Water Quality

State of Water Quality of Kettle River 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 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. Environment Canada has monitored the Kettle River at Midway station since 1980 collecting 26 samples per year. 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 of Midway at the point where the Kettle River crosses back into B.C. The Kettle River at Gilpin station is located downstream of the Carson site but 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 Kettle river 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 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.
- There is an apparent declining trend in non-filterable residue and turbidity. This may be due to declining peak flows and better land management, or both.

The main recommendation is:

Continue 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. Design and implement a specific monitoring program to study this impact. The Kettle river at Midway serves as an excellent "background site" for the collection of water quality data before the Kettle River crosses into the U.S.

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ACKNOWLEDGMENTS (Reviewers)

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1. 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 was 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 1980, and the data are stored on the federal data base, ENVIRODAT, under station number BC08NN0021. This report assesses the 15 years of data from 1980 through 1994. The water quality data are plotted in alphabetical order in Figures

3 to 43.

The purpose of the water quality monitoring has been long-term trend assessment for a trans-boundary river 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 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. 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 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 variables affected were cadmium, chromium, copper, cyanide, 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 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 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.

Flow (Figure 2) as recorded from the nearest location which is downstream of the ferry crossing near Midway, has remained fairly stable over the 1979 to 1993 period with a slight downward trend in peak spring flows after the freshet of 1986. The lowest spring peak over the period was recorded during the freshet of 1992.

Total alkalinity (Figure 3) and **calcium** (Figure 9) show that the river has a low sensitivity to acid inputs (i.e., is well-buffered), except during spring freshet when a moderate sensitivity occurs.

Total aluminum (Figure 4) had peak values during spring freshet that were well above drinking water and aquatic life criteria for dissolved aluminum. However, the peak total aluminum was caused by the higher suspended sediment concentrations (see residue, non-filterable and turbidity), in freshet, and thus is probably not of concern because dissolved aluminum levels would be lower. There was an apparent decline in peak aluminum levels from 1990 to 1994, probably due to declining peak flows and suspended sediment levels. Dissolved aluminum should be monitored for direct comparison to the criteria, if there is any concern about aluminum in the future.

Total cadmium (Figure 8) 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 11) exceeded the aquatic life criterion (for phyto and zoo-plankton) of 0.002 mg/L in early to mid 1990. The high values were probably due to artificial contamination. Since mid 1992, total chromium values have been at or below the 0.002 mg/L criterion level.

Apparent colour (Figure 13) exceeded the true colour criteria for drinking water and recreation during spring freshet, 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 as relevant and current guidelines are geared towards true colour and TAC.

Total copper (Figure 15) values during 1986 to 1991 exhibited widespread artificial contamination due to the gradual failure of the Teflon cap liners resulting in leaching from the bakelite preservative vial caps. Data assessment since early 1991 when the vials were changed reveals values below the aquatic life criteria of 0.002 to 0.004 mg/L for the river water hardness range to 100 mg/L.

Fluoride (Figure 16) frequently exceeded the tentative aquatic life criterion due to the natural geologic conditions in the watershed. We are not aware of any problems with fish in the Kettle River due to elevated fluoride levels and expect that the fish populations are acclimated and adapted to the natural higher levels. One value, exceeding the drinking water criterion in early 1982, is believed to be an error in measurement.

Hardness (Figure 17) showed that the water was soft, usually within or below the optimum range for drinking water, but still quite acceptable. The unusually low value reported in early 1985 is probably a blank.

Total iron (Figure 18) was frequently above the criterion for drinking water (aesthetics) and aquatic life during spring freshet when flow and suspended sediment were higher. The iron is probably due to the iron content of the suspended sediment and thus of no concern. Drinking water use during freshet would require turbidity removal, which would probably lower iron values below the criterion.

Total lead (Figure 19) exceeded the drinking water and aquatic life criteria prior to 1990, probably introduced as a result of artificial contamination from preservative vial cap liner failures, and false positives near the old MDL (0.001 mg/L). All criteria have been met since early 1989 with a steady improvement (i.e., downward trend) into late 1994. This downward trend is associated with a decrease in detection limits and the use of cleaner methods.

Total manganese (Figure 22) exceeded the aesthetic drinking water criterion during spring freshet when suspended sediments were naturally elevated. This is not of concern as it was due to the manganese content of the suspended sediment, which would normally be removed by drinking water treatment during turbidity removal. The aquatic life criteria were not reported to be exceeded during the 15 year period.

Nitrogen, total dissolved (Figure 26) and **nitrate/nitrite** (Figure 25) values were well below criteria and showed an apparent decline in peak values after about 1988. There appears to be ample nitrogen available for algal growth except during summer.

pH (Figure 27) values met all criteria. The lower pH values in 1986-89 were due to a loss of control in pH measurement in the laboratory. This data has been flagged as questionable and unreliable.

Total phosphorus (Figure 28) showed peak values during spring freshet when suspended sediments were naturally elevated. The elevated phosphorus is associated with the suspended sediment and thus largely biologically unavailable. There are no criteria for phosphorus in B.C. rivers.

Non-filterable residue (NFR) (i.e., suspended solids or sediment) (Figure 32) and **Turbidity** (Figure 41) both show peaks during spring freshet when suspended sediments were naturally elevated. NFR was below the general fisheries criterion of 25 mg/L (Newcombe, 1986), except during freshet. The turbidity criterion for swimming was always met, but the raw drinking water criterion for water without turbidity removal (1 NTU) was often exceeded during freshet. Turbidity removal prior to drinking would be needed in freshet. NFR and, to a lesser extent, turbidity showed an apparent declining trend in peak values from mid-1982 to 1994. This may be due to declining peak river flows. Turbidity responds similarly to NFR but is 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 31 and 33) 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 30) values were well below criteria. Specific conductivity is a more precise and cheaper variable to monitor and it has a reasonably constant relationship with filterable residue. We recommend that conductivity be used as a surrogate for FR in future monitoring.

Total and Extractable selenium (combined in Figure 34) consistently met the drinking water criterion of 0.01 mg/L and the aquatic life criterion of 0.001 mg/L.

Silicon as Si (Figure 35) showed a stable although at times highly seasonally variable trend throughout the sampling period with little or no environmental significance. The high and low values correspond well with flow data for the Kettle River in this area. This plot has been corrected to reflect a method change in 1990 which 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). A minor step change in level is apparent when the method changed in 1990. There are no criteria for silica in ambient fresh water.

Water temperature (Figure 40) met the drinking water criterion (aesthetics) except during summer, when it was warm enough for water-contact recreation such as swimming but somewhat less appealing as drinking water.

Total zinc (Figure 43) values occasionally exceeded the aquatic life criteria prior to 1990, probably due to the failure of the preservative vial cap liners experienced in the late 1980s. These criteria have not been exceeded since 1991. We are observing a downward trend in zinc values since about 1991, which is consistent with the low zinc values in this relatively pristine (for zinc sources) watershed, declining detection limits, and the use of cleaner methods.

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

- Water quality patterns are usually closely matched to seasonal patterns in flow.
- The water quality at the Kettle River at Midway site was excellent during 1980 to 1994, as would

be expected from a watershed with a low population and little industry, forestry and mining upstream of this site.

- The water was well-buffered against acid inputs although soft for drinking water.
- The water was cool or cold except in summer, when it warms enough to permit water-contact recreation such as swimming, but was then less aesthetically pleasing for drinking.
- The water is naturally high in fluoride due to the geology of the watershed, making it possibly less than ideal for fish. We are not aware of any affects on resident fish which may have adapted to the natural high levels of fluoride in the river.
- The water is clear, except during spring freshet when higher flows result in increased erosion, suspended sediment, and turbidity. The extent to which human land use activities contribute to this natural phenomenon is unknown.
- The increased turbidity makes it necessary to treat drinking water to remove turbidity prior to use during freshet.
- Freshet also 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 therefore, the metals and phosphorus are largely biologically unavailable.
- There has been an apparent decline in peak turbidity and suspended solids over the period of record. This may be due to apparent declining peak flows and better land management, or both.

Comparison to other Kettle River watershed water quality station reports:

> Please refer to the three Water Quality Branch Kettle River basin companion reports; Kettle River at Carson, Kettle River at Gilpin and Boundary Creek at Midway (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 continued at this station because there are regional concerns with respect to resource developments in Washington State which may affect the Kettle River before it re-enters Canada at Carson. Water quality data collected from this site (and the Carson site) serve as important upstream and downstream baseline data sources in determining the potential impact of mining operations in this part of the watershed. The Crown Jewel project, for example, is a mining proposal in Washington State, draining to the Kettle River between Midway and Carson.

- We recommend that the potential for this mine to impact the Kettle River be considered, and that, if warranted, a monitoring program specific to the potential impacts of the mine be designed and implemented.

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, contamination-free, field-filtration unit needs to be developed.
- Measure true or TAC colour where colour is of concern. Apparent colour is 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

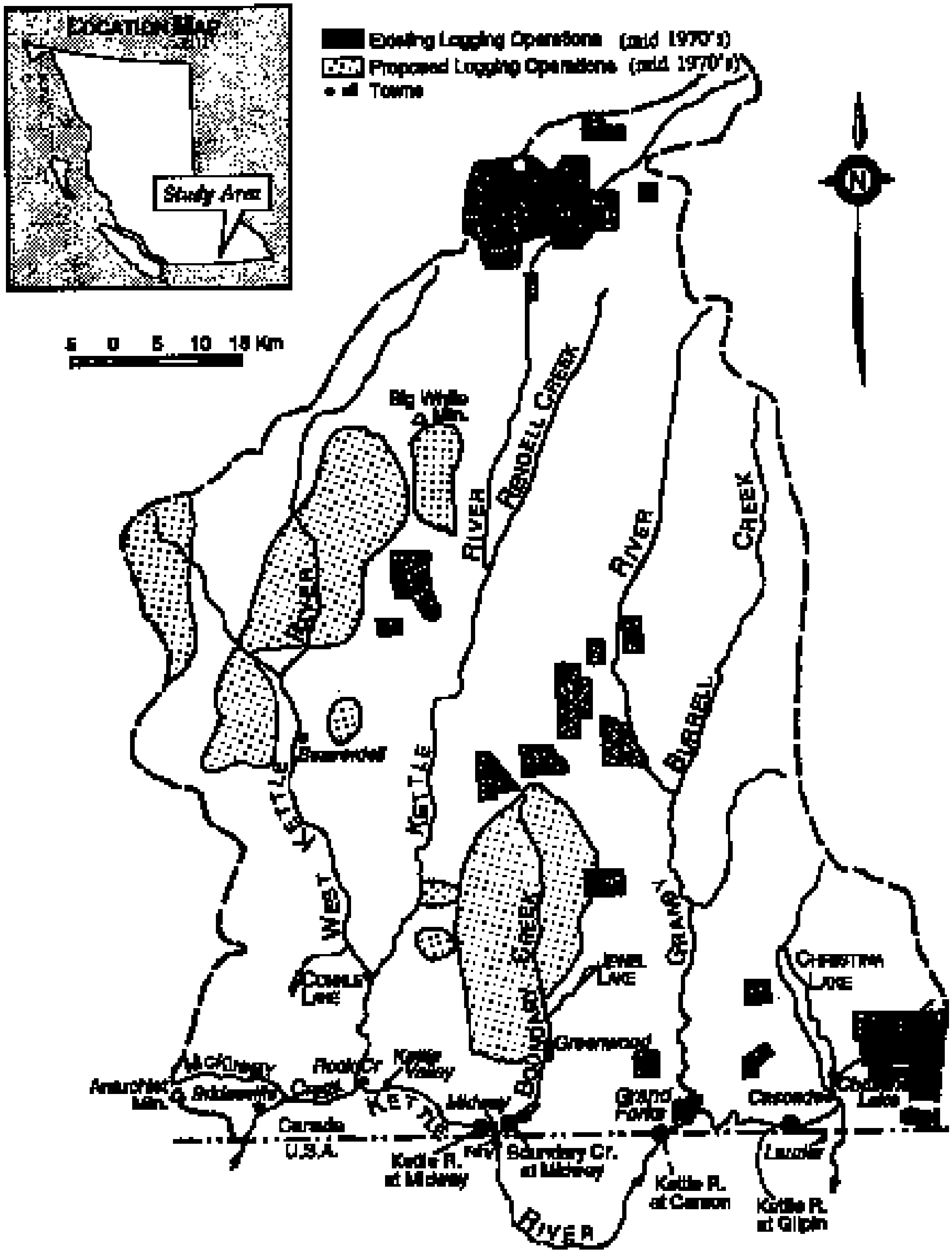


Figure 2 Flow

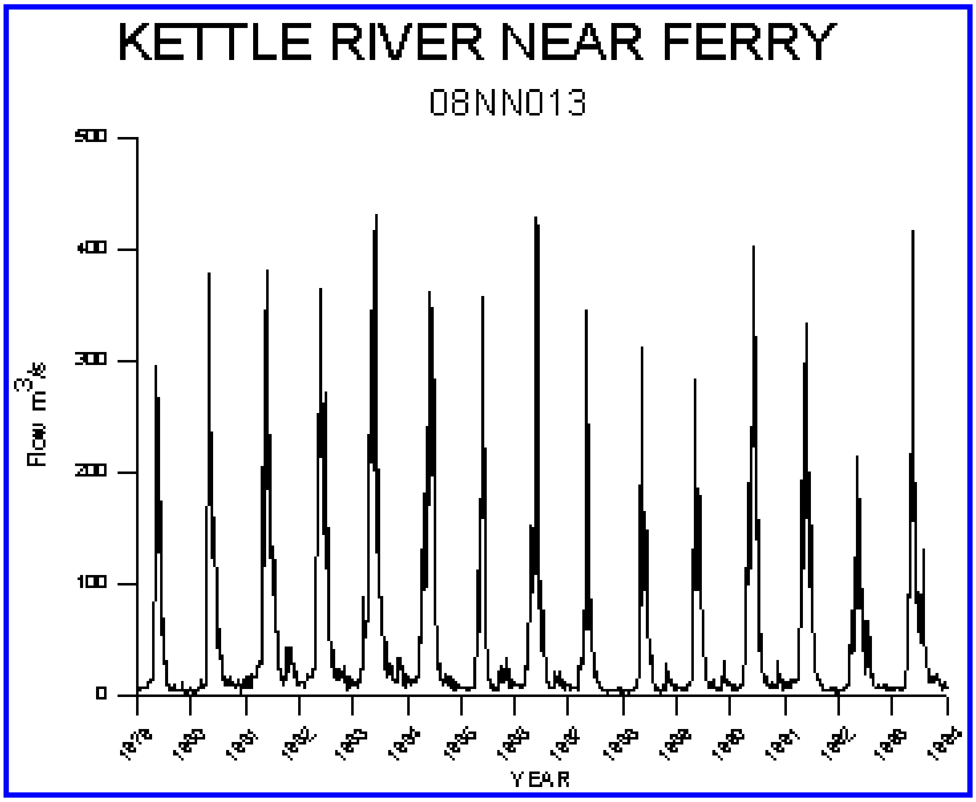


Figure 3 Total Alkalinity

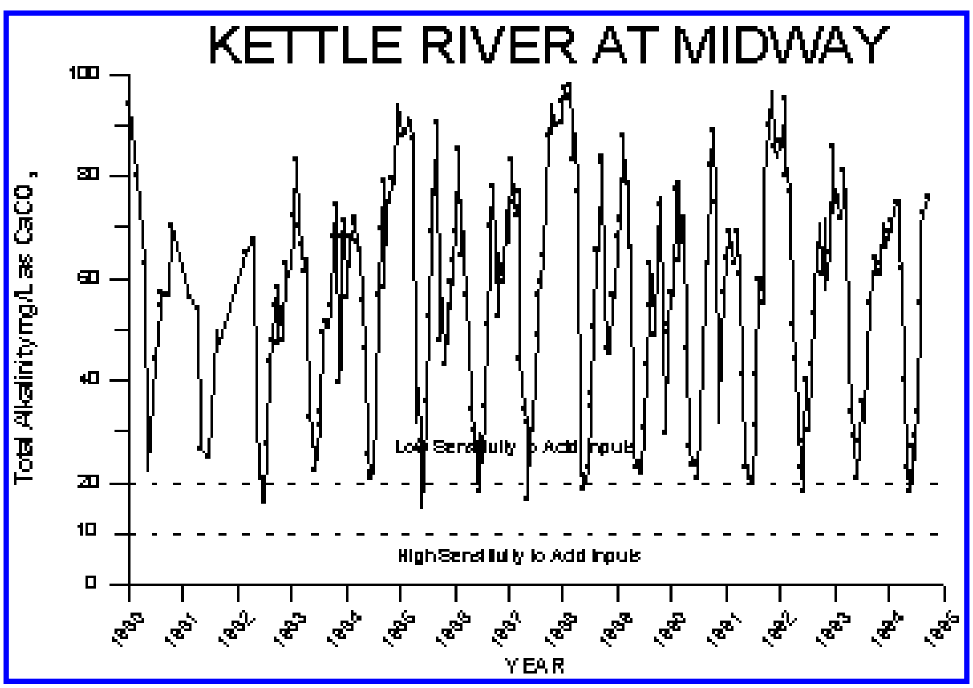


Figure 4 Total Aluminum

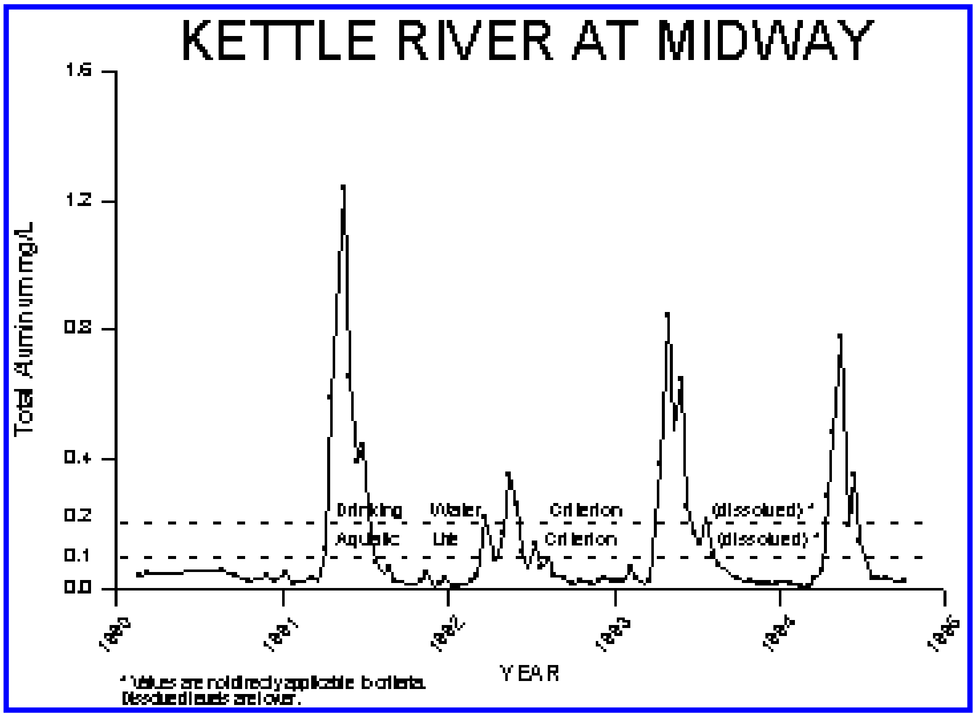


Figure 5 Total Arsenic

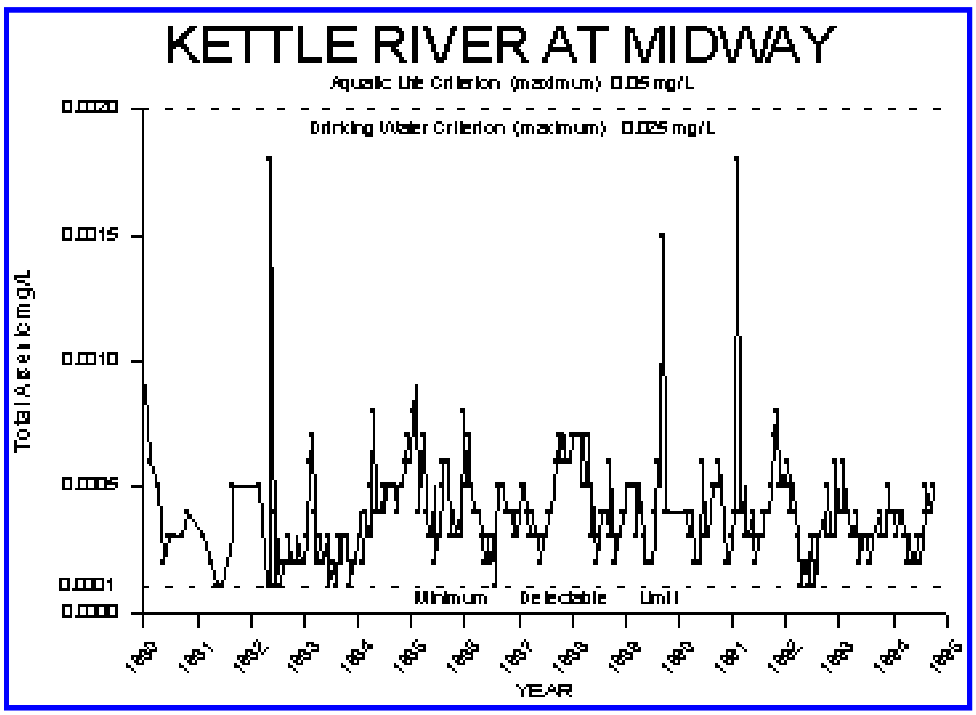


Figure 6 Total Barium

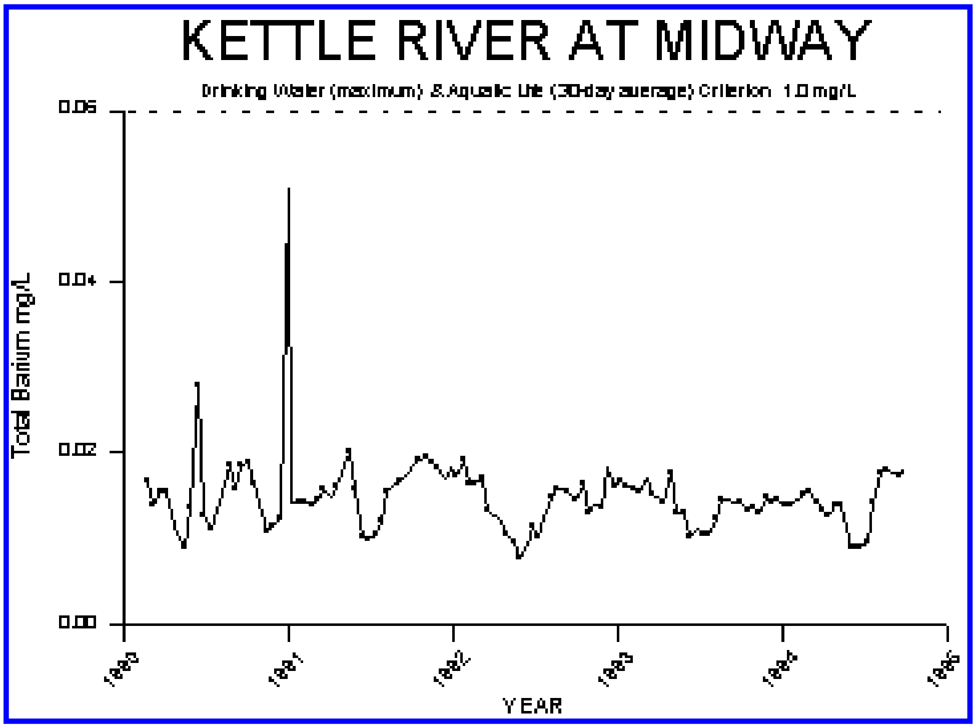


Figure 7 Total Beryllium

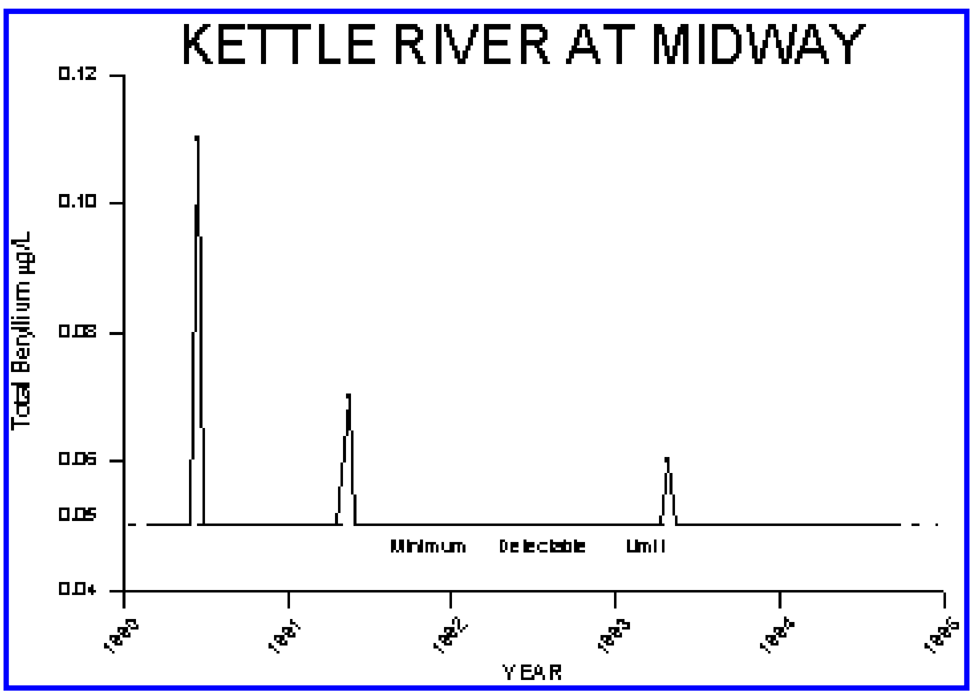


Figure 8 Total Cadmium

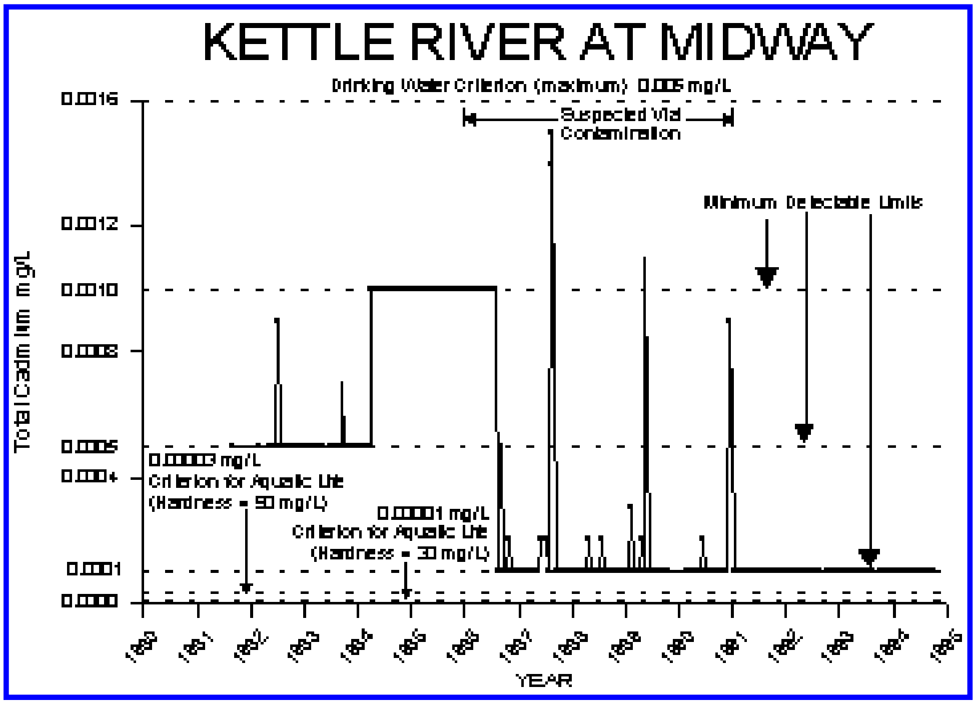


Figure 9 Calcium

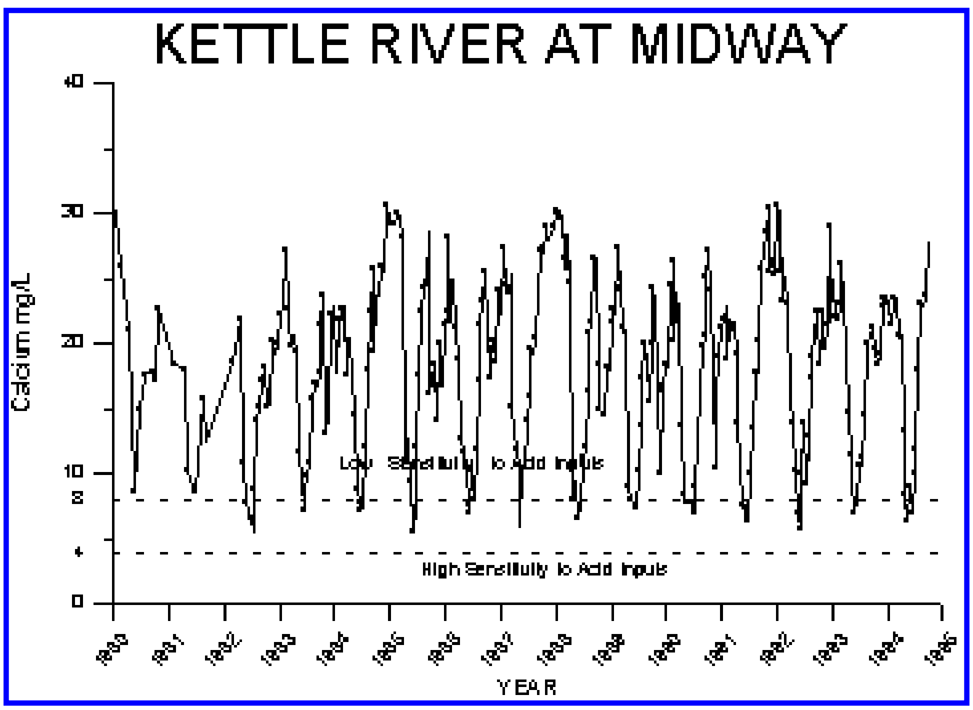


Figure 10 Dissolved Chloride

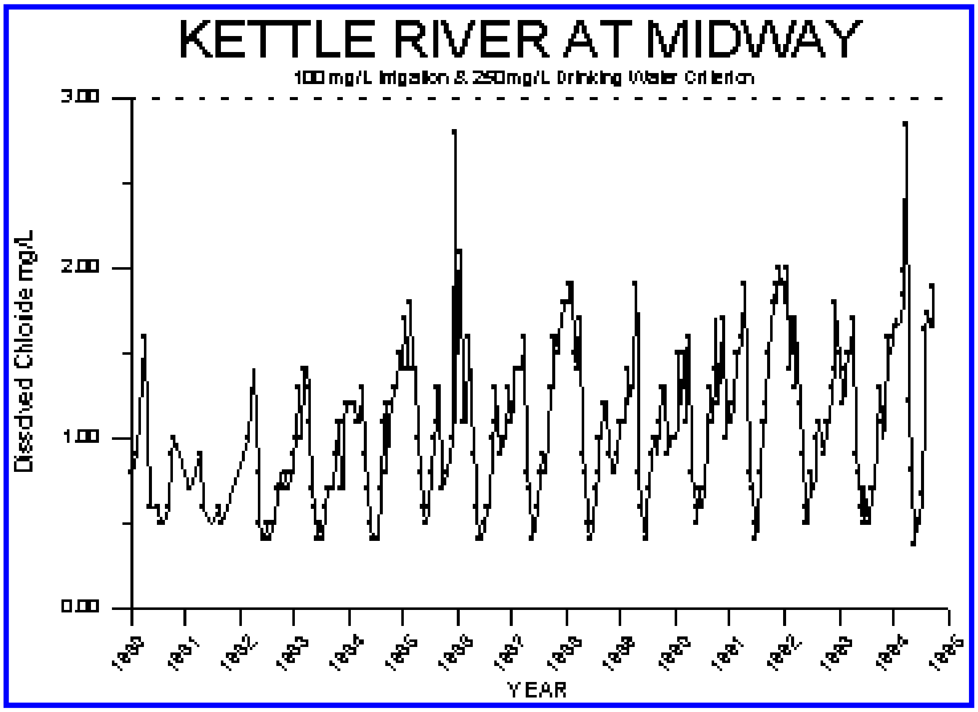


Figure 11 Total Chromium

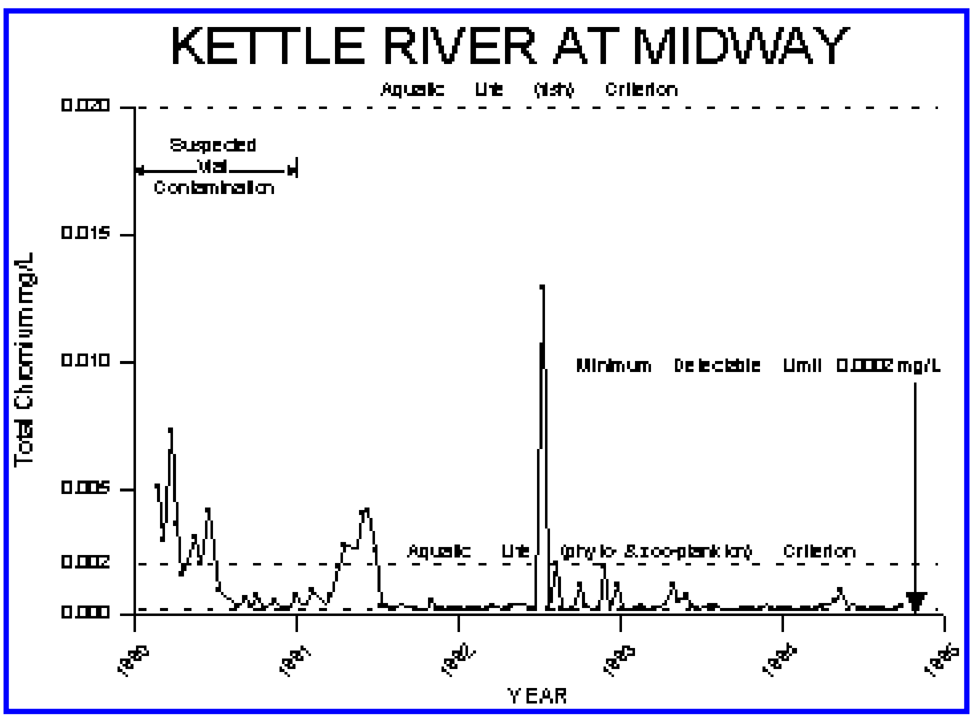


Figure 12 Total Cobalt

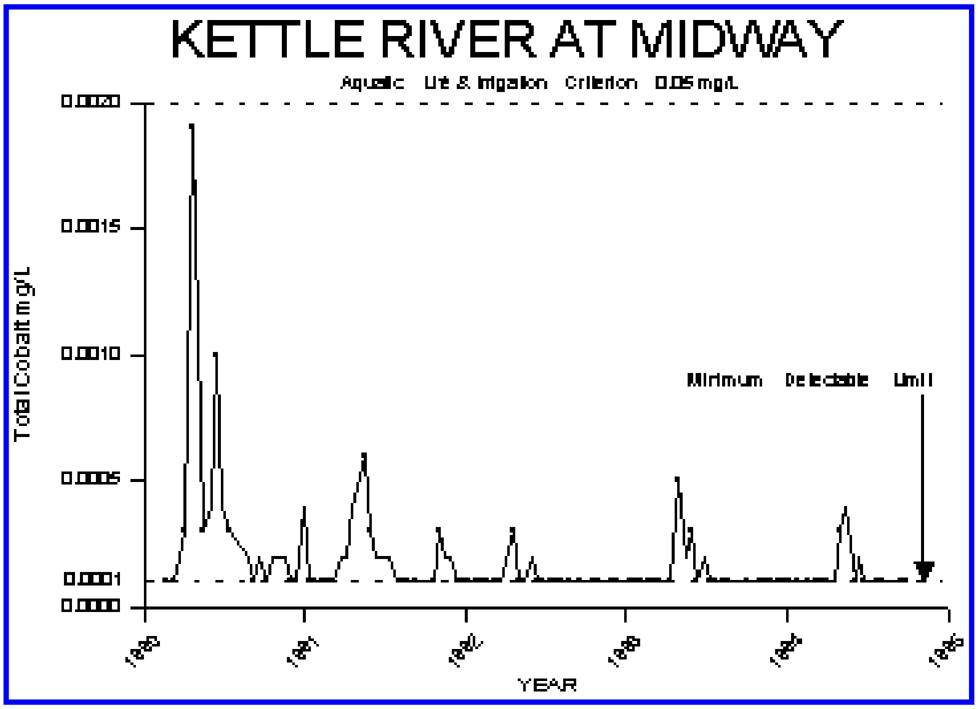


Figure 13 Apparent Colour

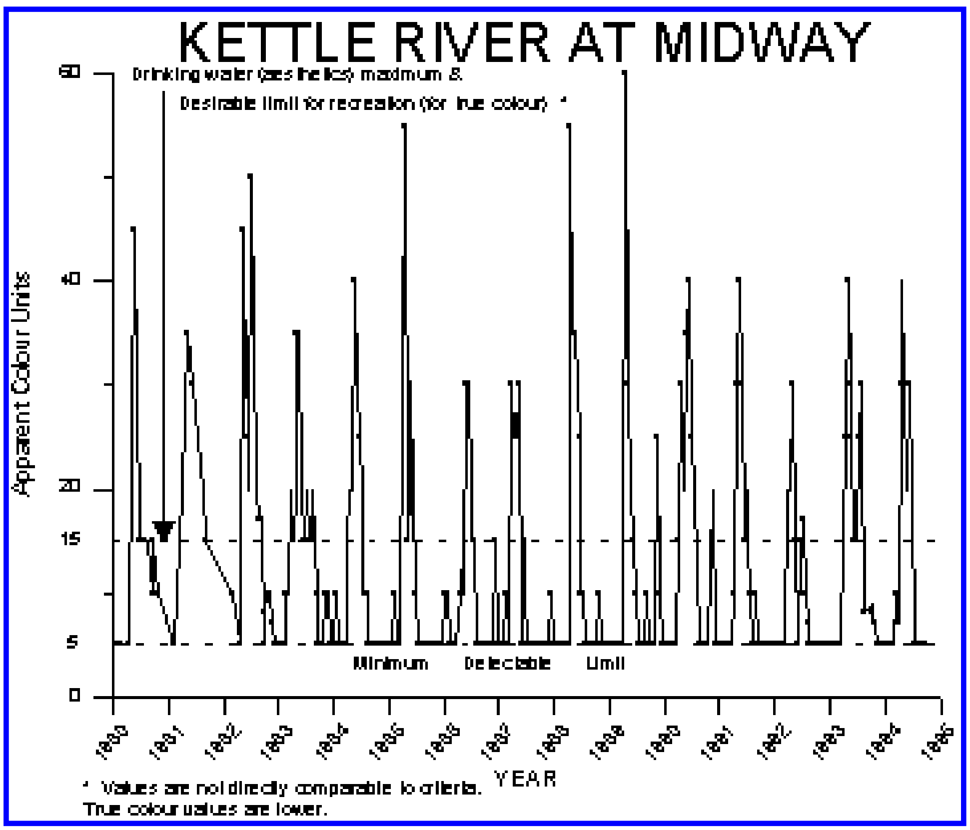


Figure 14 Specific Conductivity

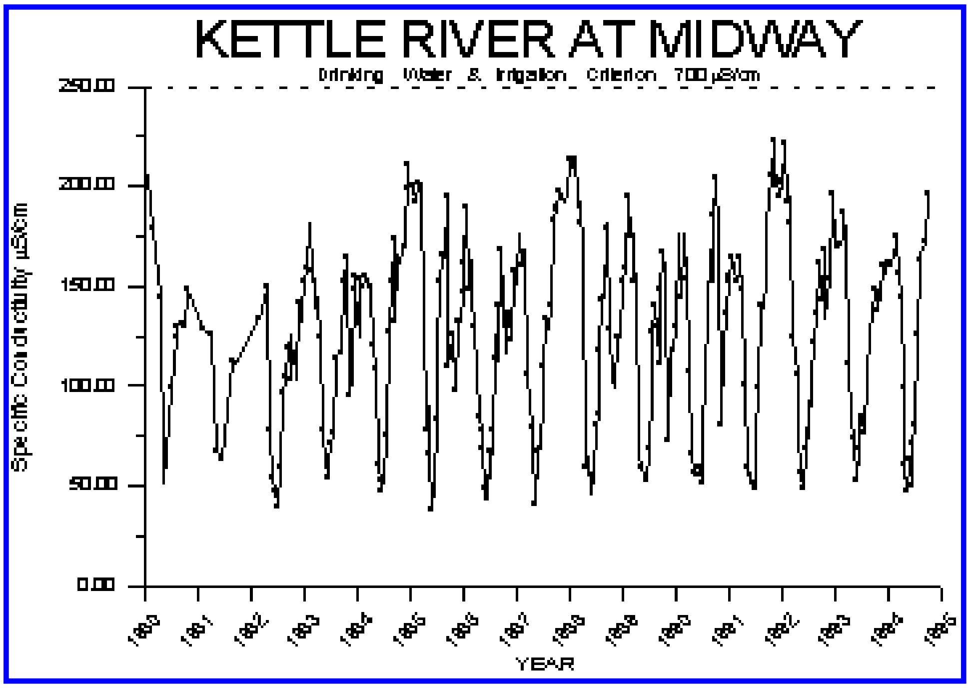


Figure 15 Total Copper

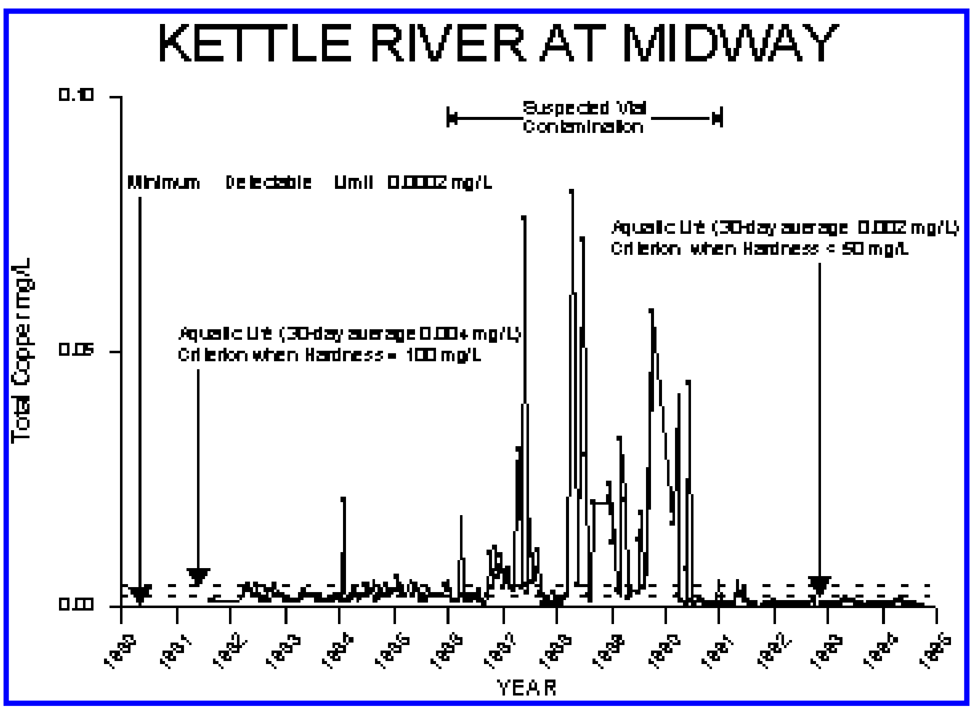


Figure 16 Dissolved Fluoride

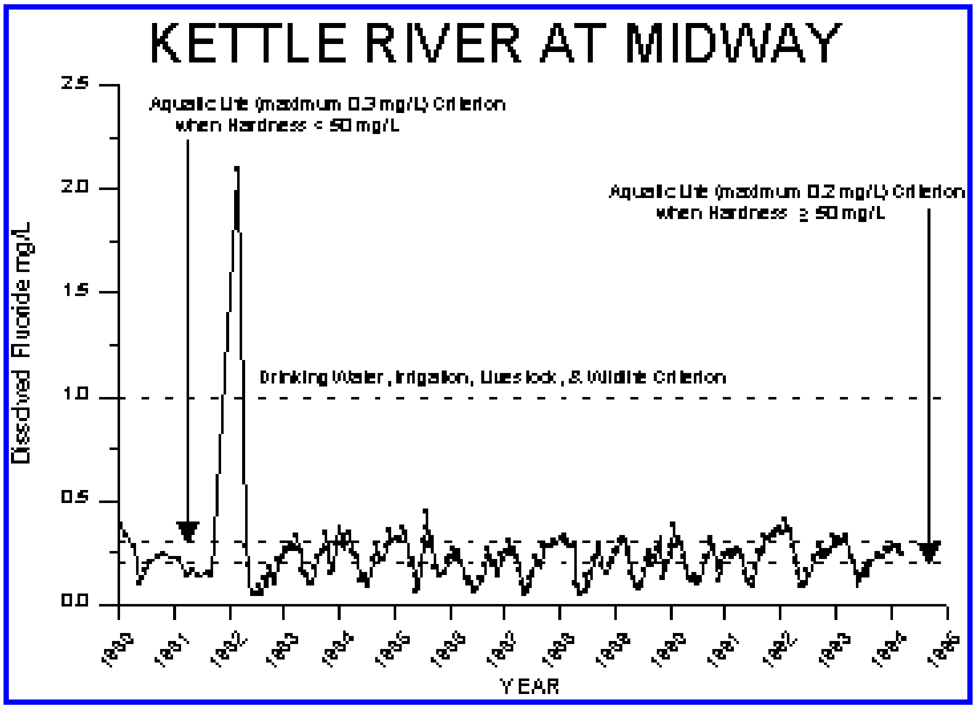


Figure 17 Hardness

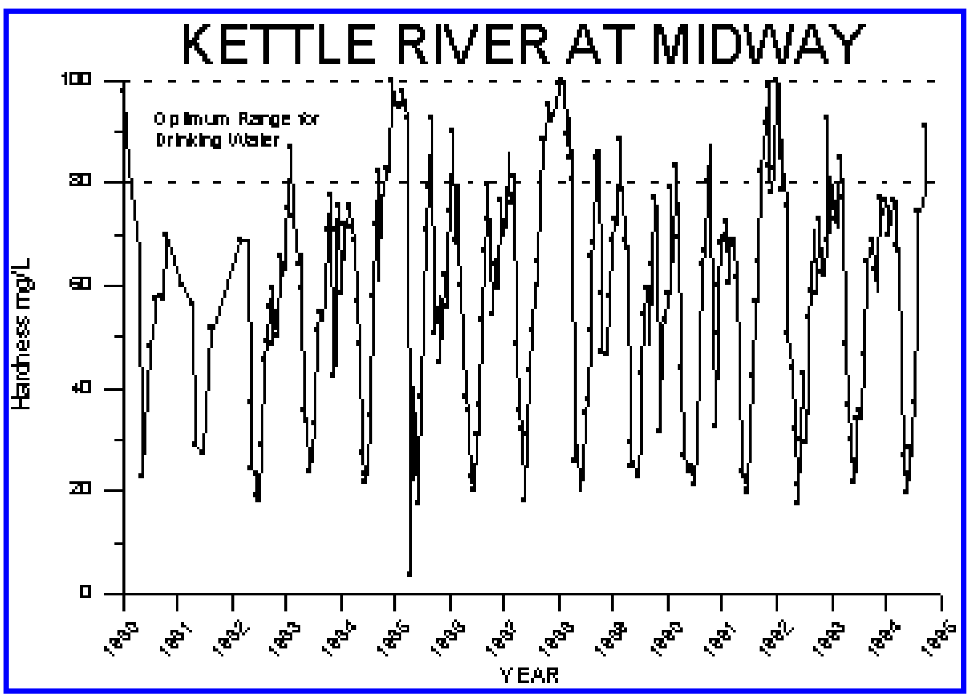


Figure 18 Total Iron

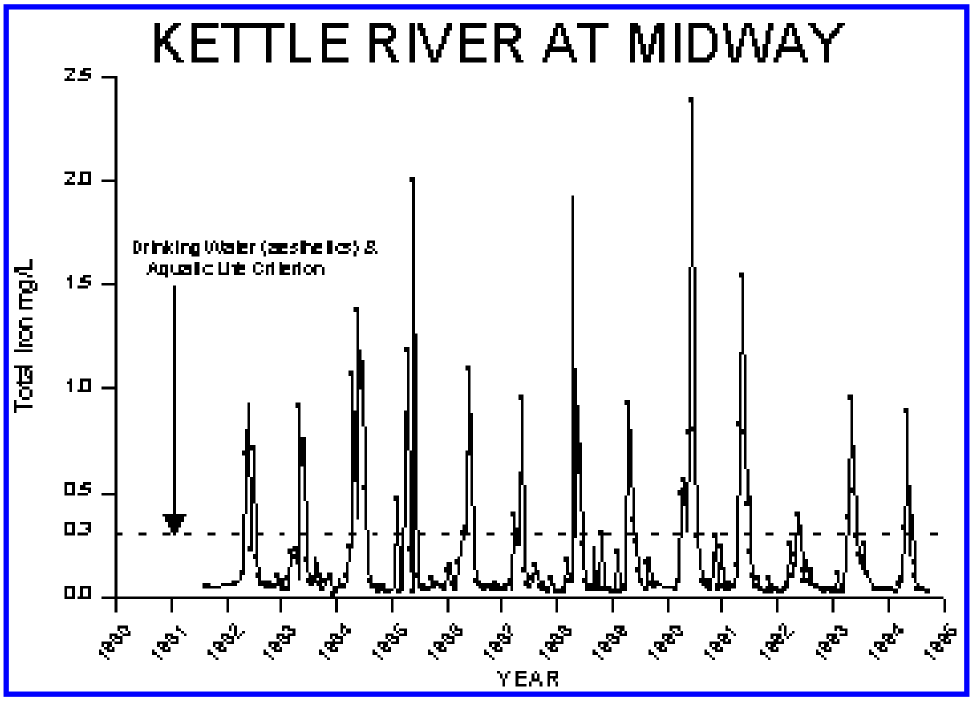


Figure 19 Total Lead

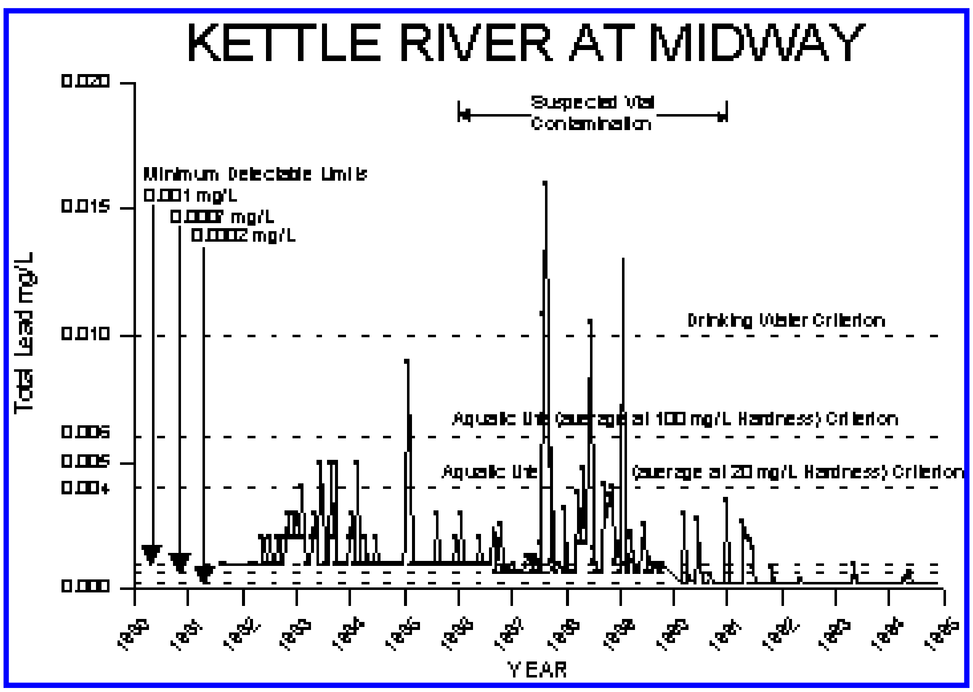


Figure 20 Total Lithium

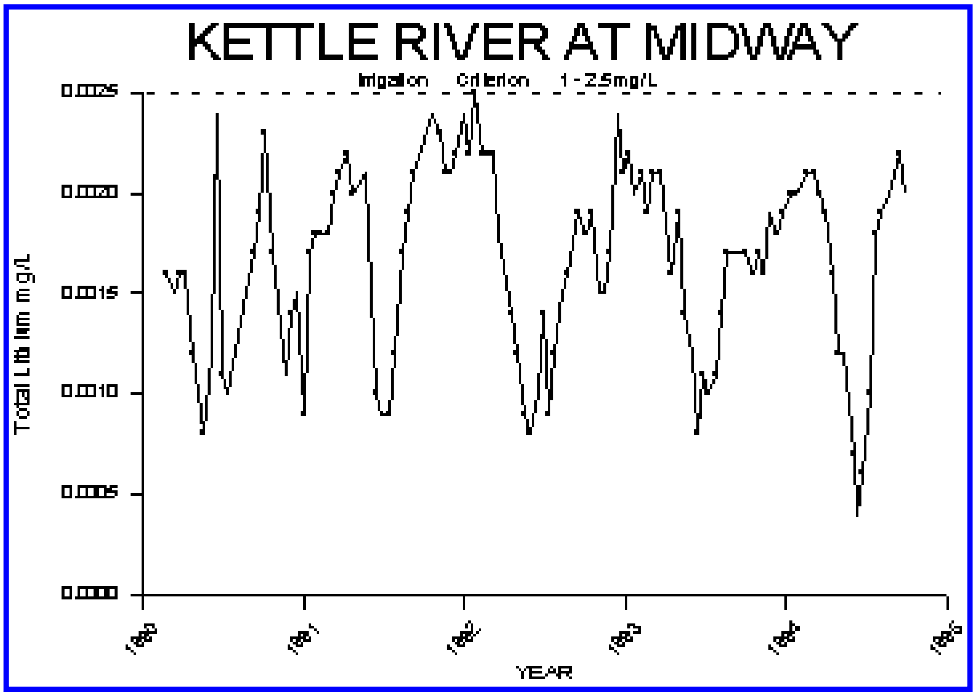


Figure 21 Magnesium

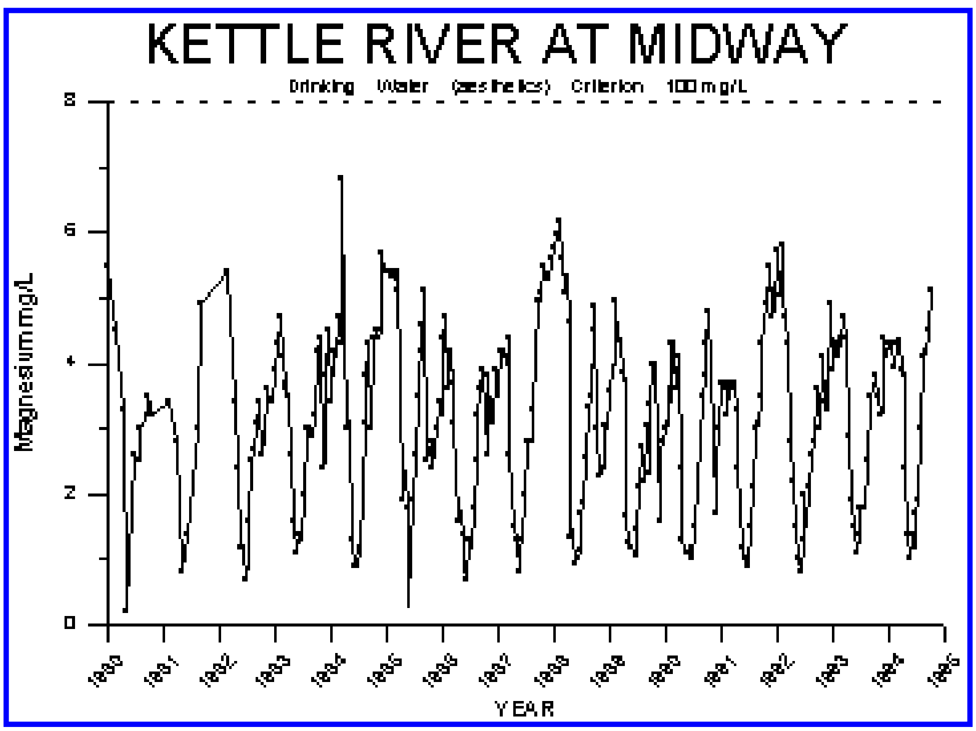


Figure 22 Total Manganese

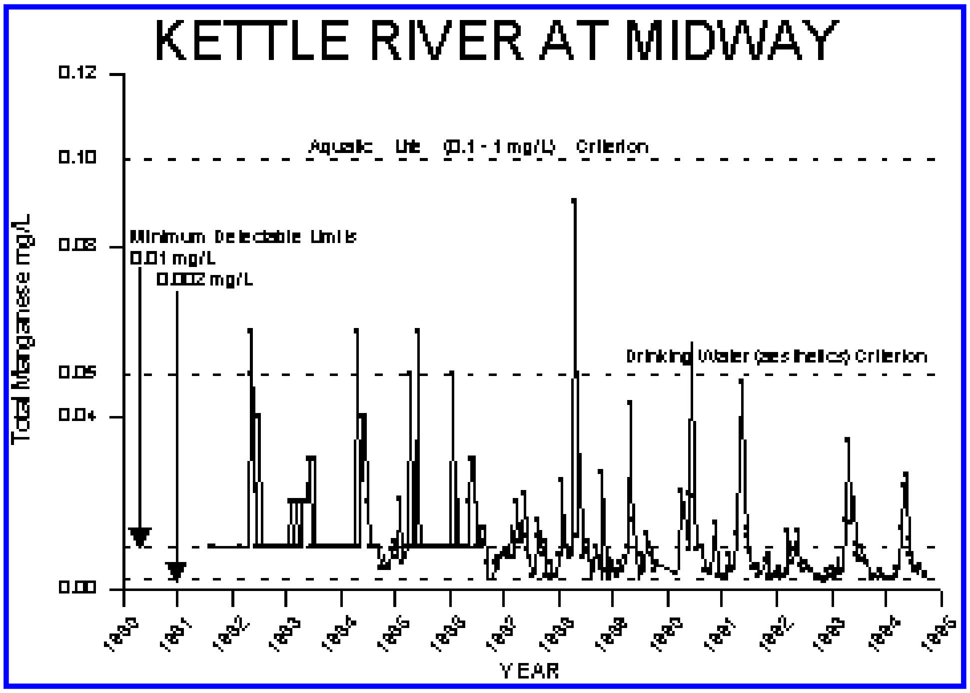


Figure 23 Total Molybdenum

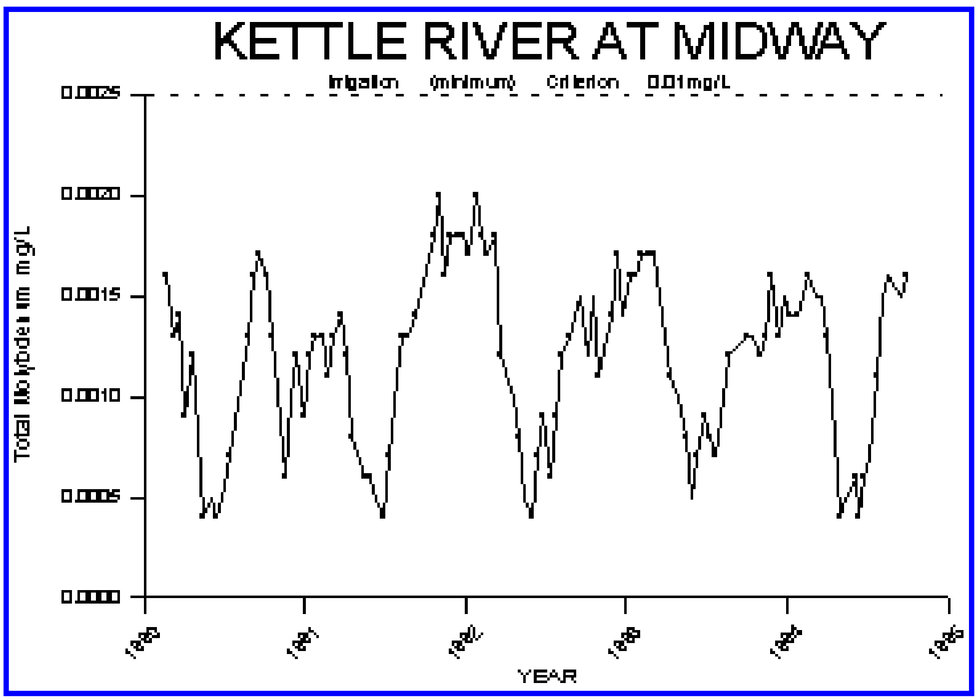


Figure 24 Total Nickel

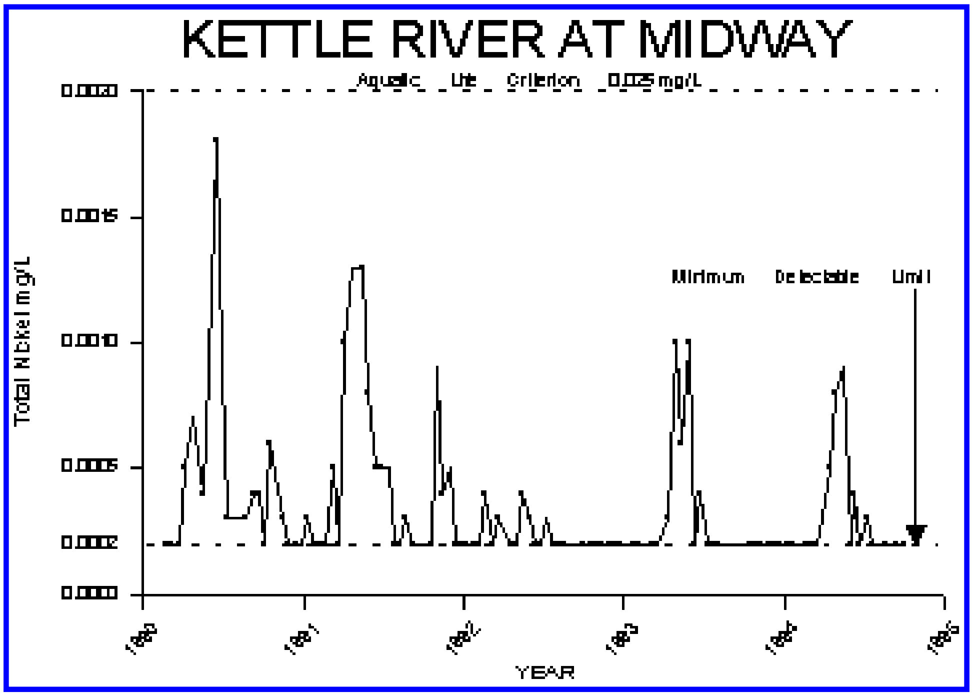


Figure 25 Nitrogen (Nitrate/Nitrite)

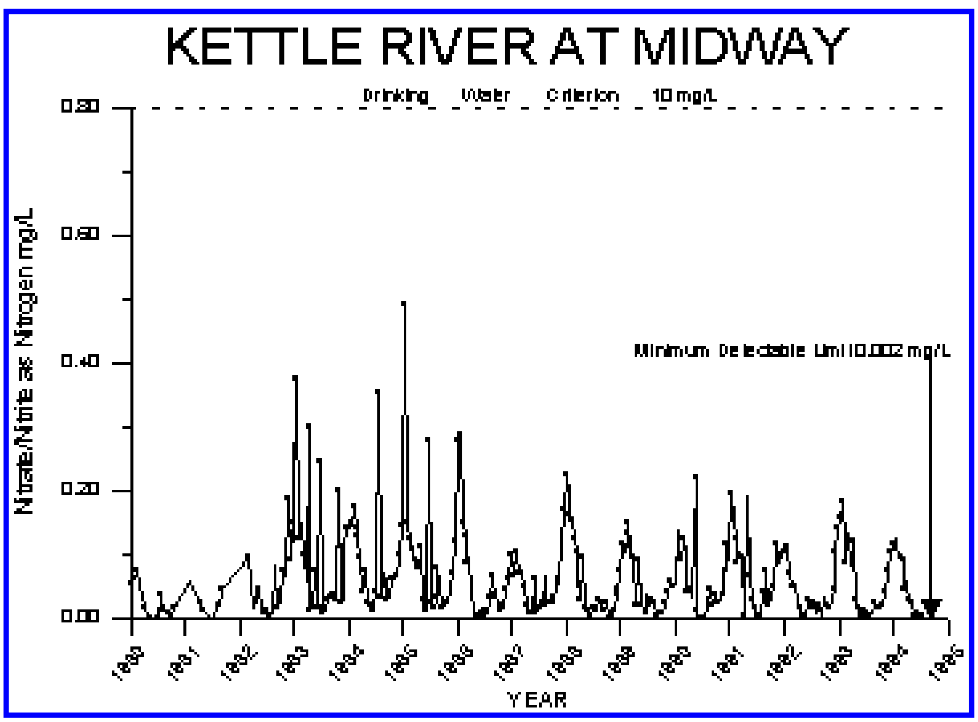


Figure 26 Total Dissolved Nitrogen

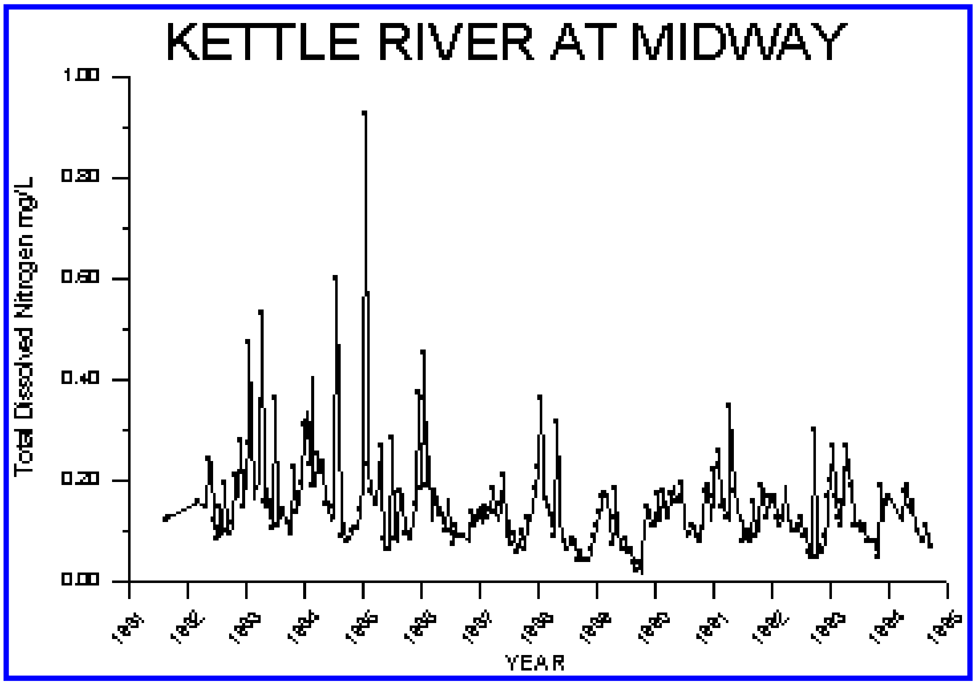


Figure 27 pH

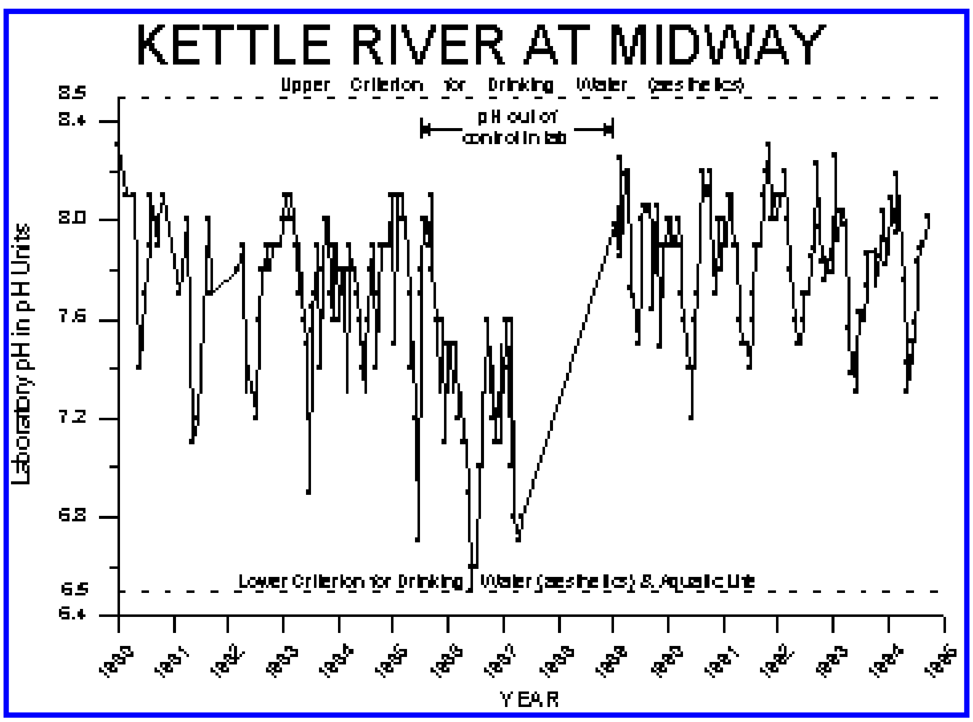


Figure 28 Total Phosphorus

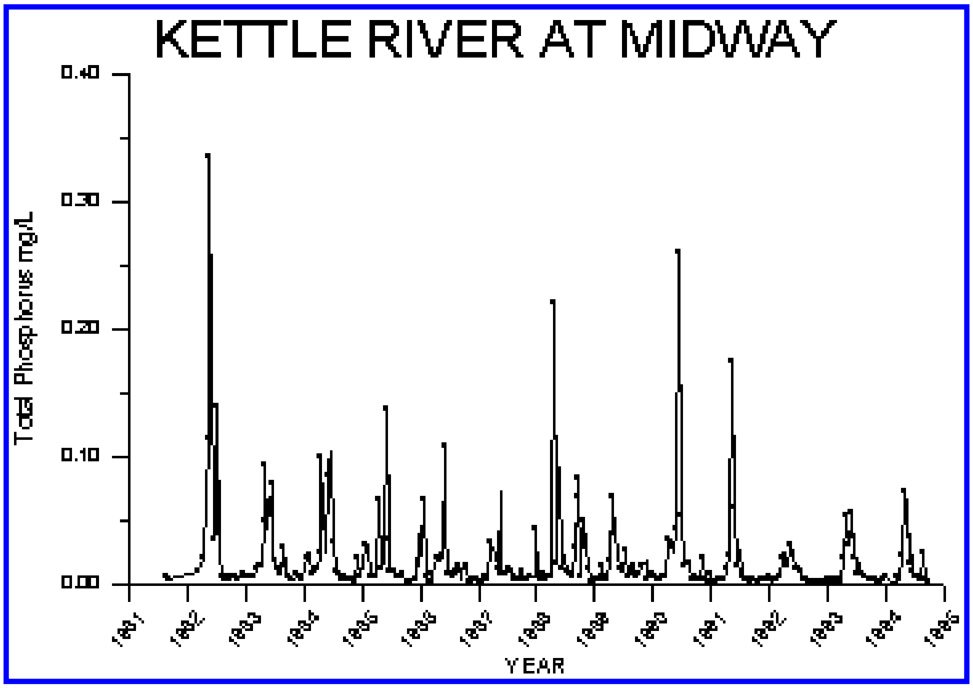


Figure 29 Potassium

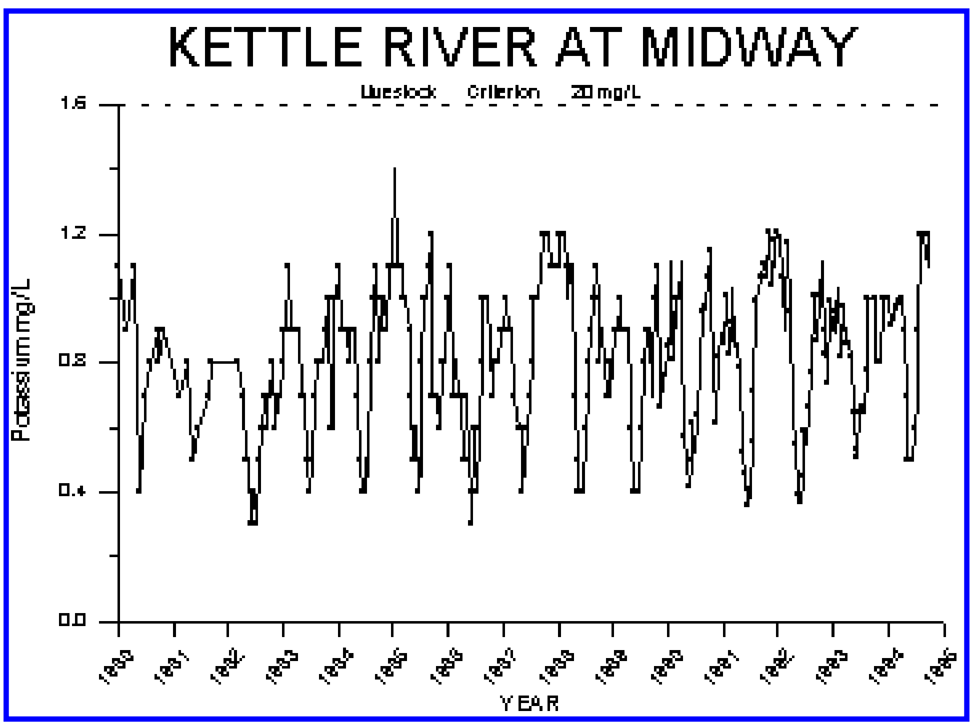


Figure 30 Filterable Residue

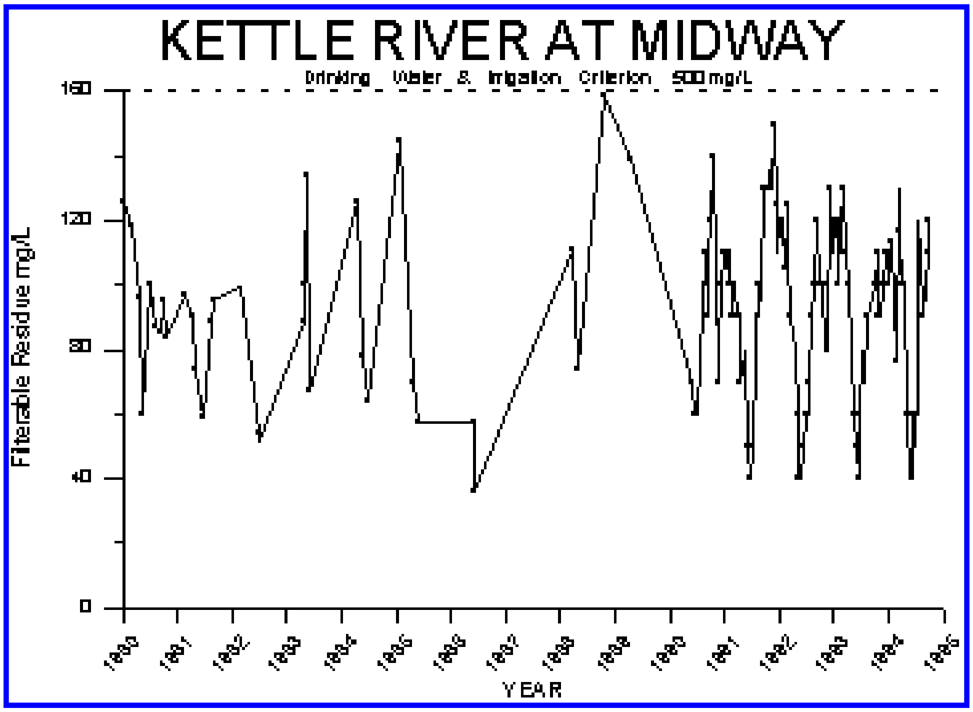


Figure 31 Fixed Filterable Residue

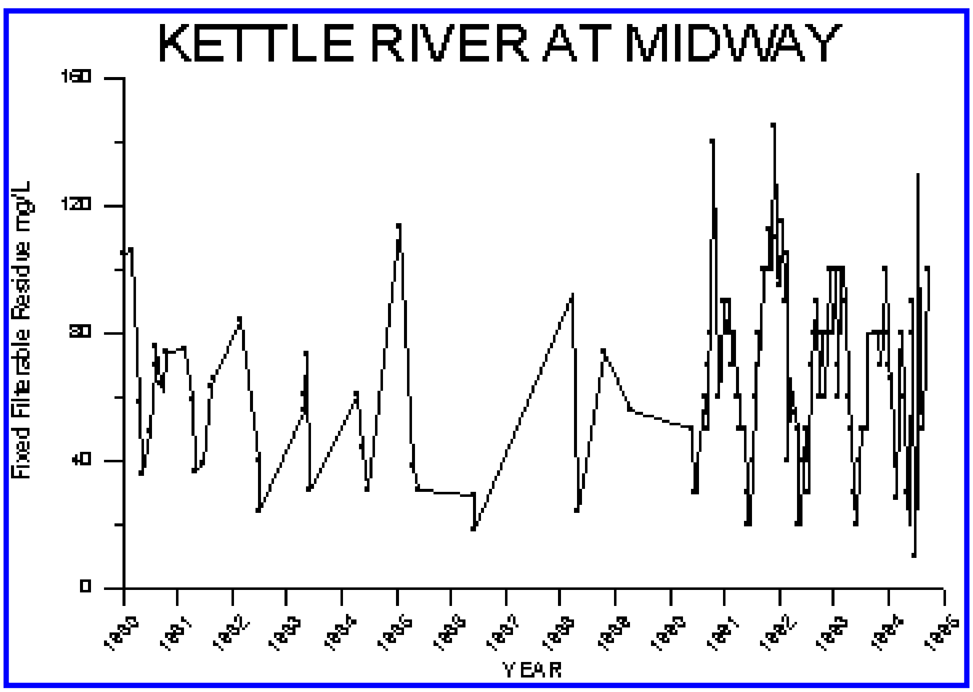


Figure 32 Non-Filterable Residue

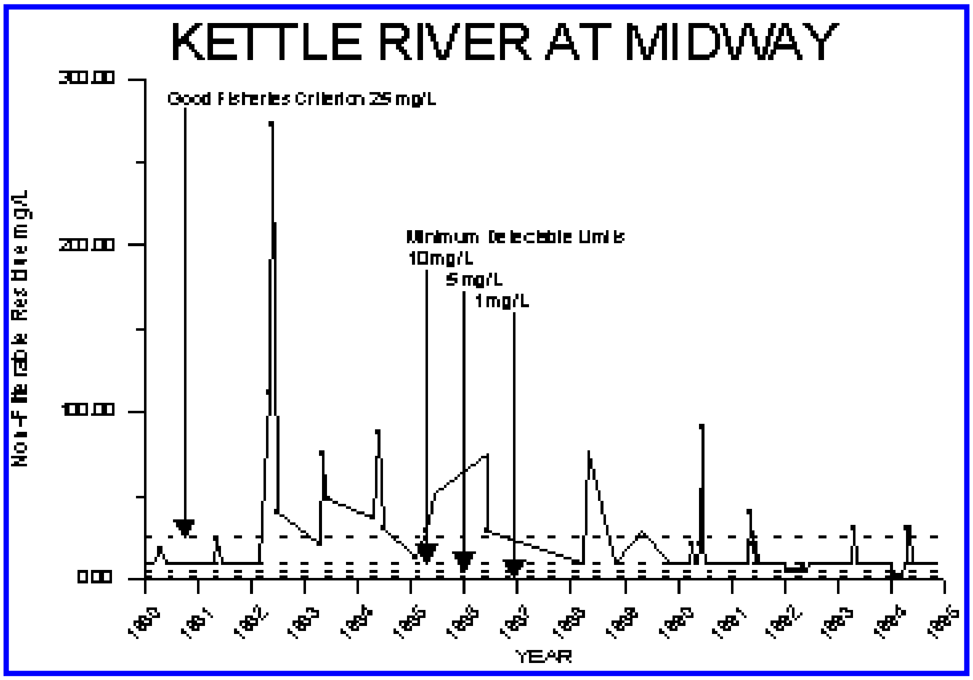


Figure 33 Fixed Non-Filterable Residue

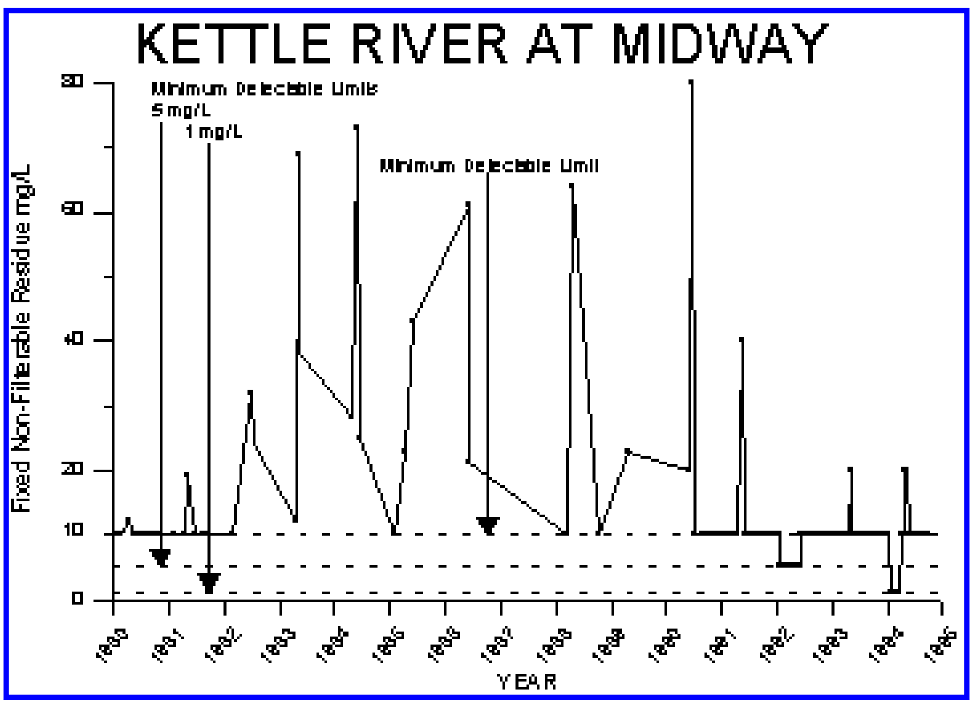


Figure 34 Total Selenium

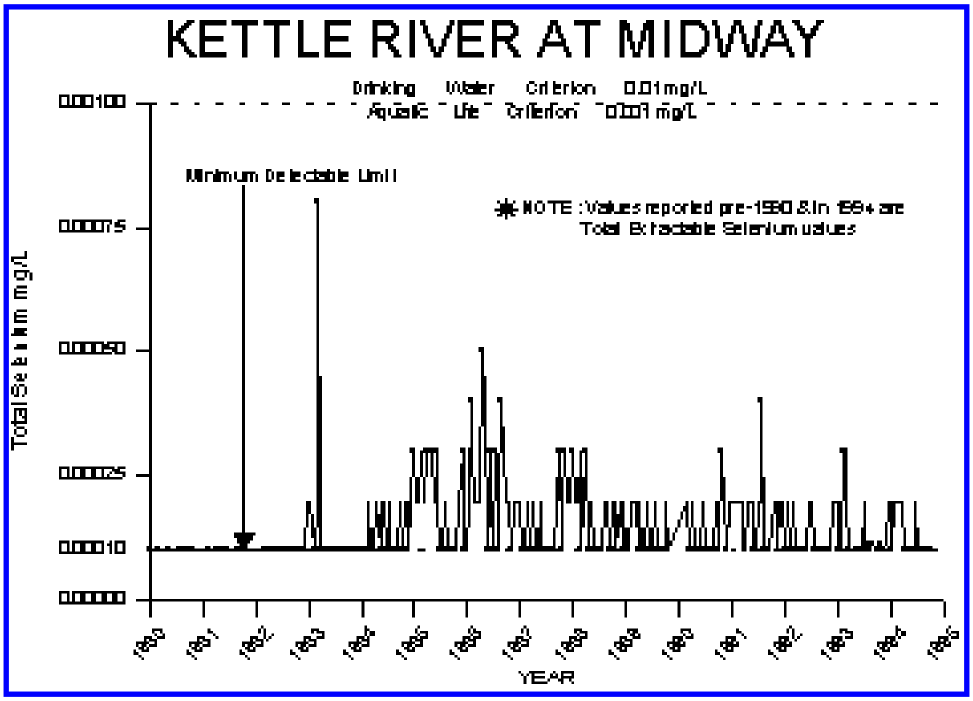


Figure 35 Silica

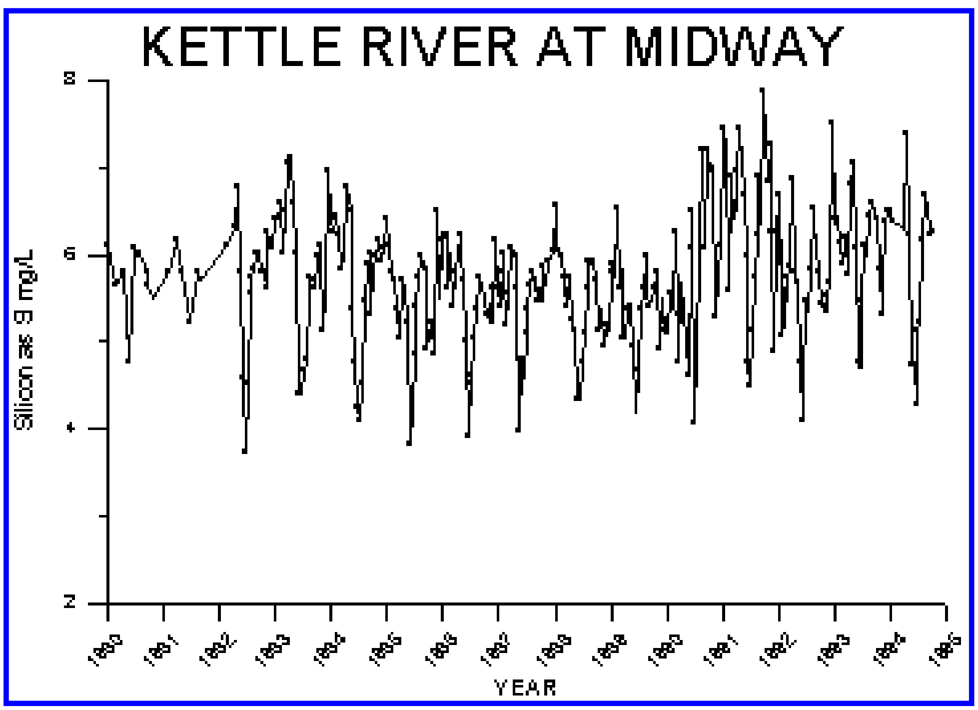


Figure 36 Sodium

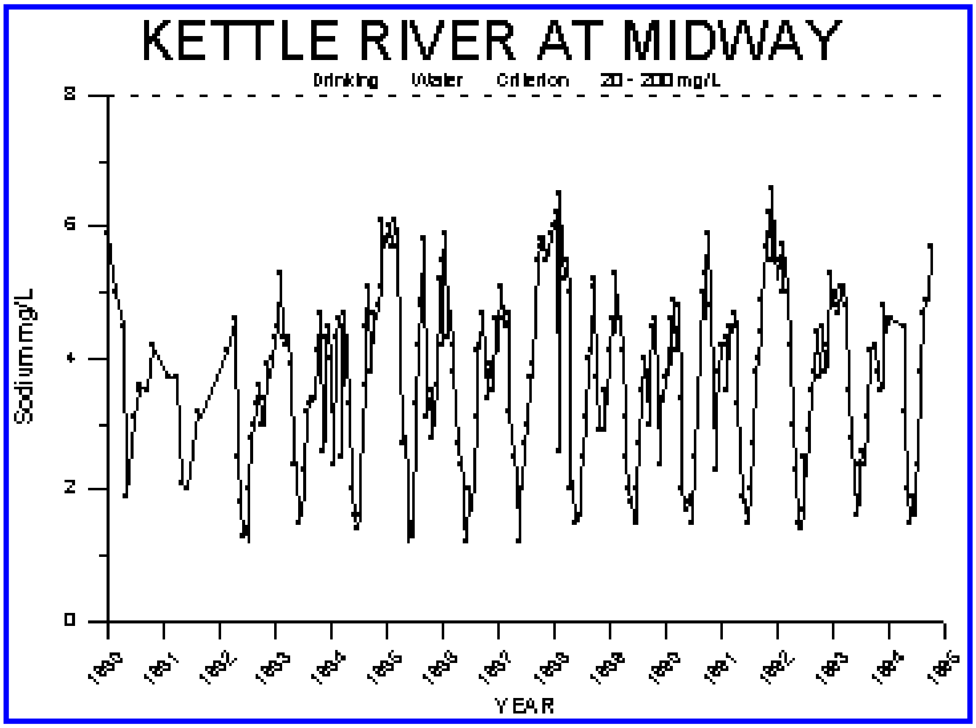


Figure 37 Total Strontium

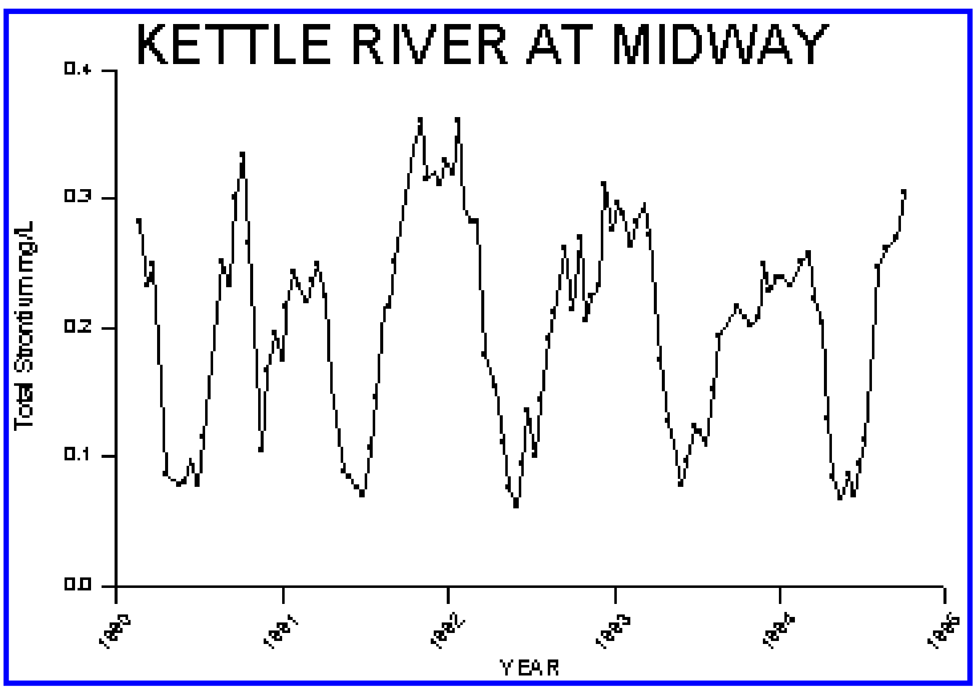


Figure 38 Dissolved Sulphate

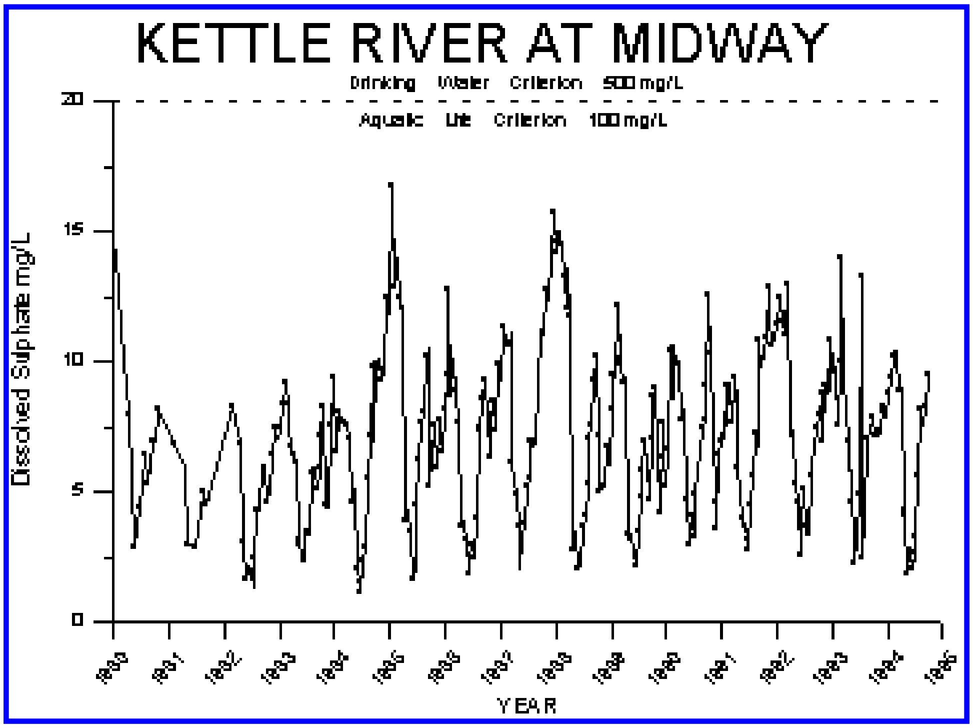


Figure 39 Air Temperature

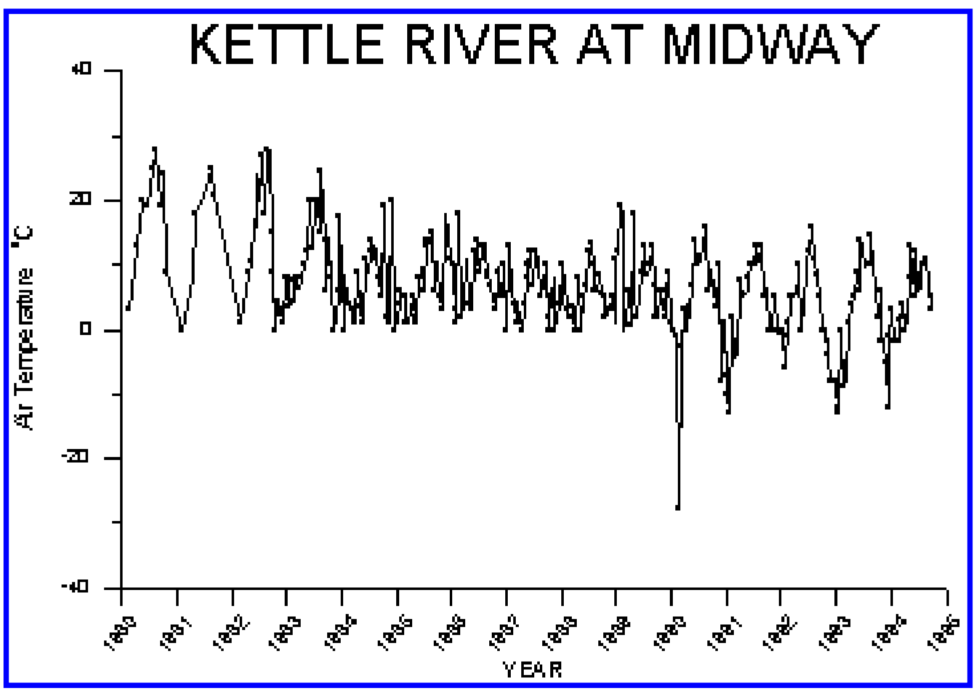


Figure 40 Water Temperature

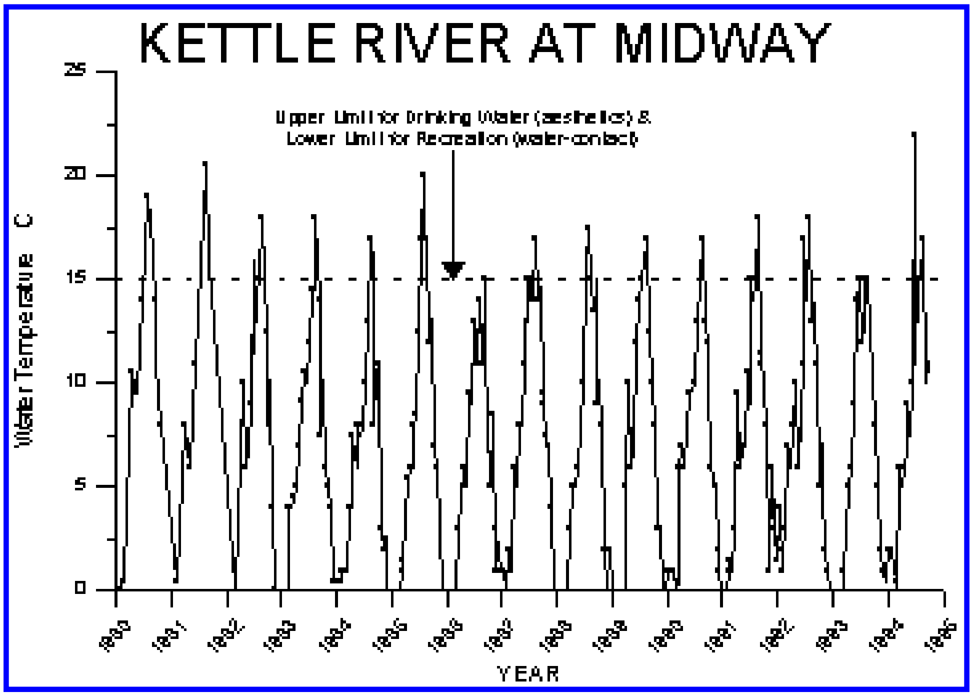


Figure 41 Turbidity

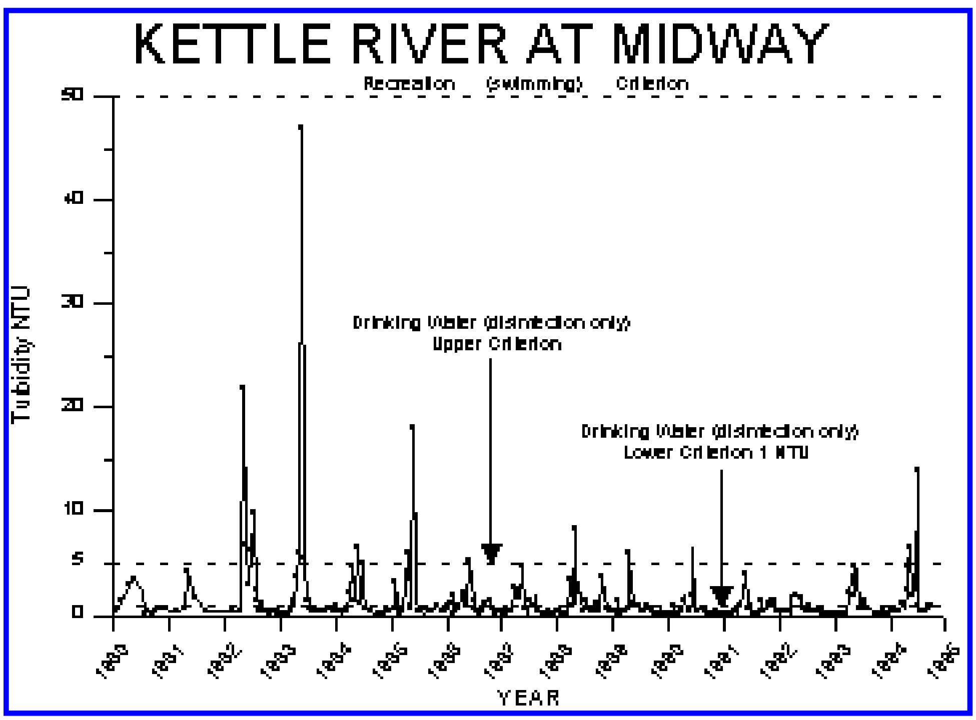


Figure 42 Total Vanadium

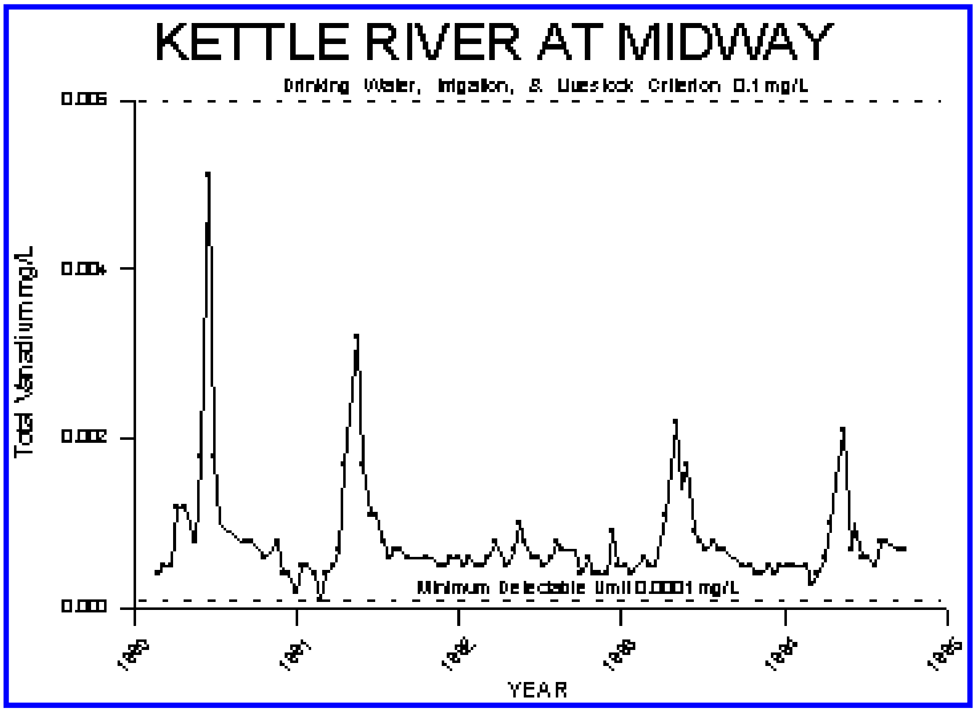
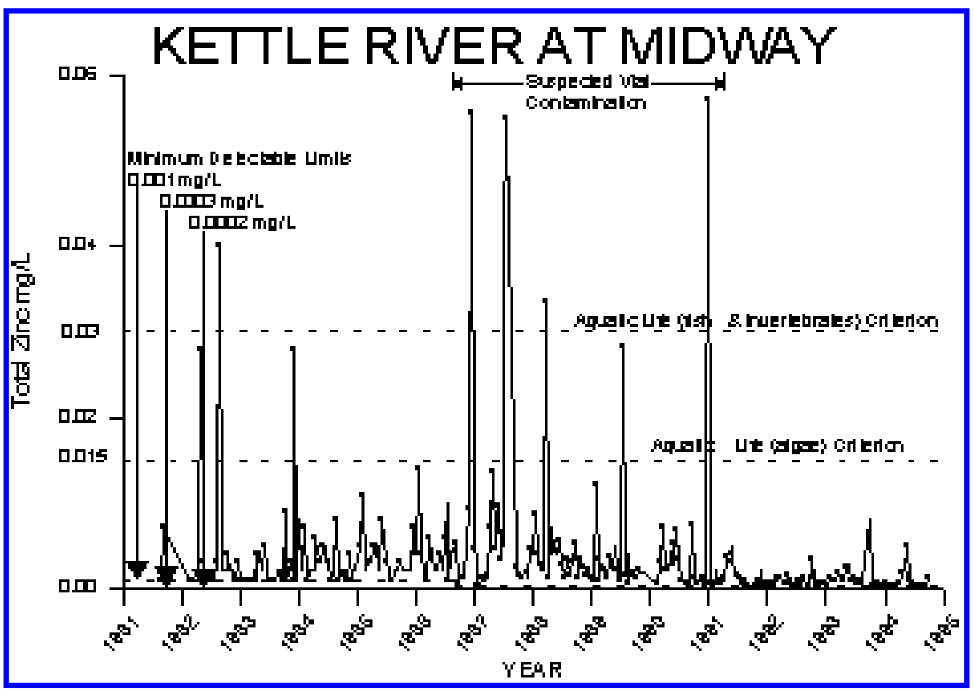


Figure 43 Total Zinc



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