

**Guidelines For Subwatershed Groups On
Preparing Scientific Study Designs**

Final Report

November 9, 1995

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First Edition, November, 1995

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INTRODUCTION

The **Merrimack River Initiative** was started in 1988 to promote holistic management of natural resources throughout the Merrimack basin. Participants recognize the dual benefits of developing a watershed-wide base of information and of building a strong watershed constituency by supporting citizen groups who want to conduct their own surveys. To meet these objectives, the **Volunteer Environmental Monitoring Network** (VEMN) was organized.

The VEMN is developing an array of organizational and training services for new and existing groups. One major aim of the VEMN is to more closely integrate volunteer monitoring programs into environmental management decisions that are made in the Merrimack Basin every day at every level of human activity.

The guidelines laid out in this and in other VEMN handbooks, should help citizen groups build effective local programs that also contribute to a watershed-wide view of health of the Merrimack basin.

The VEMN strongly recommends that all river and lake monitoring groups in the Merrimack River Watershed produce a written document called a “Study Design” that describes your monitoring effort and the rationale behind it. This manual guides you through the process of producing this document and describes the type of information it should contain.

A WORD OF ENCOURAGEMENT

The sheer weight alone of this manual may be enough to intimidate any group out of trying to research and write a scientific study design. The Volunteer Environmental Monitoring Network (VEMN) for the Merrimack River Watershed is here to tell you that it is not as scary as it looks. The manual is very thorough because we wanted to make it as self explanatory as possible. Here’s why it is not as bad as it looks:

- The VEMN will conduct workshops on writing study designs upon request and at regularly scheduled times.
- The VEMN is available for personal and telephone consultations so that we may facilitate the process for any group willing to design their monitoring study.
- The VEMN has materials that can significantly reduce some of the effort of researching and describing field and laboratory methods and quality control procedures. These are described in the next section of the introduction.

- There are handy worksheets for each section of your study design located at the end of each step in Part I that will make the process fairly straightforward.
- We've suggested a place to start in the form of three core surveys. These surveys suggest water quality indicators and methods to answer specific questions about your river or lake that will also add to our picture of the watershed as a whole.

WHY WRITE A STUDY DESIGN

We cannot emphasize enough the usefulness of designing a scientific monitoring study. It serves some very important purposes to your group and to the people you hope will use your data. These are:

- it forces you to establish what you are trying to accomplish with your monitoring program
- it prevents waste of time and money on equipment and procedures that are inappropriate for your group
- it allows you to select the best monitoring parameters and sampling locations and times to address the issues that are important to you and your community
- it allows everyone who might use your data to have confidence in the results you produce because you clearly document your sampling and analysis methods and quality assurance procedures
- it prevents changes in leadership in your organization from destroying the continuity of your monitoring plan because anyone can refer to your study design and pick up where the last person left off
- it allows your group to reevaluate your monitoring study easily every year and make changes as needed

ONE EASY WAY TO GET STARTED

Preparing a study design document involves making choices about the why, what, how, where, when and who of monitoring. As you'll see when you read Part I ("How To Do A Study Design") of this document, there are lots of possibilities. It can seem overwhelming. So we're suggesting a place to start.

This document suggests three basic assessments that we recommend volunteer river and lake monitoring groups carry out:

1. Watershed Assessment - a visual survey and evaluation of some of the basic watershed characteristics to help focus your other monitoring activities.
2. Health Risk Assessment - a combination of water sampling and data gathering on actual disease occurrence to see if there's a relationship between water quality, contact with the water and illness.
3. Water Quality Standards Assessment - water sampling and analysis of river or lake water quality indicators that the states of Massachusetts and New Hampshire use to determine how well our waters comply with state standards for their designated uses.

So we've suggested some choices for the "what" and "how" of your study design. You'll still need to make the other choices, but they should be easier by starting with these three assessments.

VEMN MATERIALS AVAILABLE TO MAKE THE PROCESS EASIER

There are four VEMN products in addition to this manual which are available free of charge to any water monitoring program active in the Merrimack River Watershed. They are:

1. "Characteristics of a Successful Volunteer Monitoring Program"
2. "The VEMN Integrated Support System"
3. "Designing a Volunteer Water Monitoring Study in the Merrimack River Watershed"
4. "Training Manual for Core VEMN Monitoring Parameters and Methods"

Items number 3. and 4. above will be particularly helpful in the study design process. Item 1. will be useful in the long term program planning process and item 2. may help provide some of the support you need in designing and planning your monitoring study. A brief description of each of the above materials follows.

Characteristics of a Successful Volunteer Monitoring Program

This outline includes organizational and technical characteristics that the VEMN has found to be associated with successful programs. It can be used as a means for volunteer groups to evaluate themselves and plan for future work. The document outlines organizational characteristics:

- Mission
- Community Support
- Funding
- Leadership
- Volunteers
- Data Use
- Achievement

- Community Outreach and Public Education

It also outlines the following technical characteristics:

- Study Design
- Quality Control
- Data Management and Reporting

The VEMN Integrated Support System

This product is useful for locating all types of sources of support for your monitoring program. Organizations are listed which can provide support in the following areas:

- Training
- Consultation
- Work
- Funds
- In-Kind Support
- Information Available
- Expertise

The VEMN coordinator is the liaison between the organizations listed and volunteer monitoring groups. This listing includes organizations and people that can lend support in every aspect of designing, researching, funding, and carrying out a volunteer monitoring program. It also notes the organizations for which fees may be required for these services. This product is available in both computer database format (you will need Microsoft Access for Windows to run the database) or report format.

Designing a Volunteer Water Monitoring Study in the Merrimack River Watershed

This is a comprehensive guidance document to help freshwater river and lake monitoring groups design customized monitoring programs to address issues important to their watersheds. It is perhaps the most useful product the VEMN offers to volunteer monitoring groups interested in designing studies which will provide data to users from state and federal agencies to local town citizens and businesses. This document includes:

- How To Do A Study Design
- A Complete Guide To Identifying Issues and Questions That Monitoring Can Address
- A Guide To Matching Data Users and Uses With Data Quality Goals and Objectives
- A Guide To Selecting Indicators, Methods, Sites, Frequency of Monitoring and Quality Assurance/Quality Control

This guidance document you are reading is based on the information we developed for the comprehensive guidance document. However, this one is more focused

on specific sampling procedures that will answer the most common questions that volunteer monitoring groups try to address and at all levels of data quality: Questions like, “Is human water contact recreation a health risk?” and “What are the impacts of non-point source (NPS) pollution on human use and ecological integrity of the river system or specific waterbodies?”

Training Manual for Core VEMN Monitoring Parameters and Methods

The VEMN recommends that every group do three types of assessments at a minimum:

1. Watershed Assessment - how to carry out a visual survey and evaluation of the water and surrounding areas in order to gather basic resource information in preparation for other types of monitoring.
2. Health Risk Assessment - how to carry out a combination of water sampling and data gathering (by sampling the human population via questionnaires and other techniques) on actual disease occurrence to see if there’s a relationship between water quality, water contact and illness.
3. Water Quality Standards Assessment - how to collect and analyze water samples for water quality indicators that the states of Massachusetts and New Hampshire use to determine how well our waters comply with state standards for their designated uses.

These core assessments will help us gather basic information on watershed characteristics, assist communities and water users to assess health risks associated with water contact, and contribute to federal and state information on the quality of our waters. Our “Training Manual of Core VEMN Monitoring Parameters” fully describes and documents the procedures and quality control measures needed to do the core assessments listed above.

HOW TO USE THIS DOCUMENT

Part I will take you through the study design process. Read this section to become familiar with the study design process. It includes worksheets for each part of your study design which you can fill out as you go and you can actually use the compilation of these worksheets as your final study design document. If you start with the three core assessments, you can fairly easily complete the worksheets for Steps 2 through 5 and Step 9 (there are only 9 steps) of your study design. You will still need to determine where and when you will monitor and who will do the monitoring.

When you are ready to design your study, Parts II and III will help you with the specific steps.

Part II is a listing of issues and questions that monitoring can address. Seven basic questions with more specific subquestions are listed. Use this to help with Step 2 in the study design process; to choose questions that best suit your group. The

questions that the core assessments can address are bolded and italicized in this section. We recommended these questions because we feel they will provide a useful base of information throughout the watershed. If you do not find the specific questions that you want to try to answer by monitoring, you are welcome to make up new ones. If you do come up with new questions, please let us know so we can add them to the list for use by other volunteer groups.

Part III is a guide to choosing users and uses of data and data quality goals that your group can live with. Use this part to help you with Step 4 in your study design process.

PART I: HOW TO DO A STUDY DESIGN

WHAT IS A STUDY DESIGN?

A study design describes the choices you make about why, what, where, when, who, and how you intend to monitor the water. We suggest the following process for making these choices. It frames the choices in the form of questions:

The Study Design Process:

STEP 1: GETTING STARTED: ORGANIZE A TECHNICAL COMMITTEE

STEP 2: WHY ARE YOU MONITORING?

STEP 3: WHAT WILL YOU MONITOR?

STEP 4: WHAT ARE YOUR DATA QUALITY GOALS AND OBJECTIVES?

STEP 5: HOW WILL YOU MONITOR?

STEP 6: WHERE WILL YOU MONITOR?

STEP 7: WHEN WILL YOU MONITOR?

STEP 8: WHO WILL MONITOR?

STEP 9: WHAT ARE YOUR QUALITY ASSURANCE MEASURES?

FINISHING: PUT IT IN WRITING AND EVALUATE IT ANNUALLY

WHY DO A STUDY DESIGN?

It may be tempting to get right into the water and begin sampling. However, it's worth taking the time to figure out what you want to do first. Your monitoring is much more likely to be successful and sustainable over a longer time.

A study design may be the most important step in organizing your whole monitoring effort.¹ Think of it this way: In 10 years someone is looking at your water quality data and wants to know how you came up with those numbers. This person should be able to find out by reading your study design document.

Finally, by using a consistent format, monitoring groups will enable quick review and comment by the people who are expected to use their results.

HOW TO USE THIS CHAPTER

In the following sections, each part of the study design process is explained and steps to finding the information are suggested. Each section ends with an outline of the information you should include.

¹ For information on how to organize a monitoring program, see River Watch Network's "Program Organizing Guide," Montpelier VT 1995 and the "Adopt a Stream Workbook" by MA Riverways Programs, Boston MA 1988.

STEP 1: GETTING STARTED -- ORGANIZE A TECHNICAL COMMITTEE

Form a technical committee of people who can provide you with advice and assistance in preparing your study design.

Following are examples of agencies, organizations, and people who might be helpful on your technical committee:

- NH Department of Environmental Services
- MA Department of Environmental Protection
- MA Riverways Program
- River Watch Network
- Massachusetts Water Watch Partnership
- Watershed Associations
- The VEMN Coordinator
- University Cooperative Extension
- Soil and Water Conservation Districts
- College and University Faculty

This committee can review and comment on your study design and provide helpful advice. This is also a good way to involve and build interest from different organizations in your community for your program.

STEPS TO ORGANIZE A TECHNICAL COMMITTEE:

Step 1: Determine what expertise you need on your technical committee.

Suggested areas of expertise include:

- river/lake biology
- river/lake hydrology
- local river/lake uses and problems
- data management compliance
- field and lab methods
- river/lake chemistry
- how state agencies work
- data interpretation
- business environmental
- laws and regulations

Step 2: Identify the resource people you will approach to be on your technical committee. Don't forget local businesses, they often have environmental compliance staff who can provide good expertise and good connections with the business community.

Step 3: Clarify what the role of your technical committee will be and write up a job description for it, including how much time you are asking from people. The technical committee should meet when there is a technical issue to resolve, such as reviewing and commenting on your study design, helping you figure out problems with a laboratory procedure, or helping you interpret the results.

Sample Job Description: Technical Committee:

Role: Advise project staff on the technical aspects of the program.

Responsibilities:

- a. Decide on data use goals and data quality objectives to address the program goals and objectives.
- b. Develop study questions.
- c. Review, and comment on the study design.
- d. Recommend, review, and comment on quality assurance/quality control procedures.
- e. Assist staff in solving technical problems with the monitoring.
- f. Review and comment on drafts of manuals and training materials.
- g. Review protocols annually and recommend changes as needed.
- h. Assist staff in interpreting the results.
- i. Review and comment on reports.

Step 4: Ask the resource people you identified in step 2 to serve on the committee. Give or send them a copy of the job description and be clear as to what is expected of them in terms of their time and expertise. Remember, you're asking professionals to donate services. The least you can do is let them know the extent of the donation you're requesting so they can decide if it's something they can do.

IN YOUR STUDY DESIGN:

- A. List the members of your technical committee and what their expertise is.**
(The worksheet for this part of the study design is at the end of the next step).

ORGANIZE A TECHNICAL COMMITTEE

What expertise will you need on your technical committee?

- | | |
|---|--|
| <input type="checkbox"/> River/Lake Biology | <input type="checkbox"/> Data Management |
| <input type="checkbox"/> River/Lake Hydrology | <input type="checkbox"/> Data Interpretation |
| <input type="checkbox"/> River/Lake Chemistry | <input type="checkbox"/> Field and Lab Methods |
| <input type="checkbox"/> Local River/Lake Uses and Problems | <input type="checkbox"/> Business Environmental Compliance |
| <input type="checkbox"/> How State Agencies Work | <input type="checkbox"/> Laws and Regulations |

Others:

People to Invite to Join the Committee	Did They Accept?	Job Description
<u>Biology people:</u>		
<u>Hydrology people:</u>		
<u>Chemistry people:</u>		
<u>Uses and Problems people:</u>		
<u>Data Management people:</u>		
<u>Data Interpretation people:</u>		
<u>Field and Lab Methods people:</u>		
<u>Business Environmental Compliance people:</u>		
<u>State Agency Workings people:</u>		
<u>Laws and Regulations people:</u>		
<u>Others:</u>		

STEP 2: WHY ARE YOU MONITORING?

The next step in your study design is to define the questions you would like to answer by monitoring. Why are you monitoring? What specific water-related questions are you trying to answer?

Part II of this document suggests monitoring questions for the Merrimack River Watershed. We advise that you turn to that section at this time to help you choose questions you might want to work on. As mentioned in the introduction, the VEMN recommends that every group use the questions highlighted in Part II as a base monitoring program (we have a manual of field and lab procedures for these questions). Again, you may choose any questions that best reflect the issues your monitoring group wants to address but we do ask that you consider our recommendations so we may better understand the Merrimack River Watershed as a whole.

To decide which questions you would like to answer by monitoring, find out everything you can about your river or lake. A combination of research and public workshops is a good approach.

Research: There are two kinds of research you might want to pursue. These are ***researching prior studies*** and ***researching water law, policy and water quality standards in your state or locality***:

Prior study research: This type of research might give you useful information about what problems (or what significant resources, like a reproducing brook trout population) are known to exist and where.

Water law, policy and water quality standards research: This type of research will help you decide how to construct and conduct your program. For example, Massachusetts Water Quality Standards contain precise requirements for dissolved oxygen (DO) and temperature. It is a fairly straightforward matter to produce information which compares DO and temperature data with state standards, and then to show the Massachusetts Department of Environmental Protection (MADEP) or your town boards and conservation commissions whether your river meets the standards. On the other hand, composition of substrate (amount of silt, gravel, or cobbles on your river bed) is important to the river's health, but the water quality standards do not provide measurable standards for bottom composition. If you want to make an issue of the substrate composition in your river, you will need to figure out who to present your information to and how to portray it to make an impression. You can come up with your own standard and compare your results to that to show that there is a problem.

Workshops: Public workshops are a great way to involve watershed residents in your program, and to learn about how your river or lake is being used, what

people think is important, and problem areas. These are also a good way to build a list of potential monitoring volunteers. After all, they came to your workshop, they must be interested in the water!

Workshops should happen at any point in your program when you need information or help from watershed residents. A workshop on identifying uses, values, and threats is suggested in step 3 below.

STEPS TO GET THE INFORMATION

Step 1: Try to get copies of existing reports that include your river or lake. Examples include the NH and MA water quality standards, state water quality assessment reports to congress (also known as the “305(b)” reports), basin plans or watershed assessments, special studies etc.

Step 2: Find out the classification and designated uses and values associated with your river or lake. Look at the NH or MA water pollution control law and/or the water quality standards to find out how the water is classified. The whole river or lake may be classified as “B”, for example. Or certain segments of a river or a lake may classified as “A,” because they are public water supplies. Frequently, the classifications are shown on a map of the state’s waters.

Step 3: Find out how your river or lake is actually being used ,what it’s special attributes are, and what the threats to these uses and values are. What are the existing river uses? What’s special about the river or lake (its values) and where? What and where are the activities that threaten these water-related uses and values? Have any of them been determined to be causing problems?

<u>Examples of Uses, Values and Threats:</u>	
Uses	
• Swimming	• Fishing
• Irrigation	• Public Water Supply
• Waste Assimilation	• Canoeing/Kayaking
Values	
• Aquatic Life Habitat	• Flood Storage
• Scenic Quality	• Wildlife Habitat
• Unique Natural Features	• Ecosystem Functions
Threats/Problems	
• Channel Alterations	• Pollution Discharges
• Sedimentation of Aquatic Habitat	• Polluted Runoff
• Combined Sewer Overflows	• Loss of Habitat
• Conflicts Among Uses	• Flow Alterations
• Loss of Riparian Vegetation	

You're probably already familiar with some or most of these. We suggest giving members of your watershed communities an opportunity to help you identify water-related uses, special attributes and problems by holding one or more public workshops. At these workshops, explain your program ideas. Then assemble the topographic maps, or some other clear base maps, that cover your watershed. Invite participants to identify and locate water use areas, special attributes and problem areas using labeled or color-coded "post-it" notes. You can learn a surprising amount about your water body through this exercise.

Step 4: Identify the issues facing your river or lake and what is being done, if anything, to address them. Based on your research, identify the issues which will need to be addressed in order for your river or lake to support designated and identified uses and values, deal with the threats, and solve the problems. A good place to start is your state's water quality assessment report to congress – a.k.a. the "305(b)" report. This report identifies the rivers, lakes, and segments that fully support, partially support, or do not support their designated uses. The report also identifies the causes or reasons why the water body does not fully support its designated uses. It may list many of the threats you've identified in your workshops. Many states have recently completed non-point source pollution assessments. These may contain more up to date lists of problem areas and causes.

There may already be efforts underway to address these problems, at the federal, state and local level. Find out who's doing what to address the problems.

Step 5: Identify what you need to know about the river or lake in order to address the issues, to define and evaluate the extent of the problems, or to evaluate the effectiveness of solutions. Based on your research and workshops it may be that you haven't identified any water-related problems. The issue may be lack of information about the present condition of the waterbody and monitoring can help you fill the gap.

Step 6: Identify the specific questions you have about your river or lake. Come up with the questions that, if answered through monitoring, will help define and evaluate the problems. Refer to Part II for the questions we suggest be addressed by volunteer monitoring groups in the Merrimack River Watershed.

IN YOUR STUDY DESIGN:

- A. Identify background information on your river or lake: describe the geography of your watershed. (1) What water body(ies) will you monitor? (2) Where are the headwaters? (3) Where are the lake's inlets and outlets? (4) Where does the river join a larger water body? (5) What is the watershed like?**
- B. List and/or map the classifications and the designated uses and values associated with your river or lake.**
- C. List the (1) uses, (2) values and (3) threats identified by members of your watershed communities.**
- D. Describe the issues facing your river or lake posed by the threats or conflicts and what, if anything, is being done to address them.**
- 1) List the lakes, rivers or river segments that do not support, or only partially support, their designated uses.**
 - 2) List the threats, causes or reasons for specific water bodies or segments as to why the uses are not supported.**
 - 3) List the watershed protection or restoration efforts underway to address the problems.**
- E. List the information you will need in order to address the issues.**
- 1) What information will you need to define or evaluate the extent of the problems?**
 - 2) What information will you need to define or evaluate the effectiveness of solutions?**
- F. List the specific questions you will try to answer through monitoring.**

C. (2) Values identified by members of your watershed communities:

C. (3) Threats identified by members of your watershed communities:

D. (1) List the lakes, rivers or river segments that do not support, or only partially support their designated uses.

D. (2) List the threats, causes or reasons for specific water bodies or segments as to why the uses are not supported.

D. (3) List the watershed protection or restoration efforts underway to address the problems.

E. (1) List the information you will need to define or evaluate the extent of the problems.

E. (2) List the information you will need to define or evaluate the effectiveness of the solutions.

F. List the specific questions you will try to answer through monitoring.

STEP 3: WHAT WILL YOU MONITOR?

The Merrimack River Watershed is a very complicated system of inter-related physical, chemical, and biological characteristics. The characteristics that are measurable are often referred to as “indicators.”² Which indicators you choose to monitor will depend upon the question(s) you are asking as well as your available human and financial resources.

Things To Consider In Selecting Indicators:

Scientific Considerations:

- Does it help answer your question?
- Can you measure and quantify it?
- Does it respond to changes over a reasonable time period?
- Does it respond to the impacts you’re evaluating?
- Can you isolate the conditions that cause it to change?
- Does it integrate effects over time and space?
- Does it respond to changes in other indicators?
- Is it a true measure of an environmental condition?
- Is there a benchmark or reference condition against which it can be evaluated?
- Does it provide early warning of changes?

Practical and Program Considerations:

- Do you have the human and financial resources to measure it?
- How difficult is it to monitor?
- Does it help you understand a major component of the ecosystem?
- Is it understandable/explainable to your target audience?

Some indicators, such as heavy metals and many complex chemical contaminants such as pesticides, are not recommended for volunteer monitoring since they are difficult to sample and require expensive and sophisticated laboratory equipment and procedures to analyze.

COMMON PHYSICAL INDICATORS:

Width: Baseline indicator of the size of the water body. Also used to estimate flow.

² The Intergovernmental Task Force on Monitoring Water Quality (ITFM) defines "environmental indicator" as follows: "A measurable feature which singly or in combination provides managerially and scientifically useful evidence of environmental and ecosystem quality or reliable evidence of trends in quality." ITFM, 1993 Report, Technical Appendixes, Appendix A.

Depth: Baseline indicator of the size of the water body. Also used to estimate flow.

Temperature: Baseline indicator that determines the rate of many bio-chemical reactions in the water body.

Water Clarity: Light penetration is an important determinant of plant growth. It's also an aesthetic consideration and an indicator of suspended material in the water.

Suspended Solids: Fine organic and inorganic material suspended in the water column can reduce light penetration and may indicate erosion problems.

Water Color: Unusual water color is an aesthetic consideration and a likely indicator of pollution.

Habitat Characteristics: Physical characteristics of the aquatic habitat that determine what can live there:

Current Velocity: How fast the water is moving determines, to some extent, what can live there. Used to assess benthic macroinvertebrate habitat and estimate flow.

Bottom Materials: What the bottom is made of determines, to some extent, what can live there.

Embeddedness: The extent to which larger particles (boulder, cobble, and gravel) are surrounded by fine sediment. High embeddedness reduces available habitat for bottom-dwelling critters.

Velocity/Depth Regimes (Rivers): The presence of all four regimes (slow-deep, slow-shallow, fast-deep, fast-shallow) provides a healthy diversity of habitat opportunities for stream critters.

Channel Alteration: Straightening or confining the stream channel reduces habitat complexity and opportunities for stream critters.

Sediment Deposition: Changes the composition of the river bottom, the shape of the channel, and reduces habitat diversity.

Fish Cover: The presence of submerged logs, stable undercut banks, overhanging rocks and other places that provide shelter for fish.

Riffle Characteristics (Rivers): Frequent and well-developed riffles provide diverse habitat and feeding opportunities for many stream critters.

Channel Flow Status (Rivers): The amount of river bottom exposed. Frequent exposure reduces the available habitat.

Bank Characteristics: These include bank vegetation, eroding and unstable banks and other characteristics. A stable vegetated bank provides food and shade to the aquatic habitat and prevents contamination from reaching it.

Riparian Zone Characteristics: This zone of land along the river or lake serves a number of important ecological functions: shading, nutrient and sediment trap, food, and bank stability. The width of this zone and its vegetative composition determine how well it performs these functions.

Shading: The shade provided by trees and other vegetation helps moderate water temperatures in the summer and provides food for aquatic animals.

Channel Sinuosity (Rivers): A meandering channel provides a diversity of bottom, flow, and habitat conditions.

Pool Variability: A mix of large and small, deep and shallow pools provide a diversity of habitat conditions.

COMMON CHEMICAL INDICATORS:

pH: The acidity of the water is measured on a scale from 0 - 14 pH units. Acidity determines the rate of many bio-chemical reactions in the waterbody. Extreme conditions can be toxic to aquatic life.

Alkalinity: The ability of the water body to neutralize acid from precipitation or discharges. Waters with low alkalinity are subject to dramatic fluctuations in pH, which disrupt aquatic life.

Conductivity: Water contains various natural and polluting materials that have the ability to pass an electric current. Conductivity is a measure of this ability of water to pass an electrical current. It is used as an indicator of the presence of chlorides, nitrates, sulfates and phosphate anions (ions that carry a negative charge) and sodium, magnesium, calcium, iron and aluminum cations (ions that carry a positive charge). High conductivity levels may indicate the potential for problems from any of the materials.

Dissolved Oxygen (DO): Water contains oxygen in dissolved form. Some aquatic life requires high levels in order to flourish. Low DO levels can indicate pollution.

Oxygen Demanding Wastes: Some pollutants use oxygen as they decompose or undergo chemical changes in the water. Measuring the bio-chemical oxygen demand (BOD) of the water tells us whether oxygen demanding wastes might cause low DO levels at times.

Phosphorus: Phosphorus is an essential plant and animal nutrient that, in excess amounts, can cause rapid increases in biological activity of certain organisms. This may disrupt the ecological integrity of the aquatic system. It's also an indicator of sewage, animal manure, fertilizer, and other types of contamination. In most streams, phosphorus is the nutrient in short supply, so that relatively small amounts can cause impacts.

Nitrogen: See phosphorus. In the right ratio with phosphorus, nitrogen can cause dramatic impacts. In some waters, nitrogen is the nutrient in short supply, so that relatively small amounts can cause impacts.

COMMON BIOLOGICAL INDICATORS:

Bacteria: Certain types of bacteria are indicators of the presence of fecal material and a risk to human health from water contact. In many states, the bacteria indicator of choice for fresh water is *Escherichia coli*, (or *E. coli* for short) and enterococcus for salt water.

Benthic Macroinvertebrates (Rivers): These are aquatic organisms with no backbone that spend at least a part of their life cycles in communities on the river bottom. The abundance and types of macroinvertebrates found and the structure of the community can tell us about the biological health of the river and its response to pollution.

Algae: These tiny, primitive, aquatic plants grow on rocks, other plants and woody debris and in the water column. They are food for macroinvertebrates and fish. Certain types of algae, in excess amounts, can indicate an overload of nutrients.

Macrophytes: These rooted aquatic plants grow from the bottom. They provide attachment surfaces for macroinvertebrates and cover for fish. Certain types of macrophytes, in excess amounts, can indicate an overload of nutrients and be a nuisance for human use and alter the aquatic ecosystem.

STEPS TO GET THE INFORMATION

Step 1: Consult with your technical committee and/or VEMN staff to help you determine which water quality indicators will help you answer your questions. Use the suggested indicators in the VEMN document “Designing a Volunteer Water Monitoring Study in the Merrimack River Watershed” or “Training Manual for Core VEMN Monitoring Parameters and Methods” as a guide starting point.

Step 2: Find out what human and financial resources will be required to monitor those indicators. You’ll need to consult with VEMN staff and/or members of your technical committee who are familiar with how these indicators are monitored. Find out how much time, money, equipment and expertise are required to monitor each indicator.

Step 3: Determine which indicators you have the resources and capabilities to monitor. Use the practical considerations listed at the beginning of this section to help you select appropriate indicators. Your human and financial resources and expertise may limit the water quality indicators you can monitor.

IN YOUR STUDY DESIGN:

A. List the indicators you will monitor.

B. Describe the significance of each indicator and how it will help you answer your questions.

STUDY DESIGN FOR: _____ **Date:** _____

WHAT WILL YOU MONITOR?

List the specific question you will try to answer through monitoring. (Same as for last worksheet).

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A. INDICATORS YOU WILL MONITOR	B. SIGNIFICANCE OF INDICATOR (how it will help you answer your questions)
<u>Physical indicators:</u>	
<u>Chemical indicators:</u>	
<u>Biological indicators:</u>	
<u>Other indicators:</u>	

STEP 4: WHAT ARE YOUR DATA QUALITY GOALS AND OBJECTIVES?

Who do you expect to use your monitoring information? How do you expect them to use it? How good does your information need to be to be useful?

DATA QUALITY GOALS

Data quality goals are your general intentions and hopes for use of your data.

Examples of Data Quality Goals:

- use data in court
- use data for government management decisions
- use data to make personal choices as to the use of a waterbody

Part III lists four levels of data quality goals of increasing difficulty and rigor. You must decide which level of data quality you need in order to provide information useful to those you expect to use your data

DATA QUALITY OBJECTIVES

Data quality objectives are narrative statements that link your data quality goals to specific users and uses for your data. These statements identify whom you expect to use the data and for what purpose.

Example of Data Quality Objective:

Suppose you want to evaluate the health risk of water contact at a popular swimming hole. Your data quality objective might be:

To produce data that your local health officer could use to determine whether or not to post a warning sign.

Part III of this manual lists the potential users and uses of data from volunteer monitoring programs in the watershed.

DATA QUALITY REQUIREMENTS

Data quality requirements are the performance standards that must be met in order to ensure that you reach your data quality goals and objectives. There are different data quality requirements for each aspect of your program, specifically **sampling, analysis,** and **data management.** These are:

Sampling:

Completeness: Do you have enough samples to pass the statistical requirements for your data quality goals and objectives?

Representativeness: Do your samples represent actual conditions in your waterbody?

Example: If you take a pond sample at the mouth of a pipe discharge, your sample probably does not represent the quality of your waterbody as a whole.

Conversely, a sample taken one meter below the surface at the deepest part of your pond probably represents water quality in the pond as a whole quite well.

Comparability: Can you compare the results from samples taken at different sites?

Example: If you sample a river from the main current above, in and below the swimming hole, your comparability of those three river locations will be good. However, if you sample above the swimming hole in the main current, in the swimming hole in an eddy pool, and below the swimming pool right next to the bank, it will be difficult to compare the water quality at those three locations.

Accuracy: Are you using proven field techniques?

Analysis:

Precision: Does your analysis produce repeatable results?

Example: You can usually answer this question if you analyze 5 - 10% of your samples in duplicate and get results within a certain range that you establish for each indicator.

Accuracy: How close are your results to the true value as expressed by some accepted reference?

Example: If you test a reference sample (a sample for which the results have already been established by an outside lab or agency) along with your samples using the same analysis techniques and get the right results, you can be sure that your analysis is accurate.

Sensitivity: At what detection limit can you confidently report your results?

This depends on the analysis methods, materials and/or instruments that you are using.

Example: If you are reading pH from a meter that gives results to the 0.000000000001 decimal place, it is important to know to which decimal place the meter is accurate (this will be mentioned in the paperwork that comes with the meter). It may only be accurate to the 0.01 decimal place and that is the sensitivity of your analysis.

Data Management:

Chain of Custody: Do you have documentation to ensure that the sample you collected is the same one that was analyzed and for which the results were recorded?

Example: Correct chain of custody means that your sample container is marked with the same identification number that is on your field sheets, lab sheets and result sheets and signed off by each person that handles the samples including people that collect, transport, store, and analyze them.

Check Data Entry: Double check that your computer data sheets agree with your field and analysis sheets.

Check Accuracy of Translated Values: Have you translated correctly between your analysis results and the final units in which you will report your data?

Example: Dissolved Oxygen (DO) digits = real mg/L.

Adequate Data Management System: Does your system allow for retrieval and checking of your data and including your quality control results?

Example: You don't have to have a fancy computer system to manage your data. Even if you keep your records by hand on pieces of paper in a file you still want to make sure that you can retrieve and check information when you need to.

Example of Data Quality Requirements:

As in the earlier example, suppose you want to evaluate the health risk of water contact at a popular swimming hole.

Data quality requirements for sampling might be:

- to collect samples at least six times during the season (for completeness),
- to collect samples from the main river current above, in, and below the swimming hole (representativeness and comparability),
- collect duplicate samples (representativeness and comparability).

Data quality requirements for analysis might be:

- to include an analytical method that would enable you to enumerate (count) the number of bacteria colonies in order to determine whether the number exceeds the state standard for swimming in Class B waters (sensitivity),
- to produce results within the same log of results (same order of magnitude: e.g. the numbers 40 and 57 are in the same log but 40 and 540 are not) for samples split for analysis at another lab (precision and accuracy),
- to produce results within the same log of results for samples with known bacteria concentrations (accuracy),
- to produce results within the same log of results for samples analyzed several times (precision).

Data quality requirements for data management might be:

- to have chain of custody sheets that are signed off by each person that handles the samples (chain of custody),
- to have a data check system in place like having two people be responsible for data entry where one person enters data and another checks that it is entered correctly (check data entry),
- to report results consistently in the same units that your data user will require (check accuracy of translated values),
- to have a data management system that allows for retrieving and checking data as well as including quality control results (adequate data management).

Data quality requirements for each indicator and method suggested in this document are listed in the methods (sensitivity) and quality assurance (precision and accuracy) sections of *Designing a Volunteer Water Monitoring Study in the Merrimack River Watershed.*”

STEPS TO GET THE INFORMATION

- Step 1: Identify the decision-makers who are (or should be) interested in the answers to your questions. See the lists in Part III. Find out what actions they might take or decisions they might make as a result of your information. List these actions or decisions (uses) and the decision-makers (users).*
- Step 2: Consult with the decision-makers to find out if, and under what circumstances, they will use your information. This will be the basis of your data quality goals and objectives. Put this information in the form of a narrative statement.*
- Step 3: Determine how sensitive, accurate and precise your data must be in order to be useful to the intended users. See Part III. Consult with your technical committee. Find out what levels of each water quality indicator you must be able to measure in order to find meaningful impacts to or changes in the river or lake. Accuracy and precision relate to the confidence your data users must have in your information in order to use it. Information that might be challenged or used for legal or regulatory proceedings must be very accurate and precise.*

IN YOUR STUDY DESIGN:

- A. List the intended (1) uses and (2) users of the information you collect.**
- B. List your data quality objectives.**
- C. List your data quality requirements for sampling and analysis for each indicator.**
- **Accuracy: how close your results are to the true value.**
 - **Precision: how close the results of repeated analyses of the same sample are to each other.**
 - **Sensitivity: the smallest change or lowest concentration you seek to detect.**

STUDY DESIGN FOR: _____ **Date:** _____

WHAT ARE YOUR DATA QUALITY GOALS AND OBJECTIVES?

A. (1) Intended uses of information	A. (2) Intended users of information

B. Data quality objectives:

C. Data Quality Requirements:

Indicator	Data Quality Requirements for Sampling (Accuracy, Precision and Sensitivity)	Data Quality Requirements for Analysis (Accuracy, Precision and Sensitivity)



STEP 5: HOW WILL YOU MONITOR?

Determining how you will monitor involves making choices as to the appropriate monitoring approach, as well as the specific field and lab methods that you will use.

Things To Consider In Selecting Methods:

Scientific Considerations:

- Does it meet your data quality requirements?
 - How accurate is it?
 - How precise (reproducible) is it?
 - How sensitive is it?
- Will it measure the indicator in the range that you need?
- What lab facilities are required?
- What equipment is required?
- Does it yield samples that are representative?
- Is it comparable to methods used by agencies collecting similar information?

Practical and Program Considerations:

- Do you have the human and financial resources to do it?
- How difficult is it?
- How time-consuming is it?
- Will it produce data useful to the target audience?

“Designing a Volunteer Water Monitoring Study in the Merrimack River Watershed” lists the analytical methods for each water quality indicator and data quality level suggested in this document.

This section describes the basic monitoring approaches and methods suggested in “Designing a Volunteer Water Monitoring Study in the Merrimack River Watershed”.

BASIC MONITORING APPROACHES

There are five basic monitoring approaches suggested in this document:

Water Sampling and Analysis: Water samples are collected in containers from the river or lake and analyzed in the field or the lab for the selected indicators. Indicators that are monitored this way include:

- Bacteria
- Nutrients (various forms of phosphorus and nitrogen)
- Dissolved Oxygen
- pH/Alkalinity
- Conductivity
- Chlorine
- Water Clarity
- Suspended Solids
- Color

Visual Surveys: Monitors estimate and record observations about selected indicators in the field. Examples include field surveys and air photo analysis. Indicators that are monitored this way include:

- Water Clarity
- River bank erosion
- Color
- Habitat Characteristics
- Sedimentation
- Pollution threats

Field Measurements: The indicator is measured directly from the waterbody without collecting a sample in a container. Indicators that are monitored this way include:

- Dissolved Oxygen
- Sedimentation (actual depths, depths in traps)
- pH
- Conductivity
- Water Clarity
- Width
- Depth
- Temperature

Benthic Macroinvertebrate Surveys (Rivers): This is a special type of monitoring that involves the following activities:

- Field Collection:
 - a. with nets directly off the river bottom
 - b. placing artificial substrates in the river and allowing the critters to colonize them over a period of weeks.

- Field Habitat Assessment
 - Field or lab identification of organisms to major group or family level.
- The samples are identified to a taxonomic level appropriate to the resources and skills of the participants.

Water User Surveys: These involve asking standardized questions of water users. Common types of surveys include:

- Epidemiological Surveys for Common Water Borne Illnesses
- Angler and Creel Surveys

COMMON FIELD AND LAB METHODS

Monitoring is performed according to commonly accepted *methods*. A method is a package of procedures and specifications for equipment and supplies in written form. *Procedures* are the specific steps you will follow to do the analysis.

Water Sampling and Analysis/Field Measurements: The basic references for water sampling and analysis methods are the American Public Health Association's Standard Methods for the Examination of Water and Wastewater (generally referred to as "Standard Methods") and the U. S. EPA Methods for Chemical Analysis of Water and Wastes. In these thick books you will find methods to analyze most any water quality indicator you can think of. However, they are written in a technical style that assumes a certain level of experience with laboratory procedures. Often you will find several methods for analyzing a given indicator.

Here are a few of the most common types of analytical methods:

- **Titration:** Determining the concentration of an indicator in a sample by adding to it a standard reagent of known concentration in carefully measured amounts until a color change or electrical measurement is achieved, and then calculating the unknown concentration. Common indicators measured this way are dissolved oxygen and alkalinity.
- **Colorimetric:** Determining the concentration of an indicator in a sample by adding to it a reagent that causes a color change in direct proportion to the concentration of the indicator being measured. The intensity of the color (as measured by the extent to which it absorbs or transmits light) is measured using a meter and either read directly in appropriate reporting units or read in "% absorbance" or "% transmittance" units and converted to reporting units. Common indicators measured this way are nutrients.
- **Electrode:** Determining the concentration of an indicator in a sample by using a meter with an attached electrode which measures the electric potential (millivolts) of the sample. This amount of electric potential is a function of the activity of ions or molecules in the sample and proportional to the concentration of the indicator being measured. The electrode is selected based on its response to specific ions (known as an "Ion Selective Electrode")

(or ISE), general ionic activity (conductivity) or molecules (for example, a Membrane Electrode). The meters can either display results in either millivolts (mV) or in appropriate reporting units. Common indicators measured this way are dissolved oxygen, pH, conductivity, and nutrients.

- **Gravimetric:** Determining the concentration of an indicator in a sample by filtering a specified quantity of the sample and determining the weight of the material retained on the filter. Common indicators measured this way are total solids and total suspended solids.
- **Nephelometric:** Determining the clarity of a sample by measuring the intensity of light scattered by particles in the sample and comparing this with that of a known solution. The higher the intensity of the scattered light, the higher the turbidity, reported in nephelometric turbidity units (NTU's).
- **Membrane Filtration and Incubation:** Determining the bacteria concentration of a water sample by filtering a specified quantity through a specified gridded membrane filter, which retains the bacteria and other particles larger than 0.45 microns. After filtration, the membrane containing the bacterial cells is placed on a specific nutrient medium and then incubated at a specified temperature for a specified length of time. Colonies growing on the filter are then counted.

Visual Surveys: There are a variety of surveys available. These range in complexity, experience and training required.

Benthic Macroinvertebrate Surveys: The US EPA's "Rapid Bioassessment Protocols" and various state agency methods are used by professionals for regulatory purposes. For water quality assessment purposes, more user-friendly variations of these are acceptable in many areas.

Macroinvertebrate surveys involve the following steps:

- 1) **Collection:** Collecting and analyzing benthic macroinvertebrate samples involves using some sort of sampling device and procedure to collect the organisms from the stream bottom. The VEMN recommends two types of sampling devices: a collection net and two types of artificial substrates.
 - **Nets** are used to catch organisms which are dislodged by the sampler from the river bottom immediately upstream.
 - **Artificial Substrates** are devices which are placed on the river bottom, or suspended in the water column, and provide a place for the macroinvertebrates to colonize over a period of time – usually 3-5 weeks. The devices are then retrieved and the organisms washed from the substrate material.
 - **Multi-plate Samplers** consist of tiles stacked with spacers on an aluminum turnbuckle.

- **Rock Baskets** consist of a wire mesh basket filled with similar sized rocks (4 to 12 cm in diameter) collected from an exposed area along the stream.
- 2) **Habitat Assessment** is performed at collection site. This consists of various field measurements and observations of primary habitat characteristics (substrate composition, current velocity, and embeddedness) and secondary habitat characteristics (such as bank condition, vegetation, riffle characteristics, etc.).
 - 3) **Processing** involves picking a sub-sample of the field sample and identifying the organisms to a specified taxonomic level (usually order or family).

How do you choose among these methods? You don't have to re-invent the wheel. River Watch Network, your state water quality agency, and the Extension Service can help. They have developed user-friendly procedures based on Standard Methods that volunteers are currently using successfully. They can help you choose a method that will match your data quality requirements and the limits of your human and financial resources.

In any case, your study design should specify the elements of the sample collection and analysis procedures you will use. These are listed in the "In Your Study Design" section below.

STEPS TO GET THE INFORMATION

- Step 1: Consult with your technical committee and/or VEMN staff to help you determine which methods will help you answer your questions and meet your data quality requirements.*
- Step 2: Find out what human and financial resources will be required to use these methods. Find out how much time, money, equipment and expertise are required for each method.*
- Step 3: Determine which methods you have the resources and capabilities to monitor. Your human and financial resources and expertise may limit the methods you can use.*
- Step 4: Refer to the procedures in relevant manuals to find the information listed in the suggested outline.*

IN YOUR STUDY DESIGN:

A. Describe how you will collect samples

- 1) **What will be sampled (e.g. water, river bottom, lake sediments)**
- 2) **Type of sampling containers or devices to be used**
- 3) **Quantity of sample to be collected**
- 4) **Number of samples to be collected per site**
- 5) **Brief description of procedure (reference a particular method if applicable)**

B. Describe how you will analyze the samples

- 1) How samples will be transported to the lab (if applicable)**
- 2) How soon after collection will samples be analyzed**
- 3) What method will be used to analyze samples – cite a particular method (for example “EPA Method 360.2” or “River Watch Network Benthic Macroinvertebrate Monitoring Manual”)**
- 4) Brief description of procedure**
- 5) The units in which the results will be reported**

STEP 6: WHERE WILL YOU MONITOR?

Sampling locations are selected to answer your question(s). “Designing a Volunteer Water Monitoring Study in the Merrimack River Watershed” lists site selection criteria for each question and data quality level.

Below are some suggested sampling site selection criteria for different types of monitoring:

GENERAL WATERSHED SAMPLING SITE SELECTION CRITERIA:

- 1) Sampling stations should be located at a variety of sites that represent the variety of conditions in the watershed. These might include:
 - waters located in areas of different land uses (urban, agricultural, forested),
 - streams and rivers of different orders (sizes),
 - waters located at different altitudes,
 - waters receiving point source discharges,
 - waters receiving non-point pollution.
- 2) Where possible, sites historically monitored by the state water quality agency.
- 3) Sites at areas of public use for water contact recreation (e.g. swimming areas).
- 4) At habitat areas of sensitive species (e.g. holding or spawning areas important to Atlantic Salmon and other cold water species).
- 5) Sites which are representative of the part of the water body of interest.
- 6) Sites which are safely accessible. Avoid steep, slippery or eroding banks or sites where landowner permission cannot be obtained.
- 7) Sites should be located in the main river current or the deepest part of a lake or a lake section of special concern and away from the banks. If that is not possible for a river, locate the site next to the bank where homogeneous mixing of the water occurs, such as on an outside bend of the river.
- 8) Consider variable river flow patterns caused by artificial physical structures such as dams, weirs, and wing walls. These may influence the representative quality of the water.

BENTHIC MACROINVERTEBRATE NET SAMPLING SITE SELECTION CRITERIA (RIVERS)

- 1) Shallow (1-2' deep), “riffle” areas
- 2) Current between 0.4 and 2.5 feet per second
- 3) Predominately cobble and gravel bottoms

POLLUTION OR EROSION IMPACT SAMPLING SITE SELECTION CRITERIA (RIVERS)

Generally, three sites should be chosen to “bracket” the polluting/eroding areas:

- 1) **a reference or control site** immediately upstream of any potential impact,
- 2) **an impact site** immediately downstream of the alteration (at the point where the impact is completely integrated with the water),
- 3) **a recovery site** downstream of the impact (where the water has at least partially recovered from the impact).

It is very important that all the sites be as similar as possible in every respect except for the impact being assessed.

TRIBUTARY IMPACT SAMPLING SITE SELECTION CRITERIA (RIVERS):

Consider tributaries as non-point discharge “pipes” to the main stem. Four sites should be chosen to bracket the tributary confluence.

- 1) **a reference or control site** immediately upstream of the tributary confluence,
- 2) **an impact site** immediately downstream of the tributary at a point where the water from the tributary is completely integrated with the main stem water.
- 3) **a recovery site** downstream of the tributary where the main stem water has at least partially recovered from the impact (for example, downstream from where a cleaner tributary has entered).
- 4) **an “integrator” site** in the mouth of the tributary. Be sure that you are not sampling a backwater of the main stem.

WHERE WILL YOU ANALYZE SAMPLES?

Where you analyze³ samples – in the field or in a lab – depends on the water quality indicators and the requirements of the analytical methods you’ve chosen.

Simple Field Observations and Measurements: Some of the water quality indicators listed previously are not really “sampled” in the sense that you collect them. Some are analyzed by merely observing and estimating them or by simple direct measurements. Examples include width, depth, current velocity, water color, shading, bottom composition, algae cover, temperature, and bank characteristics.

More Complicated Field Sampling and Analysis: For some indicators and methods, the quantity of the indicator must be measured, either by collecting a water sample and analyzing it in the field or by measuring the indicator directly in the water using an electronic instrument. Field analysis is necessary for water quality indicators, such as dissolved oxygen, that might change either immediately or within hours after the sample is collected. In this case, the

³ Analysis is the testing of a sample to isolate and quantify the water quality indicator being measured.

indicator could either be measured directly from the water with a dissolved oxygen meter or a sample could be collected and treated immediately in the field in order to “fix” or stabilize the level of the water quality indicator in the sample and analyzed later in a lab. Field meters may be used for dissolved oxygen, pH and turbidity, for example. However, meters may be expensive, difficult to operate, and/or less sensitive than laboratory methods. Moreover, the number of sites you can sample will be limited by the number of meters you have, especially if you want all the measurements collected at approximately the same time. Analysis of some indicators, like pH, alkalinity, and dissolved oxygen, can also be performed in a lab, as long as the sample is fixed or stabilized. Benthic macroinvertebrates may be identified in the field to a limited extent.

Laboratory Analysis: Laboratory analysis is required to produce precise and accurate results for some indicators. Bacteria, certain forms of phosphorus and nitrogen, suspended solids, biochemical oxygen demand and benthic macroinvertebrate identification to family level must be done in the lab because they require special equipment or facilities that can't be brought into the field. For others, like pH, alkalinity, and dissolved oxygen, analysis in the lab is easier but not required.

Identify the laboratories that will be performing the analyses of your samples or performing quality control (see Quality Assurance/Quality Control section below) for your program.

STEPS TO GET THE INFORMATION

- Step 1: Consult with your technical committee and/or VEMN staff to help you determine criteria for sample site selection to answer your questions.*
- Step 2: Use a topographic map to do a preliminary selection of sites that appear to meet your criteria.*
- Step 3: Field check each site for accessibility, representativeness, safety, and appropriateness. Record directions to the site, a brief description of the site, and other relevant information on a site evaluation sheet.*
- Step 4: Photograph each site at the sample collection point.*
- Step 5: Place the site description and the photograph in a loose-leaf binder for permanent archiving.*
- Step 6: Map each site.*
- Step 7: Determine how many of these sites you can monitor. Consider safety, accessibility, your human resources, and how many samples you can analyze.*
- Step 8: Identify the laboratory where the analysis of samples will be performed.*

IN YOUR STUDY DESIGN:

- A. List the criteria you used to select sampling sites.**
- B. List each sampling site and the rationale for each. This should be in a table with the following column headings:**
 - 1) Site number**
 - 2) Brief description of location**
 - 3) How the site will be sampled (e.g. wading, from shore, by boat)**
 - 4) Why the site is being monitored**
- C. List where each indicator will be analyzed (field or lab)**

STUDY DESIGN FOR: _____

Date: _____

WHERE WILL YOU MONITOR?

A. Criteria used to select sampling sites:

B. Sampling Sites:

1) Site number	2) Brief description of location	3) How the site will be sampled (e.g. wading, from shore, by boat)?	4) Why site is being monitored

STEP 7: WHEN WILL YOU MONITOR?

Next, you will put together your sampling schedule. Since the time of day, holding frequency, and time of year that you sample can greatly affect your results, consider these when you put together the sampling schedule.

Time of Day: Dissolved oxygen is an example of a water quality indicator that changes with the time of day. For example, in waters with dense aquatic vegetation, dissolved oxygen levels fluctuate dramatically over a 24-hour period, with the lowest levels found at sunrise and the highest levels in mid-afternoon. So if you want the worst-case scenario, sample at sunrise.

Holding Time: Take into account the maximum holding time the sample can be held for each test. 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.

Frequency: How often you need to sample depends on what you want to know. For example, if you want to detect sewage pollution events from a possibly failing wastewater treatment plant analyze bacteria as frequently as you can stand it – daily, perhaps even hourly if you're trying to establish a relationship between storm events and treatment plant failure. Benthic macroinvertebrates need only be sampled once or twice per year.

Time of year: In deciding the time of year to conduct sampling, consider the uses of the water. If you want to know if the water is safe to swim in, sample in the summer. In some cases, the nature of the indicator determines the best sampling season. Also take into account the ease of field work: Do you need to send volunteers out in freezing weather?

“Designing a Volunteer Water Monitoring Study in the Merrimack River Watershed” suggest the frequency time of day, holding time, and time of year for each question and for each level of data quality.

STEPS TO GET THE INFORMATION

Step 1: Consult with your technical committee and/or VEMN staff to help you determine the time of year, frequency and time of day for each type of sampling.

Step 2: Determine how frequently and what time of year and day you can sample considering your human and financial resources. You'll need to be sensitive to the schedules and interest level of your samplers, as well as considering the scientific requirements.

Step 3: Pick a number of sampling dates.

IN YOUR STUDY DESIGN:

- A. List the holding time for each type of sample.**
- B. List the sampling and analysis dates for each type of sampling, including the time of day.**

STUDY DESIGN FOR: _____ **Date:** _____

WHEN WILL YOU MONITOR?

Type of Sampling	Holding Time	Sampling Dates	Sampling Time	Analysis Dates	Analysis Time

STEP 8: WHO WILL MONITOR?

Who is going to collect and analyze the samples? How are they going to be trained? Who will coordinate their activities?

Make a list of all the tasks that need to be done and identify someone to be in charge of each task. Some examples of the jobs that need to be done are: volunteer coordinator, field monitor, lab analyst, lab coordinator, sampling team leader, data manager, quality assurance supervisor, etc.

STEPS TO GET THE INFORMATION

Step 1: Determine the tasks that will need to be done in order to carry out the sampling and analysis.

Step 2: Develop specific jobs to carry out the tasks. Write simple job descriptions for each.

Step 3: Determine whether each position will be paid or volunteer.

Step 4: Recruit people to fill each position.

IN YOUR STUDY DESIGN:

A. List the paid and volunteer positions.

1) Title

2) Responsibilities

3) Name, address, and phone number of the person

B. Describe how your field and lab volunteers will be trained.

C. What manuals will they use?

B. How will your volunteers be trained?

Field:

Lab:

C. What manuals will your volunteers use?

STEP 9: WHAT ARE YOUR QUALITY ASSURANCE MEASURES?

Quality Assurance (QA) measures are the operating procedures that you use to assure and assess the quality of the information you collect. They are designed to assure that the information you collect meets your data quality goals and requirements as described in Step 3.

“Designing a Volunteer Water Monitoring Study in the Merrimack River Watershed” suggest quality assurance measures for each indicator for each level of data quality.

Quality assurance includes procedures for sampling and analysis and data management.

Quality Assurance for Sampling and Analysis includes training, documentation, quality control, and quality assessment.

Quality Assurance for Data Management includes measures to assure that the data are properly recorded on field and lab sheets and accurately transferred to a computer or summary sheet.

QUALITY ASSURANCE FOR SAMPLING AND ANALYSIS

Training is a form of quality assurance that has already been covered in this workbook. In the quality assurance section of your study design, you simply describe the training procedures to assure that your field and laboratory personnel are properly trained. Describe any training workshops or other types of training that volunteers must undergo before they can collect and analyze samples. Some programs even require that program personnel certify in writing that each volunteer has completed a training workshop or series.

Documentation of your field and laboratory procedures is critical for quality assurance. In fact, your study design itself is an example of this type of quality assurance. Other examples include your field and laboratory manuals that the volunteers will use to collect and analyze samples, written directions to the sampling locations, sample labels, and your field and laboratory data recording sheets. This also includes a set of procedures known as “chain of custody.” Chain of custody refers to documenting each person that handled the sample. Unless your data is going to be used in some legal or regulatory proceeding, it can be as simple as having places on your field and data sheets for samplers and analysts to sign when they take custody of and complete their work on a sample.

Quality Control (QC) consists of the steps you take during the collection and analysis of your samples to ensure the *accuracy* (how close to the real result you are) and *precision* (how reproducible your results are) of your monitoring. The purpose of quality control procedures is to let you know right away if you have a problem, so that you can correct it. Quality control procedures include both *internal checks* performed by the project field volunteers, staff, and a lab and

external checks performed by non-volunteer field staff and a lab (also known as a “quality control lab”). Common types of quality control samples and how they are assessed are listed in the next two sections of this part.

Quality Assessment is your assessment of how accurate and precise your data actually are after you’ve collected and analyzed the samples. This involves calculating the accuracy and precision of your quality control samples and comparing them to your data quality requirements (See Step 3 of Part I for definitions of these terms). Assessment of quality control samples is described in the next section.

For some quality control results, the following statistical measures are used:

Standard deviation is used to compare how closely three or more values are clustered around the average value. It is expressed as \pm from the average value. The lower the value, the more precise the results.

Coefficient of Variation: This is the standard deviation as a percentage of the average. The lower the percentage, the more precise the results.

Relative Percent Difference is used to compare how close the result from a water sample is to the true result. It is expressed as either a positive difference (the sample result is higher than the true value) or negative difference (the sample result is lower than the true value). The lower the value, the more precise the results.

% Recovery: This is the percentage of the substance added to a spiked sample (see below) that is detected. It’s the difference between the concentration detected in the spiked sample and that detected in the unspiked sample, divided by the concentration of the substance added to the spiked sample.

Your study design should describe the measures you will take if you don’t meet your data quality requirements. Examples might include not using some of your data; changing laboratory methods, equipment, or field procedures; requiring more training; changing the field or lab sheets; etc.

COMMON INTERNAL QUALITY CONTROL SAMPLES AND HOW THEY ARE ASSESSED:

These are checks performed by the project field volunteers, staff, and lab.

Trip (Field) Blanks: A trip blank (also known as a field blank) is de-ionized water which is poured into a sample container in the field as if it were a river or lake sample. Trip blanks are usually collected at 10% of the sampling sites. They are used to identify errors or contamination in sample collection and analysis.

Assessment of Results: The results should be “0.”

Negative and Positive Plates (For bacteria): *Negative plates* result when the buffered rinse water (the water used to rinse down the sides of the filter funnel during filtration) has been filtered the same way as a sample. This is different from a field blank in that it contains reagents used in the rinse water. There should be no bacteria growth on the filter after incubation. It is used to detect laboratory bacteria contamination of the sample. *Positive plates* result when water known to contain bacteria (such as wastewater treatment plant influent) is filtered the same way as a sample. There should be plenty of bacteria growth on the filter after incubation. It is used to detect procedural errors or the presence of contaminants in the laboratory analysis that might inhibit bacteria growth. Positive and negative plates are usually run before the first water sample is filtered, every ten samples thereafter, and after the last sample has been filtered.

Assessment of Results: The results for negative plates should be “0.” The results for positive plates should be “too numerous to count.”

Field Duplicates: A field duplicate is a duplicate river or lake sample collected by another sampler or team. Field duplicates are usually collected at 10% of the sampling sites. They are used to determine total (both sampling and laboratory analysis) precision.

Assessment of Results: The results for two samples should be compared using the relative percent difference between them. The results for three or more samples should be compared using the standard deviation among them. Results are compared with data quality requirements.

Lab Duplicates: A lab duplicate is a sample that is split into two or more sub-samples at the lab. Each sub-sample is then analyzed and the results compared. Usually, 10% of the samples are split into lab duplicates. They are used to determine the precision of the laboratory analysis.

Assessment of Results: The results for two samples should be compared using the relative percent difference between them. The results for three or more samples should be compared using the standard deviation among them. Results are compared with data quality requirements.

Calibration Blank: A calibration blank is de-ionized water processed like any of the samples and used to “zero” the instrument. It is the first “sample” analyzed and used to set the meter to zero. This is different from the field blank in that it is “sampled” in the lab. It is used to check the measuring instrument periodically for “drift” (the instrument should always read “0” when this blank is measured). It can also be compared to the field blank to pinpoint where contamination may have occurred.

Assessment of Results: The results of periodic checks should be “0.”

Calibration Standards: Calibration standards are used to calibrate a meter. They consist of one or more “standard concentrations” (made up in the lab to specified concentrations) of the indicator being measured, one of which is the calibration blank. Calibration standards can be used to calibrate the meter before running the test, or they can be used to convert the units read on the meter to the reporting units (for example, absorbance to milligrams per liter).

Assessment of Results: The meter should read the expected concentration.

Spike Samples: A sample is split into two subsamples in the lab. One is analyzed according to the specified procedure. The other is treated by adding a known amount and concentration of the indicator being measured, then running the specified procedure. This should increase the concentration in the spiked sample relative to the unspiked sample by a predictable amount. Usually, 10% of the samples are split and spiked. They are used to test the accuracy of the laboratory method.

Assessment of Results: The percent of the indicator “recovered” by comparing the spiked to the unspiked sample is determined. Results are compared with data quality requirements.

COMMON EXTERNAL QUALITY CONTROL SAMPLES AND HOW THEY ARE ASSESSED:

These are checks performed by non-volunteer field staff and a lab (also known as a “quality control lab”). The results are compared with those obtained by the project lab.

External Field Duplicates: An external field duplicate is a duplicate river or lake sample collected and processed by an independent (e.g. professional) sampler or team. It is used to estimate total (sampling and laboratory) analysis accuracy.

Assessment of Results: The results for two samples should be compared using the relative percent difference between them.

Split Samples: A split sample is a sample that is split into two sub-samples at the lab. One sub-sample is analyzed at the project lab and the other is analyzed at the independent lab and the results compared. Usually, 10% of the samples are split.

Assessment of Results: The results for the two samples should be compared using the relative percent difference between them.

Taxonomic Verification (for Benthic Macroinvertebrates): Benthic macroinvertebrate samples identified by volunteers should be preserved and archived. Usually, 10% of these samples are identified to the same taxonomic level as the volunteers by a professional biologist or entomologist. A reference collection should be assembled with representatives of key taxa.

Assessment of Results: The identifications are compared.

Knowns: The quality control lab sends samples for selected indicators, labeled with the concentrations, to the project lab for analysis prior to the first sample run. Usually, three knowns are supplied that contain concentrations at the low end, in the middle, and at the high end of the range likely to be found in the water samples. These samples are analyzed and the results compared with the known concentrations. Problems are reported to the Quality Control Lab.

Assessment of Results: The results for the two samples should be compared using the relative percent difference between them.

Unknowns: The quality control lab sends samples to the project lab for analysis for selected indicators, prior to the first sample run. The concentrations of these samples are unknown to the project lab. Usually, three unknowns are supplied that contain concentrations at the low end, in the middle, and at the high end of the range likely to be found in the water samples. These samples are analyzed and the results reported to Quality Control Lab. Discrepancies are reported to the project lab and a problem-identification and solving process will follow.

Assessment of Results: The results for the two samples should be compared using the relative percent difference between them.

QUALITY ASSURANCE FOR DATA MANAGEMENT

This includes measures to assure that the data are properly recorded on field and lab sheets and accurately transferred to a computer or summary sheet.

Field and Lab Sheets: These should be laid out clearly with the following information:

- Samplers' Names
- Site #
- Sample Container Type
- Container #
- Time the Sample Was Taken
- Sample Preservation (if any)
- Time the Sample Was Dropped off at the Lab
- Name of the Person Who Checked the Samples In (person transporting samples)
- Results in Analysis Units
- Results in Final Reporting Units
- Analysts Name
- Time Analysis Was Performed

Data Entry and Validation: If a computer is used, data should be entered by one person, if possible. The data entered into the computer must be checked against the raw data from the field and lab sheets to assure that it has been entered correctly. Ideally, this should be done by someone other than the person who entered the data.

Data Analysis: Even if your results are entered correctly and meet your data quality objectives, you should be on the lookout for numbers which seem to be much higher or much lower than typical results. These are called outliers. Do you have confidence that these numbers are reliable? Verify that these numbers were transcribed or entered correctly.

STEPS TO GET THE INFORMATION

Step 1: Consult with your technical committee and/or VEMN staff to help you determine quality assurance/quality control measures you will use to answer your questions and meet your data quality requirements

Step 2: Locate a quality check lab – an independent lab that can run external checks for you.

Step 3: Determine which quality checks you have the resources and capabilities to carry out. Your human and financial resources and expertise may limit the water quality indicators you can monitor.

If your monitoring program uses federal funds, you will be required to prepare a Quality Assurance Project Plan (QAPP).⁴ Otherwise, you can simply document your quality assurance measures in your study design.

IN YOUR STUDY DESIGN:

A. List and briefly describe the quality assurance measures you will use:

- 1) Training**
- 2) Documentation**
- 3) Internal Quality Control Samples**
- 4) External Quality Control Samples**

B. Briefly describe how you will assess your quality assurance procedures.

C. What measures will you take if you don't meet your data quality requirements?

D. What measures will you take to assure that the data are correctly entered on field and lab sheets and on your computer?

⁴ An excellent guide for preparing quality assurance project plans is available from EPA Region 8: [Integrating Quality Assurance into Tribal Water Programs.](#)

STUDY DESIGN FOR: _____ **Date:** _____

WHAT ARE YOUR QUALITY ASSURANCE MEASURES?

A. List and briefly describe the quality assurance measures you will use:

1) Training:

2) Documentation:

3) Internal Quality Control Samples:

4) External Quality Control Samples:

B. How will you assess your quality assurance procedures?

C. What measures will you take if you don't meet your data quality requirements?

D. What measures will you take to assure that the data are correctly entered on the field and lab sheets and on your computer?

A FINAL WORD ABOUT STUDY DESIGN – PUT IT IN WRITING AND EVALUATE IT ANNUALLY

When you've answered the above why, what, how, where, when, and who questions, it's very important to organize and write down the answers in a study design document. This is your program's basic reference document.

You will need to re-evaluate and, if necessary, rework your study design annually, considering the results of your previous year's work.

The study design process may seem like a lot of work. However, time spent on designing the study can ultimately save you and your volunteers many hours of wasted effort and frustration by assuring that your monitoring matches your goals and resources.

PART II. ISSUES AND QUESTIONS MONITORING CAN ADDRESS

The first step in designing your monitoring study is to define the reasons for it. Why are you monitoring the river or lake? What specific questions about the river or lake are you trying to answer? Your sampling and analytical activities should be designed to answer specific questions that address issues faced by decision-makers in the Merrimack River Watershed.

This section lists the suggested issues and questions that volunteer monitoring can address in the Merrimack River Watershed. The issues have been identified by various committees and reports of the Merrimack River Initiative. The questions have been identified by the VEMN Steering Committee as desirable and appropriate to address these issues.

The questions are divided into two types: basic questions about the watershed and monitoring questions. The basic question is listed first, then the issue it addresses, followed by specific monitoring questions. Bolded, *italicized* monitoring questions below can be addressed by the three core assessments that the VEMN recommends as a base for all monitoring groups. These are:

1. ***Watershed Assessment*** - a visual survey and evaluation of some of the basic watershed characteristics to help focus your other monitoring activities.
2. ***Health Risk Assessment*** - a combination of water sampling and data gathering on actual disease occurrence to see if there's a relationship between water quality, contact with the water and illness.
3. ***Water Quality Standards Assessment*** - water sampling and analysis of river or lake water quality indicators that the states of Massachusetts and New Hampshire use to determine how well our waters comply with state standards for their designated uses.

Field and lab procedures that support these assessments are included in the "Training Manual for Core VEMN Monitoring Parameters and Methods".

BASIC QUESTION I: IS THE RIVER SYSTEM OR LAKE SUPPORTING ITS USES AND VALUES?

Issue Addressed: Maintain water quality for beneficial water uses and values.

Monitoring Questions:

A. Is human water contact recreation a health risk?

- 1) ***swimming, water skiing, windsurfing, etc. (primary: accidental ingestion likely)***

- 2) *boating, wading, fishing, etc. (secondary: accidental ingestion unlikely)*
- B. Does the water meet MA and NH Water Quality Standards?**
- C. Is eating the aquatic life a health risk?**
- 1) *fish*
 - 2) *shellfish*
 - 3) *turtles*
- D. Do physical, chemical and biological lake / river conditions support healthy aquatic life when compared with regional reference conditions?
- E. Do lake / river conditions support economic uses (irrigation / water supply, snow, industrial, etc.)?
- F. Are the existing standards adequate for their designated water uses and values and restoring and maintaining ecological integrity?

BASIC QUESTION II: WHAT ARE THE IMPACTS OF HUMAN ALTERATIONS OF THE RIVER SYSTEM OR LAKE ON HUMAN USE AND ECOLOGICAL INTEGRITY?

Issue Addressed: The impacts of pollution sources and various water uses on human use and ecological integrity of the river system or lake.

Monitoring Questions:

- A. What are the impacts of water withdrawals on human use and ecological integrity of the river system or specific water bodies?
- B. What are the impacts of non-point source (NPS) pollution on human use and ecological integrity of the river system or specific water bodies?
 - 1) developed areas
 - 2) dairy farms
 - 3) construction
 - 4) on-site septic systems
 - 5) logging
 - 6) parking lots
- C. What are the impacts of point discharges on human use and ecological integrity of the river system or specific water bodies?
- D. What are the impacts of flow management on human use and ecological integrity of the river system or specific water bodies?
- E. What are the impacts of water uses on erosion and subsequent impacts on human use and ecological integrity of the river system or specific water bodies?

- F. Is water quality having a positive or negative effect on economic conditions (i.e. property values, tourism, industrial locations)?

BASIC QUESTION III: HOW EFFECTIVE ARE SITE SPECIFIC AND WATERSHED-WIDE WATER AND LAND MANAGEMENT STRATEGIES IN RESTORING AND PROTECTING HUMAN USE AND ECOLOGICAL INTEGRITY?

Issue Addressed: The effectiveness of water quality protection and improvement measures in restoring and maintaining human use and ecological integrity.

Monitoring Questions:

- A. 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?
- 1) developed areas
 - 2) dairy farms
 - 3) construction
 - 4) on-site septic systems
 - 5) logging
 - 6) parking lots
- B. What is the effectiveness of land use planning and zoning in restoring and protecting human use and ecological integrity of the river system or specific water bodies?
- C. How effective is remediation for restoring and protecting the ecological integrity and/or human use of the river system or specific water bodies?
- D. 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?
- E. What is the effectiveness of habitat / stream restoration in restoring and protecting human use and ecological integrity of the river system or specific water bodies?

BASIC QUESTION IV: ARE PERMIT CONDITIONS EFFECTIVE?

Issue Addressed: Effectiveness of permits in restoring and maintaining human use and ecological integrity of the river system or specific water bodies.

Monitoring Questions:

- A. Are permit conditions being met?
 - 1) NPDES, (Wastewater Discharge Permits)
 - 2) FERC (Hydropower Permits and Licenses)
 - 3) Dredge and Fill
 - 4) Water Withdrawal
 - 5) Stream Alteration
- B. Are permit (e.g. NPDES, FERC, Dredge and Fill, Water Withdrawal, Stream Alteration) conditions adequate to restore and maintain human use and ecological integrity of the river system or specific water bodies?

BASIC QUESTION V: WHERE ARE PROBLEM AREAS THAT SHOULD BE A HIGH PRIORITY FOR REMEDIATION?

Issue Addressed: Pollution source identification.

Monitoring Questions:

- A. ***What and where are the specific pollution sources (sites) that are impairing human use and ecological integrity of water bodies?***
- B. Which pollution sources should be the highest priority for remediation?
- C. Where are candidate areas for resource (e.g. fish habitat) restoration?

BASIC QUESTION VI: WHERE ARE SPECIAL NATURAL AND CULTURAL RESOURCES?

Issue Addressed: Locating resources for protection.

Monitoring Questions:

- A. ***Where is the access for swimming, boating, and fishing?***
- B. ***Is access for swimming, boating, and fishing adequate?***
- C. ***Where are the habitats for rare, threatened or endangered species?***
- D. ***Where are the outstanding physical features (e.g. waterfalls and gorges)?***
- E. ***Where are habitats for important game species (e.g. spawning and nursery areas)?***
- F. ***Where are the important water-dependent tourism attractions?***

BASIC QUESTION VII: ARE CONDITIONS CHANGING?

Issue Addressed: Tracking trends and changes over time.

Monitoring Questions:

- A. Are the answers to any of the above questions changing over time (years)?
- 1) What conditions?
 - 2) Where?
 - 3) How?
 - 4) Why?

PART III: USERS AND USES OF DATA AND DATA QUALITY GOALS

Volunteer monitors are faced with a fundamental question common to all project planners; how do you produce the highest quality product for the least amount of work, expertise and money - all of which seem to be in chronically short supply? The answer to this rests on the relationship between the producer (the data provider) and the consumer (the data user). What are the user's expectations for quality of the product? Depending on the user, the expectations may vary greatly. The farmer and the agency scientist may have very different ideas on what constitutes credible data. A volunteer program can make just as big a mistake by "over-designing" the program -spending too much on fancy equipment, training and technique- as by taking too little care. On the one hand, overdesign can mean fewer sites or dates can be monitored, or it could mean that the group "burns out" faster. On the other hand, all effort may be wasted if the target audience does not respect and will not use the data.

To establish a program that is "just right" in terms of efficiency and rigor, we recommend some simple rules:

- know what you want to use the data for,
- know who you want to use the data, and what their expectations are,
- develop data quality objectives that meet your target audiences' needs,
- design and conduct sampling programs that achieve those data quality objectives, and
- don't spend any more effort than is necessary!

A. USERS AND USES OF WATER MONITORING DATA

Data *uses* and data *users* are different things that are closely tied together. A data *use* is an activity, program, or forum that achieves an end with the help of the data, or information. Examples: a court case that charges someone with violating a discharge permit, development of a fisheries management plan, determining if a public beach is safe for swimming, or educating the watershed association's board (and the larger community) on the general health of the river. Data *users* are the people and institutions who make the decisions. Examples (based on those above): the judge deciding the case, the fisheries agency, the town health officer - and the bathers, the watershed association and the general public. The challenge for the volunteer monitor is to determine which actions and which decision-makers are important enough to convince, and then figure out what they need in order to be convinced.

To help volunteer monitors on the latter question, we have developed a list - based on our experience - of common data users and uses of water monitoring data.

Table 1. Data Users and Uses

User	Uses
1. Individual Citizens	<ul style="list-style-type: none"> · Risk assessment (Should I actually jump in that water?) · Stewardship · Support for policy & program expenditures and changes
2. Legislators	<ul style="list-style-type: none"> · Set and evaluate goals, policies, and programs
3. Regulators	<ul style="list-style-type: none"> · Program planning, management, and evaluation · Protect human and ecosystem health · Compliance with standards and permits · Funding · 305(b) reports
4. Resource Managers (e.g. Farmers, Conservation Commissions, non-regulatory agencies, large land owners)	<ul style="list-style-type: none"> · Plan and policy development · Operational decision making · Conflict and dispute resolution · Program evaluation · Resource evaluation
5. Municipalities and Industry (Dischargers)	<ul style="list-style-type: none"> · Water supply and discharge planning and management · Identifying sites for development · Standards and permit compliance · Identifying sites for protection · Public health · Economic development/Tourism
6. Environmental Groups	<ul style="list-style-type: none"> · Self and government policy and program evaluation · Support programs - ORW designation (or suing) · Stewardship, environmental awareness, education · Advocacy support
7. Scientists	<ul style="list-style-type: none"> · Improve scientific understanding of ecological relationships
8. Civic Groups	<ul style="list-style-type: none"> · Boosterism - supporting economic development/tourism · Advocacy · Stewardship · Stakeholder roles
9. Educational Institutions	<ul style="list-style-type: none"> · Awareness · Stewardship · Involvement · Career Development
10. Monitoring Groups	<ul style="list-style-type: none"> · Advocacy · Program evaluation · Monitoring program evaluation

B. DATA QUALITY GOALS

Once you've identified the intended users and uses of your data, you need to establish data quality goals. These are narrative statements that link the quality of data with the intended use of the data. Most of your other monitoring decisions (what, how, where, how often) will be based on your data quality goals.

We've identified four possible data quality goals for the VEMN:

- 1) Level of quality necessary to meet legal, regulatory and scientific peer review requirements.**
- 2) Meets evaluation and assessment requirements of state and federal agencies.**
- 3) Meets requirements for evaluation, assessment and management at the community or watershed level.**
- 4) Data quality sufficient to increase awareness and knowledge of resource values and conditions.**

These goals are arranged in decreasing order of scientific rigor required to meet them. Think of these goals as benchmarks along a continuum from level 1 through level 4. A brief discussion of each follows:

1) Level of quality necessary to meet legal, regulatory and scientific peer review requirements.

This goal requires a very high level of scientific rigor that can stand up to the highest level of scrutiny in a court of law, regulatory proceeding, or peer review for a scientific journal that reports research results. Meeting this goal will require that you use the most precise, accurate and sensitive methods available and that you undertake a rigorous program to assure the quality of your results. This is a very difficult and potentially prohibitively expensive goal to meet. Given some of the inherent issues associated with using non-professionals to collect data, it's highly unlikely that data collected by volunteer monitors will be used this way.

2) Meets evaluation and assessment requirements of state and federal agencies.

Evaluation and assessment are data uses that enable decision-makers to make non-regulatory water management decisions about allocating staff and funding resources to address problems. Data that meets this goal can be included in EPA and state biennial reports to Congress (also known as 305(b)) reports that describe the extent to which waters support their designated uses and values. This goal requires that the indicators; the precision, accuracy, and sensitivity of the methods; the sites; the frequency; and the quality assurance measures you choose match or are equivalent to those used by agency programs. While still a challenging goal, state and federal agencies in the watershed have begun to use volunteer monitoring data gathered in this way. Remember that your audience here are professional water resources people who understand the limits of your ability to collect water

monitoring data, but who also need data to supplement their own. Depending on the nature of the monitoring, meeting this goal may require substantial human and financial resources.

3) Meets requirements for evaluation, assessment and management at the community or watershed level.

Evaluation, assessment, and management decisions at the community or watershed level typically involve municipal and landowner land and water planning and use decisions. It may be as simple as an individual deciding whether or not the water is clean enough to swim in or a farmer deciding whether or not to fence dairy cows out of the stream. Or it may involve local regulations that protect water quality by establishing undeveloped areas along the water body. This goal requires that the indicators; the precision, accuracy, and sensitivity of the methods; the sites; the frequency; and the quality assurance measures you choose convince both professional and non-professional water resource managers at the community level that your data is reliable. While a degree of scientific rigor is required, your methods may be geared toward identifying gross problems, for example, rather than subtle changes over time and space. Community level resource managers may or may not have a good understanding of aquatic ecosystems and monitoring, so you may need to educate them at the same time. Many volunteer monitoring groups meet this goal using relatively easy and inexpensive methods.

4) Data quality sufficient to increase awareness and knowledge of resource values and conditions.

Awareness of water resource values and conditions is a prerequisite for public support of efforts to restore, protect, and maintain water resources. In this case, the audience is the general public. Your monitoring program should be tailored toward increasing public understanding of problems, opportunities, and special resource values that enhance the quality of life in the area. This does not require rigorous sampling and analytical methods. Many school water monitoring programs, for example, use simple and inexpensive methods just to get students to experience the water itself, teach the concept of monitoring, and to reveal ecological processes at work in the real world. All volunteer monitoring programs meet this goal to one degree or another, just by getting people to experience their local stream or lake.

Many programs start with the least rigorous goal, and evolve into more sophisticated efforts over time. Which data quality goal(s) you select depends on the intended users and uses of your data.

C. DATA QUALITY GOALS NEEDED FOR INTENDED USES OF WATER MONITORING DATA

This section lists data quality goals that match intended data uses for some of the common data uses addressed by volunteer surveys. By consulting this list - and consulting the VEMN for assistance in applying it to a particular survey, volunteer monitors should be able to design programs that are tailored to the intended users and uses.

LEVEL 1 USES: *Level of quality necessary to meet legal, regulatory and scientific peer review requirements.*

- inclusion in 305(b) reports
- determine compliance with permit requirements
- enforce pollution control laws and regulations
- improve scientific understanding

LEVEL 2 USES: *Meets evaluation and assessment requirements of state and federal agencies.*

- inclusion in 305(b) reports
- determine if water quality standards are being met
- evaluate effectiveness of pollution control programs
- evaluate effectiveness of pollution control projects
- discharge planning and management
- determine human / ecosystem health
- improve scientific understanding
- develop public support for program/policy funding and decisions
- program planning/management: determine where and how to allocate human and financial resources
- advocacy for legislation, funding, management decisions
- evaluate resources for different uses
- resolve conflicts
- operational decisions for equipment and land management
- land use planning
- career development

LEVEL 3 USES: *Meets requirements for evaluation, assessment and management at the community or watershed level.*

- risk assessment (individual)
- develop public support for program/policy funding and decisions

- program planning/management: determine where and how to allocate human and financial resources
- advocacy for legislation, funding, management decisions
- evaluate resources for different uses
- resolve conflicts
- operational decisions for equipment and land management
- land use planning
- career development
- funding

LEVEL 4 USES: *Data quality sufficient to increase awareness and knowledge of resource values and conditions.*

- education/awareness/stewardship
- boosterism: advertise availability of high quality community resources
- funding

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