# CANADA – BRITISH COLUMBIA
## WATER QUALITY MONITORING AGREEMENT

# WATER QUALITY ASSESSMENT OF QUINSAM RIVER NEAR THE MOUTH (1986 – 2000)

BWP Consulting

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Environment Canada Environnement Canada

BRITISH COLUMBIA Ministry of Environment

# EXECUTIVE SUMMARY

The Quinsam River is located on eastern Vancouver Island, west of the town of Campbell River, B.C. (Figure 1). The total drainage area of the Quinsam River is 280 $km^2$. The main economic activities pertaining to the Quinsam River are fishing, coal mining, and hydroelectric power. This report assesses water quality and flow data collected by Environment Canada at stations near the mouth of the Quinsam River between 1986 and 2000.

## CONCLUSIONS

- The hydrograph for the Quinsam River is typical of coastal B.C. streams, with flows dominated by heavy fall and winter rains.
- Values that exceeded water quality guidelines were recorded for metals such as aluminum, cadmium, cobalt, copper, iron, lead, 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 biologically available and would be removed by the treatment needed before use as drinking water.
- The Quinsam River had a low to moderate sensitivity to acid inputs (was relatively well-buffered), as evidenced by moderate alkalinity and calcium concentrations. Both of these parameters showed strong seasonal fluctuations associated with water level. Additionally, both alkalinity and calcium concentrations appear to be increasing over time.
- 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.
- Fluoride concentrations occasionally exceeded the aquatic life guidelines.

- The Quinsam River had relatively low hardness (the water is quite soft), with concentrations below the optimum drinking water range.
- Water temperatures were measured only sporadically prior to 1986, but after this time they exceeded the aesthetic drinking water guideline most years. In addition, the general fisheries guideline was exceeded in five summers between 1986 and 2000.
- Turbidity values were frequently above guideline levels for drinking water (both aesthetic and health).
- There appeared to be an increasing trend in magnesium, sodium, sulphate, alkalinity and calcium at this site. These increases are likely indications of neutralized acid drainage originating from the Quinsam Coal mine.

The Quinsam River sustains an important fishery and is a potential drinking water supply. We recommend that monitoring be continued at this site on the Quinsam River near the mouth due to increasing trends in a number of water quality indicators. These increases, while not a direct threat to aquatic life at present, will also be addressed through additional monitoring near the mine.

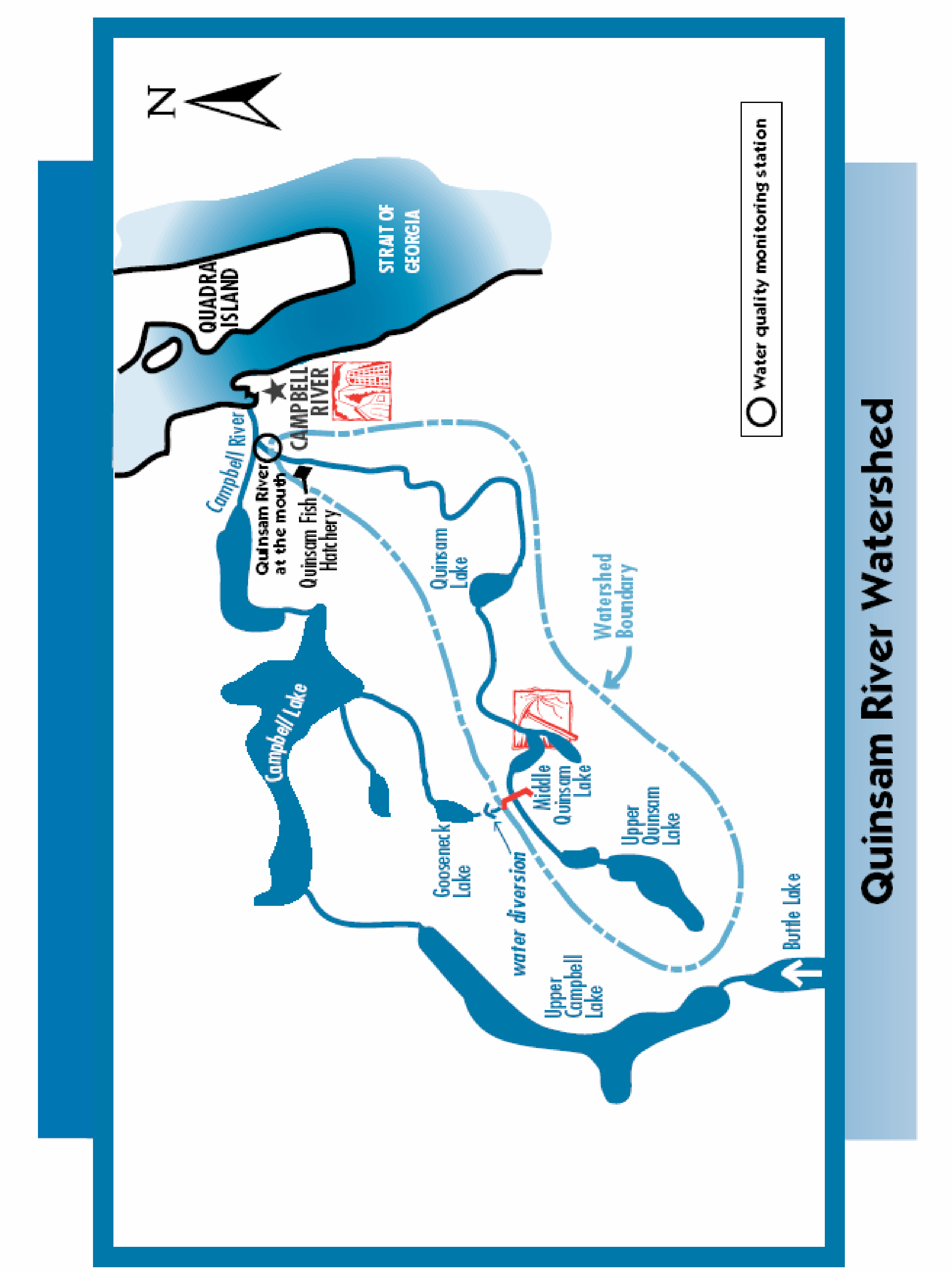


Figure 1 Quinsam River Watershed

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## INTRODUCTION

The Quinsam River is located on eastern Vancouver Island, west of the town of Campbell River, B.C. It is a tributary to the Campbell River, which it joins 3 km inland from the Strait of Georgia. The Quinsam River basin is surrounded by various water bodies. The Campbell River and Campbell Lake border it to the north, Upper Campbell and Buttle Lakes are to the west, the Oyster River is to the south, and the Strait of Georgia is to the east (Figure 1). The main tributary to the Quinsam River is the Iron River, which flows from the south and meets the Quinsam River in between Quinsam and Middle Quinsam Lakes. The total drainage area of the Quinsam River is 280 $km^2$.

The Quinsam River originates south of Upper Quinsam Lake, roughly 30 km southwest of Campbell River, B.C. It flows north for about 5 km into Upper Quinsam Lake and then Wokas Lake. The second part of the river flows east for about 5 km before entering Middle Quinsam Lake. This portion of the Quinsam River has two B.C. Hydro dams, established in the 1950's. The second dam, located about 2 km upstream from Middle Quinsam Lake, diverts most of the water in the Upper Quinsam River through Gooseneck Lake into the Campbell River chain for hydroelectric use.

After leaving Middle Quinsam Lake, the river flows east for 10 km to Quinsam Lake. The third part of the river has two main features: a falls and a major tributary. The falls are 2 km downstream from Middle Quinsam Lake, below which is a valuable salmon spawning area. The Iron River joins the Quinsam River upstream from Quinsam Lake. The fourth segment of the Quinsam River is approximately 25 km long. It flows east and then north toward its confluence with the Campbell River. On this stretch of the river are the Quinsam River Hatchery and Elk Falls Provincial Park, as well as the flow and water quality stations. The hatchery, operated by the Department of Fisheries and Oceans, is situated 3 km from the mouth of the river. The park is located near the mouth.

Fishing is a major water use associated with the Quinsam River. The river is home to a wide range of salmon, both wild and hatchery, as well as steelhead and cutthroat trout.

Pacific salmon typically spawn below the falls downstream from Middle Quinsam Lake. This is the farthest upstream that the fish can migrate. Hatchery salmon are often introduced above the falls to encourage spawning in other parts of the river system. Kangasniemi (1989) reported that the Greater Campbell River Water District had applied for a domestic water licence on the Quinsam River. To date, there are no permitted withdrawals for drinking water on the Quinsam River. The five water licenses currently issued for the Quinsam River are for hydroelectric power, fisheries conservation, frost protection (by the Ministry of Forests), and irrigation (for the Cape Mudge Indian Band).

Coal mining was introduced to the area when Quinsam Coal Ltd. began mining in December, 1987. The activity is concentrated near Middle Quinsam and Long Lakes, 27 km from Campbell River. Logging and generation of hydroelectric power are other important economic activities in the region. The Quinsam River watershed is uninhabited.

This report assesses data from a station on Quinsam River near its mouth. Environment Canada has taken bi-weekly samples at the site since 1986. The federal data are stored under ENVIRODAT station number BC08HD0004. The water quality variables are plotted in Figures 3 to 42. Water Survey of Canada operates a flow gauge just upstream (site number BC08HD005). Flow data from 1986 to 2000 are graphed in Figure 2.

## QUALITY ASSURANCE

The water quality graphs were inspected and erroneous values were removed. There were erroneous values for copper, specific conductivity and chromium. Metals such as chromium, copper, lead and zinc had high values between 1986 and 1991. This contamination was caused by the break down of preservative vial liners and lids. Mercury data were not plotted because all detectable values were likely due to contamination (Pommen, 1994). All pH values before 1989 were low due to laboratory problems. The next section gives more details regarding quality assurance.

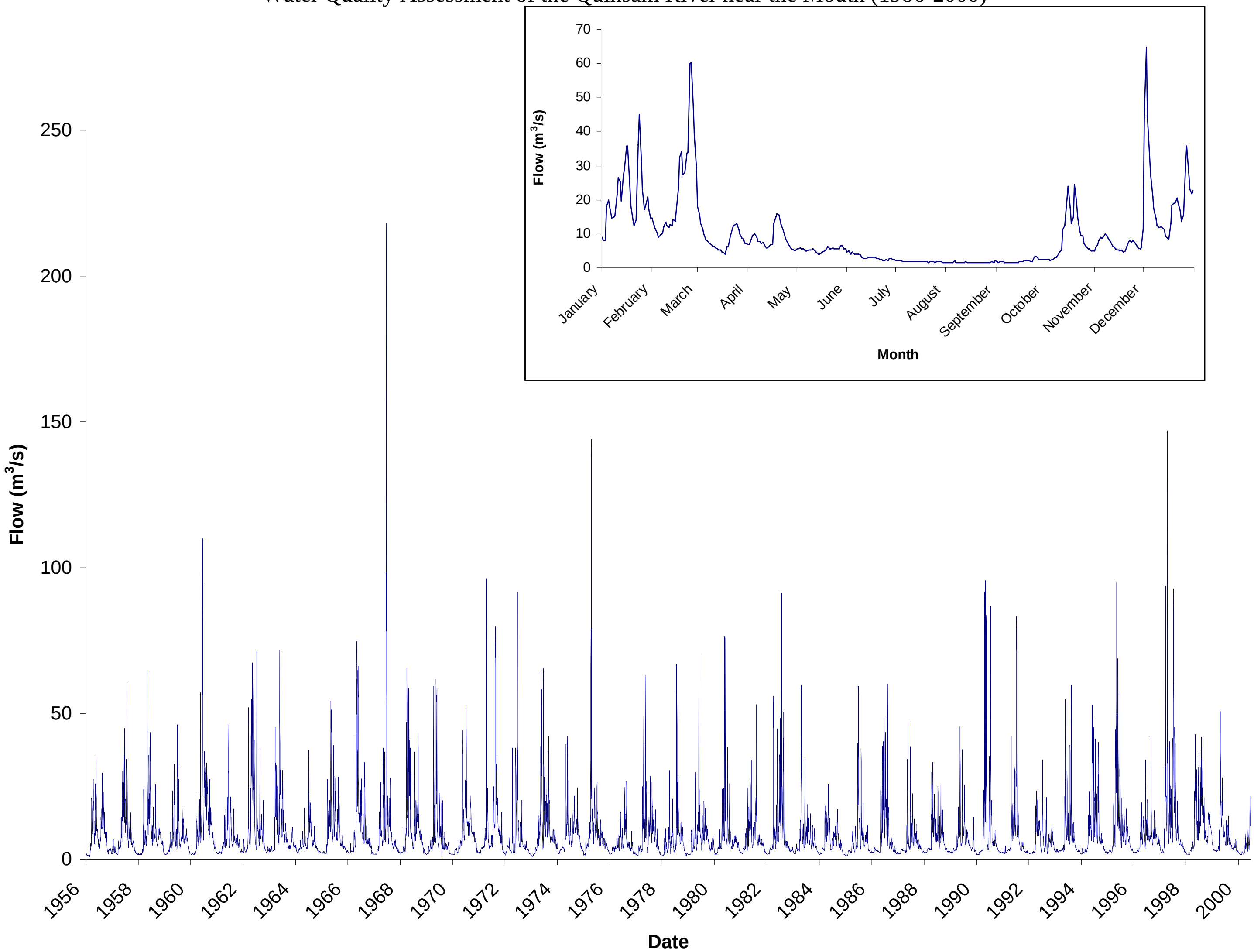


**Figure 2.** Flow data for the Quinsam River near the Mouth (1956 – 2000). Inset shows typical annual hydrograph.

## STATE OF THE WATER QUALITY

The state of the water quality is judged by comparing the data to Ministry of Environment, Lands and Parks' Approved and Working Guidelines for Water Quality (MELP 2001a, 2001b) and any site-specific water quality objectives that have been established. The following site-specific water quality objectives were set to protect aquatic life, wildlife, aesthetics, irrigation, drinking and recreational use of the Quinsam River downstream from Middle Quinsam Lake (Kangasniemi, 1989):

**Table 1. List of Water Quality Objectives for Quinsam River downstream from Quinsam Lake.**

| Designated Uses | aquatic life, wildlife, aesthetics, irrigation, drinking water |
|---|---|
| periphyton biomass | less than or equal to 50 $mg/m^2$ chlorophyll-a mean |
| turbidity | less than or equal to 1.0 NTU 30-day mean, 5.0 NTU maximum or, 1 NTU over u/s control during major rainstorms |
| nitrate-nitrogen | 10 mg/L maximum |
| total cobalt | 0.05 mg/L maximum |
| total manganese | 0.05 mg/L maximum |
| non-filterable residue | less than or equal to 5 mg/L 30-day mean 25 mg/L maximum or 10 mg/L over u/s control during major rainstorms |
| total ammonia | See "Maximum and Average Concentration of Total Ammonia Nitrogen for Protection of Aquatic Life." Tables |
| nitrite-nitrogen | less than or equal to 0.02 mg/L 30-day mean, 0.06 mg/L maximum |
| pH | greater than or equal to 6.5 mg/L 30-day 90th percentile<br>greater than or equal to 6.9 mg/L running 30-day median |
| dissolved aluminum | less than or equal to 0.05 mg/L 30-day mean 0.1 mg/L maximum |
| total arsenic | 0.05 mg/L maximum |
| total cadmium | less than or equal to 0.0002 mg/L 30-day mean 0.0003 mg/L maximum |
| total copper | less than or equal to 0.002 mg/L 30-day mean |
| total iron | less than or equal to 0.3 mg/L 30-day mean |
| total lead | less than or equal to 0.003 mg/L 30-day mean 0.005 mg/L maximum |
| total mercury | less than or equal to 0.0001 mg/L maximum 0.5 mg/kg total Hg in fish muscle by wet weight |
| total nickel | 0.025 mg/L maximum |
| total silver | 0.0001 mg/L maximum |
| total zinc | 0.03 mg/L maximum |

Several indicators increased over the period of record, but few values exceeded guidelines for designated water uses. The most striking trend was for sulphate. These values increased by 3-4 times between 1988 and 1994. Smaller increases were observed for values of specific conductivity, sodium, magnesium, strontium, calcium and hardness. Selenium was the only water quality indicator that appeared to decrease over time. Variables plotted but not mentioned below showed no clear trends over time and met all criteria. These variables are: total arsenic, total barium, total beryllium, dissolved chloride, total cobalt, dissolved fluoride, total lithium, total molybdenum, total nickel, total phosphorus, potassium, filterable residue, non-filterable residue, fixed filterable residue, fixed non-filterable residue, silica, and total vanadium.

The hydrograph for Quinsam River shows that peak **flows** occurred in winter, due to rainstorms, and lowest flows occurred in the summer (Figure 2). Most of the discharge from the Quinsam basin occurs between November and March.

**Total alkalinity** concentrations ranged from about 14 mg/L to 54 mg/L, with a mean of 31 mg/L (Figure 3). **Calcium** concentrations ranged from 4.7 mg/L to 16.4 mg/L, with a mean of 10 mg/L (Figure 12). Both alkalinity and calcium showed seasonal trends, with higher fall flows diluting ions and resulting in lower concentrations during this period. As well, both alkalinity and calcium concentrations showed evidence of increasing over the period of record. Mean concentrations of both alkalinity and calcium indicate that the river is fairly well buffered against acid inputs (the threshold for this rating is considered to be about 20 mg/L for alkalinity and 8 mg/L for calcium). However, as concentrations of these ions decrease during fall high-flow periods, the river is moderately sensitive to acid inputs during this time.

**Total aluminum** concentrations were measured 394 times between 1983 and 2000, with values ranging from 0.023 mg/L to 7.5 mg/L (Figure 4). Only this maximum value (occurring on December 13, 1993 during a rainstorm) exceeded the 5 mg/L criterion for wildlife, livestock and irrigation. Total aluminum concentrations frequently exceeded the 0.05 mg/L **dissolved aluminum** guideline for aquatic life and the 0.2 mg/L **dissolved aluminum** guideline for drinking water and recreation. However, total aluminum values are not directly comparable to dissolved criteria because dissolved concentrations are generally much lower than the total value (except in situations with extremely low pH, something that does not occur in the Quinsam River). There was a strong correlation between total aluminum and turbidity (Figure 4), which implies that the highest aluminum values were probably in a particulate form and may not have been biologically available. Dissolved aluminum should be measured for comparison to criteria and to the site-specific water quality objective.

**Total cadmium** values measured prior to 1991 were suspect due to preservative vial contamination. In addition, minimum detectable limits (0.1 micrograms/L, 1 micrograms/L) were between 3 and 33 times above the most sensitive guideline (0.01 micrograms/L for aquatic life). Since that time, four of the 228 values were above the detection limit (Figure 11). These values occurred during winter rainstorms when turbidity was high. This implies a relationship between total cadmium and suspended sediments, and suggests that the cadmium was probably in a particulate form and may not have been biologically available. Extractable cadmium concentrations have been measured since 1997, with a detection limit of 0.000005 mg/L. The majority of extractable cadmium values (76 of 97 samples collected) had concentrations at or below the detectable limit, but five values exceeded the **total** cadmium guideline of 0.00001 mg/L. To evaluate the guideline for aquatic life accurately, the minimum detectable limit for total cadmium should be lowered to at most one-tenth of the 0.00001 mg/L criterion. Extractable cadmium concentrations should continue to be measured.

**Dissolved organic carbon** has been measured in the Quinsam River since 1997 (Figure 13). Values ranged from 0.5 to 6.2 mg/L for 89 samples collected between 1997 and 2000. 12 values exceeded the drinking water guideline for dissolved organic carbon, primarily during elevated fall and spring flows. There may be a slight decrease in DOC concentrations over the period of record, but more data is required over a longer time period to determine if this trend is significant.

**Total chromium** had high values due to suspected preservative vial contamination between 1986 and 1991 (Figure 15). As well, all data collected prior to August 2000 is suspect due to instrument interference. Therefore, no useful assessment of chromium concentrations can be made at this time, but it is hoped that future samples will allow an assessment of this metal.

**Total cobalt** concentrations ranged from below detectable limits (<0.0001 mg/L) to a maximum of 0.0055 mg/L for 246 samples collected between 1990 and 2000 (Figure 16).

A total of seven samples had concentrations exceeding the aquatic life guideline of 0.0009 mg/L, and all values were well below the irrigation guideline of 0.05 mg/L. There was an excellent correlation between total cobalt concentrations and turbidity, suggesting that when total cobalt concentrations were high, the majority of the cobalt was associated with particulate matter and therefore may not have been bioavailable. Extractable cobalt was measured 97 times between 1997 and 2000, with values ranging from 0.000002 mg/L to 0.000886 mg/L. The mean ratio of extractable cobalt to total cobalt suggests that approximately 60% of the cobalt present in a given sample is in the extractable form.

**Fecal coliforms** were measured sporadically between 1971 and 1981, with values ranging from <2 MPN to a maximum of 540 MPN (Figure 17). As Quinsam River water is not currently used as a drinking water source, these occasional high values are not a concern. If, in the future, water licenses are issued for domestic water use, fecal coliform concentrations should be measured regularly to determine their potential impact on drinking water quality.

**Total colour** was measured 110 times in the years between 1971 and 1978 and between 1997 and 2000 (Figure 19). Between 1978 and 1997, only **apparent colour** was measured. Values were highest during the winter months, and were generally at the minimum detectable limit (5 ACU) during the summer months. As guideline values are reported in terms of true colour, only these data can be assessed. For the 110 true colour samples collected, 31 had values exceeding the 15 TCU guideline for aesthetic drinking water, with a maximum value of 50 TCU. Colour itself does not have a potential to impact health, but high colour values indicate the presence of organic materials called tannins. If water high organic content is disinfected with chlorine for the purposes of human consumption, by-products of this disinfection may have impacts on human health. For this reason, true colour should continue to be monitored as long as the Quinsam River remains a potential source of drinking water.

**Specific conductivity** values ranged from 42 microSiemans/cm to a maximum of 167 microSiemans/cm for 551 values collected between 1972 and 2000 (Figure 20). Specific conductivity values followed a seasonal trend, decreasing during high-water periods (fall and spring) and increasing during low-flow periods (primarily the summer). It appears that specific conductivity may be increasing over time at this site.

**Total copper** had high values due to suspected preservative vial contamination between 1986 and 1991. Since that time, 33 of the 228 values (14%) exceeded the 0.002 mg/L average aquatic life guideline, and less than 2% (four values) exceeded the maximum guideline of approximately 0.005 mg/L (Figure 21). Many of these values occurred in samples collected during winter rainstorms and periods of high river flow. There was a strong correlation between total copper concentrations and turbidity (Figure 21), suggesting that when copper is present in high concentrations, the majority of it may be associated with particulate matter and therefore not available to biota. Extractable copper was measured 97 times between 1997 and 2000, and 10 values (10% of samples) exceeded the average guideline for total copper. None of the values exceeded the maximum guideline. As a minimum of five samples within a 30-day period are required to determine an average value, an increased sampling frequency is required to determine if in fact the average guideline for total copper is being exceeded. Total and dissolved copper should be measured. There was no apparent trend for copper concentrations at this site.

**Total fluoride** concentrations exceeded the 0.3 mg/L aquatic life guideline on two occasions, with a maximum reported value of 1.86 mg/L for 106 values measured between 1994 and 2000 (Figure 22). Prior to 1994, only dissolved fluoride was measured. There does not appear to be any trend in fluoride concentrations at this site.

**Hardness** concentrations appear to be increasing over the period of record (Figure 23). The water was soft, with values generally ranging from 20-60 mg/L (as $CaCO_3$), and were below the optimum range for drinking water aesthetics (80-100 mg/L is considered the optimum range for drinking water). Hardness should continue to be measured because of its role in influencing metal toxicity.

**Total iron** exceeded the 5 mg/L criterion for irrigation once, during a rainstorm on December 13, 1993 (Figure 24). 139 of 482 samples collected between 1971 and 2000 exceeded the 0.3 mg/L criterion for aquatic life and drinking water, and the site-specific water quality objective. High iron and turbidity were reported together in these samples (Figure 24). This implies a relationship between total iron and suspended sediments, and suggests that the iron was probably in a particulate form, may not have been biologically available, and would have been removed by the turbidity removal needed prior to drinking.

**Total lead** had high values due to preservative vial contamination between 1986 and 1991. Since that time, one value exceeded the average guideline for aquatic life (0.004 mg/L, based on an average hardness of 34 mg/L), and no values exceeded the maximum guideline value (0.02 mg/L) (Figure 25). High lead and turbidity were reported together in this sample collected during a rainstorm on December 13, 1993. This would indicate that the lead was probably in a particulate form and may not have been biologically available. Total and dissolved lead should be measured.

**Magnesium** (Figure 27), **sodium** (Figure 46), and **sulphate** (Figure 47) concentrations all appeared to increase over the period of record. None of these variables exceeded any of their respective guidelines. Sulphate is a good indicator of acid drainage and it is probable that acid production is being neutralized at the Quinsam Coal mine (Pommen, 1996). Calcium, also an indicator of acid drainage, increased after 1993. There were no trends in pH, alkalinity, or metals values in the river, indicating that the any acid was being neutralized well upstream from the water quality station. Magnesium, sodium and sulphate should continue to be monitored as an indicator of trends in acid drainage.

**Total manganese** values exceeded the 0.05 mg/L drinking water (aesthetics) guideline in 9 of 395 samples (2% of values) collected between 1986 and 2000 (Figure 28). There was a strong correlation between turbidity and total manganese concentrations, suggesting that during periods of elevated manganese, the majority of the metal is associated with particulate matter.  In this case, treatment necessary to remove turbidity prior to consumption would therefore also remove excess manganese.

**Nitrate/nitrite** and **total dissolved nitrogen** (Figures 31, 32, 33, and 34) did not display any apparent trends and met all guidelines.  Nitrogen often increases downstream from surface mines due to the loss of nitrogen from nitrogen-based explosives.  We recommend that total dissolved nitrogen continue to be monitored for this reason, and that dissolved phosphorus and periphyton chlorophyll *a* be added to track any trends in these related indicators.

**pH v**alues measured before 1989 were deemed suspect due to federal laboratory problems.  After this time, values ranged from 6.8 to 8.3 (Figure 37).  All values were within the acceptable range for drinking water (6.5 to 8.5 pH units).  We recommend that pH continue be measured due to potential acidification and the role of pH in influencing other water quality indicators.

**Water temperature** exceeded the 15 degrees C criterion for drinking water aesthetics in 11% of samples (45 of 395 values collected between 1971 and 2000) (Figure 48).  The general fisheries guideline of 19 degrees C was exceeded by six samples (<2% of all samples collected).  Temperature should continue to be monitored due to its basic role in influencing other water quality indicators and because of potential global warming.

**Turbidity** values exceeded the 5 NTU drinking water guideline for aesthetics in six percent of samples collected (188 of 420 samples) (Figure 50).  Forty-five percent of the values exceeded the 1 NTU drinking water guideline for health.  Typically, these values occurred during high winter flows – the highest turbidity value was 73 NTU on December 13, 1993.  This sample also had the highest values for many other water quality indicators.  The water would require turbidity removal and disinfection prior to drinking. Turbidity should continue to be measured due its influence on other water quality indicators and due to upstream land disturbances.

**Total zinc** had high values due to preservative vial contamination between 1986 and 1991. Since that time, only three of 390 values (<1%) exceeded the average aquatic life guideline to protect algae (0.0075 mg/L) (Figure 53). No values exceeded the maximum aquatic life guideline for total zinc (0.033 mg/L). There was a fairly strong correlation between total zinc concentrations and turbidity. This indicates that the zinc values was probably in a particulate form and may not have been biologically available. No trend was evident in total zinc concentrations at this site. Total and dissolved zinc should be monitored.

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Pommen, L.W. 1994. Mercury Monitoring Issue (Mark II). Presented at the Environmental Impact Biologists' Meeting. February 21-22, 1994. Victoria, B.C. Water Quality Branch, Environmental Protection Department, Ministry of Environment, Lands and Parks, Victoria, B.C.

**Figure 3. Quinsam River Near the Mouth - Alkalinity**

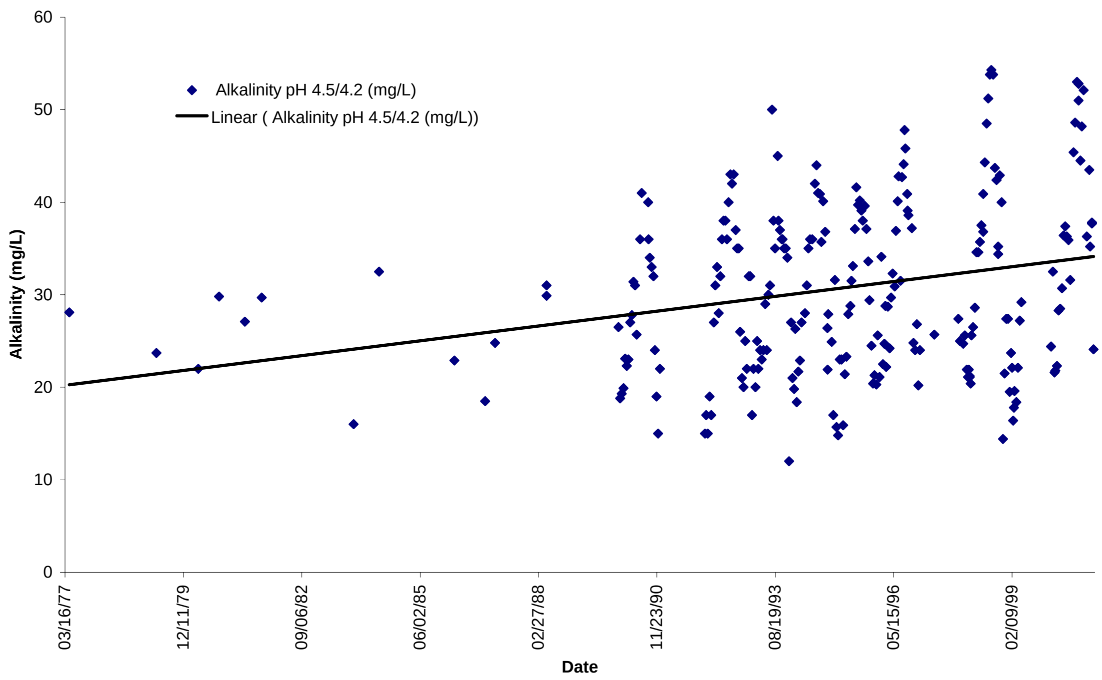


**Figure 4. Quinsam River Near the Mouth - Aluminum, Total**

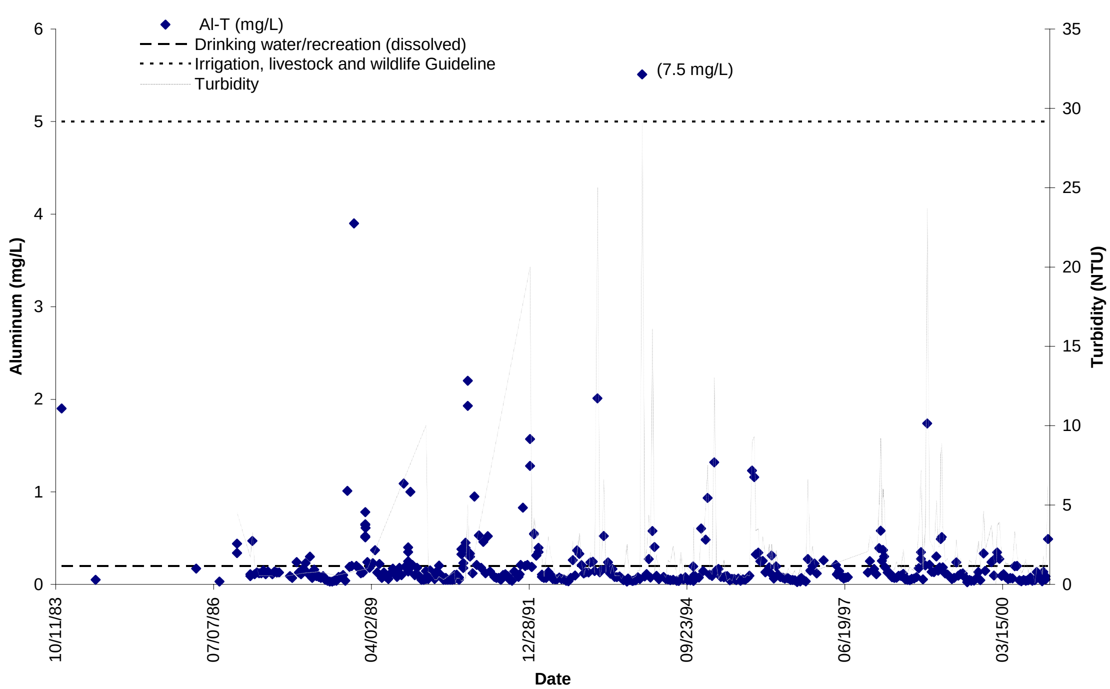

**Figure 5. Quinsam River Near the Mouth - Ammonia**

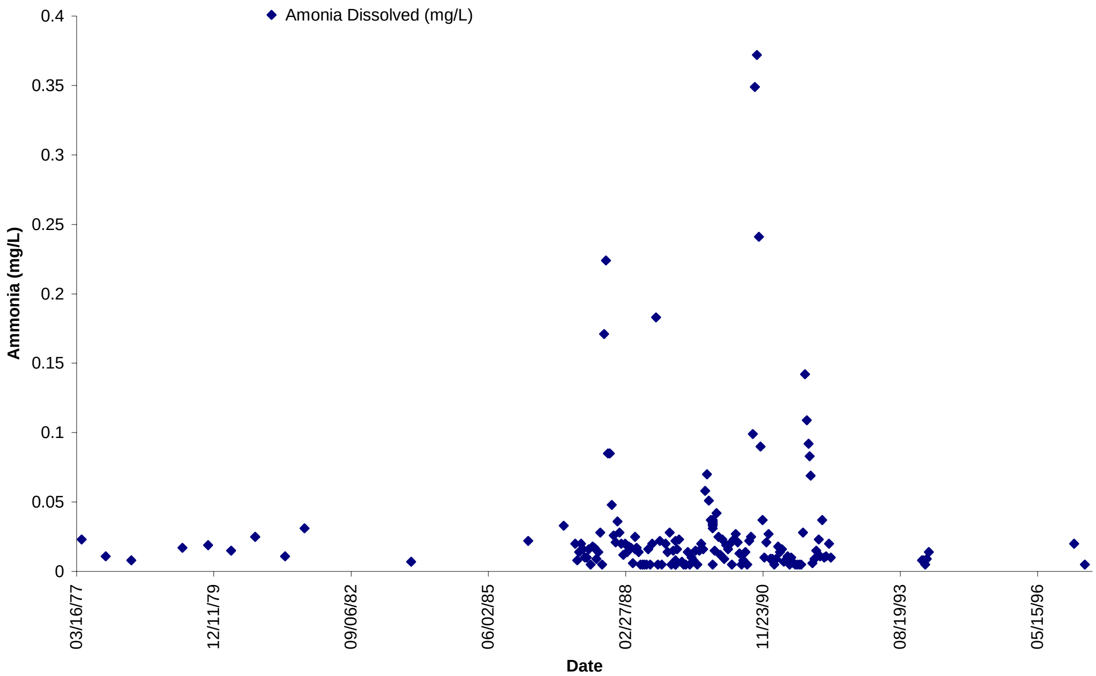


**Figure 6. Quinsam River Near the Mouth - Arsenic, Total**

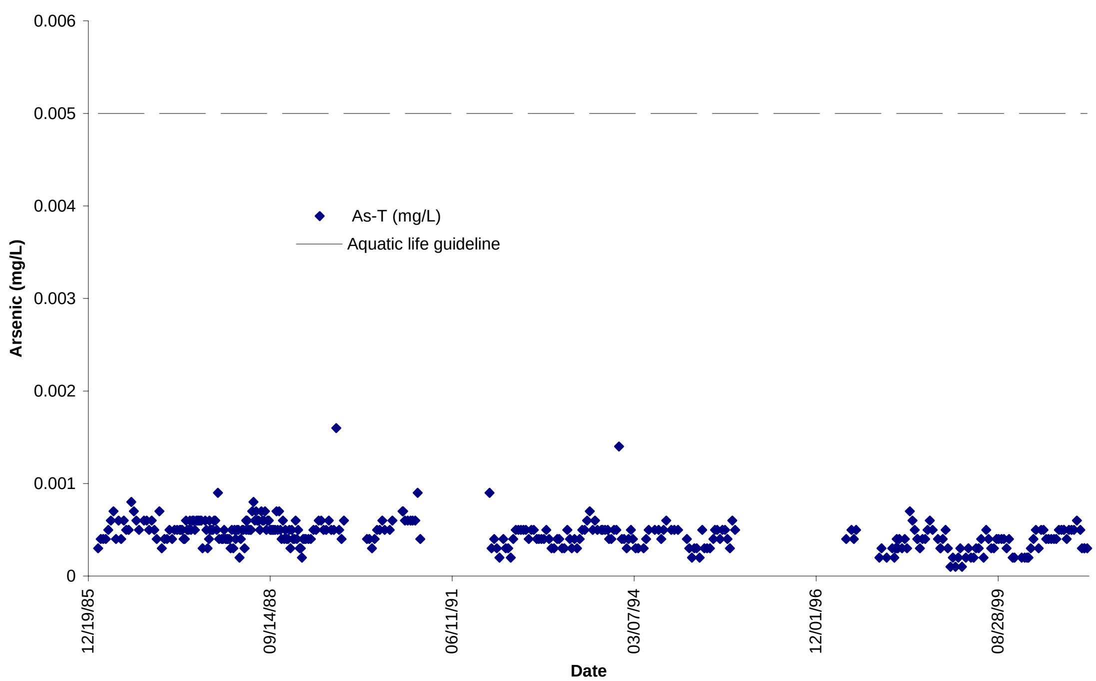

**Figure 7. Quinsam River Near the Mouth - Barium**

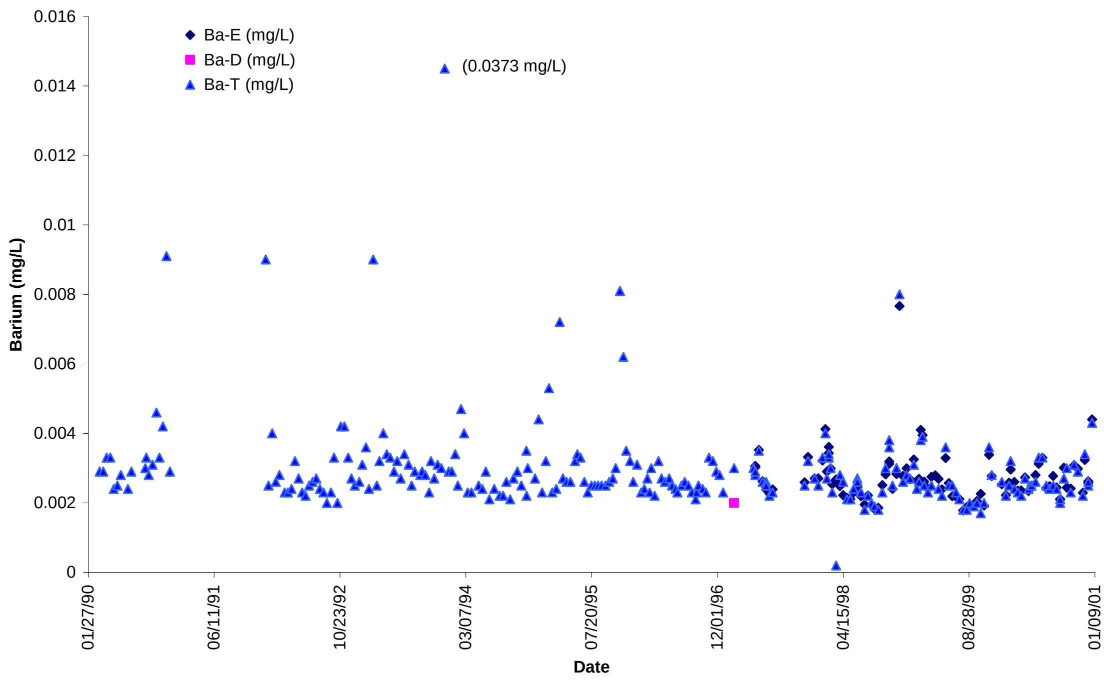


**Figure 8. Quinsam River Near the Mouth - Beryllium**

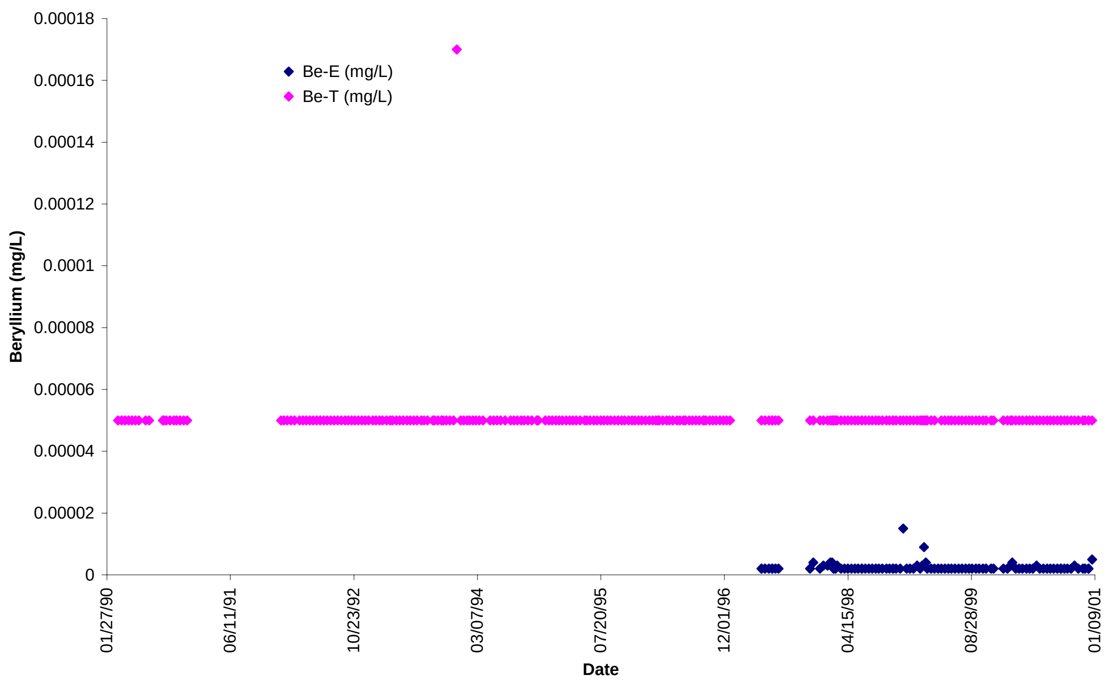

**Figure 9. Quinsam River Near the Mouth - Boron**

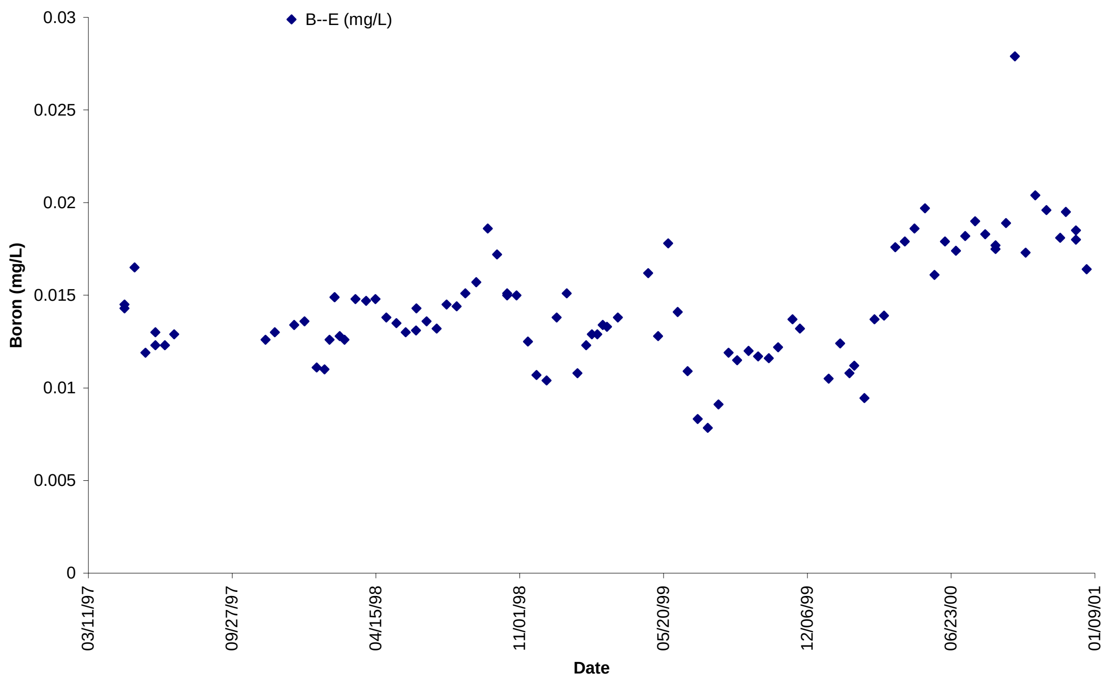


**Figure 10. Quinsam River Near the Mouth - Bromide**

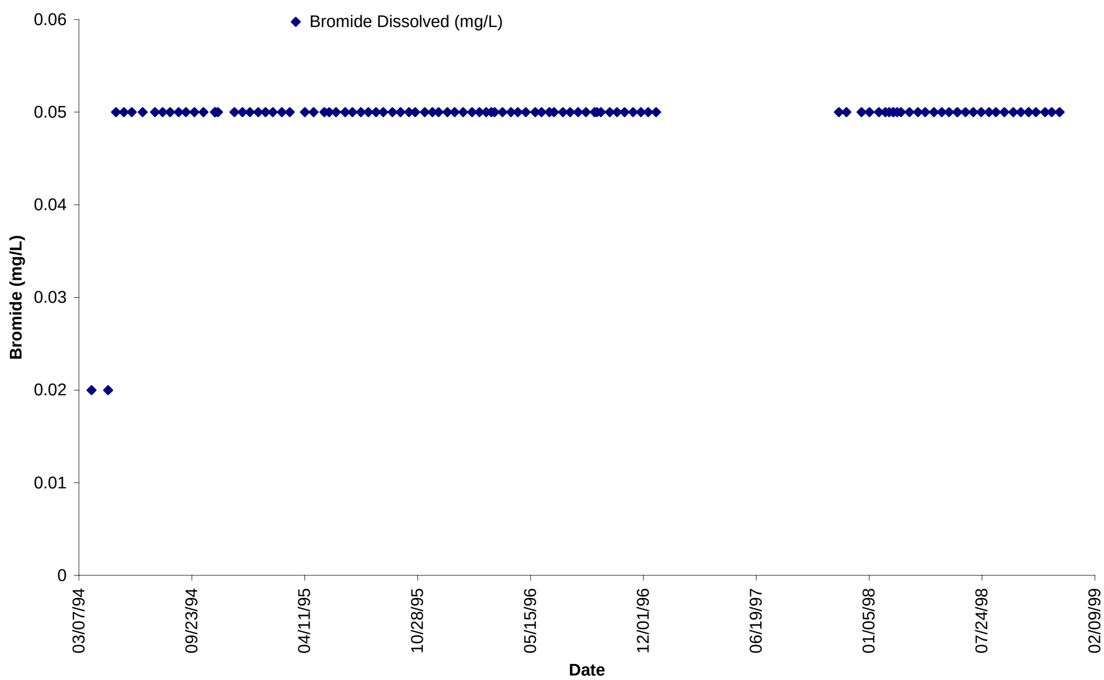

**Figure 11. Quinsam River Near the Mouth - Cadmium**

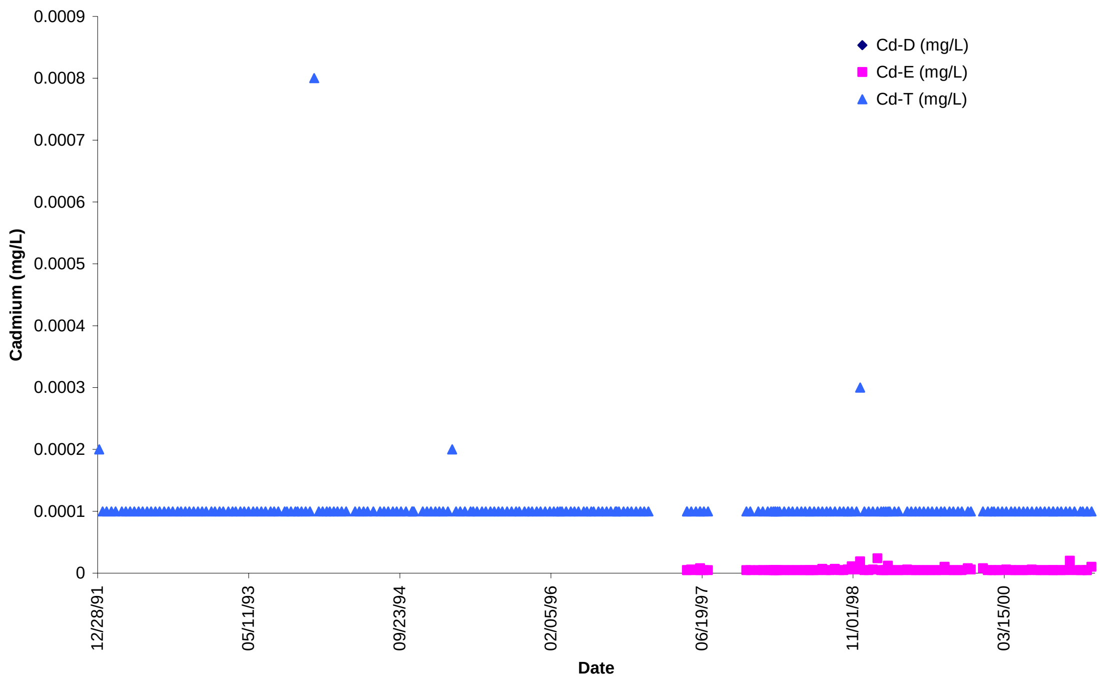


**Figure 12. Quinsam River Near the Mouth - Calcium**

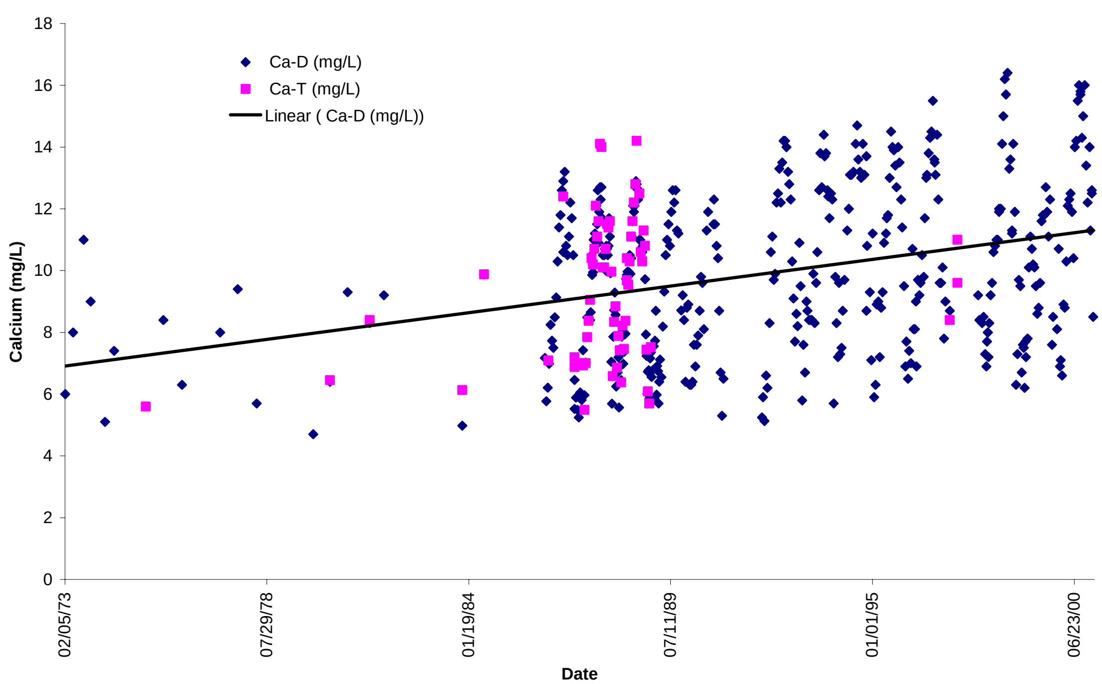

**Figure 13. Quinsam River Near the Mouth - Carbon, Dissolved Organic**

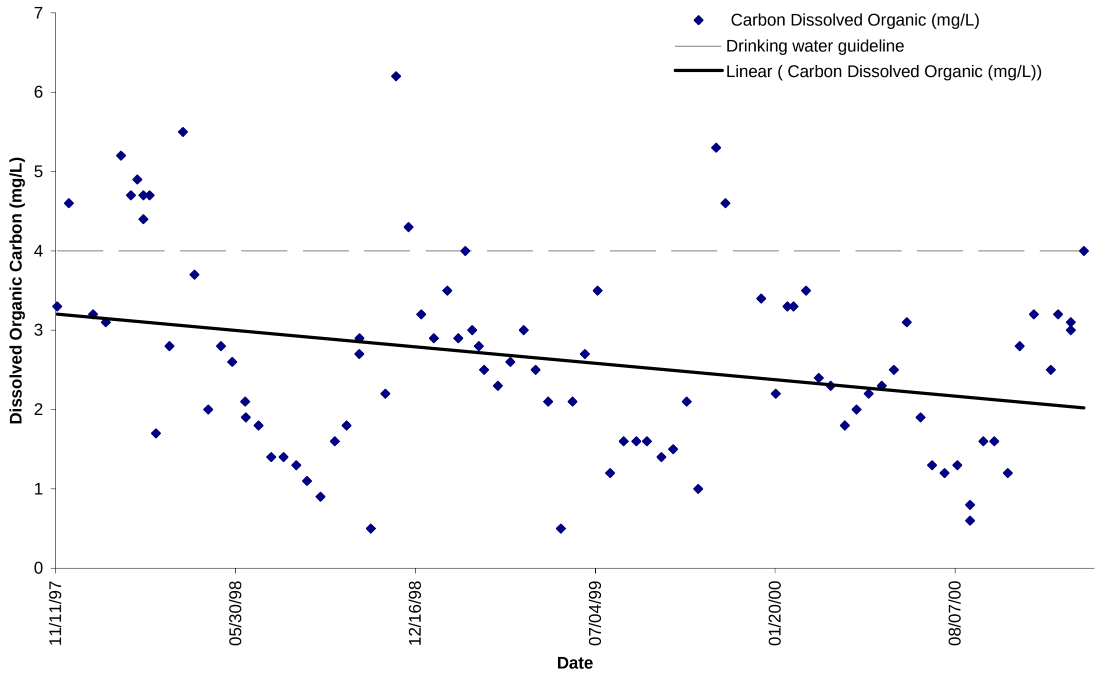


**Figure 14. Quinsam River Near the Mouth - Chloride**

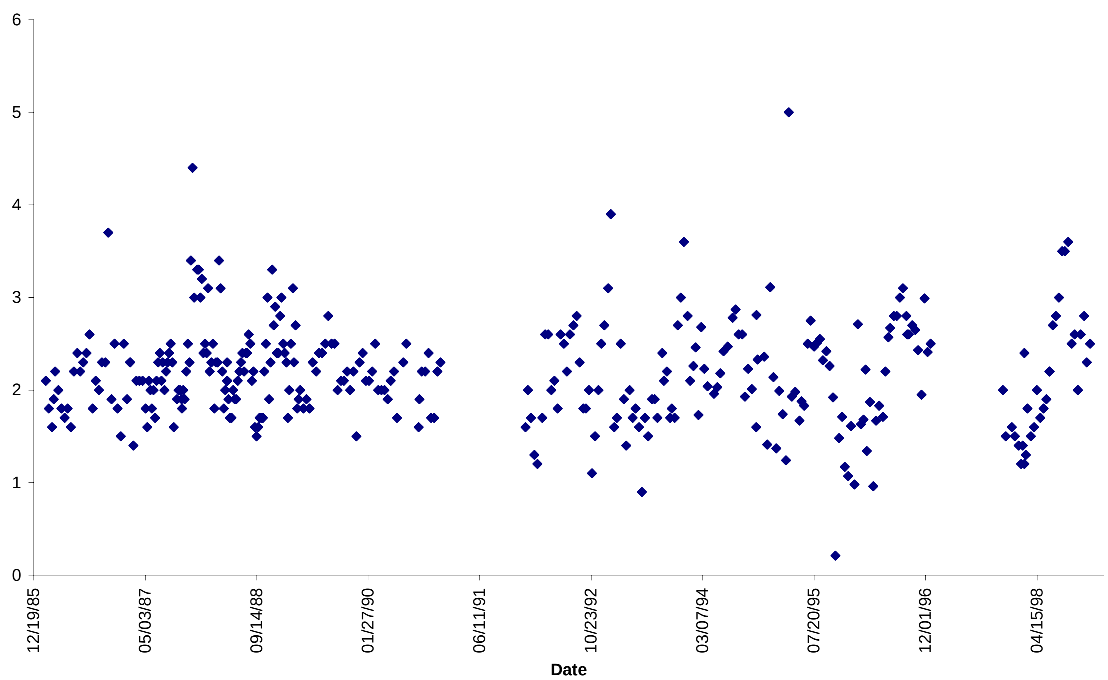

**Figure 15. Quinsam River Near the Mouth - Chromium and Turbidity**

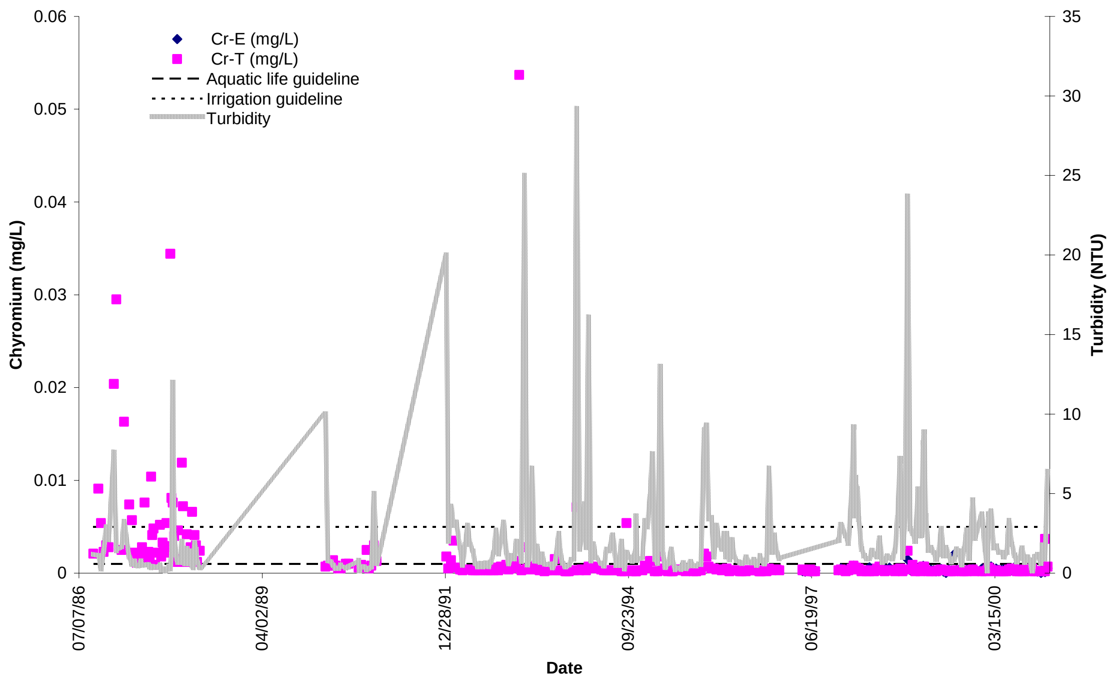


**Figure 16. Quinsam River Near the Mouth - Cobalt**

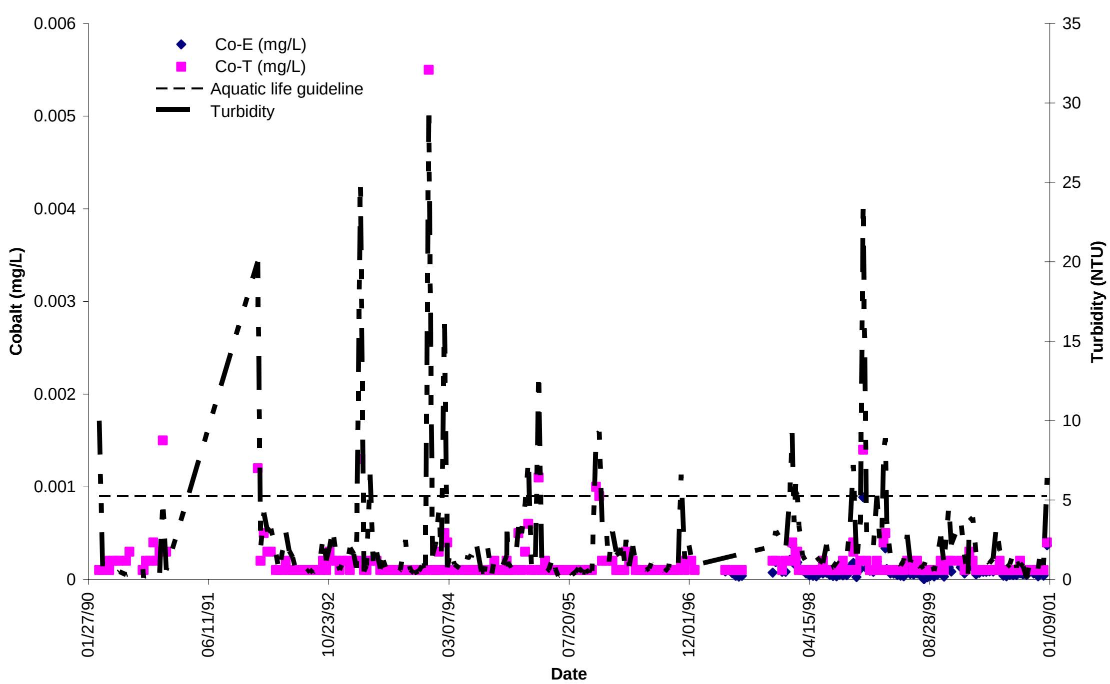

**Figure 17. Quinsam River Near the Mouth - Coliforms, Fecal**

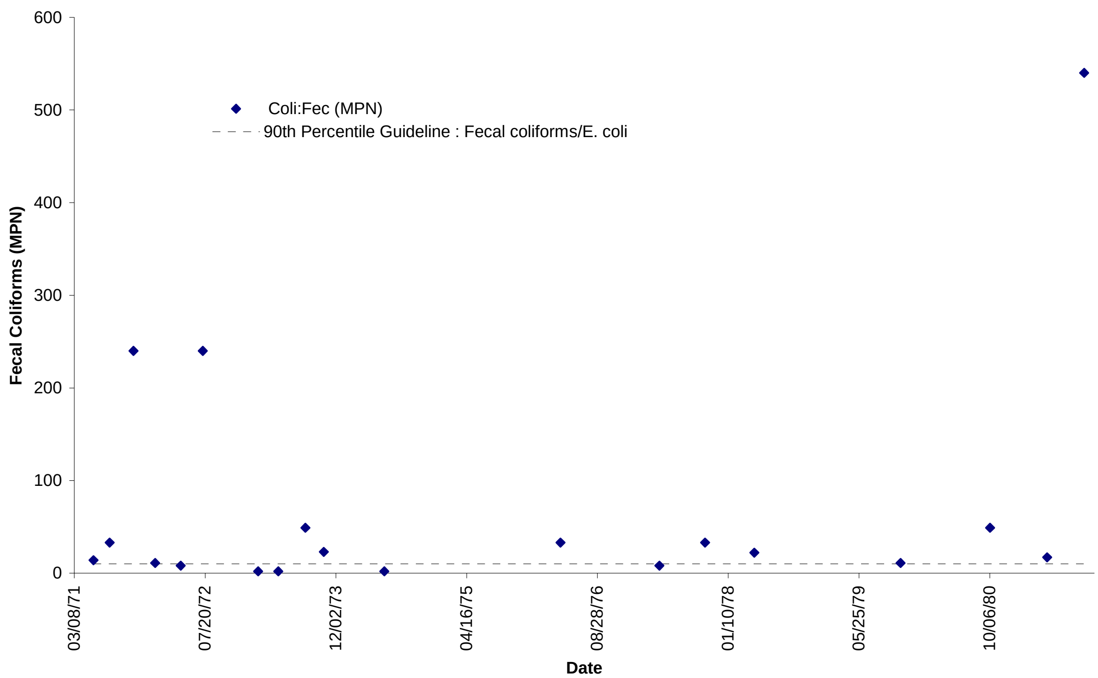


**Figure 18. Quinsam River Near the Mouth - Coliforms, Total**

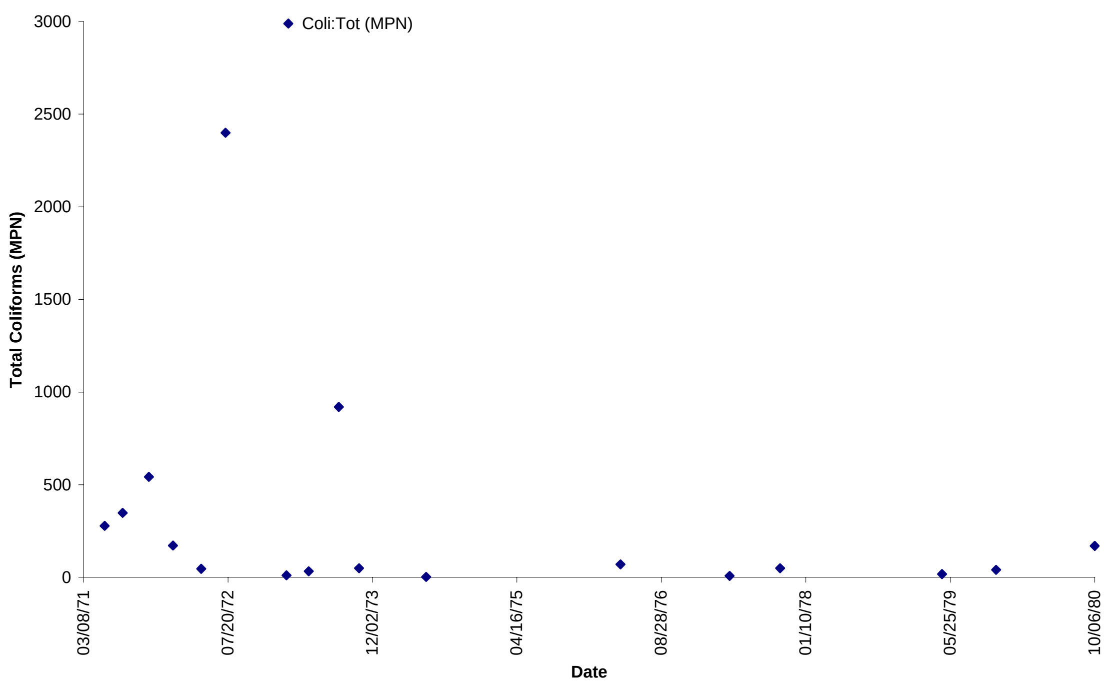

**Figure 19. Quinsam River Near the Mouth - Colour**

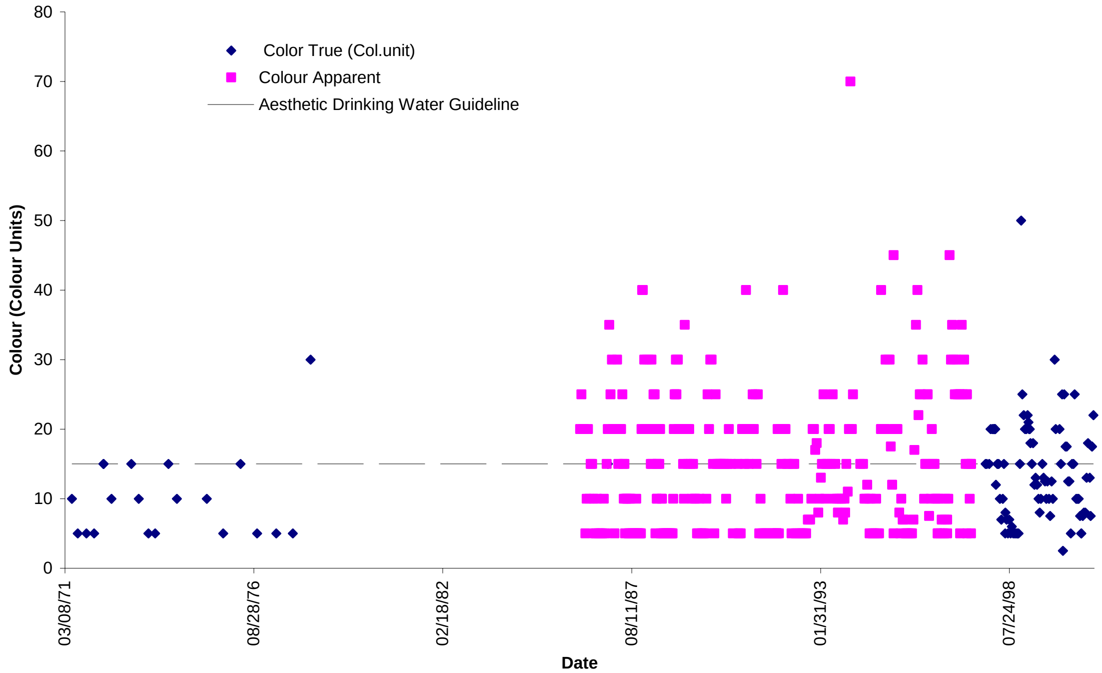


**Figure 20. Quinsam River Near the Mouth - Conductivity, Specific**

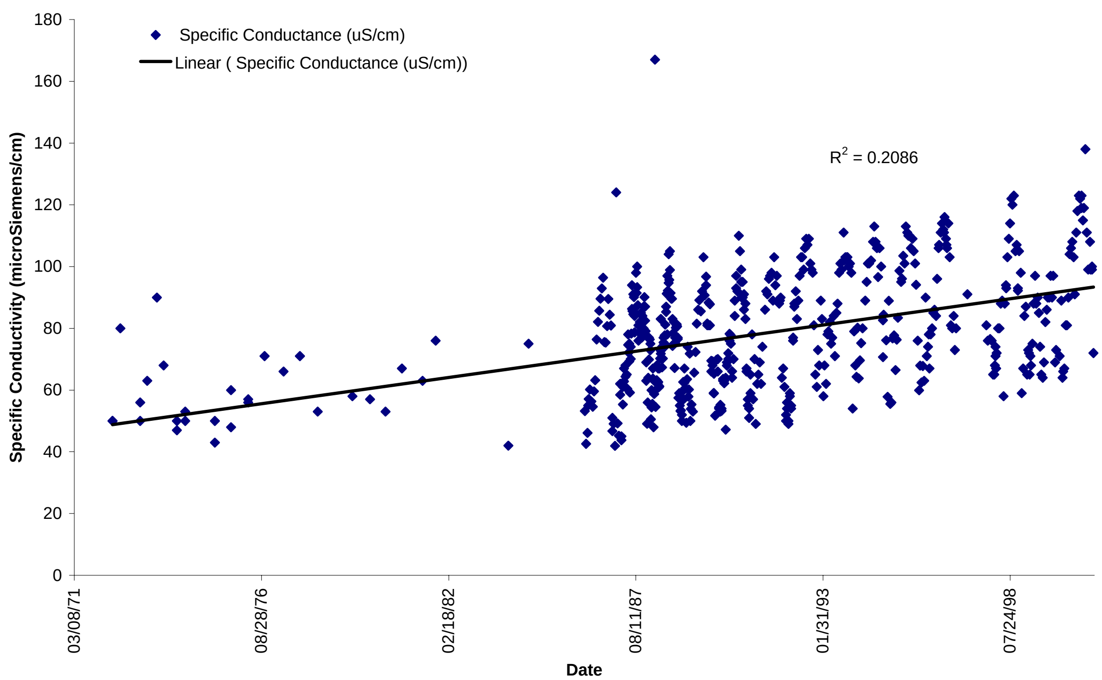

**Figure 21. Quinsam River Near the Mouth - Copper**

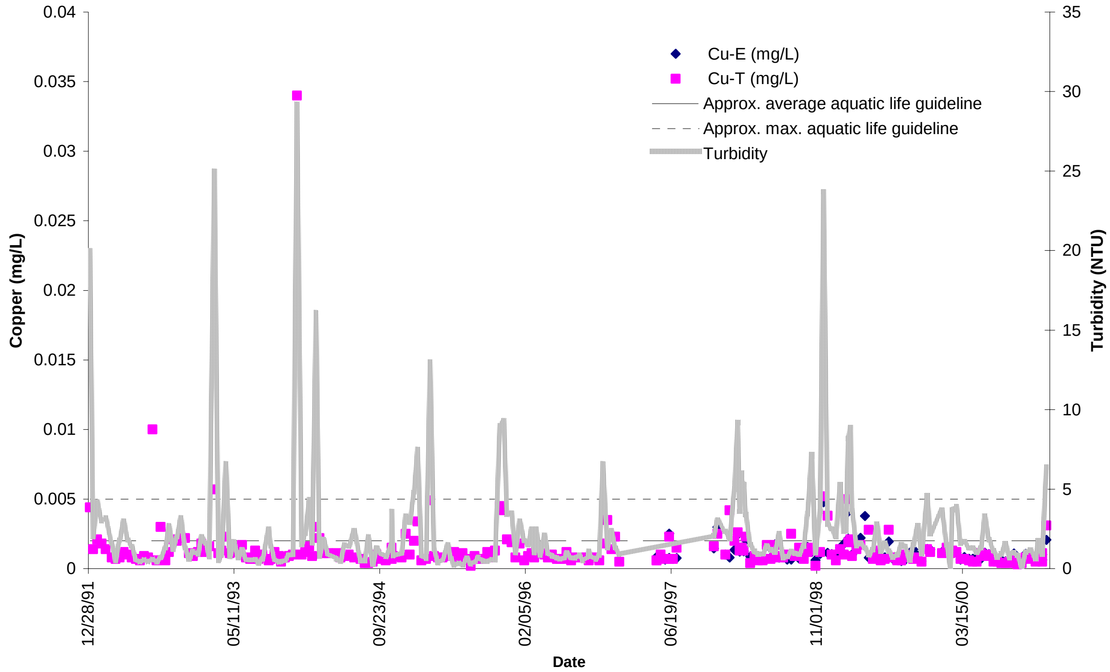


**Figure 22. Quinsam River Near the Mouth - Fluoride**

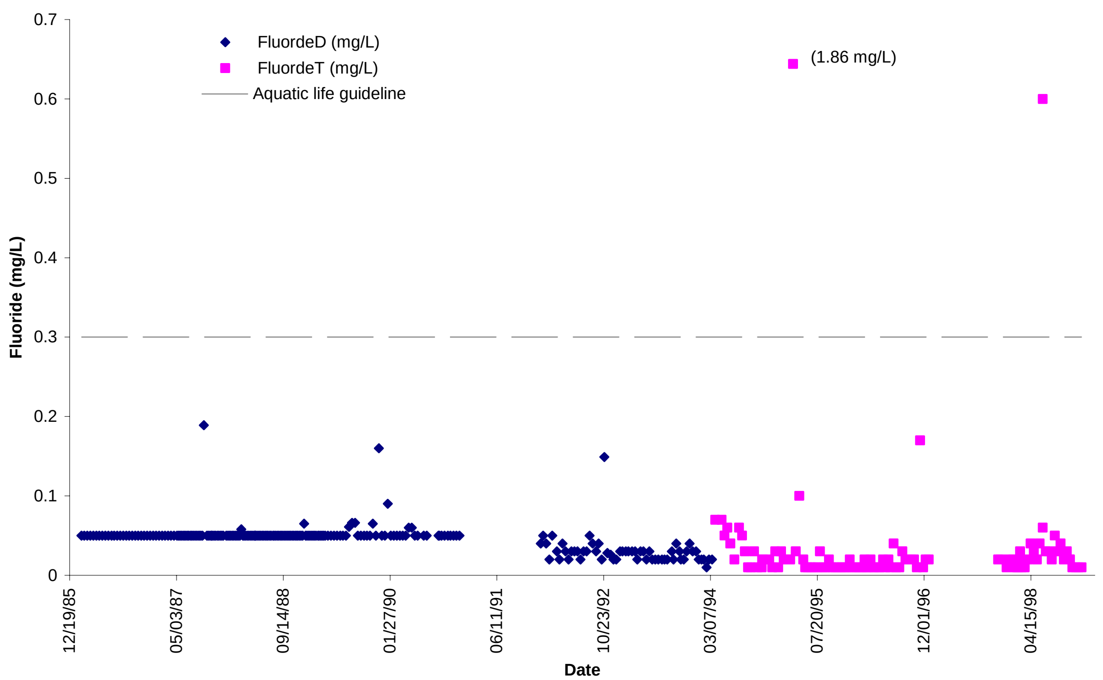

**Figure 23. Quinsam River Near the Mouth - Hardness**

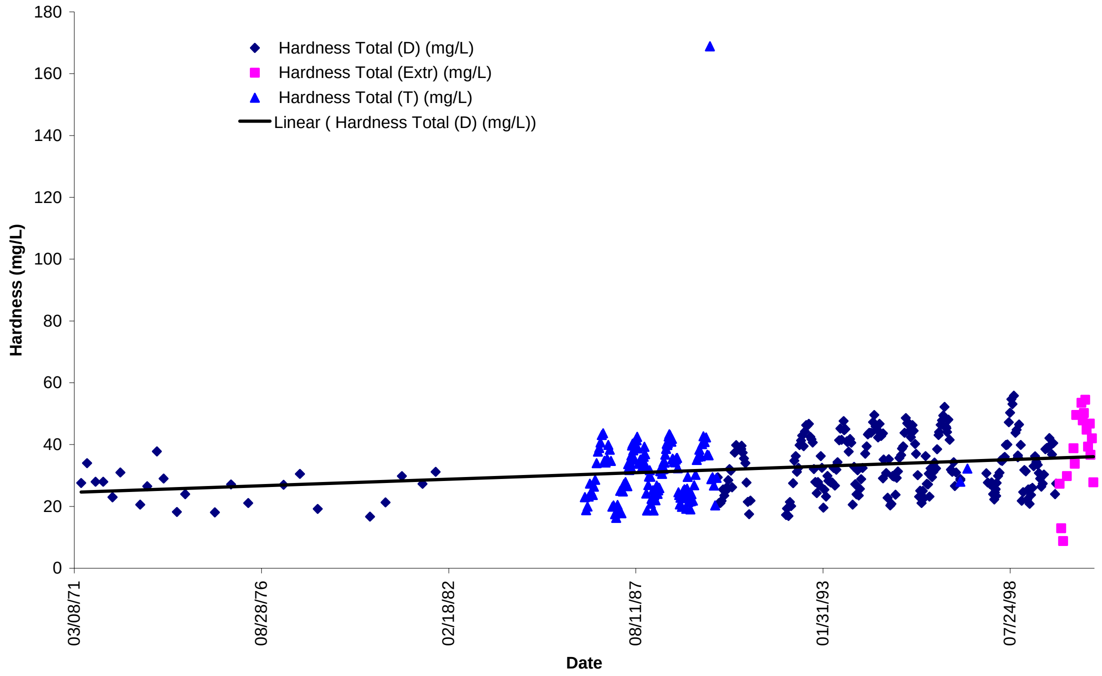


**Figure 24. Quinsam River Near the Mouth - Iron**

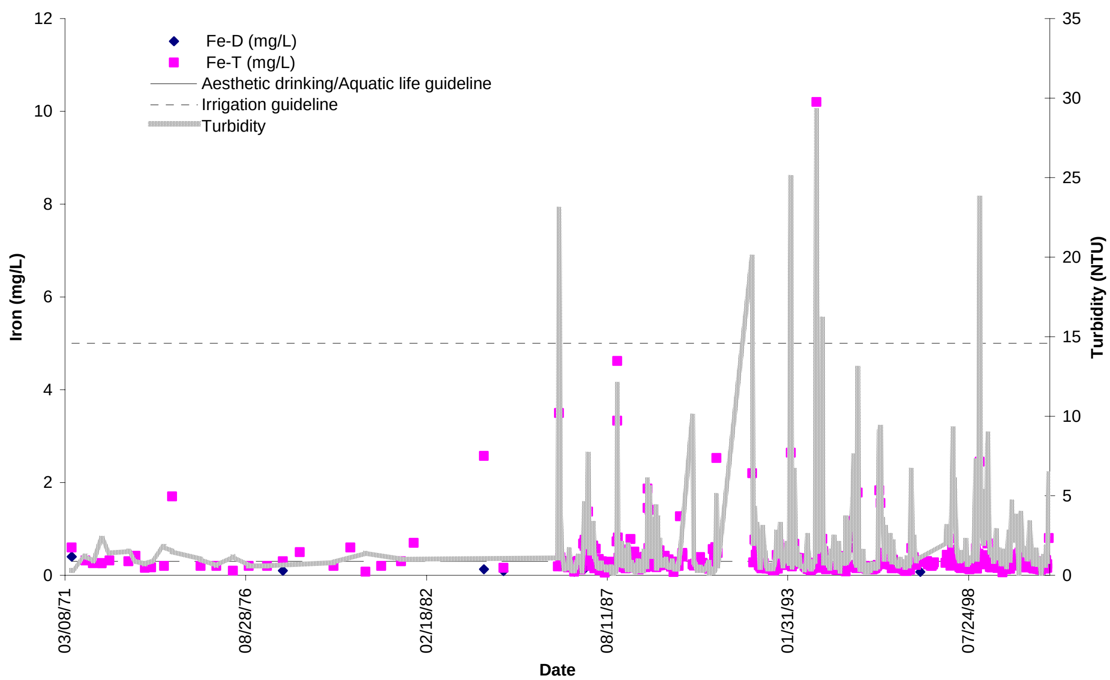

**Figure 25. Quinsam River Near the Mouth - Lead**

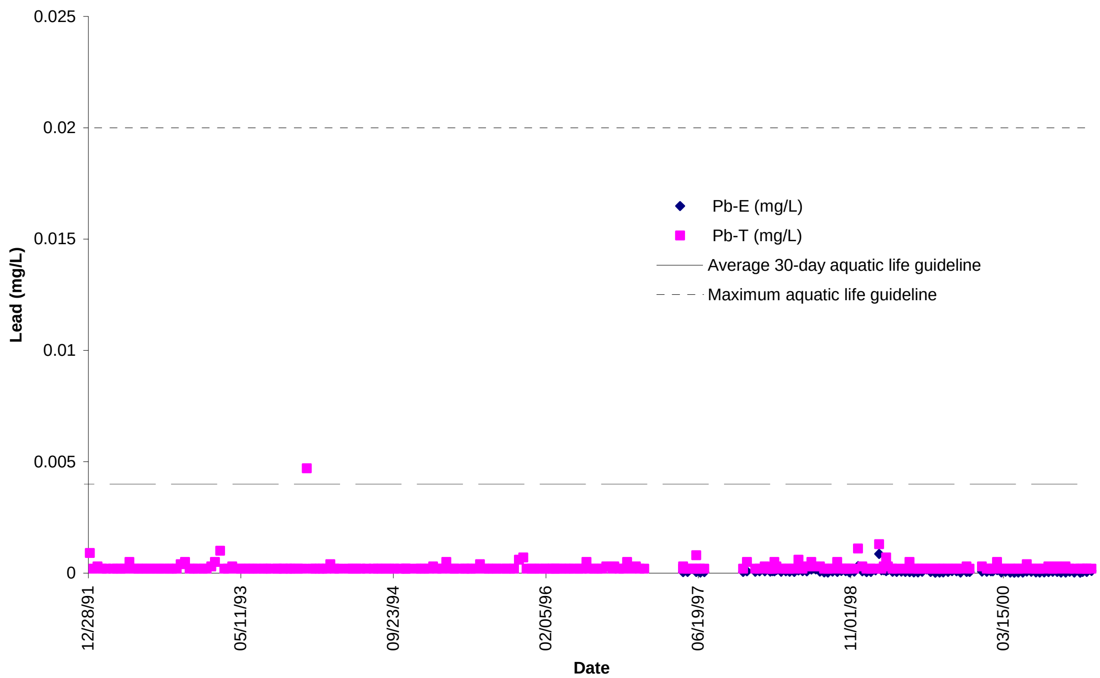


**Figure 26. Quinsam River Near the Mouth - Silver**

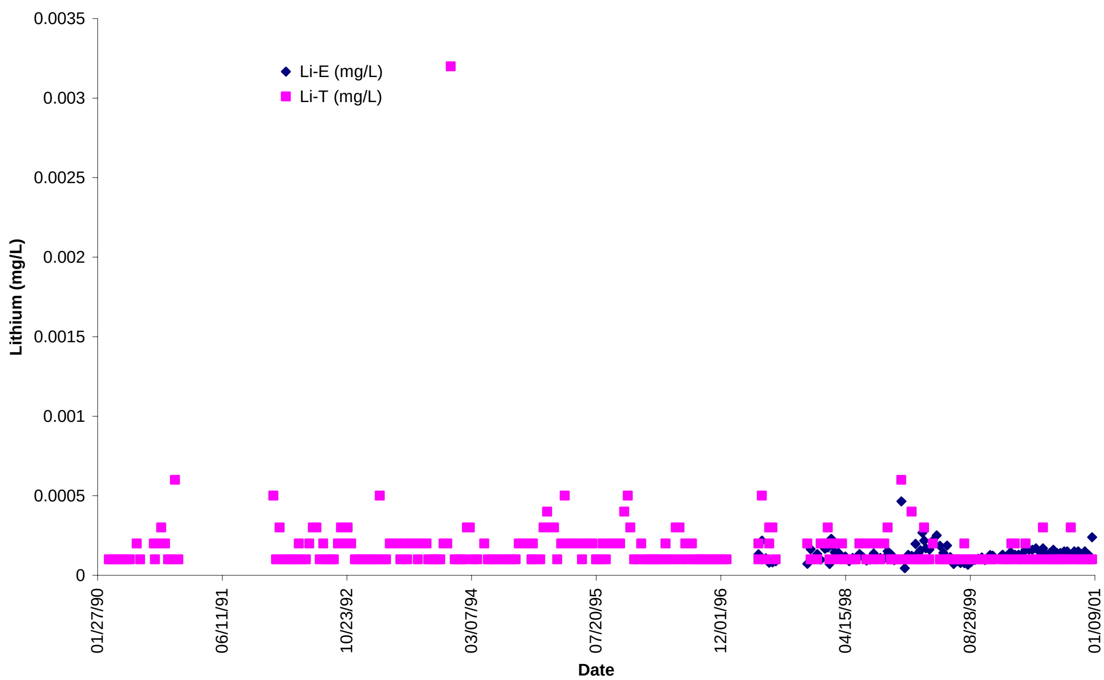

**Figure 27. Quinsam River Near the Mouth - Magnesium**

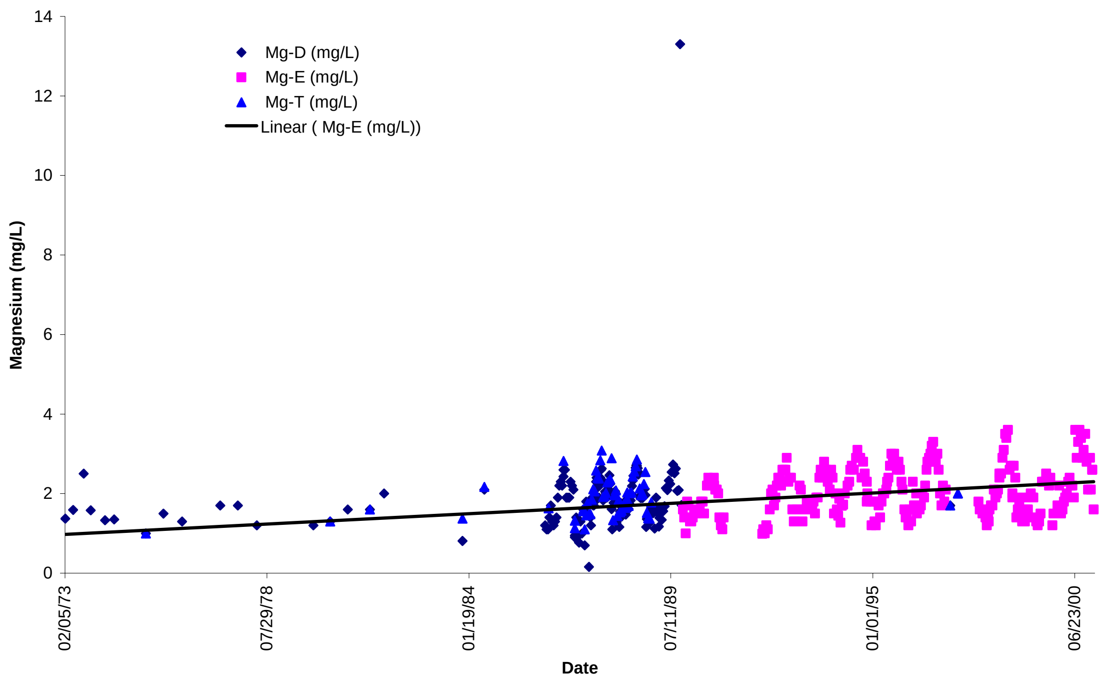


**Figure 28. Quinsam River Near the Mouth - Manganese**

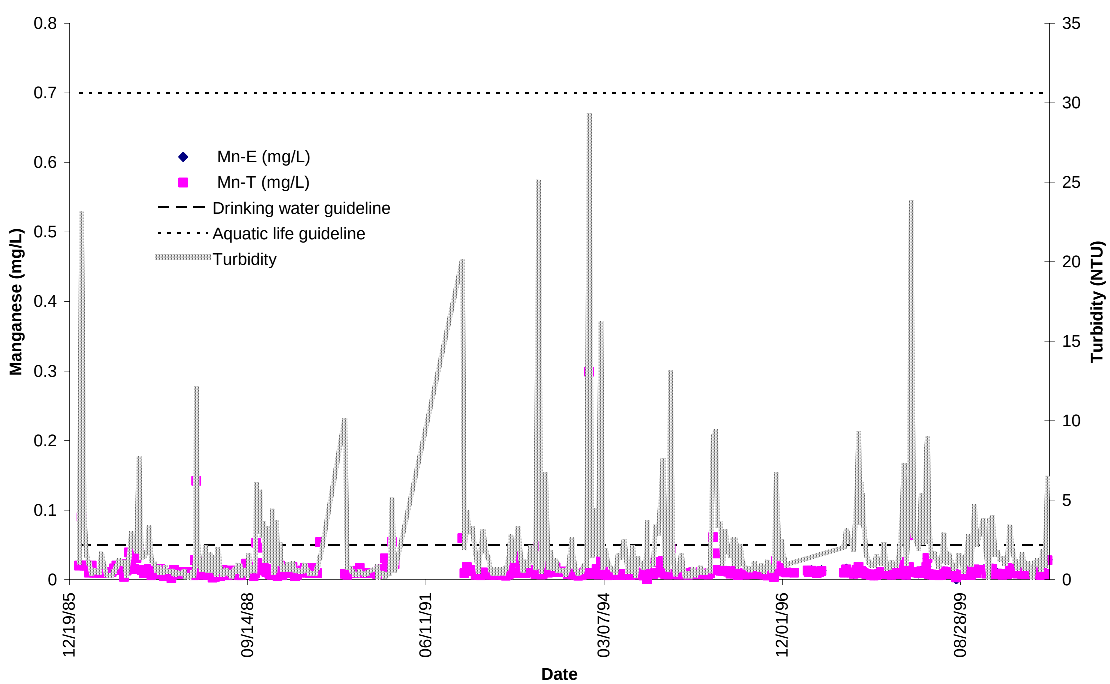

**Figure 29. Quinsam River Near the Mouth - Molybdenum**

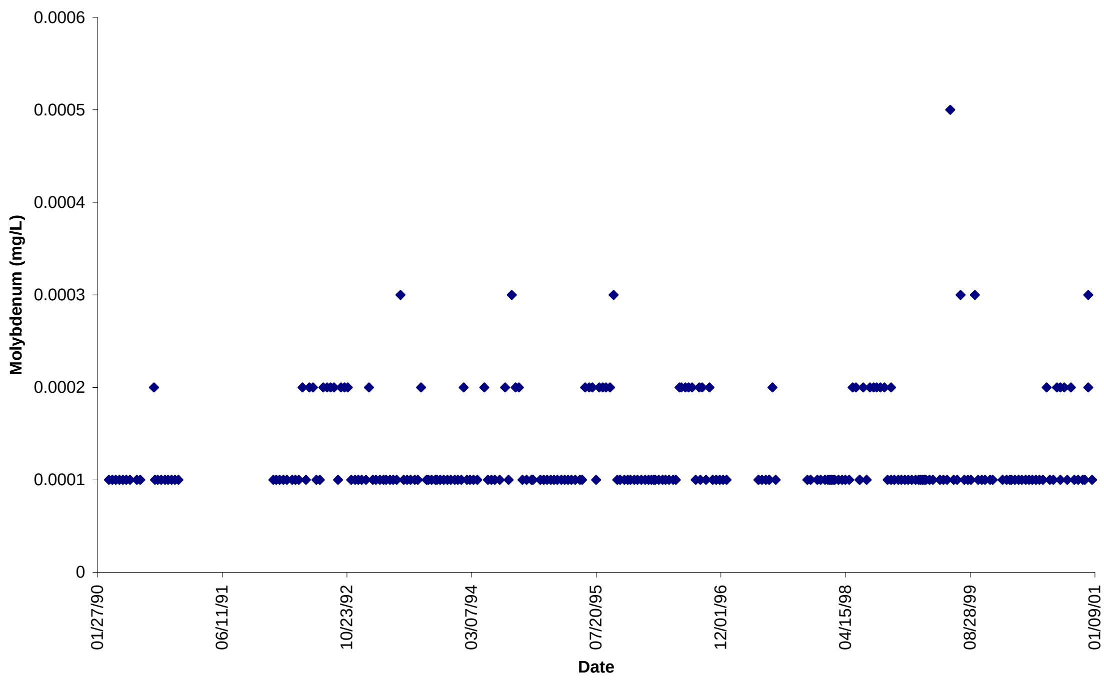


**Figure 30. Quinsam River Near the Mouth - Nickel**

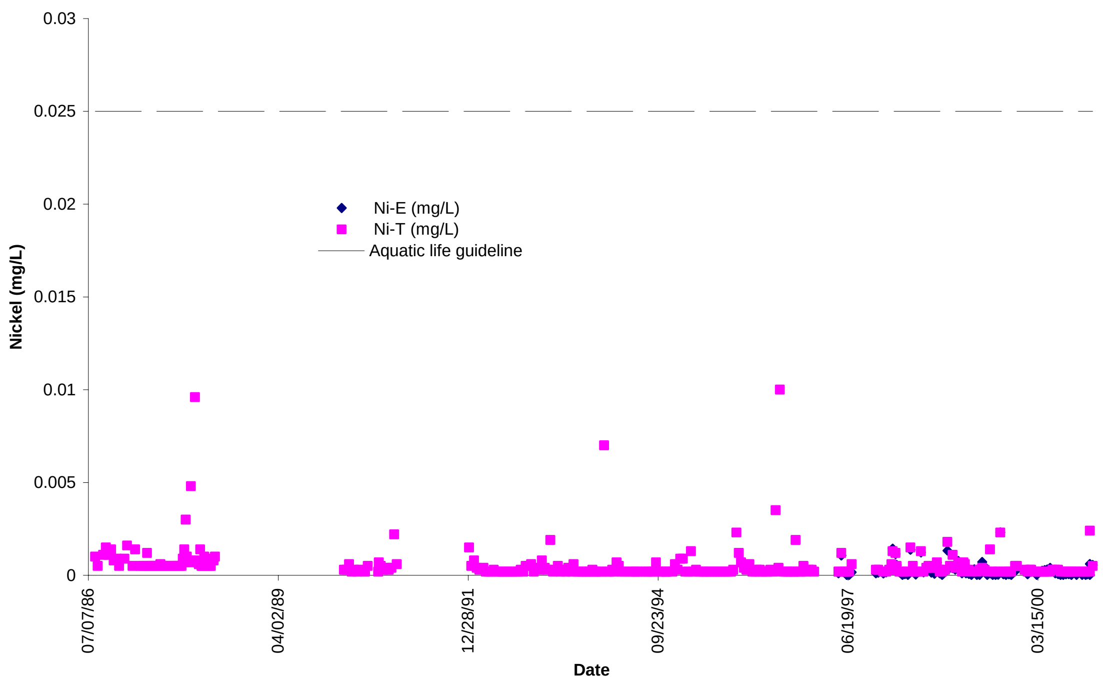

**Figure 31. Quinsam River Near the Mouth - Nitrate**

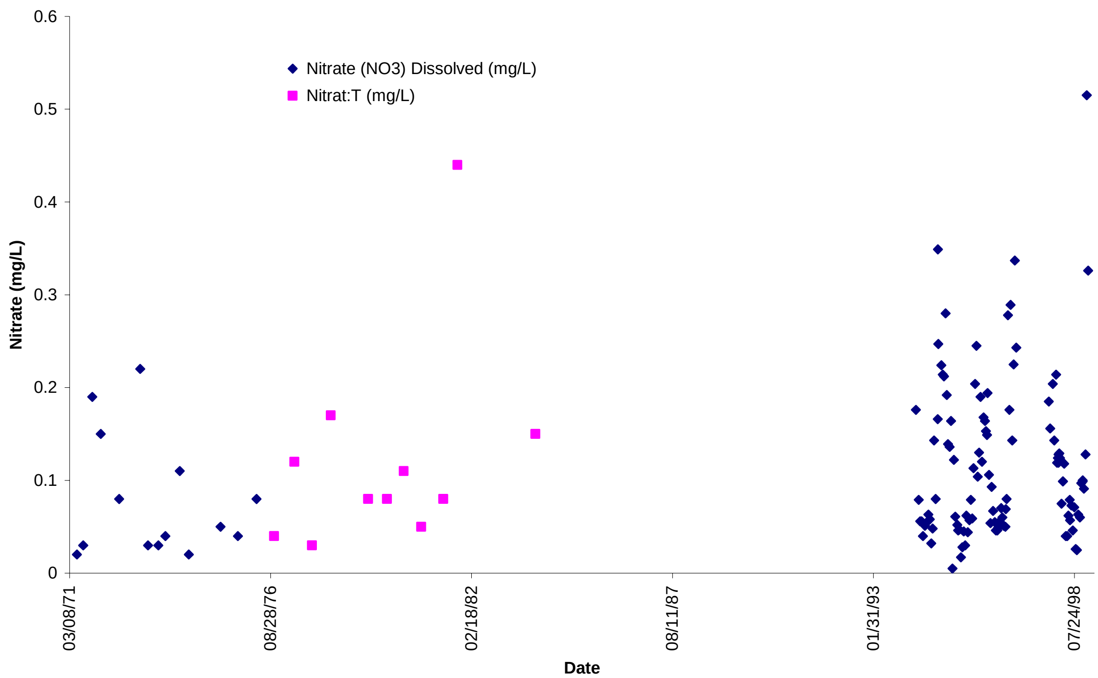


**Figure 32. Quinsam River Near the Mouth - Nitrate + Nitrite**

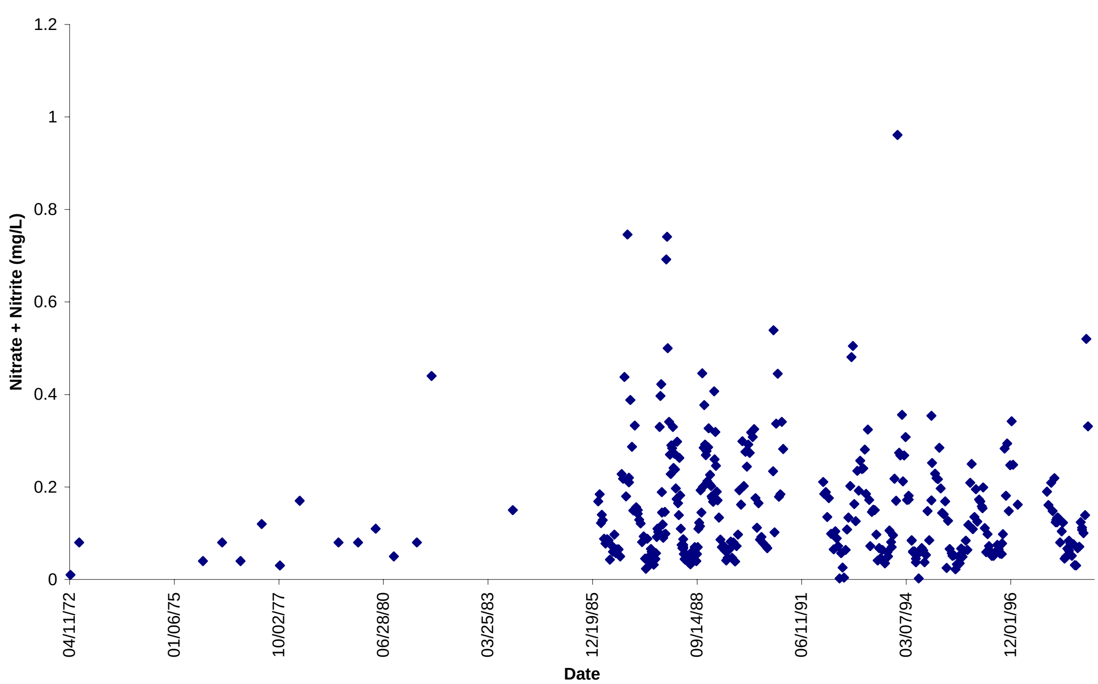

**Figure 33. Quinsam River Near the Mouth - Nitrite**

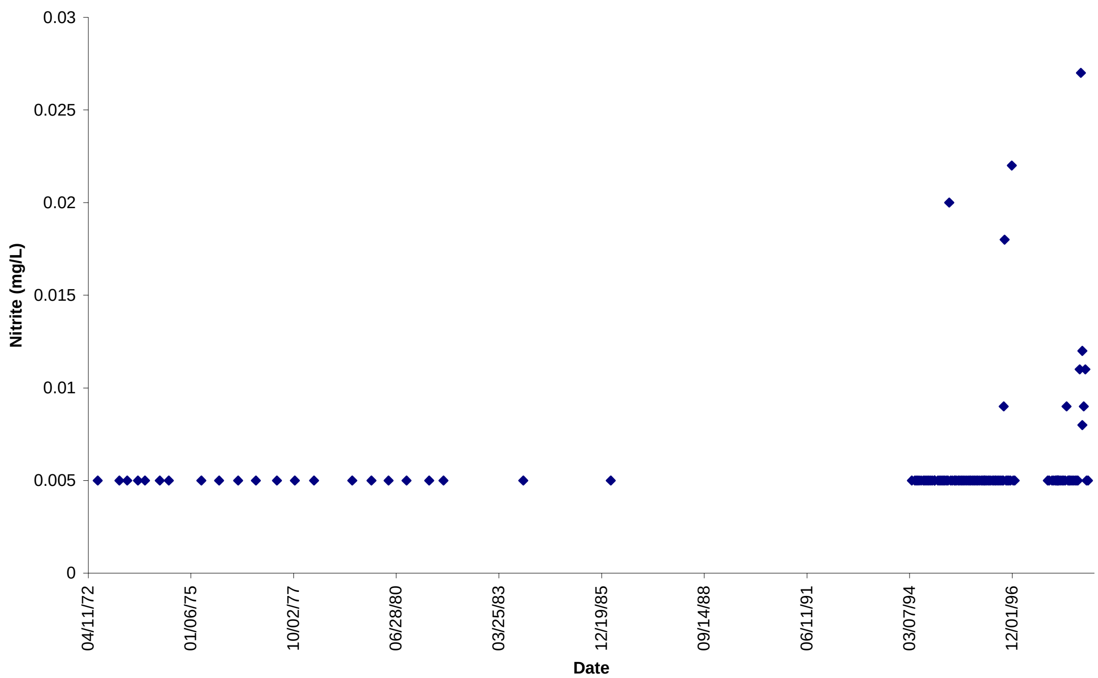


**Figure 34. Quinsam River Near the Mouth - Nitrogen**

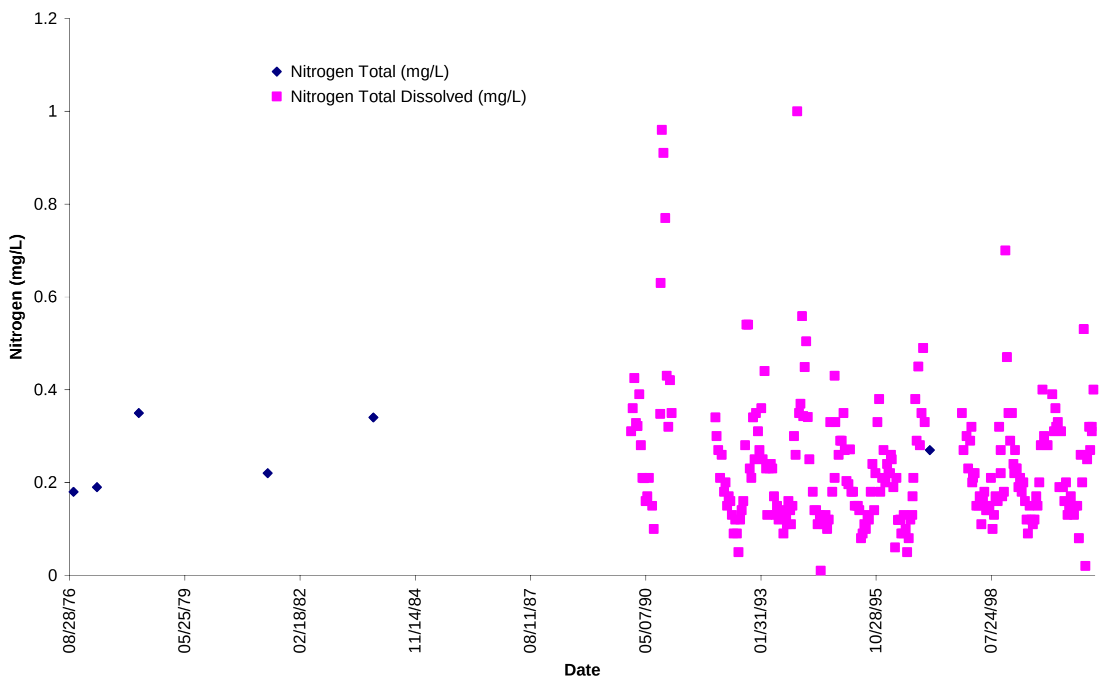

**Figure 35. Quinsam River Near the Mouth - Nitrogen, Kjeldahl**

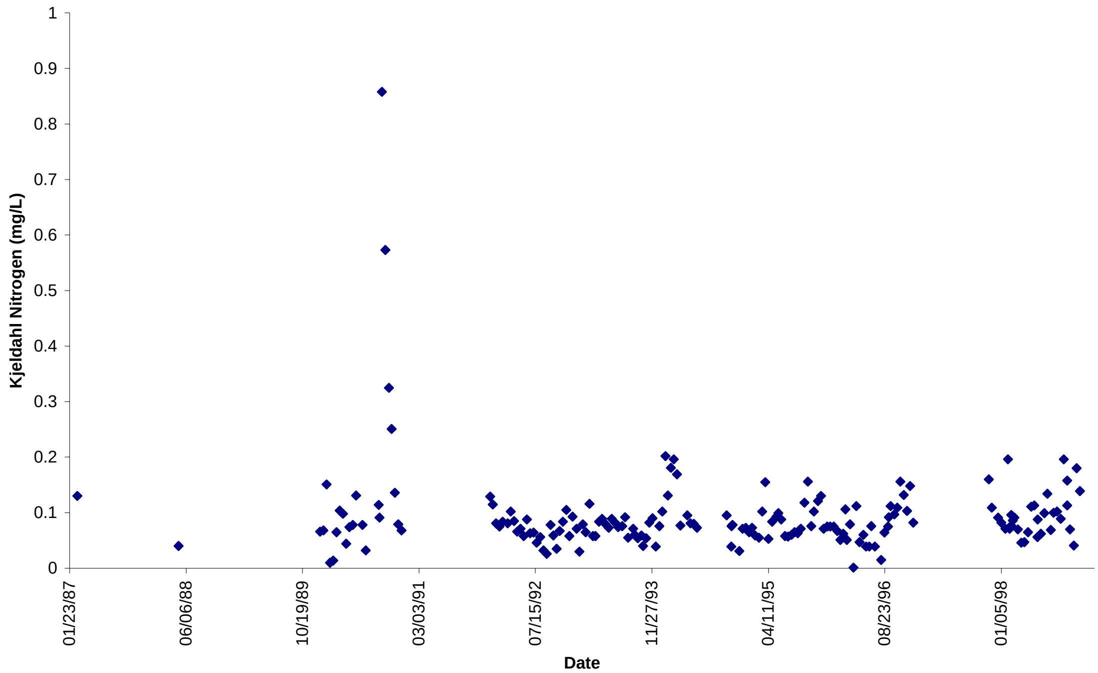


**Figure 36. Quinsam River Near the Mouth - Oxygen, Dissolved**

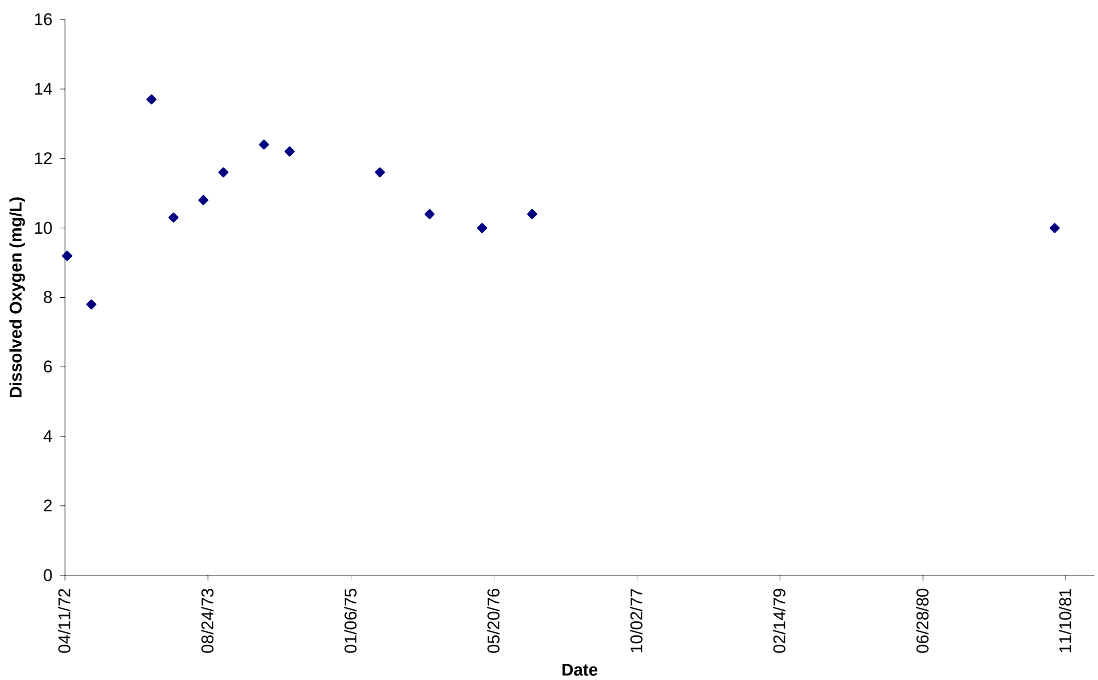

**Figure 37. Quinsam River Near the Mouth - pH**

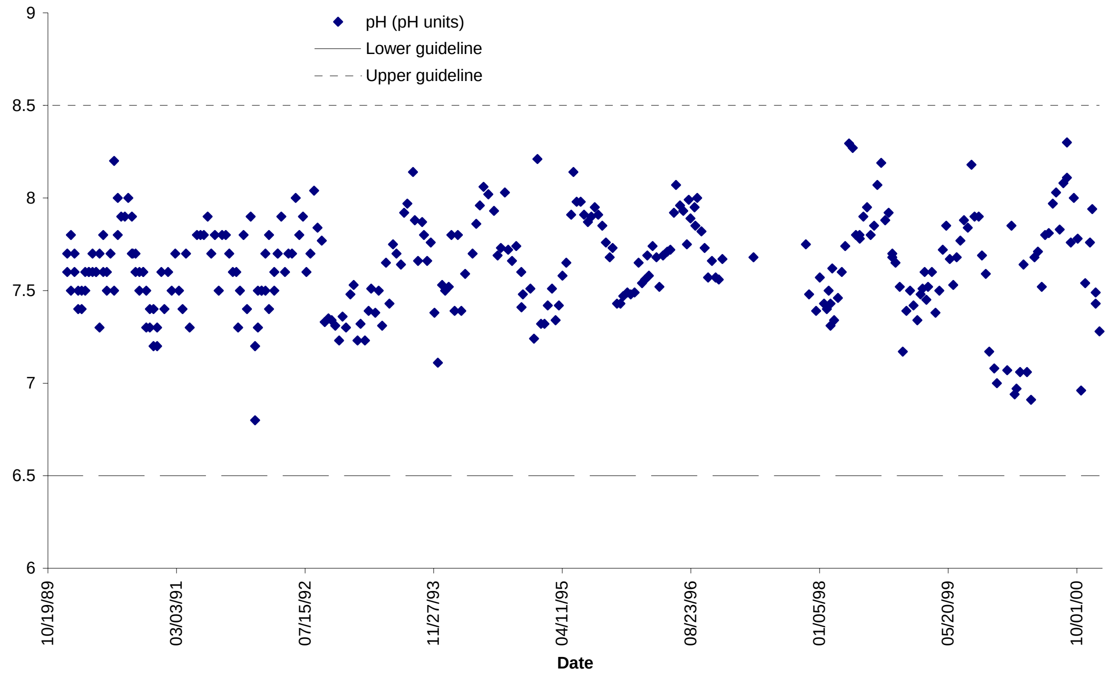


**Figure 38. Quinsam River Near the Mouth - Phosphorus**

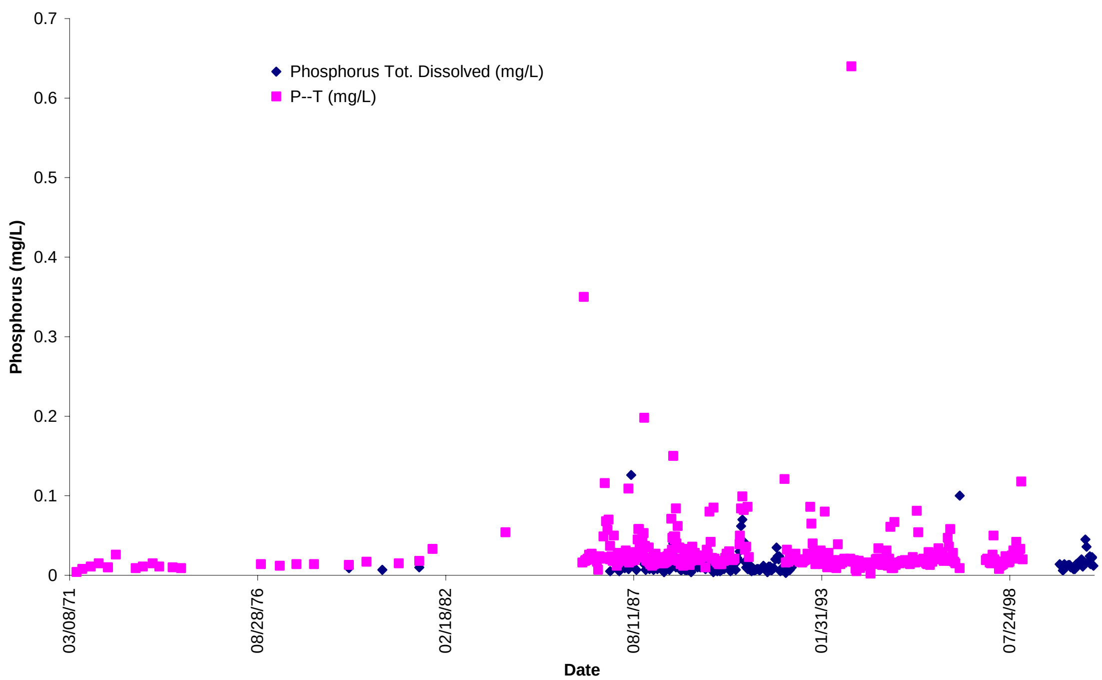

**Figure 39. Quinsam River Near the Mouth - Potassium**

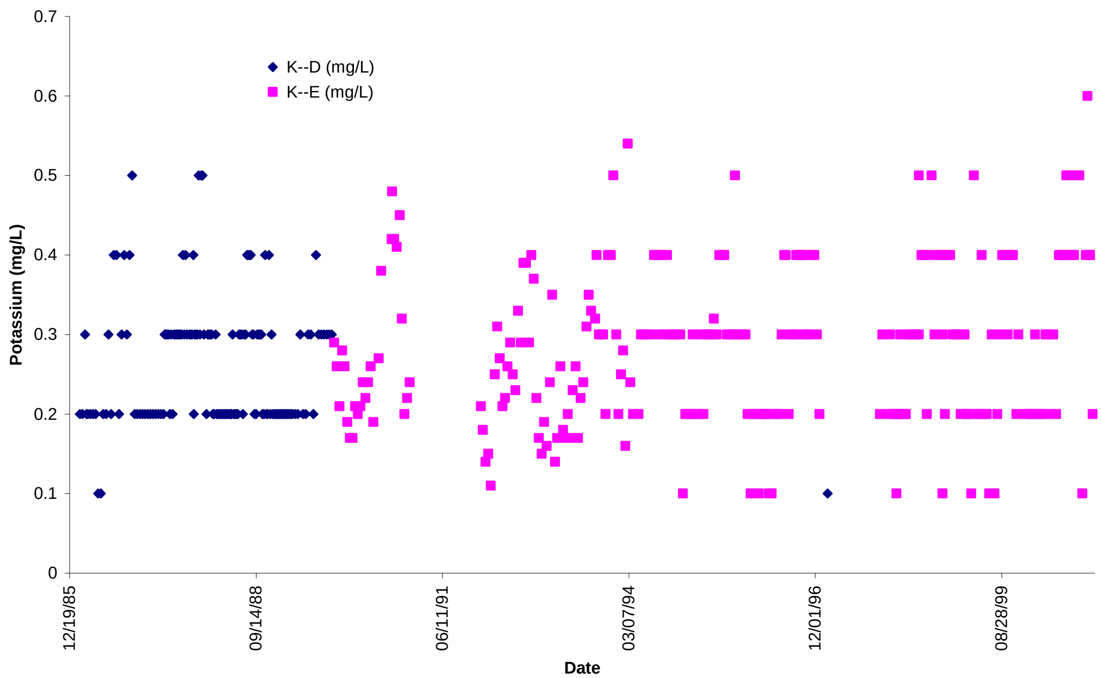


**Figure 40. Quinsam River Near the Mouth - Residue, Non-Filterable**

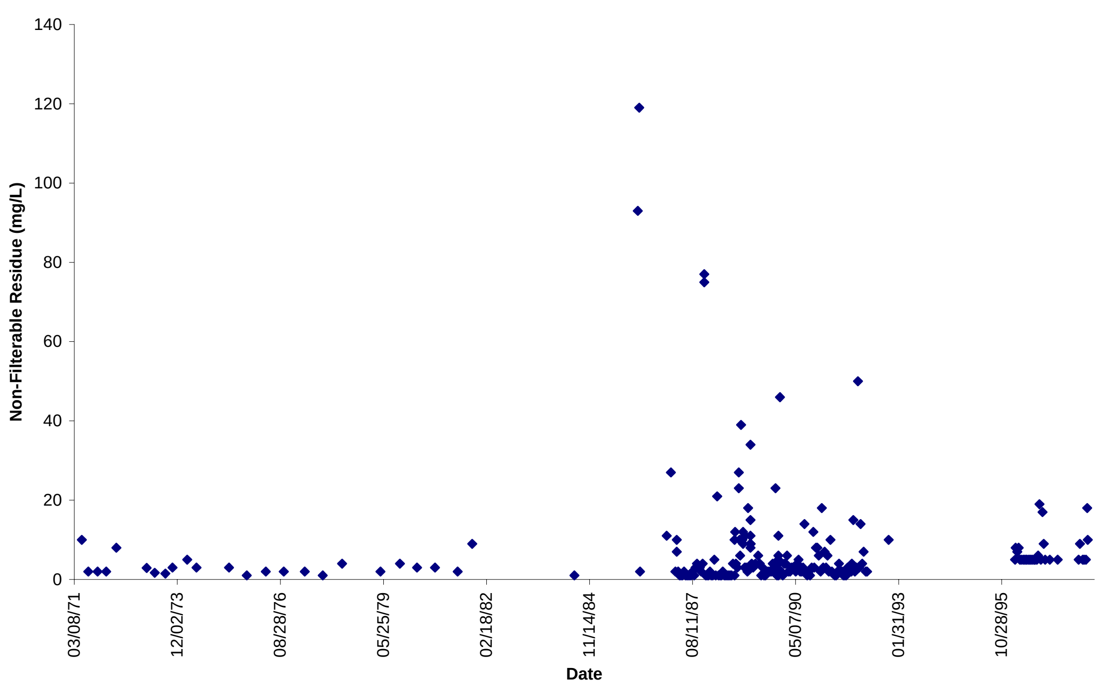

**Figure 41. Quinsam River Near the Mouth - Residue, Filterable**

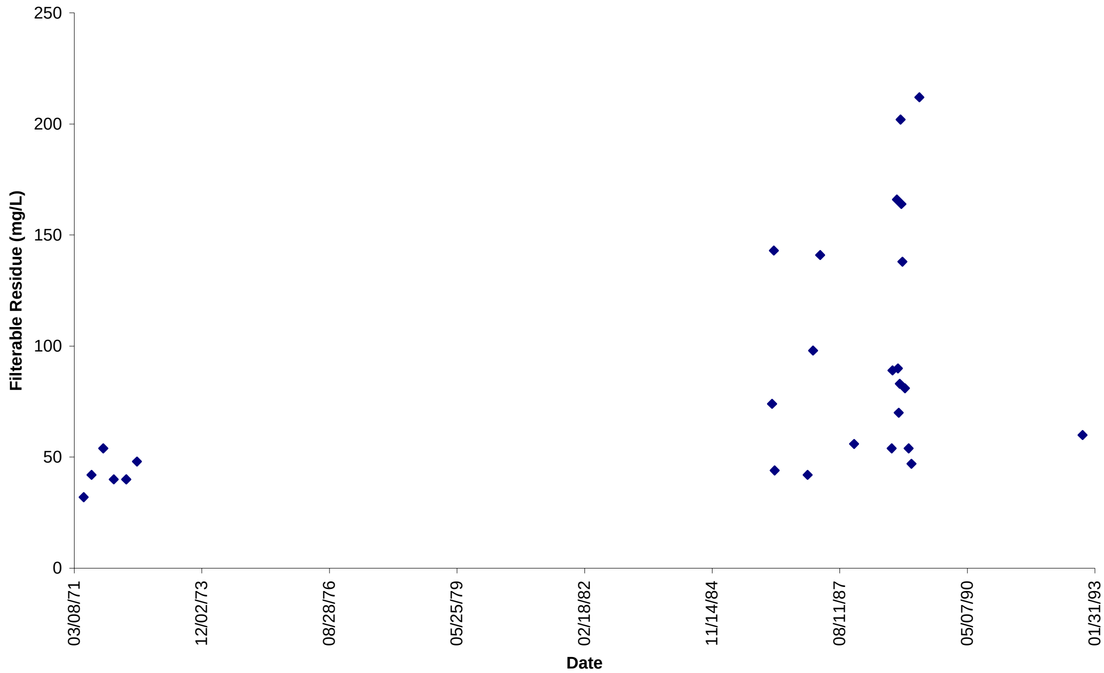


**Figure 42. Quinsam River Near the Mouth - Selenium**

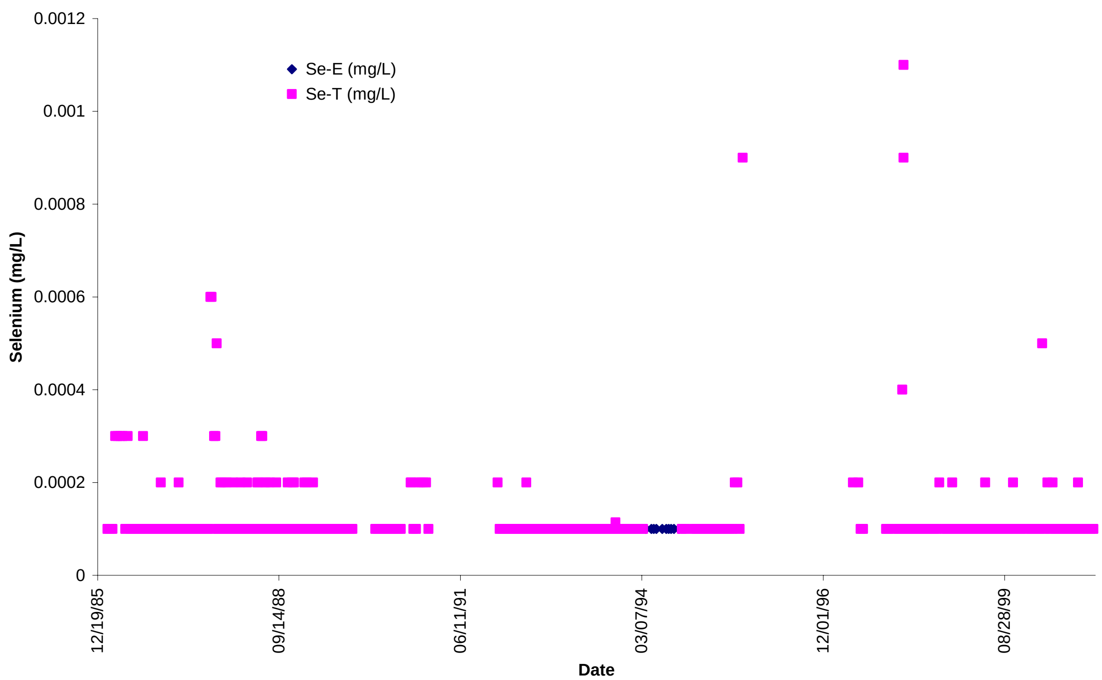

**Figure 43. Quinsam River Near the Mouth - Silica**

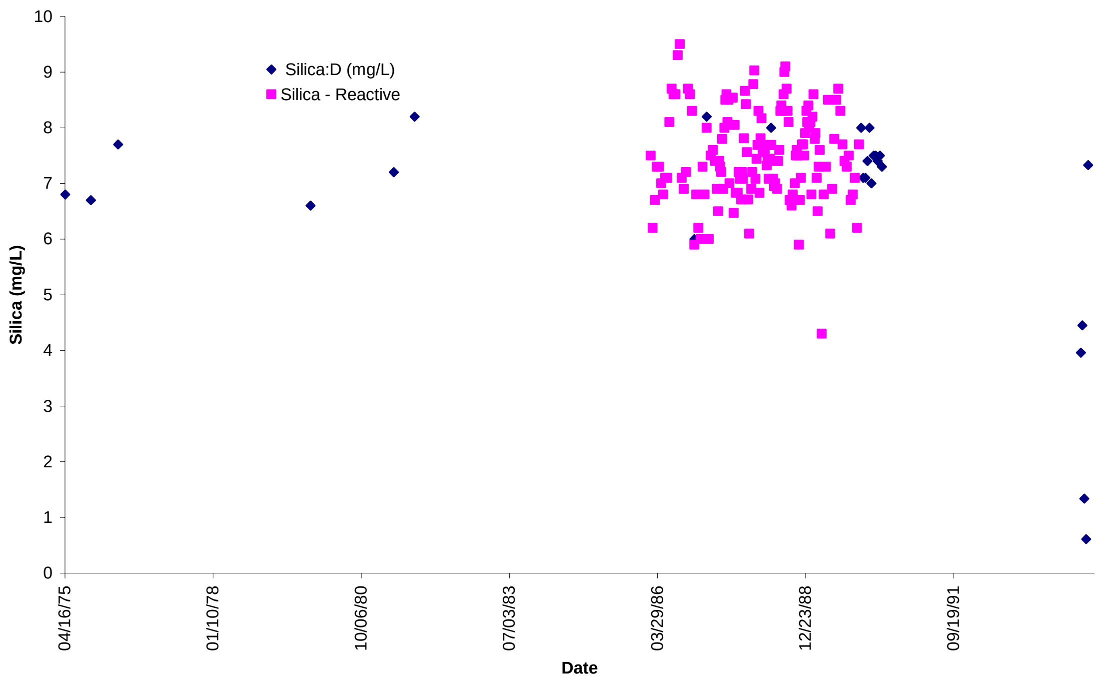


**Figure 44. Quinsam River Near the Mouth - Silicon**

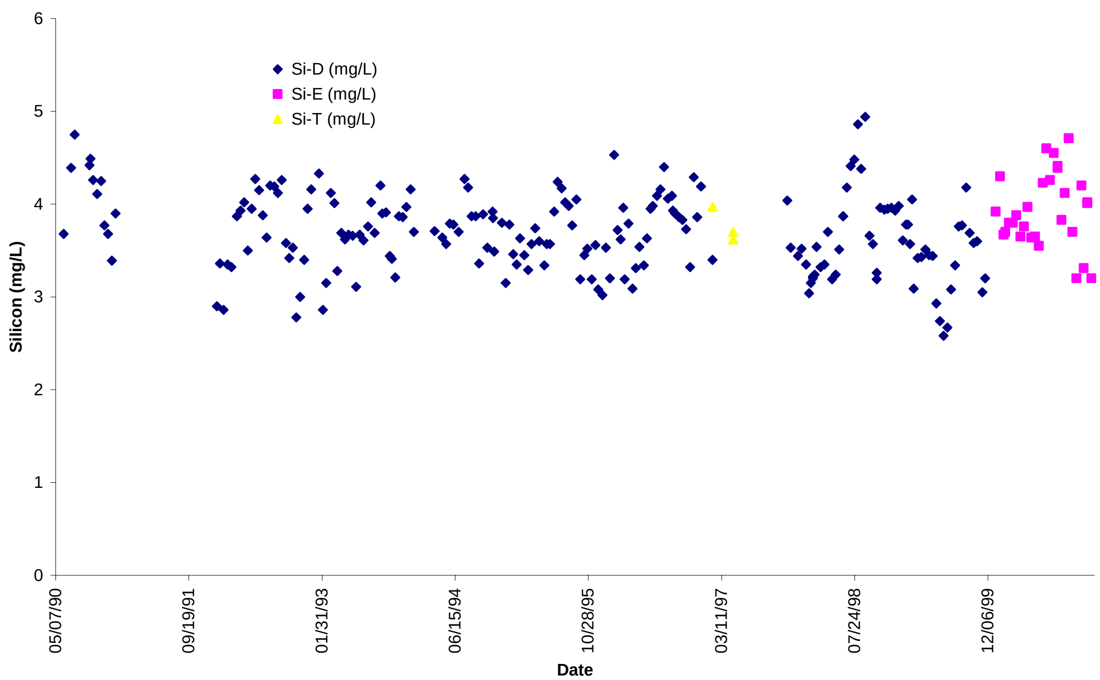

**Figure 45. Quinsam River Near the Mouth - Silver**

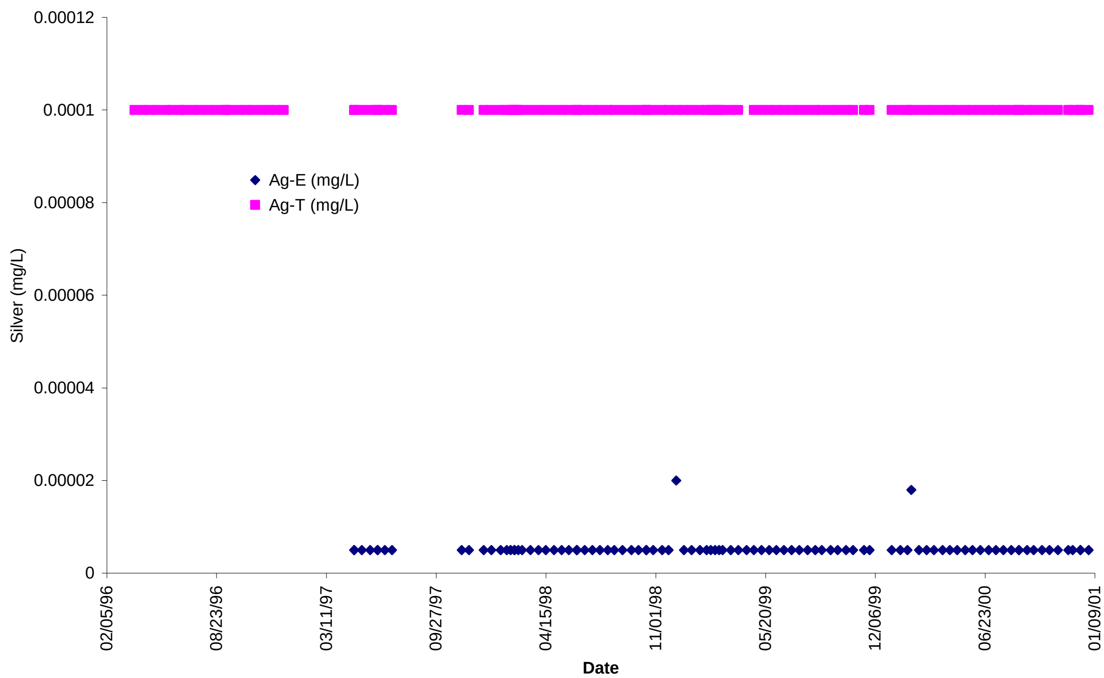


**Figure 46. Quinsam River Near the Mouth - Sodium**

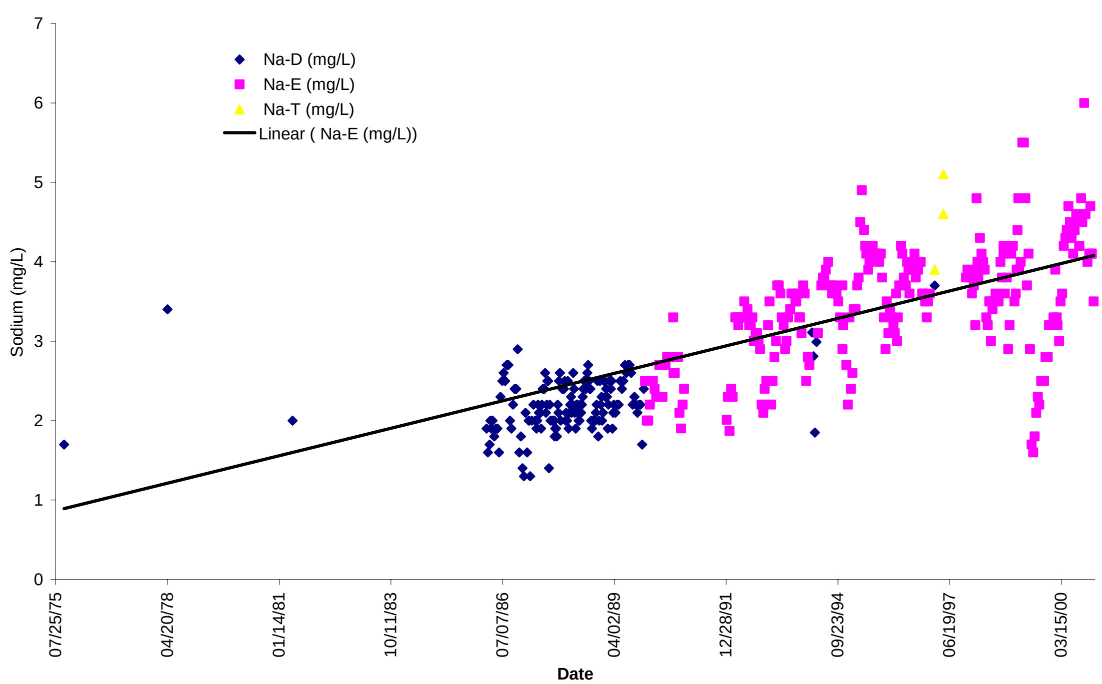

**Figure 47. Quinsam River Near the Mouth - Sulphate**

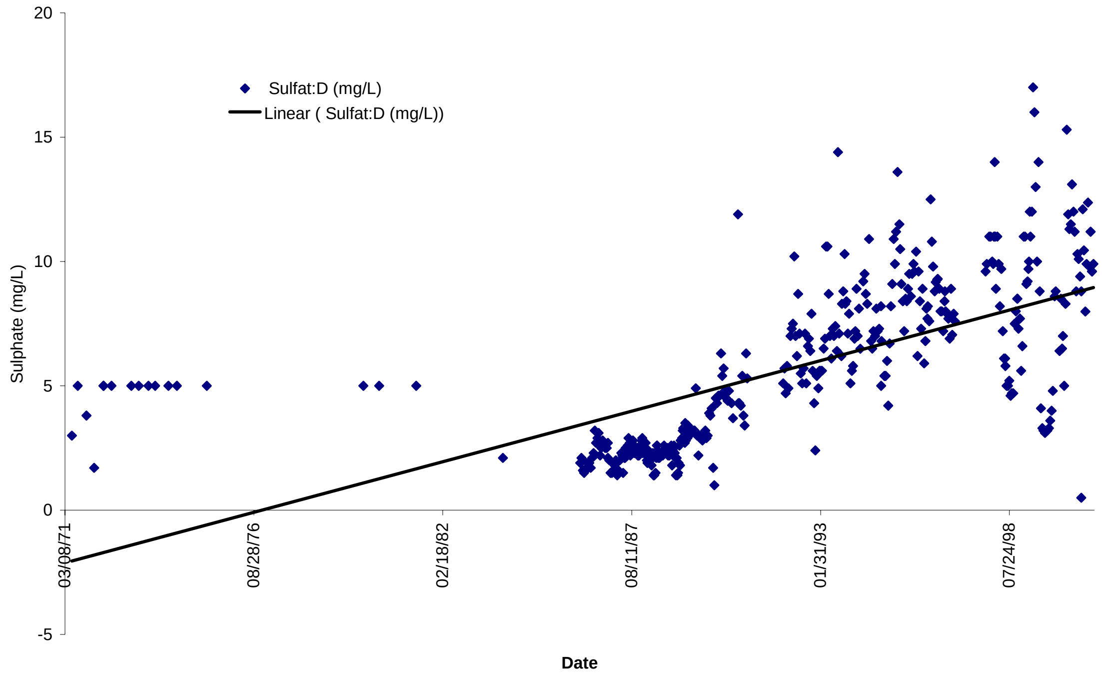


**Figure 48. Quinsam River Near the Mouth - Temperature, Water**

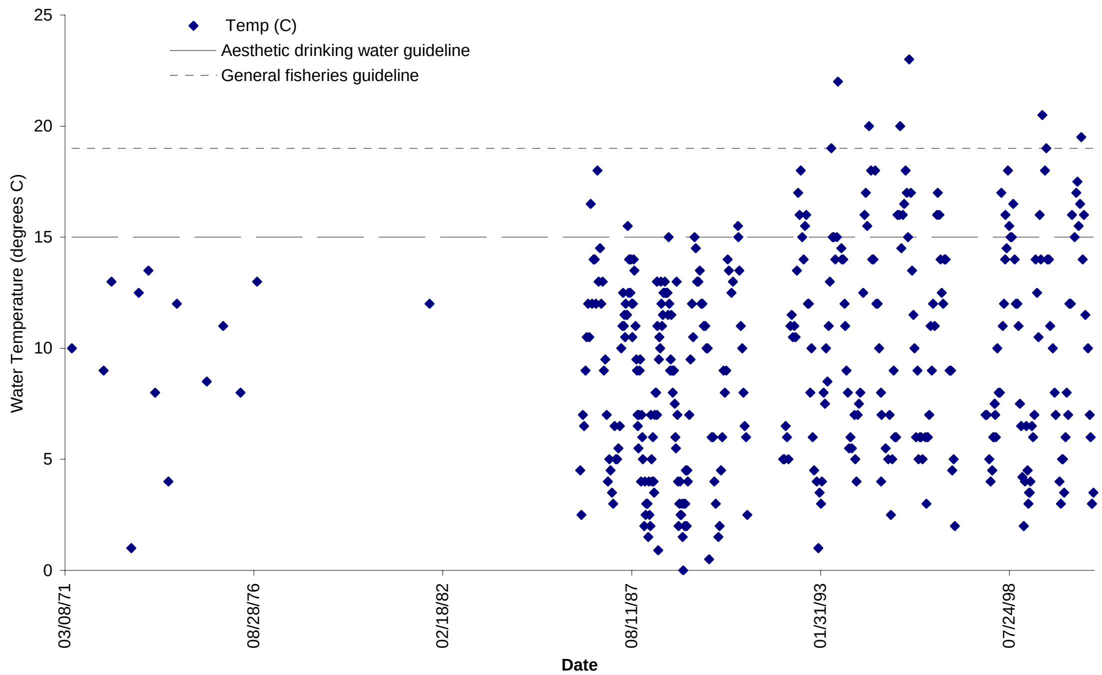

**Figure 49. Quinsam River Near the Mouth - Thallium**

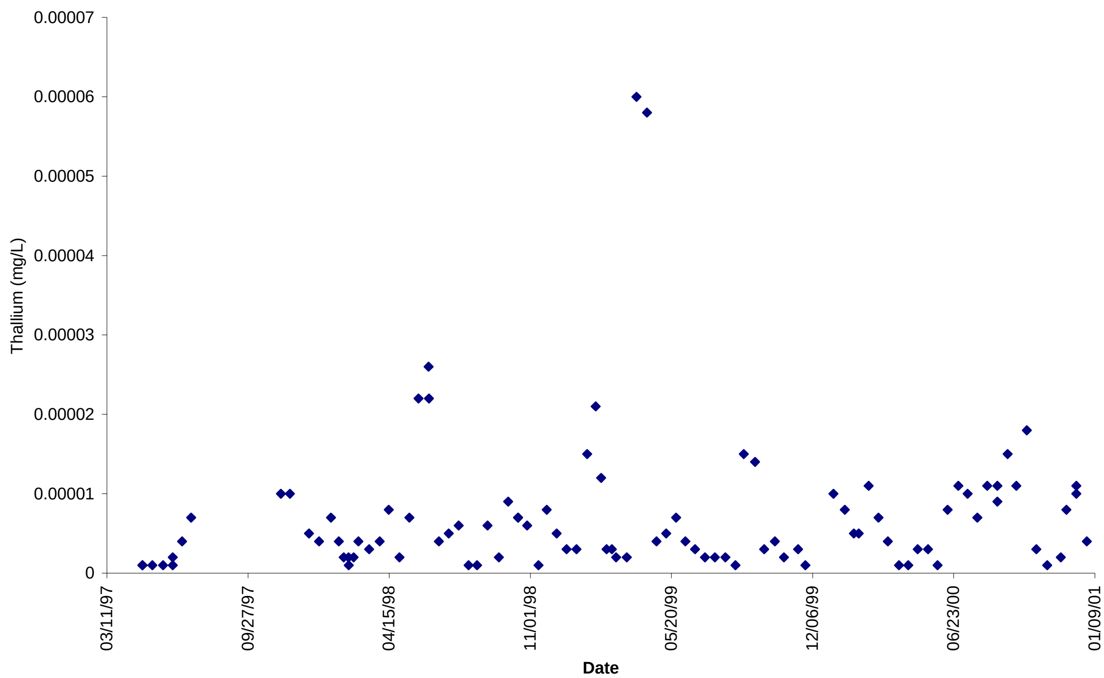


**Figure 50. Quinsam River Near the Mouth - Turbidity**

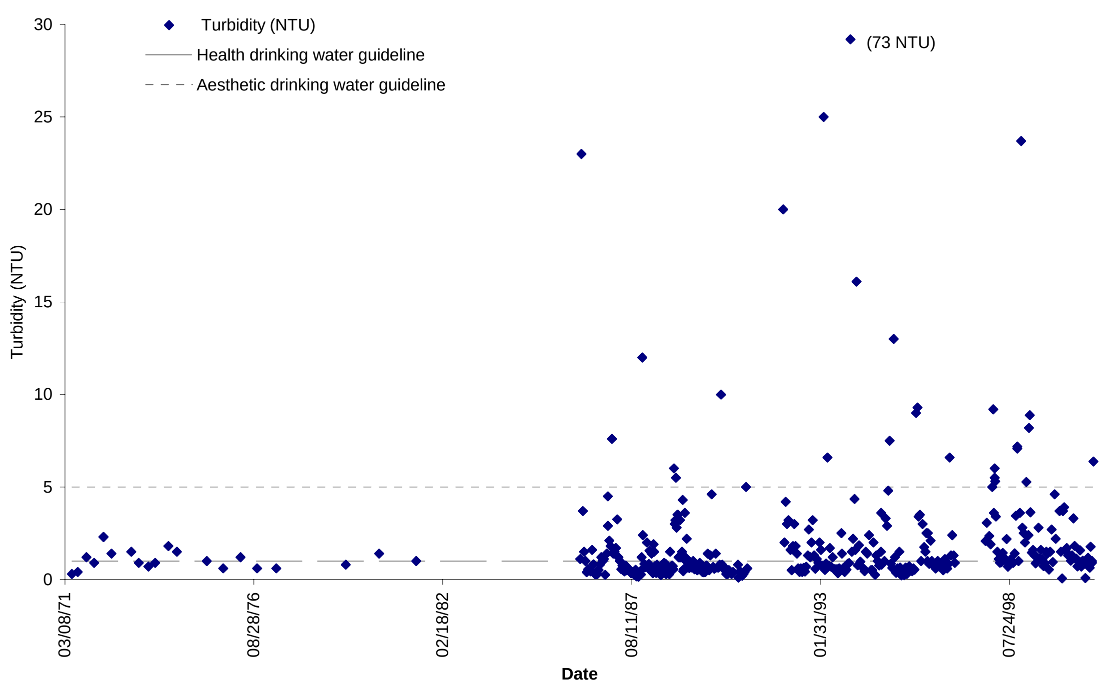

**Figure 51. Quinsam River Near the Mouth - Uranium**

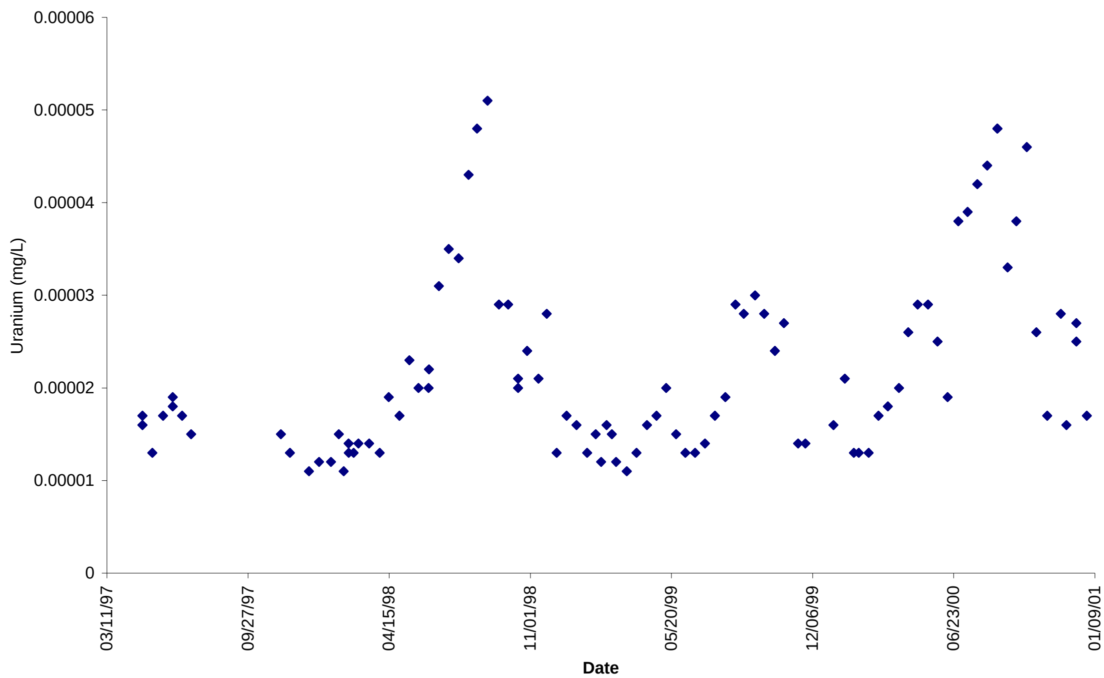


**Figure 52. Quinsam River Near the Mouth - Vanadium**

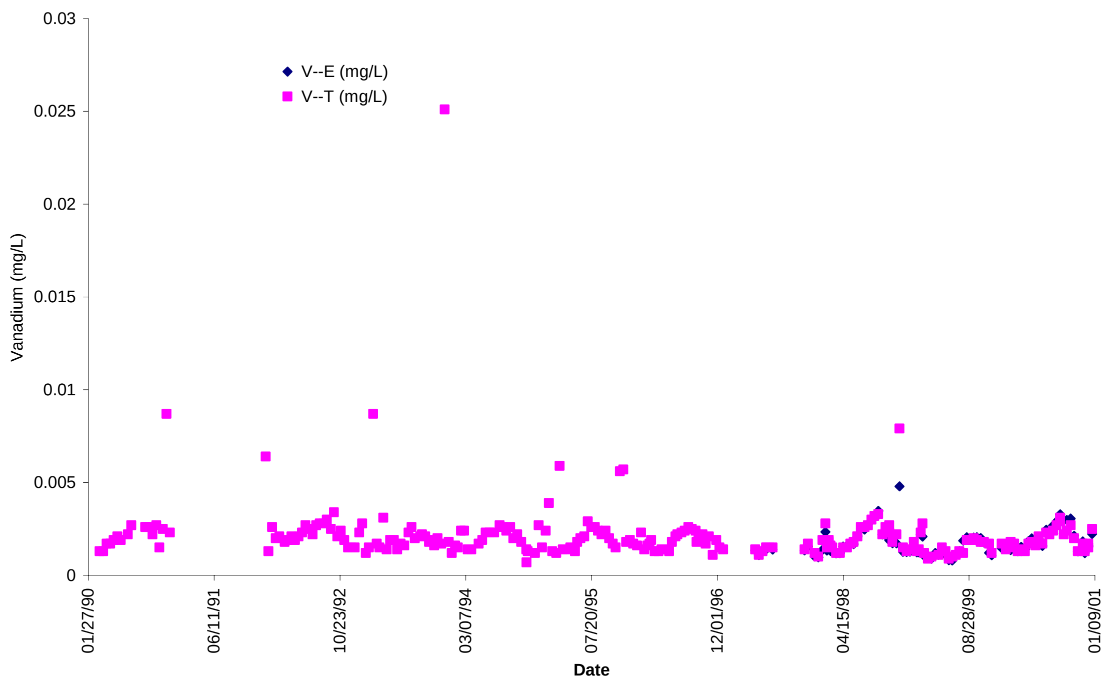

**Figure 53. Quinsam River Near the Mouth - Zinc**