CANADA – BRITISH COLUMBIA
WATER QUALITY MONITORING AGREEMENT

WATER QUALITY ASSESSMENT OF KOOTENAY RIVER AT CRESTON (1965 – 2000)

Water Quality Section
Water Protection Branch
Ministry of Water, Land and Air Protection

Aquatic Sciences Section
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Environment Canada
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Executive Summary

The Kootenay River watershed is located in the southeast corner of British Columbia. It is a transboundary river, which joins the Elk River and then flows into Koocanusa Lake (the reservoir of Libby Dam in Montana), which straddles the Canada – U.S. border. At Creston, the river re-enters British Columbia after making the loop through northern Montana and Idaho, draining 36,700 km^2 (21,200 km^2 in B.C. and 15,500 km^2 in the US). The water quality sampling station on the Kootenay River at Creston is located 15 km downstream from the US border and 15 km upstream from Kootenay Lake. This assessment is based on up to 36 years of water quality data during 1965-2000. The main human activities in the Kootenay River watershed were the Sullivan lead-zinc mine, concentrator and former fertilizer plant at Kimberley in the St. Mary River watershed, the Libby Dam, forestry, agriculture, and residential and commercial development. The water quality trends identified below have not yet been confirmed by statistical analysis.

CONCLUSIONS

- Completion of the Libby Dam in Montana in 1972 caused substantial decreases in calcium, magnesium, hardness, conductivity and turbidity in the Kootenay River at Creston. Waste abatement at Cominco's operation on the St. Mary River at Kimberley before 1971 may also have contributed to the decreases in calcium, conductivity and hardness. There has been little or no change in these water quality indicators since then.
- The combined effect of the Libby Dam and the abatement of the waste discharges from the Cominco operation on the St. Mary River at Kimberley caused substantial decreases in iron and phosphorus in the Kootenay River at Creston during the two decades from the late 1960s to the late 1980s. Iron showed no change after1980, while phosphorus levels showed no change after the late 1980s or early 1990s.
- The initial decreases in phosphorus eliminated the algal blooms in Kootenay Lake, but as levels continued to decrease, Kootenay Lake became starved for phosphorus, and it was necessary to begin fertilization of the lake in 1992 to boost fish production.
- Fecal coliforms decreased substantially after 1977, probably due to improved sewage treatment at Creston and in the US. During 1978-2000, the water was suitable for drinking water after partial treatment (e.g., filtration) and disinfection, irrigation, livestock, and recreation.
- Nitrogen levels increased during 1981-2000, due at least in part to the increasing trend in the Elk River due to coal mining. The effect of the trend would be to reduce any nitrogen limitation to algal growth.
- Turbidity levels decreased due to the Libby Dam, improving the water for recreation and drinking water, but water treatment to remove turbidity would still be needed before drinking water use. Turbidity peaks during spring freshet and high flow releases from Libby Dam caused metals such as cobalt, cadmium, copper, iron, manganese, silver and zinc to peak and exceed guidelines for aquatic life and/or drinking water. These exceedances were probably not serious because they were rare

and because the turbidity-associated metals may not have been bio-available and would be removed by the water treatment needed before drinking water use.

- Zinc levels may have decreased slightly during 1991-2000 in response to the on-going waste abatement at the Cominco Sullivan Mine at Kimberley.
- Summer water temperatures often exceeded the upper optimum temperatures for the fish species resident in the Kootenay River, despite the cooling influence of the Libby Dam.
- Chromium and lead levels exceeded guidelines for aquatic life or irrigation on occasion and further investigation is needed to identify the forms of the metals and causes.

RECOMMENDATIONS

- Monitoring for the current suite of water quality indicators should continue because the Kootenay River at Creston is a transboundary waterbody, flowing into Kootenay Lake, which has important fisheries and recreational values.
- Implement low-level analyses of total and dissolved or extractable cadmium, chromium, lead and silver to identify the levels and forms of these metals.
- Implement analyses of low-level hexavalent and trivalent chromium, when they become available, to enable comparison to water quality guidelines.

- **FIGURE 1 MAP OF THE KOOTENAY RIVER BASIN**

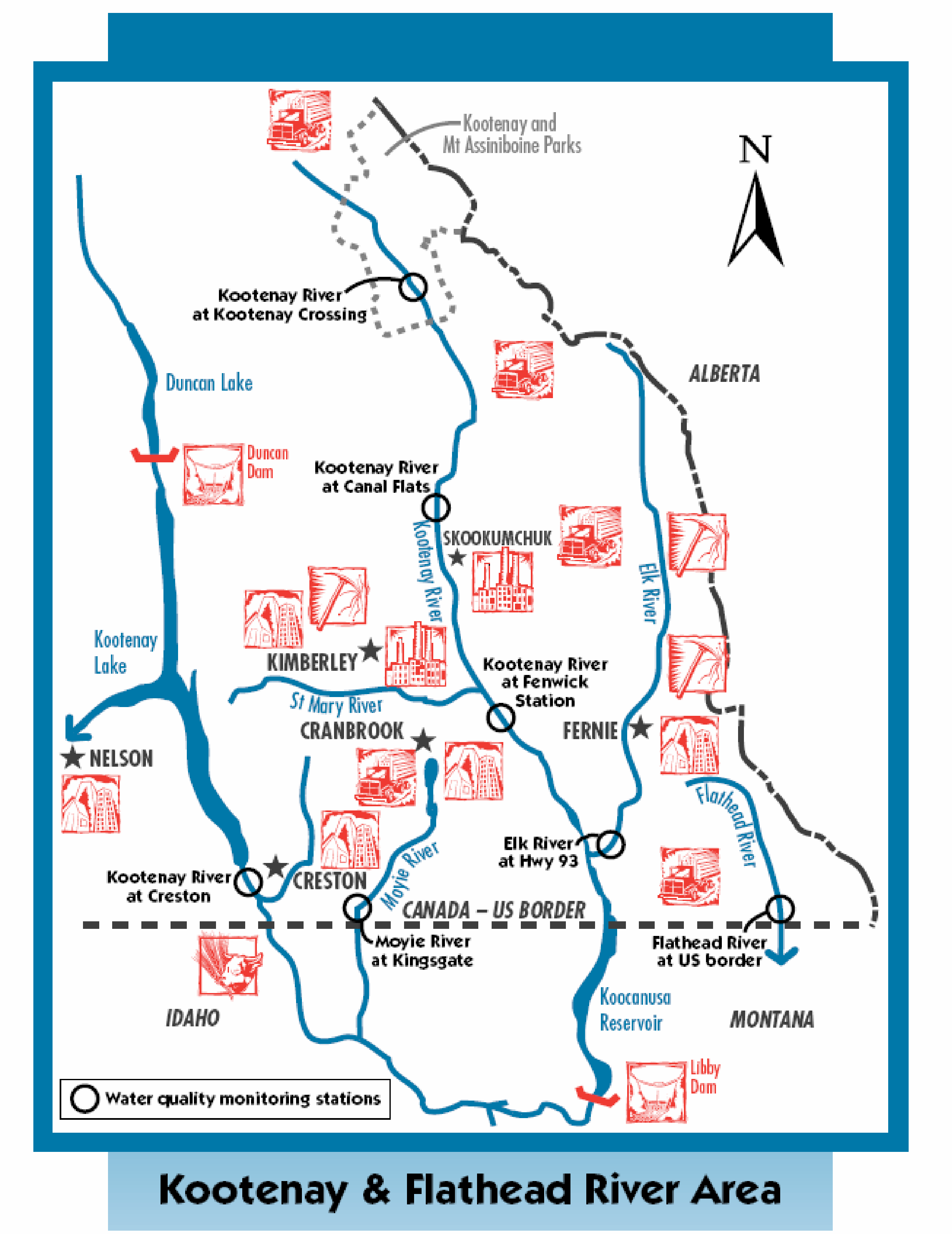

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (CONT'D) Page

1. INTRODUCTION

The Kootenay River at Creston water quality monitoring station is located west from Creston, B.C. on the Highway 3 bridge, 15 km upstream from Kootenay Lake and 15 km downstream from the US border (Figure 1). The drainage area of the river is 36,700 km^2, with 21,200 km^2 in B.C. and 15,500 km^2 in the US. This reach of the river supports significant fisheries (e.g., westslope cutthroat trout, bull trout, whitefish and sturgeon) and the water is used for recreation, wildlife conservation, and irrigation. Major influences on water quality at Creston have included:

- the Cominco Ltd. Sullivan lead-zinc mine (expected to close in 2002), concentrator and former fertilizer plant (closed in 1987) located in the St. Mary River watershed at Kimberley
- the Libby Dam (completed in 1972) and its reservoir, Koocanusa Lake in Montana
- municipal sewage discharges from Creston
- forestry and agriculture

Flow in the Kootenai River at Porthill, about 15 km upstream from the Creston station, has been monitored since 1928. The flow data are stored on the Water Survey of Canada database under station number BC08NH021. Thirty-six years (1965-2000) of flow data are plotted in Figure 2. The Province and Environment Canada began collecting water quality data at Creston in 1965 and the data are stored on the Environmental Monitoring System (EMS) under site number 0200013. Environment Canada began regular monitoring of water quality at Creston in 1979, and since 1985 Canada and B.C. have jointly operated the station as a federal-provincial station. Water quality data have been collected every two weeks since 1984 and are stored on the ENVIRODAT database under station number BC08NH0005 and on EMS under site number E206587. Up to thirty-six years (1965-2000) of water quality data were used in this report by merging suitable data from EMS sites 0200013 (east bank) and E206587 (midstream). The data for the current suite of water quality indicators are plotted in Figures 3 to 39. These are the water quality indicators that were recommended by a previous assessment (Ministry of Environment, Lands and Parks and Environment Canada, 1996) and that have been monitored up to the present.

2. WATER QUALITY ASSESSMENT

The status and trends of water quality were assessed by plotting the water quality indicators over time and comparing the values to the Province's approved and working water quality guidelines (Ministry of Environment, Lands and Parks, 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, are described below in alphabetical order.

Water quality indicators that were plotted but not discussed because they easily met all water quality guidelines and showed no harmful trends were: aluminum, total, arsenic, total, barium, total, beryllium, total, lithium, total, molybdenum, total, nickel, total, selenium, total, sodium, strontium, total, and vanadium, total.

Cadmium, total (Figure 7) was monitored during 1971-2000, but the data prior to 1986 were excluded owing to high detection limits (0.01, 0.001 and 0.0005 mg/L). Only data with a detection limit of 0.0001 mg/L, which is still above the aquatic life guidelines (0.00001-0.00005 mg/L), were included. Nevertheless, there were 24 (7.3%) detectable values above the guidelines during 1986-2000. Two-thirds of these occurred during 1986-90 and may have been due to contamination from the preservative vials. Four detectable values occurred in the 1997 freshet when turbidity was elevated, suggesting that the cadmium was particulate-bound and not likely to have been bio-available. The four detectable values corresponded to the peak values upstream at the Kootenay River at Fenwick Station in the spring of 1997. However, the data must be used with caution because all of the values were within 11 times the detection limit and thus below the limit of quantification (Clark & Whitfield 1994). The maximum value of 0.0011 mg/L was still below the drinking water guideline of 0.005 mg/L. Measurement of cadmium using a lower detection limit (e.g., 0.000005 mg/L or lower) is desirable.

Calcium (Figure 8) was monitored during 1965-2000. Dissolved and extractable calcium data were combined in Figure 10, since the method switched from dissolved to extractable in 1989. There was a decreasing trend during 1965-76, possibly due to waste abatement at Cominco’s Kimberley operation prior to 1971 and the completion of the Libby Dam in 1972. There has been little or no change during 1977-2000. Calcium and magnesium are the two main components of water hardness, and decreasing calcium levels made the water more aesthetically desirable for drinking water.

Carbon, dissolved organic (Figure 9) was monitored during 1997-2000. Two values (4.3 & 14.5 mg/L), which comprise 2.8% of the values, exceeded the drinking water guideline for raw water that will be chlorinated. The record is too short to comment on trends.

Chromium, total (Figure 10) was monitored during 1971-2000, but the data prior to 1990 were excluded due to high detection limits (0.01 and 0.005 mg/L) and contamination from preservative vials during 1986-90. The comparison of the total chromium data to guidelines is confounded because the guidelines are for the hexavalent and trivalent forms of chromium. During 1991-2000, 23 values (10%) exceeded the 0.001 mg/L aquatic life guideline for hexavalent chromium and three values (1.3%) exceeded the 0.009 mg/L aquatic life guideline for trivalent chromium. Four values exceeded the 0.005 mg/L irrigation guideline for trivalent chromium, and three of these values exceeded the 0.008 mg/L irrigation guideline for hexavalent chromium. The three highest values were measured when turbidity was low (0.83-2.6 NTU), and thus the chromium was not associated with suspended sediment and may have been in a bio-available form. Measurement of hexavalent and trivalent chromium with suitably low detection limits (at least 0.0001 mg/L) are needed to determine the extent to which guidelines are exceeded. There was no apparent change in mean total chromium levels during 1991-2000.

Cobalt, total (Figure 11) was monitored during 1973-2000, but data prior to 1990 were excluded due to a high detection limits (0.1 & 0.001 mg/L). During 1990-2000, a detection limit of 0.0001 mg/L was used and three values (1.2%) exceeded the 0.0009 mg/L aquatic life guideline. These peaks occurred during the 1997 spring freshet due to elevated turbidity and thus were probably not bioavailable. There were no apparent changes over time.

Coliforms, fecal (Figure 12) were monitored during 1968-70 and 1975-2000. There was a dramatic decrease in fecal coliform levels after 1977 and then little or no change during 1978-2000. The decrease after 1977 was probably due to improved sewage treatment and disposal by the Town of Creston and in the US. The maximum level during 1978-2000 was 210/100 mL, and the next highest value was 99/100 mL, indicating that the water met the guidelines for swimming, livestock and irrigation (200/100 mL geometric mean) and raw drinking water that receives partial treatment and disinfection (100/100 mL 90^{th} percentile).

Colour, true (Figure 13) was monitored during 1972-77 and 1997-2000, and there is no apparent difference between the two time periods. The aesthetic guideline for drinking water (15 true colour units) was exceeded only once, in 1999.

Conductivity, specific (Figure 14) was monitored during 1965-2000. There was a dramatic decreasing trend during 1965-76, possibly due to waste abatement at Cominco's Kimberley operation prior to 1971, and due to the completion of the Libby Dam in 1972 (Whitfield & Woods 1984). There was little or no change during 1977-2000. The maximum value was 420 microSiemans/cm in 1973, which was well below the lowest guidelines for drinking water and irrigation (700 microSiemans/cm), and thus the trend was of little environmental significance.

Copper, total (Figure 15) was monitored during 1967-2000, but data prior to 1991 were excluded due to high detection limits (0.01-0.001 mg/L) and contamination from preservative vials in 1986-90. During 1991-2000 a detection limit of 0.0002 mg/L was used, and nine values (4%) exceeded the 0.002-0.0044 mg/L hardness-dependent average guidelines for aquatic life with a maximum of 0.0207 mg/L. Most of these exceedances (7 of 9) occurred during spring freshet when turbidity was high, and thus the copper was likely particulate-bound and not bio-available. There was no apparent change over time.

Hardness (Figure 16) was monitored during 1965-2000 and exhibited a dramatic decreasing trend during 1965-76, possibly due to waste abatement at Cominco's Kimberley operation prior to 1971 and the completion of the Libby Dam in 1972. This decrease made the water more aesthetically pleasing for drinking water. There appears to have been a slight increasing trend during 1977-2000 due to an increasing trend in magnesium (calcium and magnesium are the main components of hardness). However, since the maximum hardness value was only 139 mg/L, and well below the poor, but tolerable, aesthetic guideline for drinking water, the trend is of little significance.

Iron, total (Figure 17) was monitored during 1967-2000. There was an apparent decreasing trend during 1969-80, probably due to abatement of the Cominco waste discharges to the St. Mary River (Ministry of Environment, 1981, Ministry of Water, Land and Air Protection & Environment Canada, 2001c) and the completion of the Libby Dam in 1972. There was no apparent change during 1981-2000. The decreasing trend made the water more suitable for irrigation, aquatic life and drinking water. Prior to 1981, four values (0.7%) exceeded the 5 mg/L guideline for irrigation (maximum of 14 mg/L), but the guideline was not exceeded since then. These peak values occurred during spring freshet when turbidity was elevated. Iron is the fourth most abundant element in the Earth's crust and the suspended sediment present during freshet accounts for the higher total iron levels. The 0.3 mg/L guideline for drinking water and aquatic life was exceeded for 17% of the values, whenever turbidity was elevated due to the particulate-bound iron in the suspended sediment. Particulate-bound iron is unlikely to be bio-available and would be removed by the water treatment needed to remove turbidity prior to use as drinking water.

Lead, total (Figure 18) was monitored during 1973-2000 and data with a detection limit of 0.001 mg/L or lower were included. There appears to be a slight downward trend, probably due to the decline in detection limits from 0.001 to 0.0007 to 0.0002 mg/L over this time. There was little or no change during 1991-2000, when only the 0.0002 mg/L detection limit was used. During 1973-2000, 21 of 493 values (4.3%) exceeded the average aquatic life guidelines (0.004-0.0075 mg/L, depending on hardness), and one value exceeded the maximum aquatic life guidelines. There was no consistent pattern to the exceedances; they occurred when turbidity was high (9 of 21) and low (12 of 21) and during freshet (12 of 21) and non-freshet (9 of 21). Further investigations should be done to identify the forms of the lead and the cause(s) of the elevated levels.

Magnesium (Figure 20) was monitored during 1965-2000 by dissolved, extractable and total methods, and the data have been combined in Figure 20. A decreasing step change occurred in early 1973, probably due to the completion of the Libby Dam in 1972. During 1974-2000, there has been a small increasing trend, but it had little environmental significance since the maximum hardness (hardness is mainly calcium plus magnesium expressed as $CaCO_3$) of 139 mg/L was well below the poor, but tolerable, aesthetic guideline for drinking water.

Manganese, total (Figure 21) was monitored during 1965-2000. There was an apparent declining trend during 1977-87, followed by no change during 1988-2000. Declining detection limits (0.02, 0.01, and 0.0001 mg/L) caused the downward trend. Six values (1.2%) exceeded the aesthetic guideline for drinking water of 0.05 mg/L, all due to elevated turbidity. The manganese was associated with particulate matter and would be removed by the water treatment needed prior to use as drinking water. The maximum of 0.17 mg/L was well below the average aquatic life guideline of 0.9 mg/L at 75 mg/L of hardness.

Nitrogen, total dissolved (Figure 24) was monitored during 1981-2000. There was an increasing trend over this time period. (An apparent outlier of 3.2 mg/L on March 1, 2000 was omitted.) The source of the increased nitrogen levels was due at least in part to the increasing levels in the Elk River (Ministry of Water, Land and Air Protection & Environment Canada, 2001d), which enters the Kootenay River near the head of Koocanusa Lake. There may be other sources of nitrogen, because the mean annual flow in the Elk River was about 1/6th of the mean annual flow of the Kootenay River at Creston, while the nitrogen levels were about three times higher in the Elk River. This indicates that the Elk River could have accounted for about one-half of the increase. The nitrogen levels were well below guidelines for drinking water and aquatic life. The increasing trend has reduced any nitrogen limitation for algal growth, but algal growth in the Kootenay River was limited by the availability of phosphorus, which has shown no change during 1987-2000 or 1993-2000 (see phosphorus, dissolved ortho and total).

pH (Figure 25) was monitored during 1965-2000 and ranged from 6.9 to 9.0 pH units. The aquatic life guideline of 9 units was not exceeded, but 16 values (2 %) exceeded the aesthetic drinking water guideline of 8.5 units. All but two of the values >8.5 were field measurements. Field values are expected to be higher than laboratory values because of lower temperatures and lower carbon dioxide concentrations during measurement. Because of pH instability due to CO_2 diffusion enroute to the laboratory, field measurement of pH is desirable, but high quality field pH measurements are difficult to obtain due to increased operator error and poor equipment performance (McKean and Huggins, 1989). There was an apparent slight increasing trend over time, but it does not appear to be environmentally significant with respect to guidelines.

Phosphorus, dissolved ortho was monitored during 1967-2000. Figure 26 shows a dramatic downward trend during 1967-76 due to abatement of Cominco's fertilizer plant discharge to the St. Mary River (Ministry of Water, Land and Air Protection & Environment Canada, 2001c) and the completion of the Libby Dam in 1972 (Whitfield & Woods, 1984). Figure 27 shows that the downward trend continued until the fertilizer plant was closed in 1987, although it was partly due to lower detection limits starting in 1985. Figure 28 shows that there was no change during 1988-2000. However, all of the data during 1977-2000 were below the limit of quantitation (e.g., 3-20 times the detection limit), and thus must be used with caution (Clark and Whitfield, 1994). The effect of the initial downward trend (e.g., 1967-76) was to prevent nuisance algal growths and blooms as far downstream as Kootenay Lake. However, as the downward trend continued, the levels dropped below natural levels, and Kootenay Lake became starved for phosphorus. It has been necessary to fertilize the lake with phosphorus since 1992 to boost fish production (Ministry of Environment, Lands and Parks and Environment Canada, 2000).

Phosphorus, total was monitored during 1965-2000. Like dissolved orthophosphorus, Figure 29 shows a dramatic downward trend during 1971-76 due to abatement at the Cominco fertilizer plant and the completion of the Libby Dam in 1972, followed by a slight downward trend until about 1993 (Figure 30). There was no apparent change in total phosphorus levels during 1994-2000 (Figure 31). However, much of the phosphorus data was below 20 times the detection limit, and thus may be below the limit of quantification and must be used with caution. The effect of the initial downward trend (e.g., 1967-76) was to prevent nuisance algal growths and blooms as far downstream as

Kootenay Lake. However, as the downward trend continued, the levels dropped below natural levels, and Kootenay Lake became starved for phosphorus. It has been necessary to fertilize the lake with phosphorus since 1992 to boost fish production (Ministry of Environment, Lands and Parks and Environment Canada, 2000).

Silver, total was monitored during 1996-2000 with a detection limit of 0.0001 mg/L (Figure 33). All of the values were at the detection limit, with the exception of three values of 0.0002–0.0006 mg/L. The highest value, which exceeded the aquatic life guidelines, occurred during spring freshet when turbidity was high (30 NTU). The three detectable values may also be false positives, being so close to the detection limit. There was no change in silver over time. Silver should be measured at a detection limit of at least 0.000005 mg/L to obtain values that can be compared to the aquatic life guidelines.

Temperature, water (Figure 36) was monitored during 1965-2000. There may have been a slight increasing trend over time, but that may have been due to more frequent monitoring during 1985-2000. Water temperatures often (19% of all values) exceeded 15 degrees C during summer, which is the aesthetic guideline for drinking water, but the lower limit for swimming. The summer water temperatures often exceeded the optimum upper temperatures for the fish species known to inhabit the Kootenay River (e.g., 3.4 % of values exceeded 19 degrees Cesius). Whitfield and Woods (1984) noted that the Libby Dam had reduced the summer water temperatures downstream from the dam, starting in 1972, and that a selective withdrawal structure was added in 1977. This structure permits the discharge of water from the dam at any desired temperature.

Turbidity (Figure 37) was monitored during 1965-2000 and is an optical measure of the amount of suspended sediment in water. There was a dramatic decline in turbidity after 1972 due to the completion of the Libby Dam. There was no apparent change during 1994-2000. The recreation guideline of 50 NTU was exceeded 14 times (1.9%), mostly before the completion of the Libby Dam in 1972. The drinking water guidelines of 1-5 NTU were often exceeded (17% of values for 5 NTU and 70% for 1 NTU), indicating that water treatment to remove turbidity (e.g., filtration) would be needed before using the river for drinking water.

Zinc, total (Figure 39) was monitored during 1967-2000, but the data prior to 1991 were excluded due to high detection limits and artificial contamination from preservative vials during 1986-90. There may have been a slight decreasing trend during 1991-2000 due to renewed zinc abatement at the Sullivan Mine, beginning in the summer of 1990. The effect of the downward trend would have been to make the water safer for aquatic life. During 1991-2000, the average guidelines for aquatic life (0.0075 mg/L or more, depending on hardness) were exceeded on four occasions (1.8% of the sampling dates) and the maximum guidelines were not exceeded. Turbidity (15-105 NTU) was elevated on all four occasions. The last exceedances in the spring of 1997 corresponded to the exceedances upstream in the Kootenay River at Fenwick Station.

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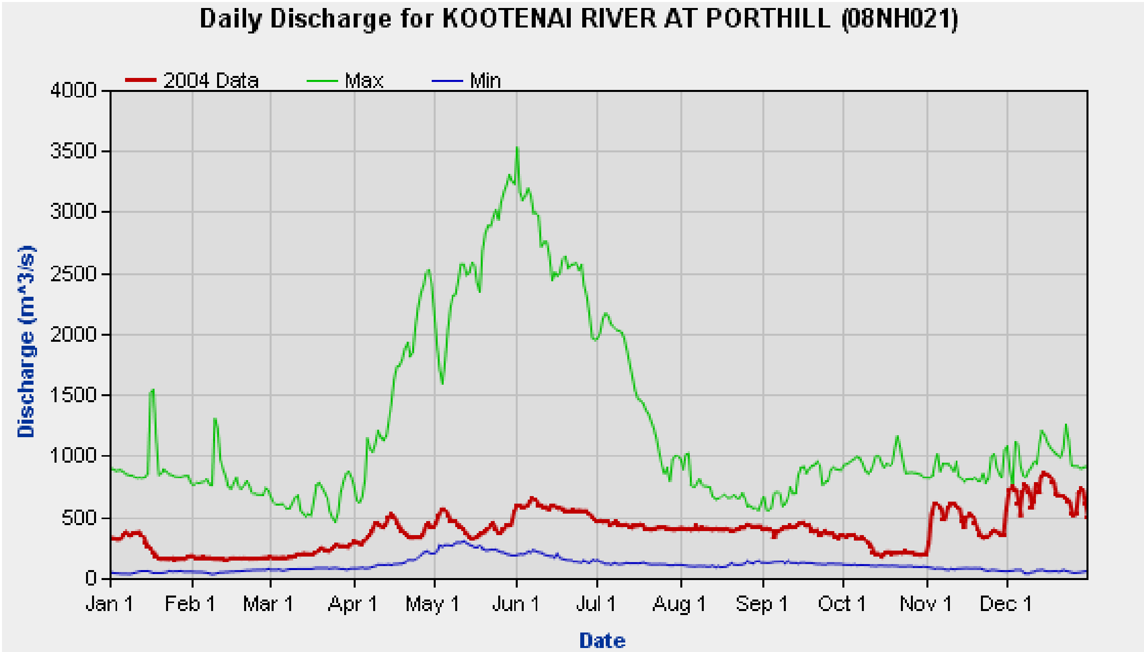

Figure 3 Kootenay River at Creston - Aluminum, Total

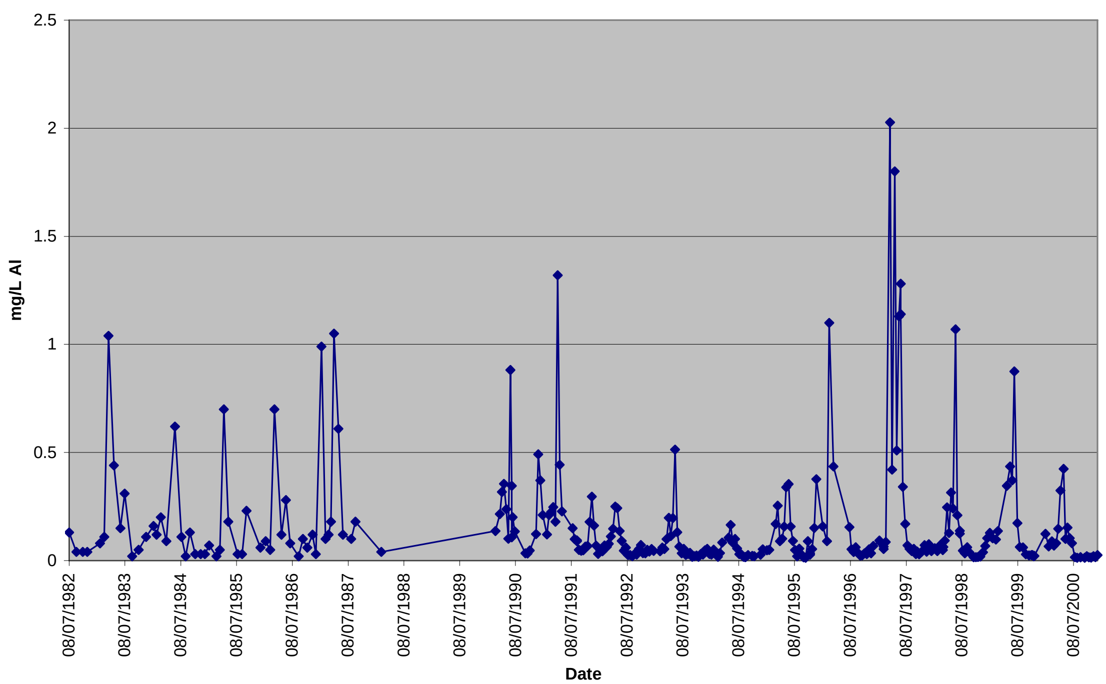

Figure 4 Kootenay River at Creston - Arsenic, Total

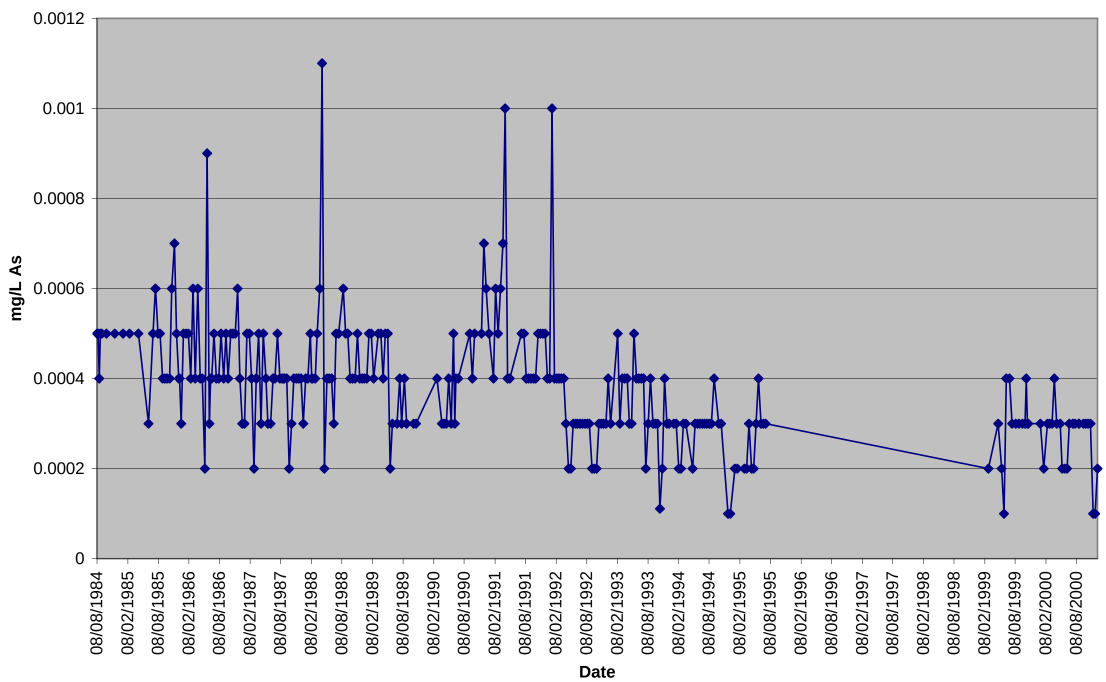

Figure 5 Kootenay River at Creston - Barium, Total

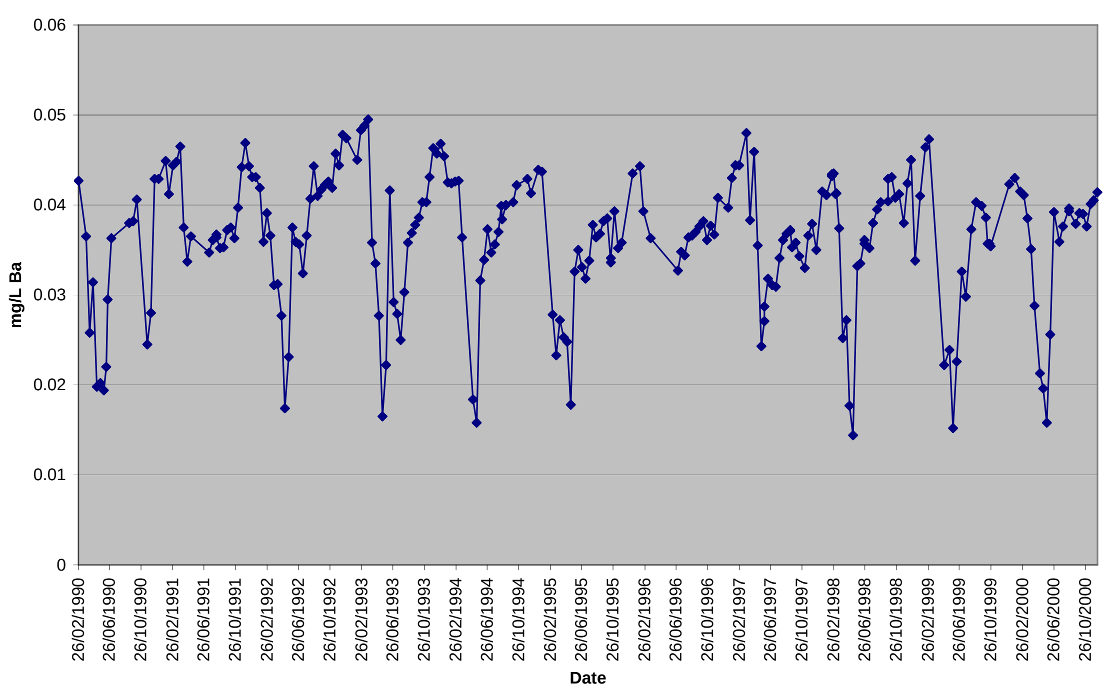

Figure 6 Kootenay River at Creston - Beryllium, Total

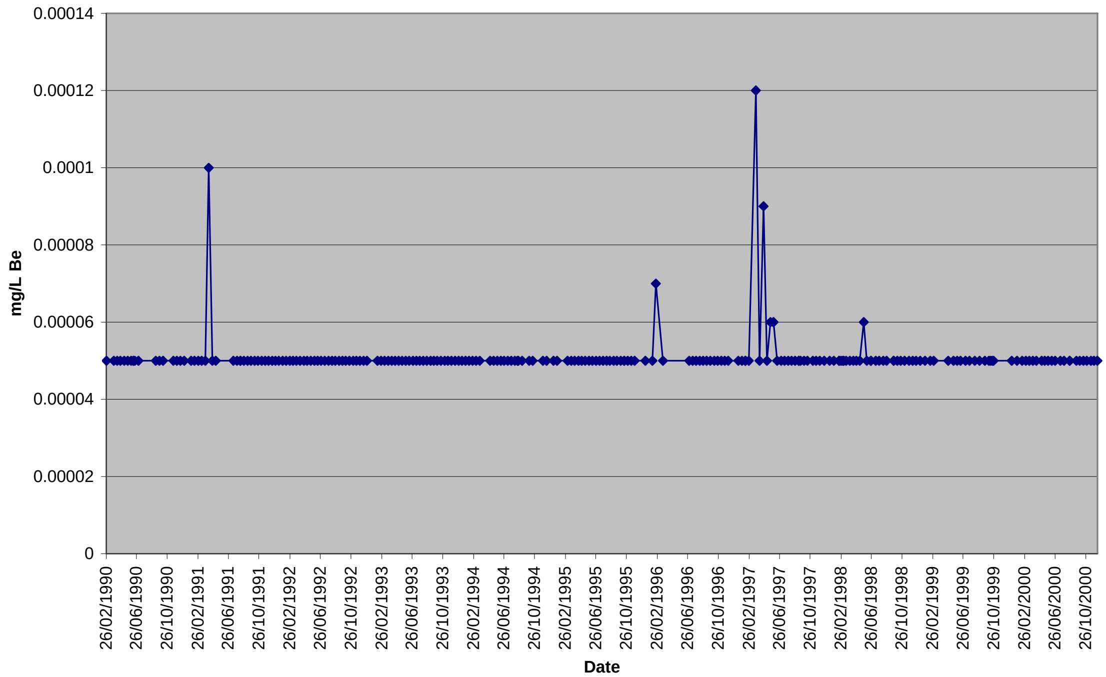

Figure 7 Kootenay River at Creston - Cadmium, Total

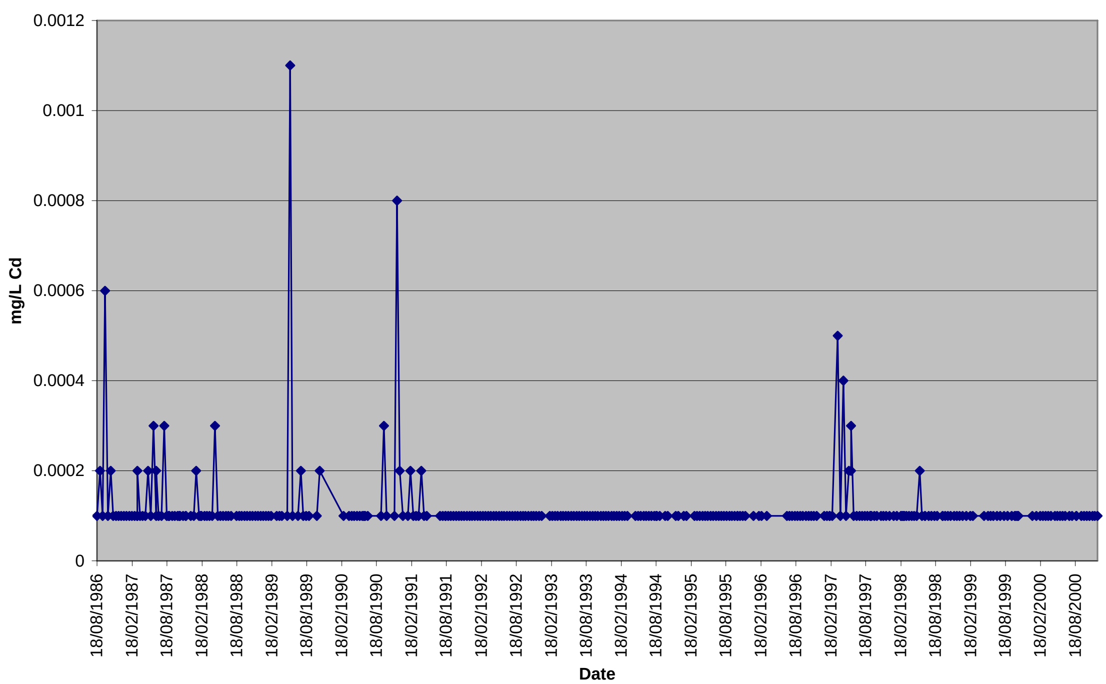

Figure 8 Kootenay River at Creston - Calcium

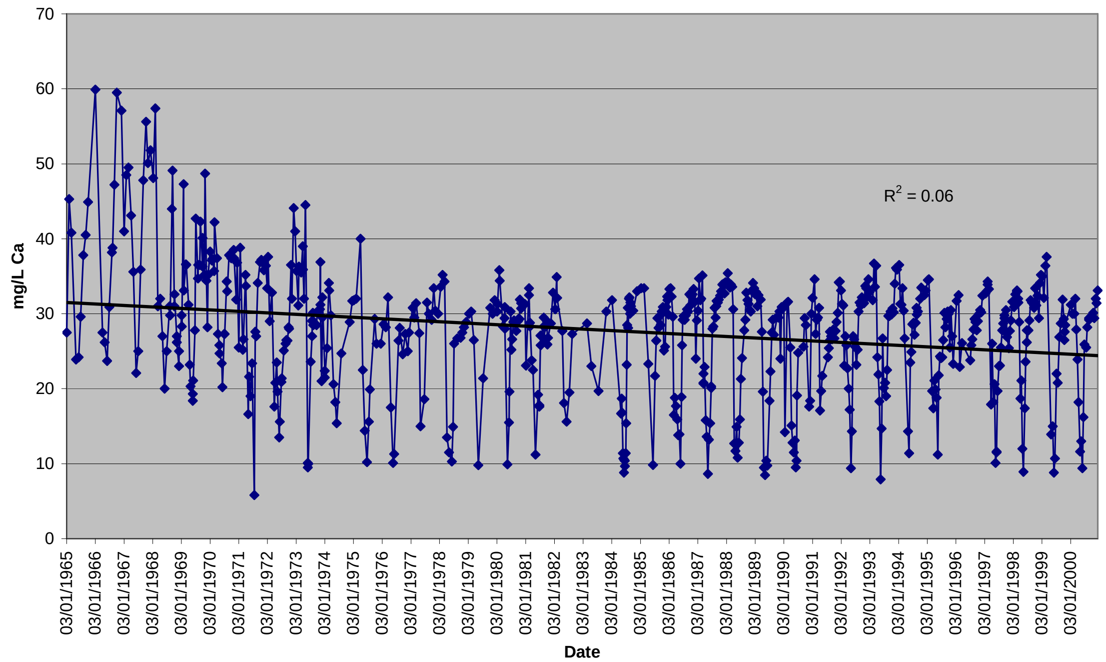

Figure 9 Kootenay River at Creston - Carbon, Dissolved Organic

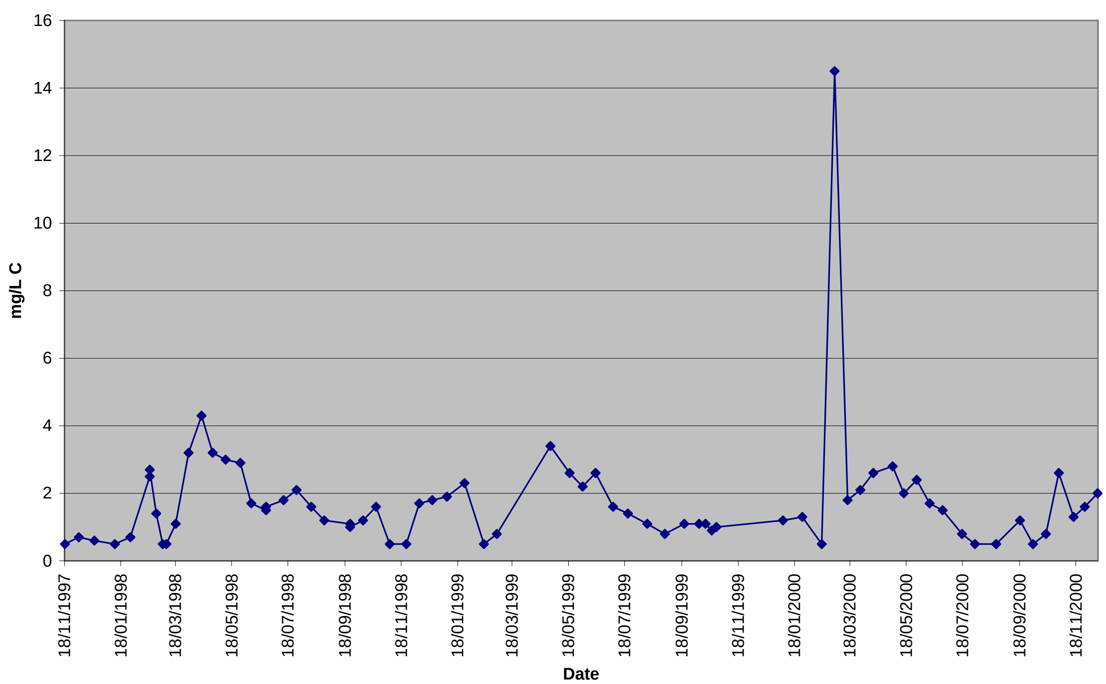

Figure 10 Kootenay River at Creston - Chromium, Total

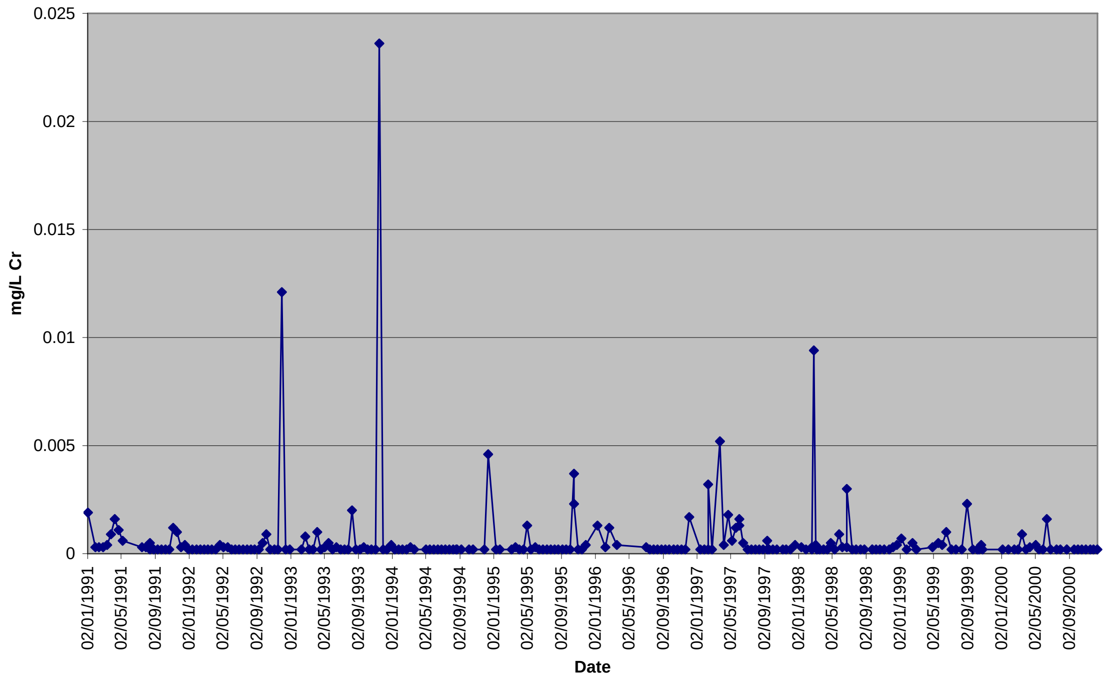

Figure 11 Kootenay River at Creston - Cobalt, Total

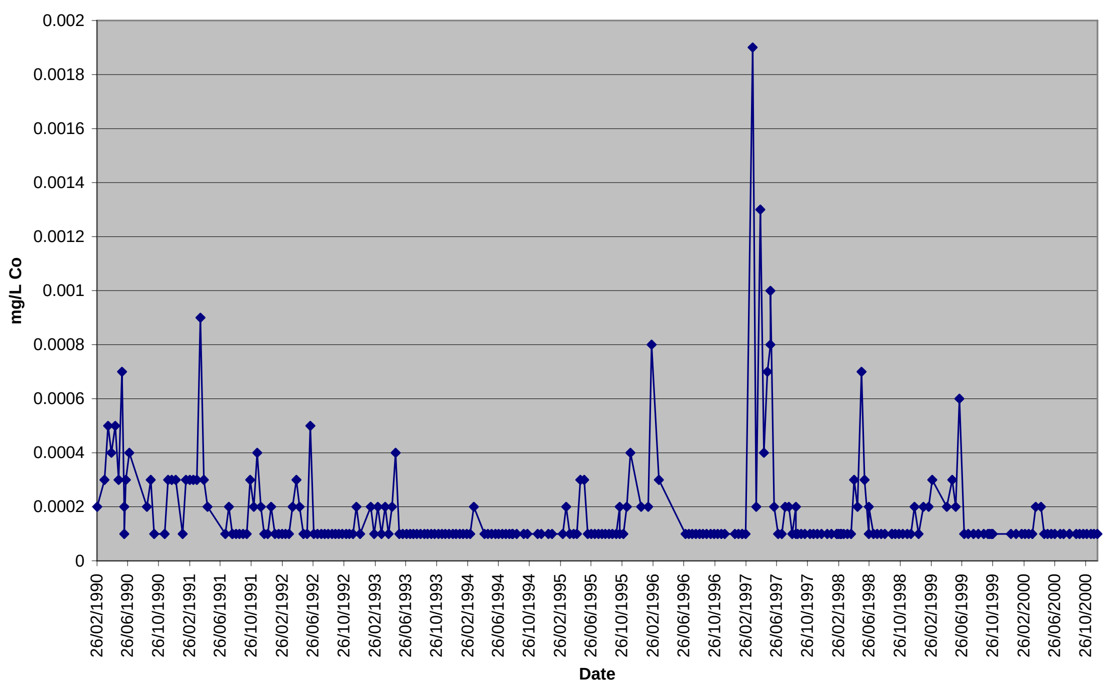

Figure 12 Kootenay River at Creston - Coliforms, Fecal

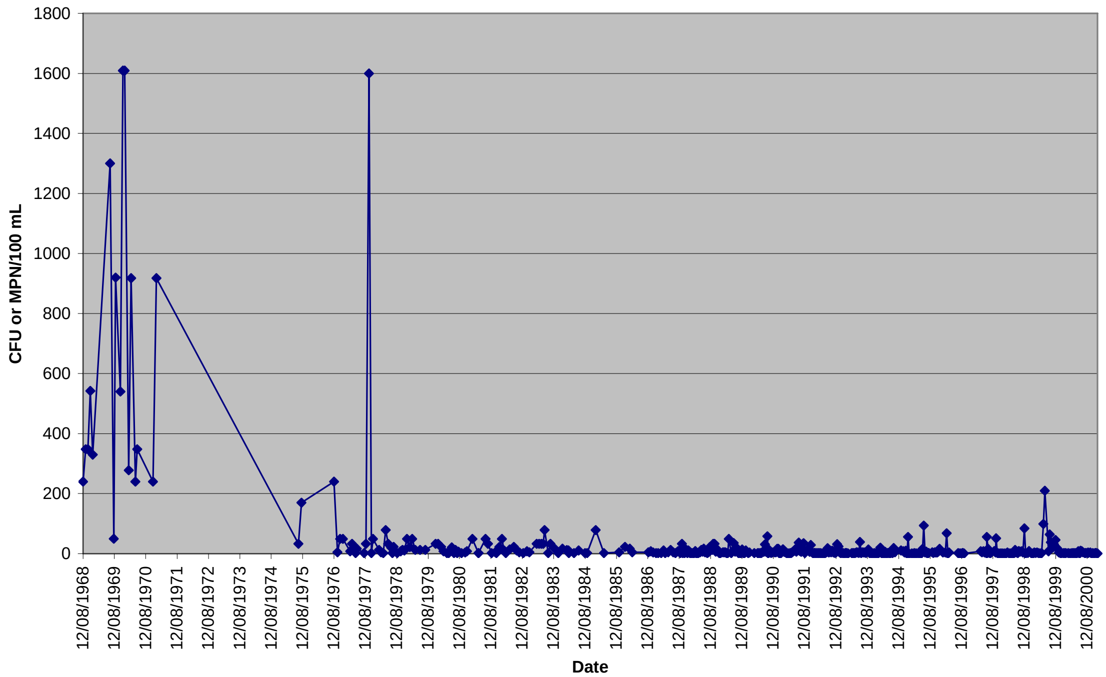

Figure 13 Kootenay River at Creston - Colour, True

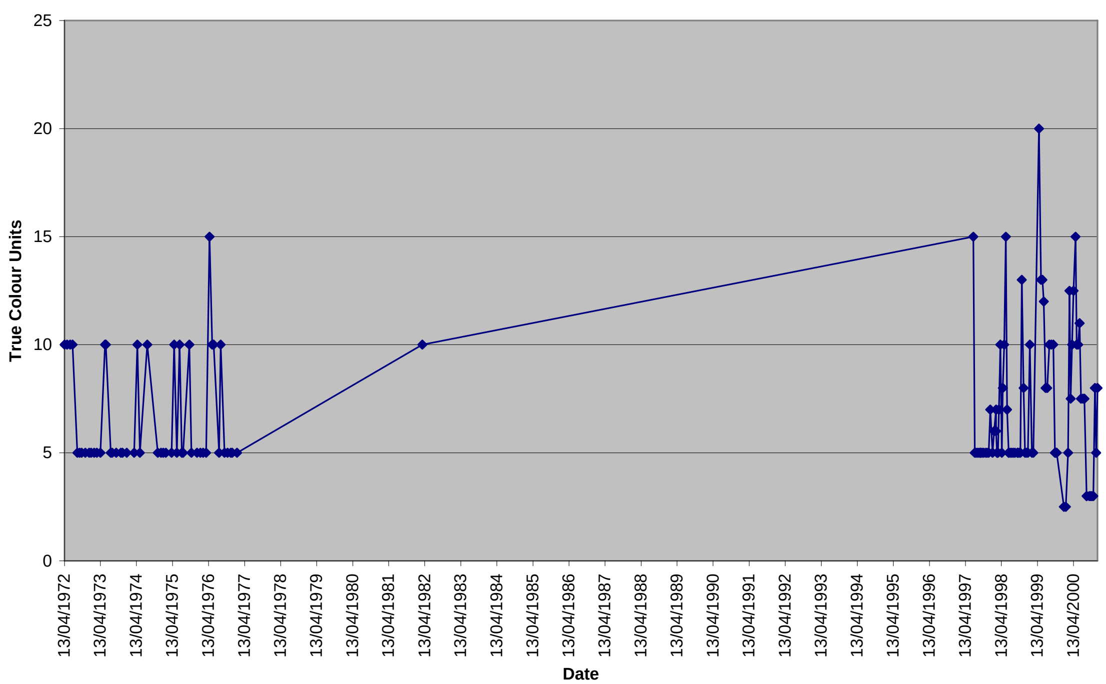

Figure 14 Kootenay River at Creston - Conductance, Specific

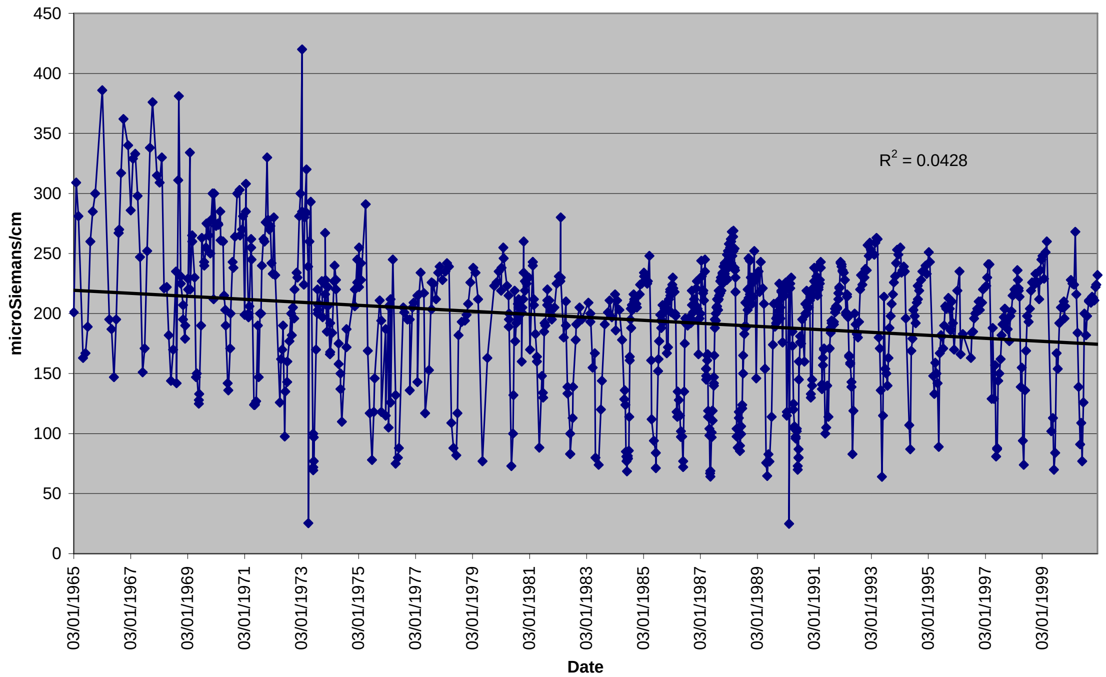

Figure 15 Kootenay River at Creston - Copper, Total

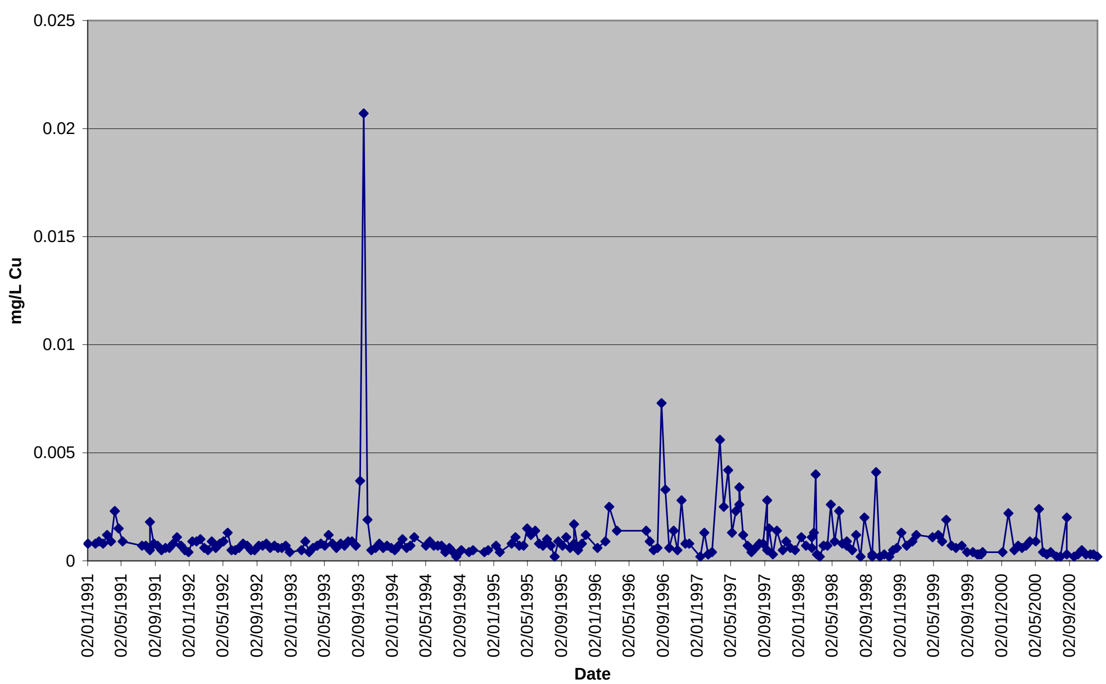

Figure 16 Kootenay River at Creston - Hardness

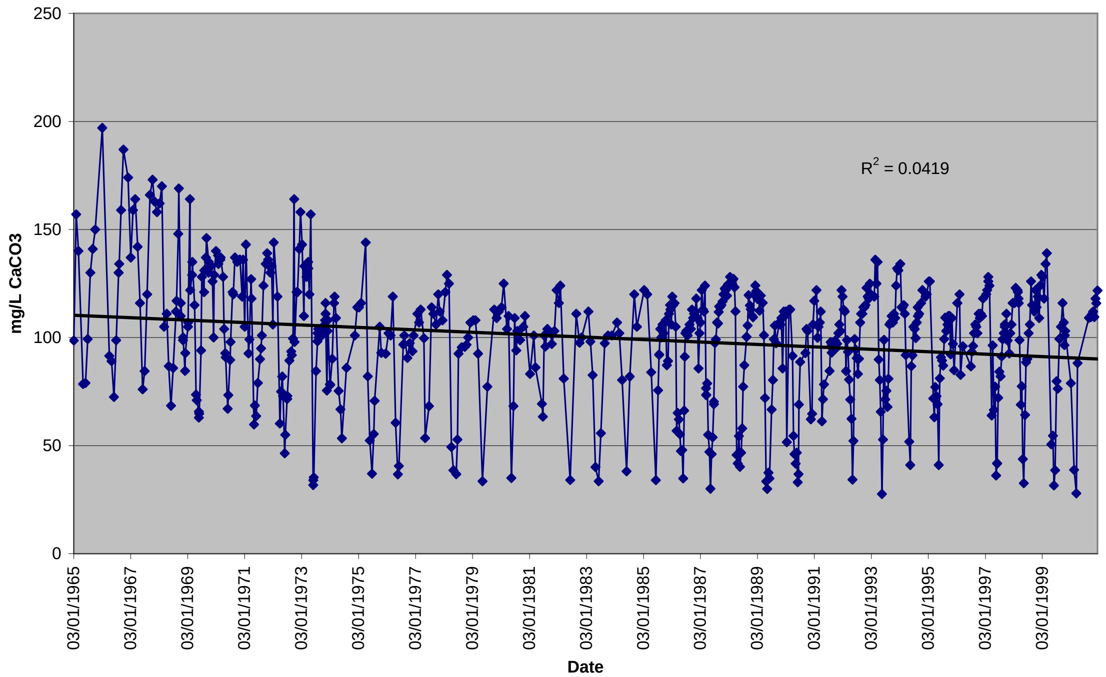

Figure 17 Kootenay River at Creston - Iron, Total

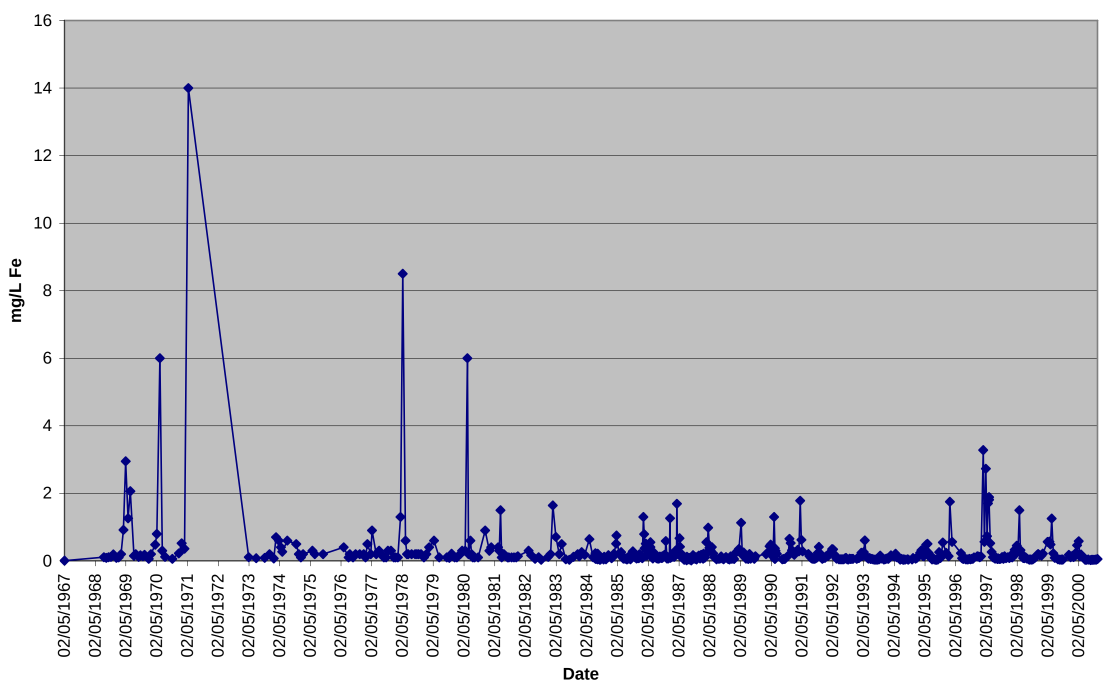

Figure 18 Kootenay River at Creston - Lead, Total

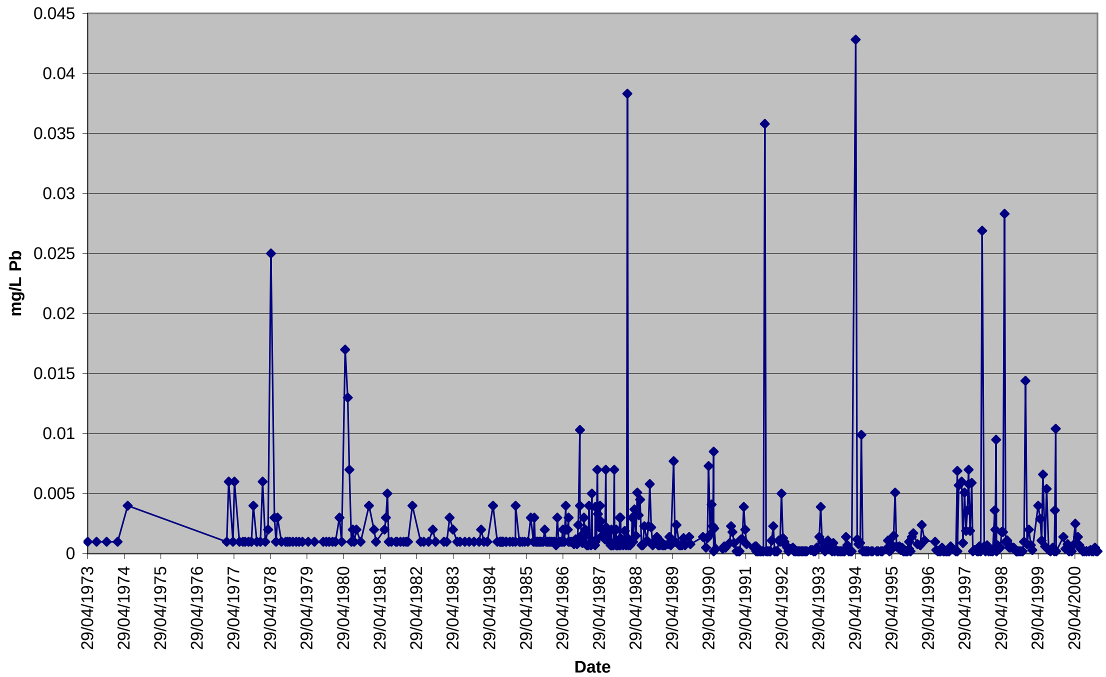

Figure 19 Kootenay River at Creston - Lithium, Total

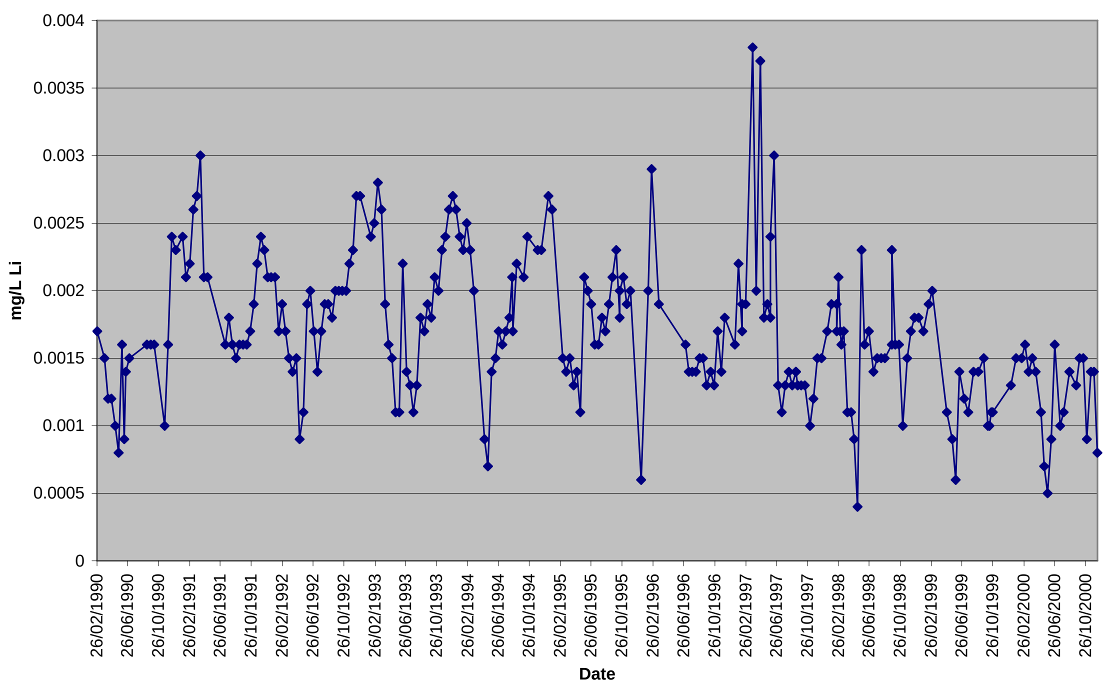

Figure 20 Kootenay River at Creston - Magnesium

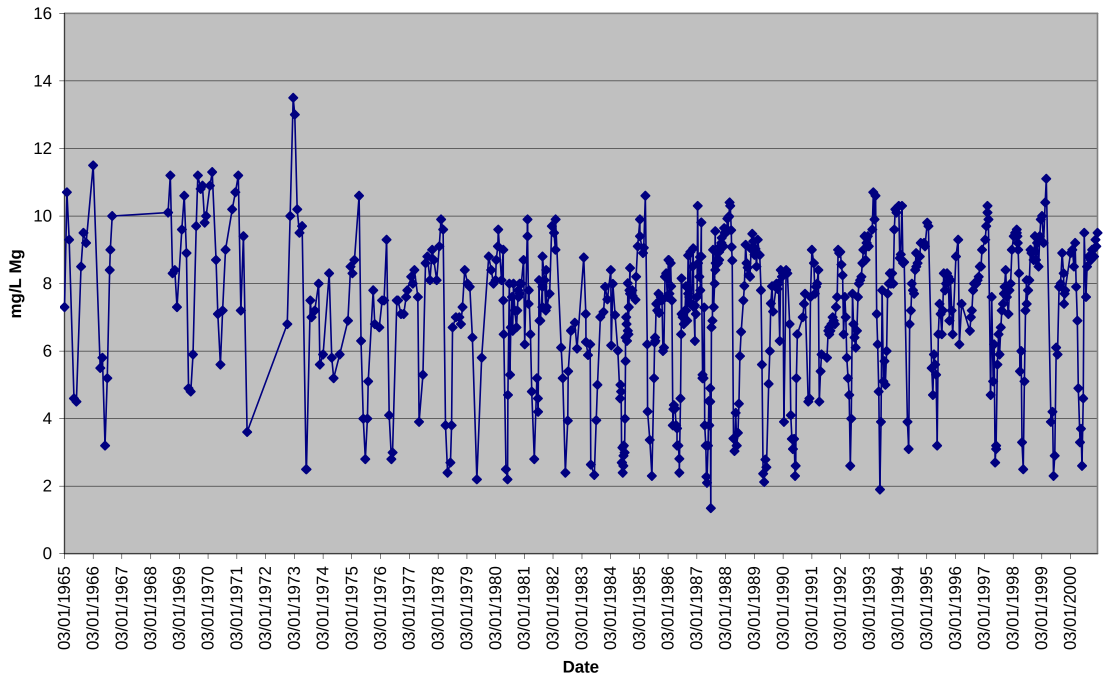

Figure 21 Kootenay River at Creston - Manganese, Total

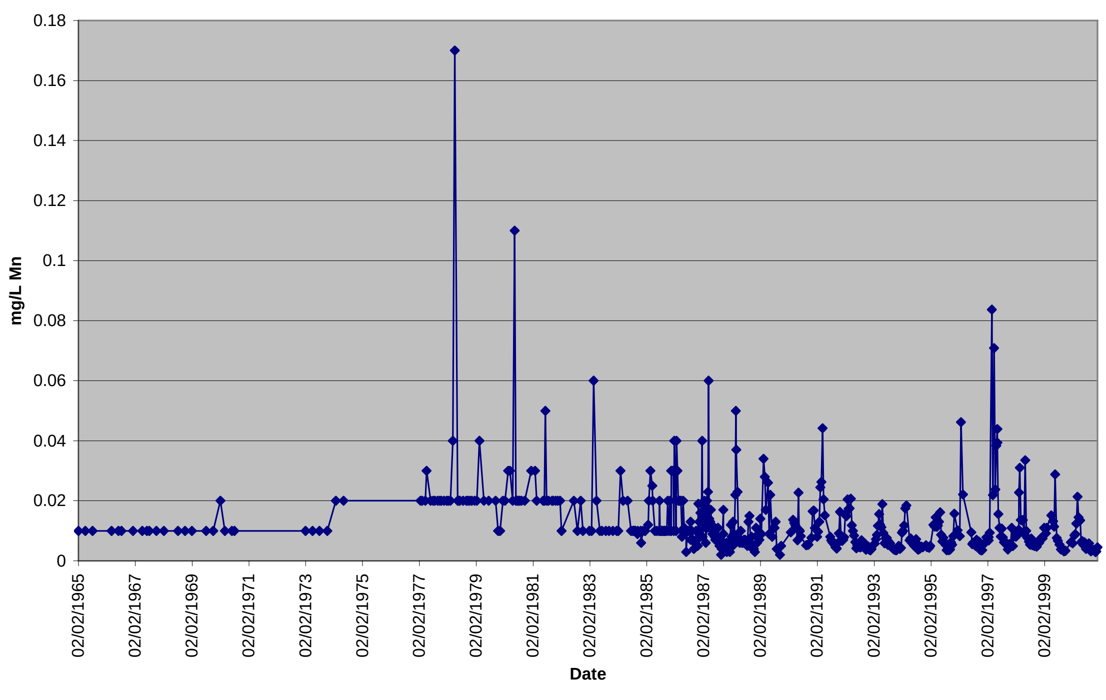

Figure 22 Kootenay River at Creston - Molybdenum, Total

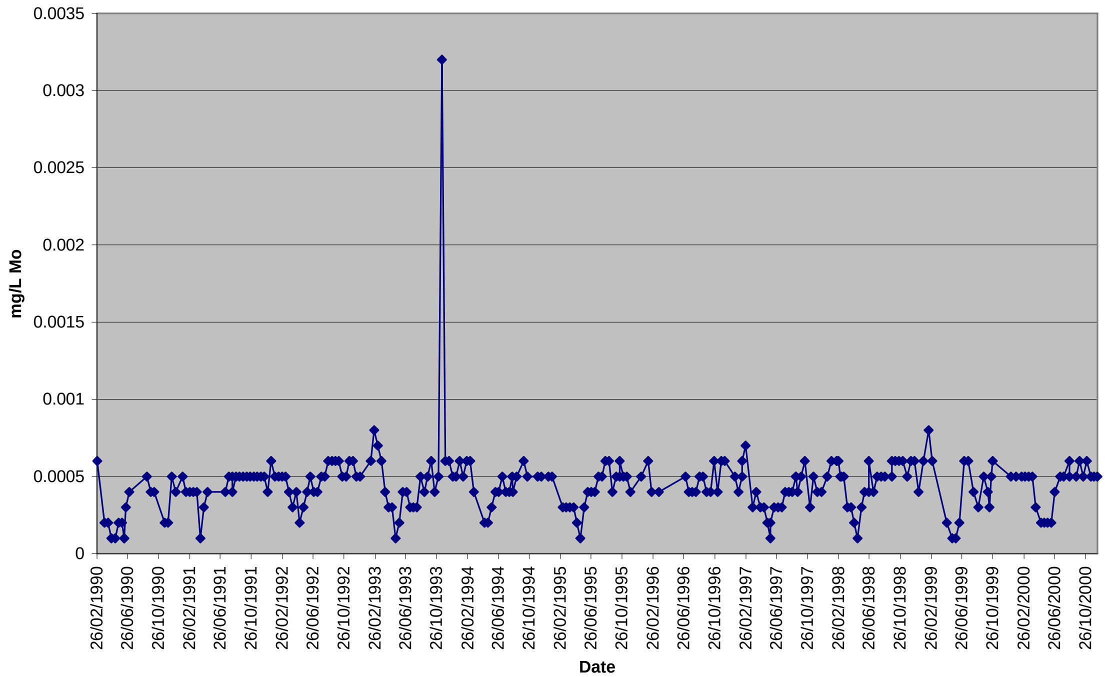

Figure 23 Kootenay River at Creston - Nickel, Total

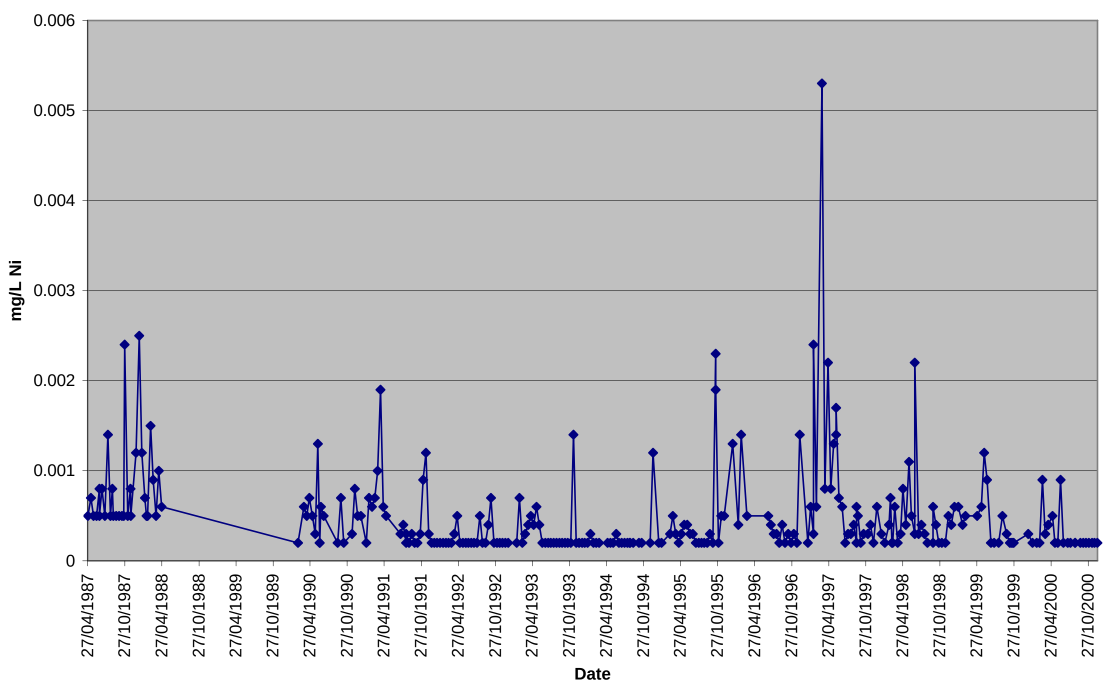

Figure 24 Kootenay River at Creston - Nitrogen, Total Dissolved

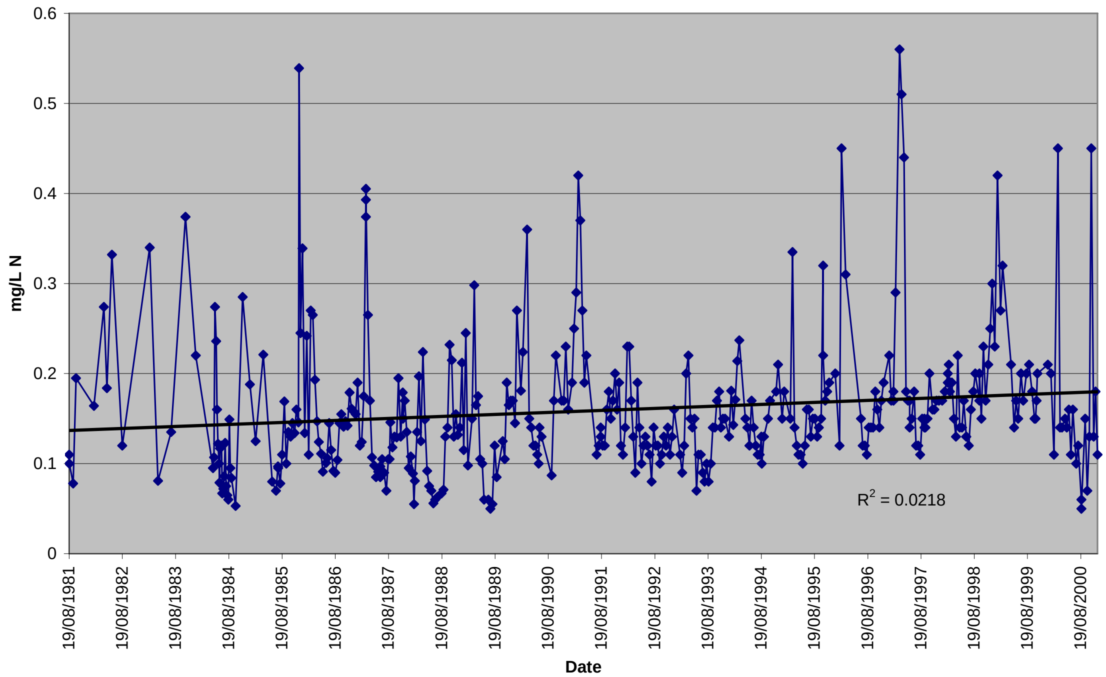

Figure 25 Kootenay River at Creston - pH

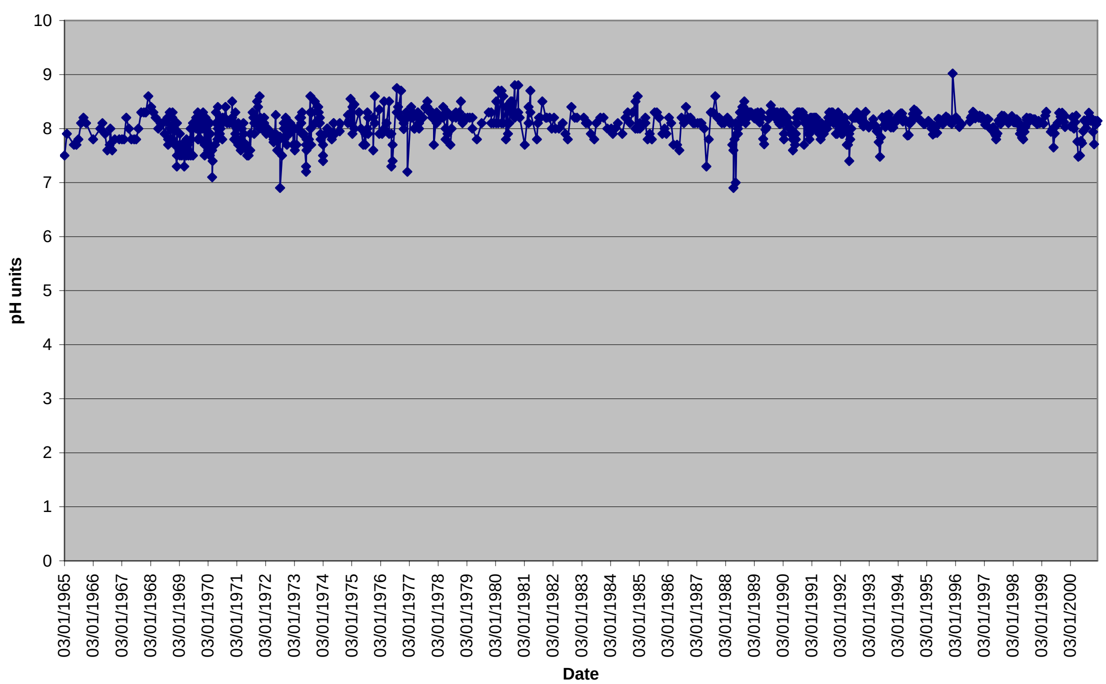

Figure 26 Kootenay River at Creston - Phosphorus, Dissolved Ortho, 1967-2000

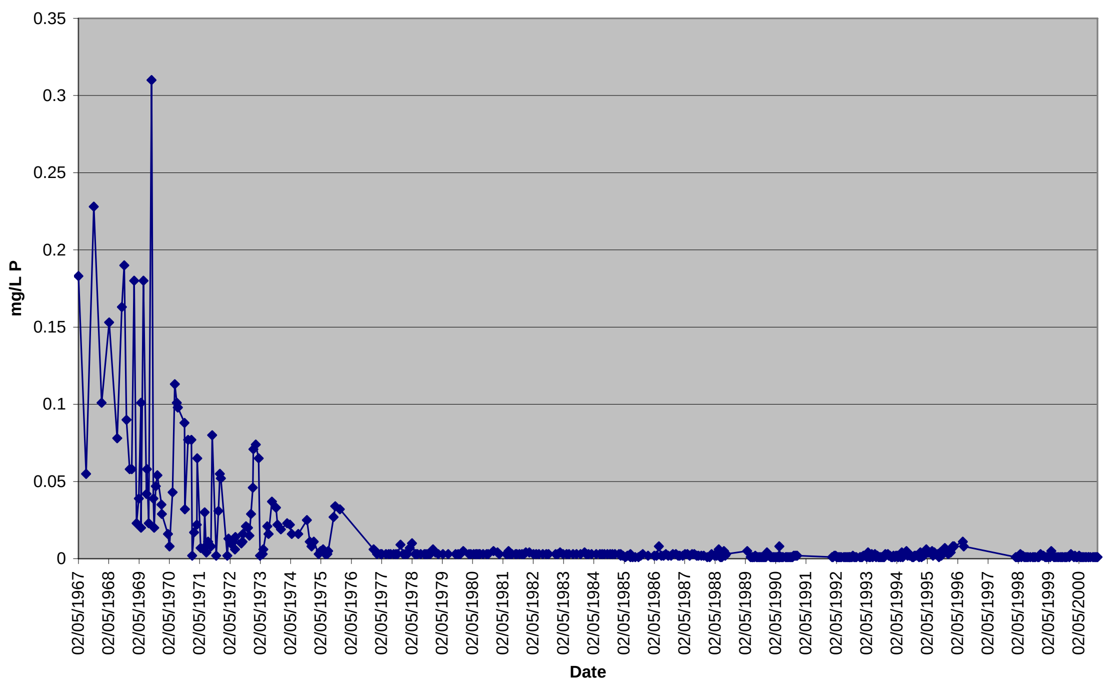

Figure 27 Kootenay River at Creston - Phosphorus, Dissolved Ortho, 1977-87

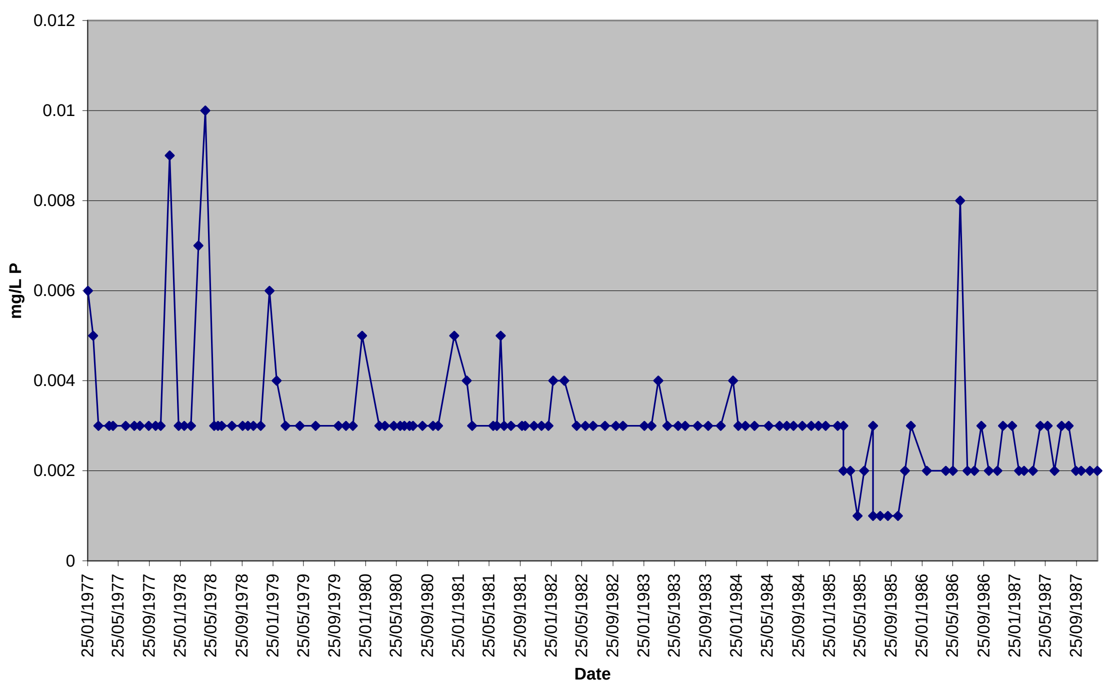

Figure 28 Kootenay River at Creston - Phosphorus, Dissolved Ortho, 1988-2000

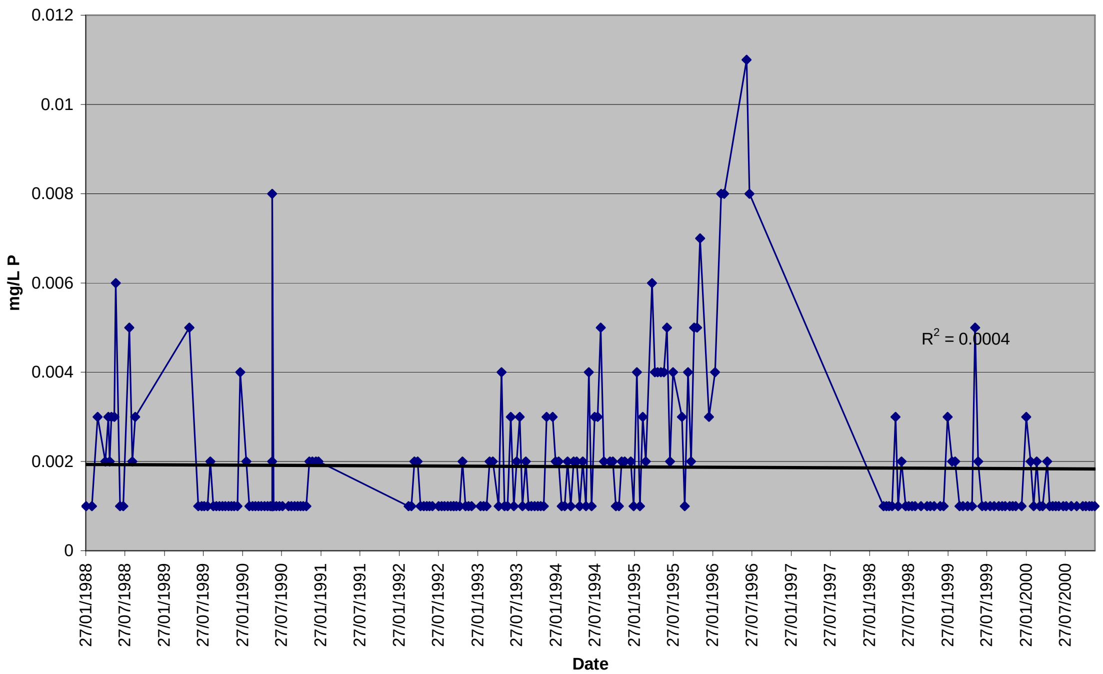

Figure 29 Kootenay River at Creston - Phosphorus, Total, 1965-2000

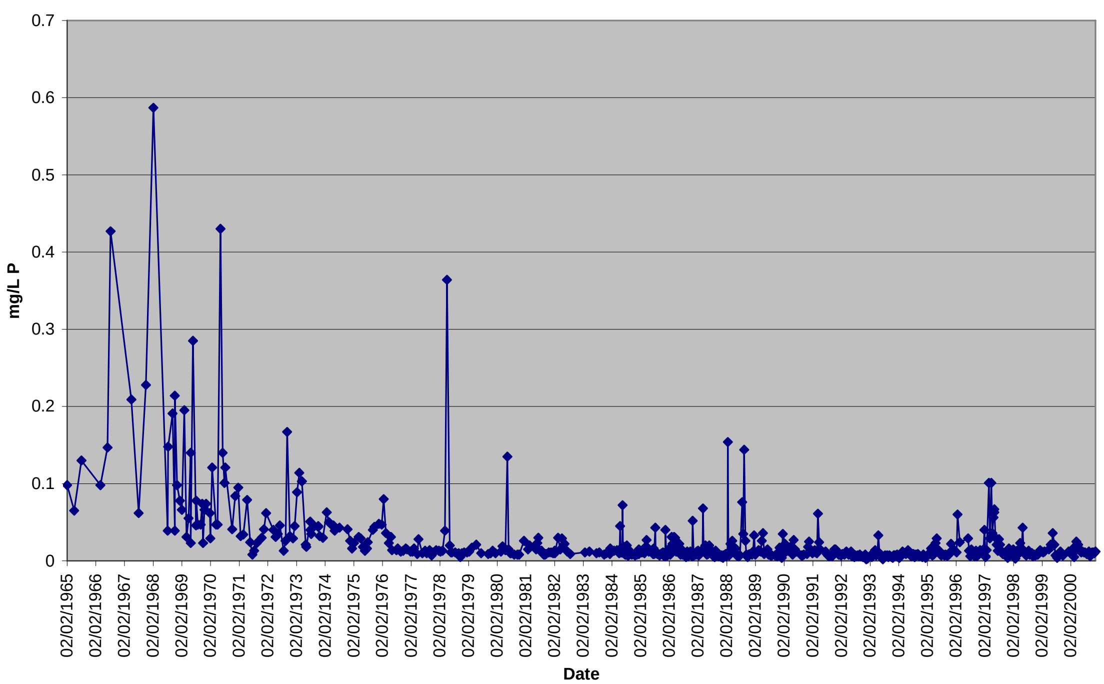

Figure 30 Kootenay River at Creston - Phosphorus, Total, 1977-93

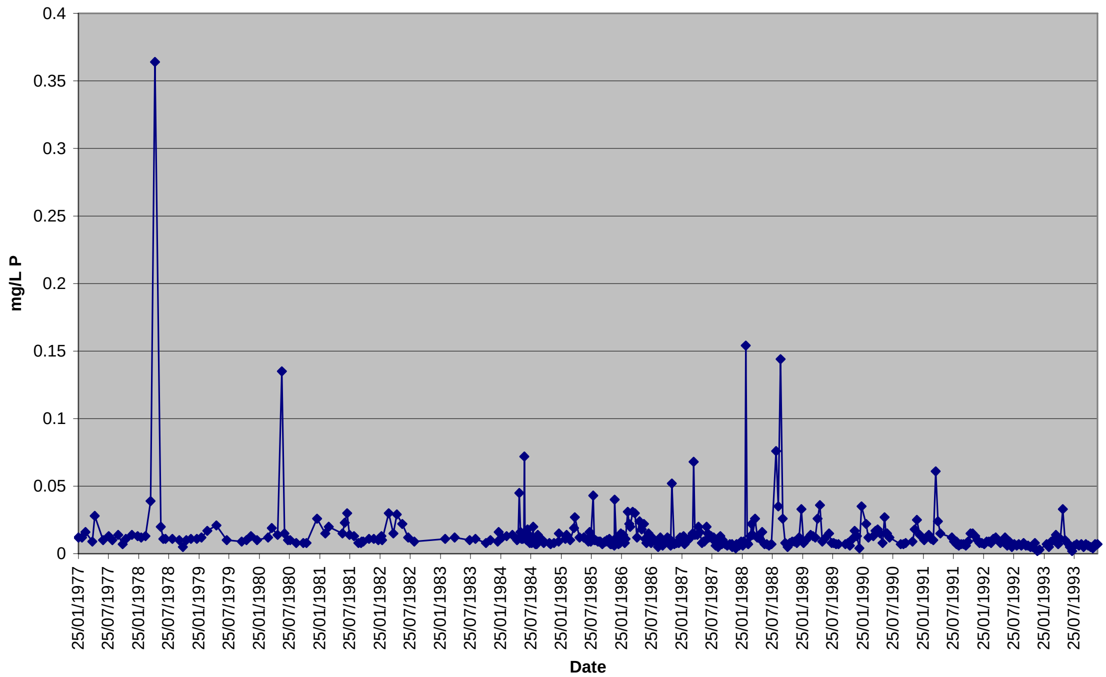

Figure 31 Kootenay River at Creston - Phosphorus, Total, 1994-2000

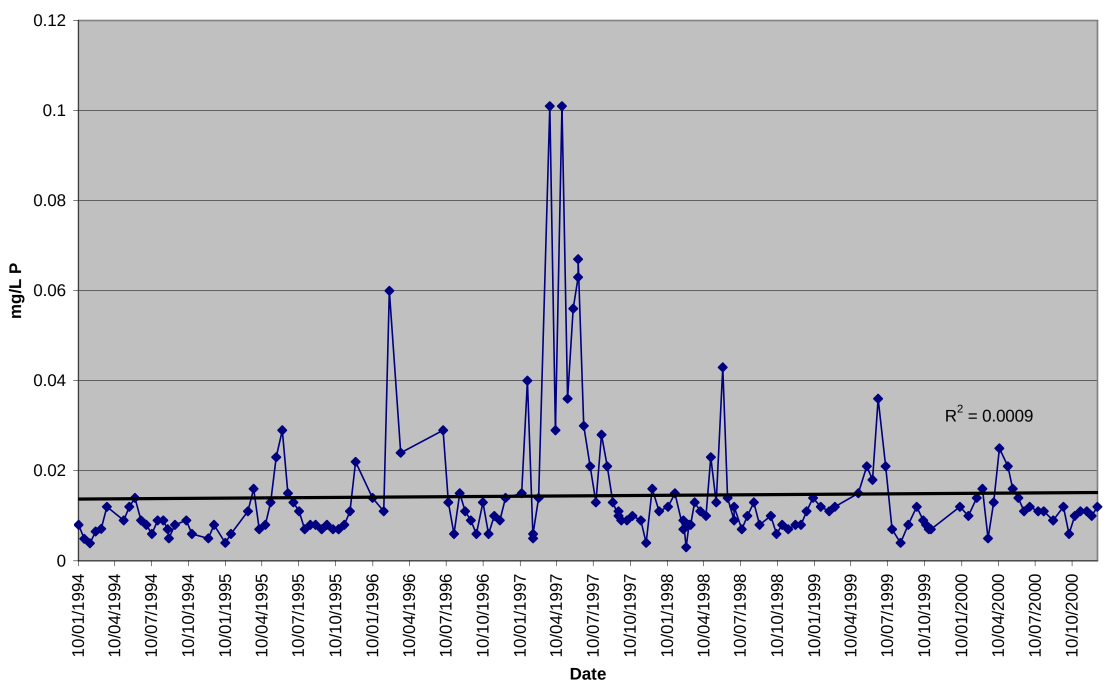

Figure 32 Kootenay River at Creston - Selenium, Total

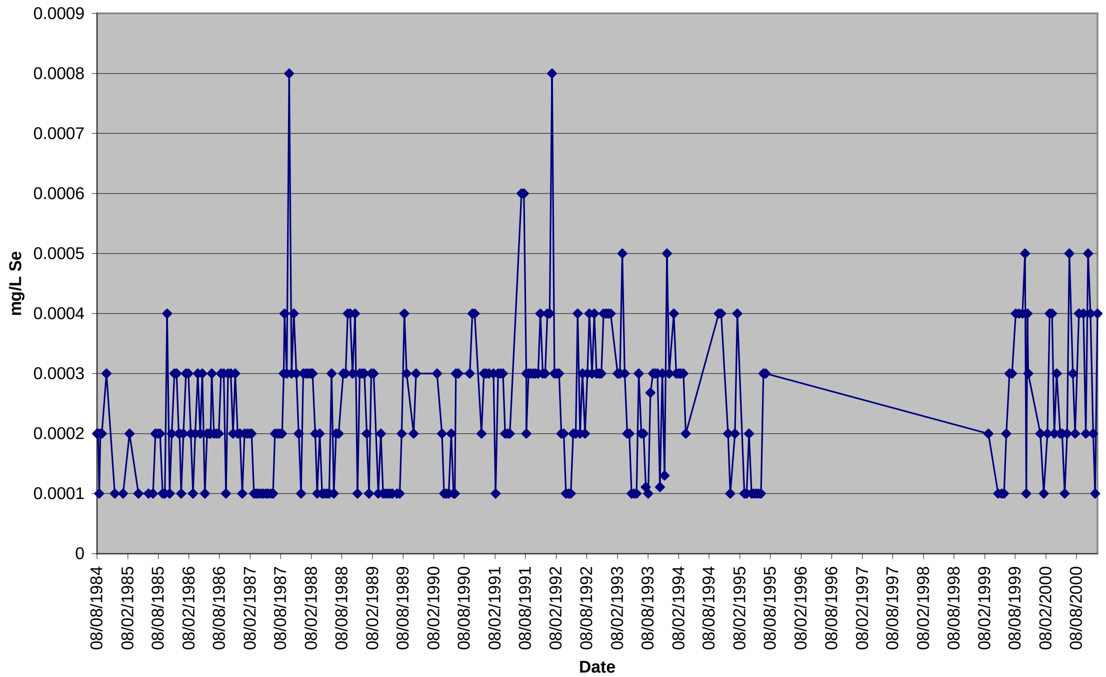

Figure 33 Kootenay River at Creston - Silver, Total

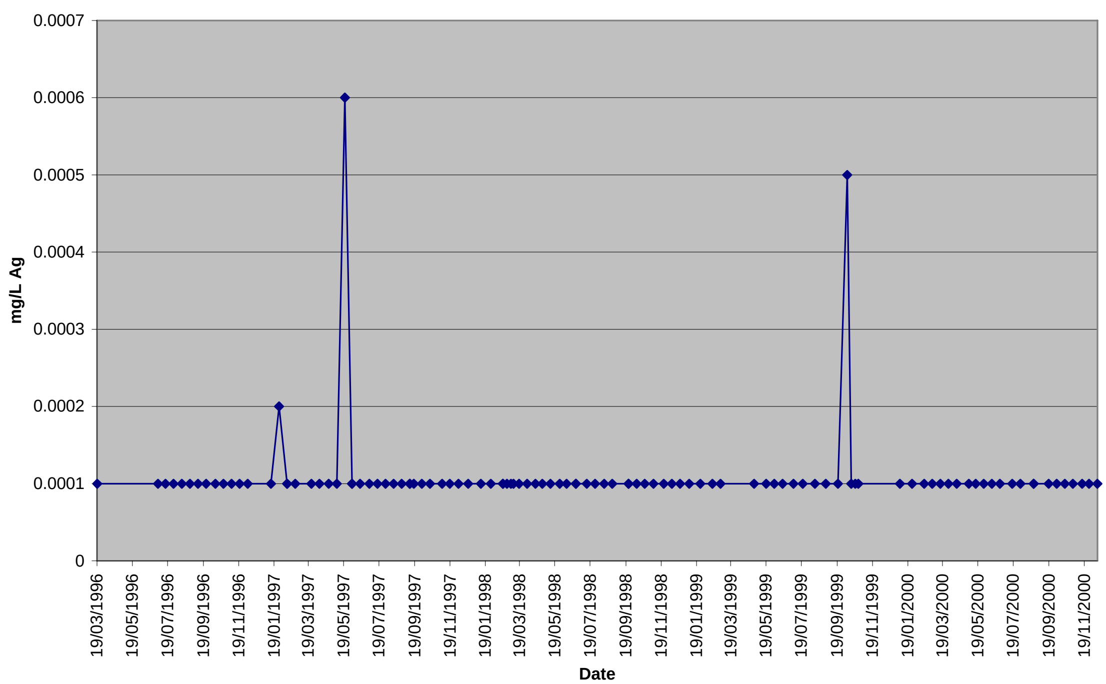

Figure 34 Kootenay River at Creston - Sodium

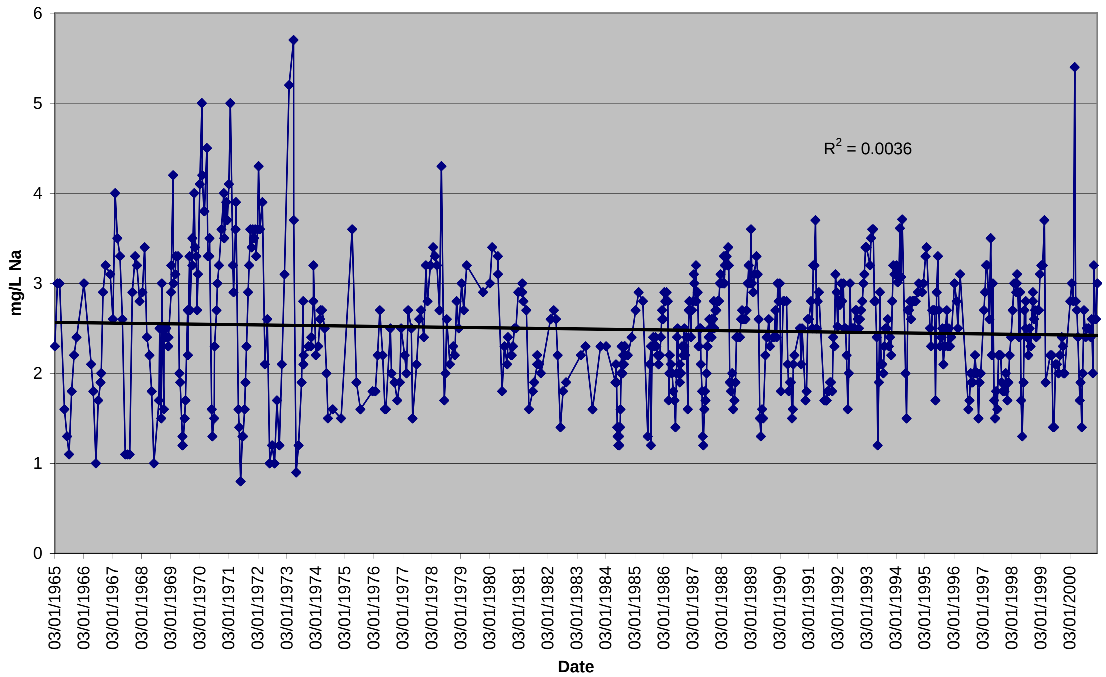

Figure 35 Kootenay River at Creston - Strontium, Total

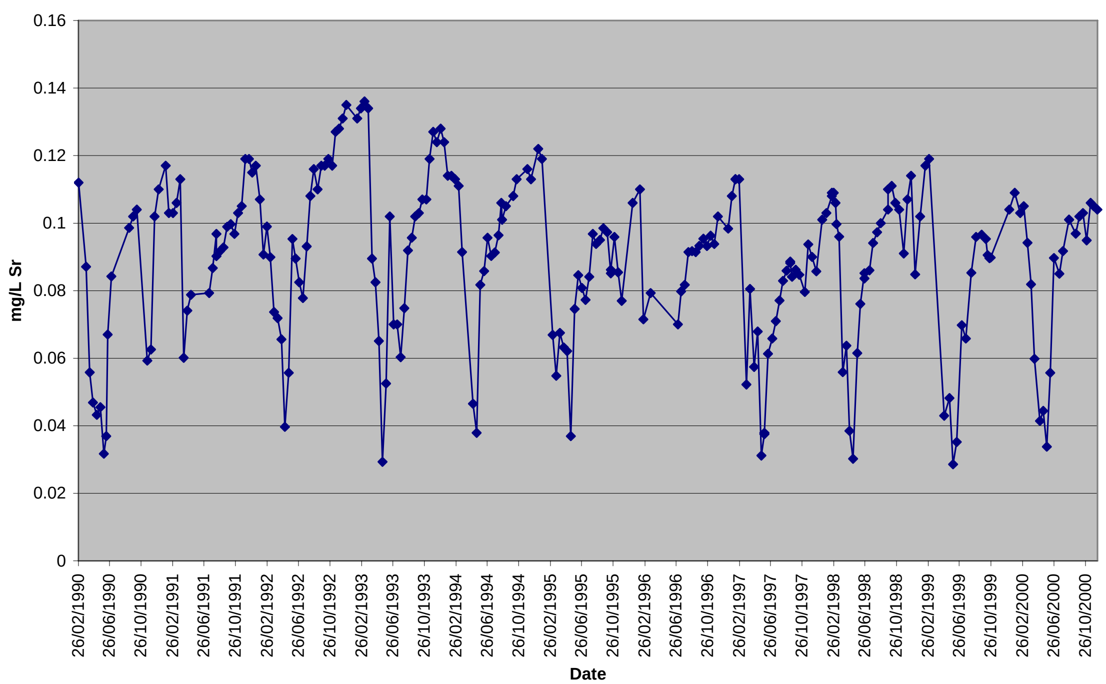

Figure 36 Kootenay River at Creston - Temperature, Water

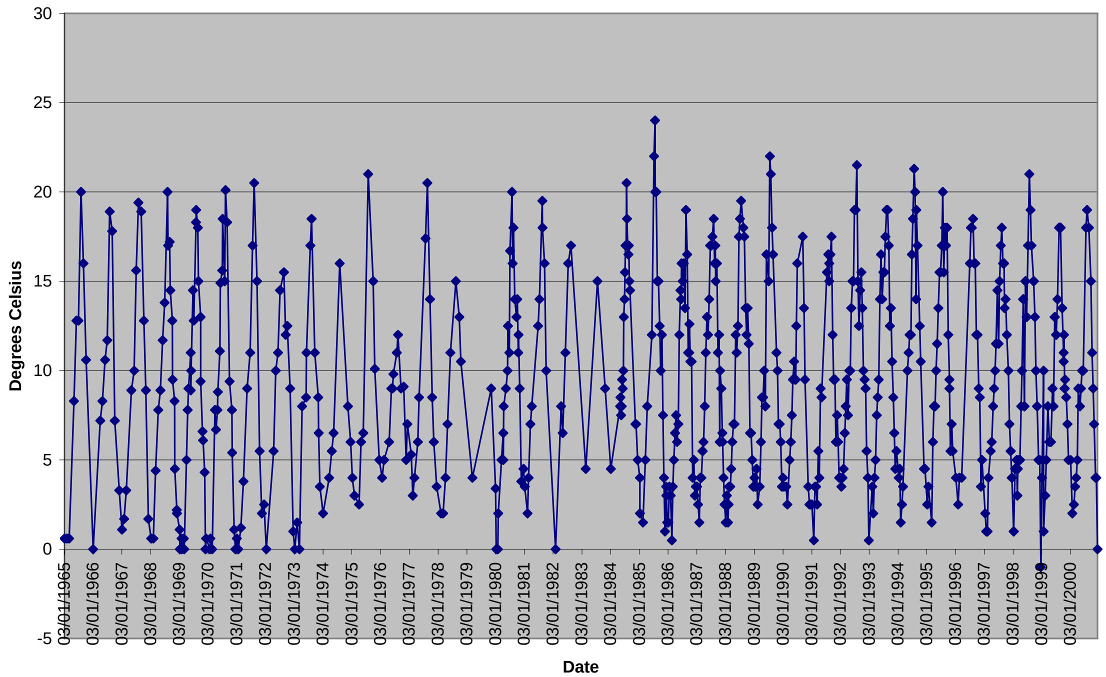

Figure 37 Kootenay River at Creston - Turbidity

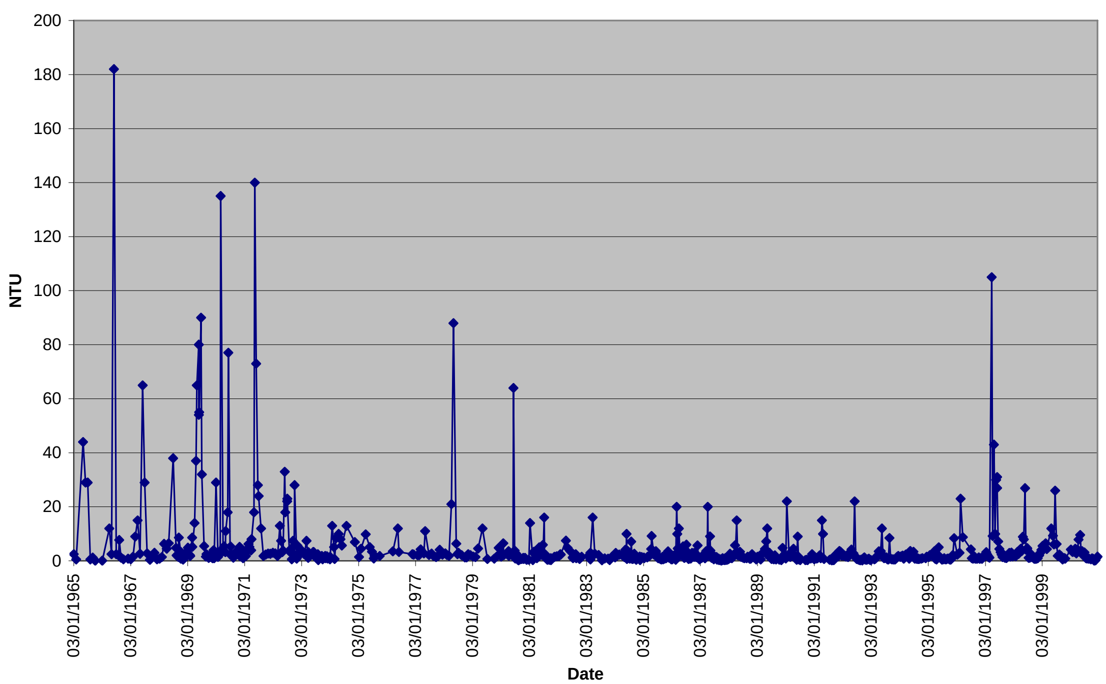

Figure 38 Kootenay River at Creston - Vanadium, Total

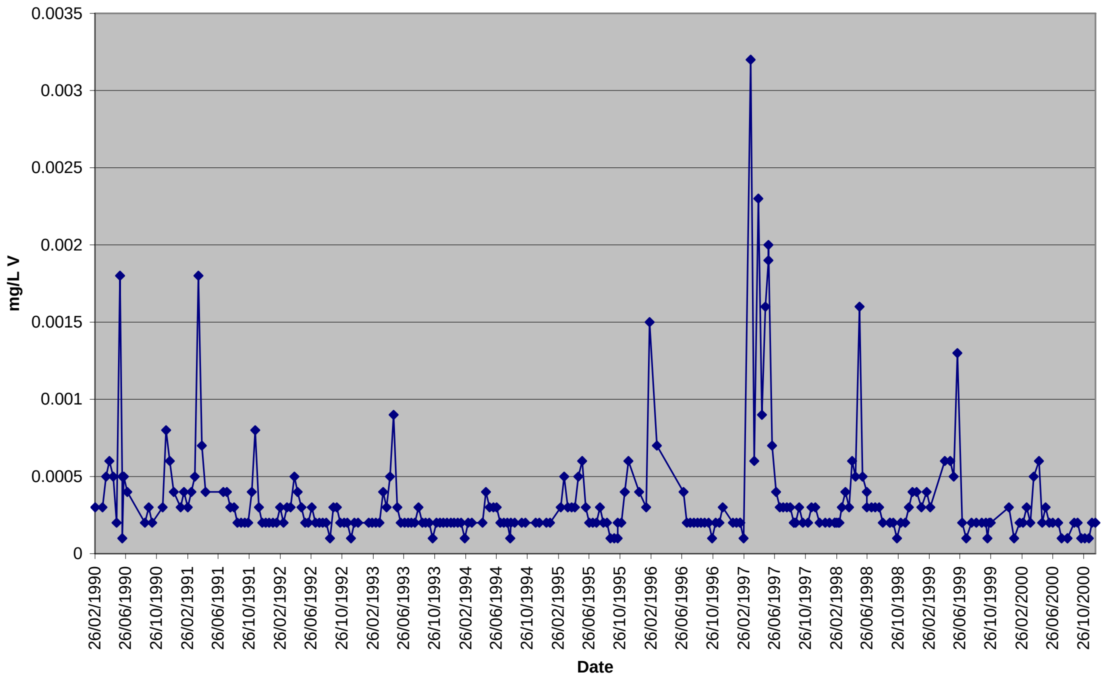

Figure 39 Kootenay River at Creston - Zinc, Total