Water Quality

State of Water Quality of Boundary Creek at Midway (1980-1994)

Canada - British Columbia Water Quality Monitoring Agreement

Water Quality Section
Water Management Branch
Ministry of Environment, Lands and Parks

Monitoring and Systems Branch
Environment Canada
Pacific and Yukon Region

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SUMMARY

This report assesses the long-term water quality trends in the Boundary Creek, a trans-boundary stream which flows from south central B.C. into Washington State. 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 Boundary Creek at Midway station is located a short distance east of the town of Midway and very near the point where Boundary Creek joins the Kettle river before it crosses the international boundary. Environment Canada has monitored the Boundary Creek at Midway station since 1980 collecting 6 to 8 samples per year. Three other related monitoring stations within the B.C. portion of the Kettle River watershed are the Kettle River at Midway, the Kettle River at Carson, and the Kettle River at Gilpin. The Kettle River at Midway station is located near the town of Midway just upstream of the Canada-U.S. border. The Kettle River at Carson station is located south west of Grand forks, B.C. near the point where the Kettle River crosses back into B.C. The Kettle River at Gilpin station is located downstream of the Carson site and just upstream of 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.

The main conclusions of this assessment are as follows:

- The water quality of the Boundary Creek at this site was generally excellent during 1980 to 1994.
- This water is well buffered against acid input yet soft enough for drinking.
- The water is naturally high in fluoride and occasionally exceeds criteria for aquatic life. We are also not aware of any effects on the local fish populations and expect that fish may be adapted to the higher levels of fluoride.

- Water quality patterns in this watershed are usually closely matched with flow patterns. As a result, increased turbidity (i.e., during freshet) makes it necessary to treat the water for drinking purposes.
- The increased levels in total phosphorus and total metals are related to seasonal increased flows due to suspended sediments and thus are largely biologically unavailable.

The main recommendation is:

Monitoring should be suspended at this station.

AUTHORS

T.N. Webber, B.Sc., RPBio, Water Quality Branch, Environmental Protection Department, B.C. Environment, Victoria, B.C.
L.W. Pommen, MSc, PEng. Water Quality Branch, Environmental Protection Department, B.C. Environment, Victoria, B.C.

ACKNOWLEDGMENTS (Reviewers)

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1. Introduction

The Boundary Creek at Midway site is located slightly east of the town of Midway, B.C., where Boundary Creek joins the Kettle River before it crosses the Canada-U.S. border (Figure 1). The drainage area of the Boundary Creek at Midway watershed is 593 km². The river flow monitoring at the Environment Canada station on Boundary Creek has been abandoned for many years. There is no flow data available for this stream.

Environment Canada has monitored the water quality at this station since 1980, and the data are stored on the federal data base, ENVIRODAT, under station number BC08NN0010. This report assesses the 15 years of data from 1980 through 1994 and for some variables, 4 years from 1990 to 1994. The water quality data are plotted in alphabetical order in Figures 2 to 42.

The purpose of the water quality monitoring has been long-term trend assessment for the Boundary Creek, a trans-boundary stream flowing from Canada to the U.S.A. Other related monitoring stations are the Kettle River at Carson and Gilpin, which are located further downstream, and Kettle River at Midway, located a short distance upstream from the Kettle River and Boundary Creek confluence. The watershed upstream from the Boundary Creek at Midway station is relatively pristine, with a small population concentrated at Greenwood and no environmentally significant industrial impacts other than forestry and some old historic mining operations. Table 9-3 of the 1977 Kootenay Air and Water Quality Study Report summarizes water licenses on the Kettle River and Boundary Creek.

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2. 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, the preservatives would leak and leach out trace metals and other contaminants 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 trace metals affected were cadmium, chromium, copper, lead, mercury, and zinc during this sampling period. There were known problems due to pH methodology at the Environment Canada Laboratory in Vancouver from about the beginning of 1986 to the end of 1988.

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3. 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 Boundary Creek. 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 are deleterious to 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.

Total aluminum (Figure 3) had peak values during spring freshet that were somewhat above drinking water and aquatic life criteria for dissolved aluminum. However, the peak total aluminum values were caused by the higher suspended sediment (see residue, non-filterable and turbidity), in freshet, and thus probably not of concern as the dissolved aluminum component would be lower. Dissolved aluminum should be monitored for direct comparison to the criteria, if there is any concern about aluminum in the future.

Total cadmium (Figure 7) had MDLs that were 10-100 times above the aquatic life criteria and levels that are typical in pristine waters. We believe that the detectable values are nothing more than artificial contamination and false positives close to the MDLs. Any future cadmium monitoring should use an MDL of 1 ng/L or lower.

Total chromium (Figure 10) exceeded the aquatic life criterion (for phyto and zoo-plankton) of 0.002 mg/L observed in 1990, 1991, and 1993. The high values were probably due to artificial contamination from preservative vials (1990) and elevated levels of suspended sediment during spring freshet (1991 and 1993). The chromium associated with suspended sediment is expected to be largely biologically unavailable.

Apparent colour (Figure 12) exceeded the true colour criteria for drinking water and recreation during spring freshet (spring and early summer), probably due to the higher turbidity at this time. True colour would have been lower because the turbidity is removed before measurement. True colour or total absorbance colour should be measured if there are colour concerns in the future.

Total copper (Figure 14) results showed widespread artificial contamination due to the failure of the Teflon lined preservative vial caps during 1986-91. Data assessment since early 1991 when the vials were changed reveals values below the aquatic life criteria of 0.002 to 0.006 mg/L for the river water hardness range to 150 mg/L. The small spike in April of 1993 corresponds to high flow and turbidity at that time.

Fluoride (Figure 15) occasionally exceeded the tentative aquatic life criteria due to the natural geologic conditions in the watershed. We are not aware of any known problems with fish in Boundary Creek due to elevated fluoride levels and expect that the fish populations are acclimated and adapted to the naturally high background levels. Measurements after mid 1985 met the aquatic life criteria when water hardness was taken into account. One value exceeding the drinking water criterion in early 1982 is believed to be an error in measurement.

Hardness (Figure 16) showed that the water was soft, periodically just above and below the optimum range for drinking water, but still quite acceptable.

Total iron (Figure 17) was occasionally above the criterion for drinking water (aesthetics) and aquatic life during spring freshet when flow and suspended sediment were higher. This is particularly evident with the April 26 measurement in 1993 when NFR was recorded at 80 mg/L. The iron is probably due to the iron content of the suspended sediment and thus of little concern. Drinking water use during freshet requires turbidity removal, which would probably reduce iron below the criterion.

Total lead (Figure 18) exceeded the drinking water and aquatic life criteria prior to 1988, probably due to artificial contamination as a result of the failure of the preservative cap liners, and false positives near the old MDL (0.001 mg/L). All criteria have been met since early 1988 with a steady improvement (i.e., lowering trend) into late 1993. This downward trend is associated with a decrease in detection limits and the use of cleaner methods.

Total manganese (Figure 21) exceeded the aesthetic drinking water criterion of 0.05 mg/L during spring freshet only once on April 26, 1993 when suspended sediments were very elevated. This is not of concern since this was due to the manganese content of the suspended sediment, which would normally be removed by drinking water treatment during turbidity removal.

Nitrogen, total dissolved (Figure 25) and **nitrate/nitrite** (Figure 24) values were well below criteria, stable and showed no apparent trends. There appears to be ample nitrogen available for algal growth except during summer. The maximum for both variables has been reported at identical sampling times of April 30, 1984 and is considered of little concern.

pH (Figure 26) met all criteria. The lower pH values in 1986-89 were due to a loss of control in pH measurement in the laboratory. The data has been flagged as questionable and unreliable.

Total phosphorus (Figure 27) showed the occasional peak values during spring freshet when suspended sediments were naturally elevated, again most notably in April 26, 1993 when NFR values were reported at 80 mg/L. There are no criteria for phosphorus in B.C. rivers.

Non-filterable residue (NFR) (i.e., suspended solids or sediment) (Figure 31) and **Turbidity** (Figure 40) both show peaks during spring freshet when suspended sediments are naturally elevated. NFR usually exceeded the general "good fisheries" criterion of 25 mg/L (Newcombe, 1986) during spring freshet. The turbidity criterion for swimming was always met, but the raw drinking water criterion of 1 NTU for water without treatment for turbidity removal was occasionally exceeded during freshet. Turbidity removal prior to drinking would be needed in freshet. Turbidity responds similarly to NFR but tends to be more sensitive (lower MDL & fewer non-detects), cheaper, has better criteria and thus we recommend that it be used as a surrogate for NFR in any future monitoring.

Fixed filterable and fixed non-filterable residue (Figures 30 and 32) have no criteria, and are generally uninterpretable, with little value for water quality assessment. We recommend that they be replaced with more relevant and specific measures of organic or inorganic constituents.

Filterable residue (FR) (dissolved solids) (Figure 29) was well below the drinking water and irrigation criterion of 500 mg/L. Specific conductivity is a more precise and cheaper variable to monitor and it has a reasonably constant relationship to filterable residue. We recommend that conductivity be used as a surrogate for FR in future monitoring.

Total Selenium (Figure 33) had one value that exceeded the aquatic life criterion in late 1983 when the turbidity was low. We have no reason to doubt the validity of this value, but all other values were well below the criterion and showed no trend.

Silicon as Si (Figure 34) showed a slight increase after 1990 due to the method change. The new method changed the mode of expression from SiO2 to Si, thus reducing the values by a factor of 2 (i.e., SiO2 = 28 + (16)2 = 60, and Si = 28; 60/28 = 2.14), but the values have been corrected in this plot. There are no criteria for silica in B.C. rivers.

Water temperature (Figure 39) met the drinking water criterion (aesthetics) except during 2 or 3 summers when the water was barely warm enough for water-contact recreation such as swimming.

Total zinc (Figure 42) regularly exceeded aquatic life criteria prior to 1990, in part due to the failure of the preservative vial cap liners experienced in the mid to late 1980s, and possibly due to elevated suspended sediment during spring freshet. Dissolved zinc is largely bio-available and thus of concern, whereas particulate zinc is not. These same criteria have not been exceeded since late 1989, and generally trend downward after that time.

Other variables were all well below all water quality criteria for the sensitive water uses and showed no environmentally significant trends.

Conclusions - State of Water Quality

- There is a close relationship between water quality patterns and flow patterns in this system.
- The water quality in Boundary Creek was very good during 1980-94, as would be expected from a watershed with a low population and little impact from industry or forestry with the possible exception of old mining and smelting operations.
- The water was well-buffered against acid inputs although soft for drinking water.
- The water was cool or cold most of the year except occasionally in summer when it warms enough to permit water-contact recreation such as swimming, but is then less aesthetically pleasing for drinking.
- The water is clear, except during the occasional spring freshet such as in April of 1993 when higher flows result in increased erosion, suspended sediment, and turbidity. The extent to which human land use activities contribute to this otherwise natural phenomenon is unknown.
- The water appears to be naturally high in fluoride as the criteria was occasionally exceeded prior to 1985. The geology of the Boundary Creek watershed may be contributing to this making it possibly less than ideal for fish although we are not aware of any affects on fish which may have adapted to the higher levels of fluoride.
- The increased turbidity during freshet such as that experienced in April of 1993, makes it necessary to treat drinking water to remove turbidity prior to use.
- Freshet also occasionally brings increased levels of metals, phosphorus, and possibly colour, but these are not of concern because they are due to the increased suspended sediment in the water, and the metals and phosphorus are largely biologically unavailable.

Comparison to other Kettle River stations (3):

Please refer to the three Water Quality Branch Kettle River basin companion reports; Kettle River at Midway, Kettle River at Carson and Kettle River at Gilpin (Webber and Pommen, 1996) for additional data assessment conclusions and recommendations.

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4. Recommendations for Water Quality Management

4.1 Remediation

There are no water quality remediation measures needed at this time.

4.2 Monitoring

- *We recommend that monitoring be suspended at this station.*

Some general monitoring recommendations for this station and other stations are:

- Measure dissolved aluminum at all times for direct comparison to current drinking water and aquatic life criteria.
- Measure dissolved metals when waters are turbid to estimate the bio-available fraction. A standardized, simple, easy to use, and contamination-free, field-filtration unit needs to be developed.
- Measure true or TAC colour where colour is of concern. Apparent colour measurements are confounded by turbidity.
- Use lower minimum detectable limits for cadmium. The MDL should be at least 10 times below the lowest relevant criterion.
- Do not attempt to measure mercury in water unless ultra-clean methods are used. Analysis of mercury in fish tissue is a better indicator of mercury contamination and much less prone to artificial contamination.
- Measure turbidity as a surrogate for non-filterable residue.
- Measure specific conductivity as a surrogate for filterable residue.
- Do not measure fixed filterable and non-filterable residues; more specific, relevant indicators are available.

Figure 1 Map of the Kettle River Basin

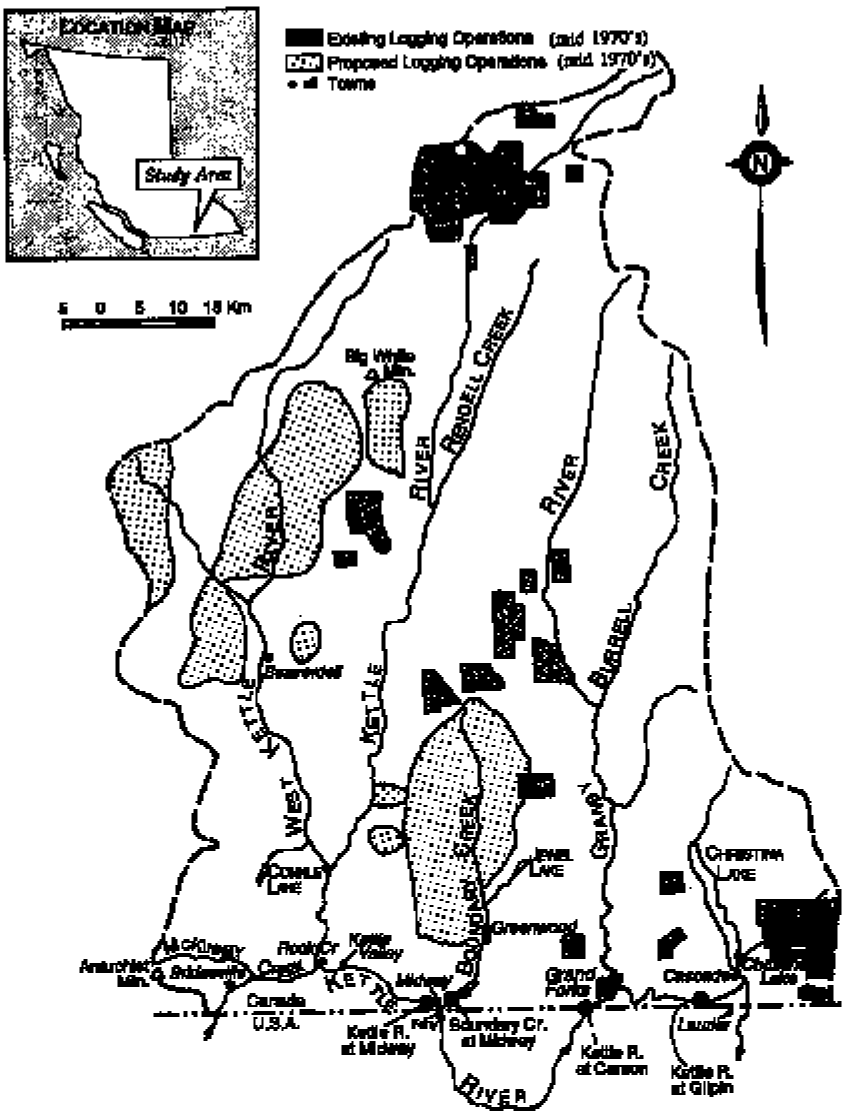


Figure 2 Total Alkalinity

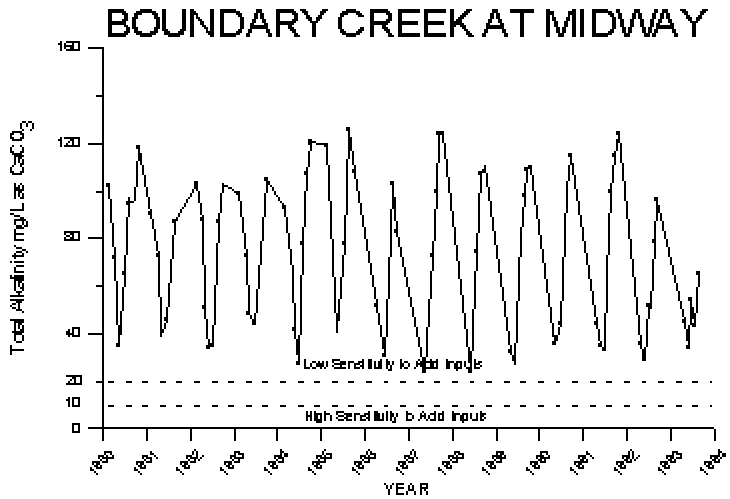


Figure 3 Total Aluminum

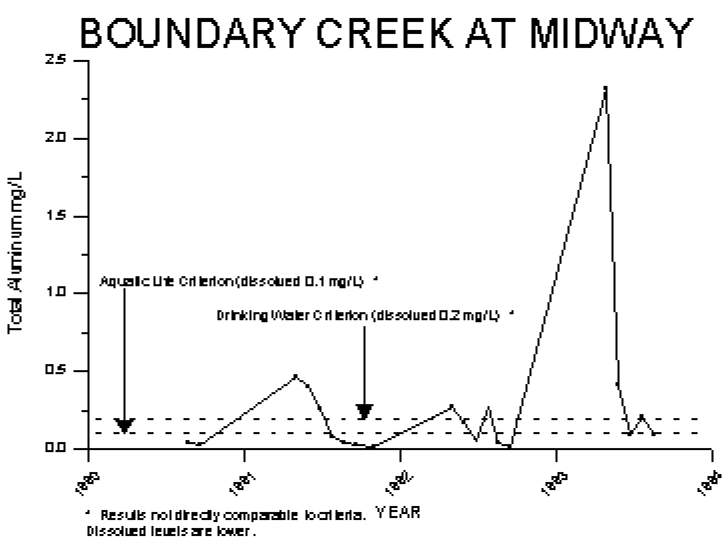


Figure 4 Total Arsenic

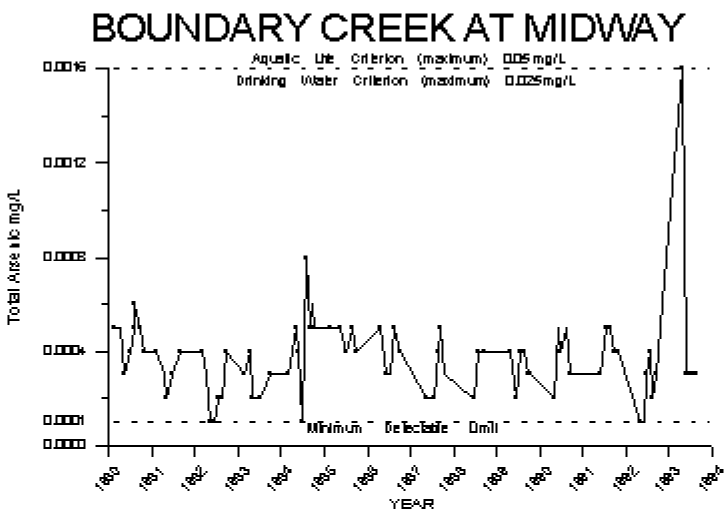


Figure 5 Total Barium

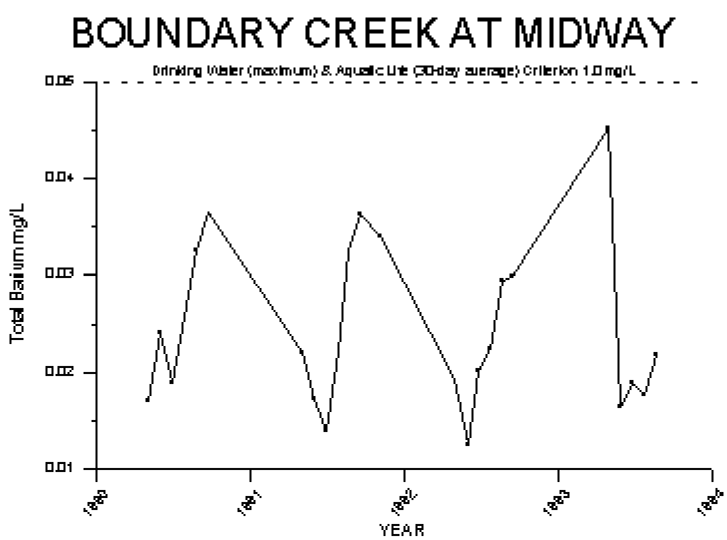


Figure 6 Total Beryllium

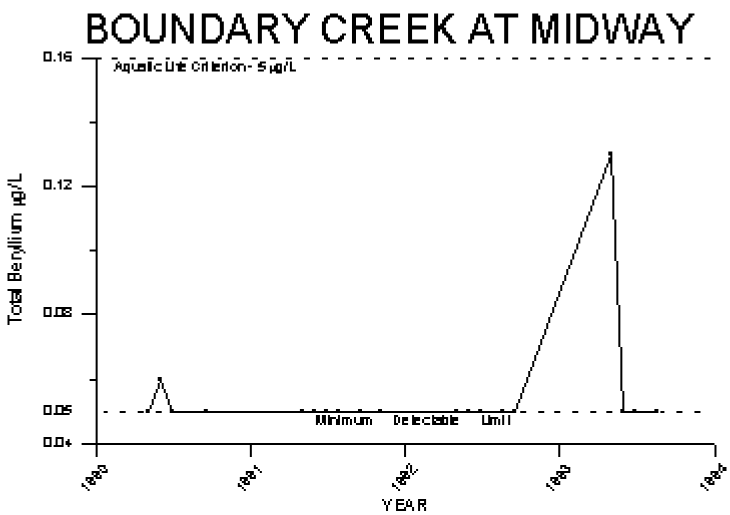


Figure 7 Total Cadmium

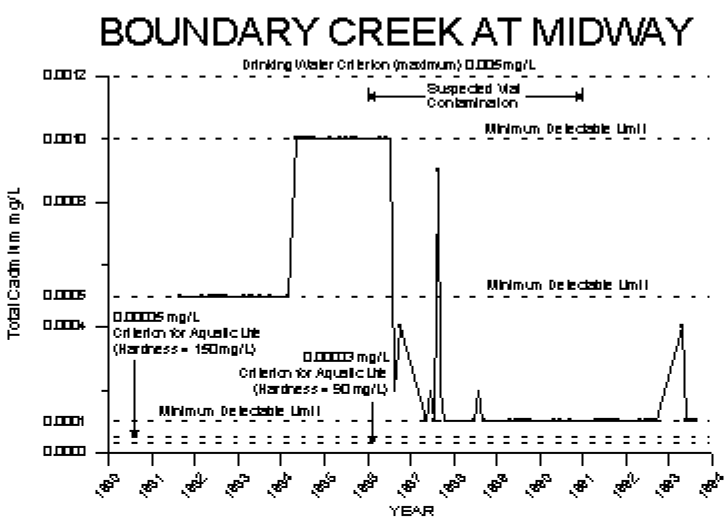


Figure 8 Calcium

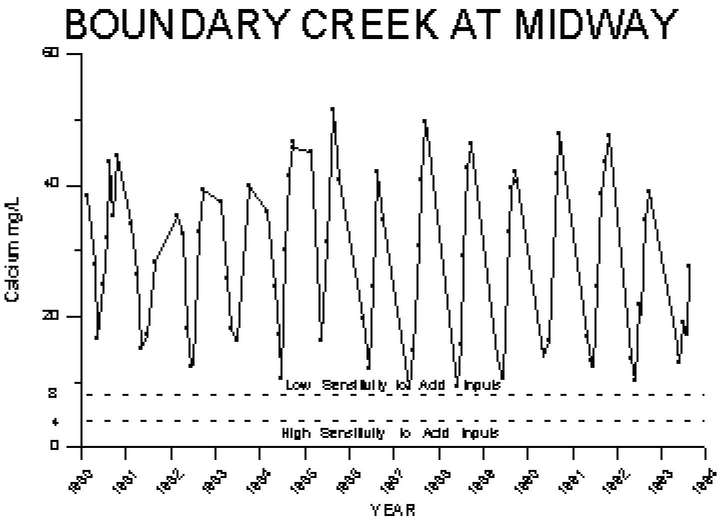


Figure 9 Dissolved Chloride

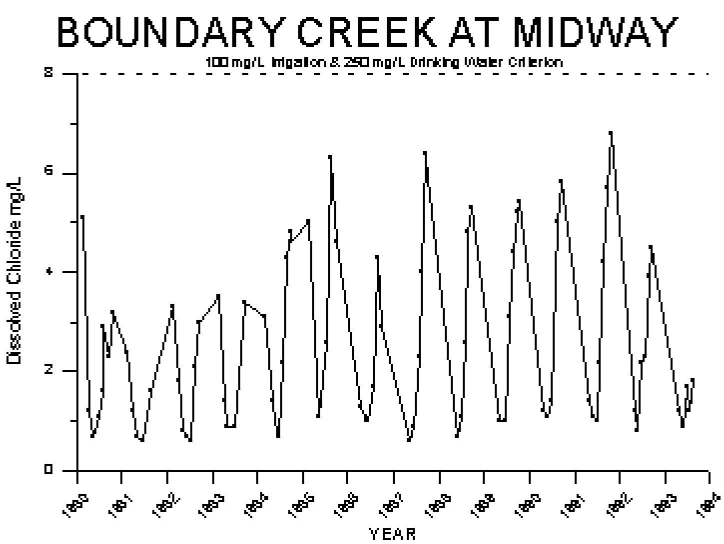


Figure 10 Total Chromium

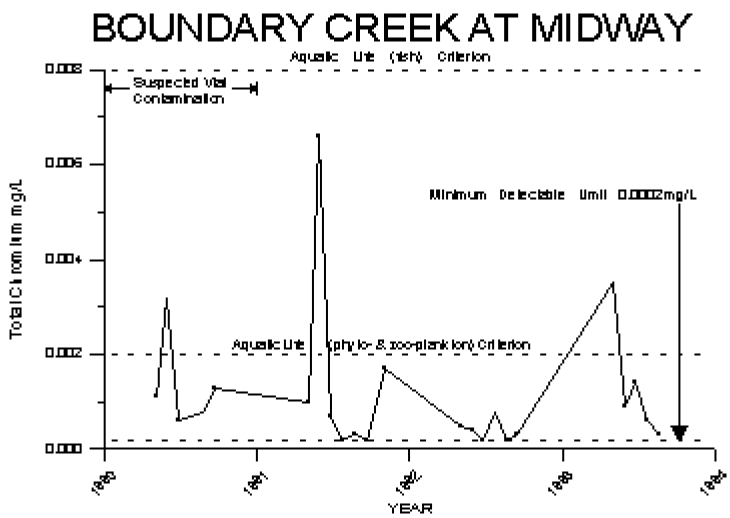


Figure 11 Total Cobalt

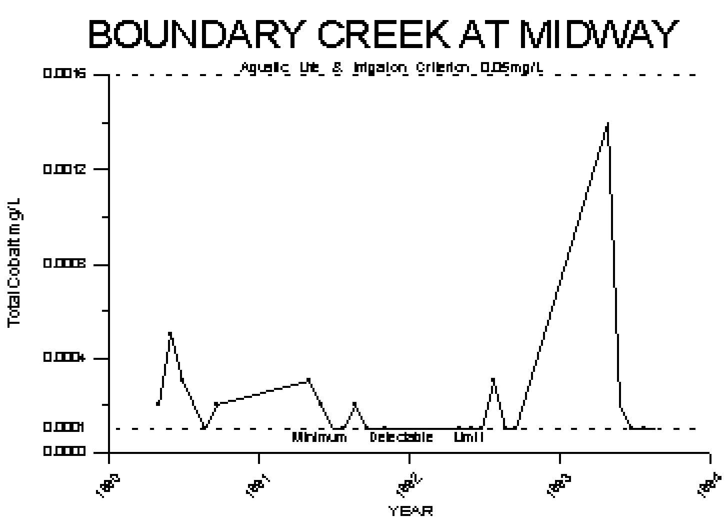


Figure 12 Apparent Colour

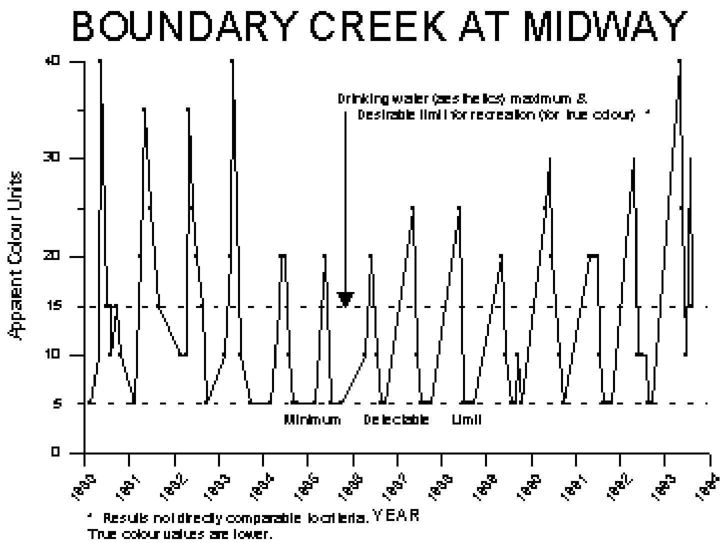


Figure 13 Specific Conductivity

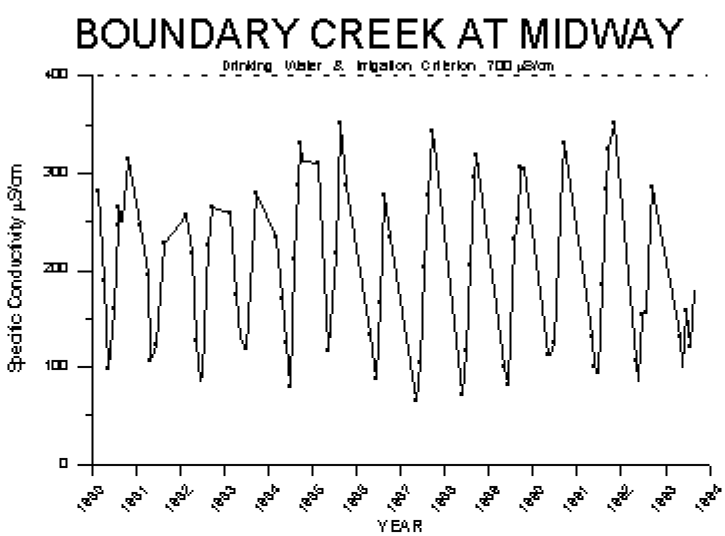


Figure 14 Total Copper

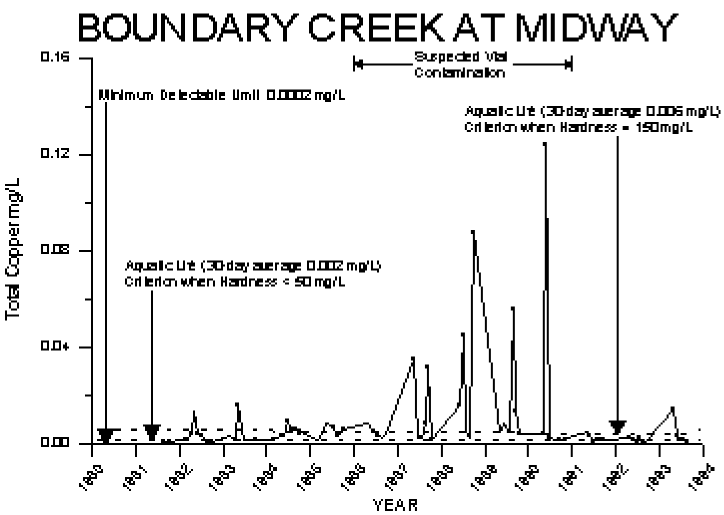


Figure 15 Dissolved Fluoride

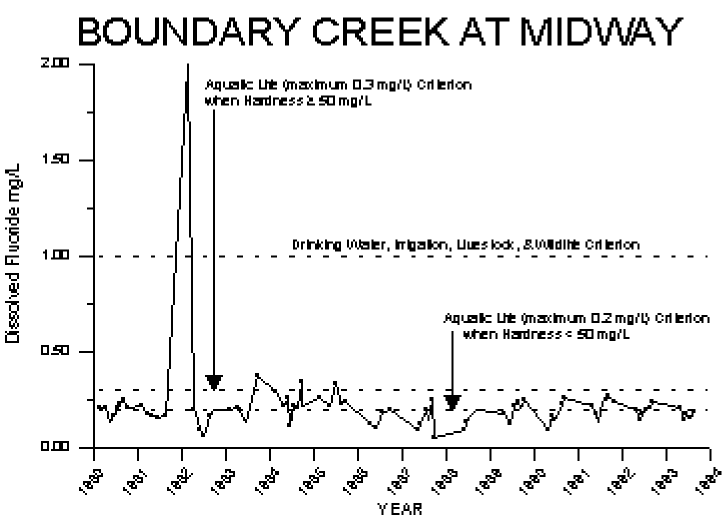


Figure 16 Hardness

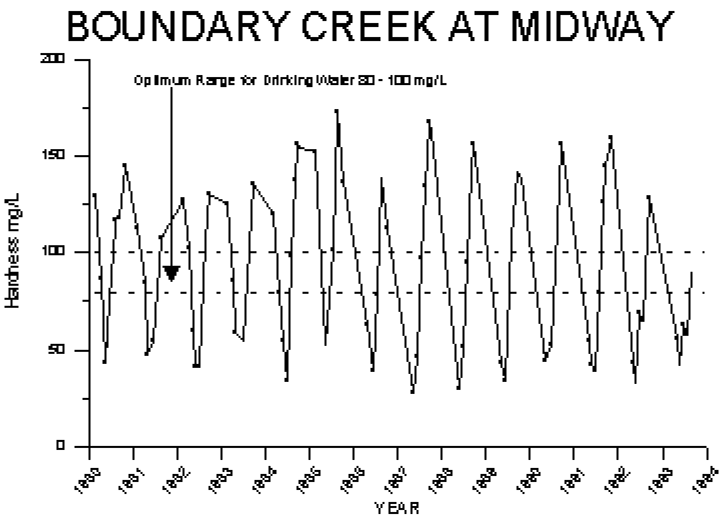


Figure 17 Total Iron

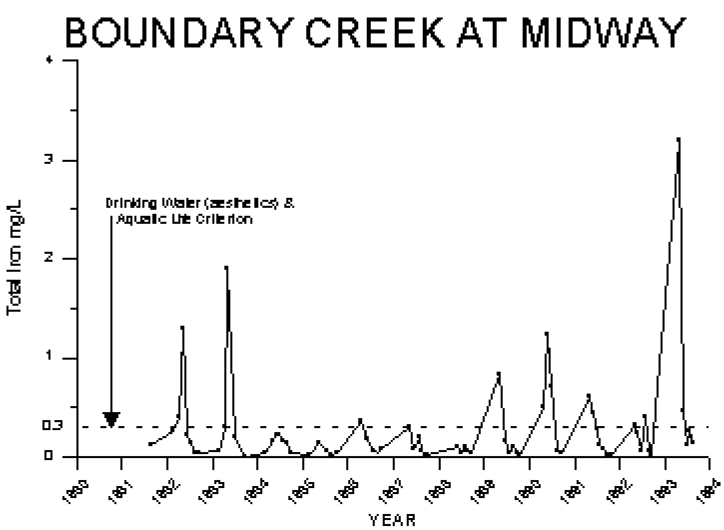


Figure 18 Total Lead

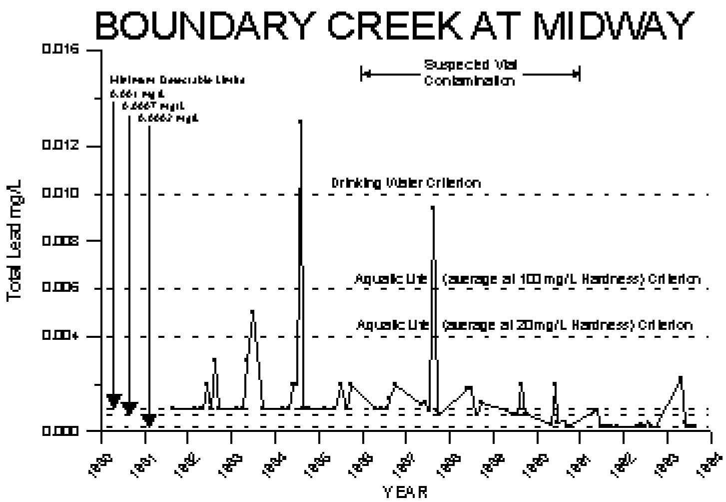


Figure 19 Total Lithium

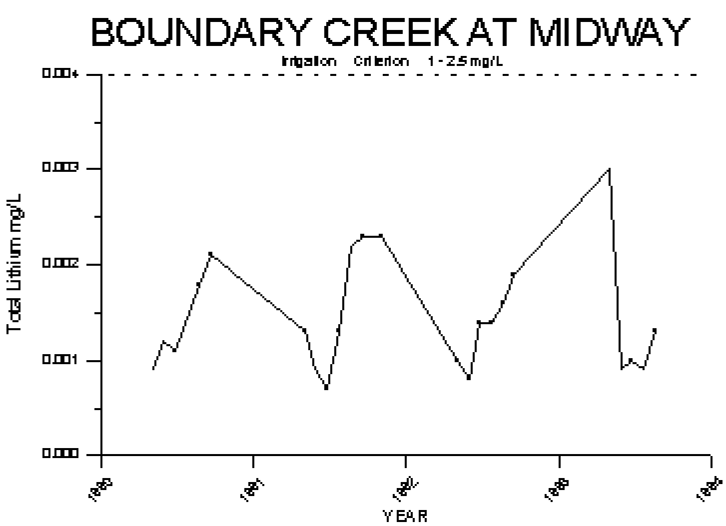


Figure 20 Magnesium

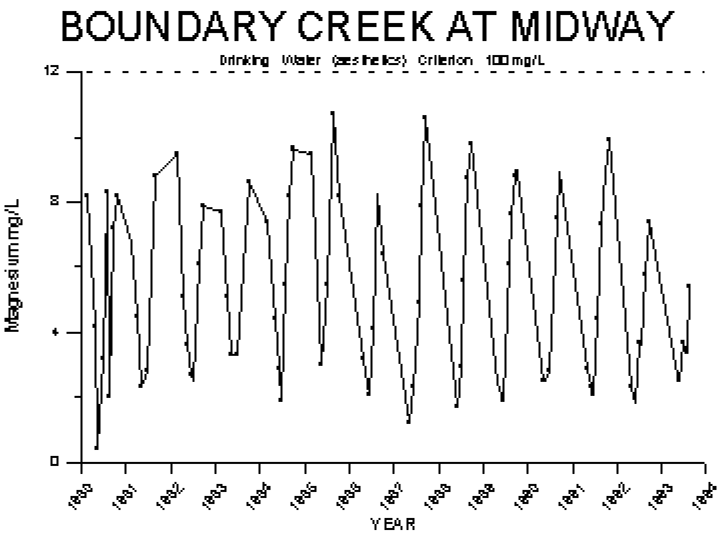


Figure 21 Total Manganese

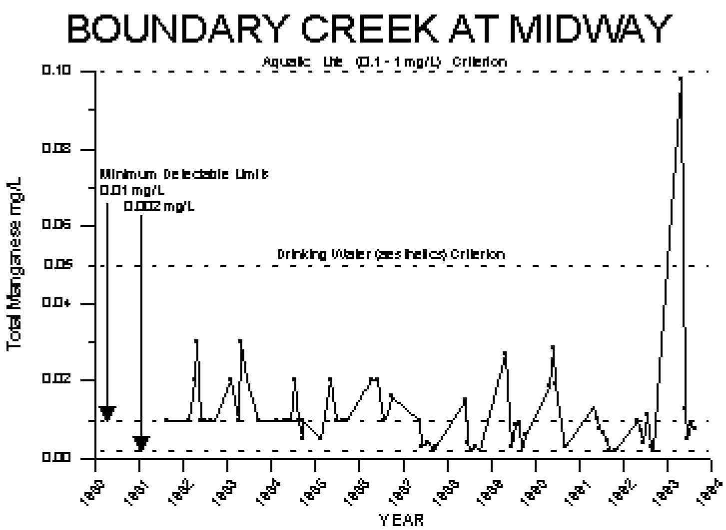


Figure 22 Total Molybdenum

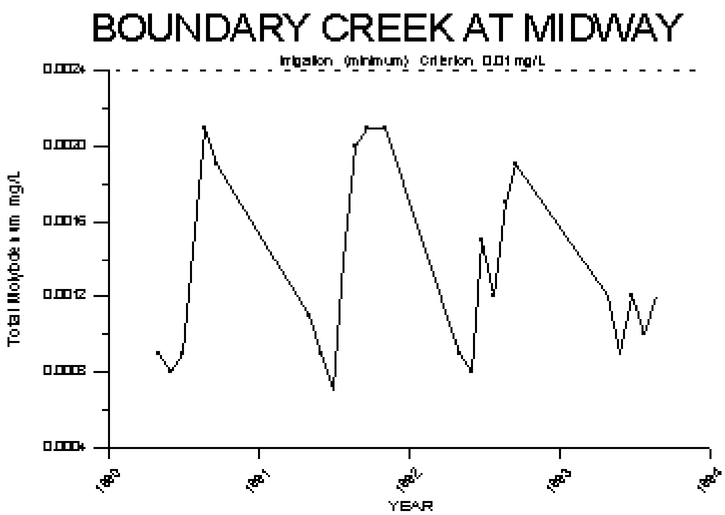


Figure 23 Total Nickel

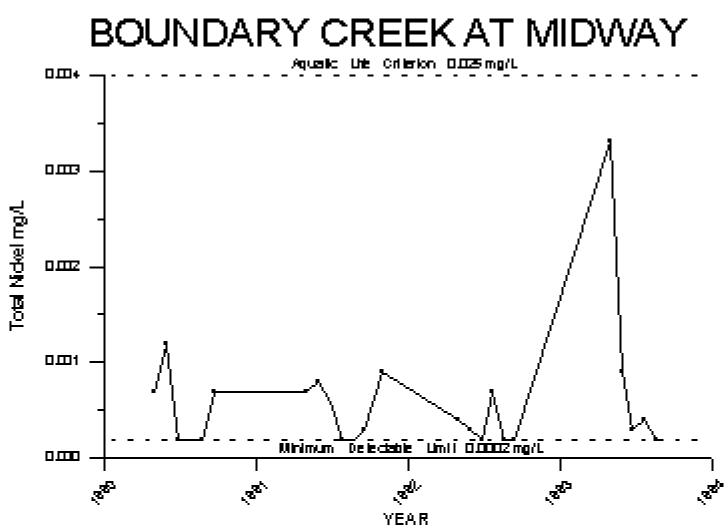


Figure 24 Nitrogen (Nitrate/Nitrite)

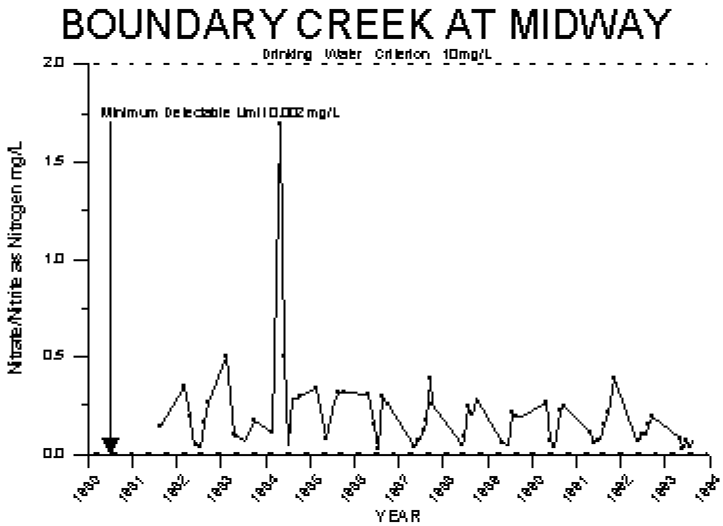


Figure 25 Total Dissolved Nitrogen

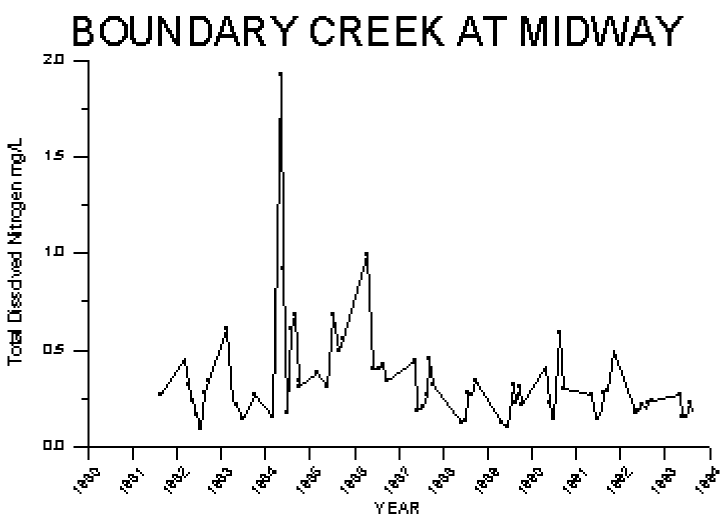


Figure 26 pH

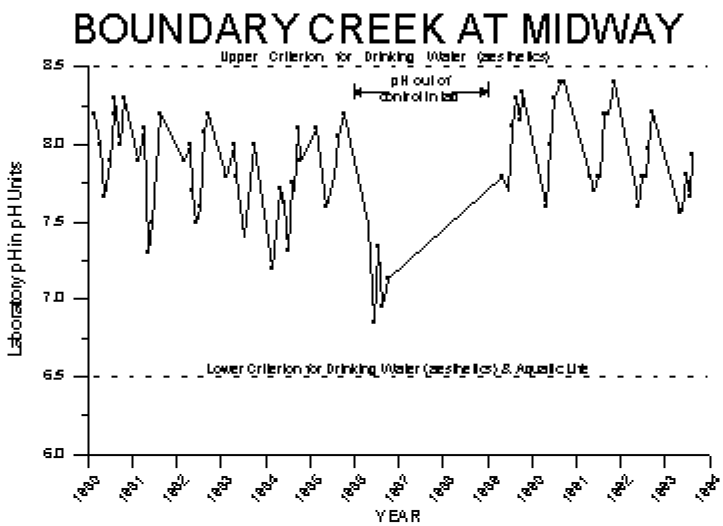


Figure 27 Total Phosphorus

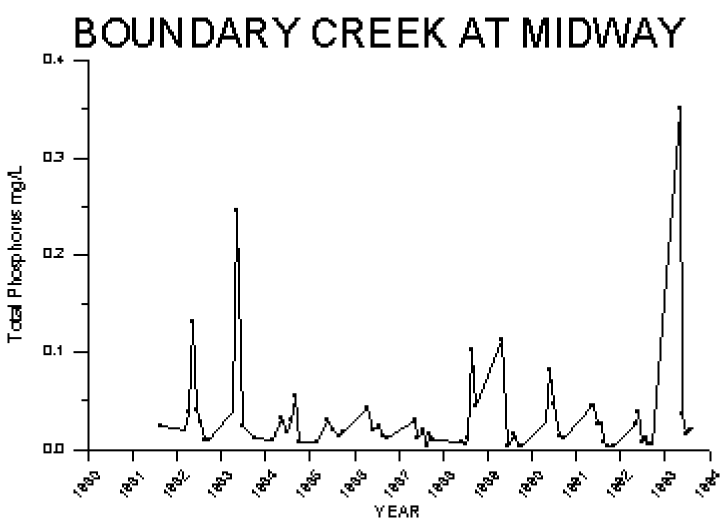


Figure 28 Potassium

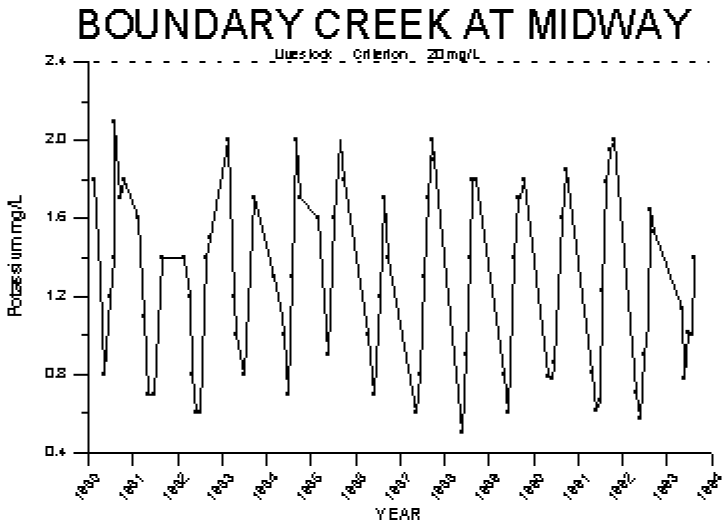


Figure 29 Filterable Residue

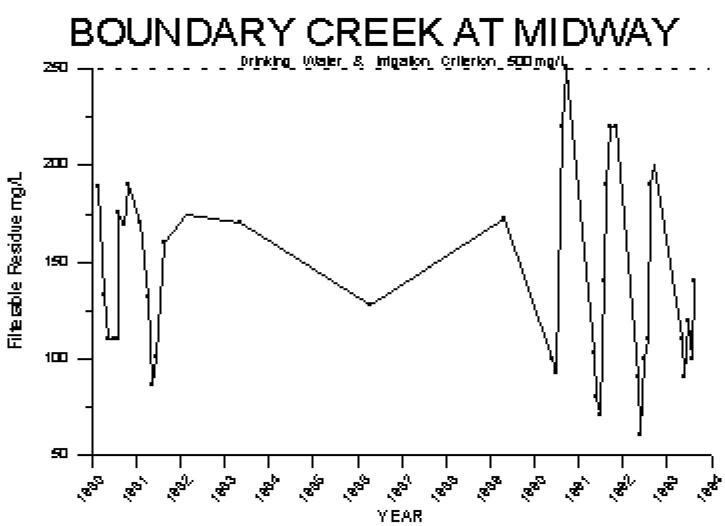


Figure 30 Fixed Filterable Residue

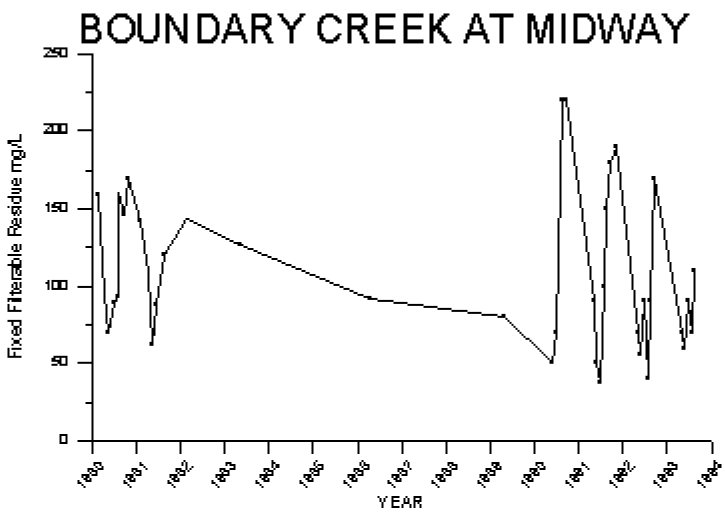


Figure 31 Non-Filterable Residue

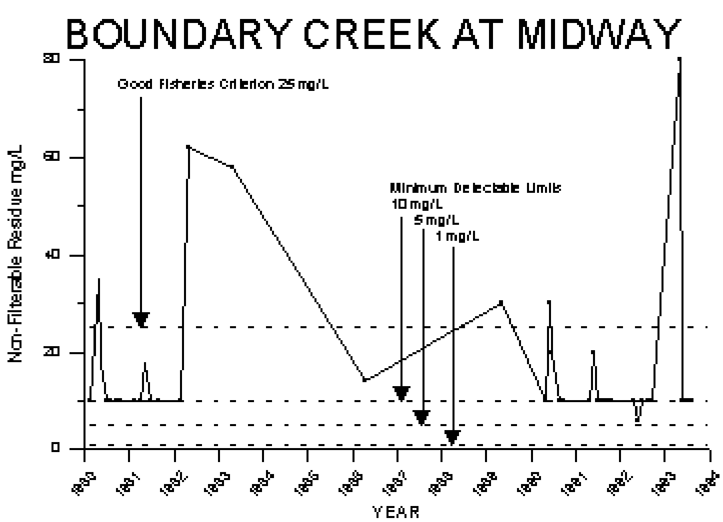


Figure 32 Fixed Non-Filterable Residue

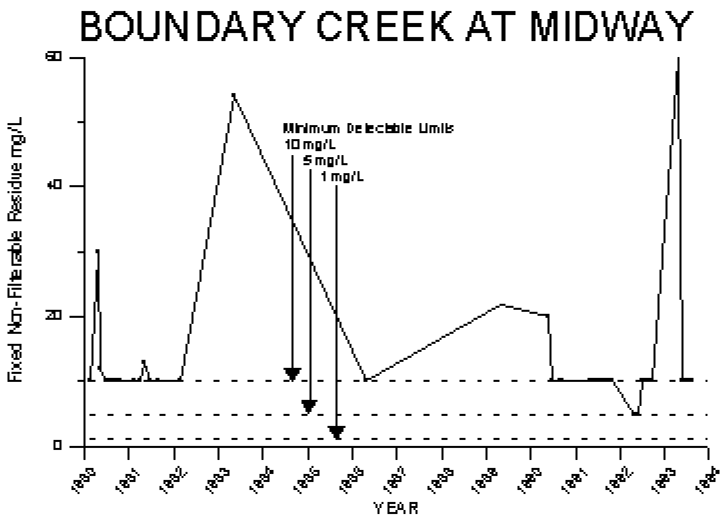


Figure 33 Total Selenium

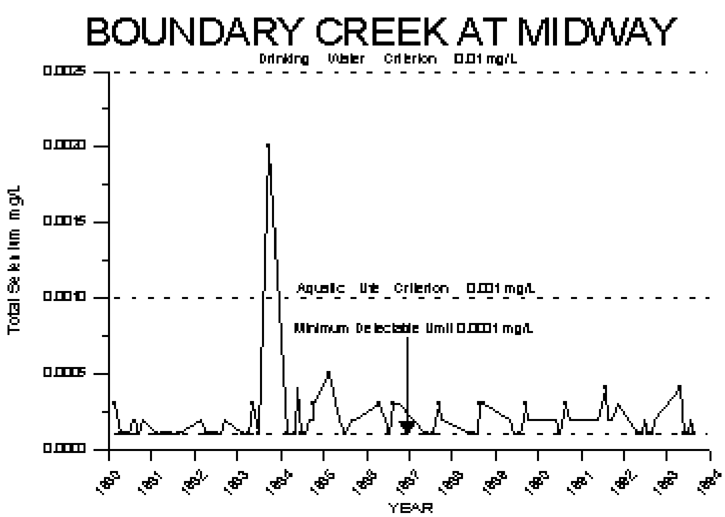


Figure 34 Silica

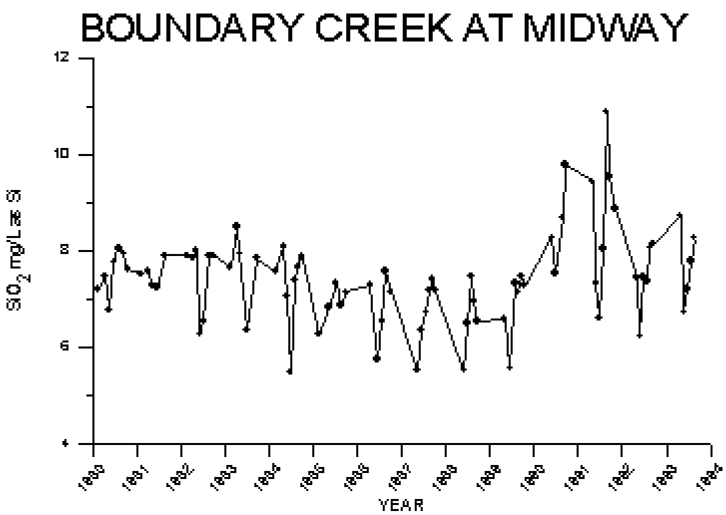


Figure 35 Sodium

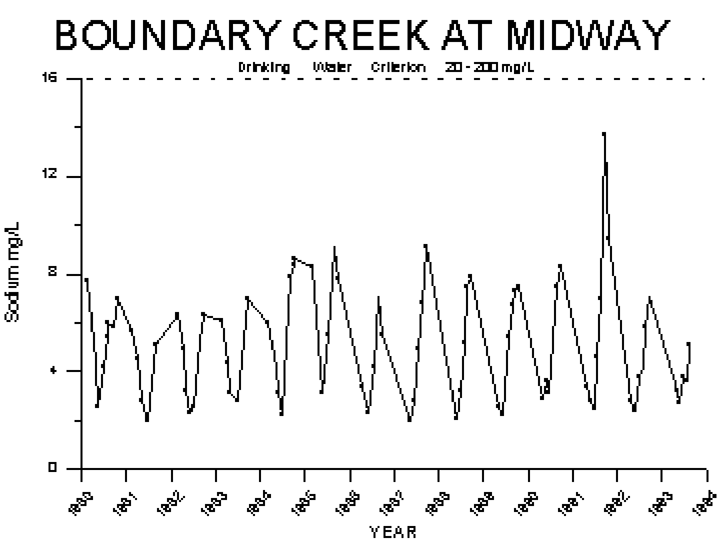


Figure 36 Total Strontium

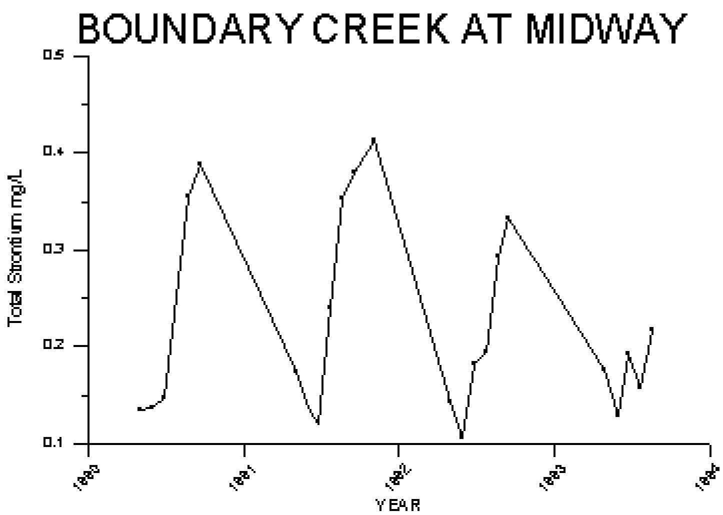


Figure 37 Dissolved Sulphate

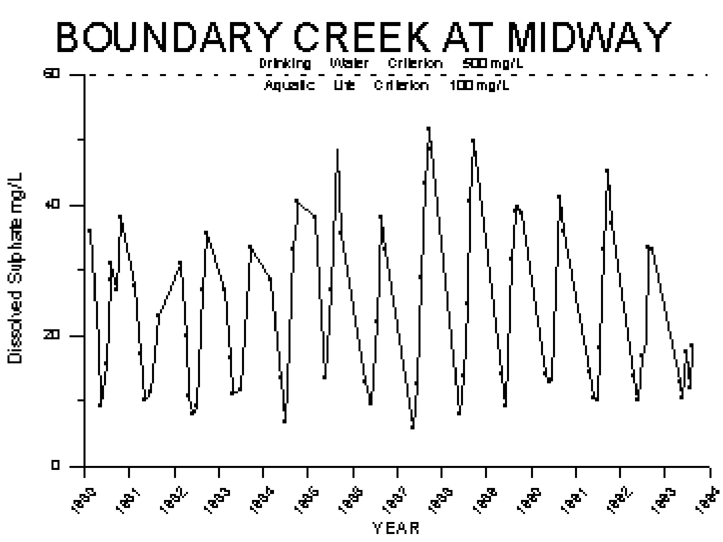


Figure 38 Air Temperature

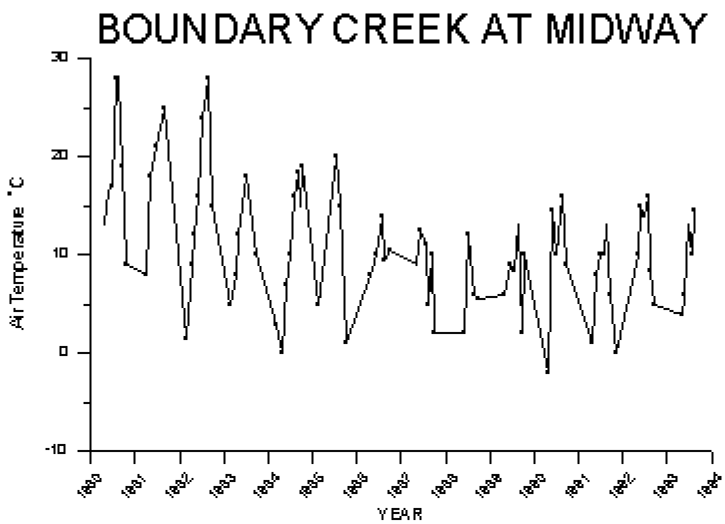


Figure 39 Water Temperature

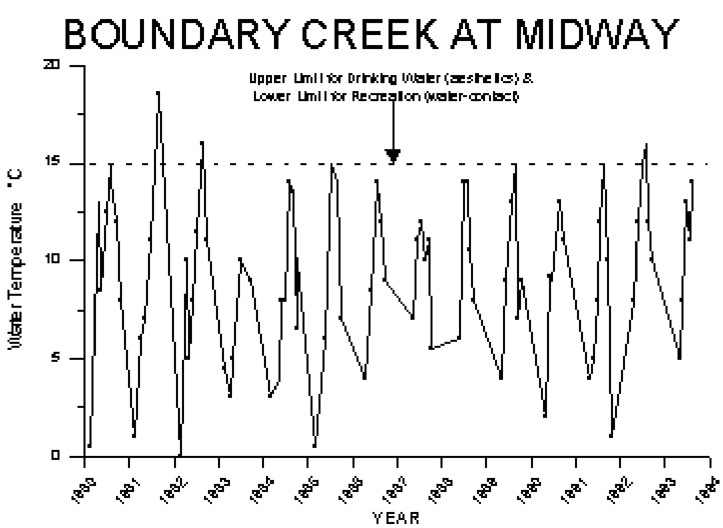


Figure 40 Turbidity

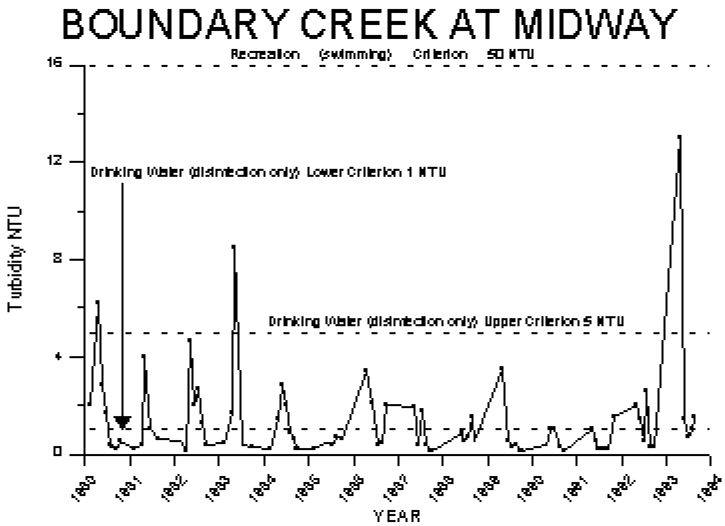


Figure 41 Total Vanadium

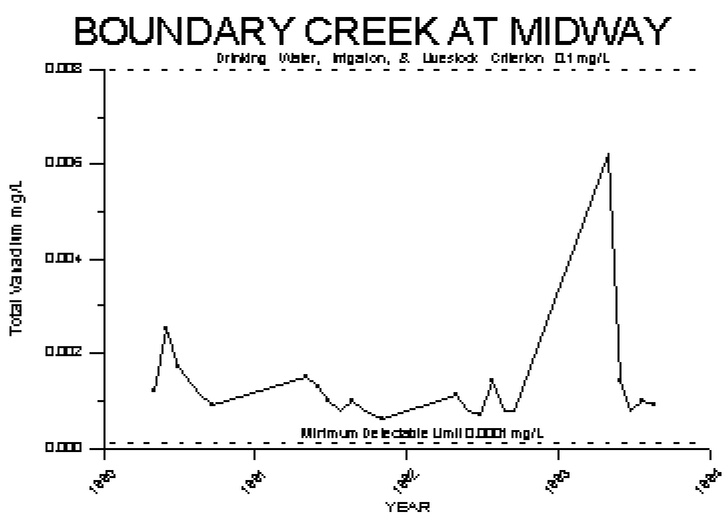
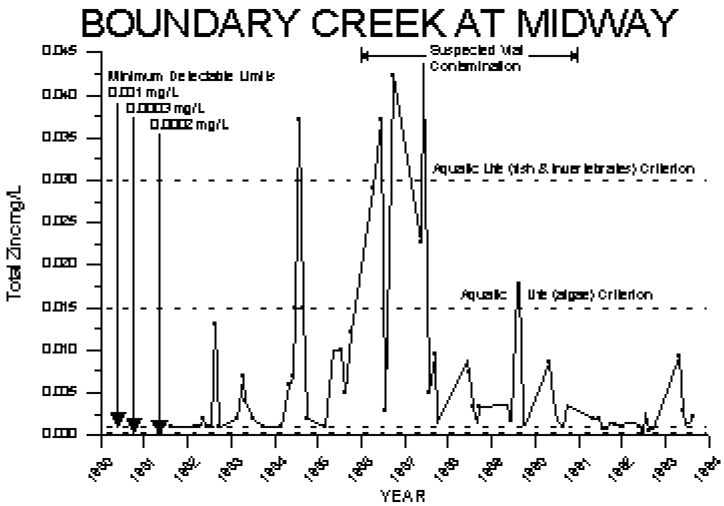


Figure 42 Total Zinc



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