



State Of Water Quality Of The Bonaparte River Near Mouth 1985-1995

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Canada Canada

Ministry of Environment,
Lands and Parks

Canada - British Columbia
Water Quality Monitoring Agreement

State of Water Quality of the
Bonaparte River near Mouth
1985-1995

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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EXECUTIVE SUMMARY

The Bonaparte River, located in British Columbia's southern interior, is a main tributary to the Thompson River (Figure 1). River water quality is important for uses such as drinking water, recreation, irrigation, and livestock watering, as well as for aquatic life and wildlife. Water quality is affected by ranching and agriculture, two sewage treatment plants, two landfill sites, urbanisation and forestry. Previous studies on this river have observed high levels of fecal coliforms, suspended solids, turbidity and algae.

In this report, 10 years of data (1985-1995), obtained under the Canada - B.C. Water Quality Monitoring Agreement, were assessed for trends and concerns in water quality. Monitoring was carried out monthly at the mouth of the river from 1985 - 1995 for 47 variables. These variables were graphed, and then compared to Approved and Working Criteria for Water Quality (Nagpal *et al.*, 1995) and to site-specific objectives set by the Ministry of Environment, Lands and Parks. Related sites within this watershed include: Thompson River at Spences Bridge, South Thompson River at Kamloops, and North Thompson River at Kamloops.

The main conclusions of this study are:

- No environmentally significant trends in water quality were detected through visual assessment of the data.
- Fecal coliforms at times exceeded the site-specific objective designed to permit drinking water use after partial treatment and disinfection. It appears that complete water treatment and disinfection are needed, and that consumption during spring freshet should be avoided.
- Periphyton chlorophyll-*a* (a measure of attached algal growth) consistently exceeded the site-specific objective to protect recreation and aquatic life. Dissolved phosphorus levels were elevated, indicating an ample supply to support algal growth.
- Non-filterable residue (suspended solids) and turbidity were often elevated during spring freshet, and site-specific objectives were regularly not met. Turbidity removal (complete water treatment) and disinfection are needed before drinking water use.
- The pH was slightly high for drinking water, possibly affecting chlorination effectiveness and causing encrustation and scaling.
- The river was well buffered against acid and metal inputs.
- Hardness levels during the winter were poor for drinking water aesthetics but still tolerable.
- The variables that exceeded criteria during spring freshet were: aluminum, chromium, copper, iron, manganese, titanium and zinc. These metals were largely associated with high levels of turbidity and suspended sediments, suggesting that the metals were in particulate form, probably not biologically available, and would be removed by the drinking water treatment needed to remove turbidity.

Recommendations

1. Remediation

- Efforts to reduce fecal coliforms, non-filterable residue, turbidity, and periphyton chlorophyll-a levels in this river should continue as outlined in the B.C. Water Quality Status report, including rehabilitating streamside vegetation, and preventing direct access to the water by cattle (Ministry of Environment, Lands and Parks, 1996).

2. Monitoring

- Monitoring should continue for the following variables related to agriculture, forestry and urbanisation: flow, hardness, periphyton chlorophyll-a, fecal coliforms, true colour, *E. coli*, ammonia, total dissolved nitrogen, pH, total dissolved phosphorus, non-filterable residue, sulphate, turbidity and specific conductivity.
- The following metals have had levels exceeding criteria within the past two years (i.e., 1994-95), and thus should be monitored (total and dissolved): aluminium, chromium, copper, iron, manganese, and titanium.
- Minimum detectable limits (MDLs) should be lowered for antimony, arsenic, cadmium, chromium, copper, lead, selenium, silver, thallium and zinc. MDLs should be at least 10 times below the water quality criteria for all variables.
- Increased sampling of 5 samples in 30 days should be employed for copper, *E. coli* and fecal coliforms to compare to criteria and objectives more precisely.

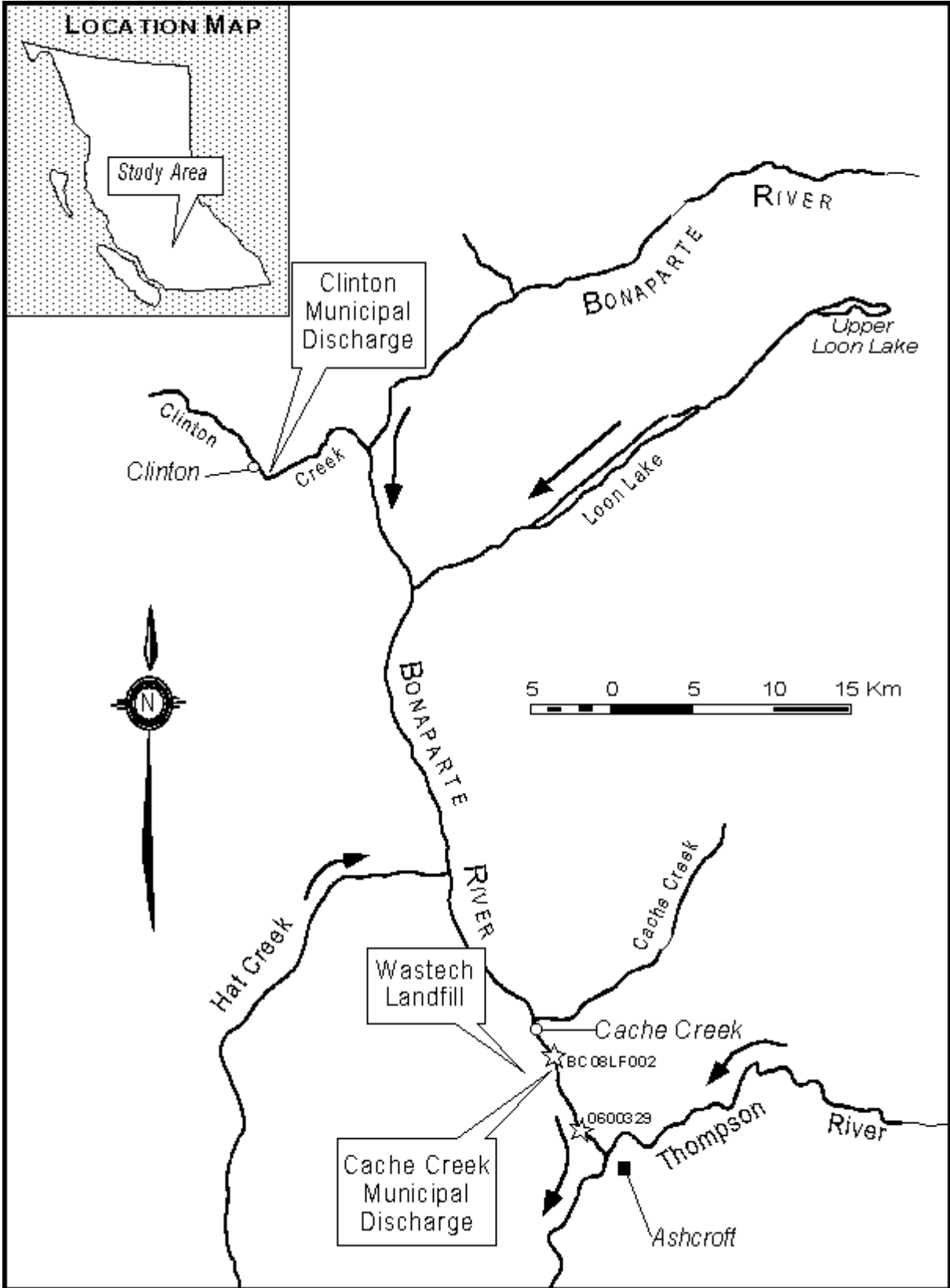


Figure 1 Map of the Bonaparte River Basin

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1. Introduction

The Bonaparte River is a scenic river, originating in the British Columbia's southern interior near Bridge Lake. It flows southwest toward Clinton (Figure 1), south through the Town of Cache Creek, and then joins the Thompson River north of Ashcroft. Important tributaries to the river are Clinton Creek, which flows east and joins the Bonaparte River east of Clinton, and Loon Creek, which flows southwest and joins the Bonaparte River downstream from the Clinton Creek confluence. Other tributaries are Hat and Cache creeks, both located downstream from Loon Creek. The drainage area of the Bonaparte River below Cache Creek is 5 020 km² (Environment Canada, 1991).

The Bonaparte watershed is influenced by agriculture, urbanisation and forestry. Ranching continues to be of importance, but a significant change to the agriculture industry has been the introduction of ginseng farming (Grace, 1996). No potential impacts of increased ginseng farming, such as frequent fungicide usage, have been identified to date (Grace, 1996). There are two sewage treatment plants (STP) within

the Bonaparte River watershed, one downstream from the Town of Clinton which discharges into Clinton Creek, and a second plant downstream from the Town of Cache Creek, which discharges into the Bonaparte River. An ultra-violet disinfection system has been operational at the Village of Cache Creek STP since November 5, 1990, eliminating residual chlorine discharge into the river (Wong, 1996). Three landfill sites are also located in the watershed. Wastech Services Limited, near Cache Creek, is one of the largest landfills in British Columbia, handling approximately 500 000 tonnes/year from Greater Vancouver. This site replaces the refuse and septic tank sludge disposal site near Ashcroft, which was decommissioned in 1989 (Wong, 1996). A smaller landfill is located near Clinton, but the impacts of both operational landfills were considered minimal due to the arid climate, and the subsequent small amount of leachate produced (Grace, 1996; Swain, 1986).

Water quality was monitored at the Bonaparte River near the mouth by BC Environment from 1985 to 1995. Chlorophyll-*a* was monitored since 1978. The data are stored on the province's EMS data base under site number 0600329. Flow was monitored below Cache Creek by Environment Canada at station number BC08LF002, and is plotted in Figure 2. The water quality variables are plotted in alphabetical order in Figures 3 to 48. There are no other long-term monitoring stations in this watershed, but other long-term sites in this region include: South Thompson River at Kamloops (Webber, 1997a), North Thompson River at North Kamloops (Webber, 1997b), and Thompson River at Spences Bridge (Webber, 1997c).

A number of water quality assessments have been conducted in past years. Loon and Clinton Creek have been reported to have had fecal coliform levels consistently in exceedence of objectives (Swain, 1986 and Ministry of Environment, Lands and Parks, 1996). High levels of suspended solids, turbidity and algae growth have also been noted for Clinton Creek (Ministry of Environment, Lands and Parks, 1996). Variables which have exceeded criteria in the Bonaparte River were fecal coliforms, and suspended solids (Swain, 1986), and turbidity and algae (Ministry of Environment, Lands and Parks, 1996). Naturally high levels of copper, iron and lead have also been observed in this river (Swain, 1986).

2. Quality Assurance

Quality assurance samples, consisting of field blanks, were taken since 1994, and sequential replicates were taken since 1993. All water quality data were scanned for accuracy and errors. Zinc contamination since 1992 has been confirmed, and values since then were excluded from this assessment.

3. State of Water Quality

The state of water quality was assessed by comparing values obtained for each variable to Approved and Working Criteria for Water Quality (Nagpal *et al.*, 1995), and to site-specific objectives set by the Ministry of Environment, Lands and Parks (Swain, 1986). Assessment of the data was based entirely on visual interpretation of the graphed variables. The following variables met criteria and showed no environmentally significant trends: total aluminum, barium, beryllium, boron, dissolved chloride, cobalt, magnesium, ammonia, nickel and vanadium. Criteria were not available for the following variables, nor were potentially significant trends apparent: bismuth, total silica, total strontium, total tellurium, total tin, and total zirconium. Minimum detectable limits were too high to permit comparison to all or some of the

criteria for: antimony, arsenic, cadmium, lead, selenium, silver and thallium. Variables discussed below displayed levels that were potentially detrimental to designated water uses such as drinking water, recreation, irrigation, livestock watering, aquatic life and wildlife, or merited some explanation.

Flow (Figure 2) values showed consistent seasonal variations, with highest annual flow during spring freshet and lowest in the fall and winter. Magnitudes varied considerably among years. Flows were relatively higher in 1985 and from 1990-1993, with a peak flow of 84.3 m³/s in 1990, which caused increased erosion and non-filterable residue (Figure 34) levels. A period of relatively lower flows occurred between 1986-1989, resulting in lower non-filterable residue levels. Flow monitoring should continue because of its importance in assessing water quality indicators.

Total aluminum (Figure 3) values met the criterion for wildlife, livestock and irrigation. Measurements of dissolved aluminum should be implemented to permit comparison to the criteria for drinking water and aquatic life.

Total arsenic (Figure 5) had values less than the minimum detectable limits which were in excess of most criteria. Only one value was detectable, 0.06 mg/L on January 24, 1995, exceeding criteria for drinking water (0.025 mg/L), aquatic life (0.05 mg/L), and proposed for aquatic life (0.005 mg/L). However, this value may well have been a false positive close to the 0.04 mg/L detection limit. Monitoring of this variable should continue, and the MDL (minimum detection limit) should be lowered to at least 10 times below the 0.005 mg/L proposed criterion for aquatic life, for more accurate assessment.

Calcium (Figure 11) values indicate that the Bonaparte River was well buffered against acid inputs and metal contaminants.

Total chromium (Figure 14) values were consistently below criteria for aquatic life (fish at 0.02 mg/L) and drinking water (0.05 mg/L), but values exceeded the criterion for protecting phyto- and zooplankton (0.002 mg/L) approximately 29% of the time. Non-filterable residue (Figure 34) and turbidity (Figure 45) were elevated at the same time, suggesting that the levels were associated with suspended sediments and probably not biologically available. Both total and dissolved chromium should be measured, and detection limits should be at least ten times below the 0.002 mg/L criterion.

Fecal coliform (Figure 16) levels exceeded the <1000 CFU/100 mL general irrigation criterion once, on October 24, 1994. Fifteen percent of the values exceeded the <200 CFU/100 mL criterion for irrigation and recreational use, 38% of the samples surpassed the <100 CFU/100 mL site-specific objective and criterion for raw drinking water receiving partial treatment and disinfection, and 90% of the samples surpassed the 10 CFU/100 mL criterion for raw drinking water receiving disinfection only. **E coli** (Figure 19) is a fecal coliform that is somewhat more specific to fecal contamination, and the levels were reasonably similar to those of fecal coliforms. Most coliform criteria were exceeded at times, but for a more accurate comparison, an increased frequency of monitoring (5 samples in 30 days) would be required. The Ministry of Environment, Lands and Parks (1996), and Swain (1986) found high coliform levels to be affecting water quality in previous studies, suggesting that high coliform levels continued to impact water quality.

Values exceeded criteria or objectives consistently during spring freshet, which correlated with high non-filterable residue (Figure 34) and flow (Figure 2) levels. This suggests that fecal coliforms may have been related to manure runoff from agricultural lands. High results which occurred occasionally in winter could have been due to increased erosion from low-elevation snowmelts (Grace, 1996). Other potential

contributors to high fecal coliform levels in the river were the Cache Creek and Clinton Sewage Treatment Plant (STP) discharges. At the Cache Creek STP, a new UV disinfection plant has been operating since 1990 (Wong, 1996), lowering the bacterial levels in the river downstream from the plant (Grace, 1996). This likely contributed to the apparent stability of fecal coliform levels between 1990-1994, when increased levels of fecal coliforms would be expected due to relatively higher flows during those years.

Complete water treatment and disinfection are needed for drinking water, and consumption of this water should be avoided during spring freshet, if possible. Rehabilitation of streamside vegetation to prevent erosion and generally preventing cattle direct access to the water (Ministry of Environment, Lands and Parks, 1996) are measures that should help to reduce fecal coliform levels in this river.

Total absorbance colour (Figure 17) values cannot be directly compared to the true colour criteria since total absorbance is measured differently than true colour. However, total values were well below the 100-unit maximum true colour criterion for recreation. The 15-unit drinking water criterion and desirable recreation criterion for true colour were exceeded twice, on April 19, 1994 and on May 19, 1994 during spring freshet. True colour should be monitored to compare the data to the criteria more accurately.

Total copper (Figure 18) values exceeded the 0.013 mg/L upper criteria for aquatic life 6% of the time, and the 0.004 mg/L lower criteria for aquatic life 12% of the time, considering the appropriate daily hardness levels. This river had some naturally high copper levels (Swain, 1986) and values prior to 1993 could have been false positives close to the 0.01 mg/L detection limit. As well, high values of both total copper and non-filterable residues (Figure 34) occurred together during freshet, suggesting that they are related to suspended sediments, and probably not biologically available. Since samples were collected less often than the required five samples in 30 days for proper comparison to criteria, an increased frequency of measurements is recommended. Total and dissolved copper should be measured using a detection limit at least 10 times lower than the lowest criterion.

Hardness (Figure 20) levels were often poor for drinking water aesthetics (>200 mg/L), but still tolerable.

Total iron (Figure 21) values exceeded the criteria for drinking water aesthetics and aquatic life (0.30 mg/L) 46% of the time. Iron levels were naturally high in this river (Swain, 1986). Most of the high values occurred in conjunction with peak flow (Figure 2) and non-filterable residues (Figure 34). This suggests that the iron was probably in a particulate form, probably not biologically available, and would be removed by the turbidity removal needed prior to drinking.

Total manganese (Figure 24) levels were consistently below the 0.2 mg/L criterion for irrigation, and exceeded the 0.10 mg/L criterion for aquatic life only twice (on May 19, 1993 and on April 19, 1994). The 0.05 mg/L aesthetic criterion for drinking water was exceeded 15% of the time. High manganese levels occurred during spring freshet, and years of higher flows (1993-1995) (Figure 2), as well as in conjunction with high non-filterable residue levels (Figure 34). This suggests that manganese was in a particulate form, was probably not biologically available, and would be removed by drinking water treatment needed for turbidity.

Molybdenum (Figure 25) levels exceeded the irrigation criterion of 0.01 mg/L twice: on February 22, 1988, and on July 19, 1988; however the criterion has not been surpassed since 1993.

Total Kjeldahl nitrogen (Figure 28) values increased together with high fecal coliform levels during spring freshet, and years of higher flow (Figure 2), implying a correlation to agricultural runoff. Higher levels could also have been due to increased instream algal production in the spring to summer months (Grace, 1996).

pH (Figure 30) values met criteria for aquatic life, and the site-specific objective, but exceeded the drinking water (aesthetics) upper criterion of 8.5 20% of the time. Above pH 8.5, the frequency of encrustation and scaling may be increased, and there is a progressive decrease in the efficiency of chlorine disinfection processes with increasing pH levels (Health Canada, 1996).

Total phosphorus (Figure 31) peak values often occurred when non-filterable residues were elevated (Figure 34) during freshet or years of relatively high flows, likely due to increased erosion and agricultural runoff. The total phosphorus values were generally two times higher than dissolved phosphorus (Figure 32), suggesting that about half of the total phosphorus load may not have been biologically available for algal growth. Agriculture, two sewage treatment plants, forestry, and industry were potential sources of anthropogenic nutrients to the river. Swain (1986) stated that total phosphorus values generally increased in a downstream direction in the Bonaparte River. No criteria have been set for total phosphorus in B.C. rivers with periphyton chlorophyll-*a* criteria being used instead.

Total dissolved phosphorus (Figure 32) and **Dissolved Ortho-phosphorus** (Figure 33) levels and patterns were nearly identical, and we recommend that only one of them be measured as an indicator of bio-available phosphorus. Concentrations of both variables peaked in winter, and generally decreased in summer when phosphorus was being taken up by algae and bacteria. Values were higher in years of reduced rainfall (1987-1989) than in years of more rainfall (1990-1995) due to the dilution effect. Dilution as a result of flow patterns may also have resulted in the apparent slight decline in values over the 10-year sampling period. Although no criteria have been set for phosphorus in B.C. rivers, levels appear excessive according to the chlorophyll-*a* values. Mean **periphyton chlorophyll-*a*** values (Figure 13) exceeded the 100 mg/m² aquatic life criterion and the 50 mg/m² recreation criterion and site-specific objective 54% and 79% of the time, respectively. If attainment was calculated since 1986, values in exceedence of criteria occurred 72% and 100% of the time, respectively. High levels of chlorophyll-*a* and phosphorus, were noted in earlier studies of this river (Swain, 1986, and Ministry of Environment, Lands and Parks, 1996). Chlorophyll-*a* should continue to be monitored as an indicator of algal growth, and dissolved phosphorus should be monitored as an indicator of the bio-available phosphorus supply.

Non-filterable residue (NFR) (i.e., suspended solids or sediment) (Figure 34) and **Turbidity** (Figure 45) values were highest during spring freshet, and years of increased flows, due to enhanced erosion. The NFR fisheries criterion (25 mg/L) and the turbidity criterion for drinking water aesthetics (5 NTU) were exceeded 38% and 37% of the time, respectively, most often during these times of peak flows. The 1 NTU turbidity criterion for drinking water for health was exceeded in 87% of the samples. Turbidity removal (complete water treatment) and disinfection are needed prior to drinking water use. Peaks in both variables during late winter may have been due to runoff from roads and urban areas or agricultural runoff from low-level snowmelt (Grace, 1996). Swain (1986) noted that suspended solid levels were high enough to possibly affect aquatic life, based on data collected from 1972-1977, and the Ministry of Environment, Lands and Parks (1996) stated that turbidity and suspended solids objectives were regularly not met from Cache Creek downstream between 1987 and 1993.

Since March 18, 1987, development of the Wastech Landfill could potentially have increased NFR due to heightened erosion from the construction of diversions, roads, and a wood chip plant (Grace, 1996). Comparison of our data with those of Swain (1986), who summarised data monitored for NFR between

1974-1979 just upstream from our site, indicate that NFR levels may have increased. (Median, Mean, Maximum, and Minimum values of 6, 28, 310, and 2 mg/L, respectively, in Swain (1986), and Median, Mean, Maximum and Minimum Values of 20, 35, 452, and 1 mg/L, respectively, since March, 1987, according to our data). We recommend that non-filterable residue and turbidity continue to be measured as indicators of erosion and suspended sediment generation.

Specific conductivity (Figure 38) met the drinking water and irrigation criterion, except on February 1, 1988, a day of particularly low flow. Values were highest during years of low flows (1986-1989) and winter droughts, but declined during spring freshets and between 1990-1993 due to increased dilution. We recommend that conductivity continue to be measured as an indicator of salinization.

Dissolved Sulphate (Figure 40) peak values, as with specific conductivity, generally occurred together with low flows (Figure 2). Sulphate slightly exceeded the criterion for aquatic life (100 mg/L) once, on December 21, 1988, a time of very low flow. We recommend that sulphate be continued to be measured.

Titanium (Figure 44) peaked twice above the drinking water and aquatic life criteria, on May 19, 1993 and on May 19, 1994. Since the high values occurred during periods of high flow and non-filterable residues, the metal was probably largely biologically unavailable, and would be removed with treatment needed to remove turbidity.

Total zinc (Figure 47) had artificial contamination during 1993-95. Prior to 1993, levels were regularly below criteria except on two occasions in 1987. These two values were also close (2 times) to the 0.01 mg/L minimum detectable limit, and thus they may have been false positives. We recommend that total and dissolved zinc with a detection limit of ≤ 0.002 mg/L be measured to determine present levels. Quality assurance samples, including field blanks and replicates should also be analysed.

Conclusions - State of Water Quality

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- No environmentally significant trends in water quality were detected through visual assessment of the data.
 - Fecal coliforms at times exceeded the site-specific objective designed to permit drinking water use after partial treatment and disinfection. It appears that complete water treatment and disinfection are needed, and that consumption during spring freshet should be avoided.
 - Periphyton chlorophyll-*a* (a measure of attached algal growth) consistently exceeded the site-specific objective to protect recreation and aquatic life. Dissolved phosphorus levels were elevated, indicating an ample supply to support algal growth.
 - Non-filterable residue (suspended solids) and turbidity were often elevated during spring freshet, and site-specific objectives were regularly not met. Turbidity removal (complete water treatment) and disinfection or remediation are needed before drinking water use.
 - The pH was slightly high for drinking water, possibly affecting chlorination effectiveness and causing encrustation and scaling.
 - The river was well buffered against acid and metal inputs.
 - Hardness levels during the winter were poor for drinking water aesthetics, but still tolerable.
 - The variables that exceeded criteria during spring freshet were: aluminum, chromium, copper, iron, manganese, titanium and zinc. These metals were largely associated with high levels of turbidity and

suspended sediments, suggesting that they were in particulate form, probably not biologically available, and would be removed by the drinking water treatment needed to remove turbidity.

4. Recommendations for Water Quality Management

4.1 Remediation

· Efforts to reduce fecal coliforms, non-filterable residues, turbidity, and periphyton chlorophyll-a levels in this river should continue as outlined in the B.C. Water Quality Status report, including rehabilitating streamside vegetation, and preventing direct access to the water by cattle (Ministry of Environment, Lands and Parks, 1996).

4.2 Monitoring

· Monitoring should continue for the following variables related to agriculture, forestry and urbanisation: flow, hardness, periphyton chlorophyll-a, fecal coliforms, true colour, *E. coli*, ammonia, total dissolved nitrogen, pH, total dissolved phosphorus, non-filterable residue, sulphate, turbidity and specific conductivity.

· The following metals have had levels exceeding criteria within the past two years, and thus should be monitored (total and dissolved): aluminium, chromium, copper, iron, manganese, and titanium.

· Minimum detectable limits (MDLs) should be lowered for antimony, arsenic, cadmium, chromium, copper, lead, selenium, silver, thallium and zinc. MDLs should be at least 10 times below the water quality criteria for all variables.

· Increased sampling of 5 samples in 30 days should be employed for copper, *E. coli* and fecal coliforms to compare to criteria and objectives more precisely.

Figure 2 Flow

BONAPARTE R. BELOW CACHE CREEK

BC08LF002

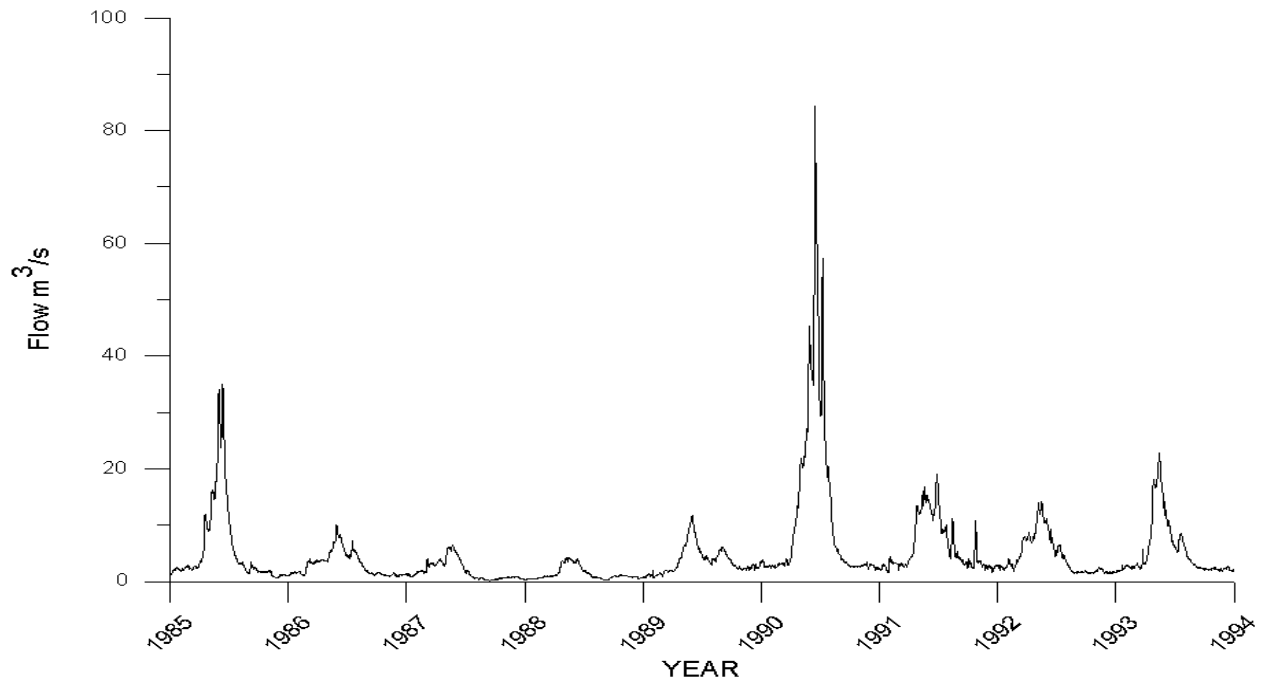


Figure 5 Total Arsenic

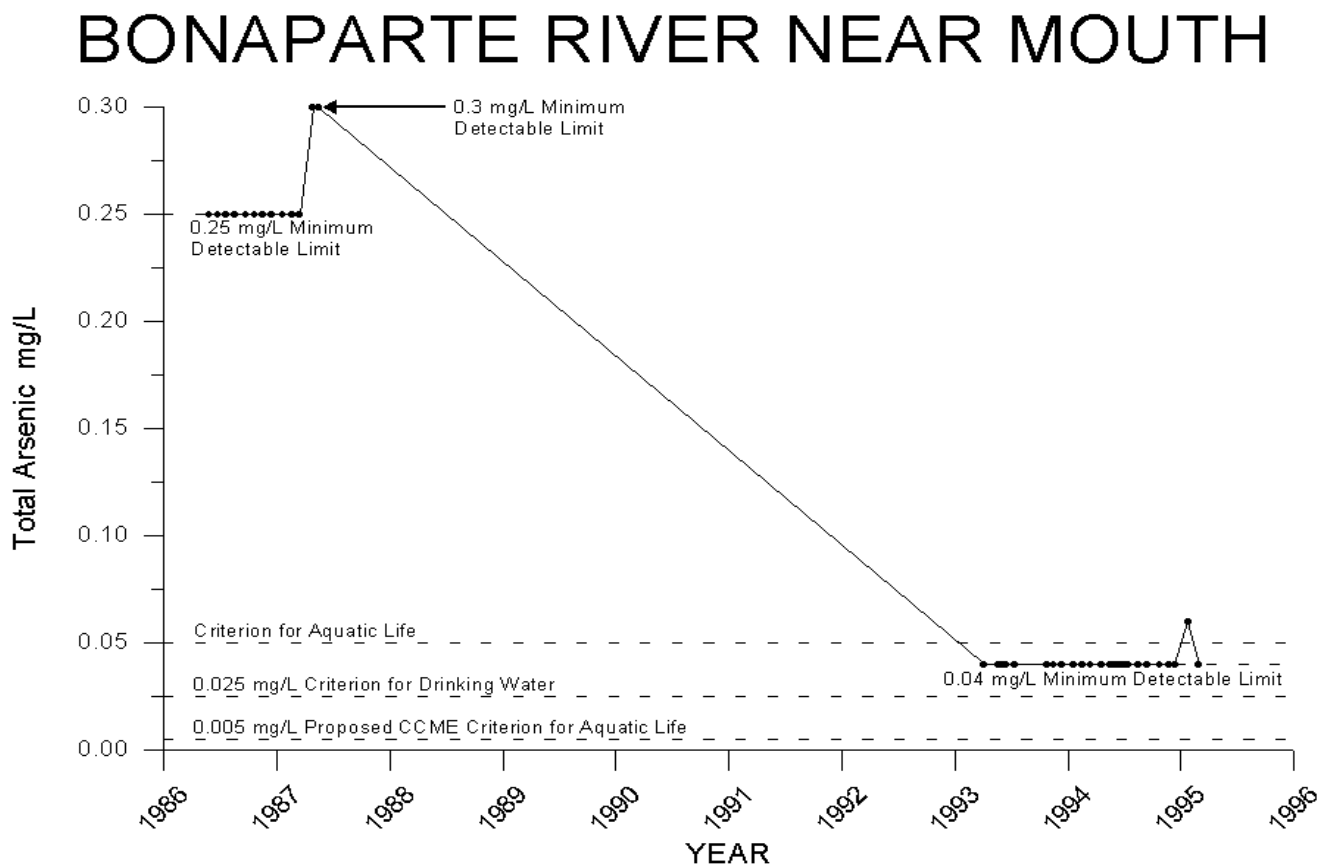


Figure 6 Total Barium

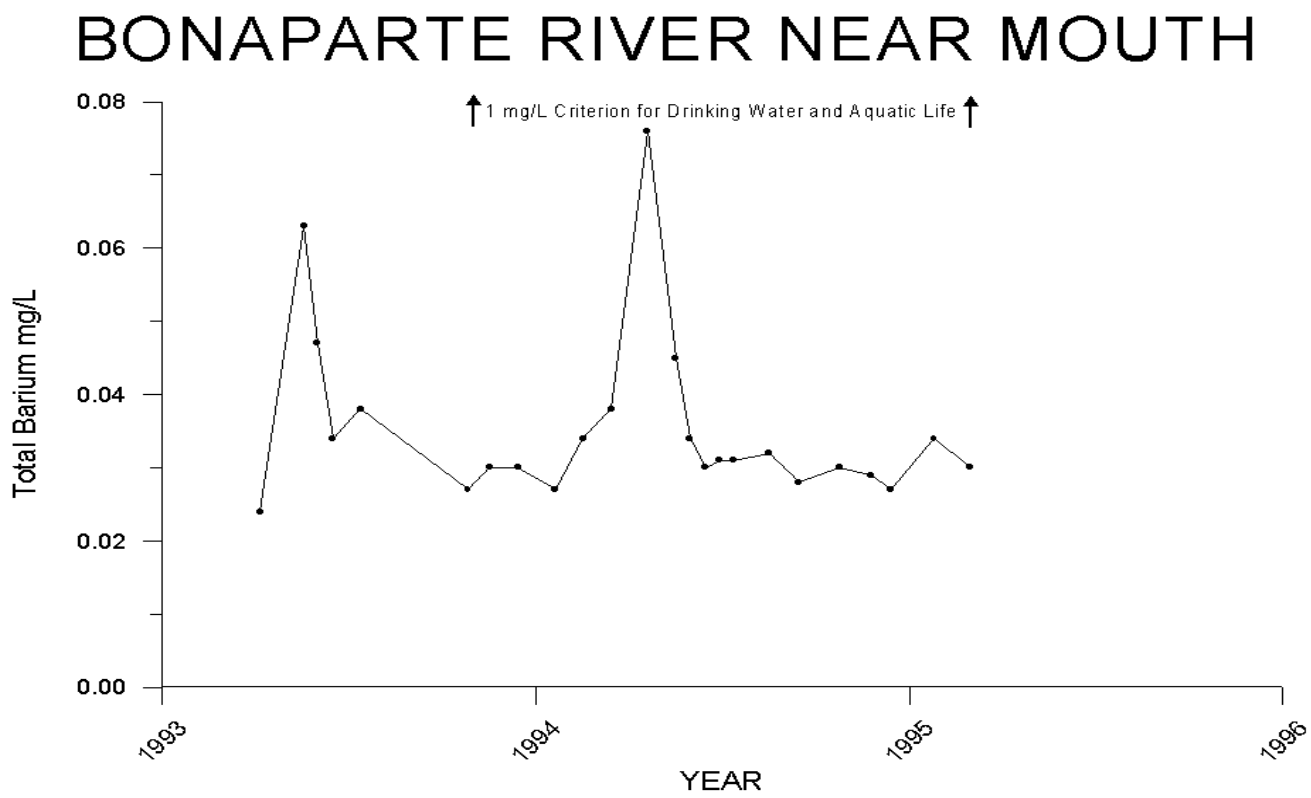


Figure 10 Total Cadmium

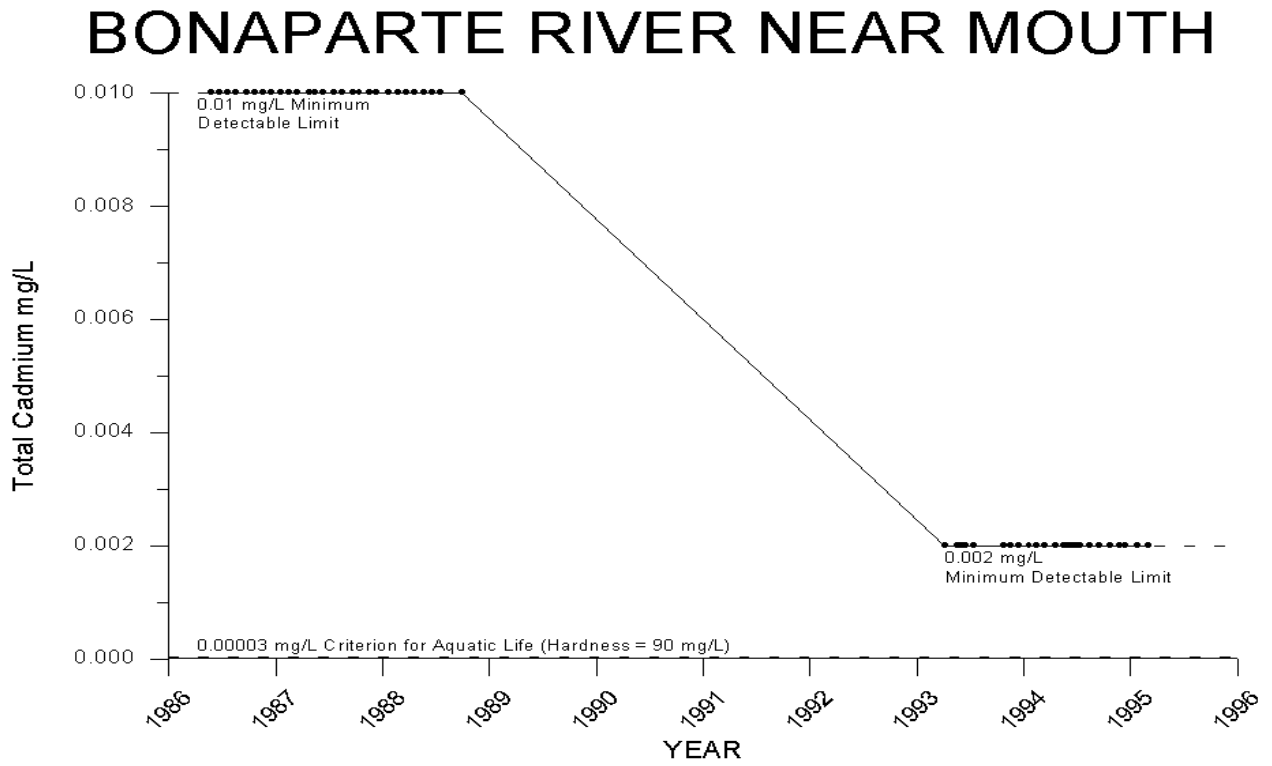


Figure 11 Calcium



BONAPARTE RIVER NEAR MOUTH

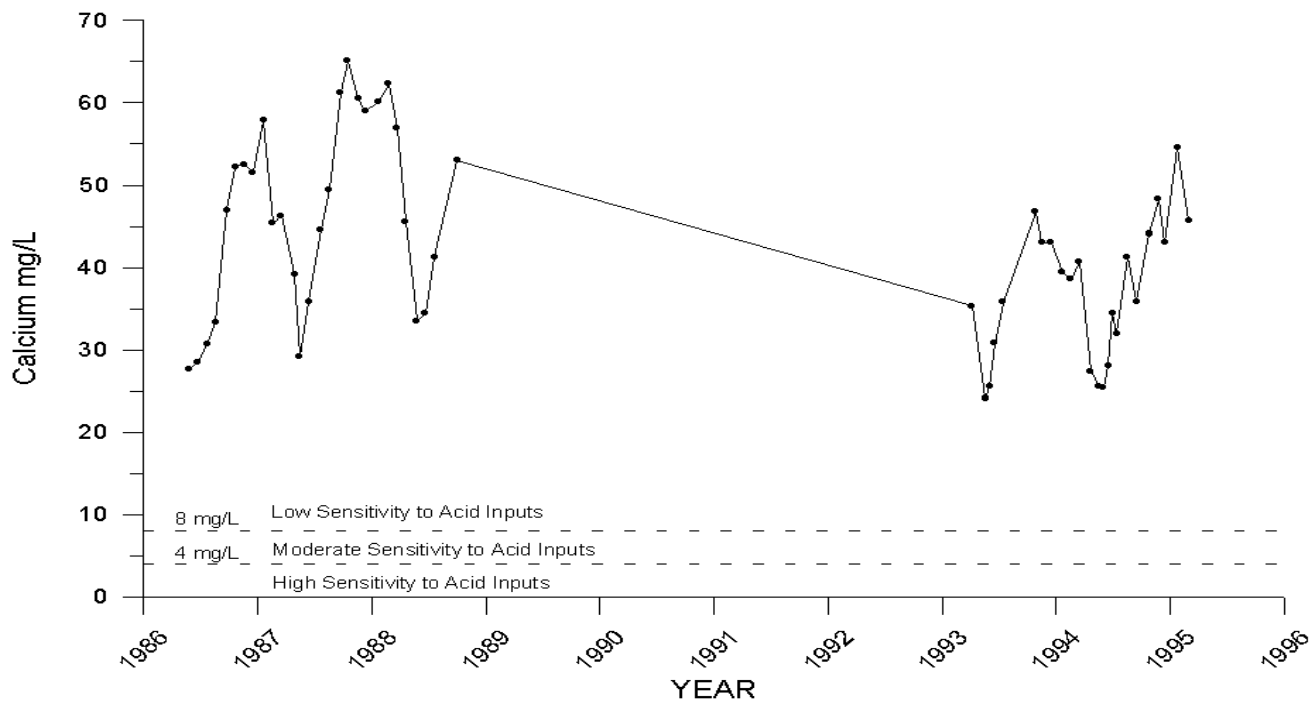


Figure 12 Dissolved Chloride

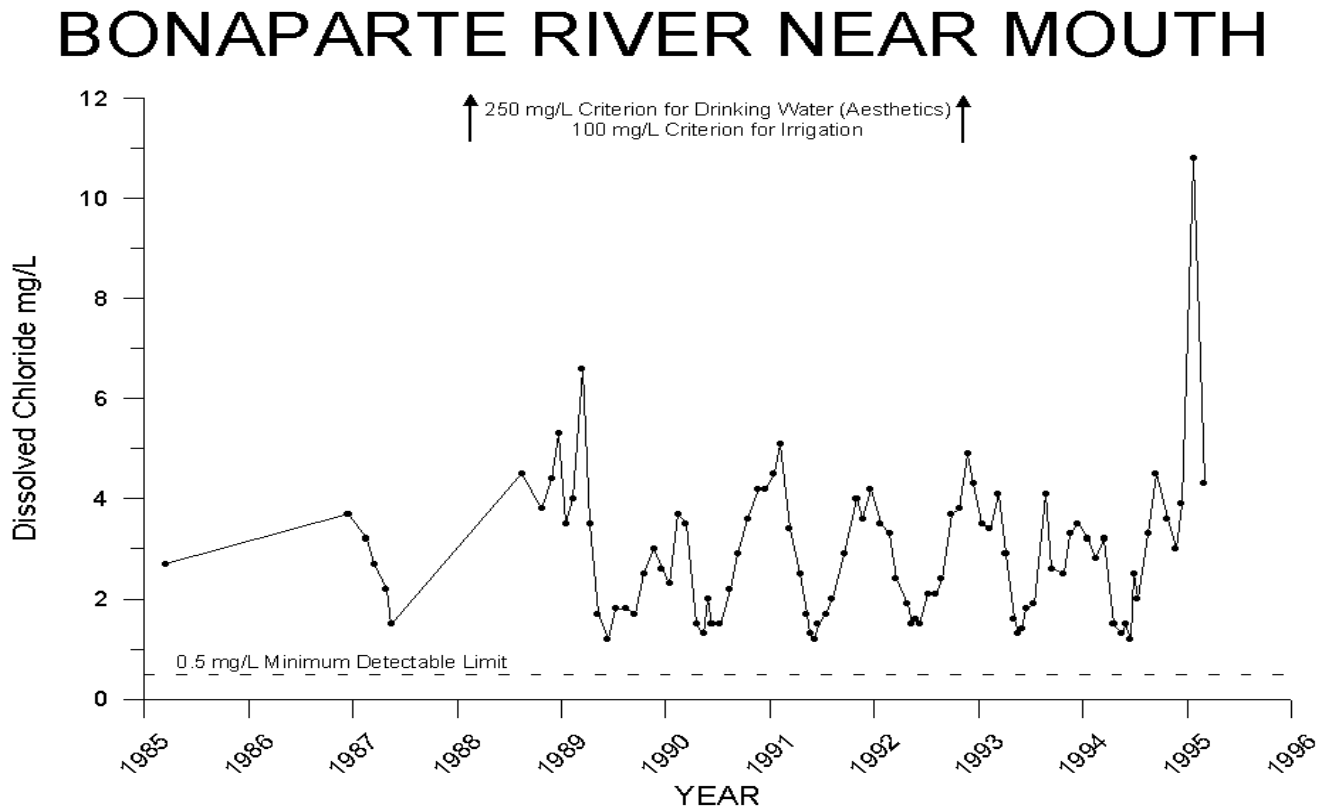


Figure 13 Total Chlorophyll a

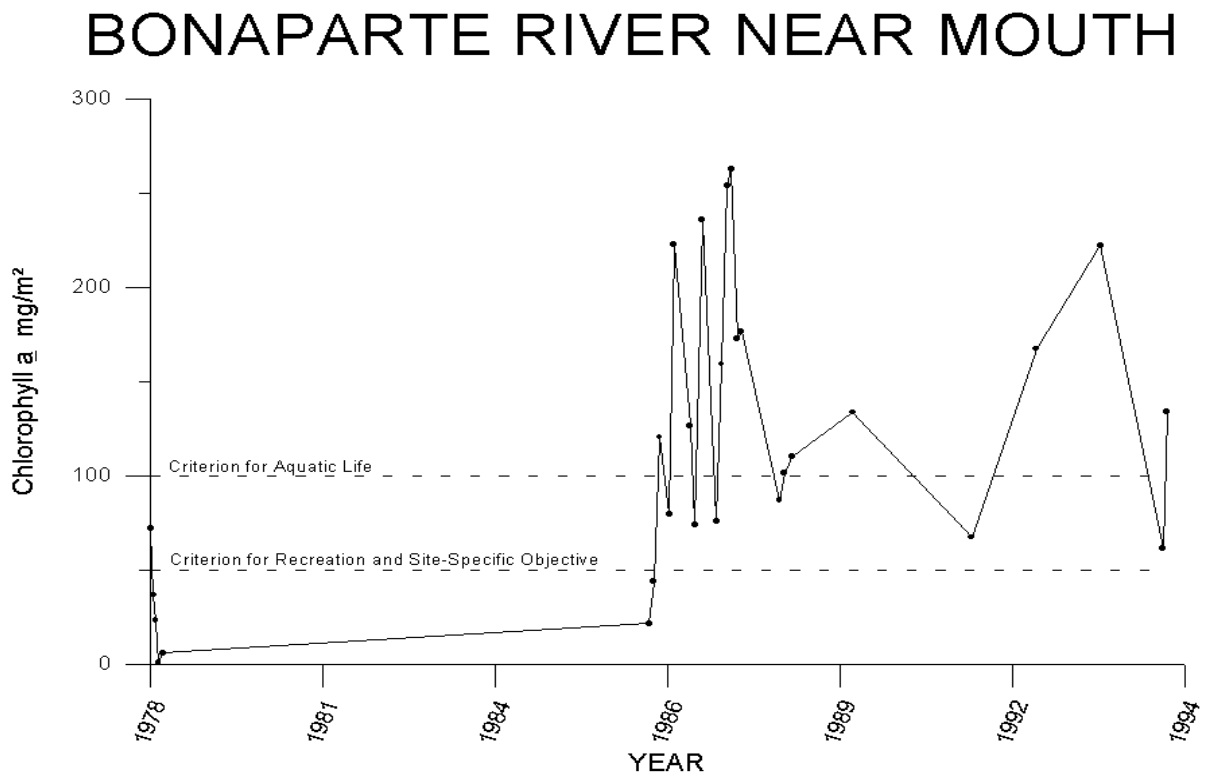


Figure 14 Total Chromium

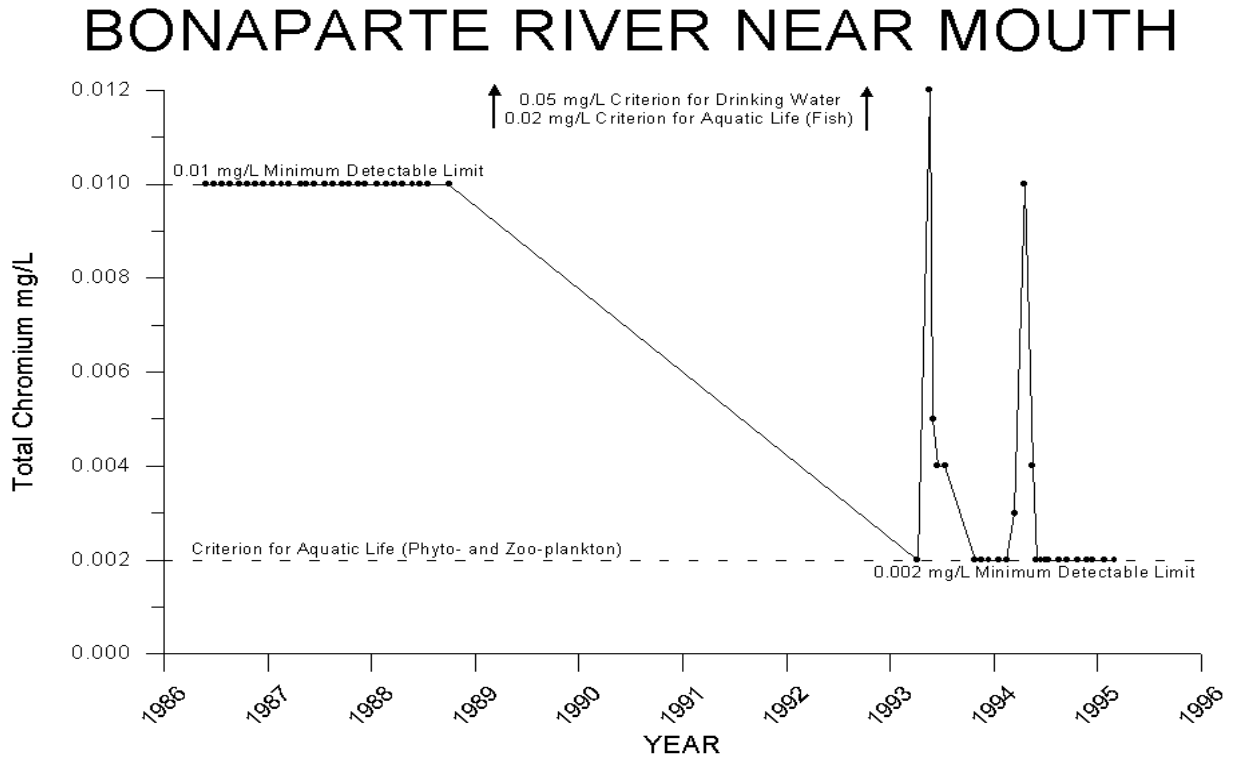


Figure 15 Total Cobalt

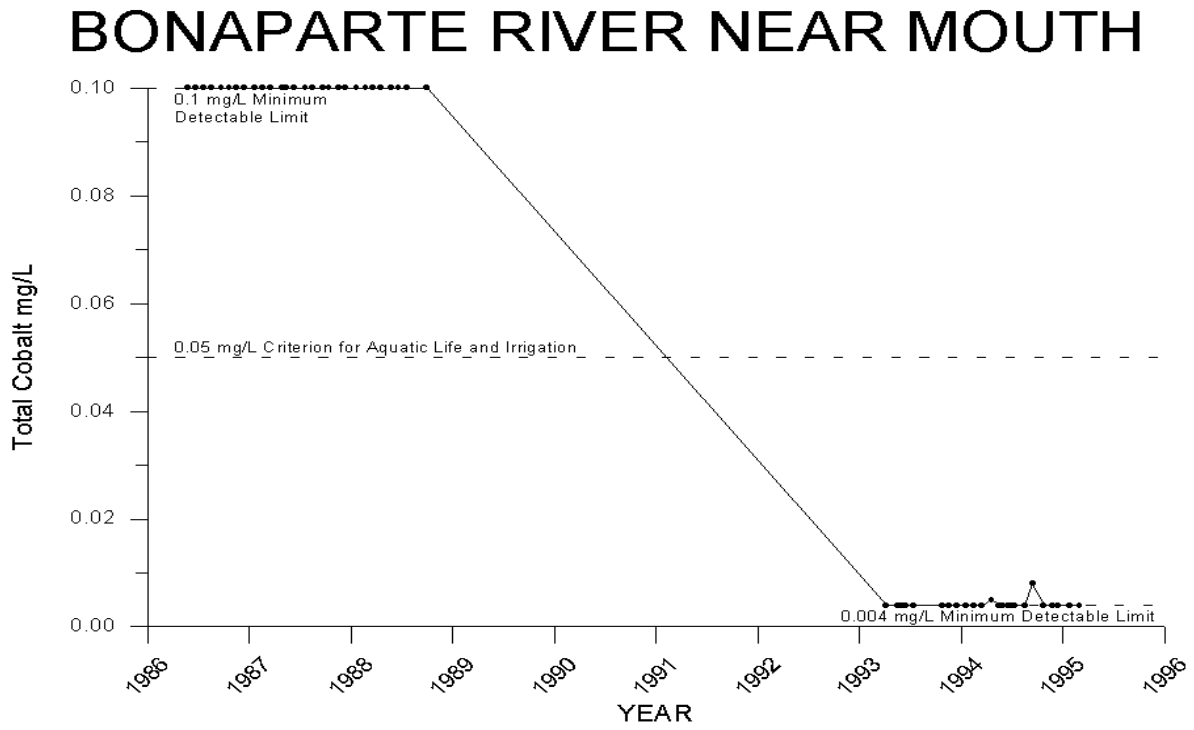


Figure 16 Fecal Coliforms

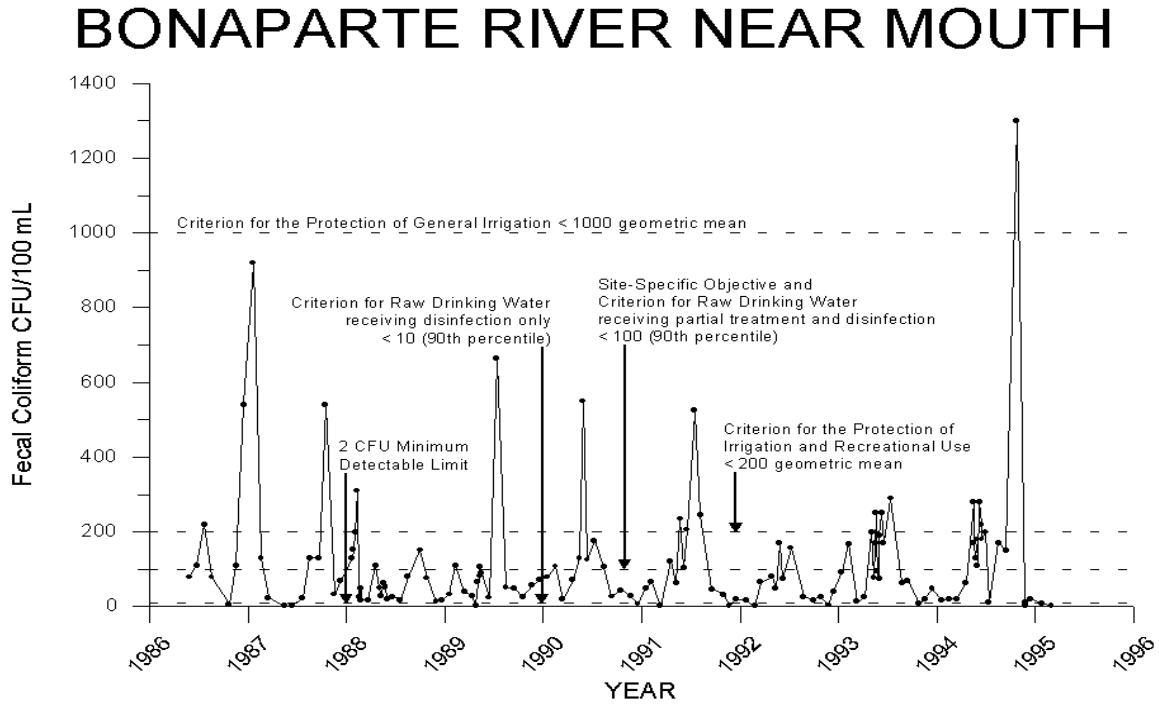


Figure 17 Colour (TAC)

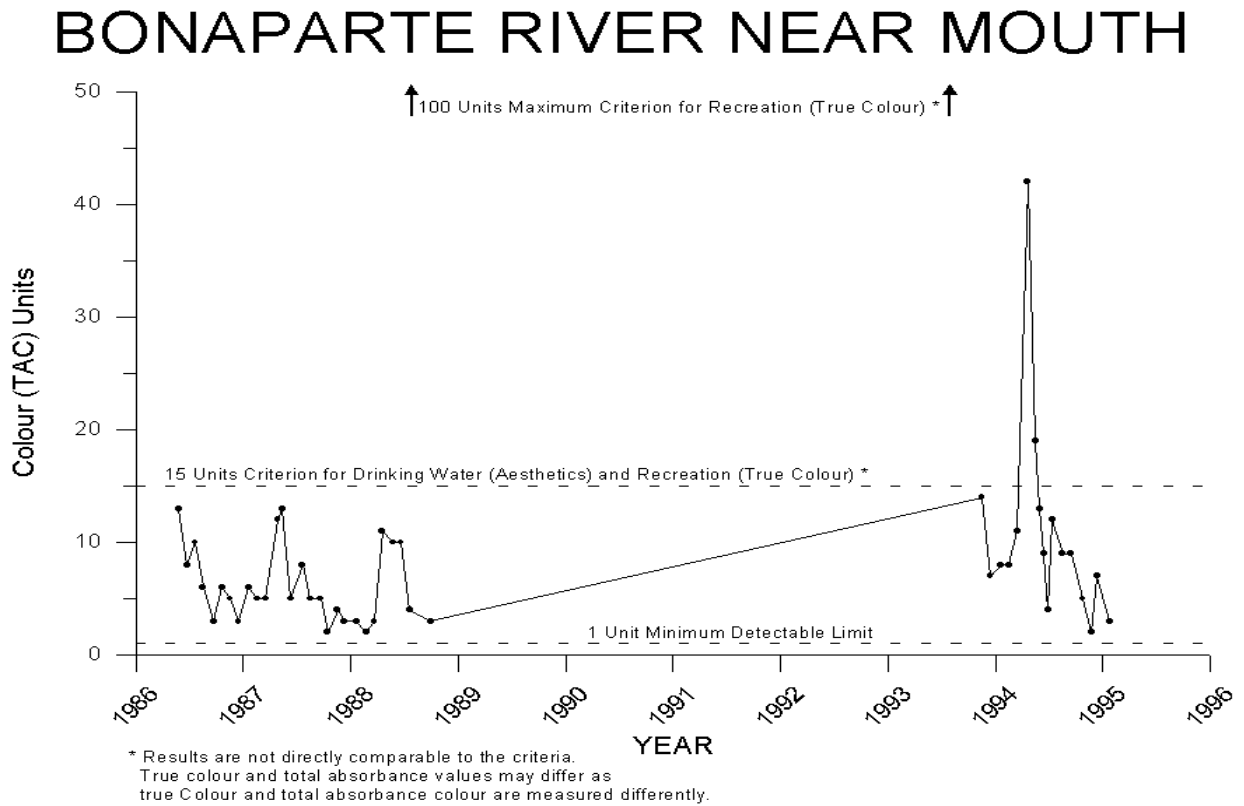


Figure 18 Total Copper

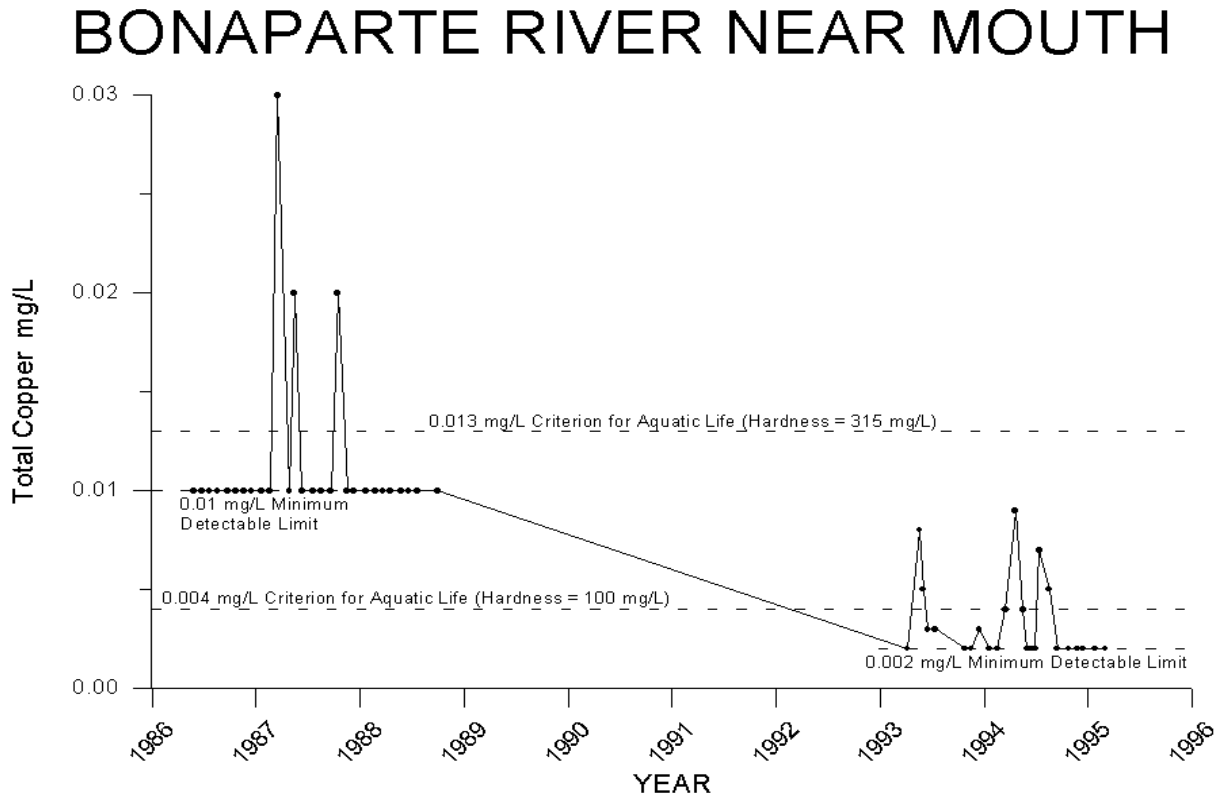


Figure 20 Hardness

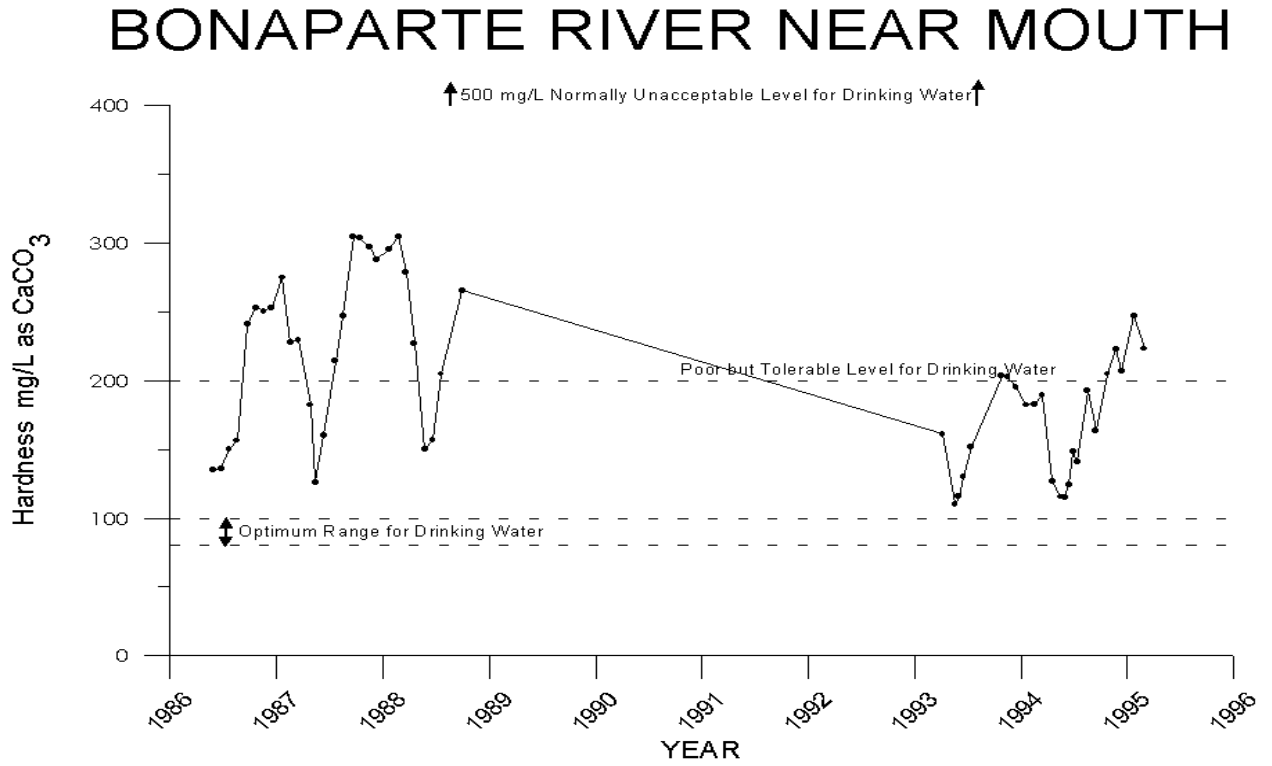


Figure 22 Total Lead

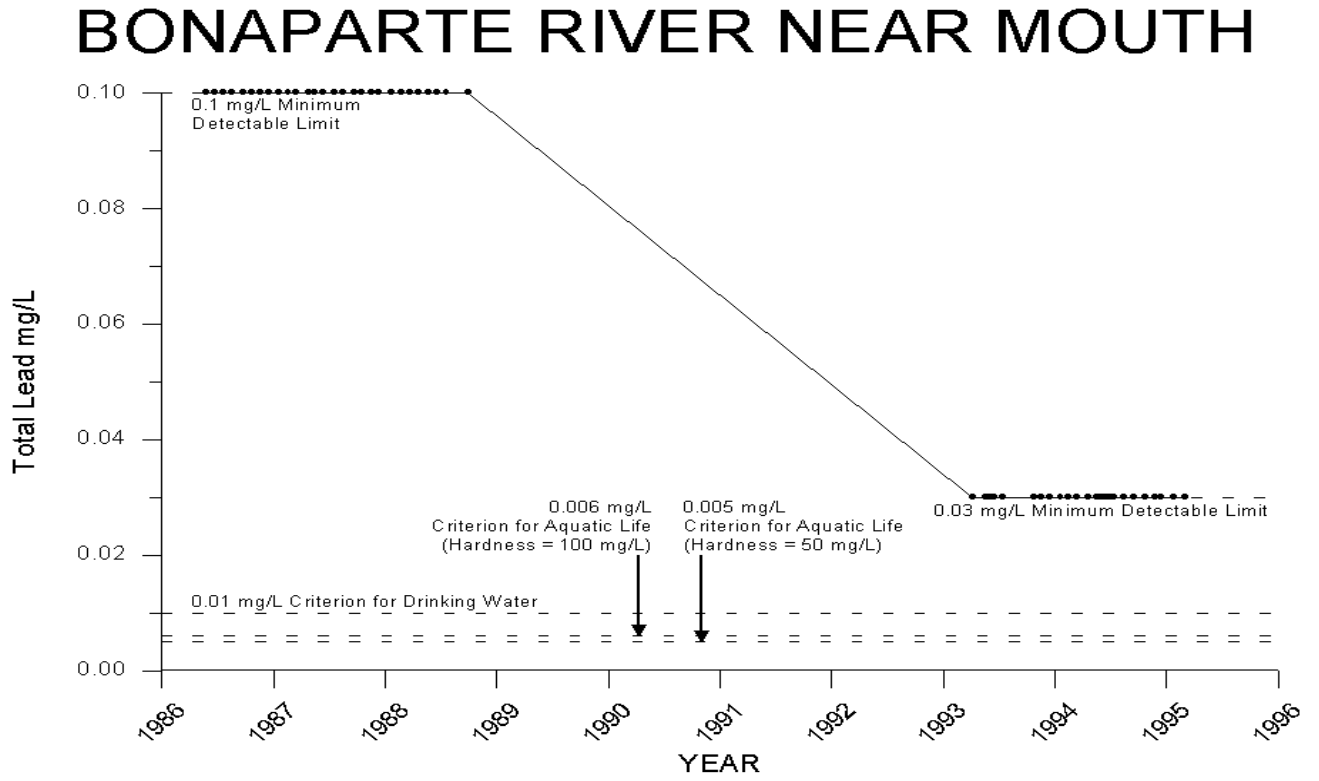


Figure 23 Magnesium

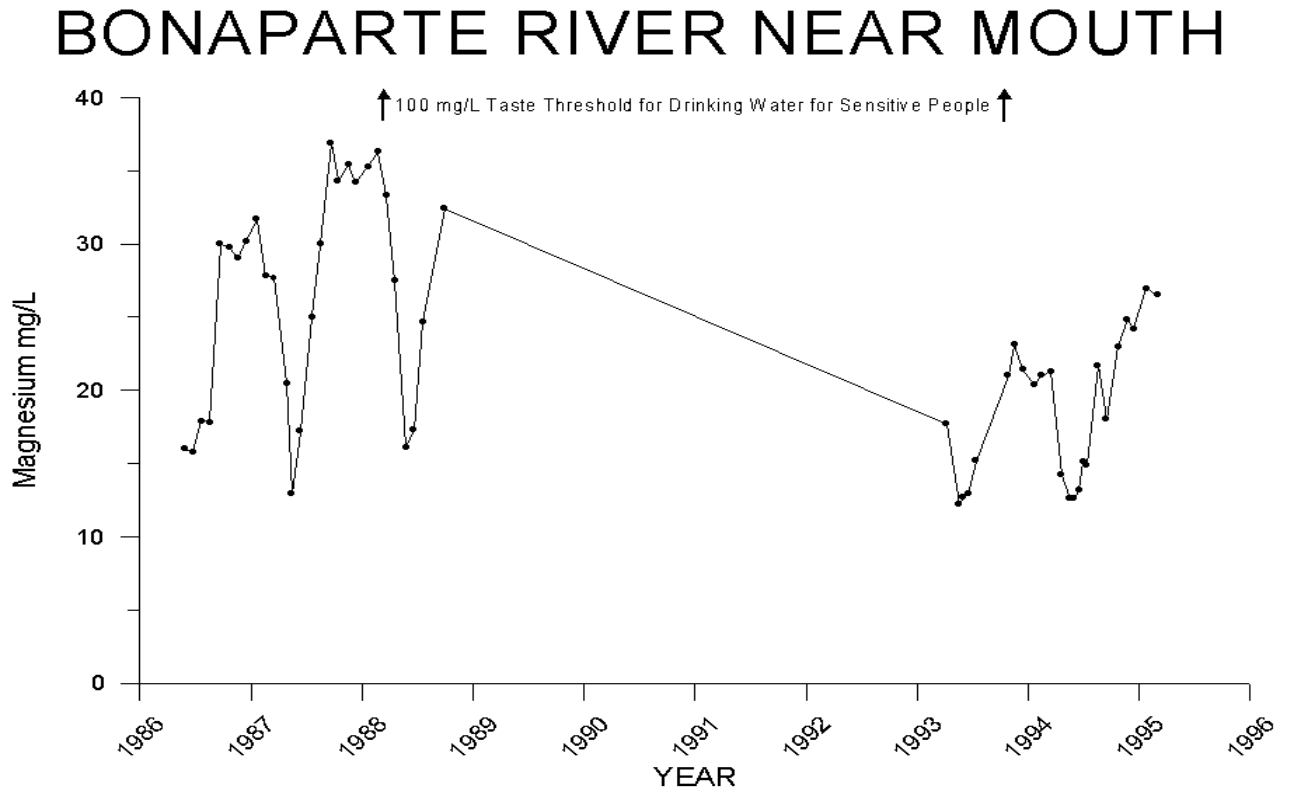


Figure 24 Total Manganese

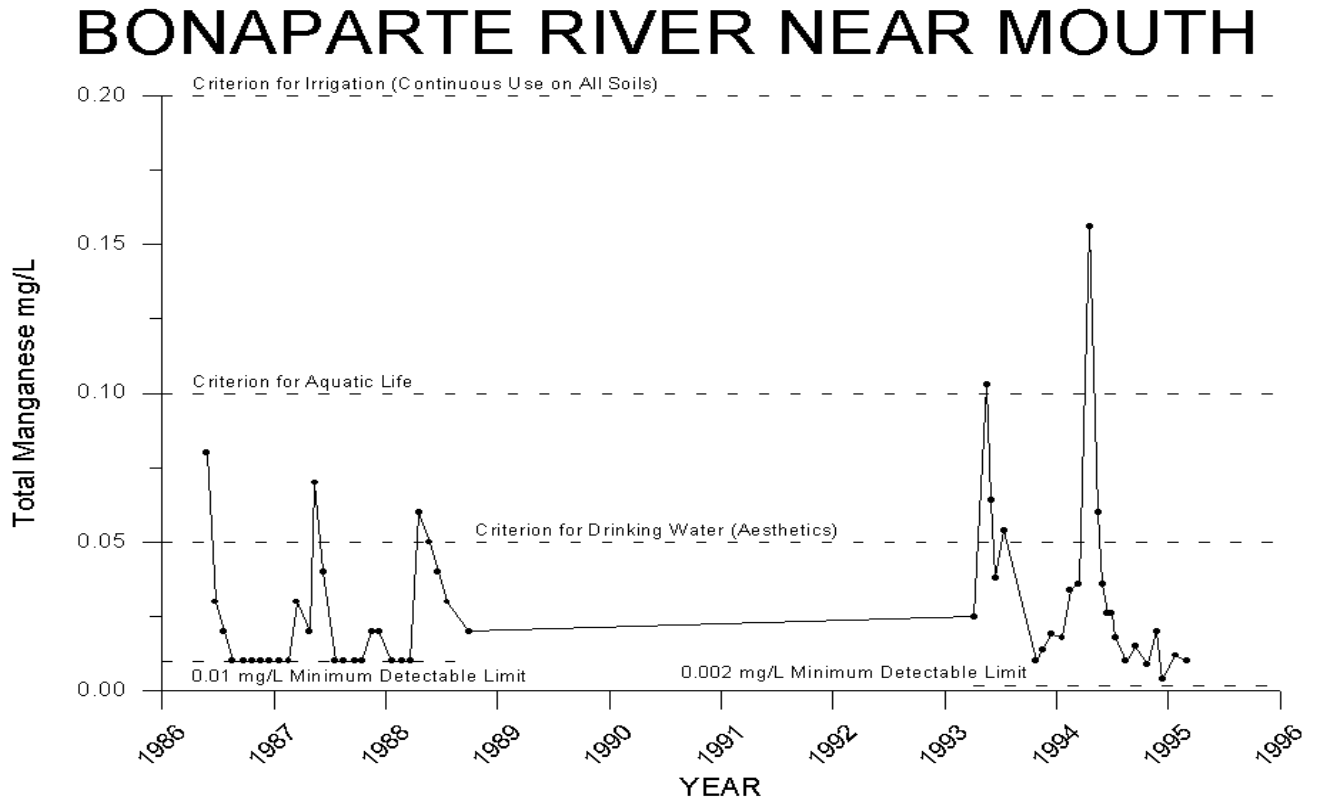


Figure 25 Total Molybdenum

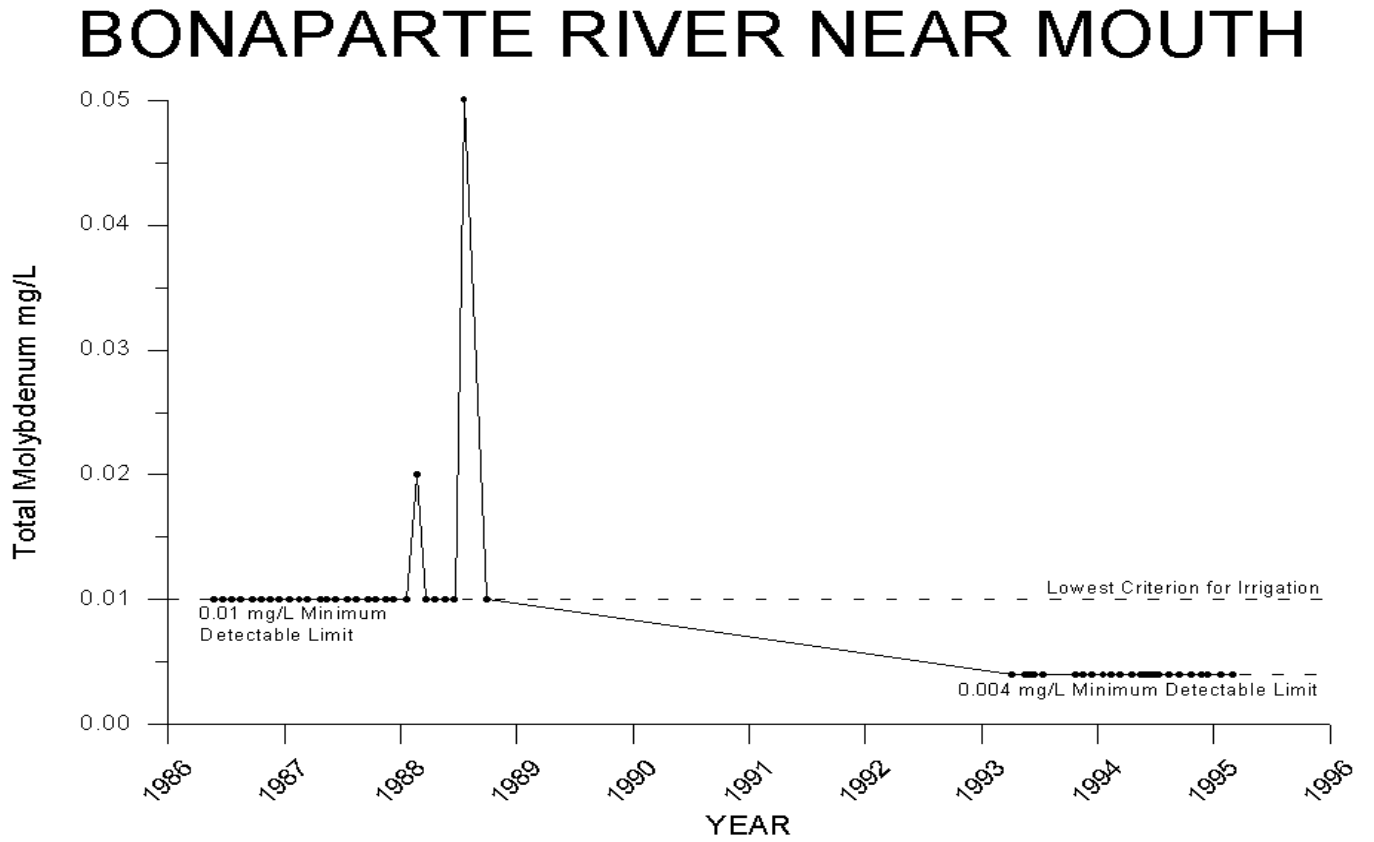


Figure 26 Total Nickel

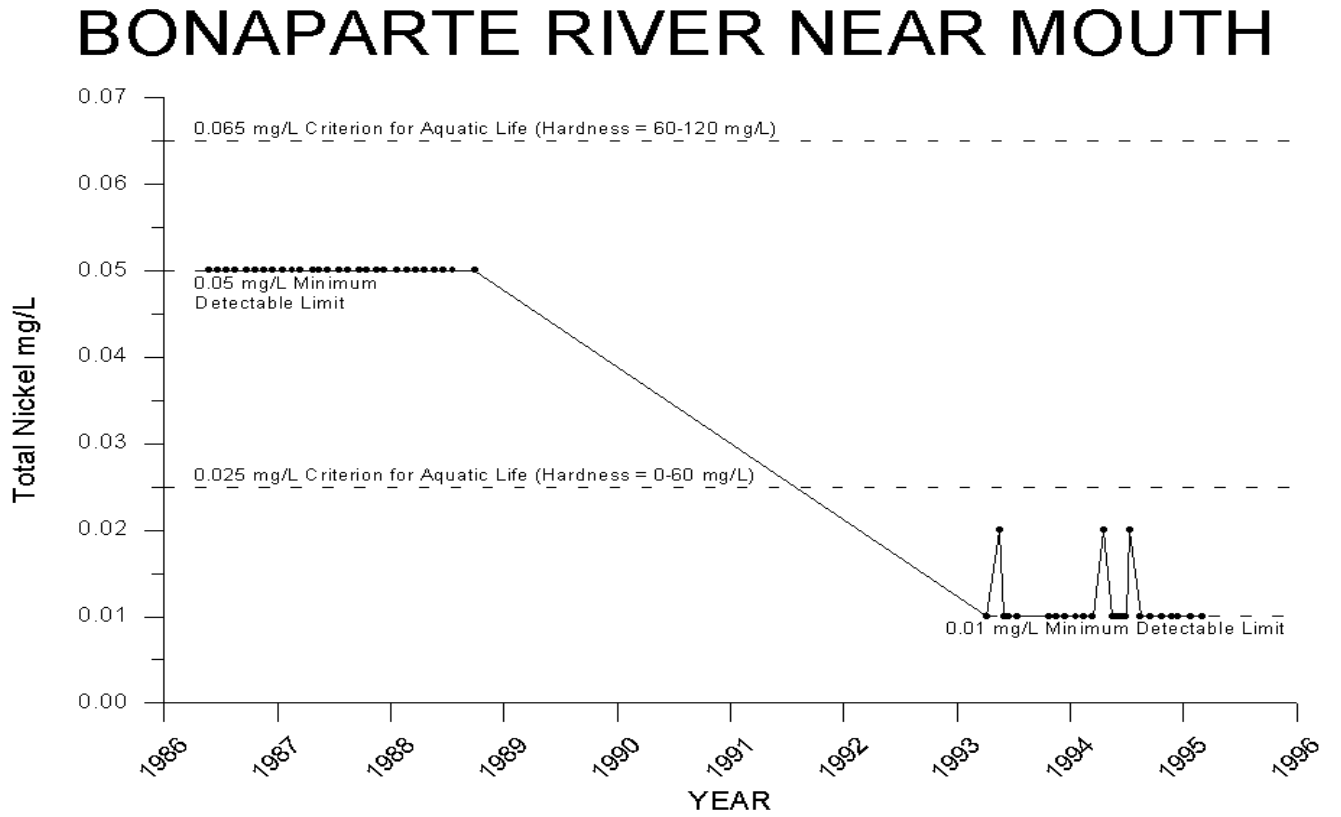


Figure 27 Nitrogen (Ammonia)

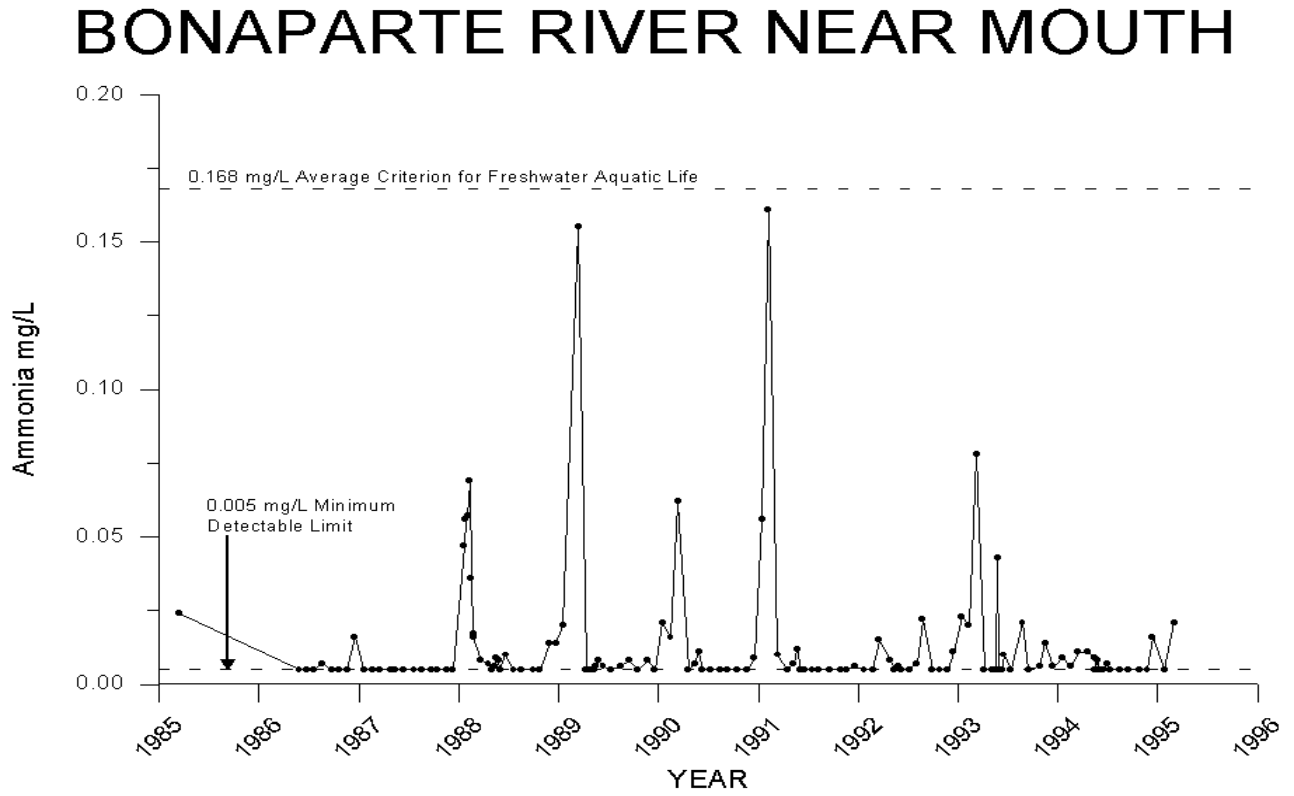


Figure 28 Nitrogen (Kjeldahl)

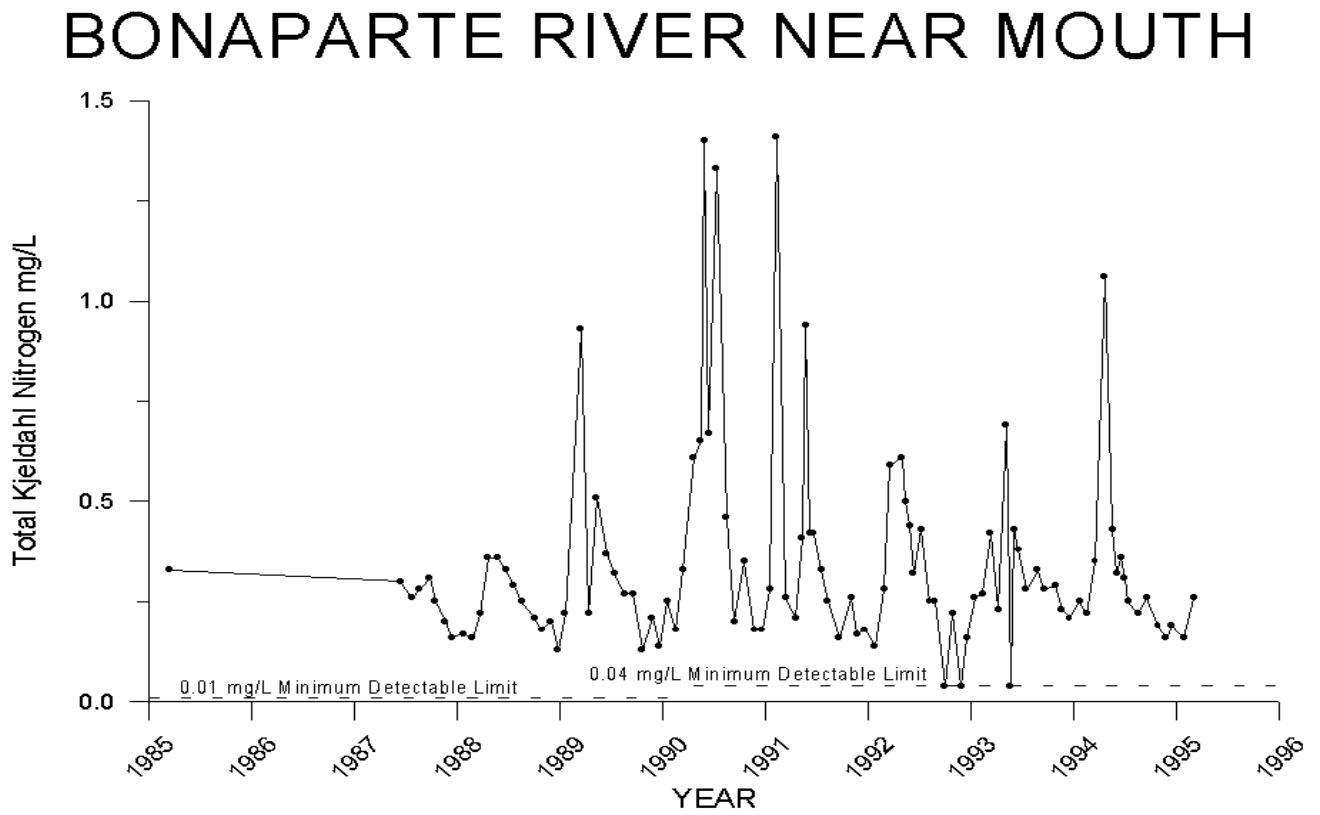


Figure 29 Nitrogen (Nitrate/Nitrite)

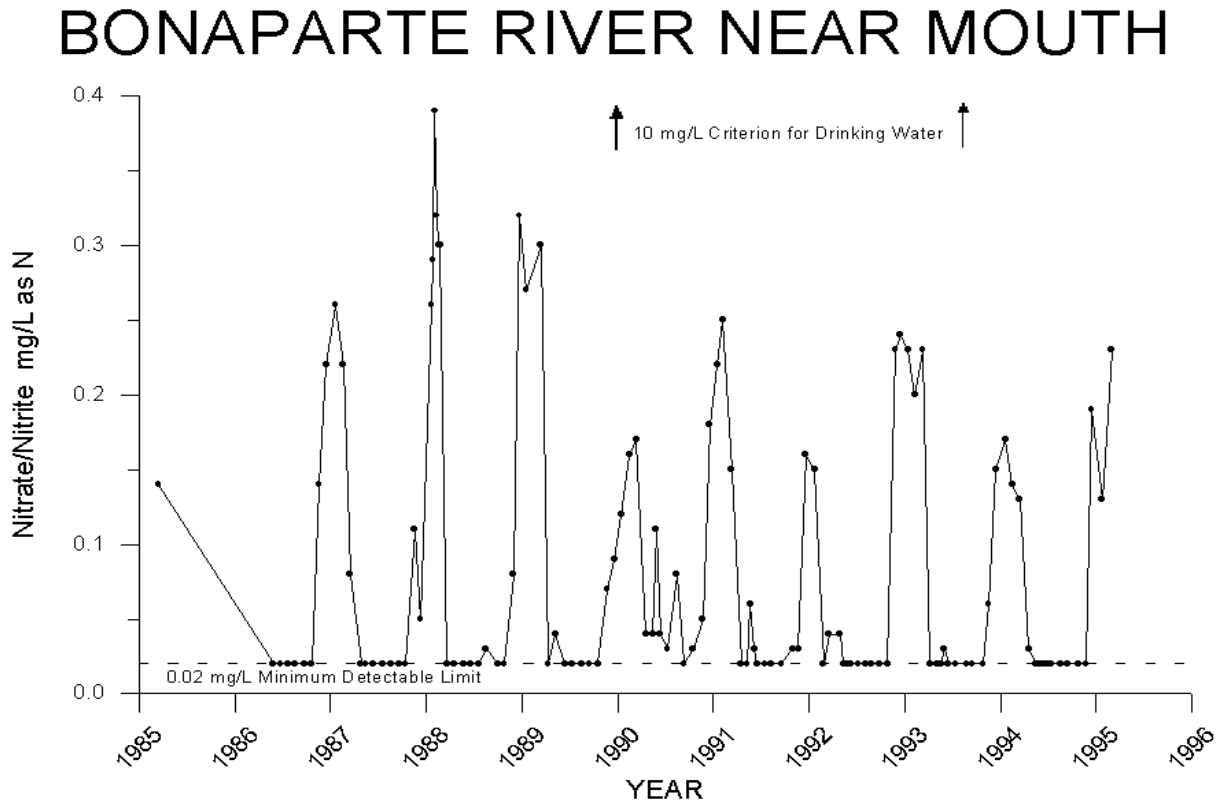


Figure 30 pH

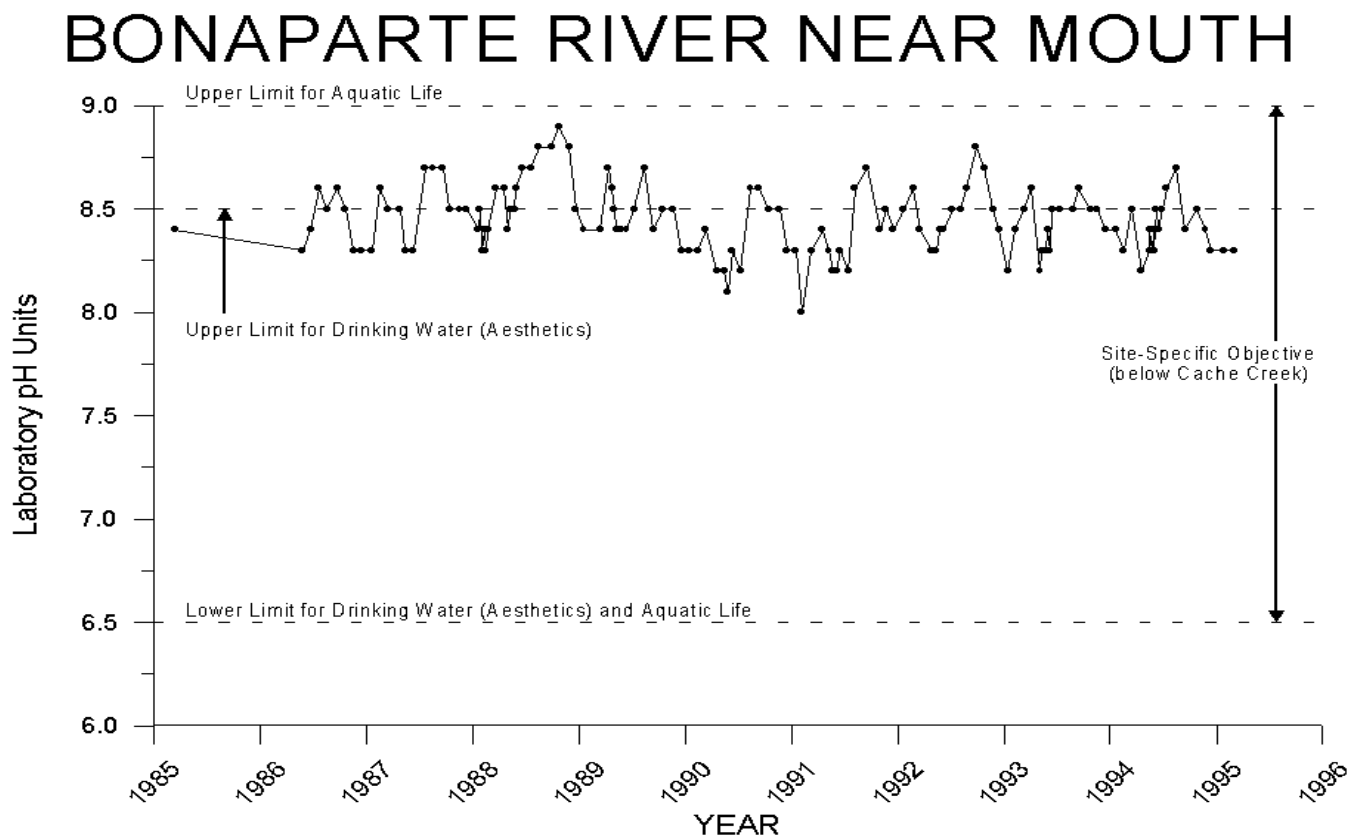


Figure 31 Total Phosphorus

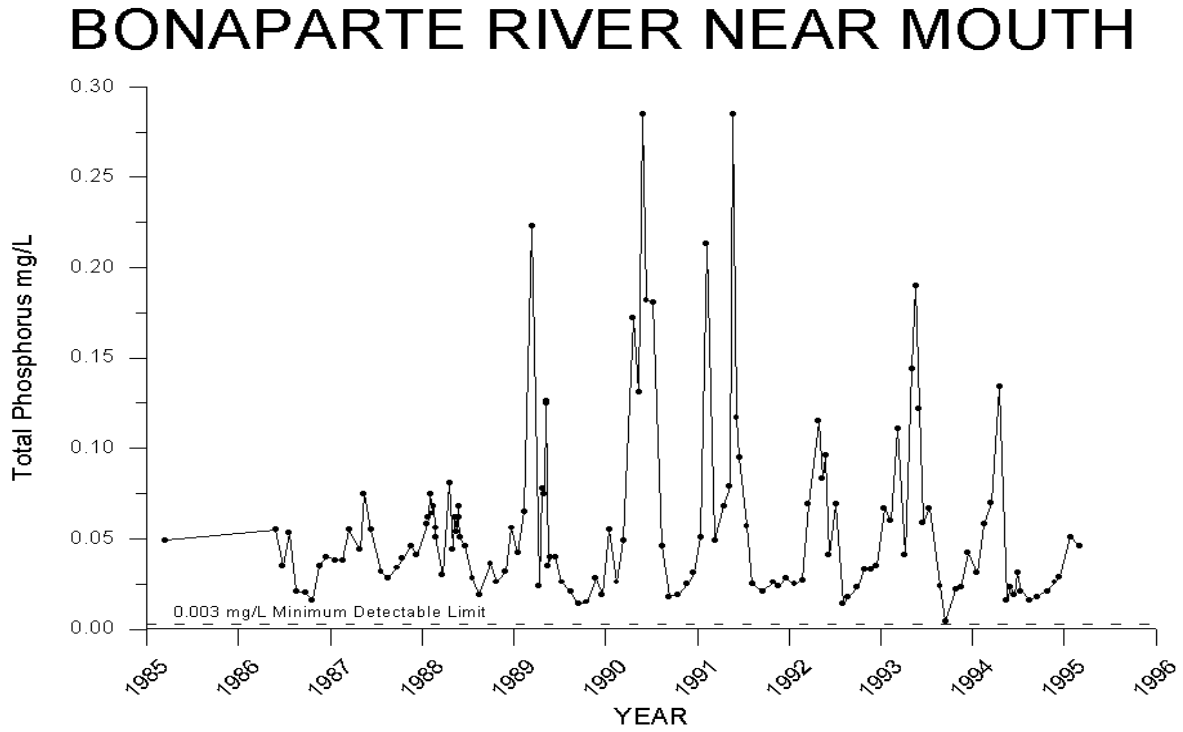


Figure 33 Dissolved Ortho-phosphorus

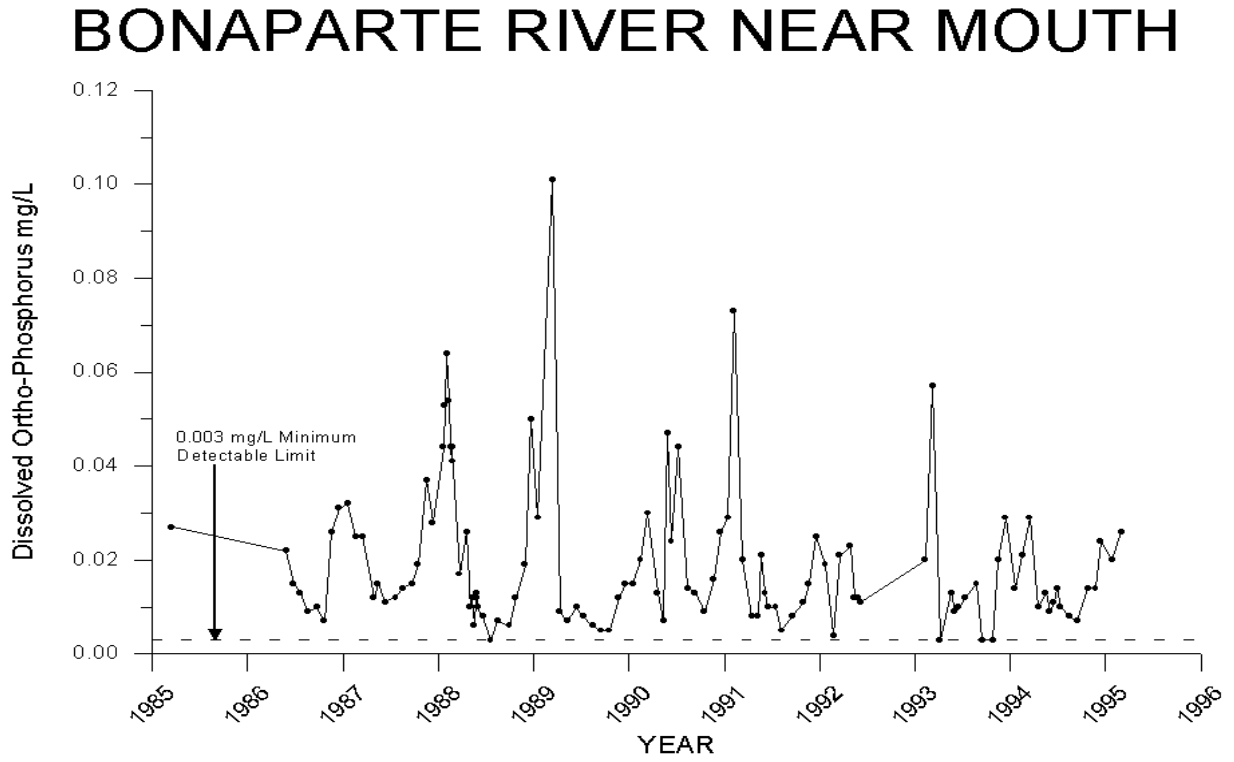


Figure 34 Non-Filterable Residue

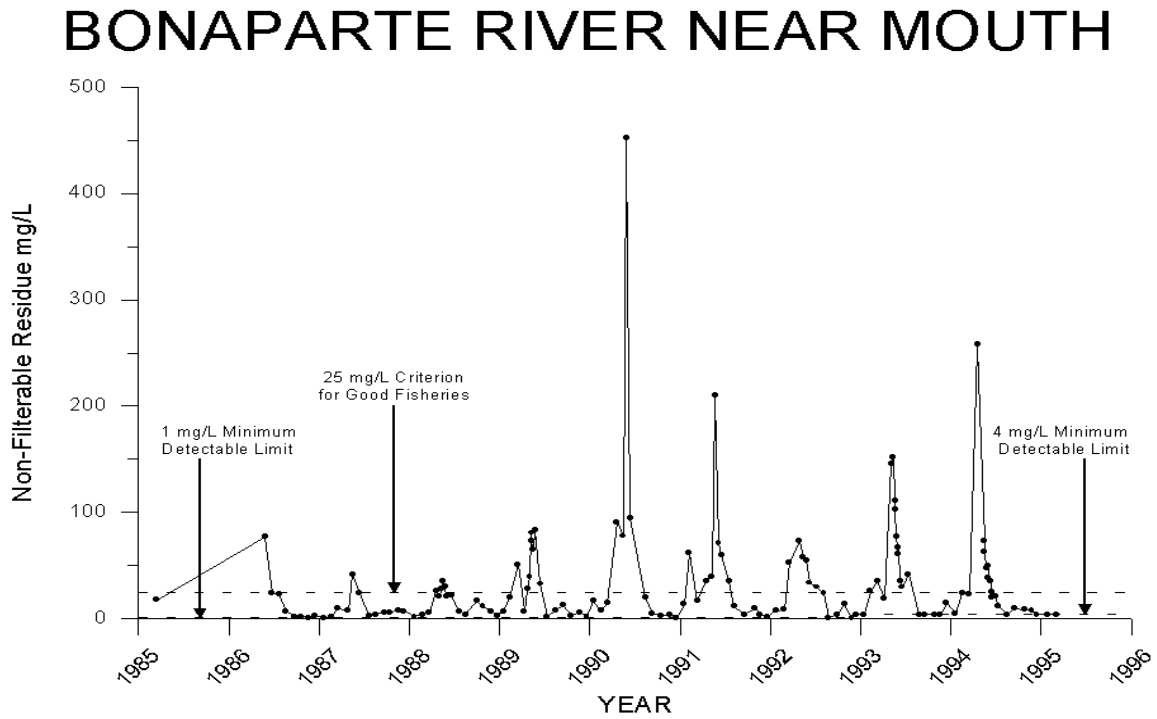


Figure 35 Total Selenium

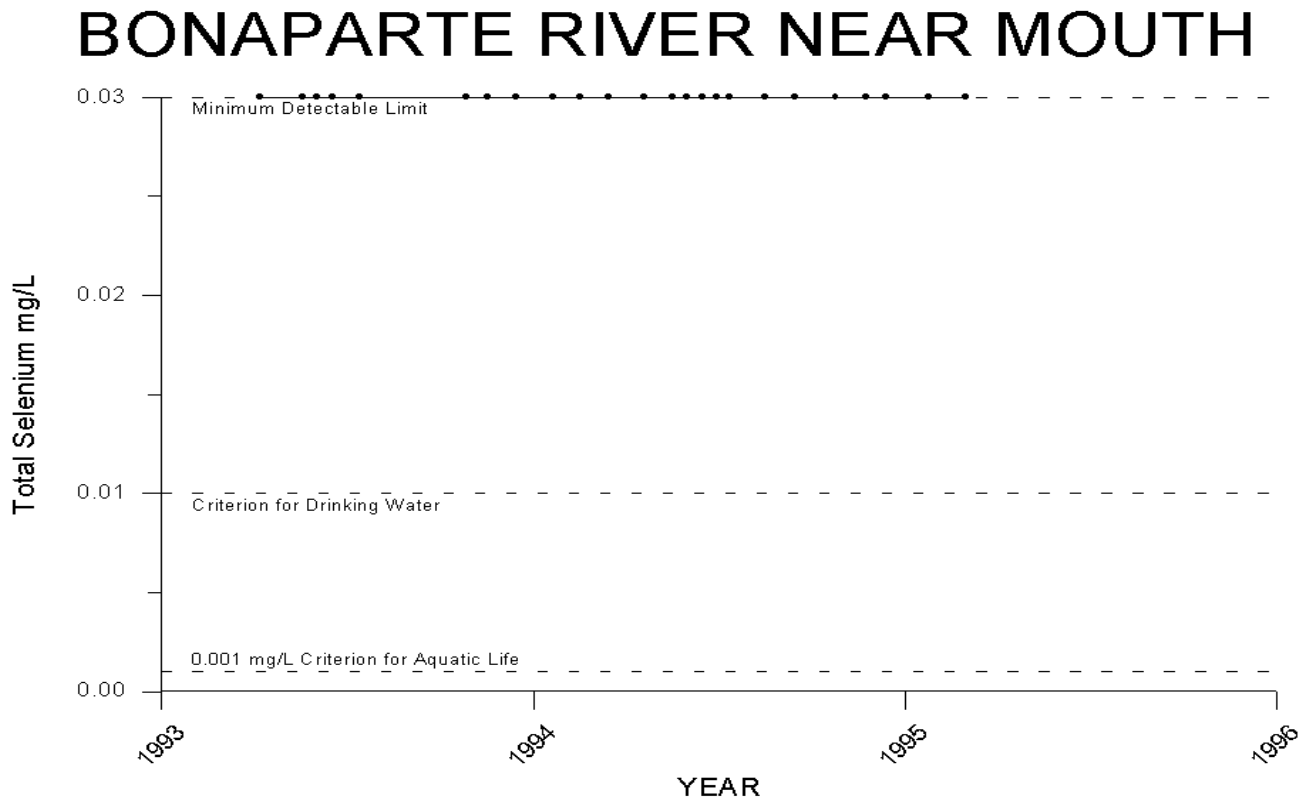


Figure 36 Silica

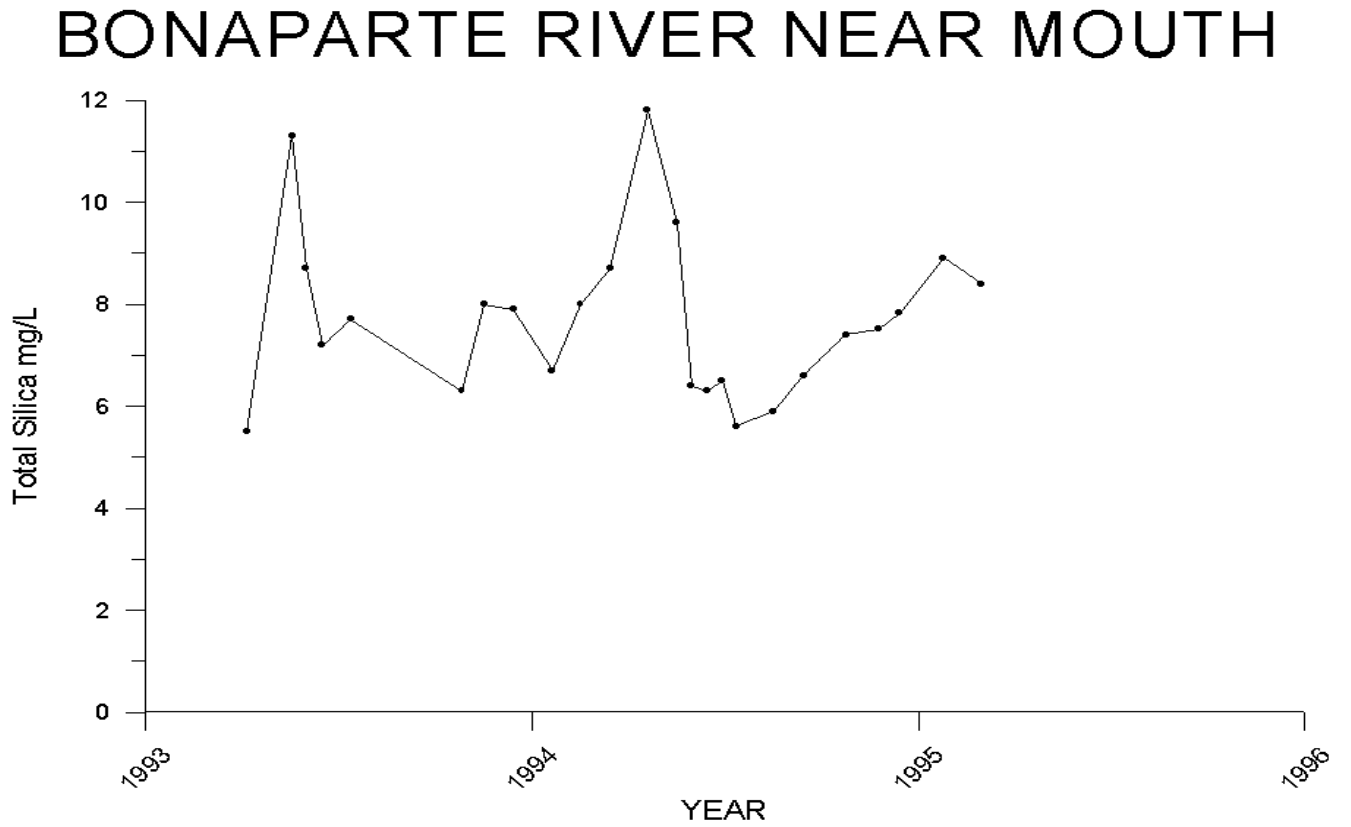


Figure 38 Specific Conductivity

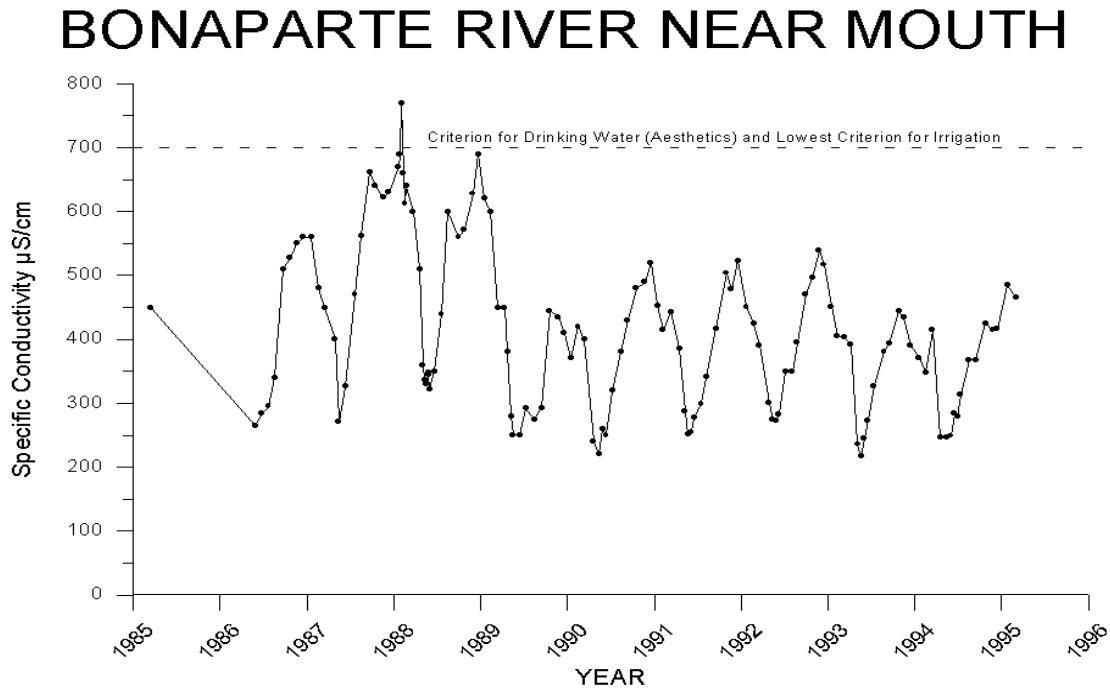


Figure 39 Total Strontium

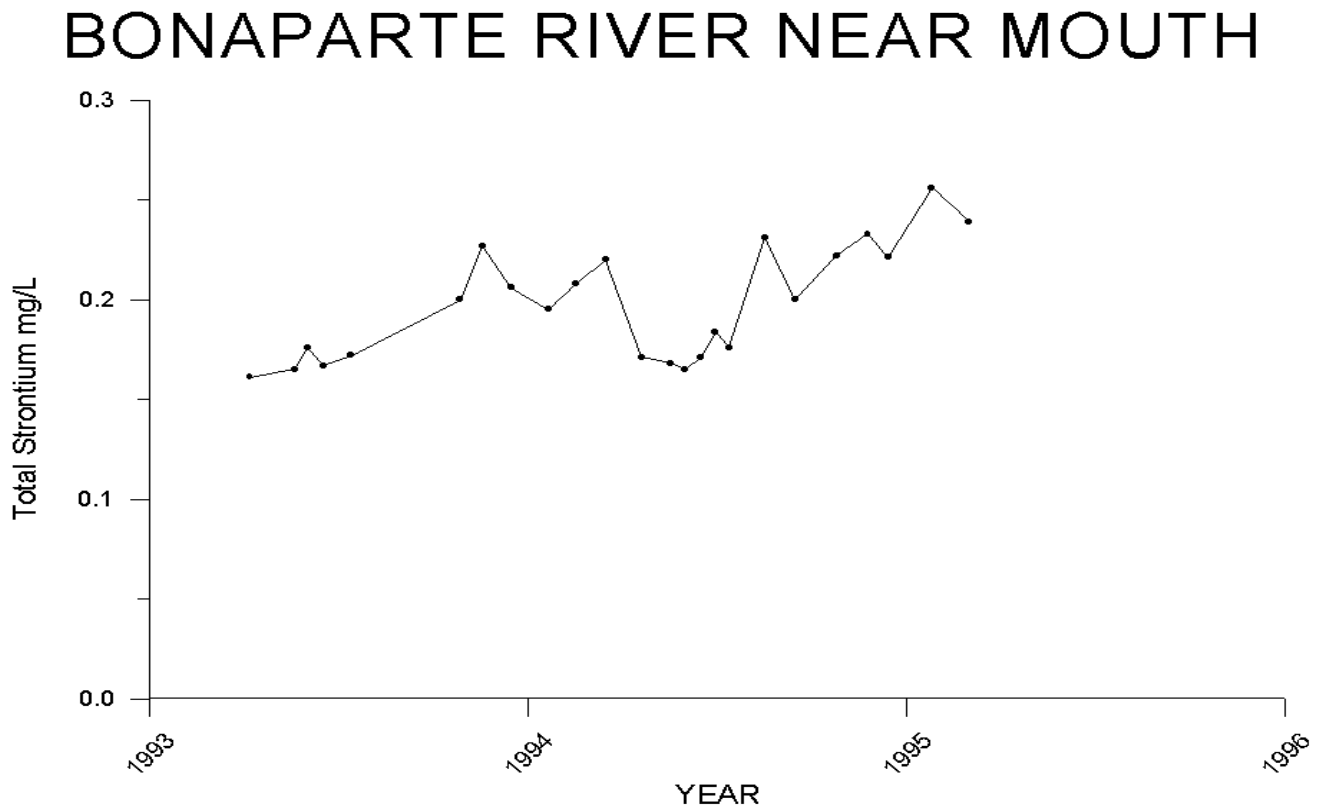


Figure 40 Dissolved Sulphate



BONAPARTE RIVER NEAR MOUTH

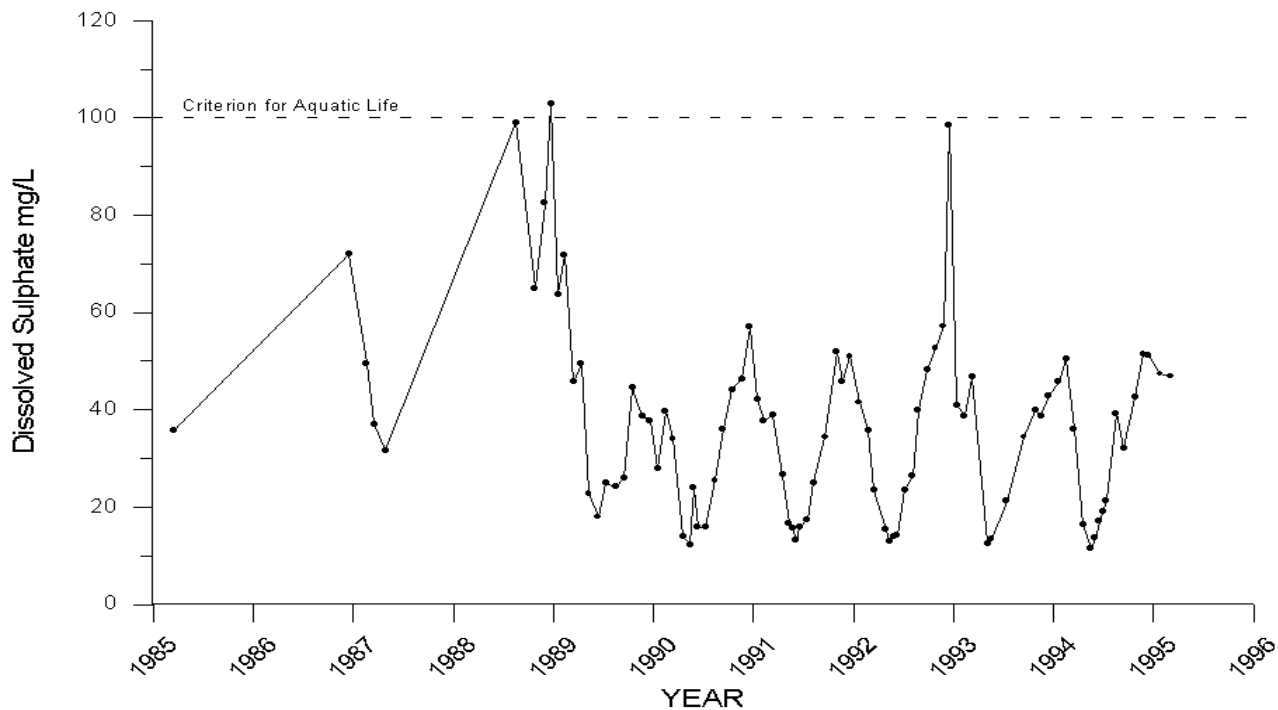


Figure 42 Total Thallium

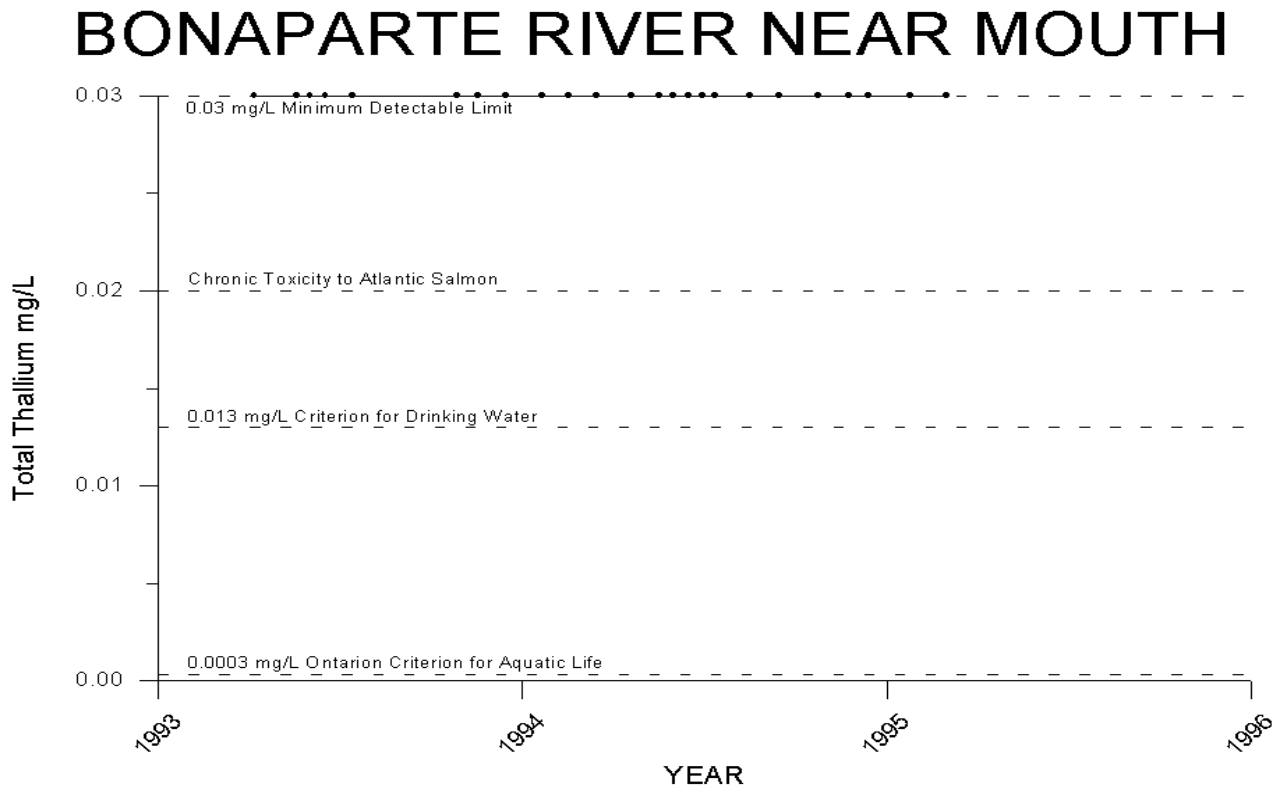


Figure 44 Total Titanium

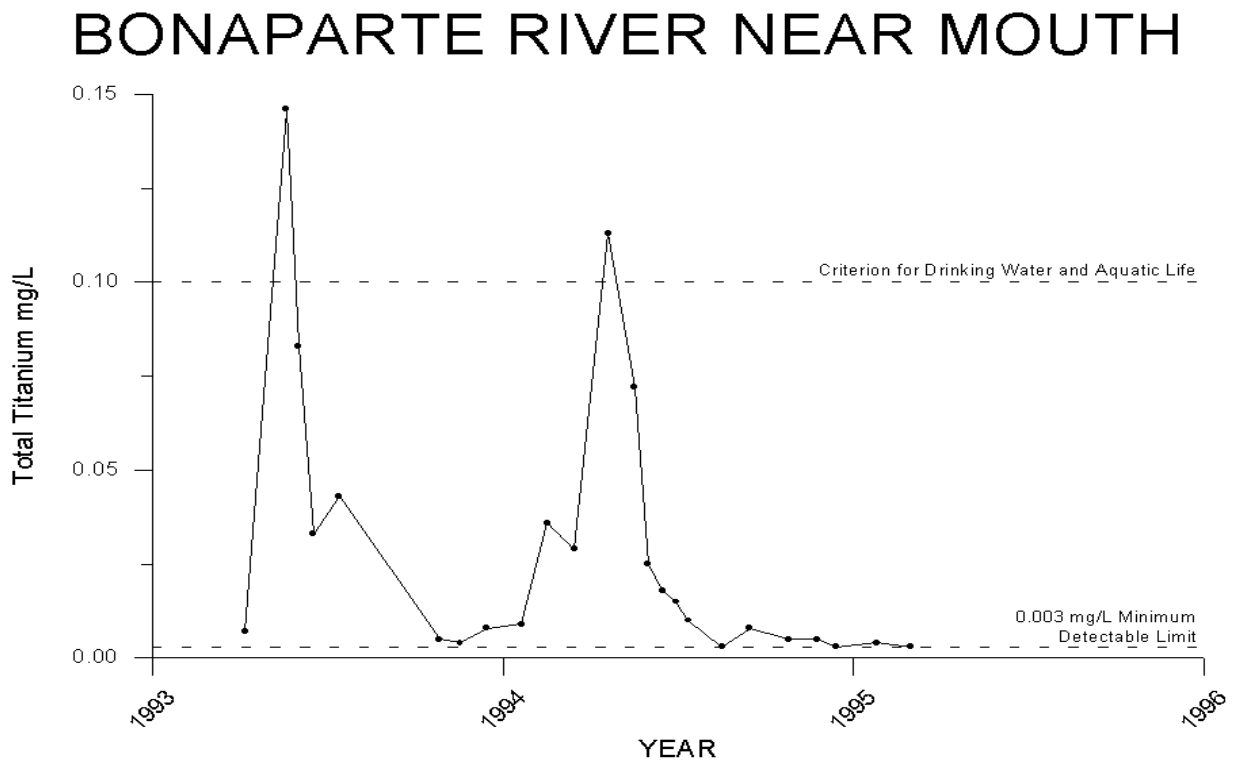


Figure 45 Turbidity

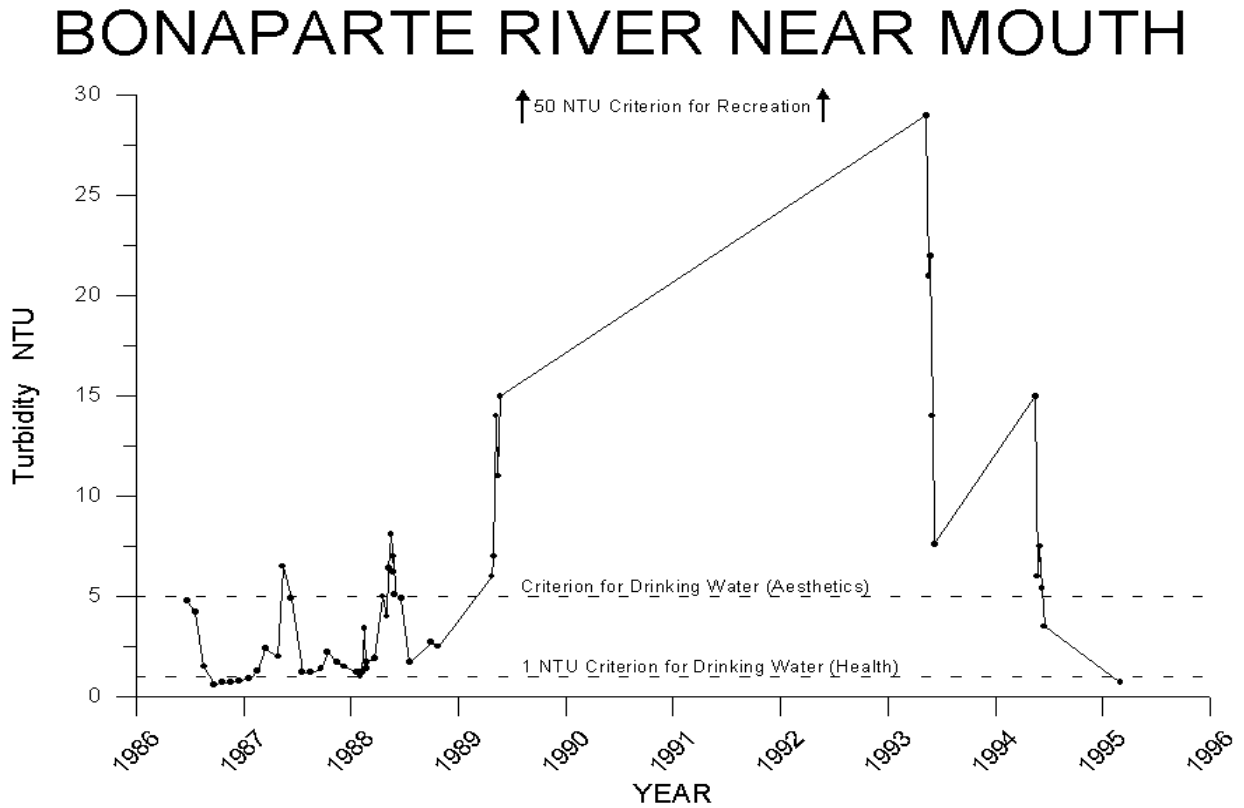


Figure 46 Total Vanadium

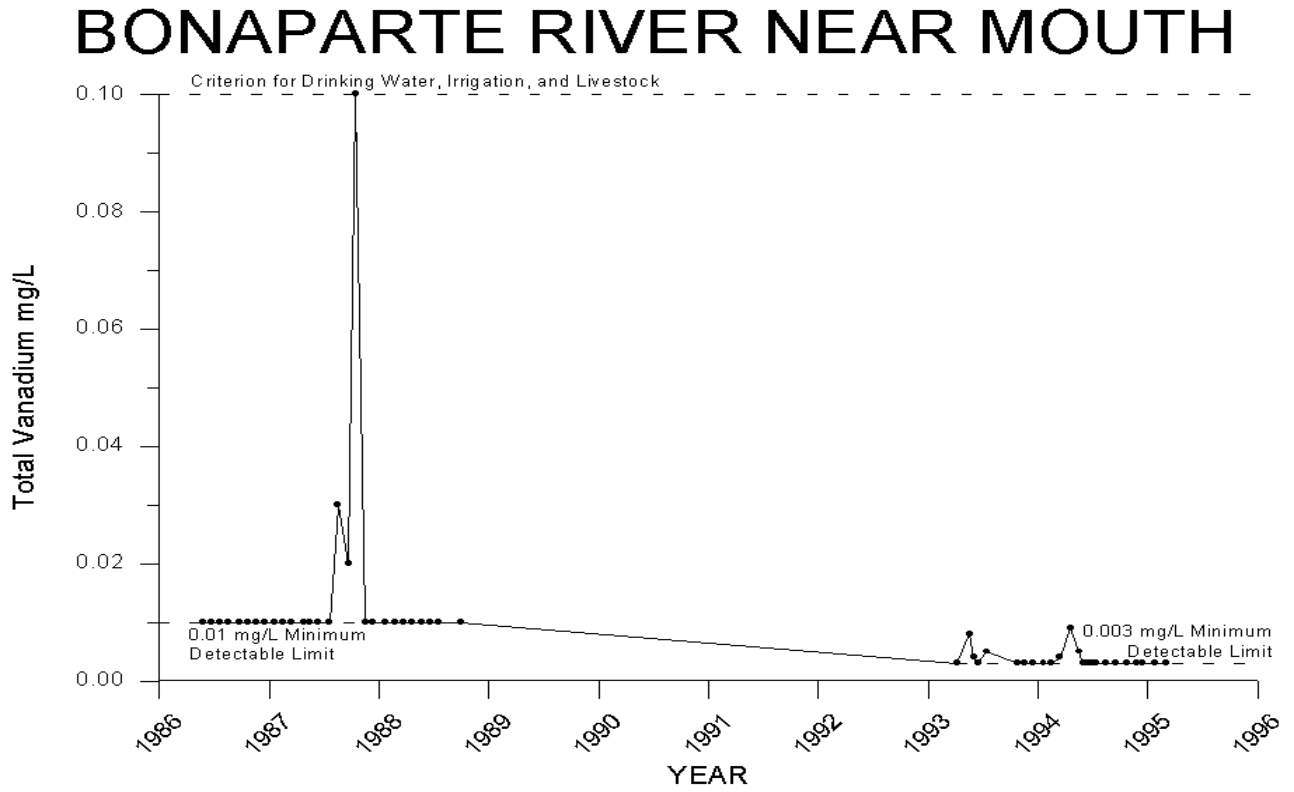
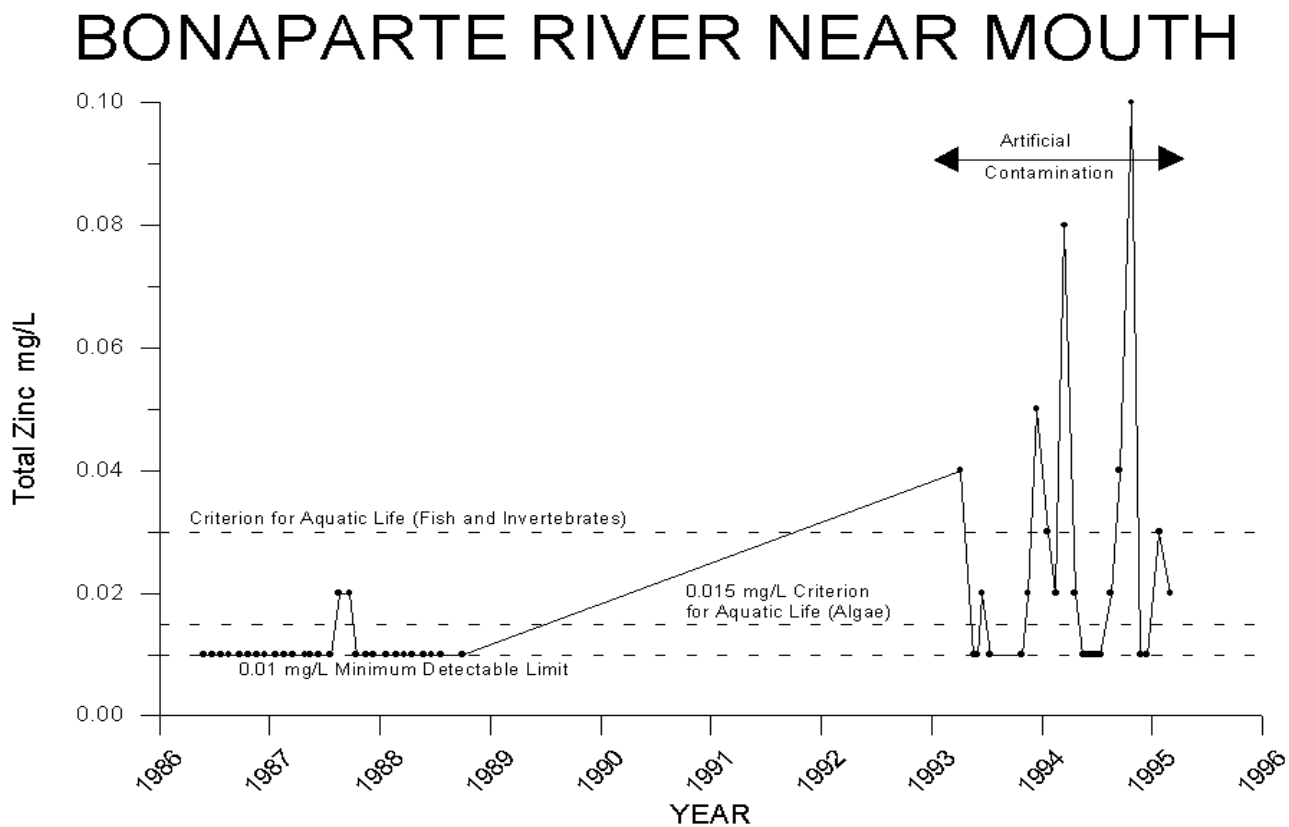


Figure 47 Total Zinc



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