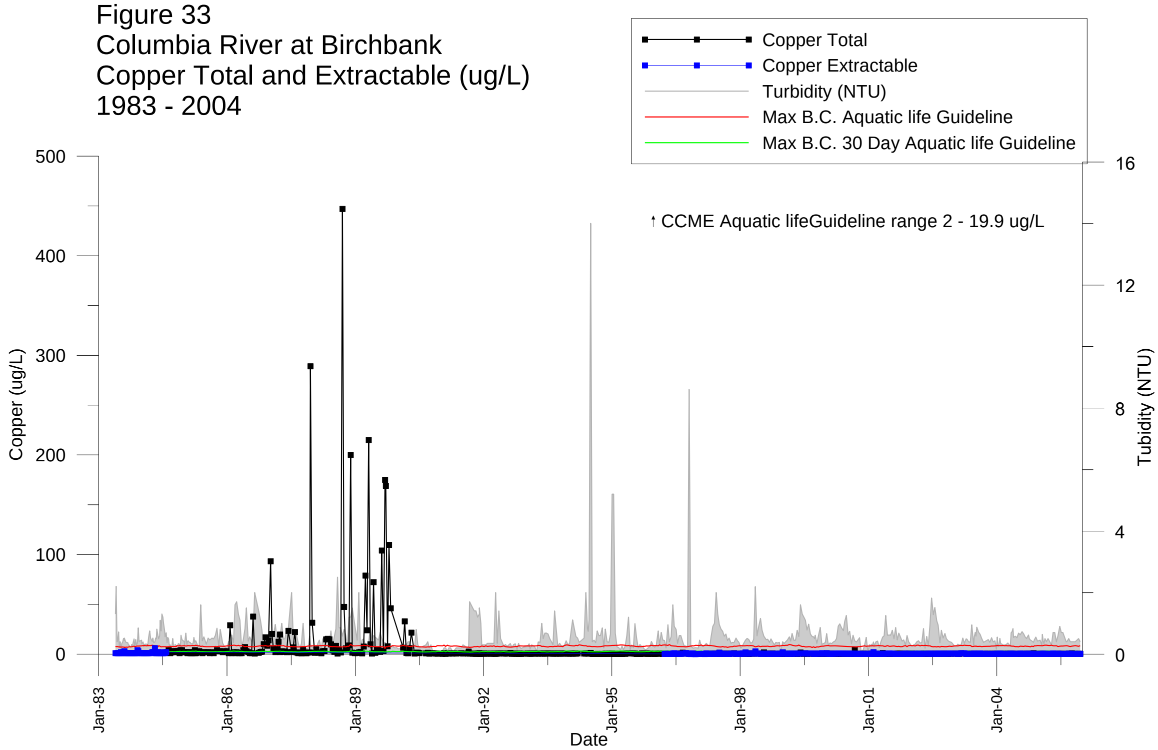


Figure 34
Columbia River at Birchbank
Copper Total and Extractable (ug/L)
1990 - 2003

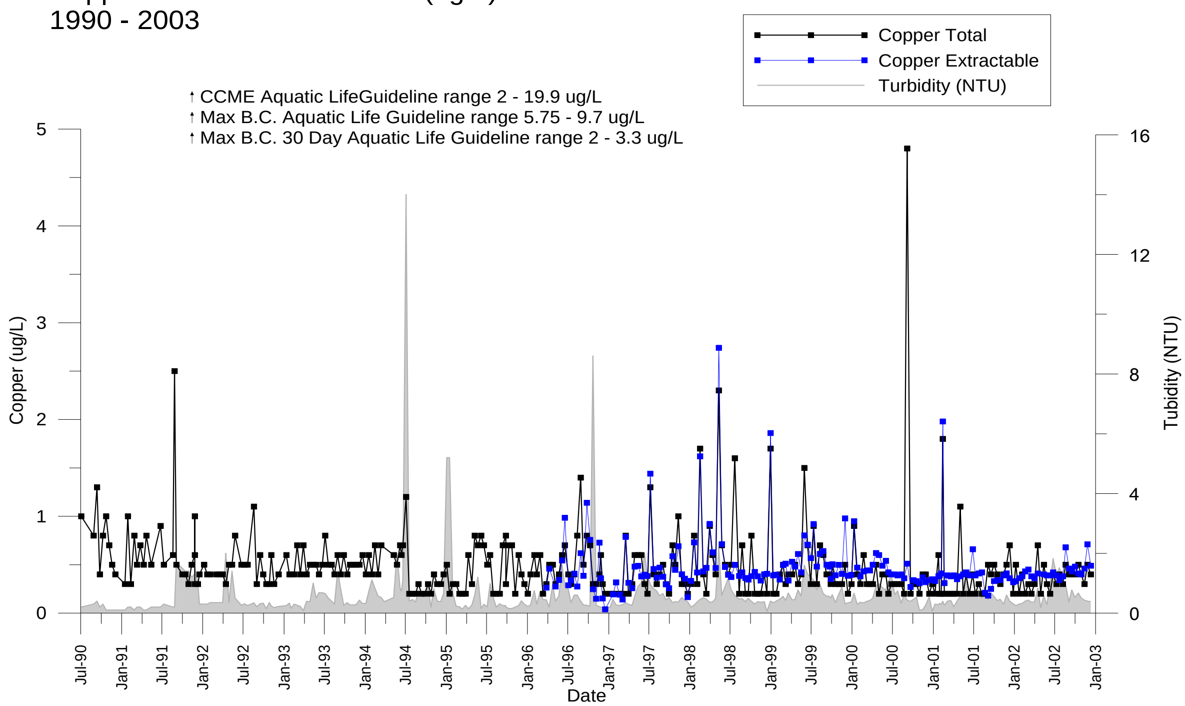


Figure 35
Columbia River at Birchbank
Copper Total and Extractable (ug/L)
2003 - 2006

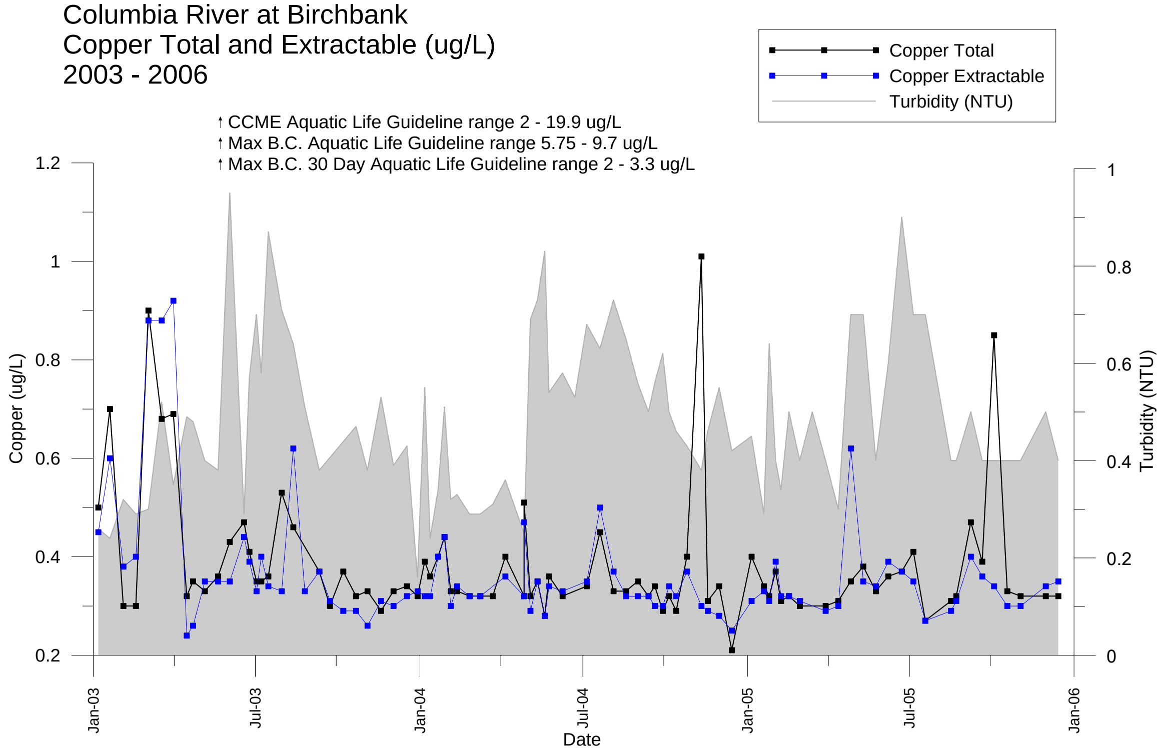


Figure 36
Columbia River at Birchbank
Cyanide Total (ug/L)

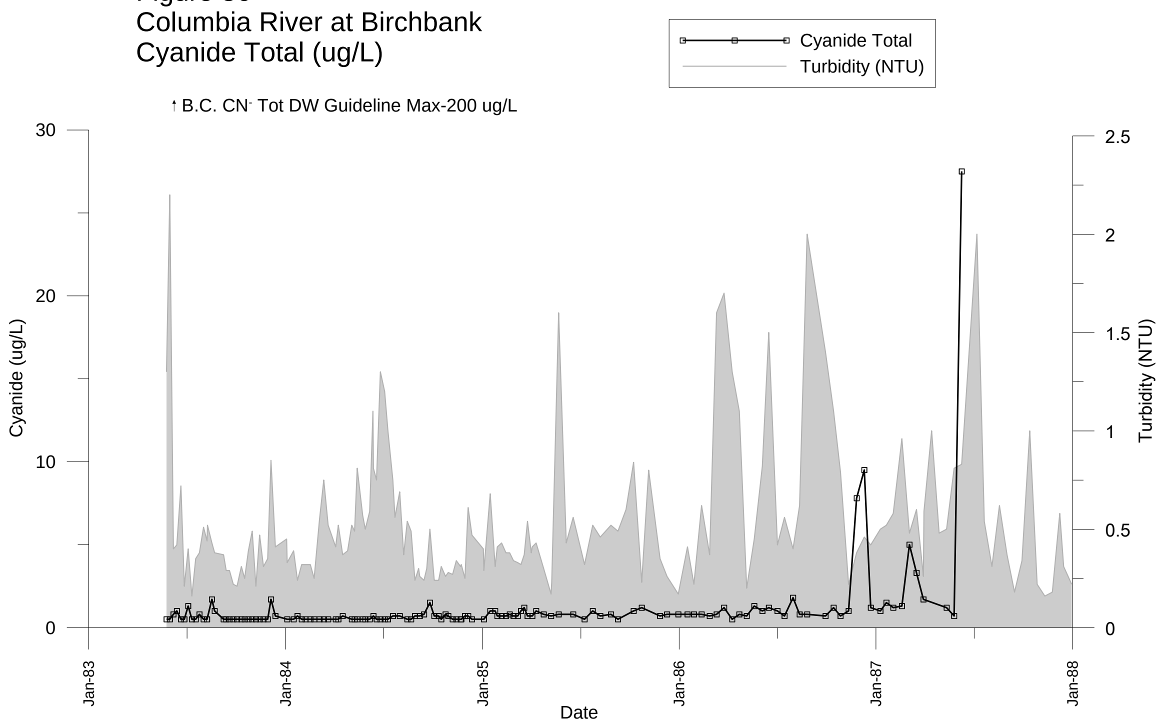


Figure 37
Columbia River at Birchbank
Fluoride Total and Dissolved (mg/L)

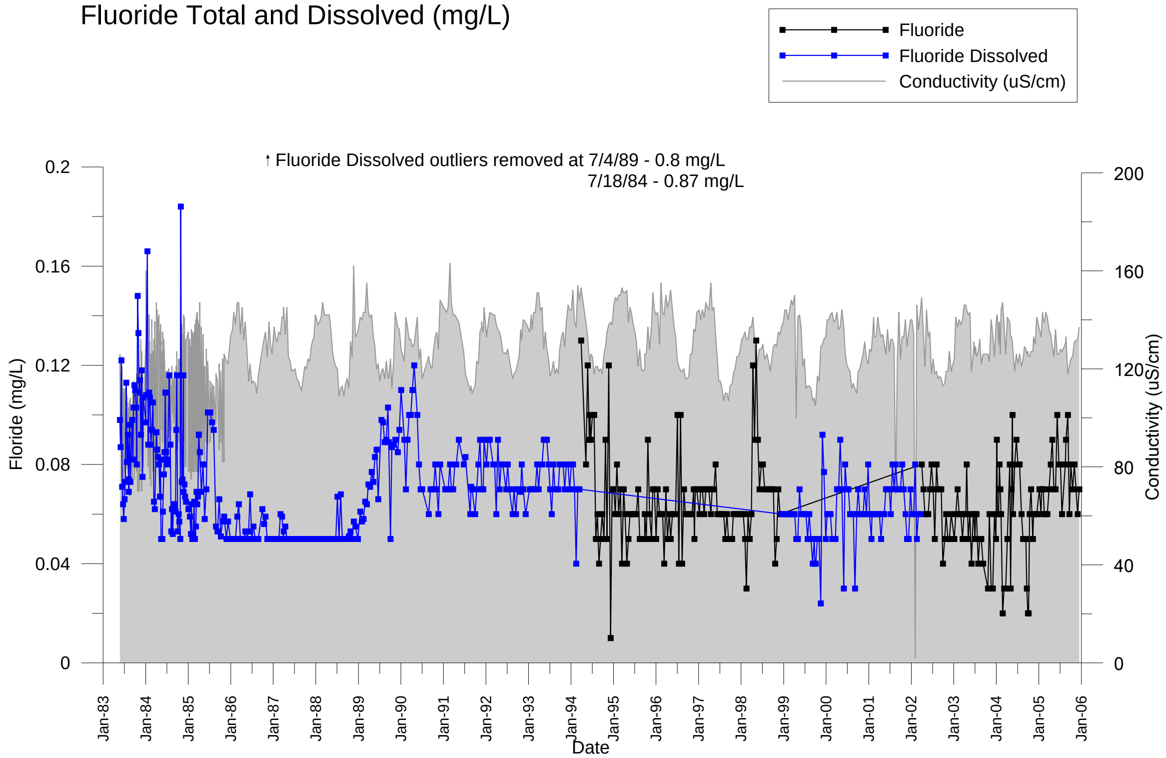


Figure 38
Columbia River at Birchbank
Gallium Total and Extractable (ug/L)
1996 - 2006

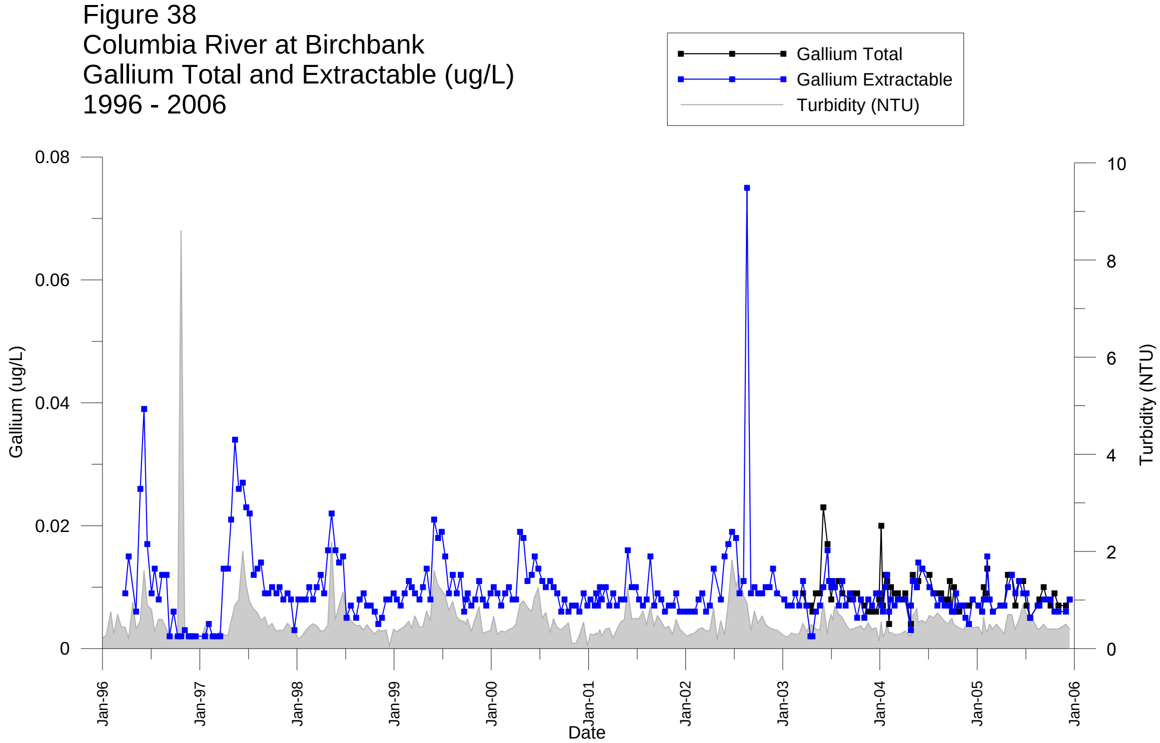


Figure 39
Columbia River at Birchbank
Gallium Total and Extractable (ug/L)
2003 - 2005

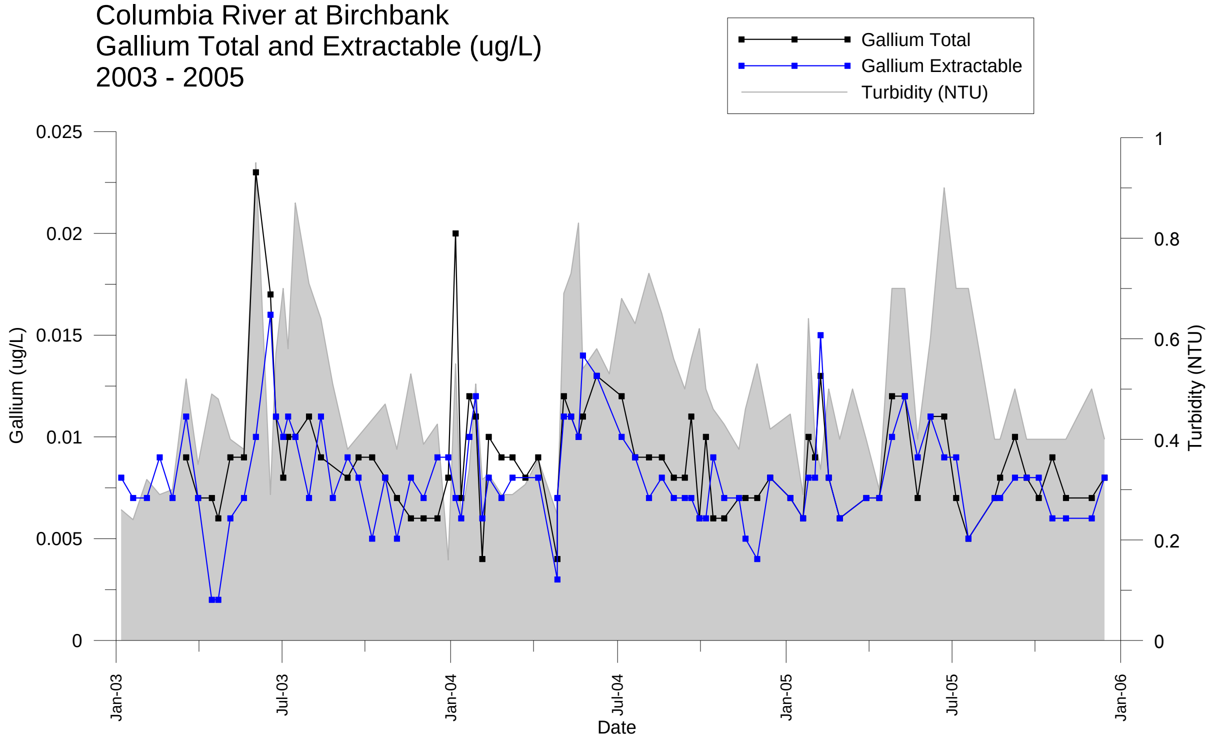


Figure 40
Columbia River at Birchbank
Hardness Total (mg/L $CaCO_3$)

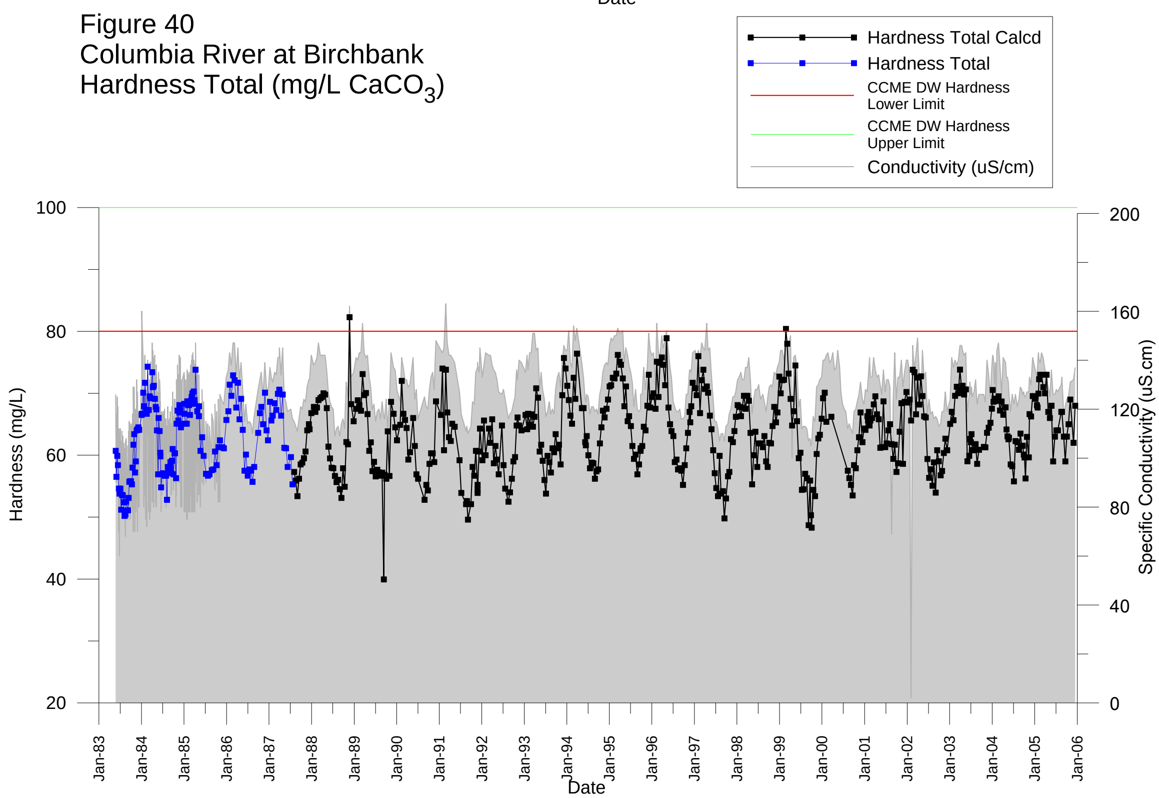


Figure 41
Columbia River at Birchbank
Iron Total and Extractable (ug/L)

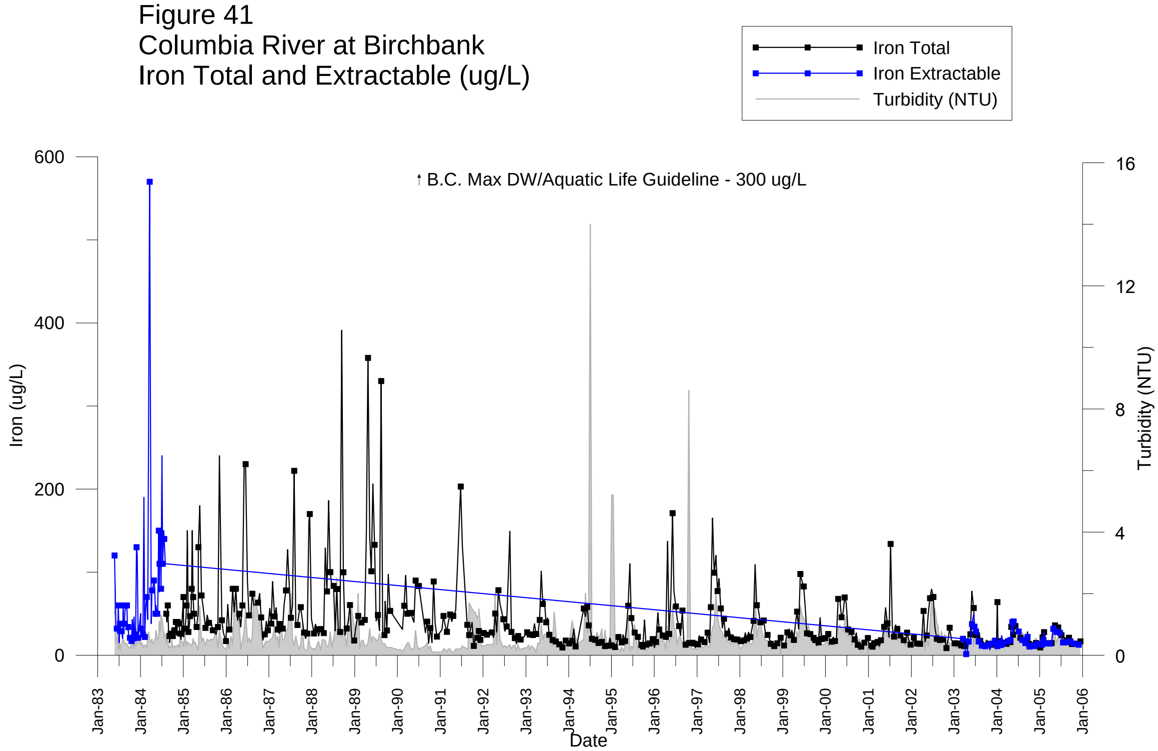


Figure 42
Columbia River at Birchbank
Lanthanum Total and Extractable (ug/L)
1996 - 2006

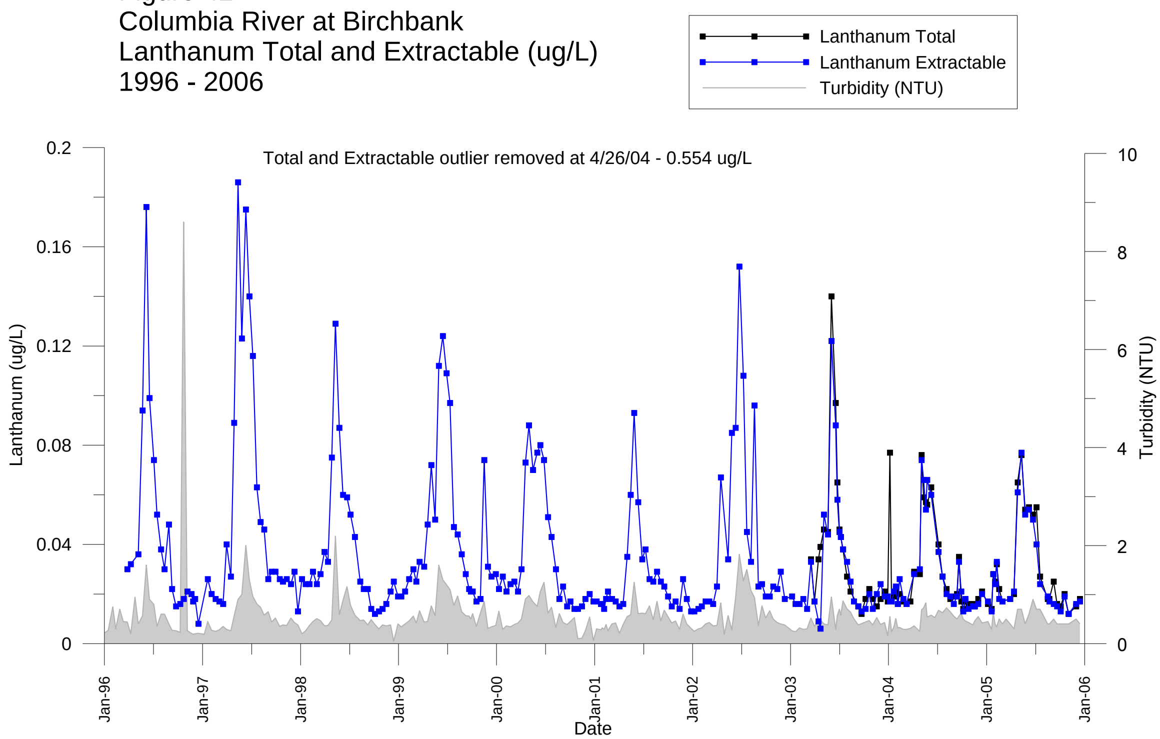


Figure 43
Columbia River at Birchbank
Lanthanum Total and Extractable (ug/L)
2003 - 2006

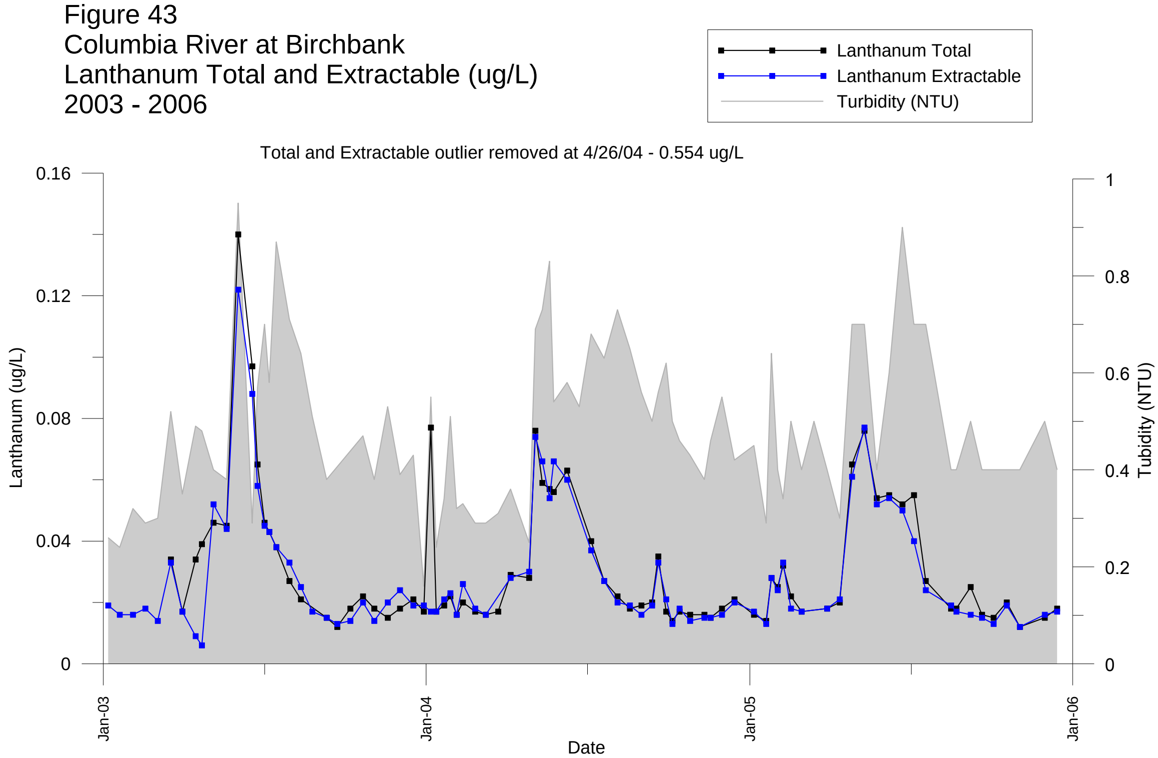


Figure 44 (a)
Columbia River at Birchbank
Lead Total and Extractable (ug/L)
1983 - 2006

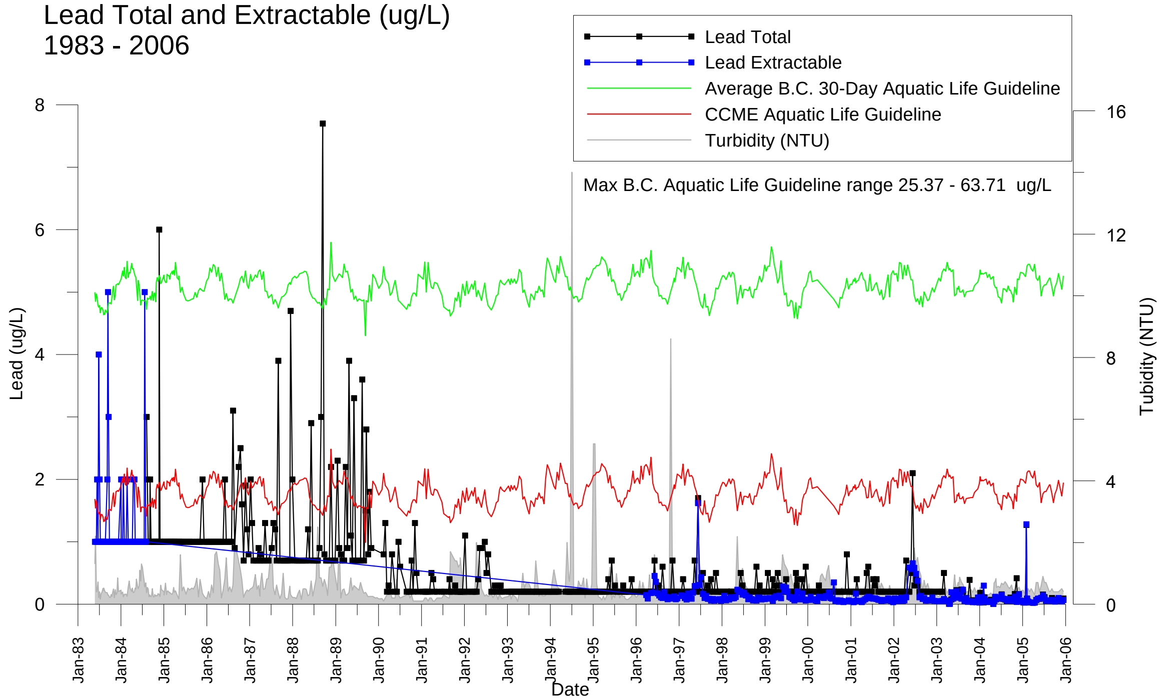


Figure 44 (b)
Columbia River at Birchbank
Lead Total and Extractable (ug/L)
1996 - 2006

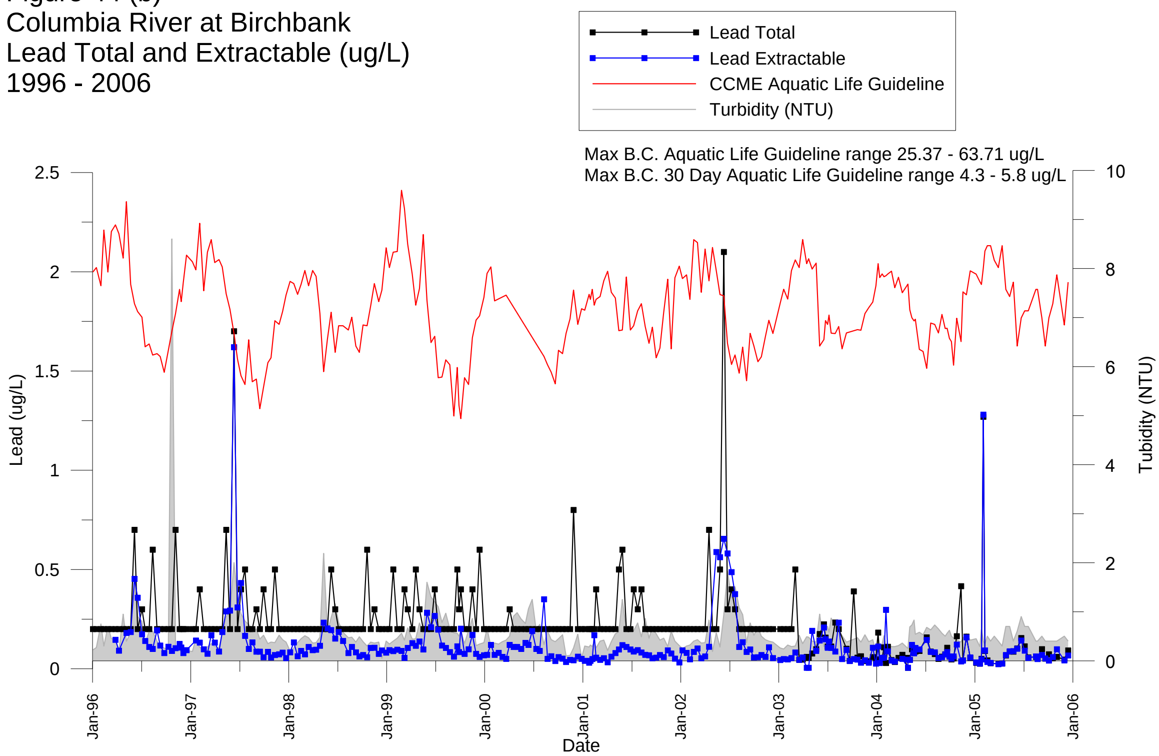


Figure 44 (c)
Columbia River at Birchbank
Lead Total and Extractable (ug/L)
2003 - 2006

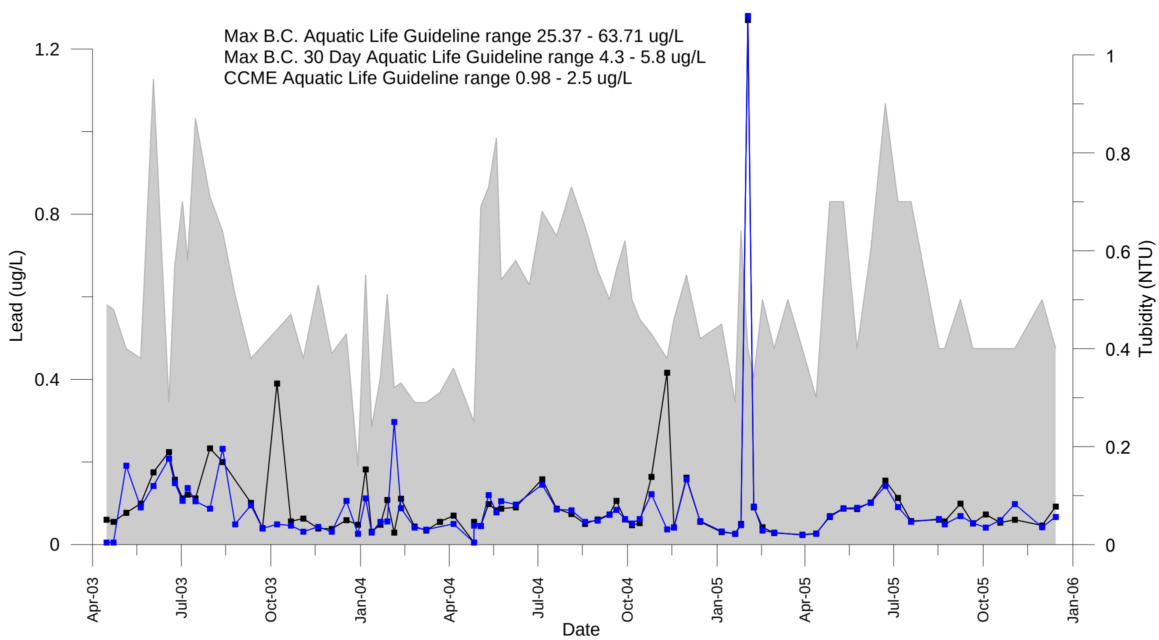


Figure 45
Columbia River at Birchbank
Lithium Total and Extractable (ug/L)

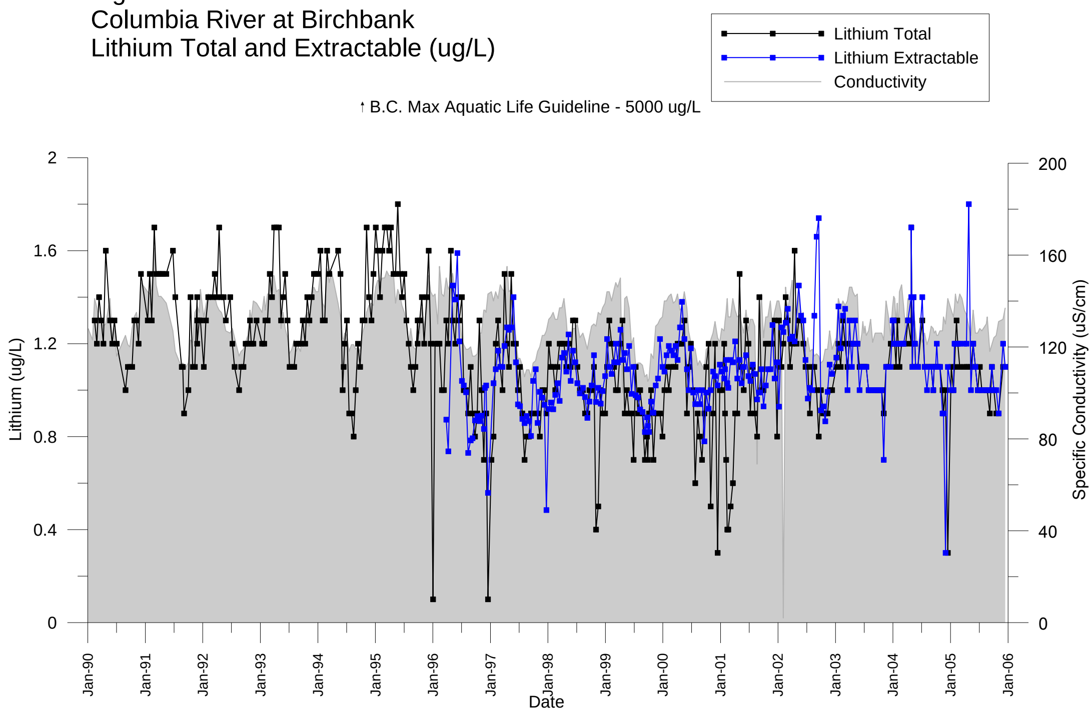


Figure 46
Columbia River at Birchbank
Magnesium - Dissolved and Extractable (mg/L)

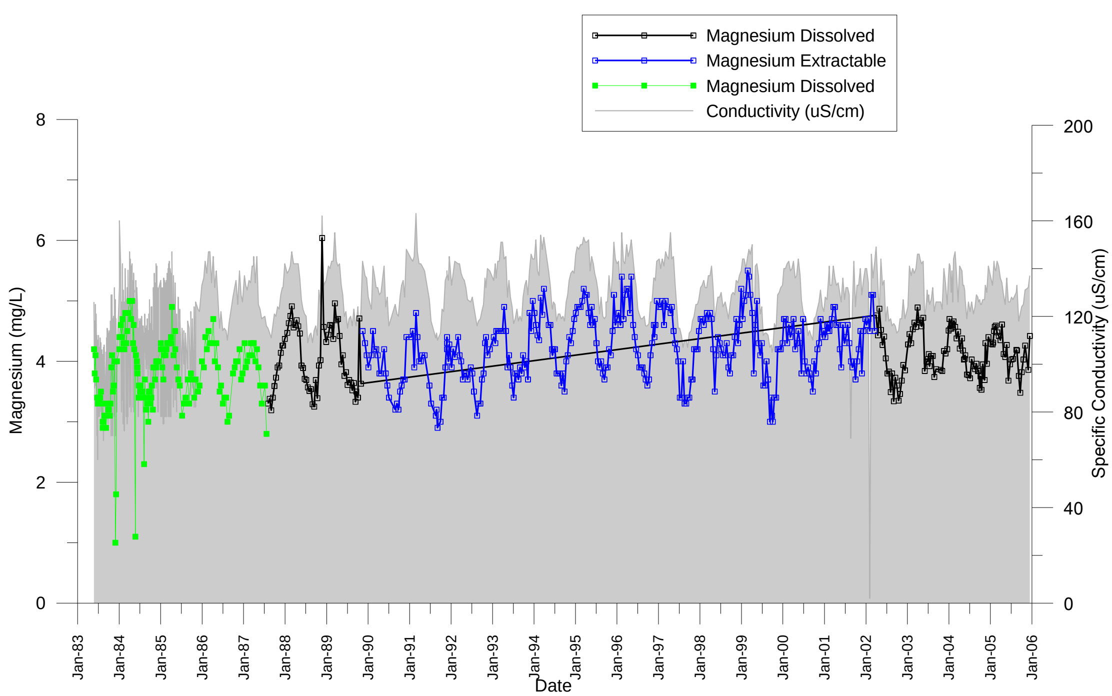


Figure 47
Columbia River at Birchbank
Manganese Total and Extractable(ug/L)
1983 - 2006

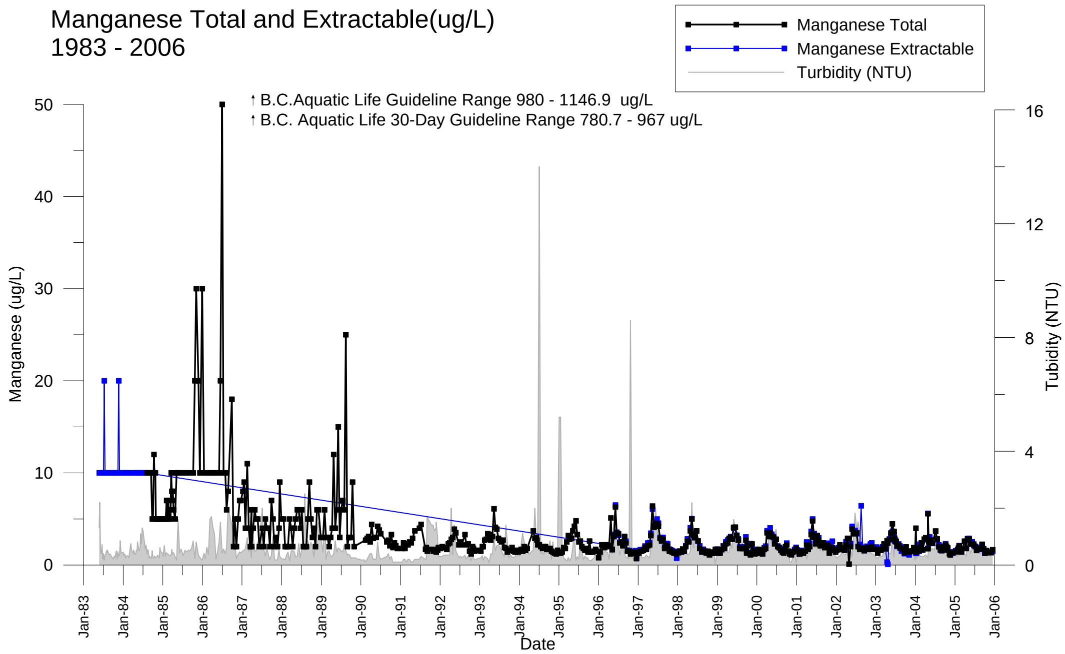


Figure 48
Columbia River at Birchbank
Manganese Total and Extractable(ug/L)
1996 - 2006

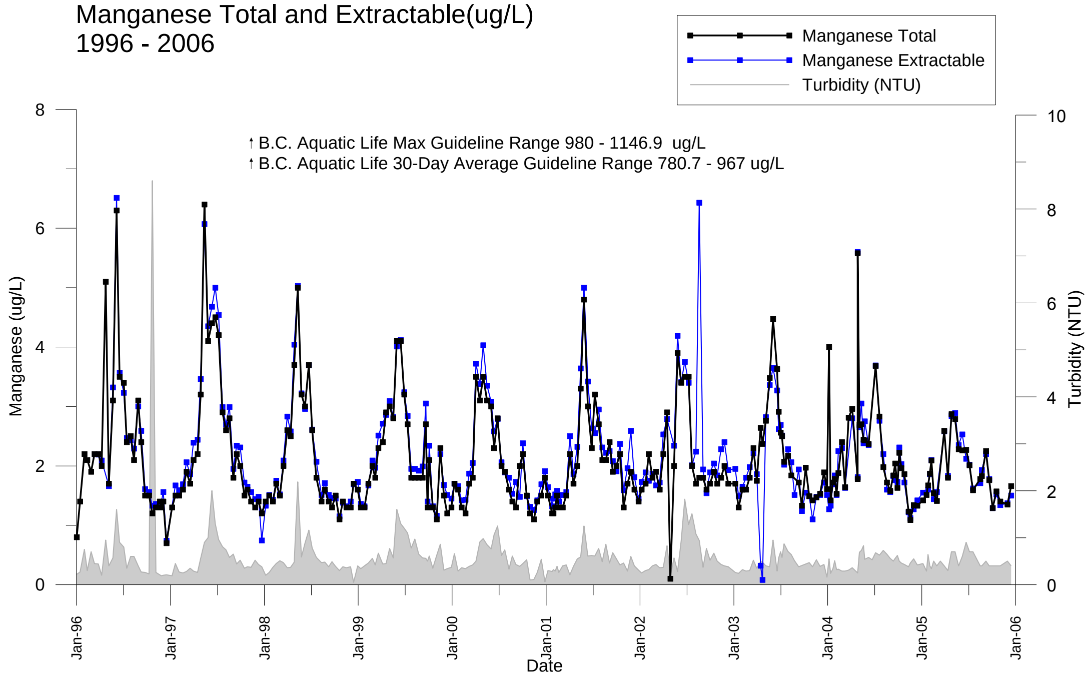


Figure 49
Columbia River at Birchbank
Molybdenum Total and Extractable (ug/L)
1988 - 2006

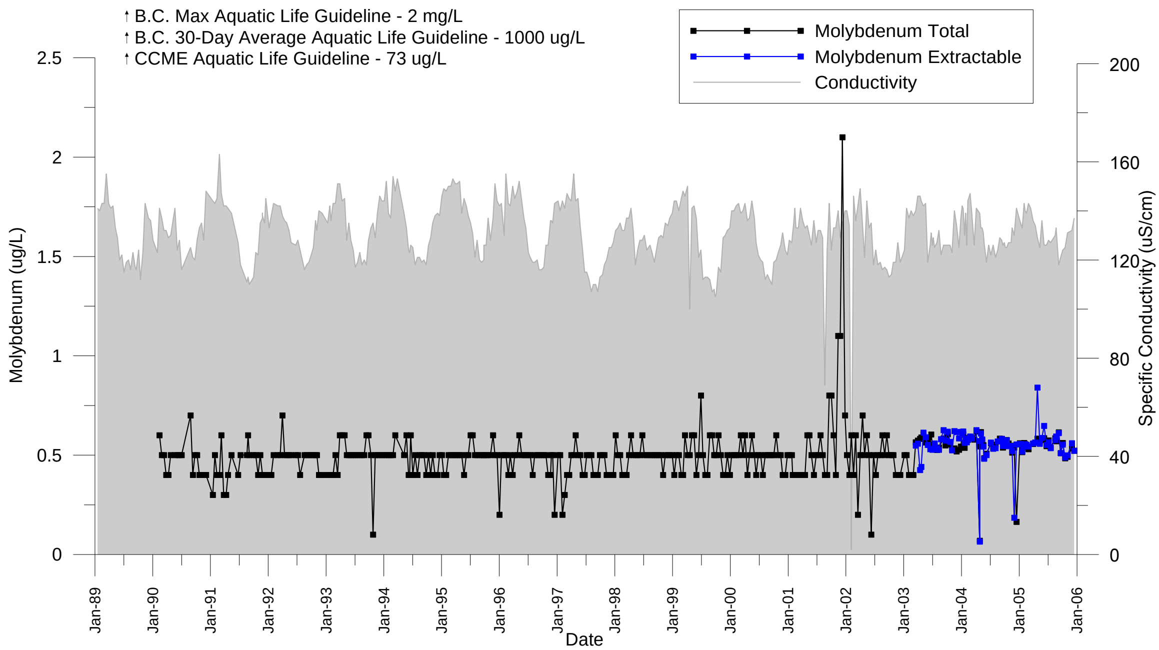


Figure 50
Columbia River at Birchbank
Molybdenum Total and Extractable (ug/L)
2003 - 2006

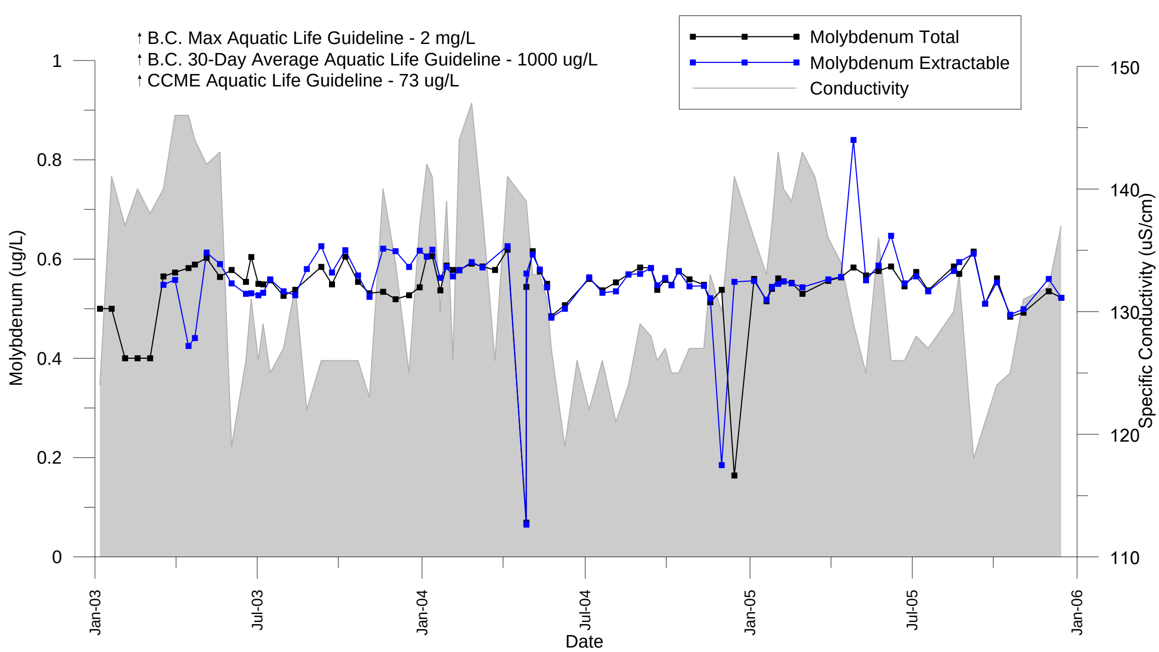


Figure 51
Columbia River at Birchbank
Nickel Total and Extractable (ug/L)
1987 - 2006

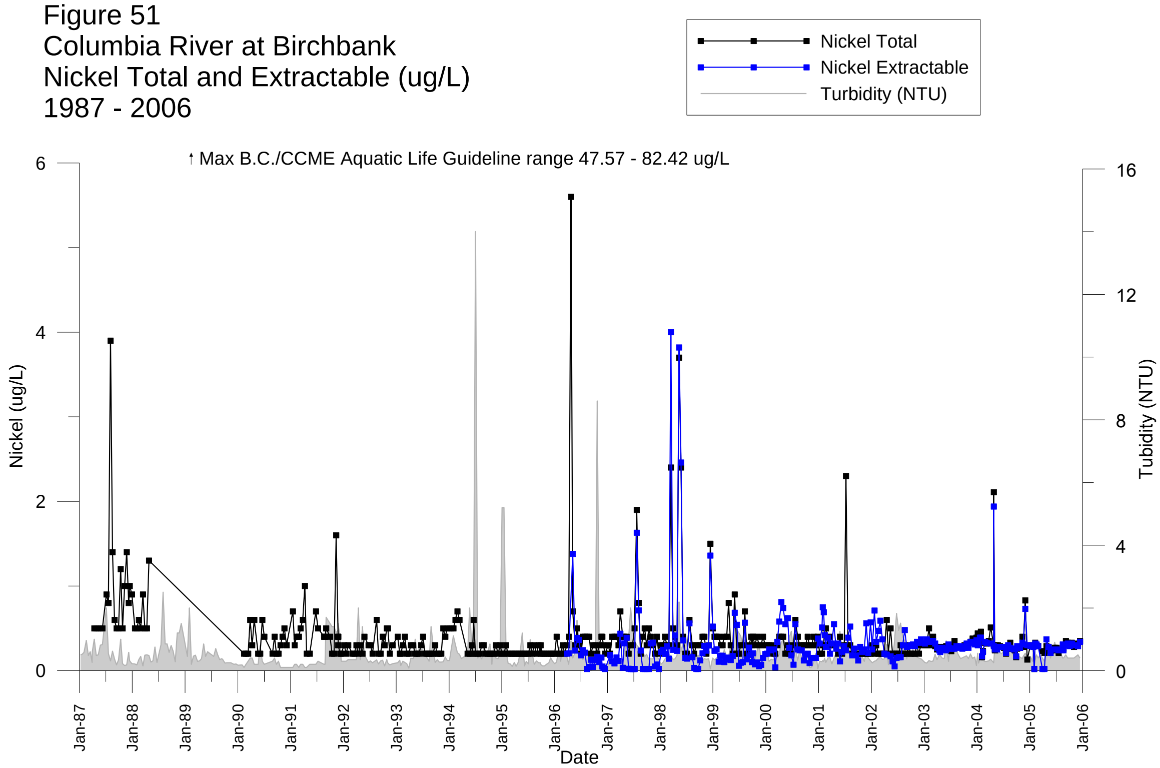


Figure 52
Columbia River at Birchbank
Nickel Total and Extractable (ug/L)
1996 - 2006

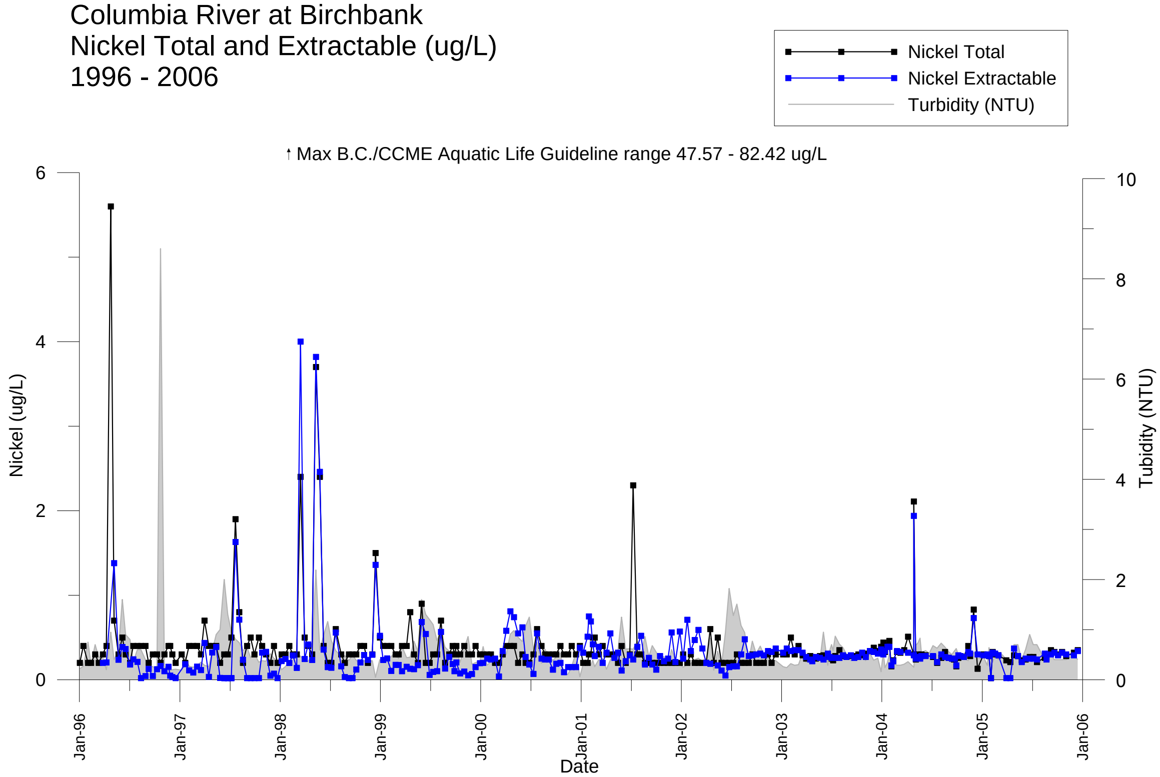


Figure 53
Columbia River at Birchbank
Niobium Extractable (ug/L)
2004 - 2006

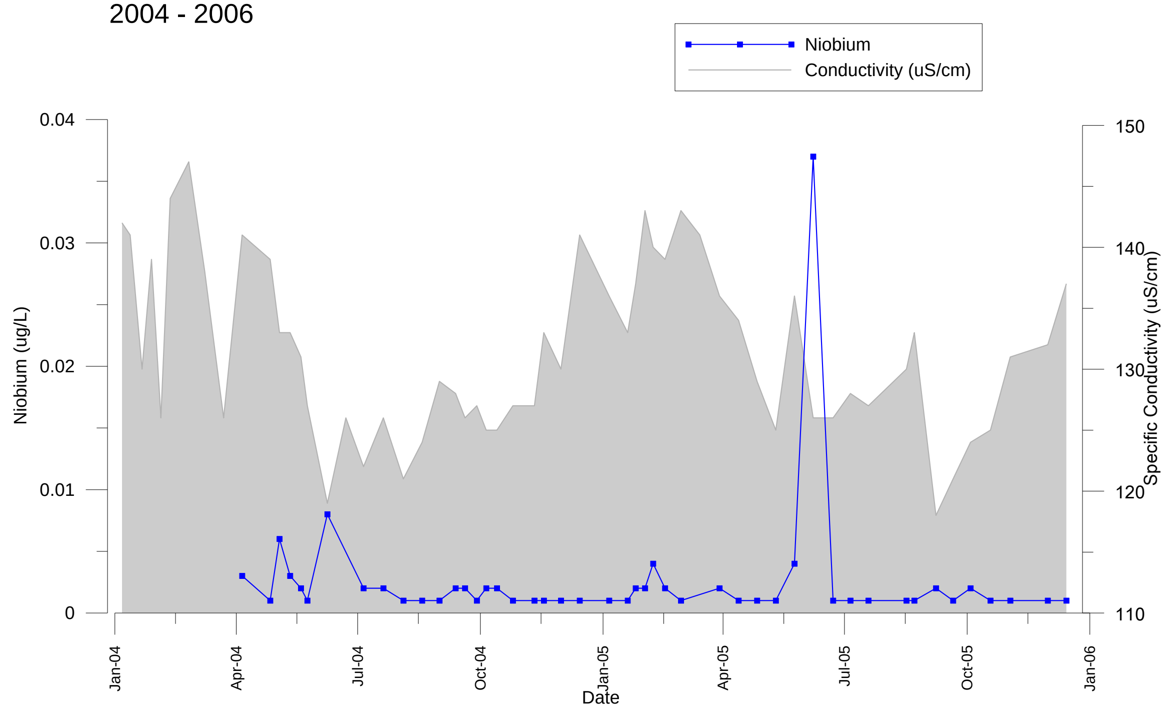


Figure 54
Columbia River at Birchbank
Nitrogen - Dissolved Nitrate (mg/L)
1994 - 1998

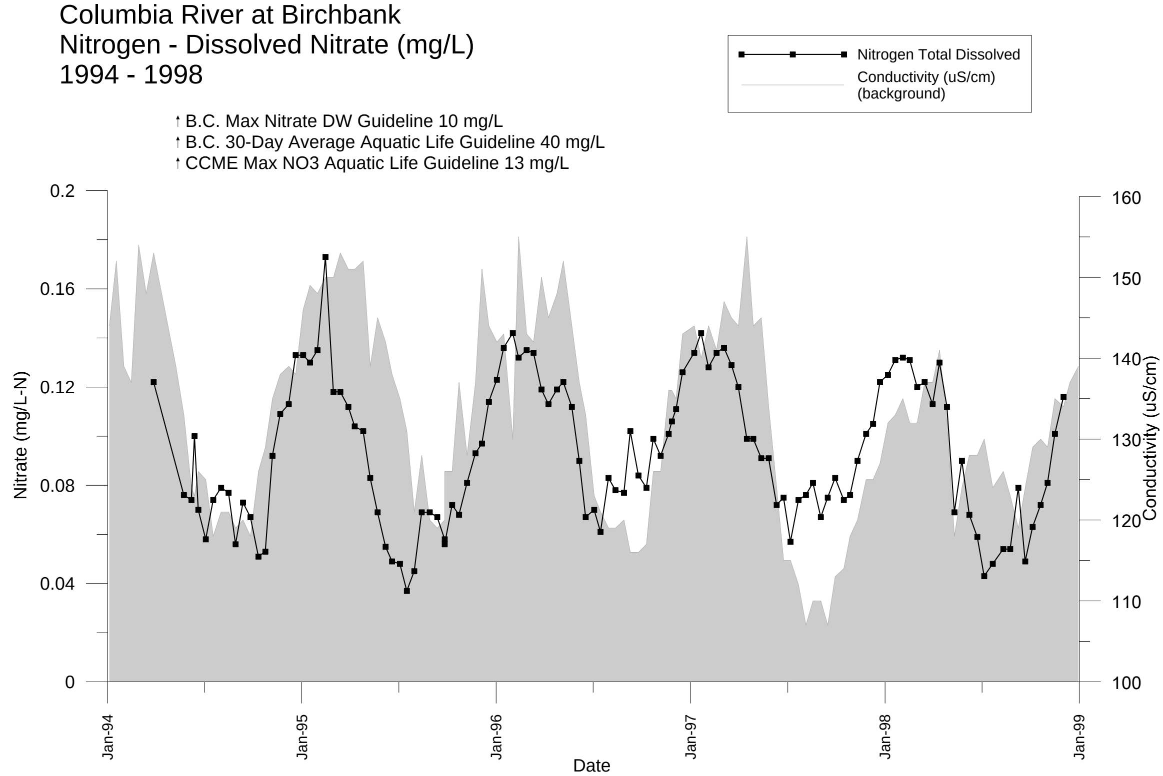


Figure 55
Columbia River at Birchbank
Nitrogen Nitrate + Nitrite (mg/L)
1983 - 1996

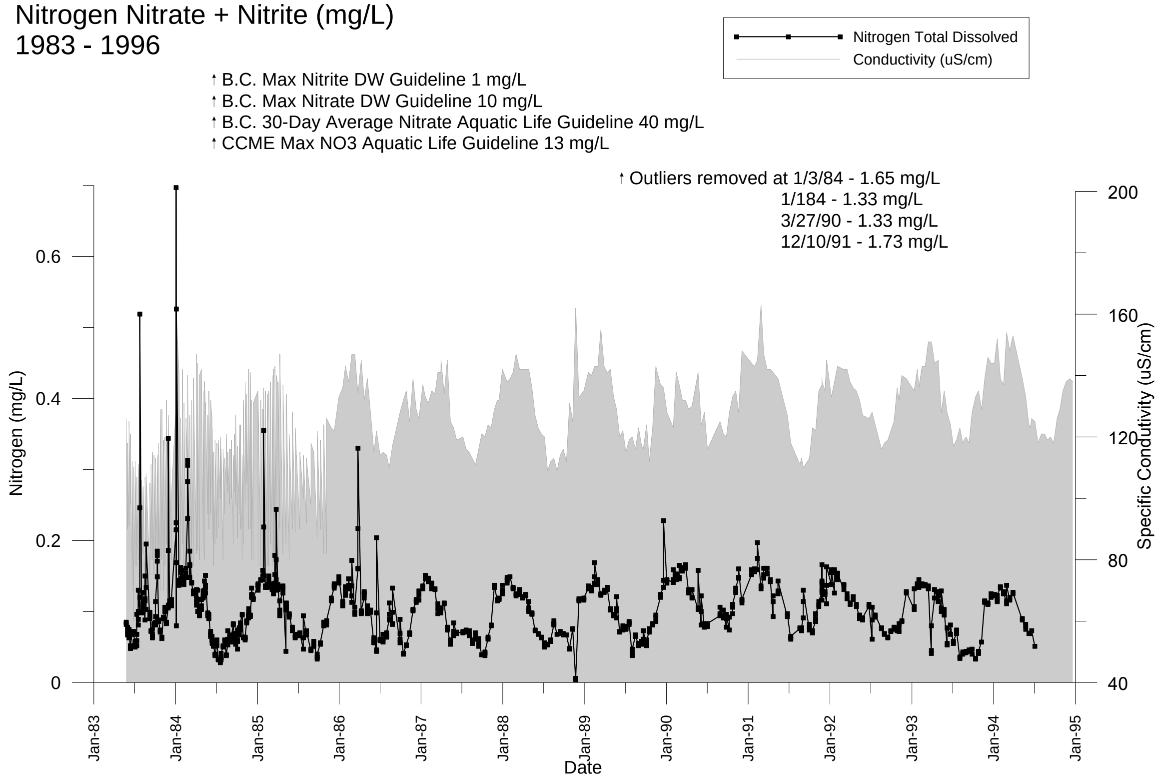


Figure 56
Columbia River at Birchbank
Nitrogen - Nitrite (mg/L)
1994 - 1998

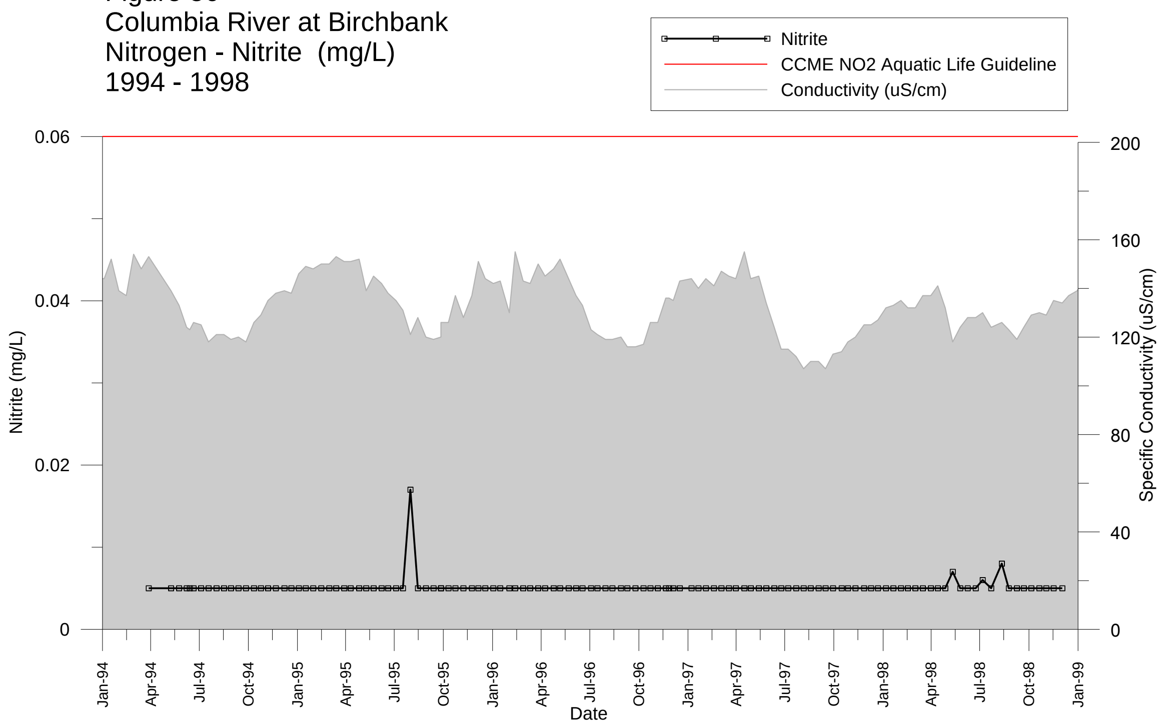


Figure 57
Columbia River at Birchbank
Nitrogen Total (mg/L)

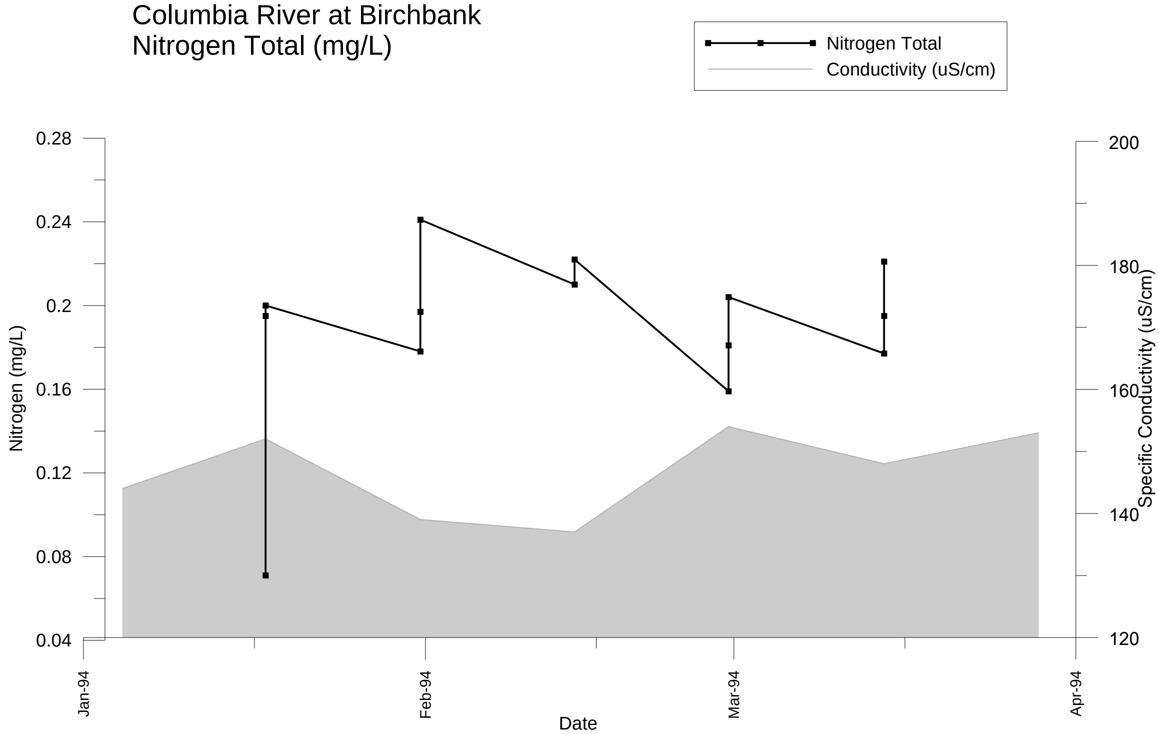


Figure 58
Columbia River at Birchbank
Nitrogen Total Dissolved (mg/L)
1983 - 2005

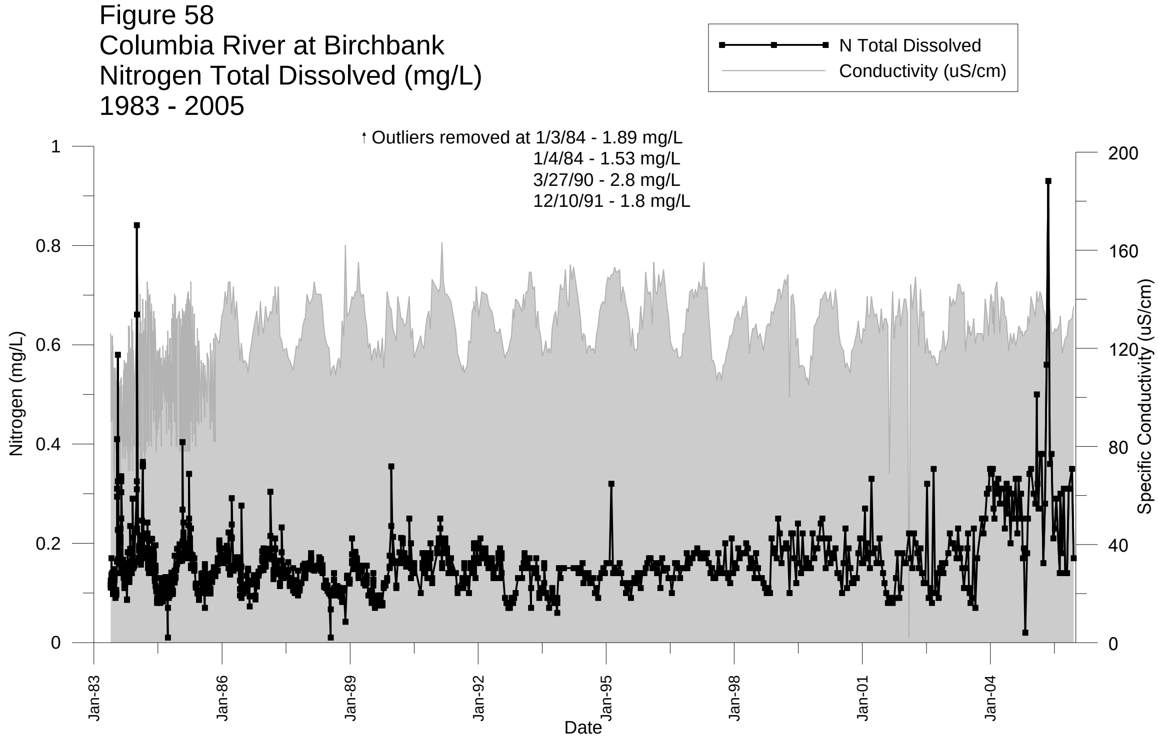


Figure 59
Columbia River at Birchbank
pH (pH units)

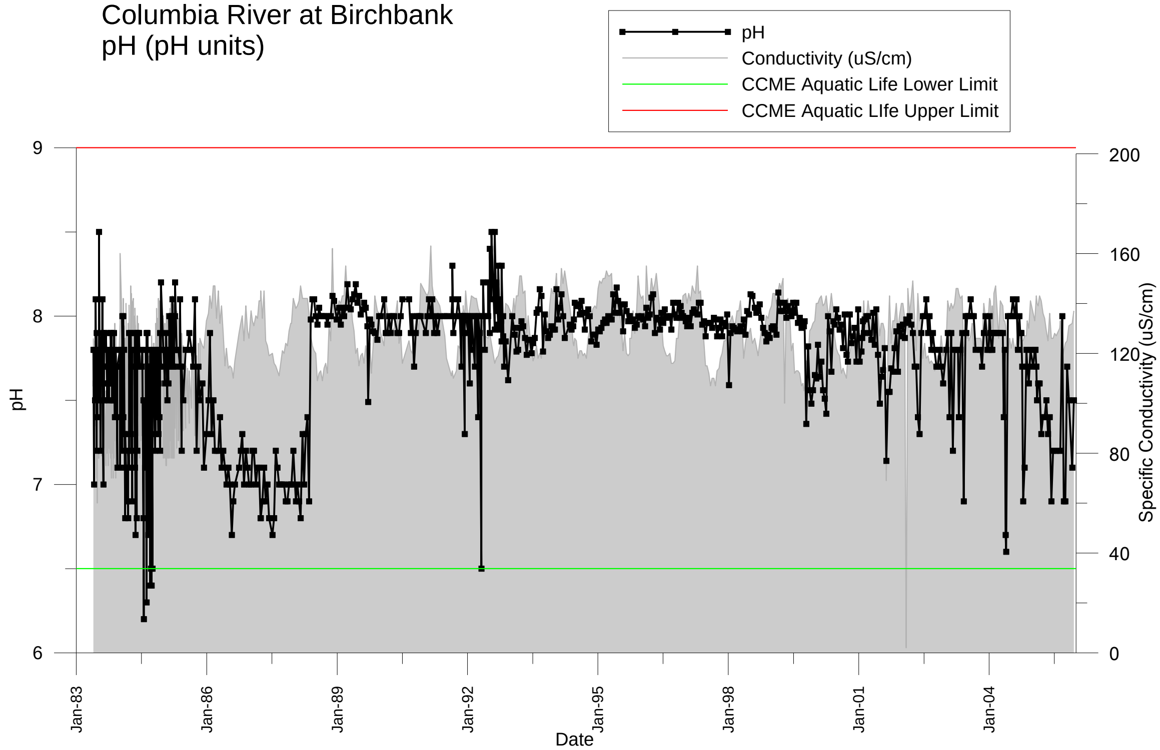


Figure 60
Columbia River at Birchbank
Phosphate Dissolved Ortho (mg/L)

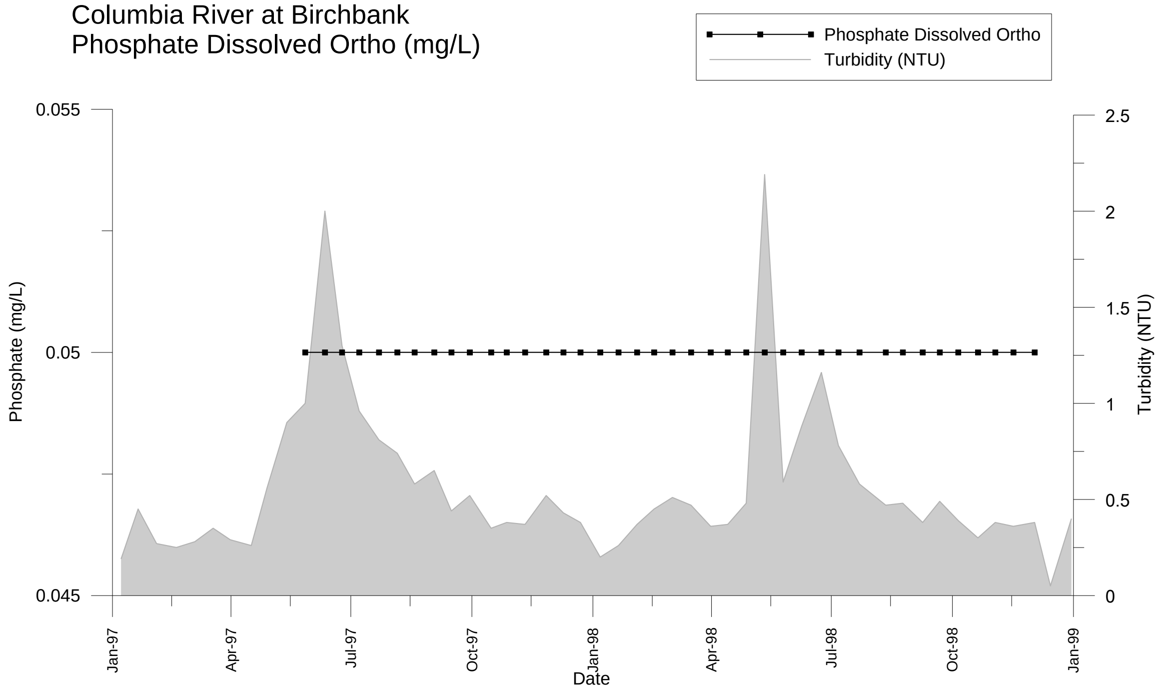


Figure 61
Columbia River at Birchbank
Phosphorus Total (mg/L)
1983 - 2004

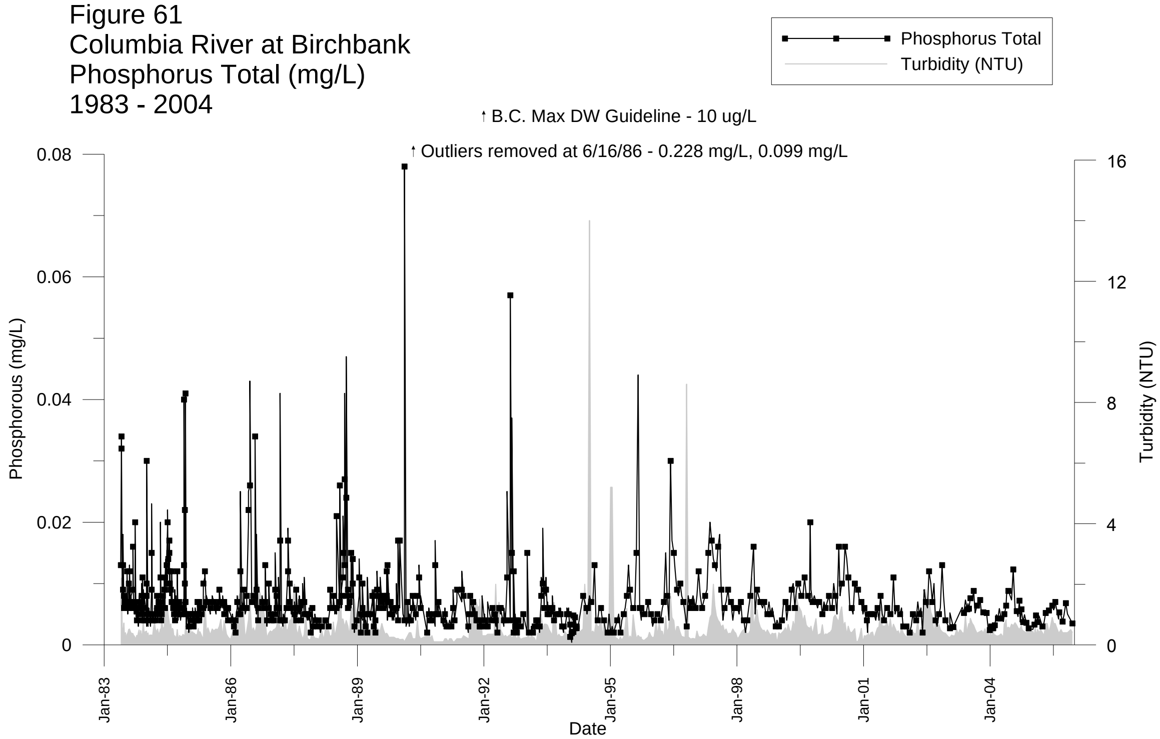


Figure 62
Columbia River at Birchbank
Phosphorus Total Dissolved(mg/L)
1998 - 2006

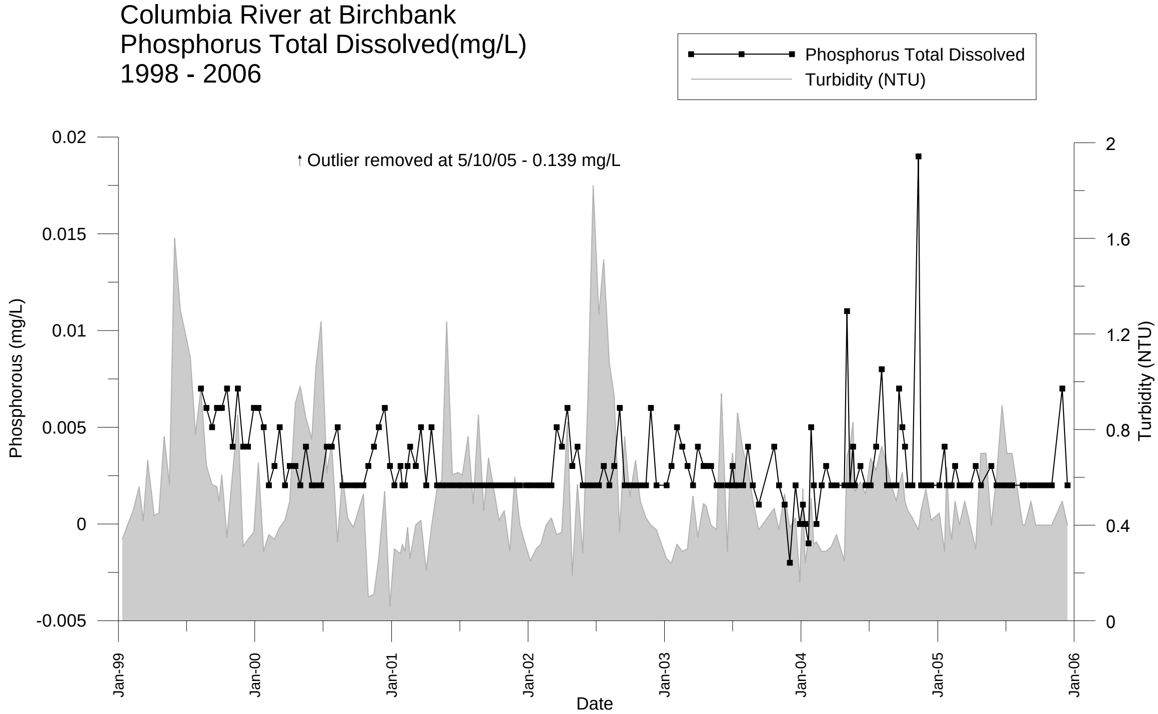


Figure 63
Columbia River at Birchbank
Potassium Extractable and Dissolved (mg/L)

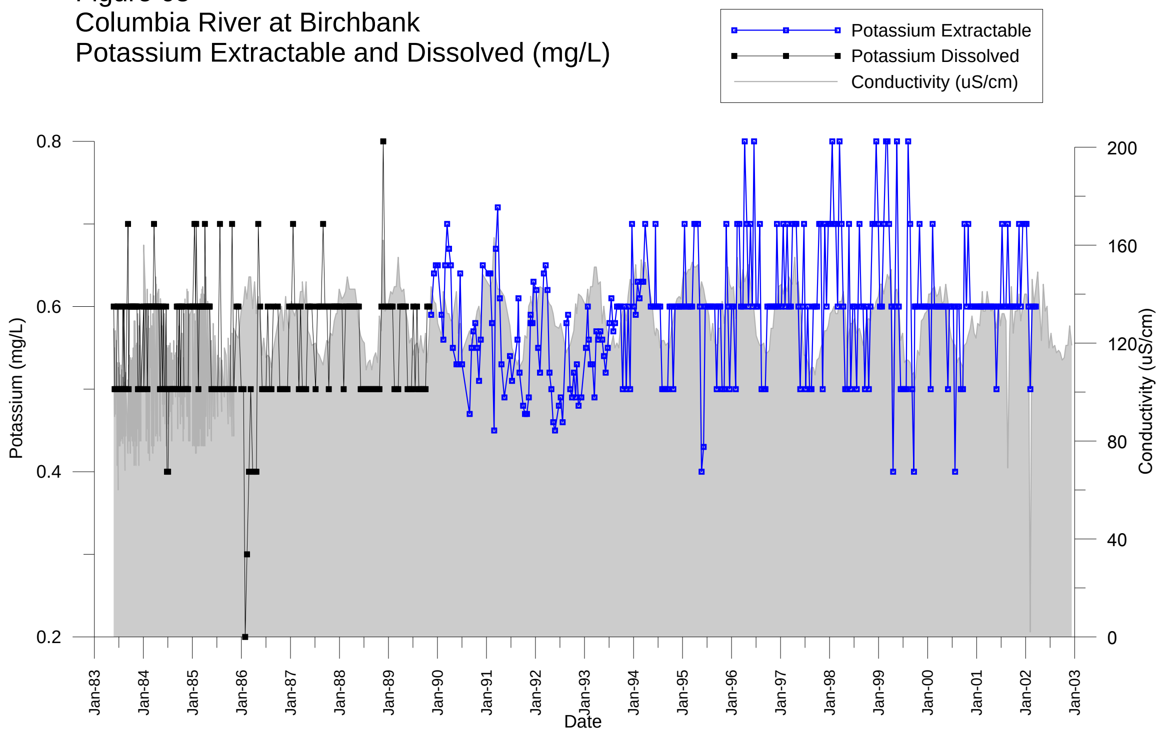


Figure 64
Columbia River at Birchbank
Rubidium Total and Extractable (ug/L)
1996 - 2006

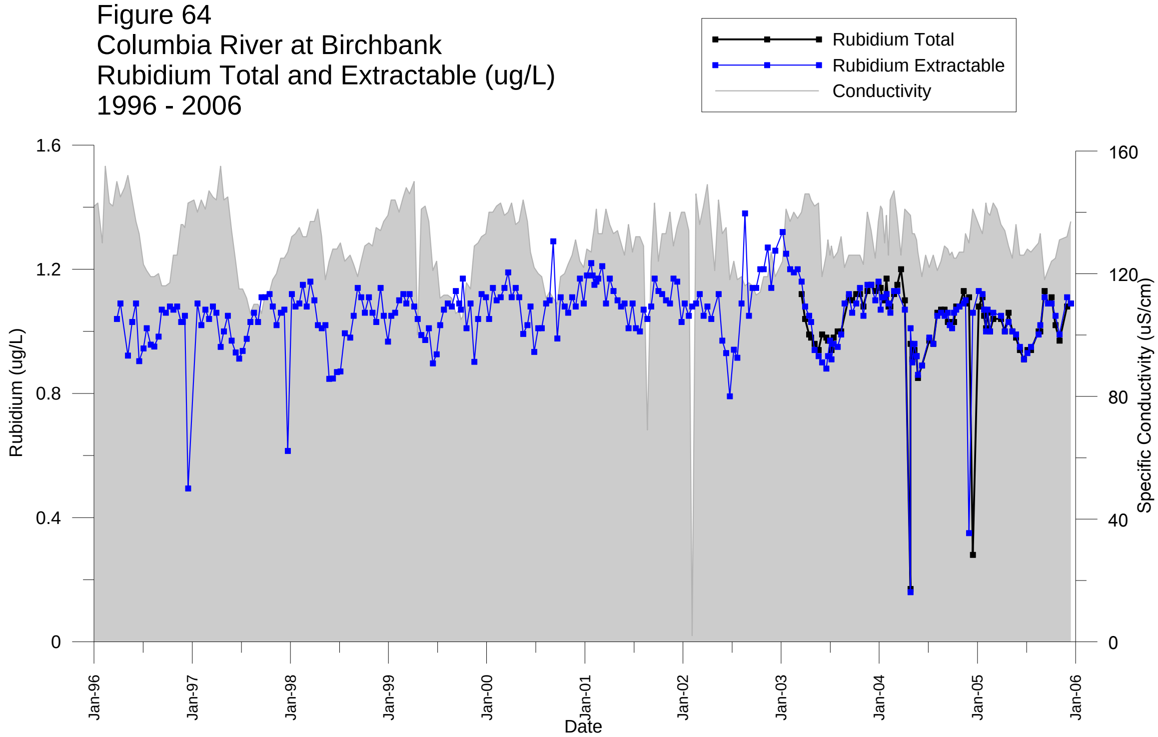


Figure 65
Columbia River at Birchbank
Rubidium Total and Extractable (ug/L)
2003 - 2006

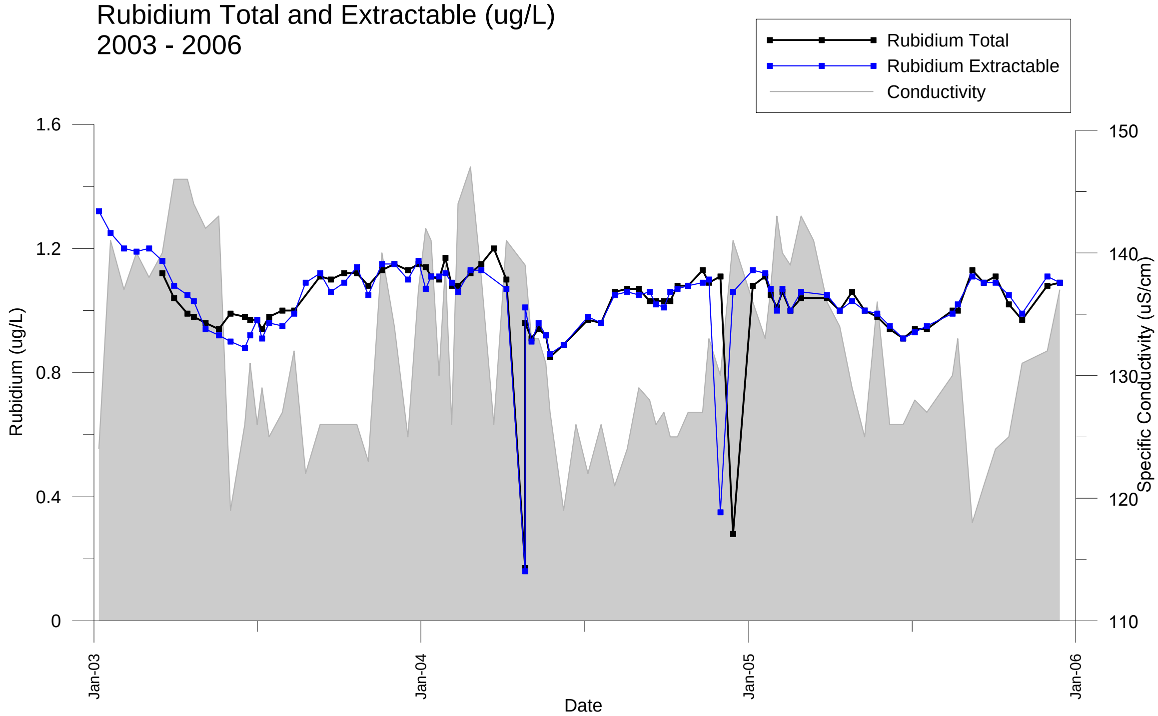
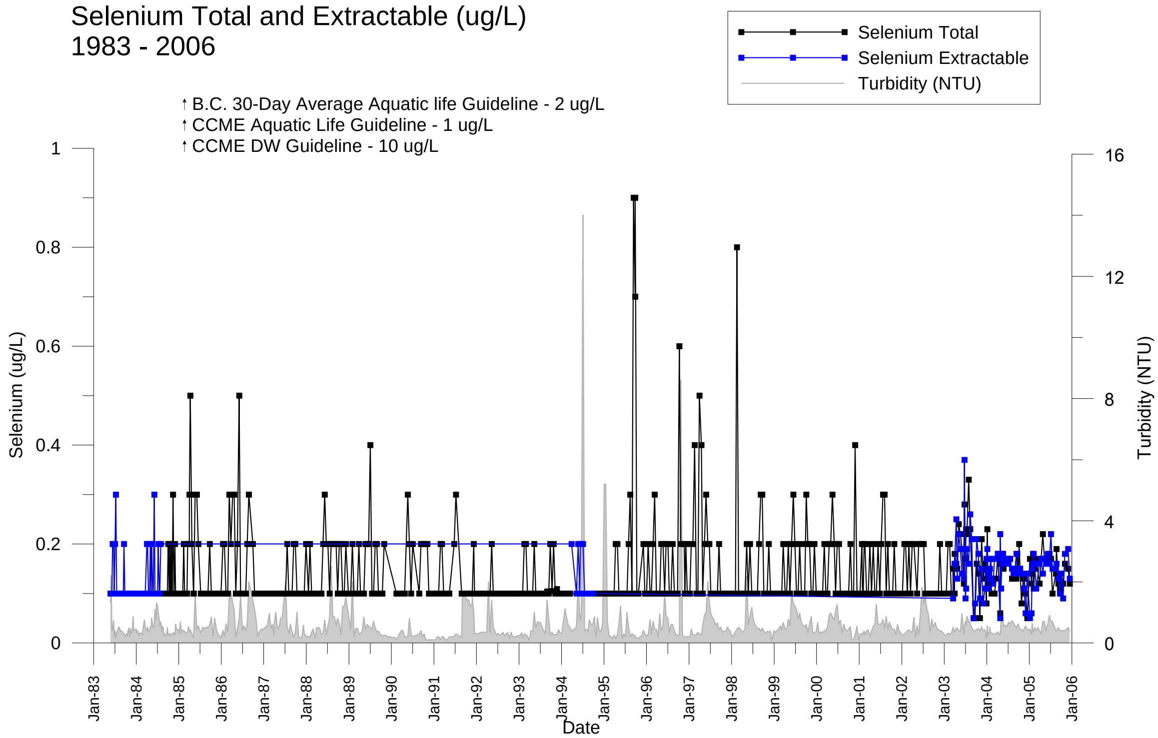


Figure 66
Columbia River at Birchbank
Selenium Total and Extractable (ug/L)
1983 - 2006



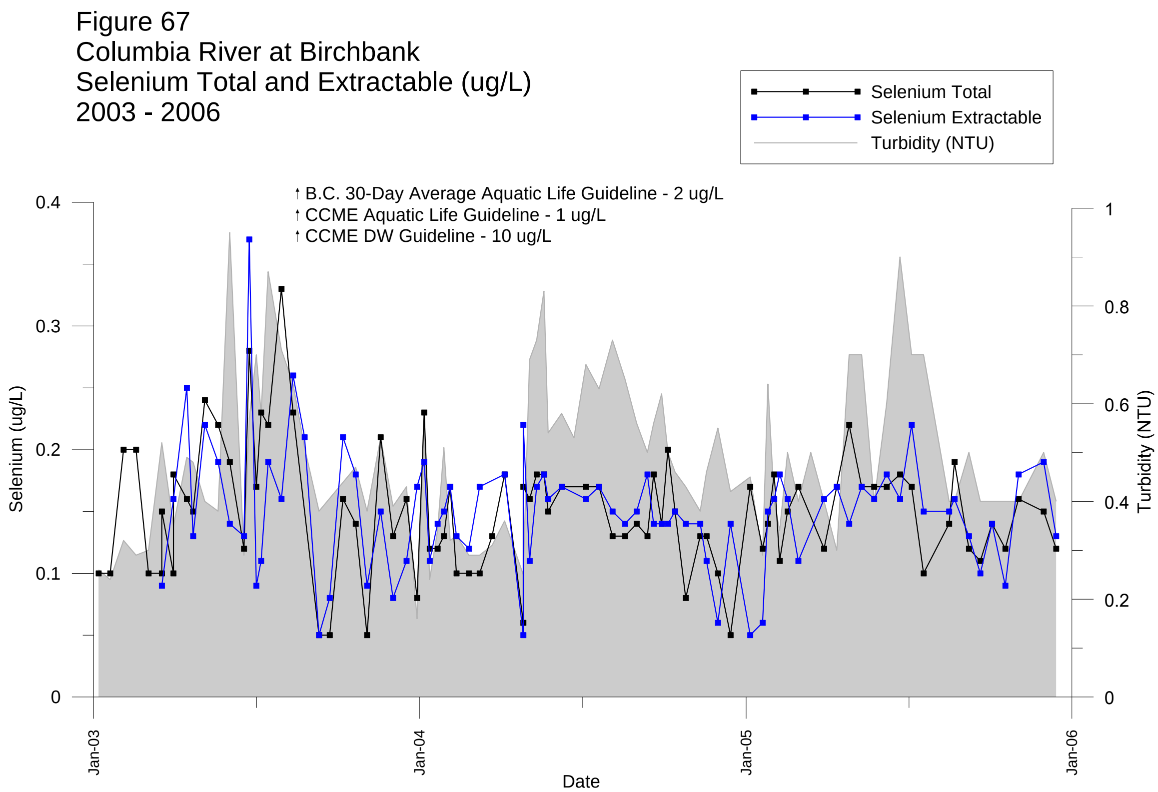


Figure 67
Columbia River at Birchbank
Selenium Total and Extractable (ug/L)
2003 - 2006
Selenium Total
Selenium Extractable
Turbidity (NTU)
↑ B.C. 30-Day Average Aquatic Life Guideline - 2 ug/L
↑ CCME Aquatic Life Guideline - 1 ug/L
↑ CCME DW Guideline - 10 ug/L
Selenium (ug/L)
Turbidity (NTU)
0.4
0.3
0.2
0.1
0
1
0.8
0.6
0.4
0.2
0
Jan-03
Jan-04
Jan-05
Jan-06
Date

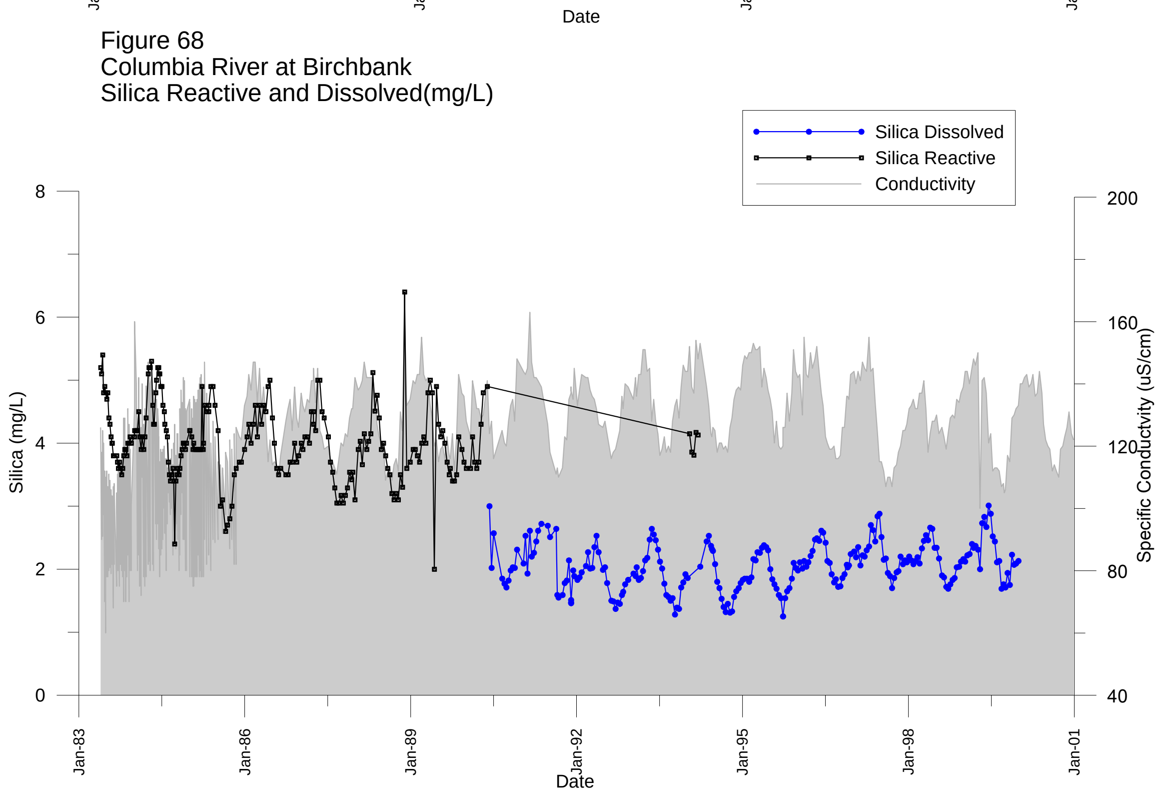


Figure 68
Columbia River at Birchbank
Silica Reactive and Dissolved(mg/L)
Silica Dissolved
Silica Reactive
Conductivity
Silica (mg/L)
Specific Conductivity (uS/cm)
8
6
4
2
0
200
160
120
80
40
Jan-83
Jan-86
Jan-89
Jan-92
Jan-95
Jan-98
Jan-01
Date

Figure 69
Columbia River at Birchbank
Silicon Extractable (mg/L)

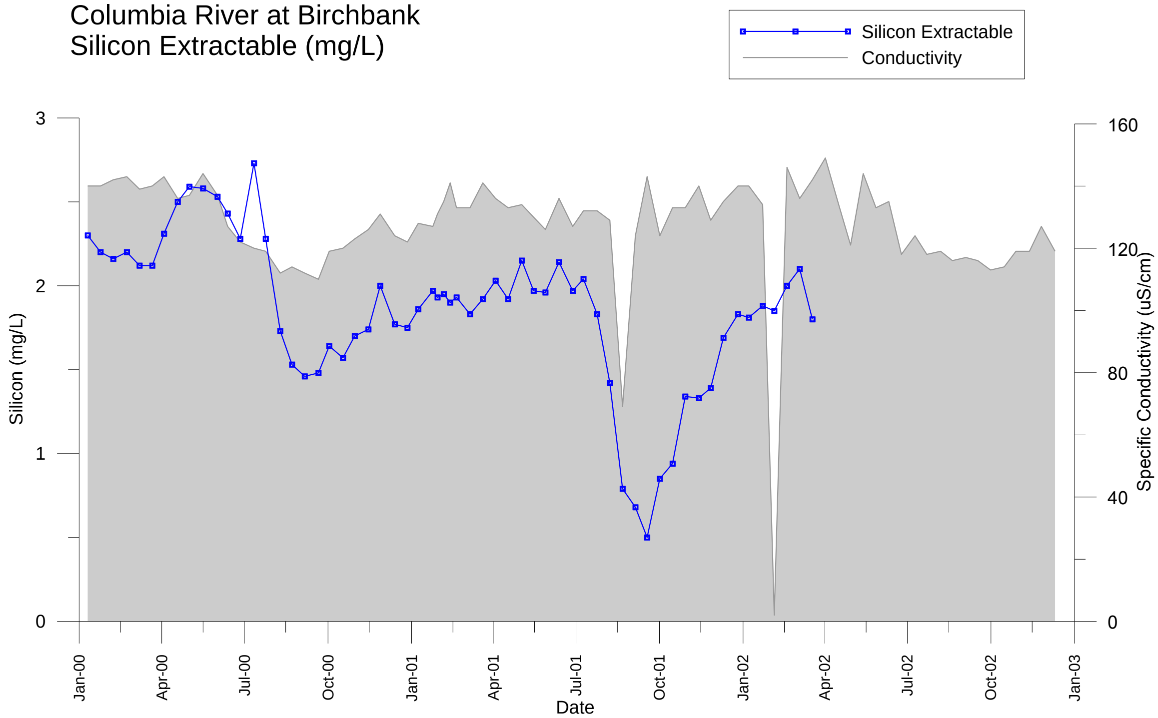


Figure 70
Columbia River at Birchbank
Silver Total and Extractable (ug/L)
1996 - 2006

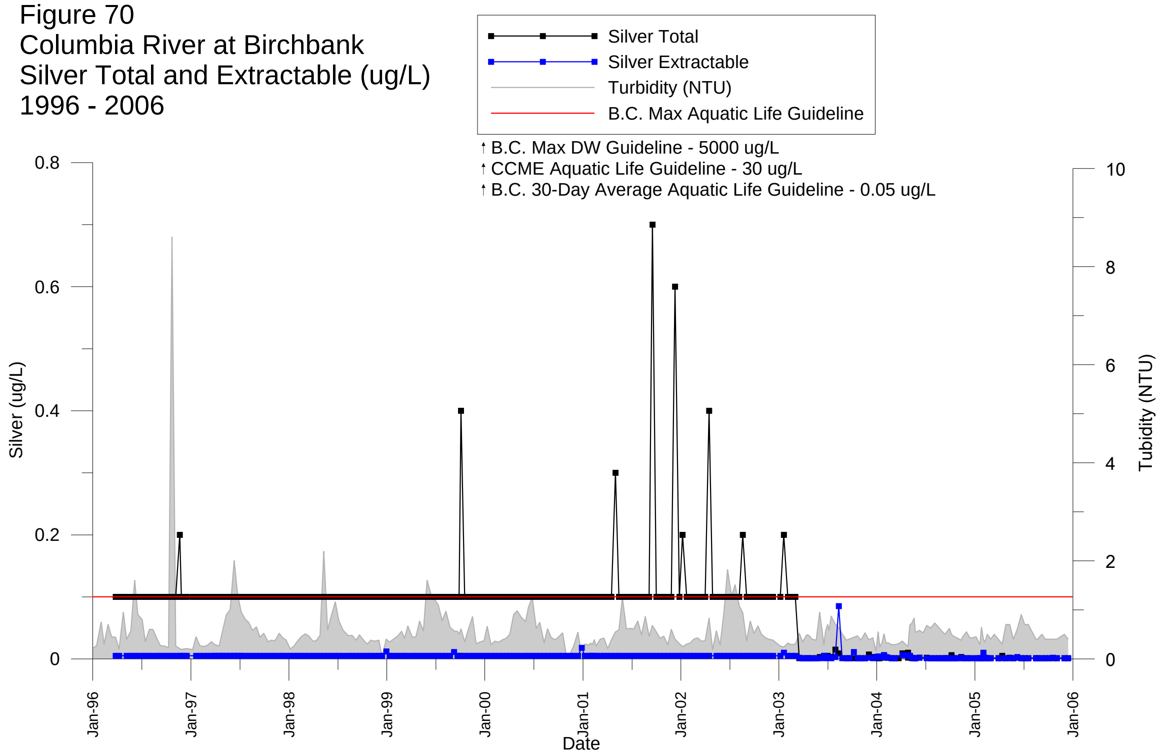


Figure 71
Columbia River at Birchbank
Silver Total and Extractable (ug/L)
2003 - 2006

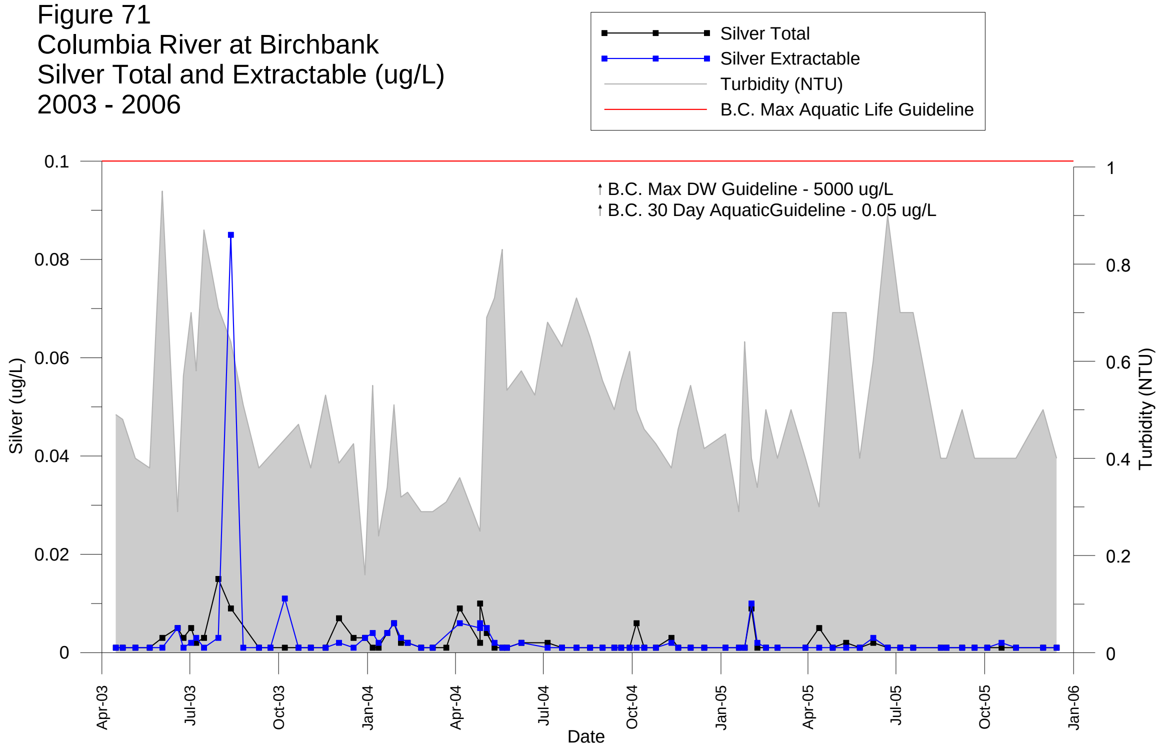


Figure 72
Columbia River at Birchbank
Sodium Dissolved and Extractable (mg/L)

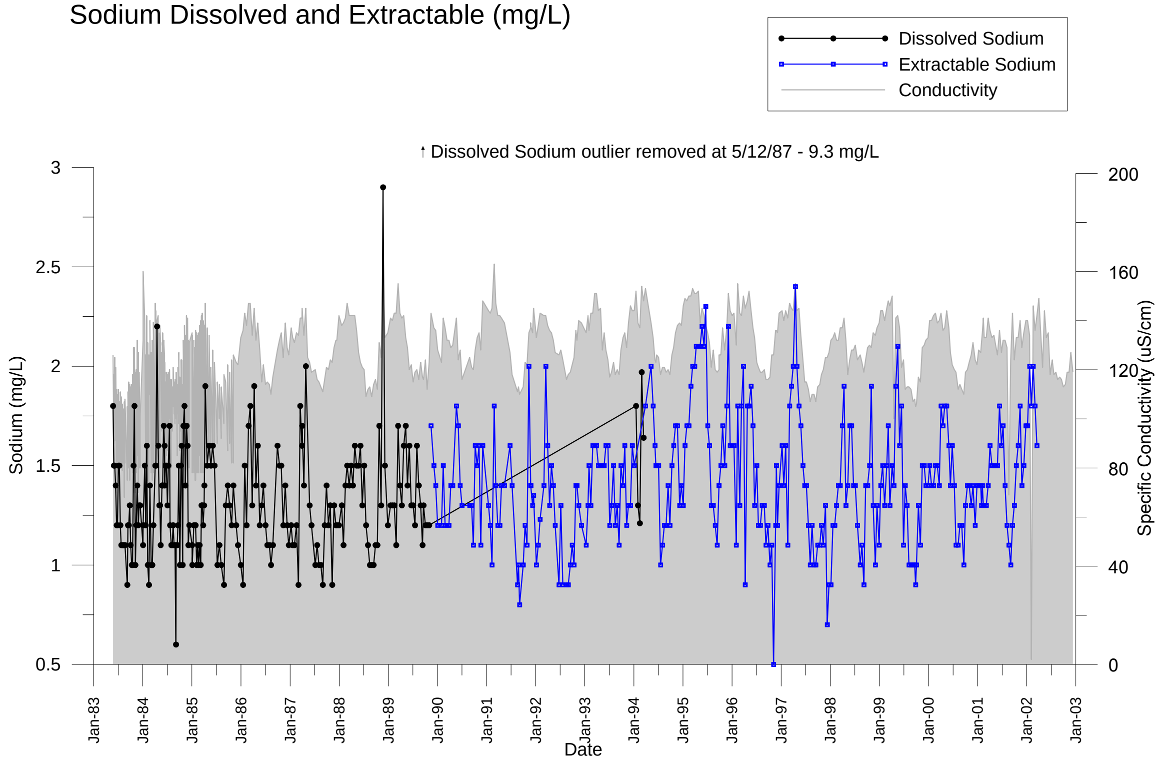


Figure 73
Columbia River at Birchbank
Specific Conductivity (uS/cm)

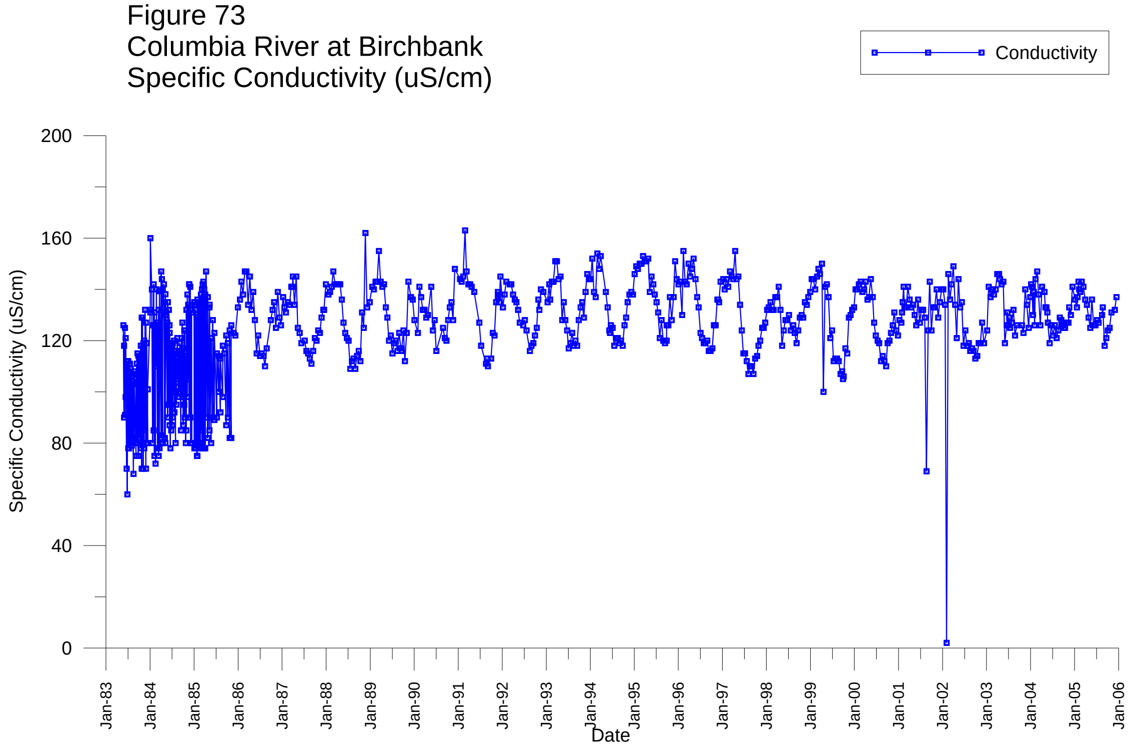


Figure 74
Columbia River at Birchbank
Strontium Total and Extractable (ug/L)

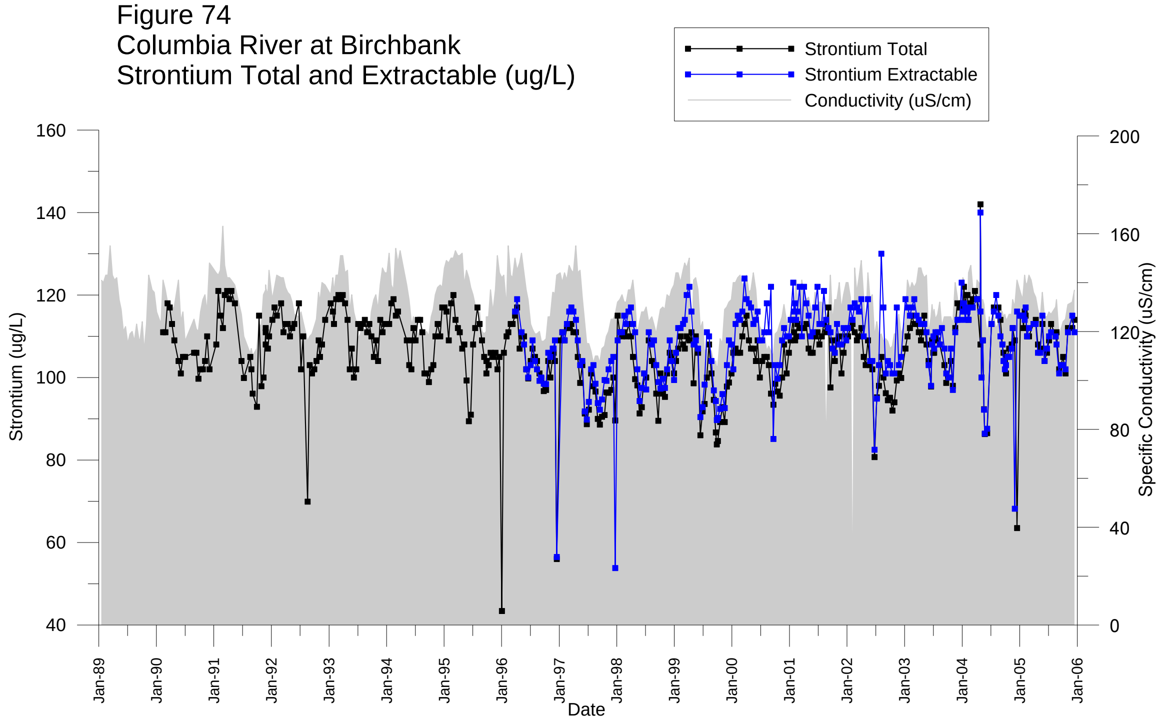


Figure 75
Columbia River at Birchbank
Sulphate Dissolved (mg/L)

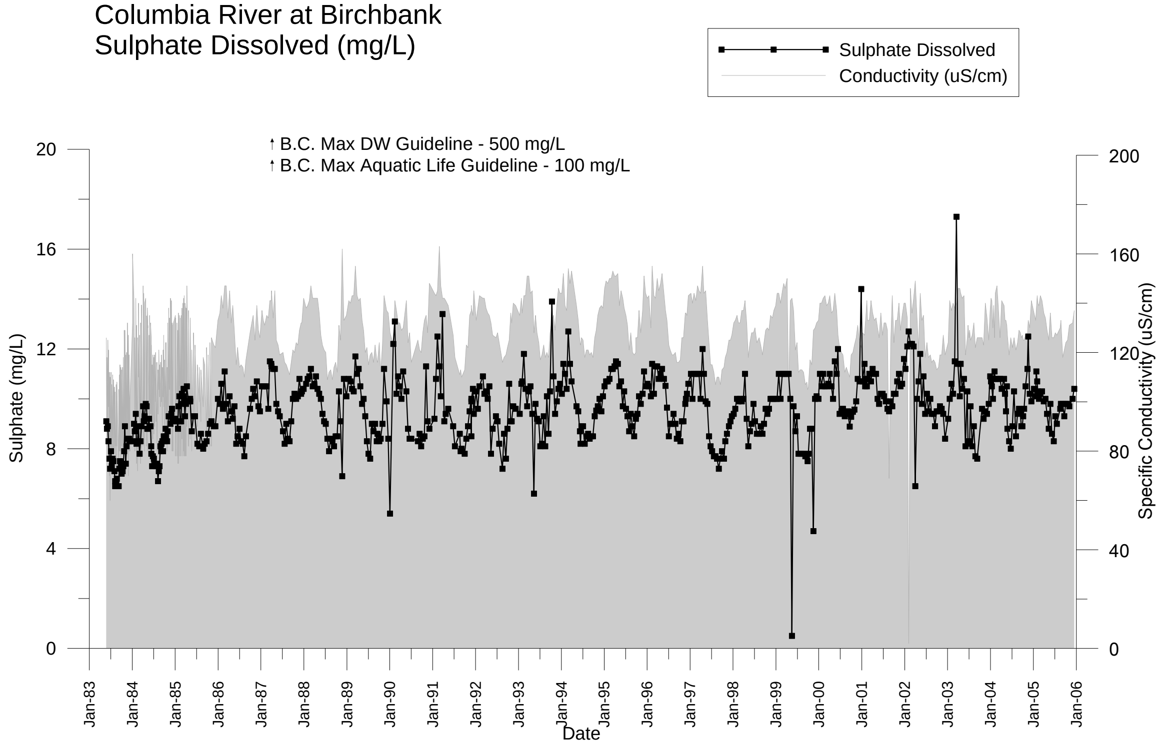
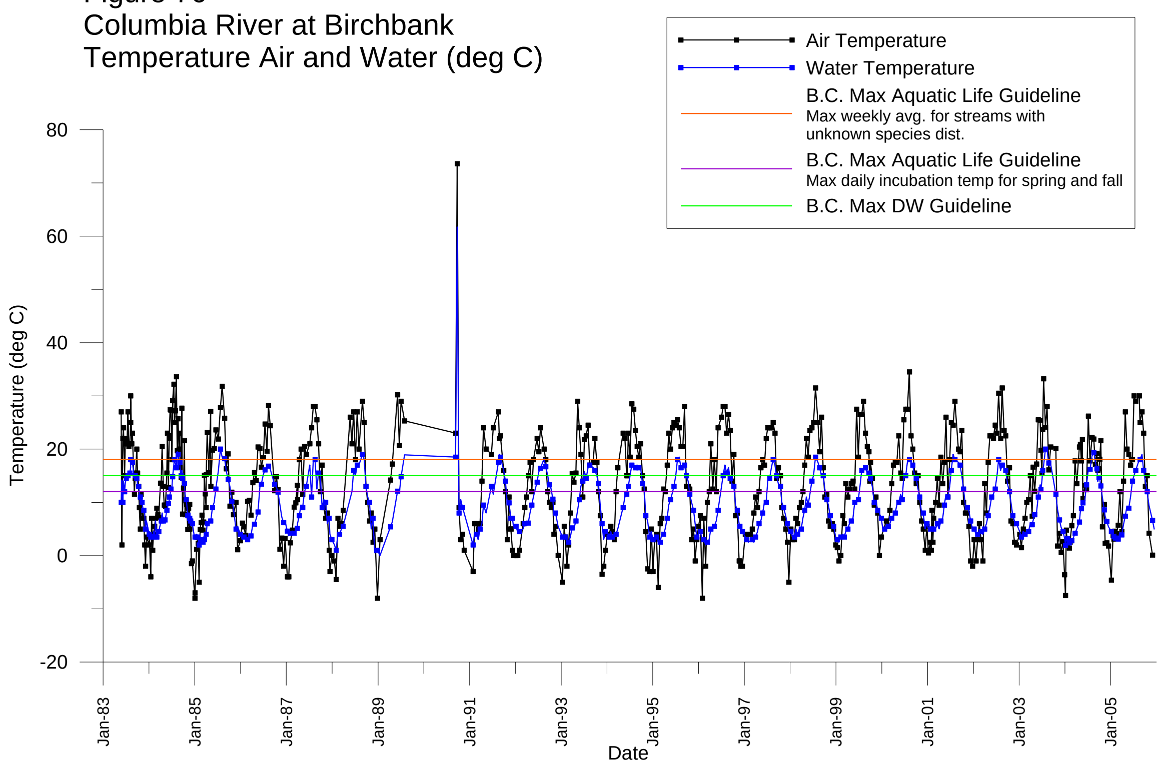


Figure 76
Columbia River at Birchbank
Temperature Air and Water (deg C)



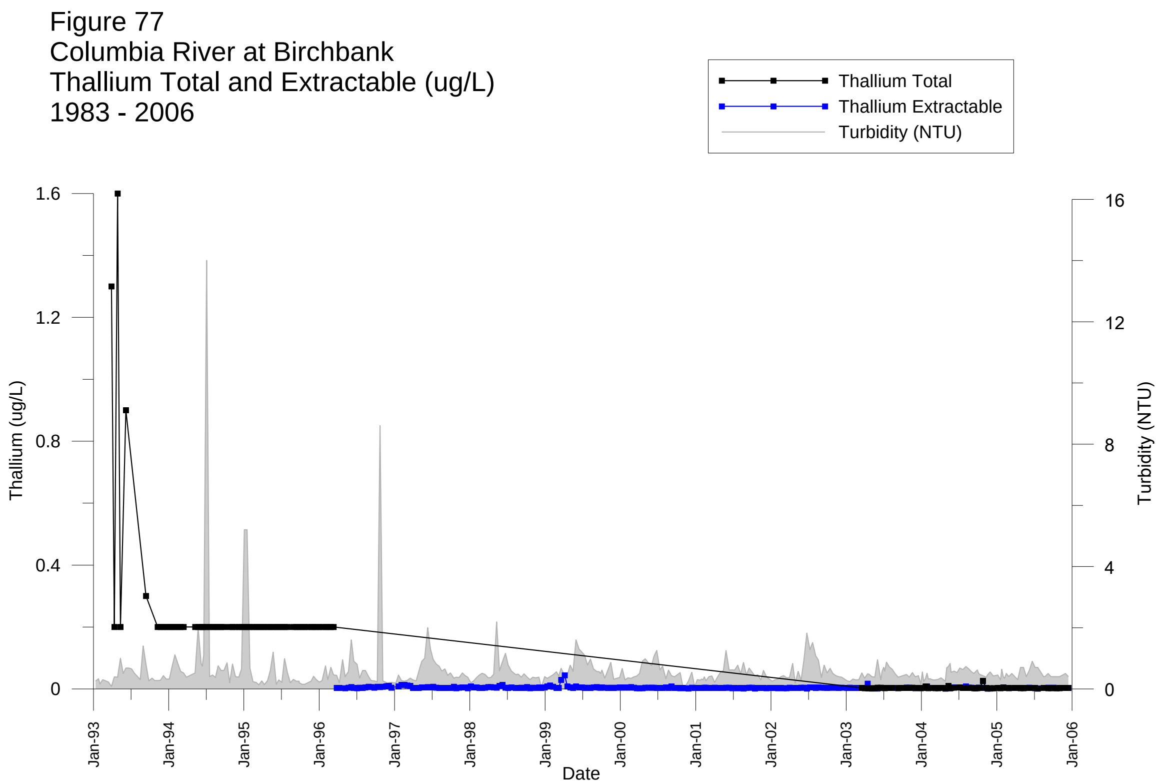


Figure 77
Columbia River at Birchbank
Thallium Total and Extractable (ug/L)
1983 - 2006
Thallium Total
Thallium Extractable
Turbidity (NTU)
Thallium (ug/L)
Turbidity (NTU)
0
0.4
0.8
1.2
1.6
0
4
8
12
16
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Date

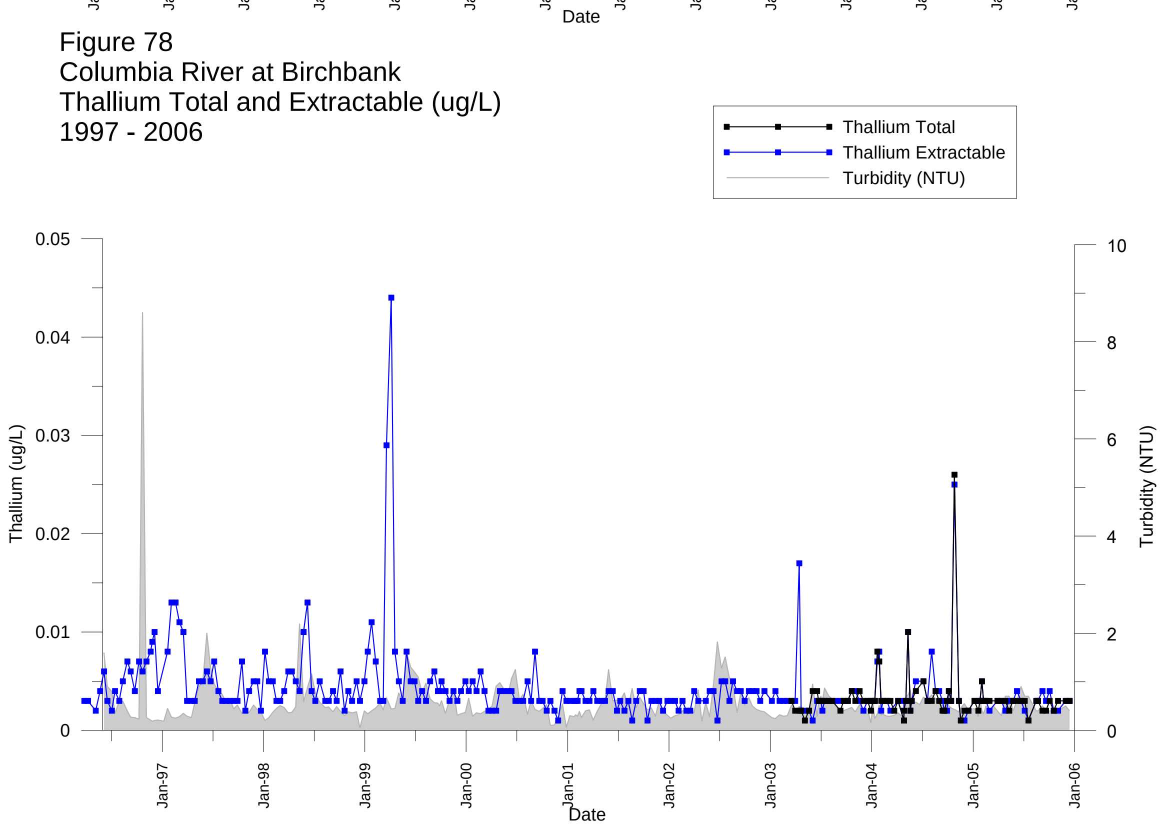


Figure 78
Columbia River at Birchbank
Thallium Total and Extractable (ug/L)
1997 - 2006
Thallium Total
Thallium Extractable
Turbidity (NTU)
Thallium (ug/L)
Turbidity (NTU)
0
0.01
0.02
0.03
0.04
0.05
0
2
4
6
8
10
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Date

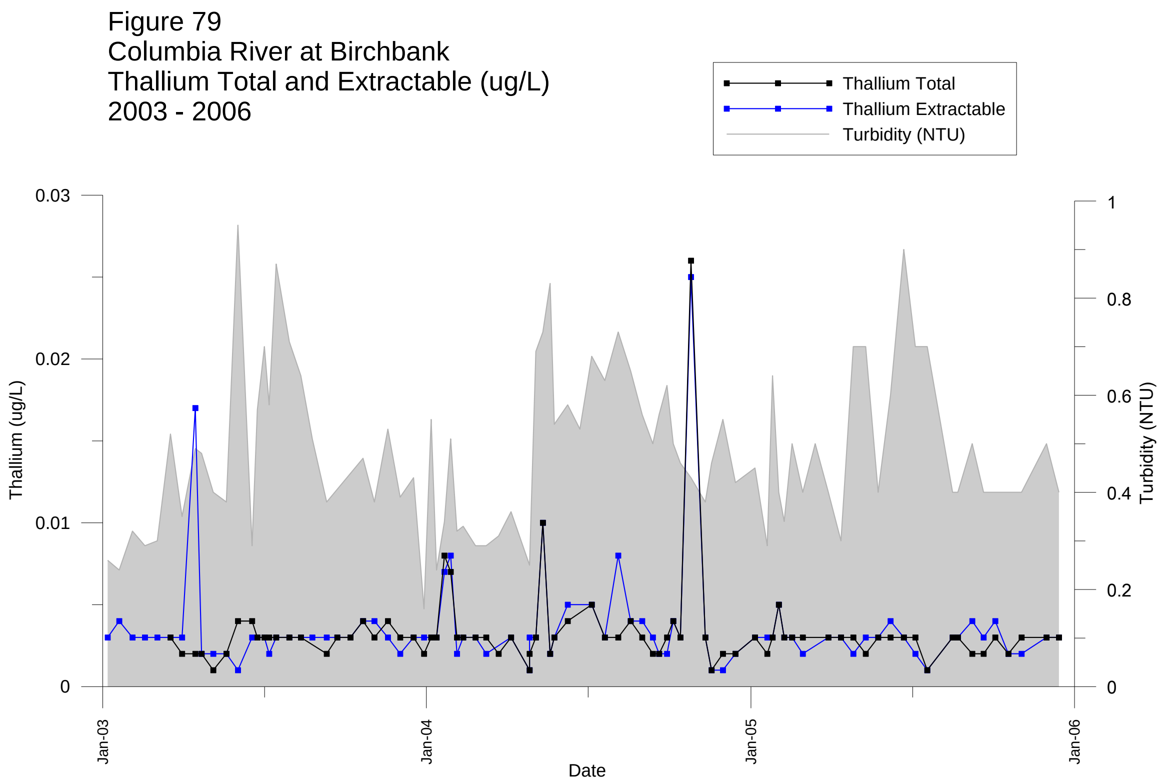


Figure 79
Columbia River at Birchbank
Thallium Total and Extractable (ug/L)
2003 - 2006

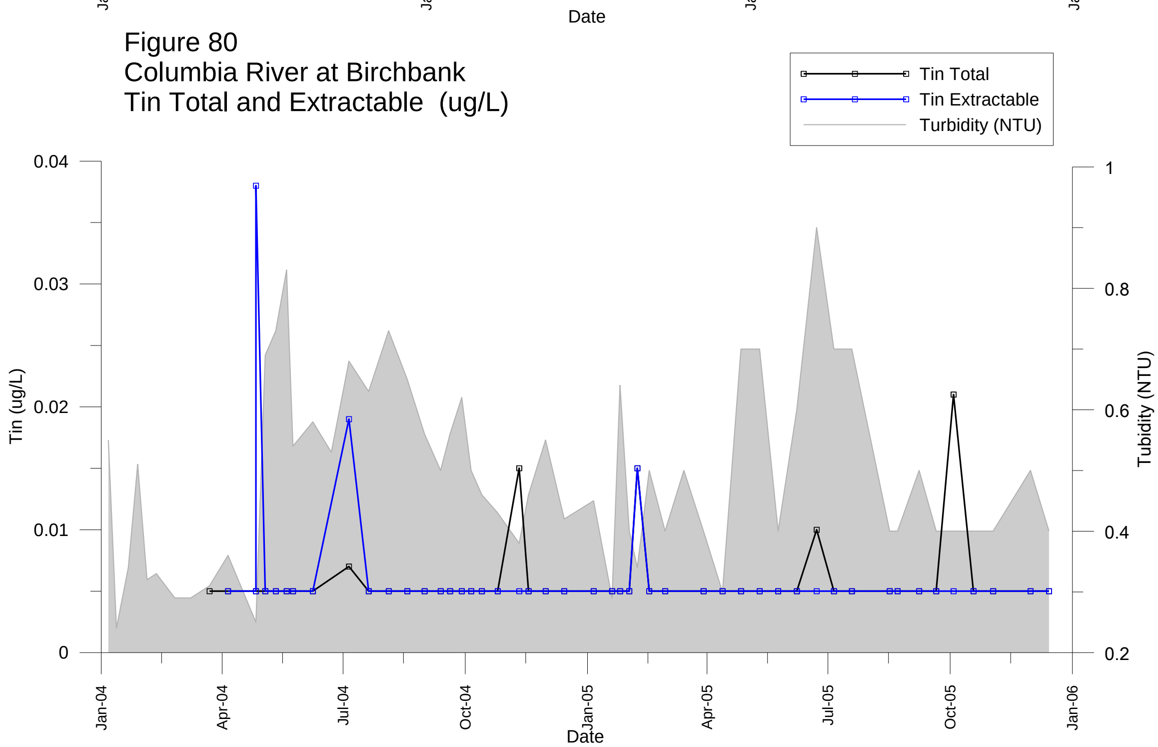


Figure 80
Columbia River at Birchbank
Tin Total and Extractable (ug/L)

Figure 81
Columbia River at Birchbank
Turbidity (NTU)

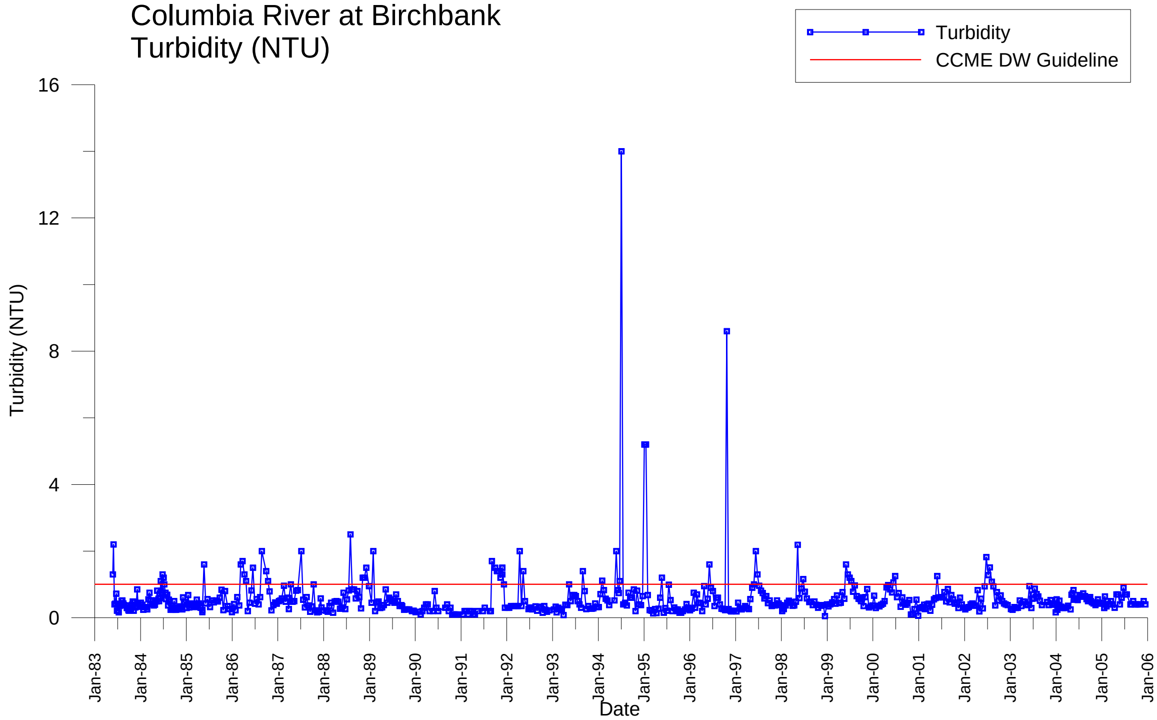


Figure 82
Columbia River at Birchbank
Uranium Total and Extractable (ug/L)
1996 - 2006

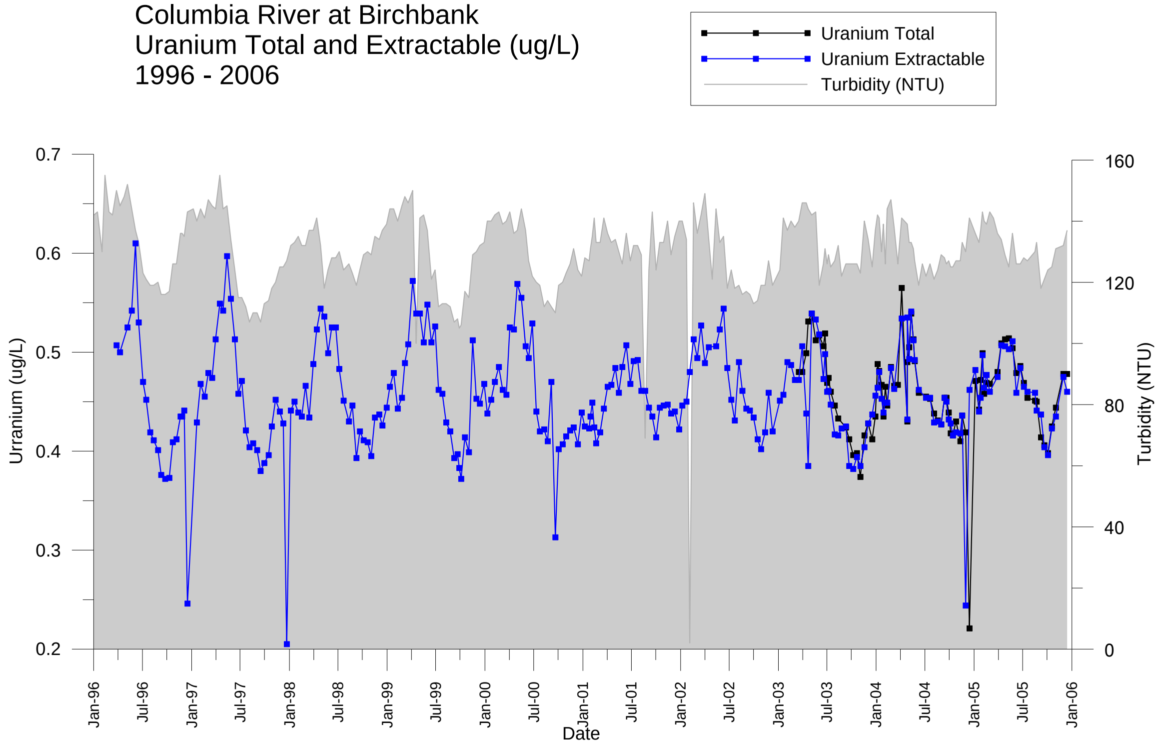


Figure 83
Columbia River at Birchbank
Uranium Total and Extractable (ug/L)
2003 - 2006

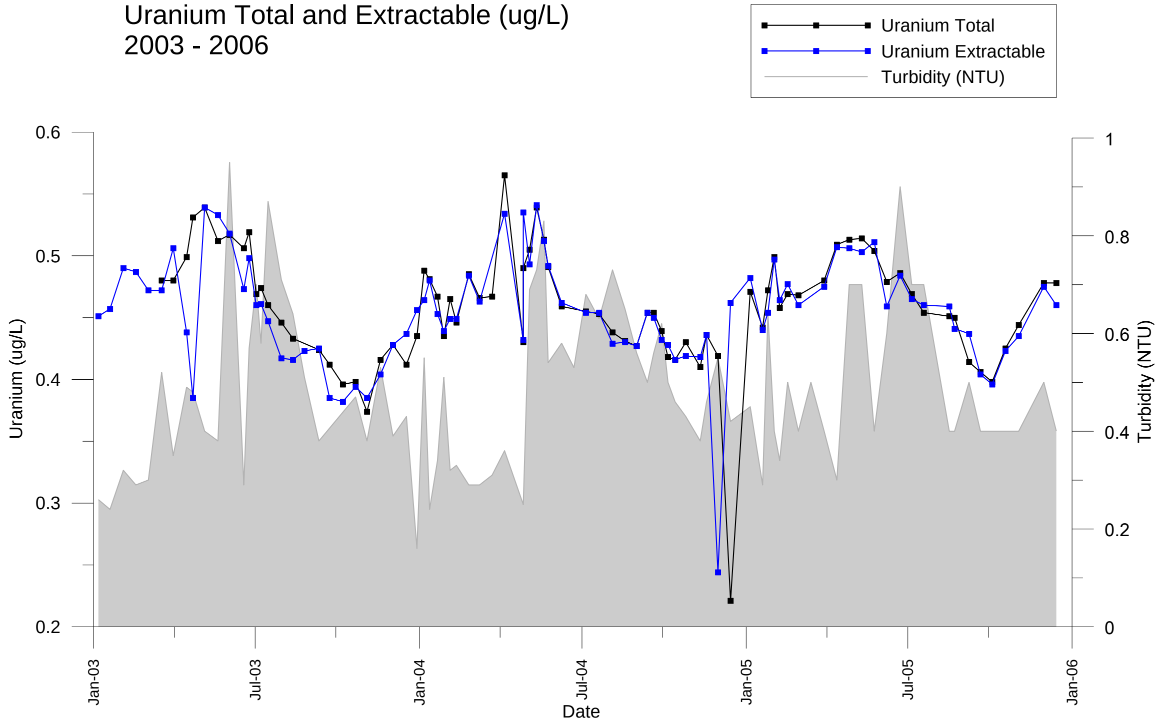


Figure 84
Columbia River at Birchbank
Vanadium Total and Extractable (ug/L)
1990 - 2006

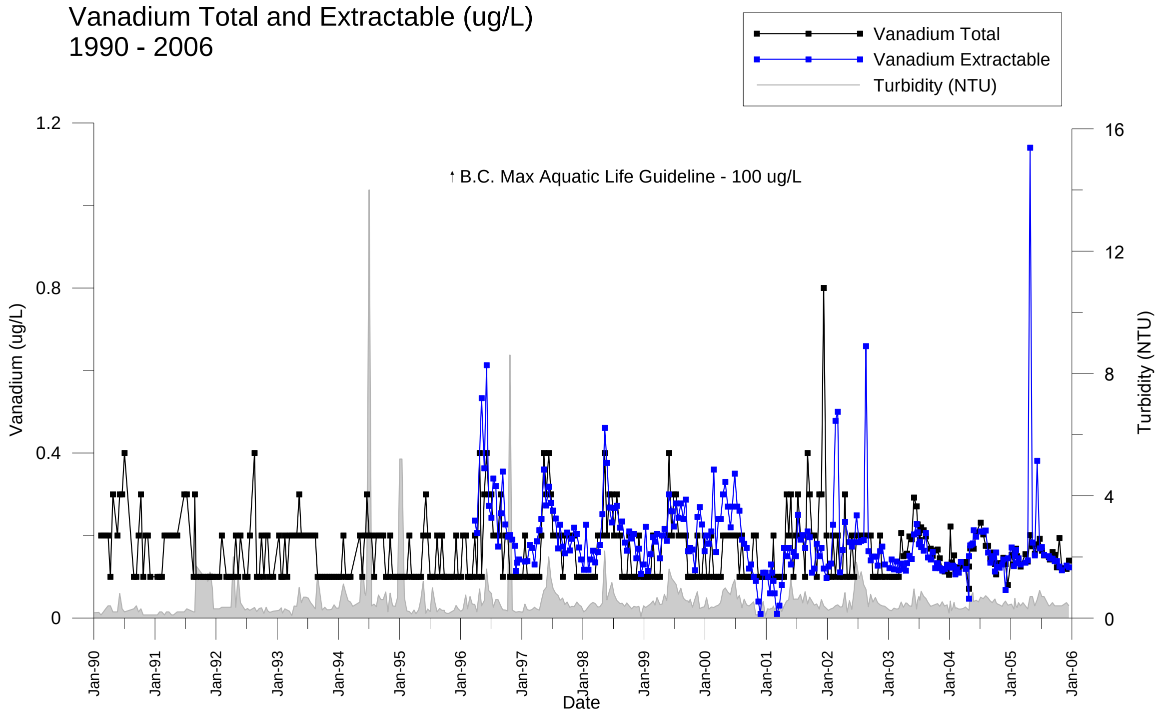


Figure 85
Columbia River at Birchbank
Vanadium Total and Extractable (ug/L)
1996 - 2006

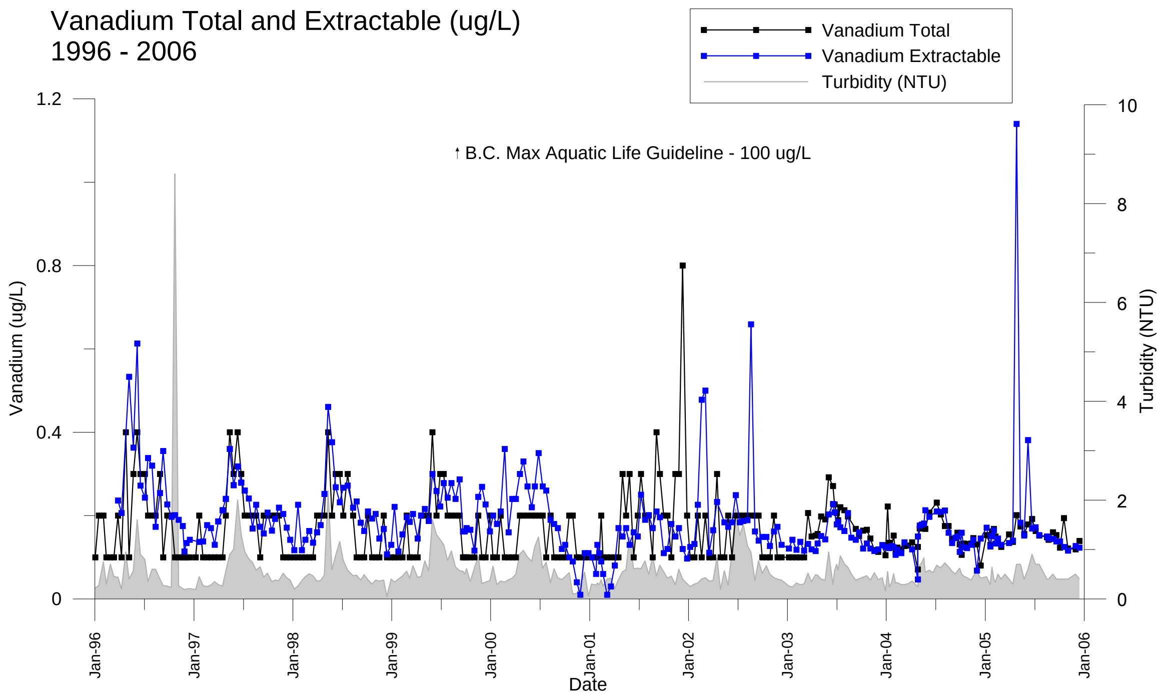


Figure 86
Columbia River at Birchbank
Zinc Total and Extractable (ug/L)
1983 - 2004

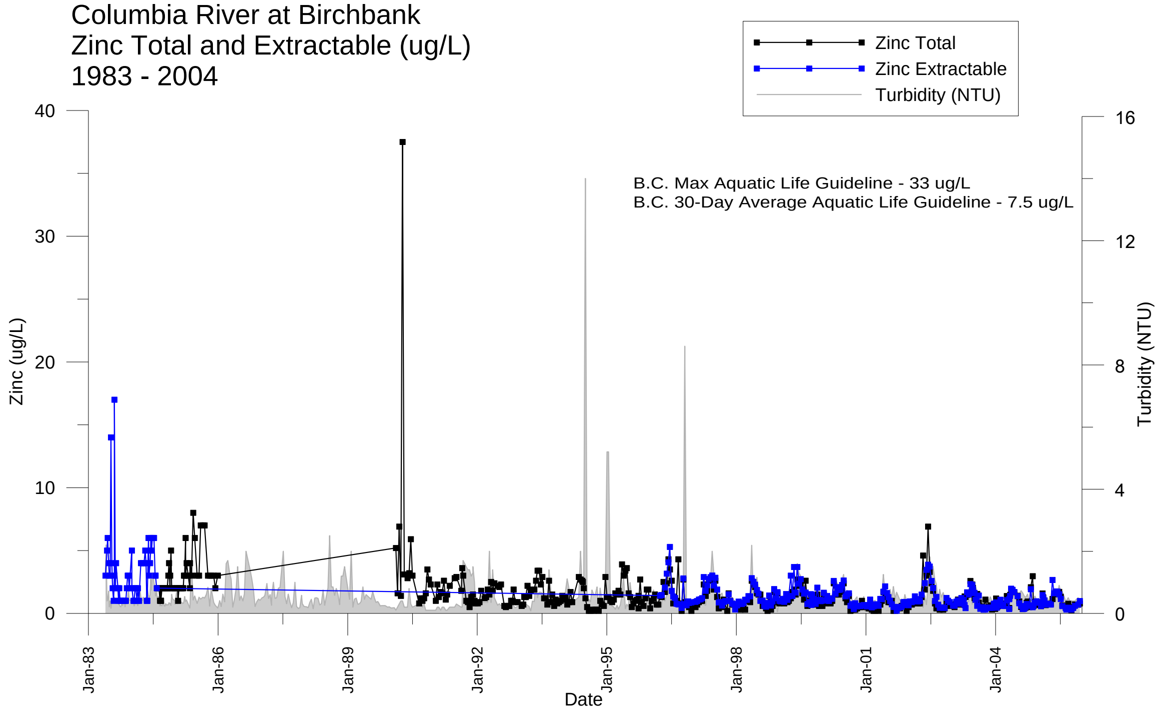


Figure 87
Columbia River at Birchbank
Zinc Total and Extractable (ug/L)
1996 - 2006