# PROCEDURES MANUAL

## for the

## Clean Annapolis River Project
## River Guardians Programme

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# I. Introduction

Welcome to the Clean Annapolis River Project (CARP) River Guardians Programme. As a River Guardian you will be collecting valuable and much needed information on the water quality of the Annapolis River. In return for your efforts you will learn how to perform numerous tests used to evaluate water quality, learn how to interpret the results of your testing, and gain an understanding of the many factors that influence water quality. The information you will be obtaining will lead to an assessment of the water quality of the Annapolis River, identification of existing or potential problems and, if necessary, recommendations for actions to improve the water quality of the Annapolis River and, through subsequent monitoring, an idea of how successful these actions have been. The data collected will be made available to university, local, provincial and federal government agencies, and other groups having an interest or responsibility for establishing guidelines and programmes relating to water quality in the Annapolis River. Hopefully you, as an informed and knowledgeable citizen, will also become involved in decision-making processes that concern the Annapolis River.

Financial support for this programme is being provided by the Environmental Partners Fund of Environment Canada, and a variety of local business organizations who are the 'partners'. You also are a partner through the contribution of your time and effort. The funding has been made available based partly on the realization that extensive and consistent long-term monitoring is essential to realistically evaluate water quality trends, and that if left solely to government agencies the cost would be prohibitive. As a result regulatory agencies are encouraging the public to take on a greater responsibility for ensuring that our water bodies are maintained in a healthy state.

Evaluation of water quality involves measurement of a number of variables using standard procedures. This manual describes the logistics of the monitoring programme and provides details of parameters and techniques that are to be used in the CARP River Guardians Monitoring Programme. The concepts behind the techniques, as well as in the interpretation of the data collected, are not very difficult to understand and there is no reason why collecting this information need be left solely to trained scientists.

This manual is printed on waterproof paper and can be carried to the field. You will probably find, however, that after a few trips the procedures will become routine, and you will seldom have need to refer to the manual when carrying out the various field and laboratory procedures. However, it is always a good idea to have the manual nearby.

# II. Overview of the Monitoring Programme

## 1. The Value of Monitoring

Evaluating the quality of a water body, be it as small as a brook or as large as the ocean, requires consistent periodic monitoring. Water quality measurements taken at only one time, although useful, are very limited because water bodies are always changing, particularly on a seasonal basis and often on a yearly basis. It is important that these changes be documented so that natural variability can be separated from variability that reflects a real change, either positive or negative, in water quality. Without long-term data it is difficult if not impossible to determine if there are changes occurring that are a cause for concern. In fact, it is becoming obvious to many researchers that realistic evaluation of water quality requires a data base that spans at least several years, and perhaps even decades.

## 2. Description of the Annapolis River

The Annapolis River spans a distance of approximately 100 kilometers. It begins as a small stream at Caribou Bog near Aylesford and runs in a southwesterly direction to Bridgewater where it mixes with seawater to become part of the Annapolis Estuary. The difference in elevation between the source and tidal water is about 40 meters. Two large tributaries, the Nictaux River and Paradise Brook, flow into the river, together with numerous smaller tributaries. The depth of the river increases from less than a meter in the upper reaches to about 12 meters in the headpond created by the Annapolis causeway. Prior to construction of the causeway the lower 30 kilometers of the river was a tidal floodplain and experienced tides as high as nine meters in amplitude. Construction of the causeway reduced the extent of tidal influence from the area of Paradise, to Bridgetown about 15 kilometers above the causeway, and reduced the tidal amplitude to about one meter.

The land area draining into the Annapolis River (called the watershed or drainage basin) is bordered by two small land ridges, the North and South mountains, located about 15 kilometers apart, and covers an area of about 1,600 square kilometers (see the map located at the back of this manual). The underlying geology of the valley portion of the watershed is mostly sandstone while the North and South mountains are composed largely of basalt and granite respectively. Although soil fertility is low, the soils are deep and hold moisture well, making them excellent for agriculture.

Land use is primarily agricultural and residential intermixed with tracts of managed and unmanaged secondary growth coniferous forests. Cleared agricultural land totals about 26,000 hectares or approximately 16 percent of the drainage basin. Lakes, located mainly on the slopes of the bordering mountains, comprise about one percent of the drainage basin area and other wetlands, mainly marshes, cover an additional two percent. Most of the river basin population, which totals about 20,000, is located in Aylesford, Kingston, Middleton, Bridgetown and Greenwood. Farming activities include mixed farming, dairy farming, vegetable farming and fruit orchards. There is also considerable livestock farming involving beef, hogs and poultry. Industrial development within the watershed is not extensive, being generally limited to the processing of forestry and agricultural products and includes lumber mills, dairies, a distillery and a plastics manufacturing plant.

There are numerous wildlife habitats within and adjacent to the river. Sport fisheries include speckled and brown trout, salmon, striped bass and shad. Salmon, striped bass and shad are anadromous fish that come into the river from the ocean to feed and spawn. Numerous other estuarine species, such as winter flounder, are also present in the lower parts of the river. Marshlands bordering the shoreline, particularly within the estuarine part of the river, provide important nesting and feeding grounds for numerous species of wild ducks.

### 3. Water Quality Parameters

Evaluation of water quality involves sampling a water body for a number of parameters. Although a comprehensive analysis of water quality can be quite expensive and time consuming - involving determination of such things as heavy metal and pesticide concentrations - very useful and valuable information can be obtained through persistent measurement of a few very basic water quality parameters. The parameters chosen for this programme have been selected partly on the basis of their relative importance in determining overall water quality, and partly on their ease of measurement. All of the parameters are relatively simple to measure and require a minimal amount of time for both field and laboratory analysis.

Table 1 lists the parameters selected for measurement along with a brief description of the general analysis procedures. Three of the parameters deal with physical factors (water level, water temperature, and water clarity), three deal with chemistry (salinity or conductivity, pH and dissolved oxygen), and two deal with biology (chlorophyll and coliform bacteria). There are also a few, such as weather conditions, that involve simple general observations.

**Table 1. Parameters to be measured and measurement techniques.**

| Parameter | Technique |
|---|---|
| Weather Conditions | General Observation |
| Water Level | Depth Gauge |
| Water Temperature | Thermometer |
| Water Clarity | |
| Secchi Disc Depth | Secchi Disc |
| Suspended Particulate Matter | Filtration/Gravimetric* |
| Color | Visual Observation |
| Salinity (Within estuary) | Salinometer* |
| Conductivity (Within river) | Conductivity Probe |
| pH | pH Probe |
| Chlorophyll | Filtration/Spectrophotometric* |
| Dissolved Oxygen | Winkler Titration* |
| Fecal Coliform Bacteria | Membrane Filtration** |

* Requires some analysis by the CARP or ACER laboratory.

** Requires analysis at a certified laboratory.

## 4. Sampling Sites and Times

We have selected a number of specific sampling sites that span the entire watershed of the Annapolis River. These sites were chosen partly on the basis of their potential for providing the most useful information, and partly for their ease of access and sampling. Seven of the sites are located at bridges spanning the river. These were chosen because of the advantages provided by having a bridge to sample from. The remaining sites were selected to provide complete coverage of the river. All of the sites provide easy access to the river, an important concern, particularly during winter when snow cover may make travelling to a site difficult.

Some of you may want to sample at sites other than those selected, perhaps one that is of particular interest to you or especially convenient, such as in front of your summer cottage. This is perfectly acceptable and we will make every attempt to accommodate additional sites.

The logistics of the monitoring programme are designed to accommodate weekly sampling. More frequent sampling would probably be difficult with the resources available and a less frequent sampling programme does not provide adequate monitoring. It is also best that you try to monitor your site at the same time and on the same day each week, and that all sites be monitored at approximately the same time. Although this may prove impractical if a large number of sites is being monitored, it is an ideal to work towards. It is important that you understand a commitment is involved if you choose to become a River Guardian and that you must be faithful to carrying out the monitoring tasks. We hope to arrange to have each site monitored by at least two persons working together, not only for safety reasons, but also to ensure that if one partner has an unavoidable conflict, the other can carry out the monitoring tasks.

## 5. What Happens to all the Data?

The data collected will be tabulated in computer format and be made available to all agencies and persons who may wish to use it. On a monthly basis each participant will receive a summary, in easily intelligible format, of the data collected at all of the sites being monitored. This will allow each participant to compare conditions at their site with all other sites. At three to four month intervals a general meeting of all participants will be held during which time the results of the monitoring programme will be discussed. This is also the time participants will be able to meet with each other, review the programme's goals, discuss common problems and make suggestions for improvements to the programme.

## III. General Comments on Sample Collection and Analysis Procedures

Before describing the procedural details involved in measurement of the various water quality parameters, a few important points are worth noting with regard to general procedures involved in sample collection and analyses.

### 1. The Importance of Good Quality Data

It is very important that the data you collect be of an acceptable quality to those agencies who may wish to use it for various reasons. This is also important to you personally if you wish to make a point concerning a condition or change in water quality that you have observed and feel requires attention. Although the techniques you will be using are not particularly sophisticated or difficult, they are standard techniques commonly employed for measurement of water quality and, when carried out properly, will produce high quality data. Both federal and provincial agencies have been involved in the development of this programme to ensure that the data collected is both relevant and of an acceptable quality.

Obtaining reliable data requires, above all, consistency. It is important that all participants in the monitoring programme carry out the procedures in exactly the same manner. Only in this way can we be sure that the data collected at the different sites, as well as at different times, is comparable. Some participants may feel uncomfortable with some of the laboratory procedures but still wish to participate in the programme. We have tried to accommodate this by providing options for the amount of laboratory work you can choose to do. If for example, you do not desire to carry out the laboratory analysis required to measure dissolved oxygen, the sample can be stored and the analysis carried out by the CARP laboratory. This option also allows you to perform the field tasks even though, on a particular day, you may not have time to immediately carry out the laboratory tasks. Some participants, on the other hand, may wish to become more involved in the laboratory analyses and may like to volunteer time to process samples at the CARP or ACER laboratory. We would certainly welcome this initiative.

### 2. Some Hints on Working Efficiently

The following are a few basic guidelines to help you become proficient in performing the various monitoring tasks.

To work efficiently it is important to be organized. It is very frustrating to travel to the field and find that you have forgotten an important piece of sampling equipment. This is also true of laboratory equipment. Some of the analyses are best carried out as soon after sample collection as possible. If you have run out of a reagent or other essential laboratory supply, your effort in the field may become wasted. A checklist of field and laboratory equipment is provided in Section IV of this manual. **Be sure to check it before going to the field.**

It also helps greatly to develop a routine sequence for performing your sampling and analysis tasks. We make some suggestions for a logical sequence but you may find that a different sequence works better for you in which case you should feel free to make any changes. Be sure, however, that you are not undermining any logic behind the suggested sampling and analysis sequence.

Proper sampling of a water body is sometimes difficult. The idea is to obtain a ***representative*** water sample. Since conditions often change with regard to distance from the shoreline or depth, this is not always an easy task, particularly if you must sample from the shoreline in an area of shallow water and cannot easily wade into deeper water. Within the Annapolis River the best location for sample collection is probably at mid-river and mid-depth. Sampling from a boat anchored midway across the river is the optimum way to obtain a good sample but this will probably not be convenient for most participants and should only be attempted by volunteers having considerable boating experience. Sampling from a bridge, or even the end of a wharf, is a good alternative and much more convenient. If you must sample from the shoreline in an area of shallow water you will have to use a technique that allows you to reach out and away from the shoreline to collect your sample. There are various devices that can be used for this purpose and you will be provided with one if your sampling site requires it. It is especially important that **once you choose a particular spot from which to collect your water samples, all subsequent samples are collected from the same spot.**

If you are sampling from a boat or bridge, be sure that the end of the line attached to your sampling equipment is securely fastened to a solid object. It is surprisingly easy to have a line slip out of your hand with the resulting loss of a piece of equipment.

Use a pencil for recording data. Many pens contain inks that are water soluble and a single drop of water can easily make your recordings illegible. And be sure not to rely on your memory to record data at a later time. The results of measurements are easily forgotten or confused and should always be recorded immediately.

Many of the laboratory analyses involve analytical procedures which must be carried out carefully to produce reliable results. Some of the steps of a particular procedure may require more care than others. The best way to determine where you have to be careful and where you can be a bit sloppy during a procedure is to be sure that you understand the reason behind each step of the analysis. This is also true with regard to how soon the laboratory analyses should be carried out following sample collection. We have tried to indicate the critical steps in the specific instructions dealing with each procedure.

You will have to set up a small space at home to serve as a laboratory. This might be in your basement, garage, workshop or kitchen. It need not be a permanent space, but if you can dedicate a space for laboratory work, it will simplify setting up your equipment and allow you to carry out the laboratory tasks a bit more quickly. Remember to clean up well afterwards (especially if you happen to work in a kitchen that is not yours!). Wash and rinse all glassware after use, and be sure to clean up any reagent spills.

### 3. Safety

Safety is also an important concern (River Guardians are valuable and we don't want to lose any of you!!). Be careful if working from a boat, bridge or the edge of a steep bank. The use of a boat should only be attempted by persons having experience in safe boating procedures. We hope that all Guardians will be able to work in pairs; If that is not possible, **when departing for the field always let someone else know exactly where you are going and at what time you expect to return.** Be especially careful about sampling when ice is present on the river. We do **not** encourage you to attempt walking over ice or making holes in ice in order to collect water samples.

Treat reagents as though they were strong medicines. Some are very caustic and it is important to keep them out of the reach of children and pets. They should also be stored in a cool, dark place. If you accidentally spill a reagent onto your skin, or some splashes into your eye, flush the area immediately using large amounts of water. We will be providing you with safety information on all the reagents you will be using. If need be, you can obtain further information from the Poison Control centre at 1-428-8161, or call any of the contact persons listed at the end of this manual as being knowledgeable about the laboratory procedures used in the monitoring programme.

## IV. List of Field and Laboratory Equipment

### 1. Field Equipment:

Techniques Manual
Clipboard and Field Data Sheets
Pencils
Two 1 liter Plastic Sample Bottles (for Chlorophyll and SPM)
100 ml Sample Bottle (for Salinity)
100 ml Sterile Sample Bottle (for Fecal Coliforms)
Dissolved Oxygen Sample Bottle
Reagent I Powder Pillows (Manganous Sulfate)
Reagent II Powder Pillows (Alkaline Iodide-Azide)
Thermometer
Water Sampler with Messenger / or Bucket and Rope
Secchi Disc with 10 Meter Line
pH Meter
Scissors or Pocket Knife
Backpack to Carry Equipment to Field
Conductivity Meter

### 2. Laboratory Equipment:

Dissolved Oxygen Apparatus:
- PAO Titrant
- Sulfamic Acid Powder Pillow
- Saturated Starch Solution
- Burette Stand
- Burette Clamp
- 25 ml Titration Burette
- Funnel
- 250 ml Graduated Cylinder
- Small Plastic Bucket

Filtering Apparatus:
- Hand Operated Vacuum Pump
- Filter Holder

Vacuum Filtration Flask
1000 ml Graduated Cylinder
Forceps
Whatman GF/F Glass Filters
Millipore 0.45 *u*m Filters (weighed in containers)

Other:

Conductivity Meter
Calibration Solution for Conductivity Meter
ph Buffers (pH 4 and 7)
4 Small Plastic Beakers
Distilled Water
Clear Glass Jar or Test Tube
Small Screwdriver
Gummed Labels
Small Styrofoam Cooler
Wash Bottle
Filter Containers

## V. Sample Data Sheets for Field and Laboratory

You will be provided with two separate data sheets, one for data collected in the field and one for data collected during the laboratory analyses. Although both are printed on waterproof paper they should always be protected by your clipboard cover.

Both data sheets are designed to help you remember the measurements to be made, samples to be collected and the analyses that need to be carried out. Generally, unless you decide on a better sequence, working from top to bottom of the data sheet, rather than skipping around it, will result in a logical sequence of sample collection and analysis.

## 1. Field Data Sheet

**FIELD DATA SHEET**
**CARP RIVER GUARDIANS PROGRAMME**

**Name 1.** _____ **Site No.** _____ **Time** _____ **Date** _____
**2.** _____

1. Weather Conditions:

   a. Precipitation:
   Rain: None ___ Drizzle ___ Moderate ___ Heavy ___
   Snow: None ___ Flurries ___ Moderate ___ Heavy ___

   b. Wind: Calm ___ Slight ___ Moderate ___ Heavy ___

   c. Cloud Cover _____ percent

   d. Air Temperature _____ °C

2. Water Level: _____ meters

3. Secchi depth: Disappears _____ meters. Reappears _____ meters.

4. _____ Collect SPM sample (in 1 liter plastic bottle).

5. _____ Collect Chlorophyll sample (in 1 liter plastic bottle).

6. Water Temperature: _____ °C

7. Conductivity: _____ ppm (Water Temp. @ Time of Reading ___ °C)

   **OR** _____ collect salinity sample (in 100 ml plastic sample bottle).

8. pH: _____

9. ___ Collect and fix dissolved oxygen sample (in glass BOD bottle).

10. ___ Collect fecal coliform sample (in 100 ml sterile bottle).

11. Miscellaneous Observations:

## 2. Laboratory Data Sheet

**LABORATORY DATA SHEET**
**CARP RIVER GUARDIANS PROGRAMME**

**Name 1.** _____ **Site No.** _____ **Time** _____ **Date** _____
**2.** _____

1. ___ Refrigerate Fecal Coliform Sample.
2. ___ Refrigerate Salinity Sample if collected.
3. Color of unfiltered water sample: _____.
4. Measure pH and conductivity and **record on field data sheet** if not done previously.
5. ml of water filtered for SPM: _____ ml
6. ml of water filtered for Chlorophyll: _____ ml
7. Color of filtered water sample: _____.
8. _____ Freeze SPM and Chlorophyll samples (in labeled plastic dishes).
9. Dissolved Oxygen Analysis:

| ml titrant Start (A) | ml titrant End (B) | ml titrant used (B-A) |
|---|---|---|
| | | |
| | | |

a. Calculate Dissolved Oxygen Concentration:

$$\text{DO (ppm)} = \frac{200 \times \text{ml titrant}}{\text{volume titrated}} = \frac{200 \times (\quad)}{(\quad)} = \_\_\_\_\_ \text{ ppm}$$

b. Water Temperature at time of collection: _____ °C

c. Percent Saturation (from nomogram): _____ %

10. Comments:

## VI. Field and Laboratory Procedures

This section describes the details of the procedures involved in collecting and processing samples. It also provides some background information on the importance of each water quality parameter and some guidelines to help you interpret your results.

Not all of the procedures described are applicable to all sites. Measurements of salinity, for example, are only appropriate for sites potentially containing salt water, such as those below Bridgetown. Because each site is unique, each participant will be provided with a separate information sheet describing what should and should not be done, along with other details about their site.

## 1. Weather Conditions

The weather conditions at the time of water sampling can influence the results obtained. Strong winds tend to mix the water column and this may resuspend bottom sediments causing a decrease in water clarity. Heavy rains may also decrease water clarity by washing soil and other materials into the river. It is therefore important that weather conditions during sampling be observed and recorded. The most important factors are air temperature, wind strength, cloud cover and precipitation.

### Field Equipment:

Thermometer

### Field Procedure:

The field data sheet contains a list of the weather conditions you are most likely to encounter. Simply check the appropriate condition.

- In estimating wind strength it is helpful to observe the tops of trees.

- Estimate cloud cover as the percent of sky covered by clouds.

- To measure air temperature, remove the thermometer from its protective case and hang it on a tree branch or bush out of direct sunlight. Allow the thermometer to equilibrate for 3 to 4 minutes and then record the air temperature to the nearest degree.

## 2. Water Level

The variation in water level in a river is influenced primarily by the amount of water entering the river via runoff and groundwater which is in turn determined largely by snow-melt and rainfall. When the water level is high the river tends to *flush* meaning that what comes in also tends to be washed out. When the water level is low, however, materials coming into the river tend to accumulate within the river. If these materials are toxic, or contain large amounts of organic matter, such as manures from urban or farm sources, the result is usually much more harmful than when water levels are high. Dissolved oxygen levels may decline, creating conditions that lead to the growth of potentially harmful microorganisms and the accumulation of toxic substances such as methane, hydrogen sulfide and ammonia. Since low water levels during summer are usually accompanied by high water temperatures this can easily lead to conditions harmful to many aquatic organisms and is often the primary cause of summer fish kills.

### Field Equipment:

Water Level Gauge

### Field Procedure:

Each of the sampling sites will be provided with a depth gauge for monitoring water depth. It will be installed in the river attached to a bridge support or some other object that is unlikely to move. Simply read the gauge and record the reading to the nearest centimeter on the field data sheet.

### 3. Water Temperature

Water temperature, and the way it varies in time and space, provides a great deal of useful information about the nature of a water body. Water temperature influences the metabolic rate of aquatic organisms, the amount of oxygen that can be dissolved in water and the sensitivity of organisms to toxic substances. Many organisms have specific temperature tolerances and are either limited in their distribution to a certain range in temperature or die when the water temperature, for some reason, falls outside their tolerance range.

**Field Equipment:**

Thermometer

**Field Procedure:**

Collect a water sample from your sampling site and fill one of your sample bottles. Remove the thermometer from its protective case and place it into the water sample. Allow the thermometer to equilibrate for 3-4 minutes and then read and record the temperature to the nearest degree.

## 4. Water Clarity

Water clarity, or turbidity, is important for aesthetic reasons as well as for the influence it may have on biological processes. A water body that is turbid often lacks enough light to allow photosynthesis and thus biological productivity of the system may be severely limited. In addition, organisms that feed by sight may have difficulty in finding food materials. If the turbidity is the result of particles suspended in the water it may result in clogging of the gills of fish and other aquatic organisms. Excessive turbidity is also an indication of severe erosion and potential siltation problems that may lead to the destruction of aquatic habitats, particularly fish spawning sites.

In addition to visual observations of water color, the monitoring programme incorporates two different measurements for determining water clarity; Secchi disc depth and Suspended Particulate Matter (SPM) concentration. Secchi disc depth provides a direct measurement of water clarity and is influenced by the presence of particulate substances as well as dissolved substances that color the water. SPM concentration provides a direct measurement of the amount of particulate material present in the water.

### 4.1 Secchi Disc Depth

The Secchi disc, named after the Italian oceanographer who invented it, is a 20 centimeter diameter white and black disc. In use the disc is slowly lowered into the water and then retrieved. The average of the depths at which it disappears and reappears is the Secchi disc depth. The clearer the water body, the larger the Secchi disc depth. Secchi disc readings can be made from a boat, bridge or the end of a wharf. Although the Secchi disc is weighted to help it sink into the water, its shape and large surface area make it difficult to use properly if there is a strong water current. As a result, there will probably be times when you will have to omit making this measurement.

**Field Equipment:**

- Secchi Disc with 10 meter Marked Line

**Field Procedure:**

1. Slowly lower the Secchi disc into the water and record the depth at which it just disappears.
2. Slowly raise the Secchi disc and note the depth at which it reappears.
3. Record both depths to the nearest tenth of a meter (0.1 m) on the field data sheet.
4. If the water depth is shallow and the Secchi disc is still visible when it reaches the bottom, make a note of this on your data sheet along with the water depth.

**NOTE:** If possible readings should be made from the **shaded** side of a boat, bridge or wharf to reduce the confounding effect of surface reflection.

### 4.2 Suspended Particulate Matter (SPM)

Measurement of suspended particulate matter (SPM) provides direct quantitative information on the amount of particulate material in a water body. Particulate materials are diverse in origin and may consist of soils that have washed into the water through land erosion, materials resuspended from the bottom of the river, as well as microscopic organisms such as algae and bacteria.

Measurement of SPM requires that you collect a 1 liter water sample and filter it through a pre-weighed filter. The particulate materials are collected on the filter which is later dried and re-weighed at the CARP or ACER laboratory. During both collection and filtering it is important that you do not contaminate the sample with foreign particles (soil, dust, pieces of paper toweling, etc.)

**Field Equipment:**

Water Sampler (if your site requires one), or a Bucket
1 liter Plastic Bottle

**Field Procedure:**

Simply collect a water sample and fill a 1 liter plastic sample bottle.

**Laboratory Equipment:**

Pre-weighed Millipore Filters (in plastic containers)
Forceps
Filter Flask
Filter Holder
Hand Operated Vacuum Pump
1000 ml Graduated Cylinder

**Laboratory Procedure:**

1. Using a blunt forceps, remove a Millipore filter from the plastic container and place it onto the center of the filter holder.

2. Gently screw the top of the filter holder onto its base, being careful not to tighten it so much that the filter becomes distorted.

3. Swirl sample bottle to resuspend particulates.

4. Pour about 200 ml of the sample into the filter housing.

5. Using the vacuum pump create a suction in the filtering flask.

6. Continue to add the sample to the filter housing until the entire sample is filtered (see Note 1). Try not to let the filter become sucked dry until after the entire sample is processed.

7. Remove the vacuum pump to release the suction, unscrew the filter housing and, using the blunt forceps, remove the filter and place it back into its original container.

8. Remove the filter holder from the filtering flask and measure the amount of water filtered by pouring it into a 1000 ml graduated cylinder.

9. Mark the container label with the **date, collection site, and ml of water filtered.**

10. Store the filter in a freezer.

**NOTE:** If the water sample contains a great deal of particulate matter, you may not be able to filter the entire sample before the filter becomes clogged. If this is the case you will probably notice that the rate of filtration becomes very slow, at which point you should stop adding water to the filter funnel. This is not a problem as long as you measure and record the total amount of water you have filtered.

**Interpretation:**

SPM levels between 0-10 are about normal for clear waters. SPM levels between 10-25 indicate moderate suspended particulate matter concentrations and levels above 50 indicate particularly high concentrations.

### 4.3 Color

Water color is closely related to turbidity and it is useful to make observations on the color of the water at the time of sampling. Water color depends on two factors: the kinds of particulate substances ***suspended*** in the water and the kinds of substances ***dissolved*** in the water. The color resulting from suspended materials is called ***apparent*** color and that caused by dissolved substances is called ***true*** color. Apparent color is caused by such things as microscopic algae and clay and silt particles. True color is usually caused by various substances leached from the soil within the watershed - especially decomposition products of plants - and then carried into the river as runoff.

Although water color is difficult to quantify meaningfully, simple observations of color before and after filtration provide useful information on apparent and true color with little effort. Since you will be filtering water samples for chlorophyll and SPM analyses, it will be easy for you to determine both the apparent and true color of your water sample. All that is required is to observe the color of a water sample before and after filtration. This is most easily done by filling a clear glass jar or test tube with the sample and holding it up to the light to observe the color. Natural sunlight is best, but any good white light will do.

**Field Equipment:**

None required

**Field Procedure:**

No special field procedure.

**Laboratory Equipment:**

A clear glass jar or test tube
A source of white light

**Laboratory Procedure:**

1. Fill the glass jar or test tube with an unfiltered water sample, hold it up to a source of white light and record the color observed as apparent color.

2. Repeat using water filtered for chlorophyll or SPM analysis and record the color as true color.

**Interpretation:**

Apparent colors you are most likely to observe are a light green due to algae or an opaque brown due to suspended clays. True color will often be a light to dark yellow-brown tea color caused by tannins and humic acids arising from the decomposition of coniferous trees. You might record this color as weak, normal or strong tea (some of you may be better in relating it to the color of Scotch). Of course in some cases the sample may have no color and will appear clear.

## 5. Salinity and Conductivity

Salinity and conductivity are measures of the amount of dissolved salts present in the water. For water bodies that have high dissolved salt concentrations, such as estuaries and the ocean, the amount of salt present is expressed as parts per thousand (usually abbreviated as ppt or ‰). Sea water has a salinity of about 35 ‰. For water bodies having lower dissolved salt concentrations, such as most freshwater systems, the amount of salt present is expressed as conductivity (a measure of the ability of the water to conduct an electrical current, which is directly related to salt content and temperature). Conductivity values are expressed in a number of different ways. The instrument you will be using measures conductivity as equivalent parts per million (ppm) of potassium chloride.

The amount of salt present in water has a strong influence on the physical characteristics of a water body. Since salt **increases** the density of water, water with a high salinity tends to sink to the bottom. In an estuary where freshwater flows toward the sea and seawater moves toward the land there is a tendency for the freshwater to float on top of the seawater. Unless the tidal forces are strong or there is a great deal of wind energy to mix the two water masses, the system will become *stratified*, i.e., the two water masses will remain unmixed, the lighter freshwater of the river lying on top of the heavier seawater. This is the case in the Annapolis River estuary where a salty bottom layer extends as far upriver as Bridgetown, and perhaps even further during spring tides. You will find a more detailed description of this in Annapolis River Issues No. 2.

The amount of salt in a water body also influences the abundance and distribution of aquatic plants and animals. This is particularly obvious in estuaries where there is a gradient from ocean to river in the abundance and species composition of sessile bottom dwelling organisms. As one moves upriver there is a gradual transition from marine to freshwater species. Particular species are adapted to live within a certain salinity range and will either migrate or fail to survive if the salinity falls outside of that range.

A stratified system presents some sampling problems. Because there are really **two** different water masses present it becomes necessary to sample both surface and bottom water which requires that a sub-surface water sampler be used, one that allows a bottom sample to be collected and retrieved without becoming contaminated with surface water. There are numerous sampling devices for this purpose and if your sampling station is one which experiences stratification you will be provided with an appropriate water sampler.

Depending on the specific location of your sampling site, you will be asked to collect a water sample for **either** salinity **or** conductivity **but not both.**

## 5.1. Salinity

### Field Equipment:

Water Sampler
100 ml Plastic Sample Bottle

### Field Procedure:

Simply collect a water sample and fill a 100 ml plastic sample bottle.

### Laboratory Equipment and Procedure:

Measurement of salinity requires special equipment and will be carried out at the CARP or ACER laboratory.

Simply store the sample, being certain the cap of the sample container is properly tightened to prevent loss of water through evaporation. You may want to store the sample in a refrigerator, but this is not absolutely necessary.

### Interpretation:

Within the Annapolis River salinities above 2-3 ‰ are a strong indication of the presence of seawater. If your sampling site is located below Bridgetown you will probably experience salinities of this magnitude or greater, especially in water samples taken near the bottom.

## 5.2. Conductivity

Conductivity can be measured in the field or, if more convenient, in the laboratory using one of the samples collected for either chlorophyll or SPM analysis. In either case, the conductivity meter must be calibrated each time just prior to use. This should be done at home, even though you may chose to measure conductivity in the field.

**Calibration Equipment:**

Conductivity Meter
Calibration Solution
Distilled Water (in squeeze bottle)
Screwdriver
Thermometer
Small Plastic Beaker

**Calibration Procedure:**

1. Remove the cap from the conductivity meter and rinse the tip of the meter with distilled water from the squeeze bottle.

2. Press the ON/OFF button to turn the meter ON.

3. Remove the top from the calibration solution and place a thermometer in the solution.

4. Place the tip of the meter into the calibration solution, being careful **not to immerse the meter above the brown color band.**

5. Allow one to two minutes for both the thermometer and meter to acclimate to the temperature of the calibration solution.

6. Read the temperature of the calibration solution.

7. Refer to the calibration chart on the following page and note the conductivity reading corresponding to the temperature of the calibration solution.

8. Using the screwdriver, adjust the small screw on the back of the meter until the display reads the appropriate value.

9. Press the ON/OFF button to turn the meter OFF, rinse the electrode tip with distilled water from the squeeze bottle, and replace the cap.

## CALIBRATION READINGS

| Water Temperature (°C) | Conductivity Reading |
|---|---|
| 10-12 | 150 |
| 13-14 | 160 |
| 15-17 | 170 |
| 18-20 | 180 |
| 21-23 | 190 |
| 24-26 | 200 |
| 27-28 | 210 |
| 29-30 | 220 |

### Field or Laboratory Equipment for Conductivity:

Conductivity Meter (previously calibrated)
Thermometer

### Field or Laboratory Procedure for Conductivity:

1. Remove the cap from the conductivity meter.
2. Press the ON/OFF button to turn the meter ON.
3. Place the thermometer into the sample.
4. Place the tip of the meter into the sample, being careful **not to immerse the meter above the brown color band.**
5. Allow one to two minutes for both the thermometer and meter to acclimate to the temperature of the sample.
6. Record the water temperature and conductivity reading on the **FIELD DATA SHEET.**
7. Turn the ON/OFF button to turn the meter OFF and replace the cap.

7. Turn the ON/OFF button to turn the meter OFF and replace the cap.

**Interpretation:**

Freshwater systems with conductivity values ranging between 0-50 ppm are considered to be ***softwater*** systems while those having conductivities greater than 100 ppm are considered

## 6. pH

pH is a measure of the acidity of a liquid. Values of pH can range between 0 and 14. pH values less than 7 indicate acidic conditions and pH values greater than 7 indicate basic conditions. A pH of 7 (the value for pure water) indicates a neutral solution. pH values are based on a logarithmic scale which means that a solution with a pH of 4 is ten times more acidic than one with a pH of 5, and 100 times more acidic than one having a pH of 6.

Seawater usually has a pH between 8.0 and 8.5 which means it is slightly basic. In addition, the pH of seawater seldom changes because many of the salts present in seawater act as buffers to counteract the effect of the addition of acids. This is why acid precipitation (i.e., rain and snow) is not usually a problem in marine ecosystems. In contrast, freshwater systems usually have much lower salt contents and, as a result, few salts to act as buffering agents to offset the effect of acidic inputs. pH values for freshwater systems usually range between 5 and 8.

Low pH values tend to be more harmful than high pH values. The acidic conditions associated with low pH results in low overall productivity, the potential for enhanced heavy metal toxicity, reduced spawning success by many fish and amphibians, and general physiological stress leading to reduced growth rates.

pH can be measured in the field or, if more convenient, in the laboratory using one of the samples collected for either chlorophyll or SPM analysis. In either case, the pH meter must be calibrated each time just prior to use. This should be done at home, even though you may chose to measure pH in the field.

### Calibration Equipment:

pH meter
Buffers (pH 4 and 7)
Distilled Water (in squeeze bottle)
2 Small Plastic Beakers

**Calibration Procedure:**

1. Fill each of the two beakers half-way with one of the two buffer solutions.
2. Remove the cap from the pH meter and press the ON/OFF button to ON.
3. Press the CAL button to enter the calibration mode.
4. Immerse the meter about 1 inch into the pH 7 buffer solution, stir gently while waiting for the display to stabilize.
5. Once the display stabilizes press the HOLD/CON button to confirm and complete the calibration.
6. Remove the meter and rinse the electrodes with distilled water using the squeeze bottle.
7. Repeat steps 3 to 6 using the pH 4 buffer.
8. Press the ON/OFF button to OFF and replace the cap.
9. Discard the used buffer solutions.

**Field or Laboratory Equipment:**

pH Meter (previously calibrated at home)

**Field or Laboratory Procedure:**

1. Remove the cap and press the ON/OFF button to ON.
2. Immerse the meter about 1 inch into the sample solution and stir gently while the meter stabilizes.
3. Once the display has stabilized note and record the pH on the **FIELD DATA SHEET.**

4. Remove the meter and press the ON/OFF button to OFF.

5. Moisten the sponge contained in the cap with a few drops of distilled water and replace the cap.

**Interpretation:**

pH values below 5 indicate potentially harmful acidic conditions and are a cause for concern. pH values above 9 are also a cause for concern, but it is very unlikely that you will ever experience values this high in the Annapolis River. Values as high as 8.5 may, however, be experienced if there is a significant amount of seawater present.

## 7. Chlorophyll

Chlorophyll is the pigment that gives plants their green color. By measuring the amount of chlorophyll in a water body we can obtain an estimate of the quantity of plant material present and this is closely related to the productivity of the system. In aquatic ecosystems there are two basic types of plants: the larger ***macrophytes*** and the smaller ***phytoplankton.*** Common macrophytes include such things as cattails, bullrushes, salt marsh grasses and seaweeds, and are mostly found attached or rooted to the bottom. Phytoplankton are mostly microscopic plants found suspended and floating within the water. The technique we will be using measurers the chlorophyll present in phytoplankton.

Measurement of chlorophyll requires collection and filtration of a 1 liter water sample, extraction of the chlorophyll in an acetone solution and spectrophotometric determination of the amount of chlorophyll present. The collection and filtration will be carried out by you, and the extraction and spectrophometric determination at the ACER laboratory.

### Field Equipment:

Water Sampler (if your site requires one)/or Bucket
1 liter Plastic Bottle

### Field Procedure:

Simply collect a water sample and fill a 1 liter plastic sample bottle.

### Laboratory Equipment and Procedure:

The equipment and procedure for processing chlorophyll samples is almost the same as that used for suspended particulate matter samples (see Section VI.4.2, p. 6) **except** for the following:

1. Use a Whatman GF/F glass filter.

2. **Do not touch the filter with your bare hands** (use forceps) as chlorophyll is a very sensitive molecule and will break down upon contact with the acids in your skin.

3. After filtration, avoid exposing the filter to bright light as this will also break down chlorophyll.

**Interpretation:**

Chlorophyll values are reported as milligrams per cubic meter of water. Chlorophyll values generally range from less than 1 to as high as 30. Values between 0-5 indicate relatively unproductive conditions. Values between 5-10 indicate moderately productive conditions. Values above 15 indicate very productive waters.

## 8. Dissolved Oxygen

Perhaps one of the most informative tests that can be carried out with regard to water quality is the level of dissolved oxygen present within a water body. As with land dwelling organisms, oxygen is necessary for most forms of aquatic life. In terrestrial systems air usually contains an abundance of oxygen which is produced and released into the atmosphere by photosynthesizing plants. In aquatic systems, for various reasons, photosynthetic plants may be absent or unable to photosynthesize due to a lack of light. If this is coupled with an input of organic matter that is decomposed by microorganisms, oxygen levels may become seriously low, resulting in such things as fish kills and the accumulation of toxic decomposition products.

Actually, what is more important than the absolute amount of dissolved oxygen present is the ***percent*** oxygen saturation. This varies greatly with water temperature. At 100 percent oxygen saturation, 0 °C water contains almost twice as much oxygen as does water at 30 °C.

Determining the amount of dissolved oxygen in a water sample is one of the more complicated techniques of the water quality monitoring programme. Care must be taken both in collecting the water sample and in measuring the level of oxygen it contains.

### Field Equipment:

Water Sampler
BOD Bottle
Reagent I Powder Pillows
Reagent II Powder Pillows
Scissors or Pocket Knife

### Field Procedure:

Taking a good oxygen sample requires some practice. The trick is to fill the sample bottle with water, add two different reagents, and then stopper the bottle without contaminating the water sample with oxygen from the atmosphere. With a little practice this becomes routine. The special BOD bottles are designed to allow the stopper to be put in place without trapping air in the sample bottle.

1. Using the water sampler, collect a water sample from the desired depth.

2. Transfer the water sample to a BOD bottle with as little agitation as possible using the following technique:

   a. Insert the siphon (the rubber tube) of the water sampler into the **bottom** of the BOD bottle.

   b. Open the spigot of the water sampler and allow the BOD bottle to overflow 2 to 3 times its volume (see **NOTE 1**).

   c. Slowly withdraw the siphon **without closing the spigot.**

3. Fix the sample by adding one Reagent I Powder Pillow (Manganous Sulfate) followed by one Reagent II Powder Pillow (Alkaline Iodide-Azide).

4. Incline the BOD bottle slightly and, with a quick twisting motion, introduce the glass stopper. **Be careful not to trap air bubbles in the BOD bottle at this point** - if this happens you will have to discard the sample and start over.

5. Mix the reagents with the sample by rapidly inverting the BOD bottle 10 to 20 times using a strong wrist-snapping motion. (If dissolved oxygen is present a brownish floc will form.)

Once the sample is fixed it can be stored for later analysis. If the sample is to be stored for more than a few hours, it should be placed **underwater** to prevent atmospheric oxygen from entering the sample as the BOD bottle expands and contracts due to changes in temperature. This can be done by placing the stoppered BOD bottle into a bucket containing enough water to cover the stopper of the BOD bottle.

Many of the River Guardians will send these samples to the CARP laboratory for final analysis. If you are one of them, this is as far as you need to go - just make sure the sample is properly kept cool and under water until the CARP courier picks it up. If you are going to do your own analysis, then go on to the laboratory procedure which follows.

**Laboratory Procedure:**

1. Using a funnel, fill the titration burette with PAO titrant to somewhere just above the 15 ml mark (see **NOTE 2**).

2. Check to be sure that the floc in the BOD bottle has settled so the upper one-half of the bottle is clear. If not, allow more time for the floc to settle.

3. Once the floc has settled remove the stopper and add the contents of one Sulfamic Acid Powder Pillow, restopper and mix using the same technique as in steps 4 and 5 of the field procedure. If dissolved oxygen is present the sample will turn yellow.

4. Remove **200 ml** of the sample by pouring it into the graduated cylinder. Set this aside as it may be needed later.

5. Add 5-10 drops of starch solution to the remaining sample in the BOD bottle and gently swirl to mix (this will turn the sample blue).

6. Note the ml of titrant in the burette and record this on the **LABORATORY DATA SHEET** (see **NOTE 3**).

7. While gently swirling the flask, slowly add titrant to the sample until the blue color **just** disappears. Disregard any reappearance of the blue color (see **NOTE 4**).

8. Record the ml of titrant remaining in the burette on the **LABORATORY DATA SHEET**.

9. Calculate ppm of oxygen in the sample as follows:

$$\text{Dissolved Oxygen (ppm)} = \frac{200 \times \text{ml titrant used}}{\text{volume titrated in ml*}}$$

* The BOD bottle holds 300 ml, but since you removed 200 ml the volume remaining to be titrated is 100 ml.

10. Calculate the percent saturation as follows:

    Using Rawson's nomogram (page 25), place a straight edge to line up with **oxygen concentration** on the lower scale and with **water temperature** (at the time the sample was collected) on the upper scale. **Percent saturation** is read off where the straight edge crosses the middle line.

11. Record ppm dissolved oxygen and percent saturation on the **LABORATORY DATA SHEET.**

**NOTE 1:** This is an important step. Allowing the BOD bottle to overflow its volume by three or four times forces out any air that may be trapped in the bottle. Failure to do this will contaminate the sample with atmospheric oxygen.

**NOTE 2:** Be careful that you do not trap air bubbles in the burette or this will result in inaccurate readings. If this does happen the bubbles can be removed by either tapping the side of the burette or, with your finger over the top, inverting the burette several times. Be sure to fill the tip of the burette (the part below the stopcock) by allowing a small amount of titrant to run out the stopcock. Collect this in a waste container and discard it.

**NOTE 3:** It may be helpful to place a piece of white paper behind the burette to make it easier to read.

**NOTE 4:** If you accidentally overrun the end-point of the titration, add an additional 20 ml of your fixed sample to the titration flask. This should make the color reappear. Re-titrate, remembering to correct for the volume titrated when using the formula in instruction 9 above (i.e., the volume titrated would be 120 ml instead of 100 ml).

**Additional NOTE:** If you have PAO titrant remaining in the burette after completing the titrations, it should be discarded—**DO NOT** pour it back into the PAO reagent bottle.

**Sample Calculations:**

1. Titrating 100 ml to the endpoint using 5.0 ml of PAO:

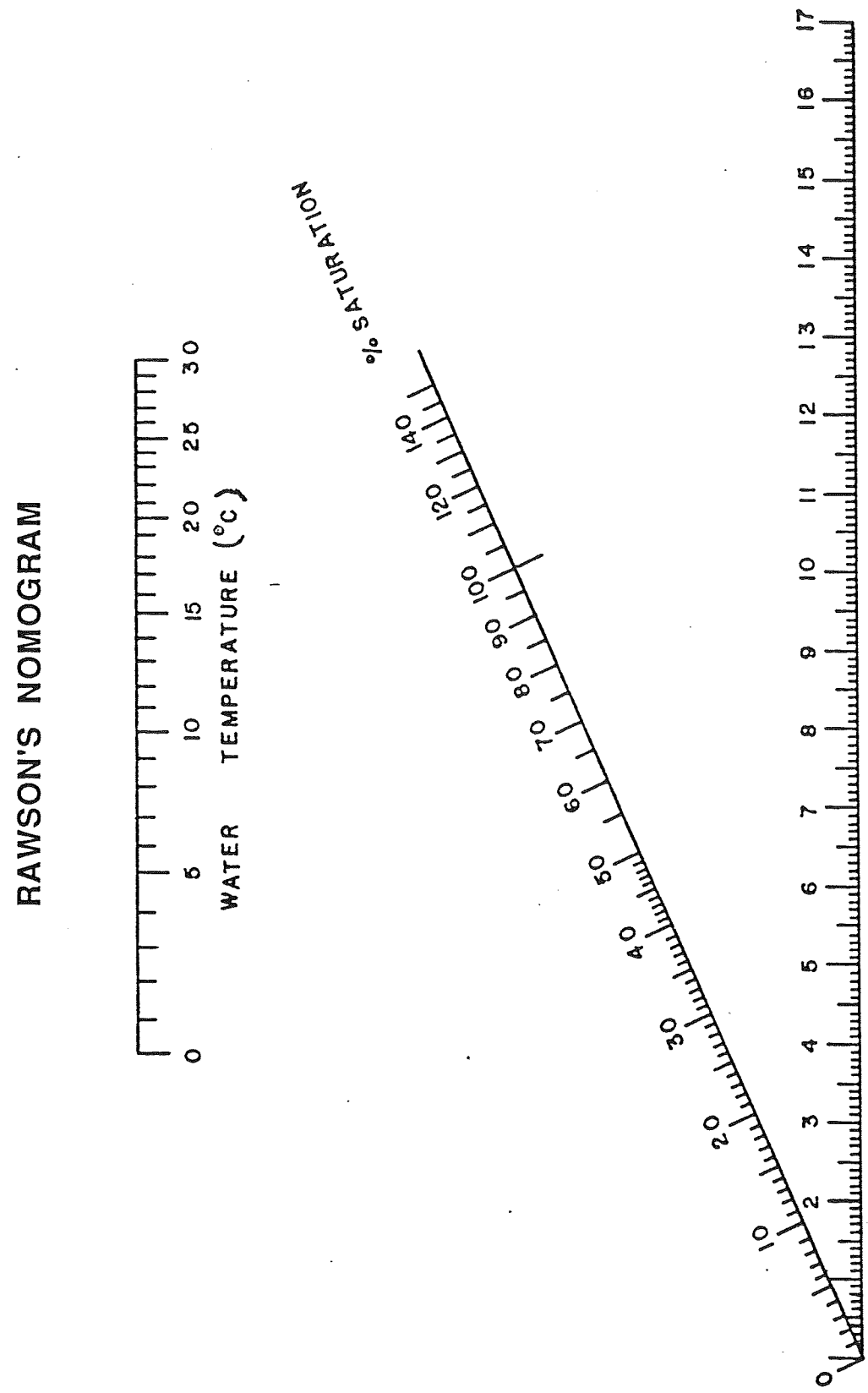
$$\text{Dissolved Oxygen (ppm)} = \frac{200 \times 5.0}{100} = 10.0$$

2. Overshooting the endpoint, adding an additional 20 ml of fixed sample, and then titrating accurately to the endpoint using a total of 6.0 ml:

$$\text{Dissolved Oxygen (ppm )} = \frac{200 \times 6.0}{120} = 10.0$$

**Interpretation:**

Generally, oxygen concentrations below 3 to 4 ppm are lethal for most fish and many other aquatic organisms. Percent saturation values above 90 generally indicate healthy conditions. Values less than 50 are cause for concern.




Rawson's nomogram for calculating percent saturation of dissolved oxygen in water in relation to temperature from saturated air at 760 mm Hg pressure.

## 9. Fecal Coliform Bacteria

Coliform bacteria are bacteria that are common in the intestines of warm-blooded animals. Although they are not toxic in themselves, they are an indicator of the presence of fecal material that is potentially harmful to humans. In aquatic ecosystems coliforms often originate from poorly treated human sewage which is a cause for real concern. They may also originate, however, from run-off from farm feedlots and pastures, and even from wild waterfowl such as ducks.

Measurement of coliform bacteria must be carried out with great care. Contamination of a water sample is very easy and sterile procedures must be strictly adhered to. However, because of the valuable information it provides, it has been included as part of the monitoring programme.

The general procedure is to collect a water sample and incubate it on a special medium designed to enhance the growth of coliforms. Each bacterium in the sample will form a separate colony which can be observed and counted without the use of a microscope. Because this procedure requires special equipment and precise control, the analysis will be carried out at an approved laboratory. You will, however, be asked to collect the water sample required for the analysis and, if for some reason it cannot be picked up by the CARP courier within 24 hours, to bring it to the appropriate lab within that time period.

### Field Equipment:

- Sterile 100 ml sample bottle

### Field Procedure:

1. Collect a water sample, trying to avoid both the water surface and sediments as these areas often contain greater numbers of coliforms than is typical of the river.

2. Remove the cap from the sterile sample bottle, being careful **not to touch** the inside of the cap.

3. Fill the sample bottle being careful **not to contaminate the water sample** by allowing it to come into contact with your hands.

4. Replace the cap on the sample bottle.

**Laboratory Procedure:**

1. Complete an appropriate label and attach it to the sample bottle.

2. Store the sample in a refrigerator.

**NOTE:** Coliform samples must be processed within 24 hours after collection. You will be instructed on arrangements for pick-up of your sample.

***Interpretation:**

Acceptable fecal coliform numbers depends on the proposed use of the water. The following are some maximum limits listed in the " Canadian Water Quality Guidelines', March 1987:

Drinking water for humans - 0 per 100 ml

Drinking water for livestock - 20 to 50 per 100 ml

Irrigation of produce for human consumption - 100 per 100 ml

Recreation (e.g. swimming, board-sailing) - 200 per 100 ml

*This section was contributed by R. Rowe and G. Proszynska of the Nova Scotia Department of Health.

## 10. Other Observations

Brief notes describing general observations, particularly of unusual events, should be recorded on the field data sheets. These sorts of observations are an extremely important, but often neglected part of any field programme.

Making good observations is somewhat of an art and is often what separates good from bad scientists. There are a number of things you can do to enhance your ability to make significant observations. The most important is to become familiar with the area surrounding your sampling site. A good way to do this is to obtain an aerial photograph or good topographic map of the area surrounding your sampling site and, using this as a guide, walking about the area upriver and downriver of your site noting characteristics of the watershed that may potentially influence water quality (be sure to obtain permission from local landowners if this involves travelling over private property). Of particular interest are land use patterns and activities. Is the watershed mainly agricultural, forest, or urban? If agricultural what specific use is the land being put to - pasture, hayland, what kind of crops, if any, are being grown? If the surrounding area is mainly forested, is it conifers, hardwoods or a mixture of the two? Is it a young or mature forest? Is there any evidence of recent forestry activity that may result in increased soil erosion? Note the presence of any important wildlife habitats. Be especially alert to changes in land use activities. Alterations within the drainage basin are the most common cause of changes in water quality and it is very important that they be documented if we are to understand the reason behind an observed change in water quality.

Also important is the nature of nearby water inputs. Where is the nearest stream input? Is it upstream or downstream of your sampling site? Are there any storm sewage or domestic sewage inputs nearby? Are there any houses nearby that probably have septic tanks? Even the presence of drainage ditches emptying into the river are worthy of note. Be especially observant of unusual water inputs during or immediately after heavy rains or snowmelt.

When collecting samples note if the river looks particularly clear or muddy, or whether or not it has an unusual color or odor. Note the presence of unusual surface films, particularly oils and algal blooms. Have you sighted any waterfowl or other aquatic organisms, perhaps a muskrat or otter? The possibilities for making significant observations are endless and it is by no means possible to list them all here.

You may also want to record the time it takes to collect the water samples and to perform the various analyses as well as any comments regarding general or specific aspects of the monitoring programme, particularly with respect to items that you find confusing. Your input is an essential part of the programme. It has been designed primarily with you in mind and its success depends largely on your effort. We want to be sure that you feel it to be a worthwhile, enjoyable and informative experience.

## VII. Summary of Field and Laboratory Procedures

### 1. Preparation:

Prior to departure to field site:

a. Check field equipment against list.

b. Calibrate pH and Conductivity meters.

c. Check to be sure you have all the necessary laboratory supplies.

### 2. Field Procedure:

a. Fill out header information on data sheet (date, time, location, etc.).

b. Make weather observations.

c. Measure air temperature.

d. Measure and record Secchi disc depth.

e. Collect water samples
   - Measure water temperature
   - Fill two 1 liter bottles for Chlorophyll and SPM analyses
   - Measure pH and conductivity (Note: you may prefer to do this back at your lab).

f. Collect oxygen sample and fix with two reagents.

g. Collect fecal coliform sample.

h. Record miscellaneous observations.

### 3. Laboratory Procedure:

a. Refrigerate fecal coliform sample.

b. Using the water sample collected for either Chlorophyll or SPM, measure conductivity and pH if not done previously in the field.

c. Observe and record the color of an unfiltered water sample.

d. Filter Chlorophyll and SPM samples.

e. Observe and record the color of a filtered water sample.

f. Measure dissolved oxygen by titration.

g. Properly store samples for analysis by CARP and ACER.

## VIII. Contact Persons

1. If you have any general questions about this programme, or specific questions about the monitoring procedures, contact any of the following persons:

   Jane Barteaux or Steve Hawbolt
   Clean Annapolis River Project
   P.O. Box 118
   Clementsport, N.S. B0S 1E0
   532-7533

   Graham Daborn or Mike Brylinsky
   Acadia Centre for Estuarine Research
   Acadia University
   Wolfville, N.S. B0P 1H0
   542-2201

2. For oil, pesticide, and chemical spills, fish kills and other environmental emergencies the general contact should be environmental emergencies 1-800-565-1633. They will coordinate the response.

3. For raw sewage inputs, dead animals in the water (contact the representative nearest to the problem):

   Bob Rowe or Harland Gillis
   Department of Health
   136 Exhibition St.
   Kentville, N.S. B4N 4E5
   679-6086

   Bryan Young
   Department of Health
   P.O. Box 211
   Middleton, N.S. B0S 1P0
   825-3411

Mr. Art Oakley
Department of Health
P.O. Box 203
Bridgetown, N.S. B0S 1P0
665-4511

4. For fish kills, excessive erosion, harmful instream work, man induced low flows or poor land use practices contact either DFO or NSDOE at the addresses listed below.

   DFO area offices:

   Hank Sweeny
   P.O. Box 755
   Kentville, Nova Scotia
   B4N 3X9
   Tel 679-5571

   Terry Matheson
   P.O. Box 207
   Annapolis Royal, Nova Scotia
   B0S 1A0
   Tel 532-5269

   or

   Habitat Management
   P.O. Box 550
   Halifax, Nova Scotia
   B3J 2S7
   Tel 426-8105
   Fax 426-3479

   NSDOE, Western Region Office
   David Wigmore
   P.O. Box 1240
   Middleton, Nova Scotia
   B0S 1P0
   Tel 825-2123
   Fax 825-4471

## IX. Suggestions For Further Reading

If you would like to learn more about some of the concepts and techniques presented in this manual you may find the following texts, books and articles of use. All are present in the library at Acadia University and those marked with an asterisk are present at the CARP office (located at the Historic Gardens, Annapolis Royal).

*__Cole, G.A. 1983.__ Textbook of Limnology. Waveland Press, Inc., Illinois, 400 pp.

__Hynes, H.B.N. 1970.__ The Ecology of Running Waters. University of Toronto Press, Toronto. 555 pp.

*__Mitchell, M.K. and W.B. Stapp. 1990.__ Field Manual for Water Quality Monitoring. Thomson-Shore, Inc., 224 pp.

*__Task Force on Water Quality Guidelines. 1987.__ Canadian Water Quality Guidelines. Canadian Council of Resource and Environment Ministers, Ottawa, Ontario.

*__Water Quality Branch. 1983.__ Sampling for Water Quality. Environment Canada, Ottawa, Ontario. 55 pp.

*__Wetzel, R.G. and G.E. Likens. 1991.__ Limnological Analyses. Springer-Verlag, New York. 391 pp.

Also of interest is a series of articles dealing with various aspects of the Annapolis River published by the Clean Annapolis River Project entitled **'Annapolis River Issues'**.

## CARP River Guardians Programme

### Additional Contact Persons

For oil, pesticide, and chemical spills, fish kills and other environmental emergencies the contact should be environmental emergencies 1-800-565-1633. They will coordinate the response.

For raw sewage, dead animals in the river, excessive erosion, harmful instream work, man induced low flows or poor land use practices contact either DFO or NSDOE at the addresses listed below.

DFO area offices:

Hank Sweeny
P.O. Box 755
Kentville, Nova Scotia
B4N 3X9
Tel 679-5571

Terry Matheson
P.O. Box 207
Annapolis Royal, Nova Scotia
B0S 1A0
Tel 532-5269

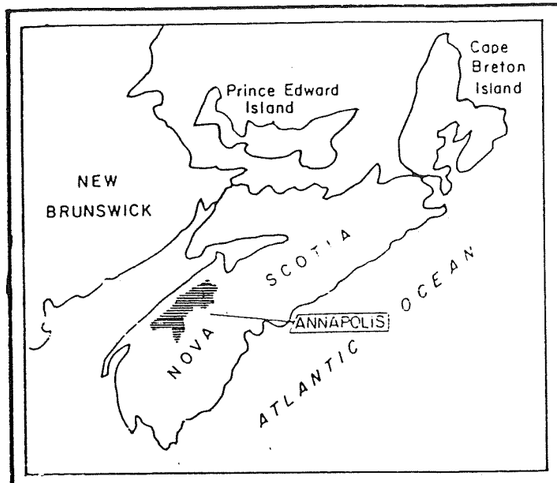
Yvon Thibeault
P.O. Box 1330
Digby, Nova Scotia
B0V 1A0
Tel 245-2544

Peter Winchester
Area Habitat Coordinator
215 Main Street
Yarmouth, Nova Scotia
B5A 1C6
Tel 742-6450

or

Habitat Management
P.O. Box 550
Halifax, Nova Scotia
B3J 2S7
Tel 426-8105
Fax 426-3479

NSDOE, Western Region Office
David Wigmore
P.O. Box 1240
Middleton, Nova Scotia
B0S 1P0
Tel 825-2123
Fax 825-4471




# ANNAPOLIS RIVER DRAINAGE BASIN

BAY OF FUNDY

ANNAPOLIS BASIN

65° 15'

65° 00'

64° 45'

64° 30'

45° 00'

44° 45'

AYLESFORD

To Halifax

Rockland Bk

KINGSTON

GREENWOOD

Hutchinson Bk

South Annapolis R.

MIDDLETON

NICTAUX

Mumford R.

Parker Lake

Randall Lake

Annapolis R.

Falles River

LAWRENCETOWN

Leonard Bk

Jones Brook

Nictaux River

BRIDGETOWN

Weir Brook

Eel Brook

BELLEISLE

GRANVILLE CENTRE

Creek

Corbett Lake

Paradise Lake

Paradise Brook

Trout Lake

Scrag Lake

Shannon Lake

Waterloo Lake

To Bridgewater

Mc. Gill Lake

Big Molly Upsim Lake

GRANVILLE FERRY

ANNAPOLIS ROYAL

To Yarmouth

Lake La Rose

Evans Brook

Tupper Brook

Goldsmith Lake

Bloody Creek

Kms

5 0 5 10