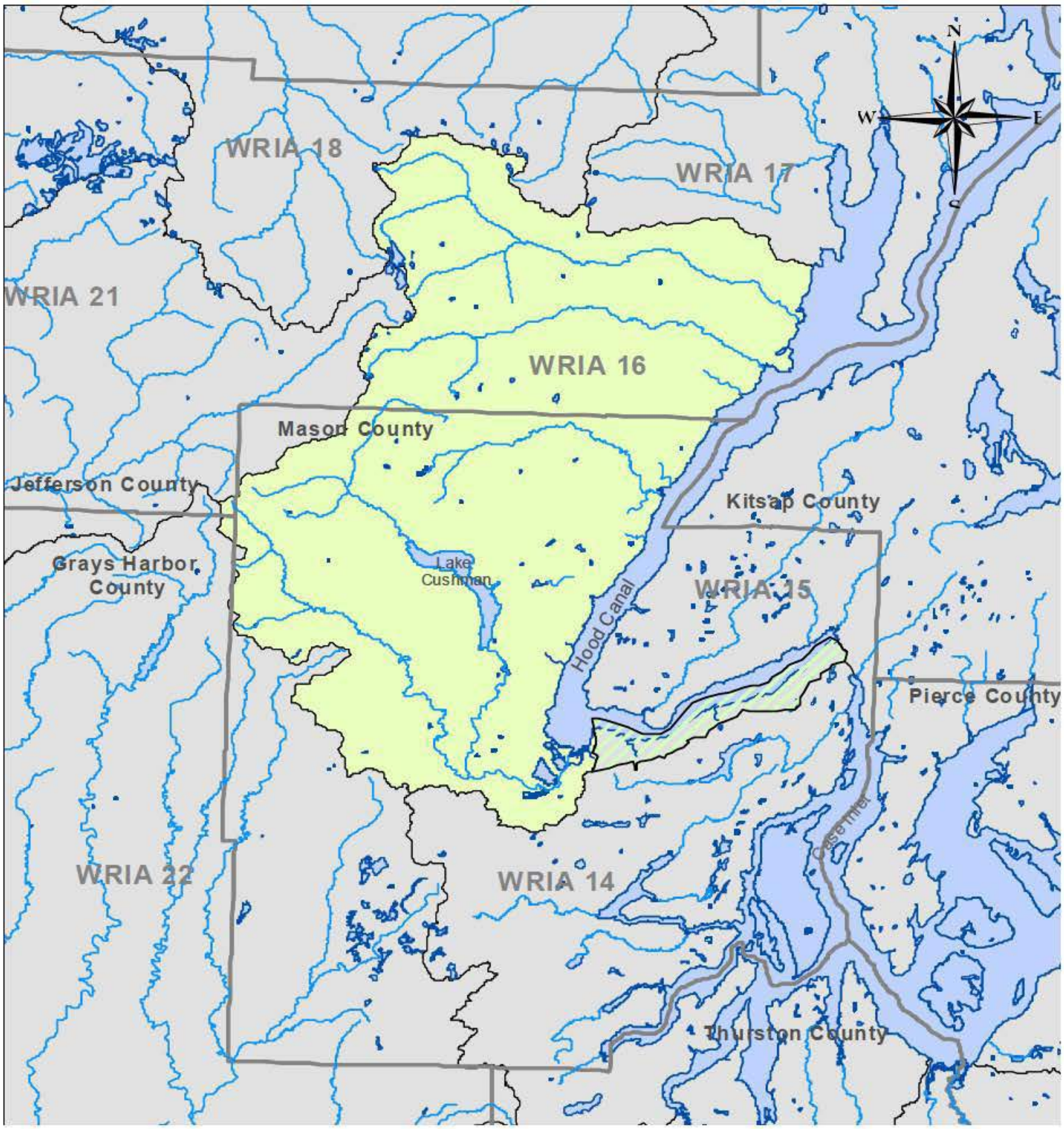
WRIA 16
SURFACE WATER QUALITY MONITORING STRATEGY



PRODUCED FOR THE WRIA 16 PLANNING UNIT THROUGH A WATERSHED PLANNING WATER QUALITY GRANT FROM THE DEPARTMENT OF ECOLOGY (#G0300126)

PRODUCED BY: ENVIROVISION CORPORATION **SEPTEMBER 2003**

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PURPOSE AND NEED

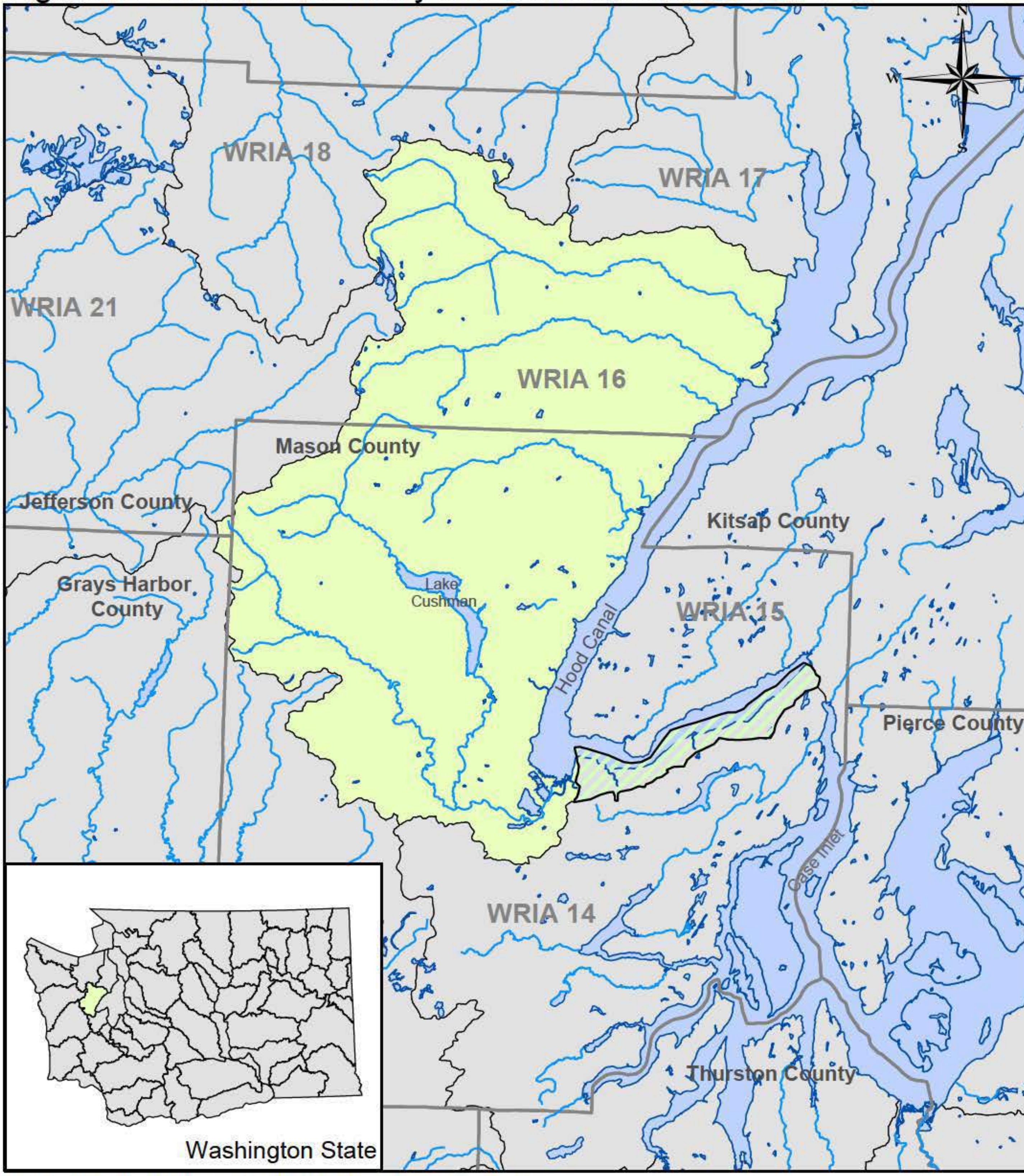
Stakeholders within Water Resource Inventory Area (WRIA) 16 are developing a watershed plan under the rules of the Watershed Management Act of 1998 (RCW 90.82). Ultimately the watershed plan will be a guide to the long-term management of water resources in the WRIA. One of the requirements for understanding the long-term condition of water resources is a method for assessing that condition over time. The purpose of this monitoring plan as described in the Watershed Management Act (RCW 90.82.090) is to provide a "…means of monitoring by appropriate government agencies whether actions taken to implement the approach to bring about improvements in water quality are sufficient to achieve compliance with water quality standards." Some goals of the monitoring plan as set by the planning unit members were to; formulate a process for collecting available data, provide quality assurance and consistency in reporting, and improve coordination of water quality monitoring data among jurisdictions, agencies, citizens and other stakeholders. This surface water quality monitoring strategy represents one part of the overall assessment approach that will be required to meet the Watershed Plans goals. The primary objectives of this strategy are to identify long-term trends in surface water quality and impacts of land use. It is expected that the resulting information will eventually be useful for evaluating potential impacts to the marine environment.

WATERSHED OVERVIEW

Water Resource Inventory Area (WRIA) 16 is located in Mason (59%), Jefferson (41%) and Grays Harbor (<1%) counties, Washington and is approximately 660 square miles in size. Also known as the Skokomish-Dosewallips Watershed, WRIA 16 is bounded on the east by Hood Canal (Puget Sound) and the west by the Olympic Mountains. The watershed is bounded on the south by the Kennedy-Goldsborough Watershed (WRIA 14) and the Chehalis River Basin (WRIA 22), and on the north by the Quilcene River watershed (WRIA 17) (Figure 1). (In order to consolidate planning for Hood Canal, the portion of WRIA 14 that drains into the south shore of the canal has been transferred to WRIA 16 by an inter-local agreement.)

WRIA 16 elevations range from sea level at Hood Canal to the 7,788 foot peak at Mount Deception in the Olympic Mountains. This watershed also includes three distinct ecoregions: Cascade (including the Olympic Mountains), Puget Lowland, and Coast Range (Golder, 2003). Because the watershed encompasses these three ecoregions, the geology and associated hydrogeologic conditions are complex. The basic geology of the watershed can be summarized as older bedrock primarily of sedimentary and volcanic origin in the Olympic Mountains, with more fluvial or glacial rock deposits in the northern lowlands. The southern lowlands contain significant deposits of recessional outwash containing sand, gravel, silt, and clay. The most recent alluvium deposits occur in the floodplain of the Skokomish River and include find sand and silt with smaller amounts of clay and peat. The glacial deposits and alluvial sediments within the river valleys and lowlands contain significant amounts of groundwater. Relatively mild summer and winter temperatures

Figure 1: WRIA 16 Boundary and General Location



Data Source: Washington State Department of Ecology and Mason County

0 3 6 12 18 24 Miles

Legend

Rivers
Water Bodies
Other WRIAs
WRIA 16
South Shore (Portion of WRIA 14 included in WRIA 16 planning)

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characterize this watershed. Except in the western mountainous regions, there is not significant accumulation of snow over prolonged time periods. Winters are usually quite wet while summers are relatively dry. Annual precipitation ranges from 70 inches in the northeast corner of the watershed to over 300 inches at the headwaters of the Skokomish River in the Olympic Mountains (Golder, 2003). Average annual discharge of the entire watershed is approximately three million acre-feet per year. Delayed runoff from snow melt is more common in the rivers and streams originating from higher elevations in the northern and western portions of the watershed, while rivers and streams in the southern portion of the watershed have peak discharge primarily in the wet winter months that are concurrent with the highest precipitation (Golder, 2003).

The watershed is divided into nine sub-basins based primarily on surface water divides (Table 1, Figure 2). There are several main rivers that drain this WRIA. The Dosewallips River is the northernmost river in WRIA 16 and drains an area from the Olympics extending eastward into the northern portion of Hood Canal. The Duckabush River in southeastern Jefferson County also drains an area from the Olympics to Hood Canal. The Hamma Hamma River receives water from several alpine lakes in its upper reaches as well as Jefferson Creek, and drains the central portion of WRIA 16. Lilliwaup Creek originates in extensive wetlands associated with Price Lake, eventually flowing into a well-developed floodplain and estuary north of Hoodsport. The Skokomish River has a North and South Fork that combine near the southern boundary of the watershed and discharges more water than all the other rivers and streams in Mason County combined. These rivers all have mouths into Hood Canal. In addition to the main river systems, there are several small streams that drain independently into Hood Canal.

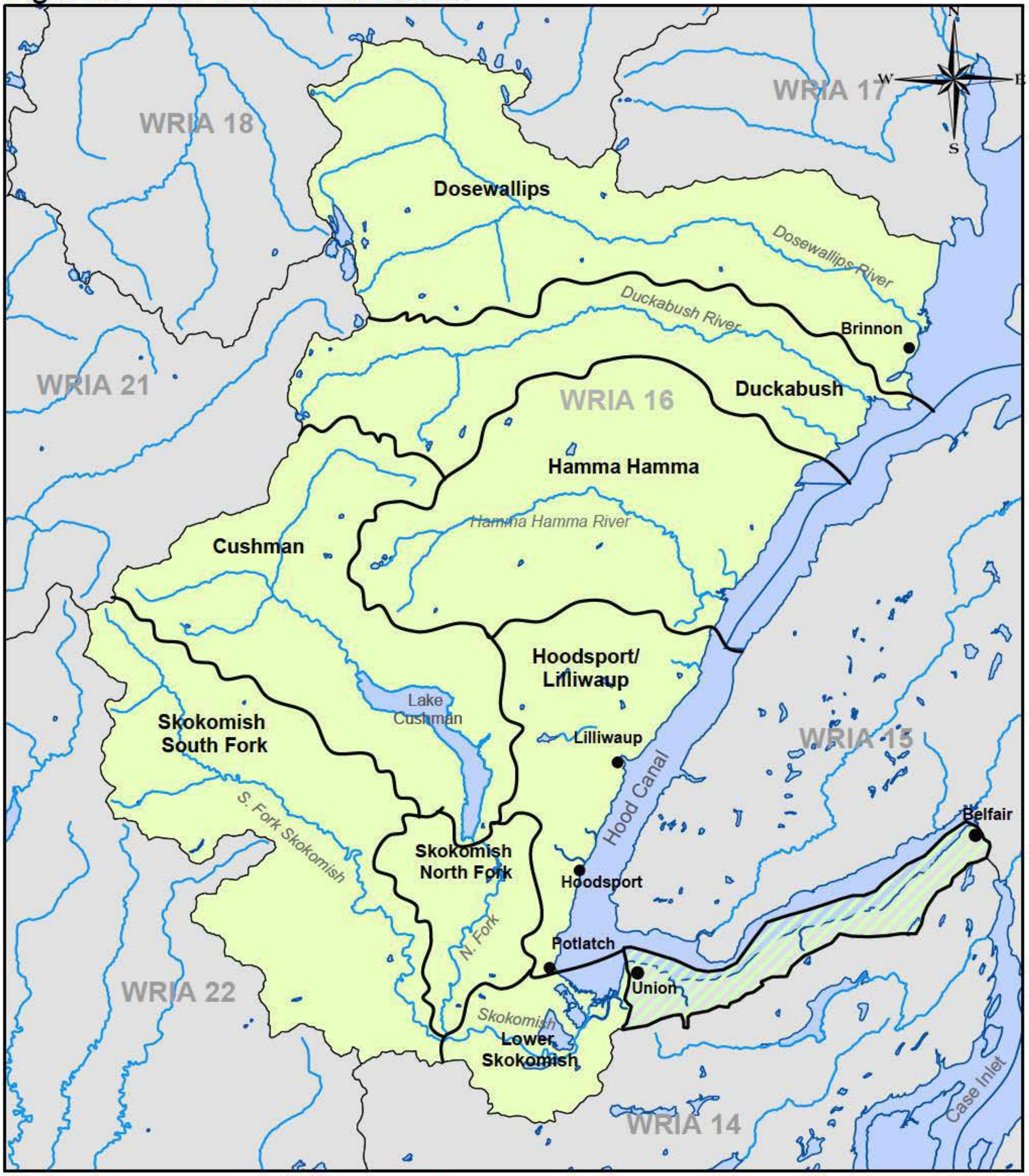
The “South Shore” area of Hood Canal has been included in the WRIA 16 planning area. This area of the watershed includes low lying hills and several small creeks including Alderbrook, Deveraux, Twanoh Falls, Dalby, Big Bend, and Happy Hollow Creeks as well as several unnamed creeks. Each of the creeks discharges directly into Hood Canal and originates from springs and ground water discharges.

Table 1. Subbasin characteristics of WRIA 16.

Sub-basin	**Total Area** (mile^2)	**Average Annual Precipitation** (inches)	**Average Annual Discharge** (cfs)	**Unit Runoff** (cfs/mile^2)	**2000 Population Density** (People/mile^2)
Dosewallips River	92.7	80	446	4.8	6.4
Duckabush River	130.9	87	411	3.1	2.8
Hamma Hamma River	117.5	84	520	4.4	2.5
Hoodsport/Lilliwaup Creek	54.7	82	-	-	20.2
South Fork Skokomish River	29.1	131	757	26.0	8.5
Cushman	229.1	134	515	2.2	1.2
North Fork Skokomish River	32.4	89	115	3.5	24.3
Lower Skokomish River	81.6	69	1,224	15.0	16.6
South Shore	104.3	60	-	-	26.6

Revised from Golder, 2003

Figure 2. Sub-Basin Boundaries



Data Source: Washington State Department of Ecology and Mason County

0 1.5 3 6 9 12 Miles

Legend

Rivers

Water Bodies

Other WRIAs

WRIA 16

South Shore (portion of WRIA 14 included in WRIA 16 planning)

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The Lower Skokomish Subbasin is supplied by three other Subbasins (Skokomish North Fork, Skokomish South Fork and Cushman) and has the highest average annual discharge (1,224 cfs) in the watershed (Figure 2). The three northernmost Subbasins (Dosewallips, Duckabush, and Hamma Hamma) have lower average annual discharge rates (411-520 cfs). The South Fork and Lower Skokomish River Subbasins have the highest average unit runoff (26.0 and 15.0 cfs/mi^2, respectfully) while the Cushman and Duckabush Subbasins have the lowest (2.2 and 3.1 cfs/mi^2, respectfully). No discharge data is available for the Lilliwaup and South Shore Subbasins.

The population in WRIA 16 is located mostly along the coastline of Hood Canal and along the entire South Shore, as well as the eastern shore of Lake Cushman and the Skokomish Tribal Reservation at the mouth of the Skokomish River. There are no incorporated towns or cities within WRIA 16; the largest communities are Hoodsport, Lilliwaup, Potlatch, Brinnon, Union and Belfair. The overall population within this watershed was 7,748 in 2000 (Golder, 2003). The southern end of the watershed contains approximately 68% of the population (Hoodsport/Lilliwaup, Lower Skokomish River, and South Shore Sub-basins) while the largest population growth rates since the 1990 census occurred in the South Shore, Lower Skokomish River, and Lower North Fork Skokomish River Sub-basins.

The majority of the watershed (80%) is forested land dominated by western hemlock, Douglas fir, red alder, and at higher elevations Pacific fir (http://www.ecy.wa.gov/programs/wq/wria_summaries/wria16.pdf). Most of the forested acreage is owned by the federal or state government with the remainder being privately owned. The Olympic National Park and Olympic National Forest are the largest land parcels in the watershed, especially in those sub-basins north of the Skokomish River (Figure 3). In the sub-basins associated with the Skokomish River, commercial and noncommercial land use activities such as cattle and other livestock, hay and Christmas tree production, vegetable production, and shellfish harvesting exist. Several hatcheries also exist in the South Fork Skokomish Sub-basin. The remaining land base in the watershed is spread among rangeland (5%), lakes and reservoirs (6%) and other uses (8%) such as rural residential, commercial, industrial, and other minor categories.

Much of the area's economy is dependent upon forestry and agricultural practices, including Christmas tree farms, commercial logging, traditional farming and shellfish farming. The streams within the WRIA are primarily used for domestic irrigation as well as private and commercial water supplies. A notable exception is the North Fork of the Skokomish River, which is used by the City of Tacoma to generate power at Cushman Dams No. 1 and 2.

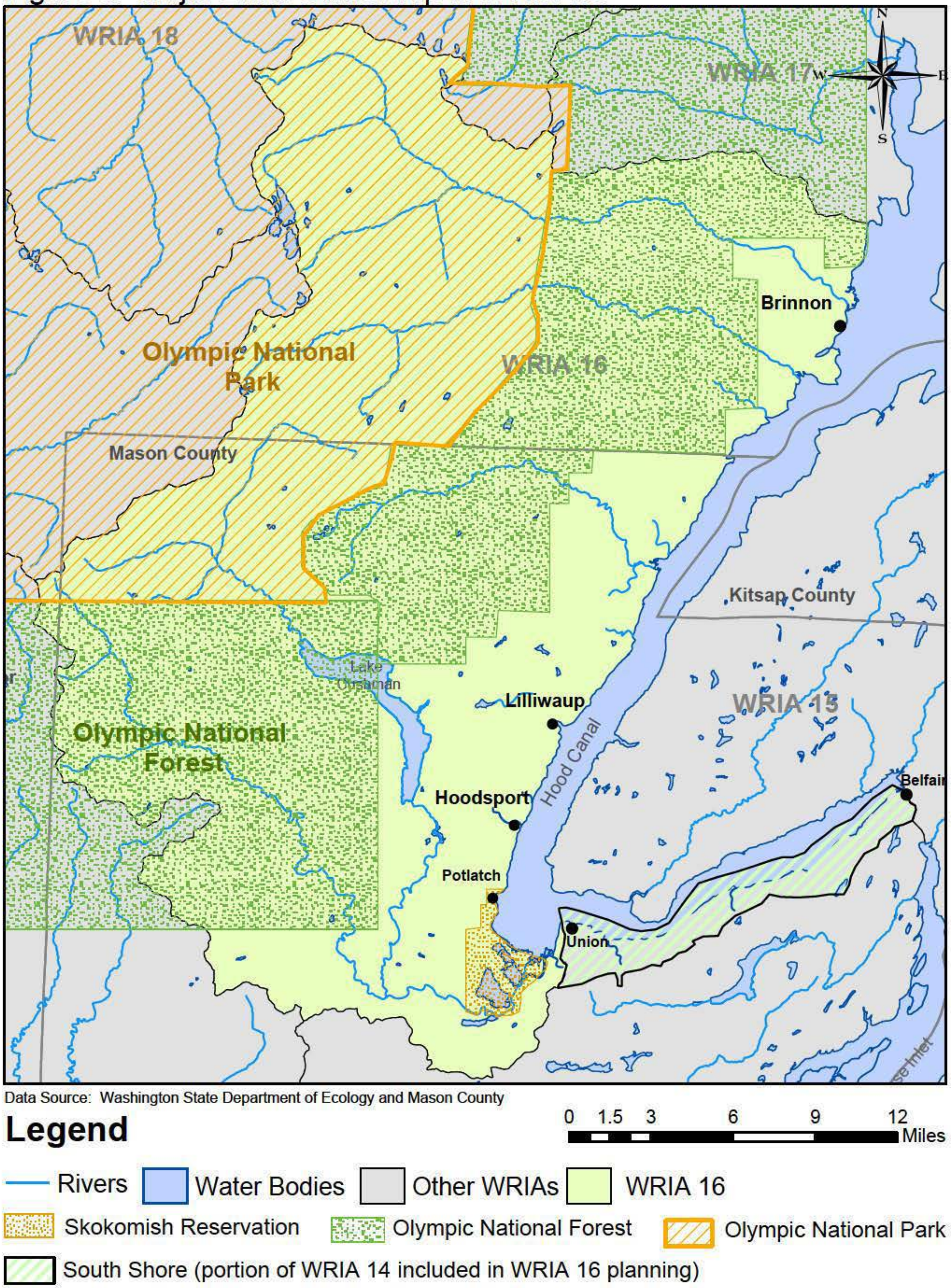
MONITORING STRATEGY DEVELOPMENT

An effective monitoring strategy must account for the known condition of surface waters and past and existing monitoring efforts, and balance these against established monitoring objectives. The following is a summary of this background information as it pertains to WRIA 16.

KNOWN SURFACE WATER QUALITY

The first step in development of the monitoring strategy is to assess the existing water quality. The Level 1 Assessment for WRIA 16 (Golder, 2003) was reviewed as a means of summarizing the known water quality condition in WRIA 16. There is a wide range of water quality within the

Figure 3. Major Land Ownership in WRIA 16.



Data Source: Washington State Department of Ecology and Mason County

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WRIA 16 ranging from poor to excellent. However, in the vast majority of the WRIA the quality of the water is unknown due to lack of information. In general, water quality in the watershed is good.

The Level 1 Assessment also supplied a summary of those waters not in compliance with current State water quality standards. Those areas were determined to not be in compliance through earlier (1990's) monitoring efforts, and were classified as impaired waters in the Environmental Protection Agency's (EPA) 303(d) list under the Clean Water Act. These 303 (d) listings in WRIA 16 for 1998 as well as those waters (or segment of a water resource) where instream flow requirements as defined in WAC 173-514 are not met are shown in Table 2. (The 303(d) list for 2002 was not available at the time of this report but is expected to be accessible in the fall of 2003.) It is not known if the other waters within each Sub-basin meet State water quality standards. It must be noted that most of the water resources in the WRIA do not have any data to support this assumption.

Table 2. Summary of WRIA 16 Water Resources that are Impaired.

Waterbody Name	303(d) Listing	Flow Limited Closures	Township, Range, Section
Freshwater			
Happy Hollow Creek (1)	Fecal Coliform, pH	No	22N 02W 22
Twanoh Falls Creek (1)	pH	Yes (2)	22N 02W 21
Unnamed Creek (1)	pH	No	22N 02W 22
Purdy Creek	Fecal Coliform	No	21N 04W 14/15
Hunter Creek	Fecal Coliform	No	21N 04W 17
Skokomish River	Fecal Coliform	No	21N 03W 7/12/15
Lower Skokomish N.F.	NA	Yes	22N 04W 16
Ten Acre Creek	Fecal Coliform	No	21N 04W 16
Weaver Creek	Fecal Coliform	No	21N 04W 16
Alderbrook Creek (1)	NA	Yes (2)	
Marine Water			**Lat., Long.**
Great Bend (1)	Dissolved Oxygen/pH	NA	47.355N, 123.025W
Lynch Cove (1)	Fecal Coliform/ Dissolved Oxygen/pH	NA	47.425N, 122.855W
Hood Canal (South) (3)	Fecal Coliform	NA	47.645N, 122.925W
Hood Canal (South) (3)	Fecal Coliform	NA	47.645N, 122.935W
Hood Canal (South) (3)	Fecal Coliform	NA	47.685N, 122.895W

Source: Final 1998 Section 303(d) List and Golder (2003)

(1) These waters are located in WRIA 14 but are part of the South Shore Sub-basin and are being considered with WRIA 16.
(2) No minimum instream flows established but closed to further consumptive appropriation from May 1 through October 31.
(3) Waterbody name is taken directly from 303(d) listing. These refer to areas near the Dosewallips, Duckabush and Lilliwaup Rivers.

A total of eight streams or stream segments and five marine water segments are listed as having water quality impairments in WRIA 16. High concentrations of fecal coliform bacteria occur in six out of the eight freshwater and four of the five marine water bodies, forming the primary known water quality concern in the watershed. Potential sources of fecal coliform bacteria include failing septic systems, stormwater runoff from agricultural lands, livestock, wildlife, and pet waste and recreationalists.

No minimum instream flows have been adopted for this WRIA. The North Fork of the Skokomish River has substantially reduced flow on a year-round basis due to the diversion of water for power generation purposes. Twanoh Falls and Alderbrook creek are closed to further consumptive appropriations from May 1 through October 31 to protect anadromous fish.

The Level 1 Assessment (Golder, 2003) presented a number of data gaps or recommendations for further assessment. Most of the data gaps were associated with water quantity issues related to water rights, use, and instream flows. The following is a summary of those that were water quality based or may be significant to development of a surface water quality monitoring strategy:

- ✓ Quantify instream habitat needs for fish. (Note: In terms of water quality, temperature and dissolved oxygen can help define fish habitat limitations.)
- ✓ Re-establish past stream flow gaging stations and establish new sites.
- ✓ Coordinate monitoring efforts and develop a centralized water resource database.
- ✓ Focus additional water resource assessment efforts in more densely populated areas or areas with the highest population growth rates and pending applications for new water rights.

EXISTING/PAST MONITORING EFFORTS

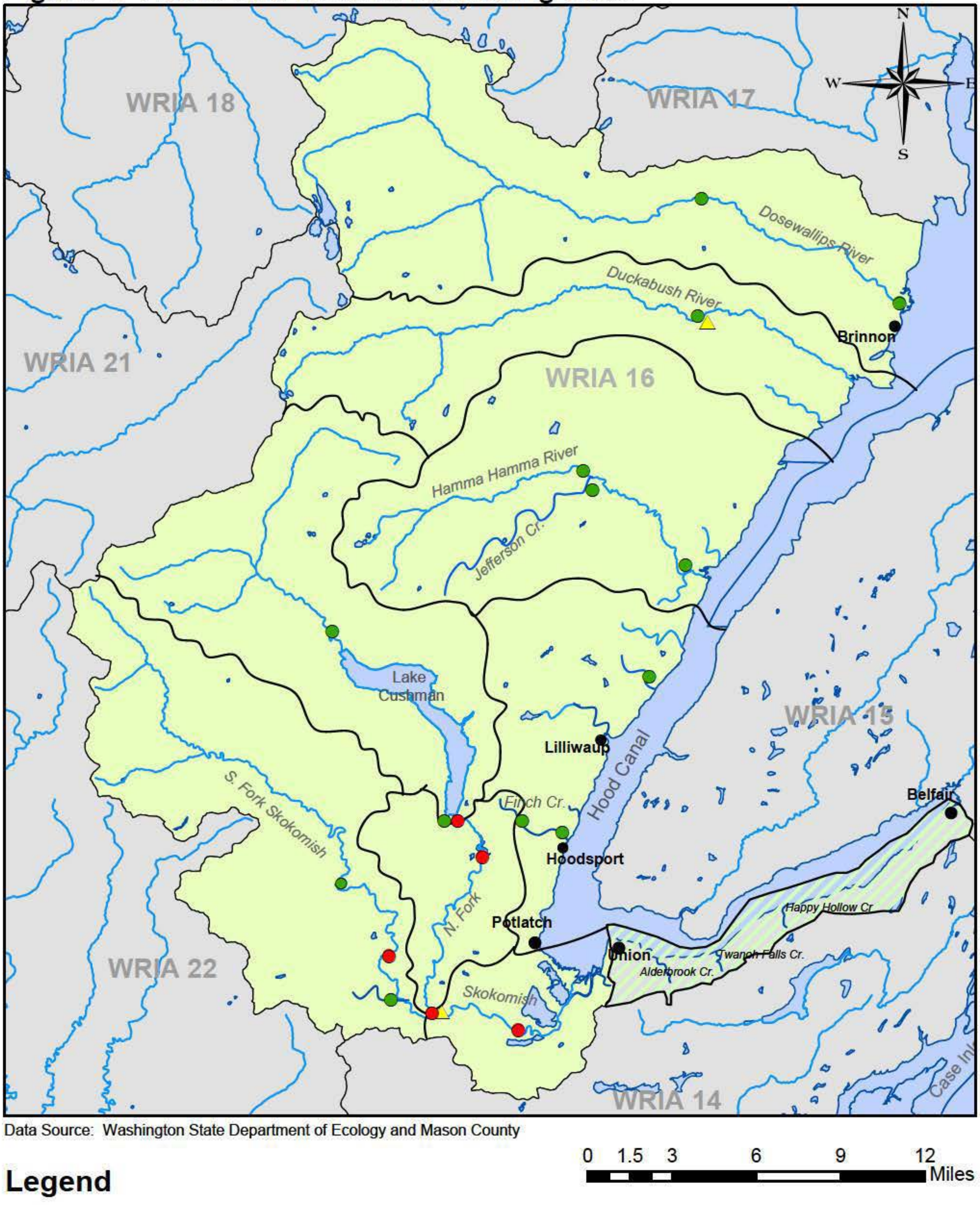
To be most cost-effective the WRIA-wide monitoring should complement existing monitoring efforts. Local and state agencies and tribes were contacted to begin to develop a summary of monitoring efforts and available data. The United States Geological Survey (USGS), United States Forest Service (USFS), Washington State Departments of Ecology, Fish and Wildlife, and Health, and the Skokomish Tribe have all been involved in monitoring water quality in the watershed. The following is a summary of their monitoring efforts.

The USGS historically maintained a number of gaging stations in WRIA 16 although most are currently inactive (Golder, 2003). There are at least five active gaging stations within the watershed; Skokomish River near Potlatch (site #12061500), South Fork Skokomish River near Union (site #12060500), North Fork Skokomish River near Potlatch (site #12059500) and below the Cushman Dam (site #12058800), and North Fork Skokomish River near Hoodsport (site #12058000) (Figure 4).

The USFS has done temperature monitoring in the watershed. This included monitoring on the mainstem of the rivers in 1998-2002. There is also limited project specific temperature monitoring (Noble, K. Pers. Comm.).

The Washington State Department of Ecology (Ecology) has two long-term monitoring stations in this WRIA that are monitored as part of their Ambient Monitoring program. These stations are located at the Skokomish River near Potlatch (Station 16A070) and the Duckabush River near Brinnon (Station 16C090) and the data record extends back to 1948. Data collected at these stations will be valuable for making historical comparisons. The data record includes measurement of a fairly comprehensive list of parameters including temperature, pH, conductance, phosphorus,

Figure 4. Active and Inactive Monitoring Sites



Data Source: Washington State Department of Ecology and Mason County

Legend

Rivers | Other WRIAs | WRIA 16

Water Bodies | USGS Gage (active) | USGS Gage (inactive) | Ecology Site (active)

South Shore (portion of WRIA 14 included in WRIA 16 planning)

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dissolved oxygen, flow, and fecal coliform and nitrate+nitrite. A limited amount of benthic invertebrate samples have been collected from the Duckabush River station in the past few years as well (Wiseman, C. pers. comm.). There are also five “roving” monitoring stations in WRIA 16 that Ecology monitors on an infrequent basis. Data from these stations should also be reviewed for establishing historical conditions (Figure 4).

In 1985, Ecology established an Instream Resource Protection Program in WRIA 16 and drafted an instream flow regulation (WAC 173-516); however it was never adopted by rule. This study used an Instream Flow Incremental Methodology (IFIM) and focused on the Dosewallips, Duckabush, and Hamma Hamma Rivers and on Finch, Eagle, Johns, Jorsted, and Fulton Creeks. The North, South, and mainstem of the Skokomish (North and South Forks, and mainstem) have been the focus of an IFIM conducted by the U.S. Fish and Wildlife Service while the City of Tacoma has completed an IFIM study of the lower North Fork Skokomish River.

The Washington State Department of Health (WDOH) performs routine bacterial (FC bacteria) monitoring in the marine waters and nearshore areas associated with commercial and recreational shellfish beds. This monitoring includes monthly sampling at stations in Conditionally Approved Areas and monitoring six times per year in Approved and Restricted Areas. All marine sampling station locations within Hood Canal and WRIA 16 are shown in the 2001 Annual Inventory of Commercial and Recreational Shellfish Areas of Washington State.

Washington State Department of Fish and Wildlife (WDFW) funded a two-year study of FC bacteria conditions in the lower Duckabush River (Envirovision, 1996).

Mason County Department of Health is involved in bacteria monitoring on the Skokomish River as part of the TMDL development monitoring needs and also collects FC bacteria data in marine waters of WRIA 16 as part of their Threatened Area Response Strategy. This work includes mapping discharges, delineating source areas, and sanitary surveys. These are short-term investigative efforts that are grant funded and therefore, not considered to be long-term in nature.

Mason County Public Utility District #1 monitors nine public drinking wells in WRIA 16 but does not conduct any surface water monitoring (Halloway, S., 2003). This monitoring may provide collaborative evidence of a connection between low stream flows and local water well levels.

The Skokomish Tribe monitors four stations on a permanent basis within the Reservation at the mouth of the Skokomish River (Bullchild, L., 2003). Their data record also includes results from occasional monitoring at up to 87 additional sites; approximately 20 sites are sampled during any given month. Monitoring includes measurements of temperature, dissolved oxygen and FC bacteria. The Tribe has done this monitoring since 1995. Although data gaps exist from 1995-2000, monitoring has been more consistent since 2000.

Lastly, because fecal coliform levels were not meeting water quality standards in the lower Skokomish River, the Skokomish Tribe and Department of Ecology conducted a Total Maximum Daily Load (TMDL) study in 1999 and 2000 (WDOE, 2001). Ecology collected samples at 18 different sites in the Sub-basin, seven of which were concurrently sampled by the Tribe. All samples were analyzed for fecal coliform and dissolved oxygen in an effort to identify impaired waters and ultimately to protect the health of the local freshwater and marine water resources. The study did identify that the water quality standards for fecal coliform were not exceeded for Hunter Creek, which may preclude the creek from being on the 303(d) list for 2002 (Golder, 2003).

In summary,

- There are five active stream gaging stations maintained by the USGS.
- There is little data record for most of the WRIA.
- The most significant known water quality concern in WRIA 16 rivers and streams is associated with fecal coliform bacteria
- Water quality ranges from poor to excellent, but in most locations the quality of water is unknown.

MONITORING OBJECTIVES

The following are the primary monitoring objectives approved by WRIA 16 planning unit members:

- Develop a database that can be used to monitor long-term trends in surface water quality conditions.
- Determine whether there are water quality conditions or trends that can be attributed to land use and development practices.
- Develop a consistent, reliable, comparable dataset.

The need to assess compliance with State water quality standards was listed as a secondary objective. For most parameters that can be achieved indirectly by meeting the primary objectives identified.

MONITORING STRATEGY

The following strategy has been developed to optimize the use of existing monitoring efforts while also meeting priority monitoring objectives aimed at a more comprehensive evaluation of the quality of surface water resources. The Baseline Strategy represents a minimal approach and focuses on the main river basins in the WRIA and would allow assessment of general trends and conditions. The Investigative Monitoring portion of the strategy would allow for site and issue specific monitoring efforts. Additional monitoring elements that have been included for future consideration are priority pollutants, aquatic macroinvertebrates, and lakes.

BASELINE STRATEGY

The baseline monitoring program refers to the stations, parameters, and frequency that form the framework for long-term monitoring. Because the intention is to perform this monitoring on a permanent basis, this is the information that will be most valuable for assessing possible trends. Minimizing the number of stations, parameters, and sampling frequency is an important consideration for minimizing long-term resource requirements. Since WRIA 16 is largely comprised of a few large river systems and most of the land mass is protected from development because of the National Park, these monitoring needs should be uncomplicated.

There are 11 stations that have been identified for inclusion in the Baseline strategy. These stations were selected because they represent major river systems, represent populated or populating areas, or represent a potential land use impact (e.g., forestry and recreational impacts associated with the Park or Forest).

Station locations are shown on Figure 5. They include:

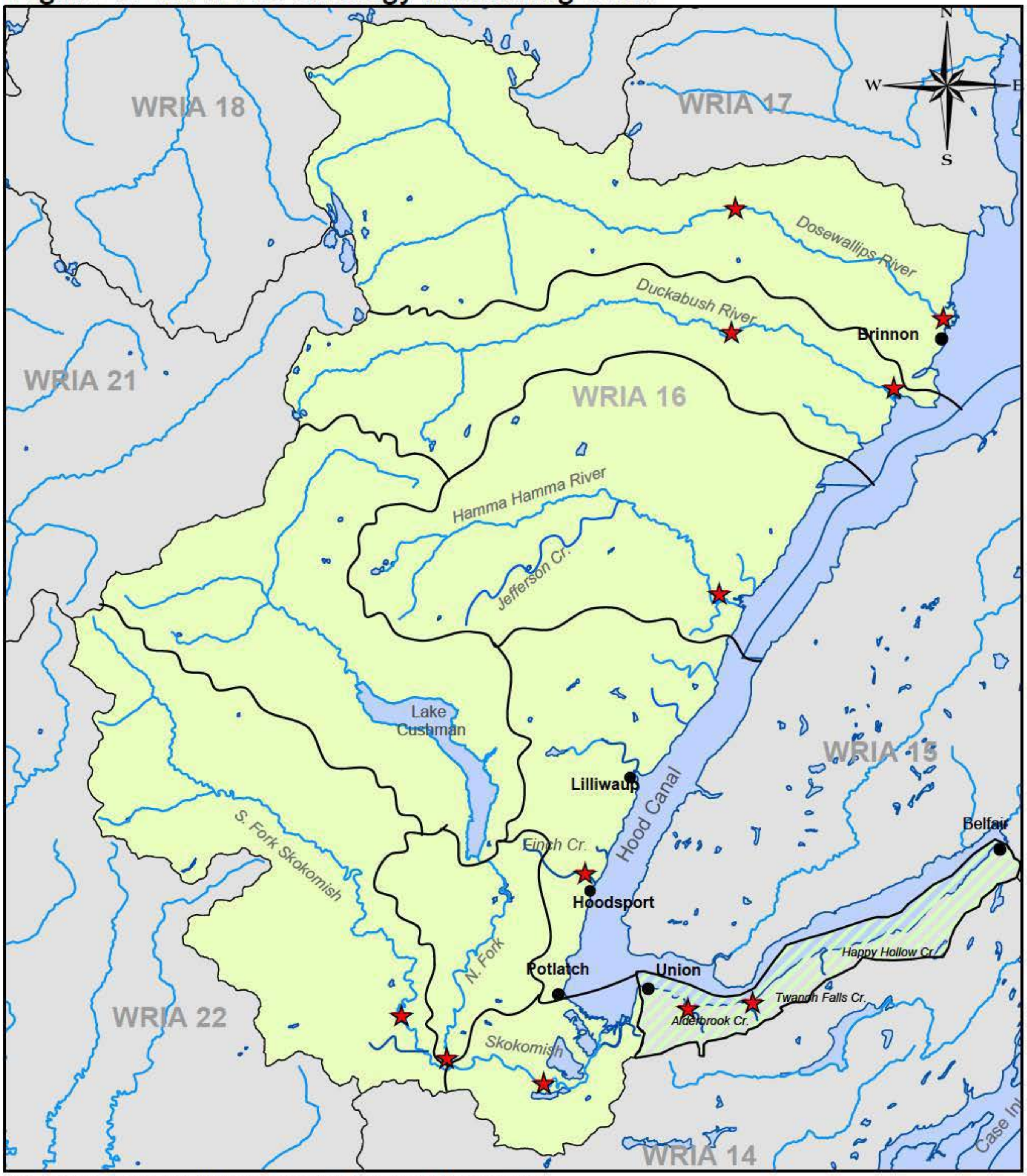
- Skokomish River near Potlatch (@ Highway 101 bridge/ USGS site # 12-0615-00). This is an Ecology ambient monitoring site.
- South Fork Skokomish (@USGS site # 12-0605-00)
- North Fork Skokomish (@USGS site # 12-0595-00)
- Finch Creek (@ USGS site # 12-0560-00)
- Hamma Hamma (@ USGS site # 12-0555-00. Inactive gage.)
- Duckabush River (at Hwy 101 bridge)
- Duckabush River (@ USGS site # 12-0540-00. Inactive gage.) This is an Ecology ambient monitoring site.
- Dosewallips (@ USGS site # 12-0535-00. Inactive gage.)
- Dosewallips ((@ USGS site # 12-0530-00. Inactive gage.)
- Alderbrook (@ the mouth)
- Twanoh Falls Creek (@ the mouth)

Essentially upstream stations on the Duckabush and Dosewallips were placed so as to represent "background" conditions as the rivers flow out of the designated Wilderness Area. (On the Dosewallips, the stream corridor is designated as National Forest, however it is surrounded by Wilderness Area.) There are pollutant sources that exist in these upper watersheds. Recreational use of the area and even wildlife can cause water quality problems and certainly forestry activity on National Forest lands can be a cause for concern. However, this approach will allow evaluation of any change in water quality condition as the rivers flow through the lower more developed portion of the watershed. Generally, the upstream site on the Duckabush should provide the best representation of background conditions because the station is located near the boundary with the Park and therefore should not be affected by forestry activity. The downstream stations were selected to represent the "end product" as the rivers enter marine waters. These downstream stations are located in the area of influence from tides and marine waters, thus their selection causes monitoring constraints in terms of timing of sample collection to coincide with lower tides.

At each key station the following parameters will be measured: Fecal and E. coli bacteria, total phosphorus (TP), total suspended solids (TSS), nitrate+nitrite (N+N), biochemical oxygen demand (BOD), temperature, pH, dissolved oxygen, turbidity, and conductivity. Analytical methods for these are listed in the QAPP (Appendix A). Flow should be measured at all of the long-term monitoring sites. Since the USGS is actively measuring flow at all of the stations on the Skokomish, this will require establishing gaging sites on 8 of the 11 stations. Most of the stations have been located at current or old USGS gaging sites so some flow data may be available. (Note: It is possible that the Hood Canal Salmon Enhancement group will begin flow monitoring on the Hamma Hamma River. This would further decrease rating curve development needs.)

A seasonal approach to monitoring that focuses on a few critical time periods can be a quicker and more cost effective way of obtaining data that can be used for trend analysis. However, both the Skokomish Tribe and Ecology are monitoring on a monthly frequency. This, in combination with the fact that there appears to be no known near term water quality concerns in the WRIA (outside of

Figure 5. WRIA 16 Strategy Monitoring Sites



Data Source: Washington State Department of Ecology and Mason County

0 1.5 3 6 9 12 Miles

Legend

- Rivers
- Water Bodies
- Other WRIAs
- WRIA 16
- ★ Baseline Monitoring Sites
- South Shore (portion of WRIA 14 included in WRIA 16 planning)

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those already being assessed in the Skokomish River or those that should be addressed through investigative efforts) makes monthly monitoring a reasonable choice.

The more monitoring efforts can be coordinated, the more comparable data will be. It is best to monitor all of the baseline stations on the same day. It is especially critical that stations monitored in the same system (i.e., up and downstream stations) are monitored on the same day. This creates an issue with the Duckabush River and Skokomish River where data for the downstream station would be provided through Ecology's ambient monitoring program. This will either require coordinating sampling days with Ecology or arranging to have Ecology monitor at the upstream sites as well.

A consideration for decreasing the level of effort for implementing this strategy is to only monitor the upstream sites for two out of every five years. Another consideration for decreasing costs is to not analyze all parameters during all monitoring events. In this case, the field measurements, temperature, pH, DO, conductivity, flow, and turbidity and FC bacteria would be measured at all stations/all events, but the nutrients and TSS would only be monitored during a few months in summer (July through September) and a few months during winter (November through February).

FLOW MONITORING

Collecting accurate flow data will be the most difficult task associated with implementation of this strategy. First, staff gages need to be set up at all of the ungaged sites. These gages should be professionally surveyed to insure the data record could be saved if they should be lost to a flood or vandalism. (It is possible that USGS staff gages are still in place at these sites, in which case they should be used for gaging.) A staff gage reading should be taken each time a site is visited. While actual flow measurements to develop flow rating curves should be made on separate trips to the sites. (This is because flow measurements are time consuming and would negate the ability to monitor all eleven sites in one field day.)

Accurate flow measurements are required to establish a flow-rating curve for each site. During low to moderate flows, the rivers in the WRIA are wadable and therefore, it is practical to collect flow data from in the stream. However, during high flows most of the rivers cannot be waded. The most practical method of measuring flow at these times is to take measurements from a bridge or other over water structure. This requires some specialized equipment. Making high flow measurements might best be treated as a separate study. A minimum collection of three samples is adequate to develop a rating curve. These measurements could all be made during the first year of monitoring. However, the rating curves would need to be reset or verified every 5 years. It is also possible to establish relationships between sites and therefore reduce the number of actual measurement sites. Many of these tasks require the skills of a professional hydrologist.

INVESTIGATIVE EFFORTS

Development in WRIA 16 and the South Shore area is primarily along the shoreline of Hood Canal and at Lake Cushman. There is also agricultural development in the Skokomish Valley as well as forestry and road building practices throughout both private and public forestland. Special investigative studies may occasionally be planned for these areas. Investigative studies are inherently different from long-term, baseline monitoring strategies. Typically, they include a larger number of stations over a smaller area that is monitored over a shorter period of time with a focus on a few problem parameters. A bacteria study on the Skokomish to support TMDL efforts is one local example of an investigative study.

One area of known interest for more focused investigations is the shoreline of the southern arm of Hood Canal (The part of the watershed that is formally located in WRIA 14). Shoreline development and on-site septic systems are a concern for local, recreational and commercial shellfish harvest and the general health of the marine water in this area. Although two streams along this shore have been selected for long-term monitoring (i.e. Alderbrook and Twanoh Falls), additional efforts may be required. There are numerous small streams that drain to the canal in this area. They include Big Bend, Dalby, Alderbrook, Twanoh, Twanoh Falls, Happy Hollow, Holyoke, Lakewood, and Devereaux. Winter wet weather bacteria monitoring at the mouths of these streams would help with delineation of bacteria sources. Collecting 6 samples at the mouth of each creek over the course of a 12 week period would help to establish conditions. Depending upon the data generated, this effort should be continued for a two-year period. This monitoring should be coupled with ongoing shoreline monitoring and septic system testing. This type of investigative effort may need to be repeated as a means of monitoring possible trends or new problems.

PRIORITY POLLUTANTS AND AQUATIC MACROINVERTEBRATES

The baseline monitoring targets conventional water quality parameters and concerns associated with such things as increased sediment and nutrient loads. To create a more comprehensive assessment of the health of stream systems, priority pollutant contaminants and aquatic macroinvertebrate monitoring should be considered.

The priority pollutants selected for measurement include the heavy metals and the group of organic priority pollutants that is captured through analysis of the chlorinated acid herbicides and organochlorine pesticides. (Note: The analytical method used determines which of the heavy metals and organic pollutants are specifically measured. The analytical method is noted in Appendix A.) Total organic carbon will also need to be measured to enhance interpretation of the information. Heavy metals were selected for analysis because they are related to development impacts and road runoff. The pesticides can be an indicator of agricultural or urban impacts.

Priority pollutants such as heavy metals and pesticides are rarely seen at measurable concentrations in water samples, consequently, sediment sampling is recommended. Samples are collected from depositional areas near the mouths of streams but well above the area of salt-water influence. Given the low level of development in this WRIA, a minimal approach with infrequent collection at a few stations should be sufficient. Stations should be located near the mouths of the Dosewallips, Duckabush, Skokomish, Alderbrook, Devereaux, Twanoh Falls, Lakewood, Finch and Lillwaup Creeks. These stations were selected because they are near developed areas. Monitoring could be scheduled at as a low a frequency as once every five years, unless there are indications of contaminants or contaminant increases. Samples should be collected in late June when stream flows will have decreased enough to allow formation of good depositional areas for sediment sampling. (Note: Although this schedule does not coincide with maximum summertime use of the project area, it was selected to coincide with the end of the major runoff/loading period.) All samples should be collected from depositional areas upstream of tidal influence. This may require baseline measurements of salinity or conductivity to identify the extent of the “salt wedge” in each stream.

Aquatic macroinvertebrate abundance and diversity estimates provide an indirect measure of overall stream health and therefore can be good long-term indicators. Samples should be collected from riffle areas above the area of impact from tides, as described in the accompanying QAPP (Appendix A). Aquatic macroinvertebrate sampling could be scheduled to occur once every two years. Monitoring in mid to late spring (May or June) when these organisms are still in larval form is recommended.

LAKE MONITORING

Lake monitoring could be undertaken as short-term investigative efforts. Because lakes are highly variable in terms of depth, water sources, configuration, and concerns, an effective monitoring strategy would need to be lake specific. A minimal sampling approach for a lake might include monitoring one station near the middle of the lake and monitoring inflowing streams. At a minimum, monitoring should be done twice monthly during the June to September period. Lake station monitoring should include depth profiles of temperature, dissolved oxygen, pH, and specific conductance. The nutrients, total and soluble phosphorus and nitrate+nitrite, should be measured near the surface and bottom of the lake along with chlorophyll*a* measurements. Secchi disk depth and total water depth should also be measured. Measurements in the inflowing stream should include; total and soluble phosphorus, nitrate+nitrite, temperature, specific conductance, dissolved oxygen, and flow. In lakes that experience large algal blooms, routine checks for the presence of toxic cyanobacteria should also be considered.

A specific lake should be monitored over at least a two-year (two summers) period because of the wide variation in conditions that can occur between years. The key lakes in WRIA 16 that should be considered for this monitoring include Cushman, Kokanee, and Prickett.

Lakes often have a strong base of support from local residents and therefore lend themselves to monitoring by volunteers. There are many volunteer based lake monitoring programs. Some are simple and include just Secchi disk depth and total water depth measurements. Some include the collection of nutrient and chlorophyll samples from the near surface waters, since this can be done without the use of special equipment. Other programs include the entire gamut of measurements and measurement locations with all of the requisite training in equipment calibration and care. More discussion of volunteer monitoring considerations is included later in this report.

ROLES AND RESPONSIBILITIES

MONITORING

The identification of a lead agency that is responsible for implementing this monitoring plan and coordinating with other entities is critical to its success. In many areas, this responsibility lies with the County government, however a separate agency/entity could also be created to carry out these efforts. This does not imply that one agency or entity must perform all of the monitoring and evaluation, but it must at least coordinate and oversee the effort for the WRIA. In addition to overseeing the implementation of this plan, the lead agency could also be responsible to overseeing implementation of TMDL's or other efforts, and generally tracking monitoring efforts and the condition of the water resource. The final Watershed Plan for WRIA 16 should clearly identify the responsible agency.

Using the Skokomish Tribes monitoring efforts as a starting point, and assuming that it would continue and the data would be accessible to all stakeholders, the following outlines the additions/changes that would need to be made to implement this plan.

- The five stations not monitored by the Tribe would need to be monitored by some other entity. (It is also possible that Ecology could be contracted to include the upper river sites on the Duckabush and Skokomish into their ambient program.)
- Also, the Tribes program would need to be expanded to include the water quality parameters listed in this plan.
- Investigative monitoring because of its nature is best performed by a local agency. Mason County would probably be the best choice for the investigative effort described for the south shore of Hood Canal.
- No sediment monitoring for priority pollutants is currently being done in the WRIA and aquatic macroinvertebrates samples are not collected routinely. The addition of these elements would represent an expansion of existing efforts.

DATA MANAGEMENT AND ACCESSIBILITY

Data entry and QA of field and lab results should be done by the same person who performs the monitoring following the procedures outlined in Appendix A. However, the process of making the data accessible to the rest of the WRIA stakeholders could be performed by another agency. Initially, this could be in the form of distribution of data CD's on an "as requested" basis. However, over the long-term, a web-based approach such as used by Ecology and Thurston County is preferable. While there continues to be discussions on a State level of a web site that contains all State water quality data there has yet to be a process in place at Ecology for handling this. The data CD approach may be the appropriate level of effort until this process develops. By following Ecology's data management and entry methods outlined in Appendix A, the eventual transfer of the data to an Ecology maintained website will be smoother.

DATA EVALUATIONS

At a minimum the collected data should be used for regular reporting on the condition of WRIA 16 water resources. The report should provide range and mean values for the different seasons of interest, and a discussion for each water body on whether there are indicators of possible water quality problems or water quality standards violations. Pollutant load and yield calculations should be used to compare between streams and between stations in streams. As the data set increases the report should also include some assessment of possible trends in concentrations or pollutant yields.

RESOURCE NEEDS AND AVAILABILITY

No financial or human resources have been assigned to implementation of this monitoring strategy. Typically, monitoring strategies are developed to meet resource constraints, thus it is likely that the specifics of this strategy will be modified as the financial and human resources become available. The following is provided as a general summary of the resources that might be required for implementing this monitoring strategy.

EQUIPMENT

Implementation of this monitoring strategy would require; field meters (oxygen, pH, conductivity, turbidity, flow, temperature), personal gear (waders, field vests, field notebooks), other miscellaneous equipment, and access to an automobile. There is a wide range of costs associated with each of these items. Lake sampling would require different types of field meters, a mechanism for collecting water from below the surface, a boat, Secchi disk, and other miscellaneous equipment.

ANALYTICAL

Bacteria, nutrients (nitrate+nitrite and total phosphorus), BOD, and total suspended solids, all require laboratory support. A per station cost of approximately $140 should be appropriate for planning level estimates of analytical costs. This would be slightly higher for lake sampling to account for the additional nutrient and chlorophyll measurements. To monitor all 9 stations (2 of the 11 are monitored by Ecology) on a monthly basis would require approximately $17,000 per year, including QA costs. Priority pollutants analysis of sediments (approximately $500 per station) and aquatic macroinvertebrate sorting and identification (approximately $100 per station) also require laboratory support.

PERSONNEL

Each field monitoring event requires one field day (typically a 10 hour day) plus time for preparation, data QA, and data entry. This equates to approximately 16 hours per event. If a two-person crew were required for the fieldwork, those hours would increase to 26. This is in addition to time spent establishing gaging stations and doing other support tasks. Personnel time will also be required for database management and eventual reporting. The reporting element could range from a simple description of methods and table of results to a lengthy description of results by station, season, and year. Clearly, the cost for this effort is widely variable. At 16 hours per event and assuming 80 hours of annual reporting, the annual labor estimate is a minimum of 272 hours. (This does not include time spent setting up staff gages and conducting flow monitoring and other support activities.)

VOLUNTEER PROGRAMS

Development of a volunteer monitoring program may eventually be considered as a means of supplementing monitoring efforts. Volunteer programs can range from fairly simple efforts to complex monitoring schemes with rigorous training on protocols, QA, and even data evaluation. The advantages of a volunteer program also vary according to the program design. There are always at least two great advantages. The first is that there are more “eyes and ears” in the watershed and the second is that the people involved typically become strong advocates for water resource protection. However, it is commonly believed that these programs are free or low cost. This is not the case. Costs are incurred in training, recruitment, data management, and staff support for the program. The more rigorous the program the higher these costs are.

Volunteer programs like all monitoring programs must be designed to meet stated objectives. The following should be considered:

- The quality of data obtained is directly related to the training provided to volunteers. If professional quality data is desired, then training and data QA protocols must reflect that need. And, since volunteer turnover can be high, training sessions need to be scheduled at regular intervals.

- Recruitment of new volunteers also must be considered to keep the program going. (Recruitment often occurs through advertising of training events.)

- Volunteer programs require support staff to manage the program and to respond to volunteer's concerns. From an agency perspective, volunteer programs can fail if there is not adequate support from the agency to answer all of the questions and concerns that are generated by having more people in the field.

- Data management and reporting are also critical.

There are many resources for volunteer programs. The Streamkeeper's of Clallam County (2002) has an excellent volunteer monitoring program that could be used as a template. The program places much of the responsibility of monitoring into the hands of citizens, especially those areas related to volunteer recruitment and safety. The volunteer handbook details the specifics of each monitoring protocol, the safety issues surrounding stream monitoring, and recruitment opportunities for volunteers. The program includes annual reviews for changes in monitoring frequency, stream needs, and volunteer recruitment.

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APPENDIX A

WRIA 16 MONITORING STRATEGY

QUALITY ASSURANCE PROJECT PLAN

WRIA 16
SURFACE WATER QUALITY MONITORING STRATEGY QUALITY ASSURANCE PROJECT PLAN

The following plan describes specific procedures and methods that should be followed when implementing this monitoring strategy. These protocols were developed to help insure consistency in data collection and reporting and to enable the eventual development of a coordinated water quality database. It has been assumed in developing this QAPP that it will be implemented by a professional who has experience with standard protocols and methods for water quality monitoring. References for more detailed protocols are provided.

1.0 OVERVIEW OF PROJECT QUALITY OBJECTIVES

The following elements define the data quality objectives for the surface water quality monitoring and specify the methods used to evaluate them. Further detail on the use of these methods to evaluate the precision, bias is provided in Section 4.0, Quality Control Procedures.

- **Precision** is a measurement of the scatter in data due to random error and is stated in terms of percent relative standard deviation (RSD). Major sources of random error are the sampling and analytical procedures. The total precision of results can be estimated from the results of replicate samples. For laboratory analysis, precision will be assessed using laboratory duplicates. To assess precision in the field, water quality field replicates will be collected for at least 10 percent of the samples submitted for analysis.

- **Bias** is a measure of the difference between the result for a parameter and the true value due to systematic errors**.** Potential sources of bias include; (1) sample collection, (2) physical or chemical instability of samples, (3) interference effects, (4) inability to measure all forms of a determinant, (5) calibration of the measurement system, and (6) contamination.

  Previous studies pertaining to the sources of bias due to sampling have led to the recommended procedures currently in use. Thus, careful adherence to standard procedures for collection, preservation, transportation, and storage of samples will reduce or eliminate most sources of bias. Bias affecting laboratory measurement procedures will be assessed by the use of matrix spike recovery, method blanks, and check samples in accordance with the laboratory Quality Assurance (QA) Plan. Analysis of split samples will provide an estimate of overall sampling bias including variation in concentration due to sample heterogeneity. Matrix spikes are used to detect interference effects due to the sample matrix. An estimate of bias due to calibration is calculated from the difference between the check standard results and the true concentration.

- **Detection Limits** for the parameters to be analyzed for this project represent the measurement quality objectives.

- **Representativeness** is achieved by selecting sampling locations, methods, and times so that the data describe the site conditions that the project seeks to evaluate. The sampling design was developed to ensure the data are representative. Samples will be taken at the same location and at nearly the same time during the monitoring period. Samples will be collected systematically through entire monitoring period. Additionally, representativeness of the data is assured through definition of stream locations and qualifying conditions.

- **Comparability** will be maintained by ensuring usage of standard operating procedures when collecting and handling samples. Various reporting methods such as unit measures will be consistent between samplings and all sampling methods will be consistent with the standard procedures outlined in this report. Careful planning of fieldwork and methods will maximize the amount of accurate and comparable data. Designing each monitoring “tier” so that it can be accomplished in one field day or that up and down stream stations are monitored somewhat simultaneously also enhances comparability.

2.0 SCHEDULE

The monitoring schedule will be as follows:

- The Baseline monitoring will occur monthly including parameters of temperature, dissolved oxygen, pH, conductivity, flow, turbidity and FC bacteria. The nutrients (total phosphorus and nitrates+nitrites) and TSS would only be monitored during a few months in summer (July through September) and a few months during winter (November through February

- Stream gage data should be collected for each sampling event. However, actual in-stream flow measurements to support the gage data should be scheduled separately because of the extra time it takes to accurately measure flow and the limited time available in a typical field day. The goal should be to collect at least 5 low to moderate flow measurements and a 5 high flow measurements. A rating curve for low flow and channel forming flow can be established using this schedule.

- Priority pollutants and macroinvertebrates will be monitored during mid-spring on a bi-annual (once every two years) basis.

- Lake monitoring will occur during the summer months between June and September.

- The schedule for investigative monitoring will need to be developed to meet the objectives of the investigation.

3.0 DATA MEASUREMENT AND ACQUISITION

3.1 FIELD PREPARATION

The following field preparation practices provide the setting to develop quality data collection:

- Calibrate all field meters as per manufacturers specifications. (Note: The DO meter should be calibrated against the Winkler method.)
- Bottles should be collected, organized and labeled for sample collection including labeling of blind and replicate sample bottles.
- Equipment should be checked for damage and wear and tear. Additionally, an equipment checklist should be developed that lists all equipment needed and provides place to mark damage and date checked.
- A random quality assurance (QA) site should be selected prior to field collection. The same should be labeled as a blind sample.

3.2 FIELD PROCEDURES

During a field day the major priority is to make sure that everything is well documented through field notes. The following are some sample collection ground rules that should be adhered to.

- Prior to sampling at each stream site, the field staff will record the approximate temperature, weather, time, and date as well as provide a summary of weather conditions in the previous days. In addition, observations with respect to adjacent land use and flow conditions within the stream should be recorded.
- All sampling should be consistent. The field staff should maintain the same sampling method, collection location and equipment for each station. If a change is necessary, then appropriate documentation is required.
- Documentation of equipment used, problems incurred, batch sizes, calibration results, etc, should be recorded so that a permanent record is maintained.

Water Chemistry

Field Meters (temperature, pH, DO, specific conductance, turbidity)

A water quality probe will be held upstream from the entry point in stream for at least two minutes until measurements stabilize. Parameter measurements will be recorded on data sheets or in data logger, as will be site location, date and time. If temperature, DO, or pH results indicate that water quality standards are not met, additional measurements will be taken along the stream cross-section to evaluate the consistency and reliability of the result and determine its extent.

Grab Samples: (Nutrients, TSS, fecal coliform, E. coli, and BOD)
The analytical laboratory will provide sterile bottles and testing facilities. Samples should be collected by entering the water downstream of the sample site. Each sample bottle, except bacteria and those that may contain preservative, will be rinsed three times prior to sample collection and contamination minimized. Samples are collected by facing upstream, turning the bottle upside down and plunging it vertically through the water surface and then facing the bottle into the flow and slowly moving the bottle up and out of the water. Sample bottles should be labeled with sample number, date, time, sample type (i.e. nutrients, bacteria, etc) and location and logged onto a data sheet. Samples should be stored in an iced cooler until delivered to the laboratory for analysis.

Samples that Require Special Care: (Bacteria and DO)
Bacteria samples must be collected to minimize potential for contamination. Care must be taken to not touch the inside, edge or cap of the sterilized bottle when collecting the sample. Also, because bacteria collect on the surface film of the water, the method of sampling described above, which requires the bottle to be plunged quickly through the surface film, is very important.

Dissolved oxygen also requires special care. The probe and membrane are vulnerable to deterioration and contamination and results may "float" up or down over the course of a field day. Therefore the probe should be calibrated by collecting two samples each field day for verification by the Winkler method. Winkler samples must be collected into a special glass BOD bottle. Precautions must be taken to ensure the Winkler sample isn't aerated during collection and that no bubbles are trapped in the container.

Sediment Chemistry
Sediment samples will be collected for analysis of pesticides including organochlorine pesticides, chlorinated acid herbicides, priority pollutant metals and total organic carbon. The methods below will be used when collecting sediment samples at monitoring locations:

- Three discrete sediment grab samples will be obtained from each station using a Ponar-type sampling system. Each grab sample will be placed into a stainless steel bowl and observed for color, odor, and general soil characteristics. Once these observations have been made and recorded the contents of the bowl should be mixed with a stainless steel spoon until uniform in texture and appearance. The contents of this bowl will be transferred into an appropriately cleaned glass or Teflon jar and labeled. When a field replicate is required it should be collected as a subsample from the same bowl of homogenized sediment sample.

- After each stream is sampled, the equipment will be thoroughly washed with a non-phosphate detergent, rinsed with dilute acid and rinsed with DI water.

All sediment samples will be placed into individual four-ounce jars and labeled. Samples collected should be placed into a cooler on ice until they are delivered to the laboratory or can be put under more permanent refrigeration.

Aquatic Macroinvertebrates

The Department of Ecology procedures for benthic macroinvertebrate monitoring (*Benthic Macroinvertebrate Biological Monitoring Protocols for Rivers and Streams* (Plotnikoff and Wiseman, 2001) will be followed for all sampling. Below is a summary of the collection protocols described in Plotnikoff and Wiseman (2001). Only riffle habitat samples will be collected from each stream monitored.

- Macroinvertebrates will be collected from riffle habitats using a D-Frame kicknet (500 μm net mesh) sampling a streambed area of 0.19 m^2.
- Large substrate material will be removed and scrubbed and streambed agitated to stir aquatic macroinvertebrates into the water column for collection.
- All collected samples will be stored in ethanol filled containers. Replicate samples will be collected and stored in separate containers.
- All samples will be stored in 85% ethanol and labeled with stream name, location, habitat type (i.e., riffle), date, sample number and collector's name.

Flow Monitoring

Stream flow/discharge measurements are critical for assessing water quality trends. Flow should be measured at a suitable location within the designated reach. The most suitable locations are those within a fairly straight section of channel that is free of major obstructions and undercut banks. Flow monitoring sites should be selected to avoid areas of flow diversions, side channels, undercut banks, or other obstructions. A glide area with a "U" shaped channel that is free of obstructions typically provides the best conditions.

The most common procedure for measuring discharge is based on "velocity-area" calculations. Because velocity and depth can vary greatly across a stream, accuracy in flow measurement is achieved by measuring the mean velocity at many incremental distances over the cross-section of the stream (Figure 1). The standard is to measure flow at 20 places in the cross section. (Done by dividing the total stream width by 20 and using the result as the measurement interval).

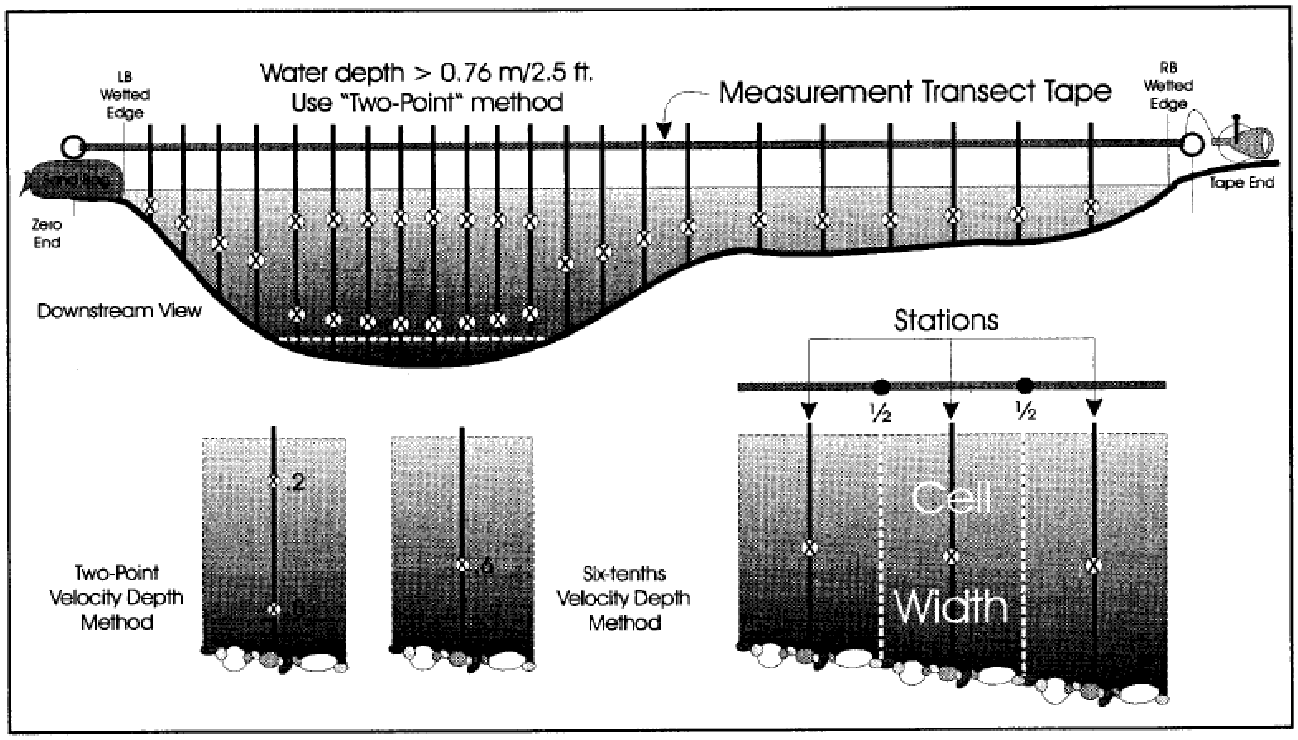
Velocity varies vertically at each point in the stream. Stream hydrologists have determined that in a stream segment that is less than 2.5 feet deep, the best estimate of average velocity occurs at 60 percent of the total depth. If a segment is greater than 2.5 feet deep, a velocity measurement should be taken at 20 and 80 percent depths and the average of these two values used to represent average velocity at that location.

Station number, stream name, and total stream width should be recorded for each flow monitoring station. Total water depth and depth of velocity measurement should be recorded as well as the velocity measured at each depth.

More detailed references for stream flow monitoring can be found in:

- TFW Monitoring Program Method Manual for Wadeable Stream Discharge Measurement (1999).
- Department of Ecology, Guidance for Conducting Water Quality Assessments (1989)
- Michaud, Joy P. A Citizen's Guide to Understanding and Monitoring Lakes and Streams (1991)

Figure 1: Cross section of stream showing tape position, depth and velocity measurement stations, and cell width boundaries. (TFW, 1999)



Lake Sampling

No specific lake monitoring program has been developed for WRIA 14 and therefore specific sampling methods and protocols cannot be provided. The analytical methods and detection limits provided in Table 2 are also appropriate for lake sampling as are the requirements for data QA and reporting. References for lake sampling protocols include:

- Michaud, Joy P. A Citizen's Guide to Understanding and Monitoring Lakes and Streams (1991).
- EPA, Volunteer Monitoring: A Methods Manual, Publication EPA440-4-91-002

3.3 LABORATORY PROCEDURES

Analytical parameters and methods, detection limits and units, preservation methods, and holding times for samples collected during monitoring are summarized in Table 2. The laboratory will take the lead on laboratory analysis and internal QA checks.

TABLE 2. Parameters and analytical methods.

Parameter	Method[1]	Matrix/Type	Detection Limit[2]	Holding Time
Total Suspended Solids	160.2	Water/Grab	1 mg/L	7 days
Phosphorous (total)	365.2	Water/Grab	0.01mg/L	28 days
Nitrate-Nitrite	300.0	Water/Grab	0.05 mg/L	28 days
Fecal coliform	APHA – 9222 D.	Water/Grab	0/100 mL	30 hours
E. coli	APHA - 9225	Water/Grab	0/100 mL	30 hours
Biochemical oxygen Demand (5-day)	405.1	Water/Composite	2 mg/L	48 hours
Organochlorine Pesticides	8081A	Sediment/Composite	Varies	14 days
Chlorinated Acid Herbicides	8151A	Sediment/Composite	Varies	14 days
Priority Pollutant Metals	6010B/7471A	Sediment/Composite	Varies	6 months
Total Organic Carbon	EPA 9060	Sediment/Composite	1 mg/L	28 days

(1) U.S. Environmental Protection Agency (EPA) Publications EPA/600/4-79-020, EPA/600/R-94-111, EPA/600/R-93-100, and SW-846. APHA Standard Methods, 1992.

(2) mg/L = milligrams/liter
μg/L = micrograms/liter

Aquatic macroinvertebrate samples will be analyzed by the following protocol summary from Plotnikoff and Wiseman (2001).

- Riffle habitat samples will be sub-sampled to a 500-organism count using a gridded tray.
- All major macroinvertebrates will be identified to genus level using suggested taxonomic keys located in Plotnikoff and Wiseman (2001).

4.0 QUALITY CONTROL PROCEDURES

Quality control samples will be collected for both and field and laboratory activities. Field quality control samples will include the collection of field replicate samples. Field replicates will be collected at a minimum frequency of 10 percent of samples. Laboratory quality control samples will include laboratory blanks, laboratory duplicates, matrix spikes, and laboratory control samples. These will be analyzed with a minimum frequency of 5 percent for each analytical parameter batch. The following field and laboratory quality control procedures apply to the entire data set for a given parameter measured during a specific laboratory "batch" are summarized as follows:

- **Field Replicates:** Field replicates are collected to represent field variation. These results are not used to make decisions to "accept" or "reject" data, however the data should be examined to assess variation and look for possible problems. Replicates should not be identified when submitted to the laboratory. Replicate results should be reported separately in the database, but the average of the two results will be used for data evaluation.

- **Laboratory Blanks:** The quality control objective for the laboratory blank is for a concentration less than the specified detection limit. If the blank concentration is greater than the field samples, the values will be rejected or re-analysis will be requested, unless the field samples are below the non-detectable limit. The laboratory QA Officer will review laboratory procedures and decide if samples should be re-analyzed if blank contamination is noted.

- **Laboratory Duplicates:** Laboratory duplicates are one sample that has been split into two containers. If both sample results are below laboratory detection limits, no evaluation of duplicates is required. If duplicates are within 20 percent relative percent difference (RPD) of their twin they are acceptable. For duplicate RPD values that are greater than 20 percent:

  - Since RPD criteria may be misleading at low concentrations, all data that exceed the 20 percent RPD value should be assessed to determine whether the concentration measured was within 5 times the Detection Limit. If this is the case, the data should be accepted without reservation.

  - RPD values that do not meet the above criteria but are less than 35% RPD should be considered for inclusion as an "estimated" value if all other lab QA for that parameter (i.e., blanks, detection limits, and matrix spikes) are acceptable.

  - Parameters with RPDs of greater than 35% should be considered for rejection.

- **Matrix Spikes:** The quality control (QC) objective for matrix spike percent recovery varies with the analytical method. For samples that show matrix spike recoveries outside the QC criteria, the sample results may be assigned data qualifiers or the sample may be re-analyzed. The laboratory QA Officer will be responsible for making initial determinations, but will include the information with the submitted data.

- **Quality Control Requirements**:

  - *Field QC Checks* - Data quality will be addressed with consistent performance of valid procedures documented in this plan. Sampling locations will be clearly established and proper calibration and maintenance of instruments, handling of samples and accurate recording of data will be applied. Data quality can be further checked with replicate sampling and adherence to standard procedures.

  - *Laboratory QC Checks* - The laboratory should maintain their own standard procedures and will follow according to laboratory certification regulation.

- *Data Analysis QC Checks* – All QA checks for data will be completed before the data is entered into the database.

- **Field Meter Calibration:**

  - Field personnel will routinely inspect equipment for damage and perform routine preventative maintenance and cleaning of field equipment based on manufacturers recommendations.

  - Conductivity Probes: These should be calibrated against a known standard at the beginning and end of the field day. The measured conductivity should be within 10% of the theoretical value.

  - Oxygen and Temperature Probe: At the beginning of the field day the probe should be calibrated according to the manufacturers instructions in water saturated air. (Some probes may require 15 minutes to equilibrate before calibrating.) The calibration should be performed as close to stream temperature as possible by using stream water to fill the calibration chamber prior to equilibration. Field results should be verified against wet chemistry analysis based on the Winkler method. Winkler results should be within 0.5 mg/L of the probe reading.

  - pH Probe: These probes should be calibrated following the manufacturers recommendations, preferably using two different calibration standards. Calibration should occur at the beginning and end of each field day and after the probe is turned off.

  - Turbidity: The probe should be calibrated by following manufacturers recommendations. Calibration should occur at the beginning and end of each field day. A 10% drift tolerance is acceptable.

5.0 DATA MANAGEMENT PROCEDURES

Field staff will fill out chain of custody forms with date, time, sample and location. Copies will be retained for the project files following submittal of samples. The laboratory will send water quality data directly to the designated Task Manager with a narrative of QA/QC results and discussions of any discrepancies. Established databases of water quality data will be spot-checked (recommend 10% cross-checking by a different person) for erroneous data entry. Laboratory water quality reports and case narratives will be included as an appendix in the reports.

A good information management system will allow easy access, sharing, and manipulation of data by all potential users. Rather than creating a specific database for the WRIA, it is recommended that Ecology's Environmental Information Management (EIM) system be followed. Using the EIM protocol and format has at least two advantages: First, utilizing an existing well-established database saves resources and second, if Ecology does begin to accept and manage all water quality data the data entry and format will already be consistent. A third advantage is that Ecology staff are typically available for technical support.

The EIM essentially consists of three data submittal forms that describe the study, location, and result data. Ecology maintains a website that contains information on methods and rationale for inputting data into EIM, (http://www.ecy.wa.gov/services/as/iip/eim/index.html). This website also contains a data submittal page with downloadable Excel® based templates and help documents. It is strongly recommended that the help section be reviewed before using the templates, especially since there are some limitations based on which version of Excel is being used.

Consistent implementation of the data management system is critical when it comes to data sharing and eventual analysis. For this reason appointment of a data steward is recommended. The steward should work for an entity that is part of the data gathering process, and have a vested interest in the maintenance of good data. The steward's job would be to maintain the main data set; including checking data formatting and general QA/QC, as well as act as the liaison with Ecology's EIM manager.

6.0 REFERENCES

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