Component XI
Monitoring Plan

Table of Contents

Component XI
Monitoring Plan

INTRODUCTION

The primary purpose of this Monitoring component is to describe approaches for collecting information to answer questions that may arise during the watershed assessment. A second objective is to briefly discuss ways to measure success of restoration efforts that may come out of the assessment. The Monitoring component is intended to address the questions of What and Why to monitor, not to describe detailed monitoring procedures. Monitoring procedures are being developed by an interagency team of the Oregon Plan for Salmon and Watersheds (OPSW). To date, the OPSW monitoring team has completed a *Water Quality Monitoring Guidebook* (OPSW 1999). We refer the reader to this guidebook and other monitoring documents being prepared by this team for specific monitoring procedures.

This component will focus on the approach to filling data gaps discovered during the watershed assessment, because this will be the type of monitoring activity that watershed councils will most likely be involved in. The second objective of monitoring, measuring the success of restoration efforts, is discussed briefly in the sidebar, Monitoring Restoration Activities. This sidebar also briefly reviews the various types of monitoring to acquaint the reader with the terminology that is commonly encountered in monitoring guidebooks. The main portion of this component will present the following information:

1. A description of the process of cataloging data gaps identified during the watershed assessment

2. A description of the stages to follow in developing a monitoring plan

3. An outline of a written monitoring plan

4. A list of the sources of potential monitoring methods and other resources that may be used to implement the monitoring plan

The stages in developing a monitoring plan and the monitoring methods apply as well to measuring the success of restoration actions. The emphasis of this component is on linkages to more detailed procedures rather than a self-contained methods manual. Guidance on monitoring is contained in a number of good references that should be consulted when developing a monitoring program (see References section).

Necessary Skills

Developing a monitoring plan requires specific knowledge of the monitoring techniques related to that issue, data analysis, statistics, and quality assurance. Once a plan and data collection protocol are established, trained volunteers can often implement the field work (the fun part!) under the direction of professionals or agency mentors. Watershed councils should obtain help when developing a monitoring program from agency resource specialists, monitoring consultants, or university faculty.

Final Products of the Monitoring Component

The monitoring component provides linkages between the watershed assessment and monitoring programs being developed by the OPSW. An outcome of the watershed assessment is a list of information needs that are the basis for developing a watershed monitoring program. This list of needs can then be used in communications with state and federal agencies that may be able to fill these data gaps or to develop monitoring initiatives at the watershed council level. A second potential outcome of this component is the development of a monitoring plan to address specific data gaps or to evaluate the success of restoration activities.

Filling Data Gaps

Typical monitoring activities that watershed councils may use to follow up the watershed assessment are categorized as *filling data gaps.* As a part of the watershed assessment, data gaps and other information needs are identified. These information needs should be addressed before pursuing more costly restoration activities (see sidebar, Monitoring Restoration Activities). The potential mix of data-gap monitoring and field-verification activities varies for each component of the watershed assessment. Some components such as assessing riparian condition or verifying the location of wetlands are best completed using field observations. Other components, such as water quality monitoring, require collection of samples with an emphasis on standard operating procedures and quality control. Lastly, other components, such as evaluation of hydrologic impacts, cannot be readily monitored and rely on use of models that require a high degree of professional expertise.

Since the watershed assessment was primarily designed to use existing data, field studies to verify assumptions are an excellent follow-up activity to watershed assessment. Field verification is a type of follow-up activity that primarily uses visual observation with few measurements. In many cases observers can be trained by a resource professional to use standard methods and collect information that will be very useful to the watershed improvement goal. To be useful, the field verification needs to be completed using standard protocols and documentation. Potential field-verification activities are listed in Table 1 for the Channel Habitat Type Classification, Riparian/Wetlands, Sediment Sources, Channel Modification, and Fish and Fish Habitat assessment components.

Intensive monitoring activities that include collection of field samples are more costly and require more detailed planning to be successful. Monitoring activities may be undertaken for a number of purposes. Some common purposes are to: (1) evaluate the existing condition or status of the resource, (2) identify the cause-and-effect relationships, and (3) determine trends in water quality or habitat conditions in response to specific actions. The first objective is undertaken if little or no information exists about an important issue or to evaluate a series of potential causative agents at a cursory level. The second objective, cause-and-effect studies, are designed to pinpoint the major cause of an impact or geographic focus to be able to prioritize restoration. For example, it may be known that nutrients are high in a mixed land use watershed, but no specific source has been identified. A cause-and-effect study would try to identify the relative contribution from agricultural runoff from urban runoff by bracketing these land use areas with monitoring sites. The third type, trend studies, requires intensive monitoring over a long time period because of the natural change in conditions that may occur from year to year or decade to decade.

It is important to be very clear about the objective for intensive monitoring before planning data-collection efforts. The monitoring objective ultimately determines the location, duration, and frequency for sample collection. Evaluating current conditions may be accomplished by making measurements during one season, and constitutes a snapshot in time. (For an example, see Appendix VIII-A in the Water Quality component). Trying to evaluate a trend over time requires a greater level of effort and a commitment of resources over several years or decades. For these reasons, watershed councils should focus on monitoring efforts that address specific data gaps in watershed assessment rather than long-term monitoring efforts.

MONITORING RESTORATION ACTIVITIES

Once restoration actions are taken, the council will want to know if they were installed correctly (if the action involves structures) and if they are going to be successful. Monitoring methods that evaluate restoration activities have been described as *implementation* and *effectiveness monitoring*. Documents that describe monitoring methods often refer to these terms, so it will be useful to understand this terminology.

Implementation monitoring asks: **Was the management practice or restoration activity implemented properly?** This monitoring should be a part of every project and is normally performed during or shortly after restoration. Monitoring during the project can lead to mid-course corrections that save the project from failure. Implementation monitoring after the project is necessary to report the success of the restoration effort to the watershed council and the funding agency. Implementation monitoring can be as simple as counting the number of structures installed and evaluating if the structures were installed as designed. The actual monitoring activity consists of visual inspections, field notes, and photographs. For example, if improved road maintenance was the restoration action, implementation monitoring would consist of checking to see if ditches and culverts were cleaned and functional, and if cut and fill slopes were seeded, or to determine if seasonal road closures were installed in time.

Implementation monitoring is simple, and it is a cost-efficient form of monitoring. This essential part of any monitoring effort is often taken for granted: assuming that the best management practice (BMP) was undertaken and completed as planned. Before we measure the effectiveness of the restoration activity, we must ensure that the planned action was completed as designed. Although this may seem to be an obvious part of restoration, taking the time to document what was completed is easily overlooked.

Effectiveness Monitoring asks: **Were restoration actions effective in meeting the restoration objectives and in attaining the desired outcome?** This kind of monitoring is more complex than implementation monitoring because we need to connect some action with an outcome in the riparian area or stream channel. In the road maintenance example, we may want to determine if ditches and culverts plugged during a storm, if the vegetation seeded on the slope was established in time to prevent erosion, and if the road closures prevented rills on the road surface. With stream restoration projects, some actual evidence of an improved condition may not be become evident until several cycles of high flows or after many years.

Other types of monitoring that are commonly described include *validation*, *baseline*, and *trend monitoring*. *Validation monitoring* is a research level of monitoring that addresses basic scientific questions about watershed processes and will generally not be undertaken by watershed councils. *Baseline monitoring* is undertaken to establish conditions prior to management activities or in a paired watershed or reference site. Baseline monitoring in a less-disturbed drainage is important to calibrate the effects of natural disturbance such as mass wasting, floods, and fire. *Trend monitoring* tracks conditions in streams and watersheds over years and requires a long-term commitment of resources. While all types of monitoring might be used, watershed councils will likely focus on filling data gaps and on the implementation and effectiveness of restoration activities.

IDENTIFYING DATA GAPS

The first stage in developing a monitoring program is to identify the list of data gaps and prioritize the potential list of monitoring studies. The potential list of information needs is compiled from the watershed assessment and should be completed as part of the Watershed Condition Evaluation. Based on this list we might categorize the potential list of monitoring activities as field-verification activities, short-term monitoring activities, and long-term monitoring activities. The second consideration at this stage is to determine which of these activities are within the jurisdiction of other entities and should be completed by them. For example, you may want to encourage an agency to add new stations to its monitoring program, request a major landowner to take the lead in a study, or recruit the interest of a research organization at a state or federal agency. An example of a potential list of data gaps and monitoring activities is provided in Table 1.

Table 1. Examples of data gaps identified from the watershed assessment.

Manual Component	Potential Data Gaps
Channel Habitat Type Classification	Field verification of channel habitat types gradient, cross-sectional shape, or valley shape
Hydrology & Water Use	Streamflow gaging stations Land use mapping
Riparian	Field verification of recruitment condition and shade Field measure of stream shade and canopy Riparian plant communities Width of riparian areas Breaks in riparian areas and causes
Wetlands	Type, location, and size of wetlands Wetland functions and conditions Connectivity Restoration opportunities
Sediment Sources	Field verification of sources Road stability Culvert survey Erosion – crop-land areas Erosion – range conditions
Channel Modification	Field verification of channel modifications
Water Quality	Temperature and dissolved oxygen pH and heavy metals Nutrients Turbidity and suspended sediment Bacterial sources and impacts
Fisheries	Distribution of fish in the watershed Location and severity of migration barriers Condition of spawning and rearing habitat Fine-sediment impacts

Data gaps can be listed and compared to watershed issues and their influence on future actions. Follow-up monitoring activities should be prioritized on the basis of moving forward on potential restoration options. For example, temperature and riparian conditions are often a major issue in a watershed. The watershed assessment may have indicated that temperatures at the mouth of tributaries were in excess of state water quality standards. Riparian conditions based on aerial photographs indicated potential areas of insufficient shade. A 1-year intensive data-collection effort of temperature data loggers (monitoring activity) and riparian condition (field-verification observations) may answer landowners' questions about specifically where the canopy cover is insufficient and how it is affecting temperature.

DEVELOPING A MONITORING PLAN

Once the data gaps and monitoring needs are identified, a monitoring plan can be developed to answer specific questions. A written monitoring plan is a necessary tool to conduct any monitoring program. The monitoring plan is like a set of blueprints for building a new home. Once finalized, the blueprints and materials list provide the basis for a contract between the homeowner, the builder, and subcontractors to ensure that there is always a basis for clear communication. The monitoring plan performs the same function—it lays out the objectives, identifies the people and equipment needed, and describes what and where the monitoring activities will take place. Like a set of blueprints, the monitoring plan will need to go through several drafts and peer reviews before there is agreement that the plan makes sense and can be completed with the resources available.

The process that should be followed to complete a monitoring plan is illustrated in Figure 1. We refer to these as stages, because they are part of a decision process and may vary depending on the type of monitoring; they are not steps in a to-do list as described in other components. The monitoring plan should be viewed as an iterative process. The best-designed monitoring program may not work for a variety of reasons, such as access limitations, unanticipated high flows, inadequate equipment, or higher variability than anticipated. For that reason, data should be evaluated frequently and the monitoring plan revised as needed to ensure a successful project.

Stage 1: Objectives

The first stage in developing a monitoring program is to establish a clear set of objectives. These objectives start with a statement of the data gap or the question to be answered. Examples of data gaps are listed in Table 1. Examples of questions are: "Does this stream meet the Oregon Department of Environmental Quality water quality standards for temperature and dissolved oxygen?"; and "Are BMPs effective at reducing sediment inputs to the stream channel?". Data gaps and questions such as these are the beginning point for developing the set of monitoring objectives.

Once the data gap or question is identified, a helpful procedure is to briefly outline the potential study design as shown in Table 2. Briefly specify the objective, the question to be addressed, parameters to be sampled, monitoring method, study design, potential sample locations, duration, and sample frequency. This brief outline connects the objective to the other stages in developing a monitoring plan and should raise critical implementation questions. What resources are needed? What kind of expertise is needed? And specifically, what potential monitoring equipment, methods, and funding will be needed?

Three of the *Watershed Issues and Action Opportunities* discussed in the Watershed Condition Evaluation (Component X) can be used to illustrate this initial stage in developing a monitoring plan. Please refer to Appendix XI-A for an outline of these examples. The three examples address temperature, bacterial contamination, and fine-sediment sources. The temperature study is designed initially as a one-season study to evaluate where potential problem areas are and if they are related to lack of shade. The bacterial contamination study combines storm-event monitoring to locate the sources of bacteria and a 1-year-long study to evaluate the severity and duration of the bacterial contamination. The sediment source study is planned for completion in a few weeks or months by monitoring turbidity during several runoff events.

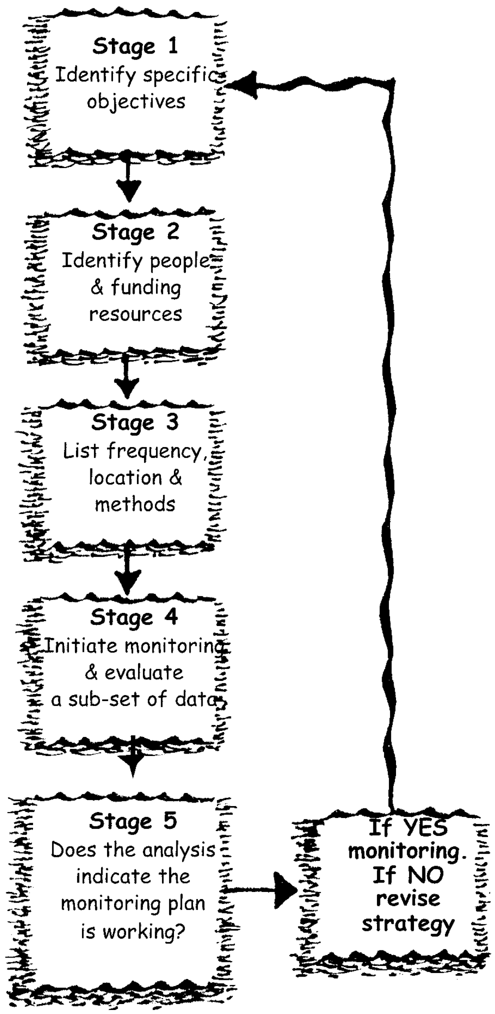

Figure 1. The process that should be followed to complete a monitoring plan is described in stages. The plan should be considered an iterative process, and the stages may vary depending on the type of monitoring.

Table 2. Example of initial monitoring strategy.

	Outline Example
Question/Data Gap	Does the stream meet state standards for temperature and dissolved oxygen?
Objective	Measure temperature and oxygen during critical seasonal periods and times during the day to detect exceedance of criteria.
Parameters	Temperature, dissolved oxygen
Methods	Continuous temperature data loggers, dissolved oxygen meter
Study Design	Upstream/downstream of major canopy openings, reference sites, etc.
Locations	Based on study design, access, vandalism.
Study Duration	At least one season
Sample Frequency	Data loggers—hourly

Stage 2: Resources

After an initial monitoring outline is completed, the next stage is to evaluate resources to carry out the project. This includes the people that are needed, the budget, the field equipment, laboratory analysis, and supplies. If the program is too ambitious, as is often the case, it is better to pare down expectations at this stage than have to deal with problems later. This is a good time to contact a monitoring specialist or mentor and determine if all the resource bases are covered.

Stage 3: Monitoring Details

Identify the specific set of parameters, the methods to be used, the sample frequency required, and the location of potential monitoring sites. This process should provide feedback on costs, equipment needs, and level of skill needed. Equipment and supplies for water quality studies such as temperature are listed in the *OPSW Water Quality Monitoring Guidebook*.

Stage 4: Pilot Project

Conduct field reconnaissance of all monitoring sites to be sure that access is secured and that conditions are safe throughout the monitoring period. It is a good idea to plan on conducting a pilot project for a short period or complete some trial runs prior to committing to a long-term monitoring program.

Stage 5: Review and Revise

Review the data collected after a short pilot period to determine if the information being collected will answer the overall monitoring objective, and that it meets the quality assurance objectives. Any bugs in the monitoring program can be worked out before more effort is expended. For temperature data loggers, for example, a standard procedure is to check the data logger against a standardized thermometer before installation in the stream.

WRITTEN MONITORING PLAN

Once you have gone through the iterative process of developing a monitoring approach, it is important to document these decisions in a written monitoring plan. The monitoring plan documents why, how, when, and where you plan to conduct the monitoring activity. You can return to the monitoring plan throughout the course of a monitoring project to help maintain consistency and provide documentation to others about your efforts. Listed in the sidebar, Monitoring Plan Components, are the topics that should be included in the monitoring plan. A more detailed description is provided in the *OPSW Water Quality Monitoring Guidebook*. Refer to this document for further details on developing the monitoring plan, selecting sites, data quality discussion, and recommendations for data storage and analysis.

MONITORING PLAN COMPONENTS

Background
This information can be summarized directly from the Watershed Condition Evaluation Assessment component. Describe the watershed and the previous studies and data available on the issue. This section, as does the rest of the monitoring plan, communicates to others about your monitoring project. The background section provides the basic context for the study and includes such facts as geology, soils, land uses, channel types, and historical context.

Problem Statement, Goals, and Objectives
Summarize the information derived from Stage 1 to document the statement of the data gap to be addressed or the question to be answered.

Site Description
The site description provides the context of the sampling sites in comparison to other sites in the watershed and provides comparability to potential reference sites in other watersheds. The site description can be based on the information from maps generated during the watershed assessment such as Channel Habitat Type, adjacent riparian condition, and elevation. Monitoring sites need to be located specifically on a topographic map so that the exact location can be described using the latitude and longitude.

Methods
The methods section describes the technical portion of the monitoring project. It documents the techniques that will be used to collect samples or field measurements, equipment and equipment calibration, what specific parameters are to be collected, and target periods. This section documents the decisions made in Stage 3 of the planning process. Quality Assurance and Quality Control (QA/QC) are essential elements of any monitoring plan. They provide you with evidence that your data is accurate and precise enough to address the questions being asked. These elements are addressed in detail in the OPSW Water Quality Monitoring Guidebook.

Data Storage and Analysis
Thinking through this section is critical early in the monitoring process so you have the support necessary to store, transport, or analyze the data. The Oregon Department of Environmental Quality has developed a data storage template that can be used to format data records (see OPSW Water Quality Monitoring Guidebook for details). Planning ahead can save time and money, and spare the agony of lost data.

Timetable and Staff Requirements
Each monitoring project will have a unique schedule of activities that must occur for it to be successful. These planning and implementation activities take time. The OPSW Water Quality Monitoring Guide contains general examples of the sequencing of stages and time requirements for a monitoring project.

MONITORING PROTOCOLS

Typical monitoring activities and methods that may be anticipated to fill data gaps identified in each section of the watershed assessment are shown in Tables 3 and 4. The potential activities cover a technical range from field verification of assumptions made in the office to running hydrologic and erosion models. This range of technical expertise reflects the complexity of natural systems and is not intended to suggest that watershed councils undertake all these activities. Natural resource professionals should guide the selection of potential monitoring activities that can be undertaken.

Some monitoring protocols have been designed for watershed volunteers. These monitoring programs are very useful in increasing involvement from the local community and in providing educational opportunities. Information from these less-specialized procedures may provide valuable information on the watershed. However, it is important to carefully evaluate what can be accomplished by a volunteer program versus what is needed to answer critical questions about the watershed. The US Environmental Protection Agency (EPA) has completed Volunteer Monitoring Guides for estuaries, lakes, and streams (EPA 1991, 1993, and 1997).

ADDITIONAL RESOURCES FOR DEVELOPING MONITORING PLANS

This watershed assessment manual cannot anticipate all the types of restoration activities that watershed councils may undertake. There are, however, some good guidance documents that provide detailed direction in developing monitoring programs for implementation and effectiveness monitoring. The article by Kershner (1998) in *Watershed Principles and Practices* provides a brief review of what is needed in a monitoring plan for restoration activities. The guidance documents by MacDonald et al. (1991) and Dissmeyer (1994) provide detailed monitoring guidelines for assessing forestry activities, and the guidance document by Bauer and Burton (1993) provides specific protocols for assessing effects of grazing management on water quality. The EPA (1997) document, *Monitoring Guidance for Determining the Effectiveness of Nonpoint Source Controls*, is an excellent reference document available at no cost that addresses the development of monitoring plans, data analysis and statistics, and quality assurance procedures.

Table 3. Monitoring methods for watershed characterization and source assessment.

Manual Component	Monitoring Follow-Up	Monitoring Method
Channel Habitat Type Classification (Component III)	Field verification of CHTs	Described in Channel Habitat Type Classification component (Component III).
	Detailed verification method	Rosgen 1996.
	Reference channel sections	Harrelson et al. 1994.
		TFW Ambient Monitoring Program Manual (Shuett-Hames et al. 1994).
Hydrology and Water Use (Component IV)		See Hydrology (Component IV) section for list of further hydrologic analyses.
Riparian (Component V)	Field verification of recruitment situation and shade	Described in Riparian section, Component V.
	Field measure of stream shade	Described in Riparian section.
	Riparian plant community	Riparian Area Management: Greenline Riparian-Wetland Monitoring (Cagney 1993).
	Riparian evaluation procedure	Integrated Riparian Evaluation Guide (USDA Forest Service 1992).
	Urban riparian inventory	Oregon Urban Riparian Inventory and Assessment Guide (1998)
	Riparian physical processes	Users Guide to Assessing Proper Functioning Condition (Bureau of Land Management 1998).
Wetlands (Component V)	Field verification of wetland attributes	Limited OFWAM Evaluation (Option A) described in Wetland section, Component V.
	Intensive methods	Wetland Functional Assessment (Option B) described in Wetland section.
Sediment Sources (Component VI)	Field verification of sources	Described in Sediment Sources component (Component VI).
	Rural road instability	Forest Road Hazard Inventory Protocol (Oregon Department of Forestry [ODF]).
	Erosion—crop land	Universal Soil Loss Equation (USDA Agricultural Handbook #703).
	Erosion—range land	Monitoring Primer for Rangeland Watersheds (Bedell and Buckhouse 1994).
	Forest management practices	Evaluating the Effectiveness of Forestry BMPs (Dissmeyer 1994).
Channel Modification (Component VII)	Field verification	Described in Channel Modification component (Component VII).

Table 4. Water quality and fisheries monitoring methods.

Manual Component	Monitoring Follow-Up	Monitoring Method
Water Quality (Component VIII)	Intensive monitoring methods	Described in Oregon Water Quality Monitoring Guidebook (OPSW 1999) • Temperature—continuous recorders • Dissolved oxygen—Winkler Method or dissolved oxygen meter • Intergravel dissolved oxygen—field sampling protocol • pH and conductivity meters • Nitrogen and phosphorus—laboratory analysis • Turbidity—field meter or laboratory analysis • Macro-invertebrates—identification and counts • Fecal bacteria—laboratory analysis • Pesticides and toxins—laboratory analysis
	Water quality effects of grazing	Monitoring Protocols to Evaluate Water Quality Effects of Grazing Management in Western Riparian Areas (Bauer and Burton 1993)
	Water quality effects of forestry	Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska (MacDonald et al. 1991)
Fish and Fish Habitat (Component IX)	Fish distribution	Surveying Forest Streams for Fish Use (ODF)
	Migration barriers	Oregon Road/Stream Crossing Restoration Guide (GWEB 1998)
	Pool habitat condition survey	ODFW Stream Habitat Surveys (Moore et al. 1997)
	Large woody debris, spawning gravel, habitat units	TFW Ambient Monitoring Program Manual (Shuett-Hames et al. 1994)

REFERENCES

Bauer, S.B. and T.A. Burton. 1993. Monitoring Protocols to Evaluate Water Quality Effects of Grazing Management of Western Rangeland Streams. US EPA, Region 10, Water Division, Surface Water Branch. EPA 910/R-93-017.

Bedell, T.E., and J.C. Buckhouse. 1994. Monitoring Primer for Rangeland Watersheds. US Environmental Protection Agency. EPA 908-R-94-001.

Bureau of Land Management, Oregon Division of State Lands. 1998. Urban Riparian Inventory and Assessment Guide.

Cagney, J. 1993. Riparian Area Management, Greenline Riparian-Wetland Monitoring. Bureau of Land Management. Tech. Ref. 1737-8.

Dissmeyer, G.E. 1994. Evaluating the Effectiveness of Forestry Best Management Practices in Meeting Water Quality Goals and Standards. US Department of Agriculture Forest Service, Southern Region, Atlanta Georgia.

Governor's Watershed Enhancement Board (GWEB). 1998. Oregon Road/Stream Crossing Restoration Guide: Summer 1998 Draft.

Harrelson, C.C., C.L. Rawlins, and J.P. Potyondy. 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Technique. US Department of Agriculture Forest Service: Gen. Tech. Report RM-245.

Kershner, J.L., 1997. Monitoring and Adaptive Management. Chapter 8 *in* J.E. Williams, C.A. Wood, and M.P. Dombeck, editors. Watershed Restoration: Principals and Practices. American Fisheries Society, Bethesda, Maryland.

MacDonald, L.H., A.W. Smart, and R.C. Wissmar. 1991. Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska. US Environmental Protection Agency, Region 10, Water Division, Seattle, Washington. EPA/910/9-91-001.

Moore, K.M.S., and K.K. Jones. 1997 (in prep.) Analysis and Application of Stream Survey Data for Restoration Planning and Quantification of Change at the Watershed Scale. Oregon Department of Fish and Wildlife Research Section, Corvallis.

Moore, K.M.S., K.K. Jones, and J.M. Dambacher. 1997. Methods for Stream Habitat Surveys. Oregon Department of Fish and Wildlife, Portland.

National Resource Conservation Service. Revised Universal Soil Loss Equation (RUSLE). Agricultural Handbook #703. US Department of Agriculture.

Oregon Plan for Salmon and Watersheds. 1999. Water Quality Monitoring Guide Book.

Oregon Department of Forestry. Forest Road Hazard Inventory Protocol.

Oregon Department of Forestry and Oregon Department of Fish and Wildlife. Surveying Forest Stream for Fish Use.

Rosgen, D. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, Colorado.

Shuett-Hames D., A. Pleus, L. Bullchild, and S. Hall. 1994. Ambient Monitoring Program Manual. Washington State Department of Natural Resources, TFW-AM9-94-001, Olympia.

US Department of Agriculture Forest Service. 1992. Integrated Riparian Evaluation Guide, Intermountain Region. Ogden, Utah.

US Environmental Protection Agency. 1993. Volunteer Estuary Monitoring: A Methods Manual. EPA842-B-93-004. http://www.epa.gov/owow/monitor/estusrvm.html

US Environmental Protection Agency. 1991. Volunteer Lake Monitoring: A Methods Manual. EPA440-4-91-002. http://www.epa.gov/owow/monitor/lakevm.html

US Environmental Protection Agency. 1996. The Volunteer Monitor's Guide to Quality Assurance Project Plans. EPA440-4-91-002. http://www.epa.gov/owow/monitoring/volunteer/gappcovr.html

US Environmental Protection Agency. 1997. Volunteer Stream Monitoring: A Methods Manual. EPA841-B-97-003.

US Environmental Protection Agency. 1997. Monitoring Guidance for Determining the Effectiveness of Nonpoint Source Controls. US EPA, Region 10, Water Division, Surface Water Branch. EPA 910/R-93-017.

Appendix XI-A
Monitoring Outline for Selected Issues

APPENDIX XI-A: MONITORING OUTLINE FOR SELECTED ISSUES

Primary Monitoring Issue	***Temperature***
Subwatershed: **Location:** **Map Symbol:**	***Nonsense Creek*** (see Watershed Issue description in Component X). Lower 1.3 mile section NC1
Background	The condition evaluation indicates that water temperatures in late summer are as high as 72°F in the lower portion of Nonsense Creek. Land uses in the lower section of the watershed are farm lands, composed of a mixture of crops and grazing. There is currently very little riparian vegetation along this section of the stream. There is limited water removal from the stream. The upper watershed is forested and has a good population of rainbow trout. The water temperature data was observed during a stream habitat survey; there is no other water temperature information.
Monitoring Question/ Data Gap to be Addressed	Are high temperatures impacting fish populations in the lower section of the stream? If so, are these high temperatures related to lack of riparian canopy cover, water withdrawals, or both?
Study Objectives	1. Identify temperature patterns in the mainstem of the creek and key tributaries. 2. Verify riparian cover findings identified from aerial photos.
Parameters	Primary: Temperature; Secondary: Canopy cover
Methods	Temperature data loggers, (Guidebook for Water Quality Monitoring, OPSW 1998). Densiometers for canopy cover (See Appendix V-B in this manual). QA/QC Issues: Verify accuracy of data loggers prior to field installation; install loggers according to protocols to avoid effects of local warming.
Study Design (& critical period)	Use upstream-downstream approach to bracket areas of high and low canopy cover. Locate data loggers in upper watershed in areas of known fish occurrence to determine temperature zones in which fish appear to be thriving. Install data loggers with sufficient time prior to and after expected warm period (June – August) to document the duration of high temperatures.
Station Locations	Locate stations at mouth of tributaries to document temperature regime in these sub-basins. Locate stations above and below canopy openings, and at land use breaks.
Study Duration	A study during one season provides comparison between locations to identify areas of warming or cooling. Annual monitoring may be needed to verify these results, to note differences between years, or as a follow-up to restoration actions.
Sample Frequency	Temperature data loggers should be set to short intervals (e.g., 15-20 minutes) to capture the daily extremes in temperature accurately.
Analyses	Graphical: Plot the temperature on the X axis against time in days on the Y axis. Look for periods of exceedance of the Oregon water quality criteria of 64°F. (Data logger software usually provides these plots and calculates daily maximum, minimum, and mean.) Evaluate any exceedance of temperature criteria against the canopy cover evident in aerial photos and compared with canopy measurements if these were collected. Other: Calculate the number of days that temperature exceeds the 7-day moving average (64°F) in the Oregon Water Quality Standards.

Primary Monitoring Issue	***Bacterial Contamination***
Subwatershed: **Location:** **Map Symbol:**	***Big River*** (see Watershed Issue description Component X). Lower 10 miles between the mouth and Elk City Red line along lower Big River
Background	The Big River summary indicates that bacterial numbers increase along the reach of stream from Elk City to the mouth of the river. Potential sources of bacterial contamination along this reach include urban/suburban runoff; runoff from pastures, confined animal feeding areas and other livestock and pet wastes; and failing septic systems.
Monitoring Question/ Data Gap to be Addressed	What are the contributing sources and severity of bacterial contamination to Big River below Elk City?
Study Objectives	1. Confirm the degree of severity of the bacterial pollution in Big River. Is there a consistent problem or was the initial finding an anomaly? 2. Locate specific contributing sources of *E. coli* to identify problem areas and potential solutions.
Parameters	*E. coli* bacteria samples
Methods	Grab samples for analysis at certified laboratory QA/QC Issues: Sterilized sample containers, store on ice, transport to lab within specified holding time.
Study Design (& critical period)	To address the first objective, a few selected index stations will be sampled on a monthly basis to determine the severity and duration of the problem. For the second objective, a set of intensive stations will be monitored during representative storm events at key tributaries and river locations to bracket land use areas.
Station Locations	Determined by location of sources, land use, and accessibility. Stations are located above and below major land uses on tributaries and to segregate regions along the river.
Study Duration	Measure index stations over a 6-12 month period to represent both high and low periods. Monitor intensive survey stations 3-4 times during this period.
Sample Frequency	Index stations–monthly basis. Intensive survey stations as needed to sample storm events.
Analyses	Graphical: Plot results of storm-event monitoring with bacterial numbers on X axis and stream miles along the Y axis. Look for a consistent pattern of increases to identify bacterial sources. (Note: Bacterial counts often need to be converted to a different scale such as a logarithmic scale). Other: Tally the percent exceedance of water quality criteria to identify areas that exceed water quality standards.

Primary Monitoring Issue	***Fine Sediment (turbidity)***
Subwatershed: **Location:** **Map Symbol:**	***Elk Creek*** (see Watershed Issues description in Component X). Lower 2 miles EC1
Background	Elk Creek passes through farms for the first mile and then drains private forest lands. In comparison to similar streams in this area, there appears to be large amounts of fine sediments deposited on the channel bottom, sometimes filling up shallow pools. It is not known where the sediments are coming from; the increase in sediments has been noted to correspond to the increased truck traffic over the last 2 years. There may be increased turbidity associated with the sedimentation.
Monitoring Question/ **Data Gap to be Addressed**	What are the contributing source(s) of sediment to this section of Elk Creek? Are roads and truck traffic the primary source of fine sediment?
Study Objectives	1. Determine the severity of fine sediment inputs to Elk Creek. 2. Identify the sources of sediment delivery. 3. Specifically, assess the condition of the adjacent roads during periods of sediment runoff.
Parameters	Turbidity (as a surrogate for suspended sediments. Note that turbidity is useful for very fine soil particles – silts and clays – but, is not generally useful for sand-sized particles.) Road condition
Methods	Turbidity: Portable turbidimeter provides ability to process samples quickly in the field. Samples can also be taken to a laboratory. Road Condition: Detailed Rural Road Runoff Survey (See Component VI for description, Table 12).
Study Design **(& critical period)**	Sample turbidity at locations along the stream and incoming sources during the wet weather period. Repeated surveys should show a pattern of obvious source areas. The road survey provides a detailed assessment by section which will link the sources to road segments needing improvement.
Station Locations	Identify potential source areas prior to sample collection such as road fill that is adjacent to the stream, cross-drain outlets, and other drainage sources. Flag and record these on a map as sample locations.
Study Duration	Several repeated visits should be adequate to identify source areas. The survey can be repeated after road improvements are made (during comparable conditions) to evaluate effectiveness of the treatments.
Sample Frequency	As described above.
Analyses	The turbidity levels during a survey can be plotted on a detailed map in relation to road features and other sources. Areas of higher turbidity may be linked to specific source areas using the Road Runoff Survey.