

DEVELOPING AN EFFECTIVE VOLUNTEER WATER
QUALITY MONITORING PLAN

by

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Water quality is a key component in protecting and restoring watersheds. A growing base of volunteer water quality monitoring programs is emerging across the US to assess and monitor waterbodies. Recently, state and federal agencies have begun to incorporate data from volunteer programs in their water quality status reports to Congress. Both the Environmental Protection Agency and state water quality regulatory agencies are working to develop standard protocols and provide technical guidance for groups interested in initiating volunteer monitoring programs. This thesis addresses the question of how to develop a comprehensive and effective volunteer water quality monitoring plan that meets program goals and produces useful data. Based on research, interviews with monitoring coordinators, and my own experience developing a monitoring plan, I identified a set of key components that should be incorporated into an effective plan and outlined strategic resources for volunteer groups to utilize in the plan development process.

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TABLE OF CONTENTS

Chapter	Page
I. INTRODUCTION.....	1
II. BACKGROUND ON WATER QUALITY MONITORING	6
Methodology	6
Governmental Monitoring.....	7
Volunteer Monitoring.....	12
National Directory of Volunteer Environmental Monitoring Programs.....	12
Examples of Volunteer Monitoring Organizations.....	15
National Water Quality Monitoring Council (NWQMC)	22
National Monitoring Conference 2002	24
Summary	26
III. VOLUNTEER WATER QUALITY MONITORING IN OREGON	28
History.....	28
Resources for Volunteer Programs	31
Volunteer Water Quality Monitoring Standards	33
Oregon's Volunteer Monitoring Approach	36
Summary	37
IV. KEY COMPONENTS OF AN EFFECTIVE VOLUNTEER WATER QUALITY MONITORING PLAN.....	38
Methodology	39
Goals and Objectives.....	41
Specific Research Questions	44
Influence on Sampling Design.....	45
Development Process.....	48
Background Research.....	52
Collaboration.....	53
Resources	55
Sampling Design	59
Parameters to Monitor	59
Sampling Methods	64
Monitoring Frequency	64
Site Selection	65
Quality Assurance/Quality Control (QA/QC).....	67
Data Uses and Users.....	68

Chapter	Page
Data Management, Analysis and Reporting.....	71
Data Management	71
Data Analysis	72
Data Reporting.....	75
Other Considerations.....	76
Implementation Challenges and Successes	77
Evolution of Water Quality Monitoring Programs	79
Interview Conclusions.....	80
Summary	81
V. DEVELOPMENT OF THE MIDDLE FORK WILLAMETTE WATER QUALITY MONITORING PLAN.....	83
Methodology	84
Results of the Plan Development Process	94
Lessons Learned.....	95
VI. SUMMARY OF FINDINGS	97
APPENDIX	
A. LIST OF ACRONYMS	100
B. INTERVIEW QUESTIONS	102
C. GOALS AND OBJECTIVES OF THREE VOLUNTEER WATER QUALITY MONITORING PROGRAMS	104
D. SPECIFIC RESEARCH QUESTIONS	106
E. MIDDLE FORK WILLAMETTE WATER QUALITY MONITORING PLAN	109
F. RESOURCES FOR VOLUNTEER GROUPS.....	145
BIBLIOGRAPHY	154

LIST OF FIGURES

Figure	Page
1. National Monitoring Conference Logo, 2002	25
2. Selected Watershed Councils in Western Oregon	40

LIST OF TABLES

Table	Page
1. Data Quality Matrix: Water Quality Parameters by Data Quality Level	35
2. Top Ten Parameters Monitored for Rivers and Streams	61
3. Commonly Monitored Water Quality Parameters by Volunteer Programs.....	63
4. Oregon's Final 1998 Water Quality Limited Streams – 303(d) List	88

CHAPTER I

INTRODUCTION

Over the past couple of decades, activities to protect the health of watersheds have become increasingly prevalent, not only among well-established river conservation organizations, but also with local citizen groups. Watershed councils and similar types of organizations devoted to protecting, enhancing, and restoring waterbodies and their surrounding habitats and wildlife have sprung up across the nation. Each year, thousands of citizens participate in restoration projects, monitoring programs, cleanup events, education and awareness campaigns, and other related activities.

A primary component of watershed health is water quality. A growing base of volunteer water quality monitoring programs is emerging across the US to assess and monitor the health of rivers, lakes, estuaries, and coastal waters. In recent years, state and federal agencies have begun to incorporate data from these volunteer programs in their biannual reports to Congress on the status of the nation's waterbodies, provided that the data meet certain standards. Volunteer programs have the potential to fill gaps in water quality monitoring data that exist due to states' limited funding and personnel resources. Because volunteer data have traditionally been viewed with skepticism and because tremendous variety exists among volunteer monitoring groups in terms of parameters

measured, methods of measurement, quality assurance/quality control (QA/QC) procedures, and reporting and analysis techniques, the Environmental Protection Agency (EPA) and a number of state water quality regulatory agencies have been working to develop standard monitoring protocols and provide technical guidance for developing sampling designs and writing QA/QC plans to groups interested in starting up volunteer water quality monitoring programs. There are many helpful information manuals and guides in print and online to assist groups in developing their monitoring plans. However, this information is not always well-advertised or well-known and it may be difficult for a watershed council or similar group starting from scratch to locate these resources and write an effective water quality monitoring plan, especially if the volunteers are unfamiliar with the subject matter.

In this thesis, I address the question of how to develop a comprehensive and effective volunteer water quality monitoring plan. Based upon my research, interviews, and firsthand experience in writing a volunteer water quality monitoring plan (see Chapter V), I am defining an effective water quality monitoring plan as one that has three basic elements:

- 1) The plan should contain specific goals and objectives for the monitoring program. These goals and objectives will help to further define and shape the technical aspects of the monitoring plan and are critical in keeping the program focused.
- 2) The plan should provide useful information to end users, and not end up collecting dust on a shelf somewhere or stored unused in a computer. End users may include anyone from state or federal environmental agencies to the general

public, and data uses may range from regulatory or planning purposes, to screening for water quality problems, to raising public awareness about water quality issues. The important point is that the data are put to use and successfully communicated to the appropriate audience. A monitoring plan should ideally be designed with specific end uses in mind.

- 3) The plan should contain a strong QA/QC component that specifies the particular procedures for collecting and analyzing water quality data (based on the purposes of the monitoring), outlines training protocols for volunteers, and contains methods for validating data to ensure that it is of sufficient quality for intended uses.

It is important to note that the definition of an effective monitoring plan that I am using in my thesis reflects a plan that has the *potential* to be effective. This means that it contains certain characteristics that, if incorporated, should lead to a high quality monitoring program that meets initial goals and objectives. Another way of evaluating a monitoring plan would be to look at the relative success of its implementation and determine whether it actually met program objectives, which is out of the scope of this thesis. In other words, I am positing that in order for a water quality monitoring plan to be effective and produce credible data, it must contain certain components and meet certain criteria.

Creating such a plan is not a simple process, and there are a number of important components that any rigorous water quality monitoring plan must incorporate including

goals and objectives, specific research questions, background research, collaboration, resources, sampling design, QA/QC, data uses and users, and data management, analysis and reporting. In this thesis, I examine each one of these components in depth and explore ways to address the issues they raise most effectively. While my thesis focuses primarily on water quality monitoring in Oregon, the results should be general enough to apply to the development of any volunteer water quality monitoring plan in the nation.

In order to address my main research question, I followed three major approaches:

- 1) I researched the major types of water quality monitoring programs that exist nationwide, primarily via the internet, a volunteer monitoring listserver sponsored by the EPA, and also by attending a national water quality monitoring conference.
- 2) I focused more closely on the kind of volunteer water quality monitoring currently occurring in Oregon and conducted interviews with people from three watershed councils who had already developed and implemented water quality monitoring programs.
- 3) I developed a volunteer water quality monitoring plan from scratch for the Middle Fork Willamette Watershed Council in western Oregon.

It is my hope that the results from this analysis and my experience in creating a volunteer water quality monitoring plan will be a helpful guide for volunteer groups starting from ground zero who wish to develop comprehensive and effective water quality monitoring plans.

* * *

This document is organized in the following manner: Chapter II gives a brief history of water quality monitoring in the US and surveys the wide range of water quality monitoring programs that exist nationwide. It also explains the role of the National Water Quality Monitoring Council in water quality monitoring and how its current projects may affect future water quality monitoring. Chapter III examines the evolution of volunteer water quality monitoring in Oregon. Chapter IV investigates the key components of volunteer water quality monitoring plans and compares and contrasts the plan development and implementation of three water quality monitoring programs in Oregon as a result of interviews with watershed council coordinators, water quality monitoring coordinators, and the state volunteer monitoring coordinator in Oregon. Chapter V details the development phases and thought processes behind the development of the Middle Fork Willamette Watershed Council's volunteer water quality monitoring plan. Finally, Chapter VI summarizes my findings based upon the research that I engaged in, the interviews I conducted, and my personal experience in writing a volunteer water quality monitoring plan.

The appendices include the volunteer water quality monitoring plan that I developed for the Middle Fork Willamette Watershed Council and submitted to the Oregon Department of Environmental Quality (Oregon DEQ), as well as an extensive compilation of resources relating to water quality monitoring and plan development that may be useful to new volunteer monitoring groups.

CHAPTER II

BACKGROUND ON WATER QUALITY MONITORING

Methodology

In order to better understand the context and need for volunteer water quality monitoring programs, I investigated the main types of water quality monitoring programs that are in existence nationwide. This includes both volunteer and government-run monitoring programs. I looked at who is conducting the monitoring, the overall purpose of the monitoring program, what parameters are being monitored and where, and who is using the resulting data. In addition to written materials and publications, a large part of the research was conducted online and involved examining programs ranging from large federal agencies (such as the EPA and US Geological Survey [USGS]), to non-profit river conservation groups, to small, local volunteer monitoring groups. The EPA conducted a survey of volunteer monitoring programs in 1997, which also provided good background information and served as a starting point for further research (US Environmental Protection Agency, 2002c). A number of personal contacts were made via the EPA Office of Water's volunteer monitoring listserver, which was created to facilitate the exchange of information among the nation's volunteer monitoring programs. Finally, I attended the National Water Quality Monitoring Council's biannual National

Monitoring Conference, where I learned even more about the current status of water quality monitoring across the country, as well as where and how volunteer water quality monitoring programs fit into the overall national context of water quality monitoring.

Governmental Monitoring

The 1972 Clean Water Act lays out a number of goals, one of which is “to restore and maintain the chemical, physical, and biological integrity of the nation’s waters” (Adler, 1993). In order to accomplish this goal, water quality monitoring is necessary to understand and characterize the current condition of waterbodies and to determine which of those do not meet state water quality standards. In addition, monitoring can help to identify potential causes and sources of pollution. With this base information, planners and policy-makers at all levels can develop and implement effective management practices and other measures to address water quality problems.

Many different organizations at the local, state, and federal levels, as well as volunteer groups, conduct water quality monitoring of the nations’ rivers, lakes, reservoirs, estuaries, and coastal shorelines. My thesis focuses on the monitoring of our nation’s rivers and streams, which account for over 3.6 million miles (US Environmental Protection Agency, 2000a).

Certain types of water quality monitoring are mandated under the Clean Water Act. Section 402 requires any facilities that discharge pollutants into a river (such as factories and wastewater treatment plants) to obtain a National Pollutant Discharge

Elimination System (NPDES) permit from the EPA. In addition, these facilities are required to self-monitor their discharges and send the results to the EPA in the form of a Discharge Monitoring Report (DMR) (The Clean Water Act Handbook, 1994).

Under section 305(b) of the Clean Water Act, states are mandated to report on the water quality status of their rivers, lakes, and other waterbodies every two years. In addition, they are required to produce a list, known as the 303(d) list, of all waterbodies that are impaired, meaning that they do not meet state water quality standards or their designated beneficial uses. (Currently, a consolidated listing is in the process of being enacted, whereby states will now be able to report on the water quality status of their waterbodies in one report that includes components of both the 305(b) and 303(d) reports (US Environmental Protection Agency, 2002a)). The EPA then compiles the information from individual states into a single, comprehensive report documenting the condition of the nation's waterbodies.

In order to produce these reports, states assess the condition of their waterbodies through monitoring and information from previous studies. In their 305(b) reports, *monitored* waterbodies are those in which chemical, biological, or physical data have been collected within the last five years. *Evaluated* waterbodies refer to those where states rely on qualitative information or monitoring data older than five years in order to make an assessment (US Environmental Protection Agency, 2000a). In the face of budget cuts and limited monitoring resources, a significant percentage of assessed streams are in fact evaluated, meaning that the reports are not based upon recent monitoring data. The National Water Quality Inventory 1998 Report to Congress

reported that 23% (approximately 840,000 miles) of rivers and streams in the US were assessed, and of those, 43% were monitored, 45% were evaluated, and 12% were not specified (US Environmental Protection Agency, 2000a). Therefore, high quality data collected by citizen monitoring groups has the potential to become extremely useful to states in producing more meaningful assessments of their waterbodies.

Each state has a specific agency that is responsible for protecting and maintaining water quality, such as a Department of Environmental Quality (DEQ) or Department of Environmental Management (DEM). These departments receive EPA grants and technical guidance for implementing monitoring programs that measure chemical, physical, and biological components of water quality. States use monitoring data from these programs to develop the required 305(b) reports and 303(d) lists. They also monitor in order to develop total maximum daily loads (TMDLs) for rivers that are 303(d) impaired. TMDLs place quantitative limitations on discharges (in the form of specific load allocations) to a river along with a margin of safety so that the river will presumably be able to meet applicable water quality standards. TMDLs are the primary mechanism for controlling nonpoint source pollution in a river; however, they also take into account point sources¹. Finally, states also perform monitoring to determine the effectiveness of best management practices and other pollution control strategies and to review, revise, and/or develop water quality standards (US Environmental Protection Agency, 2000a).

¹ There are two basic sources of water pollution: point source and nonpoint source. Point source pollution is generally defined as the discrete transport of pollutants to a waterbody through a mechanism such as a pipe, tunnel, channel, or vessel. Nonpoint sources, on the other hand, refer to diffuse sources of pollution generally in the form of runoff from agriculture, timber harvesting, or urban development, atmospheric deposition, drainage, or seepage of some type of contaminants (Elder, 1999).

At the local level, city and county agencies typically conduct water quality monitoring related to their water and wastewater treatment plants and stormwater system discharges.

On a broader level, a number of federal agencies have developed extensive water quality monitoring programs that examine water quality on a regional or national scale. The EPA has developed a program known as the Environmental Monitoring and Assessment Program (EMAP), the purpose of which is to monitor, assess, and evaluate trends in water quality and ecological conditions in the United States (<http://www.epa.gov/emap/>). Monitoring activities are carried out by several partners, including states, tribes, EPA regional offices, the USGS, and the National Oceanic and Atmospheric Administration (NOAA). Currently, the EPA is in the midst of a 5-year project, known as EMAP-West, to evaluate water quality and ecological resources at both state and regional scales across 14 states in the western US. Monitoring data will be collected and uploaded to STORET, EPA's water quality monitoring database (US Environmental Protection Agency, 2002b).

Section 319 of the Clean Water Act established a national monitoring program designed to achieve a better understanding of nonpoint source pollution and evaluate the long-term success of certain control measures or technologies. The EPA is responsible for implementing this program and provides funding to states and tribes for projects approximately 6-10 years in duration that attempt to manage nonpoint source pollution and that employ certain standardized protocols. The main focus of this program is on

watershed-wide projects that involve a variety of partners or stakeholders (Elder, 1999, Water Environment Federation, 1997).

The USGS has two major monitoring programs that address water quality. The National Water Quality Assessment (NAWQA) Program was developed in 1991 to gather long-term information the condition of rivers (<http://water.usgs.gov/nawqa/about.html>). Specifically, data on water chemistry, hydrology, land use, stream habitat, and aquatic life are collected in more than 50 major river basins and aquifers across the United States. Data are used to support water resource management and policy decisions and are meant to examine how water quality is changing over time and how it is affected by both natural watershed characteristics and human activities. Each individual NAWQA assessment follows specific study designs and protocols so that collected data and resulting analyses can be compared across the nation. Summary reports detailing key findings for areas such as pesticides, nutrients, trace metals, and aquatic ecology have been published by the USGS and are available to the public (http://water.usgs.gov/nawqa/nawqa_sumr.html).

The National Stream Quality Accounting Network (NASQAN) is another program coordinated by the USGS. Since 1995, it has consisted of 40 monitoring stations in four large river basins in the US (the Mississippi, Columbia, Colorado, and Rio Grande) (<http://water.usgs.gov/nasqan/>). Chemicals, including pesticides and trace elements, as well as suspended sediments and discharge are measured and evaluated to determine the current status of water quality in those basins and characterize the types of contaminants, their concentrations, and loading rates.

Other entities that perform water quality monitoring include universities and other research organizations, watershed councils, environmental groups, other non-governmental organizations (NGOs) and private industries (e.g., timber companies).

Volunteer Monitoring

The other rapidly-growing sector of water quality monitoring is volunteer monitoring. This generally involves individual citizens or citizens working with watershed associations or other river protection groups to monitor and characterize the water quality of rivers and streams at a more local level. Volunteer data have most commonly been used to establish baseline conditions for a watershed, screen for particular water quality problems, and raise public awareness. However, as volunteer monitoring programs continue to grow and expand, and states continue to face monitoring resource shortages and budget cuts, volunteer data are becoming increasingly valuable and useful to these agencies in a variety of contexts, including state water quality 305(b) reports and the development of TMDLs.

National Directory of Volunteer Environmental Monitoring Programs

In 1998, the EPA published a directory entitled the National Directory of Volunteer Environmental Monitoring Programs, which lists volunteer monitoring programs across the country (US Environmental Protection Agency, 1998). The vast

majority of the 772 groups contained within this directory are focused on monitoring aquatic environments, though many also monitor vegetation, wildlife, and land use within watersheds as a whole. The number of monitoring groups has increased since the previous edition (published in 1994), which reported 517 monitoring groups. It is important to note that the data in this directory were obtained from a 1997 survey conducted by the EPA, so the listing represents only these groups that responded to the survey. Thus the actual number of existing monitoring groups is likely to be underrepresented. Surveys were mailed to the more than 10,000 subscribers of the EPA's newsletter *The Volunteer Monitor* and over 2,000 contacts from state and national listings of monitoring programs, as well as distributed at conferences and meetings.

The introduction to this directory, available online at <http://www.epa.gov/OWOW/monitoring/dir.html>, summarizes some interesting statistics gathered from the survey data. Seventy-five percent of the monitoring programs engage in river monitoring and 44% have some type of quality assurance/quality control (QA/QC) plan (27% state-approved, 18% EPA-approved). Spatially, much of the monitoring is concentrated in the Northeast, Great Lakes region, and along the West Coast, and not in the much drier Great Plains region of the country. Over half of the programs are relatively small in size (under 50 volunteers), but 35% of the programs consist of over 100 volunteers. In addition, 52% of programs included teachers and/or students in their pool of volunteers. Numbers of volunteers are difficult to interpret, as not all groups could provide accurate estimates and it is also difficult to get a sense of how many volunteers are active on a regular basis.

Further analysis of the monitoring programs revealed that the most frequently measured parameters are temperature, dissolved oxygen (DO), and pH, primarily because they are “relatively easy to measure and important indicators of ability of any surface water... to support aquatic life” (US Environmental Protection Agency, 2002c).

Monitored parameters vary depending on the type of program under consideration. For the groups that monitor only rivers and streams, the top three parameters are temperature, pH, and macroinvertebrates (with DO as number 4). Most commonly monitored parameters for lakes and estuaries, for example, are different due to the different characteristics and concerns for those types of waterbodies. Oftentimes, river monitoring is part of a larger watershed program that encompasses other environmental activities such as cleanups and restoration activities.

There are a number of potential data users for the information collected by the monitoring programs, the primary one being the monitoring programs themselves (85%), followed by state and local governments, and community organizations. In terms of data uses, the top four were education (84%), establishing baseline conditions (67%), screening for problems (61%), and research (53%). Other uses included advocacy, community organizing, watershed planning, assessing nonpoint source pollution, planning restoration projects, and land use decisions. In addition, 35 states used data from volunteer monitoring programs in assessing water quality of rivers and streams in their 1998 305(b) reports.

Federal, state, and local governments are a significant funding source for volunteer monitoring programs. In addition, a number of programs are supported by their own members, donations, and grassroots fundraising.

In addition to being available in printed format, the monitoring directory database is online at the Environmental Protection Agency's volunteer monitoring website: <http://yosemite.epa.gov/water/volmon.nsf>. Users can search for monitoring programs by name or by state, as well as update or add new information on their own volunteer monitoring programs.

Examples of Volunteer Monitoring Organizations

There are numerous types of volunteer groups monitoring water quality nationwide. Most of the groups described below are primarily “umbrella” organizations that provide resources and expertise to assist smaller local groups in initiating their own water quality monitoring programs. These particular examples were chosen to illustrate the wide variety of water quality monitoring support networks and programs that exist. All of these programs maintain websites describing their programs in more detail.

One of the oldest and best known conservation organizations is the Izaak Walton League of America (<http://www.iwla.org/>), originally founded in 1922 by 54 fishermen from Chicago in response to concerns about industrial discharges and sewage pollution in the Illinois River. Today the group has over 50,000 members who work to accomplish the league's mission “to conserve, maintain, protect and restore the soil, forest, water and

other natural resources of the United States and other lands; to promote means and opportunities for the education of the public with respect to such resources and their enjoyment and wholesome utilization.” The organization’s Save Our Streams (SOS) component (<http://www.iwla.org/sos/history.html>) is the national watershed education and outreach program that has been in existence for over 30 years and provides technical assistance and training for groups interested in water quality monitoring, as well as education programs and workshops for schools and the general public. There are many local chapters of SOS, such as the Virginia Save Our Streams non-profit program (<http://www.sosva.com>), whose main goal is to train and certify volunteers to monitor water quality through workshops conducted around the state. Over 350 volunteers have been certified through this program and monitor approximately 250 locations in streams statewide.

River Network (<http://www.rivernetwork.org/>) is an organization formed in 1988 to support grassroots activities to protect and enhance rivers. River Network’s mission is “to help people understand, protect and restore rivers and their watersheds.” It maintains an extensive set of resources online to support and assist “partner groups” in water quality monitoring and other river conservation activities. Resources include: a directory of river conservation groups, lists of funding sources, a calendar of events, a resource library, case studies of volunteer group successes, publications, books and guides for purchase, information about the Clean Water Act, links to water quality regulations and standards, contacts for individual states, technical guides and monitoring resources, and training events and workshops.

The Adopt-A-Stream Foundation (AASF) (<http://www.streamkeeper.org/>) is a non-profit organization established in 1985 in Washington State “to teach people to become stewards of their watersheds.” It provides support to citizens, schools, and other community groups to “adopt-a-stream,” which basically involves making a long-term commitment to performing monitoring, restoration, and educational activities for a particular stream or watershed.

Kentucky Water Watch (<http://water.nr.state.ky.us/ww/>) is an organization that maintains a network of over 500 water quality monitoring sites in the state. Volunteers conduct both chemical and biological monitoring at these sites. In addition, the organization provides an extensive set of technical resources to assist local volunteer groups in setting up monitoring programs and publishing collected data online. It also facilitates communication about water quality monitoring programs among the eight major watersheds of the state through an interbasin coordinating committee. In particular, the Kentucky Water Watch site contains an extremely useful page with links to selected international, national, state, and local volunteer water quality monitoring programs and resources (<http://water.nr.state.ky.us/ww/vm.htm>). This page is often referenced by other water quality monitoring organizations.

Missouri has a volunteer water quality monitoring program (<http://www.rollanet.org/~streams/vm.html>) sponsored by the Missouri Departments of Conservation and Natural Resources, the Conservation Federation of Missouri, and the Citizens of Missouri. It coordinates the Missouri Stream Team Program, which works to establish water quality monitoring groups across the state. There are currently about 865

stream teams performing monitoring activities. This site provides links to monitoring resources and training workshops in the state, and also hosts an online database where volunteers may submit their monitoring data and data from statewide monitoring can be viewed online.

Iowater (<http://www.iowater.net/>) is another volunteer water quality monitoring organization founded in 1998 whose mission is “to protect and improve Iowa’s water quality by establishing and supporting a statewide volunteer water monitoring program.” It was formed through a collaboration of natural resource agencies and NGOs in the state: Iowa Department of Natural Resources (Divisions of Information and Education, Environmental Protection, Fish and Wildlife), Iowa Division of the Izaak Walton League, Iowa Environmental Council, Iowa Farm Bureau, Natural Resources Conservation Service, and the University of Iowa Hygienic Laboratory. Iowater provides support for volunteer water quality monitoring efforts across the state by producing newsletters and written training materials, conducting a variety of training workshops, maintaining a directory of volunteer groups in the state, and providing funding for certain monitoring programs. In addition to maintaining a comprehensive and informative website, Iowater also has a fairly well-developed online data submission process, where certified volunteer monitors can enter their field data, which will become available for anyone to view. Currently, Iowater is developing an interface that would enable monitoring data to be submitted directly to the EPA water quality monitoring database, STORET (National Water Quality Monitoring Council, 2002a).

Pennsylvania's Department of Environmental Protection (DEP) has a citizen volunteer monitoring program (<http://www.dep.state.pa.us/dep/deputate/watermgt/WC/subjects/cvmp.htm>), which coordinates volunteer water quality monitoring efforts in the state, provides technical assistance to over 150 citizen monitoring groups, and facilitates data sharing and communication between groups in the state through the Keystone Watershed Monitoring Network (<http://www.pawatersheds.org/KWN>). A paid volunteer monitoring coordinator works closely with local groups to set up water quality monitoring programs, develop study designs and comprehensive quality assurance project plans (QAPPs), and train volunteers. The majority of volunteer groups monitor water quality in streams on a monthly basis for chemical parameters such as temperature, pH, dissolved oxygen, conductivity, turbidity, and alkalinity, and occasionally nutrients and other chemicals on agricultural lands. Other programs include additional parameters such as flow and macroinvertebrates. The DEP has also partnered with the Department of Aging and the Environmental Alliance for Senior Involvement to set up the Pennsylvania Senior Environment Corps program, a water quality monitoring program in which senior citizens are trained to monitor water quality to screen for potential problems. Any volunteer monitoring data used by the DEP must have an associated QAPP and meet certain criteria set by the state.

Some volunteer programs have different "levels" of volunteer data collection. For instance, Delaware Stream Watch (<http://www.delawarenaturesociety.org/streamwatch.htm>), a voluntary stream protection

program supported by the Delaware Nature Society and Delaware Department of Natural Resources and Environmental Control (DNREC), has three different types of monitoring programs. The Stream Adoption program trains volunteers of all ages in basic water quality monitoring techniques. The purpose of the program is to provide general information on stream health and screen for potential problems that the DNREC may want to investigate more fully. Volunteers can also participate in specialized surveys, where they engage in macroinvertebrate sampling. Finally, there is a technical monitoring program where volunteers follow specific quality control procedures to collect reliable water quality data that is used by the DNREC to develop pollution control strategies for a watershed in the northern part of the state.

The Northern Virginia Soil and Water Conservation District coordinates a volunteer water quality monitoring program in Fairfax County, VA (<http://mason.gmu.edu/~jarcisze/StreamMonitoring/index.html>). Training (based on Save Our Streams water quality protocols) and equipment are provided to volunteers, who commit to monitoring a stream four times a year for a specified set of chemical and biological parameters. Data are sent to the Virginia Department of Environmental Quality, Fairfax County, the Virginia Save Our Streams chapter, and other interested groups.

Sometimes water quality monitoring groups are formed in response to a particular concern or problem. For example, Blue Water Task Force, a citizen monitoring group in Montana, (<http://nr.is.state.mt.us/wis/vwm/bwtf>) was formed by a Montana State University professor when the Big Sky Sewer District received a permit to dump treated

effluent in the Gallatin River, downstream of Yellowstone National Park. Local citizens were worried about the possible negative impacts to water quality in the river and began to collect baseline data on a monthly basis for a set of chemical parameters as well as monitor macroinvertebrates twice a year. The program has been funded by the Montana Department of Environmental Quality. In addition, the area is currently experiencing increasing development and the population is forecast to grow extensively over the next couple of decades. Therefore, the baseline water quality data collected through this program will be valuable to have in the future to examine trends and the possible impacts of development.

A sediment study was undertaken in the Harpeth River Watershed in Tennessee at the suggestion of the Cumberland River Compact water quality advisory committee, which recognized that sediment was a significant factor contributing to nonpoint source pollution in the Cumberland River Basin. The effort was spearheaded and largely funded by a retired chemistry/environmental engineering professor and carried out as a collaborative effort between the Cumberland River Compact and the Harpeth River Watershed Association. In addition to providing information to the public about the sediment problem, a major goal of the study was to provide (previously lacking) baseline data on sediment levels in the watershed to government agencies such as the USGS, US Army Corps of Engineers (COE), and others. The data will actually be used in the creation of TMDLs in the watershed.

National Water Quality Monitoring Council (NWQMC)

One of the biggest challenges in using and sharing water quality data among various agencies and watershed groups is the lack of consistent sampling designs, collection and analysis methods, and data management techniques (National Water Quality Monitoring Council, 2002b). This complicates data interpretation and makes comparing water quality data and analyzing trends extremely difficult, if not impossible. In fact, one of the primary criticisms of the EPA's National Water Quality Inventory report to Congress is that there is a general lack of consistency in states' monitoring methods, which significantly limits the ability to draw meaningful comparisons among states' data and make decisions at the national level (United States General Accounting Office, 2000).

The National Water Quality Monitoring Council (NWQMC) was formed in May 1997 under the Federal Advisory Committee Act to succeed the Intergovernmental Task Force on Monitoring Water Quality (ITFM). The ITFM was a body in existence from 1992-1995 that had researched water quality monitoring practices across the nation and produced a comprehensive report with recommendations for developing a more collaborative and comparable national water quality monitoring strategy. In light of this report, the NWQMC's official task became: "to implement a nationwide strategy to improve water quality monitoring, assessment, and reporting." The Council consists of 35 representatives from federal, interstate, state, tribal, local and municipal governments, watershed groups, universities, and the private sector, including volunteer monitoring.

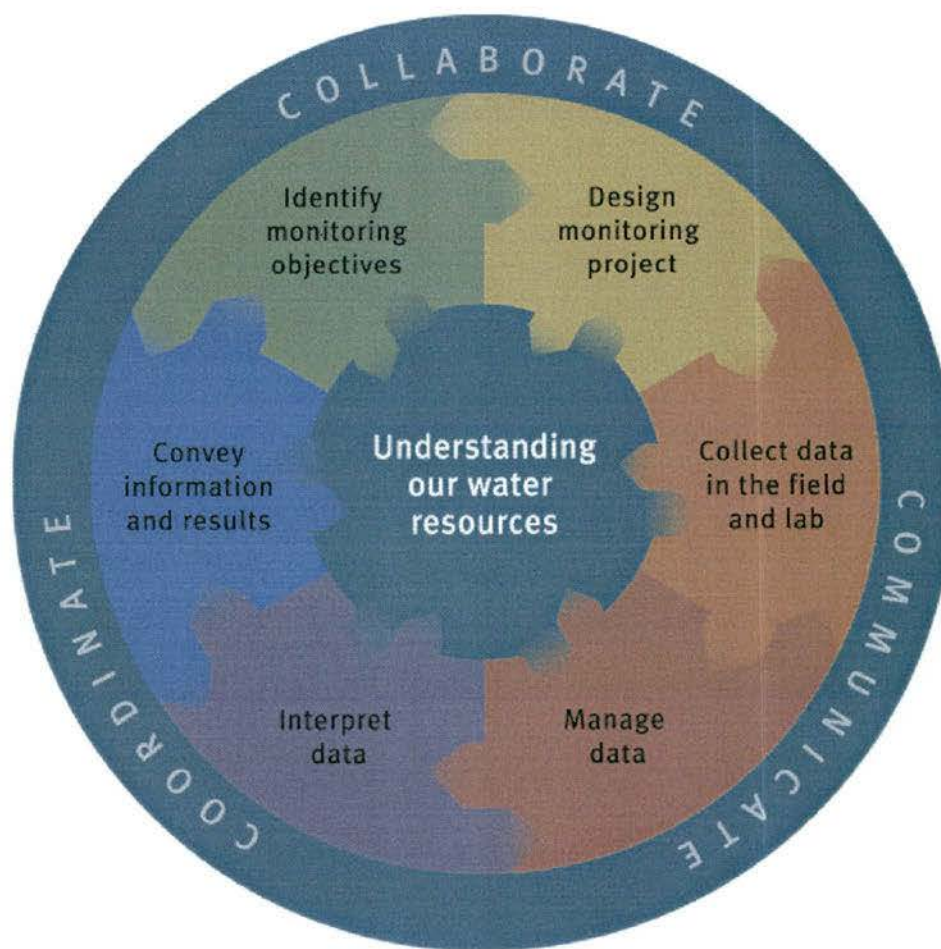
One of the primary goals of the council is to encourage the voluntary use of “consistent and scientifically defensible water quality monitoring methods” so that monitoring programs carried out by different agencies across the country can compare water quality data in a meaningful way (National Water Quality Monitoring Council, 2002c). The NWQMC has established a Methods and Data Comparability Board to promote comparability in terms of field and lab methods, data management, and data analysis. Currently this board is working on several projects including developing a database of standard, high quality field collection and lab analysis methods, developing a position on field and lab accreditation, and creating a list of basic database elements, or metadata, that should accompany water quality monitoring data during the reporting of field data (National Water Quality Monitoring Council, 2002b). (For more information, see NWQMC web page at <http://water.usgs.gov/wicp/acwi/monitoring>.)

The intent of the NWQMC is that the different standards and procedures that they develop over the next few years will be used by all types of water quality monitoring groups, from large government agencies to small volunteer organizations, to facilitate the exchange of data and subsequent data analysis and interpretation. Many volunteer groups already employ well-established, standard monitoring protocols in their water quality monitoring programs. However, this number may increase even more with new guidelines produced by the NWQMC (provided that they are relatively easy and cost effective to follow and implement), and it is conceivable that some volunteer groups may even be required to follow these guidelines in order for their data to be deemed acceptable by certain government agencies.

National Monitoring Conference 2002

Every two years, the NWQMC sponsors a National Monitoring Conference that draws people from a variety of federal, state, and local agencies, universities, and watershed groups. It consists of workshops, presentations, poster sessions, and Council workgroup discussion sessions. The conference provides valuable opportunities to hear about the current status of water quality monitoring, learn about the latest techniques and methods for collecting and analyzing data, find out how other agencies or groups have designed and implemented programs, discover how volunteer water quality monitoring programs are being incorporated into state water quality assessments, network with other water quality professionals, and provide feedback to the NWQMC on some of their proposed strategies and projects. I attended the most recent conference in May 2002 in Madison, Wisconsin, and found it to be an extremely useful forum for learning more about water quality monitoring programs.

The theme of this year's conference was "Building a Framework for the Future." This theme was represented by a circular schematic consisting of a circular core, entitled "Understanding Our Resources," surrounded by six tracks supporting this concept (Identify monitoring objectives, Design monitoring project, Collect data in the field and lab, Manage data, Interpret data, and Convey information and results) and tied together by the concepts of coordination, collaboration, and communication (see Figure 1). Although I focus primarily on the "Design monitoring project" track in my thesis, this entire framework as a whole is applicable. Each of the six components represented in the model is essential to consider and incorporate in developing a monitoring plan and all are discussed in detail in Chapter IV.



Building a Framework for the Future

FIGURE 1. National Monitoring Conference Logo, 2002.

Source: <http://www.nwqmc.org/NationalConference/2002Conference/2000Conf.htm>, Date accessed: May 2, 2002.

Summary

In this section I have attempted to portray the wide range of water quality monitoring programs that exist across the country. It is clear from these examples that water quality monitoring, despite a lack of adequate funding, is being taken seriously by federal, state, and local agencies and volunteer groups. In addition to the required monitoring of point source pollution imposed by the Clean Water Act, there are a number of initiatives and monitoring programs designed to focus on addressing nonpoint source pollution. Furthermore, the past couple of decades have seen a significant increase in volunteer monitoring activity, both grassroots and that which is sponsored by state and federal agencies. As illustrated by the above examples, volunteer monitoring organizations are extremely diverse in terms of their size, composition, funding sources, training programs, overall goals and objectives, sampling designs, and data uses and users. Despite these difference, however, the majority of these programs seem to be focused on making sure that their volunteers are trained in standard field protocols and on developing strong QA/QC components to their plans in order to obtain reliable, high quality data that can be used by government agencies and local planning offices as well as to educate and promote awareness of water quality issues locally. In addition, based on my research and experience listening to presentations and discussions during the National Monitoring Conference, it seems that a significant portion of volunteer monitoring programs (at least those that have connections to state natural resource departments) are striving to produce high caliber water quality data that will be used by

states in their biennial water quality assessments. Finally, the development of consistent monitoring and analysis methods by the NWQMC will serve to further enhance the ability of volunteer and government organizations to produce data that is consistent and comparable across organizations.

CHAPTER III

VOLUNTEER WATER QUALITY MONITORING IN OREGON

The previous chapter outlined many different types of water quality monitoring programs currently being implemented across the nation. In this chapter, I focus specifically on volunteer water quality monitoring that is occurring in Oregon and examine the kinds of state-specific resources available to groups wishing to develop monitoring programs.

History

The driving force behind much of the current volunteer water quality monitoring in Oregon was the 1997 Oregon Plan for Salmon and Watersheds. This statewide plan was developed in response to declining native fish populations throughout the state. Its primary goals are to restore declining salmon and trout populations and increase water quality statewide through community-based action, government coordination, monitoring and accountability, and adaptive management. The basic idea is to combine limited regulatory enforcement with more voluntary-oriented actions and activities in order to protect and enhance watersheds (Oregon Watershed Enhancement Board, 2002c). The

plan further promoted the establishment of watershed councils (originally recognized by the state legislature in 1995 (Oregon Watershed Enhancement Board, 2002b)), which are non-regulatory, volunteer-based organizations consisting of private landowners, industry representatives, representatives from local, state, and federal agencies, and other watershed residents and interested parties. In the past several years, watersheds councils in Oregon have become primary vehicles for restoring, maintaining and enhancing rivers, riparian areas, and wildlife habitat within watersheds. There are currently about 85 established watershed councils throughout the state (Oregon Watershed Enhancement Board, 2002a). These councils usually perform watershed assessments to determine the current status of their watersheds by assessing general areas such as historical conditions, channel habitat types, hydrology and water use, sediment sources, water quality, and fish habitat. Following the completion of a watershed assessment, councils typically develop action plans with prioritized restoration activities (e.g., planting riparian vegetation, working with farmers to reduce agricultural runoff). Watershed councils also often establish water quality monitoring programs designed to address particular issues or areas of concern within the watershed. Councils usually place a large emphasis on building educational programs to educate youth and local residents about watershed issues and encourage them to take an active role in the stewardship of their watershed. While these programs may be organized by the watershed council coordinator or another staff person, most of the actual “on-the-ground” work relies heavily upon volunteer resources. Watershed councils typically receive funding and/or technical assistance from a number of different sources including the Oregon Watershed Enhancement Board (OWEB),

Oregon DEQ, US Forest Service (USFS), US Bureau of Land Management (BLM), US Army Corps of Engineers (COE), Natural Resources Conservation Service (NRCS), Oregon Department of Fish and Wildlife (ODFW), and local government agencies. Some councils are also supported by private donations and corporations.

More than half of the watershed councils are engaged in some form of water quality monitoring to assess the current status of streams in their watersheds and aid in evaluating, protecting, and enhancing the overall stream health. Some watershed councils collaborate with government agencies such as the Oregon DEQ or USFS in monitoring water quality within their watersheds. Others have developed their own stand-alone programs, relying on a water quality monitoring coordinator to manage the program and volunteers to conduct monitoring. Programs may consist of monitoring for a variety of chemical, biological, and/or physical parameters, depending on the specific needs, interests, and resources of the watershed council. It is also becoming increasingly common for such monitoring programs to have formal quality assurance project plans (QAPPs) that document training and sampling procedures and data management, storage and analysis methods. If the QAPP is approved by the Oregon DEQ, the watershed council receives free monitoring equipment and training from the Oregon DEQ. Thus, there is a strong incentive to develop these plans and maintain monitoring programs that produce high quality data. Adhering to the standards and protocols laid out by agencies such as the Oregon DEQ and OWEB makes data gathered from these monitoring programs more credible and acceptable for use by local, state, and federal agencies (as well as the watershed councils themselves) in planning and decision-making processes.

In addition, data collected using standard methods facilitates data comparison between monitoring groups across the state. The Oregon DEQ has used water quality data from volunteer programs in developing 303(d) lists, creating TMDLs, and screening for water quality issues in rivers and streams throughout the state.

Resources for Volunteer Programs

Both the EPA at the national level and the Oregon DEQ at the state level provide a number of resources to encourage and assist local groups in setting up volunteer water quality monitoring programs. Resources include personnel, monitoring equipment, and technical manuals for creating monitoring plans, writing QAPPs, and following standard protocols for measuring different water quality parameters.

The Oregon DEQ had a full-time volunteer monitoring coordinator whose job was to assist watershed councils and other local groups with setting up and maintaining high quality water quality monitoring programs. The coordinator had a number of responsibilities, including:

- providing technical guidance on how to develop sampling designs and write QAPPs
- conducting training sessions for groups of volunteers
- reviewing and approving QAPPs
- coordinating the distribution of “loaner” water quality monitoring equipment
- reviewing volunteers’ sampling techniques in the field and conducting occasional split samples with volunteers (A split sample is a sample divided into two parts and analyzed by two different people in order to check for precision.)

- reviewing all data submissions from volunteer monitoring programs and uploading data that meet predetermined standards into DEQ's water quality monitoring database (LASAR)

The coordinator also served as a primary contact point for volunteer monitoring groups and facilitated contact between them. The coordinator has worked with about 50 volunteer water quality monitoring groups, the majority of which were watershed councils. Other groups included Soil and Water Conservation Districts, Native American tribes, and other environmental groups (Karen Williams, personal communication, May 2, 2002). The Oregon DEQ's volunteer monitoring coordinator position is currently vacant due recent budget cuts.

The former volunteer monitoring coordinator has observed that most volunteer monitoring programs have concentrated on monitoring water temperature, water quality, and macroinvertebrates. She hopes that physical parameters such as streamflow, channel width, shade, and substrate characteristics will increasingly be incorporated into these programs (Williams, 2000).

There are a variety of online and printed resources recommended by the Oregon DEQ for volunteer groups in Oregon to use in monitoring plan development. In addition to its original *Volunteer Stream Monitoring* manual (US Environmental Protection Agency, 1997), the EPA published a booklet entitled *The Volunteer Monitor's Guide to Quality Assurance Project Plans* (US Environmental Protection Agency, 1996), which explains basic QA/QC and monitoring concepts and outlines the steps necessary to develop an agency-approved QAPP. Additionally, it provides examples from a fictional

water quality monitoring program for each element of the QAPP. The Oregon DEQ volunteer monitoring coordinator strongly recommended using this guidebook to develop the QAPP for the Middle Fork Willamette Watershed Council. I found this guide to be an extremely valuable resource in writing the QAPP because it ensured that I was addressing all of the various elements that the EPA and other government agencies require.

The Oregon Watershed Enhancement Board published the *Water Quality Monitoring Technical Guidebook, Oregon Plan for Salmon and Watersheds* (Oregon Watershed Enhancement Board, 1999), another particularly helpful resource that describes in detail specific monitoring protocols for a number of commonly-monitored water quality parameters and provides references and contacts for additional information. OWEB's *Watershed Assessment Manual* (Watershed Professionals Network, 1999) also contains a detailed section on monitoring plans including recommended development stages and additional resources and references.

Volunteer Water Quality Monitoring Standards

With limited state and federal resources for water quality monitoring and a concurrent increase and interest in volunteer water quality monitoring, volunteer monitoring data are being relied upon more frequently by government agencies at all levels to assess stream conditions and screen for potential problems. Oregon, like most other states in the US, is currently unable to assess all of its waterbodies due to a lack of

data and inadequate monitoring resources and funding. For instance, in Oregon's 1998 305(b) report, only about 47% of the river miles in the state were assessed (Oregon Department of Environmental Quality, 2000). Nationwide, the percentage of rivers assessed was even smaller, at 23% (US Environmental Protection Agency, 2000c). Thus, water quality monitoring performed by watershed councils has the potential to produce valuable information about streams that may not be otherwise monitored. In addition, under the Clean Water Act, the Oregon DEQ is responsible for developing TMDLs for 91 sub-basins across the state by 2007 (Oregon Department of Environmental Quality, 1999). Volunteer data have already been used to support this mammoth effort (Walthers, 2000). The Oregon DEQ has created a data quality matrix for six commonly used water quality parameters that specifies the field methods, precision, and accuracy requirements that correspond to the three different data quality levels (see Table 1). Level A data represent the highest level of data quality and can be used for regulatory activities and to determine whether or not rivers meet state water quality standards. Level B data are primarily used to screen for potential water quality problems. Level E data are of unknown quality and should be used with caution. Level C data represent "bad" (inaccurate or imprecise) data that should be used only for educational purposes. In order for volunteer data to be used in Oregon water quality assessments, it must meet Level A or Level B standards. In the most recent data review for the 2002 305(b) and 303(d) reports, the Oregon volunteer monitoring coordinator estimated that about 70% of the volunteer data that meet data quality requirements (roughly 50% of total data submitted) was used in the assessment (Karen Williams, personal communication, June 5, 2002).

TABLE 1. Data Quality Matrix: Water Quality Parameters by Data Quality Level

Data Quality Level depends on a combination of quality control and method selection.

Data Quality Level	Quality Assurance Plan	Water Temperature Methods	pH Methods	Dissolved Oxygen Methods	Turbidity Methods	Conductivity Methods	<i>E. coli</i> Bacteria Methods	Potential Data Uses
A+	DEQ QAPP approved by DEQ QA Officer							
A	QAPP approved by DEQ. <i>QA criteria met.</i>	Thermometer or datalogger. Accuracy checked with NIST standard. A = +/- 0.5 C P = +/- 1.0 C	Calibrated pH electrode A = +/- 0.2 P = +/- 0.3	Winkler Titration or calibrated Oxygen Meter A = +/- 0.3 mg/l P = +/- 0.5	Nephelometric Turbidity Meter A = +/- 5% of std. value. P = +/- 5%	Meter. Temperature correction to 25C. A = +/- 7% of std. value. P = +/- 2%	DEQ Approved Methods Split Sample P = +/- 0.5 log	Regulatory. Permitting. Compliance with water quality standards.
B	Meets DEQ Data Acceptance Criteria	Thermometer or datalogger Non NIST accuracy check. A = +/- 2.0 C P = +/- 1.0 C	Any method with: A = +/- 0.5 P = +/- 0.5	Winkler Titration or calibrated Oxygen Meter A = +/- 1 mg/l P = +/- 1 mg/l	Any method with: A = +/- 30% P = +/- 30%	Meter. Temperature correction to 25C. A = +/- 10% of std. value. P = +/- 5%	DEQ Approved Methods Split Sample P > +/- 0.5 log	Screening level info. – Red flag or early warning
C								
D								
E	Meets DEQ Data Acceptance Criteria	Un-calibrated thermometer	Any method +/- 1 pH unit	Any method +/- > 1 mg/l	Observations clear, muddy, etc.	Meter without routine calibration.	Presence - Absence test kits	Education

Source: Oregon DEQ: <http://www.deq.state.or.us/lab/qa/techdocs.htm>

Note: In “Methods” boxes, A = Accuracy and P = Precision

Level C should be reserved for data that fail quality control checks; Level C data are known to be poor quality.

Oregon's Volunteer Monitoring Approach

Attending the National Monitoring Conference gave me a chance to learn about how other volunteer monitoring programs in the country operate. One important insight I gained through some of the sessions on volunteer water quality monitoring was the way in which some states (particularly Oregon) may differ from other states in how volunteer monitoring programs are developed and supported. For several of the states that gave presentations, I noted that the state water quality agency was instrumental in both funding and guiding the development of volunteer monitoring programs. These states used more of a top-down approach, where state agencies were more active in setting up these monitoring programs, ensuring that volunteers were well-trained in monitoring techniques, and sometimes developing online systems of data submission and publishing. In Oregon, on the other hand, many volunteer monitoring programs are developed through a more bottom-up approach and initiated through small, local groups such as watershed councils. These groups are not automatically funded by the state DEQ (although they may receive training or other technical assistance) or closely managed – instead they operate rather independently from state agencies. The reason for this different approach may be related to the Oregon Plan for Salmon and Watershed and the salmon listing crisis, which was the impetus for the establishment of watershed councils across the state. While the state has promoted the formation of these councils and formally recognizes them, it strongly encourages action and coordination at the local level. Thus, many of the monitoring and restoration projects have originated at more of a

grassroots level with strong organization and participation by citizen volunteers.

Although these groups may not receive as much direct funding from the state, they are still developing comprehensive, well-written monitoring plans similar to those in other states and they share many of the same goals, objectives, and other characteristics.

Summary

In the past several years, volunteer water quality monitoring in Oregon has grown significantly, concurrent with the development of watershed councils throughout the state. A number of different types of resources exist within the state that volunteer programs can take advantage of when creating monitoring plans, including government and natural resource agency personnel, monitoring guidebooks and publications, and online information. Across the state, agencies such as the USFS, BLM, Oregon DEQ, and local government and utility boards continue to provide technical assistance, review, and even partial funding for volunteer monitoring programs. Such resources can be extremely helpful in creating a monitoring plan with well-defined objectives and focused research questions. The Oregon DEQ has also outlined certain standards that volunteer water quality monitoring data must meet in order to be incorporated into water quality reports and used in TMDL development. Volunteer groups are increasingly meeting these standards and producing data that are extremely useful to both natural resource agencies and local planners, as well as to watershed councils themselves. In the face of the current and impending funding cuts across government agencies, volunteer groups will hopefully continue their efforts to collect and analyze high quality monitoring data.

CHAPTER IV

KEY COMPONENTS OF AN EFFECTIVE VOLUNTEER WATER QUALITY MONITORING PLAN

Regardless of whether a volunteer water quality monitoring program is collecting data for educational purposes or use by government agencies, it should have a written monitoring plan to document the goals, objectives, and specific procedures used to collect and analyze field data. Not only does a written plan compel a volunteer group to think seriously about details of the monitoring program, it also enables newcomers to the program and potential data users to quickly obtain a clear understanding of data collection and analysis procedures, and potential data uses. In addition, a written plan serves as a base for evaluating and further developing the monitoring program in subsequent years. Without a written monitoring plan, a volunteer program may waste time and money collecting data that do not meet program goals or are not useful to anyone.

There are a variety of ways to develop a volunteer monitoring plan, and plans themselves may differ considerably depending on the purpose of the monitoring program as well as the availability and expertise of volunteer resources. However, there are certain general elements that effective monitoring plans ought to include, or address in

some manner. The intent of this section is to present key components that need to be considered in a water quality monitoring plan, as well as provide specific examples of the ways in which these components have been addressed and applied by other watershed groups.

Methodology

In order to gain a better and more practical understanding of how water quality monitoring plans are actually developed and implemented, I interviewed people from three watershed councils in western Oregon. I chose to examine the programs from the Long Tom, McKenzie, and South Santiam Watershed Councils, primarily because their water quality monitoring programs had been implemented successfully and had been in existence for several years at the time of my survey (January - March 2002). In addition, these watersheds are in a similar geographic region to the Middle Fork Willamette watershed (see Figure 2) and share a number of the same characteristics (e.g., land uses) and water quality concerns.

The people whom I interviewed are as follows: Cindy Thieman, Water Quality Monitoring Coordinator for the Long Tom Watershed Council; Jim Thrailkill, Watershed Council Coordinator for the McKenzie Watershed Council; and Tom Dover, Chairman of the Technical Advisory Committee, member of the Board of Directors, and previous Acting Water Quality Monitoring Program Coordinator (summer/fall 2001) for the South Santiam Watershed Council. For the remainder of this chapter, unless otherwise stated, it

may be assumed that the information for a particular watershed council comes from personal communication with the above-mentioned people.

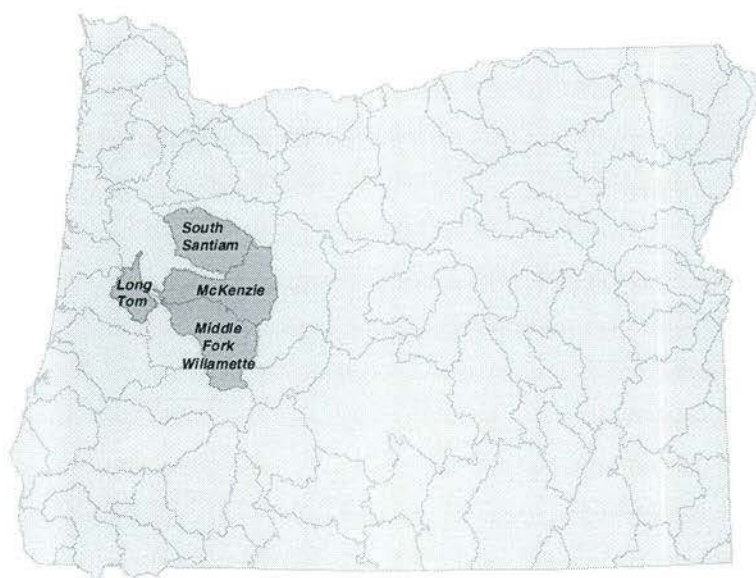


FIGURE 2. Selected Watershed Councils in Western Oregon.

First I examined each watershed council's written water quality monitoring plan, quality assurance project plan (if existing), and summary reports. I asked each interviewee a series of questions concerning the development and implementation of their water quality monitoring plans (see Appendix B). In addition, I spoke with the volunteer monitoring coordinator at the Oregon DEQ in order to get her opinion on some of the key issues, challenges, and essential considerations involved in creating volunteer water

quality monitoring plans. Based on these interviews, as well as my broader survey of written monitoring plan guides and water quality monitoring programs across the country, I identified a set of key components of an effective water quality monitoring plan: goals and objectives, specific research questions, background research, collaboration, resources, sampling design, QA/QC, data uses and users, and data management, analysis, and reporting.

Goals and Objectives

The most important first step in developing a water quality monitoring plan is to discuss and determine the primary goals and objectives of the monitoring program. This is crucial because they will guide the development of the entire monitoring plan, including the sampling design, how the data will be used and by whom, and the extent of QA/QC procedures. Without clearly defined objectives, a program may end up collecting data that do not meet program goals, answer desired questions, or which are not of high enough quality for intended data uses.

In most plans, goals refer to more general statements about the purposes of a monitoring program (such as to gather reliable baseline data or raise awareness of water quality issues) and objectives are more specific quantitative statements (such as to determine whether or not a certain stream reach exceeds state water temperature standards or to measure the amount of riparian cover along a particular stream reach). However, many watershed groups tend to use these terms interchangeably in their

monitoring plans, and some monitoring guides and organizations define these terms in slightly different ways or use other terminology.

All three of the watershed councils that I examined had similar goals and objectives, including collecting baseline data, evaluating the current water quality status of rivers and streams in the watershed, screening for potential problem areas, providing reliable data to the Oregon DEQ, and promoting education and awareness of water quality issues. (For a more detailed look at these goals and objectives, see Appendix C.) However, certain watershed council programs had different areas of emphasis. For example, the Long Tom Watershed Council was interested in using data to prioritize areas in need of restoration and plan for future enhancement projects. The monitoring coordinator also stressed the importance of employing consistent methods of monitoring and following rigorous QA/QC procedures so that data could be compared effectively between monitoring sites. The McKenzie watershed program emphasized collecting consistent, reliable baseline data to be used for long-term trend analysis. The South Santiam program was designed with an overall strategy in mind: to assess water quality in the South Santiam River and its tributaries from the mouth upstream and use the results to prioritize water quality improvements from the headwaters downstream.

There are several approaches that volunteer groups may want to incorporate in developing their goals and objectives:

- 1) Integrate input and advice from the watershed council coordinator, technical advisory committee (if one exists), and other interested watershed residents and

landowners. Creation of a monitoring plan should be a collaborative effort between the plan developer and people involved in the watershed.

- 2) Take advantage of the expertise of specialists in natural resource agencies such as the USFS, USGS, BLM, and DEQ. People working in these agencies have often been involved in monitoring programs and have the technical background to help identify sound objectives and meaningful research questions.
- 3) Use written materials that provide guidance on developing objectives and research questions. There are a number of valuable resources designed to aid in the development of monitoring plans, (e.g., OWEB *Water Quality Monitoring Technical Guidebook*, EPA's *The Volunteer Monitor's Guide to Quality Assurance Project Plans*; see Appendix F for a more complete listing of resources).
- 4) Contact the state volunteer monitoring coordinator, if one exists, at the state water quality agency (e.g., Oregon DEQ) for additional advice or suggestions. There are also designated volunteer monitoring coordinators and quality assurance officers in each of the EPA's ten regional offices.

Specific Research Questions

Before delving into the importance of developing specific research questions and how to go about this process, it is necessary to provide some brief background information on the kinds of water quality monitoring studies typically performed by volunteer groups. Based on River Network's *Testing the Waters* manual (Behar, 1996), other resources (Federal Interagency Stream Restoration Working Group, 1998), and my own research, I propose the following list of general categories around which volunteer groups tend to structure their monitoring:

- 1) *Baseline Monitoring*: to collect baseline information for certain water quality parameters (Volunteer water quality monitoring programs often monitor a suite of basic parameters such as temperature, turbidity, pH, DO, and conductivity.)
- 2) *Trend Analysis*: to evaluate water quality data over time and search for patterns or improvements (This generally requires several years worth of field data.)
- 3) *Water Quality Standards*: to determine if a river or stream reach meets state water quality standards (Results from this type of monitoring may be used in states' water quality status reports or in the development of TMDLs.)
- 4) *Land Use*: to evaluate the effect of a particular type of land use on a stream (e.g., agriculture, timber harvesting)

- 5) *Project Monitoring*: to monitor the effectiveness of a specific project designed to restore, maintain, or enhance water quality (This often requires long term monitoring in order to capture the full effects of a project.)
- 6) *Management Practices*: to evaluate the effect of a particular management practice (e.g., grazing, implementing a buffer policy) on the water quality of a stream

Volunteer monitoring programs may consist of one or more of these monitoring types, depending on the overall goals and objectives of the program.

Influence on Sampling Design

Specific research questions for a water quality monitoring program should be stated early in the plan development process because these questions will influence the technical details of the sampling design (e.g., types of parameters to monitor, location and frequency of monitoring, and field and analytical methods used).

In a baseline monitoring study, research questions might be designed to assess the current conditions of streams within a watershed. For example, a research question might be: what is the range of DO values for major streams in the watershed? It is important to have a general sense of how the parameter in question varies both spatially and temporally, so that sampling will be done at representative locations within the watershed and conducted at a frequency that will capture any important variations. Dissolved oxygen varies inversely with temperature—DO tends to be lower in the summertime and

higher during the winter when it is colder (cold water holds more oxygen). Thus it is important to sample periodically throughout the entire year in order to depict the full range of DO values for a particular stream. In addition, DO fluctuates on a daily basis and is usually highest during the middle of the day, when plants and algae are engaging in photosynthesis. Thus, the time of day should be considered when conducting DO sampling.

If an objective of a volunteer monitoring program is to determine whether state water quality standards for temperature are being violated, the way in which the standard is stated may control the frequency, location, and time of the monitoring. For example, water temperature standards in Oregon are defined in terms of maximum daily water temperatures in the summer. In order for the stream to be considered in violation of the temperature standard, the 7-day moving average temperature (average of maximum daily water temperatures for the stream's hottest consecutive 7-day period) must be above the designated temperature standard for the basin (Oregon Secretary of State, 1998). Therefore, if a question is to determine whether a stream reach violates state water temperature standards, monitoring should be carried out during the summer using continuous temperature loggers, which are devices capable of measuring maximum daily temperatures for consecutive days throughout the summer.

Other types of monitoring focus on comparing treatment and control measures, such as restoration project monitoring, or monitoring to compare different land uses or management practices. A sample research question might be to find out whether minimizing fertilizer runoff from an agricultural field to a stream is effective at reducing

the nutrient content of the stream. The approach in this case should include monitoring nutrient content upstream and downstream of the runoff location (spatial comparison) both before and after the implementation of management practices (temporal comparison) intended to reduce this input. This type of monitoring requires a longer time commitment and should also ideally be done over a multi-year period to account for any unusual year-to-year climatic or hydrologic variations. It is important to think about the feasibility of engaging in this kind of monitoring given that volunteer resources and funding may be uncertain from year to year.

If a research question is to identify the possible source of pollution in a portion of a stream where high bacteria counts had been recorded, then fecal coliform or *E. coli* would be the essential parameter to monitor. Monitoring locations might be upstream and downstream of potential pollution sources (e.g., industrial plant, dairy farm). In addition, it might be worthwhile to monitor more intensively before and after storm events, which have the potential to wash agricultural chemicals or animal waste into streams.

Thus, research questions and the technical details of a monitoring program's sampling design are inextricably linked and it is crucial to consider both of these aspects in monitoring plan development.

Development Process

When formulating research questions, it is necessary to think through the entire monitoring process to determine whether or not the research questions can be answered with the monitoring resources available. For example, if a research question is aimed at determining whether a stream violates water quality standards, there may be certain levels of precision and accuracy needed in order to address this question properly. Are there sufficient volunteer monitoring resources to collect enough meaningful data? How often, where, and over what extended time period does monitoring need to occur in order to produce adequate data for trend analysis or to illustrate spatial variation across a watershed, for example?

Formulating specific research questions can be a challenge, especially for streams where little or no monitoring has occurred. In this case, one goal of a water quality monitoring program may be to develop a baseline picture of the overall watershed. Specific research questions could include things like: how does DO vary for different streams throughout the year? What are typical turbidity levels in undeveloped portions of the watershed? Even if streams have very limited data on water quality, it is still possible to develop research questions by identifying factors which may influence water quality (e.g., land use, dams). In addition, considering what aquatic species and/or beneficial uses may be affected by water quality within a watershed can also lead to useful research questions. River Network has created a short list of generic research questions used frequently by volunteer groups with whom they work (see Appendix D). In Oregon, the

former volunteer monitoring coordinator at the Oregon DEQ created a worksheet to help volunteer groups develop focused research questions (see Appendix D).

Local residents and landowners may also be instrumental in identifying locations of potential water quality concerns and in formulating research questions, especially if they have lived in the area for a long time and possess knowledge of what river conditions were like in the past. This information may be obtained by talking to residents and landowners individually, or bringing people together at group meetings (e.g., watershed council meetings). If a watershed assessment has been completed, this may also be a valuable source of information for identifying potential areas of concern where regular water quality monitoring could be beneficial.

It is helpful to look at the state's 305(b) report and 303(d) list of impaired waterbodies. If there are listed streams or potential waterbodies of concern in the watershed, this should prompt some specific monitoring questions for volunteer groups to address, provided monitoring is not already being conducted for these rivers. Examining specific state water quality standards also helps to further focus questions. Water quality standards identify beneficial uses of streams (e.g., recreation, fish habitat) and outline specific numerical and/or narrative criteria that must be met in order to meet these standards. For example, some streams in the McKenzie watershed are designated bull trout habitat, and therefore, stream temperature should not exceed 50°F (10°C).

The unique physical characteristics of a watershed are also important to consider when formulating research questions. For example, it may be worthwhile to examine landscape history (e.g., topography, hydrology, geology, land cover history, flood

regimes) in order to obtain a solid understanding of how a watershed has operated in the past and what conditions are “normal.” Human constructions such as dams or other channel modifications may have a significant influence on water quality. For instance, there are several dams in the McKenzie watershed that affect water temperature in streams during certain times of the year. While not a part of the McKenzie’s volunteer water quality monitoring program, temperature monitoring near the dams is being conducted by the USFS and COE to examine this issue. Aquatic species and their habitats are also key elements of concern in a watershed’s ecosystem. The McKenzie watershed contains some sensitive fish species, such as spring chinook and bull trout. Bull trout are currently listed as an endangered species and require cold temperatures in order to survive and reproduce. Consequently, temperature monitoring in bull trout habitat areas is one priority for the McKenzie monitoring program. Land use is also a primary factor that affects the water quality of a watershed and has a bearing on which pollutants may be a problem. In the Long Tom watershed, 92% of the land is in private hands, and a significant portion of that land is devoted to agriculture and forestry. The Long Tom water quality monitoring program has an agricultural pilot component that monitors agricultural runoff and attempts to work with individual landowners to implement best management practices where water quality is an issue. In some of the forested sections of the McKenzie watershed, sediment is a big concern due to the extensive logging activity and associated road building. In the lower part of the McKenzie watershed near the Eugene/Springfield metropolitan area, urban runoff is a potential problem and *E. coli* is a concern in this area.

Behar et al. (1996) and the former volunteer monitoring coordinator at the Oregon DEQ both suggest performing a physical survey (“walking the river”) to identify potential issues through a visual survey of channel conditions and characteristics, observations of the presence or absence of certain fish, and evaluation of riparian vegetation. This type of survey does not necessarily need to be extremely rigorous or highly quantitative, but it can serve as a general way of uncovering issues that a monitoring program may wish to investigate.

Although the McKenzie and South Santiam monitoring programs did not have formal lists of specific questions they were trying to answer, they did have some particular areas of concentration in mind. For instance, the McKenzie Watershed Council was specifically interested in *E. coli* issues, since the river is a drinking water source for more than 200,000 Lane County residents. The South Santiam Watershed Council was primarily interested in both monitoring 303(d) listed streams and evaluating water quality in some of the tributaries of the South Santiam River for their ability to support healthy native runs of spring chinook and winter steelhead. In their first OWEB grant application for water quality monitoring, the Long Tom Watershed Council did not present a specific set of questions to answer. However, a subsequent grant application contained a detailed list of research questions that had been identified after the first couple of years of monitoring. This list is another good example of the types of research questions that a volunteer water quality monitoring program may want to investigate (see Appendix D).

Background Research

A key step in monitoring plan development is researching the types of water quality monitoring (if any) that have been conducted previously in the watershed of interest in order to identify data gaps and determine where future monitoring might be most beneficial or effective. There are several different types of data gaps that may exist: spatial, temporal, and the kinds of parameters measured. Spatial data gaps refer to “holes” or empty places in geographical space, and are often identified using a map (see Figure 3 of Appendix E, p.129). Temporal data gaps refer to time lapses in monitoring history. For example, temperature data for a stream might have been collected since the 1950s, but is lacking for a few years in the 1980s for some reason such as lack of funding, limited resources, or even misplaced data. Gaps in parameters measured refer to parameters that are not monitored in certain locations or not monitored at all. For instance, temperature, conductivity, pH, and DO might have been monitored on all of the major streams in a watershed, but little or no data might exist for turbidity.

Along the same lines, it is also critical to learn about any current monitoring that is taking place in the watershed so that volunteer groups do not duplicate monitoring efforts of other organizations. Agencies such as the USFS and BLM are frequently engaged in some form of water quality monitoring such as stream temperature or sediment studies. The COE typically monitors water flow and temperature in or near constructed reservoirs. State water quality agencies often maintain a network of ambient monitoring sites across the state, and the USGS may have gaging stations within the

watershed that could be a reliable source of flow and/or temperature data. Cities or counties frequently monitor water quality in urban areas and at water treatment plants.

All of the watershed council contacts that I spoke with performed some type of background research before writing their monitoring plans. The McKenzie Watershed Council contracted the USGS to examine previous studies conducted within the watershed. Results from this study indicated that there were too many gaps in the data to provide a meaningful baseline assessment of water quality within the watershed. This information (or rather lack thereof) helped the McKenzie Watershed Council formulate their program. Data gaps identified for both the Long Tom and South Santiam watersheds also helped these councils to determine the location of some of their monitoring sites.

Collaboration

The actual formation and writing of a monitoring plan should be a collaborative process involving the author of the plan, the watershed council coordinator, water quality professionals or representatives from local agencies and/or government planning offices, and perhaps local residents, landowners, or watershed council members.

The water quality program manager for the Long Tom Watershed Council developed the water quality monitoring plan with assistance primarily from the DEQ office in Eugene and the Technical Services Manager for the Public Works Wastewater Division of the City of Eugene. Researchers from Oregon State University also provided

input. Development of the McKenzie Watershed Council water quality monitoring plan was a collaborative effort by the watershed council coordinator and the watershed council's water quality committee, which consisted of representatives from the Lane Council of Governments, USFS, BLM, ODFW, local utilities, and cities within the watershed. Likewise, the South Santiam Watershed Council plan was a joint effort by the watershed council coordinator and water quality committee, which consisted of watershed council members and representatives from industry and the local city offices. The main point to emphasize is that it is important to gather and incorporate input from various groups and agencies within the watershed. This not only helps to make the plan stronger technically, but also increases the chance of obtaining support for the monitoring program from local agencies, private landowners, and watershed residents.

In addition to working with agencies and planners in the plan development process, it may be possible to collaborate in the actual field monitoring portion of the program. Agencies who currently conduct monitoring within the watershed may be interested in working with volunteer groups to obtain additional data in places where they are unable to monitor due to resource limitations and they may have suggestions about where to locate monitoring sites. They may also be able to lend personnel resources for monitoring periodically or at least provide training, consultation, and expertise to local groups as needed. Finally, they are valuable people to include on a volunteer water quality monitoring program's technical advisory committee. Volunteer groups may also be interested in obtaining monitoring data from these agencies for use in reports or as a source of background knowledge.

The McKenzie Watershed Council has worked out a partnership with the Oregon DEQ, which provides the manpower to collect and analyze baseline water quality data at a number of sites on the mainstem of the McKenzie River. This part of the water quality monitoring program is funded by the Oregon DEQ, the Eugene Water and Electric Board (EWEB), USFS Willamette National Forest, BLM, COE, and Springfield Utility Board (SUB). Another example of collaboration occurred in the South Santiam watershed, where volunteers partnered with the Oregon DEQ during summer 2001 to investigate potential bacteria concerns that had been identified by the council's volunteer water quality monitoring program.

Resources

In an ideal world, there would be no limit to the number of willing volunteers in a monitoring program, the type of water quality parameters that could be sampled, or the quality and quantity of available field equipment. Unfortunately, most volunteer water quality monitoring programs *are* limited by a number of resource constraints, which can greatly influence the design and scope of the monitoring program.

To begin with, available human resources are often a significant limiting factor. Volunteer monitoring programs, as the name implies, rely on the goodwill and dedication of volunteers to perform field monitoring. Sometimes it is difficult to find enough volunteers willing to commit to monitoring. Programs should try to take advantage of a variety of sources of potential volunteers such as landowners, local citizens, students, and

other community groups. As mentioned in the last section, local agencies working within the watershed might be able to provide resources or partner with volunteer programs.

Students from local schools are often valuable monitoring resources to employ, assuming that they are well supervised and trained in the appropriate sampling procedures.

However, it is also important to take into account that students may be unavailable during the summer when school is not in session. All three of the watershed councils that I examined used high school students to some degree in their monitoring programs. Plan developers may want to contact school groups and recruit volunteers at watershed council meetings on an informal basis early on in the plan development process in order to gauge the size of the volunteer resource base and select a realistic number of monitoring sites.

Another resource issue concerns the long term commitment of volunteer monitors. Most watershed councils would like to operate their monitoring programs on an ongoing basis, which of course is largely dependent on funding. Although a monitoring program may continue over several years, there may be frequent turnover of volunteers, especially among student volunteers. This requires a coordinator to continually recruit new people, so it is in the best interest of the council to retain as many volunteers as possible. Furthermore, this minimizes the amount of training that needs to be conducted. However, the monitoring coordinator must have a plan or strategy in place for both recruitment and training of new volunteers as necessary.

Both the McKenzie and South Santiam watershed councils have sometimes had difficulty finding enough volunteers to monitor on a consistent basis. Furthermore, collecting water samples on the McKenzie, which is a fairly large river, can be dangerous

and may raise liability concerns when involving volunteers. Thus it is sometimes necessary to employ professionals to collect data. The Long Tom Watershed Council has strong membership and a large population base from which to draw volunteers. The Council has been fortunate in recruiting some steady volunteers who monitor consistently throughout the year and it has also taken advantage of youth enrolled in the Northwest Youth Corps and Looking Glass (a nonprofit organization which provides a variety of youth services) to perform monitoring.

In order to run a water quality monitoring program most effectively, someone needs to coordinate the logistics of recruiting and organizing volunteers, creating sampling schedules, maintaining water quality monitoring equipment, and ensuring that existing QA/QC procedures are being followed by volunteers. In addition, someone needs to be responsible for assembling, reviewing, and submitting data to the DEQ or other agencies, and producing reports that summarize and analyze field data. These duties are often carried out by one person who serves as a paid water quality monitoring coordinator. These responsibilities can be extremely time-consuming and it is unlikely that one volunteer will be willing or able to perform these tasks effectively. In fact, one of EPA's monitoring manuals asserts that programs are sustainable "only if the monitoring organization provides or hires a volunteer coordinator." (US Environmental Protection Agency, 2000b) Thus, it is best if programs can obtain the funding to support a water quality monitoring coordinator. Programs that do not have such a position may rely on one or more volunteers or other personnel to carry out these tasks. Neither the McKenzie nor South Santiam watershed councils has a paid water quality monitoring

coordinator, but instead both rely on their watershed council coordinator to manage the program, with assistance from other staff people, advisory committee members or volunteers. The Long Tom Watershed Council has a paid part-time water quality monitoring coordinator and has recently received funding for an Americorp intern to assist with the program.

One of the biggest sources of uncertainty that volunteer monitoring programs must deal with on a continual basis is funding. In Oregon, watershed councils generally have a watershed council coordinator who is funded by OWEB, and who may or may not have time to oversee a water quality monitoring program. Water quality monitoring programs in Oregon are often funded by additional OWEB grants or from other outside sources such as private foundations or other local government agencies. If a watershed council's QAPP is submitted and approved by the Oregon DEQ, the DEQ will loan water quality monitoring equipment to the watershed council and provide training to volunteers at no cost. Monitoring equipment can be expensive, and the DEQ program (which is also funded by OWEB) has worked out well in Oregon. Approximately 50 watershed groups are currently taking advantage of this equipment (Karen Williams, personal communication, May 2, 2002). Some watershed councils purchase some of their own equipment out of their general budget (e.g., Long Tom, South Santiam) and some monitoring programs are partially supported by local match funds from cities or towns (e.g., Long Tom, South Santiam). The McKenzie Watershed Council is particularly fortunate in a partnership that they have worked out with the Oregon DEQ. The "Tier I ambient monitoring" component of their water quality monitoring program, which

collects baseline data on the mainstem of the McKenzie River, is carried out by Oregon DEQ personnel and is funded by the Oregon DEQ, EWEB, USFS Willamette National Forest, BLM, COE, and SUB. This has allowed the water quality program to concentrate its volunteer resources on the other components of the program, such as storm event and tributary monitoring. Thus, while funding can certainly limit the extent of a monitoring program, there are a number of possibilities for collaboration with other agencies in terms of monetary support, expertise, and equipment.

Sampling Design

The sampling design of a monitoring plan should describe in detail the type of parameters to be monitored and methods to be used, the season and frequency of monitoring, and location of sampling sites. It is also important to consider the unique physical characteristics of the watershed when creating a sampling design.

Parameters to Monitor

The question of which parameters to monitor generally depends on two major things: 1) research questions and 2) (particularly for volunteer monitoring programs) ease and expense of monitoring. First of all, the specific research questions that a program is trying to address will directly determine the parameters to monitor. For example, if a research question is to determine the baseline condition of a watershed, volunteers might

monitor a suite of basic parameters such as temperature, turbidity, pH, DO, conductivity, and perhaps nutrients and bacteria. More focused research questions, such as assessing whether or not a stream is safe to swim in, may require testing for a particular parameter, like bacteria. On the other hand, if one is interested in investigating possible effects of logging operations on water quality of a stream, appropriate parameters to measure may include turbidity, flow, or total suspended solids.

Availability of equipment and ease of monitoring dictate the parameters that are monitored in many volunteer water quality monitoring programs because these programs generally have limited funding and often rely on volunteers who may not have much background or expertise in water quality. Table 2 shows the top ten parameters for rivers and streams monitored by volunteer programs (US Environmental Protection Agency, 2002c). A number of these parameters (such as temperature and turbidity) appear not only because they are important parameters to monitor from a water quality standpoint, but also because they are relatively easy and inexpensive to monitor. While parameters such as nutrients, bacteria, and metals are also important constituents to monitor in streams, they are significantly more costly to monitor, since water samples generally need to be sent to a certified lab for analysis. According to the EPA survey mentioned above, metals were ranked 27th and pesticides 35th among parameters monitored. Only 9% of volunteer programs monitored metals and 2% monitored pesticides.

TABLE 2. Top Ten Parameters Monitored for Rivers and Streams

Rank	Parameter	No. (%) of Programs
1	Water temperature	215 (88%)
2	pH	191 (78%)
3	Macroinvertebrates	186 (76%)
4	Dissolved oxygen	180 (73%)
5	Nitrogen	F. 129 (53%)
6	Flow/water level	125 (51%)
7	Turbidity	124 (51%)
8	Phosphorus	120 (49%)
9	Habitat assessments	106 (43%)
10	Bacteria	84 (34%)

Source: EPA, National Directory of Volunteer Environmental Monitoring Programs (5th edition, 1998)

Table 3 shows some of the common parameters measured by volunteer monitoring programs (based on my research), along with the standard method of monitoring, relative cost, relative ease, and analysis location. It is apparent that water temperature, turbidity, pH, DO, and conductivity are relatively easy and inexpensive to monitor. Continuous temperature monitoring is a large part of many volunteer programs and requires a significant time commitment up front to calibrate and install the temperature units in streams at the beginning of the summer and remove and download field data at the end of the season. During the summer, only periodic field audits are necessary. Government agencies often use continuous temperature data to determine whether or not water quality standards have been violated and to assess habitat conditions for aquatic species. Nutrient and bacteria monitoring are not uncommon, but are

generally quite expensive since water samples need to be sent away to an outside lab for analysis (unless volunteer groups have adequate lab processing facilities). Oftentimes volunteer groups perform this type of monitoring at a subset of sites where water quality concerns are the greatest. Macroinvertebrate sampling is another parameter that is becoming increasingly prevalent among volunteer programs, both because it is a good indicator of overall water quality and because it tends to attract volunteers due to its “hands-on” nature. However, in order to obtain data useful for screening level assessments or more detailed evaluations of water quality impairment (as opposed to educational purposes or general evaluations of stream condition) it is often necessary to work with or send samples to a qualified taxonomist who can achieve a detailed level of classification.

The three water quality programs that I examined all monitor temperature, turbidity, pH, DO, conductivity, and *E. coli*. Additionally, the Long Tom Watershed Council monitors nitrogen and phosphorus concentrations at some sites, and the South Santiam Watershed Council monitors fecal coliform bacteria, nitrogen and phosphorus concentrations, total suspended solids, and salinity. The McKenzie watershed program monitors a wide range of additional parameters in their baseline monitoring component, but this is because the Oregon DEQ performs the monitoring and has the technical resources and expertise to monitor a more complex suite of parameters.

TABLE 3. Commonly Monitored Water Quality Parameters by Volunteer Programs

Parameter	Standard Equipment	Relative Cost	Ease of Monitoring	Analysis Location
Water Temperature	NIST Traceable Thermometer	inexpensive	easy, quick reading	field
pH	Portable Field Meter	inexpensive	fairly easy, slightly longer time to analyze	field or volunteer office
Dissolved Oxygen	Portable Field Meter or Titration Kit	inexpensive	fairly easy, slightly longer time to analyze	field or volunteer office
Conductivity	Portable Field Meter	inexpensive	easy, quick reading	field
Turbidity	Portable Field Meter	inexpensive	easy, quick reading	field
Nitrogen	Container for Water Sample	expensive	easy to take water sample, difficult to analyze in house	generally sent to a lab for analysis
Phosphorus	Container for Water Sample	expensive	easy to take water sample, difficult to analyze in house	generally sent to a lab for analysis
Macroinvertebrates	Kick Screen or D-Frame Net	inexpensive	depends on specific level of classification	field or volunteer office
Fecal coliform or <i>E.coli</i>	Container for Water Sample	expensive	easy to take water sample, difficult to analyze in house	generally sent to a lab for analysis
Continuous Temperature	Data Loggers	inexpensive	relatively straightforward, more time consuming at beginning and end of sampling period	field deployment and periodic field audits; after removal from field data needs to be downloaded using special software
Flow	Field Meter, Rod	inexpensive	moderately difficult and more time consuming to perform; could also be dangerous for volunteers to wade across streams	field

Sampling Methods

A complete sampling design will also identify the sampling methods used to gather field data as well as the equipment, field, and/or lab procedures used to analyze water quality data. Again, these methods will tie into the overall program goals and objectives. In addition, a sampling design should specify data quality objectives (DQOs), which, according to the EPA's *The Volunteer's Guide to Quality Assurance Project Plans*, quantitatively and qualitatively "describe how good your data need to be in order to meet program objectives." (US Environmental Protection Agency, 1996, p. 26) If the intent of the program is to collect reliable data to be used by state agencies, for example, there are most likely certain protocols that must be followed. In Oregon, the DEQ will accept volunteer data if volunteers followed the protocols outlined in the OWEB *Technical Water Quality Monitoring Guidebook* or used other procedures deemed acceptable by the DEQ. Quantitative data quality objectives include numerical requirements for precision, accuracy, representativeness, completeness, comparability, and measurement range that are explained in detail in the EPA's *The Volunteer's Guide to Quality Assurance Project Plans*.

Monitoring Frequency

Frequency and season of monitoring is another aspect of sampling design that needs to be addressed. Monthly sampling for water quality parameters is fairly standard,

although some volunteer programs may sample more or less frequently depending on the number of volunteers available, the parameter being sampled, and the time of year. Oftentimes parameters such as temperature, dissolved oxygen, pH, and *E. coli* are sampled on a more frequent basis during the summer when water quality problems relating to these parameters are more of a concern. For instance, swimming and other forms of water recreation are much more prevalent during the summer, which might make *E. coli* more of a problem. High temperatures (characteristic of summer) reduce DO levels and may render otherwise good habitat unsuitable for certain aquatic species, especially salmonids. If one is monitoring for high turbidity levels, it is probably important to sample frequently during and immediately following a storm event, when sediment levels have a tendency to be high. If one is interested in monitoring agricultural runoff, water quality sampling should be done after the application of fertilizer or pesticides, especially during the first rainstorm following the application, which often washes these chemicals off the fields and into the streams.

Site Selection

Site selection is another important component of sampling design. Volunteer water quality monitoring programs often must strike a balance between choosing sufficient representative sites to achieve their objectives and answer research questions while also being reasonable for volunteers to handle in the context of the program. River Network suggests site selection strategies for each of the three common types of studies

done by volunteer groups that they work with: characterization surveys, impact surveys, and water quality standards surveys (Dates, 2002). There is plenty of additional literature available on how to select sites that are most effective for answering certain types of monitoring questions, like evaluating the impact of agricultural runoff or monitoring the effectiveness of a restoration project (Behar, 1996; Oregon Watershed Enhancement Board, 1999) (see Appendix F for more complete listing of resources). Another key consideration in selecting sites, especially in a volunteer water quality monitoring program, is accessibility:

- Is the site safe (e.g. is it located near a busy road, is it difficult or relatively easy to physically access the stream)?
- Is the site accessible in the winter, and if not, is it all right if one or two months of sampling are missed?
- How long will it take to get to the site (consider realistic travel time expectations for volunteers)?
- Is the site located on public or private land? If it is located on private land, it is necessary to get landowner permission. Also, some landowners may allow monitoring, but do not want their names attached to data reports for privacy reasons.

In addition, placement of monitoring sites may be influenced by where volunteers live. Oftentimes volunteers want to monitor sites close to where they live or in places that are of particular concern to them.

While the McKenzie and South Santiam water quality monitoring programs monitor primarily on public land, the Long Tom water quality monitoring program has several sites on private land and is working with landowners to improve water quality where possible. The Long Tom selected baseline monitoring sites in each of the main

sub-watersheds in order to characterize water quality across the watershed, compare upstream and downstream locations, and evaluate varying land uses. Some sites on private agricultural land were chosen in order to determine whether agricultural runoff was affecting water quality. The McKenzie Watershed Council selected baseline monitoring sites along the mainstem of the McKenzie River and close to the mouths of three major tributaries, taking into account varying land uses, proximity to active gauging stations, and safety considerations. Sites within the tributary monitoring portion of the program were selected primarily because of specific water quality concerns and identification of problem areas in previous years' monitoring. The South Santiam program's monitoring locations were ranked and selected by the technical advisory committee based upon program objectives, safety considerations, representativeness of the site, and whether or not the land was publicly owned. In general, these sites bracket urban areas near the South Santiam River and are located in, upstream, and downstream of major tributaries.

Quality Assurance/Quality Control (QA/QC)

Another critical facet of a volunteer water quality monitoring plan is its quality assurance/quality control (QA/QC) procedures. According to the EPA's *The Volunteer's Guide to Quality Assurance Project Plans*, quality assurance is defined as the "overall *management system* which includes the organization, planning, data collection, quality control, documentation, evaluation, and reporting activities"(US Environmental

Protection Agency, 1996, p. 15). Quality assurance procedures ensure that the data quality meets the requirements of a particular program. Quality control, as detailed in the guide, consists of the “routine *technical activities* whose purpose is, essentially, error control.”(US Environmental Protection Agency, 1996, p. 15). Examples of quality control procedures are calibration, split samples, replicate samples, lab certification, and volunteer training. A full explanation of all of these procedures is beyond the scope of this document, but a number of resources exist that contain detailed explanations of these and other QA/QC concepts and examples of how they can be applied and implemented (see Appendix F).

In order for a monitoring program to truly be effective and collect reliable data, it must have some sort of QA/QC system to ensure that standard procedures are followed. However, the rigor of a monitoring plan’s QA/QC component depends on program objectives and the requirements of the end users of the data (see following section on Data Uses and Users). Although QA/QC is a crucial element of a monitoring plan, it is also fairly straightforward to incorporate given the number of detailed technical resources that exist.

Data Uses and Users

There are a variety of uses for water quality data, including:

- Documentation of baseline water quality conditions
- Evaluation of trends in water quality over time

- Evaluation of the status of impaired (or non-impaired) waterbodies for use in state/federal agency water quality reports
- Screening mechanism for identifying particular water quality problems in streams (and subsequently using this data to expand/refine monitoring programs)
- Evaluation of the effectiveness of restoration projects or the implementation of best management practices
- Use by local government or watershed councils in planning and prioritizing restoration and enhancement projects
- Raising public awareness and educating local citizens about water quality issues

It is wise to identify from the outset of a monitoring plan *who* will be using the data that are collected and for *what purpose*. The end uses of the data will dictate the type of data that ought to be collected, as well as the methods employed and the rigor of the quality assurance plan.

Knowing the specific questions that one is trying to answer and how the data are going to be used is extremely important in determining what type of data to collect. A volunteer water quality monitoring program should not end up in a scenario where volunteers invest considerable time and effort into collecting the wrong kind of data for the intended purpose. Thus, it is wise to plan ahead and consult with scientists from agencies like the USFS or US Fish and Wildlife Service (USFWS) to understand the kind of data that they or other agencies might need or find valuable in the future. In addition, communicating with potential data users early in the planning process may result in helpful input in the design of the monitoring program, as well as support of and perhaps involvement in the volunteer monitoring program.

Whether or not a volunteer water quality monitoring program has a formal QAPP and how in-depth and detailed it is often will depend on the intended end use of the data. For instance, if a program goal is to submit data to the state water quality agency or the EPA for use in their official water quality reports, a state or EPA-approved QAPP is necessary. This ensures that the data were collected and analyzed following certain standard protocols. The Oregon DEQ has three levels of volunteer data that they accept (see Chapter III), and a data quality matrix describing the precision and accuracy requirements for each level of data (see Table 1 on page 35). On the other hand, if the intent of a monitoring program is solely to educate the public, raise awareness of water quality issues, and/or provide a learning experience for student and local citizens, a formal QAPP may not be necessary (although it is always helpful to have this type of clear documentation). Finally, if collected data are to be submitted to or used in combination with another agency such as the USFS or a city government office, it may be prudent to find out how their data are collected and summarized. A volunteer water quality monitoring program may want to employ similar methods so that data can be readily comparable.

All three of the watershed councils that I spoke with had either already submitted or were planning to submit their data to the Oregon DEQ. The Long Tom and South Santiam programs had written QAPPs that were approved by the Oregon DEQ. The McKenzie Watershed Council's baseline component of the program does not have a formal QAPP since this component is being carried out directly by Oregon DEQ personnel.

In terms of data uses, all three of the watershed councils consider education to be a valuable program component. In addition, they all monitor to collect baseline data, screen for additional problems, and evaluate the status of 303(d) listed streams in their watersheds. Both the Long Tom and McKenzie watershed councils used their collected data to identify water quality concerns (such as elevated stream temperatures or areas of chemical agricultural runoff) and target areas of their watersheds in need of restoration or enhancement. The South Santiam Watershed Council to date has focused on using their data for evaluating the status of 303(d) listed streams, identifying water quality problem areas, and providing data to DEQ, rather than for planning purposes.

Data Management, Analysis and Reporting

Although not essential for the initial start-up of a monitoring program, a thorough volunteer water quality monitoring plan should have a strategy specifying the way in which collected field data will be managed, analyzed, and reported. This process is what makes volunteer data valuable to watershed councils, government agencies, and other end users.

Data Management

Data management may include a variety of activities, including checking data for obvious errors (this ties into QA/QC procedures) and entering data into a computer

database where it can be stored, easily accessed, and analyzed. Some volunteer groups use common spreadsheet or database software, while other groups have developed custom water quality database management systems (Werner, 1995). Data may also need to be formatted in a particular way before it is officially submitted to the EPA or state water quality agency. The Oregon DEQ has specific data formatting requirements and has posted water quality monitoring data submission forms online to assist volunteer groups in submitting their data. In addition, volunteer programs may wish to incorporate monitoring data from other agencies or organizations in their analyses. If this is the case, it is important to clearly define procedures for obtaining and using this data.

Data Analysis

After water quality data have been collected from the field and entered into a database, the next step is to translate these raw data into meaningful information that answers the initial research questions specified in the monitoring plan and can be clearly conveyed to the appropriate audience. The extent of the data analysis performed depends on the time and expertise of the monitoring coordinator or whoever is responsible for putting together the results.

There are a number of ways to summarize, analyze, and display water quality data, ranging from simple tables of field data measurements to complex statistical analyses. The type of analysis used also depends on what kind of data were collected and over what period of time, as well as the monitoring program's specific research

questions. There are a couple of resources that volunteer groups can refer to in order to select appropriate and useful methods for data analysis (Behar, 1996; Oregon Watershed Enhancement Board, 1999). In addition, the EPA published an issue of *The Volunteer Monitor* devoted entirely to managing and presenting data (US Environmental Protection Agency, 1995). Several common analysis and presentation techniques are as follows:

- *Summary data tables:* Simple tables are often most effective for organizing and displaying all of the field data measurements in an easy-to-read format. The majority of summary reports include these types of tables as appendices so that readers can refer to the original field data.
- *Graphs:* There are a variety of graphs that can be created to display data and reveal trends and relationships in an easy-to-understand visual format. For example, line graphs can be effective at illustrating variations in parameters over time. Bar or column graphs are often used to compare data values at different monitoring sites. Pie graphs may be excellent tools for portraying pollutant loadings (e.g., nitrogen, phosphorus) if streamflow information is available. Graphs are also useful for comparing field data values with the state water quality standard for a parameter. Meg Kerr wrote a useful article for the EPA's *The Volunteer Monitor* newsletter on how to select the appropriate graphs to display water quality data (Kerr, 1995).

- *Box and whisker plots:* These graphical data displays are common in volunteer monitoring reports since they are relatively easy to create and show both the full range of values for a site as well as the mean value.
- *Maps:* Maps are extremely valuable in illustrating the spatial patterns in data in a concise and understandable format. Mapping water quality monitoring sites that are impaired or do not meet state standards for particular parameters can be helpful in targeting restoration projects. Geographic information systems (GIS) are becoming increasingly common for storing, manipulating, and presenting water quality data.
- *Descriptive statistics:* These types of statistics are useful in summarizing the central tendency (mean or median values) for a set of data and its distribution, or how the data are spread out. Descriptive statistics may also be used to assess data quality and show how much variability may be associated with collected data.
- *Inferential Statistics:* Inferential statistics are generally used to interpret data, test hypotheses, and make conclusions about the water quality status of the environment being studied. They may include regressions, T-tests, multivariate analyses, and other models. Although software packages exist which can run various statistical models, these types of analyses are often beyond the scope of volunteer monitoring groups, unless the coordinator or one of the members is well versed in interpreting statistical data.

- *Trend analysis:* Trend analysis concerns examining long term patterns in data over time in order to assess changes in water quality status of streams. It is often accomplished using a combination of graphing and some statistical analyses. This more complicated analysis requires a large set of data spanning a number of years and is not easy to incorporate in volunteer programs. However, if volunteer groups are able to collect sufficient data, they may be able to obtain assistance from government agencies in performing trend analysis.

Data Reporting

Once the data are summarized and interpreted, it is important to convey the results to decision-makers, watershed residents, and other interested parties. There are several different ways to communicate data. Many volunteer groups produce annual or semi-annual reports summarizing their monitoring data, which are subsequently distributed to the watershed council and other interested parties and generally made available to the public upon request. Some volunteer groups present their data in public settings, such as watershed council meetings. Making data available online is becoming an increasingly common practice as well.

The watershed councils that I interviewed have a base list of groups or agencies to whom they send summary reports (primarily to local divisions of natural resource

agencies such as the BLM and USFS, as well as city offices and utility boards). They also report results back to watershed residents and make information available to the public upon request. The McKenzie Watershed Council is planning to put the summary reports online, but not post the actual raw data because of landowner confidentiality issues. The Long Tom Watershed Council plans to put a description of their water quality monitoring program online, but direct readers to the Oregon DEQ water quality database to view the actual field data. A number of volunteer water quality monitoring groups that I researched on a national basis have posted collected field data online for anyone to access, and some groups even have interactive web pages where their volunteers can directly enter their collected field data (e.g., Iowater: <http://www.iowater.net/database/online.asp> and Missouri Stream Teams: <http://www.rollanet.org/~streams/vmdata.html>).

Other Considerations

While the following sections do not relate to particular components of a water quality monitoring plan, they nonetheless contribute valuable information to consider in plan development. For instance, there are many lessons to be learned and ideas to be gained from looking at the implementation successes and challenges of other volunteer water quality monitoring programs. In addition, it is worthwhile to look ahead to the future and anticipate how a volunteer monitoring program might evolve and grow in the face of changing resources, goals and objectives, or water quality issues.

Implementation Challenges and Successes

After interviewing contacts from the Long Tom, McKenzie, and South Santiam watershed councils, I was able to obtain an understanding of some of the challenges they faced during program implementation, along with their positive accomplishments. All three programs have been relatively successful in implementing their programs as planned and are continuing to monitor and submit data to the Oregon DEQ. Furthermore, they have all expanded their monitoring programs in some fashion over time.

All of these watershed councils constantly face the challenge of securing funding to support their water quality monitoring programs. Most grants are for a year or two in duration and proposals for more funding must be written frequently. In addition, past support is not a guarantee for future support, especially in light of the recent budget cuts at OWEB, the primary source of funding for watershed councils in Oregon. All three of the programs have had a fairly strong base of volunteers who generously devote their time and energy to monitoring. However, two of the three programs still find it difficult at times to recruit and train sufficient volunteers.

Some of the more program-specific issues are as follows. While the Long Tom Watershed Council has been largely successful in implementing the program as planned, a couple of technical details have been changed based on field experience. For instance, the monitoring equipment for measuring pH was found to be too unreliable for volunteers

to obtain both accurate and precise data results. Therefore, the pH of water samples is now measured by the water quality monitoring coordinator in the council office following field collection. In addition, the initial quarterly sampling schedule for *E. coli* monitoring was changed to focus more on storm events, when potential problems are most likely to occur.

The McKenzie Watershed Council has had occasional problems with obtaining field data at all monitoring sites in the winter due to snowfall. The council coordinator also cited some difficulties communicating and sharing data effectively with other agencies working within the watershed. The McKenzie water quality monitoring program has an established technical advisory committee that meets consistently to evaluate and make any necessary changes to the monitoring program. The most significant change to the monitoring program occurred when the storm monitoring component was put on hold after two seasons of monitoring. It was determined that this component was not meeting program objectives and was too costly for the data that it returned. Specifically, it provided some general information about water quality conditions during storm events, but the program was not successful in explaining the extreme variation in high flow events over time. No conclusive statements could be made concerning the specific causes or management practices that led to water quality problems. (However, the data did help to identify areas with potential water quality problems that will be targeted for further investigation in the future.)

The South Santiam water quality monitoring program also faced challenges in collaborating with other agencies and obtaining permission to monitor on private lands.

In addition, although the gathered data have identified some general potential water quality issues, there is some reluctance to further refine monitoring locations to hone in on the specific areas where problems are occurring. It seems that some watershed residents are not fully making the connection between some of the high values obtained for certain water quality parameters and the associated land uses. Finally, pre- and post-project monitoring is not currently being conducted. However, the long timeframe for this type of monitoring poses challenges itself.

Evolution of Water Quality Monitoring Programs

When developing a volunteer water quality monitoring plan, it is frequently a good idea to start out small and expand the program in the future if resources and funding allow. Coordination and implementation of a monitoring program can be extremely time-consuming at the start, and developing a plan whose initial scope is manageable will increase the chances of success. Some groups start out with programs that are not particularly rigorous, but increase the level of QA/QC procedures as volunteers become more involved and experienced in monitoring. Again, size and scope of a program depends on its purpose. The three water quality monitoring programs that I examined have all added additional monitoring sites to their programs, and, in some cases, new monitoring parameters. They have also focused additional monitoring on tributaries and/or other stream reaches where field data have indicated potential water quality problems and prompted further investigation. For example, the South Santiam

monitoring program identified several tributaries with elevated temperatures near the mouth of the South Santiam River. Additional upstream sites have been monitored in successive years to better ascertain the temperature profile of these tributaries and determine potential problem reaches. The McKenzie Watershed Council also plans to implement pre- and post- project monitoring in the future, as restoration projects are carried out. The Long Tom Watershed Council has added additional sites where nutrients and bacteria will be monitored exclusively.

Interview Conclusions

Speaking with the contacts from the Long Tom, McKenzie, and South Santiam watershed councils was especially valuable because they have been through the entire process of developing and implementing a water quality monitoring plan. The lessons that they learned, as well as their insights and suggestions, were extremely helpful in obtaining ideas for monitoring plan development. Although agency personnel (e.g., from EPA, state DEQs) are very knowledgeable and can provide excellent technical assistance, it is particularly helpful to speak with monitoring program coordinators because they have more direct contact with the volunteers and are responsible for on-the-ground implementation of the monitoring plan. They have in-depth knowledge of what does or does not work from a very practical perspective.

Following are a few last suggestions from each watershed council contact concerning volunteer water quality monitoring plan development:

Long Tom: Cindy Thieman stressed the importance of developing good research questions right from the start as opposed to building a monitoring program “around reconnaissance.” She also noted that it is particularly beneficial to work with scientific or other technical people (e.g., from natural resource or government agencies) in developing the monitoring plan.

McKenzie: Jim Thrailkill emphasized launching a small, “grassroots” type of monitoring program initially if need be in order to engage people early on in the process and then worry about program expansion and developing a formal QAPP with more rigorous procedures afterwards.

South Santiam: Tom Dover recommended obtaining the commitment and support of large private riparian landowners who might be interested in water quality monitoring results and could possibly serve as historical resources as well.

Summary

This chapter illustrates the importance of thinking through and incorporating a number of critical elements into the development of a water quality monitoring plan in order for it to be most effective. Although each of the components described is important, I believe the most essential are developing clear goals, objectives, and research questions and identifying key data uses and users. These concepts truly drive the

rest of the monitoring plan in terms of sampling design, rigor of QA/QC procedures, and collaboration opportunities. Plans with vague objectives and uncertain data uses and users may waste time, effort, and money. Some of the other components (e.g., data management, analysis, and reporting) are also important to the development of an effective monitoring plan, but arguably less so since they do not have such a large and direct effect on other components. However, acceptance of a volunteer water quality monitoring plan by many state water quality agencies and the EPA does require the inclusion of all of these elements. Finally, the more input and communication that occurs with other agencies and interested parties in the watershed, the stronger the monitoring plan will be and the greater the chance for its success.

CHAPTER V

DEVELOPMENT OF THE MIDDLE FORK WILLAMETTE WATER QUALITY MONITORING PLAN

In order to better understand the process and challenges associated with developing a volunteer water quality monitoring plan, I took on the project of writing a volunteer water quality monitoring plan for the Middle Fork Willamette Watershed Council (MFWWC) in western Oregon. The MFWWC was formed in 1999 and was in the middle of completing a watershed assessment for the three lower fifth-field sub-watersheds contained within the Middle Fork Willamette (MFW) watershed when I began to work with the Council in the fall of 2001. The MFWWC coordinator at that time, had recognized that there was very little existing water quality data for the watershed and he and the Council had identified a need for a comprehensive water quality monitoring program. I volunteered to write the water quality monitoring plan as part of my thesis and have worked with the watershed council coordinator in this effort. In addition to writing the plan itself, I have worked with the council coordinator on putting together grant proposals in an effort to obtain funding for a water quality monitoring coordinator to run the program. A copy of the completed MFWWC Water Quality Monitoring Plan is included in this document as Appendix E.

Methodology

I chose to write the MFWWC water quality monitoring plan in the format of a quality assurance project plan (QAPP) that could be submitted to the Oregon DEQ in order to obtain monitoring equipment and training. The particular format that I used was developed by the EPA (US Environmental Protection Agency, 1996). It is thorough, encompassing the many aspects of a complete water quality monitoring plan, including: background on the watershed and its existing (and potential) water quality issues, sampling design, QA/QC procedures, data management, analysis, and reporting, and collaboration opportunities with other agencies. One of the main goals of the MFWWC's monitoring program is to collect credible data that can be used by government and natural resource agencies in decision-making processes. The QAPP that I wrote outlines the procedures that the MFWWC monitoring program will use to ensure that the data collected are of sufficient quality to meet this goal. In addition, I took into account the key components of an effective water quality monitoring plan that were outlined in the previous chapter.

The overall strategy that I used to construct the QAPP consisted of eight major development phases:

- 1) Familiarized myself with water quality concepts, technical details of water quality monitoring, and literature on how to design basic monitoring plans
- 2) Examined and compared water quality monitoring plans from other watershed councils
- 3) Researched previous water quality studies in the MFW watershed

- 4) Researched current water quality monitoring in the MFW watershed and identified possibilities for collaboration
- 5) Identified data gaps
- 6) Located resources to aid in plan development
- 7) Developed the water quality monitoring plan document
- 8) Revised the monitoring plan as necessary

Each of these phases is described in more detail below.

Phase 1: Familiarized myself with water quality concepts, technical details of water quality monitoring, and literature on how to design basic monitoring plans

One of the most helpful activities I engaged in initially was doing some extensive background reading and research to familiarize myself with key water quality concepts. Although I had a basic understanding of the primary factors influencing water quality, I had limited technical knowledge of how certain water quality parameters are actually monitored in the field and what types of methods are standard. In addition, obtaining an understanding of the Clean Water Act and how volunteer monitoring fits into an overall monitoring context was extremely valuable. I also researched other topics including how to create a water quality sampling design, what types of water quality parameters are typically monitored by volunteer groups and how often, and what types of QA/QC procedures are generally followed and why. There are a number of useful sources of information that provide this background in basic water quality concepts and monitoring approaches and designs (see Appendix F). After obtaining a foundation in these key water quality concepts and issues, I was more comfortable in seeking advice and

information from watershed council coordinators and monitoring coordinators. Finally, I examined water quality standards pertaining to the state of Oregon, and more specifically to the Willamette Basin, in which the MFW watershed is located. This is particularly important because water quality standards vary not only by state, but sometimes also by geographic location or hydrologic basin within the state.

Phase 2: Examined and compared water quality monitoring plans from other watershed councils

My next step involved researching the types of water quality monitoring plans that had already been developed and implemented by other nearby watershed councils. Because the MFWWC was relatively new, it was fortunate in that it could benefit from the experiences of other more established watershed councils in Oregon. I spoke directly with watershed council coordinators and water quality monitoring coordinators and examined their water quality monitoring plans, QAPPs, and summary reports to better understand their goals and objectives, find out how they developed their plans, what kind of monitoring they performed, what type of technical protocols they used to collect and analyze their data, what their QA/QC procedures entailed, whether they partnered with other groups or agencies, and how they reported and used their data. In addition, I also went out into the field with a couple of volunteers to get a feel for exactly what is involved in water quality monitoring; how long it takes, and the difficulty or ease of performing certain tests and following established protocols. I think it is essential for plan developers to go out in the field and actually perform the monitoring tasks that will

be proposed for the program in order to develop a water quality monitoring plan that is feasible for volunteers to undertake.

The primary monitoring plans that I looked at came from three watershed councils in western Oregon: the Long Tom, the McKenzie, and the South Santiam. I selected these watersheds primarily because their water quality monitoring programs have been implemented successfully and have been in existence for several years, as well as the fact that they are in a similar geographic region to the MFW watershed. They served as valuable models from which I could identify and extract useful information and ideas to incorporate in the development of the Middle Fork plan. (For a detailed discussion of the similarities and differences between the plans and their approaches to plan development, see Chapter IV.)

Phase 3: Researched previous water quality studies for the MFW watershed

My next step was to research past water quality studies conducted in the MFW watershed. This process involved numerous phone calls, emails, and web searches for information from the main local, state, and federal government agencies and other groups operating in the watershed, including the EPA, USFS, BLM, COE, Oregon DEQ, Oregon Water Resources Department (Oregon WRD), USGS, ODFW, Lost Creek Watershed Group, City of Springfield, SUB, and Springfield High School. I found sparse information on previous water quality monitoring studies aside from continuous temperature data. I also examined water quality sections of earlier watershed analyses completed by the USFS for some of the upper fifth-field sub-watersheds within the MFW

watershed. Again, results from these analyses focused primarily on water temperature, with occasional references to potential turbidity problems associated with high sediment inputs from timber harvests and old logging roads. I also examined the water quality section of the MFWWC's ongoing watershed analysis for the three lower fifth-field sub-watersheds in another attempt to glean any other historical information related to water quality monitoring (I found very little). Finally, I reviewed the most recent 305(b) and 303(d) list produced by the Oregon DEQ to find out the current listing status of the streams within the MFW watershed and get a sense of what streams had been monitored in recent times. The 1998 303(d) list for Oregon classified 15 stream reaches in the watershed as impaired, all listed for summertime violations of the temperature standard (see Table 4).

TABLE 4. Oregon's Final 1998 Water Quality Limited Streams - 303(d) List
Basin: Willamette, Sub-basin: Middle Fork Willamette

Name of Stream	Description	Parameter	Criteria	Season
Coal Creek	Mouth to Headwaters	Temperature	Rearing 64°F (17.8°C)	Summer
Fall Creek	Mouth to Fall Creek Reservoir	Temperature	Rearing 64°F (17.8°C)	Summer
Fall Creek	Fall Creek Reservoir to Headwaters	Temperature	Rearing 64°F (17.8°C)	Summer
Hills Creek	Reservoir to Juniper Creek	Temperature	Rearing 64°F (17.8°C)	Summer
Mike Creek	Mouth to Headwaters	Temperature	Rearing 64°F (17.8°C)	Summer
Monterica Creek	Mouth to Headwaters	Temperature	Rearing 64°F (17.8°C)	Summer
Packard Creek	Mouth to T22S, R2E, S24, SW1/4	Temperature	Rearing 64°F (17.8°C)	Summer

Name of Stream	Description	Parameter	Criteria	Season
Portland Creek	Mouth to Logan Creek	Temperature	Rearing 64°F (17.8°C)	Summer
Salt Creek	Mouth to South Fork of Salt Creek	Temperature	Rearing 64°F (17.8°C)	Summer
Middle Fork Willamette River	Mouth to Dexter Lake	Temperature	Rearing 64°F (17.8°C)	Summer
Middle Fork Willamette River	Hills Creek Lake to Staley Creek	Temperature	Rearing 64°F (17.8°C)	Summer
N Fk Middle Fk Willamette R	Mouth to Cristy Creek	Temperature	Rearing 64°F (17.8°C)	Summer
Winberry Creek	Mouth to North/South Confluence	Temperature	Rearing 64°F (17.8°C)	Summer
North Fork Winberry Creek	Mouth to Blanket Creek	Temperature	Rearing 64°F (17.8°C)	Summer
South Fork Winberry Creek	Mouth to Monterica Creek	Temperature	Rearing 64°F (17.8°C)	Summer

Source: Oregon DEQ, <http://www.deq.state.or.us/wq/303dlist/303dpage.htm>

Phase 4: Researched current water quality monitoring in the MFW watershed and identified possibilities for collaboration

In this phase, I identified the agencies and other groups currently performing water quality monitoring in the MFW watershed and made note of the type and frequency of sampling parameters, as well as the spatial location of monitoring sites. I found that current water quality monitoring within the watershed also focuses primarily on continuous temperature monitoring, with the exception of some more extensive chemical monitoring being conducted in the lower, more populated portions of the watershed. Results of this research are summarized in tabular format in the QAPP that I wrote (see Appendix E, pages 138-141). While doing this research, I was also able to identify

potential collaboration opportunities with other agencies and groups in the watershed in terms of sharing data and obtaining assistance with analysis of continuous temperature data.

Phase 5: Identified data gaps

Using GIS software, I mapped the locations of current monitoring activity within the watershed and used this information to identify spatial gaps in data or places where monitoring was absent. I tried to understand these data gaps by looking at the land use (public vs. private) and spatial location in the watershed (many places are considered “pristine” and devoid of water quality concerns). There were also gaps in parameters monitored around the watershed. Only a few sites in the lower portion of the watershed were monitored for the basic suite of water quality parameters (e.g. water temperature, turbidity, pH, DO, and conductivity). Most other monitoring in the watershed was continuous temperature monitoring conducted during the summer by the USFS. These sites were on national forest land in the uppers two-thirds of the watershed. Locating and understanding these data gaps was helpful in identifying monitoring locations that might be most beneficial to include in the MFWWC’s water quality monitoring program (see baseline and continuous temperature monitoring site maps, Appendix E, pages 124 and 129).

Phase 6: Located resources to aid in plan development

I sought out a variety of resources to aid in monitoring plan development, including both written and human resources. The primary written documents that I relied

upon were the detailed OWEB *Water Quality Monitoring Technical Guidebook* and the EPA's *The Volunteer's Guide to Quality Assurance Project Plans*. I also used an Oregon DEQ-approved QAPP from another watershed council to refer to as a model. In terms of human resources, I worked primarily with the Oregon DEQ volunteer monitoring coordinator for technical guidance in developing the QAPP document. For input more specific to the MFW watershed, I received advice and suggestions from water quality experts and other agency resource specialists from the USFS Willamette National Forest, BLM, state and local offices of the Oregon DEQ, and SUB about the type and scope of monitoring to consider, methods to use, and location of monitoring sites. I also met with the project manager for the MFW watershed assessment to discuss issues she uncovered in the water quality portion of the assessment and obtain suggestions and ideas for selecting monitoring sites in the lower portions of the watershed. Finally, I worked with the MFW watershed council coordinator, who shared input from other members of the watershed council and local residents. Again, it is extremely valuable to obtain input from agency personnel and watershed residents who have unique familiarity with the watershed and water quality issues.

Phase 7: Developed the water quality monitoring plan document

Based on the data gap analysis performed in Phase 5, I worked with the MFW watershed council coordinator to develop a list of water quality monitoring goals and objectives. Most of the stakeholder or citizen input came to me indirectly via the watershed council coordinator, with the exception of one or two watershed council

meetings where I received some comments and suggestions. Once the major goals and objectives had been established and agreed upon, I wrote the rest of the plan, as specified in the procedures below:

- Identified the main components of water quality monitoring program, which were baseline, continuous temperature, and focused monitoring (see Appendix E, pages 118-119 for a more detailed explanation)
- Worked together with the MFW watershed council coordinator and watershed assessment project manager to select potential monitoring sites, taking into consideration factors such as: program objectives and research questions, spatial gaps in monitoring, staff and volunteer resources, funding, and partnership with other agencies
- Designed a sampling plan outlining the type and frequency of parameters to be monitored at each site
- Determined resource needs for monitoring (personnel, equipment)
- Developed a QA/QC component so that sampling procedures would be in line with Oregon DEQ standards and the data collected would be of high enough quality for use by the DEQ in development of water quality reports such as the 303(d) list and 305(b) report
- Determined how the results of monitoring program would be analyzed and summarized

- Determined how the results of monitoring program would be shared and distributed
- Recruited a technical advisory committee to assist in program review and evaluation

Phase 8: Revised the Monitoring Plan as Necessary

I sent the first draft of the plan to local experts and agency personnel from the USFS, BLM, local office of the Oregon DEQ, and SUB for review, comments, and suggestions. After incorporating their feedback into the plan, I sent the completed QAPP to the volunteer monitoring coordinator at the Oregon DEQ for preliminary review. I revised the plan slightly after receiving her comments and resubmitted the plan. Thus, it is important to note that this phase is an iterative process. As ideas are refined and the plan is implemented and data collected, additional changes are expected (e.g., changes to monitoring sites, parameters measured, and frequency of sampling). As noted in the OWEB Watershed Assessment Manual, even well thought out monitoring plans may not work exactly as expected due to reasons including “access limitations, unanticipated high flows, inadequate equipment, or higher variability than anticipated” (Watershed Professionals Network, 1999, p. XI-7). To this list I would also add funding resources and volunteer base. In addition, the QAPP that I wrote specifies that the monitoring plan should be reviewed at least once a year by the technical advisory committee to ensure that it is meeting programs goals.

Results of the Plan Development Process

The QAPP document that I wrote after completing the above development phases was submitted to the Oregon DEQ in February 2002, and subsequently revised and resubmitted in March 2002. The plan was approved and training for MFWWC volunteers occurred on June 8, 2002. The MFWWC is currently in the process of trying to obtain funding from OWEB for a water quality monitoring coordinator.

The steps that I completed during the development process for the MFW water quality monitoring plan were time-consuming and sometimes tedious, but also necessary and worthwhile in order to create a thorough and comprehensive plan that took into account the key components addressed in Chapter IV. It is important to have a good understanding of both water quality principles as well as monitoring methods and sampling design as a foundation to aid in plan development. Research on prior and current water quality monitoring studies within the watershed is essential for determining where data gaps exist and figuring out the most beneficial locations to place monitoring sites. Taking advantage of the expertise of agency resource specialists and the local knowledge of watershed residents strengthens the technical details of the plan and increases the chances of obtaining community support and volunteer participation. Finally, investigating the possibilities for collaboration with other groups or agencies within the watershed may avoid redundant monitoring and has the potential to benefit both parties.

Lessons Learned

In retrospect, I might have done a couple of things differently during the development process for the MFW water quality monitoring plan. First of all, I probably would have contacted water quality monitoring coordinators from nearby watershed councils right from the start before delving into monitoring plan details, because their suggestions and completed plans were extremely valuable models. However, it was still worthwhile to first become familiar with water quality concepts and monitoring plans in general so that I could speak a common language with others in the field.

Secondly, I would have liked to have gotten more direct input from local residents and stakeholders (via watershed council or individual meetings) concerning their thoughts and perceptions of the type and location of water quality problems in the watershed-in addition to the input that I received from agency water quality professionals. Most of the input that I incorporated from local residents came to me indirectly through the watershed council coordinator. Although obtaining direct input may be challenging logistically, it is valuable from both a technical and political basis.

Thirdly, I would have spent more time up front working to identify specific research questions and ensure that the sampling design of the plan was consistent with these questions. The former Oregon DEQ volunteer monitoring coordinator and other monitoring plan guides stress the need to come up with detailed research questions concurrent with plan development. The former Oregon DEQ volunteer monitoring coordinator has identified the lack of explicit questions as one of the major weaknesses of

volunteer water quality monitoring plans that she has evaluated in her position (Karen Williams, personal communication, May 2, 2002).

Finally, I would have spent more time at the beginning of the process trying to locate helpful resources to aid in plan development. It was not until I was writing the plan that I discovered a number of additional valuable online resources and publications relating to volunteer water quality monitoring. I am hoping to address this issue and save other volunteer groups some time and effort through the list of resources at the end of this document (see Appendix F).

CHAPTER VI

SUMMARY OF FINDINGS

Volunteer water quality monitoring programs are extremely diverse in terms of their size, funding sources, goals and objectives, sampling designs, QA/QC procedures, data uses and users, and collaborating partners. They range from large national umbrella organizations such as the Save Our Streams program of the Izaak Walton League, which focuses on providing training and technical assistance to monitoring programs getting started; to state volunteer monitoring programs, which typically coordinate volunteer water quality monitoring activities across a state and provide technical guidance on writing a plan customized for state-specific issues; to much smaller local volunteer groups that are focused on monitoring a local stream or tributary to increase educational awareness or identify local restoration projects.

Although volunteer water quality monitoring plans may differ significantly in size and scope, there are a number of key components that are or should be common to any comprehensive and effective plan. Based on research, interviews, and personal experience, I have found that, of these components, the two most important elements are concentrating on goals, objectives, and research questions and identifying data uses and users.

There are numerous resources, both in print and online, designed to help volunteer groups develop well-written, comprehensive water quality monitoring plans. These include resources explaining water quality concepts and standard field collection protocols, how to create study designs and QAPPs, and how to summarize, analyze, and report field data. In addition, the EPA and some individual state agencies provide volunteer monitoring coordinators to assist volunteer groups who wish to start water quality monitoring programs. Conferences are also extremely valuable resources for learning about water quality monitoring concepts, obtaining ideas for water quality monitoring programs, and networking with other water quality monitoring coordinators.

One of the biggest challenges faced by volunteer water quality monitoring programs in terms of data use is convincing state, federal, and other planning agencies to accept their data as credible. Any volunteer monitoring program that is funded by the EPA is required by law to have an EPA-approved QAPP (US Environmental Protection Agency, 1996). Traditionally, some agencies have been skeptical about the quality of data collected by volunteers. However, it is becoming increasingly common for volunteer monitoring groups to write detailed QAPPs that are submitted and approved by the state and/or the EPA. Having a good QAPP ensures that data is collected and analyzed following certain standard procedures and increases the likelihood that states and federal agencies will accept and use volunteer data. Individual states have differing requirements for when and how volunteer data may be used. A handful of states even have data credibility laws that formally outline these criteria. (For an example, see Iowa's Code at <http://www.iowater.net/arc1351b.pdf>.)

Currently, the majority of states have incorporated volunteer data into their 305(b) reports. While this initial trend is positive and hopeful, it remains to be seen whether or not volunteer programs will be able to produce data that will ultimately be very useful to agencies and continue to be incorporated into water quality assessments in the longer-term future. We are at the cusp of a real revolution in volunteer water quality monitoring. With robust QA/QC plans and well-trained volunteers using standard procedures similar to those used by government and professional water quality monitoring agencies, volunteer monitoring programs have the potential to produce high quality data on virtually equal footing with professional data. As this previously-untapped resource is being used more and more frequently, it is essential that the government and other organizations continue to fund volunteer programs and provide necessary technical assistance. The surge in volunteer water quality monitoring across the nation is indicative of a real interest and concern for protecting and restoring our nation's waters and should not be taken for granted or ignored. Stewardship of our environmental resources is critical for future generations and can only work with the support of both government and planning agencies and the surrounding citizen base.

APPENDIX A

LIST OF ACRONYMS

AASF – Adopt-a-Stream Foundation
BLM – Bureau of Land Management
COE – Corps of Engineers, US Army
DEQ - Department of Environmental Quality
DEM – Department of Environmental Management
DEP - Department of Environmental Protection
DMR – Discharge Monitoring Report
DNREC – Delaware Department of Natural Resources and Environmental Control
DO – Dissolved Oxygen
DQO – Data Quality Objectives
EMAP – Environmental Mapping Assessment Program
EPA – Environmental Protection Agency
GIS – Geographic Information Systems
ITFM – Intergovernmental Task Force on Monitoring Water Quality
MFW – Middle Fork Willamette
MFWWC - Middle Fork Willamette Watershed Council
NAWQA – National Water Quality Assessment Program
NASQAN – National Stream Quality Accounting Network
NGO – Non Governmental Organization
NOAA – National Oceanic and Atmospheric Administration
NPDES - National Pollutant Discharge Elimination System
NWQMC – National Water Quality Monitoring Council
NRCS – Natural Resource Conservation Service
ODFW – Oregon Department of Fish and Wildlife
OWEB – Oregon Watershed Enhancement Board

QA/QC – Quality Assurance / Quality Control

QAPP – Quality Assurance Project Plan

SOS – Save Our Streams

SUB – Springfield Utility Board

TMDL – Total Maximum Daily Load

USFS – US Forest Service

USFWS – US Fish and Wildlife Service

USGS – US Geological Survey

WRD – Water Resources Department

APPENDIX B

INTERVIEW QUESTIONS

The following questions were the basis for the interviews that I conducted with contacts from the Long Tom, McKenzie, and South Santiam Watershed Councils.

1. When was your water quality monitoring program implemented?
2. What spurred the development of your water quality monitoring program (watershed assessment results, specific known water quality problems within the watershed, etc.)?
3. What are the overall goals and objectives of your program, how were they developed, and who developed them?
4. Are there specific research questions that you are trying to answer? How were these arrived at?
5. Who wrote the actual water quality monitoring plan? What was it based on (models from EPA or DEQ, other watershed councils, etc.)?
6. Did the author of the plan research previously-conducted water quality studies in the watershed? What kinds of studies were found, and were they useful in understanding current conditions?
7. How did the specific land uses in your watershed influence the development of your water quality monitoring program? What about hydrology? Dams? Major pollutant sources? Others?
8. Are there 303(d) listed streams in your watershed? If so, what are they listed for? Are they currently being monitored, and by whom?
9. What type of data are you collecting (chemical, physical, biological parameters)?

10. What is the data collected being used for (baseline information, trending, screening, etc.)?
11. Does your water quality monitoring program have a written quality assurance project plan? Is it approved by either the Oregon DEQ or the EPA?
12. Has the data from your program been submitted to the Oregon DEQ or other agencies for use in research or planning?
13. How is the data from your program being used, and by whom?
14. Do you produce a periodic report summarizing your data and program status? To whom is it distributed? Who assembles this report? How is the analysis/format chosen?
15. Do you have a website describing your program and/or displaying data?
16. Do you have some sort of technical advisory committee to evaluate the program?
17. Are there any agencies currently performing water quality monitoring in the watershed? Are you able to assist and/or partner with them?
18. Were funding and resources major factors in the design of your water quality monitoring program? How is your program currently funded, and where did you obtain monitoring equipment?
19. Who is responsible for the overall organization and implementation of the program (water quality monitoring coordinator, watershed council coordinator, volunteers)?
20. Has the program been implemented as planned? Have you run into any major problems in terms of resources, or the actual data sampling/collection process?
21. Do you have any changes or additions planned for the program in the future?
22. What was the most helpful resource(s) in the development of this program (other watershed council, agency personnel, technical guides, etc.)?
23. Are there any suggestions that you have for groups who are interested in developing volunteer water quality monitoring programs?

APPENDIX C

GOALS AND OBJECTIVES OF THREE WATER QUALITY MONITORING PROGRAMS

Long Tom Watershed Council

Goals of the Baseline Water Quality Monitoring Study:

- Assess water quality in many portions of the basin that currently have no regular monitoring.
- Refine our understanding of water quality in each sub-basin.
- Prioritize areas/sub-basins in need of water quality improvement.
- Prioritize types of restoration/enhancement activities.
- Identify additional water quality studies if necessary.
- Provide opportunities to educate and involve local landowners, residents, and high-school age youth in water quality monitoring and analysis.
- Share water quality information with stakeholders and decision-makers.
- Evaluate water quality issues identified on 303(d) list.
- Utilize data to identify and prioritize restoration and enhancement project sites in accordance with activities the Council is engaged in under the Watershed Restoration Project Prioritization program (an EPA funded grant).

Source: Long Tom Water Quality Monitoring Program Final Report for 1999-2001, August 25, 2001.

McKenzie Watershed Council

Objectives of the Tier I Ambient Water Quality Monitoring Program:

- Monitor the overall health of the McKenzie River.
- Determine if and how water quality is changing over time, accounting for natural and seasonal variation.
- Determine spatial distribution of water quality conditions throughout the basin.
- Determine temporal variability, both short- and long-term, of water quality conditions.
- Provide credible data upon which management decisions can be made.
- Provide an affordable and sustainable measurement tool to evaluate the effectiveness of action steps taken to protect/enhance the water quality of the McKenzie River.
- Provide an early warning system to signal if any adverse trends are developing.
- Utilize historical data, as much as practicable, to develop longer trends.

Source: <http://www.mckenziewatershedcouncil.org/waterQM.html>

South Santiam Watershed Council

Water Quality Monitoring Program Objectives:

- Provide water quality education for citizens, especially young people.
- Measure baseline conditions and trends for the South Santiam and its tributaries.
- Provide water quality information to decision makers: ODEQ, EPA, BLM, USFS, SSWC.
- Identify problems areas and concerns in the watershed.
- Involve watershed landowners and people in watershed assessment.
- Test compliance with ODEQ 303(d) listing for fecal coliform and temperature.

Source: South Santiam Water Quality Monitoring Program: Draft Water Quality Assessment Plan, January 1997.

APPENDIX D

SPECIFIC RESEARCH QUESTIONS

River Watch Sample Research Questions

Source: River Watch

This is a list of common questions addressed by River Watch groups. These questions are general and should be made more specific and tailored to a particular river or stream in order to be effective research questions. For more information about River Watch monitoring, visit them online at: <http://www.riverwatch.org>

Is our river safe to swim in?

What are the impacts of a wastewater treatment plant or possible failing septic systems?

How is a particular construction project affecting the water quality?

Does the water meet state water quality standards?

How do selected indicators in the river change from source to mouth?

How do the dioxins in the sediment from an old paper mill affect water quality?

Oregon DEQ: Developing Sample Research Questions

Source: Karen Williams, former Volunteer Monitoring Coordinator, Oregon DEQ

This is a list of questions designed to assist volunteer groups in coming up with appropriate monitoring questions for their particular watersheds.

Focus your monitoring by asking specific questions.

Think you don't have enough data to come up with specific questions? Start with broad ones, then work on narrowing the questions to those that can be answered with monitoring data.

Here are some example questions you could ask without having any quantitative data:

How has the stream/watershed changed in the last several years? ("When I was a kid...")

How is the land used in the watershed? What percentage is rural, forested, urban, industrial, agricultural?

What has been the historical land use?

Are there any point sources (treatment plants, industry)?

Are there any "concentrated" non-point sources (storm drains, ditches)?

How is water used in the watershed (irrigation withdrawals, dams)?

What does the stream look like when it rains?

What are the beneficial uses of water in the watershed?

Do people swim or fish in the water body?

How do the river banks look (vegetated, overhanging, eroded, steep...)?

Are there any landslide prone areas?

What is the topography of the watershed? What is the gradient (steepness) of the stream?

How much land does the stream drain? How long is the stream?

What is the geology of the watershed?

Does the stream change course significantly in different seasons?

Is the water body listed as being "water quality limited" on the 303(d) list? If so, what data is that based on?

Have previous studies been done? What were their conclusions?

Long Tom Water Quality Monitoring Plan: Specific Research Questions

Source: Cindy Thieman, Long Tom Watershed Council

The following is a list of research questions that the Long Tom Watershed Council plans to focus on in their future water quality monitoring.

1. Do the trends we see in the first 2 years of monitoring data continue? What (if any) chronic water quality problems exist in each sub-basin?
2. What are the average loading rates (lbs./acre/year) of each water quality parameter in each sub-basin? Do some sub-basins have higher rates than others?
3. Are *E. coli* loading rates associated with particular stream reaches and/or land use or is the load fairly evenly distributed throughout the basin?
4. How do *E. coli* levels relate to dissolved oxygen and nutrient levels in streams? This may explain whether fecal contamination is a major source of biological oxygen demand and nutrients.
5. Are phosphorus loading rates associated with particular stream reaches and/or land use or is the load fairly evenly distributed throughout the basin? We may be able to estimate background levels of phosphorus and in turn estimate anthropogenic contributions.
6. Are sediment loading rates associated with particular stream reaches and/or land use or is the load fairly evenly distributed throughout the basin?
7. How do sediment and *E. coli* levels driven by storm events compare between sub-basins?
8. What is the relationship between turbidity and total suspended solids/total solids levels? Can we use turbidity to predict TSS/TS in most cases?

APPENDIX E

MIDDLE FORK WILLAMETTE WATER QUALITY MONITORING PLAN

Quality Assurance Project Plan
for the
Middle Fork Willamette Water Quality Monitoring
Program

Prepared by
Nancy Toth
Middle Fork Willamette Watershed Council
Lowell, OR

February 2002

to be determined

Monitoring Coordinator	Signature	Name/Date
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Juan Welsh

Watershed Council Coordinator	Signature	Name/Date
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Technical Advisory Chair

Signature

Name/Date

Karen Williams

DEQ Volunteer Monitoring Coordinator	Signature	Name/Date
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Chris Redman

DEQ Quality Assurance Manager	Signature	Name/Date
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Table of Contents	Page
Distribution List.....	1
Project Task/Organization.....	2
Introduction.....	3
Goals and Objectives.....	3
Problem Definition/Background.....	3
Overall Project Description.....	9
Sampling Process Design.....	10
Methods.....	20
Quality Assurance/Quality Control.....	22
Reporting.....	24
Project Oversight.....	25
Collaboration with Other Agencies	26
Appendix A. Recent Water Quality Studies within the Middle Fork Willamette Sub-Basin.....	27
Appendix B. Standard Operating Procedures for the Middle Fork Willamette Water Quality Monitoring Program.....	31
Appendix C. Field Data Sheet.....	33

List of Tables

Table 1. Oregon's Final 1998 Water Quality Limited Streams – 303(d) List for the Middle Fork Willamette Sub-Basin.....	6
Table 2. Baseline Monitoring Sites.....	11
Table 3. USGS Gauging Stations within the Middle Fork Willamette Watershed.....	12
Table 4. Continuous Temperature Monitoring Sites.....	15
Table 5. Focused Monitoring Sites.....	15
Table 6. Water Quality Monitoring Parameters.....	16
Table 7. Precision, Accuracy, and Measurement Range.....	21

List of Figures

Figure 1. Middle Fork Willamette Fifth-Field Watersheds.....	5
Figure 2. Baseline Monitoring Sites in the Middle Fork Willamette Watershed.....	13
Figure 3. Continuous Temperature Monitoring Sites in the Middle Fork Willamette Watershed.....	18
Figure 4. Focused Monitoring Sites in the Middle Fork Willamette Watershed.....	19

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Introduction

This document presents an overview of the Middle Fork Willamette (MFW) Watershed and describes the goals and objectives of the Middle Fork Willamette Watershed Council's proposed water quality monitoring program. It outlines the program's main components, sampling design, and quality assurance/quality control procedures, and describes the planned analysis and use of the water quality data in future decision-making processes.

Goals and Objectives

Due to the fact that limited water quality data exists for the MFW sub-basin (see discussion below), the Middle Fork Willamette Watershed Council (MFWWC) would like to perform some inventory monitoring to gain baseline information about water quality in the sub-basin and further define future monitoring goals.

The MFWWC Water Quality Monitoring Program objectives are as follows:

- Establish baseline water quality conditions across the entire watershed.
- Evaluate water quality trends over time.
- Identify potential problem areas within the watershed that may warrant further study.
- Monitor trends in water quality for stream reaches listed on the 303(d) list.
- Educate local residents, landowners, and youth in water quality issues and monitoring techniques and analysis.
- Integrate water quality data from other groups currently performing monitoring within the watershed (USFS, BLM, high school groups, etc.).
- Provide and present credible water quality data to watershed council decision makers, citizens, and government agencies.
- Provide credible water quality data to the watershed council to be used in the development of an overall watershed action plan and the prioritization of restoration/enhancement activities.

Problem Definition/Background

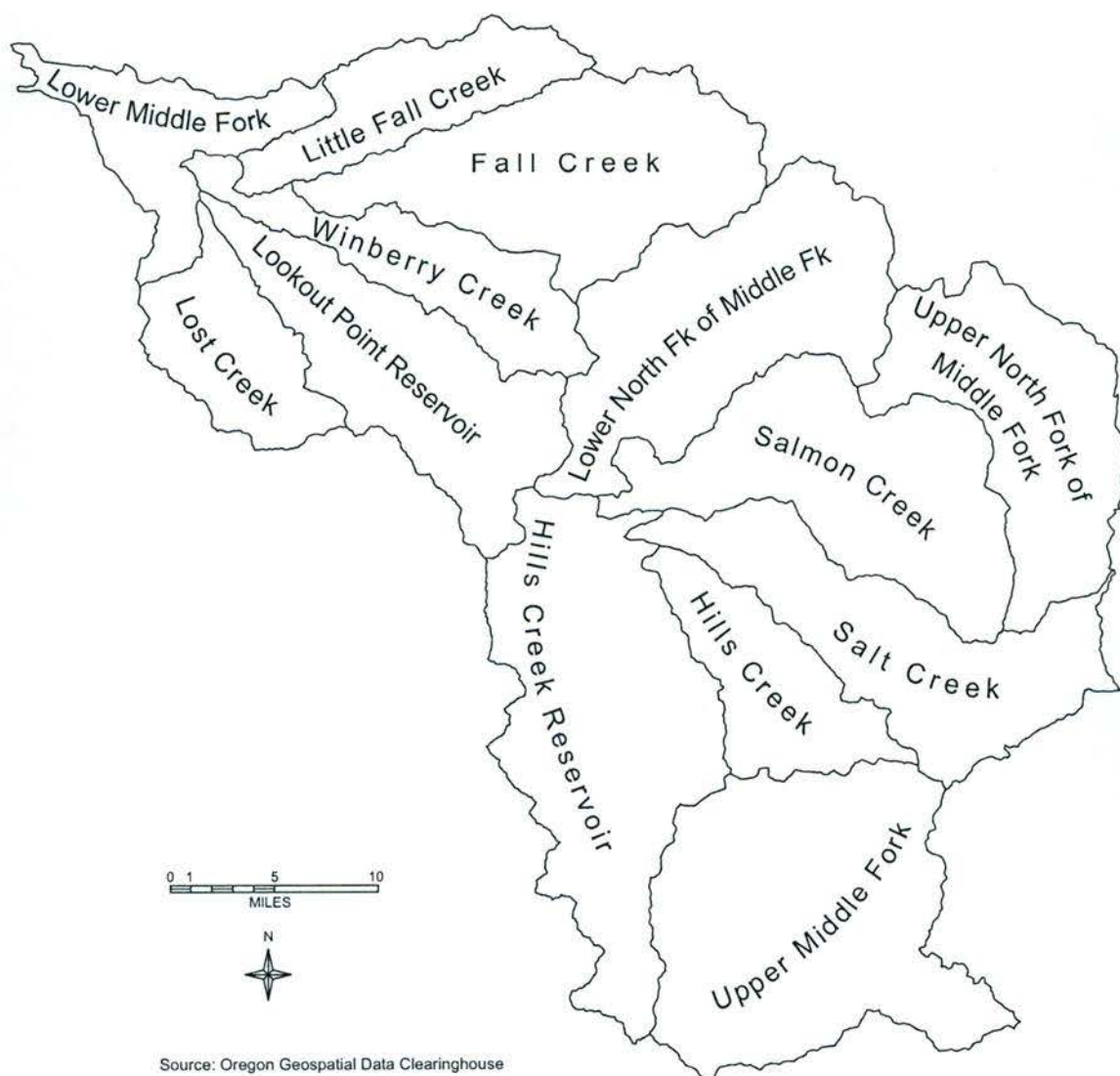
The Middle Fork Willamette watershed is a USGS fourth-field sub-basin covering over 870,000 acres and comprised of thirteen fifth-field watersheds (*see Figure 1*), located just southeast of the

Eugene-Springfield metropolitan area on the western side of the Oregon Cascades. The USDA Forest Service (USFS) manages approximately two-thirds of the sub-basin. The remaining one-third is a mixture of rural residents (including farmers and ranchers), private timber companies, the State of Oregon (Departments of Forestry and Parks and Recreation), US Army Corps of Engineers (COE), USDI Bureau of Land Management (BLM), and cities and communities (Oakridge, Lowell, Dexter, Westfir, Jasper, Fall Creek, and portions of south Springfield and Pleasant Hill). Three major flood control dams and one re-regulating reservoir are located within the watershed and have significantly reduced native fish populations by blocking and/or severely limiting upstream and downstream fish passage for anadromous fish species. Currently, there are 15 stream segments within the watershed that were listed in the 1998 Water Quality Limited 303(d) report produced by the Oregon DEQ for elevated temperatures (*see Table 1*).

The Middle Fork Willamette Watershed Council was formed in 1999 and is currently in the process of completing a watershed assessment for the three lower fifth-field watersheds: Lost Creek, Little Fall Creek, and the Lower Middle Fork of the Willamette. Other watershed assessments/analyses have been conducted by the USFS, BLM, and Weyerhaeuser between 1995 and 1997. There is a need to integrate and analyze water quality information from these sources on a basin-wide scale, but this has not been done to date.

As mentioned above, elevated stream temperatures are a primary water quality concern for this watershed, as they can adversely affect the survival of fish populations. Three species of fish in the watershed currently appear on the Endangered Species List: spring chinook (threatened), bull trout (threatened), and the Oregon chub (endangered). In addition to the streams on the DEQ 303(d) list, the watershed assessment conducted in the lower watersheds has identified other reaches that exceed state water temperature standards for salmonid rearing during the summer low flow season. USFS assessments have indicated potential turbidity problems in some areas due to both land management activities (logging, road construction) and natural sources.

Figure 1. Middle Fork Willamette Fifth-Field Watersheds



Finally, some watershed residents have expressed concerns to the watershed council about possible *E. coli* and nutrient problems in isolated areas in the lower portion of the watershed (particularly in areas of rural residential and agricultural land use).

Table 1. Oregon's Final 1998 Water Quality Limited Streams - 303(d) List for the Middle Fork Willamette Sub-Basin

Name of Stream	Description	Parameter	Season
Coal Creek	Mouth to Headwaters	Temperature	Summer
Fall Creek	Mouth to Fall Creek Reservoir	Temperature	Summer
Fall Creek	Fall Creek Reservoir to Headwaters	Temperature	Summer
Hills Creek	Reservoir to Juniper Creek	Temperature	Summer
Mike Creek	Mouth to Headwaters	Temperature	Summer
Monterica Creek	Mouth to Headwaters	Temperature	Summer
Packard Creek	Mouth to T22S, R2E, S24, SW 1/4	Temperature	Summer
Portland Creek	Mouth to Logan Creek	Temperature	Summer
Salt Creek	Mouth to South Fork of Salt Creek	Temperature	Summer
Middle Fork Willamette River	Mouth to Dexter Lake	Temperature	Summer
Middle Fork Willamette River	Hills Creek Lake to Staley Creek	Temperature	Summer
N Fk Middle Fk Willamette R	Mouth to Cristy Creek	Temperature	Summer
Winberry Creek	Mouth to North/South Confluence	Temperature	Summer
North Fork Winberry Creek	Mouth to Blanket Creek	Temperature	Summer
South Fork Winberry Creek	Mouth to Monterica Creek	Temperature	Summer

Source: Oregon DEQ, <http://www.deq.state.or.us/wq/303dlist/303dpage.htm>

A variety of water quality studies have been conducted in the Middle Fork Willamette watershed during the past fifty years by different agencies including the USFS, Oregon Department of Environmental Quality (Oregon DEQ), COE, and BLM. The majority were short-term studies that focused on a specific issue and are not ongoing. The Oregon DEQ currently maintains a statewide ambient water quality monitoring network of approximately 150 sites. Results from

this monitoring have indicated that water quality in the Middle Fork Willamette is high relative to many other fifth-field sub-basins in the state.¹ However, there is only one ambient monitoring site in the Middle Fork Willamette which is located in the lower portion of the watershed (Middle Fork Willamette at Jasper Bridge) and thus does not capture any spatial variability in water quality conditions. Many of the most recent studies conducted by the USFS and BLM have concentrated primarily on summertime continuous temperature monitoring in the watershed and have identified a number of stream reaches where the 7-day moving average exceeded state temperature standards. There is currently very limited data on water quality parameters other than temperature. The only regular water quality monitoring of a variety of parameters is being conducted in the lower portion of the MFW watershed. This consists of the Oregon DEQ ambient monitoring site at Jasper Bridge, a few sites on the Springfield Mill Race monitored by Springfield High School students, and a set of sites being monitored by volunteers from the Lost Creek Watershed Group. In addition, the Springfield Utility Board (SUB) has conducted one year of water quality monitoring near the mouth of the Middle Fork as part of a drinking water treatment process design. (This sampling has been temporarily suspended but will resume when their treatment plant is completed in October 2002.) (*see Appendix A for a list of recent studies*) Thus, due to the spatially-limited nature of water quality data that exists, there is a need to establish baseline water quality monitoring on representative sites across the entire watershed.

The MFWWC is proposing a three-part water quality monitoring program targeted to begin in the summer of 2002.

Components of the monitoring program are as follows:

1. A *baseline water quality monitoring* component which will begin to address existing data gaps on water quality, establish reference conditions, illustrate any spatial variability in water quality across the watershed, and act as a screening mechanism to identify problems areas that may warrant more focused studies in the future. Baseline monitoring parameters will include temperature, turbidity, pH, conductivity, dissolved oxygen, and stage height or flow.

¹Cude, C.G., 1997. Oregon Water Quality Index Report for Upper Willamette Basin (Water Years 1986-1995). Oregon Department of Environmental Quality, Portland, OR.
(website: <http://www.deq.state.or.us/lab/WQM/WQI/upwill/upwill3.htm>)

2. A *continuous temperature-monitoring* component to track summertime temperatures of both 303(d) listed streams and other sites that may be similarly impaired.
3. A *focused monitoring* component that will address other water quality parameters (namely *E. coli*, nutrients) that are of concern in a particular area or land use category within the watershed.

The data collected through this program will be integrated with results from other monitoring groups within the watershed and used to provide an overall picture of current water quality conditions in the MFW watershed.

Data will be used in the following ways:

- *Watershed characterization:* Monitoring results will help to provide an overall picture of current water quality conditions across the entire watershed and will be used to establish baseline/reference conditions.
- *Trends in water quality:* As more and more data is collected over time, we will be able to investigate trends in water quality throughout the watershed.
- *Warning signal:* Monitoring results may be indicators of water quality problems which need to be investigated further, either through volunteer monitoring or by state or federal agencies.
- *Support data gathering efforts by Oregon DEQ:* Data will be submitted to the Oregon DEQ for evaluation in the creation of their 303(d) reports and development of TMDLs.
- *Decision-making:* Water quality monitoring results will contribute important information to the watershed council that can aid in the development of their overall action plan and prioritization of restoration activities within the watershed.
- *Education:* Results from the water quality monitoring will also be used to educate volunteers, youth, and other members of the community about water quality issues in the watershed.

In addition, to obtaining baseline measurements for all parameters, specific questions to be answered with the monitoring data include the following:

- 1) Which continuous temperature monitoring sites exceed Oregon water quality standards for temperature during the summer low flow season? At what time of day do maximum temperatures occur?
- 2) Do the current 303(d) listed streams still violate state water temperature standards? (If they do not, there may be potential for a de-listing in the future.)
- 3) Is there a significant difference in turbidity measured at the mouths of major tributaries under various flow conditions, specifically between low flow and high flow time periods?
- 4) Is there a significant difference in baseline turbidity values among monitoring sites located throughout the watershed?
- 5) What type of relationship exists between turbidity values and flow conditions?
- 6) Where and at what time of year are dissolved oxygen standards violated, if at all? Do such violations appear to correspond with high temperatures and/or low flow?
- 7) Which focused monitoring sites exceed Oregon water quality standards for *E. coli* bacteria?
- 8) Do nutrient concentrations at the focused monitoring sites correspond at all with diurnal pH and DO measurements (especially in the late spring – summer time period)?

Overall Project Description

The MFWWC's proposed water quality monitoring program will commence in the late spring/early summer of 2002 and run year-round. Volunteers will be recruited during the spring by the MFWWC and ideally consist of watershed council members, local landowners and residents, and students from local schools. A formal training session led by the Oregon DEQ will be conducted for volunteers prior to the beginning of the program.

The program will be overseen by a Water Quality Monitoring Coordinator, whose main responsibilities include coordinating all volunteer monitoring efforts, working with government agencies and other groups within the watershed to obtain and integrate their water quality data, producing an annual report summarizing and analyzing results from the monitoring program, and working with the Technical Advisory Committee to review, evaluate, and make any necessary changes to the existing monitoring program. The MFWWC Technical Advisory Committee is a

small group of people consisting of representatives from state and federal agencies and other local experts who are committed to making the design and implementation of a scientifically credible water quality monitoring program.

Volunteers will take monthly or bi-monthly water quality measurements of temperature, turbidity, pH, conductivity, and dissolved oxygen at all baseline sites within the watershed, as well as read stage measurements of stream height and make a qualitative assessment of flow. Continuous temperature will be monitored from the beginning of June through the end of September at eleven sites in the lower portion of the watershed (Lost Creek, Lower Middle Fork Willamette, Fall Creek, and Little Fall Creek fifth-field watersheds) in places where the USFS, BLM, and Lost Creek Watershed Group do not have monitoring sites. The Water Quality Monitoring Coordinator will sample four sites in the lower portion of the watershed on a monthly basis for nitrate-nitrite, ortho-phosphate, and *E. coli* bacteria.

Sampling Process Design

As described above, the MFWWC's proposed water quality monitoring program will consist of three primary components. We worked in conjunction with both the USFS Willamette National Forest District and the local DEQ office in Eugene to develop a manageable system of baseline monitoring. This consists of a representative set of sites in the watershed that will be sampled on a monthly or bi-monthly basis. In the upper fifth-field watersheds, which are primarily Forest Service land, we chose monitoring sites at the mouths of major tributaries. Because large reservoirs can have significant impacts on flow and water quality (especially temperature), we chose to include sites upstream and downstream of the major reservoirs in the watershed. We also selected a site located in the bull trout reintroduction area of the Upper Middle Fork of the Willamette and a relatively undisturbed site on the North Fork of the Middle Fork of the Willamette (a wild and scenic river). For the lower fifth-field watersheds, we also selected sites at the mouths of a few of the major tributaries (*see Table 2*). Finally, as mentioned above, the following groups currently perform some type of baseline water quality monitoring in the MFW watershed: Lost Creek Watershed Group, DEQ, Springfield High School students, and SUB (starting in October 2002). We plan to incorporate summarized results from these groups into our own analysis and reporting of water quality conditions in the MFW watershed. (*see Figure 2 for map of proposed and existing sites*)

Table 2. Baseline Monitoring Sites

Site Name	ID	Type	Latitude	Longitude	Elevation (ft)
Mouth of Hills Creek, Lower Mid Fork	LM1	mouth of major tributary	43.99600	-122.90400	579
Mouth of Rattlesnake Creek	LM2	mouth of major tributary	43.97100	-122.89019	594
Mouth of Little Fall Creek	LF1	mouth of major tributary	43.95800	-122.81200	651
Fall Cr above Fall Cr Reservoir	FC1	upstream of reservoir	43.97342	-122.57031	932
Mouth of Fall Creek	WC1	mouth of major tributary, downstream of reservoir	43.97200	-122.86100	603
Winberry Creek near Lowell	WC2	upstream of reservoir	43.91400	-122.68750	892
Middle Fork Willamette above Lookout Point Reservoir	LP1	upstream of reservoir	43.80140	-122.55970	
Mouth of North Fork of Middle Fork Willamette	NF1	mouth of major tributary	43.75886	-122.51525	1092
North Fork of Middle Fork Willamette, near Cayuse Creek	NF2	reference site, relatively undisturbed	43.86900	-122.17061	2527
Mouth of Salmon Creek	SM1	mouth of major tributary	43.74097	-122.45644	1318
Mouth of Salt Creek	SC1	mouth of major tributary	43.72600	-122.43600	1283
Mouth of Hills Creek	HC1	mouth of major tributary	43.67800	-122.36700	1750
Middle Fork Willamette below Hills Creek	HR1	downstream of reservoir	43.72106	-122.43822	1295
Middle Fork Willamette above Hills Creek Reservoir	HR2	upstream of reservoir	43.59736	-122.45614	1663
Middle Fork Willamette, above Bechel Creek	UM1	bull trout reintroduction area	43.50072	-122.31383	2506

The other main consideration that we used in selecting our monitoring sites was the location of current and historical US Geological Survey (USGS) gauging stations in the Middle Fork

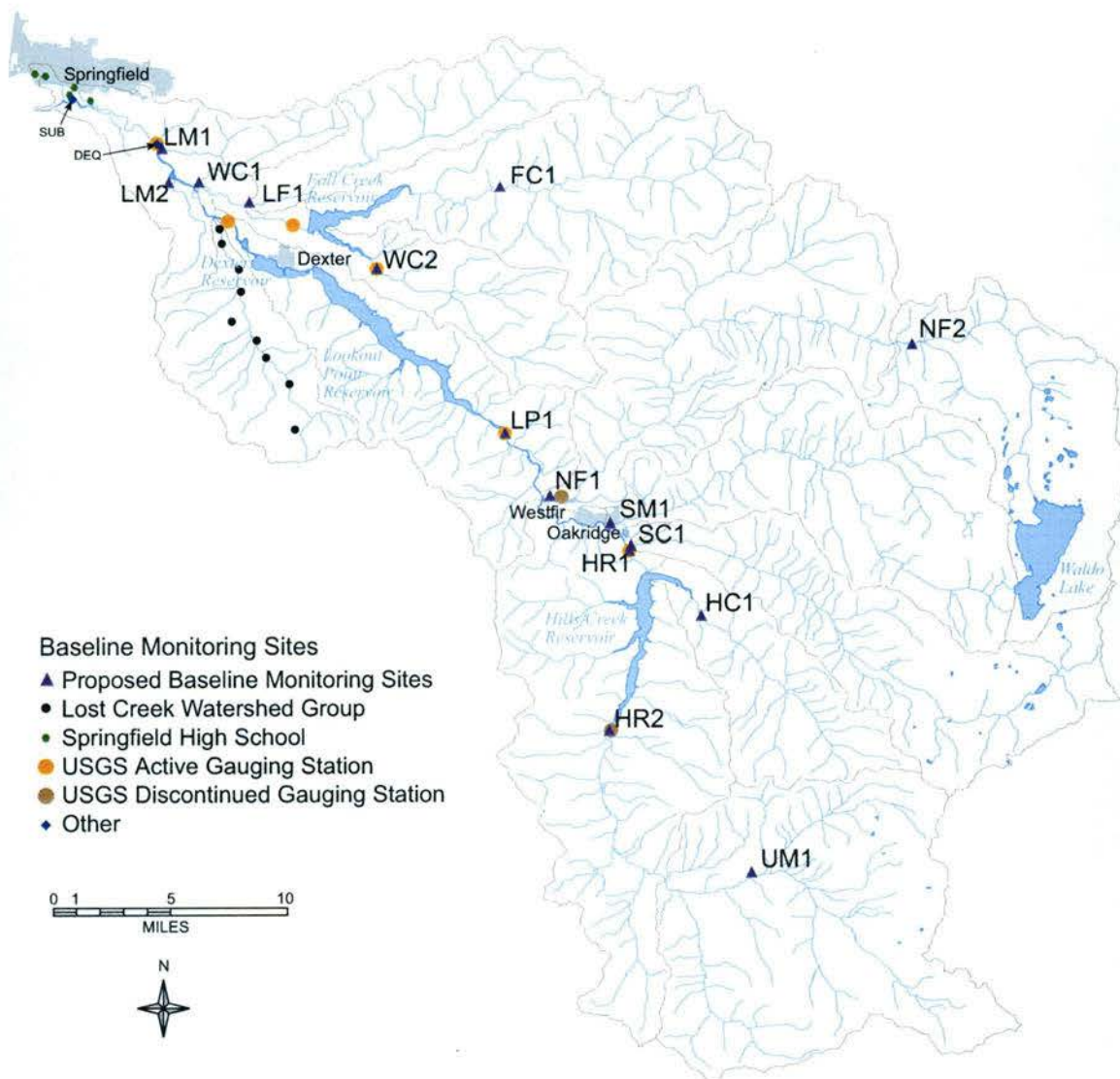
Willamette watershed. We recognize the importance of flow in the analysis and interpretation of water quality data and would like to incorporate flow measurements for our monitoring sites wherever possible. This will improve the quality of our data and capitalize on flow data that is currently being measured, reducing the amount of flow measurements that we would have to take for our monitoring sites. The USGS currently maintains six gauging stations within the watershed. Three of these stations are telemetered and real-time discharge data is available online at the USGS website. Discharge measurements for the other three stations are collected and posted periodically on the USGS website. In addition, two other recently discontinued stations are located at or near two of our proposed baseline monitoring sites (*see Table 3*).

Table 3. USGS Gauging Stations within the Middle Fork Willamette Watershed

USGS Station #	Station Name	Latitude	Longitude
14145500	M F WILLAMETTE R AB SALT CR., NR OAKRIDGE, OREG	43.72222	-122.43750
14148000	MF WILLAMETTE RIVER BLW N FORK, NR OAKRIDGE, OR.	43.80139	-122.55972
14150000	MIDDLE FORK WILLAMETTE RIVER NEAR DEXTER, OREG.	43.94583	-122.83611
14150800	WINBERRY CREEK NEAR LOWEL, OR	43.99833	-122.68750
14151000	FALL CREEK BLW WINBERRY CREEK, NEAR FALL CREEK, OR	43.94444	-122.77361
14152000	MF WILLAMETTE R AT JASPER, OR	43.99833	-122.90472
14144800	MIDDLE FORK WILLAMETTE RIVER NR OAKRIDGE (discontinued)	43.59722	-122.45556
14147500	N FK OF M FK WILLAMETTE R NR OAKRIDGE (discontinued)	43.75833	-122.50833

Source: USGS, http://oregon.usgs.gov/data_dir/datapage.html

Figure 2. Baseline Monitoring Sites in the Middle Fork Willamette Watershed



Sources: Oregon DEQ, USGS, Springfield Utility Board, Springfield High School, Lost Creek Watershed Group, and Oregon Geospatial Data Clearinghouse

Surface water quality measurements for temperature, turbidity, pH, conductivity, and dissolved oxygen will be collected every other month on a rotating basis for ten baseline sites located within the upper portion of the watershed where the water quality is thought to be relatively high. (Logistically, sampling will alternate between five of these sites one month, and the other five sites the next month.) In addition, five sites in the lower portion of the watershed, where there are more intensive human impacts, will be sampled on a monthly basis. Ambient conditions such as air temperature, weather, water color, vegetation, qualitative assessment of flow, etc. will also be recorded as field notes for each site at the time of sampling. Volunteers will be asked to take a simple stage measurement of stream height for sites not located at or near USGS gauging stations. (This may involve either reading an installed staff gauge or measuring the distance from a bridge to the surface of the stream.) This information can at least provide a very rough estimate of flow in the absence of a useable rating curve. It is our intent that the monitoring coordinator will take discharge measurements during the year at varying levels of flow (at sites not near USGS gauging sites) in order to construct rating curves. Stage heights read by the volunteers can then be used to estimate flow at the time of sampling. Estimates of stream flow should improve as more flow measurements are taken and points are added to the rating curve. We recognize that the development of an accurate rating curve is a long and involved process. Our intent is to partner with other agencies such as the Water Resources Department and USFS and take advantage of their expertise and perhaps equipment in order to gradually develop these rating curves.

As mentioned previously, the USFS maintains a fairly comprehensive network of continuous temperature monitoring sites in the upper portion of the watershed. In addition, the BLM and Lost Creek Watershed Group currently monitor a number of continuous temperature sites in the lower part of the watershed. This monitoring is conducted during the summer low flow season (approximately June through the end of September). The MFWWC water quality monitoring program will conduct similar summertime continuous temperature monitoring at eleven sites within the watershed. These sites will be comprised of our 5 baseline sites not on USFS land plus an additional 6 sites selected in an attempt to fill in some of the spatial gaps in continuous temperature monitoring in the watershed (*see Table 4 and Figure 3*). Summarized continuous

temperature results from the USFS, BLM, and Lost Creek Watershed Group will be incorporated into the MFWWC's annual water quality monitoring report.

Table 4. Continuous Temperature Monitoring Sites

Site Name	ID	Latitude	Longitude
Mouth of Hills Creek, Lower Mid Fork	cLM1	43.99600	-122.90400
Middle Fork Willamette at Jasper Park	cLM2	43.98600	-122.89300
Mouth of Rattlesnake Creek	cLM3	43.97100	-122.89019
Middle Fork Willamette above Fall Creek	cLM4	43.96600	-122.86600
Mouth of Little Fall Creek	cLF1	43.95800	-122.81200
Little Fall Creek at Fish Ladder	cLF2	44.01100	-122.63600
Mouth of Fall Creek	cWC1	43.97200	-122.86100
Middle Fork Willamette above Lost Creek near boat ramp	cLP1	43.94900	-122.84300
Carr Creek at Lost Creek road bridge	cLC1	43.86600	-122.81000
Gosage Creek at Lost Creek road bridge	cLC2	43.86000	-122.80500
Mouth of Guiley Creek	cLC3	43.85000	-122.79500

Five sites in the lower part of the watershed have been selected for nutrient and bacteria monitoring due to their agricultural land use and/or proximity to local septic systems (*see Table 5 and Figure 4*). Nutrients, specifically nitrate-nitrite, total phosphorous, and ortho-phosphate, will be measured monthly, along with the six baseline parameters. If possible, the monitoring coordinator may measure pH and DO during both morning and late afternoon (not necessarily on the same day) since these parameters can fluctuate widely throughout the day due to biological activity of algae, for example. These parameters tend to be lower during the early morning and much higher in the later afternoon. *E. coli* will be sampled quarterly, with five sampling periods within a thirty-day period, following DEQ protocol for *E. coli* testing. The MFW water quality monitoring coordinator will be responsible for conducting this monitoring.

Table 5. Focused Monitoring Sites (nutrients and bacteria)

Site Name	ID	Latitude	Longitude
Mouth of Wallace Creek	nLM1	44.00008	-122.90592
Mouth of Hills Creek, Lower Mid Fork	nLM2	43.99600	-122.90400
Mouth of Little Fall Creek	nLF1	43.95800	-122.81200
Mouth of Lost Creek	nLC1	43.94800	-122.84900
Lost Creek below Wagner Creek	nLC2	43.90200	-122.82400

The following table provides a summary of the type, frequency, and method of monitoring each water quality parameter listed above:

Table 6. Water Quality Monitoring Parameters

Number of Sites	Parameters	Sampling Frequency	Data Collection Responsibility	Method
15	Temperature	Monthly or Bi-monthly (10 sites sampled per month)	Monitoring team	Portable field meter
15	Turbidity	Monthly or Bi-monthly (10 sites sampled per month)	Monitoring team	Portable field meter
15	pH	Monthly or Bi-monthly (10 sites sampled per month)	Monitoring team	Portable field meter
15	Dissolved Oxygen	Monthly or Bi-monthly (10 sites sampled per month)	Monitoring team	Winkler titration kit
15	Conductivity	Monthly or Bi-monthly (10 sites sampled per month)	Monitoring team	Portable field meter
15	Stage	Monthly or Bi-monthly (10 sites sampled per month)	Monitoring team	Field measurement or staff gauge reading
11	Continuous Temperature	June 1 – September 30; hourly	Monitoring team and monitoring coordinator	Continuous data loggers
5	E.coli	Quarterly; 5 times/quarter within 30 days	Monitoring coordinator	Samples taken to lab for analysis
5	Nutrients: nitrate-nitrite and ortho-phosphate	Monthly	Monitoring coordinator	Samples taken to lab for analysis

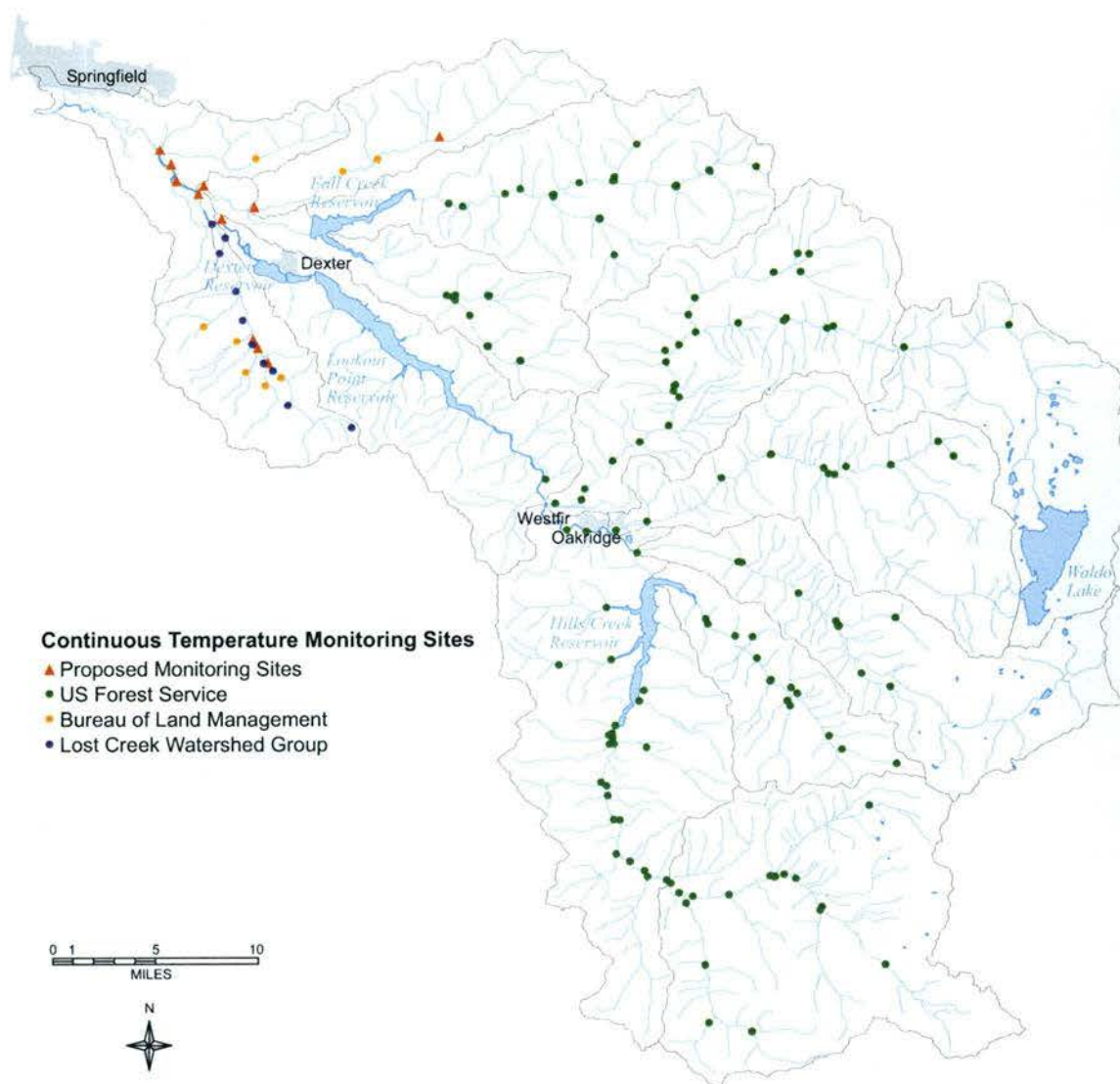
All of our water quality monitoring will be carried out in accordance with the standard protocols outlined in the Oregon Watershed Enhancement Board (OWEB) Water Quality Monitoring Technical Guidebook². The intent is that the data from this monitoring will be of sufficient quality to be used by government agencies in their studies and decision-making processes.

²Oregon Watershed Enhancement Board. 1999. Water Quality Monitoring Technical Guide Book, Oregon Plan for Salmon and Watersheds.

Volunteers will work in groups of at least two people and collect field data monthly over a 2-3 day period during the morning hours, if possible, to ensure consistency with other samplers and attempt to control for diurnal fluctuations in parameters such as dissolved oxygen. If volunteers are unable to conduct their scheduled monitoring for any reason, they should contact the monitoring coordinator as soon as possible so that arrangements can be made for a substitute.

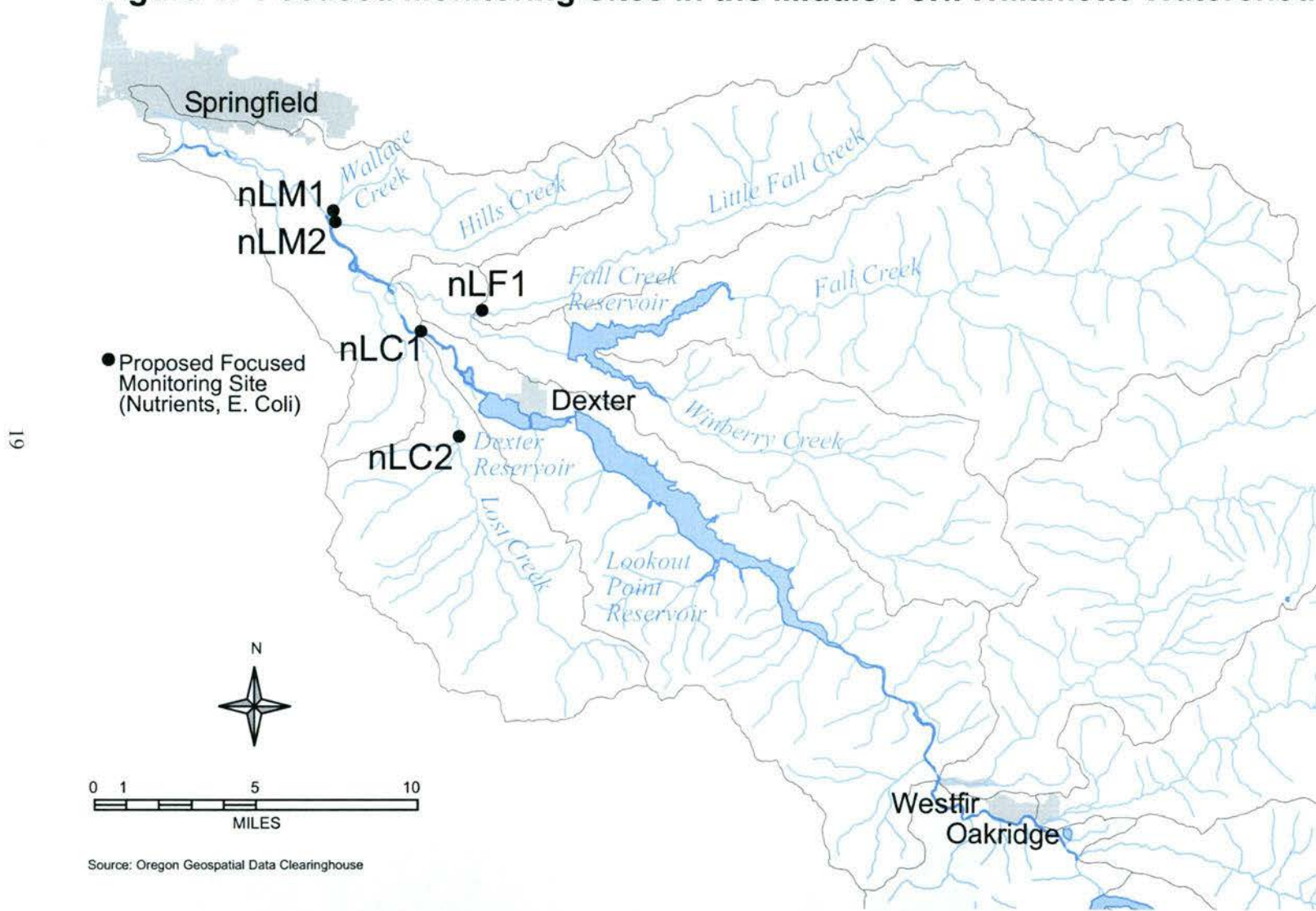
Volunteers will be trained in water quality monitoring procedures prior to participation in the program and will be given written sampling protocols to follow. In addition, they must also adhere to the safety precautions outlined by the MFW water quality monitoring program (*see Appendix B*). A couple of the baseline monitoring sites in the upper portions of the watershed may be difficult to access in the winter due to snowfall and road closures, and volunteers must make a judgment call as to whether or not it is safe to conduct field monitoring during their scheduled time.

Figure 3. Continuous Temperature Monitoring Sites in the Middle Fork Willamette Watershed



Sources: USFS, BLM, Lost Creek Watershed Group, and Oregon Geospatial Data Clearinghouse

Figure 4. Focused Monitoring Sites in the Middle Fork Willamette Watershed



Methods

All water quality monitoring will be carried out in accordance with the standard protocols outlined in the Oregon Watershed Enhancement Board (OWEB) Water Quality Monitoring Technical Guidebook. The intent is that the data collected as a result of this monitoring will be of sufficient quality to be used by government agencies in their studies and decision-making processes.

Before actual sampling begins, the locations of all monitoring sites will be recorded by using a Global Positioning System (GPS) in the field to obtain the most accurate latitude, longitude, and elevation readings as possible. Site descriptions will also be written for each site so that volunteers can make visual assessments and comparisons over time and documents any significant changes to the site. Photos may also be taken for each site as another method of visual documentation.

Temperature, conductivity, turbidity, pH, and dissolved oxygen will be measured in the field. However, in the case of inclement weather, pH and dissolved oxygen may be measured inside shortly after field collection of water samples. Water samples may be stored in a cooler and transported to an indoor location for testing. However, three powder reagents must be added to the dissolved oxygen sample in a timely manner before transport.

Water samples used for E.coli and nutrient testing will be taken to a certified laboratory within 24 hours of collection. Ideally, samples will be taken to the laboratory on the same day as collection since bacterial analysis within 6 hours is most accurate. Samples will be transported on ice in dark containers and each sample will be clearly labeled with a sample ID number, sample location, time and date of collection and the sampler's name. Following analysis, the laboratory results for each sample will be returned to the watershed council office for storage and data entry.

Standard laboratory testing procedures such as the Standard Methods for the Examination of Water and Wastewater 4500 series for nutrients and Standard Methods 9213D or the IDEXX Colilert system for bacteria will be used to analyze the water quality samples. If the monitoring

program decides to use a laboratory where these methods are not standard, separate documentation will be written outlining the procedures, instrumentation, and quality control methods employed.

Continuous temperature loggers are factory-calibrated, but will be checked for accuracy prior to and following field deployment, following DEQ-approved protocol (outlined in OWEB guidebook). They will be set to record temperature on an hourly basis throughout the summer season. During this time period, volunteers will perform field audits approximately once a month to ensure accuracy.

Precision, Accuracy, and Measurement Range

The following table outlines the necessary precision, accuracy, and measurement range for each baseline water quality parameter assessed in order for data to meet the DEQ data quality standards for Level A (highest quality) data:

Table 7. Precision, Accuracy, and Measurement Range

Parameter	Precision	Accuracy	Measurement Range
Water temperature	+/- 1.0 d C	0.5 C	-5 to 35 C
Turbidity	+/- 5% of std value	+/- 5% of std value	0 to 1000 NTU
Conductivity	+/- 2% of std value	+/- 7% of std value	0 to 4999m S/cm
pH	+/- 0.3 SU	+/- 0.2 SU	0 to 14 SU
Dissolved oxygen	+/- 0.5 mg/l	+/- 0.3 mg/l	1 to 20 mg/l

Source: OWEB Water Quality Monitoring Technical Guidebook.

Representativeness

Water quality samples will be collected as close to the center of the stream as possible, where the water is well-mixed and flowing freely. Most of the study sites are located at bridge crossings, which facilitates sampling from the center of the channel. For sites that are not near bridges, care should be taken to sample from the most representative part of the channel that can be safely accessed. Continuous temperature loggers will be installed where water is well mixed and most representative of typical stream temperature conditions, while also providing a stable site to avoid loss of equipment. Loggers should not be located in side channels or shallow areas of the channel that might become exposed during low flow conditions.

Comparability

One of the objectives of the MFWWC water quality monitoring program is to produce accurate and reliable data that can be used by government agencies and compared directly to similar studies. This objective will be met by following the standard sampling, analysis, and reporting methods described in the OWEB manual and adhering to DEQ standards.

Completeness

It is expected that samples will be collected from at least 90% of the sites unless unexpected weather conditions prevent sampling. A couple of monitoring sites are located in portions of the watershed that are sometimes hard to access during the winter due to road closures. It is also likely that one of our nutrient/bacteria sites (Wallace Creek) might be dry during a portion of the summer. Samples should be collected on a continual basis throughout the year whenever possible so that the effects of seasonality (fall/winter/spring high flow periods vs. low flow summer periods) can be analyzed. In this regard, samples should be collected at least twice a quarter.

Quality Assurance/Quality Control

As mentioned above, water quality monitoring in the MFW watershed will be coordinated by a Water Quality Monitoring Coordinator whose main responsibilities include coordinating all volunteer monitoring efforts, working with government agencies and other groups within the watershed to obtain and integrate their water quality data, producing an annual report summarizing and analyzing results from the water quality monitoring program, and working with the Technical Advisory Committee to review, evaluate, and make any necessary changes to the existing monitoring program. Baseline water quality monitoring will be carried out by volunteers working in close contact with the monitoring coordinator. Volunteers may include watershed council members, local landowners and residents, and students from local schools. The Oregon DEQ Volunteer Monitoring Coordinator will hold a training session for volunteers prior to the commencement of sampling (targeted for the spring of 2002, which will consist of both classroom-based and field-based training. Volunteers unable to attend this session will be trained by the MFW water quality monitoring coordinator. All volunteers must receive training before sampling.

Volunteers will take duplicate samples for all of the parameters at a subset of sites (approximately 10%) during each sampling period for quality assurance purposes. In addition, the monitoring coordinator will go out into the field with different volunteers on a rotating basis to ensure that they are following established monitoring protocols and provide any necessary feedback on their techniques. The monitoring coordinator will evaluate the need for refresher training courses for volunteers and arrange these sessions with the Oregon DEQ Volunteer Monitoring Coordinator as necessary (probably on an annual basis). Finally, the monitoring coordinator will perform split samples with the Oregon DEQ Volunteer Monitoring Coordinator once or twice a year if possible.

Instrument/Equipment Testing, Inspection, and Maintenance Requirements

The monitoring coordinator will oversee testing, maintenance, and calibration of all monitoring equipment used in the program. All water quality monitoring kits will be kept clean and checked periodically to make sure they are functioning properly. Each piece of equipment will be calibrated following the methods described in OWEB Water Quality Monitoring Technical Guidebook or procedures specified by the equipment manufacturer. Records of maintenance and calibration will be updated as appropriate by the monitoring coordinator and stored in the watershed council office.

Documentation and Records

Volunteers will enter field data into their own personal log books in addition to completing field data sheets for each sampling site at the time of sampling. Field data sheets will be returned to the monitoring coordinator at the watershed office. These will consist of the site location and ambient conditions, time and date of sample collection, actual field measurements and calculations, and any additional comments (*see Appendix C*). Data sheets will also be maintained for each continuous temperature logger. Field data sheets will be archived at the watershed council office for at least three years, and the data will also be stored electronically.

At the end of each sampling period, the monitoring coordinator will review all of the field data sheets for any obvious errors or inconsistencies before entering the data into the computer. Any data outliers will be flagged for further investigation and follow-up by the monitoring coordinator. The monitoring coordinator will also be responsible for recording lab results from

any bacteria and/or nutrient samples that were sent away to a lab. After all data has been entered, it will be printed out and proofread against the original field data sheets for quality control. Data will be entered into spreadsheets developed by the Oregon DEQ for reporting water quality data and formatted appropriately. The monitoring coordinator will calculate measurements for precision, accuracy, and completeness of the sampling data. If data does not meet the monitoring program's QAPP standards, the monitoring coordinator may decide to discard the data and/or consider resampling. This determination will be made by the monitoring coordinator with consultation from the Technical Advisory Committee or QA manager as needed. If an error due to equipment failure is determined to be the cause of unusable data, maintenance and calibration procedures may be reviewed and altered, if necessary. If sampling team error is the cause, volunteers may need to be retrained. Any data quality problems encountered will be noted in the annual water quality monitoring report.

The monitoring coordinator and QA manager will review all water quality monitoring data to ensure that it meets QA objectives. Data may also be reviewed by a member of the Technical Advising Committee or other resource agency member before publication.

Some of the data used in the annual water quality monitoring report is expected to come from outside sources such as the USFS, BLM, SUB, and Springfield High School students. Information gathered from these groups should also include documentation of their calibration records, sampling protocols, and QA/QC procedures so that the monitoring coordinator can determine whether or not the data meets the standards set by the MFWWC monitoring program and make a decision as to whether or not to include the data. If data that does not adhere to MFWWC program standards is used, this should be noted explicitly in the report document.

Reporting

The monitoring coordinator will be responsible for summarizing and analyzing water quality monitoring data in an annual report to be distributed near the end of each calendar year. Reports will consist of data from the previous water year (October 1 – September 30) and will include monitoring results, analysis and interpretation of data, QA/QC assessments, and any other

relevant information about the program status and volunteers involved. These reports will be distributed to members of the Technical Advising Committee, general watershed council members, and local, state, and federal government agencies involved in the watershed. Summary reports will also be made available to the general public upon request. Finally, raw field data will be submitted to the Oregon DEQ, (following their required format) for entry into their water quality database (LASAR). The monitoring coordinator will give periodic updates on the water quality monitoring and present results at watershed council meetings throughout the year.

Project Oversight

The monitoring coordinator and Technical Advisory Committee will meet at least twice a year to review and evaluate the current water quality monitoring program and make changes as needed. The monitoring coordinator will present any feedback or recommendations obtained throughout the year from the QA manager or state and federal agencies in the watershed.

The following list of questions provides a starting basis for evaluation of the effectiveness of the water quality monitoring program:

- Has monitoring been performed successfully on a consistent basis following DEQ protocols?
Has collected data met DEQ standards for Level A data?
- Have reports been developed to summarize and analyze field data?
- Has the MFWWC water quality monitoring data been integrated effectively with data from other groups and agencies within the watershed?
- Has baseline data contributed to a better understanding of current water quality conditions in the watershed?
- Have results been used to develop plans for further water quality studies as needed?
- Have results provided the appropriate type of information for effective use in developing plans for restoration activities within the watershed?
- Have a variety of volunteers participated in the monitoring program? Are there enough volunteer resources or is more recruitment needed?
- What types of feedback and suggestions have come from agencies within the watershed (such as BLM and USFS)?

Based on the answers to these questions and actual monitoring results, the monitoring coordinator and Technical Advisory Committee may decide to alter the objectives or monitoring components of the program to address new issues of concern or improve the effectiveness of current procedures. If the water quality monitoring program is working well and there is a growing volunteer base, it may be desirable to expand the monitoring program to encompass additional monitoring sites and/or parameters (such as macroinvertebrate sampling). Storm event sampling may be another important monitoring component to consider. Any significant alterations to the program which will affect the QAPP should be discussed with the Oregon DEQ Volunteer Monitoring Coordinator before implementation.

Collaboration with other Agencies

As mentioned at the beginning of this document, there are currently several state and federal agencies and other groups who perform water quality and/or continuous temperature monitoring in the MFW watershed. The BLM has agreed to assist us with our continuous temperature data analysis by running it through a macro that generates daily maximum and minimum temperatures along with the standard 7-day moving average temperature, and graphs the results. Both the USFS and Oregon Water Resources Department have offered to work with us on developing a strategy for measuring flow at monitoring sites and provide some in-the-field training for volunteers.

One of the objectives of the MFWWC water quality monitoring program is to work together with these groups to facilitate information sharing and avoid redundant sampling within the watershed. The monitoring coordinator will be responsible for obtaining data summaries from these groups and integrating them into the monitoring program's water quality analysis and annual reports. Such collaboration will help to fill in current data gaps in water quality within the watershed and provide a more complete and integrated picture of water quality status over the entire watershed.

Appendix A. Recent Water Quality Studies within the Middle Fork Willamette Watershed Sub-Basin

Agency	Location of Monitoring	Years of Record	Frequency	Parameters	Comments	Significant Findings	Will Monitoring Continue?
US Forest Service (USFS)	Fall Creek, Winberry Creek, Upper and Lower North Fork of Middle Fork Willamette, Salmon Creek, Salt Creek, Hills Creek, Hills Creek Reservoir, Upper Middle Fork Willamette	Varies by site; most monitoring started in the mid-1990s	Daily during summer season	Continuous temperature	Many sites are still monitoring sites	Several stream reaches exceeded the DEQ standard of 64 degrees F during multiple years and were included on the 303(d) list; additional stream reaches that were not listed (based on '97 data) have exceeded temperature standards since then.	Most sites will continue to be monitored during the summer season.
Oregon Department of Environmental Quality	Lower Middle Fork of the Willamette (MFW near Jasper Bridge)	Data exist from as early as 1950	Most recently: bi-monthly sampling (1990-1992), quarterly (1993-1997), bi-monthly (1998-present)	A large variety of water quality parameters	this is the only "ambient" water quality monitoring site in the MFW subbasin	Results from this site indicate that the Middle Fork Willamette sub-basin has excellent overall water quality compared to the rest of the state (see 1999 OWQI Index report). However, this is the only ambient water quality monitoring site maintained by DEQ in the MFW sub-basin; results do not show any spatial variation in water quality in the MFW.	Yes

Agency	Location of Monitoring	Years of Record	Frequency	Parameters	Comments	Significant Findings	Will Monitoring Continue?
	Various sites within MFW sub-basin	Summer 1999-summer 2000	Daily continuous temperature monitoring, some grab samples	Water chemistry, physical habitat, macroinvertebrates	sites are randomly generated	Data is part of a Regional Environmental Monitoring and Assessment Project (REMAP) and will be summarized for entire Western Cascades sometime during the next year.	Currently there is no designated funding to continue monitoring, but ideally REMAP would continue if supported financially.
Lost Creek Watershed Group	Nine sites in Lost Creek fifth-field watershed	June 1999- present	Monthly grab samples	Temperature, turbidity, pH, dissolved oxygen, conductivity	data collected is submitted to DEQ	Several sites exceeded DEQ temperature standards for salmonid rearing and a couple of sites had low levels of dissolved oxygen.	Yes
	Ten sites in Lost Creek fifth-field watershed	Summer 1998 - present	Daily during summer season	Continuous temperature	BLM helps analyze some of the temp data	Several sites exceeded DEQ temperature standards for salmonid rearing	Yes
Bureau of Land Management (BLM)	Lost Creek, Lower Middle Fork Willamette, Little Fall Creek	Varies by site from 1998 - present	Daily during summer season	Continuous temperature		Several sites exceeded DEQ temperature standards for salmonid rearing	Yes

Agency	Location of Monitoring	Years of Record	Frequency	Parameters	Comments	Significant Findings	Will Monitoring Continue?
MFW Watershed Council	Lost Creek, Little Fall Creek, Lower Middle Fork Willamette	Summer 2001	Daily during summer season	Continuous temperature		Several sites exceeded DEQ temperature standards for salmonid rearing	No - monitoring conducted just for the watershed assessment.
Springfield Utility Board (SUB)	Intake from Mid Fork @ RM 189, several wellfield sites	May 2000- January 2001	At least weekly	Temperature, turbidity, pH, dissolved oxygen, conductivity, some metals, flow		Results indicated occasional instances of low dissolved oxygen levels, high fecal coliform counts, and high turbidities associated with high flow events. However, water is of high enough quality to be treated effectively as a drinking water source for Springfield (Chuck Davis).	Monitoring has been temporarily discontinued during construction of the new drinking water treatment plant, but is scheduled to resume in October 2002.
Springfield High School	Several sites along the Springfield Millrace	Since 1998	Bi-weekly grab samples	Basic WQ parameters, nutrients, pesticides		Results indicated problems with high temperatures, high pH values, and low dissolved oxygen during low flow summer months. Some fecal coliform and <i>E. coli</i> counts have exceeded state standards.	Yes

Agency	Location of Monitoring	Years of Record	Frequency	Parameters	Comments	Significant Findings	Will Monitoring Continue?
Oregon Department of Fish and Wildlife (ODFW)	Willamette Fish Hatchery	1977-1982	Monthly	Temperature		No standards violated	N/A
		1983-2001	Daily from approximately June - mid April	Temperature (maximum, minimum, and average values)		No monthly averages exceeded the state standard of 64 degrees F; however, monthly maximum temperature have been as high as 67 (1992, 1994)	Yes
		2001.00	Weekly for a month, four times per year (highest production mo. in a quarter)	pH	6/01 = salmon outflow; 9/01 = trout outflow	pH range 7.16-7.93 (not to be outside of 6.0-9.0 range)	Yes
				Settleable solids		No standards violated	Yes
	Dexter Fish Hatchery	Similar to Willamette Fish Hatchery	Similar to Willamette Fish Hatchery	Similar to Willamette Fish Hatchery	Similar to Willamette Fish Hatchery	Similar to Willamette Fish Hatchery	Yes

Appendix B. Standard Operating Procedures for the Middle Fork Willamette Water Quality Monitoring Program

Safety Guidelines

Please adhere to the following safety guidelines when collecting samples for water quality monitoring:

1. If you feel that weather, high flow conditions, or traffic is creating an unsafe situation, do not try to collect a sample. Instead, report any unsafe conditions to the water quality monitoring coordinator.
2. Be aware of surrounding traffic, especially when sampling from a bridge and modify your activities as necessary. This may involve taking your water sample to a nearby location out of the way of traffic to complete your water quality testing.
3. Make sure you are dressed appropriately for sampling, wearing hip waders and/or boots with good traction to avoid slipping on rocks in the stream.
4. Wash your hands thoroughly after working with stream samples and especially after handling chemicals.
5. Be careful to avoid getting chemicals on your clothing.
6. Shake bottles with chemicals away from you to avoid bodily contact with the chemicals.
7. Carry a first aid kit and a squirt bottle of plain water.
8. Make sure to dispose of chemicals properly. This generally involves pouring all wastewater into a designated container to dispose of after sampling is complete. (See procedures for each individual parameter)
9. Rinse all equipment and sampling containers before and after testing.

Collecting a Sample

1. Always collect your sample to the upstream side of where you are wading so that your sample is not affected by any turbulence or sediment that you may have stirred up.
2. Remove the top without touching the inside of the sampling container so that you do not contaminate your sample.
3. Submerge the sampling container several inches below the surface of the water, with the opening facing into the current.
4. Empty out the sampling container downstream from you and repeat steps 3 and 4 two more times. This procedure gets rid of any remaining water from rinsing the container. Now you are ready to collect your sample.
5. Again, submerge the sampling container several inches below the surface of the water, with the opening facing into the current. Fill the container completely and then place the top on.

Bridge Sampling

When sampling from a bridge, be alert to any road traffic around you and use caution when sampling.

1. Lower the sampling bucket on a rope into the stream from the pre-determined marked location on the bridge. This location should be near the center of the channel where the water is fairly well-mixed.
2. Submerge the bucket at least several inches below the water surface or midway between the surface and bottom.
3. Rinse the bucket with water from stream and empty it several times before collecting your actual sample.
4. Conductivity and water temperature can be measure directly from the bucket. Carefully sampling containers in order to test the other parameters.

Note: Adapted from River Watch Network's *Testing the Waters*, 1996.

Appendix C. Field Data Sheet

Site #: _____
 Stream Name: _____
 Sampled By: _____

Date: _____
 Time: _____

Weather Conditions:

Additional Observations: (water color, flow, wildlife, disturbed vegetation, streambank erosion or human modification, etc.)

Field Data:

Parameter	Measurement	Duplicate Measurement (if applicable)	Reporting Unit
Air temperature (°C)			Report to tenths
Water temperature (°C)			Report to tenths
Conductivity (µS/cm)			Report 2 significant digits
Dissolved Oxygen (mg/l)			Report to tenths
Dissolved Oxygen (% saturation)			Report to tenths
pH			Report to tenths
Turbidity (NTU)			Report 2 significant digits

Sampling Problems and/or Additional Comments:

APPENDIX F

RESOURCES FOR VOLUNTEER GROUPS

Developing a comprehensive and effective volunteer water quality monitoring plan can be a daunting task, especially for someone who does not have much background in water quality or is not familiar with monitoring plan design. However, there are a number of well-written, helpful manuals and online informational resources, as well as agency resource specialists and other human contacts who can provide assistance in a wide range of areas, including basic water quality concepts, sampling design, water quality monitoring protocols, QA/QC procedures, data management, analysis, and presentation, and training resources and workshops.

Following is an annotated list of resources that I found to be particularly helpful and relevant for developing water quality monitoring plans. This list is not exhaustive by any means, but I have tried to incorporate a variety of resources spanning the range of topics mentioned above. In addition, I have provided online links to selected volunteer water quality monitoring programs that I researched on the web and thought were particularly good examples of volunteer programs. Several of these provide an extensive list of additional references and links to other volunteer water quality monitoring

resources and contacts. I am hoping that this extensive compilation of resources will serve as a useful starting point for watershed councils or other similar volunteer organizations that wish to create volunteer water quality monitoring programs.

Print:

The Clean Water Act: An Owner's Manual: This manual provides both history and comprehensive descriptions of the various sections of the Clean Water Act in layperson's terms. It also focuses on practical ways in which citizens can use the Clean Water Act to protect watersheds and it provides useful case studies and suggestions for taking action. *Elder, D., Gayle Killam, and Paul Koberstein. 1999. The Clean Water Act: An Owner's Manual. River Network, Portland.*

EPA's National Water Quality Inventory Report to Congress: This is a biennial report summarizing the water quality status of the nation's waterbodies. It includes information on basic water quality concepts, water quality monitoring and assessment strategies, and explanations of beneficial uses for each different type of waterbody. It describes programs to restore and protect waterbodies and gives summaries of water quality status in each state. Available in print or online at: <http://www.epa.gov/305b>. *US Environmental Protection Agency. 2000. National Water Quality Inventory 1998 Report to Congress, Rep. No. EPA841-R-00-001. Office of Water, US EPA, Washington DC.*

EPA's The Volunteer Monitor's Guide to Quality Assurance Project Plans: This document provides specific guidance on how to develop an EPA-approved quality assurance project plan. It includes descriptions and specific examples for each of the 24 identified elements of a QAPP. The guide also provides additional references and contact information for the quality assurance officers and volunteer monitoring coordinator in each of the EPA's 10 regional offices. *US Environmental Protection Agency. 1996. The Volunteer Monitor's Guide to Quality Assurance Project Plans.*

State 305(b) Reports: These reports provide more in-depth coverage of the water quality status of waterbodies in each state. They are generally available in paper format by request or online at the state's environmental resource agency website.

Stream Corridor Restoration Manual: This resource presents background information on water quality monitoring and restoration principles. Although this manual primarily focuses on approaches to stream corridor restoration, it also contains information pertaining to developing robust monitoring plans. It contains some good suggestions for identifying goals and objectives and outlines important steps in the monitoring plan development process, which may be applied specifically to water quality monitoring. The information in the manual is directed towards a broad audience, including land managers, contractors, agency personnel, landowners, and volunteers.

<http://www.usda.gov/stream%5Frestoration/newgra.html>

Federal Interagency Stream Restoration Working Group. 1998. Stream Corridor Restoration: principles, processes, and practices. Natural Resources Conservation Service, Washington D.C.

Testing the Waters: This book provides helpful information on basic water quality concepts and monitoring techniques, as well as detailed steps and considerations for developing volunteer water quality monitoring plans and managing and presenting data effectively. In addition to serving as an informative guide about water quality concepts and the nation's associated regulatory system, this book is also geared toward encouraging teachers to incorporate water quality topics and actual monitoring into school curriculum. Finally, this resource includes sample field data and analysis sheets. *Behar, S., Jack Byrne, and Geoff Dates. 1996. Testing the Waters: chemical and physical vital signs of a river. River Watch Network, Montpelier, VT.*

Volunteer Stream Monitoring: A Methods Manual: This is a technical guide for water quality monitoring of streams developed by the EPA specifically for volunteer water quality monitoring groups. It includes sections on designing a monitoring study, methods for conducting a watershed survey, measuring biological, chemical, and physical parameters, and ways of managing and presenting data. Also available online at: <http://www.epa.gov/volunteer/stream/index.html>.

US Environmental Protection Agency. 1997. Volunteer Stream Monitoring, Rep. No. EPA 841-B-97-003. US Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Wetlands Division, Washington, DC.

Water Quality Monitoring Technical Guide Book, Oregon Watershed Enhancement Board: This technical resource provides background on basic water quality monitoring parameters, presents detailed guidelines and techniques for measuring water quality for several commonly monitored parameters in order to ensure consistent methods across the state, outlines monitoring strategies and plan development, and lists additional references, as well as mentors, within the state.

Oregon Watershed Enhancement Board. 1999. Water Quality Monitoring Technical Guide Book, Oregon Plan for Salmon and Watersheds.

Watershed Assessment Manual, Oregon Watershed Enhancement Board: This detailed manual was produced by OWEB in order to assist watershed councils and others with a step-by-step process for conducting a complete watershed assessment. It includes chapters on water quality assessment and developing monitoring plans.
Watershed Professionals Network. 1999. Oregon Watershed Assessment Manual. Governor's Watershed Enhancement Board, Salem, OR.

Online Links:

Clean Water Act: This site provides basic information and history of the Clean Water Act; produced by the EPA. <http://www.epa.gov/owow/cwa/index.html>

Enviromapper: This is a web-based GIS application that allows users to view and create maps showing bodies of water with attached water quality and other environmental information. <http://www.epa.gov/waters/enviromapper>

EPA Office of Water: This is the main entry point to a wide range of information on all aspects of water, including surface water, groundwater, drinking water, water quality standards, wastewater management, monitoring and assessment, and a variety of education and training resources as well as publications. <http://www.epa.gov/ow>

EPA Office of Wetlands, Oceans, and Watersheds: A main link from the Office of Water page, this page provides information on monitoring rivers, streams, lakes, coastal estuaries, wetlands, and has links to volunteer monitoring, educational pages, and information on TMDLs. <http://www.epa.gov/OWOW/index.html>

Know Your Watershed: This site is a vast storehouse of water-related resources, including links to state contacts, watershed groups, scientific publications, and TMDL information, among other topics. <http://www.ctic.purdue.edu/KYW/>

Monitoring and Assessing Water Quality: This is the EPA's main homepage for water quality monitoring information. It contains links to a variety of subjects, including introductory and background information, volunteer monitoring, biological monitoring, water quality reporting, data storage systems, and mapping tools.
<http://www.epa.gov/owow/monitoring/>

National Directory of Volunteer Monitoring Programs: This introductory document provides informative introduction summarizing key findings and statistics from a 1997 EPA-conducted survey of volunteer monitoring programs nationwide and contains a link to the actual database directory of the 700+ documented volunteer monitoring programs.
<http://www.epa.gov/OWOW/monitoring/dir.html>

National Environmental Methods Index (NEMI): This new online resource is currently in a prototype phase, but is scheduled to be released to the public in the near future. It was created by the Methods and Data Comparability Board (MDCB), which consists of water quality professionals from federal, state, and local government agencies, tribes, industry, and private organizations. The purpose of NEMI “is to provide a mechanism to compare and contrast the performance and relative cost of analytical, test, and sampling methods for environmental monitoring.” Currently, the database contains primarily water quality analytical methods, but will be expanded in the future to encompass field methods and other topical areas including air and soil. NEMI’s targeted users include regulators and scientists from government agencies, academic researchers, and volunteer groups. <http://www.nemi.gov>

National Hydrography Dataset: This is a large set of geospatial data pertaining to surface water features in the US. It incorporates EPA river reach (RF3) classifications and Digital Line Graph (DLG) information from the USGS and is intended for use in both mapping and performing in-depth analyses of water-related features. <http://nhd.usgs.gov>

Oregon DEQ Laboratory: This site provides information about environmental monitoring performed by the DEQ, including air and water quality assessments and biological monitoring. <http://www.deq.state.or.us/lab/lab.htm>

Oregon DEQ Water Quality Program: This resource contains information about water quality in Oregon, including water quality standards, beneficial uses, 305(b) and 303(d) reports, point and nonpoint source rules, regulations, and programs. <http://www.deq.state.or.us/wq/>

Oregon Watershed Enhancement Board (OWEB): This site contains information about the history and structure of OWEB and watershed councils, links to watershed councils in Oregon, and links to monitoring publications such as the Water Quality Monitoring Guide. <http://www.oweb.state.or.us/>

Oregon Plan for Salmon and Watersheds: This site age presents information pertaining to the history, status, and organization of the Oregon Plan, as well as education and outreach materials and grant applications. <http://www.oregon-plan.org/>

Science in Your Watershed: This site provides an array of scientific information, projects, publications, and links to other water quality information organized by watershed. <http://water.usgs.gov/wsc/index.html>

Surf Your Watershed: This site allows users to search for a watershed of interest and examine a variety of environmental data relating to that watershed. It also provides links to other environmental tools, websites, programs, and campaigns.

<http://www.epa.gov/surf>

USGS: Water Resources of the United States: This is the entry point to water information at the USGS. It contains links to USGS programs, technical resources, current and historical water data for all states, and publications and products, and current water-related news items. <http://water.usgs.gov>

Volunteer Monitoring: This is the EPA's central starting point for volunteer groups who wish to become involved with water quality monitoring. It contains links to fact sheets about EPA volunteer monitoring and starting monitoring programs, methods manuals, the national volunteer newsletter, events and conference proceedings, and lists of other volunteer monitoring groups nationwide. <http://www.epa.gov/owow/monitoring/vol.html>.

Water Where You Live: This site provides links to state water resources, volunteer monitoring programs, and case studies. <http://www.epa.gov/ow/states.html>

Watershed Information Network: This site provides links to publications on monitoring and protecting watersheds, listings of national conferences and events, and contains information on watershed concepts and terms. <http://www.epa.gov/win/>

Newsletters:

The Volunteer Monitor (The National Newsletter of Volunteer Water Quality Monitoring): This is a free newsletter published by the EPA that "facilitates the exchange of ideas, monitoring methods, and practical advice among volunteer environmental monitoring groups across the nation."

http://www.epa.gov/OWOW/volunteer/vm_index.html

State volunteer monitoring newsletters: Some state environmental agencies publish volunteer monitoring newsletters summarizing volunteer activity in the state and providing useful informational articles and case studies.

Examples:

Oregon's *The Data Logger*

http://www.deq.state.or.us/lab/Biomon/bio_news.htm

Pennsylvania's *Monitoring Matters*,

<http://www.dep.state.pa.us/dep/deputate/watermgt/wc/Newsletters/newsletter.htm>

People:

Agency resource specialists: There are a variety of scientists and other professionals involved in water quality monitoring or similar fields from organizations such as the USFS, USFWS, BLM, COE, city or local planning department. They may be extremely useful in providing technical assistance and expertise.

EPA regional contacts: Each of the ten regional EPA offices has a volunteer monitoring coordinator and quality assurance officers who can assist volunteer groups. For a listing of EPA regions and contacts, see <http://www.epa.gov/OWOW/monitoring/volunteer/qapp/qappappb.pdf>

State volunteer monitoring coordinator: This is a position usually housed within the state water quality agency. The coordinator is generally responsible for providing guidance and technical assistance to volunteer groups in the state.

Water quality monitoring coordinators from other volunteer monitoring programs in the state or nationwide. These people are valuable resources in that they have firsthand experience dealing with on-the-ground issues that volunteer monitoring programs face.

Conferences and Events:

National Citizen's Volunteer Water Monitoring Conference: This is a national conference focused on volunteer water quality monitoring that occurs every few years. Proceedings are available as EPA reports. The two most recent conference proceedings are online at <http://www.epa.gov/owow/monitoring/vol.html>.

National Monitoring Conference: This is a biennial conference sponsored by the National Water Quality Monitoring Council consisting of workshops, presentations, poster sessions, and working group sessions relating to all types of water quality monitoring nationwide. <http://www.nwqmc.org>

National Water Quality Monitoring Day: This event is designed to raise awareness about water quality and encourage local stewardship. It is a chance for all interested citizens to perform a handful of water quality monitoring tests on a stream or rivers of interest and submit data to a national "clearinghouse" for collection. <http://www.yearofcleanwater.org>.

State volunteer monitoring conferences: Some state volunteer water quality monitoring programs, such as the Citizen's Volunteer Monitoring Program in PA (<http://www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/cvmp.htm>), sponsor statewide volunteer monitoring conferences.

Selected Volunteer Water Quality Monitoring Programs:

Iowater: <http://www.iowater.net> - This site is another example of a well-developed state volunteer monitoring program, with information on its history, newsletters, training events, and state-specific laws. It also contains a sophisticated online database where volunteers can submit their field data online, as well as a geographic image map server that shows detailed quadrangles and orthophotos spanning the state.

Izaak Walton League of America, Save Our Streams:

<http://www.iwla.org/sos/history.html> - The Save Our Streams section of the Izaak Walton web page contains information on the history of the program, technical tools, resources, and training events for water quality monitoring, publications, information on campaigns, newsletters, and links to equipment purchasing.

Kentucky Water Watch: <http://water.nr.state.ky.us/ww/> - This site provides a wealth of information on the extensive water quality monitoring network in Kentucky, water quality concepts in general, and technical resources, as well as an extensive list of local, national, and international water quality monitoring groups.

Missouri Volunteer Water Quality Monitoring Program:

<http://www.rollanet.org/~streams/vm.html> - This comprehensive volunteer monitoring site has information on the state's volunteer water quality monitoring program organization, links to other volunteer monitoring groups, technical resources for getting started with chemical or biological monitoring, information on upcoming training sessions, and mapping resources. It also hosts an online database where volunteers can submit and view their monitoring data.

River Network: www.rivernetwork.org or www.riverwatch.org - This is an extremely informative site for volunteer water quality monitors and contains a vast amount of resources including: a directory of river conservation groups, lists of funding sources, a calendar of events, a resource library, case studies of volunteer group successes, publications, books and guides for purchase, information on the Clean Water Act, links to water quality regulations and standards, contacts for individual states, technical guides and monitoring resources, and training events and workshops.

Adopt-A-Stream: <http://www.streamkeeper.org/>

BlueRiverTask Force: <http://nris.state.mt.us/wis/vwm/bwtf> (check link)

Citizen Stream Monitoring Program (MN):

<http://www.pca.state.mn.us/water/csm.html>

Delaware Stream Watch: <http://www.delawarenaturesociety.org/streamwatch.htm>

Global Rivers Environmental Education Network: <http://www.green.org/>

Merrimack Watershed Council: <http://www.merrimack.org/index.html>

Northern Virginia Soil and Water Conservation District:

<http://mason.gmu.edu/~jarcisze/StreamMonitoring/index.html>

Pennsylvania Department of Environmental Protection:

<http://www.dep.state.pa.us/dep/deputate/watermgt/WC/subjects/cvmp.htm>

Texas Watch: <http://www.texaswatch.geo.swt.edu>

Virginia Save Our Streams: <http://www.sosva.com>

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