CANADA – BRITISH COLUMBIA
WATER QUALITY MONITORING AGREEMENT

WATER QUALITY ASSESSMENT OF Nechako River AT PRINCE GEORGE (1985 – 2004)

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Prepared for:

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and

Environment Canada

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Environment Canada **Environnement Canada**

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EXECUTIVE SUMMARY

The Nechako River is one of the major tributaries to the Fraser River, affecting both its hydrology and its water quality. The headwaters of the Nechako River are located in the Nechako Reservoir drainage basin, and flows in the upper watershed are controlled by the Kenney Dam. The drainage area of the river at Prince George is 46,000 km^2. Nechako River water quality is influenced by the water quality of the Stuart, Nautley, and Chilako rivers. Water uses for the Nechako River at Prince George include irrigation, livestock watering, primary and secondary-contact recreation (*i.e.*, swimming and boating), drinking water with partial treatment, and use by aquatic life and wildlife.

CONCLUSIONS

- The Nechako River at Prince George had occasionally high turbidity values, generally as a result of spring freshet or high precipitation. Treatment to remove turbidity is needed before using the water for drinking. Peak turbidity values seem to be higher in recent years.
- When drinking water and aquatic life guidelines were exceeded for metals such as aluminum, cadmium, chromium, cobalt, copper, lead, manganese, iron, silver, and zinc, there was a strong correlation with high turbidity values, suggesting that these metals were in particulate form and therefore not biologically available. In addition, water treatment (*e.g.*, filtration) necessary prior to consumption would remove the majority of these suspended metals from drinking water.
- With reduced detection limits in recent years, concentrations of cadmium and silver generally have met guideline levels for aquatic life. The relation of measured values to high detection limits was a concern expressed in the last assessment that has been addressed.
- Water temperatures exceeded the guidelines for migration to protect salmonids during most summers.
- Fecal coliform concentrations met the objective (i.e., were within acceptable limits for water that undergoes partial treatment (e.g., filtration) plus disinfection prior to drinking). pH also met its objective.

- Total organic carbon often exceeded the guideline for raw drinking water that will be chlorinated, and treatment to remove organic carbon and alternate disinfectants should be considered before drinking water use.
- True and apparent colour data exceeded the aesthetic guidelines for true colour in drinking water. These values in excess of the guideline were related to turbidity.
- High total and dissolved phosphorus levels are related to turbidity.

RECOMMENDATIONS

We recommend that monitoring be continued on the Nechako River at Prince George. Water quality data collected at this site would be used to:

- represent the water quality from the upper portion of the interior plain ecosystem,
- show the cumulative effects of water from the Stuart, Nautley, and Chilako rivers on water quality and hydrology,
- check attainment of water quality objectives established for the Nechako River, and
- determine changes in the water quality of the Fraser River downstream from the Nechako River confluence.

Water quality indicators that are important for future monitoring are:

- flow, water temperature, specific conductivity, pH,
- total dissolved phosphorus, total dissolved nitrogen, periphyton chlorophyll-*a*,
- dissolved oxygen, fecal coliforms, and
- true colour, turbidity, hardness, dissolved aluminum, total and dissolved copper, lead, nickel, and zinc.
- Trihalomethane (THM) concentrations should be measured in treated drinking water supplies to ensure that the high levels of dissolved organic carbon are not resulting in high residual THMs after water is chlorinated for drinking.
- The trivalent and hexavalent forms of chromium should be measured in the future, when the methods become available, to permit comparison to the aquatic life guidelines.

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INTRODUCTION

The Nechako River is one of the major tributaries that affect flow and water quality in the Fraser River. Its headwaters are located in a chain of lakes known as the Nechako Reservoir drainage basin (Figure 1). The reservoir was formed as a result of the Kenney Dam, which was erected in 1952 at the outlet of Knewstubb Lake. This dam helps divert water to generate hydroelectric power for Alcan's aluminum plant at Kitimat. Water that is not required for power generation is released from Ootsa Lake, flowing east to the Nechako River via Skins, Cheslatta and Murray lakes. It then flows northeast to Fort Fraser and the confluence with the Nautley River. The Nechako River then flows in an easterly direction for 40 km, past the City of Vanderhoof, to the confluence with the Stuart River. The river then meanders for another 35 km, past Isle Pierre, to the confluence with the Chilako River, where it then flows through the City of Prince George and discharges into the Fraser River.

The Nechako River site characterizes the water quality of the upper portions of the interior plateau. The drainage area for the site is 46 000 km^2 and represents the effects on water quality from the Stuart, Nautley, and Chilako rivers. Nechako River water is used for irrigation, livestock watering, primary and secondary-contact recreation (*i.e.*, swimming and boating), drinking water with partial treatment, and to sustain aquatic life and wildlife (Swain and Girard, 1987).

The Nechako River at Prince George has been jointly operated as a federal-provincial water quality monitoring station since 1985. This report assesses twenty years of water quality data. The provincial EMS station number is E206583 and the federal ENVIRODAT station number is BC08KE0010. Flow is plotted in Figure 2, showing 1985 – 2004 data from Water Survey of Canada station BC08JC002 at Isle Pierre, which has a drainage area of 42 500 km^2, including 14 000 km^2 behind the Kenney Dam. Water quality data are plotted in Figures 3 to 49. Data for the Nechako River at Prince George 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 to assess attainment of water quality objectives. In addition, quality assurance samples (blanks and replicates) are collected three times per year.

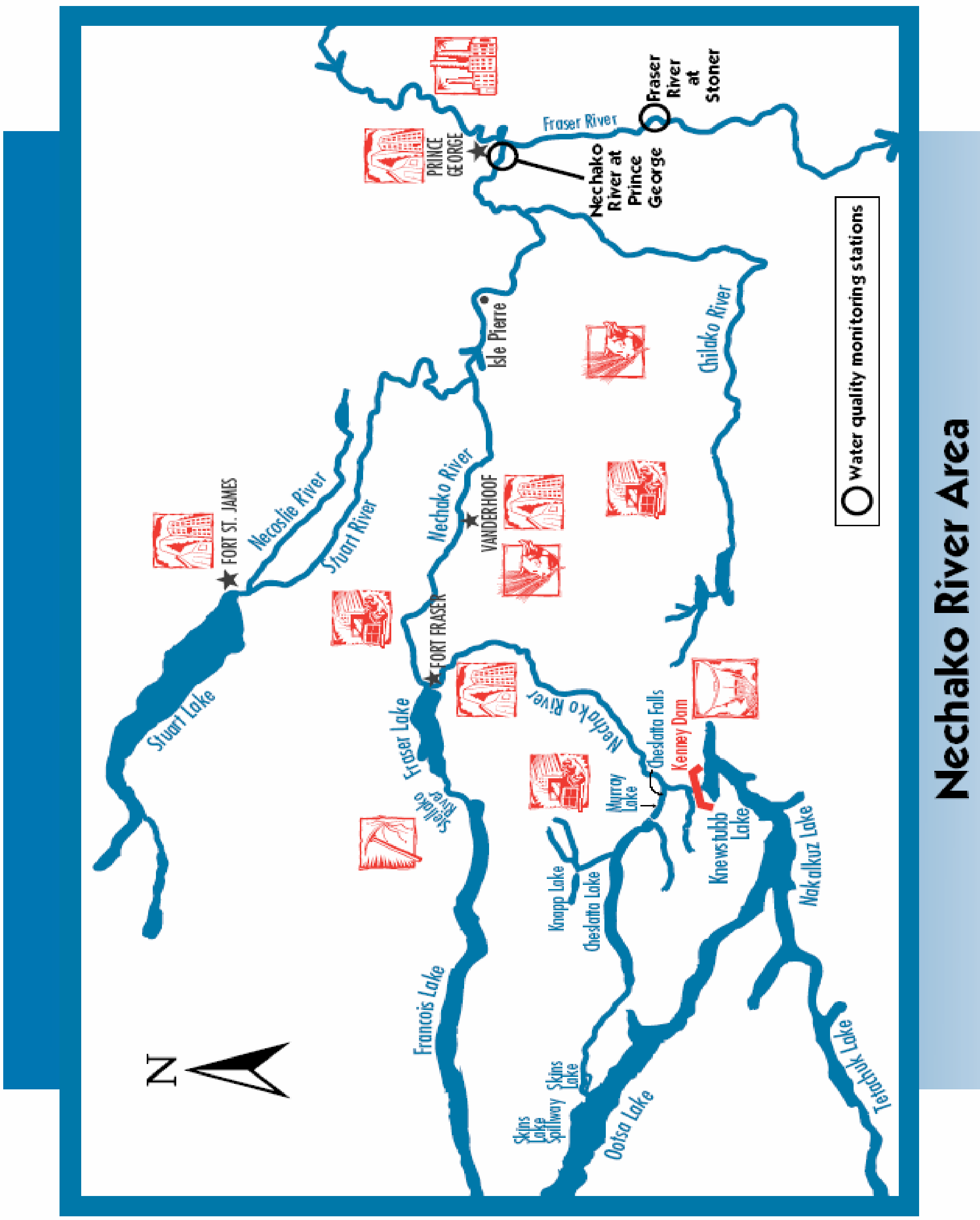
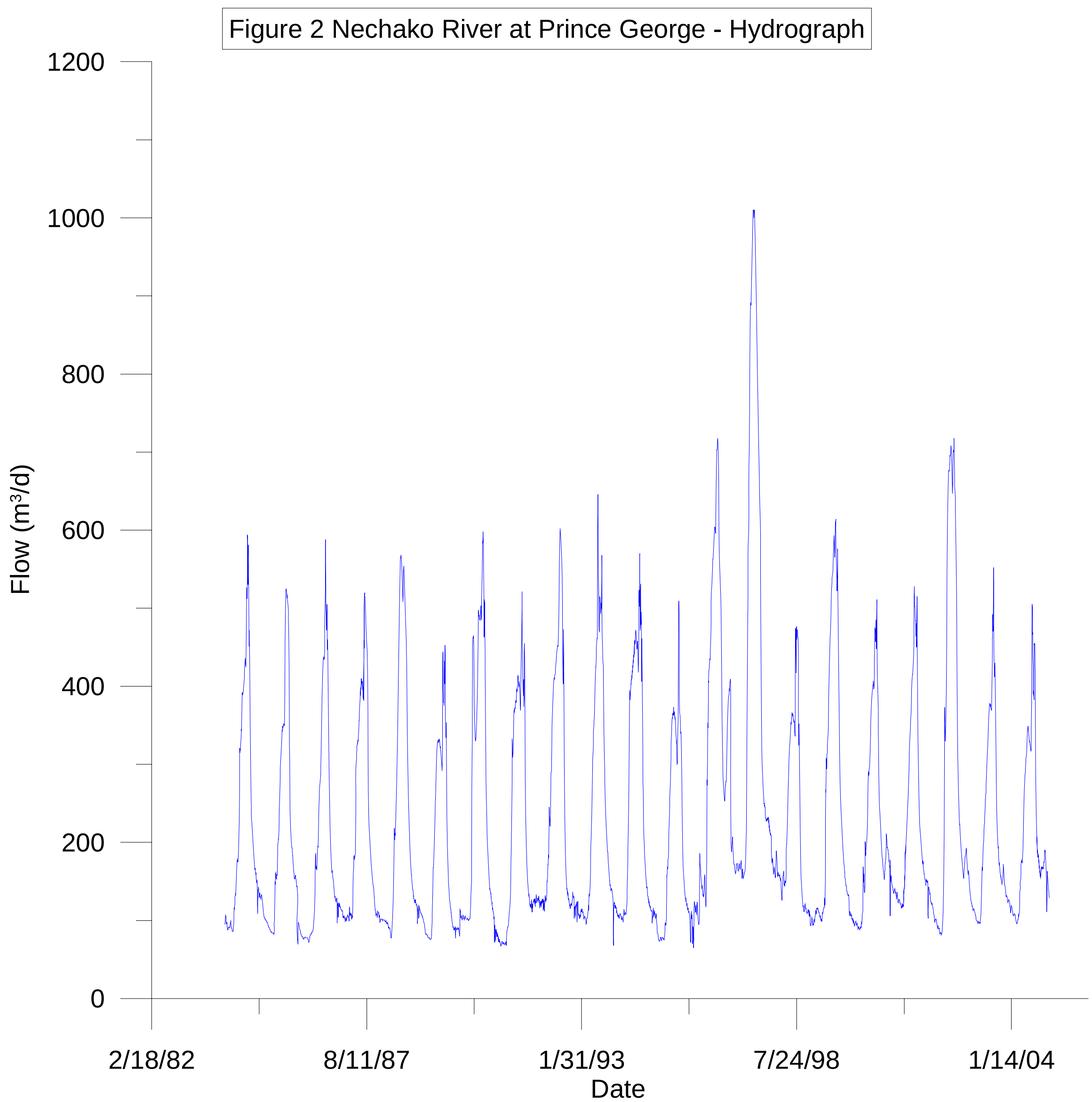


Figure 1: Nechako River at Prince George



WATER QUALITY ASSESSMENT

The status and trends of various water quality indicators were assessed by plotting the indicators over time and comparing the values to the Province's approved and working water quality guidelines (Ministry of Environment, 2001a & 2001b). Any levels or changes of the indicators over time that may have been harmful to sensitive water uses, such as drinking water, aquatic life, wildlife, recreation, irrigation, and livestock watering, are described below in alphabetical order. Water quality indicators were not discussed if they were in no danger of exceeding water quality guidelines and showed no harmful trends. These included: alkalinity, antimony, arsenic, barium, beryllium, bismuth, boron, calcium, carbon, chloride, specific conductivity, fluoride, hardness, lithium, magnesium, molybdenum, nickel, nitrate/nitrite, total dissolved nitrogen, pH, phosphorus, potassium, selenium, sodium, strontium, solids, sulphate, thallium, tin, and vanadium.

Total aluminum (Figure 4) exceeded the water quality guideline for the protection of wildlife, livestock and irrigation (5 mg/L) once. The highest values are concurrent with high turbidity values (see Figure 4), which suggests that the majority of the aluminum was associated with particulate matter and not in the dissolved form. It is recommended that the concentration of dissolved aluminum be measured in the future to allow a useful comparison with the guidelines for aquatic life and drinking water. No change was noted in total aluminum concentrations over the duration of record.

Cadmium concentrations (Figure 11) have been hampered by high levels of detection that have made interpretation of results difficult. Detection limits were improved (lowered by an order of magnitude) in 2003 to 0.001 µg/L and values measured since have usually been less than the guidelines for the protection of aquatic life (0.008 µg/L at minimum hardness of 20 mg/L, and 0.024 µg/L at average hardness of 70 mg/L). No values have exceeded guidelines since the change in detection limit.

Organic carbon (Figure 13) frequently exceeds the guideline (4 mg/L) for raw drinking water that will be chlorinated, and treatment to remove organic carbon and alternate disinfectants should be considered before drinking water use.

Total chromium concentrations occasionally exceeded the aquatic life guidelines of 1 µg/L for hexavalent and 9 µg/L for trivalent chromium (Figure 15). Irrigation guidelines are a maximum of 5 µg/L trivalent and 8 µg/L hexavalent chromium. Measurements of the trivalent and hexavalent forms of chromium with detection limits of 0.1 µg/L or lower should be made when the analytical methods become available.

Total cobalt values are generally unchanged during the period of record (Figure 16). One value exceeded the B.C. guideline for the protection of aquatic life (4 μg/L), however turbidity that day was also high.

Fecal coliform concentrations have only been measured since early 2000 (Figure 17). All individual values were below the 90th percentile guideline for the protection of drinking water that will receive partial treatment (100 CFU/100 mL).

True and apparent colour values (Figure 18) at times exceed the aesthetic guideline for drinking water of 15 TCU. Colour values are related to turbidity, with coincident increases in each.

Total copper (Figure 20) appear to be decreasing; however, when the values from the 1980's are excluded from the analysis, values appear to be stable. The aquatic life guidelines for copper are hardness-dependent. The guideline corresponding to the average hardness was exceeded by some individual samples although not since 2000; however, these were related to high turbidity values. This suggests that much of the copper present at these times was associated with particulate matter which decreases its availability to biota.

Total iron (Figure 23) concentrations regularly exceeded the aesthetic drinking water and aquatic life guideline of 0.3 mg/L. These exceedances occurred almost invariably when turbidity levels were relatively high. The occasional high concentrations of iron are due to natural sources, as there are no known human sources of iron upstream from this point. There was no apparent change in iron levels over time.

The guidelines for **total lead** (30-day mean of 4.6 μg/L for aquatic life) was exceeded by only one sample collected during the entire period of record (Figure 24); this occurred when turbidity was elevated. There seems to be some correlation between total lead concentrations and turbidity.

Total manganese concentrations have exceeded the drinking water guideline of 50 µg/L, usually when turbidity is high (Figure 27). There does not appear to be a trend in turbidity concentrations.

Total silver concentrations occasionally exceeded the 30-day average freshwater guideline of 0.05 µg/L and the maximum of 0.10µg/L, but only prior to 2003, before a lower detection limit was implemented. (Figure 37). All individual values have met the 0.05 µg/L guideline since this time.

Water temperature (Figure 43) regularly exceeds the guideline for fish migration during summer periods. There is no trend in the data through time.

Turbidity values frequently exceeded both the drinking water guideline for health (1 NTU), and occasionally exceeded the aesthetic drinking water guideline (5 NTU) (Figure 46). This indicates that the water would require partial treatment (*e.g.*, filtration) plus disinfection before use as drinking water. Turbidity values appear to be increasing slightly over the years, although this needs to be confirmed using appropriate statistics. The strong correlation between flow and turbidity values is shown in figure 47.

Total zinc levels appear to be correlated with turbidity events. The aquatic life guideline, which is hardness-dependent, is a 30-day average of ≤7.5 µg/L. Some individual total zinc values exceeded this guideline; however, these are correlated with turbidity (Figure 49), and therefore likely unavailable to aquatic life. It does not appear that zinc concentrations are changing over time at this site. There are no known anthropogenic sources of zinc in the Nechako River watershed.

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Swain, L.G. and R. Girard 1987. Takla-Nechako Area Nechako River Water Quality Assessment and Objectives. Water Quality Branch, Water Management Department, Ministry of Environment, Lands and Parks, Victoria, B.C.

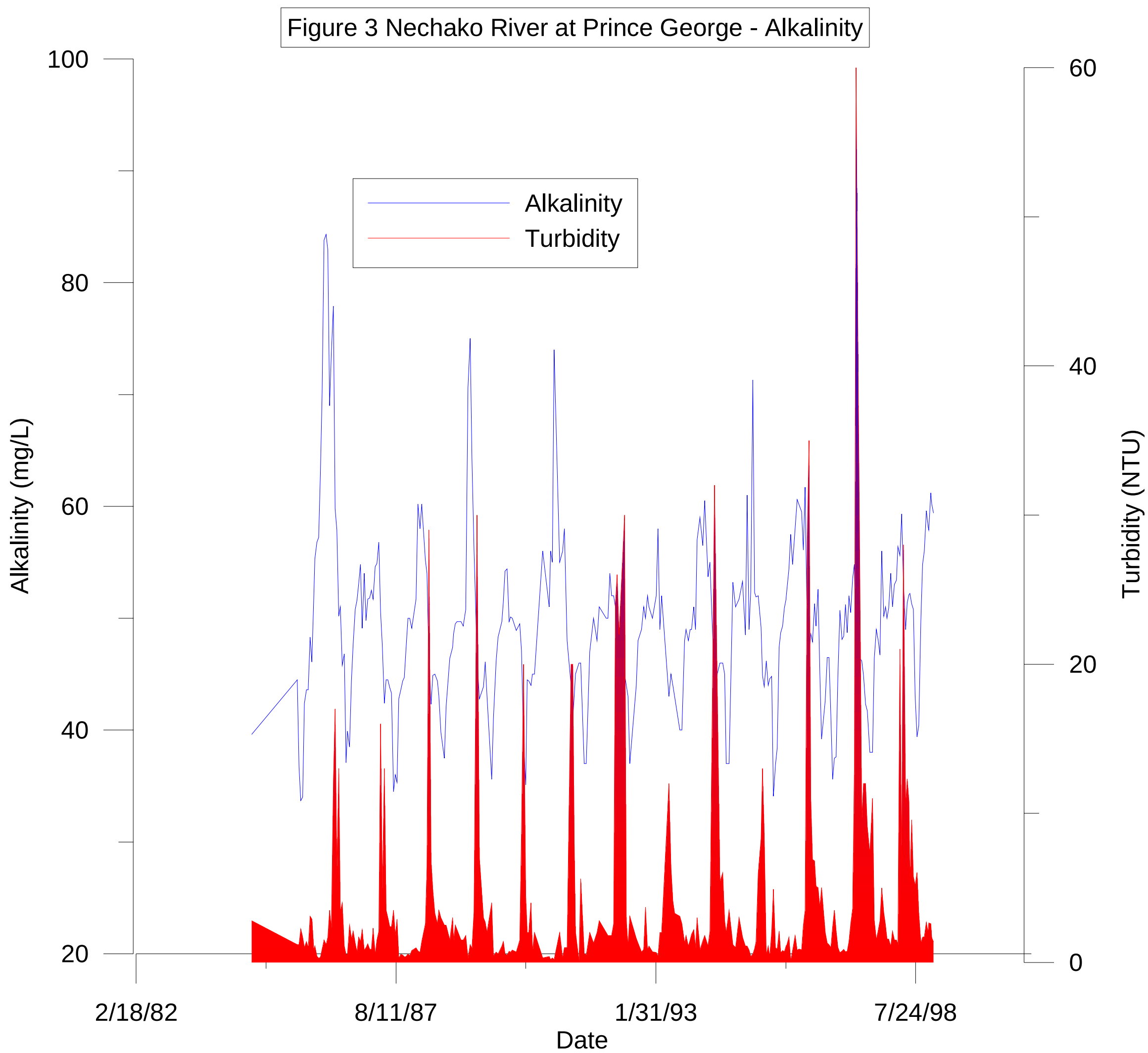
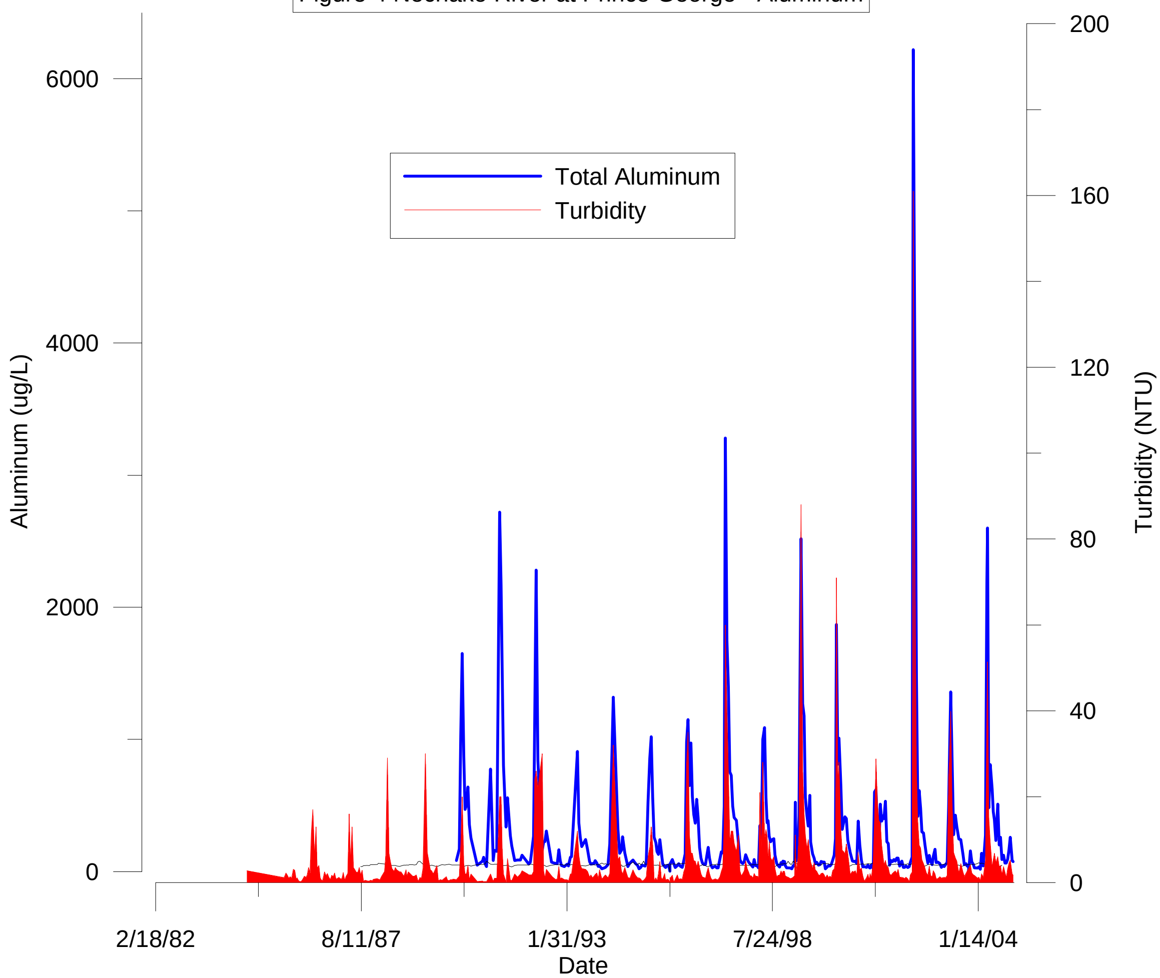


Figure 3 Nechako River at Prince George - Alkalinity
Alkalinity
Turbidity
Alkalinity (mg/L)
Turbidity (NTU)
100
80
60
40
20
60
40
20
0
2/18/82
8/11/87
1/31/93
7/24/98
Date

Figure 4 Nechako River at Prince George - Aluminum



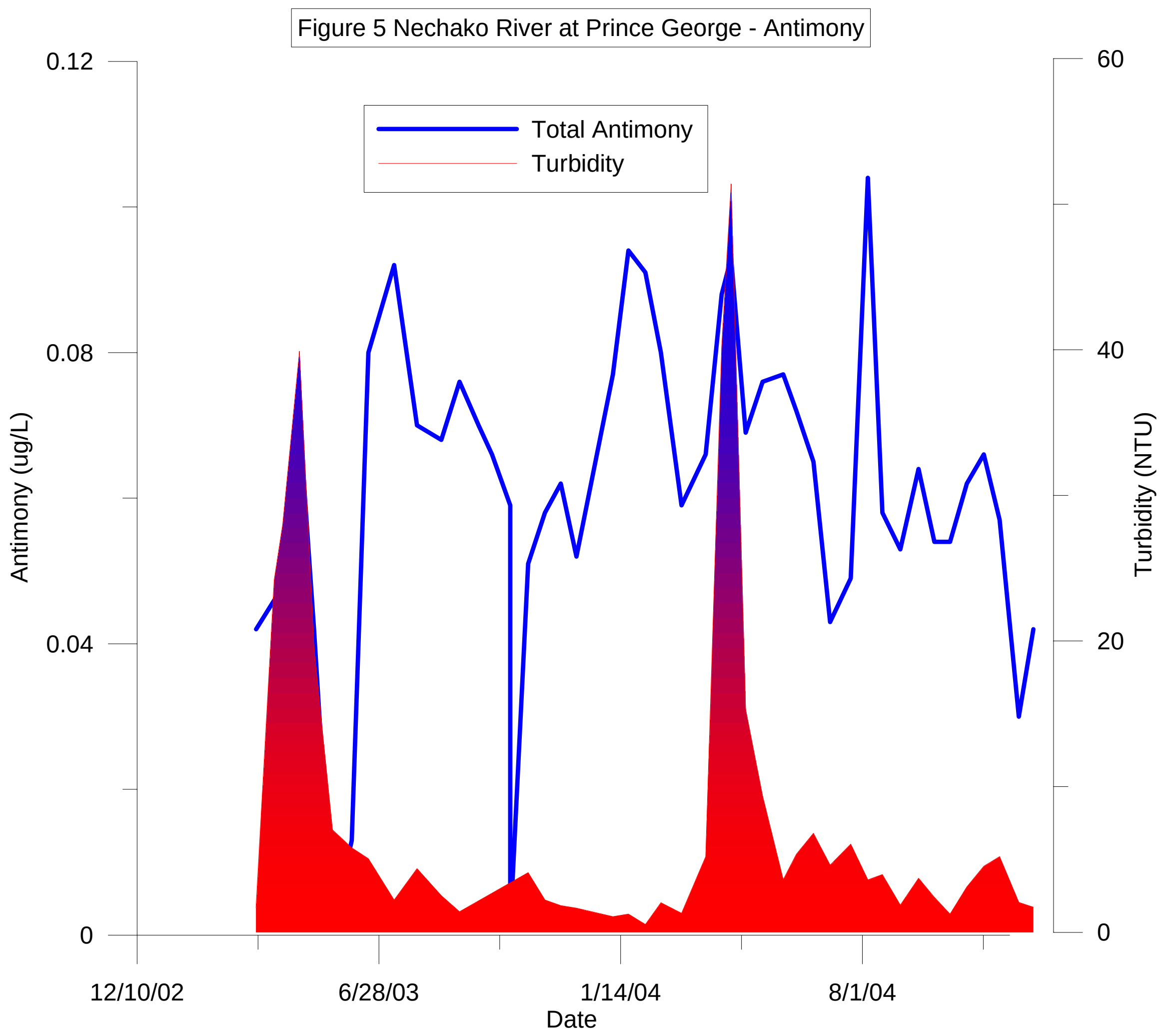


Figure 5 Nechako River at Prince George - Antimony
Total Antimony
Turbidity
Antimony (ug/L)
0.12
0.08
0.04
0
Turbidity (NTU)
60
40
20
0
12/10/02
6/28/03
1/14/04
8/1/04
Date

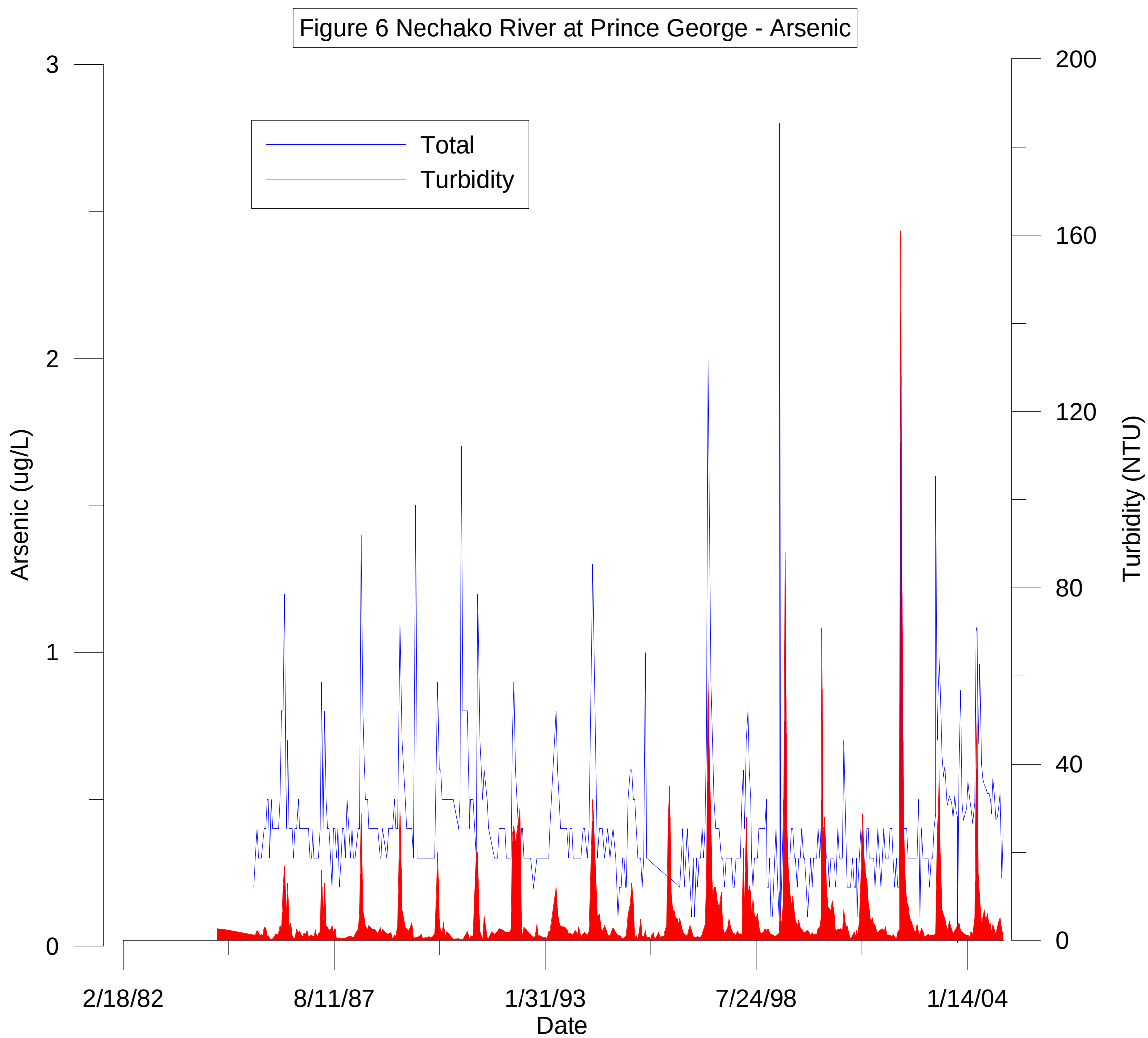
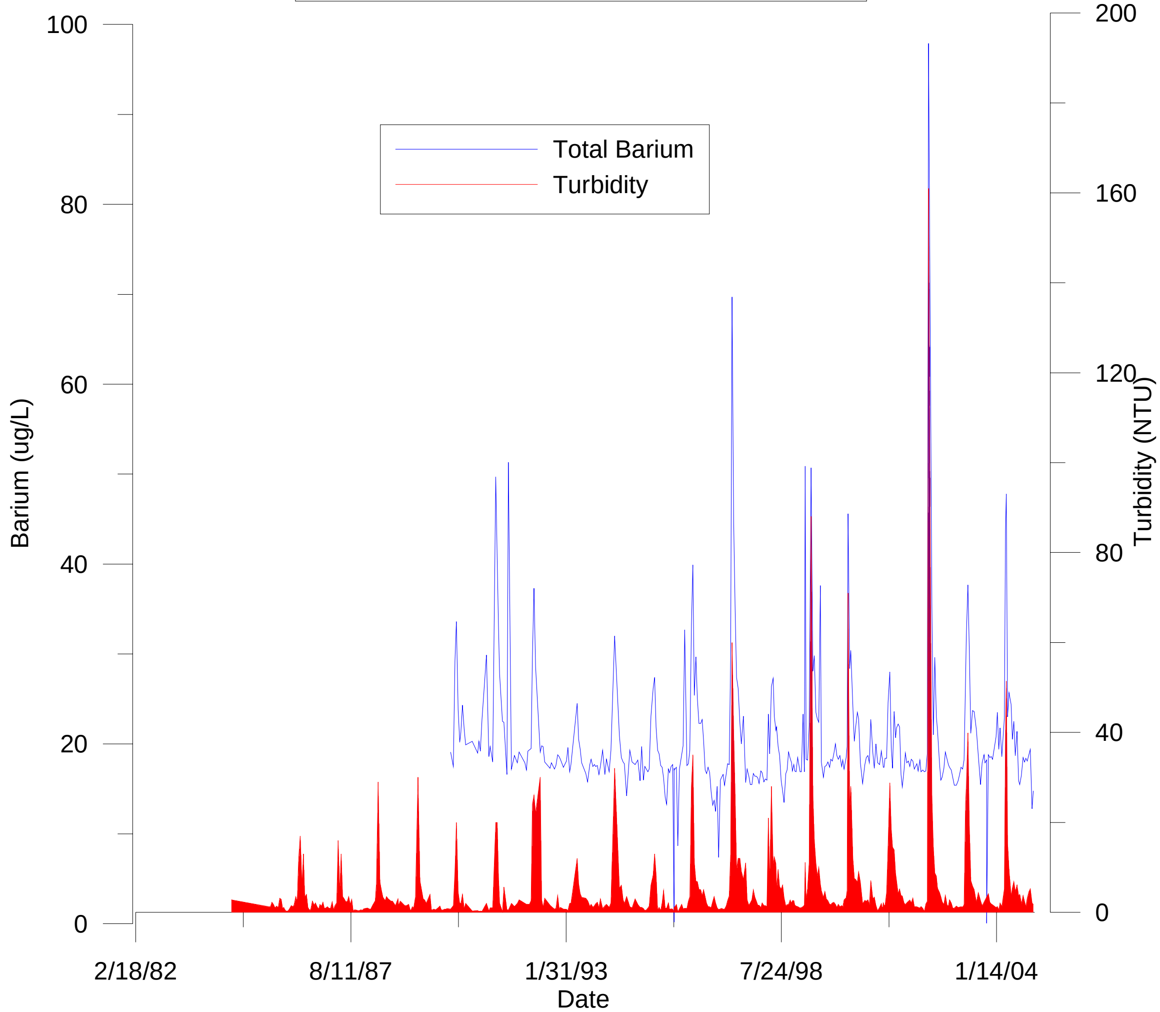


Figure 6 Nechako River at Prince George - Arsenic
Total
Turbidity
Arsenic (ug/L)
3
2
1
0
Turbidity (NTU)
200
160
120
80
40
0
2/18/82
8/11/87
1/31/93
7/24/98
1/14/04
Date

Figure 7 Nechako River at Prince George - Barium



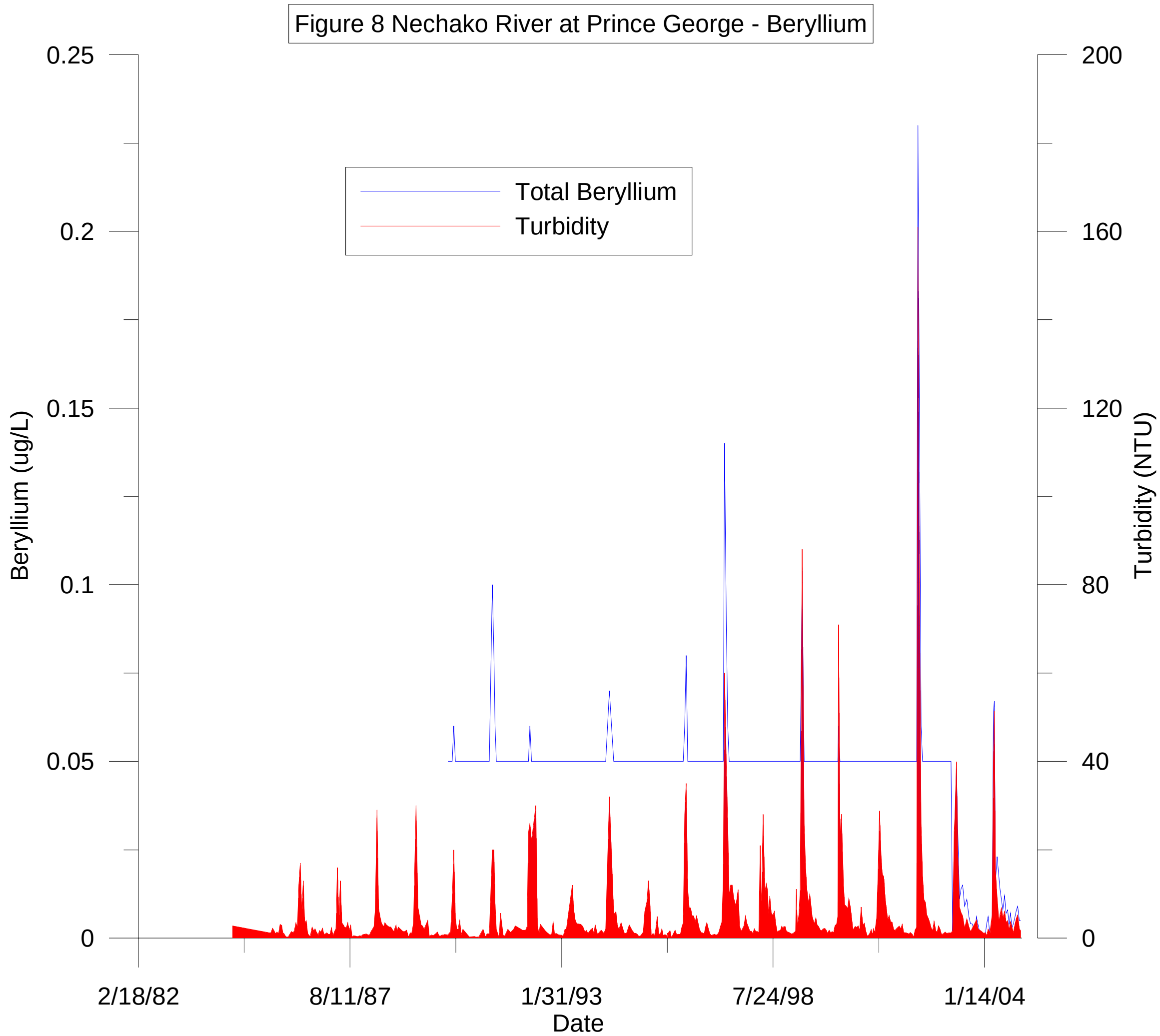


Figure 8 Nechako River at Prince George - Beryllium
Total Beryllium
Turbidity
Beryllium (ug/L)
Turbidity (NTU)
0.25
0.2
0.15
0.1
0.05
0
200
160
120
80
40
0
2/18/82
8/11/87
1/31/93
7/24/98
1/14/04
Date

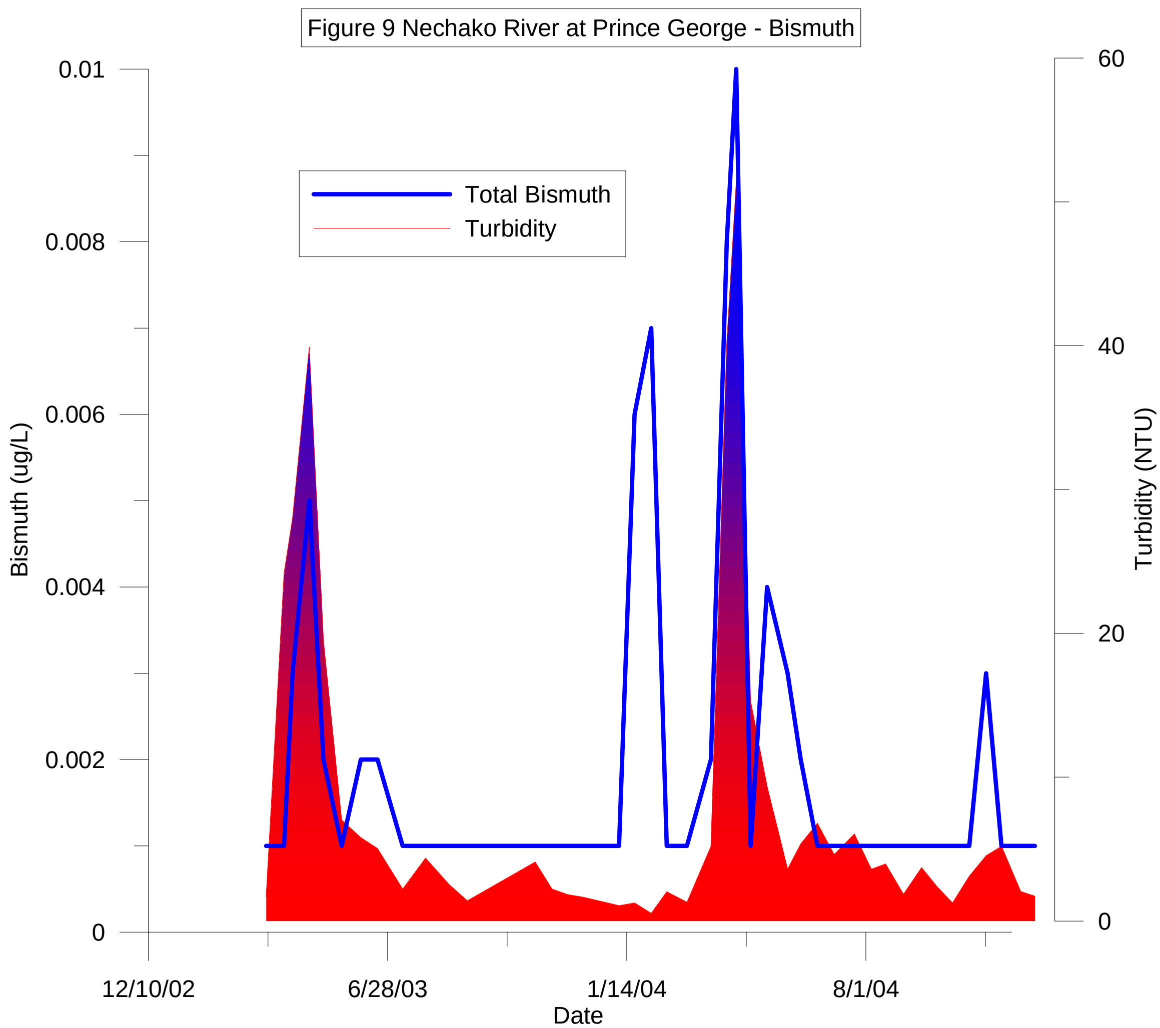


Figure 9 Nechako River at Prince George - Bismuth
Total Bismuth
Turbidity
Bismuth (ug/L)
Turbidity (NTU)
0.01
0.008
0.006
0.004
0.002
0
60
40
20
0
12/10/02
6/28/03
1/14/04
8/1/04
Date

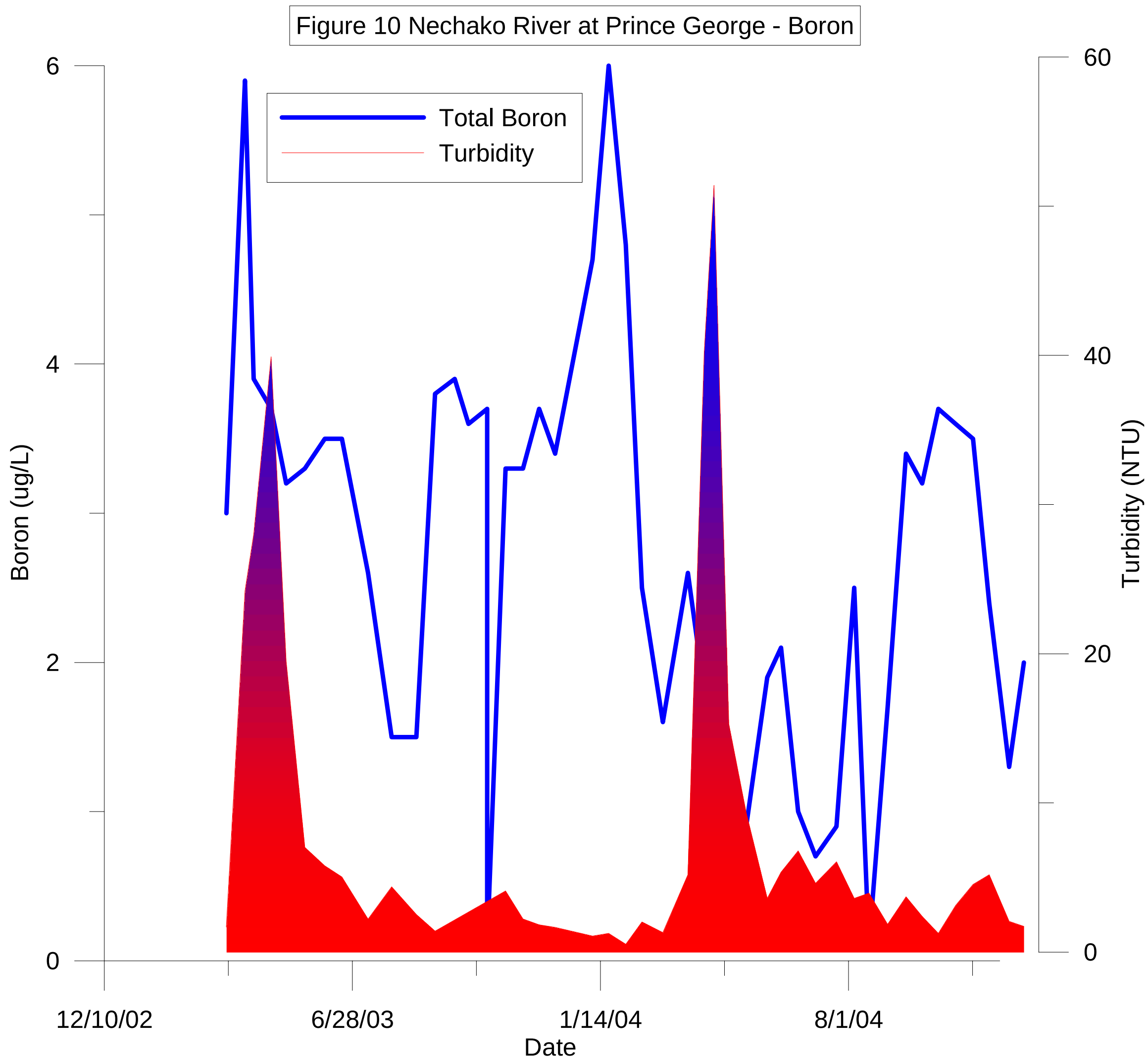


Figure 10 Nechako River at Prince George - Boron
Total Boron
Turbidity
6
4
2
0
Boron (ug/L)
60
40
20
0
Turbidity (NTU)
12/10/02
6/28/03
1/14/04
8/1/04
Date

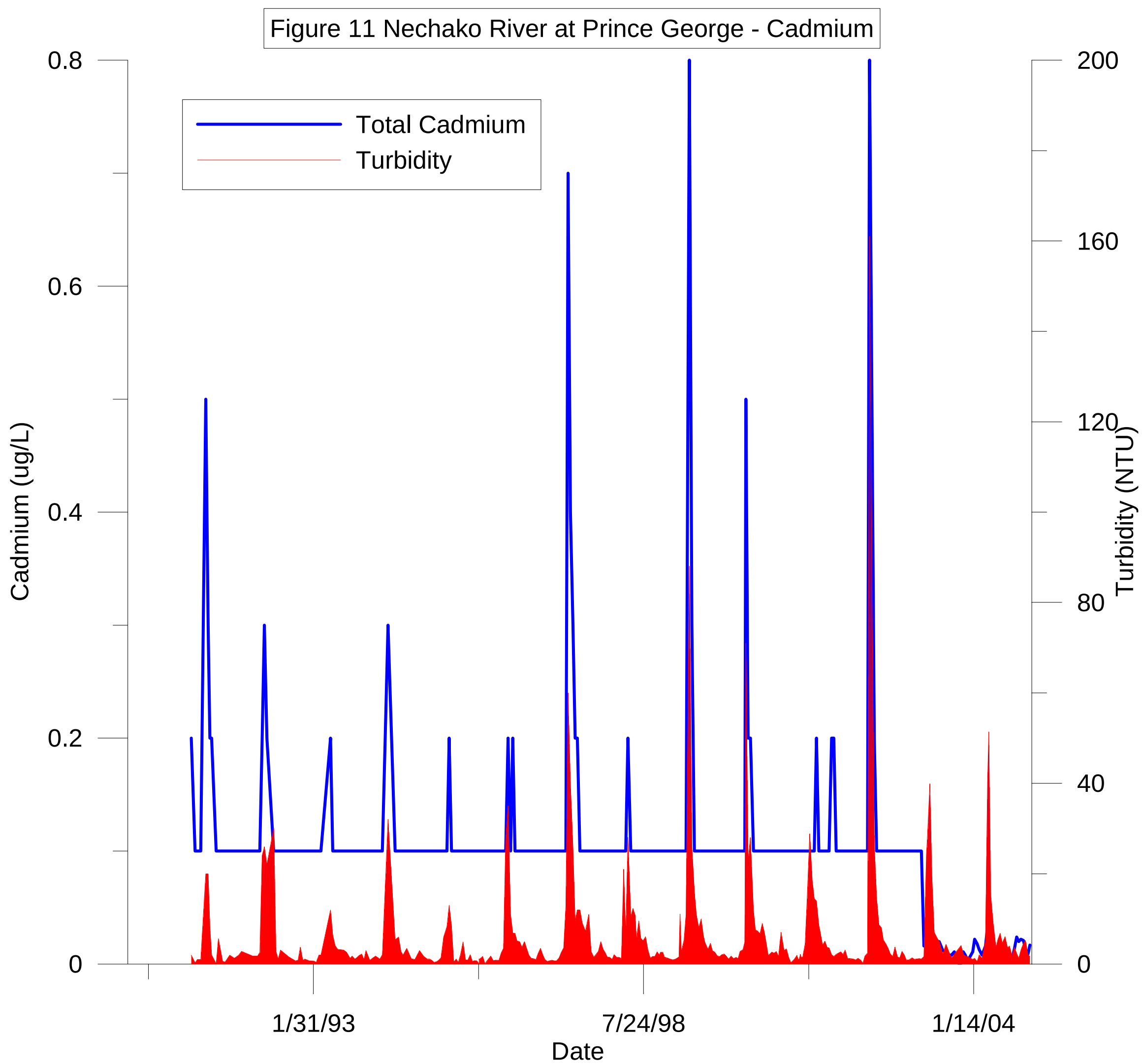


Figure 11 Nechako River at Prince George - Cadmium
Total Cadmium
Turbidity
Cadmium (ug/L)
Turbidity (NTU)
0.8
0.6
0.4
0.2
0
200
160
120
80
40
0
1/31/93
7/24/98
1/14/04
Date

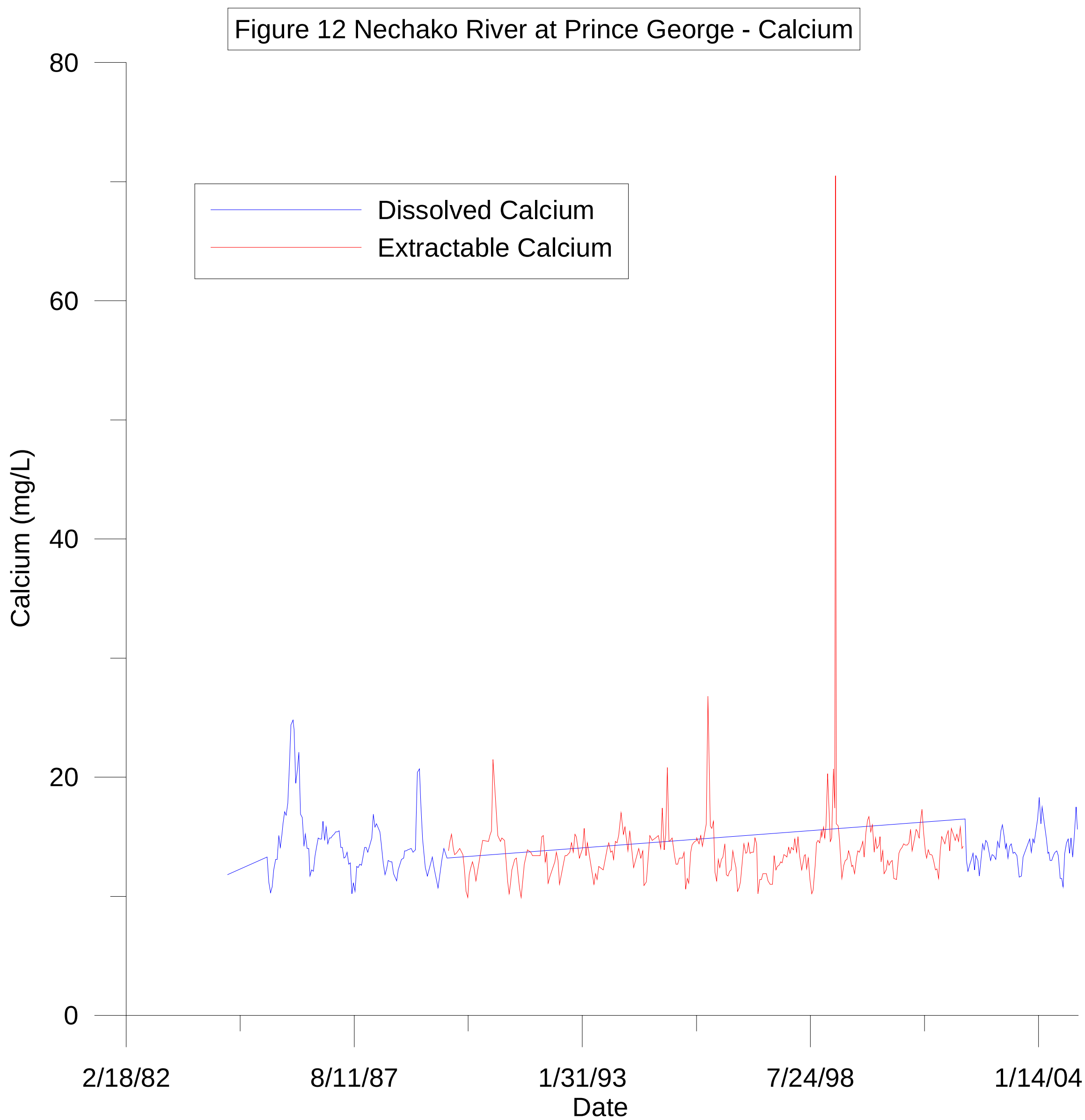


Figure 12 Nechako River at Prince George - Calcium
Dissolved Calcium
Extractable Calcium
Calcium (mg/L)
80
60
40
20
0
2/18/82
8/11/87
1/31/93
7/24/98
1/14/04
Date

Figure 13 Nechako River at Prince George - Carbon

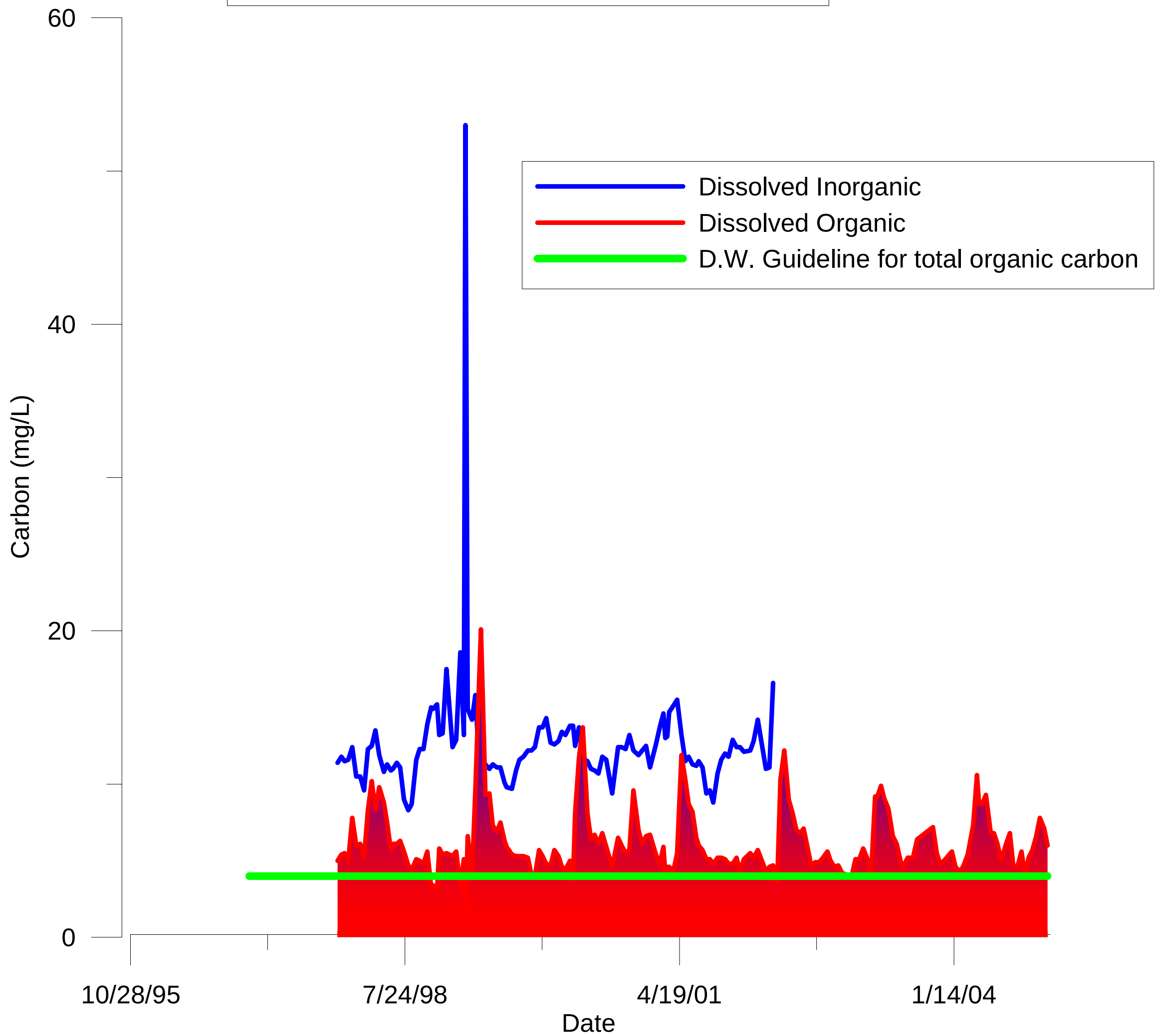


Figure 14 Nechako River at Prince George - Chloride

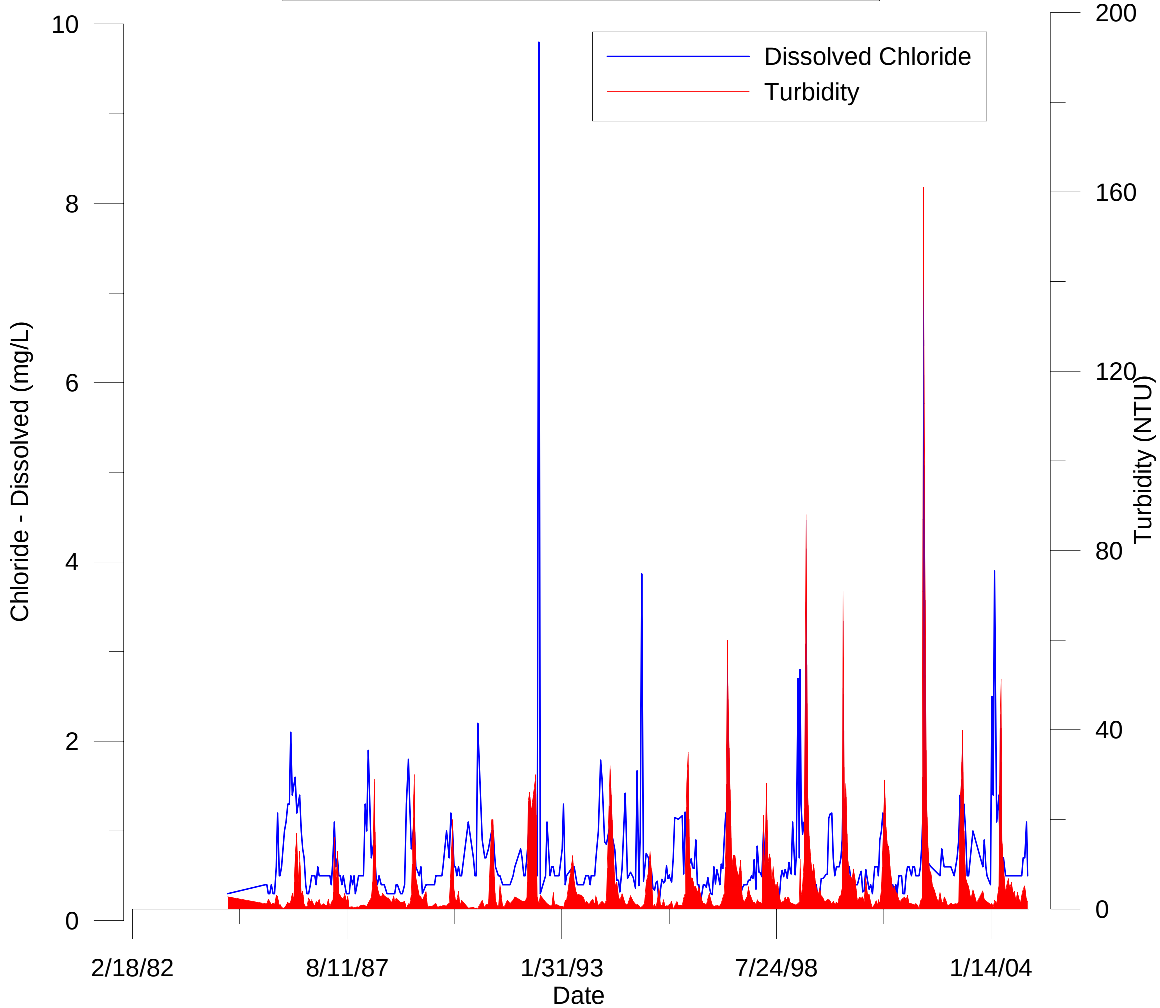
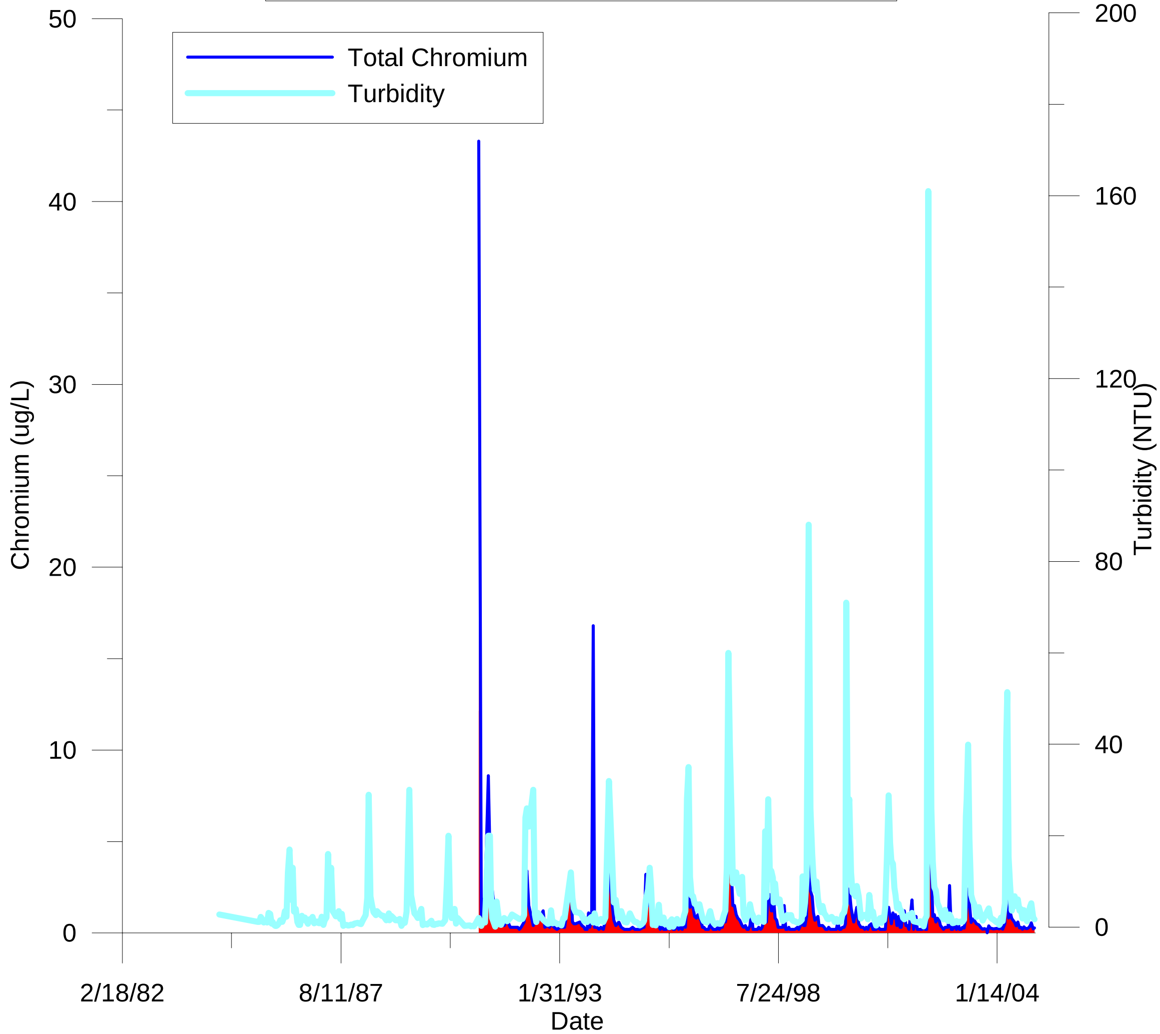


Figure 15 Nechako River at Prince George - Chromium



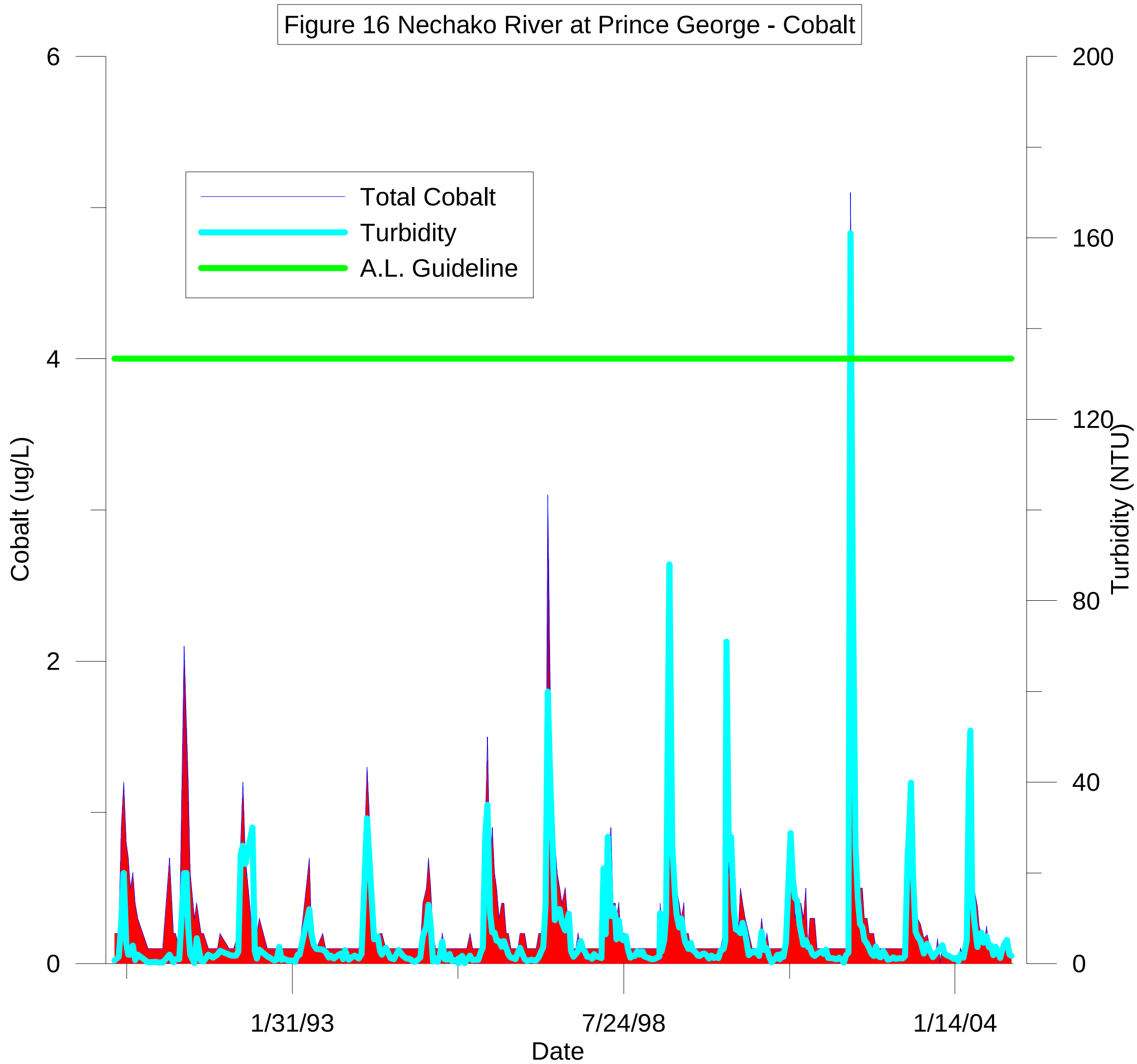


Figure 16 Nechako River at Prince George - Cobalt
Total Cobalt
Turbidity
A.L. Guideline
Cobalt (ug/L)
Turbidity (NTU)
0
2
4
6
0
40
80
120
160
200
1/31/93
7/24/98
1/14/04
Date

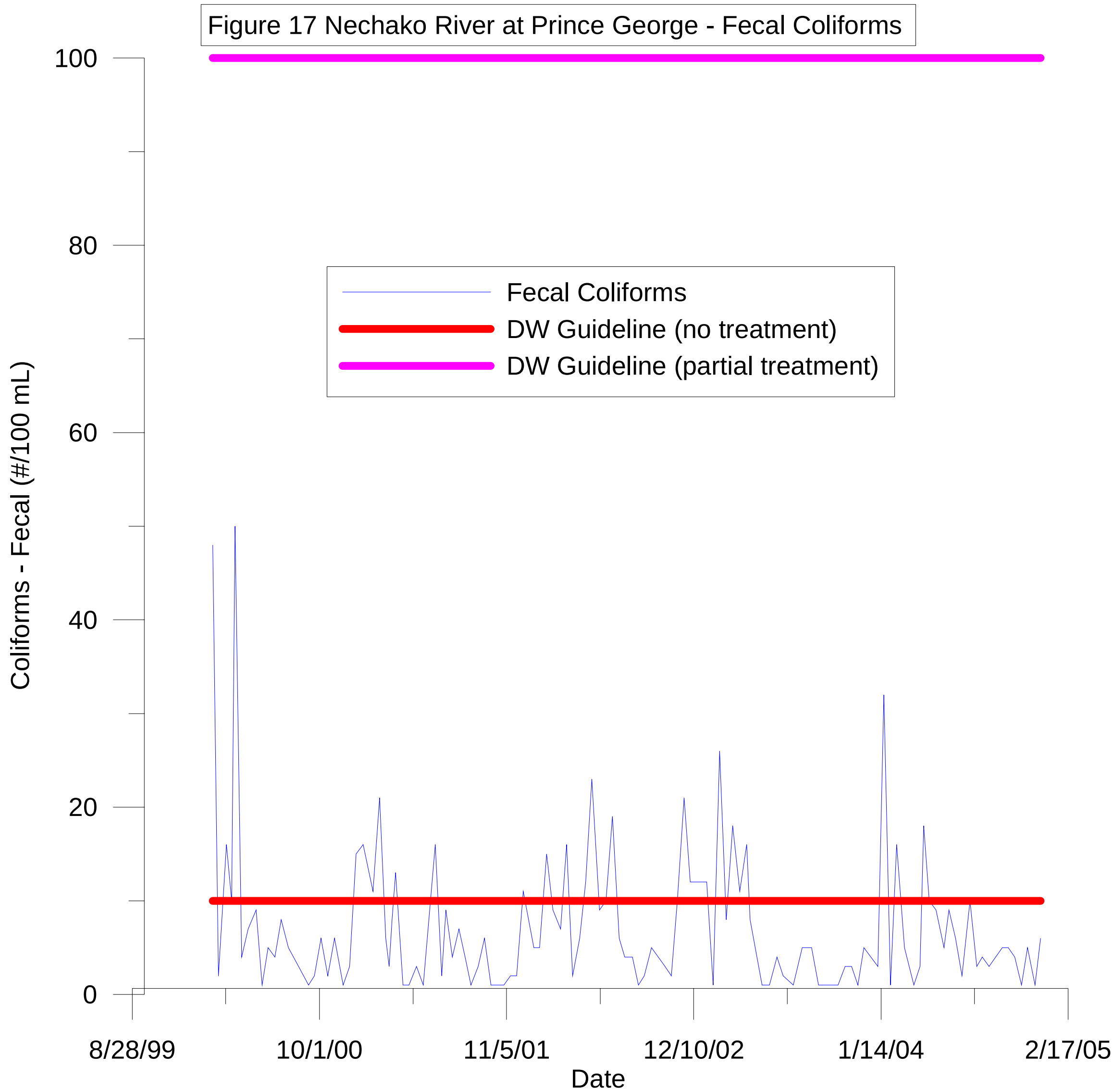


Figure 17 Nechako River at Prince George - Fecal Coliforms
100
80
60
40
20
0
Coliforms - Fecal (#/100 mL)
Fecal Coliforms
DW Guideline (no treatment)
DW Guideline (partial treatment)
8/28/99
10/1/00
11/5/01
12/10/02
1/14/04
2/17/05
Date

Figure 18 Nechako River at Prince George - Colour

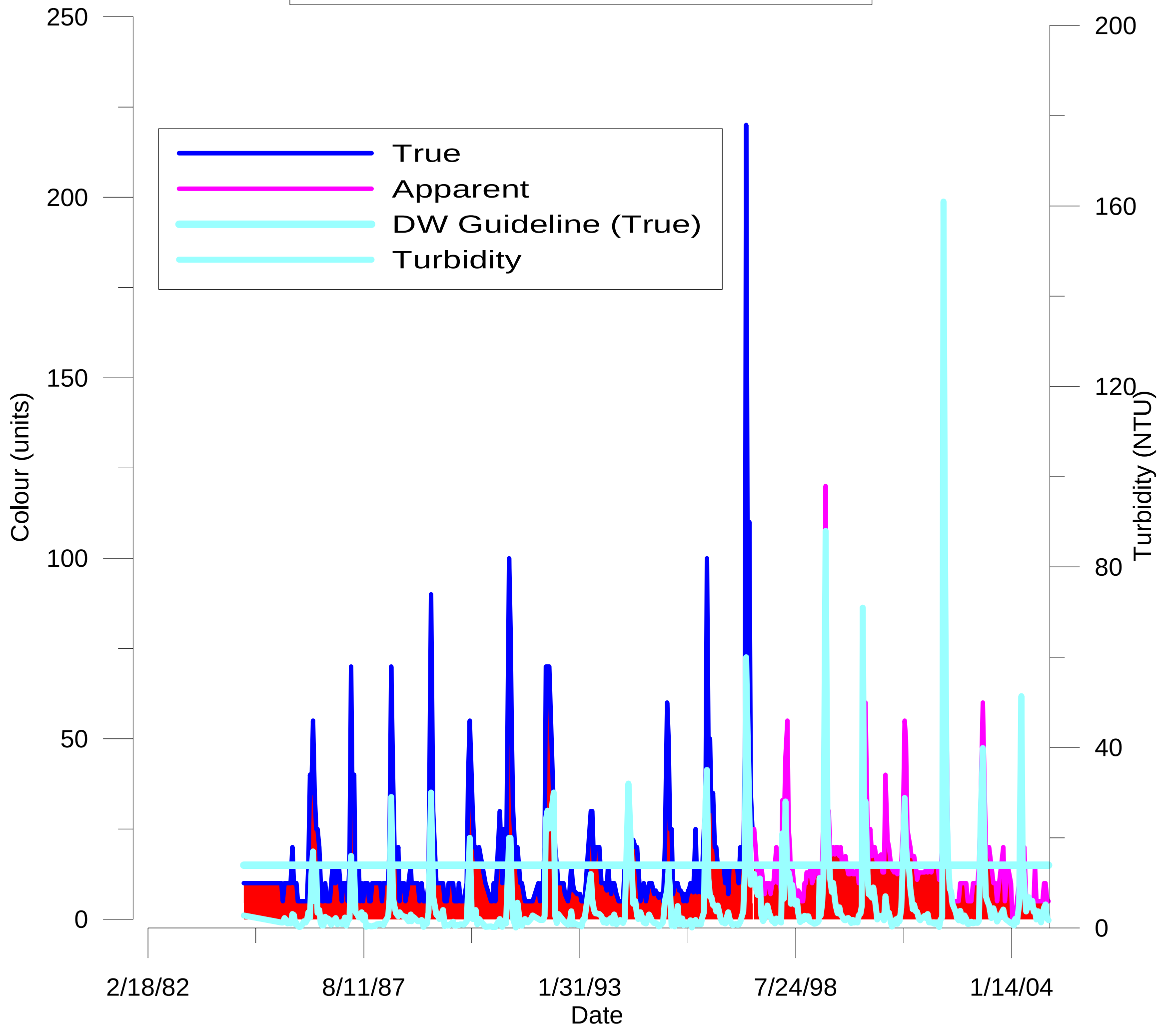
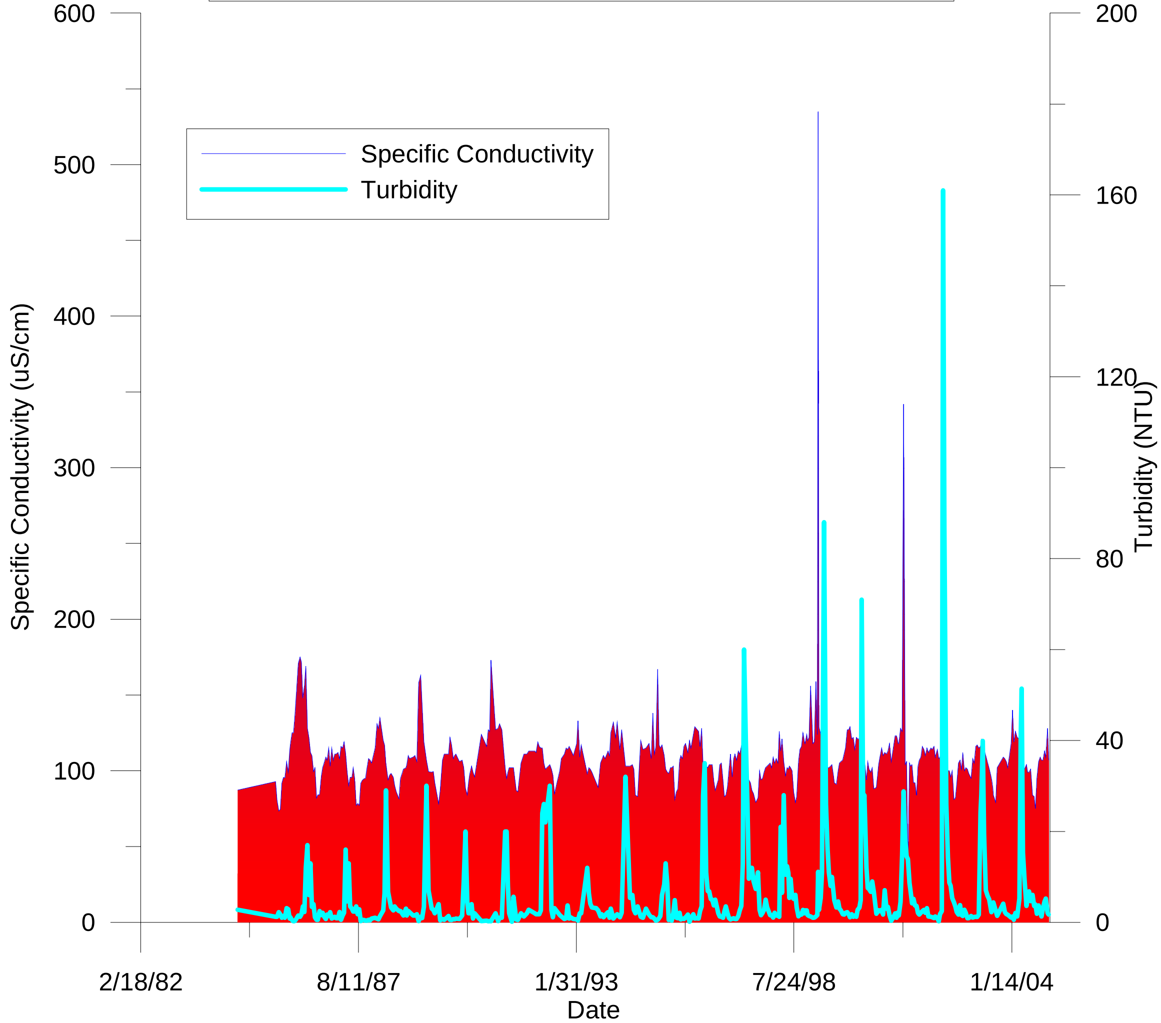


Figure 19 Nechako River at Prince George - Specific Conductivity



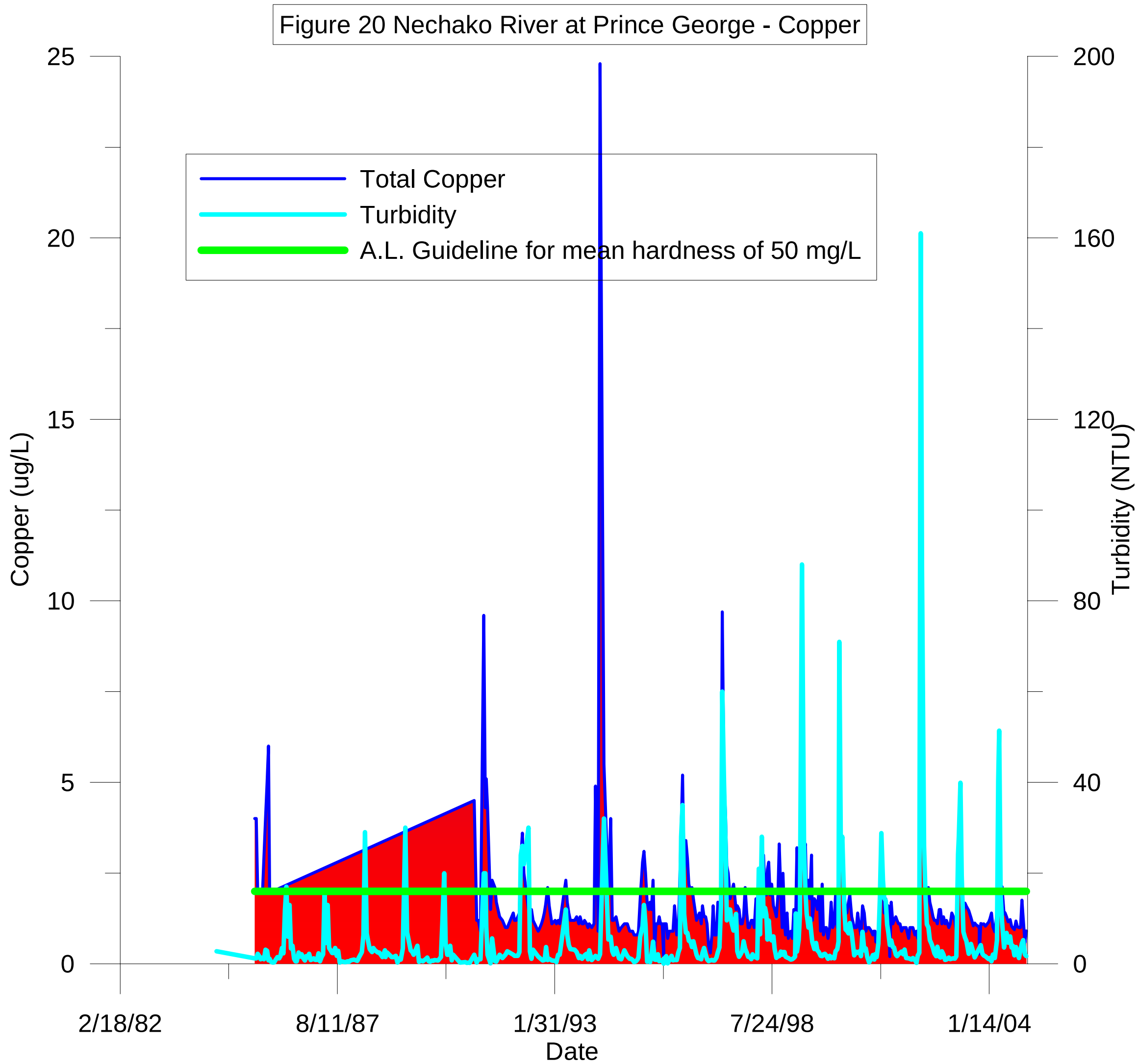
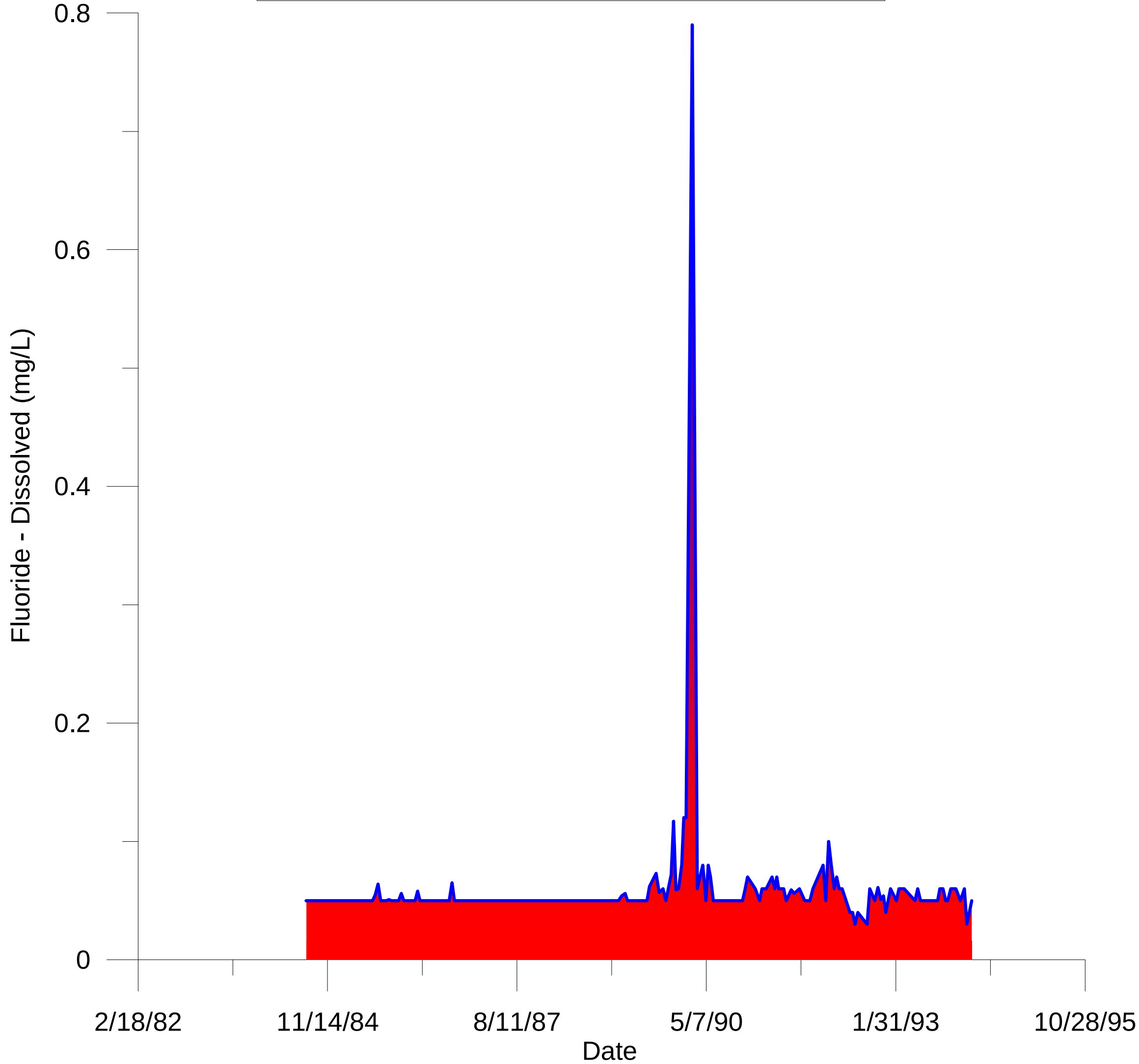


Figure 20 Nechako River at Prince George - Copper
Total Copper
Turbidity
A.L. Guideline for mean hardness of 50 mg/L
Copper (ug/L)
Turbidity (NTU)
25
20
15
10
5
0
200
160
120
80
40
0
2/18/82
8/11/87
1/31/93
7/24/98
1/14/04
Date

Figure 21 Nechako River at Prince George - Fluoride



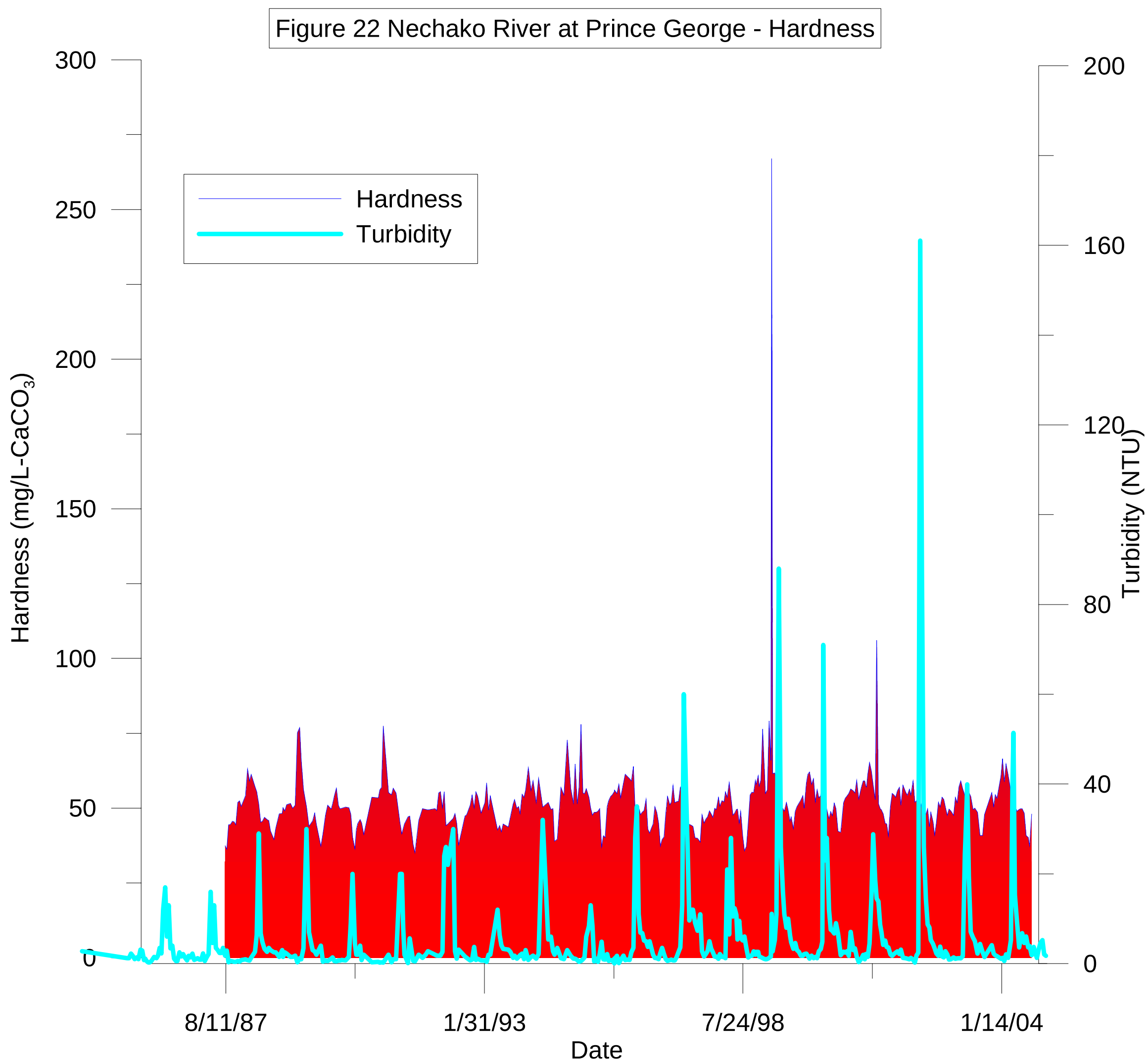


Figure 22 Nechako River at Prince George - Hardness
Hardness
Turbidity
Hardness (mg/L-CaCO3)
Turbidity (NTU)
300
250
200
150
100
50
0
200
160
120
80
40
0
8/11/87
1/31/93
7/24/98
1/14/04
Date

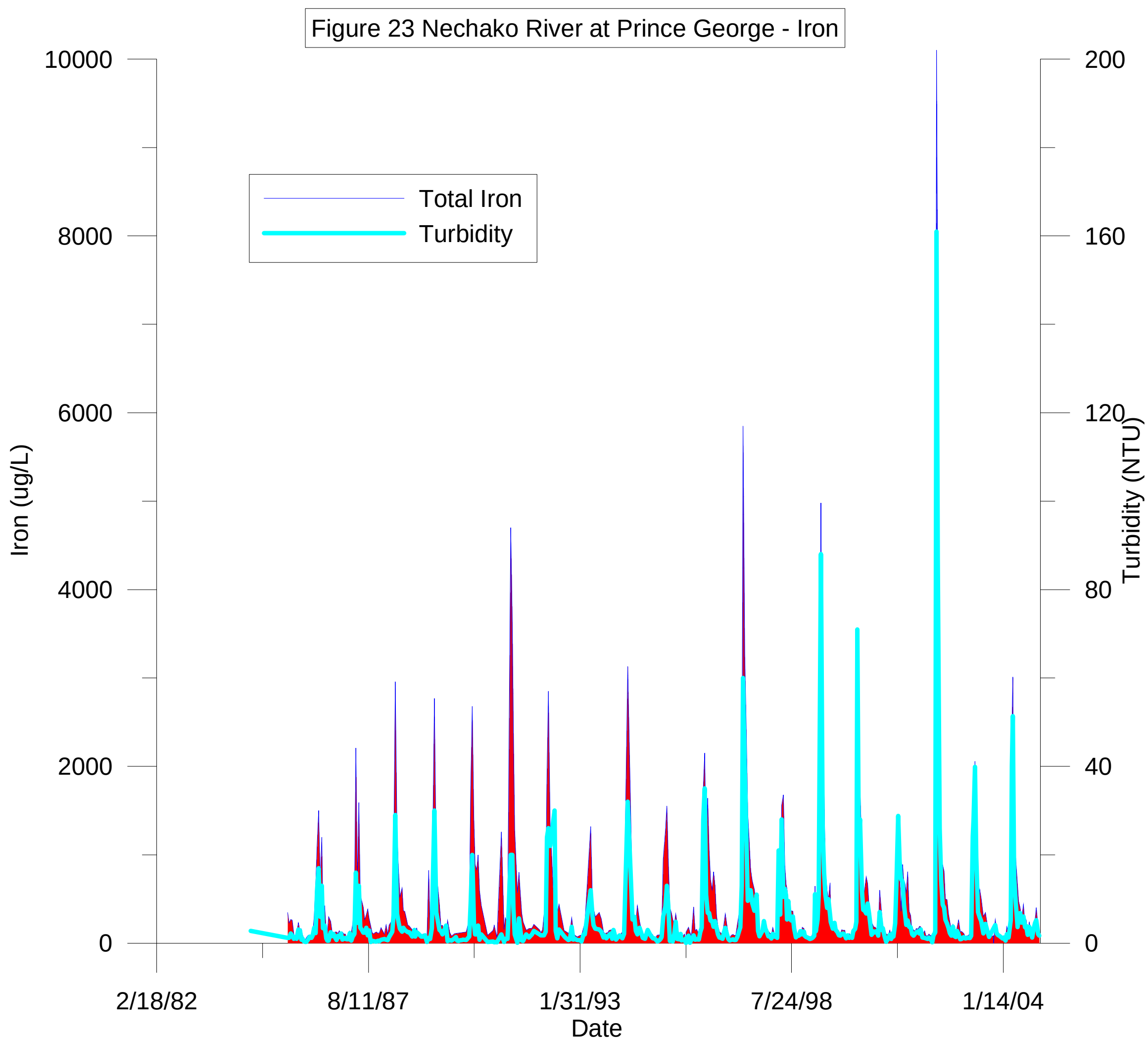
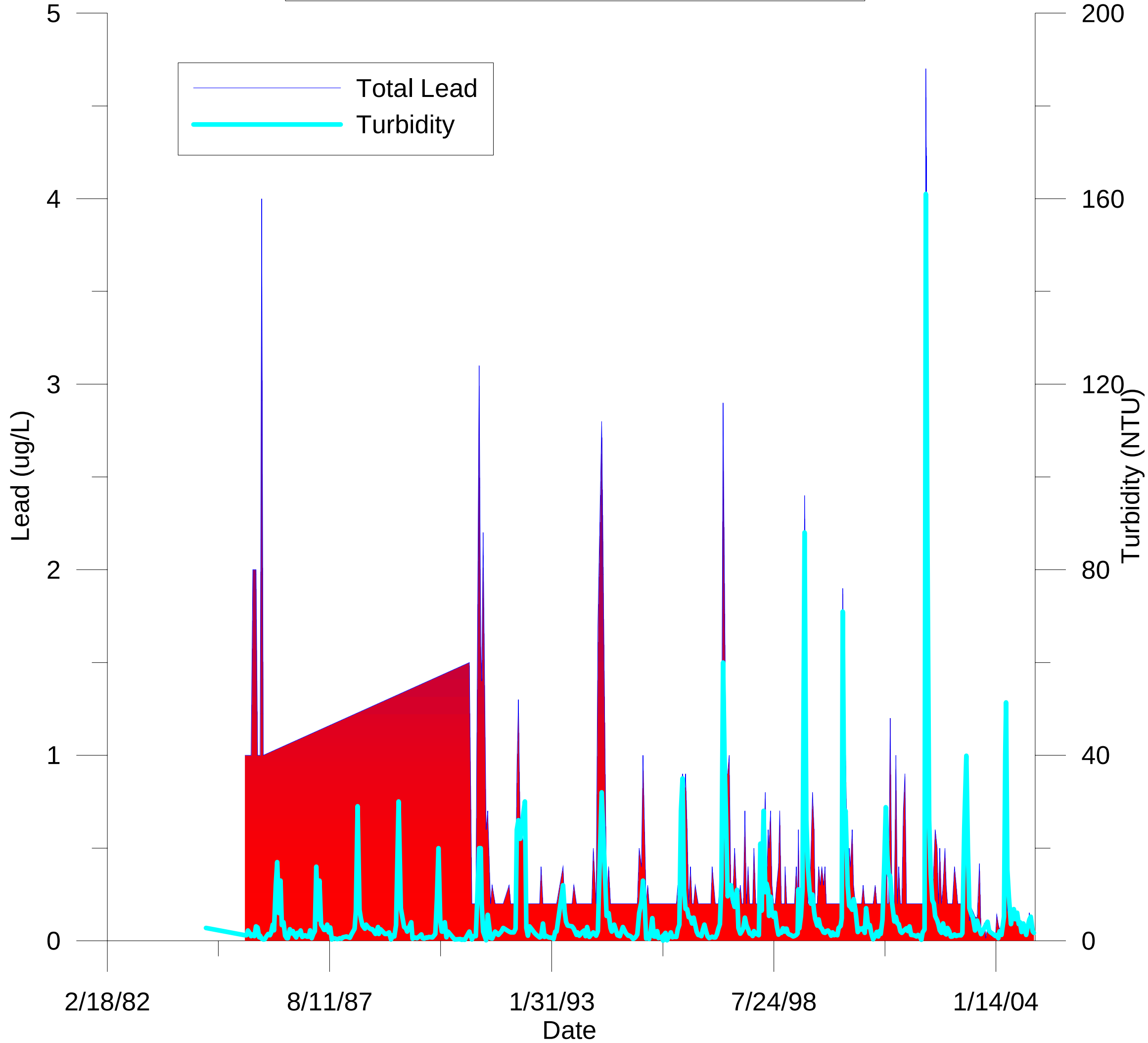


Figure 23 Nechako River at Prince George - Iron
Total Iron
Turbidity
Iron (ug/L)
Turbidity (NTU)
10000
8000
6000
4000
2000
0
200
160
120
80
40
0
2/18/82
8/11/87
1/31/93
7/24/98
1/14/04
Date

Figure 24 Nechako River at Prince George - Lead



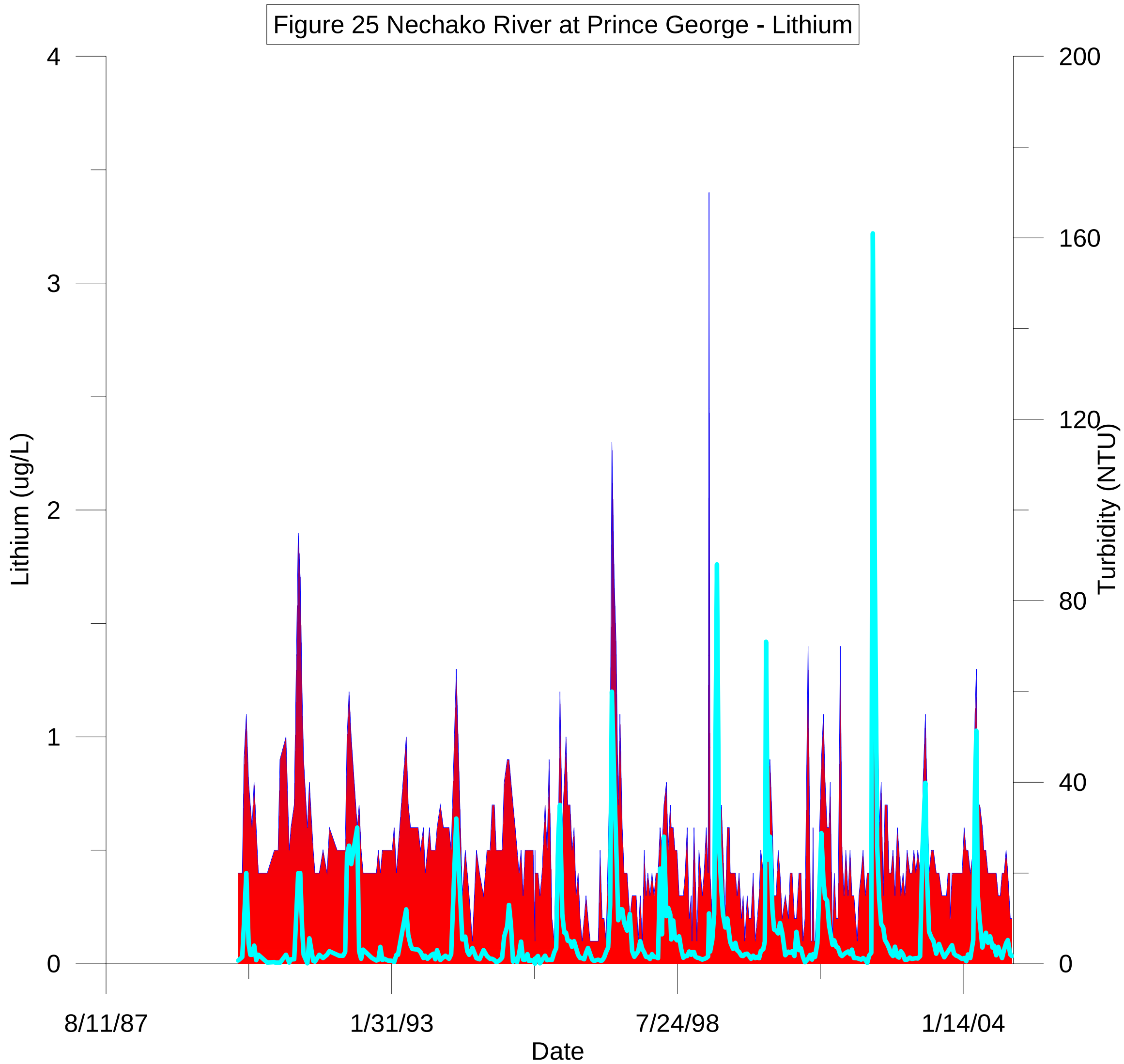


Figure 25 Nechako River at Prince George - Lithium
Lithium (ug/L)
Turbidity (NTU)
Date
0
1
2
3
4
0
40
80
120
160
200
8/11/87
1/31/93
7/24/98
1/14/04

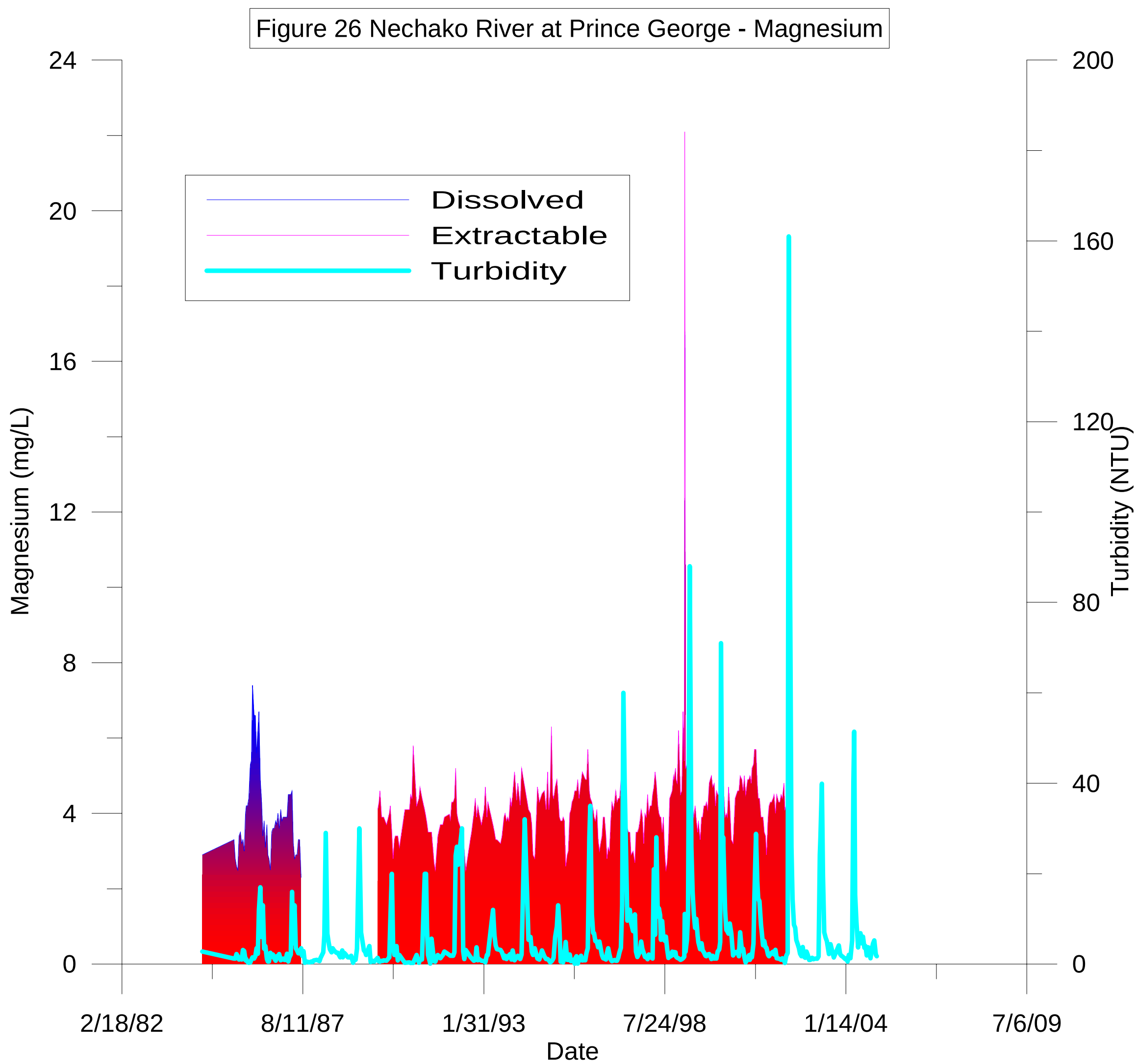


Figure 26 Nechako River at Prince George - Magnesium
Dissolved
Extractable
Turbidity
Magnesium (mg/L)
Turbidity (NTU)
Date
0
4
8
12
16
20
24
0
40
80
120
160
200
2/18/82
8/11/87
1/31/93
7/24/98
1/14/04
7/6/09

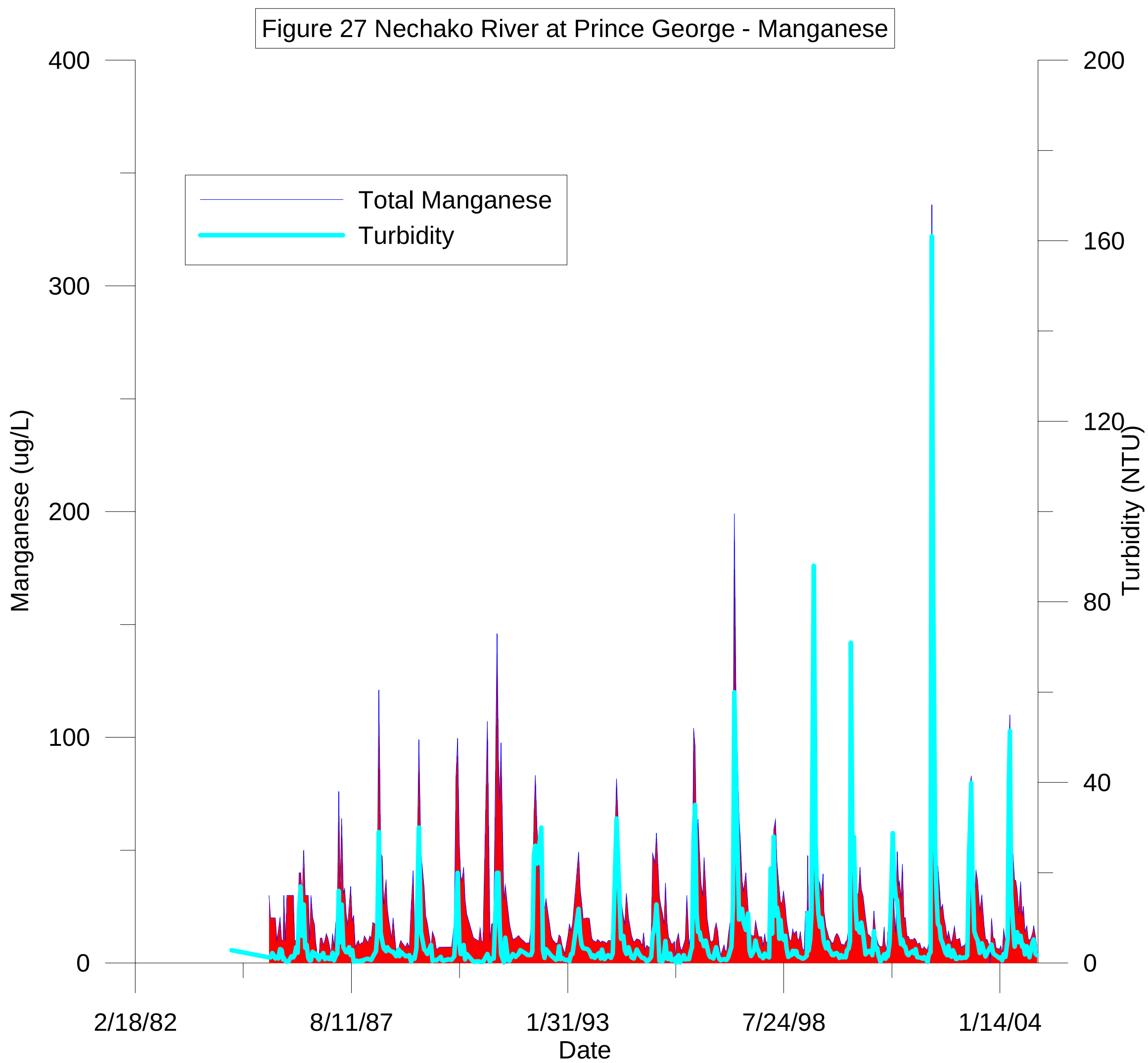


Figure 27 Nechako River at Prince George - Manganese
Total Manganese
Turbidity
Manganese (ug/L)
Turbidity (NTU)
400
300
200
100
0
200
160
120
80
40
0
2/18/82
8/11/87
1/31/93
7/24/98
1/14/04
Date

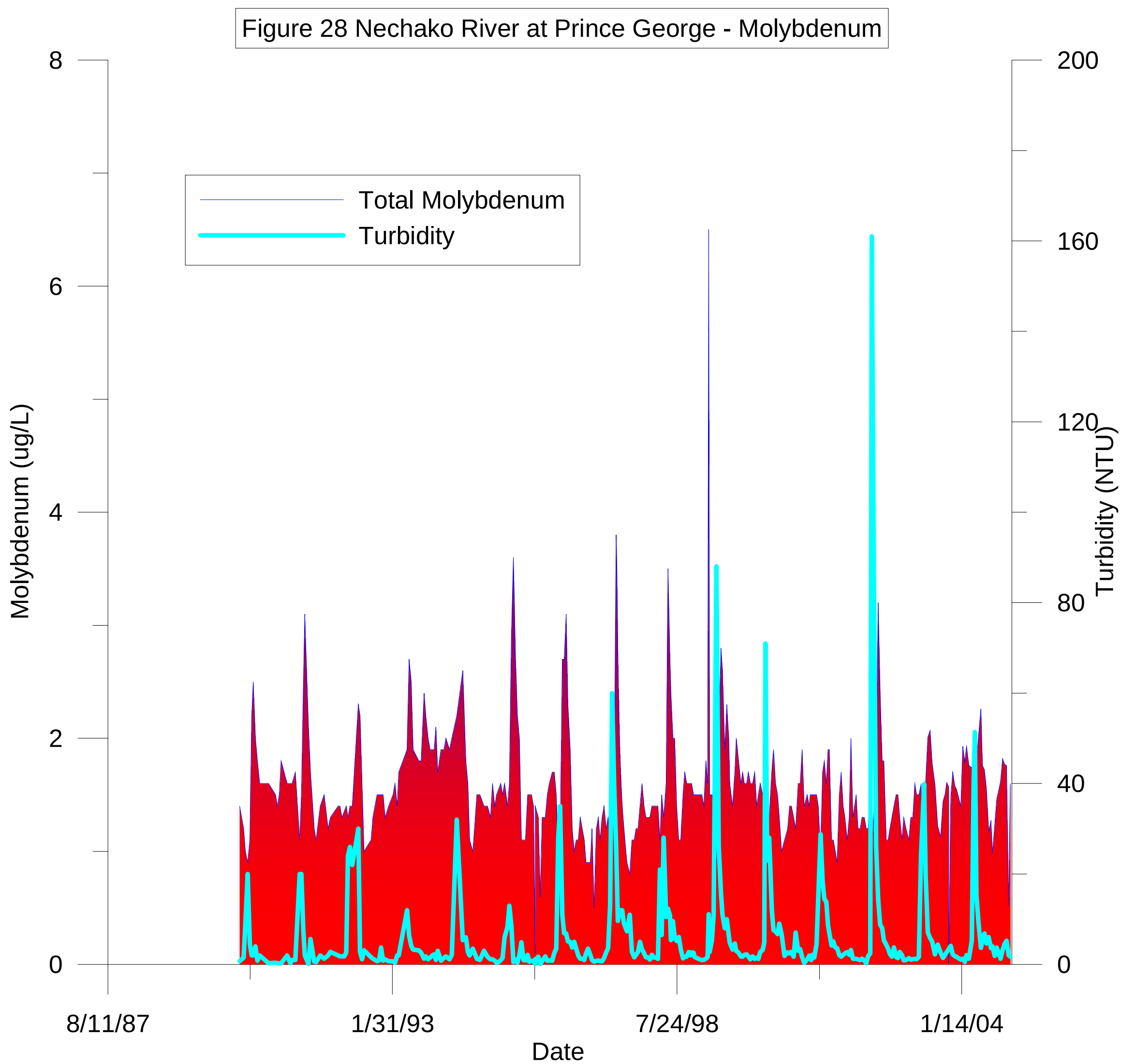
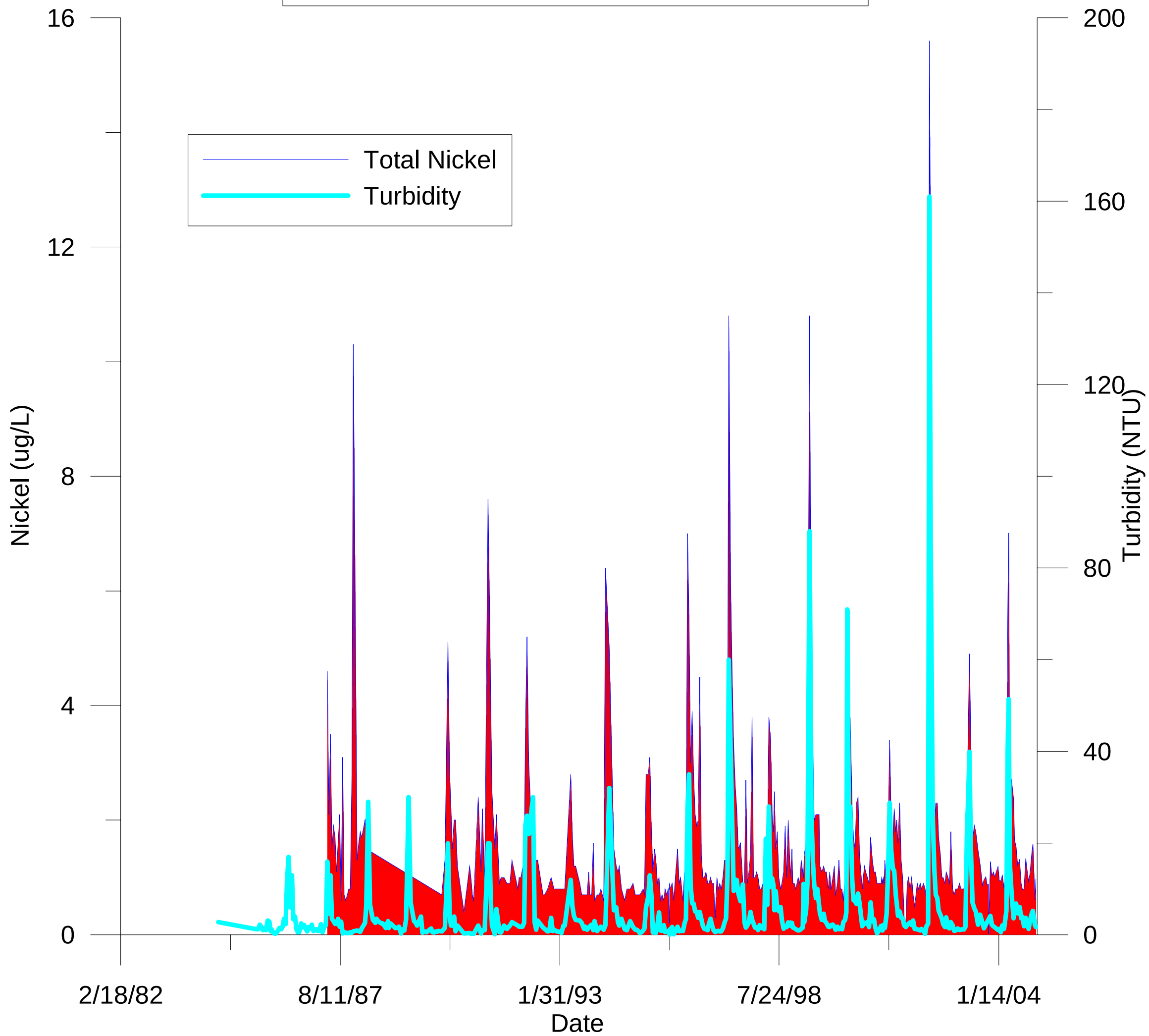


Figure 28 Nechako River at Prince George - Molybdenum
Total Molybdenum
Turbidity
Molybdenum (ug/L)
Turbidity (NTU)
Date
0
2
4
6
8
0
40
80
120
160
200
8/11/87
1/31/93
7/24/98
1/14/04

Figure 29 Nechako River at Prince George - Nickel



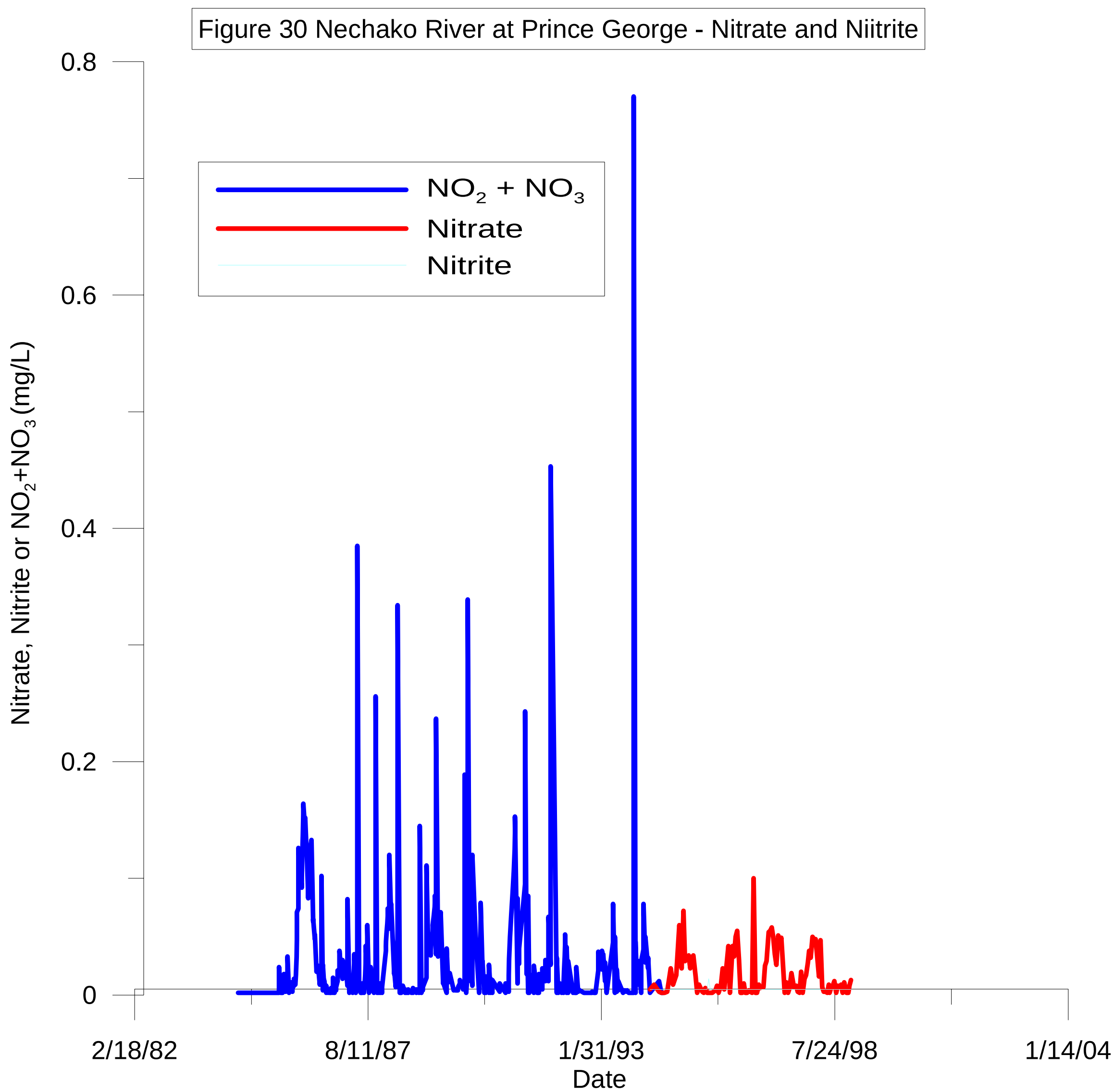
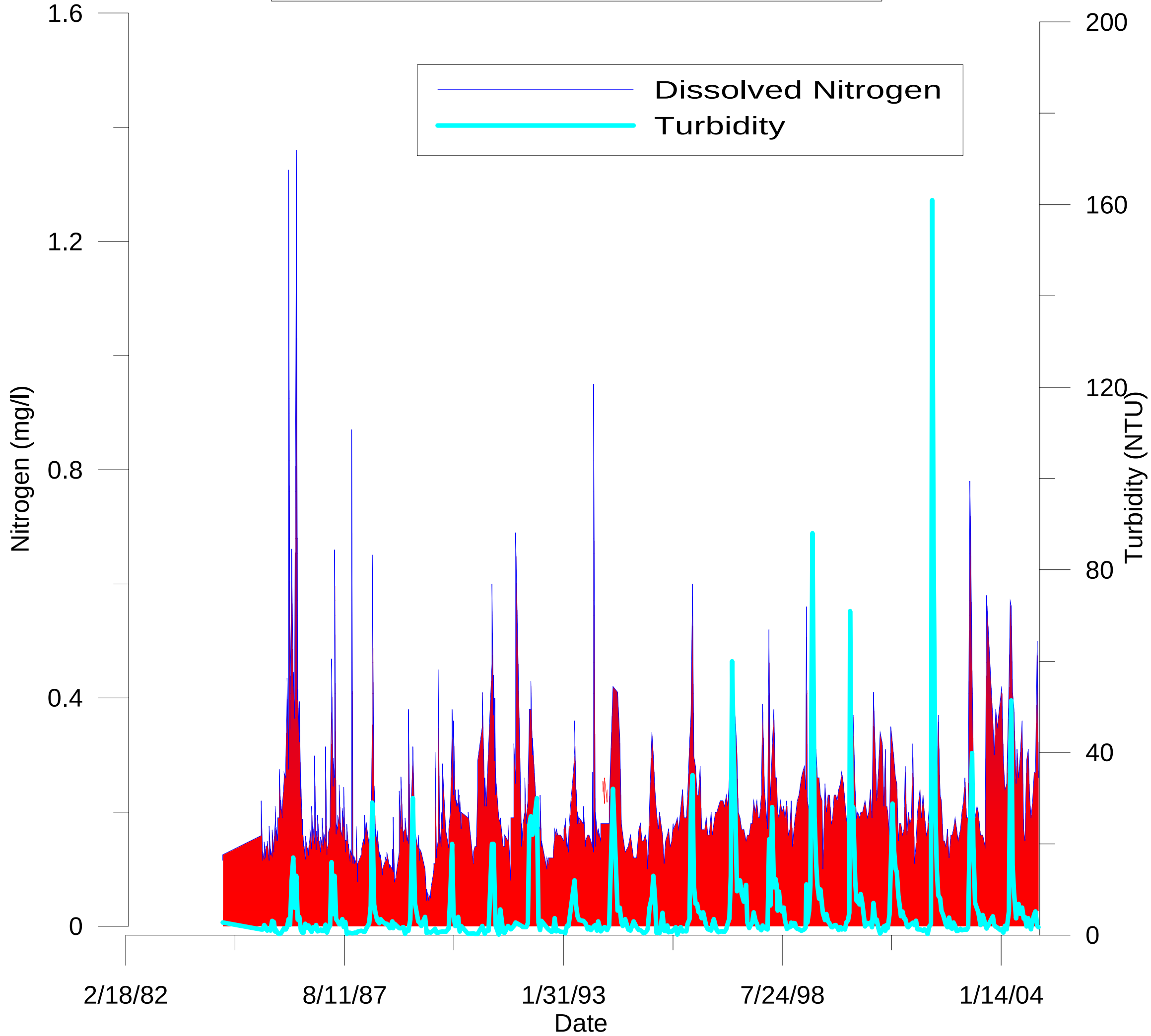


Figure 30 Nechako River at Prince George - Nitrate and Niitrite
$NO_2 + NO_3$
Nitrate
Nitrite
Nitrate, Nitrite or NO_2+NO_3 (mg/L)
0.8
0.6
0.4
0.2
0
2/18/82
8/11/87
1/31/93
7/24/98
1/14/04
Date

Figure 31 Nechako River at Prince George - Nitrogen



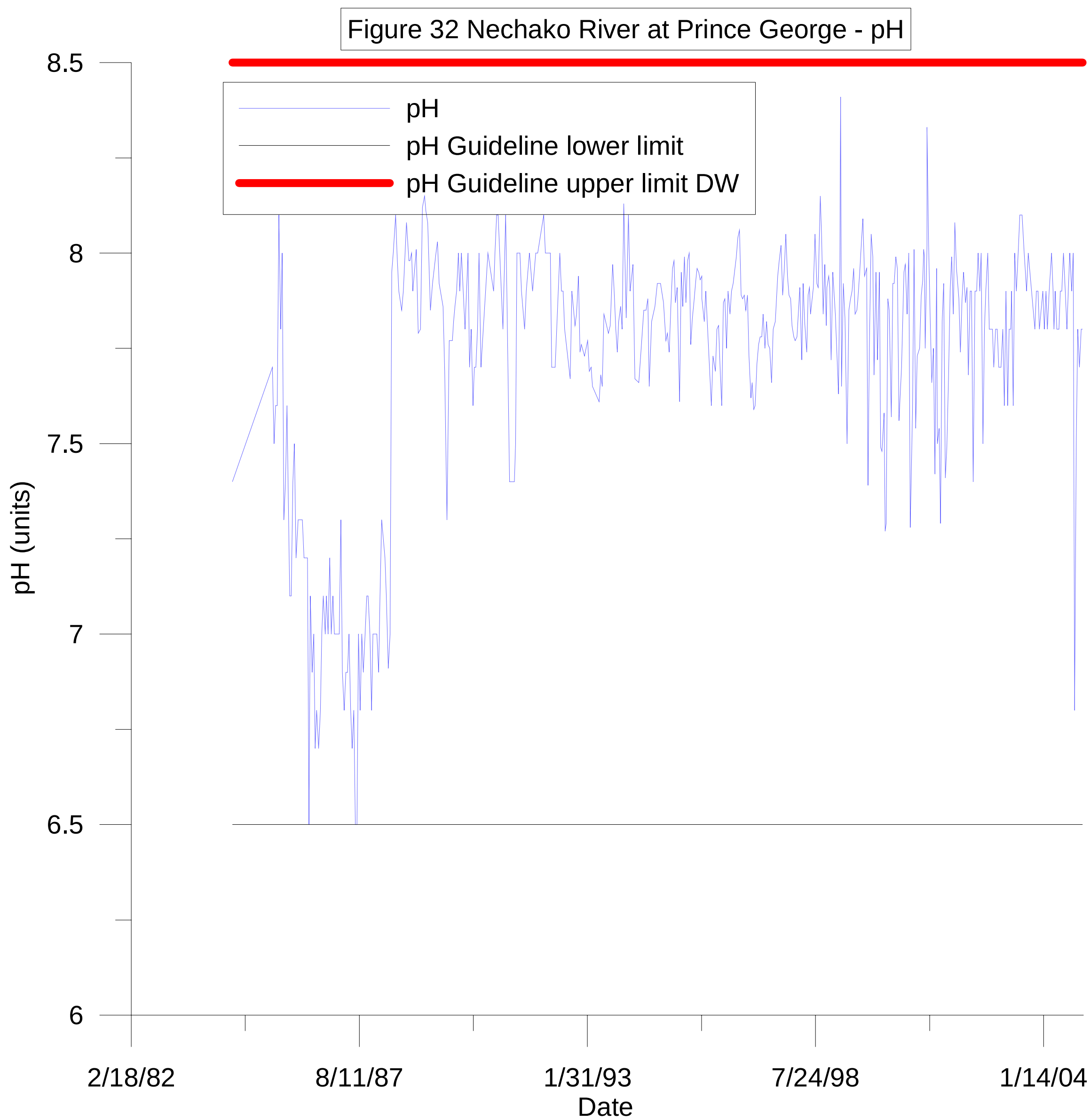


Figure 32 Nechako River at Prince George - pH
pH
pH Guideline lower limit
pH Guideline upper limit DW
8.5
8
7.5
7
6.5
6
pH (units)
2/18/82
8/11/87
1/31/93
7/24/98
1/14/04
Date

Figure 33 Nechako River at Prince George - Phosphorus

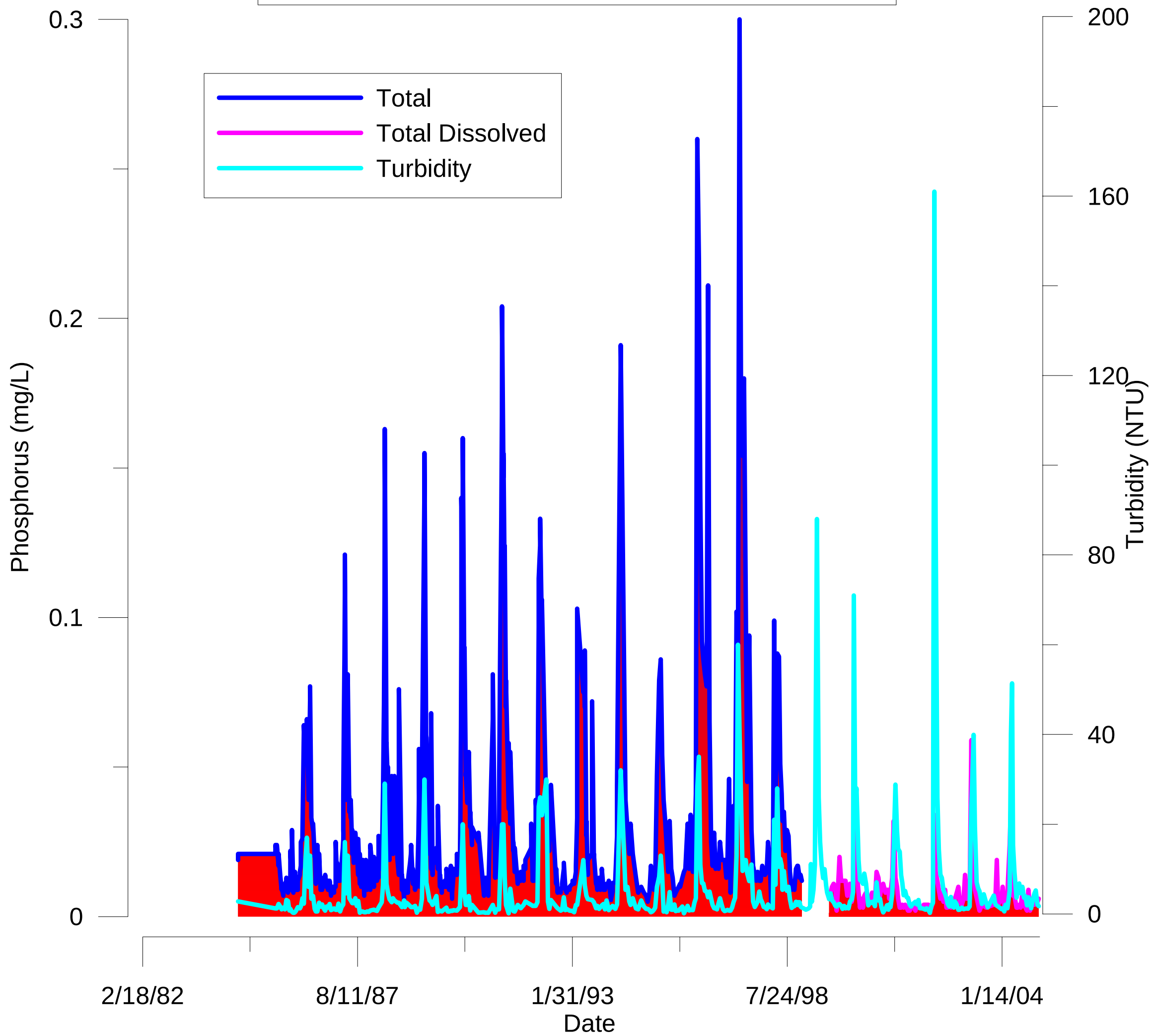
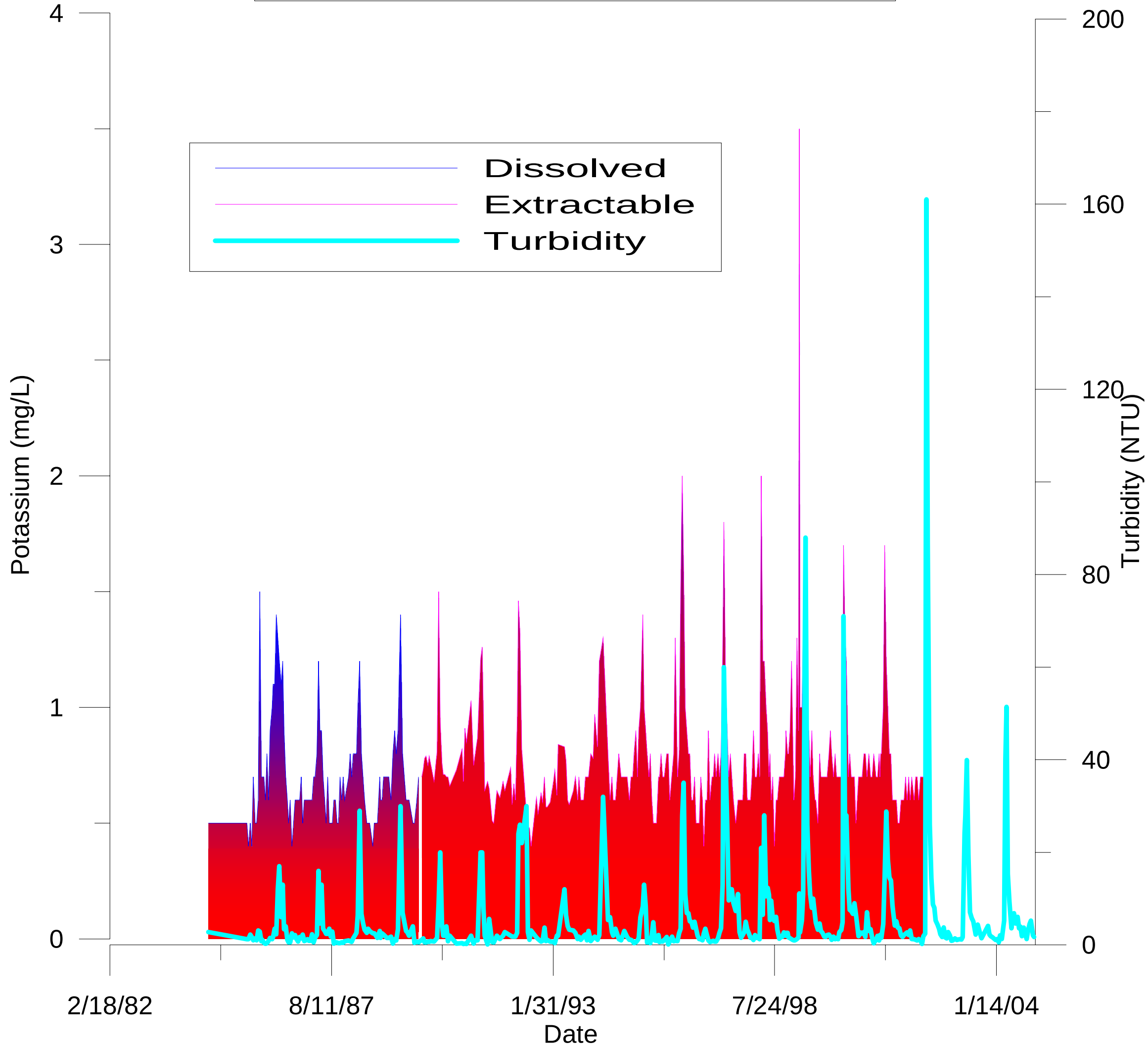


Figure 34 Nechako River at Prince George - Potassium



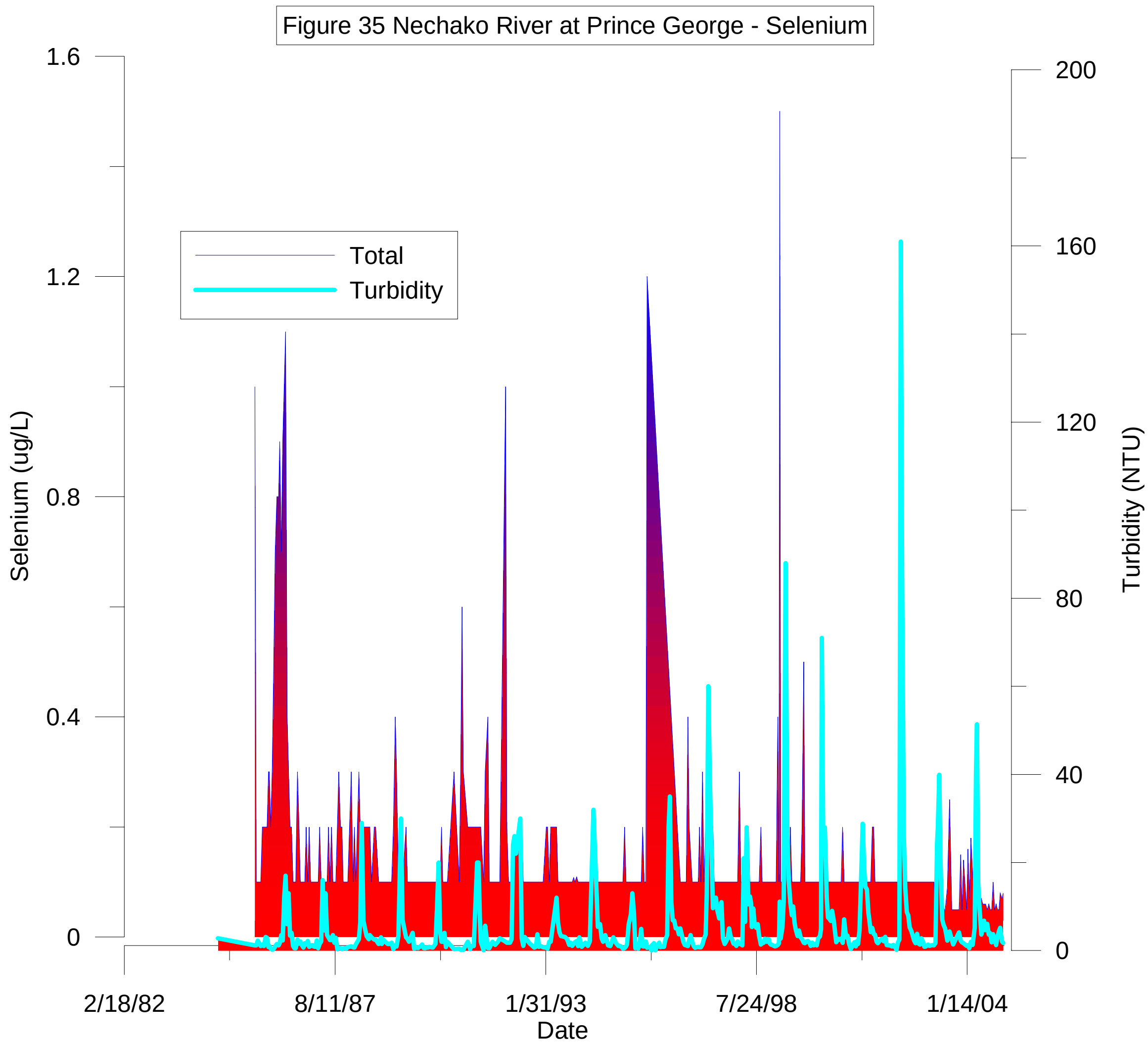


Figure 35 Nechako River at Prince George - Selenium
Total
Turbidity
Selenium (ug/L)
Turbidity (NTU)
1.6
1.2
0.8
0.4
0
200
160
120
80
40
0
2/18/82
8/11/87
1/31/93
7/24/98
1/14/04
Date

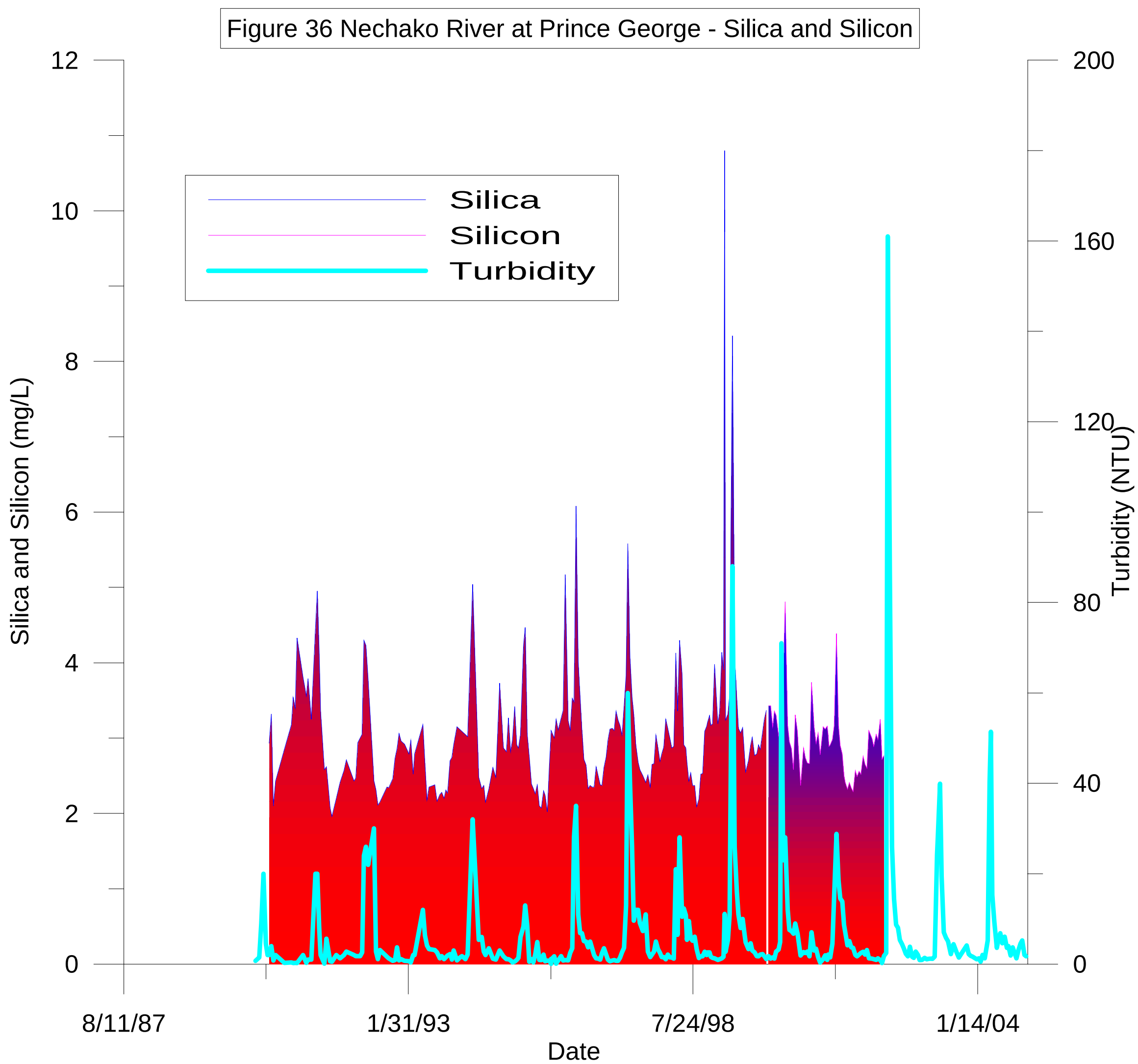
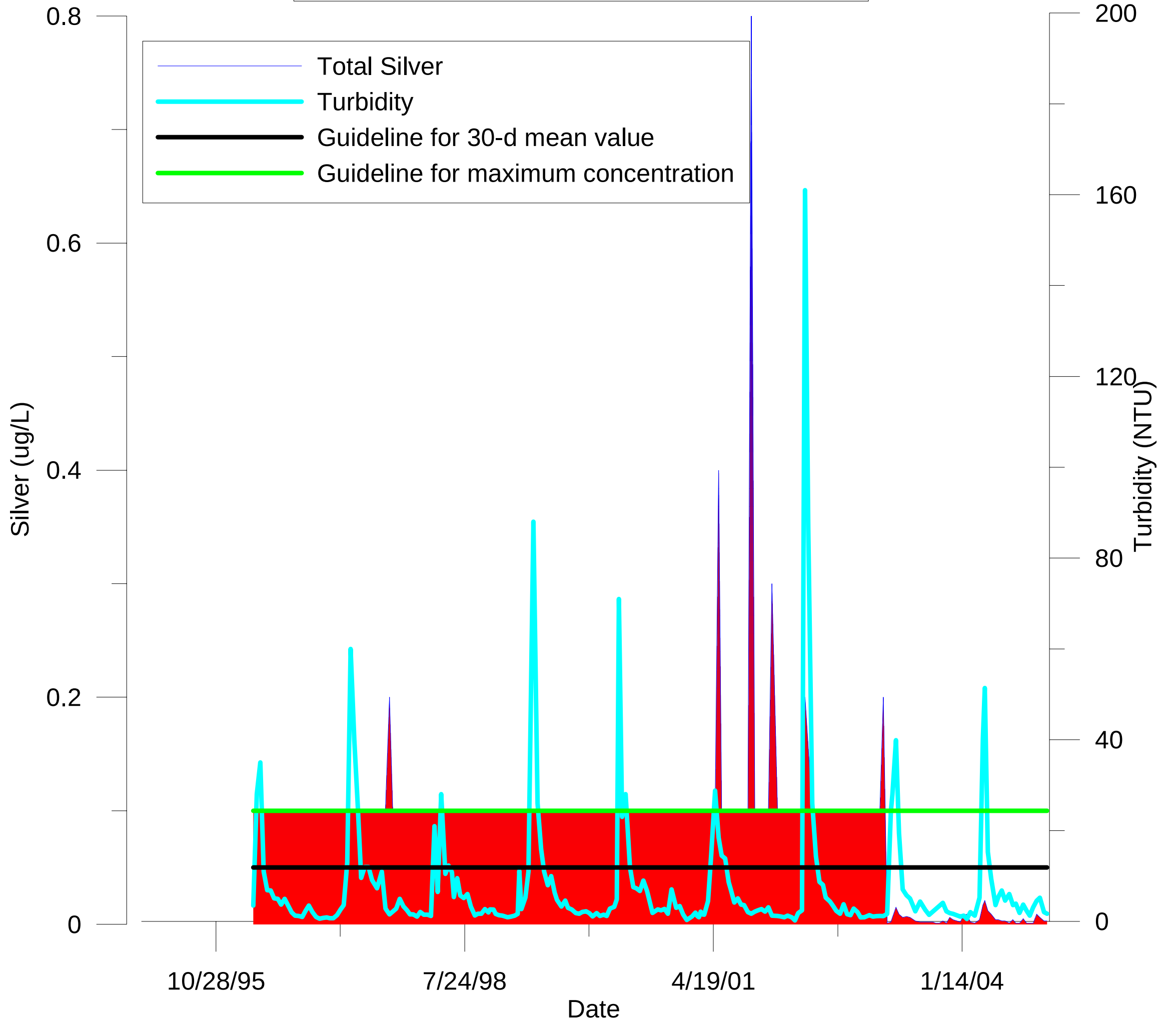


Figure 36 Nechako River at Prince George - Silica and Silicon
Silica
Silicon
Turbidity
Silica and Silicon (mg/L)
Turbidity (NTU)
0
2
4
6
8
10
12
0
40
80
120
160
200
8/11/87
1/31/93
7/24/98
1/14/04
Date

Figure 37 Nechako River at Prince George - Silver



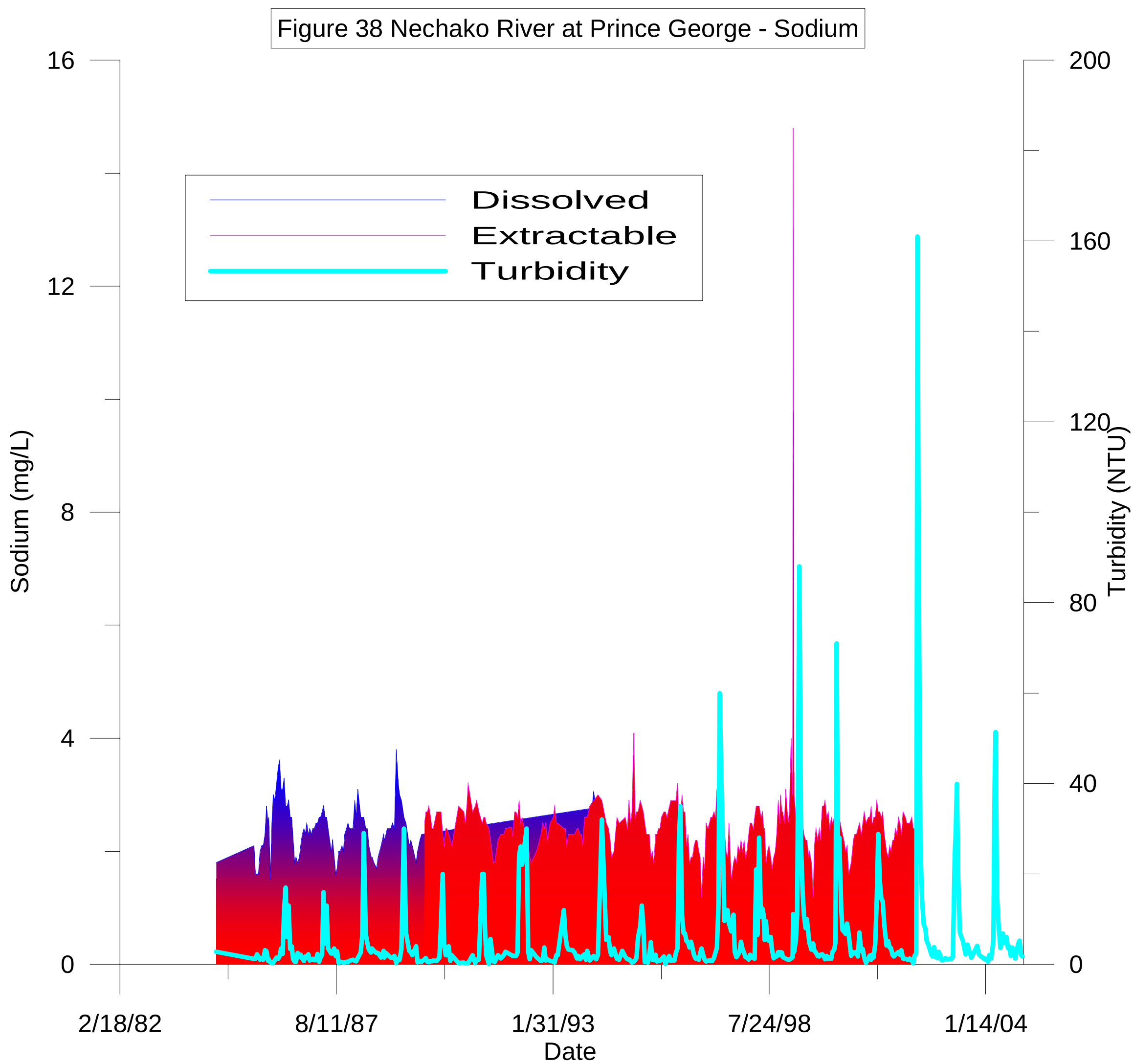


Figure 38 Nechako River at Prince George - Sodium
Dissolved
Extractable
Turbidity
Sodium (mg/L)
Turbidity (NTU)
16
12
8
4
0
200
160
120
80
40
0
2/18/82
8/11/87
1/31/93
7/24/98
1/14/04
Date

Figure 39 Nechako River at Prince George - Solids - Dissolved

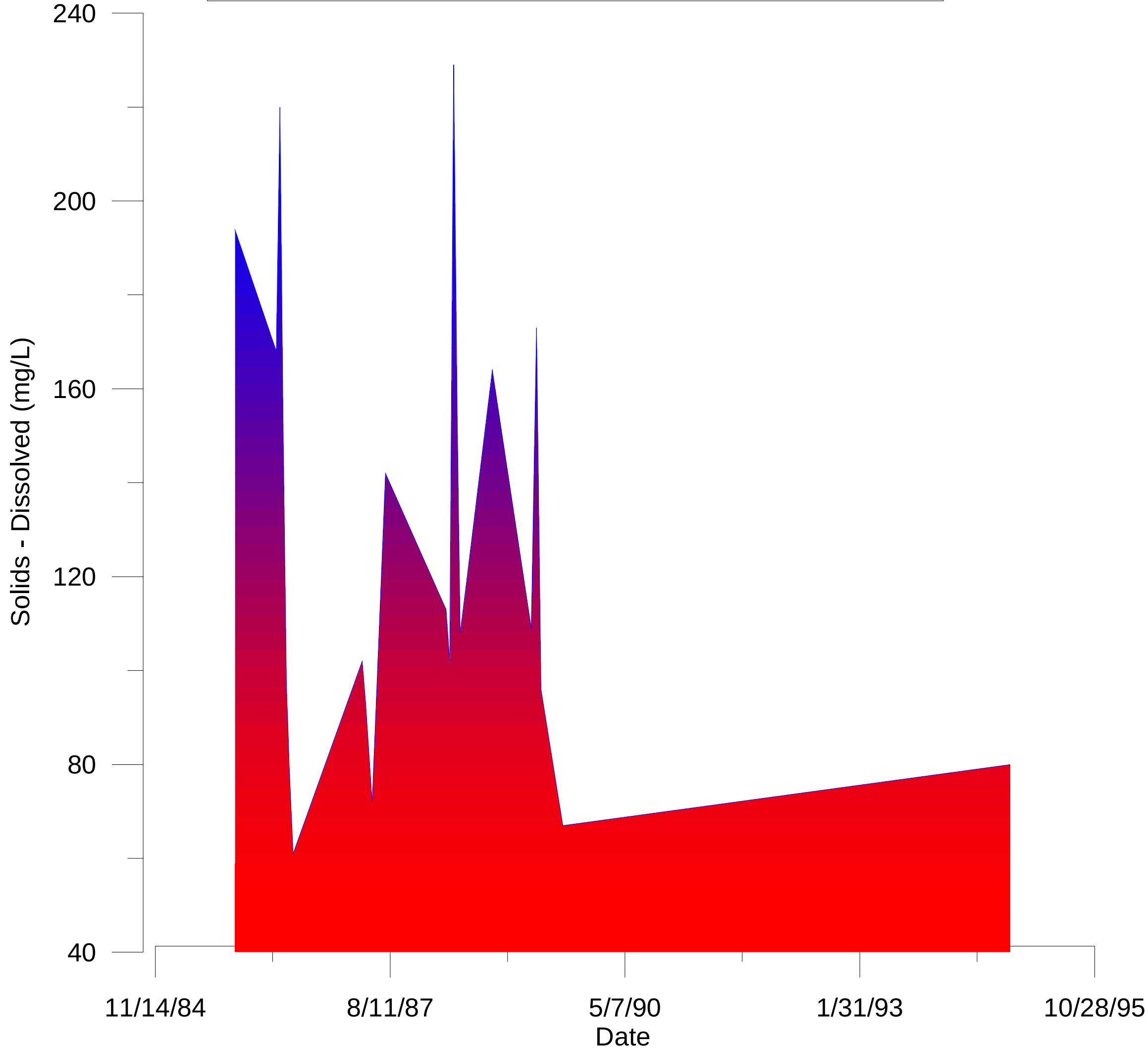
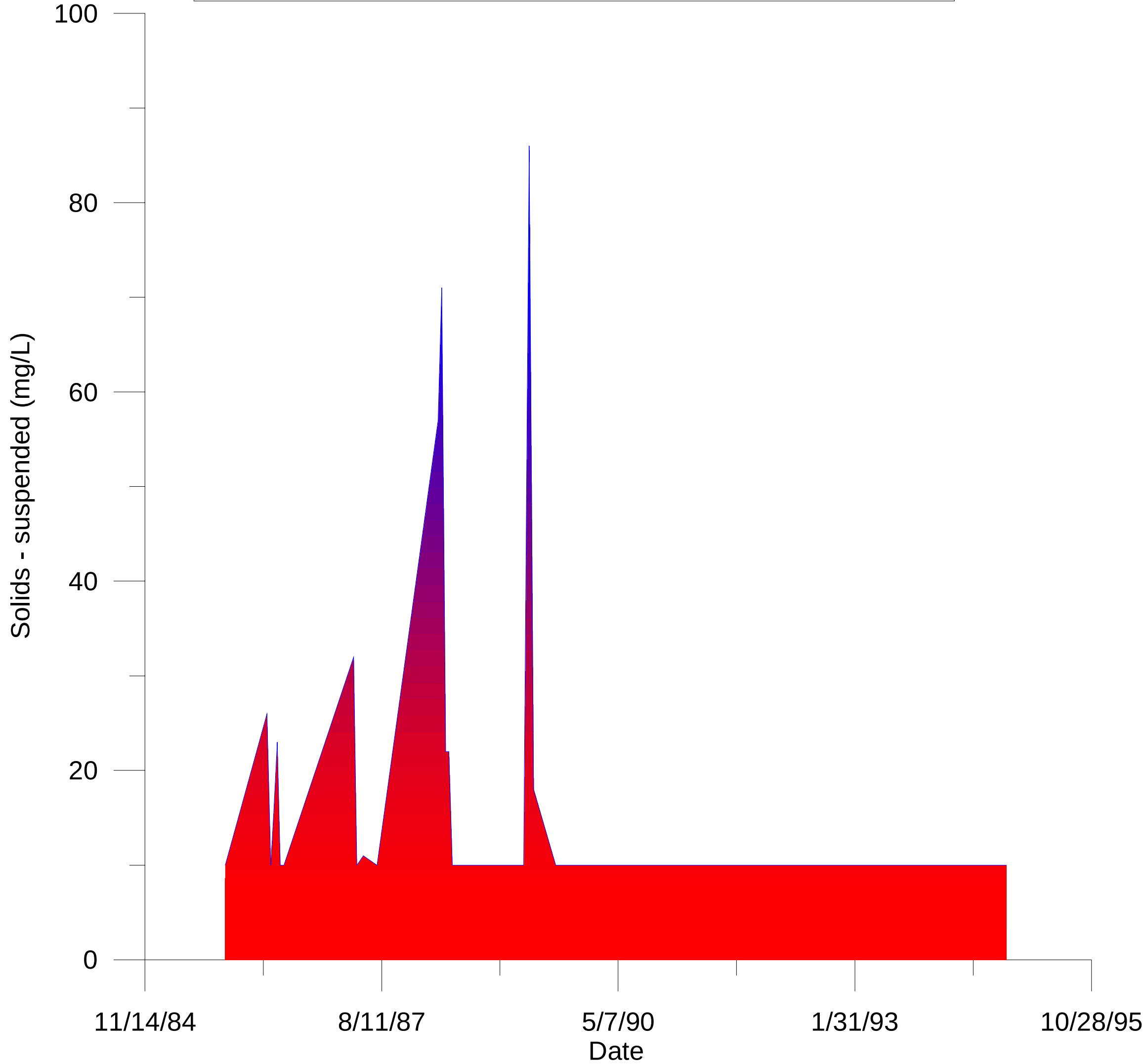


Figure 40 Nechako River at Prince George - Solids - Suspended



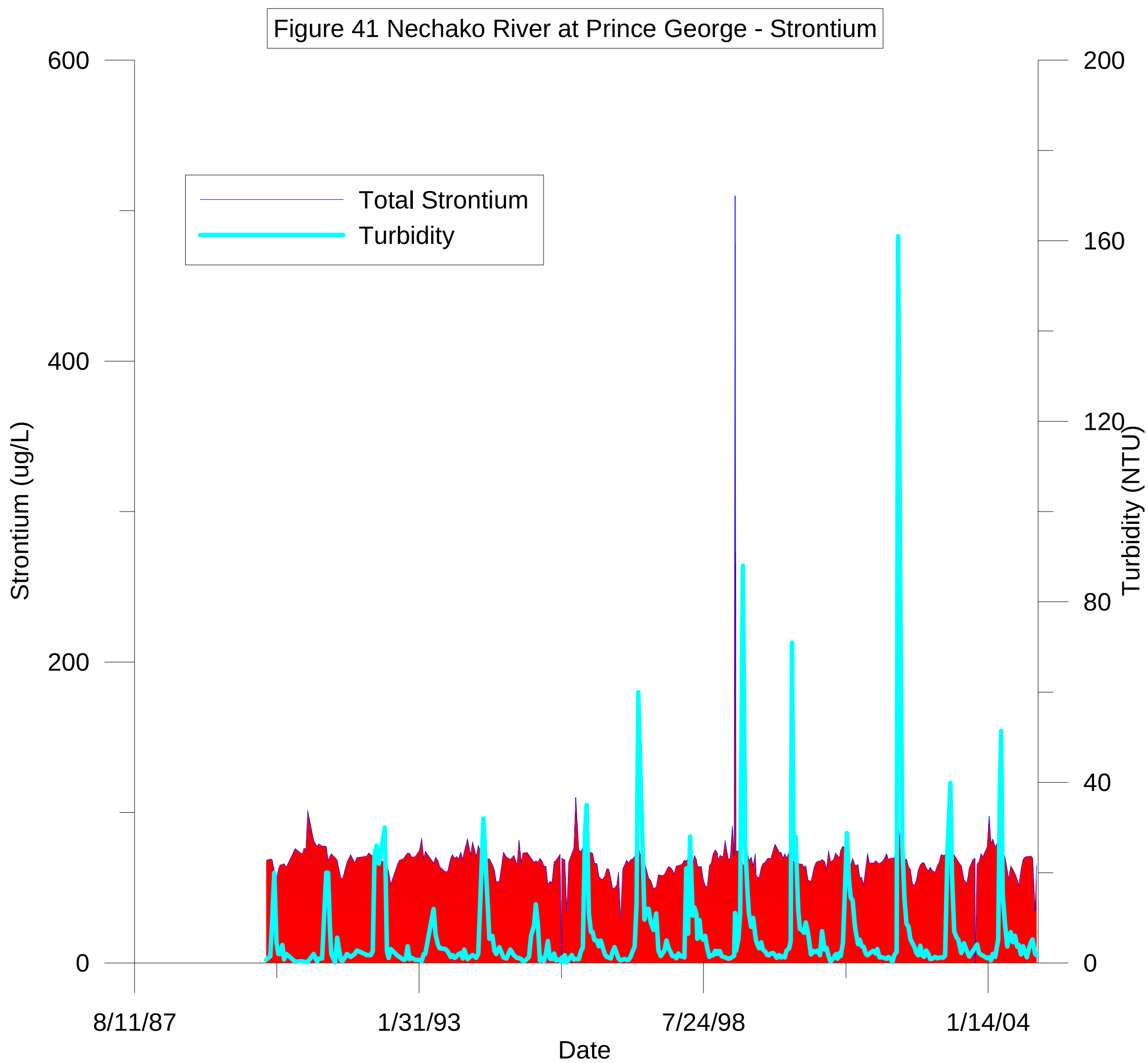


Figure 41 Nechako River at Prince George - Strontium
Total Strontium
Turbidity
Strontium (ug/L)
Turbidity (NTU)
600
400
200
0
200
160
120
80
40
0
8/11/87
1/31/93
7/24/98
1/14/04
Date

Figure 42 Nechako River at Prince George - Sulphate

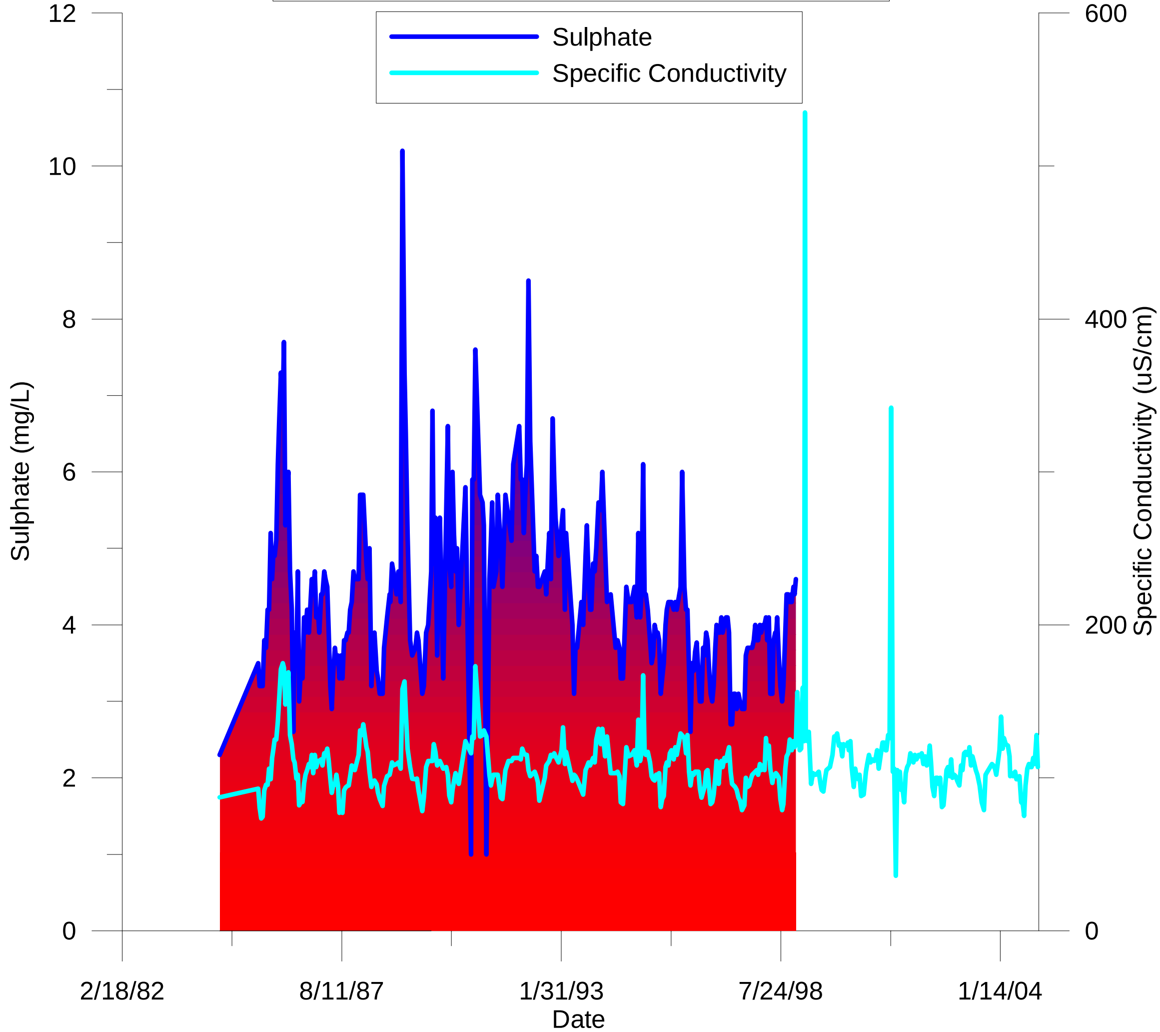


Figure 43 Nechako River at Prince George - Water Temperature

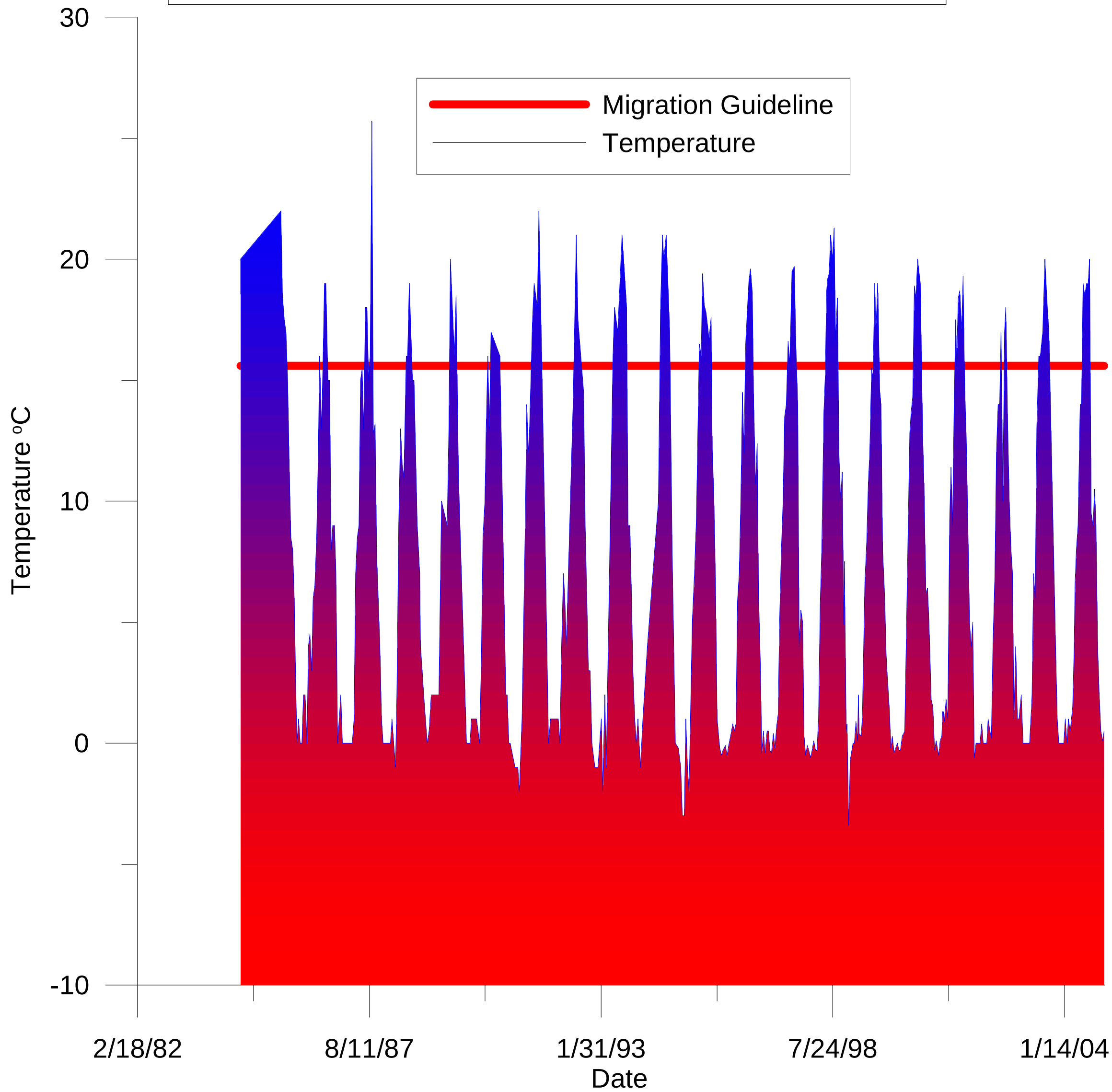
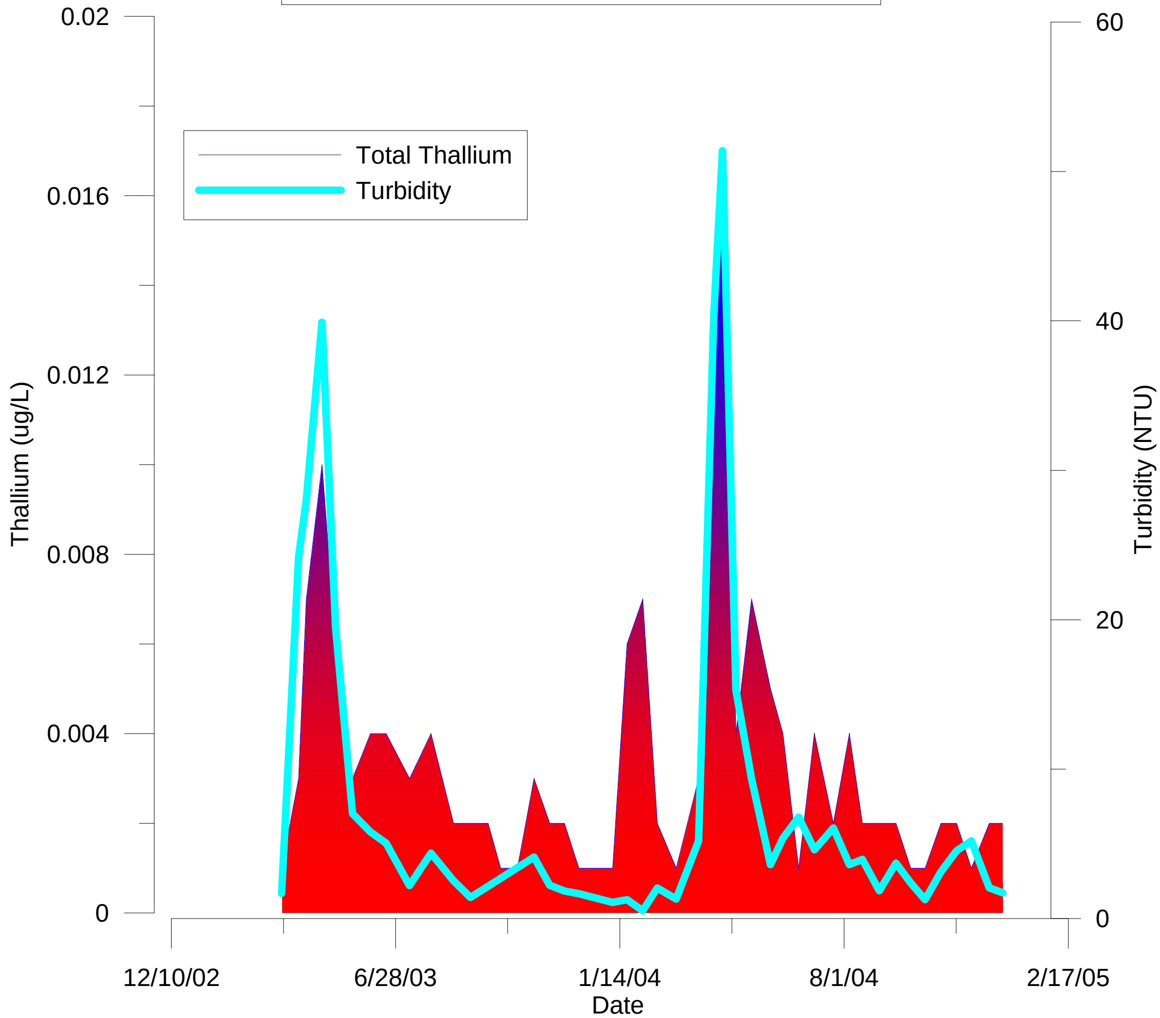


Figure 44 Nechako River at Prince George - Thallium



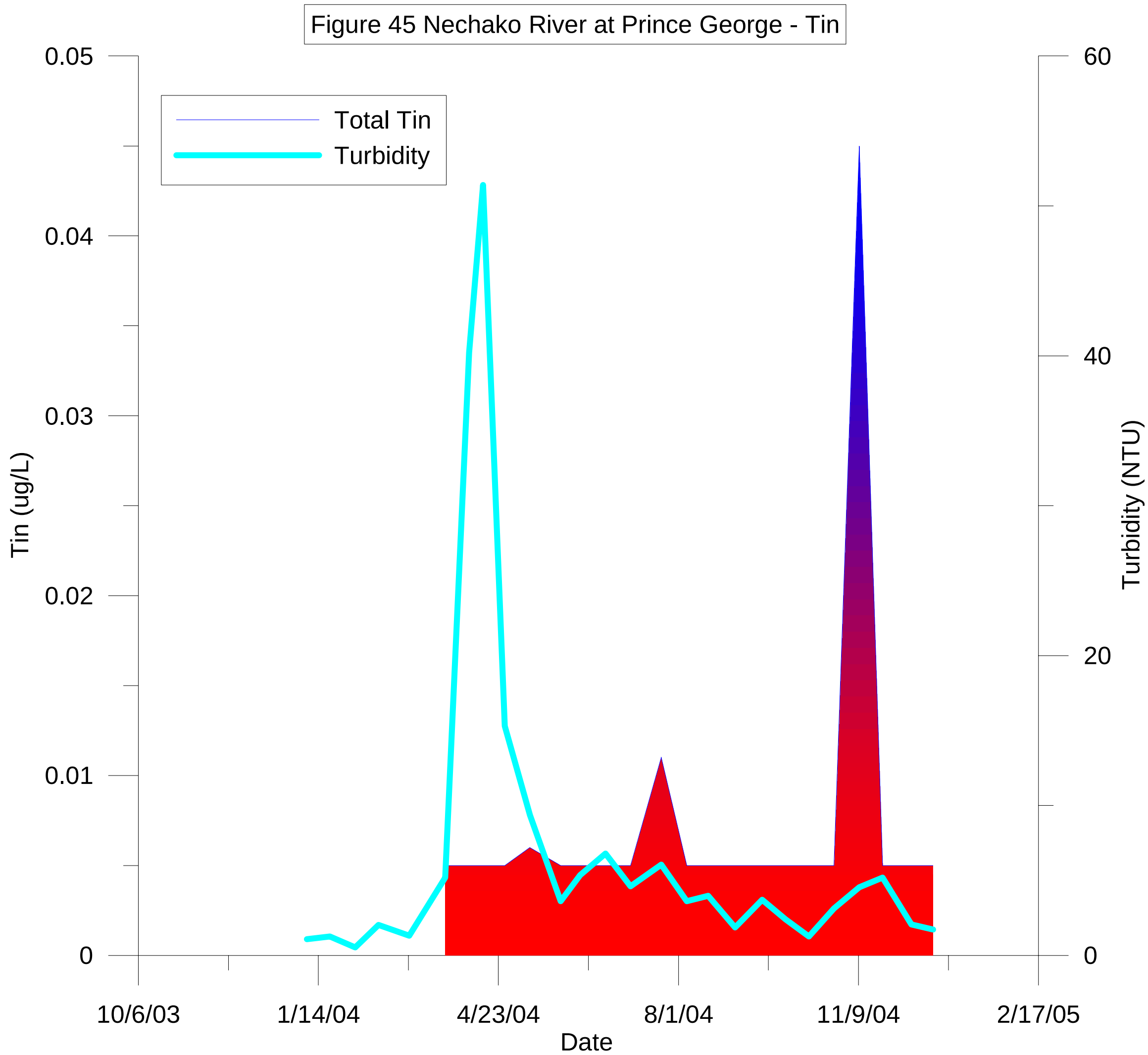


Figure 45 Nechako River at Prince George - Tin
Total Tin
Turbidity
Tin (ug/L)
Turbidity (NTU)
0.05
0.04
0.03
0.02
0.01
0
60
40
20
0
10/6/03
1/14/04
4/23/04
8/1/04
11/9/04
2/17/05
Date

Figure 46 Nechako River at Prince George - Turbidity

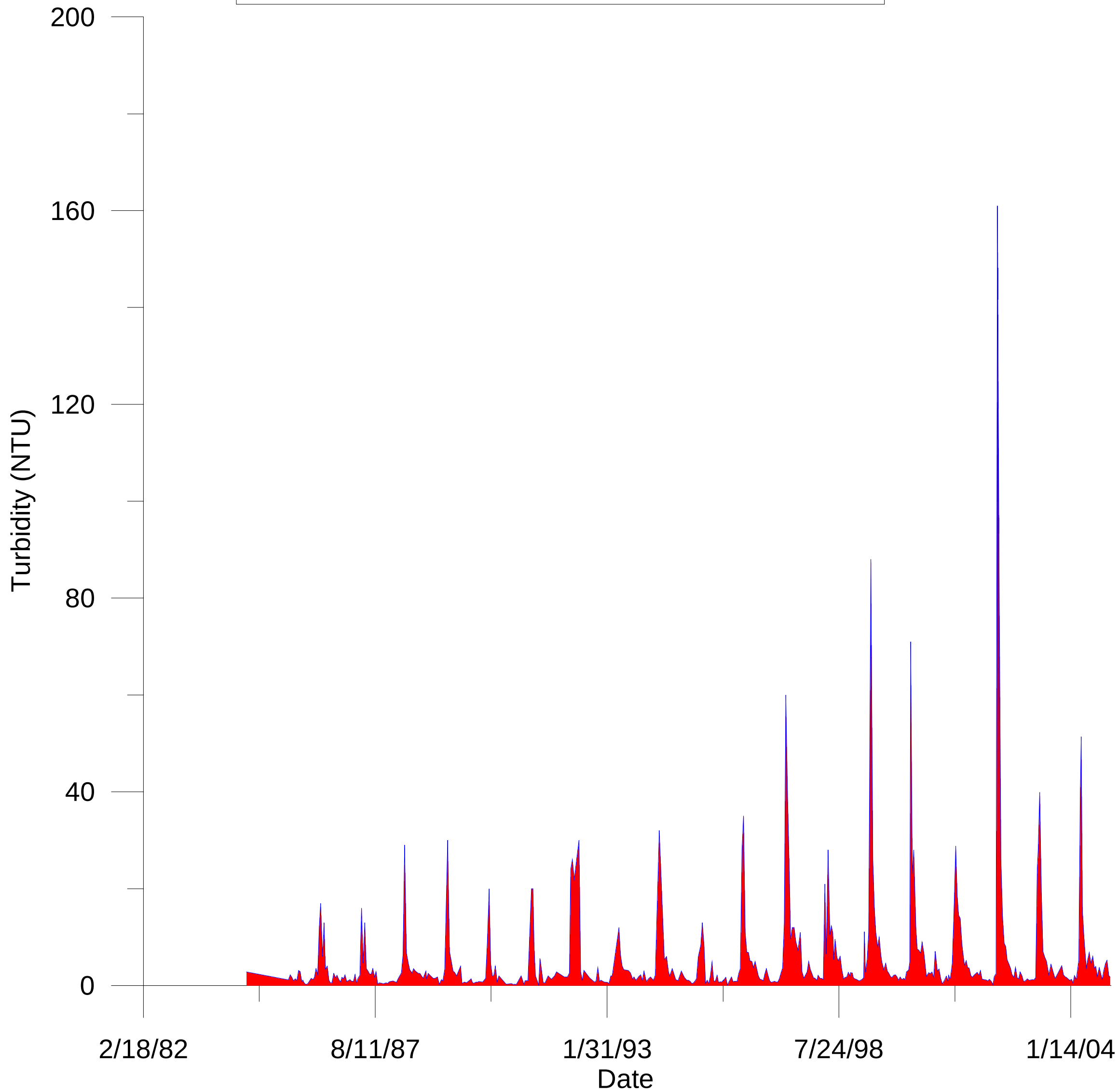


Figure 47 Nechako River at Prince George - Turbidity versus Flow

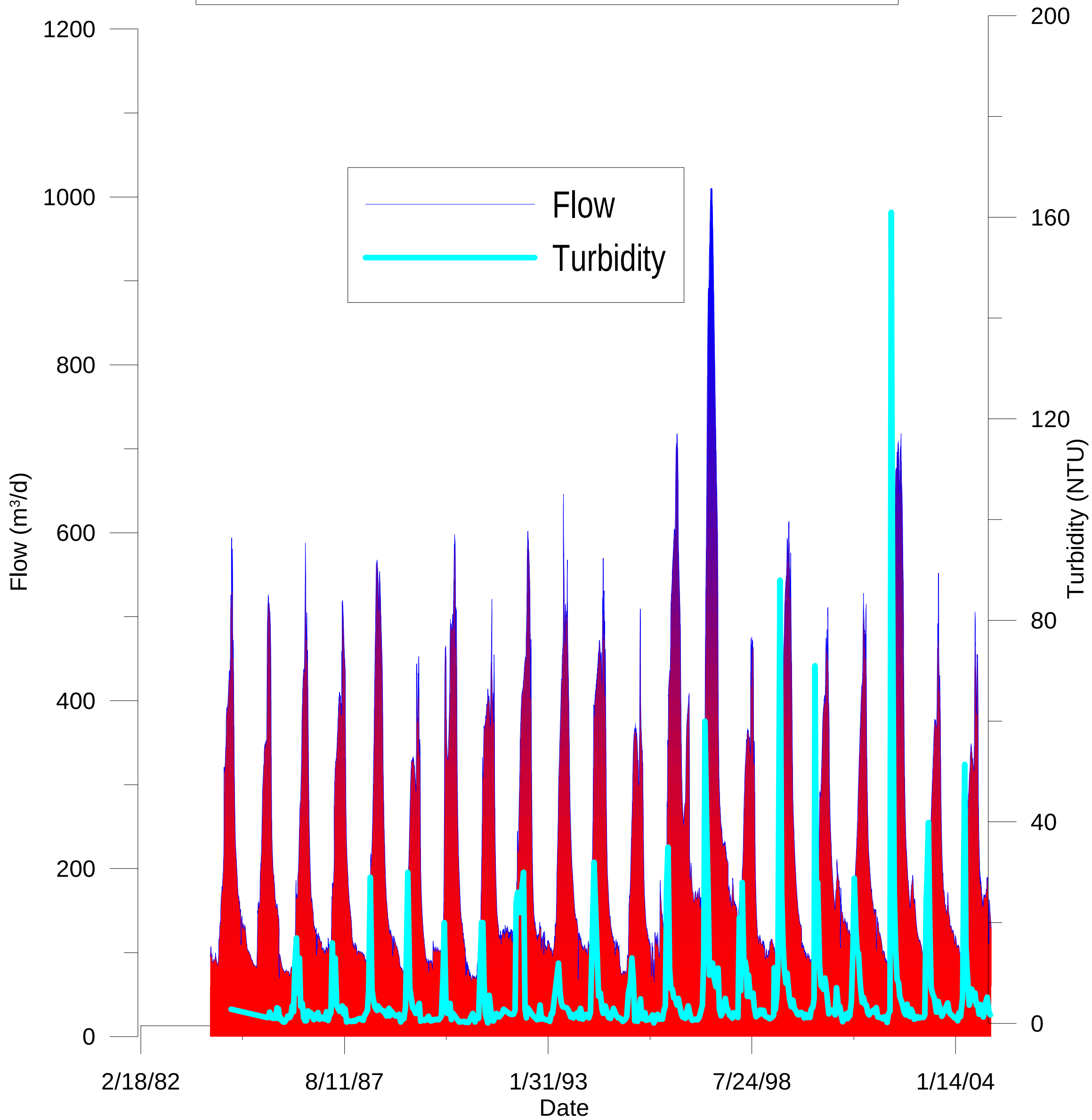
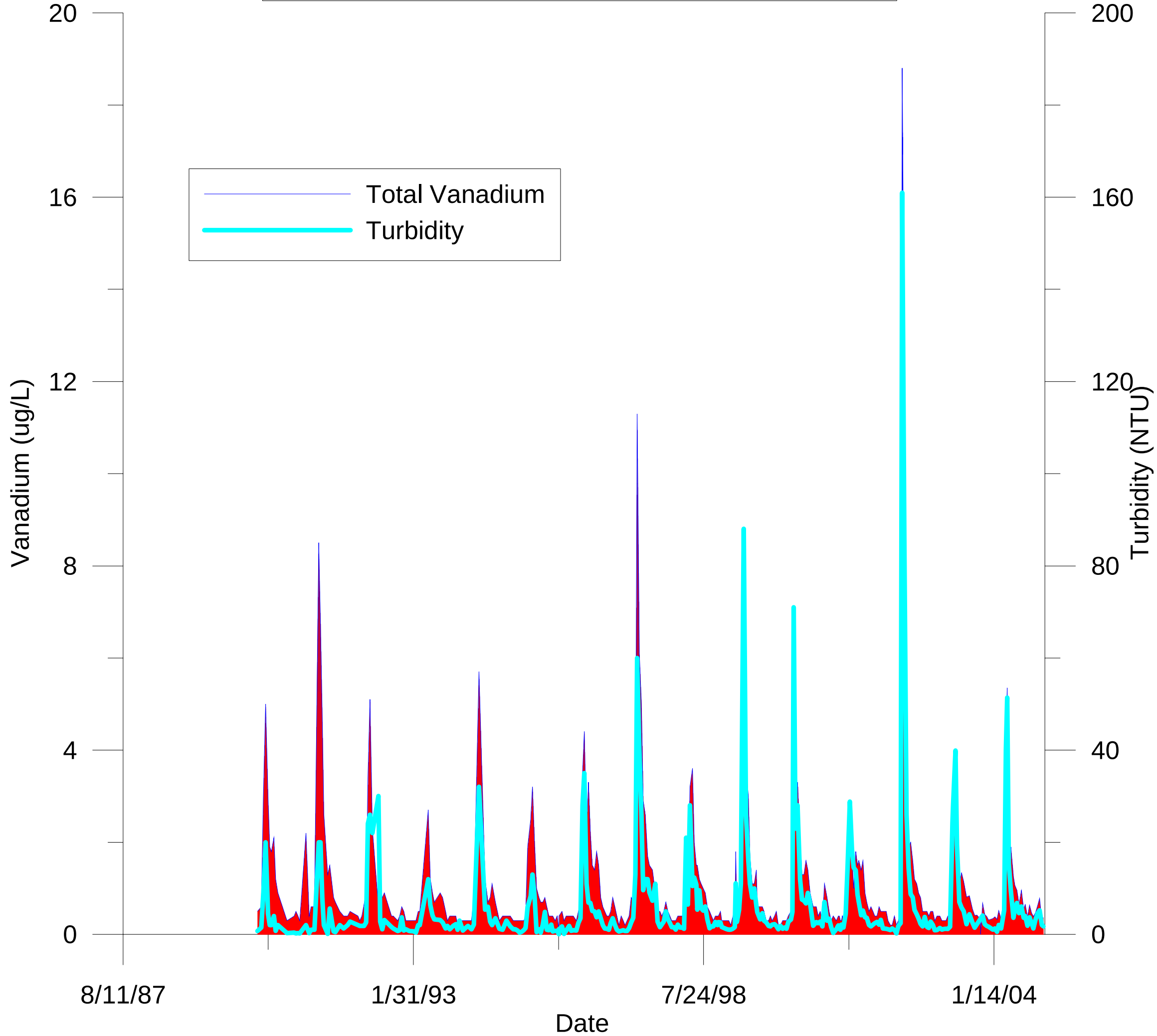


Figure 48 Nechako River at Prince George - Vanadium



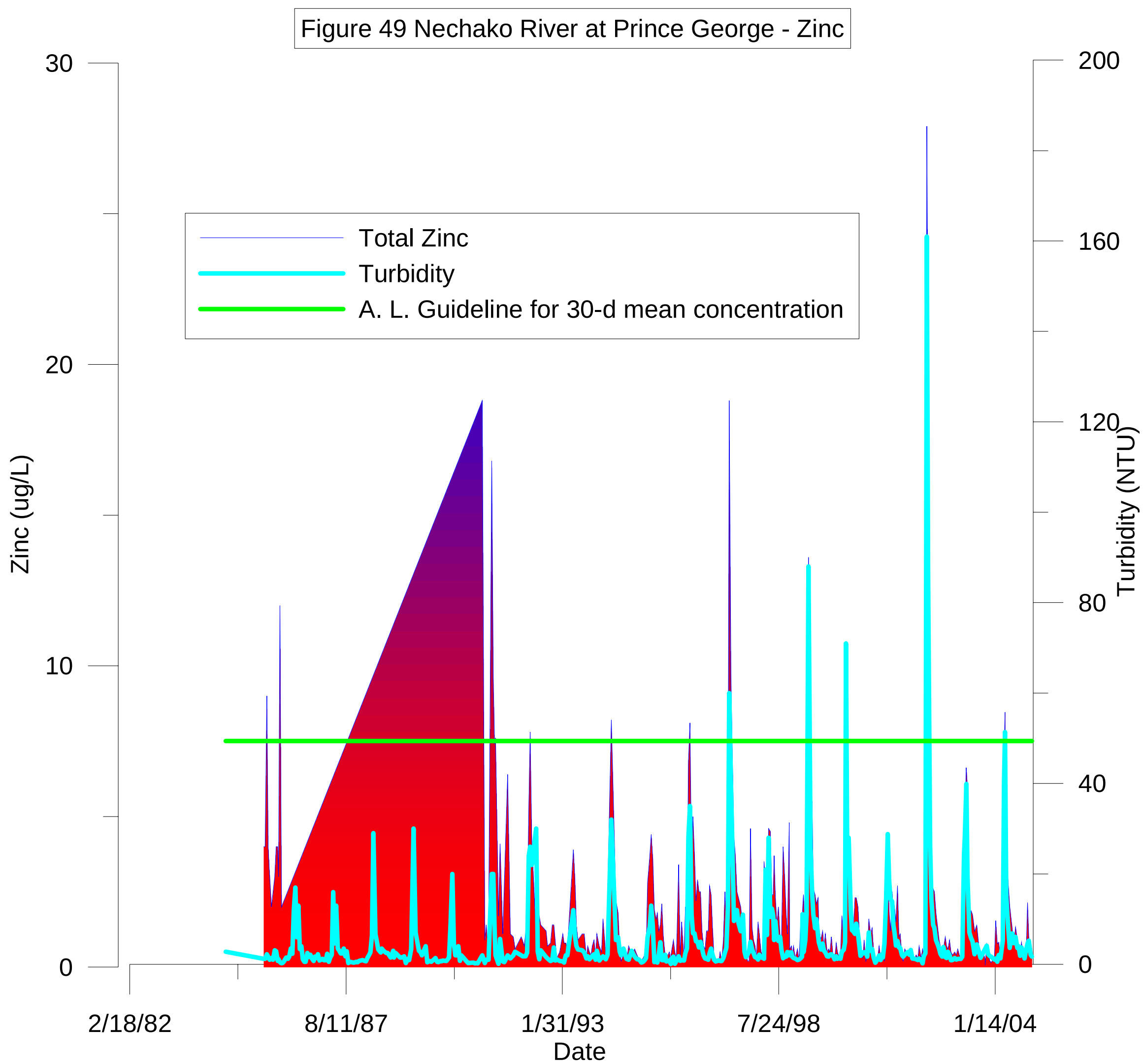


Figure 49 Nechako River at Prince George - Zinc
Total Zinc
Turbidity
A. L. Guideline for 30-d mean concentration
Zinc (ug/L)
0
10
20
30
Turbidity (NTU)
0
40
80
120
160
200
2/18/82
8/11/87
1/31/93
7/24/98
1/14/04
Date