MONITORING APPENDIX

This appendix is intended to provide general guidelines for developing monitoring plans for streambank protection and stream restoration projects. Monitoring is defined as the collection and assessment of repeated observations or measurements over time to evaluate the effectiveness of restoration or management actions. It is never too early to consider a monitoring plan for a restoration or management action. Deciding if monitoring is important, what to monitor and why will help clarify the uncertainty associated with the activity, allow you to measure success, and will help build a better understanding of cause and effects.

1 REASONS TO MONITOR

Monitoring allows stakeholders to measure the effectiveness of projects through time and under a range of changing environmental conditions such as flooding or drought, channel shifts and erosion, beaver activity, or the effects of animal grazing. In addition, monitoring helps identify maintenance and project repair needs, and can provide information on ways to improve and refine management/restoration techniques. Monitoring can also be used to evaluate watershed restoration strategy—not limited to a single project, to learn from mistakes and adapt future restoration projects to the lessons learned.

Monitoring is designed and conducted to provide data useful to understand why techniques and practices work, and, equally important, why some fail. Thus modifications to a restoration project, and future projects in the same watershed, are informed by data analysis, rather than trial and error. Monitoring is an essential component of project design and evaluation, and is required not only to determine success of the restoration project, but critical to restoration program accountability and improvement. Monitoring is also a critical component of adaptive management. Because of uncertainties about the physical and ecological behavior of complex river systems, restoration needs to remain flexible enough to allow project modification in response to system responses identified through monitoring.[1]

This appendix will introduce the key components of monitoring streambank protection and stream restoration projects. Additional information on monitoring streambank protection and stream restoration projects (hereafter referred to as projects) can be found in the *Techniques* chapters of the Integrated Streambank Protection Guidelines (ISPG)[2] and Stream Habitat Restoration Guidelines (SHRG).

2 TYPES OF MONITORING

The following types of monitoring are not mutually exclusive and often the distinction between them is determined more by the purpose of monitoring than by the type and intensity of measurements.[3]

1. Baseline monitoring: characterizes existing conditions. The intent of baseline monitoring is to capture temporal variability of resource indicators before the project begins. Baseline monitoring establishes the benchmark against which success of the project can be measured.

2. Implementation monitoring: assesses whether project activities were carried out as planned. This is also sometime called compliance monitoring. For example, was large wood (of the appropriate size) placed in the stream according to the restoration plan?

3. Effectiveness monitoring: Effectiveness monitoring is used to evaluate whether the project had the desired effect on resource indicators (e.g., habitat conditions or stream processes). For example, a post project survey documents changes in pool depth or volume after placement of in-channel large woody debris when compared to baseline.

4. Validation monitoring: is used to establish a cause-and-effect relationship between the project and the biological indicator (e.g., fish or macro invertebrates) the project was intended to benefit.[4] For example did large woody debris placed in the stream result in fish density changes in the stream reach.

3 Monitoring Plan

Monitoring begins during project planning as existing conditions are assessed and project alternatives developed. Monitoring plans should be written during the planning phase when the goals and performance criteria are developed for the project. During the planning phase, project objectives, restoration measures, criteria for achieving and measuring success, contingency measures, and evaluation techniques should be fully explored. Clearly defining project objectives is central to post-project evaluation.

All monitoring should be based on a plan which includes 1) background on the projects (i.e., what is known about effects on this type of project etc., 2) the questions to be answered via monitoring, 3) methods for collecting and analyzing data, and 4) expected results, and 5) budgets. The reason for monitoring should be clearly stated prior to the collection of data. Monitoring can be a powerful tool to evaluate project success and impacts, watershed restoration strategy success, to compare the effectiveness of various techniques, and to determine the need for maintenance activities and repairs. However, monitoring without a definable goal is a waste of time.

4 Monitoring Plan Development

The following list can serve as a checklist of topics and details that should be included in any monitoring plan. See chapter 6b of Stream Corridor Restoration by the Federal Interagency Stream Restoration Working Group[5] (http://www.usda.gov/stream_restoration/newgra.html) for details on how to develop a monitoring plan based on a similar outline.

Planning

Step 1: Define the question the monitoring is supposed to answer.

Determine what decisions will be based on the results of monitoring and how results will guide decision-making.

Step 2: Develop a strategy to answer those questions

- Avoid mission creep

- Develop a broad strategy based on:
- Before/after study design
- Treatment/control study design

Step 3: Choose performance criteria. Monitoring plan design should utilize knowledge of the system being studied.

- Link performance to goals
- Develop criteria
- Identify reference sites

Step 4: Choose monitoring variables and methods

- Use statistical expertise in design so that method chosen can detect a meaningful change
- Resource indicators selected should be sensitive to change
- Establish methods for sampling design, sampling protocol, and sample handling/processing
- Determine the level of effort and duration of monitoring consistent with questions and everything else

Step 5: Estimate cost

- Cost for developing the monitoring plan itself
- **Quality assurance**
- Data management
- Field sampling program
- ***Laboratory sample analysis***
- **Data analysis and interpretation**
- Report preparation
- Presentation of results
- Get budget commitments

B. Implementing and Managing

- Clearly define roles and responsibilities
- The designer of the monitoring plan should participate in all phases of project
- Enact quality assurance procedures
- Analyze the data and interpret the results as soon as possible
- Manage the data
- Provide for contracts

C. Responding to the Monitoring Results

- Maintenance
- Adding, abandoning, or decommissioning plan elements
- Modification of project goals
- Adaptive management
- Documentation and reporting
- Dissemination of results
- The technical analysis in a monitoring report should discuss options to address project deficiencies and result in regular monitoring reports.[6]

5 BASELINE DATA

We focus on baseline data below because it is an integral part of monitoring that is often left out of monitoring plans. Prior to commencing maintenance or restoration actions, baseline data should be collected. This data can be used to document starting conditions against which success can be measured. It is important to consider the timing of monitoring. Baseline-data collection and subsequent monitoring should be conducted at the same time of the year relative to fish life cycles, plant phrenology, bird migration and hydrologic conditions, [6] unless restoration objectives dictate otherwise. Baseline data collection may include, but should not be limited to:

- Establish permanent benchmarks (located away from areas of potential bank erosion);
- An as-built survey to document the project's configuration relative to permanent benchmarks;
- A summary of site hydrology (including location of the nearest gauging station if one exists and is relevant) and values for critical flows that will be used to initiate monitoring events;
- Document aerial photography, summary of erosion history and any other geomorphic data pertinent to project design;
- Document pre-project site and reach data pertaining to fish and wildlife use, the riparian corridor, floodplain function and overall habitat condition; and
- Document any other conditions related to project objectives.

Additionally, baseline data should be collected using the methods established in the monitoring protocol. It is crucial that qualitative and quantitative baseline-data collection be thorough and appropriate to provide a sound foundation for subsequent data collection and monitoring[6]. Keep in mind that all monitoring plans need to be tailored to the project and questions being posed.

6 GEOGRAPHIC ESTENT OF MONITORING

It is important to identify the geographic extent of monitoring if a project includes risks or benefits to the upstream or downstream channel or habitat processes. The longitudinal extent of impacts is related to the scope of the project, the geomorphic setting and the specific technique applied. As a general rule, a study reach that is 20 to 50 channel widths in length should be sufficient for monitoring impacts to channel form[7]. It is important to remember, however, that the longitudinal extent of monitoring is site-specific and should be based on specific project objectives.

7 MONITORING DURATION AND FREQUENCY

Both the duration and frequency of monitoring are important components of a monitoring plan. A monitoring duration of three years should be considered a minimum for most bank protection and stream restoration projects. A three-year monitoring period allows a project to be exposed to a range of flows and gives vegetation time to pass form the critical establishment period to a more mature phase. However, changes in channel form may require a high flow or a series of high flows that have a low probability of occurrence during a three-year period. In other words, the geomorphic success of a project may not be properly evaluated until such flows occur. In addition, riparian vegetation may take many years of growth before its success in bank stabilization or providing stream shade and temperature reductions can be evaluated with any confidence. Any upstream and downstream project effects will likely require a series of high flows before they become apparent. It may be appropriate to extend monitoring activities following certain flow events, for example within one month of any 10-year or greater flow. The primary determinants of a monitoring period should be project scope and risk. Projects with numerous structural components that are subjected to considerable scrutiny or exposed to substantive risk should probably be monitored for five years. Monitoring these projects for a shorter period of time may fail to detect important indicators of project performance. Monitoring frequency refers to how often monitoring activities will occur during any monitoring year and what time of year they should occur. In many cases, a single, annual monitoring effort is sufficient. The monitoring frequency many need to be based on the occurrence of specific flood events, especially when project risk is a factor, such as when a project is protecting a valuable resource, or project failure could endanger a valuable resource. Alternatively, the monitoring frequency may be systematic during certain times of year. For example, it may be appropriate to conduct all habitat monitoring on one frequency interval that is tied to spawning schedules; while whole bank protection and in-stream structures are monitored on another frequency that is tied to hydrologic sequences. An economical solution to limited monitoring budgets is to adjust the schedule of the monitoring plan so that more intensive, quantitative data is collected during the critical first three years. After this initial period, the scope of monitoring can be reduced. For example, vegetative success may be sampled intensively for statistical analysis during the first three years. But after that, a qualitative descriptor of revegetation patterns may be sufficient to evaluate project success. After a few years, the objectives, scope, and monitoring duration may change to reflect maintenance needs, rather than to achieve success criteria.

8 Examples Of Restoration Objectives

Table 1 provides some examples of restoration objectives linked to monitoring variables (adapted from Kondolf and Micheli 1995).

General Objectives	Monitoring Variables
Improve channel dimensions, pattern, profile and stability	Channel cross sections
	Flood stage surveys
	Width-to-depth ratio
	Rates of bank or bed erosion
	Longitudinal profile
	Aerial photography interpretation
8.1.1.1 Protect Streambank	Channel cross sections
	Streambank profile
	Bank pins to measure rate of bank erosion
8.1.1.2 Improve aquatic habitat	Water depths
	Water velocities
	Percent overhang, cover, shading
	Pool/riffle composition
	Stream temperature
	Bed material composition

	Population assessments for fish, invertebrates, macrophytes
	Fish passage barrier assessment
	Large woody debris survey
8.1.1.3 Improve riparian habitat	Percent vegetative cover
	Plant species density
	Plant size distribution
	Plant age class distribution
	Plantings survival
	Plant reproductive vigor
	Bird and wildlife use
	Aerial photography
Improve water quality	Temperature
	Ph
	Dissolved oxygen
	Conductivity
	Nitrogen
	Phosphorous
	Herbicides/pesticides
	Turbidity/opacity
	Suspended/floating matter
	Trash loading
	Odor
Recreation and community involvement	Visual resource improvement based on landscape control point surveys
	Recreational use surveys
	Community participation in management

9 Table References

The following references provide details on how to use each of the monitoring variables identified in the above table:

Bain, Mark and Nathalie Stevenson, editors. 1999. Aquatic habitat assessment: common methods. American Fisheries Society, Bethesda, MD.

- This document provides methods for measuring stream cross-sections, stream longitudinal profiles, bank stability, fish passage barrier assessment mostly on culverts/, bed material composition, large woody debris survey, pool/riffle composition, riparian vegetation surveys, and temperature. Governor's Watershed Enhancement Board. 1993. Photo plots: a guide to establishing points and taking photographs to monitor watershed management projects. Salem, OR. 16p. Harrelson, Cheryl, C.L. Rawlins, and J. Potyondy. 1994. Stream channel reference sites: an illustrated guide to field technique. Gen. Tech. Rep. RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61p. www.stream.fs.fed.us/PDFs/RM245.PDF

- This document provides methods for measuring stream cross-sections and longitudinal profiles, establishing permanent benchmarks, and basic survey techniques. Kaufmann,

Phillip and E. G. Robinson. 1994. Section 6 *in* Klemm, Donald and James Lazorchak, editors. Environmental monitoring and assessment program: surface waters and Region 3 regional environmental monitoring and assessment program. Environmental Monitoring Systems Laboratory, Environmental Protection Agency, Cincinnati, OH.

- This document provides methods for measuring stream water quality variables. MacDonald, L.H., A.W. Smart, and R.C.Wissimar. 1991. Monitoring guidelines to evaluate effects of forestry activities on streams in the Pacific Northwest and Alaska. EPA/910/9-91-001. Seattle, WA: U.S. Environmental Protection Agency and University of Washington. 166p. http://www.epa.gov/epahome/publications.htm

- This document provides methods for measuring stream water quality variables, cross sections, width/depth ratio, bank stability, macroinvertebrate, macrophyte and fish surveys, bed material, large woody debris, water depths, pool parameters, and riparian vegetation. Moore, Kelly, Kim Jones, and Jeff Dambacher. 1998. Methods for stream habitat surveys: aquatic inventory project. Oregon Department of Fish and Wildlife: Natural Production Program. Corvallis, OR. 35p.

- This document provides methods for measuring in-stream aquatic habitat variables. Oregon Plan for Salmon and Watersheds. 1999. Water quality monitoring: technical guide book. http://www.oweb.state.or.us/publications/mon_guide99.shtml

- This document provides methods for measuring stream shade and all water quality variables. Platts, William, C. Armour, G. Booth, M. Bryant, J. Buffort, P. Culpin, S. Jensen, G. Lienkaemper, W. Minshalll, S. Monsen, R. Nelson, J. Sedell, and J. Tuhy, 1987. Methods for evaluating riparian habitats with applications to management. Gen. Tech. Rep. INT-221. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 177p.

- This document provides methods for measuring streambank and channel stability, % vegetation overhang and cover, and riparian vegetation species density and distribution. Rosgen, Dave. 2001. A stream channel stability assessment methodology. Proceedings of the Seventh Federal Interagency Sedimentation Conference, Vol. 2, pp. II - 18-26, March 25-29, 2001, Reno, NV

- This document provides methods for measuring streambank and bed stability. Rosgen, David L. 2001. A Practical method for computing streambank erosion rate. Proceedings of the Seventh Federal Interagency Sedimentation Conference, Vol. 2, pp. II - 9-15, March 25-29, 2001, Reno, NV

- This document provides methods for measuring streambank stability. Winward, Alma H. 2000. Monitoring the vegetation resources in riparian areas. Gen. Tech. Rep. RMRS-GTR-47. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 49p.

- This document provides methods for measuring riparian vegetation % cover, species density, size/age distribution and reproductive vigor. Johnson, D. H., N. Pittman, E. Wilder, J. A. Silver, R. W. Plotnikoff, B. C. Mason, K. K. Jones, P. Roger, T. A. O'Neil, and C. Barrett. 2001. Inventory and Monitoring of Salmon Habitat in the Pacific Northwest - Directory and Synthesis of Protocols for Management/Research and Volunteers in Washington, Oregon, Idaho, Montana, and British Columbia. Washington Department of Fish and Wildlife. Olympia, Washington. 212 pp.

- This document reflects an effort to establish a consistent format for the collection of salmonid habitat data across the Pacific Northwest. Its objectives are to: 1) provide a synthesis of the salmon habitat protocols applicable to the Pacific Northwest, 2) recommend a subset of these protocols for use by volunteers and management/research personnel across the region, 3) link these protocols with specified types of habitat projects, 4) establish a Quality Assurance/Quality Control framework for the data derived from the use of these protocols, and 5) to the degree possible, identify the format and destination where the data is routinely sent.

10 Additional Reading

Johnson, D. H., N. Pittman, E. Wilder, J. A. Silver, R. W. Plotnikoff, B. C. Mason, K. K. Jones, P. Roger, T. A. O'Neil, C. Barrett. 2001. Inventory and Monitoring of Salmon Habitat in the Pacific Northwest - Directory and Synthesis of Protocols for Management/Research and Volunteers in Washington, Oregon, Idaho, Montana, and British Columbia. Washington Department of Fish and Wildlife, Olympia, Washington. 212 pp.

Oregon Watershed Enhancement Board. 1999. Oregon Watershed Assessment Manual. Monitoring Plan. Component XI. http://www.oweb.state.or.us/publications/wa_manual99.shtml
Roni, Philip, Liermann, Martin, and Ashley Steel. Monitoring and evaluating responses of salmonids and other fishes to instream restoration. IN: Montgomery, D. R., Bolton, S., and Booth, D.B. (editors). Restoration of Puget Sound Rivers, University of Washington Press, in preparation.

USDA – NRCS. 1999. Stream corridor inventory and assessment techniques. Watershed Science Institute Technical Report. 30p.

11 References

[1]Kondolf, G. M. 2000. Some suggested guidelines for geomorphic aspects of anadromous salmonid habitat restoration. Restoration Ecology 8(1): 48-56.

[2] Cramer, M., K. Bates, D. Miller, K. Boyd, L. Fotherby, P. Skidmore, and T. Hoitsma. 2003. *Integrated Streambank Protection Guidelines*. Co-published by the Washington departments of Fish & Wildlife, Ecology, and Transportation. Olympia, WA. 435 pp.

[3] MacDonald, L. H., A. W. Smart, and R. C. Wissimar. 1991. Monitoring guidelines to evaluate effects of forestry activities on streams in the Pacific Northwest and Alaska. EPA/910/9-91-001.

Seattle, WA: U.S. Environmental Protection Agency and University of Washington. 166p.

[4] Botkin, D. B., D. L. Peterson, and J. M. Calhoun (technical editors). 2000. The scientific basis for validation monitoring of salmon for conservation and restoration plans. Olympic Natural Resources Center Technical Report. University of Washington, Olympic Natural Resources Center, Forks, WA. 82p.

[5] Federal Interagency Stream Restoration Working Group. 1998. Stream Corridor Restoration: Principles, Processes, and Practices.

[6] Kondolf, G. M. and E. R Micheli. 1995. Evaluating Stream Restoration Projects. Environmental Management 19(1): 1-15.

[7] Kondolf, G. M. 1995. Five elements for effective evaluation of stream restoration. Restoration Ecology 3(2): 133-136.