Quality Assurance Project Plan

Sequim-Dungeness Watershed Water Pollutant Concentration Pilot Sampling Project

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All data gathered under this project will be available by January 2010 from these websites:
• Clallam County: http://www.clallam.net/streamkeepers/html/reports.asp, “Stormwater Monitoring” link
• WA Dept. of Ecology: http://www.ecy.wa.gov/eim/
• U.S. Environmental Protection Agency: http://www.epa.gov/storet/dw_home.html

The overall project area is depicted in Figure 1 in the text. Specific sites and watercourses intended for sampling are listed in Table 2 in the text. 303(d) and TMDL water bodies in the overall project area are listed in Table A-1 in Appendix A.

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Water Pollutant Concentration
Pilot Sampling Project

November 2008

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EPA – U.S. Environmental Protection Agency
EAP – WA Dept. of Ecology Environmental Assessment Program
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Abstract

This Quality Assurance Project Plan (QAPP) describes the objectives and procedures of a one-year pilot study of stormwater-related pollutants in surface waters of the Sequim-Dungeness watershed on the Olympic Peninsula of Washington State (the project area—see Figure 1 below).

This plan is part of a larger project to develop a comprehensive stormwater management plan for Clallam County; we focus here on the Sequim-Dungeness watershed because it is undergoing the most rapid development in the county and is undergoing cleanup plans under both state shellfish-protection law and the federal Clean Water Act. These cleanup plans have recognized the significance of stormwater in local pollution problems, and the federal Environmental Protection Agency (EPA) has provided a three-year grant to Clallam County to help develop a stormwater-management plan, initially focusing on the project area.

This first-year pilot study is designed to provide a preliminary assessment of storm-related surface-water pollutants in the project area. (Other information-gathering activities expected in the first year will focus on hydrologic disturbances, groundwater pollutants, and possibly stream-sediment pollutants.) A second goal is to aid in the design of a more formal monitoring plan to be implemented during the subsequent two years of the EPA grant. This subsequent plan will aid in the stormwater management plan’s long-term adaptive management.

Roughly $10,000 worth of laboratory work is being donated for this pilot study by the Washington State Department of Ecology, and we will primarily limit laboratory analysis to this amount. To prioritize, an advisory committee has chosen sites reflecting a broad range of land uses and stormwater conveyances, as well as being representative of other parts of the project area. Seasonal and within-storm timing are chosen to reflect critical points in pollutant runoff as well as indicate baseline conditions.

After completion of the study, a final report describing results will be posted to the Internet.

Background/Problem Statement

This project accompanies the development of a comprehensive stormwater management plan for Clallam County. Much of the funding for development of this plan comes from a three-year EPA Targeted Watershed Grant (# WA-96074701-0) under the West Coast Estuary Initiative. This grant focuses on the eastern portion of Clallam County in the Sequim/Dungeness Valley area (see Figure 1), where rapid development and accompanying disturbances to natural systems have caused a variety of water-quality problems. Clallam County’s only TMDL (Total Maximum Daily Load) mandated cleanup plan under the federal Clean Water Act is located in this part of the County, on Dungeness Bay and the lower Dungeness River.

The project area is roughly the planning area addressed by the WRIA 18 East watershed-planning group, otherwise known as the Dungeness River Management Team, officially designated under the state Watershed Planning Act, RCW 90.82. The area has also been designated as the Clallam County Clean Water District, a shellfish protection district required
Figure 1: Study area map.
under RCW 90.72 due to high bacterial counts in shellfishing waters. And roughly the same area has been designated under RCW 70.118A as a Marine Recovery Area where on-site septic systems contribute to marine water quality problems.

The Jamestown S’Klallam Tribe, a federally-recognized Tribe whose Usual and Accustomed hunting and gathering area includes the project area, is a partner with Clallam County on this project. The long-term goal of the County and Tribe is to improve water quality through stormwater management. The project will develop a Comprehensive Stormwater Management Plan; adopt Clearing and Grading and Stormwater Ordinances; assess stormwater impacts by monitoring of chemical, nutrient, and bacterial pollutants; update “Geographic Information System” (GIS) database layers; and provide peer and public outreach. Expected outcomes include properly managed stormwater, minimized increases in effective impervious surfaces in a rapidly urbanizing watershed, and improved water quality. The project partners anticipate an innovative bottom-up regulatory development approach similar to the 2006/2007 Stakeholder Workgroup that implemented state-mandated septic inspections in Clallam County. We will adapt this method to stormwater management, focusing where most County growth is predicted. Stormwater management is one of eight key objectives in the Puget Sound Partnership’s 2020 Action Agenda, and dovetails with local plans to reduce bacteria and nutrient loading to surface water, upgrade septic systems, protect groundwater, and restore threatened salmon stocks.

To leverage available resources with volunteer effort, we are organizing this project under the auspices of Clallam County’s Streamkeepers program, which has a ten-year record of organizing volunteers to gather and manage environmental data (see http://www.clallam.net/streamkeepers). It is hoped that the planning, coordination, field work, and data management for this project will be accomplished with significant volunteer support.

In order to better plan this project, we have formed a Stormwater Monitoring Advisory Committee consisting of all the non-federal staff in Table 3 below, plus representatives from the Jamestown S’Klallam Tribe, the Clallam County Environmental Health division, the Cities of Sequim and Port Angeles, the Clallam Conservation District, the Puget Sound Partnership, the North Olympic Peninsula Lead Entity salmon-recovery group, irrigators in the Sequim-Dungeness Valley, the largest private sewage-treatment plant operator in the project area, and the Streamkeepers Volunteer and Technical Advisory Committees. This group has consulted in meetings, emails, and phone conferences beginning in August 2008, and the project presented here is the end-result of the Committee’s deliberations.

The overall goal of data collection and analysis in relation to this three-year project is to gather and analyze data in support of the stormwater management plan’s design and adaptive management. Objectives include:

- Gather data to help characterize stormwater problems and sources.
- Provide a baseline for comparison with future data.
- Correlate stormwater problems with land-uses and Best Management Practices (BMPs).
- Predict stormwater impacts to aquatic resources at “build-out,” with and without BMPs.
- Provide the above data to aid in stormwater management planning.
- Continue gathering data to evaluate the effectiveness of the stormwater management plan, for the purposes of adaptive management.
In the first year, the goal of data collection and analysis is a pilot program to help characterize the broad scope of stormwater problems and gather experience and knowledge to aid in the design of a more formal and long-term monitoring plan to be implemented during the subsequent two years. This more formal monitoring plan will include modeling impacts at buildout with current and proposed management, as well as an adaptive management plan that ties the monitoring to the stormwater program’s action agenda.

Some data have already been collected in the project area, but little has been directed specifically at stormwater. For example, Streamkeepers and the Jamestown S’Klallam Tribe have conducted ambient monitoring of both water-chemistry and benthic macroinvertebrates; the Clean Water District has formed a Clean Water Work Group which has investigated bacterial and nutrient pollution in the lower Dungeness area; and a Battelle Marine Sciences Laboratory study commissioned by Clallam County sampled streambed sediments for metals, hydrocarbons, and pesticides typically found in stormwater (Brandenberger et al., 2003). Our goal is to build upon and utilize these earlier data.

**Project Description**

As stated above, the first year of data-gathering is intended to set the stage for the larger project. In the first year of this grant project, this pilot monitoring plan is designed to answer a variety of questions about stormwater pollutants in the project area. We envision four potential components in the first year:

- A water-borne pollutant sampling plan.
- A study of hydrologic disturbance, which may consist of analyzing extant data, gathering new data, or both.
- A groundwater pollutant assessment, which may consist of analyzing extant data, gathering new data, or both.
- A sediment-core pollutant sampling plan similar to that conducted by Brandenberger et al., 2003. (The Advisory Committee is still discussing whether to implement this component.)

This QAPP addresses the first component; the others will be addressed in separate QAPPs or reports.

Because of the multiplicity of land uses, potential pollution sources, and stormwater conveyances in the project area, several study areas are involved, each designed to investigate particular problems. Each study area is to be considered a sub-project. Figure 1 shows the locations of these study areas/sub-projects:

- Agnew
- Lotzgesell
- East Sequim
- Meadowbrook
- Eureka
- Safeway
Each is described more fully in the “Study Areas, Sampling Sites, and Laboratory Parameters” section of this QAPP.

**Experimental Design**

The goal of this plan is to assess concentrations of water-borne pollutants in the project area during the first year of the project, in order both to pinpoint problem areas and to help design a more formal monitoring program in subsequent years. Objectives include to:

- Characterize storm-event concentrations of pollutants presumed most likely to be found in water conveyances deemed most likely to carry pollutants, whether or not these conveyances are known to deliver to receiving waters. Because of Sequim’s relatively low rainfall and high permeability, much of the stormwater in the project area infiltrates before delivering to receiving waters. However, the Committee decided that stormwater should be assessed regardless of its apparent destination, because infiltrated pollutants might cause problems for groundwater or for surface waters farther downslope.
- Make an initial assessment of some possible stormwater pollutant sources.
- Explore how pollutant concentration levels differ during the course of a storm event, between different storms, and between different sites.

A significant constraint on our experimental design is available funding. Although our EPA grant includes funding for laboratory analysis over the three-year period, the funds cannot cover all the data gaps that have been identified by our advisory committee. So we prioritized in light of the funds available.

We have secured assistance from the Washington Department of Ecology’s Environmental Assessment Program for the period 7/1/08 – 6/30/09. This assistance includes general advising, technical and field support, equipment loan, and approximately $10,000 worth of laboratory work. Because of the need to stretch laboratory funds as far as possible in the EPA grant, we have decided to largely limit our first-year pilot sampling to the funding provided by Ecology. This decision limits the numbers of sites, storm events per site, and laboratory-analyzed samples per event. In order to maximize the number of sites, we have decided to limit sampling at a given site to what we consider to be the minimum sampling needed to form an initial characterization of the site:

- Number of storm events per site: 2. Scheduling of these events will depend on the particular site, according to the following criteria:
  - We have divided sites into three types of ideal seasonal timing for sampling:
    - “First Flush” sites will carry water during smaller storms in the early part of the storm season and should be sampled as early in the season as possible.
    - “Larger, Later Storm” sites will carry water only in larger storms when the ground is already wetter, and can only be sampled under those conditions.
    - “Post-Land-Treatment” sites should be sampled after some kind of treatment is done on the land, such as plowing or chemical application.
  - These three types of site will be sampled during storm events appropriate to each type. Because this QAPP will not be approved until late November 2008, we have already missed optimal conditions for “First Flush” sampling and may
collect samples from those sites during “Larger, Later Storm” events. (This situation is unfortunate but necessitated by the one-year window for laboratory analysis subsidized by the WA Department of Ecology.) In all cases, we will keep to a minimum criterion of a preceding 48-hour dry period. (We hope to sample longer preceding dry periods, but have not yet determined the likelihood of long dry periods followed by qualifying storms, per local climate data.)

- Number of laboratory samples analyzed per site per event: 2-3, per Table 1 below. We expect to collect many more samples than will be submitted for analysis. The timing of samples, decision criteria for whether the storm qualifies for analysis, and the selection of samples to send for laboratory analysis will depend on the type of site.

Table 1. Sample collection, selection, and qualification criteria. (“Sampling rotation” refers to the target interval between sample grabs, beginning with the first sample.)

<table>
<thead>
<tr>
<th>Site/ basin hydrologic response type</th>
<th>Flow pre-storm?</th>
<th>Example</th>
<th>“Zero-time” defined as:</th>
<th>Sampling rotation interval</th>
<th>1st sample to submit to lab</th>
<th>2nd sample to submit to lab</th>
<th>3rd sample to submit to lab</th>
<th>Qualifying storm (preceded by 48 hr of no measurable rain)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast</td>
<td>Y</td>
<td>Large-system storm sewer</td>
<td>Observable flow increase</td>
<td>30' Pre-“Zero-time”</td>
<td>“Zero-time” + 30’</td>
<td>“Zero-time” + 60’</td>
<td>Enough to visibly increase flow</td>
<td></td>
</tr>
<tr>
<td>Fast</td>
<td>N</td>
<td>Parking lot</td>
<td>First runoff</td>
<td>30’ “Zero-time” + 5-30’</td>
<td>1st sample + 30’</td>
<td></td>
<td>Enough to cause runoff</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>Y</td>
<td>Stream</td>
<td>Observable bank runoff or stage rise</td>
<td>60’ Pre-“Zero-time” a.s.a.p. after “Zero-time”</td>
<td>Peak stage within 1st 12 hr</td>
<td></td>
<td>0.05” in 12 hr</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>N</td>
<td>Dry irrigation ditch</td>
<td>Flow adequate to collect samples</td>
<td>60’ “Zero-time” + 30-60’</td>
<td>Peak stage within 1st 12 hr*</td>
<td></td>
<td>0.05” in 12 hr</td>
<td></td>
</tr>
<tr>
<td>Slow</td>
<td>Y</td>
<td>Pond outflow</td>
<td>Observable flow increase</td>
<td>60’, then 4 hr. “Zero-time” + 60’</td>
<td>Peak flow (visit every 4 hr)</td>
<td></td>
<td>0.1” in 24 hr</td>
<td></td>
</tr>
<tr>
<td>Slow</td>
<td>N</td>
<td>Pond outflow in early fall</td>
<td>Observable outflow</td>
<td>60’, then 4 hr. “Zero-time” + 60’</td>
<td>Peak flow (visit every 4 hr)</td>
<td></td>
<td>0.1” in 24 hr</td>
<td></td>
</tr>
</tbody>
</table>

*Exception—solids samples: collect at/near actual storm peak if possible.
• In the same vein of making optimal use of available funding, we will be looking for peak acute-concentration levels rather than Event Mean Concentrations or loading levels, and we do not expect to achieve QA/QC levels sufficient to submit results for 303(d) consideration.

• In addition to parameters analyzed in a laboratory, we plan to collect and analyze data at (or near) our sampling sites on two parameters: turbidity and stage. Details of sampling procedures for these parameters are provided below. Both provide important information at minimal cost with volunteer help, particularly since the majority of the field work for this project is expected to be performed by volunteers for Streamkeepers of Clallam County, a volunteer program administered by the Clallam County Department of Community Development.

• Laboratory parameters to be analyzed will depend on the study area and site; see Table 2 and discussion below.

**Study Areas, Sampling Sites, and Laboratory Parameters**

Site selection is a major challenge for this project, given the scarcity of funding for sampling and the short time frame, and is based on the recommendations of the Stormwater Monitoring Advisory Committee, plus factors such as site permission, access, clustering, and the likelihood that stormwater will flow at that site in a given storm condition. Furthermore, incoming data from sites may influence the Committee to revise site selection. Therefore, the study areas and sites presented here represent our best judgment at this time, rather than a fixed set, keeping in mind that this project is conceived as a pilot stormwater-pollutant sampling plan.

Study areas, sampling locations, and laboratory parameters to be analyzed are summarized in Table 2 and depicted in Figures 2-6 below and described in more detail thereafter. Note that for the sites in Table 2, sample collection, selection, and qualification criteria will be based on their hydrologic response type and whether they have a pre-storm flow, as described in Table 1.
Table 2. Study areas, sites, and laboratory parameters for analysis. These study area and sites are tentative; see discussion above. Seasonal timing codes: FF = first flush; LLS = larger, later storms; PLT = post-land-treatment; see “Experimental Design” above.
PAH = Polynuclear aromatic hydrocarbons; Pesticides = PESTMS (Pesticides mass spectrometry) + Herbicides

<table>
<thead>
<tr>
<th>Study area</th>
<th>Sampling site abbreviation</th>
<th>Water-course name</th>
<th>Source/Receiving water</th>
<th>NHD Reach Code (if known)</th>
<th>If site is not on a stream, name (if known) of receiving water destination (if known)</th>
<th>NHD Reach Code (if known) of receiving water destination if known (if site is not on a stream)</th>
<th>Ideal seasonal timing</th>
<th>Hydrologic response time</th>
<th>Flow pre-storm?</th>
<th>Laboratory analytes:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bacteria (fecal coliform)</td>
</tr>
<tr>
<td>Agnew</td>
<td>AgFnHall</td>
<td>Agnew Ditch</td>
<td>S</td>
<td></td>
<td>Strait of Juan de Fuca</td>
<td></td>
<td>PLT medium</td>
<td></td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Lotzgesell</td>
<td>LotzWdck</td>
<td>Lotzgesell Creek</td>
<td>R</td>
<td>17110020000636</td>
<td></td>
<td></td>
<td>PLT slow</td>
<td></td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>E_Sequim</td>
<td>HldWash</td>
<td>Highland Ditch</td>
<td>S</td>
<td>17110020003288</td>
<td>Bell Creek</td>
<td>17110020002095</td>
<td>FF medium</td>
<td></td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>E_Sequim</td>
<td>BelBlake</td>
<td>Bell Creek</td>
<td>R</td>
<td>17110020002095</td>
<td></td>
<td></td>
<td>FF medium</td>
<td></td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>E_Sequim</td>
<td>HldHpyVly</td>
<td>Highland Ditch</td>
<td>S</td>
<td></td>
<td>Johnson Creek</td>
<td>17110020000354</td>
<td>LLS medium</td>
<td></td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>E_Sequim</td>
<td>SqBayRd</td>
<td>Highland Ditch</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td>FF fast</td>
<td></td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Meadowbrook</td>
<td>MdwCr</td>
<td>Meadowbrook Creek</td>
<td>R</td>
<td>17110020000832</td>
<td></td>
<td></td>
<td>LLS medium</td>
<td></td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Meadowbrook</td>
<td>MdwDtch</td>
<td>Highland Ditch</td>
<td>S</td>
<td>17110020005418</td>
<td>Meadowbrook Creek</td>
<td>17110020000832</td>
<td>LLS medium</td>
<td></td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Eureka</td>
<td>EurWash</td>
<td>Eureka Ditch</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td>LLS medium</td>
<td></td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Safeway</td>
<td>SfwyCB</td>
<td>Storm drain</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td>FF fast</td>
<td></td>
<td>N</td>
<td>Y</td>
</tr>
</tbody>
</table>

*At E_Sequim/BelBlake, the Priority Pollutant Metals suite (As, Ag, Sb, Be, Cd, Cr, Cu, Hg, Pb, Ni, Se, Tl, Zn) will also be analyzed.
Figure 2: Agnew study area.
Figure 3: Lotzgesell study area.
Figure 4: East Sequim study area.
Figure 5: Meadowbrook study area.
Figure 6: Eureka and Safeway study areas.
**Study Area: Agnew Irrigation Ditch near terminus (“Agnew”)**

This study area focuses on the terminus of the Agnew Ditch, an irrigation system that conveys Dungeness River water across a broad area to the east and south. This system carries stormwater during large storms and drains a variety of land uses, including agricultural, roads, and residential, then terminates in a large pipe which empties directly into the Strait of Juan de Fuca to the west of Dungeness Bay. This terminus was selected because the ditch superintendent noted it as a significant stormwater source, and because of the extent and variety of the land uses draining into this point during storms.

Objectives of this study include:

- Characterizing storm-event concentrations of pollutants presumed most likely to be found in the Agnew Ditch, based on upslope land uses (see above).
- Comparing pollutant concentrations in this ditch with those near the termini of other ditches.
- Comparing pollutant concentrations in this ditch with those of another site that drains a much smaller area (see Lotzgesell study area below).
- Examining how pollutant levels differ during the course of a storm event, between the beginning of stage rise and peak flow.

Site location and laboratory parameters to be analyzed (see Figure 2 above for orthophoto view):

- **AgFnHall**: This site is on the Agnew Ditch just downstream of Finn Hall Road, just before the ditch terminates in a pipe that empties into the Strait of Juan de Fuca. Contributing land uses include residential, roads, and agricultural.
  - Bacteria; Nutrients; Solids; Pesticides

**Study Area: Lotzgesell Creek downstream of Woodcock Rd. (“Lotzgesell”)**

This study area focuses on Lotzgesell Creek downstream of Woodcock Road. Lotzgesell Creek has its origin in a spring several hundred feet upstream of this point, which flows through a wetland that flows into a culvert under Woodcock Road and then continues downstream for another several hundred feet before transforming into a more defined stream channel. The wetland runs between a seed farm and a golf course, neither of which seem to deliver surface water to the wetland, judging by topography and vegetation. This area was selected because both the seed farm and golf course are believed to use agricultural chemicals, and we want to assess if these chemicals show up in the wetland when storms infiltrate the pollutants downward and soil moisture brings the water table upward.

Objectives of this study include:

- Characterizing storm-event concentrations of pollutants presumed most likely to be found in the wetland, based on upslope land uses (see above).
- Comparing pollutant concentrations and timing in this small watershed system with those of a much larger watershed system (see the Agnew study area above).
- Examining how pollutant levels differ in this wetland/pond complex during the course of a storm event, between the beginning of stage rise and peak flow.
Site location and laboratory parameters to be analyzed (see Figure 3 above for orthophoto view):

- **LotzWdck**: This site is on Lotzgesell Creek just downstream of the culvert. Contributing land uses include agricultural and a small area of road.
  - *Nutrients; Pesticides*
  - *Solids will not be sampled here because they are presumed to settle out in the wetland.*

**Study Area: East Sequim from Sequim Avenue to Happy Valley Road (“E_Sequim”)**

This study area focuses on the eastern part of Sequim, from Sequim Avenue east to roughly Happy Valley Road, most of which lies within the Sequim city limits. The Highland Irrigation Ditch system and Bell and Johnson Creeks run through this area. The Highland Irrigation District maintains an irrigation system which conveys Dungeness River water as far east as Sequim Bay in numerous laterals, in both open ditch and piped segments, which intersect Bell Creek at multiple locations. Bell Creek runs through the heart of the City of Sequim and then empties into Sequim Bay at Washington Harbor. Johnson Creek runs along the eastern edge of Sequim and empties into Sequim Bay at Pitship Point (John Wayne Marina).

This area was selected because of its complexity of land use and interactions between ditch and stream systems. In one place, Bell Creek and the Highland Ditch run near one another for nearly half a mile before meeting behind the Bell Creek Shopping Plaza, and although the ditch flows even when not carrying irrigation water, Bell Creek is often dry, so the ditch may carry water that would otherwise run in the creek. Bell Creek Plaza, near the point of their confluence, has a history of flooding during storms, and several years ago, the creek channel in the area of the confluence was enlarged to be able to carry stormwater without flooding the Plaza. Another lateral of the Highland Ditch heads east of downtown Sequim, skirting residential developments and splitting multiple times. One of these laterals skirts more residential development and then empties into Johnson Creek; another is intersected by a long ditch running alongside East Washington Street that drains a significant portion of commercial area, including a construction site for a new Holiday Inn Express/Black Bear Diner.

Objectives of this study include:

- Characterizing storm-event concentrations of pollutants presumed most likely to be found in several different laterals of the Highland Ditch, as well as Bell Creek after input from the ditch, based on upslope land uses (see above).
- Examining the relationship between storm pollutant concentrations in these interconnected water bodies.
- Examining how pollutant levels differ during the course of a storm event, between pre-stage rise, the beginning of stage rise, and peak flow.
- Comparing storm pollutant levels in Bell Creek with biological-integrity scores based on the Benthic Index of Biological Integrity (B-IBI).

Site locations and laboratory parameters to be analyzed (see Figure 4 above for orthophoto view):
• **HldWash:** This site is on the Highland Ditch north of East Washington Street between Highway 101 Outpost and Staples, just upstream of Bell Creek Plaza. Contributing land uses include residential, roads, and some forestry.
  o **Bacteria; Nutrients; Solids**

• **BclBlk:** This site is on Bell Creek downstream of where the above ditch empties into it, down-gradient of the Bell Creek Plaza shopping area which contains Staples. The site is just downstream of the culvert under Blake Avenue. Contributing land uses include residential, roads, commercial, and some forestry.
  o **Bacteria; Nutrients; Solids; Metals + Hardness; Hydrocarbons**
  o At this site, in addition to copper and zinc, we will also analyze for the Priority Pollutant Metals suite, so that we’ll have a broader profile of storm-borne metals at one site. This site was chosen because Bell Creek is a significant receiving water, and because the routing of Bell Creek Plaza runoff water is unknown at this time, due to the Plaza’s age.

• **HldHpyVly:** This site is on the Highland Ditch just downstream of Happy Valley Road, near Huffman Heights Road. This ditch lateral runs past both the Bell Hill and Huffman Heights residential developments. Contributing land uses include residential, roads, and some forestry.
  o **Bacteria; Nutrients; Solids**

• **SqBayRd:** This site is near West Sequim Bay Road, downstream of where a lateral of the Highland Ditch meets a long roadside ditch running along East Washington Street. The irrigation lateral runs alongside the recently-built Elk Creek Apartments multi-family housing development, and the roadside ditch drains part of the runoff from the Holiday Inn Express/Black Bear Diner construction site. Contributing land uses include residential, roads, commercial, construction, and some forestry.
  o **Bacteria; Nutrients; Solids; Metals + Hardness; Hydrocarbons**

**Study Area: Meadowbrook Creek / Sequim-Dungeness Way area**
("Meadowbrook")

This study area focuses on the area around Meadowbrook Creek downstream of Sequim-Dungeness way, in the lower reach of the creek. The creek runs through both residential and agricultural areas, and it is joined at multiple points by laterals of the Highland Ditch system which run deep into the Sequim-Dungeness Valley, also running through both residential and agricultural areas. This area was selected because Meadowbrook Creek has been implicated in pollution problems in Dungeness Bay, and the Jamestown S’Klallam Tribe has conducted sampling in this area.

Objectives of this study include:
• Characterizing storm-event concentrations of pollutants presumed most likely to be found in Meadowbrook Creek and the Highland Ditch, based on upslope land uses (see above).
• Examining the relationship between storm pollutant concentrations in these interconnected water bodies.
• Examining how pollutant levels differ during the course of a storm event, between pre-stage rise, the beginning of stage rise, and peak flow.
• Comparing data from this project with previous data collected in this area.
• Comparing storm pollutant levels in Meadowbrook Creek with biological-integrity scores based on the Benthic Index of Biological Integrity (B-IBI).

Site locations and laboratory parameters to be analyzed (see Figure 5 above for orthophoto view):

• **MdwCr**: This site is on Meadowbrook Creek just upstream of the input from the ditch described below. Contributing land uses include residential, roads, and agricultural.
  - **Bacteria; Nutrients; Solids**

• **MdwDtch**: This site is on a lateral of the Highland Ditch system east of Meadow Drive, just upstream of its confluence with Meadowbrook Creek. Contributing land uses include residential, roads, and agricultural.
  - **Bacteria; Nutrients; Solids**

**Study Area: Eureka Irrigation Ditch near West Washington St. (“Eureka”)**

This study area focuses on a portion of the Eureka Irrigation Ditch just upstream of the Sequim commercial zone. This ditch then runs through the commercial zone in a pipe, and it is not yet clear to us where it ultimately delivers its stormwater. This area was selected because the Clallam Conservation District believes there to be stormwater problems in the ditch originating from agricultural practices.

Objectives of this study include:

• Characterizing storm-event concentrations of pollutants presumed most likely to be found in the ditch, based on upslope land uses (see above).

• Comparing storm pollutant concentrations in this ditch with those in unrelated ditches.

• Examining how pollutant levels differ during the course of a storm event, between pre-stage rise, the beginning of stage rise, and peak flow.

Site location and laboratory parameters to be analyzed (see Figure 6 above for orthophoto view):

• **EurWash**: This site is on the Eureka Ditch system just before it goes into a pipe under the Sequim commercial zone near 7th Avenue and West Washington Street. Contributing land uses include residential, roads, and agricultural.
  - **Bacteria; Nutrients; Solids**

**Study Area: Safeway Plaza at 7th Av. and West Washington St. (“Safeway”)**

This study area focuses on the shopping plaza anchored by the Sequim Safeway store, at the northeast corner of 7th Avenue and West Washington Street. This area was selected because it is one of the largest and oldest impervious surfaces in Sequim. This plaza recently installed a new drywell as part of a new building project; prior to this drywell, stormwater from the plaza was believed to be delivered to small underground infiltration sites connected to each storm catch basin, and the street area up-gradient of the plaza was subject to flooding.

Objectives of this study include:

• Characterizing storm-event concentrations of pollutants presumed most likely to be found flowing over the impervious surfaces of this plaza.
• Comparing metal and hydrocarbon concentrations between this site and other sites primarily influenced by roads rather than commercial areas.
• Examining how pollutant levels differ during the course of a storm event, between the beginning of stage rise and peak flow.

Site locations and laboratory parameters to be analyzed (see Figure 6 above for orthophoto view):
• **SfwyCB**: This site is a catch basin within the Safeway plaza. We plan to collect the sample by lifting the manhole cover and catching the water as it flows over the lip of the hole. Contributing land uses include roofs, parking areas, and a bit of landscaping.
  o **Bacteria; Nutrients; Solids; Metals + Hardness; Hydrocarbons**
  o Because roofs and parking areas are likely to generate different types of pollutants, we are contemplating sampling bacteria and nutrients at a catch basin collecting significant roof runoff, and sampling solids, metals, and hydrocarbons at one collecting significant parking-lot runoff.
## Organization and Schedule

### Staffing

Table 3. Organization of project staff and responsibilities.

<table>
<thead>
<tr>
<th>Staff</th>
<th>Title/Function</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edward Chadd, CCDCD</td>
<td>Sampling Project Manager &amp; Principal Investigator</td>
<td>Writes the QAPP, oversees field sampling and transportation of samples to the laboratory, manages other staff and volunteers, conducts QA review of data, analyzes and interprets data, enters data into County and EPA databases, and writes the draft and final reports.</td>
</tr>
<tr>
<td>Robert Knapp, CCDCD</td>
<td>Project Assistant</td>
<td>Helps with all the above.</td>
</tr>
<tr>
<td>Carol Creasey, CCDCD</td>
<td>Stormwater Program Project Manager</td>
<td>Provides internal review of the QAPP, approves the budget, reviews the final QAPP, and oversees the Stormwater Program.</td>
</tr>
<tr>
<td>Streamkeeper volunteers</td>
<td>Field and data technicians</td>
<td>Gather samples and field data, transport samples, track rainfall and organize volunteer teams, enter and check data, perform data analysis.</td>
</tr>
<tr>
<td>Steven Golding, ECY/EAP</td>
<td>Environmental Engineer</td>
<td>Liaison with WA Dept. of Ecology and Manchester Laboratory, provides technical assistance, helps with QAPP preparation and review.</td>
</tr>
<tr>
<td>Debbie Sargeant, ECY/EAP</td>
<td>TMDL coordinator</td>
<td>Provides technical assistance and serves on advisory committee.</td>
</tr>
<tr>
<td>Hansi Hals, Jamestown</td>
<td>Environmental Planning Manager</td>
<td>Serves on advisory committee and reviews the final QAPP.</td>
</tr>
<tr>
<td>Lori DeLorm, Jamestown</td>
<td>Natural Resources Technician</td>
<td>Serves on advisory committee and assists with field sampling.</td>
</tr>
<tr>
<td>Don Matheny, EPA Region 10</td>
<td>Quality Assurance Officer</td>
<td>Approves the final QAPP.</td>
</tr>
<tr>
<td>Tony Fournier, EPA Region 10</td>
<td>Grants Specialist / West Coast Estuaries Initiative Project Officer</td>
<td>Approves the final QAPP.</td>
</tr>
</tbody>
</table>

CCDCD – Clallam County Department of Community Development  
ECY/EAP – WA Department of Ecology, Environmental Assessment Program  
EPA – Environmental Protection Agency  
QAPP – Quality Assurance Project Plan
Scheduling

Table 4. Schedule for completing field and laboratory work, data entry, and reports.

<table>
<thead>
<tr>
<th>Field and laboratory work</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Field work completed</td>
<td>June 2009</td>
</tr>
<tr>
<td>Laboratory analyses completed</td>
<td>August 2009</td>
</tr>
<tr>
<td>Data review completed</td>
<td>September 2009</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Database entry</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Entry into EPA Storet, ECY Environmental Information Management, and Clallam County Water Resources databases</td>
<td>Edward Chadd</td>
</tr>
<tr>
<td>Data uploaded to databases</td>
<td>December 2009</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Final report</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Author lead</td>
<td>Edward Chadd</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Schedule</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Draft due to advisory committee</td>
<td>November 2009</td>
</tr>
<tr>
<td>Final report due on web</td>
<td>December 2009</td>
</tr>
</tbody>
</table>

Field Team Mobilization and Management

Table 5. Sampling team mobilization and deployment criteria.
NOTE: These are general guidelines which may not always be met in actual conditions and are subject to revision as needed. Timings are to be as close as possible to guidelines, given site-rotation logistics necessary for a given team.

<table>
<thead>
<tr>
<th>DECISION</th>
<th>CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organize potential field teams 3 days ahead if:</td>
<td>&lt;50% chance of rain forecast for next 2 days and &gt;50% forecast for 3rd day.</td>
</tr>
<tr>
<td>Put teams on alert if:</td>
<td>No rain for past 1-2 days and next-day forecast of rain ≥60%.</td>
</tr>
<tr>
<td>Set start-time for “rain-scout mobilizer” duty and for teams’ “on call” status:</td>
<td>One hour earlier than earliest hour when chance of rain &gt;30% and &gt;0.05” predicted for ensuing 12-hour period.</td>
</tr>
<tr>
<td>Mobilize teams to begin sampling:</td>
<td>When any rain is seen or recorded on nearby gages.</td>
</tr>
</tbody>
</table>
| Teams rotate through their assigned sites and sample per “sampling rotation interval” in Table 1 and “hydrologic response time” + “pre-storm flow?” in Table 2, until: | • Conditions for last sample are confirmed by field team.  
• Another team takes over.  
• Mobilizer calls off sampling.  
• Team cannot continue.  
• Conditions become unsafe. |
| Samples to be sent for laboratory analysis will be chosen: | Upon termination of sampling. |
Quality Objectives

Decision Quality Objectives

This project is a screening-level study. The intent is to provide data on pollutant concentrations in a broad spectrum of typical stormwater runoff, such as creeks, ditches, stormwater catch basins, ponds, and wetlands. In many cases the data will serve as an indication of water quality for sites for which there has been no prior sampling. Data quality need not be as stringent as that for other uses such as enforcement of water quality criteria or creating Total Maximum Daily Loads (TMDLs).

Because this is a screening-level study rather than one for determinations of compliance or allocation of wastewater loads, decision quality objectives governing whether data are useable will be based on the goal of providing general information and preliminary evaluation. However, in each case, the data will be assessed for appropriateness for comparing to state water quality standards. In general, the reporting limits for the parameter results should allow for such comparisons, since low-concentration analytical procedures will be used. However, metals collection techniques being used in this study will not conform to standard low-level sampling techniques, so there may be cases in which a reported result that exceeds a state water-quality standard lacks the resolution to conclusively indicate exceedance of that standard.

To develop criteria to decide when the resolution of data is adequate to make a certain conclusion, one must understand the difference between a Method Detection Limit (MDL) and a Practical Concentration Limit (PQL). MDL is defined in 40 CFR Part 136, Appendix B as the minimum concentration of a substance that can be measured from analysis of a sample in a given matrix, and reported with 99% confidence that the analyte concentration is greater than zero. However, a result at the MDL only confirms that the analyte is present; the PQL represents the lowest level that can be reliably measured within specified limits of precision and accuracy during routine laboratory operating conditions, and the PQL rather than the MDL sets the standard for the lowest possible concentration that can be reported without an “estimate” qualifier (“J” in the parlance of Ecology’s Environmental Information Management system). As a practical rule, studies will set the PQL as a certain multiple of the MDL; the more stringent the study, the greater the multiple. Multiples usually range from 5-10. For the purposes of this study, we will use a multiple of 5; in other words, any result less than 5 times the MDL will receive a “J” qualifier, indicating that the result can be taken as an estimate only.

In cases where monitoring is to occur during storm events, acute as well as chronic criteria will be compared with pollutant concentrations. Although water quality criteria apply directly only to receiving waters, they may be compared with runoff discharge concentrations. It should be recognized that stormwater conveyances and ponds are classified as waters of the state.

Results can vary from true values by the following three sources of error: bias; precision; and accuracy. Measures to reduce them through laboratory QA appear in Table 6.
Bias can be defined as systematic error due to contamination, sample preparation, calibration, or the analytical process. Sources of bias will be minimized by adherence to established protocols for collection, preservation, transportation, storage, and analysis of QA samples.

Precision is a measure of the ability to consistently reproduce results. Precision will be evaluated by analysis of duplicates/replicates, matrix spikes, and blanks. Field replicates will be analyzed to estimate overall precision of the entire sampling and analysis process. Analysis of laboratory duplicates, which consist of aliquots from one sample container, will estimate laboratory precision. The difference between the precision of the laboratory duplicates and the field replicates is an estimate of field precision.

Accuracy is the closeness of analytical results to true values of a parameter. To the extent that bias is low and precision is high, results will be accurate. Accuracy will be evaluated by analysis of laboratory control standards/samples.

Table 6 shows the number and kind of laboratory QA samples for the project. These laboratory analyses form the basis for quality assessment of project data.

Table 6. Number and Kind of Samples for Laboratory QA.

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Laboratory Control Sample</th>
<th>Standard Reference Material</th>
<th>Method Blank</th>
<th>Analytical Duplicate</th>
<th>Matrix Spikes &amp; Spike Duplicates</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR* PP metals</td>
<td>1/batch</td>
<td>1/batch</td>
<td>1/batch</td>
<td>1/batch</td>
<td></td>
</tr>
<tr>
<td>TR and Dissolved Copper</td>
<td>1/batch</td>
<td>1/batch</td>
<td>1/batch</td>
<td>1/batch</td>
<td>1/set</td>
</tr>
<tr>
<td>TOC</td>
<td>1/batch</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Bacteria</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Hardness</td>
<td>1/batch</td>
<td>1/batch</td>
<td>1/batch</td>
<td>1/batch</td>
<td></td>
</tr>
<tr>
<td>Nutrients</td>
<td></td>
<td>1/batch</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspended Sediment Concentration</td>
<td>1/batch</td>
<td>1/batch</td>
<td>1/batch</td>
<td>1/batch</td>
<td>N/A</td>
</tr>
<tr>
<td>Pesticides</td>
<td>1/batch</td>
<td>1/batch</td>
<td>1/batch</td>
<td>1/batch</td>
<td>1/batch</td>
</tr>
<tr>
<td>PAH (std)</td>
<td>1/batch</td>
<td>1/batch</td>
<td>1/batch</td>
<td>1/batch</td>
<td>1/set</td>
</tr>
</tbody>
</table>

*Total Recoverable

Analytical Methods

Most project samples will be analyzed at the WA Department of Ecology’s Manchester Laboratory, with the following exceptions:

- Due to holding time requirements, some SSC, NO$_2$–NO$_3$, and fecal coliform samples may be sent to other state-accredited laboratories.
- Turbidity samples will be analyzed with field-quality instruments (see below), either in situ or near the project area, following the sample handling and holding time requirements described herein.
Table 7 shows field preparation procedures, expected ranges of results, and analytical methods for this project. Zinc and Copper will be analyzed by ICP or ICP/MS. At one site (see Table 2), we will also sample for the Priority Pollutant (PP) metals suite (see Table 7 below). This will provide us a broader view of stormwater metals at one site as well as provide a basis to compare dissolved with total metals, since Zinc and Copper single-analyte samples will be analyzed for dissolved metals only, whereas the PP metals will be analyzed for total recoverable metals. The laboratory may use other appropriate methods following consultation with the project lead.

Table 7. Field Preparation, Expected Range of Results and Laboratory Methods.

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Field Prep</th>
<th>Analysis</th>
<th>Expect Range of Results</th>
<th>Sample Prep Method</th>
<th>Analytical Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metals (Zn and Cu dissolved), as well as PP metals</td>
<td>Filtered water; Whole water</td>
<td>Dissolved; TR*</td>
<td>0.1 – 500 µg/L</td>
<td>HNO3/HCL digest</td>
<td>SW-846 Method 6010 &amp; 6020 (except Hg: EPA Method 245.1 or 245.7)</td>
</tr>
<tr>
<td>Bacteria</td>
<td>Collect in sterile container</td>
<td>Total</td>
<td>1-700 count</td>
<td>Membrane filter</td>
<td>MP 9221 E2</td>
</tr>
<tr>
<td>Hardness</td>
<td>Whole water</td>
<td>Total</td>
<td>10 - 90 mg/L</td>
<td>---</td>
<td>SM2340</td>
</tr>
<tr>
<td>Nutrients</td>
<td>Standard Methods 4500</td>
<td>Total</td>
<td>2-60 mg/L</td>
<td>Various; see 9th ed. MEL users guide</td>
<td>Standard Method 4500</td>
</tr>
<tr>
<td>SSC</td>
<td>Whole water</td>
<td>Total</td>
<td>1-500 mg/L</td>
<td>---</td>
<td>ASTM D3977B</td>
</tr>
<tr>
<td>Pesticides</td>
<td>Whole water</td>
<td>Total</td>
<td>0.1 - 20 µg/L</td>
<td>---</td>
<td>SW-846 Method 8321A.</td>
</tr>
<tr>
<td>PAH</td>
<td>Whole Water</td>
<td>Total</td>
<td>0.01 - 10µg/L</td>
<td>---</td>
<td>SW846 Method 8270</td>
</tr>
<tr>
<td>Turbidity</td>
<td>Whole Water</td>
<td>Nephelometric</td>
<td>0 – 400 NTU</td>
<td>---</td>
<td>SM2130</td>
</tr>
</tbody>
</table>

*PP = Priority Pollutant metals suite: As, Ag, Sb, Be, Cd, Cr, Cu, Hg, Pb, Ni, Se, Tl, Zn
TR = Total Recoverable; see Table 2 for site(s) being analyzed for PP Metals as well as Zn + Cu.

Measurement Quality Objectives (MQOs) will be determined from data acceptance limits set by the WA Dept. of Ecology’s Manchester Laboratory, as well as from laboratory case narratives. Standard QC samples will be analyzed for metals, pesticides, and PAH. These will include field blanks to show background levels associated with the sampling process, and replicates to indicate field variability. Laboratory QC samples will include at least one blank, duplicate, and laboratory control sample per batch. Spike and spike duplicates will be analyzed to show interference of the sample matrix.
Sampling Procedures

All samples will be collected as individual grabs or time-proportional grab composites. Samples will be collected directly into sample containers or with a laboratory-supplied container attached to a pole with duct tape or other means. Sampling containers will be held with container openings facing upstream to prevent contamination during sampling. Field personnel will wear powder-free nitrile disposable gloves. Each sample will be given a field identification, tagged, and kept cool at 4ºC. Chain-of-custody procedures will be observed and samples delivered to the laboratory within the allowable holding times for each parameter.

It will be assumed that sampling sites will have well-mixed conditions so that single grabs are representative of water quality. Field personnel will record the degree of turbulence or quiescence as well as the width of the waterbody and/or a description of water flowing in a constructed conveyance.

Because of the unpredictable nature of rainfall and runoff extent prior to or during a storm, there may be cases in which samples collected early in a storm period will not be used because the storm and storm peak occur considerably later. In most stormwater studies for which results need to be defended, containers filled early are discarded. For this survey-level study, however, those containers can be used later in the storm after rinsing at least six times in the water to be sampled. This procedure will yield samples that have integrity but that simply do not follow more stringent protocols. For transfer blanks, however, only fresh bottles will be used.

Sampling containers for direct grabs (either by hand or with pole attached to laboratory-supplied container) will be pre-cleaned by the laboratory. It will be made certain that if a sample is transferred (either for collection purposes or to form grab-composite samples), that only laboratory-supplied containers are permitted to come in contact with the sample.

A summary of parameters, collection containers, preservation, and holding times appears in Table 8.
Table 8. Sample Size, Container, Preservation, and Holding Time by Parameter.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sample Size</th>
<th>Container</th>
<th>Preservation</th>
<th>Holding Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSC</td>
<td>1000 mL</td>
<td>1000 w/m poly</td>
<td>cool to 6ºC</td>
<td>48 hours</td>
</tr>
<tr>
<td>PP Metals</td>
<td>500 mL</td>
<td>1 L HDPE</td>
<td>HNO₃ to pH&lt;2</td>
<td>6 months, except</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28 days for Hg</td>
</tr>
<tr>
<td>Hardness</td>
<td>100 mL</td>
<td>125 mL n/m poly</td>
<td>cool to 6ºC, H₂SO₄ to pH&lt;2</td>
<td>6 months</td>
</tr>
<tr>
<td>NH₃</td>
<td>125 mL</td>
<td>125 mL clear w/m poly</td>
<td>cool to 6ºC, H₂SO₄ to pH&lt;2</td>
<td>28 days</td>
</tr>
<tr>
<td>NO₂⁻-NO₃</td>
<td>(2 bottles) 125 mL each</td>
<td>125 mL amber and clear w/m poly</td>
<td>cool to 6ºC, H₂SO₄ to pH&lt;2 in clear</td>
<td>48 hours</td>
</tr>
<tr>
<td>Total P</td>
<td>125 mL</td>
<td>125 mL clear w/m poly</td>
<td>cool to 6ºC, H₂SO₄ to pH&lt;2</td>
<td>28 days</td>
</tr>
<tr>
<td>PP Metals (TR)*</td>
<td>500 mL</td>
<td>1 L HDPE</td>
<td>HNO₃ to pH&lt;2</td>
<td>6 months, except</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28 days for Hg</td>
</tr>
<tr>
<td>PAH</td>
<td>1 gallon</td>
<td>1 gallon organics-free glass jar</td>
<td>cool to 6ºC</td>
<td>7 days</td>
</tr>
<tr>
<td>Pesticides</td>
<td>1 - 4 L</td>
<td>1L amber glass bottle</td>
<td>cool to 6ºC</td>
<td>7 days</td>
</tr>
<tr>
<td>Herbicides</td>
<td>1 L</td>
<td>1L amber glass bottle</td>
<td>keep at 6ºC</td>
<td>7 days</td>
</tr>
<tr>
<td>Fecal Coliform</td>
<td>250 mL</td>
<td>250 mL glass/propylene autoclaved</td>
<td>Fill to neck, keep at 6ºC</td>
<td>24 hours</td>
</tr>
<tr>
<td>Turbidity</td>
<td>≥ 473 mL (16 oz)</td>
<td>poly bottle ≥ 473 mL (16 oz)</td>
<td>cool to 6ºC, keep in darkness</td>
<td>48 hours</td>
</tr>
</tbody>
</table>

*Total Recoverable

Field-parameter measurement procedures

Two parameters will be measured outside a laboratory: stage and turbidity.

Stage will be assessed in the following manner:
- Where possible to measure stage, crest gages will be installed, and with each sampling visit, stage will be recorded. At the end of the storm event, crest height will be recorded.
- Where not possible to measure stage, samplers will qualitatively assess the amount of water flowing at the site. Critical points to estimate are the onset of flow or of stage rise and the peak flow. At these sites, photographs will be taken as a qualitative record of the water flowing. After the storm, when determining which samples to send for laboratory analysis, the photographs can be used for deciding which samples best met sample-timing criteria, and will also serve as permanent documentation of flow conditions. These photographs will be archived with the Clallam County Water Resources database.

Turbidity will be measured with two instruments for comparison purposes. Ecology is loaning a ratio meter, and Streamkeepers has several non-ratio meters. Turbidity readings in the high ranges are said to be less accurate with non-ratio meters, and the side-by-side analysis will provide us with some data comparing the two types. In both cases, samples will be analyzed within 48 hours of collection.
• Hach Model 2100P—WA Dept. of Ecology

Turbidity measurements will be made according to the manufacturer’s directions using a Hach 2100P ratio-type portable turbidimeter (Hach, 2001). Calibration of the portable turbidimeter (nephelometer) will be performed prior to the field season with known formazin standards, and a check of the turbidimeter calibration with formazin standards will be made at the end of the field season, and possibly at intervening points. Additionally, the meter will be verified at each use by measuring the turbidity of known portable Gel-ex secondary standards. Deviations of turbidimeter readings from secondary standard values will trigger re-checking and possible re-calibration with primary standards.

The Hach 2100P measures the ratio of scattered light to transmitted light from a 90° signal in nephelometric turbidity units (NTU). The accuracy is ± 2% of the reading plus stray light (<0.02NTU). Repeatability is ± 1% or 0.01 NTU, whichever is greater. In one study, Ecology found that the field turbidimeter was as accurate as the bench-top laboratory ratio-type model, Hach 2100N, when the samples were also sent to the laboratory, such that the results could be paired and differences between field and laboratory readings assessed (Lubliner, Golding 2005).

• HF Scientific Model DRT-15CE—Streamkeepers of Clallam County

Turbidity measurements will also be made according to the manufacturer’s directions using an HF DRT-15CE non-ratio-type portable turbidimeter (HF Scientific, 2004). Calibration of the turbidimeter will be performed prior to the field season with known NIST-traceable primary standards, and a calibration check with primary standards will be made at the end of the field season, and possibly at intervening points. Additionally, the meter will be verified at each use by measuring the turbidity of a known secondary standard. Deviations of turbidimeter readings from secondary standard values will trigger re-checking and possible re-calibration with primary standards.

The HF DRT-15CE measures in non-ratio fashion the scattered light from a 90° signal in nephelometric turbidity units (NTU). The accuracy is ± 5% of full scale of the range in which the instrument is being read (10, 100, or 1000 NTU). Repeatability is ± 1% of full scale of the range in which the instrument is being read (10, 100, or 1000 NTU). To improve the reliability of turbidity measurements, we will analyze three samples from each sample bottle and report the mean of the three readings, rounded to the nearest whole number.
Field Quality Control (QC) Samples

Table 9 lists the field QC samples to be analyzed for the project. Field QC will consist of replicate samples and filter blanks. Replicates will consist of two samples collected one after the other close to the same time and location.

Transfer blanks are prepared just before sampling. Reagent-grade deionized water supplied by the laboratory will be poured into the same type of container used for collecting a grab of the actual sample. In cases where sample is collected in one container and transferred to another, the transfer blank will consist of laboratory deionized water poured into the collection container, then transferred to the container to be sent to the lab. This blank should be made with clean containers, before the containers are used to collect samples.

Filter blanks will consist of deionized water supplied by the laboratory and placed in an HDPE metals container, taken to the field during sample collection, filtered, transferred to a new bottle, acidified, and returned to Manchester Laboratory as other samples for analysis.

<table>
<thead>
<tr>
<th>Parameter</th>
<th># Field Replicates</th>
<th># Field Blank or Filter Blank</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP metals (total recoverable)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Zn and Cu (dissolved) – filter blank</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Nutrients</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>SSC</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Bacteria</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>PAH</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Turbidity</td>
<td>Approximately 1/10 of samples taken</td>
<td></td>
</tr>
</tbody>
</table>
Recording information in the field

Sampling personnel will keep records on waterproof (Rite-in-the-Rain) data sheets, using pencil. The field entries should include:

- Name of study and location
- Weather conditions
- Changes to the plan
- Name(s) of personnel sampling
- Time arriving at site
- Degree of mixing—a qualitative description of how well-mixed (turbulent) the water or how quiescent. Also width of water (e.g. stream width).
- Date, time, location, identification of sample (site name, parameter, lab log #). When samples are composite grabs, the time of each grab and portion of whole sample should be recorded.
- Instrument calibration procedures
- Field measurement times and results
- Photo numbers taken and descriptions
- Unusual circumstances that may affect interpretation of data

Data Management Procedures

Case narratives included in the data package from Manchester Laboratory will discuss any problems encountered with the analyses, corrective action taken, changes to the requested analytical method, and a glossary for data qualifiers. Data will be presented in the report with any pertaining qualifiers.

Laboratory QC results will also be included in the data package. This will include results for surrogate recoveries, laboratory duplicates, matrix spikes, and laboratory blanks. The information will be used to evaluate data quality, determine if the Measurement Quality Objectives were met, and act as acceptance criteria for project data. Data will appear in the report with qualifiers.

Field and laboratory data will be reviewed by the project manager by September 2009 and entered by December 2009 into the following databases:

- The Clallam County Water Resources (CCWR) database
- The U.S. Environmental Protection Agency Storage and Retrieval (STORET) database.
- Laboratory data from Manchester Laboratory will be downloaded directly into the WA Dept. of Ecology Environmental Information Management system (EIM) from Manchester Laboratory’s data management system (LIMS).

In addition to data collected under this project, we will attempt to access additional data submitted to Ecology under their Construction Stormwater General Permit (CSWGP). As of
October 1, 2008, projects disturbing 5 or more acres of soil use a turbidity meter to perform turbidity monitoring, and operators of 1-5 acre sites are required to sample turbidity with either a meter or a 60 cm. transparency tube. Operators are required to sample once per calendar week when there is a discharge of stormwater (or authorized non-stormwater) from the site, including discharges to surface waters within the site, and must submit a Discharge Monitoring Report (DMR) to Ecology each month, by the 15th of the following month. Turbidity measurements with a transparency-tube result \( \leq 6 \) cm or a turbidity result \( \geq 250 \) NTU, must be reported to Ecology by phone within 24 hours. These data will both help us identify potential sampling sites and provide additional data with which to compare ours, particularly when one of our sampling sites is related to a construction site.

**Audits and Reports**

Manchester Laboratory participates in performance and system audits of their routine procedures. Results of these audits are available upon request.

A draft report of the study findings will be completed by the project lead in November 2009 and a final report in December 2009. The report will include at a minimum the following:

- A map showing all sampling locations and any other pertinent features to the study area.
- Coordinates of each sample site.
- Description of field and laboratory methods.
- Discussion of data quality and the significance of any problems encountered.
- Summary tables of the chemical and physical data and a comparison with relevant water quality standards.
- An evaluation of the significant findings and comparisons of historical data to current conditions.
- Recommendations for 303(d) listings, if appropriate, and if there are any such recommendations, a complete set of chemical and physical data and MEL QA review in the Appendix.

Data, once submitted to the above-listed databases in December 2009, will be available from the following websites:

- U.S. Environmental Protection Agency: [http://www.epa.gov/storet/dw_home.html](http://www.epa.gov/storet/dw_home.html)
- WA Dept. of Ecology will have data from samples analyzed at its Manchester Laboratory: [http://www.ecy.wa.gov/eim/](http://www.ecy.wa.gov/eim/)
Data Verification and Validation

Data Verification

Data verification is a review process to assess the quality and completeness of analytical datasets. Verification of laboratory data is normally performed by a Manchester Laboratory unit supervisor or an analyst experienced with the method. It involves a detailed examination of the data package using professional judgment to determine whether the method quality objectives (MQOs) have been met.

Data verification involves examining the data for errors, omissions, and compliance with quality control (QC) acceptance criteria. Manchester Laboratory’s SOPs for data reduction, review, and reporting will also be evaluated in meeting the needs of the project. Data packages, including QC results, conducted by Manchester Laboratory, will be assessed by laboratory staff using EPA Functional Guidelines. Manchester Laboratory staff will provide a written report of their data review, which will include a discussion verifying if MQOs were met; and whether proper analytical methods and protocols were followed; calibrations and controls were within limits; and whether the data were consistent, correct, and complete, without errors or omissions.

Data Validation

Final acceptance of the project data is the responsibility of the sampling project manager and stormwater program project manager. The complete data package, along with Manchester Laboratory’s written report, will be assessed for completeness and reasonableness. Based on these assessments, the data will either be accepted, accepted with qualifications, or rejected and re-analysis considered.

Data Quality (Usability) Assessment

After the project data have been reviewed and verified, the sampling project manager and stormwater program project manager will determine if the data are of sufficient quality to make decisions for which the study was conducted. Laboratory and quality assurance staff familiar with assessment of data quality may be consulted. The project final report will discuss data quality and whether the project objectives were met. If limitations in the data are identified, they will be noted. Analysis of Standard Reference Material SLRS-4 will be compared with its standard values.
References


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Appendices

Appendix A. 303(d) & TMDL Water Bodies in the Project Area

Table A-1. Clallam County Marine Recovery Area 2008 WA Water Quality Report Category 5 [303(d)] & Category 4a [TMDL] Water Bodies

<table>
<thead>
<tr>
<th>Category</th>
<th>Water Body Name</th>
<th>WBID</th>
<th>WASWIS</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>4A</td>
<td>Dungeness Bay</td>
<td>390KRD</td>
<td>Fecal Coliform</td>
<td></td>
</tr>
<tr>
<td>4A</td>
<td>Dungeness River</td>
<td>NJ31PC</td>
<td>Fecal Coliform</td>
<td></td>
</tr>
<tr>
<td>4A</td>
<td>Matriotti Creek</td>
<td>AZ07IY</td>
<td>Fecal Coliform</td>
<td></td>
</tr>
<tr>
<td>4A</td>
<td>Meadowbrook Creek</td>
<td>JQ29HX</td>
<td>Fecal Coliform</td>
<td></td>
</tr>
<tr>
<td>4A</td>
<td>Meadowbrook Slough</td>
<td>WA-15-3010</td>
<td>ZJ70GP</td>
<td>Fecal Coliform</td>
</tr>
<tr>
<td>5</td>
<td>Siebert WF</td>
<td>SF89WR</td>
<td>Dissolved Oxygen</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Meadowbrook Creek</td>
<td>JQ29HX</td>
<td>Dissolved Oxygen, pH</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Meadowbrook Slough</td>
<td>WA-15-3010</td>
<td>ZJ70GP</td>
<td>pH</td>
</tr>
<tr>
<td>5</td>
<td>Lotzgesell Creek</td>
<td>BV22BE</td>
<td>Fecal Coliform</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Johnson Creek</td>
<td>JW80JU</td>
<td>Fecal Coliform, Dissolved Oxygen</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>JimmyComeLately Creek</td>
<td>JE42HJ</td>
<td>Bioassessment, Fecal Coliform, Dissolved Oxygen</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Cline Ditch</td>
<td>JE42HJ</td>
<td>Bioassessment, Fecal Coliform, Dissolved Oxygen</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Cassalery Creek</td>
<td>JE42HJ</td>
<td>Bioassessment, Fecal Coliform, Dissolved Oxygen</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Bell Creek</td>
<td>WA-18-1100</td>
<td>ZX800Y</td>
<td>Bioassessment, Fecal Coliform, Dissolved Oxygen</td>
</tr>
<tr>
<td>5</td>
<td>Anderson Road Irr Ditch</td>
<td>WA-18-1600</td>
<td>YM49RG</td>
<td>Bioassessment, Fecal Coliform, Dissolved Oxygen</td>
</tr>
<tr>
<td>5</td>
<td>Bagley Creek</td>
<td>WA-18-1600</td>
<td>YM49RG</td>
<td>Bioassessment, Fecal Coliform, Dissolved Oxygen</td>
</tr>
<tr>
<td>5</td>
<td>Bear Creek (Dungeness Trib)</td>
<td>YM49RG</td>
<td>Bioassessment, Fecal Coliform, Dissolved Oxygen</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Cooper Creek</td>
<td>YM49RG</td>
<td>Bioassessment, Fecal Coliform, Dissolved Oxygen</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Matriotti Ditch (Matriotti trib)</td>
<td>YM49RG</td>
<td>Bioassessment, Fecal Coliform, Dissolved Oxygen</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Mudd Creek (Matriotti trib)</td>
<td>YM49RG</td>
<td>Bioassessment, Fecal Coliform, Dissolved Oxygen</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>North Ditch (Matriotti trib)</td>
<td>YM49RG</td>
<td>Bioassessment, Fecal Coliform, Dissolved Oxygen</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>South Ditch (Matriotti trib)</td>
<td>YM49RG</td>
<td>Bioassessment, Fecal Coliform, Dissolved Oxygen</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Unnamed Creek (Hurd)</td>
<td>YM49RG</td>
<td>Bioassessment, Fecal Coliform, Dissolved Oxygen</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Unnamed Ditch (Meadowbrook trib)</td>
<td>YM49RG</td>
<td>Bioassessment, Fecal Coliform, Dissolved Oxygen</td>
<td></td>
</tr>
</tbody>
</table>
Appendix B. Field Procedures for Turbidity—Ratio Meter

Ratio Meter: Hach Model 2100P—WA Dept. of Ecology

The following procedure will be used to obtain field turbidity measurements (turbidimeter procedures are more completely described in the instrument manual):

1. Rinse a 1000 mL TSS bottle with the water to be sampled.
2. Obtain a sample in a 1000 mL TSS bottle from a well-mixed location.
3. Cap the bottle and shake vigorously and pour immediately into clean turbidimeter cell.
   From this point on, allow as little time for sample settling as possible.
4. Quickly insert rubber stopper with syringe and pull a suction until visible bubbles are removed.
5. Wipe the cell with a clean lint-free cloth.
6. Apply a few drops of oil, just enough to dampen outside of cell. Wipe almost dry with lint-free cloth.
7. Cap cell, place in turbidimeter, line on cell matching mark on meter.
8. Turn meter on.
9. Select AUTO-RNG and select SIGNAL AVERAGE.
10. Press READ. Write down the first four readings and turn meter off.
Appendix C. Field Procedures for Turbidity—Non-Ratio Meter

Non-Ratio Meter: HF Scientific DRT-15CE—Streamkeepers of Clallam County

EQUIPMENT NEEDED:
Note: Don’t leave this equipment out in freezing temperatures unless you’re using it. If air temperatures are just below freezing, keep the turbidity standards in your pocket.

- Tarp
- HF-DRT 15CE turbidimeter
- watch with second hand or stopwatch
- sample collection bottle with screw top
- squirt bottle of purified water
- small spray bottle of glass-cleaning solution
- box of lint-free tissues
- data sheet, clipboard, pencil
- [sampling wand]
- [plastic tub with tight-fitting lid]

PROCEDURE:
One person can perform these tests. If you want to sample immediately upon arriving at the first site, turn on the meter 15 minutes ahead of time (see below).

Where to sample: Pick an area where the stream is flowing and appears to be well mixed. Do not sample downstream of where your team has disturbed the bottom.

Field Replicates: Our quality control plan requires that at ≥ 10% of your sampling visits, you take a second set of readings. Such field replicates give an indication of how much variability there is in the equipment, sampling techniques, and environment. To make this procedure easy, take a replicate set of readings with your first, eleventh, twenty-first, etc., sample. At that reach, perform the test a second time, as soon as possible after the first, re-dipping the sample bottle. You do NOT need to re-zero or recheck calibration between tests. Record/initial results on the replicate section of the data sheet.

Replicate Deviation & QA: Our Quality Assurance plan requires us to take replicates in order to check the precision of our data. If your replicate for a given parameter differs widely enough from the original sample, we have to label ALL the data for that parameter for your team for that season as “Estimated” or “Rejected”. For turbidity, the allowed difference between sample and replicate is ±1 NTU, if the numbers are small, or the Sum of sample + replicate ≥ the Difference x 30, if the numbers are large. If any of your sample/rep differences are beyond these limits, take further replicates until you have a pair of readings within the limits. Then label the first of the pair your “sample” and the second your “replicate.”
INITIAL INSTRUMENT PREPARATION:

1. The meter is water-resistant but not waterproof. If it’s raining, close the cover or cover the unit with your body.

2. Turn the meter on to the lowest range to begin its 15-minute *warm-up*. If the screen reads “BAT,” you must recharge the instrument or plug it into an outlet to use it; see “If Turbidimeter battery is too low” instructions at the end of this protocol.

COLLECTING A WATER SAMPLE: Wear powder-free Nitrile gloves, and you can use a sampling wand to avoid having to wade in the stream. Before collecting the sample, you need to open the reusable plastic screw-top sample-collection bottle and rinse it and the lid three times in the stream, facing upstream, at a place where your team has not disturbed the bottom—preferably at mid-stream and mid-depth. Empty the bottle downstream of where you are going to take your sample, so as not to stir up the bottom.

Here is the procedure if you can find water that is at least 6” deep:

1. Enter the stream downstream of where you plan to sample, to avoid contaminating the sample from your boots or stirred-up sediment. Sample at a point within the regular monitoring reach where the stream is flowing, well mixed, and preferably at least 6” deep. Get as far away from the banks as you can. Choose a spot that appears undisturbed and has little or no sediment stirred up in the water, if possible. It is preferable to use a sampling wand, as this stirs up the bottom less than walking in the creek.

2. Uncap the bottle, holding the bottle near the bottom and the cap near the top edge. Do not let anything touch the inside of the cap. Do not set the cap down. Do not rinse the bottle or cap. If the bottle becomes contaminated (e.g., if you touch the threads or hit it on the stream bottom), go through the rinsing procedure again.

3. Hold the bottle near its base and plunge it below the water surface with the opening pointing downward. Collect the sample 8-12” below the surface, or midway between the bottom and the surface if the water is shallower. Turn the bottle underwater into the current and away from you. In slow-moving stream reaches, push the bottle underneath the surface and away from you in an upstream direction. Take the bottle out of the water when it is filled.

If the water is <6” deep, you have a couple of options:

1. Sample in shallow, fast-moving water, preferably at a point where the water is forced up a bit. Hold the bottle facing upstream so as to catch the moving water in it. Avoid hitting the bottom.

2. If there is a drop-off somewhere, as from a cascade or culvert, you can sample from this drop-off so long as the bottle touches nothing but the falling water.

3. Recap the bottle carefully, without touching the inside.
TURBIDITY MEASUREMENT:

**Handling the vials:** Inside the meter will be one sample vial and two reference vials—one marked on the cap with a number near zero, and the other at some higher number of NTU (a measure of turbidity).

1. **Do not ever open the reference vials** or unscrew their caps.
2. **Take care not to scratch or get dirt on any of the vials.** Do not put them down anywhere except inside the meter case.
3. When moving closed vials, **hold by the caps only.** When opening, closing, or sampling, **hold the glass portion of the vials in the area just below the neck,** which is outside of their critical measuring area (see diagram below). When possible, hold the vial with a lint-free tissue.

![](image)

**Taking the readings (with meter still on after the warm-up period):**

1) **Zero the meter:** Take the ~zero NTU reference vial out of the trough, holding by the cap or upper part only. Clean the critical measuring area with cleaning solution and a lint-free tissue. Place this vial in the meter-well, aligning the arrow on the cap with the plastic pin in the well collar. (The meter should still be turned to the lowest range.) Then adjust the REFERENCE ADJUST until the display reads the same as whatever the vial cap is marked as.

2) **Check calibration:** Take the higher-number sealed reference vial out of the trough, holding by the cap or upper part only. In the space marked “Field Calibration Check,” record the # of NTUs listed on the vial and its expiration date. Clean the critical measuring area with cleaning solution and a lint-free tissue. Place this vial in the meter-well, aligning the arrow on the cap with the white plastic pin in the well collar. The meter should be set to its lowest range. Record the reading on the meter to the nearest 0.01 NTU.
3) **Calibration check problems:** If the above reading differs from what’s written on the vial by more than 10%, try to improve the reading by cleaning the vial again, warming it if it keeps fogging up, or drying the meter-well if it’s wet. If reading is still more than 10% off, continue with the following steps—the data you collect may still be useable.

4) **Fill the sample vial (remember to hold by the upper part only):**
   a) Thoroughly agitate the sample in the collection bottle—but avoid introducing bubbles by shaking. Immediately fill the sample vial 1/4-1/3 full and shake with the cap on loosely. Empty the sample vial. Repeat this rinse. Then agitate the collection bottle and fill the vial to just below the bottom of the threads. Retighten the vial’s cap.
   b) Holding the sample vial **by the cap**, spray cleaning solution on the outside of the glass and wipe it dry with a lint-free tissue.

5) **Take the readings:**
   a) Gently invert the vial several times to mix—be careful not to create bubbles.
   b) Quickly insert the sample vial in the meter well, aligning the arrow on the vial’s cap with the white pin on the well’s collar ring. The readings will change rapidly, then probably slow down after a few seconds. Watch the meter for 30 seconds, then record the **whole** number (or zero) to which the readings tend most closely during those 30 seconds. (For example, you would record "1" if most readings fall between 0.5 and 1.5.)
   c) If the meter displays “▲~1 .", with a space between the 1 and the decimal point, move to the next higher range. If the meter shows a similar display at its highest range, record “>200" for the model 15C or “>1000" for the 15CE.
   d) Repeat steps 5 & 6 twice more, for a total of three readings. If readings vary greatly, take more readings until you have three that are close (one unit or 10%, whichever is greater). Record these three readings and the sampler’s initials.
   e) If you are collecting replicates at this site, gather another sample in the sample bottle and repeat this procedure, then see the beginning of this protocol to see if you have an acceptable replicate.
   f) If the battery goes dead while you’re sampling, see the “If the battery is too low” procedure at the end of this protocol.

6) **Clean and store:**
   a) Turn off the meter until you get to your next reach, unless this will be <15 minutes away.
   b) Holding the sample vial by the portion just below the neck, rinse it as follows:
      i) Pour out the sample water.
      ii) Fill 1/4-1/3 full with purified water.
      iii) Screw the cap on loosely.
iv) Shake upside down.
v) Empty the vial, twisting so that water rinses the sides.
vi) Repeat this rinsing one more time.
vii) Empty the vial and recap it.

c) Place the .02 reference vial in the measuring well, and put the empty sample vial in the trough on the right side of the meter, along with the higher-number reference vial.
d) Close the meter.
e) Empty the sample collection bottle, recap and store.

**COLLECTING TURBIDITY SAMPLES TO ANALYZE INDOORS**: You can collect a sample in a clean jar (at least pint-sized) using the sample-collection procedure described above. Label the jar with the site and time of collection. Do the same with samples at your other sites that day. Samples can be kept on ice and in the dark for 48 hours. You can then analyze the samples indoors, with the meter plugged in, so you don’t have to worry about battery charge (see directions below). Either let the samples return to room temperature before testing, or else check to make sure condensation hasn’t formed on the outside of the vial after you’ve taken your reading. On the data sheet, record collection and reading times.

**TURBIDIMETER BATTERY CHARGERS** are in marked ziplock bags in the field kit; the charger port is the front hole on the left side of the vials-trough (take out the vials and foam to see it). The unit does not need to be fully discharged before charging. Turn the meter on, then plug in the charger; you should see a “~” in the upper-left of the window. Then you can turn the meter off and let it charge, or turn the meter on and use it while charging. A full charge takes up to 12 hours but it’s okay to partially recharge it. The fully-charged meter will operate for up to 20 hours.