Annapolis River Guardians
Volunteer Water Quality Monitoring Program

2003 Annual Report

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Clean Annapolis River Project
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Contents

This report is available electronically at *www.annapolisriver.ca*

Acknowledgements

The Annapolis River Guardians is a volunteer-based program. Without the dedication of the volunteers, the program would not be the success that it is. We would therefore like to extend our thanks to the volunteers who have contributed their time and energy during the 2003 season. The River Guardian volunteers include:

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The success of the River Guardians program is in part due to its approach of bringing together a variety of stakeholders who have an interest in the health of the Annapolis River. We would like to thank the following partners who have worked with us to deliver the Annapolis River Guardians program:

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Cover photographs by Ken Maher

Executive Summary

In 2003, the Annapolis River Guardians completed their 11th year of continuous water quality monitoring on the Annapolis River. Fourteen sites were monitored by fifteen volunteers over the course of the season, which ran from April to November. A number of variables were examined, including dissolved oxygen, fecal coliform, nitrates and nitrites, air and water temperature, as well as local weather conditions.

Since the River Guardian program was started in 1992, the most significant improvement in fecal coliform levels have been observed on the down-river monitoring stations: Middleton, Lawrencetown, Paradise and Bridgetown. There has been limited, if any, improvement in fecal coliform levels at the Aylesford and Kingston monitoring sites. Of the main river sites monitored, Aylesford continues to have the highest fecal coliform levels. During 2003, 130 main-river samples were analyzed for fecal coliforms, of which 18% exceeded the contact water recreation guideline of 200 cfu/100 ml.

In August of 2003, extremely high fecal coliform levels were recorded at a number of locations along the river. An investigation was conducted to determine the sources of the high counts. The investigation concluded the most likely cause was that of contamination of the sampling equipment. Following an examination of all sampling equipment, the contamination was found to be isolated to only two samplers. The fecal coliform results from the contaminated samplers have been removed from the River Guardians database, and are not included in the following analysis. Actions are currently underway to prevent this from occurring in the future.

Dissolved oxygen levels in the river, when examined over the period of 1992 to 2003, have been found to be highly variable, with no evident trend. Dissolved oxygen levels along the main river are generally good, with the exception of the Aylesford site.

Temperature monitoring has indicated that during the summer months, the river becomes progressively warmer as one progresses downstream, with Bridgetown recording temperatures approximately 3ºC higher than Aylesford. The monitoring data appears to indicate a possible warming trend in water temperatures during the summer months, particularly since 1996. The summer mean water temperature for 2003 was 19.9ºC. Should this trend continue, this raises concerns for the health of aquatic life in the river, in particular, trout and salmon species.

Introduction

History

The Annapolis River Guardians volunteer monitoring program began collecting water quality data in the Annapolis River watershed in 1992. The Clean Annapolis River Project (CARP) initiated the program as a public awareness project, and has had numerous volunteers test for a variety of parameters over the years. It is one of the longest running and most extensive volunteer based water quality programs in Eastern Canada. It is also CARP's longest running and only on-going project. At least 200 volunteers from the Annapolis Watershed community have participated in the program over the years, with over 3500 water samples being collected and analyzed.

The program was initiated in the early 1990's by Dr. Graham Daborn and Dr. Mike Brylinsky of the Acadia Centre for Estuarine Research. Many groups were involved in the planning process for the program, including staff with the Nova Scotia Department of Health, the Nova Scotia Department of Environment, Nova Scotia Community College, and CARP. Although the program has undergone slight changes over the last ten years, the basics remain the same, and the Annapolis River Guardians program is still going strong.

The initial program design called for 11 sites to be monitored by 17 volunteers. The initial response from the community was excellent and the project was significantly expanded between 1992 and 1994. In 1994, 38 sites were monitored by 43 River Guardians from 36 households (Pittman *et al* 2001). This intensity of monitoring placed considerable strain on the capacity of CARP. While some of the initial enthusiasm surrounding the program has diminished, a core group of 10 to 15 dedicated volunteers has been maintained over the past number of years.

Program Objectives

The Annapolis River Guardians program has four objectives:

- To establish and support a regular observation system which will provide an early warning of environmental problems.
- To provide a long term record of the river's health.
- To develop interest in the Annapolis River and community stewardship to ensure a viable resource for future generations.
- To provide a knowledgeable group of local individuals who can promote the preservation, rehabilitation, and use of these aquatic resources in the future.

Overview of 2003 Monitoring Season

The 2003 monitoring season commenced on April 27 and concluded on November 16. Samples were collected fortnightly, with a total of 152 samples being collected for analysis during the season. Samples were analysed for a variety of parameters, including fecal coliform, dissolved oxygen, temperature, nitrates and nitrites. Further information on the testing procedures can be found in Appendix A.

During 2003, 11 stations along the Annapolis River and Black River were sampled. In addition, two sample stations in Round Hill and one on the Allains River were also monitored. This monitoring was actively supported by the program's 14 dedicated volunteers. Further information on these and historic sampling locations is contained in Appendix B. The following section of this report describes the monitoring results for the main-river and Black River sampling locations, unless otherwise noted. The results for Allains River and Round Hill sites are summarized in Appendix C. Figure 1 shows the Annapolis Watershed and the 2003 monitoring sites. The data collected by the volunteers is stored in an Access database, as well as a publicly accessible web-based, searchable database at www.fundybay.com

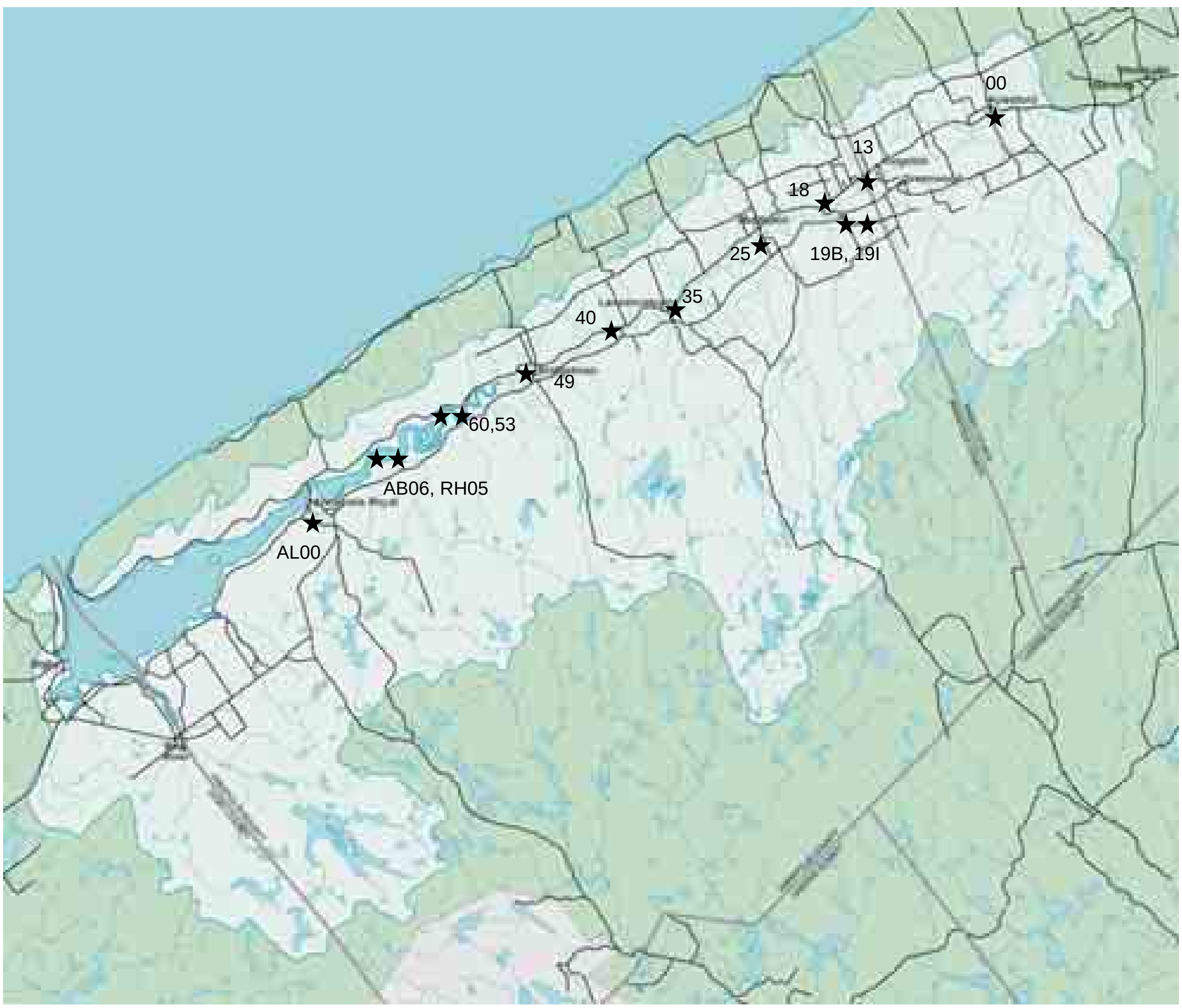

Figure 1: Annapolis Watershed with Monitoring Sites

The 2003 River Guardian Sampling Locations were:

60	Centrelea	19I	Black River
49	Bridgetown	19B	Black River
40	Paradise	18	Wilmot
35	Lawrencetown	13	Kingston
25	Middleton	00	Aylesford
AB06	Aboiteaux Creek, Round Hill	RH05	Round Hill
AL00	Allains River	53	Bloody Creek

In August and September 2003, a number of extremely high fecal coliform counts were found at several sites on the Annapolis River. A subsequent investigation indicated that the high counts were most likely the result of the contamination of sampler equipment. All water samplers were examined, with the problem confined to only two of the units. The fecal coliform results from the contaminated samplers have been removed from the River Guardians database, and are not included in the following analysis. This investigation, and the follow-up actions to prevent its recurrence, are described in Appendix D.

2003 Monitoring Results

The following sections describe the monitoring results for the main-river sampling locations.

Fecal Coliform

Introduction

Fecal coliforms have been identified in the past as a major cause of concern in the Annapolis River watershed (Pittman *et al* 2001), and are widely used as an indicator of human pathogens. The intestines of warm-blooded animals are the predominant source of fecal coliform bacteria.

In the Annapolis River watershed, potential sources of fecal contamination include central sewage treatment plants, malfunctioning on-site septic systems, aquatic wildlife (i.e. beavers, muskrats, waterfowl), agricultural livestock and manure. Many factors in a particular ecosystem affect the abundance of fecal coliforms in rivers. In addition to factors that affect die-off, other factors include the type of source, the transport mechanism with which the fecal coliform is deposited, and soil types. The result is that fecal coliform densities are highly variable.

The survival of fecal coliforms in surface waters is not well understood, and is dependent on many factors. These include the rate of predation by other microbes, amount of sunlight, salinity of the water, and composition and abundance of sediment (Davies *et al* 1995). There are a range of estimates for the survival times of *E.coli* :

- Cow pats: 49 days at 37°C, 70 days at 5°C (also dependent on moisture content) (Chalmers *et al* 2000)
- Drinking water: Between 28 and 84 days (Edberg *et al* 2000)
- Soil Cores with grass roots: 130 days (Chalmers *et al* 2000)
- In situ Freshwater Sediment: 57days (Davies *et al* 1995)

Canadian Water Quality Guidelines

Various governmental agencies have created water quality guidelines to protect the safety of the general public. Health Canada is responsible for the guidelines for drinking and recreational waters. The Canadian Council of Ministers of the Environment have incorporated these guidelines in the comprehensive Canadian Water Quality Guidelines (CCME 2002). CARP has summarized the guidelines for fecal coliform contamination into a concise table for public awareness purposes (Table 1). The table is published in the local media monthly, and is represented on highway signs at River Guardian sampling sites. The table is also periodically presented in The River Guardian, the program newsletter.

Table 1: Summary of Water Quality Guidelines for Fecal Coliforms

cfu/100ml*	Water Use	Source
0	**Acceptable for drinking**	**Health Canada, fecal coliforms/100ml.**
< 50	**Acceptable for livestock watering**	**Interpretation of CCME Guidelines "high-quality water given to livestock."**
< 100	**Acceptable for food crop irrigation**	**CCME Guidelines, cfu/100ml.**
< 200	**Acceptable for recreational use**	**Health Canada, Geometric Mean should not exceed 200 cfu/100 mL.**

**cfu = colony forming units*

It should be noted that some guidelines are in maximum concentrations, while others are in geometric means over a period of time. Also, the numeric "50" in the table for acceptable livestock watering is based on rationale for coliforms from experiences in Ontario (CCME), not fecal coliforms.

Monitoring Results

The River Guardians fecal coliforms data from the last eleven years are analyzed below, with trends identified. Fecal coliform densities are site and time specific (although to what extent is not known in the Annapolis Watershed) and are influenced by numerous factors.

Over the period of 1992 to 2003, numerous initiatives have been undertaken which have contributed to the improvement of water quality in the Annapolis River. For example, in the winter of 1994, 14 Wing Greenwood discontinued the discharge of untreated aircraft wash-water into a tributary of the Annapolis River. In August 1998, the base discontinued the operation of its own sewage treatment plant, redirecting its waste to the Greenwood municipal facility.

While the core Rive Guardian monitoring program has been maintained over the period of 1992 to 2003, a number of modifications have been made. For example, in 1996, the collection of fecal coliform samples was standardised to a fortnightly basis. During the period of 1997 to 2002, fecal coliform numbers were determined using the IDEXX Colilert procedure, which specifically identifies *E. coli*. With the change to a new laboratory, the 2003 samples were analyzed using the Membrane Filtration procedure, which enumerates fecal coliforms. (See Appendix A). Fecal coliform results are presented as colony forming units per 100 ml of sample (cfu/100 ml).

a) How have fecal coliform counts changed over 11 years of monitoring on the main Annapolis River?

The inherent variability of fecal coliform measurements presents a number of challenges with respect to data analysis. Samples collected from a single site can vary by two and sometimes three orders of magnitude (e.g. 3 cfu per 100 ml to 3000 cfu per 100 ml). The use of standard data analysis methods, such as calculating and comparing mean values, inadequately describe the distribution of fecal coliform results. The following analysis is therefore based on the proportion of samples analysed that exceed particular water quality thresholds.

Table 2 presents the proportion of fecal coliform samples exceeding 50 cfu/100 ml, the water quality guideline for livestock irrigation. Table 3 presents the proportion of fecal coliform samples exceeding 100 cfu/100 ml, the water quality guideline for food crop irrigation. Table 4 presents the proportion of fecal coliform samples exceeding 200 cfu/100 ml, the water quality guideline for contact recreation.

Table 2: Proportion of Fecal Coliform Samples Exceeding 50 cfu/100 ml

	Aylesford	Kingston	Wilmot	Middleton	Lawrencetown	Paradise	Bridgetown
1992	1.00	0.33	1.00	1.00	1.00	1.00	
1993	0.91	0.79	0.81	0.86	0.93	0.86	
1994	0.83	0.73	0.88	0.91	0.81	0.86	0.92
1995	0.40	0.14			0.80	0.50	0.71
1996	0.50	0.80		0.75	0.93	0.75	0.80
1997	0.86	0.81	0.81	0.88	0.71	0.50	0.65
1998	0.92	0.75	0.40	0.50	0.55	0.60	0.75
1999	0.86	0.67	0.71	0.55	0.33	0.43	0.65
2000	0.60	0.53	0.45	0.46	0.50	0.57	0.36
2001	0.67	0.83	0.83	0.54	0.33	0.55	0.20
2002	1.00	0.53	0.64	0.38	0.38	0.20	0.60
2003	1.00	0.90	1.00	0.56	0.50	0.50	0.55

From the data presented in Table 2, it is evident that a high proportion of samples exceeded 50 cfu/100 ml at all sites during the early years of the program (1992,1993 and 1994). During recent years, a decreased proportion of samples from the lower river sample sites have exceeded the 50 cfu/100 ml threshold.

Figure 2 presents the proportion of fecal coliform samples collected in 2003 that exceeded 50 cfu/100 ml. This graph presents a clear distinction between the monitoring locations in the upper river (Aylesford, Kingston and Wilmot) and those on the lower river.

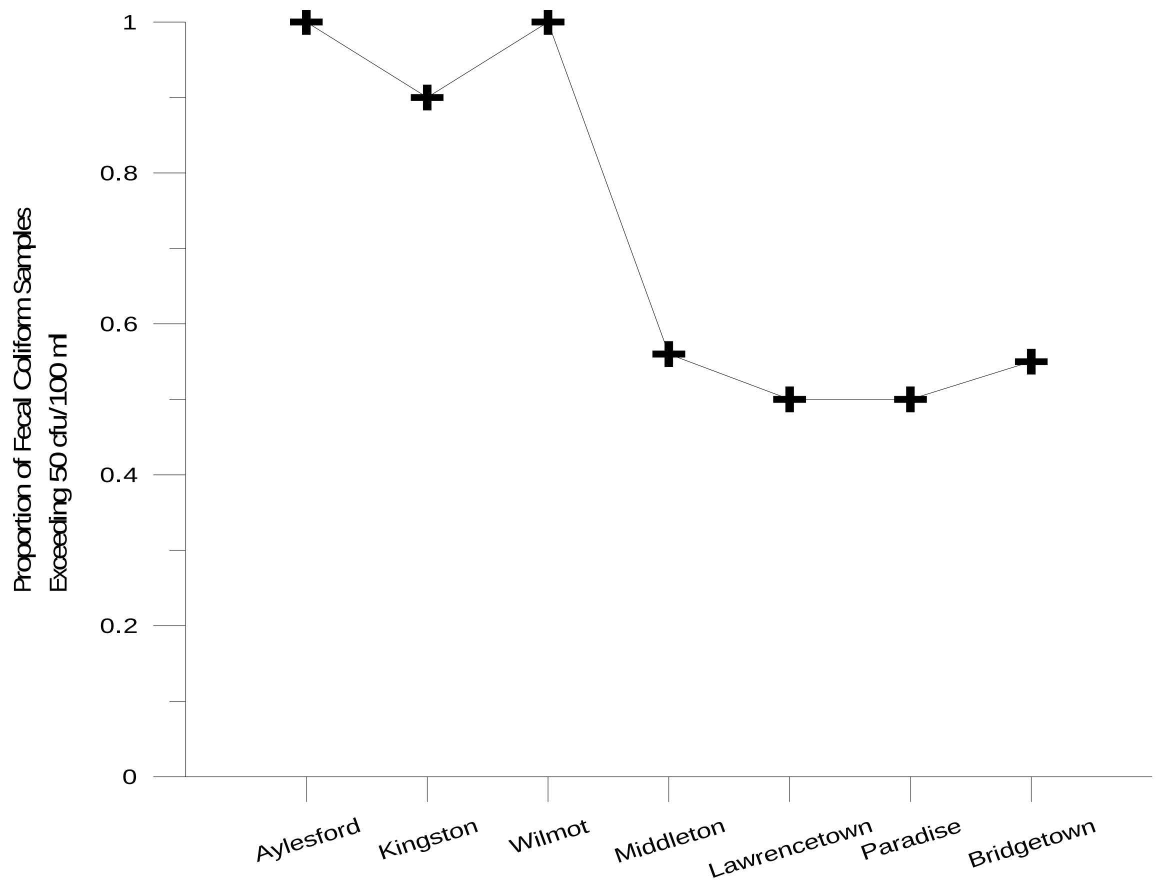

Figure 2: Proportion of 2003 Fecal Coliform Samples Exceeding 50 cfu/100 ml

Table 3: Proportion of Fecal Coliform Samples Exceeding 100 cfu/100 ml

	Aylesford	Kingston	Wilmot	Middleton	Lawrencetown	Paradise	Bridgetown
1992	1.00	0.00	0.67	0.67	0.67	1.00	
1993	0.82	0.57	0.69	0.71	0.79	0.71	
1994	0.67	0.55	0.88	0.82	0.75	0.57	0.69
1995	0.40	0.14			0.80	0.50	0.57
1996	0.50	0.50		0.63	0.79	0.56	0.60
1997	0.71	0.44	0.69	0.63	0.36	0.14	0.53
1998	0.83	0.50	0.10	0.50	0.27	0.40	0.25
1999	0.71	0.53	0.43	0.45	0.00	0.29	0.41
2000	0.60	0.40	0.27	0.23	0.33	0.43	0.07
2001	0.56	0.42	0.50	0.31	0.08	0.45	0.13
2002	1.00	0.33	0.29	0.06	0.38	0.10	0.27
2003	0.70	0.80	0.45	0.33	0.29	0.25	0.36

Table 3 presents the proportion of River Guardian fecal coliform samples that exceed 100 cfu/100 ml, the CCME guideline for food crop irrigation. Of the sites monitored, a relatively high proportion of the samples collected at Aylesford exceed this threshold. For 2003, 0.70 or 70% of the samples collected at Aylesford exceeded 100 cfu/100 ml. A number of sites further downriver have shown progressive improvement over the period of 1992 to 2003 with respect to this threshold. An example of this would be the data for Lawrencetown, which is presented in Figure 3.

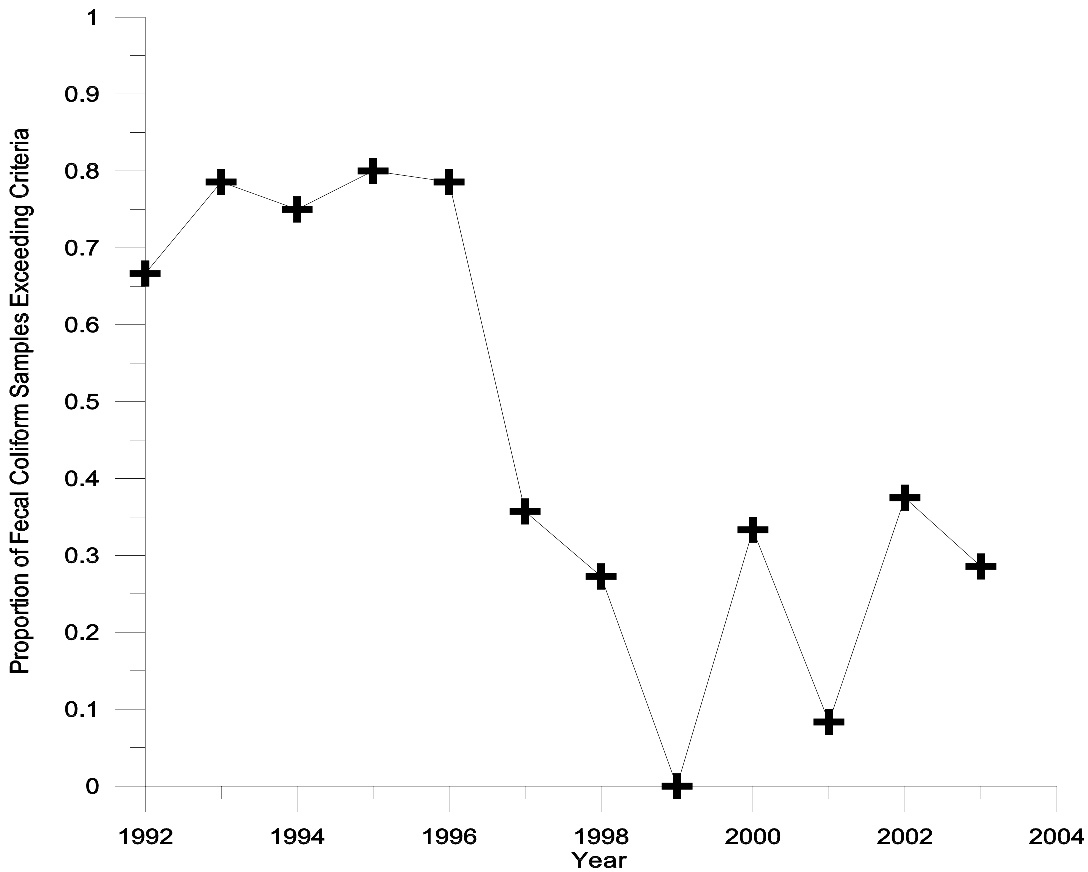

Figure 3: Proportion of Fecal Coliform Samples Exceeding 100 cfu/100 ml at Lawrencetown

Table 4: Proportion of Fecal Coliform Samples Exceeding 200 cfu/100 ml

	Aylesford	Kingston	Wilmot	Middleton	Lawrencetown	Paradise	Bridgetown
1992	0.50	0.00	0.67	0.67	0.33	0.33	
1993	0.55	0.21	0.50	0.29	0.57	0.36	
1994	0.50	0.55	0.56	0.55	0.31	0.57	0.46
1995	0.20	0.14			0.40	0.33	0.29
1996	0.50	0.40		0.38	0.43	0.44	0.40
1997	0.43	0.13	0.19	0.13	0.07	0.07	0.06
1998	0.58	0.13	0.00	0.25	0.09	0.20	0.08
1999	0.43	0.33	0.29	0.18	0.00	0.14	0.18
2000	0.40	0.07	0.18	0.15	0.25	0.43	0.00
2001	0.22	0.25	0.33	0.15	0.08	0.09	0.13
2002	0.50	0.13	0.14	0.00	0.00	0.00	0.13
2003	0.10	0.40	0.27	0.22	0.21	0.08	0.27

Table 4 presents the proportion of River Guardian fecal coliform samples that exceed 200 cfu/100 ml, the CCME guideline for contact water recreation. The data indicates a general improvement with respect to this threshold, particularly those on the lower river. Figure 4 presents the proportion of fecal coliform samples collected at Middleton that exceed 200 cfu/100 ml. While the data is highly variable, a general trend of improvement is observed.

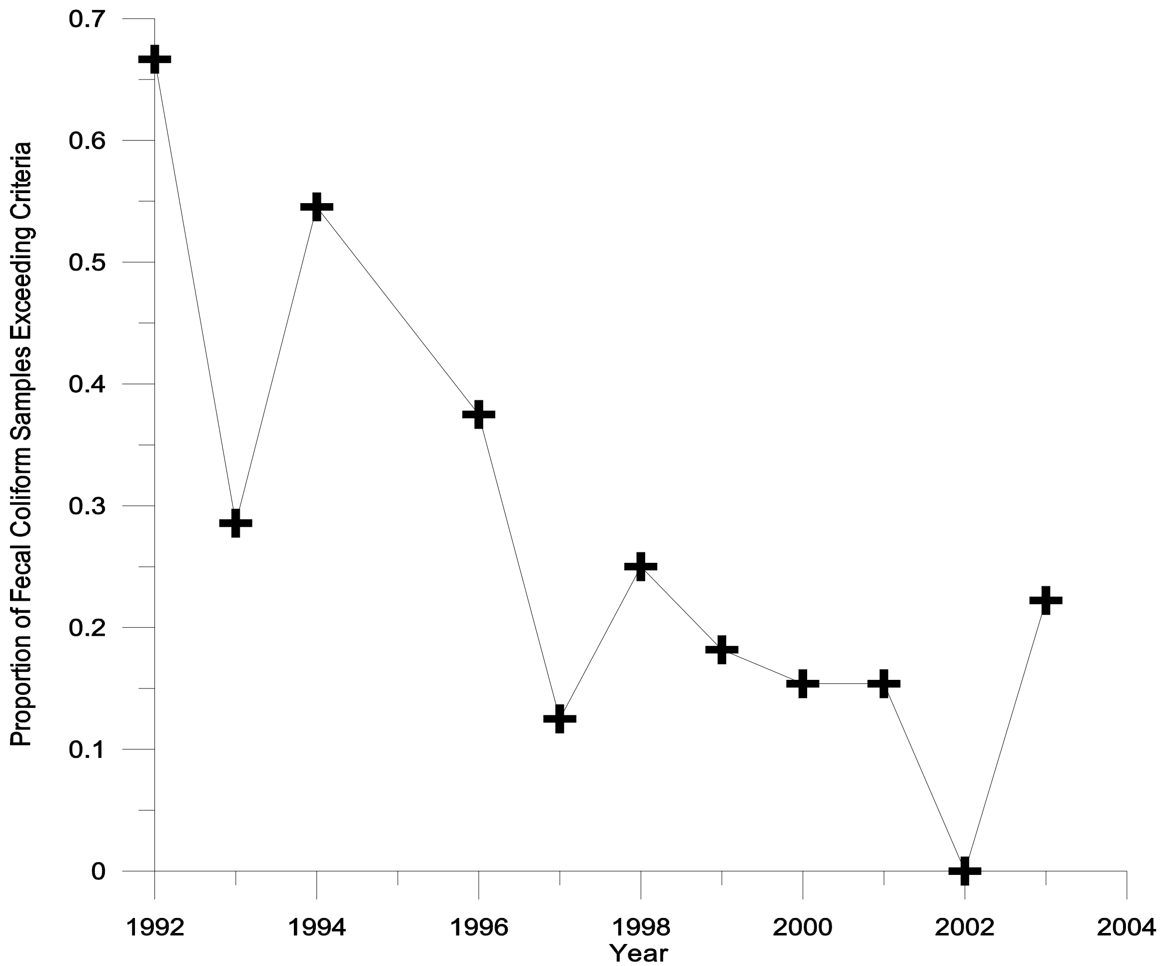

Figure 4: Proportion of Fecal Coliform Samples Collected At Middleton Exceeding 200 cfu/100 ml.

Dissolved Oxygen

Introduction

Dissolved oxygen (DO) is a widely used and important general indicator of the health of a river system (Addy *et al* 1997). Dissolved oxygen in solution is required by aquatic organisms, just as terrestrial organisms need oxygen for external respiration. Oxygen in the atmosphere, which is readily available to terrestrial organisms, must be dissolved into the water and is present at much lower concentrations. Wind, wave action, rainfall, and photosynthesis help aerate waterways and increase dissolved oxygen levels. Sewage, other high organic inputs and lower rates of photosynthesis due to ice cover can lead to decreased oxygen levels.

As the temperature of water decreases, a greater concentration of oxygen is able to dissolve in the water. The amount of oxygen in water can be report to two ways, as a concentration measurement (mg/L) or as percent saturation. The percent saturation measurement has a theoretical maximum of 100%, and incorporates the temperature of the water.

Monitoring Results

a) How have Dissolved Oxygen levels changed over 11 years of monitoring on the main Annapolis River?

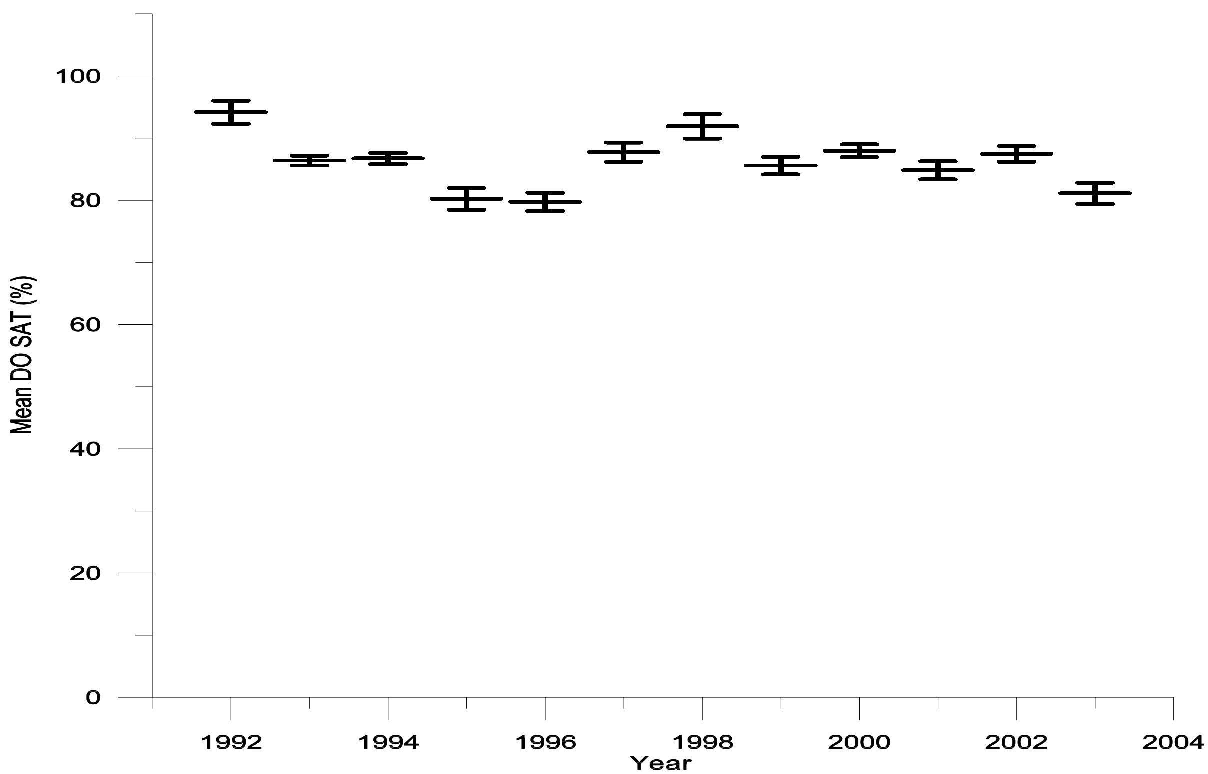

Figure 5: Mean Dissolved Oxygen Saturation (DO SAT) by year 1992 to 2003 (showing standard error of the mean) (using 2003 sampling locations only)

During the period of 1992 to 2003, annual mean dissolved oxygen (percent saturation) levels have varied from a high of 94.2% in 1992, to a low of 79.7% in 1996 (Figure 5). For the values recorded during 2003, the mean dissolved oxygen saturation was 81.1%. There does not appear to be any trend in the data over the 11-year period.

b) How do Dissolved Oxygen levels differ between each of the main river sites?

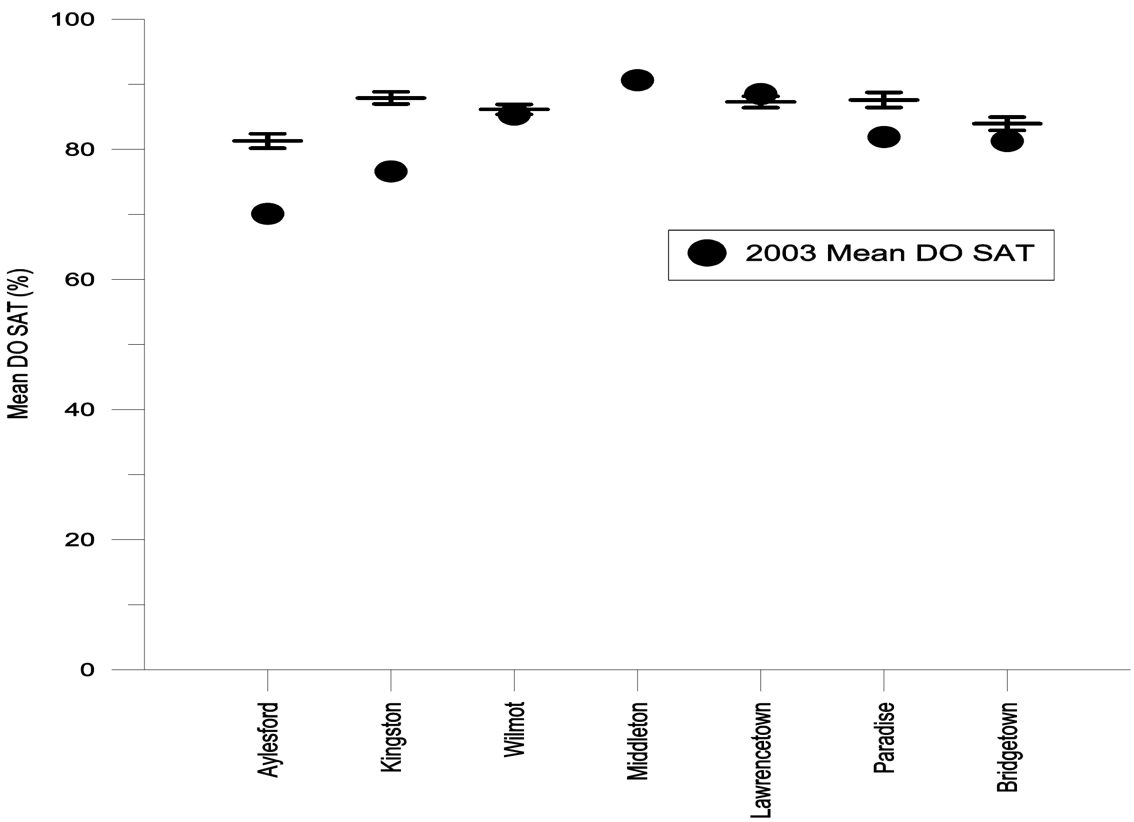

Figure 6: Mean Dissolved Oxygen Saturation (DO SAT) by sampling site, 1992 to 2003 (showing standard error of the mean)

Figure 6 presents the 11-year mean dissolved oxygen (percent saturation) values for each of the main river monitoring sites. The standard error of this mean is shown with error bars. This is overlaid with the mean values for the 2003 monitoring season. For the Aylesford and Kingston sites, the 2003 data is approximately 11% lower than the 11-year average. Annual dissolved oxygen values for Aylesford and Kingston, for the past several years, have been examined. From this data, there does not appear to be a statistically significant decreasing trend. Based on this, it must be concluded that the lower values for 2003 must therefore be the result of natural variability, sampling error or an environmental factor occurring in 2003. An 11-year mean for Middleton is not available, as dissolved oxygen monitoring was not conducted at this site during 1995, 1996, and 1997.

c) Which River Guardian monitoring sites experienced low dissolved oxygen levels in 2003?

Table 5: Dissolved Oxygen Percent Saturation (DOSAT) Thresholds for Annapolis River.

Site	Number of Samples Collected in 2003	Percentage with DOSAT below 60%	Percentage with DOSAT below 75%	Percentage with DOSAT above 75%
Aylesford	26	15	31	69
Kingston	24	0	17	83
Wilmot	27	0	7	93
Black River (B)	14	0	0	100
Black River (I)	14	0	0	100
Middleton	23	4	9	91
Lawrencetown	29	0	3	97
Paradise	25	0	0	100
Bridgetown	26	0	4	96

The data presented in Table 5 identifies the Aylesford site as having the lowest dissolved oxygen levels. Of the 26 dissolved oxygen measurements recorded at Aylesford in 2003, 15 percent had percent saturation levels below 60%. Dissolved oxygen levels below 60% saturation are known to cause stress to aquatic life, including fish. The Middleton site also has one sample with a DOSAT below 60%. Dissolved Oxygen levels at the other River Guardian sites were generally good.

Temperature

Introduction

Water temperature, like dissolved oxygen, serves as a broad indicator of water quality. The temperature of water has a direct bearing on the aquatic species present and their abundance. For example, trout and salmon species experience stress at water temperatures in excess of 20ºC, with lethality occurring with prolonged exposures to temperatures over 24ºC (MacMillan *et al*, 2003).

Monitoring Results

For the following analysis, the data has been grouped into 3 periods as follows: Spring (April, May, June), Summer (July, August, September), and Fall (October, November, December).

a) How do water temperatures change over the course of the river?

Figure 7 presents the mean water temperature for spring, summer and autumn along the main Annapolis River. As expected, there is a trend in the warming of the river, the further downstream the sampling location. This is particularly the case with the summer data. Between Aylesford and Bridgetown, the temperature of the Annapolis River increases by approximately 3ºC during the summer.

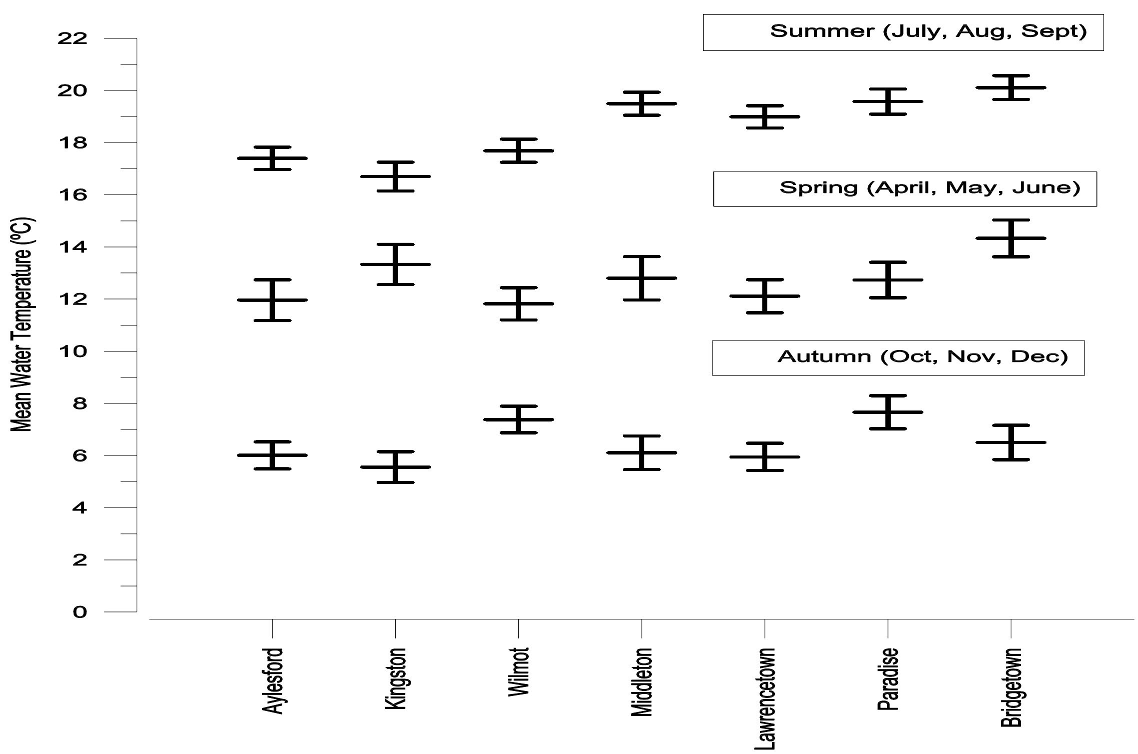

Figure 7: Mean Seasonal Water Temperature by Site, 1992 to 2003
(showing standard error of the mean)

b) How have water temperatures changed on an annual basis over the entire river?

Figure 8 presents the mean seasonal water temperature for all the mainstem monitoring sites. The data for the summer months may indicate a warming trend in the river particularly between 1996 and 2003. The magnitude of this change over this period is potentially significant and cause for concern, particularly should the trend continue.

The Nova Scotia Department of Agriculture and Fisheries, in cooperation with community environmental groups, has been conducting a temperature-monitoring program in many of the province's rivers (MacMillan *et al*, 2003). Since the program has been operating for only 3 years, there is insufficient data to provide multi-year trend analysis. Between June 15 and September 5, 2001, a temperature logger was placed in the Annapolis River, which recorded temperatures every 30 minutes. The mean temperature recorded for this period was 20.9 ºC. This correlates well with the 2001 summer mean temperature recorded by the River Guardians of 19.8ºC.

Mean monthly air temperatures, as recorded at Greenwood, have been examined over the period of 1992 to 2001. Over period, the mean monthly air temperatures for July, August and September appear to exhibit a warming trend of approximately 1ºC.

There may be numerous factors leading to the apparent warming trend in summer water temperatures in the Annapolis River. These may include increases in air temperatures, and changes in land use in the watershed. The loss of riparian buffers, which provide shade to streams and rivers, has been shown elsewhere to result in increases in water temperature (Brown, 1991). While no comprehensive study of land use change has been conducted, forestry and agricultural activities along tributaries, coupled with the loss of shade trees along the main river, are thought to contribute in part to the warming observed.

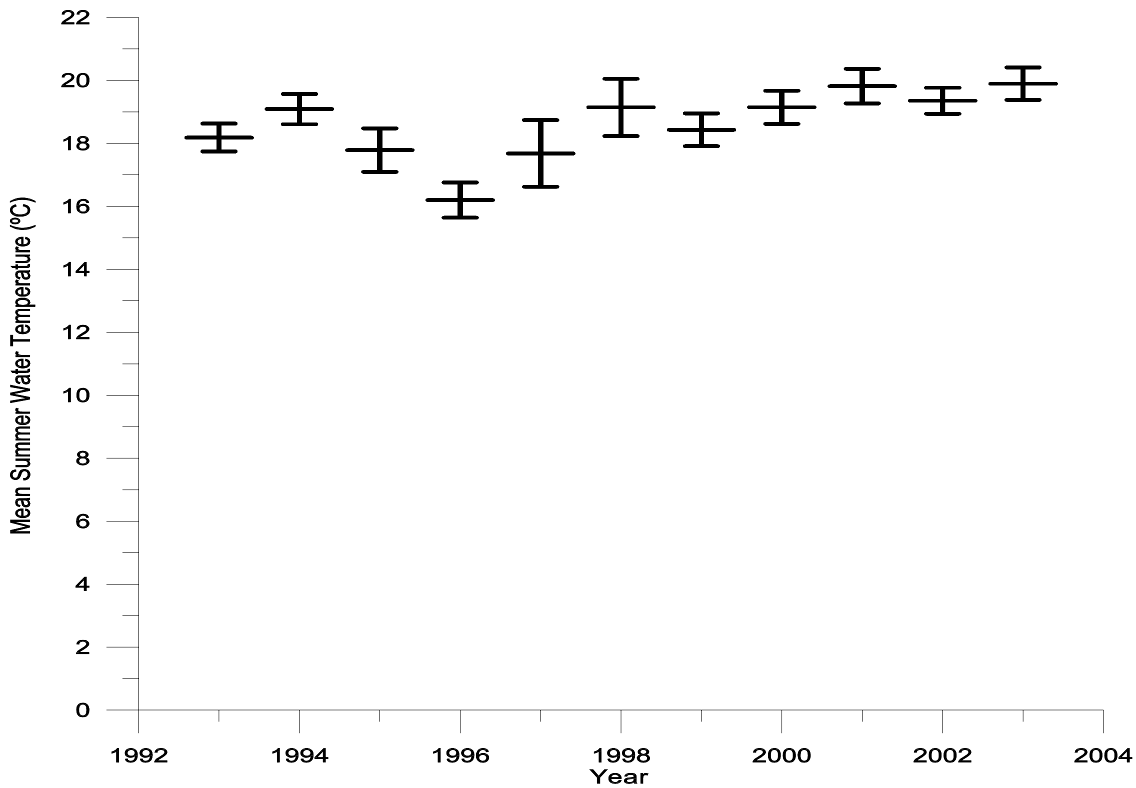

Figure 8: Mean Summer Water Temperature by Year, 1992 to 2003
(showing standard error of the mean)

Nitrates and Nitrites

Introduction

Elevated levels of nitrogen in aquatic systems can originate from a variety of sources, including municipal waste water, the use of chemical fertilizers and manure on agricultural land, industry, and atmospheric deposition. Nitrate concentrations in the range of 1 to 10 mg/L have been found to have adverse effects on salmon and trout eggs. Nitrates are also thought to be at least partly to blame for declines in amphibian populations in Canada. Nitrite concentrations in the range of 1 to 3.5 mg/L have been observed to have an adverse impact on amphibians (Indicators and Assessment Office). When comparing these values with the data below, 1 ppm (part per million) can be assumed to equal 1 mg/L.

Dalziel *et al* reported in 1998 on an investigation into the inorganic water quality of major rivers in the Maritimes. During the period of analysis (1992 to 1996) this study found that the Annapolis River had some of the highest levels of nitrate + nitrite of all rivers in mainland Nova Scotia. Concentrations were found in the range of 2 to 6 ppm (nitrate + nitrite).

Qualitative determination of nitrate and nitrite concentrations was conducted using Hach Test Strips. After dipping the strips in water, volunteers matched the strip to a colour chart to determine nitrate and nitrite concentrations in parts per million (ppm). Although the test strips were stored in sealed containers with desiccant material at all times, a gradual discolouration of the strips was observed through the course of the season. For this reason, and given the qualitative nature of the colour comparison, the results presented in Table 4 must be viewed with caution. The highest mean nitrate, and second highest mean nitrite values are observed at Aylesford.

Given that elevated nitrate levels have been reported in the past on the Annapolis River, and that the 2003 monitoring recorded a number of high concentrations, it is recommended that some nitrate monitoring be undertaken in 2004, but with a different technique.

Table 6: River Guardian Nitrate and Nitrite Data

Site	Mean Nitrate (ppm)	Median Nitrate (ppm)	Mean Nitrite (ppm)	Median Nitrite (ppm)
Aylesford-00	2.1	1.00	0.56	0.23
Kingston-13	1.4	1.00	0.00	0.00
Wilmot-18	1.4	1.00	0.01	0.00
Middleton-25	0.1	0.00	0.02	0.00
Lawrencetown-35	1.4	1.00	0.09	0.00
Paradise-40	0.6	0.50	0.02	0.00
Bridgetown-49	0.5	0.07	0.60	0.02
Centrelea-53	0.3	0.00	0.05	0.00
Centrelea-60	0.1	0.15	0.38	0.15

Conclusions

Conclusions for each parameter

Fecal coliform levels in the Annapolis River have decreased over the period of 1992 to 2003 for the downriver monitoring sites: Middleton, Lawrencetown, Paradise and Bridgetown. Of the main river sites monitored, Aylesford continues to have the highest fecal coliform levels. During 2003, 130 main-river samples were analyzed for fecal coliforms, of which 18% exceeded the contact water recreation guideline of 200 cfu/100 ml.

Dissolved oxygen levels in the river, when examined over the period of 1992 to 2003, have been found to be highly variable, with no evident trend. Dissolved oxygen levels along the main river are generally good, with the exception of the Aylesford site.

Temperature monitoring has indicated that during the summer months, the river becomes progressively warmer as one progresses downstream, with Bridgetown recording temperatures approximately 3ºC higher than Aylesford. The monitoring data appears to indicate a possible warming trend in water temperatures during the summer months, particularly since 1996. The summer mean water temperature for 2003 was 19.9ºC. Should this trend continue, this raises concerns for the health of aquatic life in the river, in particular, trout and salmon species.

During 2003, for the first time the River Guardians analysed nitrate and nitrite levels. Problems were experienced with the qualitative test strips used to conduct the measures. As such, it is not possible to draw any conclusions from the data. Further monitoring of this parameter is recommended with a different technique.

Program Specific Recommendations

- Improve training for volunteers, to ensure standardized techniques are used.
- Examine the location of monitoring sites with respect to adjacent outfalls from municipal waste water treatment facilities.
- Use this program to direct remediation. Activities need to be based on good science. Volunteers will be attracted and committed to the program only if they can see some tangible improvements being made in the watershed.

<u>REFERENCES</u>

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Appendix A

Parameters Tested

Parameters Analyzed in 2003	Additional Parameters Analyzed in Previous Years of the Program
Fecal coliform densities	pH
Dissolved Oxygen	Conductivity
Temperature (Water and Air)	Total Suspended Solids (TSS)
Weather conditions	Colour
Nitrates and Nitrites	Transparency
	Chlorophyll a
	Salinity

Methods

Fecal coliform enumeration

For the 2003 season, the membrane filtration procedure was used to determine fecal coliform densities. The analysis was conducted at the Synova Diagnostic Inc. laboratory in Lawrencetown. The Synova lab is accredited by the Canadian Association for Environmental Analytical Laboratories (CAEAL) to perform the membrane filtration procedure.

Analytical laboratories are not currently required to report the percent error with their fecal coliform results. This is currently being phased in though by CAEAL over the next 12 to 24 months. As part of its internal quality control procedures, the Synova laboratory regularly assesses the accuracy of their procedures. For fecal coliform samples in the range of 0 to 50 cfu/100 ml, the laboratory has found that their reported results are accurate to within 11% of reference standards.

Following collection, fecal coliform samples are refrigerated until delivery to the lab, typically within 24 hours of collection. A measured volume of the sample is filtered through a filter pad, which is in turn transferred onto an absorbent pad containing fecal coliform selective growth media. Samples are incubated for 24 hours at 44.5 ºC. Visible colonies of navy blue colour are counted to give the number of colony forming units (cfu) per 100 ml of sample.

From 1997 to 2003, fecal coliform densities were determined using the IDEXX Colilert procedure, to give a Most Probable Number of *E.coli* bacteria present. Preliminary investigations locally have indicated that the membrane filtration procedure and the IDEXX system provide comparable results (B. Reid, pers. com). For the analysis present in this report, it is assumed that the results from these two methods are comparable.

The analysis of fecal coliform densities presented in this report makes use of the geometric mean, which like the more traditional arithmetic mean, measures the central tendency of a data set. However, the geometric mean is less influenced by very high and very low numbers and is therefore more representative of the true tendencies in highly skewed data sets. Since it is quite normal for fecal coliform levels to vary by several orders of magnitude from one sampling event to the next, the geometric mean is a recommended method for presenting results.

Dissolved Oxygen Content

Modified Winkler Titration - See Annapolis River Guardians Procedure Manual. The Winkler titration procedure is a widely recognized standard for determining dissolved oxygen. The procedure is reported to have an accuracy of at least +/- 1 mg/L. Dissolved oxygen as percent saturation is determined using Rawson's nomogram.

Nitrate and Nitrite

Qualitative determination of nitrate and nitrite was conducted using Hach Test Strips (Catalogue No. 27454-25) as per the instructions on the container. The manufacturer provides no estimation of the accuracy of the procedure.

Appendix B

Sites Monitored

The following sites have been monitored by the Annapolis River Guardians program over the period of 1992 to 2003. The sites monitored during 2003 are highlighted. These sites also have Global Positioning System coordinates given, in Universe Transverse Mercator, as recorded on a hand-held GPS (Durland pers. comm. 2002).

SITE	LOCATION	Easting	Northing
A1	Aylesford East, Parker Road, bridge		
A21	Aylesford, Sun Valley Drive (by the Cranberry Farm)		
A22	Aylesford, Hwy 1, bridge over Patterson Brook		
00	**Aylesford, Victoria Road, bridge at the Post Office**	**353313.34**	**4985418.70**
01	Aylesford, Maple Ave. (bridge below Sewage Treatment Plant)		
A3	Millville, Bridge over South River		
A14	Auburn, Musgrave Road, bridge		
A5	Auburn, Sawmill, bridge		
A6	Greenwood, Hwy 201, (Glebe Road), bridge		
13	**Kingston, Bridge Street, bridge**	**346748.46**	**4982480.39**
14a	Kingston, Bridge St. bridge over Zeke Brook, below CFB Greenwood		
14b	Greenwood, hall Road culvert, above CFB Greenwood		
A8	Greenwood, Hwy 201, bridge over Fales River		
15a	Kingston, south from Hwy 1, railway bridge over Walker		
17a	Wilmot, south from Hwy 1, railway crossing over Wiswall Brook		
17b	Wilmot, Hwy 1, bridge over Wiswall Brook		
17e	Melverne Square, Spa Springs Road, bridge over Wiswall Brook		
A20	Wilmot, Dodge Road, river shore		
18	**Wilmot, Old Mill Road, bridge**	**342100***	**4979500***
19a	Wilmot, Todd Branch Road, bridge over Black River		
19b	**Meadowvale near Kingston, Torbrook Rd, bridge over Black River**	**343471.26**	**4979526.19**
19c	Torbrook, Uhlman Branch Road, bridge over Black River		
19d	Torbrook, Torbrook Road, bridge over Black River		
19e	Torbrook, Messenger Rd, bridge over Black River		
19f	Torbrook, Messenger Road, Black River tributary (W. of county line)		
19g	Torbrook, Messenger Road, Black River tributary (W. of R. Chase farm)		
19h	Torbrook, Meadowvale Rd. Black River tributary (E. of county line)	346261.48	4979025.04
19I	**Torbrook, Meadowvale Road, bridge over Black River**	**346967.55**	**4979305.53**
21	West Wilmot, Bayard (previously Carleton) Road, bridge		

24a	Nictaux, Hwy 201, bridge over Nictaux River at old sawmill dam		
24m	Nictaux, Nictaux River's mouth		
25	**Middleton, Highway 10, bridge**	**336981.58**	**4978044.59**
31	Brickton, Mount Hanley Road, bridge		
31-x	North Williamston, Keith Lane, bridge over Delancey Brook		
35	**Lawrencetown, Lawrencetown Lane, bridge**	**329581.15**	**4971984.70**
40	**Paradise, paradise Lane, bridge**	**325738.51**	**4970620.51**
49	**Bridgetown, Queen Street, bridge 318900**	**318900.00**	**4967621.30**
50a	Bridgetown, Highway 1, bridge over the Solomon Chute Brook		
50b	Bridgetown, Church St. bridge over the Solomon Chute Brook		
51	Bridgetown, Jubilee Park, river shore		
53	**Bridgetown, below mouth of Bloody Creek, on the river from a boat**	**317000***	**4966500***
53a	Bridgetown, Highway 201, bridge over Bloody Creek		
60	**Centrelea, 300m below Britex, on the river from a boat**	**314800***	**4965400***
A19	Belleisle, Hebb's Landing (picnic park), river shore		
64	Upper Granville, river shore or from a boat		
75.1	Granville Centre, on river from boat (surface water at the depth of 1 m)		
75.6	Granville Centre, on river from boat (subsurface water at depth of 6 m)		
75a	Granville Centre, Brun Creek		
80	Mochelle, above the mouth of the Saw Mill Creek, river shore		
81.a	Mochelle, Highway 201, bridge over the Saw Mill Creek		
81b	Mochelle, bridge over the Saw Mill Creek in South Mountain		
82	Mochelle, north of Hwy 201, Mochelle Brook mouth, river shore		
82b	Mochelle, Hwy 201, bridge over Mochelle Brook		
RH05	Round Hill River	307800*	4959900*
AB06	Aboiteaux Creek	307500*	4960300*
AL00	Allains River	302400*	4955400*

** coordinates determined from 1:50,000 map sheet*

Appendix C

Summary of Monitoring Results for Bloody Creek, Centrelea, Allains River, Round Hill River and Aboiteaux Creek

In addition to monitoring on the long-term main-river sites described above, volunteers participated in the monitoring of a number of other locations and tributaries in the watershed. These results are reported here separately, as they typically cover a shorter time span than to the long-term main-river sites.

Bloody Creek (53), Centrelea

Over the past 11 years, CARP has undertaken sporadic monitoring of Bloody Creek, near Centrelea. Samples for site 53 are typically collected by boat, near where Bloody Creek discharges into the Annapolis River. As it has been a number of years since this location was last sampled, only the 2003 data is reported here.

Date	Fecal Coliform (cfu/100 ml)
20/07/2003	113
24/08/03	167
8/09/03	396
Geometric Mean	196

Centrelea (60), Annapolis River

Over the past 11 years, CARP has undertaken sporadic monitoring of the Annapolis River near Centrelea. Samples for site 60 are typically collected by boat, near mid-stream. As it has been a number of years since this location was last sampled, only the 2003 data is reported here.

Date	Fecal Coliform (cfu/100 ml)
20/07/2003	174
24/08/03	588
8/09/03	297
Geometric Mean	312

Monitoring data from previous years for site 60 (1999 and 2000) have indicated that fecal coliform levels are highly variable, with a range of 12 to 1986 cfu/100 ml. Given this variability and the limited current data available for this site, it is not possible to draw any conclusions concerning trends in fecal coliform levels at this location.

Allains River (AY00), Near Annapolis Royal
CARP undertook preliminary monitoring of this tributary for the first time in 2003, with the support of a local volunteer. The river is principally forested and undeveloped for most of its length, before passing through the community of Lequille and discharging into the Annapolis Basin.

Date	Fecal Coliform (cfu/100 ml)	Temperature (ºC)
03/09/2003	10	12.00
16/09/2003	16	15.0
13/10/2003	10	9.50
28/10/2003	36	10.00
Geometric Mean	**15**	

Preliminary monitoring of the river in the summer of 2003 has indicated a geometric mean for fecal coliform of 15 cfu/100 ml. This is a low count, when compared with other tributaries in the watershed, with fecal coliform levels likely approaching background levels.

Round Hill River (RH05)
For the past several years, CARP has undertaken monitoring of the Round Hill River system, which is located between Annapolis Royal and Bridgetown. During 2002 and 2003, monitoring was concentrated in the lower stretches of the river, close to its discharge into the Annapolis River.

The Round Hill River is principally forested and undeveloped for most of its length, before passing through the community of Round Hill and discharging into the Annapolis River. Land uses in the lower stretches of the river are principally agriculture, including a mixed dairy/beef operation.

Date	Fecal Coliform (cfu/100 ml)
22/07/2003	2
05/08/2003	106
19/08/2003	142
28/10/2003	427
16/11/2003	43
Geometric Mean	**56**

The geometric mean for 2003 is considerably higher than the value for 2002 of 13 cfu/100 ml. Given the relatively small number of samples collected (5 samples in each of 2002 and 2003) it is unclear whether this is due to environmental changes or the result of natural variability.

Aboiteaux Creek (AB06), Round Hill

Aboiteaux Creek is a small, ephemeral tributary which discharges into the Annapolis River near the mouth of the Round Hill River. Land uses are principally grazing agriculture.

Date	Fecal Coliform (cfu/100 ml)
22/07/2003	26
05/08/2003	378
19/08/2003	34
28/10/2003	88
Geometric Mean	74

The geometric mean for 2003 is considerably higher than the value for 2002 of 19 cfu/100 ml. Given the relatively small number of samples collected (5 samples in each 2002 and 2003) it is unclear whether this is due to environmental changes or the result of natural variability.

Appendix D

Abnormally High Fecal Coliform Results – August 2003

Introduction

On August 10, a volunteer on the lower river collected water samples having Fecal Coliform counts of 8,000 and 60,000 cfu/100 ml, near Centrelea. These results were covered in several newspaper articles. The Department of Environment and Labour and Environment Canada were also notified.

On August 24, a volunteer collected a water sample at Middleton having 43,700 fecal coliforms/100 ml. On August 25, CARP staff collected a water sample on the Black River, having 53,600 cfu/100 ml.

Follow-up

Following the report of these high results, CARP conducted additional sampling on the Annapolis River, the Black River and their tributaries. All results were within normal ranges. CARP staff also conducted extensive tests of the water sampler units, to establish if they were contaminated. These tests included: collection of duplicate samples, collection of blanks from sampler units, culturing and identification of bacterial species present, and collection of microbiology swabs from sampler units.

Findings

The Synova laboratory was successful in isolating the species that gave rise to the very high counts. These were forwarded to the Kentville Hospital Microbiology lab for identification of the bacterial species present. The two bacterial species were identified as:

Klebsiella pneumoniae

- A fecal coliform – found in gut of humans & other animals, in soil and on plants and a frequent cause of hospital-acquired bacterial infections.

Acinetobacter calcoaceticus-baumannii complex

- Ubiquitous, part of normal flora of the skin, respiratory, gastrointestinal and genitourinary tracts of humans & other animals.
- Commonly found in soil and water
- Known to cause hospital-acquired bacterial infections.

All water sampler units were checked for contamination by flushing with distilled water. For the Middleton and Centrelea samplers, pale beige colonies, being too numerous to count, were recorded. All other samplers had negligible coliform counts.

Microbiological swabs were collected from the various parts (i.e. surgical tubing, end cups, discharge tube, etc) of Centrelea sampler, and two other units. The Microbiology

Lab at Valley Regional Hospital was successful in identifying the Klebsiella and Acinetobacter species, noted above.

Conclusion

The results of the above analysis were forwarded to Dr. Greg Bezanson, Acadia University, and Mr. Christopher Craig, Environment Canada, for independent expert assessment. From the examination of all the information available, they agreed that the above high Fecal Coliform results were most likely the result of contamination of the sampler units.

From the available data, the contamination appeared to be isolated to two sampler units. The source of contamination of these units remains unclear. All other samplers currently used were checked, with negligible results.

Follow-up Actions

Based on the above conclusion, the CARP Board agreed to take the following actions:

- A press release be issued describing the above conclusion, and steps to be taken to avoid a repeat of this.
- CARP membership be notified through an article in the upcoming newsletter.
- In conjunction with advice from the Department of Environment and Labour, Environment Canada, and others, develop a new procedure for the collection of Fecal Coliform samples, for implementation in 2004.
- For the 2004 season, institute a program of regular quality control checks on sampling equipment and methods.
- The River Guardians Science Advisory Committee is to be re-established
- In the future, should high Fecal Coliform counts be recorded, the Science Advisory Committee will first be consulted as to the appropriate steps to be taken.