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January 4, 2008

BRIEFING MEMORANDUM

TO: Council members

FROM: Peter Paquet, Manager Wildlife & Resident Fish

SUBJECT: Update on Data Management Workplan

PROPOSED ACTION:

No action is required is require at this time.

BACKGROUND

Over the last several months, the staff has discussed a number of strategies for addressing regional data management issues in a more comprehensive fashion. A general comprehensive framework for data management has been proposed and will likely be further developed through the upcoming Fish and Wildlife Program amendment process and direction from regional executives resulting from the October 2006 Executive Summit. In order to meet these needs, and to continue with ongoing processes and data management infrastructure there are a number of short-term needs that will need to be addressed during the remainder of FY 2008. The purpose of this memo is to initiate a discussion of the best way to meet these needs, including a recommended review and funding process to meet the needs of the Northwest Environmental Data-Network (NED) and other high priority data initiatives.

DISCUSSION

I. Three short-term actions are needed to progress toward more effective information management and sharing needed to manage the Fish and Wildlife Program.

A. First, at a broad scale, resource management agencies and others need to develop a common set of core information management practices and guidelines.

B. Second, critical data gaps must be addressed. Particularly important is the potential loss of orphan data sets and data that are not organized into database formats.

C. Finally, use incentives where possible to encourage agencies to adopt more effective information management practices. For instance, common data management tools and applications needed to be implemented in a manner that does not significantly increase the workload for data providers.

II. Specific actions include:

A. Realign existing projects within this framework

B. Create pilot efforts to address gaps

C. Identify the priority data that needs to move from collection to reporting to provide the most cost effective and accurate information to support decision-making. This may include data format, metrics, and general best practices for data collection to support management needs.

III. There is a need to develop strategies and guidelines to facilitate regional information management and exchange

A. Standards and/or best practices are being developed, documented and distributed for comment through NED and PNAMP. A regional dialog is needed to complete development of Best Practices and adopt deployment strategies.

B. NED has developed or is currently working on Best Practices recommendations and an implementation strategy for policy support. The following issues are being addressed:

1. Metadata and metadata tools. Metadata is essential for exchanging, sharing and using data. For distributed architectures they provide the basis for searchable indices of information

2. Geographic data guidelines: latitude and longitude, map coordinate datum and map coordinate projection.

3. Data management guidelines: for example common calendar/data policy, methods codes, regional data dictionary, common monitoring methods, codes and station names.

4. Quality assurance and quality control practices: Procedures and consistent approaches to complete quality assurance and quality checking. Users of data must be able to understand the quality of the data.

5. Documentation guidelines for derived data: Written material that explains how the product was generated and what assumptions were used. Much is maintained in a metadata record however, it is important that detailed descriptions of data derivation be maintained.

6. System security protocols: It is necessary to define security protocols and chain of custody, shared data sets, for example: who has ability to create, update, delete or edit data files. Users also need to know that the data is backed up and/or mirrored data sets are available.

C. Address critical data gaps

1. The StreamNet project will address salmon abundance and productivity gaps identified by Status Of The Resource (SOTR) and CSMEP by:

- a) Maintaining the functionality of the present system
- b) Reprioritizing data efforts as requested by NED/CBFWA DMFS work group to:
 - Update and expand SOTR abundance data
 - Develop pilot efforts to obtain productivity metrics
 - Provide services as needed for the CSMEP project
 - Develop a plan to address internal agency data flow bottlenecks

2. The Northwest Habitat Institute will address data gaps by:

- a) Maintaining the Interactive Biodiversity Information System and other existing data sets
- b) Updating and refining wildlife basin, ecoprovince, and sub-basin habitat maps, including a hierarchical approach for habitat mapping (coarse-scale to fine-scale).
- c) Develop wildlife, habitat, and GIS tools and services. Including developing and maintaining map services, a wildlife data collection tool on the Internet, a regional GIS Repository for wildlife and habitat data, and provide GIS support to state agencies and tribal organizations.
- d) Work with wildlife managers to develop, implement and support new Habitat Assessment protocols to evaluate mitigation and impact sites.
- e) Work with wildlife managers to develop a database for support of operational loss assessments (e.g. how operational changes affect wildlife populations and functional relationships) c.f. Scott Soltz (wildlife M&E white paper).

3. Provide one-time additional funds through HSRG to capture orphan data from the Hatchery Reform project and house and maintain them at StreamNet.

4. Identify tribal data management and sharing options and evaluate potential solutions through StreamNet.

5. Deploy the NED Internet Data Portal.

6. Use incentives/ business rules to implement change

a) There are five ways to provide incentives for implementing new information management practices – increase functionality and value, reducing overall cost of change, and increasing the available resources.

Increasing functionality and value – by providing access to more information; new reporting and decision support tools

Reducing cost – no single entity bears full cost of developing new practices; local costs are minimized by greater automation of procedures

Increasing resources – through collaborative efforts and shared staff expertise and applications

Add language to contracts requiring data management practices consistent with the NED Best Practices Guidelines and publishing to the Internet.

Developing policies and procedures that support the above practices

In order to address the above needs, NED has developed a draft workplan (Attachment 1) which identifies the tasks and funding for the remainder of FY 2008. Although funding estimates have been provided for each of the tasks, sources of those funds have not been identified. In some cases, funding may be contributed by participating agencies. For example, many NED coordination functions have been contributed by participating entities. Additionally, some tasks identified by NED as high priority would be covered through modifications of the StreamNet budget (Attachment 2).

ATTACHMENT 2

Work Plan Options for the StreamNet Project in Fiscal Year 2008

Bruce Schmidt
 StreamNet Program Manager
 2008/01/03

Option A, Level Funding. Contract in place

Under the fifth year of level funding, routine data operations will continue, but coverage will be decreased in Washington and Oregon, and will have to be decreased in Idaho next year. In Washington, data activities will occur as normal in the Lower Columbia, but will be dropped in the eastern Washington subbasins. In Oregon, work will be pursued on a subbasin by subbasin approach for all usual data types, but it is anticipated that with reduced staffing not all subbasins will be included by year end. Work in Idaho will focus on Chinook salmon and steelhead data only. The StreamNet library will need to drop journal subscriptions. All other work will continue.

Option B, Parity Staffing. Additional cost of \$290,675

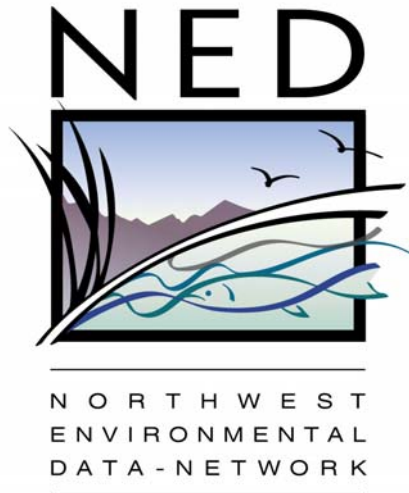
Parity staffing would restore staffing levels similar to those available at the beginning of the last funding cycle. Parity funding would restore full geographic coverage in the states, would provide abundance indicator data for all subbasins for the traditional species in the StreamNet database, would complete development of the ocean and mainstem harvest database, and would restore funding to continue journal subscriptions in the library. Data would be developed primarily for anadromous species and for resident species in Montana. This option also includes temporary data technician time for CSMEP data support services. This amount is only slightly above the MSRT recommended funding level for FY-08 of \$2,500,000.

Additional Data Development. Variable cost, depending on priorities selected.

This is additional data development, depending on regional priorities.

Work	Cost est
Option C. Extends data coverage in the states to all focal species	\$177,300
Tribal data sharing. Adds FTEs for anadromous and resident tribes	\$230,000
Capture hatchery evaluation data. Now included in HSRG contract	removed
Digitize StreamNet Library. Prerequisite to making most contents available on line, and preliminary to relocating library to smaller space to reduce cost.	\$72,900
Develop new data types. Cost estimates not fully developed: Hatchery Fraction on spawning grounds Size and sex composition on spawning grounds Comprehensive harvest data Smolt abundance Derived data, such as abundance estimates, productivity, etc. Hatchery releases, by individual locations and dates Documented occurrence/distribution Barriers (expand data) Diversions and screening Other data	

ATTACHMENT 2



DRAFT

NORTHWEST ENVIRONMENTAL DATA NETWORK

FY 2008 SUMMARY OF NED TASKS, NED PILOTS AND RELATED PILOTS

2007-12-11

1.0 Purpose and Rationale

The purpose of this **SUMMARY OF NED TASKS, NED PILOTS AND RELATED PILOTS** is to describe proposed Northwest Environmental Data-network (NED) efforts for the second year (FFY08) of the Phase II NED effort to develop resources, arrangements and capabilities for improved management of regional water quality, fishery and habitat data. Related Pilots, not sponsored through NED, but important for regional data management are also identified.

The proposed work follows the Phase I NED effort which completed a regional information study by Science Applications International Corporation (SAIC), *Recommendations for a Comprehensive and Cooperative Columbia River Information Management System*¹, and the development of a Northwest Environmental Data-network Memorandum of Understanding (MOU).

This work summary is guided by consideration of the findings and recommendations from the SAIC study (above) and other materials listed below.²

The Northwest Power and Conservation Council has supported a phased approach – to accomplishing regional data network improvements and this summary is consistent with that approach. The work summary:

- Is limited to the support of improved data management for fish and wildlife and their aquatic and terrestrial habitats as outlined in the Northwest Environmental Data-network MOU.
- Includes a strong emphasis on the development of protocols and standards and working with existing regional data entities.
- Complements efforts of the Pacific Northwest Aquatic Monitoring Partnership (PNAMP), Federal Columbia River Power System (FCRPS) recovery planning, the Pacific Northwest Regional Geographic Information Council (PNW-RGIC) and others.

¹ Recommendations for a Comprehensive and Cooperative Columbia River Information Management System, April 30, 2003. Submitted to the Northwest Power Planning Council (NPPC), by Science Applications International Corporation (SAIC)

²

Review of Databases Funded Through the Columbia River Basin Fish and Wildlife Program (ISRP 2000-3) May 11, 2000

Recommendations from Beyond Ad-Hoc Workshop: Organizing, Administering, and Funding a Northwest Environmental Data Network. Portland, Oregon, May 2005

Proposal for a Columbia River Basin Data Center. NPCC 4/24/2006, and comments received.

Review of NPCC Proposal for a Columbia River Basin Data Center. (ISAB 2006-5) July 18, 2006

- Includes pilot level and other efforts that together help to address the needs identified in the Council's Columbia River Basin Data Center Proposal.

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SUMMARY OF NED TASKS, NED PILOTS AND RELATED REGIONAL DATA MANAGEMENT PILOTS						
EXISTING NED WORK PLAN TASK	#	TASK DESCRIPTION	NED PRIORITY	Needed Resources/Estimated Cost	FISH and WILDLIFE Program Cost Share \$	REGIONAL Cost Share \$
CORE NED TASKS						
Develop Organizational and Administrative Arrangements for Regional Data Network.	1	<p>Identify and facilitate development and adoption of organizational and administrative arrangements to improve regional data sharing and networking.</p> <p>Identify and coordinate available staff resources for NED tasks (assigned, in-kind or through contracts).</p> <p>Provide briefings and outreach to regional executive managers and data managers, as needed.</p> <p>Make NED work plans and products available to inform Council or other decision makers on funding decisions for regional data projects; and for use in making solicitations on needed regional projects.</p>	High	NED Coordinator and Steering Committee can complete these tasks with annual base funding and in-kind staff contributions from participating entities. The annual base funding including all travel and overheads is. \$169K	?	Yes \$169K
Maintain a regional data network resource plan.	1A	<p>Develop and maintain a strategy to achieve improvements in regional data quality, quantity and access.</p> <p>Identify options, tasks and likely cost of completing parts of the strategy</p>	High – Other examples such as Puget Sound are not ranked	See #1 above..		Yes

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	1.A.1	<p>The FCRPS is currently evaluating a transition from current pilot data management efforts to a broader more regional approach.</p> <p>Before a broader regional approach can be adopted the FCRPS is expected to:</p> <p>Identify FCRPS regional data management needs and strategy, and solicit regional input and comments.</p> <p>Identify standards and protocols for collection, QA/QC, data management and dissemination of data that comply with regional needs.</p> <p>Evaluate the existing pilot efforts for their ability to satisfy these regional data needs and identify gaps.</p> <p>Propose a regional solution for FCRPS data management that integrates with existing regional data entities.</p> <p>Identify business rules, responsibilities and cost share agreement for collecting and managing FCRPS data.</p>		NED Coordinator and Steering Committee can participate in development of an FCRPS Strategy and Standards with annual base funding. However, FCRPS deployment, detailed cross walks, and framework development would require separate additional funding that is not detailed within this proposal.		
Coordinate across regional pilot efforts	2.A	Provide an advisory function to regional pilot efforts approved by the Council. See the suggested pilot efforts below.	High	NED Coordinator and Steering Committee can complete coordination of these efforts with annual base funding.		Yes
Identify sources and mechanisms for funding.	3.A	Identify equitable mechanisms and a process for funding regional data network projects.	High			Yes

Draft a Regional Data Sharing Agreement.	4.A	Coordinate development and adoption of data stewardship and sharing agreements to facilitate a regional data management framework. Time-line depends on specific needs of data-sharers.		Summit follow up task and coordination.		Yes
Inform data collection and management entities on the value of consistent regional data management protocols and encourage their use.	5.A	<p>Encourage the use of NED-developed or adopted data standards and protocols in agencies internal and external business practices – such as in contracting and program implementation.</p> <p>Develop/identify training and educational programs to promote understanding and advantages of data standards deployment.</p> <p>Meet directly with data source agencies to discuss their capabilities and needs related to data management.</p>		NED Coordinator and Steering Committee can complete this task with annual base funding. The USGS is providing in-kind metadata training at no cost to interested regional participants.		Yes
Develop and maintain tools that can support scientific and resource decision makers – See also NED Sponsored and Managed Pilot tasks 10-14 below	6.A	Develop protocols to provide access to regional data networks, and management systems as they become available, for fish and wildlife and their aquatic and terrestrial habitat and water data via the world wide web.		NED Coordinator and Steering Committee can complete this task with annual base funding.		Yes
	7.A	Maintain and update the NED web page.		NED Coordinator and Steering Committee can complete this task with annual base funding.		Yes
	8.A	Collaborate with Federal, State, Tribal and other entities including PNW-RGIC to identify, review and apply any applicable framework spatial and metadata requirements/guidance applicable to the Northwest region.		NED Coordinator and Steering Committee can complete this task with annual base funding.		Yes
<p>PILOT EFFORTS - NED SPONSORED AND MANAGED</p> <p>The need for these regional information management tools/services is well established, through SAIC reports to the Council, 2005 Workshop White Papers and other reports. The Council and NED SC have supported a regional strategy to move towards Portals and distributed approaches to data integration. If funded the NED Steering Committee will provide active support for each of these efforts and maintain interagency coordination.</p>						

<p>Support the NED Portal</p>	<p>10</p>	<p>NED has researched, deployed and is now beginning to populate a NED Portal. It is based on International Standards and is fully compliant with National Standards. Business rules for Portal operation and a data-sharing agreement for the use of participants have been finalized. To succeed, the Portal must be staffed and supported by an executive cross-agency commitment to publish data to the Portal. NED proposes pilot level deployment of the Portal for one year with one full time Portal Channel Steward. Longer term success will also require commitments from regional data providers and agencies to post the data to the web. NED recommends the use of a formal data sharing agreement to accomplish this.</p>	<p>High</p>	<p>Commitments are needed to fund a full time position (1 FTE) for one year for a Portal Channel Steward to manage Portal Content and a part time position (0.5FTE for one year) to maintain technical infrastructure. Currently the USGS/NBII program is considering funding about \$10K of the Channel Steward task. Including in-kind contributions from data providers.</p>	<p>??</p>	<p>\$175K</p>
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<p>Develop web supported data integration</p>	<p>11</p>	<p>Pilot a Distributed Database Management System for Salmonid Abundance and Trend data and link to water quality data. Develop or identify protocols and rules for sharing data using open standards protocols such as established XML Schema and "web mapping services". Pilot the use of DDBMS technology within the Portal to exchange regional data across existing databases. Leverage the use of technology already developed by the US EPA</p>	<p>Medium</p>	<p>Cost of establishing the protocols and initiating the network, including project management, is \$450K. Cost of establishing each Network node is \$50K. Suggested nodes in an initial pilot are StreamNet, ISEMP Integrated Status and Effectiveness Monitoring Program, CRITFC and OBMEP (Okanagan Basin Monitoring and Evaluation Program) over a period of 2 years. State of Washington has applied for 2008 funding to flow salmonid smolt data for Puget Sound and to identify project reporting needs and there may be an opportunity to collaborate with this effort. Note: Regional efforts such as NED are now eligible for EPA Challenge grants.</p>	<p>\$250K</p>	<p>\$250k</p>
<p>Improve data quality</p>	<p>12</p>	<p>Develop a draft Best Practices for Salmonid Trend and Abundance Data Quality Assurance and Quality Control. There is no standard or common approach to regional Data Quality Assurance and Control and this is a major impediment to comparing data collected by different groups. It is necessary to develop a standard QA/QC language and framework that can be applied, as a standard, to regional data collection efforts.</p>	<p>High</p>	<p>This task would be best completed through a consultancy. The cost including contract management is estimated at \$125-\$175K for a period of one year. An equal amount of in-kind staff contributions from participating entities would be expected.</p>	<p>\$75K</p>	<p>\$75K</p>

<p>Capture and maintain orphaned data sets.</p>	<p>13</p>	<p>Pilot Regional Data Recovery Effort. Many regional data sets are created without planning for their longer-term maintenance. This work is, therefore, at risk of being lost once the project is completed. The Hatchery Reform Project is an example of this problem. The Pilot will capture and integrate data created during the Hatchery Reform Project with other databases important for subbasin, provincial and ESA recovery planning efforts and the NED Portal. Experience gained during this Pilot will be used to develop a strategy for assessing the value of other regional data sets and a planning process to ensure that highly valued data sets are not lost to the region. This Pilot Project will be used as a case study for this effort and build off the lessons learned from the Sub basin Planning data recovery effort.</p>	<p>High</p>	<p>CRITFC will lead this effort and the cost will be about \$75K and will be provided through the HSRG process.</p>		<p>\$75K</p>
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<p>PILOT EFFORTS – SPONSORED and MANAGED OUTSIDE OF NED PROGRAM</p> <p>NED will coordinate with each of these efforts and incorporate into regional information mgt planning and review.</p>						
<p>Improve geo-referencing</p>	<p>14</p>	<p>Develop a regional NED locator that allows monitoring information as well as other ancillary data sets to be recorded within a Sub basin or watershed. Prototype Non-Aquatic Wildlife and Habitat Data Collection Tool. This proposal is initially targeting wildlife and their habitat data in upland and riparian areas and will include instream locations.</p>		<p>The NWHI would lead on this effort. Cost \$ \$78.5K. Additional grant has been submitted to Wildlife Conservation Society to work with State Conservation Strategies for \$53.2K. Total project cost is \$131.7K.</p>		

<p>Pilot Tribal Anadromous Fish Data</p>	<p>15</p>	<p>Most tribal anadromous fish data are not shared regionally because tribes generally lack IT infrastructure for this purpose. This Pilot will bring together the 6 tribes collecting these data to develop and test efficient tools and procedures for sharing tribal data. To the extent practicable, tribes will share tools and expertise, thus reducing pilot costs. Each tribe will use data from a salmon population typical of its program for the pilot. Procedures and data flows consistent with emerging regional standards and the subbasin planning data framework will be used. Information and metadata generated in this effort will be published and made available through the NED Portal.</p>		<p>CBFWA will coordinate management support for the three tribal data pilots through its technical committee structure. NED will coordinate technical oversight of the tribal pilots and with existing data projects. CRITFC will coordinate development of the anadromous fish data tools and procedures with the 6 participating tribes. Cost is expected to be about \$410,000 contracted through appropriate existing projects to expedite implementation.</p>		
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<p>Pilot Tribal Resident Fish Data</p>	<p>16</p>	<p>Most tribal resident fish data are not shared regionally because tribes generally lack IT infrastructure for this purpose. This Pilot will bring together tribes collecting these data to develop and test efficient tools and procedures for sharing tribal data. To the extent practicable, tribes will share tools and expertise, thus reducing pilot costs. Each tribe will use data from a resident fish project typical of its program for the pilot. Procedures and data flows consistent with emerging regional standards and the subbasin planning data framework will be used. Information and metadata generated in this effort will be published and made available through the NED Portal.</p>		<p>CBFWA will coordinate management support for the three tribal data pilots through its technical committee structure. NED will coordinate technical oversight of the tribal pilots and with existing data projects. MFWP and IDFG will coordinate with other entities to develop of the resident fish data tools and procedures with the participating tribes. Cost estimates will be available in February 07.</p>		
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<p>Pilot Tribal Wildlife Data</p>	<p>17</p>	<p>Most tribal wildlife data are not shared regionally because tribes generally lack IT infrastructure for this purpose. This Pilot will bring together tribes collecting these data to develop and test efficient tools and procedures for sharing tribal data. To the extent practicable, tribes will share tools and expertise, thus reducing pilot costs. Each tribe will use data from a wildlife project typical of its program for the pilot. Procedures and data flows consistent with emerging regional standards and the subbasin planning data framework will be used. Information and metadata generated in this effort will be published and made available through the NED Portal.</p>		<p>CBFWA will coordinate management support for the three tribal data pilots through its technical committee structure. NED will coordinate technical oversight of the tribal pilots and with existing data projects. NHI will coordinate development of the wildlife data tools and procedures with the participating tribes. Cost estimates will be available in February 07</p>		
<p>Pilot Regional Data Dictionary</p>	<p>18</p>	<p>The USBOR has taken the lead on developing a Protocol Manager (prototype). The PM tool and associated data dictionary is being applied and validated under ISEMP. The regional web-based deployment would be subject a separate request and a regional cost share. PNAMP is taking the lead to coordinate this work.</p>		<p>NED supports this effort as a high priority.</p>		

<p>Pilot Data Collection Standards</p>	<p>19</p>	<p>Data Collection Standards. PNAMP has taken the lead and begun the task of developing and proposing standard protocols for data collection. The PNAMP program is planning on being able to propose pilot standard protocols which would then require testing. PNAMP is best placed to complete this work and has prepared a separate budget request.</p>				
<p>Pilot Data Gap Inventory</p>	<p>20</p>	<p>CBFWA is developing a State of the Resource report and as a part of the effort is identifying gaps in Salmonid Trend and Abundance data.</p>				

Work Statement Summaries**TASK 1-9 Northwest Environmental Data Coordinator**

Coordination, Work Group Leadership and Outreach

- Coordinate Monthly Steering Committee Meetings
- Coordinate with Co-Chairs as needed
- Technical Support (where Coordinator's skills are appropriate)
- Outreach
- Program Planning and Evaluation

TASK 2-6 NED Summit Project

Northwest Environmental Data Network:

- Support for Executive Information Summit Products
- Coordination with Summit Executive
- Input to Summit Task 4

TASK 10 Deploy NED Portal

Data Channels and Data Steward Roles

- The objective of the NED Portal program is to direct scientific and resource management users of data to a consistent source of environmental geospatial and tabular data with related metadata.
- To achieve this objective, NED has established a data Portal that is intended to function as a significant source of regional data and related metadata and operate as a harvestable data resource for the National Geospatial One-Stop system at GeoData.gov.
- The term 'Channels' will be used to refer to both the Portal's Data Categories and multi- theme featured activities. Both are structured and managed similarly within the Portal.
- Channel Steward Roles and Responsibilities
- Complying with the Northwest Environmental Data Network (NED) Portal
- Data Sharing Agreement
- Customizing the content of the Channel page(s)
- General maintenance and update of the Channel content.
- Creating and fostering a Channel Community.
- Helping to support the harvesting of NED Data by GOS.

TASK 11 Distributed DDBMS for Fish Status, Trend Water Quality

Integrating Water and Water Quality Data and Habitat Data with Fish Data

- Nearly all regional data sets are currently maintained in user specific data management systems operated by different entities.
- Some collaborative systems with standardized data include: The Pacific Northwest Water Quality Data Exchange, StreamNet, ISEMP Washington Department of Ecology's EIM Database
- Current systems do not allow for effective integration and analysis of both fish and water quality data across tribal, state, federal and other institutions

PROPOSED EFFORT

- Collaborative state, tribal and federal effort to:
- Make selected fish data sets available via DDBMS technology,
- link these data sets to currently available water quality data sets from locations such as the PNW-WQX, and
- Identify analytic tools needed to provide reports and user queries on these data sets. The pilot level effort would be completed for selected data sets within the Columbia Basin, including some Tribal data sets that are currently not being integrated.

A prerequisite to success is to develop and expand the use of common exchange formats for fish data. Relevant formats for comparison purposes could include, StreamNet exchange definitions, data definitions identified by PNAMP and CSMEP and ISEMP.

The project would provide pilot deployment, testing and evaluation of the practical potential to deploy web service technologies to fish population data collection and dissemination in the Pacific Northwest – to improve the foundation for regional resource management decision making challenges.

Tasks for Pilot Water/Fish Data Integration:

- Develop a pilot project management structure.
- Identify exchangeable Pacific Northwest fish data sets
- Develop a regional data dictionary that identifies the fish data that must be exchanged.
- Develop data exchange formats for the fish data within the data dictionary.
- Develop a pilot exchange node for the fish data.
- Improve data warehouses/infrastructure at state F&W agency or regional level in the states of WA, ID, OR and MT such that those HQ offices could operate as “node clients” that could feed data to the network.
- Use standard metadata and Web Map and/or Feature Services to link the node clients to the NED Portal.
- Develop capability to routinely exchange data from the fish data nodes and the WQX data nodes, and then provide query and reporting tools for this data.
- Test operation of the system and fine tune
- Develop ongoing organizational and administrative arrangements for data exchange.

TASK 12 Development of Best Practices for Data Quality Assurance and Quality Control for Pacific Northwest Salmonid Data

- The Best Practices development work is primarily designed to meet the need identified in the Columbia Basin Data Center Proposal, at a regional level with a scope of work concerning QA/QC for salmonid population, abundance and productivity data that is collected, reported, managed and analyzed for harvest, hatchery, habitat and hydro and recovery operations in the Pacific Northwest.

TASK 13 Capture Hatchery Reform Data

- Obtain data and other information used by the Hatchery Reform Project.
- Integrate data developed by the Hatchery Reform Project with related data used for watershed assessments during subbasin planning.
- Make the Hatchery Reform and updated Subbasin Planning watershed assessment data available to regional users
- Publish Hatchery Metadata for harvest by the NED Portal

TASK 14 Wildlife and Habitat Data Collection Tool

- Operate, update and maintain IBIS in support of subbasin planning
- update and refine wildlife-habitat mapping at basin, ecoprovince, and subbasin levels and tie in high level indicators (HLI) so we can know state/status of the resource
- Develop wildlife, habitat and GIS tools and services, especially a) GIS repository to house and catalog spatial data of past and current BPA funded projects b) a tool to help record spatial and temporal project data, c) map services to enhance and maintain active and current links to the NED portal, Implement and updated Habitat Assessment protocols that are more ecologically based to evaluate mitigation and impact sites, and phase out the Habitat Evaluation Procedures (HEP) approach
- Create methodologies to assess operational losses due to hydropower development
- Monitor wildlife populations
- Developing wildlife, habitat and GIS tools and services

TASK 15 Tribal Anadromous and Resident Fish Data SOW

- This project will address the tribal data gap by documenting the tribal data holdings, evaluating and testing several available data management tools, and developing a data management and sharing strategy for each participating tribe. Implementation of these strategies is beyond the scope of this project.
 - Inventory and prioritize tribal anadromous and resident fish data for regional sharing
 - Identify existing tribal data management capacity
 - Evaluate tools and procedures for effective local data management and regional sharing of priority data
 - Develop recommendations for long term management of tribal anadromous and resident fish-related data

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January 4, 2008

DECISION MEMORANDUM

TO: Council members

FROM: Peter Paquet, Manager Wildlife & Resident Fish

SUBJECT: Public release of macroinvertebrate protocols

PROPOSED ACTION:

Release the Methods for Collection and Analysis of Benthic Macroinvertebrate Assemblages in Wadeable Streams of the Pacific Northwest document for public review and comment.

BACKGROUND

The Pacific Northwest Aquatic Monitoring Partnership (PNAMP) Steering Committee has requested (Attachment 1) that the new protocol: *Methods for the collection and analysis of benthic macroinvertebrate assemblages in wadeable streams of the Pacific Northwest* (Attachment 2) be adopted and implemented by PNAMP partners.

The sampling protocols described in this document are 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.

At this meeting staff is seeking Council approval to circulate the document for a comment period of 30 days. Following this, staff will seek Council approval of the document and recommend that Bonneville incorporate the protocols in future Fish and Wildlife Program implementation contracts. Additionally, staff would recommend that the Council include the approved Best Practices document as part of the guidance for the FY 2008 Fish and Wildlife Amendment Process.

C ncl mbrs

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JS
MW

December 3, 2007

2007012004

Mr. Tom Karier
Chair
Northwest Power and Conservation Council
851 SW Sixth Ave, Suite 851
Portland, OR 97204-1348

Dear Mr. Karier,

On behalf of the Steering Committee, I would like to inform you, as a member of the Executive Network of the Pacific Northwest Aquatic Monitoring Partnership (PNAMP), of a new recommendation emerging from PNAMP technical participants.

The Steering Committee has recommended that the new protocol: *Methods for the collection and analysis of benthic macroinvertebrate assemblages in wadeable streams of the Pacific Northwest* be adopted and implemented by PNAMP partners.

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.

This protocol describes field, laboratory and data analysis methods for benthic macroinvertebrates. It is highly recommended that other physical habitat, biological and/or water quality data also be collected at any given site. PNAMP continues to strive to produce recommendations regarding protocols for these types of data in the near future.

We recognize that integrating existing methods requires significant work by program staff and we would like to acknowledge the contribution of many experts to create this product. The concept for a standardized protocol on this topic emerged from the Northwest Biological Assessment Workgroup (NBAW) and the members of NBAW were primary contributors and reviewers of this product. This protocol was 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)

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- 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. However, nothing in the protocol or PNAMP's endorsement is intended to diminish existing authorities for information collection or reporting. However, we believe the adoption of consistent protocols for data collection can improve transparency and sharing of monitoring results.

If you have any concerns with this recommendation, please contact me or your representative to the PNAMP Steering Committee. Attached for your reference is the current roster of PNAMP signatories and names of the respective Executives and Steering Committee members.

Thank you for your continued support for the goals and principles of PNAMP.

Sincerely,



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Enclosures

Pacific Northwest Aquatic Monitoring Partnership Charter Signatories

cc: PNAMP Steering Committee

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Jane O'Keeffe, Oregon Watershed Enhancement Board
Jeff Koenings, Washington Department of Fish and Wildlife
Michael S. Mottice, US Bureau of Land Management
Brian Lipscomb, Columbia Basin Fish and Wildlife Authority
Frank Shipley, US Geological Survey
Kaleen Cottingham, WA Recreation Conservation Office

December 3, 2007

Pacific Northwest Aquatic Monitoring Partnership Charter Signatories

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
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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
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May 31, 2007

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.

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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 1ft² 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 ft² 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 compositing 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 5.3ft² of stream bottom and that 100% of the 45 taxa were collected within 19.4ft² of stream bottom. Clearly, collection of a single Surber sample is inadequate. Sampling from 8ft² 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 8ft² sample.

7. Number of samples in the composite

There is more than one method to attain a single composited sample that represents 8ft² 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 (8ft²), 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 ft² fixed-area samples are taken from each habitat unit for a total of 8 samples (a total of 8ft² of stream bottom sampled), or ;
- *8 different riffle habitats.* One 1 ft² fixed-area sample is taken from each habitat unit for a total of 8 samples, (a total of 8ft² 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 8ft² of stream bottom sampled).
- *8 evenly spaced transects along the reach.* One 1 ft² fixed-area sample is taken at 8 evenly spaced transects along the entire reach (a total of 8ft² 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 8ft² stream bottom being sampled.
Placement of sampling device	Any of the following methods are acceptable: <u>Riffle/fast-moving habitats:</u> 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 macroinvertebrate 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 1ft² (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.

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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 background 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 m² 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.

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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.