Quality Assurance Project Plan
for
Streamkeepers of Clallam County
Environmental Monitoring Program

Revised edition – November 2011

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Revision of Streamkeepers' prior
Quality Assurance Project Plan
(Baccus and Chadd, 2000)

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Background

Need for this Revision

This document represents an update of Streamkeepers' previous Quality Assurance Project Plan, designed to accompany our submittal of data for the Washington State Department of Ecology (henceforth "Ecology") 2012 Freshwater Water Quality Assessment and candidate 303(d) list under the federal Clean Water Act, as well as the Assessment for marine waters planned for 2014, and subsequent reports. This revision is required by the state Water Quality Data Act codified in RCW 90.48.570 through 90.48.590, and interpreted by Ecology's Water Quality Program Policy, Chapter 2, "Ensuring Credible Data for Water Quality Management" (2006). Subsequent to publication of this policy, we began upgrading our procedures and documentation, and except as noted within, the procedures presented here have been followed since July 2007.

Geology and History of Study Area and Surroundings

The text for the following sections is based on *State of the Waters* (Clallam County, 2004), a groundbreaking comprehensive report on the watersheds of Clallam County funded by the State Centennial Clean Water Fund.

The waters of Clallam County provide abundant resources for fish, wildlife and humans. They provide recreational, aesthetic, economic and ecological benefits for citizens and visitors. In Clallam County, recreational as well as commercial uses of these waters have always been important, including boating, fishing, and shellfish harvesting. The County's rivers, creeks, lakes, wetlands and estuaries provide habitat for a diversity of fish and wildlife species, including many different stocks of salmonids. Its groundwater aquifers supply drinking water as well as baseflow to most streams and wetlands.

Clallam County's waters all flow from the Olympic Mountains that form the core of Washington's Olympic Peninsula. The heart of the peninsula has been preserved as Olympic National Park, and has been described as "more than 1,400 square miles of rugged mountains, richly forested river valleys, and pristine wilderness coast." For more than a century, the forests of the Olympics were prized by lumbermen and other residents for their record-size trees. Because of the richness of these forests, logging and other development have left a legacy of impacts on both habitat and water quality across the peninsula. While each stream has its own distinctive characteristics, some qualities are common to all of them. Unless in the rainshadow of the Olympics, the watersheds generally have abundant rainfall in the winter that can result in hydrologic stress, especially if the stream is in a disturbed condition. Those streams originating high in the mountains often descend rapidly, then flow across a lower elevation floodplain, before entering salt water in the Pacific Ocean or Strait of Juan de Fuca. Geologic conditions provide for sediment-rich streams, with natural landslides regularly occurring on many peninsula rivers. When such streams were heavily forested, erosion usually proceeded at a more periodic rate. Once logged, especially in the steep upper watersheds, the amount of sediment entering the streams accelerated, often causing severe downcutting, failing banks, blockages, and excessive fine sediments instream, causing problems for aquatic wildlife, including spawning and rearing salmon.

Two major types of human impact have occurred to floodplain functions on peninsula streams. First, many channels have been disconnected from their floodplains. Second, many of the peninsula streams have lost their rich, deep riparian streamside corridors, which in the past provided shading, instream habitat, filtering, and aquatic food resources. Once removed, these benefits were no longer provided for fish, wildlife and water quality; many streams now lack forest cover and have limited large woody debris instream, resulting in poor channel habitat, increased summer water temperatures, low dissolved oxygen, and excessive turbidity. Other floodplain impacts on some of these streams include dams, diking, channelization, riparian roads, animal access and other effects of development. While some streams on the peninsula maintain healthy ecosystems, human activities have directly impacted the quality of the water and habitat in the majority of them, compromising both fish and wildlife resources as well as human uses in the watershed. In an ecological context, "compromised" means showing signs of ecological degradation, with impacts expected to one or more salmon life-stages, for example (Clallam County, 2005).

Parameters of Concern

Sources of pollution in the study area are numerous, varied and sometimes difficult to detect. Surface water runoff can contain a mixture of nutrients, bacteria, sediments, petroleum products, metals and other toxic ingredients. The cumulative effect of these "nonpoint source pollutants" on water quality and aquatic life can be significant. Human alterations to water quality and salmonid habitat can be expected to have different consequences for different fish and wildlife species. Across Clallam County, land use activities associated with forest practices, agriculture, rural development, and industry have had negative impacts on water quality and salmonid habitat.

Excessive sediment is one of the most common "pollutants" and a major limiting factor for salmonid production across the peninsula. It can cause channel instability and degrade water quality and salmon habitat. Excess silt in stream gravels can make it difficult for fish to spawn and stream invertebrates to survive. Causes of excessive sediment include increased input from landslides, removal of vegetation and other ground-disturbance associated with logging and roads (particularly when built on steep slopes), agricultural practices, and construction activities. On the other hand, decreased amounts of gravels (medium-sized "sediment") suitable for fish spawning is also sometimes a problem, and has been caused by dams, dikes and other floodplain constrictions.

Excessive nutrients and bacterial contamination are relatively common pollutants in peninsula streams, estuaries and groundwater. Food (e.g., shellfish) gathered where fecal coliform bacteria levels are high can be harmful if eaten by humans. It is not known if fecal coliform bacteria is specifically harmful to salmonids, although its presence may indicate that other pollutants are present that are known to be harmful to fish. Excessive nutrients often result in the rapid growth of algae in streams, causing problems for fish (including declines in dissolved oxygen and increases in temperature), and often aesthetic problems for humans. This contamination can be caused by trampling and unrestricted animal access into riparian corridors or into the stream itself, leaking septic and sewer systems, excessive fertilizers and chemicals applied to the land, and general stormwater runoff.

Low flows cause some salmon to spawn in less stable areas of the stream, possibly increasing the likelihood that fish redds will be washed out during high flow events. Low flows also cause higher water temperatures and lower dissolved oxygen conditions than those needed by many fish and the "high-quality bugs" that salmon need to sustain their populations. Causes of low flows include water withdrawals, the operation of dams and diversions, alteration of floodplains and wetlands, and changes in vegetation patterns.

Anthropogenic changes can cause or exacerbate flooding, which can seriously degrade stream channel conditions and bring pollutants into the stream, and eventually out into estuaries and bays. These pollutants are harmful to many species, including humans if they eat shellfish or other food gathered from these waters. Flooding is often due to channelization, routing of stormwater through irrigation systems, the presence of roads and impervious surfaces, and increased stormwater from lands where native vegetation has been removed.

Need for Data

Because of these challenges, various parties in Clallam County have focused great attention and effort to restore dwindling salmon populations, restore degraded shellfish beds, and restore natural ecological functions. Numerous stream restoration, mitigation, and Best Management Practices projects have been completed, are underway, or are planned; active watershed planning councils are working on long-range watershed management plans; and funding is being directed to numerous groups seeking to improve streams and fish habitat. All of these efforts share a need for good, ongoing data on stream health. While numerous studies have been conducted on various streams, there has been little consistent baseline water quality data available that can be used to identify specific ongoing problems, plan watershed management, or track the effectiveness of restoration projects.

History of the Streamkeepers Program

Responding to the above needs, several watershed management plans completed in the 1990s (Sequim Bay Watershed Management Committee, 1991; Dungeness Watershed Management Committee, 1993; Clallam County, 1995) recommended that volunteer "stream adoption" teams be established to help build stewardship of stream resources by area citizens. The plans also suggested that these teams monitor water quality parameters and become involved in solving problems they identify. A volunteer stream-monitoring program gives interested citizens a way of becoming actively and meaningfully involved in a broad-based effort to learn about, protect, and restore streams and whole watersheds across Clallam County.

In 1996, the Eight Streams Project (a 3-year Washington State Centennial Clean Water Fund grant program administered by Washington State University Cooperative Extension of Clallam County) initiated a volunteer stream monitoring program on streams in Port Angeles and Sequim, under a Quality Assurance Project Plan approved by Ecology (Washington State University Cooperative Extension, 1997). When the grant expired in 1999, Clallam County established Streamkeepers of Clallam County to continue the stream-monitoring component of the Eight Streams Project. Program staff, in consultation with volunteers and technical advisors, revised the sampling plan and procedures and received Ecology's approval on a new Quality Assurance Project Plan (Baccus and Chadd, 2000).

Since that time, Streamkeepers of Clallam County's volunteer monitoring program has provided a suite of monitoring protocols, and a body of trained data collectors, to document the ambient (physical, chemical and biological) conditions of surface water streams in Clallam County. We also apply these protocols to help partner agencies and citizens' groups carry out special monitoring projects connected with watershed protection and restoration. In that time, the need for data has not abated and is expected to increase over time (Clallam County, 2004).

Project Description

Description of the Problem: See "Background" section above.

Goals

Streamkeepers of Clallam County was created to involve residents in caring for watersheds, primarily by monitoring them, providing credible and useful data to help guide decision-makers in the protection and restoration of the County's streams.

Objectives

In terms of stream monitoring, Streamkeepers' objectives are as follows:

- Define and document baseline physical, chemical and biological conditions of local streams
- Measure spatial and temporal variability of stream attributes
- Look for signs of degraded stream condition in a geographically broad manner
- Identification of sources of degradation
- Assess trends in watershed degradation or restoration
- Provide information to assist in watershed planning, management, restoration and adaptive management

Information Needed to Meet Objectives

All of the above objectives require informed and responsive management, as well as dependable and accountable data collection and analysis. This document describes those processes in detail.

Target Population

The Streamkeepers program is primarily designed to assess the chemical, physical, and biological integrity of the County's streams. However, part of that assessment involves gathering data from riparian areas and entire watershed basins, and we are also equipped to apply some of our protocols to lakes, wetlands, and nearshore marine environments on request.

Study Boundaries

As a program of Clallam County, the Streamkeepers program focuses on Clallam County's streams. However, it can go beyond County boundaries upon request of outside parties, particularly if the study question crosses those boundaries.

Tasks Required to Collect the Data

In general, Streamkeeper volunteers use commonly-established, detailed protocols to collect the data. These methods are described in more detail later in this document, and are described in full detail in the Streamkeepers Volunteer Handbook (latest edition: Chadd, 2011). This set of Standard Operating Procedures generally undergoes revision each year, in order to:

- Better explain procedures and make data-collection more efficient
- Account for additional special circumstances
- Improve data quality

Revisions made will not in any case reduce data quality below the stated objectives for a given parameter.

Constraints on Study Design

In an ideal world, we would gather continuous data on all of Clallam County's streams. However, we are limited by available funding, equipment, staff resources, technical expertise, and volunteer deployment. Hence, we must prioritize our efforts. This prioritization takes place on a continual basis, under the advisement of our Technical and Volunteer Advisory Committees (see next section). In devising our sampling plan, our advisors must balance two primary competing values: the continuity of long data sets, which enable evaluation of long-term trends and provide a stable reference for other data, versus the value of breadth of coverage. Another value to consider is volunteers' motivations: sometimes volunteers want to make a commitment to a particular stream, and other times they feel they have gathered enough data from a stream and want to move on. Usually the volunteers accept the recommendations of the technical advisors, but sometimes it works the other way around.

Decisions to Be Based on Project Data

The Streamkeepers program is not the primary end-user of the data we collect; rather, we gather, manage, analyze, and report on data under the direction of and for the use of other entities—those agencies and organizations actively working to protect and restore streams. Our primary end-user is Clallam County itself, but our data helps to advance the missions of a multiplicity of local, state, tribal, and federal agencies, as well as non-governmental groups and individual citizens. In general, these entities use Streamkeeper data to:

- Design, adaptively manage, and evaluate watershed-management plans, restoration projects, ordinances and regulations
- Assure compliance with permitting requirements
- Discover and remediate pollution problems
- Increase knowledge about local watersheds

Streamkeepers data is public information available on request.

Organization and Schedule

Project Planning Team

Streamkeepers is currently part of the Clallam County Department of Community Development. Our ultimate accountability is to the Director of the Department of Community Development and the Board of County Commissioners, and through them to the citizens of the County. As of December 1, 2011, Streamkeepers will become part of the Clallam County Public Works-Roads department, which is directly responsible to the Board of County Commissioners.

The program direction is guided by the Streamkeepers Steering Committee, which itself consists of two committees: our Volunteer Advisory Committee and our Technical Advisory Committee.

The VOLUNTEER ADVISORY COMMITTEE is composed of any volunteers who care to participate. It recommends changes to any aspect of the program, including program components, activation or inactivation of sites and streams, and stream cleanups or other projects. It meets as needed, convened by program managers or at the request of volunteers. Its one regular meeting in the fall produces recommendations for program changes for the coming year.

The TECHNICAL ADVISORY COMMITTEE consists of people with technical expertise from local, state, tribal and federal agencies; academia; businesses and consulting firms; and knowledgeable local residents. This group connects the Streamkeepers program to other watershed management efforts and local technical expertise, by recommending priorities for sites, streams, parameters monitored, special projects, and reports, as well as by providing guidance on technical questions. It meets as needed, convened by program managers or at the request of advisors or volunteers. Its one regular meeting in the fall reviews the Volunteer Advisory Committee's recommendations and produces recommendations of its own.

The STREAMKEEPERS STEERING COMMITTEE consists of the VOLUNTEER ADVISORY and TECHNICAL ADVISORY Committees. It makes final recommendations on program direction. Its one regular meeting is in late fall, to finalize the work plan for the coming year.

STREAMKEEPERS PROGRAM STAFF works with these groups every year to evaluate the prior year's programming and plan the next. Staff often makes recommendations of its own.

Beginning and End Target Dates

This document represents an update of an ongoing study rather than a new study. Because Streamkeepers is designed as an ongoing program, there are no fixed start or end dates for sampling, reports, or submittal of data to Ecology's Environmental Information Management (EIM) system. Sampling and reporting occur on schedules determined by Streamkeepers' end-users; for example, submittals of data to EIM will occur when there is a call for data for the State Water Quality Report or Ecology grant projects require such submittal.

Sampling Process Design (Experimental Design)

Sampling Design and Rationale

As described in the "Project Description" above (see "Goals," "Objectives," and "Constraints"), the Streamkeepers program is intended to be a long-term effort which maximizes available human, capital, and financial resources to meet the needs of those concerned with Clallam County's watersheds. Because resources and needs change over time, a single sampling design would not be appropriate. However, the basic design of the Streamkeepers monitoring program can be described as follows:

1) *Long-term Ambient Monitoring:* Regularly scheduled field sampling events to collect data on a suite of parameters of physical, chemical, and biological stream health at established monitoring reaches on selected streams. Parameters, sites, and scheduling are determined in consultation with Streamkeepers' supervisors and advisory committees, as described in "Organization and Schedule" above.

2) Special Project Work: Special projects performed at the request of a partner entity, to that entity's specifications. These projects may be performed under Streamkeepers' QAPP, a separate QAPP, or no QAPP, depending on the nature of the project. These projects are also approved by Streamkeepers' supervisors and advisory committees.

Site Selection

1) *Long-term Ambient Monitoring*

Streamkeepers' monitoring focuses on wadeable streams, most of which arise in the foothills of mountains and are of relatively short length—often just a few miles. The choice of which streams to monitor is made by consultation between Streamkeepers staff, supervisors, and advisory groups. These choices are reflected in our annual work plans and sampling plans, available on our website: http://www.clallam.net/SK/programplanning.html.

During occasional rapid-assessment Streamwalks, volunteers try to assess the entire length of their streams. But for our suite of more detailed scientific parameters, specific monitoring sites must be established, and this, like our choice of streams, is a matter of consensus judgment. We generally try to establish three or more monitoring sites on a given stream: ideally, one at or near the mouth, one in a developed area, and one above the developed areas. This arrangement allows some comparison between stream characteristics at different elevations and levels of human impact. The exact number and location of monitoring sites will depend on characteristics specific to each creek (including access, owner permission, creek history, etc.). Because we are an ongoing program designed to meet the long-term informational needs of local resources managers, the sites change over time. For instance, after several years of monitoring a particular site, we may decide that an adequate baseline of data has been collected and therefore mothball the site. Specific streams and sites monitored are reviewed annually and may be adjusted each year, according to the recommendations of Streamkeepers' supervisors, technical advisors and volunteers. These changes are reflected in the Streamkeepers workplan devised prior to each calendar year accompanied by individual plans for water quality, fecal coliform, benthic macroinvertebrates, and physical habitat, and posted on our website: http://www.clallam.net/SK/programplanning.html. All sites are entered as points in Clallam County's

Geographic Information System (GIS), and customized maps locating sites can be generated on request.

Ambient monitoring sites are generally selected using the following criteria:

- Giving a representative view of the stream as a whole and typical for its location in the watershed
- Reasonable and safe access by volunteers
- Publicly owned land or permission of landowner to access and mark sites
- At least 165' upstream or 660' downstream of bank alterations such as bridges, riprap, etc., if possible, unless the site is established to track the impact of the alteration
- Containing both pools and riffles, if possible
- Above saltwater and tidal influence
- Located at least one half-mile apart, if possible

Sampling sites, once established, consist of either a central monitoring point, a transect across a stream or longitudinal line along it, or a two-dimensional area including the stream corridor. In any case, determination of a specific spot to perform a particular type of sampling is generally made by the field team in situ, because certain conditions must prevail for certain types of sampling, e.g., flow, water chemistry, or benthic macroinvertebrate collection. Details of how to determine the best spot for a given procedure are described in Streamkeepers' Volunteer Handbook (Chadd, 2011).

Fecal/nitrate sampling is usually constrained by funds available for laboratory analysis, and therefore a typical scheme is to collect a single sample on a stream, near the mouth. In circumstances where pollutants are consistently high and funding is available to sample more extensively, additional samples will be collected at points upstream to better identify sources.

2) Special Project Work

Special project monitoring reaches are selected by the initiating partner agency, to meet their program's objectives. Often, the sites chosen are sites already established by Streamkeepers, which offer the advantage of a separate body of data and known access and permission.

Parameters, Frequency, Rationale, and Targets

1) *Long-term Ambient Monitoring:* Parameters currently measured, their frequency, rationale, and target values are described in Table 1 below. However, depending on informational needs, some sites are sampled only during the low-flow period, and some sites may be monitored more frequently. Specific schedules are posted on our annual sampling plans, available on our website at http://www.clallam.net/SK/programplanning.html.

2) *Special Project Work:* Rationale, parameters, frequency, and targets are selected by the initiating partner agency, to meet their program's objectives.

Table 1: Parameters Measured under Streamkeepers' Long-Term Ambient Monitoring Program

(† Procedure is suitable for regulatory purposes as "credible data" [WA Dept. of Ecology, 2006])
Monitoring Quarters: Winter—January, Spring—April, Summer—August, Fall—Sept. 15 – Oct. 15

Type of Parameter	Indicator	When	Why	Desired Level or Range
Chemical (i.e., measuring the quality of the water itself)	† Temperature	Quarterly	Important habitat component for salmonids and an indicator of watershed disturbance	16° C maximum (*Class A, 18° C); consistent, cool temperatures
	† Dissolved Oxygen (DO)	Quarterly	Vital to growth and development of aquatic life	> 9.5 mg/L (*Class A, 8.0 mg/L)
	† Conductivity	Quarterly	High electrical conductivity indicates various chemical and biological pollution problems.	No standard established for streams, but unusually high readings away from salt water influence are cause for concern
	† pH	Quarterly	Some aquatic life forms can only live within a narrow pH range; others are more tolerant.	6.5-8.5 (*Same for Class A)
	† Turbidity	Quarterly	Turbidity results from suspended solids such as silt. High levels of silt destroy fish habitat.	No more than 5 NTU above "natural" levels (or 10% above if "natural" level is >50).
	Nitrate-Nitrogen	Quarterly screening; lab samples when requested	Excess nitrogen allows excessive plant growth, leading to eutrophication of water bodies. Sewage and animal waste add nitrogen to rivers.	1 mg/L would be cause for concern (Mitchell and Stapp, 1996).
Physical *(parameters listed below "gradient" are optional to monitor, pending further program decisions)*	Fixed-vantage photographs	January, August, and during macroinvertebrate collection	Characterize conditions and track changes in stream over time	----------------------
	Flow: wade-across, other in-situ methods, stage gages	Quarterly unless a calibrated gage is nearby; plus during extremes as desired/possible	Track flow regime, calibrate hydrology models, interpret water-quality data	Similar to historical conditions
	Bank stability	August	Track disturbances	Stable banks
	Gradient	New sites, and as needed	Characterize stream geomorphology	Will vary along the length of the stream

	Broad survey (Streamwalk)	Occasional, usually summers	Overall picture of stream health	Naturally-functioning stream system
	Broad survey photographs	July (with Streamwalk)	Document potential problems	----------------------
	Reach map	For two-dimensional reaches	Track changes in stream over time	----------------------
	Cross-section	August	Upstream activities can change channel shape	Relatively stable cross-section
	Erosion and/or revetment	August	**Sign** of channel instability and biological disturbance	Stable banks, little erosion or armoring
	Substrate (Pebble Count)	August	Indicator of physical and biological functioning of stream channels	Sediment of a size appropriate to the stream size and gradient
	Pools	August	Fish habitat	Abundant, stable pools
	Large woody debris (LWD)	August	Major influence on habitat structure, sediment transport, stream energy, nutrient load	Many large downed logs--conifers if they were historically present
	Canopy closure percentage	January, August	Shade regulates stream temperature and provides cover for fish	Multi-storied canopy, abundant shade year-round
	Canopy type percentages	August	Large conifers are crucial to fish habitat	Near historic number of large conifers present in riparian corridor
	Conifer stems	January - every 5 years	Riparian & LWD recruitment	Density close to natural conditions
Biological	Fish/wildlife	quarterly plus Streamwalk (July)	Signal of stream biological integrity	Abundant, diverse populations
	Noxious weeds	Streamwalk (July); update as needed	Signal of stream system and riparian area integrity	No noxious weeds
	† Fecal Coliform, E Coli, & Enterococci	Lab samples collected quarterly or more frequently	Fecal Coliform, E Coli, and Enterococci bacteria indicate human and animal waste which pollutes water.	For fecal coliform, geometric mean of 50 colonies per 100 mL and ≤10% of readings >100 colonies for "Extraordinary Primary Contact" waters & 100 geomean & ≤10% < 200 for "Primary Contact" waters
	† Benthic macro-invertebrates	Sept 1- Oct 15	Diverse populations of macroinvertebrates signal a healthy stream system.	"Healthy" B-IBI score
* Surface water quality standards, Chapter 173-201A WAC. All Clallam County streams are "Extraordinary Primary Contact", except for the following "Primary Contact" waters: Dungeness River and tributaries downstream of Canyon Creek (RM 10.8), Port Angeles Harbor tributaries (to Lees Creek), and Dickey River.				

Representativeness:

- Overall site & stream selection: Both streams and monitoring sites are targeted at salient features chosen by our advisory groups (see site selection criteria); because random sampling was not used in their selection, these streams and sites are not chosen to be representative of any larger geographic area.
- Chemical water quality sample representativeness is sought at a given site by taking the sample at or near the center of the stream channel where water is well mixed and most representative of ambient conditions, and by maintaining probes in the stream until a stable reading is achieved; for turbidity, three sub-samples are taken for further representativeness.
- Physical habitat sample representativeness: Permanent cross-section monuments are established across a riffle, run or glide, preferably at a fairly straight and even stretch of stream. Substrate measurements are performed at a channel-spanning riffle or run, at a point where the bottom appears relatively homogeneous.
- Macroinvertebrate sample representativeness: We collect 3 replicates per sample, between mid-September and mid-October, in mid-channel riffle habitat. If riffles are not available, we use a glide or the fastest part of the stream. The purpose of these procedures is to collect a standard sample from a common and easily identified habitat that can be compared to other similar samples across the region and state (Fore, Paulsen & O'Laughlin, 2001; Karr, 1999). Each replicate is comprised of 3 sub-replicates, which are combined to be more generally reflective of the entire riffle and to strive for a minimum of 500 specimens per replicate.
- Assumptions regarding sampling intervals: Streamkeepers' advisors have recommended a basic format of quarterly sampling, based on assumptions of general seasonal variation of data, in order to gather data representative of the different seasons:
  - Winter: January; cold temperatures, high baseflows, storms
  - Spring: April; high baseflows, warmer temperatures, snowmelt, plant budding
    - For fecal/nitrate sampling, the spring window is April/May
  - Summer: August; low flows, high temperatures, full leaf-out
    - For fecal/nitrate sampling, the summer window is August 1 – Sept. 15
  - Fall: September 15 – October 15; often either lowest flows or first storms of the season; leaf fall and plant die-off
    - The required time period for B-IBI sampling of benthic macroinvertebrates is Sept. 1 – Oct. 15 (Karr 2009)
    - For fecal/nitrate sampling, the fall window is Oct. 5 – 31
- Exceptions to sampling intervals: This quarterly format is amended in individual cases on the recommendations of advisors (the most frequent amendment being to limit sampling to summer and fall, to try to catch the low-flow period). Volunteers can sample at any point within the sampling window, and in some cases may sample a few days outside of the sampling window for a given season, if program managers approve (generally, as long as the weather is not radically different than during the sampling window). Furthermore, certain types of studies will dictate different sampling schedules. For example, a stormwater study will be timed to track a storm event, a summer low-flow study will be timed to catch the lowest flows, and a study of pollutants in recreational areas will focus on times of heaviest use.
- Limitations of sampling schedule:
  - Intervals: Our seasonal samples are assumed to be adequate for generalized watershed characterization, but they tend to miss extreme events, which are crucial to understanding certain

watershed-process phenomena such as flood impacts, "first-flush" effects, and extreme low flows or temper-atures. For example, an Ecology study at 42 stations indicated that monthly spot-sampling, on average, underestimated the summer maximum temperature by 3.7°C and under-estimated the maximum seven-day average of daily maxima by 2.9°C (Hallock and Ehinger, 2003).

- Timing within sampling window: Most sampling windows are a month long, and samples can be collected any time during that period. Results may need to be adjusted statistically to a common date.
- Time of day: Samples are not collected at a uniform time of day, and therefore diurnal variations may influence data for certain parameters, particularly temperature, pH, and dissolved oxygen. Results may need to be adjusted statistically to a common time prior to trend analysis.
- Chance events: A summer rainstorm can significantly impact water-quality parameters, so recent higher-flow events may need to be considered when analyzing data.

Order of sampling: During ambient monitoring, if there are multiple sampling sites on a given stream, sites should generally be visited from downstream to upstream. This order avoids the problem of downstream contamination caused by samplers walking in the stream. It also enables better comparisons of turbidity data during and after a storm event, because turbidity tends to rise sharply and then decline slowly. Therefore, if a downstream sample has a higher turbidity than an upstream sample taken later the same day, one can be fairly confident that the difference is due to the geographic difference between the two sites and not the possibility that turbidity was rising in the entire system due to the rising curve of a storm event. A similar reasoning holds for temperature measurements, which tend to rise diurnally; a lower temperature taken at an upstream site later in the day will be the result of geography, not timing. Exceptions to this rule may occur, for example if a downstream site is tidally influenced and the tide is up at the beginning of the sampling day. In all cases, times are recorded along with measurements to make temporal relationships clear.

Order of sampling and cross-contamination: We note that concerns over cross-contamination of exotic organisms between water bodies dictates a preference for sampling from the least to most-impacted sites. We have not yet implemented this change in our protocols but plan to soon, along with decontamination protocols as described on the Ecology website:
http://www.ecy.wa.gov/programs/eap/InvasiveSpecies/AIS-PublicVersion.html

Comparability with data from other projects: Streamkeepers data is often combined with other data sets for analysis. The following rules will govern such combination:

1. The purpose of the analysis will dictate the stringency of combination rules. For general watershed characterization studies, all data believed to be reasonably accurate might be accepted, including data not gathered under a Quality Assurance Project Plan (QAPP), or for which the QAPP was not completely followed, or for which QA procedures were not completely documented. This was the case for Clallam County's *State of the Waters* report (Clallam County, 2004). More rigorous standards will be applied for more rigorous purposes: for example, for Ecology's Water Quality Reports, only data gathered to the specifications of Ecology's "credible data" policy (WA Dept. of Ecology, 2006) will be accepted for bundling and submission.

2. Streamkeepers special projects in which data is collected under this QAPP will be considered equivalent to Streamkeepers ambient-monitoring data. Some common-sense adjustments may be made to QA procedures in order to assure comparability: for example, if a project is not organized according to stream-teams, replicates will be collected at 1/10 of the sampling sites rather than at one of the team's sites for a given sampling season.
3. Data collected under a separate QAPP, but which references the Streamkeepers Handbook for field and QA procedures, will be considered equivalent to Streamkeepers data.
4. Streamkeepers uses standard procedures whenever possible for a given parameter, in order to maximize comparability. See Table 2, "Data Quality Objectives," for references.
5. To be collated or compared, data must measure the same parameter or be comparable in some manner. For instance, "fecal coliform colonies per 100 mL" is straightforward, but "large woody debris" can depend on definition. If data do not measure the same parameter, a determination will have to be made whether they can be made comparable.

Completeness of data: Because Streamkeepers is an ongoing program rather than a discrete sampling project, there is no set standard for completeness of data. In general, we aim to gather at least 90% of the data outlined in our annual work and sampling plans (http://www.clallam.net/SK/programplanning.html). Occasionally volunteers are unavailable to monitor their assigned streams; whenever possible, staff will assign alternate teams and/or individuals to complete the data collection, or assist with data collection themselves. Custodial sample loss will be minimized with sturdy sample storage vessels and adequate labeling of each vessel (see procedures in our Volunteer Handbook). In spite of these precautions, however, as a volunteer program, we cannot guarantee any standard of completeness. Therefore, when doing a study based on Streamkeepers data, it is up to the analyst to evaluate the completeness of the data set and qualify conclusions accordingly. (There may be exceptions to this qualification, if a special-project client requires a certain completeness standard and funds Streamkeepers staff to guarantee it.)

Quality Objectives

The data quality objectives (DQOs) for this project are presented in Table 2. Industry standard field methods will be used whenever possible to minimize measurement bias (systematic error) and to improve precision (random error), and all laboratory-bound samples will be collected, preserved, stored, and otherwise managed using accepted procedures for maintaining sample integrity prior to analysis.

The range of precision varies among the methods described below. In sampling design, methods will be chosen to fit the particular purpose for which the data will be used. For example, data destined for submittal to Ecology's Water Quality Report will be collected by methods meeting standards required for that report.

Stormwater and sediment parameters: In addition to the DQOs in Table 2, we have written QAPPs for the sampling of stormwater and stream sediment, each approved by Clallam County, the Jamestown S'Klallam Tribe, and EPA Region 10; all of these are available at http://www.clallam.net/SK/stormwatermonitoring.html. These QAPPs are incorporated by reference into this document.

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Table 2: Data Quality Objectives (* = protocol in Streamkeepers Volunteer Handbook; mfr. = manufacturer; "session" = quarterly monitoring session lasting one month, or some equivalent unit of monitoring undertaken within a limited timeframe; SM = Standard Methods for Examination of Water & Wastewater; see American Public Health Association 1998 in References section)

Type	Indicator	Method	Source	Equipment	Sample holding time & analyzers	Expected range of results	Resolution	Accuracy	Precision
WtrQuality	Tempera-ture (contin-uous)	Data logger thermistor	Dunham et al. 2005	Submersible continuous-reading loggers	Data download	0 - 20 °C	0.1 °C	± 0.2°C	± 0.2°C
	*Tempera-ture (grab sample)	Thermistor	SM2550	Electronic in-situ meter	In situ	0 - 20 °C	0.1 °C	± 0.2°C	± 0.2°C
	*Dissolved Oxygen	Membrane electrode	SM4500 O-G	Electronic in-situ meter	In situ	6 - 15 mg/L; 70-120% saturation	0.1 mg/L; 1% sat.	± 0.3 mg/L	± 0.3 mg/L
	*Dissolved Oxygen	Azide Modifi-cation	SM4500 O-C	Iodometric titration	2 hr holding time after adding manganous sulfate & alkali-iodide-azide	6 - 15 mg/L; 70-120% saturation	0.1 mg/L;	± 0.2 mg/L	± 0.2 mg/L

WtrQuality	*Conduc-tivity	Electrode	SM2510B	Electronic in-situ meter	In situ	25 to 400 µS/cm	1 µS/cm	± 5% of standard value	5% RSD
	*Salinity	Electrode	SM2520B-F	Electronic in-situ meter	In situ	0 to .2 ppt freshwater ; up to 32 marine	0.1 PSS	Calibrated with Conductiv-ity	0.1 or 5% RSD
	*pH (meter)	Gel probe	SM4500-H+	Electronic in-situ meter	In situ or 2 hr. holding time	6.5-8.5 pH units	0.1 pH unit	± 0.2 pH unit	± 0.2 pH unit
	*Turbidity	Nephelo-metric	SM2130B	Electronic meter; poly bottle ≥ 100 mL	In situ or 48 hr. holding time in darkness at 4°C	0 - 200 NTU	1 NTU; MDL = 0.5 NTU	± 0.5 or 5% of standard value	5% RSD or ± 1 NTU (MDL in field)
	*Nitrate-Nitrogen (screening)	Color test strips	USEPA 1997 + mfr.	Hach nitrate test strips or equivalent	In situ or 2 hr. holding time	0 – 5 mg/L	7 values on color chart	NA	NA
	*Nitrate-Nitrogen (lab)	Grab samples; nitrate ion electrode method	SM4500N03-D; CCEHL 2006	Poly bottles ≥125 mL, Orion 940 Ion Ana-lyzer (etc.)	Accredited laboratory; see cited sources for holding times (24 hr. at 4° C for nitrate)	0 – 5 mg/L for nitrate-nitrogen	0.1 mg/L for nitrate-nitrogen	± 20%	7% RSD
	Settleable solids	Volumetric	SM2540F	Imhoff cone	At home or office	Readings may vary widely	1 mL/L; MDL = 1 mL/L		
Air	*Temper-ature	Thermo-meter	USGS 1998	Various thermo-meters	In situ	-5—+35°C	1°C	± 1°C	
	Barometric pressure	Barometer	ASTM D3631	Barometer	In situ or nearby weather station	27-31 in Hg	0.01 in Hg	± 0.05 in Hg	± 0.05 in Hg

Biological	*Benthic macroin-vertebrates†	10-metric genus-level B-IBI	Karr and Chu 1998; Fore 1999	Surber sampler, 500µ mesh and sieves; 95% ethanol	ID & QC by professional taxonomic lab	B-IBI scores from 10 - 50	See text for details	± 4 points on B-IBI scale	± 4 points on B-IBI scale
	† Beginning in 2012, we will switch to sampling, taxonomic, and analytical protocols currently being developed under an EPA Scientific Studies and Technical Investigations Assistance Grant, "Enhancement and Standardization of Benthic Macroinvertebrate Monitoring and Analysis Tools for the Puget Sound Region"—see http://www.epa.gov/pugetsound/funding/index.html#science								
	*Fish/ wildlife	Observa-tion	Murdoch, Cheo & O'Laughlin 1996	Field guides	In situ	NA	NA		
	*Noxious weeds	Observa-tion	Clallam County & WA State Noxious Weed Control Boards	Field guide	In situ + ID confirmation by Clallam County NoxiousWeed Board	NA	NA		
	*Fecal Coliform count	Grab samples; membrane filtration	SM9222D; USEPA 2005; CCEHL 2006	M-FC broth; membrane filter & water bath	Sterilized poly bottle ≥125 mL; accredited laboratory; 8 hr. holding time at 4° C	Readings may vary widely	1 colony/ 100 mL; MDL = 100 ÷ volume filtered	NA	± 10 or 85% RSD (i.e., Base 10 log-transformed values ± 0.6)
	*Entero-coccus	Grab samples; membrane filtration		IDEXX Enterolert enzyme substrate method; 100 mL	Sterilized poly bottle ≥125 mL; accredited laboratory; 8 hr. holding time at 4° C	Readings may vary widely	1 MPN/100 mL; MDL = 100 ÷ volume filtered	NA	± 10 or 85% RSD

	Total coli form & E. coli	Grab samples; chromogen-ic substrate test	SM9223; Manufacturer	Coli-lert; Quanti-tray; Coliscan EasyGel; etc.	Analyzed by staff or trained volunteers	Presence/ absence or Most Probable Number	1 colony/ 100 mL	See 95% Confidence Limits from SM9221C	
Habitat	*Broad survey (Stream-walk)	EPA Stream-walk	USEPA, 1994; USEPA 1997; USDA 1998	Measuring tape	In situ	NA	NA		
	*Broad survey photo-graphs	EPA Stream-walk	USEPA, 1994	Camera	Photo record	NA	NA		
	*Photo-graphs	Photo-point	Booth & Comings 1998; Freudenthal 1999; Karr & Chu 1998	Camera; cross-section monuments	Photo record	NA	NA		
	*Reach map	Scaled grid; reference points	Murdoch, Cheo & O'Laughlin 1996, adapted	Compass, tape measure, graph paper	In situ	NA	NA		
	*Flow	Wadeable Stream Discharge Measure-ment	Pleus 1999, simplified; Schuett-Hames et al. 1994	Electronic current/ depth meter (e.g., Swoffer, Pygmy, Marsh-McBirney)	Summation of depth/width/ velocity cells taken in situ	NA	0.1 cubic feet per second (cfs)	± 10%	10% RSD
	Flow	Staff gage or refer-ence point	Butkus 2005	Staff gage	In situ	NA	0.01 ft.		
	*Flow	One-point hydraulic	Perry 2003	Current meter	In situ	Usually <1 cfs	0.01 cfs		

	*Flow	Bucket	Perry 2003	Bucket, stopwatch	In situ	Usually <1 cfs	0.001 cfs		
Habitat	*Gradient	Sight level	Harrelson et al 1994; Freudenthal 1999	Leveling rod and sight level	In situ	0-16%	0.1%		
	*Cross-section profile	Permanent monuments	Booth & Comings 1998	Monuments, tape, string, string level, stadia rod	In situ	NA	0.1 sq. ft.		
	*Erosion and/or revetment	Observa-tion & measure-ment	Scholz & Booth 1999; City of Bellevue 1998; Freudenthal 1999	Tape measure	In situ	NA	1 ft. height and width		
	*Bank stability	Observa-tion & classifica-tion	Henshaw & Booth 2000	Field guide	In situ	NA	4 classes		
	*Substrate	Pebble count	Kondolf 1997; Scholz & Booth 1999	Half-phi ruler	In situ	NA	Half-phi classes		
	*Pools	Count per criteria	Pleus, Schuett-Hames & Bullchild 1999, simplified; Scholz and Booth 1999; Freudenthal 1999	Stadia rod	In situ	NA	1 pool		

Habitat	*Large woody debris (LWD)	Classified count	Schuett-Hames et al. 1999, simplified; Scholz and Booth 1999; Freudenthal 1999	Tape measure, ruler	In situ	NA	1 piece		
	*Canopy closure percentage	Gridded count	Pleus and Schuett-Hames 1998, simplified	Spherical densiometer	In situ	0 – 100%	1%		
	*Canopy type percen-tages	Visual estimate	Freudenthal 1999-2000	NA	In situ	0 – 100%	3 classes for both conifers & deciduous		
	*Conifer stems	Visual count	Freudenthal 1999	Reach map; tape; compass	In situ	Limit at 60 per 10,000 sq. ft.	1 stem		

Sampling and Measurement Procedures

In-Situ Sampling Procedures: A basic schema of sampling and measurement procedures is presented in Table 2, "Data Quality Objectives," in the Quality Objectives section above. The Streamkeepers Volunteer Handbook (http://www.clallam.net/streamkeepers/assets/applets/Field_Procedures_Master.pdf; latest edition: Chadd, 2011), hereby incorporated by reference into this document, gives further details relating to:

- collection of samples and associated field QC samples
- analytical methods for measurements/analyses done in the field as well as the laboratory
- required equipment and in-situ calibration and maintenance procedures
- required content and format of field log entries
- requirements for photographic documentation
- sampling equipment and methods for its preparation and decontamination
- sample containers, sample size, labeling, preservation, holding time requirements, and chain of custody

This handbook is revised on a regular basis, so detailed procedures for a given year are given in the Handbook governing that year, and past editions are available from the Streamkeepers office. However, as noted above in "Project Description," these revisions do not change the basic procedures but rather:

- better explain procedures and make data-collection more efficient
- account for additional special circumstances
- reduce the occurrence of "flagged" data

Revisions will never reduce data quality below the stated objectives for a given parameter or compromise comparability with past data for the same parameter.

Maintenance, Calibration, and Quality Control of Test Equipment: Detailed procedures for maintenance and calibration of test equipment prior and subsequent to field sampling are posted on Streamkeepers' website: http://www.clallam.net/streamkeepers/html/quality_assurance.htm. These procedures cover all analytical instruments in use. As with Streamkeepers' Volunteer Handbook, these procedures get revised on a regular basis to better explain procedures, deal with special situations, or reflect our deeper understanding of maintenance and calibration issues; these revisions will never reduce data quality below the stated objectives for a given parameter or compromise comparability with past data for the same parameter. Maintenance and calibration procedures are summarized in Table 3.

Table 3: Maintenance, Calibration, and Quality Control of Sampling Equipment and Standards

** indicates procedures covered by Streamkeepers SOP's*

RSD in the table below refers to the relative standard deviation or RSD (also known as the coefficient of variation), which, when n = 2 (as when comparing a sample with a replicate), is defined as follows:

RSD = abs(difference/sum) x sqrt(2), where abs = absolute value and sqrt = square root

Equipment / Standard	Office prep (beginning of each quarter or as noted)	Maintenance measures (office & field)	Field prep/ checks	Quarterly post-season checks (plus mid-season as possible)	Accuracy flagging/ adjustment	Replicates for precision control	Precision flagging/ adjustment (per rep/sample difference)
Temperature logger (continuous)	2-point calibration with NIST-traceable thermometer (see Dunham et al. 2005)	Periodic station checks (see meter (see Dunham et al. 2005))	Side-by-side measurement with calibrated thermistor (see meter (see Dunham et al. 2005))	Side-by-side measurement with NIST-traceable thermometer; 2-point calibration check with NIST-traceable thermometer	"J" if >±0.2°C "REJ" if >± 0.5°C	NA because side-by-side testing done with NIST-traceable thermometer	NA
*Thermistor	2-pt. (~0° & 20°C) check vs. NIST-traceable thermometer	Keep sensor clean		Post-season 2-pt. calibration check vs. NIST-traceable thermometer	"J" if >±0.2°C "REJ" if >± 0.5°C	1 replicate per team per session (or minimum 1/10 ratio)	"J" if >±0.2°C; "REJ" if >± 0.5°C
*NIST-traceable thermometer	Annual check/ calibration performed by an ISO-compliant laboratory		Annual check will qualify post-checks of thermistors performed with this instrument		"J" if >±0.05°C or "REJ" if >±0.1°C in range including data		
*Barometer	1-point check vs. weather station	Handle with care		1-point check vs. weather station	"J" if >± 0.05 in.Hg; "REJ" if >± 0.1 in.Hg	1 replicate per team per session (or minimum 1/10 ratio)	"J" if >± 0.05 in.Hg; "REJ" if >± 0.1 in.Hg

Equip-ment / Standard	Office prep (beginning of each quarter or as noted)	Main-tenance measures (office & field)	Field prep/ checks	Quarterly post-season checks (plus mid-season as possible)	Accuracy flagging/ adjust-ment	Repli-cates for precision control	Precision flagging/ adjust-ment (per rep/sample difference)
*Dis-solved Oxygen meter	Side-by-side testing vs. replicated Winkler titrations (with membrane/ fluid replacement & electrode cleaning)	Membrane & fluid replacement & electrode cleaning at least quarterly	Check/rinse probe; in-situ saturated air calibration at stream temperature, with pressure adjustment; drift check of meter following measurement; recalibrate & resample if check fails	Post-season side-by-side testing vs. replicated Winkler titrations	Meter listed at ±0.3 mg/L & Winkler listed at ±0.2 mg/L (Hallock & Ehinger, 2003); therefore, "J" if difference >±0.5 mg/L; "REJ" if difference >±1 mg/L	1 replicate per team per session (or minimum 1/10 ratio)	"J" if >± 0.3 mg/L; "REJ" if >± 0.55 mg/L
*Conduc-tivity meter	Calibration with NIST-traceable standard	Electrode cleaning solution	Check /rinse electrodes	Post-season check against NIST-traceable standard	"J" if >±10% of standard value; "REJ" if >±15% of standard value	1 replicate per team per session (or minimum 1/10 ratio)	"J" if RSD >5%; "REJ" if RSD >10%
*pH meter	3-point calibration with NIST-traceable standards	Clean/ replace probe as needed if perfor-mance fails	2-point calibration at beginning of each day; 1-point calibration check after each sampling; recalibrate & resample if check fails	Post-season 3-point check with NIST-traceable standards	"J" if post-checks bracketing range of field values are >±0.2 pH unit; "REJ" if >±0.5 pH**	1 replicate per team per session (or minimum 1/10 ratio)	"J" if >±0.2 pH unit; "REJ" if >±0.5 pH unit
**If one or more post-check vs. a buffer is outside the acceptable range, values taken with the meter might still be acceptable. For example, if the field reading was 6.8, and the drift checks showed the meter within specs with the 7 buffer but off by 0.3 with the 4 buffer, the calibration curve would be such that the 6.8 reading would be well within the meter's accurate range. Curve calculations from drift readings can determine this issue.							

Equip-ment / Standard	**Office prep (beginning of each quarter or as noted)**	**Main-tenance measures (office & field)**	**Field prep/ checks**	**Quarterly post-season checks (plus mid-season as possible)**	**Accuracy flagging/ adjust-ment**	**Repli-cates for precision control**	**Precision flagging/ adjust-ment (per rep/sample difference)**
*Turbidity meter (ratio or non-ratio)	4-pt. calibration with NIST-traceable standards	Keep sampling well & outsides of vials dry and clean; avoid scratching vials	Poly bottle ≥ 100 mL; in-situ reading or observe holding specs. Mix sample well before reading. Zero meter and 1-pt. check with NIST-traceable standards; triplicate samples	Post-season 4-pt. check with NIST-traceable standards prior to next calibration, plus check of field standards	"J" if post-checks bracketing range of field values show difference > both 0.5 and 5% of standard value; "REJ" if difference > both 1.0 and 10% of standard value	1 replicate set (of 3) per team per session (or minimum 1/10 ratio)	"J" if difference > 1 NTU (the field MDL) and > 5% RSD; "REJ" if difference > 1 NTU (the field MDL) and >10% RSD
*Field standards (if used for field calibration)	Tested with freshly-calibrated instruments	Keep well-sealed and within tem-perature specifi-cations	Used to check and/or calibrate instruments in the field	Re-check vs. office standards or freshly-calibrated instruments	At end of sampling period, instruments are re-calibrated with field standards and then tested with office standards; apply control criteria applicable to that instrument		
*Pocket thermo-meter (for air temp)	2-pt. (~0° & 20°C) calibration vs. NIST-traceable ther-mometer		Make sure thermometer is dry; 2^{nd} reader encouraged	Post-season 2-pt. check vs. NIST-traceable thermometer	"J" if >±1°C; "REJ" if >±2°C	NA	NA
Imhoff Cone (settleable solids)		Keep clean	Proper collection technique		NA	Replicates not normally taken	NA
*Nitrate-Nitrogen test strips	Check pull dates	Keep strips dry	Record pull dates	As possible, side-by-side sampling with laboratory nitrate samples	NA	1 replicate per team per session (or minimum 1/10 ratio)	"J" if > 1 increment unit; "REJ" if > 2 units

Equip-ment / Standard	**Office prep (beginning of each quarter or as noted)**	**Main-tenance measures (office & field)**	**Field prep/ checks**	**Quarterly post-season checks (plus mid-season as possible)**	**Accuracy flagging/ adjust-ment**	**Repli-cates for precision control**	**Precision flagging/ adjust-ment (per rep/sample difference)**
*Nitrate-Nitrogen (lab)	In-lab calibration per CCEHL 2006		Proper collection technique	Pre- and post-sample blanks; post-sampling meter check	Adjust data per blanks; "J" if post-check >±20% of standard value; "REJ" if post-check >±30% of standard value	Field and lab replicates for 1/10 of samples	"J" if RSD >± 20%; "REJ" if RSD >30%
*Fecal Coliform (lab); (also may test for total coliform/E. coli and entero-coccus)	Verification of colonies once a month; annual proficiency testing with state; see CCEHL 2006	Checks of medium, filters, funnels, thermo-meter, rinse & dilution water;	Sterilized bottles, 4 oz. (125 mL) minimum; observe holding specs	Pre- and post-sample blanks; control blanks for 1/10 of samples	Adjust/flag data as needed per blank results	Field and lab replicates for 1/10 of samples	"REJ" if >± 10 or Base 10 log-transformed values >± 0.6 (RSD > 85%)
Coliscan Easygel (total coli-form & E. coli)		Preserve broth per mfr. instructions	Observe holding times; take post-sample blanks	Replicates of 1/10 of samples for lab fecal coliform counts	NA; flag at staff discretion	Field and lab replicates for 1/10 of samples	"REJ" if RSD > 85%
*Flow meter	Retesting of rotor/ prop units 2x/year	Replace rotor/prop units when <90% of new performance	Spin, count, and blow tests of rotor/prop units; spares provided	Comparison with stream gage data	NA	Occasional side-by-side sampling	NA
Flow—stage gage	Stage/ discharge curve, least-squares method (Bovee and Milhous, 1978)	Choose a stable channel segment; field-reference the gage; check plumb	Minimum of 3 wade-across measure-ments to establish the curve	Recheck stage/ discharge relationship	"J" if calculated value <0.4 times the min. or >2.5 times the max. discharge measured	NA	NA

Responsibilities for Collecting and Shipping Samples, and Additional Chain-Of-Custody Procedures: Besides the chain-of-custody procedures described in the Streamkeepers Volunteer Handbook, the Streamkeepers office maintains chain-of-custody records for benthic macroinvertebrate samples, which include the year, site, and # of containers of the sample, and initials and date for receipt in Streamkeepers' office, submission to and return from ID & QC labs, and placement in long-term storage. Streamkeepers and the primary and secondary (quality-control) taxonomy laboratories together arrange for the delivery and return of these samples.

Laboratories Used: Accredited laboratories will be used for all laboratory analyses of water and sediment samples, when data is reported to Ecology. For fecal coliform and nitrate analysis, the primary laboratory to be used is the Clallam County Environmental Laboratory. If that laboratory is unable to perform needed functions for any reason, another accredited laboratory will be used. For benthic macroinvertebrate analysis, no official accreditation is listed by Ecology; Streamkeepers will contract with benthic macroinvertebrate taxonomy laboratories generally recognized as competent by the community of such laboratories, and will assure quality by additional quality control checks as described later in this document.

Field Samplers: Streamkeepers data will be collected by Streamkeepers volunteers or staff, or by other competent natural-resource professionals who are familiar with our monitoring protocols. Training requirements for volunteers are described later in this document.

Quality Control

Streamkeepers' In-House Quality Control Designations:
In general, Streamkeepers QC officers apply one of the following QC designations to all data:

- **Acceptable:** Monitoring procedures have been followed and documented, and all QC screens have passed; the data is acceptable for all purposes for which that parameter's Data Quality Objectives (see Table 2 above) are appropriate. For procedures marked by "†" in that table, data are acceptable for regulatory purposes under Ecology's "credible data" standards (WA Dept. of Ecology, 2006).
- **Questionable:** Monitoring procedures have not all been followed and/or documented, or one or more QC screens have not passed; but program managers believe the data to be reasonably trustworthy for non-regulatory purposes.
- **Unacceptable:** Monitoring procedures have not all been followed and/or documented, or one or more QC screens have not passed; and program managers believe the data to be untrustworthy for any purposes.

After a monitoring event, QC officers review data sheets and communicate with the monitoring team to ascertain if there have been deviations from standard operating procedures; on this basis, managers apply QC downgrades as appropriate. Further QC screens and corrective actions are described below.

Use of Ecology's EIM Database Quality Control Qualifiers:
For data to be submitted for the State Water Quality Report, a qualifier field will be attached which is identical to the "Result Qualifier" field in Ecology's EIM database, and which will govern Ecology's interpretation of the data. In general, Streamkeepers' "Unacceptable" corresponds to Ecology's "REJ" (reject), and Streamkeepers' "Questionable" corresponds to Ecology's "J" (estimate).

Controls for Accuracy and Precision:

Bracketing Qualifiers Based on QC Controls: For each QC control performed, qualifiers indicated by a QC test will be applied to all data governed by that test. Such qualifications will occur at a variety of levels, from an individual result up to an entire multiple-visit sampling episode. In general, a drift-check of an instrument will apply to all data taken with the instrument since its last substantive maintenance or replacement (e.g., change of a membrane or probe solution), calibration, or equivalent drift check. For example, pH meters are subject to periodic in-field drift checks with field standards as well as periodic drift checks with office standards; in each case, any qualification resulting from these checks would apply to all data taken since the last equivalent check.

Post-Period Drift Check Is Sufficient: Instrument drift away from accuracy is presumed to progress in a single direction, either above or below the accuracy target. Therefore, in a case where an instrument was checked for accuracy only subsequent to a sampling episode, if the instrument passes its QC post-check, it is presumed that the instrument performed to specifications prior to that check (Katznelson, 2011), so long as no substantive maintenance or replacement of instrument parts was performed in between. This situation is to be avoided, because samplers run the risk of downgrading an entire set of data due to not having checked instrument accuracy at the outset.

Water Quality Parameters—Accuracy: Accuracy and bias of water quality measurements (parameters labeled "Water Quality" in Table 2 above) is estimated by performance evaluation measurements of the equipment, both in the field and at the office; see Table 3 above and the discussion below for details.

Office Calibration, Validation, and Drift Checks: Instruments are given a complete calibration or validation (depending on whether they can be calibrated) at the office prior to the sampling period, and then drift-checked at the end, using NIST-traceable non-expired "office" standards, certified equipment, and Standard Methods (APHA, 1998); see Table 3. These office checks are the ultimate check of instrument performance.

Field Calibration, Validation, and Drift Checks: In the field, samplers calibrate, zero, and test instruments as appropriate prior to sampling with NIST-traceable non-expired "field" standards (see Table 3). Field calibrations minimize instrument drift, and where field calibration is not practical, field calibration tests provide an interim check on instrument performance, to alert samplers to possible problems requiring recalibration or replacement. After sampling, where possible, instruments are checked for drift per Table 3. If drift exceeds the target control values listed in Table 3, the instrument should be recalibrated or replaced, or the data will be downgraded per Table 3.

Checks of Field Standards: Field standards are checked for drift against the office standards at the end of their sampling periods.

Detailed Equipment Calibration, Validation, and Maintenance Procedures are described on Streamkeepers' website at http://www.clallam.net/streamkeepers/html/quality_assurance.htm and are hereby incorporated by reference into this document.

Water Quality Parameters—Precision: Precision of water quality measurements (parameters labeled "Water Quality" in Table 2 above) is estimated by analysis of replicate samples taken in the field at one site (randomly selected) per team per sampling season, or at least one replicate per ten samples. Details on field replicate-sampling procedures are described in the "Water Chemistry—General Guidelines" section of the Streamkeepers Volunteer Handbook (Chadd, 2011). The variation between these sample and replicate values is a measure of variability due to short-term environmental factors, instrument operation, and sampling procedure. See Table 3 above for acceptance criteria and control limits based on comparing replicates with their paired samples.

QC qualifiers are then applied to all samples in the grouping covered by that replicate/sample pair—for example, the entire group of samples taken by that team during that season, or the group of ten samples from which the replicate was taken. These qualifiers are only applied if they downgrade already-applied QC qualifiers; for example, if program managers have already applied a "REJ" qualifier to a result, a downgrade value of "J" based on replicate/sample comparison will not change the "REJ" designation for that result.

Grab-samples for laboratory analysis: Field and lab replicates are taken with approximately 10% of samples. Details on field replicate-sampling procedures are described in the "Grab Sampling for Lab Analysis" section of the Streamkeepers Volunteer Handbook (Chadd, 2011). Rather than randomly choosing samples for field and laboratory duplicates, we have been choosing samples likely to have high counts, on the notion that replicated samples with no counts provide little information (Lombard, 2007). Samples are analyzed at a laboratory accredited by Ecology. If data is qualified by the laboratory or adjusted due to blanks, replicates, spikes, or blind standards, these adjustments are documented along with the data and flagged appropriately per Ecology's Environmental Information Management (EIM) database Results Qualifiers. The following acceptance criteria and control limits are based on comparing field and laboratory replicates with their paired samples:

Table 4: Analytical Laboratory Quality Control Measures for Bacterial Samples

Control measure used: variance between sample and field or lab replicate
If absolute difference ≤ 10 or difference between base-10 logs ≤ 0.6 (Relative Standard Deviation ≤ 85%): No qualifier
Otherwise, qualify per the following, using best professional judgment of program manager and laboratory analyst: --Flag that sample as "REJ" (unacceptable); --If other rep/sample pairs from that day's analysis were within tolerance, do not flag the other data, unless there is reason to question the entire batch; --If no other rep/sample pairs in that batch, use best professional judgment of laboratory and monitoring program managers to decide whether to flag other data. --If other rep/sample pairs from that day's analysis exceeded tolerance, consider flagging all the data from that day, or possibly from the team(s) which collected those samples.

As a further QC follow-up, program managers will periodically study variances between field reps and samples, and between lab reps and samples, to assess the sensitivity and bias of the data (not including data that has been flagged "REJ").

Benthic macroinvertebrate samples: Field quality-control measures include checking the sampling net before and after each use to check for tears or organisms left in the net, as well as timing the digging, per the "Benthic Macroinvertebrate Sampling" protocol in the Streamkeepers handbook (Chadd, 2011). Three replicate samples are taken at each site, per the B-IBI for the Puget Sound Lowlands (Karr and Chu 1998; Fore 1999). Laboratory quality-control measures are as follows: 10% of the macroinvertebrate replicates from a given year's sampling are given to an independent taxonomist certified by the North American Benthological Society, who rechecks those replicates for both sorting efficiency and ID accuracy. If the QC taxonomist finds sampling, sorting, or taxonomic identification problems, the data are modified, qualified, re-identified, or discarded, depending on the degree of the problem, following discussion between the taxonomy laboratories and Streamkeepers program managers. A taxon found to have been systematically mis-identified will be reclassified for that year's sample batch will be reclassified. In case of dispute, specimens may be sent to additional taxonomists for resolution. If uncertainties in sample interpretation persist, resolution will be sought from a professional bio-statistician. (This role has been filled by Leska Fore, a statistical consultant who helped develop the B-IBI—see Fore, Karr, and Wisseman, 1996.) To facilitate consensus identification of taxa, Streamkeepers maintains a synoptic reference collection of best-quality specimens of all taxa found, labeled and confirmed by at least one additional taxonomist. Taxonomists performing ID are instructed to add to this collection when they find new taxa. Furthermore, Streamkeepers maintains a number of more specific documents concerning classification of local fauna, taxonomic procedures, sorting, and subsampling, all of which are incorporated by reference into this document (http://www.clallam.net/streamkeepers/html/quality_assurance.htm); taxonomists are expected to use these documents as guides, revising them in consultation with other professionals as needed. To the extent possible, we engage services of laboratories with knowledge of the local macroinvertebrate fauna. The following control limits apply to the taxonomic laboratory work:

Table 5: Taxonomic Laboratory Quality Control Measures for Benthic Macroinvertebrate Samples

QC activity	QC target	QC actions
Sorting efficiency and ID accuracy	Sorting and ID errors do not result in a change in the target index score greater than the index's sensitivity (±4 for the B-IBI)	Systematic mis-ID's will be systematically corrected; if target not met for 1 replicate (or <10% of all QC'd replicates), flag data by individual sample; if target not met for >1 or >10% of all replicates, determine whether problem was systematic or specific, and qualify data accordingly. In an extreme case, all data taken in that year will be flagged or samples re-identified.
Synoptic reference collection	Vouchered collection of all taxa identified, confirmed by two taxonomists	If the first two taxonomists disagree on ID, the taxon is sent to additional taxonomists as needed.

Training: Streamkeepers offers annual training to volunteers, based on the procedures in the Volunteer Handbook (Chadd, 2011). Volunteers see the procedures demonstrated and have the opportunity to practice them, under supervision of staff or experienced volunteers. Attendance at all training events is recorded in Streamkeepers' database. New volunteers are then assigned to teams with experienced volunteers guiding them through procedures. Usually several outings are required before new volunteers feel comfortable performing procedures on their own. Only volunteers trained in a given procedure will be allowed to attach their initials to data gathered under that procedure. The Streamkeepers database connects all data with a sampler, whose training history is recorded in a separate table in that database.

Side-by-Side Sampling—External: As possible, Streamkeepers volunteers or staff participate in Ecology's Side-by-Side Sampling program (http://www.ecy.wa.gov/programs/eap/fw_riv/SxSIndex.html), whereby water-quality monitors test water bodies at the same time Ecology tests them as part of their monthly Ambient Monitoring Program. This program affords both parties the opportunity for additional validation of their data. To date, agreement between our data and Ecology's has been quite good (Hallock, 2011).

Side-by-Side Sampling—Internal: On occasion, Streamkeepers staff or experienced volunteers perform split sampling alongside a Streamkeepers volunteer team. Results are compared and actions taken as appropriate, such as qualifiers on past data for that individual or team; additional training for that individual, team, or the entire volunteer corps; or additions/revisions to field procedures. Targets are as follows:

Table 6: Quality Control Measures for Split Sampling in the Field

Type of parameter	Target	QC actions if target not met
In-situ water quality	Same as precision targets (see Table 2)	Data qualifiers, additional training, revised instructions as appropriate
Flow and physical habitat	RSD $\leq$ 10%, or best professional judgment of program managers if results can't be compared statistically	Data qualifiers, additional training, revised instructions as appropriate

Other General QC Measures:

- Clear, user-friendly, and detailed instructions for all procedures, minimizing judgment calls
- Equipment checked for damage prior to sampling
- Multiple observers when possible
- Each sampling team has an experienced leader
- Photo documentation of physical-habitat data
- Questionable noxious weed samples brought in for professional ID
- Staff review of data, including comparing values year-to-year
- Values compared to external data from other agencies, such as stream gage data

Data Management Procedures

Recording Field Data: Streamkeepers field data are collected on custom-designed data sheets, templates of which are included in our Volunteer Handbook (Chadd, 2011). Field samplers record and initial data on these sheets. When all data have been collected at a site, the team leader looks over the sheets for completeness, legibility, and obvious errors, and gets further information from team members as appropriate. Any problems with data collection are noted in a "Comments" section of the data sheet. The team leader initials and dates this review, then initials and dates again when turning the sheets in to the office. Then staff initials and dates receipt and QC review of the data. This latter review is a thorough process that includes troubleshooting for decimal and rounding errors, data entered into the wrong field, incomplete data, etc.

At some point in the future, Streamkeepers may implement a system whereby some or all of the data is entered directly into hand-held Personal Digital Assistant (PDA) units. These units would offer the advantage of being able to screen for completeness, questionable data, and data that differ significantly from past data. If we implement such a system, we will seek advice from Ecology as to whether to generate a paper trail.

Requirements for Laboratory Data Packages: The microbiology and chemical laboratories will, at minimum, write sample results on Streamkeepers' data sheets, including field and laboratory replicates, and "OK," initial, and date each data sheet at the bottom to indicate that all QA/QC procedures were followed, met, and documented. These laboratories will not be required to submit internal QA/QC documentation, such as blanks, spikes, and blind standards, used to determine the adequacy of the analytical procedures, providing their procedures met all internal laboratory QA/QC requirements; but they will be required to keep all such internal records for a minimum of five years.

Benthic macroinvertebrate laboratories are required to maintain and document custody of samples, to store separate taxa in separate vials, and to provide data in conformance with the needs of the Clallam County Water Resources database. For details concerning benthic macroinvertebrate laboratory procedures, see http://www.clallam.net/streamkeepers/html/quality_assurance.htm.

Transferring Data to Electronic Form: Once data sheets have been received and reviewed at the office, volunteers enter the data into the Clallam County Water Resources (CCWR) database (Microsoft Access software). Detailed procedures are provided to the volunteers, both in written form and in one-on-one training, and staff members are available to volunteers as they perform data entry. Volunteers subsequently check the database entries against the field sheets, and then later perform an additional troubleshooting double-check.

Automated Data Checks: Our intention is to program the CCWR database to automatically perform the statistical checks described in the "Quality Control" section above, and in some cases to downgrade data automatically as appropriate (leaving a record of the downgrade). In other cases the database will display a message instructing program managers to examine data and apply downgrades as appropriate. These automated routines will ensure compliance with QC procedures. Until this automation takes place, data downgrades are done manually by QC officers.

Photo Storage: Site photographs are part of the Streamkeepers sampling plan. Photos are taken in or transferred to electronic form, labeled and described per notes taken in the field (see Streamkeepers Volunteer Handbook), stored on a computer hard drive, and linked to the appropriate site-visit record in the CCWR database.

Final Sign-Off of Data: Once all of the above checks have been performed, Streamkeepers program managers do a final review of data, including examination of outliers, and sign off that the data are ready for publication.

Data Sets from Agencies of Clallam County Government Other than Streamkeepers: The CCWR database is designed to incorporate data sets from across Clallam County. As such, other agencies of Clallam County government, such as the Health Department, also generate data sets stored in CCWR. These other agencies within Clallam County follow their own QC procedures, detailed in separate documentation and described as metadata within CCWR.

Data Sets from Historical Projects and Non-Clallam County Sources: The CCWR database also contains data from older monitoring projects undertaken by Clallam County, and from projects undertaken by other entities besides Clallam County. Our policy has been to accept datasets which were gathered under a QAPP or equivalent document, or else gathered by professionals working within their fields of expertise. In each case, metadata documentation is provided for these projects, so data end-users can decide whether a given dataset is appropriate for their use.

Management and Storage of Database: The CCWR database is managed by the Streamkeepers of Clallam County program, in the Department of Public Works-Roads. It is stored on Clallam County's network drive, which is backed up daily. The database itself is actually two files: CCWR_data consists exclusively of data tables, while CCWR_user comprises data-entry forms, database queries, reports, lookup tables, metadata, and other database objects. This structure provides stable storage for the data.

Retrieval of Data: Data can be retrieved from the CCWR database in a variety of ways. A number of custom-made reports and queries have been designed, which report out virtually all the environmental data in the database. Data can also be retrieved via user queries. A variety of CCWR data is also available on the Streamkeepers website: http://www.clallam.net/SK/studies.html.

Audits and Reports

Performance Audits and Reports: Streamkeepers program managers are responsible for overseeing implementation of this QAPP. Qualitative audits of conformance occur on a continual basis and at a variety of levels:

- Team members check one another's work as they follow procedures in the Volunteer Handbook.
- Experienced field team leaders oversee the work of their teams and review data sheets.
- Program managers review data sheets prior to data entry and communicate with teams about any omissions or problems they find.
- Oversight is particularly stringent in the case of new volunteers.
- Multiple checks, both human and automated, occur as data is transferred from field sheets to electronic form. At least two people are involved in the data-entry and verification process to avoid errors from fatigue or oversight, and a last check is performed after data has been entered and checked.
- Procedures described above in "Quality Control" are performed.
- Program managers review datasets to troubleshoot outliers.

In all cases, as problems are found, they are corrected or flagged, and discussed with the relevant personnel. These findings are recorded in a "Comments" field connected to the data in the CCWR database. Streamkeepers program managers do not write formal performance reports, but with a small staff (currently one), they are intimately involved in both day-to-day operation of the program and implementation of QC procedures, and accordingly are continually making improvements to the overall operation of the program. Improvements to procedures are written into revisions of the documents that govern the program. For example, the Streamkepers Volunteer Handbook (Chadd, 2011) has been revised annually from 1999 to date.

As a program that submits data to the State Water Quality Report, Streamkeepers is subject to periodic formal audits, as described in Ecology's "credible data" document (WA Dept. of Ecology, 2006).

Data Reports: As an ongoing ambient monitoring program, Streamkeepers program managers issue periodic reports in a variety of forms; there is no final report per se. However, special projects performed by Streamkeepers for outside clients may require formal data and performance reports, and these reports will be described in documents governing those projects.

Data Report Peer Review: Streamkeepers' data reports are shared with Streamkeepers' Technical Advisory Committee, outside agencies, and the volunteer corps, many of whom have extensive scientific and technical backgrounds. This audience provides considerable peer review.

Data Verification and Validation

As described above in “Audits and Reports,” Streamkeepers data undergoes verification and validation at a number of stages and levels. Performance of these measures is overseen by Streamkeepers program managers. Program managers verify that QC results have been evaluated and data qualifiers have been applied as necessary; where possible, these routines are programmed into the CCWR database. When program managers do final sign-off of data in the database, they verify that Data Quality Objectives have been met, and that data not meeting those objectives have received a qualifying flag.

Data Quality (Usability) Assessment

Because the Streamkeepers ambient-monitoring program is an ongoing program rather than a discrete data-gathering project, there is no single set of requirements for representativeness, completeness, and comparability. Those issues depend on the particular use to which the data will be put, and data quality assessment must occur on a case-by-case basis. For example, program managers verify the usability of the data when they certify the data sent to Ecology for the State Water Quality Report; and Clallam County's *State of the Waters* report (Clallam County, 2004) contains extensive evaluation of the quality of the data used for that report, including an appendix devoted to "Uncertainty Analysis for Health Ratings."

In general, Streamkeepers' data-quality requirements are determined by the Objectives listed in the "Project Description" section above. In a broad sense, therefore, usability of data will be determined as follows:

Table 7: Data-Quality Requirements for Streamkeepers' Ambient-Monitoring Program Objectives

Objective	Data-Quality Requirements
Define and document baseline physical, chemical and biological conditions of local streams	Determination of whether adequate baseline has been established (e.g., Clallam County, 2004)
Measure spatial and temporal variability of stream attributes	Adequacy of data for statistical analysis of seasonal and geographical differences
Look for signs of degraded stream condition in a geographically broad manner	Adequacy of data to generalize to broader geographic areas
Assess trends in watershed degradation or restoration	Adequacy of data to show statistical proof of trends
Analyze data to understand the relationship between land use and watershed condition	Adequacy of both stream and land-use data
Provide information to assist in watershed planning, management, restoration and adaptive management	Usability of data for planning and management purposes

These determinations will be carried out by those who are analyzing the data, which could be Streamkeepers' staff, Technical Advisory Committee, volunteers, Clallam County, or outside clients. To the extent that the data are found inadequate for one or more of the above objectives, Streamkeepers' sampling plan may be modified over time to correct those deficiencies.

The Streamkeepers program was created with the assumption that most data analysis would be carried out by natural-resources professionals from other agencies; however, to the extent possible, Streamkeepers has performed various analyses of data, assisted by its Research Team, a group of Streamkeeper volunteers with advanced scientific degrees.

Special monitoring projects undertaken by Streamkeepers may have more discrete objectives, and those projects may specify data quality goals and reporting requirements, at the discretion of the project sponsor. When necessary, those projects will submit their own QAPPs, or Streamkeepers may submit addenda to this QAPP.

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