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# Inland Waters Directorate
# Western and Northern Region

# Direction générale des eaux intérieures
# Région de l'ouest et du nord



Canada

# An Assessment of the Banff Sewage Lagoon and its Effects on the Bow River during February 1988

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**Abstract**

Water quality studies were undertaken in February 1988 to assess the performance of the Banff sewage lagoon and its effects on the Bow River. The study found that the sewage treatment plant generally delivered an effluent of good bacteriological quality; better than in previous years. At the time of the study, the effluent was found to have little impact on the bacteriological quality of the Bow River near the Park Boundary. The effluent was shown however to have a significant impact on the concentrations of nutrients, phosphorous in particular, in the Bow River. Significant diurnal variations in the quality of the Bow River near the Park Boundary were shown to be present and related to releases of water from the Cascade Hydroelectric Plant near Banff.

**Résumé**

En février 1988, on a entrepris des études sur la qualité de l'eau en vue d'évaluer l'efficacité du bassin de stabilisation des eaux usées et ses effets sur la rivière Bow. L'étude a révélé que les effluents de la station d'épuration des eaux usées étaient de bonne qualité du point de vue bactériologique, qualité supérieure à celle observée au cours d'années antérieures. L'étude a démontré que les effluents avaient alors peu d'incidences sur la qualité bactériologique de l'eau de la rivière Bow près de la limite du parc. Les effluents avaient cependant une forte incidence sur les concentrations d'éléments nutritifs (en particulier du phosphore) dans la rivière Bow. On a également observé qu'il y avait des variations diurnes importantes de la qualité de l'eau de la rivière près de la limite du parc et que ces variations étaient liées aux décharges d'eau de la centrale hydroélectrique Cascade près de Banff.

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## 1.0 Introduction

During recent years there have been several complaints about the quality of the Bow River below Banff. Reports of 'sludge', 'human waste', and 'odour' in the Bow River below Banff have been publicized. The operating capacity of the Banff sewage treatment plant has been exceeded and at times the plant has malfunctioned. While major renovations of the sewage treatment plant are planned, they will not be complete until the fall of 1989. As an interim measure, alterations were made to the Banff sewage treatment plant during the fall of 1987. These alterations seemed to improve the performance but the degree of improvement was difficult to assess because the changes were made at a time when there was a declining number of visitors to the Park.

Because of the winter Olympics, a record number visitors were expected in the Park during February 1988. This was expected to cause a high rate of loading to the Lagoon. Accordingly, this time was chosen to assess the quality of the effluent from the Banff lagoon and its effects on the Bow River. If a malfunction at the treatment plant was evident, perhaps it could be corrected prior to the busy summer season.

This report presents and discusses the results and findings of the February study and compares these results to supporting data from the study area.

This study was undertaken as a joint project by the Environmental Protection Directorate and the Water Quality Branch of the Conservation and Protection Service, together with Warden Service, Banff National Park.

## 2.0 Study Objectives:

a) To assess the impact of the Banff sewage effluent on the quality of the Bow River.

b) To assess the performance of the Banff sewage treatment plant during a period when the loading to the lagoon would be high.

c) To assess the diurnal variability in the quality of the effluent from the Banff sewage lagoon and in the waters of the Bow River near the Park Boundary.

## 3.0 Sampling program

The following three sites were selected for sampling during the study period of February 8 to March 3, 1988. Most samples were collected by Warden Service, Banff National Park.

Site #1: Bow River above Banff lagoon (00AL05BD0002)
Site #2: Effluent from Banff lagoon (21AL05BB0001)
Site #3: Bow River near Park Boundary (left bank - 00AL05BE0013)

Since during the design of the study, it was thought that bacteriological data would provide the most useful information to address the study objectives, the study emphasized bacteriological work. Accordingly, samples for bacteriological analyses were collected daily at each of the above sites during the entire study period. This work was augmented with sampling for physical parameters and nutrients. During the period February 10 to February 26, samples were collected daily at site #3 (Bow River near Park Boundary). Sites #1 (Bow River above Banff Lagoon) and #2 (Effluent from Banff Lagoon) were sampled February 10, daily during the period February 15 to 19, and on March 3.

Additional samples were collected to assess the precision of the study results and the diurnal variability in the quality at each site. Details on this work are presented later.

## 4. Analytical Program

Samples for bacteriological parameters were analysed in the mobile laboratory of Environmental Protection, which during the study period was located in Banff. Laboratory analyses included the following:

- total coliforms (T. Coli)
- fecal coliforms (F. Coli)
- fecal streptococci (F. Strep)
- standard plate count (Std P Count)

Samples for nutrients and physical parameters were analysed at the Water Quality Branch laboratory in Saskatoon for the following parameters:

- Phosphorous - total (P-total)
- Phosphorous - total dissolved (P-total diss)
- Phosphorous - particulate (P-part) [calc'd]
- Nitrogen - dissolved (DN)
- Nitrogen - particulate (PN)
- Nitrogen - total (TN) (calc'd)
- Nitrogen - Nitrate + Nitrite (NO3+NO2)
- Ammonia - total (NH3-total)
- Carbon - particulate organic (POC)
- Carbon - dissolved organic (DOC)
- Carbon - total organic (TOC) [calc'd]
- Sp. Conductance (Sp. Cond.)
- Turbidity (turb.)
- Colour - true (colour-t)
- Nonfilterable Residue (NFR)
- pH

The analytical methods for these parameters are described in the methods manual of the Water Quality Branch (Water Quality Branch, 1979).

Effluent samples were analyzed for residual chlorine by Parks Canada staff at the Banff sewage treatment plant.

## 5. Results and Discussion

### 5.1 General

The analytical results from the study are summarized in Table 1 and are appended (Appendix A). The results are discussed by parameter group.

#### 5.1.1 Bacteriological Parameters

As is evident in Table 1, the bacteriological counts at all sites were quite low during the study period and for both site #2 (Effluent from Banff Lagoon) and site #3 (Bow River near Park Boundary) were lower than anticipated given the heavy loading to the Lagoon. In the effluent, total coliform counts were below the analytical detection limit of 10 organisms per DL[1] in 26 of 51 samples while fecal coliforms were below the analytical detection limit in nearly all (50 of 51) samples (mean value of <10). Fecal Streptococci bacteria were usually present in measurable but low concentrations with typical values ranging from 50 to 500 per DL (mean value of 251 per DL). From this it is evident that the chlorination of the effluent is effectively reducing the bacterial counts. This is being done while maintaining the average residual chlorine levels under 1.0 mg/L (Appendix A).

With bacteriological counts in the effluent being this low, it is not surprising that the effluent did not have a large effect on the bacteriological quality of the Bow River. At site #1 (Bow River above Banff Lagoon) the mean total coliform count was 7.6 per DL while at site #3 (Bow River near the Park Boundary) the mean count was only 5.5 per DL. Mean fecal coliform counts at both sites were L1 (less than 1) per DL while the corresponding counts for fecal streptococci were 1.7 and 3.1 per DL respectively (Table 1).

To put the study results in perspective, a review of supporting data is warranted. Supporting data is available from the Water Quality Branch which has monitored the quality of the Bow River near the Park Boundary on a regular (monthly) basis since 1978. These results, together with the study data are presented as Figures 1 to 3.

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[1]. 1 DL = 100 mL

Reference to Figures 1 to 3 indicates that during the study period, the bacteriological quality of the Bow River near the Park Boundary was not typical of previous years; it was noticeably better. In fact it has, since the fall of 1987, been better than in previous years. This is especially true for both total coliforms for which typical values have dropped from 50 to 5000 per DL to less than 10 per DL (Figure 1) and fecal coliforms which have dropped from typical values of about 5 to 500 per DL to less than 2 per DL Figure 2). A less pronounced change was evident in fecal streptococci for which typical counts were reduced from 2 to 200 per DL to less than 10 per DL. The improvement is attributed to the changes made to the Banff sewage treatment plant during the fall of 1987.

**Table 1. Summary of Study Results**

**(Mean values for period February 8/88 to March 3/88)**

| Parameter | Site 1 Bow River above Lagoon (00AL05BD0002) | Site 2 Effluent, Banff Lagoon (21AL05BB0001) | Site 3 Bow River near Park Boundary (00AL05BE0013) |
|---|---|---|---|
| Colour-T (Rel. Units) | L5. | 26.7 | L5. |
| Sp. Cond. (usie/cm) | 323. | 692. | 347. |
| Turb. (NTU) | 0.68 | 24.5 | 1.1 |
| TOC | 0.87 | 29.4 | 1.15 |
| DOC | 0.73 | 11.7 | 0.86 |
| POC | 0.14 | 17.7 | 0.29 |
| NO3+NO2 | 0.09 | 0.05 | 0.08 |
| NH3-total | 0.015 | 9.7 | 0.057 |
| TN | 0.15 | 13.9 | 0.21 |
| DN (LF) | 0.14 | 10.9 | 0.17 |
| PN | 0.011 | 3.1 | 0.030 |
| pH | 8.17 | 7.48 | 8.22 |
| NFR | 1.9 | 31.3 | 4.0 |
| P-total diss | L0.003 | 2.9 | 0.016 |
| P-total | L0.003 | 3.5 | 0.025 |
| P-part | 0.003 | 0.59 | 0.009 |
| T-Coliform (no./DL) | 7.6 | 135. | 5.5 |
| F-Coliform (no./DL) | L1. | L10. | L1. |
| Fecal Strep (no./DL) | 1.7 | 251. | 3.1 |
| Std P Count (no./mL) | 11.3 | 5268. | 57.5 |

Results are in mg/L unless otherwise noted. In the calculation of the mean, values below the analytical detection limit (Lx) have been interpreted as x/2. LF indicates that the sample was filtered in the lab. No./DL is number per 100 mL.

**Figure 1 Historical Levels of Total Coliforms in the Bow River Near Banff Park Boundary During February 1988 (no/DL)**

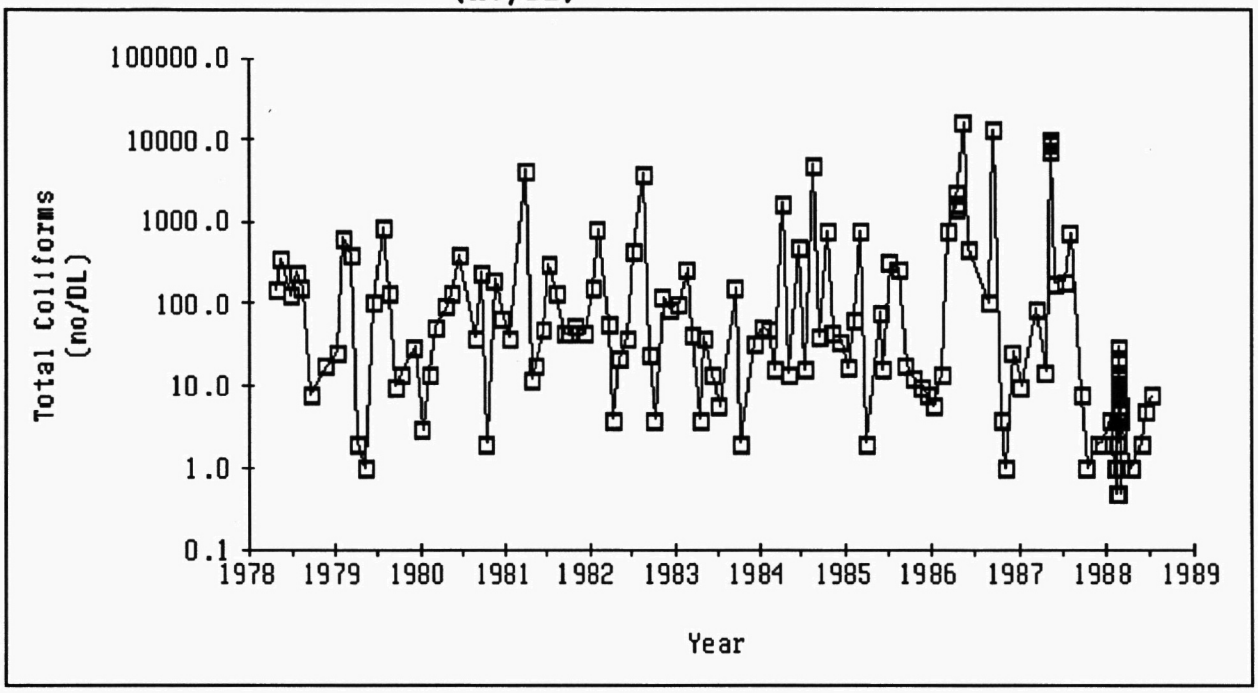



**Figure 2 Historical Levels of Fecal Coliforms in the Bow River near Banff Park Boundary During February 1988 (no/DL)**

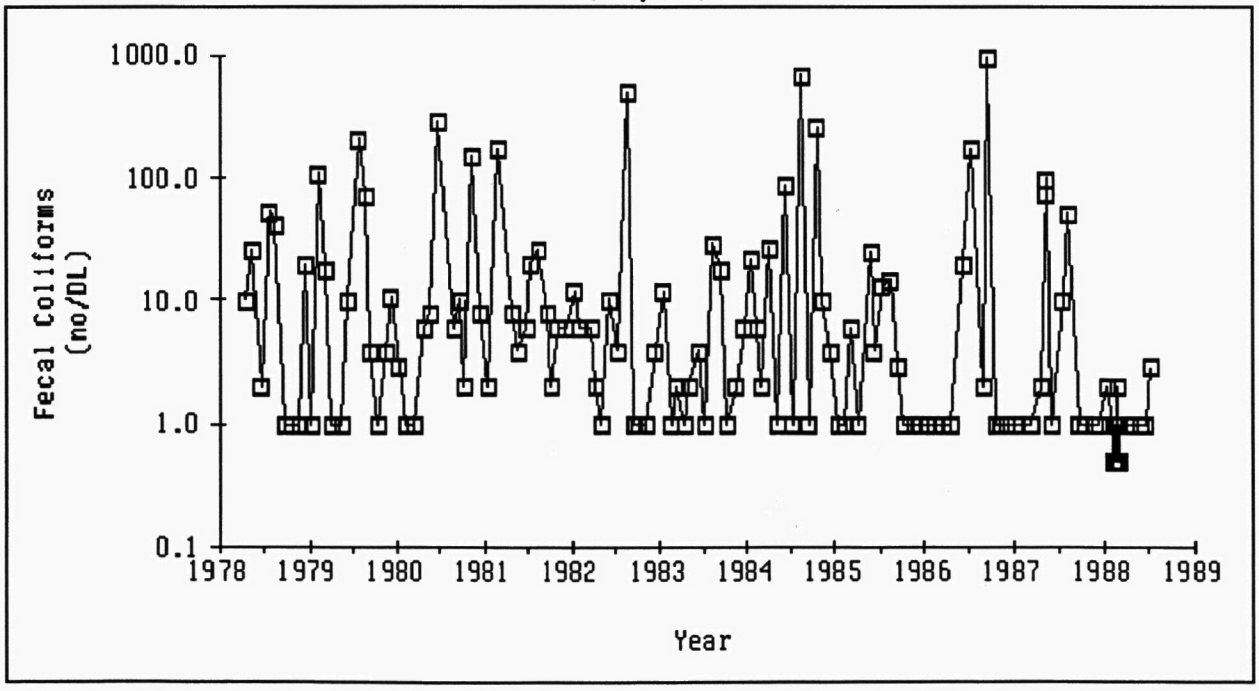
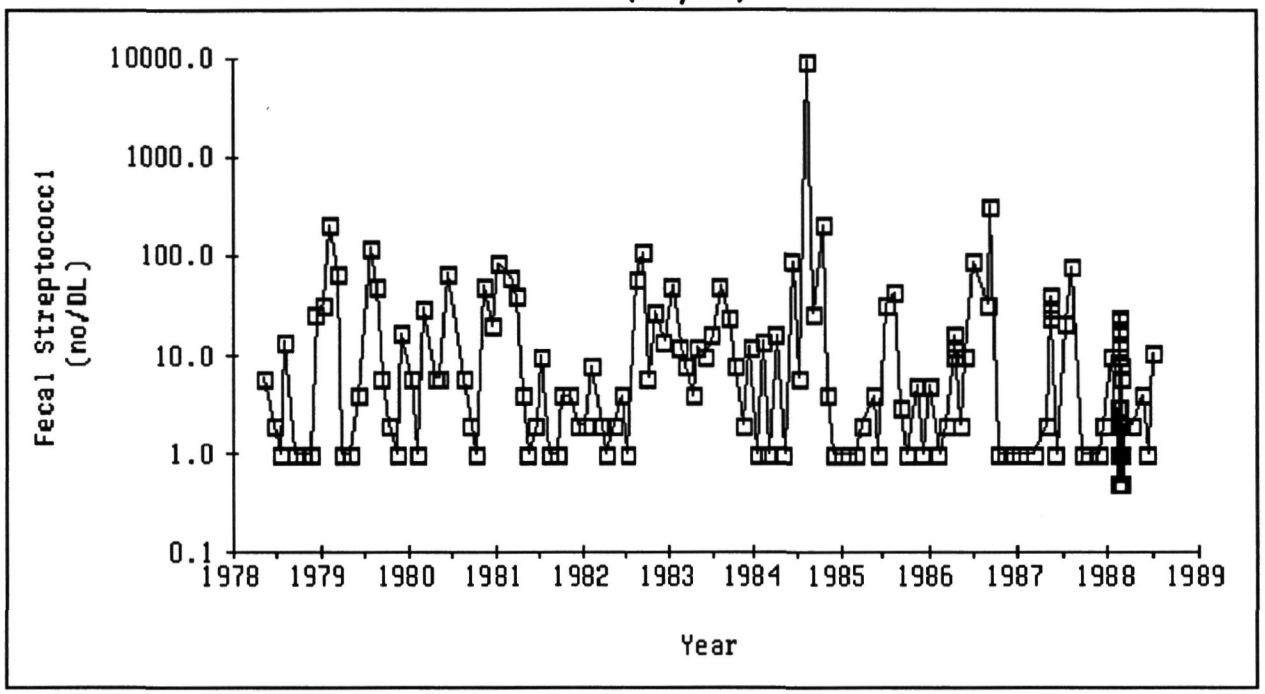


**Figure 3** **Historical Levels of Fecal Streptococci in the Bow River near Banff Park Boundary During February 1988 (no/DL)**




### 5.1.2 Nutrients and Physical Parameters

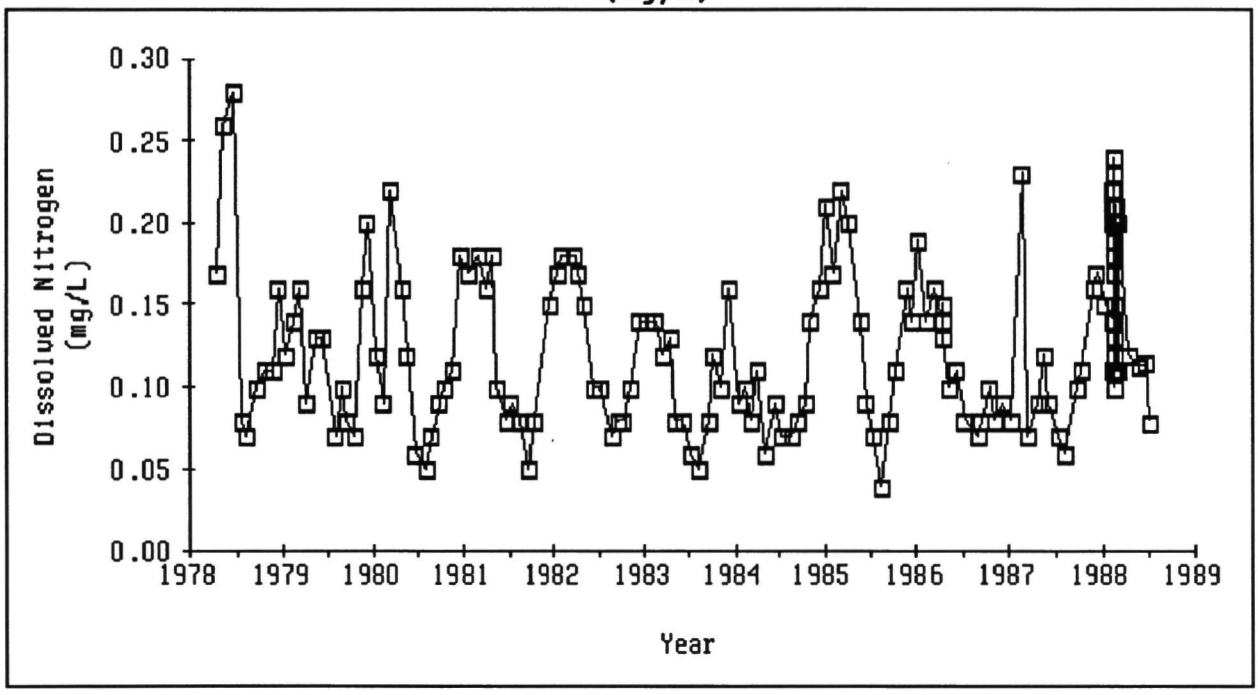
In the case of physical parameters (colour-t, Sp. Cond., turbidity, pH, and NFR) the effluent had very little effect on the quality of the Bow River as concentrations at the downstream site were about the same as they were at the upstream site. (Table 1).

In the case of the nutrients however, the differences were larger and were in all cases significant (paired t-test, $\alpha = 0.05$). Ammonia (total) increased from a background level of 0.015 to 0.057 mg/L (mean values) while particulate nitrogen increased from 0.011 to 0.030 mg/L; an approximate 3 fold increase in each case. Both dissolved nitrogen and total nitrogen experienced an approximate 50% increase with DN being increased from 0.14 to 0.17 mg/L while TN increased from 0.15 to 0.21 mg/L. The largest increases, about 10 fold, were evident in phosphorous compounds. In the Bow River above the Lagoon, both total phosphorous and dissolved phosphorous were present at less than 0.003 mg/L, the analytical detection limit, while near the Park Boundary the corresponding mean values were 0.025 and 0.016 mg/L respectively.

To put the study results for nutrients in perspective, the mean values for the study period can be compared to the historical

levels present at the Park Boundary. As can be seen from the data summary of Table 2, the study results for nutrients and physical parameters are nearly identical to the mean February values of preceding years. This fact is also illustrated graphically in Figure 4 where the results for dissolved nitrogen, typical of the nutrients, is presented.

**Figure 4 Historical Levels of Dissolved Nitrogen in the Bow River near Banff Park Boundary During February 1988 (mg/L)**




## 5.2 Diurnal Variability

The quality of surface waters, like that of an effluent, is not static. The quality is subject not only to changes from year to year and from season to season, but may also be subject to changes within a day. During this study, each of the three sites was examined to determine if significant variations in the quality occurred within a time period of 24 hours.

**Table 2. Historical Summary of Selected Water Quality Parameters for the Bow River near Banff Park Boundary (00AL05BE0013)**

**(Mean Values for the period indicated)**

| | Colour True (Rel. Units) | Specific Cond. (usie/cm) | Turb. (NTU) | TOC | DOC | POC | NO3+NO2 | NH3 | TN total | DN (LF) | PN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | 2.9 | 343.8 | 0.67 | 1.13 | 0.61 | 0.22 | 0.110 | 0.051 | 0.168 | 0.144 | 0.022 |
| Feb | 4.0 | 348.8 | 1.64 | 1.22 | 0.78 | 0.15 | 0.100 | 0.045 | 0.197 | 0.152 | 0.028 |
| Mar | 3.2 | 350.2 | 1.23 | 1.13 | 0.68 | 0.20 | 0.101 | 0.050 | 0.197 | 0.152 | 0.031 |
| Apr | 4.3 | 335.5 | 0.97 | 1.10 | 0.91 | 0.23 | 0.089 | 0.062 | 0.187 | 0.143 | 0.042 |
| May | 4.3 | 280.8 | 4.69 | 3.45 | 1.53 | 1.05 | 0.061 | 0.035 | 0.179 | 0.125 | 0.060 |
| Jun | 6.4 | 213.5 | 10.81 | 2.35 | 1.32 | 1.04 | 0.061 | 0.039 | 0.150 | 0.111 | 0.065 |
| Jul | 3.9 | 217.1 | 3.36 | 1.30 | 0.70 | 0.40 | 0.042 | 0.037 | 0.103 | 0.074 | 0.027 |
| Aug | 5.4 | 236.3 | 2.64 | 0.95 | 0.62 | 0.24 | 0.043 | 0.045 | 0.089 | 0.068 | 0.025 |
| Sep | 3.6 | 250.6 | 1.70 | 0.94 | 0.64 | 0.18 | 0.053 | 0.039 | 0.100 | 0.082 | 0.019 |
| Oct | 3.6 | 284.6 | 0.74 | 0.85 | 0.62 | 0.15 | 0.059 | 0.046 | 0.133 | 0.097 | 0.031 |
| Nov | 4.3 | 315.2 | 0.73 | 1.17 | 0.78 | 0.12 | 0.083 | 0.044 | 0.186 | 0.124 | 0.052 |
| Dec | 3.6 | 331.9 | 0.68 | 0.92 | 0.64 | 0.13 | 0.111 | 0.052 | 0.165 | 0.155 | 0.018 |
| Period of Record | 4.1 | 291.1 | 2.44 | 1.43 | 0.83 | 0.35 | 0.075 | 0.045 | 0.155 | 0.119 | 0.036 |
| Study | 2.5 | 346.6 | 1.08 | 1.15 | 0.86 | 0.29 | 0.075 | 0.057 | 0.205 | 0.175 | 0.030 |

| | pH | NFR | P-total diss | P-total | P-part | Total Coliform (no./DL) | Fecal Coliform (no./DL) | Fecal Strep (no./DL) |
|---|---|---|---|---|---|---|---|---|
| Jan | 8.02 | 2.55 | 0.0114 | 0.0184 | 0.0067 | 42.0 | 5.7 | 19.4 |
| Feb | 8.05 | 1.06 | 0.0101 | 0.0231 | 0.0121 | 271.9 | 37.5 | 38.3 |
| Mar | 8.08 | 1.28 | 0.0143 | 0.0220 | 0.0078 | 727.2 | 4.6 | 17.0 |
| Apr | 8.16 | 1.42 | 0.0129 | 0.0220 | 0.0089 | 694.5 | 4.8 | 7.2 |
| May | 8.19 | 20.62 | 0.0072 | 0.0231 | 0.0182 | 4144.5 | 37.2 | 12.2 |
| Jun | 8.10 | 20.10 | 0.0042 | 0.0378 | 0.0389 | 191.7 | 44.3 | 19.0 |
| Jul | 8.22 | 5.60 | 0.0032 | 0.0087 | 0.0060 | 298.9 | 53.9 | 33.0 |
| Aug | 8.18 | 3.55 | 0.0053 | 0.0101 | 0.0046 | 1166.8 | 146.6 | 943.4 |
| Sep | 8.20 | 1.30 | 0.0053 | 0.0080 | 0.0030 | 1425.6 | 101.7 | 49.4 |
| Oct | 8.26 | 1.15 | 0.0056 | 0.0083 | 0.0030 | 98.2 | 28.1 | 23.5 |
| Nov | 8.14 | 1.20 | 0.0077 | 0.0120 | 0.0045 | 56.9 | 17.9 | 9.7 |
| Dec | 8.01 | 2.50 | 0.0085 | 0.0115 | 0.0033 | 37.7 | 6.2 | 9.6 |
| Period of Record | 8.14 | 5.54 | 0.0079 | 0.0173 | 0.0100 | 891.5 | 40.3 | 97.0 |
| Study | 8.22 | 4.00 | 0.0161 | 0.0251 | 0.0086 | 5.5 | 0.6 | 3.1 |

- Results in mg/L unless otherwise noted.
- LF indicates lab filtered.
- In all calculations, values below the analytical detection limit (Lx) have been interpreted as x/2. Mean values for each month and for the period of record were calculated using historical data of the period April 1978 to January 1988 inclusive. Mean values for the study were computed using the study results from the period February 8 to March 3, 1988

To assess the variability which occurs in a 24 hour period, it is necessary to sample at various times of the day. The results from the different times can then be compared to determine if the daily variations are significant. Before attempting to compare the results of samples collected at different times of the day, it is important to establish the reliability of individual results. Accordingly this issue is addressed next.

Measurements in scientific work are seldom without some uncertainty. In the tasks of sampling and analyses, there exist uncertainties which may affect the result being reported. This variability is termed precision. While it may be desirable to know the precision associated with each task, it is equally important to estimate the combined (overall) precision of the two tasks. One method of estimating this precision is to collect samples in triplicate and measure the variability in the reported results. This variability may be expressed as the coefficient of variation (CV). The coefficient of variation (in %) for a set of samples is simply (SD/M)x100 where SD is the standard deviation of the set of results and M is the mean value for the set.

During this study a number of samples were collected in triplicate to permit this calculation. For each set of triplicates, the CV was calculated for each parameter. An average CV for each parameter was then calculated. These results are summarized in Table 3.

Reference to Table 3 indicates that the CV's for most parameters is low, generally in the range of 1 to 7 % indicating good reproducibility in the collection of samples and the laboratory analyses. It is noted that the reported CV's for the bacteriological parameters were higher than they were for the other parameters, ranging from 9.8% (for fecal coliforms) to 48.1% (for fecal streptococci). Considering the nature of bacteriological tests and the fact that the bacteria counts in most samples were very low, (which results in non-ideal plate counts), these CV's are considered quite good. This suggests that the reported results should provide a reliable estimate of the concentration present in the stream or effluent at the time of sampling. Having established this, we can address the third study objective; the preliminary assessment of the diurnal variability in the quality of both the Bow River sites and effluent from the Banff lagoon.

To address this objective, two days (February 17 and February 19) were selected for more rigorous sampling, with samples being collected approximately every 7 hours during each of these days. These results are included in Appendix A .

The first step in the assessment of these results was to obtain a measure of the variability in the results for each day. These were again calculated as a CV. The CV's for the two days were

**Table 3. Coefficients of Variation for Triplicate Samples (average values)**

| Parameter | CV(%) | Parameter | CV(%) |
|---|---|---|---|
| Colour-T | 3.3 | PN | 3.6 |
| Sp. Cond. | 0.1 | pH | 0.2 |
| Turb. | 2.9 | NFR | 4.4 |
| TOC | 6.4 | P-total diss | 2.8 |
| DOC | 7.6 | P-total | 1.2 |
| POC | 7.0 | P-part | 6.2 |
| NO3+NO2 | 5.0 | T-Coliform | 37.8 |
| NH3-total | 2.2 | F-Coliform | 9.1 |
| TN | 2.3 | Fecal Strep | 48.1 |
| DN (LF) | 2.5 | Std P Count | 32.7 |

averaged to provide an average daily CV for each parameter. These are summarized in Table 4.

A comparison of the average daily CV's to the CV's of the triplicate samples (samples CV's) reveals a few noteworthy points: The data from the effluent samples are discussed first followed by a discussion of the data from the river samples.

Effluent samples:

For nutrients and physical parameters, the data of February 17 indicate that the variability within the day is generally about the same as the variability within sets of triplicates (Table 4). Typical CV's for each are about 1 to 7%. This suggests that for these parameters, the diurnal variations are not significant.

For bacteriological parameters, diurnal data are available for both February 17 and February 19. These data suggest that the variation within the day (for which CV's range from 20 to 136%) is larger than the variation within the sets of triplicates (with CV's of 9 to 48%). These differences suggest that the daily variation may be significant; large enough at least to warrant a more detailed examination.

The individual bacteriological data used to assess the diurnal variability in the effluent are presented in Table 5. Reference to these data indicate that on both days the poorest quality was in the samples collected near midnight. Both samples appear to be analytically correct as most parameters (T. Coliforms, F. Strep., and standard plate counts) are high. It is further noted that these two samples, which are the only two samples collected at that time of day, had the highest bacteria counts of all samples collected during the study period.

One possible explanation is that there was a problem at the

sewage treatment plant. This however could not be substantiated. Given the retention time in the lagoon, a large diurnal variation is not expected. While the reason for the high values remains unclear, the results do suggest that the present plant does not always deliver effluent of a uniform quality as significant variations within the day may occur.

Table 4. A Comparison of the Daily Variability to Sample Variability

| Parameter | Sample CV's * (%) | Daily CV's | | |
|---|---|---|---|---|
| | | Effluent Samples | River Samples | |
| | | | Bow River above lagoon | Bow River near Park Boundary |
| Colour-T | 3.3 | 0.0 | 0.0 | 0.0 |
| Sp. Cond. | 0.1 | 0.2 | 0.4 | 1.3 |
| Turb. | 2.9 | 2.2 | 33.4 | 52.8 |
| TOC | 6.4 | 5.2 | 14.4 | 24.8 |
| DOC | 7.6 | 0.0 | 12.5 | 17.6 |
| POC | 7.0 | 7.9 | 41.7 | 54.3 |
| NO3+NO2 | 5.0 | 5.6 | 10.4 | 40.5 |
| NH3-total | 2.2 | 2.5 | 16.4 | 47.9 |
| TN | 2.3 | 3.5 | 7.1 | 30.9 |
| DN (LF) | 2.5 | 3.7 | 7.7 | 36.7 |
| PN | 3.6 | 5.1 | 0.0 | 20.2 |
| pH | 0.2 | 0.4 | 0.3 | 0.9 |
| NFR | 4.4 | 9.4 | 50.0 | 88.4 |
| P-total diss | 2.8 | 1.7 | 0.0 | 55.2 |
| P-total | 1.2 | 10.6 | 0.0 | 26.3 |
| P-part | 6.2 | 7.5 | 0.0 | 27.5 |
| T-Coliform | 37.8 | 136. | 58.6 | 83.2 |
| F-Coliform | 9.1 | 20.0 | 62.9 | 0.0 |
| Fecal Strep | 48.1 | 125. | 55.5 | 138. |
| Std P Count | 32.7 | 91.8 | 81.6 | 23.6 |

* Variability due to sampling and analysis. Calculated from triplicate samples as discussed in preceding section.

**Table 5 Daily Variability in Bacteriological Quality of Effluent from the Banff Lagoon (21AL05BB0001)**

| DATE | TIME | ZONE | T. Coli. | CV(%)* T. Coli. | F. Coli. | CV(%)* F. Coli. | F. Strep | CV(%)* F. Strep | Std P Count | CV(%)* Std P Count |
|---|---|---|---|---|---|---|---|---|---|---|
| 17-FEB-88 | 0030 | MST | 740 | 136.9 | L10 | 0 | 1600 | 140.0 | 18000 | 80.4 |
| 17-FEB-88 | 0745 | MST | 200 | | L10 | | 220 | | 7500 | |
| 17-FEB-88 | 1443 | MST | 40 | | L10 | | 250 | | 18000 | |
| 17-FEB-88 | 2118 | MST | 10 | | L10 | | 10 | | 50 | |
| 19-FEB-88 | 0025 | MST | 3700 | 135.8 | L10 | 40 | 1100 | 110.5 | 14000 | 103.1 |
| 19-FEB-88 | 0800 | MST | 20 | | L10 | | 270 | | 3400 | |
| 19-FEB-88 | 1430 | MST | L10 | | L10 | | L10 | | 55 | |
| 19-FEB-88 | 2130 | MST | 1400 | | 10 | | 330 | | 5600 | |

- In this table values below the analytical detection limit (Lx) have been interpreted as x/2 during all calculations.

River samples:
Data from each site are discussed separately.

Bow River above Banff lagoon:

At this site the daily CV's for most parameters were higher than the sample CV's. The reason for this was investigated to ascertain if the variability was significant and whether it was random or was systematic which would be indicative of a true diurnal variation. An attempt was made to rank the concentrations of each parameter in each set of samples. A ranking number of 1 was to be assigned to the lowest concentration and a number of 4 to the highest concentration. Three points quickly became apparent; first, that the CV's were high because the reported concentrations were very low; second, that the concentrations were so similar that the ranking numbers had little meaning and third, that the ordering of the ranking numbers was random; as even among similar parameters the concentrations did not fluctuate in a similar manner.

Thus it appears that no significant diurnal fluctuations are present at this site. Instead it appears that the 'daily' CV's for this site are larger than the sample CV's because of small (nonsignificant) random variations in the quality of the River within the day.

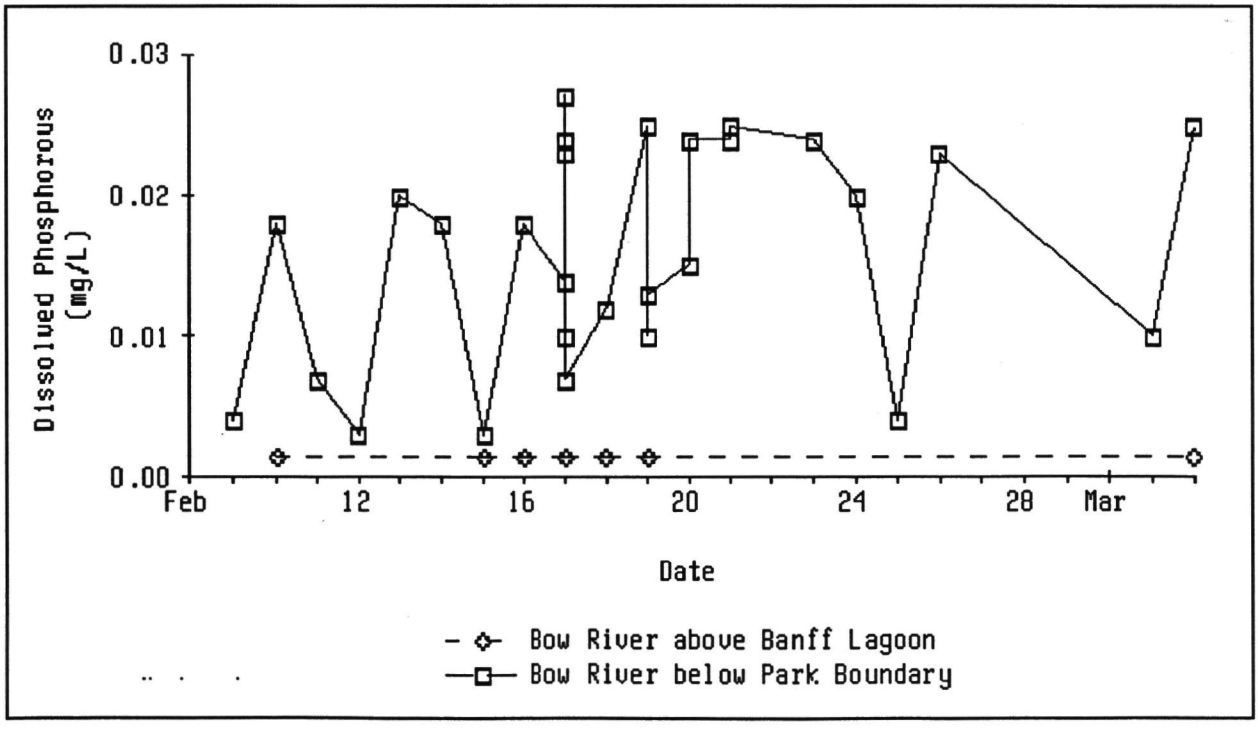
Bow River near Park Boundary:

At this site samples were collected approximately every 7 hours on both February 17 and February 19 (Appendix A).

Reference to Table 4 indicates that the daily CV's for all parameters at this site are quite large; being larger than both the sample CV's and the daily CV's at the site above the lagoon. This is not surprising considering the large daily fluctuations in flow in this section of the Bow River. Fluctuations in flow result from releases of water from Lake Minnewanka through Two Jack Lake and the Cascade hydroelectric plant.

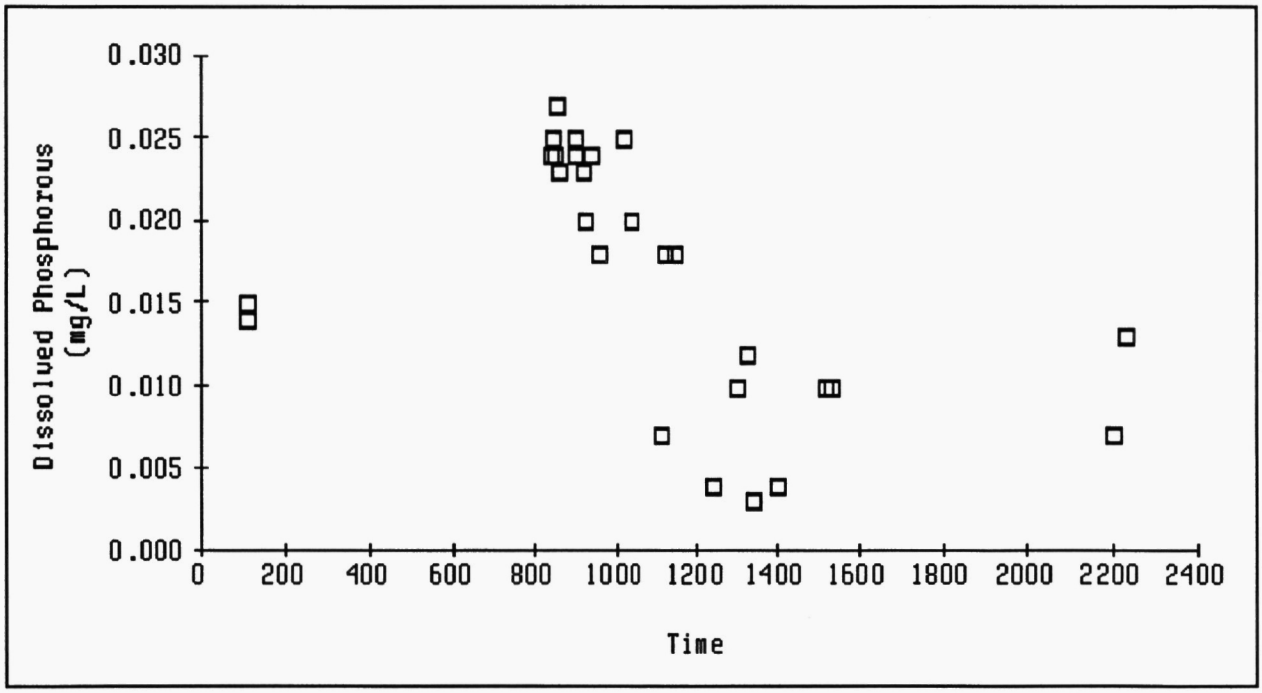
A review of the diurnal results for February 17 and 19 indicates that the concentrations of NO3+NO2, NH3-total, TN, DN, P-total diss, P-total and fecal coliforms were highest in the samples collected between 08:00 and 10:00 each day and lowest during the afternoon and evening samples (Appendix A). The diurnal changes in the concentrations of these parameters is significant. If one examines as an example, the concentration of total dissolved phosphorous during the study period, it becomes evident that the variation within the day is nearly as large as the variation during the study period (Figure 5).

**Figure 5** **Concentrations of Total Dissolved Phosphorous in the Bow River During February 1988 (mg/L)**



The results for February 17 and February 19 are not considered unusual. This point is perhaps better illustrated by looking at the reported concentrations from all days of the study period as a function of time. An example, again using the results for dissolved phosphorous to illustrate the point, is presented in Figure 6. This serves to illustrate that throughout the study the highest concentrations of the aforementioned parameters occurred at this site, in the time interval of 08:00 to 10:00 while the lowest concentrations were present in the afternoon and evening samples.

**Figure 6 Concentrations of Total Dissolved Phosphorous in the Bow River at the Park Boundary During February 1988 As a Function of the Time of Sampling (mg/L)**




The above observations appear to be consistent with the 0expected fluctuations in flow at the monitoring site during the winter period. The Cascade plant which operates during the late fall and winter period is, like many hydroelectric plants, operated on a demand basis. In the case of the Cascade plant, if the demand for power is high, two turbines are operated. At lesser demand levels, one or both turbines may be shut down. At the Cascade Plant, each turbine requires about 20 cms[2] of water to operate. During the study period, one turbine was generally operated about

[2] 1 cms = 1 cubic meter per sec

12 hours per day (8 AM to 8 PM) while the second unit was only operated about one hour (near noon) (Lyle Nelson, 1988).

To assess the significance of the release, one needs to consider both the relative magnitude of the release and the time of travel from the power plant to the site near the Park Boundary. During February 1988, the mean daily flow in the Bow River above the Cascade Hydro Plant was 9.6 cms (Provisional data, Water Survey of Canada). A release of up to 40 cms is therefore, quite significant. The time of travel from the Plant to the Park Boundary is estimated to be about 4 1/2 hours (Lyle Nelson, 1988). Based on the foregoing operating schedule at the Cascade Plant, 'high' flow conditions would be present at the Park Boundary from about noon to midnight each day. The reported concentrations at the Park boundary are consistent with this diurnal pattern in the flow.

## 6.0 Summary and Conclusions

This study was undertaken to assess the performance of the Banff sewage treatment plant and its effects on the Bow River during February 1988.

The study found that the sewage treatment plant generally delivered an effluent of good bacteriological quality with only minor deviations from the norm. Because the bacteria counts in the effluent were very low, the effluent had very little impact on the bacteriological quality of the Bow River at the Park Boundary. Like most sewage effluents, the Banff effluent was found to contain relatively high concentrations of nutrients. As a result, the effluent had a significant impact on the concentrations of nutrients, phosphorous in particular, in the Bow River.

The bacteriological quality of the Bow River at the Park Boundary was found to be of significantly better quality than during previous years. Reference to supporting data indicated that the bacteriological quality has, since the fall of 1987, been better than during previous years. This is attributed to improvements made at the Banff sewage treatment plant at that time. The concentrations of nutrients and physical parameters however were the same as those recorded in previous years.

Each of the study sites was examined to ascertain if diurnal variations in quality were significant. No significant variations were evident in the quality of the Bow River above the Banff sewage treatment plant. Similarly, for most parameters, the effluent was found to be of consistent quality throughout the day for each of the days examined. In the case of the bacteriological parameters however, variations were noted. The quality of the Bow River at the Park Boundary was shown to exhibit significant diurnal variations in most parameters. These were shown to be correlated to

fluctuations in river flow caused by releases of water from the Cascade Hydroelectric Plant near Banff.

**References:**

1. Water Quality Branch, 1979; Analytical Methods Manual. Inland Waters Directorate, Environment Canada.
2. Lyle Nelson, 1988; Trans-Alta Utilities, personal communication

# Appendix A

## Study Results

**Residual Chlorine Levels in the Effluent From the Banff Lagoon (mg/L)**

| Date | Time | Chlorine Residual | |
|---|---|---|---|
| 1-FEB-88 | 923 | 2.0 | 1.0 |
| 2-FEB-88 | 936 | 2.0 | 1.0 |
| 3-FEB-88 | 833 | 2.0 | 1.0 |
| 4-FEB-88 | 821 | 2.0 | 1.0 |
| 5-FEB-88 | 830 | 2.0 | 1.0 |
| 6-FEB-88 | 900 | 0.0 | 0.0 |
| 7-FEB-88 | 900 | 2.0 | 1.0 |
| 8-FEB-88 | 830 | 1.0 | 0.5 |
| 9-FEB-88 | 842 | 0.7 | 0.3 |
| 10-FEB-88 | 833 | 0.8 | 0.5 |
| 11-FEB-88 | 835 | 0.2 | |
| 12-FEB-88 | 1055 | 0.8 | 0.8 |
| 13-FEB-88 | 907 | 1.5 | 0.8 |
| 14-FEB-88 | 910 | 0.8 | 0.8 |
| 15-FEB-88 | 845 | 0.8 | 0.8 |
| 16-FEB-88 | 843 | 0.7 | 0.7 |
| 17-FEB-88 | 824 | 0.8 | 0.4 |
| 18-FEB-88 | 835 | 0.8 | 0.5 |
| 19-FEB-88 | 855 | 0.4 | 0.4 |
| 20-FEB-88 | 915 | 1.0 | 0.4 |
| 21-FEB-88 | 905 | 0.4 | 0.8 |
| 22-FEB-88 | 849 | 1.5 | 1.5 |
| 23-FEB-88 | 859 | 0.1 | 0.3 |
| 24-FEB-88 | 835 | 0.8 | 0.8 |
| 25-FEB-88 | 840 | 0.1 | 0.1 |
| 26-FEB-88 | 842 | 0.7 | 0.6 |
| 27-FEB-88 | 905 | 1.5 | 1.8 |
| 28-FEB-88 | 900 | 1.5 | 2.0 |
| 29-FEB-88 | 906 | 2.5 | 2.5 |

For Feb 88:
Average = 0.947 mg/L
Minimum = 0.0 mg/L (Feb 6, 1988)
Maximum = 2.5 mg/L (Feb 29, 1988)

## Study Results for Bow River above Banff Lagoon (00AL05BD0002)

| Date | Time | Zone | Sample | Project /SID | Colour-T 02021L Rel Units | Sp. Cond. 02041L usie/cm | Turb. 02081L NTU | TOC * 06002L mg/L | DOC 06104L mg/L | POC 06901L mg/L | NO3+NO2 07110L mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10-FEB-88 | 827 | MST | 872642 | 322 | L5. | 325. | 0.41 | 0.77 | 0.7 | 0.07 | 0.11 |
| 15-FEB-88 | 1215 | MST | 872662 | 331 | L5. | 321. | 0.48 | 0.76 | 0.7 | 0.06 | 0.11 |
| 16-FEB-88 | 1045 | MST | 872668 | 322 | L5. | 323. | 1.43 | 1.03 | 0.6 | 0.43 | 0.084 |
| 17-FEB-88 | 720 | MST | 872684 | 322 | L5. | 320. | 0.81 | 0.87 | 0.8 | 0.07 | 0.098 |
| 18-FEB-88 | 1210 | MST | 872700 | 331 | L5. | 320. | 0.45 | 0.77 | 0.7 | 0.07 | 0.093 |
| 19-FEB-88 | 730 | MST | 872703 | 322 | L5. | 322. | 0.76 | 1.02 | 0.9 | 0.12 | 0.085 |
| 19-FEB-88 | 1410 | MST | 872709 | 322 | L5. | 322. | 0.4 | 0.77 | 0.7 | 0.07 | 0.073 |
| 19-FEB-88 | 2100 | MST | 872712 | 322 | L5. | 324. | 0.79 | 0.97 | 0.8 | 0.17 | 0.07 |
| 03-MAR-88 | 930 | MST | 872790 | 322 | L5. | 328. | 0.62 | 0.88 | 0.7 | 0.18 | 0.081 |

| Date | Time | Zone | NH3-total 07540P mg/L | TN * 07603L mg/L | DN (LF) 07651L mg/L | PN 07901L mg/L | pH 10301L pH units | NFR 10401L mg/L | P-total diss 15103L mg/L | P-total 15406L mg/L | P-part * 15901L mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10-FEB-88 | 827 | MST | 0.013 | 0.14 | 0.13 | 0.01 | 8.11 | 1. | L0.003 | 0.007 | L0.006 |
| 15-FEB-88 | 1215 | MST | 0.014 | 0.15 | 0.14 | 0.01 | 8.2 | L1. | L0.003 | L0.003 | L0.006 |
| 16-FEB-88 | 1045 | MST | | 0.15 | 0.13 | 0.02 | 8.21 | 6. | L0.003 | 0.006 | L0.006 |
| 17-FEB-88 | 720 | MST | 0.014 | 0.15 | 0.14 | 0.01 | 8.13 | 1. | L0.003 | L0.003 | L0.006 |
| 18-FEB-88 | 1210 | MST | 0.012 | 0.14 | 0.13 | 0.01 | 8.18 | 1. | L0.003 | L0.003 | L0.006 |
| 19-FEB-88 | 730 | MST | 0.018 | 0.15 | 0.14 | 0.01 | 8.16 | 2. | L0.003 | L0.003 | L0.006 |
| 19-FEB-88 | 1410 | MST | 0.013 | 0.14 | 0.13 | 0.01 | 8.19 | 1. | L0.003 | L0.003 | L0.006 |
| 19-FEB-88 | 2100 | MST | 0.015 | 0.13 | 0.12 | 0.01 | 8.21 | 3. | L0.003 | L0.003 | L0.006 |
| 03-MAR-88 | 930 | MST | 0.019 | 0.17 | 0.16 | 0.01 | 8.18 | 2. | L0.003 | 0.003 | L0.006 |

**Study Results for Bow River above Banff Lagoon**
**(00AL05BD0002)**

| Date | Time | Zone | T-Coliform 36002F no/DL | F-Coliform 36012F no/DL | Fecal Strep 36103F no/DL | Std P Count 36905F no/mL |
|---|---|---|---|---|---|---|
| 08-FEB-88 | 1200 | MST | L2. | L2. | L2. | 1. |
| 10-FEB-88 | 0827 | MST | 4. | L2. | L2. | L10. |
| 10-FEB-88 | 1555 | MST | 1. | L1. | L1. | 2. |
| 11-FEB-88 | 1015 | MST | L1. | L1. | L1. | 1. |
| 12-FEB-88 | 1215 | MST | 3. | L1. | 1. | 1. |
| 12-FEB-88 | 1216 | MST | 1. | L1. | L1. | 1. |
| 12-FEB-88 | 1217 | MST | 3. | L1. | L1. | 1. |
| 13-FEB-88 | 0920 | MST | 6. | L1. | L1. | 3. |
| 14-FEB-88 | 1050 | MST | 4. | L1. | L1. | 4. |
| 15-FEB-88 | 1215 | MST | 6. | L1. | 3. | 10. |
| 15-FEB-88 | 1216 | MST | 9. | L1. | 10. | 8. |
| 15-FEB-88 | 1217 | MST | 2. | L1. | 4. | 5. |
| 16-FEB-88 | 0820 | MST | 7. | L1. | 2. | 17. |
| 17-FEB-88 | 0009 | MST | 17. | L1. | L1. | 4. |
| 17-FEB-88 | 0720 | MST | 6. | L1. | L1. | 8. |
| 17-FEB-88 | 1425 | MST | 3. | L1. | L1. | 34. |
| 17-FEB-88 | 2105 | MST | 5. | 1. | 3. | 16. |
| 18-FEB-88 | 1210 | MST | L1. | L1. | L1. | 12. |
| 18-FEB-88 | 1211 | MST | 1. | 1. | L1. | 15. |
| 18-FEB-88 | 1212 | MST | 3. | L1. | 6. | 12. |
| 19-FEB-88 | 0730 | MST | 12. | L1. | L1. | 1. |
| 19-FEB-88 | 0845 | MST | 10. | L1. | L1. | 15. |
| 19-FEB-88 | 1410 | MST | 18. | 2. | L1. | 6. |
| 19-FEB-88 | 2100 | MST | 8. | L1. | L1. | 8. |
| 21-FEB-88 | 0730 | MST | 28. | L1. | L1. | 11. |
| 21-FEB-88 | 0731 | MST | 25. | 1. | 2. | 17. |
| 21-FEB-88 | 0732 | MST | 21. | 1. | 1. | 14. |
| 22-FEB-88 | 0745 | MST | 4. | L1. | 1. | 22. |
| 23-FEB-88 | 0730 | MST | 6. | L1. | 2. | 4. |
| 24-FEB-88 | 1005 | MST | 11. | L1. | L1. | 21. |
| 24-FEB-88 | 1006 | MST | 13. | L1. | 1. | 14. |
| 24-FEB-88 | 1007 | MST | 8. | L1. | L1. | 26. |
| 25-FEB-88 | 1145 | MST | 2. | L1. | L1. | 11. |
| 26-FEB-88 | 0825 | MST | 18. | 1. | 3. | |
| 27-FEB-88 | 1000 | MST | 10. | L1. | L1. | 17. |
| 27-FEB-88 | 1001 | MST | 9. | L1. | 8. | 8. |
| 27-FEB-88 | 1002 | MST | 11. | L1. | 8. | 25. |
| 28-FEB-88 | 1150 | MST | 7. | L1. | L1. | 19. |
| 29-FEB-88 | 0850 | MST | 10. | L1. | 4. | 6. |
| 01-MAR-88 | 1025 | MST | 3. | L1. | L1. | 24. |
| 01-MAR-88 | 1026 | MST | 6. | L1. | 1. | 21. |
| 01-MAR-88 | 1027 | MST | 8. | 1. | L1. | 19. |
| 02-MAR-88 | 1130 | MST | 4. | L1. | L1. | 4. |
| 03-MAR-88 | 0930 | MST | L2. | L2. | L2. | |

## Study Results for Effluent from Banff Lagoon (21AL05BB0001)

| Date | Time | Zone | Sample | Project /SID | Colour-T 02021L Rel Units | Sp. Cond. 02041L usie/cm | Turb. 02081L NTU | TOC * 06002L mg/L | DOC 06104L mg/L | POC 06901L mg/L | NO3+NO2 07110L mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10-FEB-88 | 0845 | MST | 872643 | 331 | 20. | 675. | 20. | 26. | 12. | 14. | 0.092 |
| 10-FEB-88 | 0850 | MST | 872644 | 331 | 20. | 676. | 20. | 25. | 12. | 13. | 0.087 |
| 10-FEB-88 | 0855 | MST | 872645 | 331 | 25. | 675. | 21. | 26. | 13. | 13. | 0.086 |
| 15-FEB-88 | 1245 | MST | 872663 | 322 | 20. | 682. | 24. | 28.9 | 9.9 | 19. | 0.021 |
| 16-FEB-88 | 0845 | MST | 872666 | 331 | 25. | 694. | 25. | 34. | 13. | 21. | 0.022 |
| 17-FEB-88 | 0745 | MST | 872685 | 322 | 20. | 700. | 27. | 26.9 | 8.9 | 18. | 0.022 |
| 18-FEB-88 | 1240 | MST | 872701 | 322 | 30. | 692. | 22. | 24.3 | 8.3 | 16. | 0.028 |
| 19-FEB-88 | 0805 | MST | 872705 | 331 | 30. | 695. | 26. | 30. | 11. | 19. | 0.032 |
| 19-FEB-88 | 0810 | MST | 872706 | 331 | 30. | 695. | 25. | 31. | 11. | 20. | 0.03 |
| 19-FEB-88 | 0815 | MST | 872707 | 331 | 30. | 696. | 28. | 34. | 12. | 22. | 0.03 |
| 19-FEB-88 | 1430 | MST | 872710 | 322 | 30. | 693. | 27. | 34. | 11. | 23. | 0.029 |
| 19-FEB-88 | 2130 | MST | 872713 | 322 | 30. | 696. | 26. | 34. | 11. | 23. | 0.027 |
| 03-MAR-88 | 0850 | MST | 872786 | 331 | 30. | 701. | 26. | 29.4 | 13.4 | 16. | 0.064 |
| 03-MAR-88 | 0855 | MST | 872787 | 331 | 30. | 701. | 26. | 27. | 14. | 13. | 0.064 |
| 03-MAR-88 | 0900 | MST | 872788 | 331 | 30. | 701. | 25. | 29.9 | 14.9 | 15. | 0.063 |

| Date | Time | Zone | NH3-total 07540P mg/L | TN * 07603L mg/L | DN (LF) 07651L mg/L | PN 07901L mg/L | pH 10301L pH units | NFR 10401L mg/L | P-total diss 15103L mg/L | P-total 15406L mg/L | P-part * 15901L mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10-FEB-88 | 0845 | MST | 8.9 | 12. | 9.5 | 2.5 | 7.41 | 25. | 2.58 | 3.2 | 0.62 |
| 10-FEB-88 | 0850 | MST | 8.2 | 11.7 | 9.3 | 2.4 | 7.41 | 27. | 2.6 | 3.12 | 0.52 |
| 10-FEB-88 | 0855 | MST | 8.4 | 11.7 | 9.3 | 2.4 | 7.43 | 28. | 2.62 | 3.2 | 0.58 |
| 15-FEB-88 | 1245 | MST | 9.25 | 12.7 | 9.7 | 3. | 7.59 | 34. | 2.8 | 3.3 | 0.5 |
| 16-FEB-88 | 0845 | MST | 9.35 | 13.7 | 10.2 | 3.5 | 7.58 | 31. | 2.87 | 3.4 | 0.53 |
| 17-FEB-88 | 0745 | MST | 9.65 | 13.7 | 10.4 | 3.3 | 7.47 | 34. | 2.95 | 3.56 | 0.61 |
| 18-FEB-88 | 1240 | MST | 10.2 | 13.5 | 10.4 | 3.1 | 7.37 | 30. | 2.88 | 3.4 | 0.52 |
| 19-FEB-88 | 0805 | MST | 10.35 | 13.8 | 10.1 | 3.7 | 7.52 | 37. | 2.94 | 3.5 | 0.56 |
| 19-FEB-88 | 0810 | MST | 9.95 | 14.3 | 10.6 | 3.7 | 7.48 | 32. | 2.9 | 3.6 | 0.7 |
| 19-FEB-88 | 0815 | MST | 10.45 | 14.9 | 11.2 | 3.7 | 7.48 | 34. | 2.97 | 3.62 | 0.65 |
| 19-FEB-88 | 1430 | MST | 9.9 | 15. | 10.9 | 4.1 | 7.53 | 37. | 2.95 | 3.55 | 0.6 |
| 19-FEB-88 | 2130 | MST | 10.35 | 15.3 | 11.4 | 3.9 | 7.54 | 41. | 3. | 3.56 | 0.56 |
| 03-MAR-88 | 0850 | MST | 10.4 | 15.7 | 13.2 | 2.5 | 7.46 | 27. | 3. | 3.6 | 0.6 |
| 03-MAR-88 | 0855 | MST | 10.25 | 15.5 | 13.4 | 2.1 | 7.47 | 25. | 3.04 | 3.68 | 0.64 |
| 03-MAR-88 | 0900 | MST | 10.25 | 15.2 | 13.2 | 2. | 7.48 | 27. | 3.04 | 3.7 | 0.66 |

**Study Results for Effluent from Banff Lagoon**
**(21AL05BB0001)**

| Date | Time | Zone | T-Coliform 36002F no/DL | F-Coliform 36012F no/DL | Fecal Strep 36103F no/DL | Std P Count 36905F no/mL |
|---|---|---|---|---|---|---|
| 08-FEB-88 | 1200 | MST | L2. | L2. | 6. | 80. |
| 09-FEB-88 | 2200 | MST | 2. | L2. | L2. | 60. |
| 10-FEB-88 | 0855 | MST | L10. | L10. | 10. | 50. |
| 10-FEB-88 | 1535 | MST | L10. | L10. | 20. | 5. |
| 10-FEB-88 | 1536 | MST | L10. | L10. | L10. | 7. |
| 10-FEB-88 | 1537 | MST | L10. | L10. | 20. | 4. |
| 10-FEB-88 | 2200 | MST | L2. | L2. | 4. | 8. |
| 11-FEB-88 | 1030 | MST | L10. | L10. | 50. | 380. |
| 12-FEB-88 | 1230 | MST | 30. | L10. | 80. | 13. |
| 13-FEB-88 | 0940 | MST | L10. | L10. | 580. | 750. |
| 13-FEB-88 | 0941 | MST | 10. | L10. | 5100. | |
| 13-FEB-88 | 0942 | MST | 10. | L10. | 210. | |
| 14-FEB-88 | 1105 | MST | 10. | L10. | 20. | 1900. |
| 15-FEB-88 | 1245 | MST | L10. | L10. | 90. | 2300. |
| 16-FEB-88 | 0830 | MST | 30. | L10. | 140. | 4600. |
| 16-FEB-88 | 0840 | MST | 70. | L10. | 90. | 3100. |
| 16-FEB-88 | 0845 | MST | 10. | L10. | 80. | 5300. |
| 17-FEB-88 | 0030 | MST | 740. | L10. | 1600. | 18000. |
| 17-FEB-88 | 0745 | MST | 200. | L10. | 220. | 7500. |
| 17-FEB-88 | 1443 | MST | 40. | L10. | 250. | 18000. |
| 17-FEB-88 | 2118 | MST | 10. | L10. | 10. | 50. |
| 18-FEB-88 | 1240 | MST | 110. | L10. | 50. | 15000. |
| 19-FEB-88 | 0025 | MST | 3700. | L10. | 1100. | 14000. |
| 19-FEB-88 | 0800 | MST | 20. | L10. | 270. | 3400. |
| 19-FEB-88 | 0801 | MST | L10. | L10. | 250. | 2200. |
| 19-FEB-88 | 0802 | MST | 30. | L10. | 320. | 3900. |
| 19-FEB-88 | 1430 | MST | L10. | L10. | L10. | 55. |
| 19-FEB-88 | 2130 | MST | 1400. | 10. | 330. | 5600. |
| 20-FEB-88 | 0900 | MST | 170. | L10. | 240. | 2500. |
| 21-FEB-88 | 0800 | MST | L10. | L10. | 140. | 68000. |
| 22-FEB-88 | 0805 | MST | L10. | L10. | 50. | 5300. |
| 22-FEB-88 | 0806 | MST | 10. | L10. | 90. | 6900. |
| 22-FEB-88 | 0807 | MST | L10. | L10. | 90. | 5200. |
| 23-FEB-88 | 0750 | MST | 30. | L10. | 220. | 3600. |
| 24-FEB-88 | 1025 | MST | 30. | L10. | 90. | 4200. |
| 25-FEB-88 | 1200 | MST | 20. | L10. | 60. | 6400. |
| 25-FEB-88 | 1201 | MST | 20. | L10. | 40. | 4300. |
| 25-FEB-88 | 1202 | MST | 20. | L10. | 50. | 5500. |
| 26-FEB-88 | 0840 | MST | L10. | L10. | 50. | |
| 27-FEB-88 | 0955 | MST | L10. | L10. | 60. | 3800. |
| 28-FEB-88 | 1200 | MST | L10. | L10. | 50. | 96. |
| 28-FEB-88 | 1201 | MST | L10. | L10. | 50. | 140. |
| 28-FEB-88 | 1202 | MST | L10. | L10. | 70. | 140. |
| 29-FEB-88 | 0905 | MST | L10. | L10. | 170. | 130. |
| 01-MAR-88 | 1038 | MST | 20. | L10. | 30. | 7900. |
| 02-MAR-88 | 1145 | MST | L10. | L10. | 10. | 1200. |
| 02-MAR-88 | 1146 | MST | L10. | L10. | 10. | 1500. |
| 02-MAR-88 | 1147 | MST | L10. | L10. | 70. | 4000. |
| 03-MAR-88 | 0850 | MST | L10. | L2. | 70. | |
| 03-MAR-88 | 0855 | MST | L10. | L2. | 90. | |
| 03-MAR-88 | 0900 | MST | L10. | L2. | 90. | |

## Study Results for Bow River near Banff Park Boundary (00AL05BE0013)

| Date | Time | Zone | Sample | Project /SID | Colour-T 02021L Rel Units | Sp. Cond. 02041L usie/cm | Turb. 02081L NTU | TOC * 06002L mg/L | DOC 06104L mg/L | POC 06901L mg/L | NO3+NO2 07110L mg/L | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 09-FEB-88 | 1400 | MST | 872602 | 314 | L5. | 351. | 2. | 1.29 | 1. | 0.29 | 0.074 | 10D |
| 10-FEB-88 | 0955 | MST | 872646 | 322 | L5. | 344. | 0.56 | 1.28 | 0.9 | 0.38 | 0.1 | |
| 11-FEB-88 | 1110 | MST | 872647 | 331 | L5. | 351. | 1.15 | 1.18 | 0.9 | 0.28 | 0.057 | |
| 12-FEB-88 | 1340 | MST | 872650 | 322 | L5. | 351. | 4.1 | 2.03 | 1.1 | 0.93 | 0.04 | |
| 13-FEB-88 | 1040 | MST | 872648 | 322 | L5. | 343. | 0.61 | 0.87 | 0.7 | 0.17 | 0.11 | |
| 14-FEB-88 | 1145 | MST | 872649 | 331 | L5. | 341. | 0.52 | 0.89 | 0.7 | 0.19 | 0.11 | |
| 15-FEB-88 | 1340 | MST | 872664 | 322 | L5. | 351. | 2.8 | 1.83 | 1. | 0.83 | 0.03 | |
| 16-FEB-88 | 1120 | MST | 872667 | 322 | L5. | 343. | 0.85 | 0.94 | 0.6 | 0.34 | 0.074 | |
| 17-FEB-88 | 0107 | MST | 872683 | 322 | L5. | 347. | 0.7 | 0.94 | 0.8 | 0.14 | 0.085 | |
| 17-FEB-88 | 0855 | MST | 872686 | 331 | L5. | 340. | 0.74 | 0.88 | 0. | 0.18 | 0.08 | |
| 17-FEB-88 | 0857 | MST | 872687 | 331 | L5. | 340. | 0.73 | 0.87 | 07 | 0.17 | 0.096 | |
| 17-FEB-88 | 0900 | MST | 872688 | 331 | L5. | 340. | 0.74 | 1.06 | .9 | 0.16 | 0.1 | |
| 17-FEB-88 | 1518 | MST | 872698 | 322 | L5. | 347. | 0.79 | 1.28 | 0.9 | 0.38 | 0.056 | |
| 17-FEB-88 | 2205 | MST | 872699 | 322 | L5. | 350. | 2.1 | 1.04 | 0.9 | 0.14 | 0.04 | |
| 18-FEB-88 | 1320 | MST | 872702 | 322 | L5. | 348. | 0.62 | 1.16 | 1. | 0.16 | 0.046 | |
| 19-FEB-88 | 0900 | MST | 872708 | 322 | L5. | 340. | 0.54 | 1.03 | 0.8 | 0.23 | 0.077 | |
| 19-FEB-88 | 1530 | MST | 872711 | 322 | L5. | 348. | 1.39 | 2.04 | 1.3 | 0.74 | 0.035 | |
| 19-FEB-88 | 2230 | MST | 872714 | 322 | L5. | 348. | 1.2 | 1.58 | 1.1 | 0.48 | 0.042 | |
| 20-FEB-88 | 0105 | MST | 872715 | 322 | L5. | 346. | 0.52 | 0.93 | 0.8 | 0.13 | 0.073 | |
| 20-FEB-88 | 0940 | MST | 872716 | 331 | L5. | 342. | 0.58 | 1.01 | 0.8 | 0.21 | 0.089 | |
| 21-FEB-88 | 0840 | MST | 872719 | 322 | L5. | 347. | 0.78 | 1.09 | 0.8 | 0.29 | 0.1 | |
| 21-FEB-88 | 0845 | MST | 872720 | 322 | L5. | 347. | 0.62 | 0.9 | 0. | 0.20 | 0.1 | |
| 23-FEB-88 | 0850 | MST | 872721 | 331 | L5. | 344. | 1.25 | 0.85 | 0.7 | 0.15 | 0.1 | |
| 24-FEB-88 | 0925 | MST | 872735 | 322 | L5. | 350. | 0.65 | 0.95 | 0.8 | 0.15 | 0.095 | |
| 25-FEB-88 | 1240 | MST | 872736 | 322 | L5. | 351. | 2.3 | 1.42 | 1.1 | 0.32 | 0.034 | |
| 26-FEB-88 | 0920 | MST | 872766 | 331 | L5. | 351. | 0.45 | 0.88 | 0.7 | 0.18 | 0.1 | |
| 02-MAR-88 | 1300 | MST | 872795 | 314 | L5. | 362. | 0.6 | 0.97 | 0.8 | 0.17 | 0.063 | 10D |
| 03-MAR-88 | 1015 | MST | 872789 | 322 | L5. | 343. | 0.51 | 0.89 | 0.8 | 0.09 | 0.097 | |

| Date | Time | Zone | NH3-total 07540P mg/L | TN * 07603L mg/L | DN (LF) 07651L mg/L | PN 07901L mg/L | pH 10301L pH units | NFR 10401L mg/L | P-total diss 15103L mg/L | | P-total 15406L mg/L | P-part * 15901L mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 09-FEB-88 | 1400 | MST | 0.032 | 0.17 | 0.14 | 0.03 | 8.14 | 5. | 0.004 | 03D | 0.018 | 0.014 |
| 10-FEB-88 | 0955 | MST | 0.063 | 0.25 | 0.22 | 0.03 | 8.15 | 6. | 0.018 | | 0.032 | 0.014 |
| 11-FEB-88 | 1110 | MST | 0.034 | 0.17 | 0.14 | 0.03 | 8.33 | 5. | 0.007 | | 0.017 | 0.01 |
| 12-FEB-88 | 1340 | MST | 0.022 | 0.15 | 0.11 | 0.04 | 8.36 | 16. | 0.003 | | 0.025 | 0.022 |
| 13-FEB-88 | 1040 | MST | 0.059 | 0.23 | 0.2 | 0.03 | 8.3 | 1. | 0.02 | | 0.025 | L0.006 |
| 14-FEB-88 | 1145 | MST | 0.056 | 0.24 | 0.21 | 0.03 | 8.31 | 1. | 0.018 | | 0.025 | 0.007 |
| 15-FEB-88 | 1340 | MST | 0.023 | 0.16 | 0.12 | 0.04 | 8.33 | 14. | 0.003 | | 0.022 | 0.019 |
| 16-FEB-88 | 1120 | MST | 0.063 | 0.23 | 0.19 | 0.04 | 8.26 | 3. | 0.018 | | 0.025 | 0.007 |
| 17-FEB-88 | 0107 | MST | 0.058 | 0.19 | 0.17 | 0.02 | 8.16 | 1. | 0.014 | | 0.019 | L0.006 |
| 17-FEB-88 | 0855 | MST | 0.076 | 0.26 | 0.23 | 0.03 | 8.14 | 1. | 0.027 | | 0.028 | L0.006 |
| 17-FEB-88 | 0857 | MST | 0.077 | 0.25 | 0.22 | 0.03 | 8.12 | 1. | 0.023 | | 0.028 | L0.006 |
| 17-FEB-88 | 0900 | MST | 0.075 | 0.26 | 0.23 | 0.03 | 8.13 | 1. | 0.024 | | 0.028 | L0.006 |
| 17-FEB-88 | 1518 | MST | 0.038 | 0.14 | 0.11 | 0.03 | 8.29 | 3. | 0.01 | | 0.015 | L0.006 |
| 17-FEB-88 | 2205 | MST | 0.026 | 0.12 | 0.1 | 0.02 | 8.28 | 8. | 0.007 | | 0.011 | L0.006 |
| 18-FEB-88 | 1320 | MST | 0.032 | 0.16 | 0.14 | 0.02 | 8.28 | 2. | 0.012 | | 0.02 | 0.008 |
| 19-FEB-88 | 0900 | MST | 0.074 | 0.27 | 0.24 | 0.03 | 8.18 | 2. | 0.025 | | 0.03 | L0.006 |
| 19-FEB-88 | 1530 | MST | 0.026 | 0.17 | 0.13 | 0.04 | 8.3 | 13. | 0.01 | | 0.02 | 0.01 |
| 19-FEB-88 | 2230 | MST | 0.043 | 0.18 | 0.15 | 0.03 | 8.26 | 7. | 0.013 | | 0.024 | 0.011 |
| 20-FEB-88 | 0105 | MST | 0.06 | 0.21 | 0.18 | 0.03 | 8.2 | 1. | 0.015 | | 0.025 | 0.01 |
| 20-FEB-88 | 0940 | MST | 0.093 | 0.25 | 0.21 | 0.04 | 8.19 | 3. | 0.024 | | 0.036 | 0.012 |

## Study Results for Bow River near Banff Park Boundary (00AL05BE0013)

| Date | Time | Zone | NH3-total 07540P mg/L | TN * 07603L mg/L | DN (LF) 07651L mg/L | PN 07901L mg/L | pH 10301L pH units | NFR 10401L mg/L | P-total diss 15103L mg/L | | P-total 15406L mg/L | P-part * 15901L mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21-FEB-88 | 0840 | MST | 0.098 | 0.26 | 0.22 | 0.04 | 8.13 | 3. | 0.024 | | 0.036 | 0.012 |
| 21-FEB-88 | 0845 | MST | 0.099 | 0.23 | 0.2 | 0.03 | 8.17 | 1. | 0.025 | | 0.036 | 0.011 |
| 23-FEB-88 | 0850 | MST | | 0.24 | 0.21 | 0.03 | 8.13 | 1. | 0.024 | | 0.035 | 0.011 |
| 24-FEB-88 | 0925 | MST | 0.091 | 0.23 | 0.2 | 0.03 | 8.2 | 1. | 0.02 | | 0.03 | 0.01 |
| 25-FEB-88 | 1240 | MST | 0.027 | 0.14 | 0.11 | 0.03 | 8.33 | 6. | 0.004 | | 0.015 | 0.011 |
| 26-FEB-88 | 0920 | MST | 0.094 | 0.23 | 0.2 | 0.03 | 8.16 | 1. | 0.023 | | 0.03 | 0.007 |
| 02-MAR-88 | 1300 | MST | 0.029 | 0.12 | 0.11 | 0.01 | 8.12 | 3. | 0.01 | 03D | 0.014 | L0.006 |
| 03-MAR-88 | 1015 | MST | 0.072 | 0.22 | 0.2 | 0.02 | 8.2 | 1. | 0.025 | | 0.034 | 0.009 |

## Study Results for Bow River near Banff Park Boundary (00AL05BE0013)

| Date | Time | Zone | T-Coliform 36002F no/DL | F-Coliform 36012F no/DL | Fecal Strep 36103F no/DL | Std P Count 36905F no/mL |
|---|---|---|---|---|---|---|
| 08-FEB-88 | 1200 | MST | L2. | L2. | L2. | L1. |
| 09-FEB-88 | 1400 | MST | 2. | L2. | L2. | |
| 10-FEB-88 | 0955 | MST | 4. | L1. | L1. | 2. |
| 10-FEB-88 | 1500 | MST | 1. | L1. | 1. | 1. |
| 11-FEB-88 | 1110 | MST | 1. | L1. | 1. | 2. |
| 11-FEB-88 | 1111 | MST | 2. | L1. | L1. | 6. |
| 11-FEB-88 | 1112 | MST | L1. | L1. | L1. | 7. |
| 12-FEB-88 | 1340 | MST | 1. | L1. | 1. | 4. |
| 13-FEB-88 | 1040 | MST | 1. | L1. | 3. | 1. |
| 14-FEB-88 | 1145 | MST | 1. | L1. | L1. | 5. |
| 14-FEB-88 | 1146 | MST | 2. | L1. | L1. | 3. |
| 14-FEB-88 | 1147 | MST | 2. | L1. | L1. | 3. |
| 15-FEB-88 | 1340 | MST | 2. | L1. | L1. | 9. |
| 16-FEB-88 | 0930 | MST | 9. | L1. | 1. | 15. |
| 17-FEB-88 | 0107 | MST | 31. | L1. | 2. | 46. |
| 17-FEB-88 | 0855 | MST | 5. | L1. | 12. | 48. |
| 17-FEB-88 | 0857 | MST | 10. | L1. | 17. | 47. |
| 17-FEB-88 | 0900 | MST | 7. | 1. | 24. | 41. |
| 17-FEB-88 | 1518 | MST | 2. | L1. | 1. | 51. |
| 17-FEB-88 | 2205 | MST | 8. | L1. | L1. | 45. |
| 18-FEB-88 | 1320 | MST | 2. | L1. | L1. | 8. |
| 19-FEB-88 | 0105 | MST | 9. | L1. | 3. | 46. |
| 19-FEB-88 | 0830 | MST | 6. | L1. | 18. | 470. |
| 19-FEB-88 | 0900 | MST | 3. | L1. | 10. | 15. |
| 19-FEB-88 | 1530 | MST | 6. | L1. | 1. | 33. |
| 19-FEB-88 | 2230 | MST | 14. | L1. | L1. | 45. |
| 20-FEB-88 | 0910 | MST | 22. | L1. | 23. | 360. |
| 20-FEB-88 | 0940 | MST | 8. | L1. | L1. | 23. |
| 20-FEB-88 | 0941 | MST | 9. | L1. | L1. | 18. |
| 20-FEB-88 | 0942 | MST | 11. | L1. | L1. | 17. |
| 21-FEB-88 | 0805 | MST | 11. | L1. | 6. | 120. |
| 21-FEB-88 | 0840 | MST | 7. | L1. | 1. | 31. |
| 22-FEB-88 | 0810 | MST | 3. | L1. | 6. | 94. |
| 22-FEB-88 | 0840 | MST | 13. | L1. | L1. | 8. |
| 23-FEB-88 | 0800 | MST | 11. | L1. | 8. | 870. |
| 23-FEB-88 | 0850 | MST | 4. | 2. | 1. | 5. |
| 23-FEB-88 | 0851 | MST | 11. | 1. | L1. | 16. |
| 23-FEB-88 | 0852 | MST | 5. | 2. | L1. | 9. |
| 24-FEB-88 | 0925 | MST | 3. | L1. | L1. | 21. |
| 25-FEB-88 | 1240 | MST | 2. | L1. | L1. | 19. |
| 26-FEB-88 | 0920 | MST | 4. | L1. | 1. | 14. |
| 26-FEB-88 | 0921 | MST | 3. | L1. | 1. | 140. |
| 26-FEB-88 | 0922 | MST | 6. | L1. | L1. | 16. |
| 27-FEB-88 | 0930 | MST | L1. | L1. | 1. | 9. |
| 28-FEB-88 | 1125 | MST | L1. | L1. | 1. | 12. |
| 29-FEB-88 | 0945 | MST | L1. | L1. | L1. | 9. |
| 29-FEB-88 | 0946 | MST | 3. | L1. | L1. | 12. |
| 29-FEB-88 | 0947 | MST | 3. | L1. | L1. | 7. |
| 01-MAR-88 | 1125 | MST | 6. | L1. | L1. | 29. |
| 02-MAR-88 | 1215 | MST | 1. | L1. | L1. | 5. |
| 02-MAR-88 | 1300 | MST | L2. | L2. | 2. | |
| 03-MAR-88 | 1015 | MST | 4. | L2. | 2. | |

Block, Howard

An assessment of the Banff Sewage Lagoon and its effects on the Bow River during February 1988

| DATE | ISSUED TO |
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