CHAPTER III. VOLUNTEER WATERSHED MONITORING OPTIONS

Introduction

In the following sections, we have assembled "packages" of indicators and monitoring tools, methods, site selection / timing and frequency guidance , and training required to address specific monitoring questions and data quality goals described in the previous chapter. From this point on, we'll refer to these as "surveys." These surveys are included in this guide because documentation (manuals) exists and training is available.

This guide contains the following surveys:

A. Preliminary Watershed Assessment
B. Water Contact Health Risk Assessment
C. Water Quality Standards Assessment
D. Baseline Monitoring: Rivers and Lakes
   D1. Rigorous Baseline Monitoring: Wadeable Rivers
   D2. Rigorous Baseline Monitoring: Non-Wadeable Rivers
   D3. Basic Baseline Monitoring: Wadeable Rivers
   D4. Basic Baseline Monitoring: Non-Wadeable Rivers
   D5. Rigorous Baseline Monitoring: Lakes
   D6. Basic Baseline Monitoring: Lakes
E. Wastewater Treatment Plant Impact Assessment
   F1. Rigorous Wastewater Treatment Plant Impact Assessment
   F2. Basic Wastewater Treatment Plant Impact Assessment
F. Non-Point Source Pollution Impact Assessment
   F1. Rigorous Non-Point Source Pollution Impact Assessment
   F2. Basic Non-Point Source Pollution Impact Assessment
G. NPS Site Evaluation
H. Stormwater Discharge Monitoring
I. Wastewater Compliance Survey

These surveys are described in the rest of this chapter. For each survey, we describe the following:

What Is It?

This contains a basic description of the survey and the type of monitoring activities that are included.

Why Do This Survey?

This section explains why a group should consider undertaking this survey: its purposes, the questions it answers, and what the data is used for.

Primary Data Quality Goals Addressed

This section lists the data quality goals that are addressed by this survey. These data quality goals are listed as follows:

- ☐ Education, awareness, and problem screening
- ☐ Community & watershed level evaluation, assessment, and management
- ☐ State, interstate, and Federal water quality evaluation and assessment

If this survey addresses the goal, a check appears in the box preceding it, like this: ☑. These goals are discussed in Chapter 1.

Monitoring Options

This section consists mainly of a table which lists the indicators / tools, analytical methods, and types of sites that could be involved in the survey.

Menu of Indicators/Tools: This column lists either indicators (for example, bacteria) or tools (for example, a habitat assessment) that would be appropriate for this survey. You will likely not do all of these. This is a menu from which you (with the advice of your technical committee would select indicators / tools that address specific pollution types and sources, your organization's resources, and the nature of your receiving waters.

Examples of Methods (Source): This column lists examples of methods that are appropriate for each indicator / tool in order to meet the data quality goals of the survey. The table does not list all the appropriate methods. In most cases, there are a number of methods that are appropriate. We list the examples as a reference point -- we know the methods listed will meet the stated data quality goals. Equivalent methods are certainly acceptable, if the people or organizations that you expect to use your data approve.

Site Location Considerations: This column lists things to consider or types of sites that will help you locate your specific sampling sites. Site selection is discussed in detail in the VEMN "Guidelines for Subwatershed Groups On Preparing Scientific Study Designs."

How Frequently and When Should You Monitor?

This section describes how to figure out a monitoring schedule for each type of activity in the survey. For this, you need to consider the time of year, frequency, time of day, and weather conditions:

Times of Year: Aquatic ecosystems change with the seasons. Water flows, temperatures, chemistry, food sources, and the level of biological activity all vary with seasonal cycles. So, in the ideal study, you would sample during all seasons

to determine how your ecosystem varies. However, this is not practical, nor necessary, for most volunteer programs. Consider sampling during critical periods when the ecosystem is under the most stress and perhaps during periods when they are under least stress, as a benchmark. Consult with your technical committee to determine critical and benchmark sampling periods for your program.

Times of Day: Certain indicators, like dissolved oxygen and pH vary according to the time of day. In order to understand this daily variability, you may have to sample these indicators at different times of the day, perhaps even hourly over several 24-hour periods. For others, like benthic macroinvertebrates, the time of day is not important. Consult with your technical committee to determine which indicators should be sampled to determine daily variability.

Frequency: For each of the different conditions described above, you should sample as often as practical for as many years as possible. There are statistical methods to help you determine how many samples from a given area you should collect to be able to quantify the relationships among the different indicators you are monitoring. But these are beyond the scope of this guide. Consult with your technical committee, or a water quality professional who knows these statistical methods to help you determine how frequently you should monitor.

Weather Conditions: Weather affects aquatic ecosystems in profound ways -- some reduce stress and some cause stress. Since weather varies with the season, see the preceding section for the general considerations. Within seasons, however, consider sampling a variety of weather conditions: storm events, droughts, "normal" conditions, relatively hot weather, relatively cool weather, etc. Since weather can occur without much warning, sampling to capture different weather events is challenging. However, you can learn a lot about how your river or lake responds to these changes.

The schedule for different activities will vary. For example, water sampling and analysis usually happens much more frequently than benthic macroinvertebrate sampling. So, the considerations listed above are addressed for each type of monitoring activity.

Data Analysis

This section describes, in very general terms, how the data are analyzed -- what they are compared with to answer the questions addressed by the survey. Detailed guidance is contained in the VEMN guidance document: "How To Interpret Monitoring Data."

Quality Assurance/Quality Control (QA/QC)

There is a whole chapter (IV) on quality assurance and quality control in this guide. This section highlights QA / QC considerations specific to the survey.

Training Required

This section describes the field sampling and lab analysis training required to undertake each survey. In most cases, a VEMN partner should be involved in the initial training. Chapter V lists where to get this type of assistance.

A. PRELIMINARY WATERSHED ASSESSMENT

What Is It?

A Preliminary Watershed Assessment is the collection of new and existing information on conditions and processes at the watershed level. This information can be used to identify problem areas for corrective action; to decide on whether, where, and what type of monitoring is needed; and to bolster watershed awareness at all levels, from the individual landowner to state and federal permits.

A *preliminary watershed assessment* is the first step in a comprehensive watershed assessment[1] program. It has two parts:

1) *Research:* a compilation of existing information from reports and interviews, and
2) *Field Surveys:* easily-gathered visual observations on various watershed characteristics, conditions, and activities.

Why Do A Preliminary Watershed Assessment?

We suggest the preliminary watershed assessment as a starting point in your monitoring program. It enables you to get to know your watershed and determine which areas or issues you'll focus on for future monitoring. It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes

The main purposes for a preliminary watershed assessment are

- to identify watershed improvement and protection actions,
- to identify existing recreational and other uses,
- to help you decide whether or not to carry out a comprehensive watershed assessment or another intensive type of monitoring, and
- to help you decide those characteristics and areas that are most important for further monitoring.

Questions Answered

The preliminary watershed assessment helps answer two of the VEMN's basic questions:

1) *Where are problem areas that should be a high priority for remediation?*

[1] *Comprehensive watershed assessment* includes gathering new information through extensive field monitoring of the physical, chemical and biological characteristics of the water column, river channel or lake basin, shoreline, corridor and upland areas.

2) *Where are the special natural and cultural resources?*

3) *Where are recreational and other river uses occurring?*

Data Use

The answers can be used for several things:

- Identify areas where data that are needed to make management decisions are lacking,
- Identify problems and conflicts which need to be resolved by some management decision,
- Identify special areas in need of protection,
- Plan and implement specific projects to address problems identified in the assessment, and
- Provide an educational and awareness-building experience for participants by getting to know their watershed and its important characteristics.

The preliminary watershed assessment also prepares your group for monitoring by identifying issues, characteristics, conditions, processes, human activities, and problem areas that you might wish to monitor. You can then design a program to monitor the selected characteristics that are most important to your watershed, thereby maximizing your group's financial and time resources.

Primary Data Quality Goals Addressed

☑ Education, awareness, and problem screening

☑ Community & watershed level evaluation, assessment, and management

☐ State, interstate, and Federal water quality evaluation and assessment

Monitoring Options

The Preliminary Watershed Assessment is a process of narrowing down the geographic and topical scope of your efforts through research and then focusing on a specific reach or area of the watershed that includes the uses, values and threats that you wish to assess in the field through a visual survey.

Instructions for carrying out a preliminary watershed assessment are contained in the VEMN Training Manual.[2]

Monitoring options are listed in the following table.

Menu of Indicators/Tools	**Examples of Methods (Source)**	**Site Location Considerations**
1) Research existing information → Literature search	Review existing reports and plans	• Sites that contain problem areas which might be a high priority for some corrective action.
• Uses, values, and threats exercise →	Meeting participants locate uses, values, and threats on a map (River Watch Network)	• Sites that contain special resource areas.
2) Field survey of river, riparian, and watershed characteristics, uses, values, and threats →	Windshield Watershed Survey (Massachusetts Water Watch Partnership Manual) Shoreline Survey for Volunteers (Massachusetts Riverways Programs Adopt-A-Stream Manual) River Walk (River Watch Network "River Walk" form) Watershed Non-point Source Evaluation and Site Assessment (UNH Cooperative Extension "Following the Flow" manual)	• Sites that contain threats to human and aquatic life uses of the water.

Additional notes on the methods are contained in Appendix 1.

[2] *Training Manual for Core VEMN Monitoring Parameters and Methods*, available from the Merrimack River Watershed Council,

How Frequently and When Should You Carry Out Field Surveys?

Field surveys should be carried out at least once per year, to track long term changes and trends. Depending on your questions, you may wish to carry them out more frequently, perhaps seasonally or during large runoff events. For example, if your main concern is polluted runoff from agricultural land, you may wish to conduct your field surveys during or immediately after a period of heavy runoff to get a sense of how the characteristics you are surveying change in response. See the Non-point Source Pollution Impact Assessment for further information on monitoring runoff events.

Data Analysis

The results of the Preliminary Watershed Assessment are a set of qualitative observations. These observations should be mapped in order to reveal and present problem areas for action.

Quality Assurance/Quality Control (QA/QC)

A preliminary watershed assessment does not require complex QA / QC, since its purpose is primarily problem screening and education and awareness. However, some of the general QA / QC for sampling and analysis and general quality assurance measures for data management in Chapter IV should be reviewed. In addition, photo and / or video documentation of the sites is recommended to serve as visual documentation of problems and processes as well as to provide a tool to train surveyors.

Training Required

Surveyors should initially be trained by the organization or agency that developed the survey (e.g. MA Riverways for the Adopt a Stream Shoreline Survey) or a designated VEMN partner. At or following the training, surveyors should be observed in the field, gathering data, to assure that they are following procedures correctly. Follow up field audits can also help catch problems which may develop. New surveyors should be trained by the program coordinator or by an experienced surveyor.

B. WATER QUALITY STANDARDS ASSESSMENT

What Is It?

A water quality standards assessment involves water sampling and analysis for water quality indicators used by the states of Massachusetts and New Hampshire use to determine whether these waters support their *designated uses*. These are uses of the water -- such as swimming, public water supply, fishing, aquatic life habitat, irrigation, and industrial processing and cooling -- that are to be achieved and protected. The water quality standards list *water quality criteria* for each indicator. These criteria specify minimum or maximum levels or ranges necessary to support the designated uses. The information gathered in a water quality standards assessment is used by the states and the US EPA in their biennial reports to Congress which describe the condition of the state's waters relative to the Clean Water Act. This is used for a variety of water resources planning purposes.

The VEMN Water Quality Standards Assessment includes river and lake water sampling and analysis for selected indicators contained in the criteria in the water quality standards. The indicators selected are those that we consider appropriate for volunteer monitors (these indicators are listed in the table in the "Monitoring Options" section). The results are then compared with the criteria for each indicator listed in the MA and/or NH Water Quality Standards.

Why Do A Water Quality Standards Assessment?

We suggest that you undertake a Water Quality Standards Assessment if your primary interest is whether your river supports its legally designated uses and values and you need to produce data that federal and state agencies will use for their assessment activities.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes

The main purpose for doing a water quality standards assessment is to provide additional data that Massachusetts and New Hampshire can use to assess whether the surface waters in the watershed meet their water quality standards. This assessment is reported in "305(b) reports." This is important because these reports help the states and EPA determine how to allocate their pollution control resources to achieve and protect the human and aquatic life uses of our waters.

Other purposes include:

- to identify problem areas, and
- to identify watershed improvement and protection actions.

Questions Answered

The water quality standards assessment helps answer one of the VEMN's basic questions:

1) *Does the water meet MA and NH Water Quality Standards?*

Data Use

The answers can be used for several things:

- Identify areas where action is needed to enable the water body to support its designated uses,
- Identify problems and conflicts which need to be resolved by some management decision,
- Identify high quality waters which may receive special protection as "outstanding resource waters" or under the "anti-degradation" provisions of the water quality standards,
- Set priorities for funding water pollution control projects, and
- Evaluate whether pollution control measures are working.

Primary Data Quality Goals Addressed

☑ Education, awareness, and problem screening
☑ Community & watershed level evaluation, assessment, and management
☑ State, interstate, and Federal water quality evaluation and assessment

Monitoring Options

A Water Quality Standards Assessment is done by collecting water samples (or direct field measurements) and analyzing those samples for the indicators contained in the water quality standards. Instructions for collecting and analyzing water samples for the indicators listed above are described detail in the VEMN Training Manual. Following is a table of the monitoring options for the water quality standards assessment.

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
E. coli Bacteria (NH) →	Membrane filtration w / mTEC *with* confirmation (EPA# 1103.1 or equivalent)	• Designated beaches and areas designated for swimming, wading, diving, and water skiing.
Fecal Coliform Bacteria (MA) →	Membrane filtration w / mTEC *without* confirmation (EPA# 1103.1 or equivalent)	• Informal swimming, wading, diving, and water skiing areas.
Dissolved Oxygen →	**1)** Modified Winkler Titration with a buret, syringe, or digital titrator (SM #4500-OG or equivalent) *Rivers*: surface sample *Lakes*: sample at various depths **2) Direct measurement with a membrane electrode meter (SM #4500-OG or equivalent)** ***Rivers:* measure at surface** ***Lakes:* measure at various depths**	• Boat launch ramps and fishing access areas. • Cold and Warm water fish habitat areas (spawning, nursery, and resting sites). • Near water supply intakes. • Where possible, sites historically monitored by the NH DES or MA DEP. • Sites which are representative of the part of the river of interest.
Turbidity (rivers) →	Sample collected and measured with a nephelometer (SM #2130 or equivalent)	• Sites which are safely accessible.
Secchi Transparency (lakes) →	Transparency depth measurement using a secchi disk (MassWWP or UNH CE Method)	• Sites where the main river current is accessible -- where the water is thoroughly mixed.
Temperature →	Direct measurement with a thermometer, thermocouple, or	• Deepest part of the main lake or significant arm or bay.

	thermistor	

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
pH	**1)** Sample collected and measured with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent) **2) Direct measurement with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent)**	**See previous page.**

Additional notes on the methods are contained in Appendix 1.

How Frequently and When Should You Monitor?

For a water quality standards assessment, you should conduct enough sampling events at the right time of year to relate your results to attaining designated uses. That means that the number sampling events and when they occur depend on the uses you are assessing. The two primary uses that the standards address is water contact recreation and fisheries. Here are some considerations for determining the frequency and timing of your sampling.

1) Sample during the times of year when the designated uses are occurring. For water contact recreational use, that means the warm summer months. For fishing, there is a longer season that spans mid-spring through mid-fall.
2) For water contact recreation, sample for bacteria at least three times over a 60-day period to enable the calculation of a geometric mean consistent with the NH water quality criterion. Sampling frequency and time of year depends on the spawning and life cycle of the target type of fish.
3) For assessing dissolved oxygen suitability for fish, be sure to sample during the stressful low flow, high temperature periods in the summer. Also be sure to sample early in the morning in order to sample theoretical low oxygen levels.[3]
4) Consider daily variations in each indicator. For example dissolved oxygen and temperature are both typically lowest at sunup and highest in mid-day.

[3] The lowest DO levels are typically at sunup, due to the lack of oxygenation from plants at night.

Critical (low) levels of DO for fish will likely occur in the early morning. Critical (high) temperature levels for fish will likely occur in mid-afternoon. So, your sampling schedule might be different for some indicators.

5) Consider the maximum time the sample can be held for each test as well as how much time your lab needs to do the analysis. For example, the maximum holding time for *E. coli* bacteria is 6 hours in a container with ice. If the sample cannot be analyzed within this time frame, the results won't be valid. That means that for a time consuming indicator like bacteria, samples should be collected in the morning and transported to the lab immediately so that the lab has time to run the analysis within the 6-hour window.

Keeping these in mind, we recommend the following:

- *Frequency:* sample at least two or three times per month during the monitoring season.
- *Time of day:* sample during early morning for dissolved oxygen, late afternoon for temperature. (Also consider 24-hour studies for these indicators to determine daily variability.)
- *Time of year:* Sample during the warmer month, when recreational water contact uses occur.
- *Weather:* For fish, be sure to sample during low flow, high temperature periods in the summer.

Data Analysis

The results are compared with numerical criteria in each state's water quality standards. These are contained in Appendix 3.

Quality Assurance/Quality Control (QA/QC)

A Water Quality Standards Assessment requires rigorous QA / QC. Specific quality control measures for each indicator are listed in Table 1 in Chapter IV. Also applicable in Chapter IV is information on internal and external quality controls and how they are assessed, general quality assurance for sampling and analysis and quality assurance for data management.

Periodic field and lab audits by VEMN partners are recommended. During these audits, VEMN partners observe the operation of sampling and analytical procedures. Suggestions for improvements are discussed with the program and lab coordinator. Audits will be conducted as specified in your study design, quality assurance plan or at the request of the program coordinator.

Training Required

Sampling: Initially, the Program Coordinator and a core group of field samplers should be trained in proper water sample collection techniques by a VEMN Partner. The Program Coordinator should then designate people from this core group who are qualified to train others. Official certification of trainers by the program coordinator through a letter or certificate should be considered.

Lab Analysis: For personnel in the program lab,[4] proper training is essential. There should be a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator should conduct all training of analysts. Each analyst should be assigned to certain analyses by the coordinator. Official certification by the program coordinator of all analysts to perform specific analyses through a letter or certificate should be considered.

[4] This is a lab set up by a watershed group or school

C. WATER CONTACT HEALTH RISK ASSESSMENT

What Is It?

Assessing the health risk of water contact involves the study of a representative sampling of a population by assessing their exposure to disease-causing agents in the water (including fish contamination) and the actual presence of disease.

Health assessments involve at least two main elements:

- *Collection of water or fish samples and their analysis for the contaminant(s) of interest (for example, E. coli bacteria in water).* This data is used to assess human exposure to the contaminant(s).
- *Information on the behavior and health status of the target group (e.g. a community, a sub-group) of interest or a reasonable substitute.* The types of information collected will typically include indicators of health status, perhaps behaviors associated with exposure to the contaminant(s), and any exposures to other types of contaminants.

The design of a water contact health risk assessment is tailored to the location, issues, problems, and situation in specific areas. There is no one template that will be appropriate for all situations in the watershed. So, VEMN partners will guide volunteer monitoring groups through a generic process[5] to help them develop an approach that will match their goals, needs, and resources. This process will result in specific data gathering tools and procedures that you can use. ***This process should be undertaken with the assistance of a resource person experienced in the design of community health surveys.*** This will help avoid common procedural errors that might needlessly frighten community members and/or bias[6] sampling.

Why Do A Water Contact Health Risk Assessment?

We suggest that you undertake a Water Contact Health Risk Assessment if your primary interest is in the human health risks associated with water contact or fish/shellfish consumption and you need to produce data that health officials will act upon.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purpose

The main purpose of this assessment is to evaluate the health risk of coming in contact with the river or lake water -- by swimming or wading in it, eating the

[5] This process is described in the VEMN Training Manual

[6] A statistical sampling error caused by systematically favoring some outcomes over others.

fish from it, or ingesting it. Put more simply: if you come in contact with the water in any of these ways, what is the risk that you'll get sick? Or, if you got sick, what is the likelihood that it is associated with contact with contaminated water?

Questions Answered

The water quality standards assessment helps answer two of the VEMN's basic questions:

1) Is human water contact recreation a health risk?
2) Is eating the aquatic life a health risk?

Data Use

The answers can be used for several things:

- Identify areas where action is needed to enable safe water contact recreation and fish consumption,
- Identify problems and conflicts which need to be resolved by some management decision,
- Set priorities for funding water pollution control projects, and
- Evaluate whether pollution control measures are working.

Primary Data Quality Goals Addressed

☑ Education, awareness, and problem screening
☑ Community & watershed level evaluation, assessment, and management
☐ State, interstate, and Federal water quality evaluation and assessment

Monitoring Options

A water contact health risk assessment is done by collecting and analyzing water samples for contaminant(s) of interest and surveying the target population that comes in contact with this water.

Methods for collecting and analyzing water samples for *E. coli* are described detail in the VEMN Training Manual and in brief in the "Water Quality Standards Assessment" section of this guidance document. Sampling and analysis for other contaminants will follow EPA-approved protocols carried out by certified labs.

Methods for surveying the target population will be designed by Cynthia Lopez, a Doctoral Candidate in Epidemiology and Ecology at the Harvard School of Public Health and a consultant to River Watch Network.

Following is a table of the monitoring options for the water quality standards assessment:

Required Indicators/Tools	**Examples of Methods (Source)**	**Site Location Considerations**
1) Collection of water or fish samples and their analysis for the contaminant(s) of interest. Options: *E. coli* bacteria in water	Membrane filtration w / mTEC with confirmation (EPA# 1103.1 or equivalent)	**Water/Fish Sampling and Analysis** • Designated beaches and areas designated for swimming, wading, diving, and water skiing
• Selected contaminants in water	As recommended by consultant or advisory committee	• Non-designated (Informal) swimming, wading, diving, and water skiing areas
• Selected contaminants in fish or shellfish tissue	As recommended by consultant or advisory committee	• Boat launch ramps and fishing access areas • Near water supply intakes
2) Information on the behavior and health status of the target group.	Epidemiological survey per RWN guidance	• Where possible, sites historically monitored by the NH DES or MA DEP **Health Data Gathering from Target Population** • Depends upon the target population

Additional notes on the methods are contained in Appendix 1.

How Frequently and When Should You Collect Samples?

For a water contact health risk assessment, the frequency of water sampling and community health data gathering depends on the nature of exposure to suspected disease-causing agents and type of water contact (e.g. swimming or eating fish), the human population being surveyed, and the nature of the suspected or known health problems. This should be determined on a case-by-case basis. However, if exposure to water-borne fecal contamination is the focus of water sampling, then the following guidelines apply:

1) Sample during the times of year when water contact is occurring. That means the warm summer months.
2) Sample water for bacteria at least three times over a 60-day period to enable the calculation of a geometric mean consistent with the NH water quality criterion.

Data Analysis

Once checked for errors, the data are ready for statistical analysis. In almost all cases, statistics that describe the data set in various ways will be computed. The selection of appropriate statistics describing associations and risk will depend upon the nature of the data.

Quality Assurance/Quality Control (QA/QC)

A Water Contact health Risk Assessment requires fairly rigorous QA / QC. Specific quality control measures for bacteria are listed in Table 1 in Chapter IV. Also applicable in Chapter IV is information on internal and external quality controls and how they are assessed, general quality assurance for sampling and analysis and quality assurance for data management.

Periodic field and lab audits by VEMN partners are recommended. During these audits, VEMN partners observe the operation of sampling and analytical procedures. Suggestions for improvements are discussed with the program and lab coordinator. Audits will be conducted as specified in your study design, quality assurance plan or at the request of the program coordinator.

Training Required

Community Health Survey Interviewers must be trained by a resource person experienced in the administration of community health surveys to ensure reliability and to avoid bias. This person should be approved by River Watch Network and the state department of health.

Sampling: Initially, the Program Coordinator and a core group of field samplers should be trained in proper water and / or fish tissue sample collection techniques by a VEMN Partner or by the professional lab personnel who will do

the analysis.. The Program Coordinator should then designate people from this core group who are qualified to train others. Official certification of trainers by the program coordinator through a letter or certificate should be considered.

Lab Analysis: For personnel in the program lab,[7] proper training is essential. There should be a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator should conduct all training of analysts. Each analyst should be assigned to certain analyses by the coordinator. Official certification by the program coordinator of all analysts to perform specific analyses through a letter or certificate should be considered.

[7] This is a lab set up by a watershed group or school

D. BASELINE MONITORING: RIVERS AND LAKES

Baseline monitoring of rivers and lakes is the collection of information about some of the basic physical, chemical and biological conditions. This information is used as a "baseline" or benchmark against which to assess future changes. Baseline monitoring is extremely difficult and time consuming because, in order to do it well, you must sample as many indicators under as many different hydrologic conditions as possible.

Even more important, *baseline monitoring is a long-term* commitment. In order to detect trends, understand how your river or lake changes over time or in response to natural or human-caused changes, we suggest that you sample over a period of many years -- 5 at a minimum, preferably 10 or 20. Trends are not established in a year.

We also suggest that you consider monitoring waters that are not impaired by human activities. Monitoring these waters is critical as a reference point against which to assess the impacts of decision affecting these waters. Further, some of these waters may serve as reference points to assess similar waters that have been affected by human activities.

Because of the difficulty in carrying out a truly comprehensive baseline monitoring program, we suggest six options which cover different levels of effort (rigorous and basic) and different types of water bodies (wadeable rivers, and non-wadeable rivers, and lakes):

D1 Rigorous Baseline Monitoring: Wadeable Rivers

D2 Rigorous Baseline Monitoring: Non-Wadeable Rivers

D3 Basic Baseline Monitoring: Wadeable Rivers

D4 Basic Baseline Monitoring: Non-Wadeable Rivers

D5 Rigorous Baseline Monitoring: Lakes

D6 Basic Baseline Monitoring: Lakes

These monitoring options are geared to meet different data quality goals, available resources, and types of water bodies.

Each of these options is described in the following sections.

D1. RIGOROUS BASELINE MONITORING: WADEABLE RIVERS

What Is It?

Rigorous Baseline Monitoring is the most comprehensive and difficult baseline monitoring covered in this guide. It is watershed-wide in scope. It includes a wide range of monitoring activities that assess as many of the physical, chemical, and biological indicators of river health as is practical for volunteer monitors, using methods that are comparable to those used by state agencies:

- water sampling and analysis,
- benthic macroinvertebrate sampling and analysis and habitat assessment,
- visual surveys of river uses, values, and threats, and
- field measurements of flow and channel characteristics.

Many of these activities are only possible where rivers are wadeable. Wadeable rivers are waters less than 2 feet deep, where it is possible to see and access the bottom to collect samples of habitat and aquatic life. Activities appropriate for non-wadeable rivers are covered in the next section (D2.)

Rigorous Baseline Monitoring is geared to produce a great deal of high quality information which can be used by state and federal agencies for their assessment efforts.

Why Do Rigorous Baseline Monitoring?

We suggest that you undertake Rigorous Baseline Monitoring if your primary interest is in the long term ecological health of your river and you need to produce data that federal and state agencies will use for their assessment activities.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes

The main purposes for a preliminary watershed assessment are

- to establish baseline physical, chemical, and biological conditions against which future changes can be measured,
- to identify problem areas,
- to identify watershed improvement and protection actions, and
- to help you decide those characteristics and areas that are most important for intensive monitoring.

Questions Answered

Are conditions changing over time? What? Where? How? Why?

Data Use

The results from Rigorous Baseline Monitoring can be used for several things:

- Identify areas where action is needed to enable the water body to support healthy aquatic life,
- Identify problems and conflicts between human and aquatic life uses which need to be resolved by some management decision,
- Identify waters with significant ecological value, which may need protection as "Class A ," "outstanding resource waters" or under the "anti-degradation" provisions of the water quality standards,
- Identify waters that can serve as "reference conditions" (least impaired) waters against which progress in restoring impaired waters can be compared,
- Set priorities for funding water pollution control projects, and
- Evaluate whether pollution control measures are working.

Primary Data Quality Goals Addressed

☑ Education, awareness, and problem screening

☑ Community & watershed level evaluation, assessment, and management

☑ State, interstate, and Federal water quality evaluation and assessment

Monitoring Options

Rigorous Baseline Monitoring for Wadeable Rivers involves collecting and analyzing water and aquatic life samples, assessing habitat conditions and channel shape, and gathering visual information about uses, values, and threats.

You might not need to (or be able to) use all the indicators and tools listed in the table below. Consider it a menu and consult with your technical advisory committee to select the indicators, methods, and sites appropriate for your river and your human and financial resources:

Menu of Indicators/Tools	**Examples of Methods (Source)**	**Site Location Considerations**
E. coli Bacteria (NH) →	Membrane filtration w / mTEC *with* confirmation (EPA# 1103.1 or equivalent)	**Sampling throughout watershed as follows:** • Designated beaches and areas designated for swimming, wading, diving, and water skiing.
Fecal Coliform Bacteria (MA) →	Membrane filtration w / mTEC *without* confirmation (EPA# 1103.1 or equivalent)	• Informal swimming, wading, diving, and water skiing areas.
Dissolved Oxygen →	**1)** Modified Winkler Titration with a buret, syringe, or digital titrator (SM #4500-OG or equivalent) *Rivers*: surface sample *Lakes*: sample at various depths **2) Direct measurement with a membrane electrode meter (SM #4500-OG or equivalent)** ***Rivers:* measure at surface** ***Lakes:* measure at various depths**	• Boat launch ramps and fishing access areas. • Cold and Warm water fish habitat areas (spawning, nursery, and resting sites). • Near water supply intakes. • Where possible, sites historically monitored by the NH DES or MA DEP. • Sites which are representative of the part of the river of interest. • Sites which are safely accessible
Turbidity (rivers) →	Sample collected and measured with a nephelometer (SM #2130 or equivalent)	• Sites where the main river current is accessible -- where the water is thoroughly mixed.
Temperature →	Direct measurement with a thermometer, thermocouple, or	• Water sampling from all habitats

	thermistor	
Menu of Indicators/Tools	**Examples of Methods (Source)**	**Site Location Considerations**
pH →	1) Sample collected and measured with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent) 2) Direct measurement with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent)	**(Continued from previous page)** • Benthic macroinvertebrate sampling from riffle habitats • Streams and rivers of different orders (sizes) and at different altitudes • Reference sites in undeveloped or least-impaired areas
Total Alkalinity →	Double end point sulfuric acid titration w / digital titrator and pH meter (RWN or MassWWP manual)	• Waters located in areas of different land uses (urban, agricultural, forested)
Conductivity →	Direct measurement with meter (SM #2510 B or equivalent)	• Waters receiving point source discharges and polluted runoff
Total Phosphorus →	Persulfate digestion followed by ascorbic acid method and spectrophotometry (EPA Method #365.2 or equivalent)	1) Tributary Impacts: *Reference Sites:* upstream of confluence on main stem • *Impact Sites:* downstream of confluence on main stem, downstream of where mixing has occurred *Integrator Sites:* at tributary mouths
Nitrogen Series • Total Kjeldahl →	Digestion followed by Nesslerization followed by spectrophotometry (SM #4500-Norg B or equivalent)	
• Nitrates →	Cadmium Reduction followed by spectrophotometry (SM #4500-NO3-E or equivalent)	2) **Pollution Source Impacts:** *Reference Sites:* upstream of source
• Ammonia →	Distillation followed by Nesslerization followed by spectrophotometry (SM #4500-NH3 C or	• *Impact Sites:* downstream of source where mixing has occurred - avoid mixing zones

	equivalent)	

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Intensive Benthic Macroinvertebrate Assessment	Field collection w/ net, lab id. of major groups or families, assess based on comparison to reference condition (RWN Benthic Macroinvertebrate Monitoring Manual - adaptation of EPA RBP II or equivalent)	**See previous page.**
Benthic Macroinvertebrate Habitat Assessment	Field observation and rating of key habitat characteristic relative to reference condition (RWN Benthic Macroinvertebrate Monitoring Manual - adaptation of EPA RBP II or equivalent)	
Visual field survey of river, riparian, and watershed characteristics, uses, values, and threats	Shoreline/Windshield Survey (Massachusetts Riverways Programs Adopt-A-Stream Manual or equivalent)	
River Flow	Embody Float Method (EPA Volunteer Stream Monitoring Methods Manual - Field Test Draft)	
Channel cross - section	Measure elevations at intervals across stream ("Stream Channel Reference Sites" USFS or equivalent)	
Longitudinal Profile	Elevations of channel bottom and water surface("Stream Channel Reference Sites" USFS or equivalent)	

Additional notes on the methods are contained in Appendix 1.

How Frequently and When Should You Monitor?

Rigorous Baseline Monitoring requires the collection of as many samples collected under as many different conditions as your resources will allow. A good baseline study will increase your understanding of how various indicators behave under different conditions, called *variability*. Further, in order to produce information that can help you understand variability, you must sample over a long period of time -- 5 years at a minimum.

We suggest the following for each of the activities in Rigorous Baseline Monitoring:

Water Sampling and Analysis:

- *Frequency:* sample at least two or three times per month during the chosen time of year.
- *Time of day:* sample during critical periods of the day for those indicators that fluctuate daily -- early morning for dissolved oxygen, late afternoon for temperature. (Also consider 24-hour studies for these indicators to determine daily variability)
- *Time of year:* Sample during critical periods of ecosystem stress, such as summer, and less stressful periods, such as mid-late spring.
- *Weather:* a variety of weather conditions: storm events, droughts, "normal" conditions, relatively hot weather, relatively cool weather, etc.

Benthic Macroinvertebrate Sampling and Analysis and Habitat Assessment

- *Frequency and time of year:* sample at least twice per year, once in the mid-spring and once in late summer or early fall (before leaf fall).
- *Time of day and weather:* Not a consideration, though high flows should be avoided.

Visual Surveys of River Uses, Values, and Threats

- *Frequency and time of year:* sample at least once per year, before the leaves emerge or after they fall.
- *Time of day and weather:* Not a consideration, though high flows should be avoided.

Field Measurements of Flow and Channel Characteristics

- *Frequency and time of year:* Measure flows at least as frequently as water sampling (even daily if possible). Measure channel characteristics at least twice per year, once after spring runoff, and once during low flows in late summer. Consider more frequent sampling associated with weather.
- *Time of day:* not a consideration

- *Weather:* before and after a variety of flow conditions: storm events, droughts, and "normal" conditions.

Data Analysis

Results will be compared with various reference conditions during the sampling season, and over time from year to year. Reference conditions include the water quality standards, informal guidelines established by your technical advisory committee, or actual results from regional reference sites.

Quality Assurance/Quality Control (QA/QC)

Rigorous Baseline Monitoring requires rigorous QA / QC. Specific quality control measures for each indicator are listed in Table 1 in Chapter IV. Also applicable in Chapter IV is information on internal and external quality controls and how they are assessed, general quality assurance for sampling and analysis and quality assurance for data management.

Periodic field and lab audits by VEMN partners is recommended. During these audits, VEMN partners will observe the operation of sampling and analytical procedures. Suggestions for improvements will be discussed with the program and lab coordinator. Audits will be conducted as specified in your study design, quality assurance plan or at the request of the program coordinator.

Training Required

Field Sampling: Initially, the Program Coordinator and a core group of field samplers should be trained in proper water and benthic macroinvertebrate sample collection, visual survey, channel characteristics measurements, and habitat assessment techniques by a VEMN Partner. The Program Coordinator should then designate people from this core group who are qualified to train others. Official certification of trainers by the program coordinator through a letter or certificate should be considered.

Lab Analysis: For personnel in the program lab,[8] proper training is essential. There should be a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator should conduct all training of analysts. Each analyst should be assigned to certain analyses by the coordinator. Official certification by the program coordinator of all analysts to perform specific analyses through a letter or certificate should be considered.

[8] This is a lab set up by a watershed group or school

D2. RIGOROUS BASELINE MONITORING: NON-WADEABLE RIVERS

What Is It?

Rigorous Baseline Monitoring is the most comprehensive and difficult baseline monitoring covered in this guide. It is watershed-wide in scope. It includes a wide range of monitoring activities that assess as many of the physical, chemical, and biological indicators of river health as is practical for volunteer monitors working in non-wadeable waters, using methods that are comparable to those used by state agencies:

- water sampling and analysis,
- benthic macroinvertebrate sampling and analysis and habitat assessment, and
- visual surveys of river uses, values, and threats.

Non-Wadeable rivers are waters greater than 2 feet deep, where it is not possible to see and access the bottom to collect samples of habitat and aquatic life. Special methods are used to assess these waters.

Rigorous Baseline Monitoring is geared to produce a great deal of high quality information which can be used by state and federal agencies for their assessment efforts.

Why Do Rigorous Baseline Monitoring?

We suggest that you undertake Rigorous Baseline Monitoring if your primary interest is in the long term ecological health of your river and you need to produce data that federal and state agencies will use for their assessment activities.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes

The main purposes for a preliminary watershed assessment are

- to establish baseline physical, chemical, and biological conditions against which future changes can be measured,
- to identify problem areas,
- to identify watershed improvement and protection actions, and
- to help you decide those characteristics and areas that are most important for intensive monitoring.

Questions Answered

Are conditions changing over time? What? Where? How? Why?

Data Use

The results from Rigorous Baseline Monitoring can be used for several things:

- Identify areas where action is needed to enable the water body to support healthy aquatic life,
- Identify problems and conflicts between human and aquatic life uses which need to be resolved by some management decision,
- Identify waters with significant ecological value, which may need protection as "Class A ," "outstanding resource waters" or under the "anti-degradation" provisions of the water quality standards,
- Identify waters that can serve as "reference conditions" (least impaired) waters against which progress in restoring impaired waters can be compared,
- Set priorities for funding water pollution control projects, and
- Evaluate whether pollution control measures are working.

Primary Data Quality Goals Addressed

☑ Education, awareness, and problem screening

☑ Community & watershed level evaluation, assessment, and management

☑ State, interstate, and Federal water quality evaluation and assessment

Monitoring Options

Rigorous Baseline Monitoring for Non-wadeable Rivers is similar to that for wadeable rivers. It involves collecting and analyzing water and aquatic life samples, assessing habitat conditions, and gathering visual information about uses, values and threats.

Monitoring options for non-wadeable waters for most indicators are essentially the same as for wadeable waters (refer to the table in section D1 for the methods). However, benthic macroinvertebrate sampling and habitat assessment are different, given the more difficult access to the river bottom.

Menu of Indicators/Tools	**Examples of Methods (Source)**	**Site Location Considerations**
E. coli (NH) Fecal Coliforms (MA) Dissolved Oxygen Turbidity Temperature pH Shoreline Survey for Volunteers Total Alkalinity Conductivity Total Phosphorus Nitrogen Series	**Same methods as Rigorous Baseline Monitoring for Wadeable Rivers (D1) except as follows:**	**Sampling throughout watershed at same types of sites as Rigorous Baseline Monitoring for Wadeable Waters, but focus is on deep water habitats (riffle and possibly run habitats are missing)**
Intensive Benthic Macroinvertebrate Assessment	Field collection with *rock baskets*, lab id. of major groups or families, assess based on comparison to reference condition (RWN Adaptation of ME DEP Method or equivalent)	
Benthic Macroinvertebrate Habitat Assessment	Use habitat assessment for muddy bottom streams (EPA Volunteer Stream Monitoring Methods Manual - Field Test Draft)	

Additional notes on the methods are contained in Appendix 1.

How Frequently and When Should You Monitor?

Rigorous Baseline Monitoring requires the collection of as many samples collected under as many different conditions as your resources will allow. A good baseline study will increase your understanding of how various indicators behave under different conditions, called *variability*. Further, in order to produce information that can help you understand variability, you must sample over a long period of time -- 5 years at a minimum.

We suggest the following for each of the activities in Rigorous Baseline Monitoring:

Water Sampling and Analysis:

- *Frequency:* sample at least two or three times per month, during the monitoring season.
- *Time of day:* sample during critical periods of the day for those indicators that fluctuate daily -- early morning for dissolved oxygen, late afternoon for temperature. (Also consider 24-hour studies for these indicators to determine daily variability)
- *Time of year:* Sample during critical periods of ecosystem stress, such as summer, and less stressful periods, such as mid-late spring.
- *Weather:* a variety of weather conditions: storm events, droughts, "normal" conditions, relatively hot weather, relatively cool weather, etc.

Benthic Macroinvertebrate Sampling and Analysis and Habitat Assessment

- *Frequency and time of year:* sample at least twice per year, once in the mid-spring and once in late summer or early fall (before leaf fall).
- *Time of day and weather:* Not a consideration, though high flows should be avoided.

Visual Surveys of River Uses, Values, and Threats

- *Frequency and time of year:* sample at least once per year, before the leaves emerge or after they fall.
- *Time of day and weather:* Not a consideration, though high flows should be avoided.

Data Analysis

Results will be compared with various reference conditions during the sampling season, and over time from year to year. Reference conditions include the water quality standards, informal guidelines established by your technical advisory committee, or actual results from regional reference sites.

Quality Assurance/Quality Control (QA/QC)

Rigorous Baseline Monitoring requires rigorous QA / QC. Specific quality control measures for each indicator are listed in Table 1 in Chapter IV. Also applicable in Chapter IV is information on internal and external quality controls and how they are assessed, general quality assurance for sampling and analysis and quality assurance for data management.

Periodic field and lab audits by VEMN partners is recommended. During these audits, VEMN partners observe the operation of sampling and analytical procedures. Suggestions for improvements are discussed with the program and lab coordinator. Audits will be conducted as specified in your study design, quality assurance plan or at the request of the program coordinator.

Training Required

Field Sampling: Initially, the Program Coordinator and a core group of field samplers should be trained in proper water and benthic macroinvertebrate sample collection, visual survey, and habitat assessment techniques by a VEMN Partner. The Program Coordinator should then designate people from this core group who are qualified to train others. Official certification of trainers by the program coordinator through a letter or certificate should be considered.

Lab Analysis: For personnel in the program lab,[9] proper training is essential. There should be a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator should conduct all training of analysts. Each analyst should be assigned to certain analyses by the coordinator. Official certification by the program coordinator of all analysts to perform specific analyses through a letter or certificate should be considered.

[9] This is a lab set up by a watershed group or school

D3. BASIC BASELINE MONITORING: WADEABLE RIVERS

What Is It?

Basic Baseline Monitoring seeks to balance limited time and resources with the goal of sampling as many different aspects of the river ecosystem as possible. Unlike Rigorous Baseline Monitoring, it need not cover an entire watershed. The focus may be limited to relatively small areas or even particular reaches. It includes a wide range of monitoring activities that assess as many of the physical, chemical, and biological indicators of river health as is practical for volunteer monitors, using relatively simple methods:

- water sampling and analysis,
- benthic macroinvertebrate sampling and analysis and habitat assessment, and
- visual surveys of river uses, values, and threats.

Wadeable rivers are waters less than 2 feet deep, where it is possible to see and access the bottom to collect samples of habitat and aquatic life.

Given that the methods used in Basic Baseline Monitoring, for most indicators, are not comparable to those used by state agencies, this information will likely be used by state and federal agencies to identify problem areas for further monitoring, rather than assessment. However, Basic Baseline Monitoring will provide an enriching experience and produce information which can be used for education and awareness purposes at the school, community, or watershed level.

Why Do Basic Baseline Monitoring?

We suggest that you undertake Basic Baseline Monitoring if your primary interest is in the long term ecological health of your river and you don't need to produce data that federal and state agencies will use for their assessment activities.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes:

- to educate and raise awareness of the participants and the public regarding some of the river's important physical, chemical, and biological characteristics,
- to identify gross problem areas, and
- to help you decide those characteristics and areas that are most important for intensive monitoring.

Questions Answered

Are there gross problem areas?

Data Use

The results from Basic Baseline Monitoring can be used for several things:

- Identify areas where more rigorous monitoring is needed to confirm problems that may require further action,
- Raise the level of community awareness about water quality,
- Bring gross problem areas to the attention of community, state, and federal officials, and
- Give students experience in analyzing data sets.

Primary Data Quality Goals Addressed

☑ Education, awareness, and problem screening
☐ Community & watershed level evaluation, assessment, and management
☐ State, interstate, and Federal water quality evaluation and assessment

Monitoring Options

Basic Baseline Monitoring for Wadeable Rivers involves collecting and analyzing water and aquatic life samples, assessing habitat conditions, and gathering visual information about uses, values and threats. It assesses many of the same indicators as the Rigorous Baseline Monitoring, but uses simpler methods.

Following is a menu of monitoring options from which to select indicators, methods, and sites appropriate for your river and your group's resources:

Menu of Indicators/Tools	**Examples of Methods (Source)**	**Site Location Considerations**
Fecal Colif./*E. coli* Bacteria →	Various methods that detect presence-absence or produce an estimate of bacteria density	**Focus may be limited to relatively small areas of the watershed, a small number of sites throughout the watershed, or to particular reaches.**
Dissolved Oxygen →	Modified Winkler Titration w/ a syringe or eyedropper (Mitchell & Stapp)	**Same types of sites as Rigorous Baseline Monitoring for Wadeable Waters.**
pH →	Sample collected and measured with a pH meter, pocket meter or paper	
Temperature →	Direct measurement with a thermometer	
Total Alkalinity →	Sulfuric acid titration w/ digital titrator and pH meter (RWN)	
Conductivity →	Direct measurement with meter (EPA Volunteer Methods Manual) or pen (RWN)	
Total Phosphorus →	Persulfate digestion followed by ascorbic acid method and color comparator (Mitchell & Stapp)	
Turbidity →	Sample collected and measured with a nephelometer and reported as NTU's (RWN) or turbidity tube reported in centimeters or inches (Australia Water	

	Watch)	

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Biochemical Oxygen Demand →	BOD 5-day procedure w/ Modified Winkler Titration w/ a syringe or eyedropper (Mitchell & Stapp)	**See previous page.**
Nitrates →	Cadmium Reduction followed by color comparator (Mitchell & Stapp)	
Visual field survey of river, riparian and watershed characteristics, uses, values, and threats →	Shoreline/Windshield Survey (Massachusetts Riverways Programs Adopt-A-Stream Manual or equivalent) and/or photo-documentation	
Streamside Benthic Macroinvertebrate Assessment →	Field collection, identification of major groups, assessment based on relative abundance and estimated richness (RWN Benthic Macroinvertebrate Monitoring Manual)	

Additional notes on the methods are contained in Appendix 1.

How Frequently and When Should You Monitor?

Basic Baseline Monitoring requires the collection of as many samples collected under as many different conditions as your resources will allow. A good baseline study will increase your understanding of how various indicators behave under different conditions, called *variability*. Further, in order to produce information that can help you understand variability, you must sample over a long period of time -- 5 years at a minimum.

We suggest the following for each of the activities in Basic Baseline Monitoring:

Water Sampling and Analysis:

- *Frequency:* sample at least two or three times per month, during the monitoring season.
- *Time of day:* sample during critical periods of the day for those indicators that fluctuate daily -- early morning for dissolved oxygen, late afternoon for temperature. (Also consider 24-hour studies for these indicators to determine daily variability).
- *Time of year:* Sample during critical periods of ecosystem stress, such as summer, and less stressful periods, such as mid-late spring.
- *Weather:* a variety of weather conditions: storm events, droughts, "normal" conditions, relatively hot weather, relatively cool weather, etc.

Benthic Macroinvertebrate Sampling and Analysis and Habitat Assessment

- *Frequency and time of year:* sample at least once per year, once in the mid-spring or once in late summer or early fall (before leaf fall).
- *Time of day and weather:* Not a consideration, though high flows should be avoided.

Visual Surveys of River Uses, Values, and Threats

- *Frequency and time of year:* sample at least once per year, before the leaves emerge or after they fall.
- *Time of day and weather:* Not a consideration, though high flows should be avoided.

Data Analysis

Results will be compared with various reference conditions during the sampling season, and over time from year to year. Reference conditions include the water quality standards, informal guidelines established by your technical advisory committee, or actual results from regional reference sites.

Quality Assurance/Quality Control (QA/QC)

Basic Baseline Monitoring does not require rigorous QA / QC. Specific quality control measures for each indicator are listed in Table 2 in Chapter IV. Note that only internal controls are recommended, though external controls will enhance the credibility of the data and provide a valuable educational experience for participants. Also applicable in Chapter IV is information on internal quality controls and how they are assessed, general quality assurance for sampling and analysis, and quality assurance for data management.

Training Required

Sampling: Initially, the program coordinator and a core group of field samplers should be trained in proper water and benthic macroinvertebrate sample collection and visual survey techniques by a VEMN Partner. The program coordinator should then designate people from this core group who are qualified to train others.

Lab Analysis: For personnel in the program lab,[10] proper training is essential. We suggest a designated lab coordinator responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator or someone trained by the coordinator should train other analysts. Each analyst should be assigned to certain analyses by the coordinator.

[10] This is a lab set up by a watershed group or school

D4. BASIC BASELINE MONITORING: NON-WADEABLE RIVERS

What Is It?

Basic Baseline Monitoring seeks to balance limited time and resources with the goal of sampling as many different aspects of the river ecosystem as possible. Unlike Rigorous Baseline Monitoring, it need not cover an entire watershed. The focus may be limited to relatively small areas or even particular reaches. It includes monitoring activities that primarily assess as many of the physical and chemical indicators of river health as is practical for volunteer monitors, using relatively simple methods:

- water sampling and analysis, and
- visual surveys of river uses, values, and threats.

Non-wadeable rivers are waters greater than 2 feet deep, where it may not be possible to see and access the bottom to collect samples of habitat and aquatic life. Unfortunately, non-wadeable waters do not allow a simple method of collecting benthic macroinvertebrate samples or to assess habitat conditions.

Given that the methods used in Basic Baseline Monitoring, for most indicators, are not comparable to those used by state agencies, this information will likely be used by state and federal agencies to identify problem areas for further monitoring, rather than assessment. However, Basic Baseline Monitoring will provide an enriching experience and produce information which can be used for education and awareness purposes at the school, community, or watershed level.

Why Do Basic Baseline Monitoring?

We suggest that you undertake Basic Baseline Monitoring if your primary interest is in the long term ecological health of your river and you don't need to produce data that federal and state agencies will use for their assessment activities.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes

- to educate and raise awareness of the participants and the public regarding some of the river's important physical, chemical, and biological characteristics,
- to identify gross problem areas, and
- to help you decide those characteristics and areas that are most important for intensive monitoring.

Questions Answered

Are there gross problem areas?

Data Use

The results from Basic Baseline Monitoring can be used for several things:

- Identify areas where more rigorous monitoring is needed to confirm problems that may require further action,
- Raise the level of community awareness about water quality,
- Bring gross problem areas to the attention of community, state, and federal officials, and
- Give students experience in analyzing data sets.

Primary Data Quality Goals Addressed

☑ Education, awareness, and problem screening

☐ Community & watershed level evaluation, assessment, and management

☐ State, interstate, and Federal water quality evaluation and assessment

Monitoring Options

Basic Baseline Monitoring for Non-wadeable Rivers is similar to that for wadeable waters. It involves collecting and analyzing water and aquatic life samples, assessing habitat conditions, and gathering visual information about uses, values, and threats.

Monitoring options for non-wadeable waters are essentially the same as for wadeable waters (refer to the table in section D3 for the methods). However, benthic macroinvertebrate sampling and habitat assessment are not possible using simple methods, given the lack of access to the river bottom:

Menu of Indicators/Tools	**Examples of Methods (Source)**	**Site Location Considerations**
Fecal Colif. / *E. coli* Bacteria Dissolved Oxygen pH Temperature Total Alkalinity Conductivity Total Phosphorus Turbidity Biochemical Oxygen Demand Nitrates Visual field survey of river, riparian, and watershed characteristics, uses, values, and threats	**Same methods as Basic Baseline Monitoring for Wadeable Rivers (D3)**	**Focus may be limited to relatively small areas of the watershed, a small number of sites throughout the watershed, or to particular reaches. Same types of sites as Rigorous Baseline Monitoring for Wadeable Waters, but focus is on deep water habitats (riffle and possibly run habitats are missing)**

Additional notes on the methods are contained in Appendix 1.

How Frequently and When Should You Monitor?

Basic Baseline Monitoring requires the collection of as many samples collected under as many different conditions as your resources will allow. A good baseline study will increase your understanding of how various indicators behave under different conditions, called *variability*. Further, in order to produce information that can help you understand variability, you must sample over a long period of time -- 5 years at a minimum.

We suggest the following for each of the activities in Basic Baseline Monitoring:

Water Sampling and Analysis:

- *Frequency:* sample at least two or three times per month, during the monitoring season.
- *Time of day:* sample during critical periods of the day for those indicators that fluctuate daily -- early morning for dissolved oxygen, late afternoon for temperature. (Also consider 24-hour studies for these indicators to determine daily variability).
- *Time of year:* Sample during critical periods of ecosystem stress, such as summer, and less stressful periods, such as mid-late spring.
- *Weather:* a variety of weather conditions: storm events, droughts, "normal" conditions, relatively hot weather, relatively cool weather, etc.

Visual Surveys of River Uses, Values, and Threats

- *Frequency and time of year:* sample at least once per year, before the leaves emerge or after they fall.
- *Time of day and weather:* Not a consideration, though high flows should be avoided.

Data Analysis

Results will be compared with various reference conditions during the sampling season, and over time from year to year. Reference conditions include the water quality standards, informal guidelines established by your technical advisory committee, or actual results from regional reference sites.

Quality Assurance/Quality Control (QA/QC)

Basic Baseline Monitoring does not require rigorous QA / QC. Specific quality control measures for each indicator are listed in Table 2 in Chapter IV. Note that only internal controls are recommended, though external controls will enhance the credibility of the data and provide a valuable educational experience for participants. Also applicable in Chapter IV is information on internal quality controls and how they are assessed, general quality assurance for sampling and analysis and quality assurance for data management.

Training Required

Sampling: Initially, the Program Coordinator and a core group of field samplers should be trained in proper water sample collection and visual survey techniques by a VEMN Partner. The Program Coordinator should then designate people from this core group who are qualified to train others.

Lab Analysis: For personnel in the program lab,[11] proper training is essential. We suggest a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator or someone trained by the coordinator should train other analysts. Each analyst should be assigned to certain analyses by the coordinator.

[11] This is a lab set up by a watershed group or school

D5. RIGOROUS BASELINE MONITORING: LAKES

What Is It?

Rigorous Baseline Monitoring is lake-wide in scope. It includes a wide range of monitoring activities that assess as many of the physical, chemical, and biological indicators of lake health as is practical for volunteer monitors, using methods that are comparable to those used by state agencies:

- water sampling and analysis,
- aquatic weed mapping,
- visual surveys of shoreline uses, values, and threats, and
- lake level measurements.

Rigorous Baseline Monitoring for lakes is focused on the lake itself, though visual surveys may be extended to the watershed. It is geared to produce a great deal of high quality information which can be used by state and federal agencies for their assessment efforts.

Why Do Rigorous Baseline Monitoring?

We suggest that you undertake Rigorous Baseline Monitoring if your primary interest is in the long term ecological health of your lake and you need to produce data that federal and state agencies will use for their assessment activities.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes:

- to establish baseline physical, chemical, and biological conditions against which future changes can be measured,
- to identify watershed improvement and protection actions, and
- to help you decide those characteristics and areas that are most important for intensive monitoring.

Questions Answered:

Are conditions changing over time? What? Where? How? Why?

Data Use

The results from Rigorous Baseline Monitoring can be used for several things:

- Identify areas where action is needed to enable the water body to support healthy aquatic life,

- Identify problems and conflicts between human and aquatic life uses which need to be resolved by some management decision,
- Identify waters with significant ecological value, which may need protection as "Class A ," "outstanding resource waters" or under the "anti-degradation" provisions of the water quality standards,
- Identify waters that can serve as "reference conditions" (least impaired) waters against which progress in restoring impaired waters can be compared,
- Set priorities for funding water pollution control projects, and
- Evaluate whether pollution control measures are working.

Primary Data Quality Goals Addressed

☑ Education, awareness, and problem screening
☑ Community & watershed level evaluation, assessment, and management
☑ State, interstate, and Federal water quality evaluation and assessment

Monitoring Options

Rigorous Baseline Monitoring for Lakes involves collecting and analyzing water samples, aquatic vegetation mapping, a visual shoreline survey of uses, values, and threats, and measurement of water clarity and lake level.

You might not need to (or be able to) use all the indicators and tools listed in the table below. For example, some may not be relevant to your lake or you may not have the resources to use them all. Consider it a menu and consult with your technical advisory committee to select the indicators, methods, and sites appropriate for your lake and your human and financial resources:

Menu of Indicators/Tools	**Examples of Methods (Source)**	**Site Location Considerations**
E. coli Bacteria (NH) →	Membrane filtration w / mTEC *with* confirmation (EPA# 1103.1 or equivalent)	**Sampling throughout lake** • Deepest part of the lake
Fecal Coliform Bacteria (MA) →	Membrane filtration w / mTEC *without* confirmation (EPA# 1103.1 or equivalent)	• Deepest part of significant arms or bays • Mouths of tributaries ("integrator" sites)
Secchi Transparency (lakes) →	**Transparency depth measurement using a secchi disk (MassWWP or UNH CE Method)**	• Sites at areas of public use for water contact recreation (e.g. swimming) areas
Temperature →	Direct measurement with a thermometer, thermocouple, or thermistor	• Where possible, sites historically monitored by the state water quality agency
Dissolved Oxygen →	1) Integrated or multiple depth sample analyzed by Modified Winkler Titration with a buret, syringe, or digital titrator (SM #4500-OG or equivalent) 2) Direct measurement at various depths with a membrane electrode meter (SM #4500-OG or equivalent)	• Waters receiving non-point source discharges and polluted runoff • Outlet • Waters located in areas of different land uses (urban, agricultural, forested) • Near-shore areas for weed mapping

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
pH →	Integrated or multiple depth sample analyzed by a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent)	**See previous page.**
Total Alkalinity →	Integrated or multiple depth sample analyzed by double end point sulfuric acid titration w/ digital titrator and pH meter (MassWWP Manual)	
Total Phosphorus →	Integrated or multiple depth sample analyzed by persulfate digestion followed by ascorbic acid method and spectrophotometry (EPA Method #365.2 or equivalent)	
Cholorophyll *a* →	Pigment extraction followed by spectrophotometry (SM #10200 H)	
Aquatic Vegetation Mapping/ Identification →	MassWWP and UNH Coop. Ext. methods	
Visual field survey of lake, riparian, and watershed characteristics, uses, values, and threats →	MassWWP, UNH Coop. Ext., NH DES methods	
Lake levels →	Staff gage anchored to fixed object	

Additional notes on the methods are contained in Appendix 1.

How Frequently and When Should You Monitor?

Rigorous Baseline Monitoring requires the collection of as many samples under as many different conditions as your resources will allow. A good baseline study will increase your understanding of how various indicators behave under different conditions, called *variability*. Further, in order to produce information that can help you understand variability, you must sample over a long period of time -- 5 years at a minimum. Consider sampling the following to determine variability:

Water Sampling and Analysis:

- *Frequency:* sample at least two or three times per month, during the monitoring season.
- *Time of day:* sample during critical periods of the day for those indicators that fluctuate daily -- early morning for dissolved oxygen, late afternoon for temperature. (Also consider 24-hour studies for these indicators to determine daily variability).
- *Time of year:* Sample during critical periods, or lake turnover periods, of ecosystem stress, such as summer, and less stressful periods, such as mid-late spring.
- *Weather:* a variety of weather conditions: storm events, droughts, "normal" conditions, relatively hot weather, relatively cool weather, etc.

Visual Surveys of River Uses, Values, and Threats:

- *Frequency and time of year:* sample at least once per year, before the leaves emerge or after they fall.
- *Time of day and weather:* Not a consideration, though high levels should be avoided.

Aquatic Weed Mapping:

- *Frequency and time of year:* survey at least once per year, during mid-summer when plants are well established.
- *Time of day and weather:* Survey when the light is good.

Lake Level Measurements:

- *Frequency and time of year:* Measure at least in conjunction with water sampling, daily if possible.
- *Time of day:* not a consideration.
- *Weather:* before and after a variety of flow conditions: storm events, droughts, and "normal" conditions.

Data Analysis

Results will be compared with various reference conditions during the sampling season, and over time from year to year. Reference conditions include the water quality standards, informal guidelines established by your technical advisory committee, or actual results from regional reference sites.

Quality Assurance/Quality Control (QA/QC)

Rigorous Baseline Monitoring requires following rigorous QA / QC protocols. Specific quality control measures for each indicator are listed in Table 1 in Chapter IV. Also applicable in Chapter IV is information on internal and external quality controls and how they are assessed, general quality assurance for sampling and analysis, and quality assurance for data management.

Periodic field and lab audits by VEMN partners is recommended. During these audits, VEMN partners observe the operation of sampling and analytical procedures. Suggestions for improvements are discussed with the program and lab coordinator. Audits will be conducted as specified in your study design, quality assurance plan, or at the request of the program coordinator.

Training Required

Field Sampling: Initially, the program coordinator and a core group of field samplers should be trained in proper water sample collection, secchi, visual survey, and weed mapping techniques by a VEMN Partner. The program coordinator should then designate people from this core group who are qualified to train others. Official certification of trainers by the program coordinator through a letter or certificate should be considered.

Lab Analysis: For personnel in the program lab,[12] proper training is essential. There should be a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator should conduct all training of analysts. Each analyst should be assigned to certain analyses by the coordinator. Official certification by the program coordinator of all analysts to perform specific analyses through a letter or certificate should be considered.

[12] This is a lab set up by a watershed group or school

D6. BASIC BASELINE MONITORING: LAKES

What Is It?

Basic Baseline Monitoring seeks to balance limited time and resources with the goal of sampling the most important and integrative aspects of the lake ecosystem as possible. The focus is limited to one or two areas in the deepest part of the lake. It includes monitoring activities that visually assess physical and biological indicators of lake health:

- measurement of transparency,
- aquatic weed mapping, and
- visual surveys of shoreline uses, values, and threats.

Basic Baseline Monitoring for lakes is focused on the lake itself, though visual surveys may be extended to the watershed. Given the limited scope of this monitoring and the fact that the methods are not as sensitive to change as the ones used by state agencies, the information will likely be used by state and federal agencies to identify problem areas for further monitoring, rather than assessment. However, Basic Baseline Monitoring will provide an enriching experience and produce information which can be used for education and awareness purposes at the school, community, or watershed level.

Why Do Basic Baseline Monitoring?

We suggest that you undertake Basic Baseline Monitoring if your primary interest is in the long term ecological health of your lake and you don't need to produce data that federal and state agencies will use for their assessment activities.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes:

- to educate and raise awareness of the participants and the public regarding some of the river's important physical, chemical, and biological characteristics,
- to identify problem areas, and
- to help you decide those characteristics and areas that are most important for intensive monitoring.

Questions Answered

Are there gross problem areas?

Data Use

The results from Basic Baseline Monitoring can be used for several things:

- Identify areas where more rigorous monitoring is needed to confirm problems that may require further action,
- Raise the level of community awareness about water quality,
- Bring gross problem areas to the attention of community, state, and federal officials, and
- Give students experience in analyzing data sets.

Primary Data Quality Goals Addressed

☑ Education, awareness, and problem screening

☐ Community & watershed level evaluation, assessment, and management

☐ State, interstate, and Federal water quality evaluation and assessment

Monitoring Options

Basic Baseline Monitoring for Lakes involves collecting and analyzing water samples, aquatic vegetation mapping, a visual shoreline survey of uses, values, and threats, and measurement of water clarity and water level. It assesses many of the same indicators as the Rigorous Baseline Monitoring, but uses simpler methods.

Following is a menu of monitoring options from which to select indicators, methods, and sites appropriate for your lake and your human and financial resources:

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Secchi Transparency →	MassWWP or UNH CE Method	**Sampling one or a few representative sites:** • Deepest part of the lake
Aquatic Vegetation Mapping/ Identification →	MassWWP and UNH Coop. Ext. methods	• Near-shore areas for vegetation mapping
Visual field survey of lake, riparian, and watershed characteristics, uses, values, threats → and	MassWWP, UNH Coop. Ext., NH DES methods	• Deepest part of significant arms or bays

Additional notes on the methods are contained in Appendix 1.

How Frequently and When Should You Monitor?

Basic Baseline Monitoring requires the collection of as many samples collected under as many different conditions as your resources will allow. A good baseline study will increase your understanding of how various indicators behave under different conditions, called *variability*. Further, in order to produce information that can help you understand variability, you must sample over a long period of time -- 5 years at a minimum.

For a rigorous baseline study, we recommend sampling different times of day, different seasons, and under different weather conditions. For a basic baseline study, we suggest that you consider focusing on sampling *one* of the following to determine variability:

Secchi Transparency:

- *Frequency:* sample at least two or three times per month, during the monitoring season.
- *Time of day:* sample during the same time of day each sampling event.

- *Time of year:* Sample during critical periods of ecosystem stress, such as summer, and less stressful periods, such as mid-late spring.
- *Weather:* a variety of weather conditions: storm events, droughts, "normal" conditions, relatively hot weather, relatively cool weather, etc.

Visual Surveys of Lake Uses, Values, and Threats:

- *Frequency and time of year:* sample at least once per year, before the leaves emerge or after they fall.
- *Time of day and weather:* Not a consideration.

Aquatic Weed Mapping:

- *Frequency and time of year:* survey at least once per year, during mid-summer when plants are well established.
- *Time of day and weather:* Survey when the light is good.

Data Analysis

Results will be compared with various reference conditions during the sampling season, and over time from year to year. Reference conditions include the water quality standards, informal guidelines established by your technical advisory committee, or actual results from regional reference sites.

Quality Assurance/Quality Control (QA/QC)

Basic Baseline Monitoring does not require rigorous QA / QC. Specific quality control measures for each indicator are listed in Table 2 in Chapter IV. Note that only internal controls are recommended, though external controls will enhance the credibility of the data and provide a valuable educational experience for participants. Also applicable in Chapter IV is information on internal quality controls and how they are assessed, general quality assurance for sampling and analysis, and quality assurance for data management.

Training Required

Sampling: Initially, the program coordinator and a core group of field samplers should be trained in proper water sample collection, weed mapping, and visual survey techniques by a VEMN Partner. The program coordinator should then designate people from this core group who are qualified to train others.

Lab Analysis: For personnel in the program lab,[13] proper training is essential. We suggest a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator or someone trained by the coordinator should

[13] This is a lab set up by a watershed group or school

train other analysts. Each analyst should be assigned to certain analyses by the coordinator.

E. WASTEWATER TREATMENT PLANT IMPACT ASSESSMENT: RIVERS

Wastewater Treatment Plant Impact Assessment is the collection of information about the impact of a wastewater treatment plant discharge on the river's ecological health and human use. It typically involves *instream* monitoring of various indicators upstream and downstream of the plant using *reference, impact*, and *recovery* sites. Results at the impact and recovery sites (downstream of the plant) are compared with those at the reference site (upstream of the plant) to determine the extent of the impact attributable to that plant. The indicators are selected based on the nature of the discharge and its likely impacts.

Given the nature of the assessment -- comparison of conditions upstream of the plant with those downstream of the plant -- and the fact that there are no discharges allowed to lakes -- it is limited to rivers.

We suggest two options which cover two different levels of effort (rigorous and basic):

E1 Rigorous Wastewater Treatment Plant Impact Assessment

E2 Basic Wastewater Treatment Plant Impact Assessment

These monitoring options are geared to meet different data quality goals and available resources.

Each of these options is described in the following sections.

E1. RIGOROUS WASTEWATER TREATMENT PLANT IMPACT ASSESSMENT: RIVERS

What Is It?

A Rigorous Wastewater Treatment Plant Impact Assessment is the collection of selected information about the impact of a wastewater treatment plant on the river's ecological health and human use. It includes a wide range of monitoring activities that assess as many of the physical, chemical, and biological indicators of river health likely to be affected by the discharge as is practical for volunteer monitors, using methods that are comparable to those used by state agencies:

- water sampling and analysis for indicators of discharge impacts,
- benthic macroinvertebrate sampling and analysis and habitat assessment, and
- visual surveys of river uses, values, and threats.

These activities occur upstream and downstream of the plant at *reference*, *impact*, and *recovery* sites. Results at the impact and recovery sites (downstream of the plant) are compared with those at the reference site (upstream of the plant) to determine the extent of the impact attributable to that plant's discharge of treated effluent.

A Rigorous Wastewater Treatment Plant Impact Assessment is geared to produce high quality information which can be used by state and federal agencies and communities to set pollution control priorities, as well as to assess the need for changes in plant operation or upgrades.

Why Do Rigorous Wastewater Treatment Plant Impact Assessment?

We suggest that you undertake Rigorous Wastewater Treatment Plant Impact Assessment if your primary interest is in the impact of wastewater discharges on the long term ecological health and human use of your river, and you want to produce data that federal and state agencies will use for their assessment activities.

It will help you to accomplish the purposes, answer the questions, and provide information for the data uses listed below.

Purposes:

- to assess the impact of a wastewater treatment plant on the river's physical, chemical, and biological characteristics,
- to provide information communities can use to assess the need for changes in plant operations or upgrades, and

- to provide information state and federal officials can use to set pollution control funding priorities.

Questions Answered:

1) *What are the impacts of point discharges on human use and ecological integrity of the river system or reach?*

2) *What is the effectiveness of water pollution control facilities (wastewater treatment plants or on-site systems) in restoring and protecting human use and ecological integrity of the river system or specific water bodies?*

Data Use

The results from Rigorous Wastewater Treatment Plant Assessment can be used for several things:

- Identify plants where operational changes or upgrades are needed to enable the water body to support healthy aquatic life or designated human uses,
- Set priorities for funding water pollution control projects, and
- Evaluate whether pollution control measures are working.

Primary Data Quality Goals Addressed

☑ Education, awareness, and problem screening
☑ Community & watershed level evaluation, assessment, and management
☑ State, interstate, and Federal water quality evaluation and assessment

Monitoring Options

The Rigorous Wastewater Treatment Plant Assessment involves collecting and analyzing water samples for indicators of the impacts of wastewater discharge; collecting and analyzing benthic macroinvertebrate samples; assessing benthic macroinvertebrate habitat quality; and a visual shoreline survey of uses, values, and threats. These activities are carried out above and below the plant.

Following is a menu of monitoring options from which to select indicators, methods, and sites appropriate for your river, the nature of the discharge from the plant, and your human and financial resources:

Menu of Indicators/Tools	**Examples of Methods (Source)**	**Site Location Considerations**
Select appropraite indicators/tools for the nature of discharge		
E. coli Bacteria (NH) →	Membrane filtration w / mTEC *with* confirmation (EPA# 1103.1 or equivalent)	• **reference or control site** immediately upstream of the plant • **impact site** immediately downstream of the alteration (downstream of the mixing zone at a point where the impact is completely integrated with the water) • **recovery site** downstream of the impact site (where the water has at least partially recovered from the impact). • Note: It may be difficult to isolate the treatment plant from other impacts on a river reach -- it may be necessary to bracket a group of impacts together.
Fecal Coliform Bacteria (MA) →	Membrane filtration w / mTEC *without* confirmation (EPA# 1103.1 or equivalent)	
Dissolved Oxygen →	**1)** RWN adaptation of Modified Winkler Titration (SM #4500-OG) with a digital titrator **2) Direct measurement with a membrane electrode meter (SM #4500-OG)**	
Turbidity →	Sample collected and measured with a nephelometer (RWN adaptation of Standard Methods #2130)	
Biochemical Oxygen Demand →	5-day BOD test (SM #5210-B) using Modified Winkler	

	Titration	

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
pH	1) Sample collected and measured with a meter (MassWWP adaptation of EPA Method 150.1) 2) Direct measurement with a meter (EPA Method 150.1)	**See previous page.**
Conductivity	Direct measurement with a meter (EPA Volunteer Methods manual	
Temperature	**Direct measurement with a thermometer**	
Total Phosphorus	Persulfate digestion followed by ascorbic acid method and colorimetry (EPA Method #365.2 or equivalent)	
Nitrogen Series • Total Kjeldahl Nitrogen	Digestion followed by Nesslerization followed by spectrophotometry (SM #4500-NO3-E or equivalent)	
• Nitrates	Cadmium reduction followed by spectrophotometry (SM #4500-NH3 C or equivalent)	
• Ammonia	Distillation followed by Nesslerization followed by spectrophotometry (SM #4500-NH3 C or equivalent)	
Chlorophyll *a*	Pigment extraction followed by spectrophotometry (SM #10200 H)	

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Visual field survey of river, riparian, and watershed characteristics, uses, values, and threats	Shoreline / Windshield Survey (Massachusetts Riverways Programs Adopt-A-Stream Manual or equivalent)	**See previous page**.
Intensive Benthic Macroinvertebrate Assessment	Field collection w / net or rock basket, lab id. of families, assess based on comparison to upstream reference site (RWN Adaptation of EPA RBP II)	
Benthic Macroinvertebrate Habitat Assessment	Field observation and rating of key habitat characteristic relative to upstream reference site (RWN Methods)	

Additional notes on the methods are contained in Appendix 1.

How Frequently and When Should You Monitor?

In general, we suggest monitoring wastewater treatment plants when they are likely to have the greatest impacts on the aquatic ecosystem and on water contact recreation. This will likely be in the summer months, during periods when people are swimming in the water and when low flows frequently combine with high temperatures to stress aquatic organisms.

Within the summer months, we suggest water sampling during the early morning hours, when dissolved oxygen levels are likely to be at their lowest.

This will vary according to the size of the plant, the nature of its discharge and the nature of the receiving water. Following are some basic considerations:

Water Sampling and Analysis:

- *Frequency:* sample at least two or three times per month, during the monitoring season.
- *Time of day:* sample during critical periods of the day for those indicators that fluctuate daily -- early morning for dissolved oxygen, late afternoon for temperature. (Also consider 24-hour studies for these indicators to determine daily variability).

- *Time of year:* Sample during critical periods of ecosystem stress, such as summer, and less stressful periods, such as mid-late spring.
- *Weather:* a variety of weather conditions: storm events, droughts, "normal" conditions, relatively hot weather, relatively cool weather, etc.

Benthic Macroinvertebrate Sampling and Analysis and Habitat Assessment:

- *Frequency and time of year:* sample at least twice per year, once in the mid-spring and once in late summer or early fall (before leaf fall).
- *Time of day and weather:* Not a consideration, although high flows should be avoided.

Visual Surveys of River Uses, Values, and Threats:

- *Frequency and time of year:* sample at least once per year, before the leaves emerge or after they fall.
- *Time of day and weather:* Not a consideration, although high flows should be avoided.

Data Analysis

Results will be compared with various reference conditions during the sampling season, and over time from year to year. At a minimum, reference conditions will include the water quality standards and the results from the reference station immediately upstream of the plant. Comparisons to the reference station can be tricky and require statistical analysis to determine whether difference are significant. Your technical advisory committee should help you assess this.

Quality Assurance/Quality Control (QA/QC)

Rigorous Wastewater Treatment Plant Assessment requires following rigorous QA / QC protocols. Specific quality control measures for each indicator are listed in Table 1 in Chapter IV. Also applicable in Chapter IV is information on internal and external quality controls and how they are assessed, general quality assurance for sampling and analysis, and quality assurance for data management.

Periodic field and lab audits by VEMN partners is recommended. During these audits, VEMN partners observe the operation of sampling and analytical procedures. Suggestions for improvements are discussed with the program and lab coordinator. Audits will be conducted as specified in your study design, quality assurance plan or at the request of the program coordinator.

Training Required

Field Sampling: Initially, the program coordinator and a core group of field samplers should be trained in proper water and benthic macroinvertebrate sample collection, visual survey, and habitat assessment techniques by a VEMN Partner. The program coordinator should then designate people from this core group who are qualified to train others. Official certification of trainers by the program coordinator through a letter or certificate should be considered.

Lab Analysis: For personnel in the program lab,[14] proper training is essential. There should be a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator should conduct all training of analysts. Each analyst should be assigned to certain analyses by the coordinator. Official certification by the program coordinator of all analysts to perform specific analyses through a letter or certificate should be considered.

[14] This is a lab set up by a watershed group or school

E2. BASIC WASTEWATER TREATMENT PLANT IMPACT ASSESSMENT: RIVERS

What Is It?

A Basic Wastewater Treatment Plant Impact Assessment is the collection of relatively easy-to-gather information about the impact of a wastewater treatment plant on the river's ecological health and human use. It includes monitoring activities that assess the physical, chemical, and biological indicators of river health likely to be affected by the discharge and practical to monitor for schools or groups with limited human and financial resources:

- water sampling and analysis for indicators of discharge impacts,
- benthic macroinvertebrate sampling and analysis and habitat assessment (in wadeable waters only), and
- visual surveys of river uses, values, and threats.

These activities occur upstream and downstream of the plant at *reference*, *impact*, and *recovery* sites. Results at the impact and recovery sites (downstream of the plant) are compared with those at the reference site (upstream of the plant) to determine the extent of the impact attributable to that plant.

Given that the methods used in Basic Wastewater Treatment Plant Impact Assessment, for most indicators, are not comparable to those used by state agencies, this information will likely be used by state and federal agencies and communities for education and awareness and to identify problem areas for further monitoring, rather than setting priorities or determining the need for operational changes. However, a Basic Wastewater Treatment Plant Impact Assessment will provide an enriching experience and produce information which can be used for education and awareness purposes at the school, community, or watershed level.

Why Do A Basic Wastewater Treatment Plant Impact Assessment?

We suggest that you undertake a Basic Wastewater Treatment Plant Impact Assessment if your primary interest is in the impact of wastewater discharges on the long term ecological health and human use of your river and you don't need to produce data that federal and state agencies will use for their assessment activities.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes

- to educate and raise awareness of the participants and the public regarding the impact of a wastewater treatment plant on the river's physical, chemical, and biological characteristics, and
- to identify gross problem areas that might need action or further monitoring.

Questions Answered

1) *What are the impacts of point discharges on human use and ecological integrity of the river system or reach?*
2) *What is the effectiveness of water pollution control facilities (wastewater treatment plants or on-site systems) in restoring and protecting human use and ecological integrity of the river system or specific water bodies?*

Data Use

The results from Basic Wastewater Treatment Plant Assessment can be used for several things:

- Identify plants where more rigorous monitoring is needed to confirm problems that may require further action,
- Raise the level of community awareness about their wastewater treatment plants and water quality,
- Bring gross problem areas to the attention of community, state, and federal officials, and
- Give students experience in analyzing data sets.

Primary Data Quality Goals Addressed

☑ Education, awareness, and problem screening
☐ Community & watershed level evaluation, assessment, and management
☐ State, interstate, and Federal water quality evaluation and assessment

Monitoring Options

The Basic Wastewater Treatment Plant Assessment involves collecting and analyzing water samples for indicators of the impacts of wastewater discharge; collecting and analyzing and benthic macroinvertebrate samples (wadeable rivers only); and a visual shoreline survey, of uses, values and threats. These activities are carried out above and below the plant. It assesses many of the same indicators as the Rigorous Wastewater Treatment Plant Assessment , but uses simpler methods.

Following is a menu of monitoring options from which to select indicators, methods, and sites appropriate for your river, the nature of the discharge from the plant, and your human and financial resources:

Menu of Indicators/Tools	**Examples of Methods (Source)**	**Site Location Considerations**
Select appropraite indicators/tools:		
Fecal Colif./*E. coli* Bacteria →	Various methods that detect presence-absence or produce an estimate of bacteria density	• **reference or control site** immediately upstream of the plant • **impact site** immediately downstream of the alteration (downstream of the mixing zone at a point where the impact is completely integrated with the water) • **recovery site** downstream of the impact site (where the water has at least partially recovered from the impact). • Note: It may be difficult to isolate the treatment plant from other impacts on a river reach -- it may be necessary to bracket a group of impacts together.
Dissolved Oxygen →	Modified Winkler Titration w / a syringe or eyedropper (Mitchell & Stapp)	
pH →	Sample collected and measured with a pH meter, pocket meter or paper	
Temperature →	**Direct measurement with a thermometer**	
Total Alkalinity →	**Sulfuric acid titration w/digital titrator and pH meter (RWN)**	
Conductivity →	Direct measurement with meter (EPA Volunteer Methods Manual) or pen (RWN)	
Total Phosphorus →	Persulfate digestion followed by ascorbic acid method and color comparator (Mitchell &	

	Stapp)	

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Turbidity →	Sample collected and measured with a nephelometer and reported as NTU's (RWN) or turbidity tube reported in centimeters or inches (no source yet)	**See previous page**.
Nitrates →	Cadmium reduction followed by color comparator (Mitchell & Stapp)	
Biochemical Oxygen Demand →	**BOD 5-day procedure w/ Modified Winkler Titration w/ a syringe or eyedropper (Mitchell & Stapp)**	
Visual field survey of river, riparian, and watershed characteristics, uses, values, and threats →	Shoreline/Windshield Survey (Massachusetts Riverways Programs Adopt-A-Stream Manual or equivalent)	
Basic Benthic Macroinvertebrate Assessment (wadeable rivers only) →	Field collection w/ net. lab id. of major groups, assess based on comparison to upstream reference site (RWN Method)	

Additional notes on the methods are contained in Appendix 1.

How Frequently and When Should You Monitor?

In general, we suggest monitoring wastewater treatment plants when they are likely to have the greatest impacts on the aquatic ecosystem and on water contact recreation. This will likely be in the summer months, during periods when people are swimming, and when low flows frequently combine with high temperatures to stress aquatic organisms.

Within the summer months, we suggest water sampling during the early morning hours, when dissolved oxygen levels are likely to be at their lowest.

Sampling will vary according to the size of the plant, the nature of its discharge and the nature of the receiving water. Following are some basic considerations:

Water Sampling and Analysis:

- *Frequency:* sample at least two or three times per month, during the monitoring season.
- *Time of day:* sample during critical periods of the day for those indicators that fluctuate daily -- early morning for dissolved oxygen, late afternoon for temperature. (Also consider 24-hour studies for these indicators to determine daily variability).
- *Time of year:* Sample during critical periods of ecosystem stress, such as summer, and less stressful periods, such as mid-late spring.
- *Weather:* a variety of weather conditions: storm events, droughts, "normal" conditions, relatively hot weather, relatively cool weather, etc.

Benthic Macroinvertebrate Sampling and Analysis and Habitat Assessment:

- *Frequency and time of year:* sample at least once per year, once in the mid-spring or once in late summer or early fall (before leaf fall).
- *Time of day and weather:* Not a consideration, although high flows should be avoided.

Visual Surveys of River Uses, Values, and Threats:

- *Frequency and time of year:* sample at least once per year, before the leaves emerge or after they fall.
- *Time of day and weather:* Not a consideration, although high flows should be avoided.

Data Analysis

Results will be compared with various reference conditions during the sampling season, and over time from year to year. At a minimum, reference conditions will include the water quality standards and the results from the reference station immediately upstream of the plant. Given the methods used in the basic

wastewater treatment plant impact assessment, the comparison with the upstream reference site will be qualitative, rather than statistical. Only large differences in results will be noted.

Quality Assurance/Quality Control (QA/QC)

Basic Wastewater Treatment Plant Impact Assessment does not require rigorous QA / QC. Specific quality control measures for each indicator are listed in Table 2 in Chapter IV. Note that only internal controls are recommended, though external controls will enhance the credibility of the data and provide a valuable educational experience for participants. Also applicable in Chapter IV is information on internal quality controls and how they are assessed, general quality assurance for sampling and analysis and quality assurance for data management.

Training Required

Sampling: Initially, the program coordinator and a core group of field samplers should be trained in proper water and benthic macroinvertebrate sample collection and visual survey techniques by a VEMN Partner. The program coordinator should then designate people from this core group who are qualified to train others.

Lab Analysis: For personnel in the program lab,[15] proper training is essential. We suggest a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator or someone trained by the coordinator should train other analysts. Each analyst should be assigned to certain analyses by the coordinator.

[15] This is a lab set up by a watershed group or school

F. NON-POINT SOURCE POLLUTION IMPACT ASSESSMENT

Non-Point Source Pollution Impact Assessment is the collection of information about the impact of runoff from a non-point pollution source on the river's ecological health and human use. Non-point pollution sources are land-based and diffuse, rather than coming out of a pipe. Examples of potential sources include construction sites, logging operations, agriculture, animal husbandry, on-site septic systems, lawns and gardens, and urban runoff.

This assessment typically involves *instream* monitoring of various indicators upstream and downstream of the source using *reference*, *impact*, and *recovery* sites. Results at the impact and recovery sites (downstream of the source) are compared with those at the reference site (upstream of the source) to determine the extent of the impact attributable to that source. The indicators are selected based on the nature of the source, contaminants likely to be found in the runoff, and likely impacts on the river.

Given the nature of the assessment -- comparison of conditions upstream of the source with those downstream of the plant -- it is limited to rivers.

We suggest two options which cover two different levels of effort (rigorous and basic):

F1 Rigorous Non-Point Source Pollution Impact Assessment

F2 Basic Non-Point Source Pollution Impact Assessment

These monitoring options are geared to meet different data quality goals and available resources.

Each of these options is described in the following sections.

F1. RIGOROUS NON-POINT SOURCE POLLUTION IMPACT ASSESSMENT

What Is It?

A Rigorous Non-Point Source Pollution Impact Assessment is the collection of selected information about the impact of runoff from a non-point pollution source on the river's ecological health and human use. It includes a wide range of monitoring activities that assess as many of the physical, chemical, and biological indicators of river health likely to be affected by the runoff from these sources as is practical for volunteer monitors, using methods that are comparable to those used by state agencies:

- water sampling and analysis for indicators of runoff impacts,
- benthic macroinvertebrate sampling and analysis and habitat assessment,
- visual surveys of river uses, values, and threats,
- estimates or measures of river channel composition and stability, and
- measurements of rainfall and river flow.

These activities occur upstream and downstream of where runoff from the source enters the river at *reference*, *impact*, and *recovery* sites. Results at the impact and recovery sites (downstream of the source) are compared with those at the reference site (upstream of the source) to determine the extent of the impact attributable to that source.

Rigorous Non-Point Source Pollution Impact Assessment is geared to produce a great deal of high quality information which can be used by state and federal agencies and communities to set pollution control priorities, as well as to assess the need for changes in land use and management practices.

Why Do A Rigorous Non-Point Source Pollution Impact Assessment?

We suggest that you undertake Rigorous Non-Point Source Pollution Impact Assessment if your primary interest is in the impact of non-point source pollution on the long term ecological health and human use of your river and you need to produce data that federal and state agencies will use for their assessment activities.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes

- to assess the impact of a specific non-point pollution source on the river's physical, chemical, and biological characteristics,

- to provide information communities can use to assess the need for changes in land use planning and regulation, and
- to provide information state and federal officials can use to set pollution prevention and control priorities.

Questions Answered

1) *What are the impacts of non-point pollution sources on human use and ecological integrity of the river system or reach?*

2) *What is the effectiveness of best management practices (BMPs) to control polluted runoff in restoring and protecting human use and ecological integrity of the river system or specific water bodies?*

Data Use

The results from Rigorous Non-Point Source Pollution Impact Assessment can be used for several things:

- Identify areas where land use and management changes and are needed to enable the water body to support healthy aquatic life and human uses,
- Identify problems and conflicts between human and aquatic life uses which need to be resolved by some management decision,
- Set priorities for funding water non-point source pollution control projects, and
- Evaluate whether best management practices and other pollution control measures are working.

Primary Data Quality Goals Addressed

☑ Education, awareness, and problem screening
☑ Community & watershed level evaluation, assessment, and management
☑ State, interstate, and Federal water quality evaluation and assessment

Monitoring Options

The Rigorous Non-Point Source Pollution Impact Assessment involves collecting and analyzing water samples for indicators of non-point source pollution; collecting and analyzing benthic macroinvertebrate samples; assessing benthic macroinvertebrate habitat quality; and a visual shoreline survey of uses, values, and threats. These activities are carried out above and below the plant. Note that the indicators and methods listed here are appropriate for wadeable rivers only.

Following is a menu of monitoring options from which to select indicators, methods, and sites appropriate for your river, the nature of the non-point source pollution, and your human and financial resources:

Menu of Indicators/Tools	**Examples of Methods (Source)**	**Site Location Considerations**
Select appropraite indicators/tools depending on the NPS source:		
Visual field survey of river, riparian, and watershed characteristics, uses, values, and threats →	Shoreline / Windshield Survey (Massachusetts Riverways Programs Adopt-A-Stream Manual or equivalent)	• **reference or control site** immediately upstream of the source
Intensive Benthic Macroinvertebrate Assessment →	Field collection w / net or rock basket, lab id. of major groups or families, assess based on comparison to upstream reference condition (RWN) (Adaptation of EPA RBP II)	• **impact site** immediately downstream of the source (at the point where the impact is completely integrated with the water)
Benthic Macroinvertebrate Habitat Assessment →	**Field observation and rating of key habitat characteristic relative to reference condition (RWN Method)**	• **recovery site** downstream of the source (where the water has at least partially recovered from the impact).
Fecal colif. / *E. coli* Bacteria →	membrane filtration w / mTEC with and without confirmation (EPA #1103.1 or equivalent)	• Note: It may be difficult to isolate a particular pollution source from other pollution sources on a river reach -- it may be necessary to bracket a group of sources together.

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Select appropriate indicators/tools depending on the NPS source:		**See previous page.**
Total Phosphorus →	Persulfate digestion followed by ascorbic acid method and colorimetry (EPA Method #365.2 or equivalent)	
Nitrogen Series		
• Total Kjeldahl Nitrogen →	Digestion followed by Nesslerization followed by spectrophotometry (SM #4500-Norg B or equivalent)	
• Nitrates →	Cadmium reduction followed by spectrophotometry (SM #4500-NO3-E or equivalent)	
• Ammonia →	Distillation followed by Nesslerization followed by spectrophotometry (SM #4500-NH3 C or equivalent)	
Turbidity →	Sample collected and measured with a nephelometer (RWN adaptation of Standard Methods #2130)	
Embeddedness →	Estimated for 4 particles at each of 11 cross sections at site (EPA EMAP Protocol or equivalent)	
Channel cross-sections →	Measure elevations at intervals across stream ("Stream Channel Reference Sites" USFS or equivalent)	

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Select appropriate indicators/tools depending on the NPS source:		**See previous page.**
Bottom Composition →	Pebble count ("Stream Channel Reference Sites" USFS or equivalent)	
Longitudinal Profile →	Elevations of channel bottom and water surface ("Stream Channel Reference Sites" USFS or equivalent)	
River Flow →	Embody Float Method (EPA Volunteer Stream Monitoring Methods Manual - Field Test Draft)	
Rainfall →	Rain Gage or NOAA Data	

Additional notes on the methods are contained in Appendix 1.

How Frequently and When Should You Monitor?

In general, we suggest monitoring non-point pollution sources when they are likely to have the greatest impacts on the aquatic ecosystem and on water contact recreation. This will vary according to the nature of its non-point pollution source and the nature of the receiving water. However, it will likely be in the summer months, during and after runoff events. We also suggest monitoring during dry weather conditions as a benchmark.

Storm event related monitoring is a challenge, because it requires being ready to collect and analyze samples on short notice. We suggest the following for each of the activities in Non-point Pollution Source Assessment:

Water Sampling and Analysis:

- *Frequency:* sample at least two or three times per month during the chosen time of year, both during storms and during dry weather.
- *Time of day:* Runoff event sampling is challenging. Ideally samples should be collected at regular intervals before, during and after the storm event. This is likely impractical, so we recommend three samplings for each storm event: at

the onset of the rain event (to establish baseline conditions), during (to catch the "first flush" and establish conditions during rising flows), and after (to establish conditions during high or falling flows).

- *Time of year:* Sample during critical periods of ecosystem stress, such as summer, and less stressful periods, such as mid-late spring.
- *Weather:* During storm events of various intensity and duration and during dry weather.

Benthic Macroinvertebrate Sampling and Analysis and Habitat Assessment

- *Frequency and time of year:* sample at least twice per year, once in the mid-spring and once in late summer or early fall (before leaf fall).
- *Time of day and weather:* Not a consideration, though high flows should be avoided.

Visual Surveys of River Uses, Values, and Threats

- *Frequency and time of year:* sample at least once per year, before the leaves emerge or after they fall.
- *Time of day and weather:* Visual surveys can be conducted during storm events to locate active runoff channels for non-point source pollution.

Field Measurements of Flow and Channel Shape

- *Frequency and time of year:* Measure flows at least as frequently as water sampling, daily if possible. Measure channel characteristics in association with runoff events (see below)
- *Time of day:* not a consideration.
- *Weather:* Measure channel characteristics before and after major storm events.

Data Analysis

Results will be compared with various reference conditions during the sampling season, and over time from year to year. At a minimum, reference conditions will include the water quality standards and the results from the reference station upstream of the non-point pollution source or sources being assessed. Comparisons to the reference station can be tricky and require statistical analysis to determine whether differences are significant. Your technical advisory committee should help you assess this.

Quality Assurance/Quality Control (QA/QC)

Rigorous Non-Point Source Pollution Impact Assessment requires following rigorous QA / QC protocols. Specific quality control measures for each indicator are listed in Table 1 in Chapter IV. Also applicable in Chapter IV is information on internal and external quality controls and how they are assessed, general

quality assurance for sampling and analysis and quality assurance for data management.

Periodic field and lab audits by VEMN partners is recommended. During these audits, VEMN partners observe the operation of sampling and analytical procedures. Suggestions for improvements are discussed with the program and lab coordinator. Audits will be conducted as specified in your study design, quality assurance plan or at the request of the program coordinator.

Training Required

Field Sampling: Initially, the program coordinator and a core group of field samplers should be trained in proper water and benthic macroinvertebrate sample collection, visual survey, and habitat assessment techniques by a VEMN Partner. The program coordinator should then designate people from this core group who are qualified to train others. Official certification of trainers by the program coordinator through a letter or certificate should be considered.

Lab Analysis: For personnel in the program lab,[16] proper training is essential. There should be a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator should conduct all training of analysts. Each analyst should be assigned to certain analyses by the coordinator. Official certification by the program coordinator of all analysts to perform specific analyses through a letter or certificate should be considered.

[16] This is a lab set up by a watershed group or school

F2. BASIC NON-POINT SOURCE POLLUTION IMPACT ASSESSMENT

What Is It?

A Basic Non-Point Source Pollution Impact Assessment is the collection of relatively easy-to-gather information about the impact of runoff from a non-point pollution source on the river's ecological health and human use. It includes monitoring activities that assess the physical, chemical, and biological indicators of river health likely to be affected by the runoff and practical to monitor for schools or groups with limited human and financial resources:

- water sampling and analysis for indicators of runoff impacts,
- benthic macroinvertebrate sampling and analysis (wadeable rivers only),
- visual surveys of river uses, values, and threats,
- estimates of river channel composition and stability, and
- measurements of rainfall and river flow.

These activities occur upstream and downstream of the plant at *reference*, *impact*, and *recovery* sites. Results at the impact and recovery sites (downstream of the plant) are compared with those at the reference site (upstream of the plant) to determine the extent of the impact attributable to that plant.

Given that the methods used in Basic Non-Point Source Pollution Impact Assessment, for most indicators, are not comparable to those used by state agencies, this information will likely be used by state and federal agencies and communities for education and awareness and to identify problem areas for further monitoring, rather than setting priorities or determining the need for land use or management changes. However, Basic Non-Point Source Pollution Impact Assessment will provide an enriching experience and produce information which can be used for education and awareness purposes at the school, community, or watershed level. This may inspire voluntary efforts to reduce non-point source pollution.

Why Do A Basic Non-Point Source Pollution Impact Assessment?

We suggest that you undertake Basic Non-Point Source Pollution Impact Assessment if your primary interest is in the impact of non-point source pollution on the long term ecological health and human use of your river and you don't need to produce data that federal and state agencies will use for their assessment activities.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes

- to educate and raise awareness of the participants and the public regarding the river's physical, chemical, and biological characteristics, and the impacts of non-point source pollution on them, and
- to identify gross non-point source pollution problem areas that might need action or further monitoring.

Questions Answered

1) *What are the impacts of non-point pollution sources on human use and ecological integrity of the river system or reach?*
2) *What is the effectiveness of best management practices (BMPs) to control polluted runoff in restoring and protecting human use and ecological integrity of the river system or specific water bodies?*

Data Use

The results from Basic Non-Point Source Pollution Impact Assessment can be used for several things:

- Identify plants where more rigorous monitoring is needed to confirm problems that may require further action,
- Raise the level of community awareness about local land use practices and water quality,
- Bring gross problem areas to the attention of community, state, and federal officials, and
- Give students experience in analyzing data sets.

Primary Data Quality Goals Addressed

☑ Education, awareness, and problem screening
☐ Community & watershed level evaluation, assessment, and management
☐ State, interstate, and Federal water quality evaluation and assessment

Monitoring Options

The Basic Non-Point Source Pollution Impact Assessment involves collecting and analyzing water samples for indicators of non-point source pollution; collecting and analyzing and benthic macroinvertebrate samples; assessing benthic macroinvertebrate habitat quality; and a visual shoreline survey of uses, values, and threats. These activities are carried out above and below the plant. This basic assessment monitors many of the same indicators as the rigorous assessment, but uses simpler methods. Note that the indicators and methods listed here are appropriate for wadeable rivers only.

Following is a menu of monitoring options from which to select indicators, methods, and sites appropriate for your river, the nature of the non-point source pollution, and your human and financial resources:

Menu of Indicators/Tools	**Examples of Methods (Source)**	**Site Location Considerations**
Select appropraite indicators/tools depending on the NPS source:		
Embeddedness →	Estimated for 4 particles at each of 11 cross sections at site (EPA EMAP Protocol or equivalent)	• **reference or control site** immediately upstream of the source
Bottom Composition	Pebble count ("Stream Channel Reference Sites" USFS or equivalent)	• **impact site** immediately downstream of the source (at the point where the impact is completely integrated with the water)
Basic Benthic Macroinvertebrate Habitat Assessment →	**Field collection w/ net, lad id. of major groups, assess based on comparison to upstream reference site (RWN Method)**	• **recovery site** downstream of the source (where the water has at least partially recovered from the impact).
Fecal Colif./*E. coli* Bacteria →	Various methods that detect presence-absence or produce an estimate of bacteria density	
Orthophosphate →	Ascorbic acid (EPA Method #365.2)	

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Select appropraite indicators/tools depending on the NPS source:		**See previous page.**
Nitrates →	Cadmium Reduction followed by color comparator (Mitchell & Stapp)	
Turbidity →	Sample collected and measured with a nephelometer and reported as NTU's (RWN) or turbidity tube reported in centimeters or inches (no source yet)	
River Flow →	**Embody Float Method (EPA Volunteer Stream Monitoring Methods Manual - Field Test Draft)**	
Rainfall →	Rain Gage or NOAA Data	

Additional notes on the methods are contained in Appendix 1.

How Frequently and When Should You Monitor?

In general, we suggest monitoring non-point pollution sources when they are likely to have the greatest impacts on the aquatic ecosystem and on water contact recreation. This will vary according to the nature of its non-point pollution source and the nature of the receiving water. However, it will likely be in the summer months, during and after runoff events. We also suggest monitoring during dry weather conditions as a benchmark.

Storm event related monitoring is a challenge, because it requires being ready to collect and analyze samples on short notice. We suggest the following for each of the activities in Non-point Pollution Source Assessment:

Water Sampling and Analysis:

- *Frequency:* sample at least two or three times per month during the chosen time of year, both during storms and during dry weather.
- *Time of day:* Runoff event sampling is challenging. Ideally samples should be collected at regular intervals before, during and after the storm event. This is likely impractical, so we recommend immediately after storm events (to establish conditions during high or falling flows).
- *Time of year:* Sample during critical periods of ecosystem stress, such as summer, and less stressful periods, such as mid-late spring.
- *Weather:* During storm events of various intensity and duration, and during dry weather.

Benthic Macroinvertebrate Sampling and Analysis and Habitat Assessment

- *Frequency and time of year:* sample at least twice per year, once in the mid-spring and once in late summer or early fall (before leaf fall).
- *Time of day and weather:* Not a consideration, though high flows should be avoided.

Visual Surveys of River Uses, Values, and Threats

- *Frequency and time of year:* sample at least once per year, before the leaves emerge or after they fall.
- *Time of day and weather:* Visual surveys can be conducted during storm events to locate active runoff channels for non-point source pollution.

Field Measurements of Flow and Channel Shape

- *Frequency and time of year:* Measure flows at least as frequently as water sampling, daily if possible. Measure channel characteristics in association with runoff events (see below)
- *Time of day:* not a consideration.
- *Weather:* Measure channel characteristics before and after major storm events.

Data Analysis

Results will be compared with various reference conditions during the sampling season, and over time from year to year. At a minimum, reference conditions will include the water quality standards and the results from the reference station immediately upstream of the non-point pollution source. Given the methods used in the basic non-point source assessment, the comparison with the upstream reference site will be qualitative, rather than statistical. Only apparently large differences in results will be noted.

Quality Assurance/Quality Control (QA/QC)

Basic Non-Point Source Pollution Impact Assessment does not require rigorous QA / QC. Specific quality control measures for each indicator are listed in Table 2 in Chapter IV. Note that only internal controls are recommended, though external controls will enhance the credibility of the data and provide a valuable educational experience for participants. Also applicable in Chapter IV is information on internal quality controls and how they are assessed, general quality assurance for sampling and analysis, and quality assurance for data management.

Training Required

Sampling: Initially, the program coordinator and a core group of field samplers should be trained in proper water and benthic macroinvertebrate sample collection and visual survey techniques by a VEMN Partner. The program coordinator should then designate people from this core group who are qualified to train others.

Lab Analysis: For personnel in the program lab,[17] proper training is essential. We suggest a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator or someone trained by the coordinator should train other analysts. Each analyst should be assigned to certain analyses by the coordinator.

[17] This is a lab set up by a watershed group or school

G. NON-POINT SOURCE POLLUTION SITE EVALUATION

What Is It?

A Non-point Source Pollution Site Evaluation is a systematic approach for trained volunteers to evaluate the seriousness of non-point source pollution. Non-point pollution sources are land-based and diffuse, rather than come out of a pipe. Examples of potential sources include construction sites, logging operations, agriculture, animal husbandry, on-site septic systems, lawns and gardens, and urban runoff. This evaluation takes place at a particular site.

For each type of non-point source site to be evaluated there are specific questions on site worksheets that relate to visual indicators, impacts, best management practices (land management activities that minimize polluted runoff), and characteristics of the particular land use activity.

The evaluation covers the following processes at work on a site (working from the site to the receiving water):

- potential for non-point source pollution production,
- evidence of non-point source pollution production,
- control measures,
- potential for export from the site, and
- evidence of export from the site.

Each type of land use activity has its own worksheet and evaluation process.

When combined with river and/or lake monitoring, this evaluation gives a comprehensive picture of the production, transport, and impact of non-point source pollution from a specific site. This information can be used by communities and landowners to assess the need for changes in land use practices and management to protect rivers and lakes from non-point source pollution.

Why Do A Non-Point Source Pollution Site Evaluation?

We suggest that you undertake Non-Point Source Pollution Site Evaluation if your primary interest is in the potential of specific sites to produce polluted runoff which may affect your river or lake and you need to produce semi-quantitative data that will enable communities to take action, or to change land use or management practices. When coupled with Non-point Source Pollution Impact Assessment, you can also assess the impact of these discharges on the river or lake ecosystem.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes

- to assess the potential for land use practices in the watershed to affect waters,
- to assess the on-site effectiveness of best management practices, and
- to establish high priority sites for remediation.

Questions Answered

What is the potential for land use practices in the watershed to affect waters?

Data Use

The results from Non-Point Source Pollution Site Evaluation can be used for several things:

- Identify sites where land use and management changes are needed to enable the water body to support healthy aquatic life and human uses,
- Set priorities for funding water non-point source pollution control projects, and
- Evaluate whether on-site best management practices are working.

Primary Data Quality Goals Addressed

☑ Education, awareness, and problem screening
☑ Community & watershed level evaluation, assessment, and management
☐ State, interstate, and Federal water quality evaluation and assessment

Monitoring Options

The Non-Point Source Pollution Site Evaluation involves a series of on-site observations of various indicators of the production, transport, and control of polluted runoff. These observations are organized on field sheets, with different pages for different types of land uses (e.g. logging, construction, dairy farming, etc.) that have the potential to cause non-point source pollution problems. Surveyors select the method that assesses the relevant land use:

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Various on-site indicators of production, transporrt, and attenuation of NPS pollution	UNH Coop. Ext.	• Sites where it is suspected that non-point source pollution may be polluting surface waters.

Additional notes on the methods are contained in Appendix 1.

How Frequently and When Should You Monitor?

We recommend carrying out a Non-Point Source Pollution Site Evaluation at least once per year. Also consider carrying out evaluations after runoff events.

Data Analysis

Observations made for the evaluation are scored (from 0 - 1.0). Observations and scores are grouped by the following categories:

- potential for NPS production,
- evidence of NPS production,
- effectiveness of control measures,
- potential for export off the site, and
- evidence of export off the site.

Scores for the observations are totaled in each of these categories. Scores are evaluated low, medium, or high.

Quality Assurance/Quality Control (QA/QC)

A Non-Point Source Pollution Site Evaluation does not require extensive quality assurance. However, some of the general QA / QC for sampling and analysis and general quality assurance measures for data management in Chapter IV should be reviewed. In addition, photo and / or video documentation of the sites is recommended to serve as visual documentation of problems and processes as well as to provide a tool to train surveyors.

Training Required

In New Hampshire surveyors should initially be trained by the University of New Hampshire Cooperative Extension, who developed the evaluation, or a designated VEMN partner. In Massachusetts, surveyors should be trained by a designated VEMN partner. At or following the training, surveyors should be observed in the field, gathering data, to assure that they are following procedures correctly. Follow up field audits can also help catch problems which may develop. New surveyors should be trained by the program coordinator or by an experienced surveyor.

H. STORMWATER DISCHARGE MONITORING

What Is It?

Stormwater Discharge Monitoring focuses on locating pipes that discharge stormwater (as opposed to sanitary wastewater) and sampling the effluent coming out of those pipes during dry and wet weather to determine its quality and potential to affect rivers and lakes. The effluent is sampled and analyzed using methods that are comparable to those used by state agencies.

Rigorous Non-Point Source Pollution Impact Assessment is geared to produce high quality information which can be used by state and federal agencies and communities to set pollution control priorities, as well as to assess the need for changes in stormwater management practices.

Why Do Stormwater Discharge Monitoring?

We suggest that you undertake Stormwater Discharge Monitoring if your primary interest is in the location and quality of stormwater discharges and you want to produce data that federal and state agencies will use for their assessment activities. When coupled with Non-point Source Pollution Impact Assessment, you can also assess the impact of these discharges on the river or lake ecosystem.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes

- to assess the quality of stormwater discharges,
- to estimate pollution loadings from stormwater,
- to provide information communities can use to assess the need for changes in stormwater management and treatment, and
- to provide information state and federal officials can use to set pollution prevention and control priorities.

Questions Answered

How effective are stormwater management and treatment strategies?

Data Use

The results from Stormwater Discharge Monitoring can be used for several things:

- Identify stormwater discharges that may be receiving sanitary wastewater flows,

- Identify stormwater discharges that have the potential to affect human use and aquatic life,
- Set priorities for funding water combined stormwater/sewer separation projects, and
- Evaluate whether stormwater management measures are working.

Primary Data Quality Goals Addressed

☑ Education, awareness, and problem screening

☑ Community & watershed level evaluation, assessment, and management

☑ State, interstate, and Federal water quality evaluation and assessment

Monitoring Options

Stormwater Discharge Monitoring involves an inventory of the stormwater discharge pipes in the area, coupled with collection and analysis of samples of the effluent discharged from the pipes.

Following is a menu of monitoring options from which to select indicators, methods, and sites appropriate for your river, the suspected nature of the discharge from the pipes, and your human and financial resources.

Menu of Indicators/Tools	**Examples of Methods (Source)**	**Site Location Considerations**
Select appropraite indicators/tools depending on the NPS source:		Stormwater is sampled at outfalls
E. coli Bacteria (NH) →	Membrane filtration w / mTEC with confirmation (EPA# 1103.1 or equivalent)	
Fecal Coliform Bacteria (MA) →	Membrane filtration w / mTEC *without* confirmation (EPA# 1103.1 or equivalent)	
Biochemical Oxygen Demand →	**5-day BOD test (SM #5210-B) using Modified Winkler Titration**	
Turbidity →	Sample collected and measured with a nephelometer (SM #2130 or equivalent)	
pH →	1) Sample collected and measured with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent) 2) Direct measurement with a meter equipped with probe suitable for low ionic strength waters (EPA Method 150.1 or equivalent)	

Menu of Indicators/Tools	Examples of Methods (Source)	Site Location Considerations
Total Dissolved Solids	Gravimetric methods: Total Solids Dried at 103-105 degrees C (SM #2540 B) and Total Dissolved Solids Dried at 180 degrees C (SM #2540 C)	Stormwater is sampled at outfalls
Temperature	Direct measurement with a thermometer	
Total Phosphorus	**Persulfate digestion followed by ascorbic acid (RWN adaptation of EPA Method #365.2)**	
Visual field survey of river, riparian, and watershed characterisitics, uses, values, and threats (including pipe inventory)	Shoreline / Windshield Survey (Massachusetts Riverways Programs Adopt-A-Stream Manual or equivalent)	
Conductivity	Direct measurement with meter (EPA Volunteer Methods Manual) or pen (RWN)	

Additional notes on the methods are contained in Appendix 1.

How Frequently and When Should You Monitor?

We suggest monitoring stormwater discharges during storm events, when they are flowing. Also sample during dry weather if they are flowing. Storm event related monitoring is a challenge, because it requires being ready to collect and analyze samples on short notice.

Data Analysis

Results should be analyzed according to permit conditions (if applicable), water quality standards, or other water quality criteria or guidance recommended by your technical committee.

Quality Assurance/Quality Control (QA/QC)

Stormwater Discharge Monitoring requires rigorous QA / QC. Specific quality control measures for each indicator are listed in Table 1 in Chapter IV. Also applicable in Chapter IV is information on internal and external quality controls and how they are assessed, general quality assurance for sampling and analysis, and quality assurance for data management.

Periodic field and lab audits by VEMN partners is recommended. During these audits, VEMN partners observe the operation of sampling and analytical procedures. Suggestions for improvements are discussed with the program and lab coordinator. Audits will be conducted as specified in your study design, quality assurance plan, or at the request of the program coordinator.

Training Required

Field Sampling: Initially, the program coordinator and a core group of field samplers should be trained in proper water sample collection and pipe survey techniques by a VEMN Partner. The program coordinator should then designate people from this core group who are qualified to train others. Official certification of trainers by the program coordinator through a letter or certificate should be considered.

Lab Analysis: For personnel in the program lab,[18] proper training is essential. There should be a designated lab coordinator, responsible for seeing that all analysts are properly trained. Initially, the lab coordinator and a core group of analysts should be trained in proper water analysis techniques by a VEMN Partner. Thereafter, the lab coordinator should conduct all training of analysts. Each analyst should be assigned to certain analyses by the coordinator. Official certification by the program coordinator of all analysts to perform specific analyses through a letter or certificate should be considered.

[18] This is a lab set up by a watershed group or school

I. WASTEWATER COMPLIANCE SURVEY

What Is It?

A Wastewater Compliance Survey focuses on reviewing the discharge monitoring reports from wastewater treatment plants. Discharge monitoring reports summarize the results of periodic testing of the effluent from the plant as required by the plant's NPDES[19] permit. This survey is sometimes known as "the good, the bad, and the ugly."

A Wastewater Compliance Survey examines discharge monitoring reports to see whether nine indicators are within the *effluent limits* set in the plant's permit. Effluent limits specify acceptable levels of pollutants in the discharge. A high percentage of violations signifies a high pollution potential and the possible need for wastewater treatment plant upgrades.

A Wastewater Compliance Survey is geared to produce information which can be used to raise the level of community awareness regarding the performance of their wastewater treatment plants.

Why Do A Wastewater Compliance Survey?

We suggest that you undertake a Wastewater Compliance Survey if your primary interest is in the compliance of a particular plant with their permit and the possible need for an upgrade. When coupled with Wastewater Treatment Plant Impact Assessment, you can also assess the impact of these discharges on the river or lake ecosystem.

It will help you to accomplish the purposes, answer the questions and provide information for the data uses listed below.

Purposes

- to increase public awareness of wastewater treatment issues, and
- to encourage public support for treatment plant upgrades, where needed.

Questions Answered

Is a wastewater treatment plant operating within the limits of its permit?

Data Use

The results from the Wastewater Compliance Survey can be used for several things:

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[19] NPDES = National Pollution Discharge Elimination System. EPA issues NPDES permits, but can delegate this authority to qualifying states. Permits are renewed (and possibly amended) every 5-years. Public hearings are a part of the renewal process.

- alert the public to the fact that there are treated discharges to waters and that water quality is still an issue,
- encourage communities to support funding for upgrades to their plants, and
- to provide information communities can use to assess the need for changes in wastewater treatment.

Primary Data Quality Goals Addressed

☑ Education, awareness, and problem screening
☑ Community & watershed level evaluation, assessment, and management
☐ State, interstate, and Federal water quality evaluation and assessment

Monitoring Options

A Wastewater Compliance Survey involves a review of the effluent limits in a wastewater treatment plant's permit and a review of the plant's discharge monitoring reports for a year. The review focuses on nine indicators:

- Biochemical Oxygen Demand
- Oil and Grease
- Fecal Coliforms or *E. coli*
- Metals
- Flow
- Total Suspended Solids
- Chlorine
- Toxicity[20]
- Temperature

Each instance where the level of an indicator is outside the limits in its permit, it is flagged as a violation.

Following is a menu of monitoring options from which to select indicators, methods, and sites appropriate for your river, the suspected nature of the discharge from the pipes, and your human and financial resources.

How Frequently and When Should You Monitor?

Discharge monitoring reports should be reviewed annually.

Data Analysis

The number of violations for each indicator is divided by the total number of samples for all indicators to come up with a percent violation. A percent violation of <5% is considered "good", 6-25% is considered "bad", >25% is considered "ugly". This analysis does not consider the effectiveness of the permit, only the extent to which the facility complies with its NPDES limits.

[20] Based on tests on representative organism

Quality Assurance/Quality Control (QA/QC)

A Wastewater Compliance Survey does not require QA / QC, since it does not involve actual sampling. However, figures transcribed from permits and discharge monitoring reports should be double-checked for accuracy.

Training Required

The training involved with the Wastewater Compliance Survey is focused on how to read the effluent levels in a permit and how to read discharge monitoring reports. Surveyors should be trained by either MA Riverways or Mass Audubon.