PACIFIC NORTHWEST AQUATIC MONITORING PARTNERSHIP

Annual Report for 2007

Performance Period:
January 1, 2007 - December 31, 2007

DATE SUBMITTED
February 2008

SUBMITTED BY
Jennifer Bayer and Jacquelyn Schei
PNAMP Coordination Team

Table of Contents

List of Figures

Executive Summary

In 2007, PNAMP continued to focus on providing opportunities for inter-organizational committees to work together to identify needs and address elements of its goals. PNAMP workgroups and subcommittees continue to advance coordination goals by tackling projects and exchanging information about their respective agencies' monitoring activities. In addition, the PNAMP Steering Committee advanced our first formal recommendations to the partners, worked with regional information management entities to sponsor an executive summit to foster a regional environmental information strategy, and began to outline a "regional monitoring operational plan" that could meet aquatic resource information needs.

PNAMP workgroups and subcommittees continued progress on many projects. Many technical experts contributed to making PNAMP tasks successful, including:

- initiation of a project to explore needs with respect to fish population monitoring methods (the "Tagging, Telemetry, and Marking Project"),
- progress on a protocol catalogue/data dictionary (Protocol Manager),
- initiation of an integrated status and trend monitoring demonstration project,
- a draft manuscript outlining the results from the habitat Protocol Comparison study,
- and consideration of new needs, such as coordination between aquatic and riparian monitoring and the invasive species early detection network.

The PNAMP Steering Committee supported several key regional initiatives, including working with the Northwest Environmental Data Network and Pacific Northwest- Regional Geographic Information Council to define roles of the three groups in providing regional information management. As a result, these groups sponsored an Executive Summit - *Sharing*

Information for Improved Decisions (held October 2, 2007), designed to bring executives together to discuss information management issues and needs.

Another significant advancement in coordination was the PNAMP Steering Committee's decision to initiate an 'operational plan' that proposes design, adoption, and implementation of a coordinated and integrated approach to monitoring of aquatic resources in the Pacific Northwest. The plan identifies common management questions to foster coordination of relevant monitoring initiatives and knits together many tasks PNAMP has tackled since its inception. Since costs of monitoring needed to address common management questions are more than one program can support alone, only through the combined efforts of multiple entities can a sufficient level of information be developed to guide regionally shared resource management decisions through coordinated, standardized and programmatic approaches to monitoring. These tasks are complex and resolution involves partnership with other regional and national organizations as well as many individual participants. However, successful collaboration on these fundamentals could be a first step in the creation of a regional monitoring effort.

Lastly, in addition to specific tasks, PNAMP continuously functions as a forum where monitoring practitioners and policy staff can interact and exchange information. PNAMP strives to produce tools and products to assist with information exchange, such as production of *PNAMP Pursuits* (our first newsletter), and continuous improvements to the PNAMP website.

We believe the opportunity provided by PNAMP to assist experts to collectively focus on issues, results, and future needs related to monitoring increases coordination and collaboration in the near term, and increases effectiveness and efficiency of aquatic resource monitoring on a regional scale in the long term.

Section I. Background

Federal, state, tribal, local, and private aquatic monitoring programs in the Pacific Northwest have evolved independently in response to different organizational mandates, jurisdictional needs, issues and questions. Planning and coordination of federal, state and tribal monitoring activities have evolved slowly but steadily over the past ten years. In 2004, the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) emerged from an ad hoc effort to become a formal institution charged with providing a forum for coordination of aquatic monitoring efforts in the region. The geographic area of this coordination includes the Pacific Northwest region from Northern California to Canada where the participating entities are implementing monitoring efforts. As of 2007, 19 state, tribal, federal, and regional entities signed the PNAMP Charter (Appendix A).

The basis of PNAMP is that monitoring will be improved if: all programs use consistent monitoring approaches and protocols; follow a scientific foundation; support monitoring policy and management objectives; and collect and present information in a manner that can be shared. These goals will require considerable effort and commitment to collaboration by many entities and individuals. PNAMP strives to provide the forum where this collaboration can occur and to facilitate the exchange among technical experts and between technical and policy staff that is necessary to accomplish these goals.

Although we are eager for more participation, we believe PNAMP has the right combination of types of participants to address these goals. PNAMP's organizational structure includes a Steering Committee, Coordinator and Assistant Coordinator, and technical workgroups defined by aquatic monitoring topics: watershed condition monitoring, fish population monitoring, estuary monitoring, project effectiveness monitoring, and data management. The Steering Committee is composed of representatives from all entities that are signatory to the Charter and leaders of the technical workgroups, a combination which allows the interface of technical and policy interests. The agency representatives are responsible for communication to PNAMP regarding their respective agencies' work and needs, as well as delivering PNAMP progress and challenges to their agencies.

More recently, PNAMP has developed a better understanding of how the goals and tasks of each technical workgroup, PNAMP subcommittee, and individual partners are inherently interdependent. PNAMP has identified and been working on a number of concepts important to establishing a regional partnership for aquatic resource monitoring that bridge technical focus areas and individual agencies. These are critical elements of a large scale, efficient, coordinated effort to monitor resources. We refer to these as "cross cut tasks":

- Protocols: what to measure and how to measure it
- Survey design: how to decide where and when to monitor
- Data management: what are our data needs; what must we do before, during, and after data collection to facilitate data sharing
- Monitoring inventory: better facilitate coordination by describing 'who is doing what monitoring where'
- High level indicators: seek agreement on a set of indicators (and metrics necessary to determine indicators) to describe landscape level changes in the region
- Regional network of monitoring efforts: explore ways to continuously improve our efficiency and effectiveness of monitoring on a regional scale

Each of these tasks is complex and resolution involves collaboration with other regional and national organizations, as well as many individual participants. However, successful coordination and collaboration on these fundamentals could be a first step in the creation of a regional monitoring effort.

The PNAMP Steering Committee, Workgroup Leaders and Coordination Team share the responsibility to work across PNAMP to accomplish our goals efficiently and consistently. We encourage those in the region who seek assistance with aquatic resource monitoring issues to contribute to PNAMP. Coordination on complex topics with many partners takes time and hard work. Since PNAMP is a voluntary organization, our progress is directly correlated to participation. Support is essential for PNAMP to respond to needs of the region; we need to hear from both technical and policy staff what is needed for better coordinated aquatic resource monitoring.

Section II. 2007 PNAMP Activities

Section II (a). Coordination Team

The PNAMP Coordination Team includes the Coordinator (Jennifer Bayer) and Assistant Coordinator (Jacque Schei). The Coordination Team's goals are to facilitate the transfer of information within PNAMP and across all relevant organizations, work to support relationships between science and monitoring and to promote communication among organizations to help assure that monitoring plans and information are coordinated across the Pacific Northwest. The Coordination Team works to initiate and facilitate the development, presentation, and distribution of products aimed as heightening understanding of PNAMP issues, successes, and problems and to serve as a clearinghouse for PNAMP activities and products.

The Coordination Team is responsible for administrative requirements of PNAMP activities (e.g. meeting logistical support, record keeping, and responsibility for maintenance of membership information). Organizational support was provided to PNAMP by developing and negotiating fiscal support with government and non-government entities, and managing budgets and associated contracts with government and non-government entities. Required progress reporting regarding Coordinator's activities (within PNAMP) and PNAMP activities to interested external parties was completed. In addition, the Coordinator conducted briefings at meetings, for individual agencies, executives, etc. throughout the region as requested regarding PNAMP's activities. The Coordination Team, with input from Steering Committee members, also produced PNAMP's first newsletter, *PNAMP Pursuits,* in October of 2007 (Appendix B). The PNAMP website continues to improve as the Coordination Team makes updates, including the addition of a page that serves as a resource for monitoring information in the region (http://www.pnamp.org/web/Content.cfm?SectionID=9).

Section II (b). Workgroup and subcommittee activities

Currently, there are five technical workgroups (WG) within PNAMP (Watershed Monitoring, Project Effectiveness Monitoring, Fish Population Monitoring, Data Management, and Estuary Monitoring), as well as a number of subcommittees (Protocol Manager/data dictionary; High Level Indicators; Invasive Species Coordination) formed to tackle specific tasks. Workgroups and subcommittees have met throughout the year on an as needed basis. Workgroup leaders initiate these meetings; the Coordination Team leads meeting preparation, facilitation, and follow-up, and assists with WG products.

Workgroups

Section II (b.1). Watershed Monitoring Workgroup

The Watershed Monitoring WG has evolved to using small workgroups to pursue areas of interest. The focus for the last three years has been: 1) a comparison of instream habitat assessment monitoring protocols (PNAMP Protocol Comparison Project) and 2) discussion of the development of status and trend monitoring survey design based on the “master sample concept” (Integrated Status & Trends Monitoring Project).

Protocol Comparison Project - The goal of the PNAMP Protocol Comparison Project is to expand on previous work on defining acceptable levels of variability within stream habitat protocols. An evaluation was conducted on the correlation between attributes measured by different monitoring programs and more intensive ground measurements of the same attributes (i.e., the “truth”). A multi-author manuscript is in preparation to suggest minimally acceptable criteria that monitoring programs should have to meet when conducting stream evaluations. The benefits of such criteria should be integration of stream habitat data resources so as to increase statistical power, improve trend detection, and reduce total cost of aquatic monitoring programs. The manuscript will be submitted for peer-review publication in 2008.

Integrated Status and Trend Monitoring (ISTM) project - The ISTM project is intended to demonstrate an approach and utility of an integrated design framework for the collection of information to address questions on the status and trends of physical, chemical, and biological attributes in stream networks. To date progress has involved PNAMP workshops and work sessions with local partners to scope and refine the project, compilation of information and beginning analyses related to use of the master sample concept, consideration of available information and gaps, and identification of implications associated with implementation of the approach. A demonstration project is underway in the lower Columbia Recovery area (Figure 1).

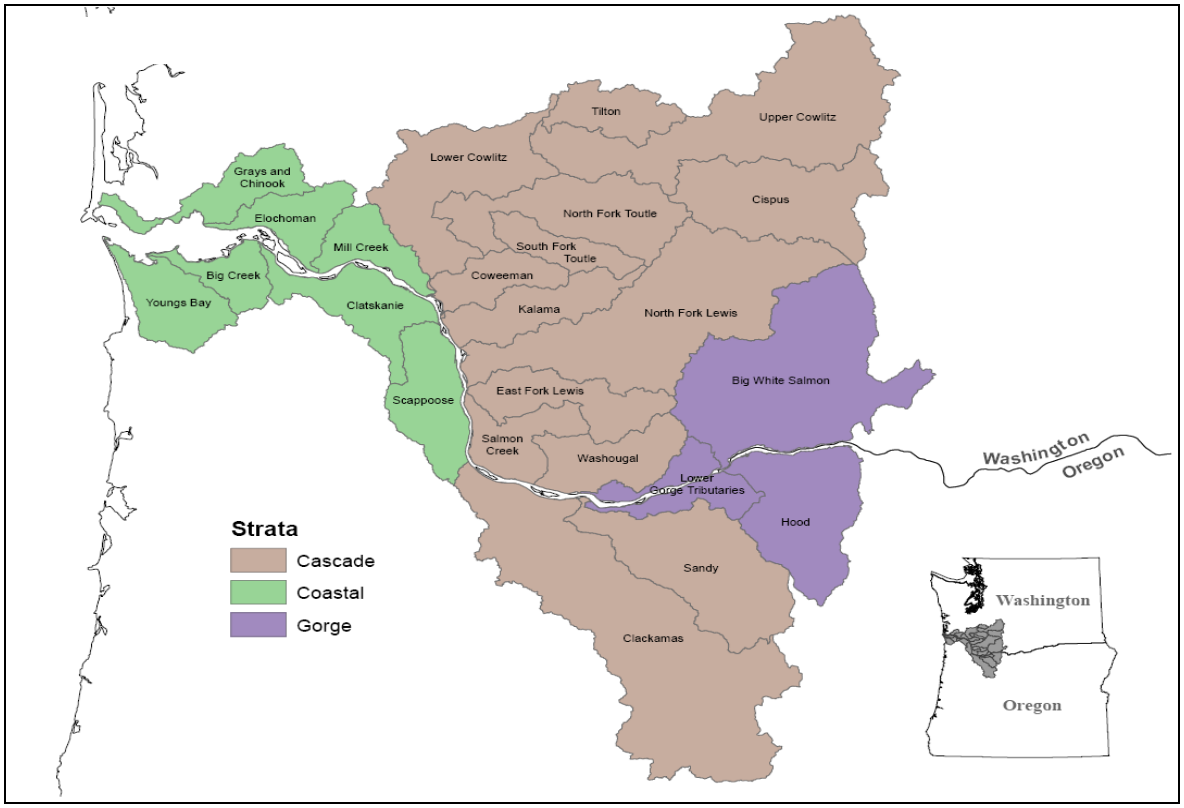


Figure 1. Lower Columbia River demonstration area

Section II (b.2). Project Effectiveness Monitoring Workgroup

The Project Effectiveness Monitoring WG, which includes a subcommittee dedicated to Intensively Monitored Watershed (IMW) topics, is focused on addressing the need to understand the effectiveness of watershed health and salmon recovery investments in terms of their stated outcomes and the resulting effect on salmon populations, water quality, water quantity, and habitat. PNAMP supports the development of a regional framework for determining which habitat projects are most effective, including addressing habitat project implementation monitoring, effectiveness monitoring, and the response of fish populations (validation monitoring) through intensively monitored watersheds

As part of the review of ongoing project-scale effectiveness monitoring programs and their protocols, the PNAMP Project Effectiveness Monitoring WG is developing methods for assessing the quality (validity) of effectiveness monitoring projects. This work intends to address the quality of effectiveness monitoring programs at the project or reach scale, although the methods could be applied at larger spatial scales. Results from this work can be used to help identify gaps, allow construction of a coordinated effectiveness monitoring network at a regional scale, and mesh effectiveness monitoring at the project scale with status and trend monitoring.

In 2005, PNAMP recommended establishing a regional network of "Intensively Monitored Watersheds" (IMWs) to evaluate the effectiveness of restoration projects, programs and policies at the landscape scale. Effectiveness monitoring at the IMW scale addresses the following general questions: Does the collective effect of restoration and/or management actions result in improved watershed condition and fish response? Why or why not? What are the causes of those responses?

In 2007, the IMW subcommittee produced a white paper to describe the overall suite of action effectiveness approaches and a context for how IMWs fit in ("Intensively Monitored Watersheds in Context"; Appendix C.1). In addition, the group initiated a review of the PNAMP IMW strategy and is working to estimate costs for a network of IMWs (draft "Overview of PNAMP strategy and preliminary costs to establish a network of Intensively Monitored Watersheds in the Pacific Northwest"; Appendix C.2). In 2008, the IMW subcommittee plans to continue to update the characterization of all IMWs and the IMW map (Figure 2) as needed; draft results and implications of landscape classification work on IMW strategy; look at what current IMWs address and what gaps exist; and initiate discussion regarding technical and policy-level adjustments in the IMW network.

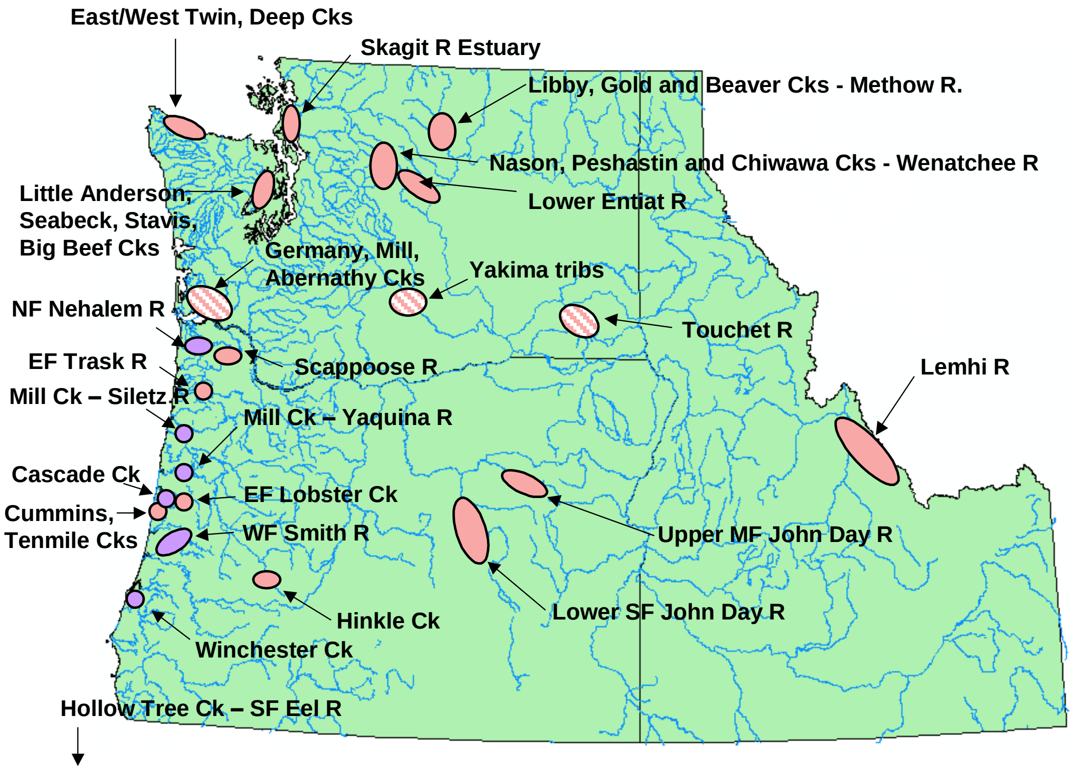


Figure 2. PNAMP Phase I Intensively Monitored Watersheds

Section II (b.3). Fish Population Monitoring Workgroup

In 2007, the Fish Population Monitoring WG initiated a task to review and catalog tagging, telemetry, and marking protocols in the region. The proposed Techniques Guide will provide new information, case studies, design and technological advances and will describe methods and protocols. The closing chapters will provide a summary of commonalities and areas of technical convergence. We will use a comparative analysis approach to propose recommendations that will improve tagging, telemetry and marking programs and techniques. This proposal will be reviewed by the NPCC's Independent Science Review Panel in early 2008, to assist the PNAMP Steering Committee in making decisions about the final nature of this product.

Section II (b.4). Estuary Monitoring Workgroup

The Estuary Monitoring WG was reinvigorated in 2007. New workgroup leadership is focusing on increasing participation and defining topics to address. The WG is working toward a review and future recommendation regarding estuary protocols in use in the Pacific Northwest, such as the Columbia River and Estuary Monitoring Protocols, newly developed OWEB protocols, and EPA protocols. In addition, the WG discussed continuing the inventory process and will start data dictionary content work soon.

Section II (b.5). Data Management Workgroup

The Data Management Workgroup continued to benefit from support from the Northwest Environmental Data Network (NED) and the NED coordinator also serves as the lead for this workgroup. PNAMP data management items were routinely brought to the NED Steering Committee (via shared meetings) for input and review. Conversely, NED work items and products were shared with PNAMP Steering Committee and workgroups. In late 2007, the PNAMP Steering Committee agreed to support hiring a full time data steward staff position to the PNAMP Coordination Team. The PNAMP Data Steward will be responsible for specific projects (such as Protocol Manager) and also facilitate dialog between PNAMP technical workgroups, regional information management groups, and regional application development teams. The Data Steward will be responsible for providing recommendations to the PNAMP Coordinator and Steering Committee on regional data management issues, tools, and procedures; communicating with monitoring practitioners to identify needs; communicating user requirements to development teams.

Subcommittees

Section II (b.6). Protocol Manger Subcommittee

PNAMP continues to support development of Protocol Manager, a relational database application designed to serve as a data dictionary for monitoring data. As a data dictionary, Protocol Manager prescribes standardized methods, by providing abstracts and citations for reference documents describing data collection procedures, and specifically defines the data elements (attributes) that represent habitat and biological variables. Testing of Protocol Manager software continued throughout 2007, including additional content updates, discussion of business rules, testing of FeatFiremon software, and development of a data dictionary template. In addition to beta testing, the team continues to discuss collaboration between the Protocol Manager team and related projects, such as the Integrated Status and Effectiveness Monitoring Project team and further progress on data entry template work. A Protocol Manager progress report was prepared in November 2007 (Appendix D).

Section II (b.7). High Level Indicators Subcommittee

PNAMP continued efforts to craft a white paper to facilitate selection and use of "High Level Indicators" as common currency to assess watershed health and salmon or steelhead recovery. "High level" is not intended to connote a high degree of importance; rather, high-level indicators (HLI) are biological and physical habitat variables that are monitored and evaluated over time at a watershed and regional scale, and can be communicated in easily understood terms. The white paper will describe a "Core List" of 17 generic indicators, a minimum Short List subset of seven indicators, a process to shape evaluation, and suggestions to address constraints that could and have stopped indicator implementation.

Substantial work on indicators has been done by PNAMP partners and other programs. We did not comprehensively cover all programs, but reviewed key indicators and programs important to the Pacific Northwest. Applications of this paper, however, are expected for the Northwest, the Nation, and through established collaboration, to the Pacific Rim. The white paper is expected to be complete in the beginning of 2008.

Section II (b.8). Invasives Species Monitoring Coordination

A new subcommittee formed this year to discuss aquatic and riparian invasive/nonnative species monitoring coordination issues. The subcommittee requested PNAMP facilitate a workshop in early 2008 to identify specific actions that can be taken in the 2008 field season to increase coordination between existing monitoring programs and invasive/nonnative early detection efforts. A second workshop is planned for spring 2008 to discuss invasive/nonnative monitoring data management and sharing coordination issues (this workshop will likely be co-sponsored by NED).

Section II (c). Steering Committee Activities

The PNAMP Steering Committee (SC) provides the science-policy interface between the Executive partners and technical workgroups, guides work of technical workgroups, obtains resources needed to accomplish tasks, and directs the activities of the Coordinator. The SC provides assistance to PNAMP initiatives by participating in the formulation, development, and review of recommendations for activities of PNAMP workgroups and integrating these activities with agency activities. The SC facilitates the transfer of information between PNAMP and their respective agencies. By promoting communication among organizations, the SC strives to assure that monitoring plans and information are coordinated across the Pacific Northwest.

The SC met ten times in 2007 for regular, monthly meetings. The primary activity at these meetings was tracking the progress of current activities and discussion of new tasks that align with PNAMP's goals. These meetings also facilitated information exchange between SC members and WG members. The PNAMP Coordination Team facilitated meetings and prepared notes following the meetings. In addition, the SC met for a two-day retreat in June to discuss strategic directions for PNAMP. Subgroups of the SC also met to discuss PNAMP's role in the region, alongside the Northwest Environmental Data Network and Pacific Northwest- Regional Geographic Information Council. Representatives from the three groups discussed the roles each plays in providing regional information management and how they can complement each other.

The result of these discussions was the October 2007 Executive Summit - *Sharing Information for Improved Decisions*, which brought executives from 32 entities and staff from a number of additional agencies (Appendix E.1) together to discuss information sharing issues and needs. Staff from PNAMP, NED, and PNW RGIC prepared several products in advance of the summit, including a business case and descriptive "Focus" document, to help describe the background and present goals for the summit (Appendix E.2, E.3).   Of particular interest to PNAMP partners is the monitoring case study developed for the Business Case. This excellent case study, highlighting monitoring coordination in the Upper Columbia, was developed by the Upper Columbia Regional Technical Team (Appendix E.2, pages 62-64).

Section II (d). PNAMP Formal Recommendations

PNAMP advanced four products to formal recommendation to the Executive Network in 2007 (Appendix F). A formal recommendation requests that the partners of PNAMP adopt and implement the product in their organizations. The first three recommendations were "Data Management Needs for Regional Project Tracking to Support Implementation and Effectiveness Monitoring", "NED Best Practices for Reporting Location and Time Related Data", and the "Salmonid Field Protocols Handbook". These recommendations were sent out to the Executive Network in March of 2007 and finalized as PNAMP recommendations in April. The fourth recommendation, “Methods for the collection and analysis of benthic macroinvertebrate assemblages in wadeable streams of the Pacific Northwest”, was formally recommended to the Executive Network and accepted in November 2007.

In 2008, PNAMP will consider how to measure results and impacts of recommendations and products advanced to the PNAMP partners.

III. Appendices

Section III (A). Entities signatory to the PNAMP Charter, December 2007.

PNAMP Partners	PNAMP Steering Committee Representative	PNAMP Executive Network Representative
Bonneville Power Administration	Jim Geiselman	Greg Delwiche VP Environment, Fish and Wildlife
California Department of Fish and Game	Scott Downie	Gary Stacey Northern Regional Manager
Columbia Basin Fish and Wildlife Authority	Ken MacDonald	Dan Diggs Chair
Columbia River Intertribal Fish Commission	Phil Roger	Olney Patt, Jr. Executive Director
Confederated Tribes of the Colville Reservation	John Arterburn	Joe Peone Director, Fish and Wildlife Department
Environmental Protection Agency	Gretchen Hayslip	Elin D. Miller Regional Administrator
NOAA Fisheries	Kim Kratz	Usha Varanasi Science and Research Director
Northwest Indian Fisheries Commission	Bruce Jones	Mike Grayum Executive Director
Northwest Power and Conservation Council	Steve Waste	Tom Karier Chair
Oregon Watershed Enhancement Board	Greg Sieglitz	Tom Byler Executive Director
Pacific States Marine Fisheries Commission	Bruce Schmidt	Randy Fisher Executive Director
US Army Corps of Engineers	Paul Ocker	Colonel Steven R. Miles, P.E. US Army Commander and Division Engineer
US Bureau of Land Management	Al Doelker	Edward W. Shepard State Director Oregon/Washington
US Bureau of Reclamation	Michael Newsom	J. William McDonald Regional Director
US Forest Service	Linda Ulmer	Linda Goodman Regional Forester Pacific Northwest Region
US Geological Survey	David Woodson	Ione Taylor Acting Northwest Area Executive
Washington Department of Ecology	Ken Dzinbal	Josh Baldi Environmental Assessment Program Manager
Washington Governor's Salmon Recovery Office	Steve Leider	Chris Drivdahl Team Leader
Washington Salmon Recovery Funding Board	Bruce Crawford	Steve Tharinger Chair

Section III (B). PNAMP Newsletter - PNAMP Pursuits

Link to document on PNAMP website: http://www.pnamp.org/web/workgroups/General/documents/General/2007_0927PNAMPNewsletter_vol.%201.pdf

PNAMP Pursuits

Newsletter of the Pacific Northwest Aquatic Monitoring Partnership

Volume 1, Issue 1 **October 1, 2007**

Pacific Northwest Aquatic Monitoring Partnership

Inside this issue:

PNAMP Charter Members:

- Bonneville Power Administration
- California Department of Fish and Game
- Columbia Basin Fish and Wildlife Authority
- Columbia River Intertribal Fish Commission
- Confederated Tribes of the Colville Reservation
- Environmental Protection Agency
- NOAA Fisheries
- Northwest Indian Fisheries Commission
- Northwest Power and Conservation Council
- Oregon Watershed Enhancement Board
- Pacific States Marine Fisheries Commission
- US Army Corps of Engineers
- US Bureau of Land Management
- US Bureau of Reclamation
- US Forest Service
- US Geological Survey
- Washington Department of Ecology
- Washington Governor's Salmon Recovery Office
- Washington Salmon Recovery Funding Board

Welcome to the first PNAMP Newsletter!

The Pacific Northwest Aquatic Monitoring Partnership (PNAMP; www.pnamp.org) is a forum for coordinating state, federal, and tribal aquatic habitat and salmonid monitoring programs. PNAMP was founded on the belief that improved communication, shared resources and data, and compatible monitoring efforts will provide increased scientific credibility, cost-effective use of limited funds and greater accountability to stakeholders. PNAMP strives to provide leadership through the development and the advancement of recommendations and agency level agreements that are considered for adoption by the participating agencies.

PNAMP would like to thank all of you who have contributed to collaborative projects, workgroups, workshops, and discussions during our first three years. Your participation has made PNAMP a successful forum for monitoring coordination in the Pacific Northwest! In order to celebrate your hard work and encourage others to join us, we offer this newsletter as a way to keep you up to date on progress and ideas for new projects.

You will generally see names of task leaders in these newsletter articles; please feel free to reach out to these people with any questions. If you have any feedback or ideas about content for future issues of the newsletter, please contact Jacque Schei (jschei@usgs.gov).

Regional Data Sharing Needs

Adequate access to high quality monitoring data, analyzed information, and reports is a critical, and as yet, unmet need for many PNAMP partners. The overall PNAMP data management goal is to assist scientists in the identification and development of data standards as it relates to the monitoring of fish and aquatic habitat. The objective is to identify solutions that improve access, sharing, and coordination among different collectors and users of fish and aquatic habitat monitoring data.

On a regional scale, many entities use different information collection methods and procedures , even though they may manage different parts of the same landscape, species, stream, road, or infrastructure. As a result, collecting, sharing, and communicating information for many decisions is cumbersome, complicated, and inefficient.

There has been a strong consensus that we need executive guidance for regional information coordination. PNAMP, the Northwest Environmental Data-Network, and Pacific Northwest—Regional Geographic Information Council are hosting an executive summit this fall to discuss improved sharing of regional information. Summit goals include consensus on why being able to share data is so important for decisions, what the benefits are, and what actions and organizational arrangements are essential for success.

For more information on data sharing, please contact Joy Paulus (joyp@rco.wa.gov) and Stewart Toshach (Stewart.Toshach@noaa.gov).

Salmonid Field Protocols Handbook

The Steering Committee has recommended that **The Salmonid Field Protocols Handbook: Techniques for assessing status and trends in salmon and trout populations** (by Johnson et al) be used as a reference guide by PNAMP partner entities when planning, implementing, and reporting on projects that monitor the status and trends of salmon and trout populations.

The Handbook was developed by the State of the Salmon Project in collaboration with dozens of fisheries experts throughout the region. The handbook describes 18 monitoring techniques for salmonids and covers sampling designs and data management strategies that will help field practitioners and fisheries managers generate, maintain and share quality field data. The Handbook has been peer reviewed and was published by the American Fisheries Society in May of this year. Books can be purchased from the AFS online bookstore (http://www.afsbooks.org/55055p.html). Additionally, a free electronic version of the book can be downloaded from the State of the Salmon website (www.stateofthesalmon.org).

Over four dozen fisheries experts throughout the Pacific Northwest and beyond contributed to the handbook.

New Fish Population Monitoring Workgroup Tasks

By Keith Wolf and Jennifer O'Neal

Two Fish Population Monitoring (FPM) workgroup projects are currently underway. The first is to form a committee to provide additional fish population monitoring recommendations to update the recently published Salmonid Field Protocols Handbook (Johnson, D.J., 2007). This committee will include members of the PNAMP workgroups, outside reviewers and will be led by the FPM workgroup. The committee will begin its work in October or November of this year, allowing time to review the current publication.

Secondly, the PNAMP steering committee has tasked an FPM committee of regional scientists and agency representatives to produce a Tagging, Telemetry & Marking (TTM) product that unites disparate and individual program information, projects, technical information and research uses. The goal is to produce technical information and possibly a guidance manual. The form of this product is currently being vetted and individual topical contributions from authors are being sought at this time. If adopted as a recommendation by PNAMP partners, this information is intended to assist in standardization of designs, analytical & decision techniques resulting in creditable improvements in the science and ultimately, improvements upon concurrent analyses provided to decision-makers. The beneficiaries could be all sectors of fish management using TTM, but who may be doing so in an uneven and possibly inefficient manner.

The goal of this project is: ***Combine the disparate tactical and individual efforts regarding the science of tagging, telemetry and marking into a strategic technical product for recommendation to the Executive Network by the PNAMP Steering Committee.***

The objectives of this project are:

- Integrate & compile information from the large & disparate discipline of TTM designs & practices;
- Compile & publish the sum total of TTM information available as resources allow;
- Provide a standardized set of design recommendations & methods for interpretation of the science;
- Create a durable & enduring pathway & process for future amendments to the science;
- Improve TTM cost-effectiveness through resource sharing & elimination of duplicative efforts, and,
- Establish a web-based TTM program resource for practitioners & managers.

For more information on these tasks, please see the FPM WG webpage (http://www.pnamp.org/web/content.cfm?WorkGroupID=3) on the PNAMP website or contact Keith Wolf (kwolf@kwaecoscience.com) and Jennifer O'Neal (Jennifer.ONeal@tteci.com).

Integrated Status and Trends Monitoring Program

During a workshop to discuss the concept of an integrated status and trends monitoring program in 2006, participants determined that their respective agencies could support a '10 year vision' for such a concept.

Synopsis of 10 year vision: Within 10 years, an integrated interagency, aquatic status and trends monitoring program will provide annual, statistically sound information on a set of agreed upon key stream, riparian, and upslope indicators of the condition of aquatic/riparian resources across the Pacific Northwest at statewide and finer scales of spatial resolution.

Specific goal of a 'master sample design' (MSD): Determine if a Master Sample facilitates organizing the sites that people monitor so that information can be readily used for multiple purposes, i.e., can different objectives be met through a common set of sites from which sampling locations are chosen?

Since the workshop, PNAMP has continued to see interest in developing a 'pilot' effort to demonstrate what an integrated approach to status and trends monitoring programs might look like. A small workgroup met on February 23rd of this year to initiate an effort to describe what this means, define what resources might be needed, and how implementation might proceed. You can find notes from this work session by going to the PNAMP calendar for February 23 (http://www.pnamp.org/web/calendar/PNAMPDayPage.cfm?compdate=02/23/2007). The next steps in this process involve creating a presentation to educate groups on the effort and drafting a white paper to describe the effort to inform potential funding agencies.

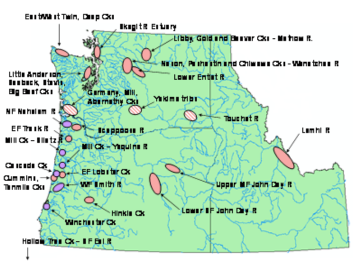
For more information on this project, please contact Steve Lanigan (slanigan@fs.fed.us) or Phil Larsen (larsen.phil@epa.gov).

What's New With Intensively Monitored Watersheds?

By Steve Leider

The Pacific Northwest Aquatic Monitoring Partnership is working to develop and implement a network of Intensively Monitored Watersheds (IMWs) in the Pacific Northwest. This effort was outlined in "***Establishing a Network of Intensively Monitored Watersheds in the Pacific Northwest***" (PNAMP 2005; http://www.pnamp.org/web/workgroups/PEM/meetings/2005_0830/2005_0405IMWPlan.doc). The concept of an IMW network responds to the need to determine how well restoration actions result in their desired ecological outcomes, particularly in terms of fish response. It draws heavily upon current and planned IMW efforts across the Pacific Northwest.

Work has begun with setting an IMW context and conceptual framework, delineating criteria against which candidate IMWs could be compared, and laying out a process for coordination. A total of 19 candidate IMWs have been identified by PNAMP in the first phase of work (see map).



Completing the first phase will involve summarizing study plans for each IMW, and characterizing things like management issues, monitoring questions, and recovery actions that would be explored in each IMW.

This information will be viewed in the context of an overarching landscape classification, to explore the extent to which results from IMWs can be extrapolated across broader areas.

The next phase will involve reviewing the results of the first phase at technical and policy levels, identifying issues and needs, and working to adapt the network as warranted.

Contact Steve Leider for more information (leidesal@dfw.wa.gov).

The PNAMP Inventory Pilot Project is complete! The project, led by the Pacific States Marine Fisheries Commission StreamNet project, was designed to determine availability of and begin obtaining basic information on who is conducting what monitoring activities where. Results can be found on the StreamNet website (http://pnampsurvey.streamnet.org/) and in the project report (see link at bottom). Please take a look and share your suggestions for next steps for this project.

(ftp://ftp.streamnet.org/pub/streamnet/projman_files/2004-002-00_28571_FinalReport.pdf)

PNAMP Completes Recommendations

In March 2007, after a lot of hard work and many reviews, PNAMP completed its first three recommendations to the Executive Network of entities that have signed the charter.

The Steering Committee has recommended:

Data Management Needs for Regional Project Tracking to Support Implementation and Effectiveness Monitoring by Stephen L. Katz, Katie Barnas, and Stewart Toshach (NOAA Fisheries, Northwest Fisheries Science Center) - Regionally, we see an increasing need to validate the effectiveness of restoration projects. However, to design efficient effectiveness monitoring programs, it is essential first to obtain specific information on the *what*, *where* and *when* of the restoration that has occurred or is planned for the near term. This proposal describes project-level information that is needed for both implementation and effectiveness monitoring, including justification, design and performance requirements.

Best Practices for Reporting Locational and Time Related Data developed by the Northwest Environmental Data-Network (NED) - In the Pacific Northwest there are hundreds of research, monitoring and evaluation and environmental management projects creating substantial quantities of data. Most of this data has location and time related data elements that are often reported using different standards and formats. Because of the data has been reported without common standards, data integration is time consuming and expensive. This document attempts to address the idea of adoption of consistent standards and move the region toward a more robust and functional methodology that will allow a higher level of data standardization.

The Salmonid Field Protocol Handbook: Techniques for assessing status and trends in salmon and trout populations (see article on page 2).

In addition, PNAMP is working on its fourth recommendation, ***Methods for the Collection and Analysis of Benthic Macroinvertebrate Assemblages in Wadeable Streams of the Pacific Northwest*** developed by the Northwest Biological Assessment Workgroup. The purposed of this protocol is to characterize the macroinvertebrate assemblage for a stream reach as an indicator of biological integrity and stream health. We should see a final recommendation of this product to the Executive Network before the year is out!

Pacific Northwest Aquatic Monitoring Partnership

Did you see your agency in the Charter Membership list on page one and want more information? Follow this link to see your contact on the PNAMP Steering Committee. (http://www.pnamp.org/web/Content.cfm?SectionID=7).

www.pnamp.org

Contact the PNAMP Coordinator:
Jen Bayer, USGS
Phone: 509.493.3702
Email: jennifer_bayer@usgs.gov

PNAMP MISSION STATEMENT:

PNAMP provides a forum to enhance the capacity of multiple entities to collaborate to produce an effective and comprehensive network of aquatic monitoring programs in the Pacific Northwest based on sound science designed to inform public policy and resource management decisions.

PNAMP has adopted the following goals:

- Provide a technical forum for practitioners to work together to develop, coordinate and inform monitoring and evaluation (M&E) programs, ultimately improving scientific information needed to inform resource policy and management questions and decisions.
- Provide a forum for communication with decision makers to facilitate resource and information sharing between monitoring programs across state, tribal, and federal organizations.
- Be a clearinghouse for sample design, protocol development, and data management activities in order to seek efficiencies and cost-effectiveness across monitoring programs through compatible and cooperative monitoring efforts.
- Promote science-based credibility of monitoring and assessment efforts.

Section III (C). Intensively Monitored Watershed Subcommittee Products

Section III (C.1). Intensively Monitored Watersheds in Context

Link to document on PNAMP website:
http://www.pnamp.org/web/workgroups/PEM/meetings/2007_1018/2007_1018PNAMPIMWcontext.doc

Intensively Monitored Watersheds in Context[1]

PNAMP IMW Subcommittee

In general, the implementation of region-wide watershed recovery actions are intended to increase pre-spawning survival of adults, increase the survival of juveniles (e.g., egg-smolt), and/or expand the geographic distribution of target populations. In all cases, the ultimate performance measure is survival (or productivity) and/or distribution of the "population." That is, successful restoration or improvements should translate into survival and distribution benefits at the scale of populations, not just at the scale of the implemented actions. Monitoring should therefore be sensitive to responses not only at small spatial scales (e.g., reach or small watershed), but also at the scale of populations. This burden is not easily resolved under traditional monitoring programs, because most programs have lacked critical elements of experimental design (replication, randomization, independence, and controls/references), have collected data at the wrong spatial or temporal scales, or lacked sufficient institutional controls to maintain the integrity of the monitoring design over a time period sufficient to generate reliable results. Nevertheless, existing monitoring programs can be tweaked, or new ones can be developed, that should provide information necessary to detect changes at the appropriate spatial and temporal scales.

Effectiveness Monitoring Precepts

In general, lessons from past monitoring activities of habitat actions in watersheds include:
Status and trend monitoring of population and habitat conditions is needed to establish baseline conditions and to develop a reference for large-scale, long-term patterns that may confound population-scale analyses of habitat restoration effects.

Population-level responses to habitat actions can only be detected at the appropriate spatial and temporal scales. Measurements of the effects of restoration actions may occur at multiple spatial and temporal scales, but monitoring programs must be designed to evaluate responses at population scales, or at least the scale of major life-history components, and over multiple years or generations.

Individual habitat actions generally do not directly impact population processes. Their direct effect is to modify physical or biological habitat condition. Therefore, responses of individual habitat actions are most easily detected at the scale of the action (i.e., reach or habitat unit scale).

The mechanism(s) by which a given action generates a response at the population scale is usually unknown and may differ across populations.

Given these precepts, one should be able to develop valid approaches to monitoring the effects of actions.

[1] Adapted from material submitted by BPA to the Pacific Northwest Aquatic Monitoring Partnership's Effectiveness Monitoring Workgroup.

Ideal Effectiveness Monitoring Approaches

In general, the basic Before-After, Control-Impact (BACI) experimental design provides a foundation for monitoring the effects of actions on population productivity and distribution. The validity of the basic BACI design can be extended by including sampling at multiple Control and Impact locations on multiple occasions during the Before and After periods (MBACI). Better yet, the certainty of inferences may be further improved by establishing several pairs of Control and Impact locations that are sampled on multiple occasions during the Before and After periods (MBACI(P)). The intent of these designs is to reduce the likelihood of alternative explanations for differences seen in treatment and control locations. These designs, if implemented correctly, include the four essential ingredients of an ideal design: randomization, replication, controls, and independence.

Problems with Ideal Approaches

In practice, the "ideal" design is rarely, if ever, feasible at population scales because of losses of control and/or treatment areas, spatial arrangements of populations, lack of randomization, lack of independence, the nature of variables measured, and institutional and economic arrangements. BACI-type designs require institutional controls over the time and place of implementation of treatments and the selection and preservation of control areas. This is rarely feasible at the scale of populations. In reality, controlling social, economic, and political arrangements at the scale of populations is very difficult and the lack of experimental control often results in treatments being implemented at different times and intensities, and control areas being treated (loss of independence). Maintaining control populations for comparison with treated populations for long periods of time is very difficult institutionally.

In addition, some performance measures, such as fish abundance, biomass, and productivity are quite variable in space and time. Variability in fish metrics may result from different seeding levels (recruitment) and density-dependent factors that can be independent of habitat conditions. Large variability in fish metrics makes it difficult to assess effects of habitat actions on population productivity.

Given the problems associated with implementing BACI-type designs at the scale of populations, complementary alternative approaches are needed. Although these alternatives do not provide the level of certainty of inference that attends MBACI or MBACI(P) designs, the alternatives may demonstrate causation at the population scale if implemented correctly.

Effectiveness Monitoring Approaches

There are two general types of approaches that can be implemented to assess action 'treatment effects' on population productivity and distribution – intensively monitored watershed approaches and levels-of-evidence approaches.

Intensively Monitored Watershed (IMW) Approaches

There are at least two IMW approaches that differ depending on the number of types of habitat actions implemented.

Intensively Monitored Watershed (Single Habitat Action Type)—This IMW involves the implementation of a single action type in a population-scale area. The treated area is matched with a control population-scale area. Effects of a specific action type are assessed through monitoring population productivity in a treatment-control or intervention-analysis context.

Intensively Monitored Watersheds (Multiple Habitat Action Types)—This IMW involves the implementation of multiple action types in a population-scale area. The treated area is matched with a control population-scale area. Cumulative effects of the actions are assessed through monitoring population productivity in a treatment-control or intervention-analysis context. This approach cannot by itself separate the effects of individual action types on population productivity.

Both IMW approaches provide inferences at the population scale; however, only the IMW (single habitat action type) can assess the effects of specific action types on population productivity. The lack of spatial replication and randomization limits the certainty of inferences of IMWs. In addition, they require long-term institutional controls, which means that relatively few of these can be implemented successfully.

Levels-of-Evidence Approaches

The levels-of-evidence approaches consist of at least three interdependent approaches to monitoring actions to determine biological benefit:

Watershed-scale Monitoring—This approach is similar to IMWs, but is implemented at a sub-population scale (a watershed scale smaller than the geographic area of the population). As with IMWs, this approach may include control-treatments in multiple habitat action types or single action types. Because watershed-scale monitoring does not directly measure the effects of actions at the population scale, status/trend monitoring should be used to assess possible changes at the scale of the population.

Project-based Monitoring—Project-based monitoring includes measuring physical and biological effects of individual actions at a reach or habitat unit scale. Because this type of monitoring does not directly measure the effects of actions on the population, complementary status/trend monitoring is needed to assess possible changes at the scale of the population. Effects of individual actions or classes of actions can be assessed through extrapolation of action influence and modeled connection of habitat condition to population processes.

Status/Trend Monitoring—Status/trend monitoring of population productivity and habitat condition is a long-term effort (decades) that can assess effects of actions through correlation of productivity change to habitat condition and action reporting. Status/trend monitoring provides higher certainty of inference if before-after data are collected at the population scale and physical and biological effects are measured at the reach or habitat unit scale.

These approaches are not mutually exclusive, and as shown in Table 4, lie along a gradient of inferential certainty from relatively strong to relatively weak. IMWs provide more inferential certainty at the population scale than do levels-of-evidence approaches, to the extent that IMWs are design-based at the population scale. That is, inferences from IMWs are based on the design rather than model assumptions. However, the lack of randomization and replication of IMWs may not allow their results to be easily generalized to other populations.

Comparison of approaches to determine population-scale biological effect of restoration and protection actions.

Monitoring Approach	Scale		Type of Inference		Certainty of Cause-and-Effect at Population Scale	Identify Mechanism (Action specific)	Sensitivity to Institutional Control	Notes
	Spatial	Temporal	Design Based (Test/Control)	Model Based (Correlational)				
IMW (one or more action type)	Watershed-Population	Short	Yes at all scales	No	High	Yes at all scales	High	Difficult to implement, rare opportunities
Level of evidence: Watershed scale	Watershed-sub-population (scaled to population indirectly using status/trend)	Short-Moderate	Yes at all scales	No	High	Yes at small scale. No at population scale.	High	Confounded with multiple treatments, rare opportunities
Level of evidence: Action-based (Reach or site scale)	Small (but scaled to population indirectly using status/trend)	Long (decades)	Yes at small scale. No at population scale.	No at small scale. Yes at population scale.	Low-Moderate	Yes at small scale. No at population scale.	Medium at small scale. Low at population scale.	Relatively inexpensive, and does not provide population level answers
Level of evidence: Status/Trend	Large (population, MPG, ESU)	Long (decades)	No	Yes	Low-Moderate	No	Low	Confounded by lack of controls, replicates, and multiple treatments

The three levels-of-evidence approaches rely on correlative data to try and make a case for causal inference. Correlation is used to rule out alternative hypotheses (note-as much if not more is known by disproving plausible alternatives than by showing that data are consistent with an hypothesis). Although the levels-of-evidence approaches may allow robust inferences at small spatial scales (scales smaller than the population), inferences at the population scale are usually inferred from correlation. The following criteria are often used to demonstrate causation from levels-of-evidence approaches:

Strength of Association—Measures the size of the change in performance measures associated with the incidence of treatments. In some respects, this is similar to gradient analysis. One can compare the percentage difference in average value of performance measures at locations that received treatments to those that did not.

Consistency of Association—An association between performance measures and the treatment that is observed many times provides higher confidence than if no such consistency is observed.

Specificity of Association—The association is only seen in the presence of the treatment (i.e., an observed change in the performance measures occurs after the onset of the treatment).

Temporality—If the treatment causes some change, then the change must follow the onset of the treatment. Temporality is a particularly useful criterion, because it has the potential to discard explanations – either the treatment explanation or alternative ones.

Biological or Ecological Gradient—If one can observe a distinct increase in the magnitude of effect with increasing intensity of the treatment, then there is further evidence of causality.

Summary

Given the uncertainty of maintaining the integrity of robust monitoring designs (e.g., BACI designs, IMWs, etc.), addressing effectiveness questions will require implementing a combination of effectiveness monitoring approaches. To account for inherent variability, implementation of IMWs should be focused on where institutional controls on the integrity of the design can be maintained for at least 12 years, or about three generations. Project-based and/or watershed-based monitoring in concert with status/trend monitoring should be implemented where institutional control is less feasible.

Importance of Habitat Models

Not all habitat actions can be monitored, nor can the effects of actions be measured for all populations. In that light, analytical tools or models can be applied that describe the potential effects of habitat actions on population productivity across the many populations that will be treated with habitat actions. Such analytical tools range from the simple (e.g., professional-judgment-guided models) to the very complex (e.g., Ecosystem Diagnosis and Treatment model). The goal should be to use transparent models that can be applied across different landscapes and populations, and provide reasonably accurate results. It is important that habitat and fish population monitoring support the development of such analytical tools. This means that monitoring should be conducted at spatial and temporal scales sufficient to develop and populate models and to provide data to validate the models.

Assessing Effectiveness

- Different monitoring approaches with important trade-offs
- Status & trends is part of assessing effectiveness

Approach	Where applied	How long?	Certainty	Opportunities
Intensively monitored watersheds (IMW)	Population & watershed	Short	High	Rare
Sub-watershed monitoring	Subpopulation or sub-watershed			
Local project assessments	Site or stream reach			
Status & trend monitoring	Population & ESU	Long	Low	Many

Section III (C.2). Overview of PNAMP strategy and preliminary costs to establish a network of Intensively Monitored Watersheds in the Pacific Northwest

Link to document on PNAMP website:
http://www.pnamp.org/web/workgroups/PEM/meetings/2007_1018/2007_0612PNAMPIMWupdate&CostOverview.doc

Overview of PNAMP strategy and preliminary costs to establish a network of Intensively Monitored Watersheds in the Pacific Northwest

PNAMP IMW subcommittee

The Pacific Northwest Aquatic Monitoring Partnership (PNAMP) is working to identify, refine, and implement a network of Intensively Monitored Watersheds (IMWs) in the Pacific Northwest. This effort, outlined in "*Establishing a Network of Intensively Monitored Watersheds in the Pacific Northwest*" (PNAMP 2005), responds to the need to determine the extent to which restoration actions result in desired ecological outcomes, especially in terms of fish response. It draws heavily upon currently ongoing and planned efforts of parties engaged in IMW efforts across the Pacific Northwest.

As outlined in PNAMP (2005), work began with setting an IMW context, identifying the conceptual framework, delineating criteria against which candidate IMWs could be compared, and laying out a process for coordination. A total of 19 candidate IMWs have been identified by PNAMP as part of the first phase of work.

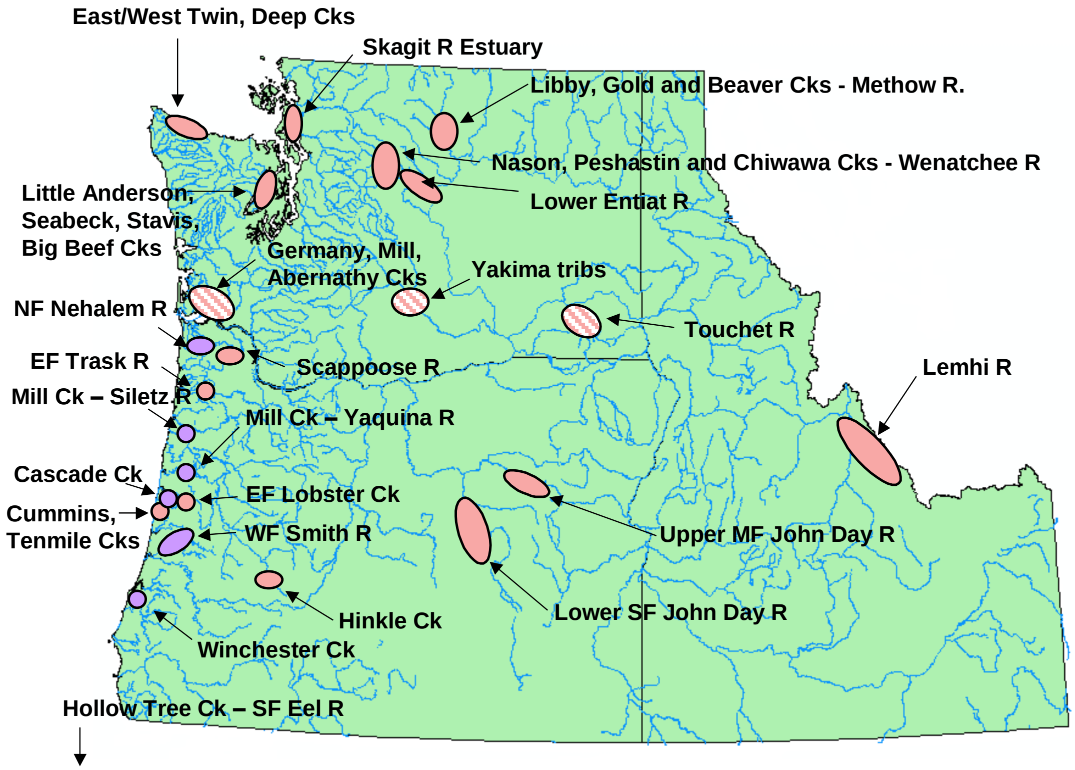
Completing phase 1 involves compilation of detailed study plans for each IMW, to include identifying the scope and nature of the management issues, monitoring questions, and restoration/recovery actions that would be tested in each IMW. In addition, articulating the basis and nature of study designs and implementation schedules for each IMW will be key elements of completing phase 1.

Finally, critical to completing phase 1 will be summarizing information on individual IMWs and an overarching landscape classification effort, to determine the extent to which results from ongoing IMWs can be extrapolated and inferences made across the PNAMP area. This important step will assess the extent to which coverage of the current IMWs addresses priority ecological strata, listed species, geographic areas, and policy/management priorities are addressed by the PNAMP phase 1 IMW network.

Phase 2 will involve reviewing the results of phase 1 at technical and policy levels, addressing issues and needs, and adapting the network as warranted.

As part of PNAMP's phase 1 IMW work, preliminary information on annual IMW costs and current funding is being compiled on: IMW time frames, current estimated or projected annual costs for both the monitoring and restoration treatment components of each IMW (as applicable), and the average annual cost of the combined monitoring and restoration components by IMW and the network in total over the stated IMW timeframes. Predominant funding sources will also be identified. Restoration costs would accrue even if IMW activities did not occur, assuming the restoration ranked sufficiently high as restoration priorities in the implementation of recovery plans. (Note: restoration treatment costs are typically expended over a shorter duration than the costs associated with monitoring the responses to those treatments.)

PNAMP Phase 1 Intensively Monitored Watersheds



DRAFT

PNAMP Phase 1 Intensively Monitored Watersheds:

Preliminary currently estimated or projected annual costs and major funding sources

State	IMW or IMW complex	Time frame	Currently estimated[2] or projected costs[3]		Current total annualized cost and predominant funding source[4]
			Monitoring	Restoration	
Washington	Lower Skagit estuary	10+ years – SRFB IMW program funding began in 2003	$1M per year for all combined	$1.5M per year for all combined (over 5 years)	WA SRFB - Ave. about $1.75M per year for all, over 10 years
	Hood Canal complex				
	Strait of Juan de Fuca complex				
	Lower Columbia complex				
	Wenatchee	10 years	$1.5M per year for Wenatchee ($900k) and Entiat ($600k)	$500k per year in Entiat only (for the first three years)	BPA, NOAA – Ave. about $1.65M per year over 10 years
	Entiat				
	Methow	4 years	$250k per year	Under development	***BOR – over $250k per year; total under development***

[2] Cost information is preliminary and is intended for general comparisons only. Estimated or projected cost for some IMWs are still being developed. In addition, costs do not necessarily represent all monitoring or restoration/protection actions or projects in IMWs. For example, in-kind contributions from entities partnering in IMW work are not reflected.
[3] Totals reflect monitoring and restoration costs annualized over the timeframe, depending on duration of treatments and total timeframes. Total cost figures are not simply additive for each IMW.
[4] Shown are predominant funding entity(ies) only; all funding partners are not reflected, and in-kind contributions are not included.

State	IMW or IMW complex	Time frame	Currently estimated[2] or projected costs[3]		Current total annualized cost and predominant funding source[4]
			Monitoring	Restoration	
	Yakima	10+ years	TBD (under development)	TBD (under development)	***NOAA – (First year $53k for study plan)***
	Touchet - Snake	10+ years	TBD (under development)	TBD (under development)	***NOAA – (First year $187k for study plan)***
Oregon	NF Scappoose	Under development	$642k per year for all combined (emphasis on fish monitoring to date)	Under development	ODFW, OWEB – over $642k per year; total under development
	Six Coastal Life Cycle Monitoring Basins (Nehalem River to Coos River)				
	EF and upper Lobster Ck				
	Cummins/Tenmile Creeks				
	Trask River	15 years	$320k for first year (study plan being developed)	NA	ODF and Weyco – over $320k per year; total under development
	Hinkle Creek (Umpqua River)	10 years	$700k per year	NA	OSU and partners – $700k per year
	Bridge Creek (John Day River)	10 years	$150k per year	$150k per year (for the first three years)	BPA, NOAA – Ave. about $195k per year over 10 years

State	IMW or IMW complex	Time frame	Currently estimated[2] or projected costs[3]		Current total annualized cost and predominant funding source[4]
			Monitoring	**Restoration**	
	SF John Day	4 years	$150k per year	$105k per year	***BOR, BPA and others – Ave. $255k per year over 4 years***
Idaho	Lemhi River (Salmon River)	10 years	$700k	To be determined	BPA, NOAA – over $700k per year; total to be determined
California	Hollow Tree Creek (SF Eel River)	20 years	$43k per year for last five years	$342k per year	CDFG – Ave. about $353k per year over 20 years
TOTALS			$5.455M per year	$2.597M per year during years of treatment	Ave. $7.986M per year

PNAMP Intensively Monitored Watersheds network:

Overview of current estimated annual costs by major funding source

Funding entity	Estimated or projected annual funding	Primary involved IMWs
BPA	$2.55M	3
SRFB	1.75M	4
NOAA Fisheries	1.176M	4
OSU and partners	0.7M	1
ODFW/OWEB	0.642M[5]	5
BOR	0.505M	2
CDFG	0.353M	1
ODF and partners	0.320M[6]	1
Total	$7.986M	19

[5] Partial cost only; restoration costs and all monitoring costs not yet included.
[6] First year cost only; study plan is being developed.

Section III (D). Protocol Manager Progress Report

November 30, 2007

<u>PNAMP Protocol Manager Database: Application, Content, and Organization</u>
Prepared by Mike Beaty, US Bureau of Reclamation, Boise, ID

Acknowledgements: Jen Bayer, Jacque Schei, Chris Jordan, Jeff Cowen, Rod Davidson, Steve Rentmeester, Carol Volk, Stewart Toshach, Russell Scranton, Jim Geiselman, Phil Rogers, Kim Johnson, Michael Newsom, Kristin Swoboda, Greg Gault.

Introduction

The Protocol Manager Database application and content continue to mature as a data management tool and data dictionary to support regional standardization of monitoring data for Research, Monitoring and Evaluation (RME) Program purposes.

Protocol Manager is a relational database application designed to serve as a data dictionary for monitoring data. As a data dictionary, Protocol Manager prescribes standardized methods, by providing abstracts and citations for reference documents describing data collection procedures, and specifically defines the data elements (attributes) that represent habitat and biological variables. As such, Protocol Manager provides standardized, pre-defined metadata for monitoring data.

Originally developed by Spatial Dynamics, Inc., Boise, ID, for the National Park System fire ecosystem monitoring program, located at the National Interagency Fire Center (NIFC), Protocol Manager has been adopted as a data management tool by the salmon recovery RME Program, its associated the Integrated Status and Effectiveness Monitoring Program (ISEMP), and the Pacific Northwest Aquatic Monitoring Partnership (PNAMP).

ISEMP and PNAMP, along with Northwest Environmental Data Network (NED) and Columbia River Intertribal Fisheries Council (CRITFC) among others, are coordinating Protocol Manager development to integrate the development and use of protocols in the full monitoring data life cycle and associated work processes. The data life cycle begins with management questions and includes monitoring project planning, field data collection, data processing (summaries, validation, etc.), hosting, and analysis.

The RME Protocol Manager is developed in accord with the “Guidelines for long-term monitoring protocols” (Karen L. Oakley, Lisa P. Thomas, and Steven G. Fancy; Wildlife Society Bulletin 2003, 31(4):1000-1003), a comprehensive, high level template for “the recommended content and format of monitoring protocols”. In consultation with the National Resource Monitoring Partnership (NRMP), PNAMP and ISEMP protocol development and usage includes all of the components identified by this peer reviewed paper. (See USGS NBII National Resource Monitoring Partnership (NRMP) link
http://science.nature.nps.gov/im/monitor/protocols/ProtocolGuidelines.pdf)

Much of the development team's efforts have been directed towards defining the protocol concept from its abstract, vernacular usage to a concrete, working set of data management concepts, relationships, work processes, and business rules. In simplest terms, protocols are defined as collections (sets) of methods, with methods defined as collections of attributes with their associated collecting and processing procedures. Methods are the "atomic unit" for Protocol Manager's schema and can be associated with one or many protocols, monitoring projects, and programs, as well as with the biological and habitat indicators their data inform.

The development team has recently begun applying object oriented concepts to protocols and their associated data. This approach will accommodate the exchange of protocols between independently developed applications and database systems that create, modify, and use them. In essence, protocols become metadata objects with properties and methods (in the computer science sense of the word). For example, the ISEMP Aquatic Resource Schema (ARS) and Status Trend and Effectiveness Monitoring (STEM) databases incorporate Protocol Manager's schema in their own more extensive schemas. (See below Figure 1. Data Flow of ISEMP Data Management Strategy)

Interest in Protocol Manager is steadily growing as regional understanding matures in effectively defining and using monitoring protocols. Next steps include completing and validating current content, i.e. EMAP, PIBO/AREMP, and AFS Salmonid Protocol Field Handbook, and formalizing RME Program requirements for future development.

Protocol Manager Development

Protocol Manager Development includes three components: Application (tool); Content; and Organization.

Application: User acceptance testing of the beta versions conducted by PNAMP, in coordination with NED, generally concluded the application is intuitive, relatively easy to use, and of great potential value for monitoring practitioners.

Users cited a need for report capabilities to support protocol comparisons and quality control for data entry; report functions are being developed for release in early 2008. Users also identified a need for better descriptions of Protocol Manager data fields and a user guide for content entry.

Our current version, FFI and Protocol Manager Version 1.01.00.00, was released by Spatial Dynamics, Inc. on November 15, 2007. Protocol Manager is a desktop application using a .Net framework and hosted by MS SQL Express or SQL Server relational database management systems (RDBMS).

The current release has been largely developed using FFI (FEAT/Firemon Integration) formal requirements, with RME Program requirements only informally or partially identified. We have therefore identified a need to develop formal RME Program requirements for Protocol Manager, which includes a thorough review of current FFI requirements to determine how they do or do not meet our needs.

Content: The U.S. Environmental Protection Agency (EPA) Environmental Monitoring and Assessment Program (EMAP) and U.S. Forest Service Pacfish/Infish Biological Opinion (PIBO) protocols have been entered up to their respective 2003 versions. TetraTech, Inc. recently completed entry of protocols documented in the American Fisheries Society (AFS) Salmonid Field Protocols Handbook. U.S. Forest Service also began updating the PIBO 2003 protocols, many of which are also used by the Aquatic and Riparian Effectiveness Monitoring Program (AREMP), but this effort was interrupted by a change in staff.

PNAMP, NOAA Fisheries, and ISEMP are developing higher level data dictionary categories for organizing protocol methods and their resulting data according to the habitat and biological indicators they inform, e.g. Temperature [Water] and Number of Adults, Spawners, or Redds. These organizing categories are to be harmonized with and will replace those used in the current Protocol Manager database as adopted from the Upper Columbia Monitoring Strategy (Tracy Hillman, February 2004).

Most user acceptance comments cited content gaps or deficiencies as the biggest drawback to Protocol Manager's utility as a reference and data management tool. Content development faces three significant issues: 1. Effective and complete protocols are a complex composite of numerous elements; 2. Documentation is frequently lacking or incomplete; and 3. Data entry requires extensive research to acquire, compile, and validate the requisite information.

We therefore conclude that Protocol Manager needs a full time librarian dedicated to developing and maintaining content that supports the use of standardized protocols across the region.

Organization:

PNAMP, ISEMP, and NED have made extensive outreach efforts to inform and enlist other organizations in Protocol Manager development. These have included, among others, Streamnet; Washington Salmon Recovery Funding Board (SRFB); Columbia River Intertribal Fisheries Council (CRITFC); Oregon Department of Environmental Quality (ODEQ); Oregon Watershed Enhancement Board (OWEB); and Idaho Department of Fish and Game (IDF&G). Internal PNAMP outreach has included the Effectiveness, Estuary, and Fish Population Monitoring Work Groups.

Additionally, PNAMP has consulted with the Bonneville Power Administration (BPA) Fish and Wildlife Program PISCES (project tracking database) team to consider Protocol Manager's potential contribution to a greater regional data dictionary.

Dialogues with these organizations have significantly advanced the collective knowledge of monitoring program processes and needs. In general, organizations around the region recognize the pressing need for protocol standards and the value of data dictionaries for data management. As various organizations begin to tackle protocols and comprehend their complexities and usage as scientific and data management best practices, they are generally able to validate the concepts, relationships, and business rules included in Protocol Manager.

This general recognition and acceptance are encouraging, but also lead us to conclude that sustained outreach and technology transfer efforts are necessary to meet RME Program and other regional data management objectives.

History

The RME Program is associated with the National Marine Fisheries Service (NMFS) and the US Fish and Wildlife Service (USFWS) Federal Columbia River Power System (FCRPS) Biological Opinion (BiOp) of December 2000. The BiOp has specific research, monitoring and evaluation requirements to support periodic assessments of the adequacy of implementation of reasonable and prudent alternatives (RPAs). The Federal Action Agencies have completed an Implementation Plan (IP) for the BiOp. The Plan includes a research, monitoring and evaluation (RME) section. (See Draft RME Data Management Work Group Plan, BiOp Implementation Plan Appendix F, May 14, 2003.)

In FY2004, Reclamation initiated the John Day Basin, OR RME Data Management Pilot project in collaboration with the concurrent Wenatchee Basin, WA Pilot supported by BPA and NOAA Fisheries. The RME Data Management Plan (2003) proposed a third pilot, to be conducted in the Lemhi River Basin in Idaho, but this effort was never fully supported or initiated.

The primary objectives for these pilots were to: A. Develop an RME Data Dictionary that completely documents the monitoring data collected in these two basins and B. Design and populate a tabular and geospatial (GIS) database to host and analyze these monitoring data.

The June 1, 2004 published RME Data Dictionary (entitled John Day Basin RME Pilot Project, Phase 1 Report, Monitoring Data Dictionary Review) was produced through intensive data analysis and consultation with all the Federal and State agencies, research scientists, and monitoring teams active in the John Day and Wenatchee Basins. The RME Data Dictionary is based on the various monitoring data collecting protocols used in these two basins, as referenced in the Upper Columbia Basin Monitoring Strategy (Hillman, 2004), including those used by EPA EMAP and USFS PIBO monitoring programs.

In FY2005, the RME Data Dictionary was converted to a dynamic database application, Protocol Manager. First developed by Spatial Dynamics, Inc. to support the National Park Service Fire Ecosystem Assessment Tool (FEAT), Protocol Manager was deployed by the fire ecology monitoring program to standardize and support data collection across the various parks.

In FY2006, participating members of the PNAMP, including its Steering Committee and Effectiveness Monitoring Group, agreed to adopt Protocol Manager as a regional tool for managing and standardizing monitoring protocols and their resultant data. In this capacity, Protocol Manager serves as a data dictionary to prescribe standardized methods for field data collection and specifically define the data elements that represent habitat and biological variables.

PNAMP, with RME Program support, provides a forum for coordinating state, federal, and tribal aquatic habitat and salmonid monitoring programs. Improved communication, shared resources and data, and compatible monitoring efforts provide increased scientific credibility, cost-effective use of limited funds and greater accountability to stakeholders. PNAMP provides leadership through the development and the advancement of recommendations and agency level agreements that are considered for adoption by the participating agencies. (See http://www.pnamp.org/web/Content.cfm?SectionID=8)

The RME Program and PNAMP also coordinated their efforts with NED to develop Protocol Manager as a regional data management tool. NED served as a forum for enlisting broader multi-organizational support for Protocol Manager and assisted with application development and user acceptance testing, specifically to advance the concept of a regional data dictionary. NED's mission is to improve the quality, quantity, and availability of regional data and related information on fish, wildlife and their aquatic and terrestrial habitats using a publicly supported approach to information systems management. NED is working cooperatively on actions and joint activities to improve the collection, management and sharing of environmental data and information. NED goals include supporting and coordinating production of a regional data dictionary, the common use of query tools to metadata and the development of a data networking plan with funding support. NED is interested in supporting or helping to develop agreements, standards and protocols and the technology necessary to improve data sharing and discovery across multiple regional partners, and in identifying and promoting administrative and organizational and funding arrangements needed to support regional data management. A NED Steering Committee has been established to support cooperative actions through an MOU. Current signatories include NPCC, NOAAF (NWRO and NWFSC), EPA, BPA, WA Monitoring Forum, OR Geographic Information Council, British Columbia Integrated Land Management Bureau, CRITFC, USACE, PSMFC and State of the Salmon Consortium. (See http://www.nwcouncil.org/ned/background.htm)
In FY2006, NOAA Fisheries and Reclamation formed the Integrated Status and Effectiveness Monitoring Program (ISEMP) to develop a cohesive monitoring program and analytical framework across the geographic range of threatened and endangered salmonid Evolutionary Significant Units (ESU's). ISEMP closely coordinates with PNAMP to identify, develop, and approve monitoring protocols and has also adopted Protocol Manager as one of its key data management tools.

ISEMP, in consultation with the Wenatchee Regional Technical Team (RTT), is developing a set of MS-Access database templates, the Aquatic Resource Framework (ARF), to provide a standard format for monitoring data collected in the field. The populated ARF templates normalize and stage these data for transfer to the Status Trend and Effectiveness Monitoring (STEM) Database, hosted by the NOAA Fisheries Northwest Fisheries Science Center (NWFSC) Science Data Management Team. STEM is a regional repository for monitoring data and serves as a source for analysis and display. (See below Figure 1. Data Flow of ISEMP Data Management Strategy)

ISEMP is also developing geodatabase technology applications and tools for multi-tiered (reach, watershed, basin) analysis capabilities. STEM monitoring data will be combined with data on habitat restoration and related salmon recovery projects to analyze the relative effectiveness of the various measures and actions implemented across the ESU's.

In FY2007, PNAMP initiated Protocol Manager application and content development to support Bonneville Power Administration (BPA) Fish & Wildlife program requirements for monitoring projects using PNAMP approved protocols. Reclamation, NOAA Fisheries, and BPA contracted with TetraTech, Inc. to document the protocols published in the American Fisheries Society (AFS) Salmonid Field Handbook.

<u>Next Steps</u>

Reclamation has contracted with Spatial Dynamics, Inc. for Protocol Manager Beta Version database application programming and user support services. The Beta Version, now being used by PNAMP and ISEMP provides basic data entry, browsing, and report capabilities for interim use as a region wide data management tool.

Use of Protocol Manager is being coordinated with the CRITFC (Columbia River Intertribal Fisheries Council) and with NED, led by NOAA and the Northwest Power and Conservation Council (NPCC). NED and NOAAF are evaluating the Beta Version for its potential in developing a region wide data dictionary.

In FY2008, PNAMP and ISEMP will continue to work on Protocol Manager application, content, and organizational development. Activities include: 1. Initiating the process to upgrade the Beta Version of Protocol Manager to meet the overall, long term RME Program and salmon recovery requirements; 2. Updating EMAP, AREMP/PIBO protocols to current versions and completing entry of the AFS Salmonid Field Handbook protocols; and 3. Developing PNAMP capacities for content management (data steward/protocol librarian) and user (monitoring practitioners, data managers, research scientists, etc.) support through staffing and partner relationships.

Reclamation will contract for services to define stakeholder needs, develop requirements, and conduct the design process for the upgraded application. The final deliverable will be a design document to develop an application that specifically addresses salmon recovery requirements, multi-organization data management processes, and distributed information technology architectures.

The proposed upgrade will accommodate protocols and methods used by estuary, hatchery, and water quality monitoring programs, and integration with the ISEMP ARF and STEM databases and data management processes.

Development will be done in consultation with the National Park Service and U.S. Forest Service Fire Ecosystem Assessment Tool/Firemon System Integration (FFI) project. FFI offers the RME Program (and its partnering organizations) an opportunity to share development costs and learn from the experience gained by these monitoring programs. This collaboration will also foster the exchange of information between the salmon recovery and fire ecology communities.

The RME Protocol Manager will provide a common database structure that will accept data for different protocols and data collection sources, i.e. one database structure with multiple protocols. Data collections will be self documenting, with metadata capture being a part of the workflow. The new version will support the integration of protocols and methods, field data, and GIS/remote sensing data, and analysis with a common tool set.

Design document development steps include:

1. Conduct an FFI Case Study Overview featuring presentations by NPS and USFS monitoring program leaders and support staff and discussions with their RME counterparts;

2. Conduct a facilitated requirements analysis to identify stakeholders, related applications, and mission requirements for monitoring data;

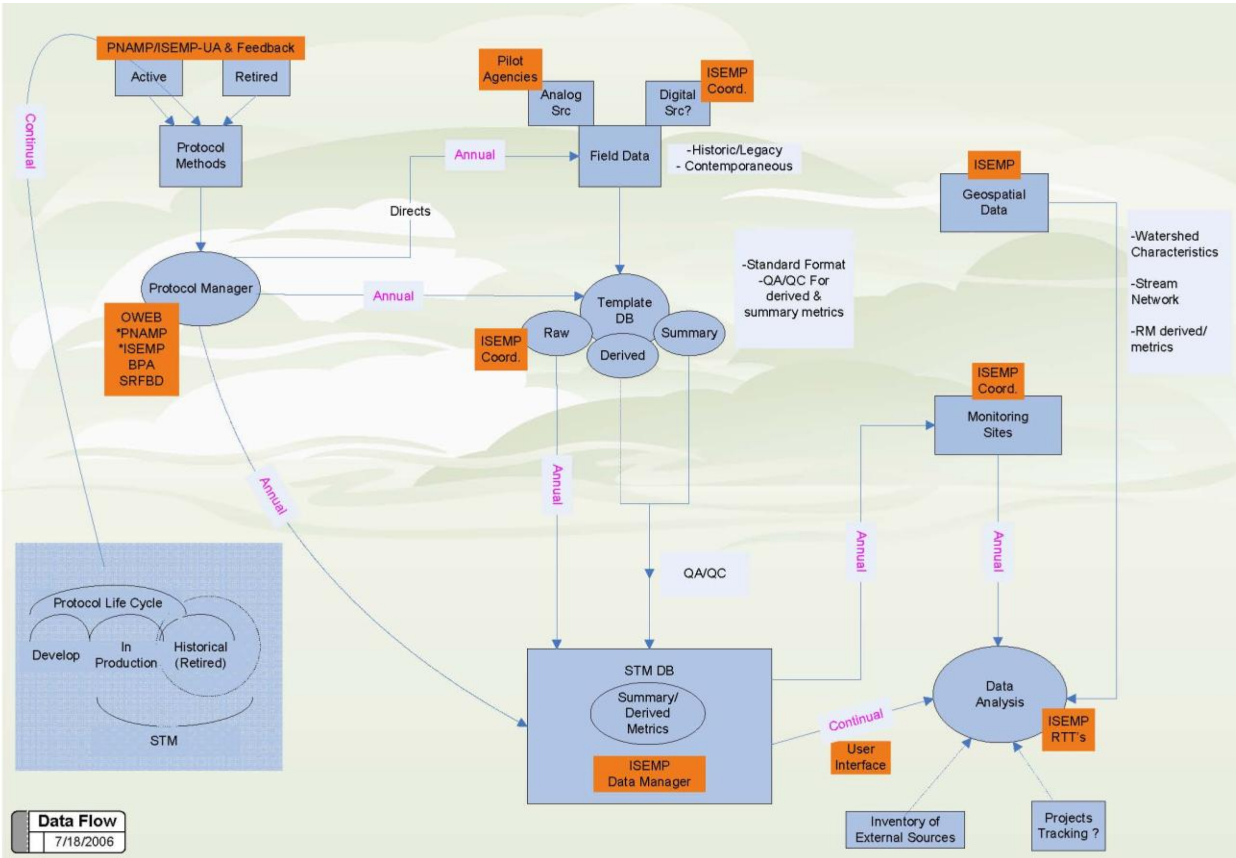
3. Compare RME requirements with the current FFI design and capabilities and identify unmet requirements;

4. Demonstrate supported solutions and document (and demonstrate when feasible) new or modified solutions;

5. Complete a design process to document specific use cases, architecture, entity relationships, and work flows.

Assuming key stakeholders are consistently available for project participation, the contractor will require an estimated sixteen weeks to complete the above tasks. We plan to initiate the RME Program requirements and design process in January 2008.

Figure 1. Data Flow of ISEMP Data Management Strategy



Section III (E). Document from Executive Summit - Sharing Information for Improved Decisions

Section III (E.1). Attendees at Executive Summit

Participants (by Agency)

Name	Agency
Greg Delwiche	Bonneville Power Administration
Jim Geiselman	Bonneville Power Administration
Larry Buttress	Bonneville Power Administration
Evert Kenk	British Columbia Integrated Land Management Bureau
Brian Lipscomb	Columbia Basin Fish & Wildlife Authority
Tom Iverson	Columbia Basin Fish & Wildlife Authority
Ken MacDonald	Columbia Basin Fish & Wildlife Authority
Michele Dailey	Columbia River Gorge Commission
Phil Roger	Columbia River Inter-Tribal Fish Commission
Bill Towey	Colville Confederated Tribes
John Arterburn	Colville Confederated Tribes
Cathy Kellon	Ecotrust
Rick Mogren	Federal Caucus
Bart Butterfield	Idaho Department of Fish and Game
Keith Wolf	KWA
Janet Hess-Herbert	Montana Fish, Wildlife & Parks (phone)
Craig Dalby	National Park Service
Danny Burgett	Natural Resources Conservation Service
Barry Thom	NOAA Fisheries, Northwest Region
Kim Kratz	NOAA Fisheries, Northwest Region
John Stein	Northwest Fisheries Science Center
Stewart Toshach	Northwest Fisheries Science Center
Tom O'Neil	Northwest Habitat Institute
Amber Johnson	Northwest Habitat Institute
Bruce Jones	Northwest Indian Fisheries Commission
Tom Karier	Northwest Power and Conservation Council
Peter Paquet	Northwest Power and Conservation Council
Melinda Eden	Northwest Power and Conservation Council
Mike Carrier	Office of Governor Ted Kulongoski
Scott Smith	Oregon Department of Administrative Services
Cy Smith	Oregon Department of Administrative Services
Ed Arabas	Oregon Department of Administrative Services
Dick Pedersen	Oregon Department of Environmental Quality
Aaron Borisenko	Oregon Department of Environmental Quality
Ed Bowles	Oregon Department of Fish and Wildlife
Cedric Cooney	Oregon Department of Fish and Wildlife

Name	Agency
Roy Elicker	Oregon Department of Fish and Wildlife
Doug Tindall	Oregon Department of Transportation
Gail Achterman	Oregon Institute for Natural Resources
Randy Dana	Oregon Ocean-Coastal Management Program
Tom Byler	Oregon Watershed Enhancement Board
Stan Allen	Pacific States Marine Fisheries Commission
Bruce Schmidt	Pacific States Marine Fisheries Commission
Doug Taki	Shoshone-Bannock Tribes
Witt Anderson	U.S. Army Corps of Engineers
Rock Peters	U.S. Army Corps of Engineers
Mike Mottice	U.S. Bureau of Land Management
Duane Dippon	U.S. Bureau of Land Management
Karl Wirkus	U.S. Bureau of Reclamation
Michael Newsom	U.S. Bureau of Reclamation
Tom Eaton	U.S. EPA Region 10
Dave Tetta	U.S. EPA Region 10
Linda Ulmer	U.S. Forest Service
Deborah Konnoff	U.S. Forest Service
Dru Burks	U.S. Geological Survey
Sheri Schneider	U.S. Geological Survey
Alan Mikuni	U.S. Geological Survey
Jen Bayer	U.S. Geological Survey, PNAMP
Jacque Schei	U.S. Geological Survey, PNAMP
Dan Diggs	USFWS Region 1 - Pacific
Mark Bagdovitz	USFWS Region 1 - Pacific
Josh Baldi	Washington Department of Ecology
Ken Dzinbal	Washington Department of Ecology
Erik Neatherlin	Washington Department of Fish and Wildlife
Chris Drivdahl	Washington Governor's Salmon Recovery Office
Steve Leider	Washington Governor's Salmon Recovery Office
Rachael Langen	Washington Recreation & Conservation Office
Jim Fox	Washington Recreation & Conservation Office
Bruce Crawford	Washington Recreation & Conservation Office
Carol Smith	Washington State Conservation Commission
Nancy Tosta	Ross & Associates Environmental Consulting, Ltd.
Kristen Durance	Ross & Associates Environmental Consulting, Ltd.

Section III (E.2). Executive Summit Business Case Document

Link to document on PNAMP website:
http://www.pnamp.org/web/workgroups/SC/meetings/2007_1002/2007_0917InfoSharingBusCase.pdf

SHARING INFORMATION TO IMPROVE DECISIONS

EXAMPLES OF BENEFITS AND COST AVOIDANCE

"…you cannot fix what you can not see."[1]

TABLE OF CONTENTS

INTRODUCTION

This paper documents snapshots and case studies of information management projects and programs that quantify benefits from improved information collection, management and sharing or show how costs could have been avoided if different, yet known, information management practices had been followed.

The examples here have been put together to support a planned Northwest Region Executive Summit - focused on developing an understanding of changes needed to improve environmental information – from collection through analysis.

In planning for the workshop the primary sponsors: the Northwest Environmental Data Network (NED); the Pacific Northwest Aquatic Monitoring Partnership (PNAMP); and the Pacific Northwest Regional Geographic Information Council (PNW-RGIC), met in January 2007. At the meeting it was agreed that a business case showing benefits from regional information management should be developed, and that these groups needed to join together to bring their concerns to regional executives.

NED, PNAMP and PNW-RGIC Steering Committee members agreed to collaborate to advance this task.

What are the Information Management Challenges?

Environmental problems are significant and costly. Loss of habitat, loss of production from managed systems, increased frequency and severity of natural events, especially floods and fires, loss of naturally occurring diversity, increases in impacts from humans, reduced water quality, increased listings of threatened and endangered species, and disturbing climate change all challenge our organization, budget, and decision-making abilities.

They also expose many unmet information needs. What are the ecosystem consequences of these impacts and what are the best solutions? What regulatory or other responses are needed to satisfy legal mandates? What are the economic impacts of these changes and needed actions? What level of monitoring is needed to provide scientific and management certainty? How effective are the solutions?

These answers are far from trivial and are inherently difficult to answer because the causes and consequences cross organizational and administrative boundaries. Local, Tribal, State, National and Public interests can all be affected across river-basins and larger regional scales. For the most part, the governmental and private entities have separate information systems, with different rules, standards, and operating procedures.

Improving our collective ability to share and exchange information at a regional scale will require a regional administrative and organizational solution – to address the technical and other issues. Unfortunately, a regional scale organizational and administrative solution is not in place.

For many needed decisions, just getting all the information so we can use it to take our best shot at fixing problems is daunting. Many problems involve multiple stakeholders who cannot see and share all the information. One example is the information needed to recover salmon populations, another is the information needed to manage and recover from natural disasters.

Without more decision-making certainty, we are effectively mandated to operate conservatively, so the most promising solutions may be beyond our decision making grasp – at least without improved information when we need it.

Many have concluded through independent studies, workshops, or everyday reasoning, that we should all be able to do a better job of sharing the information that we already have and a better job of collaborating to collect the new information that we need. They have concluded that this would result in more efficient and better use of public and other resources.

This paper identifies many such efforts and regional scale studies within the Pacific Northwest that have returned similar findings.[2] In addition, there are other efforts not highlighted here, including international efforts. For example, in 2004 the United States signed a Global Earth Observation System Agreement to work on global data sharing across 47 Nations - "Dozens of observation systems are now generating reams of data that could be far more powerful if they were combined and widely disseminated".[3] The Northwest Environmental Data Network has summarized "Lessons Learned" from its efforts and the experiences. These lessons are summarized in the table below with some suggested solutions.

This paper provides examples of benefits that have been realized through investments in information system improvements. The authors completed this task by completing internet and other searches and by asking colleagues and others for documents that quantified costs and benefits from improved information sharing or related information management tasks.

Lesson Learned	Suggested Solution
Data quality is compromised and the cost of management rises if it is created before a plan exists for how it will be maintained and shared	Require a data management plan before undertaking new data-creating projects
Data have value beyond their immediate use when they are integrated with other data sets	Each data-creating activity should follow a core set of standards to facilitate regional sharing and integration
Effective information management requires an ongoing effort and is not an episodic task	Provide services to maintain regional information management and sharing and assist local stakeholders
Consistent data management practices require policy-level support	Develop a basic MOA on information management practices essential for regional management and sharing
Data management practices have a direct effect on the usefulness of data collected and how it is shared	Adopt data standards and protocols for data collection and sharing of information
Scientist will generate data in formats that meet their needs	Data systems need to be flexible and accommodating; scientist need to adopt minimum data standards, study designs can be recommended that satisfy local needs as well as regional needs
Data needs to be shared and to do so is time consuming; data are often not compatible	Data exchange formats need to be designed collaboratively and standards employed when possible
Difficulty in understanding spatial and tabular data when transferred to others	Require mandatory metadata for spatial and tabular data
Technology will continue to evolve	Data systems should be reliable, well-maintained, dynamic and modular to permit future modifications
Data management schema need both distributed and warehouse approaches	Identify and support key data management projects: regional data warehouses or repositories and projects that provide data support services directly to providers
Scientists who want to publish data may delay its immediate use	Develop and adopt clear data reporting and sharing policies
Quality and reliability of the data are often unknown	Establish Quality Assurance/Quality Control protocols
Data management requires iterative improvements	To improve regional data management: evaluate and enhance existing projects and fill gaps with pilot or new projects

EXECUTIVE SUMMARY

Environmental problems are significant and costly. Loss of habitat, loss of production from managed systems, increased frequency and severity of natural events, especially floods and fires, loss of naturally occurring diversity, increases in impacts from and to humans, reduced water quality, increased listings of threatened and endangered species, and disturbing climate change all challenge our organization, budget, and decision-making abilities.

They also expose some unmet information needs. What are the ecosystem consequences of these impacts and what are the best solutions? What regulatory or other responses are needed to satisfy legal mandates? What are the economic impacts of these changes and needed actions? What level of monitoring is needed to provide scientific and management certainty? How effective are the solutions?

This paper shows that there are significant documented benefits from information management and technology sharing. For example:

- The EPA reported Return On Investment (ROI) from Exchange Network Projects ranging from 15 to 62% with payback periods from 1.6 to 6.9 years.
- The Upper Columbia Regional Technical Team identified direct cost savings of approximately $500K and improved return on existing and future investments through greater use of exiting data, a central data storage system, and common collection and quality control procedures.
- The Minnesota Department of Natural Resources Lake Survey Project saves thousands of work hours and over $216,000 annually, ensures better quality data, and allows easier sharing with the public.
- The National States Geographic Information Council estimated that applying uniform standards and applying other improvements to imagery acquisition and processing saved $160 million per three-year cycle, an ROI of 19%.
- The Federal Drug Administration reported savings of $10 million over a $200 million dollar IT budget using an enterprise solution.
- The state of Oregon predicts staff annual savings of more than $80 million for state agencies, at least $100 million savings for city and county governments throughout the state, and actual cost savings and revenue enhancement (increase) of well over $80 million over a 10-year period with a fully deployed GIS utility.
- The Department of Housing and Urban Development reported a $12 million dollar return from a $9 million dollar investment.
- An Illinois mapping consortium of local utilities, IMAGIS, in 1992-93 showed over $24 million in business benefits for city, county and utility participants including over $7 million in cash return or cost prevention.
- Six "*Snapshots*" showed benefits from various geographic information system collaborative efforts ranging from $50,000 per year to $4 million per year.

The studies also identified practices and actions (lessons learned) that contributed to these business successes. The chance of information management success is improved when:

- an enterprise or framework approach is adopted;
- planning prevents avoidable costs;
- there is a connection between these improvements and the business benefit;
- organizational and administrative arrangements are in place; and,
- there is strong executive support.

SNAPSHOTS

Benefits from Sharing Information or Cost Avoidance[4]

Cost Avoidance through Web Sharing
The County of Riverside, California, avoided staff costs of $4 million per year by providing developers, engineers, and consultants with development information via the web. For example, an environmental hazards map was provided.

Delivering Accurate Information on the Fly and Saving Money
Remote sensing data (LIDAR) saved Richland County, South Carolina, $140,000 by avoiding a field survey for elevation, slope and drainage.

Keystone to e-Government Strategy
The cost savings realized through this "build once, use many times" portal application is exactly the vision of the OMB's e-government initiatives. This was based on a federal mandate for improved efficiencies and cost savings.

Mapping Municipal Accountability
City of Baltimore introduced a real-time performance measurement and accountability system resulting in $70,000 in savings over 3 years. "Baltimore replaced a culture of delay and avoidance with a culture of accountability and results…".

County Monitors False Alarms, Raises Revenue and Reduces Costs
Charles County, Maryland, is saving more than $1.3 million per year with an automated alarm registration system. Revenue has also increased $250,000 per year.

Automated Addressing Saves Money
Automation of data feeds to a customer information system saves CenterPoint Energy, Houston, Texas, $50,000 per year.

CASE STUDIES

Lake Survey Project

Minnesota Department of Natural Resources

Minnesota's Department of Natural Resources (MN DNR) developed and implemented a robust mobile Fisheries Lake Survey system. This new system saves thousands of work hours and over $216,000 annually, ensures better quality data, and allows easier sharing with the public.

Documented accomplishments include:

- **Estimated cost benefits from implementing this application are $216,170 each year.** This was accomplished by eliminating redundant data entry from paper forms and eliminating data cleaning and consolidation; with additional savings in training, updated version distribution, and reporting.
- Eliminated 27 separate lake survey databases and weeks of data consolidation annually.
- Ensured better data quality by providing validation when the fish is still in-hand.
- Shortened data entry learning curve; eliminated need to memorize dozens of 3 digit codes.
- Improved research possibilities for their research biologists and other agencies as well.
- Added hardware flexibility; runs on any hardware device with a Java-compatible OS.
- Allows for meeting future business needs because of the modular data structure.

MN DNR now uses rugged tablets in its survey boats and validates data entry with fish in-hand to eliminate redundant data entry and reduce errors. The previous survey system required handwriting information onto paper forms and then typing the same information in offices across Minnesota. Dozens of Fisheries Area databases were methodically analyzed for errors and consolidated in a process that took months every year. The new data system now captures more valid data with less effort and provides quicker analysis reports and public information.

Additional innovative uses of technology with this system include: designing the application to work on any hardware platform that runs Java, using open source software on the tablet PCs to cut license costs, using the same data entry screens in the office and on the lake, automated delivery of updated drop-down menu lists, customizable short lists of drop-down menus, and reference links to geographic information allowing spatial mapping of fisheries data.

This Java client Lake Survey application is delivered to rugged tablets and desktop workstations over the Internet and provides statewide access to a single database and reports over the DNR intranet. Data captured, stored, and analyzed by this system includes current and historic physical, chemical, and biological information regarding habitat, water quality, and fish population characteristics. This information is used to manage Minnesota's fisheries.

The system components and capabilities include:

- Single state-of-the-art database accessed via the Internet.
- Entry validation on a rugged tablet PC in the boat.
- Intuitive screens with drop-down value selections.
- Rapid and flexible reporting once the data are uploaded.
- Integrated Age and Growth analysis and reporting**.**
- Improved connectivity with other databases enabled by common data formats.
- Automatic software updates deployed via the Internet.

TAKING THE LONG-TERM VIEW
Federal Enterprise Architecture

Department of Housing and Urban Development

An article in Federal Computer Week, May 2, 2005[5], reported from Dick Burk, Office of Management and Budget's Chief Information architect,

> "Enterprise architects in the Department of Housing and Urban Development modernized systems underpinning the mortgage insurance line of business and reduced the number of systems by 80 percent. The effort cost $9 million in development, modernization and enhancement dollars but reduced the total cost of ownership by $12 million...Those systems increased the number of loans per day, identified faster mortgage lenders discriminating against customers or making bad loans, and made it easier to prevent fraud...Those were issues critical to the program office...Mission performance is the bottom line."

National Institutes of Health

The National Institutes of Health (NIH) identified 6 benefits from the use of enterprise architecture approaches:

- Links information technology (IT) to the mission of NIH,
- Improves interoperability and integration (including making information available whenever and wherever needed),

- Enables agility,
- Reduces costs,
- Improves security, and
- Reduces technical risks.

Food and Drug Administration
The Food and Drug Administration was able to realize direct IT savings of $10 million from an IT Budget of $200 million by adopting an enterprise planning approach.

Across Federal Agencies
The Results of FY 2007 Federal Enterprise Architecture Assessment shows that:

> "…the majority of agencies (19 out of 24) were also able to demonstrate they are realizing IT cost savings, cost avoidance, and/or satisfactory program performance…"

INFORMATION TECHNOLOGY INVESTMENTS BASED ON ENTERPRISE ARCHITECTURE
EFFECTIVE AND BETTER INVESTMENTS

National Association of State Chief Information Officers

Information investment decisions are not easy to make and many seem like lose/lose decisions For example, executives or managers may want to solve a business problem by collecting more information in the hope that the problem will be solved with the latest data, or perhaps by investing in new IT, to access existing data faster. What is the right decision? The use of Enterprise Architecture can help to inform these decisions.
In their Research Brief[6], the National Association of State Chief Information Officers reported that state and local governments were expected to invest an estimated $48 billion dollars in information technology (IT) in 2005. It is the biggest information management cost and spending was anticipated to increase by 48.5% to $70 billion by fiscal year 2010.
The brief also recommended the benefits of Enterprise Architecture (EA) to "blue print" information investment decisions. The brief shows how Enterprise Architecture can be used to improve state IT procurement. Through a closer alignment of IT procurement and EA it would be possible to:

- Enhance the role of government as a steward and wise-investor of taxpayer dollars
- Increase the efficiency and effectiveness of IT service delivery, and
- Simplify and streamline the IT investment and contracting process.

IT procurement is just one part of information management, albeit the most expensive. The authors concluded that increased value from IT investments can be realized by using Enterprise Architecture to guide IT decisions which translates into more efficient government processes and services which ultimately improve the ability of government to serve its citizens.

DATA MANAGEMENT PLANNING IMPROVES USE

OF COLLECTED DATA
USDA Forest Service

The USDA Forest Service was involved in coordinating the collection of significant data sets for the Northwest Forest Plan across multiple agencies and programs. The service spent (internally) around $130,000 to aggregate one needed information component - an estimate of the extent of road construction and decommissioning where the data existed but was not already organized. This estimate did not include the cost of aggregating vegetation, intermittent streams, land use, culverts, ground disturbing activities and many other data sets. The lack of a comprehensive interagency plan prevented many data sets from being collected.[7]

The task of estimating costs and benefits is not easy, and it is difficult to even estimate potential efficiencies with seven resource analysis topics across eight federal agencies with 25 million acres of land in three states. The burden for inter-operability is substantial. Information for the Forest Plan came from 19 Forest Service and six Bureau of Land Management units (each with an average of three sub-units), the states of Oregon, Washington, and California (each with a total of a dozen or so counties), and 76 Tribes. The Regional Ecosystem Office GIS shop had three people working for 10 years at about $100,000 per person, per year – about $3 million, a total cost that did not include the other agencies and units.

Data aggregation for "ground disturbing activities" is an example of where all (approx. 75) units in the plan area had between two and five people creating the relevant data. However, it was not created in a standard format and could not be compiled.

Considerable investments in data collection from the effort were not usable because it couldn't be compiled due to integration barriers. The data could have been used if the issue or integration barrier was solved ahead of collection efforts. The barriers, in order of importance are data: Existence; Accessibility; Consistency (standardization); Compilation; Maintenance; and Documentation.

SHARING PROVIDES COST SAVINGS AND IMPROVES PRODUCTS

Indianapolis Mapping and Geographic Infrastructure System Consortium

In the mid 1980’s, 28 agencies across three Indianapolis Counties were spending nearly $9 million per year in map related activities. These groups formed the Indianapolis Mapping and Geographic Infrastructure System (IMAGIS) consortium to share the costs and benefits of shared GIS resources. A City-County Council consortium was formed, with the highest executive of each organization as the directorate and with a technical committee to make recommendations to the Board. Both meet monthly.

The cost for hardware, software conversion and staff was $7.2 million for the first 4 years. Ongoing costs averaged about $400,000 for day to day operations, data integrity, hardware and software maintenance, data updates and coordination between participants. The data sharing arrangements have been working for 20 years and include a "Participants' Service Agreement".

“A good GIS is an error finding machine…..for example comparing billing systems to geography always finds unbilled customers”.

In 2004, IndyGIS compared solid waste customers to the IMAGIS aerial photos, and found over $300,000 in uncollected annual fees for Department of Public Works. Ten years ago, a study of the sewer billing system found over $1,000,000 per year in unpaid bills to Department of Public Works.

A study done for IMAGIS in 1992-93 showed over $24 million in business benefits for city, county, and utility participants, including over $7 million in cash return or cost prevention. IMAGIS considers that similar benefits continue to this day.[8]

SUB-BASIN PLANNING - AVOID COSTS WITH UPFRONT DATA MANAGEMENT PLANNING

Northwest Power and Conservation Council

The Northwest Power and Conservation Council (NPCC) provided local watershed groups with approximately $15 million to collect and manage information for subbasin planning and develop plans. When the funding was made available a data management plan to require standard reporting or to maintain each data set was not in place to maintain the data across all subbasins.

An after-the-event effort to collect and archive the fish and aquatic habitat data was completed to try to protect the value of the $15 million data collection investment. Contracts and in-kind efforts to collect and archive the data cost $251,000. Even with this effort, not all data was able to be recovered. About 90% was recovered where local planners used Ecosystem Diagnosis and Treatment or QHA tools . In other areas recovery was probably less than 50%.

Information recovery difficulty was compounded by basic problems with data documentation. For example, plans did not always reference the data sets they relied on so it was not possible to work backwards. In other cases, data were no longer accessible or were stored in such a way that they could not be separated.

Terrestrial data sets had similar problems and challenges. It is estimated that of 56 Sub-basins, information is available only for approximately 25. In practice this means that only about 35-40% of wildlife information is currently available and useful.

The main lesson is that planning for data capture and management should have been completed before information collection. Data management planning saves time and money and the data can be used for other purposes once it has been collected and carefully documented.

DATA MANAGEMENT PLANNING AVOIDS COSTS

National Biological Information Infrastructure

Sain Roan Mountain: this study[9] carefully documents the challenge of bringing together collected priority legacy data sets for a critical natural resource area. The study includes quantitative measures of the time and effort spent to compile the information. Besides describing problems associated with data management the cost information shows the importance of proper planning and data management from the outset of an initiative.

For this project, researchers spent 3,564 hours and incurred direct costs of $68,392 (plus in-kind costs) to assemble the legacy data sets. These costs were avoidable if standard yet basic data collection and management practices had been followed – in particular the creation of metadata records and the placement of data within viable data repositories.

SIGNIFICANT CROSS AGENCY AND REGIONAL COST SAVINGS WITH NATIONAL IMAGERY

National States Geographic Information Council

The National States Geographic Information Council (NSGIC) Imagery for the Nation (IFTN) program would offer all levels of government a first-ever, large-scale imagery program completely funded by the federal government. It has been adopted as a line item for consideration in the 2008 U.S. Geological Survey (USGS) federal budget.

USGS and U.S. Department of Agriculture (USDA) agreed to fund an in-depth cost benefit analysis for IFTN, a critical step to having it seriously considered for federal funds and a strong indicator that federal agencies see great value in the program

The USDA's existing National Agricultural Imagery Program will be responsible for annually providing 1-meter orthophoto imagery over all states except Alaska. The USGS will administer a companion program for Alaska that will provide 1-meter orthos every five years. The agency will also make 1-foot imagery available once every three years for all states east of the Mississippi River, and for all counties west of the Mississippi River with population densities greater than 25 people per square mile. (1-foot imagery is also being considered for the remaining areas of the Western states.)

IFTN is seen as a sustainable, consistent, and flexible spatial program that will provide the needed resources to help mobilize local and state governments to better coordinate their own countywide — or ideally, statewide — imagery programs.

Under the proposed IFTN, users will have access to 1-foot imagery such as this. Produced by EarthData and provided by the Maryland Department of Natural Resources, this image was taken shortly after an F4 tornado struck Charles County in Southern Maryland.

Using "buy-up" options in the IFTN, government agencies can fund the cost of acquiring and producing 6-inch-resolution imagery. This false-color infrared image of Miami, Florida, was produced by Sanborn..

At present, the NSGIC and National Digital Orthophotography Program estimate that the IFTN will cost $111 million a year, which covers imagery acquisition and processing costs, contract management, quality control, quality assurance, data distribution, and archiving. Nationally, that equates to an estimated $160 million savings per three-year cycle, a benefit largely attributed to IFTN's ability to contract for larger areas, reduce duplicate programs, eliminate certain overhead costs, and provide a return on investment of approximately 19 percent by applying uniform standards. The NSGIC expects the results of the USGS and USDA's cost-benefit analysis, which is due in June 2007, to refine the current cost estimates.

SOME JUNK DATA IS ANOTHER RESEARCHER'S TREASURE

National Aeronautics and Space Administration

Gavin Schmidt[10] is a climate researcher at the NASA Goddard Institute for Space Studies, a regular contributor to *RealClimate*, and an expert in gathering information about *isotope ratios* from all sources. He offers this view on the importance of data sharing:

"All over the world, data gathered by environmental researchers is gathering dust on 8 inch computer tapes, on 5 inch floppies and in decaying notebooks forgotten at the back of never-again-to-be-opened cabinets. These data, most often paid for by taxpayers, didn't necessarily make it into the publication, was perhaps thought uninteresting or was simply left behind when the investigator moved to a better-paid job in finance.

In my experience there are vast treasure stores of data sitting around laboratories that haven't ever been collated because it just didn't seem important, or it was something that one might eventually "get round to doing".

Environmental research today is complex and deals with a vast number of intertwined problems. It's so intertwined that data collected for one purpose may end up playing a key role in some quite unrelated field. Add to that the need for global data sets to compare with global models or remote-sensing information and it's clear that rescuing these individual pieces of information is more important than ever."

Gavin quietly points out what might ordinarily be obvious, that we are not wise enough or have enough vision to be able to predict how useful our data will be to others, when or for what reason. It is important then to make our data available beyond the initial purpose for which is was collected.

OREGON BUSINESS CASE – BENEFITS FOR THE STATE AND LOCAL GOVERNMENTS
State of Oregon

Public agencies and non-governmental organizations in Oregon depend on maps and geographical referenced information to support day-to-day operations and longer-term planning and decision-making.[11] But users experience limited access to important GIS information or the technology to use it. At least 80 percent of the information collected and managed by governmental bodies is geographic in nature—referencing location.

Some benefits of multi-jurisdictional geographic information management are:

- Information management can be more efficient and better coordinated;
- Organizations can more fully capitalize on past and current investments in GIS;
- Considerable redundancy and duplication in data collection, data maintenance, data storage, and system resources across and within organizations can be reduced;
- High-quality GIS data coverage that is incomplete and data quality that will not allow all broad-based user needs and citizen expectations to be met could be completed;

- Procedures, standards, and stewardship practices for effective maintenance of regional and local geographic data can be improved;
- Access to data and technology can be more consistent, with less regional disparity; and
- Opportunities for leveraging outside funds can be more fully explored and realized.

For a wide range of programs and projects, staff and program managers spend a considerable amount of time just gathering or pulling together information from a wide range of sources. Geographic information is hard to find, access, and integrate in a manner that makes it useful to those who need it, when they need it.

The problem is rooted largely in policy and organizational procedure and not, as commonly assumed, in technical hurdles. Administrative barriers, poorly defined management authority, problems in allocating and using available funding, and inadequate management controls have resulted in missed opportunities, duplication of resources and effort, and inconsistencies in data format and quality, which inhibit the use of valuable geographic data and complicate ongoing data maintenance processes.

Proposed Solution

The Oregon Geographic Information Council (OGIC) and the Information Resources Management Division (IRMD) propose the development of the Oregon Statewide GIS Utility to help solve these problems. The GIS Utility initiative will establish and maintain an administrative and operational structure to support effective creation, maintenance, sharing, and access to geographic information and it will do so in a way that supports the program needs of state agencies and the wider governmental and non-governmental communities throughout Oregon.

Its overall impact will be to reduce the cost and duplication of geographic information management while delivering tangible benefits to a large community of users statewide. The results of the analysis presented in this report confirm the short-term and long-term benefits of the GIS Utility and justify the investment in time and resources to initiate the program and bring the GIS Utility to a full operational status.

Benefits and Outcomes in Oregon

The proposed GIS Utility development case shows substantial, ongoing benefits for public agencies, private companies, and the general public. It documents a clear, long-term return on investment, as well as significant non-financial benefits that will improve operations, delivery of services, and the effectiveness of public agency programs at the state, regional, and local level.

- Staff efficiency/productivity increases which, when measured in monetary terms, can result in annual savings of more than $80 million for state agencies and at least $100 million for city and county governments throughout the state when the GIS Utility is fully deployed.
- Opportunities for actual cost savings and revenue enhancement (increase) of well over $80 million over a 10-year period.
- Greatly increased opportunities for securing outside funds for GIS development and related technology projects statewide.
- Tangible, non-financial benefits resulting in robust information security, improved quality of service, enhanced emergency preparedness and public safety, responsiveness to needs of Oregon citizens and businesses, and better management of the state’s environment and infrastructure.

- Support for state-regional-local collaboration and the extension of information technology capabilities to currently underserved jurisdictions.
- Stimulus for economic and business development and public-private partnerships.

ENVIRONMENTAL INFORMATION EXCHANGE NETWORK RETURN ON INVESTMENT

US Environmental Protection Agency

The Exchange Network Return on Investment (ROI) and Business Process Analysis Project[12] was conducted to better understand the effects Exchange Network Technologies have on the quality and efficiency of environmental data exchanges for states, tribes and local agencies. A Return on Investment Model quantified the savings associated with the implementation of Exchange Network projects.

The Project Team selected five data flows to include in the ROI analysis. These flows are:

- Air Quality System (AQS)
- Resource Conservation and Recovery Act (RCRA)
- Safe Drinking Water Information System (SDWIS)
- Toxics Release Inventory (TRI)
- Electronic Discharge Monitoring Report (eDMR)

Four state agencies participated in the development of this study: the Michigan Department of Environmental Quality, the New Jersey Department of Environmental Protection, the Pennsylvania Department of Environmental Protection, and the Washington Department of Ecology. Each agency selected three to four data flows to be analyzed out of five total flows that were included in the ROI analysis. In the table below are the total results for multiple flows found at each state:

	Michigan	New Jersey	Pennsylvania	Washington
Data Flows Examined	**AQS** **eDMR** **SDWIS** **TRI**	**AQS** **RCRA** **SDWIS**	**AQS** **eDMR** **RCRA** **SDWIS**	**AQS** **RCRA** **TRI**
Total Annual Operational Cost Pre-EN ($/year)	$1,622,120	$1,266,519	$1,352,807	$311,560
Total Annual Operational Cost Post-EN ($/year)[1]	$834,407	$672,789	$710,181	$272,294
Initial Capital Investment ($)[2]	$1,095,940	$845,233	$1,002,390	$139,422
Post-EN Annual Maintenance Cost ($/yr)	$107,983	$75,831	$105,609	$19,014
Post-EN Annual State Savings ($/year) [3]	$679,730	$535,192	$537,017	$20,252
ROI Summary				
Average ROI (5 year basis)	62%	61%	54%	15%
Payback period (years)	1.6	1.6	1.9	6.9

"This table shows the total cost to operate all of the data flows implemented by each state (of the five that were included in this study) both before and after the implementation of Exchange Network technologies. By dividing the net savings of the project by the initial investment, a Return on Investment percentage was determined. All states participating experienced a positive return on their investment in Exchange Network technologies to flow data. Implementation of additional data flows would likely improve these individual state ROI values."

EXPECTED BENEFITS OF INFORMATION SHARING AND EXCHANGE
Northwest Environmental Data Network

The Pacific Northwest's natural resource and environmental management agencies and inter-agency organizations recognize the value of information technology (IT) and information exchange.[13] However, environment and natural resources do not conveniently align with political and jurisdictional boundaries. Cross-boundary work requires ready access to information across those boundaries, systems and jurisdictions.

State and tribal departments, inter-governmental organizations, non-governmental organizations and federal agencies all broadly agree that the use of common data standards, data dictionaries and cross-walk tables and read/copy access to databases… information paid for almost entirely by public funding, can, would and does improve our control and protection of the environment and our management of natural resources.

How would this be accomplished?

Many of these departments, agencies and organizations have committed to advance the exchange of environmental information across the region. Commitment to information exchange is found in the Pacific Northwest's natural resource and environmental management program reviews and some interagency charters.[14 15]

The Northwest Environmental Data network has completed assessments, strategies and plans showing the need for and value of an enterprise-level environmental information network including standards and protocols to support interoperability and distributed interconnected databases.[16]

The primary issues and challenges to expanding the information or data exchange network are institutional in nature rather than technological. Current information technology has proven its ability to locate access, transfer and present data with common data and IT vocabularies, languages, standards and procedures for the location, access, and transfer of data.

Our challenge is to move past our insular views and investments and to embrace changes in IT, information management, and local work flows that promote a greater good at system and enterprise levels. Case studies show that these approaches are cost effective.

Business Impacts and Benefits

Save Money/ Avoid Costs
Save Time
Increase Efficiency
Increase Accuracy
Increase Productivity
Increase Communication and Collaboration

Support Decision-making
Automate and Improve Work Flow
Expand and Enhance Information Bases

E-GOVERNMENT CASE STUDY[17]
State of Washington

A Business Portal Project Team in the State of Washington developed a case study for an information system portal. Approximately 85 businesses attended roundtable discussions over eight months. They told the Team they wanted:

- One place to go to understand all the requirements for state and local government.
- A consistent screen layout when they complete any type of transaction with any level of government.
- Online processes to apply for and renew their licenses and environmental permits.

Without a consolidated permitting process each environmental permit must be applied for separately. Three of the common environmental permits required much the same information during the application process. Complicated permit applications often caused errors and delays in processing. For example, 20 percent of the 6,400 Forest Practices Applications processed annually for the past two years were returned to the applicant at least once for additional information. Businesses wanted one efficient, consolidated process that is easy to understand in order to apply for all the permits needed to operate in cities, counties, and the state.
A major purpose of the Portal was to provide businesses with relevant requirements and services in one place to help them "get it right the first time". Higher accuracy up front would reduce wasted time and effort for businesses and government agencies. In addition, the Portal would reduce the need to access or understand multiple systems by delivering government information and processes to businesses through a single location.

- Streamlined business processes within and across state and local government
- Integration of systems and data between state and local agencies
- An online, consolidated service center to assist existing and prospective businesses to understand and fulfill their state and local regulatory requirements (licensing, permitting, taxation, filing of reports, etc.). This online service center will provide a convenient, "one-stop" gateway to a variety of state and local government services and information sources.

These initiatives provided that state government entities must work together to streamline processes and make it simple for businesses to meet requirements so they can spend time operating successfully and staying in business. The Enterprise Business Portal is a central part of Washington's response to the concern businesses and citizens have about Washington's business climate.

WHY COORDINATION OF MONITORING AND DATA MANAGEMENT RESOURCES MAKES BUSINESS SENSE
Upper Columbia Regional Technical Team

Summary

The Upper Columbia Region is currently implementing many large programs that will increase the likelihood of salmon recovery. Large- and small-scale projects associated with salmon recovery are currently underway and information pertaining to the effectiveness of these projects is being collected. The Upper Columbia has already developed and begun implementing a coordinated monitoring strategy (Hillman 2004, 2006) that has made large improvements in standardizing monitoring protocols and indicators throughout the region.

During development of the monitoring strategy, the Upper Columbia Regional Technical Team (RTT) identified a need for coordinated management of monitoring data as part of the larger strategic plan for salmon recovery in the region. As part of the solution, a centralized, properly managed data repository and infrastructure are currently being developed. Along with this repository, the region is working to standardize protocols for compiling, storing, and analyzing information. These efforts will ensure that financial and natural resources are not wasted and general data access is assured.

Background

The salmon recovery plan, biological opinions for the federal hydro system, habitat conservation plans for local public utilities, and similar conservation efforts are being implemented. As such, information is being collected to monitor progress of implementing these complex programs.

To date, each entity that is implementing the above programs has determined protocols for collecting, storing, and analyzing data without a large amount of coordination between agencies. This has led in some cases to inefficiencies of labor, waste of money, and incompatibility of information between programs (if protocols or indicators differ). Additionally, there has not been a centralized data storage system so it is difficult to determine what information is collected and where the data are housed. This also leads to difficulty in conducting comprehensive analysis for stock status and action effectiveness.

Identifying a Solution

Having a well-managed data storage system will enable all entities currently implementing programs to have a better understanding of what is taking place within the Upper Columbia Region, and will ensure that resources are used in the most cost efficient manner.

Recognizing the need for coordinated data management, the RTT recommended establishing a locally operated, standardized, and coordinated data management system for Upper Columbia fish, habitat, and water quality data. The data management system will be managed and coordinated by a Data Steward, housed and supervised by the Upper Columbia Salmon Recovery Board (UCSRB).

Rather than starting the data management system from scratch, the RTT identified existing data management tools and resources within the region. Principally, NOAA Fisheries Service had already developed the Status, Trend, and Effectiveness Monitoring Databank (STEM Databank), and is currently utilizing this databank as part of the Wenatchee and Entiat River Integrated Status and Effectiveness Monitoring Plan (ISEMP). The RTT identified the various public and private entities collecting data on fish, habitat, and water quality in the region and concluded that most are willing to begin using the STEM Databank. For example, in the Okanogan subbasin the Colville Tribes hold monitoring data that can be rapidly assimilated into the STEM databank. However, due to agency obligations and time constraints, there is a need for additional technical support and guidance.

This additional technical support and guidance will be provided by the Data Steward. The function of the Data Steward will be to work with existing and future data collectors to refine data management protocols to integrate collected data into a regional data repository, the STEM Databank. Importantly, this process will also provide the individual practitioners with a more efficient and accountable data management system that will serve their agencies' needs. The finalized product is expected to be a comprehensive database, publicly available on the web and regularly updated, containing all the information collected from the various entities within the region.

In addition to benefiting the Upper Columbia Region, more coordinated data management within the Upper Columbia will facilitate larger Columbia Basin or statewide efforts, such as the NPCC Fish and Wildlife Program, FCRPS BiOp, Columbia River Initiative, Salmon Recovery Funding Board, and others.

<u>Implementation, Cost Savings, and Benefits</u>

By making the information publicly available in a consolidated location and regularly updated on the web, the UCSRB and RTT hope to avoid the access, incompatibility, and duplication of efforts currently encountered by resource managers. The Data Steward will start in October of 2007 to standardize data management protocols and continue (what ISEMP has started) working with data collection practitioners to use standardized database formats.

Cost Savings - Data Management Repository: Instead of multiple parties developing their own ESU-wide database, the Upper Columbia Region is electing to use an existing database. This is potentially a cost savings of over $500,000.[18]

Greater Utilization of Existing Monitoring Data: As part of their hatchery monitoring and evaluation (M&E) programs, the PUDs are responsible for collecting information related to abundance, productivity, spatial structure, and genetic diversity[19] of the populations where they have hatchery supplementation programs. The ISEMP and OBMEP (Okanogan Basin Monitoring and Evaluation Program) programs are collecting information related to these criteria as well as information pertaining to habitat restoration.

Since 2004, several million dollars have been spent to collect data across the Upper Columbia ESU. By ensuring that the information collected is coordinated and integrated with salmon recovery, duplication of effort will be minimized. If this information is collected, stored, and analyzed properly, NOAA Fisheries Service and others will be able to access the information more readily which is currently not the case. There will be greater utilization of the existing monitoring investments in the Upper Columbia Region.

Significant Improvements to Prioritization of Projects: Coordinated monitoring and evaluation data is essential for assisting in the prioritization and development of projects to restore salmon in the Upper Columbia. Many efforts require prioritization of projects as part of their programs, such as the Federal Columbia River Power System Biological Opinion, ESA recovery implementation, the Salmon Recovery Funding Board, the NPCC's Fish and Wildlife Program, and the State and Tribal salmon recovery and management efforts. A coordinated monitoring and data management program in the Upper Columbia will significantly improve our understanding of habitat limiting factors and project effectiveness that will lead to better prioritization and sequencing of restoration and protection projects.

Conclusion

The Upper Columbia Region has identified the need for coordinated management of monitoring data. This has culminated in key decisions by recovery partners, such as selecting a databank and associated data management protocols to populate a monitoring repository. By selecting an existing databank, initial capital costs are directly saved.

In addition to direct cost savings, the coordination of data collection and management will improve return on existing and future investments. Tremendous investments of monitoring, restoration, and protection dollars are being made in the Columbia Basin. The objective to increase return on investments necessitates greater utilization of the existing monitoring data. By having a well managed, centralized data storage system, all of the agencies involved with data collection and analysis will be assured that information is collected in a quality controlled and cost efficient manner. This information will significantly improve the prioritization of projects in the Upper Columbia Region. The coordination of these data collection efforts will ensure that all of the various goals (salmon recovery, mitigation for hydro losses, and effectiveness of hatchery programs) and objectives will be achieved quickly and efficiently.

CONCLUSION

Understanding information management costs and benefits is a key to being able to respond to regional data sharing and integration opportunities. Decision makers want assurance that improvements to regional information management arrangements would benefit the Pacific Northwest Region as a whole, and as individual Federal, State, Local and Tribal sectors.

These "Snapshots" and "Case Studies" provide examples of costs and benefits from a variety of information management efforts across federal, state and local sectors. They also provide lessons in what helped to make these efforts a success.

The chance of success is improved when an enterprise approach is adopted, when planning prevents avoidable costs, when there is a clear connection between the improvements and the planned use of the regional information, when organizational and administrative arrangements are in place, and when there is strong executive support.

The case studies identified significant tangible dollar benefits (in excess of costs) and also some intangible benefits (benefits that could not be assigned dollar values) for information sharing and management improvements at different scales, for example:

- The EPA reported Return On Investment (ROI) from Exchange Network Projects ranging from 15 to 62% with payback periods from 1.6 to 6.9 years.

- Minnesota Department of Natural Resources Lake Survey Project saves thousands of work hours and over $216,000 annually, ensures better quality data, and allows easier sharing with the public.
- National States Geographic Information Council estimated that applying uniform standards and applying other improvements to imagery acquisition and processing saved $160 million per three-year cycle, an ROI of 19%.
- The Federal Drug Administration reported savings of $10 million over a $200 million dollar IT budget.
- The state of Oregon predicted staff efficiency/productivity increases as annual savings of more than $80 million for state agencies, at least $100 million for city and county governments throughout the state with a fully deployed GIS utility and actual cost savings and revenue enhancement (increase) of well over $80 million over a 10-year period.
- The Department of Housing and Urban Development reported a $12 million dollar return from a $9 million dollar investment.
- An Illinois mapping consortium of local utilities, IMAGIS, in 1992-93 showed over $24 million in business benefits for city, county and utility participants including over $7 million in cash return or cost prevention.
- Six "*Snapshots*" showed benefits ranging from $50,000 per year to $4 million per year.
- The Upper Columbia Regional Technical Team identified direct cost savings of approximately $500K and improved return on existing and future investments through greater use of exiting data, a central data storage system and common collection and quality control procedures.

Other reports or examples identified costs that would have been avoided from improved information management planning: $68K for the NBII-Sain Roan Mountain study and $251K for the NPCC subbasin planning data recovery. These identified benefits are really avoidable costs. If the projects had addressed these issues up front, the costs would not have accrued and therefore are potential benefits.
Importantly, the studies also identified practices and actions that contributed to these business successes:

- The use of an enterprise level (or framework) approach can significantly increase the likelihood of success in terms of products and in terms of cost savings for IT decisions. Enterprise methodologies require an iterative approach – and most importantly documentation of the business needs.
- Basic information management planning can avoid costs that must be paid later if information is needed at a different scale from the scale of collection, e.g. regional instead of local.
- Organizational and administrative arrangements are especially necessary for information management efforts that cross organizations – whether for a shared GIS resource in Indianapolis, or the management of National Traffic Safety data at the National Highway Traffic Safety Administration (NHTSA).
- Significant effort is necessary to coordinate, develop and maintain organizational arrangements. For example, the NHTSA learned that information sharing is much more than databases and networks (IT).[20] Groups working to share information put

only 20 percent of their effort into technical issues; with 80 percent spent creating organizational arrangements for information sharing and exchange.

- Active executive support is a factor in successful long term efforts.
- Convention investment in IT can benefit when they are ‘blueprinted’ on a planned or Enterprise Architecture approach. IT alone does not automatically provide needed information management goals, or the motivation to apply it.
- Northwest Environmental Data Network reported multiple lessons learned from many regional information system improvement efforts.

ACKNOWLEDGEMENTS

In planning for the workshop the primary sponsors: the Northwest Environmental Data Network (NED); the Pacific Northwest Aquatic Monitoring Partnership (PNAMP); and the Pacific Northwest Regional Geographic Information Council (PNW-RGIC), met in January 2007. The meeting was facilitated by Scott Riordan from the Oregon Department of Administrative Services. At the meeting, it was agreed that a business case showing benefits from regional information management should be developed, and that these groups needed to join together to bring their concerns to regional executives. NED, PNAMP, and PNW-RGIC Steering Committee members agreed to collaborate to advance this task. Scott Riordan met twice more with a joint work group to facilitate discussions. Joy Paulus (WA, RCO) and Stewart Toshach (NOAAF) then took a lead on researching and writing this document. Julie Morgan, Chuck Peven, John Arterburn, Casey Baldwin, and Steve Rentmeester authored the Monitoring example. Jacquelyn Schei completed the document layout and final edit.

[1]R. W. Greene. June 2000. *GIS in Public Policy*. ESRI Press.
[2]Scientific Applications International Corporation. April 30, 2003. *Recommendations for a Comprehensive and Cooperative Columbia River Information Management System*. Northwest Power Planning Council (NPPC), Portland, Oregon.
[3]Science. 30April 2004. Vol 304:p.661

[4]Christopher Thomas and Milton Ospina, ESRI Press, July 2004. *Measuring Up – The Business Case for GIS*

[5]www.fcw.com/article88733-05-02-05-Web

[6]http://www.naisco.org/publications/documents/NASCIO-EA_IT_Procurement_brief100305.pdf

[7]Palmer,C., Morganti, R.and Bingham, B. 2004. Interagency Resource Information Management: Issues, Vision, and Strategies, and Roberto Morganti, pers com

[8]http://www6.indygov.org/imagis/

[9]Thomas Burley, Nora Schubert, Judy Murray, John Peine and Mary Thompson. 8/30/06. *NBII-SAIN FY05 Roan Mountain Project Final Report*

[10]http://www.realclimate.org

[11]Oregon IRMD-Geospatial Enterprise Office. January 17, 2006. *Business Case for the Development of a Statewide GIS Utility*.
[12]EPA Environmental Information Exchange Network. Final Report, Sept. 5, 2006. *Exchange Network Return of Investment and Business Process Analysis.*

[13]NPCC May 2006 *White Papers and Recommendations from the May 25th and 26th, 2005 Intergovernmental Workshop. Beyond Ad-Hoc: Organizing, Administering, and Funding a Northwest Environmental Data-Network.* NPCC, Portland Oregon.
[14]http://www.nwcouncil.org/dropbox/Data%20Sharing/NED%20MOU.pdf

[15]http://www.pnamp.org/web/Content.cfm?SectionID=1

[16]Scientific Applications International Corporation. ibid

[17]Office of Financial Management March 200*6 07-09 Office of Financial Management Decision Package. Washington State Enterprise Business Portal.* Olympia WA.

[18]Estimate from the Northwest Fisheries Science Center - Science Data Management Team.

[19]These are the viable salmonid population (VSP) parameters, which will be used by NOAA Fisheries Service to determine the status of the endangered or threatened populations within the Upper Columbia.

[20]National Highway Traffic Safety Administration http://www.tfhrc.gov/pubrds/novdec99/km.htm

Section III (E.3). Executive Summit Focus Document

Link to document on PNAMP website:
http://www.pnamp.org/web/workgroups/SC/meetings/2007_1002/2007_0917REIF_Summit_Focus.pdf

EXECUTIVE SUMMIT FOCUS

SHARING INFORMATION FOR IMPROVED DECISIONS

1.0 Executive Summary

In October 2007 regional executives are coming together to discuss the sharing of regional[1] information resources with a goal of identifying executive actions that could be taken to expedite and improve information management leading to more effective data sharing. Suggested summit outcomes, identified by the project sponsors are:

Develop a regional executive level commitment, through an MOU or similar instrument, to:

- Identify priority information sharing needs;
- Improve information sharing and complete a regional ecosystem and information framework;
- Develop indicators, information collection standards, and protocols and information sharing arrangements;
- Develop an executive leadership group to steer this effort and other necessary organizational and administrative arrangements including consideration of roles for NED, PNAMP and PNW-RGIC;
- Identify resources for these tasks; and,
- Set overall timelines and review progress.

This focus document provides further information on the summit sponsors, identifies common ecosystem information sharing challenges, describes an ecosystem and information framework and development steps. A companion document, ***Sharing Information to Improve Decisions-Examples of Benefits and Cost Avoidance*** has been prepared to provide a business case for needed executive actions.

2.0 Why the Summit is Necessary

Currently ecosystem information is collected across multiple programs and efforts, using many different methods and is maintained in many different technical systems. The result is that

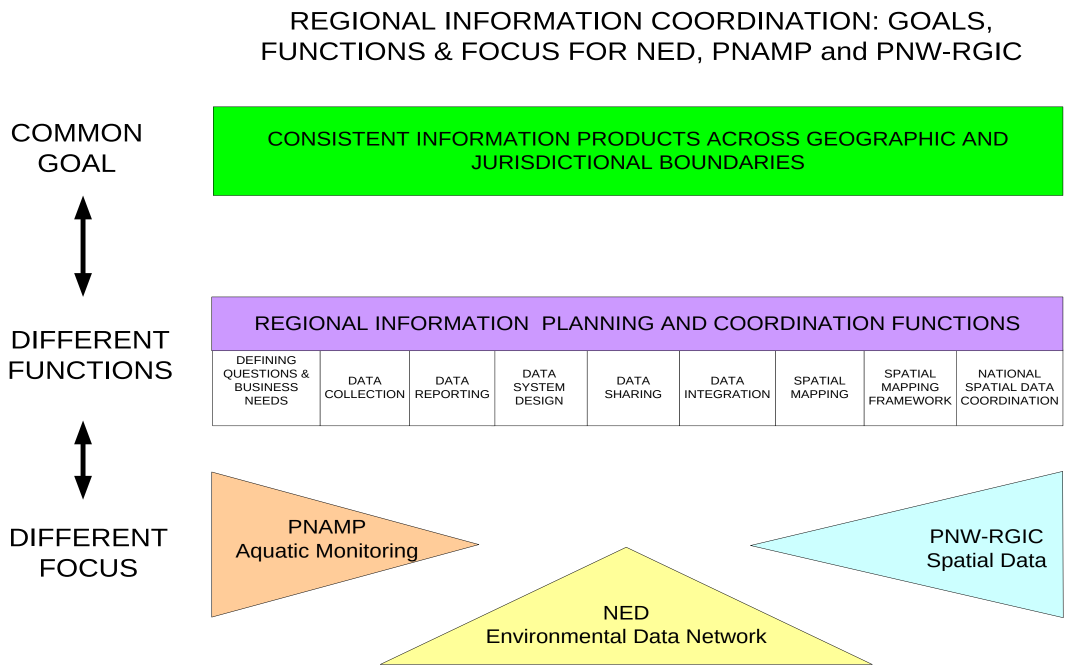
[1] Pacific Northwest Geographic Scope involving: Federal, State, Provincial, Tribal, Local and NGO interests associated with the Columbia Basin, Puget Sound and the Coastal Pacific Northwest.

it is difficult, and in some cases practically impossible to assemble the data into ecosystem level views that cross geographic and administrative boundaries.
To make many difficult regional level decisions; to report progress to congress, governors, legislators, and constituents; to demonstrate that public agencies are using public funds in a coordinated and cost effective manner; and for many other reasons, managers will most probably need:

- Access to significantly more high quality information than they have now, including cross boundary and organizational information;
- readily available information about the projects they manage and the projects managed by others;
- Ability to compare information and reports developed by multiple agencies for consistency and accuracy;
- To correlate the actions of multiple agencies with regional spatial information; and,
- Flexibility to adapt as needs change and more is known and understood.

3.0 Summit Sponsors

The Northwest Environmental Data Network (NED), the Pacific Northwest Aquatic Monitoring Partnership (PNAMP), and the Pacific Northwest Regional Geographic Information Council (PNW-RGIC) have collaborated to organize this summit. PNAMP is an effort to understand why, how, and where aquatic data are collected, NED is about regional scale solutions for sharing and integration of multiple environmental data sets and PNW-RGIC is about developing regional spatial framework layers and national coordination. PNAMP is an example of a content focused group in the region, there are other groups.
While many groups participate in information management in the region only a few have a coordination role crossing multiple programs and geographies. NED, PNAMP, and PNW-RGIC have different and complementary coordination roles as shown in the Regional Information Coordination diagram on the next page.



NOTES: Triangles show main focus of each group: PNAMP is about why, how and where aquatic data is collected; NED is about regional solutions for sharing and integration of multiple environmental sets; and PNW-RGIC it about developing spatial framework layers and national coordination.

PNAMP is an example of a content focused group in the region - there are many others.

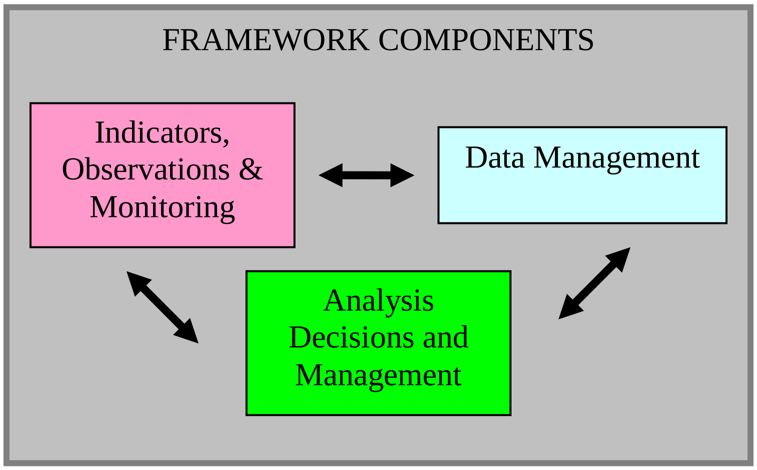
4.0 Why is a Framework Necessary?

Ecosystem science and management, information management and other disciplines can all contribute, but we also need a framework to help "connect the dots" between the many efforts – to allow contributions to a coordinated "whole" that is bigger than each individual program, agency or groups' own interest.

It is important to understand that an ecosystem and information framework does not presume any particular technical outcome such as "a single database for all data". Instead, it is an operational prescription for an information management environment that provides for efficient collection of more high quality information, open-sharing and access, sound analysis and use across multiple providers and users.

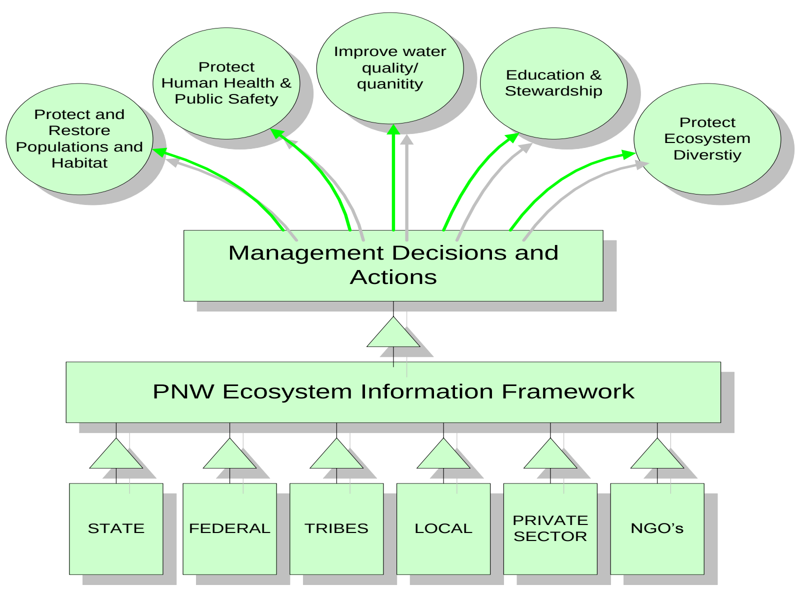
5.0 What's an Ecosystem and Information Framework?

An ecosystem and information framework is a description of the needed components of an information system – together with a description of how they would work together. It describes the functions of a full information management cycle (from information collection design, indicators/protocols, to data collection, to technical data management, to analysis, to decisions and feedback). In a regional context, because of existing ecosystem and information management efforts, it is also about how these efforts can make existing "legacy" data more useful, consistent and accessible.



Framework components to meet these needs are likely to include:

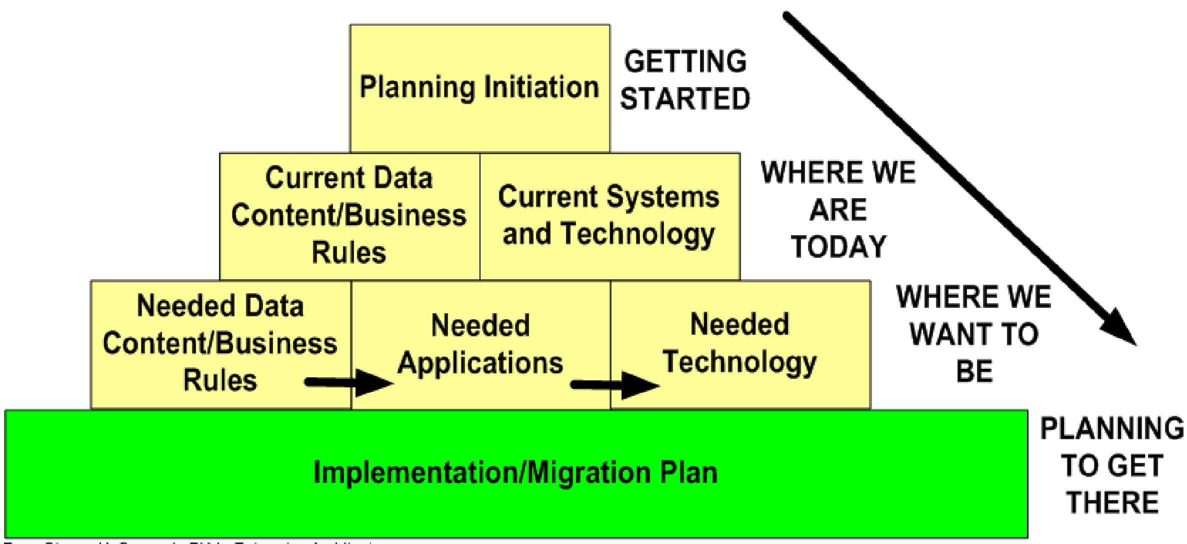
- details about the critical questions that must be answered;
- indicators and benchmarks;
- a shared understanding of needed information collection, handling and sharing
- defined roles and responsibilities of the participating entities
- a common language and consistent tools for information exchange;
- some common analytical tools; and,
- an ecosystem and information framework to pull it all of this together to "connect the dots".



A thoughtfully designed ecosystem and information framework would be able to serve multiple groups, goals and content areas.
An effective ecosystem and information framework would be technology neutral – creating a place – in the framework for all regional providers who are willing to participate and enabling access to the information for all users who want to use it.

6.0 A Model Process

A multidisciplinary process is essential because people working on parts of an ecosystem and information framework (including scientists and resource managers, information collectors, data managers, analysts, and GIS specialists, and decision makers) are usually from different disciplines and backgrounds.
A successful outcome will depend on active participation from all these groups – and this involves executive level commitments to joint activity and products.
Because ecosystem science monitoring and information management involves multiple partners, entities, interests, needs and technologies, **a model process** can help to work through this complexity.
The "Wedding Cake" model[2] (see diagram below) is a step-by-step way to systematically identify, design and deploy a framework. The model provides for development of end-to-end understanding of the information management needs from monitoring and observations through data management to decision tools to decisions and a systematic way to address those needs. It is understood that different groups are working on ecosystem information system improvements at different levels. It is essential to understand these differences and account for them in a regional model and in any implementation steps or migration plans that are developed. It is also important that information system improvements are based on a sound and consistent planning foundation.
The model has four levels (see Figure below).



From Steven H. Spewark, PHd - Enterprise Architecture Planning

[2]From Steven H. Spewark - Enterprise Architecture Planning.

At Level one **"Getting Started"**, there is a necessary commitment by project sponsors to systematically address the information, data management and decision making needs with a framework approach.

Level two describes **"Where we are today"**. What data is currently collected and what business rules apply to that collection? What information system applications (software) and technologies (hardware) are currently used?

Level three describes **"Where do we want to be"**. This includes future needed data content, business rules, applications and technology. It defines future needs in relation to future decisions that must be made. The differences between level two and level three are commonly called gaps.

Level four describes how to get from **"where we are today"** to **"where we want to be".** This task includes defining necessary content, business rule, application and technology needs. Level four is a plan that describes who will do what, when and where and with what resources, agreements and technology.

7.0 Possible Summit Outcomes

Steering Committee members and coordinators of NED, PNAMP and PNW-RGIC have met together and separately to discuss desirable outcomes for the summit and have identified the following:

Develop a regional executive level commitment, through an MOU or similar instrument, to:

- Identify priority information sharing needs;
- Improve information sharing and complete a regional ecosystem and information framework;
- Develop indicators, information collection standards, and protocols and information sharing arrangements;
- Develop an executive leadership group to steer this effort and other necessary organizational and administrative arrangements including consideration of roles for NED, PNAMP and PNW-RGIC;
- Identify resources for these tasks; and,
- Set overall timelines and review progress.

Section III (F). PNAMP Recommendations to Executive Network

Section III (F.1). Data Management Needs for Regional Project Tracking to Support Implementation and Effectiveness Monitoring

Full document is attached at the end of this report.

Link to document on PNAMP website:
http://www.pnamp.org/web/workgroups/PEM/documents/general/2006_1030ProjecttrackingME.pdf

Data Management Needs for Regional Project Tracking to Support Implementation and Effectiveness Monitoring

Stephen L. Katz, Katie Barnas, Stewart Toshach NOAA Fisheries, Northwest Fisheries Science Center

Executive Summary

Funders and sponsors of regional restoration projects have an increasing need to validate the effectiveness of their projects. The design and execution of efficient effectiveness monitoring requires several prerequisite tools – no matter who will perform the monitoring or at what scale. One prerequisite tool is specific information on the *what, where* and *when* of the restoration that has occurred or is planned for the near term – i.e. a comprehensive project tracking system.

To be useful, the relevant project information needs to be contained in an accessible, comprehensive data system. This proposal describes project-level information that is needed for both implementation and effectiveness monitoring; the vision, justification, design and performance requirements.

This data design, alone, does not constitute effectiveness monitoring – rather, it is a tool that is required to design and execute effectiveness monitoring efforts. ***The design is driven by the needs of Effectiveness RM&E (Research, Monitoring and Evaluation).***

This design is informed by an intensive survey of existing project tracking systems. Regionally there is a wide diversity of project tracking systems that were designed to track contracts and work elements rather than satisfy effectiveness monitoring needs. This document describes the steps needed to advance beyond project or contract tracking to provide the additional information needs for research, monitoring and evaluation. It has grown and been refined by experiences with the Pacific Coast Salmon Recovery Fund (PCSRF), the Pacific Northwest Habitat Restoration Project Tracking Database (PNSHPTD), and the National River Restoration Science Synthesis (NRRSS) and refines and adds to these efforts.

The information needs required for R M&E include all of what is currently part of PCSRF plus:

- Spatially explicit locations and project type designation for every project at the work site level (current project records may refer to multiple separate implementation sites or may contain insufficient spatial locations),
- References to all habitat restoration projects regardless of funding source, and
- Measures of treatment magnitude.

This document presents of a set of minimum metrics and metadata for RM&E data design. They represent a reasoned compromise between the technical need to collect numerous metrics and the practical limitations of what can be collected by regional partners.

The data system is designed to be flexible to respond to the unique needs of diverse regional partners. It is currently being incorporated into diverse regional monitoring projects, such as the Integrated Status and Effectiveness Monitoring Project and the Pacific Coast Salmon Recovery Fund project tracking systems to demonstrate its utility and performance.

Data Management Needs for Comprehensive Regional Project Tracking to Support Implementation and Effectiveness Monitoring

I Regional Habitat Restoration Project Tracking and its Relationship to R M&E

Habitat restoration is a cornerstone of regional recovery efforts for endangered salmon. Nearly $400 million dollars per annum are spent on salmon recovery in the Columbia River basin with a significant fraction addressing habitat management actions (GAO, 2002). There is a growing need to validate that these expenditures are producing desired consequences. The validation will require several complimentary tools. This paper is a description of only one of those tools – habitat project tracking -- and a description of how that tool complements the others.

Fundamental information needed to validate the efficacy of habitat restoration includes knowledge of what habitat improvements are being planned and implemented; knowledge provided by project tracking systems. Project tracking systems are about collecting and managing this information, rather than validating that information; it is not monitoring *per se*.

The Pacific Northwest Monitoring Partnership (PNAMP) focuses on monitoring, and PNAMP has defined two kinds of monitoring that rely on project tracking information: Implementation monitoring and Effectiveness monitoring. PNAMP defines Implementation monitoring as:

> *The* ***monitoring of management actions*** *to determine if they were implemented properly or comply with established standards. This is normally associated with a restoration project where an engineered solution has been constructed, or where a best management practice (BMP) has been implemented. Implementation monitoring documents the type of action, the location, and whether the action was implemented successfully. It does not require environmental data and is usually a low-cost monitoring activity.* [Emphasis added]

PNAMP has also defined two varieties of Effectiveness monitoring, Project Scale Effectiveness Monitoring and Validation Monitoring; both of which rely on project tracking:

> [Project Scale Effectiveness Monitoring] *Most salmon or watershed projects are implemented at a small scale, with defined sets of actions intended to protect or enhance specific habitat features or habitat-forming processes. Project scale effectiveness monitoring measures environmental parameters to ascertain whether* ***the actions implemented*** *were effective in creating a desired change in habitat conditions.*
>
> [Validation Monitoring or Action Effectiveness Research] *This type of monitoring (or research) attempts to establish "cause and effect" or inferential relationships between fish conditions, habitat conditions, and/or management actions. It pertains to* ***evaluation of projects and programs*** *meant to protect or enhance habitat conditions or fish*

> *production. These studies are complex and technically rigorous, and often require measuring many parameters under a very structured statistical design to detect the variable affecting change.* [Emphasis added]

In each case there clues provided about the tools required to perform the task. However, in each case the tools are going to have different specific features. For example, each type of monitoring contains an expectation that some direct observations will be made, but exactly where and when observations will be made will be different in the different varieties of monitoring. ***This paper is does not specify the features of those direct observations.***

For PNAMP monitoring there is a common prerequisite for information on what habitat management actions have occurred or are planned, where they are, how big they are and when they happened. Effectiveness monitoring can not be designed, or inferences extended to other locations without the knowledge of the distribution and intensity of restoration in the relevant locations.

That monitoring programs will depend on coordinated tools is often implicitly recognized, although precisely how the tools will work together is harder to express. For example the PNAMP guidance ***Establishing a Network of Intensively Monitored Watersheds in the Pacific Northwest*** (PNAMP, 2005) lists criteria for watersheds to be included in an IMW program.

> The IMW network:
>
> a. shall capitalize to the extent possible on the pre-existing availability of suitable scientific knowledge
> b. shall have long term commitments to juvenile, outmigrant, and adult fish monitoring
> c. shall support important management questions of PNAMP members
> d. shall be distributed across areas/ecoregions, species, and categories of project and/or management activities consistent with (a)
> e. shall have ***sufficient type and duration of management actions*** for reliable implementation of long term experimental designs [emphasis added]
> f. shall apply experimental designs with appropriate and viable controls
> g. shall have broad base of support in the locally affected area

Each of these criteria reflects, at least implicitly, a tool that is required to successfully deploy an IMW:

a. Information about what habitat data is available in the watershed (characterization of habitat)
b. Information about the current and historic levels of adult and smolt monitoring (current and historical monitoring)
c. Information about the complexity and diversity of the watershed in the context of providing treatment and control opportunities (experimental design opportunities)
d. Information about the level of local participation and administrative control over the watershed (integrity and maintenance of experimental design)
e. Information about what habitat projects and management are occurring in the watershed

(project tracking)

These criteria are summarized in the figure 1:

So there are several tools, all working together that are required to perform successful effectiveness monitoring and research in IMW's. This paper is about the project tracking tool (the red box in figure 1). One may anticipate that parallel design guidance will be developed to support the other components of successful effectiveness monitoring—in IMW's and elsewhere and it can be shown that similar requirements exist for project level effectiveness monitoring and so these needs are generic (see below).

This document describes the design of the data system for project tracking – what data are in it, what its information needs are, and the justification of the data needs. It does not describe how such a system would be regionally adopted. Exactly who would participate and under what set of rules will require significant negotiation between funders, project sponsors, regulatory authorities and diverse data holders. Regional data holders have their own needs to maintain project tracking data and how they would participate in a coordinated data management system will vary widely. Regardless of individual roles, agreement on a standard for project tracking data, such as the system described in this paper, is a prerequisite for regionally coordinated project tracking, or beyond that, coordinated R M&E.

This design is informed by the lessons learned from development of the NWFSC Pacific Northwest Habitat Restoration Project Tracking Database (PNSHPTD). PNSHPTD surveyed regional holders of data for restoration actions occurring in the last 10 years and was designed to service the technical needs of M&E. The initial scope of PNSHPTD was the Federal Action Agency Research, Monitoring and Evaluation Plan for the Federal Columbia River Power System Biological Opinion, but it has grown to include project tracking across the states of OR, WA, ID & MT. Development of PNSHPTD highlighted several features of data system development that we considered in the design of the Project Tracking for M&E system. They are outlined below.

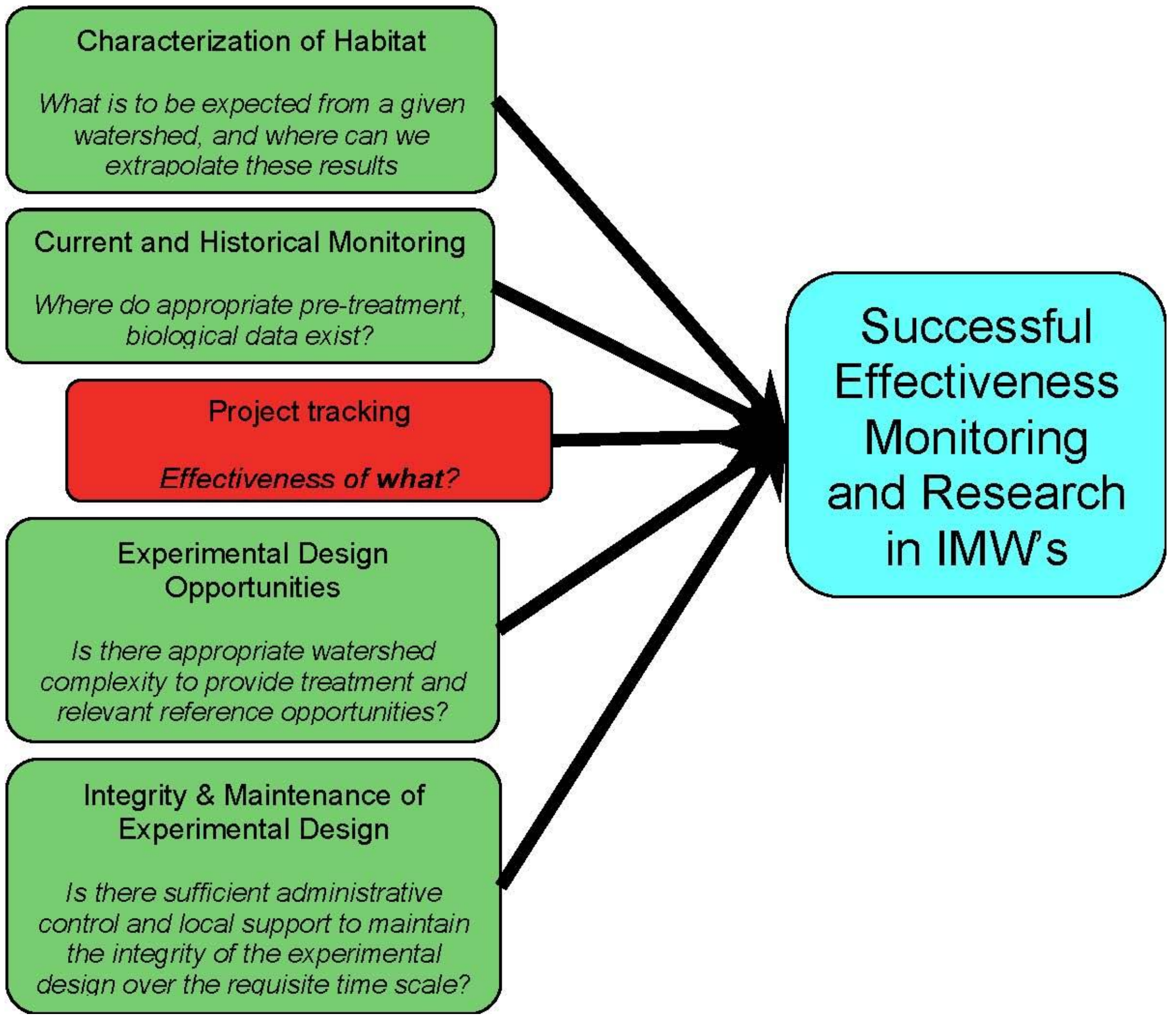


Figure 1. The relationship between project tracking and other elements in Intensively Monitored Watershed (IMW) selection. The components will also determine aspects of monitoring program. Project tracking, as defined in this paper, is one tool among several (red box) which must work in a coordinated fashion with the other tools, and whose design is determined by that coordination.

In addition, the PNSHPTD identified the need for a common set of standards for project tracking data. PNSHPTD obtained data from 30 sources directly, and many of these were holding data from numerous other independent contributors. The total sources of data were in excess of ninety. Since there is no regional standard for data formats, this results in a tremendous diversity of data types, that in many cases, are incompatible. For example, in the data collected by PNSHPTD there are 24 ways of expressing project location with resolutions from meters to tens of kilometers. If spatial data is collected with high resolution, the lower resolution data can usually be "back-filled" with automated protocols – as is done for example in Washington's PRISM data system where latitude and longitude are used to inform county and HUC. Thus, one objective if this proposed design is to collect data with high spatial resolution to service the greatest number of needs.

In the absence of standardized data formats and automated back-fill protocols only 20% of the project resources were used to obtain the data, with the remaining 80% applied to data stewardship, including the cross-walking of diverse data types. In addition to being more costly, the process of data migration and quality assurance added significant delays to the availability of data useful in the context of M&E (Katz *et al.,* Rest. Ecol., In press).

A common data design for project tracking data will reduce these delays and improve the utility of existing data collection programs. To demonstrating this increased utility the design is being used in the ongoing work of the Integrated Status and Effectiveness Monitoring Project (ISEMP) in the Wenatchee and John Day pilot M&E projects. It is also being deployed by NOAA's Pacific Coast Salmon Recovery Fund (PCSRF) as part of its maturing program of tracking management actions for recovery of threatened and endangered salmonids. These demonstrations will be used to inform other efforts to develop or improve data systems for regional monitoring and evaluation.

II What does M&E need from a project tracking system?

Current project tracking systems, such as the current PCSRF, track information to answer questions about resource distribution. This kind of accountability places specific design requirements on the data system. For example, one needs to know how much money is being allocated per project, and where the recipients of the funds are located. Other examples of needed information include, who is doing the work, when the work happened, where the work occurred and some measure of what kind of restoration work is happening. The information collected can answer general questions like how much activity is located within a particular jurisdiction, County or State. It is important to note that the PCSRF project tracking system was designed to answer questions about projects, not the effectiveness of the projects

Effectiveness monitoring is a very different enterprise than tracking project resource distribution. Effectiveness monitoring must assess the success or progress of habitat restoration projects in addressing some identified ecological need or pathology. ***Therefore, while not by themselves effectiveness monitoring, project tracking systems that service effectiveness monitoring must look to the relevant effectiveness monitoring questions to determine what the information needs are—the design of project tracking is driven by the needs of Effectiveness RM&E.*** In some cases the information needs of M&E are similar to resource distribution but in more detail, and in other cases they are whole new data elements. This design for project tracking is built on the data elements that already exist in PCSRF, supplemented or modified as necessary. PCSRF has had wide regional exposure and review, has a large geographic footprint and funds a significant fraction of the restoration in the region. Therefore, the current PCSRF system was a good starting place to design the next generation or project tracking system.

What information needs do we glean from Effectiveness Monitoring and Research to design project tracking?

Like all other types of monitoring, the data needs are specified by the questions being asked. The questions addressed in a specific monitoring design will usually be one-off custom questions with little generic or "template" character. However, there are three overarching classes of questions that have been identified:

1. Is a single restoration action effective?
2. Is a diverse set of restoration actions implemented within some spatial domain, such as a watershed or subbasin effective?
3. Is a given class of similar restoration projects effective?

In each case, the word *effective* is contextual and must be defined in a manner relevant to the project and the study. In one case it might refer to how a physical process is altering habitat character, while in another it could refer to responses seen in a population of salmon that are impacted by a change in some habitat character. The questions determine the information needed to answer them, and the information needs in turn define the data collection design. For example, to address question 2 above, we would need to know about all restoration projects in a particular basin and would also need to collect data on the net productivity of fish in that basin. We may also need to know the distribution of restoration projects and productivity in adjacent basins to provide contrast and thereby separate the impact of those restoration actions from some other large-scale driver of the system. This is the variety of question addressed in the IMW program and which determined the criteria described above.

Figure 2a illustrates this approach in the John Day Basin in Oregon. The John Day basin consists of 5 large sub-basins each with a diverse set of restoration projects based on data from PNSHPTD. We could define effectiveness in this case as the relative change in fish productivity by sub-basin as a consequence of different levels of habitat treatment. To describe the performance of these restoration actions we might place a series of smolt traps and adult counting weirs at each outflow point of the sub-basins. We could then compare the amount of treatment (restoration actions) and the population productivity for a rough measure of effectiveness.

On the other hand, if we were going to address question 3, or what PNAMP refers to as "project-scale" effectiveness monitoring, we might develop some criteria for identifying similar projects that could serve as replicates in an experimental design. For example, we could develop criteria for a study of riparian function improvement projects such as:

- Find all projects that are of a single type (e,g, riparian improvement)
- Find all projects that are on wade-able streams.
- Find all projects that are the only treatment in their stream.
- Find all projects that have adjacent streams with projects that could as reference sites.

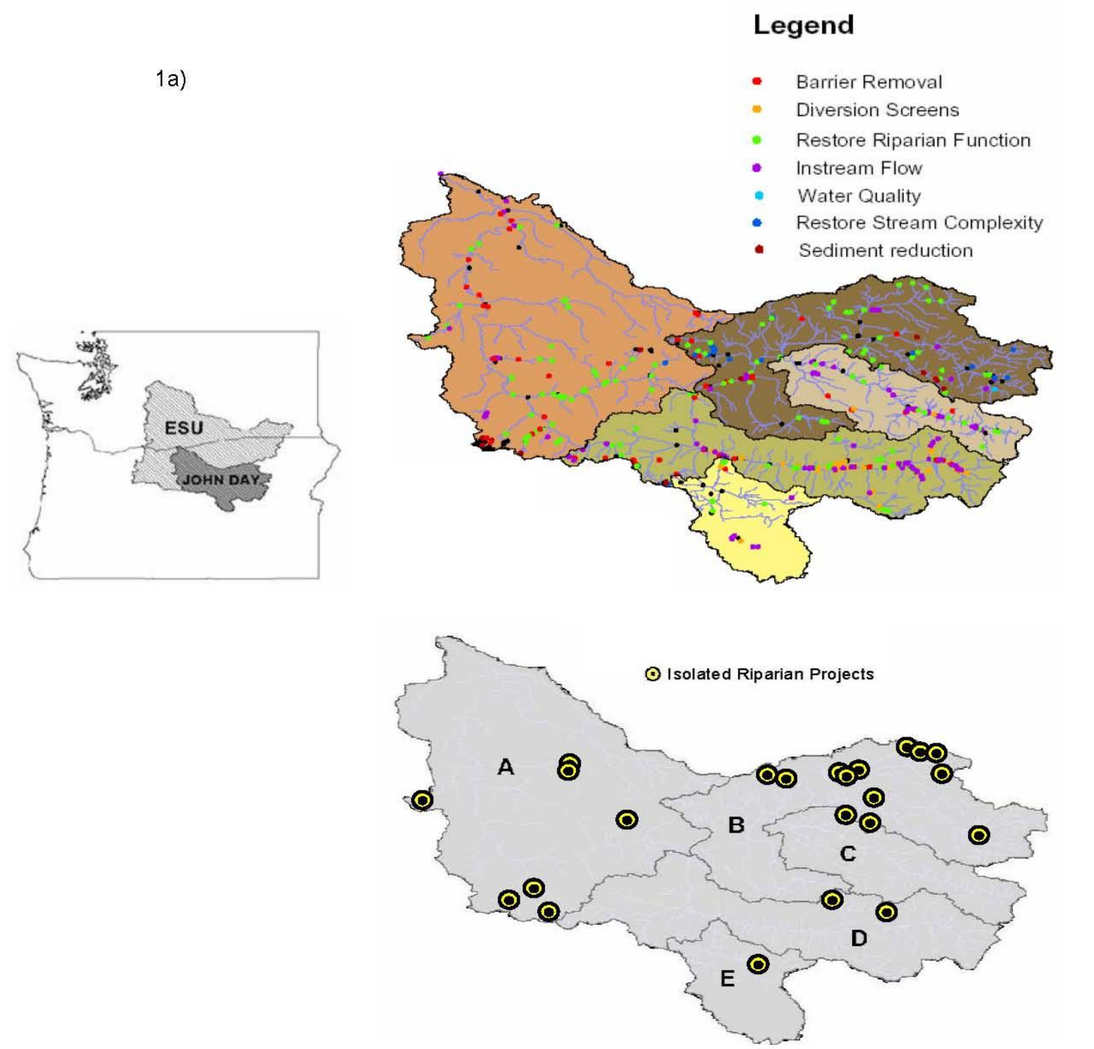


Figure 2: Conceptual design for project effectiveness monitoring Designs applied to the John Day Basin in Oregon, USA. Fig. 1a: Design for assessing the effectiveness of diverse actions in changing population responses within a reasonable demographic domain. Inventory of projects within five sub-basins are correlated with fish productivity measures for those sub-basins assessed at traps and weirs located at the outflow points of the sub-basins. Fig. 1b: Design for assessing the effectiveness of a single class of restoration action – in this case riparian improvement projects. Total project inventory was filtered to leave a subset of projects that are candidates for replicates based on location, project type, distribution of other projects in the same location and the presence of a reference area close by.

In Figure 2b this set of criteria has been applied to the data in the John Day basin from PNSHPTD. Approximately 30 riparian improvement projects have been identified that, if monitored over the right time period, could serve as replicates to estimate the characteristic performance of these types of projects. It is likely that some other aspect of these 30 would prevent all of them from serving as replicates, but these 30 would serve as a short list of candidates.

It is critically important to understand that regardless of which class of question one addresses, this design exercise defines the information needed for effectiveness monitoring. These information needs include ***everything in the current PCSRF Project Tracking system*** plus:

- ***Spatially explicit data on project location (i.e. the work-site), not the location of the project contract***. To identify the relevant habitat data to analyze these projects such as location of relevant reference sites based on stream gradient, vegetation cover type and so on, one needs to know exactly where the restoration project is in some kind of consistent coordinate system—like latitude and longitude in decimal degrees. The current system of documenting project location in PCSRF, as well as some other data holders in the region, does not specifically locate the implementation site in the stream. The Project tracking for M&E design proposes latitude and longitude as the standard referent for location because from this reported data, the entire spectrum of location referents (LLID, county, HUC, etc) can be generated automatically. These recommendations are parallel to the Best Practices for Reporting Location and Time Related data developed by the Northwest Environmental Data-network.

- ***Project level data on all implementations—not just PCSRF funded ones***
  Characterizing the net impact of diverse restoration actions (figure 2a) and clearly identifying replicates that are unimpacted by adjacent restoration actions (figure 2b), both require knowledge of all other restoration actions in the watershed. In the former case one needs to accurately characterize the net magnitude of the treatments, while in the latter, one needs to identify the presence of potentially confounding treatments. Therefore, both the design and analysis of effectiveness M&E require information about PCSRF projects as well as all the projects regardless of funding source.

- ***A measure of the magnitude of the action.***
  For each action tracked some measure of magnitude or "treatment" is necessary. Measures of the treatment magnitude are useful in three contexts.

  1) <u>To identify potential replicates for an effectiveness M&E study, the level of treatment is critical</u>. One would not compare the effect of a fencing project that excluded cattle from 1 km of stream length with a project that excluded cattle from 500 km of stream length.

  2) <u>Assessment of project performance</u> – Some M&E assessments will be comparisons of levels of treatment with levels of response. Although the actual statistical comparison may be more sophisticated, on a conceptual level the comparison is simple. It is illustrated in figure 3. If projects are to be deemed effective, one expects to see more recovery (eg # of fish) with more treatment (eg # of culverts). Therefore, some

measure of treatment extent needs to be incorporated into a project tracking system as a prerequisite to service M&E.

3) Prioritizing project placement – Planning and prioritizing restoration has often occurred at local levels. If M&E efforts are to inform the prioritization of new action implementation at any scale, then some measure of implemented treatments must be available to planners. More and larger-scale coordination on the placement of restoration actions is needed (where large-scale refers to the scale of the Columbia River Basin or salmon recovery domains.) It is unreasonable to expect coordinated results at spatial scales over which there is little coordination of planning or implementation.

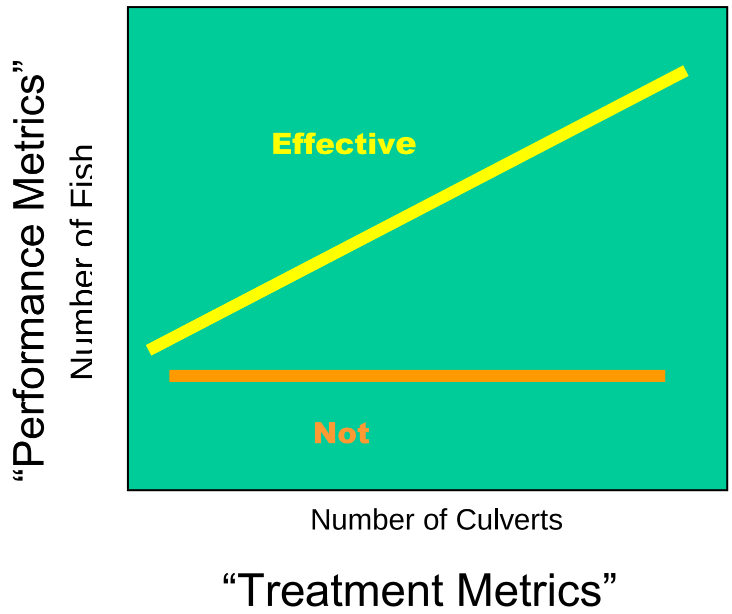


Figure 3: Conceptual application of project inventory to assessment of project effectiveness. Ultimately, assessments will amount to treatment to amount of response. Lack of significant response in the face of treatment will constitute “not-effective”. Given the lack of simple systems with single restoration project types, the actual statistical analysis will require more sophistication. Conceptually, however, the discrimination between “effective” and “not-effective” will amount to a similar comparison.

III Project Tracking Needs for M&E Design

In addition to PCSRF the additional information needs required for M&E are, spatial referents for implementation, referents for all implementations, and measures of treatment magnitude. We can now turn to a description of what Project Tracking for M&E would look like.

Project Tracking for M&E will utilize the three following tools:

1) ***A project taxonomy that maps the diverse sets of restoration actions onto factors that limit the recovery of listed fish***. This is accomplished through a two-level taxonomy. The higher level, termed project type, is a synthesis of the current PCSRF project tracking system which was based on a combination of project location and type of action, and PNSHPTD which was defined based on type of action. These two systems have been combined and the functional components of each have been preserved in a single list that is proposed for adoption. Each of these project types can be associated with a habitat

limiting factor. This allows the direct comparison of what has been done in watersheds to limiting factors that will require treatment.

Below the project type level are more detailed, sub-type designations. For example, fish passage is a major limiting factor in the Pacific Northwest, and there is a project type that addresses all fish passage types. Fish ladders, log weirs, dam breaches and culvert repair are all sub-types of the fish passage type, and, clearly, are not all equivalent. Clearly there is a wide diversity of restoration actions that address passage that would not make equivalent replicates for an effectiveness monitoring study.

The other project types contain similar diversity of project sub-type. The proposed project tracking taxonomy contains 84 project subtypes. The taxonomy is presented in total in Appendix A.

2) ***A data dictionary that describes the metrics, units of measure, needed data resolution and associated metadata.*** The data dictionary is the foundation reference document for the design of any data system. The data dictionary provides the definitions of each of the data elements: data element name, data element description, data element unit of measure, and data organization or taxonomy. Many different databases track projects with similar nomenclature, but among the lessons of PNSHPTD are that the same words mean very different things in different systems.

   The data dictionary is the tool that allows anyone to assess whether data from different sources can be combined, to, for example, increase the analytical capability of the aggregate data. In addition to defining all the terms, the data dictionary specifies the units of measure, the resolution and other metadata that is required to validate data compatibility. As will be mentioned below, there are reasons why many regional data holders may wish to continue with their own nomenclature, but if regional project tracking is to be useful for regional effectiveness monitoring activities, then one single foundation reference document must be available for all potential users. The proposed data dictionary is provided in Appendix B.

3) ***The conceptual design for the data base structure.*** The power of a relational database system is not simply containing the data; a flat-file spreadsheet could do that. Rather it is in the relationships that are built between the data elements. The relationships allow searchers to extract information from the data in a systematic and documentable fashion. The conceptual design maintains the relationship between project information, metrics, and the specific worksite(s) locations where the restoration actions occurred. A diagrammatic representation of the relationships between data elements is provided in Appendix C.

These three elements contain significant overlap in content. Their different conceptual content will serve different users. That there is overlap expresses the consistency in our proposed design.

IV Needs: Adoption of Consistent Metrics

Success in cooperative monitoring projects will depend on several key components, among them the use of standard data formats. In this case the ability to track restoration projects from multiple data holders will depend on the adoption of common project-level metrics, examples of which are provided in the Appendices.

Are these metrics reasonable, necessary and sufficient?

Appendix C provides a list of metrics collected for each project. Readers will appreciate that providing this information will result in increased effort or resources. Therefore, it is important to explain that the needed data is, essential, is reasonable and will be useful.

It must be emphasized again that we are describing the design of a system for project tracking that services implementation and effectiveness monitoring, ***but is not implementation or effectiveness monitoring itself.*** If we were defining metrics for effectiveness monitoring the needed level of data detail and diversity would be much higher and there would be no single generic list for all monitoring designs. The more detailed list of data needs for the actual monitoring is termed "Response Metrics" in figure 4 below.

This project tracking design does not specify the field protocols or sampling design that would be a part of a complete monitoring design. The specific features of these other tools will require parallel development.

For project tracking we need some measure of the magnitude of treatment, which may be as simple as the number of miles fenced in a riparian fencing project. These are termed "Implementation Metrics" in Figure 4. In many cases the Implementation Metrics will be a subset of, and so look like the Response Metrics. For example, if we are examining a restoration action that specifically altered stream flow by a specified amount, then the Implementation and Response Metrics would both include a measure of stream flow.

The list of implementation metrics that characterize treatment extent in Appendix B & C are at most, one to three in number for each project implementation. Not all metrics will be reported for every project.

The two questions that arise are: Are these project tracking metrics appropriate and are they sufficient?

To guarantee completeness in project tracking one would collect data on a very wide list of project attributes. If resources were unlimited, having this level of information for all restoration projects would provide the highest expectation for successful monitoring programs. Unfortunately, this is likely to be expensive. Even if one did monitor a long list of project attributes, it is not clear that one would use all of those metrics in the design of monitoring or the analysis of project implementation. Therefore a reasoned solution is necessary – one that balances the resources it would take to collect more detailed data against the minimum amount of information that is necessary for implementation monitoring – to track and to adequately

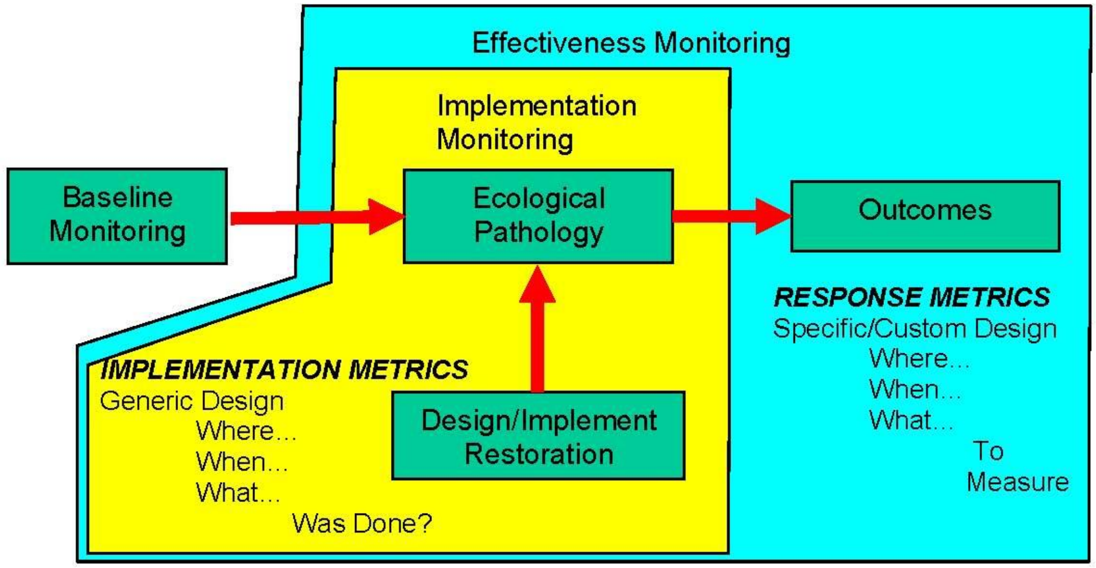


Figure 4. Rational Design Scheme for implementation of restoration. In a rational world, baseline monitoring would be ongoing and in specific cases would identify environmental or ecological pathologies. In response to these pathologies the design and implementation of restoration would be triggered. These implementations would be monitored with some form of project tracking, implementation monitoring, which would measure a thin set of "Implementation Metrics" at each and every restoration action. Environmental outcomes would be documented with a more in depth effectiveness monitoring program that would include "Response Metrics". For many reasons, the more detailed analytical design and longer list of metrics in effectiveness monitoring would likely be performed at only a subset of all restoration actions. The choice of which ones and when would be critically dependant on a complete set of Implementation Metrics.

design effectiveness monitoring. The list in Appendix C has been evaluated and reviewed by restoration professionals (NRRSS) and represents such a compromise.

There is no pre-existing consensus on a list of needed implementation metrics across the region. However, the list in Appendix C is informed by what metrics are currently being collected, from the PNSHPTD project survey. PNSHPTD also cataloged what diverse data holders are recording as metrics in a wide array of monitoring programs. Appendix C is also informed by the current PCSRF system. PCSRF included numerous workshops and meetings among the PCSRF partners to develop a minimum set of project tracking metrics. Although some of the objectives of PCSRF differ from this project tracking design, the utility of the metrics remains. In many cases ongoing use of exiting metrics or new metrics are logical measures of treatment magnitude and the utility is apparent on inspection. Examples include: Number of miles fenced for fencing projects, Number of acres planted for planting projects, Miles of roads decommissioned on road decommissioning projects, and so on.
The scope of needed data collection is substantial To estimate feasibility, there are no similar models linking project tracking to effectiveness monitoring to which this design can be compared. Heretofore, effectiveness monitoring has only occurred on the reach or single implementation scale, rather than entire sub-basins or large-scale applications of specific project types. Therefore, an important component of the development of this project tracking design is

an explicit, functional link to an effectiveness monitoring component. The Northwest Fisheries Science Center is developing a model mechanism to evaluate the utility and completeness of all aspects of the project tracking design, including metrics, along with some mechanism for adjusting the program as we incorporate new knowledge and testing.

Among the activities in progress to provide this test of functionality are coordination of this data system design with PNAMP and US Bureau of Reclamation Protocol Manager application, the Integrated Status and Effectiveness Monitoring Project (ISEMP), integration into the adaptive management plan used by NOAA-Fisheries as part of its delisting process and framework, and the Northwest Environmental Data Network (NED).

V Needs: Contributions of Data

By identifying the generic needs of effectiveness monitoring in relation to existing data this data system design can be of most use to interested parties across the region. A consequence of addressing these generic needs is the realization that populating the system with data from all sources is critical. In return, the data system may serve as an efficient regional resource for planning, tracking and assessing habitat improvements, and demonstrating the importance of collaborative efforts

The demands for data and/or service that Project Tracking for M&E places on the state and tribal partners will vary based on what the partners are already doing. For the PCSRF partners, there will be no additional requirement beyond those currently being planned for PCSRF Phase II. In some cases state, federal and tribal partners would need to populate the project tracking data system with new data, or in some cases the same data but in a more standardized format. In this event partners will continue to host their own data and service their diverse project tracking needs with their own data intact. On the other hand, other contributors of data may seek some degree of hosting from a central project tracking data system.

Whatever the users' needs, the purpose of a regional project tracking system is to create a comprehensive set of data about restoration actions, where the data are collected and maintained in a single database, in a single format, with integrity and with verifiable data quality.

Overall, the expectation is that these new requirements represent a reasoned balance between what is the minimum requirement of a project tracking system to service effectiveness monitoring, what is optimal for that purpose, and what is a reasonable burden on data contributors.
One of the additional lessons of PNSHPTD was that while some individual data holders are up to date, the region as a whole experiences approximately an 18-24 month lag between project implementation and project tracking data being available in any format. Reconciling diverse project-level data to a single format adds an additional 18-24 months before the data can be provided back to the region. If the definitions provided here can provide a useful regional standard and some degree of hosting for project tracking data, it will reduce these two significant impediments to timely project tracking.

All of these points are given additional urgency with the recognition that the region is at a critical crossroads with respect to salmonid recovery. At the very time that the next phase of PCSRF is being designed, regional salmon recovery plans are also being developed and a new Biop is being prepared by NOAA Fisheries. Many management and recovery plans are also being written by diverse local, municipal, tribal and other sub-basin planning groups. These groups are working hard to complete their plans within a short time horizon, but with little explicit guidance on M&E – particularly the monitoring of restoration actions.

This guidance for project tracking will service this important regional need and help to support the need to move to effectiveness monitoring. Failure to capitalize on the common implementation monitoring needs of PCSRF partners and other regional recovery planners when a useful model is in hand would be a regrettable missed opportunity.

Appendix A

Type	Subtype
Fish Screening	Fish Screen Fish Screen Replaced
Fish Passage	Fish Ladder Improved Fish Ladder Installed Fishways (ladders, chutes, or pools) Barriers (dam sor log jams) Diversion Dam/ push up dam removal Road Crossings (bridges or culverts) Culvert Improvements/ upgrades Culvert Installation Culvert Replacement Culvert Removal Weirs (log or rock)
Instream Flow	Water leased or purchased Irrigation practice improvement Water flow returned to stream
Instream	Streambank Stabilization Channel Connectivity Channel reconfiguration (includes channel roughening) Deflectors/ barbs Log (control) weirs Off channel habitat Plant removal/ control Rock (control) weir Signage Site Maintenance Spawning Gravel Placement Large Woody Debris Stream Channels Boulders Rootwads Structure/ Log Jam Beaver Introduction
Instream Wetland	Wetland Creation Wetland Improvement/ Enhancement Wetland Restoration Wetland Vegetation Planting Wetland Invasive Species Removal
Riparian	Livestock Water Development Water Gap Development Fencing Forestry Practices/ Stand Management Planting Livestock Exclusion Conservation Grazing Management Weed Control
Sediment Reduction	Road Reconstruction Road Relocation Road Stream Crossing Improvements (=Rocked Ford) Road Drainage System Improvements Road Obilteration Erosion Control Structures Sediment Traps Upland Erosion Control (sediment conrol basins, windbreaks, planting, conservation land management)

UplandAgriculture	Livestock Management Agriculture Management (BMPs) Fencing Water Development
Upland Vegetation	Planting Invasive Plant Control Vegetation/ Stand Management Slope Stabilization
Upland Wetland	Wetland Creation Wetland Improvement/ Enhancement Wetland Restoration Wetland Vegetation Planting Wetland Invasive Species Removal
Water Quality Improvement	Return Flow Cooling Refuse Removal Toxic Cleanup
Outmigrant Survival Improvement (Estuary)	Invasive Species Treated Creation of new estuarine area Removal of existing fill material Channel Modification Increased Freshwater Flow Dike Breaching/ Removal Tidegate Alteration/ Removal Dike Reconfiguration
Land Protected, Acquired, or Leased	Streambank Protected Wetland or Estuarine are Protected
Nutrient Enrichment	Fertilizer Carcass Analog Carcass Placement

Appendix B Part I. General information fields for all projects

Basic Project Information

Column Name	Definition	Format/ Mandatory?
Project Grantee	This the official PCSRF Grantee (State or Tribal group)	Lookup Value, Y
PCSRF Objective	The PCSRF Objective under which the project is conducted: Watershed and Su b- basin Planning and Assessment; Salmon Habitat Protection and Restoration; S almon Enhancement; Salmon Research, Monitoring, and Evaluation; or Public Outreach and Education.	Lookup Value, Y
Project Reference	This is the identification number given to the project by the Grantee	Varchar Text (20 Char), Y
Project Name	The name of the project given by the Grantee	Varchar Text (100 Char), Y
Primary Subgrantee	The Tribe or State Agency that will assign the project work to be completed (i.e. NWIFC member tribe, CRITFC member tribe, KRITFWC member tribe, OR sta te agencies, WA state agencies)	Lookup Value
Selection Date	Date funding was committed to the subgrantee through state/tribal decision-making process.	Date (mm/dd/yyyy)
Start Date	The date that the project lead/subgrantee proposes to start the project.	Date (mm/dd/yyyy)
Deliverable Date	The date that the project worksite deliverables are completed. The project deliv erable date can be entered when deliverables are due beyond the project end date (in A7 above).	Date (mm/dd/yyyy)
Scheduled End Date and Actual E	nd DateThe date that the project's lead/subgrantee contract is scheduled and is actually completed	Date (mm/dd/yyyy)
Fund Year	The Federal fiscal year in which the PCSRF funding was awarded to the state/t ribe.	Year (yyyy), Y
PCSRF Funds (Proposed and Actual)	The amount of PCSRF Federal funds being expended on this project in dollars.	Number (13 Char.), Y
State Funds (Proposed and Actual)	Amount of State funds being expended on this project in dollars.	Number (13 Char.)
Project Description	Short description of the project. The fish stock(s) and or ESUs targeted by the p roject should be identified as a part of this description.	Varchar Text (4000 Char.)
Project Benefits	Short description of the expected benefits to fish, for example to improve the ra nge, the breeding or the spawning of a Salmonid population.	Varchar Text (4000 Char.)
Geographic Area Name	On land the Geographic Area Name is defined as the name of the 5th field Hyd rologic Unit (HUC).	Varchar Text (200 Char.)
Project Status	Grantees may use the project status as they see fit. For the Reports on the web site and the Report to Congress, projects are classified as Complete if the Actu al End Date (or the Scheduled End Date if there is no Actual) is in the past.	Lookup Value
Progress Reports	Grantees and Primary Subgrantees can submit multiple progress reports coveri ng any time period.	Varchar Text (4000 Char.)
Project Lead(s)/Subgrantee(s)	The name of the entity receiving funds to do the actual project work.	Lookup List
Project Contact(s)	Contact person/people for the project.	Lookup List

Worksite Information

Column Name	Definition	Format/ Mandatory?
Work Start Date	The date that work was started at the current worksite.	Date (mm/dd/yyyy)

Work End Date	The date that work ended at the current worksite.	Date (mm/dd/yyyy)
State	State that worksite is located in.	Lookup Value
County	County that worksite is located in.	Lookup Value
Latitude	The Latitude coordinate value for the worksite. Value should be reported as a positive number from 0 to 90 degrees with up to 8 decimal places.	Number (0-180 Degrees and up to 8 Decimal Places)
Longitude	The Longitude coordinate value for the worksite. Value should be reported as a negative number from 0 to 180 degrees with up to 8 decimal places.	Number (0-180 Degrees and up to 8 Decimal Places)
Streamname	The name of the stream where the worksite is located. This name should be taken from the stream data layer provided by StreamNet, so that this name is consistent.	Varchar Text (60 Char.)
LLID	The LLID of the stream where the worksite is located. An LLID is a stream number method used only in the Northwest region that is based on Latitude/Longitude coordinates of the stream confluences.	Number (25 Char.)
Begin Ft.	This marks where on a stream network a worksite begins. Begin Ft is a distance measure on a stream network from the confluence.	Number
End Ft.	This marks where on a stream network a worksite ends. End Ft is a distance measure on a stream network from the confluence.	Number
Township	A public land surveying unit of 36 sections or 36 square miles. This displays the Township where the worksite is located.	Varchar Text (20 Char.)
Range	A north-south strip of townships, each six miles square, numbered east and west from a specified meridian in a U.S. public land survey. This displays the Range within a Township that the worksite is located in.	Varchar Text (20 Char.)
Section	A land unit equal to one square mile (2.59 square kilometers), 640 acres, or 1/36 of a Township. This displays the Section that the worksite is located in.	Varchar Text (20 Char.)
3rd Field HUC	H.U.C. is an acronym for Hydrologic Unit Codes. Hydrologic unit codes are a way of identifying all of the drainage basins in the United States in a nested arrangment from largest (Regions) to smallest (Cataloging Units).	Lookup Value
4th Field HUC	H.U.C. is an acronym for Hydrologic Unit Codes. Hydrologic unit codes are a way of identifying all of the drainage basins in the United States in a nested arrangment from largest (Regions) to smallest (Cataloging Units).	Number (25 Char.)
5th Field HUC	H.U.C. is an acronym for Hydrologic Unit Codes. Hydrologic unit codes are a way of identifying all of the drainage basins in the United States in a nested arrangment from largest (Regions) to smallest (Cataloging Units).	Number (25 Char.)
Targeted ESU (Evolutionary Significant Unit)		Lookup Value, Y

Appendix B

Part I. General information fields for all projects

Description	Definition	format (units) for proposed actions and field length	format (units) for completed actions
Project identification number	This is the number given to the project by the State or Tribe	text field	not applicable
Project Grantee	This the official PCSRF Grantee (State or Tribal group)	Lookup Value	
Primary Subgrantee	The Tribe or State Agency that will assign the project work to be completed (i.e. NWIFC member tribe, CRITFC member tribe, KRITFWC member tribe, OR state agencies, WA state agencies)	Lookup Value	
Project name	This is the name given to the project by the State or Tribe	text field	not applicable
Geographic area name	On land the Geographic Area Name is defined as the name of the 5th field Hydrologic Unit (HUC). For ocean/estuarine areas not covered by 5th field HUC's the Geographic Area is the name of the water body as shown on NOAA charts or the name of the statistical area. The NWFSC will provide web access to a set of NOAA nautical charts.	text field	not applicable
Geospatial reference/location	This is locational data for each treatment site where the project work is done. Report as a point, line or polygon for all treatment locations. Latitude and longitude from GPS is preferred.	Point, line or polygon. Latitude/ longitude from GPS is preferred. Beginning and end points of stream segment can also be provided if available.	Point, line or polygon. Latitude/ longitude from GPS is preferred. Beginning and end points of stream segment can also be provided if available.
Project Lead/Subgrantee name	The name of the entity receiving funds to do the actual project work.	text field	not applicable
Project start date	The date that the project lead/subgrantee proposes to start the project.	mm/dd/yyyy	not applicable
Project end date	The date that the project's lead/subgrantee contract is completed	mm/dd/yyyy	mm/dd/yyyy
Project deliverable date	The date that the project worksite deliverables are completed. The project deliverable date can be entered when deliverables are due beyond the project end date (in A7 above).	not applicable	mm/dd/yyyy
PCSRF Objective	The PCSRF Objective under which the project is conducted: Watershed and Sub-basin Planning and Assessment; Salmon Habitat Protection and Restoration; Salmon Enhancement; Salmon Research, Monitoring, and Evaluation; or Public Outreach and Education. Choose one objective for each project.	pull down list	not applicable
PCSRF Federal funds	The amount of PCSRF Federal funds being expended on this project in dollars.	# ($)	not applicable
State funding	Amount of State funds being expended on this project in dollars.	# ($)	not applicable

Federal Fiscal Year	The Federal fiscal year in which the PCSRF fundin g was awarded to the state/tribe.	yyyy	not applicable
Date of project selection	Date funding was committed to the subgrantee thr ough state/tribal decisionmaking process.	mm/dd/yyyy	not applicable
Project description	Short description of the project. The fish stock(s) a nd or ESUs targeted by the project should be ident ified as a part of this description.	narrative, limited to 1000 char. Addi tional documentation can be attach ed (e.g. project plans).	narrative, limited to 1000 char. Additional documentation can be attached (e.g. project plans).
Expected benefits of the proj ect	Short description of the expected benefits to fish, f or example to improve the range, the breeding or t he spawning of a Salmonid population.	narrative, limited to 1000 char.	not applicable
Project Status	Grantees may use the project status as they see fi t. For the Reports on the web site and the Report t o Congress, projects are classified as Complete if the Actual End Date (or the Scheduled End Date if there is no Actual) is in the past. All other project	Lookup Value	
Progress Reports	Grantees and Primary Subgrantees can submit m ultiple progress reports covering any time period.	Varchar Text (4000 Char.)	
Project Contact(s)	Contact person/people for the project.	Lookup List	
Habitat Restoration & Protect ion $	Dollars Spent on Habitat Restoration & Protection.	Number (13 Char.)	
Instream Funds $	Dollars Spent on Instream Activities for a Habitat Restoration & Protection project.	Number (13 Char.)	
Fish Screening $	Dollars Spent on Fish Screening Activities for an I nstream project.	Number (13 Char.)	
Fish Passage Improvement $	Dollars Spent on Fish Passage Improvement for a n Instream project.	Number (13 Char.)	
Instream Flow $	Dollars Spent on Instream Flow activities for an In stream project.	Number (13 Char.)	
Instream Habitat $	Dollars Spent on Instream Habitat activities for an Instream project.	Number (13 Char.)	

Upland Habitat $	Dollars Spent on Upland Habitat activities for a Ha bitat Restoration & Protection project.	Number (13 Char.)	
Water Quality $	Dollars Spent on Water Quality activities for a Habi tat Restoration & Protection project.	Number (13 Char.)	
Riparian Habitat $	Dollars Spent on Riparian Habitat activities for a H abitat Restoration & Protection project.	Number (13 Char.)	
Estuarine $	Dollars Spent on Estuarine activities for a Habitat Restoration & Protection project.	Number (13 Char.)	
Land Acquisition $	Dollars Spent on Land Acquisition activities for a H abitat Restoration & Protection project.	Number (13 Char.)	
Wetland $	Dollars Spent on Wetland activities for a Habitat R estoration & Protection project.	Number (13 Char.)	
Subbasin Planning $	Dollars Spent on Watershed Subbasin Planning & Assessment.	Number (13 Char.)	
Research Monitoring $	Dollars Spent on Research Monitoring & Evaluatio n	.Number (13 Char.)	
Work Start Date	The date that work was started at the current work site.	Date (mm/dd/yyyy)	
Work End Date	The date that work ended at the current worksite.	Date (mm/dd/yyyy)	
State	State that worksite is located in.	Lookup Value	
County	County that worksite is located in.	Lookup Value	
Latitude	The Latitude coordinate value for the worksite. Val ue should be reported as a positive number from 0 to 90 degrees with up to 8 decimal places.	Number (0- 180 Degrees and up to 8 Decimal Places)	

Longitude	The Longitude coordinate value for the worksite.V alue should be reported as a negative number fro m 0 to 180 degrees with up to 8 decimal places.	Number (0- 180 Degrees and up to 8 Decimal Places)	
Streamname	The name of the stream where the worksite is loca ted. This name should be taken from the stream d ata layer provided by StreamNet, so that this nam e is consistent.	Varchar Text (60 Char.)	
LLID	The LLID of the stream where the worksite is locat ed. An LLID is a stream number method used only in the Northwest region that is based on Latitude/ Longitude coordinates of the stream confluences. This number should be taken from the standardize d data l	Number (25 Char.)	
Begin Ft.	This marks where on a stream network a worksite begins. Begin Ft is a distance measure on a strea m network from the confluence.	Number	
End Ft.	This marks where on a stream network a worksite ends. End Ft is a distance measure on a stream network from the confluence.	Number	
Township	A public land surveying unit of 36 sections or 36 s quare miles. This displays the Township where the worksite is located.	Varchar Text (20 Char.)	
Range	A north-south strip of townships, each six miles square, nu mbered east and west from a specified meridian in a U.S. public land survey. This displays the Rang e within a Township that the worksite is located in.	Varchar Text (20 Char.)	
Section	A land unit equal to one square mile (2.59 square kilometers), 640 acres, or 1/36 of a Township. This displays the Section that the worksite is located in .	Varchar Text (20 Char.)	
3rd Field HUC	H.U.C. is an acronym for Hydrologic Unit Codes. H ydrologic unit codes are a way of identifying all of t he drainage basins in the United States in a neste d arrangment from largest (Regions) to smallest (Cataloging Units). A drainage basin is an area or r eg	Lookup Value	
4th Field HUC	H.U.C. is an acronym for Hydrologic Unit Codes. H ydrologic unit codes are a way of identifying all of t he drainage basins in the United States in a neste d arrangment from largest (Regions) to smallest (Cataloging Units). A drainage basin is an area or r eg	Number (25 Char.)	
5th Field HUC	H.U.C. is an acronym for Hydrologic Unit Codes. H ydrologic unit codes are a way of identifying all of t he drainage basins in the United States in a neste d arrangment from largest (Regions) to smallest (Cataloging Units). A drainage basin is an area or r eg	Number (25 Char.)	

Targeted ESU (Evolutionary		Lookup Value	
Reporting for projects that assess current or baseline habitat condition/s and or prioritize factors limiting native salmonid production such as amount of freshwater flow and address measures n eeded to eliminate limiting factors. Types of reports include recovery plans, water shed plans, subbasin plans and habitat inventory reports, and Tribal Resource Management Plans. Projects c an include recovery planning and participation in NMFS Technical Recovery Teams, watershed assessments, including mapping/inventory for plans, subbasin planning, development of habitat inventory reports, support for watershed councils and organizational infrastructure and staffing for local conservation groups and tribal entities.			
Support local watershed grou p?	Does the project fund operations of watershed councils, or provide technical assistance to wat ershed councils?	Y/N	not applicable
Support tribal or agency infra structure?	Does the project provide staff support and/or inf rastructure costs directly related to assessment s or recovery planning?	Y/N	not applicable
Plan/assessment in develop ment?	Does this project support development of a plan or assessment? If so, record the name of the pl an/assessment.	Y/N or name of plan/assessment	not applicable
Plan/assessment completed?	Has the plan or assessment funded with PCSR F been completed? This will show how many pl ans were completed each year.	not applicable	Y/N or Citation: Author, date, name, source, source address. En dnote citation format.
Identify/prioritize factors limiti ng production?	Does the plan/assessment identify/prioritize spe cific factors limiting the production of population s and ESUs or conservation opportunities at the watershed scale?	Y/N	Y/N
Biological goals?	Does the plan/assessment incorporate biologic al goals consistent with State or Tribal conserva tion plans or Technical Recovery Team recom mendations?	Y/N	Y/N
Identify necessary actions?	Does the plan/assessment identify actions need ed to meet goals?	Y/N	Y/N

Part II. Project specific information fields

Type	Type Definition	Subtype	Subtype Definition	Metric	Metric Definition
Fish Screening	Projects that result in the installation or improvement of screening systems that prevent Salmonids from passing into areas that do not support salmonid survival, for example into irrigation diversion channels.	Fish Screen Installed	Adding screen to an unscreened diversion to keep juveniles from being diverted.	#, cfs	A total count of screens proposed for installation and actually installed, recognizing that a project may install more than one screen, The flow rate at the screened diversion(s) from the water right. (CFS to nearest 0.01 CFS)
		Fish Screen Replaced	Replacement, repair or improvement of an existing fish screen	#, cfs	A total count of screens proposed for installation and actually installed, recognizing that a project may install more than one screen, The flow rate at the screened diversion(s) from the water right. (CFS to nearest 0.01 CFS)
Fish Passage	Projects that affect or provide fish migration up and down stream including road crossings (bridges or culverts), barriers (dams or log jams), fishways (ladders, chutes or pools), and weirs (log or rock). Barriers may be complete or partial.	Fish Ladder Improved	Improvement or upgrade of an existing fish ladder	#, target species	There may be more than one fish passage installation per project. Report a count of all blockages that are proposed for removal or improvement and those that are actually removed or improved as part of this project. Latin name of target species.
		Fish Ladder Installed	Installation of a fish ladder where there was not one previously	#, target species	There may be more than one fish passage installation per project. Report a count of all blockages that are proposed for removal or improvement and those that are actually removed or improved as part of this project. Latin name of target species.
		Fishways (chutes or pools) Installed	Placement of an engineered way around a barrier (usually a side channel/ or pool) or any bypass that isn't specified as a fish ladder that is used by salmon migrating upstream; or a chute, used to ease salmon migrating downstream over a dam.	#, target species	There may be more than one fish passage installation per project. Report a count of all blockages that are proposed for removal or improvement and those that are actually removed or improved as part of this project. Latin name of target species.
		Barriers (dams or log jams)	Removal of a dam other than a push-up or diversion dam; or removal of a naturally formed log or debris jam that created a passage barrier	#	There may be more than one fish passage installation per project. Report a count of all blockages that are proposed for removal or improvement and those that are actually removed or improved as part of this project. Latin name of target species.
		Diversion Dam/ push up dam removal	Removal of a push-up dam (earthen dam), or removal of a diversion dam (permanent structure)	#	There may be more than one fish passage installation per project. Report a count of all blockages that are proposed for removal or improvement and those that are actually removed or improved as part of this project. Latin name of target species.
		Road Crossings in stream beds (other than culverts)	Establishment of engineered passage associated with road placement that may include placement of a bridge.	#	There may be more than one fish passage installation per project. Report a count of all blockages that are proposed for removal or improvement and those that are actually removed or improved as part of this project. Latin name of target species.
		Culvert Improvements or Upgrades	Improve, upgrade or replace an existing culvert	#	There may be more than one fish passage installation per project. Report a count of all blockages that are proposed for removal or improvement and those that are actually removed or improved as part of this project. Latin name of target species.
		Culvert Installation	Add a passable culvert where none previously existed.	#	There may be more than one fish passage installation per project. Report a count of all blockages that are proposed for removal or improvement and those that are actually removed or improved as part of this project. Latin name of target species.
		Culvert Removal	Removal of culvert (often replaced by a non-blocking structure, bridge etc. or removed because the structure it was associated with was removed, a road etc.)	#	There may be more than one fish passage installation per project. Report a count of all blockages that are proposed for removal or improvement and those that are actually removed or improved as part of this project. Latin name of target species.
		Weirs (Incomplete dams)	Placement, modification or removal of a incomplete dam that is a passage barrier to fish	#	There may be more than one fish passage installation per project. Report a count of all blockages that are proposed for removal or improvement and those that are actually removed or improved as part of this project. Latin name of target species.

Instream Flow	Projects that maintain and/or increase the flow of water to provide needed habitat conditions. These can include releases of water from dams or impoundments or water conservation projects to reduce stream diversions or extractions.	Water leased or purchased	Purchase of water rights. These water allocations are not withdrawn from the stream.	cfs	Water volume proposed for lease or purchase and actually leased or purchased should be reported in CFS to nearest 0.01 CFS.
		Irrigation practice improvement	Installation of a headgate with water gauge that controls water flow into irrigation canals and ditches. Regulates flow on previously unregulated diversions. Also the addition of other water sources (wells etc.) so that water from diversion is lessneeded or improvement in irrigation systems eg. replacing open canals with pipes to reduce water loss to evaporation.	cfs	The flow of water returned to the stream (not including water that is maintained in the stream). (CFS to nearest 0.01 CFS)
Instream	Projects that increase or improve the physical conditions within the stream environment (below the ordinary high water mark of the stream) to support an increased salmonid population	Streambank Stabilization	The use of rock barbs, log barbs, revetments, gabions etc. to stabilize stream banks	length treated in miles	The number of miles of of treatment. Add length treated on both sides when both sides are stabilized. Add one side when one side is treated. (miles to .01 miles)
		Channel Connectivity	Increasing channel connectivity between stream channels, wetlands, and/ or off-channel habitat and floodplain channels. May include increase of historic or new connectivity.	Length treated in miles	This refers to meander miles of instream habitat treatments. Count actual stream length treated to nearest 0.01 miles.
		Channel reconfiguration	Changes in channel morphology, e.g. pools added/ created, meanders added, former channel bed restored, channel roughening etc.	Length treated in miles	This refers to meander miles of instream habitat treatments. Count actual stream length treated to nearest 0.01 miles.
		Deflectors/ barbs	Placement of triangular structures of rock or logs that extend into the stream to narrow and deepen the channel	Length treated in miles	This refers to meander miles of instream habitat treatments. Count actual stream length treated to nearest 0.01 miles.
		Log weirs	Placement of logs to collect and retain gravel for spawning habitat, to deepen existing resting/jumping pools, to create new pools above and/or below the structure, to trap sediment, aerate the water, or promote deposition of organic debris.	Length treated in miles	This refers to meander miles of instream habitat treatments. Count actual stream length treated to nearest 0.01 miles.
		Off channel habitat	Creation of off-channel habitat consisting of side-channels, backwater areas, alcoves or side-pools, off-channel pools, offchannel ponds, and oxbows.	Length treated in miles	This refers to meander miles of instream habitat treatments. Count actual stream length treated to nearest 0.01 miles.
		Plant Removal/ Control	The removal or control of aquatic non-native plants and noxious weeds growing in the stream channel.	Length treated in miles	This refers to meander miles of instream habitat treatments. Count actual stream length treated to nearest 0.01 miles.
		Rock Weirs	The placement of rocks to collect and retain gravel for spawning habitat, to deepen existing resting/jumping pools;and/or to create new pools, to trap sediment, aerate the water, and to promote deposition of organic debris.	Length treated in miles	This refers to meander miles of instream habitat treatments. Count actual stream length treated to nearest 0.01 miles.
		Spawning Gravel Placement	Addition of spawning gravel to the channel	Length treated in miles	This refers to meander miles of instream habitat treatments. Count actual stream length treated to nearest 0.01 miles.
		Large Woody Debris	Placement of individual logs in the stream that are not part of engineered structures or log jams or other large woody debris not specified as rootwads	Length treated in miles	This refers to meander miles of instream habitat treatments. Count actual stream length treated to nearest 0.01 miles.
		Boulders	Addition of large rocks or boulders to a stream channel	Length treated in miles	This refers to meander miles of instream habitat treatments. Count actual stream length treated to nearest 0.01 miles.
		Rootwads	Placement of a stump with roots attached extending into the stream. Rootwads are a type of large woody debris.	Length treated in miles	This refers to meander miles of instream habitat treatments. Count actual stream length treated to nearest 0.01 miles.
		Wood Structure/ Log Jam	Placement of Wood Structure/Log Jam with multiple logs fastened together to form increasing instream habitat	Length treated in miles	This refers to meander miles of instream habitat treatments. Count actual stream length treated to nearest 0.01 miles.
		Beaver Introduction	The introduction or management of beavers to add natural stream complexity (beaver dams, ponds, etc).	# of beavers introduced	# of beavers introduced to increase instream structure/ complexity

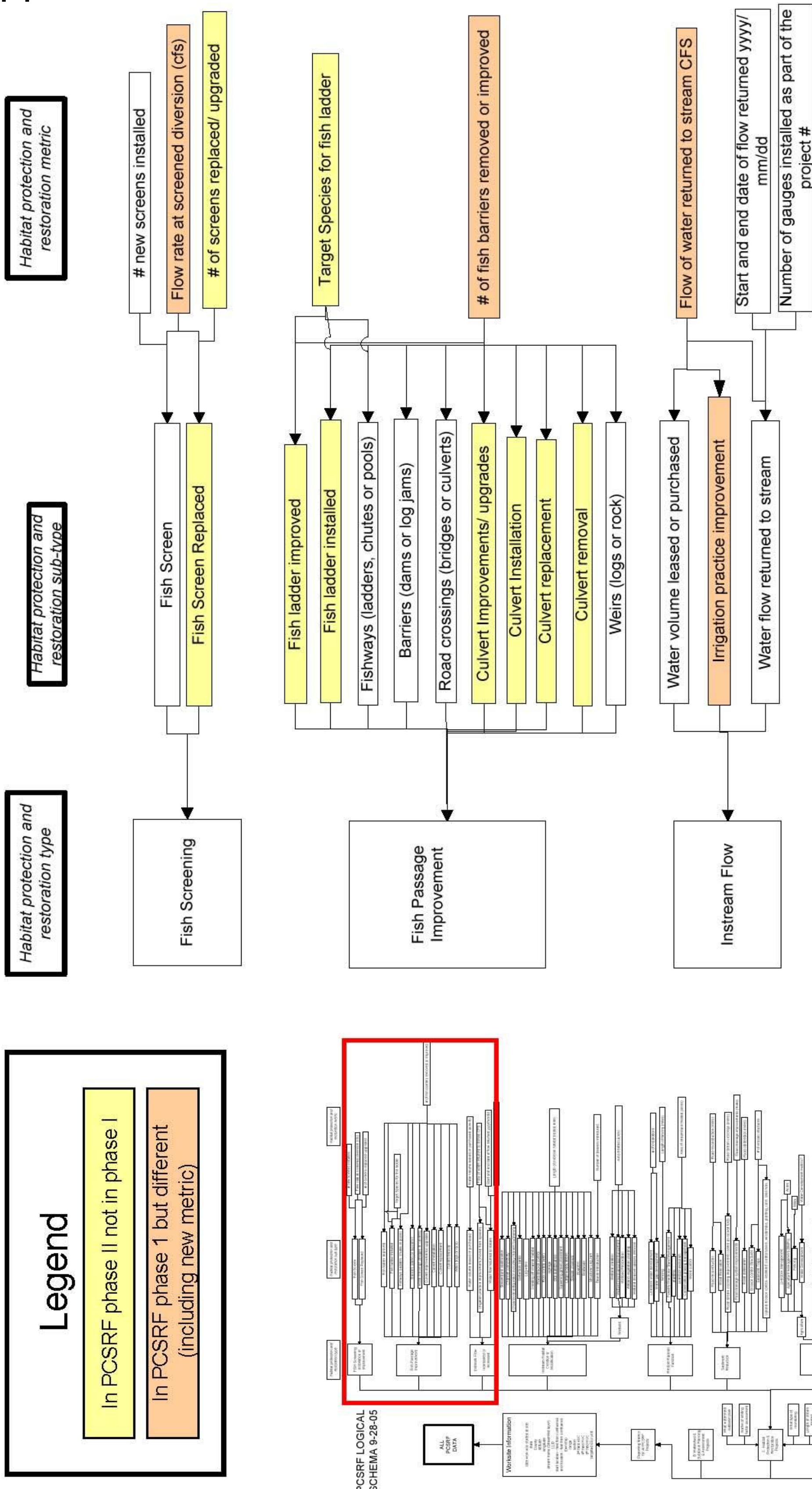
Instream- Wetland	Projects designed to protect, create or improve connected wetland areas (that meet the standard for federal delineation) that are known to support salmonid production. For example salmonid populations, especially juveniles, can benefit from access to connected wetland areas where conditions provide food supply, protection from high flows and protection from predators.	Wetland Creation	Creation of wetland area where it did not previously exist	area treated (acres)	Acres of artificial wetland proposed to be created and actually created from an area not formerly a wetland. (Acres to nearest whole acre)
		Wetland Improvement/ Enhancement	Improvements or enhancements to an existing wetland	area treated (acres)	Acres of wetland proposed for treatment and actually treated. (Acres to nearest whole acre)
		Wetland Restoration	Restoration of existing or historic wetland	area treated (acres)	Acres of wetland proposed for treatment and actually treated. (Acres to nearest whole acre)
		Wetland Vegetation Planting	Planting of native wetland species in wetland areas.	area treated (acres)	Acres of wetland proposed for treatment and actually treated. (Acres to nearest whole acre)
		Wetland Invasive/Noxious Weed Species Removal	Remove or control Non-native species and/or noxious weeds in a wetland area	area treated (acres)	The acreage of invasive species proposed for treatment and actually treated in the wetland project. The proposed project area may only be a portion of an existing wetland such as removing an area of purple loosestrife. (Acres)
Riparian	Projects that change areas (above the ordinary high water mark of the stream and within the flood plain of streams) in order to improve the environmental conditions necessary to sustain Salmonids throughout their life cycle.	Livestock Water Development	Provision of water supply for livestock that is out of the riparian zone. Also called livestock water development or livestock water supply.	# of installations	# of installations, may be more than 1 per project
		Water Gap Development	Provision of a fenced livestock stream crossing	# of installations	# of installations, may be more than 1 per project
		Fencing	Creation of livestock exclusion or other riparian fencing	length of fencing	This refers to meander miles of stream bank proposed for treatment and treated. Report the actual length of proposed treatment, adding lengths of treatment on both sides if treatment was on both sides. (miles to .01 miles)
		Forestry Practices/ Stand Management	Prescribed burnings, stand thinnings, stand conversions, silviculture, vegetation management	area treated (acres)	Total acres proposed and actually treated to nearest whole acre. Examples of treatment include riparian plantings, or protection of riparian zone with a fence.
		Planting	Riparian planting, native plant establishment	Species; area treated (acres)	Species Planted (Latin name);Total riparian acres proposed and actually treated to nearest whole acre. Examples of treatment include riparian plantings, or protection of riparian zone with a fence.
		Livestock Exclusion	Remove livestock from riparian areas	area treated (acres)	Total riparian acres proposed and actually treated to nearest whole acre. Examples of treatment include riparian plantings, or protection of riparian zone with a fence.
		Conservation Grazing Management	Alteration of agricultural land use practices to reducing grazing pressure for conservation. E.g. Rotate livestock grazing to minimize impact on riparian areas	area treated (acres)	Total riparian acres proposed and actually treated to nearest whole acre. Examples of treatment include riparian plantings, or protection of riparian zone with a fence.
		Weed Control	Removal and/or control of non-native species and noxious weed	Species; area treated (acres)	Total riparian acres proposed and actually treated to nearest whole acre. Examples of treatment include riparian plantings, or protection of riparian zone with a fence.
Sediment Reduction	Projects the diminish sediment transport into streams	Road Reconstruction	Reconstruction and restoration of road in place (not a road relocation) and for a restoration purpose (eg. road is crumbling into stream and needs to be reinforced). Road reconstruction does not include drainage improvement projects.	miles	Proposed and actual treatments include road(s) decommissioned (closed, obliterated), upgraded, relocated or restored. (miles to .01 miles)
		Road Relocation	Abandonment of existing road in riparian or streambed area with or without rehabilitation and with a new road constructed in a less sensitive area.	miles	Proposed and actual treatments include road(s) decommissioned (closed, obliterated), upgraded, relocated or restored. (miles to .01 miles)
		Road Stream Crossing Improvements (same as Rocked Ford)	Creation or improvement of a reinforced rock roadbed that crosses the stream without restricting the stream flow. Does not include stream crossing improvements that have a fish passage goal.	miles	Proposed and actual treatments include road(s) decommissioned (closed, obliterated), upgraded, relocated or restored. (miles to .01 miles)
		Road Drainage System Improvements	Placement of structures to contain/ control run-off from roads. Includes surface drainage, peak flow drainage improvements and roadside vegetation	miles	Proposed and actual treatments include road(s) decommissioned (closed, obliterated), upgraded, relocated or restored. (miles to .01 miles)
		Road Obilteration	Road closed with or without rehabilitation. Not a road relocation.	miles	Proposed and actual treatments include road(s) decommissioned (closed, obliterated), upgraded, relocated or restored. (miles to .01 miles)
		Erosion Control Structures	Hillside stabilization, grassed waterways wind breaks, planting, conservation land management, and waterbars.	# of erosion structures	# of sediment control installations
		Sediment Control	sediment basins, sediment ponds and sediment traps.	# of erosion structures	# of sediment control installations

Upland-Agriculture	Upland restoration activities relating to agricultural use	Livestock Management	Any upland livestock management including livestock watering schedules and grazing management plans	acres	Total acres proposed for each treatment to nearest whole acre.
		Agriculture Management Best Management Practices	Implementation of best management practices eg low/ no till agriculture	acres	Total acres proposed for each treatment to nearest whole acre.
		Fencing	Placement of exclusion and non-exclusion fencing	miles	Total miles of fencing to nearest 0.01 mile
		Water Development	Irrigation and livestock water development including ditches, wells, ponds, springs etc.	type and #	Type of water development project (ditch, well, pond, etc.) and number of treatments.
Upland- Vegetation	Upland restoration activities relating to vegetation, includes forestry	Planting	Upland plant installation, seeding, and revegetation	area treated (acres)	Total acres for each treatment to nearest whole acre.
		Invasive Plant Control	Removal and control of non-native plants and noxious weeds	area treated (acres)	Total acres for each treatment to nearest whole acre.
		Vegetation/ Stand Management	Prescribed burns, stand thinning, stand conversion, silviculture, vegetation management, selective thinning, hazard reduction	area treated (acres)	Total acres for each treatment to nearest whole acre.
		Slope Stabilization	Implementation of slope stabilization methods including landslide reparation and terracing.	area treated (acres)	Total acres for each treatment to nearest whole acre.
Upland- Wetland	Projects designed to protect, create or improve connected wetland areas (that meet the standard for federal delineation)	Wetland Creation	Wetland area created where it did not previously exist	area treated (acres)	Acres of artificial wetland created from an area not formerly a wetland. (Acres to nearest whole acre)
		Wetland Improvement/ Enhancement	Changes to an existing wetland	area treated (acres)	Acres of wetland actually treated. (Acres to nearest whole acre)
		Wetland Restoration	Restoration of existing or historic wetland	area treated (acres)	Acres of wetland actually treated. (Acres to nearest whole acre)
		Wetland Vegetation Planting	The planting of native wetland species in wetland areas	area treated (acres)	Acres of wetland actually treated. (Acres to nearest whole acre)
		Wetland Invasive Species Removal	Removal and/or control of non-native species and/or noxious weeds in a wetland area.	area treated (acres)	The acreage of invasive species actually treated in the wetland project. The proposed project area may only be a portion of an existing wetland such as removing an area of purple loosestrife. (Acres to nearest whole acre)
Water Quality Improvement	Projects that result in an improvement of water quality conditions for example through improved water quality treatment, capture toxic highway runoff, reduction in the use of herbicides, pesticides and fertilizers, and other point sources.	Return Flow Cooling	All projects with a goal of directly reducing or directly limiting increase in water temperature. Most are return flow cooling projects which generally consist of replacing old open return ditches with underground PVC pipe. The primary benefits are to eliminate nutrient and thermal loading, by filtering flows underground where they cool before returning to the river.	water temp measured	Water temp before and after project completion (if at a point source then avg water temp before at after of point source emission) in degrees Celsius to nearest whole degree.
		Refuse Removal	Removal of garbage in the waterway	lbs of trash collected	Pounds of trash collected from stream and wetland areas to nearest 100 pounds.
		Sewage Clean-up	Clean up of sewage outfall, etc.		
		Toxic Clean-up	Clean up/prevention of mine tailings, hebicide, pesticide, toxic sediments, etc.	Toxin, area treated (acres)	Name of Toxic species, element or material Total acres, wet and/or dry for each cleaned up to nearest whole acre.
Outmigrant Survival Improvement (Estuary)	Projects that result in improvement of or increase in the availability of estuarine habitat such as tidal channel restoration, floodplain connectivity, floodgate fish passage or diked land conversion. This habitat is important for salmonid out migration where juvenile Salmonids begin the transition from fresh to salt water environments and where predatory pressures are known to be high. Estuarine habitat is distinct from other wetland habitat in being tidally influenced.	Invasive Species Treated	Control or removal of invasive or exotic estuarine species e.g. Spartina alterniflora	Invasive species, area treated (acres)	Invasive species (latin name); Acres of estuary proposed for treatment and actually treated to nearest whole acre.
		Creation of new estuarine habitat	Creation of an estuarine area where one did not exist previously	area created (acres)	Acres of estuary proposed for treatment and actually treated to nearest whole acre.
		Restoration/Rehabilitation of estuarine habitat	Restoration of existing or historic estuarine habitat	area created (acres)	Acres of estuary proposed for treatment and actually treated to nearest whole acre.
		Removal of existing fill material	Removal of fill that isn't associated with a dike e.g. removal of tideflat fill.	area treated (acres)	Acres of estuary proposed for treatment and actually treated to nearest whole acre.
		Channel Modification	Deepening or widening existing tidal channel	Type of modification, length treated in miles	Type of channel modification and Length of channel modified in miles to nearest 0.01 miles)
		Dike Breaching/ Removal	Removal or breaching of a barrier constructed to contain tidal flooding. Breaching/ removal allows for natural flow/flood regime and potential for off-channel habitat usage.	#; length of treatment (miles)	Number of Dikes breached or removed, total aggregate length of dike reconfigured in miles to .01 miles.
		Tidegate Alteration/ Removal	Removal or changes to tidegate that allows water to flow freely when the tide goes out, but which prevents the water from flowing in the other direction. Changes are generally made to allow fish passage at low and high tide.	#	Number of tide gaits removed or altered
		Dike Reconfiguration	Modification of location or design of an embankment to confine or control water flow.	#, length of treatment (miles)	Number of reconfigurings, total aggregate length of dike reconfigured in miles to .01 miles.

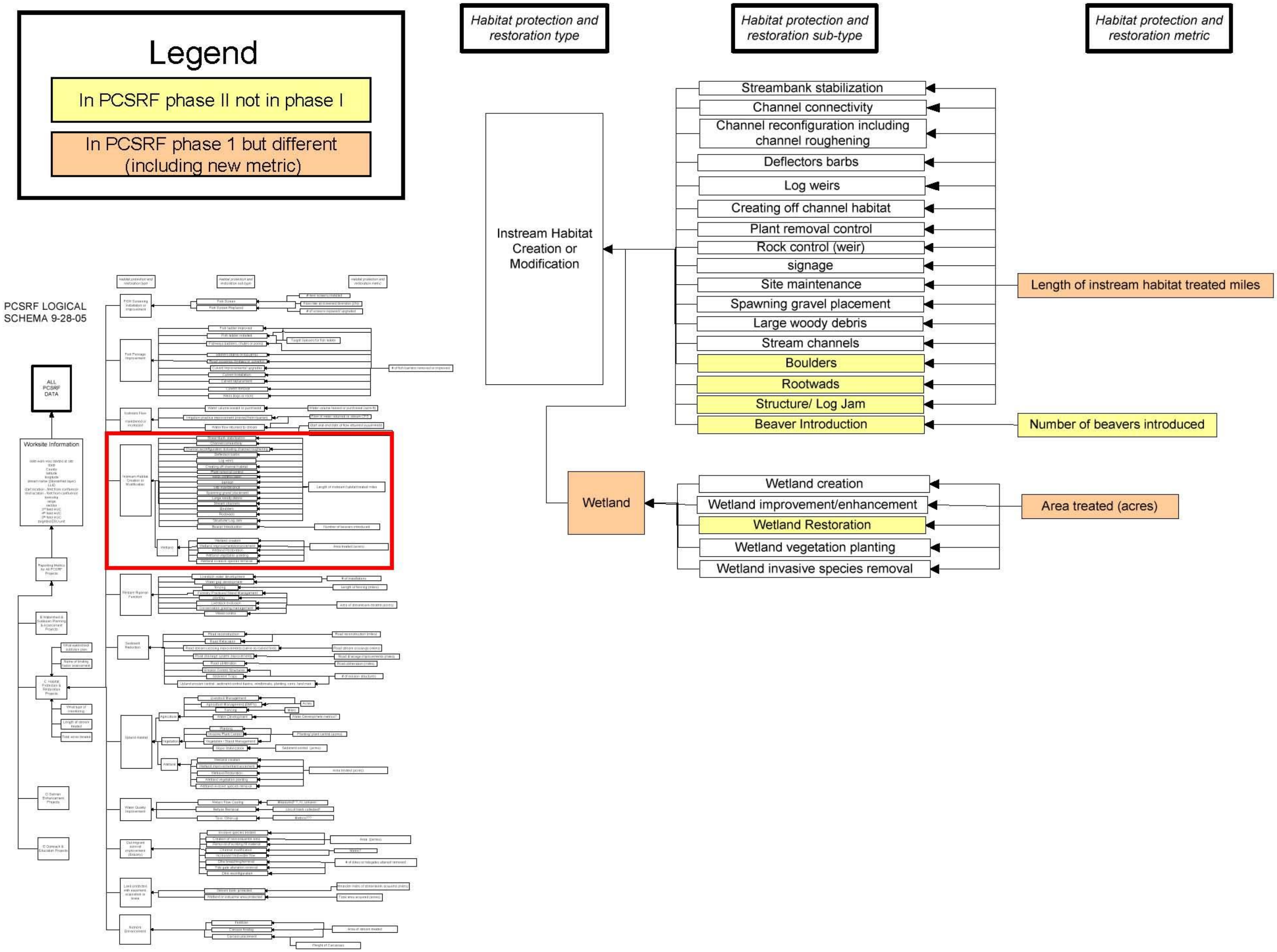
Land Protected, Acquired, or Leased	Projects that involve the acquisition or lease of land or riparian areas.	Streambank Protection	Protection of section of streambank from further degradation or development through purchase, lease, negotiated agreement, statute or other mechanism.	meander miles	This refers to meander miles (to nearest 0.01 mile) of stream bank proposed for protection and actually protected by acquisition, easement or lease. Count miles on both sides of stream if both sides are acquired. Count on one side if only one side is acquired.
		Wetland or Estuarine Area Protection	Protection of wetland or estuarine area from further degradation or development through purchase, lease, negotiated agreement, statute or other mechanism.	acres	The acreage reported should be the total acreage proposed for protection and actually protected regardless of whether all of the habitat is applicable to the desired goals for acquisition. (Acres to nearest whole acre)
Nutrient Enrichment	Projects to add marine derived nutrients back into the system	Fertilizer	Nutrients placed in stream to increase nutrient availability	Weight of fertilizer, area treated (acres)	Total of fertilizer delivered (pounds to nearest 100 pounds); Total acres of each treatment to nearest whole acre.
		Carcass Analog	Fish meal bricks placed in the stream to increase nutrient availability	Weight of fertilizer, area treated (acres)	Total of fertilizer delivered (pounds to nearest 100 pounds); Total acres of each treatment to nearest whole acre.
		Carcass Placement	Dead salmon added to stream	area treated (acres), weight of carcasses	Total acres of each treatment to nearest whole acre, total weight of salmon carcasses placed in the stream
Project Maintenance	Projects that maintain the functionality of Salmonid Restoration Projects	Site Maintenance	Maintenance of the restoration project site eg.replanting trees that failed to survive	length treated in miles	This refers to meander miles of instream habitat treatments. Count actual stream length treated to nearest 0.01 miles.

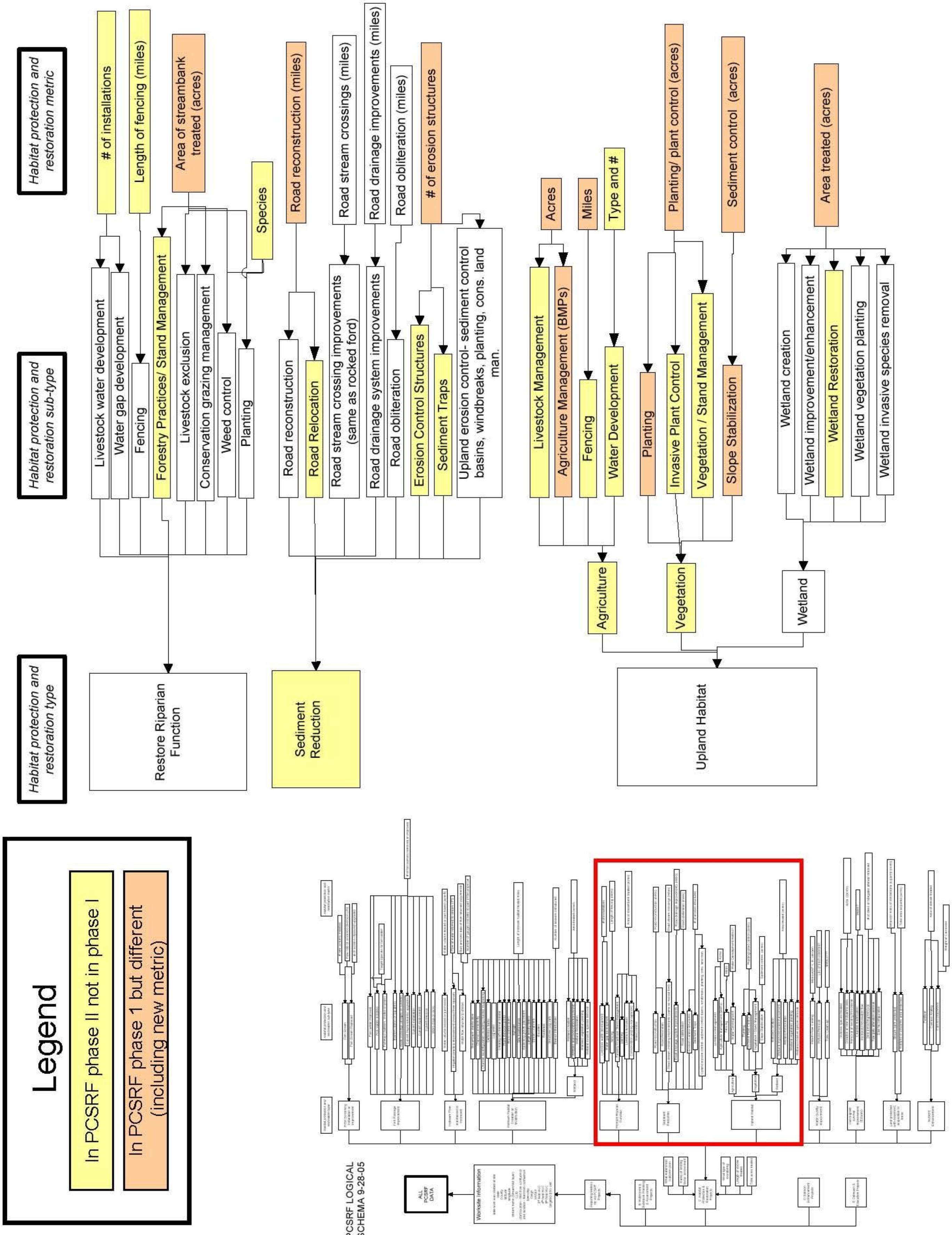
Yellow = in PCSRF Phase II, Not in PCSRF Phase I
Orange = In PCSRF Phase I, but different (including new metric)

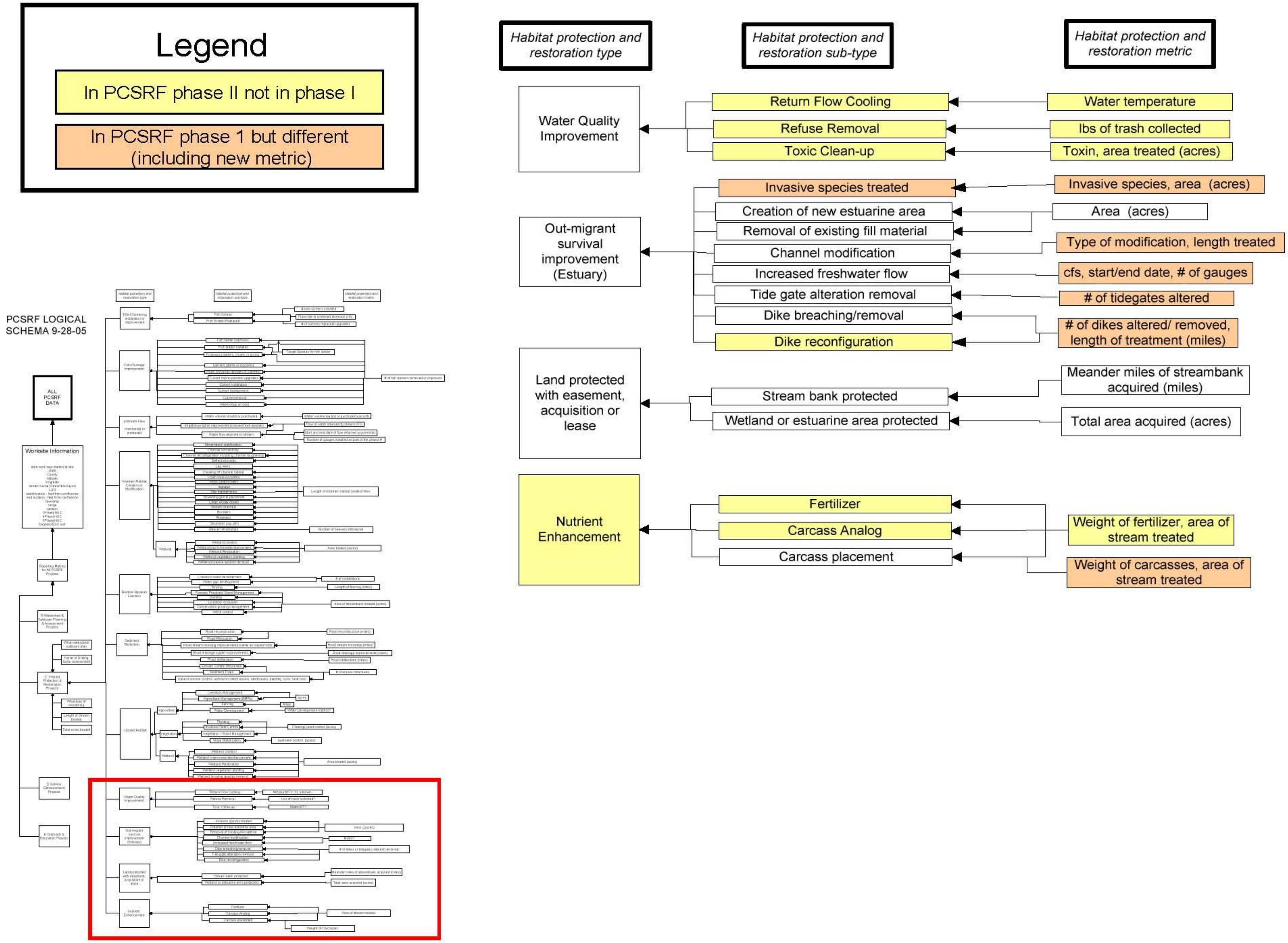
Appendix C



Habitat protection and restoration type
Habitat protection and restoration sub-type
Habitat protection and restoration metric
Fish Screening
Fish Screen
Fish Screen Replaced
new screens installed
Flow rate at screened diversion (cfs)
# of screens replaced/ upgraded
Fish Passage Improvement
Fish ladder improved
Fish ladder installed
Fishways (ladders, chutes or pools)
Barriers (dams or log jams)
Road crossings (bridges or culverts)
Culvert Improvements/ upgrades
Culvert Installation
Culvert replacement
Culvert removal
Weirs (logs or rock)
Target Species for fish ladder
# of fish barriers removed or improved
Instream Flow
Water volume leased or purchased
Irrigation practice improvement
Water flow returned to stream
Flow of water returned to stream CFS
Start and end date of flow returned yyyy/ mm/dd
Number of gauges installed as part of the project #
Legend
In PCSRF phase II not in phase I
In PCSRF phase 1 but different (including new metric)
PCSRF LOGICAL SCHEMA 9-28-05
Worksite Information
ALL PCSRF DATA


Legend
In PCSRF phase II not in phase I
In PCSRF phase 1 but different (including new metric)
PCSRF LOGICAL SCHEMA 9-28-05
ALL PCSRF DATA
Worksite Information
Habitat protection and restoration type
Habitat protection and restoration sub-type
Habitat protection and restoration metric
Instream Habitat Creation or Modification
Streambank stabilization
Channel connectivity
Channel reconfiguration including channel roughening
Deflectors barbs
Log weirs
Creating off channel habitat
Plant removal control
Rock control (weir)
signage
Site maintenance
Spawning gravel placement
Large woody debris
Stream channels
Boulders
Rootwads
Structure/ Log Jam
Beaver Introduction
Length of instream habitat treated miles
Number of beavers introduced
Wetland
Wetland creation
Wetland improvement/enhancement
Wetland Restoration
Wetland vegetation planting
Wetland invasive species removal
Area treated (acres)


Habitat protection and restoration type
Habitat protection and restoration sub-type
Habitat protection and restoration metric
Restore Riparian Function
Livestock water development
Water gap development
Fencing
Forestry Practices/ Stand Management
Livestock exclusion
Conservation grazing management
Weed control
Planting
# of installations
Length of fencing (miles)
Area of streambank treated (acres)
Species
Sediment Reduction
Road reconstruction
Road Relocation
Road stream crossing improvements (same as rocked ford)
Road drainage system improvements
Road obliteration
Erosion Control Structures
Sediment Traps
Upland erosion control- sediment control basins, windbreaks, planting, cons. land man.
Road reconstruction (miles)
Road stream crossings (miles)
Road drainage improvements (miles)
Road obliteration (miles)
# of erosion structures
Upland Habitat
Agriculture
Livestock Management
Agriculture Management (BMPs)
Fencing
Water Development
Acres
Miles
Type and #
Vegetation
Planting
Invasive Plant Control
Vegetation / Stand Management
Slope Stabilization
Planting/ plant control (acres)
Sediment control (acres)
Wetland
Wetland creation
Wetland improvement/enhancement
Wetland Restoration
Wetland vegetation planting
Wetland invasive species removal
Area treated (acres)
Legend
In PCSRF phase II not in phase I
In PCSRF phase 1 but different (including new metric)
PCSRF LOGICAL SCHEMA 9-28-05
ALL PCSRF DATA
Worksite information



Legend
In PCSRF phase II not in phase I
In PCSRF phase 1 but different (including new metric)
PCSRF LOGICAL SCHEMA 9-28-05
Habitat protection and restoration type
Habitat protection and restoration sub-type
Habitat protection and restoration metric
Water Quality Improvement
Return Flow Cooling
Refuse Removal
Toxic Clean-up
Water temperature
lbs of trash collected
Toxin, area treated (acres)
Out-migrant survival improvement (Estuary)
Invasive species treated
Creation of new estuarine area
Removal of existing fill material
Channel modification
Increased freshwater flow
Tide gate alteration removal
Dike breaching/removal
Dike reconfiguration
Invasive species, area (acres)
Area (acres)
Type of modification, length treated
cfs, start/end date, # of gauges
# of tidegates altered
# of dikes altered/ removed, length of treatment (miles)
Land protected with easement, acquisition or lease
Stream bank protected
Wetland or estuarine area protected
Meander miles of streambank acquired (miles)
Total area acquired (acres)
Nutrient Enhancement
Fertilizer
Carcass Analog
Carcass placement
Weight of fertilizer, area of stream treated
Weight of carcasses, area of stream treated

Section III (F.2) NED Best Practices for Reporting Location and Time Related Data

Link to document on PNAMP website:
http://www.pnamp.org/web/workgroups/DM/documents/General/2007_0312Location%20&Time_v3.3.pdf

NED

NORTHWEST
ENVIRONMENTAL
DATA-NETWORK

WHITE PAPER

Best Practices for Reporting Location and Time Related Data

Version 3.3, 2007-03-12

Acknowledgements

A Spatial and Temporal Work Group of the Northwest Environmental Data-Network (NED) have developed these Best Practices.

NED operates under a 2004 Memorandum of Understanding, which supports collaborative action and joint activities with respect to improving the collection, management, and sharing of environmental data and information.

Participants in the Spatial and Temporal work group include Michael Beaty (US Bureau of Reclamation), Greg Robillard (State of the Salmon Consortium), Brendan Sylvander and Jeff Cowen (National Oceanographic and Atmospheric Administration - Fisheries), Bobbi Riggers and Doug Terra (Oregon Watershed Enhancement Board).

The primary authors are Joy Paulus (WA Office of the Interagency Committee) and Stewart Toshach (National Oceanographic and Atmospheric Administration - Fisheries).

Dick O'Connor (Washington Department of Fish and Wildlife), Stan Frazier (US Bureau of Land Management), Tom Pansky (Bonneville Power Administration), Curtis Cude (Oregon Department of Environmental Quality), Roberto Morganti (US Forest Service), Paul Ocker (US Army Corps of Engineers), Tom O'Neil (Northwest Habitat Institute), Kristen Swodoba (US Bureau of Reclamation), Mike Banach, Bruce Schmidt and Van Hare (StreamNet), David Graves and Denise Kelsey (Columbia River Intertribal Fisheries Commission), John Arterburn (Colville Confederated Tribes) and Rebekka Lindskoog (Summit Environmental Consulting Ltd.) all provided valuable reviews. Comments on the draft were solicited from the Pacific Northwest Aquatic Monitoring Partnership, the Pacific Northwest Regional Geographic Information Council and NED.

Much of the physical data structure outlined in this document is based on work conducted at the WA State Department of Ecology on the Environmental Information Management System initiative in early 2000.

Photographs provided by the Washington Office of the Interagency Committee's Grant Application System PRISM.

Introduction and Background

In the Pacific Northwest there are hundreds of research, monitoring and evaluation and environmental management projects creating substantial quantities of data. Most of this data has location and time related data elements that are often reported using different standards and formats.

There is a region-wide need, for multiple purposes, to be able to view and analyze these data at different landscape-scales. This need requires the creation of integrated data products (maps, tables, charts, statistical analyses) from multiple data sets. Unfortunately, because the data has been reported without common standards, the data integration task is time-consuming and expensive. And, because data conversion is needed, errors are introduced. In many instances the burden of data integration and error checking prevents data analysis.

Version History

Version 3.2 2006-11-14, replaced version 3.1 (May 2006). The significant change between these versions was to adopt a best practice for reporting date that is consistent with International Standards Organization standard 8601 standard notation.

This version, 3.3 2007-03-12, replaces version 3.2 2006-11-14. The change is to include instructions at page 8 about how to select the yyyy/mm/dd format for managing date information within cells or groups of cells when using Microsoft Excel:

Intended Users of These Guidelines

The guidelines have been prepared for two types of users:

1) Users who are not presently tracking environmental project data within a geographic information system (GIS) and who are managing their information within a database or spreadsheet. The guidelines are focused on the needs of these users.

2) Users who are already employing GIS systems to track monitoring and restoration projects. This group is strongly encouraged to track similar elements using established state and federal data and metadata (information about data) standards.

Example of more detailed federal standards can be found at:

- EPA (for detailed geolocational standards http://iaspub.epa.gov/edr/epastd$.startup
- FGDC (for metadata) http://www.fgdc.gov/standards/
- Water Information Coordination Program/Advisory Committee Water Resources (for Water monitoring) http://water.usgs.gov/wicp/acwi/

Nothing in these guidelines is intended to diminish existing authorities for information collection or reporting. For example, most Federal entities are already required to provide FGDC compliant metadata about spatial, temporal, and other data collection efforts.

These guidelines represent what is considered to be the minimum set of location and time information that should be considered for collection and reporting. This is not meant to limit your collecting additional information that may be pertinent to, and best determined by, the collecting organization.

For more information about GIS and other technical terms used in this guidance and what they mean, please look at:

- http://gis.esri.com/showcase/showcase.cfm
- http://support.esri.com/index.cfm?fa=knowledgebase.gis

Why Use Data Standards

A minimum set of mapping standards is necessary to ensure the successful implementation of a multi-agency approach to data collection. Consistent use of common reporting standards would have significant benefits to the region by:

- Reducing errors and improving data quality;
- Increased understanding of the information content;
- Leveraging existing technical advances and investments that have been made in spatial and temporal data collecting and viewing. In particular: Geographic Positioning Systems (GPS) for determining location (and time) and GIS for creating spatial products;
- Reducing the cost of analysis and increasing confidence in analytical products;
- Allowing easier and more widespread use of data collected across different programs and entities;
- Increasing data consistency; and
- Improving data maintenance over time.

The use of consistent minimum location and time data reporting standards are not a technical challenge: it is a policy choice. It requires action within agencies to support or require the use of consistent standards within relevant agency projects and programs.

Acquiring Latitude and Longitude Coordinates for Your Projects, Sites and Features

All projects have some form of locational information. Locational information about a project may include the location of the **project** itself, the locations where actual **site** work for the project is completed and details of **features** at sites. Features are things carried out at sites, for example building a fence, sampling water quality, or counting fish. It is very important to identify what locations are being associated with each project, site or feature, using detailed latitude and longitude information.

For example: a salmon habitat restoration project is located on the Skagit River at the confluence with the Sauk River (the project location). At the confluence there are 3 separate places of work (site locations) where fence installations (feature location information) are being completed. If monitoring was also completed as a part of the project, there may also be records of monitoring site locations with feature level detail about each of those sites, for example, transect location information.

Each case may be different.

The following sources of coordinate information may help to make reporting information about your project area easier. This material is not intended to be a complete guide for working with GIS or GPS, but rather, a guide for building the needed attributes in a database so you can track project information at the simplest level.

Hardcopy Map Sources

- USGS quad sheets have lat/long coordinate grids along the side of the map.

Map Data From Your Computer

- National Geographic sells USGS quad data on CD/DVD's for individual states that can be loaded on your PC.

Free On-line Map Sources

There are on-line USGS maps that can be accessed on-line from different sources. For example:

- TopoZone http://www.topozone.com

- MapTech's http://www.maptech.com/
- Microsoft's http://terraserver.microsoft.com/

These sites allow you to search for your area of interest and then display the area selected. By holding your mouse over a point on the map it will display the lat/long coordinates of that point.

Web Mapping Services

For organizations that need access to frequent and accurate geocoding information there are services that can provide you with this sort of support. One example would be ArcWeb Services for Geocoding.

For a glossary on more information about spatial information go to:

- http://gis.esri.com/showcase/showcase.cfm
- http://support.esri.com/index.cfm?fa=knowledgebase.gis

Reporting Date and Time data for Your Projects, Sites and Features

The recommended best practice is consistent with the ISO 8601 standard notation.

Calendar date is reported as an eight digit sequence composed of numeric characters in the format YYYY-MM-DD where YYYY is the year in the Gregorian calendar, MM is the month of the year between 01 (January) and 12 (December), and DD is the day of the month between 01 and 31.

Time is reported according to the international standard notation of HH:MM:SS where HH is the complete number of hours that have passed since midnight, from 00 to 24, MM is the number of complete minutes that have passed since the start of the hour (00-59), and SS is the number of complete seconds since the start of the minute. If the hour value is 24, then the minute and second values must be zero.

If the date and the time are stored in the same data field then they should be separated by the Latin capital letter T, eg 19950123T235959.

For these Best Practices the time zone is assumed to be the local time unless there are further additions.

To indicate that a time is being reported in Universal time (UTC) it is necessary to append a Z eg 23:59:59Z. The Z stands for zero meridian. The strings +HH:MM or +HH can be used to indicate when the local time zone is ahead of the UTC. Strings of –HH:MM or – HH can be used when the local time zone is behind UTC.

Note:

When using Microsoft Excel a user can select the yyyy/mm/dd format for managing date information within cells or groups of cells as follows:

> Select Format/Cells/Date/Locale(Location)/English(Canada) e.g. 2001-03-14

Real World Examples of How Data Reporters Can Conform to These Guidelines

The spatial and temporal standards described in this document are for use in any *Observation Based Data* collection effort[7]. *Observation Based Data* are generated during an *activity* (e.g. fish and wildlife counting, habitat survey), performed by *participants* (e.g. Data Collector) where *observations* (recorded data) are collected about a subject (e.g. fish passage or bird inventory) following a *methodology* (screw trap method 2 or point counts) at a *location* during a *period* (2005 05-04 to 2005-05-08) and for a particular *purpose* (measuring smolt production or counting various birds in an area).

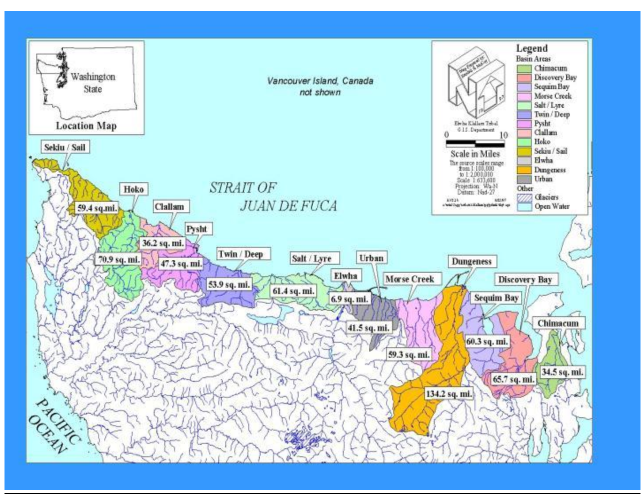
While data analysts usually want to know all of the *italicized* information above, this document is intended to provide minimum standards for reporting on the *location* and the *period* of an Observation Based Data collection effort.

There are many different types of participants involved in data collection and reporting with different levels of technical support. Examples are provided below for two types of *participants*:

- Data collectors with limited data or GIS resources
- Data collectors with expanded data or GIS resources (or large organization) data collectors.

Data collectors with limited data resources would typically be working on smaller scale projects, often without support from an enterprise level information system.

Data collectors with expanded resources would typically be working within an organization that has enterprise level GIS support. Most participants working for a government scientific program enjoy the support of a GIS department or staff with an established data management system.



[7] Draft Fish Monitoring Protocols Workshop -Data Management Work Group -Welches, OR, May 2005

Example 1: Collector with Limited Data Resources

The participant collects water quality data in a stream environment and determines the sampling location from a paper map. The time of sampling is reported as HH:MM:SS from a personal watch that is not synchronized. Later, in the office, the user logs onto a map web service (e.g. http://www.maptech.com/ or http://www.topozone.com) to identify the sampling latitude and longitude (in decimal degrees) from the map web service.

The participant would report, at the least, a brief description of the location method (along with other needed metadata[8]): e.g. "I marked the location on a 1:100,000 typographical map in the field and then used the http://www.maptech.com/ or http://www.topozone.com or http://terraserver.microsoft.com/

Web service to get a lat/long in decimal degrees. Time of sampling was reported from a personal unsynchronized watch".

Example 2: Collector with Limited Data Resources

The collector is validating the planting of an area of riparian planting. While the site can be located, survey stakes cannot be located to delineate the work site. The collector walks to the estimated center location (centroid) of the tree-planting project and measures the location using a hand-held GPS. Later, in the office, the collector reports the data by keying the location information from the GPS into a spreadsheet and makes a description of the spatial and temporal data method used as a part of the needed metadata record: e.g. "I walked to the approximate center of the planting and estimated the location with a "Garmin E-Trex" GPS using an unknown methodology. The datum used was NAD83 (North American Datum 1983). I could not locate survey stakes."

Example 3: Collector With Expanded Data Resources

The participant collects water quality data in a stream environment from multiple sites and observes and reports the sampling locations in decimal degrees, the date (YYYY-MM-DD), and the time of sampling (HH:MM:SS), into a PDA with an integrated "Garmin 18" GPS unit. The time is taken from the GPS. When reporting the data, on return to the lab, the GPS data is downloaded from the users PDA to a corporate database and a description of the spatial and temporal methods used is attached along with other metadata, including a reference to the datum used (NAD83) and the use of automatic loading of spatial and temporal data from the Garmin GPS 18 unit.

---

[2] Other needed metadata could include:

1. Description of what the dataset is, who collected, created, or processed the data, and the dates these were completed.
2. Any access/use constraints associated with the data—is it sensitive, copyright, etc.
3. A descriptive title or naming convention for the dataset.
4. Originator of the data-who? When it was published.
5. A point of contact for the data. Name, organization, contact phone number, address or email.
6. Any processing that was done from the data from it's original state-who, when, what, where and how.
7. What is the data quality? Is it complete, logical, consistent? What is the accuracy or precision of the data?

Example 4: Collector With Expanded Data Resources

The participant is validating the planting of an area of riparian planting. While the site can be located, survey stakes cannot be located to delineate the work site. The collector describes a polygon (shape file) for the boundary of the planting by walking the boundary of the planting and using a hand held GPS to enter waypoints at changes of direction along the boundary. In the office the data is downloaded from the GPS into the corporate database.

When reporting the data, a description of spatial and temporal methods used and other needed metadata, should be attached to the data: For example: "The area of planting was located by walking the perimeter of the planting using a hand-held Garmin Map 60 GPS, reporting way points at boundary direction changes. The datum was NAD83 (North American Datum 1983). In the office the data was downloaded into the database."

How to Understand and Use the "Multi-Level" Guidelines

These guidelines, for reporting location (spatial) and time (temporal) related data, were designed with flexibility in mind. Since some projects are simpler than others, the **"Multi-Level"** structure allows project managers to track projects and location information at the needed level of detail. See Table 1 for descriptions of Level 1, Level 2, and Level 3.

Simple projects can typically be tracked using **Level 1,** which provides managers and end users with just enough general information, such as project name, sponsor, and project type, along with a general physical description of the project's location and its time duration. An example of this sort of project could be an environmental education project that associated with a scientific program where locational data is not collected.

But, as we know, certain projects can become complex, especially when they entail specific sampling or other activities. In these instances, a project can cover a large area with discrete places where information is tracked and collected, for example, a project to replace culverts at multiple sites. In this case you could track project information at **Level 1** and **Level 2, which provides for more detailed collection**.

In some cases, tracking information at **Level 2** may not be sufficient. During some projects, multiple sites could be visited many times with the sampling of detailed environmental data at each of the sites in addition to the location and time data. Project Sites where water chemistry and a stream's morphology are collected along different reach segments is an example of when **Level 3** information would be needed. With this complexity you would need to be tracking project information at all three levels.

This "*leveled*" (or multi-tiered) structure for tracking project location and duration was created for this reason. To allow the reporting of information on simple to complex projects as the need arises while still being able to connect the project, site, and feature information.

As you go through these levels, you expose more levels of detail related to your project collection and reporting efforts. This is one of the primary benefits of this leveled reporting approach.

Using the Location and Time Element Tables

The standards are designed to support consistent reporting of data that is collected. For example, the standards do not require programs or projects to collect the time of water quality sampling to the nearest second. But if data is being collected to the nearest second, then the data should be consistently reported at that time interval. The data tables are provided as a guideline. The physical attribute examples or format may not meet your organizations rules but as long as you document what physical attributes and formats you are using you meet the intent of the standards. In order to compare information across organizations it is important that you follow the predefined meaning of each element, it its definition and associated codes.

The following tables are broken down into their separate, essential elements **as a guide for information managers**. To attain consistency across regional organizations, the actual element (logical) names and name definitions should be adopted "as is" along with the code tables listed under "*Element Code, Code Range, or Description*". But, the elements' physical names (the names used in the database, e.g. PRJ_ID) themselves are only provided as guidance. Your own agency physical data naming conventions may need to be followed.

The more consistency you use in implementing these standards, the better we'll all be able to link information together. Note, as you define your naming standards you will also need to define the business rules for how you will represent project, site, and feature location: For example, if you wish to characterize a watershed with a single point you could define that point as the centroid for the watershed. Similarly, if you are defining a single point for a fence you could define that point as the mid-point of the fence. Whatever method you use must be described as a part of the metadata record.

The tables do not require the user to provide elevation related data. This data can be generated if the user needs it and therefore it is not essential to report it separately. If your organization wants to report elevation data, the type of information can be found in Table 5.

Table 1: Project Level Summary Table (Levels 1-3)

This provides the user with an overview of the "multi-level" data approach, associated definitions, and data elements. It also provides an outline of the types of other project information that you might want to consider collecting. The **bolded** headings represent the location and time information that we suggest should be added to existing and new project tracking systems.

Table 2: Location and Time Data Elements Associated with Projects (Level 1)

This provides detailed information about the types of location and time information that should be associated with all general projects. It also provides information on the following data elements – the name, its definition, an example of a database name, the associated codes to track the information properly, along with examples. The **bolded** headings represent the location and time information that we suggest should be added to existing and new project tracking systems.

Table 3: Location and Time Data Elements Associated with Project Sites (Level 2)

This provides the user with an overview of how you would implement the location and time information in a more complex project, such as projects where you are tracking specific and/or numerous locations or where the project's sites exist over time. Not all projects will need this level of detail or the data may not be available for reporting. Following this format would enable the reporting of more detailed information concerning actual activities that are being performed in the field.

The Table also provides information regarding the project site and its associated location and time elements. You will also find examples of database attributes and their associated code tables. The **bolded** headings represent the minimum spatial and temporal elements that should be added to existing and new project tracking systems.

Table 4: Location and Time Data Elements Associated with Project Site Features (Level 3)

Provides the user with an overview of how you would implement the location and time information in a more complex project which requires the project manager to track specifically measured features in the field at a given project site. Again, not all projects may need to be tracked at this level of detail. The table outlines the spatial and temporal elements of site features. You will find examples of database attributes and their associated code tables and examples of how this would be applied in the field. The **bolded** headings represent the minimum spatial and temporal elements that should be added to existing and new project tracking systems.

Table 5: Optional Elevation Data Elements Associated with Projects, Sites, or Features

Table 5 provides the user with an option of reporting elevations for Projects, Sites, or Features.

Table 6: Examples of
Location and Time Data Reporting for Different Types of Data Collection Efforts

Provides the user with examples of how features can be reported at different levels of spatial and temporal detail, depending on whether or not the data is from an "independent" or "corporate" data collector.

Table 1: **Project Level Summary Overview Table**

	Level Definition	**Minimum Location (Spatial) and Other Common Data Elements**	**Minimum Time (Temporal) Data Elements**
Level 1	<u>*Project Definition:*</u> *A project is an administrative unit of work that's defined by an organization or entity.* *PROJECT* = one project present per grant/activity/etc	<u>Project Guideline</u> **Project ID (unique system identifier, Primary Key)** Project Name (user defined name) Project Type **Project Location Description – text field** (physical place where project collection/measurement/observation occurred) **Project Location** (Longitude/Latitude in decimal degrees. The minimum reporting standard is a single point **Datum** (horizontal reference model) **Project Location Collection Method** (GPS, Digital Elevation Model, map derived, etc.)	***Project Guideline*** **Project Start Date** (date the project started) E.g. 1998-01-23 **Project End Date** (date the project ended) E.g. 2005-05-31
Level 2	<u>*Site Definition*</u> *The location where project work is done.* *SITE* = one or many sites may be contained in a project	<u>Site Guideline</u> **Project ID (Secondary Key)** **Site ID (unique system identifier, primary key)** Site Name (user defined name) Site Type **Site Location Description** (physical place where collection/measurement/observation occurred) **Site Location** (Longitude/Latitude in decimal degrees) The minimum reporting standard is a single point. **Datum** (horizontal reference model) **Site Location Collection Method** (GPS, DEM, map derived, etc.)	<u>Site Guideline</u> **Site Start Date** (date the site collection, measurement, observation started) E.g. 1998-01-23 **Site End Date** (date the site collection, measurement, observation ended) E.g. 2005-05-31
Level 3	<u>*Feature Definition:*</u> *The location of things or activities at sites* *FEATURE* = one or many features may be present at a site	<u>Feature Guideline</u> **Project ID (Secondary Key)** **Site ID (Secondary Key)** **Feature ID (unique system identifier, primary key)** Feature Type (fence, transect, planting area, etc.) **Feature Location Description** (physical place where collection/measurement/observation occurred) **Feature Location** (Longitude/Latitude in decimal degrees) The minimum reporting standard is	<u>Feature Guideline</u> **Feature Start Date** (date the collection, measurement, observation started at this site) E.g. 1998-01/23 **Feature End Date** (date

	a single point. **Datum** (horizontal reference model) **Feature Location Collection Method** (GPS, DEM, map derived, etc.)	the collection, measurement, observation ended at this site) E.g. 2005-05-31 **Feature Start Time** (time the collection, measurement, observation started - using a 24hr clock at local time) (HH;mm;ss) E.g. 16:43:22 **Feature End Time** (time the collection, measurement, observation ended - using a 24hr clock at local time) (HH;MM;SS) E.g. 17:52:31

Notes on Table 1:

- **Highlighted** elements are further described in Tables 2, 3, and 4

- Other data elements could be added if needed. For example, some users may want to include a comment field to document any pertinent information about a record that could not be conveyed in other fields, while other users might want to include routed hydrography data.

Table 2: **General Location and Time Data Elements Associated with Projects**

Level 1 **General Project Information** **(This information should be reported unless it is not applicable)**			
Logical Name	**Element Definition**	**Physical Name (For Example Only)**	**Element Code, Code Range and Examples**
Project Identifier	A project is a unit of work defined by an organization or entity. A project may include one or more sites or one or more types and number of activities. Unique system identifier	PRJ_ID	Examples Skagit River Habitat Restoration Project Okanogan Water Quality Sampling Project Oregon North Coast Nearshore Monitoring Project Deschutes River Flow Monitoring Project
Project Location Description	Term that best describes the field location in relation to the surrounding environment.	PRJ_LOC_DESC	Text field Examples: Okanogan watershed ESA Region SW ¼ of Section 36 of Township 29 Range 01
Project Location Latitude Coordinate	Distance north or south of the equator. Decimal equivalent to the degrees-minutes-seconds latitude value.	PRJ_LOC_LAT_COORD	Float, 2 places, 6 decimals; (4 decimals minimum) E.g. Range for WA: 45.000000- 49.999999
Project Location Longitude Coordinate	Distance east or west of the Central Meridian (Greenwich, England). Decimal equivalent to the degrees-minutes-seconds longitude value	PRJ_LOC_LONG_COORD	Float, 3 places, 6 Decimals, will accommodate signed values (4 decimals minimum); E.g. Range for WA: -116.000000 – -125.999999
Project Horizontal Datum	Model used to match the horizontal position of features on the ground to coordinates and locations on a map. NOTE - When taking GPS measurements, it is very important to record your datum!	PRJ_HORZ_DAT	01 - N. American Datum 1927 (NAD27- used on many USGS quad maps or NOAA charts); 02 - N. American Datum 1983 (NAD83 or 91 Adj. – based on Earth and satellite observations, similar to WGS84 but specific to North America.); 03 - High Accuracy Reference Network (HARN – similar to

			NAD83, but more accurate per GPS observations); 04 - World Geodetic System of 1984 (WGS84 – world datum, based on Earth and satellite observations); 99 - unknown.
Logical Name	**Element Definition**	**Physical Name (For Example Only)**	**Element Code, Code Range and Examples**
Project Location Collection Method	Technique used to collect the horizontal coordinates of a Location.	PRJ_LOC_COLL_MTH	1 - Address Matching - Block Face; 2 - Address Matching - House Number; 3 - Address Matching - Street Centerline; 4 - Address Matching - Unknown; 5 - Aerial Photography - Rectified; 6 - Aerial Photography - Unknown; 7 - Aerial Photography - Unrectified; 8 - Cadastral Survey (conventional land survey); 9 - Census Block 1990 Centroid; 10 - Census Block Group 1990 Centroid; 11 - Conversion from STR; 12 - Digital or manual raw photo extraction; 13 - Digitized off CTR screen/digital data; 14 - Digitized - paper map; 15 - GPS carrier phase (employs the satellite Code's carrier signal to improve accuracy); 16 - GPS code phase (measurements based on pseudo random code broadcast by satellite); 17 - GPS kinematics (tracking location while moving using carrier phase); 18 - GPS (Unknown); 19 - Hand measured - paper map (interpolation); 20 - LORAN-C; 21 - Orthophotography - digital; 22 - Orthophotography - paper; 23 - Satellite Imagery - Landsat MSS (Multi-Spectral Scanning); 24 - Satellite Imagery - Landsat TM (Thematic Mapper); 25 - Satellite Imagery - Other; 26 - Satellite Imagery - SPOT Panchromatic; 27 - Satellite Imagery - SPOT Multi Spectral; 28 - Zip Code Centroid; 29 - GPS (Code/Differential);

			30 - Estimated Value; 31 - GIS Interpretation Centroid of polygon; 32 - GIS Interpretation Centroid of transect; 33 - GPS Beginning of Transect; 34 - GPS End of Transect; 35 - GPS Center of Project; 36 - Web based internet mapping system; 99 - unknown
Logical Name	**Element Definition**	**Physical Name (For Example Only)**	**Element Code, Code Range and Examples**
Project Start Date	The date that the project activity commenced.	PRJ_STR_DT	Date, YYYY-MM-DD format. (Only if applicable) E.g.2003-03-12 03/12/2003. Use a date of 1800-01-01 to indicate that the Start Date is not specified or is unknown.
Project End Date	The date that the project activity ended.	PRJ_END_DT	Date, YYYY-MM-DD format. (Only if applicable) E.g. 2004-03-12. Use a date of 1800-01-01 to indicate that the End Date is not specified or is unknown.

Notes:

Other data elements could be added if needed. For example, some users may want to include a comment field to document any pertinent information about a record that could not be conveyed in other fields, while other users might want to include routed hydrography data.

Table 3: **Location and Time Data Elements Associated with Tracking Project Sites**

Level 2 The Following Site Elements Are Nested Under Projects (This detail may not be necessary for all reporting purposes)			
Logical Name	**Element Definition**	**Physical Name (For Example Only)**	**Element Code, Code Range or Examples**
Project Site Identifier	The place where site activities that are associated with a project occur or the area where the work is done. Each site will pertain to just one project but there can be more than one site for any given project. Location of the site or activities where work is conducted - on the ground activities Unique system identifier	PRJ_SITE_ID	*This needs to be defined based on the type of project site work that is being done, E.g.* *Skagit River Habitat Restoration Sites- 2 stream reaches* *Okanogan Water Quality Sampling Site – 4 monitoring sites in study* *Oregon North Coast Nearshore Monitoring Sites- 3 coastal reaches in project* *Deschutes Flow Monitoring Sites – 2 gauging stations in project*
Project Site Location Description	Term that best describes the site location in relation to the surrounding environment. Information that describes the place a Location exists.	PRJ_SITE_LOC_DESC	Text field E.g. 200 yards north of the cattle crossing on Laumann Road, north of the intersection with Heidi Road
Project Site Location Latitude Coordinate	Distance north or south of the equator. Decimal equivalent to the degrees-minutes-seconds latitude value.	PRJ_SITE_LOC_LAT_COORD	Float, 2 places, 6 decimals; (4 decimals minimum) E.g. Range for WA: 45.000000-49.999999
Project Site Location Longitude Coordinate	Distance east or west of the Central Meridian (Greenwich, England). Decimal equivalent to the degrees-minutes-seconds longitude value.	PRJ_SITE_LOC_LONG_COORD	Float, 3 places, 6 decimals, (4 Decimals minimum); will accommodate signed values; E.g. Range for WA: -116.000000 – -125.999999

Project Site Horizontal Datum	Model used to match the horizontal Position of features on the ground to coordinates and locations on a map. NOTE - When taking GPS measurements, it is very important to record your datum!	PRJ_SITE_HORZ_DAT	01 - N. American Datum 1927 (NAD27- used on many USGS quad maps or NOAA charts); 02 - N. American Datum 1983 (NAD83 or 91 Adj. – based on Earth and satellite observations, similar to WGS84 but specific to North America.); 03 - High Accuracy Reference Network (HARN – similar to NAD83, but more accurate per GPS observations); 04 - World Geodetic System of 1984 (WGS84 – world datum, based on Earth and satellite observations); 99 - unknown.
Logical Name	**Element Definition**	**Physical Name (For Example Only)**	**Element Code, Code Range or Examples**
Project Site Location Spatial Data Collection Method	Technique used to collect the horizontal coordinates of a site location.	PRJ_SITE_LOC_COLL_MTH	1 - Address Matching - Block Face; 2 - Address Matching - House Number; 3 - Address Matching - Street Centerline; 4 - Address Matching - Unknown; 5 - Aerial Photography - Rectified; 6 - Aerial Photography - Unknown; 7 - Aerial Photography - Unrectified; 8 - Cadastral Survey (conventional land survey); 9 - Census Block 1990 Centroid; 10 - Census Block Group 1990 Centroid; 11 - Conversion from STR; 12 - Digital or manual raw photo extraction; 13 - Digitized off CTR screen/digitial data; 14 - Digitized - paper map; 15 - GPS carrier phase (employs the satellite code's carrier signal to improve accuracy); 16 - GPS code phase (measurements based on pseudo random code broadcast by satellite); 17 - GPS kinematics (tracking location while moving using carrier phase); 18 - GPS (Unknown); 19 - Hand measured - paper map (interpolation); 20 - LORAN-C; 21 - Orthophotography - digital; 22 - Orthophotography - paper; 23 - Satellite Imagery - Landsat MSS (Multi-Spectral

			Scanning); 24 - Satellite Imagery - Landsat TM (Thematic Mapper); 25 - Satellite Imagery - Other; 26 - Satellite Imagery - SPOT Panchromatic; 27 - Satellite Imagery - SPOT Multi Spectral; 28 - Zip Code Centroid; 29 - GPS (Code/Differential); 30 – Estimated Value; 31 - GIS Interpretation Centroid of polygon; 32 - GIS Interpretation Centroid of transect; 33 - GPS Beginning of Transect; 34 - GPS End of Transect; 35 - GPS Center of Project; 36 - Web based internet mapping system; 99 - unknown
Logical Name	**Element Definition**	**Physical Name (For Example Only)**	**Element Code or Code Range or Examples**
Project Site Start Date	The date that the site activity (sample collection, field measurement, field observation) commenced. If a site activity is essentially instantaneous, a Site End Date is often not specified.	PRJ_SITE_STR_DT	Date, YYYY-MM-DD format. (Only if applicable) E.g. 2003-03-12. Use a date of 1800-01-01 to indicate that the Start Date is not specified or is unknown.
Project Site End Date	The date that the site activity (sample collection, field measurement, field observation) ended. If a field activity is essentially instantaneous, a Site End Date is often not specified.	PRJ_SITE_END_DT	Date, YYYY-MM-DD format. (Only if applicable) E.g. 2004-03-12. Use a date of 1800-01-01 to indicate that the End Date is not specified or is unknown.

Table 4: ***Location and Time Data Elements Associated with a Complex Project Tracking Specific Site Features***

Level 3 **The Following Elements are Nested under Project Sites** **(This detail may not be necessary for all reporting purposes)**			
Logical Name	**Definition**	**Element Name (For Example Only)**	**Element Code, Code Range, or Examples**
Site Feature Identifier	The structure, form, or appearance of what is being tracked, measured or observed at any given project site. Within any give project site there may be various features represented as single points, linear features or aerial extents. Unique system identifier	SITE_FEA_ID	*This needs to be defined based on the type of scientific/field information that is being collected* *Example Code Tables:* *Transect measurement point* *Fence* *Wells* *Fish hatchery raceway* *Reach segments* *Examples of Site Features:* *Water sampling well locations* *Individual gauging station location* *Location of addition to spawning gravel*
Site Feature Location Description	Term that best describes the feature location in relation to the surrounding environment. Information that describes the place a Location exists.	SITE_FEA_LOC_DESC	Text field, E.g. 200 yards north of the cattle crossing on Laumann Road, north of the intersection with Heidi Road
Site Feature Location Latitude Coordinate	Distance north or south of the equator. Decimal equivalent to the degrees-minutes-seconds latitude value of a	SITE_FEA_LOC_LAT_COORD	Float, 2 places, 6 decimals; (4 decimals minimum) E.g. Range for WA: 45.000000-49.999999
Site Feature Location Longitude Coordinate	Distance east or west of the Central Meridian (Greenwich, England). Decimal equivalent to the degrees-minutes-seconds longitude value.	SITE_FEA_LOC_LONG_COORD	Float, 3 places, 6 decimals, (4 Decimals minimum); will accommodate signed values; E.g. Range for WA: -116.000000 – -125.999999

Logical Name	**Element Definition**	**Physical Name (For Example Only)**	**Element Code, Code Range or Examples**
Site Feature Horizontal Datum	Model used to match the horizontal position of features on the ground to coordinates and locations on a map. NOTE - When taking GPS measurements, it is very important to record your datum!	SITE_FEA_HORZ_DAT	01 - N. American Datum 1927 (NAD27- used on many USGS quad maps or NOAA charts); 02 - N. American Datum 1983 (NAD83 or 91 Adj. – based on Earth and satellite observations, similar to WGS84 but specific to North America.); 03 - High Accuracy Reference Network (HARN – similar to NAD83, but more accurate per GPS observations); 04 - World Geodetic System of 1984 (WGS84 – world datum, based on Earth and satellite observations); 99 - unknown.
Site Feature Location Collection Method	Technique used to collect the horizontal coordinates of a feature location.	SITE_FEA_LOC_COLL_MTH	1 - Address Matching - Block Face; 2 - Address Matching - House Number; 3 - Address Matching - Street Centerline; 4 - Address Matching - Unknown; 5 - Aerial Photography - Rectified; 6 - Aerial Photography - Unknown; 7 - Aerial Photography - Unrectified; 8 - Cadastral Survey (conventional land survey); 9 - Census Block 1990 Centroid; 10 - Census Block Group 1990 Centroid; 11 - Conversion from STR; 12 - Digital or manual raw photo extraction; 13 - Digitized off CTR screen/digital data; 14 - Digitized - paper map; 15 - GPS carrier phase (employs the satellite code's carrier signal to improve accuracy); 16 - GPS code phase (measurements based on pseudo random code broadcast by satellite); 17 - GPS kinematics (tracking location while moving using carrier phase); 18 - GPS (Unknown); 19 - Hand measured - paper map (interpolation); 20 - LORAN-C;

			21 - Orthophotography - digital; 22 - Orthophotography - paper; 23 - Satellite Imagery - Landsat MSS (Multi-Spectral Scanning); 24 - Satellite Imagery - Landsat TM (Thematic Mapper); 25 - Satellite Imagery - Other; 26 - Satellite Imagery - SPOT Panchromatic; 27 - Satellite Imagery - SPOT Multi Spectral; 28 - Zip Code Centroid; 29 - GPS (Code/Differential); 31 - GIS Interpretation Centroid of polygon; 32 - GIS Interpretation Centroid of transect; 33 - GPS Beginning of Transect; 34 - GPS End of Transect; 35 - GPS Center of Project; 36 - Web based internet mapping system; 99 - unknown
Logical Name	**Element Definition**	**Physical Name (For Example Only)**	**Element Code. Code Range, or Examples**
Site Feature Activity Frequency	The frequency of time at the location for treatments or collecting information	SITE_FEA_FREQ	Continuous, Hourly Daily Weekly Bi-weekly Monthly Quarterly Biannually Annually Decadal Alternating Time Frame (Rotating Panel)
Site Feature Start Date	The date that the feature activity (sample collection, field measurement, field observation) commenced. If a Feature activity is essentially instantaneous, a Feature End Date is often not specified.	SITE_FEA_STR_DT	Date, YYYY-MM-DD format. (Only if applicable) E.g. 2003-03-12. Use a date of 1800-01-01 to indicate that the Start Date is not specified or is unknown.

Site Feature End Date	The date that the feature activity (sample collection, field measurement, field observation) ended. If a feature activity is essentially instantaneous, a Feature End Date is often not specified.	SITE_FEA_END_DT	Date, YYYY-MM-DD format. E.g.2004-03-12. Use a date of 1800-01-01 to indicate that the End Date is not specified or is unknown.
Site Feature Start Time	The time that the feature activity began, for example the time of sampling	SITE_FEA_STR_TM	**Feature Start Time** (time the collection, measurement, observation started -using a 24hr clock at local time) (HH:MM:SS) e.g. 16:43:22
Site Feature End time	The time that the feature activity ended, for example the end of sampling	SITE_FEA_END_TM	**Feature End Time** (time the collection, measurement, observation ended -using a 24hr clock at local time) (HH:MM:SS) e.g. 17:52:31 (Only if applicable)

Table 5: **Optional Elevation Data Associated with Projects, Sites or a Feature**

Logical Name	Element Definition	Physical Name (For Example Only)	Element Code, Code Range, or Examples
Elevation	The measure of the elevation of the project site above a reference datum.	PRJ_SITE_VERT	Float, will accommodate signed values
Elevation Units	The unit of measurement used to describe the elevation value.	PRJ_SITE_VERT_UNIT	Text field; example Meters Feet
Elevation Datum	The code for the reference datum used to determine the vertical measure	PRJ_SITE_VERT_DAT	Navd88 Ngvd29 Mean Sea-Level Local Tidal Datum Other
Elevation Collection Method	The technique used to establish the elevation or depth of the sampling site	PRJ_SITE_VERT_COLL_MTH	GPS Carrier Phase Static Relative Position GPS Carrier Phase Kinematic Relative Position GPS Code (Pseudo Range) Differential GPS Code (Pseudo Range) Precise Position GPS Code (Pseudo Range) Standard Position (Sa Off) GPS Code (Pseudo Range) Standard Position (Sa On) Other Altimetry Precise Leveling-Bench Mark Leveling-Non Bench Mark Control Points Trigonometric Leveling Photogrammetric Topographic Map Interpolation

Table 6: **Examples of Location and Time Reporting for Different Types of Features (Data Elements describing the features themselves are not included in this Table)**

Feature Name	**Examples of location/time reporting detail from data collectors** with limited data or GIS resources	**Examples of location/time reporting detail from *corporate* data collectors** with expanded data or GIS resources
Install Fish Screen	Location of screen: (Lat/Long dec degree). Date of install: YYYY-MM-DD	Location of screen: (Lat/Long dec degree) Date of install: YYYY-MM-DD
Stream Bank Stabilization	Start and end point of stabilization: (Lat/Long dec degree) Date of stabilization: YYYY-MM-DD	Polygon of stabilization area: (Lat/Long dec degree) Date of stabilization: YYYY-MM-DD
Riparian Area Treated	Start and end point (Lat/Long dec degree) Date of treatment: YYYY-MM-DD	Polygon of area treated: (Lat/Long dec degree) Date of treatment: YYYY-MM-DD
Road Obliteration Project	Start and end point (Lat/Long dec degree) Length of treatment (miles) Date of obliteration: YYYY-MM-DD	Line detail of road treatment: (Lat/Long dec degree) Date of obliteration: YYYY-MM-DD
Sediment Control Basin	Centroid of basin: (Lat/Long dec degree). Date of sediment control: YYYY-MM-DD	Polygon of basin: (Lat/Long dec degree) Date of sediment control: YYYY-MM-DD
Wetland Creation Project	Centroid of area created: (Lat/Long dec degree) Date of wetland creation: YYYY-MM-DD	Polygon of area created: (Lat/Long dec degree) Date of wetland creation: YYYY-MM-DD
Invasive Species Treatment	Centroid of treatment area: (Lat/Long dec degree) Date of treatment: YYYY-MM-DD	Polygon of treatment area (Lat/Long dec degree) Date of treatment: YYYY-MM-DD
Hatchery Fry/Smolt Release	Location of point of release (Lat/Long dec degree) Date of release: YYYY-MM-DD Time of release HH:MM:SS	Location of point of release: (Lat/Long dec degree) Date of release: YYYY-MM-DD, Time of release: HH:MM:SS
Sampling Site	Location: (Lat/Long dec degree) Date of sample: YYYY-MM-DD Time of Sample: HH:MM:SS	Location: (Lat/Long dec degree) Date of sample: YYYY-MM-DD, Time of Sample: HH:MM:SS
Livestock Exclusion Fencing	Start and end point: (Lat/Long dec degree)	Line detail: (Lat/Long dec degree)

Section III (F.3). Salmonid Field Protocols Handbook

The Salmonid Field Protocols Handbook is too large to include in this document. A preview of the Handbook can be found on the PNAMP website (link: http://www.pnamp.org/web/workgroups/FPM/documents/General/2006_1011SoSFPHpreview.pdf). An electronic version of the Handbook can be found on the State of the Salmon website (http://www.stateofthesalmon.org/page.php?pgID=72).

Section III (F.4). Methods for the collection and analysis of benthic macroinvertebrate assemblages in wadeable streams of the Pacific Northwest

Link to document on PNAMP website:
http://www.pnamp.org/web/workgroups/SC/meetings/2007_0821/2007_0612PNAMP_macroinvert_protocol_final.pdf

PACIFIC NORTHWEST AQUATIC MONITORING PARTNERSHIP (PNAMP)

METHODS FOR THE COLLECTION AND ANALYSIS OF BENTHIC MACROINVERTEBRATE ASSEMBLAGES IN WADEABLE STREAMS OF THE PACIFIC NORTHWEST

Suggested citation: Hayslip, Gretchen, editor. 2007. Methods for the collection and analysis of benthic macroinvertebrate assemblages in wadeable streams of the Pacific Northwest. Pacific Northwest Aquatic Monitoring Partnership, Cook, Washington.

TABLE OF CONTENTS

LIST OF TABLES

I. BACKGROUND AND OBJECTIVES

A. BACKGROUND AND PURPOSE OF THIS DOCUMENT

Benthic macroinvertebrates, or benthos, (benthic = bottom, macro = large, invertebrate = animal without a backbone) are organisms that live on the bottom of streams and rivers. The sampling protocols described in this document were designed to generate data sufficient to characterize the benthic macroinvertebrate assemblage and evaluate impacts from human caused disturbances. The purpose of this protocol is to characterize the macroinvertebrate assemblage for a stream reach as an indicator of biological integrity and stream health. It is not intended to characterize the condition of individual stream habitats or to provide data to analyze the macroinvertebrates as a food source for fish.

These protocols describe field, laboratory and data analysis protocols for benthic macroinvertebrates and do not cover safety issues which are covered in other documents (Peck et al., 2006). It is highly recommended that other physical habitat, biological and/or water quality data also be collected at any given site, however the protocols for this type of data will not be described in this document.

These benthic macroinvertebrate protocols apply only to streams that are perennial and wadeable. These protocols were synthesized from the following protocols:

- Oregon Department of Environmental Quality
- Washington Department of Ecology (Ecology, 2001)
- Multi-federal agency sponsored monitoring program (U.S.F.S., 2004)
- U.S. Environmental Protection Agency (EPA)'s Environmental Monitoring and Assessment Program (Peck et al., 2006)
- Bureau of Land Management (BLM)'s National Aquatic Monitoring Center (Hawkins et al., 2001)

These collection procedures, along with other environmental data, will allow analysis of biotic data with either multi-metric [e.g., an Index of Biotic Integrity (IBI)] or predictive models [e.g., River InVertebrate Prediction and Classification System (RIVPACS)] methods. Use of these procedures will allow users to share data, express their data in terms of standardized bioassessment measures, and thus directly compare their results with all other parties using these methods. Their general use does not preclude use of other sampling procedures that may be needed to address the specific objectives of individual projects.

In this document, we are attempting to strike a balance between providing flexibility while still ensuring that the resultant data are sufficiently compatible to be combined for analysis. There are subjects where there is agreement between all of the protocols listed above, for example mesh size. In these cases, we make a single recommendation. However, there are subjects where there is not such agreement, for example placement of the sampling device in the stream. For these subjects, we examined the different methods and as long as the different methods **did not** appreciably affect the ability of the data to be combined, we have included multiple recommendations.

B. RATIONALE FOR SELECTING THIS RESOURCE TO MONITOR

Macroinvertebrates are good indicators of watershed health because they live in the water for all or most of their life, are easy to collect, differ in their tolerance to amount and types of pollution/habitat alteration, can be identified in a laboratory, often live for more than one year; have limited mobility, and are integrators of environmental condition.

C. MEASURABLE OBJECTIVES

The presence and numbers of the different types of benthic macroinvertebrates provide accurate information about the health of a stream and watershed. It is the objective of the Clean Water Act - to "restore and maintain the chemical, physical and biological integrity of the Nation's waters". Biological integrity is commonly defined as "the ability to support and maintain a balanced, integrated, and adaptive community of organisms having a species composition, diversity and functional organization comparable to those of natural habitats within a region" (Karr, J. R. and D. R. Dudley. 1981).

II. SAMPLING DESIGN

A. RATIONAL FOR SELECTING THIS SAMPLING DESIGN OVER OTHERS

Overall sample site selection or design, including the distribution and location of sample sites, the number of sites to sample, etc., is not part of these protocols. These protocols are limited to actual sampling/collecting methods once the site has been selected. These protocols apply to most types of sampling designs that incorporate benthic macroinvertebrate sampling for wadeable streams.

B. SITE SELECTION

Stream reaches or sites for benthic macroinvertebrate monitoring are typically selected using either a targeted or probabilistic design depending on the study design. Sites selected using a targeted design generate data that is relevant for measuring impacts from a known source or answering other site specific questions. Sites selected using a probabilistic design provide information of the overall status or condition of the watershed, basin, or region. The type of sampling design chosen will depend upon the objectives of your monitoring program. These protocols apply to both targeted and probabilistic sampling designs.

C. SAMPLING FREQUENCY AND REPLICATION

Stream reaches or sites are sampled at a minimum of once during the index period. To address annual variation 10% of the sites or reaches in your study should be re-sampled annually. Targeting individual sites for sampling at the beginning and end of the index will generate data that explains temporal variation.

D. RECOMMENDED NUMBER AND LOCATION OF SAMPLING SITES

The number and location of your sampling reach or site will depend upon your monitoring objectives and sampling design.

E. RECOMMENDED FREQUENCY AND TIMING OF SAMPLING

Sampling and comparisons of data from the same seasons (or index periods) as the previous year's sampling provides some correction and minimization of annual variability. The index period recommended in this protocol is July 1st -October 15th. This is discussed in detail in section 3.

III. FIELD METHODS AND QUALITY ASSURANCE

A. FIELD METHODS

1. Type of Sampler

The most commonly used gear types in the Pacific Northwest are the D-frame kick net and Surber sampler. Either type of gear will work for the methods described below. An important factor in the choice of gear is the desire to be consistent with others in your state or watershed and/or to use an existing data set in your analysis. For many monitoring activities, this is likely to be the overriding factor in gear type selection. Cazier (1993) found very little difference between the sampler types for their use in the collection of organisms for bioassessment metrics in Northern Idaho Palouse streams. Barton and Metcalfe-Smith (1992) also found no differences in several benthic sampling devices for summarized index data. Cao et al (2005) compared surber and D-frame kicknet samples and found that subsamples with the same number of individuals were highly and consistently comparable between sampling devices.

D-frame kick net: The D-shaped frame for the net commonly used by laying the spine of the net firmly onto the stream bottom. The dimensions of the D-shaped frame are 1 ft. wide (along the spine) and 1 ft. tall where the widest part of the "D" attaches to a long pole. The net is either cone or bag-shaped for the capture of organisms. This type of net is easy to transport and can be used in a variety of habitat types. However, the D-net must have a defined or delimited area that is sampled/kicked. This area will either be $1ft^2$ or 1ft x 2ft.

Surber: The dimensions of the Surber frame are approximately 1 ft. x 1 ft.. It is horizontally placed on cobble substrate to delineate an approximately 1 ft^2 area. A vertical section of the frame has the net attached and captures the dislodged organisms from the sampling area. The use of the Surber is generally restricted to depths of less than 1 ft..

2. Mesh Size

The mesh size refers to the size of the openings in the net of the sampling device. A 500 µm mesh size is recommended for use in stream bioassessments in the Pacific Northwest regardless of the type of sampler (D-frame kick net or surber). A mesh size of approximately 500 µm is consistently used across all states and federal biological assessment programs in the Pacific Northwest.

3. Sample Reach Length

Sample reaches need to be long enough to incorporate local habitat-scale variation. In the Pacific Northwest, the use of sample reaches that increase in proportion to stream size (e.g. multiples of wetted- or bankfull stream width), is by far the most commonly used reach length method. Forty times the width of the sample reach length, while based on research related to fish assemblages, is also considered adequate for characterizing the benthic assemblage and the associated habitat. This length is adequate to insure that the repeating patterns of variation that are associated with riffle-pool sequences and meander bend morphology are accounted for most wadeable streams in the Pacific Northwest. At each site, the stream reach location is determined by identifying the lower end of the study unit and estimating an upstream distance of 40 times the average wetted stream width. Note that other parameters that you may be sampling such as physical habitat or fish community may influence the length of the sample reach. Use of this reach length identification strategy assumes the channel segment type does not change within the estimated distance.

4. Habitats sampled

Riffles (or fast moving water habitats, this document will use the term riffle for simplicity) are the primary habitat type recommended for sampling macroinvertebrates in the Pacific Northwest. Riffle areas have relatively fast currents, moderate to shallow depth, and cobble/gravel substrates. These areas generally have the most diverse macroinvertebrate assemblage. Also, standardization of field methods is simplified by using a single, readily identifiable habitat type. Throughout most of Washington, Oregon and Idaho, riffles are common features of wadeable streams. Past research has demonstrated that biological signals from riffles are consistent and easily detected from surveys in this habitat type.

We also provide a transect based approach in this protocol. It is useful in places where riffles do not occur or for programs that apply to very broad geographic areas. Gerth and Herlihy (2006) compared transect based and riffle sampling results and found that these sample type differences did not influence the detection of important environmental gradients.

5. Compositing

Compositing is taking multiple macroinvertebrates samples from the study reach and combining them into a single sample. From this combined sample, a portion of the sample is identified and enumerated in the laboratory. Carter and Resh (2001) found that across the nation 74.4% of state bioassessment programs composited their samples. The primary advantages of composting sample are that it is less expensive (one sample for laboratory analysis versus many samples) and that it represents more individual microhabitat patches. Compositing samples generates data sets with a larger amount of taxonomic information.

6. Area of stream bottom sampled

Due to the patchy nature of macroinvertebrate distribution, a very important factor is how much of the stream bottom is actually sampled. The area of stream bottom sampled will have significant consequences on how representative your sample is of a reach. Sampling larger areas will yield more species and therefore be more representative of the stream. However, there is a point of diminishing returns, combined with the feasibility (and habitat destruction) of collecting samples from an extremely large portion of the stream bottom. In the Palouse region of Washington and Idaho, Cazier (1993) found that 75% of the taxa were collected by sampling 5.3ft^2 of stream bottom and that 100% of the 45 taxa were collected within 19.4ft^2 of stream bottom. Clearly, collection of a single Surber sample is inadequate. Sampling from 8ft^2 of stream bottom is recommended. Be aware that the outcome of sampling a greater area be results with larger values (for both multi-metric indices and predictive models) than that produced from a standard 8ft^2 sample.

7. Number of samples in the composite

There is more that one method to attain a single composited sample that represents 8ft^2 of stream bottom. A total of 4 or 8 samples can be distributed within the reach length using the gear types described above. Taking more, smaller samples would increase the number of individual microhabitat patches encountered. However, there is little evidence, given a standard amount of stream bottom sampled (8ft^2), that there is a difference between using 4 or 8 samples to make up a composite sample. Therefore, the following are all recommendations for methods to distribute the sample collection sites within a reach. Macroinvertebrate samples should be taken from either:

- *4 different riffle habitats.* Two separate 1 ft^2 fixed-area samples are taken from each habitat unit for a total of 8 samples (a total of 8ft^2 of stream bottom sampled), or ;
- *8 different riffle habitats.* One 1 ft^2 fixed-area sample is taken from each habitat unit for a total of 8 samples, (a total of 8ft^2 of stream bottom sampled), or;
- *4 different fast-water habitats.* One 2 ft. by 1 ft. fixed area sample is taken from each habitat unit for a total of 4 samples (a total of 8ft^2 of stream bottom sampled).
- *8 evenly spaced transects along the reach.* One 1 ft^2 fixed-area sample is taken at 8 evenly spaced transects along the entire reach (a total of 8ft^2 of stream bottom sampled).

The 4 or 8 individual samples will be composited into a single sample for taxonomic identification and enumeration that will be used to represent the sample reach.

8. Placement of sampling device

Once the stream reach of interest has been identified, the selection of which riffle/fast-moving habitat(s) to sample within this reach needs to be decided (see above, Section III.A.7). Then once the riffle/fast-moving habitat is identified, the location within that riffle/fast-moving habitat of where the sampler is placed must be determined.

The transect-based method does not rely on the identification of riffle/fast-moving habitat(s). Once evenly spaced transects are laid out along the reach, place the ¼ of the way across the stream width on the left side. Then continue to sample at each transect, alternating between left, center (1/2 way across the stream) and right (3/4 of the way across) for each of the 8 transects.

For those methods, using riffle/fast-moving habitats, there are four primary methods for determining where to place your sampling device in the riffle/fast-moving habitat unit. They are referred to here as the random, systematic, grid, and best professional judgment methods. Any of these methods are acceptable, the random, systematic, or grid methods are recommended for field crews with less experience.

Random method: Determine net placement within riffle/fast-moving habitat by generating 2 pairs of random numbers between 0 and 9 for each sample. The first number in each pair (multiplied by 10) represents the percent upstream along the habitat unit's length. The second number in each pair represents the percent of the stream's width from bank left. Take samples where the length and width distances intersect (estimate by eye). If it is not possible to take a sample at the locations (log in the way, too deep, etc.), draw additional random numbers until you can.

Systematic method: The beginning sampling point either left side, center, or right side, within the riffle/fast-moving habitat is assigned at random using a die or other suitable means (e.g., digital watch). Once this first sampling point has determined, points at successive riffles are assigned in order (Left, Center, Right as you face downstream) as 25%, 50%, and 75% of the wetted width, respectively.

Grid method: Beginning at the downstream end of the reach, select the first riffle/fast-moving habitat and collect one sample from each riffle/fast-moving habitat. Visualize a 3 x 3 grid over each riffle/fast-moving habitat. As shown below, for the first habitat area, select the lower left square, for the second select the lower center; third, the lower right; etc.

7	8	
4	5	6
1	2	3

Best Professional Judgment method: A variety of riffle/fast-moving habitat habitats are chosen within the reach to ensure representativeness of the biological community. The locations within a reach are determined by finding representative combinations of the following variables: depth of riffle/fast-moving habitat, substrate size, and location within a riffle/fast-moving habitat area of the stream (forward, middle, back). This method assumes the largest variety of benthic macroinvertebrate taxa will be collected and that any differences identified through numerical analyses will represent change over time (if the same site) or divergence from a reference condition.

9. Field Processing

Field processing includes activities such as sorting, removing debris and sieving macroinvertebrate samples in the field. In the Pacific Northwest, generally very little field processing is done other than removing the largest pieces of organic debris (i.e. sticks) and rocks from the sample, after ensuring that any attached organisms are removed. Removal of these large objects from the sample reduces damage to the organisms and allows for a smaller sample so that less preservative is needed.

10. Preservatives

All states and other agency programs in the Pacific Northwest preserve organisms with ethanol ranging in concentration from 70 - 95%. The use of 95% ethanol is recommended. Care is taken that adequate quantity of preservative is used (i.e. 3 parts preservative to 1 part sample by volume) and that the preservative is added in a timely manner (within an hour or two of collection). This often requires that preservative be packed into the field. Preservatives should be added to the lip of the container and as much air removed as possible to minimize damage to the organisms.

11. Sampling season (index period)

Macroinvertebrate assemblages integrate stressor effects over the course of the year, and their seasonal cycles of abundance and taxa composition are fairly predictable within the limits of interannual variability (Gibson et al., 1996). Sampling and comparing data from the same season (or index period) as the previous year's sampling provides some correction and minimization of annual variability. The index period is a time frame during the year in which samples are collected and are assumed to contain uniformly representative life stages of species in the community.

The index period recommended in this protocol is July 1st -October 15th and it was chosen for the following reasons: adequate time is available for the instream environment to stabilize following natural disturbances (e.g. spring floods); many macroinvertebrates reach body sizes that can be readily identified, and; representation of benthic macroinvertebrate species reaches a maximum, particularly during periods of pre-emergence (typically mid-spring to late-summer).

Table 1 Summary of Field Method Recommendations

ISSUE	RECOMMENDATION
Type of Sampler	Either D-frame or Surber
Mesh Size	500 micron
Sample Reach Length	Depends on monitoring objectives, but generally 40 times the channel width.
Habitats sampled	Riffle (fast water habitat) or transect based
Area of stream bottom sampled	8 ft^2 of stream bottom (requires 4-8 subsamples).
Compositing	Yes, multiple samples are combined in the field into one sample for laboratory identification and enumeration.
Number of samples in composite	Multiple, either: **4 different riffle/fast-moving habitats** – two separate 1 ft^2 fixed-area samples from each riffle/fast-moving habitat for a total of 8 samples to composite, or ; **8 different riffle/fast-moving habitats** - one 1 ft^2 fixed-area sample from each riffle/fast-moving habitat for a total of 8 samples to composite, or; **4 different riffle/fast-moving habitats** - One 2 ft. by 1 ft. fixed area sample from each riffle/fast-moving habitat for a total of 4 samples to composite. **8 evenly spaced transects along the reach -** One 1 ft^2 fixed-area sample is taken at evenly spaced transects along the entire reach. **All methods total 8ft^2 stream bottom being sampled.**
Placement of sampling device	Any of the following methods are acceptable: Riffle/fast-moving habitats: **Random**: Determine net placement within each riffle/fast-moving habitat unit by generating 2 pairs of random numbers between 0 and 9. The first number in each pair (multiplied by 10) represents the percent upstream along the habitat unit's length. The second number in each pair represents the percent of the stream's width from bank left. Take samples where the length and width distances intersect (estimate by eye).

	Systematic: The beginning sampling point within the riffle/fast-moving habitat is selected at random, points at successive transects are selected in order as 25%, 50%, and 75% of the wetted width (left, center, right as you face downstream). **Grid method:** Beginning at the downstream end of the reach, select the first riffle/fast-moving habitat and collect one sample from each riffle/fast-moving habitat. Visualize a 3 x 3 grid over each riffle/fast-moving habitat. For the first habitat area, select the lower left square, for the second select the lower center; third, the lower right; etc. **Best Professional Judgment:** A variety of riffle/fast-moving habitat habitats are chosen within the reach by finding representative combinations of the following variables: depth of riffle/fast-moving habitat, substrate size, and location within a riffle/fast-moving habitat area of the stream (forward, middle, back). <u>Transect-based approach:</u> Once evenly spaced transects are laid out along the reach, place the ¼ of the way across the stream width on the left side. Then continue to sample at each transect, alternating between left, center (1/2 way across the stream) and right (3/4 of the way across) for each of the 8 transects.
Field Processing	Minimal removal of large material.
Preservatives (field)	95% ethanol
Sampling season (index period)	July 1 – October 15

B. FIELD QUALITY ASSURANCE

The overarching quality assurance objective for field data is to ensure that data of known quality are generated. To achieve this goal, data must be reviewed for 1) precision, 2) representativeness, 3) comparability, and 4) completeness.

1. Precision

Precision is the degree of agreement among repeated measurements of the same characteristic, or
parameter, and gives information about the consistency of methods. Precision is estimated by re-sampling 10% of the reaches sampled annually using the same protocols and the same field crew.

2. Representativeness

Representativeness is the extent to which measurements actually represent the true environmental condition. It is the degree to which data from the project accurately represent a particular characteristic of the watershed that is being tested. Representativeness of samples is ensured by adherence to standard field sampling and measurement and laboratory protocols. The sampling protocol is designed to produce consistent and repeatable results in each stream reach. Physical variability within riffle/fast-moving habitats is accounted for through sampling based on depth, substrate distribution, and location within the riffle habitat.

3. Completeness

Completeness is defined as the proportion of useable data gathered (Kirchmer and Lombard 2001). Sample loss is minimized with sturdy sample storage vessels, adequate labeling of each vessel, adequate and timely addition of preservatives. Sample contamination occurs when containers are improperly sealed or stored. Loss of benthic material or desiccation diminishes the integrity of the sample. The goal for completeness of benthic macroinvertebrate data sets is 95% of the total samples collected. Completeness is defined as the total number of samples that we are confident in using for further data analysis following field collection (Ecology, 2001).

4. Comparability

Comparability describes the confidence in comparing one data set to another. Comparability of data sets is primarily achieved through adherence to commonly accepted protocols (e.g. field sampling, analytical methods and objectives). The primary purpose for this document is to improve comparability among monitoring programs in the Pacific Northwest Region.

C. SEQUENCE OF EVENTS

- Check field equipment against list before leaving.
- Review protocols.

- Evaluate and delineate the reach (how this is done will depend upon your objectives and is not covered in this protocol).
- Collect or measure water quality parameters of interest (not covered in this protocol).
- Collect macroinvertebrates as described in section D.
- Conduct physical habitat site measurements (not covered in this protocol).
- Send macroinverebrate samples to the laboratory for identification and enumeration.

D. DETAILS OF TAKING MEASUREMENTS

Field procedures follow a sequence of measurements that ensure quality information is collected and a reasonable amount of time is spent at each site. Sampling will begin at the first fast-water habitat encountered at the site and will continue upstream with the next 3 (or 7) fast-water habitat units.

Once the location for sampling within the riffle/fast-moving habitat is determined, with the net opening facing into the flow of water, position the net quickly and securely on the stream bottom to eliminate gaps under the frame.

Collect benthic macroinvertebrates from within the $1ft^2$ (or 1ft x 2ft) sampling frame in front of the net. If no sampling frame is used, visually imagine the square sampling plot in front of the net and restrict your sampling to within that area.

Work from the upstream edge of the sampling plot backward and carefully pick up and rub stones directly in front of the net to remove attached animals. Quickly inspect each stone to make sure you have dislodged everything and then set it aside. If a rock is lodged in the stream bottom, rub it a few times concentrating on any cracks or indentations.

After removing all large stones, keeping the sampler securely in position, starting at the upstream end of the quadrat, vigorously kick the remaining finer substrate within the sampling area for 30 seconds.

Pull the net up out of the water. Immerse the net in the stream several times or splash the sides of the net with stream water to remove fine sediments and to concentrate organisms at the end of the net. After completing the sample, hold the net vertically and rinse material to the bottom of the net.

After taking a sample, empty the net's contents into the bucket. If the net has a cup at the end, remove the cup over the top of the bucket and wash it out.

Carefully transfer the material from the bucket (benthic macroinvertebrates and organic matter) into the sample jar. Inspect the bucket for any organisms that might remain. Remove any remaining organisms by hand and place in the sample jar.

Repeat the above procedure at the remaining riffle/fast-water habitats.

The composite sample will be preserved in one or more sample jars (generally one jar) depending on the amount of material collected.

The macroinvertebrate field samples are preserved in 95% ethanol.

Storage containers can be either heavy-duty freezer bags or plastic wide-mouth jars. Plastic wide-mouth jars are preferred. A double bag system is used when storing samples in freezer bags. Extra care must be taken when using freezer bags due to the increased risk of breakage and leakage that would result in sample loss and a hazardous situation. Sample labels are placed in the dry space between the inner- and outer freezer bags. Jars are labeled both inside with a paper label and outside on both the lid and bottle.

Label information should contain at the following information, at a minimum, the following: name of stream, date of collection, County and State, project name (if applicable), and collector's name.

IV. LABORATORY METHODS AND QUALITY ASSURANCE

After samples are collected in the field, they will be shipped to a taxonomic laboratory. While it is possible to conduct your own taxonomic identifications and enumerations, it requires a great deal of specialized knowledge. It is recommended that samples be sent to a laboratory that specializes in the identification and enumeration of macroinvertebrates and is familiar with the taxa from the Pacific Northwest.

A. LABORATORY METHODS

1. Subsampling/number of organisms identified

Taking a benthic sample and only using a fraction of the sample obtained from the field for identification and enumeration is called "subsampling". Subsampling has been crucial to the reduction in the cost and time associated with processing benthic samples (Barbour, et al. 1999). The goal of subsampling is to provide an unbiased representation of a larger sample (Barbour and Gerritsen, 1996). Subsampling procedures developed by Hilsenhoff (1987) and modified by Plafkin et al. (1989) were used in the original Rapid Bioassessment Protocols. Over half of the state bioassessment programs in the Nation use only a 100 organism count (Carter and Resh, 2001). In Rocky Mountain streams of Wyoming, it was found that a 200 organism subsample was adequate in terms of information return for the investment (Gerritsen et al., 1996). However, others (Kerans and Karr, 1994) have advocated identifying all organisms in the sample. Most agencies in the Pacific Northwest use a 300 to 500 organism subsample as a balance between maximizing the information obtained from a sample while keeping costs feasible. A 300 organism count is the minimal level recommended. However, if data will be analyzed using a predictive model (e.g., RIVPACS), then a 350 count or greater is recommended (Ostermiller and Hawkins, 2004).

2. Subsample approach: Fixed Count/known area of tray

A "fixed count" refers to approach where a predetermined number of organisms are sorted and numerated from a sample (not to be confused with actual sample size). It is useful for rapid return of data and appropriate for generation of proportional metrics. The most commonly use type of tray for this method is the Caton tray, which is a sampling tray with 30 6x6 cm grids.

3. Amount of tray area evaluated

The sample is spread out in the tray and grids are randomly selected. Macroinvertebrates are then picked out of the grid. A minimum of 3 randomly selected grids of the tray are evaluated until the desired number of organisms has be subsampled.

4. Large and Rare Organisms

After subsampling, the remainder of the sample is visually examined for large and rare organisms for a fixed amount of time (i.e. 10 minutes). These organisms are identified and added to the total taxa list either directly into the database or in the comments. In the scientific community there is some disagreement about whether to conduct these searches, and if they are conducted, what to do with the resulting data.

Vinson and Hawkins (1996) found that conducting a large-rare search before subsampling the remaining sample increased the number of taxa that will be encountered. They also found that adding these taxa to the raw taxa richness values (from subsamples with >300 organisms) produces data that are defensible regardless of the metrics that these data were used to calculate. VanSickle (2005) found that excluding rare taxa from predictive models either increased average predictive model or had no effect.
In the Pacific Northwest, the use of this method varies and is therefore an optional method depending upon the type of project.

5. Taxonomic levels and specific taxa

In the Pacific Northwest, most organisms are identified to the lowest practical taxonomic level (generally genus or species) by a qualified taxonomist using a dissecting microscope. Genus/species provides more accurate information on ecological relationships and sensitivity to environmental impairment. All States and most Federal agencies in the Pacific Northwest use lowest practical level (genus/species) of identification with the exception of oligochaetes, molluscs, microcrustaceans, and mites. Each taxa found in a sample is recorded and enumerated. Each taxa should also be assigned the appropriate Integrated Taxonomic Information System (ITIS) code.

Table 2 Summary of Laboratory Method Recommendations

ISSUE	RECOMMENDATION
Sub-sampling	Yes
Minimum number of organisms identified	500 optimal (300 minimum, 350 if using predictive models)
Subsample approach: Fixed Count/known area of tray	Yes
Amount of tray area evaluated	Minimum of 3 randomly selected grids of the Caton tray.
Large and rare search	Optional
Taxonomic level and specific taxa	Lowest practical level (genus/species) of identification with the exception of oligochaetes, molluscs, microcrustaceans, and mites.

B. LABORATORY QUALITY ASSURANCE

1. Macroinvertebrate Sorting

Precision of the sub-sampling process is evaluated by re-sorting a new sub-sample of the original samples. Ten percent of the benthic macroinvertebrate samples (e.g. 1 of 10 samples) are re-sorted by a second laboratory technician. Sorting results that are less than 95% similar would indicate the need for
more thorough distribution of sample materials in the sub-sampling tray or more special attention given to easily missed taxa when sorting (i.e. increased magnification).

2. Taxonomic Accuracy and Precision

Correct identification of benthic organisms is important for accurate description of community structure and function. Taxonomic misidentification results in inadequate stream biology characterization. Errors in identification of benthic macroinvertebrate taxa should be $\leq$ 5% of the total taxa in the sample. Re-identification of samples is done for 10% of the total number of samples collected in each year. Secondary identification is conducted by experienced taxonomists in order to maintain confidence in the data set. Difficult taxa are sent to museum curators whose specialty includes members of a particular taxa.

V. DATA HANDLING, ANALYSIS, AND REPORTING

In this section, we will describe how to handle, analyze and report macroinvertebrate data. This section will assume that you have collected your data according to the protocols described in this document and have sent your samples to a professional taxonomist for identification and enumeration.

A. METADATA

"Metadata" is data about the data. In the context of macroinvertebrate field data collection or laboratory identification and enumeration, the metadata would include who collected the data, who identified and enumerated the organisms, the project that the effort is a part of, when and where these tasks were completed, and what methods were used.

In designing a data collection and reporting effort it is important to identify how much data and metadata is needed and what is the most efficient way to collect it. It is possible, with thoughtful design to minimize duplication of data collection effort. For example a field form (or an electronic version of the same) might be designed to capture common metadata – for example project name, date of sample, data collectors name, sample site and method in a header - while variable information – sample numbers and other details are captured in a details section. This will depend on the individual circumstances, for example it may be that the location of sampling changes with each sample so that detail would need to be captured with each sample. When a system can be devised to capture common metadata it is necessary to develop a way to link the metadata to the detailed data. This can be completed with a code – often some combination of the data collectors name and date.

When you send your samples to the laboratory for taxonomic identification and enumeration, be sure to place both an exterior label and an interior label into each sample container. Use a soft lead pencil or waterproof marker on the labels for the following information (at a minimum):

Sample Identification -	sample number or alphanumeric code
Stream Name -	name of the stream where your sample was collected.
State -	name of the State
Latitude -	latitude* decimal degree
Longitude -	longitude* decimal degree
Sampling Date and Time -	date and time* when the sample was taken (YYYY-MM-
DD, HH:MM:SS	24hr clock)
Sampling Method -	description or citation of what field methods were used
Sampling area (ft^2) -	amount of stream bottom sampled, in this protocol ($8ft^2$)
Collector(s)	name(s) of people who collected the sample
Collector phone number	phone number of data collector (___) ___ ____
Collector e-mail	

If a sample must be divided between two or more containers, please indicate that clearly. For example, a single sample comprising 3 containers requires three separate labels marked (sample #) 1-3, (sample#) 2-3, (sample#) 3-3, or some equivalent. Sample numbers must be unique.

Note: The detail of minimum information above identifies minimum metadata information needed for collection of one sample (or possibly one sample in multiple containers). If many samples are being collected by the same person using the same methods, as is often the case, it may be more efficient to link the multiple sampling events to a common set of metadata using an appropriate code.

***Best Practices for Reporting Location and Time Related Data have been developed by the Northwest Environmental Data Network and are available at http://www.nwcouncil.org/ned/time.pdf**

There is also metadata that you will want to ensure that you receive back from the taxonomic laboratory for each sample. This could include:

Name of the taxonomist completing the identification and enumeration
Name of the Laboratory
Address of Laboratory
Date of Analysis
Method of analysis used

% of Sample Identified -	how much of the actual sample was used to obtain the desired number of organisms.
Number of Organisms -	the number of organisms identified in the laboratory

B. DATA ENTRY, VERIFICATION AND EDITING

In the taxonomic laboratory data will either be initially entered on bench sheets and then entered into an electronic database, or directly entered into an electronic data entry program. In either case, you should ask for a description of the analytical method used to help you determine the level of data quality for your data management system. The most common data entry mistakes include: typographic errors, duplicates, etc.

C. DATA FORMAT

From the taxonomic lab you will generally receive for each sample a taxa list with associated counts and often a list of community metric calculations (depending upon what you request). You may also request a biological reference table from the taxonomic lab which includes tolerance values, habits, feeding guilds and taxonomic codes for each taxon. You will also receive QA/QC reports for the project. You can receive your data both in hard copy and in an electronic format that you will need to specify such as: Access databases, Excel, etc. When you receive your data you should follow sound data management practices to maintain the original data and any derived data. You should clearly identify and mark the original data. In particular make sure that the data, and associated metadata is backed up using an approved method. Typically this involves creating a hard copy and keeping the copy at a secure site separate from the primary location of your work. The data management planning for the collection effort (see VIa) below should specify the steps you need to take. It is also important to make sure that a copy of the data is registered, where possible, with regional metadata portals or other repositories so that it can be located and used by other researchers for other purposes.

D. RECOMMENDATIONS FOR DATA ANALYSIS AND INTEPRETATION

This section is provided as an introduction to analyzing and interpreting aquatic macroinvertebrate sample results. The data collected by these protocols can be used for any of the analyses described below. Many different approaches have been used to prepare and analyze macroinvertebrate assemblage data. But they all start out with a list of macroinvertebrates that were collected, identified and counted. Depending upon your objectives, there are many other ways to examine macroinvertebrate assemblage data (such as ordination and other statistical tools) that are not presented in this document. The data analysis tools presented in this section those that are commonly used by State and Federal agencies to analyze and interpret macroinvertebrate data.

All of the data analysis procedures described in this document have as a foundation the concept of using a “reference condition” in order to determine divergence from expected conditions. Whether you develop this information yourself, or rely on what others have developed, the following is a brief description of the reference condition.

1. Reference Conditions

Reference conditions are the expectations on the state of aquatic biological communities (in this case macroinvertebrates) in the absence of human disturbance and pollution. For the purposes of assessing stream condition, biological integrity is defined as the biological attributes (species composition, diversity, functional organization) of anthropogenically undisturbed or minimally disturbed aquatic systems (reference condition). Impairment (diminished or lack of integrity) is evident when the biological attributes of a particular site differ from those of undisturbed or minimally disturbed systems. Biological changes in a waterbody that are associated with anthropogenic disturbances are evidence of impairment.

The reference condition establishes the basis for making comparisons and for detecting stream impairment. Depending upon the objectives of your monitoring activity, the reference condition can be defined on one of two scales. One scale is site specific, where the reference condition is specifically applicable to an individual waterbody. Another scale is ecoregional, where the reference condition represents biological expectations for streams across larger landscape areas (e.g., ecoregion scale).

Reference sites must be selected with care because the resulting database will be used as a benchmark against which test sites are compared. Additional information is available concerning reference site selection from many sources including Hughes, R.M. (1994), Plafkin et al. (1989), and U.S.EPA, (1996).

The State of Washington (Department of Ecology) monitors 10 reference sites annually throughout the State and calculates metrics, RIVPACs scores and provides IBI information. This information is available through the following website:
http://www.ecy.wa.gov/programs/eap/fw_benth/ambient.html#tenrefsites

2. Data Analysis

There are three major categories of data analyses that can be conducted with your macroinvertebrate data they are individual metrics, a biological index (often called an IBI, or Index of Biological Integrity) and predictive models (i.e. RIVPACs). The type of analysis you do will depend upon your capabilities, the type of questions that you are trying to answer (your monitoring objectives), the amount of data that you have and, if you are using existing reference condition, then type of tool that was used to develop this reference condition.

3. Individual Metrics

A quick and easily interpreted method for analyzing biological data is to evaluate individual metrics. A metric is a measurable characteristic of the macroinvertebrate assemblage that changes in some predictable way with increased human influence. Using a benthic macroinvertebrate taxa list several numerical values can be calculated. Many taxonomic labs will calculate these metrics for you. Calculated values are then compared to values from the reference condition. This is a useful and simple way to get a general idea of stream condition; however it is not appropriate for more regulatory decision making.

There are generally four categories of metrics (additional information can be found in Barbour, et al., 1999):

Taxa richness metrics, or the number of distinct taxa, represents the diversity within a sample. There are a variety of taxa richness metrics; the most common being total Taxa Richness which is simply the number of identified taxa within a sample. Taxa richness can also be evaluated as designated groupings of taxa, often as higher taxonomic groups (i.e., genera, families, orders, etc.) in assessment of invertebrate assemblages. For example, EPT richness, a commonly used metric, is the number of taxa in the sample that belong to the insect Orders Ephemeroptera, Plecoptera, and Trichoptera (EPT). These orders are commonly considered sensitive to pollution.

Composition metrics reflect key taxa and their relative abundance in the sample. Key taxa are those that are of special interest or ecologically important. For example, as noted above organisms in the insect order Plecoptera are a key taxa that are considered sensitive to pollution. Percentage of the assemblage that is made up of organisms in the order Plecoptera (% Plecoptera) generally decreases with increasing human influence.

Feeding group metrics provide information on the type and balance of feeding strategies (food acquisition and morphology) in the benthic assemblage. The taxonomic lab will generally provide you information on the functional feeding group for each taxa. Feeding groups include scrapers, shredders, gatherers, filterers, and predators. In stressed conditions there can be unstable food dynamics and an imbalance in functional feeding groups can result. For example, the metric of % shredders, which are generally considered more sensitive organisms and are thought to be well represented in healthy streams, will decrease with increased human disturbance.

Tolerance/Intolerance metrics are intended to be representative of relative sensitivity to perturbation and may include numbers of pollution tolerant and intolerant taxa or percent composition (Barbour et al. 1995). The taxonomic lab will generally provide you information on the tolerance/intolerance level for each taxa. An example metric in this category is percent of the organisms that are considered to be tolerant to pollution (% tolerant taxa) which generally increases with increasing stress.

Habit (or behavioral) metrics refer to the mechanisms for maintaining position and moving about in the aquatic environment (Merritt et al. 1996). Habit categories include movement and positioning mechanisms such as skaters, planktonic, divers, swimmers, clingers, sprawlers, climbers, burrowers. Percent clingers is a metric commonly used in the northwest.

4. Multimetric index

A multimetric index combines indicators, or metrics, into a single index value, often called an Index of Biological Integrity or IBI. The individual metrics that provide information on diverse biological attributes are integrated into an index to provide an overall indication of biological condition. This document will not cover how to develop an IBI, however, detailed methods for the multi-metric IBI development are outlined in Kerans and Karr (1994) and Barbour et al. (1999). Multi-metric Indexes (IBIs) that have been developed in the northwest and their applicability to data collected using the field protocol are cited in this document.

Use of a multi-metric index requires use of comparable field protocols and taxonomic laboratory protocols for generating biological data. Multi-metric indexes are developed for specific regions on the landscape and use of the analytical tool is restricted to streams within this region (i.e. small streams in the Puget Lowland ecoregion).

The Washington State Department of Ecology (Wiseman, 2003) has developed and calibrated multi-metric indices for the Puget Lowland and Cascades ecoregions. If you are sampling streams in either of these ecoregions using the protocol described in this document, then this index is applicable. Below are summary tables (Tables 3 and 4) showing the applicable metrics and scoring criteria for the indices developed for the Puget Lowlands (Table 3) and Cascades (Table 4) ecoregions. To use this index, following sample collection, the laboratory processing should include generation of the metrics described in one of the two tables depending on ecoregion of the stream.

Table 3 Scoring criteria for Puget Lowland metrics for Ecology's multi-metric index.

Category	Metric	Scoring Criteria		
		1	3	5
Richness	total richness	<24	24-33	>33
Richness	Ephemeroptera Richness	<4	4-6	>6
Richness	Plecoptera Richness	<3	3-5	>5
Richness	Trichoptera Richness	<4	4-6	>6
Tolerance	intolerant richness (bi)	<2	2	>2
Tolerance	% Tolerant (TV7)	>19	11-19	<11
Tolerance	% top 3 abundant	>70	54-70	<54
Trophic/Habit	% Predators	<11	11-19	>19
Trophic/Habit	% Clingers	<26	26-47	>47
Voltinism	Long-Lived Richness	<3	3-5	>5

Table 4 Scoring criteria for Cascade metrics for Ecology's multi-metric index.

Category	Metric	Scoring Criteria		
		1	3	5
Composition	% Ephemeroptera	<35	35-57	>57
Richness	total richness	<37	37-52	>52
Richness	Plecoptera Richness	<5	5-9	>9
Richness	Trichoptera Richness	<9	9-12	>12
Richness	Clinger Richness	<12	12-16	>16
Tolerance	intolerant richness	<6	6-9	>9
Tolerance	% Tolerant (bi)	>23	12-23	<12
Tolerance	HBI	>3.8	2.8-3.8	<2.8
Trophic/Habit	% Clingers	<36	36-54	>54
Trophic/Habit	% Filterers	>28	15-28	<15

The scores for each metric (1, 3 or 5) are then added for an overall index score. The minimum multi-metric index score possible is 9 and the maximum score is 50. This overall score is then assessed as good, fair and poor using the benchmarks in Table 5.

Table 5 Narrative assessments by Ecoregion using Ecology's index values

Narrative Assessment	Puget Lowlands	Cascades
Good	> 30	> 28
Fair	20-30	23-28
Poor	< 30	<23

If you are planning on using Ecology's index, you will need the additional detailed information on this index and is available from (Wiseman, 2003) at the following website:

http://www.ecy.wa.gov/programs/eap/fw_benth/index.html

Currently, multi-metric indexes are unavailable for other ecoregions in Washington State. Construction of this analytical tool is dependent on characterization of adequate numbers of reference sites within a landscape area.

In addition, EPA's Office of Research and Development developed a set of multi-metric indices for large ecological regions of the western United States (Table 6). Additional details on the application and development of these indices is available in Stoddard et al (2005a and 2005b) which is available at the following website:
http://www.epa.gov/wed/pages/publications/authored.htm

Table 6 Metrics from Stoddard et al (2005a and 2005b).

Mountains Ecoregion Metrics	Xeric Ecoregion Metrics
% non-insect individuals	% non-insect taxa
% individuals in top 5 taxa	Shannon Diversity
% omnivore taxa	Shredder taxa richness
% burrower individuals	% clinger taxa
EPT taxa richness	EPT taxa richness
% tolerant taxa	% non-tolerant taxa

5. RIVPACS (River InVertebrate Prediction and Classification System)

RIVPACs is an empirical (statistical) model that predicts the macroinvertebrate taxa that would be expected to occur at a site in the absence of environmental stress. The number of observed taxa (O) at a test site is divided by the expected taxa (E), yielding a ratio. A ratio of 1 indicates that all expected taxa are present. As a site becomes more degraded, fewer expected taxa are observed, yielding a smaller ratio.

If you have used the field and lab methods described in this protocol, you can use the RIVPACs model if a model is available for streams in your area. Companion information to the biological samples collected for each site serves as the "predictor" variables and are used for determining expected species composition. These predictor variables are often a mix of features that can be derived from map sources and some are from field measurements. You may need to collect additional water column and habitat variables in addition to macroinvertebrates to use RIVPACs. Additional detailed information is available at the Western Center for Monitoring and Assessment of Freshwater Ecosystems (Western Center) website:
www.cnr.usu.edu/wmc

In addition to information on constructing predictive models like RIVPACS, users can access the Western Center website to run data on existing models. Use of the software on the website requires manipulation and creation of input files that must be in text (ASCII) format. Because some data files may have more than 256 columns, you may not be able to use a spreadsheet program to manipulate and create these files. A full set of instructions for use of this on-line analytical tool is available from the web site.

The Western Center has constructed models for streams and rivers in Oregon, Washington, and Idaho, among other States and regions. These models all differ in their specific data requirements, largely associated with the predictor variables and level of taxonomy used to describe the biological community. When running these models, you will need to follow the specific data guidelines as well as the general guidelines outlined on the website.

For the State of Oregon, the Predictive Assessment Tool for Oregon (PREDATOR) consists of three regional RIVPACs type models that assess the biological integrity of wadeable streams. The Oregon Department of Environmental Quality (DEQ) developed the models with the intent of supplying a scientifically rigorous bioassessment tool that is easy to use and understand by a large audience. The overall goal is to promote better understanding of the conditions of Oregon's streams.

The Xerces Society for Invertebrate Conservation has developed a web guide for using Oregon DEQ's PREDATOR models. The information presented on the website below provides users with backgound to the model and guidance to convert existing data, run the models, and interpret your results.

http://www.xerces.org/aquatic/predator/predator.htm

VI. PERSONEL REQUIREMENTS AND TRAINING

A. ROLES AND RESPONSIBILITIES

Field operations can be completed with a minimum of two people to gather benthic macroinvertebrate samples and measure other environmental variables at each site. The project leader will design and
direct the biological monitoring project. The project leader should develop a brief plan of how the data will be collected, reported and subsequently managed as a part of the biological monitoring project design effort. A two page "Check List for Organizing Field Collection and Management of Data" can be used to guide this task and is available at http://www.nwcouncil.org/ned/Checklist.pdf. The plan will identify data management roles and responsibilities.

Laboratory identification and enumeration of benthic macroinvertebrates should be conducted by a laboratory with documented standard operating procedures.

B. QUALIFICATIONS

For the field collections, the personnel must be able to safely operate stream sampling equipment for measuring biological communities and physical variables.

The personnel who conduct the laboratory identification and enumeration must have sufficient knowledge and training to be able to identify organisms to the genus/species level.

C. TRAINING PROCEDURES

One advantage of field sampling of benthic macroinvertebrates is that it is relatively simple. A one day training session in the field with a experienced aquatic biologist should be sufficient for training in the field collection of benthic macroinvertebrates.

Laboratory sorting of benthic macroinvertebrates can be conducted by trained technicians. The amount of training that is required for sorting will depend upon the other duties, such as data management, that may or may not be assigned to the sorting technician.

The identification of benthic macroinvertebrates requires someone educated in aquatic biology and experience in taxonomic identification of benthic macroinvertebrates. This need for specialized experience is why this protocol recommends the use of a professional taxonomic lab.

VII. OPERATIONAL REQUIREMENTS
A. FACILITY AND EQUIPMENT NEEDS

The following are suggested lists of facility and equipment needs:

Field sampling equipment:
0.09 m^2 Surber sampler with 500 µm mesh net or D-frame kick net and 4 ft. handle
Buckets, plastic, 8-10 qt. Capacity
Sieve with 500µm mesh
Sieve bottom bucket, 500µm mesh openings
Wash bottle, 1-L capacity
White plastic wash tub
Plastic wide-mouth jars with screw caps
Small spatula, scoop or spoon to transfer sample
Forceps
Funnel with large bore spout
95% ethanol
Rubber gloves
Cooler
Labeling materials
Field data forms
If using a RIVPACs model, additional field equipment may be needed to collect predictor variable data

Laboratory equipment/supplies for macroinvertebrate identification:
Standardized gridded pan, such as a Caton tray, which is a sampling tray with 30 6X6 cm grids (30 cm x 36 cm)
500 micron sieve
Forceps
White plastic or enamel pan for sorting
Specimen vials with caps or stoppers
Sample labels
Dissecting microscope (generally 10x power)
Compound microscope
Light source
Ethanol
Laboratory data forms

Appropriate taxonomic keys, which should include, ***but are not limited to***:

- An Introduction to the Aquatic Insects of North America, 3rd ed. (Merritt and Cummins 1996), please note that a 4th edition is expected to be published this year.
- The Stoneflies (Plecoptera) of the Rocky Mountains (Baumann et al. 1977)
- Nymphs of North American Stonefly Genera (Plecoptera), 2nd ed. (Stewart and Stark 2002)

- Larvae of the North American Caddisfly Genera (Trichoptera), 2nd ed. (Wiggins, 1995)
- Manual of Nearctic Diptera, Volume 1 (McAlpine et al. 1981)
- Freshwater Snails (Mollusca: Gastropoda) of North America (Burch 1982)
- Pennak's Freshwater Invertebrates of the United States: Porifera to Crustacea, 4th Edition. (Smith 2001)
- Ecology and Classification of North American Freshwater Invertebrates, 2nd ed. (Thorp and Covich 2001)

B. STARTUP COSTS AND BUDGET CONSIDERATIONS

Another advantage of macroinvertebrate field sampling is that it requires little expensive equipment. The most expensive piece of equipment is probably the sampling net which ranges in price from $180-$500, depending upon the type of net chosen. The following are some potential sources for sampling gear.

Wildlife Supply Company
http://www.wildco.com/
800-799-8301

Ward's Natural Science
http://www.wardsci.com/
800-962-2660

BioQuip
http://www.bioquip.com/
310-667-8800

Forestry Suppliers, Inc.
http://www.forestry-suppliers.com/
800-647-5368

Sending benthic macroinvertebrate samples to a laboratory for taxonomic identification and enumeration generally costs around $200 to $350 per sample. This will depend upon many factors and you will need to get a more accurate estimate from the taxonomic lab of your choice. The Xerces Society (a non-profit organization) aquatic invertebrate conservation program provides a list of taxonomic laboratories in the Pacific Northwest (http://www.xerces.org/aquatic/).

VIII. REFERENCES

Barbour, M.T., J.B. Stribling, and J.R. Karr. 1995. Multimetric approach for establishing biocriteria and measuring biological condition. Pages 63-77 in W.S. Davis and T.P. Simon (editors). Biological assessment and criteria. Tools for water resource planning and decision making. Lewis Publishers, Boca Raton, Florida.

Barbour, M.T. and J. Gerritson, 1996. Subsampling of benthic samples: A defense of the fixed-count method. Journal of the North American Benthological Society 15(3):386-391.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition, EPA 841-B-99-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

Barton, D.R. and J.L. Metcalfe-Smith. 1992. A comparison of sampling techniques and summary indices for assessment of water quality in the Yamaska River, Québec, based on benthic macroinvertebrates. Environmental Monitoring and assessment 21:225-244.

Baumann, R.W., A.R. Gaufin, and R.F. Surdick. 1977. The Stoneflies (Plecoptera) of the Rocky Mountains. Memoirs of the Station Technical Bulletin. 134: 1- 152.

Burch, J.B. 1982. Freshwater snails (Mollusca: Gastropoda) of North America. EPA-600/382-026. United States E.P.A., Cincinnati, Ohio, 294 pp.

Cao, Y., C.P. Hawkins, and A.W. Storey. 2005. A method for measuring comparability of different sampling methods used in biological surveys: implications for data integration and synthesis. Freshwater Biology, 50:1105-1115.

Carter, J.L. and V.H. Resh .2001. After site selection and before data analysis: sampling, sorting, and laboratory procedures used in stream benthic macroinvertebrate monitoring programs by USA state agencies. Journal of the North American Benthological Society 20(4):658-682.

Cazier, L. D., 1993. Bioassessment of small agricultural streams: the Palouse-Camas Prairie Region of Northern Idaho. MS Thesis. University of Idaho.

Ecology, 2001. Benthic Macroinvertebrate Biological Monitoring Protocols for Rivers and Streams – 2001 Revision. Washington State Department of Ecology, Olympia, WA. Publication No. 01-03-028.

Edmondson, W.T. 1959. Freshwater Biology, 2nd ed. John Wiley & Sons, N.Y. 1248 pp.

Gerritsen, J., J.S. White and M.T. Barbour. 1996. Variability of stream habitat assessment and biological sampling: Middle Rockies, Wyoming. Wyoming Department of Environmental Quality, Sheridan, Wyoming.

Gerth, W.J. and A.T. Herlihy. 2006. Effect of sampling different habitat types in regional macroinvertebrate bioassessment surveys. Journal of the North American Benthological Society 25(2):501-512.

Gibson, G.R., M.T. Barbour, J.B. Stribling, J. Gerritsen, and J.R. Karr. 1996. Biological criteria: Technical guidance for streams and small rivers. U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA 822-B-96-001.

Hawkins, C., J. Ostermiller, M. Vinson, and R. J. Stevenson. 2001. Stream Algae, Invertebrate, and Environmental Sampling Associated with Biological Water Quality Assessments - Field Protocols. Utah State University, Logan, UT.

Hilsenhoff, W.L. 1987. An improved biotic index of organic stream pollution. Great Lakes Entomologist 20:31-39.

Hughes, R.M. 1994. Defining acceptable biological status by comparing with reference conditions. Pages 31-47 in W.S. Davis and T.P. Simon (editors). Biological assessment and criteria. Tools for water resource planning and decision making. Lewis Publishers, Boca Raton, Florida.

Karr, J.R., and D.R. Dudley. 1981. Ecological perspective on water quality goals. Environmental Management 5:55-68.

Kerans, B.L. and J.R. Karr. 1994. A benthic index of biotic integrity (B-IBI) for rivers of the Tennessee Valley. Ecological Applications 4:768-785.

Kirchmer, C.J. and S.M. Lombard. 2001. Guidelines for preparing quality assurance project plans for environmental studies. Washington State Department of Ecology, Environmental Assessment Program, Olympia, WA. Publication No. 01-03-003.

McAlpine, J.F., B.B. Peterson, G.E. Shewell, H.J. Teskey, J. R. Vockeroth, and D.M. Wood (coords.). 1981. Manual of Nearctic Diptera, Vol. 1. Research Branch of Agriculture Canada, Monograph 27, 674 pp.

Merritt R.W. and K.W. Cummins (eds). 1996. An Introduction to the Aquatic Insects of North America, 3rd ed. Kendall/Hunt Publishing Company, Dubuque, IA, 862 pp.

Merritt, R.W., K.W. Cummins, and V.H. Resh. 1996. Collecting, sampling, and rearing methods for aquatic insects. Pages 12-28 in R.W. Merritt and K.W. Cummins (editors). An introduction to the aquatic insects of North America. 3rd edition. Kendall/Hunt Publishing, Dubuque, Iowa.

Ostermiller, J.D. and C.P. Hawkins. 2004. Effects of sampling error on bioassessments of stream ecosystems: application to RIVPACS-type models. Journal of the North American Benthological Society, 23(2)363-382.

Peck, D. V., A. T. Herlihy, B. H. Hill, R. M. Hughes, P. R. Kaufmann, D. Klemm, J. M. Lazorchak, F. H. McCormick, S. A. Peterson, P. L. Ringold, T. Magee, and M. Cappaert. 2006. Environmental Monitoring and Assessment Program-Surface Waters Western Pilot Study: Field Operations Manual for Wadeable Streams. U.S. Environmental Protection Agency, Washington, DC, EPA/620/R-06/003.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid Bioassessment Protocols for use in Streams and Rivers; Benthic Macroinvertebrates and Fish. U.S. Environmental Protection Agency, Washington D.C. EPA-444/4-89-001.

Smith, D.G. 2001. Pennak's Freshwater Invertebrates of the United States: Porifera to Crustacea, 4th Edition. John Wiley & Sons; 4th edition.

Stewart, K. W., and B. P. Stark. Nymphs of North American Stonefly Genera (Plecoptera), 2nd ed. Columbus, OH: Caddis Press, 2002.

Stoddard, J.L., D.V. Peck, S.G. Paulsen, J. Van Sickle, C.P. Hawkins, A.T. Herlihy, R.M. Hughes, P.R. Kaufmann, D.P. Larsen, G. Lomnicky, A.R. Olsen, S.A. Peterson, P.L. Ringold, and T.R. Whittier. 2005a. Environmental Monitoring and Assessment Program: Western Streams and Rivers Statistical Summary. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC. EPA 620/R-05/006

Stoddard, J.L., D.V. Peck, A.R. Olsen, D.P. Larsen, J. Van Sickle, C.P. Hawkins, R.M. Hughes, T.R. Whittier, G. Lomnicky, A.T. Herlihy, P.R. Kaufmann, S.A. Peterson, P.L. Ringold, S.G. Paulsen, and R. Blair. 2005b. Environmental Monitoring and Assessment Program: Western Streams and Rivers Statistical Summary. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC. EPA 620/R-05/006

Thorp, J. H. and A. P. Covich. 2001. Ecology and Classification of North American Freshwater Invertebrates, 2nd Edition. Academic Press.

U.S. EPA. 1996. Biological Criteria: Technical Guidance for Streams and Small Rivers. U.S. EPA, Office of Water. EPA 822-B-96-001.

U.S. Forest Service. 2004. Field Protocol Manual - Aquatic and Riparian Effectiveness Monitoring Program - Regional Interagency Monitoring for the Northwest Forest Plan. Portland, Oregon.

VanSickle, J., D. P. Larsen and C. P. Hawkins, 2005. Presentation at the Northwest Biological Assessment Workgroup meeting. Port Townsend, Washington. “Excluding Rare Taxa Increases the Average Sensitivity of RIVPACS-type Predictive Models”.

Vinson, M.R. and C. P. Hawkins. 1996. Effects of sampling area and subsampling procedure on comparisons of taxa richness among streams. Journal of the North American Benthological Society 15(3):392-399.

Wiggins, G.B. 1995. Larvae of the North American caddisfly genera (Trichoptera), 2nd ed. University of Toronto Press, Toronto.

Wiseman, C.D., 2003. Multi-Metric Index Development for Biological Monitoring in Washington State Streams. Washington Department of Ecology, Olympia, WA. Publication No. 03-03-035.