CANADA – BRITISH COLUMBIA
WATER QUALITY MONITORING AGREEMENT

WATER QUALITY ASSESSMENT OF KETTLE RIVER AT MIDWAY (1972 – 2000)

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Environment Canada Environnement Canada

BRITISH COLUMBIA Ministry of Environment

EXECUTIVE SUMMARY

This report assesses the long-term water quality trends in the Kettle River, a trans-boundary river which flows from south central B.C. into Washington State crossing the international border at the town of Midway, B.C. and then re-entering B.C. at Carson.. Three other related monitoring stations within the B.C. portion of this watershed are the Boundary Creek at Midway, the Kettle River at Carson, and the Kettle River at Gilpin sites. Boundary Creek, a major tributary from the north, joins the Kettle River a short distance downstream from Midway, B.C. very near the international boundary between Canada and the U.S. The Kettle River at Carson station is located downstream from Midway at the point where the Kettle River crosses back into B.C. The Kettle River at Gilpin station is located downstream from the Carson site but just upstream from where the Kettle River returns to the U.S.

Known errors were removed and the plotted data were compared to B.C. Environment's *Approved and Working Criteria for Water Quality*. Of special interest are water quality levels and trends that are deemed deleterious to sensitive water uses including drinking water, aquatic life, fish and wildlife, recreation, irrigation and livestock watering.

CONCLUSIONS

The main conclusions of this assessment are as follows:

- Concentrations of alkalinity and calcium indicate that the water is well buffered and has a low sensitivity to acid inputs. Alkalinity may be increasing over time at this site.
- The water is naturally high in fluoride and exceeded guidelines for aquatic life on a few occasions, as well as the drinking water guideline on one occasion. We are not aware of any effects on the local fish populations and expect that fish may be adapted to the higher levels of fluoride. There is no known anthropogenic source of fluoride in the watershed.

- Water quality patterns in this watershed are usually closely matched with flow patterns. As a result, increased turbidity during spring freshet makes it necessary to treat the water for drinking purposes.
- The increased levels in total phosphorus, dissolved organic carbon, and total metals such as aluminum, chromium, copper, iron, lead and zinc are related to seasonal increased flows due to suspended sediments and thus are largely biologically unavailable. Copper values that exceeded guidleines between 1986 and 1991 were likely due to contamination of samples by the preservative leaching substances from bottle lids.
- True and apparent colour values also varied seasonally, increasing to above the drinking water guideline during spring freshet.
- Metals such as arsenic, cobalt, manganese, and selenium showed occasional values in excess of their respective guidelines, but these occasional excursions are not likely a cause for concern.
- Fecal coliform concentrations were often high, exceeding the guideline for drinking water that undergoes primary treatment (i.e., disinfection) only.
- Water temperatures frequently exceeded both the aesthetic drinking water guideline as well as the general fisheries guideline.
- Dissolved chloride may be increasing slightly over time at this site. The cause for this increase is unknown, as are its potential effects.
- The minimum detectable limit used for cadmium analyses was much too high to determine guideline compliance. Tests with much lower analytical limits (maximum 1/10 the guideline, or 0.000003 mg/L) should be used when they become available.
- Hardness may be increasing slightly over time at this site.
- A few very low pH values were recorded between 1995 and 2001, but are likely the result of laboratory or reporting errors.

No remedial activities appear to be necessary at this time.

RECOMMENDATIONS

We recommend continued monitoring at this station because there are regional concerns related to resource development within the Kettle River watershed (U.S. and Canada). The potential for the proposed Washington State mine should be considered as mining development will impact the watershed. A specific monitoring program to study this impact should be designed and implemented. The Kettle River at Midway serves as an good "background site" for the collection of water quality data before the Kettle River crosses into the U.S. In addition, other water quality indicators such as benthic invertebrates, sediment chemistry and fish tissues could also be examined to determine if long-term trends are occurring.

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INTRODUCTION

The Kettle River at Midway is located at the town of Midway, B.C., where the Kettle River first crosses the Canada-U.S.A. border from its headwaters in B.C. to Washington State (Figure 1). The drainage area of the Kettle River at Midway is 5750 km^2, and the river flow is monitored at the nearby downstream Environment Canada station number BC08NN013 (Kettle River at Ferry). The flow data are plotted in Figure 2.

Environment Canada has monitored the water quality at this station since 1972, and the data are stored on the federal data base, ENVIRODAT, under station number BC08NN0011. This report assesses the 30 years of data from 1972 through 2002. The water quality parameters are plotted in alphabetical order in Figures 3 to 51 at the end of this document.

Other related monitoring stations are the Kettle River at Carson and Gilpin, which are located further downstream, and Boundary Creek at Midway, which joins with the Kettle River a short distance downstream from the Kettle River at Midway station. The watershed upstream from Midway is relatively pristine, with a small population, and no environmentally significant anthropogenic impacts other than forestry. Consumptive water uses for the Kettle River include agricultural, and industrial uses.

Substances that met their respective guidelines and showed no environmentally significant trends included: arsenic, barium, boron, bromide, dissolved organic carbon, fecal coliforms, true colour, specific conductivity, cyanide, gallium, hardness, lanthanum, lithium, magnesium, molybdenum, nickel, nitrate/nitrite, nitrogen, pH, phosphorus, potassium, filterable residue, rubidium, silica, silicon, silver, strontium, sulphate, thallium, uranium and vanadium.

Figure 1: Map of Kettle River Basin

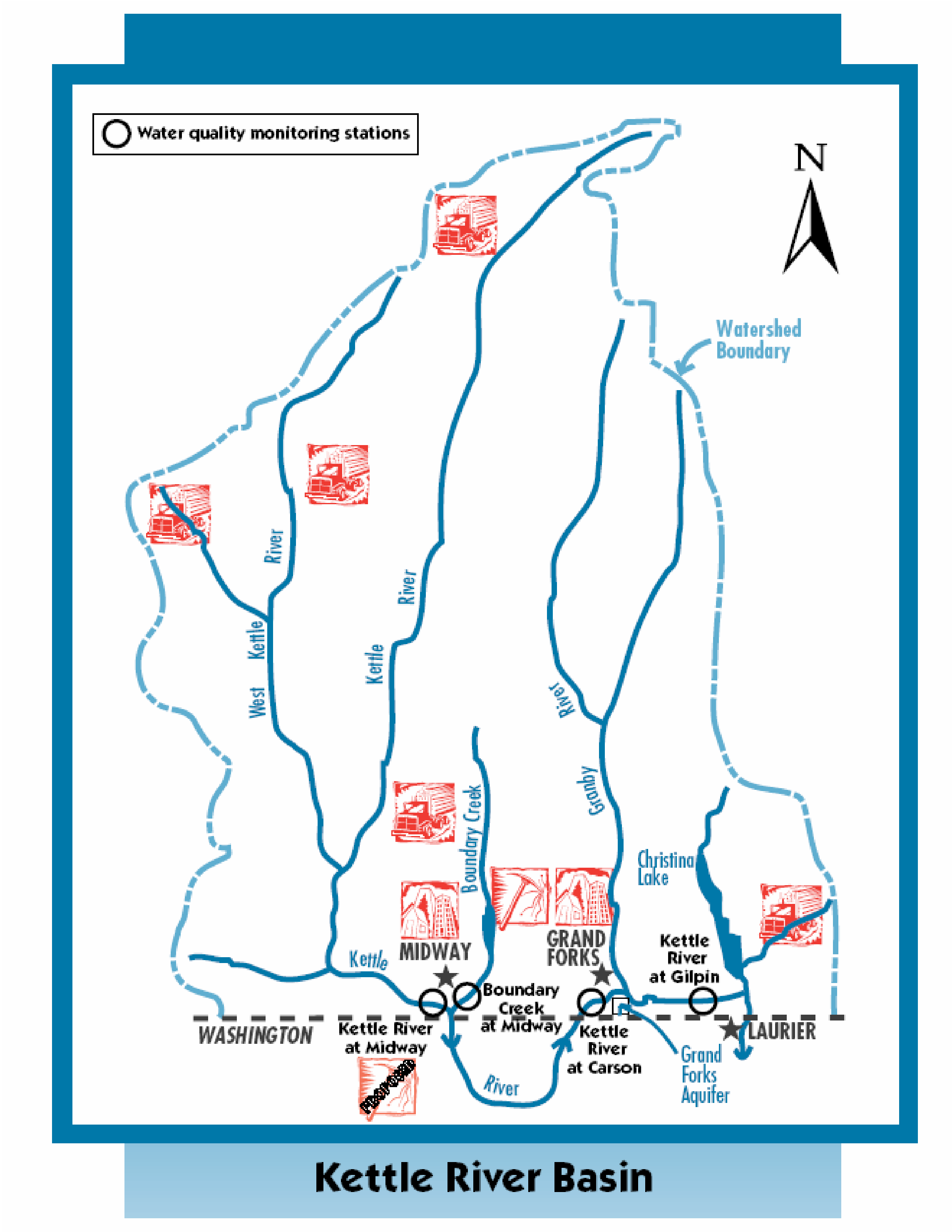
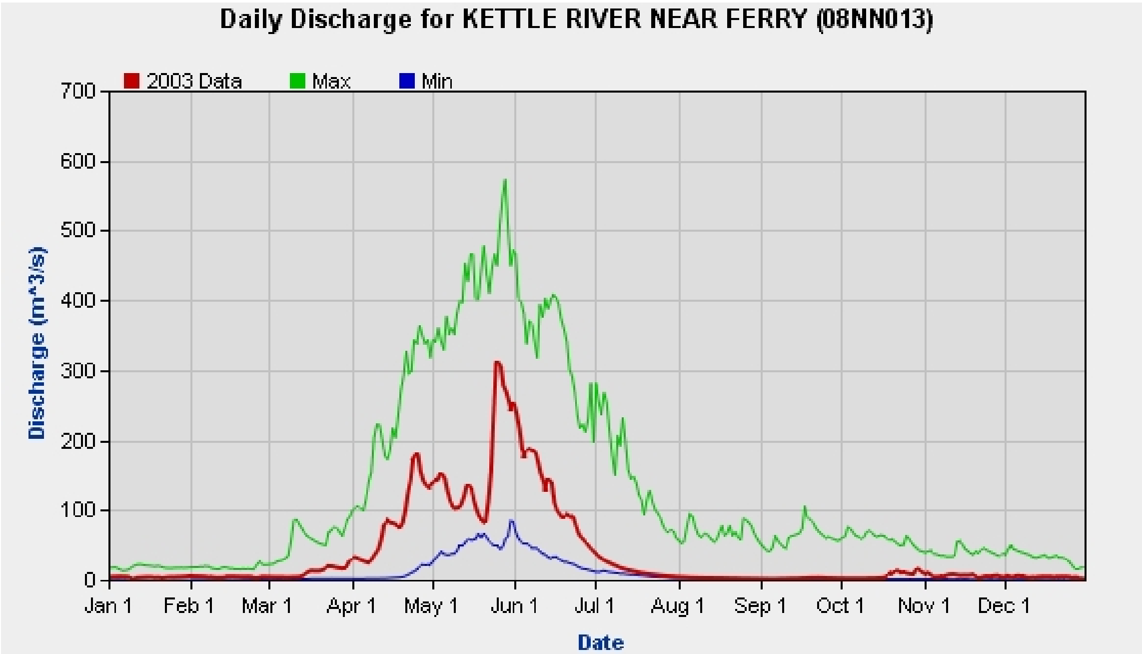


Figure 2: Daily Discharge for the Kettle River Near Ferry



QUALITY ASSURANCE

The water quality plots were reviewed, and values that were known to be in error or questionable were removed. The total mercury plot has been removed as it showed many detectable values which were probably errors due to false positives near the minimum detectable limits (MDLs) and artificial contamination due to the sample collection and laboratory measurement method used. Natural mercury levels in pristine areas are typically <1-2 ng/L and are 5-10 ng/L in grossly mercury-polluted waters (Pommen, 1994). These levels are at or below the lowest MDL used for mercury. Mercury monitoring in ambient water was terminated in 1994. Mercury in resident fish tissue should be monitored if there are any mercury concerns upstream in this watershed. There were known quality assurance problems due to the gradual failure of the re-usable Teflon liners in the bakelite preservative vial caps. Over time, preservatives would leak and leach out contaminates from the bakelite vial caps and contaminate many of the 1986 to 1991 samples. This contamination problem was known to affect federal water quality data province-wide. The primary variables affected were cadmium, chromium, copper, cyanide, lead, mercury, and zinc during this sampling period. There also were known problems due to pH methodology at the Environment Canada Laboratory in Vancouver from the about the beginning of 1986 to the end of 1988.

STATE OF THE WATER QUALITY

The state of the water quality is assessed by comparing the values to B.C. Environment's *Approved and Working Criteria for Water Quality* (Nagpal, Pommen & Swain, 1995). There are no site-specific water quality objectives for the Kettle River. All comments and observations regarding apparent trends are based solely on the visual examination of the graphically displayed data.

Any levels or trends in water quality that may have a negative effect on sensitive water uses, including drinking water, aquatic life and wildlife, recreation, irrigation, and livestock watering, are noted. Variables that exhibited no apparent environmental problems have not been discussed although all of these variables have been plotted and included in this report.

Concentrations of **alkalinity** (Figure 3) and **dissolved and extractable calcium** (Figure 11) indicate that the Kettle River at Midway is well buffered against acidity. It appears that alkalinity may have been increasing slightly until 1997 when sampling for alkalinity was discontinued at this site.

Concentrations of **total aluminum** were often high, with a maximum concentration of 2.5 mg/L (Figure 4). One hundred and five of the 340 samples (31%) collected between 1990 and 2002 exceeded the aquatic life guideline of 0.1 mg/L for dissolved aluminum, and 78 samples (23%) exceeded the drinking water guideline of 0.2 mg/L. However, as only total aluminum was measured, an accurate assessment of this guideline cannot be made. It must also be noted that total aluminum concentrations were strongly correlated with turbidity values (see Figure 4), suggesting that higher levels of aluminum were associated with particulate matter. In this case, they would likely be unavailable to biota, and would also be removed by treatment necessary for reducing turbidity prior to consumption as drinking water.

Total and extractable arsenic concentrations were generally well below the aquatic life guideline of 0.005 mg/L (Figure 5), with the exception of a single value of 0.0059 mg/L on September 11, 1995. There is a slight negative correlation between arsenic and turbidity (correlation coefficient = -0.11, p = 0.025), suggesting that elevated levels of arsenic may tend to occur during low-flow periods.

Total cadmium concentrations invariably exceeded the aquatic life guideline of 0.00003 mg/L (Figure 10), but this was due to the fact that the detection limits used in the analyses were between 30 and 300 times higher than the guideline limit. Ninety-four percent of the 505 samples collected between 1981 and 2002 were at or below their respective detection limits. Only four of 158 extractable cadmium concentrations above the detection limit and measured between 1996 and 2002 exceeded this guideline. In order to properly assess cadmium concentrations, it is essential that analytical methods with a detection limit of no more than one-tenth the guideline level be employed when such methods become available.

Dissolved chloride concentrations appear to be increasing over time in the Kettle River at Midway (Figure 13). There is currently no guideline for chloride, and this increase is unlikely to be environmentally significant. It is not know whether this change is a result of the change in methodology in mid-1991 from an automated colorimetric method to ion chromatography.

Total chromium concentrations measured prior to 1991 may have been elevated due to suspected preservative vial contamination (Figure 14). Since that time, 29 samples (9% of the 330 samples collected between 1991 and 2002) exceeded the aquatic life guideline of 0.001 mg/L, with a maximum concentration of 0.0385 mg/L. Almost one-half of the values (13 of 29) occurred in 1991 and 1992.

Total cobalt concentrations exceeded the aquatic life guideline of 0.0009 mg/L on four occasions between 1991 and 2002 (Figure 15). Prior to 1991, cobalt samples may have been contaminated due to preservative vial contamination. The irrigation guideline of 0.05 mg/L was not exceeded on any occasion. Increased cobalt concentrations seem to coincide with increases in turbidity (correlation coefficient = 0.68, $p < 0.001$).

Specific conductivity values also showed a strong seasonal trend, fluctuating between about 35 µS/cm in the spring when dilution was high to about 250 µS/cm in the winter, when ions were more concentrated (Figure 18). All values were well below the drinking water guideline of 750 µS/cm. There was a strong negative correlation between specific conductivity and flow (correlation coefficient = -0.74, $p<0.001$), showing that maximum conductivity values occurred during low-flow periods.

Total copper samples collected between 1988 and 1991 are suspect due to preservative vial contamination. Prior to that time, 19% of values exceeded the average aquatic life guideline, and 6% of values exceeded the maximum aquatic life guideline (Figure 19). After 1991, only 4% of individual total copper values exceeded the average aquatic life guideline, and well less than 1% exceeded the guideline for maximum concentrations.

Dissolved fluoride concentrations exceeded the hardness-dependent aquatic life guideline of 0.2 mg/L at hardness <50 mg/L and 0.3 mg/L at hardness >50 mg/L on 93 occasions between 1980 and 2002 (18% of samples) (Figure 21). The drinking water guideline of 1 mg/L was exceeded by a single value of 2.1 mg/L on February 24, 1982.

Total hardness concentrations ranged between about 20 mg/L and 100 mg/L, with a strong seasonal correlation (Figure 23). Hardness may be increasing slightly over time at this site.

Total iron concentrations often exceeded the aquatic life and aesthetic drinking water guideline of 0.3 mg/L (16% of 505 samples) (Figure 24). However, there was a strong correlation between iron and turbidity. This suggests that higher concentrations of iron were associated with particulate matter and would therefore likely not biologically available.

Concentrations of **total lead** measured between 1988 and 1991 are suspected to be contaminated as a result of faulty preservative vial seals. After 1991, no samples contained total lead concentrations that exceeded either the average or maximum aquatic life guidelines (Figure 25).

One **total manganese** concentrations exceeded the irrigation guideline of 0.2 mg/L, with a maximum value of 0.23 mg/L occurring on April 25, 1983 (Figure 28). All samples were well below the aquatic life guideline.

The majority of **pH** values fell within the upper and lower drinking water guidelines of 6.5 and 8.5, respectively (Figure 33). The exceptions were six values, two of which (8.6 and 8.7 pH units) occurred in 1980, and the remainder (1.55 – 6.35 pH units) occurred between 1995 and 2001. The lower pH values are likely a result of either laboratory or reporting error, as they are very unlikely to reflect the actual conditions of the river, given the consistency of the other data and the extremity of the event necessary to cause such a lowering in pH.

Non-filterable residue (total suspended solids) concentrations were seasonally correlated, with maximum values occurring annually during spring freshet. Values ranged from below detectable limits (< 1 mg/L) to a maximum of 273 mg/L (Figure 38). Fourteen percent of values exceeded the general fisheries guideline of 25 mg/L.

Of the 436 samples analyzed for **total selenium** between 1980 and 2002, only one (0.0023 mg/L) exceeded the aquatic life guideline of 0.002 mg/L (Figure 39). As the next highest value was only 0.0006 mg/L, selenium is not likely to be a metal of concern in the Kettle River at Midway.

Water temperatures in the Kettle River at Midway were exceeded the general fisheries guideline of 19°C most summers (Figure 46).

As expected, **turbidity** values followed a trend similar to that of non-filterable residue, with maximum values occurring during the spring freshet (Figure 48). Turbidity and flow were strongly correlated (correlation coefficient = 0.44, p 0.001). Two values (320 NTU on April 25, 1983 and 1171 NTU on January 12, 1998) were questionably high compared with the remainder of the data. These were the only two values which exceeded the aesthetic recreation guideline of 50 NTU, and 92% of values were below the aesthetic drinking water guideline of 5 NTU. As values were occasionally higher than the aesthetic drinking water guideline and frequently higher than the health drinking water guideline of 1 NTU, treatment to remove turbidity prior to consumption as drinking water is required.

Five hundred and two samples were analyzed for **total zinc** concentrations between 1981 and 2002 (Figure 51). Of these, 27 (5%) individual values exceeded the hardness-dependent aquatic life guideline for average concentrations and seven values (1%) exceeded the aquatic life guideline for maximum concentrations. Zinc concentrations were well-correlated with turbidity (Figure 51), indicating that it is likely not bio-available.

Figure 3. Kettle River at Midway - Alkalinity, Total

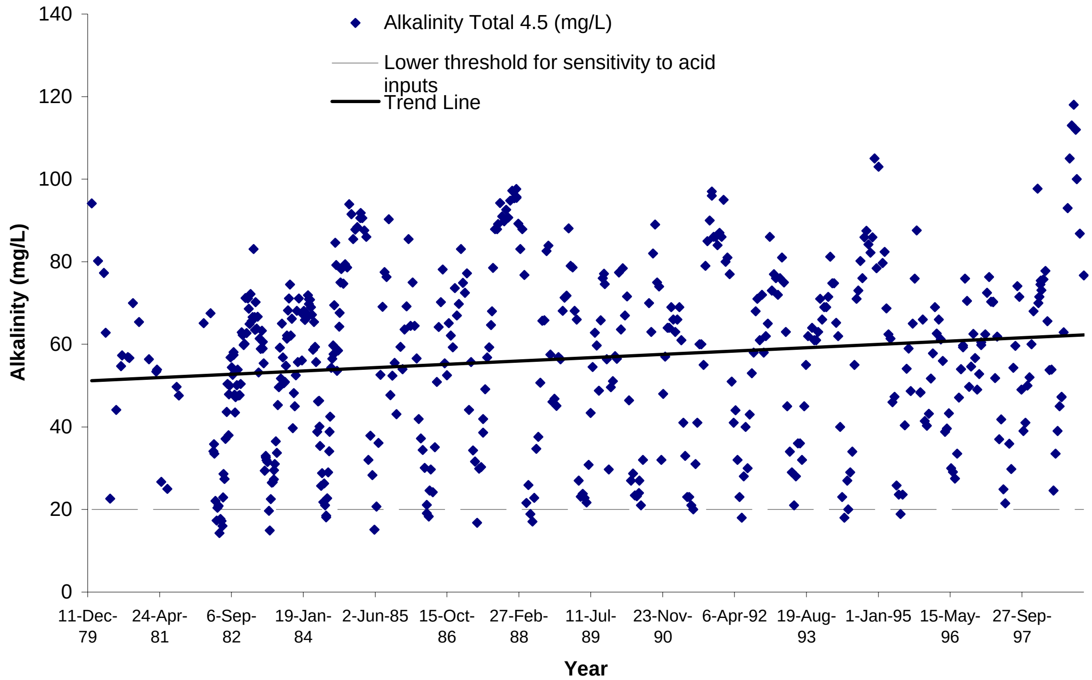


Figure 4. Kettle River at Midway - Aluminum, Total

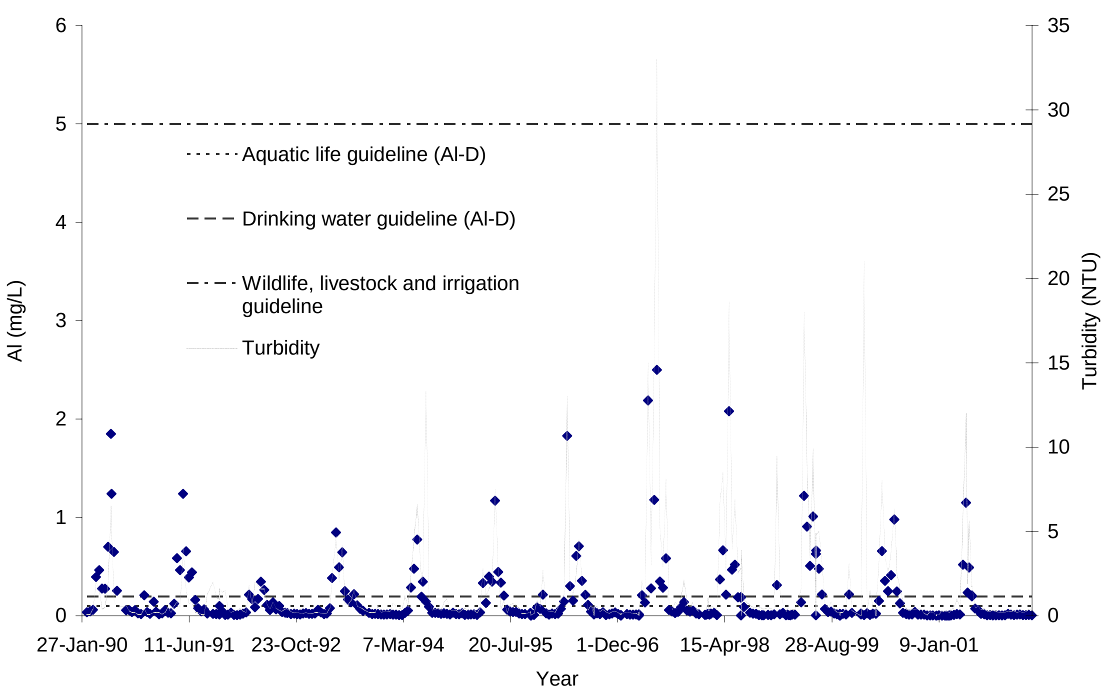


Figure 5. Kettle River at Midway - Arsenic, Total and Extractable

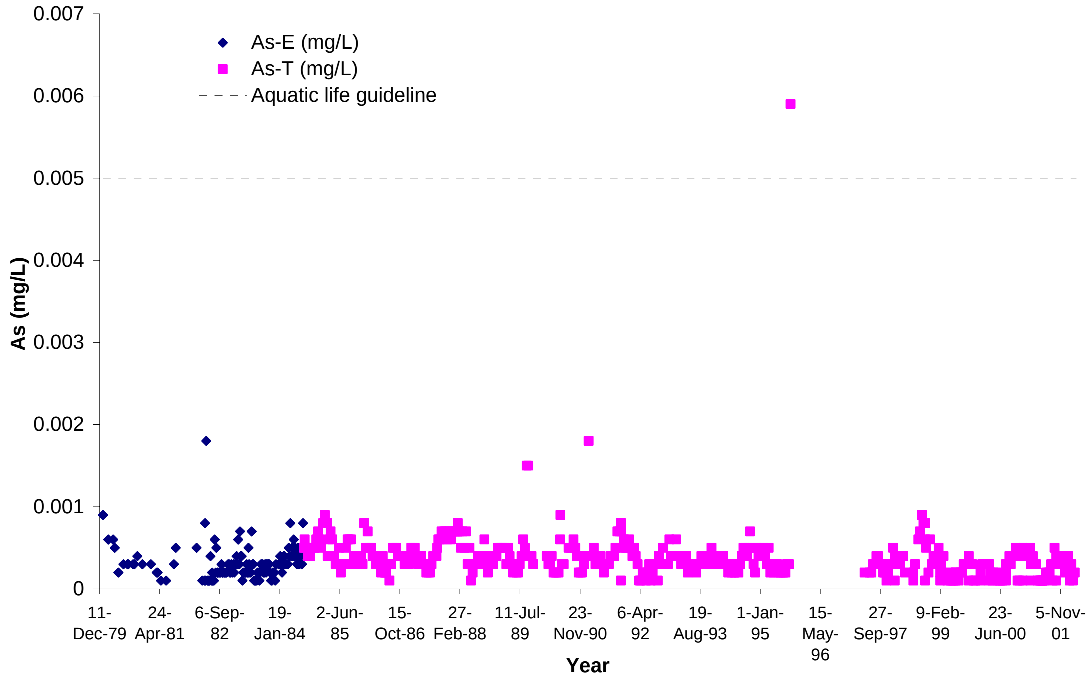


Figure 6. Kettle River at Midway - Barium, Total and Extractable

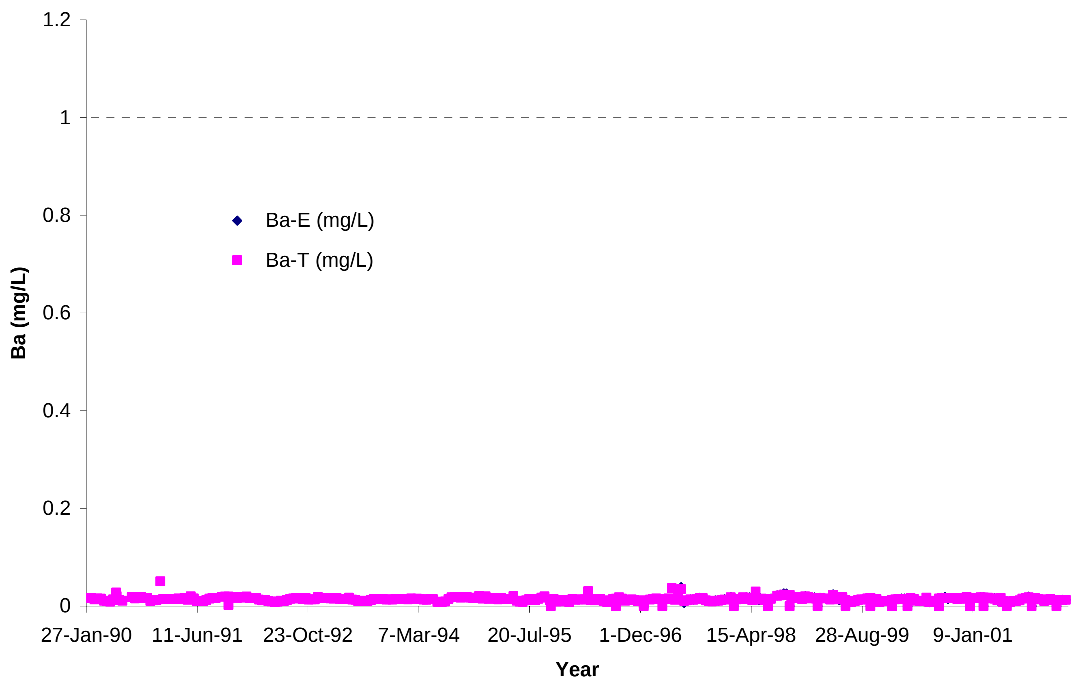


Figure 7. Kettle River at Midway - Beryllium, Total and Extractable

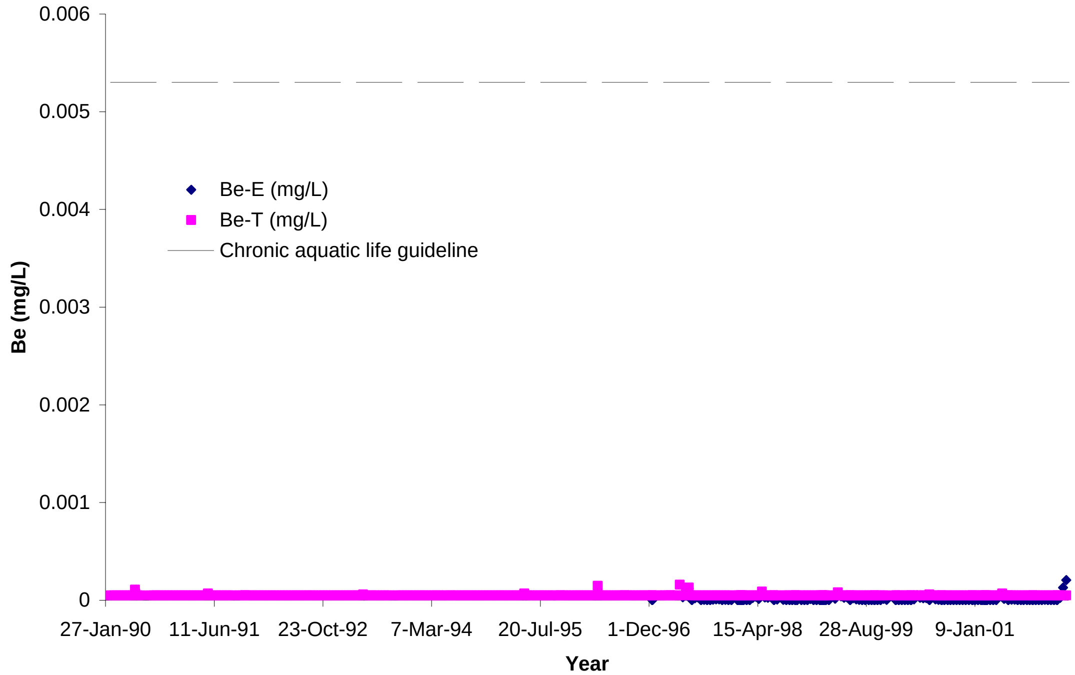


Figure 8. Kettle River at Midway - Boron, Extractable

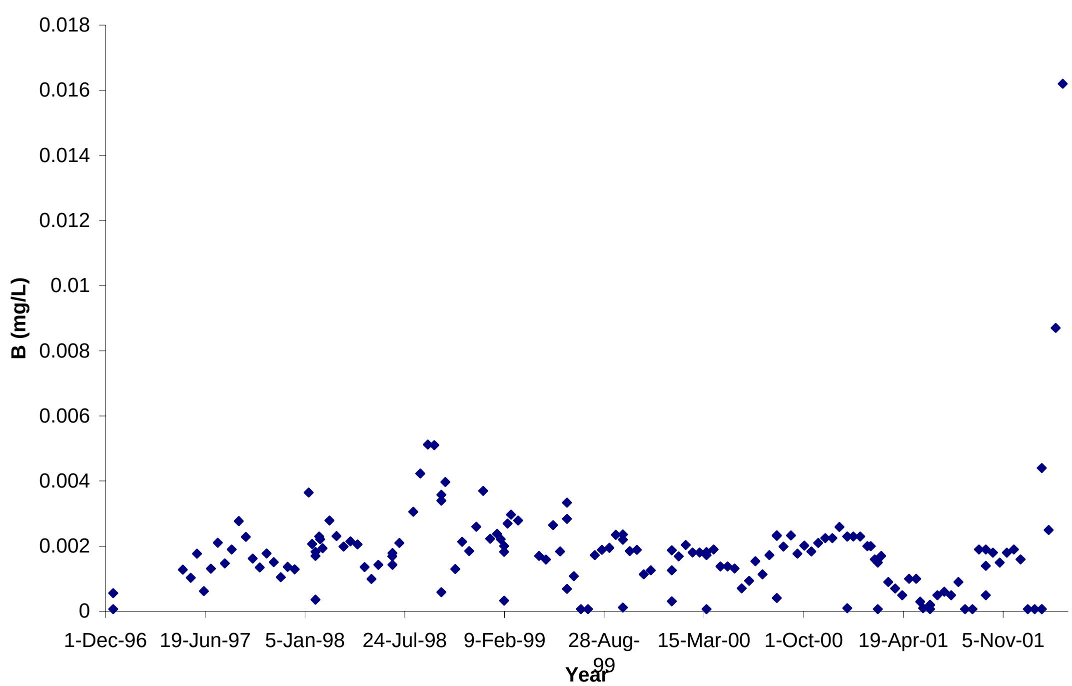


Figure 9. Kettle River at Midway - Bromide, Dissolved

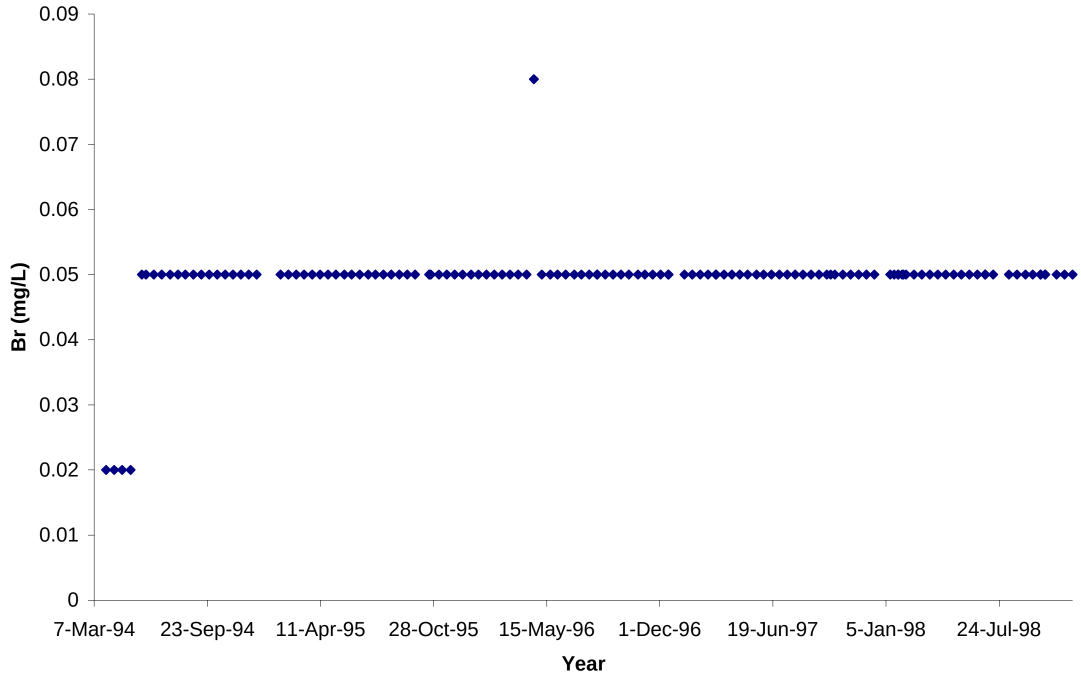


Figure 10. Kettle River at Midway - Cadmium, Total and Extractable

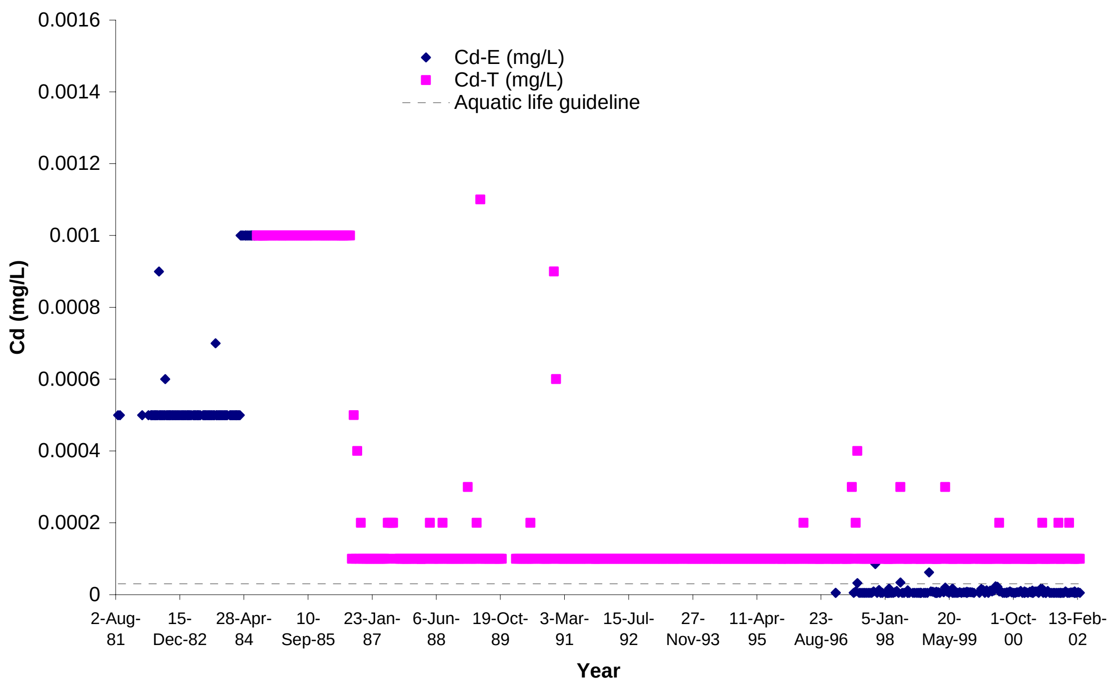


Figure 11. Kettle River at Midway - Calcium, Dissolved and Extractable

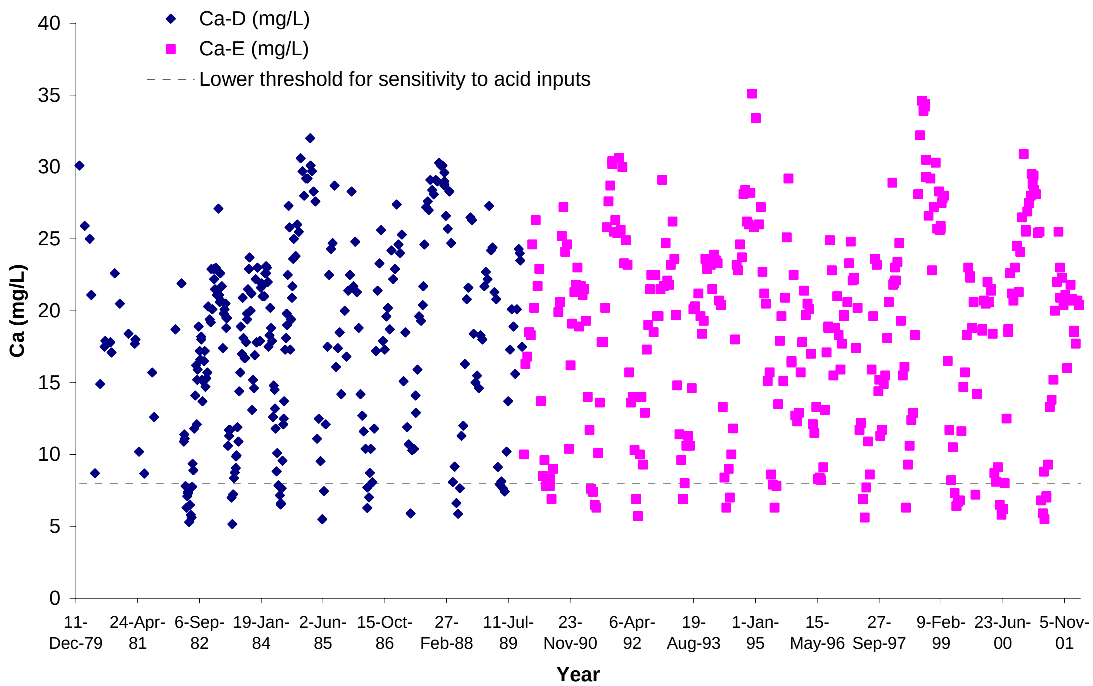


Figure 12. Kettle River at Midway - Carbon

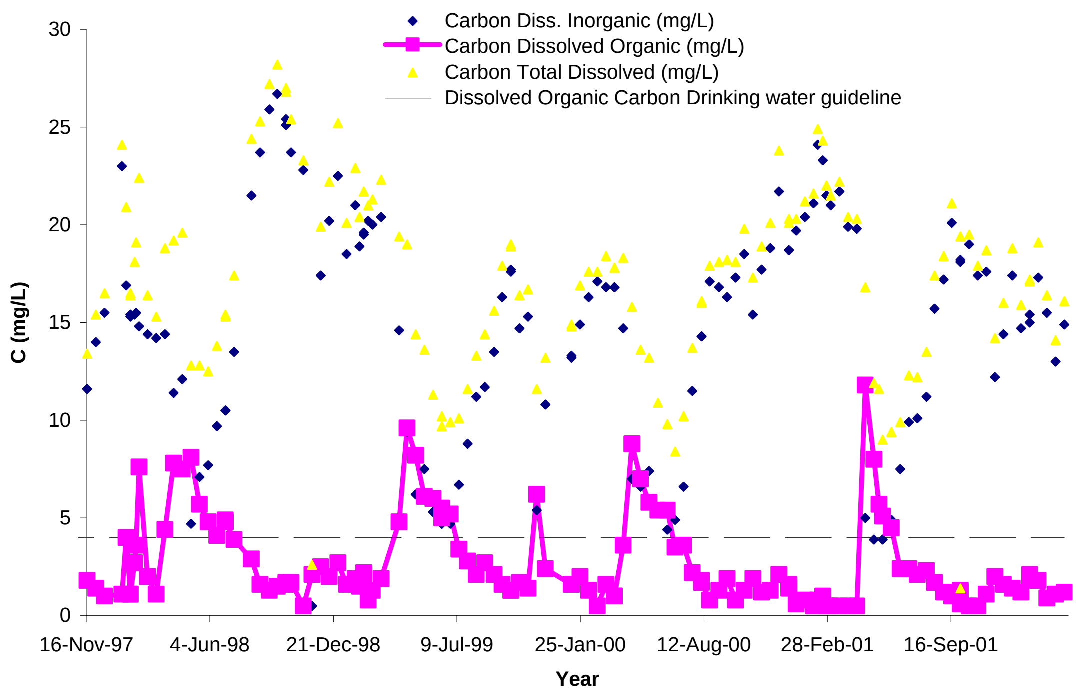


Figure 13. Kettle River at Midway - Chloride, Dissolved

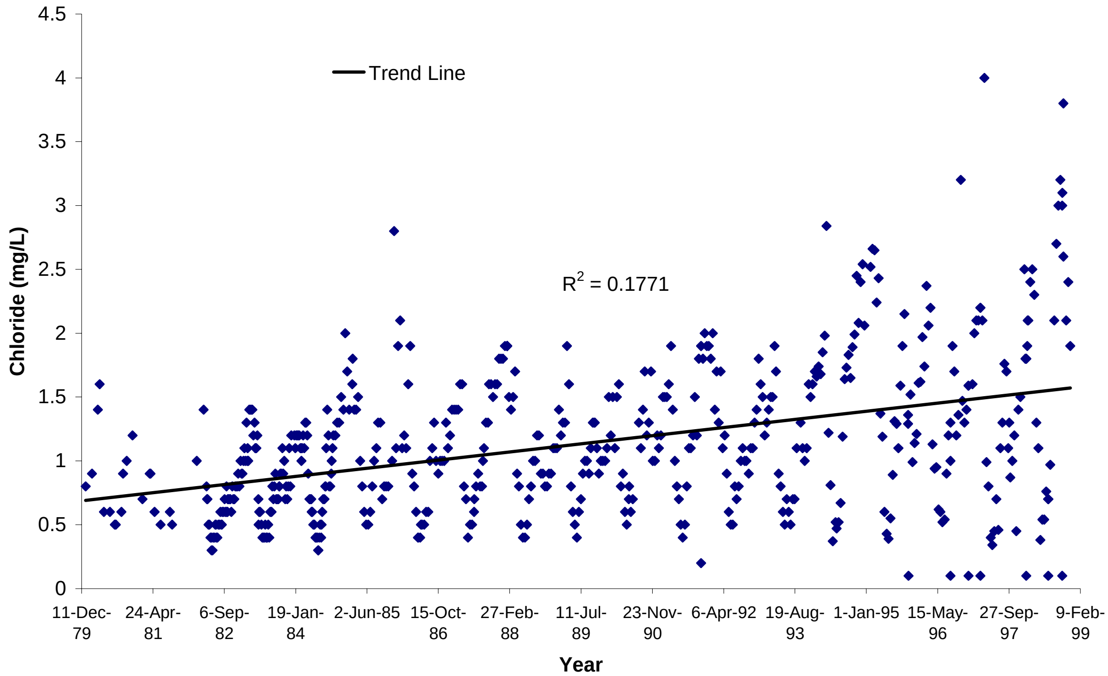


Figure 14. Kettle River at Midway - Chromium, Total and Extractable

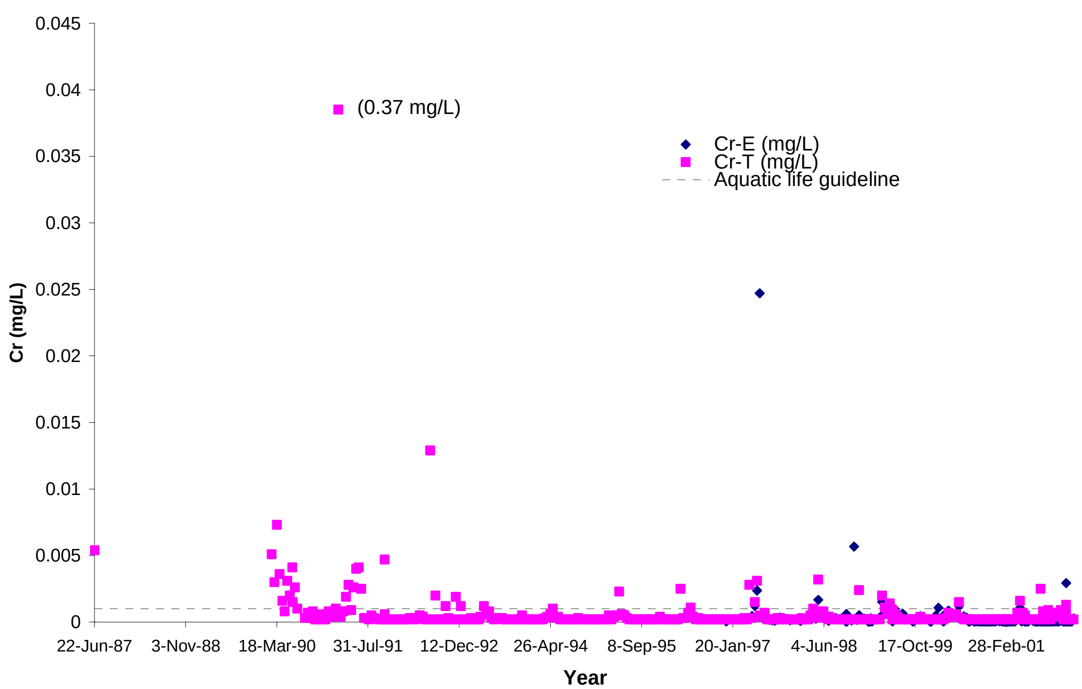


Figure 15. Kettle River at Midway - Cobalt, Total and Extractable

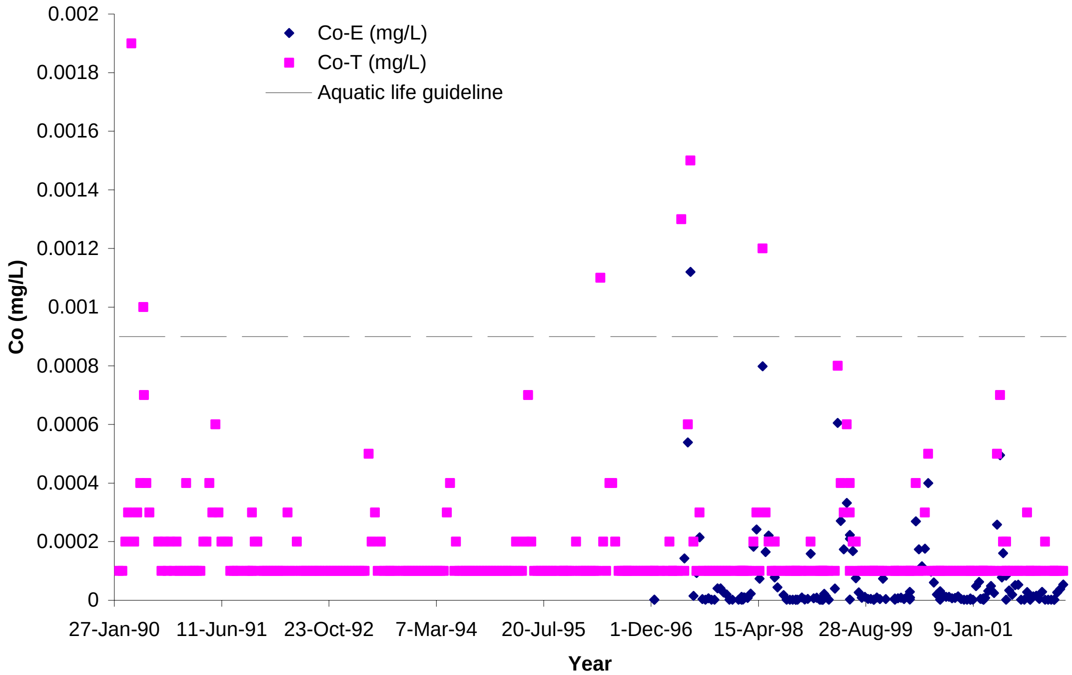


Figure 16. Kettle River at Midway - Fecal coliforms

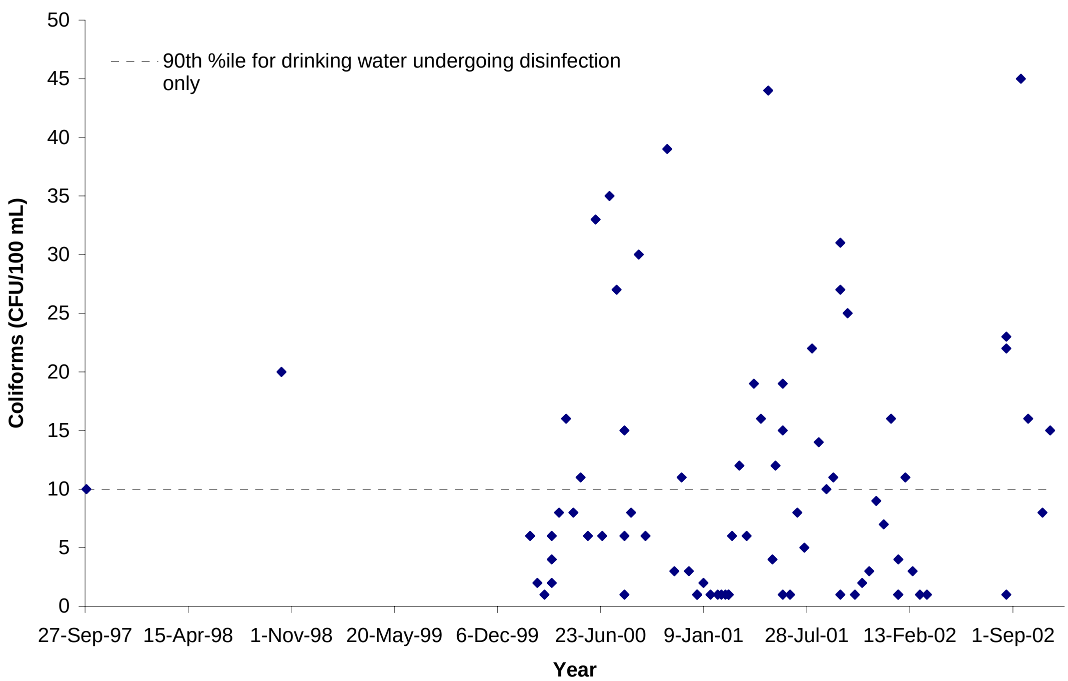


Figure 17. Kettle River at Midway - Colour, True and Apparent

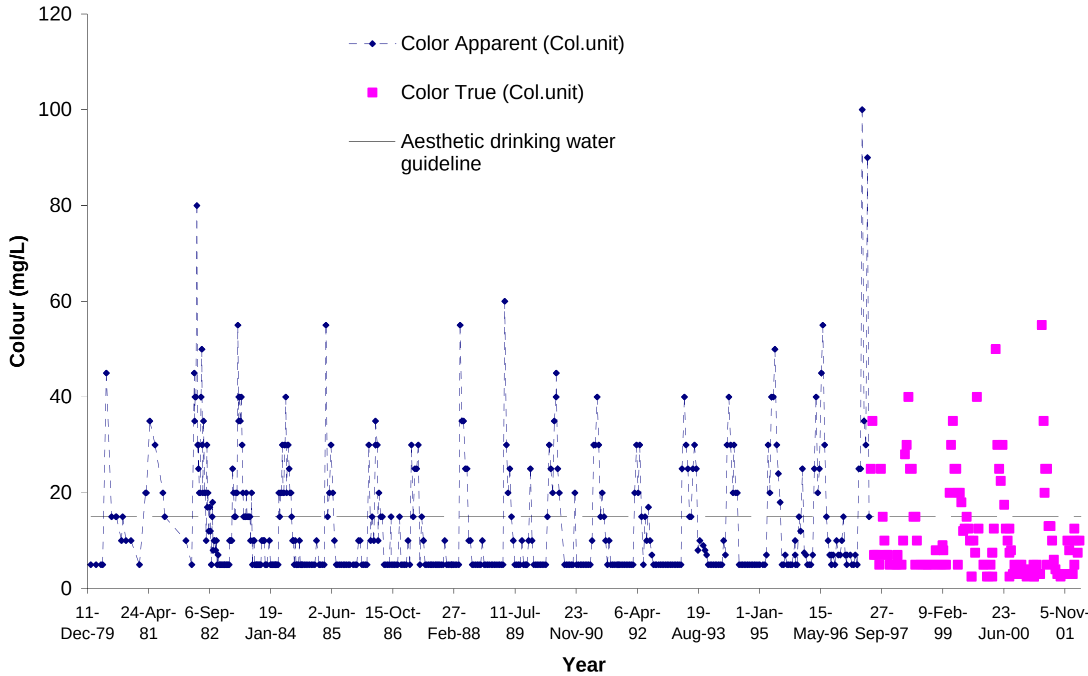


Figure 18. Kettle River at Midway - Conductivity, Specific

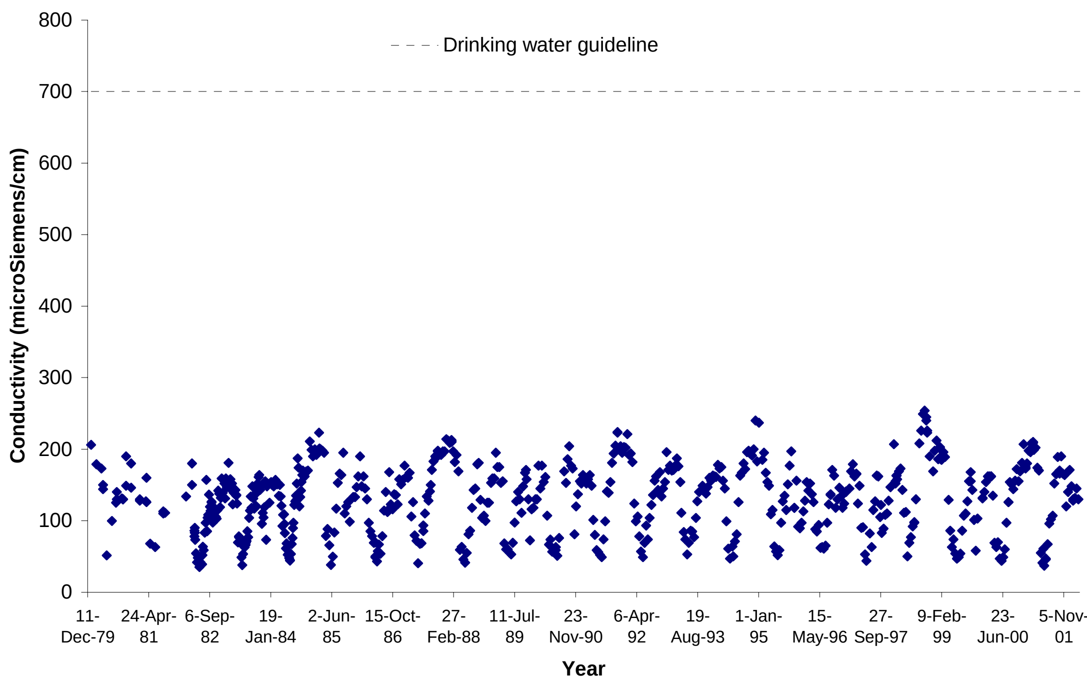


Figure 19. Kettle River at Midway - Copper, Total and Extractable

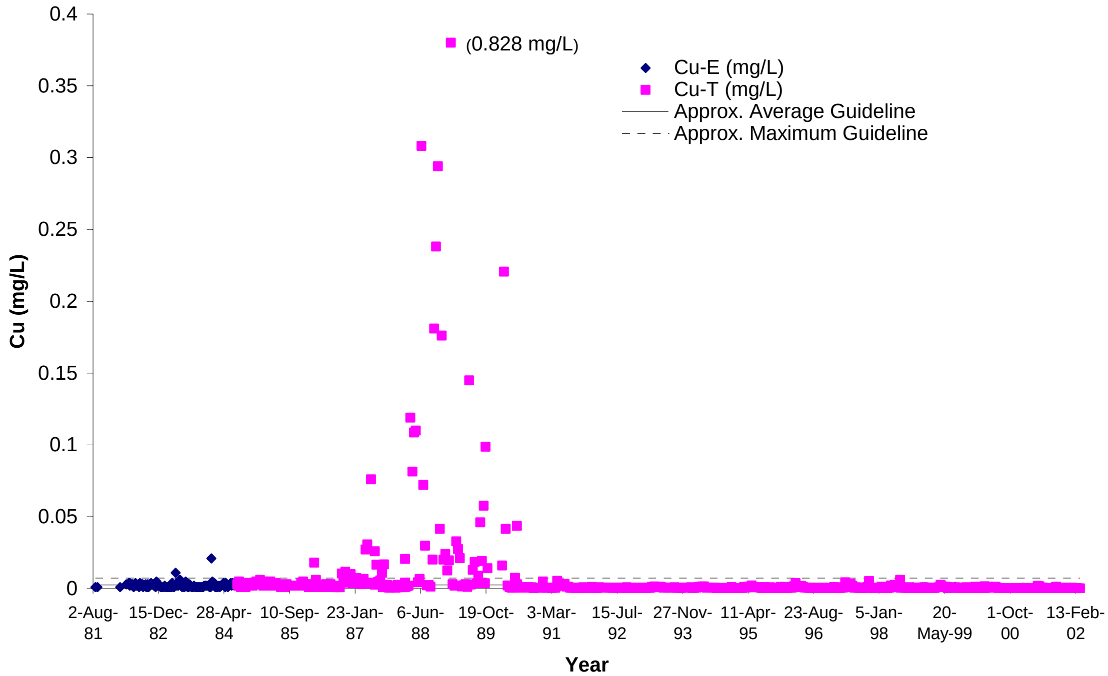


Figure 20. Kettle River at Midway - Cyanide, WAD and SAD+SCN

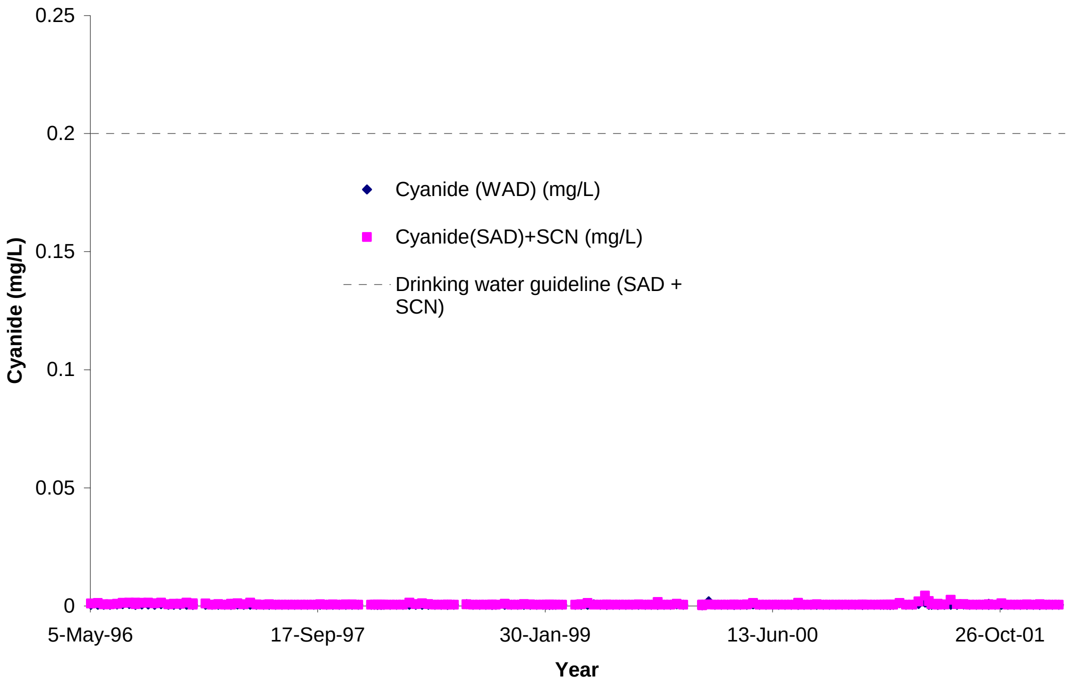


Figure 21. Kettle River at Midway - Fluoride, Dissolved

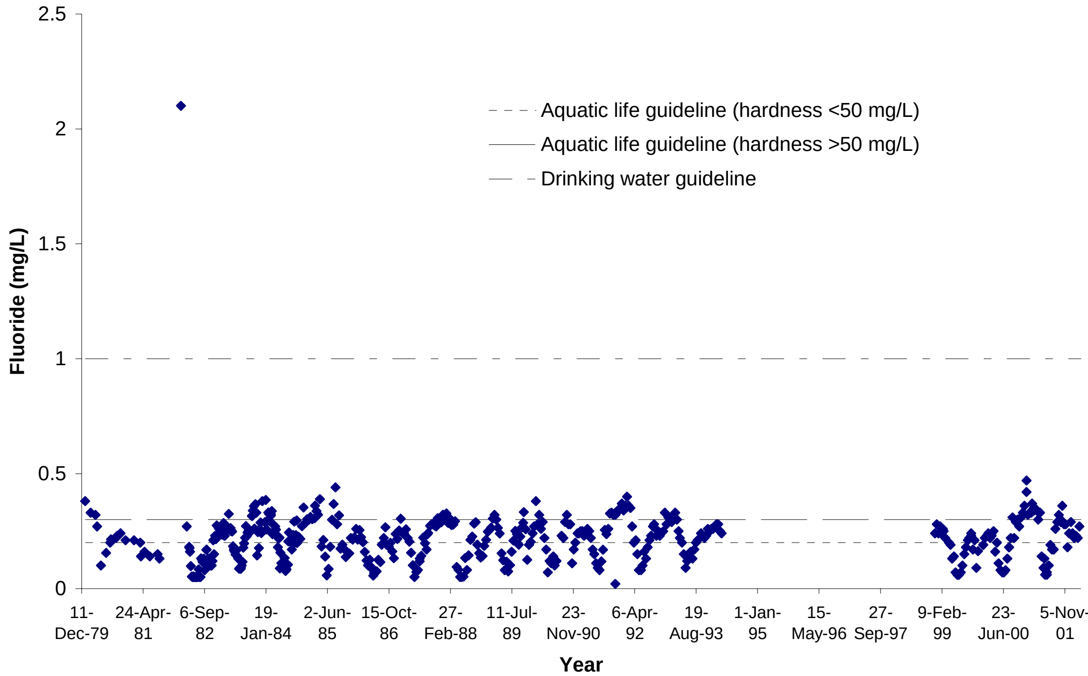


Figure 22. Kettle River at Midway - Gallium, Extractable

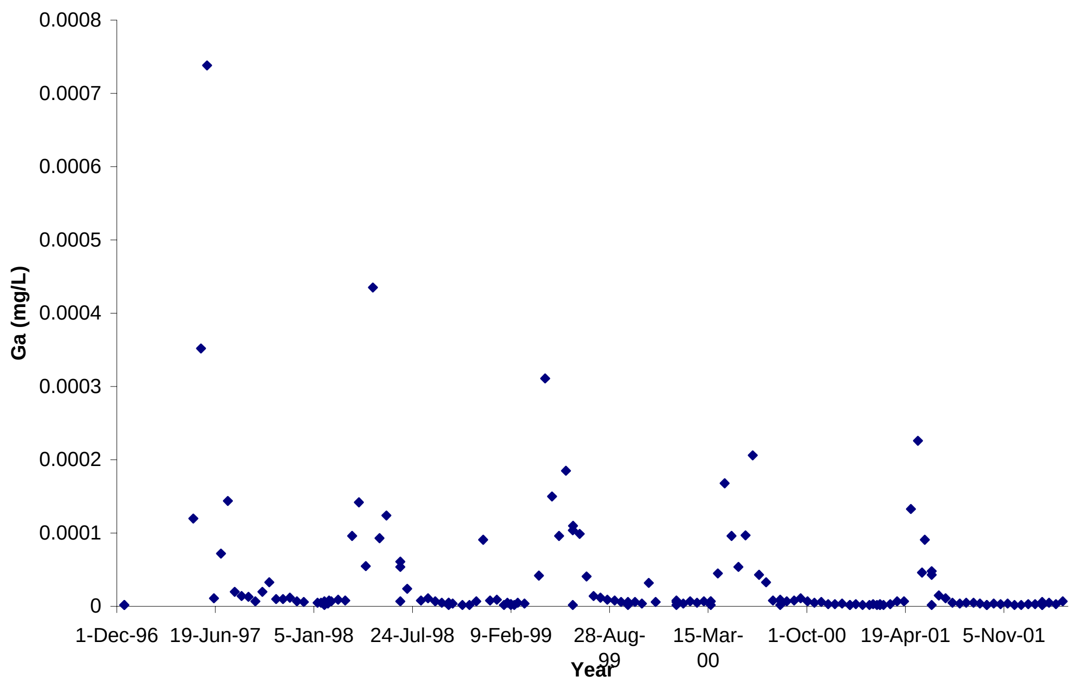


Figure 23. Kettle River at Midway - Hardness

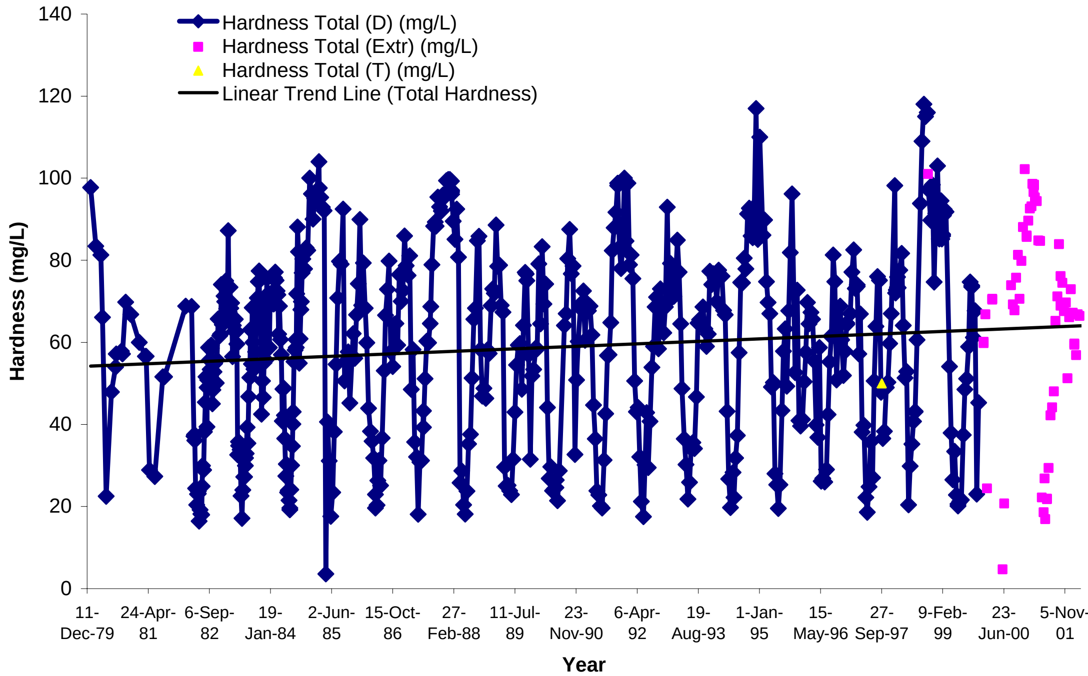


Figure 24. Kettle River at Midway - Iron, Total and Extractable

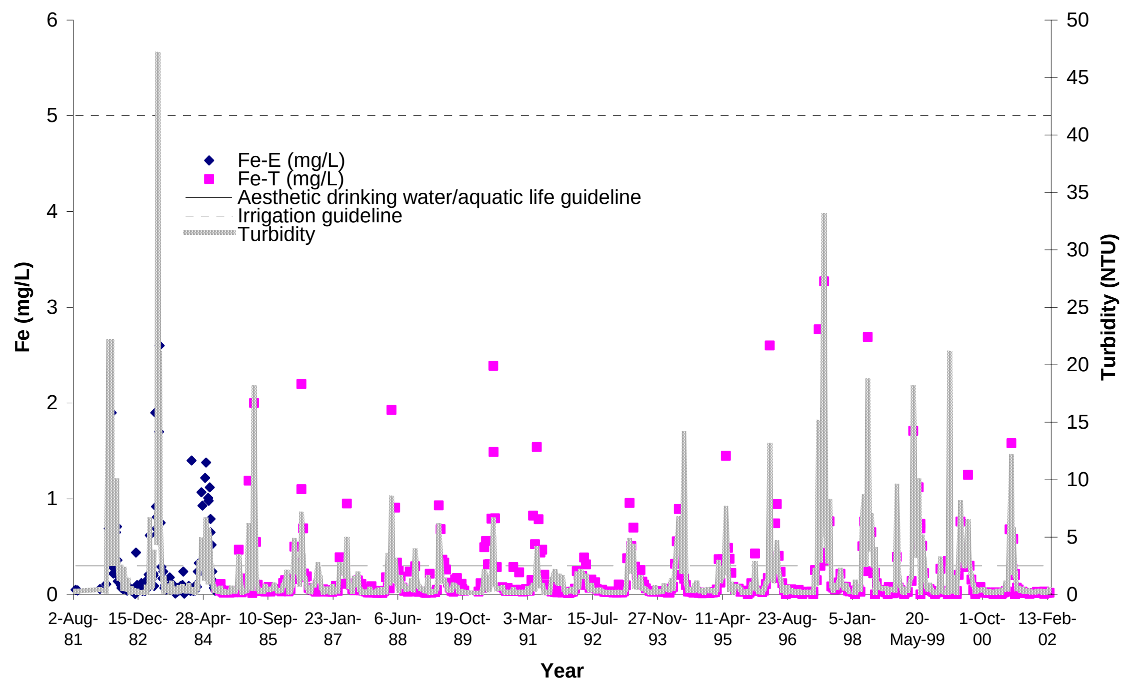


Figure 25. Kettle River at Midway - Lead, Total and Extractable

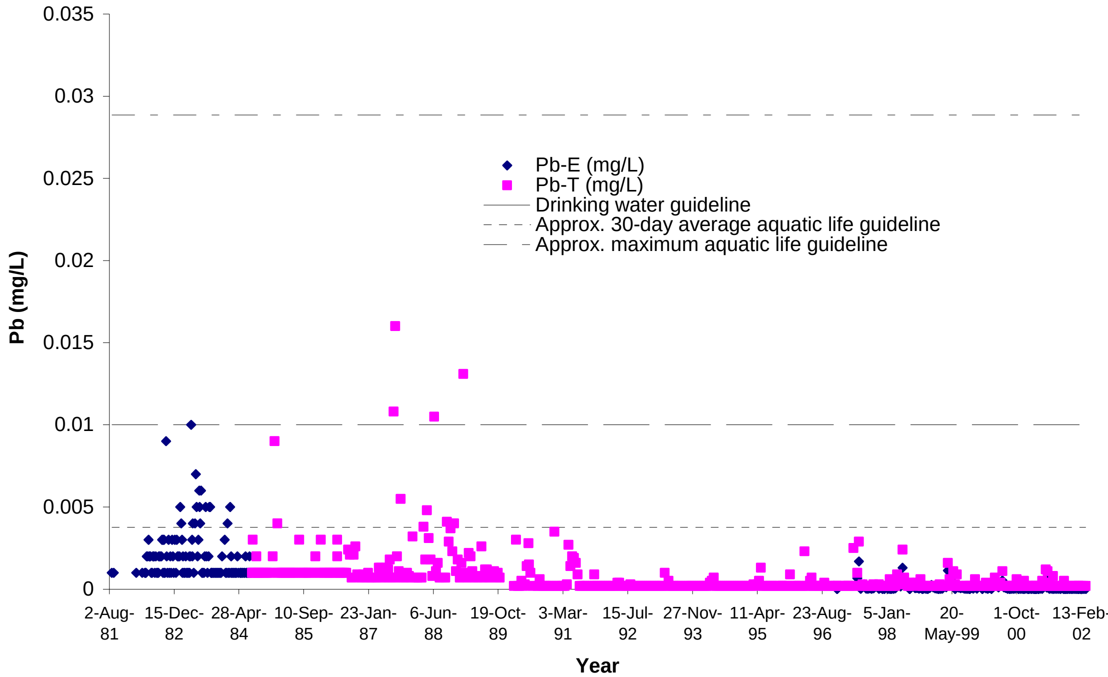


Figure 26. Kettle River at Midway - Lithium, Total and Extractable

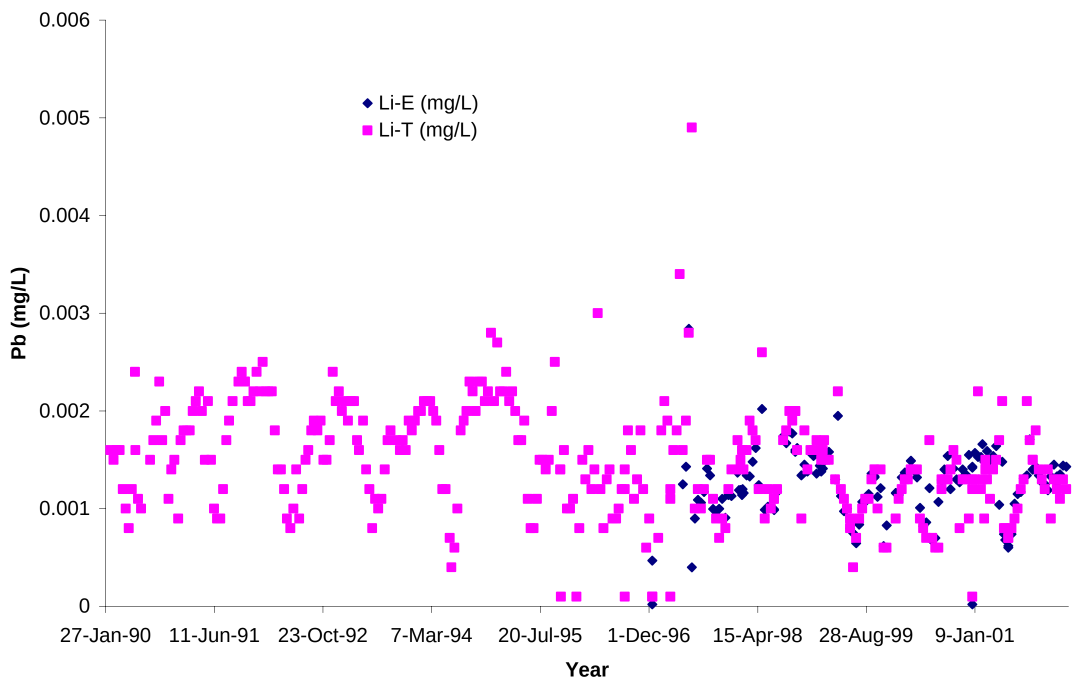


Figure 27. Kettle River at Midway - Magnesium, Dissolved, Total and Extractable

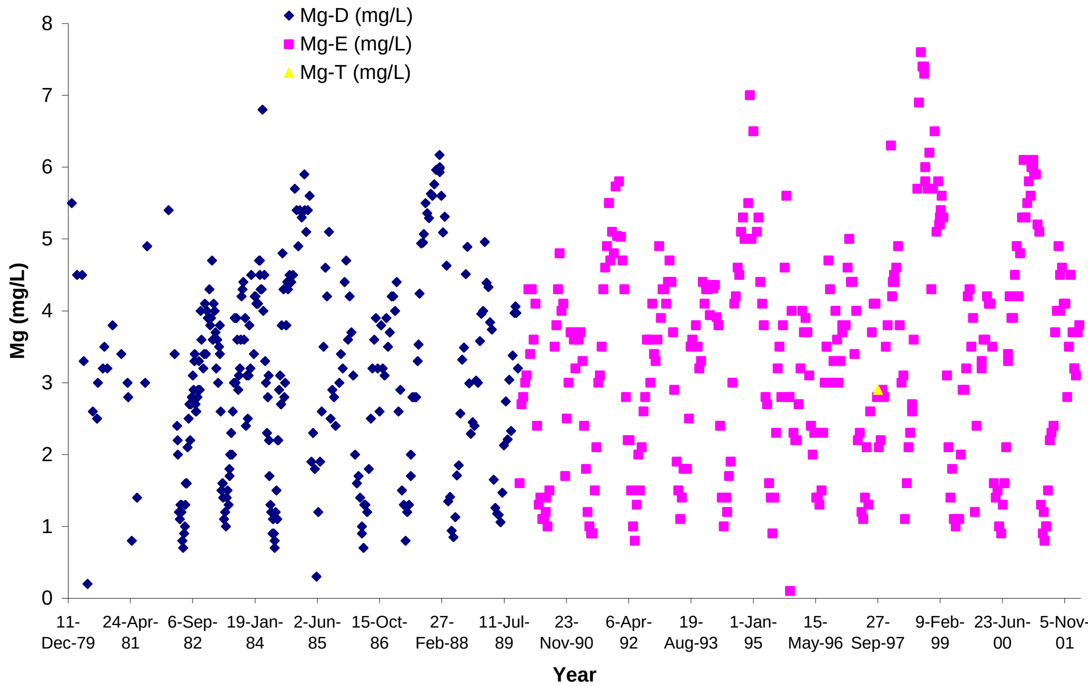


Figure 28. Kettle River at Midway - Manganese, Total and Extractable

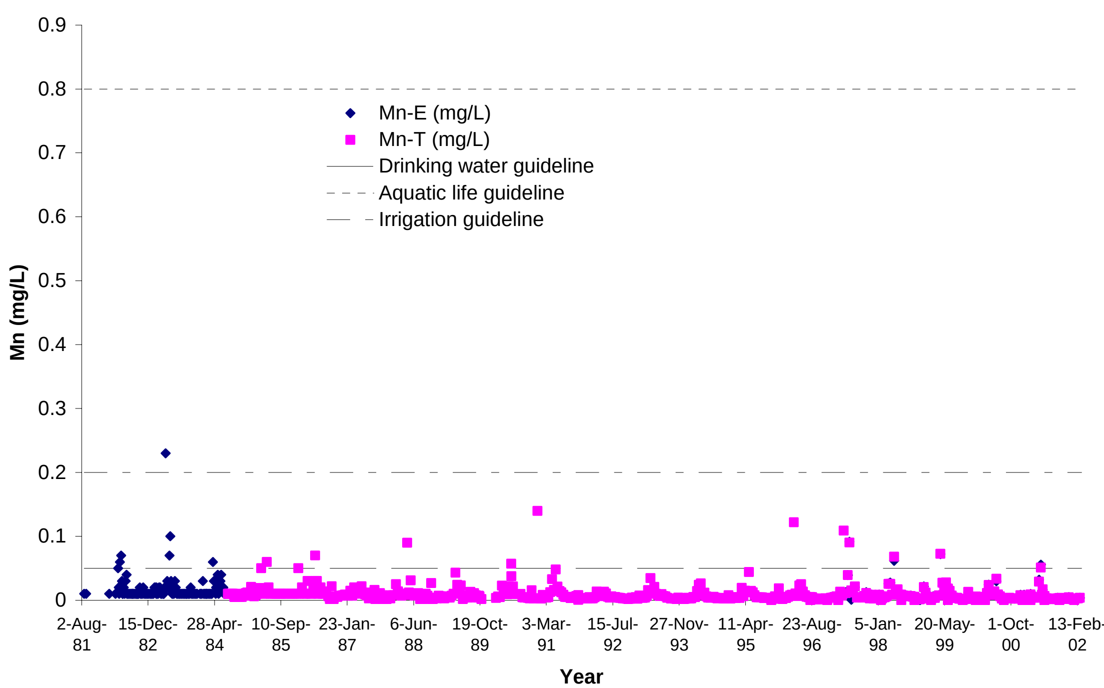


Figure 29. Kettle River at Midway - Molybdenum, Total

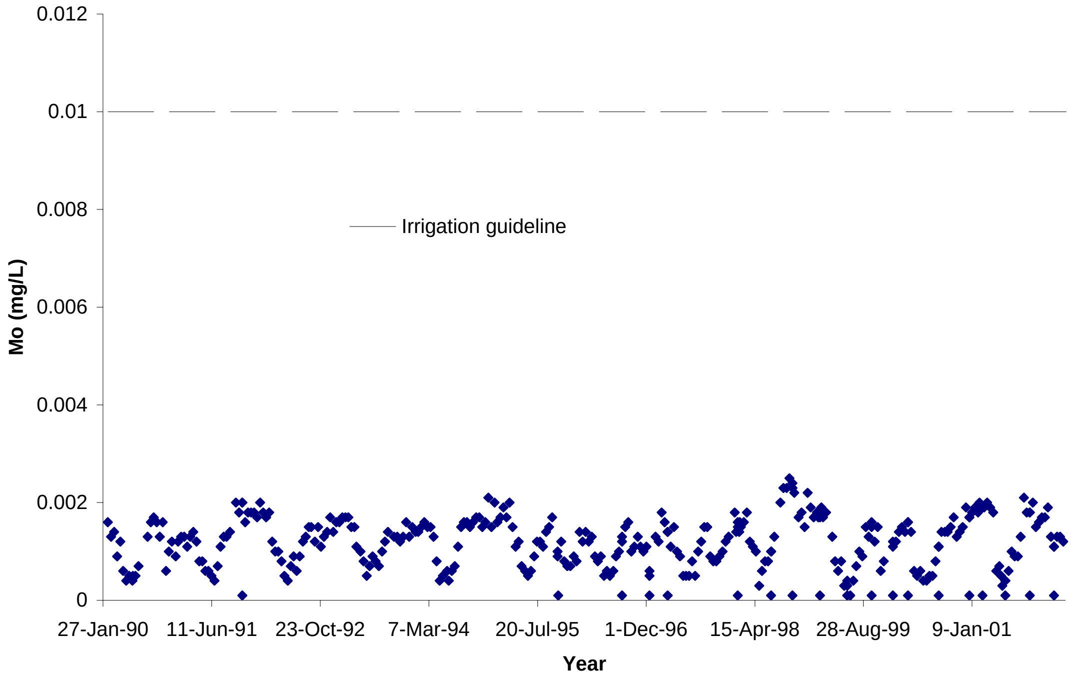


Figure 30. Kettle River at Midway - Nickel, Total and Extractable

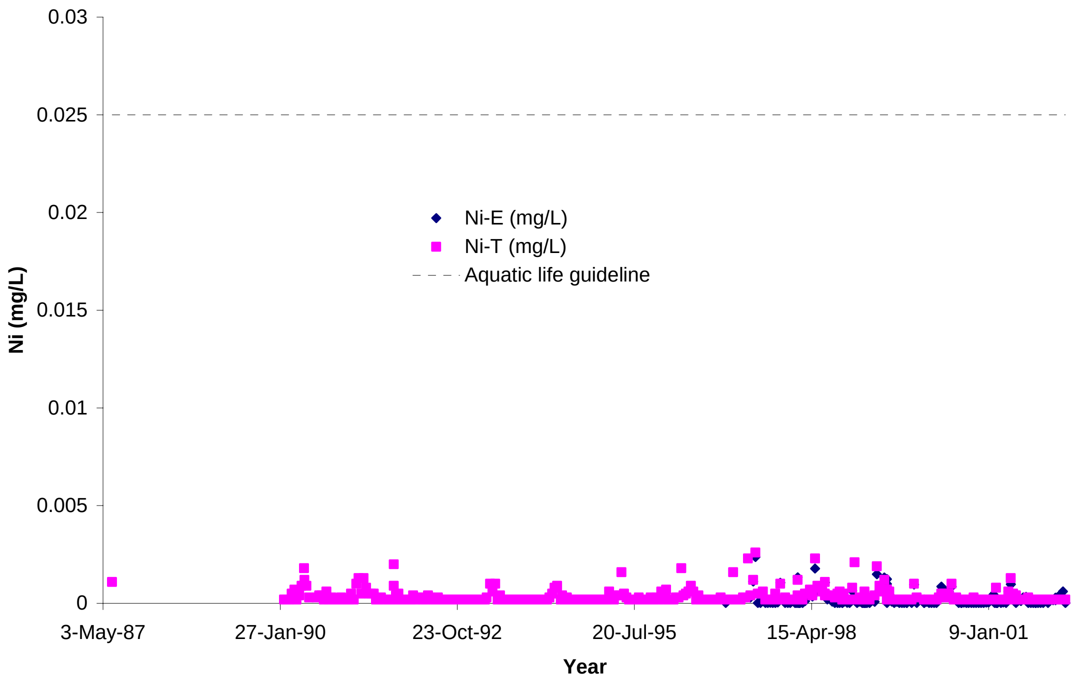


Figure 31. Kettle River at Midway - Nitrate and Nitrite

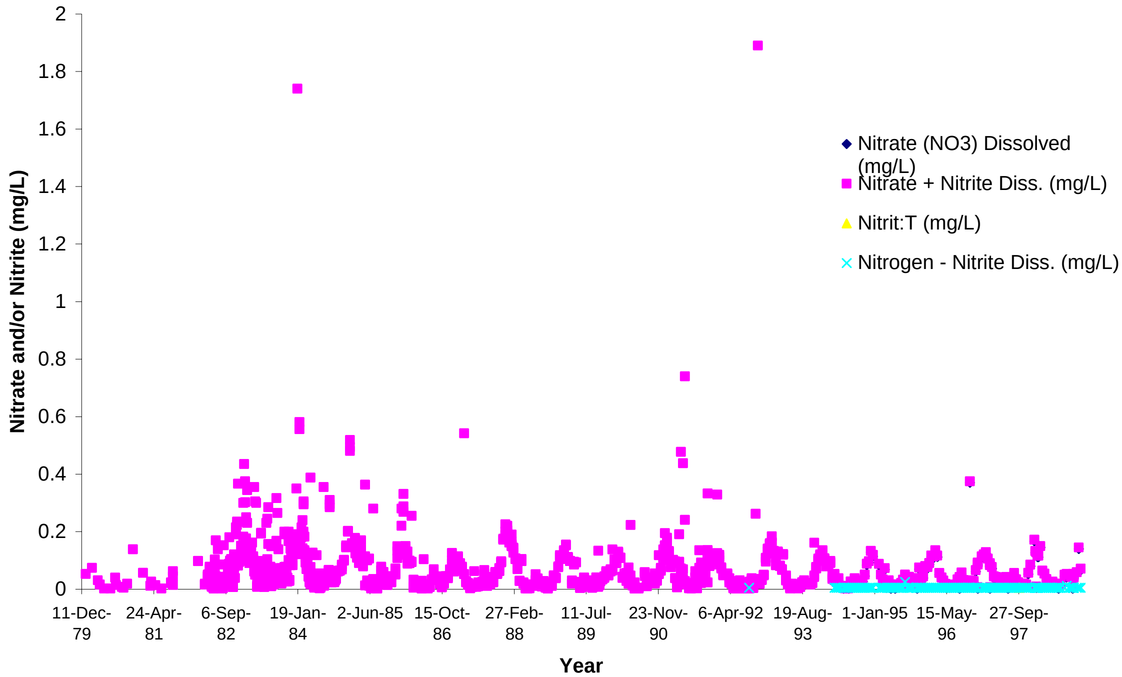


Figure 32. Kettle River at Midway - Nitrogen, Total and Dissolved

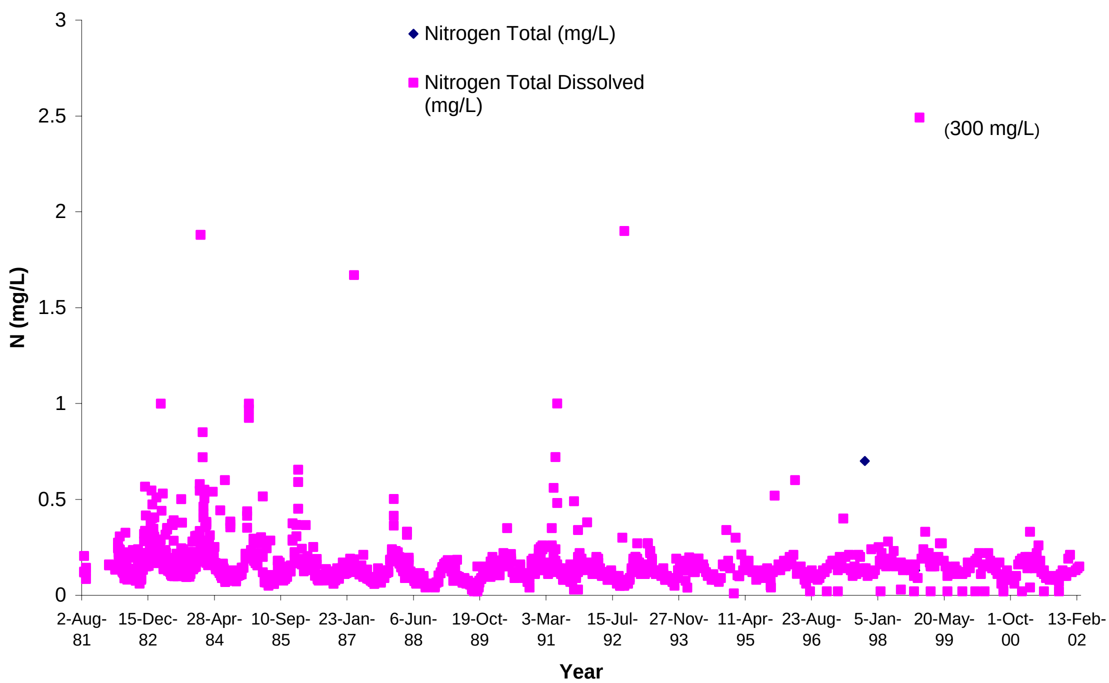


Figure 33. Kettle River at Midway - pH

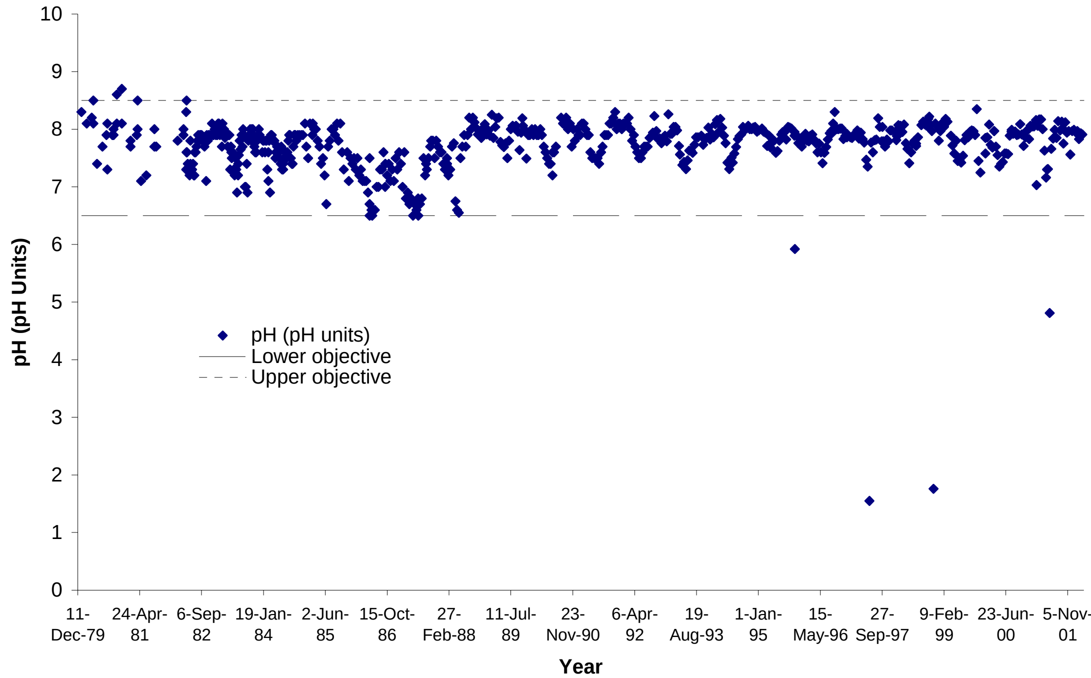


Figure 34. Kettle River at Midway - Phosphorus, Total and Dissolved

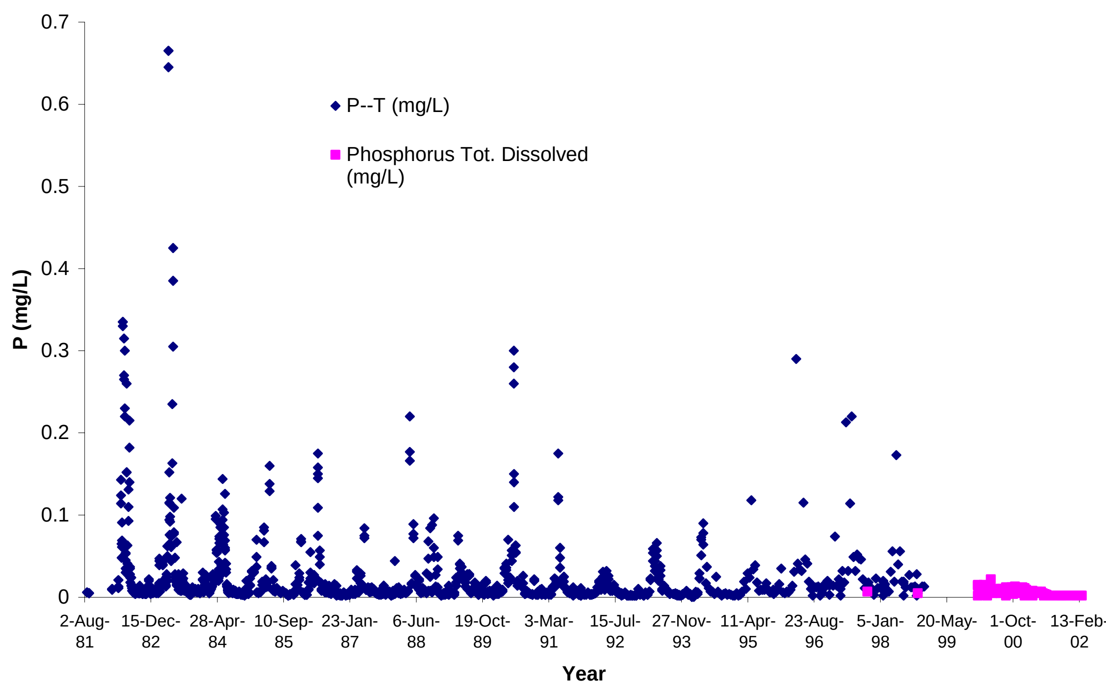


Figure 35. Kettle River at Midway - Potassium, Total, Dissolved and Extractable

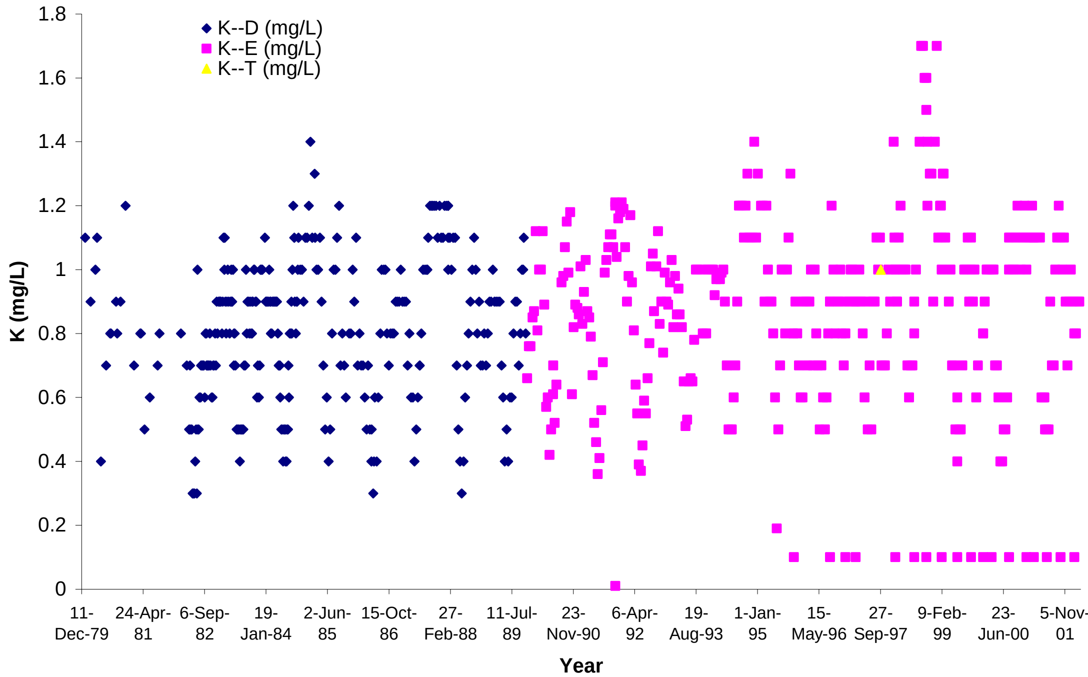


Figure 36. Kettle River at Midway - Rubidium, Extractable

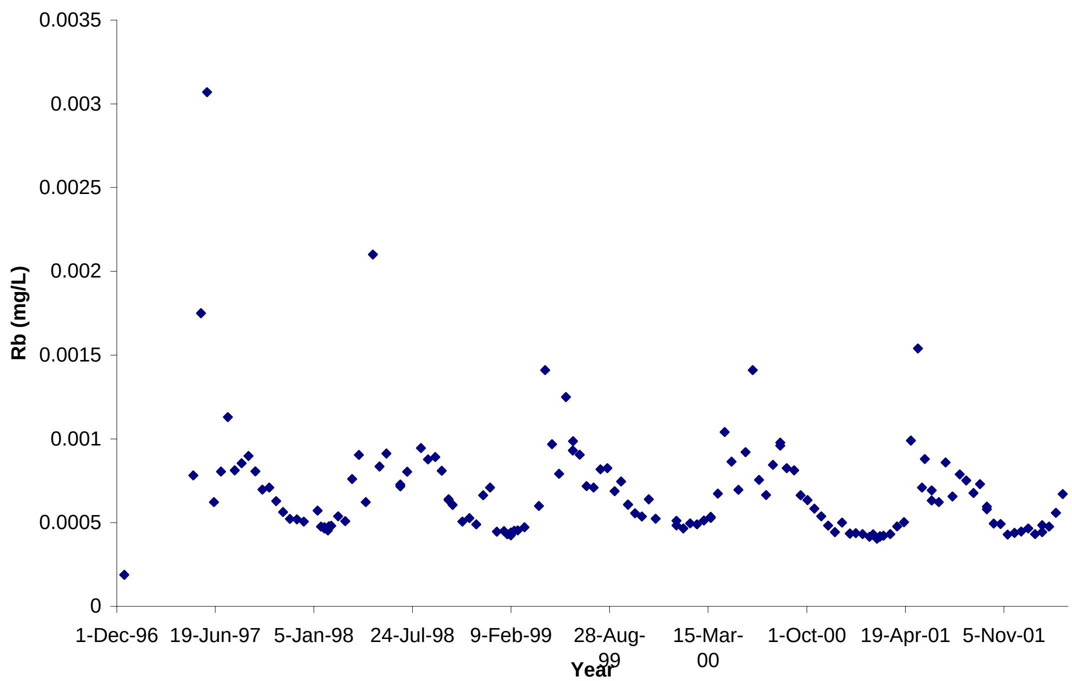


Figure 37. Kettle River at Midway - Residue, Filterable

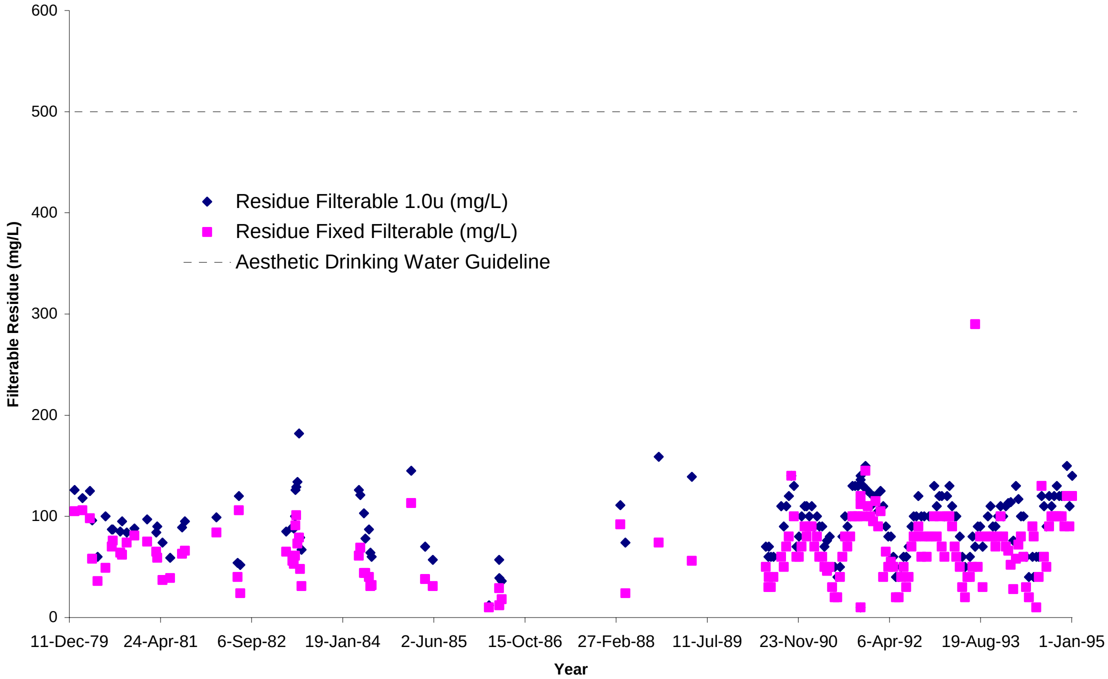


Figure 38. Kettle River at Midway - Residue, Non-Filterable

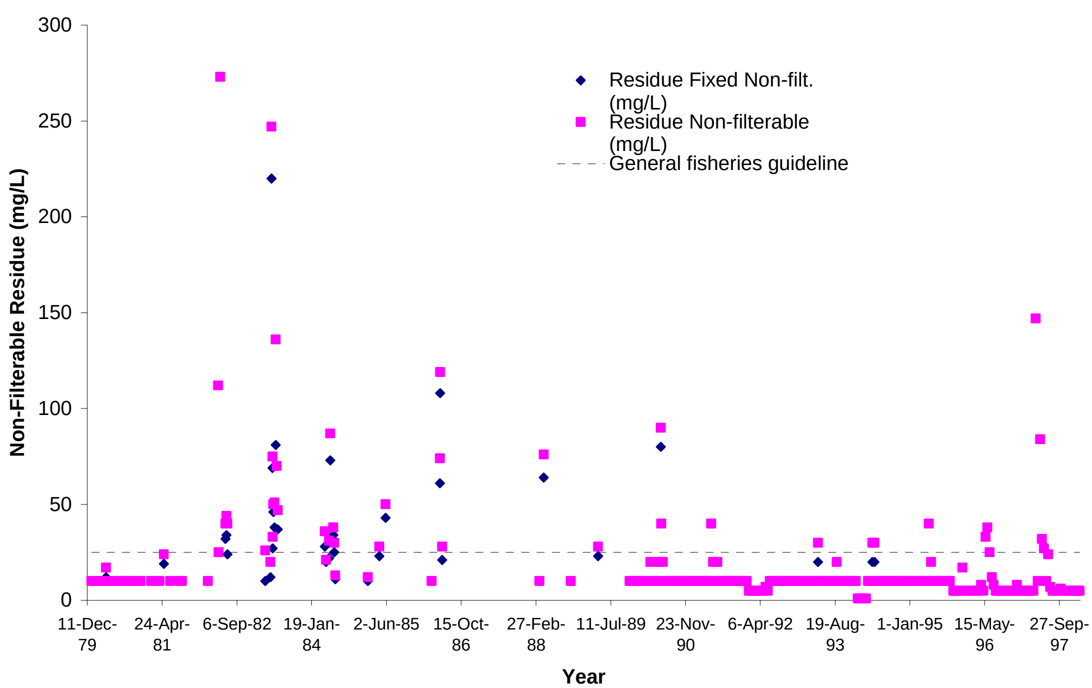


Figure 39. Kettle River at Midway - Selenium, Total and Extractable

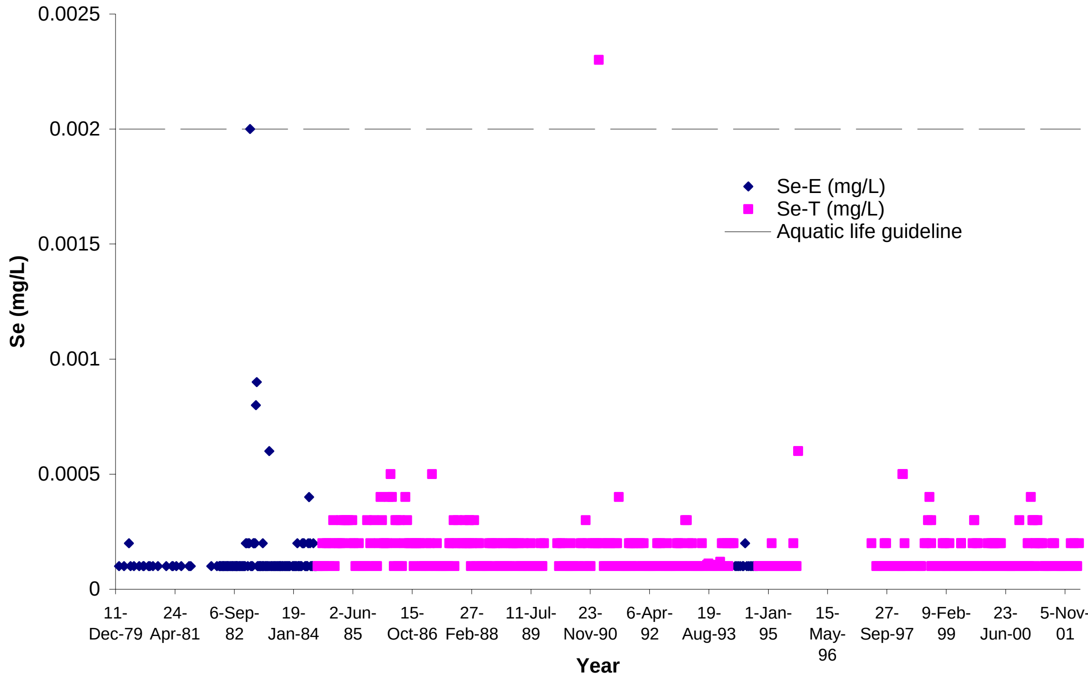


Figure 40. Kettle River at Midway - Silica, Dissolved

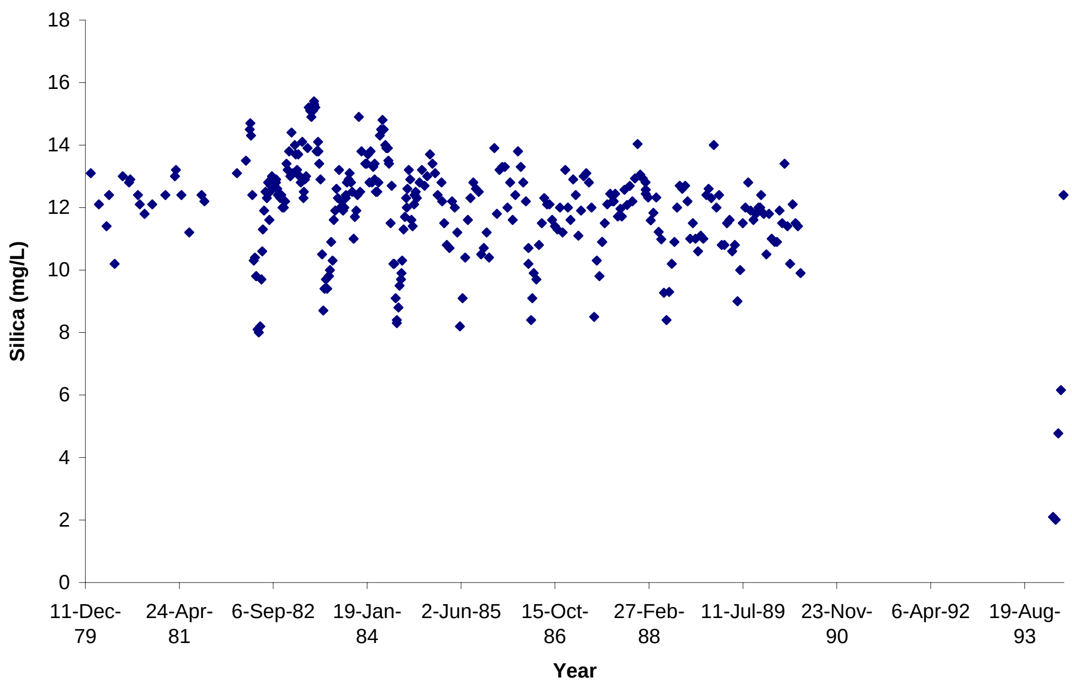


Figure 41. Kettle River at Midway - Silicon, Total, Dissolved and Extractable

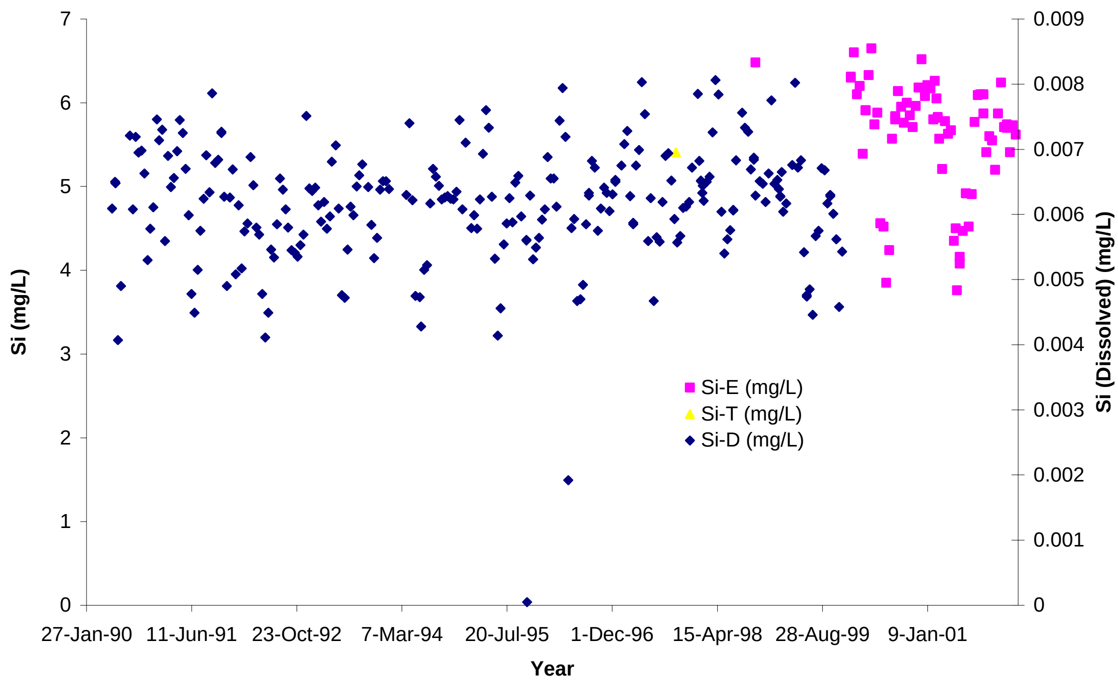


Figure 42. Kettle River at Midway - Silver, Total and Extractable

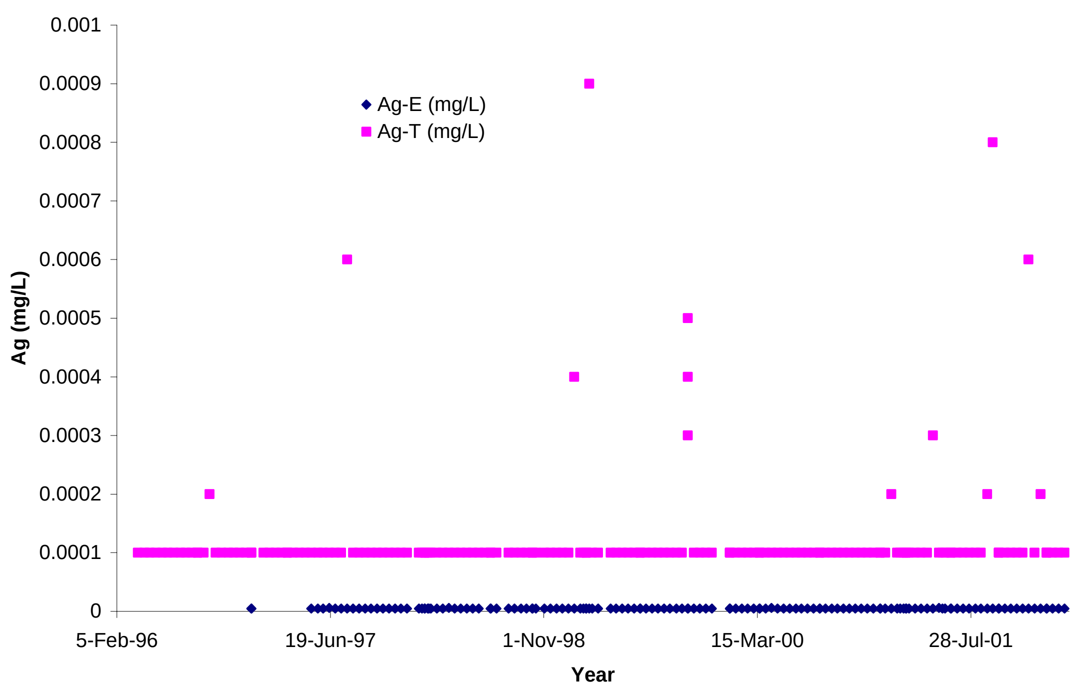


Figure 43. Kettle River at Midway - Sodium, Total, Dissolved and Extractable

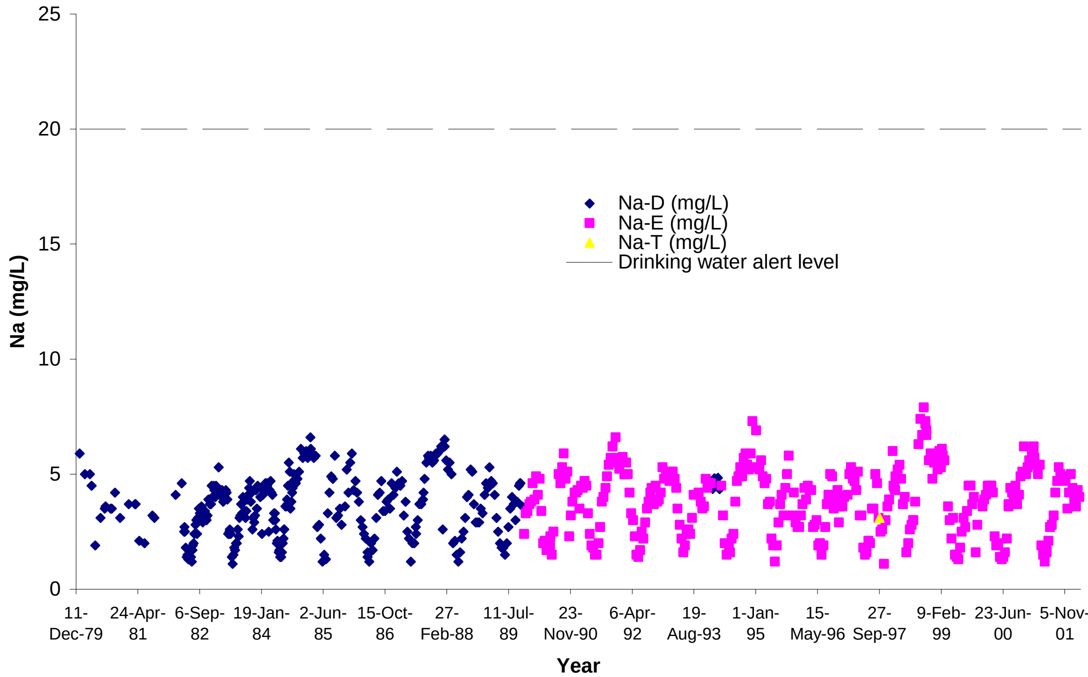


Figure 44. Kettle River at Midway - Strontium, Total and Extractable

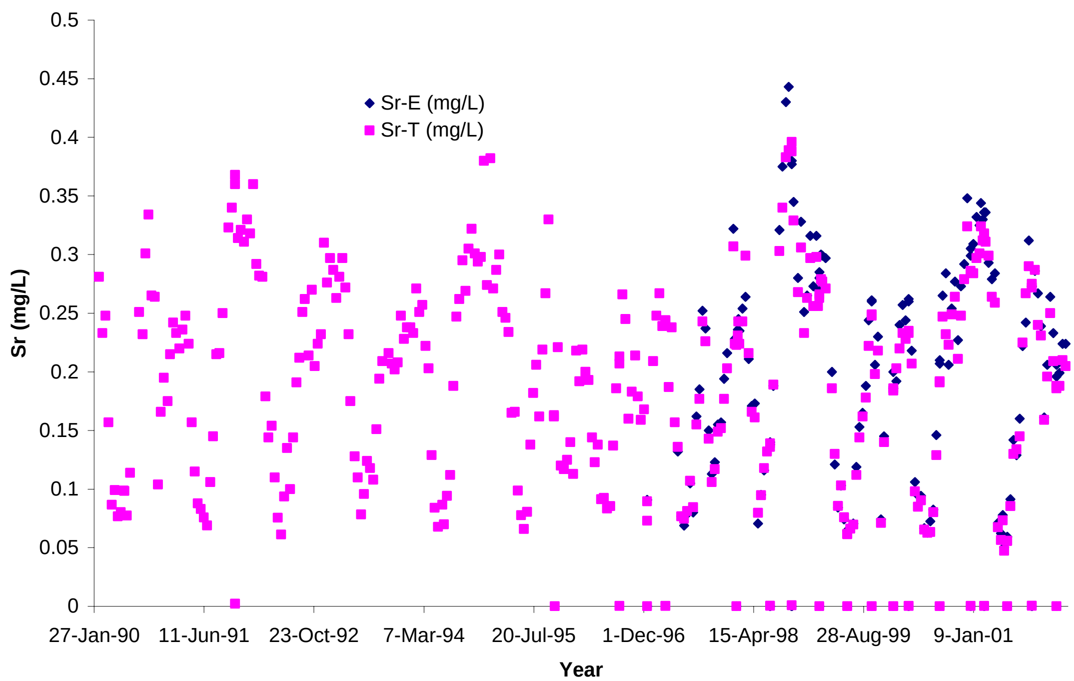


Figure 45. Kettle River at Midway - Sulphate, Total and Dissolved

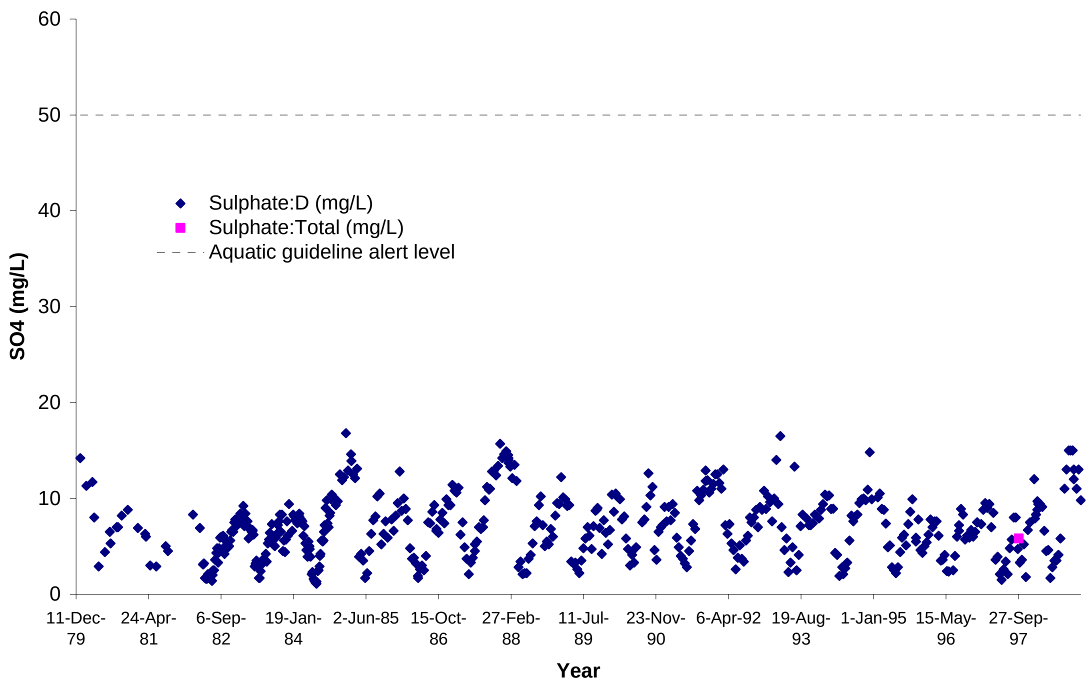


Figure 46. Kettle River at Midway - Temperature

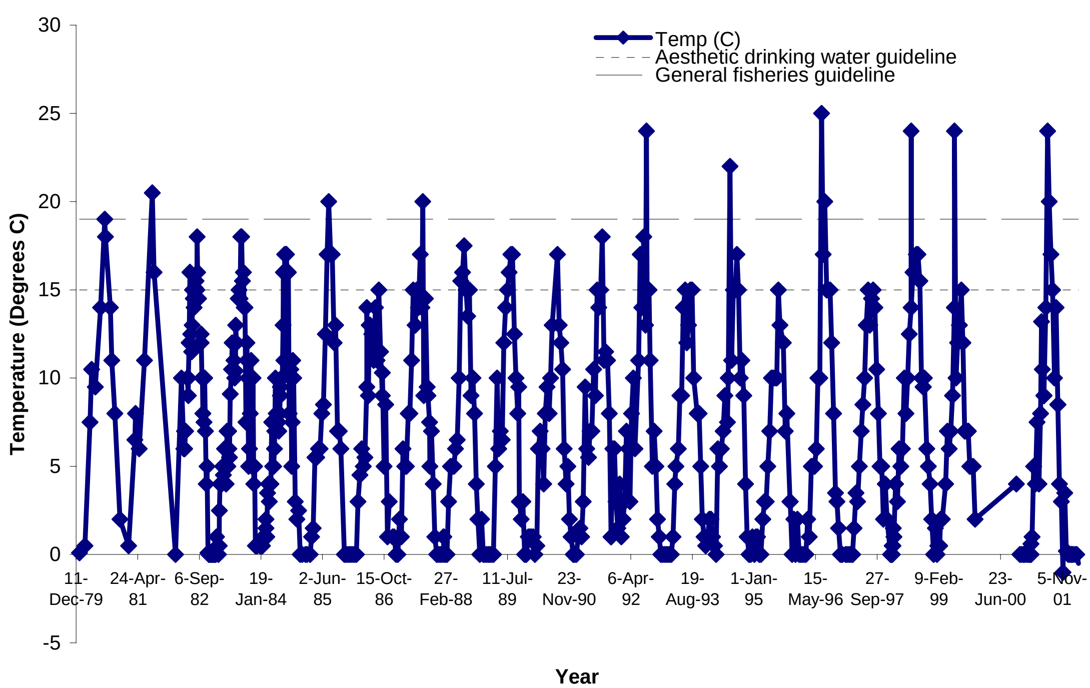


Figure 47. Kettle River at Midway - Thallium, Extractable

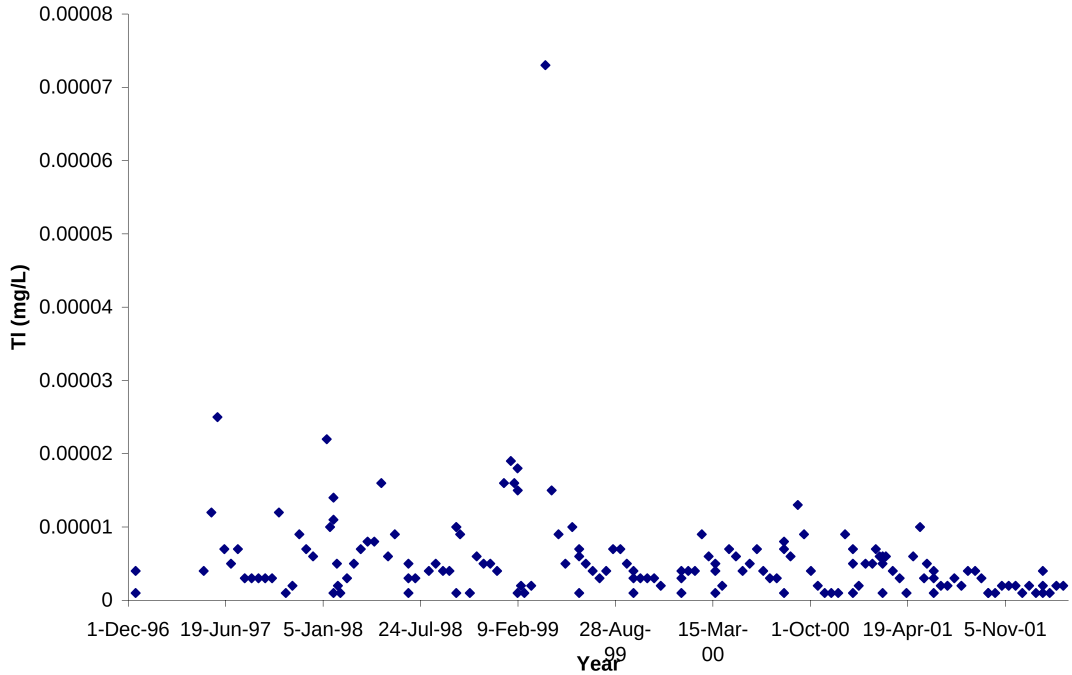


Figure 48. Kettle River at Midway - Turbidity

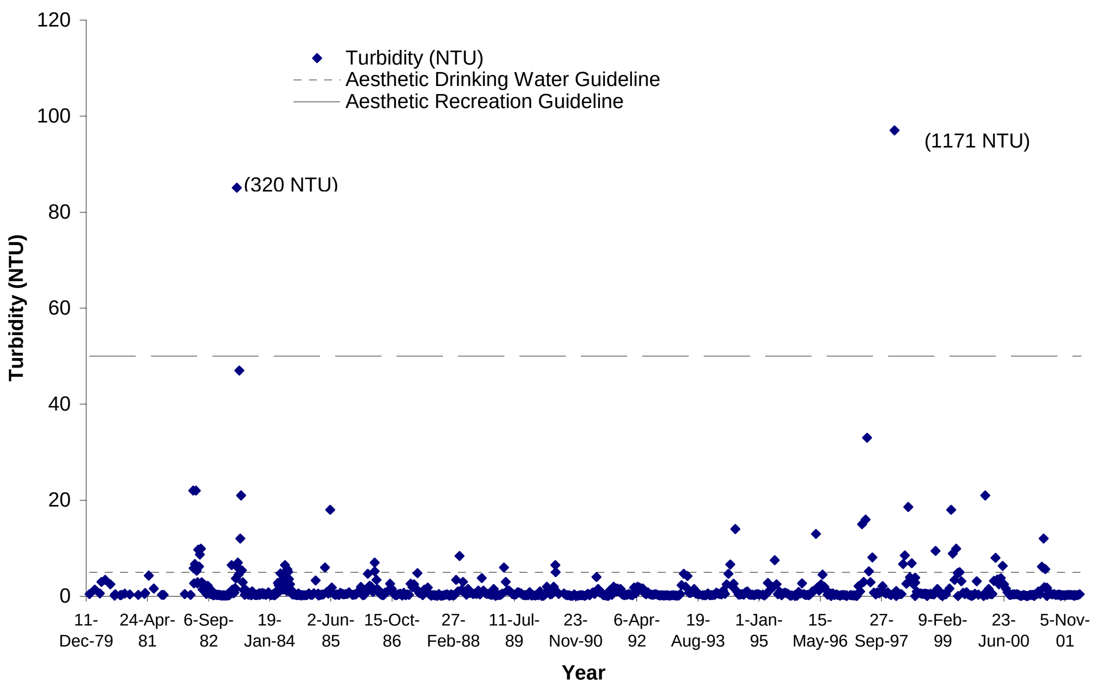


Figure 49. Kettle River at Midway - Uranium, Total and Extractable

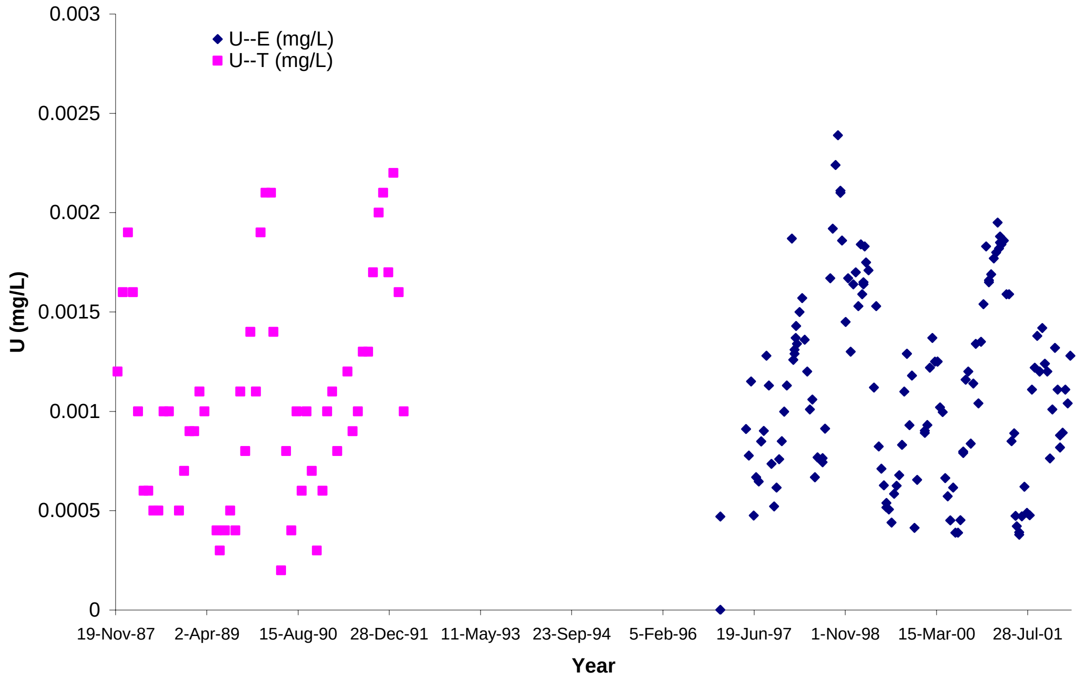


Figure 50. Kettle River at Midway - Vanadium, Total and Extractable

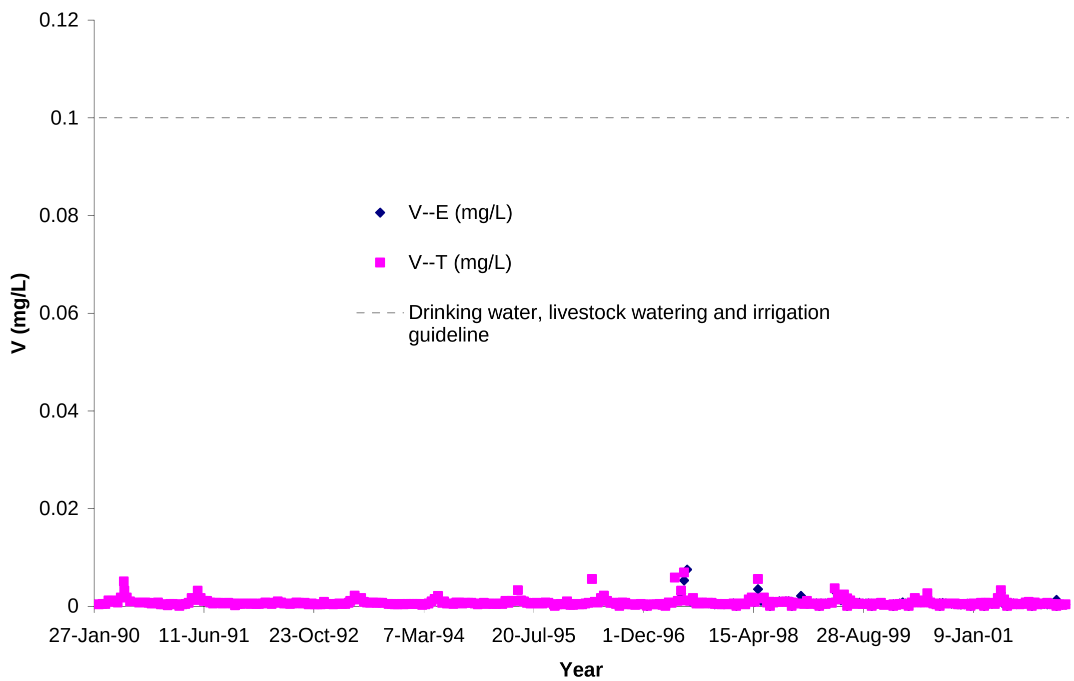


Figure 51. Kettle River at Midway - Zinc, Total and Extractable