Integrated Aquatic Community and Water Quality Monitoring of Wadeable Streams in the Klamath Network...

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Natural Resource Stewardship and Science

Integrated Aquatic Community and Water Quality Monitoring of Wadeable Streams in the Klamath Network

Narrative and Standard Operating Procedures

Natural Resource Report NPS/KLMN/NRR—2013/669

ON THE COVER
West Branch Mill Creek, Redwood State and National Parks, September 2009
Photograph by: Mara Denny

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This report received formal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data, and whose background and expertise put them on par technically and scientifically with the authors of the information.

This report is available from the Klamath Inventory and Monitoring Network web site http://science.nature.nps.gov/im/units/klmn/index.cfm and the Natural Resource Publications Management web site (http://www.nature.nps.gov/publications/NRPM).

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Executive Summary

The long-term sampling protocol for wadeable streams in the Klamath Inventory and Monitoring Network is the result of a collaborative effort of park personnel and the Network staff. This protocol covers five of the six Network park units: Crater Lake National Park, Oregon Caves National Monument, Lassen Volcanic National Park, Redwood National and State Parks, and Whiskeytown National Recreation Area. Lava Beds National Monument is not covered due to lack of surface water resources.

Key steps covered in the narrative include a brief history of "water quality" monitoring and justification for use of key parameters as biomonitoring tools.

An always revisit panel design was chosen over more complicated designs based on: (1) Logistics of site establishment, (2) Trend detection, (3) Conceptual simplicity, and (4) Ease of data analysis. Sampling will occur every three years, in an alternating cycle. Cycle one will include the sampling of Whiskeytown National Recreation Area followed by Lassen Volcanic National Park. Cycle two, in the following year, will include sampling in Oregon Caves National Monument, followed by Redwood National and State Parks and conclude in Crater Lake National Park. This follows a pattern of sampling in lower elevational units early in the season, followed by the higher elevational parks. Target sample size is 30 stream reaches in every park, except Oregon Caves National Monument with a total of three stream reaches.

Parameters were selected for:

- It directly or indirectly addresses protocol objectives.
- It is mandated by National Park Service Water Resources Division.
- It can be used to develop or derive an index or indices that address protocol objectives.
- It places other parameters in a context to better address protocol objectives.
- It assists in making correlative statements between response variables and stressors.
- It is a cost-effective alternative to other parameters.

Parameters selected were: temperature, pH, conductance, dissolved oxygen, water level, acid neutralizing capacity, anions/cations, dissolved organic carbon, nutrients, oxidation/reduction potential, turbidity, substrate, instantaneous discharge, riparian and physical environmental measures, chlorophyll, and aquatic communities (vertebrates and benthic invertebrates). The protocol will also make use of a number of derived indices: Observed/Expected ratios of biodiversity and indices of biotic integrity.

Power analyses on multivariate community data, the sort collected in this protocol, are problematic, but high power was found in univariate measures based on community data (e.g., species richness). Power analyses were moderate to low for chemical parameters.

Twenty-four standard operating procedures are provided that detail all aspects of implementing the protocol, from the initial hiring and preparation, to the reporting of data and how to revise the protocol if revisions are needed.

The standard operating procedures includes a detailed Quality Assurance Project Plan (QAPP) that has been written to meet the requirements of the National Park Service, Water Resources Division, the State of California Surface Water Ambient Monitoring Program Quality Assurance Program, and the Klamath Network Data Management Plan. The QAPP addresses the needs of measurement quality objectives, sample contamination, field measurements, sample handling, instrumentation testing and calibration, and audits. The QAPP also include information on the preferred method to document cumulative bias, which arises when personnel, equipment, or contract laboratories are changed. The cumulative bias procedures will allow the crosswalk of data before and after changes are made to maintain the integrity of the data.

Data management of the data collected from this protocol is also detailed within the standard operating procedures, including database use, data entry, metadata guidelines, and archiving the data.

Reporting will consist of two primary report formats: Annual reports, produced every three years, and covering the basic summaries of the physical, chemical, and biological data collected for that year; and Analysis and Synthesis reports that will provide in-depth analyses covering classification and characterization of the wadeable streams, as well as trend analyses.

Eighteen appendixes are provided, covering important topics such as field safety (safety handbook and Job Hazard Analyses), field forms, equipment manuals, identification guides, and tolerance values used in analyzing the data.

Taken together, this protocol sets the standards for water quality monitoring wadeable streams for future monitoring in the Klamath Inventory and Monitoring Network.

Acknowledgments

Many individuals have contributed to the design and development of this protocol. Bob Hoffman (USGS) was instrumental in getting the ball rolling in the early stages of the Klamath Network aquatic monitoring projects, and did much of the background work. Park specialists have contributed at many stages and include: Nancy Nordensten, Mike Magnuson, Sean Eagan, John Roth, David Hering, Mark Buktenica, David Anderson, Vicki Ozaki, Brian Rasmussen, and Jennifer Gibson. Guidance on quality control, to improve the overall project, came from Roy Irwin (Water Resources Division). Within the Klamath Network, Dennis Odion and Sean Smith helped as experts in riparian vegetation. The pilot project field crew maintained a great spirit, despite the shifting nature of the pilot study: Travis Albert and Mara Denny. Elizabeth Perry deserves special mention for logistical support and her editing skills. Dave Herbst, 2 anonymous reviewers, and the staff at NPS Water Resources Division greatly improved the quality of the protocol in the review process.

1.0 Background and Objectives

1.1 Rationale for Integrated Monitoring of Streams

The National Park Service (NPS) recognizes that "aquatic resources are some of the most critical and biologically productive resources in the national park system" and that they "are vulnerable to degradation from activities both within and external to parks" (NPS 2000). Wadeable streams of the Klamath region are sensitive ecosystems and distribute water, sediments, and nutrients across landscapes. Consequently, streams integrate upstream processes of landscape scale impacts, such as land use and consumptive uses (e.g., water diversion or extraction) (Hynes 1975, Wang et al. 1997, Allan 2004, Allan and Castillo 2007). Stream communities serve as powerful monitoring tools to the watershed on multiple temporal scales including short-term impacts such as acute point-source stressors (e.g., sewage spills) and chronic long-term impacts such as non-point source stressors (e.g., sedimentation, climate change, livestock grazing, mining) (Rosenberg and Resh 1993, Karr and Chu 1999). Stream flow reflects mountain snowpack, spring-seeps, water table status, and direct precipitation (Leopold 1997), providing a linkage to atmospheric dynamics and synoptic stressors (e.g., climate change) (Meyer et al. 1999, Barnett et al. 2005). Within streams themselves, water flow acts as a "master variable," controlling geomorphic, nutrient transport, disturbance, and biological dispersal processes (Gray and Fisher 1981, Newbold 1992, Leopold 1997, Hart and Finelli 1999).

The Klamath Network vital sign selection process resulted in identifying two aquatic resource vital signs: Aquatic Communities and Water Quality (Sarr et al. 2007). Prioritization of these vital signs was driven by their ecological and management significance, legal requirements for management reporting, and their feasibility for monitoring. Generally, it was agreed by Klamath Network parks that monitoring should be integrative in nature and encompass physical, chemical, and biological characteristics of aquatic ecosystems. Current existing identified stressors of park aquatic resources included (1) climate change; (2) atmospheric deposition of pollutants and nutrients; (3) introduced and invasive species; (4) recreational visitor use; and (5) land use, including park maintenance activities. However, our multidisciplinary monitoring plan is not focused on specific stressors, either currently known or anticipated. Rather, we aim to develop a broad scheme focused on the overall ecosystem, so that any significant stressor effect may be detected. Although stream physical, chemical, and biological components compose different scientific disciplines, we chose to develop an integrated monitoring protocol to reflect the view of streams as integrative ecosystems within park landscapes.

Aquatic communities and water quality are intrinsically related. The "quality" of a water body is usually related to its ability to support life. In the words of Dr. Robert Wetzel, late Professor of Aquatic Ecology, University of North Carolina, Chapel Hill, "Water quality is biological" (Wetzel 2001). Hence, water quality goes beyond regulatory standards, and in this protocol we strive to use "water quality" in terms of the "natural conditions," and not just human consumptive needs. This is aligned with the broad purpose of the National Park Service in maintaining natural conditions "unimpaired for future generations."

Initial selection of aquatic communities and water quality did not discern between lentic (lake and pond) versus lotic (stream) habitats. Fundamental differences in ecosystem structure and process of streams versus lakes dictated a basic division in sampling methodology. Lentic sampling is covered in a separate protocol (Dinger et al. in review).

Streams are dynamic ecosystems that vary in time and space. The River Continuum Concept (Vannote et al. 1980) offers a conceptual framework for understanding linkages and importance of upstream processes (e.g., headwater streams) to downstream processes (e.g., lowland streams) (Figure 1). In brief, the River Continuum Concept lays out the idea that physical and biological conditions vary in predictable, interconnected, and cumulative ways from headwaters to ocean. For instance, in heavily forested headwater reaches, where stream channels are narrow, steep, and shaded, terrestrial (allochthonous) inputs such as falling leaves are processed (e.g., consumed by macroinvertebrates termed "shredders"), so that smaller particles are then consumed by biota downstream (macroinvertebrates termed "filterers"). As stream order increases, and riparian canopies cannot cover the wider channels, light impinging upon the stream bottom increases, and algal growth on stream substrates (termed "periphyton," autochthonous inputs) becomes the primary food source for organisms. With rivers deepening and widening further downstream, a secondary resource shift from periphyton to phytoplankton occurs, and rivers start to resemble lentic ecosystems. Fish assemblages shift, from fast water fish with high oxygen demands to slower water fish, and their feeding guilds change to reflect the changing food base and physical conditions. Because many watershed processes aggregate down the watershed, stream communities are not only indicative of local conditions but also are often a direct reflection of upstream biological and geological processes, including environmental impacts (e.g., Ward and Stanford 1983).

Water quality monitoring and stream bioassessments have a long history, and relationships to stressors go back to the 1850s (for example, the London sewage pollution of the River Thames, causing the "Year of the Great Stink" in 1858). Established effects of acid mine pollution (Gerhardt et al. 2004), thermal stress (Vinson 2001), denuding of riparian zones (Waters 1995), livestock grazing (Armour et al. 1994), sewage impacts (Whitehurst and Lindsey 1990), exotic invasive species (Hall et al. 2006), and sediment pollution (Waters 1995) have all been studied, establishing stressor-response relationships, providing a rich context for monitoring and bioassessment. Consequently, aquatic habitats are known to respond to physical and biological stressors in predictable ways (e.g., Resh and Rosenberg 1984, Rosenberg and Resh 1993). As temperature-sensitive organisms with known stress responses, aquatic communities provide important indication and aid in interpretation of environmental alterations such as climate change.

Since streams are integrated ecosystems central to park landscapes, we have chosen to monitor physical, biological, and chemical parameters in concert. These varied parameters provide a broad view of change in time and space. For instance, macroinvertebrate assemblages respond rapidly to impacts, while fish and amphibians (with longer life cycles) will demonstrate longer duration, time-integrated responses. Changes in geomorphic and riparian vegetation features manifest at yet longer time scales. The use of multiple indicators for measuring ecosystem change will provide us with an integrated and robust system for interpreting natural dynamics, and detecting trends in key ecological features and diverse impacts over time.

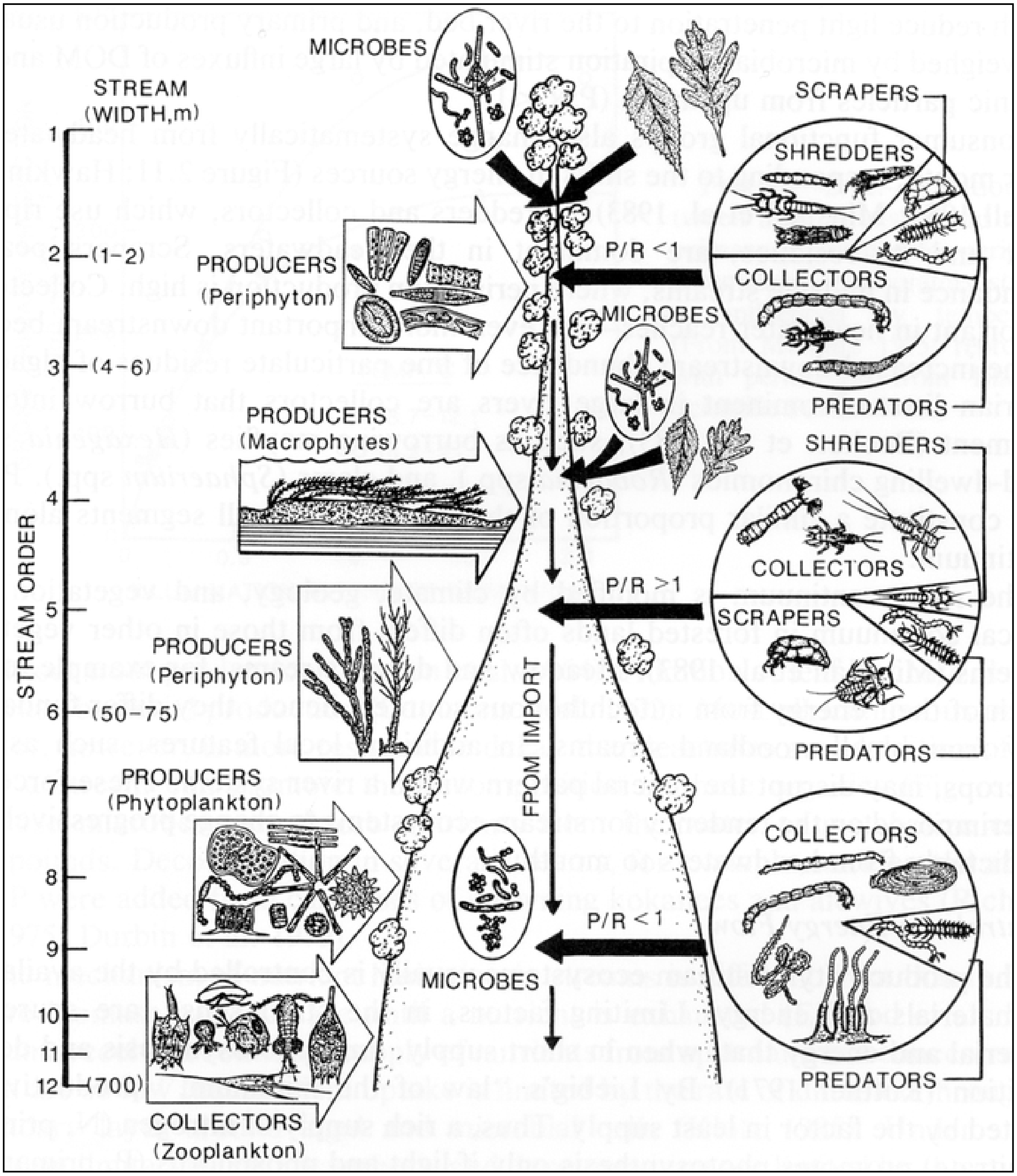

Figure 1. Conceptual model of stream ecosystems known as the River Continuum Concept, showing changes in aquatic community along a downstream gradient (from Vannote et al. 1980).

1.2 Link to National and Regional Strategies

Current stream monitoring is carried out by many agencies, all with differing protocols and objectives:

- County Health Departments
- State agencies:
  - Departments of Environmental Quality
  - Departments of Game and Fish
  - Departments of Forestry
- Federal agencies:
  - USDI Bureau of Land Management
  - USDI United States Geological Survey
  - USDA Forest Service
  - USDI Environmental Protection Agency
  - USDI National Park Service
  - USDI Bureau of Reclamation

The monitoring objectives of each agency dictate different approaches to sampling design and protocols. For example, the objectives of the US Forest Service (USFS) Upper Columbia Basin effectiveness monitoring program (PACFISH/INFISH Biological Opinion, PIBO) focuses on salmonid habitat assessment and surveys over 250 Upper Columbia Basin sites every year. The Environmental Protection Agency (EPA), through the EMAP (Environmental Monitoring and Assessment Program) project aimed to develop monitoring tools for a range of end-users over the entire western US and to conduct Wadeable Streams Assessments every 5 years in the National Rivers and Stream Assessment (NRSA). Bureau of Land Management (BLM) aquatic monitoring programs are more project-specific (e.g., monitoring aquatic macroinvertebrates in specific drainages containing acid mine effects) and to date are not under any national BLM plan. They are also dependent upon district or regional offices to determine specific protocols, with monitoring often done in conjunction with partners (for example, the PIBO project by the USFS includes BLM lands). However, the BLM is currently taking steps to develop a national probabilistic monitoring design in conjunction with the Utah State University National Aquatic Monitoring Center. The United States Geological Survey (USGS) has developed protocols under the National Water-Quality Assessment (NAWQA) program, which focuses on targeted-site designs to study the causes of water quality problems. Bureau of Reclamation monitoring protocols are also project-specific, and vary accordingly.

State agency monitoring is focused on ensuring that waterways meet water quality standards for listed beneficial uses (including fish and wildlife) established by state and federal law (e.g., Endangered Species Act, Clean Water Act). In California, stream monitoring is overseen by the Surface Water Ambient Monitoring Program (SWAMP) of the State Water Resources Control Board. The SWAMP program established stream monitoring protocols (Ode 2007) that are used by individual state agencies conducting stream monitoring (Regional Water Quality Control Boards, California Department of Fish and Game, municipalities, counties, etc.). The SWAMP protocols are close modifications of the EPA EMAP program. In Oregon, the task of stream monitoring is split between two state agencies: Department of Fish and Wildlife (ODFW) and Department of Environmental Quality (ODEQ). The ODFW conducts habitat and fish surveys, whereas the ODEQ conducts macroinvertebrate and water quality analyses. The ODFW habitat and fish protocols are derived from protocols developed at Oregon State University, in conjunction with USFS researchers. The ODEQ protocols focus on macroinvertebrate collection (EMAP based), water chemistry, and continuous monitoring.

Lastly, the National Park Service is implementing nationwide water quality monitoring through the Inventory and Monitoring Program. However, the vital sign selection process, unique to each network, along with varied resource concerns specific to networks have resulted in different approaches to water quality monitoring. For example, the Cumberland Piedmont Network is monitoring selected water quality parameters (pH, acid neutralizing capacity, nutrients), all through water samples on a monthly or bimonthly basis. The Cumberland Piedmont protocol does not sample the biological communities or physical habitat parameters. However, each network performing water monitoring is required to sample a set of "core" parameters (pH, temperature, conductivity, dissolved oxygen), but the methodology and frequency vary from network to network. A brief overview of the Inventory and Monitoring networks in the western US, and their protocol status, is given in Table 1.

In the Klamath Network, we selected parameters to meet the needs of our parks. Methodology was selected from three existing protocols: (1) EMAP, (2) ODEQ, and (3) SWAMP. The specific

Table 1. Summary of western US NPS Inventory and Monitoring Network stream monitoring protocols. All parameters listed are for streams; many are still in development. Networks may be monitoring other indicators in other habitats (spring-seeps, lakes, etc.). DEQ = Department of Environmental Quality; NAWQA = National Water-Quality Assessment; EMAP = Ecological Monitoring and Assessment Program; SWAMP = Surface Water Ambient Monitoring Program. PIBO = PACFISH/INFISH Biological Opinion. Note that Wyoming and Montana DEQ protocols are based on EMAP.

Network	Parameters	Protocol Sources
Greater Yellowstone	Chemistry, macroinvertebrates	Wyoming and Montana DEQ, NAWQA
Mediterranean Coast	Amphibians, fish	USGS Amphibian protocols (Corn et al. 2005)
Mojave Desert	Water quality, stream discharge	Unknown - still in draft stage
North Coast and Cascades	Fish	Unknown - still in draft stage
Northern Colorado Plateau	Chemistry	Utah DEQ, USGS
Rocky Mountain	Macroinvertebrates, periphyton, chemistry, habitat	EMAP
San Francisco Bay Area	Stream flow, water quality, fish	EMAP, SWAMP
Sierra Nevada	Chemistry	
Sonoran Desert	Fish, macroinvertebrates, periphyton, water quality, physical	EMAP
Southern Colorado Plateau	Chemistry, macroinvertebrates	NAQWA
Upper Columbia Basin	Continuous (pH, DO, temperature, etc.), macroinvertebrates, habitat	EMAP, PIBO

methods were those that best matched our needs. Deviations from these protocols are based on logistic or budgetary necessities and are detailed below. In most cases, measured parameters will allow comparisons, and deviations are omitted parameters, rather than different measurement techniques.

1.3 Monitoring History

Past monitoring, research, and aquatic resources in Klamath Network park units was summarized in the Network's Phase II Water Quality Report (Hoffman et al. 2005). The comprehensive summary therein should serve as the primary source for integrating future monitoring into historical context. However, special attention to specific, ongoing research and monitoring programs within each park served to inform this protocol. Most of these projects are stressor/response driven (e.g., specific sedimentation monitoring due to abandoned logging roads in RNSP) or inventory projects. In integrating these projects in the current monitoring protocol, we found that the best strategy is to use our protocol to supplement ongoing monitoring, e.g., adding macroinvertebrate and riparian monitoring to the ongoing sediment monitoring.

1.3.1 Crater Lake National Park (CRLA)

The bulk of monitoring and research projects in CRLA have occurred within the caldera and in Crater Lake proper. Extra-caldera monitoring and research has focused on exotic brook trout (*Salvelinus fontinalis*) eradication and restoration of bull trout (*S. confluentus*) in Sun Creek. Other studies have included amphibian and fisheries surveys (e.g., Bergmann 1997 [Amphibians], Wallis 1947 [trout]) or flow and water chemistry (Frank and Harris 1969).

1.3.2 Lassen Volcanic National Park (LAVO)

Aquatic monitoring and research in LAVO have focused on either lake inventories, with associated fish and amphibians (e.g., Stead et al. 2005, Parker 2008), or on geothermal hot springs (e.g., Thompson 1983, Siering et al. 2006). Existing water quality data are summarized in a NPS Water Resource Division Baseline Water Quality Data Inventory and Analysis report (NPS-WRD 1999). Very little has been done in the streams of LAVO.

1.3.3 Oregon Caves National Monument (ORCA)

The NPS WRD Baseline Water Quality Data Inventory and Analysis report (NPS-WRD 1998) for ORCA lists 19 water quality stations within the park: 11 in the cave and 8 outside the cave. These stations are limited to water chemistry (including temperature, dissolved oxygen, etc.). There have been no biological surveys or physical habitat surveys of Cave Creek or Panther Creek (the two named creeks in the park), although the cave habitats and fauna have been surveyed (Roth 1994).

1.3.4 Redwood National and State Parks (RNSP)

The streams and creeks of RNSP (RNSP is as an alternative acronym to REDW to denote that state parks are included in the sampling) have a rich and diverse history of monitoring and research projects. Activities within RNSP have been driven by two factors: (1) Clean Water Act impaired streams [303(d) streams] and (2) threatened and endangered species. Redwood Creek, in the southern portion of the park, has been the subject of extensive sediment, temperature, and geomorphic monitoring, which remains a high priority (Hoffman et al. 2005). Within Redwood Creek, fisheries studies have included: invertebrate drift/juvenile salmonid habitat (Anderson 1981), migration (McKeon 1985), fish food habits, coho salmon (*Oncorhynchus kisutch*) monitoring (Anderson 1994), spawning surveys (1991 to 2003, e.g., Pacific Coast Fish, Wildlife, and Wetlands Restoration Association 2002), and steelhead (*O. mykiss*) monitoring (1991 – 2002, e.g., McCanne 2002).

Other monitoring in RNSP has included multiple studies of fish distribution, organic debris (woody debris), and fish redd (fish egg deposition locations) composition studies. Timber industry has also done monitoring of select parameters in portions of RNSP watershed (e.g., Stone 1994). An additional 18 assorted Masters theses from Humboldt State University have been completed in and around RNSP (Hoffman et al. 2005). Historic and active restoration of abandoned logging roads and associated erosion control efforts has also accumulated a large body of monitoring data (Hoffman et al. 2005).

Since the historic and ongoing monitoring have been stressor driven (e.g., temperature and sediment), species-specific (e.g., coho salmon), and/or site-specific (e.g., Redwood Creek), the current monitoring protocol has been designed to *supplement, and not supplant* the ongoing monitoring.

1.3.5 Whiskeytown National Recreation Area (WHIS)
Monitoring at WHIS has historically been short-termed projects, with the exception of long-term monitoring in the reservoir, or on Clear and Willow Creeks (NPS-WRD 2000). The monitoring on Clear and Willow Creeks has been sporadic, and one site on Clear Creek has a 20 year record, but with only seven observations within that time frame. Most of this monitoring has been standard water quality variables (i.e., pH, temperature, conductance) or occasional heavy metal monitoring (e.g., copper, zinc, cadmium).

Other short-term programs have occurred since 1995, primarily in the form of USGS projects. One focused on mercury in aquatic biota (Primary Investigator: R. L. Hothem), while the other focused on overall aquatic biota, habitat, and water quality in all the watersheds of WHIS (Primary Investigator: J. T. May) (Hoffman et al. 2005). Neither of these has produced USGS technical reports or other reports. Amphibians and turtles in WHIS have been actively surveyed by USGS researchers (Bury et al. 2002).

1.4 Integrated Conceptual Model of Aquatic Communities and Water Quality
The Klamath Network presented graphical conceptual models supporting its overall monitoring design in their vital signs monitoring plan (Sarr et al. 2007). The models outlined a conceptual approach for combining water quality and aquatic communities into a unified protocol (Figure 2) that encompasses ecosystem composition, structure, and function (Figure 3). For example, we will monitor the ecosystem structure of streams (e.g., riparian cover, instream substrate, discharge) and aquatic community composition (fish, macroinvertebrates, amphibians, algal biomass). These parameters, combined with multiple water chemistry parameters (e.g., pH, alkalinity, and nutrients), will give us the opportunity to describe and evaluate functional aspects of the trophic structure of these ecosystems.

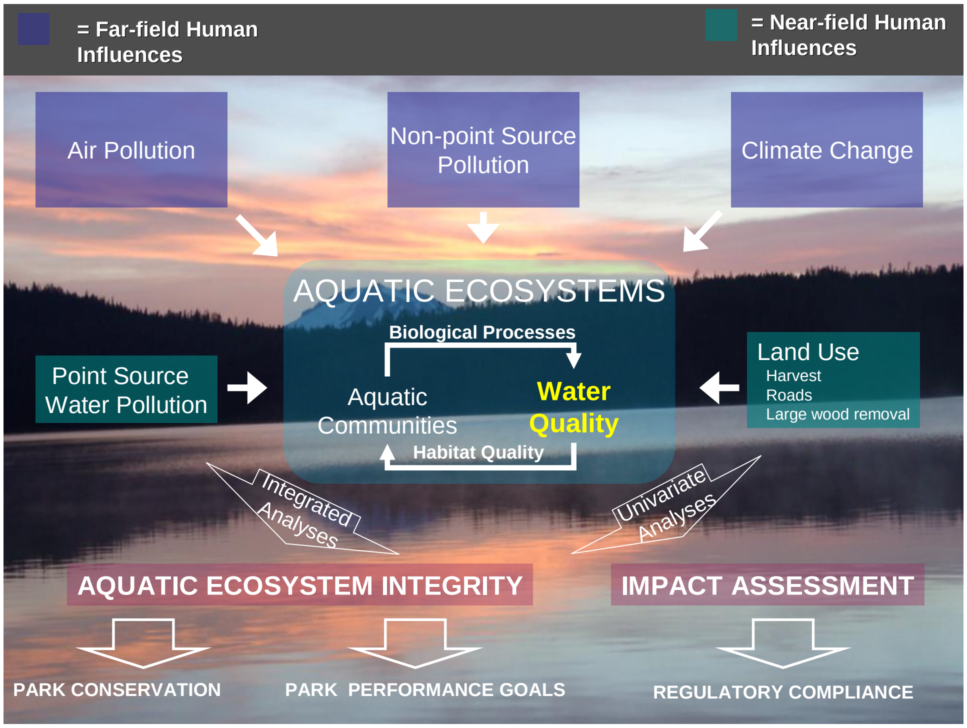

Figure 2. Conceptual ecological model showing the integral relationships between water quality and aquatic communities in aquatic ecosystems.

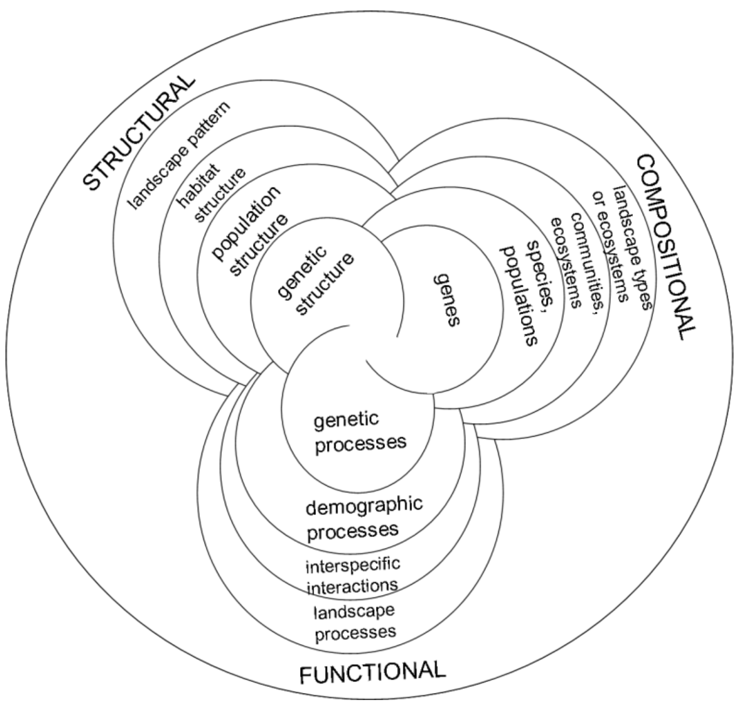

Figure 3. Conceptual model of the multiscale hierarchy of biodiversity indicators that describe composition, structure, and function at each level of organization (from Noss 1990).

In addition to integrating biological, chemical, and physical dimensions of the stream ecosystem, we employ a multispecies approach to analysis of change. Previous authors have argued that multispecies assessment provides the most comprehensive and robust way to ensure important trend detection (e.g., Karr and Chu 1999, Manley et al. 2004). Since biological assemblages contain a rich set of information, monitoring multiple species and attributes together can track changes in ecosystem composition, function, and structure better than single species or univariate (e.g., water chemistry) approaches (Clarke and Warwick 2001).

1.5 Existing and Potential Ecosystem Stressors

In addition to the Klamath Network Vital Signs scoping process, a supplemental workshop for water quality monitoring (described in Hoffman and Sarr 2007) identified existing and potential stressors to the aquatic resources of the Klamath Network parks (Sarr et al. 2007, Figure 4). The identified stressors, by park, depended largely on the position of the parks in their watershed. High elevation parks, Crater Lake National Park and Lassen Volcanic National Park, identified: (1) aquatic nuisance species, (2) visitor and park activities impacts, (3) climate change, and (4) atmospheric deposition of nutrients and pollutants. Lower elevation parks, Redwood National and State Parks, Whiskeytown National Recreation Area, and Oregon Caves National Monument face a much more extensive list of potential stressors. Identified stressors of low elevation parks were: (1) temperature impairment, (2) abandoned mining operations, (3) septic field leaching, (4) herbicide applications, (5) marijuana farming, (6) cattle grazing, (7) abandoned logging roads, (8) fire management techniques, (9) upstream land use activities, and (10) recreational fishing. All stressors (recreational fishing was considered to be a part of visitor and park activities) were considered in the selection of parameters to monitor, and are briefly summarized below. Furthermore, the aforementioned multi-parameter and multispecies monitoring schemes should be robust for emerging or unforeseen stressors.

Note that the US EPA (2006) uses the term “stressors” differently: stressors are measured directly instream as nutrients or sediments. In our model, these are potential effects or outcomes of the following stressors.

1.5.1 Abandoned Logging Roads

A history of logging in the watersheds of RNSP and WHIS resulted in a large network of logging roads that can negatively impact streams and their biota. Roads impact streams through several mechanisms: (1) acting as a sediment source; (2) hydrological alteration (road incuts interrupt subsurface flow, so that overland flow emerges, increasing soil erosion and transport into stream channels); and (3) stream crossings, roads pass either directly through the stream, or over it with culverts. Increased sediments from roads can fill spawning gravels, thereby degrading habitat and smothering and suffocating fish eggs and aquatic invertebrates (Waters 1995). Improperly designed culverts also impede fish migration and passage (Gibson et al. 2005) and can plug with debris, dramatically increasing the risk of debris flows (Wemple et al. 2001).

1.5.2 Abandoned Mining Operations

Historic and current mining operations in the watersheds above Whiskeytown National Recreation Area stress the streams and reservoir through three mechanisms: (1) mercury and mercury methylation, (2) acidification of stream water, and (3) arsenic poisoning. Mercury is released during the amalgamation process of gold mining and by exposing more mercury in slag to the environment (Rytuba 2000). Acidification occurs when sulfite rich rocks are exposed to the atmosphere, creating sulfuric acid (Skousen et al. 2000). Acidification of streams also increases the mercury methylation process (which is the most toxic form). Arsenic comes from the finely ground tailings of gold mining and is released as downstream sediment dispersal (Straskraba and Moran 1990).

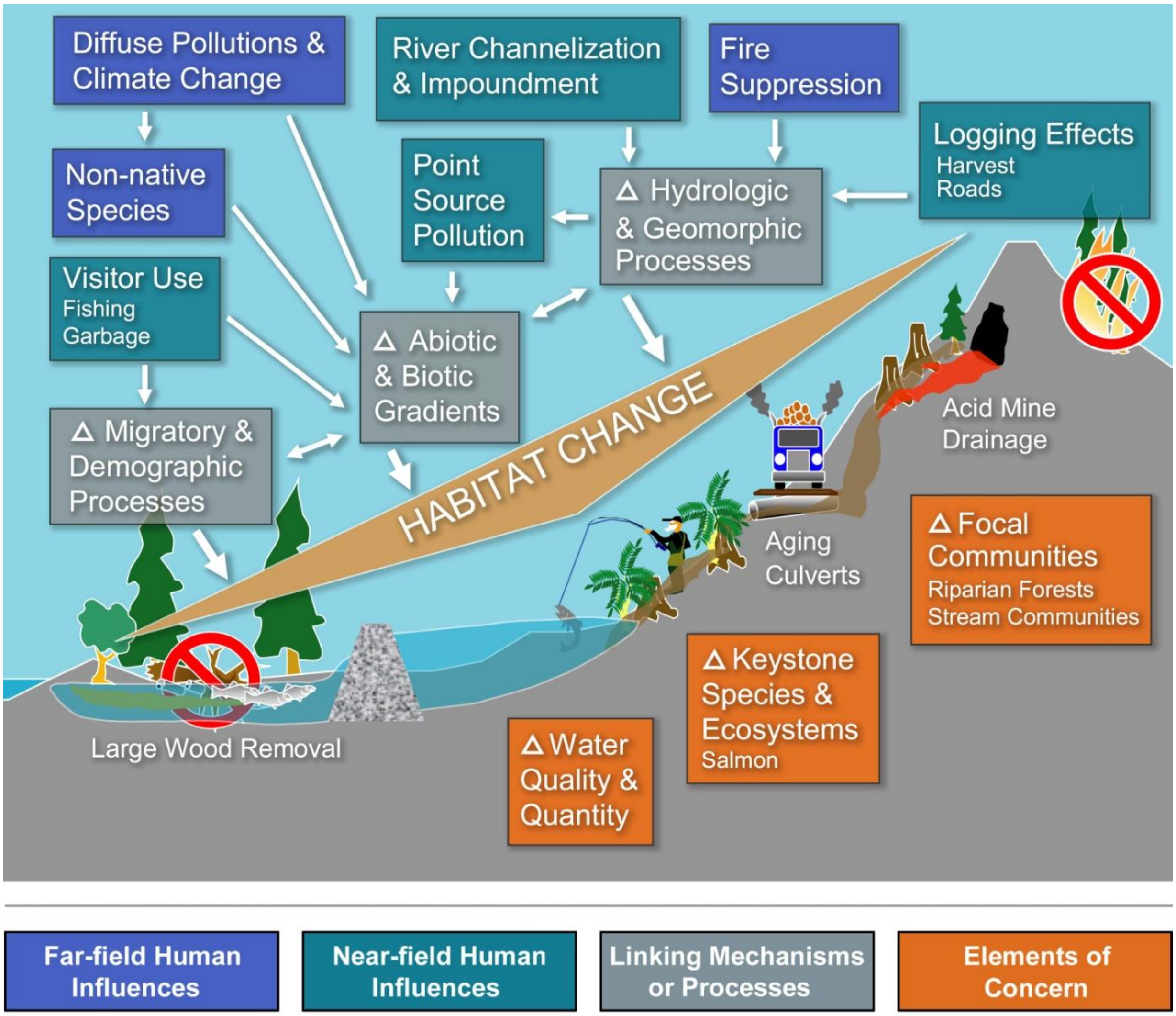

Figure 4. Conceptual model showing linkages of stressors to habitat changes and impacts to water quality and aquatic communities vital signs.

1.5.3 Atmospheric Deposition

Atmospheric contaminants have been recognized as a potential stressor of aquatic and terrestrial ecosystems for several decades (Schindler 1987, Landers et al. 2008). A classic example is acid rain, where SO_x and NO_x precursors from industrial combustion are transported thousands of kilometers from their source and deposited by precipitation, causing acidification of poorly buffered ecosystems (Likens et al. 1979). Similar concerns with nutrients (e.g., from agricultural fertilizers) and pollutants (e.g., volatile organic chemicals, toxicants, etc.) can also perturb ecosystems by eutrophication processes or toxicity effects (Landers et al. 2008).

1.5.4 Cattle Grazing

Cattle grazing may impact parks of the Klamath Network in two ways: (1) trespass cattle grazing and (2) watershed impacts affecting downstream water quality. Trespass grazing is likely to be a rare event, and not prolonged; however, potential impacts include riparian zone denuding, trampling of stream biota, and increased sediments (Platts 1982). Generalized watershed impacts from grazing allotments in watersheds above park boundaries include eutrophication, fecal contamination (ORCA, Roth, J. E., Chief of Natural Resources, pers. comm.), and sedimentation (Belsky et al. 1999).

1.5.5 Climate Change

Concerns about global climate change impacts are well documented (IPCC 2007). Researchers have documented various physical, chemical, and biological characteristics of aquatic ecosystems can act as indicators of impacts due to climate change (McKnight et al. 1996, Arnott et al. 2003, O'Reilly et al. 2003). Even modest temperature increases in the western United States may cause significant changes to the hydrologic cycle, as manifested in earlier snowmelt, earlier ice-out on lakes, reduced summer base flows (Dettinger et al. 2004), a lower snowpack volume at lower to mid elevations (Knowles and Cayan 2001), and increased flooding due to rain-on-snow events in winter (Heard et al. In Prep). Although the overall precipitation patterns are currently not expected to change as much in the Klamath Network as in other regions of the West, the hydrograph (i.e., the magnitude and timing of spring run-off) will likely shift to earlier floods. These changes will, in turn, likely affect the seasonal dynamics of stream and riparian biota (Palmer et al. 2009).

1.5.6 Fire and Fire Management Techniques

Wildland fire and fire management activities directly and indirectly affect Klamath Network streams through several mechanisms. Fuels reduction efforts change the vegetation structure, volume, and water use of vegetation. These changes, in turn, can affect the geomorphic and water temperature dynamics and nature of litter inputs to streams. Direct suppression efforts may sometimes affect streams if fire retardants enter into the water column. Wildfires typically cause temporary increases in flood and debris flow risks, which can strongly affect stream communities. Western US stream ecosystems, however, have experienced fire for millennia and fire may be an important component for maintaining riparian diversity (Rieman et al. 2005). Altered fire regimes, caused by continued fire suppression over the past decades and the buildup of fuels, combined with a drier climate, may result in more intense burns in riparian zones. More severe fires will increase the likelihood of large scale floods and erosion, negatively impacting stream ecosystems. Fires have direct, indirect, short-term and long-term impacts, including mortality of fish and invertebrates, changes in erosion patterns, woody debris accumulation, and vegetation patterns (Gresswell 1999). Techniques used to manage fires, such as fire lines and post-fire rehabilitation activities, can increase fine sediment delivery to streams, negatively impacting stream biota (McCormick et al. 2010).

1.5.7 Herbicide Applications

Herbicide is used in two main programs: (1) control of roadside vegetation and (2) control of invasive species (note that these are often, but not always, the same). Typical herbicides, such as 2,4D and glyphosate (Roundup), are often used by counties and the National Forest Service (Colborn and Short 1999). Active vegetation control is also practiced by NPS units within park boundaries. Some herbicides are extremely toxic to aquatic invertebrates and are not legally applicable to areas where run-off will enter waterways, usually clearly labeled on herbicide labels. Additional impacts due to treated vegetation entering the stream as leaf litter are unstudied and unknown to our knowledge. Knowledge of impacts to other stream biota (fish and amphibians) is also lacking.

1.5.8 Marijuana Farming

Illegal marijuana cultivation is occurring in Whiskeytown National Recreation Area and Redwood National and State Parks. Other network parks have concerns that marijuana cultivation may soon occur within their park boundaries. Security concerns with scientists working in and around areas of illegal cultivation have prevented detailed studies (Joyce 1999), but stream ecosystem impacts will resemble those from legal agriculture, including (1) water diversion, (2) increased sediments, and (3) eutrophication through the use of fertilizers (Allan 2004).

1.5.9 Non-native and Introduced Species

Introduced, non-native species can cause large changes to native biodiversity and trophic dynamics of aquatic ecosystems (Vander Zanden et al. 1999, Knapp et al. 2001, Parker et al. 2001, Schindler and Parker 2002, Boersma et al. 2006). In Klamath Network parks, historical introductions of rainbow trout (*Onchorhynchus mykiss*), brook trout (*Salvelinus fontinalis*) and brown trout (*Salmo trutta*) are potential ecosystem stressors. Other invasives include both vertebrate (e.g., American bullfrogs [*Rana catesbeiana*]) and invertebrate (e.g., New Zealand mudsnails [*Potamopyrgus antipodarum*]) taxa. Considerable threats also exist from emerging diseases, such as chytrid fungus (*Batrachochytrium dendrobatidis*), which affects native amphibians and whirling disease (*Myxobolus cerebralis*) that impacts native salmonids. Non-native plants in riparian zones can also alter structure (e.g., salt cedar [*Tamarix* sp.] in the American Southwest). Threats in the Klamath region include reed canary grass (*Phalaris arundinacea*), Himalayan blackberry (*Rubus armeniacus*), and the aquatic macrophyte water hyacinth (*Eichhornia crassipes*).

1.5.10 Non-recreational Land Use Practices within and External to Parks

Land use practices that include potential stressors to Klamath Network parks include: park operations (e.g., construction and road maintenance), water withdrawal, dam operations, fire management, timber harvest, and geothermal explorations (Hoffman and Sarr 2007). Potential pathways include increased sediments, pollutants, and hydrologic changes from direct and indirect impacts (Allan 2004).

1.5.11 Septic Field Leaching

Leaching of septic field sewage is a potential stressor to park waterways both from septic systems within the park and external to the park. Sewage contains nutrients (resulting in eutrophication) and bacterial or viral diseases (Vaughn et al. 1983, Yates 1985).

1.5.12 Temperature Impairment

Excessively high temperatures can be extremely detrimental to aquatic biota. Moreover, temperature determines the ability for water to maintain high dissolved oxygen concentrations, which affects many aquatic organisms. Salmonid species, in particular, are sensitive to stress caused by increased temperature, both in the oxygen content of the water and overall stress (e.g., at higher temperatures salmonids exhibit a reduced immune response to disease [Sanders et al.

1978]). Temperature is also critical for amphibian development and reproduction, with the tailed frog, *Ascaphus truei*, having some of the lowest tolerances to increased temperature of amphibians in North America (Bury 2008). Temperature is also a cue in the development and hatching of aquatic insects, so that under alteration, emergence and life cycles are offset with historical norms. This can cause insects to emerge too early, so that the adult stage is exposed to winter storms or other extreme events causing mortality (Vinson 2001). Projected effects of climate change on summer air temperatures, the nature of riparian vegetation, and the timing of snowmelt will likely all have interactive effects on the levels of summer low flows and peak water temperatures.

1.5.13 Visitor Recreational Activities

Potentially damaging recreational uses include improper camping, pack-stock use, boating, and fishing. Recreational impacts include mechanisms from the other stressor categories above. For example, camping can cause the input of nutrients from improper disposal of camper waste, or anglers and boat use can contribute to introduction and dispersal of non-native species.

1.6 Vital Signs Objectives

The programmatic goals of the Klamath Network are (from Sarr et al. 2007):

- To determine status and trends in selected indicators of the condition of park ecosystems to allow managers to make better informed decisions
- To provide early warning of abnormal conditions and impairment of selected resources to help develop effective mitigation measures and reduce costs of management
- To provide data to foster better understanding of the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other altered environments
- To provide data to meet legal and Congressional mandates related to natural resource protection and visitor enjoyment
- To provide means of measuring progress towards performance goals
- To support park interpretation and educational programs

Applications of these programmatic goals, and the specific wadeable streams objectives to meet these goals were largely determined at scoping meetings with Network ecologists, USGS specialists, and park resource experts. Refinement based on feasibility, logistics, and budgetary realities determined during the pilot project (Appendix A) were also taken into consideration.

1.6.1 Monitoring Objectives

Objective 1: Determine the status and trends of ecological conditions in Klamath Network wadeable streams. Through careful selection of indicators, we can inform managers to help with decision making, warn of abnormal conditions, and gain understanding of the park ecosystems. Through quality control, data analysis, and multiple reporting formats, we can meet legal requirements, measure performance goal progress, and help education programs. Together, this will meet the Network’s programmatic goals.

To meet this goal, several terms must be clearly defined:

- “Ecological condition” – From the EPA Report on the Environment, “ecological condition” is defined as “the state of the physical, chemical and biological characteristics of the environment, and the processes and interactions that connect them (U.S. EPA 2008).”
- “Status” – “defined as some statistic (e.g., a mean/median/proportion) of a parameter over all monitoring sites within a single or well-bounded window of time. Status will always have some measure of statistical precision (e.g., a confidence interval, standard error, variance)…(Sarr et al. 2007).”
- “Trend” – “defined as a non-cyclic, directional change in a response measure that can be with or without pattern (Urquhart et al. 1998).”

The very definition of ecological condition speaks to the need for integrating indicators from a range of physical, chemical, and biological characteristics.

Objective 2: Assist parks with “impaired quality waters,” also known as “303d” lists as defined by the Clean Water Act. The method of assisting should be in two functions:

a. Gather information on the pollutants that exceed standards that will assist the park and the state to design specific pollution prevention or remediation programs through Total Maximum Daily Loads.

b. Determine whether the overall program goal of improved water quality is being achieved after the implementation of effective pollution control actions.

Currently, there are two Clean Water Act, Section 303d listed (hereafter simply 303d) sites within Redwood National and State Parks: Redwood Creek is listed for water temperature (> 5°F above natural levels), and the Klamath River is listed for nutrients (“biostimulatory substances;” above levels that cause nuisance or adverse effects) and water temperature (North Coast Regional Water Quality Control Board, 2010). Redwood Creek is currently being monitored by the park; however, the Network will assist the park by implementing this protocol at two sites within the affected reaches of Redwood Creek. The Klamath River is intensively monitored by other agencies, both governmental and non-governmental, and its large size precludes it from being applicable to this protocol (Hoffman and Sarr 2007).

Objective 3: Assist parks with monitoring of “Outstanding National Resource Waters” or Tier 3 waters as defined by the Clean Water Act. The method of assisting should be in two functions:

a. Allow characterization of existing water quality and to identify changes or trends in water quality over time.

b. Identification of specific existing or emerging water quality problems.

Currently, there are no Outstanding National Resource Waters in any of the parks of the Klamath Network. This specific objective and functions dictated by the Water Resources Division are met by monitoring the lakes and streams of the Network parks.

1.6.2 Measurable Objectives

Measurable objectives to meet the objectives of this protocol (see relevant SOPs for details) include:

- Use probabilistic sampling to establish accessible wadeable stream reaches within the five park units covered by this protocol.
- Measure physical environment parameters at each wadeable stream reach: substrate composition, depth, gradient, discharge, stream width, bank height, etc.
- Collect core water quality parameters in a single well-mixed section of each stream reach: dissolved oxygen, temperature, specific conductivity, turbidity, and pH.
- Measure stream water anions, cations, and nutrients along each stream reach every three sampling periods.
- Collect a composite of 11 algal samples to determine periphyton biomass at each stream reach.
- Collect quantitative samples of reach-wide benthic macroinvertebrates.
- Conduct Visual Encounter Surveys for amphibians to develop species lists.
- Survey for fish populations using electrofishing to determine presence and catch per unit effort of fish populations.
- Photograph stream reaches in a systematic manner so images can provide visual comparisons over time.
- Develop and maintain a database and associated metadata derived from the sampling procedures.
- In an Annual Report, report status of key parameters for each park surveyed that year.
- Write Analysis and Synthesis reports every 3 years that explore relevant topics in depth. Specifically, individual Analysis and Synthesis reports will detail trends in core parameters and species composition and abundances, explore data patterns to relate stressors to observed trends, utilize observed/expected models for species assemblages, and utilize indices of biotic and ecological integrity.

1.6.2.1 Questions To Be Answered and Protocol Limitations

The large volume of data and parameters to be collected above suggest potential scores of questions that can be addressed through this protocol implementation. For example, the physical habitat data collected, following EPA EMAP protocols, allows for the calculation of Relative Bed Stability (Dingman 1984). But given a limited number of sites within each park, and lacking context of interpretation, it would be unwise to state that we will answer, “What is the Relative Bed Stability of Network streams?” An answer is possible, but how does that particular question help management, especially if the confidence intervals of our answer are extremely wide? Furthermore, with protocol implementation and long-term data, questions currently unknown to us may be answerable. Or, by measuring multiple parameters (biological, physical, and chemical), can Structural Equation Modeling (Grace 2006) be used to simultaneously study influences and response to understand causal relationships?

Although a large number of questions can be addressed through the data collected in the protocol, it is best to outline the key questions to be asked, both immediately and in the future, that are a priority for the Network:

1. What are the status and trends of the biological conditions of streams? Biological conditions being defined as: macroinvertebrate assemblages and derived metrics, vertebrate presence/absence and derived metrics, algal biomass, and riparian community and derived metrics.
2. What are the proportions of streams meeting water quality thresholds in the network? Water quality thresholds being defined as: biocriteria or chemical values (nutrients) or physiochemical (e.g., dissolved oxygen) where they exist either as promulgated standards or simple condition estimates, and when the Network is monitoring that exact parameter. How are these proportions changing over time?
3. What are the values of EPA "stressors" in the Network streams? Stressors, defined by the EPA (U.S. EPA 2006) as chemical: total phosphorous, total nitrogen, acid neutralizing capacity, and salinity (measured as specific conductance); and physical as: streambed sediments, in-stream habitat complexity, riparian vegetative, and riparian disturbance.
4. On a landscape scale, are there certain groups of stream types – classified by chemical, physical, or biological characters – that can form distinct management units? How are they distributed across the park landscape?

These four questions will drive the selection of parameters and how we measure them. However, other parameters will also be collected to: (1) act as potential cofactors, (2) provide context for other parameters, and (3) to fully integrate into other regional monitoring efforts.

2.0 Sampling Design

We use the unified terminology presented in McDonald (2003) for monitoring programs designed for estimating status and trends in environmental indicators. The sampling design describes both how sample units are selected from the sampled population (membership design) and how those units are visited over time (revisit design). Careful consideration of the trade-offs and constraints in designing sampling schemes over long time periods and vast spatial areas are imperative for protocol success in meeting objectives.

This protocol covers five of the six Klamath Network parks: Crater Lake National Park, Oregon Caves National Monument, Redwood National and State Parks, Lassen Volcanic National Park, and Whiskeytown National Recreation Area. Lava Beds National Monument, the only Klamath Park unit not covered by this protocol, has no perennial streams.

In brief, Klamath Network streams are sampled using an always revisit [1-0] design (McDonald 2003) and each stream reach and park is sampled in the summer months every 3 years. In each park, between 30 stream reaches (or sites) are probabilistically selected using a spatially balanced design (the exception to this is Oregon Caves National Monument, with only a single stream and three total sites). These 30 sites will be sampled every three years. Each park additionally has between one and two judgment streams selected by park specialists (section 2.1.1). Not every park is sampled every year; in a three year rotation, year one is spent sampling lakes, year two is spent sampling streams in two parks, and year three is spent sampling streams in three parks not yet sampled. In year four, the pattern repeats. Although this prolongs the period required to start trend analyses, it ensures that detected trends are true long-term patterns, and not short-term cyclical events not needing management intervention.

2.1 Rationale for Selection of Sampling Design

An always revisit design was chosen for several reasons. It: (1) maximizes the ability to detect trends, (2) reduces logistical and budgetary issues of establishing new sampling reaches, (3) simplifies data analysis, and (4) standardizes the design with other Network protocols. Other more complex sampling designs, such as a split panel design with rotating panels with different revisit schedules, were carefully considered but were not chosen for the following reasons: (1) methodology integrating different panels in long-term trend analysis is not clear, (2) considerable expense is incurred in land-marking an increasing number of safe and accessible stream reaches, and (3) low numbers of perennial streams in *most* Network parks negates the need for increasing spatial coverage with additional panels.

Although a rotating panel design, with an always-revisit panel and supplemental panels sampled at longer intervals, is considered more "powerful" for status, this is a verbal argument and not a statistical one (Kirk Steinhorst, Professor Emeritus of Statistics, University of Idaho, pers. communication, 30 November 2010). The rationale is that because different sites are included from sampling year to year, a "better" estimate of status is obtained from increased inclusion of sites. The chances for an "unrepresentative" random sample are reduced. This ignores, however, the fact that the sample size for the status assessment for any particular year is still fixed by the sample size for that year, and only that year (i.e., the sites sampled three years prior are not factored into a current year "status" assessment).

The Klamath Network has worked closely with statisticians and water quality professionals from Colorado State University, University of Idaho, Montana State University, and the National Park Service Water Resource Division to ensure a sampling design that provides the greatest ability to determine status and detect trends.

2.1.1 Judgment Sites

In addition to probabilistic reaches, judgment reaches will also be monitored. Judgment reaches, as defined in Sarr et al. (2007), comprised of sites that are subjectively selected because either: (1) they have a history of sampling, (2) they are accessible, or (3) the target population is very specialized and/or unique. Another justification is that certain reaches may be facing specific threats and monitoring for these threats is best concentrated at such reaches. Continuation of existing or focused monitoring for special populations or threats is valuable, but because such reaches are not probabilistic, they can only be used to make inferences to the specific reach in question. Recognizing these caveats, judgment reaches were minimized and were selected with input from park specialists at protocol scoping meetings.

Crater Lake National Park

- Sun Creek: This stream is habitat where the federally listed bull trout (*S. confluentus*) is readily accessible to the public along a major access road, and is the site of intensive ecological restoration.

Lassen Volcanic National Park

- Hot Springs Creek: This stream is representative of geothermally-influenced streams that make up one of the unusual features of the park. It is also subject to impacts from existing park infrastructure, including buildings, leach fields, and visitor use. An unusual fen is also a portion of the riparian zone of this creek.

Oregon Caves National Monument

- Cave Creek: This stream flows through the ORCA cave-complex, has a history of monitoring, is a central feature of the park, and is subject to visitor use.

Redwood National and State Parks

- Godwood Creek: This stream is relatively pristine and is the only stream through the roadless, old-growth area in RNSP.
- Redwood Creek: This creek is a 303(d) listing for impairment in temperature and sediments, has been the subject of active restoration, and is habitat to a number of anadromous fish.

Whiskeytown National Recreation Area

- Willow Creek: This creek has historically been on 303(d) lists for impairment from acid mine drainages, with heavy metal accumulation, and has a history of monitoring.

2.2 Target Population

The target population, as defined by Irwin (2008), is "the larger universe of all possible values (bounded in time and space) that one is sampling from and wishes to make statistical inference (conclusions) about." For this protocol, temporal and spatial frame errors (over- and under-coverage) are minimized to justify that the probabilistically sampled population is the same as the target population. In the Klamath Network, the target population per strict definition is all possible values sampled during "index" periods, during daylight hours, and wadeable streams fitting the following criteria:

- Perennial – This selection criterion is applied to remove habitats that are influenced by seasonal desiccation which could mask other stressors of interest and add excessive variation to the parameters. It also ensures that data collection can always occur at the sites, assisting in data completion goals (SOP #19: Quality Assurance Project Plan).
- Less than 1000 m from a passable road or trail – This selection criterion reduces logistical constraints to field crews, such as travel time, to ensure that each site can be sampled in the allotted time frame for achieving sampling objectives.
- Stream gradients with slope less than 15 percent – This selection criterion ensures crew safety and that access to streams is doable.

In defining the target population, two additional terms must be defined: (1) wadeable streams are defined as 1st through 5th order streams based on the Strahler stream order (Strahler 1957). In the Klamath Network, the Klamath River (at the mouth in RNSP) is an 8th order stream, the Smith River is 6th order, and Redwood Creek is on the cusp at 5th order. However, some of the remaining streams may be unsafe for field crews to enter depending on observed conditions. For example, lower Redwood Creek is a 5th order river, but winter and spring debris-laden high flows prohibit safe entry. Streams portions may also include unwadeable pool habitats, although the rest of the stream may be wadeable.

The second term needing defining are "index" periods. Index periods are timing of stream base flows, with the concept that sampling over the broad index period are comparable. In California, index periods are broadly defined based on elevation and latitude, so that northern areas (including the Klamath Network) are sampled in "late summer." There is no defined index period for Oregon; however, the Pacific Northwest Aquatic Monitoring Partnership (Hayslip 2007) defines index periods as being from July 1st to October 15th for the Pacific Northwest. Ongoing studies of California bioassessment utilize an index period of June 1st to September 31st for California (Fetscher et al. 2010). This protocol adopts the California standard as the index period for the Klamath Network to allow early work in low elevation California parks, with follow-up in the higher elevation parks (one in OR, one in CA).

An important concept concerning the target population is the limitation of inference that can be made to the stream based on data collected under these conditions. Clearly, certain parameters vary on a daily, seasonal, and annual basis (e.g., water temperature). A single point in time measurement of water temperature cannot be taken as indicative of water temperature outside the bounds of the temporal target population. However, certain stream parameters integrate over large temporal scales. For instance, aquatic macroinvertebrates assemblages include both long- and short-lived taxa, so that short-lived invertebrates respond to recent disturbance, and long-lived taxa are sensitive to events that may have occurred the past year. Likewise, severe disturbance, such as debris flows will be manifested in the stream invertebrate assemblage for years after the initial disturbance. Additionally, changes in pool/riffle/glide macrohabitat respond over yearly time frames, whereas reach-wide characteristics (e.g., sinuosity) respond over decadal or longer timespans. Hence, although some stream environmental characteristics are sampled at a single point in time within the target population, they provide valuable information outside the temporal span of the target population.

2.2.1 Changes in Sampling Frame
It is possible, given the long-term nature of this program, that the sampling frame will change over time. An example is that climate change may decrease the amount of perennial streams within a park, or a park may acquire new tracts of land. In these cases, there are two options: (1) may it clear that the extrapolation and inferences of the protocol do not include the changes to the sampling frame (either in contraction or expansion), or (2) redo the sampling frame to incorporate the changes; including new site selection. If the latter option is done, it should be accomplished by adding sites so as to not jeopardize long-term data from previous sampling periods. The Program Lead, with input from park staff, should judge when a sampling frame has changed.

2.3 Sample Reach Selection
Stream reaches (sites) are selected using a Generalized Random Tessellation Stratified design (GRTS – pronounced “grits”) (Stevens and Olsen 1999, 2004). This design employs a systematic sampling technique to obtain a spatially balanced probabilistic sample. A particularly attractive feature of GRTS is the ability to accommodate unequal probability sampling by allowing the probability of individual sampling units to vary. The draw is performed on all streams (excluding *a priori* judgment streams, and the two non-wadeable rivers [the Klamath and Smith Rivers]). This procedure also produces a spatially balanced over-sample (i.e., a list of additional sites to sample if sites need to be replaced or added). Since the GRTS method creates spatially balanced and dispersed sites, it minimizes spatial autocorrelation and maximizes the effective sample size for a given number of sites, thereby helping to increase statistical power. We use a spatially balanced design because a simple random sample, although conceptually easy and statistically simple to implement, can produce a clustered site distribution.

The National Hydrography Dataset (NHD), containing geospatial hydrologic data that enumerate and identify all perennial wadeable stream habitats within the park, was used to populate the Geographical Information System (GIS) database for running the GRTS draw with a custom script in the statistical software program *R*. The *R* script “spsurvey” was used to draw the stream list from remaining locations in each park (Kincaid 2006). Table 2 provides a summary of the numbers and proportions of stream kilometers available for inclusion, excluded by the criteria, and total number of reaches to be sampled in the protocol.

Step by step site selection procedures are done by Network staff using GRTS and are further outlined in SOP #3: Site Selection. However, the process of using the computer program *R* is beyond the scope of this protocol. Note however, that SOP #3: Site Selection should only have to be used at the initiation of the protocol prior to the first field season and will not need to be done prior to every field season. It is provided to give the field crews and incoming Project Leads the proper context for the survey design and rationale. It is also possible that a new GRTS draw may be necessary if the sampling population changes over time (as in Irwin 2008).

Table 2. Comparison of total streams, stream kilometers (km), and number of streams and stream reaches to be sampled through protocol implementation.

Park Unit	Total number of stream km in park	Number of stream km included in target population	Number of named streams	Number of streams to be sampled	Total number of stream reaches
Crater Lake National Park	198.94	105.33	29	15	30
Lassen Volcanic National Park	101.34	71.63	18	15	30
Redwood National and State Parks	382.35	180.23	57	15	30
Whiskeytown National Recreation Area	74.19	54.21	11	10	30

2.4 Frequency and Timing of Sampling

2.4.1 Sample Frequency

Sampling of wadeable streams occurs every 2 out of 3 years as a part of the overall design of integrated aquatic communities and water quality (Table 3). In the single year between stream sampling, mountain lakes and ponds (covered in a separate protocol) will be implemented. In stream sampling years, a low elevation park (WHIS, RNSP) is paired with a high elevation park (CRLA, LAVO). Early season, sampling will first occur in the lower elevation park, with late season sampling in the high elevation park. Judgment streams at ORCA will occur with sampling CRLA and RNSP, every 3 years.

Table 3. Temporal revisit design of integrated water quality and aquatic communities for both lakes and wadeable streams. After 2015, the pattern continues.

Habitat type	Park units	2010	2011	2012	2013	2014	2015
Lakes	Lassen Volcanic National Park	X			X		
	Crater Lake National Park	X			X		
	Redwood National and State Parks	X			X		
Wadeable Streams	Whiskeytown National Recreation Area		X			X	
	Lassen Volcanic National Park		X			X	
Wadeable Streams	Oregon Caves National Monument			X			X
	Redwood National and State Parks			X			X
	Crater Lake National Park			X			X

2.4.2 Sample Timing

Sample timing encompasses both the timing of sampling efforts across years and the time of day that sampling is accomplished, but also considers issues of comparability and logistical scheduling. Timing of sampling efforts at sample reaches across years will be kept as constant as logistically possible. This reduces inter-annual variation caused by phenological characteristics of the sampled streams. For example, if Willow Creek (WHIS) is sampled on 15th July 2011, the repeat visit will occur around the 10th-20th July 2014. Sampling Willow Creek later in the field season, (e.g., late August or early September) would introduce variation from changes in insect emergence and lower flows. After the first field season, dates for all sample reaches will be used for planning the next sampling period in perpetuity (Figure 5).

Another aspect of sample timing that can affect results is diurnal shifts in parameters. For instance, primary production may peak during high noon, so that dissolved oxygen correspondingly increases at midday. Measurements of dissolved oxygen taken at midday will differ from values taken at dawn. Amphibian behavioral differences from mid-day to dusk activities can also affect detectability during surveys. To reduce variability in these parameters, field crews will perform all sampling during standard daylight hours; generally between 9AM and 4PM. Clearly, logistics of reach access will dictate actual start times, but crews cannot start sampling pre-dawn. Time of sampling will be recorded for measured parameters to help in the interpretation of variation relative to time of sampling.

However, by adherence to “index” periods for aquatic macroinvertebrates, broad comparability across years, parks, and stream reaches for macroinvertebrate assessment techniques is defensible. To what degree these broad comparisons are valid for other measurements (e.g., water chemistry, amphibians) is unknown and under studied.

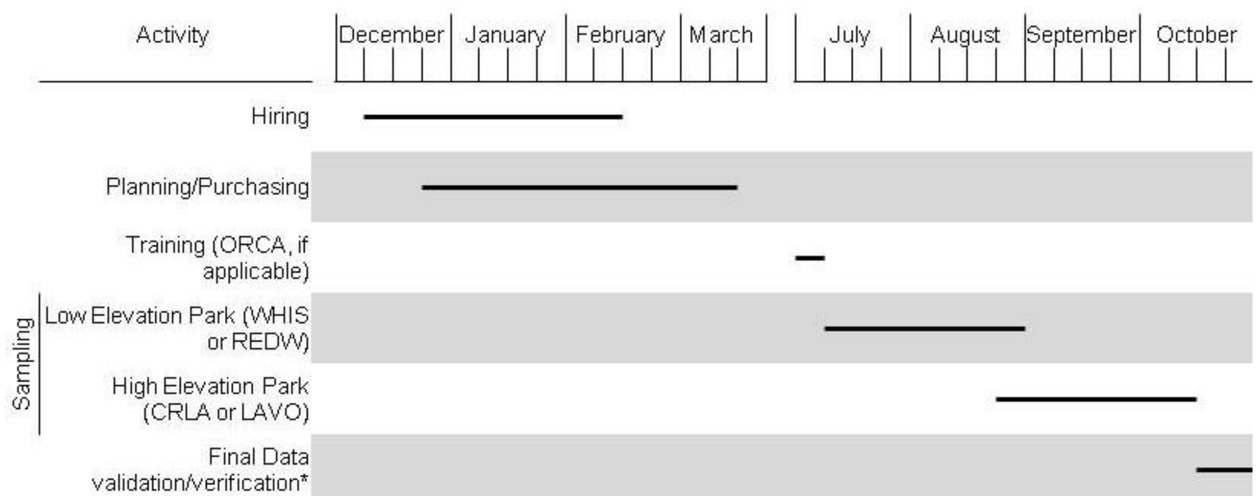

Figure 5. Timeline for hiring, planning, training and sampling. *Data validation and verification is done by Crew Leader throughout the project, final validation and verification is by Project Lead.

2.5 Rationale for Selection of Parameters

Each parameter to be measured was chosen for the following reasons:

- It directly or indirectly addresses protocol objectives.
- It is mandated by National Park Service Water Resources Division.
- It can be used to derive an index or indices that address protocol objectives.

- It places other parameters in a context to better address protocol objectives.
- It assists in making correlative statements between response variables and stressors.
- It is a cost-effective alternative to other parameters.

In this context, parameters are defined as features allowing quantitative or semiquantitative measurements (e.g., numerical, ordinal, or categorical data) through field visits or laboratory analyses. Table 4 provides a summary overview of parameters to be monitored; the text below explores the context and rationale for each parameter in more detail.

2.5.1 Core Parameters

The core parameters represent a set of water quality attributes that will be measured as part of all NPS Water Resource Division funded water quality monitoring protocols. As such, these attributes contribute some measure of consistency and comparability of water quality conditions among multiple NPS monitoring programs (NPS 2002). However, the use of the word "core" does not imply that these parameters are more or less important than other parameters. Due to their diel and seasonal variability, these parameters are being sampled as cofactors to help with contextual interpretation of aquatic communities, and to help describe conditions at the time of sampling. The synoptic sampling of these variables does not lend themselves to trend analyses using this sampling scheme. Specific conductance will be used as one the US EPA (2006) chemical "stressors."

Water temperature is a critical variable controlling many ecosystem processes, both physical and biological, and it can impact almost all functions within an ecosystem (Allan and Castillo 2007). Water temperature is also a critical parameter for tracking climate change's manifestation in these important park ecosystems.

Water pH, the measure of water hydrogen ion concentration, is a critical attribute of any water body with many physical and biological effects. Low pH (<7) indicates acidic waters and high pH (>7) indicates basic water. Most aquatic species occur within specific habitat envelopes of pH conditions and changes to pH will likely result in changes in species assemblages. In addition, the pH determines the solubility of many heavy metals, which has negative impacts on invertebrate biodiversity (Wiederholm 1984, Allan and Castillo 2007).

Specific conductance, or simply *conductance*, the ability of a water body to conduct an electric current, is directly correlated with dissolved ion concentrations in water bodies. In essence, the "purer" the water, the lower the concentrations of dissolved salts and thus the lower the conductance. Changes in conductance suggest changes in major ions or nutrients, such as potassium, calcium, and other anions and cations.

Table 4. Parameters to be measured under this protocol. See SOPs for more details. 1 Water Quality "Sonde" is the industry standard term for Water Quality Probe.

	Parameter	SOP #	Methodology summary
Water chemistry - Field			
	Dissolved oxygen	7	Multiprobe water quality sonde cross section[1]
	pH		
	Specific conductivity		
	Temperature		
	Turbidity		
	Acid neutralizing capability	8	Field titration kit
Water chemistry - Lab			
	Anions (Cl^-, $SO4^{2-}$)	8	Ion chromatography
	Cations (Na^{2+}, Ca^+, K^+, Mg^{2+})		Spectrophotometry
	Dissolved organic carbon		Combustion-Infrared
	Total nitrogen		Persulfate Digestion
	Total phosphorous		Spectrophotometry, Persulfate, sulfuric acid digestion
Stream environment			
	Riparian	14	Transect based, estimates of coverage
	Dominant trees	14	Visual estimates, laser range finder
	Channel morphology	6,12	Reach and transect based direct measurements
	Shading	12	Transect based spherical densiometer
	Substrate	12	Transect based cross sections
	Discharge	10	Velocity meter cross sections
Aquatic Community			
	Algal biomass	11	Chlorophyll *a* from cobble scrubbing
	Benthic macroinvertebrates	9	Reach wide benthos
	Amphibians	15	Visual encounter surveys, electrofishing
	Fish	15	Electrofishing

Dissolved oxygen, a critical element for the aquatic biota, is closely linked to physical and biological processes. For instance, respiration, photosynthesis, and atmospheric exchange (through turbulence in rapids and riffles) are the principal processes that affect or are affected by dissolved oxygen concentrations. In addition to high water temperatures, high microbial activity, driven by organic pollution, drives demand for dissolved oxygen resulting in anoxic conditions. High oxygen levels are especially critical for the metabolism of aquatic insect and salmonid eggs.

Discharge is a fundamental indicator of the conditions of a stream at the time of sampling. Discharge is also used as a grouping factor in categorizing streams and as a potential co-variable explaining temporal variation. Discharge and the timing of peak and low discharge events is also an expected response variable to climate change.

2.5.2 Water Chemistry Parameters

Water chemistry parameters are indicative of ecosystem quality and have a profound effect on aquatic organisms. By themselves, they can equate to the generalized notion of "water quality," indicative of water pollution or a stressor and effect (for example, high nutrient load leading to eutrophication). Analysis of water chemical characteristics is fundamental to effective water quality monitoring. These parameters will help to categorize the streams of the network, to help identify stream "types." Their variability may impede analyses of long-term trends, however some may be of use in this regard. Additionally, Acid Neutralizing Capacity and nutrients are used as measures of chemical stressors by the U.S. EPA (2006). However, daily and seasonal variation in these parameters may limit their usefulness to detect long-term trends and are sampled primarily to characterize the stream as co-factors. Long-term trends may be tested for with the recognition that the effect size will have to be substantial, and will have little power to detect subtle trends.

Acid Neutralizing Capacity (ANC) is the resistance of water bodies to acidification. It is measured in the field using unfiltered water (note: when done on filtered water, it is termed Alkalinity; when on unfiltered water it is ANC). Here, we perform the tests on unfiltered water to obtain the actual ANC value for a site. As a measure of buffering capacities of streams, it is indicative of resistance to pH declines owing to acid stream drainages, as well as natural processes or other anthropogenic stressors.

Anions/Cations being monitored include the two predominant anions (negatively charged ions – SO_4^{2-} and Cl^-) and four cations (positively charged ions – Ca^{2+}, Na^+, K^+, and Mg^{2+}). These six ions, along with carbonates (estimated with the ANC measurement), make up most of the ions in stream water. These ions are important indicators of the watershed context of the stream, with different ion concentrations reflecting variation in geology, vegetation, and weathering processes. However, SO_4^{2-} is also common as an indicator of pollution (e.g., from mining waste or fertilizers). It is important to note that SO_4^{2-} is common in volcanic regions such as CRLA and LAVO. Anions and cations are relatively stable both seasonally and annually, so that they may be measured only periodically (every 9 years depending on budgets).

Dissolved organic carbon is a measure of detritus in the water column. Sources of dissolved organic carbon (DOC) can be from autochthonous (within the stream) processes through extracellular release by algae or senescing organisms or bacterial degradation or allochthonous (terrestrial) processes (e.g., leaf litter breakdown carried into the lake by wind or water). Utilization and uptake of DOC by bacteria and periphyton is enhanced by higher temperatures and light; hence decreasing trends in DOC may indicate climate change, although acidification is also a potential cause in decreasing DOC (Schindler et al. 1992, Wetzel 2001). An additional use of DOC is as a mercury cofactor (Barkay et al. 1997).

Nutrients include the dominant forms of nitrogen and phosphorous. Both elements may be limiting nutrients to aquatic ecosystems, controlling ecosystem productivity, as well as being indicators of eutrophication caused by external stressors (e.g., atmospheric deposition or visitor use activities). Nitrogen will be measured as total nitrogen.

Similar to nitrogen, phosphorous is an important limiting nutrient and can be the most limiting. We will be monitoring total phosphorous.

Turbidity is a measure of water clarity. Water with high turbidity (e.g., low clarity) indicates either high amounts of suspended solids (i.e., siltation) or high productivity.

2.5.3 Stream Environmental Parameters

Environmental measurements serve as co-variables to help us understand patterns in the aquatic communities and also as monitoring parameters themselves. Principally used as co-variables in this protocol, environmental variables are useful in predicting presence/absence of organisms based on habitat heterogeneity or on total habitat availability and may help explain important spatial variation in other parameters of interest across the sampling frame. They are important components of aquatic resource monitoring because these characteristics help describe the context or template for ecosystem function and condition (Southwood 1977, Warren 1979, Frissell et al. 1986, Larson et al. 1994, 1999). Additionally, as monitoring parameters of their own, trends in specific parameters (e.g., increases in the percent of fine sediments) can indicate a stressor such as land use or visitor impacts. This group of parameters also includes estimates of nearby human influences, used by the US EPA as a stressor of "riparian disturbance" (US EPA 2006). Other measures used as stressors are: summed riparian canopy cover, relative bed stability, and summed fish cover.

Environmental parameters are sampled either as reach-wide characteristics or transect based characteristics.

2.5.3.1 Transect Based Environmental Parameters

Bank measurements – This includes left and right bank angles, undercut distance, stream width, width of bars (if present), bankfull width, bankfull height, and incised height. These offer basic geomorphological measurements of the stream channel, providing information on bank stability, habitat availability, and fish cover.

Canopy cover – A measure of shading over the stream, canopy cover indicates the amount of vegetative overstory. Highly shaded streams are likely to be dominated by allochthonous inputs, whereas streams without cover are more likely to be driven by autochthonous production. Streams without cover are also more likely to exhibit greater temperatures and larger diel shifts.

Stream substrate, depth, and embeddedness – these points, measured at the left bank, 25% width, 50% width, 75% width, and right bank, also give basic measures of habitat type, availability, and sediment deposition.

Human influence – Presence/absence and proximity of a suite of human influences (e.g., buildings, roads, pipes, trash, etc.) give indicators of near-field human impacts.

Fish/Amphibian Cover – Categorical area estimates provide information on macroscale cover (e.g., filamentous algae, macrophytes, woody debris, etc.) for aquatic vertebrates. Cover is important as refuge from predation and cooler temperatures.

Riparian estimates – Categorical area estimates of vegetation classes (canopy, understory, and ground cover) along with broad type of vegetation (e.g., deciduous or coniferous) provides information about riparian zone structure and function.

Woody debris – Large woody debris storage and retention is a common response variable in degraded versus pristine streams. Woody debris provides habitat for invertebrates and vertebrates and can play a role in channel structure (e.g., logjams).

Dominant trees – Dominant trees are the largest riparian trees, are important components of the riparian zone structure, and provide habitat for terrestrial vertebrates. The type, height, distance from stream, and categorical estimate of diameter breast height are recorded. These trees are called "legacy" trees in the EPA terminology, whereas we use the term "dominant" to coincide with the KLMN Vegetation Monitoring Protocol.

Invasive species – Invasive plant species in the riparian zone are recorded as important components.

2.5.3.2 Reach-wide Environmental Parameters

Thalweg – Thalweg is the section of the river cross-section that is deepest, and measurements are useful in characterizing habitat heterogeneity and are important for the relative bed stability calculations.

Slope – Stream gradient is a fundamental aspect of stream geomorphology and in structuring the stream community.

Discharge – Discharge is taken at a single point in the stream channel but is representative of the entire stream reach. It is also a fundamental component of stream ecosystems, structuring both the physical and biological elements.

Channel variables – Channel patterns (i.e., braided or not), percent channel constrained, constraining features, evidence of recent flooding, and valley width are all recorded as co-variables.

2.5.4 Aquatic Communities

Aquatic communities are made up of different taxonomic components, spanning the spectrum of functional roles: primary production, consumption, predation, and decay. Any one taxonomic component (e.g., macroinvertebrates) is not a "community," but rather an assemblage that makes up an important part of the entire aquatic community. By sampling multiple aspects of the aquatic community, we will effectively be sampling the stream food chain (or trophic structure), aimed at determining status and trends in stream functional ecology. By examining the large portions of the aquatic ecosystem, interactions between organisms can be better understood so that predictive models of how park ecosystems respond to specific stressors or extirpations can be evaluated (Agrawal et al. 2007). As indicators of biological condition, they are the focus of the Network for the analysis and reporting of status and trends.

Aquatic communities are important components of aquatic ecosystems that are determined by and sensitive to the conditions of the habitats within which they reside (Loeb and Spacie 1994). Part of their utility as monitoring indicators is that each assemblage can react individually to different stressors. For example, increasing sediment inputs can create negative responses in fish due to clogging of gills or smothering of eggs, whereas certain insects (e.g., certain

Chironomidae midges) will respond positively to increases in habitat for burrowing. An additional advantage is that aquatic communities integrate responses to stressors over time, with some components responding rapidly to changes and others responding gradually to longer-term stressors. For instance, benthic macroinvertebrates act as continuous monitors of water quality issues, so that even a point-in-time measurement can provide information about seasonal or annual trends without the need for continuous sampling (Hawkes 1979).

Integrated biological sampling provides cost-effective monitoring of aquatic resources, when compared to other types of monitoring. A review of cost/benefits comparing biological monitoring to physical, chemistry, and toxicity monitoring showed the greatest gain and understanding from using biomonitoring alone, and that when combined with physical and chemical monitoring, provided the best overall ecosystem assessment (Brinkhurst 1996).

Algal biomass is a measure of stream productivity driven by autochthonous production. High values can indicate nutrient enrichment. In general, high values should also be positively correlated with higher order streams with large wetted widths and negatively correlated with increasing riparian cover and stream shading. Abnormal conditions from this pattern can signal impacts. Biomass is measured as the standing crop of periphyton chlorophyll *a* (algae growing on any submerged surface).

Benthic macroinvertebrates have a rich scientific history as biomonitoring tools (Rosenberg and Resh 1993). Changes in macroinvertebrate assemblages have been successfully demonstrated as indication of ecological impairment (e.g., Lenat et al. 1981, Rosenberg et al. 1986). Benthic macroinvertebrates form the basis of predictive models of impairment, using O/E (observed to expected ratios), comparing observed to expected conditions (assuming no impact). Such predictive models include the River Invertebrate Prediction and Classification System (RIVPACS, Wright et al. 1989) models and also integrated multi-metric IBIs (index of biological integrity) (Karr and Chu 1999).

Amphibians are perhaps the premiere “early-warning detection system,” being exceptionally sensitive to changes in water chemistry, chemical pollution, and introduced pathogens. Amphibians world-wide are experiencing population declines due to a large number of distinct and interacting stressors (e.g., exotic species, impaired habitat, pollutants, climate change, etc.). For this reason, many populations are currently imperiled and necessitate monitoring for inherent conservation reasons. Integrated into stream monitoring, amphibians represent signals of introduced exotic species (Stead et al. 2005, Fellers et al. 2008), emerging wildlife diseases (Collins and Storfer 2003), and declining ecological integrity (Knapp et al. 2005).

Fish, as long-lived top predators in stream ecosystems, serve as integrated monitors of the stream ecosystem. Fish have the advantage of migrating large distances, so that fish responses also integrate over a larger spatial scale (including anadromous fish from the Pacific Ocean). As threatened species, the bull trout, chinook, and coho salmon are of inherent interest. Given that state water quality designated beneficial uses of Klamath Network streams include the category, Coldwater Fisheries, monitoring fish assemblages provides valuable information in managing stream ecosystems.

2.5.5 Derived and Integrated Metrics/Indices

From the various classes of monitoring parameters, we will derive a number of useful metrics and indices for assessments of status and trend, as well as data exploration. Most metrics will be based on EPA protocols. Some metrics are used as simple correlative parameters (e.g., habitat volume) for classification or data exploration; other metrics serve as explanatory variables (e.g., shoreline development), which should equate to habitat complexity (Wetzel 2001). The actual calculation of these metrics is detailed in SOP #22: Data Analysis and Analysis.

Shannon index, and Evenness are classical measures of diversity that incorporate dominance, or lack of dominance, of taxonomic groups. We use these in addition to normal measures of diversity, such as basic *Taxa Richness*, because macroinvertebrate responses to stressors are often manifested as dominance changes, with one or two species dominating the assemblage. In these cases, Shannon index and Evenness may provide more power to evaluate stressor response of the aquatic community.

Hilsenhoff Biotic Index (HBI)/Assemblage Tolerance Index (ATI) are weighted averages of tolerance values derived from empirical observations of macroinvertebrate responses to pollution (Hilsenhoff 1987, 1988; Whittier and Van Sickle 2010). Since these responses have been extended to a variety of impacts, the HBI and ATI are useful ways of examining macroinvertebrate changes to stressors. The HBI is a long standing index, whereas the Assemblage Tolerance Index is a recent development from the US EPA EMAP program (Whittier and Van Sickle 2010). Until the ATI is commonly used, we will utilize both indices.

Multi-metric Index (MMI) is a traditional approach used to assess stream health based on stream assemblages (Stoddard et al. 2005). This provides managers with a single value, integrating multiple components of the assemblage, ranging from 0 to 100, with high scores indicating undisturbed ecosystems, and low scores indicating impairment. We will use combinations of MMI (also called Indices of Biological Integrity, IBI) developed by the EPA and state (CA and OR) monitoring agencies to assess stream health both on fish assemblages (EPA only) and invertebrate assemblages (EPA and state).

O/E Index is a complementary approach using a predictive model of expected taxonomic diversity, specific to macroinvertebrates, drawn from reference sites across multiple, natural gradients (Hawkins et al. 2000). Using predictor variables, such as elevation, stream size, gradient, latitude, and longitude, expected taxonomic diversity of macroinvertebrates can be predicted. The observed, sampled diversity is then used in the O/E ratio, so that values outside a model reference range indicate impairment, but with a readily interpretable meaning (>1.0 = higher than expected diversity, < 1.0 = lower than expected diversity).

Physical Habitat Summary Metrics have been developed as part of the EPA EMAP protocols for quantifying physical habitat in wadeable streams (Kaufmann et al. 1999). Metrics include summation and averages for riparian shading, fish and amphibian cover, and total habitat availability, and include the US EPA stressor categories of habitat complexity, riparian vegetation, and sediment sediments.

2.6 Power Analysis

A power analysis is a valuable step to assess whether the proposed sampling effort in terms of number of wadeable streams sampled per park unit over time is sufficient for detecting long-term trends in environmental indicators. Power is a function of the sample size (number of streams), number of years of sampling, variance of the indicator, and type one error (probability of detecting a trend when in fact there is not one). The variance of an indicator is typically unknown and is therefore estimated from available pilot data. For the indicators of interest in this protocol, unfortunately very few long-term data are available at this point. However, we use available macroinvertebrate data from PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO) to explore the power to detect annual trends in the observed to expected ratios, one of the primary bioassessment tools.

We make the assumption that the variability inherent in the PIBO data is representative of that within the sampling frames of the five parks covered under the KLMN wadeable streams protocol. In this protocol, there are a combination of probabilistic and judgment (non-random) streams selected for monitoring. We only consider how to model trend within the probabilistically selected sites which provide park-wide inferences about long-term trends.

In order to perform a power analysis for univariate trend, a model must be assumed for the future data. We adopt the linear model presented in Urquhart et al. (1998). The model is as follows where is the observed characteristic of interest (e.g., average observed to expected ratio) for stream *i* in year *j*, , , , and the components are assumed independent. There have been many modifications to this general model idea (Van Leeuwen et al. 1996, Piepho and Ogutu 2002), allowing for different trends across streams. We used the functions written by Tom Kincaid to estimate power based on the model above; for specific details on the power calculations, refer to the paper by Urquhart et al. (1998). These are *estimates* of the power because we are estimating the variance components. These estimates can be improved once more sampling is conducted within the specific KLMN parks.

We use a log transformation such that trend on the O/E scale is in terms of a multiplicative change in the median O/E over time, whereas on the log-scale the trend is in terms of an additive increase or decrease in the mean of the logs. This interpretation assumes the log-transformed data have symmetric distributions. The log transformation is typically appropriate for biological data that display exponential growth and increasing variability with an increase in mean. The residuals appeared to meet the model assumptions better on the log-scale for the PIBO data. The data used in the power analysis are displayed in Figure 6.

The Observed-to-Expected ratios for streams to be sampled within the Klamath Network should be consistent with those displayed in Figure 6. We maintain that the O/E ratios from the PIBO data represent a model of the site and annual variation because: (1) identical collection techniques were used, and (2) O/E models are built and calibrated regionally using identical methods, so that the performance characteristics should comparable.

The estimated power is based on the assumption that 15 streams are surveyed every 3-year period (always revisit design) and the available PIBO pilot data O/E represents the stream-to-stream, year-to-year, and stream by year variation within a Klamath Network sampling frame. For 10 sampling occasions or 30 years of elapsed monitoring, there is greater than 80% power to detect a 5% or 10% three-year decrease in median O/E with 10% type one error (Figure 7). For a smaller 3-year change of 2%, the power is substantially lower (as expected). For example with a 5% 3-year change, if the median O/E ratio was 1.0 for year 1 of sampling after 30 years we would expect the median O/E ratio would decline to 0.61 [exp(-.05*10) = 0.61]. If we assumed a 10% 3-year change, the median O/E ratio would decline to 0.37 after 30 years. Notice a real sample would not display these estimates exactly; these are the assumed values of the parameters under the alternative hypothesis for a power analysis or the biologically meaningful decline of interest to detect.

Additionally, many of our protocol objectives focus on a multivariate approach because we have chosen to analyze community change using species assemblages. Primary methods for the analysis of community data are non-parametric methods, for which there is no theoretical basis for power analyses (Somerfield et al. 2002). In other words, it is impossible with the current body of statistical literature to run power analyses on our primary method of data analysis. The utility of using univariate measures to assess a sampling program based on multivariate analyses is summarized by Somerfield et al. (2002):

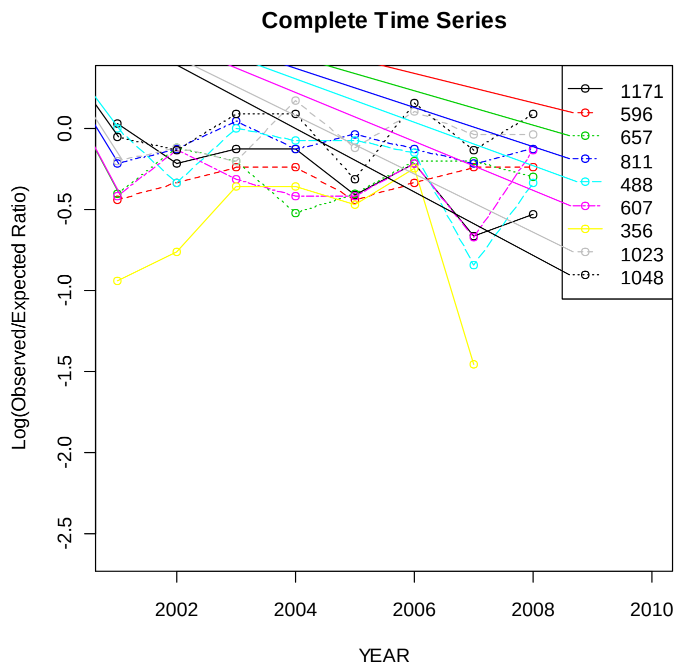

Figure 6. PIBO O/E ratios on the log-scale from nine sites sampled in 2001-2008. Numbers refer to PIBO site codes.

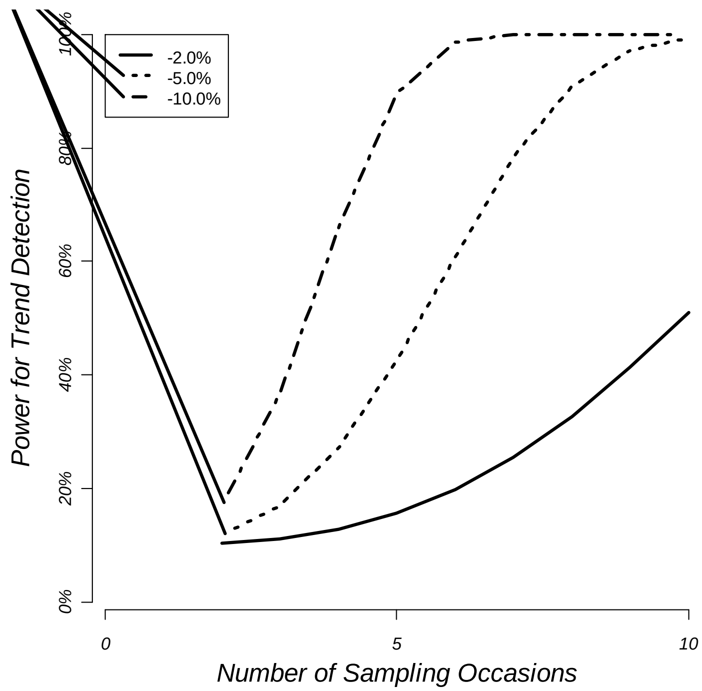

Figure 7. Power for O/E ratio using variance component estimates based on only the PIBO displayed in Figure 6. Assuming 15 sites surveyed every 3 years with an every 3 year change of ¯2, ¯5, and ¯10 percent change in the median O/E.

> *“Multivariate techniques have been shown repeatedly to be more “sensitive” (i.e. powerful) than univariate techniques (Warwick and Clarke 1991, Somerfield and Clarke 1997, Clarke and Warwick 2001) and although there is no general framework for determining power in the multivariate context the repeated demonstration that multivariate technique produce significant results when univariate techniques do not may be taken as evidence that a survey designed to have adequate power in a univariate context (e.g. for diversity indices) should have adequate power in the multivariate context (of changes in whole community composition).”*

Second, many of our variables are measured to provide context for other parameters. For example, anions and cations are measured to understand stream chemistry in relation to the biological community but not as parameters for trend detection by themselves. So, although some parameters may have extremely low power due to high variability, this does not limit their usefulness for the monitoring program.

3.0 Field and Laboratory Methods

3.1 Data and Sample Collection

The attached Standard Operating Procedures (SOPs) describe field collection methods in detail, including pre-season preparation, water sampling and handling, physical habitat sampling, aquatic community sampling, shipping of samples, and end of season procedures (Table 5).

Table 5. Standard Operating Procedures covering the preparation, collection, and recording of field data for the integrated aquatic community and water quality sampling of streams.

SOP	Title and Description
SOP #1	**Preparations, Equipment, and Safety**
	A general overview of the steps necessary for the initiation of a field season. It covers tasks that the Project Lead will have to start early on in the planning process: hiring of field crews, equipment preparation, scheduling of crews, and basic safety is discussed.
SOP #2	**Field Crew Training**
	Covers the requirements for getting crews trained for the upcoming season, including field sampling procedures, ethical considerations, administrative processes, and data management training.
SOP #3	**Site Selection**
	Provided to give an overview of the site selection process and to inform the field crews of how the sites were initially selected, but this protocol will only have to be performed once at the initial implementation of the program.
SOP # 4	**Data Entry**
	Explains the use of tablet computers and data sheets used to record data collected during field procedures.
SOP #5	**Work Flow**
	Describes the most efficient method for performing the remaining SOPs to minimize time and so that any one sampling activity does not interfere with or contaminate another.
SOP #6	**Site Arrival Tasks and Sample Reach Layout**
	Describes the initial tasks the crew must achieve upon arrival to the reach and how to layout the transects that form the basis of the sampling.
SOP #7	**Water Quality Multiprobe Calibration and Field Measurement**
	Describes how to calibrate the water quality sonde prior to sampling, and the methodology of using the instrument to collect and record field data.
SOP #8	**Water Chemistry Sample Collection and Processing**
	Describes the methodology used for collecting water samples and how to process and store them.
SOP #9	**Macroinvertebrate Collection**
	Describes the process of collecting reach-wide benthic macroinvertebrates.
SOP #10	**Discharge Measurements**
	Describes the steps to calculate the instantaneous discharge at the time of sampling.
SOP #11	**Periphyton Sampling**
	Describes where and how to collect, process, and preserve the algal periphyton sample.

Table 5. Standard Operating Procedures covering the preparation, collection, and recording of field data for the integrated aquatic community and water quality sampling of streams (continued).

SOP	Title and Description
SOP #12	**Stream Habitat Characterization**
	Describes methodology of transect-based physical habitat characterization.
SOP #13	**Slope Measurements**
	Describes the process of measuring slope for the reach.
SOP #14	**Riparian, Invasive Plant, and Dominant Tree Characterization**
	Describes the monitoring methodology for basic riparian, invasive plant, and dominant tree measurements.
SOP #15	**Aquatic Vertebrate Monitoring**
	Describes techniques for electrofishing and visual encounter surveys.
SOP #16	**Photo Points and Photo Management**
	Describes the placement and method of photo points and photo management.
SOP #17	**Post-Site Tasks**
	Describes the necessary steps and tasks to be undertaken after sampling, and before sampling a new reach
SOP #18	**Post-Field Season**
	This SOP describes tasks to be undertaken by the field crew at the end of the season, including equipment clean-up, inventorying, storage, and post-season de-briefing.

3.1.1 Field Season Preparation

Standard Operating Procedure #1: Preparations, Equipment, and Safety details the necessary steps needed for ensuring a well organized field season. Tasks are briefly summed here, but SOP #1 provides greater depth and detail.

It is imperative that field season preparations start by January of the sampling year. Preparation should start with field crew hiring. Ideally, positions will be announced in January, so it may be necessary to have Human Resources start the procedure as early as December of the previous year. Other preparations to be arranged prior to the field season include obtaining permits and scheduling park housing for field staff.

Field vehicles needs should be calculated in January. In coordination with the Network Program Assistant, the Project Lead should arrange for a vehicle through: (1) use of existing Network vehicles, (2) procurement of a new Government Service Administration (GSA) vehicle, or (3) a rental vehicle (arranged through GSA).

Purchasing and preparation of supplies should begin in February of the year in which sampling is to take place. Consumables (bottles, calibration solutions, etc.) should be inventoried and prepped according to procedures outlined in the SOPs. It is the responsibility of the Project Lead to check that all electronic equipment is functioning properly and all software is up to date.

Training should start with supplying the protocol to new hires upon completion of the hiring paperwork. The Project Lead should include scheduled classroom time for instruction in equipment use, followed by practical hands-on use at a field site, allowing ample time for instruction in all aspects of the protocol.

Permit requirements may change from year to year, depending on which parks are scheduled to be sampled and current requirements of park staff. Some parks require permits while some may allow research and collections by NPS employees without permits. Minimum Requirement Analyses (MRA) for sampling in wilderness areas may be required, especially at LAVO. Minimum Requirement Analysis is a method that park units use to ensure projects occurring in wilderness are justified and impart as minimal impact to the landscape as possible. The process to complete the MRA is administered as a follow-up to the park permitting process. The Project Lead will need to coordinate with the Chief of Natural Resources at scheduled parks well in advance of the beginning of the field season to ensure that all permits are secured.

Focal species covered by this protocol include fish and amphibians listed under the Endangered Species Act, for example: Crater Lake National Park contains bull trout (*Salvelinus confluentus*) and Redwood National and State Parks contains Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*Oncorhynchus kisutch*), and steelhead (*Oncorhynchus mykiss irideus*). For anadromous fish, sampling (either in mortalities or handling [aka "take"]) is regulated by the National Oceanographic and Atmospheric Administration (NOAA) in their National Marine Fisheries Service (NMFS). For other threatened and endangered species, take is regulated by US Fish and Wildlife Service. It is the responsibility of the Project Lead to apply for permits well in advance of the sampling season (minimum 6 month lead time). Information for permits can be found at: http://www.nmfs.noaa.gov/pr/permits/.and http://www.fws.gov/Endangered/permits/index.html. Note that either agency may require the possession of state permits as well.

For California, the permit procedure is available at: http://www.dfg.ca.gov/licensing/pdffiles/fg1379.pdf

For Oregon, the permit procedure is combined with the NMFS procedure.

All reporting requirements for park, state, or federal permits are the responsibility of the Project Lead.

3.1.2 Field Work

Crews check-out field equipment and double check that all gear and field supplies are present in appropriate quantities and in proper functioning condition. Crews hike or drive to sampling reaches. Crews generally work from the downstream end to the upstream end of the stream reach to minimize effects of sampling disturbances on the accuracy of subsequent transects. For warmth and safety, crews wear chest high waders during sampling and should have spare clothes available. Crews will be carrying heavy loads into the backcountry; lightweight personal and sampling gear is encouraged. The sampling frame has placed an emphasis on streams that are accessible and can be sampled in a single day of travel. No overnight camping in wilderness should be necessary, but it will be encouraged if it facilitates sampling multiple sites efficiently.

Following the guidelines in SOP #5 (Order of Work), and for establishing the site (SOP #6: Site Arrival Task and Sample Reach Layout), crews collect water samples (SOPs #7 and 8), physical habitat data (SOPs #10, 12, 13, 14, 16), algal biomass samples (SOP #11), macroinvertebrates (SOP #9), and vertebrates (SOP #15). Invertebrate samples will be sent to an aquatic entomology laboratory but fish and amphibians will be processed and released in the field. At the discretion of the park, exotic fish may be euthanized and disposed in the field. Amphibians will be sampled using Visual Encounter Surveys. Amphibians will be handled only occasionally, as necessary to confirm species identifications.

Crews perform field alkalinity analyses using a portable test kit with minimal chemical requirements (mild sulfuric acid). All generated waste will be carried out by the crew and disposed of properly, meeting requirements of the Chemistry Department of Southern Oregon University.

3.1.3 Sample Handling and Shipping
Employees handling samples are required to adhere to quality control procedures to ensure sample integrity. All procedures detailed in the SOPs must be performed (SOP #17: Post-site Tasks). No “short-cuts” by field crews will be allowed. Water samples must be placed in a designated freezer or refrigerator as soon as possible by field crews upon return from the field. It is the responsibility of the Project Lead to secure access to such facilities for field crews. Water samples are shipped overnight to the lab from the Southern Oregon University mail room, using the Klamath Network administrative task agreement to cover charges. Samples should be shipped early in the week, to avoid the potential for samples to show up at the end-of-week workday, at a time when no one is available to receive them.

Macroinvertebrate samples are stored in 95% ethanol to ensure adequate preservation. It is the responsibility of field crews to ensure that enough room in the sample vials exists to achieve this. All macroinvertebrate samples are retained by the Project Lead or field crews until the end of the season, when they will be shipped to an aquatic entomology laboratory. It is the Project Lead’s responsibility to ensure that samples are properly tracked (SOP #19: Quality Assurance Project Plan) and shipped legally (it is illegal to ship Ethanol and other flammable liquids without special certification and training). The Project Lead should work with the aquatic entomology laboratory to meet these requirements. One possible solution to shipping Ethanol is the temporary replacement of Ethanol with water and overnight shipping. The aquatic entomology laboratory can than replace the water with Ethanol, so that minimal degradation to the samples has been incurred.

3.1.4 End of Season Procedures
Once sampling is complete at all sites, gear is decontaminated a final time, cleaned, repaired as needed, and stored. Crews will make a list of gear needing to be replaced or repaired and it is the Project Lead’s responsibility to make certain the gear is ready for the following field season following the procedure in SOP #18: Post-season Tasks.

The Project Lead will conduct a post-season debriefing with field crews to discuss the season and make sure that all necessary protocol-related processes have been done. Any departures from the protocol will be discussed and analyzed. Necessary revisions and improvements to protocols will be discussed and if necessary, done in accordance to SOP #24: Revising the Protocol. Prior to the Crew Leader leaving, the Project Lead needs to review all data components with him/her to make certain final copies of all data related to the project are stored in their proper location on the KLMN Server, data on electronic equipment have been removed, and data-related questions or issues have been resolved.

3.2 Field and Laboratory Analyses

Laboratory methodologies and instrumentation have been chosen that match national standards, that are identical to methods used at Crater Lake National Park, and that match the methods used by the North Coast and Cascades Network. With the exception of the measurements that will be made in the field (acid neutralizing capacity, temperature, dissolved oxygen, pH, conductivity, and turbidity [Table 6]), all chemical analyses will be performed by contract laboratories (Table 7). The Project Lead must ensure that all analyses comply with Measurement Quality Objectives (MQOs) as detailed in SOP #19: Quality Assurance Project Plan.

Field analyses and methodological details are presented in Table 4. Seven cross transect measurements are made to ensure that water chemistry sampling is in a well mixed location using the *Manta* multi-parameter sonde (Eureka Environmental). In keeping with the nature of a long-term monitoring program, the probe used may change as equipment wears out, technological improvements are made, and companies go in and out of business. Any change of equipment will follow the SOP #19: Quality Assurance Project Plan guidelines for cumulative bias, to ensure continuity of reliable data and documented using equipment log books.

Table 6. In situ measurements, methods, and quality standards for water quality measurements. Specifications from Eureka Environmental, **www.eurekaenvironmental.com**. NTU = Nephelometric Turbidity Units.

Measurement	Method	Range	Accuracy	Resolution
Dissolved oxygen	Optical luminescence	0 - 25 mg/L	± 1% or 0.2 mg/L, whichever is higher	0.01 mg/L
pH	Reference electrode	2 - 12 units	± 0.2 units	0.01 units
Redox potential	Reference electrode	-999 - 999 mV	± 20 mV	1 mV
Specific Conductance	4-Electrode Graphite Conductivity Sensor	0 - 5 mS/cm	± 1%	0.001 mS/cm
Temperature	30k ohm thermistor	- 5° C - 50° C	± 0.1° C	0.01° C
Turbidity	McVan NEP9500 type	0 - 3000 NTU	<1% when under 400 NTU	0.1 NTU

The sole field chemical analysis will be the determination of stream acid neutralizing capacity. Acid neutralizing capacity measurements will be accomplished using a Hach Digital Titrator Model 16900, following Hach procedure 8203. The range of this test kit is 10 – 4000 mg/L as $CaCO_3$; accuracy of the Digital Titrator is ± 1% for samples within the range of the test; resolution is one digit (1 mg/L for most circumstances), titrating to a pH endpoint of 4.8.

Klamath Network and Network park units do not have facilities, equipment, or personnel to conduct other laboratory analyses in-house, necessitating the contracting to a specialized laboratory. In general, the procedures will follow those recommended by the American Public Health Association (Eaton et al. 2005) and approved by the US Environmental Protection Agency for water chemistry samples and by recognized standards for macroinvertebrate

processing (Caton 1991, Vinson and Hawkins 1996). Macroinvertebrate laboratories must also use only taxonomists certified by the North American Benthological Society.
Ideally, contract laboratories will be reused from year to year to reduce laboratory bias. When change in laboratories is necessary, the cumulative bias procedure outlined in SOP #19: Quality Assurance Project Plan *must be followed*. Minimum internal laboratory Quality Assurance/Quality Control guidelines for contractor labs are provided in SOP #19: Quality Assurance Project Plan.

At the start of protocol implementation, the chosen water chemistry contract laboratory is the Cooperative Chemical Analytical Laboratory (CCAL), Oregon State University, 321 Richardson Hall, Corvallis, OR, 97331; phone (541) 737-5122; ccal@oregonstate.edu. For chlorophyll *a*, the contract laboratory is Cascade Research, John Salinas, PO Box 5208, Grants Pass, OR 97527; phone (541) 660-5783; JohnSalinas@charter.net. Both laboratories were chosen for their prior analyses of other park units, allowing consistency and comparability. The Project Lead is responsible for arranging necessary contracting, communicating with the laboratory manager, and arranging for sample preparations (detailed in SOPs).

Table 7. Laboratory analyses to be conducted by a contract laboratory; minimum MDL, ML, and precision requirements. [1]= example instrumentation used by contract laboratory (Oregon State University CCAL) for pilot project. APHA = American Public Health Association (Eaton et al. 2005); MDL = Method Detection Limit; ML = Minimum level of quantification.

Parameter	Method	Instrumentation[1]	MDL (mg/L)	ML (mg/L)	Precision (± mg/L)
Calcium	APHA 3111 D	Varian SpectrAA220	0.06	0.19	0.06
Chloride	APHA 4110 B	Dionex 1500 Ion Chromatograph	0.01	0.03	0.01
Dissolved Organic Carbon	APHA 5310 B	Shimadzu TOC-VCSH Combustion Analyzer	0.05	0.16	0.05
Magnesium	APHA 3111 B	Varian SpectrAA220	0.02	0.06	0.02
Potassium	APHA 3111 B	Varian SpectrAA220	0.03	0.1	0.03
Sodium	APHA 3111 B	Varian SpectrAA220	0.01	0.03	0.01
Sulfate	APHA 4110 B	Dionex1500 Ion Chromatograph	0.02	0.06	0.02
Total Nitrogen	APHA 4500-NO3 F; APHA 4500-P J. Persulfate digestion	Total Technicon Auto-Analyzer II	0.01	0.032	0.01
Total Phosphorous	APHA 4500-P B; APHA 4500-P E	Milton-Roy 601 Spectrophotometer with 10 cm pathlength	0.002	0.003	0.002

4.0 Data Management, Analysis, and Reporting

The clear, concise, and consistent collection, recording, analysis, archiving, and reporting of data is essential to the success of the long-term monitoring of Klamath Network wadeable streams project and will be a top priority for all personnel. Data management is an ongoing cycle for each year the project is implemented and includes training, data collection and entry, validation and verification processes, documentation, distribution of project products, storage, and archiving (Mohren 2007). These steps are described in detail in the SOPs referenced below.

4.1 Quality Assurance Project Plan

A key component of data management is Quality Assurance/Quality Control. Quality Assurance is methodical, systematic planning of a program to ensure that products produced meet specified standard requirements (Irwin 2008). These steps include elements of sample design, parameter selection, reporting, and a feedback loop to improve quality. Quality Assurance also includes the important steps of Data Management: (1) Validation, (2) Verification, and (3) Certification (see below). Quality Control is the documentation of the standard requirements to be met under the program, and include quantitative performance characteristics like precision, bias, and sensitivity for all parameters measured. These steps are integrated into a single document, SOP #19: Quality Assurance Project Plan (QAPP). This SOP lists the steps and processes needed to ensure that data produced in the project is of a known quality.

4.2 Database Design

The water quality component of the Natural Resource Challenge (NRC) requires that all NPS networks archive any physical, chemical, and biological water quality data collected with NRC water quality funds in the WRD STORET (STOrage and RETrieval databases). To assist in this process, networks have the opportunity to make use of a relational database patterned after the Natural Resource Database Template (NRDT) and developed by the Water Resources Division (WRD) called NPSTORET, or they can utilize any of the numerous databases already available as long as they can export that data into a format that meets the STORET Electronic Data Deliverable (NPSEDD) specifications. We have opted to develop a NRDT compliant, network-specific database that meets the NPSEDD specification for all aquatic and water quality monitoring projects. It was determined that NPSTORET did not have all the functionality needed to account for all the data being collected as part of this integrated protocol. The relational database was developed using the NPS Natural Resource Database Template (NRDT) and is described in detail in SOP #20: Database.

Crews use the project database (s) to enter data using Tablet PCs (SOP #4: Data Entry) at each monitoring site, with paper field forms as a backup. After QAPP procedures (including validation, verification, and certification) are completed, this database is used to create summaries and conduct data analysis for annual reports. At the end of the year, the data are uploaded to a master database for long-term storage and future analyses.

4.2.1 Metadata Procedures

Creation of metadata is an integral part of any project that collects samples that generate data and information. Metadata consists of information that documents the information contained within data files and information products. In other words, metadata is “data about data.” The overall goals of metadata creation are to develop a comprehensive document that explains enough about the project data to ensure they are useable by future personnel and the scientific community (providing important future context). Metadata development begins at the start of every project; as the project develops, so does the metadata. Within the sideboards set by the program and federal requirements, the process of metadata creation will vary depending on goals and objectives, funding, and scope of the project. It is the responsibility of the Data Manager to set forth the metadata requirements and the process used to create the metadata.

Database, Spreadsheets, and Data Sheets*:* The metadata for a project should be created prior to implementing the field season and will need to be updated at the end of each field season. The Klamath Network utilizes a Metadata Interview form that describes the various attributes of a dataset. The interview form includes information about the time frame, description, sensitivity, collection location, and purpose of the data, plus various other pieces of information needed to develop the metadata for the dataset. It is the Project Lead's responsibility to complete a new Metadata Interview form before the start of the first field season and at the end of each additional field season. In addition to the Metadata Interview form, a data dictionary is provided for all databases and spreadsheets used as part of this protocol (SOP #20: Database). During the winter months, prior to starting the field work, the Project Lead will review the data dictionary and work with the Data Manager to make any necessary changes.

GIS & GPS Files*:* Similar to the data products above, the KLMN will utilize the Metadata Interview form to manage the metadata for these products. The metadata for all GIS files created as part of this protocol will consist of Federal Geographic Data Committee compliant metadata before being made available to non-Network staff.

Photographs*:* The Klamath Network requires metadata to be provided for each photograph used to capture some aspect of a monitoring project (e.g., field crew, sites, sampling method). These details are provided in SOP #16: Photo Points and Photo Management.

Documents*:* We expect to develop several types of reports as part of this protocol including publications, technical reports, outreach materials, resource briefs, and in-house reports. All reports should contain the following information when applicable: first and last name of the author(s), affiliation, version number (when in draft form), date the report was completed, series number, and the NatureBib accession number (in the document properties).

4.1.2 Storage

When collecting data electronically in the field, a backup of the database will be made prior to leaving a field site. The backup of the database should be stored to a source that is external of the electronic device. Once back to the field base (e.g., park housing), data from the electronic devices should be stored in a desktop or laptop computer. These steps are detailed in SOP #17: Post-site Tasks.

When returning to the Klamath Network office, data should be reviewed by the Project Lead. Once the data have undergone all validation and verification processes, they should be transferred to the Network Data Manager. Data will follow the backup process implemented by Southern Oregon University that includes nightly, weekly, and quarterly backups stored for two months (nightly and weekly backups) or one year (quarterly backups) (SOP #23: Data Transfer, Storage, and Archive).

4.3 Data Collection

Steps and procedures used for data collection is the primary purpose of SOP #s 4 through 17. It is the responsibility of the Field Crew Leader and Project Lead to adequately train field crews in data collection and management methodologies outlined in this protocol (SOP #2: Field Crew Training). Since this protocol is a long-term commitment and crew turnover is expected, a training session on the database, based on the Data Entry SOP (#4), is necessary each season. A log should be kept outlining the training sessions each crew member attends and logs should be transferred to the Data Manager at the end of each field season.

All data collection and data management tasks related to the entry of data are detailed in SOP #4: Data Entry, which includes the use of backup paper data sheets in case of electronic equipment failure. Data sheets and logs (documenting training, equipment calibration, and other events) are scanned into .pdf format for electronic archival at the end of the season following methods outlined in SOP #23: Data Transfer, Storage, and Archive.

4.4 Data Verification, Validation, and Certification

Data verification is the process of ensuring that data entered into a database accurately duplicate data recorded in the field. Field crew members and the Project Lead use the following process to verify data and are described in detail in SOP#19: Quality Assurance Project Plan: (1) Visual review at data entry, (2) Visual review after data entry, and (3) Final review.

Data validation is the process of reviewing the finalized data to make sure the information presented is logical and accurate. The accuracy of the validation process can vary greatly and is dependent on the reviewer's knowledge, time, and attention to detail. General data validation procedures are detailed in SOP #19: Quality Assurance Project Plan and include: (1) Data entry application programming, (2) Outlier detection and review, (3) Measurement Quality Objective checks, and (4) Review of what makes sense.

After data validation and verification, the Project Lead will turn in a Data Certification form(s) (from the Klamath Network Data Management Plan, Mohren 2007) to the Data Manager. This form is used to ensure:

- The data are complete for the period of time indicated on the form.
- The data have undergone the quality assurance checks indicated in the protocol.
- Metadata for all data has been provided.
- Project timelines are being followed and all products from the field season have been submitted.
- The level of sensitivity associated with the deliverable is appropriate.

A new Certification form should be submitted each time a product is submitted. If multiple products are submitted at the same time, only one form is necessary. The form and further instructions for data certification are provided in SOP #19: Quality Assurance Project Plan.

4.5 Data Analysis, Reporting, and Dissemination

Data analysis, reporting, and dissemination guidelines are covered in SOP #22: Data Analysis and Reporting. This SOP covers a comprehensive approach by the Klamath Network of the reporting of data for the next 12 years. There will be two elements of our reporting strategy: (1)

Annual Reports describing field sites visited, interesting findings, and status of the measured parameters completed every sampling period and (2) Analysis and Synthesis reports completed every three years that focus on trends and comprehensive descriptions of the attributes of the stream ecosystems. Reporting topics, timelines, and dissemination are covered in more detail in SOP #22: Data Analysis and Reporting.

4.5.1 Annual Reports

Annual reports are summaries of the wadeable streams sampled for a field season. An example of an annual report is provided in Appendix A, from the data collected during the pilot project. These reports will focus on providing managers a current status assessment, defined using measures of central tendency (means or medians) of the park habitats. Since wadeable streams have a large history of bioassessment tools (e.g., Indices of Biotic Integrity), annual reports will include these summary values assessing ecosystem condition. Reporting tools will focus on mean conditions, along with user-friendly graphical presentations. Unusual or significant findings will also be highlighted. Annual reports serve to update the park units where sampling occurred for their use in management and reporting goals.

Due to necessary turn-around times for contract laboratories, summary reports will be due June 1st of the year following stream sampling. This will provide approximately 180 days for the contract laboratories to process invertebrate samples and an additional three months for the Project Lead to complete the report. Report format will be the Natural Resources Technical Report (NRTR) series format.

4.5.2 Analysis and Synthesis Reports

Analysis and Synthesis reports form the basis of trend analysis for the integrated aquatic communities and water quality vital signs. In the spirit of long-term sampling, the protocol will run through several sampling periods before meaningful analyses can be completed. The first Analysis and Synthesis report will occur after the second sampling period, two years after implementation, and include all parks sampled as a part of this protocol. As in the Annual Reports, they will occur every three years thereafter. Reporting format will follow the NRTR format.

The initial Analysis and Synthesis reports will focus on describing the fundamental aspects and gradients of the streams: (1) Physical, (2) In-stream communities, and (3) Riparian Interactions. An individual report will be devoted to each aspect of the stream, starting with the least variable: the physical environment. The second will focus on the in-stream communities (invertebrates, amphibians, and fish) of the stream ecosystems. The third Analysis and Synthesis report will examine how riparian measures interact with the physical and biological aspects of the stream communities. This report will, where applicable, integrate data from other vital signs that are sampled near the stream reaches (Landbirds, Vegetation Communities, and Land Cover).

The fourth Analysis and Synthesis report will be the first major analysis of trends. This will be after four sampling periods and will be due on the 1st of November, 2025. Although this lag between implementation and the first trend analysis seems unduly long (14 years), this is close to the minimum number of sampling periods needed to achieve significant trends with the Mann-Kendall test at the α level of 0.05 level (Rohlf and Sokal 1995); trend analyses prior to this would be of limited usefulness. This report will be a comprehensive study on the techniques to detect trends and will outline the methods to be used in future trend analyses, recognizing that the field of ecological statistics and trend analysis will always be an innovative and evolving one. The Project Lead is encouraged to explore other aspects of monitoring and research as well. Possible topics include: (1) Bayesian statistics applications; (2) Status and trends in a regional context (i.e., integrating data from other regional programs); and (3) Reanalysis of sampling frame (e.g., have streams become inaccessible, park land base increased, or have perennial habitats become ephemeral). In determining the topics to be covered by Analysis and Synthesis reports, park staff at the respective park units should be consulted to explore specific management or research needs that may be answerable using the data from this protocol.

4.5.3 Data Dissemination

It will be the Project Lead and the Klamath Network Data Manager's responsibility to utilize the season's certified raw data along with the materials presented in the Annual report, Analysis report, and Metadata Interview form to populate or update the NPS Inventory and Monitoring databases including NPSpecies and the NPS Reference Application. In general:

- All reports will be posted to the reference application and links provided on the KLMN Internet and Intranet web pages.
- The full report will be sent to the Resource Chiefs of each park and to any park staff that are associated with the project.
- A short, one-page summary of the report will be sent to all park staff.
- Reports will be linked to the corresponding species in NPSpecies.
- Photographs and metadata provided for photographs will be stored in the project folder located on the Klamath Network shared drive, where only the Data Manager will have write access but all KLMN employees will have read access.
- After all QA/QC procedures have been completed (including validation, verification, and certification) of all data products (field and lab), the data are sent annually to the Water Resources Division for inclusion in WRD STORET. Water Resources Division then uploads the data, once they have done any edits or QA/QC procedures, to the EPA STORET National Data Warehouse (www.epa.gov/storet/dw_home.html).
- Once Annual reports, raw data, and GIS files have been reviewed and finalized, they will be packaged together along with their associated metadata and posted to the reference application system after the holding period listed below.

4.5.4 Holding Period

To permit sufficient time for priority in publications, when data are sent to the park staff or the public, it will be with the understanding that these data are not to be used for publication without contacting the Network Contact. The raw data is sent to WRD and reference application one year after collection for general distribution. Note that this hold only applies to raw data and not to metadata, reports, or other products that are posted to NPS clearinghouses immediately after being received and processed.

4.5.5 Sensitive Information

Certain project information related to the specific locations of rare or threatened taxa may meet criteria for protection and as such should not be shared outside NPS, except where a written confidentiality agreement is in place prior to sharing. Before preparing data in any format for sharing outside NPS, including presentations, reports, and publications, the Project Lead should refer to the guidance in SOP #21: Sensitive Data. Certain information that may convey specific locations of sensitive resources may need to be screened or redacted from public versions of products prior to release. All official FOIA requests will be handled according to NPS policy. The Project Lead will work with the Data Manager and the FOIA representative(s) of the park(s) for which the request applies.

5.0 Personnel Requirements, Training, and Safety

5.1 Roles and Responsibilities

The Integrated Aquatic Community and Water Quality Monitoring of Wadeable Streams in the Klamath Network program is the responsibility of the Network Aquatic Ecologist, also referred to as the Project Lead. The Project Lead is a GS-9/11/12 level scientist who is trained and experienced in aquatic ecology, with hands-on experience in lentic and lotic habitat ecology, either through postgraduate education or work experience. The Project Lead is responsible for managing the day-to-day activities of the streams project; supervises seasonal crew members and provides them with tactical and logistical support during the field season; verifies, validates, and analyzes data; and writes and completes Annual and Analysis and Synthesis reports.

Assisting the Project Lead is the Network Coordinator, who has overall responsibility for implementing and supervising this project; is responsible for the successful completion of all aspects of the project; and directly supervises the Project Lead and Data Manager. The Data Manager is responsible for creating and maintaining the seasonal and master database; providing data management guidance and training to project staff; and ensuring the data are accurate, properly documented, stored, archived in a secure manner, and made available to a diverse audience. The field crew will consist of four members: a senior Field Crew Leader and three junior Field Crew Members. With the number of reaches to be visited in this protocol at 60 or 61 (depending on the parks to be sampled), a single crew can sufficiently sample all reaches during the field season.

The Field Crew Leader is supervised by the Project Lead, is accountable for supervising crew members and any volunteers in the field, and is responsible for the successful completion of the field component of this protocol. This includes but is not limited to the collection, storage, and shipment of field samples and the collection and entry of data into the monitoring program database. The Field Crew Leader is responsible for the calibration, use, and/or maintenance of monitoring program equipment. He or she is also responsible for providing recommendations on how to improve the task outlined in the protocol. The Field Crew Leader needs experience in conducting aquatic field work in relatively remote locations, at least some experience in supervising peers, and the ability to live and work cooperatively with others under often stressful and challenging conditions for extended periods.

The field crew members are supervised by the Field Crew Leader and will be responsible for successfully completing all monitoring program tasks, including but not limited to the collection, storage, and shipment of field samples and collection, verification, and entry of field data. The field crew members will have at a minimum some experience in conducting aquatic field work in relatively remote locations and have demonstrated ability to live and work cooperatively with others under often stressful and challenging conditions for extended periods.

5.2 Training Procedures

A standardized, comprehensive training program for all personnel is necessary to ensure that data collection is consistent and meets the data quality objectives listed in various SOPs in this protocol and the data standards defined in the Klamath Network Data Management Plan. The training program should last 2 weeks, although actual data collection under Project Lead supervision can and should be conducted during this period.

The training program should start with classroom sessions, with the Project Lead, working closely with the Data Manager, GIS Specialist, and Program Assistant, developing instructional materials that cover the following topics (the list can be expanded):

1. Background on I&M program objectives.
2. Administrative tasks (timesheets, vehicle procedures, reimbursement, etc.).
3. Sampling design, and data analysis.
4. Field sampling methods and QA/QC concerns.
5. Equipment operations and maintenance.
6. Field and laboratory sample processing and handling.
7. Fish and amphibian species identification, handling, and a primer on wildlife diseases.
8. Recording and storing data, both manually and digitally.
9. Safety in the backcountry.
10. Orienteering.
11. Backcountry rules and ethics.
12. Computer data entry.

This educational period is supplemented with the protocol narrative, standard operating procedures, and appendices, but these materials (to be supplied before the Entrance on Date [SOP #1: Preparations, Equipment, and Safety]) are not to be used as a substitute for a training period.

Classroom training material will be developed by the Project Lead and stored in electronic form on the Klamath Network server, following protocols in the Data Management Plan. Over the course of this protocol implementation, these materials will be refined and improved by the Project Lead.After the classroom sessions, additional training focuses on hands-on collection of data in the field. This can take place at an established reach within the appropriate park unit and be used as actual data for the program, with the Project Lead on hand to supervise and train the crew in proper techniques. For example, the Project Lead can take a water quality sample as a demonstration, which will be actual sample of “record,” but can be repeated by the field crew members to learn the sampling techniques. Each crew member will be certified in each SOP, with date certified, individual responsible for certification, and specific SOP certified recorded using the forms provided in Appendix F.

5.3 Safety

Safety of the field crews is a top priority of this project. The program architecture included this consideration in the sampling frame, ensuring that site areas are accessible and can be sampled within a single day, minimizing the need for travel outside of daylight hours. Likewise, we will only sample streams with a less than 15% slope, so that crews are not working on steep streams. Additionally, field crews are provided with a copy of the USGS Safety Manual (Appendix C) and Job Hazard Analyses (Appendix N), and are required to read and adhere to all guidelines therein.

6.0 Operational Requirements

6.1 Annual Workload and Field Schedule

Necessary tasks for the implementation of this protocol are presented in Table 8. Preparation for the upcoming field season starts the year before, ideally in December or earlier. By January, the Project Lead should re-inventory and recheck the condition of the field gear and order replacements or send them to the manufacturer for servicing as necessary. (Checks will be done at the close of the last season, but with 2 years between sampling, gear must be rechecked.) In April, the Project Lead should obtain bids for specimen processing (macroinvertebrates) and renew contracts (water chemistry, and chlorophyll *a*), and initiate contracting to the laboratories (CCAL for water chemistry and Cascade Research for Chlorophyll *a*). Water chemistry bottles should be acid washed (or confirm that pre-acid washed bottles are ready in suitable numbers) and filters prepared for water sample collection (SOP #1: Preparations, Equipment, and Safety) in April, with all associated tasks completed by the middle of June. Training of the field crew should begin in July, at the start of the field season. Training is an on-going activity; periodic checks will be made to ensure that QA/QC procedures are followed. Although data entry will occur throughout the field season, a final QA/QC will occur with the presence of the field crew, so that any remaining questions may be answered. Upon data certification and receipt of the data deliverables of the specimen contractors, the Project Lead will formulate and write the Annual report and/or Analysis and Synthesis report, as appropriate. The first stages of this could occur in October. However, initiation of the report writing may be delayed relative to the availability and delivery of the required data. Report(s) should be finalized by June of the following year.

Table 8. Summary of annual tasks and workload for implementation of protocol. N/A indicates not applicable, either an ongoing task, or open ended.

Task	Timeframe to initiate	Deadline
Hiring of Field Crew	December of previous year	End of January
Inventory and maintain field gear	January - February	End of February
Purchase required field gear	March	March
Acquire bids for specimen processing, arrange contracting	March	End of May
Prepare water chemistry bottles and filters	April	Middle of June
Training and orientation	June	N/A
Field work	June - September	N/A
Final Data Entry and QA/QC	October	November
Annual Report and Analysis and Synthesis Reports	November	June of following year

6.2 Facility and Equipment Needs

Facilities necessary for the completion of this protocol include office space with access to computers for the Project Lead, as well as computers for data input from the seasonal field crew. Minimal laboratory facilities are necessary for the steps of acid washing bottles and filter prep and are all available through Southern Oregon University Chemistry Department. Seasonal housing for the field crews is also necessary, along with access to refrigeration/freezer usage for storing water samples.

A large amount of equipment is necessary for the completion of this protocol. A complete equipment list is provided in Appendix M, along with quantity needed per site and per sampling season. The large amount of bulky equipment, along with a four-person crew, necessitates a large vehicle for transport.

6.3 Budget Considerations

Total annual operating budget of the protocol is budgeted for $110,000. This budgetary figure does not include the costs of the core Network staff (see below). The annual cost is split between WRD budgetary funds and Klamath Network funding. The first year of the implementation budget has been developed to be under this amount so that inflationary cost increases over the long-term will not jeopardize program viability. Our goal has been to ensure that the program stays financially sound for a minimum of 7 years, under an assumption of no programmatic budget increases. We have assumed a typical inflationary increase in all costs (salary, benefits, sample processing, and equipment) of 3% per year. Hence, to come just under the budget of $110,000, our budget for 2011 (the first year of implementation) is $91,484.40 (Table 7).

Additional budget considerations and costs come from the core Network staff, consisting of:

- Project Lead (assuming GS-11 level): approximately 20 pay periods at $2,600 per = $52,000 (the Project Lead time in a streams year will also include preparation work for stream or lake monitoring in upcoming year).
- Network Coordinator (assuming GS-12 level): approximately 1 pay period at $3,200 per = $3,200.
- Network Administrative Assistant (assuming GS-07 level): approximately 1.5 pay periods at $1,406 per = $2,107.
- Network Data Manager (assuming GS-11 level): approximately 1.5 pay periods at $2,600 per = $3,900.
- Total costs of core Network staff = $61,207.

Table 9. Budget for implementation of the Integrated Aquatic Community and Water Quality Wadeable Streams in the Klamath Network Protocol. Numbers in parentheses and red indicate a programmatic deficit, assuming no budgetary increases**.**

Program Item (@2010 costs)		**2011**	**2012**	**2014**	**2015**	**2017**	**2018**
Salary							
	GS-7 Field Crew Leader 1FTE @10PP; $1460.80 per PP	$14,608.00	$15,046.24	$15,962.56	$16,441.43	$17,442.72	$17,966.00
	GS-5 Crew Members 3FTE @9PP; $1179.20 per PP	$31,838.40	$32,793.55	$34,790.68	$35,834.40	$38,016.71	$39,157.22
Vehicle							
	Field transport/fuel	$3,000.00	$3,090.00	$3,278.18	$3,376.53	$3,582.16	$3,689.62
Travel							
	Lodging and per diem	$4,000.00	$4,120.00	$4,370.91	$4,502.04	$4,776.21	$4,919.50
Equipment							
	Consumables, field computers, replacement parts, etc.	$5,000.00	$5,150.00	$5,463.64	$5,627.54	$5,970.26	$6,149.37
Specimen Processing							
	Macroinvertebrates; 61 @ $250	$15,750.00	$16,222.50	$17,210.45	$17,726.76	$18,806.32	$19,370.51
	Water Chemistry; 61 @ $160	$10,080.00	$10,382.40	$11,014.69	$11,345.13	$12,036.05	$12,397.13
	Chlorophyll a; 61 @ $35	$2,205.00	$2,271.15	$2,409.46	$2,481.75	$2,632.89	$2,711.87
QAPP							
	10% extra samples; verification; probe and electroshocker maintainence, etc.	$5,000.00	$5,150.00	$5,463.64	$5,627.54	$5,970.26	$6,149.37
	Total	$91,481.40	$94,225.84	$99,964.20	$102,963.12	$109,233.58	$112,510.58
	Surplus/Deficit	$18,518.60	$15,774.16	$10,035.80	$7,036.88	$766.42	$(2,510.58)

7.0 Literature Cited

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Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #1: Preparations, Equipment, and Safety

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP explains what procedures will be completed prior to implementing the field season, including reviewing the budget, hiring the field crew, reviewing equipment needs, preparing site description forms, creating maps, preparing data forms, setting up the database, setting up equipment, meeting park requirements, planning the training, and scheduling field crews.

The timeline for preparing for the upcoming field season is shown in Table 1 to assist in planning preparations.

Reviewing the Budget

The Project Lead will work with the Network Coordinator each year to review the budget and ensure it meets salary, equipment, travel costs, and projected costs for sample analyses.

Hiring the Field Crew

The Project Lead will be responsible for hiring the field crew leader and field crew member(s). If possible, priority consideration should be given to previous years' crew members to maximize year-to-year consistency in field operations and methods. Overlapping skills from the Lakes and Ponds protocol are substantial enough that prior crews should receive consideration.

Hiring of seasonal employees should be initiated in the December of the preceding year to allow adequate time to advertise the position hire the field crew. The hiring should be complete no later than March.

Table 10. Approximate timeline for starting preparatory tasks for implementing the Wadeable Streams protocol, with a field start date of 15 July. * indicates prior calendar year. EOD = Entrance on Duty date.

Task	Anticipated task start date	Must be completed on date
Reviewing the projected budget	1 October*	31 January
Hiring the field crew		
Position information to Human Resources	1 November*	14 November*
Post position for 2-3 weeks on USAJOBS.gov	1 December*	31 January
EOD date for Field Crew Leader	21 June	
EOD date for Field Crew	1 July	
Equipment needs/reviewed/new gear ordered	1 November*	30 November*
Prepare site folders	1 March	30 April
Prepare data forms	1 March	30 June
Coordinate park requirements	1 January	28 February
Prepare and schedule training	1 March	31 May
Schedule field work	1 May	31 May
Prepare database with sites & contacts	1 May	31 May
Prepare water quality sampling equipment	1 June	1 July
Prepare Electronic Units	1 June	1 July

The target qualifications of the Crew Leader are:

1. Prior experience in implementing aquatic monitoring protocols.
2. Stream ecology experience and training (preferably graduate level education).
3. Water quality analysis experience (e.g., water sample collection and processing).
4. Substantial backcountry orienteering and backpacking experience.
5. Experience and aptitude using Global Positioning Systems.
6. High level of physical fitness (ability to carry an average pack weight of 60 pounds over 3^+ miles of rough terrain, spend 6 hours sampling a stream, and to return the 3^+ miles in a single 12 hour period).
7. Familiarity with the geography and natural communities of the Klamath-Siskiyou region.
8. Leadership experience and ability to diffuse conflicts.
9. Strong organizational skills.
10. Ability to get along well with others in a field crew setting.
11. Certification in wilderness first aid (Wilderness First Responder preferred).

12. Ability to manage field crews for long periods of time.

13. Data management skills including basic computer knowledge.

Note that all qualifications may not be possible in any one individual and it is the task of the Project Lead to select for the best combination of the above qualifications. Once selected, the Crew Leader should review the protocol and discuss any questions with the Project Lead. The Crew Leader's Enter on Duty date should also begin a week prior to the rest of the crew to assist the Project Lead in implementing this SOP.

The target qualifications of the field crew member are:

1. Knowledge and training in aquatic ecology (a demonstrated high interest in ecology can substitute)

2. High level of physical fitness (ability to carry an average pack weight of 60 pounds over 3^+ miles of rough terrain, spend 6 hours sampling a stream, and to return the 3^+ miles in a single 12 hour period).

3. Ability to get along well with others in a field crew setting.

4. Backcountry orienteering and backpacking experience.

5. Familiarity with Klamath-Siskiyou region.

6. Knowledge of (or preferably, certification in) wilderness first aid.

7. Data management skills including basic computer knowledge.

Soon after being hired, technicians should be mailed the following:

A written description of expectations, duties, and responsibilities, to be signed and returned (Appendix B: Expectation of Field Crew).

A copy of the Integrated Water Quality and Aquatic Communities – Wadeable Stream Protocol, including all appendixes.

A list of required and recommended personal equipment.

Equipment Needs

Equipment will be organized and inventoried for the field season by the Project Lead several months (should be done in January) in advance of the training session. This allows time to make needed repairs and order equipment and supplies (Appendix L: Equipment List).

Appendix L presents the complete list of equipment needed to implement this protocol. Although the quantities listed are for the minimum number of stream reaches needed to accomplish the sampling objectives, extra consumable supplies should be a part of each field kit (e.g., extra 250 mL vials, extra filters). Not all gear is required to be taken into the field and should instead be kept in the field vehicle or housing unit (e.g., laptop and computer cables).

Gear must be assured to be in excellent working order, and routine maintenance should be done on gear, as specified in later SOPs (e.g., care and cleaning of water quality multiprobes).

Prepare Site Folders

A folder for each stream reach to be sampled is developed and includes a site description and map (see example in Appendix G, Example of Site Folder). This site folder should collate and summarize information relevant to planning and field work from previous site visits to assist the new field crew. An additional laminated sheet of field sites (to be prepared by the Project Lead) will be included with the folders. Field site descriptions are completed by the field crew the first year a field site is sampled. Site descriptions include the trailhead or parking location, time taken to hike to the site in previous field visits, latitude and longitude coordinates, and a written description (if necessary) to help navigate to the site. The Project Lead, along with the Crew Leader, will mark and highlight all sites to be sampled in the field season on a set of USGS 7.5 min topographic maps. Coordinates will also be pre-loaded into the Garmin 60 CSx /76CSx or equivalent GPS unit for navigation purposes prior to the start of the field season. It is the responsibility of the Project Lead to make sure project folders are complete prior to the start of the field season and at the end of the field season.

Prepare Data Forms

An adequate number of data forms to fulfill training needs and provide for backup use to the tablet PC should be printed on waterproof paper using a laser-jet printer (at least 10 sets). The sheets will be individually numbered and meet the requirements of the Klamath Network Data Management Plan (Mohren 2007). The data forms will include the data sheets for all types of data (physical, biological, and chemical), as well as the event, incidental photo, calibration/equipment, and training logs. Example data sheets and forms are provided in Appendix F: Field Data Sheets and Logs. These sheets are a backup to electronic data collection, in case of field failure of electronic equipment

Preparing Database

Prior to beginning the field work, the project database needs to be set up for field work following the methods described in SOP #20: Database. In order to use the database, a GIS shapefile of streams to be surveyed and a contact list of all members of the project need to be developed by the Project Lead working with the GIS Specialist. These two files automatically upload into the Access database and it is imperative that field names are kept the same from year to year. Since this protocol utilizes an always revisit design, the shapefile will be created prior to implementing the first field season. The GIS shapefile should be a polygon file projected as NAD83 Zone 10. The shapefile is stored following the KLMN GIS standards and is located at: S:\Data_Management\GIS\DATABASE\KLMN\DATA\Monitoring\Water_Quality_Streams\Sampling Locations. The shapefile should contain the following fields:

a. Network
b. Park
c. Stream Name
d. Site Name
e. GRTS Code
f. X-Coordinate (Latitude, DD)

g. Y-Coordinate (Longitude, DD)
h. X-Coordinate (UTM)
i. Y-Coordinate (UTM)
j. Coordinate System
k. PLSS
l. Watershed
m. Subwatershed
n. County
o. USGS Map
p. GIS ID Number
q. GIS Shapefile Name

The contact lists should be in an Excel format and include any individual that may be using the database or collecting data as part of this protocol. The files should include the following fields.

a. Last Name
b. First Name
c. Middle Initial (if available)
d. Organization
e. Position Title
f. Address
g. Email
h. Phone Number

The tablet PC for field data entry should be prepared as described in SOP#20: Databases.

Park Requirements

In January, the Project Lead should communicate with the two or three parks to be sampled that year to determine the contact person for each park**.** The Project Lead should contact each park to inform them of the survey schedule and to arrange for:

1. Crew housing and refrigerator facilities.
2. Necessary permits for sampling/backcountry access.
3. Keys necessary for crews to access facilities.
4. Park-specific radio training for field crews.

Prepare for and Schedule Training

The training sessions should be scheduled and materials should be prepared as detailed in SOP #2: Field Crew Training.

Scheduling Field Work

The target field season for monitoring of wadeable streams is the beginning of July to the middle of October. Sampling should begin reasonably soon after peak snow melts in the low elevation parks (Whiskeytown National Recreation Area or Redwood National and State Parks), allowing for safe access to remote sites (but will not begin prior to July 1st). In years with late snowmelt, the Project Lead and Crew Leader will jointly decide when it is safe enough to commence sampling. For hiring purposes, however, it should be assumed that the start of the field season will be on or around July 1st each year. In the event that a field season is delayed, the preferred option is to delay the crew start date as needed, but another option is to spend extra time training or assisting other monitoring efforts as needed, if sampling can still be accomplished within the budget. This may be a reality in heavy snow years, but it is not anticipated that delaying the field season will be a regular occurrence. Effects of heavy snow years will also be mitigated by scheduling the lower elevational parks first, followed by the higher elevational parks.

A further priority in determining field schedule is to match the previous sample dates from prior years to the current years. For example, if Redwood Creek in Redwood National and State Parks was first sampled on July 16th, then the crews should aim for July 16th plus or minus 5 days the following sampling cycle. This will help the comparability of samples across years.

Personnel Safety

During field operations, the motto of the USGS should be adopted: "Safety first." All members of the field crew should be thoroughly familiar with the USGS safety manual: *USGS National Field Manual for the Collection of Water Quality Data: Chapter A9. Safety in Field Activities* (Appendix C), which is provided to them prior to the beginning of the field season. This manual should be considered the standard reference for safety questions and safety protocols; in case any clarification is needed, the Project Lead should be consulted. Although this manual is comprehensive and not all elements may apply to the field crew, it is mandatory reading. These points are reiterated in Appendix N: Job Hazard Analyses. It is the responsibility of the Project Lead to go over and certify each crew member on the Job Hazard Analyses.

The following points also bear reinforcing:

- There are two main dangers of aquatic work: drowning and hypothermia.
- Automatic inflating suspender personal flotation devices (SPFD) must be worn while wearing waders.
- These must be worn on the outside of all clothing layers to ensure proper functioning. Crews are responsible to check that the CO_2 cartridge is not discharged in each device.
- Crews are highly encouraged to carry a spare set of dry clothes in case of accidental submersion.
- Basic first aid and CPR should be known by at least one member of each crew.
- Crews should pay particular attention to lightning storms; the mixture of water, high elevation, and electricity does not make for safe working conditions. Crews should consult the USGS Safety Manual on working in thunderstorms in Appendix C.

Preparing Water Quality Contracts

In March prior to the field season, the Project Lead must initiate contracting for water quality laboratories (Chlorophyll *a*, water chemistry, and macroinvertebrates). The Project Lead should consult the Klamath Network Administration Handbook (Perry et al. 2011) for guidelines for arranging contracts (Chlorophyll *a*, water chemistry), and bidding for macroinvertebrates. The Project Lead will work closely with the Program Assistant and the Contracting Agent at Redwood National Park to finalize contracts.

Currently, samples for chlorophyll *a* are performed by John Salinas at:

Cascade Research
PO Box 5208
Grants Pass, OR 97527
(541) 660-5783
JohnSalinas@charter.net
www.cascaderesearch.com

Currently, samples for water chemistry are performed by Cameron Jones at:

Cooperative Chemical Analytical Laboratory (CCAL)
Oregon State University
321 Richardson Hall
Corvallis, OR 97331
ccal@oregonstate.edu
www.ccal.oregonstate.edu

Preparing Water Quality Sampling Equipment

Preparing water quality equipment is a time-consuming process. Ideally, the Crew Leader can be brought on a week before crew training and start preparing equipment, helping the Project Lead with this task.

Acid Washing Bottles

Clean, uncontaminated bottles and lids are essential for ensuring accurate results from field and laboratory analyses. Even slight amounts of contamination can contribute to large inaccuracies in measurements. Hence, the following protocols must be adhered to in the strictest sense.

These bottles need to be free from contaminants; washing them in a mild (0.5 Normal Hydrochloric Acid [HCl]) will accomplish this. Hydrochloric Acid, even when diluted to a relatively weak concentration, is still a hazardous substance and all precautions for personal safety should be followed. Employees conducting this SOP should frequently consult with the Project Lead or the SOU Chemistry Stockroom manager concerning facilities and safety requirements. At a minimum, the employee should have available:

- A fume hood with ample work room
- Protective eyewear
- Protective gloves (latex type okay)
- Protective lab coat
- Eyewash/shower station nearby (in the same room is preferable; if not located in the same room, then know location of nearest station)
- Ample amounts of a neutralizing agent (e.g., baking soda; sodium bicarbonate)

The bottles that need to be washed are: seventy-five 250 mL Amber HDPE Nalgene collection vials, two 2 L Amber HDPE Nalgene collection vials, and seventy-five 60 mL Amber Boston Rounds collection vials. Consult SOP #8: Water Chemistry Sample Collection and Processing for further details on bottle use. This calculation is based on 61 sites, with the possibility of two samples at each site, plus 10% extra for potential loss or breakage. The 2 L collection vials should be washed when they are brand new and at the beginning of a field season; however, they will be reused throughout the field season without acid washing in between sites (SOP #8: Water Chemistry Sample Collection and Processing).

Protocol for Acid Washing Bottles:

1. Needed materials:

    a. Safety gloves (latex okay)
    b. Safety glasses/goggles (prescription eyewear is *not* sufficient)
    c. Lab jacket/coat
    d. Concentrated HCl
    e. Distilled Water
    f. 1000mL Graduated Cylinder
    g. Glass jugs for storing and pouring HCl (2)
    h. Funnel, large
    i. Shallow trays (two or more)
    j. Baking Soda (2^+ pounds)
    k. pH meter
    l. Fume hood/Chemistry Lab Facilities
    m. Glass stirring rod

2. Start by diluting concentrated HCl (which is 12 “Normal” [N]) down to 0.5N. Do all pouring and measuring in a fume hood. Use appropriate safety gear. At a minimum, wear a lab coat, gloves, and safety goggles or glasses.

    a. Mix 1 liter at a time (or less, if only small quantities are required).
    b. Use the $C_1V_1=C_2V_2$ formula, where C = concentration and V = volume. So, to make 1 L (or 1000 mL) of 0.5N HCl from 12N HCl, use dimensional analysis to solve for the unknown quantity of the 12N acid needed (here denoted as V_1):

$$(12N)(\text{Unknown } [V_1]) = (0.5N)(1000 \text{ mL})$$

$$12\ V_1 = 500$$

$$V_1 = 500/12$$

$$V_1 = 41.667 \text{ mL of 12N HCl necessary}$$

(Note that N [Normality] cancels out and you can round up to 42 mL)

    c. Measure 958 mL distilled water in large graduated cylinder (note that 958 mL is the amount added to 42 mL HCl for a final volume of 1000 mL).
    d. Pour (using funnel) into 1 L glass jug.
    e. Measure 42 mL of HCl in a large graduated cylinder (note that it does not have to be exact - ± 2 mL is probably fine (although err on side of too strong).

f. Using a funnel, add the 42 mL of 12N HCl to the 958 mL distilled water the glass jug.
g. Acidic fumes may be given off in this step, so be sure to perform this in a fume hood with hood turned on.

3. After mixing 0.5N HCl, transfer a small aliquot to another glass jug. This is to facilitate easier pouring of the acid, which should minimize spillage.

4. Lay out the bottles to be washed in a shallow tray. Place caps in a separate, shallow tray.

5. Slowly pour enough 0.5N HCl into each bottle, making sure the acid reaches the top. This must also be done in a fume hood. Pour the acid into the bottle so that spillage is contained in the shallow tray. Some spillage is unavoidable, but careful pouring should minimize the spills.

6. When all bottles have been filled, let sit for up to 8 hours, as time allows. After the 8 hours, carefully dump the used acid into a 25 liter bucket, again in a fume hood, wearing appropriate protective gear.

7. Refill the bottles with 0.5N HCl for an additional wash period. Repeat step 6 after it has sat for 8 hours.

8. For the caps, fill a shallow tray with 0.5 HCl and add the loose caps into the acid. While wearing gloves, ensure that each cap is submerged, so that the cap threads are adequately soaked.

9. Let sit for 8 hours, as time allows. Repeat with fresh acid, as you do for the bottles.

10. After the second acid soak, fill the bottles with distilled water and again let soak for 8 hours, or as time allows. After this, rinse all bottles and caps a minimum of three times under flowing distilled water.

11. Allow to completely dry, using a drying oven at 60° C, if available.

12. Cap the bottles and store in a large Tupperware type container.

13. Label the container with the following: type of bottle, acid washed with 0.5N HCl, date washed, and by whom.

14. Dispose of the waste acid that has been poured into the 25 L bucket by neutralizing the acid. When pouring waste acid into the bucket, *do not fill the bucket over half way*.
    a. Place the bucket with ~12.5 L of 0.5N HCl in a fume hood. SLOWLY add powdered baking soda into the acid.
    b. The sodium bicarbonate in the baking soda will react with the acid to neutralize the pH. This is an exothermic reaction; the acid will bubble and foam as heat is produced.

c. Slowly continue to add baking soda to the acid. When the amount of bubbling and foaming begins to lessen, carefully use the pH meter to monitor the pH of the waste acid. A glass stirring rod can expedite the mixing process to accelerate the neutralizing process. The baking soda addition will gradually increase the pH to 6 or 7. When the pH is above 6.5, the waste can safely be poured down the drain.

15. In case of spills, pour a sufficient amount of baking soda onto the spilled acid. After foaming subsides, the neutralized acid can be cleaned up with paper towels.

Preparing Filters for Dissolved Organic Carbon

Samples for dissolved organic carbon (DOC) must be filtered (0.7 µm glass-fiber filters only – Whatman GF/F; Whatman product number: 1825-047) in the field for proper analyses. The filtering process removes suspended particles that may result in erroneous values for analyses of dissolved constituents. Similar to the bottles, the filters must be prepared by cleaning the contaminants and carbon off of the filters. For this, the filters should be pre-combusted prior to use. The methodology for this is simple: Place filters in folded rectangles of aluminum foil large enough to cover filters (approximately 110 mm X 55 mm) with the dull side in (touching the foil). The foil and filters should then be combusted in a muffle furnace at 500°C for 4 hours. After cooling, the foil and filters should be placed in a plastic Ziploc type bag for field use. For specific instructions on muffle furnace operations, the manual supplied with the muffle furnace should be consulted.

Preparing Filters for Water Samples

The standard filter for water chemistry (anions, cations, nutrients) is Whatman GF/C (1.2 µm glass-fiber filters; Whatman product number: 1822-047). These must be prewashed in deionized water prior to use. To prewash, soak in a clean tub (acid washed tub) filled with deionized water for a few minutes and then dry in a drying oven at 60 °C. Store in original packing for transport to the field.

Preparing Bottles for Dissolved Organic Carbon

Amber glass vials for Dissolved Organic Carbon analyses must be pre-treated similar to the filters. Vials (without the lids) should be placed into a muffle furnace and heated to 475° C for 8 hours. After 8 hours, the furnace should be shut off and the bottles allowed to cool to air temperature overnight. They should then be capped and stored for use. Note that the lids should not be combusted, only acid washed.

Preparing the Electronic Equipment

Garmin GPS Units

Programming of GPS units needed for navigation (e.g., Garmin 76CSx units) to field locations should be undertaken with the help of the Network Data Manager or GIS Specialist. Entries should be set up to allow the easy use of the GPS unit, e.g., habitats are identified in the unit both with stream name and GRTS code. The datum NAD 83, Zone 10N is the Klamath Network standard that will be used for this protocol.

Trimble Pocket PC

Trimble units are used to collect points at the A, F, and K transects. Field crews are issued 2 Trimble units (1 to collect data and 1 as a backup) which will need to be setup prior to going into the field. To setup the Trimble units, complete these steps:

1. Create a folder named with the year (YYYY) in the following location: S:\Monitoring\Stream Monitoring\Stream_GIS\Seasonal Data
2. Within this folder, create 3 additional folders. One of the folders name "Trimble_Example". The other 2 folders name "Trimble_XXXXXXX" where the XXX's are the serial number of the Trimble unit.
3. Within each of these folders create 3 additional folders called "ArcMap Project", "Geodatabase", and "Stream_Monitoring".
4. Copy the Geodatabase located at: S:\Monitoring\Stream Monitoring\Stream_GIS\ArcPad Template\ArcPad_Geodatabase
    a. Paste a copy of the geodatabase in each of the geodatabase folders you created in step 3.
5. Open ArcCatalog and in the content window browse to one of the folders you setup in step 3. Complete the steps below to GPS-enable the shapefiles in the geodatabases.
    a. Within the Trimble folder, open the Geodatabases folder. You should see the geodatabases.
    b. Right click on the Geodatabases and go to properties. You should see 3 tabs (General, Domains, and Trimble GPS Analys). Select the "Trimble" tab.
        i. If you do not see the trimble tab, go to tools→extensions and make certain it is checked.
        ii. If you do not see this option, you need to install the Trimble GPS Analyst software on your computer so contact the Data Manager
    c. Check the "GPS-enable geodatabase" box. Click the "Select All" button to select the feature classes. Click OK and a new form will open.
    d. The "Convert from" and "Into" fields should already be populated. In the "Using" field, select "NAD_1983_To_WGS_1984_5" and click OK.
    e. Repeat step 5 for each geodatabase in each Trimble and example folders. There should be a total of 3 geodatabases (1 per Trimble folder, 1 example folder).
6. Open up ArcMap and compete the following steps.
    a. Go to tools→extensions and make certain the "Trimble GPS Analyst" extension is checked. Also go to view→toolbar and make certain the "Trimble GPS Analyst" extension is checked.
    b. Working with only 1 geodatabase, add the feature classes
    c. You will be asked to set the transformation, use "NAD_1983_To_WGS_1984_5"
    d. On the "Trimble GPS Analyst" toolbar click the  "Get Data for ArcPad" button.
    e. A form will open and you will need to make certain of the following.
        i. On the first screen, click "Select All"
        ii. On the second screen, click "Select All". Make certain the "Only check out schema of layers" is NOT checked. Make certain the Size of editing is set to "130x130"

iii. On the third screen, make certain the "The full extent of the selected layers" is checked. UNCHECK "only get features specified in layers definition query" and "only get features specified as visible layers properties". In the "Specify a name for the folder that will be created to store the data" field enter "Project_Data". UNCHECK the "Create and ArcPad Map referencing the data" option.
iv. Click Finish

f. In the upper, right corner of the ArcMap project, click the "New map File" option and it will ask if you want to save this project. CLICK YES.
   i. Browse to:

   S:\Monitoring\Invasive_Species_Monitoring\Stream_GIS\Seasonal_Data\YYYY\Trimble_xxxxxxxxxxx\ArcMap Projects

   and save the ArcMap project using the "Stream" and the year of the survey as the naming convention (e.g. Stream_2011).
g. Repeat step 6 for each of the geodatabase used for this project (3 of them)
h. Once you are done, close ArcMap.

7. On the KLMN server, COPY all the files (2 of them, Stream_Locations.APL, Stream_Locations.txt) in the following location:

   S:\Monitoring\Stream Monitoring\Stream_GIS\ArcPad Template\ArcPad_APLs

   a. Paste a copy of these files at:

   S:\Monitoring\Stream_Monitoring\Stream_GIS\Seasonal_Data\YYYY\Trimble_XXXXXXXXXX\ Stream_Monitoring \Project_Data

   b. You will be asked if it is OK to replace the files currently stored there, select YES
   c. Repeat this process for each of the Trimble folders and the example folder.
8. On the KLMN server, COPY all the files (2) in the following location:

   S:\Monitoring\Stream Monitoring\Stream_GIS\ArcPad Template\ArcPad_Project

   a. Paste a copy of these files at:

   S:\Monitoring\Stream_Monitoring\Stream_GIS\Seasonal_Data\YYYY\Trimble_XXXXXXXXXX\ Stream_Monitoring \Project_Data

   b. Repeat this process for each of the Trimble folders and the example folder.
9. Browse to the stream list located at:

   S:\Monitoring\Stream Monitoring\Stream_GIS\ArcPad Template\ArcPad_Streams

a. Copy the .dbf file and paste it into the appropriate folder located at:

   S:\Monitoring\Stream_Monitoring\Stream_GIS\Seasonal_Data\YYYY\ Trimble_XXXXXXXXXX\ Stream_Monitoring \Project_Data

b. Repeat this process for each of the Trimble folders and the example folder.

10. For each Trimble unit, copy the appropriate Stream_Monitoring folder located at:

    S:\Monitoring\Stream Monitoring\Stream_GIS\Seasonal Data\2011\ Trimble_XXXXXXXX

    And paste it to the Trimble unit. Do the same for the example folder.

11. The Trimble units should now be ready for training and data collection.

Cameras

Digital cameras should be set to the automatic functions, date and time are accurate, and for maximum resolution. A SD memory card of at least 2 GB should be installed and ready to use. Camera displays should show the picture number so it can be recorded properly.

Preparing the Amphibian Unit

Similar to the GPS units, the *Amphibian* (the trade name of the Eureka Environmental computer for running the water probe, ***not*** *a unit for monitoring "amphibian" species*) unit (or similar water quality data logger) should be loaded with pre-made files prior to the start of the field season. See SOP #7: Water Quality Multiprobe Calibration and Field Measurements for more details.

Preparing the Laptop and Tablet Computers

A laptop computer, for the use of the field crew, is to be prepared for the upcoming season if a desktop computer is not available at the park where they will be working. The use of the computer is for backing up data (from the tablet PC, Amphibian, and digital cameras). In addition, tablet computers will also be used to collect data while in the field and should be setup following guidance in other protocols (SOP #4: Data Entry, SOP #20: Database). The file structure will be set up by the Project Lead for this purpose. Additional files included on the computer will be backups of protocol-associated programming (e.g., site list for loading onto the Navigation GPS unit) as well as electronic copies of the complete protocol, appendixes (i.e., this current document), previous field season images, reports, and any incidental materials of use to the field crew.

The folders that will be included are:

Data. This folder includes a backup folder where crews can store the backups of the database that is on the tablet computer.

Documentation. This folder will contain any documentation that might be needed while in the field (e.g., Wadeable Streams Protocol, Equipment User Guides, etc.).

GIS. This folder contains a copy of all the GIS data that were loaded on the Garmin and Trimble units prior to starting the field season. These data are available as a backup in case something goes wrong with the layers on the handheld units.

Images. This folder will contain backups of images taken while working on the project. This folder may also include metadata if the crews use the Excel Photo Metadata Template.

Identification. This folder will contain any information needed to help with the identification of animals (e.g., Fish Identification Guides, ID Cards).

Other. An additional folder that can be used for any data files that do not “fit” into one of the above categories.

Literature Cited

Mohren, S. R. 2007. Data management plan, Klamath Inventory and Monitoring Network. Natural Resource Report NPS/KLMN/NRR—2007/012. National Park Service, Fort Collins, CO.

Perry, E. E., D. A. Sarr, S. B. Smith, and S. R. Mohren. 2011. Klamath Network administrative handbook. Klamath Network, National Park Service. Ashland, Oregon.

Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #2: Field Crew Training

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP explains what procedures will be completed to ensure that the field crew is adequately trained. Training should include procedures on sample collection and processing, data management methods, identification of fish and amphibians, emergency procedures and safety, as well as National Park Service rules and ethics.

Sample Collection and Processing Training

Ensuring that field crews are adequately trained begins with the selection of qualified individuals who have prior knowledge of and experience in methods of aquatic ecology and data management. However, since it will not always be possible to hire an "idealized" individual, a comprehensive training should be implemented so that crews are familiar with all techniques used in the field and prepared to respond to possible contingencies. The training protocols should always be adhered to, even if highly experienced individuals are hired. Because standardized field sampling methods are essential to the Klamath Vital Signs Monitoring Program, field crew members are under no conditions to skip training sessions or to "ad lib" in the field. The collection and processing techniques presented within these protocols are susceptible to error from improper collection techniques (e.g., water chemistry contamination) or by modifying sampling approaches (e.g., invertebrate collection). Hence, even highly experienced crews should be trained and retrained each field season if comparable data are to be obtained. Quality training is the first step of this protocol's QAPP (SOP #19: Quality Assurance Project Plan).

The training will start with classroom sessions, where the Project Lead instructs the two crew members in the following:

13. Background on I&M program objectives.
14. Administrative tasks (timesheets, vehicle procedures, reimbursement, etc.).
15. Sampling design and data analysis.
16. Field sampling methods and QA/QC concerns.
17. Equipment operations and maintenance.
18. Field and laboratory sample processing and handling.

19. Fish and amphibian species identification, handling, and a primer on wildlife diseases.
20. Recording and storing data, both manually and digitally.
21. Safety in the backcountry.
22. Orienteering.
23. Backcountry rules and ethics.
24. Data Management standards and methods.

Many of the training elements may be best demonstrated in the field; hands-on training is crucial. The preferred format for training is for the Project Lead to accompany the entire field crew to sites during the first week of the field season. The Project Lead conducts a workshop at the first site to be sampled, instructing the crew on proper techniques. In this process, extra time is taken to perform each technique, with the Project Lead also providing rationale for each method to give the crew members the proper context for the methodology.

After the initial demonstration site, the Project Lead should observe the field crew at a minimum of two additional sites, giving corrective comments to ensure proper collection techniques of each protocol. If additional training sites are necessary, the Project Lead and Crew Leader should adjust the site schedule as necessary.

The training should extend to tasks and SOPs relating to activities occurring at the field lodging (e.g., SOP #17: Post-site Tasks, electronic data backup, data storage, probe maintenance, etc.)

As each SOP is discussed, demonstrated in a workshop, and mastered by crews in the field, the training should be documented using Training Logs (Appendix F).

Specific Concerns

In addition to the specific protocols, the field crew should read, be familiar with, and follow the practices of:

1) "*Leave No Trace*," from the Center for Outdoor Ethics (provided in Appendix D); and
2) "*Guidelines for use of live amphibians and reptiles in field and laboratory research*" from the American Society of Ichthyologists and Herpetologists (relevant sections, as provided in Appendix K)

First Aid, Safety, and Emergency Procedures

Crews are required to read and be trained in all aspects of safety, as provided in the KLMN Safety Plan (Dinger et al., in prep). All project personnel will be working in remote areas at some point during the field season; it is therefore essential that everyone, to the extent possible, be prepared for emergency situations. A one to two day training in First Aid and CPR will be arranged and provided for.

Crews should also discuss the Job Hazard Analyses (Appendix N) with the Project Lead and potential responses to theoretical emergency situations, having a clear understanding of what to do if they or someone else on the crew becomes seriously injured or goes missing.

In addition, all crew members should be trained in the use of handheld 2-way radios that will be provided to each team (Appendix E: Icom Radio Use Handbook).

Backcountry Rules and Ethics

In addition to the standard guidance of "*Leave No Trace*" (Appendix D), project personnel should receive instruction on backcountry regulations for the parks, including permit requirements and procedures, campsite restrictions, food storage, fire season restrictions, etc. Note that some of these rules differ among the parks. If possible, arrangements should be made for a backcountry ranger or other qualified Park Service employee to meet with the crew to discuss these topics. Regardless, it is the Project Lead's responsibility to make sure that all crew members understand the rules they must follow.

Data Entry, Management, and Organization

Project Leads, technicians, and interns will be trained in a variety of data management topics including but not limited to the I&M programs vision of data management, the KLMN Data Management Plan, data collection and entry, data organization and storage, and quality control procedures, according to SOP #4: Data Entry and SOP #19: Quality Assurance Project Plan at the onset of the field season. As a group, the data entry and database SOPs will be reviewed. Each pertinent database will be demonstrated on the tablet computer by entering several example records. Time will be allotted for the field crew to practice the data entry system and for questions to be answered. The functions of the camera and metadata data sheet will be reviewed. In addition, the concept of the log books (event, datasheet, equipment, and training) will be discussed. In addition to specific data entry and backup methods, each crew member will be trained on the importance of careful data management techniques for achievement of the overall science and conservation goals of the program.

Midseason Field Audits

It is recommended that the Project Lead periodically accompanies the crew to the field to ensure that protocols are being followed. At this time, the Project Lead should review electronic data taken to date and check for compliance with SOP #4: Data Entry, SOP #17: Post-Site Tasks, and SOP #19: Quality Assurance Project Plan. These audits do not have to be limited to a single visit; preferably they will occur multiple times throughout the season.

An audit should consist of the Project Lead observing the *entire* sample cycle, from preparations to post-site activities. It the field crew misses or incorrectly performs a procedure this should be noted and **immediately pointed out** to correct the mistake on the spot. The Project Lead should review the results of the audit immediately at the end of the sample site to point out strengths and weaknesses. Time should be allotted to hear concerns and comments from the crew. This audit is based on the audits used by USEPA in the Wadeable Stream Assessment (USEPA 2004).

Literature Cited

Dinger, E.C., and others. 2012. Klamath Network Safety Plan. Unpublished Network document. Ashland, OR. Available at: S:\Administrative\Safety\KLMN_Safety

USEPA. 2004. Wadeable Stream Assessment: Integrated Quality Assurance Project Plan. EPA/841/B-04/005. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, D.C.

Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #3: Site Selection

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

The SOP explains the procedure that is undertaken by Network staff to develop the list of sites that the field crews are to sample for a particular field season. Rationale for choosing these methods are detailed in the protocol narrative and the reader is referred to the relevant section for more details.

Site Selection for Wadeable Streams

The procedure for developing a site list will only be necessary once, at the beginning of the project.

1. Available GIS shapefiles from the National Hydrography Dataset project are obtained from their web site (http://nhd.usgs.gov) or from the park GIS Specialist.
2. A list of suitable perennial streams is created based on the following criteria:
    a. The stream has sections <1000 m from an established trail or road.
        i. All stream sites within the criteria are considered available, even if other portions of the stream fall outside this criteria.
    b. The slope of the surrounding terrain is <15%.
3. The remaining stream segments are then used in GRTS (Generalized Random Tessellation Stratified) software, a plug-in for the statistical program “R,” (Stevens and Olsen, 2004; below text and Figure 1). This application compiles a list of site coordinates that when sampled in order of listing, provides a spatially balanced design.
4. These sections are then sampled in order to obtain a spatially balanced sample within each stream.

Running GRTS in the statistical software package “R” requires knowledge of the program and programming that is beyond the scope of this protocol. However, background information and how to information is included here: http://www.epa.gov/nheerl/arm/designing/design_intro.htm The code used in “R,” once the library spsurvey is added, should look like this:

```
## Choosing Lakes: GRTS Example
path←"\\Stream_Monitoring\\Streams_GIS\\GRTS\\working\\"
```

```
library(spsurvey)

design  <- list(None=list(panel=c(Index=2, Time1=2, Time2=2, Time3=2,
Time4=2,Time5=2, Time6=2, Time7=2, Time8=2, Time9=2,Time10=2,
seltype="Equal", over=30))

grts(design, DesignID="Site", SiteBegin=1, type.frame="linear",
  src.frame="shapefile", in.shape=paste(path,"streams_select",sep=""),
sp.object=NULL, att.frame=NULL,
  id=NULL, xcoord=NULL, ycoord=NULL, stratum=NULL, mdcaty=NULL,
startlev=NULL,
  maxlev=11, maxtry=1000, shift.grid=TRUE, do.sample=TRUE,shapefile=TRUE,
  prjfilename=NULL, out.shape=paste(path,"LAVO_Stream_Sites1",sep=""))

design  <- list(None=list(panel=c(Index=2, Time1=2, Time2=2, Time3=2,
Time4=2,Time5=2, Time6=2, Time7=2, Time8=2, Time9=2,
Time10=2),seltype="Equal",over=30))

grts(design, DesignID="Site", SiteBegin=1, type.frame="linear",
  src.frame="shapefile", in.shape=paste(path,"streams_select",sep=""),
sp.object=NULL, att.frame=NULL,
  id=NULL, xcoord=NULL, ycoord=NULL, stratum=NULL, mdcaty=NULL,
startlev=NULL,
  maxlev=11, maxtry=1000, shift.grid=TRUE, do.sample=TRUE,shapefile=TRUE,
  prjfilename=NULL, out.shape=paste(path,"LAVO_Stream_Sites2",sep=""))
```

Specific purposes of the programming are detailed in Figure 1.

Literature Cited

Stevens, D. L., and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association 99:262-278.

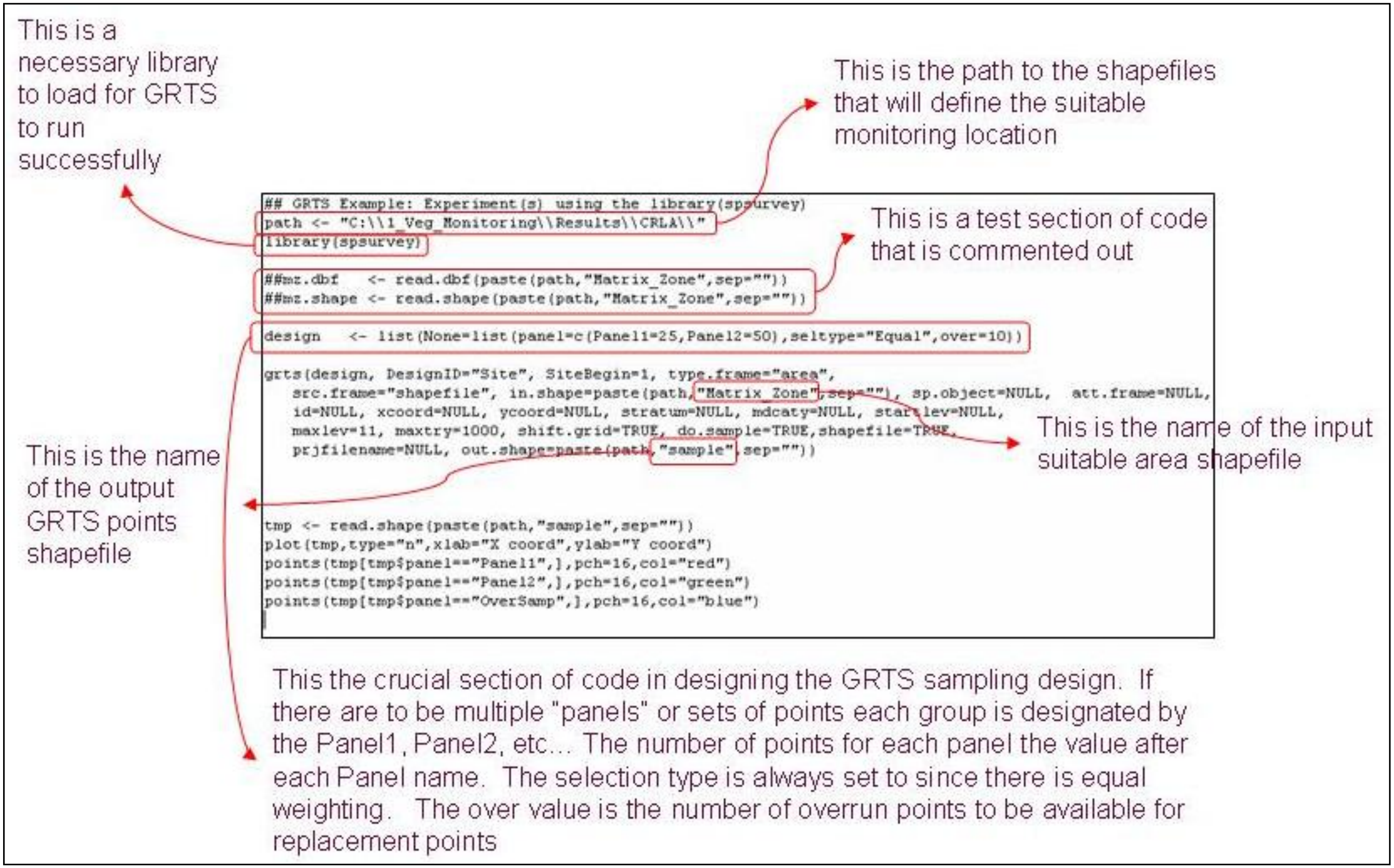


Figure 8. Layout of GRTS code to be run in the Software “R.”

Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #4: Data Entry

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP provides the details on collecting data using a tablet computer along with a Microsoft Access database or by using hardcopy datasheets. This SOP only details the preparation, usage, storage, and care of the tablet computer, plus how to enter data into the database and on paper datasheets (Appendix F). Information on how the measurements are made, how to merge the project databases together, how to submit data to the water resource division, and how to run annual summary reports are covered in the appropriate SOPs. In the case of a tablet PC not functioning, the recording procedure on datasheets is identical to the tablet PC data form described below, albeit manually done on weather-proof paper with a pencil.

Field Work Preparations

Prior to starting the field work, the Data Manager is responsible for setting up the tablet computers (SOP #20: Database). During the training sessions, the Field Crew Leader should double check this equipment to make certain it is set up and functioning properly (SOP #2: Field Crew Training). In the near future, the KLMN will use a Trimble YUMA rugged tablet computer to collect data. This model is lightweight and can withstand the environmental conditions associated with monitoring streams in the park units that comprise the Klamath Network.

Equipment

When preparing to go into the field, one member of each crew should check out the following equipment, which should already be set up by the Data Manager.

- 2 Tablet computer
- 2 Tablet computer power cord
- 2 Vehicle adapter for power cord
- 2 Eight gigabyte (or greater) flash drives
- 2 Cleaning cloth
- 4 Spare batteries (the tablet computer operates on two)
- 6 Stylus
- 2 Power inverter

It is the responsibility of the individual who checks out the equipment to make certain everything is charged and working properly. It is also the responsibility of the field crew to make certain it is treated properly while conducting field work. The tablet computer represents a substantial monetary investment and should be treated as such.

Tablet Computer

For the near future, the KLMN will use a Trimble YUMA rugged tablet computer to collect data (Figure 9). Complete operating procedures, usage, and specifications can be found in Appendix P.

Figure 9. YUMA tablet computer used to store stream monitoring data while in the field.

Charging Equipment

Before heading into the field, make certain the tablet computer and spare batteries are charged. This equipment should be plugged in to the power inverter while in the field vehicle and should be checked each night to make certain it is fully charged. Please note the tablet computer is set up to be energy efficient. Do not change this setting without checking with the Data Manager.

Project Folder

Turn on the tablet computer by pressing the green button on the left side of the screen. Using the stylus, tap on the Crew Member user icon. A shortcut to the Stream Project Folder should be located on the desktop; double tap on the icon and you should see the folder structure shown in Figure 10.

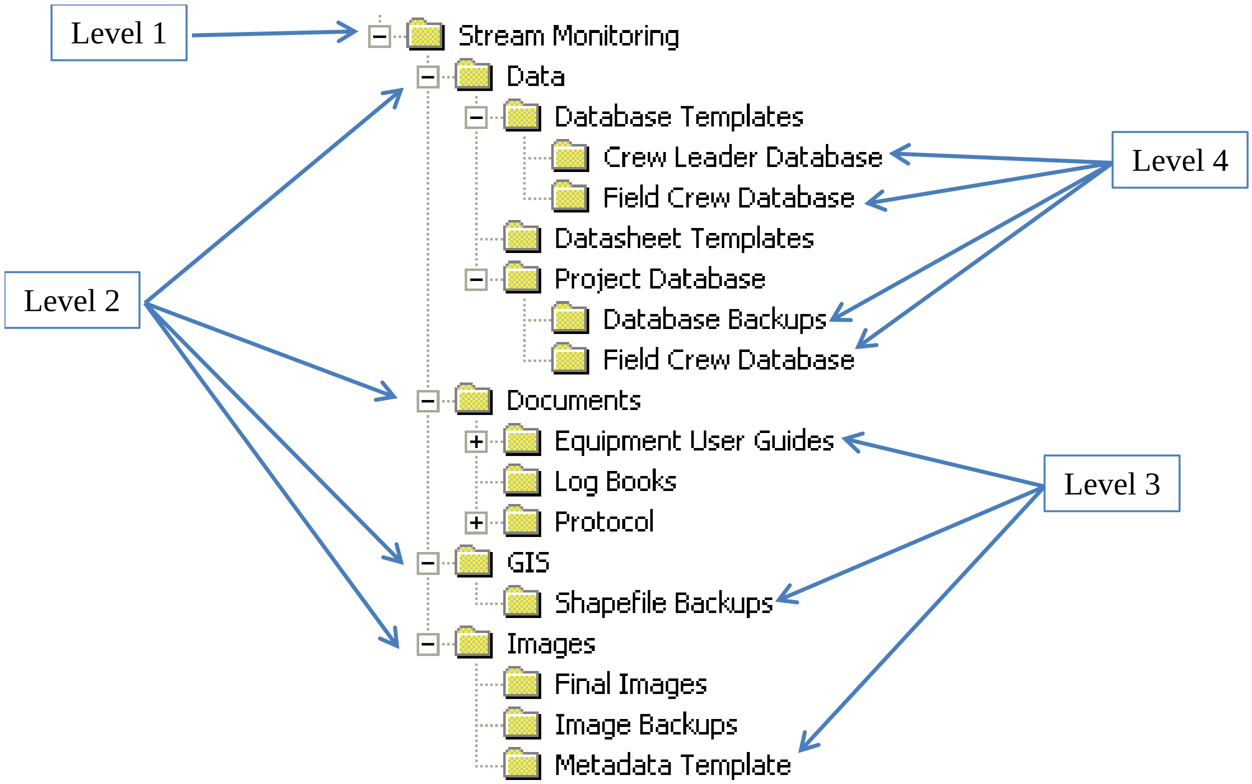


Figure 10. File structure used on tablet computers to support the stream monitoring protocol.

This folder structure is located on the D:\ drive of the tablet computer. The core of this filing structure (Levels 1 and 2) mimics the file structure of all KLMN project folders located on the KLMN office server and on the flash drive used for project data backup. The third and fourth level of the folder structure has standardized folders, which are described below but may also contain additional folders that are project-specific. Field crew members and project leads can add information to these folders as necessary; however, folder names should only be altered with the permission of the Data Manager. Standard third level folders include the following:

Data Folder

- Database Templates – This folder contains blank (no existing data) Crew Leader and Field Crew project databases that can be copied and used in the event something happens to the active project database.
- Datasheet Templates – This folder contain a copy of the datasheets.
- Project Database – This folder contains either the Crew Leader Project Database or the Field Crew Project Database that will be used to collect data. Along with a folder used to store backups of the database. Figure 10 shows an example using the field crew database.

Documents Folder

- Equipment User Guides – This folder contains documents pertaining to equipment used for this project. This can include user guides, technical guides, etc.
- Log Books – Log books are forms used to document specific items for QA/QC purposes. This folder contains the five log books used in this project including the Training (SOP

#2), Event (SOP #18), Datasheet (SOP #18), Calibration (SOP #7) and Equipment (SOP #18) logs.

- Protocol – Contains a copy of this protocol.

GIS Folder

- Shapefile Backups – This folder contains a backup copy of all shapefiles used on any Trimble or Garmin GPS units. These can be used in an instance where the active shapefiles become corrupted.

Images Folder

- Final Images – At the end of the field season, the final images are placed in this folder along with photograph metadata (e.g., description, date, location, etc.).
- Image Backups – Backup copies of images are placed in this folder to ensure they are not lost if damage occurs to the camera.
- Metadata Template – This is a template of the required metadata for each picture taken while working on a KLMN project. If you are taking pictures at a site, these data can also be entered directly into the database (SOP #16).

Utilizing the Databases

This project utilizes two databases to collect data while in the field. One database is managed by the Crew Leader and one database is managed by the field crew. At the end of the season, after the data has been reviewed by the Project Lead, these two databases are merged into one seasonal database that will be used to complete the annual data summaries (SOP #22: Data Analysis) and to export data for upload into STORET. Once the annual report is complete, the data in the seasonal database will be uploaded to the Master Stream Database that is used for multi-season data summaries and analysis (SOP #20: Database). The methods to enter data vary depending on which database you are using (Crew Leader vs Crew Member databases) and are described below. However, the first few steps of data collection, no matter what database you are using, are similar and are also described below.

Crew Leader and Crew Member Database Tasks

When getting ready to collect data, the Crew Leader and the Crew Member who is entering the data should get together and complete the following steps:

1. Double tap on the "Stream Monitoring" icon on the desktop of the tablet computer.
2. Go to: Stream Monitoring→Data→Project Database
3. Double click on: Stream_**CL**_FE_ProjectDatabase_v1.0.mdb if you are the Crew Leader or click on the Stream_**FC**_FE_ProjectDatabase_v1.0.mdb if you are the field crew member entering data.
4. The project database should open and you should see the main screen (Figure 11).
5. The stream monitoring databases used for this project relies on a back-end/front-end structure to enter data. The back-end database contains the tables and associated data while the front-end database contains the forms and queries used in this database system. In most cases, the databases should be linked when you open the front-end database. On the bottom right corner of the main page of the database, you should see the pathway to

the back-end database. Make certain this is correct before entering data. This path should read:

D:\Stream Monitoring\Data\Project_Database\Stream_CL_FE_ProjectDatabase v1.0.mdb

if you are the Crew Leader or

D:\Stream Monitoring\Data\Project_Database\Stream_FC_FE_ProjectDatabase v1.0.mdb

if you are the crew member.

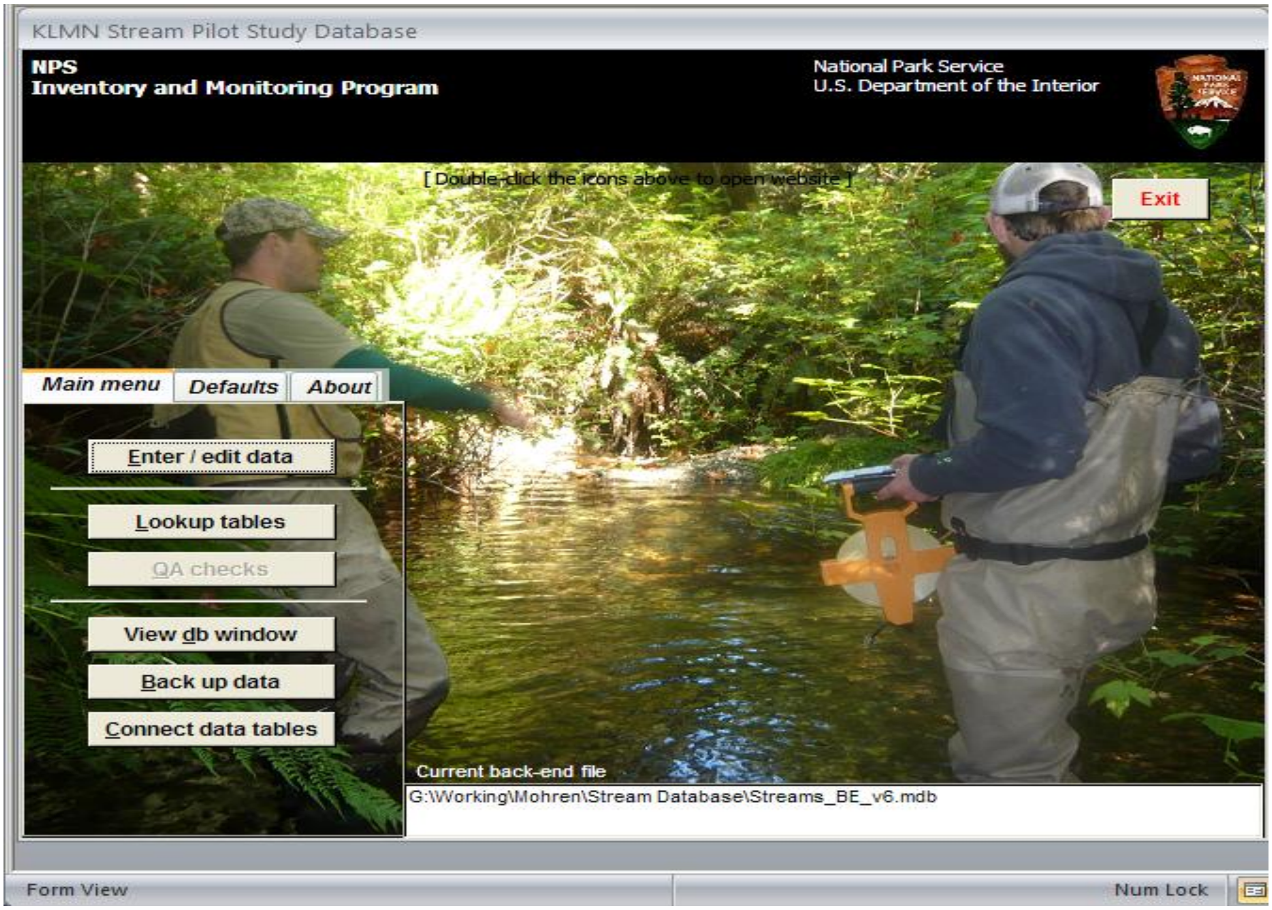


Figure 11. The starting switchboard for the stream monitoring database.

6. If the pathway is incorrect or you get a linking error when you open the database, follow the steps listed below:
    a. From the main menu, click the “Connect data tables” command button.
    b. Click the browse button and go to the back-end database following the pathway listed above.
    c. Click “Open.”
    d. Click “Update Links.”
    e. You should now be linked to the proper database.
7. If you are collecting stream monitoring plot data, click the “Enter / Edit Data” button.

   a. For the processes described below, if data are being transferred from paper datasheets into the database(s), either onto a tablet computer or desktop (and laptop) computer, the methods are the same, except that a mouse can be used instead of tapping with a stylus.

8. Using the drop down list in the "User" field, select your name. If your name is not in the list, click the "New User" button and populate **ALL** the information and then tap "Close." Make certain the additional fields on the "Set application default values" form match the list below.
   a. Park = The park where you are working
   b. Datum = Datum you are using to collect data (NAD83 is the KLMN standard)
   c. UTM Zone = 10N
   d. Protocol = Stream Protocol v1.0 (or latest version of the stream protocol)
   e. Project = KLMN Stream Monitoring
9. Once these fields are properly populated, click "OK."
10. A list of sites to be surveyed will open and you may or may not see a list of all the records that have already been entered. Do not alter these records unless you are doing an edit.
    - If you are entering data for a site that has not been visited that year, go to step 11.
    - If you are editing data from a previous visit, in the filter box enter the park that has the data you want to edit (Figure 12). Find the record you want to edit and double click on the "Visit Date" field. Make any necessary edits if you are editing or go to step 11 if you are continuing data entry from a previous day.
11. If you are entering data from a new visit (the most common reason), at the top of the screen, tap the "Add a New Record" button.
12. At the top of the form (Figure 14), use the drop down list in the "Location" field and select the name of your site.
    IT IS CRITICAL THAT THE SAME LOCATION GETS ENTERED INTO EACH DATABASE. THE CREW LEADER SHOULD CHECK EACH DATABASE TO MAKE SURE THE NAMES ARE THE SAME BEFORE GOING ANY FURTHER.
13. Once this has been completed, the FIELD CREW MEMBER entering data can skip to the "Field Crew Data Entry" section below and the CREW LEADER should skip to the "Crew Leader Data Entry" section below.

Crew Leader Data Entry

The Crew Leader is responsible for entering data related to the site verification, slope, woody debris, transects, discharge, specimens, and photographs. Complete the following steps to enter data for these parameters.

1. Using the dropdown menu, select the name of the location you are sampling. Once selected, the X/Y coordinates and Unit code should automatically populate.
2. Next to the "Location" field at the top of the form, click the "Edit" button (Figure 5).

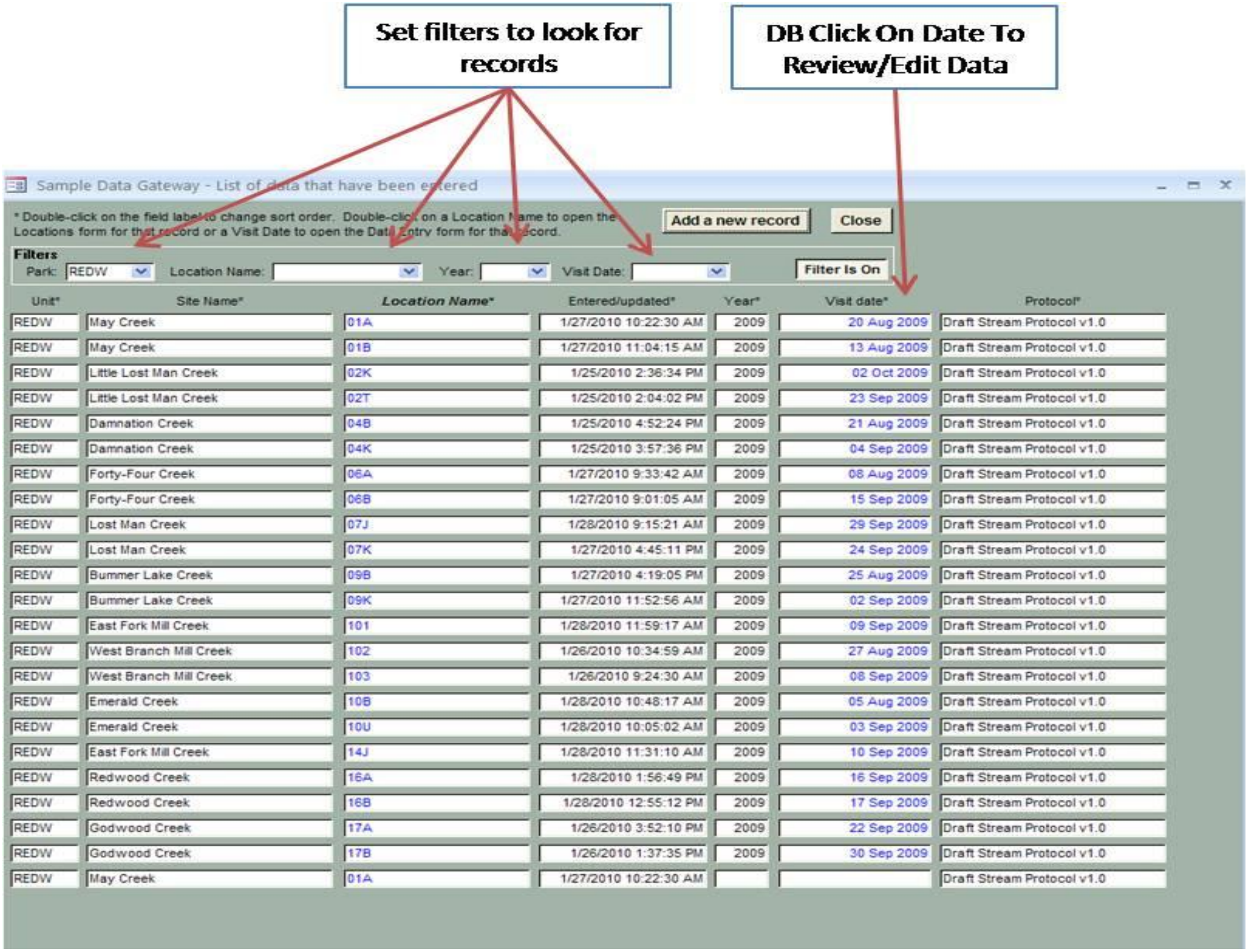


Figure 12 Sample Data Gateway. Double Click (DB click) on visit date to edit, or “Add a new record” to start a new site.

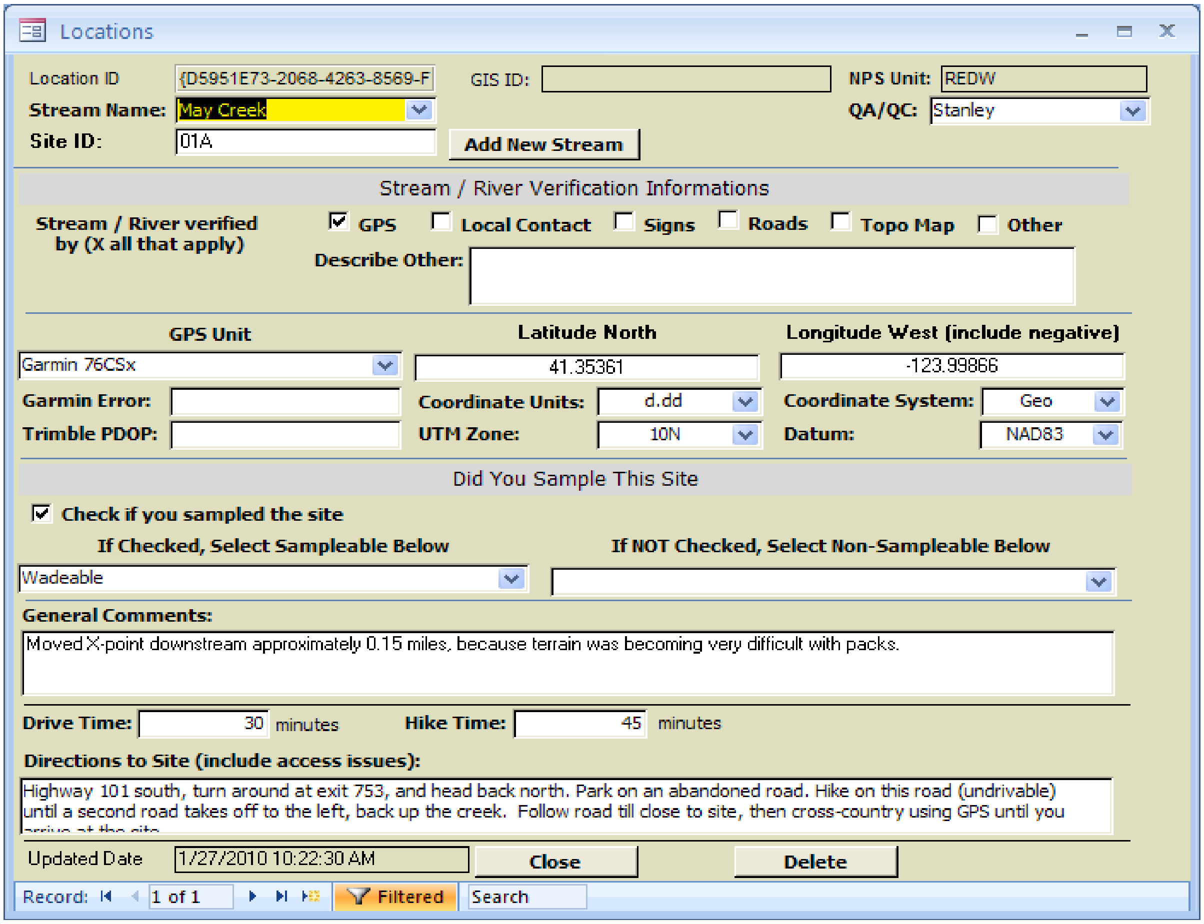


Figure 13. Location form used by the crew leader to enter data about the site that is going to be sampled.

3. Complete all the fields on this form as thoroughly as possible.
    a. **Stream Name:** The name of the stream you are working on. If the stream name is not in the pick list, click the "Add New Stream" button and add it to the list.
    b. **Site ID:** A unique number/letter combination used to name the point marking transect F for each reach surveyed.
    c. **QA/QC:** This field is completed once all the data are entered and someone has reviewed the form. Select the name of the person who reviewed this form.
    d. **Stream / River Verified by:** Check each method used to verify that you were at the right location. If "other" is checked, describe what the other method was in the appropriate box.
    e. **GPS Unit:** Select unit type used to find or confirm the site location.
    f. Depending on the type of GPS unit used, enter the **epe error** (Estimated position error) for a Garmin unit (e.g., +/-3 feet) or **PDOP** (Positional Dilution of Precision) for a Trimble unit (e.g., PDOP 3).
    g. Enter the **Latitude** and **Longitude**, being sure to include the negative sign in the longitude field.
    h. Enter **Coordinate Units, Zone, System, and Datum** used to collect the data.

i. If you sampled this site, click the checkbox marked "**Check if you sampled the site**."
j. If you checked the box in step J, select a "**Sampleable**" method. If you did not check the box, select a "**Non-Sampleable"** method
k. If there are any general comments about the site, describe them in the **comment** box. Such comments could include issues with the location of the site, difficulties monitoring the site, etc. Comments should be written in complete sentences and sentence case so they can be used in future report summaries.
l. **Drive Time**: Enter the amount of time it took to drive to the site. Time should be in minutes and you should include the starting point in the **Directions to Site** field.
m. **Hike Time**: Enter the time it takes to hike from the parking/camping site to the stream site. Time should be entered in minutes.
n. **Directions to site**: Using sentence case and complete sentences, enter the directions to the site and include aspects such as access issues, potential issues, road signs, etc. Be sure to use direction instead of Right/Left to describe how to turn.

2. Once all the fields have been completed, tap the "Close" button.
3. Using the drop down menu, select the name of the protocol you are using (Figure 14).
4. The "Start Date" in the format mm/dd/yyyy and "Start Time" in the format hh:mm should automatically populate, however be sure to check this information to make certain it is correct.
5. At the top right side of the screen, use the pick list to enter the names of the crew members and their roles in sampling the data **in this database** for that site. Names are entered multiple times if they have completed multiple roles.

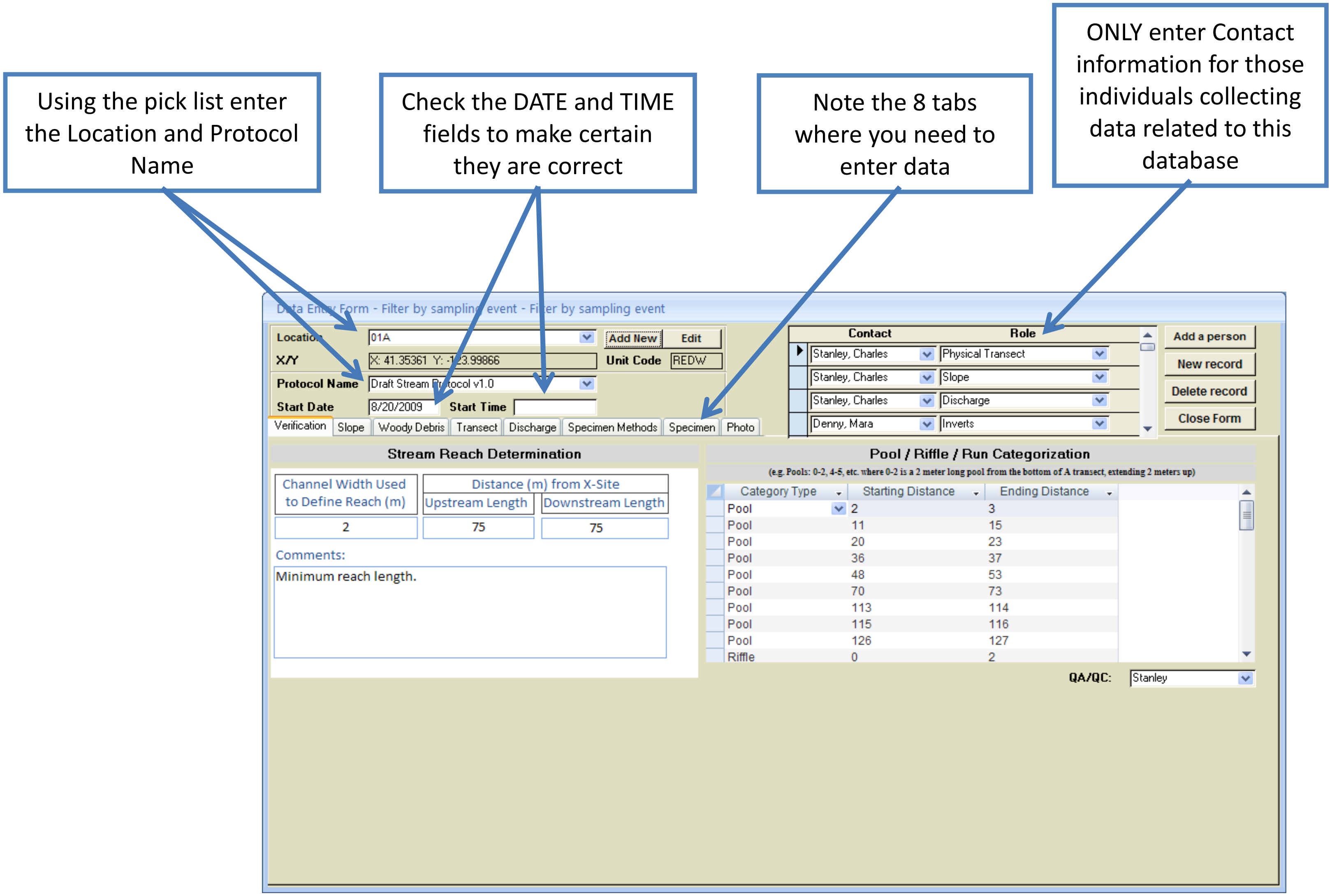


Figure 14. Data entry screen showing location header (top) and Stream Certification tab (bottom)

6. Make certain the **VERIFICATION** tab is active (Figure 15) and complete the following:
    a. Enter the **channel width** used to define the reach in meters
    b. Enter the **upstream** and **downstream** lengths in meters
    c. Enter any **comments** about the stream verification data.
    d. For each Pool, Riffle, or Run enter the **Category Type**, **Starting Distance**, and **Ending Distance**. If this is a duplicate sample, check the box.
    e. At the end of the sampling day, have one of the crew members review the data to make certain nothing is missing or mistakenly entered and have them enter in their name under the **QA/QC** field in this form.
    f. You are now done entering the verification data, click the **SLOPE** tab.

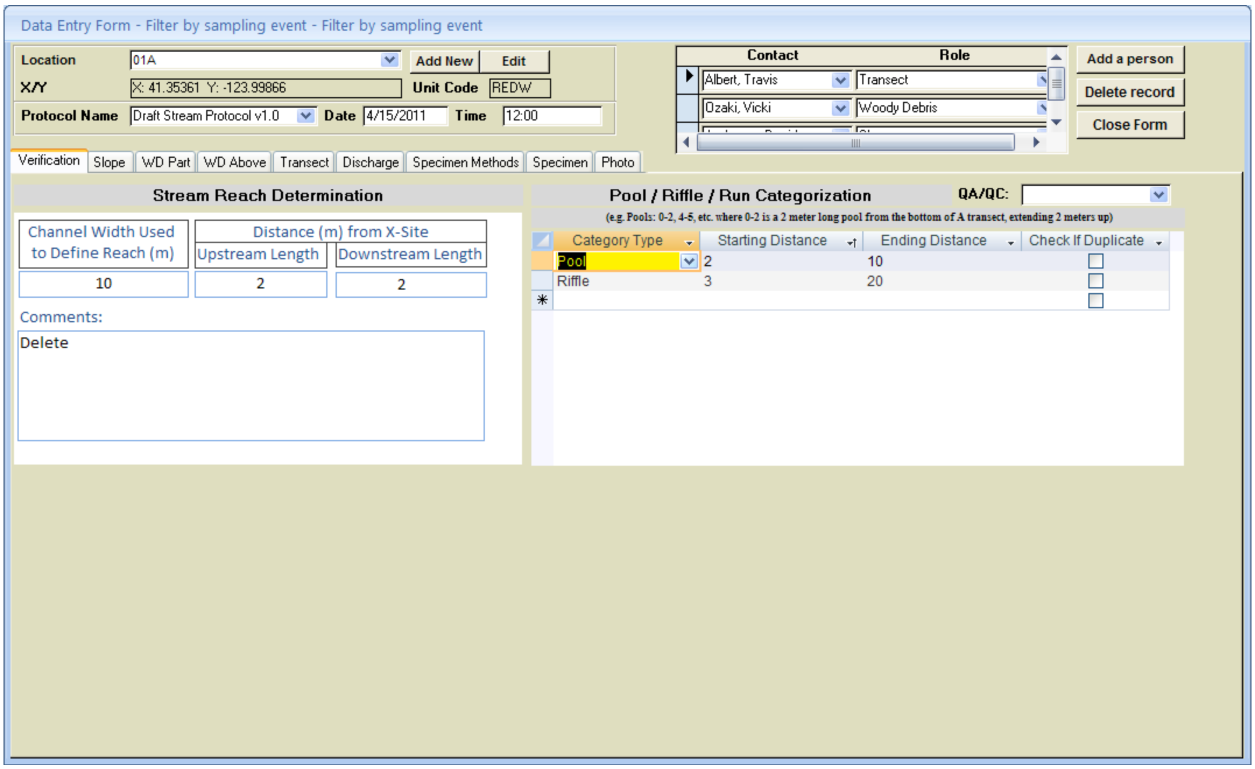


Figure 15. Data entry screen for stream verification data.

7. Make certain the **SLOPE** tab is active (Figure 16). If this is a duplicate measure go to step d, if this is the original measure complete the following:
    a. For the distance between each **transect**, enter the **upper and lower reading** for the slope in percent.
    b. Enter any **general comments** about the slope reading.
    c. At the end of the sampling day, have one of the crew members review the data to make certain nothing is missing or mistakenly entered and have them enter in their name under the **QA/QC** field in this form.
    d. To complete a duplicate measure, click the “Add Repeated Measure” button and then complete steps a-c above.
    e. You are now done entering the slope data, click the **WD Part** tab.

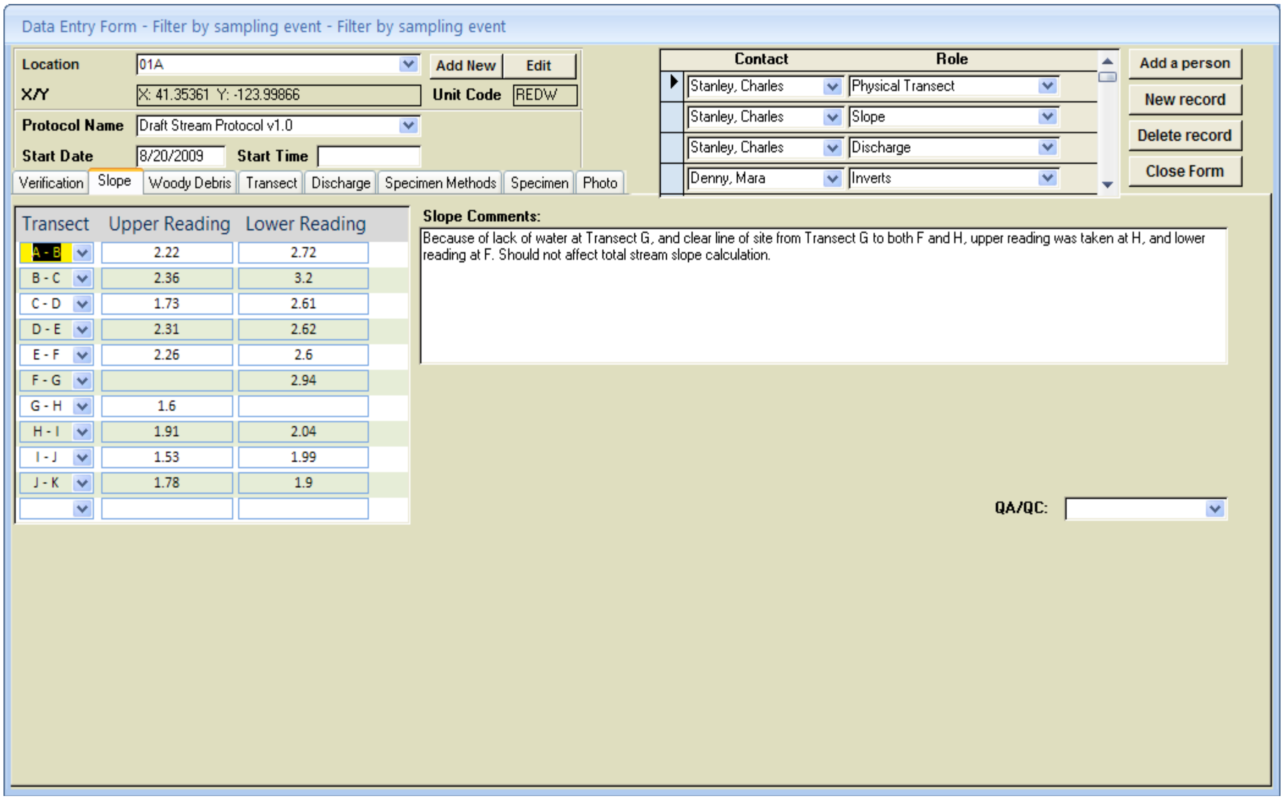


Figure 16. Data entry screen for slope data.

8. Make certain the **WD** tab is active (Figure 17). Woody debris data is collected on 2 tabs the "WD Part" is used to record data that is "All or Part of Bankfull" and "WD Above" is used to record woody debris data that is "Above Bankfull". If this is a duplicate measure skip to step d, if it is the original measure, make certain you are on the appropriate tab and complete the following:
   a. Looking at the left side of this form you will notice the data is displayed in a hierarchal method starting with Bankfull or Above Bankfull locations, then each location is divided into 3 length categories, then each length category is divided into 4 diameter categories. BE SURE to make sure you are in the correct location for adding data.
   b. Each field is populated with a "0" and all you need to do is double tap on the number to increase it by 1. You can also highlight the number and then use the key board to enter a specific number.
      (i) Be careful when resting you hand on this form, although unlikely you could accidentally increase the field value by double tapping a field with your hand.
   c. At the end of the sampling day, have one of the crew members review the data to make certain nothing is missing or mistakenly entered and have them enter in their name under the **QA/QC** field in this form.
   d. To complete a duplicate measure, click the "Add Repeated Measure" button and then complete steps a-c above.
   e. You are now done entering the woody debris data, click the **TRANSECT** tab.

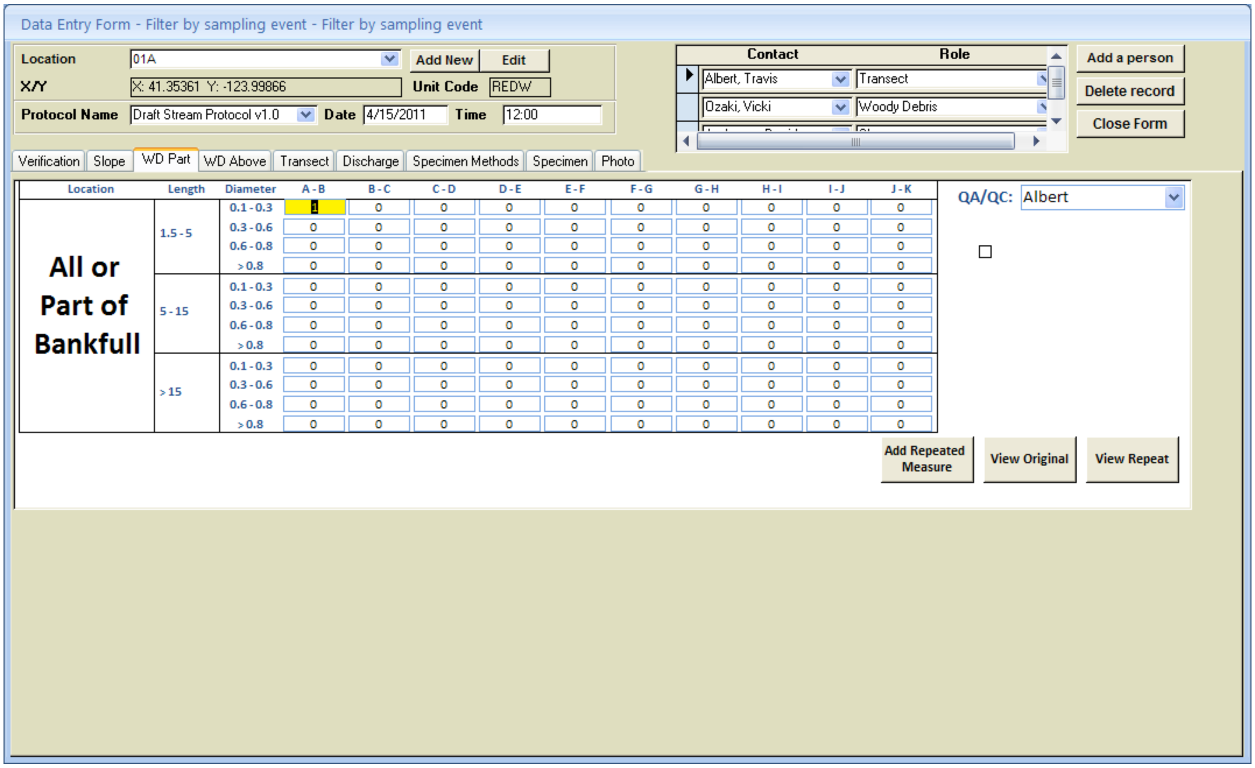
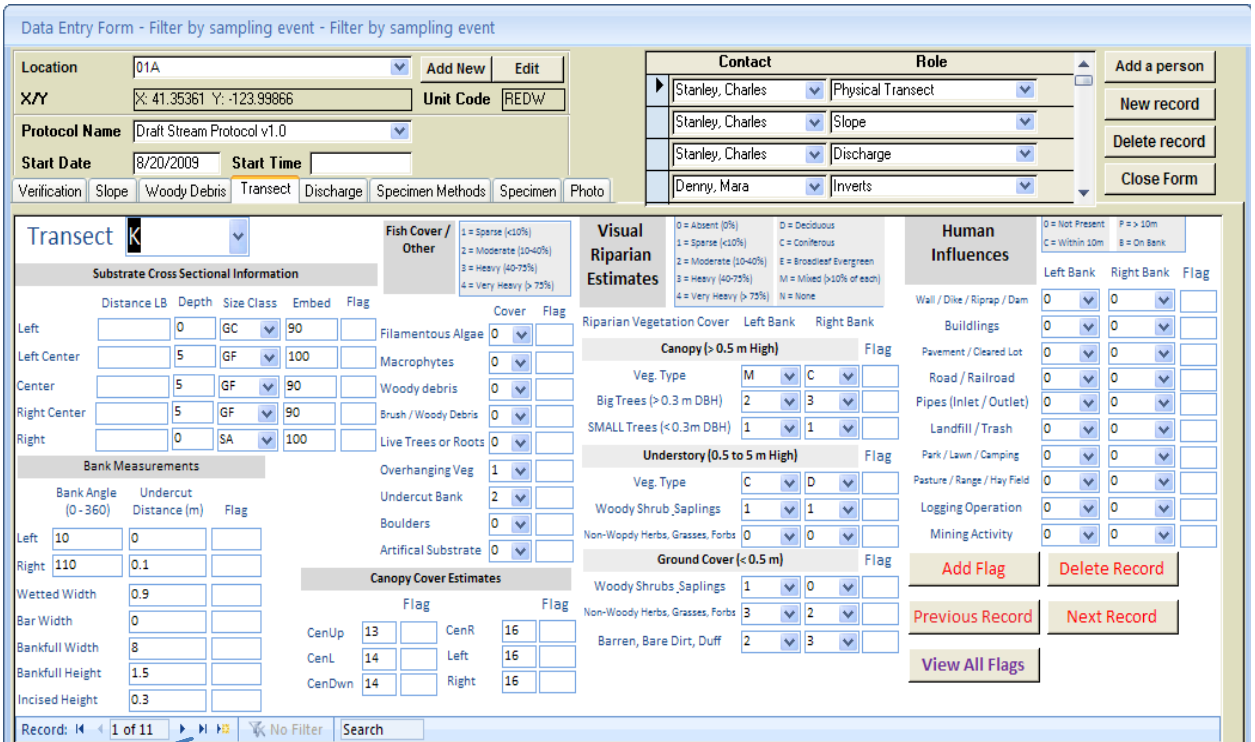


Figure 17. Data entry screen for the “all or part of bankfull” woody debris data.

9. Make certain the **TRANSECT** tab is active (Figure 18) and complete the following:
   a. Use the pick list to enter the **transect letter**.
   b. If this is a duplicate measure be sure to check the checkbox.
   c. In the “Substrate Cross Sectional Information” section enter the **Distance, Depth, Size Class, and Embed** values for the left, left center, center, right center, and right portions of the transect. If there are any **flags**, enter the flag number and then click the red “Add Flag” button and enter the flag info.
   d. In the “Bank Measurement” section enter the **bank angle** and **undercut distance** fields for the left and right back. Next enter the **wetted width**, **bar width**, **bankfull width**, **bankfull height**, and **incised height**. If there are any **flags**, enter the flag number and then click the red “Add Flag” button and enter the flag info.
   e. In the “Fish Cover / Other” section enter the cover code for **filamentous algae, macrophytes, woody debris, brush, live trees and roots, overhanging vines, undercut banks, boulders, and artificial substrate**. If there are any **flags**, enter the flag number and then click the red “Add Flag” button and enter the flag info.
   f. In the “Canopy Cover” section, enter the **canopy information** CenUp, CenL, CenDwn, CenR, Left, and Right. If there are any **flags**, enter the flag number and then click the red “Add Flag” button and enter the flag info.
   g. In the “Visual Riparian Estimate” section, enter the left and right bank information for the **Canopy, Understory, and Ground Cover** parameters using the pick list. If there are any **flags**, enter the flag number and then click the red “Add Flag” button and enter the flag info.

h. In the "Human Influence" section, enter the left and right bank information for each **influence type** listed. If there are any **flags**, enter the flag number and then click the red "Add Flag" button and enter the flag info.
i. Once complete, click the red "Next Record" button and follow steps a-h. Repeat this process for every transect surveyed.
j. At the end of the sampling day, have one of the crew members review the data to make certain nothing is missing or mistakenly entered and have them enter in their name under the **QA/QC** field in this form.
k. You are now done entering the transect data, click the **DISCHARGE** tab.



Note how 11 transects were entered

Figure 18. Data entry screen for transect data.

10. Make certain the **DISCHARGE** tab is active (Figure 19). If this is a duplicate measure skip to step h, if it is the original measure complete the following:
a. Enter the **stream width at the point of the discharge** calculation in meters.
b. Select the **nearest transect to the point of discharge** using the pick list.
c. Enter the **model and KLMN number** of the discharge meter used.
d. Select the **distance, depth, and velocity units** used to measure the discharge.
e. For each point, enter the **point number, distance from the bank, depth, and velocity**. Repeat until all values have been entered.
f. For each point, click the "Flag" button to enter a flag if necessary

g. At the end of the sampling day, have one of the crew members review the data to make certain nothing is missing or mistakenly entered and have them enter in their name under the **QA/QC** field in this form.

h. To complete a duplicate measure, click the "Add Repeated Measure" button and then complete steps a-g above.

i. You are now done entering the discharge data, click the **Specimen Methods** tab.

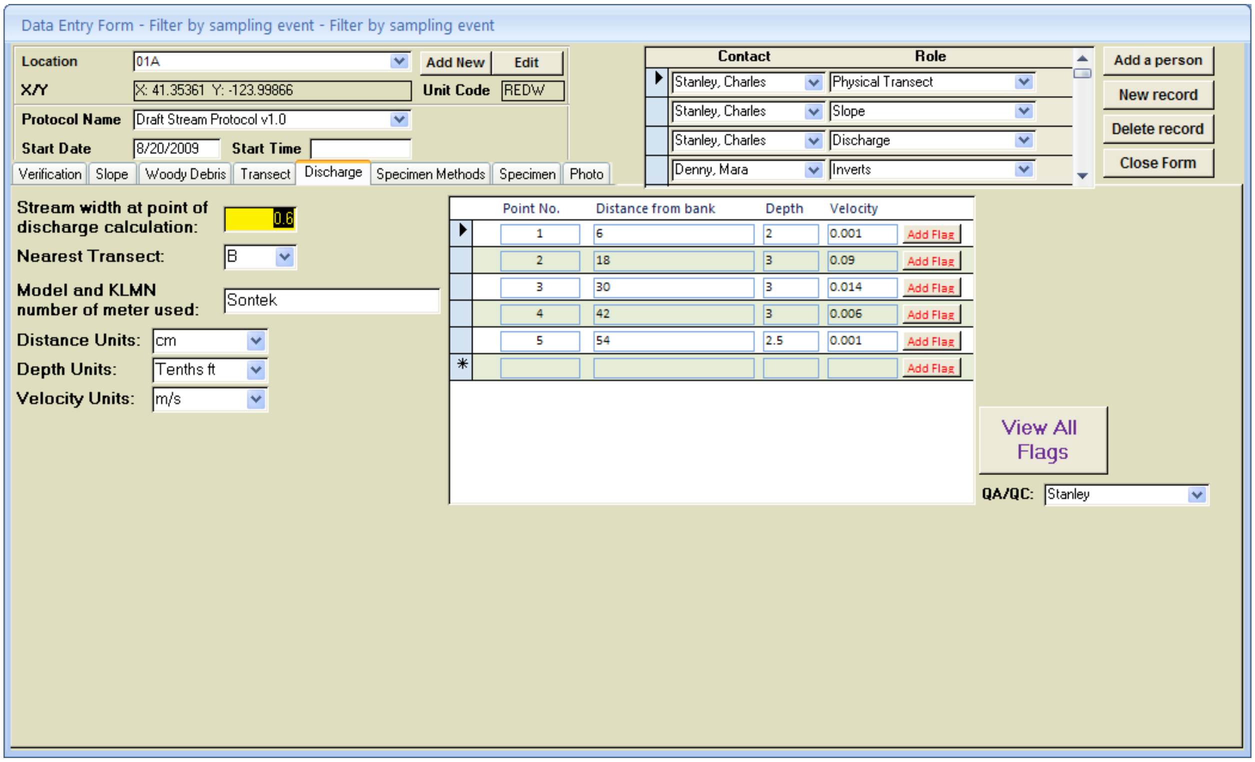


Figure 19. Data entry screen for discharge data.

11. Make certain the **SPECIMEN METHOD** tab is active (Figure 20) and complete the following:

a. If **snorkeling, seine netting, or electrofishing** was implemented, check the appropriate boxes.

b. If electrofishing was checked, enter the **wave form, volts, watts, pulse rate, amps, pulse width, total shock time, total fishing time, and sampling distance**. Use pick list when appropriate.

c. If the site was **not fished or if no fish** were collected, check the appropriate boxes.

d. Select the **visibility of the water** using the pick list. There are two possible options:

(i) Good

(ii) Poor

e. At the end of the sampling day, have one of the crew members review the data to make certain nothing is missing or mistakenly entered and have them enter in their name under the **QA/QC** field in this form.

f. You are now done entering the specimen methods data, click the **Specimen** tab.

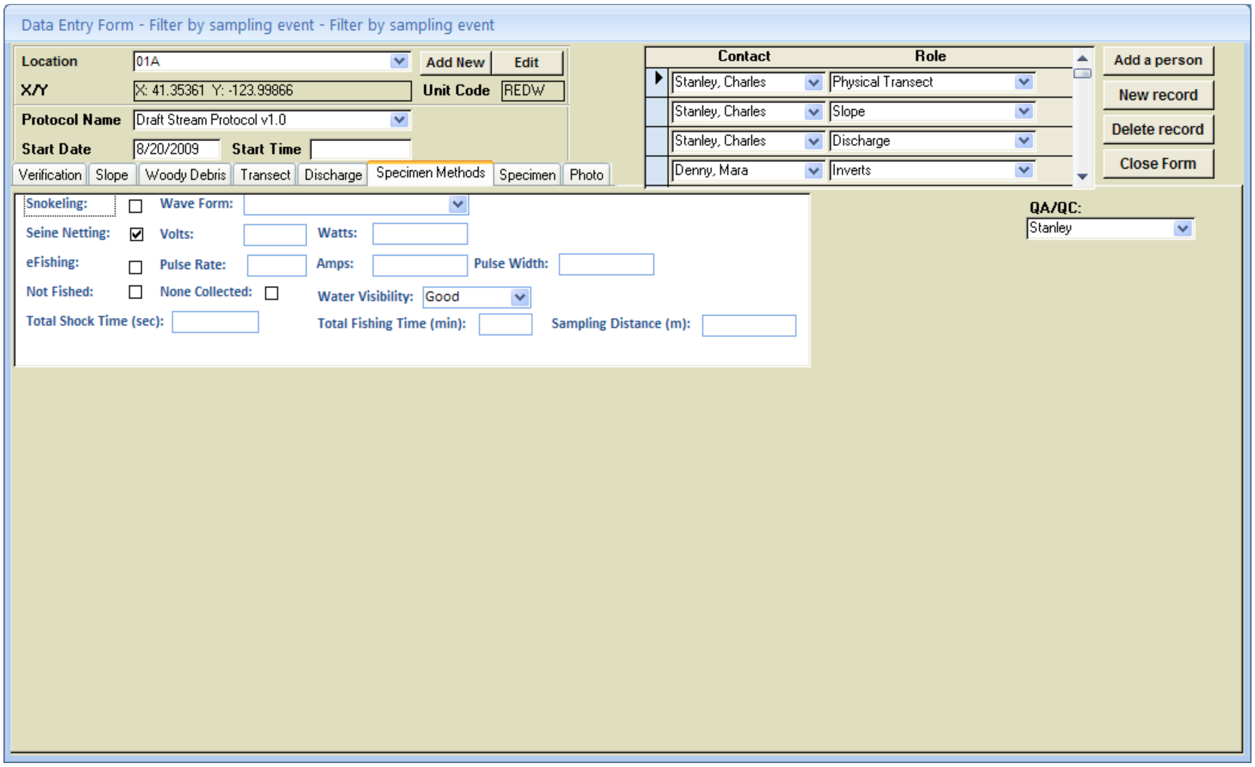


Figure 20. Data entry screen for the specimen methods data.

12. Make certain the **SPECIMEN** tab is active (Figure 21) and complete the following:
    a. For each **amphibian or fish species observed/collected**, enter the following information:
        (i) **Species number** – Chronological count of the individuals observed.
        (ii) **Common name** of the species using the pick list. If the value is not available you can enter it using the key board.
        (iii) **Total Count** of species observed – Number of species observed in one location. You can use the +/- buttons or you can enter the number using the key board.
        (iv) **Minimum length** in mm – If more than one individual was found, provide the length of the smallest individual.
        (v) **Maximum length** in mm – If more than one individual was found, provide the length of the largest individual.
        (vi) **Anomaly count** – Number of individuals with an anomaly. You can use the +/- buttons or you can enter the number using the key board.
        (vii) **Mortality count** – Number of individuals found dead. You can use the +/- buttons or you can enter the number using the key board.
        (viii) Check the **transect** where the species was observed.
    b. Repeat step "a" for each observation.
    c. If you need to **flag the observation**, click the "Add Flag" button next to the observation. Enter the appropriate flag number and comments.
    d. At the end of the sampling day, have one of the crew members review the data to make certain nothing is missing or mistakenly entered and have them enter in their name under the **QA/QC** field in this form.

e. You are now done entering the specimen methods data, click the **Specimen** tab.

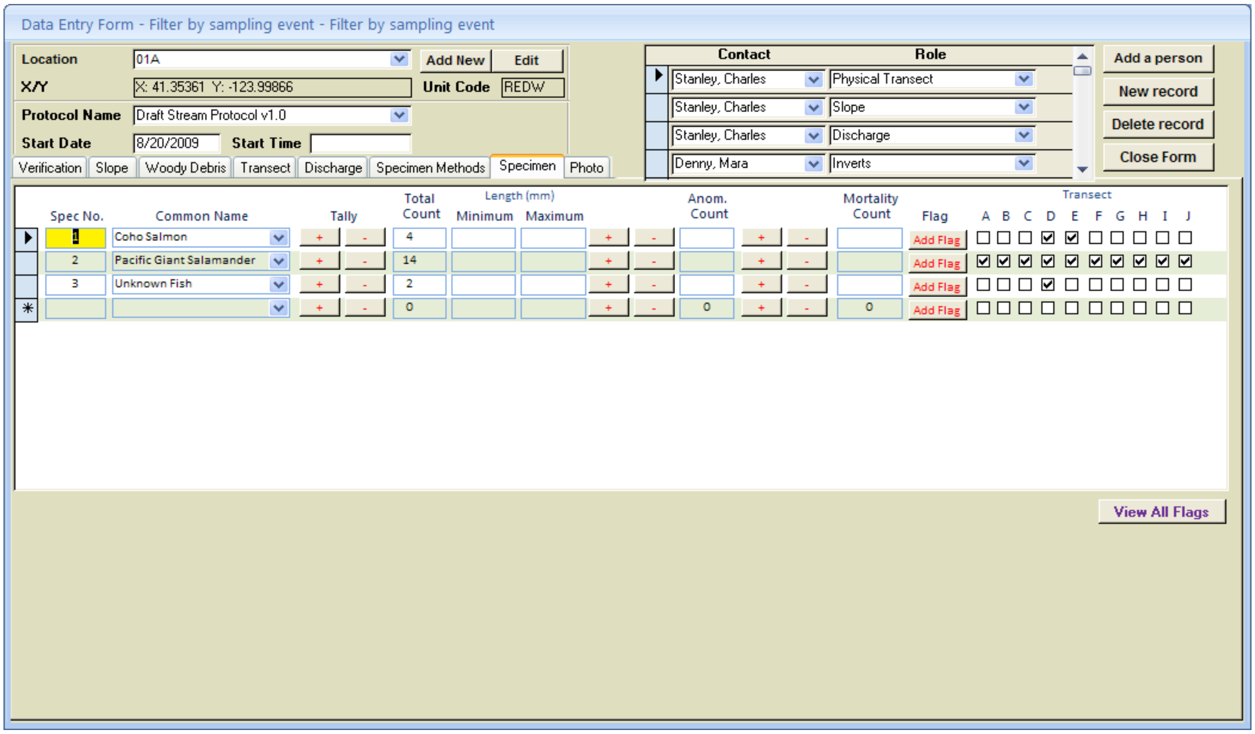


Figure 21. Data entry screen for specimen data.

13. Make certain the **PHOTO** tab is active (Figure 22) and complete the following:
   a. Full **name of the photograph**, not including the extension.
   b. Name of the **photographer**.
   c. **Detailed description** of the photograph.
   d. **Date** the photo was taken. (Auto-populates with today's date.)
   e. If this is a really good photograph (something that can be used in reports or web sites), check the "**Is this a great photo"** box.
   f. **Photo extension**. (Auto populates with ".jpg.")
   g. Repeat steps a-f for each photograph.
   h. At the end of the sampling day, have one of the crew members review the data to make certain nothing is missing or mistakenly entered and have them enter in their name under the **QA/QC** field in this form.
   i. Note, if the photograph does not relate to this site then it should not be entered on this form. Use the Excel spreadsheet (SOP #16: Photo Points and Photo Management) or click on the incidental photograph button at the bottom of the form and enter the record there.

14. You should now be done collecting data for this site. In the upper, right corner of the screen, click the QA/QC button. This will run a report that reviews a variety of aspects of the data you just entered and flags POTENTIAL issues.
15. For each issue, review the data, make any necessary corrections, and then you are finished sampling the site. Click the "Close Form" button which will bring you back to

the list of sites sampled, close this form as well and you should be back at the main page (Figure 11).

16. Click the “Exit” button to close the database.

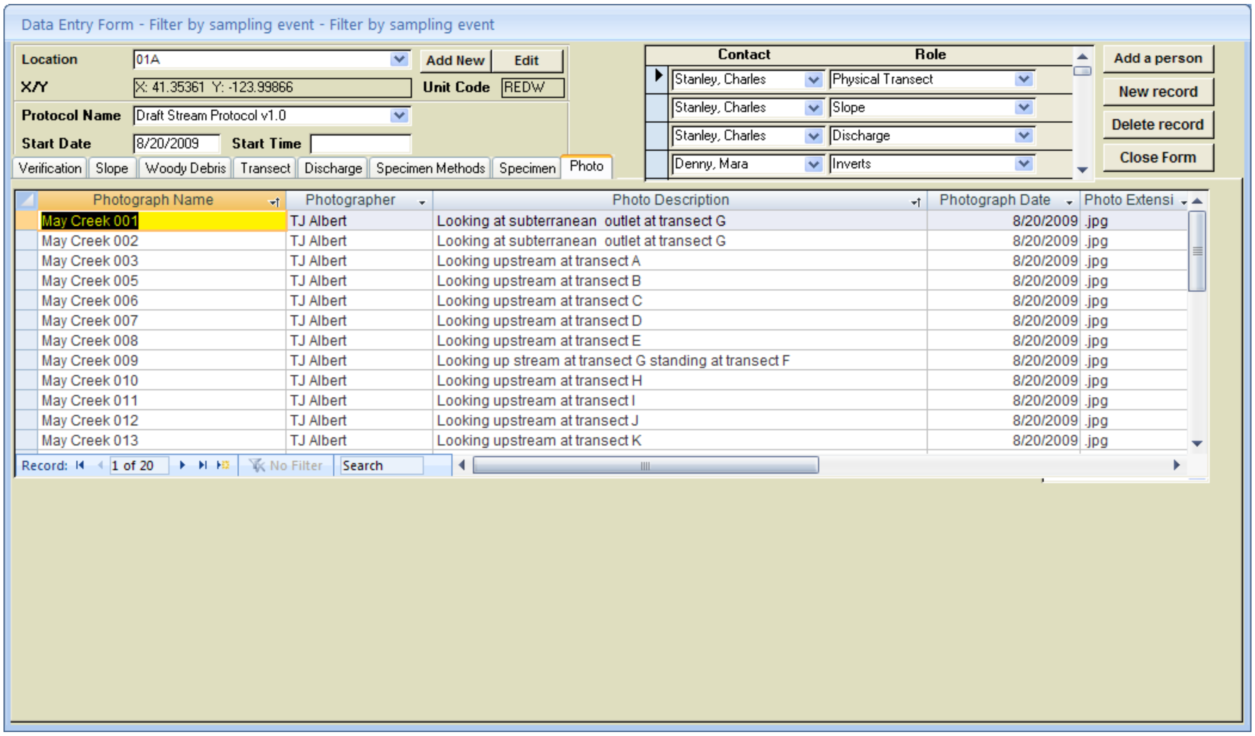


Figure 22. Data entry screen for photographs.

17. You will be asked if you want to backup the database, click “Yes”.
18. Using the naming convention automatically populated, browse to:

    D:\Monitoring\Stream Monitoring\Data\Project Database\Database Backups

    and save the backup.

19. Browse to the backup copy and right click on the file, select copy, and then paste the copy on the thumbdrive at:
    \Monitoring\Stream Monitoring\Data\Project Database\Database Backups
20. Using the “Start” menu in the bottom, right corner turn off the tablet computer. Remove the thumb drive and store it in a cool, dry location. You are now done collecting data at this site.

Crew Member Data Entry

The crew member who is responsible for entering data should record data related to thalweg, vegetation, torrent, probe, channel, benthos, periphyton, and photographs. Complete the following steps to enter data for these parameters.

1. Make certain you have followed the steps in the “Crew Leader and Crew Member Database” section of this document before starting these tasks.

2. Using the drop down menu, select the name of the protocol you are using (Figure 14).
3. The “Start Date” in the format mm/dd/yyyy and “Start Time” in the format hh:mm should automatically populate, however be sure to check this information to make certain it is correct.
4. At the top right side of the screen, use the pick list to enter the names of the crew members and their roles in sampling the data **in this database** for that site. Names are entered multiple times if they have completed multiple roles.
5. Make certain the **Thalweg** tab is active (Figure 23) and complete the following:
    a. Select the **transect** range where you are sampling.
        (a) If you selected “A-B” enter the **increment** and **total reach length** in the upper left corner of the form.
    b. If this is a duplicate measure be sure to check the duplicate measure box.
    c. Enter the **station number**.
        (a) If you selected station 5 or 7 be sure to enter the substrate data in the lower right corner of the form.
    d. Enter the **depth** and **wetted width** in meters.
    e. Check “Y” or “N” if **bar width** was measured. If “Y” then enter the measurement in **Dist**.
    f. Select the **channel unit code** and **pool form code**.
    g. Check “Y” or “N” if a **side channel** is present.
    h. Check “Y” or “N” if **back water** is present.
    i. Click the “Add Flag” button to enter a **flag** related to this record.
    j. At the end of the sampling day, have one of the crew members review the data to make certain nothing is missing or mistakenly entered and have them enter in their name under the **QA/QC** field in this form.
    k. You are now done entering the thalweg data, click the **VEGETATION** tab.
        (a) Note: When you leave the thalweg tab a message will check to make certain you have entered the substrate, increment, and total reach length. If you have done this, click “Yes” and continue on to the next form, if you have not done this click “No”, and click the A-B transect or the 5 or 7 point and enter the appropriate data.

Figure 23. Data entry screen for thalweg data.

6. Make certain the **Vegetation** tab is active (Figure 24) and complete the following:
    a. **Transect** – Use the picklist to select the transect letter.
    b. Check the box marked “**Check if tree is not visible**” if you cannot see the tree.
    c. Check the box marked “**Check if Duplicate**” if this is a duplicate measure.
    d. Use the pick list to select the **DBH** category of the tree on the right and left. There are five possible choices.
        (i) 0.0 – 0.1
        (ii) 0.1 – 0.3
        (iii) 0.3 – 0.6
        (iv) 0.6 – 0.8
        (v) 0.8 – 2.0
        (vi) >2.0

e. Enter the **Height** of the tree in meters for the right and left tree in meters.
f. Enter the **distance** of the tree to the stream in meters for the right and left tree.
g. Enter the broad **category type** for the right and left tree.
   (a) Deciduous
   (b) Conifer
   (c) Broadleaf Evergreen
h. Select the **taxonomic category** for the right and left tree. If you are able to identify the specific tree species, enter it instead of one of the selected classes.
i. **Check the boxes for all invasive plants that are present**. If no plants are present, check **NONE**.
j. Repeat steps A-H for each transect surveyed.
k. Enter any general comments about the vegetation data collection.
l. At the end of the sampling day, have one of the crew members review the data to make certain nothing is missing or mistakenly entered and have them enter in their name under the **QA/QC** field in this form.
m. You are now done entering the vegetation data, click the **Torrent** tab.

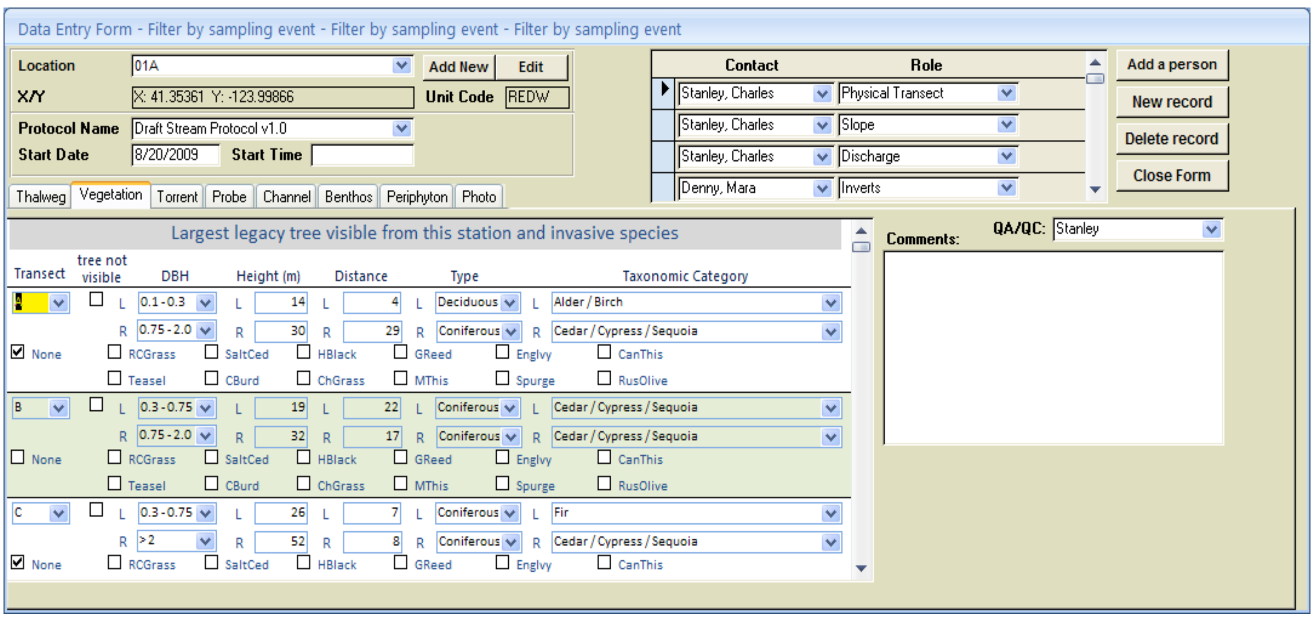


Figure 24. Data entry screen for large tree and invasive species data.

7. Make certain the **Torrent** tab is active (Figure 25). If this is a duplicate measure go to step c, if this is the original measure complete the following:
   a. **Evidence of Torrent Scouring / Deposits:** Select one of the following:
      01- Stream channel has a recently de-vegetated corridor two or more times the width of the low flow channel. This corridor lacks riparian vegetation with the possible exception of fireweed, even-aged alder or cottonwood seedlings, grasses, or other herbaceous plants.
      02- Stream substrate cobbles or large gravel particles are NOT IMBRICATED (meaning that they do not lie with the flat sides horizontal, like roof shingles) Stones laying unorganized, lying "every which way." Substrate may be angular (not water-worn).

03- Channel has little evidence of pool-riffle structure. (Could you ride a mountain bike down the stream?)
04- The stream channel is scoured down to bedrock.
05- There are gravel or cobble berms (levees) above bankfull height.
06- Downstream of the scoured reach, there are massive deposits of sediment, logs, or other debris.
07- Riparian trees have fresh bark scars at main points, at very high levels above the channel bed.
08- Riparian trees have fallen into the channel as a result of scouring near their roots.
09- There are massive deposits of sediment, logs, and other debris in the reach. They may contain wood and boulders that, in your judgment, could not have been moved even at extreme flood stage.
10- If the stream has begun to erode newly laid deposits, it is evident that these deposits are "matrix supported" (meaning that large particles are not necessarily touching but have silt and sand in between them and these fine materials support the larger particles).
11- No evidence of torrent scouring or torrent deposits.

b. At the end of the sampling day, have one of the crew members review the data to make certain nothing is missing or mistakenly entered and have them enter in their name under the **QA/QC** field in this form.
c. To complete a duplicate measure, click the "Add Repeated Measure" button and then complete steps a-b above.
d. You are now done entering the Torrent data, click the **Probe** tab.

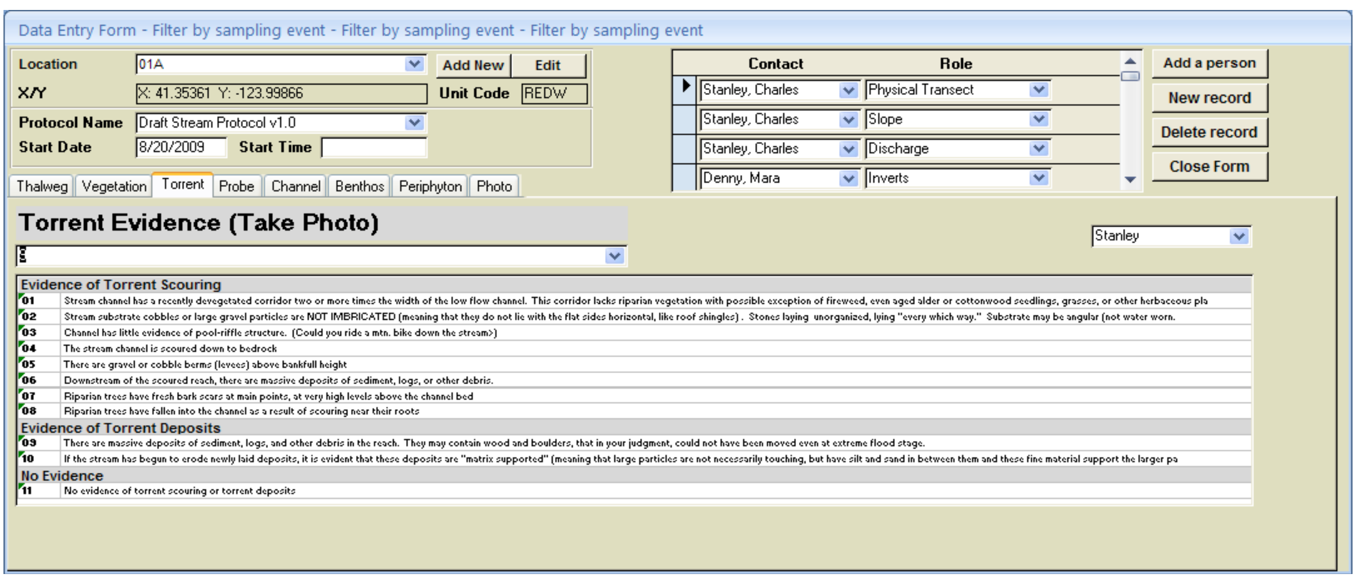


Figure 25. Data entry screen for torrent evidence data

8. Make certain the **Probe** tab is active (Figure 26).). If this is a duplicate measure go to step g, if this is the original measure complete the following:

a. For pH, enter the **standard**, **reading**, and **check the box** if you recalibrated the meter or replaced the membrane.
b. For Condition, enter the **standard**, **reading**, and **check the box** if you recalibrated the meter or replaced the membrane.
c. For DO Sat, enter the **standard**, **reading**, and **check the box** if you recalibrated the meter or replaced the membrane.
d. For Alkalinity samples 1, 2, and 3 enter the **water volume** in milliliters, **titrant strength**, and the **reading**.
e. Enter any comments related to the data on this form.
f. At the end of the sampling day, have one of the crew members review the data to make certain nothing is missing or mistakenly entered and have them enter in their name under the **QA/QC** field in this form.
g. To complete a duplicate measure, click the "Add Repeated Measure" button and then complete steps a-f above.
h. You are now done entering the Probe data, click the **Channel** tab.

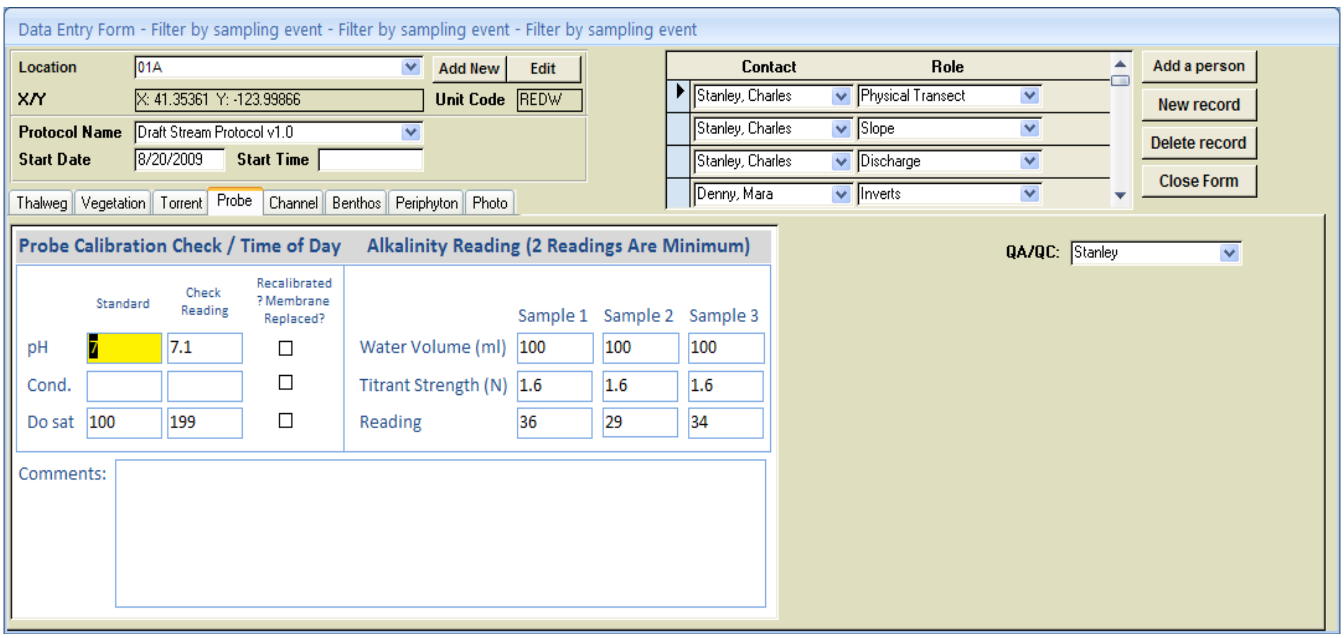


Figure 26. Data entry screen for Probe and Alkalinity data.

9. Make certain the **Channel** tab is active (Figure 27). If this is a duplicate measure go to step i, if this is the original measure complete the following:
   a. In the "Channel Constraint" section use the pick list to select a "**Channel Pattern**."
      (a) *One Channel* – One channel.
      (b) *Braided Channel* – Multiple short channels branching and rejoining, mainly one channel broken up by numerous mid-channel bars.
      (c) *Anastomosing* – Relatively long major and minor channels branching and rejoining.
   b. Use the pick list to select a "**Channel Constraint**."

(a) *Constrained In V-Shaped Valley* – Channel very constrained in V-Shaped valley (i.e., it is very unlikely to spread out or erode a new channel during a flood).
(b) *Broad Valley* – Channel is in Broad Valley but channel movement by erosion during floods is constrained by Incision.
(c) *Narrow Valley* – Channel is in Narrow Valley, not very constrained but limited in movement by relatively narrow adjacent hillslopes.
(d) ***Unconstrained in Broad Valley*** – Channel is Unconstrained in Broad Valley (i.e., during flood it can fill off-channel areas and side channels, spread out over flood plain, or easily cut new channels by erosion).

c. Use the pick list to select a "**Channel Feature**."
   (a) *Bedrock.*
   (b) *Hillslope.*
   (c) *Terrace.*
   (d) *Human Bank Alterations.*
   (e) *No Constraining Features.*

d. Enter the **% of channel length with margin in contact with constraining features**.

e. Enter the "**Bankfull Width**" in meters.

f. Enter the "**Valley Width**" in meters.

g. If you are not able to see the valley border, **check the appropriate box**.

h. At the end of the sampling day, have one of the crew members review the data to make certain nothing is missing or mistakenly entered and have them enter in their name under the **QA/QC** field in this form.

i. To complete a duplicate measure, click the "Add Repeated Measure" button and then complete steps a-h above.

j. You are now done entering the Channel data, click the **Benthos** tab.

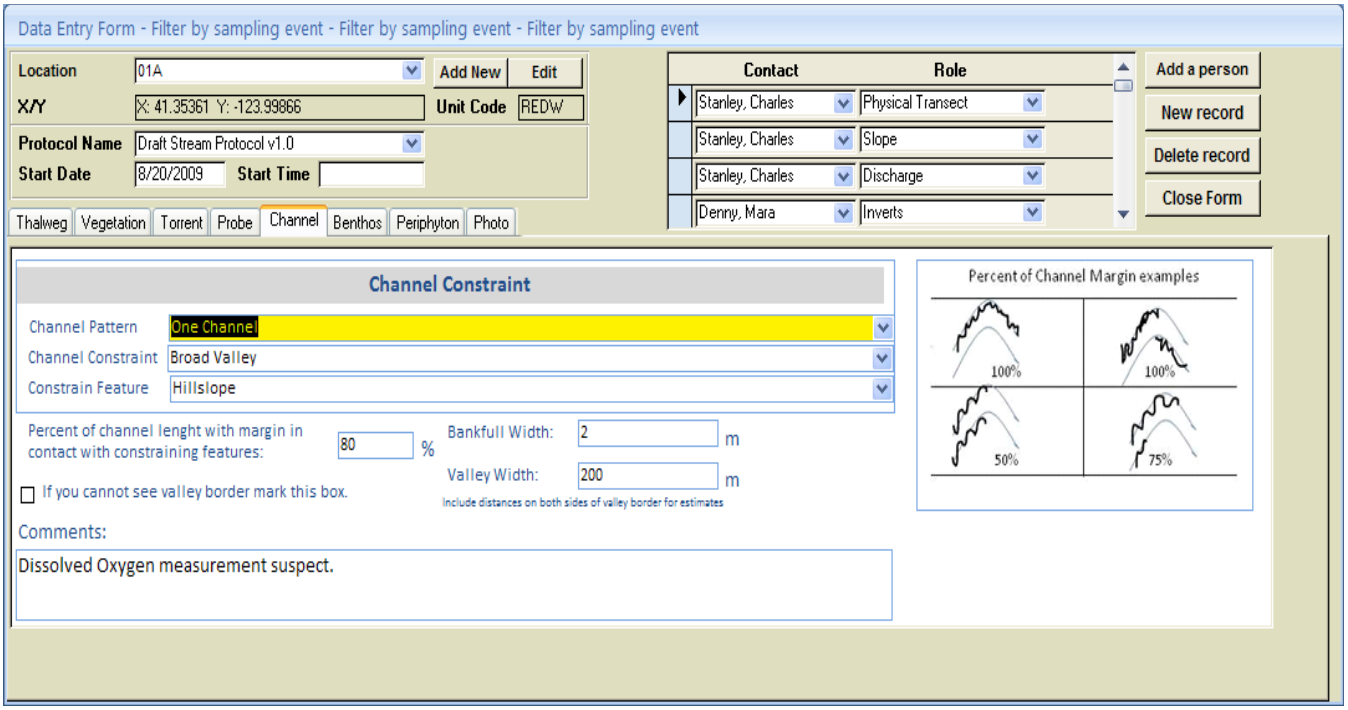


Figure 27. Data entry screen for Channel data.

10. Make certain the **Benthos** tab is active (Figure 28). If this is a duplicate measure go to step i, if this is the original measure complete the following:
    a. If you **collected water chemistry** check the box.
    b. Use the pick list to select the **transect** where the water chemistry sample was taken.
    c. Enter any **comments** about the water chemistry sample.
    d. Enter the **Air and Water temperature** in degrees Celsius.
    e. Enter the **number of vials** used for the benthos sample.
    f. Enter any **general comments** about the benthos sample.
    g. Using the pick list, select the **nearest transect** and **substrate type** for each of the benthos samples. Repeat this step until all samples have been entered.
    h. At the end of the sampling day, have one of the crew members review the data to make certain nothing is missing or mistakenly entered and have them enter in their name under the QA/QC field in this form.
    i. To complete a duplicate measure, click the “Add Repeated Measure” button and then complete steps a-h above.
    j. You are now done entering the Benthos data, click the **Periphyton** tab.

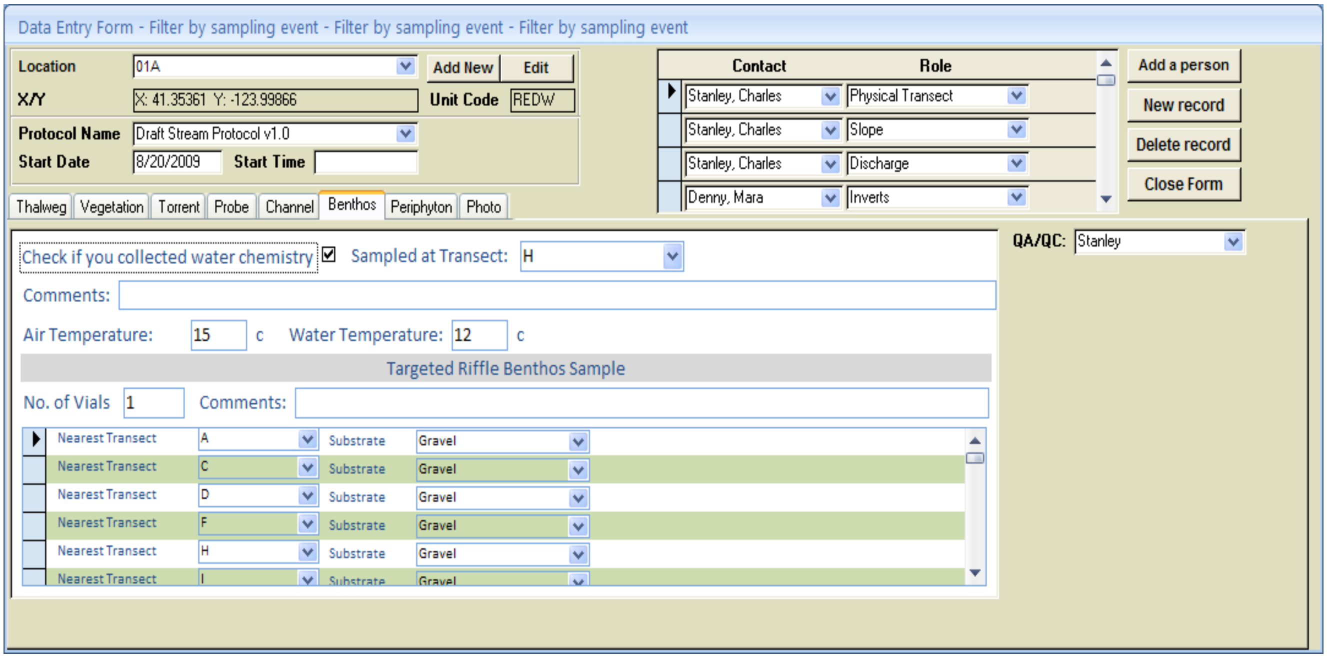


Figure 28. Data entry screen for Benthos data.

11. Make certain the **Periphyton** tab is active (Figure 29). If this is a duplicate measure go to step f, if this is the original measure complete the following:

a. Enter the **number of cobble scrapped** for the periphyton ash sample.
b. If you need to enter a flag for the number of cobble scrapped, click the "Add Flag" button and enter the flag code and comment.
c. Enter the **nearest transect** for each sample and repeat this step for each sample.
d. Enter any **general comments** about the periphyton sample.
e. At the end of the sampling day, have one of the crew members review the data to make certain nothing is missing or mistakenly entered and have them enter in their name under the QA/QC field in this form.
f. To complete a duplicate measure, click the "Add Repeated Measure" button and then complete steps a-e above.
g. You are now done entering the Periphyton data, click the **Photo** tab.

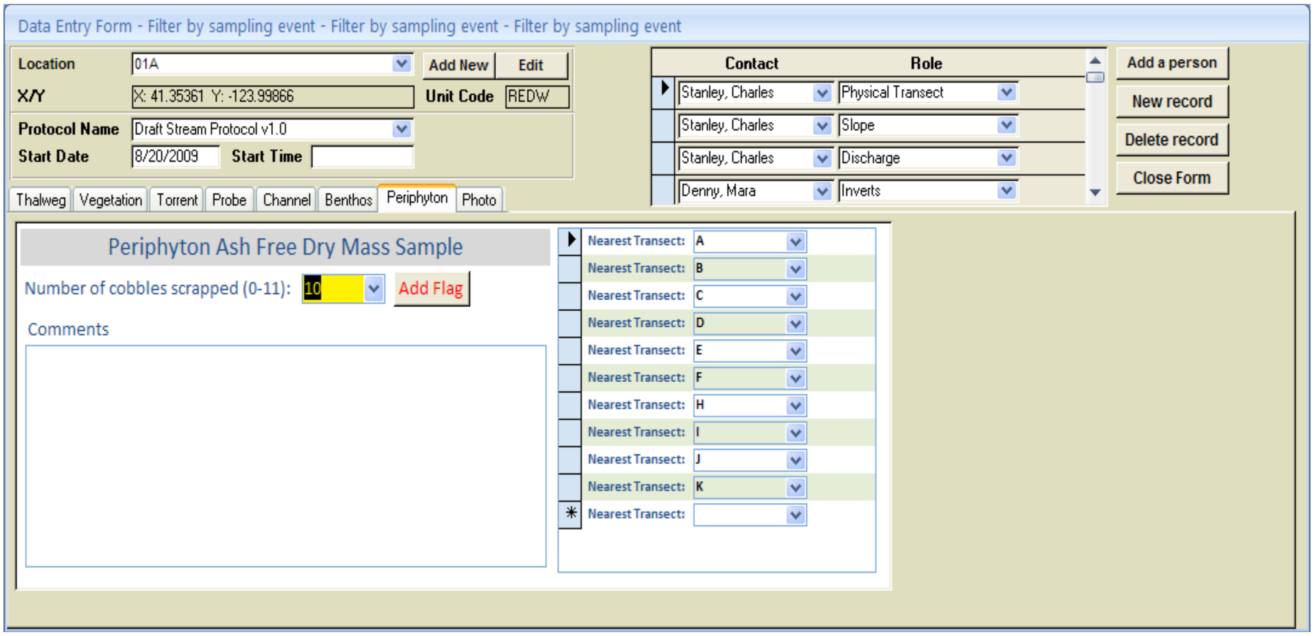


Figure 29. Data entry screen for Periphyton data.

12. Make certain the **Photo** tab is active (Figure 30) and complete the following:
    a. Full **name of the photograph**, not including the extension.
    b. Name of the **photographer**.
    c. **Detailed description** of the photograph.
    d. **Date** the photo was taken. (Auto-populates with today's date.)
    e. If this is a really good photograph (something that can be used in reports or web sites) ,check the "**Is this a great photo"** box.
    f. **Photo extension**. (Auto populates with ".jpg.")
    g. Repeat steps a-f for each photograph.
    h. At the end of the sampling day, have one of the crew members review the data to make certain nothing is missing or mistakenly entered and have them enter in their name under the **QA/QC** field in this form.
    i. Note, if the photograph does not relate to this site then it should not be entered on this form. Use the Excel spreadsheet (SOP #16: Photo Points and Photo Management) or click on the incidental photograph button at the bottom of the form and enter the record there.
13. You should now be done collecting data for this site. In the upper, right corner of the screen, click the QA/QC button. This will run a report that reviews a variety of aspects of the data you just entered and flags POTENTIAL issues.
14. For each issue, review the data, make any necessary corrections, and then you are finished sampling the site. Click the "Close Form" button which will bring you back to the list of sites sample, close this form as well and you should be back at the main page (Figure 11).
15. Click the "Exit" button to close the database.

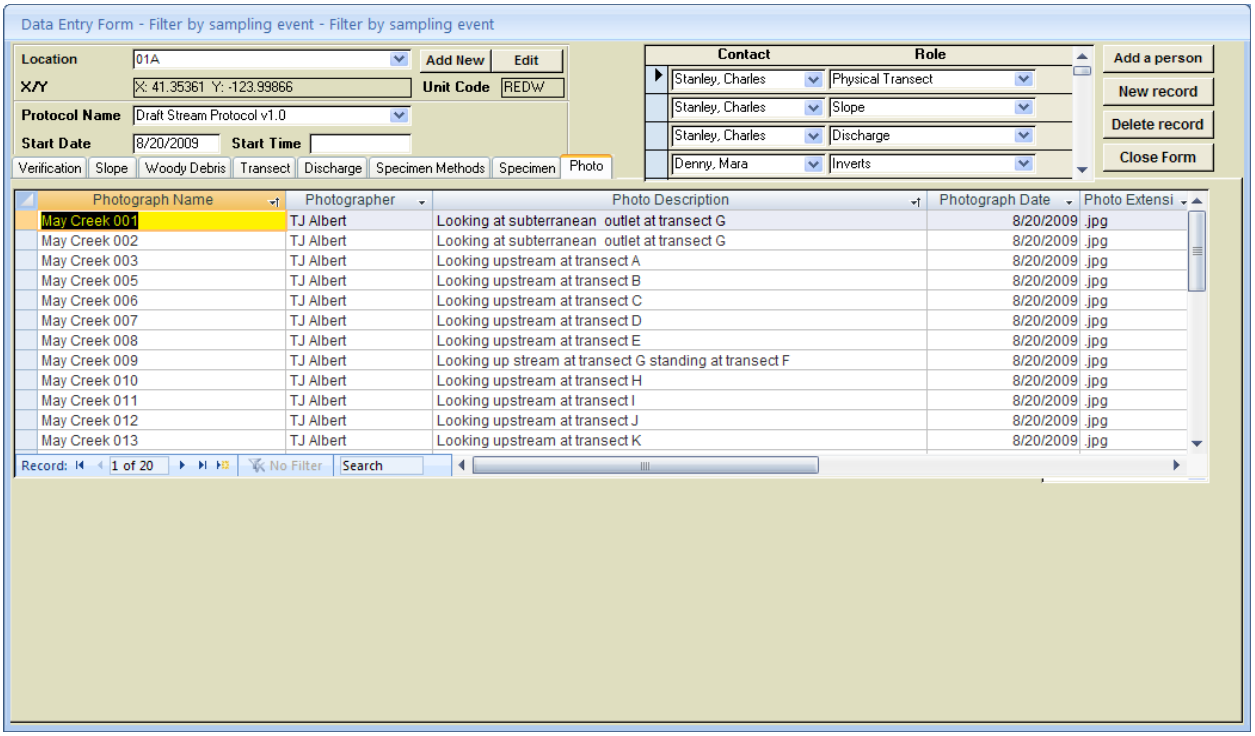


Figure 30. Data entry screen for Photograph data.

16. You will be asked if you want to backup the database, click "Yes".
17. Using the naming convention automatically populated, browse to:

    D:\Monitoring\Stream Monitoring\Data\Project Database\Database Backups

    and save the backup.

18. Browse to the backup copy and right click on the file, select copy, and then paste the copy on the thumbdrive at:
    \Monitoring\Stream Monitoring\Data\Project Database\Database Backups
19. Using the "Start" menu in the bottom, right corner turn off the tablet computer. Remove the thumb drive and store it in a cool, dry location. You are now done collecting data at this site.

Data Validation and Verification

In addition to the at-site validation and verification, final validation and verification is done by the Project Lead. After surveying each park, it is the responsibility of the Project Lead to review all data collected by the field crew. In addition to looking for errors similar to the ones described above, techniques such as outlier detection and automated data analysis should be done to look for additional errors. This task should be completed prior to releasing field crews from service, so that potential problems can be resolved, if possible.

After the data have gone through the validation and verification process and the data, along with a certified datasheet, have been submitted to the Data Manager, it is the Data Manager's responsibility to conduct an additional review of the data to look for any potential errors missed by the field crew or Project Lead. Once complete and discrepancies addressed, the data are loaded into the seasonal and master database (SOP #20: Databases).

Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #5: Order of Work

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP lays out an example flow of work for the field crew. The goal is for a four person crew to be able to sample a small sample reach in 4-6 hours and a larger sample reach in 6-8 hours. This will then allow adequate access time to sample the largest of streams in a 10-12 hour workday. Additionally, it is ambitious to assume that two sample reaches could be completed in 1 day. However, if conditions are optimum and it is believed that a second reach can be fully completed, it should be attempted.

Unlike other SOPs, this SOP should be flexible for different crews. As long as certain principles are held and individual SOPs are adhered to, crews should be free to modify the order of tasks as they see efficient. For example, if a local park specialist accompanies the crew for a day, there may be a more efficient way for the crews to accomplish the workload with an additional person.

For most crews, a certain amount of standardization will work the best. However, certain sampling locations will differ in the amount of time necessary to complete certain tasks. For example, some sites will have very quick woody debris counts, while others may take 1 to 2 hours. Hence, flexibility is needed in the flow of work to obtain maximum efficiency.

Crew Specialization

Crew members are encouraged to learn and engage in as many sampling protocols as possible. However, tasks associated with certain SOPs require consistency and efficiency that are only acquired through repetition. Crew members should designate who completes the components of these SOPs and adhere to these designations throughout the field season. Cross training in all SOPs is still required.

These specializations are:

1. Physical Habitat Specialist
2. Riparian Habitat Specialist
3. Stream Technician

This SOP explains how the following SOPs are integrated into an overall workflow so that procedures do not interfere with each other (Figure 1). Hence, the following descriptions do not detail the steps but instead refer to the other SOPs.

The order of work presented represents a schematic of what worked well during the pilot project used in developing these SOPs. The primary considerations and limitations in modifying this order of work are:

1. Do not conduct any sampling activities upstream of the X-point until a crew member has completed water quality analysis and collected water samples for water chemistry analysis. Scouting is the exception to this rule and should be done by the Crew Leader only, taking care to not disturb the stream channel. The rationale for this is that the disturbance of stream substrates will bias the resulting water samples.
2. All sampling events prior to electrofishing should be done with care not to disturb the aquatic habitat. This includes laying out the sample reach (SOP #6: Site Arrival and Sample Reach Layout), which requires entering the aquatic environment. Electrofishing should be initiated as soon as possible to reduce the effect of sampling events on capture efficiency.
3. Electrofishing should always be initiated by three crew members to ensure that it is completed quickly and efficiently to reduce the handling time of collected specimens. However, if numbers of collected specimens are low, the task may be finished with just two individuals.

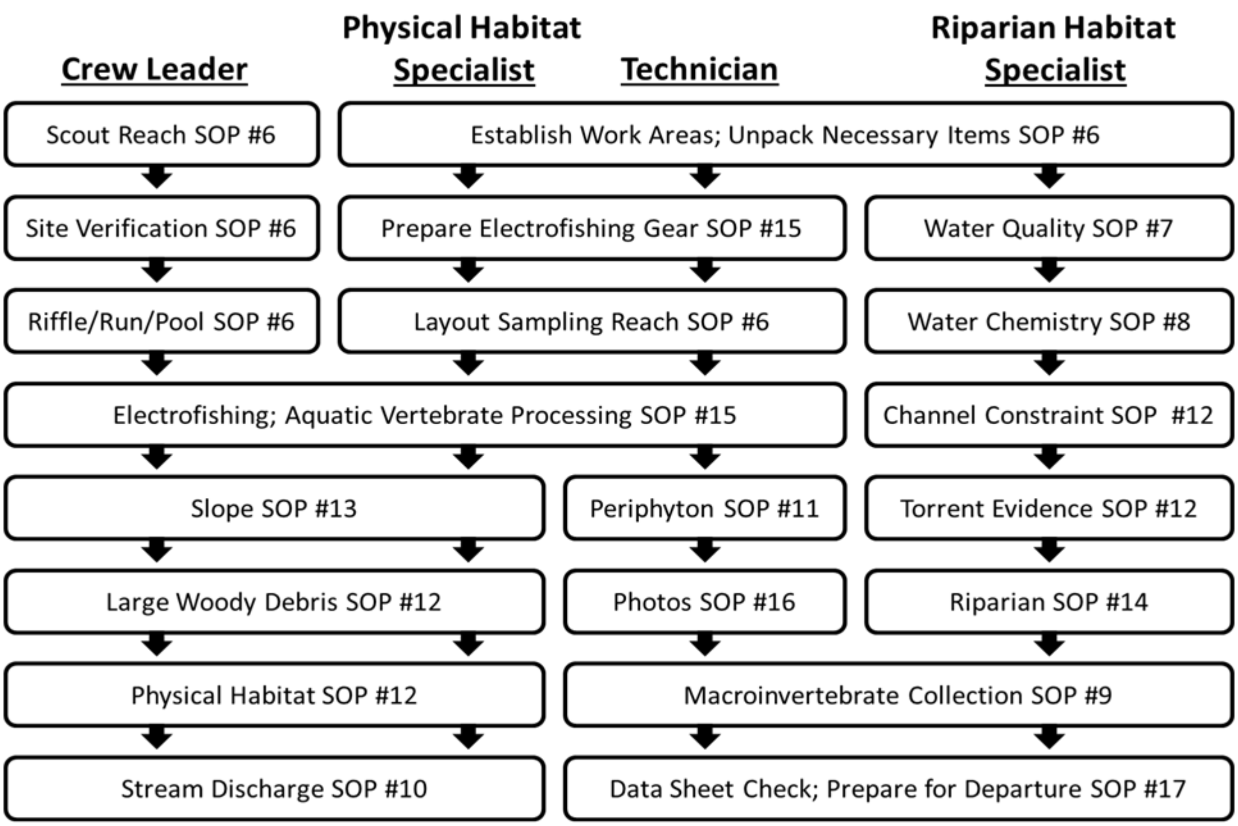


Figure 1. Suggested roles and responsibilities and order of work for efficient sampling of streams. Rectangles indicate which of the above listed crew members should participate in each task.

Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #6: Site Arrival Tasks and Sample Reach Layout

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP explains the immediate tasks that need to be completed upon site arrival and includes the miscellaneous tasks associated with sampling that may not be included in other SOPs.

To reduce the possibility of transporting disease and exotic organisms to other sites, crews should keep their aquatic footwear and trail footwear separate. Upon reaching the proximity of the site, the crew should remove their hiking footwear, and don their aquatic footwear. Their hiking footwear should be left away from the aquatic habitat, to be used when all aquatic sampling is complete. Daily disinfection of aquatic footwear and sampling gear is crucial to prevent the spread of organisms between sample reaches as a direct result of sampling activities (SOP #17: Post-Site Tasks).

Locating the Sample Reach

The day prior to sampling the reach, the Field Crew Leader should identify the reach to be sampled. This will either be predetermined based on previous field season sampling or, if in the first year of implementation, there will be considerable flexibility in choosing the reach. Since accessibility of the reach will be unknown in the first year, alternate reaches should also be selected, in the order of the GRTS draw for the site (SOP #3: Site Selection).

Field crew members should use local road, trail, park atlases (if available), topographic maps, and/or premade GIS maps to determine the location of the sample reach that is to be sampled and the best route to gain access. Using a Garmin 60/76CSx (or similar) GPS handheld device, preloaded with site coordinates and navigational features such as streams, ridges, roads, and trails (SOP #1: Preparations, Equipment and Safety), they should navigate to the site using available pathways. A waypoint should be recorded at the vehicle location to ensure efficient navigation back to where the vehicle is parked.

The crew should be prepared to use alternate routes of travel, as unexpected events such as the closing of roads and trails may make the planned route invalid. The GPS device should be the primary source of navigation from the location of the field vehicle to the location of the sample reach. However, electronic gear should not replace standard route-finding techniques and awareness. Field crew members should always remember to carry a compass, list of site coordinates, and maps pertinent to the sampling event in a waterproof zip-top bag in case of GPS equipment malfunction. Such malfunctions may occur in areas of dense canopy cover, which hinders communication with GPS satellites or other equipment failure.

The sample reach will be defined as a linear length of stream; however, the GPS coordinates direct the crew to an "X-point," located in the center of the reach (Figure 1). The X-point is calculated from the National Hydrography Dataset (NHD) and error between the NHD and the GPS may place the X-point as much as 50 meters away from a flowing stream. In these cases, or in any other case where the X-point does not land directly in the streambed, the crew should make a straightline to the nearest flowing stream and establish that point as the X-point.

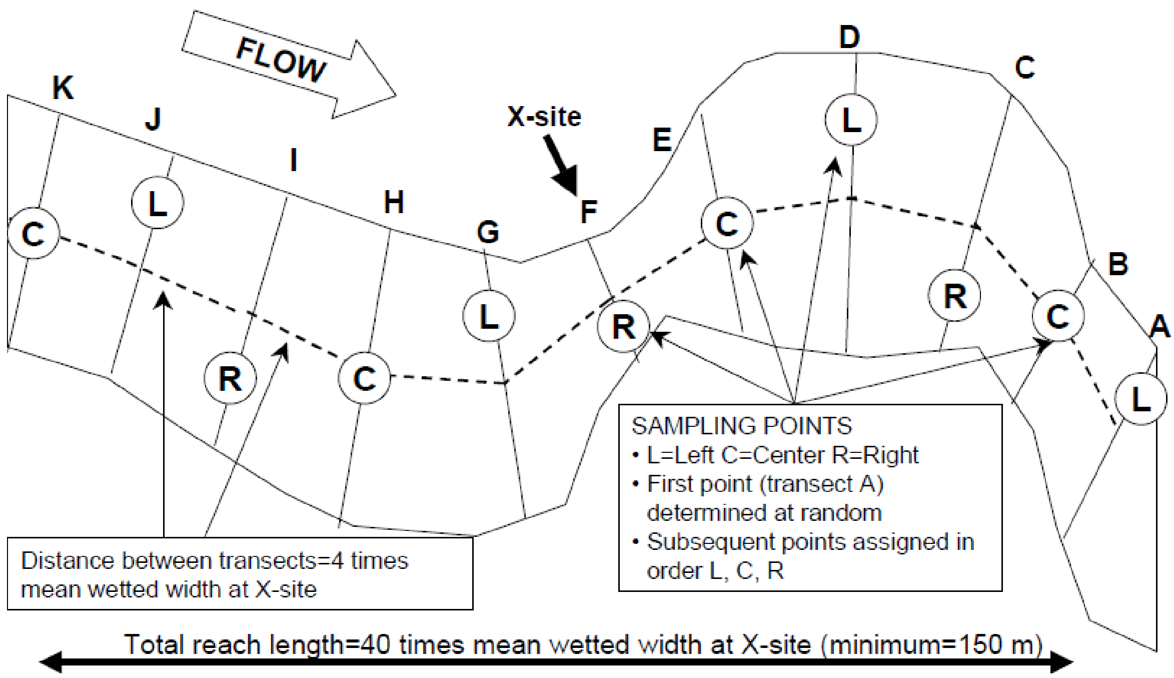


Figure 31. Schematic overview of the reach layout, showing the "X" point at the F transect and the center of stream line used to measure the distance between transects. From EMAP Western Pilot Study Field Operations Manual.

Establish a Working Area

Upon arriving at the midpoint coordinates for the proposed stream reach, the Field Crew Leader should scout the stream by walking around and observing the majority of the proposed stream reach area. Care should be taken not to walk through the aquatic environment to be sampled, as this may disturb fishes and macroinvertebrates as well as affect water quality measurements. The purpose of this scouting is to ensure that there are no limiting features within the reach area that may be dangerous to crew members, may too greatly impede the progress of sampling procedures, or may cause certain areas of the reach to be unsampleable. Certain features may be judgment calls; it is up to the Crew Leader to determine if high quality data can be obtained, but recognizing that crew safety should always be the primary consideration. Limiting features include, but are not restricted to:

a. Log-jams.
b. Confluences with tributaries.
c. Lakes, reservoirs, or ponds.
d. Large waterfalls.
e. Deep pools.
f. Dense, impenetrable vegetation.
g. Impassable rugged terrain.
h. Large boulders/rockslides.
i. Large areas of dry streambed, especially if judged to be of ephemeral nature.
j. Indications of marijuana cultivation.
k. High stream discharge events.
    i. Avoid sampling during high flow/ rainstorm events. If the stream is running at or near bank full discharge or water seems much more turbid than typical for the class of stream, do not sample that day. Do not return to sample the stream for a period of at least 14 days.
    ii. If the stream seems to be close to normal summer flows and does not seem to be unduly influenced by storm events, proceed with sampling events, even if it has recently rained or is lightly raining. The Crew Leader should keep track of local weather conditions to assist in the planning of the day's activities.

If, after scouting, it is determined that the proposed stream reach is unsuitable for sampling in its current state, the Crew Leader should attempt to find an alternate reach to be sampled from the list of alternate reach GPS coordinates (for the initial implementation only). Alternate reaches should be considered in the order that they are listed, unless the location suggests similar constraints (same part of park with high flows, late lying snows, etc.). **The reason for alternate reach selection should be recorded in the "General Comments" section of the Stream Verification tab or form.**

If by adjusting the X-point upstream or downstream, limiting features can be avoided, the Crew Leader can slide the X-point. If shifted, the coordinates of the new X-point are recorded and documented. If a tributary is found, mark it as one of the end points and slide the other end the appropriate distance. Do not slide so that reach is in a different stream order than the location of the X-point. If a lake or other lentic water body is encountered, mark that as the end point and likewise, slide the reach.

Establish a streamside workspace near the X-point of the stream reach. Find a flat, shady area, as free of debris and excess vegetation as possible.

Establish an area within the stream from which water quality and water chemistry data can be collected. The water in this area should be:

a. Well mixed, but not turbulent (SOP #7: Water Quality Sonde Calibration and Field Measurement has more guidance).
b. Adequately deep for sampling (able to completely submerge a sample vial).
c. Undisturbed by crew members.
d. Free of obstructions such as woody debris, boulders, macrophytes, and dense algae.

Preparing Gear and Equipment

1. Set up a water chemistry processing area in the shade. Using a pack towel or small tarp, arrange an area that will be debris/dirt free to minimize/eliminate contamination during water chemistry processing.

2. Unpack remaining gear in the established workspace, minimizing "gear scatter" or the dreaded "garage sale." Keep things organized for specific tasks; keep smaller items together in work vests or small bags to prevent loss; and keep electronic gear out of the sun as much as possible, a safe distance from water, and so located to prevent them rolling or sliding into the stream. If shade is limited, place gear underneath field packs. Assess and anticipate the solar and shade paths to ensure that sensitive gear will stay in the shade through the sampling period, if possible. Unpack items only as needed and return items back to the workspace when no longer in use. Electrofishing gear should be assembled and calibrated according to manufacturer's directions (SOP #15: Aquatic Vertebrate Sampling).

Prepare and Pre-label Sample Vials

This is a procedure that can be done prior to arriving at the site (e.g., the member who is not driving can do this during transit or it can be completed the night before). If it has not been done prior, it should be done upon site arrival. Because the needs of the labels depend on the SOP (e.g., water samples versus invertebrates), the needs are detailed in later SOPs. Always keep adequate supplies of unlabeled jars/vials and blank labels available in case of labeling error or break/loss of a sample container. In the event of breakage, gather all glass shards into a safe container and pack back to the vehicle; do not leave on site. Labels should be made using an electronic label maker, with print impervious to Ethanol. Backup methods of labeling are specified in later SOPs.

Preliminary Data Recording

Two databases are used to collect data while in the field, one managed by the Crew Leader and one managed by a field crew member. In SOP #4: Data Entry, the Crew Leader and one of the crew members should get together and follow the "Crew Leader and Crew Member Database Tasks" section of this SOP. Once this section is complete, they can split up and gather data independently.

Setup Stream Transects

Eleven equidistantly-spaced transects (each transect being [0.1 X Reach Length] m apart) are measured and flagged using survey flags or flagging tape that are labeled with the individual transect letter designations (Transects A-K). The distance between transects is measured by transect tape following the contour of the stream, not the straightline distance measured from the shore (i.e., do not "cut corners") (Figure 1). The measurement of distance between transects may involve being inside the stream channel, which can disturb water quality and water chemistry measurements; this should be minimized. Therefore, begin at the X-point (which is Transect F) and lay out the stream reach moving downstream towards Transect A, which is the furthest downstream transect. Return to the X-point and be certain that all water quality and water chemistry measurements are complete before continuing to lay out the stream reach moving upstream towards Transect K, which is the furthest upstream transect. Do not conduct any sampling activities upstream of the X-point unless a crew member has already completed water quality analysis and collected water samples. Scouting is the exception to this rule and should be done only by the Crew Leader, taking care to not disturb the stream channel. It is acceptable to move onto other tasks (i.e., Pool/Riffle/Run Categorization or Reach Slope measurement) to allow for more time for other crew members to complete water quality and water chemistry measurements, so long as the reach length is fully laid out shortly after the completion of these measurements.

Collecting GIS Data

Using the Trimble unit, a GPS point should be collected at the location of the A, F, and K transects. This is completed using ArcPad along with some custom forms.

Understanding ArcPad

The ArcPad project that is used for this project has three main toolbars: the main toolbar (Figure 1), browse tool bar (Figure 3), and the drawing toolbar (Figure 4). The main toolbar is used to open or save a project, create a new shapefile, add shapefiles, set the properties of shapefiles, activate the GPS, set the properties of the project, and provide some general help. Figure 1 details the general features of this toolbar.

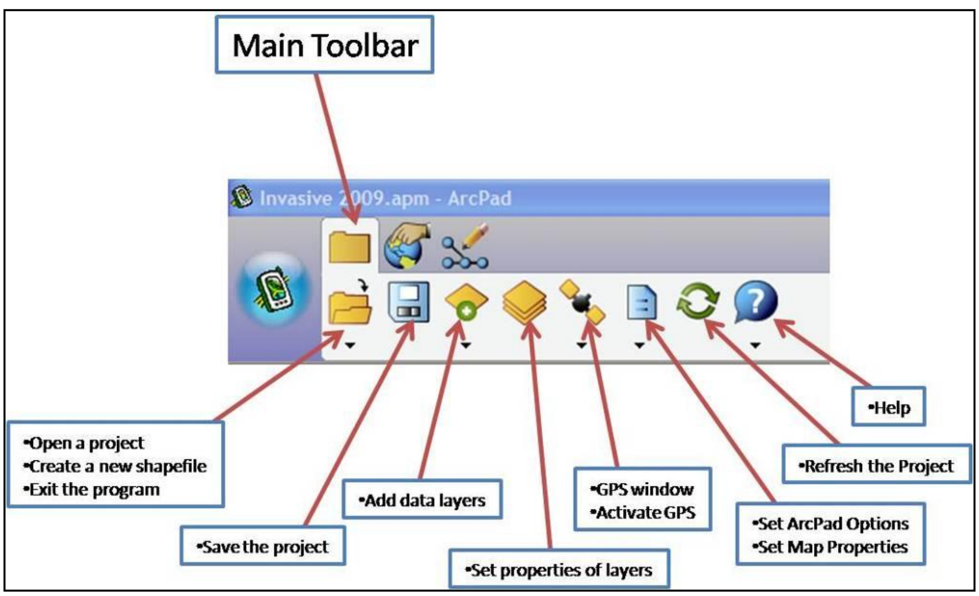


Figure 32. Description of functions available in ArcPad using the main toolbar.

The browse toolbar is used to navigate around the map. The tools available in this toolbar allow you to zoom in and out, pan, zoom to a previous view, identify an item, find an item, measure a distance, set a bookmark, and clear a selected feature. Figure 2 details the general features of this toolbar.

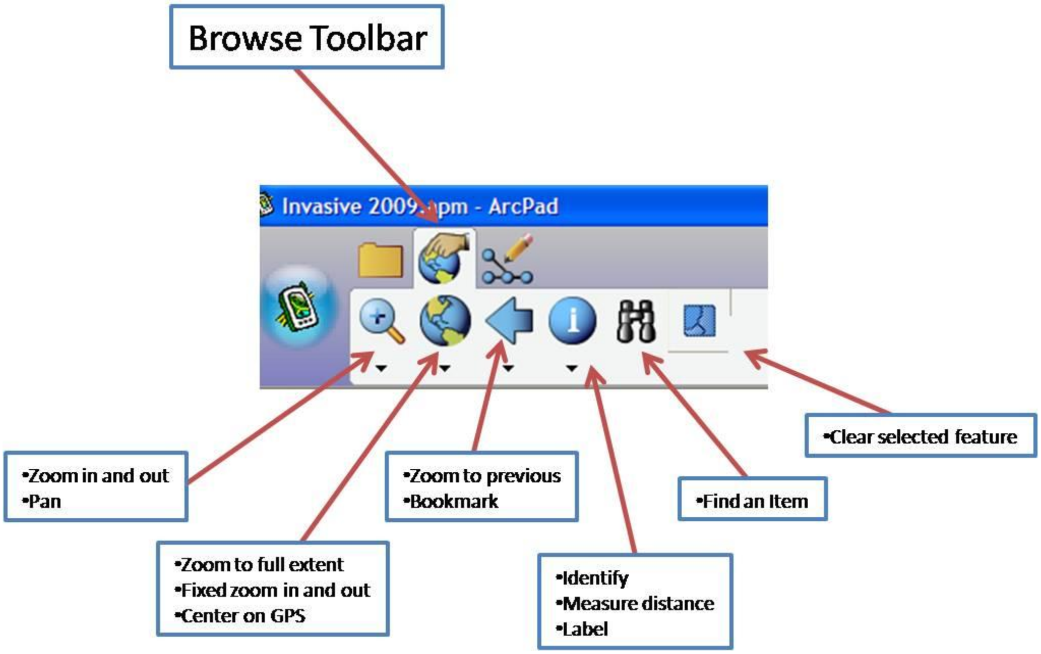


Figure 33. General features available on the browse toolbar in ArcPad.

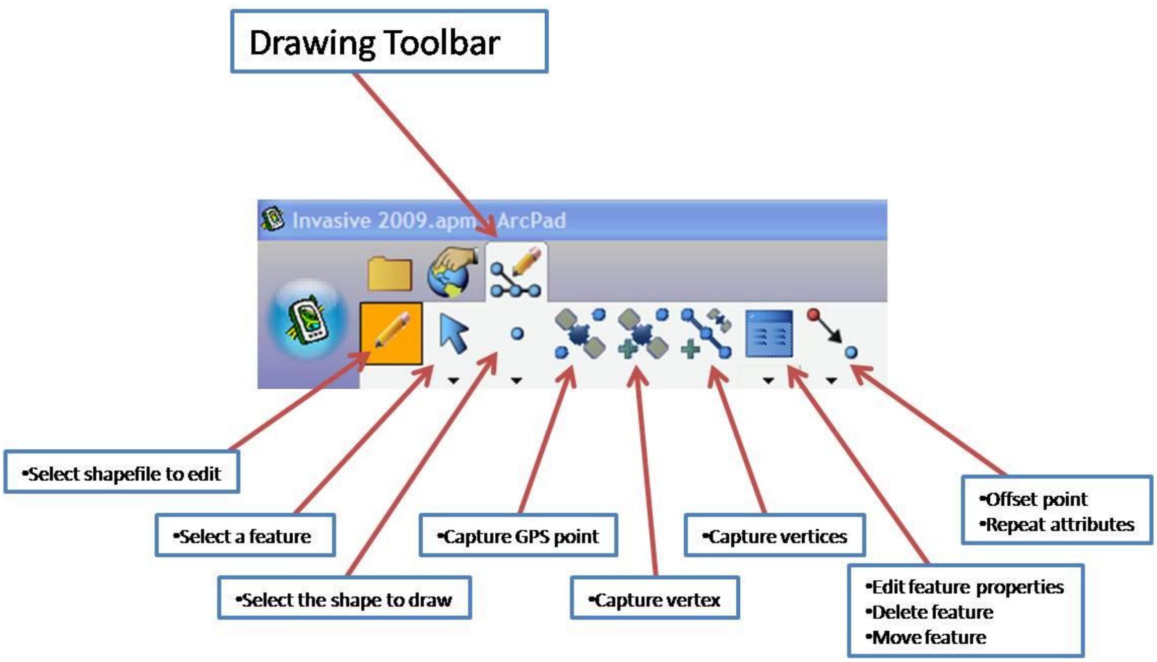


Figure 34. General features available on the drawing toolbar in ArcPad.

Data Collection

Now that you know the basics of ArcPad, you are ready to collect data. Once you have navigated to the start of the site you are surveying, you should follow the steps listed below to collect the project data.

Opening the Project File in ArcPad

A. When you arrive at the start of the site, turn on the Trimble unit by clicking the [**green**] button on the bottom of the unit. If the cover page shows general contact information, tap anywhere on the screen.

B. Tap the word [**GPS**] at the bottom, right side of the screen.

C. Be patient while ArcPad opens.

   1. The program is set up to directly take you to a list of projects, select [**Vegetation Monitoring.apm**] (Figure 5). Once selected, click the [GO] button at the bottom of the screen.
   2. If the list of projects does not open, go to step D. If you were able to select the project, go to step E.

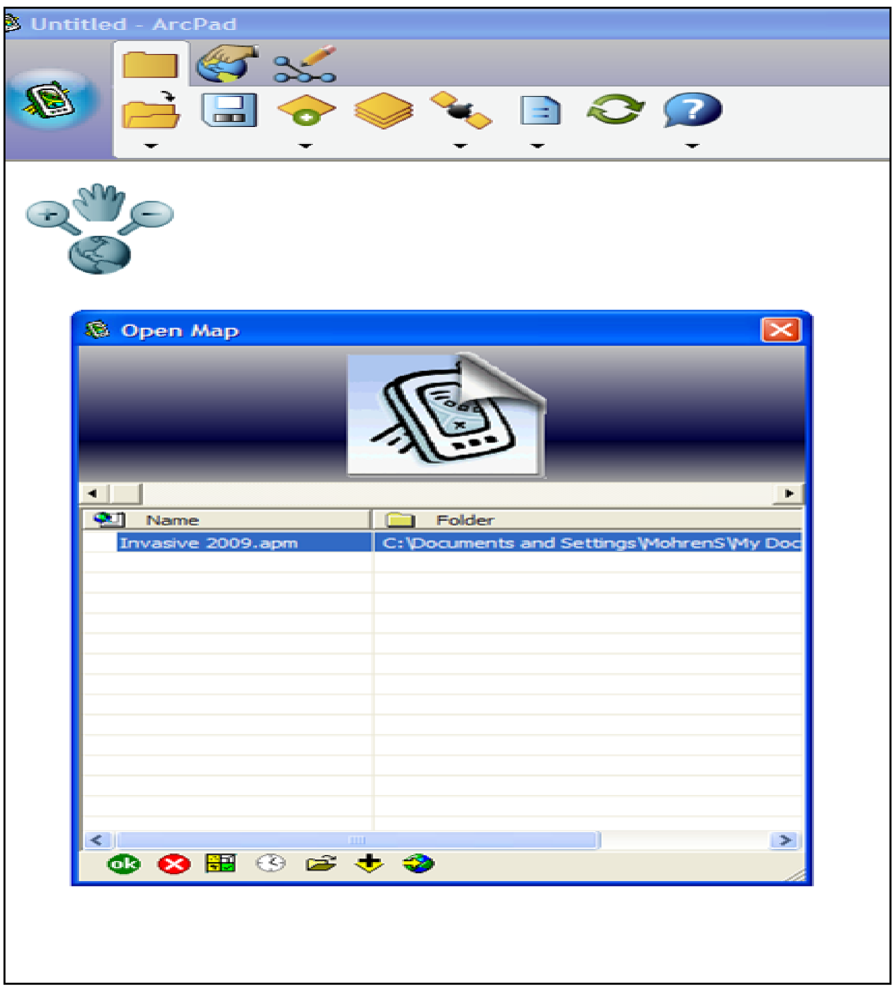


Figure 35. Selecting the project file on the Trimble unit to begin entering data.

D. If the list of projects did not open, then you will need to manually find and select the project by following the steps below.

   1. Tap the small arrow next to the [] button at the top of the screen.
   2. Tap [Open Map 

].

3. You should see the Vegetation Monitoring.apm file, Tap the file twice to open it.

E. When the project opens, it should have loaded the data shapefile. In addition, the GPS should already be turned on and the unit should begin acquiring satellites. If it does not, you will need to activate the GPS by following the steps below and looking at Figure 6.

1. under the satellite icon, select [**GPS ACTIVE**]

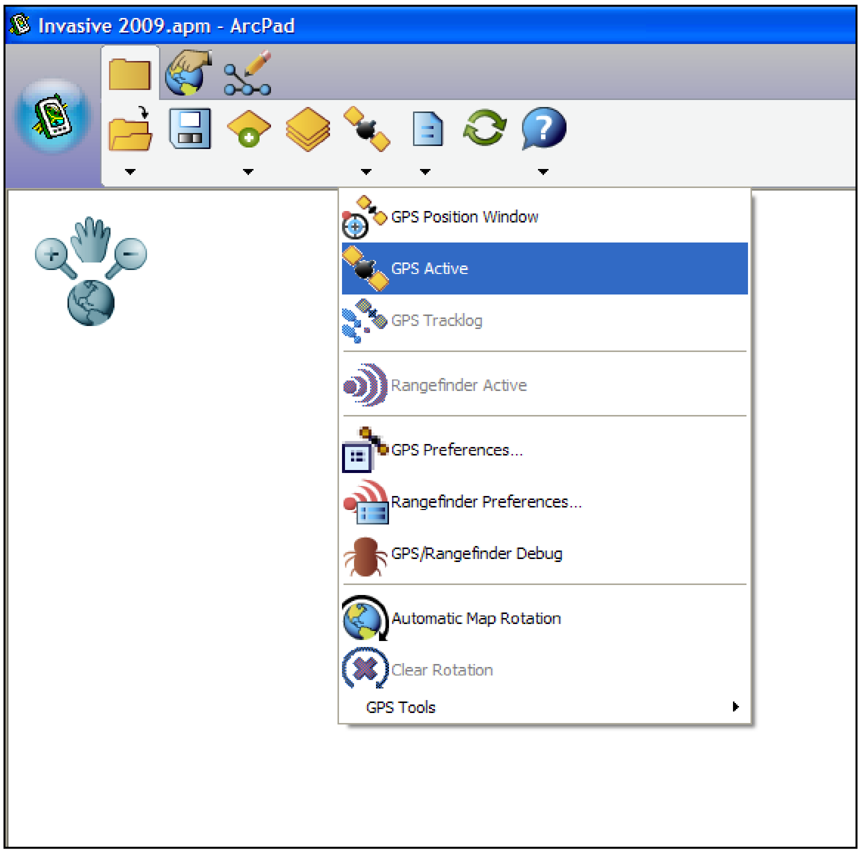


Figure 36. Activating the GPS unit so it will begin to acquire satellites.

Collecting GPS Points

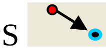
To collect the data, complete these steps:

1. Walk to the nearest transect (A, F, K) and make certain you have satellite coverage.
2. Tap the capture GPS point button and a form will open.
3. Using the pick list select the site name and the transect.
4. Repeat steps 1-3 for each transect where GPS data is captured.

Cannot Capture Satellites Using the Trimble Unit

In a few cases, you may not be able to get good enough satellite coverage to collect a point. There are two options at this point. The preferred option is to do an offset using the Trimble unit. The other option is to get the coordinates from the Garmin unit and then enter them into the Trimble unit. To do this, follow these steps.

Using an offset

1. If you cannot get a GPS signal, you need to use the Offset GPS  button.
    a. Stand in an open area where you can get a GPS signal and can see the center of the weed infestation.
    b. Click the [**Offset GPS** ] button.
    c. Click the [**Capture GPS Point** ] button.
    d. Look through the eyepiece of the rangefinder, make sure SD is selected at the bottom of the rangefinder screen, hold down the fire button, and remember the distance.
    e. Use your compass to get a bearing from the location you are standing to the location of the weed.
    f. Enter the bearing (from your compass) and the distance (in meters) from the rangefinder to the center of the infestation then click [**OK**] in the bottom right side of the screen.

Using the Garmin

1. If you still cannot get coverage.
    a. Click the [**Draw Point**] button.
    b. Using the stylus, add a point to the map as close as possible to your known location bases on the stream layer added.
2. When the form opens, enter the coordinates from the Garmin unit into the proper latitude and longitude fields on the coordinate form along with adding the site name and transect letter.

Macrohabitat Characterization

This procedure quantifies macrohabitat features by describing the length of these features within the sampling reach. Starting at Transect A (0 meters), walk along the stream reach and approximate the length of these features using inter-transect as a guide. For example, if from Transect A the first 8 meters are a pool, the next 20 meters a glide, and the next 15 meters a riffle, you should record this as 0-8 m in the pool column, 8-28 m in the run column, and 28-43 m in the riffle column. Continue describing these lengths of these features ending at Transect K ([total reach length] meters). In case of side channels within the sample reach, describe the dominant habitat that is located in the stream channel through which the majority of flow is coursing, ignoring habitats in the side channel with lesser flow.

There are four categories of macrohabitat features. These four categories are columns of the macrohabitat characterization portion of the “Site Verification” datasheet. These are defined as:

1. <u>Dry</u>: An area of dry stream bed with no surface water. Subsurface flows may be present.
2. <u>Riffle</u>: A shallow part of the stream where water flows swiftly over completely or partially submerged obstructions or substrates to produce turbulence and surface water agitation.
3. <u>Glide</u>: A relatively shallow part of the stream with moderate velocity and little or no surface turbulence.
4. <u>Pool</u>: A relatively deep part of the reach with low water velocity and little or no surface turbulence.

Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #7: Water Quality Multiprobe Calibration and Field Measurement

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP describes the usage of a multi-parameter probe (hereafter, multiprobe) for the measurement of the four "Core" parameters required by the Water Resources Division for lotic sites: Temperature, Specific Conductance, pH, and Dissolved Oxygen. Additional parameters that the KLMN has included (ORP [Oxidation/Reduction Potential] and turbidity) will also be measured using the multiprobe. Measurements are made at seven equidistant points at a well mixed stream cross section.

Over the course of the monitoring project, multiprobes will wear out, be lost, become damaged, or otherwise need replacing. Although a well maintained probe could easily last a decade or longer, the Program Lead should anticipate the need to either upgrade or replace worn out components on a biennial basis. When probes are upgraded, repaired, or replaced, steps provided in SOP #19: Quality Assurance Project Plan should be undertaken to ensure data comparability. It is also the responsibility of the Project Lead to ensure that the probes and display units are in proper functioning order a minimum of 3 months prior to the initiation of field work.

The current multiprobes employed by Klamath Network are the *Manta* multiprobe (manufactured by Eureka Environmental Engineering) and interfaced with the Trimble Yuma Tablet PC. Although this SOP should assist in many issues that may arise with multiprobe use, occasional assistance or technical support may be necessary. Their web site and support staff should be regularly contacted for upgrades to software and firmware. Their contact information is:

Eureka Environmental Engineering
2113 Wells Branch Parkway Suite 4400
Austin, TX 78728
Tel: (512) 302-4333
Fax: (512) 251-6842

www.eurekaenvironmental.com
Sales@eurekaenvironmental.com
support@eurekaenvironmental.com

The user's guide for the *Manta* is included in Appendix J. The Program Lead and crew should familiarize themselves with this documents prior to multiprobe use. After reading the document, the Project Lead and crew should begin trials with the multiprobe to ensure that all are comfortable using the equipment ***prior to field work***.

The following step-by-step guide is not a surrogate for reading the manuals. However, it will fill in the gaps of usage that may not be detailed in the manuals. It also details aspects that are specific to ensuring that data are measured, collected, stored, and managed in identical manner through the life of the project.

Multiprobe Data Collection Step by Step

A. Prior to use, the *Manta* components and Trimble YUMA should be checked for proper condition. This is the unit that is used for field data entry, and more operating instructions are given in SOP #4: Data Entry:
   1. The Trimble YUMA is a Windows Vista\Windows 7 Tablet PC. It is rugged and waterproof to allow field work.
      a. Check that battery is charged.
      b. Check that ports (USB, etc.) are clear of dirt and debris.
   2. The *Manta* probe should also be inspected (Figure 1).
      a. Check for cracks in acrylic body.
      b. Inspect the integral cable connection (Figure 1). These may crack and need replacing with time.
      c. Check that the serial port is clean and free of dirt.
      d. Check that the O-rings within the acrylic body are making contact (a thin, dark line is visible).

B. Turn the YUMA on, if not already following the instructions in SOP#4: Data Entry.

C. Double tap on the **MultiProbe Manager** to start the program: 

D. The program will start, and begin searching for the probe on a communications port:

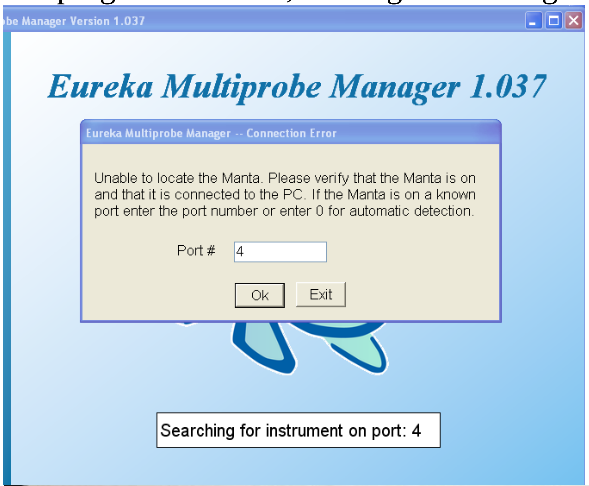
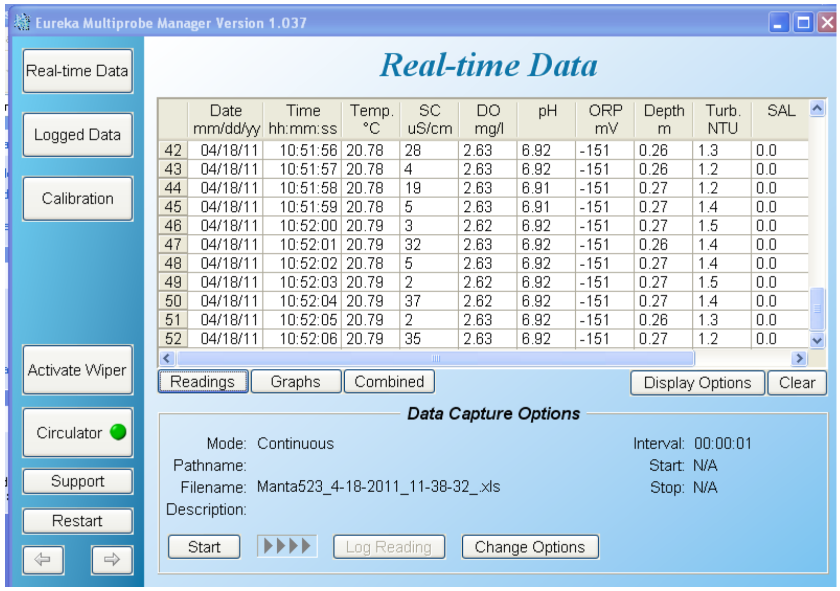


Figure 1. *Manta* overview. *Manta* parts: A) *Manta* body; B) Storage cup; C) 25 m cable; D) Waterproof, integral cable connection; E) Marine-grade serial port.

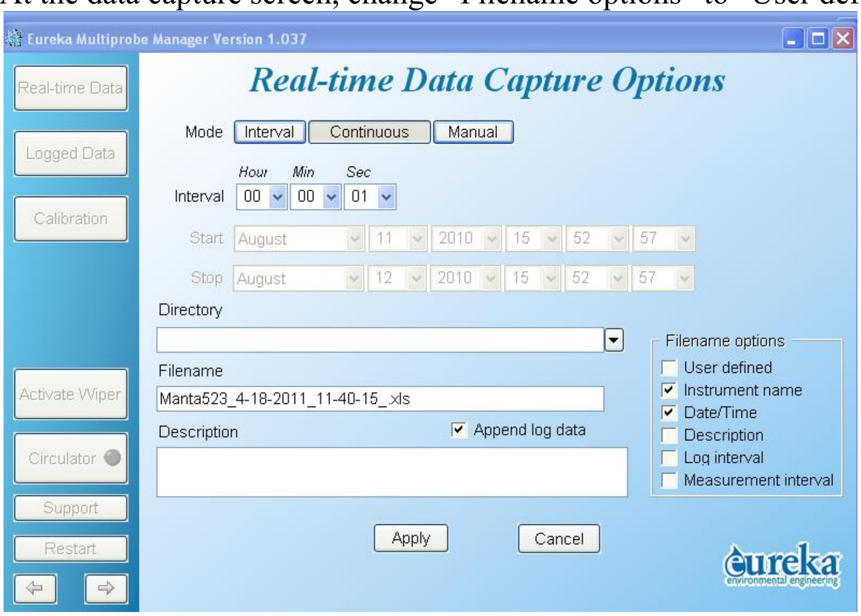
E. The program works best when instructed to search on the specific port (usually port #2).
F. BEFORE tapping "**Ok**," hook the *Manta* to the YUMA using the USB adapter cable provided with the units. Engage it to the lowermost USB port.
G. Confirm that an orange light appears within the *Manta* housing, and wait for it turn to a green, steady flash.
H. After the green light begins, double tap the "**Ok**" button on the YUMA, with the setting set on "**2**." This may have to be repeated, be patient. When working, a series of messages will appear in the text box. Again, be patient.

I. The end result will be:



J. Click the "**Change Options**" button.

K. At the data capture screen, change "Filename options" to "User defined"



L. Change Filename to Stream_Name_GRTS_mmddyyyy.xls, where the stream name is the full name spelled out (no abbreviations), GRTS is the unique code for the sample reach, and mmddyyyy is the date in month, day, yyyy; for example the 18th of April 2011 would be written as 04182011.

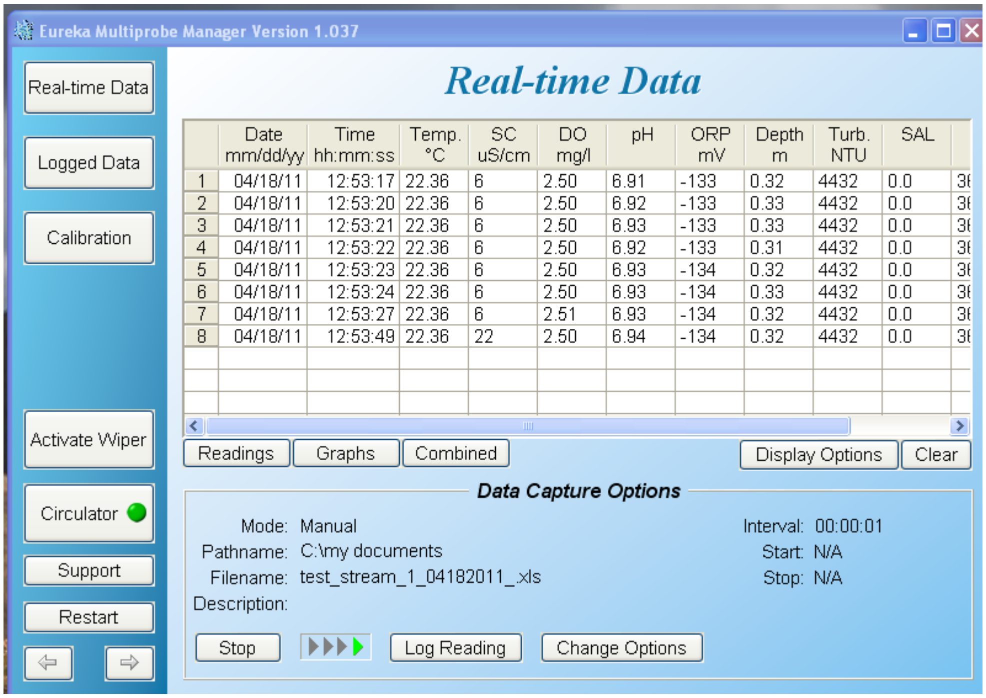
M. Click (or tap) the dropdown arrow next to "**Directory**" and change the file location to: D:\Stream Monitoring\Data\Manta\XXXX, where XXXX is the four letter park unit code.

N. Click (or tap) the "**Manual** button," which sets the unit up to record readings only when the user "manually" tells it to.

O. Click (or tap) "Apply" to return to the real-time data.

P. At this point, allow the probe readings to stabilize. When stable, click (or tap) "**Log Reading**."

Q. Repeat step P until all necessary measurements have been made (see below). The final screen should look like this:



R. Note that there are 8 readings; the last reading is the real-time reading; only 7 have been recorded into the file. Also note that the settings shown in the image above (e.g., pathname and filename) are from an arbitrary example.

S. Quit the Multiprobe Manager, by tapping the red X in the upper right corner.

T. Using Windows Explorer, navigate to the destination folder (D:\Stream Monitoring\Data\Manta\XXXX, and confirm that the file is there. Double tap the file to open and ensure that all seven readings are logged. THE PROGRAM CAN APPEAR TO WORK PROPERLY, BUT NO FILE IS CREATED, OR NOT ALL READINGS ARE PRESENT. THIS STEP CANNOT BE ASSUMED.

U. Disconnect Manta from YUMA by removing USB cord.

Stream Cross Section Step by Step

Along with the basic instructions on how to collect data, the following steps should be followed in collecting the stream cross section.

A. While on shore, calibrate dissolved oxygen (% saturation), and check the calibration of pH and conductance. If necessary, recalibrate, following the steps outlined in “Calibration Step by Step.”

B. Connect the YUMA to the *Manta* while on shore; replace the storage cup with the weight (Figure 2).

Figure 2. After removal of storage cup, weighted cup on left is attached by screwing into the *Manta* body. Note that the weight is heavy and exerts leverage. Use a firm grasp so that the weighted cup does not interfere or break any of the probes.

C. Select a cross section of the stream that fits the following criteria:
    a. Has moderate to fast velocities.
    b. Appears well mixed.
    c. Has minimal turbulence.
D. Visually break the stream into seven equidistant points and place the probe in the water at the nearest of these points. The best way to discern this is to use the width at the cross section, divided by eight. This is the distance from the near shore that the first reading should be taken. For example, if the width is 2.5 meters, the first point measurement should be at 0.31 meters from the shore.
E. Collect a single point measurement when the probe has stabilized, following the above instructions at mid-depth.
F. After recording data, move the probe over to the next point. Using the example above (2.5 m width), the probe would be moved another 0.31 meters from the shore (a total of 0.62 meters from the near shore).
G. Repeat until all seven measurements have been collected in a single file.
    a. When making the seven measurements, look for low variation in the conductivity readings. If they are highly variable, the cross section is not in a well mixed area and should be moved until a well mixed area is found. The middle of the stream of the well mixed area will serve as the collection point for the water chemistry sample (SOP #8: Water Chemistry Sample Collection and Processing).
    b. When entering the water, position your body downstream of the probe. Disturbance upstream will bias the readings.
H. Bring the probe back to the stream side and shut it down.
I. Remove the weighted cup and replace it with the storage cup. The storage cup should be approximately 1/3 full. It is not necessary to fill it completely.
J. Download the data file to the computer and archive it according to instructions in SOP #17: Post-site Tasks.

Calibration Step by Step

Regular calibration is an important component of maintaining quality control on data collected with instrumentation. The calibration, calibration check, and acceptable range schedule for each parameter should be followed as in Table 1.

Table 11. Calibration guidelines for *Manta* multiprobe. The probe should be calibrated at the beginning of the work week. When calibration checks are outside the acceptable range (compared to reference solutions), the probe should be recalibrated in the field. (NIST - *National Institute of Standards and Technology)*

Parameter	Calibration Interval	Calibration Check	Acceptable Range	Notes
Specific Conductivity	1/week	per sampling site	± 4 µS/cm or 10%	If calibration check is outside acceptable range, recalibrate on-site
Dissolved Oxygen (% Saturation)	per sampling site	per sampling site	± 10%	Calibration should be done the day before as a check for the membrane integrity, and then again at site
Dissolved Oxygen (mg/L)	NA	per week	± 0.5	Calibration check using portable Winkler titration kit.
pH	1/week	per sampling site	± 0.2	If calibration check is outside acceptable range, recalibrate on-site
Redox (ORP)	1/week	NA	± 40 mV	
Temperature	NA	1/month	± 0.5 °C or 10%	Temperature is factory calibrated, however checks against a NIST thermometer should be done 1/month.
Turbidity	1/week	NA	± 2 NTU or 10%	

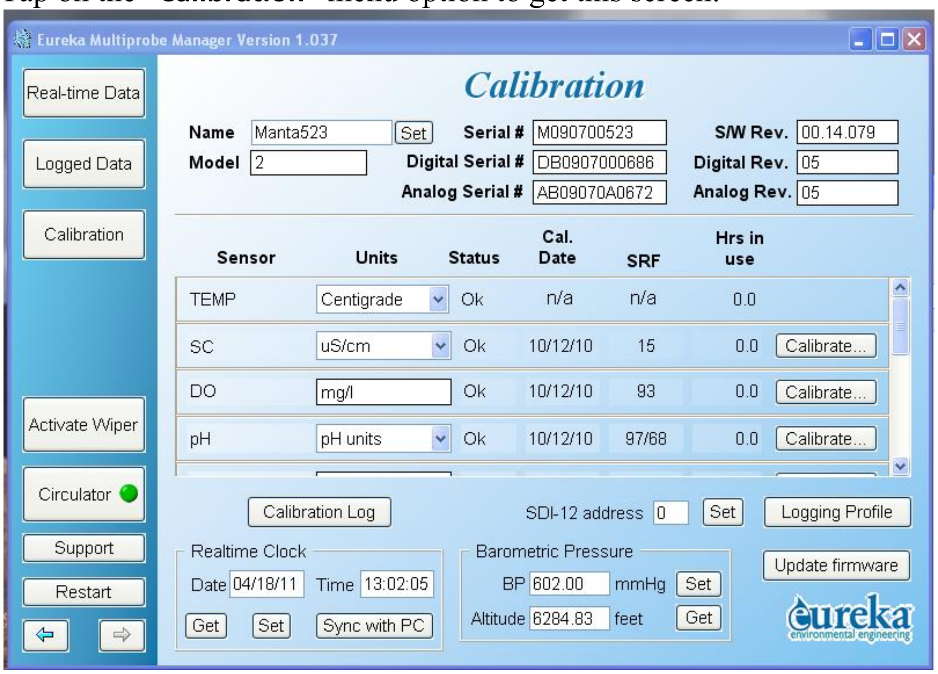
In general, the probe should be calibrated the day or evening before a work week commences. The probe should be calibrated in the five main parameters, regardless of whether or not it is in the "acceptable range." When in the field, prior to measurement, a quick check against a known solution or another reliable probe should be done. If the parameter measurement is outside the acceptable range, the technician should recalibrate prior to making measurements using a calibration solution. **Record results of calibrations and calibration checks on the appropriate logsheet (Appendix F).** Additionally, although the calibration may require a multipoint calibration, the calibration check can be against a single value, as close as possible to the anticipated measurement value.

Generic Calibration Step by Step

A. Attach *Manta* to YUMA as above for multiprobe data collection step by step, and start the multiprobe manager.
B. Once operating and the probe is reading, remove the storage cup and replace with the calibration cup (Figure 3).

Figure 3. Calibration cup with black covering used for calibration procedure.

C. At this point, the probe must be maintained "upside-down" or in an inverted state until calibration is complete.
D. Tap on the "**Calibration**" menu option to get this screen:



E. Select the parameter to calibrate by scrolling on the side of the screen.
F. Tap "Calibrate" to start the calibration procedure, and follow the on-screen instructions, in general giving all the probes a rinse with DI water, followed by a vigorous shake before filling with the calibration solution. Rinse with DI water between each calibration.
G. For the chosen parameter, select the calibration value (e.g., 7.00 if calibrating with a pH buffer of 7.00), and tap "Set value." IMPORTANT – only tap set value when the readings are stabilized. If doing multi-point calibrations, continue to the next calibration.
H. The calibrations should be utilized as follows:

Parameter	**# of calibration points**	**Calibration points**
Dissolved oxygen (%saturation)	1	@100.00% for 60 seconds (after equilibration for 3 – 5 min)
pH	3	@7.00, 4.00, 10.00 for 60 seconds
Redox (ORP)	1	@200.00mV for 1 second
Specific conductivity	1	@1000µS/cm for 60 seconds
Turbidity	2	@1.00 and 100.00 NTU for 60 seconds

I. Prior calibration, and in between solutions, rinse the probes with a wash bottle of deionized water, shake dry, and fill with the appropriate calibration solutions, so that the probe is covered.
    a. If doing dissolved oxygen, do not fill the cup. Rather, fill until just below the dissolved oxygen probe. Place the black rubber cap on top of calibration cup and let the probe equilibrate for 3 to 5 minutes. This creates a 100% saturated air pocket within the calibration cup.
    b. Dissolved oxygen calibrated to 100% Saturation also requires a current Barometric reading. Tap the "**Get**" button in the Barometric Pressure box. This will get the current barometric pressure. However, this has to be done with the probes exposed to the air, and check that there is no water in the hole in the middle of the sensor array prior to "getting" the current barometric pressure. It is also recommended that the calibration cup be wrapped in a wet white towel.
J. When doing dissolved oxygen, be sure to maintain the probe vertical, so that no water gets on the oxygen membrane.
K. Note that when doing multiple step calibrations, start at the lower concentration product (e.g., the lowest turbidity standard), and then do the higher concentration. This will minimize the possibility of contamination.
L. Record results and date and time of calibration on calibration tracking form (Appendix F).
M. Remove calibration cup and replace with storage cup or with weighted cap for data collection.

Dissolved Oxygen Membrane
When calibrating dissolved oxygen, the calibration may occasionally fail, or while using the probe, the operator may notice that an inordinate amount of time may be required for the probe to equilibrate. Both of these are signs that the membrane may be wrinkled, have an air bubble, be damaged, or has otherwise "gone bad." Such a membrane will need to be replaced, along with electrolyte solution. For this reason, the field crew should always carry spare membranes and electrolyte solution with them to the field site.

Excellent instruction on how to replace the membrane is provided in Appendix J, Eureka Environmental *Manta* manual. A digital copy of this manual will be available on the tablet PC computer the crews have in the field. Crew members should be trained in membrane replacement. Recalibration will have to be performed after replacement, ideally after a 24 hour period to allow the membrane to relax and stretch. Calibrations after the 24 hour period will be more stable and last longer. If the membrane replacement is done on-site, the calibration is still valid. However, the calibration will not "last," so that if measurements are retaken later in the day (3^+ hours, for example), the probe will need to be recalibrated. In other words, the calibration will not "hold" unless it is calibrated 24 hours later. However, accurate readings can still be taken immediately after membrane replacement.

Dissolved Oxygen Calibration Check
Once a week, the probe should be calibrated in the usual manner (% Saturation method). Thereafter, the probe should be placed in a 5-gal bucket with tap water, and allowed to equilibrate for 30 minutes, with the circulator on. After 30 minutes, utilize a Winkler Titration kit

(Hach Digital titrator or similar) to check and compare the Dissolved Oxygen reading (mg/L) of the probe to the results of the Winkler Titration. If probe reading is greater/lesser than 0.5 mg/L dissolved oxygen than the titration results, repeat. If still off, perform maintenance, calibrate using % saturation method, and retest against titration kit. If still not within plus or minus 0.5 mg/L, consult the Project Lead. Record results in the Calibration Log. Note that this should be done in the office/facilities and NOT in the field. Store waste in a labeled vial “DO Titration Waste” for disposal in Network facilities at the end of the field season according to the Material Safety Data Sheets.

Troubleshooting

The crew may occasionally experience problems with the *Manta* multiprobe. Typical issues may include:

- Failure to calibrate/maintain calibrations
- Failure to electronically communicate between *Manta* and YUMA

In the case of calibration issues, the crew should consult the *Manta* manual, perform genral maintainence, and if issues persist, contact the Project Lead. The Project Lead, if unable to help, will arrange for shipment of faulty probes back to Eureka Environmental and obtain replacement, loaner probes from Eureka Environmental.

Failure for the YUMA to detect the *Manta* using Multiprobe Manager is a potentially common occurrence. Troubleshooting should consist of:

1. Reconnect the probe by removing the cable, and then reinserting the cable, starting the program “search for probe” again.
2. Shut down the Multiprobe Manager, and restart the software.
3. If this does not work, and the software “states” that it is searching on a particular COM port, and appears “frozen,” the crew should:
    a. Make a note of which port the software is stuck on (e.g., 2,3,8, etc.).
    b. Use windows explorer or the control panel to open “Device Manager”
    c. Under Device Manager, tap on the + to expand the Ports sub-directory
    d. Scroll and search for the assigned port that the program is searching on. If no port is actively on that COM number, skip to step h.
    e. Tap to bring up the communications port properties for that COM number.
    f. Under the “Port Settings” tab, tap “Advanced”
    g. Here, you can change the COM number setting. Change it to an unused COM number.
    h. Now, go back to the Device Manager, and look for the “Prolific USB-to-Serial Bridge.” This is the device through which the probe is connected to the YUMA.
    i. Click or tap to bring up the properties for the Prolific USB-to-Serial Bridge.
    j. Under Port Settings, and Adavance, change the COM number to match the COM number that the Multiprobe Manager was “frozen” on.
    k. Restart the Multiprobe Manager, and the search should continue, but the probe should communicate now.
4. The crew should not attempt to alter any other settings under the Device Manager. If these steps do not repair the connection, seek the help of the Project Lead and/or Eureka Environmental technical support.

Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #8: Water Chemistry Sample Collection and Processing

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP describes the process for the labeling, collecting, prepping, filtering, handling, and storing of water samples (for filtered water and Dissolved Organic Carbon [DOC]) to the laboratory. It also includes steps for field analysis of alkalinity.

All of the tasks associated with this protocol are highly susceptible to contamination or bias from mishandling. As with the other protocols, it is very important that the crew completely follow these protocols to avoid the introduction of contamination and error into the analyses. Special attention should be given to the use of gloves, filter handling, and general cleanliness. Field conditions, especially wind and gusts, can make this difficult. If there are issues caused by contamination or accidents, the sampling should be repeated.

The tasks are listed in the order they should occur: 1) Labeling, 2) Sample collection, 3) Filtration preparation, and 4) Filtering (metals/ions and DOC).

Labeling

Labeling is an important task and is a common source of mishandling specimens. All labeling of water chemistry (filtered, unfiltered, and DOC), should be followed in the following formats for consistency and accuracy. Ideally, vial and bottles are pre-labeled the night before or during transit using an electronic label machine (e.g., Brother Model PT-1400 or similar). Labels produced by these label makers are resilient, are always legible, weather resistant and do not fade or smear when exposed to solvents (especially Ethanol). The only caution is that they must be placed on a dry and clean surface (hence should be done first, before sample processing). Labels should always be placed on the vial or bottle, and not on the lids.

The following information should be included: stream name, stream code, park code, date (yyyymmdd format), sample type, and county/state. Stream names, stream codes, and counties are provided in a summary sheet given to the field crews prior to the start of the field season.

Sample type is one of the following: Filtered water, unfiltered water, DOC, or Chlorophyll *a*. Examples of how labels should be laid out are presented in Figure 1.

Godwood Creek CODE 310
REDW 20100412
DOC
Humboldt Co, CA

Godwood Creek CODE 310
REDW 20100412
Unfiltered water
Humboldt Co, CA

Godwood Creek CODE 310
REDW 20100412
Filtered water
Humboldt Co, CA

Figure 37. Preferred layout for labeling sample vials. This format should be used for all samples: Dissolved Organic Carbon (DOC), unfiltered, and filtered water.

If necessary (e.g., the batteries die or the label-maker breaks), labeling can be accomplished using colored vinyl tape (preferably white) and a permanent marker (e.g., Sharpie). The same information should be recorded as above in a legible manner.

Water Sample Collection

Water sample collection for streams is a relatively simple affair:

1. Ensure that the sample point is at a well mixed cross-section (done in SOP #7: Water Quality Multiprobe Calibration and Field Measurements).
2. Ensure that no crew members have entered the stream above the collection point.
3. Precondition the 2 L amber high density polyethylene collection vial by immersing the vial under the water surface, allowing approximately 0.5 L to enter. Loosely screw the lid and shake vigorously. This should allow some water to splash out the threads of the bottle.
4. Dump the preconditioning water away from the processing area.
5. Re-immerse the bottle at the sample point, allowing the water to completely fill the bottle. Cap the lid, place in the shade, and prepare for processing.

Note that at this point, it is allowable for the other crew members to enter the stream for sampling or other SOP work.

Prepping for Filtration

Set up for processing should be done in the shade, on level ground, and in a place with minimal loose debris. Shelter from wind is also ideal. A field towel should be laid out to provide a work surface relatively free from contaminants. The equipment for filtration should be clean and set up nearby.

Water Filtration

Depending on the analyses, water must be filtered and frozen to retard biological and chemical processes that can affect the chemical constituents in the time period between collection and analysis. This time period should not be more than 28 days, but the realities of field work, shipping samples, and the sample backlog of a chemical analytical lab dictate that this period may extend beyond 28 days. Hence, it is very important that samples be adequately filtered and preserved to maintain sample integrity until analyzed. Holding times and methods for dealing with holding time exceedances are detailed in SOP #19: Quality Assurance Project Plan.

Because three different filter types are used (one for metals and nutrients, one for DOC, and one for Chlorophyll *a*; covered in SOP#11: Periphyton Collection), plastic storage bags containing the filters should be clearly labeled to avoid using an inappropriate filter for any specific sample processing.

Procedure for Cations/Anions (Filtered Water)

Water samples for cations/anions and nutrients are filtered through a 1.2 µm glass fiber filter (Whatman GF/C, Whatman product number 1822-047) into a 250 ml acid washed (SOP #1: Preparations, Equipment, and Safety) amber high density polyethylene (HDPE) bottle and frozen as soon as possible. Any changes in filtering mechanisms or filters should follow the procedures outlined in the QAPP (SOP #19: Quality Assurance Project Plan).

1. Using latex gloves and forceps, insert a clean, unused Whatman GF/C filter into the inline filter holder as shown in Figure 2. Assemble following the diagram and tighten the inflow fitting to the outflow fitting. Tighten until the body O-ring is compressed, and do not over-tighten. Make certain that the inflow fitting is a Luer fitting for attaching a Luer-lok syringe, and not a tube fitting.

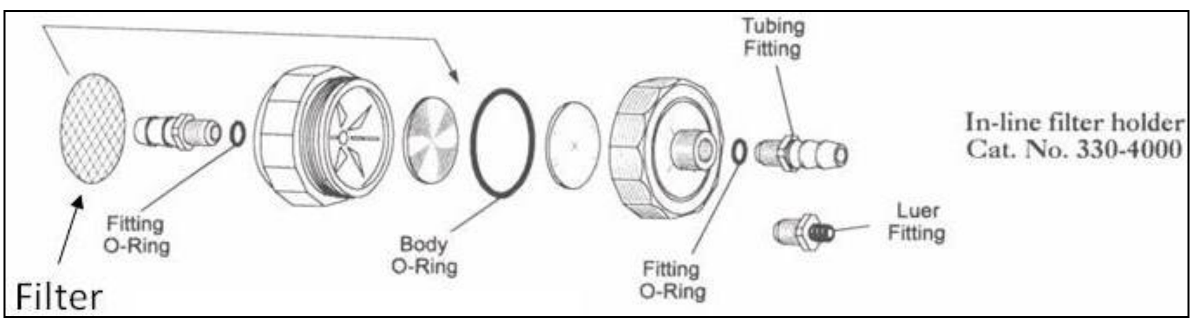


Figure 38. Diagram of inline filter holder (NALGENE®) showing assembly. In this configuration, the input is on the right (use the Luer fitting) and the outflow is on the left.

2. Using a 50 mL nylon syringe, draw 10 mL of sample water into the syringe. With the syringe inverted (i.e., plunger down, nozzle down), pull the plunger down until nearly removed from syringe body. Do not remove the plunger from the body of the syringe. Invert the syringe several times to pre-condition the syringe with sample water. Depress the plunger to expel the water onto the ground or into a waste container.

3. Draw up a full syringe of water from the sample being processed and attach the syringe to the filter holder using the Luer-Lok fitting. Precondition the filter and filter holder by depressing the plunger and expelling10 mL of water onto the ground or into a waste container.

4. Expel another 10 to 20 mL of the water into a properly labeled (see above) 250 mL sample collection bottle. Loosely attach the cap and gently shake the bottle. Dump the water onto the ground or into a waste container.
5. If any water remains in the current syringe, filter into the bottle. Refill the syringe with the sample water and continue to filter water until the bottle is filled. **Do not withdraw the syringe plunger while the syringe is still attached to the filter holder; the filter may shred inside.** Any headspace (air at the top of the bottle) in the bottle should be minimal (and ideally absent). Cap tightly.

6. Place the bottle in as cool and insulated a place as possible. This will generally be within the stream itself, using a cooler pouch with a reusable ice pack inside (within a mesh bag secured to the stream via a cord).

7. The filter holder should now be readied for filtering water for DOC analyses.

Procedure for Dissolved Organic Carbon

Dissolved organic carbon (DOC) analyses require that the sample be filtered through 0.7µm glass-fiber filters and contained in a 60 ml amber Boston Round glass vial. Glass vials and the filters should be prepared as in SOP #1: Preparations, Equipment, and Safety.

1. Sample water should be filtered following the above protocol for cations/anions and nutrients. Differences in the methods are simply the type of filter used (pre-washed 0.7 µm glass fiber filter; Whatman product number: 1825-047), the vial used (acid-washed and pre-combusted amber glass), and that the syringe does not need to be preconditioned (having been preconditioned in the above filtration).

2. Avoiding contamination is also crucial for DOC analyses. Skin oils, small soil particles, or litter particles could easily contaminate the sample. Likewise, any headspace in this vial can affect the analyses. The crew member should slowly top off the vial so that a convex meniscus is formed. Upon capping, this should eliminate any headspace.

3. The vial should then be stored in a cool and insulated place as described above.

Unfiltered Water Sample

Lastly, for total nutrients (including particulate matter), fill a 250 ml acid washed amber high density polyethylene (HDPE) bottle, making sure there is no headspace as described above. Store it in a cool place, as described above.

Procedure for Alkalinity Field Analysis

Alkalinity, or Acid Neutralizing Capacity, needs to be analyzed as soon as possible (recommendation is less than 24 hours). Alkalinity is measured in the field using a portable analytical kit. The general procedure is to add an acid to a sample and track the resulting change in pH. The amount of acid needed to achieve a certain pH is converted to the amount of alkalinity. Field analysis is identical in methodology to lab methodologies, except that a colorimetric endpoint (i.e., target color) is used to signal the target pH level.

The procedures below are for use with the Hach® Digital Titrator. If the alkalinity kit brand or style is changed or updated, data comparability procedures should be carried out following SOP #19: Quality Assurance Project Plan.

Special Consideration: This test uses a titration cartridge of concentrated sulfuric acid (H_2SO_4). As a potentially dangerous substance, the crew will review the necessary Material Safety Data Sheet (MSDS) with the Project Lead and be familiar with all safety procedures before handling the kit. The minimum safety gear to be worn during analyses is: safety glasses and latex gloves. It is the responsibility of the Project Lead to ensure that crews have access to this gear.

1. Prior to analysis, an Erlenmeyer flask and graduated cylinder should be preconditioned with sample water.
2. Wear safety gear: gloves and eyewear.
3. Follow Hach protocol method 8203 for specifics on how to perform analysis (Appendix I). Use the below guidelines.
    a. Titrate to a pH endpoint of 4.8 (light violet-gray). **When assessing color, do not wear sunglasses.**
    b. Initial analyses should be performed using 100 mL of sample water and a Titrant Cartridge of 0.16 N H_2SO_4 (see Table 1 of Method 8203 in Appendix I).
4. Record amount of sample, strength of acid, and total digits.
5. Dispose of the waste into a 1 L plastic waste vial, clearly labeled "alkalinity waste."
6. Repeat steps 1 – 5. If the calculated value of alkalinity falls outside the 10 – 40 mg/L of CaCO3 range, the sample volume and titrant strength should be adjusted accordingly. If the initial acid strength used was wrong, or if the calculated value is more than10% off from the first measurement, or if the crew member thinks they missed the endpoint, repeat a third time.

If mistakes are made at any step of the way, the specific process must be repeated. On account of this, the crew must always have spare, uncontaminated equipment (e.g., acid washed vials, filters). The 2 L collection vial should allow ample water so that any particular sampling process can be repeated, without the collection of a new sample (the original collection point will be contaminated by other crew working on other SOPs).

Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #9: Macroinvertebrate Collection

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP explains the procedures for the collection of benthic macroinvertebrates. The basic procedure used follows the EPA EMAP (Peck et al. 2006) protocol for the collection of Reach Wide Benthos (RWB). This protocol follows that of the periphyton collection in that it is not limited to the traditional targeted habitat, but rather the substrate and habitat at each of the 11 transects. Each sample from the individual transects is composited into a single sample for the entire reach.

Macroinvertebrates are collected in a D-frame net (30.5 cm wide [1 ft]; 500 µm mesh) by kicking the substrate so that disturbed invertebrates are swept into the net.

Labeling

Macroinvertebrate sample vials are double labeled. One external label is made using an electronic label maker, as for water chemistry and periphyton samples, but an additional internal paper label is also included. The backup paper label is necessary due to the ability of leaking ethanol to cause traditional labels to "bleed" the ink. The labels must include the following information: Stream Name, Stream code, Park code, date (yyyymmdd format), sample type, county/state, and **the number of vials in the sample**. Because the sample may not fit in one bottle, it is necessary to add "1 of 2" and "2 of 2." This prevents a laboratory technician at the contract lab from mistakenly processing only half of the sample. This information needs to be both on the internal and external label. The need to include the number of vials on the labels does not preclude the advance labeling of the bottles; the crew may affix the label and add a second label after sampling.

The paper label should be prepared on weather resistant paper (i.e., Rite-in-the-Rain) and filled out legibly in pencil (see premade example below).

Klamath Network, National Park Service Macroinvertebrates

Park Code:______________________

Stream Name:___________________

Site Code:________________________

Date:___________________________

County, State:____________________

_______ of _________

Collection Procedure

1. Starting downstream, begin collection 1 meter below Transect A.
2. Determine a random starting point for the cross-section using the seconds on the watch (0-19 sec: Left [25% of wetted width]; 20-39 sec: Center [50% of wetted width]; 40-60 sec: Right [75% of wetted width]).
3. If the flow at this spot is enough to fully extend the net, treat as a “riffle/run sample.” If not, treat as a “pool/glide” sample (see #4).
    a. In the section of river chosen using the random method, firmly plant the net down, with the opening facing upstream.
    b. Holding the net firmly in place with your knees, start scrubbing the substrate in front of the net, in a 1 ft^2 area directly in front of the net opening. Visually define a square quadrat, using the net frame dimensions as a guide. Another useful trick is to measure the size of the wading shoe sole, to know if your shoe is approximately a “foot” long to guide the sampling.
    c. Scrub the rocks within this quadrat using your hands or a scrub brush, until all invertebrates are dislodged from the rock. Place the rock aside and repeat until all rocks golf ball size or larger have been scrubbed.
    d. Keeping the net in position, use your feet to vigorously kick the remaining substrate, dislodging any movable rocks or any fine substrate. Kick for a 30 count.
    e. Pull the net out of the water, and wash the collected bugs, detritus, and sediments into the bottom of the net.
    f. Grabbing the bottom of the net, invert the net so that you can shake all collected material into a 5 gal bucket, partially filled with stream water.
        i. If the net has a “dolphin bucket (Figure 2),” the contents can be washed into the bottom, the dolphin unscrewed, and emptied into the bucket. Immerse dolphin in the 5 gal bucket, and tap against the side to empty contents.

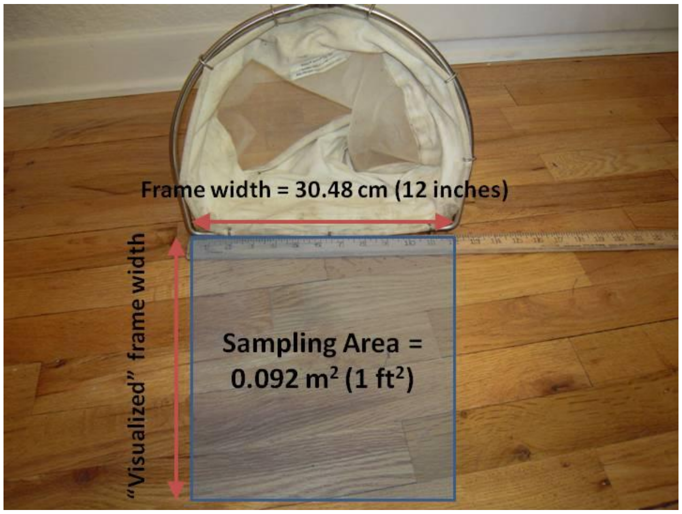


Figure 39. Example D-frame kicknet used for macroinvertebrate collection.

Figure 40. Dolphin bucket (top – attached; bottom – unscrewed for dumping) at end of invertebrate sampling net (if so equipped).

   g. **Fill out the data form**, indicating the habitat type (riffle or run) and the dominant substrate type (fine, gravel, or coarse).
   h. Proceed to the next transect. At the next transect, continue collection, 1 meter below each transect. Systematically begin taking at R,C,L position in the stream cross-section. For example, if the first transect was "C," collect the next sample at "L," and the third at "R," before starting at "C" again for the fourth.
4. If the sampling location is in a slow water habitat (pool or glide) that will not fully extend the net, use the alternate sampling technique.
   a. Delineate a square foot, as above, using the dimensions of the net as a guide.
   b. With the net in the water, pick up any larger substrates from within the quadrat and scrub the substrate, retaining the organisms within the net.
   c. After all the large substrate has been scrubbed from the quadrat, actively sample the quadrat with the net and your feet. Use a single foot to disturb the quadrat while scrapping the area behind the foot with the net. Keep the net moving to keep swimming organisms trapped within the net. Actively sample this way for a 30 count.
   d. Empty contents into the 5 gal bucket (the same one in which the detritus, bugs, etc. from previous transects were done).
   e. **Fill out the data form**, indicating the habitat type (riffle or run) and the dominant substrate type (fine, gravel, or coarse).
   f. Proceed to the next transect.
5. When all 11 transects have been sampled and data form filled out, process the sample to remove excess detritus and rocks.
   a. Ensure that the 5 gal bucket containing the sample is approximately half full or more of stream water.
   b. Try to remove large leaves, sticks, and leaves; vigorously shaking the leaves in the water to ensure no macroinvertebrates remain. Visibly inspect and gently remove any stubborn invertebrates with your finger. Generally, they will not bite.
   c. Elutriate the sample to separate the heavier substrates (rocks, gravel, and sand) from the lighter detritus and invertebrates. Using two hands, gently swirl the contents of the bucket so that lighter material is lifted up (like panning for gold). Pour off the contents into a second 5 gal bucket. Repeat a minimum of five times; you can use less water each time, which helps swirl faster.
   d. Sort through the remaining gravel, sand, and sediments for snails and rock-cased caddisflies (Trichoptera – see below) that may remain. Pick any out and add to elutriate (the decanted material containing the invertebrates and lighter detritus) that was poured off. **Do thorough scans, if necessary spread remaining minerals on backside of bucket to sort through a portion at a time to ensure no remaining organisms.**

e. Pour elutriate through a 500 µm sieve. You can do this in batches; not all the material needs to be poured through at once.
f. Once the material is on the screen, use a spoon to scoop the material and place in a 1 liter collection bottle. Continue pouring the sample through the sieve and transferring the material in the collection bottle until the entire sample has been processed.
g. Two or more bottles may be necessary, depending on the amount of detritus and sediments still in the sample. Do not fill any individual bottle more than two-thirds full with the sample (adequate space is necessary for preserving the sample).
h. Fill the collection bottle(s) with 95% Ethanol. Place paper label inside. Seal and invert several times to ensure that the Ethanol permeates the entire sample. Do not shake; this may damage the specimens, making identification difficult. Wrap bottle top with vinyl tape.
i. Make sure the sample is properly labeled, all bottles are accounted for, and the data form is properly filled out.
j. Rinse the net in the stream water, removing any lingering detritus.
k. Samples should be transported back to the housing, but no special storage is needed.

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Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #10: Discharge Measurements

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP explains the procedure for measuring the discharge of wadeable streams. Stream discharge, the volume of water passing a point over a standard unit of time (usually seconds), is equal to the product of the mean current velocity and vertical cross sectional area of flowing water. Discharge is critical for assessing chemical and biological trends in stream communities. This can be due to either dilution of solutes or its effects on sampling efficiency. For example, specific conductivity is typically lower at higher discharge levels, and the collection efficiency of macroinvertebrates decreases at above 400 cubic feet per second in smaller streams. Discharge is typically measured close to the X-Point, where chemistry is measured. However, if no suitable location for discharge is near the X-Point, it can be conducted anywhere along the sample reach. Discharge should always be determined after collecting water chemistry samples, and no sampling activity should be occurring immediately upstream (within 10 m) during the discharge measurements. We use the mid-section equation of the USGS for calculation of discharge.

Discharge Measurement

The preferred procedure for obtaining discharge data is based on "velocity-area" methods (e.g., Rantz et al. 1982, Linsley et al. 1982). Since velocity and depth typically vary greatly across a stream, accuracy in field measurements is achieved by measuring the mean velocity and flow cross-sectional area of many equal increments of width across a channel, typically between 10 and 20 increments. Each increment gives a subtotal of the stream discharge and the whole is calculated as the sum of these parts. Discharge measurements are made at only one carefully chosen channel cross-section within the sampling reach. It is important to choose a channel cross-section that is as much like a canal as possible. A glide area with a "U" shaped channel cross-section, laminar flow, and free of obstructions provides the best conditions for measuring discharge by the velocity-area method (Figure 1). You may remove rocks and other obstructions to improve the cross-section before measurements are made. It is also helpful to excavate the borders of the channel cross-section to ensure that there is adequate depth at the midsection of the first and last increments for an accurate velocity measure to be obtained. This "engineering" in no way alters the amount of discharge, however, because removing obstacles or altering the substrate of the channel cross-section affects adjacent water velocities, you must not change the cross-section once you commence collecting the set of velocity and depth measurements. Also note that if the suitable cross-section occurs at a transect, discharge and “engineering” should only occur after macroinvertebrate and periphyton sampling.

1. Locate a cross-section of the stream channel for discharge determination that has most of the following qualities (based on Rantz et al. 1982):
    a. Segment of stream above and below cross-section is relatively straight.
    b. Depths mostly greater than 0.5 ft, and velocities mostly greater than 0.15 meters/second. **Do not measure discharge in a pool**.
    c. "U" shaped, with a uniform streambed free of large boulders, woody debris, brush, and dense aquatic vegetation.
    d. Flow is relatively uniform and laminar, with no eddies, backwaters, or excessive turbulence.

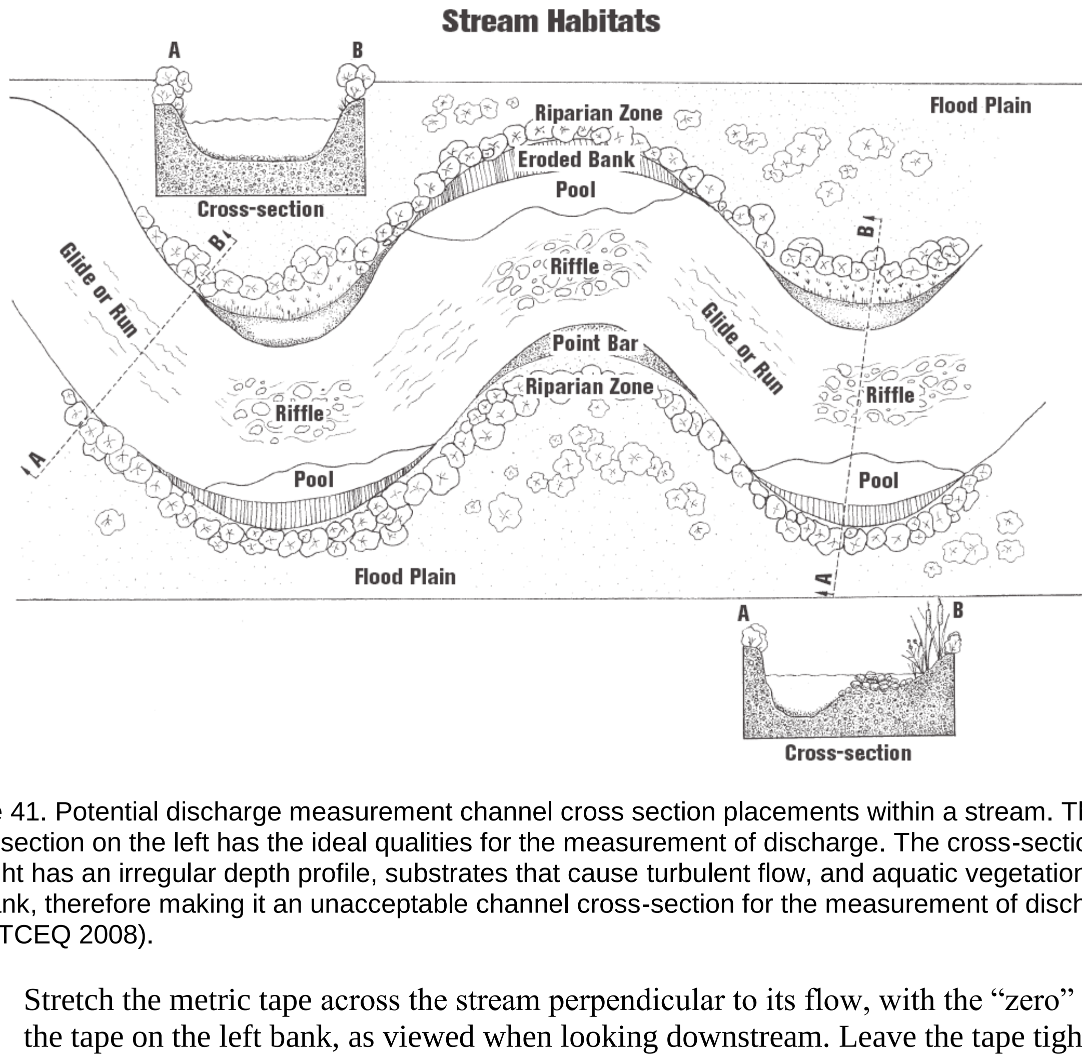

Figure 41. Potential discharge measurement channel cross section placements within a stream. The cross-section on the left has the ideal qualities for the measurement of discharge. The cross-section on the right has an irregular depth profile, substrates that cause turbulent flow, and aquatic vegetation near the bank, therefore making it an unacceptable channel cross-section for the measurement of discharge (from TCEQ 2008).

2. Stretch the metric tape across the stream perpendicular to its flow, with the “zero” end of the tape on the left bank, as viewed when looking downstream. Leave the tape tightly suspended across the stream, approximately one foot above water level. Use piles of rocks, surrounding vegetation, or tent stakes to suspend the tape above the stream. Do not

allow the metric tape to contact the stream water as this may affect velocity measurements.

3. Attach the velocity meter probe to the calibrated wading rod. Check to ensure the meter is functioning properly and the correct calibration value is displayed. Calibrate (or check the calibration) the velocity meter and probe as directed in the flowmeter's operating manual (Appendix Q); The FlowTracker ADV has an auto QC function for this purpose. An alternative, quick calibration check that can be performed in the field is to place the probe at 60% of the depth of completely motionless water in a 5 gallon bucket and to check for 0 velocity.

4. Divide the total wetted stream width into 10 or 20 equal-sized increments. Use 10 increments if the channel cross-section is less than or equal to 3 m wide and use 20 increments if the channel cross-section is greater than 3 m wide. Avoid measuring discharge at channel cross-sections greater than 10 m wide. The first increment is located at the left margin of the stream (0 cm, depth may also be 0 cm) (left when looking downstream), and the last increment is located at the right margin of the stream (right when looking downstream) (Figure 2).

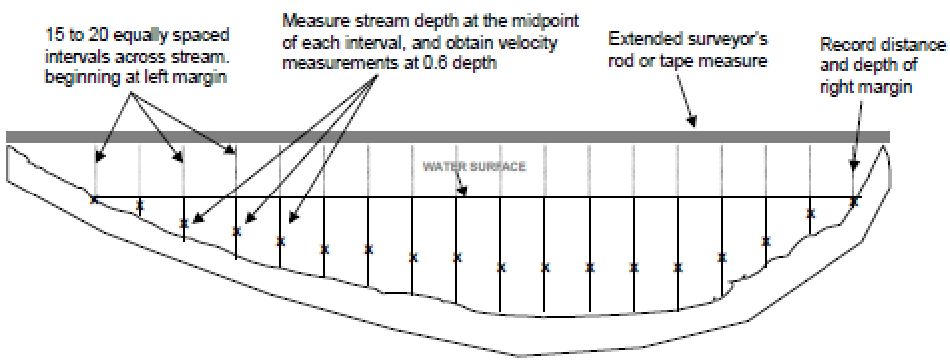

Figure 42. Diagram of placement of cross-sectional measurement for velocity.

5. Stand downstream of the tape and to the side of the first interval point (closest to the left bank if looking downstream). Keep feet shoulder width apart, hold the wading rod vertically with the hand of a fully extended arm, and keep submerged parts of your body motionless so as not to agitate the water possibly effecting the velocity measurement.

6. Place the wading rod in the stream at the midpoint of the first increment and check the attached bubble level to ensure that the wading rod is near vertical. Face the probe upstream at a right angle to the cross-section, even if local flow eddies hit at oblique angles to the cross-section.

7. If the depth of the increment is less than or equal to 2.0 ft, adjust the probe position of the probe on the wading rod so it is at 60% of the measured depth below the surface of the water. The wading rod is designed so that this can quickly be accomplished (Figure 3).

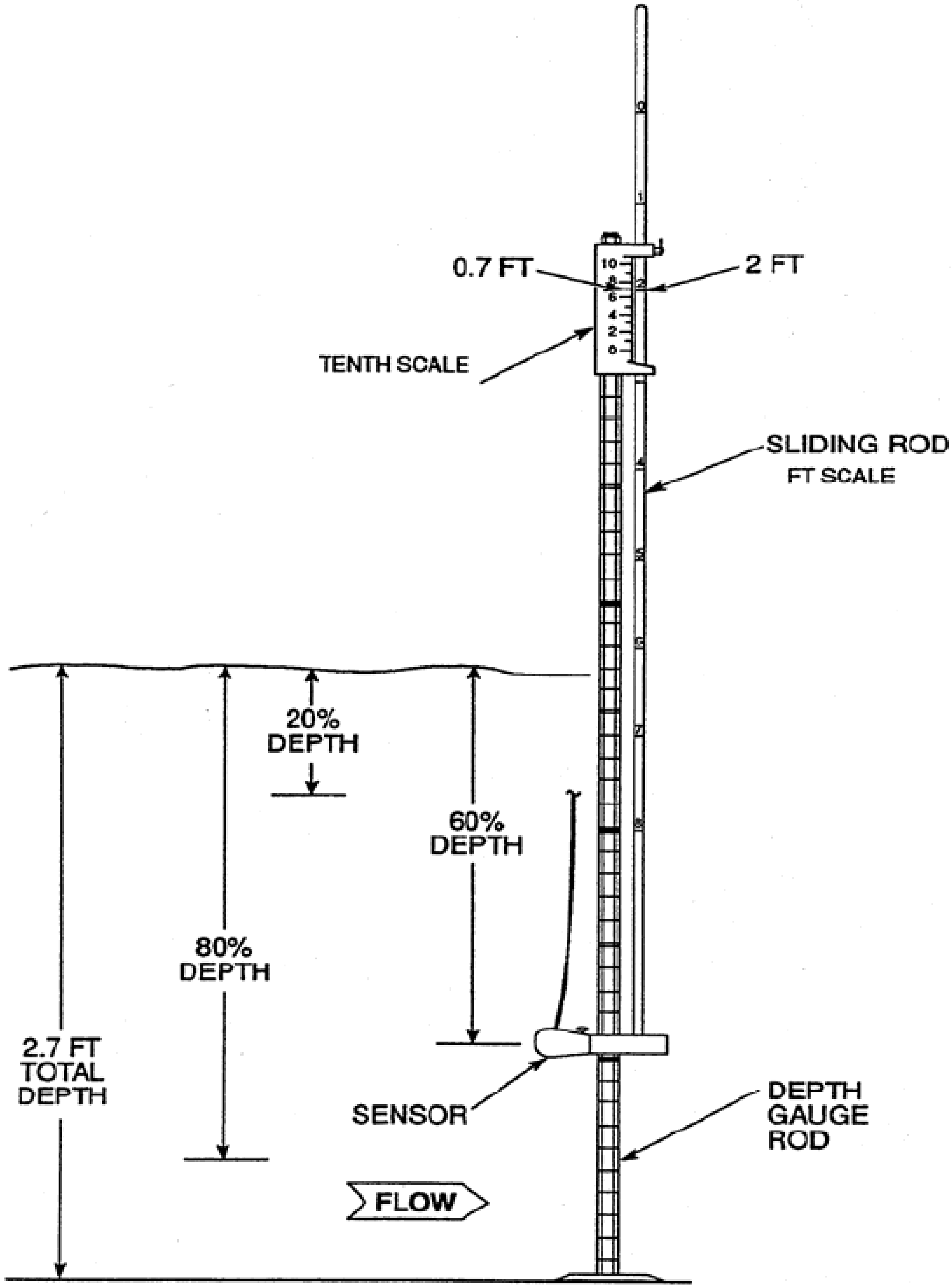

Figure 43. Diagram of the wading rod. In this example, the depth is 2.7 ft, and when the sliding rod is set at 2.7; the sensor is automatically at 60% of the water depth.

a. Each single line on the wading rod is 0.1 ft, each double line 0.5 ft, and each triple line 1.0 ft of depth. Using these marks, determine the total depth of the increment and **record on the data form, in tenths of ft**.
b. The wading rod has two side by side components that slide vertically beside each other so that the correct depth of the probe can be set. On the sliding portion are whole numbers representing feet of depth. On the stationary portion there is a tenths scale near the handle representing tenths of feet of depth (Figure 3). Slide the sliding portion upward until the whole number of the feet of measured depth aligns with the tenths-of-feet number of the measured depth (for example, if the measured depth of the increment is 1.2 ft, slide the rod upward until the "1" on the sliding portion aligns with the "0.2" on the tenths scale on the stationary portion). With the rod set in this manner, the probe is 60% of the measured depth.

8. Turn on the Sontek FlowTracker hand held unit by depressing the yellow power button and holding for 1 second.
    a. The FlowTracker is capable of auto calculating discharge in the field using a variety of equations. For ease of use, we use the FlowTracker in "General" mode to simply obtain an averaged velocity over 10 seconds. To select "General" mode and 40 seconds, enter "1" from the main menu. Follow the menu prompt to ensure the setting are: (1) Metric; (2) Avg Time (10); and (3) Mode General.
    b. Exit back to Main Menu by pressing "0."

9. To measure the velocity, press "3: Start Data Run." Create a Data File Name (this can be anything – we will not use the data file, it is merely a process required). Once a name is created, push "9: Accept name."

10. Push "9: Start" to begin data collection. If this is the first point, select "1: Run Test" when prompted under the Automatic QC Test.

11. After QC test is performed, push "Measure," the upper right button. Hold the probe steady during the 40 second countdown. **Record the Vx as the measured velocity at that point.**

12. Move to the next interval point, set the correct staff height, record the total depth, and depress "2: Repeat" to take the next velocity reading. Continue until depth and velocity measurements have been recorded for all intervals.

13. At the last interval (nearest to the right margin), record a "Z" flag on the field form to denote the last interval sampled.

14. Turn the FlowTracker off by depressing and holding the power button (about 10 seconds).

General Notes and Care about the FlowTracker

The Flowtracker is an expensive item and care should be given to prevent damage to it. While it is untenable to transport the FlowTracker to and from remote sites in the provided storage case, a bag to prevent sand and outside equipment from marring the equipment should be utilized. Also, the crew must carry spare AA batteries (8), a Philips head screwdriver to access the battery compartment, and spare thumb screws for securing the sensor to the wading staff.

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Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #11: Periphyton Collection

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP describes the method for the collection of periphyton. Periphyton is the biofilm composed of algae, fungi, bacteria, protozoa, and organic matter associated with aquatic substrates. Periphyton are useful indicators of environmental condition because they respond rapidly, are sensitive to a number of anthropogenic influences, and are an overall indication of stream autochthonous productivity. Periphyton is collected at every transect, from A to K (11 total). The samples are then composited into a single sample for processing.

Labeling

Using an electronic label maker, create two labels with the following information: Stream name, Stream code, Park code, Date (yyyymmdd format), Sample type, and County/state. Sample type should read: “Periphyton Biomass” and “Chlorophyll.” Sample labels are shown in Figure 1. Attach each label to a plastic scintillation vial.

Godwood Creek CODE 310 REDW 20100412 Periphyton Biomass Humboldt Co, CA	Godwood Creek CODE 310 REDW 20100412 Chlorophyll Humboldt Co, CA

Figure 44. Examples of labels for periphyton samples.

Sample Collection

1. Start at Transect A. Determine the location of the first sample by glancing at the two digits of the minutes reading on a digital or analog watch (00-19 seconds = Left Center; 20-39 seconds. = Center; 40-59 seconds. = Right Center. The “Substrate Cross Sectional Info” section of SOP #12: Physical Habitat Characterization has a description of the exact

location that corresponds with descriptions given here.). Subsequent samples at cross-section transects should follow the order of Left Center, Right Center, Center. For example, if the first sample taken at Transect A is taken at 9:10:15 AM, it should be taken at the Left Center location; Transect B taken at Right Center location; Transect C taken at Center location; Transect D taken at Left Center Location; and so forth.

2. Two types of samples are taken depending on the substrate composition:
    a. Erosion zones (i.e., riffles, runs) where cobbles/gravel are the dominant substrates.
        i. Collect a sample of substrate from the section of the transect denoted in step 1 (ideally a tennis ball-sized cobble that can easily be removed from the stream). Note that if no cobble is available, wood can also be used.
        ii. Place the substrate in a plastic funnel that drains into a 500 mL plastic bottle.
        iii. Use the area delimiter to define a 12 cm^2 area on the **upper surface** of the cobble or rock.
        iv. Start by scraping with a scalpel blade to dislodge large periphyton, and follow-up by scrubbing the area with a stiff toothbrush until the periphyton has been removed.
        v. Use a wash bottle with stream water to wash the scraped periphyton into the collection bottle. **Use minimal water.**
        vi. **Note: If the toothbrush has become worn out to the point of working ineffectively, replace with a new one. If in doubt, replace.**
        vii. Leave substrate on shore and proceed to the next transect.
    b. Depositional zones (i.e., pools) where sand, silt, or other fines are dominant.
        i. Using the 12 cm^2 area PVC delimiter to define the fine substrate, use a 60 mL syringe to vacuum up approximately the top 1 cm of sediments. The tip should be cut off the syringe to facilitate this.
        ii. Add this collected sediment to the 500 mL collection bottle.
        iii. Proceed to the next transect.
3. When all 11 transects have been sampled, return to the X-Point (or other processing area) for sample processing.

Sample Processing

1. Transfer the accumulated sample to a graduated cylinder and **record the total volume of the composite sample**.
2. Pour back into the bottle or a shallow tray and mix thoroughly. Work quickly, as direct sunlight can degrade chlorophyll *a* and algal biomass.
3. Using the filter apparatus from SOP #8: Water Chemistry Sample Collection and Processing, assemble the apparatus using a Whatman Glass-Fiber Filter (GF/F).
4. Using a 60 mL syringe, take a 25 mL aliquot from the mixed composite sample.
    a. Note: if fine sediment exists, allow the sediment to settle and do not uptake any as part of the aliquot.
5. Filter the 25 mL through the filter using firm, steady pressure. If too much pressure is used, the filter and algal cells can rupture, biasing the sample.
6. Remove the filter, fold on itself, cover in foil, and place in the “Periphyton biomass” scintillation vial.

7. Repeat steps 2 through 6 for the Chlorophyll *a* sample, substituting a mixed cellulose ester membrane filter (0.45 μm, 47 mm diameter, plain white surface, HAWP 047-00 manufacturer number) for the Glass Fiber filter, and place in the "Chlorophyll" scintillation vial.
8. Place both samples in a dark, cool place (with the water samples) and place in a freezer as soon as possible.

Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #12: Stream Habitat Characterization

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

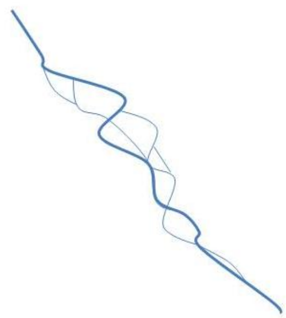
This SOP details the activities associated with describing the physical habitat of the stream channel, riparian zone, and surrounding valley based on EPA EMAP protocols (Peck et al. 2006). In a broad sense, the physical habitat of a sample reach includes all those physical attributes that influence or provide sustenance to organisms within and next to the stream. All of these attributes may be directly or indirectly altered by anthropogenic activities. Nevertheless, their expected values tend to vary systematically with naturally occurring variation in stream size, drainage area, and overall gradient. Aquatic macrophytes, riparian vegetation, and large woody debris are included in this physical habitat assessment because of their role in modifying habitat structure and light inputs.

The first three procedures discussed in this SOP are to be completed for the entire sample reach. The remaining procedures are to be completed at each of the 11 cross-section transects. The order of procedures presented here is not necessarily the order that they should be performed. Field crews should determine the most efficient way to describe the physical habitat of a sample reach based upon the unique characteristics of each sample reach. In addition, procedures performed at each of the 11 cross-section transects described in this SOP require consistency and efficiency that are acquired through repetition. Crew members should be designated to complete and be specialized in these components of this SOP and adhere to these designations throughout the field season. Cross-training in all procedures is still required, so that all members are comfortable performing all tasks in case of illness of certain members.

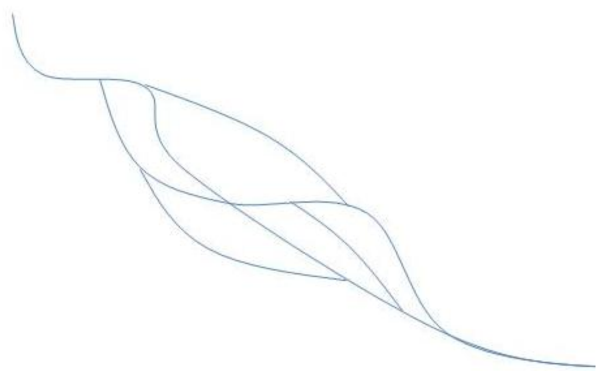
Channel Constraint Characterization

This procedure should only be completed after the crew member has observed the sample reach and surrounding valley in its entirety. On the Field Chemistry and Channel Constraint form, describe the various types of constraining features and the percentage of the sample reach that has constraining features on either bank. A constraining feature is any geological formation bordering the stream channel that would prevent water from leaving the channel, entering the surrounding flood plain, and possibly creating a new stream channel during a moderate sized flood event that would typically occur every 5-10 years.

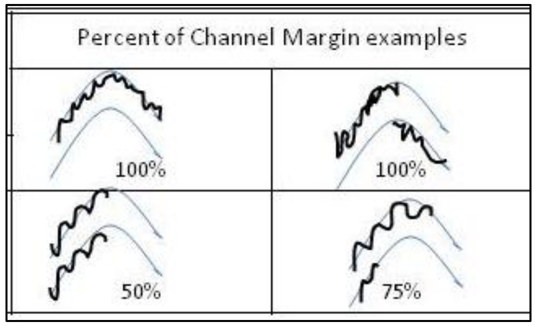
1. Under each of the categories ("Channel Pattern," "Channel Constraint," and "Constraining Features") listed on the datasheet, mark one category that best describes the surrounding geological features with an "X" in the box next to the category or using the picklist in the database. If more than one category of geological features is present within the sample reach, mark only the one that best describes the predominant feature.
    a. Channel Pattern:
        i. One channel, e.g., a single, dominant channel.
        ii. Anastomosing (complex) channel, a relatively long major channel, with minor channels branching and rejoining, as shown below:



        iii. Braided channel, where multiple short channels branch and rejoin, as shown below:



2. Record the percent of reach length with the side of the channel in contact with constraining features. If the feature is located on either bank (or both) along the sample reach, it counts toward the total percentage of the entire sample reach length. Use the below figure as a guide to assist with this determination. Note that it is not additive; the lower left panel only has half the margin constrained, even though both sides are constrained, it is still only 50% constrained.



3. Record the visually estimated average valley width of the valley surrounding the stream channel. If you are unable to see the valley borders due to surrounding vegetation or the expanse of the valley, mark the appropriate box with an “X” and record the reason you were unable to make an accurate estimation in the “Comments” section of the datasheet or electronic form.

Torrent Evidence Characterization

This procedure should only be completed after the crew member has observed the sample reach and surrounding valley in its entirety. On the Torrent Evidence Assessment form, mark each of the 10 descriptive categories listed that describe the evidence of torrents that have occurred prior to the sampling date with an “X” in the box next to the category. In making the determinations, you may also look upstream or downstream of the reach. If more than one category of torrent evidence is present, mark all categories that apply. Take pictures of any evidence of torrents and describe these pictures in the “comments” section of the datasheet. If there is no evidence of torrential events, place an “X” next to the “No evidence of torrent” category. Note that if this category is marked, it should be the only category marked on the datasheet.

Large Woody Debris Tally

This procedure is intended to produce a quantitative estimate of the number, size, total volume, and distribution of large woody debris (LWD) within a sample reach. These estimates allow inference of the effect LWD has on the flow dynamics and habitat complexity of a stream. A piece of wood is considered LWD if:

1. Its location within the stream channel is at least partially in zones 1, 2, or 3 (Figure 1).

   AND
2. The diameter of small end of the main stem of the woody piece is at least 0.1 m.

   AND
3. The length of main stem of the woody piece is at least 1.5 m.

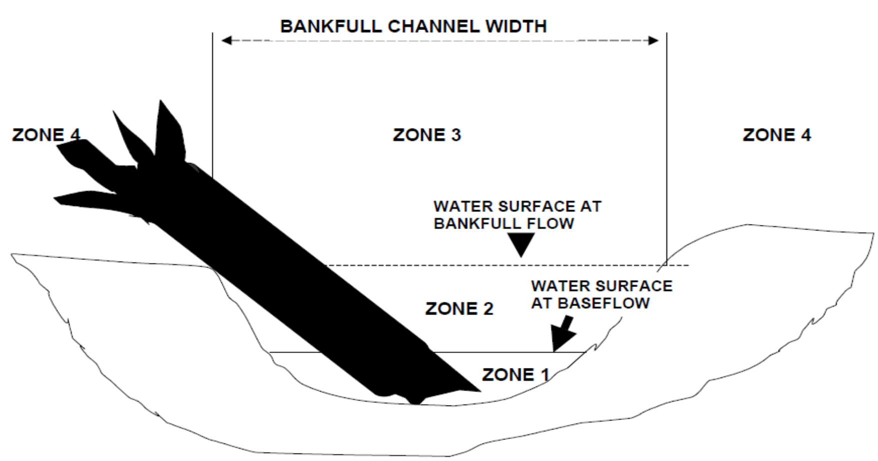


Figure 45. Large woody debris influence zones. (modified from Robison and Beschta 1990).

In order to reduce the time necessary for completion of this procedure, visual estimation of LWD dimensions is adequate. **However, at the beginning of the field season, use metric tape and Biltmore Sticks to measure various pieces of woody debris in order to calibrate the future visual estimates of crew members.** Many pieces of LWD are cylindrical and relatively linear in form, such as a fallen tree trunk, which makes visual estimation of their dimensions relatively easy. However, sometimes LWD is not cylindrical, so it has no clear "diameter." In these cases, estimate what the diameter would be for a cylindrical piece of wood with the same volume as the non-cylindrical piece in question.

1. Start at either end of the sample reach. Scan the stream segment between the first two cross-section transects for pieces of LWD.
2. For each cross-section transect pair in which there is LWD, record the number of pieces of LWD in the appropriate column on the datasheet. The larger boxes in the column are for counting pieces of LWD using tally marks; the smaller boxes are for the final numerical count of LWD pieces for that transect pair. If using the tablet PC, each tap in the category should autocount the pieces. The row in which the count is placed is based upon the location, diameter, and length classification of the LWD being observed. These classifications are:
    a. Location of LWD relative to bankfull height (as defined in "Bank Measurements" section of this SOP).
        i. <u>All or Part of Bankfull</u>- The piece of LWD is entirely or partly within the area that would be occupied by a bankfull discharge event (all or partly within influence zones 1 and/or 2 of Figure 1).
        ii. <u>Above Bankfull</u>- No part of the LWD is within the area that would be occupied by a bankfull discharge event (entirely within influence zones 3 and/or 4 of Figure 1). Also, it is not so far above the bankfull discharge level that it is implausible that a moderate flood discharge would be affected by the piece of LWD.
    b. Length of the main stem of the LWD.
        i. 1.5 m - 5 m.
        ii. 5 m - 15 m.
        iii. Greater than 15 m.
    c. Diameter of the <u>large end</u> of the main stem of the LWD.
        i. 0.1 m - 0.3 m.
        ii. 0.3 m - 0.6 m.
        iii. 0.6 m - 0.8 m.
        iv. Greater than 0.8 m.
3. Repeat steps 1 and 2 for the remaining cross-section transect pairs, recording the data in the appropriate columns of the datasheet for each transect pair.

Thalweg Profile

The thalweg is the flow path of deepest water in the stream channel. It is important in documenting stream habitat variability, determining residual pool depth, and in relative bed stability calculations. It is measured both at transect cross-sections and at even spaced intervals ("Stations") in between transects (Figure 2).

One person will walk upstream starting at Transect A with a meter stick and transect tape. The second person will walk alongside the channel to record data and assist in measuring stream widths.

1. Determine the interval for each thalweg measurement:
    a. Channel Width < 2.5 m = 1.0 meter increment, for 150 total measurements
    b. Channel Width 2.5 – 3.5 m = 1.5 meter increment for 100 total measurements
    c. Channel Width > 3.5 m = 0.01 X Reach Length for 100 total measurements
2. Start at Station 0 of Transect A.
3. Measure Wetted Width at Station 0 and at Station 5 (if doing 100 measurements total) or Station 7 (if doing 150 measurements). Include the distance across bars from wetted bank to wetted bank, but also record bar width, if present.
4. At Station 5 or 7, classify the bed substrate following the instructions under substrate cross-sectional information below (at 0%, 25%, 50%, 75%, and 100% as below). Classify the microalgae cover at the five points as well.
5. At all intertransect Stations, use the meter stick to find and measure the deepest section of the stream.
6. At each Station, determine by “feel” if there is Soft/Small sediments present (fine gravel, sand, silt, clay or “muck”).
7. At each Station, determine the channel unit code and pool forming element according to Table 1 below.

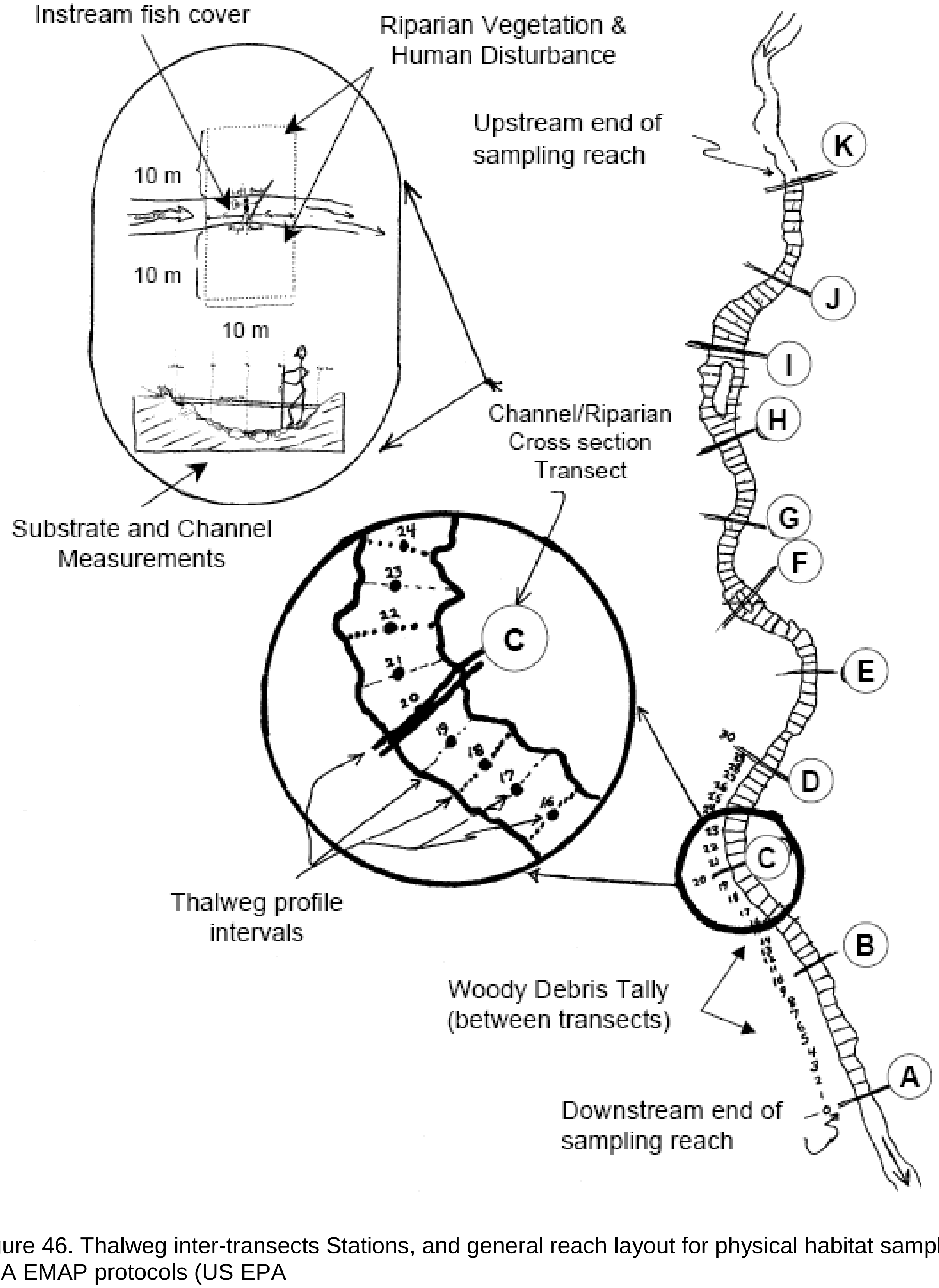


Figure 46. Thalweg inter-transects Stations, and general reach layout for physical habitat sampling. From EPA EMAP protocols (US EPA

8. Record the presence of side channels and back waters.
9. Continue working upstream until all inter-transect Stations have been done.

Table 12. Channel units and codes for inter-transect station characterization. From Peck et al. (2006).

Class	**code**	**Description**
Pools		
Plunge Pool	**PP**	Pool at base of plunging cascade/falls
Trench Pool	**PT**	Pool like trench in stream center
Lateral Scour Pool	**PL**	Pool scoured along a bank
Backwater Pool	**PB**	Pool separated from main flow off the side of channel
Impoundment Pool	**PD**	Pool formed by impoundment above dam or constriction
Glide	**GL**	Water moving slowly, with smooth, unbroken surface, low turbulence
Riffle	**RI**	Water moving quickly, with ripples, waves and eddies. No breaking waves. Sounds: babbling, gurgling
Rapid	**RA**	Water movement rapid and turbulent, intermittent white water. Sounds: continuous rushing
Cascade	**CA**	Water rapid and very turbulent over steep channel. Water broken into short, irregular plunges. Sound: Roaring
Falls	**FA**	Free falling water over vertical or near vertical drop
Dry Channel	**DR**	No water in channel

Table 13. Codes for potential pool causes.

Code	**Category/Description**
N	Not Applicable (no pool)
W	Large Woody Debris
R	Rootwad
B	Boulder or Bedrock
F	Unknown (Fluvial processes)
WR, RW, etc.	Combinations of above
OT	Other (describe as comment)

Substrate Cross-sectional Information

At the top of the Physical Habitat Characterization form, record the site ID, stream name, and sampling date. Also, indicate the cross-section transect that is being examined by placing an "X" in the appropriate box. At the transect, extend the metric tape (use the Stadia rod if preferred) across the channel perpendicular to the flow, with the "zero" end at the left bank (facing downstream).

1. Divide the wetted channel width by four to locate substrate measurement points on the cross-section (0%, 25%, 50%, 75%, and 100% of the total distance as shown in Figure 3 correspond with the "Left," "Left Center," "Center," "Right Center," and "Right" designations in the "Substrate Cross-sectional Info" portion of the Physical Habitat Assessment datasheet, respectively).
2. Depth measurements at the right and left bank will always be 0 (zero), regardless of bank angle or undercut. This is done to prevent repetitive zeroes in the dataset that would negatively skew the average depth calculated for the sample reach. Zeros should already be entered into the spaces for left and right bank depth measurements on the datasheet.

Depth should be measured using a meter stick and recorded for the "Left Center," "Center," and "Right Center" locations.

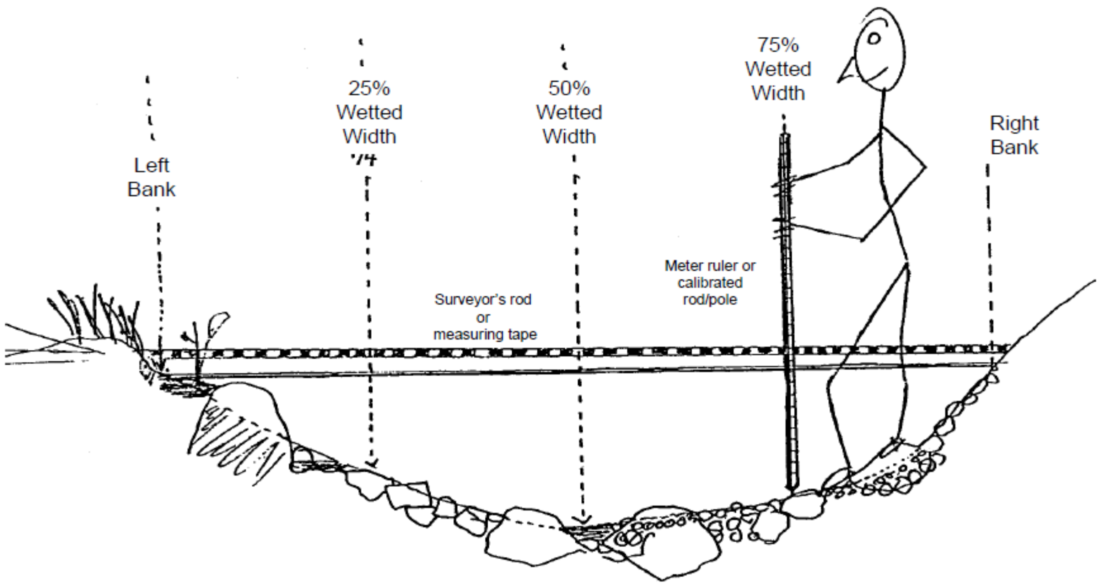


Figure 47. Cross-section schematic showing substrate measurement details.

3. Place your meter stick at the "Left" location (0 m). Pick up the substrate particle that is at the base of the meter stick (unless it is bedrock or boulder) and visually estimate its particle size, according to the Table 3. Classify the particle according to its "median" diameter (the middle dimension of its length, width, and depth). Record the size class code on the field data form. (Note that NA indicates that the substrate has no size range.) Classify the quantitative microalgae cover according to Table 4.

4. Evaluate substrate embeddedness as follows at 11 transects (A-K). Embeddedness is the fraction of a substrate's surface that is surrounded by fines or sand. For particles larger than sand, examine the surface for stains, markings, and algae to estimate coverage. For example, if stain encircles the substrate so that only 20% was exposed, use this as evidence in your estimation of 80% embeddedness. Estimate the average percentage embeddedness of particles in the 10 cm circle around the measuring rod. Record this value on the field data form. By default, "sand" and "fines" are embedded 100 percent; bedrock and hardpan are embedded 0 percent.

5. Move successively to the next location along the cross-section. Repeat steps 3 through 4 at each location. Repeat steps 1 through 5 at each new cross-section transect.

Table 14. Size dimensions and codes for substrate characterization.

Code	Size Class	Size Range (mm)	Description
RS	Bedrock (Smooth)	>4000	Smooth surface rock bigger than a car
RR	Bedrock (Rough)	>4000	Rough surface rock bigger than a car
HP	Hardpan	NA	Firm, consolidated fine substrate
BL	Boulders	>250 to 4000	Basketball to car size
CB	Cobbles	>64 to 250	Tennis ball to basketball size
GC	Gravel (Coarse)	>16 to 64	Marble to tennis ball size
GF	Gravel (Fine)	> 2 to 16	Ladybug to marble size
SA	Sand	>0.06 to 2	Smaller than ladybug size, but visible as particles- gritty between fingers
FN	Fines	<0.06	Silt/Clay/Muck (not gritty between fingers)
WD	Wood	NA	Wood & other organic particles
OT	Other	NA	Concrete, metal, tires, car, bodies etc. (describe in comments)

Table 15. Microalgae qualitative thickness for substrate measurements. From Fetscher et al. (2009).

Code	Thickness	Diagnostics
0	No microalgae present	The surface feels rough, not slimy.
1	Present, not visible	Substrate feels slimy, but layer to thin to be visible.
2	< 1 mm	Rubbing fingers on substrate produces a brown tint and scraping substrate leaves visible trail.
3	1-5 mm	
4	5 - 20 mm	
5	> 20 mm	
UD	Undetermined	Cannot determine if layer present
D	Dry	
F	Filamentous algae present	Long tufts of filamentous algae (green or blue-green)

Bank Measurements

1. To measure bank angle, lay the meter stick down against the left bank (determined as you face downstream), with one end at the water's edge. Lay the clinometer on the meter stick and read the bank angle in degrees from the **external scale** on the clinometer. Record the angle in the field for the left bank in the “Bank Measurement” section of the Physical Habitat Assessment form.
    a) A vertical bank is 90 degrees; undercut banks have angles >90 degrees approaching 180 degrees and more gradually sloped banks have angles <90 degrees. To measure bank angles >90 degrees, turn the clinometer (which only reads 0 to 90 degrees) over and subtract the angle reading from 180 degrees.
2. If the bank is undercut, measure the horizontal distance of the undercutting to the nearest 0.01 m. Record the distance on the field data form. The undercut distance is the distance from the water’s edge out to the point where a vertical plumb line from the bank would hit the water’s surface. Measure submerged undercuts by thrusting the rod into the undercut and reading the length of the rod that is hidden by the undercutting.
3. Repeat steps 1 and 2 on the right bank.

4. Visually estimate the channel incision as the height up from the water surface to elevation of the first terrace of the valley floodplain (Figure 4). Record this value in the "Incised Height" field of the bank measurement section on the field data form.
5. Examine both banks to visually estimate and record the height of bankfull flow above the present water level (Figure 4). Look for evidence on one or both banks such as:
    a) An obvious slope break that differentiates the channel from a relatively flat floodplain terrace higher than the channel.
    b) A transition from exposed stream sediments to terrestrial vegetation.
    c) Moss growth on rocks along the banks.
    d) Presence of drift material caught on overhanging vegetation.
    e) Transition from flood- and scour-tolerant vegetation to that which is relatively intolerant of these conditions.

    NOTE: The Field Crew Leader should discuss the evidence of what constitutes bankfull height with the field crew. Identification of bankflow level during baseflow conditions "requires judgment and practice; even then it remains somewhat subjective" (Peck et al. 2006). To assist in this determination, look for slope breaks that denote a floodplain and also look at the vegetative growth; most bankfull flows occur often enough to scour out vegetation. Well established and older riparian growths are obvious indicators of being outside the bankfull zone. A discussion of the available evidence at each site will assist in consistency between these measures and the Large Woody Debris counts, which also rely on identification of the bankfull height.
6. Record the wetted width value determined when locating substrate sampling points in the "Wetted Width" field in the bank measurement section of the field data form. Also, determine the bankfull channel width and the width of exposed mid-channel bars (if present).
7. Repeat steps 1 through 6 at each cross-section transect. Record data for each transect on a separate field data form.

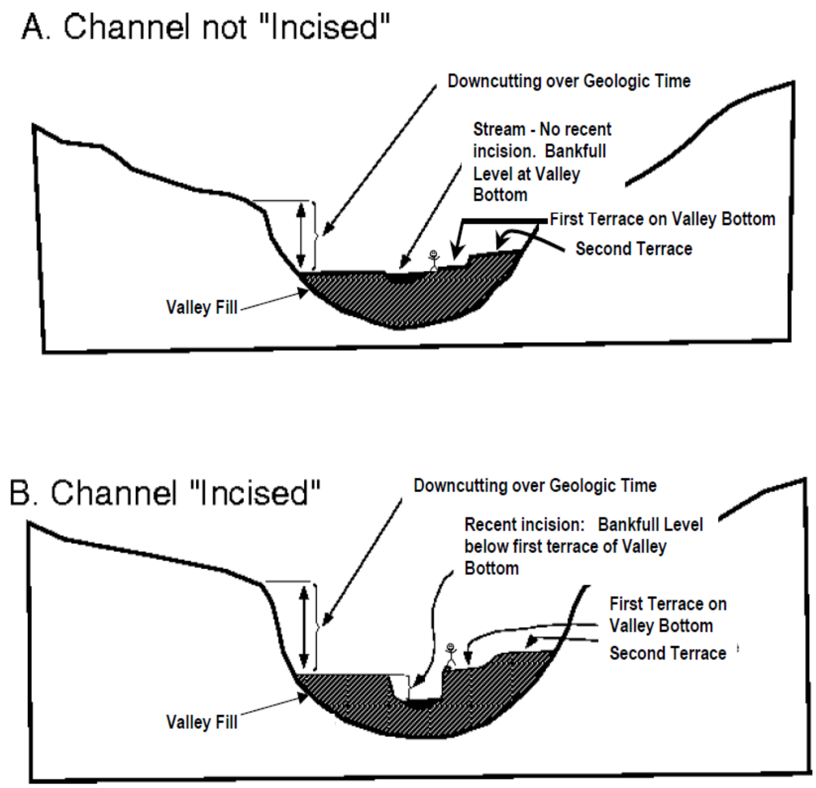


Figure 48. Schematic showing bankfull channel and incision for channels. (A) not recently incised, and (B) recently incised into valley bottom. “Recent incision” indicated on (B) is the distance to be measured and recorded as “incised height” on the field data form. Note level of bankfull stage relative to elevation of first terrace on valley bottom (stick figure included for scale).

Canopy Cover

1. At each cross-section transect, stand in the stream at mid-channel and face upstream.
2. Hold the densiometer 1 foot above the surface of the stream. Hold the densiometer level using the bubble level. Move the densiometer in front of you so your face is just below the apex of the taped “V” (Figure 5).
3. Count the number of grid intersection points within the “V” that are covered by a tree, a leaf, or an overhanging branch. Record the value (0 to 17) in the “CENUP” field of the canopy cover measurement section of the Channel/Riparian Cross-section and Thalweg Profile form.
4. Face toward the left bank (left as you face downstream). Repeat steps 2 and 3, recording the value in the “CENL” field of the field data form.
5. Repeat steps 2 and 3 facing downstream and again while facing the right bank (right as you look downstream). Record the values in the “CENDWN” and “CENR” fields of the field data form.
6. Repeat steps 2 and 3 again, this time facing the bank while standing first at the left bank, then the right bank. Record the values in the “LFT” and “RGT” fields of the field data form.

7. Repeat steps 1 through 6 at each cross-section transect. Record data for each transect on a separate field data form.

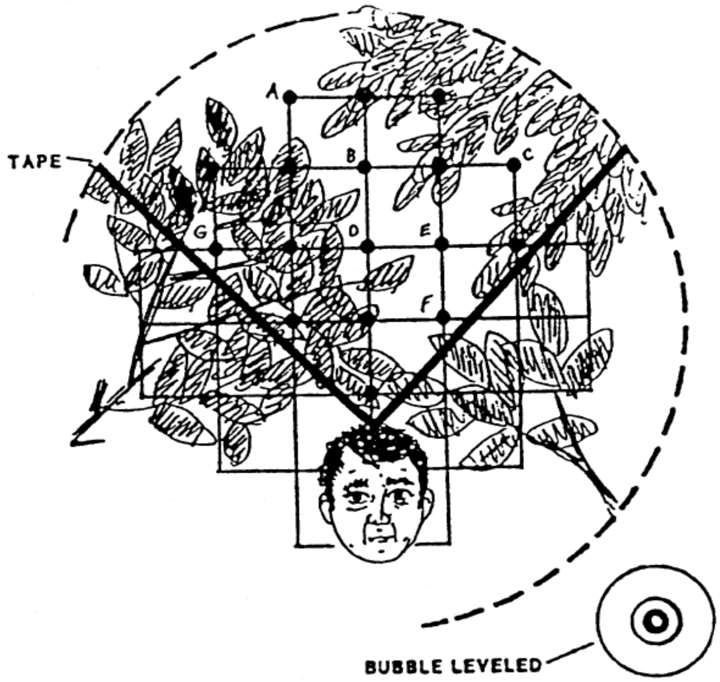


Figure 5. Schematic of modified convex spherical canopy densiometer (from Mulvey et al.1992). In this example, 10 of the 17 intersections show canopy cover, giving a densiometer reading of 10. Intersections not showing canopy cover are indicated with letters A-G. Note proper positioning with the bubble leveled and face reflected at the apex of the "V."

Fish Cover

1. Standing mid-channel at a cross-section transect, estimate a 5 m distance upstream and downstream (10 m total length; Figure 6).
2. Examine the water and the banks within the 10 m segment of stream for the following features and types of fish cover: filamentous algae, aquatic macrophytes, large woody debris, brush and small woody debris, in-channel live trees or roots, overhanging vegetation, undercut banks, boulders, and artificial structures.
3. For each cover type, estimate the areal cover. Record the appropriate cover class in the "Fish Cover/Other" section of the Physical Habitat Characterization form ("0"=absent: zero cover; "1"=sparse: <10%; "2"=moderate: 10-40%; "3"=heavy: 40-75%; or "4"=very heavy: >75%).
4. Repeat steps 1 through 3 at each cross-section transect, recording data from each transect on a separate field data form.

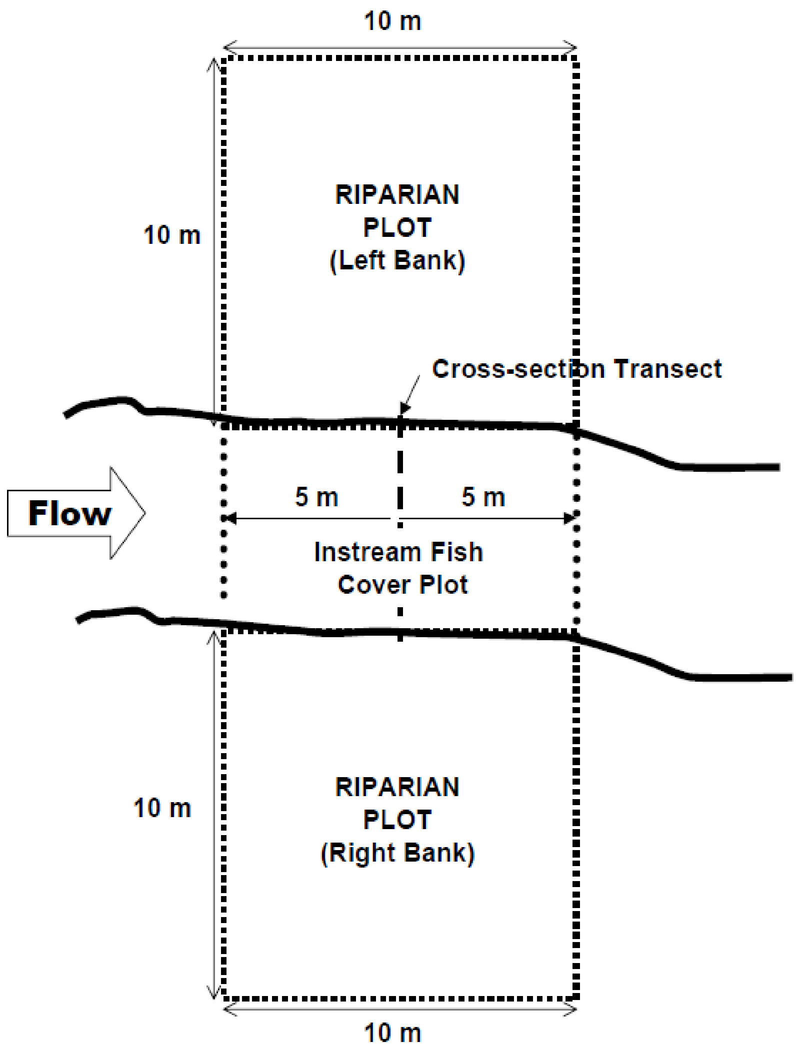


Figure 6. Boundaries for visual estimation of riparian vegetation, fish cover, and human influences.

Visual Riparian Estimates

1. Standing in mid-channel at a cross-section transect, estimate a 5 m distance upstream and downstream (10 m total length; Figure 6).
2. Facing the left bank (left as you face downstream), estimate a distance of 10 m back into the riparian vegetation.
3. Within this 10 m × 10 m area, conceptually divide the riparian vegetation into three layers: a Canopy Layer (>5 m high), an Understory (0.5 to 5 m high), and a Ground Cover layer (<0.5 m high).
4. Within this 10 m × 10 m area, determine the dominant vegetation type for the Canopy layer (vegetation >5 m high) as either Deciduous, Coniferous, broadleaf Evergreen, Mixed, or None. Consider the layer "Mixed" if more than 10% of the areal coverage is made up of the alternate vegetation type. If Mixed is chosen, indicate which other

categories are present to constitute “Mixed.” Indicate the appropriate vegetation type in the “Visual Riparian Estimates” section of the Physical Habitat Characterization form.

5. Determine separately the areal cover class of large trees (>0.3 m [1 ft] diameter at breast height [DBH]) and small trees (<0.3 m DBH) within the canopy layer. Estimate areal cover as the amount of shadow that would be cast by a particular layer alone if the sun were directly overhead. Record the appropriate cover class on the field data form ("0"=absent: zero cover; "1"=sparse: <10%; "2"=moderate: 10-40%; "3"=heavy: 40-75%; or "4"=very heavy: >75%).
6. Look at the Understory layer (vegetation between 0.5 and 5 m high). Determine the dominant vegetation type for the understory layer as described in step 4 for the canopy layer.
7. Determine the areal cover class for woody shrubs and saplings separately from non-woody vegetation within the understory, as described in step 5 for the canopy layer.
8. Look at the Ground Cover layer (vegetation <0.5 m high). Determine the areal cover class for woody shrubs and seedlings, non-woody vegetation, and the amount of bare ground present as described in step 5 for large canopy trees.
9. Repeat steps 1 through 8 for the right bank.
10. Repeat steps 1 through 9 for all cross-section transects, using a separate field data form for each transect.

.Human Influence Estimates

1. Standing mid-channel at a cross-section transect, look toward the left bank (left when facing downstream) and estimate a 5 m distance upstream and downstream (10 m total length, Figure 6). Also, estimate a distance of 10 m back into the riparian zone to define a riparian plot area.
2. Examine the channel, bank, and riparian plot area adjacent to the defined stream segment for the following human influences: (1) walls, dikes, revetments, riprap, and dams; (2) buildings; (3) pavement/cleared lot (e.g., paved, graveled, dirt parking lot, foundation); (4) roads or railroads; (5) inlet or outlet pipes; (6) landfills or trash (e.g., cans, bottles, trash heaps); (7) parks, maintained lawns, campsites, or firepits; (8) pastures, rangeland, hay fields, or evidence of livestock; (9) logging; (10) recent wildfires, and (11) mining (including gravel mining).
3. For each type of influence, determine if it is present and what its proximity is to the stream and riparian plot area. Consider human disturbance items as present if you can see them from the cross-section transect. Do not include them if you have to site through another transect or its 10 m ×10 m riparian plot.
4. For each type of influence, record the appropriate proximity class in the “Human Influence” part of the “Visual Riparian Estimates” section of the Channel/Riparian Cross-section Form. Proximity classes are: B (“Bank”) Present within the defined 10 m stream segment and located in the stream or on the stream bank; C (“Close”) Present within the 10 × 10 m riparian plot area, but away from the bank; P (“Present”) Present, but outside the riparian plot area; and O ("Absent”) Not present within or adjacent to the10 m stream segment or the riparian plot area at the transect.
5. Repeat steps 1 through 4 for the right bank.
6. Repeat steps 1 through 5 for each cross-section transect, recording data for each transect on a separate field form.

Literature Cited

Fetscher, A.E., L. Busse, and P.R. Ode. 2009. Standard Operating Procedures for Collecting Stream Algae Samples and Associated Physical Habitat and Chemical Data for Ambient Bioassessments in California. California State Water Resources Board Surface Water Ambient Monitoring Program (SWAMP). Bioassessment SOP 002. (updated May 2010).

Peck, D.V., A.T. Herlihy, B.H. Hill, R.M. Hughes, P.R. Kaufmann, D.J. 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. EPA/620/R-06/003. U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C.

Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #13: Slope Measurements

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP explains the procedure for measuring the slope (gradient) of a sample reach. Slope is defined as the ratio of channel-elevation drop divided by the curvilinear channel length. The overall stream gradient is one of the major stream classification variables, giving an indication of potential water velocities and stream power, which are in turn important controls on substrate and channel characteristics, aquatic habitat, and sediment transport within the reach. Also, the spatial variability of stream gradient within a sample reach is a measure of habitat complexity, as reflected in the diversity of water velocities and sediment sizes.

The basic principle in measuring slope is to calculate the rise/run for each transect. The run is defined as the distance between each transect flag, and the rise (or vertical drop) between each transect is measured using a surveyors level (an Abney level) and a surveyors rod (a Stadia rod). The relative height is measured at the lower transect and the upper transect. The difference between the two measurements is the vertical drop.

Measuring Slope

Two crew members are required to measure slope. One crew member should operate the Stadia (a.k.a., survey or leveler's) rod; the other should operate the Abney level.

1. Starting at Transect A (starting at Transect K and moving downstream is allowed so long as care is taken to place the correct measurements in the correct spaces on the datasheet), place the Stadia rod at the water's edge near the Transect A survey flag so that the bottom of the rod is level with the surface water level.
2. Hold the Stadia rod vertically with numbers facing the Abney level. The crew member operating the Abney level should stand near the midpoint between Transect A and Transect B. Operating the Abney level requires keeping one's body as stable as possible, as if the body was a tripod on which the Abney level was mounted. Stand with feet stable and shoulder width apart (stable sitting is allowed if surrounding terrain or vegetation

dictates its necessity), shoulders parallel to the flow of water, and posture as vertical as possible.

3. Look through the Abney level towards the Stadia rod at Transect A, ensuring that the bubble level within the Abney level indicates levelness. The bubble on the left side should be placed in between the upper and lower line (Figure 1).
4. **Record the height** of the Stadia rod that is level with the Abney level on the “Slope” datasheet in the “Lower Reading” space for the measurement between Transects A and B (Figure 2A). The measurement is taken using the middle line. Users should familiarize themselves with the units on the Stadia rod to ensure accurate readings and training should include quizzes on how to read the Stadia rod. In Figure 1, the correct reading would be 2.04 meters.
5. Next, with the crew member operating the Abney level staying in the exact same position, the crew member moves to Transect B, placing the Stadia rod near the survey flag as described above.
6. The crew member operating the Abney level then turns to face the Stadia rod, maintaining body position and levelness. **Record the height** on the Stadia rod that the is level with the Abney level on the “Slope” datasheet in the “Upper Reading” space for the measurement between Transects A and B (Figure 2B).
7. Next, with the crew member operating the Stadia rod staying in the exact same position, the crew member operating the Abney level moves upstream to the midpoint between Transects B and C in order to take the next set of measurements (Figure 2C).
8. Continue to take measurements using this “leapfrogging” movement of crew members until all transects have been measured. It should be noted that the upper measurement should always be numerically less than or equal to the paired lower measurement, because water level inherently decreases as it moves downstream.

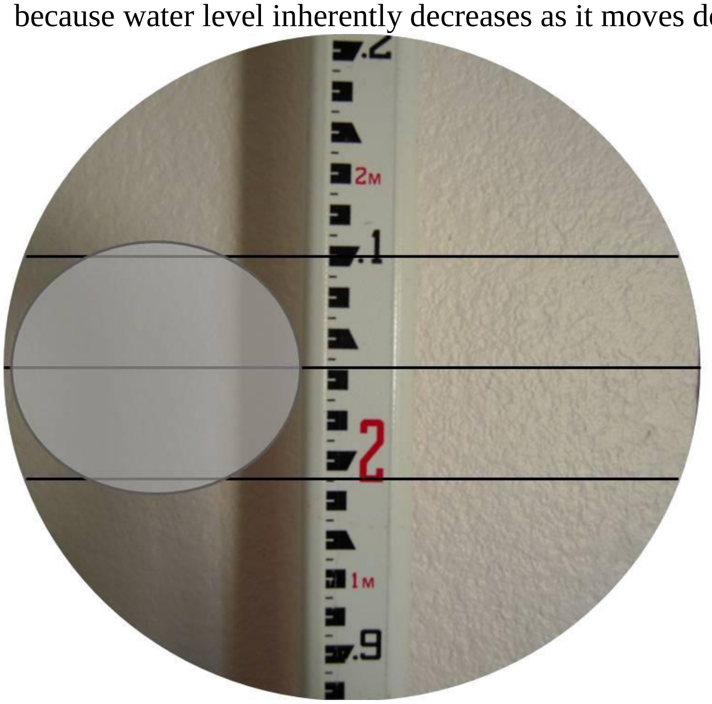
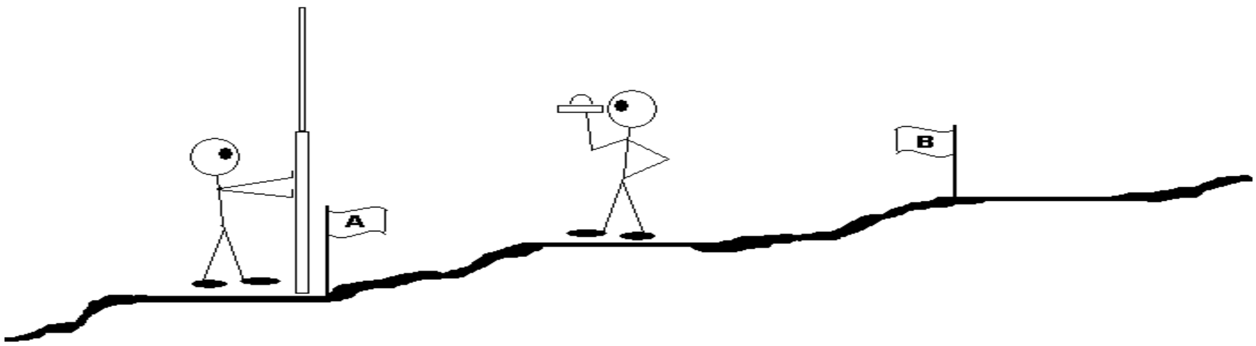
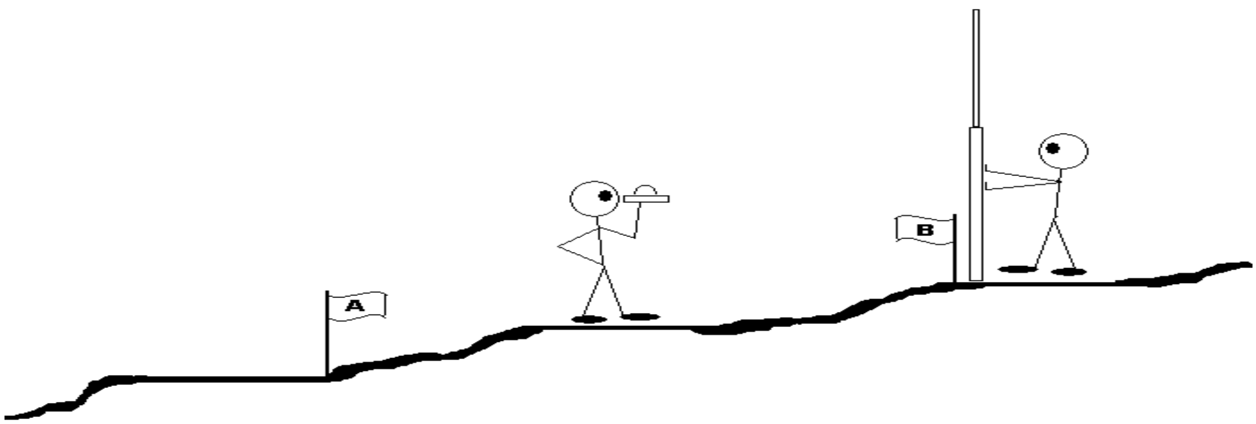


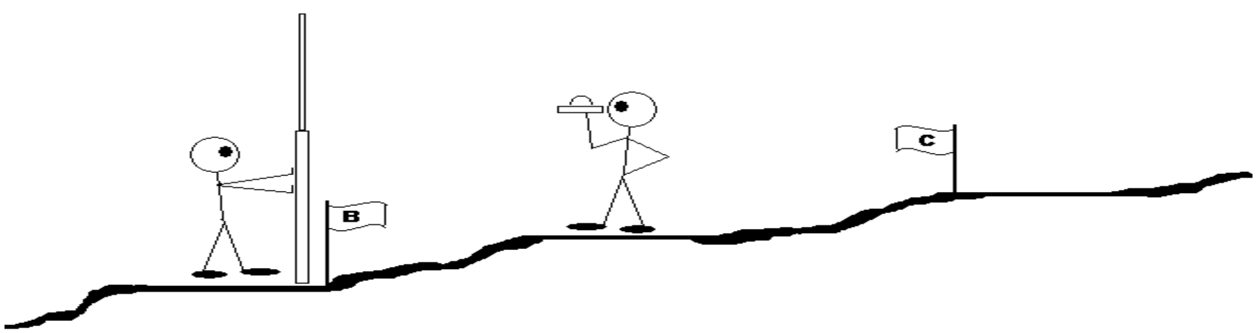
Figure 49. An approximate view through the Abney Level. The bubble on the left indicate levelness using the upper and lower lines. The reading is taken using the middle line as accurate as possible.



A) First transect pair (A-B) Lower Reading.



B) First transect pair (A-B) upper reading (Stadia rod is moved upstream).



C) Second Transect pair (B-C) lower reading (Abney Level is moved upstream).

Figure 2 (A-C). Diagram of order of events for measuring slope. Bold line represents the surface water elevation increasing as moving upstream, measured at water's edge.

You should always attempt to take all slope measurements necessary within a sample reach as this information can be used to examine variability of slope within a reach. However, if no surface water is present at a given transect within a reach, a slope measurement cannot be taken at this location. Instead, take measurements from the transects upstream and downstream of the dry stream bed area at the water's edge in the same manner as previously described. Record these measurements in the space for the dry transect and include comments about the altered measurement on the "Slope" datasheet. Doing this will allow the total slope of the stream reach to be calculated, despite dry transects within the reach.

For sample reaches greater than 300 m in length (so that the spacing between transects is 30 meters or more), or with sites with dense vegetation, it may be too difficult to read the Stadia rod using the Abney level due to increased distance or interference between the two instruments. In this case, crew members should double the number of slope measurements taken (e.g., taking measurements from a transect to the midpoint of the transect, then again from the midpoint to the next transect) in order to reduce this distance.

Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #14: Riparian, Invasive Plants, and Dominant Tree Characterization

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP explains the procedure for characterizing dominant trees and the presence of invasive species within the riparian zone. This procedure should be consistently performed by the Riparian Habitat Specialist for the duration of the field season. A list of target species are given for both procedures; however, if the Riparian Habitat Specialist is able to accurately identify the plant as a species to a higher taxonomic level than what is presented on the list, he/she is encouraged to do so. Both components of this SOP should be completed simultaneously while moving upstream from Transect A, although the riparian plots examined for each is different.

Riparian "Dominant" Tree Characterization

This procedure contributes to the assessment of "old growth" (or simply the largest local tree) characteristics of riparian vegetation and aids the determination of possible historic conditions and the potential for riparian tree growth. Note that only one tree is identified for the distance between each transect. At Transect K, the area upstream of Transect K a distance of four times the wetted width (the inter-transect distance) should be assessed. Record the type of tree, and, if possible, the taxonomic group. Record this information, along with the laser-measured height, approximate diameter at breast height (dbh), and distance from the wetted margin of the stream on the data form. Visual estimation of these parameters from the stream bank may be difficult to ascertain due to understory and ground cover vegetation blocking line-of-site. If necessary, travel into the riparian zone towards (or possibly away from) the dominant tree until an adequate estimation can be made from an unobstructed position.

1. Beginning at Transect A, looking upstream. Search both sides of the stream upstream to the next transect. Locate the largest riparian tree visible within 50 m (or as far as you can see, if less) from the wetted bank on both sides of the stream.
2. Classify this tree as deciduous, coniferous, or broadleaf evergreen (classify western larch as coniferous). Identify, if possible, the species or the taxonomic group of this tree from the following list:

a. Acacia/Mesquite
b. Alder/Birch
c. Ash
d. Maple/Boxelder
e. Oak
f. Poplar/Cottonwood
g. Sycamore
h. Willow
i. Unknown or Other Deciduous
j. Cedar/Cypress/Sequoia
k. Fir (including Douglas Fir, Hemlock)
l. Juniper
m. Pine
n. Spruce
o. Unknown or Other Conifer
p. Unknown or Other Broadleaf Evergreen
q. Snag (Dead Tree of Any Species)
    i. If the largest tree is visibly determined to be dead, enter “Snag” as the taxonomic group, regardless of whether or not the species of the dead tree can be identified.

3. Estimate the height of the dominant tree using the laser rangefinder (TruPulse 200B).
    a. Turn the rangefinder on, by pushing the “Fire” button (Figure 1).

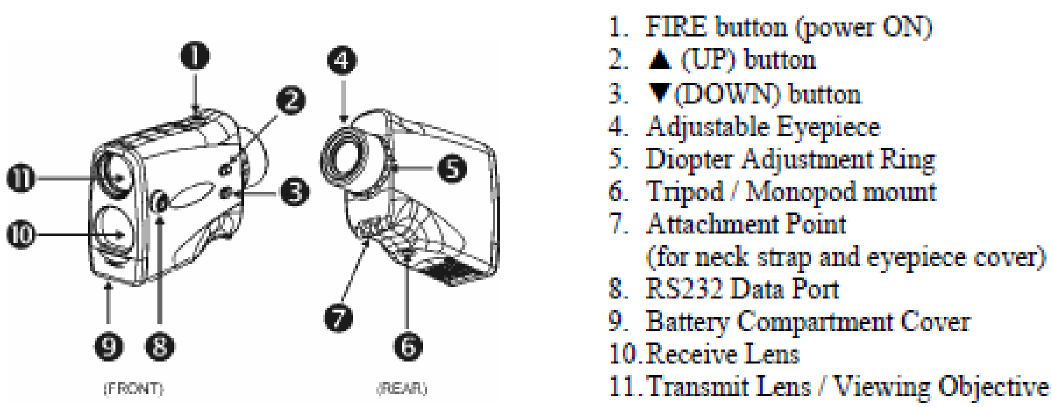


Figure 50. TruPulse 200B laser rangefinder functions.

    b. Ensure that the unit is in Height Measurement Mode (flashing “HD” and solid HT displayed in viewfinder [Figure 2]).

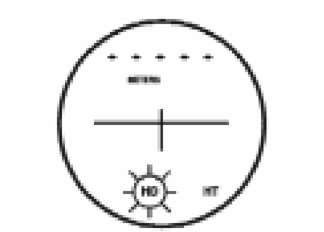


Figure 2. Height measurement mode.

c. If not, scroll through the settings with either button 2 or 3 (Figure 1).
d. Start by measuring the horizontal distance to the largest tree in the inter-transect area. Do this by pressing and holding the "Fire" button.
e. The horizontal distance will briefly flash on the top of the viewer. In most cases, this will be the distance to the tree. **Record this in the proper place**.
f. The viewfinder will then request for the first angle (this can be the top or the bottom of the tree) (Figure 3).

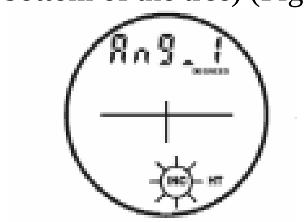


Figure 3. Viewfinder requesting the first angle.

g. Aiming at the top or bottom, press and hold the "Fire" button. The current angle will be display. When you are as close to the top or bottom as you can be, release the "Fire" Button; this locks in the measured angle.
h. The unit will now be ready for the second angle (the one you didn't measure above) (Figure 4).

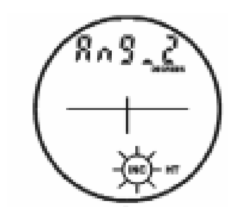


Figure 4. Viewfinder requesting the second angle.

i. Repeat step g, by pressing and holding the "Fire" button while aiming at the base or top.
j. Upon release after measuring the second angle, the calculated height will be displayed (Figure 5). **Record this as the height**.

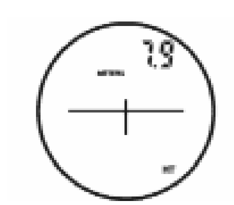


Figure 5. Viewfinder displaying calculated height.

k. If you are unable to get a clear line of sight to either the top or bottom of the dominant tree in a reasonable amount of time (1-2 minutes of scrambling), shoot to the highest point possible and add a > sign to indicate that this is a minimum measurement of tree height. Although an absolute height is the preferred measure, logistical constraints prevent more than a couple minutes spent trying to see a clear view of the top and bottom.

4. Estimate and record the diameter of the dominant tree at breast height (dbh).
5. Estimate and record the distance of the dominant tree from the wetted margin of the stream. (This may be done with the laser rangefinder, if the height is measured from within the stream channel.)
6. Repeat steps 1 through 5 for each remaining transect (B through K). At transect "K," look upstream a distance of four channel widths (the inter-transect distance) when locating the dominant tree.

Invasive Plants

A trend of increasing concern along streams in many parts of the western U.S. is the invasion of alien (non-native) tree, shrub, and grass species. A list of "target" invasive species has been prepared for California and Oregon by the EPA EMAP program and is summarized in Table 1. Note that this is not a list from the KLMN Invasive Species Early Detection monitoring but rather a targeted list of species potentially occurring in riparian zones.

At each transect, the presence of listed invasive plant species within the 10 m x 10 m riparian plots on either bank is recorded on the Riparian "Dominant" Trees and Invasive Plants field form. Note that the list of target plants varies from state to state. See Appendix H for identification keys for these target plants.

1. Beginning at Transect A, examine the 10 m x 10 m riparian plots on both banks for the presence of alien plant species. The riparian plot is centered at the cross-section transect extending 5 m upstream, 5 m downstream, and 10 m from the wetted bank into the riparian area (this riparian plot is the same dimensions as the "visual riparian assessment" plot from SOP #12: Stream Habitat Characterization; Figure 5).
2. Record the presence of any species listed within the plot on either the left or right bank by marking the appropriate box(es) on the right hand column of the Riparian "Dominant" Trees and Invasive Alien Plants field form. If none of the species listed is present in either of the plots at a given transect, check the box labeled "None" for this transect.

Table 1. Targeted invasive species for stream crews.

Common Name	Genus species	Name on form/database
Canada Thistle	*Cirsium arvense*	Can This
Giant Reed	*Arundo donax*	G Reed
Himalayan Blackberry	*Rubus discolor*	H Black
Musk Thistle	*Carduus nutans*	M This
English Ivy	*Hedera helix*	Eng Ivy
Reed Canarygrass	*Phalaris arundinacea*	RC Grass
Russian Olive	*Elaeagnus angustifolia*	Rus Ol
Salt Cedar	*Tamarix spp.*	Salt Ced
Cheatgrass	*Bromus tectorum*	Ch Grass
Teasel	*Dipsacus fullonum*	Teasel
Common Burdock	*Arctium minus*	C Burd

Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #15: Aquatic Vertebrate Sampling

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP explains the procedure for the collection and identification of aquatic vertebrates such as newts, salamanders, frogs, crayfishes (although they are invertebrates, crayfish collection and identification is done using this protocol due to their size and susceptibility to electrofishing), and fishes. The object is to collect, identify, measure, and return the organisms back into their environment with minimal harm to the organisms. Preparation and sampling efficiency is necessary to reduce the handling time of these organisms thereby reducing the likelihood of harm to them. Each organism that is collected should be treated with the utmost amount of care and respect, as if it were the crew member's own family pet.

The procedure presented here is based upon methods that proved most efficient during the pilot study. It was found that sampling half of the total sample reach and processing the collected organisms in two batches was the most efficient. However for larger reaches or reaches with abundant fish, it may be necessary to break up the sampling and processing of organisms into additional batches in order to complete effectively while minimizing risk of injury/ mortality to collected organisms.

The handling of specimens should at all times conform to the policy of the American Society of Ichthyologists and Herpetologists guidelines for the use of fish, amphibians and reptiles in research (Appendix L). NPS safe handling procedures are regulated by Reference Manual 50B, and generally cover zoonotic diseases. The applicable portions of this are covered in the KLMN Safety Plan. Crew members must also have all applicable permits in hand and follow all permit stipulations to the letter.

Electrofishing Safety

Electrofishing units have the capacity to deliver a powerful, potentially fatal shock to a crew member if proper caution is not exercised. Primary responsibility for safety while electrofishing rests with the Crew Leader; however, all crew members have the responsibility to identify and avoid potentially dangerous situations. Nonetheless, all crew members must read and follow all directions and guidelines presented in the operational manual for the electrofishing unit (Appendix Q) and the Job Hazard Analyses (Appendix N) before conducting this activity. Crew members should keep each other in constant view and communicate all activities while electrofishing. The crew member operating the electrofishing unit should constantly verbalize his/her actions (i.e., communicate, communicate, communicate) so that all crew members are aware of his/her intentions while electrofishing. While electrofishing, avoid contact with the water unless sufficiently insulated against electroshock. Use chest waders, thick rubber gloves, and proper non-slip footwear to reduce the potential for electroshock. If it is necessary for a team member to reach into the water to pick up a fish or a dropped item, do so only after the electric current is off and the anode has been removed from the water. Do not resume electrofishing until all crew members are clear of the electroshock hazard. Avoid direct contact with the anode and cathode of the electrofishing unit at all times due to the potentially severe shock hazard. Do not electrofish during rain events, as this will increase the potential for electroshock. Do not electrofish near other electronic sampling devices, as this may affect measurements or potentially damage instruments.

Pre-sampling Preparations

1. Create a fish processing area near the X-Point of the stream. Unpack identification keys, measuring board, five-gallon buckets, and aeration devices necessary for fish processing.
2. Take two 5 gallon buckets and half fill them with stream water. Attach battery powered aeration devices to the buckets and turn them on so that the water will begin saturating with oxygen. These buckets will serve as live-wells for collected fish. Place these buckets near Transects B and D so that as fish are collected, they can be quickly deposited into these live-wells. The buckets should be placed in a shady area, preferably within the stream, to prevent water temperature increase that could potentially harm collected organisms. Ensure they are secured with rocks or other anchorage. If an organism is collected that is too large to be safely contained in the live-well, immediately identify, measure, and release the organism far enough downstream to eliminate the possibility of re-capturing the released organism.
3. Don all necessary gear for electrofishing, including rubber gloves, chest waders, hats, and polarized sunglasses (hats and polarized sunglasses greatly increase sampling efficiency by reducing glare and allowing a better view into the aquatic environment). Polarized sunglasses tend to be expensive; a retaining strap is recommended.
4. Assemble nets and electrofishing gear. Turn on and test the electrofishing unit according to manufacturer's instructions. Set the voltage, pulse rate, and duty cycle of the unit (typical settings for the pilot study were between 200-600 volts, 60 Hz pulse rate, and 25% duty cycle on Pulsed DC mode, although these settings can vary greatly depending upon the unique water chemistry of each stream) and reset the trigger time counter.

Electrofishing

1. The fish sampling crew has three primary positions: (1) electrofisher operator, (2) primary netter, and (3) secondary netter. Crew members may switch responsibilities at different stream reaches as long as sampling effort and collection techniques stay roughly

constant during each sampling event. If extra help is available (e.g., park observers), they can be incorporated into the sampling as extra netters.

   a. The electrofisher operator carries the electrofishing unit, coordinates all sampling activities, and chooses the path and habitats that are to be sampled using the electrofisher.
   b. The primary netter should be the primary collector of stunned organisms and carries only the insulated dip net. He/she should follow closely behind the Electrofisher operator, keeping his/her net submerged about a meter directly behind the electrofishing unit's anode.
   c. The secondary netter carries a 5 gallon bucket with stream water for transportation of collected fishes as well as an insulated dip net. Any fishes that evade capture by the primary netter are the responsibility of the secondary netter. The secondary netter also transports collected organisms to the live-wells when the collection bucket begins to fill. If a multitude of organisms are being stunned in a particular habitat, the secondary netter should place the collection bucket in a safe location and aid in the capture of organisms to increase sampling efficiency.

2. Once the settings on the electrofisher are adjusted properly to sample effectively and minimize injury and mortality and all pre-sampling preparations are completed, begin sampling at the downstream end of the reach (Transect A) and fish in an upstream direction. This is done so that the current forces stunned organisms downstream towards the nets.
   a. Depress the switch and slowly sweep the electrode from side to side in the water in riffles and pools. Focus on submerged fish cover, such as boulders, logs, and undercuts.
   b. Move the anode wand into cover with the current on and then remove the wand quickly to draw fish out. Fish are often drawn towards the anode when stunned. In fast moving, shallow water, sweep the anode and fish downstream into a net.
   c. The netters should strategically place themselves so that stunned fish can quickly be netted.
   d. In extremely wide streams, work from the midline of the stream channel to the banks.
   e. Be sure that deep, shallow, fast, slow, complex, and simple habitats are all sampled. In stretches with deep pools, fish the margins of the pool as much as possible, being extremely careful not to step or slide into deep water.
   f. Continue fishing in this manner until the electrofishing crew reaches the fish processing area near the X-Point.
3. Stop electrofishing; retrieve the live-wells and all collected organisms; and transport them to the processing area for identification, enumeration, and measurement.
   a. Start by processing any federally or state listed specimens first, if possible. Note that "chasing" a single specimen through a bucket crowded with other specimens may injure and stress both the listed specimen and others; use judgment in retrieving the listed specimens. Minimizing harm to all is your priority.
   b. Record the scientific name for each organism identified. If an organism is unidentifiable in the field, take multiple pictures of defining characteristics of that organism so that it can be identified later using these pictures as a reference (SOP #16: Photo Points and Photo Management).

c. Measure the largest and smallest of each identified organism and record the minimum and maximum length range (total length for fish; Snout-Tail Length for amphibians) on the datasheet or in the database.
d. If any external anomalies (e.g., tumors, missing appendages, or other abnormalities) are found on the collected organisms, record how many organisms had external anomalies in the "Anomaly Count" column and make note of the type of anomaly in the "Comments" section of the datasheet.
e. For salmonids (trout and salmon), record the number of each size class: 0-60 mm, 60 – 90 mm, 90 – 120 mm, 120 – 150 mm, and > 150 mm for total length.

4. Fill in the bubbles next to the transects near where each organism was collected in order to give a distribution of that organism within the sample reach. Once processing of the first half of collected fish has been completed, release these fish downstream of the processing area, far enough to eliminate the possibility of re-capturing the released organisms (approximately 25 meters). Refill the live-wells with stream water and place them near Transects G and I in the same manner as previously described.
5. Repeat steps 2 and 3 for the area from the X-Point to Transect K at the upstream limit of the sampling reach.
6. Record the electrofishing unit's settings and the total amount of trigger time on the datasheet. In some instances when fishing in deeper/shallower habitats, it may be necessary to increase/decrease the voltage to improve sampling efficiency. If more than one setting was used during the course of sampling, be sure to include the range of settings used.

Visual Encounter Surveys

Visual encounter surveys (VES) supplement is a basic technique to sample for amphibians. While it is usually a timed search, here we use it as a basic technique to supplement the electrofishing of fish and amphibians. As the crews walk up and down the stream reach doing other sampling activities, they should opportunistically keep their eyes and ears open for other signs of amphibians. Sightings should be recorded as above on the datasheets or in the database. Unknown specimens should be photo vouchered as above.

Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #16: Photo Points and Photo Management

Version 1.0

Revision History Log:

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This SOP includes instructions for the digital photography associated with sampling activities. Photographic documentation of the sampling reach, sampling activities, and collected organisms is an important component of data collection. Photos may provide information on the variation of stream characteristics between sampling events that may not be obvious elsewhere within the tabular dataset. It is paramount to know the content of each photograph taken in the field so that this information can be entered into the computer database. It is important to maintain a standard order in which photos are taken when using the datasheets. Always attempt to make each photo as clear, focused, and informative as possible. *Check each photo after it has been taken to ensure its quality*. Erase substandard photos from the camera's memory and recapture a better image when applicable.

"Photo points" can refer to permanently marked points that are repeated at regular intervals. In this protocol, we use the term photo points for a standardized set of photos to document the conditions of the reach. However, *no permanent markers are utilized*. Instead, follow-up surveys will include printouts of previous year's photo points so that the photographer can repeat the photo as closely as possible. It is not the intent of the photo points to be used in quantitative analyses, but rather to track gross change over time, as it occurs.

Prior to taking any photographs, it is important to make certain the date on the camera is set properly (SOP #1: Preparations, Equipment, and Safety). Photographs retain many of the attributes associated with the camera, including the camera model and the date the picture was taken. This date is compared to the date entered into the metadata form as a way to ensure the correct images is being described. If the camera date is not properly set, it may cause some data validation issues.

Initial Photo Points

Photos should be taken of all cross-section transects throughout the sampling reach and additionally around the X-Point. The order in which photos are taken is important to ensure that photo metadata is entered correctly into the computer. All transect photos should have the transect flag visible in the photo. Give this consideration when placing flags during reach layout (SOP #6: Site Arrival and Sample Reach Layout).

1. Always start photographing transects beginning with Transect A (the furthest downstream transect) and then moving upstream. The photo taken at Transect A should be taken looking upstream from a position that is outside of the sample reach at a distance of four times the mean wetted width (the inter-transect distance). For example, if the mean wetted width is 3 meters, take the photo 12 meters below Transect A. This is equivalent to a “phantom” transect below Transect A.
2. The photos taken of the subsequent transects should be taken from the prior transect (e.g., photo of Transect B taken from Transect A looking upstream, photo of Transect C taken from Transect B looking upstream, and so forth). Surrounding vegetation, large distances between transects at large sample reaches, and stream meanders may obscure the photographic view of a transect flag. In this case, alter the position from whence the photo is being taken so that you are as close to the prior transect as possible while still able to see the transect flag for the transect being photographed.
3. After all transect photos have been taken, return to the X-Point of the stream and take one photo each facing downstream from the X-Point, facing upstream from the X-Point, facing the left bank from the right bank near the X-Point, and finally facing the right bank from the left bank near the X-Point in this specific order (a useful pneumonic device for remembering this order is “D.U.L.R.” or “duller,” which stands for **D**ownstream, **U**pstream, **L**eft bank, **R**ight bank).
4. These photos comprise the minimum required photos at each stream reach. Record the following photo metadata on the datasheet (Appendix F).

Subsequent Photo Points

Site revisits in following years should follow the steps and orders of the initial site photos, but the photographer should have printouts of previous years to assist in recreating the subsequent photos in matching previous years as much as possible.

Additional/Incidental Photos

1. Photos should be taken of any feature within the stream reach that seems out of the ordinary. These may include, but are not limited to, human influences and unique stream features such as large logjams, waterfalls, or subterranean flows. If you question yourself as to whether or not something is unusual enough to warrant a picture, take one. There is no downside to additional photos, other than the time to record appropriate metadata.
2. Take voucher photos of any organism that is unidentifiable (or is questionable) in the field. These photos will be used to identify these organisms at a later time. Focus upon photographing the distinguishing features of the organisms such as mouth parts, fins, body shape, coloration, tree bark, leaf structure, etc. Ensure that these images are clear and interpretable. Make certain to photograph all sides, including the underbelly, of the unidentified species. Ensure that the description matches the species designation used on the vertebrate collection data form (example: Unknown species #1, Site 07L). Be sure to include specific site information with the description to distinguish unknown species from each other at multiple sites.
3. Take photos to document field crew activities during sampling and site set up. Human interest, methodological, and aesthetic photos are encouraged but not required for all sampling sites.

4. In the case that the images are of extraordinary findings (e.g., River otters, Martens, Fishers, Bigfoot, etc.), the crew should also make an effort to record the coordinates using a GPS device, especially if the sighting and photo occurred away from the sampling site (e.g., on the hike in or out).

Photo Metadata

The Klamath Network Data Plan (Mohren 2007) specifies the required metadata for photo management. The required metadata that must be recorded for every photograph taken while working on this project are:

1. Use the photo log (Appendix F) or the field databases to **record all following fields**. Do not use notebooks or rely on memory!
2. Photo name - the file name assigned by the camera (e.g., RIMG0001). Do not include the extension in the file name. Keep in mind you need to enter the full name of the photograph. Most cameras just display the numbers on their screen so be sure you are including the letters when entering the name into the metadata.
3. Date photo taken - should be in the format mm/dd/yyyy. Note that this is different from other protocol procedures (yyyymmdd) but is in this format to comply with photo metadata standards. This field automatically populates if you are entering the metadata into the field databases directly.
4. Name of photographer - full name should be given (i.e., not just initials or E. Dinger). This is a pick list that should be used if you are using the database.
5. Location - include the name of the stream that is being sampled. This field is not necessary if you are entering data directly into the database.
6. Description of photo - should be as detailed, clear, and concise as possible. When entering into the database, caption descriptions are acceptable but keep grammar correct. The goal is that the description could be used as a caption in a report.
    a. Acceptable examples:
        i. Emerald Creek, looking upstream towards Transect B
        ii. Joe Crewman holding an unknown tadpole at Emerald Creek
        iii. Black bear seen on trail while hiking to Emerald Creek
    b. **UNACCEPTABLE** examples
        i. Emerald creek, B
        ii. Tadpole?
        iii. Bear on trail
7. For transect photos, the use of ditto marks to record descriptions is acceptable when using the forms. However, in the database you can copy and paste when necessary. See example below:

Photo file name	Photographer	Date	Location	Description
RIM0098	Joe Crewperson	10/18/2009	Emerald Creek, REDW	Looking upstream at Transect A
RIM0099	"	"	"	" B
RIM0100	"	"	"	" C
RIM0101	"	"	"	" D
RIM0102	"	"	"	" E
RIM0103	Sarah Crewperson	"	"	Unidentified Salmonid, dorsal view

Downloading Photos and File Management

The digital photos taken for the day should be copied at the end of each day (SOP #17: Post-site Tasks). Using Windows Explorer, the photos from the camera (connected to the computer using the camera's download cable) should be copied (using the shift-left click function to highlight the photos, followed by a right click and selecting "copy") and pasted to the appropriate folder. The destination folder (Stream Monitoring/Images/Backup) should then be opened and a new folder should be created with the date you copied the images. The photos then should be pasted within the date folder (e.g., 20100725 for 25 July 2010). Keep in mind, photographs from previous days will be on the camera and care should be taken to only back up photographs from that day's surveys. **A double check that the correct files were copied into the correct destination should follow.** The camera can then be disconnected using the "Safely Remove Hardware" function of Microsoft Windows. After photos have been downloaded, enter all metadata for each photo (as described in the previous section of this SOP) into the Photo_Log Microsoft Excel spreadsheet, located within the Photos_Backup folder. As information is entered in the spreadsheet from the field photo metadata sheet, simultaneously use an image viewer to confirm that the image matches the metadata. Save the photo log in the Photos_Backup folder and not in the dated image folder.

Deliver Image Files for Final Storage

It is the Project Lead's responsibility to compile all images into a common folder and to transfer processed images to the Data Manager (SOP #17: Data Transfer, Storage, and Archive). To transfer images, once compiled, place the images and the metadata into the stream project folder at: G:\Monitoring\Stream Monitoring\Stream_Images\Seaonal Data\2011 (where the year is the year the field sampling occurred). Complete the data certification form (SOP #17: Data Transfer, Storage, and Archive) and send an email to the Data Manager when these steps are complete. The Data Manager will place copies of the images in the Klamath Network Image Library. Metadata for the images will be loaded into the Klamath Network Image Database, which is linked to the photographs in the Klamath Network Image Library, making them available to all Network staff. In addition, metadata is also uploaded to the seasonal database following an automated process described in SOP #20 Databases. Images and metadata will be backed up and archived following the methodologies outlined in the Klamath Network Data Management Plan (Mohren 2007). Mohren (2007) should be consulted for additional information on photo management.

Literature Cited

Mohren, S. R. 2007. Data management plan, Klamath Inventory and Monitoring Network. Natural Resource Report NPS/KLMN/NRR—2007/012. National Park Service, Fort Collins, CO.

Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #17: Post-site Tasks

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP details the necessary tasks for the field crew to do in between sampling of sites. This includes: (1) Disinfection of field gear; (2) Storage and shipping of water samples; (3) Data backup (photos, multiprobe data, database); and (4) Tasks to prepare for the next day.

Prior to leaving the site, the crew must review each datasheet and electronic form for completion and accuracy and the Crew Leader must sign each page to verify that the data are complete. This should be done by someone other than the original data collector. However, the Crew Leader is responsible for the final verification.

In the event that a certain protocol was not doable due to equipment failure, safety reasons, etc., an event log (Appendix F: Field Datasheets, Training Logs) should be filled out prior to leaving the site.

Disinfection

It is the responsibility of the field crew to ensure that they do not participate in the transfer or spread of wildlife diseases or invasive species. To minimize the chance of disease spread, crews should switch out of hiking footwear before they approach the waterbody and switch to water wear (sandals, neoprene booties, or waders). This water footwear is then disinfected before going to another waterbody.

To combat the spread of disease and invasive species, two separate disinfections must be used: (1) Bleach to sterilize against disease, and (2) Metaquat germicidal cleaner to sterilize against invasive species.

Gear is packed up at the water's edge prior to departure and is isolated from the environment in industrial strength trash bags. **Gear should be scrubbed with a stiff brush prior to packing to remove excess debris.** Disinfection is then carried out at either the park housing or campground.

Bleach Procedure

1. The person doing the disinfection must wear safety goggles and protective gloves.

2. Start disinfection by preparing a treatment barrel and rinse barrel (13^+ gallon trash can).
    a. Prepare a 4% solution of bleach (Sodium hypochlorite). Standard household bleach (e.g., Clorox®) is 6.15%. This may vary depending on brand.
    b. Use the $c_1v_1 = c_2v_2$ formula to calculate the amount of bleach needed in the trash can to be diluted. In the case of commercial Clorox, with a final volume of 10 gallons, this is:

    $$(6.15\%) \times (\text{initial volume}) = (4\%) \times (10 \text{ gallons})$$

    $$\text{Initial volume} = 6.5 \text{ gallons}$$

    c. Under the above scenario, 6.5 gallons should be poured in one of the trash cans and 3.5 gallons of water should be used to dilute it to a final volume of 10 gallons.
3. Fill a second trash can with 10 gallons of tap water as rinse water.
4. Place gear in bleach water for 15 minutes. This must be timed and not estimated.
5. Rinse gear in clean water (in second trash can).
6. Allow to dry as thoroughly as possible before packing up again.
7. Used bleach solution must be brought back to a municipal sewage system, where it can be added to standard waste water and safely decontaminated using dilution of tap water. Two 5 gallon jugs are provided to return the bleach water from the park housing units to the municipalities.

When the above protocol is not doable (e.g., the crew is camping at isolated areas) or the crew needs to disinfect expensive electronic gear (e.g., the multiprobe), an alternative procedure should be followed:

1. Using a household spray bottle, spray 70% Ethanol over the entire surface of the equipment.
2. Allow Ethanol to permeate the equipment for at least 1 minute.
3. Rinse with tap water and allow it to dry (except for the multiprobe).

Gear to be disinfected includes all gear that came into contact with water when sampling, including but not limited to: waders, boots, sandals, nets, boats, paddles, water sampling gear, Secchi disks, etc.

Metaquat Procedure

The procedure for Metaquat is similar to that of bleach. Use the above steps, substituting a 5% solution of Metaquat for the bleach. The soaking time remains 15 minutes. Rinse in fresh water afterwards. Follow the same safety precautions as with bleach; Metaquat is highly corrosive.

Sample Storage and Shipping

Storage

Upon returning to the crew housing, the samples should be stored as follows:

Dissolved Organic Carbon: placed in a refrigerator at 4° C, in a dark container.
Filtered Water sample: placed in a freezer at $^-18°$ C in the dark.
Unfiltered Water sample: placed in a freezer at $^-18°$ C in the dark.
Chlorophyll a *filters*: placed in a freezer at $^-18°$ C in the dark.

Macroinvertebrate samples: No special storage necessary, but should be organized and stored in plastic storage bins.

Although the crew should have ensured that labels were adequately attached, accurate, and followed the protocols, the crew should double check labeling at this time too.

Shipping

It is the responsibility of the Project Lead to arrange for the shipping of samples to contract laboratories. Depending on the requirements of the contract laboratories, zooplankton and macroinvertebrate samples may be held until the field season has ended. Shipping of samples sooner may be desired if the laboratory can improve upon sample turn-around time.

Water samples must be shipped throughout the project so that sampling holding times are minimized. Most water samples can only be held for a maximum of 28 days before the quality control issues arise and EPA regulatory holding periods are exceeded (APHA 2005).

Shipping preferences will vary depending on the contract laboratory. The basic protocol below is for the contract laboratory used for the pilot project, the Cooperative Chemical Analytical Laboratory, based at Oregon State University.

1. When shipping samples, time is of the essence (e.g., do not start sample preparations on a Friday. Instead, do it on a Monday morning, so you can ship it that afternoon and the receiving lab can get it on Tuesday morning.). Also, confirm with the lab that someone will be there to receive the samples and that they are ready for them to arrive.
2. Start by ensuring that all samples to be shipped out are present and properly labeled.
3. Prepare a sample inventory sheet to provide to the laboratory, both included in the package and for electronic delivery:

NPS REDW Stream Pilot project

Sample no.	Stream Name/site code	Date (YYYYMMDD)	Type	County	State
1	Redwood Creek, 16A	20090909	filtered water	Humboldt	California
2	Redwood Creek, 16B	20090909	filtered water	Humboldt	California
…	…	…	…	…	…
…	…	…	…	…	…
9	Damnation Creek, 09K	20091005	filtered water	Humboldt	California

Contact Information: Dr. Eric Dinger, (541) 552-8574, Eric_Dinger@nps.gov

1250 Siskiyou Blvd

Klamath I&M Network

Southern Oregon University

Ashland, OR 97520

4. This inventory includes contact information, stream name, unique site code, dates, type of sample, and sampling information. A sample number is assigned and added (1 – 9,

above), to allow the lab and Network to ensure that there is no confusion about what sample is what. A template for this (details may vary depending on whether it is Chlorophyll *a* or macroinvertebrates) can be found in S:\Administrative\Procurement\Contracts and Agreements\Contracts\Monitoring Contracts\Water Quality Monitoring\Sample Inventory Templates. On the field computer and at the conclusion of the field season, it should be placed in S:\\Monitoring\Stream_Monitoring\Data\Seasonal_Data\XXXX\Sample Inventories, where XXXX is the year of sampling.

5. Secure a label to each bottle with the sample number, ensuring that the label is on the right bottle.
6. Wrap the bottle or vial lid with parafilm or vinyl electrical tape to ensure a tight seal. Place these within a large zip seal type plastic bag.
7. Using blue ice packs to keep the samples cold, place the samples in a medium sized ice chest (e.g., a 48 quart). Place the frozen water samples on the bottom, and then layer some newspaper or cardboard in between the frozen samples and the refrigerated (i.e., non-frozen) dissolved organic carbon samples.
8. When packing the dissolved organic carbon samples (in glass vials), add some padding around the vials to prevent breakage.
9. Print out a copy of the sample inventory sheet, place it in a zip seal type plastic bag, and place on top of the sample (so that it is the first thing the receiving lab will see). **Include a chain-of-custody form, detailed below (included in Appendix F: Field Datasheets, Logs).**
10. Seal the ice chest with packing tape for a secure seal.
11. Use an express carrier (e.g., UPS or Fed-Ex) to send the package **overnight**. If shipping from a university, ensure that the package is delivered to the mail room prior to the carrier pickup. The drop-off point should planned out in advance, so that the crew or Project Lead is not searching for one at the last minute.
12. If packing and shipping is done by the Crew Leader, it is the responsibility of the Project Lead to provide the Crew Leader with either pre-paid shipping labels or an account code to charge the shipping to.
13. After shipping, the Project Lead must follow-up with the recipient to ensure that the samples were safely delivered and received with no loss of sample integrity. Shipping and tracking numbers should be retained to facilitate any follow-up.

The shipping of macroinvertebrate samples is similar to the shipping of water samples. **However, the shipping of Ethanol (a flammable material) is regulated by the Department of Transportation; shipping of undeclared Ethanol is a federal offense.** The regulated shipping of Ethanol is permissible, if the shipper (the Project Lead) is certified through a Department of Transportation training program and special procedures are followed.

A safe, legal work-around to shipping Ethanol is as follows:

1. Prior to shipping, pour off the majority of the Ethanol in the shipping vial (generally 80 to 90 % of the Ethanol). Use a sieve to ensure that no specimens are lost.
2. Replace with tap water.
3. Include a letter to the laboratory, clearly stating "**stored in water – replace with Ethanol upon receiving.**"

4. Warn the lab staff that the incoming samples will need Ethanol replacement and ensure that the samples are sent **overnight**.
5. As with the water samples, send so that they arrive on a working day, when staff will be present to replace the water with Ethanol.

When shipping invertebrate samples (legally with Ethanol, if a certified shipper is known, or by replacing Ethanol with water), use the following guidelines:

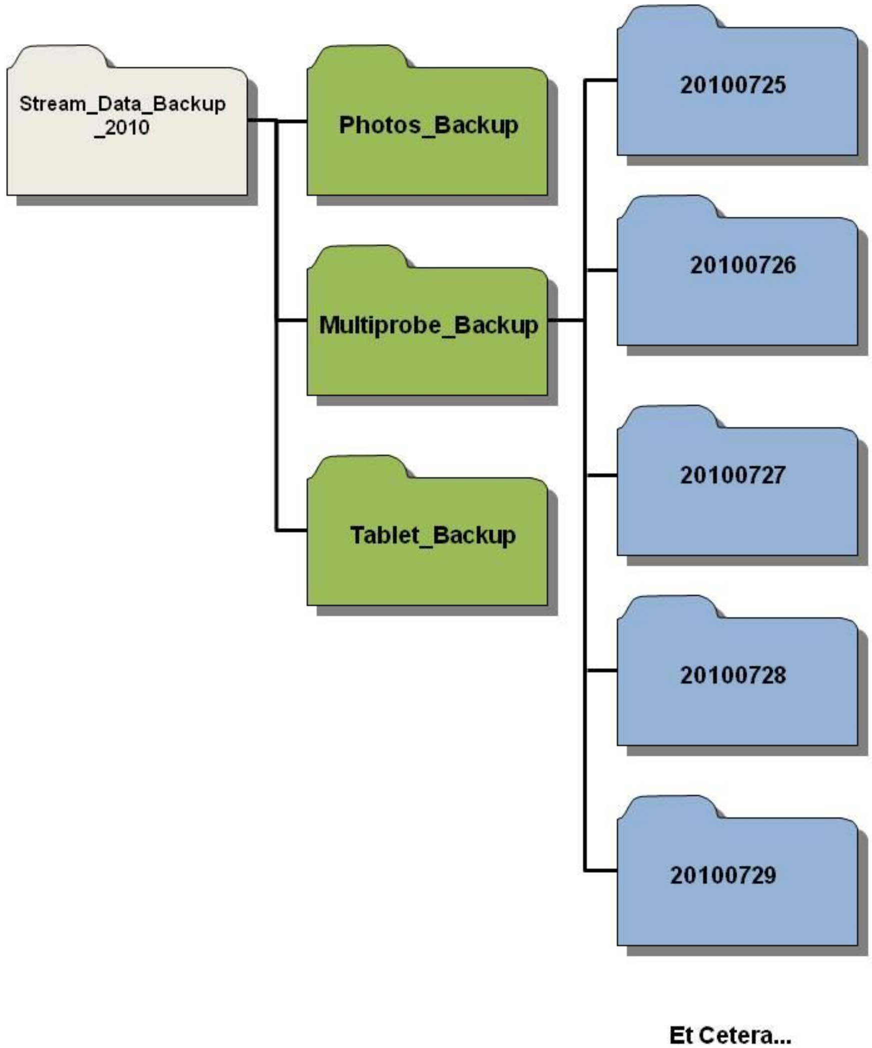
- Ship in a hard plastic container (e.g., ice chests).
- Wrap vials with Parafilm or vinyl electrical tape.
- After wrapping with Parafilm, put vials in a zip seal bag.
- Include absorbent material in the vial and packaging in case of breakage.
- Fill out and include a chain-of-custody form (in a waterproof bag, Appendix F.)
- Redundancy is good.

Chain-of-Custody Form (adapted from the Greater Yellowstone Network [O'Ney 2005])
A chain-of-custody form will document the collection and transfer of all samples originating from this protocol. The end purpose is to assure that an accurate written record is created by the field crew that will be accepted as valid evidence to trace a sample or samples from the moment of collection through laboratory testing and reporting of test results.

When shipping samples, the form must be completed and attached to the sample inventory sheet (as above, in a waterproof bag). The Project Lead, shipping the samples, retains a shipping receipt as proof of transfer of custody. Laboratory personnel receiving the samples indicate date and time received upon sample arrival. The original forms are scanned and retained, along with all other logs.

Some aspects of the chain-of-custody form replicate the sample inventory form but should be included on both sheets for regulatory purposes.

Data Back-up
Upon returning to the crew housing, all electronic data should be backed up onto a computer (either a park computer or Network laptop). This includes digital photos, multiprobe data, electronic databases, and GPS data. Prior to field crew deployment, the Project Lead should preload the laptop with the following hierarchical file structure. This file structure should start within the folder: C:\Documents and Settings\My Documents\Streams_Protocol.



The file of the first hierarchical folder (Streams_Survey_2010) should be adjusted from field season to field season, with the current year forming the last four digits. The folders for the third level (e.g., 20100725, 20100726) follow the date format of yyyymmdd. Every day that has a field sampling activity should have a representative folder within each type of data.

Note that backing up the files *does not include any renaming of files*!

Photos

The digital photos taken for the day should be downloaded after every field visit. Using Windows Explorer, the photos from the camera (connected to the computer using the camera's download cable) should be copied (using the shift-left click function to highlight the photos, followed by a right click and selecting "copy") to copy the entire set of the day's photos.

The destination folder should then be opened up in the file structure, ensuring that it is within the Streams_Survey_yyyy and Photos_Backup with the correct date folder. The photos should then be pasted within the date folder (e.g., 20100725). Keep in mind, photographs from previous days will be on the camera and care should be taken to only back up photographs from that day's surveys. **A double check that the correct files were copied into the correct destination should follow.** The camera can then be disconnected using the "Safely Remove Hardware" function of Microsoft Windows. Detailed methods on how to manage photographs are described in SOP #16: Photo Points and Photo Management.

Multiprobe Data

The multiprobe data should be backed up in a similar fashion to the photos, under Multiprobe_Backup.

Database

While in the field, prior to leaving the site, the Crew Leader and crew member entering the data should have made a backup of the crew leader and crew member databases to a thumb drive (SOP #4: Data Entry). Plug the thumb drive into the computer and navigate to:

\Monitoring\Stream_Monitoring\Data\Project Database\Database Backups

Right click on the database that has today's date in the naming convention and select copy. Following the methods described above for the photographs and manta data, browse to the "tablet backup" folder. Create a folder using today's date in the format yyyymmdd and paste the database into this folder.

Tasks for the Next Field Day

The field crew, collectively, should do the following:

1. Check consumables and replace field kits/backpacks with necessary supplies, such as filters, latex gloves, water bottles, foil for Chlorophyll *a*, datasheets, etc.
2. Batteries should be recharged, including but not limited to: Icom Radio, Amphibian data logger, GPS units (Trimble and Garmin, if applicable), camera, headlamps, electrofisher, and tablet PCs.
3. Review the field folder for the next day's site, and plan access and drive time accordingly.

Literature Cited

O'Ney, S.E. 2005. Regulatory water quality monitoring protocol, Standard Operating Procedure #7: Quality assurance/quality control procedures. National Park Service, Greater Yellowstone Network, Bozeman, MT.

Project: Klamath Inventory and Monitoring Wadeable Streams
Project Lead:
Phone:
Address:

Fax:
Email:

Park(s):
Shipped via: Fed-Ex UPS USPS
Tracking Number:

Field Crew:

Sample (may refer to an attached inventory sheet)	Date Sampled (yyyymmdd)	Time sampled (24 hour format)	Site Name	GRTS Code	Type (Filtered water, Dissolved Organic Carbon, Invertebrates, Zooplankton, Chlorophyll a)

Name and Position	Date/time received	Location received (i.e. Lab name)	Date/time relinquished	Location delivered/sent to:	Signature

Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #18: Post-season Tasks

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP explains procedures that will be completed after the field season, which include handling equipment, data forms, communication with NPS personnel, and reporting. Technicians and interns will assist the Project Lead in completing post season field tasks. This SOP is based on a similar SOP for the Klamath Network Landbird Community Monitoring Protocol (Stephens et al. 2009).

Clean, Inventory, and Store Field Equipment

1. All equipment should be inventoried and check in using the KLMN property process.
2. All equipment should be cleaned, determined to be in working order, and stored in the proper storage location. Equipment should be prepared for long-term storage (2 years in some cases), including the removal of batteries.
3. Record broken or missing equipment on the inventory sheet. Label the equipment with sufficient information so that someone else will understand the specific problem.
4. Report missing or faulty equipment and/or equipment needing repairs to the Project Lead immediately so that equipment can be repaired or replaced before the following field season. The Project Lead should schedule a time to inform the Network Coordinator about needed repairs, purchases, and projected costs early in the fiscal year planning process (i.e., no later than November 1 following the field season).
5. Vehicles should be filled up with fuel and other fluids (oil, coolant, wiper fluid) and the inside and outside should be thoroughly cleaned. Mileage reports and vehicle maintenance forms should be submitted to the Project Lead.
6. After all data have been placed in their proper locations and backed up (in accordance with previous SOPs), electronic equipment should be checked in to the Data Manager. All project data should be removed from the equipment before being submitted. Any data or information remaining on the equipment **WILL BE DELETED** upon check in.

GIS Post-Processing and Organization

The GIS Specialist and Project Lead are responsible for:

1. The GIS Specialist uses GPS Analyst and the field-recorded SSF files to correct the positioning of the data. To complete this process follow these steps.
    a. Plug the Trimble unit into the computer.
    b. On the Trimble unit, copy the "Stream_Locations" shapefile and paste it on the KLMN Server at: S:\Monitoring\Stream Monitoring\Stream_GIS\Seasonal Data\YYYY\Trimble_XXXXX\Stream_Monitoring\Project_Data.
        i. Be sure the serial number of the Trimble unit matches the Serial number of the Trimble folder.
    c. Open the ArcMap project associated with this Trimble unit. It should be located at: S:\Monitoring\Stream Monitoring\Stream_GIS\Seasonal Data\YYYY\Trimble_XXXXXXXX\ArcMap Project
        i. Be sure the serial number of the Trimble unit matches the Serial number of the Trimble folder.
    d. Complete the correction of the data.
2. Perform quality control checks of the GIS data for correct projection definitions, logical consistency with other GIS data layers, and complete metadata viewable in ArcCatalog.
3. Corrected GPS data then will be given FGDC-compliant metadata using ArcCatalog metadata tools and will include notes about processing techniques and final GPS accuracy. These files then will be saved to the Network server at Monitoring\Invasive_Species_Monitoring\ISED_GIS\Seasonal_Data\2011.
4. Once the GIS Specialist has completed his/her tasks, the Project Lead should review the shapefiles and work with the GIS Specialist to cleanup and additional issues.
5. Once finalized, the Project Lead should complete the Data Certification form and submit it to the Network Data Manager.
6. Once the Data Certification form is submitted, GIS data from each survey year will be imported into one master Geodatabase for Stream Monitoring that includes all of the Network parks. This is located on the KLMN server at \\Data_Management\GIS\database\klmn\data\monitoring\Water_Quality.
7. Once the data certification is completed and the geodatabase is uploaded, the "ArcMap Project" and "GeoDatabase" folders within each Trimble subfolder should be deleted.

Data Forms

Data forms should be submitted to the Project Lead at the end of each sampling event. At the end of the field season, it is the Project Lead's responsibility to:

1. Ensure that all surveys have been completed.
2. Ensure that all data have been entered into the databases.
3. File extra field forms in the proper file cabinet for the following year.
4. Organize the forms for transmittal to the Network Data Manager as detailed in SOP #23: Data Transfer, Storage, and Archiving.

Data Management

Prior to ending the Crew Leader's position, the data and information collected as part of this project should be stored on the KLMN server as described in the "Project Folder" section of SOP #23: Data Transfer, Storage, and Archiving. It is the Project Lead's responsibility to review and clean up this data and to submit the Data Certification form to the Data Manager prior to releasing the Crew Leader. Once the data has been certified, the Data Manager will merge the 2 field databases together into 1 Seasonal Database. Once merged, the Project Lead will upload the Manta data, Photo data, and invertebrate data. Once these 3 datasets have been uploaded, a certification form should be submitted for this aspect of the data review. Once all datasets have been certified, the electronic data deliverables can be submitted to the WRD and the Data Manager can upload the data to the Master Database. At this point analysis and data summaries can be completed (SOP #22: Data Analysis). Details for this process are described below.

Merging the Crew Leader and Crew Member Databases.
Once the Project Lead has reviewed the two field databases (Crew Leader and Crew Member) they will need to be merged together into one database that we call the Project Database. To complete this process, follow these steps.

1. Click the administrative command button on the main switchboard of the database which will open the administrative form (Figure 51. **The administrative form of the KLMN stream monitoring project database.**).

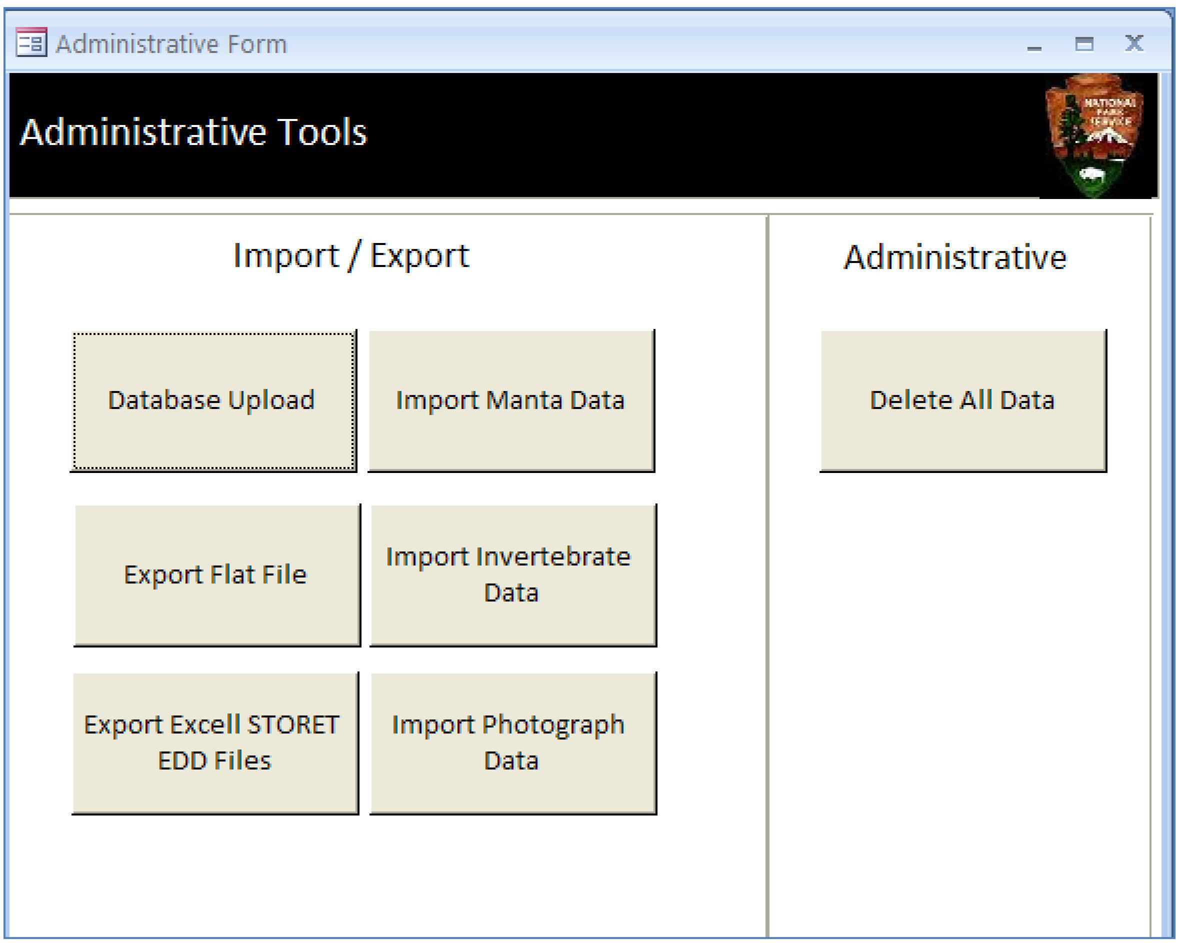


Figure 51. The administrative form of the KLMN stream monitoring project database.

2. On the administrative form, click the “Data Upload” command button. This will open a form similar to Figure 52. You will note there are 2 options on this form and you must check one of them. Upon checking the options, additional tabs will become available.

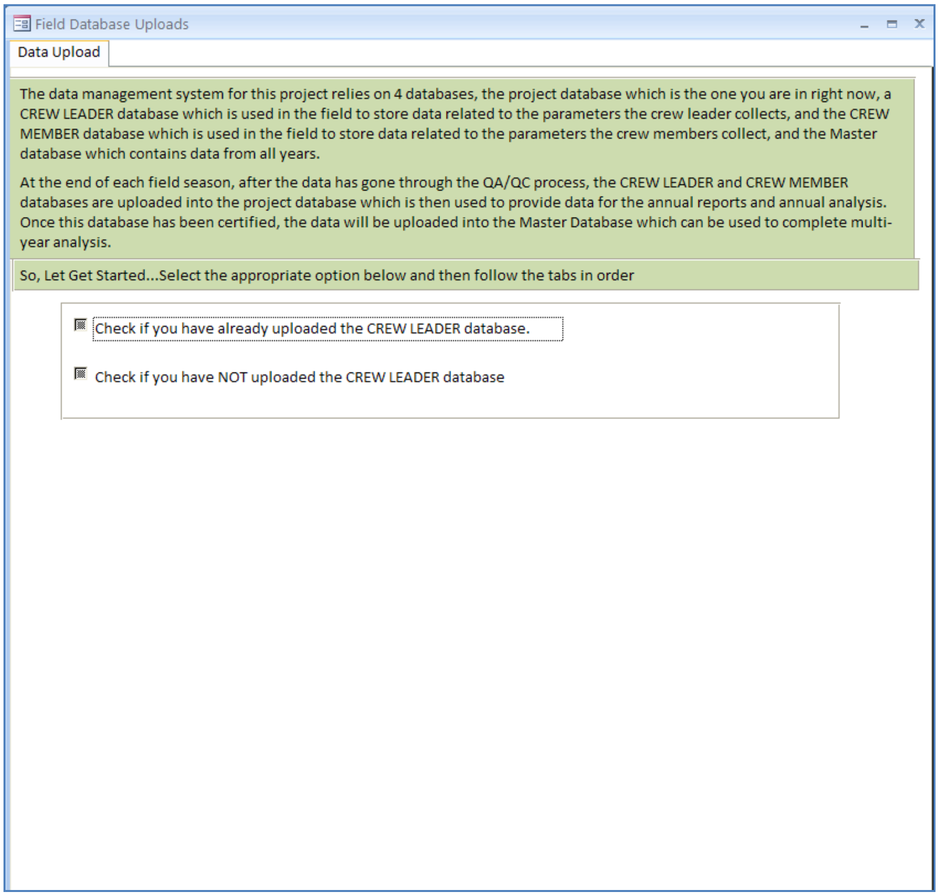


Figure 52. The main form of the data upload form used to upload data from the Crew Leader and Crew Member databases.

3. Once you select an option, 3 additional tabs will become available depending on which option you chose. Figure 53 shows an example where the second option (check if you have NOT uploaded the Crew Leader database) on the main form was chosen.
4. Using the browser, browse to the database that you want to upload. If you are on the “Crew Leader Database” tab be sure you browse to the Crew Leader database and if you are on the “Crew Member Database” tab be sure you browse to the Crew Member database (Figure 53).
    a. Please Note, if you browse to the front-end of the database you will link to the database so any changes being made will be made in both databases. If you are browsing to the back-end of the database, changes will only occur in this database which is the recommended option.
    b. Be patient while the data uploads, this can take a few seconds.
5. Once the data has uploaded, click on the “Key Issues” tab. This tab points out if the data being uploaded contains any new sites, locations, contacts, or enumeration values. It

would be a rare case when a crew would be adding this type of data so it is flagged for review. If the Project Lead agrees with the additions, continue on to the next phase.

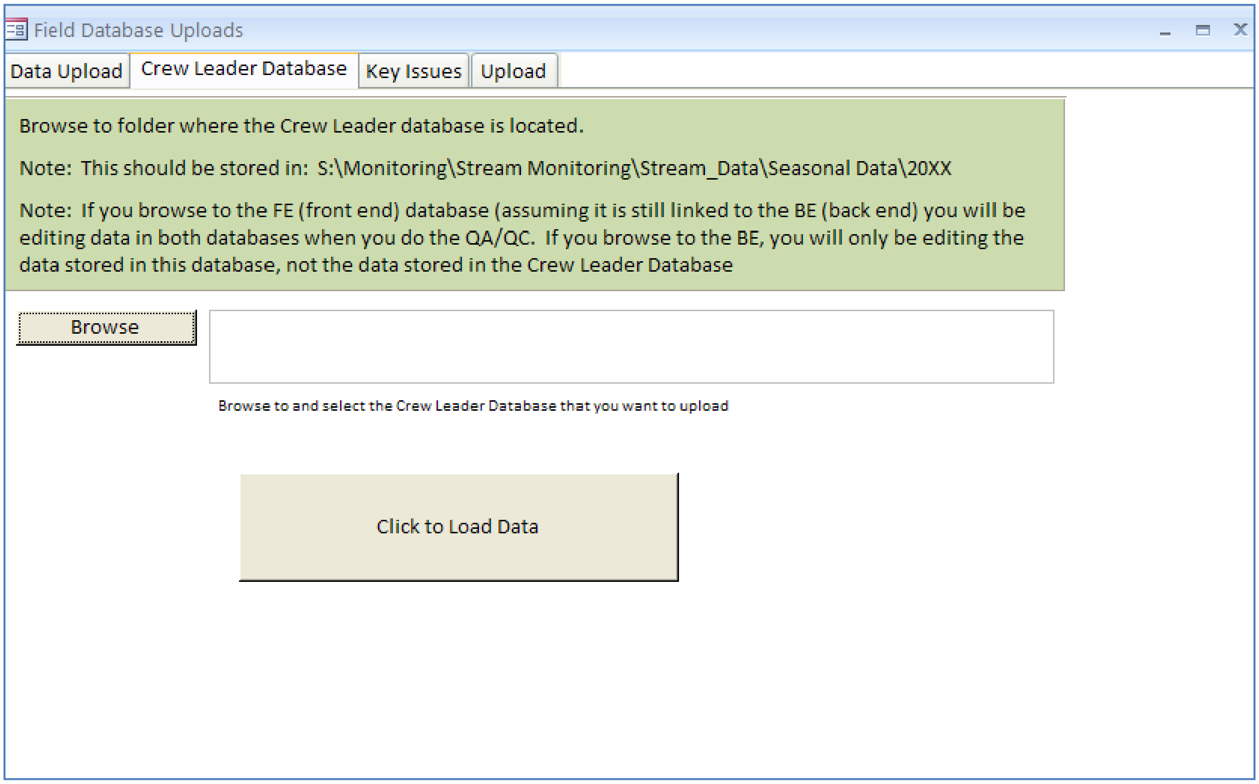


Figure 53. An example of the browser page used to browse to the database you want to upload.

6. Now click on the "Upload" tab. Depending on which database you are uploading this form may look a little different then the figure below (Figure 4).
7. Click on each command button to upload the data. You will notice the number of records in the database you are uploading (Crew Database), the number of records currently in the project database, the number of records actually uploaded, and the final number of records are tracked to help point out any issues.
8. Once you are done, click the "Finalize Data" button.
9. Repeat this process for each database that needs to be uploaded.

Uploading Manta, Invertebrate, and Photograph Data

The KLMN collects a variety of data as part of this project and in some cases specialized gear (Manta) is used to collect the data, labs are used to analyze the data (invertebrates), and datasheets are used to record data (Photographs). In the end, the Project Database will house all data collected in a season and the Master Database will house all data collected as part of this project. Therefore, these datasets mentioned above will need to be loaded into the database following the steps described below.

Manta Data. The data collected using the Manta probe should be stored in a .CSV file using the standardized template located at:

S:\Monitoring\Stream Monitoring\Stream_Data\Database Template\Manta Templates

Once the data has been downloaded and is in the proper format the Project Lead should complete the following steps.

1. Click the administrative command button on the main switchboard of the database which will open the administrative form (Figure 51. **The administrative form of the KLMN stream monitoring project database.**).
2. On the administrative form, click the “Import Manta Data” command button. This will open a form similar to the one below (Figure 54).
3. Using the browser, go to the manta .CSV file that you want to upload.
4. Once selected, click on the “Upload Manta Data” button.

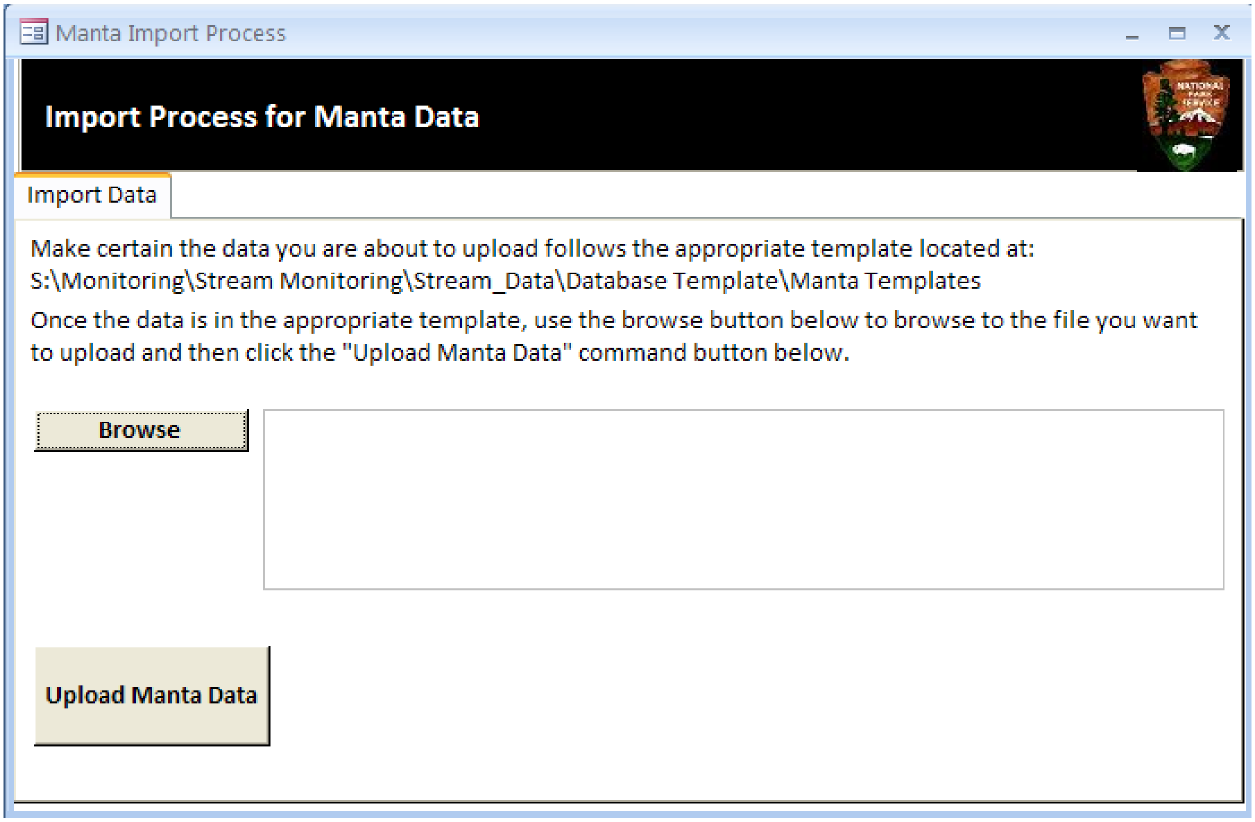


Figure 54. Form used to upload the manta data from the text file.

Invertebrate Data. The invertebrate data received from the lab needs to be in the proper format and should follow the template located at:

S:\Monitoring\Stream Monitoring\Stream_Data\Database Template\Invertebrate Templates

Once the data has been received from the lab and is in the proper format the Project Lead should complete the following steps.

1. Click the administrative command button on the main switchboard of the database which will open the administrative form (Figure 51. **The administrative form of the KLMN stream monitoring project database.**).
2. On the administrative form, click the "Import Invertebrate Data" command button. This will open a form similar to the one below (Figure 55).
3. Using the browser, go to the invertebrate .XLS file that you want to upload.
4. Once selected, click on the "Upload Invert Data" button.

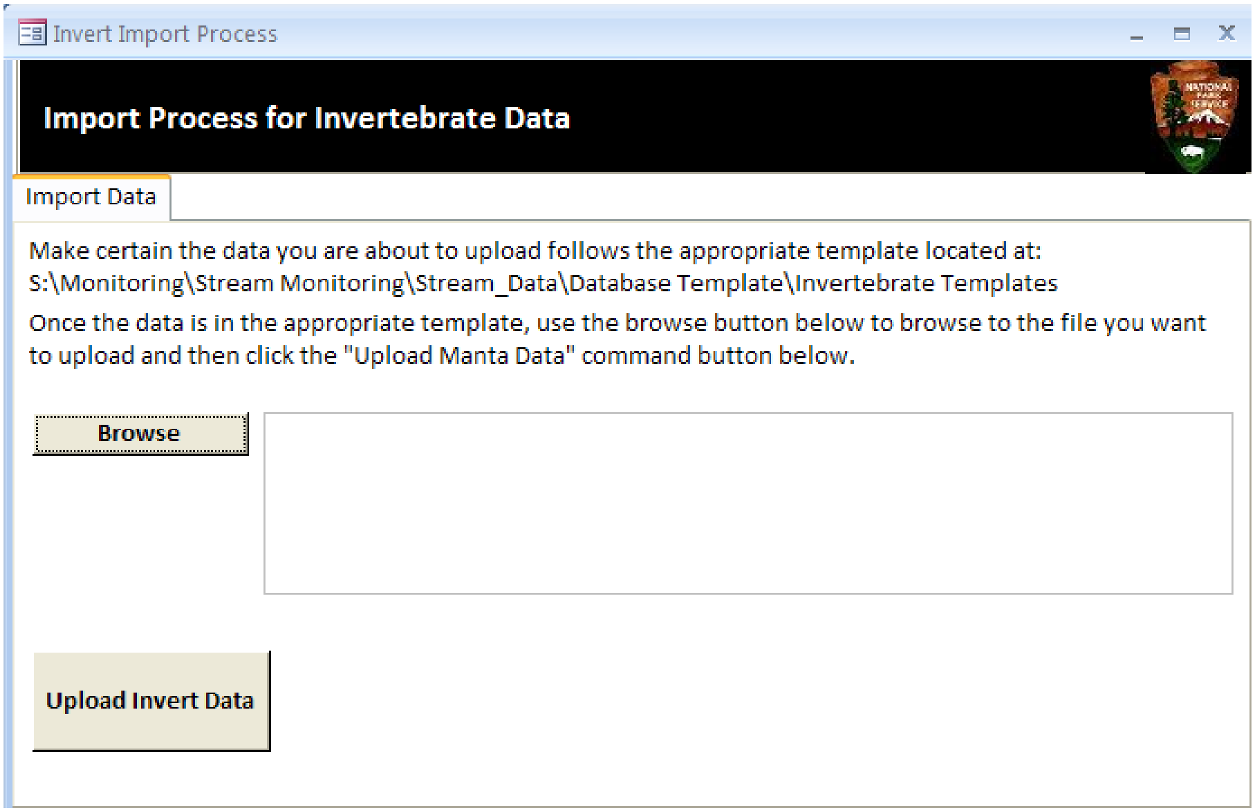


Figure 55. Form used to upload the invertebrate data received from the lab.

Photograph Data. The database used for this project has the ability to add photograph metadata for photographs taken at a site relatively quickly (preferred option); however the field crews are provided datasheets which can then be entered directly into the database (second option) or onto an Excel spreadsheet (third option). If the excel spreadsheet is used complete the following steps to upload the data into the database.

1. Click the administrative command button on the main switchboard of the database which will open the administrative form (Figure 51. **The administrative form of the KLMN stream monitoring project database.**).
2. On the administrative form, click the "Import Photograph Data" command button. This will open a form similar to the one below (Figure 56).
3. Using the browser, go to the photograph .xls file that you want to upload.
4. Once selected, click on the "Upload Photograph Data" button.

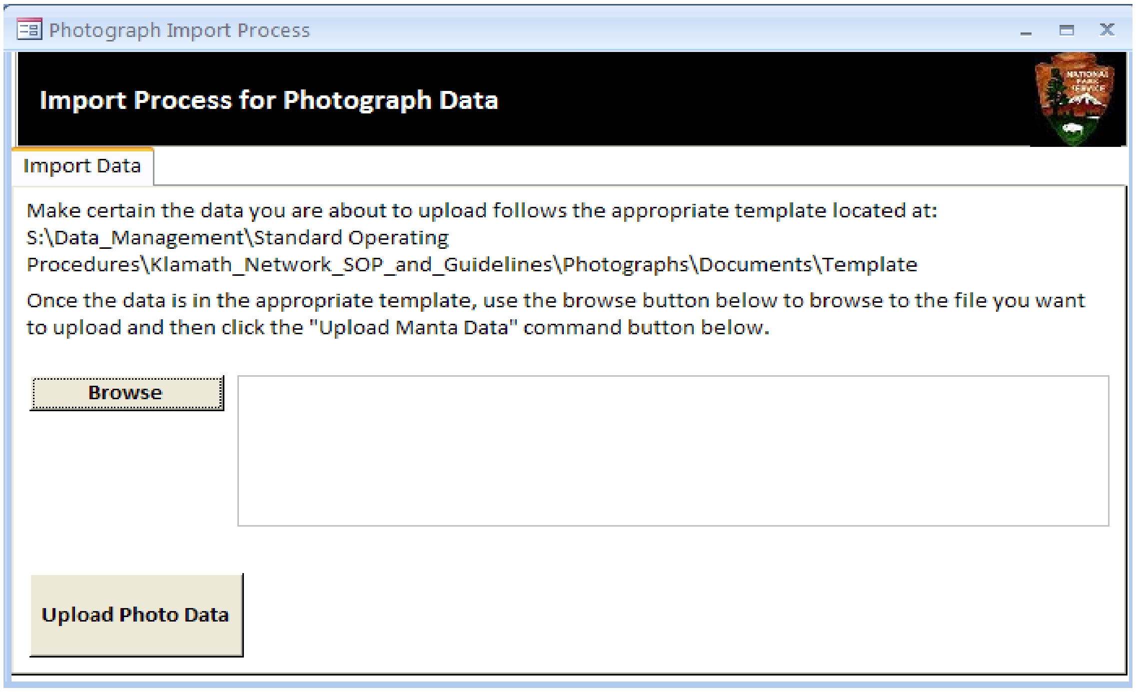


Figure 56. Form used to upload photograph metadata for pictures that can be linked to a site.

Electronic Database Deliverables

Once all of the data has been entered into the databases (including the macroinvertebrate data), the field databases have been merged together into the PROJECT database, and all QA/QC steps have been followed, the Project Lead can submit the seasonal data to the NPS Water Resource Division (WRD) utilizing the Electronic Database Deliverables template provided by WRD. In the first few years, the Project Lead should work closely with the Data Manager to complete these steps in an effort to ensure their accuracy.

This is an automated process built into the KLMN stream database and the following steps should be followed to complete this process.

1. Open the Project Database stored at: S:\Monitoring\Stream Monitoring\Stream_Data \Seasonal Data\YYYY\Project Database
2. Click on the “Administrative” command button and then click on the “Export Excel STORET EDD Files” command button (Figure 51). A form should open looking similar to the form below (Figure 58).
3. Click the “Review Project Information” tab and “Review Location Information” tabs and review the preset data fields here to make certain they are accurate. The information on these 2 tabs is standard information for this project and should not change without permission from the Project Lead. The Project Lead should pay close attention to this information and update it as needed. An example of the “Review Project Information” tab is provided in Figure 59. Note that there are 3 tabs that contain required and optional information. Most of this information should remain consistent from year to year so be careful if you decided to change anything.

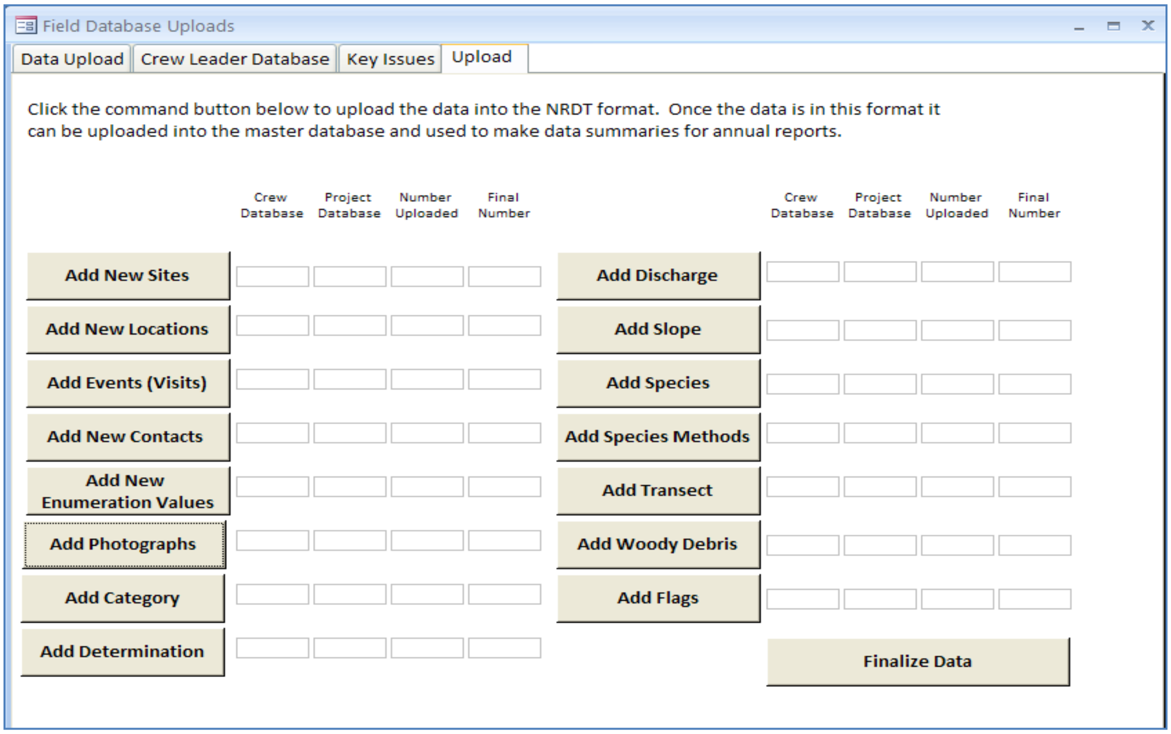


Figure 57. Data upload form used to upload date from the field databases into the project databases.

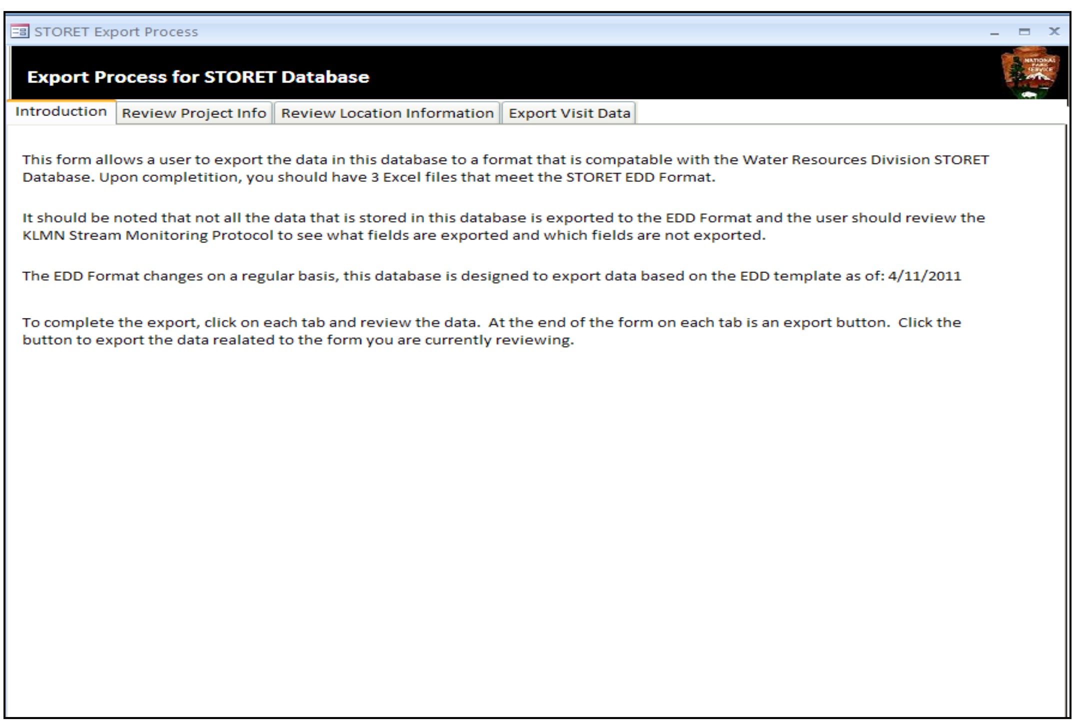


Figure 58. KLMN electronic database deliverables export form.

4. Next, click on the "Export Data" tab (Figure 59). This tab has 4 command buttons that allow you to export the data into the 4 Excel files (BioMTPC Results, Regular Results, Stations, Projects). To finalize this process complete the following steps:
   a. Using Microsoft explorer, browse to the location of the WRD EDD templates. They should be located at:

      S:\Monitoring\Stream Monitoring\Stream_Data\Database Template\EDD Templates

   b. Save a copy of all these files to the following location:

      S:\Monitoring\Stream Monitoring\Stream_Data\Seasonal Data\YYYY\WRD Submitted EDD

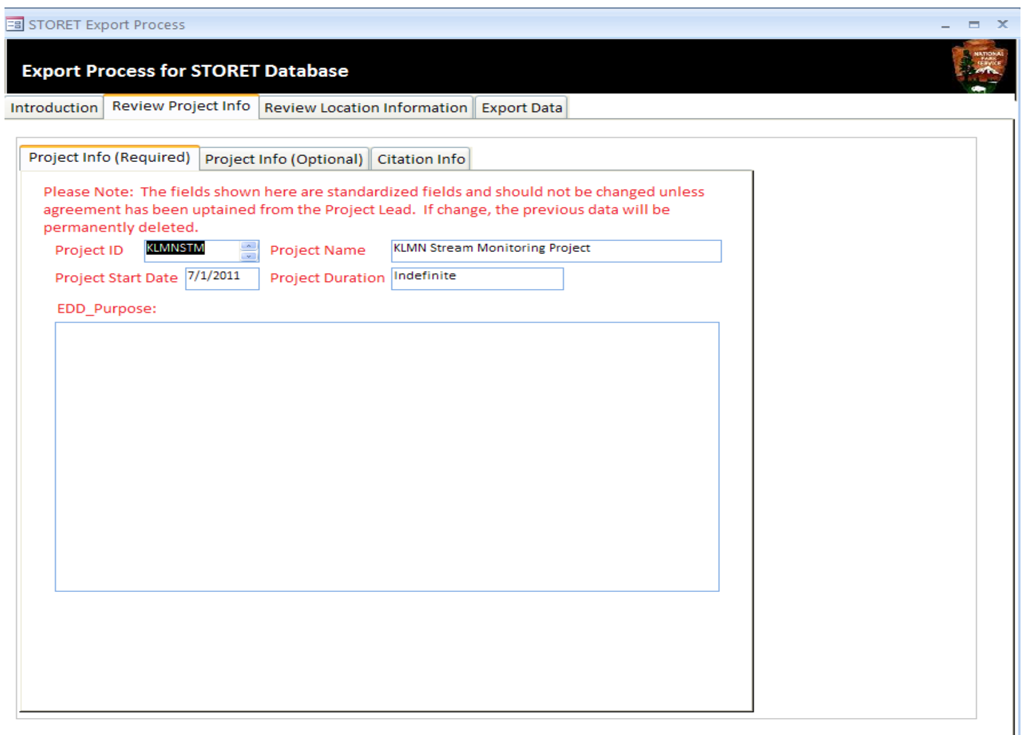


Figure 59. An example of the "Review Project Info" tab.

   c. Using the browser on the data export page (Figure 60), browse to the location of the PROJECTS.XLS file you just copied and pasted.
   d. For each file, click the associated command button to export the data.
   e. Review the Excel files to ensure they are complete.
   f. Submit the files to the NPS Water Resource Division contact.

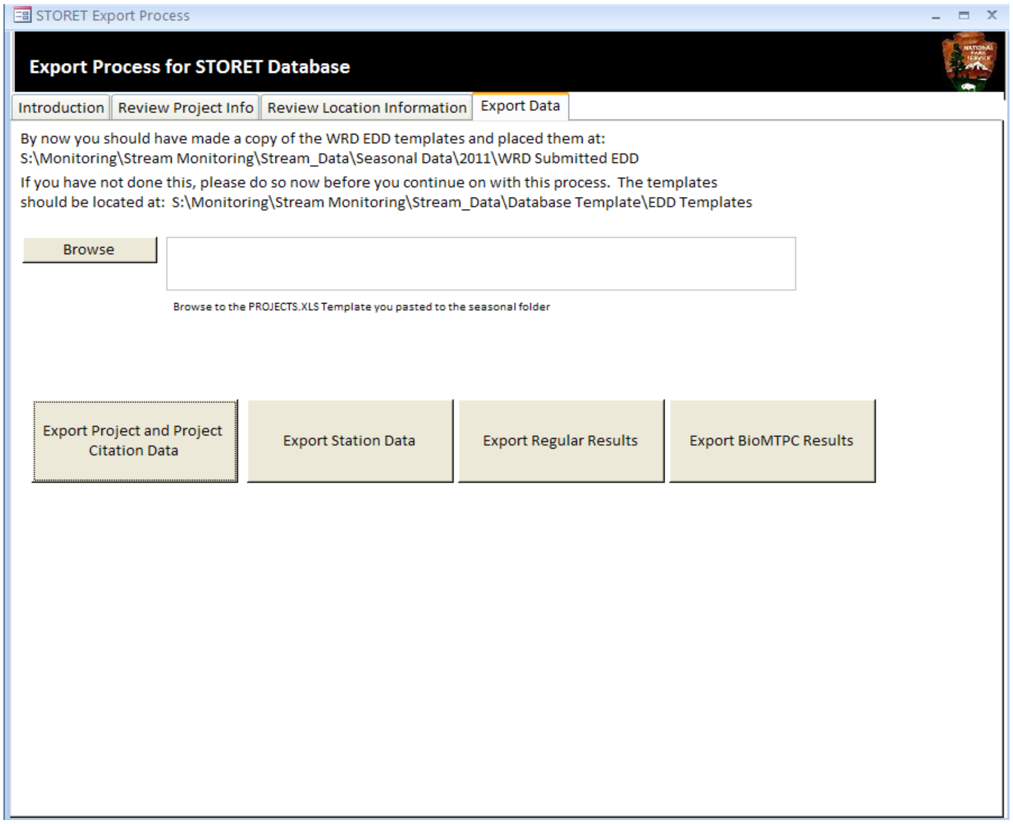


Figure 60. The data export page which is used to export the data into the WRD EDD template.

Close-out

The Project Lead should communicate with the Park Contact to determine whether keys and/or other equipment need to be returned. Once keys and equipment have been returned, the Network Contact should be notified.

Field Season Reporting

The Field Crew Leader should prepare a brief report (generally not more than three pages) that includes the following:

1. Clear enumeration of which streams were completed during the season.
2. Description of any logistic difficulties that arose and explanation of how they were addressed.
3. Clear documentation and explanation of any diversions from established protocols.
4. Discussion of any interesting or potentially important observations that may have been noted during the field season
5. Suggestions for improving the training session or field season logistics in the future.

After this brief report, there should be a debriefing session in which the entire field crew and the Project Lead discuss the field season and any issues in the report. The Network Coordinator and Network Data Manager are encouraged to attend this meeting.

Electronic Equipment

The Field Crew Leader should make certain all electronic equipment is cleaned and in working order. Electronic equipment includes the tablet PCs, GPS units, Trimble units, and cameras. Upon submitting the equipment for check-in, all project related materials (images, databases, documents, and shapefiles) should be removed from these units.

Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #19: Quality Assurance Project Plan

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

Consider the following scenario: A driver is pulled over by an officer of the law for speeding. This officer used a radar gun to determine that the driver (maybe you, the reader) was traveling 12 miles per hour over the speed limit. In your defense, you believe that you were not traveling that fast, and that maybe his or her radar gun was not functioning properly. Maybe the radar gun was reading wrong and that the margin of error on the radar was plus or minus 12 miles per hour? All valid concerns, except that the officer can confidently tell you that the radar gun was calibrated the previous day against a known speed, and that the margin of error is documented at plus or minus 2 miles per hour. Not only that, but they have written documentable proof of it, and in sum, you're *busted*. How was the officer able to know all of this? Because of a Quality Assurance Project Plan!

Just as the officer was confident of the radar gun reading, we have to be confident of our own stream measurements. Our path to confidence is also in a Quality Assurance Project Plan.

This SOP details the Quality Assurance Project Plan (QAPP) for this protocol.

The purpose of the QAPP is to ensure that data produced through this protocol is of a known, documentable, and defensible quality. A clearer way of defining the QAPP purpose is to pose example questions that it is supposed to answer:

- If we measure calcium to be 0.8 mg/L (at noon, in July, from a riffle), how do we know that it is actually 0.8 mg/L, and not 0.9 or 0.7 mg/L?
- If we measure calcium at 0.8 mg/L and in the future it is measured at 1.2 mg/L, how do we know that there has been an actual increase in the calcium and not just measurement error?
- If our multiprobe breaks and is replaced, how do we know that probe B (new) is giving comparable results to probe A (old)?

- In real world conditions, what is the variance or precision associated with our measurements, be it natural, temporal, or methodological?
- If we found insect species A in year 1, but not in year 10, is this because the species was locally extirpated, or because of a taxonomic error, or because of change in taxonomy?
- If we are making a probabilistic survey of the Network wadeable streams, how do we know our sample *really* represents the wadeable streams of the Network? If it represents it now, how do we know that it will represent the streams 30 years from now?
- If our data are compared or shared with other data sources, how do we know that our numbers are representative of other programs?
- If we produce data that do not meet certain standards, how are they handled?
- If we are not able to sample all of the sites or all parameters, do we still make inferences to the park units?
- If a field in the database is left blank, how do we know if that data was not collected, did not exist, or was accidentally not entered?
- If measurements made by the Network are used in a court of law, how do we prove that we followed the SOPs to the letter and that the data represents the best measure of "truth" possible?

The answers to these questions are dealt with in two primary methods: documentation and methodology. The documentation includes the most basic form: the current protocol, from the narrative to the last appendix, and of course, the strict adherence to the methods described in the SOPs. The delivery of data must also include documentation. In this form, much of the documentation is metadata provided with the data. It is also in the strict documentation of all events related to this protocol, even though not directly related to the data about wadeable streams (e.g., the documentation of field crew training and calibration events).

To help ensure quality data, methods are implemented to deal with the inevitable change (e.g., new instrumentation, changing analytical chemistry laboratories). Other methods affecting quality data are data validation and verification steps. In addition, the development of a data collection system that incorporates domain values, pick list, and logic checks is important.

Some aspects of this QAPP will come in the form of guidance. When possible, the following steps and methodology should be carried out. **It is through the documentation of errors, variance, etc. (whatever the source) that the quality of the data is known.** Where possible, this should be included with the metadata. For example, with the cumulative bias procedures (described below), it is recommended that a shift in personnel be accompanied by seven overlapping measurements. For a field crew change, with 2 years in between sampling periods, this is untenable. For the Project Lead, who is responsible for training the field crews, it would be wise for the outgoing Project Lead to sample with the incoming Project Lead. However, personal situations can easily prevent this from happening and the cost of processing seven extra macroinvertebrate samples can easily be out of the budget.

Sampling Frame, Sample Size, and Minimum Detectable Differences

Sampling Frame

The sampling frame for this protocol is all wadeable streams in Lassen Volcanic National Park, Crater Lake National Park, Whiskeytown National Recreation Area, and Redwood National and State Parks (the only component of our design with a probabilistic sampling design), with the following criteria:

- Perennial – This selection criterion is applied to remove habitats that are influenced by seasonal desiccation which could mask other stressors of interest. It also ensures that data collection can always occur at the sites, assisting in data completion goals.
- Less than 1000 m from a travelable road or trail – This selection criterion reduces logistical constraints to field crews, such as travel time, to ensure that each site can be sampled in the allotted time frame for achieving sampling objectives.
- In mild topographies with stream slopes <15% – This selection criterion ensures crew safety and that access to streams is doable.

As Irwin (2008) points out, long-term monitoring plans must deal with the possibility of the population of interest "drifting" in and out of the sampling frame. An example of a realistic event causing this is the park making new roads or trails (or decommissioning roads and trails). This would change the list of habitats within our sampling frame.

As part of this protocol, the adequacy of the sampling frame will be revisited on a regular interval of 15 years (every four sampling periods). If the sampling frame or population of interest is found to have changed within this period, corrective action, as necessary to accomplish the goals of this protocol, may be undertaken.

Sample Size and Minimum Detectable Differences

This protocol focuses on park-level inferences, using measures of central tendency to track changes in status and trends. To achieve this, with ample statistical power in select parameters (see narrative), a minimum sample of 25 streams is required. Based on data completeness goals (see below), we have increased the sample size to 30.

Minimum detectable differences are a question of power and are detailed in the power analysis, covered in the protocol narrative.

Data Comparability

Comparability is the measure of confidence that one dataset, element, or method can be considered as similar or identical to another (SWAMP 2008). The goal of this document is to ensure that if the programmatic requirements are fulfilled, then the data collected by this protocol is considered to be a similar quality level.

It is outside the scope of this protocol and Network budget to do comparability studies to other methodologies, be it Forest Service, academic, or state sponsored monitoring. As research or external funding is available to address these comparability studies (and as need dictates), Network staff may work towards these goals. During the development of this protocol, methods and parameters being implemented by other agencies were considered and in some cases applied to this protocol However, the fundamental goal of this QAPP and overall protocol is to ensure comparability *within* our program. The major source of potential variation that could affect data comparability is protocol or equipment changes.

Data Completeness

The Klamath Inventory and Monitoring Network recognizes that a certain percentage of samples of all types (invertebrates, water chemistry, etc.) will fail. Reasons for failing may include lost samples, dehydrated samples, samples that exceed holding times, or sample contamination.

Data completeness goals are based on a multi-step process detailing the minimum sample size needed to make statistical inferences about the population of interest (Irwin 2006). Once this minimal sampling size is calculated (see Sampling Frame and Sample Size and Minimum Detectable Differences, above), the number of samples that will fail is estimated and the sample size is increased by the same percentage. This procedure is complicated for multi-parameter protocols, such as the one here. Water chemistry samples (with multiple types), invertebrate samples, water probes, and GPS files may all fall short of precision targets, but at different failure rates. However, since we are making inferences to a population of streams, the ultimate sample size for this protocol is *the number of sites*.

During the initial scoping period, it was determined that a minimum of 25 samples are needed to characterize the population of streams with desired levels of precision (A. Merton, statistician, pers. comm..). Following the guidance of Irwin (2008), we increased our sample size to 30 streams reaches to accommodate unforeseen problems.

Cumulative Bias

The term bias has many definitions, even within the realm of statistics. Here, bias is taken to be a systematic error in measurements. Over the length of a monitoring program, bias may cumulate from many sources: collector bias, instrument bias, protocol bias, etc. With the obvious expectation that personnel and gear will change and protocols will be revised over the years (SOP# 24: Revising the Protocol), QAPP methodology for dealing with change and minimizing and documenting the cumulative bias are laid out below. Following these procedures will allow for Data Comparability.

Any change in the following categories will be documented in the metadata produced during the project. Just as field crew personnel changes from year to year are documented, the different laboratories (although changing labs should be a severe option) will also be documented.

Change in Personnel

When possible, it is recommended that personnel changes be accompanied by an overlap of seven measurements. For the streams protocol, this extrapolates to essentially duplicating the sampling effort at seven sites, in all measured parameters. This is prohibitively costly to do and hence an alternative method of documenting variance in personnel bias is presented.

It should also be stressed that control of personnel bias is done through strict, exact SOP adherence and through training. Furthermore, it is valuable to focus interpretation to measures that are less likely to be affected by personnel differences. For example, macroinvertebrate abundances can be highly affected by personnel experience; however, relative abundance or Presence/Absence measures are less affected by personnel. Hence, inferences to site or temporal impacts should be evaluated at the more robust measures first.

Change in Equipment

When possible, replacement equipment should match the original equipment. Specifications of replacement gear should also match the original equipment. If being replaced because of planned obsolescence, the new equipment should be tested against the old equipment to establish comparability. The Project Lead should strive for a large number of independent tests of comparability (greater than 30 being idealistic).

Change in Contract Laboratories

Bias from different laboratories is a source of error that is under the control of the Project Lead. Generally, a change in labs used should have solid rationales, which include (but are not limited to), the following reasons:

(1) Lab shuts down or otherwise closes.
(2) Dramatic price increase so that the Network cannot meet sample completeness goals.
(3) Lab consistently fails to meet agreed upon deadlines for data delivery.
(4) Laboratory internal QA/QC procedures change or their methodology changes.

It is the responsibility of the Project Lead to stay in communication with contracting officer representative and laboratory managers to ensure that laboratories meet the standards and that lab continuity is maintained where and when appropriate. The Project Lead should strive for a large number of independent tests of comparability (greater than 30 being idealistic).

Measurement Quality Objectives

Due to the regulatory nature of water quality, certain response variables require increased documentation of data quality. The documentation is in the form of Measurement Quality Objectives (MQOs), and serve as both thresholds for accepting data values and as reporting requirements to establish measurement variation (Table 1). For comparability, it is necessary to ensure that Network MQOs are identical, or more stringent than other labs or methods, where possible.

Alternative Measurement Sensitivity+

Alternative Measurement Sensitivity+ (AMS+) is a method of describing the variation in a measurement (Irwin 2008). It is simply a 99% confidence interval calculated by seven closely spaced field measurements. It can be viewed as a two-sided version of Method Detection Limit, as a way of documenting how precise the estimate of a mean may be. In the wadeable streams protocol, it is applicable only to data collected with the water quality multiprobe. It is a real-world method of documenting variance, since it incorporates variation due to (1) user, (2) instrumentation, (3) temporally, and (4) spatially. It is a measurement to document with reporting, but there is no “standard” or threshold for AMS+ for reporting or rejecting data.

Table 16. Summary of five measures of Measurement Quality Objectives (MQO). CI = confidence interval.

MQO Name	Acronym	Description	How measured for KLMN	Applicability	
				Multiprobe	Water Chemistry
Alternative Measurement Sensitivity+	AMS+	Real world measure of variation associated with response variable, incorporates user, temporal, and spatial variability.	99% CI of 7 field measurements	*	
Minimum Detection Level	MDL	Minimum concentration that can be reported and measured; based on 7 replicate measurements of the estimated detection limit.	MDL = t value for 99%CI*Standard deviation of 7 replicates		*
Minimum Level of Quantification	ML	Lowest level at which a method can produce a recognizable signal and acceptable calibration.	ML = MDL * 3.18		*
Precision		A measure of how repeatable a measurement is over replication.	At low concentrations, equal to MDL, above transition values, % Relative Standard Deviation		*
Accuracy		A measure of how close a measurement is to the "True" value.	% recovery during calibration = (pre-cal measurement/cal standard) * 100 and/or Net Bias = mean value of set of measurements – theoretical value	*	

Minimum Detection Limit

Minimum detection limit (MDL) is lowest level that a chemical measurement can detect the presence of an analyte. It is calculated by running seven replicate samples of a standard at the expected low detection level, and is the 99% confidence interval, so that a measured value above the confidence interval is not bounded by a "zero" reading. It is a laboratory analogue of AMS+, since both measure sensitivity/variation associated with a measurement, although MDL is one sided, and AMS+ is two sided. For laboratory purposes, it is determined on a per method/instrument basis and is not run on analytical samples. Samples with values below the MDL must be reported as "non-detects."

Minimum Level of Quantification

Minimum Level of Quantification (ML) is the lowest level that a method can give a recognizable signal of a quantifiable level. It is calculated as 10 times the standard deviation used for calculating the MDL. When based on seven replicates, this is equal to the MDL multiplied by 3.18 (as is standard and implemented here). Results falling in between the MDL and ML must be reported as "detected, below quantification limits" for WRD and EPA databases. However, numeric values reported still have interpretable use and will be retained and used by the Network. The ML is applicable to all water chemistry measurements made in a laboratory.

Precision and Accuracy

Precision and accuracy are terms that characterize the sampling adequacy of methods or techniques. Precision characterizes the repeatability of a measurement; if two replicated measurements are identical or very close, they have high precision, but if two measurements diverge, they have low precision. Accuracy contrasts to this in that it is a measure of how close a single (or multiple) measurements are to the actual real value. The differences in precision and accuracy can be best illustrated using a "bulleyes" diagram (Figure 1).

Because precision is a measure of repeatability, it is best expressed as a confidence interval, identical to AMS+. In this regard, AMS+ is a measure of precision associated with a measurement. Because it is standard to base the precision of laboratory measurements with a sample size of seven, and use 99% confidence intervals, precision reported by laboratories is identical to AMS+. However, this calculation is only used for low concentrations, and above a "transition" value the precision is expressed in relative terms (% Relative Standard Deviation). The transition value by convention is the absolute value (the AMS+) divided by the % relative objective. So if an analysis has an AMS+ of ±0.02 mg/L, and the % objective is 5%, then the transition value equal 0.02 divided by 0.05, equaling 0.4 mg/L. For values measured below 0.4 mg/L, the precision objective is thence 0.02 mg/L, and above 0.4 mg/L it is 5% Relative standard deviation.

Accuracy is more difficult to measure, since the "true" value of a sample is unknown. Even for calibration solutions, or spiked samples, the exact true value is unknown. Laboratory programs using the USGS Interlaboratory QA Studies program compare analytical results against not, true values, but "Most Likely Values," indicating the possible discrepancy in reported "truth" versus the actuality. When accuracy is consistently directed in a systematic way (e.g., consistently low readings), it is referred to as bias (Figure 1). Bias can only be measured when there is a "known" sample, or a reasonable resemblance of "known."

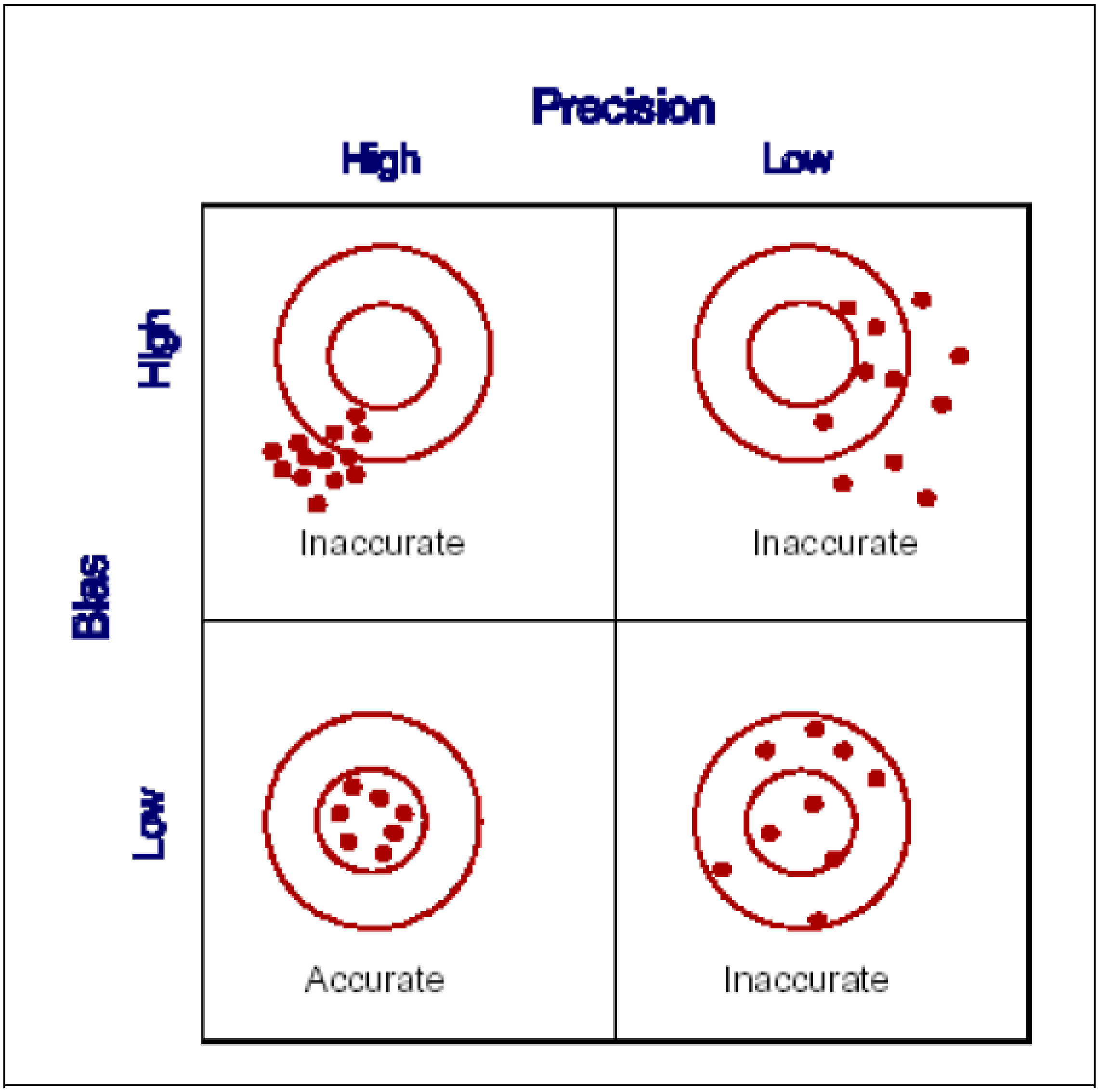


Figure 61. Diagram showing the relationship of accuracy, precision, and bias. From ODEQ (2009).

Accuracy objectives are commonly described exactly as precision objectives, e.g., the true value must fall within 0.02 mg/L, where 0.02 mg/L is the AMS+. For this reason, many laboratories report "Precision and Accuracy" in a single reporting value. For laboratories, check of accuracy rely on participation in interlaboratory studies, and cannot be done on routine basis. Accuracy is maintained in analytical runs using calibration standards and source check standards, where the recovery value must be within 10% of the theoretical value to accept the data during the analytical run.

Accuracy of multiprobes can be measured from calibration checks, and is generally expressed as % recovery using the equation:

Where $Value_{cal}$ refers to the "known" standard, and $Value_{measured}$ is the measured value of the standard (prior to calibration).

Implementing MQOs

Measurement Quality Objectives for the Network are provided in Table 2. Included is a comparison of EPA Wadeable Stream Assessment (USEPA 2004) and State MQOs in the Oregon Department of Environmental Quality Water Monitoring and Assessment Mode of Operation Manual (ODEQ 2009) and California Surface Water Ambient Monitoring Program QAPP (CA SWAMP 2008). Adopted MQOs were chosen to maximize comparability; note that in some analytes the Network MQOs are more stringent than either EPA or State standards. However, for both nutrients (Phosphorous and Nitrogen) as well as Calcium and Magnesium, the EPA standards were more stringent than current laboratory standards (chosen for comparability to existing NPS datasets).

Laboratory analyses

All chemical analyses must specify MDL, ML, and Precision/Accuracy based on laboratory specifications. Changes in labs (see Cumulative Bias) must maintain or improve upon these estimates. Reporting to WRD and EPA STORET must utilize MDL and ML qualifiers (e.g., below detection limits; detected, below quantifiable limits). Accuracy for lab analyses should be addressed through interlaboratory comparison programs (USGS Standard Reference Surface Water test program; National Water Research Institute Environment Canada testing program).

Field analyses

Multiprobe measurements must have their precision addressed using AMS+ measurements and calculations at all sites. There is no "threshold or standards" for AMS+ since this incorporates spatial and temporal variability as part of the measurement. Although preferred to be low, sites with high AMS+ can simply indicate high habitat variation. Accuracy should be addressed by recording the difference between pre-calibration readings and the actual standard solution, following the calibration schedule and bias checks in SOP #7: Water Quality Multiprobe Calibration and Field Measurement. Accuracy (or bias) should be calculated on a weekly basis during field season to determine if corrective action is needed for field analyses, including use of a portable Winkler titration for dissolved oxygen check using mg/L.

Reporting MQOs

Laboratory MQOs do not have to be specified in reports, however reports should reference this document for details on the Quality Assurance Project Plan. Data deliverables to the WRD Storet and EPA Storet must utilize reporting limits. Field analyses MQOs should be summarized as AMS+ along with reporting of mean values; either for site specific AMS+ or a global AMS+ average of all sites. Overall estimates of bias/accuracy for each field analyte (e.g., dissolved oxygen, conductance, pH, etc.) should be summarized in the annual report. Reporting should adhere to standards of significant digits: Dissolved Oxygen, temperature = 2 digits; all others = 3 digits (see USEPA 2004 for examples).

Table 17. Summary of Measurement Quality Objectives (MQOs) of relevant monitoring programs (state and national) and the adopted MQOs of the Klamath Network. See text for more details. EPA WSA = Environmental Protection Agency Wadeable Streams Assessment. MDL = Minimum Detection Limit, ML = Minimum Level of Quantification. Numbers in parentheses are the Transition Value (TV); see text.

	Oregon[1]		California[2]		EPA WSA[3]		Klamath Adopted			
Analyte	Accuracy	Precision	Accuracy	MDL	Precision and Accuracy	MDL	Precision	Accuracy	MDL	ML
Laboratory										
Calcium (mg/L)	Oregon generally adopts EPA standards[4]		80-120% recovery	0.05	± 0.02 or ± 5% (0.4)	0.02	± 0.06 or ± 5% (1.2)		0.06	0.19
Chloride (mg/L)				0.25	± 0.03 or ± 5% (0.6)	0.03	± 0.01 or ± 5% (0.2)		0.01	0.03
Dissolved Organic Carbon (mg/L)				0.6	± 0.1 or ± 10% (1.0)	0.1	± 0.05 or ± 5% (1.0)		0.05	0.016
Magnesium (mg/L)				0.02	± 0.01 or ± 5% (0.2)	0.01	± 0.02 or ± 5% (0.4)		0.02	0.06
Potassium (mg/L)				0.1	± 0.04 or ± 5% (0.8)	0.04	± 0.03 or ± 5% (0.6)		0.03	0.1
Sodium (mg/L)				0.1	± 0.02 or ± 5% (0.4)	0.02	± 0.01 or ± 5% (0.2)		0.01	0.03
Sulfate (mg/L)				1	± 0.05 or ± 5% (1)	0.05	± 0.01 or ± 5% (0.2)		0.01	0.03
Total Nitrogen (mg/L)				0.1	± 0.001 or ± 5% (0.002)	0.001	± 0.01 or ± 5% (0.02)		0.01	0.03
Total Phosphorous (mg/L)				DNE	± 0.001 or ± 5% (0.002)	0.001	± 0.002 or ± 5% (0.04)		0.002	0.003
Field										
Dissolved oxygen (mg/L)	± 1	± 1	± 0.5 or 10%	DNE	± 0.5 (NA)	NA	Measured as AMS+	± 0.5 or 10%	DNE	DNE
pH	± 0.5	± 0.5	± 0.2	DNE	± 0.075 or ± 0.15 (5.75)	NA		± 0.2	DNE	DNE
Redox potential (mV)	DNE	DNE	DNE	DNE	DNE	DNE		DNE	DNE	DNE
Specific Conductance (µS/cm)	± 10%	± 15%	± 4 or 10%	2.5	± 1 or 2% (50)	NA		± 4 or 10%	2.5	7.95
Temperature (°C)	± 1.0	± 2.0	± 0.5 or 10%	NA	± 1 (NA)	NA		± 0.5 or 10%	DNE	DNE
Turbidity (NTU)	± 30%	± 30%	± 2 or 10%	0.5	± 2 or 10% (20)	NA		± 2 or 10%	0.5	1.59

[1]Source: ODEQ (2009) based on “B” grade data, [2]Source: CA SWAMP (2008), [3]USEPA (2004), [4]Statement based on browsing assorted regional or site specific plans, and water chemistry MQOs were not included in ODEQ (2009) as part of QAPP.

Programmatic Elements of the QAPP

The following covers aspects of the day to day data acquisition and data generation that must be followed to meet the requirements of this QAPP.

1. Sampling Methods

All data generated or acquired through this protocol must adhere to all SOPs. Crews should be trained and training documented to demonstrate that this aspect has been met.

2. Replication of efforts

At 10% of the streams sites (three per park total), efforts of the crew members should be duplicated (e.g., the Field Crew Leader does a discharge measurement, followed by another crew member). Another example is in repeating alkalinity measurements by both crew members. Over the life of the protocol, this should result in a gradually building body of knowledge about the degree of variation caused by different personnel. It is recommended that the annual reports (SOP #22: Data Reporting and Analysis) include the results of this duplication of efforts as an evaluation of protocol success. If large variation between personnel is detected, this should trigger an evaluation of the parameter that the variation is large in. What thresholds of variation and technique of measuring variation might precipitate a re-evaluation will be dependent upon the parameter. Using alkalinity as an example, repeat measurements by different personnel that yield values of 20 mg/L and 23 mg/L are relatively very close and would generally be recognized as being in the neighborhood of low alkalinity, but the percent relative difference is actually somewhat high: (20 - 23)/20 = 15%. Percent relative difference is a commonly used measure for assessing QA/QC goals, but in this case, other techniques such as coefficients of variation may be more applicable. Hence, it is recommended that each parameter be evaluated by the Project Lead.

When repeating measurements at 10% of the stream sites, the repetition does not have to occur at the same sites. So alkalinity could be repeated at stream sites numbered 1, 3, 5, and 7, whereas the habitat could be repeated at stream sites numbered 2, 5, 9, and 12. The determination of what parameters to be repeated at which stream site should be a random determination by the Project Lead prior to the field season, although on the ground changes may be made so that sites can still sampled in a single day. Information for the field crews should be included in the site information folder (for example, see Appendix G). This will spread the repeat effort out across the sampling frame, so that the increased time for any one site is not beyond the logistical ability of the field crew. Care should be taken to document on the field forms and in the database which measurements are the duplicate.

If upon implementation, crews can adequately accomplish all sampling sites in the scope of their work load, consideration will be given to full replicate sampling, i.e., returning to a previously visited site several days after the initial sampling. Replicate sampling of this sort should be done within a short time span (several days) so that only sampling variability is measured, and not seasonal of temporal variability.

3. Sample Handling and Custody

Certain basic requirements concerning filter choice, holding container, storage method, and storage time (Table 3). Biotic samples are invertebrates require no special handling or holding

Table 18. Required sampling specifics to meet necessary goals of data quality for water chemistry analytes.

Analytes	Units	Required container (see SOP#1)	Required filter	Required sample volume	Required preservation	Maximum holding time
Filtered water sample:						
Anions (Cl, SO_4)	mg/L	Acid washed, HDPE	Whatman GF/C (1822-047)	50 ml	Frozen (-18°C)	28 days
Cations (Na, Ca, K, Mg)	mg/L	Acid washed, HDPE	Whatman GF/C (1822-047)	50 ml	Frozen (-18°C)	28 days
Unfiltered water sample:						
Total nitrogen	mg/L	Acid washed, HDPE	NA	100 ml	Frozen (-18°C)	28 days
Total phosphorous	mg/L	Acid washed, HDPE	NA	100ml	Frozen (-18°C)	28 days
			Total:	300 ml		
Other:						
Chlorophyll	mg/L	HDPE (storage for filter)	Millipore mixed Cellulose ester membrane (HAWP 047-00)	500 ml filtered	Frozen (-18°C)	28 days
Dissolved organic carbon	mg/L	Acid washed, furnace fired Amber Glass container	Whatman GF/F (1825-047)	60 ml	Refrigerated at 4°C	28 days

time, except to be preserved in 95% Ethanol. Chains of custody (Appendix F) must be maintained and logged to record the transfer and shipment of samples.

4. Chemical Laboratory Quality Controls

Chemical contract laboratories are required to meet certain responsibilities for assuring quality control to meet MQOs. For this protocol, the required controls are:

a) Instrument calibration prior to initiating analysis run (three to six NIST traceable standards).
b) Standards analyzed every 10 samples.
c) Detection limit standard run at least once in analysis run.
d) A minimum of 10% of the samples must be duplicated (lab duplicate, not field duplicate).
e) Field duplicates should be run (responsibility of Project Lead to provide, 10%).
f) Periodic blanks should be run.
g) The laboratory must have procedures in place for corrective action.
h) Laboratory must participate in interlab comparative studies for bias.

Filter blanks and bottle blanks should be included in the analysis. It is the responsibility of the Project Lead to have the field crew collect a minimum of four field duplicates during the field season. These are samples handled identical in every way to the original sample, but they are used to generate measures of precision for the analyses. The Project Lead must also provide bottle blanks (Acid-washed bottles filled with deionized water). Likewise, deionized water should be filtered using the protocol and then treated as samples. The purpose of these bottle and filter blanks is to ensure that there are no contamination sources in the bottle or filter preporation that may jeopardize results. Blanks, either filter or bottle, will be tracked in the database. When duplicates or standards are greater than 10% deviant, the instruments should be recalibrated and the analyses repeated back to the last successful standard check.

Laboratories not conforming to these criteria should be rejected by the program during the initial contracting period.

5. Corrective Action

If MQOs are not being met, corrective action is necessary. Contract water chemistry laboratories have internal checks using standards to ensure that the instrument does not experience drift, and are implemented by the respective laboratory.

For multiprobe MQOs, large amounts of bias or low precision should institute corrective procedures:

- Recalibrate instrument, ensure that calibration schedule is followed
- Clean and replace reference solution/membranes

If MQOs are still outside Klamath Network standards, the data should not be reported and the instrument should be returned to the manufacturer for maintainence.

6. Taxonomic Laboratory Quality Controls

Taxonomic laboratories should employ and use only taxonomists certified by the North American Benthological Society (NABS, www.benthos.org; an international scientific organization of aquatic ecologists) as trained taxonomists. There is currently no certification program for zooplankton taxonomists. For zooplankton taxonomists, a taxonomist C.V. or resume should be obtained and kept on record by the Project Lead as proof of taxonomic ability.

Macroinvertebrate taxonomy labs must be required to implement the Southwest Association of Freshwater Invertebrate Taxonomist Standard Taxonomic Effort (SAFIT STE) levels for processing Network Samples (www.safit.org; more detail provided in Appendix O: Tolerance Values, Life History Characteristics and Standard Taxonomic Effort). This will standardize the identification to increase comparability across other datasets (e.g., state monitoring agencies). Taxonomic laboratories must also either: (1) complete a voucher collection of each taxon identified, or (2) retain and curate the portion of sample sorted and identified. Either of these will allow for double checking taxonomic accuracy by later project leaders or subject area experts. Periodically, the project lead should send taxonomic specimens to secondary labs to confirm taxonomic identifications as a further check on precision.

7. Additional Documentation of Precision

Because the protocol is based on the developed protocols of other agencies and academics (particularly the USEPA), large scale studies of the precision on certain techniques may be available in published literature that are proper and relevant to the current protocol. For example, Archer et al. (2004) examines physical habitat measurements identical or similar to the methodology here (e.g., percent pools, residual pool depth, undercut depth, etc.) and examines the precision and variability in the measurements related to different observers and seasonal differences. Additionally, Kaufmann et al. (1999) provides a thorough examination of the USEPA EMAP physical habitat measurements and their precision (measured as Root Mean Square Error, Coefficient of Variation, and Signal to Noise ratio) for the exact physical habitat measurement used herein. Likewise, in techniques common to many sampling programs (such as the macroinvertebrate collection technique used here [Reach Wide Benthos]), these other programs have studied the precision associated with various techniques (Rehn et al. 2007). The above listed three references are the current known outside documentation, and the project lead should annually check for new emerging studies by other monitoring agencies on the precision associated with EMAP and associate protocols. These documents and results should be incorporated into trend tests and data interpretation as applicable.

8. Data Entry and Data Management

Data entry and data management are covered in SOP #4: Data Entry, but QA/QC procedures are described here.

Although the Klamath Network has opted to develop and maintain a Network-specific database, the database meets the requirement of the WRD to be consistent with NPS EDD (electronic data deliverables), so that all data will interface with both NPStoret and EPA STORET. This standardization and standard metadata requirements improve comparability of long-term datasets.

Prior to leaving the site, hardcopy datasheets, electronic data entry forms, specimen labels, and data logger data will be reviewed by the field crew before leaving the site. If possible, both field crew members should review all of the data. Field crew members should utilize built-in database utilities and their personal knowledge of the data to ensure all fields on the forms are complete and the entered data are logical and appropriate.

Data collected using datasheets during the project will be entered no less frequently than once a week. This will ensure (a) that details about the sampling event are still recent for the data recorders and (b) that the Project Lead can check on the progress of the data entry and associated tasks earlier rather than later. Hence, mistakes either in data collection or entry can be caught in time to rectify the problem.

Checks done by the Project Lead, both during the field season and at the end of the season include the following:

- Completeness checks - Are all forms in the database entered?
- Double checks - Are the entered values the same as on the datasheet? (A minimum of 20% should be checked; if there are a significant number of errors, 100% of the values should be checked.)

- Outlier checks - Are there any values that are outside the normal range of variability (such as measurement or natural variability, etc), that might be suspect? Full details on how to deal with outliers is presented in Irwin (2008).
- Data flagging - Are there any values that have been flagged by the crew? The Project Lead must determine if to accept, reject, or redo a flagged value, including having the field crew return to the habitat for re-measurement.
- Formal data verification - Verification of the data involves evaluating the correctness, conformance, compliance, and completeness of the entire dataset against the methods or procedures of the protocol (SWAMP 2008). Verification should be done on both field data (including field chemical analyses) and laboratory data (chemical, invertebrate, and zooplankton).
    - Data verification includes:
        - Visual review at data entry – The technician verifies each value during input. Errors are corrected immediately.
        - Visual review after data entry – After entry, data are printed out and compared to original hardcopy sheets.
        - Duplicate data entry – Randomly selected site data are entered as normal but are duplicate records. Although time consuming in that it repeats data entry efforts, this gives an estimate of the data entry accuracy.
        - Review – It is the Project Lead's responsibility to review a subset of records to insure that they are identical to the hardcopy datasheets.
        - For the duplicate data and review, the minimum number is 20% of the sites (approximately eight total sites).
- Formal data validation - After verification, the Project Lead reviews them against all criteria in the protocol, especially the QAPP criteria (e.g., holding times, laboratory duplicates, completeness goals, reporting limits). After successful validation, the Data Manager can send the data onto WRD for incorporation into WRD Storet.
    - Data Validation includes:
        - Data entry programming steps – The Project Lead, along with the Network Data Manager, will program steps designed to prevent errors involving range or logical arguments. For example, maximum reach length will not allow an entry over 500 meters. This is an example of a mistake that might occur if the technician accidentally enters "2000" instead of "200."
        - Outlier detection and review (see Irwin 2008) – Statistical review and graphical display will be used to detect outliers (unusually extreme values of a variable outside the range of normal values). In outlier review, it is important to realize that not all extreme values represent errors, but can reflect the real variation of the data in nature. Generally, outliers that cannot be ascribed to error will be flagged and retained.
        - Check to ensure that data meets MQOs, where applicable. Ensure that data is flagged if in error or, for example, is detected by under quantifiable limits.
        - Review of "what makes sense" – The Field Crew Leader and Project Lead will compare and review the tabular data to confirm that everything "makes sense." Both should be intimately familiar with the types of data being

collected and as such should be able to detect mistakes. GIS data will be plotted and confirmed to match the spatial locations.

What Happens Now?

The QAPP is designed to identify, reduce, and, if possible, correct the data collected by the project. It is also designed to quantify the quality of the data, so that the precision of measurements of this protocol are to a known amount.

Data errors can never be entirely eliminated. Variation in the data due to collector, measurement, or equipment error can never be reduced to zero. If errors are so large so that data completeness goals are not met to the quality objectives of this protocol, corrective action should occur. The corrective steps should be commensurate with the severity of the errors. Possible steps include:

- Editing and documenting the error.
- "Re-dos," when possible (e.g., re-entering all the data).
- Revising specific SOPs.
- Increasing the training period.
- Eliminating SOPs with large, uncontrollable variation.
- Changing contract laboratories.
- Programmatic review.

Literature Cited

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Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #20: Database

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP provides the details on the design and setup of the database that is to be used to enter, store, and organize data for this protocol. To learn how to use the database to enter data, see SOP #4: Data Entry.

Database

There are a variety of databases that have been developed to store and manage stream data including NPSTORET, which is currently recommended by the NPS Water Resource Division. The Klamath Network looked at several of these databases, but we were unable to find a database that could meet the majority of the needs of our project. Therefore, we have developed a database using the Natural Resource Database Template (NRDT) developed by the National Park Service. The NRDT:

- Provides both a data interchange standard and a standard MS Access database core that allow flexibility in application design.
- Serves as a starting point for application development that can be extended as necessary to accommodate any inventory or monitoring field sampling protocol.
- Standardizes location and observation data to facilitate the integration of datasets.
- Acts as a design platform for developing database applications in MS Access, allowing users to enter, edit, display, summarize, and generate reports for inventory or monitoring datasets.
- Integrates with other I&M data management systems and data standards including the NPS Data Store, Geographic Information System (GIS) tools and data, the NPS GIS Committee Data Layers Standard, and the NPS Metadata Profile.

The NRDT Front-end Application Builder (FAB) is a Microsoft Access file that is intended to be used by developers of NRDT applications to create a front-end (user-interface) to an NRDT v.3.2 back-end (database). The FAB comes with many built-in features, including:

- table linking utility
- data backup
- compaction
- lookup table management
- main menu
- standardized data entry forms for core NRDT v.3.2 tables
- standardized data "gateway" form for retrieving records

Master, Project, and Field Databases

The Klamath Network plans on maintaining a Master Stream Database which will house all the verified and validated data that are collected using this protocol (Figure 1). Members of the KLMN will have read-only access to this database and can use it to conduct data summaries and use the data to develop analysis and synthesis reports or publications. Two field databases will be provided to the crew at the beginning of the field season. Crews will use these databases (on a Tablet PC) to enter data collected at each monitoring site. After validation and verification procedures have been followed, this database will be merged together into an annual project database and used to create summaries and conduct data analysis for annual reports. At the end of the year, the data from the project database will be uploaded to the master database for long-term storage and future analysis.

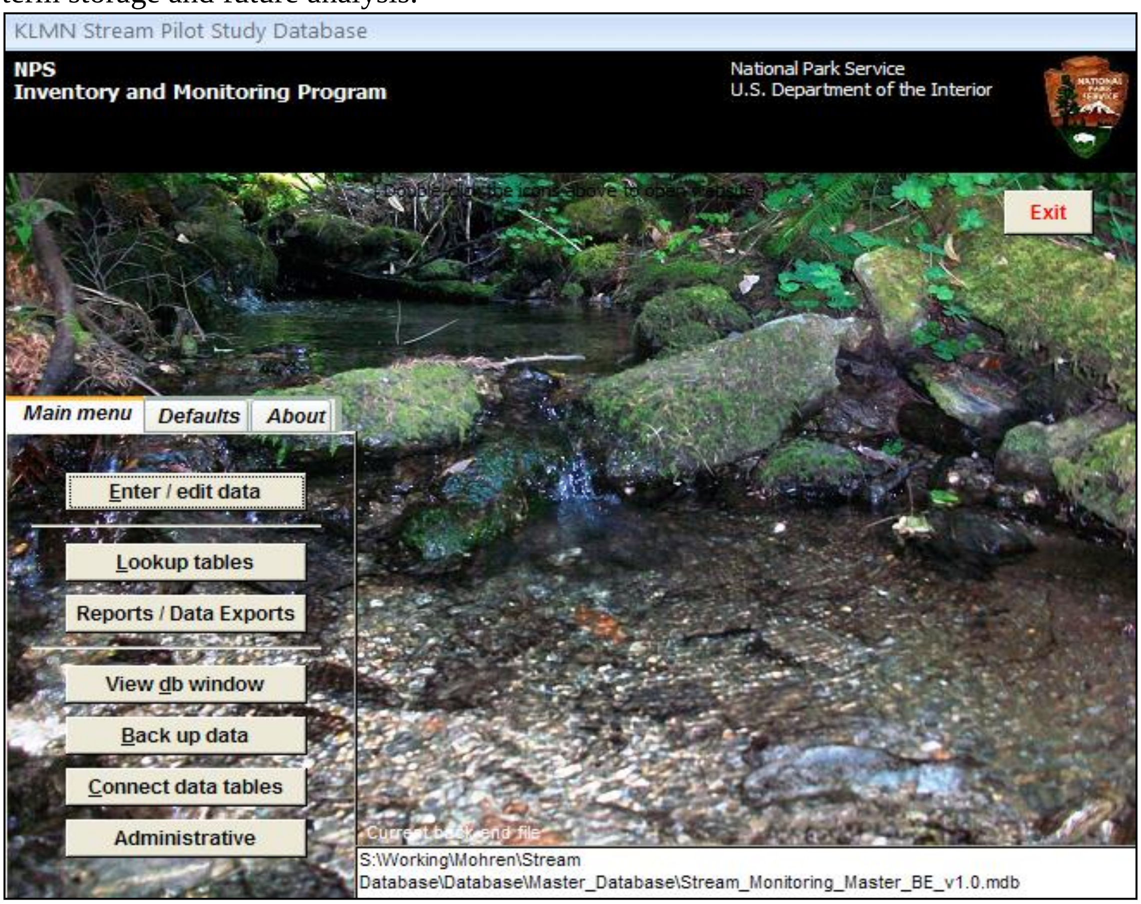

Figure 62. Main screen of the KLMN Stream monitoring database.

Preparing the Databases for Field Work

Setting up the field and project databases: Prior to the start of the field season the Data Manager should setup the 2 field databases and 1 project database that will be utilized that sampling season. To accomplish this task complete the following process.

1. Browse to the following locations:
   S:\Monitoring\Stream Monitoring\Stream_Data\ Database Template
2. Copy the “Crew Leader Database”, “Field Crew Database” and “Project Database” folders.
3. Browse to: S:\Monitoring\Stream Monitoring\Stream_Data\Seasonal Data
4. Create a folder named using the year the survey is planned to occur (e.g. 2011) and paste the folders you copied in step 2 in this newly created folder.
5. For each database, you may need to update the contact information (if new people are working on this project), location information (if new sites are being added), and species list (if new species are being added). Go to the appropriate section below to learn how to update these sections.

Updating Contact and Location Information: Prior to starting the field work, the Data Manager should obtain a copy of the blank project database that was created at the end of last year, which should be located in the Stream Data subfolder of the Stream Monitoring folder. As discussed in SOP #1: Preparations, Equipment, and Safety, the Data Manager should obtain a GIS file of the sites that the Network plans on monitoring in the upcoming year and a list of contact information for each person involved in the Stream monitoring effort. These data should be used to enter as much of the site and contact information into the project database as possible. To enter this information, the Data Manager should complete the following steps.

1. Click the “Enter / Edit Data” command button.
2. On the “Set application default values” form, use the drop down box in the “User” field to make sure names for each person involved in this project are on the list. If a person needs to be added, click the “New User” command button.
3. Enter the following fields for each person involved in the monitoring effort this year.
   a. First Name
   b. Last Name
   c. Organization
   d. Position / Title
   e. Work Phone Number
   f. Email Address
   g. Address Type
   h. Address, City, State, and Zip
   I. Country
4. Once you have completed entering the data for each person, click the “Close” button.
5. Click the “OK” button on the “Set application default values” form.
6. On the “Sample Data Gateway” form, click “Add a New Record.”
7. On the “Data Entry” form, next to the “Location” field, click the “Add New” command button.
8. Complete the following fields for each site in the GIS shapefile.

a. Network Code
b. Park Code
c. Zone
d. Site Type
e. Location Name
f. Watershed
g. Township, Range, and Section
h. USGS 7.5’ Quad Map Name

9. Once you have entered the information for each site, click the “Close” button.
10. Close all the forms until you are back at the main screen.

Setting up the Tablet PC: Once you have completed updating the database, do the following to get the database onto the Tablet PC that the field crews will use to enter data.

1. In the Stream_Data subfolder of the Stream Monitoring folder, look for a folder called “Field Crew Materials Template”.
2. Make certain this folder contains the following:
    a. The most up-to-date stream protocol.
    b. A blank copy of all log books (equipment, training, datasheet, and events).
    c. Any supporting documentation that might help crews in the field.
    d. A blank copy of the data entry sheets.
    e. User guides for all electronic equipment.
    f. A copy of base data and site location GIS files for the project.
3. Once these items have been updated, login to the Tablet PC (using the Field Crew login) and place a copy of the folder on the D drive and rename the folder “Stream Monitoring”
4. Create a shortcut to this folder on the desktop.
5. Using a thumb drive, transfer the “Crew Leader Database” and “Field Crew Database” databases that you pasted at: S:\Monitoring\Stream Monitoring\Stream_Data\Seasonal Data\YYYY.
6. Place them at D:\Stream Monitoring\Stream Monitoring\Data\Project Database

Returning from Field Work

Once the field crew returns, have them turn in the Tablet PC and their backup flash drives immediately. These should be kept in a secure location until the data have been downloaded to the Klamath Network Server. Once you have all the field crew’s data, complete the following steps.

1. Place a copy of all databases in the following location: S:\Monitoring\Stream_ Monitoring\Stream_Data\Seasonal_Data\YYYY\database, where the year is the year the field work was conducted.
2. Let the Project Lead know the databases are available for verification and validation processes.
3. Once the databases have been processed, and if there is more than one database, have the Data Manager merge the databases into one project database. Store the database in the following location: S:\Monitoring\Stream_Monitoring\Stream_Data\Seasonal_Data\YYYY\database. Where the year is the year the field work was conducted. Make certain to rename the database by adding the word final.

4. Run the built in QA/QC process to make sure the data are accurate and then inform the Project Lead you are going to load the data into the Master Database. If there are still problems with the data, work with the Project Lead to resolve any issues and then repeat steps 3 and 4.
5. You are finished. You should now have this year's validated and verified data loaded into the master database. You should also have the annual data stored in the proper location.

Creating a Blank Project Database

Now that the field season is over and the data have been QA/QCed and loaded in the proper databases, you need to create a blank database for the next field season. Follow these steps (to be completed by the Data Manager):

1. Make a copy of the back-end and front-end master database and place it in your working network folder. MAKE CERTAIN you relink the front-end and back-end databases properly.
2. Open the administrative form and click the command button to delete all records.
3. You should now have a blank database with updated locations and lookup tables. Save this database in the following folder: S:\Monitoring\Stream_Monitoring\Stream_ Data\Database\Blank_Database\2008, where the year is the year of the next survey year (e.g., if data collected in 2008, the folder would be named 2009).

Master, Project and Field Database Structure

The databases for this protocol are very similar in structure. The field database(s) forms may be slightly different to accommodate for the smaller screen size on the tablet computers. In addition, the master and project databases contain more reporting options, including the automated download to the electronic deliverable required by the WRD so data can be uploaded into the WRD STORET. The relational structure (Figure 2) of the database and the data dictionary are provided at the end of this SOP. In addition, a brief description of the tables (Table 1) and forms (Table 2) are provided below.

Updating Database Structure

While the Metadata Interview form and updated data dictionary submitted last year should indicate if any changes to the database are needed, it is always a good idea to check with the Project Lead for additional changes. Tables 1-4, the stream database relational diagram, and the data dictionary below are provided to give an overview of the database structure. This structure should NOT be altered without discussing the changes with the Data Manager.

Table 19. A brief description of the tables that are in the KLMN Stream database.

Table Name	Description
tbl_Db_Meta	Database description and links to I&M metadata tools.
tbl_Db_Revisions	Database revision history data.
tbl_Events	Sampling events.
tbl_Flags_Row	Flags related to data where 1 flag represents all the data on the row of data
tbl_Flags_Sheet	Flags related to data where 1 flag represents all the data on the data sheet
tbl_Flags_Transects	Flags related to the transect data
tbl_Invert_Main	Methods used to collect and process the invertebrate sample.
tbl_Invert_Species	Data that was collected as part of the invertebrate sampling procedures
tbl_Locations	Sampling unit locations.
tbl_Photographs	Photographs of the Site
tbl_Reach_Category	Data that was collected as part of the stream flow sampling procedures
tbl_Reach_Channel	Data that was collected as part of the Channel Morphology sampling procedures
tbl_Reach_Determination	Data that was collected as part of the reach determination sampling procedures
tbl_Reach_Discharge	Data that was collected as part of the discharge sampling procedures
tbl_Reach_Periphyton	Data that was collected as part of the periphyton sampling procedures
tbl_Reach_Probe	Data that was collected as part of the water quality sampling procedures
tbl_Reach_Slope	Data that was collected as part of the slope sampling procedures
tbl_Reach_Species	Data that was collected as part of the fish and amphibian sampling procedures
tbl_Reach_Species_Methods	Methods information that was used to sample fish and amphibians.
tbl_Reach_Transect	Data that was collected as part of the transect sampling procedures
tbl_Reach_Trees	Data that was collected as part of the large tree sampling procedures
tbl_Reach_WChem	Data that was collected as part of the water chemistry sampling procedures
tbl_Reach_WD*	Data that was collected as part of the woody debris sampling procedures
tbl_Reports	Provides a list of reports and data exports that have been developed for this database.
tbl_Sites	Streams where sampling occurs
tbl_Thalweg	Data that was collected as part of the Thalweg Sampling Procedures
tlu_Contacts	Contact data for project-related personnel.

*In the field databases, this table was divided into 2 tables (tbl_Reach_WD_Bankfull, tbl_Reach_WD_AboveBank). When they are uploaded to the project database they are merged into one table. The metadata for the tables in the field databases are provided below.

Table 20. A brief description of the forms that are used in the stream monitoring database.

Form Name	Description
frm_Admin_Console	Administrative console form for performing administrative tasks when developing application, such as release notes, bug reports, and managing table links
frm_Administrative	Main administrative switchboard
frm_App_Release	Form for viewing and entering release information
frm_Connect_Tables	Form to update back-end db connections
frm_Contacts	Form to view and edit contact information
frm_Data_Entry	Primary field data entry form
frm_Data_Gateway	Gateway to the data entry screens, for browsing and selecting from data that have already been entered
frm_Data_Upload	This form is used to upload data currently in the Trimble format, allows the user to run a QA / QC check, and then converts the data into an NRDT format
frm_EDD_Basics	This form is used to review and export data into the EDD template provided by the WRD
frm_Event_Group	Form for entering event groups (GUID string).
frm_FF_Export	This form is a switchboard that allows a user to export data to a flat file in excel
frm_Location	Form for entering Locations (GUID String)
frm_Lookup	Standard module for viewing and editing lookup domains
frm_Manage_Links	Administrative form for establishing, editing, and removing linked tables and the linked table records in tsys_Link_Tables
frm_Reports	This is the KLMN reporting tool that lets the user run canned reports and data exports based on a variety of parameters
frm_Select_Tables	Administrative form for selecting tables to link from an external database
frm_Set_Defaults	Standard module for setting application defaults
frm_Sites	Form for entering sites (Location groups) (GUID String)
frm_Switchboard	Standard module - main screen of the user interface, viewed at startup
frm_Trans_NewInfo	This form is used as a QC check to make certain the PI knows the crew added new locations, sites, enumerated codes, or contacts.
fsub_Bug_Report	Standard subform for viewing and creating application bug reports
fsub_Determination	Data entry form used to enter data related to the stream determination sampling process
fsub_EDD_Project	This form is used to review and export data into the EDD template provided by the WRD
fsub_EDD_Stations	This form is used to review and export data into the EDD template provided by the WRD
fsub_Flags_Discharge	This form shows flags related to discharge.
fsub_Reach_WD_AbvBnk	Woody debris data for above bankfull
fsub_Reach_WD_Bnk	Woody debris data for below bankfull

Relationship Diagram

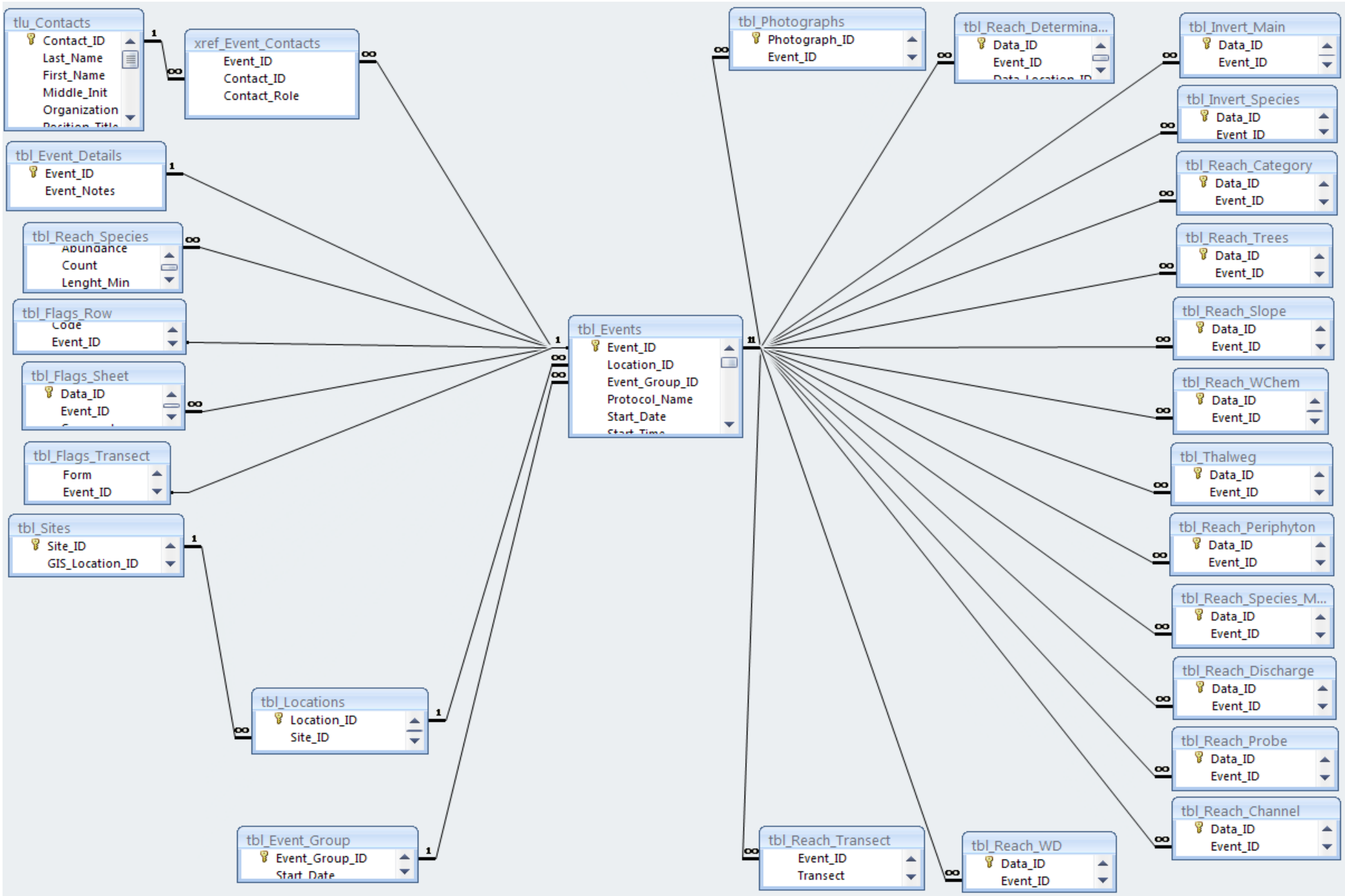

Figure 63. Relational diagram of the tables contained in the KLMN stream monitoring database.

Data Dictionary

tbl_Db_Meta: This table contains metadata about the stream monitoring database.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Db_Meta_ID	Y	Text	50	0				Local primary key
DB_Desc	Y	Memo		0				Description of the database purpose
Meta_MID	Y	Text	255	0				Link to NPS Data Store
DSC_GUID	Y	Text	50	0				Link to I&M Dataset Catalog desktop metadata tool
Meta_File_Name	N	Text	50	0				Name of the metadata file that describes this NRDT data file (must be in the same directory as this data file)

tbl_Db_Revision: This table contains the revision history of the stream monitoring database.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Revision_ID	Y	Text	50	0	NA	NA	NA	Database revision (version) number or code
Revision_Contact_ID	N	Text	50	0	NA	NA	NA	Link to tlu_Contacts
Db_Meta_ID	Y	Text	50	0	NA	NA	NA	Link to tbl_DB_Meta
Revision_Date	Y	Date/ Time	NA	0	NA	NA	NA	Database revision date
Revision_Reason	Y	Memo	NA	0	NA	NA	NA	Reason for the database revision
Revision_Desc	Y	Memo	NA	0	NA	NA	NA	Revision description

tbl_Flags_Row: This table contains descriptive data for flags related to the discharge form and specimen form.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Data_ID	Y	Text	50	NA	NA	NA	NA	Data row identifier
Comments	Y	Memo	NA	NA	NA	NA	NA	Describes why the measurement was flagged
Code	Y	Text	3	NA	NA	NA	NA	Special code for a flag that helps describe why a unit was flagged
Event_ID	Y	Text	50	NA	NA	NA	NA	Links to the event

tbl_Events: This table contains data that is specific to a visit of a stream reach.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Event_ID	Y	Text	50	NA	NA	NA	NA	Event identifier
Location_ID	Y	Text	50	NA	NA	NA	NA	Link to tbl_Locations
Event_Group_ID	N	Text	50	NA	NA	NA	NA	Link to tbl_Event_Group
Protocol_Name	Y	Text	100	NA	Draft Stream Protocol v1.0, KLMN Stream Monitoring Protocol v1.0	NA	NA	The name and version of the protocol being implemented
Start_Date	Y	Date / Time	NA	NA	NA	NA	NA	Date the survey was conducted
Start_Time	Y	Date / Time	NA	NA	NA	0:00	24:00:00	Time the survey started
Discharge_StreamWidth	Y	Number	NA	1	NA	0.0	100	Width of the stream where the discharge measure was taken
Discharge_NearTransect	Y	Text	1	NA	A, B, C, D ,E ,F ,G ,H ,I , J, K			Nearest transect to the point where the discharge measurement was taken
Discharge_Model	Y	Text	50	NA	Sontek ADV Flowtracker			Model of instrument used to measure the discharge of the stream
Scouring	Y	Text	2	NA	01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11	01	11	A code of 1-11 that describes the scouring at the reach.
Tree_Comments	N	Memo	NA	NA	NA	NA	NA	General comments about the measurement of large trees near the reach.
QC_Stream	Y	Text	50	NA	tlu_Contacts	NA	NA	Person who reviewed the Stream form
QC_Chem	Y	Text	50	NA	tlu_Contacts	NA	NA	Person who reviewed the water chemistry form
QC_Benthos	Y	Text	50	NA	tlu_Contacts	NA	NA	Person who reviewed the benthos form
QC_Discharge	Y	Text	50	NA	tlu_Contacts	NA	NA	Person who reviewed the discharge form
QC_Slope	Y	Text	50	NA	tlu_Contacts	NA	NA	Person who reviewed the slope form

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
QC_Woody	Y	Text	50	NA	tlu_Contacts	NA	NA	Person who reviewed the woody debris forms
QC_Vegetation	Y	Text	50	NA	tlu_Contacts	NA	NA	Person who reviewed the vegetation form
QC_Specimen	Y	Text	50	NA	tlu_Contacts	NA	NA	Person who reviewed the specimen form
QC_Transect	Y	Text	50	NA	tlu_Contacts	NA	NA	Person who reviewed the transect form
QC_Photograph	Y	Text	50	NA	tlu_Contacts	NA	NA	Person who reviewed the photograph form
Slope_Comments	N	Memo	NA	NA	NA	NA	NA	General comments about the slope measurement.
Discharge_DistUnits	Y	Text	10	NA	Tenths ft, cm, m/s, ft/s	NA	NA	Unit measure for the discharge distance
Discharge_DepUnits	Y	Text	10	NA	Tenths ft, cm, m/s, ft/s	NA	NA	Unit measure for the discharge depth
Discharge_VelUnits	Y	Text	10	NA	Tenths ft, cm, m/s, ft/s	NA	NA	Unit measure for the discharge velocity

tbl_Flags_Sheet: This table contains descriptive data for flags related to the water chemistry, Benthos, and Periphyton form.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Data_ID	Y	Text	50	NA	NA	NA	NA	Data row identifier
Comments	Y	Memo	NA	NA	NA	NA	NA	Describes why the measurement was flagged
Code	Y	Text	3	NA	NA	NA	NA	Special code for a flag that helps describe why a unit was flagged
Event_ID	Y	Text	50	NA	NA	NA	NA	Links to the event

tbl_Flags_Transect: This table contains descriptive data for flags related to the transect form.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Data_ID	Y	Text	50	NA	NA	NA	NA	Data row identifier
Comments	Y	Memo	NA	NA	NA	NA	NA	Describes why the measurement was flagged
Code	Y	Text	3	NA	NA	NA	NA	Special code for a flag that helps describe why a unit was flagged
Event_ID	Y	Text	50	NA	NA	NA	NA	Links to the event

tbl_Invert_Main: This table contains descriptive data about the sample used to determine the invertebrate composition

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Data_ID	Y	Text	50	NA	NA	NA	NA	Data row identifier
Event_ID	Y	Text	50	NA	NA	NA	NA	Links to the event
QAQC	N	Text	5	0	Blank, QAQC	NA	NA	If marked QAQC, this sample went through additional QAQC steps
Area	Y	Number	NA	5	NA	NA	NA	Area the sample covered
Field_Split	Y	Number	NA	0		0	100	% split if sample was split in the field
Lab_Split	Y	Number	NA	2		0	100	% split if sample was split in the lab
Organisms	Y	Number	NA	0		1	NA	Number of organisms in the sample
Samples	Y	Number	NA	0	1, 2	1	2	Sample number if more then 1 sample was taken at the site.

tbl_Invert_Species: This table contains information about the invertebrate species found in each sample of the reach.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Data_ID	Y	Text	50	NA	NA	NA	NA	Data row identifier
Event_ID	Y	Text	50	NA	NA	NA	NA	Links to the event
ITIS_Number	Y	Number	6	0	NA	NA	NA	ITIS Unique number
Abundance	Y	Number	NA	5	NA	NA	NA	Species abundance in the sample

tbl_Location: This is data related to the point (transect F) where the crew navigates to so they can start surveying.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Location_ID	Y	Text	50	NA	NA	NA	NA	Location identifier
Site_ID	Y	Text	50	NA	NA	NA	NA	Link to tbl_Sites
GIS_Location_ID	Y	Text	50	NA	NA	NA	NA	Link to GIS feature
Meta_MID	N	Text	50	NA	NA	NA	NA	Link to NR-GIS Metadata Database
X_Coord	Y	Number	6	5	NA	NA	NA	X coordinate
Y_Coord	Y	Number	7	5	NA	NA	NA	Y coordinate
Coord_Units	Y	Text	10	NA	m, d.dd	NA	NA	Coordinate distance units
Coord_System	Y	Text	3	NA	UTM, Geo, ft	NA	NA	Coordinate system
UTM_Zone	Y	Text	3	NA	10N	NA	NA	UTM Zone
Datum	Y	Text	5	NA	NAD83, WGS84	NA	NA	Datum of mapping ellipsoid
Coord_Equipment	Y	Text	15	NA	Garmin 76CSx, Garmin 60CSx, Trimble XM, Trimble XT	NA	NA	Equipment used to collect coordinate information
Est_H_Error	Y	Number	2	1	NA	NA	NA	Estimated horizontal accuracy when using Garmin units
PDOP	Y	Number	2	0	NA	NA	NA	Estimated horizontal accuracy when using Trimble units
Accuracy_Notes	N	Memo	NA	NA	NA	NA	NA	Notes about the accuracy of the location.
Loc_Name	Y	Text	3	NA	NA	NA	NA	Unique name of the site
Loc_Type	Y	Text	20	NA	Reach Center Point	NA	NA	Type of site
Update_Date	Y	Date / Time	NA	NA	Yes / No	NA	NA	Date this data was updated
Loc_Notes	N	Memo	NA	NA	Yes / No	NA	NA	General notes about the site
Verification_GPS	N	Yes / No	NA	NA	Yes / No	NA	NA	How the site was found
Verification_LC	N	Yes / No	NA	NA	Yes / No	NA	NA	How the site was found
Verification_Signs	N	Yes / No	NA	NA	Yes / No	NA	NA	How the site was found
Verification_Roads	N	Yes / No	NA	NA	Yes / No	NA	NA	How the site was found
Verification_Topo	N	Yes / No	NA	NA	Yes / No	NA	NA	How the site was found
Verification_Other	N	Yes / No	NA	NA	Yes / No	NA	NA	How the site was found
Verification_OtherDesc	N	Yes / No	NA	NA	NA	NA	NA	How the site was found
Verification_None	N	Yes / No	NA	NA	Yes / No	NA	NA	How the site was found
Site_Sampled	Y	Yes / No	NA	NA	Yes / No	NA	NA	If the site was sampled
Sampleable	N	Text	50	NA	Wadeable, Partially Wadeable, Wadeable Interrupted, Altered - Stream Present, But Not As On Map	NA	NA	If sampled, reason why

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
NonSampleable	N	Text	50	NA	Dry - Visited, Dry - Not Visited, Wetland - No Channel, Map Error - No Waterbody or Channel Present, Impounded (under lake), Other, Not Wadeable At This Time, Permission Denied, Permamently Inaccessible, Temporarily Inaccessible	NA	NA	If not sampled, reason why
DriveTime	Y	Date / Time	NA	NA	NA	NA	NA	Time it takes to drive to the parking spot
HikeTime	Y	Date / Time	NA	NA	NA	NA	NA	Time it takes to hike to the site
Directions	Y	Memo	NA	NA	NA	NA	NA	Directions to the site.

tbl_Photographs: This table contains data about photographs taken while working on this project.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Photograph_ID	Y	Text	50	NA	NA	NA	NA	Unique identifier for the photograph
Event_ID	Y	Text	50	NA	NA	NA	NA	Unique Identifier in tbl_Locations for the site
Photograph Name	Y	Text	100	NA	NA	NA	NA	Name of the photograph
Photographer	Y	Text	100	NA	tlu_Contacts	NA	NA	Individual who took the picture
Date_Photo_Taken	Y	Date / Time	NA	NA	NA	NA	NA	Date the photograph was taken
Photo_Description	Y	Memo	NA	NA	NA	NA	NA	Description of the Photograph
Non_Public_Use	Y	Yes / No	NA	NA	Yes, No	NA	NA	If checked, the NPS does not have permission to use this picture in public displays
Quality	Y	Yes / No	NA	NA	Yes, No	NA	NA	If checked, this is a great picture that can be used for coverpages, websites, etc.
Project	Y	Text	100	NA	Stream Monitoring	NA	NA	If this picture is taken as part of a project, the project name is entered here
Collection	Y	Text	4	NA	KLMN	NA	NA	NPS Require field. Which collection is photograph is part belongs too.
Publisher	Y	Text	10	NA	NPS	NA	NA	NPS Required Field. The person or organization that is making this image available
Resource_Type	Y	Text	5	NA	Image	NA	NA	NPS Required Field. The type of product.
Extension	Y	Text	4	NA	.jpg	NA	NA	Type of picture taken
Historic	Y	Text	NA	NA	Yes, No	NA	NA	Pictures are considered historic if they were collected prior to 2007
Easting	N	Number	6	0	NA	NA	NA	Coordinate
Northing	N	Number	7	0	NA	NA	NA	Coordinate

tbl_Reach_Benthos: This table contains the data about the benthos samples taken along the stream reach.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Data_ID	Y	Text	50	NA	NA	NA	NA	Data row identifier
Event_ID	Y	Text	50	NA	NA	NA	NA	Links to the event
Nearest_Transect	Y	Text	1	NA	A, B, C, D, E, F, G, H, I, J, K	NA	NA	Transect nearest to where the bentos sample was obtained
Substrate	Y	Text	10	NA	Fine / Sand, Gravel, Coarse, Other	NA	NA	Substrate type where the bethos sample was obtained

tbl_Reach_Category: This table contains information about the pools, riffles, and runs in a sampled stream reach.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Data_ID	Y	Text	50	NA	NA	NA	NA	Data row identifier
Event_ID	Y	Text	50	NA	NA	NA	NA	Links to the event
Category_Type	Y	Text	7	NA	Pool, Riffle, Glide	NA	NA	Category variable that describes the stream component being sampled
Start_Dist	Y	Number	NA	0	NA	0	500	Starting point of the structure
End_Dist	Y	Number	NA	0	NA	0	500	Ending point of the structure

tbl_Reach_Determination: This table contains the measurements used to determine the placement of the 11 transects along the stream reach.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Data_ID	Y	Text	50	NA	NA	NA	NA	Data row identifier
Event_ID	Y	Text	50	NA	NA	NA	NA	Links to the event
Channel_Width	Y	Number	NA	0	NA	0	100	Width of the channel used to determine the layout of the 11 transects.
Upstream_Lenght	Y	Number	NA	0	NA	75	250	Distance upstream to the nearest transect
Downsteam_Length	Y	Number	NA	0	NA	75	250	Distance downstream to the nearest transect
Determination_Comments	N	Memo	NA	NA	NA	NA	NA	General comments about the use of the channel width and upstream/downstream lengths used to determine the layout of the transects

tbl_Reach_Discharge: This table contains data related to the discharge measure.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Data_ID	Y	Text	50	NA	NA	NA	NA	Data row identifier
Event_ID	Y	Text	50	NA	NA	NA	NA	Links to the event
Point_Number	Y	Number	NA	0	NA	1	20	Sequential numbering of data rows
Distance	Y	Number	NA	0	NA	0	NA	Distance from bank to measurement location
Depth	Y	Number	NA	1	NA	0	NA	Water depth at measurement location
Velocity	Y	Number	NA	3	NA	-10	NA	Water velocity at measurement location

tbl_Reach_Probe: This table contains measures related to water chemistry taken while in the field.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Data_ID	Y	Text	50	NA	NA	NA	NA	Data row identifier
Event_ID	Y	Text	50	NA	NA	NA	NA	Links to the event
PH_Standard	Y	Number	NA	0	NA	4	10	pH calibration solution used
PH_Check	Y	Number	NA	1	NA	1	14	Initial Measured pH

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Conductivity_Standard	N	Number	NA	0	NA	0	10000	Conductivity solution for calibration
Conductivity_Check	N	Number	NA	1	NA	0	10000	Initial Conductivity reading
DO_Standard	Y	Number	NA	0	NA	100	100	DO calibration (should be 100%)
DO_Check	Y	Number	NA	1	NA	0	25	Measured DO
DO_Membrane	N	Yes / No	NA	NA	Yes, No	NA	NA	Was membrane replaced?
Alkalinity_Volume_1	Y	Number	NA	0	NA	50	100	Volume of water used for sample 1
Alkalinity_Volume_2	Y	Number	NA	0	NA	50	100	Volume of water used for sample 2
Alkalinity_Volume_3	Y	Number	NA	0	NA	50	100	Volume of water used for sample 3
Alkalinity_Titrant_1	Y	Number	NA	2	NA	0.16	1.6	Titrant Strength used
Alkalinity_Titrant_2	Y	Number	NA	2	NA	0.16	1.6	Titrant Strength used
Alkalinity_Titrant_3	Y	Number	NA	2	NA	0.16	1.6	Titrant Strength used
Alkalinity_Reading_1	Y	Number	NA	0	NA	0	1000	Digital titrator reading
Alkalinity_Reading_2	Y	Number	NA	0	NA	0	1000	Digital titrator reading
Alkalinity_Reading_3	Y	Number	NA	0	NA	0	1000	Digital titrator reading
Channel_Pattern	Y	Text	100	NA	One Channel, Anastomosing, Braided Channel	NA	NA	
Channel_Constraint	Y	Text	100	NA	Constrained In V-Shaped Valley, Broad Valley, Narrow Valley, Unconstrained in Broad Valley	NA	NA	
Constraint_Feature	Y	Text	100	NA	Bedrock, Hillslope, Terrace, Human Bank Alterations, No Constraining Features	NA	NA	
Channel_Percent	Y	Number	NA	0	NA	0	100	Percent of channel constrained
Bankfull_Width	Y	Number	NA	0	NA	0	NA	Estimated average bankfull width
Valley_Width	N	Number	NA	0	NA	0	NA	Estimated valley width
Valley_Border	N	Yes / No	NA	NA	Yes, No	NA	NA	Denotes whether the valley borders are visible

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Channel_Notes	N	Memo	NA	NA	NA	NA	NA	General notes about the measurements in this table

tbl_Reach_Periphyton: This table records the transect where the periphyton sample was taken.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Data_ID	Y	Text	50	NA	NA	NA	NA	Data row identifier
Event_ID	Y	Text	50	NA	NA	NA	NA	Links to the event
Transect	Y	Text	1	NA	A, B, C, D, E, F, G, H, I, J, K	NA	NA	Transect nearest to where the peryphyton sample was obtained

tbl_Reach_Slope: This table contains information about the slope of the reach.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Data_ID	Y	Text	50	NA	NA	NA	NA	Data row identifier
Event_ID	Y	Text	50	NA	NA	NA	NA	Links to the event
Transect	Y	Text	1	NA	A, B, C, D, E, F, G, H, I, J, K	NA	NA	Transects range where the slope is measured between the 2 transects listed
Upper_Reading	Y	Number	NA	2		0		Slope reading at the upper portion of the reach segment
Lower_Reading	Y	Number	NA	2		0		Slope reading at the lower portion of the reach segment

tbl_Reach_Species: This table contains data on fish and amphibian species encountered.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Data_ID	Y	Text	50	NA	NA	NA	NA	Data row identifier
Event_ID	Y	Text	50	NA	NA	NA	NA	Links to the event
Spec_Number	Y	Number	2	NA	NA	1	NA	Sequential count of species observed
Species	Y	Text	150	NA	tlu_Species	NA	NA	ITIS number for species observed
LifeStage	Y	Text	20	NA	Egg Mass, Tadpole, Fry, Fingerling, Adult	NA	NA	Life stage the species was in
Abundance	Y	Text	20	NA	??????	NA	NA	Generalized abundace category used when too many indivduals are present to count
Count	Y	Number	NA	0	NA	1	NA	Count of the number of individuals
Lenght_Min	Y	Number	NA	0	NA	1	NA	Size of the smallest individual
Lenght_Max	Y	Number	NA	0	NA	1	NA	Size of the largest individual
Anom_Count	Y	Number	NA	0	NA	0	NA	Number of species with anomolies
Mortality_Count	Y	Number	NA	0	NA	0	NA	Number of species dead
Transect_A	Y	Yes / No	NA	NA	Yes, No	NA	NA	Transect where the species was observed
Transect_B	Y	Yes / No	NA	NA	Yes, No	NA	NA	Transect where the species was observed
Transect_C	Y	Yes / No	NA	NA	Yes, No	NA	NA	Transect where the species was observed
Transect_D	Y	Yes / No	NA	NA	Yes, No	NA	NA	Transect where the species was observed
Transect_E	Y	Yes / No	NA	NA	Yes, No	NA	NA	Transect where the species was observed
Transect_F	Y	Yes / No	NA	NA	Yes, No	NA	NA	Transect where the species was observed
Transect_G	Y	Yes / No	NA	NA	Yes, No	NA	NA	Transect where the species was observed
Transect_H	Y	Yes / No	NA	NA	Yes, No	NA	NA	Transect where the species was observed
Transect_I	Y	Yes / No	NA	NA	Yes, No	NA	NA	Transect where the species was observed
Transect_J	Y	Yes / No	NA	NA	Yes, No	NA	NA	Transect where the species was observed
Species_Notes	Y	Memo	NA	NA	NA	NA	NA	General notes about the species observed.

tbl_Reach_Species_Methods: This table contains some general information about the species search including methods.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Data_ID	Y	Text	50	NA	NA	NA	NA	Data row identifier
Event_ID	Y	Text	50	NA	NA	NA	NA	Links to the event
Snokeling	MA	Yes / No	NA	NA	Yes, No	NA	NA	Was the site snorkled?
Seine	MA	Yes / No	NA	NA	Yes, No	NA	NA	Was the site seined?
eFishing	MA	Yes / No	NA	NA	Yes, No	NA	NA	Was electronic fishing conducted?
Wave_Form	MA	Text	10	NA	AC, DC, Pulsed DC	NA	NA	Parameter describing setting for efishing.
Volts	MA	Number	NA	0		NA	NA	Parameter describing setting for efishing.
Watts	MA	Number	NA	0		NA	NA	Parameter describing setting for efishing.
Pulse_Rate	MA	Number	NA	0		NA	NA	Parameter describing setting for efishing.
Amps	MA	Number	NA	0		NA	NA	Parameter describing setting for efishing.
Pulse_Width	MA	Number	NA	0		NA	NA	Parameter describing setting for efishing.
Shock_Time	MA	Number	NA	0		NA	NA	Parameter describing setting for efishing.
Fish_Time	MA	Number	NA	0		NA	NA	Parameter describing setting for efishing.
Samp_Dist	MA	Number	NA	0		NA	NA	Parameter describing setting for efishing.
Fished	Y	Yes / No	NA	NA	Yes, No	NA	NA	Was fish looked for?
Collected	Y	Yes / No	NA	NA	Yes, No	NA	NA	Was fish collected?
Visibility	Y	Text	4		Good, Poor	NA	NA	General visibility of the water?

tbl_Reach_Transect: This table contains the data related to substrate, cover, and disturbance along each of the transects.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Data_ID	Y	Text	50	NA	NA	NA	NA	Data row identifier
Event_ID	Y	Text	50	NA	NA	NA	NA	Links to the event
Transect	Y	Text	15	NA	A, B, C, D, E, F, G, H, I, J, K, Side Channel	NA	NA	Transect where the measurements were taken
Substrate_Dist_Lft	N	Number	NA	0	NA	0	0	Tracks the position of the measurement
Substrate_Dist_LftCnt	N	Number	NA	0	NA	25	25	Tracks the position of the measurement
Substrate_Dist_Cnt	N	Number	NA	0	NA	50	50	Tracks the position of the measurement

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Substrate_Dist_RghtCnt	N	Number	NA	0	NA	75	75	Tracks the position of the measurement
Substrate_Dist_Rght	N	Number	NA	0	NA	100	100	Tracks the position of the measurement
Substrate_Depth_Lft	Y	Number	NA	0	NA	0	NA	Depth measured at that point
Substrate_Depth_LftCnt	Y	Number	NA	0	NA	0	NA	Depth measured at that point
Substrate_Depth_Cnt	Y	Number	NA	0	NA	0	NA	Depth measured at that point
Substrate_Depth_RghtCnt	Y	Number	NA	0	NA	0	NA	Depth measured at that point
Substrate_Depth_Rght	Y	Number	NA	0	NA	0	NA	Depth measured at that point
Substrate_Size_Lft	Y	Text	2	NA	RS, RR, CB, GC, GF, SA, FN, HP, WD, Other, BL			Substrate type at that point
Substrate_Size_LftCnt	Y	Text	2	NA	RS, RR, CB, GC, GF, SA, FN, HP, WD, Other, BL			Substrate type at that point
Substrate_Size_Cnt	Y	Text	2	NA	RS, RR, CB, GC, GF, SA, FN, HP, WD, Other, BL			Substrate type at that point
Substrate_Size_RghtCnt	Y	Text	2	NA	RS, RR, CB, GC, GF, SA, FN, HP, WD, Other, BL			Substrate type at that point
Substrate_Size_Rght	Y	Text	2	NA	RS, RR, CB, GC, GF, SA, FN, HP, WD, Other, BL			Substrate type at that point
Substrate_Ebed_Lft	Y	Number	NA	0		0	100	Percent embeddeness at that point
Substrate_Ebed_LftCnt	Y	Number	NA	0		0	100	Percent embeddeness at that point
Substrate_Ebed_Cnt	Y	Number	NA	0		0	100	Percent embeddeness at that point
Substrate_Ebed_RghtCnt	Y	Number	NA	0		0	100	Percent embeddeness at that point
Substrate_Ebed_Rght	Y	Number	NA	0		0	100	Percent embeddeness at that point
Cover_Fli_Alg	Y	Number	NA	0	0, 1, 2, 3, 4	0	4	Estimated cover of Filamentous Algae on the transect
Cover_Macro	Y	Number	NA	0	0, 1, 2, 3, 4	0	4	Estimated cover of Macrophytes on the transect
Cover_Woody	Y	Number	NA	0	0, 1, 2, 3, 4	0	4	Estimated cover of Woody Debris on the transect
Cover_Brush	Y	Number	NA	0	0, 1, 2, 3, 4	0	4	Estimated cover of Brush on the transect
Cover_Tree	Y	Number	NA	0	0, 1, 2, 3, 4	0	4	Estimated cover of Live Trees and Roots on the transect
Cover_Overhang	Y	Number	NA	0	0, 1, 2, 3, 4	0	4	Estimated cover of Overhanging Vegetation on the transect
Cover_Undercut	Y	Number	NA	0	0, 1, 2, 3, 4	0	4	Estimated cover of Undercut Bank on the transect
Cover_Boulders	Y	Number	NA	0	0, 1, 2, 3, 4	0	4	Estimated cover of Boulders on the transect
Cover_Art_Sub	Y	Number	NA	0	0, 1, 2, 3, 4	0	4	Estimated cover of Artifical Substrate on the transect

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Canopy_CenUp	Y	Number	NA	0	NA	0	17	Spherical densiometer reading
Canopy_CenL	Y	Number	NA	0	NA	0	17	Spherical densiometer reading
Canopy_CenDwn	Y	Number	NA	0	NA	0	17	Spherical densiometer reading
Canopy_CenR	Y	Number	NA	0	NA	0	17	Spherical densiometer reading
Canopy_Left	Y	Number	NA	0	NA	0	17	Spherical densiometer reading
Canopy_Right	Y	Number	NA	0	NA	0	17	Spherical densiometer reading
Bank_Angle_Left	Y	Number	NA	0	NA	0	360	Angle in degrees
Bank_Angle_Right	Y	Number	NA	0	NA	0	360	Angle in degrees
Bank_Undercut_Left	Y	Number	NA	1	NA	0	NA	Undercut distance
Bank_Undercut_Right	Y	Number	NA	1	NA	0	NA	Undercut distance
Bank_Wetted	Y	Number	NA	1	NA	0	NA	Wetted width distance
Bank_Bar	Y	Number	NA	1	NA	0	NA	Width of bars (if any)
Bank_BF_Width	Y	Number	NA	1	NA	0	NA	Bankfull width
Bank_BF_Height	Y	Number	NA	1	NA	0	NA	Bankfull height
Bank_Incised	Y	Number	NA	1	NA	0	NA	Height of incision (if any)
RipCan_Type_Left	Y	Text	1	NA	D, C, E, M, N	NA	NA	Dominant vegetation type in the canopy layer on the left side of the stream.
RipCan_Type_Right	Y	Text	1	NA	D, C, E, M, N	NA	NA	Dominant vegetation type in the canopy layer on the right side of the stream.
RipCan_Big_Left	Y	Number	1	0	0, 1, 2, 3, 4	0	4	Estimated density of large trees (>0.3 meters DBH) on the left side of the stream.
RipCan_Big_Right	Y	Number	1	0	0, 1, 2, 3, 4	0	4	Estimated density of large trees (>0.3 meters DBH) on the right side of the stream.
RipCan_Small_Left	Y	Number	1	0	0, 1, 2, 3, 4	0	4	Estimated density of small trees (<0.3 meters DBH) on the left side of the stream.
RipCan_Small_Right	Y	Number	1	0	0, 1, 2, 3, 4	0	4	Estimated density of small trees (<0.3 meters DBH) on the right side of the stream.
RipUnd_Type_Left	Y	Text	1	NA	D, C, E, M, N	NA	NA	Dominant vegetation type in the understory layer on the left side of the stream.
RipUnd_Type_Right	Y	Text	1	NA	D, C, E, M, N	NA	NA	Dominant vegetation type in the understoy layer on the right side of the stream.
RipUnd_Wood_Left	Y	Number	1	0	0, 1, 2, 3, 4	0	4	Estimated density of woody shrubs and sapling on the left side of the stream.
RipUnd_Wood_Right	Y	Number	1	0	0, 1, 2, 3, 4	0	4	Estimated density of woody shrubs and sapling on the right side of the stream.
RipUnd_Non_Left	Y	Number	1	0	0, 1, 2, 3, 4	0	4	Estimated density of non-woody herbs, grasses and forbs on the left side of the stream.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
RipUnd_Non_Right	Y	Number	1	0	0, 1, 2, 3, 4	0	4	Estimated density of non-woody herbs, grasses and forbs on the right side of the stream.
RipGnd_Wood_Left	Y	Number	1	0	0, 1, 2, 3, 4	0	4	Estimated density of woody shrubs and sapling on the left side of the stream that represent ground cover.
RipGnd_Wood_Right	Y	Number	1	0	0, 1, 2, 3, 4	0	4	Estimated density of woody shrubs and sapling on the right side of the stream that represent ground cover.
RipGnd_Non_Left	Y	Number	1	0	0, 1, 2, 3, 4	0	4	Estimated density of non-woody herbs, grasses and forbs on the left side of the stream that represent ground cover.
RipGnd_Non_Right	Y	Number	1	0	0, 1, 2, 3, 4	0	4	Estimated density of non-woody herbs, grasses and forbs on the right side of the stream that represent ground cover.
RipGnd_Barren_Left	Y	Number	1	0	0, 1, 2, 3, 4	0	4	Estimated density of barren areas, dirt, and duff on the left side of the stream.
RipGnd_Barren_Right	Y	Number	1	0	0, 1, 2, 3, 4	0	4	Estimated density of barren areas, dirt, and duff on the right side of the stream.
Human_Wall_Left	Y	Text	1	NA	O, P, C, B	NA	NA	Influences that may be affecting the stream environment
Human_Wall_Right	Y	Text	1	NA	O, P, C, B	NA	NA	Influences that may be affecting the stream environment
Human_Build_Left	Y	Text	1	NA	O, P, C, B	NA	NA	Influences that may be affecting the stream environment
Human_Build_Right	Y	Text	1	NA	O, P, C, B	NA	NA	Influences that may be affecting the stream environment
Human_Pave_Left	Y	Text	1	NA	O, P, C, B	NA	NA	Influences that may be affecting the stream environment
Human_Pave_Right	Y	Text	1	NA	O, P, C, B	NA	NA	Influences that may be affecting the stream environment
Human_Road_Left	Y	Text	1	NA	O, P, C, B	NA	NA	Influences that may be affecting the stream environment
Human_Road_Right	Y	Text	1	NA	O, P, C, B	NA	NA	Influences that may be affecting the stream environment
Human_Pipes_Left	Y	Text	1	NA	O, P, C, B	NA	NA	Influences that may be affecting the stream environment
Human_Pipes_Right	Y	Text	1	NA	O, P, C, B	NA	NA	Influences that may be affecting the stream environment
Human_Land_Left	Y	Text	1	NA	O, P, C, B	NA	NA	Influences that may be affecting the stream environment
Human_Land_Right	Y	Text	1	NA	O, P, C, B	NA	NA	Influences that may be affecting the stream environment
Human_Park_Left	Y	Text	1	NA	O, P, C, B	NA	NA	Influences that may be affecting the stream environment
Human_Park_Right	Y	Text	1	NA	O, P, C, B	NA	NA	Influences that may be affecting the stream

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
								environment
Human_Pasture_Left	Y	Text	1	NA	O, P, C, B	NA	NA	Influences that may be affecting the stream environment
Human_Pasture_Right	Y	Text	1	NA	O, P, C, B	NA	NA	Influences that may be affecting the stream environment
Human_Log_Left	Y	Text	1	NA	O, P, C, B	NA	NA	Influences that may be affecting the stream environment
Human_Log_Right	Y	Text	1	NA	O, P, C, B	NA	NA	Influences that may be affecting the stream environment
Human_Mine_Left	Y	Text	1	NA	O, P, C, B	NA	NA	Influences that may be affecting the stream environment
Human_Mine_Right	Y	Text	1	NA	O, P, C, B	NA	NA	Influences that may be affecting the stream environment
Canopy_Percent	Y	Text	1	NA	O, P, C, B	NA	NA	Influences that may be affecting the stream environment

tbl_Reach_Trees: This table contains data about large trees along the stream reach.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Data_ID	M	Text	50	NA	NA	NA	NA	Data row identifier
Event_ID	M	Text	50	NA	NA	NA	NA	Links to the event
Transect	M	Text	1	NA	A, B, C, D, E, F, G, H, I, J, K, Side Channel	NA	NA	Transect where the measurement was taken
Trees_Not_Visable	MA	Yes / No	NA	NA	Yes, No	NA	NA	If checked, no large trees are visible
DBH_Left	MA	Text	15	NA	0.0 - 0.1, 0.1 - 0.3, 0.3 - 0.75, 0.75 - 2.0, >2.0	NA	NA	DBH of tree on left side of stream
DBH_Right	MA	Text	15	NA	0.0 - 0.1, 0.1 - 0.3, 0.3 - 0.75, 0.75 - 2.0, >2.0	NA	NA	DBH of tree on right side of stream
Height_Left	MA	Number	NA	0	NA	0	NA	Height of tree on left side of stream
Height_Right	MA	Number	NA	0	NA	0	NA	Height of tree on right side of stream
Distance_Left	MA	Number	NA	0	NA	0	NA	Distance to tree on left side of stream
Distance_Right	MA	Number	NA	0	NA	0	NA	Distance to tree on right side of stream
Type_Left	MA	Text	20	NA	Deciduous, Coniferous, Broadleaf Evergreen	NA	NA	Broad category of tree type on left side of the stream
Type_Right	MA	Text	20	NA	Deciduous, Coniferous, Broadleaf Evergreen	NA	NA	Broad category of tree type on right side of the stream

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Taxon_Left	MA	Text	150	NA	Acacia / Mesquite, Alder / Birch, Ash, Maple / Boxelder, Oak, Poplar / Cottonwood, Sycamore, Willow, Unknown or Other Deciduous, Cedar / Cypress / Sequoia, Fir, Juniper. Pine, Spruce, Unknown or Other Conifer, Unknown or Other Boradleaf Evergreen, Snag	NA	NA	Detailed category of tree type on left side of the stream
Taxon_Right	MA	Text	150	NA	Acacia / Mesquite, Alder / Birch, Ash, Maple / Boxelder, Oak, Poplar / Cottonwood, Sycamore, Willow, Unknown or Other Deciduous, Cedar / Cypress / Sequoia, Fir, Juniper. Pine, Spruce, Unknown or Other Conifer, Unknown or Other Boradleaf Evergreen, Snag	NA	NA	Detailed category of tree type on right side of the stream
Tree_Notes	MA	Memo	NA	NA	NA	NA	NA	General notes about the tree observations
Invasive_RCGrass	MA	Yes / No	NA	NA	Yes, No	NA	NA	If checked there is Reed Canary Grass on the site.
Invasive_SaltCed	MA	Yes / No	NA	NA	Yes, No	NA	NA	If checked there is Salt Cedar on the site.
Invasive_HBlack	MA	Yes / No	NA	NA	Yes, No	NA	NA	If checked there is Himalayan Blackberry on the site.
Invasive_GReed	MA	Yes / No	NA	NA	Yes, No	NA	NA	If checked there is giant arundo on the site.
Invasive_EngIvy	MA	Yes / No	NA	NA	Yes, No	NA	NA	If checked there is English Ivy on the site.
Invasive_CanThis	MA	Yes / No	NA	NA	Yes, No	NA	NA	If checked there is Canadian Thistle on the site.
Invasive_Teasel	MA	Yes / No	NA	NA	Yes, No	NA	NA	If checked there is Reed Canary Grass on the site.
Invasive_CBurd	MA	Yes / No	NA	NA	Yes, No	NA	NA	If checked there is common burdoc on the site.
Invasive_CHGrass	MA	Yes / No	NA	NA	Yes, No	NA	NA	If checked there is Chord Grass on the site.
Invasive_MThis	MA	Yes / No	NA	NA	Yes, No	NA	NA	If checked there is Mountain Thistle on the site.
Invasive_Spurge	MA	Yes / No	NA	NA	Yes, No	NA	NA	If checked there is Leafy Spurge on the site.
Invasive_RusOlive	MA	Yes / No	NA	NA	Yes, No	NA	NA	If checked there is Russian Olive on the site.
Invasive_None	MA	Yes /	NA	NA	Yes, No	NA	NA	If checked there is no invasive species

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
		No						on the site.

tbl_Reach_WChem: This table contains information about the water chemistry including temperature, periphyton information, and benthos information.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Data_ID	M	Text	50	NA	NA	NA	NA	Data row identifier
Event_ID	M	Text	50	NA	NA	NA	NA	Links to the event
Water_Chem_Lab	MA	Yes / No	NA	NA	Yes, No	NA	NA	If checked, the water chemistry was collected
Chem_Lab_Trans	MA	Text	1	NA	A, B, C, D, E, F, G, H, I, J, K	NA	NA	Transect where the water chemistry was taken
Chem_Lab_Notes	O	Memo	NA	NA	NA	NA	NA	General notes about the water chemistry
Air_Temp	M	Number	NA	0	NA	NA	NA	Temperature (Celsius) of the air when the water sample was taken
Water_Temp	M	Number	NA	0	NA	NA	NA	Temperature (Celsius) of the water when the water sample was taken
Num_Benthos_Vials	M	Number	NA	0	NA	0	11	Number of vials used to collect the benthos sample
Benthos_Notes	O	Memo	NA	NA	NA	NA	NA	General notes about the benthos sample
Periphyton_Scrapes	M	Number	NA	0	NA	0	11	Number of scrapes used to collect the periphyton sample.
Periphyton_Comments	O	Memo	NA	NA	NA	NA	NA	General notes about the periphyton sample.

tbl_Reach_WD_AboveBank: This table contains information about woody debris that is above the bank.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Data_ID	M	Text	50	NA	NA	NA	NA	Data row identifier
Event_ID	M	Text	50	NA	NA	NA	NA	Links to the event
ABF_15_0103_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.1 - 0.3, and is in between transect A and B
ABF_15_0103_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.1 - 0.3, and is in between transect B and C

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
ABF_15_0103_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.1 - 0.3, and is in between transect C and D
ABF_15_0103_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.1 - 0.3, and is in between transect D and E
ABF_15_0103_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.1 - 0.3, and is in between transect E and F
ABF_15_0103_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.1 - 0.3, and is in between transect F and G
ABF_15_0103_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.1 - 0.3, and is in between transect G and H
ABF_15_0103_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.1 - 0.3, and is in between transect H and I
ABF_15_0103_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.1 - 0.3, and is in between transect I and J
ABF_15_0103_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.1 - 0.3, and is in between transect J and K
ABF_15_0306_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.3 - 0.6, and is in between transect A and B
ABF_15_0306_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.3 - 0.6, and is in between transect B and C
ABF_15_0306_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.3 - 0.6, and is in between transect C and D

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
ABF_15_0306_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.3 - 0.6, and is in between transect D and E
ABF_15_0306_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.3 - 0.6, and is in between transect E and F
ABF_15_0306_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.3 - 0.6, and is in between transect F and G
ABF_15_0306_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.3 - 0.6, and is in between transect G and H
ABF_15_0306_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.3 - 0.6, and is in between transect H and I
ABF_15_0306_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.3 - 0.6, and is in between transect I and J
ABF_15_0306_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.3 - 0.6, and is in between transect J and K
ABF_15_0608_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.6 - 0.8, and is in between transect A and B
ABF_15_0608_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.6 - 0.8, and is in between transect B and C
ABF_15_0608_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.6 - 0.8, and is in between transect C and D
ABF_15_0608_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.6 - 0.8, and is in between transect D and E

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
ABF_15_0608_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.6 - 0.8, and is in between transect E and F
ABF_15_0608_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.6 - 0.8, and is in between transect F and G
ABF_15_0608_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.6 - 0.8, and is in between transect G and H
ABF_15_0608_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.6 - 0.8, and is in between transect H and I
ABF_15_0608_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.6 - 0.8, and is in between transect I and J
ABF_15_0608_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter between 0.6 - 0.8, and is in between transect J and K
ABF_15_08_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter >0.8, and is in between transect A and B
ABF_15_08_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter >0.8, and is in between transect B and C
ABF_15_08_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter >0.8, and is in between transect C and D
ABF_15_08_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter >0.8, and is in between transect D and E
ABF_15_08_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter >0.8, and is in between transect E and F
ABF_15_08_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter >0.8, and is in between transect F and G

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
ABF_15_08_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter >0.8, and is in between transect G and H
ABF_15_08_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter >0.8, and is in between transect H and I
ABF_15_08_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter >0.8, and is in between transect I and J
ABF_15_08_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, >15 m in length, has a diameter >0.8, and is in between transect J and K
ABF_515_0103_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.1 - 0.3, and is in between transect A and B
ABF_515_0103_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.1 - 0.3, and is in between transect B and C
ABF_515_0103_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.1 - 0.3, and is in between transect C and D
ABF_515_0103_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.1 - 0.3, and is in between transect D and E
ABF_515_0103_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.1 - 0.3, and is in between transect E and F
ABF_515_0103_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.1 - 0.3, and is in between transect F and G
ABF_515_0103_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.1 - 0.3, and is in between transect G and H
ABF_515_0103_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.1 - 0.3, and is in between transect H and I

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
ABF_515_0103_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 in length, has a diameter between 0.1 - 0.3, and is in between transect I and J
ABF_515_0103_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 in length, has a diameter between 0.1 - 0.3, and is in between transect J and K
ABF_515_0306_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.3 - 0.6, and is in between transect A and B
ABF_515_0306_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.3 - 0.6, and is in between transect B and C
ABF_515_0306_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.3 - 0.6, and is in between transect C and D
ABF_515_0306_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.3 - 0.6, and is in between transect D and E
ABF_515_0306_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.3 - 0.6, and is in between transect E and F
ABF_515_0306_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.3 - 0.6, and is in between transect F and G
ABF_515_0306_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.3 - 0.6, and is in between transect G and H
ABF_515_0306_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.3 - 0.6, and is in between transect H and I
ABF_515_0306_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.3 - 0.6, and is in between transect I and J

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
ABF_515_0306_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull,5 - 15 m in length, has a diameter between 0.3 - 0.6, and is in between transect J and K
ABF_515_0608_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.6 - 0.8, and is in between transect A and B
ABF_515_0608_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.6 - 0.8, and is in between transect B and C
ABF_515_0608_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.6 - 0.8, and is in between transect C and D
ABF_515_0608_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.6 - 0.8, and is in between transect D and E
ABF_515_0608_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.6 - 0.8, and is in between transect E and F
ABF_515_0608_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.6 - 0.8, and is in between transect F and G
ABF_515_0608_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.6 - 0.8, and is in between transect G and H
ABF_515_0608_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.6 - 0.8, and is in between transect H and I
ABF_515_0608_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.6 - 0.8, and is in between transect I and J
ABF_515_0608_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter between 0.6 - 0.8, and is in between transect J and K

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
ABF_515_08_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter >0.8, and is in between transect A and B
ABF_515_08_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter >0.8, and is in between transect B and C
ABF_515_08_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter >0.8, and is in between transect C and D
ABF_515_08_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter >0.8, and is in between transect D and E
ABF_515_08_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter >0.8, and is in between transect E and F
ABF_515_08_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter >0.8, and is in between transect F and G
ABF_515_08_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter >0.8, and is in between transect G and H
ABF_515_08_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter >0.8, and is in between transect H and I
ABF_515_08_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter >0.8, and is in between transect I and J
ABF_515_08_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 5 - 15 m in length, has a diameter >0.8, and is in between transect J and K
ABF_155_0103_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.1 - 0.3, and is in between transect A and B

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
ABF_155_0103_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.1 - 0.3, and is in between transect B and C
ABF_155_0103_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.1 - 0.3, and is in between transect C and D
ABF_155_0103_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.1 - 0.3, and is in between transect D and E
ABF_155_0103_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.1 - 0.3, and is in between transect E and F
ABF_155_0103_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.1 - 0.3, and is in between transect F and G
ABF_155_0103_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.1 - 0.3, and is in between transect G and H
ABF_155_0103_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.1 - 0.3, and is in between transect H and I
ABF_155_0103_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.1 - 0.3, and is in between transect I and J
ABF_155_0103_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.1 - 0.3, and is in between transect J and K
ABF_155_0306_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.3 - 0.6, and is in between transect A and B
ABF_155_0306_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.3 - 0.6, and is in between transect B and C

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
ABF_155_0306_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.3 - 0.6, and is in between transect C and D
ABF_155_0306_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.3 - 0.6, and is in between transect D and E
ABF_155_0306_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.3 - 0.6, and is in between transect E and F
ABF_155_0306_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.3 - 0.6, and is in between transect F and G
ABF_155_0306_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.3 - 0.6, and is in between transect G and H
ABF_155_0306_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.3 - 0.6, and is in between transect H and I
ABF_155_0306_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull,1.5 - 5 m in length, has a diameter between 0.3 - 0.6, and is in between transect I and J
ABF_155_0306_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.3 - 0.6, and is in between transect J and K
ABF_155_0608_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.6 - 0.8, and is in between transect A and B
ABF_155_0608_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.6 - 0.8, and is in between transect B and C
ABF_155_0608_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.6 - 0.8, and is in between transect C and D

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
ABF_155_0608_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull,1.5 - 5 m in length, has a diameter between 0.6 - 0.8, and is in between transect D and E
ABF_155_0608_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.6 - 0.8, and is in between transect E and F
ABF_155_0608_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.6 - 0.8, and is in between transect F and G
ABF_155_0608_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.6 - 0.8, and is in between transect G and H
ABF_155_0608_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.6 - 0.8, and is in between transect H and I
ABF_155_0608_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.6 - 0.8, and is in between transect I and J
ABF_155_0608_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter between 0.6 - 0.8, and is in between transect J and K
ABF_155_08_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter >0.8, and is in between transect A and B
ABF_155_08_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter >0.8, and is in between transect B and C
ABF_155_08_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter >0.8, and is in between transect C and D
ABF_155_08_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter >0.8, and is in between transect D and E

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
ABF_155_08_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter >0.8, and is in between transect E and F
ABF_155_08_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter >0.8, and is in between transect F and G
ABF_155_08_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter >0.8, and is in between transect G and H
ABF_155_08_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter >0.8, and is in between transect H and I
ABF_155_08_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter >0.8, and is in between transect I and J
ABF_155_08_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is above bankfull, 1.5 - 5 m in length, has a diameter >0.8, and is in between transect J and K

tbl_Reach_WD_bankfull: This table contains information about woody debris that is all or part of the bankfull.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Data_ID	M	Text	50	NA	NA	NA	NA	Data row identifier
Event_ID	M	Text	50	NA	NA	NA	NA	Links to the event
BF_15_0103_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.1 - 0.3, and is in between transect A and B
BF_15_0103_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.1 - 0.3, and is in between transect B and C
BF_15_0103_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.1 - 0.3, and is in between transect C and D

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
BF_15_0103_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.1 - 0.3, and is in between transect D and E
BF_15_0103_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.1 - 0.3, and is in between transect E and F
BF_15_0103_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.1 - 0.3, and is in between transect F and G
BF_15_0103_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.1 - 0.3, and is in between transect G and H
BF_15_0103_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.1 - 0.3, and is in between transect H and I
BF_15_0103_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.1 - 0.3, and is in between transect I and J
BF_15_0103_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.1 - 0.3, and is in between transect J and K
BF_15_0306_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.3 - 0.6, and is in between transect A and B
BF_15_0306_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.3 - 0.6, and is in between transect B and C
BF_15_0306_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.3 - 0.6, and is in between transect C and D
BF_15_0306_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.3 - 0.6, and is in between transect D and E

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
BF_15_0306_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.3 - 0.6, and is in between transect E and F
BF_15_0306_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.3 - 0.6, and is in between transect F and G
BF_15_0306_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.3 - 0.6, and is in between transect G and H
BF_15_0306_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.3 - 0.6, and is in between transect H and I
BF_15_0306_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.3 - 0.6, and is in between transect I and J
BF_15_0306_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.3 - 0.6, and is in between transect J and K
BF_15_0608_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.6 - 0.8, and is in between transect A and B
BF_15_0608_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.6 - 0.8, and is in between transect B and C
BF_15_0608_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.6 - 0.8, and is in between transect C and D
BF_15_0608_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.6 - 0.8, and is in between transect D and E
BF_15_0608_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.6 - 0.8, and is in between transect E and F

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
BF_15_0608_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.6 - 0.8, and is in between transect F and G
BF_15_0608_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.6 - 0.8, and is in between transect G and H
BF_15_0608_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.6 - 0.8, and is in between transect H and I
BF_15_0608_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.6 - 0.8, and is in between transect I and J
BF_15_0608_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter between 0.6 - 0.8, and is in between transect J and K
BF_15_08_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter >0.8, and is in between transect A and B
BF_15_08_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter >0.8, and is in between transect B and C
BF_15_08_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter >0.8, and is in between transect C and D
BF_15_08_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter >0.8, and is in between transect D and E
BF_15_08_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter >0.8, and is in between transect E and F
BF_15_08_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter >0.8, and is in between transect F and G
BF_15_08_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter >0.8, and is in between transect G and H

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
BF_15_08_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter >0.8, and is in between transect H and I
BF_15_08_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter >0.8, and is in between transect I and J
BF_15_08_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, >15 m in length, has a diameter >0.8, and is in between transect J and K
BF_515_0103_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.1 - 0.3, and is in between transect A and B
BF_515_0103_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.1 - 0.3, and is in between transect B and C
BF_515_0103_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.1 - 0.3, and is in between transect C and D
BF_515_0103_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.1 - 0.3, and is in between transect D and E
BF_515_0103_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.1 - 0.3, and is in between transect E and F
BF_515_0103_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.1 - 0.3, and is in between transect F and G
BF_515_0103_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.1 - 0.3, and is in between transect G and H
BF_515_0103_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.1 - 0.3, and is in between transect H and I
BF_515_0103_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 in length, has a diameter between 0.1 - 0.3, and is in between transect I and J

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
BF_515_0103_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 in length, has a diameter between 0.1 - 0.3, and is in between transect J and K
BF_515_0306_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.3 - 0.6, and is in between transect A and B
BF_515_0306_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.3 - 0.6, and is in between transect B and C
BF_515_0306_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.3 - 0.6, and is in between transect C and D
BF_515_0306_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.3 - 0.6, and is in between transect D and E
BF_515_0306_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.3 - 0.6, and is in between transect E and F
BF_515_0306_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.3 - 0.6, and is in between transect F and G
BF_515_0306_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.3 - 0.6, and is in between transect G and H
BF_515_0306_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.3 - 0.6, and is in between transect H and I
BF_515_0306_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.3 - 0.6, and is in between transect I and J
BF_515_0306_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull,5 - 15 m in length, has a diameter between 0.3 - 0.6, and is in between transect J and K

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
BF_515_0608_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.6 - 0.8, and is in between transect A and B
BF_515_0608_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.6 - 0.8, and is in between transect B and C
BF_515_0608_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.6 - 0.8, and is in between transect C and D
BF_515_0608_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.6 - 0.8, and is in between transect D and E
BF_515_0608_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.6 - 0.8, and is in between transect E and F
BF_515_0608_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.6 - 0.8, and is in between transect F and G
BF_515_0608_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.6 - 0.8, and is in between transect G and H
BF_515_0608_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.6 - 0.8, and is in between transect H and I
BF_515_0608_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.6 - 0.8, and is in between transect I and J
BF_515_0608_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter between 0.6 - 0.8, and is in between transect J and K
BF_515_08_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter >0.8, and is in between transect A and B
BF_515_08_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter >0.8, and is in between transect B and C

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
BF_515_08_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter >0.8, and is in between transect C and D
BF_515_08_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter >0.8, and is in between transect D and E
BF_515_08_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter >0.8, and is in between transect E and F
BF_515_08_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter >0.8, and is in between transect F and G
BF_515_08_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter >0.8, and is in between transect G and H
BF_515_08_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter >0.8, and is in between transect H and I
BF_515_08_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter >0.8, and is in between transect I and J
BF_515_08_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 5 - 15 m in length, has a diameter >0.8, and is in between transect J and K
BF_155_0103_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.1 - 0.3, and is in between transect A and B
BF_155_0103_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.1 - 0.3, and is in between transect B and C
BF_155_0103_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.1 - 0.3, and is in between transect C and D
BF_155_0103_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.1 - 0.3, and is in between transect D and E

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
BF_155_0103_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.1 - 0.3, and is in between transect E and F
BF_155_0103_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.1 - 0.3, and is in between transect F and G
BF_155_0103_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.1 - 0.3, and is in between transect G and H
BF_155_0103_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.1 - 0.3, and is in between transect H and I
BF_155_0103_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.1 - 0.3, and is in between transect I and J
BF_155_0103_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.1 - 0.3, and is in between transect J and K
BF_155_0306_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.3 - 0.6, and is in between transect A and B
BF_155_0306_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.3 - 0.6, and is in between transect B and C
BF_155_0306_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.3 - 0.6, and is in between transect C and D
BF_155_0306_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.3 - 0.6, and is in between transect D and E
BF_155_0306_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.3 - 0.6, and is in between transect E and F

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
BF_155_0306_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.3 - 0.6, and is in between transect F and G
BF_155_0306_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.3 - 0.6, and is in between transect G and H
BF_155_0306_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.3 - 0.6, and is in between transect H and I
BF_155_0306_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull,1.5 - 5 m in length, has a diameter between 0.3 - 0.6, and is in between transect I and J
BF_155_0306_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.3 - 0.6, and is in between transect J and K
BF_155_0608_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.6 - 0.8, and is in between transect A and B
BF_155_0608_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.6 - 0.8, and is in between transect B and C
BF_155_0608_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.6 - 0.8, and is in between transect C and D
BF_155_0608_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull,1.5 - 5 m in length, has a diameter between 0.6 - 0.8, and is in between transect D and E
BF_155_0608_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.6 - 0.8, and is in between transect E and F
BF_155_0608_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.6 - 0.8, and is in between transect F and G

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
BF_155_0608_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.6 - 0.8, and is in between transect G and H
BF_155_0608_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.6 - 0.8, and is in between transect H and I
BF_155_0608_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.6 - 0.8, and is in between transect I and J
BF_155_0608_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter between 0.6 - 0.8, and is in between transect J and K
BF_155_08_A-B	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter >0.8, and is in between transect A and B
BF_155_08_B-C	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter >0.8, and is in between transect B and C
BF_155_08_C-D	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter >0.8, and is in between transect C and D
BF_155_08_D-E	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter >0.8, and is in between transect D and E
BF_155_08_E-F	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter >0.8, and is in between transect E and F
BF_155_08_F-G	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter >0.8, and is in between transect F and G
BF_155_08_G-H	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter >0.8, and is in between transect G and H
BF_155_08_H-I	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter >0.8, and is in between transect H and I

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
BF_155_08_I-J	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter >0.8, and is in between transect I and J
BF_155_08_J-K	M	Number	NA	0	NA	0	NA	Count of the woody debris that is all or part of bankfull, 1.5 - 5 m in length, has a diameter >0.8, and is in between transect J and K

tbl_Sites: This table contains the general information about the survey area.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Site_ID	Y	Text	50	NA	NA	NA	NA	Unique site identifer
Site_Name	Y	Text	100	NA	See list of steams for each park.	NA	NA	Name of the 3 kilometer segment
Site_Desc	Y	Text	9	NA	Stream	NA	NA	Category of the 3 kilometer segment
Unit_Code	Y	Text	4	NA	CRLA, LABE, LAVO, ORCA, REDW, WHIS	NA	NA	Park where the site occurs
Site_Notes	N	Memo	NA	NA	NA	NA	NA	General notes about the segment
GIS_Location_ID	Y	Text	50	NA	NA	NA	NA	Unique ID that links the site to the GIS Feature Class

tlu_Contacts: This table provides the contact information for people working on this project

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Contact_ID	Y	Text	50	NA				Unique ID for each individual
Last_Name	Y	Text	50	NA				Last name of the individual
First_Name	Y	Text	50	NA				First name of the individual
Middle_Init	N	Text	1	NA				Middle initial of the individual
Organization	Y	Text	20	NA				Organization the individual is working for
Position_Title	Y	Text	20	NA				Positions they hold on the project
Address_Type	Y	Text	25	NA	Physical, Mailing, Physical and Mailing			Type of address entered
Address	Y	Text	255	NA				Their contact address
Address2	N	Text	255	NA				Their contact address
City	Y	Text	50	NA				City where they live
State_Code	Y	Text	2	NA				State where they live
Zip_Code	Y	Number	5	NA				Zipcode where they live
Country	Y	Text	3	NA				Country where they live
Email_Address	N	Text	100	NA				Email address of the individual
Work_Phone	Y	Text	14	NA				Work phone number
Work_Extension	N	Text	10	NA				Work extension number
Contact_Notes	N	Memo	NA	NA				General information

tlu_Enumeration: This table provides the values used in enumeration for lookup values.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Enum_Code	Y	Text	50	NA	NA	NA	NA	Code for lookup values
Enum_Description	N	Memo	NA	NA	NA	NA	NA	Lookup value description
Enum_Group	Y	Text	50	NA	NA	NA	NA	Category for lookup value
Sort_Order	Y	Number	NA	0	NA	NA	NA	Order in which to sort lookup values

tbl_Reports: This table contains the information needed to make the reporting tool for this database function.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Seq	Y	Number	NA	0	NA	NA	NA	A sequence so you can sort the reports
RptTitle	Y	Text	100	NA	NA	NA	NA	Title of the report, analysis, or raw data
RptName	Y	Text	100	NA	NA	NA	NA	Name of the report, analysis, or raw data
DateRange	Y	Yes / No	NA	NA	Yes, No	NA	NA	Makes the date field visible
SelPark	Y	Yes / No	NA	NA	Yes, No	NA	NA	Makes the park field visible
SelSegment	Y	Yes / No	NA	NA	Yes, No	NA	NA	Makes the segment field visible
selSegType	Y	Yes / No	NA	NA	Yes, No	NA	NA	Makes the segment type field visible
SelSpecies	Y	Yes / No	NA	NA	Yes, No	NA	NA	Makes the species field visible
SelLocType	Y	Yes / No	NA	NA	Yes, No	NA	NA	Makes the location type field visible

tbl_Reach_Thalweg: This table contains data about the thalweg profile.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Data_ID	M	Text	50	NA	NA	NA	NA	Data row identifier
Event_ID	M	Text	50	NA	NA	NA	NA	Links to the event
Transect	M	Text	5	NA	A - K	NA	NA	Transect where the sample is being taken
Station	M	Long Integer	NA	NA	0 - 14	0	14	Station where the sample will be taken
Depth	M	Double	NA	2	NA	0	NA	Depth at the transect and station in meters
Wetted_Width	M	Double	NA	2	NA	0	NA	Distance across bars from wetted bank to wetted bank in meters
Bar_Width	M	Yes/No	NA	NA	Yes/No	NA	NA	Presence / Absence of bar width
Bar_Distance	MA	Double	NA	2	NA	0	NA	Bar width distance if present
Sediment	M	Yes/No	NA	NA	Yes/No	NA	NA	Presence / Absence of sediment
Channel_Code	M	Text	2	NA	PP, PT, PL, PB, PD, GL, RI, RA, CA, FA, DR	NA	NA	Stream classification
Pool_Form	M	Text	3	NA	N, W, R, B, F, OT, or combination	NA	NA	Potential cause of the pool.

Field Name	Required	Field Type	Field Size	Decimal	Enumerated Domain	Min Value	Max Value	Field Description
Side_Channel	M	Yes/No	NA	NA	Yes/No	NA	NA	Presence / Absence of a side channel
Back_Water	M	Yes/No	NA	NA	Yes/No	NA	NA	Presence / Absence of back water
Flag	M	Text	50	NA	NA	NA	NA	Flag pointing out potential issues wit h the data.
Thalweg_Comments	M	Memo	NA	NA	NA	NA	NA	General comments
Increment	M	Double	NA	1	NA	0	NA	Increments in meters
Reach_Length	M	Double	NA	1	NA	0	NA	Total reach length in meters
Substrate_Left	M	Text	2	NA	RS, RR, BL, CB, GC, GF, SA, FN, HP, WD, OT	NA	NA	Under substrate cross-sectional information
Substrate_Left_Center	M	Text	2	NA	RS, RR, BL, CB, GC, GF, SA, FN, HP, WD, OT	NA	NA	Under substrate cross-sectional information
Substrate_Center	M	Text	2	NA	RS, RR, BL, CB, GC, GF, SA, FN, HP, WD, OT	NA	NA	Under substrate cross-sectional information
Substrate_Right_Center	M	Text	2	NA	RS, RR, BL, CB, GC, GF, SA, FN, HP, WD, OT	NA	NA	Under substrate cross-sectional information
Substrate_Right	M	Text	2	NA	RS, RR, BL, CB, GC, GF, SA, FN, HP, WD, OT	NA	NA	Under substrate cross-sectional information
Substrate_Flag	M	Text	2	NA	RS, RR, BL, CB, GC, GF, SA, FN, HP, WD, OT	NA	NA	Under substrate cross-sectional information

Integrated Water Quality and Aquatic Communities Protocol –Wadeable Streams

Standard Operating Procedure (SOP) #21: Sensitive Data

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP includes instructions for handling sensitive data. This document was adapted from the National Park Service North Coast and Cascades Network Data Management Plan (Boetsch et al. 2009).

Introduction

Although it is the general NPS policy to share information widely, the NPS also realizes that providing information about the location of park resources may sometimes place those resources at risk of harm, theft, or destruction. This can occur, for example, with regard to caves, archeological sites, tribal information, and rare plant and animal species. Therefore, information will be withheld when the NPS foresees that disclosure would be harmful to an interest protected by an exemption under the Freedom of Information Act (FOIA). The National Parks Omnibus Management Act, Section 207, 16 U.S.C. 5937, is interpreted to prohibit the release of information regarding the "nature or specific location" of certain cultural and natural resources in the national park system. Additional details and information about the legal basis for this policy can be found in the NPS Management Policies (National Park Service 2006) and in Director's Order #66. These guidelines apply to all KLMN staff, cooperators, contractors, and other partners who are likely to obtain or have access to information about protected NPS resources. The Project Lead has primary responsibility for ensuring adequate protection of sensitive information related to this project.

The following are highlights of our strategy for protecting this information:

1. *Protected resources*, in the context of the KLMN Inventory and Monitoring Program, include species that have State- or Federally-listed status and other species deemed rare or sensitive by local park taxa experts.
2. *Sensitive information* is defined as information about protected resources which may reveal the "nature or specific location" of protected resources. Such information must not be shared outside the National Park Service, unless a signed confidentiality agreement is in place.

3. In general, if information is withheld from one non-NPS requesting party, it must be withheld from anyone else who requests it, and if information is provided to one requesting party without a confidentiality agreement, it must be provided to anyone else who requests it.
4. To share information as broadly as legally possible and to provide a consistent, tractable approach for handling sensitive information, the following shall apply if a project is likely to collect and store sensitive information:
    a. Random coordinate offsets of up to 2 km for data collection locations, and
    b. Removal of data fields from the released copy that are likely to contain sensitive information.

What Kinds of Information Can and Cannot Be Shared?

Do Not Share
Project staff and cooperators should not share any information outside NPS that reveals details about the "nature or specific location" of protected resources, unless a confidentiality agreement is in place. Specifically, the following information should be omitted from shared copies of all data, presentations, reports, or other published forms of information.
1. *Exact coordinates* – Instead, public coordinates are to be generated that consist of rare and sensitive species locations being documented with the centroid coordinate of the park.
2. *Other descriptive location data* – Examples may include travel descriptions, location descriptions, or other fields that contain information which may reveal the specific location of the protected resource(s).
3. *Protected resource observations at disclosed locations* – If specific location information has already been made publicly available, the occurrence of protected resources at that location cannot be shared outside NPS without a confidentiality agreement. For example, if the exact coordinates for a monitoring station location are posted to a web site or put into a publication, then at a later point in time a spotted owl nest is observed at that monitoring station, that nest cannot be mentioned or referred to in any report, presentation, dataset, or publication that will be shared outside NPS.

Do Share
All other information about the protected resource(s) may be freely shared, so long as the information does not reveal details about the "nature or specific location" of the protected resource(s) that are not already readily available to the general public in some form (e.g., other published material). Species tallies and other types of data presentations that do not disclose the precise locations of protected resources may be shared, unless by indicating the presence of the species the specific location is also revealed (i.e., in the case of a small park).

Details for Specific Products
Whenever products such as databases and reports are being generated, handled, and stored, they should be created explicitly for one of the following purposes:
1. *Public or general use* – Intended for general distribution, sharing with cooperators, or posting to public web sites. They may be derived from products that contain sensitive information so long as the sensitive information is either removed or otherwise rendered in a manner consistent with other guidance in this document.

2. *Internal NPS use* – These are products that contain sensitive information and should be stored and distributed only in a manner that ensures their continued protection. These products should clearly indicate that they are solely for internal NPS use by containing the phrase: “Internal NPS Use Only – Not For Release.” These products can only be shared within NPS or in cases where a confidentiality agreement is in place. They do not need to be revised in a way that conceals the location of protected resources.

When submitting products to the Network Data Manager, a Certification form is required. If the submitted product was not meant for public use, it should be clearly noted on question 8 of the Certification form (SOP #23: Data Transfer, Storage, and Archive).

Datasets

To create a copy of a dataset that will be posted or shared outside NPS:

1. Make sure the public offset coordinates have been populated for each rare or endangered species documented in tbl_Species or tbl_Invert_Species.
2. Delete the following database objects to ensure consistent omission of fields that may contain specific, identifying information about locations of protected resources:
    a. tbl_Locations.Travel_Directions
    b. tbl_Locations.Loc_Notes
    c. tbl_Event_Details.Event_Notes
    d. tbl_Locations.(x_coord, y_coord [1-5])
    e. tbl_Locations.Section
    f. tbl_Locations.Parking_Easting, Parking_Northing

The local, master copy of the database contains the exact coordinates and all data fields. The Data Manager and/or GIS Specialist can provide technical assistance as needed to apply coordinate offsets or otherwise edit data products for sensitive information.

Maps and Other GIS Output

General use maps and other geographic representations of observation data that will be released or shared outside NPS should be rendered using offset coordinates (for sensitive species) and should only be rendered at a scale that does not reveal their exact position (e.g., 1:100,000 maximum scale).

If a large-scale, close-up map is to be created using exact coordinates (e.g., for field crew navigation, etc.), the map should be clearly marked with the following phrase: “Internal NPS Use Only – Not For Release.”

The Network Data Manager and/or GIS Specialist can provide technical assistance as needed to apply coordinate offsets or otherwise edit data products for sensitive information.

Presentations and Reports

Public or general-use reports and presentations should adhere to the following guidelines:

1. Do not list exact coordinates or specific location information in any text, figure, table, or graphic in the report or presentation. If a list of coordinates is necessary, use only offset coordinates and clearly indicate that coordinates have been purposely offset to protect the resource(s) as required by law and NPS policy.

2. Use only general use maps, as specified in the section on maps and other GIS output.

If a report is intended for internal use only, these restrictions do not apply. However, each page should be clearly marked with the following phrase: “Internal NPS Use Only – Not For Release.”

Voucher Specimens
Specimens of protected taxa should only be collected as allowed by law. Labels for specimens should be clearly labeled as containing sensitive information by including the following phrase: “Internal NPS Use Only – Not For Release.” These specimens should be stored separately from other specimens to prevent unintended access by visitors. As with any sensitive information, a confidentiality agreement should be in place prior to sending these specimens to another non-NPS cooperator or collection.

Sharing Sensitive Information
No sensitive information (e.g., information about the specific nature or location of protected resources) may be posted to the NPS Data Store or another publicly accessible web site, or otherwise shared or distributed outside NPS without a confidentiality agreement between NPS and the agency, organization, or person(s) with whom the sensitive information is to be shared. Note that sensitive information posted to NPS Data Store may be protected from public access, but not NPS access. In some cases (not likely in the current protocol), park personnel may wish to restrict this access as well. Only products that are intended for public/general use may be posted to public web sites and clearinghouses; these may not contain sensitive information.

Responding to Data Requests
If requests for distribution of products containing sensitive information are initiated by the NPS, by another federal agency, or by another partner organization (e.g., a research scientist at a university), the unedited product (e.g., the full dataset that includes sensitive information) may only be shared after a confidentiality agreement is established between NPS and the agency, organization, or person(s) with whom the sensitive information is to be shared.

Once a confidentiality agreement is in place, products containing sensitive information may be shared following these guidelines:
1. Prior to distribution, talk to the Project Manager and Park Resource Specialist to make sure they know the data are being distributed.
2. Always clearly indicate in accompanying correspondence that the products contain sensitive information and specify which products contain sensitive information.
3. Indicate in all correspondence that products containing sensitive information should be stored and maintained separately from non-sensitive information and protected from accidental release or re-distribution.
4. Indicate that NPS retains all distribution rights; copies of the data should not be redistributed by anyone but NPS.
5. Include the following standard disclaimer in a text file with all digital media upon distribution: “The following files contain protected information. This information was provided by the National Park Service under a confidentiality agreement. It is not to be published, handled, re-distributed, or used in a manner inconsistent with that agreement.” The text file should also specify the file(s) containing sensitive information.

6. If the products are being sent on physical media (e.g., CD or DVD), the media should be marked in such a way that clearly indicates that media contains sensitive information provided by the National Park Service.

Confidentiality Agreements

Confidentiality agreements may be created between the NPS and another organization or individual to ensure that protected information is not inadvertently released. When contracts or other agreements with a non-federal partner do not include a specific provision to prevent the release of protected information, the written document must include the following standard Confidentiality Agreement:

> **Confidentiality Agreement** - I agree to keep confidential any protected information that I may develop or otherwise acquire as part of my work with the National Park Service. I understand that with regard to protected information, I am an agent of the National Park Service and must not release that information. I also understand that by law I may not share protected information with anyone through any means except as specifically authorized by the National Park Service. I understand that protected information concerns the nature and specific location of endangered, threatened, rare, commercially valuable, mineral, paleontological, or cultural patrimony resources such as threatened or endangered species, rare features, archeological sites, museum collections, caves, fossil sites, gemstones, and sacred ceremonial sites. Lastly, I understand that protected information must not be inadvertently disclosed through any means, including web sites, maps, scientific articles, presentation, and speeches.

Note: Certain states, including the State of Washington, have sunshine laws that do not have exemptions for sensitive information. NPS should not create confidentiality agreements or share sensitive information with these states without first seeking the advice of an NPS solicitor.

If mailing or directly providing data that contains sensitive information, follow the procedures described above. In addition, have the individual sign a confidentiality agreement, which is provided on the KLMN server at: S:\Data_Management\Standard Operating Procedures\Klamath_Network_SOP_and_Guidelines\Sensitive Information.

Freedom of Information (FOIA) Requests

All official FOIA requests will be handled according to NPS policy. The Project Lead will work with the Data Manager and the park FOIA representative(s) of the park(s) for which the request applies.

References

Boetsch, J. R., B. Christoe, and R. E. Holmes. 2009. Data management plan for the North Coast and Cascades Network Inventory and Monitoring Program (2005). Natural Resource Report NPS/NCCN/NRR—2009/078. National Park Service, Fort Collins, CO.

National Park Service. 2006. Management policies. Online. (http://www.nps.gov/policy/mp/policies.htm). Accessed 6 February 2007.

Director’s Order Number 66. Freedom of Information Act and the protection of exempted information. National Park Service.

Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #22: Data Analysis and Reporting

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

Overview

This SOP describes the general philosophy and approach for data analysis and reporting of the Klamath Network Wadeable Streams protocol. The reports are intended to meet the needs for consistent and appropriate water quality condition reporting and for rigorous, quantitative descriptions of the physical, chemical, and biological aspect of park streams and their changes over time. This SOP is separated into two sections: (1) General intent, philosophical, target audiences, and recommended analysis approaches for Annual Reports, Analysis and Synthesis Reports, and Resource Briefs; and (2) Specific guidelines for water quality and aquatic community analyses. The purpose of section one is to dictate the reporting schedule and content of the reports so that they meet protocol objectives.

These reports are intended to be authored by the Project Lead with assistance from the Network Coordinator and Data Manager and with potential input from outside scientists or science communication professionals, as appropriate. The purpose of section two is to ensure that statistics used in all reports are properly and consistently done. Since water quality assessments can provide a basis for changes in management that might affect public health or livelihoods, we provide specific guidelines to ensure that they maintain continuity over time and conform to appropriate standards and guidelines.

Reporting

The target audience of reports (Annual and Analysis and Synthesis) is a broad group of interested parties, including park superintendents, resource managers, Inventory and Monitoring staff, external scientists, partners, and the public. Resource briefs will be targeted to park superintendents, interpretative staff, and park managers. The timelines and specific purposes of each report are detailed in Table 1.

Annual Reports

Annual reports serve as the main conduit for informing the audiences of the current years' monitoring activities and for conveying water quality condition information. An example of an annual report is given in Appendix A of this protocol and should serve as a template for future reports. In all annual reports, an emphasis will be put on using summary statistics (measures of central tendency and dispersion) for key water quality and community parameters of the protocol. Findings of special interest to resource managers or the public will also be highlighted. Examples of this are instances of wildlife diseases or new records of non-native species. In general, the annual reports will not lend themselves to hypothesis testing; rather, hypothesis testing (on trends) will be covered in later Analysis and Synthesis reports. However, the nature of water quality monitoring allows for the allocation of impaired versus unimpaired condition. This should be a component of all Wadeable Streams annual reports. Recommendations for protocol revisions will also be suggested as necessary.

Annual reports will follow the formatting guidelines of the Natural Resource Publications series, using the Natural Resource Technical Report (NRTR) guidelines. Since the annual reports will include analyses of impairment, it is recommended that the reports always be published in the NRTR series, not the Natural Resource Data Series.

As part of this series, the Annual Report will include:

1. Executive summary.
2. Introduction with brief explanation on project background.
3. Methods section, referencing this protocol, with a level of detail appropriate for scientific publication.
4. Summary of past Network efforts in relevant park units.
5. Results of the current sampling effort, with special reference to species observed.
6. Evaluation of water quality condition (e.g., impaired vs. unimpaired; fair, good, etc.) for both GRTS based sites and on judgment sites based on appropriate EPA and state guidelines, for the following: EPA EMAP vertebrate MMI, EPA EMAP invertebrate MMI, state IBIs, Observed/expected ratio, acid neutralizing, specific conductance, temperature, pH, total nitrogen, total phosphorous, dissolved oxygen, riparian disturbance, riparian cover, fish cover, and relative bed stability.
7. Public interest highlights.
8. Suggestions and justifications for any proposed changes to the protocol.

Table 21. Overview of data reporting for Klamath Network Streams Protocol. Year refers to the year initiated (reports will be due the following year). *Analysis and Synthesis reports in 2028 and beyond do not have a “scheduled” topic. Rather, the Network staff at that time is encouraged to explore new and emerging avenues of summaries and analyses (with emphasis on park relevant material), but will always include a trend component. CDF = Cumulative Distribution Function, IBI = Index of Biotic Integrity, O/E = Observed/Expected ratios.

Report type	Year(s)	Purpose	Method and References (if applicable)
Annual Report	Every sampling year	Summarize monitoring activities	
		Describe current status and condition of water quality parameters	Means/Medians/Variance/CDF (Stoddard et al. 2005)
		Document changes/recommendations to monitoring protocols	SOP #24: Revising the Protocol (this document)
		Increase communication between I&M program and all parties	
Analysis and Synthesis	2013	Description of Klamath Network Stream Physical gradients and patterns	Kaufmann et al.1999
	2016	Description of Klamath Network Stream Chemistry	
	2019	Description of Klamath Network Stream Community gradients and patterns	Stoddard et al. 2005
	2022	Integrated Assessment of Klamath Network Riparian Habitats	
	2025	Trend Analyses of Ecological Integrity (Select univariate & multivariate – IBI, ATI, O/E, species composition)	Time series (e.g., Mann-Kendall; progressive change) (Chatfield 2004; Phillipi et al. 1998)

Proportion of Streams Condition

Assignment of proportion of different stream conditions based on water quality standards or bioassessment is a standard method for describing monitoring results (Stoddard et al. 2005, US EPA 2006). Generally, the number of miles (or kilometers) affected is the standard and is calculated by tallying the number of miles represented by the affected site and summing up across all "impaired" miles. Tools to implement this approach are available in the *psurvey.analysis* R library provided by the EMP at: http://www.epa.gov/nheerl/arm/analysispages/software.htm.

For ease of calculation, we take a more conservative estimate based on a simple proportion impacted sites to non-impacted sites, assuming that site selection was done with equal weighting for sample inclusion. For example, if the North Coast B-IBI (see below) has nine out of 30 sites that are graded as "fair," then the total percent of "fair" streams is 30%. This method can be used for O/E scores, IBIs, and proportion of streams exceeding water quality standards. The best way to graphically present this is Empirical Cumulative Distribution Estimates. An example is shown in Figure 1, from (Stoddard et al. 2005), where the horizontal axis is the response variable and the vertical axis is the cumulative percentage of stream length (we will use percentage of sites). Note that it would be possible to create Empirical Cumulative Distribution Estimates for almost every parameter measured in this protocol, for each park monitored; this could result in a very large number of graphs. Instead of presenting countless graphs in annual reports, this technique should be relegated to helping the Project Lead as an Exploratory Data Analysis and to interpret and understand the data collected.

Confidence intervals of the Cumulative Distribution Estimate can be calculated from (Stoddard et al. 2005):

Where Z is the critical value from the student's t distribution, p is the proportion, and n is the sample size. In the Klamath Network, we will use a conservative α level of 0.10 (i.e., a 90% confidence interval) so that for a sample size of 30, the Z value is 1.697 (Rohlf and Sokal 1995). Although p varies, it is maximized at $p = 0.05$. Under these parameters, the most conservative half-width of our confidence intervals is 15.5%.

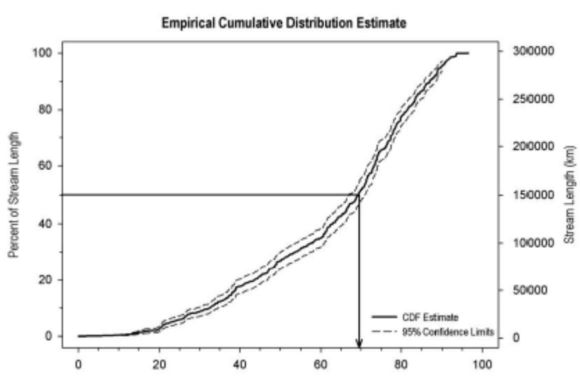

Figure 64. Example of Empirical Cumulative Distribution Estimate for display water quality data. The horizontal line (at 50%) represents the median, which in this example relates to approximately "70" of the response variable.

Analysis and Synthesis Reports

Analysis and Synthesis reports provide in-depth examinations of topics relevant to park management, creating a forum for integrating current science and statistical techniques with Network data. Like the Annual Reports, they should follow the guidelines of the Natural Resource Technical Report, yet they should address identified topics of clear ecological and management significance that have been identified to serve specific audiences within the parks or the larger scientific community. The contents of the report should be similar to scientific publications, with, at a minimum:

1. Abstract
2. Introduction
3. Methods
4. Results
5. Discussion

Depending upon length, complexity, and target audience, Analysis and Synthesis reports may be published in the NRTR series or in peer-reviewed scientific publications.

Analysis and Synthesis reports are one-time reports, outlined by the Network to deliver in-depth synthesis of existing knowledge to park specialists. Topics may be re-analyzed or re-done in the future, but this decision and future, un-seen topics are to be decided upon in later years (post 2025) by the current Project Lead, Program Manager, and park needs. These reports are intended to provide parks with useful, pertinent information on their resources until trend analyses can be completed.

Analysis and Synthesis Reports 1 – 3: Physical, Chemical, and Biological Gradients and Classification

The reports are planned to be prepared to provide a portfolio of information about our stream ecosystems arrayed as distinct but mutually reinforcing suites of information. They are planned to start with the least temporally variable geomorphic and general hydrological habitat features and move towards the more temporally variable chemical and biological species. We recognize that hydrology (e.g., the hydrograph) itself can be among the most temporally dynamic of stream parameters, but intend to describe the fundamental spatial patterns of the stream networks in each park as a foundation for subsequent temporal analyses of all parameters. An analogy would be to present the general climate features of the parks which are striking and largely consistent over time, even as daily and seasonal weather show great variability.

Analysis and Synthesis Report 1: Stream Physical Habitat Gradients and Classification – will describe the physical habitat gradients and relevant geomorphic types across the sampling frame in each park. It will be prepared after the second sampling period (2013), so that a single season of sampling has occurred in all Network parks. The first report will analyze and synthesize a large set of data, including, but not limited to: geomorphic (e.g., channel cross-section, stream gradient), large woody debris, substrate, discharge, watershed area, and stream order data to provide a comprehensive view of the array and interrelationships of physical stream habitats across the Network parks. Where possible, it will place the park streams within existing geomorphic and stream classification systems (e.g., Strahler 1957, Pfankuch 1975, Frissell et al. 1986, Rosgen 1994, Montgomery and Buffington 1997) to foster comparison with other regional landowners and to provide context for future assessments of ecological integrity in the parks.

Flow regime, quantity and size of sediment, and the topographic setting are known to set geomorphic thresholds that define changes in fluvial processes and form, separating riverine landscapes and habitats from one another (Church 2002). This variation in pattern and process comprises important dimensions of the stream ecosystem, with direct relevance to evaluations of ecological integrity (Sullivan et al. 2004). Although geomorphic conditions are transient at a given point along a stream network, the analysis and synthesis of fluvial forms and their interdependence with flow patterns will provide both quantitative descriptions of the stream template and insights into the factors creating and maintaining aquatic and riparian habitat in the parks.

Outside of the variable hydrograph, physical factors of a stream are among the more predictable, compared to the chemical and biological attributes of a stream (Gordon et al. 2004). In addition, the physical template of the stream has a large influence on the abundances, distribution, and productivity of stream organisms. Understanding the available stream types and their attributes provides context for future reports.

Assignment of stream habitats to specific classification units will follow standard rule-based systems (Rosgen 1994) to assign classes. However, such efforts may be aided with multivariate techniques for habitat classification the data collected (NMS, PCA; McCune and Grace 2002). These multivariate techniques will assist in defining classes and understanding the amount and distribution of each stream type identified. Additional incorporation of GIS applications will describe how these streams are distributed across the park landscape.

Analysis and Synthesis Report 2: Water Chemistry Patterns and Correlates addresses the fundamental chemical dimension of water quality and how it varies spatial across the park landscapes. Stream chemistry is known to vary due to fundamental watershed attributes (watershed geology, stream gradient) as well as transient dynamics of many types, such as vegetation growth, atmospheric dynamics, and pollution (Allan et al. 1997, Scott et al. 2002). This report will analyze and synthesize the spatial patterns in water chemistry to identify major water quality units of functional equivalence (low internal variance) and to identify areas with reference values or potential vulnerability. A goal will be to identify streams with both impaired and outstanding water quality features to inform managers.

Data analyses will aim to identify functional units within the stream reaches sampled in each park through standard multivariate techniques for continuous data (NMS, PCA; McCune and Grace 2002), to identify relationships between watershed parameters (e.g., geology of the basin) and chemical attributes in park landscapes (as in Clow and Sueker 2000), and if appropriate, will include development interpolated models using Geographic Information Systems (GIS) to rapidly convey spatial patterns across the stream networks of the parks. Predictive GIS models may include spatial (purely spatial autocorrelative models, such as kriging) and nonspatial mixed regression models (e.g., General Linear Models), or through models that use both (cokriging; Jager et al. 1990).

Analysis and Synthesis Report 3: Distribution and Abundance of Focal Species and Biological Communities will focus on the biological communities of the network streams (amphibians, macroinvertebrates, and fish).

For each of the biological assemblages of interest, a related set of analyses will be conducted. For species-rich invertebrate assemblages, standard ordination and classification techniques will be used to identify the major units and to portray their correlation with major environmental gradients in each park (Tate and Heiny 1995, Heino et al. 2003). The species diversity, relative abundance, and productivity of assemblages will also be summarized and compared across sample frames and across parks. Factors associated with differences in abundances and distribution will be analyzed using bubbleplots and biplots, using the physical and chemical factors examined in previous Analysis and Synthesis reports. How the physical and chemical templates influences the observed biological patterns will be a major component of this report, so that the parks can understand their biological resources in the proper context.

For fish and amphibian species, which are likely to be considerably poorer in species, analyses will seek delineation of habitats with relatively high abundances of individuals or juveniles, and how the productivity of these vertebrates interact with the physical and habitat template. Both the vertebrates and invertebrates will also include GIS applications to understand their distribution across the landscape. Information about potential stressors (e.g., land use patterns, road distribution, and atmospheric deposition) will also be included in these analyses to gain knowledge about known stressors and biological patterns. The importance of the physical and chemical factors will also be tested using the previous classifications of streams for previous reports for *a priori* groupings, which can be tested using Multi-Response Permutation Procedure or Analysis of Similarity (Clarke and Warwick 2001, McCune and Grace, 2002).

An additional analysis to be included in this report will be matching environmental to biota by maximizing observed correlational strengths using subset of environmental data (Clarke and Warwick 2001). Although an exploratory analysis, this will help identify key environmental variables having the most influence on vertebrate and macroinvertebrate communities.

In aggregate, the first three Analysis and Synthesis reports will illustrate interrelationships among physical habitat, chemical parameters, and species assemblages at sites and parks and will be useful in distinguishing spatial from temporal variation in subsequent trend detection analyses (Philippi et al. 1998), discussed below under Analysis and Synthesis Report 5.

Analysis and Synthesis Report 4: Instream and Riparian Communities

Riparian zones are focal habitats for many elements of park biodiversity. The fourth report will focus on integrating the instream communities and processes with riparian data collected by this protocol and with data collected by the Klamath Network Vegetation Monitoring and Landbird Community Monitoring Protocols, where possible. The report will explore the co-varying biological communities and their relationships with fundamental landscape gradients in climate, physical form, and water chemistry.

One method of relating these varied assemblage datasets will be with second stage NMS, where rank correlations between similarity matrices are used to display the relationships of the instream communities (fish, amphibians, invertebrates) to the riparian vegetation, landbird communities, and associated environmental variables. Correlative biplots of secondary variables drawn from the riparian and bird data will also be used to examine relationships of these diverse groups to look for similarities. These second stage ordinations will allow the examination of these diverse groups of data collect amongst the three protocols simultaneously (Clarke and Warwick 2001) and also provide a comparability study amongst the protocol. For instance, all three protocols are collecting vegetation data and their results should be broadly comparable (or if not, the *how* they are different will be examined). Knowing and investigating the interrelations between these different vital signs will set the stage for the trends analyses of all three vital signs.

Analysis and Synthesis Report 5: Trend Analyses

Analysis and Synthesis Report 5: Trends in Environmental Conditions and Environmental Integrity will be the first analysis of temporal changes in selected parameters. This will be performed after a total of five sampling periods, so that the sample size for a temporal effect will still be limited. Doing trends analyses before this point, although a major goal of this protocol, would be premature.

The trend report will be analyzed with a variety of parametric and non-parametric techniques, on both univariate and multi-variate parameters (Table 2). In general, in assessing and ascribing change in park ecosystems, a "weight of evidence approach" will be undertaken. In other words, ecosystem changes should be evidenced by multiple, interrelated pieces of physical, chemical, and biological evidence. From such a perspective, redundancy is essential. Changes in species composition over time in a diverse assemblage, therefore, provide more weight of evidence for change than declines in the population of a single species. We also suggest that there are two approaches incorporating "weight of evidence." The first is that important changes should also be detectable by multiple analytical approaches (following the ideas of R. Irwin, personal communication). For instance, if several tests (Mann-Kendall, regression, *and* multivariate) all agree that a significant change has occurred, this will be taken as strong evidence of biologically significant change, whereas a single test showing significant change (e.g., only the Mann-Kendall) will be taken as weaker evidence of biologically significant change. The second approach is a more traditional, where multiple indicators respond (e.g., decreases in invertebrate abundances, decreases in amphibian populations, increases in fine sediments, etc.). We will utilize both concepts of weight of evidence.

Behind the weight of evidence approach is a belief that much of the information and insight about temporal change will be contained in species presence, absence, and abundance. Multivariate analyses can be used to efficiently explore the data and identify progressive changes (Figure 1). Two specific techniques for analyzing plot data include assessing cumulative plot dissimilarity over time (Phillipi et al. 1998) and outlier determination and control chart development (McBean and Rovers 1998, Anderson and Thompson 2004) (Figure 2). Compositional changes can provide compelling evidence that a meaningful ecological event has occurred or that an ecological threshold has been exceeded (Clarke and Warwick 2001, Anderson and Thompson 2004). At a minimum, cumulative dissimilarity ordinations (Figures 1-2) will be developed for each sampling frame from each park for the first 15 years of the program.

Philippi et al. (1998) suggest tests for trends in matrices of similarity indices: (1) Non-parametric multivariate analysis of variance can be used with a matrix of dissimilarities which can be partitioned into residual sums of squares to test for trend from the baseline condition (time 1, or another time period or reference). Significance is determined through a test using randomization of date labels. (2) Mantel test of a locational dissimilarity matrix to the temporal time difference matrix. Randomization following the traditional Mantel test then tests for significance of association between time and species composition (Manly 1997).

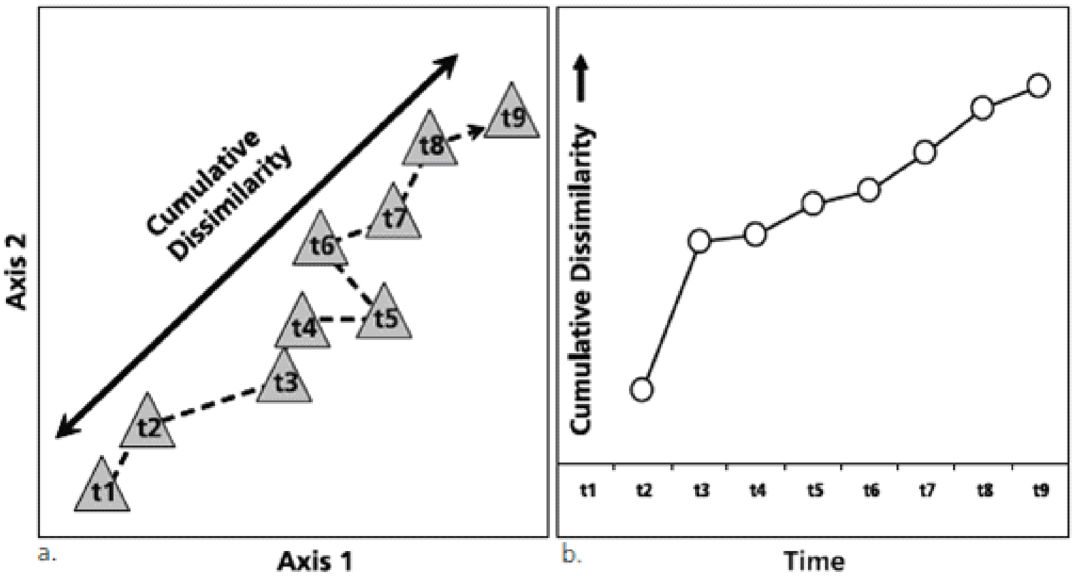

Figure 65. Cumulative change in species composition over nine sampling seasons. a.) An idealized two-dimensional ordination diagram illustrating the compositional position of a site at time one through nine, where Euclidean distance between each year (i.e., time steps t1, t2...t9) is proportional to species dissimilarity. The solid two-headed arrow is an ordination that illustrates the cumulative dissimilarity (progressive compositional change) over the whole period. b.) A graph of cumulative dissimilarity between the first year sample and successive years (i.e., t1 to tn). Note that the change is positive and sustained, suggesting a clear trend of changing composition over time.

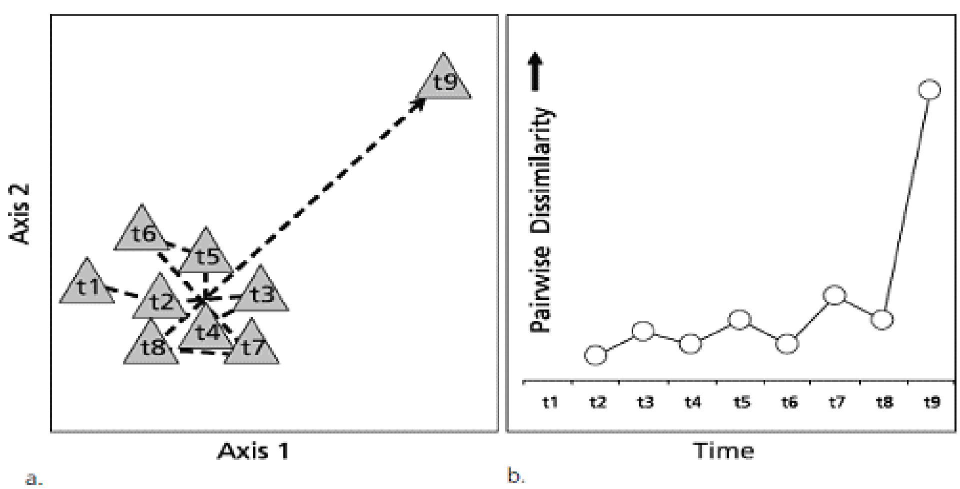

Figure 66 Year-to-year change in species composition over nine sampling seasons, with a major change at year nine. a.) An idealized two-dimensional ordination diagram illustrating the compositional position of a site at time one through nine where Euclidean distances between each pair of years (i.e., time steps t1, t2...t9) are proportional to pairwise species dissimilarity. The dashed arrow follows the year-to-year change in composition. b.) A graph of pairwise dissimilarity between each pair of successive time steps from years one to nine. Note that the composition is similar, but slightly variable in years one to eight, with a major change in year nine.

Other tests for progressive trend in assemblage data exist, such as the canonical analysis of principal coordinates (CAP) as proposed by Anderson and Willis (2003) and Anderson and Robinson (2003), and the perMANOVA test. The CAP analysis can be implemented in the R software vegan package with the capscale() function. Also, perMANOVA could be used to test for differences amongst sampling periods, amongst sites, and the error term would be the site by sampling period interaction (Anderson 2001). This can be implemented in the vegan package as well with the adonis() function; this is another permutation approach so computational time is high and the number of iterations used may have to be adjusted.

This report will also explore the standardization of the trends analyses, allowing future Analysis and Synthesis reports to include repeatable trend analyses through preparation of standardized ”R” scripts, and other analyses incorporating new annual data. It is recognized that the current software of choice is “R” but that future analyses may use a yet undeveloped software package.

We also expect that new techniques will emerge for studying trends that allow complex dynamics of species composition changes to be more clearly demonstrated. Emerging techniques will also be considered, and if applicable, applied to the trends Analysis and Synthesis report.

The essential “statistical toolboxes” for these analyses are listed in Table 2. Time series analysis (i.e., trends) is a topic spanning several textbooks filled with multiple techniques and approaches, and even an elementary introduction is beyond the scope of this SOP. However, a good starting

Table 22. Proposed analyses for trend detection in Analysis and Synthesis Report 5. DOC = Dissolved Organic Carbon; ANC - Acid Neutralizing Capacity; IBI = Index of Biological Integrity, respectively. * = note that although these parameters are "univariate," they are derived from a broader suite of multivariate information, and being tested with univariate techniques, provide a robust assessment of trend.

Univariate parameters	**Analytical tests**	**References**	**Proposed Software**
Stream Physical Parameters -	Parametric and non-parametric time series analysis (Regression models and Mann-Kendall rank correlation tests).	Quinn and Keough (2002), Chatfield (2006), Zar (2009)	Systat, "R", or similar
e.g., pool/riffle ratios, sinuosity, fish cover, etc.			
Chemistry -			
Anions, cations, DOC, nutrients, ANC			
Biological* -			
Taxa richness, Shannon Index, Hilsenhoff Biotic Index, ATI, O/E scores, IBI, Fish condition index, Chlorophyll biomass			
Multivariate			
Macroinvertebrate assemblages	Indices of multi-variate seriation	Warwick and Clarke (1991), Philippi et al. (1998), Clarke and Warwick (2001)	Primer-E, PC-ORD, or similar

point for these analyses will be two of the most elementary forms of time series, and these should be the backbone of the trends reports. To assist in the implementation, some guidelines are presented below.

Linear Regression – Although multiple models of linear regression exist, reporting and interpretation of trend will be based on (1) slope estimate and standard error of slope; and (2) significance of slope via analysis of variance (ANOVA) F tests. The slope estimate provides the effect size of the trend (if any) and the direction, positive or negative. The standard error of the slope is an estimate of the precision of the slope. The actual effect size of the slope should be evaluated by the Project Lead for biological significance. The statistical significance is provided by the ANOVA F test (Quinn and Keough 2002). In most circumstances, the Klamath Network will use an α level (Type I error; chance of falsely rejecting a null hypothesis) of 0.10. A higher than usual α level (usually set at 0.05) is justified due to the NPS concern of false negatives (saying that no change has occurred when an impact, has in fact, happened [Irwin 2008]). Although linear regression is a widely used and accepted technique, the Project Lead should also be familiar with the pitfalls of linear regression (e.g., violation of assumptions, outlier influence, curvilinear responses, etc.).

Mann-Kendall Trends Analysis – This is a non-parametric test for trends based on the Kendall's Tau (τ), a rank-order correlation coefficient of concordance. For example, if in five time periods (1 – 5), the response value increases with each period, there will be 100% concordance. If only four of the five are in concordance, there would be closer to 80% concordance.

Indices of Multivariate Seriation – This is a multivariate correlational test similar to the Mann-Kendall Trends Analyses. However, the correlation is tested between the elements of two symmetrical matrices: one based on the ecological similarity (measured with a similarity index, such as Bray-Curtis from assemblage data) and one based on temporal distances between samples (Clarke et al. 1993). A correlation coefficient is calculated by ranking the order of the elements and calculating the Kendall's Tau for concordance. Similar to the Mann-Kendall test, significance is tested by randomizing one matrix element and comparing the observed correlation coefficient to the resulting randomized distribution (Clarke and Warwick 2001). Indices of multivariate seriation can be used to assess trends in multivariate assemblages for both park-wide assessments and single revisited sites.

Resource Briefs
Upon completion of each major report, a one or two page resource brief will be prepared for dissemination to resource managers and the public. Resource briefs are intended to convey recent activities and key finding and to provide a succinct introduction to the topics in the more substantive Annual and Analysis and Synthesis reports and the Klamath Network Internet web site. Generally, the audience of the resource brief will be park resource staff, and secondarily, interpreters. Format will follow the standard resource brief template in use by the Network at the time.

Providing Report Context and Regional Databases
The Project Lead should seek to incorporate Network assessments into the larger "picture," when practical. This includes both Annual and Analysis and Synthesis reports, and serves to help managers and readers understand the status and trends of park resources in the broader

landscape. Managers understand that park units are not isolated islands, but rather that adjacent and far-field practices and status affect both the current status of resources and also their future management.

To address this, the use of regional databases is encouraged in routine reporting. Since availability, data sources, and data quality are variable and subject to change, use of these will be on a report by report basis. Resources will also change over time, so the Project Lead should perform searches (via the internet and regional experts [e.g., state agency contacts]) to ascertain data sources.

At the time of the writing of this protocol, we have identified the following potential regional datasources:

- California Surface Water Ambient Monitoring Program (SWAMP)
    - http://swamp.mpsl.mlml.calstate.edu/resources-and-downloads/database-management-systems/swamp-25-database
- California Environmental Data Exchange Network
    - http://www.ceden.org/
- Aquatic and Riparian Effectiveness Monitoring Program (AREMP)
    - http://www.reo.gov/monitoring/reports/watershed/aremp/welcome.htm
- Oregon Department of Environmental Quality (DEQ)
    - http://www.oregon.gov/DEQ/WQ/
- Oregon Department of Fish and Wildlife (ODFW)
    - http://www.dfw.state.or.us/
- EPA Storage and Retrieval System (STORET)
    - http://www.epa.gov/storet/
- Regional universities and professors (not an exhaustive list)
    - UC Davis (Peter Moyle - http://wfcb.ucdavis.edu/www/Faculty/Peter/petermoyle/Introduction.html); California State University, Stanislaus (Matt Cover - http://science.csustan.edu/cover/) ; UC Berkeley (Vince Resh - http://nature.berkeley.edu/~vresh/vincecv.htm) all have researchers who have sampled and monitored regional water bodies.
- Sierra Nevada Aquatic Research Laboratory (SNARL)
    - http://vesr.ucnrs.org/

All websites accessed and current as of 18 March 2011.

Additionally, there is opportunity for integrating existing park datasets in reporting. Feasibility of analyzing old park datasets or integrating existing datasets should be considered, as this may not be within the scope or workload of the Project Lead, however USGS researchers may be available to assist or lead this effort under the USGS National Park Monitoring Project: http://www.fort.usgs.gov/brdscience/ParkMonitoring.htm.

Guidelines for Standardized Metrics for Water Quality and Aquatic Community Analyses

The purpose of this section is to ensure standardization so that analyses of data from this program are comparable across years.

pH: Because pH is a logarithmic value, pH must be converted to the antilog (i.e., raw hydrogen ion concentration), averaged, then reconverted to pH. This should be done for averaging the cross-sections at each stream site (see example in Table 3). However, when averaging pH among streams (for example to calculate an average pH for all streams of Lassen Volcanic National Park), a standard average should be used.

Table 23. Example depth and pH readings taken in a hypothetical lake and how to average pH readings. Note that a straight average of the pH readings = 7.358; not 7.348, the correct value.

Cross-section	pH	Raw value[1]	Average raw value	Average pH[2]
1	7.3	5.01187E-08		
2	7.25	5.62341E-08		
3	7.4	3.98107E-08		
4	7.4	3.98107E-08	4.4822E-08	7.348
5	7.3	5.01187E-08		
6	7.3	5.01187E-08		
7	7.56	2.75423E-08		

[1]can be calculated in MS Excel using "=POWER(10, -value)", where 10 is the logbase, and "value" is the measured pH; note that it must be negative. [2]Average value reconverted using the "=-LOG(value,10)" function in MS Excel where value is the averaged raw value and 10 is the baselog.

Taxonomic Resolution/Operational Taxonomic Units

Taxonomic resolution may vary from site to site and year to year. One reason is that mature invertebrates (i.e., later instars of insect larvae) are more likely to have developed the diagnostic features necessary for identification. Another reason is that some taxa have only genus level keys (e.g., Ephemeroptera) and others have better developed species keys (e.g., Coleoptera: Dytiscidae). Damaged individuals may also limit taxonomic resolution. Lastly, taxonomic expertise of the individual identifying the specimen may cause differences in resolution.

Standardization of taxonomic resolution is accomplished by requiring contract laboratories to adhere to Southwest Assocation of Freshwater Invertebrate Taxonomists (SAFIT) Standard Taxonomic effort levels (http://www.safit.org/Docs/ste_list.pdf). However, the varying amounts of taxonomic resolution due to damaged or undeveloped organisms presents a problem in determining the total number of unique taxa in which to base taxa richness and Shannon index calculations. To this end, the contract laboratory provides the determination of which taxa not identified to the lowest practical level are “unique.” This allows the taxonomist to identify a species to genus/species level for one specimen, and only identify a specimen of the same family to the family level. If he or she determines that the specimen keyed to family level is “unique,” this indicates that the specimen is probably not represented by the individuals identified to the genus/species level and should be treated as a separate new taxon, despite the reduced resolution.

Additionally, in general, the standard for the Klamath Network is to report at the raw taxonomic level, so that all taxonomy is presented, regardless of the taxonomic resolution.

In certain circumstances, the Project Lead may also convert the raw taxa to “Operational Taxonomic Units.” Operational Taxonomic Units (OTUs) is a process where the investigator combines taxa into a coarser level across samples to facilitate analyses at a common level of taxonomy. A single class of taxa combined in such a way is an "OTU." This reducing step of using coarser taxonomy must *be well documented and reported*, and the raw data must always be retained. The process of creating OTUs should be conducted across the entire set of samples being analyzed; it cannot just be done to a subset. For long-term monitoring, there is also a risk that a previous investigator may assign OTUs at a certain coarse level and a later investigator may choose a different level. Hence, whenever an OTU is used for analyses, the current investigator must apply it to the entire dataset of raw taxonomy *and not just the current subset*.

Standardization of OTUs is also a common pre-condition of calculating metrics (such as O/E or MMIs) and may have to be done on a metric by metric basis. Transparency and adherence to specific rules for each metric is required. The paper on "ambiguous" taxa and OTUs by Cuffney et al. (2007) is recommended reading on this subject.

Exploratory Data Analysis

A part of any analytical prep work should include Exploratory Data Analysis (EDA). "EDA" is an "*approach to data analysis that seeks to find patterns in data, to reveal structure, to suggest possible relationships among variables, and to find other hidden secrets in the data*." (Irwin 2011). The methods of EDA are many, as are the purposes. EDA can take the form of summary statitstics, outlier analysis, graphical presentations of the data, and general pattern analysis. A danger of a prescriptive SOP such as this very one is that an investigator will only follow the prescribed analytical tools; and miss important trends or patterns because they are not "exploring" the data. The Project Lead should engage in extensive EDA as part of any report (Annual or Analysis and Synthesis) preparation. However, due to the nature of EDA, there is no mandated or prescriptive reporting of the EDA step (any attempt at conclusive EDA reporting would both burden and overshadow the normal report content). The Project Lead is encouraged to use Irwin (2011) as a guide to performing EDA.

Bioassessment Tools

We use two general classes of bioassessment tools in our protocol (1) Multi-metric models (IBIs, MMIs) and (2) Multivariate predictive models (O/E scores). Both of these tools can be distilled into clear, readily interpretable condition assessment for managers.

Although these two approaches vary in their methodology, we maintain that an integrated approach to bioassessment using both approaches gives a better assessment than any single tool by itself. For example, the North Coast IBI of California has overrated some sites in comparisons to O/E scores (Rehn et al. 2005). The O/E scores are more sensitive to loss of specific taxa, whereas the IBI is sensitive to changes in assemblage structure and function. Although we expect both methods to give comparable results in most circumstances, the deviations from this are not a paradox, but rather an indicator that suggests a closer inspection of the site. These deviations may also signal specific stressors (Rehn et al. 2005).

Likewise, multiple models of IBIs or O/E scores exist. In this protocol, we utilize both locally specific IBIs (Northern coastal California, and Western Oregon Mountains) and regionally broader IBIs (EPA EMAP models). Regionally-specific models have the advantage of being calibrated to be both precise and accurate. Broader models, fitted over a wider range of environmental conditions, are considered less precise. However, recent work has shown broad corroboration between local and regional models (Meador et al. 2008). The use of a region-wide model has the benefit of being able to apply a single metric to a network-wide assessment.

One note is that many of these bioassessment tools have been developed with a targeted riffle sampling technique originally employed by EMAP and the Forest Service. Studies have shown that application of these tools using the Reach Wide Benthos technique of macroinvertebrate collection is equally valid, albeit with a disclaimer concerning collection technique (Rehn et al. 2007).

In addition to IBIs and O/E scores, we use four other standard reporting metrics: Hilsenhoff Biotic Index (HBI); Assemblage Tolerance Index (ATI); Shannon Index; and relative abundances. Rationale and interpretation for these metrics are included in their description.

Indices of Biotic Integrity

Indices of Biotic Integrity (IBI) is a bioassessment tool pioneered by James Karr in assessing the health of fish communities (Karr 1981). Since then, it has been applied to and become the traditional approach to analyzing macroinvertebrate assemblage data (Stoddard et al. 2005). Often called B-IBI (Benthic – Integrity of Biological Integrity), various composition, tolerance, and richness characteristics are summarized for a sample set, resulting in a set of candidate metrics. A subset of 5 to 10 "best performing" (based on their quantitative ability to distinguish disturbance) metrics are then combined into a multi-metric model and scored on the basis of regional reference sites. More information on IBIs can be found in Karr and Chu (1999).

Metrics selected for inclusion often include life history or habit variables of taxa (e.g., the number of "clingers," invertebrates who cling to the surface of rocks in swift flowing water). The standard source for use in the Klamath Network for life history, feeding groups, or habits will be the EPA list of variables (Barbour et al. 1999), provided in Appendix P.

Although most prominent for use with invertebrates, IBIs are also used for stream vertebrate assemblages (Stoddard et al. 2005), even though they are more common in the streams and lakes of the midwestern and eastern US, which are characterized by a more diverse assemblage of fish. Some regional models (e.g., Mebane et al. 2003) are developed for fourth order streams or larger and are sampled with boat electrofishing. However, IBIs developed for wadeable streams using single pass electrofishing do exist.Table 4 shows the available regional and west-wide IBIs (vertebrate and invertebrate) applicable to the parks of the Network, the four available models (three invertebrate and one vertebrate) are described in detail below.

Table 24. Park units and available IBI models applicable to the units.

Park Unit	EPA West-wide	CA Northern Coastal Region	CA Sierra Nevada*	OR Western streams	EPA West-wide Vertebrate
CRLA	X			X	X
LAVO	X		X		X
ORCA	X	X		X	X
REDW	X	X			X
WHIS	X	X			X

*The application of Sierra Nevada tools to Lassen Volcanic National Park is untested, but LAVO stream features are most closely aligned to the Sierra Nevada region, so we will utilize this with qualification.

California Northern Coastal Region B-IBI

The California Regional Water Quality Control Board, North Coast Region, in conjunction with the California Surface Water Ambient Monitoring Program (SWAMP), has developed a series of B-IBIs for the coastal region and for the Klamath Mountains of northern California (Rehn et al. 2005, included in Appendix P). The coastal B-IBI can be used for stream monitoring in REDW, whereas the Klamath Mountain B-IBI can be used for both WHIS and ORCA. It should be noted that ORCA was not in the geographic region that the metrics were developed for; however, because ORCA is in the Klamath Mountain Omernik level III ecoregion, use of the Klamath B-IBI should provide useful results.

To calculate the B-IBI for these regions:

1. Obtain or calculate the following eight component metrics from the macroinvertebrate dataset for each stream reach sampled:
    a. Ephemeroptera, Plecoptera, and Trichoptera Richness
    b. Coleoptera Richness
    c. Diptera Richness
    d. % Intolerant Individuals
    e. % Non-Gastropoda Scraper Individuals (adjusted)
        i. Predict metric at each site based on watershed area (in km^2):
        ii. Calculate the difference between the observed value and predicted value (the residual).
        iii. Add 0.296 (a constant) to the residual and multiply by 100 to convert to percent.
    f. % Predator Individuals
    g. % Shredder Taxa
    h. % Non-Insect Taxa
2. Score each component metric based on the following table:

		Assigned Score										
Component Metric	Park Unit	0	1	2	3	4	5	6	7	8	9	10
EPT Richness	(All)	0-2	3-5	6-7	8-10	11-12	13-15	16-17	18-20	21-22	23-25	>25
Coleoptera Richness	(All)	0	1		2		3		4		5	≥6
Diptera Richness	(All)	0	1	2	3	4	5	6	7	8	9	≥10
% Intolerant Individuals	(All)	≤ -5	-4-0	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	≥41
% Non-Gastropoda Scraper Individuals	(REDW)	0-4	5-8	9-12	13-16	17-20	21-24	25-28	29-32	33-36	37-40	≥41
	(ORCA, WHIS)	0	1-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17	≥18
% Predator Individuals	(REDW)	0-1	2	3-4	5	6-7	8	9-10	11	12-13	14-15	≥16
	(ORCA, WHIS)	0-1	2-3	4-5	6-7	8-9	10-12	13-14	15-16	17-18	19-21	≥22
% Shredder Taxa	(REDW)	0-1	2-3	4-5	6-7	8-9	10-11	12-13	14-15	16-17	18-19	≥20
	(ORCA, WHIS)	0-1	2	3-4	5	6-7	8	9-10	11	12-13	14-15	≥16
% Non-Insect Taxa	(All)	≥57	52-56	47-51	41-46	36-40	30-35	25-29	19-24	14-18	8-13	0-7

3. Sum the metrics from all eight component metrics and multiply by 1.25 for a final score on a 100 point scale.
4. An example using two streams from the pilot project: Godwood Creek and Redwood Creek (both in REDW):

	Godwood Creek		Redwood Creek	
Component Metric	Value	Score	Value	Score
EPT Richness	38	10	23	9
Coleoptera Richness	8	10	5	9
Diptera Richness	15	10	18	10
% Intolerant Individuals*	15	4	31	8
% Non-Gastropoda Scraper Individuals	26	6	12	2
% Predator Individuals	13	8	23	10
% Shredder Taxa	16	8	4	2
% Non-Insect Taxa	15	8	9	9
	Sum of scores:	64		59
	Final Score (Adjusted by 1.25):	80		73.75

5. Stream conditions can now be assigned based upon their scores: a. **0-20** = Very Poor; **21-40** = Poor; **41-60** = Fair; **61-80** = Good; **81-100** = Very Good
6. Furthermore, allocation of "impaired" or "unimpaired" condition can be assigned to each stream reach at the threshold value of 52 (two standard deviations below the mean reference [Rehn et al. 2005]). Streams with B-IBI scores above 52 are "unimpaired" and streams 52 or below are rated "impaired." Proportion of streams and stream miles impaired in each park can now be assigned.

Western Oregon IBI

The state of Oregon developed an IBI for western Oregon streams (OWEB 1999; original methods on IBI calculation are included in Appendix P). In general, scores are calculated as above, with slight modifications: (1) there are 10 metrics total; (2) scores for each metric vary from 1 to 5; and (3) the final score is out of a total of 50. Metrics and scoring criteria are provided below:

	Score		
Component Metric	5	3	1
Taxa Richness	>35	19-35	<19
Ephemeroptera Richness	>8	4-8	<4
Plecoptera Richness	>5	3-5	<3
Caddisfly Richness	>8	4-8	<2
Sensitive Taxa	>4	2-4	<2
Sediment Sensitive Taxa	>2	1	0
Modified HBI	<4.0	4-5	>5.0
% Tolerant Taxa	<15	15-45	>45
% Sediment Tolerant Taxa	<10	10-25	>25
% Dominance of the most common taxa	<20	20-40	>40

Stream condition is then based on the score:

- >39: No impairment
- 30-39: Slight impairment
- 20-29: Moderate impairment
- <20: Severe impairment

Lassen Volcanic National Park IBI

Lassen Volcanic National Park poses an interesting conundrum in its geographic location. The state of California places LAVO in the central valley region by the State Water Resources Control Board (SWRCB). Indices of Biotic Integrity have been developed for the Central Valley by the SWRCB, but they focus on lower elevation streams not represented in LAVO. A recent IBI for streams to the eastern Sierra Nevada has been developed by Herbst and Silldorff (2009). They present 3 different indices based on 12, 10, and 8 metrics; they suggest the 10 metric as the preferred metric. Scoring is slightly different it requires interpolation if the observed value falls between the ceiling or flooring. Sum across all 10 metrics to calculate the IBI.

Metrics and scoring criteria are presented below:

Component Metric	Ceiling (10 if ≥ or ≤)	Floor (0 if ≥ or ≤)	Interpolate using:
Total Taxa Richness	≥50	≤30	10*(value-30)/20
Total Ephemeroptera Richness	≥9	≤3	10*(value-3)/6
Total Plecoptera Richness	≥6	≤1	10*(value-1)/5
Total Trichoptera Richness	≥8	≤2	10*(value-2)/6
Total Acari (Mites) Richness	≥6	≤1	10*(value-1)/5
Percent Taxa Chironomidae Richness	≤26.4	≥43.4	10*(43.4-value)/17
Percent Tolerant Taxa (7-10)	≤18.7	≥34.1	10*(34.1-value)/15.4
Percent Shredder Abundance	≥2.7	≤0	10*(value)/2.7
Percent of 3 most dominant taxa	≤42.9	≥65.9	10*(65.9-value)/23
Composite community tolerance (HBI)	≤4.05	≥5.79	10*(5.79-value)/1.74

Assignment of condition classes using the eastern Sierra Nevada IBI needs to be calibrated to regional reference (least impacted), until this is obtainable through data sharing reporting of IBIs should only report numerical values, and not assign condition assessments.

Broad Scope EPA MMIs

The EPA EMAP project has developed a west-wide model of an IBI, called a Multi-Metric Index (MMI) (the two terms are synonymous [Stoddard et al. 2005]). As an IBI covering an entire western region, more variance is possible; it has not been regionally calibrated. Until an available regional model is developed for the LAVO region, this should be utilized. As an available model, however, it has the advantage of being applicable to all parks of the Klamath Network. This makes comparability possible for a Network-wide assessment.
The EMAP west-wide (mountains) MMI/IBI is calculated as the following (and relevant portions included in Appendix P):

1. For each sample, a random draw of 300 individuals is taken (without replacement). This can be accomplished using a built-in function on the KLMN Database or another software program such as R.
2. Component metrics for each sample are calculated:

Metric	Ceiling	Floor
Burrower % Individuals	0	20
EPT Distinct Taxa Richness	28	5
Non-Insect % Individuals	0	65
Omnivore % Distinct Taxa	0	6
Percent of Individuals in Top 5 Taxa	32	90
Tolerant % Distinct Taxa	0	30

3. Metrics are scored on a scale from 0-10:
    a. Metrics below or equal to the "floor" of 5% are given "0."
    b. Metrics above or equal to the "ceiling" of 95% are given "10."
    c. Metrics in between the floor and ceiling are linearly interpolated:
        i. Scores can be interpolated with the following formula:

        ii. For example, if the dominant five taxa of a sample = 61%, the score is calculated as: = 5
4. The six component metrics are then summed and multiplied by 1.666 to create a 0 to 100 scale.
5. Although the MMI gives a score that could be graded on the California scale (above), the EPA rating system uses regional "least-disturbed reference sites" to base grading. Sites that are worse than 75% of the value of these least-disturbed sites are ranked "fair" and sites that are worse than 95% of the value are ranked "poor." If the California grading system is used, reporting should always include a relevant disclaimer.

EPA EMAP Aquatic Vertebrate MMI

The EPA EMAP MMI (or fish/amphibian IBI) is calculated as:

1. For each sample site, calculate the following component metrics (using taxa information included in Appendix P):
    a. Percent of individuals that are rheophilic (fast-water) sensitive.
    b. Percent of taxa that are supertolerant.
    c. Percent of individuals that are native, sensitive, invertivore/piscivore.
    d. Percent of taxa that are lithophile (gravel spawning fish).
    e. Percent on individuals that are in the family Cyprinidae.
    f. Percent of taxa that are native, non-tolerant, and long-lived.
    g. Percent of individuals that are alien (non-native).
2. Express percent as proportion (e.g., 0.5 instead of 50%).

3. Score on scale of 0 – 10 as above for EPA EMAP invertebrate MMI:

Component Metric	Ceiling	Floor
% individuals Rheophilic sensitive	1	0
% taxa supertolerant	0	0.2
% individuals native, sensitive, invertivore/piscivore	1	0
% taxa lithophil	1	0.3
% individuals Cyprinidae	0	0.5
% taxa native, non-tolerant, long-lived	1	0
% individuals alien	0	1

4. Use the same formula for linearly interpolating score values as above.
5. Sum component metrics; multiply result by 1.42 to put on a 0 – 100 scale.
6. The EPA does not give guidelines on interpretation of scores, but the 0-20: Very Poor; 21-40: Poor; 41-60: Fair; 61-80: Good; and 81-100: Very Good are a useable scale, with the qualification that it was adapted from the SWAMP macroinvertebrate IBI scoring.

Observed/Expected Ratios

A fundamental estimate of impairment is the impoverishment of a biological community. Observed/expected ratios, also known as "taxa lost" or RIVPACS (River InVertebrate Prediction and Classification System) models, provides a conceptually simple method of bioassessment where the number of collected taxa is compared to the number expected under unimpaired conditions (Hawkins et al. 2000). Values below 1.0 represent "lost" taxa, indicating impairment. The ratio O/E is hence readily interpretable to managers and the public. For example, an O/E score of 0.8 indicates that only 80% of the expected taxa were present.

Although conceptually simple, the derivation of the expected values require a high level of statistical knowledge and a large sample size comprised of both reference sites and impacted sites. O/E values, however, are the primary method of the EPA to assign water quality grades based on macroinvertebrate assemblages (US EPA 2006), and are a valuable tool to monitoring the wadeable streams of the Klamath Network.

Calculation of O/E scores for the monitoring efforts of the Klamath Network can be obtained in one of two ways: (1) employ the National Aquatic Monitoring Center as the contract laboratory, which can provide O/E values based on EPA models, or (2) utilize the online software of the Western Center for Monitoring & Assessment of Freshwater Ecosystems (http://cnr.usu.edu/wmc/), which has complete instructions on how to use both state-specific and west-wide models to generate O/E scores. The web site is currently being upgraded, so specific procedures cannot be detailed at this time. The final product of this draft protocol will include specific instructions as the online software is updated.

Hilsenhoff Biotic Index (HBI)

This index is specific to macroinvertebrates. It is a weighted average of tolerance values derived from empirical observations of macroinvertebrate responses to pollution (Hilsenhoff 1987, 1988). It is calculated as:

Where = the number of individuals for taxa , = the assigned tolerance value of taxa , and = the total number of individuals for a sample.

The Hilsenhoff Biotic Index (HBI) summarizes the overall tolerances of the taxa collected; changes in a site's HBI can be viewed as an indication of community change (Hilsenhoff 1987, 1988). This index is used to detect nutrient enrichment, high sediment loads, low dissolved oxygen, and thermal impacts. Taxa are assigned an index value from 0 (taxa normally found only in high quality unpolluted water) to 10 (taxa found only in severely polluted waters). Shifts in HBI from low values to high values indicate a shift toward a more pollution tolerant assemblage; a shift from high values to low values indicates a change towards a more intolerant assemblage.

For consistency, a single source for tolerance values should be utilized. The source for this protocol is tolerance values developed by Mr. Robert Wisseman of Aquatic Biology Associates and is available at: http://www.cbr.washington.edu/salmonweb/taxon/. This source has been chosen because: 1) it was developed specifically for Pacific Northwest taxa, and 2) it includes non-insect tolerance values. Tolerance values are provided as an electronic reference file in this protocol as part of Appendix O: Macroinvertebrate and Vertebrate Tolerance and Life History Characteristics for IBIs.

One advantage of the HBI is that tolerance values have been developed for Order, Family, and Genus/species. Hence, individuals that were only identified to Family can still be incorporated in the index without making assumptions or collapsing taxonomic information.

Assemblage Tolerance Index
The ATI is calculated as the HBI above, but with a different set of tolerance values derived from the US EPA EMAP program for western streams (Whittier and Van Sickle 2010). It is used here as a complement to HBI as a new emerging tool that may eventually supplant the HBI; this should be evaluated in the future to reduce the reporting requirement of the protocol.

Tolerance values are provided as an electronic reference file in this protocol as part of Appendix O: Macroinvertebrate and Vertebrate Tolerance and Life History Characteristics for IBIs.

Species Abundances
Relative abundances should be calculated for a) Macroinvertebrates (per square meter) b) Fish (catch per unit effort), and c) Amphibians (catch per unit effort).

The abundance, density, or number of aquatic organisms per unit area or catch per unit effort is an indicator of habitat availability and fish food abundance. Abundance may be reduced or increased depending on impacts or pollutants. Increased organic enrichment typically causes large increases in abundance of pollution tolerant taxa. High flows, increases in fine sediment, or the presence of toxic substances normally decrease invertebrate abundance.

Macroinvertebrates, for logistical reasons, are sub-sampled during processing. Although the sub-sampling of macroinvertebrates is quantitative in nature, additional potentially compounding error is added to the sample. Hence, data interpretation and reporting macroinvertebrates should focus on relative abundances. Although abundances for individual taxa can be ecologically relevant, the presentation of abundances for 100+ taxa over a long-term time series does not lend itself to easily interpretable summaries. Hence, presentation of abundance data should be at the gross level for these groups (e.g., all macroinvertebrates per square meter). Abundance of individual taxa should only be included if there are special considerations justifying it (e.g., endangered or invasive species).

Shannon Index (H')

Ecological diversity is a measure of community structure defined by the relationship between the number of distinct taxa and their relative abundances, incorporating both into a single measure. A Shannon Index measurement of 0 indicates that the assemblage is composed of only one species, and increases upward with increasing species richness and eveness. Typical values range from 0 to 3.

This information index incorporates both relative abundance and taxa richness (Magurran 2004). It is calculated as:

Where p_i = the proportion of the *i*th species (e.g., abundance of taxa *i* divided by the total abundance of the sample).

The calculation is straightforward and easily done in MS Excel or another spreadsheet. However, two important considerations must be made: 1) taxonomic resolution and 2) which logarithmic base to use. Taxonomy should be based on unique taxa (see above). Although examples of using different logarithmic base for the transformation exist in the literature, there is growing momentum to standardize on the natural log (ln) (Magurran 2004). **All Shannon Indices calculated for this monitoring program should use the natural log.**

US EPA Aquatic Stressor Categories and Calculations

As part of the EPA Wadeable Streams Assessment (US EPA 2006), the EPA established 8 “stressors,” or indicators of impairment for streams. The stressors are divided into two categories: Chemical and physical. The chemical impairment indicators are: total phosphorous, total nitrogen, specific conductance (note that this is sometimes referred to as “salinity”, and acid neutralizing capacity. The physical impairment indicators are: relative bed stability, riparian disturbance, in-stream habitat cover, and riparian cover. The current condition of these “stressors” then can both be assessed per stream and on a park wide level. Assignment of conditions (most disturbed, moderate, and least disturbed; Table 5; values in between least disturbed and most disturbed are “moderate”) are based on regional values in Stoddard et al. (2005), and the below descriptions are based on both Stoddard et al. (2005) and the US EPA (2006).

Total phosphorous: Total phosphorous is considered the most likely limiting nutrient in freshwaters, and may be associated with agriculture and urbanization. The raw values from the contract laboratories are used to indicate condition.

Total nitrogen: Total nitrogen is important as a contributing nutrient for algal blooms. High values may be associated with fertilizers, wastewater, animal waste, and atmospheric depositions. The raw values from the contract laboratories are used to indicate condition.

Specific conductance: Specific conductivity, as a surrogate value for salinity, is a measure of the amount of dissolved solids in water. High conductance indicates high salinity, which is often associated with water withdrawal where high evaporative losses in irrigation and slowed transit times increase salinity. The values from the multi-probe are used to indicate condition.

Acid neutralizing capacity (ANC): The lack of buffering capacity (ANC) can indicate the process of acidification, either through acid rain deposition or acid mine drainages. The values from field titration of ANC serve to indicate condition. Acid neturalizing capacity was not used as an indicator in Stoddard et al. (2005), but was used in US EPA Wadeable Streams Assessment (2006). Acid neutralizing capacity should be expressed in microequivalents/L (µeq/L), however it is calculated as mg/L of $CaCO_3$. Divide mg/L values by 0.050 to obtain µeq/L values.

Table 25. Condition criteria for EPA Wadeable Streams Assessment stressor categories. * = not available at time of protocol development. Although used as a stressor, values used to denote condition were not provided in Stoddard et al. (2005). Project Lead must periodically check for updates and availability.

Stressor	**Most Disturbed**	**Least disturbed**
Chemical		
Acid neutralizing capacity (µeq/L)	*	*
Specific conductance (µS/cm)	>1000	≤500
Total nitrogen (mg/L)	> 0.2	≤0.125
Total phosphorous (mg/L)	>0.04	≤0.01
Physical		
In-stream habitat cover	<0.14	≥0.33
Relative Bed Stability (log transformed)	<-1.3 or >0.6	≥-0.7 and ≤0.1
Riparian Cover	<0.23	≥0.67
Riparian disturbance	>0.95	≤0.35

In-stream habitat cover: This metric is a summation of cover from large wood, brush, overhanging vegetation, boulders, and undercut banks (note this was referred to as "habitat complexity" in Stoddard et al. [2005]). The full calculation is provided in Kaufmann et al. 1999, but the basic procedure is as follows:

1. At each transect, transform habitat cover variables from classes (0 = absent [0%], 1 = sparse [0-10%], 2 = moderate [10-40%], 3 = heavy [40 – 75%], 4 = very heavy [> 75%]) to the midpoint of each category (0%, 5%, 25%, 57.5%, and 87.5%). These should be recorded as proportional values (0, 0.05, 0.25, 0.575, and 0.875).
2. Calculate the average for each habitat cover variable for the whole reach. For example, the average "boulder" cover = sum of boulder cover at transect A, B, C, …, K divided by 11.

3. Sum the following categories: Boulders, Overhanging vegetation, Brush, Large woody debris, and Undercut banks). Because it sums over several categories, values greater than 1.0 are possible. This is the habitat cover score.

Riparian cover: This is a metric of all woody cover in the riparian zone, averaged for a reach-wide value, and then summed in the following catergories: Riparian canopy (>5 m) for big trees; Riparian canopy (>5 m) for small trees; Riparian mid-cover, woody; Riparin ground cover, woody). The calculations are analogous to In-stream habitat cover above, but averaged across the 22 measures (left and right bank).

Riparian disturbance: This is the sum of the averaged proximity weighted disturbance categories in for the 22 measures (left and right bank). Recall that riparian disturbance for each category is recorded as “B” for on the bank, “C” for occurring in the riparian plot, or “P” for present, behind or adjacent to the plot. Values for every “B” occurrence are scored as 1.5, 1.0 for every “C”, and 0.667 for every “P.” Every category is then averaged (e.g., average of Buildings, average of Roads, etc.). All categories are then summed to create the Riparian disturbance index.

Relative bed stability: This index is a ratio of the observed stream substrate size to the sediment size that each stream can scour during flood stage. While the observed stream substrate size is based on values measured in the protocol, the size of particles mobilized by flooding is a theoretical value based on stream size, slope, and other physical characteristics. High or low values can indicate impairment, of either 1) small, fine sediment, unstable streambeds, or 2) coarse sediment, stable, immovable streambeds.

The calculations are complex, multi-step, and the Project Lead should consult Kaufmann et al. (1999) for full details. A brief summary follows:

1. Calculate R_{bf}.

2. Calculate $R_{w.}$

3. Calculate R_p.

4. Calculate S.

5. Calculate the $\log_{10}$ of the estimated erodible substrate diameter (ESD).

6. Calculate Relative bed stability (RBS).

As can be seen, this calculation is not for the faint hearted, and relies on a substantial number of estimates and assumptions. Philip Kaufmann (U.S. EPA) has been working on creating *R* script to automatically process and calculate the RBS values. Also note that several attempts have been made to improve the metric by accounting for channel roughness (e.g., Kaufmann et al. 2008), so that the equation may be modified and need updating during protocol implementation. Likewise, reference values may be calculated for a certain version of the RBS formula, and it is the responsibility of the Project Lead to ensure compatibility of reported RBS values to scoring criteria.

Data Under Reporting Limits

Analyzing and summarizing water chemistry values can pose a special challenge when dealing with reporting limits (values below minimum quantification levels and below detection limits). Water chemistry values under detection limits do not necessarily mean that the analyte is not present, just that it is minimal and under the threshold. Substituting zeros for "non-detects" can bias the analysis or summary statistic. Other methods of substitution (e.g., substituting the reporting limit) may also bias the results. Summarization using medians is one possibility of reporting without introducing bias.

When dealing with non-detects and reporting limits, the Project Lead should consult the relevant chapter in Helsel and Hirsch (2002) for guidance on alternatives. Whichever method is used, the Project Lead must provide *transparency,* and be explicit in the methods and assumptions used for dealing with non-detects.

Although a serious statistical concern, it should be noted that non-detects may be relatively infrequent. In the water chemistry data for the Pilot Project conducted in protocol development, there were no non-detects for the chosen analytes. In sampling lakes of the network concurrent with the protocol development, there were only 12 non-detects out of 1,450 separate analyses (including triplicate and duplicates).

Water Quality Exceedances

Although this protocol is not designed to monitor for water quality standards exceedances, where measured values exceed standards, reporting should include any instances or indications of exceedances where encountered. Because the protocol sampling is a single point in time, any reports of exceedances should not constitute a call for management action. Instead, it is a signal that there may be impairment and the parameter exceeded should be investigated using state standards (e.g., 4 day average of parameter X) to determine actual exceedance. If there are indications of exceedances, follow up monitoring by the park units with assistance from the networks should be implemented.

Both the state of California and the state of Oregon have promulgated water quality standards. However, many of the standards are for toxic substances (e.g., Polyaromatic Hydrocarbons) and do not overlap with monitored parameters under these protocols. Of the California standards, they have yet to develop standards for the monitored parameters. For Oregon, most standards are centered on allowable increases or decreases from natural conditions. Table 5 presents the Oregon standards, along with National Park Service and Environmental Protection Agency standards.

These standards may be updated, expanded, and revised by the respective agencies. The Project Lead should periodically (once per sampling event) check for updates. The Project Lead should also be aware that states may introduce biocriteria (e.g., IBI or O/E standards). The sources used in Table 5 are:

- Oregon - http://www.deq.state.or.us/WQ/standards/standards.htm (accessed on 21st January 2009).
- California - http://www.waterboards.ca.gov/water_issues/programs/water_quality_goals/search.shtml (accessed on 16th April 2010).
- EPA Standards - http://www.epa.gov/waterscience/criteria/wqctable/ (accessed on 21st January 2009)
- NPS Standards – Embedded in NPS Storet, v. 1.71.

Table 26. Water quality thresholds for state of Oregon and California, EPA and NPS standards.

Parameter	NPS Standards	Oregon Department of Environmental Quality	California Drinking Water	EPA Standards Drinking Water	EPA Standards Health Advisory	EPA Standards National Ambient Water Quality Criteria	EPA Standards Region 10 Collaborative Guidance
Alkalinity (mg/l)	> 25	> 20				> 20	
Chloride (mg/l)			< 250 mg/l			< 230[1,4]; <860[2,4]	
Dissolved Oxygen (mg/l)	> 4	> 8 mg/l (Cold Water Aquatic Life)				> 8.0 1 day minimum (water column)	
Total Nitrogen (as NO2 + NO3) (mg/l)			< 10	< 10			
pH	> 6.5	6.5 to 9 (Klamath basin); 6.5 to 8.5 (Rogue basin)		6.5 to 8.5		5 to 9[3], 6.5 to 9[1](max)	
Sodium (mg/l)					< 20		
Sulfate (mg/l)				< 500		< 250[3]	
Temperature, (fall, winter, spring) (7 day average of daily maximum)							< 9 °C (Bull trout); < 13 °C (general salmon and trout); < 14 °C (Steelhead)
Temperature, maximum (7 day average of daily maximum)		< 18 °C (Salmon and Trout Rearing and Migration (ORCA)); <12 °C (Bull trout spawning and juvenile rearing (CRLA))					< 12 °C (Bull trout); < 16 °C (salmon and trout core rearing); < 18 °C (salmon and trout noncore rearing); < 20 °C (salmon and trout migration)
Turbidity (NTU)	< 50	< 10% above natural	< 1	< 1			

[1]Standard for Freshwater Aquatic Life Protection (4 day average); [2]Maximum 1 hour concentration; [3]Taste and odor standard;[4]Chloride standards only apply when dominant cation is Sodium.

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Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #23: Data Transfer, Storage, and Archiving

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This SOP explains the procedures for transferring data to the Network Data Manager. In addition, data certification, storage, archiving, and a timeline for project deliverables are addressed.

Data Transfer

All project deliverables, including but not limited to raw data, processed data, Metadata Interview forms, updated data dictionaries, images with metadata, log books, spatial files, and Certification forms will be transferred to the KLMN Data Manager following the timeline listed in Table 1. It is the responsibility of the Project Lead to ensure all products and associated documentation are delivered to the Data Manager following the timeline.

Pre-season Information

At least 3 weeks prior to the start of the field season, it is the responsibility of the GIS Specialist to work with the Project Lead to identify the sites that will be monitored as part of this protocol (SOP #1: Preparations, Equipment, and Safety). Once the sites have been identified, the GIS Specialist should provide the Data Manager with a GIS shapefile that contains the following fields.

- Unique Site Name
- Park Code where site occurs
- Watershed where center of site occurs
- Public Land Survey System Coordinates where center of site occurs
- Name of 7.5' USGS map where center of site occurs
- Habitat zone for the site (Matrix, Riparian, Alpine)
- Site type (Index, Survey)

Table 27. Deliverable products, responsible individual, target due date, and storage location for all products developed while implementing the KLMN Stream Monitoring Protocol.

Deliverable Product	Primary Responsibility	Target Date	Instructions for KLMN
List of Streams and Sites to be sampled	Project Lead	3 weeks prior to the start of the field.	Store in Stream_Data[3]
Contact Information	Project Lead	3 weeks prior to the start of the field season	KLMN Stream Database Stored in the Stream_Data[3] Folder.
Metadata Interview Form	Project Lead	Prior to beginning the first field season and by Feb 1 of the following year.	Store in Stream_Data[3], Use to create and revise full metadata.
Updated Data Dictionary	Data Manager	Prior to beginning the first field season and by Feb 1 of the following year.	Store in Stream_Data[3], Use to create and revise full metadata.
Full Metadata (Parsed XML)	Data Manager	Prior to beginning the first field season and by March 1st of the following year	Store in Stream_Data[3], Upload to NRInfo[2]
Data Certification Form	Project Lead	Every time a product(s) is submitted	Store in Stream_Document[3]
Processed GPS Data Files	Project Lead	Prior to the field crew members being released from service	Store in Stream_GIS[3], Uploaded to NRInfo[1,2]
Training Log Book	Project Lead	Prior to the field crew members being released from service	Store in Stream_Document[3]
Digital Photographs and Metadata	Project Lead	Prior to the field crew members being released from service	Store in Stream_Image[3], Copies of Photographs in KLMN Image Library, Copies of Image Metadata into KLMN Image Database linked to Photographs
Equipment Log	Project Lead	Prior to the field crew members being released from service	Store in Stream_Document[3]
Event Log Book	Project Lead	Prior to the field crew members being released from service	Store in Stream_Document[3]
Hardcopy Field Data Forms	Project Lead	December 1st	Store in AQ Office
Scanned Data Forms	Data Manager	December 15st	Scan Original, Marked-up Field Forms as PDF Files and Store in Stream_Document[3], Uploaded to NRInfo[2]
Initial Databases	Project Lead	December 1st	Store in Stream_Data[3]
Final Database	Data Manager	3 weeks after receiving macroinvertebrate lab data	Store in Stream_Data[3], Send Copy to Parks, Uploaded to NRInfo[2]
Macroinvertebrate Data	Contractor	Prior to the start of the new field season	Store in Stream_Data[3], Upload to the Project Database, , Uploaded to NRInfo[2]
WRD EDD	Project Lead	1 month after receiving macroinvertebrate lab data	Send copy to NPS WRD, Store in Stream_Data[3]
Annual Report	Project Lead	March 1st	Store in Stream_Document[3], Uploaded to NRInfo[1,2], Send Copy to Parks, Post on the KLMN Internet and Intranet Websites
Analyses and Synthesis Report	Project Lead or Contract Specialist	Every 3 years on May 1st	
Other Publications	NPS Staff, or as appropriate	as completed	

[1] Natural Resource Information Portal (NRInfo) as a stand alone product. [2] Natural Resource Information Portal (NRInfo) as a package. [3] The KLMN Stream project folder contains five folders: Stream_Documents, Stream_Data, Stream_Analysis, Stream_GIS, and Stream_Image used to separate and store data and information collected as part of the Stream monitoring.

In addition to the site information, it is the Project Lead's responsibility to provide the Data Manager with contact information for each person working on the project at least 3 weeks prior to the start of the field season. Contact information should include:

- First name
- Last name
- Position (Principal Investigator, Network Contact, Crew Leader, Crew Member, etc.)
- Mailing address
- Work number
- Email address

Training

Each crew member should have the appropriate level of training prior to beginning the field work for this protocol. It is the responsibility of the Project Lead (working with the Data Manager, GIS Specialist, and Crew Lead) to develop and implement all components of training associated with this protocol (SOP #2: Field Crew Training). A training log book should be maintained for each crew member and submitted to the Data Manager following the timeline in Table 1. The log book should record the trainer's name, trainee name, position, date, training, and name of equipment. A training log can be downloaded from the KLMN web site or obtained by contacting the Data Manager. For more information on log books, read the KLMN Log Book Guidelines, located on the KLMN web site.

Certification Form

The Klamath Network will utilize a Certification form submitted by the Project Lead to ensure:

1. The data are complete for the period of time indicated on the form.
2. The data have undergone the quality assurance checks indicated in the Stream Monitoring Protocol.
3. Metadata for all data have been provided (when applicable).
4. Project timelines are being followed and all products from the field season have been submitted.
5. The correct level of sensitivity is associated with the deliverables.

A new Certification form should be submitted each time a product is submitted. If multiple products are submitted at the same time, only one Certification form is needed for those products. Certification forms can be obtained from the KLMN web site or by contacting the KLMN Data Manager. An example of the Certification form is included at the end of this SOP.

Field Forms

For the first few years of the project, we will collect data using field forms (in addition to the tablet PC), to ensure we capture all data in an accurate manner. Hardcopy field forms will be provided to the Data Manager following the timeline in Table 1. It is the responsibility of the Data Manager to scan the datasheets into PDF documents within 1 month of receiving the hardcopies. The Project Lead should organize the field forms in the order in which they will be scanned before they are transferred to the Data Manager. Datasheets should follow this order:

1) One PDF will be created for all datasheets for each site.
2) Datasheets should be separated by park.
3) For each site, datasheets should be in the following order:

a) Stream Verification Form (two sheets)
b) Field Chemistry and Channel Constraint Form
c) Torrent Evidence Form
d) Transect Forms (11 or more sheets)
e) Woody Debris Forms (two sheets)
f) Dominant Tree and Invasives Forms (two sheets)
g) Sample Collection Form
h) Vertebrate Specimen Form
i) Discharge Form
j) Slope Form

The scanned document will be named with the park, site name, and the year the data were collected. For example, the scanned document associated with the site 004 of the 2009 stream plot at Crater Lake NP will be: CRLA_004_2009, where "CRLA" is the four letter code for the park, "004" is the site name, and "2009" is the year the data were collected.

A datasheet log should be maintained to record when a datasheet has been misplaced or when a datasheet was destroyed. Since the datasheets will be numbered, a missing datasheet (even if it was thrown out on purpose) must be accounted for at the end of the year. A datasheet log can be obtained from the KLMN web site or by contacting the Data Manager (Mohren 2007a).

Databases

At the end of the field season, following the timeline in Table 1, the Project Lead should transfer a copy of each project database to the Data Manager. The databases should have gone through all validation and verification process outlined in SOP #18: Post-Season Tasks and SOP #19: Quality Assurance Project Plan. Once transferred, the Data Manager will subject the data to one more round of validation and verification checks. The Data Manager will work with the Project Lead to correct any errors.

The initially submitted database will only include data entered into the database while in the field and data collected using the *Manta* Multiprobe. Macroinvertebrate data will take longer because of processing time by a contractor and will be uploaded at a later date, as indicated in Table 1. Once the macroinvertebrate data have been obtained from the contractor, the Project Lead should review the data to make certain they are accurate. The Project Lead should then submit the data, along with a Data Certification form, to the Data Manager where they will be uploaded into the project database.

Once the data have been thoroughly checked, the data will be uploaded into the Master Stream Database, stored on the KLMN server.

Electronic Database Deliverable

As part of this project, a subset of the data we collect is sent to the NPS Water Resource Division (WRD) to be uploaded into the WRD database STORET. To accomplish this, the Project Lead should submit data collected each year in a format following the electronic database deliverable (EDD) template provided by WRD. To accomplish this task, the KLMN has developed an automatic export process in their database that when ran will export the data we collect into the appropriate process. Once all the data has been collected (including getting macroinvertebrate data back from the lab) the Project Lead should implement the process described in SOP 18: Post season tasks. In addition to submitting this dataset to WRD, a certification form and copy of the Excel files should be submitted to the KLMN Data Manager.

Photos

Images and associated metadata will be transferred to the Data Manager in the format explained in SOP #16: Photo Points and Photo Management, following the timeline in Table 1.

GPS / GIS Files

New coordinates at Transect A, F, and K will be taken to ensure the accuracy of the location along the stream. Upon completing the download and correction of these files (SOP 18: Post-Season Tasks) the GIS Specialist should submit the certification form and data layers to the Data Manager.

Metadata

Following the timeline outlined in Table 1, the Project Lead should submit a Metadata Interview form for the Project Database after each field season. If metadata have not been completed for this project, the form will need to be completed in full. If metadata have been completed, and no updates are needed, just complete question one on the form. In addition to the Metadata form, an updated data dictionary should be submitted following the timeline in Table 1, if the data collected in this protocol have been altered (e.g., new or deleted parameters measured, additions to picklists, etc.). Prior to the start of the following field season, the Data Manager should update the full metadata (Parsed XML) and post it to the proper locations.

Equipment

The field crew should maintain an equipment log to record any updates or changes to the equipment being used to measure the various parameters described in this protocol. It is the responsibility of the Project Lead to submit the equipment log to the Data Manager following the timeline in Table 1.

Reports

There is the potential for a variety of reports and publications to be developed utilizing data collected as part of this monitoring project, including annual reports, Analysis and Synthesis reports, and scientific papers (SOP # 22: Data Analysis and Reporting).

Annual reports will be the responsibility of the Project Lead and should be submitted in the NPS Natural Resource Data Series format, unless utilizing another series format for publication. Final annual reports should be submitted following the timeline in Table 1.

Analysis and Synthesis reports will be the responsibility of the Project Lead and should be submitted in the Natural Resource Technical Report Series format, unless utilizing another series format for publication. Final reports should be submitted to the KLMN following the timeline listed in Table 1.

Data Storage

Project folders have been created for each monitoring protocol the KLMN plans to implement (Figure 1). Project folders contain five standard folders. These folders use a naming convention that includes the vital sign and one of the following: Documents, GIS, Data, Images, or Analysis. These five folders will contain all the data and information for a project as follows:

a) **Stream_Documents.** This folder contains the reports, budgets, work plans, emails, protocols, contracts, datasheets, and agreements associated with a specific project.
b) **Stream_GIS.** This folder contains shapefiles, coverages, layer files, geodatabases, GPS files, GIS/GPS associated metadata, and spatial imagery associated with a project.
c) **Stream_Data.** This folder contains the KLMN Stream database and .dbf files from the six field databases.
d) **Stream_Images.** This folder contains any photographs related to the project and associated image metadata. In addition, copies of all photographs and metadata will be transferred into the KLMN Image database. Details on the KLMN Image database can be found in the KLMN Data Management Plan.
e) **Stream_Analysis.** This folder will contain derived-data and associated metadata created during analysis.

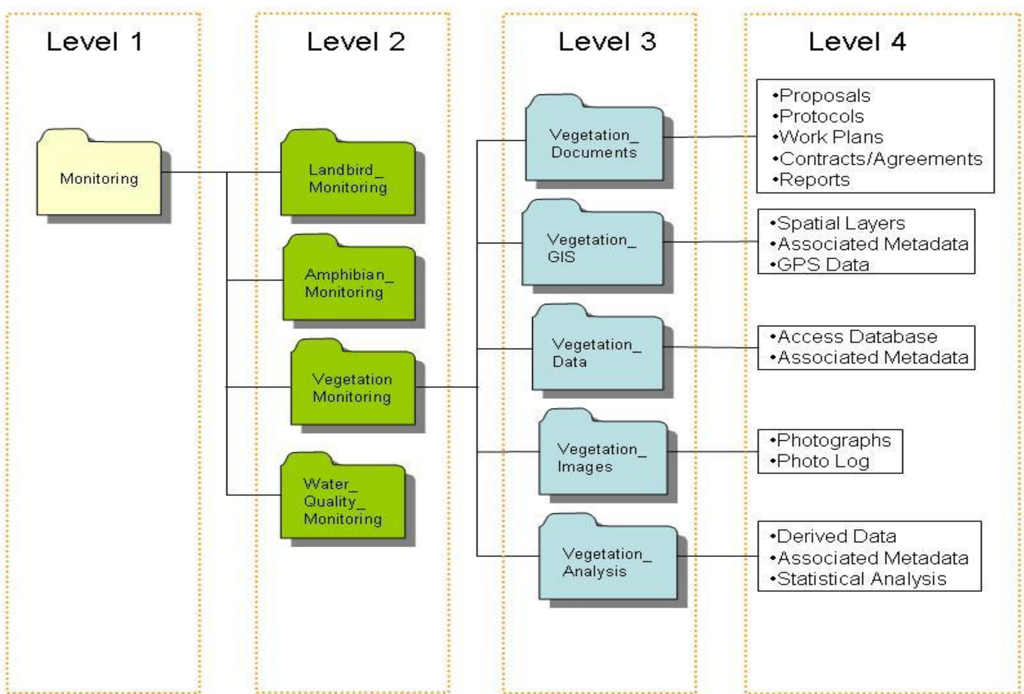

Figure 67. The example file structure the KLMN will use to store all stream data and information. Note that current structure utilizes a level 2 folder for "Stream Monitoring" and "Lakes Monitoring," and the "Water_Quality_Monitoring" folder has been removed.

Storage, Backup, and Archiving

The KLMN computer drives are subject to all backup and archiving processes described in the KLMN Data Management Plan. The KLMN relies on Southern Oregon University (SOU) for the backup and long-term storage requirements. Nightly backups are done by SOU to store information that has been edited. This is not a full backup but is intended to protect products that have been manipulated. This information is stored for a 1 week period before it is recycled. SOU begins a weekly full backup of their servers on every Friday and stores the files on tape drives. Backups are stored for 60 days before the tapes are reused. SOU will run quarterly backups on March 31st, June 30th, October 31st, and December 31st of each year. Files stored on a quarterly basis are maintained for 1 year before being recycled (Mohren 2007b).

Despite the QA/QC measures in place, finding errors in datasets in the future is inevitable. The process for documenting the correction of such errors is detailed in SOP #19: Quality Assurance Project Plan. In such instances, archived data will not be corrected; however an updated product will be placed into the archive drive along with the digital error and entry logs.

Literature Cited

Mohren, S. R. 2007a. Log book guidelines, Klamath Inventory and Monitoring Network. National Park Service, Ashland, OR.

Mohren, S. R. 2007b. Data management plan, Klamath Inventory and Monitoring Network. Natural Resource Report NPS/KLMN/NRR—2007/012. National Park Service, Fort Collins, CO.

KLMN Certification Form

1) Certification date: ____

2) Certified by: ____
Title: ____
Affiliation: ____

3) Agreement code: ____________________
Project title: ____

4) Range of dates for certified data: ____

5) Description of data being certified: ____
____
____
____

6) List the parks covered in the certified data set, and provide any park-specific details about this certification.

Park	Details

7) This certification refers to data in accompanying files. Check all that apply and indicate file names (folder name for images) to the right:

_____ Hardcopy Datasheet(s): ____
_____ PDF Datasheet(s): ____
_____ Database(s): ____
_____ Spreadsheet(s): ____
_____ Spatial data theme(s): ____
_____ GPS file(s): ____
_____ Geodatabase file(s): ____
_____ Photograph(s): ____
_____ Data Logger(s) files: ____
_____ Other (specify): ____
_____ Certified data are already in the master version of a park, KLMN or NPS database.
Please indicate the database system(s): ___________________________

8) Is there any sensitive information in the certified data which may put resources at greater risk if released to the public (e.g., spotted owl nest sites, cave locations, rare plant locations)?

_____ No   _____ Yes   Details:

____
____
____

9) Were all data processing and quality assurance measures outlined in the protocol followed?

Yes / No

If No, Explain ____
____
____

10) Who reviewed the products?
____

11) Results and summary of quality assurance reviews, including details on steps taken to rectify problems encountered during data processing and quality reviews.
____
____
____

Integrated Water Quality and Aquatic Communities Protocol – Wadeable Streams

Standard Operating Procedure (SOP) #24: Revising the Protocol

Version 1.0

Revision History Log:

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This document explains how to make and track changes to the Wadeable Streams Protocol, including its accompanying SOPs. While this monitoring protocol has been developed using current standardized methodology, all long-term monitoring programs need to be flexible to adapt to changes. As new technologies, methods, and equipment become available, this protocol will be updated as appropriate. Current best practices will be weighed against the continuity of protocol information in determining revisions. Project staff should refer to this SOP whenever edits are necessary and should be familiar with the protocol versioning system in order to identify and use the most current versions of the protocol documents. All changes will be made in a timely manner with the appropriate level of review.

All edits require review for clarity and technical soundness. Small changes to existing documents (e.g., formatting, simple clarification of existing content, small changes in the task schedule or project budget, or general updates to information management handling SOPs) may be reviewed in-house by project cooperators and Klamath Network staff. However, major changes to data collection or analysis techniques, sampling design, or response design will trigger an outside review. The Project Lead should coordinate with the Klamath Network Contact to determine if outside review is needed.

Revision Procedures

The following procedures will ensure that both minor and major revisions to this document will align with the monitoring plan.

1. Discuss proposed changes with other project staff prior to making modifications. It is imperative to consult with the Data Manager prior to making changes because certain types of changes may jeopardize dataset integrity unless they are planned and executed to avoid this. Also, because certain changes may require altering the database structure or functionality, advance notice of changes is necessary to help minimize disruptions to project operations. Consensus should be reached regarding who will be making the changes and in what timeframe.
2. Make the agreed-upon changes in the appropriate protocol document. Note that the protocol is split into separate documents for each appendix and SOP. Also note that a change in one

document may necessitate other changes elsewhere in the protocol. For example, a change in the narrative may require changes to several SOPs. Similarly, renumbering an SOP may mean changing document references in several other documents. Also, the project task list and other appendices may need to be updated to reflect changes in timing or responsibilities for the various project tasks.

3. Document all edits in the Revision History Log embedded in the protocol narrative and each SOP. Log changes only in the document being edited (e.g., if there is a change to an SOP, log those changes only in that document). Record the date of the changes (i.e., the date when all changes were finalized), author of the revision, the change and the paragraph(s) and page(s) where changes are made, the (brief) reason for making the changes, and the new version number. Version numbers increase incrementally by hundredths (e.g., version 1.01, 1.02) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0). Record the previous version number, date of revision, and author of revision; identify paragraphs and pages where changes are made, rationale for revisions, and the new version number.

4. Circulate the changed document for internal review among project staff and cooperators. Minor changes and clarifications will be reviewed in-house. When significant changes in methodology are suggested, revisions will first undergo internal review by the project staff. Additional external review including, but not limited to, National Park Service staff with appropriate water quality, aquatic communities, and statistical expertise will be required.

5. Upon ratifying and finalizing changes:
    a. Ensure that the version date (last saved date field code in the document header) and file name (field code in the document footer) are updated properly throughout the document.
    b. Make a copy of each changed file to the protocol archive folder (i.e., a subfolder under the Protocol folder in the project workspace).
    c. The copied files should be renamed by appending the revision date in YYYYMMDD format. In this manner, the revision date becomes the version number and this copy becomes the "versioned" copy to be archived and distributed.
    d. The current, primary version of the document (i.e., not the versioned document just copied and renamed) does not have a date stamp associated with it.
    e. To avoid unplanned edits to the document, reset the document to read-only by right-clicking on the document in Windows Explorer and checking the appropriate box in the Properties popup.
    f. Inform the Data Manager so the new version number(s) can be incorporated into the project metadata.

6. As appropriate, create PDF files of the versioned documents to post to the Internet and share with others. These PDF files should have the same name and be made from the versioned copy of the file.
7. Send a digital copy of the revised monitoring plan to the Network Contact and Network Data Manager. The revised monitoring plan will be forwarded to project and park staff who had been using a previous version of the affected document. Ensure that field staff have a hardcopy of the new version.

8. The Network Data Manager will place a copy of the revised protocol in the proper folder on the Klamath Network shared drive. In addition, the Network Data Manager will archive the previous version in the Klamath Network archive drive.

9. The Network Data Manager will post the revised version and update the associated records in the proper I&M databases, including but not limited to NatureBib, NPS Data Store, NRInfo, KLMN Intranet and Internet web sites, and the Protocol database.

10. Update the following table to specify the most up-to-date current version of all protocol sections.

Table 28. Protocol version tracking table showing latest version and effective date. To be updated with any revisions.

	Latest Version	Effective Date
Protocol Narrative	1.0	4/20/2011
SOP 1. Preparations, Equipment, and Safety	1.0	4/20/2011
SOP 2. Field Crew Training	1.0	4/20/2011
SOP 3. Site Selection	1.0	4/20/2011
SOP 4. Data Entry	1.0	4/20/2011
SOP 5. Order of Work	1.0	4/20/2011
SOP 6. Site Arrival Tasks and Sample Reach Layout	1.0	4/20/2011
SOP 7. Water Quality Multiprobe Calibration and Field Measurement	1.0	4/20/2011
SOP 8. Water Chemistry Sample Collection and Processing	1.0	4/20/2011
SOP 9. Macroinvertebrate Collection	1.0	4/20/2011
SOP 10. Discharge Measurements	1.0	4/20/2011
SOP 11. Periphyton Collection	1.0	4/20/2011
SOP 12. Stream Habitat Characterization	1.0	4/20/2011
SOP 13. Slope Measurements	1.0	4/20/2011
SOP 14. Riparian, Invasive Plants, and Dominant Tree Characterization	1.0	4/20/2011
SOP 15. Aquatic Vertebrate Sampling	1.0	4/20/2011
SOP 16. Photo Points and Photo Management	1.0	4/20/2011
SOP 17. Post-site Tasks	1.0	4/20/2011
SOP 18. Post-season Tasks	1.0	4/20/2011
SOP 19. Quality Assurance Project Plan	1.0	4/20/2011
SOP 20. Database	1.0	4/20/2011
SOP 21. Sensitive Data	1.0	4/20/2011
SOP 22. Data Analysis and Reporting	1.0	4/20/2011
SOP 23. Data Transfer, Storage, and Archiving	1.0	4/20/2011
SOP 24. Revising the Protocol	1.0	4/20/2011
Appendix A. Annual Report from Pilot Project	1.0	4/20/2011
Appendix B. Expectations of Field Crew	1.0	4/20/2011
Appendix C. USGS Safety Manual, Chapter A9	1.0	4/20/2011
Appendix D. Leave No Trace Handbook	1.0	4/20/2011
Appendix E. Icom Radio Use Handbook	1.0	4/20/2011
Appendix F. Field Data Sheets and Logs	1.0	4/20/2011
Appendix G. Example of Site Folder	1.0	4/20/2011
Appendix H. Example of Fish, Amphibian, and Invasive Species Guide	1.0	4/20/2011
Appendix I. Hach Digital Titrator Manual	1.0	4/20/2011
Appendix J. Eureka Environmental Manta Water Quality Probe Manual	1.0	4/20/2011
Appendix K. Trimble Yuma Tablet PC Manual	1.0	4/20/2011
Appendix L. American Society of Ichthyology and Herpetology Amphibian and Fish Handling Manual	1.0	4/20/2011
Appendix M. Equipment List	1.0	4/20/2011
Appendix N. Job Hazard Analyses	1.0	4/20/2011
Appendix O. Tolerance Values, Life History Characteristics, and Standard Taxonomic Effort	1.0	4/20/2011
Appendix P. Literature for IBI Calculations	1.0	4/20/2011
Appendix Q. Smith-Root, Inc. LR-24 Backpack Electrofishing Manual	1.0	4/20/2011
Appendix R. Operational Checklist	1.0	4/20/2011

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National Park Service
U.S. Department of the Interior

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