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ASSESSMENT OF WATER QUALITY DATA COLLECTION FOR THE KETTLE RIVER, BRITISH COLUMBIA

A.C.THORP
MARCH 1987

Inland Waters and Lands
Pacific and Yukon Region
Vancouver, B.C.

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ABSTRACT

This study at three crossings of the Kettle River over the southern boundary of British Columbia was initiated to determine:

(1) if low frequency and irregular sampling provides data which adequately represents the water quality and

(2) whether the data gathered by present practices are sufficient to support decisions regarding issues of national interest.

The results of low frequency sample collections and irregular intervals between collections are compared with data from weekly collections. Low frequency, irregular sampling is described to be adequate only where the sample concentration shows no significant variability or where its analytical result is consistently below detection.

RESUME

Le présent rapport décrit une étude de la qualité de l'eau de la rivière Kettle, qui a été menée aux trois points où la rivière traverse la frontière sud de la Colombie-Britannique. L'étude avait pour but de déterminer si un échantillonnage à intervalles espacés et irréguliers peut fournir des données représentatives sur la qualité de l'eau, et si les données recueillies présentement sont suffisantes pour appuyer des décisions d'intérêt national concernant l'eau.

Les données provenant d'un échantillonnage à intervalles espacés et irréguliers ont été comparées à celles obtenues de façon hebdomadaire. Il apparaît que l'échantillonnage espacé et irrégulier n'est valable que si une variable donnée ne change pas de façon significative ou si elle est généralement sous la limite de détection.

INTRODUCTION

In 1976, the Water Quality Branch (W.Q.B.), Pacific and Yukon Region, discontinued its routine water quality monitoring program because the practices of collection, preservation, shipping, and analyses of the water samples at that time were inadequate. Single water samples in two litre bottles were being collected from which aliquots were decanted for analyses. Oguss and Erlebach (1975) found that single water samples were not suitable for obtaining reliable data. They concluded that simultaneous, replicate sampling was necessary to determine significant differences in concentrations for specific variables, particularly nutrients. Oguss and Erlebach (1976) showed limitations of single water samples in representing mean water quality. Kleiber and Erlebach (1977) illustrated the effects of decanting aliquots and the errors associated with this practice. Kleiber, Whitfield and Erlebach (1978) evaluated the effects of single water samples on the spatial and temporal variation in nutrient concentrations. Their results also supported the abandonment of the monitoring program.

In 1979, the W.Q.B. reinstated some routine monitoring stations within the region for the purposes of providing data to NAQUADAT, the national data file on water quality. Although there was hesitation about reinstating the program because of previous findings, the need for reliable data to be in NAQUADAT for national interests was recognized. The monitoring program was reinstated but with a particular emphasis on:

(1) improved field systems;
(2) field and laboratory quality control;
(3) replicate sampling;
(4) assessing the adequacy of data;
(5) assessing the suitability of stations.

In 1980 a Multiple Sampler (Environment Canada, 1983) was designed and implemented to simplify the collections while at the same time assuring a better quality control for field operations. The program continues to evolve as more of the technical problems are recognized and overcome.

Water collections for the routine monitoring program were initially done through the cooperation of the Water Resources Branch (W.R.B.). W.R.B. field technicians were instructed to make water collections when they were in the vicinity of a water quality station for hydrometric and/or sediment measurements. This was intended to minimize the additional expense for field operations above those required for the W.R.B. As the W.R.B. already had field technicians throughout the region, it seemed logical to have them make the water collections.

This study was initiated to determine if the water quality data received, through the services of the W.R.B., were representative of the Kettle River at three of the four stations in the study.

STUDY AREA

The Kettle River study area is located in south-central British Columbia (Figure 1). The headwater of the river is a small lake in the Monashee Mountain Range east of Vernon and Lake Okanagan. It flows south and is joined by the West Kettle near Westbridge. At the community of Rock Creek it turns east and parallels highway 3 until crossing into the state of Washington at Midway. The Kettle reenters British Columbia at Carson and travels east about five kilometers where it is joined by the Granby River at Grand Forks. Continuing east, the Kettle flows past the small community of Gilpin before turning south across the border to join the Columbia River. The total length of the Kettle River is about 290 km (Sherwood, 1986) while its combined Canada - U.S. drainage

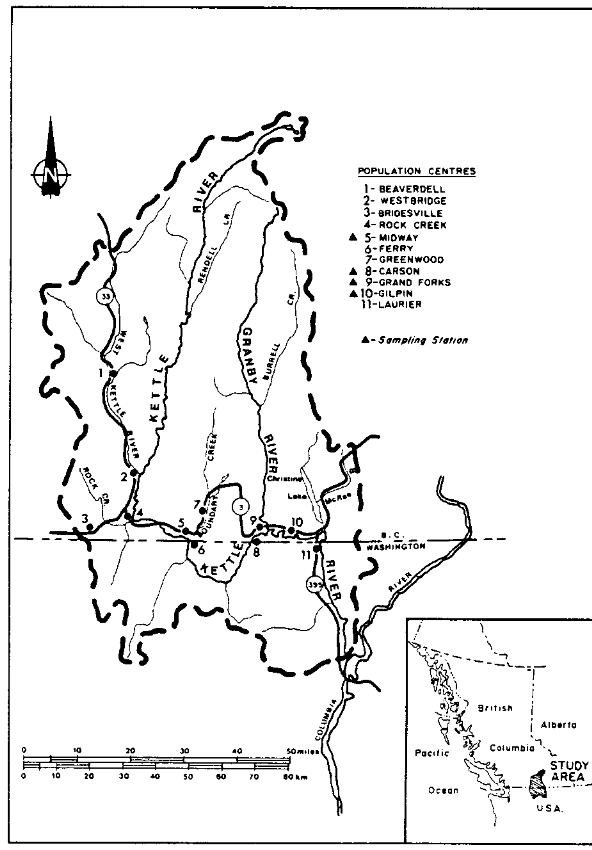

FIGURE 1. Study area showing sampling locations.

basin area covers about 10,000 km2 above the border near Gilpin.

Land use along the river includes mining activities on both sides of the border. Gold extraction using a cyanide leaching process is in operation on the West Kettle at Beaverdell, B.C. and at Vulcan Mountain in Washington. A similar operation is being reestablished on Burrell Creek, a tributary of the Granby River. The Granby River also passes directly by a large slag heap at Grand Forks that remains from a discontinued ore extraction operation. A similar slag heap is located in the community of Greenwood on the banks of Boundary Creek which empties into the Kettle River below Midway.

The major employment in the region is in the lumber industry with large mills located at Midway and Grand Forks and several other smaller operations. Other activities include farming (some with irrigation) and feedlots. Some communities have sewage treatment and disposal associated with the Kettle River. Recreational use includes swimming, canoeing, kayaking and fishing.

METHODS

Data were collected from monitoring stations on the Kettle River (Figure 1) at:
(1) Midway, 00BC08NN0011;
(2) Carson, 00BC08NN0021;
(3) Gilpin, 00BC08NN0022
plus the Granby River at:
(4) Grand Forks, 00BC08NN0026

International hydrometric gauging stations are situated on the Kettle River at Ferry, Wa., below Midway and at Laurier, Wa., downstream from Gilpin. The W.R.B. also has a manual, hydrometric level gauge at the sampling station on the Granby River located at Barbara Ann Park in Grand Forks. Daily water levels are recorded by a lay observer from which discharge data are calculated.

The daily mean discharge (Figure 2) varied for the three hydrometric stations. The discharge for the Kettle River at Ferry is considered to be equal to that at Midway. The Laurier discharge is taken to be equal to that at Gilpin.

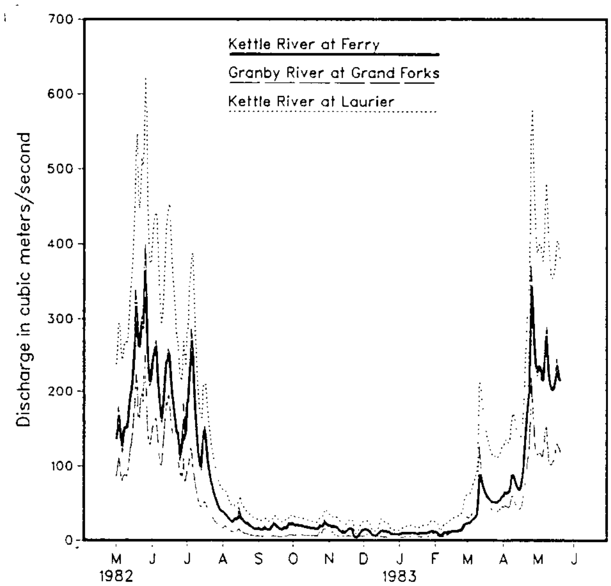

FIGURE 2. Daily mean discharge.

Five sampling trips were taken to the Grand Forks area beginning during the freshet in 1982 and ending during the freshet of 1983. The trips were approximately equally spaced to reflect the seasonal discharge and climate conditions. These sampling periods were:

May	3 - 6, 1982;
August	17 - 20, 1982;
November	23 - 26, 1982;
February	21 - 24, 1983;
May	17 - 19, 1983.

During each trip the stations at Carson and Gilpin on the Kettle

River and the Granby River were sampled every four hours for 72 hours to check for short term variability. The Midway station was not included in the 72 hour studies but instead a lay collector was contracted to sample on a weekly frequency throughout the study. The Midway station was included in this study because it was a monitoring station that was previously being sampled by the W.R.B. This allowed fixed, higher frequency collections at Midway to be compared with irregular, low frequency collections. During the study the W.R.B. made six collections at Midway, four at Carson and three at Gilpin.

All samples were collected using the W.Q.B. multiple sampler. This sampler is designed to hold thirteen bottles of various sizes. Different styles of bottles were used according to the variable being measured. Glass Pyrex bottles were used for samples to be analyzed for phosphorus, teflon bottles for mercury analyses and polyethylene bottles for all other analyses. All bottles were laboratory cleaned. Triplicate samples were collected for phosphorus and nitrogen species from which a mean value was calculated and recorded. Samples for metals and cyanide were preserved in the field according to approved methods (Environment Canada 1979).

Water collections are simplified through the use of the multiple s mpler to assure that all samples are collected in the same manner. Consistent procedures for collections and laboratory handling of samples and for providing supplies to the lay collectors have proven beneficial. Most lay collectors are not scientifically minded so are not expected to perform tasks which require the expertise and precision of a trained professional.

RESULTS AND DISCUSSION

The analytical results are not included in this report but are available upon request. Some variables such as manganese, lead and zinc showed little variation in concentration. Others such as cadmium, mercury, copper, arsenic and selenium had concentrations that were usually below or near analytical detection levels. These and other variables could be sampled at a low frequency like that used by the W.R.B. and may be representative of the Kettle River system.

Generally, variable concentrations in the Kettle River increase from Midway to their highest at Carson. The Granby River causes a dilution in the Kettle River resulting in a decrease of concentrations observed at Gilpin.

Several variables demonstrate concentrations correlated with discharge. Because this group of variables shows similar correlation, only a select few were used for comparative purposes. Total alkalinity (Figure 3A) shows its highest concentrations during periods of low flow including times of ice cover while the lowest concentrations are associated with freshet.

Alkalinity concentrations from the 72 hour studies are easily discernable in their five groupings but most evident for the Granby River. The concentrations for the Granby River are lower than those found at the Kettle River sites.

With few or no collections taken between the study trips at the Gilpin, Carson and Granby River stations, an accurate assessment of the behavior of the variable concentrations cannot be made for these times. Weekly collections at Midway show a fluctuating concentration pattern for alkalinity (Figure 3A) that is believed to be more typical of the system.

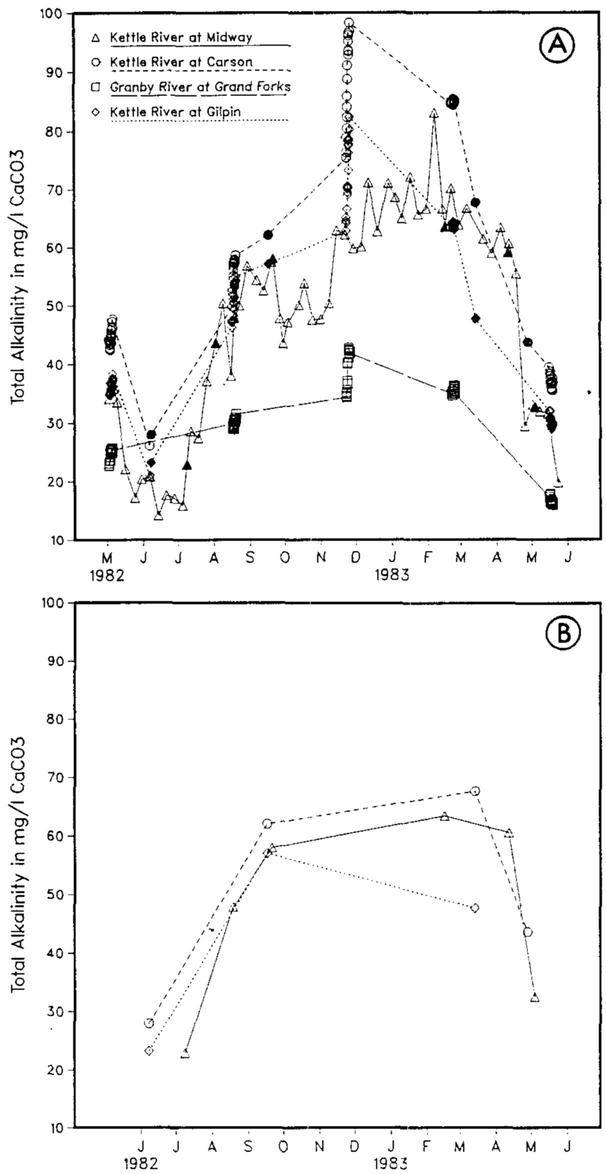

FIGURE 3. (A) Total alkalinity concentrations for the Kettle and Granby Rivers. W.R.B. collections are shaded. (B) W.R.B. collections only. Points are joined chronologically.

The frequency of collections by the W.R.B. (Figure 3B) leaves large gaps between the collection dates. The W.R.B. collections at Midway fit well with the more intensive pattern in figure 3A. Generally, the W.R.B. collections (Figure 3B) support the results obtained for figure 3A but are of limited value when examined alone. The low frequency collections do not display the pattern of fluctuation as for the Midway station (Figure 3A) nor do they reflect the seasonal pattern. Although some W.R.B. collections were made during freshet, a single sample taken at each station during this period is of limited value. The peaks of freshet were not sampled, nor was the period of low discharge between October and February. Thus the pattern shown in figure 3B does not reflect that shown in figure 3A.

Short term variation (ie. within the 72 hour sampling periods) was found to be largest in November. At the beginning of the November trip open channels existed at the Carson and Granby sites but were frozen over by the end of this period. The Gilpin site is turbulent and remained open during this time but there was an increase in the amount of submerged anchor ice. Rapid changes in variable concentrations during freeze-up have been observed elsewhere (Whitfield and McNaughton, 1986). Alkalinity (Figure 3A) best illustrates the occurrence of the short term variability in November. This demonstrates the existance of short term variation for most river systems. The alkalinity results from the November period also show that high frequency weekly collections, as for Midway, are not sufficient to observe this phenomenon for certain variables although some shifts are evident. Although the Midway lay collections reflect the fluctuation attributable to short term variation, concentrations may have varied between the collection times. Similarly, the four hour collection frequency during the 72 hour period could also have missed some extremes.

The February trip displayed the least short term variation. The alkalinity results are tightly grouped for each station (Figure 3A). Other related variables such as specific conductivity, hardness and calcium also showed a similar variation to that for alkalinity.

Dissolved sulphate (Figure 4A) displayed a greater range in concentration than alkalinity for short term variation during each trip. The patterns for sulphate concentration variability are similar at the four stations. Likewise, the distribution of data for sulphate collected by the W.R.B. (Figure 4B) is similar to that of their data for alkalinity (Figure 3B). The same limitations apply to the W.R.B. sulphate data as for alkalinity.

Phosphorus tends to display concentrations greatly affected by discharge and suspended sediments (Kleiber and Erlebach, 1977). For this reason, triplicate samples are collected during the routine monitoring program. From these three values a mean is calculated. Mean total phosphorus displays its highest concentrations during periods of high discharge (Oguss and Erlebach, 1975).

The results for the present study (Figure 5A) are no exception as the highest phosphorus concentrations occur during highest discharge periods. Greater variation in the short term is also more evident during freshet than during periods of low flow. The Kettle River at Midway best illustrates this with large fluctuations during the freshet of 1982 and 1983 and more stable, low concentrations between these times (Figure 5A).

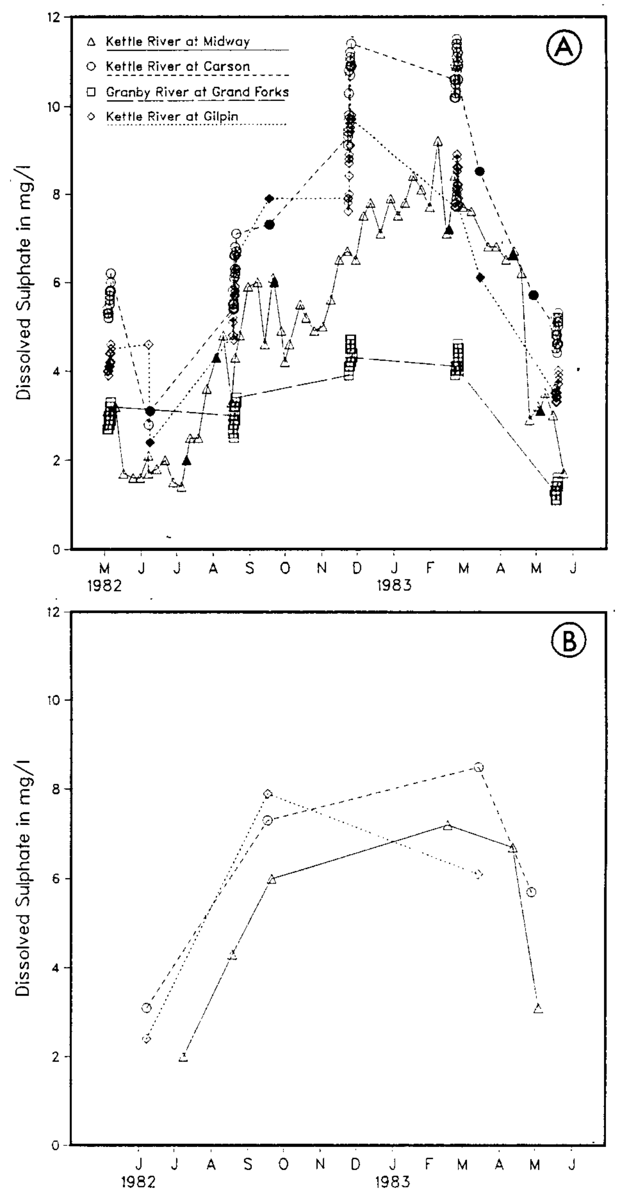

FIGURE 4. (A) Dissolved sulphate concentrations for the Kettle and Granby Rivers. W.R.B. collections are shaded. (B) W.R.B. collections only. Points are joined chronologically.

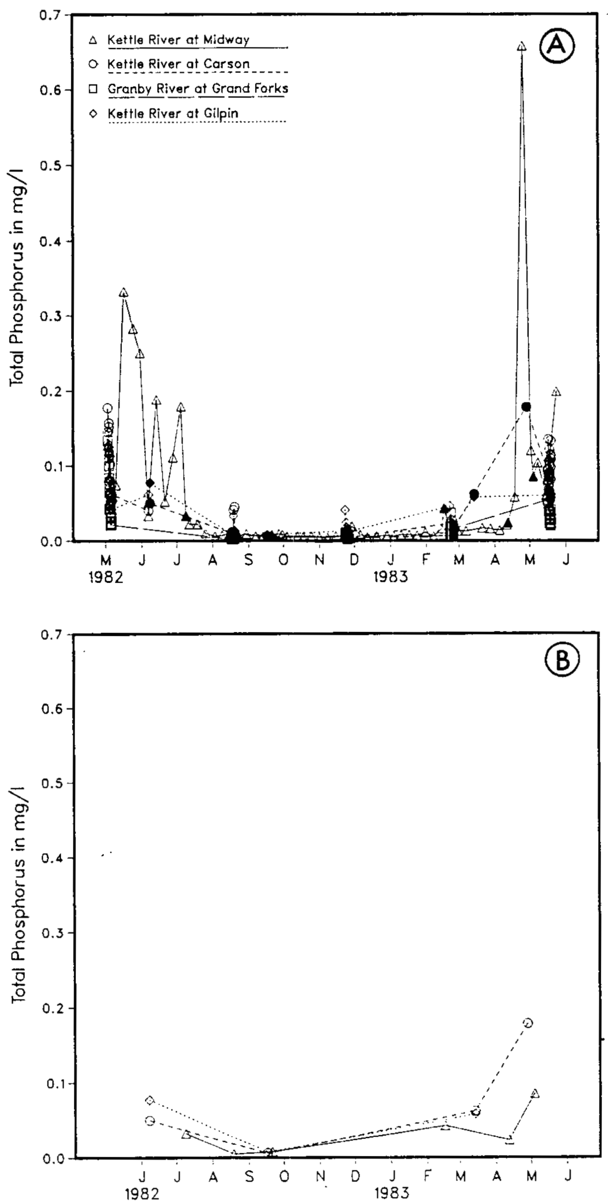

FIGURE 5. (A) Total phosphorus mean concentrations for the Kettle and Granby Rivers. W.R.B. collections are shaded. (B) W.R.B. collections only. Points are joined chronologically.

A high value for phosphorus at Midway on April 25, 1983 during freshet was first suspected of being an outlier. A review of the triplicate analyses for this date revealed results of 0.645, 0.665 and 0.665 mg/l (reported mean is 0.658 mg/l). A peak discharge at Midway, the second highest for the month, also occurred on April 25.

Collections by the W.R.B. for phosphorus (Figure 5B) show concentrations at Midway much different than those collected by the lay collector. The W.R.B. did not make collections during the 1982 freshet until it was almost over and the two collections during 1983 freshet missed the times of peak flows. Low frequency collections for phosphorus are of limited value because of the likelyhood of missing significant peaks.

Dissolved nitrate-nitrite (Figure 6A) was also collected in triplicate. Nitrate-nitrite results from Midway show much variation between collection dates, especially the low flow period from November to March. An increase in concentration was observed during ice formation in November. This increase could be attributed to particles attached to drifting ice and slush which may have been picked up during sampling. The river at Midway did not completely freeze over this winter as small holes and channels opening and closing were reported by the lay collector. Near the beginning of December, when the river had almost frozen over, a depression in concentration occurred. This depression was similar to that reported for other variables (Whitfield and McNaughton, 1986). Much variation in concentration occurred over the winter and may reflect the changing ice conditions. These events were

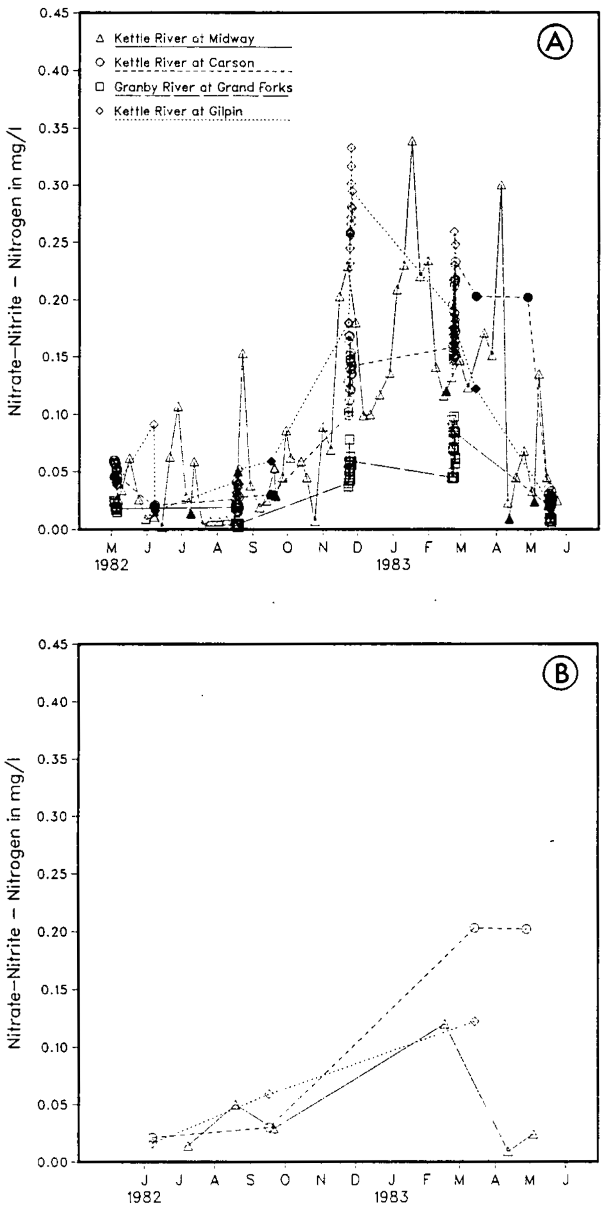

FIGURE 6. (A) Nitrate-nitrite mean concentrations for the Kettle and Granby Rivers. W.R.B. collections are shaded. (B) W.R.B. collections only. Points are joined chronologically.

completely missed by the W.R.B. collections (Figure 6B).

Generally, most W.R.B. field personnel have responded well to making water quality collections. This addition to their routine workload has, for some, created extra logistic problems. Their sample collections are infrequent and only at specific locations which has resulted in a tendency to unintentionally forget to include water sampling equipment for certain trips. Some have reported that their workload has not allowed sufficient time to obtain the samples. W.R.B. regional sub-office staff changes have also caused the discontinuation of water sampling and resulted in gaps in the data. There has also been occasional mercury contamination in W.R.B. collections which is likely associated with the use of mercury in their recording manometers.

Since the study period ended in 1983, collections by the W.R.B. at Midway, Carson and Gilpin have been discontinued. The lay collector at Midway has been retained but at a reduced biweekly frequency. Another lay collector has been contracted at Grand Forks to make collections at the Carson and Gilpin stations on a biweekly frequency. The contracting and training of local residents for water collections best supports the Water Quality Branch requirement for collecting these data. Many lay collectors, of retirement age, are able to supplement their income while doing a conscientious and dependable job. Local concerns in the Grand Forks area about mining activities involving cyanide leaching for gold extraction was identified through a lay collector and led to the inclusion of samples for cyanide analyses being collected at Carson and Gilpin.

CONCLUSION

Low frequency sampling is suitable for the collection of variables demonstrating little or no variation. In the Kettle River system these variables include manganese, lead, zinc, cadmium, mercury, copper, arsenic and selenium. Other variables such as alkalinity, sulphate, phosphorus and nitrogen require more frequent sampling because of their correlation with discharge. Due to the infrequent collections by the W.R.B., the data received for certain variables describe their concentrations in the system only at the time the collections were made. No inference can be made about the period between collections and an accurate assessment of variable concentrations cannot be made using low frequency collections. These data also do not provide for analysis such as trend assessment (Whitfield, 1983). Data from low frequency collections also should not be used as a sole source of information for impact assessments nor for decisions involving more than one jurisdiction.

Ideally, information should be obtained through pilot studies to establish the priority concerns upon which a long term monitoring program can be focused. This could limit the number of variables required to be monitored, reducing the laboratory analytical work load and being more cost effective during the surveillance period. Objectives for variable concentration levels could also be formulated through the input of pilot studies. Unfortunately, due to funding and time committments, a pilot study may not be done before a new station is implemented. If a pilot study is not feasible then a data review should be done after a specific collection period to be able to make recommendations for changes to the surveillance. This, however, assesses only the variables already being monitored and has the risk of missing additional variables which could be of concern.

To be more confident of the pattern for short term temporal variation, data is required to be collected at a higher frequency and for a longer period than was done for the present 72 hour studies. A pattern of short term variability, depending upon the variable and location, might be repeated after an unpredictable period. The cost to manually collect samples for this period at a frequency greater than every four hours may be formidable but electronic surveillance could provide information at much less expense. Various technologies are available for monitoring every 15 minutes as reported for pH measurements (Dalley, 1987). Similar high intensity data collections may be established over a short period for other variables.

RECOMMENDATIONS

1. A minimum frequency for routine sample collections should be dependent upon the requirement for the variables of concern.

2. Lay collectors within the Pacific and Yukon Region, should be contracted for fixed frequency sampling wherever feasible.

3. Lay collections should remain simplified to avoid unnecessary complications and to maintain a high standard for field quality control.

4. W.R.B. personnel within the Pacific and Yukon Region should do W.Q. sampling only where lay collectors are not available with the understanding that these data are of

limited value or where such data is desired.

5. Suitability of stations should be evaluated before implementing a station for long term monitoring.

6. Existing data should be reviewed periodically and possible program changes assessed.

7. Electronic surveillance should be used to assess short term temporal variation for some variables wherever feasible.

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