CANADA – BRITISH COLUMBIA
WATER QUALITY MONITORING AGREEMENT

WATER QUALITY ASSESSMENT OF Columbia River AT NICHOLSON (2003 – 2006)

Prepared by:
L. G. Swain, P. Eng.
B.C. Ministry of Environment

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

August 2007

Environment Canada Environnement Canada

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, and at Nicholson drains 6660 km^2 of the headwaters of the river, 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 Purcells and Rockies drain to the Columbia River and the glacial silt imparts a gray, muddy colour to the river at times.This assessment is based on up to four years of water quality data collected during 2003-2006.

The main human activities in the Columbia River watershed are forestry, outdoor tourism, and residential and commercial development.

CONCLUSIONS

- The data base is of too short a duration to detect any long-term trends of increasing or decreasing concentrations that may be present.
- 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, iron, lead and zinc.

RECOMMENDATIONS

We recommend monitoring be continued for the Columbia River at Nicholson since it serves as an upstream station for the lower Columbia River sites. It is the only site monitored on the Columbia River that does not have flows regulated by dams and thus reflects the natural pattern of concentrations relative to solids concentrations.

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

The photo on the front cover was provided by Jolene Raggett of B.C. Ministry of Environment. The graphs in this report were prepared by Sacha Wassick of Environment Canada. The draft report was reviewed by Jolene Raggett of BC Environment and Andrea Ryan of Environment Canada. Tri-Star Environmental Consulting completed the final edits for the report. We thank these individuals for their contributions to improving this document. Any errors or omissions are the responsibility of the author.

TABLE OF CONTENTS

Page

LIST OF FIGURES

Page

LIST OF FIGURES
(CONTINUED)

Page

LIST OF FIGURES (CONTINUED)

Page

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 primary 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, although the data are also used for a variety of other purposes.

The Columbia River watershed is located in the southeast corner of British Columbia. Water quality measurements for the Columbia River at Nicholson are from samples collected from the upstream side of the Nicholson Road Bridge accessed from the exit off Highway 95, 10 km south from Golden, B.C.; site coordinates are 54^{o} 14' 38" N and 116 ^{o} 54' 42" W. The drainage area at this point is 6660 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 that drain to the Columbia River and the glacial silt imparts a gray, muddy colour to the river at times.

This assessment is based on up to four years of water quality data collected during 2003-2006. The data were plotted on graphs over time, along with the relevant water quality guidelines. The graphs were inspected for guideline exceedences and potential "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. However, any visual trends that may be noted cannot be tested statistically for significance until a much longer data set (i.e. minimum eight years) is obtained.

Main influences on water quality include open pit forestry, outdoor tourism, and residential and commercial development. There are also non-point source discharges from agriculture, urban development, forestry, transportation and stream bank erosion.

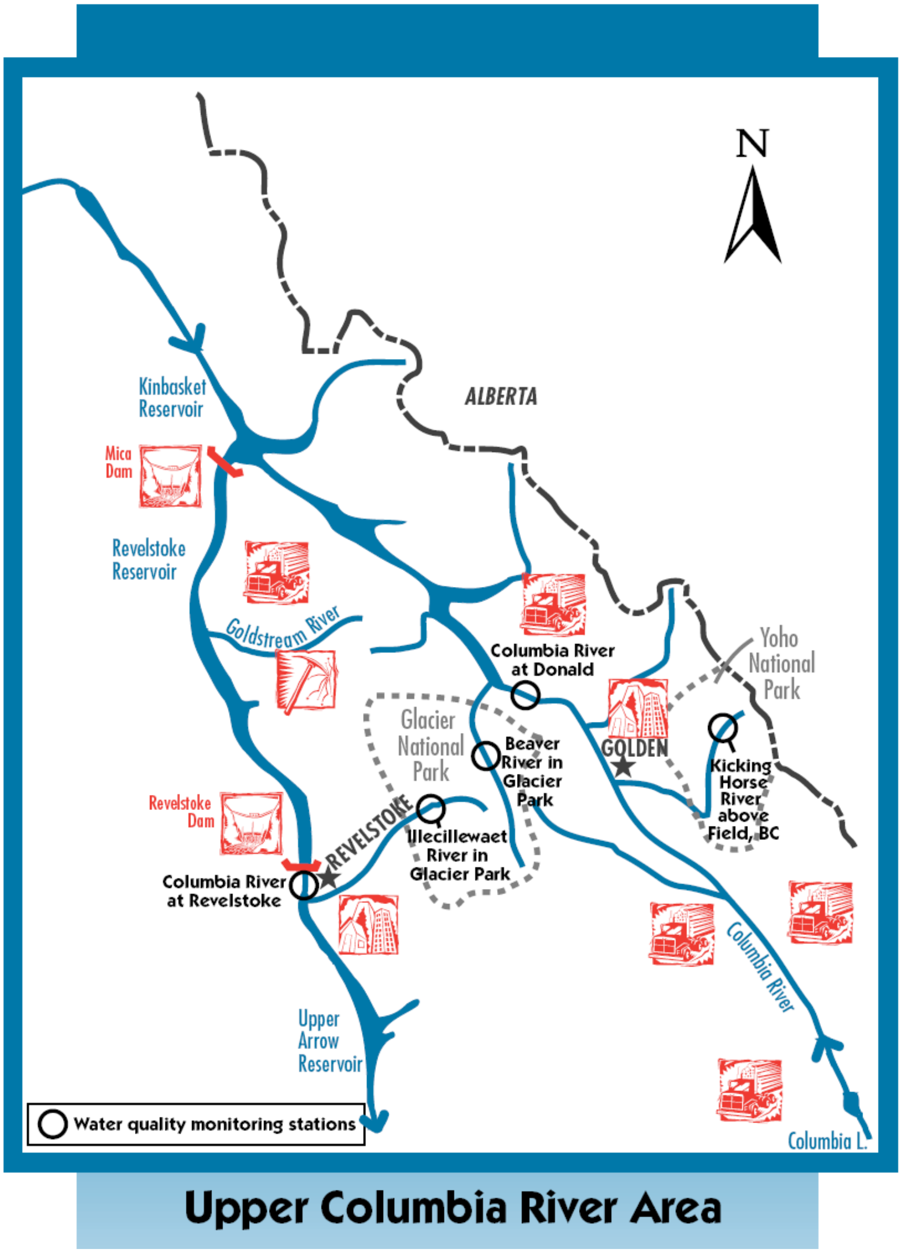


FIGURE 1: COLUMBIA RIVER AT NICHOLSON

WATER QUALITY ASSESSMENT

Data for the Columbia River at Nicholson 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 for assessment using water quality objectives. In addition, quality assurance samples (blanks and replicates) are collected three times per year. The 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) regarding possible or likely errors.

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 below.

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

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

The following water quality indicators were not discussed as they met all water quality guidelines (if guidelines exist) and showed no clearly visible trends: true colour, lithium, pH.

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 arsenic, beryllium, bismuth, cobalt, copper, gallium, lanthanum, manganese, niobium, nickel, rubidium, antimony, selenium, silver, tin, thallium, vanadium and total phosphorus.

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 did not exceed guideline values (if guidelines exist) included: alkalinity, dissolved ammonia, boron, barium, calcium, dissolved organic carbon, fluoride, hardness, magnesium, molybdenum, total dissolved nitrogen, strontium, sulphate, and uranium.

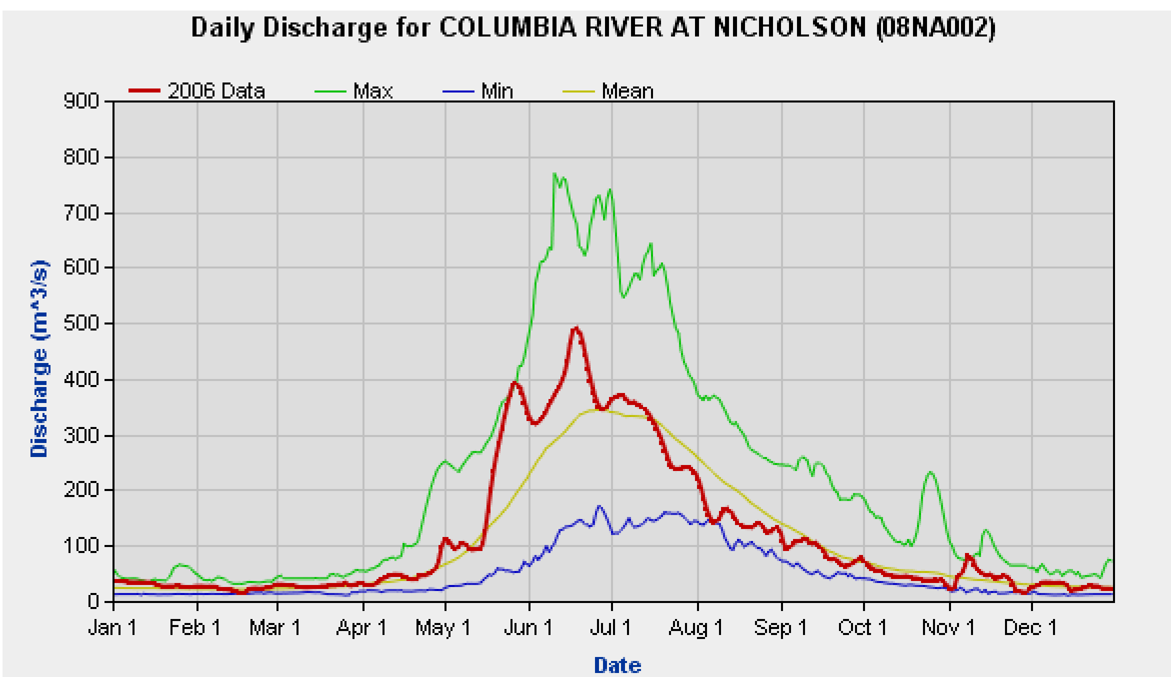


FIGURE 2: WATER SURVEY OF CANADA FLOW DATA FOR COLUMBIA RIVER AT NICHOLSON

Flow (Figure 2) values which are uncontrolled peak during the months from May through August, with lowest flows being recorded in the November through April period. Maximum flows can exceed 750 m^3/s.

Total **Aluminum** (Figure 3) concentrations frequently exceed the guidelines for dissolved concentrations; however, these high values were correlated with high turbidity levels which means that the aluminum are likely not biologically available.

Cadmium (Figure 12) exceeded the aquatic life guideline on one occasion; however, values were also correlated with turbidity levels meaning that the cadmium is likely in particulate form and not biologically available.

Fecal coliforms (Figure 15), **Escherichia coli** (Figure 19)and **Enterococus** (Figure 20) occasionally exceeded the guideline for drinking water supplies receiving only disinfection. This means that water supplies withdrawn from the Columbia River near Nicholson should receive partial treatment as a minimum, as well as disinfection.

Chromium (Figure 17) at times exceeded the guideline for hexavalent chromium of 1 ug/L; however, all values were less than the guideline value of 8.9 ug/L for trivalent chromium. Chromium concentrations were closely correlated with turbidity levels, meaning that the higher chromium was likely associated with particulate matter and would not be biologically available.

Iron (Figure 22) concentrations regularly exceeded the guideline to protect aquatic life and source waters used for drinking water supplies. The concentrations were correlated with higher turbidity levels, meaning that they would likely not be biologically available and would be removed when partial treatment for drinking waters was employed.

Lead values (Figure 26) occasionally exceeded the aquatic life guideline that is dependent on hardness concentrations. However, the degree that values exceeded the guideline was minimal. In addition, lead concentrations were correlated with turbidity levels, meaning that the lead was likely in particulate form and not biologically available.

Nitrate/nitrite (Figure 32) nitrogen values regularly exceeded the guideline for nitrite alone and correlated with specific conductivity concentrations; however, in well oxygenated systems such as the Columbia River, it is likely that nitrate would be the dominant form and that little, if any, nitrite would be present. If this is the case, all guidelines were easily achieved.

Water temperature (Figure 45) values occasionally exceeded the guideline for maximum temperatures for streams with unknown fish distributions. These higher concentrations occurred during the warm summer months.

Zinc (Figure 52) exceeded the hardness-based guideline once in 2003. Although zinc concentrations correlated with turbidity levels, and the zinc would likely be in particulate matter and not biologically available, we believe the zinc value is likely an error. The reason for this is that the total concentration on that day was nearly four times higher than the extractable concentration; every other total:extractable ratio is less than 2:1. Most other total metals exhibit a similar pattern on the same date, and will also be flagged accordingly.

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.

Figure 3
Columbia River at Nicolson
Aluminum Total and Extractable (ug/L)

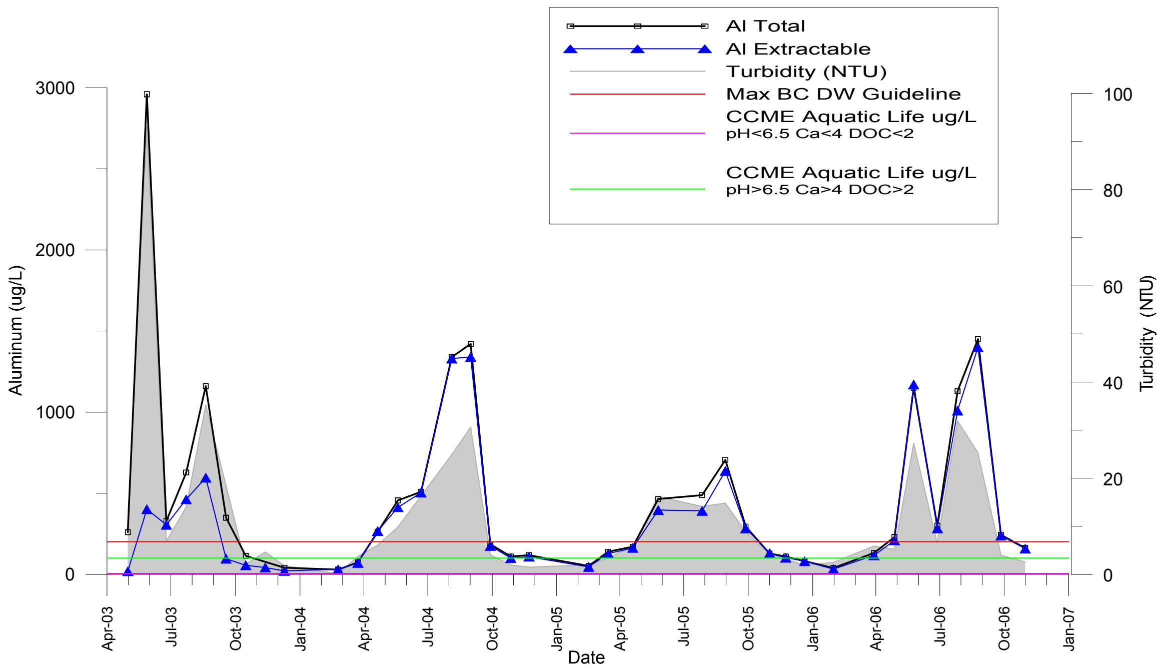
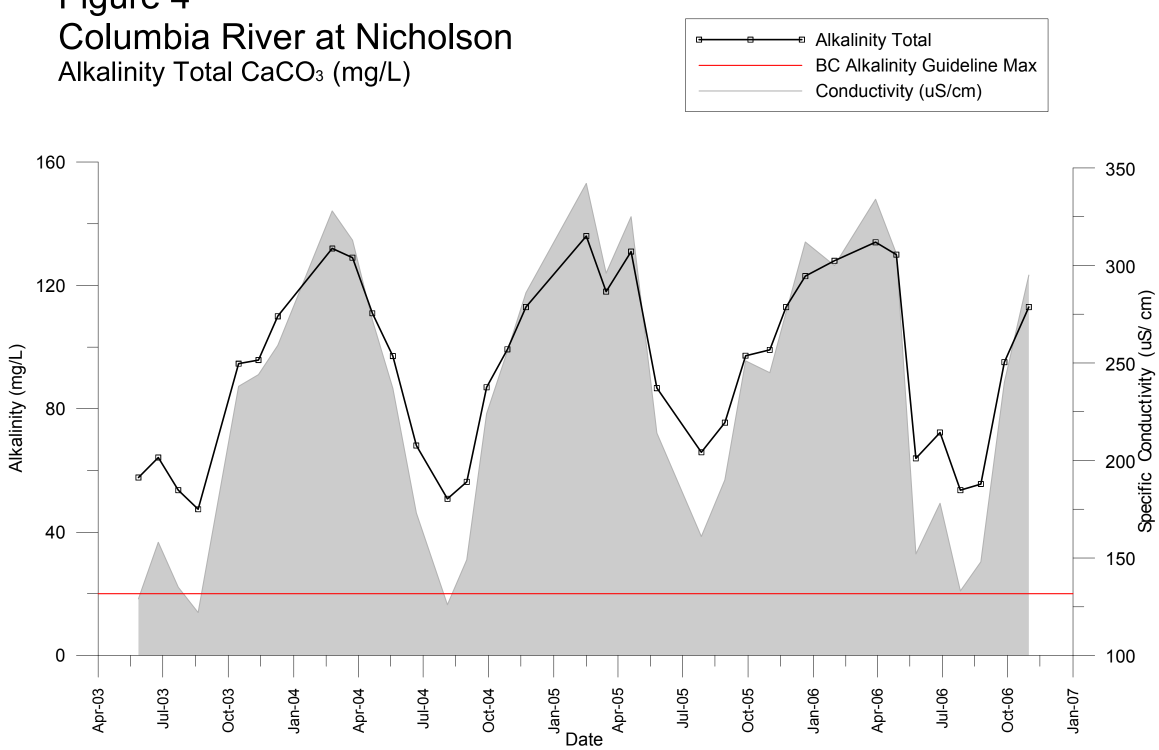


Figure 4
Columbia River at Nicholson
Alkalinity Total $CaCO_3$ (mg/L)



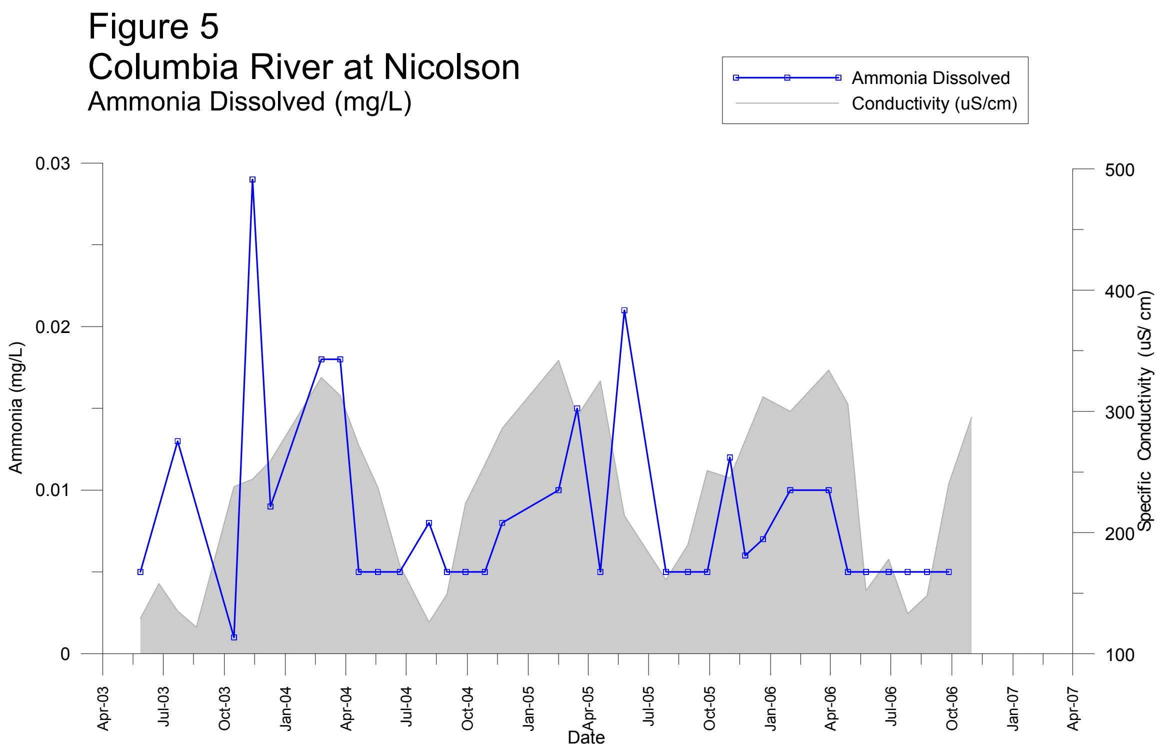


Figure 5
Columbia River at Nicolson
Ammonia Dissolved (mg/L)
Ammonia Dissolved
Conductivity (uS/cm)
Ammonia (mg/L)
Specific Conductivity (uS/ cm)
Date
0.03
0.02
0.01
0
500
400
300
200
100
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05
Apr-05
Jul-05
Oct-05
Jan-06
Apr-06
Jul-06
Oct-06
Jan-07
Apr-07

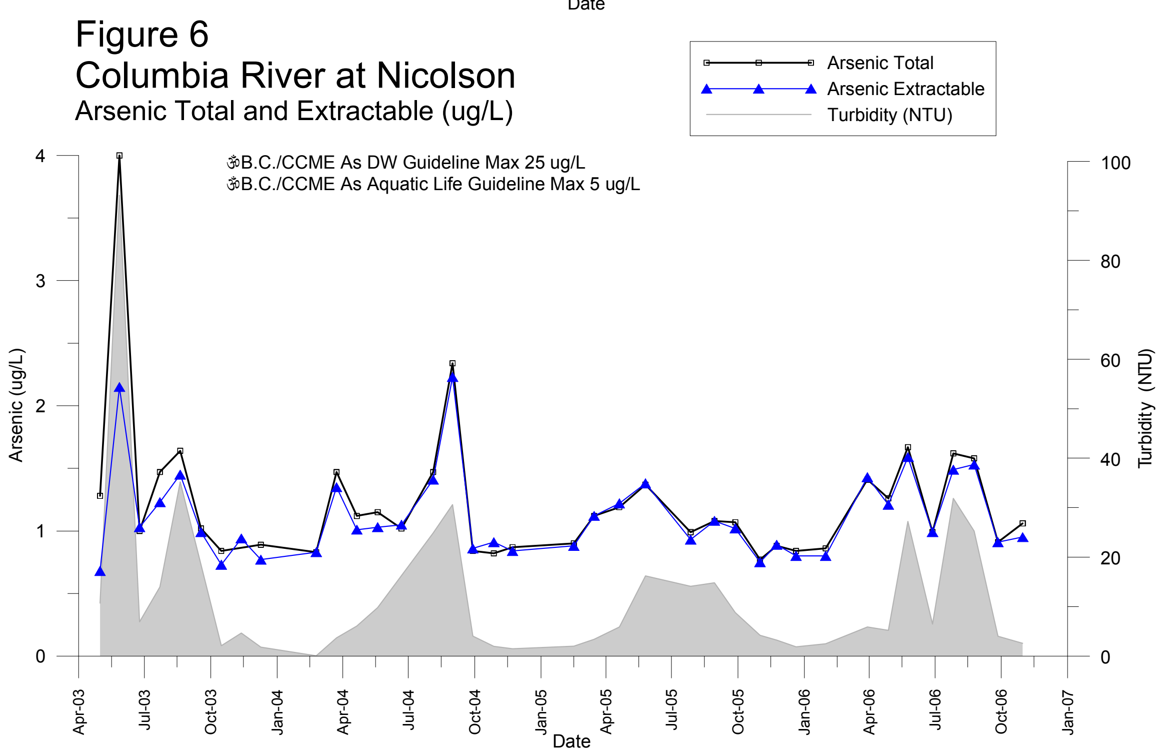


Figure 6
Columbia River at Nicolson
Arsenic Total and Extractable (ug/L)
Arsenic Total
Arsenic Extractable
Turbidity (NTU)
B.C./CCME As DW Guideline Max 25 ug/L
B.C./CCME As Aquatic Life Guideline Max 5 ug/L
Arsenic (ug/L)
Turbidity (NTU)
Date
4
3
2
1
0
100
80
60
40
20
0
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05
Apr-05
Jul-05
Oct-05
Jan-06
Apr-06
Jul-06
Oct-06
Jan-07

Figure 7
Columbia River at Nicolson
Boron Total and Extractable (ug/L)

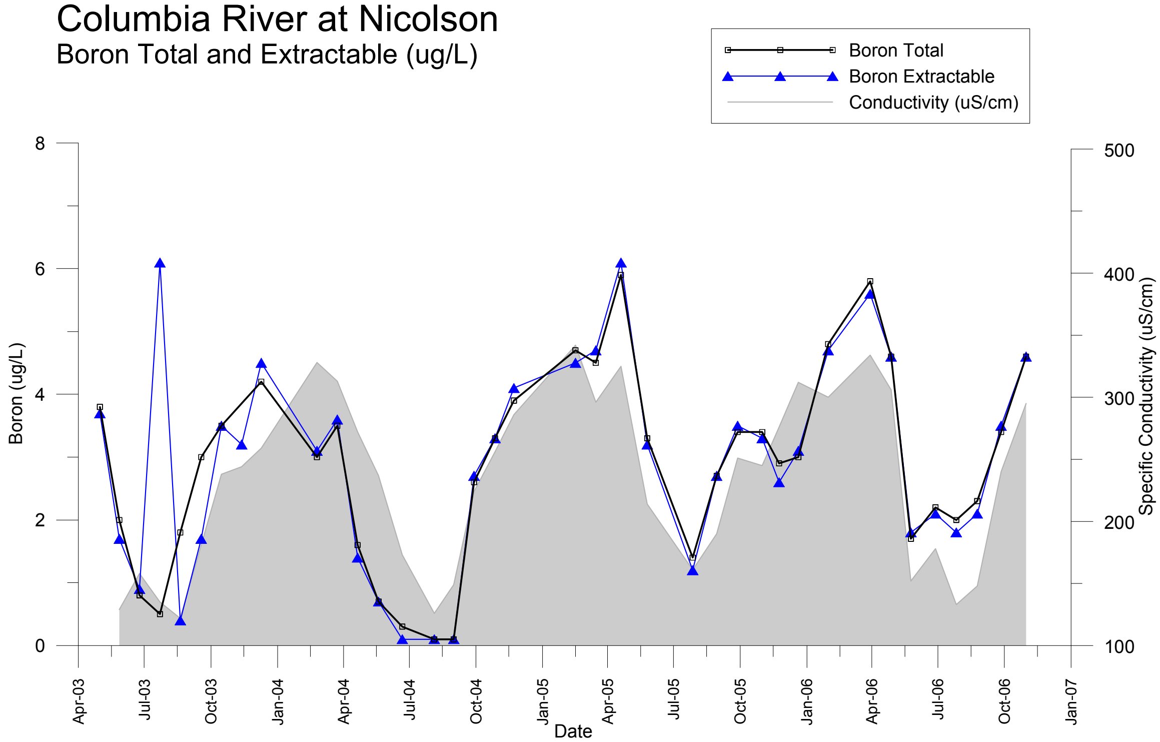


Figure 8
Columbia River at Nicolson
Barium Total and Extractable (ug/L)

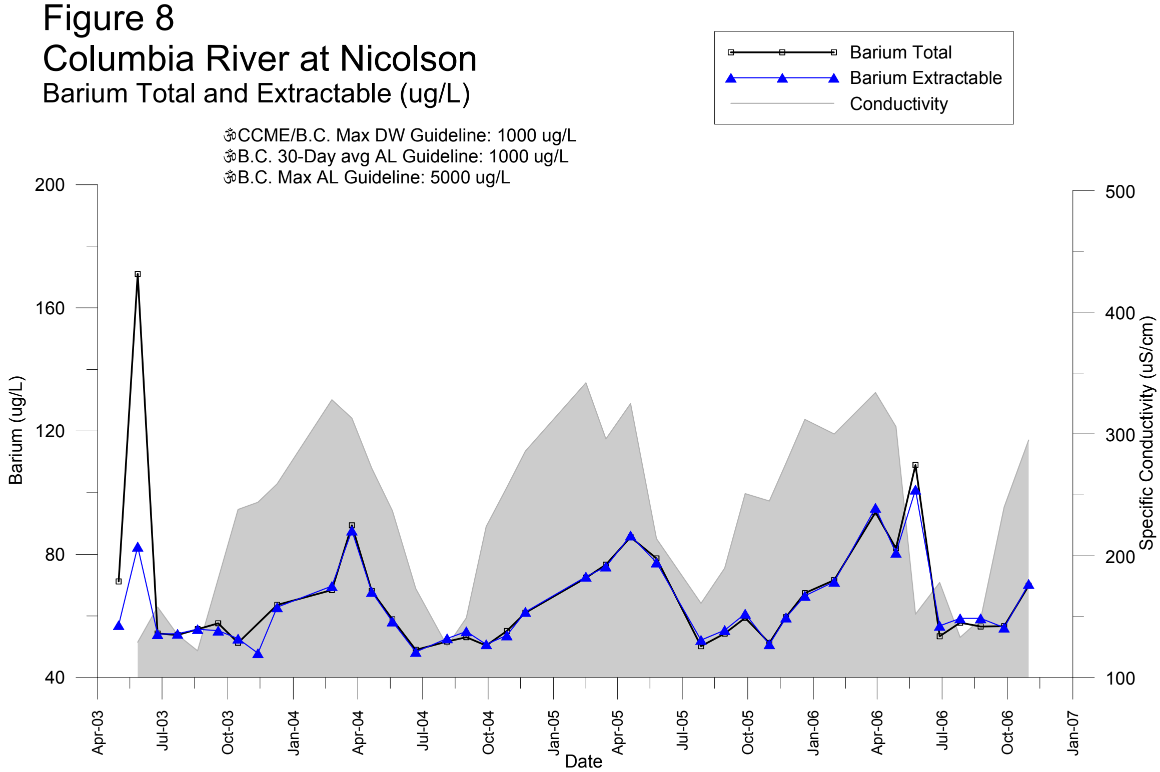


Figure 9
Columbia River at Nicolson
Beryllium Total and Extractable (ug/L)

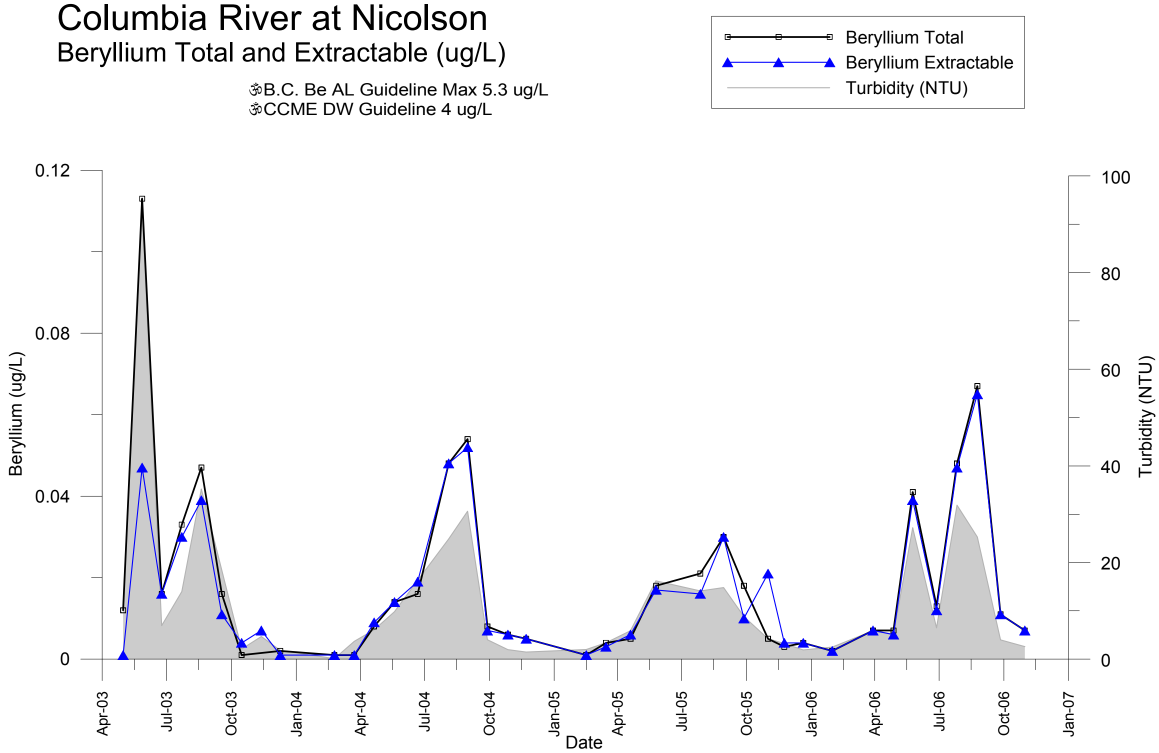


Figure 10
Columbia River at Nicolson
Bismuth Total and Extractable (ug/L)

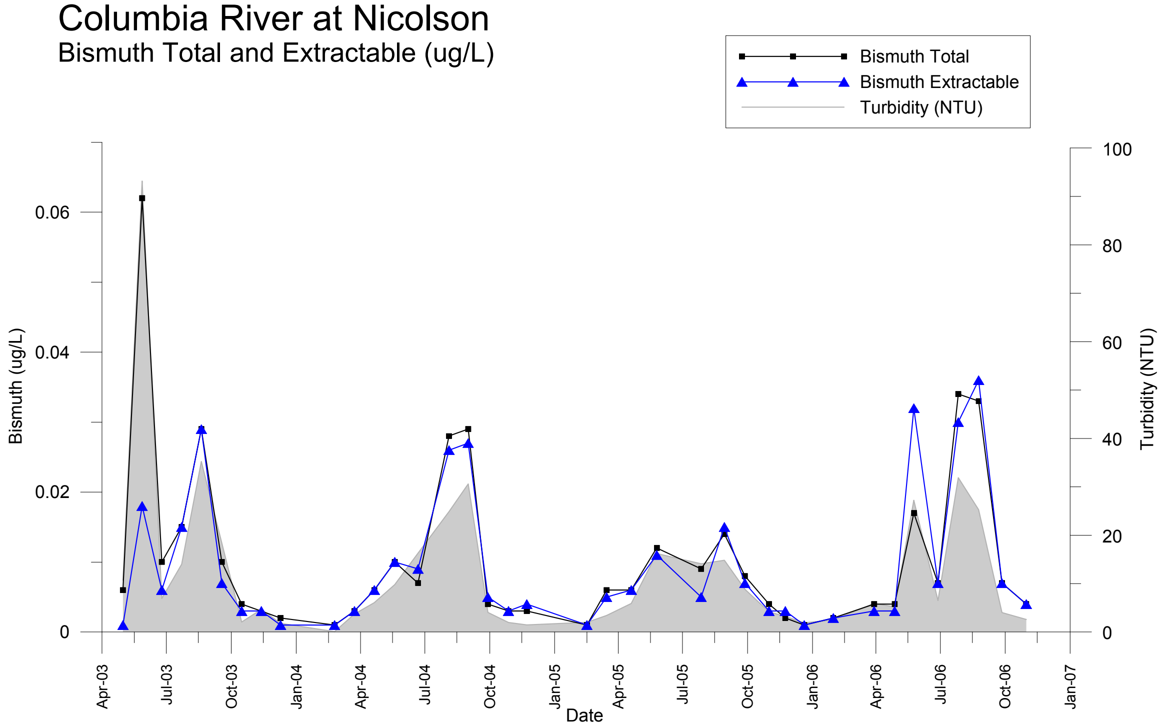


Figure 11
Columbia River at Nicolson
Calcium Dissolved (mg/L)

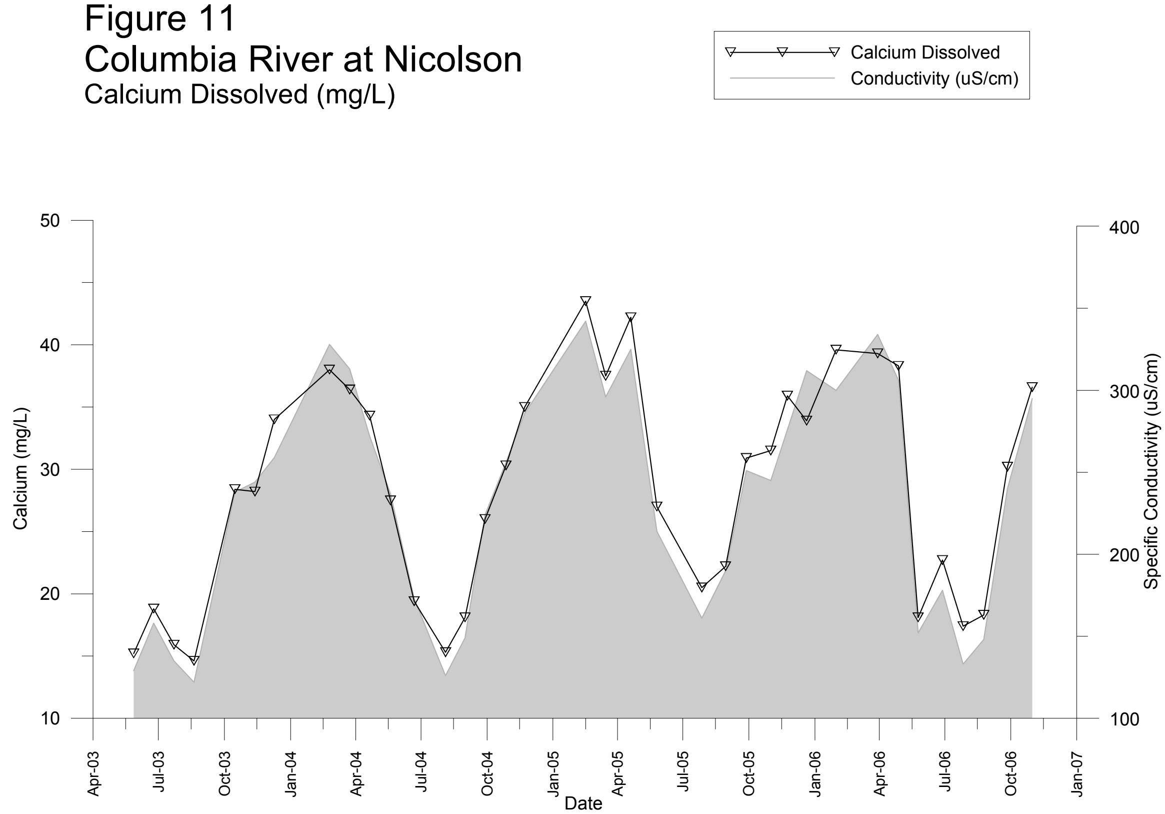


Figure 12
Columbia River at Nicolson
Cadmium Total and Extractable (ug/L)

B.C./CCME Max Cd DW Guideline: 5 ug/L

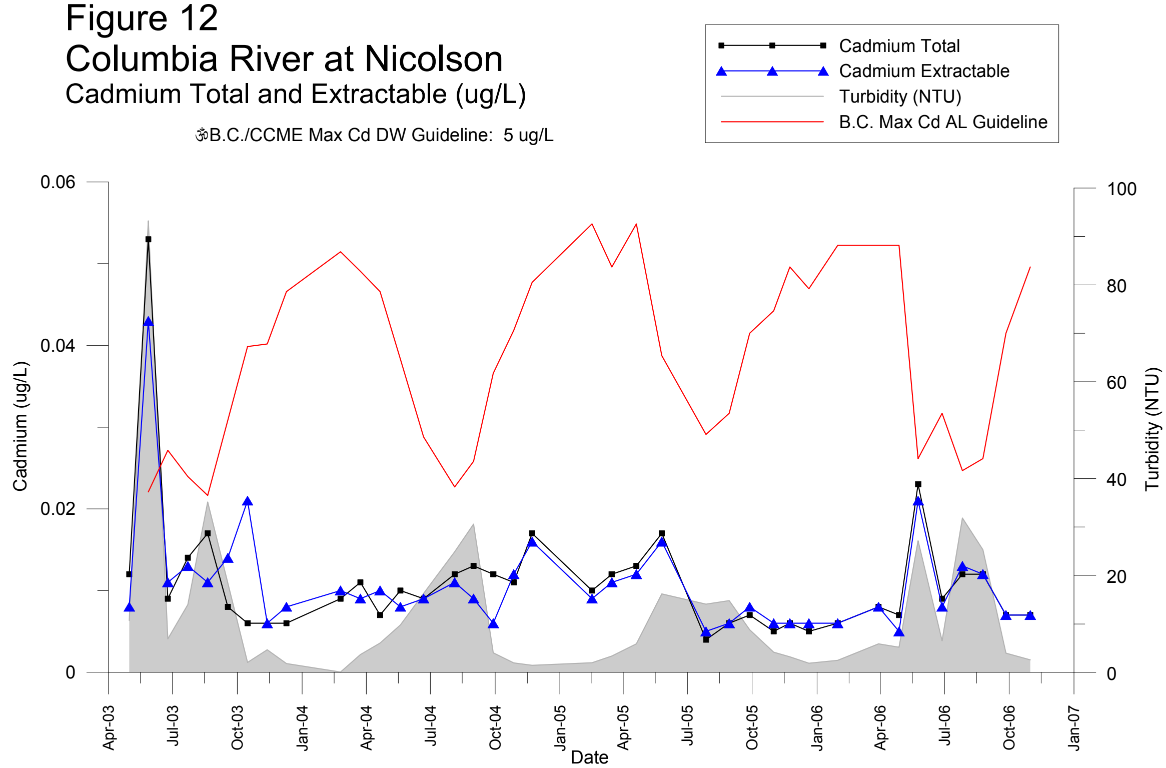


Figure 13
Columbia River at Nicolson
Cobalt Total and Extractable (ug/L)

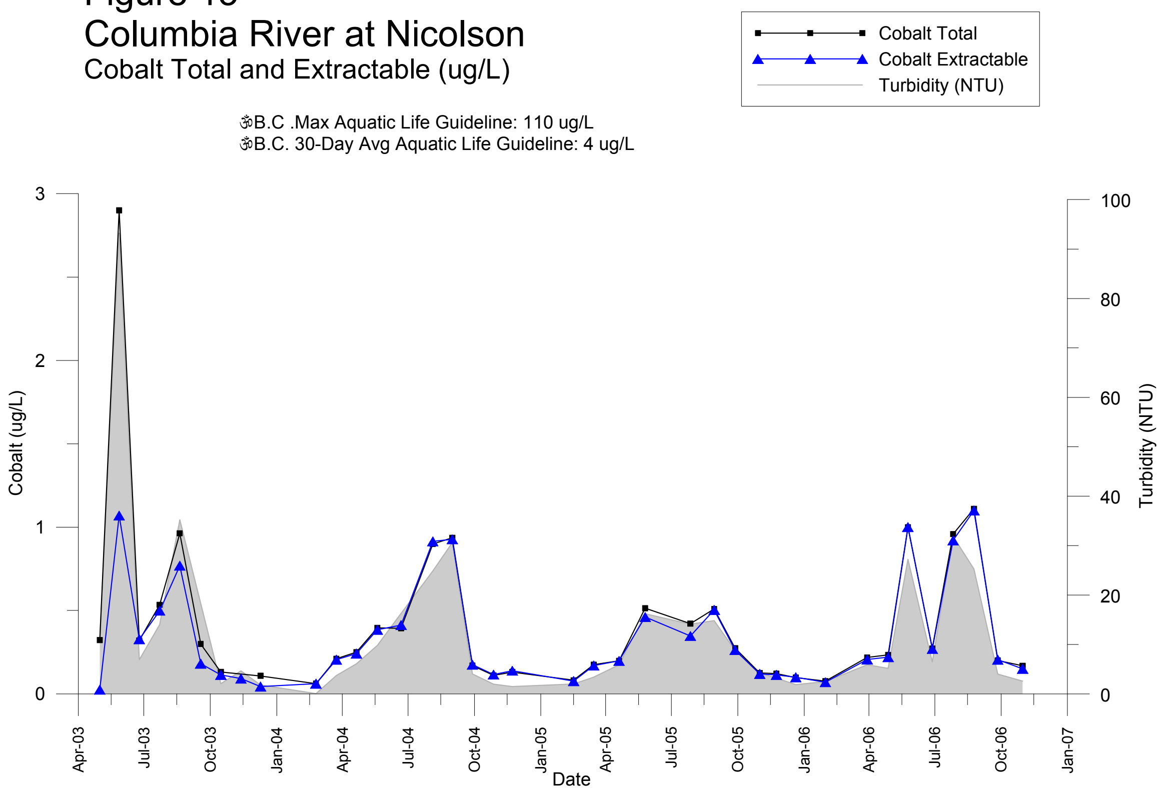


Figure 14
Columbia River at Nicolson
Carbon Dissolved Organic (mg/L)

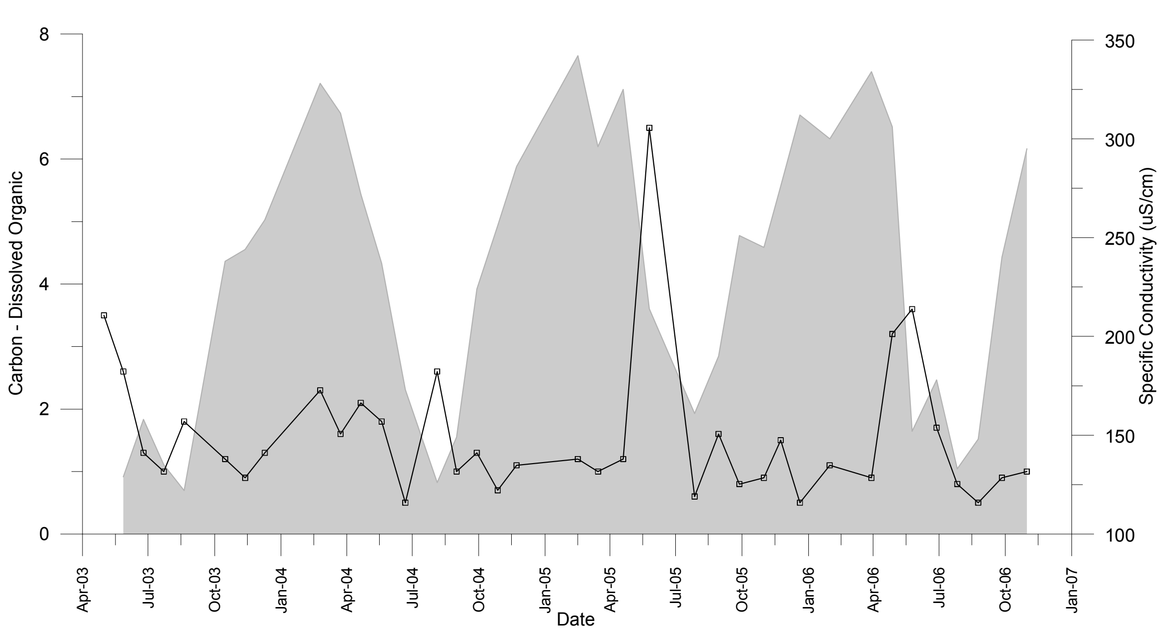


Figure 15
Columbia River at Nicholson
Coliforms Fecal (CFU/100mL)

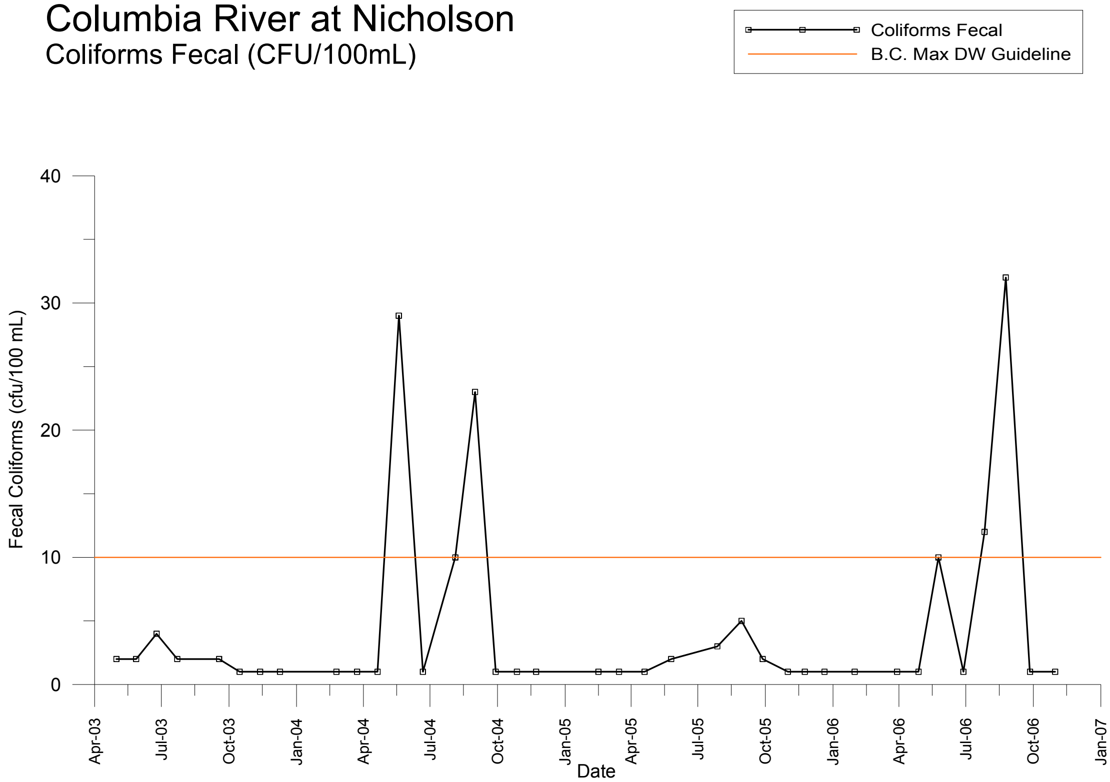
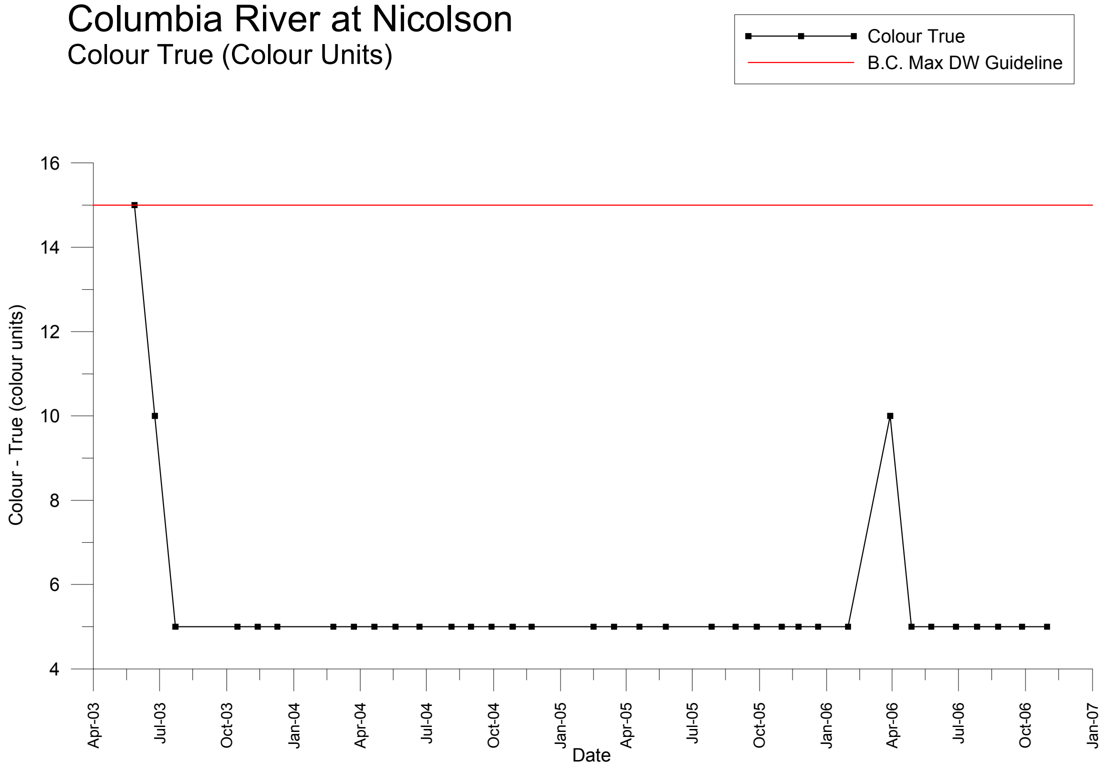


Figure 16
Columbia River at Nicolson
Colour True (Colour Units)



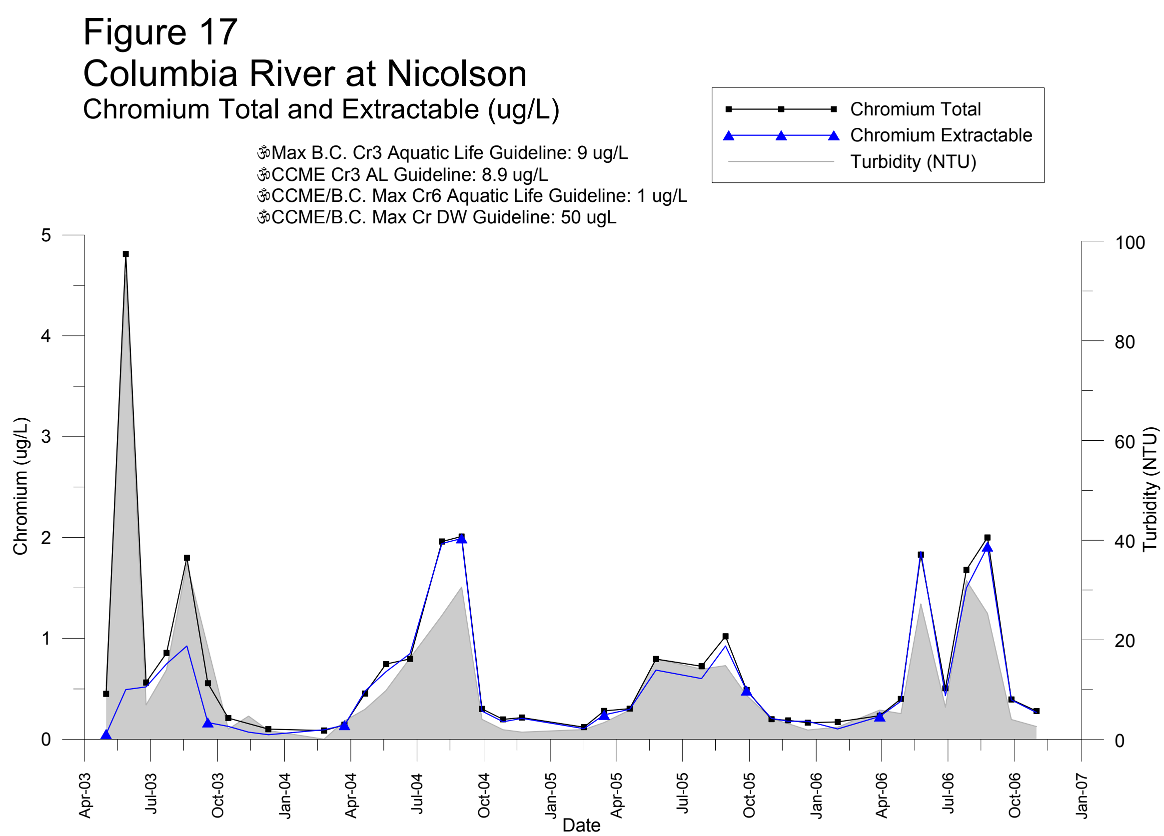


Figure 17
Columbia River at Nicolson
Chromium Total and Extractable (ug/L)
Max B.C. Cr3 Aquatic Life Guideline: 9 ug/L
CCME Cr3 AL Guideline: 8.9 ug/L
CCME/B.C. Max Cr6 Aquatic Life Guideline: 1 ug/L
CCME/B.C. Max Cr DW Guideline: 50 ugL
Chromium Total
Chromium Extractable
Turbidity (NTU)
Chromium (ug/L)
Turbidity (NTU)
Date
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05
Apr-05
Jul-05
Oct-05
Jan-06
Apr-06
Jul-06
Oct-06
Jan-07

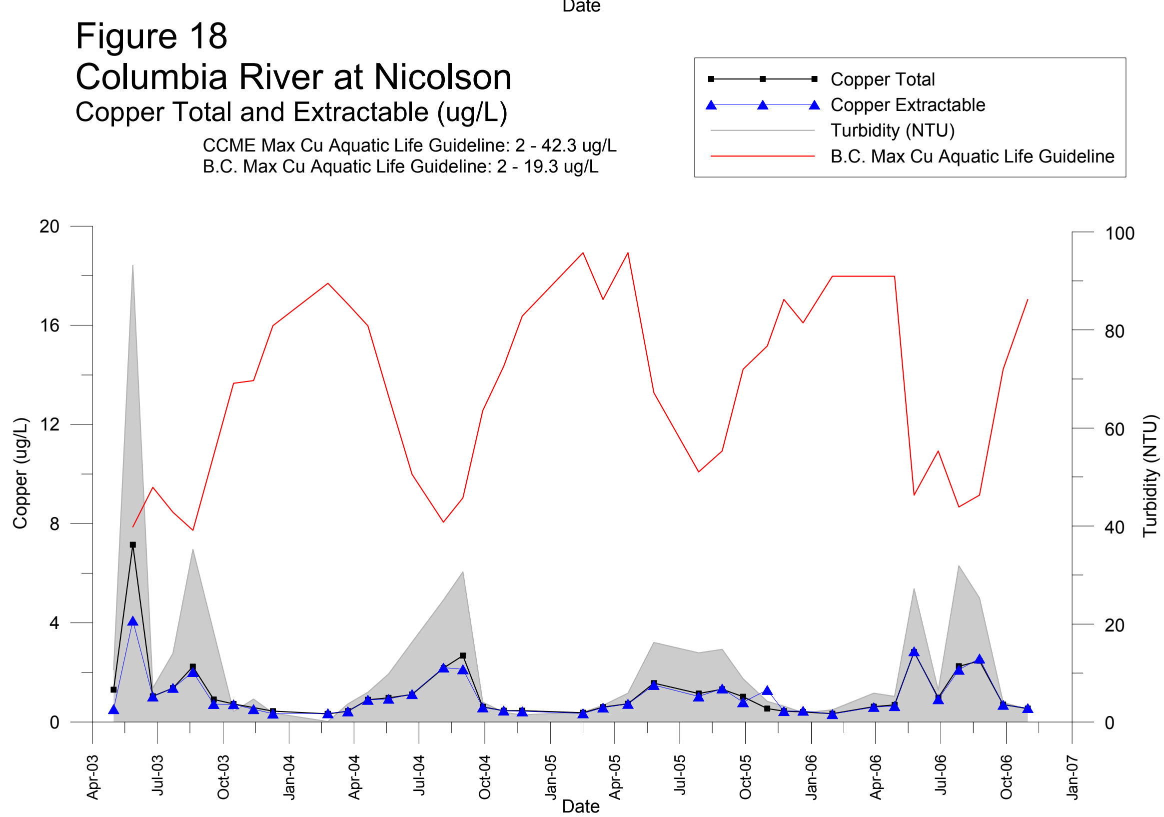


Figure 18
Columbia River at Nicolson
Copper Total and Extractable (ug/L)
CCME Max Cu Aquatic Life Guideline: 2 - 42.3 ug/L
B.C. Max Cu Aquatic Life Guideline: 2 - 19.3 ug/L
Copper Total
Copper Extractable
Turbidity (NTU)
B.C. Max Cu Aquatic Life Guideline
Copper (ug/L)
Turbidity (NTU)
Date
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05
Apr-05
Jul-05
Oct-05
Jan-06
Apr-06
Jul-06
Oct-06
Jan-07

Figure 19
Columbia River at Nicholson
Escherichia, Coli

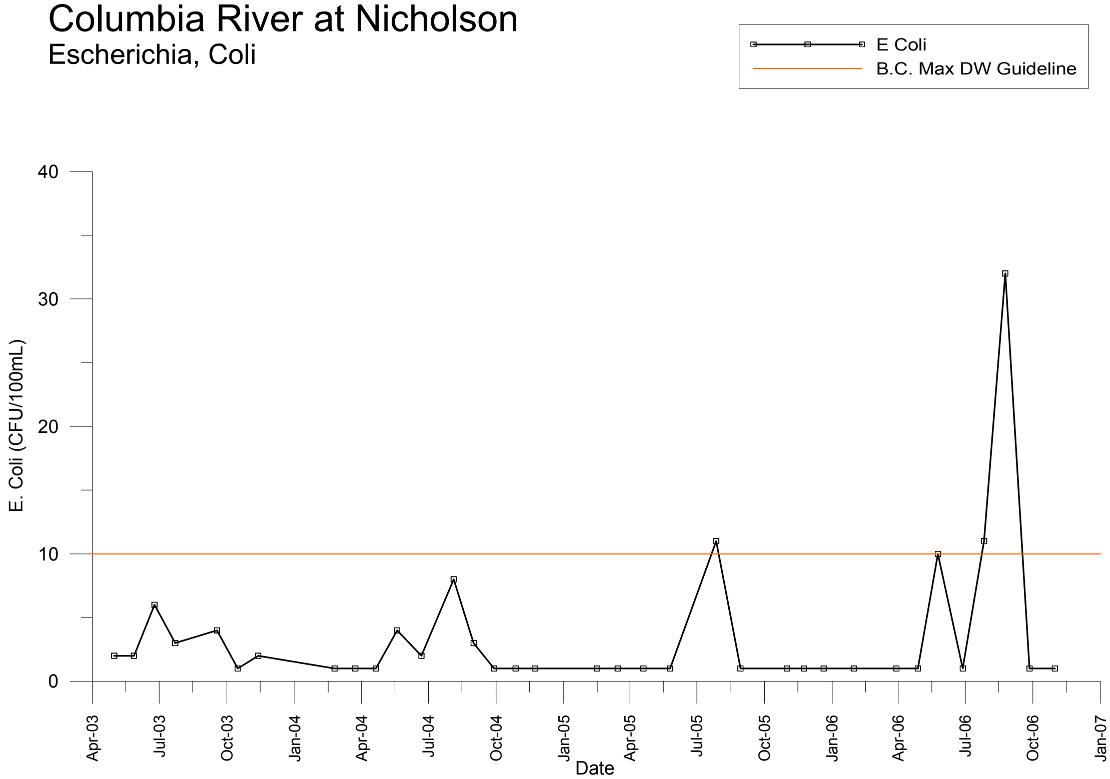
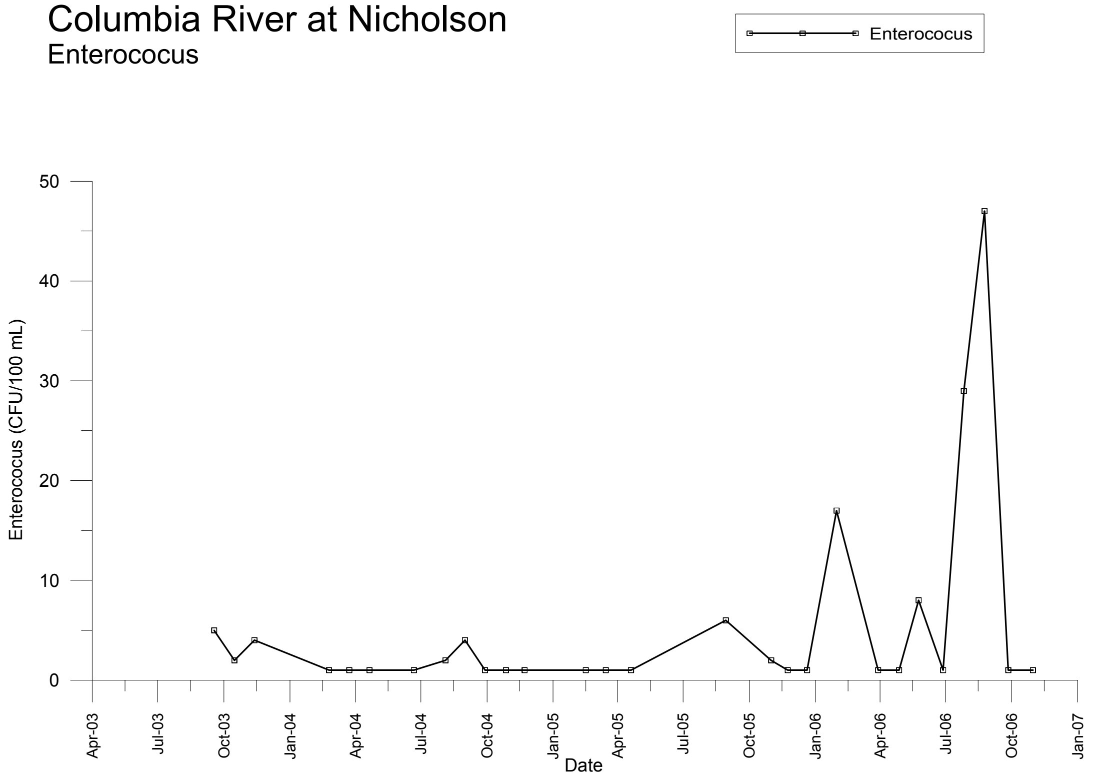


Figure 20
Columbia River at Nicholson
Enterococus



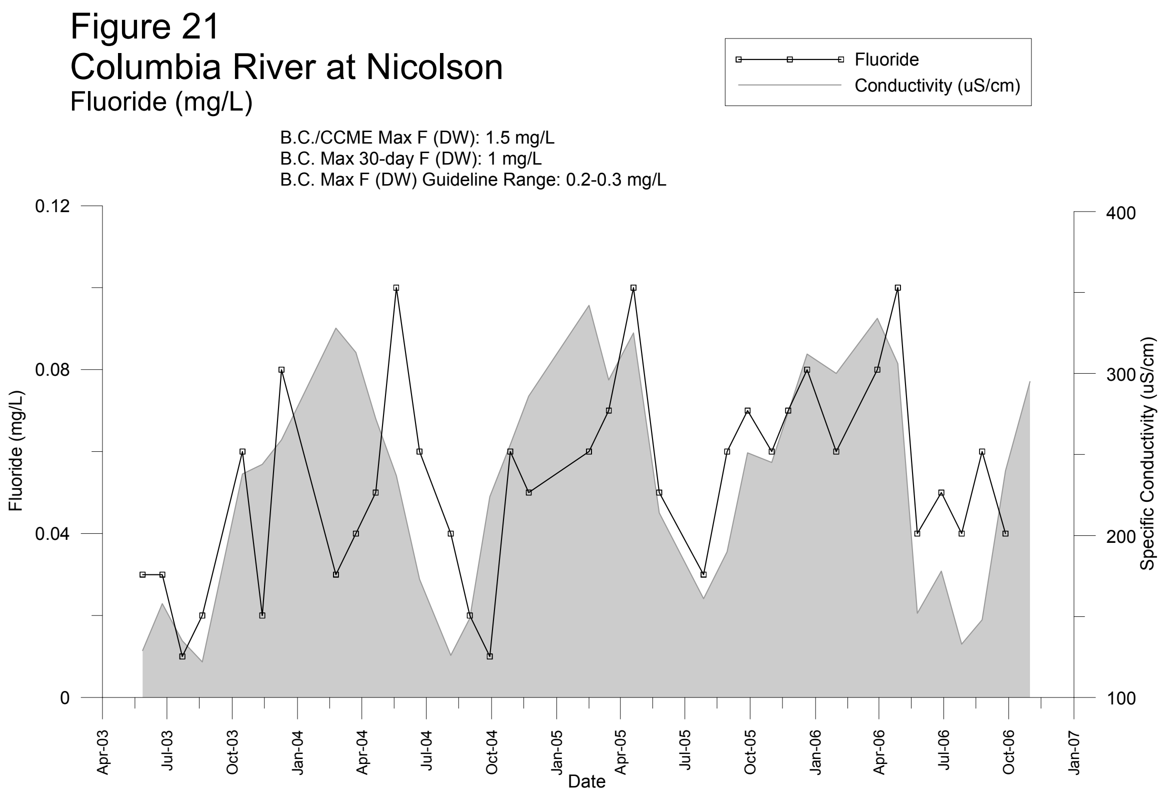


Figure 21
Columbia River at Nicolson
Fluoride (mg/L)
Fluoride
Conductivity (uS/cm)
B.C./CCME Max F (DW): 1.5 mg/L
B.C. Max 30-day F (DW): 1 mg/L
B.C. Max F (DW) Guideline Range: 0.2-0.3 mg/L
Fluoride (mg/L)
Specific Conductivity (uS/cm)
0.12
0.08
0.04
0
400
300
200
100
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05
Apr-05
Jul-05
Oct-05
Jan-06
Apr-06
Jul-06
Oct-06
Jan-07
Date

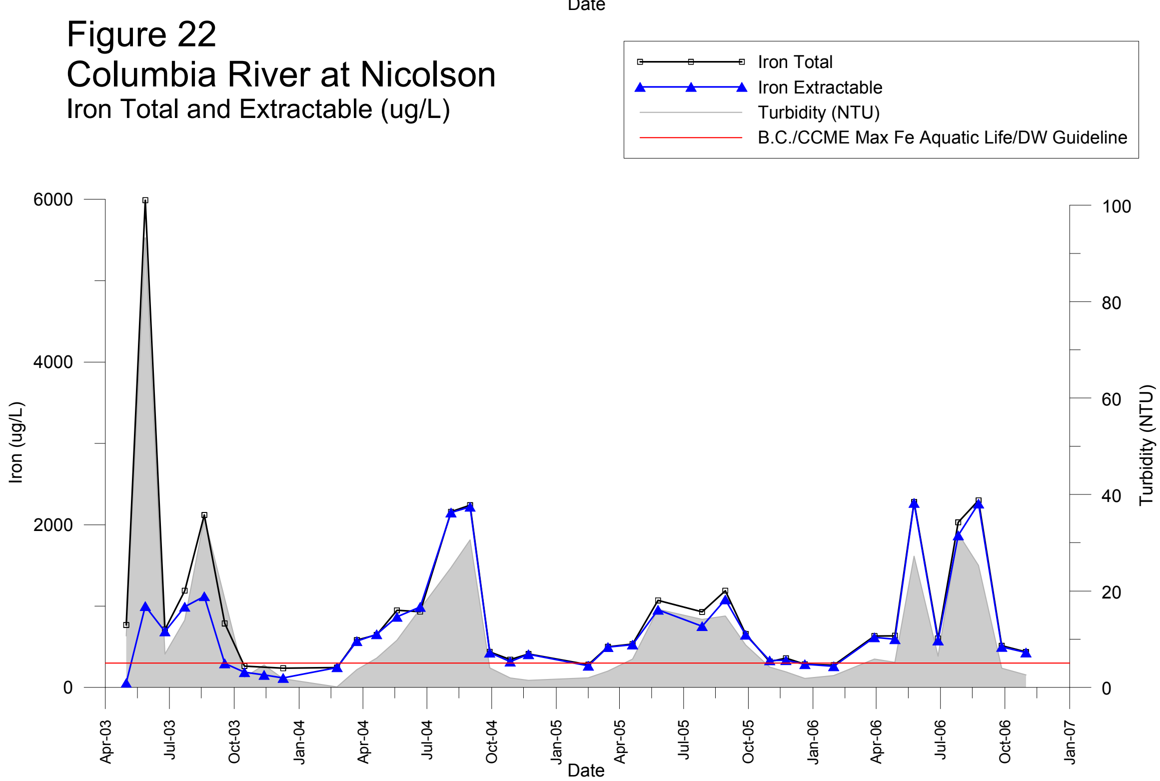


Figure 22
Columbia River at Nicolson
Iron Total and Extractable (ug/L)
Iron Total
Iron Extractable
Turbidity (NTU)
B.C./CCME Max Fe Aquatic Life/DW Guideline
Iron (ug/L)
Turbidity (NTU)
6000
4000
2000
0
100
80
60
40
20
0
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05
Apr-05
Jul-05
Oct-05
Jan-06
Apr-06
Jul-06
Oct-06
Jan-07
Date

Figure 23
Columbia River at Nicolson
Gallium Total and Extractable (ug/L)

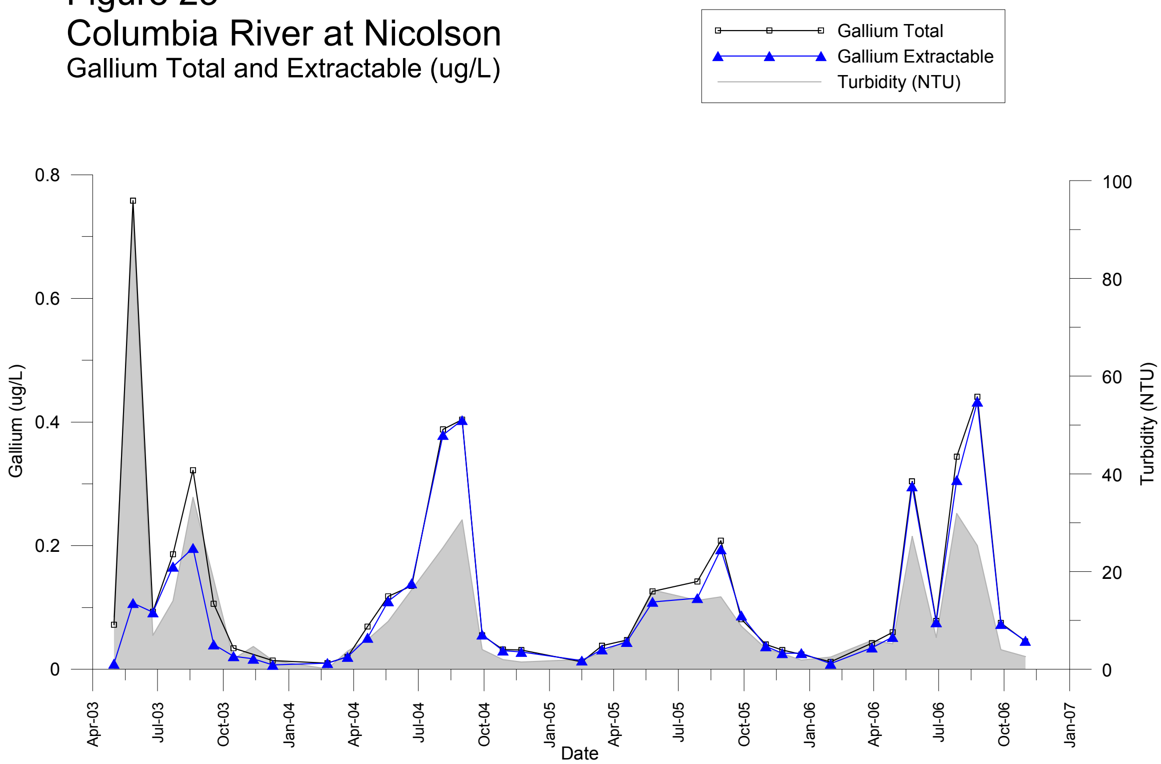


Figure 24
Columbia River at Nicolson
Hardness Total (Calcd) CaCO3 (mg/L)

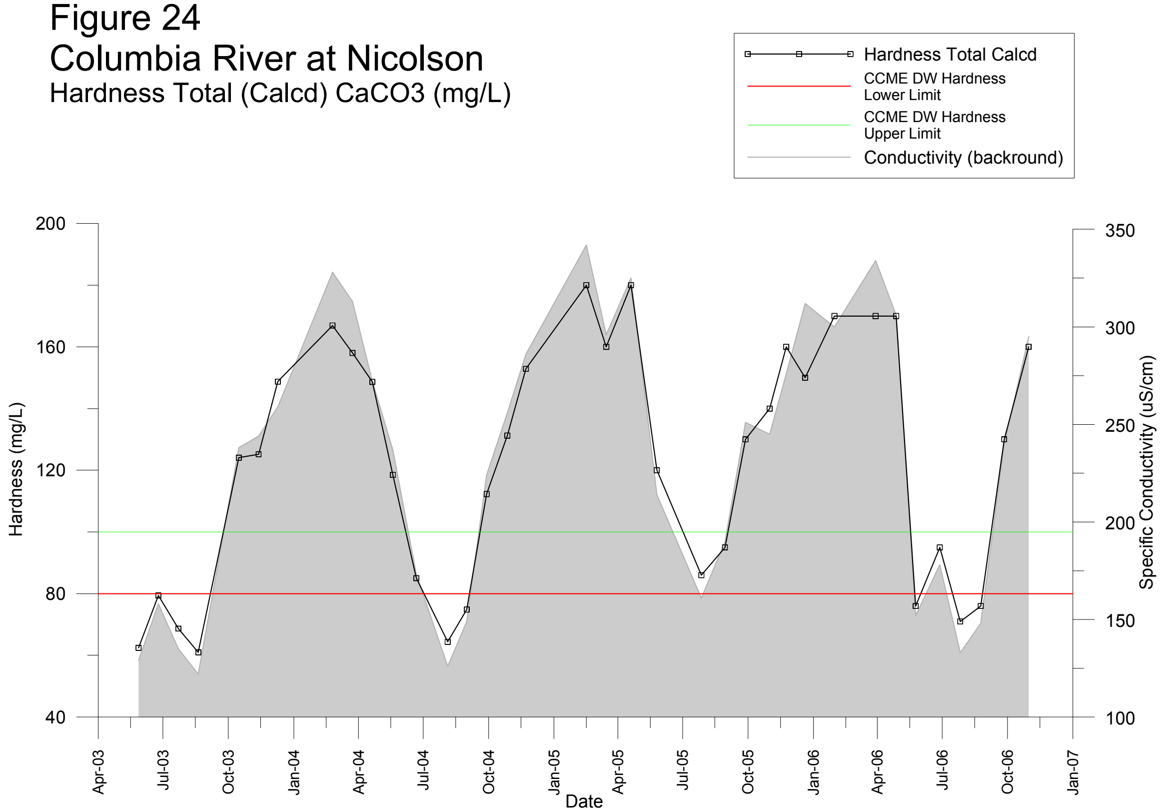


Figure 25
Columbia River at Nicholson
Lanthanum Total and Extractable (ug/L)

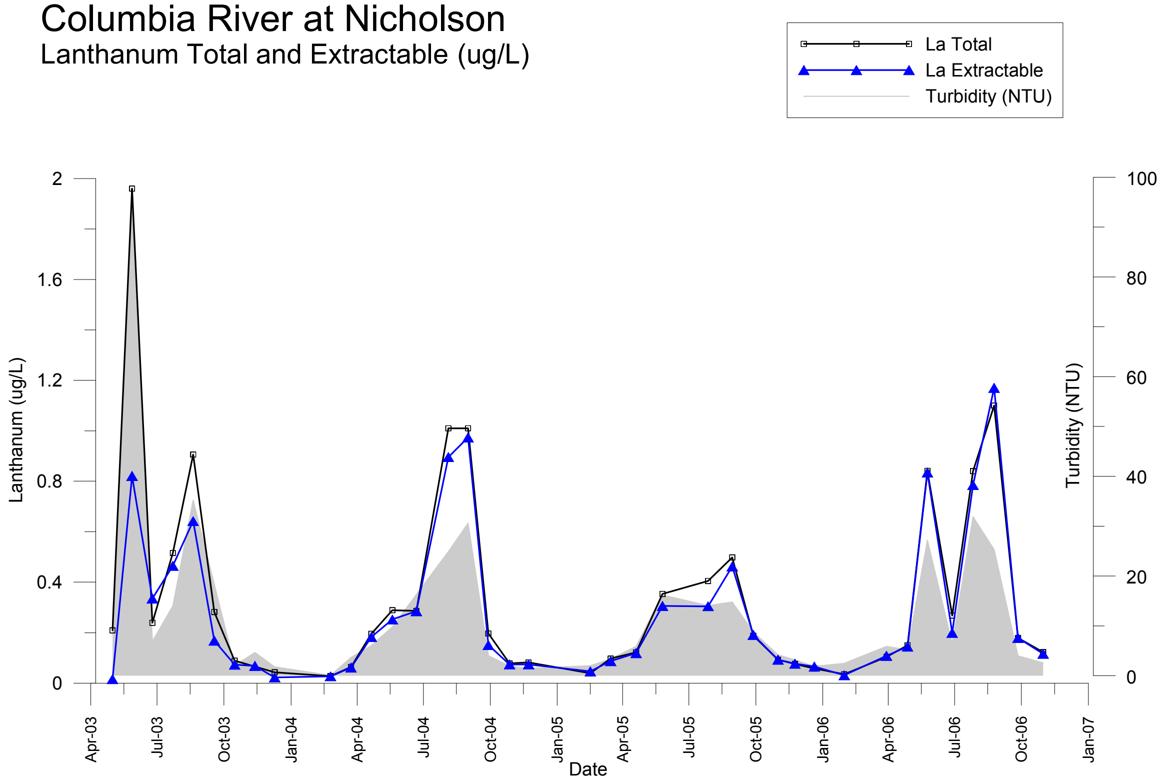


Figure 26
Columbia River at Nicholson
Lead Total and Extractable (ug/L)

B.C. Max Pb DW Guideline 50 ug/L
CCME Max Pb DW Guideline 10 ug/L
B.C. Max Pb Aquatic Life Guideline Range 43.5-172.5 ug/L
30-Day-B.C. Pb Aquatic Life Guideline Range 5.0-10.0 ug/L

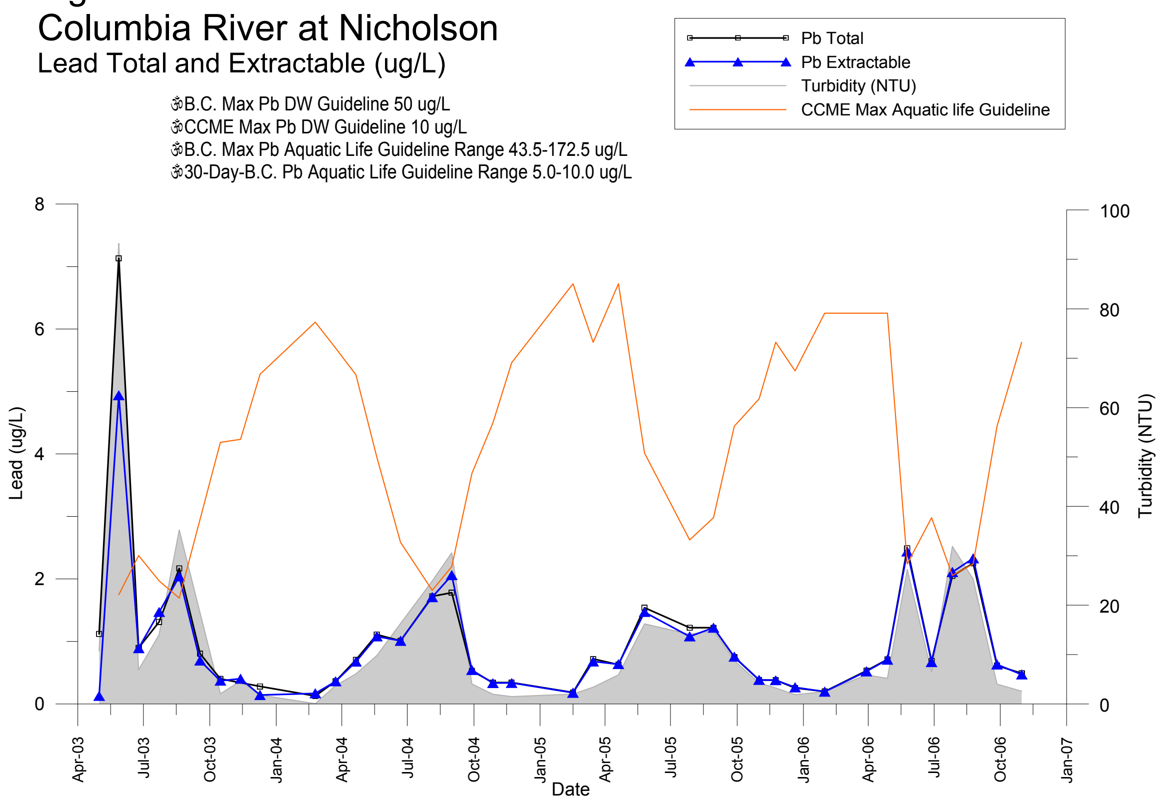


Figure 27
Columbia River at Nicholson
Lithium Total and Extractable (ug/L)

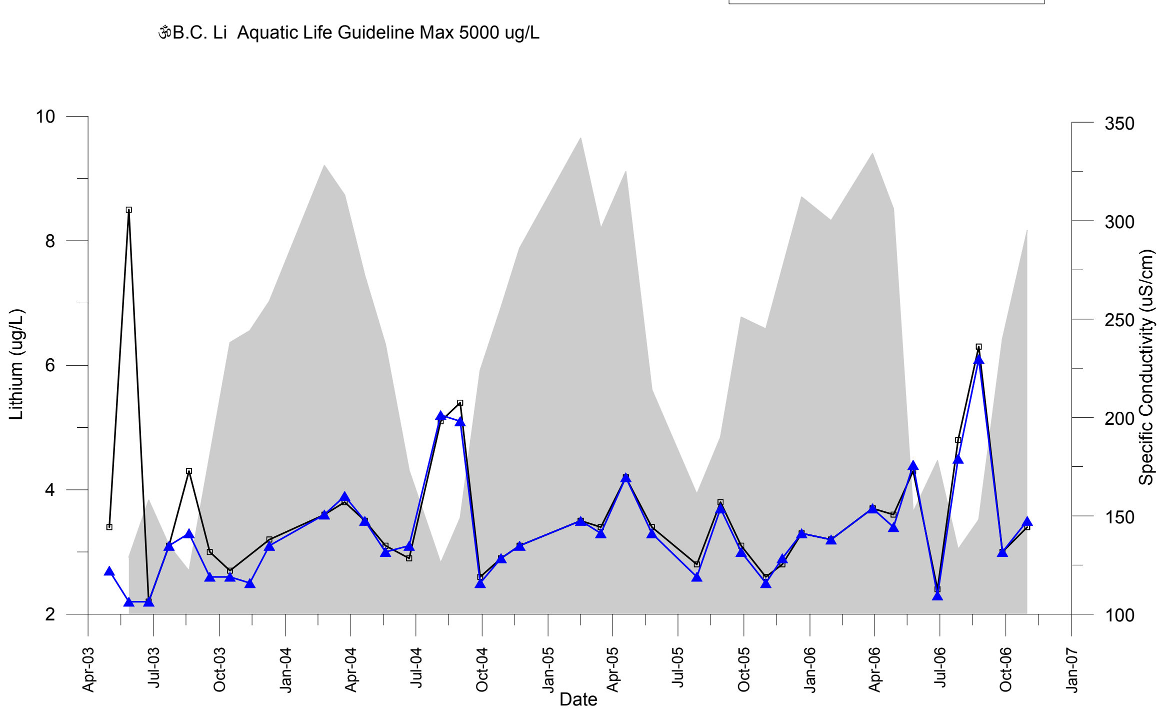


Figure 28
Columbia River at Nicholson
Lithium Total and Extractable (ug/L)

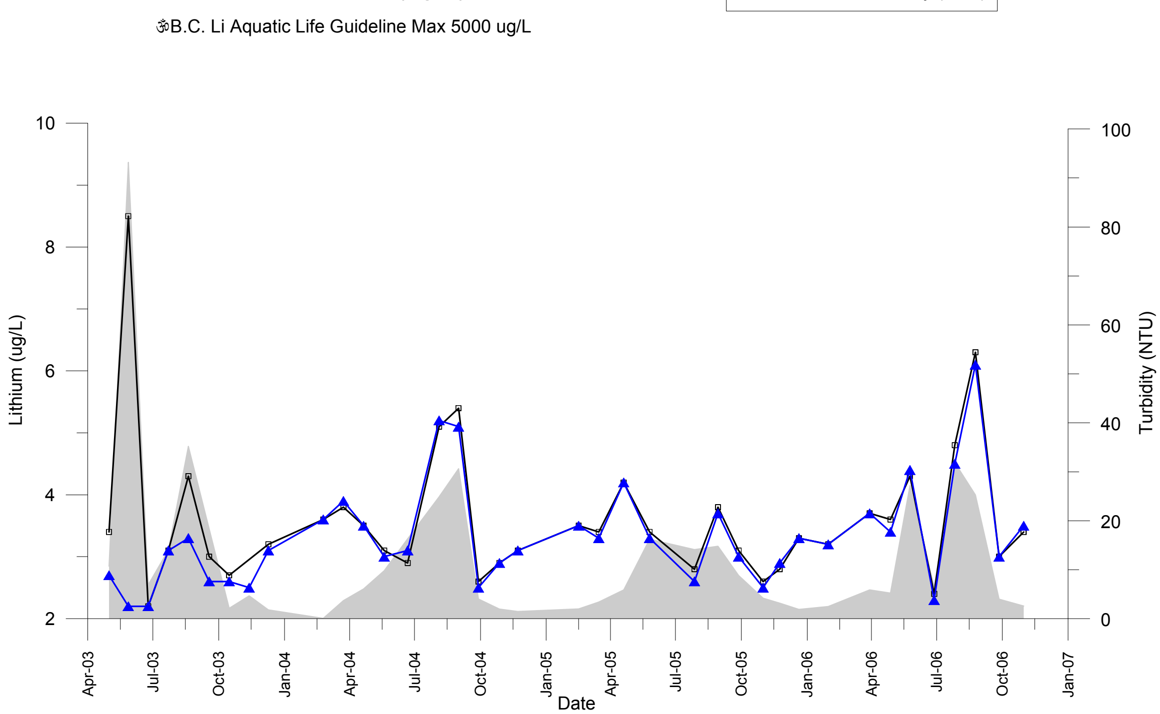


Figure 29
Columbia River at Nicholson
Magnesium Dissolved (mg/L)

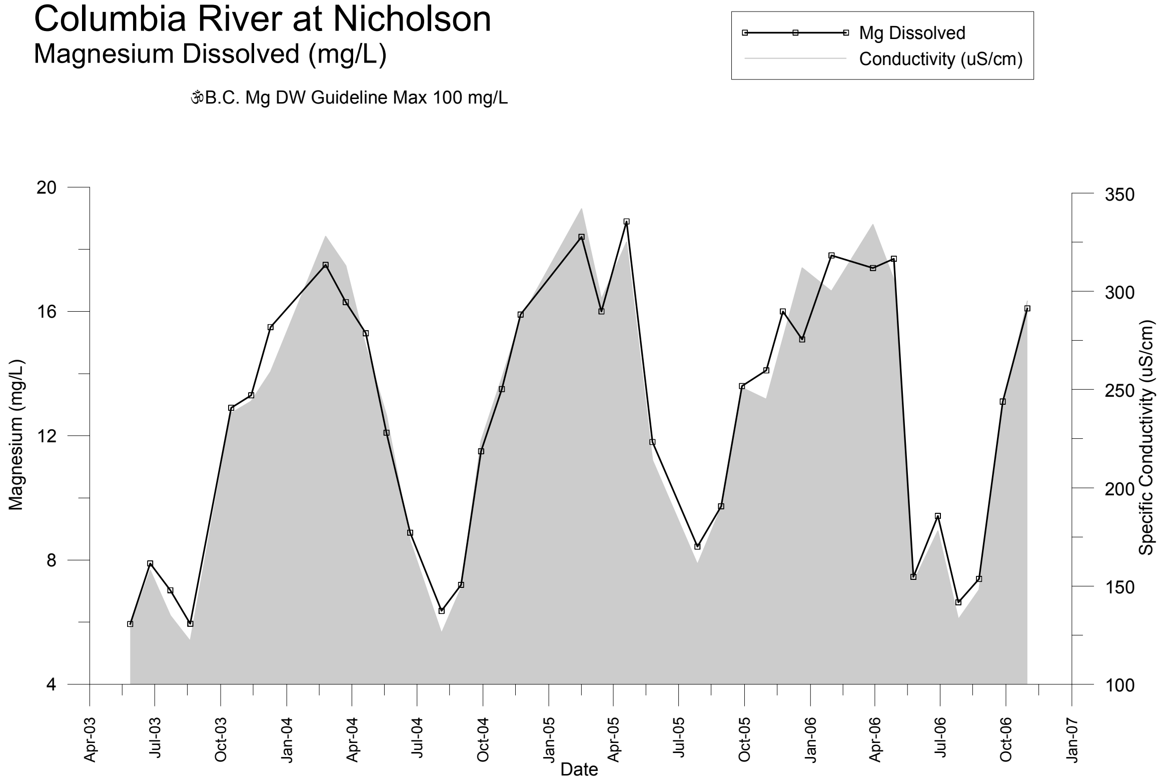


Figure 30
Columbia River at Nicholson
Manganese Total and Extractable (ug/L)

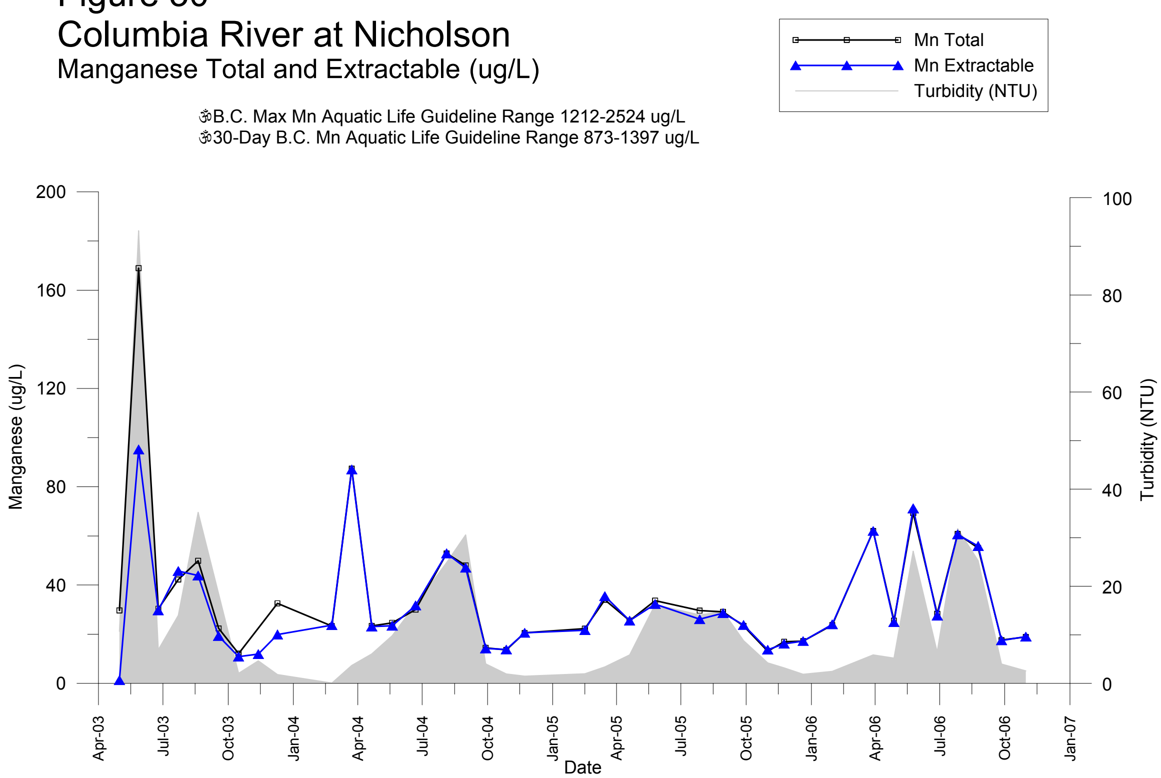


Figure 31
Columbia River at Nicholson
Molybdenum Total and Extractable (ug/L)

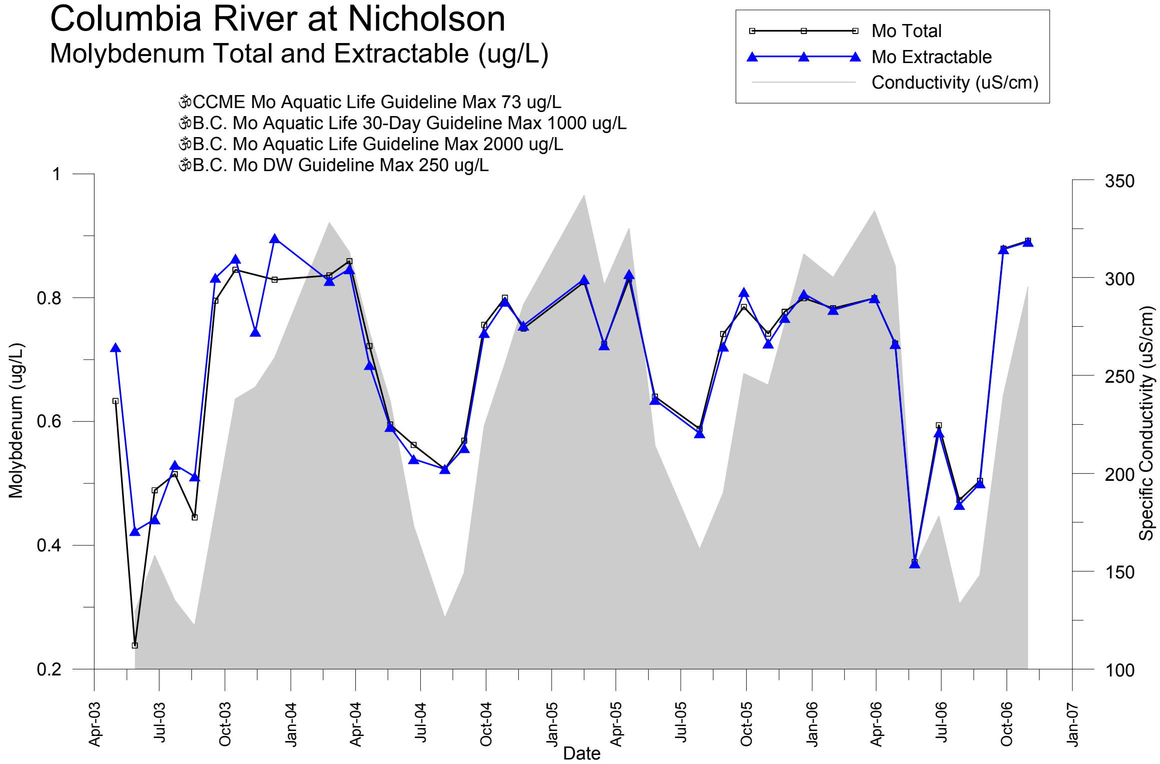


Figure 32
Columbia River at Nicholson
Nitrogen Dissolved NO3 and NO2 (mg/L)

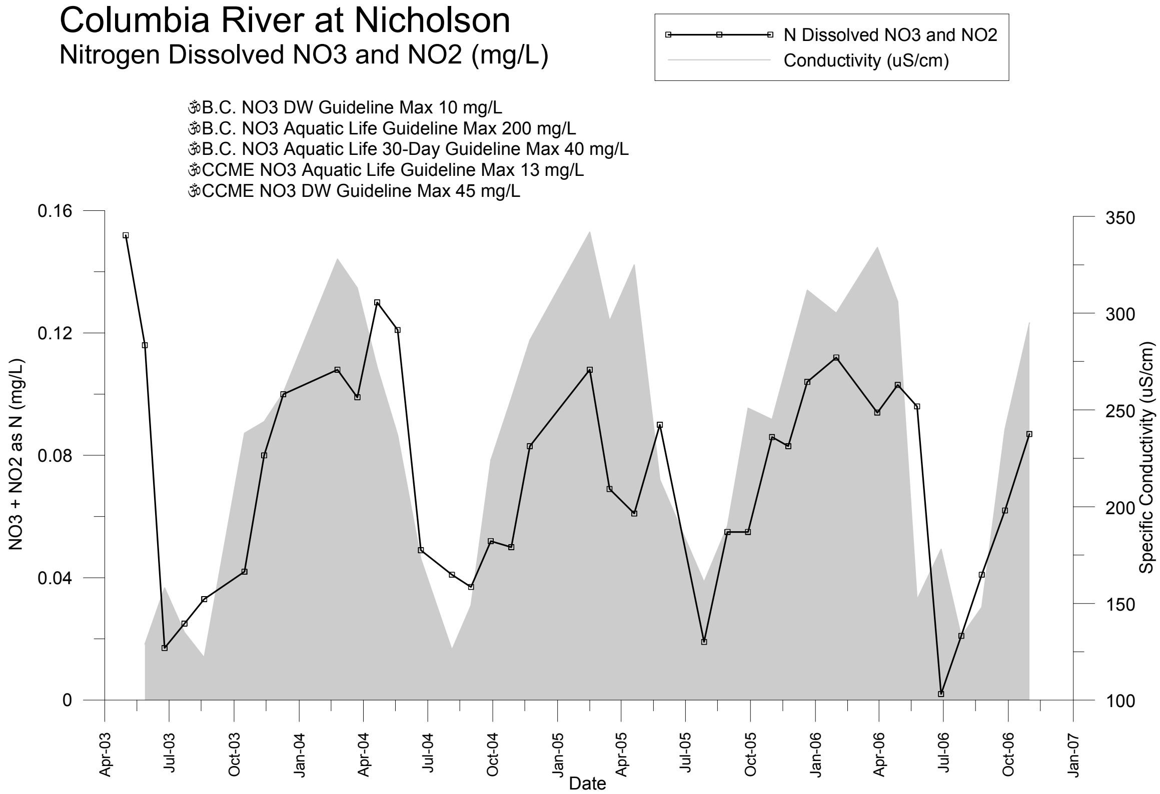


Figure 33
Columbia River at Nicholson
Nitrogen Total Dissolved (mg/L)

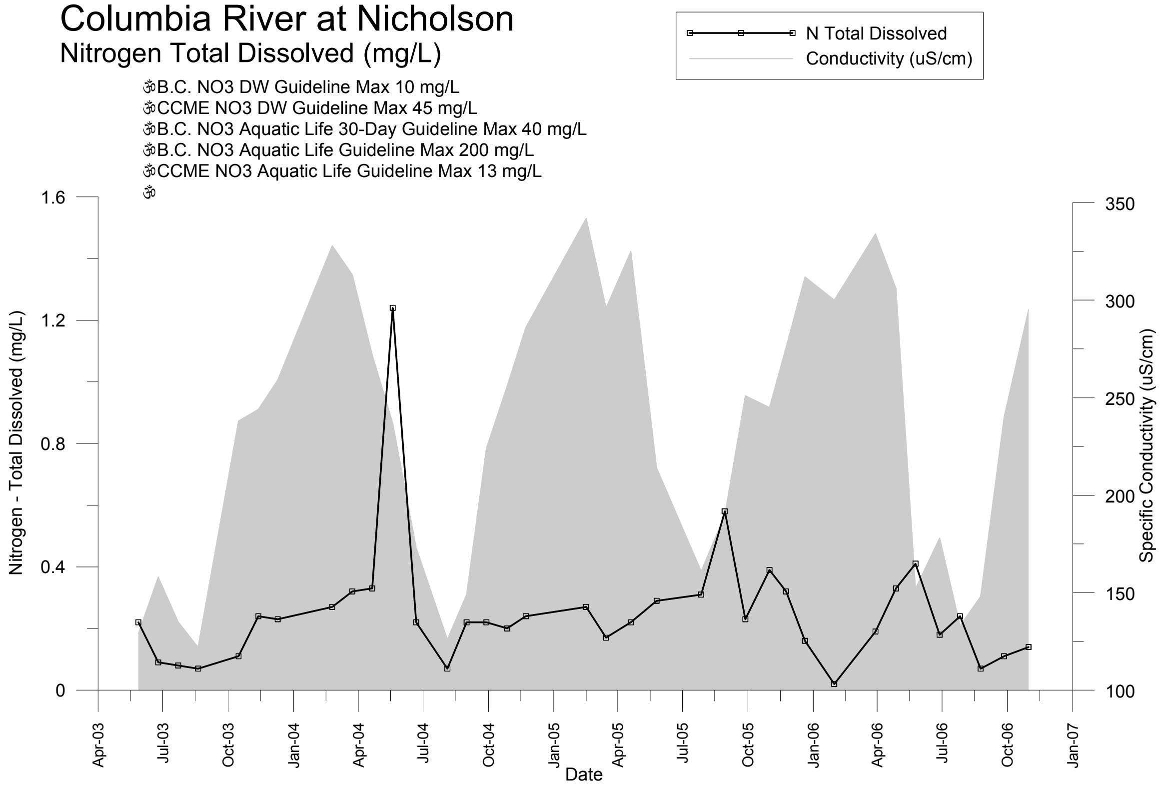


Figure 34
Columbia River at Nicholson
Niobium Extractable (ug/L)

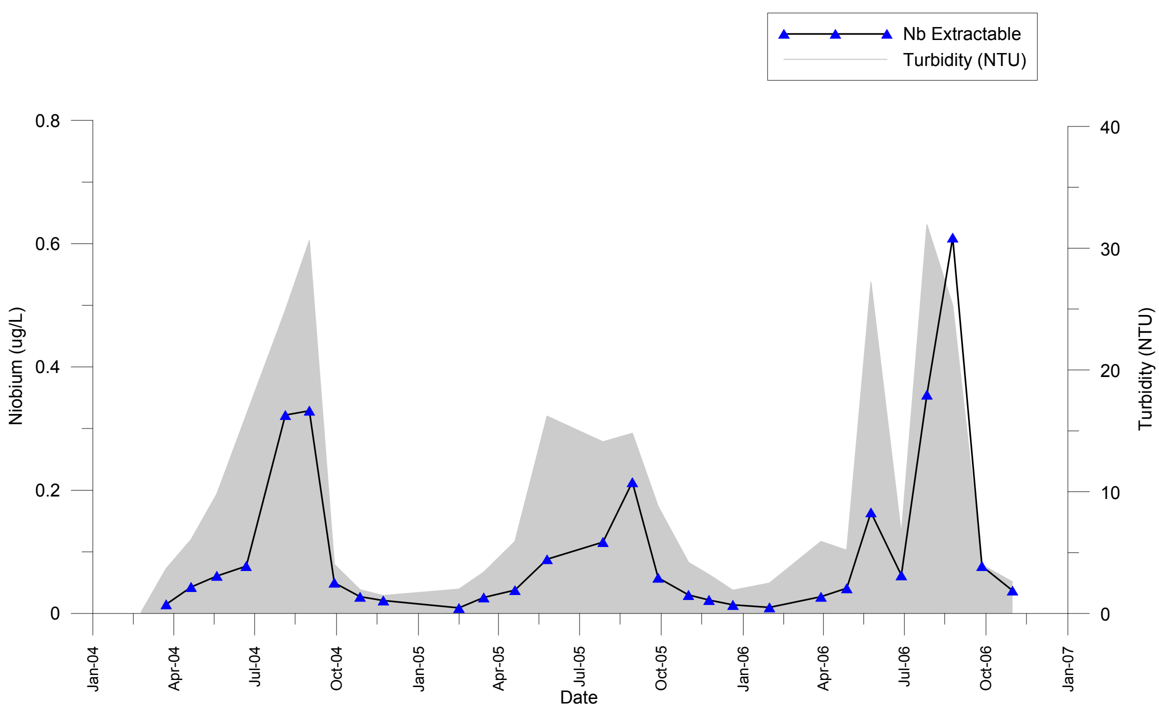


Figure 35
Columbia River at Nicholson
Nickel Total and Extractable (ug/L)

Ni Total
Ni Extractable
Turbidity (NTU)

ⓢB.C./CCME Max Ni Aquatic Life Guideline Range 65.6-149.4 ug/L

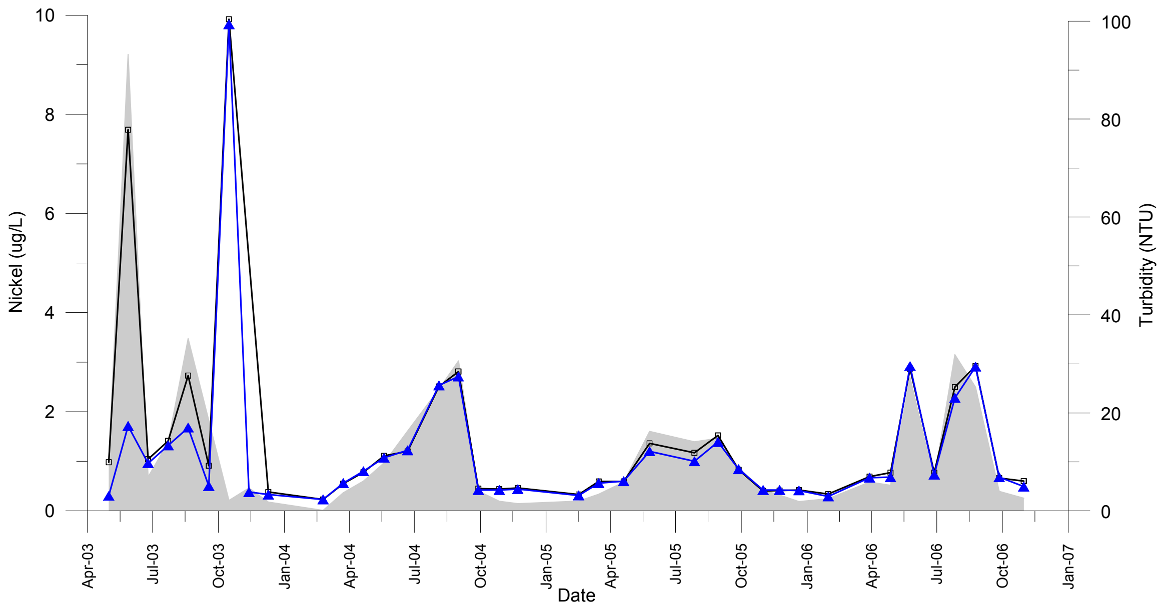


Figure 36
Columbia River at Nicholson
Phosphorus Total and Total Dissolved (mg/L)

P Total
P Total Dissolved
Turbidity (NTU)
B.C. Max TPhos DW Guideline

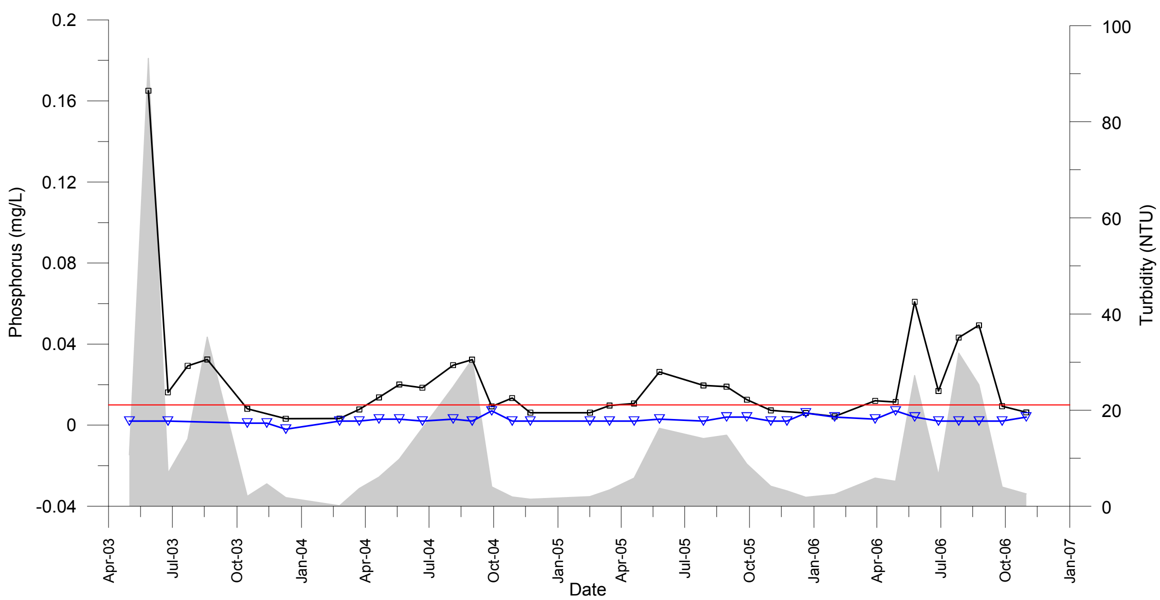


Figure 37
Columbia River at Nicholson
pH (pH Units)

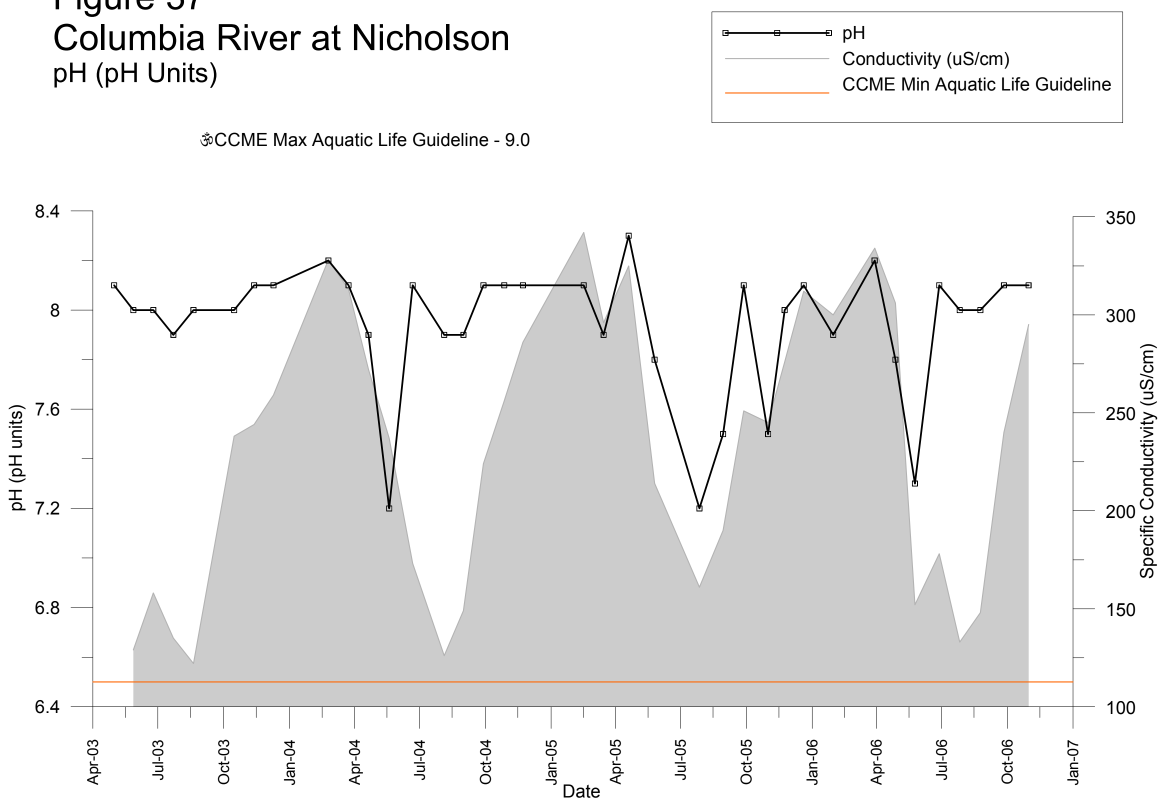


Figure 38
Columbia River at Nicholson
Rubidium Total and Extractable (ug/L)

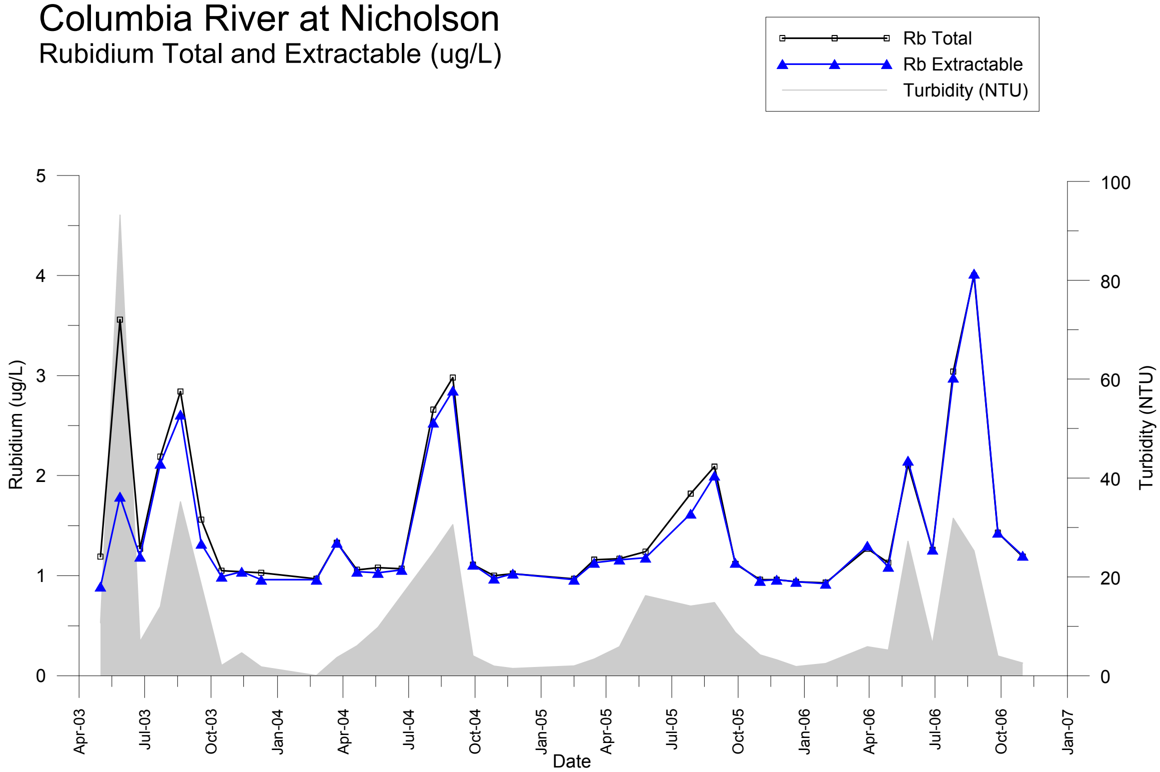


Figure 39
Columbia River at Nicolson
Antimony Total and Extractable (ug/L)

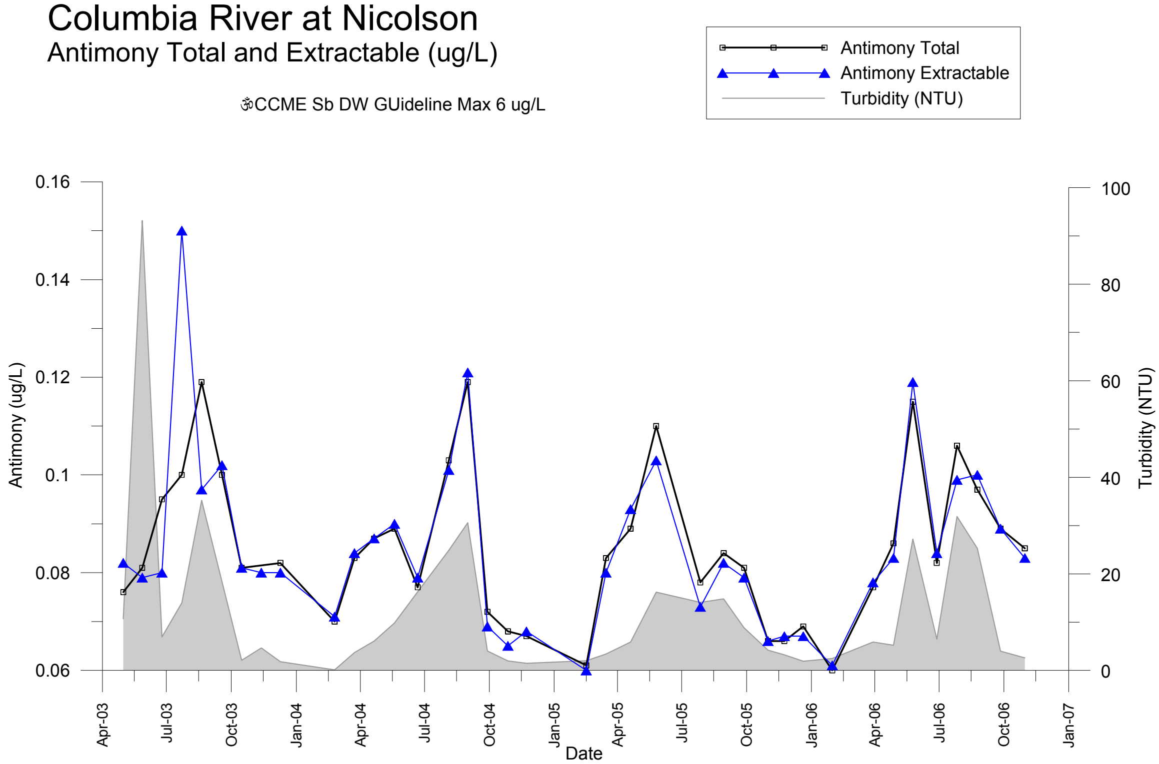


Figure 40
Columbia River at Nicholson
Selenium Total and Extractable (ug/L)

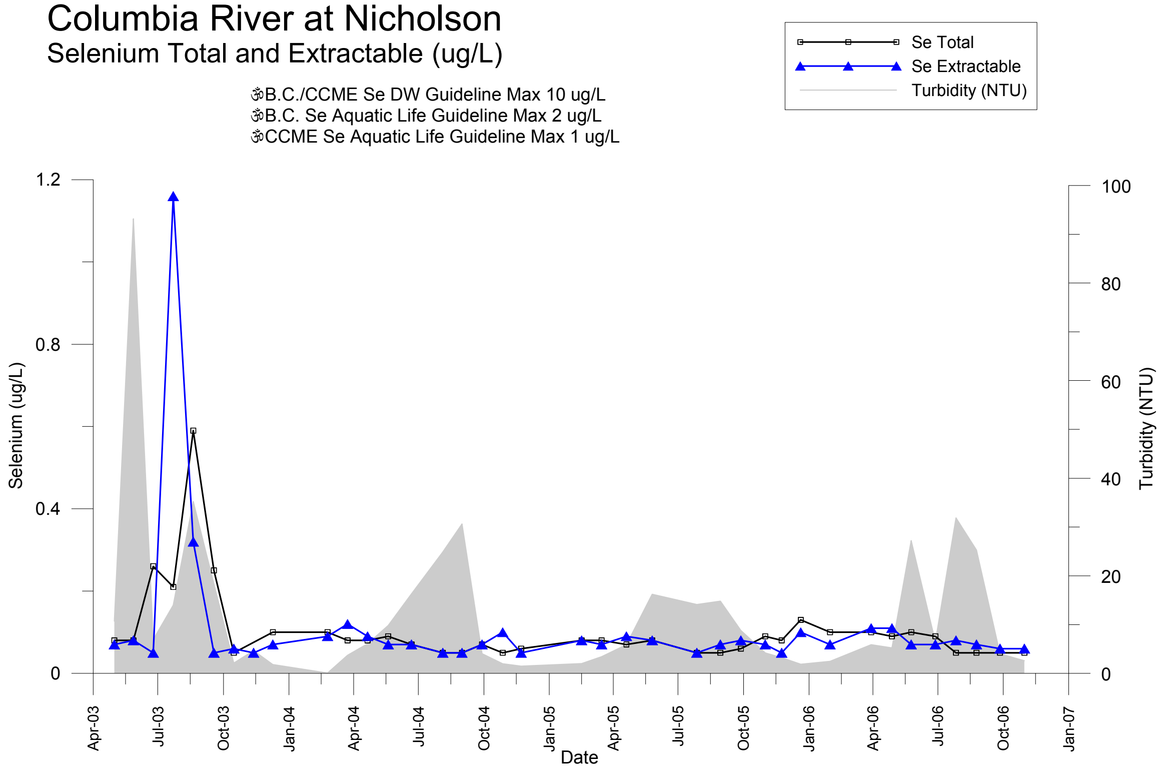


Figure 41
Columbia River at Nicholson
Silver Total and Extractable (ug/L)

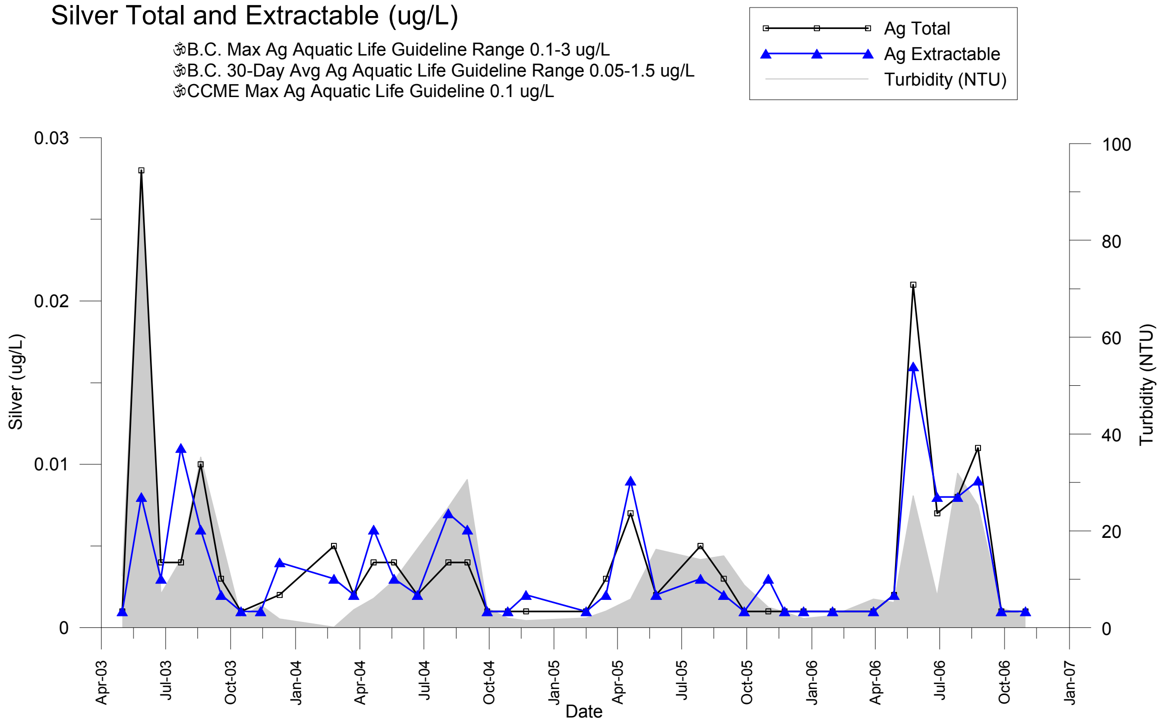


Figure 42
Columbia River at Nicholson
Specific Conductivity (uS/cm)

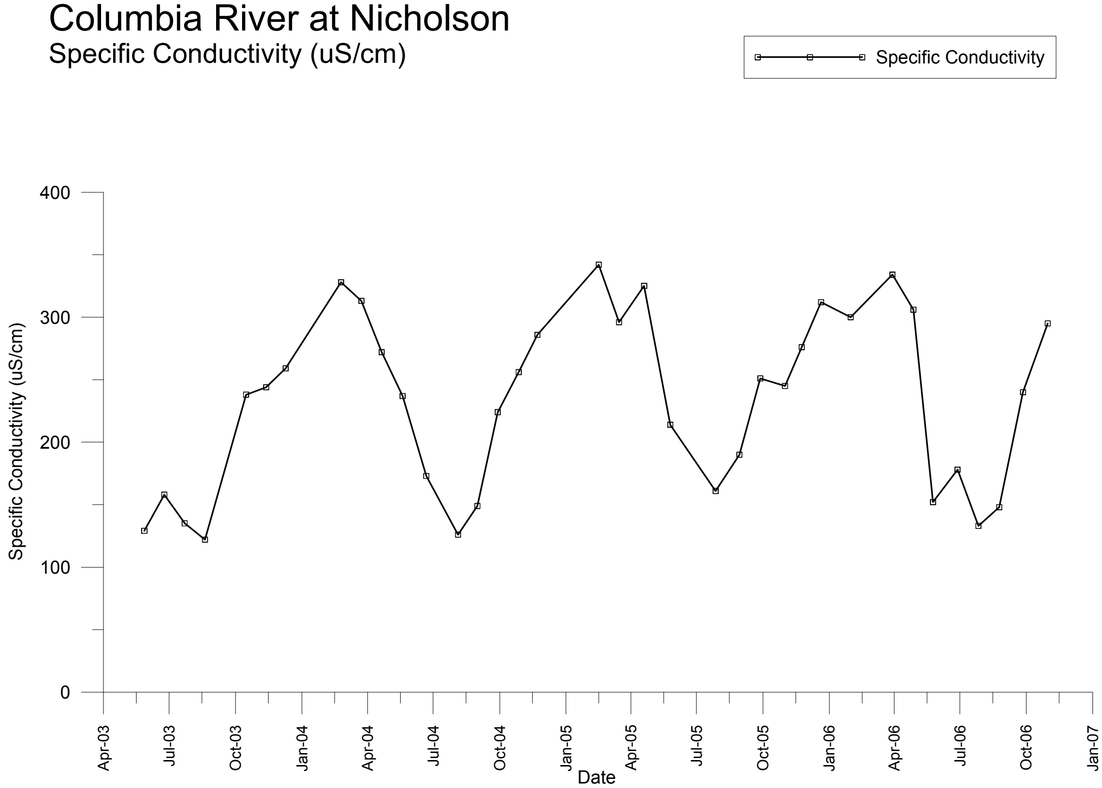


Figure 43
Columbia River at Nicholson
Strontium Total and Extractable (ug/L)

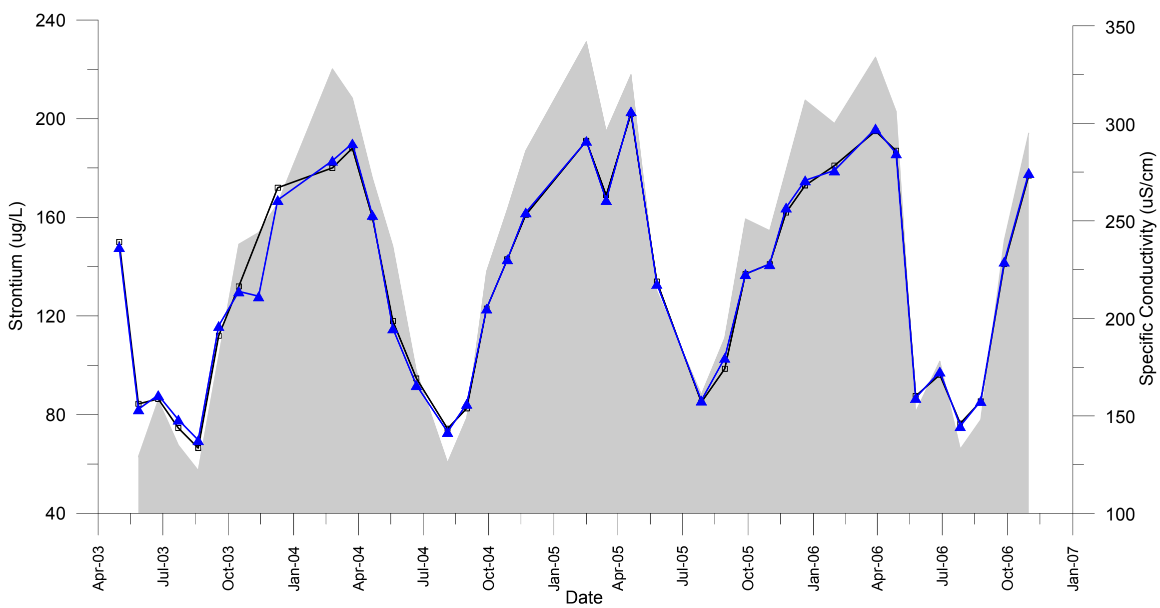


Figure 44
Columbia River at Nicholson
Sulphate Dissolved (mg/L)

ॐB.C. SO4 Aquatic Life Guideline Max 100 mg/L
ॐB.C. SO4 DW Guideline Max 500 mg/L

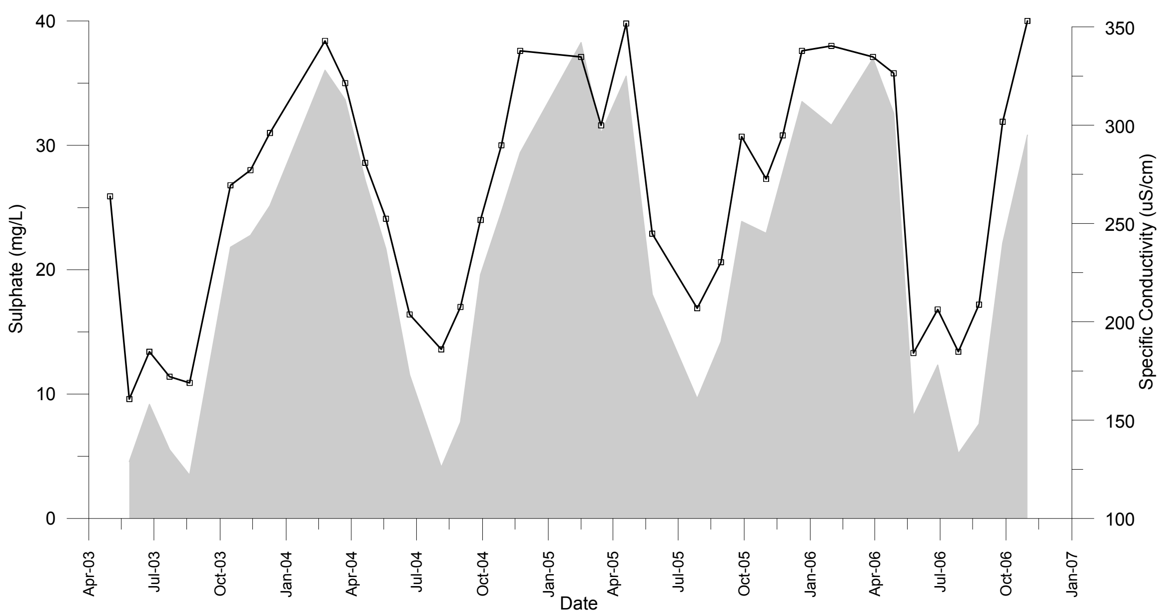


Figure 45
Columbia River at Nicholson
Temperature Air and Water (C)

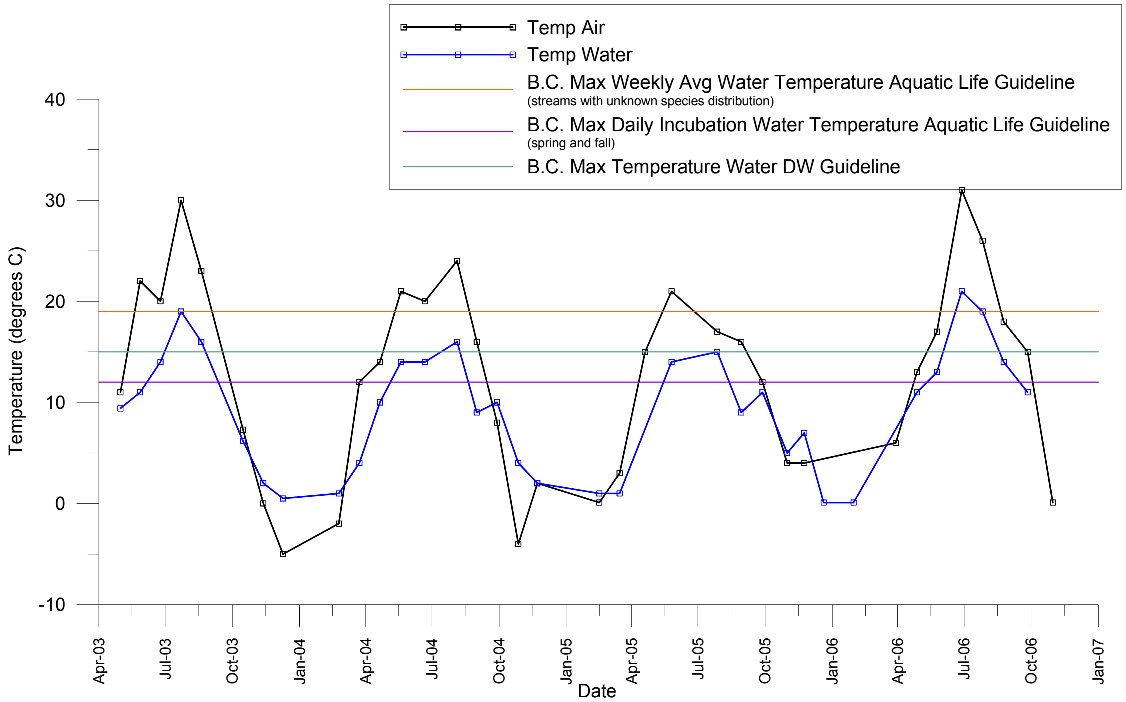


Figure 46
Columbia River at Nicholson
Tin Total and Extractable (ug/L)

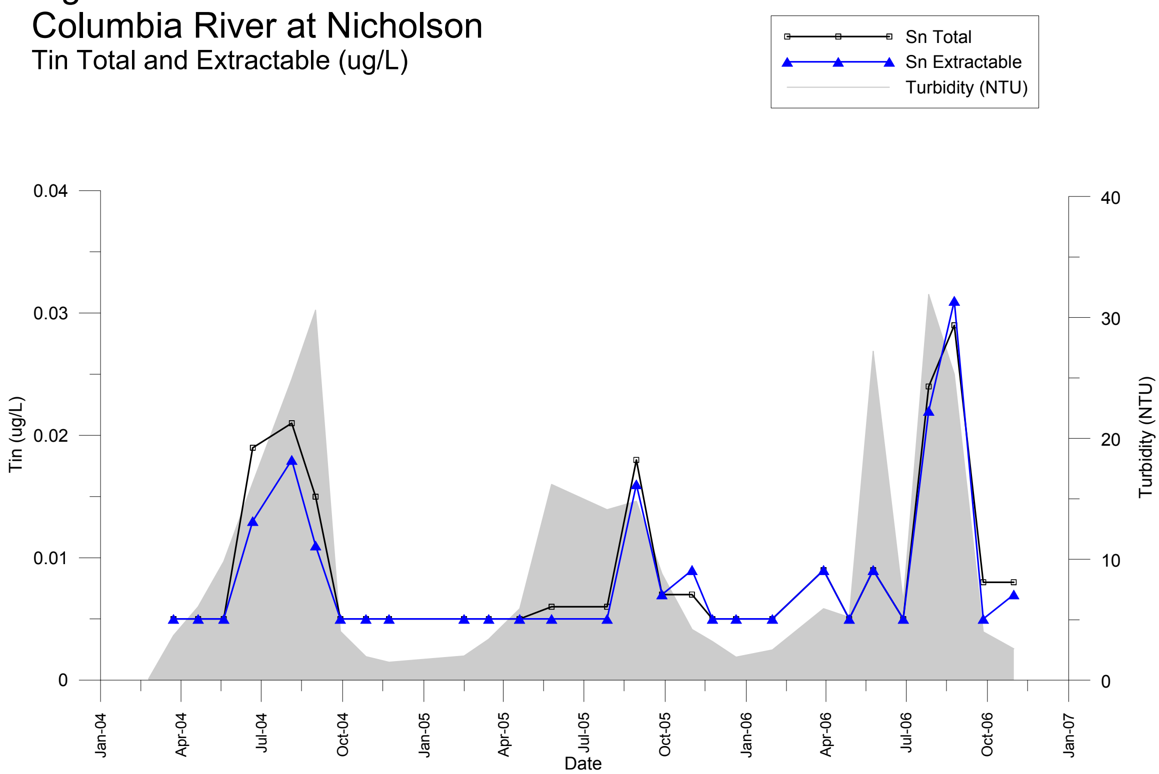


Figure 47
Columbia River at Nicholson
Thallium Total and Extractable (ug/L)

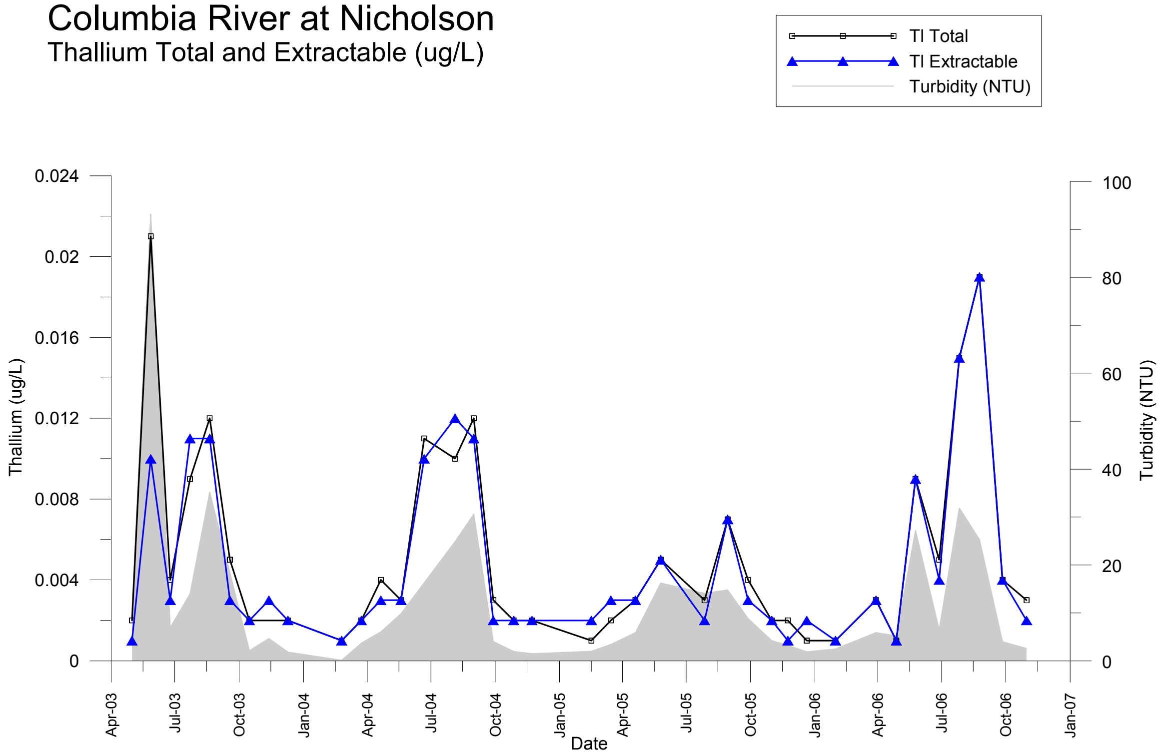


Figure 48
Columbia River at Nicholson
Turbidity (NTU)

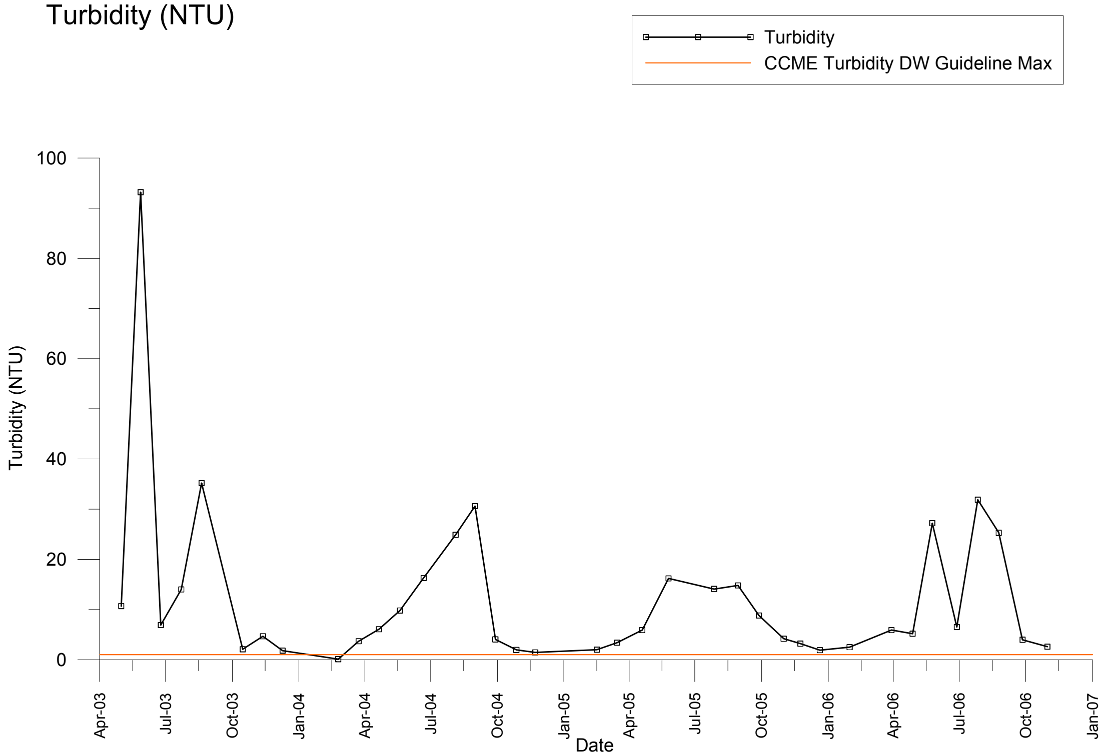


Figure 49
Columbia River at Nicholson
Uranium Total and Extractable (ug/L)

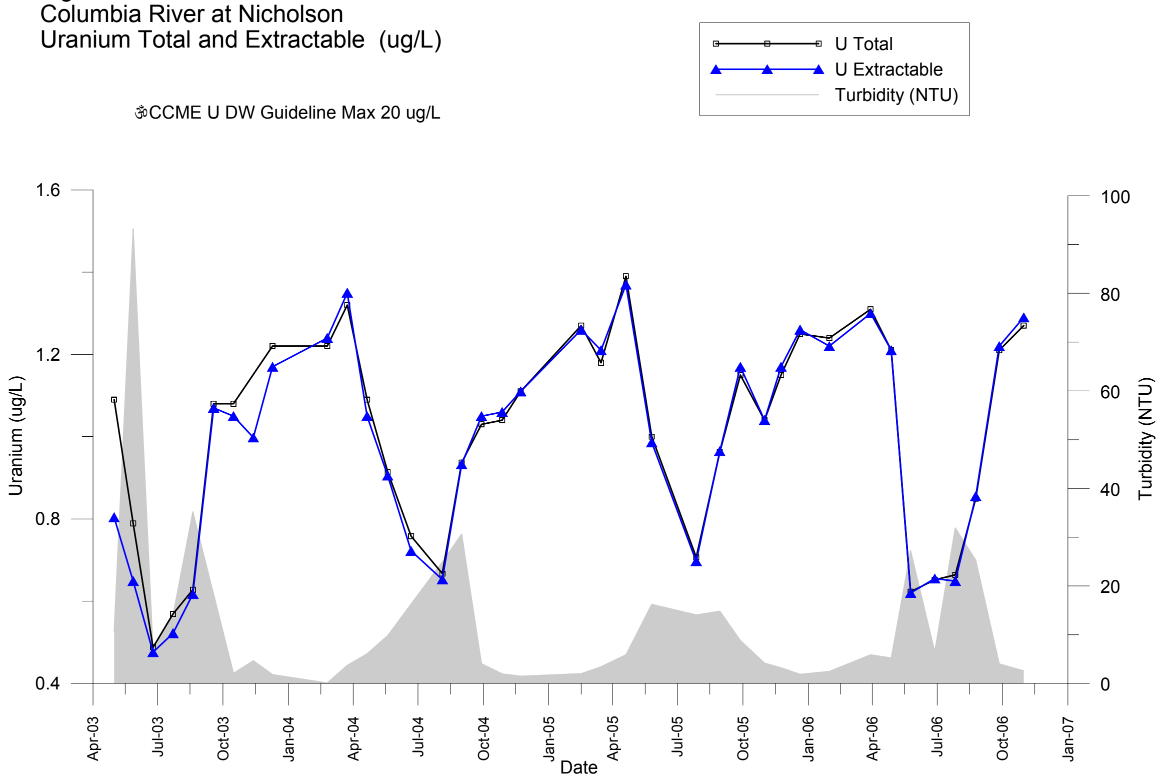


Figure 50
Columbia River at Nicholson
Uranium Total and Extractable (ug/L)

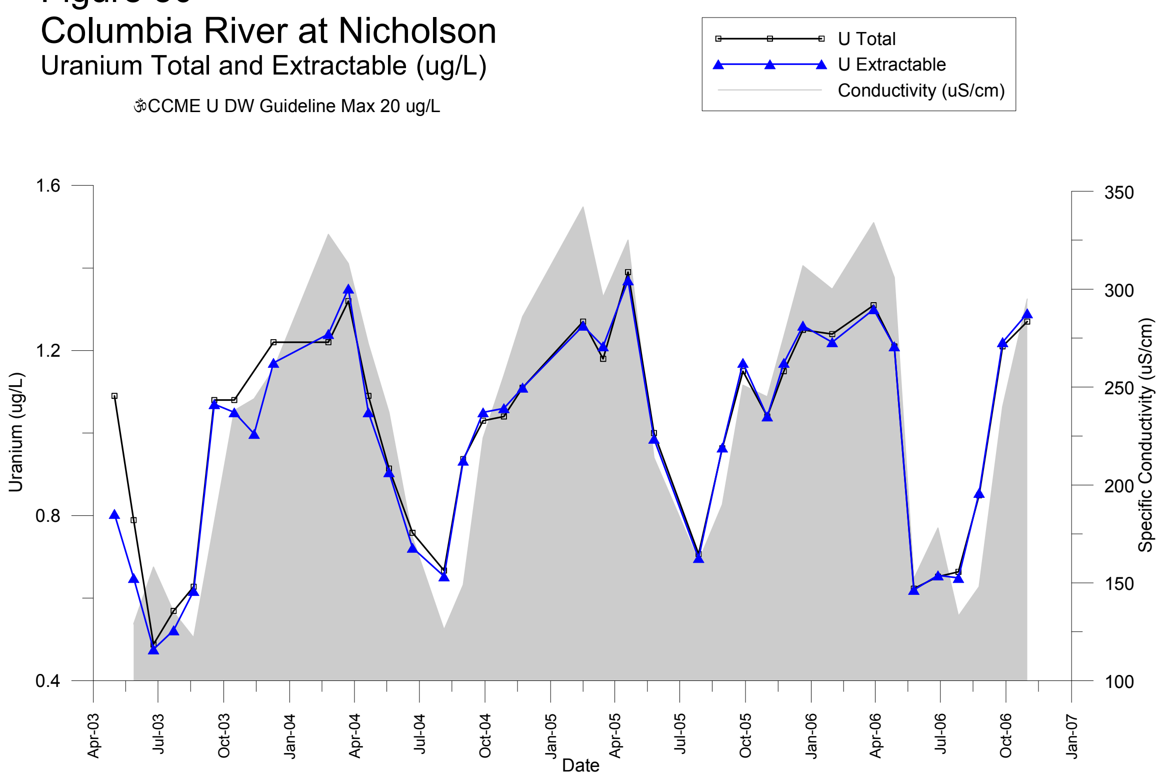


Figure 51
Columbia River at Nicholson
Vanadium Total and Extractable (ug/L)

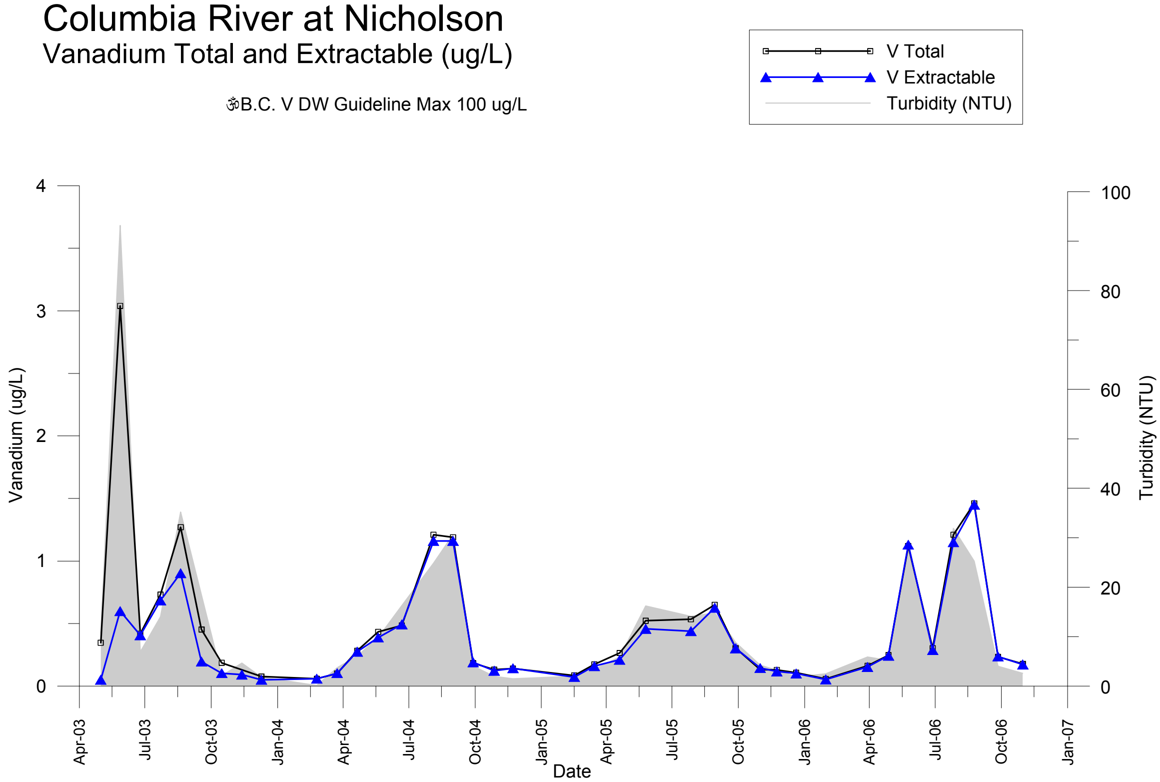


Figure 52
Columbia River at Nicholson
Zinc Total and Extractable