CANADA – BRITISH COLUMBIA
WATER QUALITY MONITORING AGREEMENT

WATER QUALITY ASSESSMENT OF SIMILKAMEEN RIVER AT PRINCETON (1966 – 2000)

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Environment Canada   Environnement Canada

BRITISH COLUMBIA   Ministry of Environment

EXECUTIVE SUMMARY

There have been three long-term water quality monitoring stations on the Similkameen River: near the US Border, at Princeton, and at Hedley (Figure 1). This report focuses on the water quality at the site on the Similkameen River near Princeton. The Similkameen River water is used for irrigation, livestock watering, drinking, primary and secondary-contact recreation, and industrial use, and sustains aquatic life and wildlife.

CONCLUSIONS

- Values in excess of water quality guidelines for metals such as aluminum, arsenic, cadmium, cobalt, copper, iron, manganese, and zinc were likely a result of occasional high concentrations of particulate matter (as evidenced by high turbidity levels). This means that these metals were probably not bio-available and would be removed by the treatment needed before use as drinking water.
- The Similkameen River had a low sensitivity to acid inputs (was relatively well-buffered), as evidenced by relatively high calcium concentrations. True colour values frequently exceeded the drinking water guideline at this site
- Detection limits used to analyze metals such as cadmium and silver were too high to accurately assess these metals in comparison to the appropriate water quality guideline. In addition, laboratory problems with cadmium prior to August 2000 render data collected before this time unreliable. Different methods should be employed in the future to allow these data to be compared to water quality guidelines.
- Weak-acid dissociable cyanide concentrations exceeded the average aquatic life guideline on two occasions, and exceeded the maximum guideline on one occasion. Strong-acid dissociable cyanide concentrations were well below guideline levels.
- Fluoride concentrations exceeded the aquatic life guidelines on one occasion.
- The Similkameen River had moderate hardness, with concentrations generally within the optimum drinking water range.

- Water temperatures exceeded the aesthetic drinking water guideline most years, and occasionally exceeded the general fisheries guideline.
- Turbidity values were frequently above guideline levels for drinking water (both aesthetic and health).

MONITORING RECOMMENDATIONS:

Monitoring should continue at the Similkameen River near Princeton, which acts as a control site, and at the downstream station near the US Border. The site near the US Border is both a trans-border station and is downstream of the largest number of industrial waste discharges to the Similkameen River.

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INTRODUCTION

The headwaters of the Similkameen River are in the Cascade Mountains. The river flows north-easterly through Manning Park to Princeton, and then south-easterly until it crosses the International Boundary just south from Cawston (Figure 1). The river enters the Okanagan River downstream from Osoyoos Lake in Washington State. There are four major population centres (Princeton, Hedley, Keremeos and Cawston) within the watershed. The area of the Canadian portion of the drainage basin is about 9,190 km^2 (Environment Canada, 1991).

The main potential human influences on water quality include: treated municipal sewage from the Princeton and Keremeos; a copper mine on Wolfe Creek, which drains to the Similkameen River between Princeton and Hedley; a gold mine on Cahill Creek, which drains to the Similkameen River downstream from Hedley; old mines in the Hedley area, agriculture (primarily cattle production), and forestry.

There are three long-term water quality monitoring sites on the Similkameen River; at Princeton, above Hedley, and near the US Border. This report focuses on the water quality at Princeton.

Similkameen River water is used for irrigation, drinking, livestock watering, primary and secondary-contact recreation, and industrial use, and sustains aquatic life and wildlife.
This report assesses results from bi-weekly samples collected by Environment Canada from 1979 to 2000 at the Similkameen River at Princeton (Water Quality monitoring site: federal site number BC08NL0001, flow station BC08NL007, provincial site number 0500629). Flow is plotted in Figure 2, and water quality data are plotted in Figures 3 to 39.

QUALITY ASSURANCE

The water quality graphs were inspected and erroneous values were removed. There were erroneous results for water temperature and total dissolved nitrogen. Chromium, copper, lead, zinc, and cyanide had high values between the start of 1986 and end of 1990. These high values likely reflect contamination that was caused by the breakdown of preservative vial liners and lids. The 1986-90 data for these variables was not used in this assessment. Environment Canada reported low pH values between 1986 and 1988 due to laboratory problems; provincial data were used to supplement

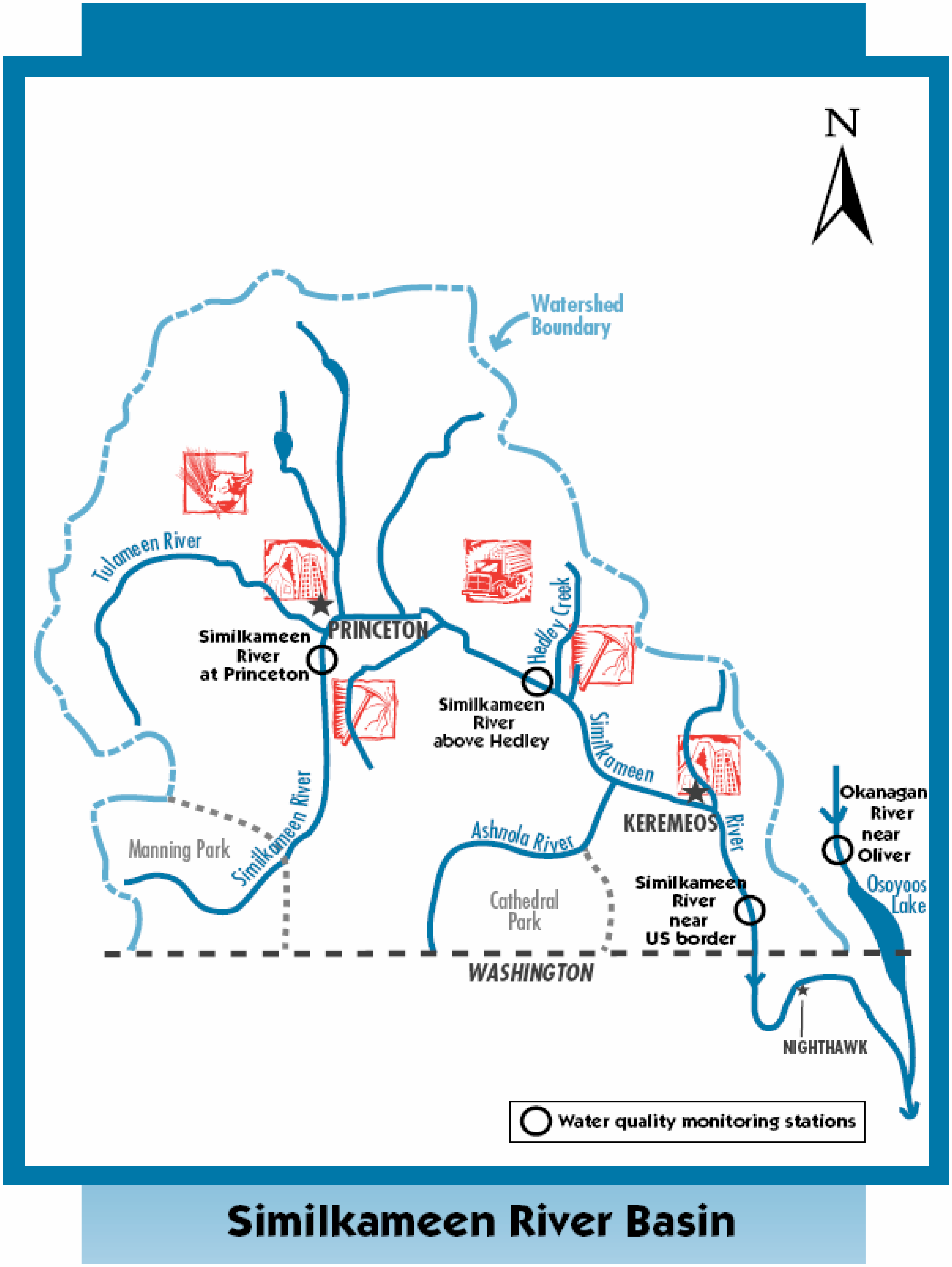

Figure 1. Map of the Similkameen River Basin

the data in this time period. Mercury data were not included in the report because all detectable values are believed to result from contamination during the collection and measurement process (Pommen, 1994). Quality assurance issues are expanded upon in the next section.

STATE OF THE WATER QUALITY

The state of the water quality was judged by comparing values to Ministry of Environment, Lands and Parks' Approved and Working Guidelines for Water Quality (Nagpal *et al.*, 1997) or to site-specific water quality objectives. The following water quality objectives for the Similkameen River between Princeton and the International Boundary, outlined by Swain (1990), were used in this report:

- fecal coliforms should not exceed 10 CFU/100 mL in 90% of at least five samples taken weekly in a period of 30 days;
- maximum turbidity should not exceed an increase of 1 NTU (upstream < 5 NTU), 5 NTU (upstream < 50 NTU), or 10% (upstream > 50 NTU);
- weak -acid dissociable cyanide (CN^-) should not exceed a maximum of 0.01 mg/L and an average of 0.005 mg/L;
- maximum strong-acid dissociable cyanide plus thiocyanate (CN^-) should not exceed 0.2 mg/L;
- total arsenic should not exceed a maximum of 0.05 mg/L, or no significant increase from upstream if upstream > 0.05 mg/L (Note: since this objective was set in 1990, the drinking water guideline has been reduced to 0.025 mg/L and the aquatic life guideline has been reduced to 0.005 mg/L, indicating that the objective may be too high);
- average total ammonia-N should not exceed a level that would be detrimental to aquatic life. The screening level chosen for this report (0.28 mg/L) is based on a "worst-case scenario" by using the highest pH (8.4) and temperature (22 °C) values reported at this site;
- Dissolved oxygen should be greater than the minimum of:

    11.0 mg/L (April to June),

    8 mg/L (July to March);

- pH values should be within the range of 6.5-8.5 or within a 0.2 unit change if background is outside this range;
- dissolved aluminum should not exceed a maximum of 0.1 mg/L and an average of 0.05 mg/L or no significant increase over upstream if upstream values are greater;
- total chromium should not exceed an average of 0.002 mg/L and a maximum of 0.02 mg/L, or no significant increase from upstream if upstream values are greater than above;
- total copper should not exceed an average of 0.04 (hardness in mg/L) micrograms/L or 2 micrograms /L if hardness is ≤ 50 mg/L, and a maximum of 0.094 (hardness in mg/L) +2 micrograms /L, or no significant increase from upstream if upstream values are greater than above. For the hardness range of 30 to 120 mg/L, this gives an average of 0.002 - 0.0048 mg/L and a maximum of 0.0048 - 0.0133 mg/L;
- total iron should not exceed 0.3 mg/L or no significant increase from upstream if upstream values are greater than above;
- total lead should not exceed 3.31 + exp. [1.273 ln (average hardness in mg/L) - 4.705] micrograms /L average and a maximum of exp. [1.273 ln (hardness in mg/L) - 1.460] micrograms /L, or no significant increase from upstream if upstream values are greater than above. For the hardness range of 30 to 120, this gives an average of 0.004 - 0.0073 mg/L and a maximum of 0.014 0 0.103 mg/L;
- total manganese should not exceed 0.05 mg/L or no significant increase from upstream if upstream is >0.05 mg/L;
- total molybdenum should not exceed a maximum of 0.05 mg/L and an average of 0.01 mg/L in samples collected between May and September;
- total nickel should not exceed a maximum of 0.025 mg/L when hardness ≤ 65 mg/L, 0.065 mg/L when hardness >65 mg/L, or no significant increase over background; and
- total zinc should not exceed an average of 0.01 mg/L and a maximum of 0.03 mg/L, or no significant increase from upstream if upstream values are greater than above.

Variables plotted but not mentioned in the discussion below showed no clear trends over time and met all guidelines. These variables were: total barium, total beryllium, total boron, dissolved organic carbon, specific conductivity, total lithium, magnesium, total molybdenum, total nickel, nitrogen, total dissolved phosphorus, total phosphorus, potassium, total selenium, total silver, total thallium, total uranium, and total vanadium.

Flow (Figure 2) during snowmelt freshet (April-July) was highest in 1986 and 1991, and lowest in 1992 and 1994. A set of secondary peaks due to rains occurred in the fall of most years, especially 1989, 1990 and 1995. Flow should continue to be measured due to its importance in interpreting water quality indicators and calculating loadings.

Total alkalinity and **calcium** (Figure 9) concentrations are both relatively high in the Similkameen River, indicating a low sensitivity to acid inputs (the river was well buffered). Concentrations of both dissolved and extractable calcium ranged from 7 mg/L to 36 mg/L for 296 samples collected between 1966 and 2000, generally well above the 8 mg/L threshold for waters sensitive to acid inputs. Both alkalinity and calcium concentrations varied seasonally, with dilution from high spring freshet flows resulting in lower concentrations between April and July and higher concentrations occurring in the fall and winter months, during low flows.

Total aluminum (Figure 3) values met the guideline for wildlife, livestock and irrigation (5 mg/L) in all of the 290 samples collected between 1990 and 2000. While dissolved aluminum concentrations were not measured, 180 samples (62%) had total aluminum concentrations higher than the 0.05 mg/L **dissolved** aluminum aquatic life guideline, and 105 samples (36%) had total aluminum concentrations exceeding the 0.2 mg/L **dissolved** aluminum guideline for drinking water. Dissolved aluminum should be measured in the future to allow these guidelines to be evaluated. There does not appear to be any trend in total aluminum concentrations.

The maximum water quality objective proposed for **total arsenic** (Figure 4) concentrations in the Similkameen River is 0.05 mg/L. However, modifications to the arsenic guidelines in 2001 set threshold levels at 0.005 mg/L for aquatic life, 0.025 mg/L for drinking water, livestock watering and wildlife, and 0.1 mg/L for irrigation. Total arsenic concentrations ranged from a minimum of 0.0001 mg/L to a maximum of 0.006 mg/L for 346 values measured between 1973 and 2000. The maximum value occurred in May of 1980, during elevated spring flows, and there in an excellent correlation between turbidity and maximum arsenic values. This indicates that the majority of arsenic is associated with particulate matter when it is present in higher concentrations. The maximum value represented the sole exceedance of the aquatic life guideline, and the drinking water and irrigation guidelines were not exceeded by any samples. There does not appear to be any trend in arsenic concentrations at this site.

Total cadmium (Figure 8) values may have been high between 1986 and 1990 due to preservative vial contamination. Since that time, 5% of the total cadmium values (16 of 300 samples collected between 1991 and 2000) were greater than the minimum detectable limit (0.0001 mg/L) and therefore exceeded the aquatic life guideline of 0.00001 mg/L. These values occurred at times of high turbidity, indicating that the cadmium was in particulate form and was probably not biologically available. Extractable cadmium concentrations measured between 1997 and 2000 support this theory, with none of the 104 samples exceeding the minimum detectable limit. The minimum detectable limits were between 10 and 100 times greater than the guideline, making it impossible to interpret values reported at or below the detectable limits with regards to the aquatic life guideline. To evaluate the attainment of guidelines for aquatic life accurately, the minimum detectable limit should be at least one-tenth of the guideline value.

Total chromium (Figure 11) concentrations measured prior to mid-2000 were suspect due to poor correlations between total and extractable results, resulting from instrument interference (Ryan, 2002 pers. comm.). For this reason, chromium concentrations will not be discussed in this report. As the problem was rectified in about August 2000, it is hoped that future data will give a more accurate picture of chromium concentrations in the Similkameen River.

Total cobalt (Figure 12)was measured 288 times between 1990 and 2000, with values ranging from below detectable limits (<0.0001 mg/L) to a maximum of 0.0037 mg/L. 13 values (5% of all samples collected) exceeded the guideline for protection of aquatic life (0.0009 mg/L). The peaks in cobalt occurred at the same time as peaks in turbidity, indicating that the cobalt likely was in particulate form and may not have been biologically available. None of the values exceeded the irrigation guideline of 0.05 mg/L. No trend in cobalt concentrations was apparent.

Fecal coliform (Figure 13)values were collected sporadically in 1987, 1989, 1993, and 2000. While sampling frequency was insufficient to determine guideline compliance (a minimum of five samples in a 30-day period are required), 12% of values (5 of 43 samples collected) exceeded the guideline of 10 CFU/100 mL. Values ranged from below detectable limits (0 CFU/100 mL) to a maximum of 20 CFU/100 mL. The 90th percentile for the 43 values was 10.4 CFU/100 mL, only slightly higher than the drinking water guideline for water that undergoes disinfection only prior to consumption (10 CFU/100 mL). It appears that fecal coliform concentrations may not meet the drinking water guideline at all times. More frequent monitoring (at least 5 to 10 samples in 30 days) is required to evaluate attainment of the objective.

True colour (Figure 14) was measured 101 times between 1972 and 2000 (almost all sampling occurring between 1997 and 2000). 13% of values (13 samples) exceeded the aesthetic drinking water guideline of 15 TCU, primarily during spring freshet. The maximum recorded colour value was 50 TCU (on April 4, 2000), and the mean colour was 9.5 TCU.

Total copper (Figure 16) values near the US Border were very high and are considered unreliable between 1986 and 1990 due to contamination from preservative vial lids. Aquatic life guidelines for total copper are hardness-dependent: at hardness levels typical for the Similkameen River upstream from the U/S Border, these would typically be a maximum of 0.007 mg/L, and a 30-day average of about 0.003 mg/L. By calculating maximum and average guidelines for each of the 268 samples collected between 1991 and 2000 based on their concurrent hardness concentrations, it was determined that 27 values (10% of all samples) exceeded their appropriate maximum guideline, while 78 samples (29%) exceeded the 30-day average guideline (Figure 12). This comparison is used only as an indication of potential exceedances, because the calculation of a 30-day average requires a minimum of 5 samples collected within a 30-day period (a criterion not met in this instance). There was a good correlation between elevated copper and elevated turbidity levels (Figure 12), suggesting that copper was often associated with particulate matter and therefore not likely biologically available. However, extractable copper concentrations measured between 1997 and 2000 also occasionally exceeded both the maximum and average guidelines, suggesting that aquatic life may be impaired by this metal. Again, all exceedances occurred during high water flows in the spring and early summer. There was no apparent change over time.

Total cyanide and **weak-acid dissociable cyanide** (Figure 18) values were high and unreliable between 1987 and 1990 probably due to contamination from preservative vial lids. Between 1991 and 2000, only two of 265 samples collected at this site (0.0097 mg/L on January 8, 1991 and 0.0124 on March 4, 1992) exceeded the 30-day average objective (0.005 mg/L) for aquatic life, while the maximum objective (0.01 mg/L) was exceeded only by the maximum recorded value. 183 of the 265 samples (69%) collected between 1992 and 2000 had concentrations below the detectable limits (< 0.0005 mg/L). **Cyanide (SAD)** (Figure 17) **+ thiocyanate** concentrations were well below guideline levels (0.2 mg/L).

Dissolved fluoride (Figure 19) concentrations ranged from 0.01 mg/L to 0.8 mg/L for 261 samples collected between 1978 and 2000. One value (0.8 mg/L, on October 15, 1991) exceeded the 0.3 mg/L aquatic life guideline for dissolved fluoride. This value was more than 10 times the concentration found in samples collected two weeks before and two weeks after the maximum value was found. The reasons for this elevated level are not clear. There is no apparent trend in fluoride concentrations.

Hardness (Figure 20) values ranged from 20 mg/L to a maximum of 121 mg/L for 447 samples collected between 1966 and 1999. The average for these 447 values was 61 mg/L. Hardness values were often within the optimum drinking water range (60 to 80 mg/L). Hardness can affect the toxicity of a number of metals, and should therefore continue to be monitored in the future. It appears that hardness concentrations may be increasing at this site.

Total iron (Figure 21) concentrations ranged from 0.008 mg/L to a maximum of 6.58 mg/L for 375 samples collected between 1973 and 2000 (Figure 20). 22% of values (84 of the 375 samples) exceeded the aesthetic drinking water guideline of 0.3 mg/L, and <1% (2 samples) exceeded the irrigation guideline of 5 mg/L. There was a strong correlation between total iron concentrations and turbidity levels, suggesting that at times when iron concentrations were high, it was likely primarily in the form of particulate matter and therefore not biologically available. There was no apparent trend in iron concentrations.

Total lead (Figure 22) values may have been high due to suspected preservative vial contamination between 1986 and 1991. Lead toxicity is hardness dependent, and therefore guideline levels are based on water hardness. At an average hardness of 61 mg/L, the maximum aquatic life guideline is 0.044 mg/L, and the average 30-day guideline is 0.005 mg/L. None of the 373 total lead concentrations exceeded either the average or the maximum guideline. There was no apparent trend in total lead concentrations.

Total manganese (Figure 25) concentrations ranged from 0.0004 mg/L to 0.156 mg/L for 360 samples collected between 1984 and 2000 (Figure 24). The most stringent water quality guidelines for manganese apply to drinking water (a maximum of 0.05 mg/L) and aquatic life (a maximum of 0.7 mg/L). The drinking water guideline was exceeded 9 times (3% of samples), while the aquatic life guideline was never exceeded. The relationship between total manganese and turbidity (Figure 25) suggests that, during periods of high manganese concentrations, the majority was associated with particulate matter and therefore not likely bio-available.

pH (Figure 29) was measured 526 times between 1966 and 2000, and values were almost invariably within the aesthetic drinking water range (6.5 to 8.5 pH units). However, there were two values (8.6 and 8.65 pH units) that exceeded this range (Figure 29). There was no apparent trend in pH at this site.

Water temperature (Figure 34) was measured a total of 464 times between 1966 and 2000, with a maximum recorded temperature of 20 degrees Celsius. The aesthetic drinking water guideline was exceeded most summers, and 22 values (5% of the 169 samples collected between June and September) exceeded this guideline. Only one value (<1% of summer values) exceeded the general fisheries guideline of 19 degrees Celsius. Summer temperatures do not appear to be changing over time.

Turbidity (Figure 36) values ranged from 0.05 NTU to a maximum of 79 NTU for 492 samples collected between 1966 and 2000. 245 of these samples (50%) exceeded the health drinking water guideline of 1 NTU, while 83 values (17%) exceeded the aesthetic drinking water guideline of 5 NTU. Trends in turbidity values were seasonal in nature, with the majority of the highest values occurring during spring freshet. Other higher values, especially in the fall, were likely a result of rain events in the watershed, washing debris and silt into the river. These regular exceedances of the guidelines indicate that treatment (e.g. filtration) is necessary to remove suspended sediments prior to consumption of this water.

Total zinc (Figure 39) values were high due to suspected preservative vial contamination between 1986 and 1990. Freshwater aquatic life guidelines are hardness dependent: at hardness values typical for the Similkameen River, the average guideline is 0.033 mg/L, while the maximum guideline is about 0.008 mg/L. Since 1990, six values (2% of the 268 samples) exceeded the average objective, while the maximum objective was not exceeded by any samples. There was good correlation between elevated zinc levels and elevated turbidity, suggesting that when zinc is present in higher concentrations, it is generally associated with particulate matter and therefore less toxic. However, one extractable zinc concentration also exceeded the average guideline at this site, so it is possible that zinc could occasionally be a problem for aquatic life. There does not appear to be any trend in zinc concentrations over time at this site.

REFERENCES

Ministry of Environment, Lands and Parks. 2001a. British Columbia Approved Water Quality Guidelines (Criteria). Water Quality Branch, Environmental Protection Department, Ministry of Environment, Lands and Parks, Victoria, B.C.

Ministry of Environment, Lands and Parks. 2001b. A Compendium of Working Water Quality Guidelines for British Columbia. Water Quality Branch, Environmental Protection Department, Ministry of Environment, Lands and Parks, Victoria, B.C.

Swain, L.G. 1990. Ambient Water Quality Objectives for the Similkameen River, Okanagan Area – First Update. Resource Quality Section, Water Management Branch, Ministry of Environment.

Figure 2. Hydrometric Record for Similkameen River at Princeton (WSC Site BC08NL007), 1984 - 2000

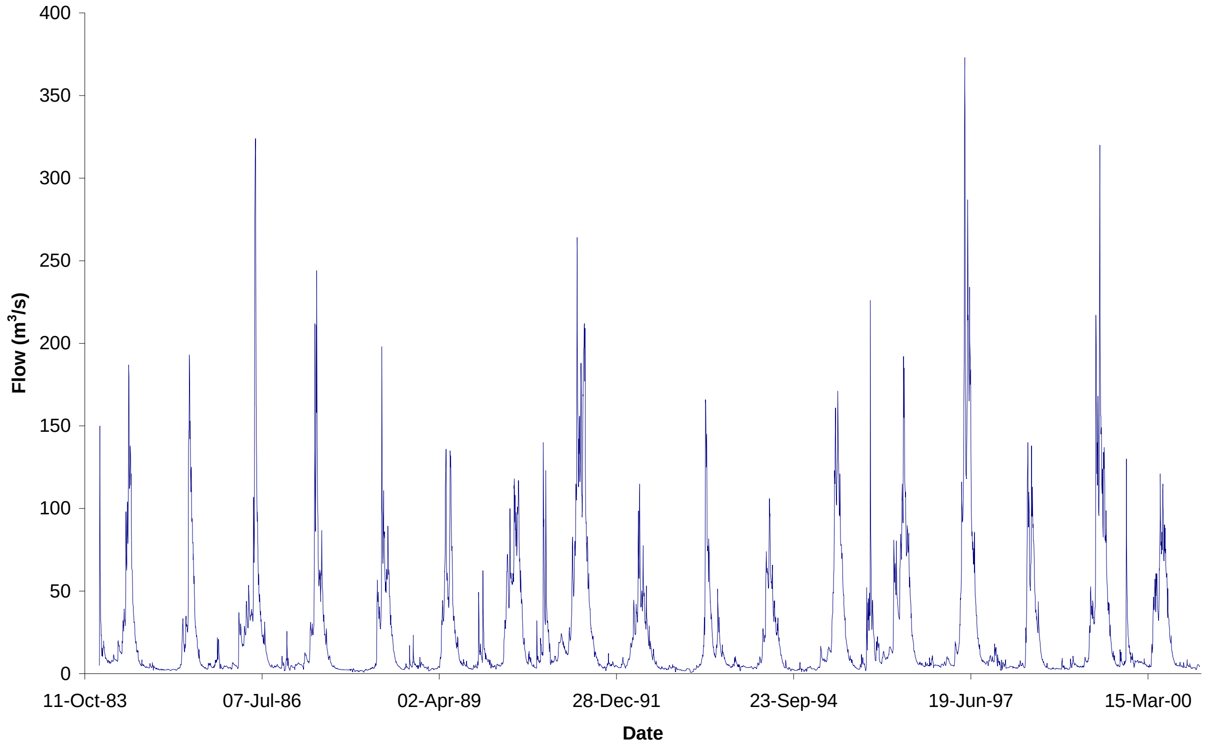

Figure 3. Similkameen River at Princeton - Aluminum

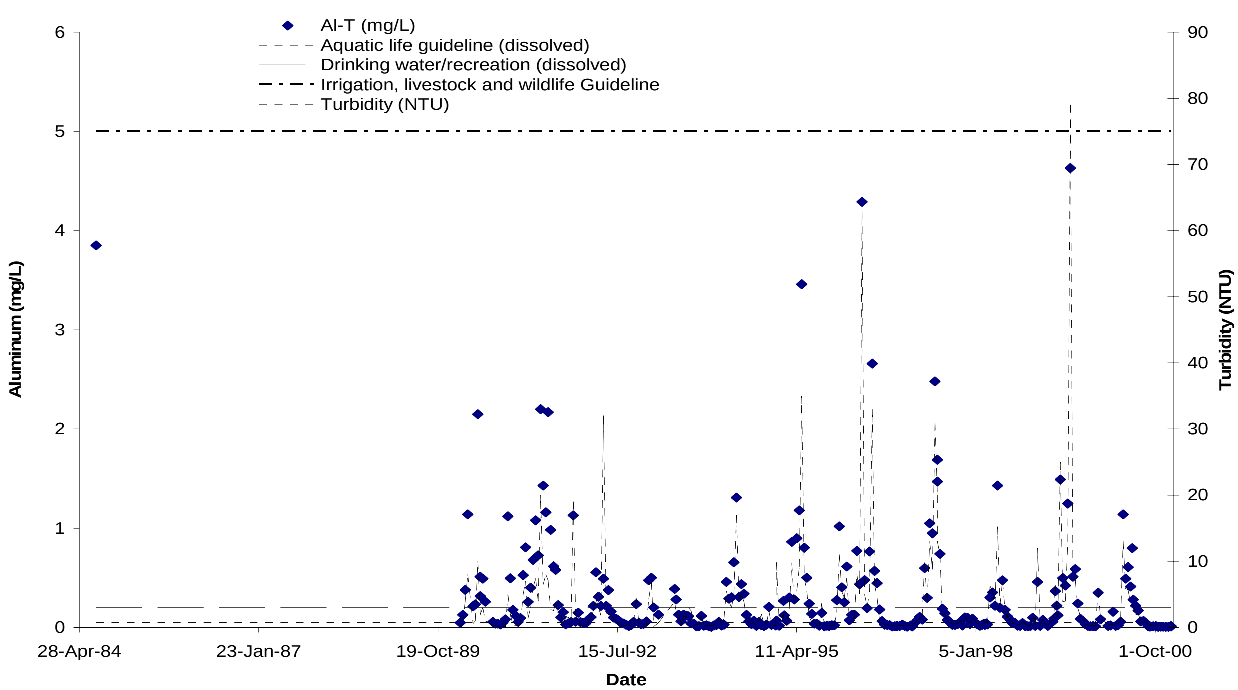

Figure 4. Similkameen River at Princeton - Arsenic

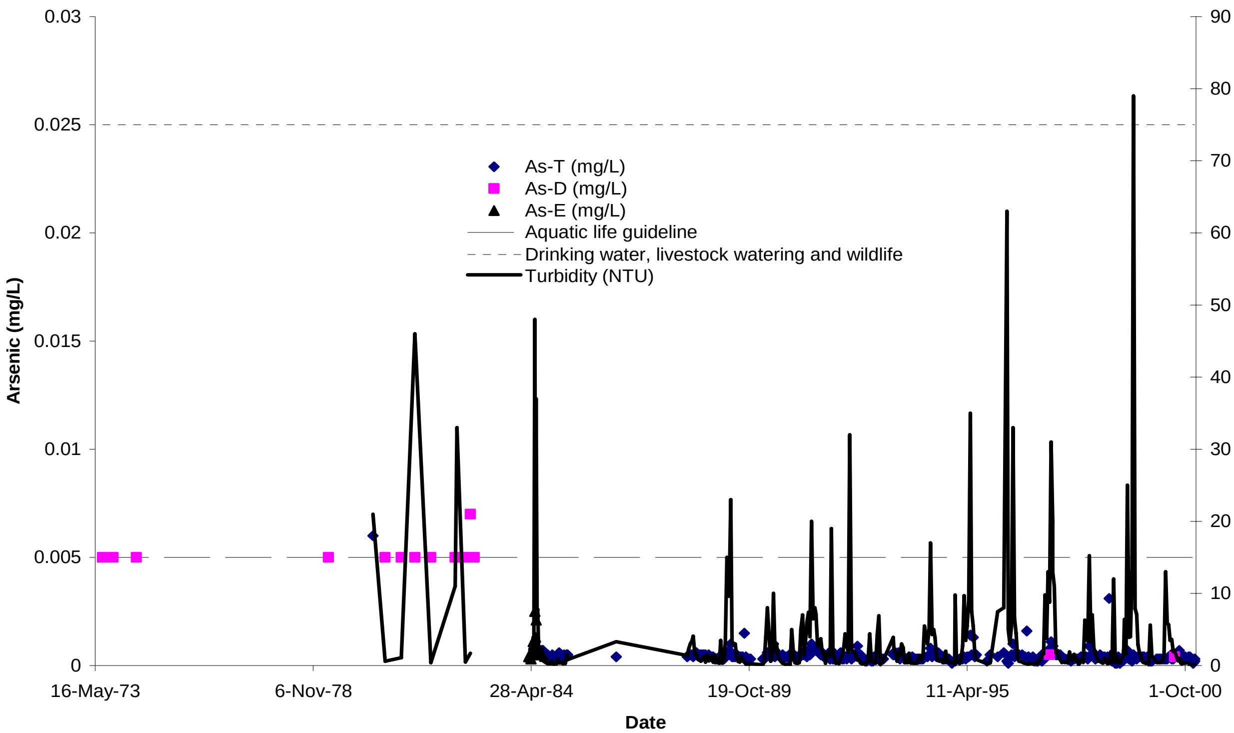

Figure 5. Similkameen River at Princeton - Barium

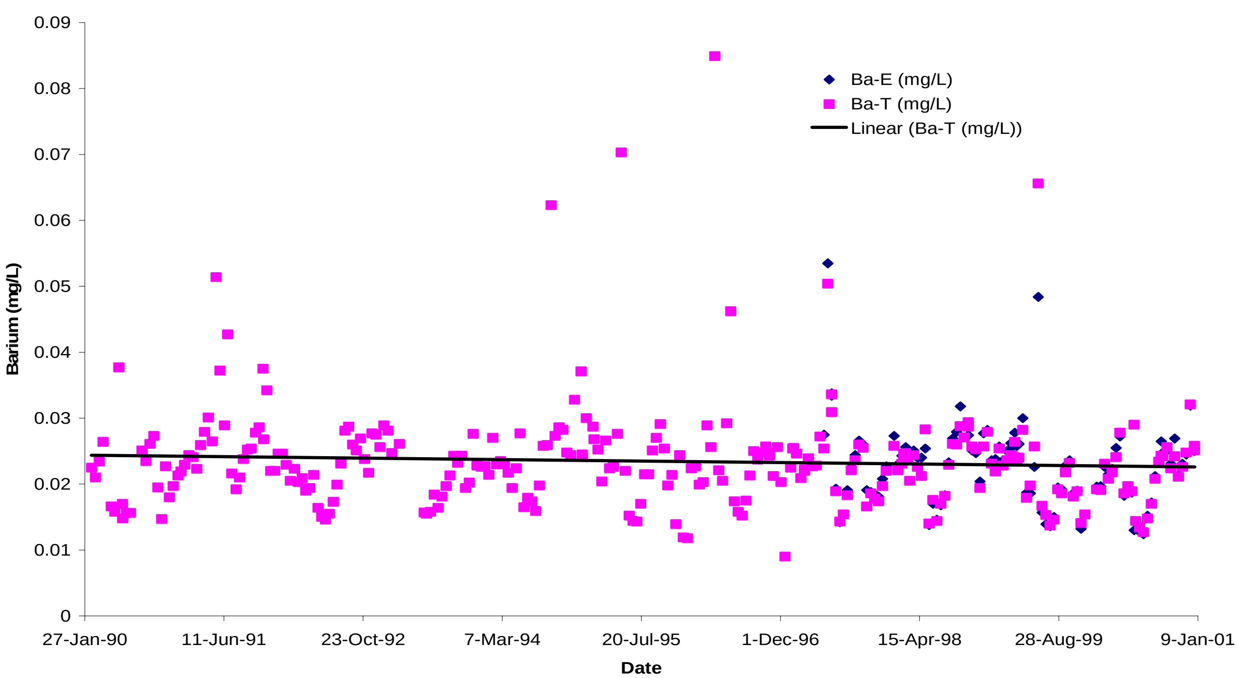

Figure 6. Similkameen River at Princeton - Beryllium

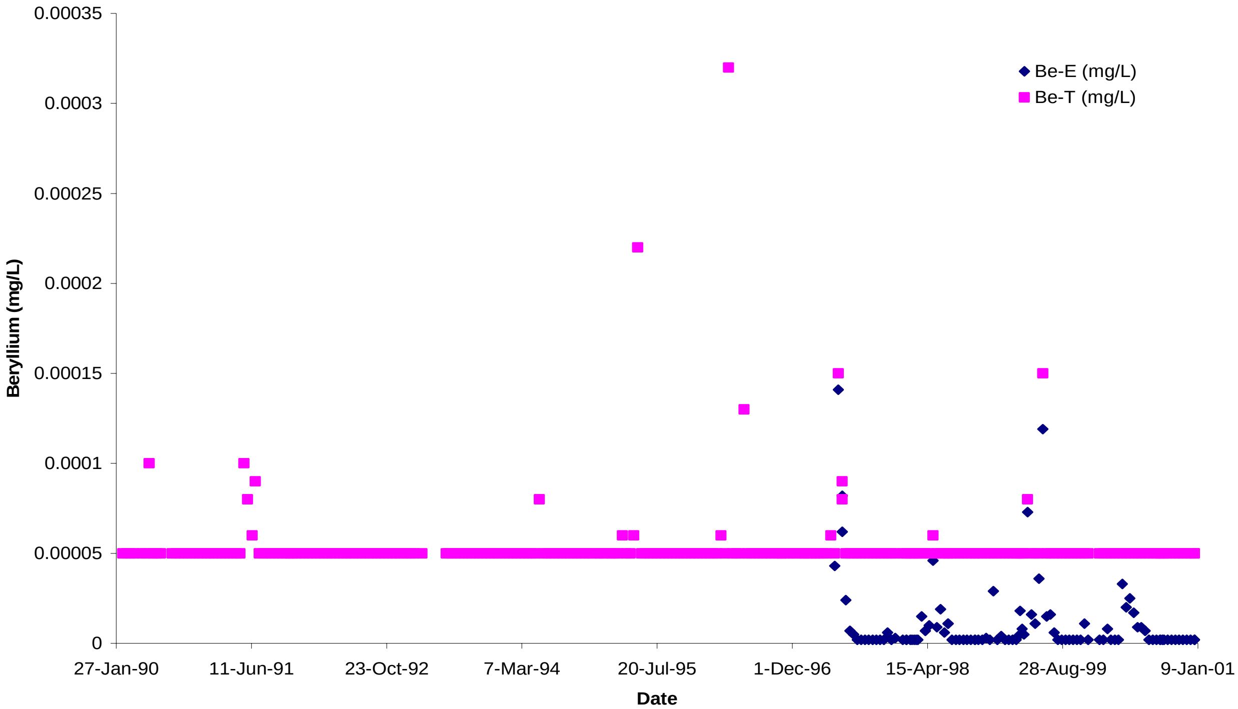

Figure 7. Similkameen River at Princeton - Boron

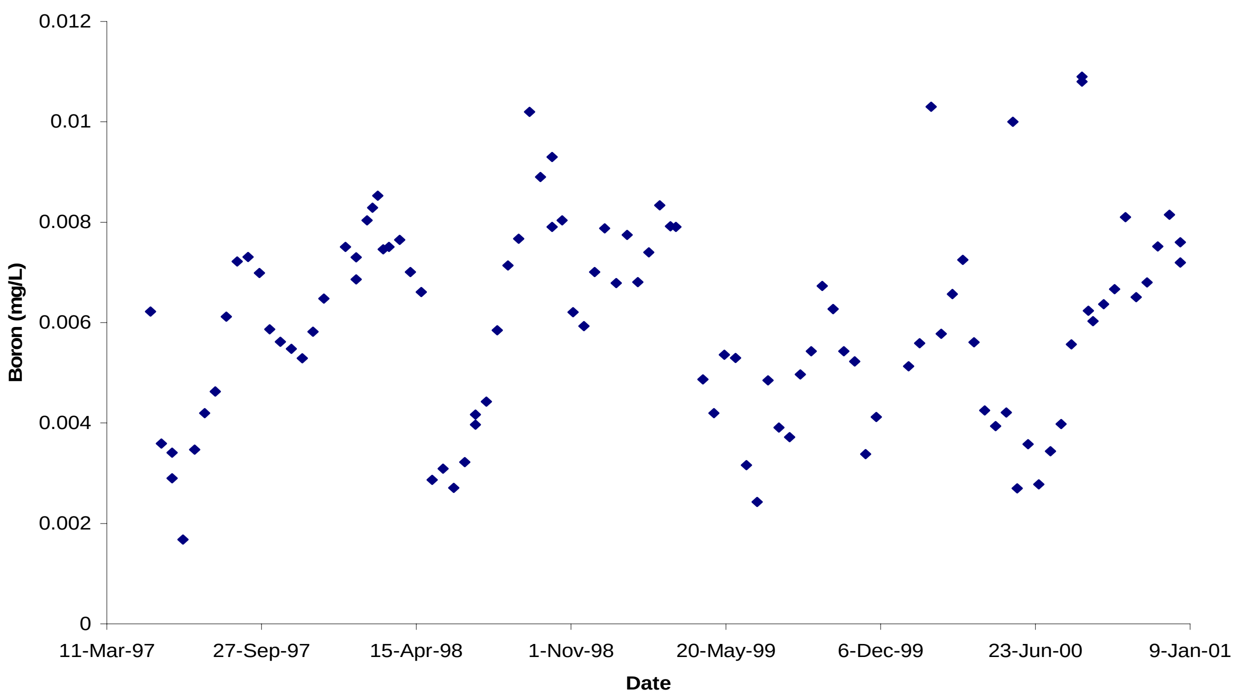

Figure 8. Similkameen River at Princeton - Cadmium

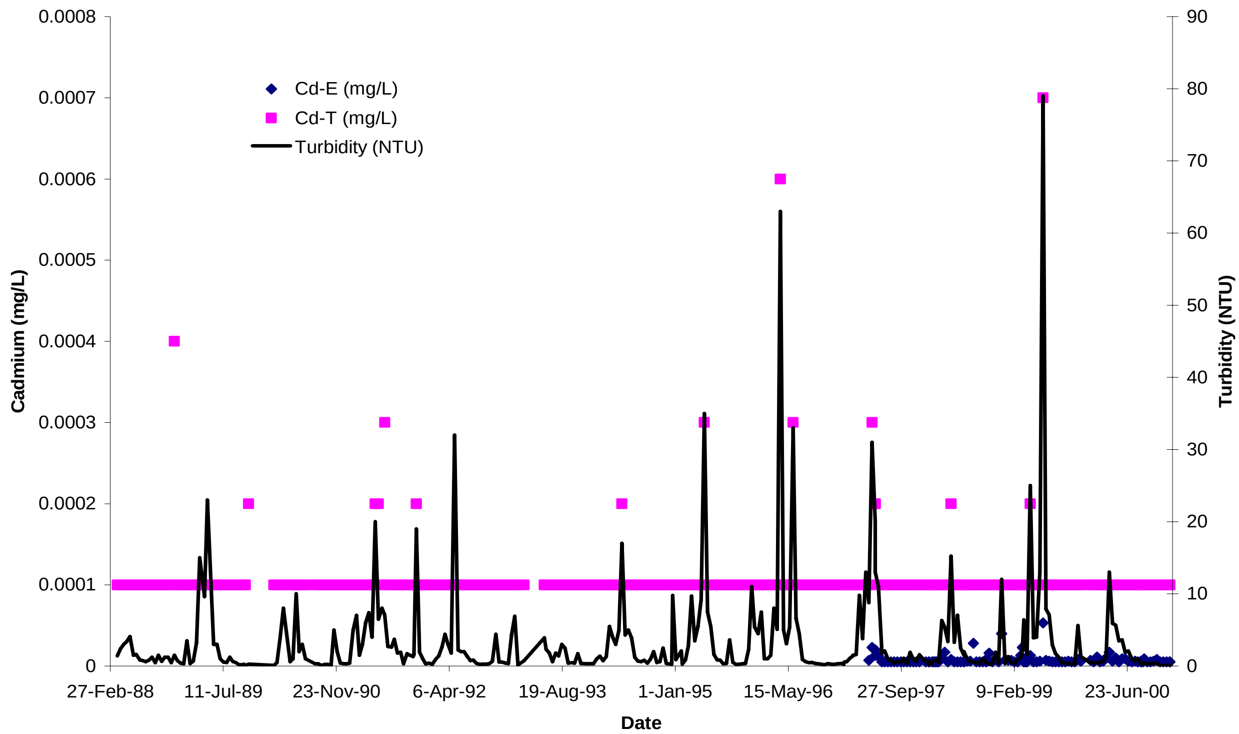

Figure 9. Similkameen River at Princeton - Calcium

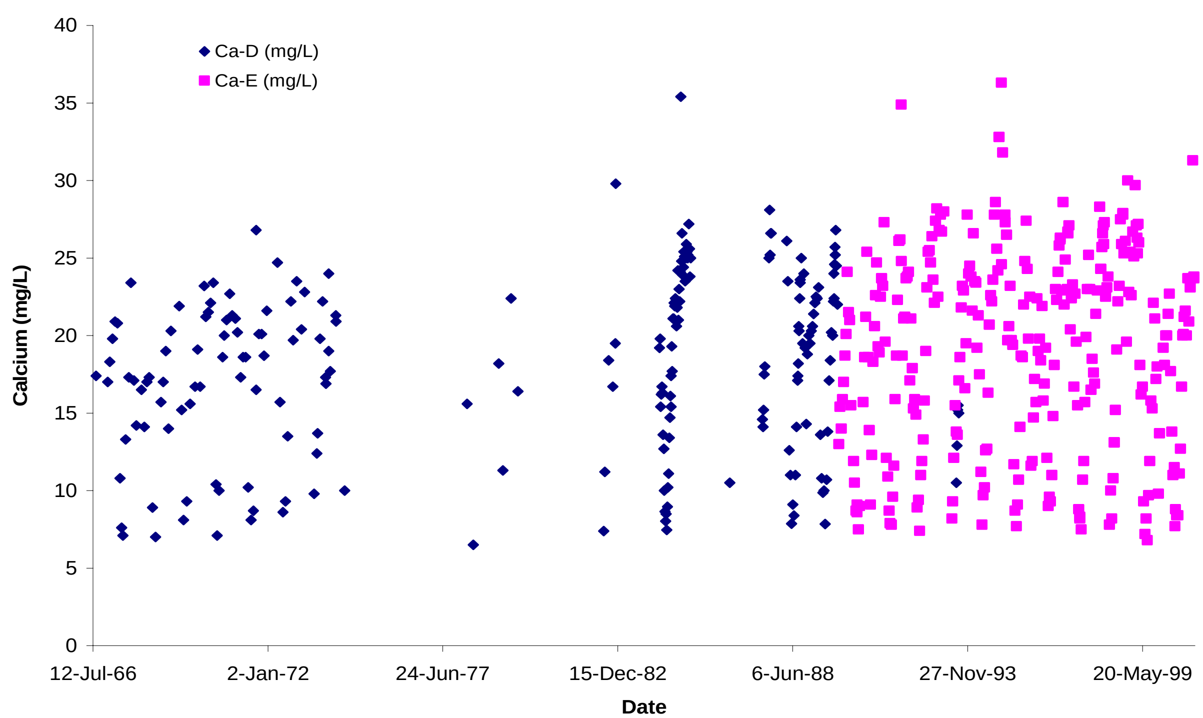

Figure 10. Similkameen River at Princeton - Carbon, Dissolved Organic

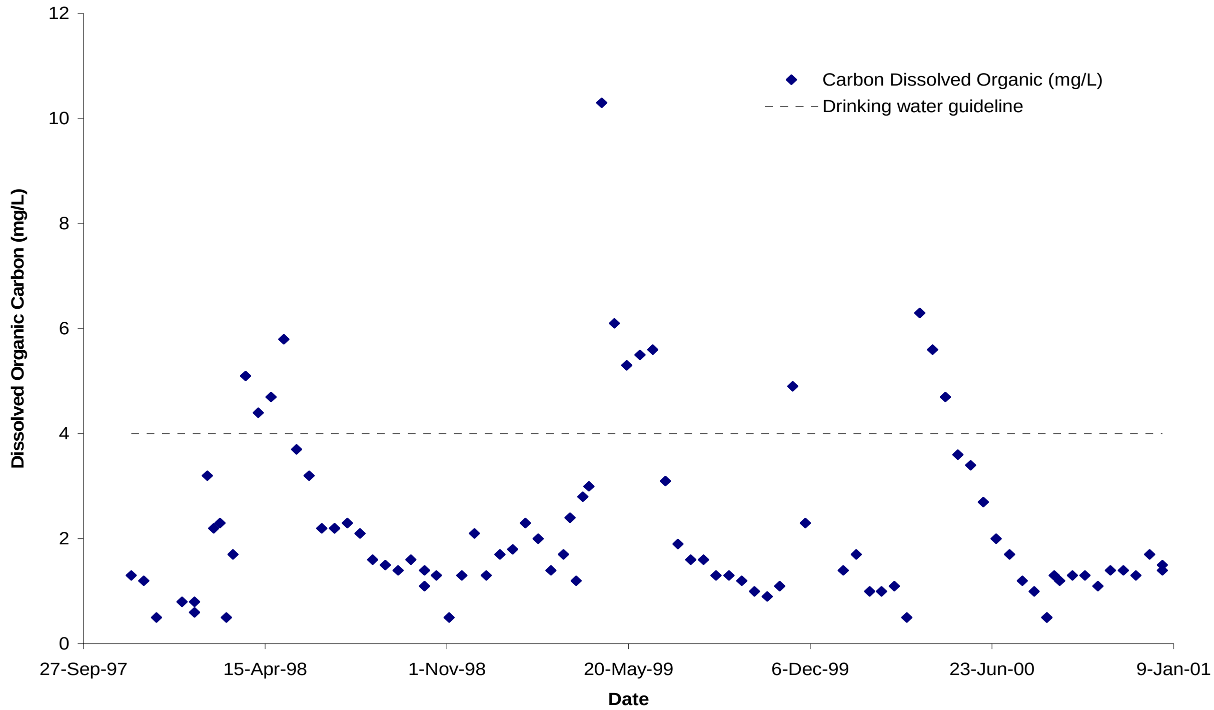

Figure 11. Similkameen River at Princeton - Chromium

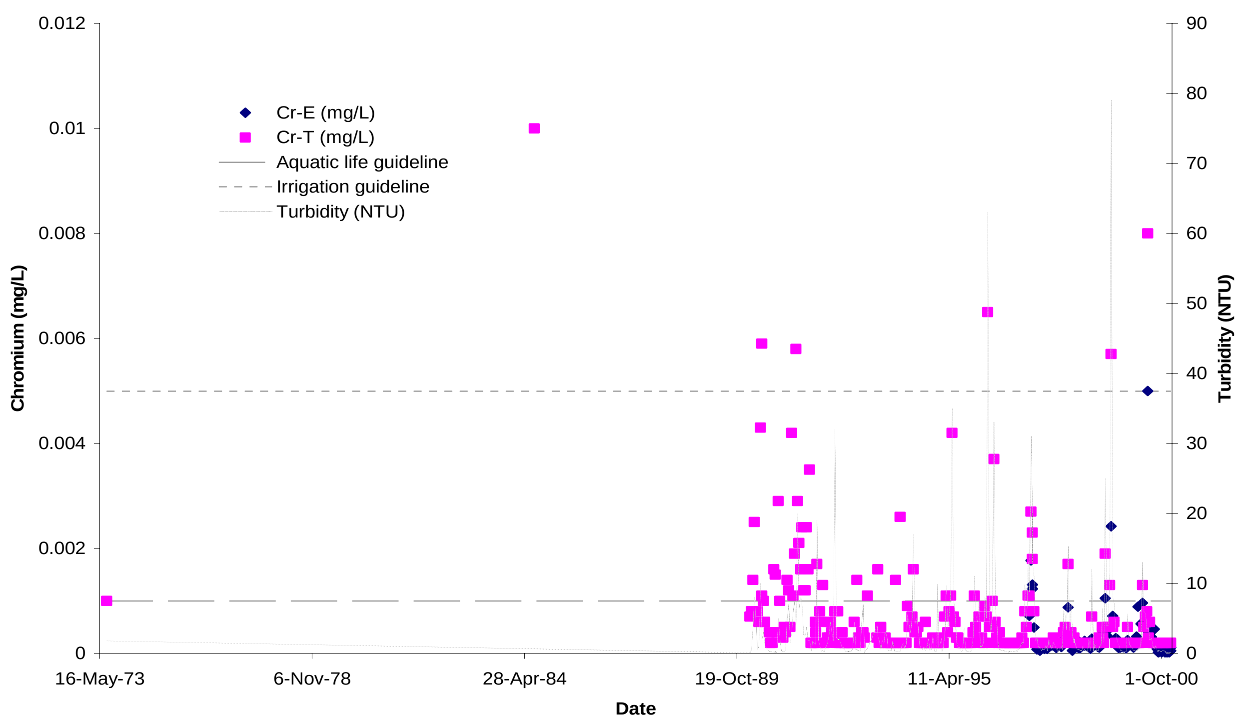

Figure 12. Similkameen River at Princeton - Cobalt

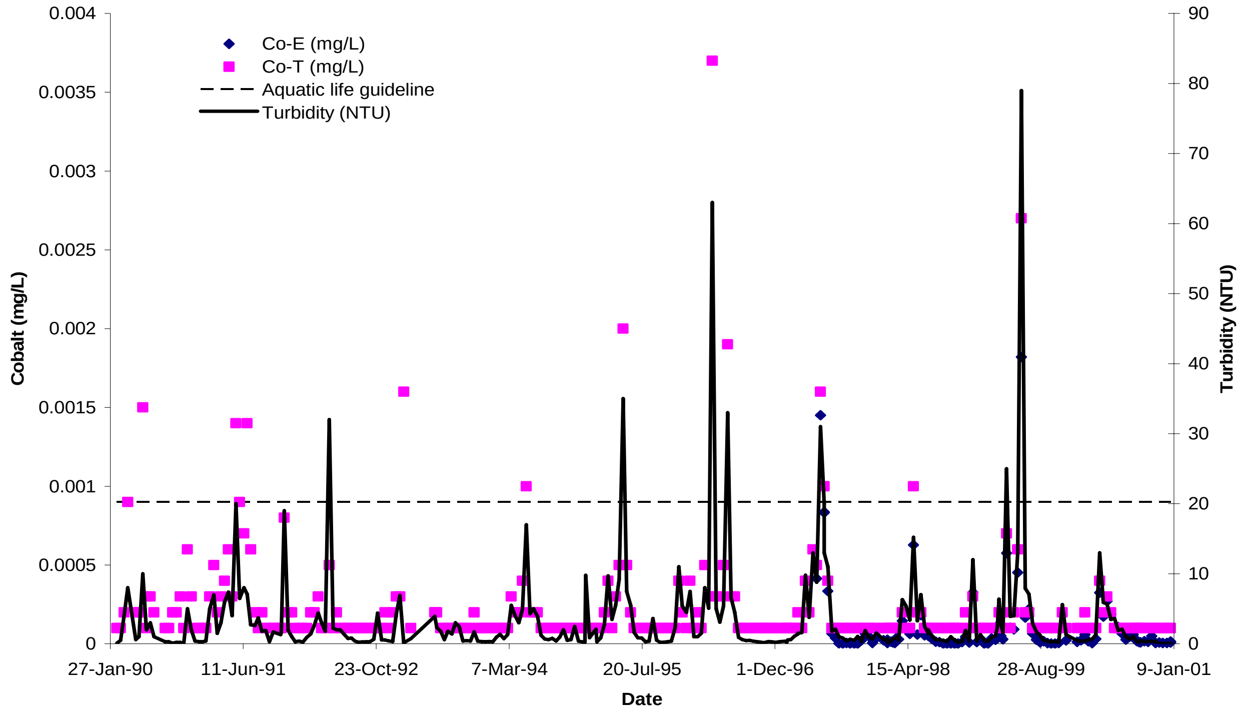

Figure 13. Similkameen River at Princeton - Coliforms, Fecal

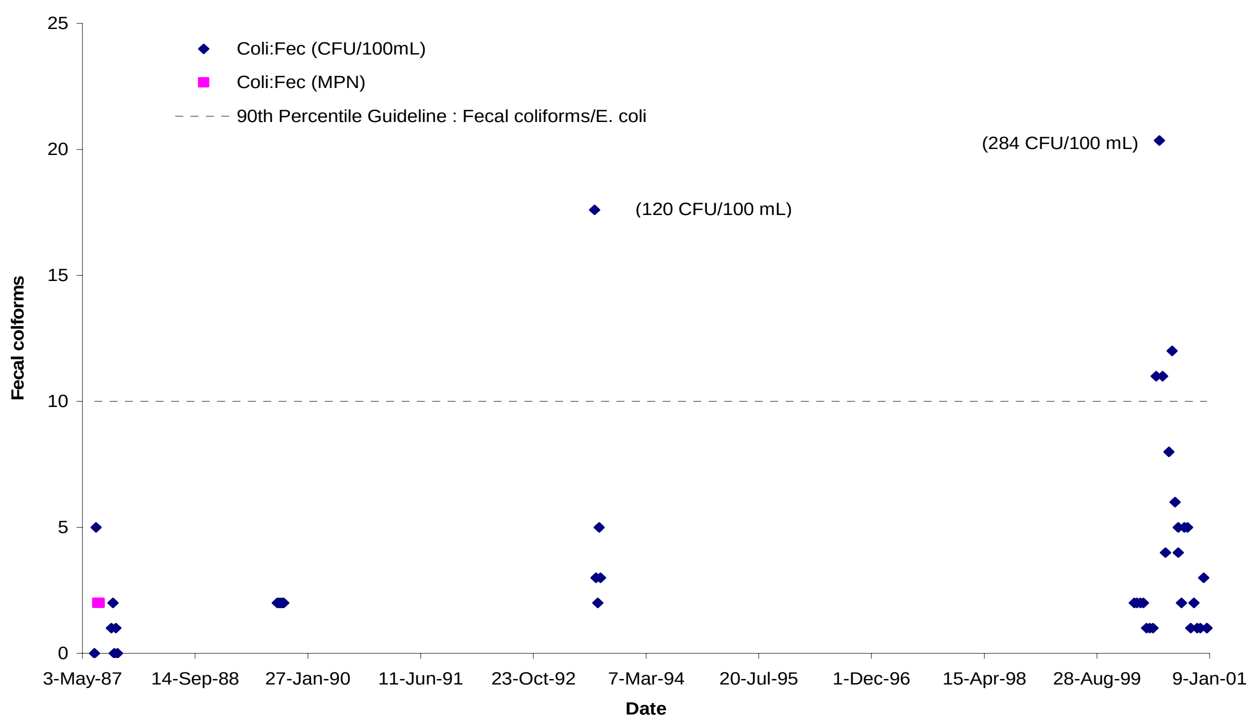

Figure 14. Similkameen River at Princeton - Colour, True

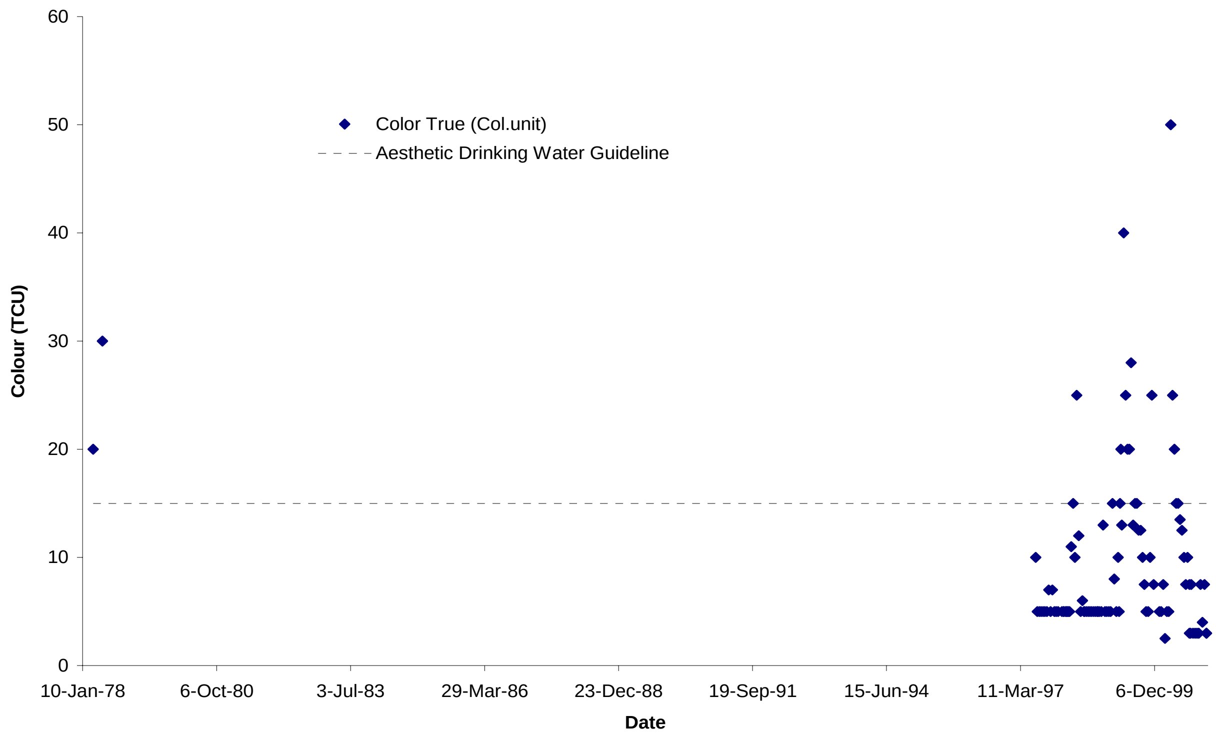

Figure 15. Similkameen River at Princeton - Conductivity, Specific

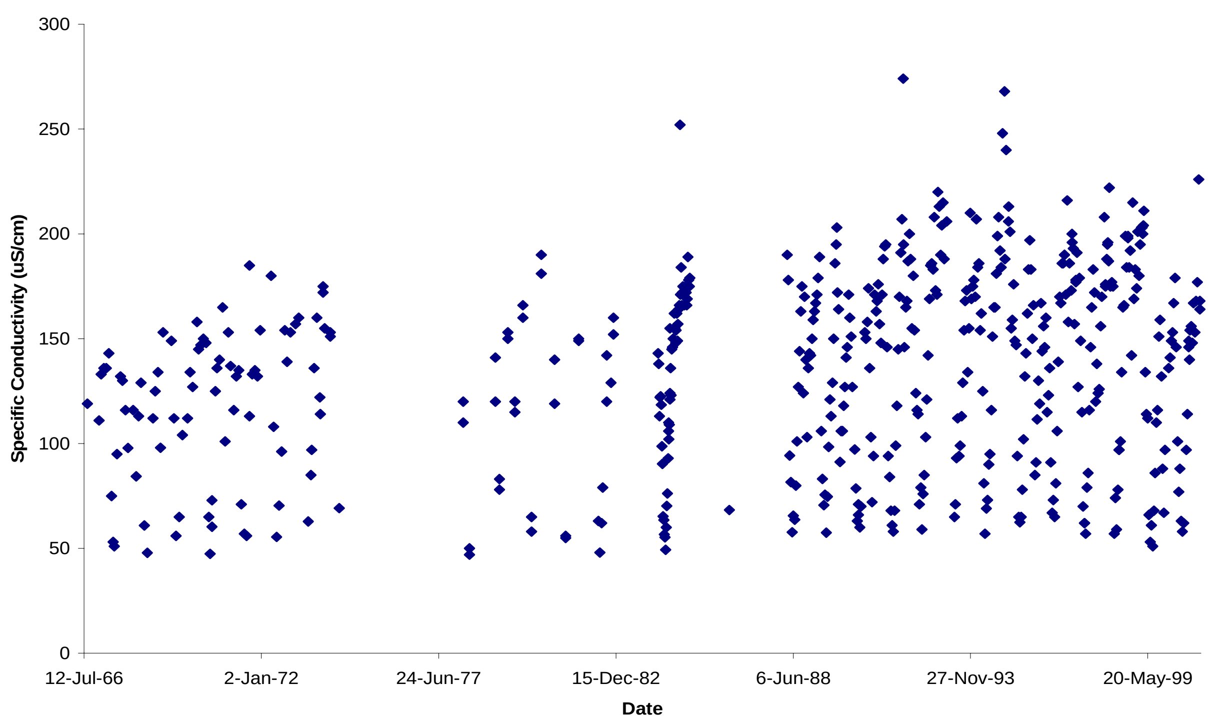

Figure 16. Similkameen River at Princeton - Copper

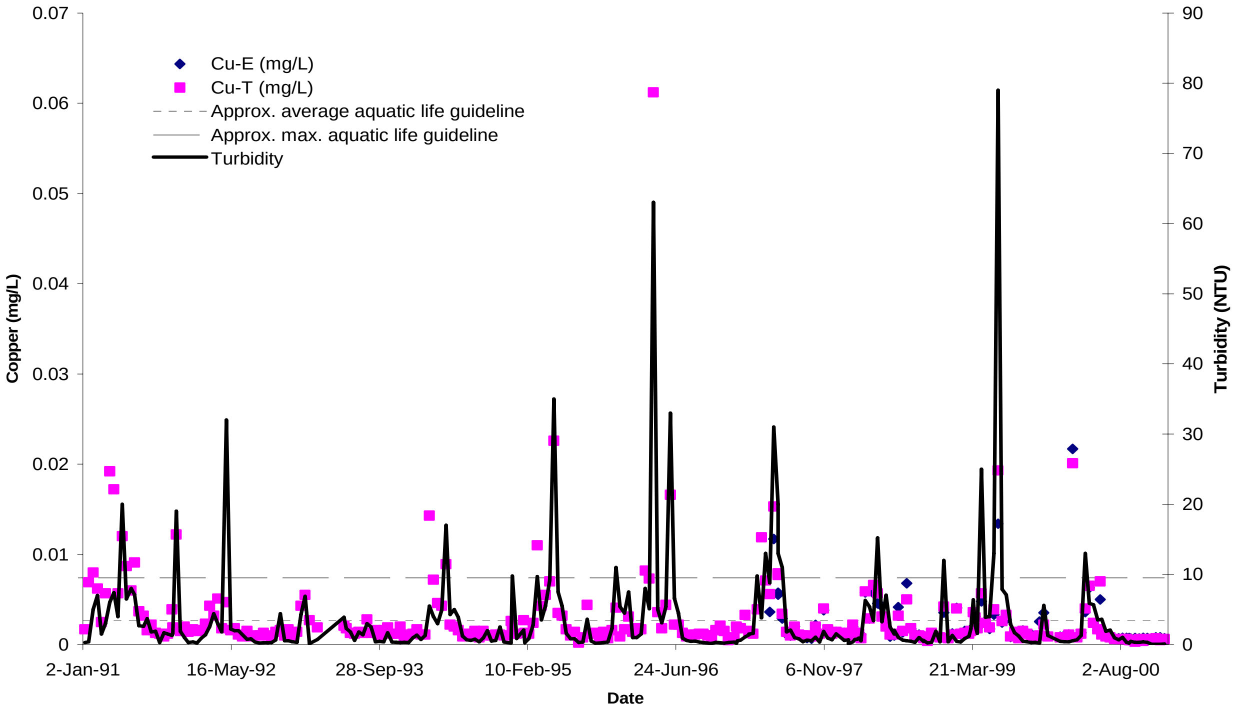

Figure 17. Similkameen River at Princeton - Cyanide (SAD)

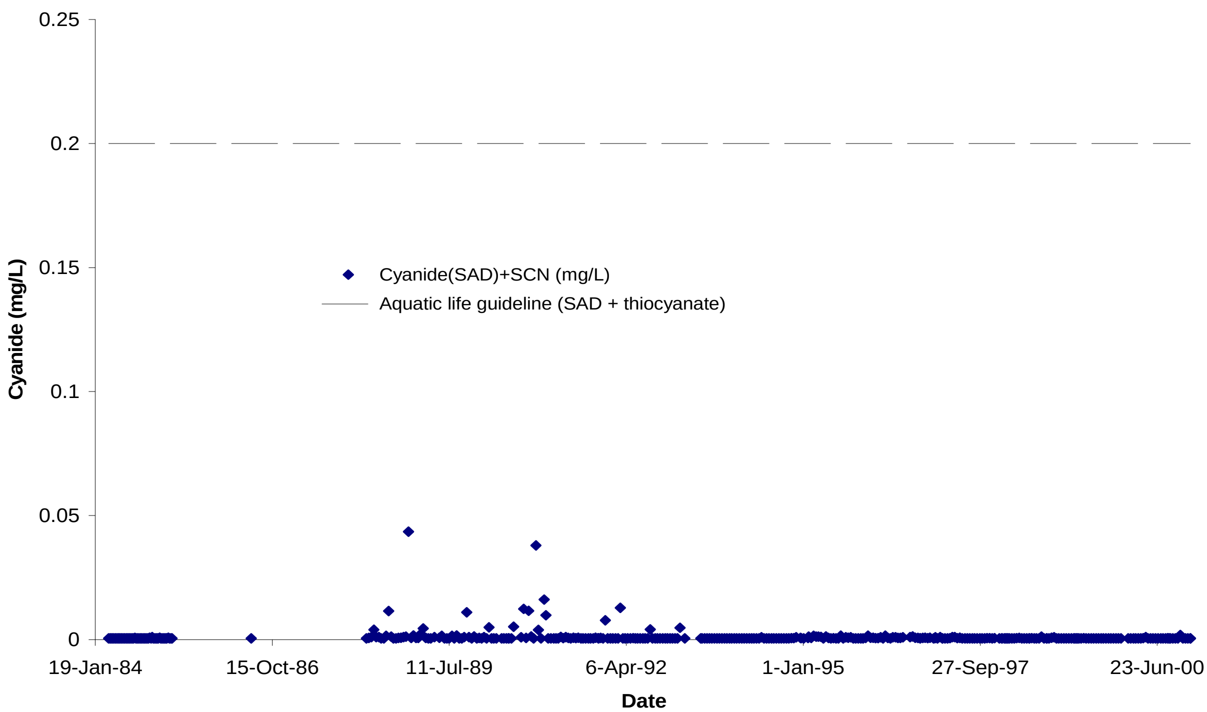

Figure 18. Similkameen River at Princeton - Cyanide (WAD)

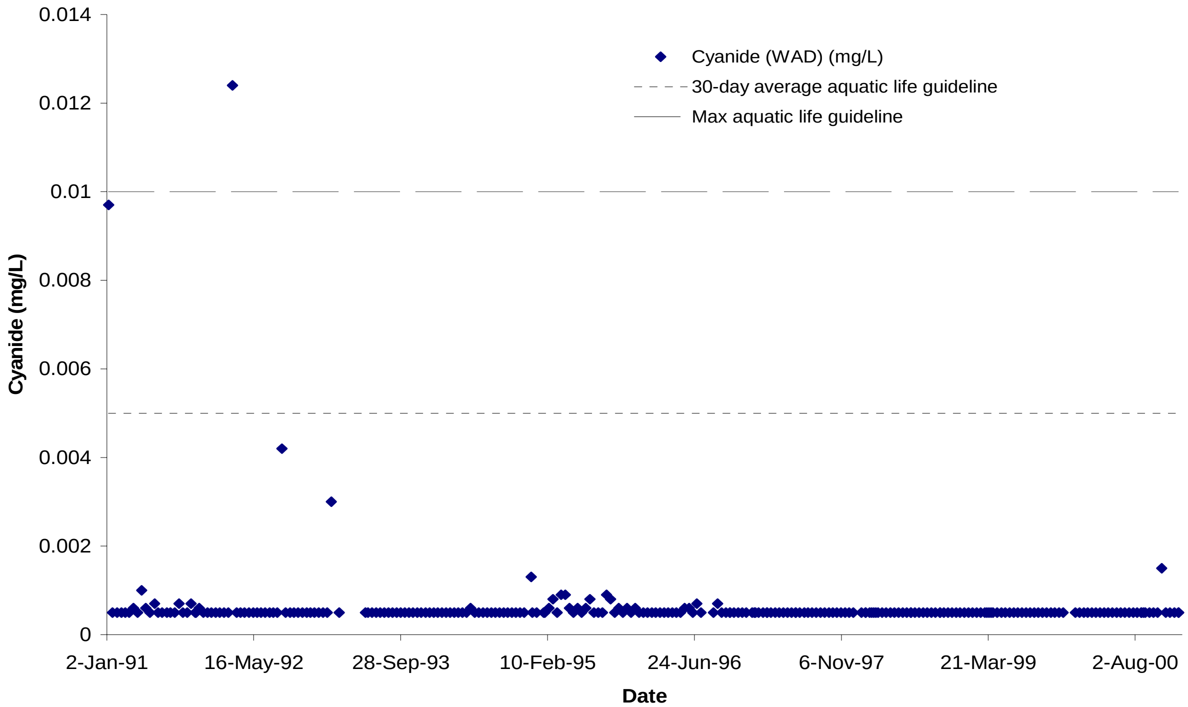

Figure 19. Similkameen River at Princeton - Fluoride

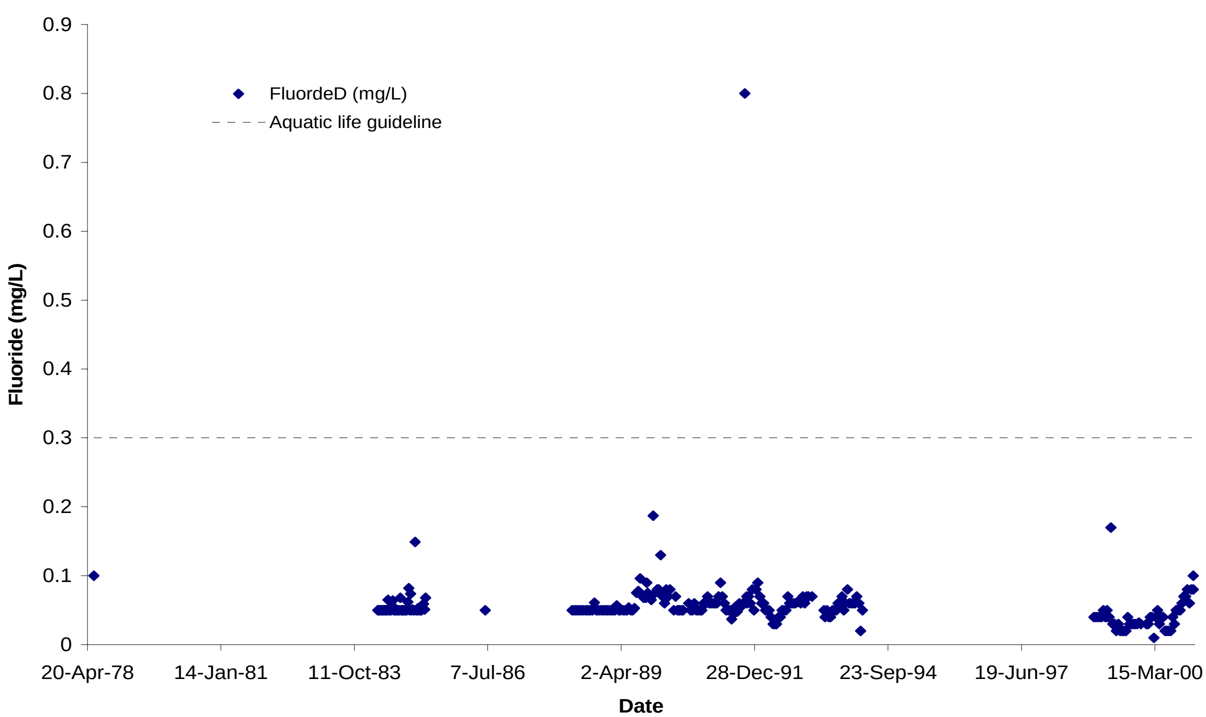

Figure 20. Similkameen River at Princeton - Hardness

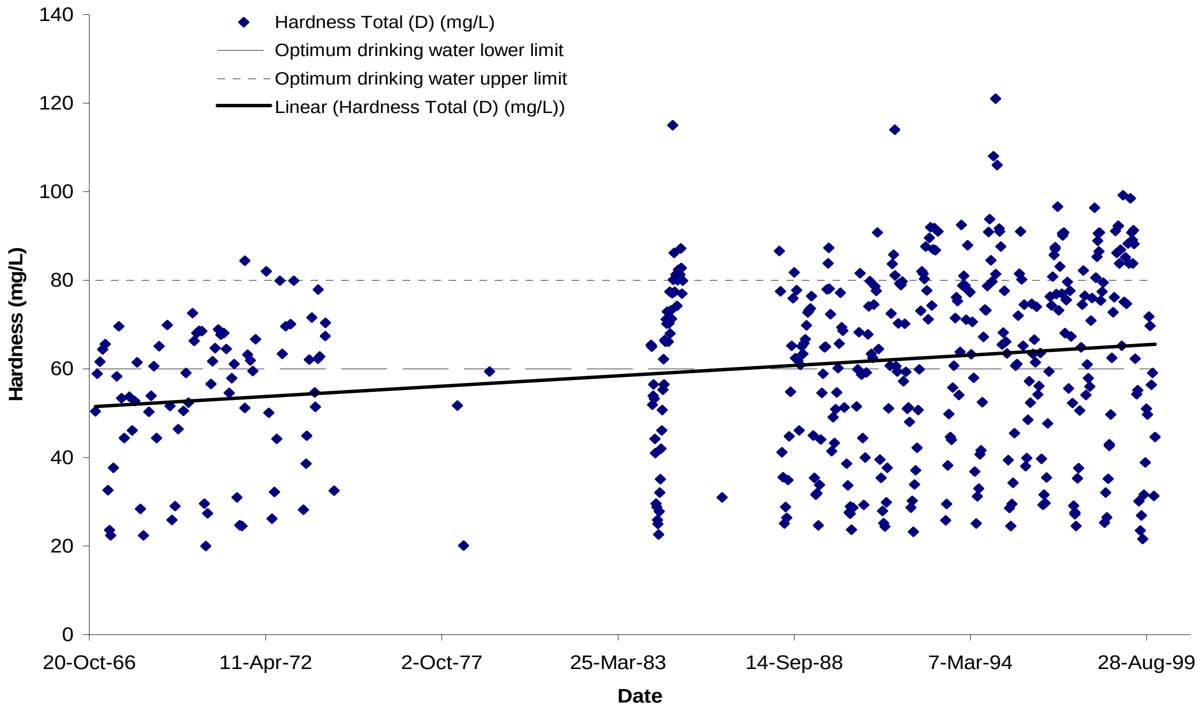

Figure 21. Similkameen River at Princeton - Iron

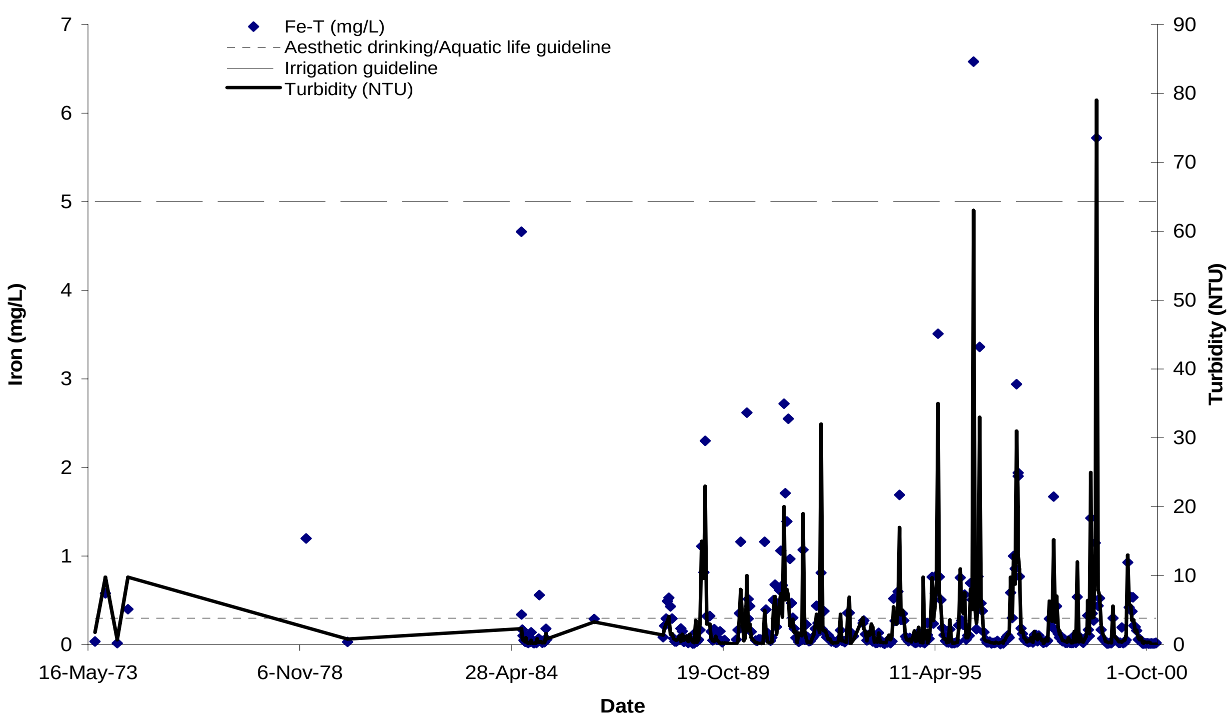

Figure 22. Similkameen River at Princeton - Lead

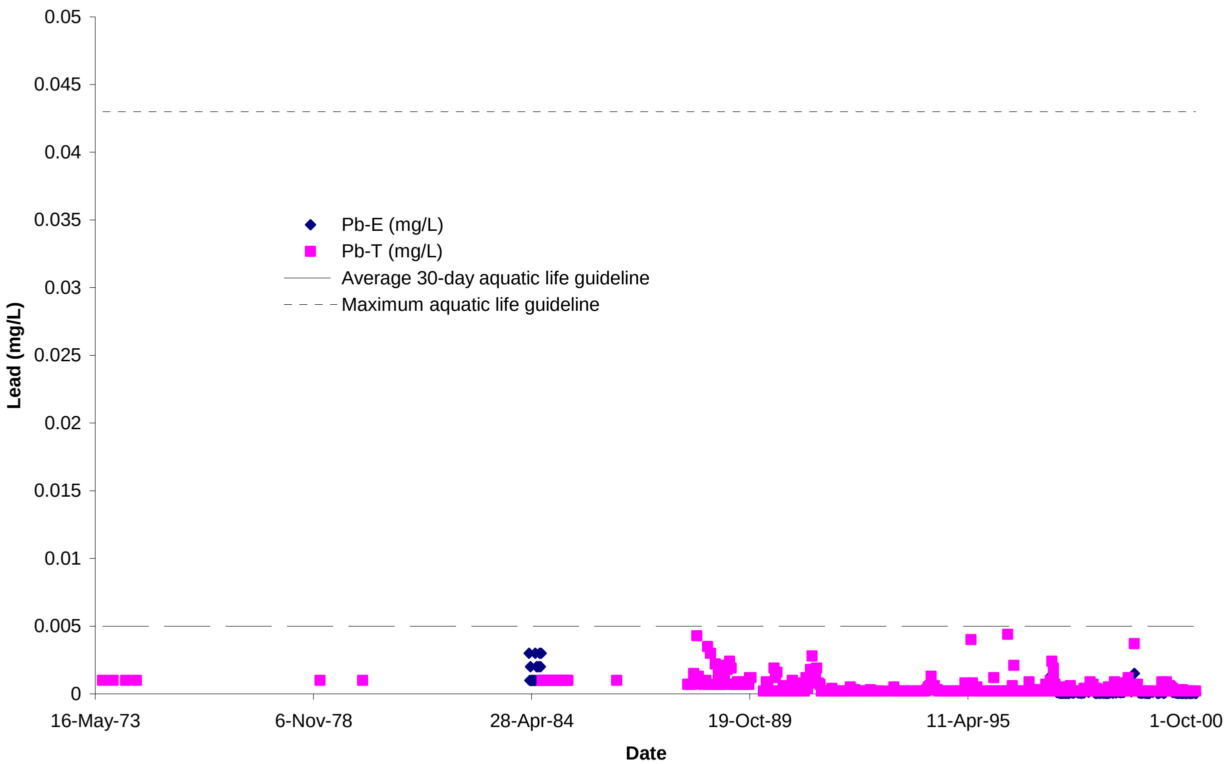

Figure 23. Similkameen River at Princeton - Lithium

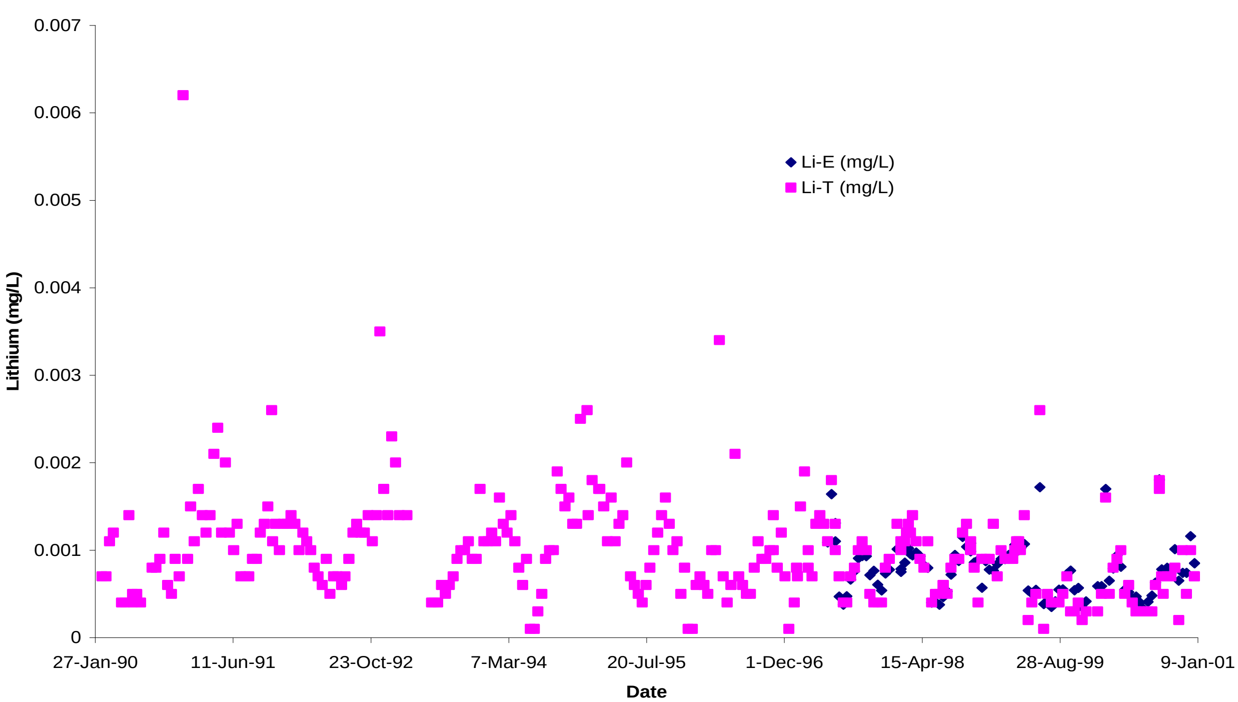

Figure 24. Similkameen River at Princeton - Magnesium

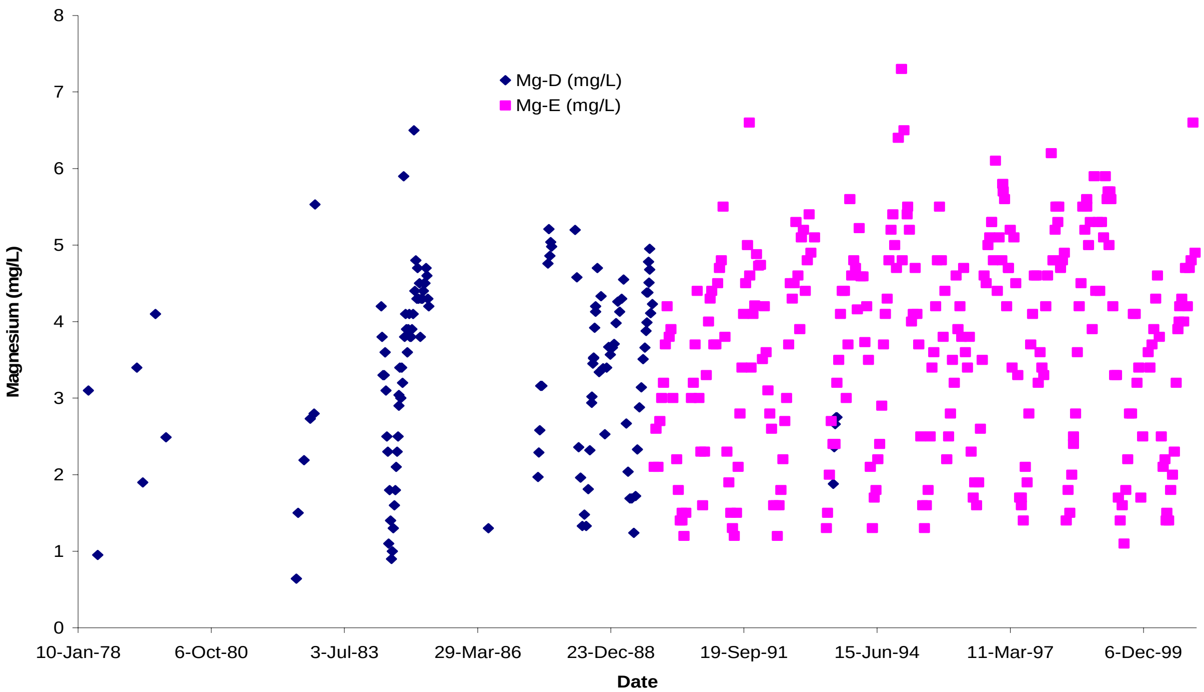

Figure 25. Similkameen River at Princeton - Manganese

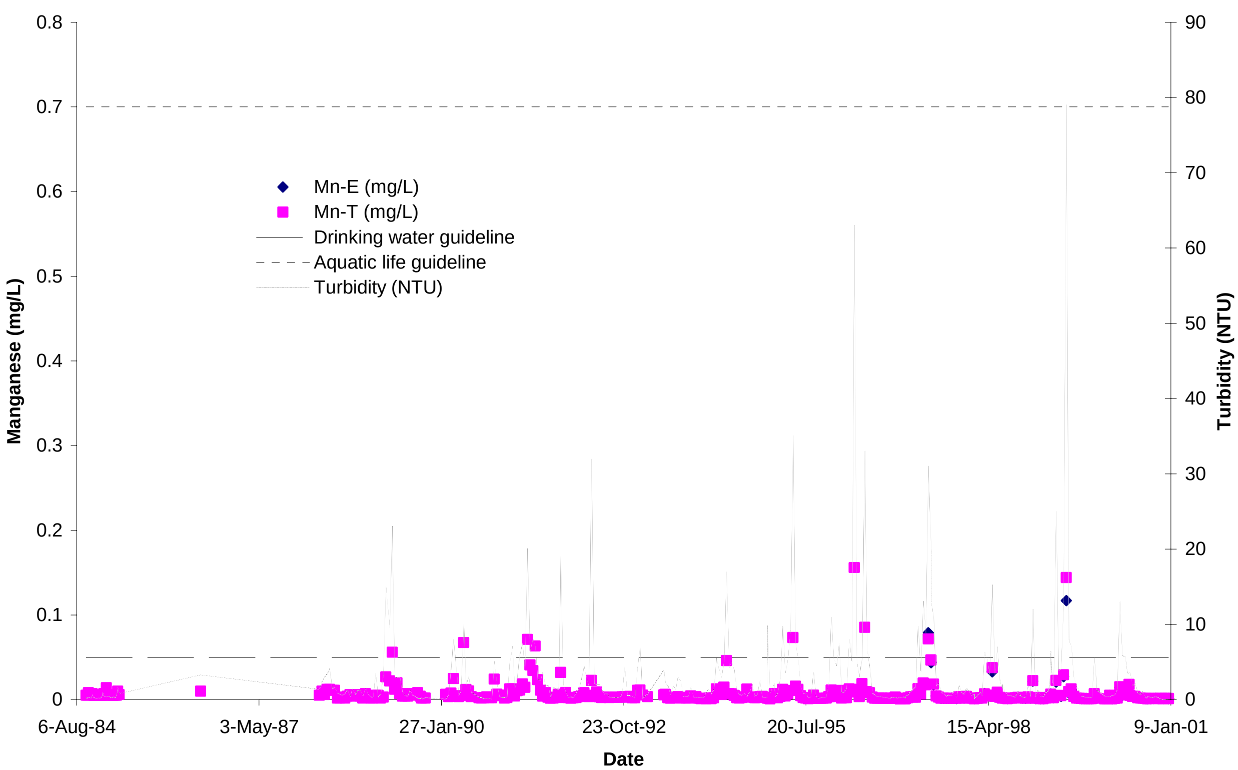

Figure 26. Similkameen River at Princeton - Molybdenum

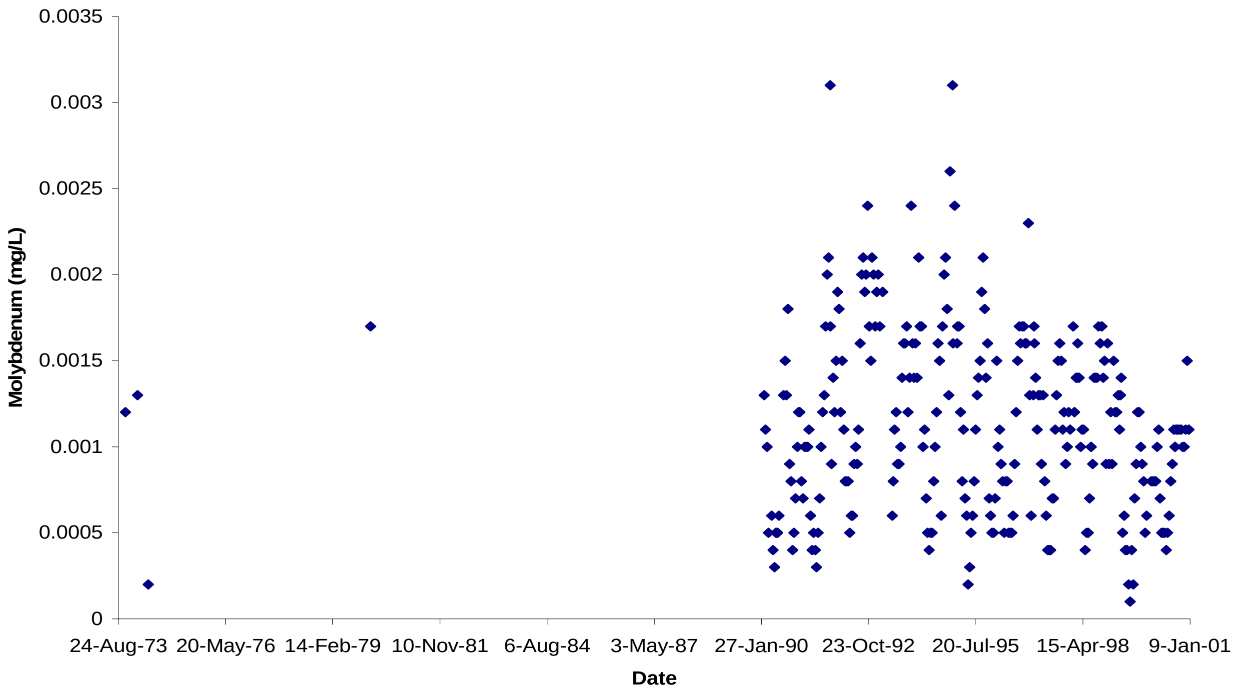

Figure 27. Similkameen River at Princeton - Nickel

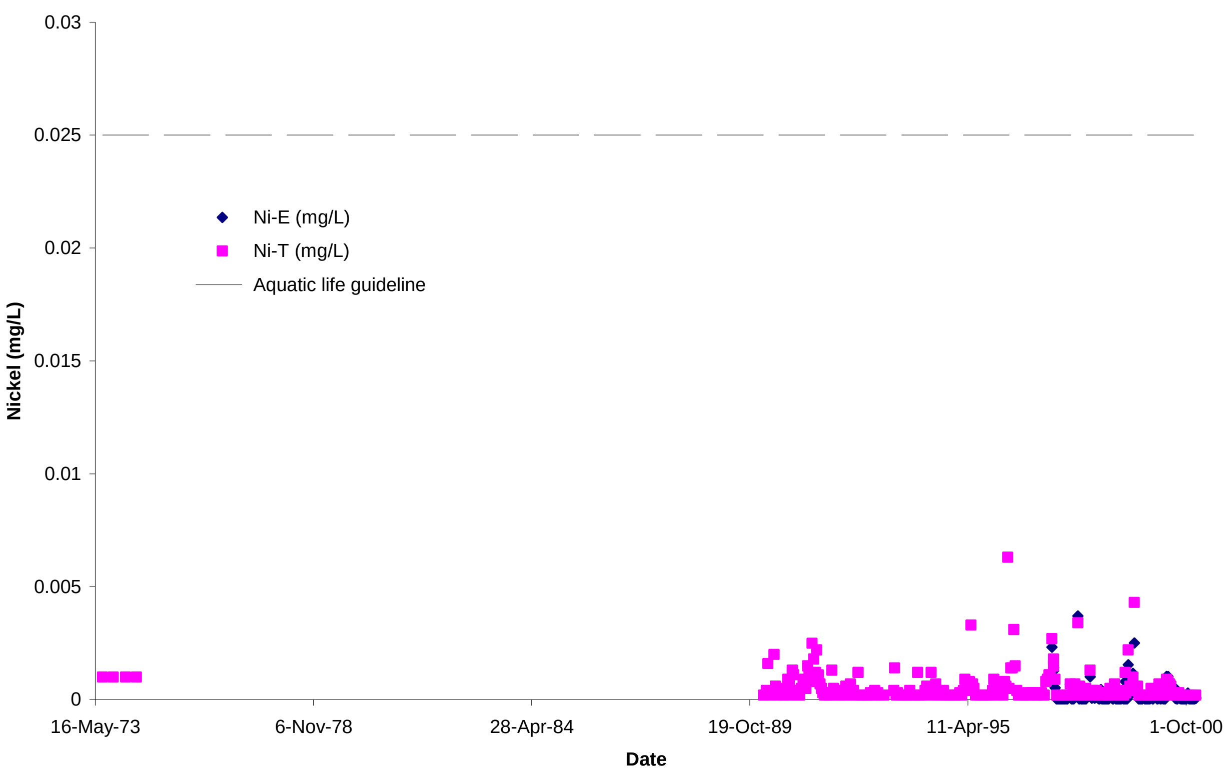

Figure 28. Similkameen River at Princeton - Nitrogen, Total Dissolved

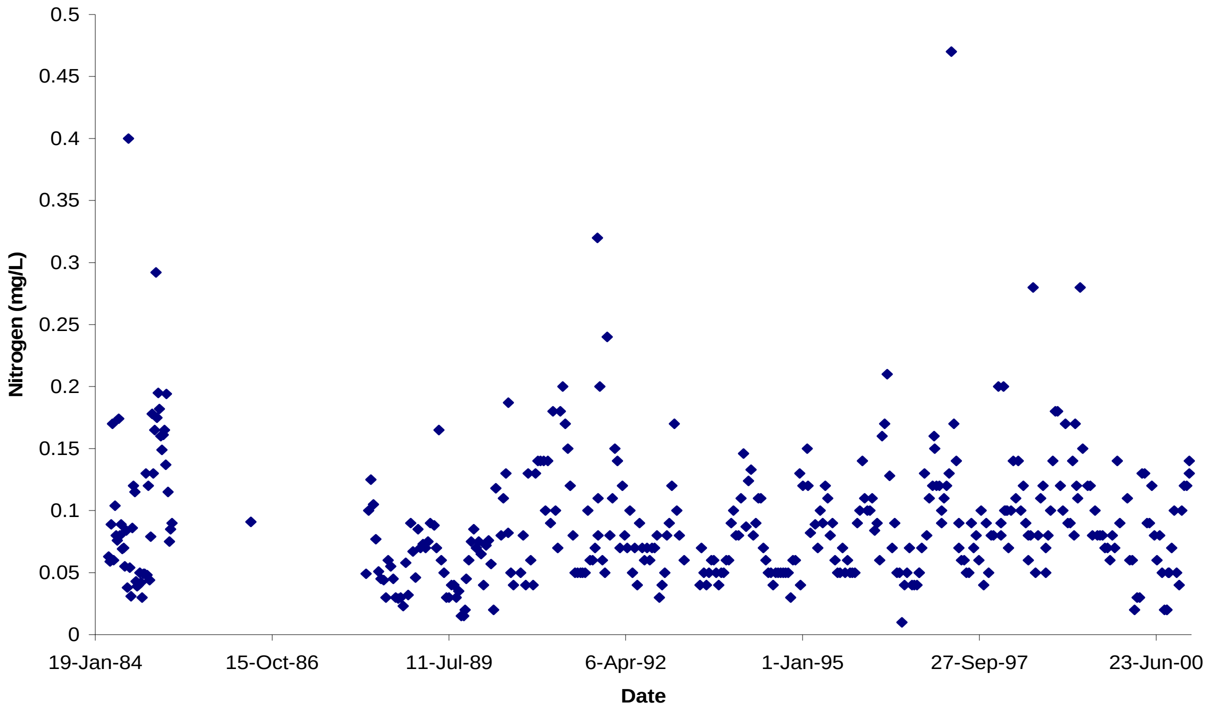

Figure 29. Similkameen River at Princeton - pH

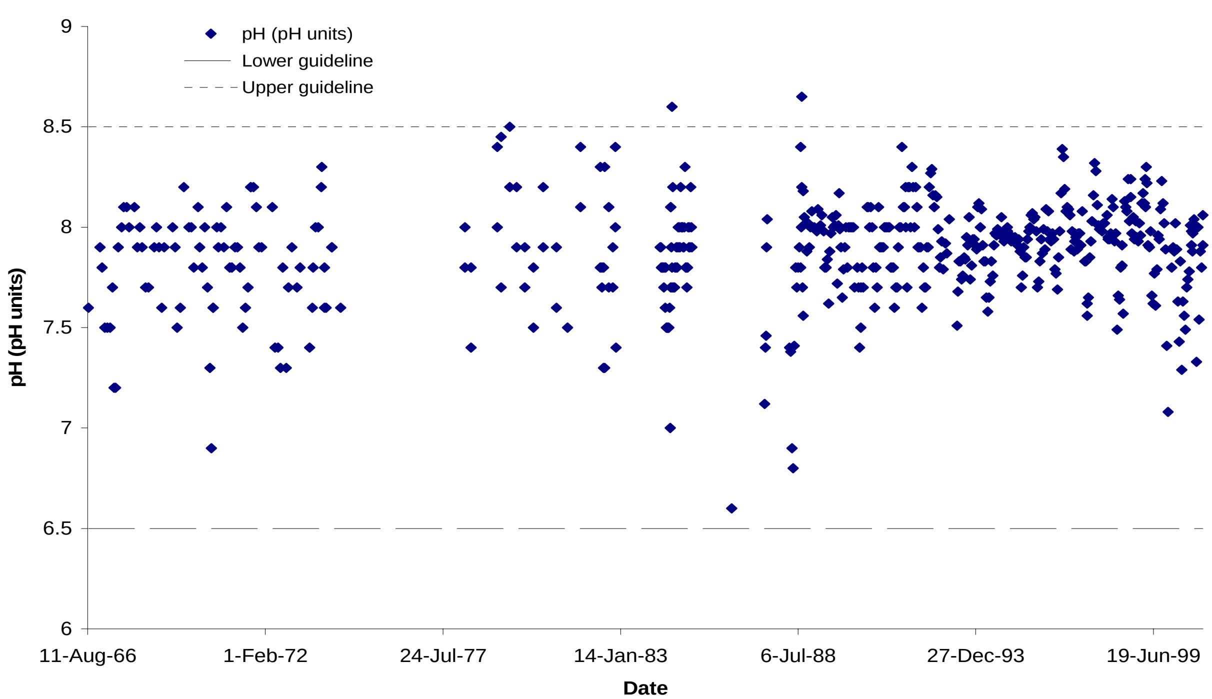

Figure 30. Similkameen River at Princeton - Phosphorus, Total Dissolved

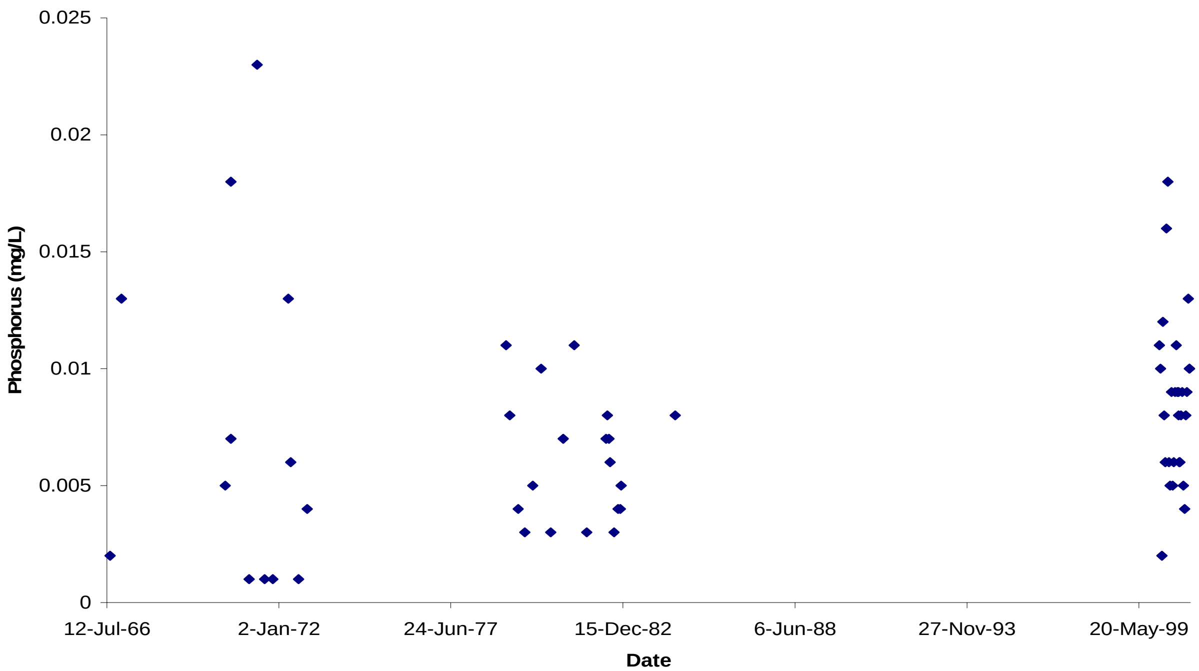

Figure 31. Similkameen River at Princeton - Phosphorus, Total

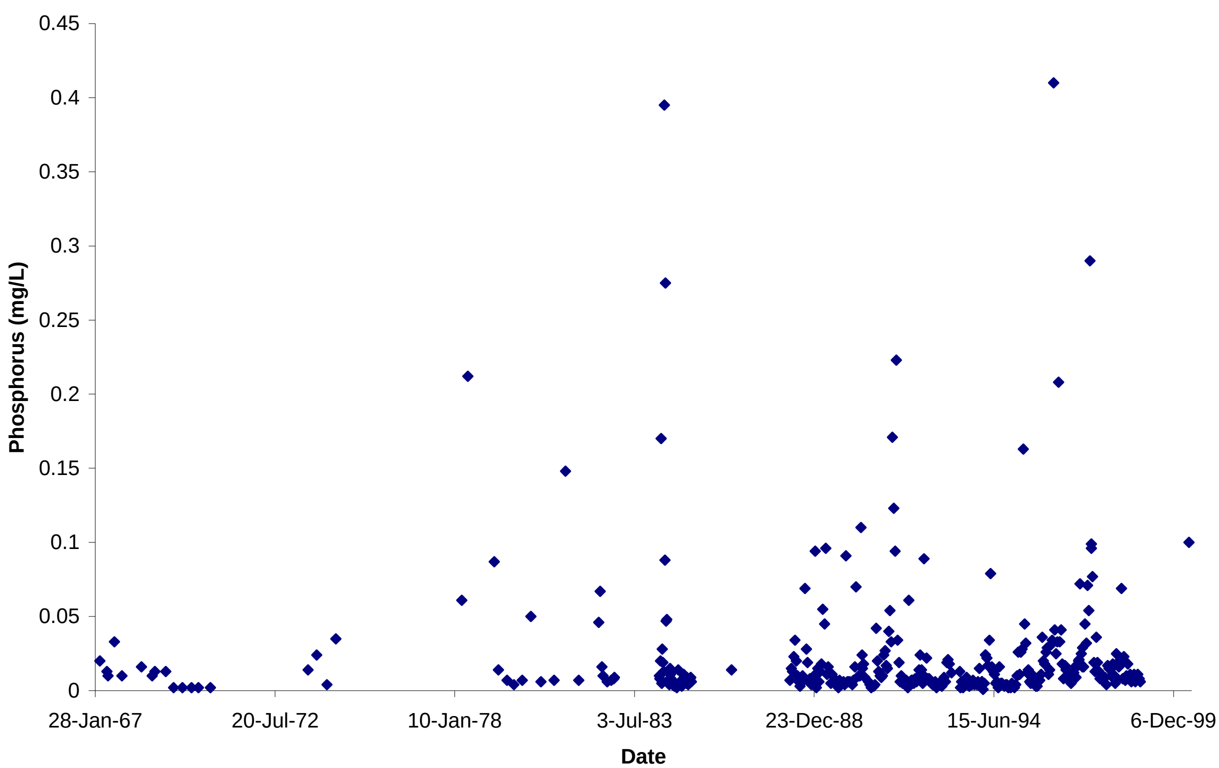

Figure 32. Similkameen River at Princeton - Selenium

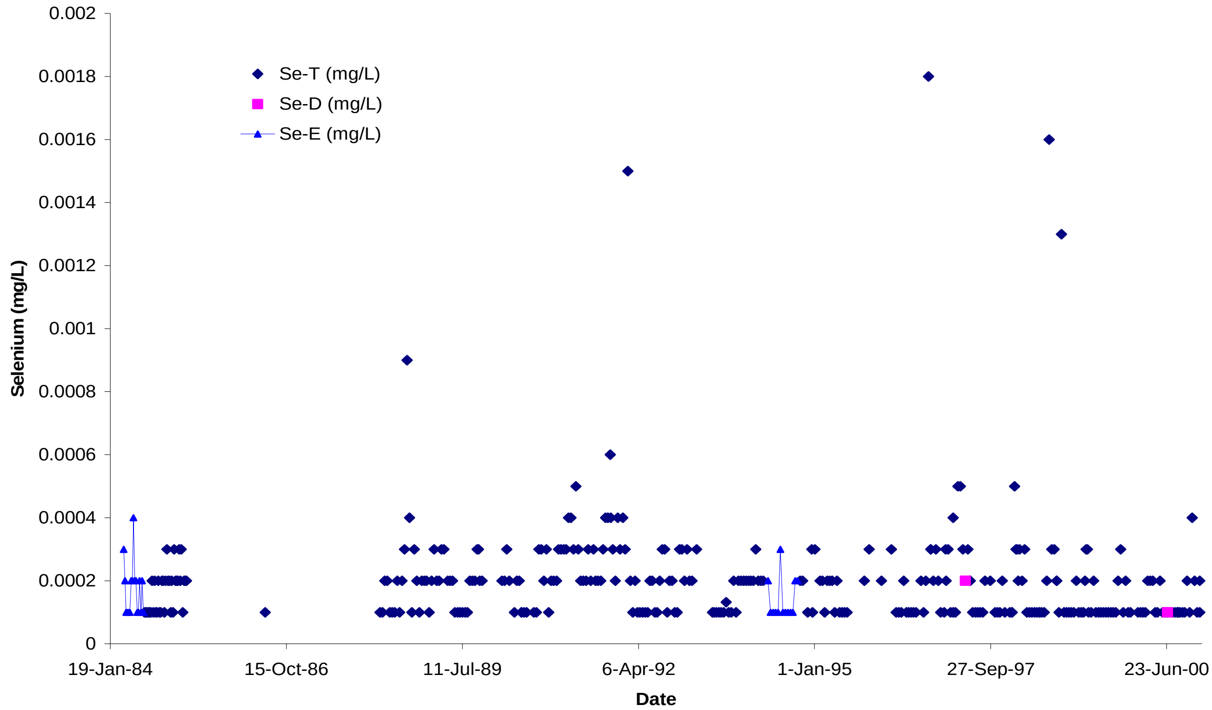

Figure 33. Similkameen River at Princeton - Silver

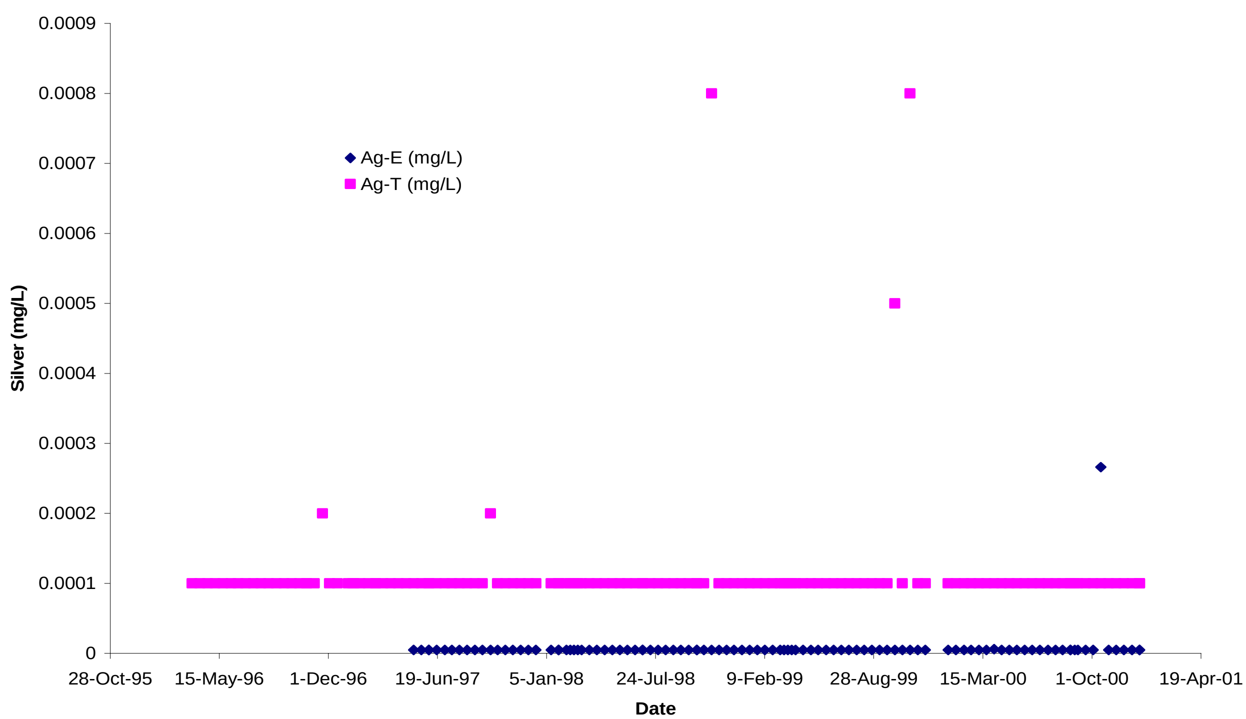

Figure 34. Similkameen River at Princeton - Temperature

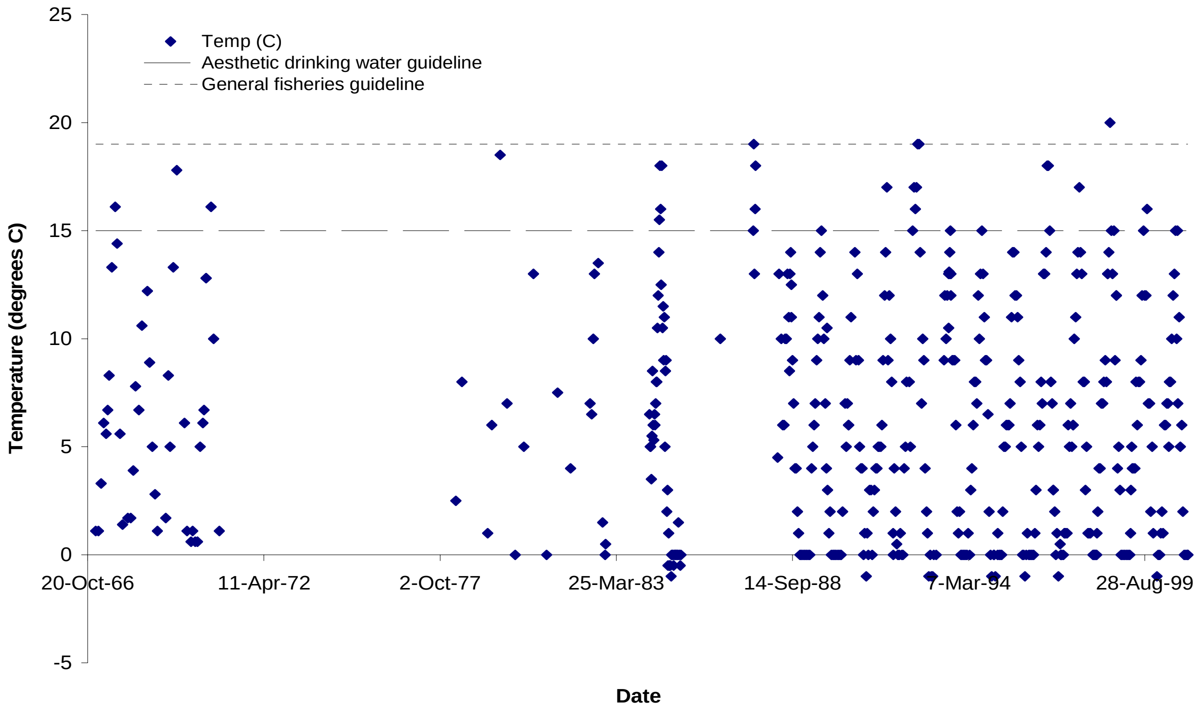

Figure 35. Similkameen River at Princeton - Thallium

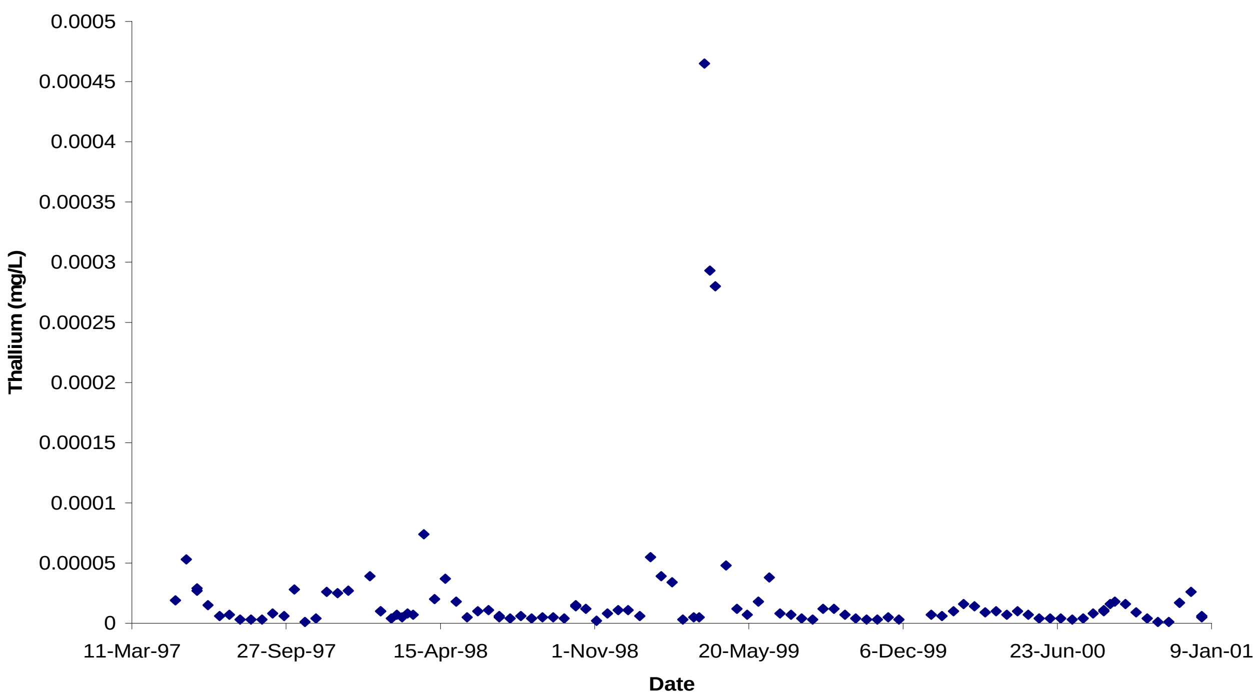

Figure 36. Similkameen River at Princeton - Turbidity

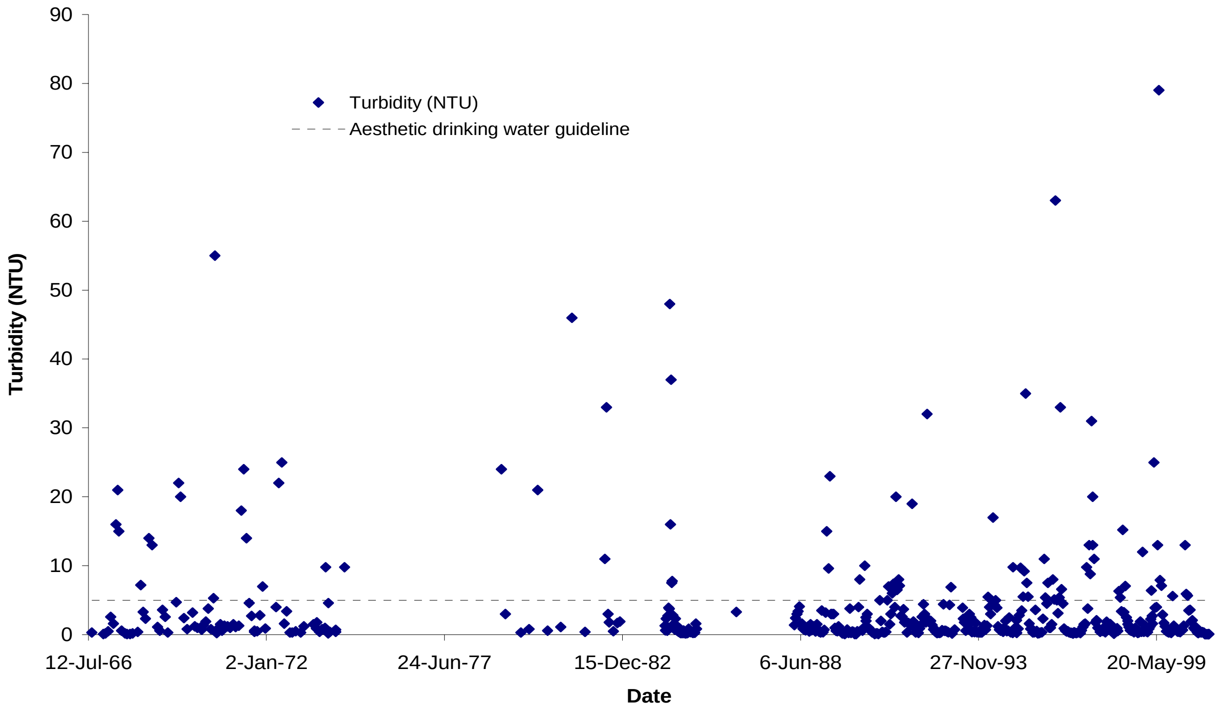

Figure 37. Similkameen River at Princeton - Uranium

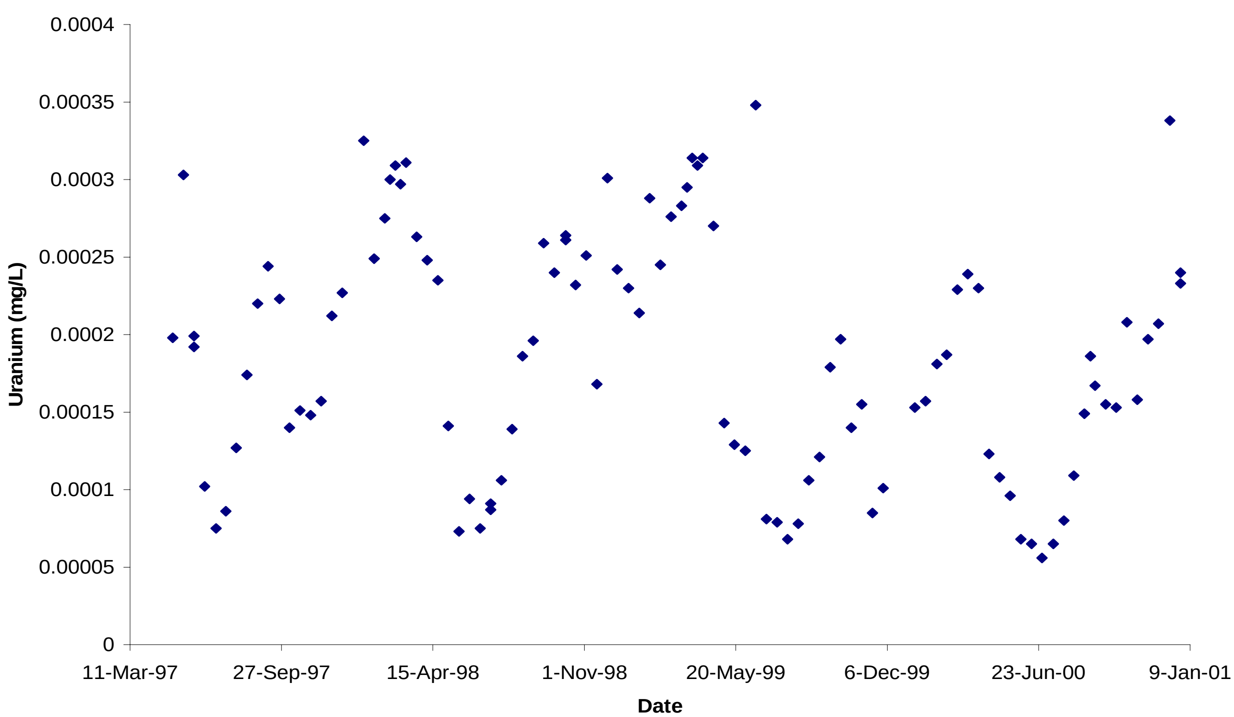

Figure 38. Similkameen River at Princeton - Vanadium

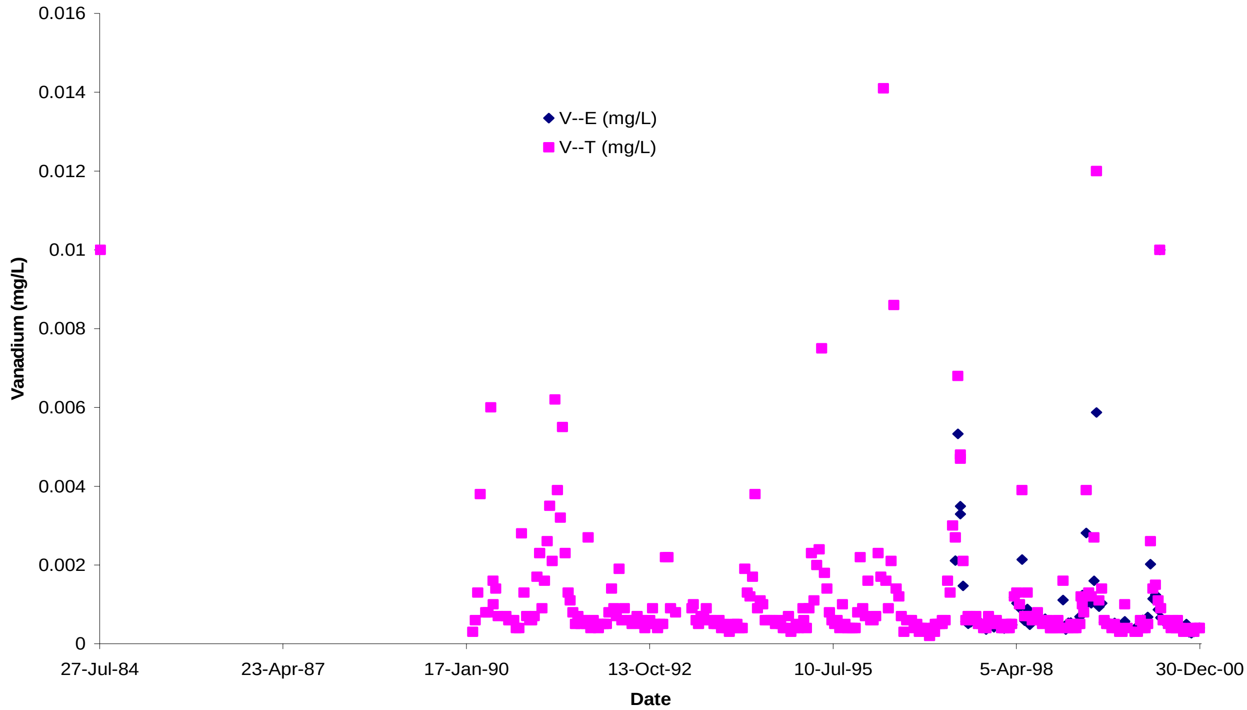

Figure 39. Similkameen River at Princeton - Zinc