Environmental and Natural Areas Management

Environment and Labour

Developing a Municipal Source Water Protection Plan: A Guide for Water Utilities and Municipalities

Step 5

Develop a Monitoring Program to Evaluate the Effectiveness of a Source Water Protection Plan

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Designing Plans for Source Water Protection in Nova Scotia

A Drinking Water Strategy For Nova Scotia describes a multiple-barrier approach to clean, safe drinking water for Nova Scotians. The first line of defence in this multiple-barrier approach is to keep clean water clean. This booklet series describes how water utilities and municipalities can do that. It guides you through the process of developing a source water protection plan for your municipal water supply.

To keep clean water clean, we must protect the source water supply area. This guide describes **Step Five** in the process recommended by Nova Scotia Environment and Labour (NSEL) for developing a source water protection plan: Develop a Monitoring Program to Evaluate the Effectiveness of a Source Water Protection Plan.

The results of carrying out **Step Five** may warrant review and modification of information developed in **Step Four**. The monitoring and evaluation plan is an effective way to determine whether or not the management plan is working properly or if any changes need to be made to it. The intensity of sampling, which means the number of locations and frequency of sample collection, depends upon the existing or potential contaminant sources identified in **Step Three** and the budget of the utility or municipality. The utility or municipality will have to weigh the benefits of investing in new equipment and collecting additional data against the added costs.

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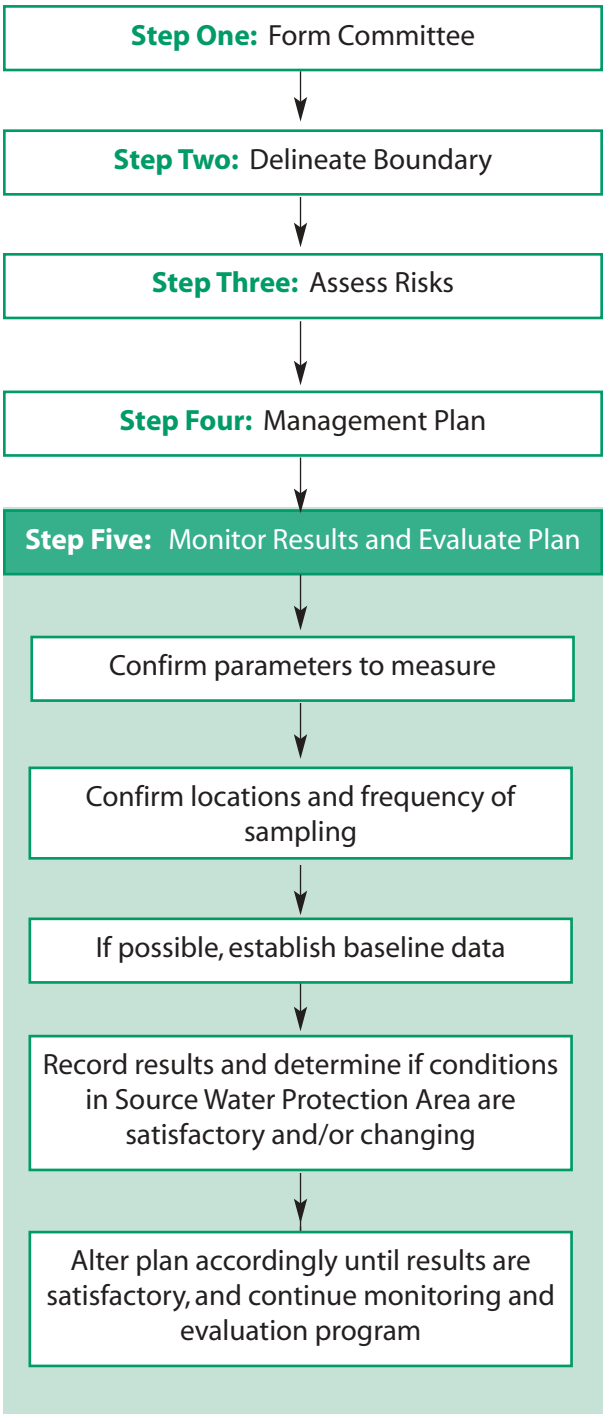
Step Five Flow Chart



Introduction

A formalized review process should be put in place to monitor the performance of the Source Water Protection (SWP) Plan formed in **Step Four**, and to ensure that the plan is regularly updated if it is not meeting its objectives. The plan may not be meeting its objectives if water quality is deteriorating in the SWP Area or the management options (such as best management practices) identified in **Step Four** are not being followed. A municipality or utility should be able to link deterioration in water quality to one or more of the risks identified in **Step Three**.

The water quality monitoring associated with this program should be designed to evaluate changes in the state or health of the SWP Area. This complements, but is different from the monitoring completed by a utility or municipality on its raw water to meet regulatory requirements. Raw water quality monitoring may be on a much more frequent basis depending on the source of supply, risk of contamination, type of treatment and similar factors.

The monitoring and evaluation program for the SWP Plan will help assure the municipality or utility that the plan remains current with changing conditions and priorities in the Source Water Protection (SWP) Area. Monitoring is the responsibility of the utility or municipality.

In addition to monitoring the SWP Area through water quality and quantity sampling, municipalities should also undertake visual monitoring of their SWP Area. For example, regular inspections of the area (a drive-by or walk-through) can identify potential water quality problems, such as all-terrain vehicles in watercourses. Surveys and discussions with local residents and business operators can reveal if they are following the Best Management Practices defined in **Step Four**. This may help determine if additional education efforts are required, identify problems that are not being adequately addressed, or may identify activities that are in violation of the bylaws or regulations that have been put in place to protect water quality.

The advisory committee should review the evaluation of changes in source water quality and quantity, as well as the success of management options and the need to improve the plan. The following contains information on each of the recommended actions for **Step Five**.

Confirm Parameters to be Measured

As part of the Protection Plan, potential and existing sources of contamination were identified in **Step Three**. The Monitoring Program should be set up so that it monitors parameters that will act as indicators for these sources of contamination. For example, if one of the potential sources of contamination is a gravel road, then the program should measure turbidity or suspended solids.

There is more information about monitoring parameters in the appendix. The number and types of parameters measured will depend on the risks posed to source water and the budget for the monitoring program.

Hints for Monitoring Groundwater:
If you are monitoring groundwater, consider partnerships with private well owners to incorporate existing wells into the monitoring network.

You should monitor the Wellhead Protection Area (WHPA) zones based on the type of substances that each zone is designed to manage. Consider the following options and tailor the program to site specific sources of contamination:

- Zone 1 - monitor for bacteria regularly, and periodically monitor general chemistry, metals, pesticides, chlorinated solvents and Total Petroleum Hydrocarbons (TPH) and benzene, toluene, ethyl benzene, xylene (BTEX)
- Zone 2 - monitor for BTEX, TPH, pesticides, chlorinated solvents, general chemistry, and metals every 2 to 5 years
- Zone 3 - monitor for pesticides, chlorinated solvents, general chemistry and metals every 5 to 25 years.

Confirm Locations and Frequency of Sampling

Try to collect data at various strategic locations during different periods of the year. The more intensive the program, the more clearly the utility or municipality will be able to detect any changes caused by activities taking place in the SWP Area. This information can also be used to determine the source of contamination.

Surface Water Hint:
Sample during periods of varying hydrological conditions (e.g. periods of low flow, after large rainfall events, during spring melt, etc.).

The selection of sampling locations depends on the characteristics of the SWP Area and any existing or potential contamination. The frequency of sampling will also depend on the amount of money available. If a utility or municipality is on a very limited budget, it should focus its monitoring in sensitive areas and on parameters that give an overall indication of the health of a SWP Area. These include low-cost tests like pH, conductivity, turbidity and coliforms.

Use the information gathered in **Steps Two** and **Three** to determine the appropriate sampling locations and frequency of sampling. NSEL can provide guidance on this. You may also wish to retain qualified professional consultants if you require detailed analysis of your SWP Area.

Raw or untreated water samples taken as part of the utility's regular testing program can be used as part of the Source Water Monitoring Program. The Source Water Monitoring Program should be part of the utility or municipality's overall monitoring program to ensure raw water quality is not deteriorating, and to establish any necessary early warning systems for treatment changes.

Management Hint:
To determine if recommended land-use practices are being implemented, compare the actual practices against the recommended ones.

Establish Baseline Data

Baseline data allow you to determine if your water quality and quantity monitoring results represent a change in the status or health of your source water area. Think of it this way, if you went to the doctor today and they measured your blood pressure you would not know if your health was the same, better or worse than it was a year ago, unless you had taken your blood pressure last year. It would be ideal to have up to three years of data collected before making any modifications to the protection plan. If this is not possible a minimum of one year of data is recommended.

Sampling frequency should be based on the characterization of the source water supply area, sources of contamination, level of risk, etc. The baseline data can then be used to determine if water quality and quantity conditions are improving, remaining stable or deteriorating. Therefore, it is very important to collect as much relevant data as possible during the initial stages of the monitoring program so that a strong understanding of the baseline conditions is established, before any changes in the SWP Area occur (e.g. an increase in development).

Sampling Protocol

To provide consistent, representative, and comparable samples for analysis and data for interpretation, any monitoring program must follow protocols established in accordance with standard accepted methods. Sampling protocols are established in the latest edition of Standard Methods for the Examination of Water and Wastewater published by the American Public Health Association, American Water Works Association and the Water Pollution Controls Federation (can be ordered on-line from bookstores at www.awwa.org or by telephone at 1-800-926-7337). Another useful reference document is The Inspector's Field Sampling Manual, latest edition, written by Environment Canada (can be purchased on-line at: http://www.ec.gc.ca; or by calling 1-800-734-3232). Useful information is also presented in the Appendix of this document. These examples may be used to develop standard operating procedures specifically designed for your utility.

It is important to understand the objective of the program and the parameters of concern because sampling protocols may vary. For example, sample filtering may be necessary in the field or special preservation methods may be needed. To ensure you have the correct sampling equipment (bottles, etc.) check your sampling requirements at least two weeks before you plan to sample. Also check with an accredited laboratory regarding any special needs that they may have.

Groundwater Monitoring Hint: Water utilities or municipalities should include a description of sampling procedures and protocols in the monitoring and evaluation plan. For groundwater, that includes how the well will be purged (e.g. 3 to 5 well volumes to remove stagnant water). The standard operating procedures should also include information on cleaning and maintaining sampling equipment as well as any calibration requirements. A monitoring program should have written Quality Assurance/Quality Control (QA/QC) protocol to go along with the sampling program.

This may include field, spiked and blind duplicate sampling procedures as well as documenting how the QA/QC sample will be evaluated and could potentially include corrective and additional sampling requirements if the sampling program does not meet the QA/QC objectives.

Record Results and Determine if Conditions Are Satisfactory and/ or Changing

After a year or more (preferably 3 years) of baseline data collection you can begin to determine if any patterns are present. Statistical analysis can be conducted on the data to better illustrate any patterns. Graphing the data and results of the statistical analysis are good ways to visualize the results.

Example:

Surface Water Monitoring You may have three years of Total Nitrate baseline measurements that show increasing levels in the summer followed by decreasing levels in the late fall and into the winter. You can now compare any new results with this baseline data to determine if any significant changes are taking place.

For example, in the future you may record higher than normal Total Nitrate levels in the summer. This large change indicates the possibility of increased nutrients being released in your SWP Area.

A statistical analysis could be used to determine if the changes are significant. If they are, you may wish to examine your SWP Area for potential causes of this change and modify management options if necessary.

Monitoring Hint: You should consider the costs of the monitoring program - capital (wells or equipment) and operational (sampling and analysis), before developing it. The utility or municipality will have to weigh the benefits of investing in new equipment and collecting additional data against the added costs.

Alter Protection Plan Accordingly Until Results Are Satisfactory, and Continue Monitoring and Evaluation Program

If the results of your Monitoring Plan indicate the quality of water in your SWP Area is not satisfactory or is changing significantly, you should re-examine your Protection Plan to determine a suitable course of action. Similarly, if certain components of your SWP Plan are not being adhered to (e.g. best management practices are not being followed) then you should evaluate the situation and determine how to improve it (e.g. conduct more education or put in bylaws). It is possible that the actions you have put in place (whether it be bylaws, land acquisition, etc.) may need to be altered to better fit the current state of your SWP Area. This is especially true as more and more time passes since you developed your Protection Plan.

For example, when a Protection Plan was first developed there may not have been any large forestry operations in the SWP Area. The municipality may have allowed the clear-cutting of land, as long as it was separated from streams by 20 metres. However, over time the intensity of forestry has increased, and this management option is no longer appropriate for the amount of trees being cut. Therefore, after re-examination of the issues and a determination that the large amount of forestry has resulted in an increase in turbidity, the Advisory Committee could work with forestry stakeholders to increase the buffer width for watercourses from 20 metres to 40 metres, and to manage the percentage of the SWP Area that is harvested.

Special attention should be paid to future water quality results if any changes are made to the Protection Plan due to the results of the Monitoring Plan. It is important to determine if the changes have produced the desired improvement in water quality. If the water quality does not improve, the Protection Plan should be re-evaluated, and this should continue until the problem is solved. The Monitoring Plan should be reviewed annually and updated every 5 years.

Using Water Quantity Measurements to Aid in Evaluation of the Protection Plan

Although it is most important to measure water *quality*, a water *quantity* monitoring program can provide useful information on the health of your SWP Area. For example, if the volume of water in your SWP Area decreases significantly, such as during a drought or due to large withdrawals by a business, then the risk of high contaminant levels in your raw water may increase. Think of it this way, if a package of juice crystals is added to a jug of water it tastes pretty good, but if you add the same amount of crystals to a small glass of water it tastes pretty bad! The more water you have in your SWP Area, the lower the risk of a given volume of contaminant causing problems for your treatment system.

As part of a water quantity monitoring program you could collect precipitation data from a nearby airport and measure the source water levels each week, or in your well(s) each month or quarterly, or use data loggers. Again, the more information collected, the more confident you can be in your results.

Final Products

The water utility or municipality should develop a monitoring and evaluation plan that helps them to determine:

- how well their source water protection plan is being implemented
- how well it is protecting their water quality and quantity

For More Information

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Appendix

LAKE WATER QUALITY MONITORING EXAMPLE

Example of Field Protocol
Field Protocol for Water Sampling of Lake

1. Less than an inch (< 25mm) of precipitation in the previous 24 hours is a prerequisite for any regular monthly sampling, but not for sampling intended to follow large rainfall events.

2. Safety should be considered of primary importance. Therefore, sampling alone or under windy or rough conditions is not recommended.

3. Using a contour map and sounding line locate sampling station which is to be located at the deepest location on the lake. Then lower anchor slowly. Care must be taken when taking soundings and when anchoring boat so that bottom sediments will not be disturbed and thereby contaminate water samples.

4. After anchoring boat, determine depth to bottom with sounding line once again and record on data sheet. Then determine transparency using a standard 8 inch black and white Secchi disk as per the standard methodology (Davies-Colley et al (1993)).

5. Determine air and surface water temperature with hand-held thermometer and record.

6. Record weather conditions as required on field data sheet.

7. Dissolved oxygen and temperature profiles will be determined at the deepest station of each lake using a YSI or similar meter.

8. Determine and record dissolved oxygen and temperature profiles using field meter if available. Alternatively, determine through sample collection and hand-held thermometer. If conductivity and/or pH meters are available, field measurements of these parameters should be undertaken.

9. Water samples are to be collected and preserved in a manner consistent with procedures outlined in *Standard Methods for the Examination of Water and Wastewater*, APHA, latest edition. These samples are to be taken at the deepest station on each lake at the surface (i.e. 0.5 meter depth), bottom (i.e. 1+ meters above bottom), and at the thermocline if present.

10. Two 500 ml water samples are to be taken at the surface, while one 500 ml sample at each of the bottom and thermocline locations will suffice.

11. *Standard Methods for the Examination of Water and Wastewater* should be consulted for specifics, but the following outlines the general procedures:

    a) Label sample bottles clearly with date, name of person taking samples, and location as per the following example for Loon Lake:
    - LL - DS1 - 0m
    - Where: LL = lake name (i.e. first initials)
    - DS1= station number (i.e. deep station #1)
    - 0m = depth from surface where sample was taken [0m indicates a surface sample, but sample should actually be taken at 0.5 meters so as to avoid any film of materials at the air / water interface]

    Water samples are to be taken at the following depths if no thermal stratification is evident:
    - 0.5 meter depth (surface).

    If thermal stratification is observed, samples are to be taken at the following additional depths:
    - 1 meter from bottom (bottom),
    - at the depth where temperature drops > 1 degree C in 1 m depth (thermocline)
    - at a depth which equals twice the Secchi depth (euphotic zone) for chlorophyll a analysis only.

    Note: If twice the Secchi disk depth is greater than the deepest lake location, take an additional sample at 1 meter off bottom for chlorophyll analysis.

Sample preservation is to be assured by immediately placing in cool, dark storage until analysis at lab. No fixatives are required to be added in the field.

b) Avoid contamination of sample bottle and water sampler by keeping closed and preferably stored in cooler or case until ready for taking of sample.

c) Thoroughly rinse sample bottles and caps with lake water (avoiding surface layer) at least three times before use.

d) Avoid contact with bottom sediments, surface scums, gasoline, oil, insect repellant, sun block, cigarette smoke, soap, etc. to prevent fouling of sample.

e) Using clean bottles obtained from certified analytical laboratory, fill bottles completely to the top of the neck.

12. Samples are to be shipped to a laboratory approved for chemistry testing (see http://www.gov.ns.ca/enla/water/labs.htm for a list of accredited laboratories), and samples should reach the lab within 24 hours of collection.

13. Analyses for all samples are to include the parameters in the monitoring plan. Note: Be sure to check the detection limit provided by the lab, as this may impact your analysis.

Sample Form to be Submitted to Laboratory

ANALYSIS REQUISITION

Report and Bill to:
Water Utility or Town Engineer

Copy to:
Municipal Engineer

Client's Phone Number:
Fax Number:

Sample Name (ID):
(ie LAKE - STATION# -DEPTH)

Sample Location:

Date and Time (24-Hr clock) Taken:

Collected By:

List of individual or group tests requested:

Analyses for **all samples** are to include:
(example only)
- Colour, turbidity, pH, sodium, potassium, chloride, sulphate, alkalinity, magnesium
- Metals analysis
- Lowest level analysis of nutrients (to 0.001 mg/l detection limit)
- TP
- TN

Additional analytes for the **surface samples** (marked 0m or surface) are to include: (example only)
- Chlorophyll a
- TSS

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