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State of Washington

Quality Assurance Project Plan

Quilcene-Snow Watershed Planning Area Assessment of Gaged Streamflows by Modeling

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Each study conducted by the Washington State Department of Ecology (Ecology) must have an approved Quality Assurance Project Plan. The plan describes the objectives of the study and the procedures to be followed to achieve those objectives. After completing the study, Ecology will post the final report of the study to the Internet.

This Quality Assurance Project Plan is available on Ecology's website at https://fortress.wa.gov/ecy/publications/SummaryPages/1303107.html

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Quality Assurance Project Plan

Quilcene-Snow Watershed Planning Area Assessment of Gaged Streamflows by Modeling

April 2013

Approved by:

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Signatures are not available on the Internet version.
SEA: Shorelands and Environmental Assistance
SWRO: Southwest Regional Office
EA: Environmental Assessment

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Abstract

The Washington State Department of Ecology (Ecology) is proposing a study during winter 2013 to evaluate Ecology streamflow monitoring gages in the Quilcene-Snow watershed planning area in western Washington State. The study area covers Water Resource Inventory Area (WRIA) 17 outside of the Sequim Bay watershed.

To predict flows at Ecology stations, regression-based streamflow models will be developed and applied. The quality of all computer modeling tools applied will be evaluated, and recommendations will be made for possible use of the models for water management by Ecology, other agencies, and local stakeholders.

Background

Overview of the Watershed

The project study area (Figure 1) is the Quilcene-Snow watershed planning area, which consists of WRIA 17 not including the Sequim Bay Watershed. (The portion of WRIA 17 in the Sequim Bay watershed is included in the Elwha-Dungeness watershed planning area.) The descriptions of the basin in this section are summarized from the WRIA 17 Stage 1 Technical Assessment (Parametrix, et al., 2000), and from the Watershed Management Plan for the Quilcene-Snow Water Resource Inventory Area (Cascadia Consulting Group, 2003).

Water Supply and Watershed Planning

Watershed planning first started in the Quilcene-Snow watershed in 1991, with the development of the Dungeness-Quilcene Plan. The plan was in place by 1994 and addressed water conservation, public education, fisheries, instream flows, water quality, and water for growth.

In 1998 the Washington legislature passed RCW 90.82 which created a statewide watershed planning program. The Quilcene Snow (WRIA 17) planning unit began working together in 1999, building on previous watershed planning under the Chelan Agreement pilot program in 1991. Jefferson County is Lead Agency for Watershed Planning under RCW 90.82 in WRIA 17. The Watershed Management Plan was adopted by the Quilcene Snow Planning Unit in 2003.

In 2010 the Planning Unit changed its name to the East Jefferson Watershed Council (EJWC, www.ejwc.org/) to better reflect its scope, focus, and geography. A variety of other planning documents have been published over the years. In 2011 the EJWC published an updated Watershed Management Plan and Detailed Implementation Plan. Although formal planning unit meetings are no longer being held, the EJWC currently has 16 members including Ecology, Jefferson County, the City of Port Townsend, Jefferson Public Utility District, the Port Gamble S'Klallam Tribe, the Skokomish Tribe, and ten non-governmental organizations.

In addition to the EJWC, the Hood Canal Coordinating Council (HCCC, http://hccc.wa.gov/) has been active in issues related to streamflows and fish habitat in the Quilcene-Snow watershed planning area. The HCCC serves as the salmon recovery organization for the Hood Canal Salmon Recovery Region (http://www.rco.wa.gov/salmon_recovery/regions/hood_canal.shtml). The EJWC and HCCC coordinate their work on salmon recovery.

Geography

The Quilcene-Snow watershed planning area includes about 625 square miles (1620 square kilometers) in the northeast Olympic Peninsula in Washington State (Figure 1). WRIA 17 includes many rivers and creeks that drain into the Strait of Juan de Fuca, Admiralty Inlet, Hood Canal and associated bays and harbors. The most significant of these streams are the subject of this study and are discussed below.

Elevations range from sea level to 7,756 feet (2364 meters) at Mount Constance. Higher elevation areas are forested, while low elevation valley bottoms are pasture. About 27,000 people live in the planning area, with the center of population in Port Townsend.

Climate

WRIA 17 experiences the Pacific Northwest maritime climate, with cool, wet winters and mild, dry summers. The Olympic Mountains affect the precipitation regime strongly. The rain shadow area in the northern basin receives rainfall of 15 to 20 inches annually (380 to 510 millimeters). Rainfall increases with elevation, with Olympic Mountain foothills to the west receiving 70 to 80 inches annually (1800 to 2000 millimeters).

Hydrology and Water Use

The highest elevation areas, which feed the Big and Little Quilcene Rivers, experience significant snowpack in the winter. Snow and Salmon Creeks drain areas of moderate elevation that experience transient snowpack. The rest of the streams in the study area drain areas of lower elevation which are rainfall-dominated.

The largest diversions of surface water are from the Big and Little Quilcene Rivers for the City of Port Townsend and the Quilcene National Fish Hatchery. Average annual water use by the City was reported to be 17.9 cubic feet per second (cfs) from the Big Quilcene River and 4.1 cfs from the Little Quilcene River, which represent about 7 to 8 percent of the annual flow. The hatchery is entitled to a water right of 15 cfs from the Big Quilcene River at all times, and can withdraw up to 40 cfs, provided flows are maintained in the bypass reach. Another 20 to 40 cfs is allocated to other users. Allocations in the Big Quilcene River total about twice the summer low flow. Actual water use and the percent of use during summer low flows are uncertain.

Groundwater resources are concentrated in areas with alluvial deposits. Many areas have shallow bedrock and therefore limited aquifer storage. The Watershed Plan estimated an annual groundwater recharge of 140,659 acre-feet and an estimated consumptive use of groundwater at 9,940 acre-feet (less than 10 percent of recharge).

Land Ownership and Land Use

About 70 percent of the study area is privately owned, with 20 percent federal and 10 percent state lands. Forestry is the predominant land use in about 40 percent of the basin. Rural residential is the second largest land use. Commercial and industrial use is concentrated around Port Townsend, and the Navy has an installation on Indian Island.

Streamflow Gages and Models

Streamflow Measurement

Ecology has historically operated 8 flow monitoring stations in the study area (Figure 1, Table 1 and www.ecy.wa.gov/programs/eap/flow/shu_main.html). These stations consist of:

- Five active *telemetry* gages where real-time data is provided.
- One historical staff gages where *manual stage-height* readings were collected infrequently (at least once per month) from a staff gage and converted to instantaneous flow values.
- Two historical gages where multiple years of *continuous* data were collected.

At all stations, direct measurements of streamflow discharge are taken on a regular basis. These measurements and direct stage-height readings are used to develop rating curves for determining flow from stage-height data.

The Ecology stations that will be analyzed in this study are shown in Table 1. All active and historical stream gages have sufficient data and will be included. One current and one historical flow gaging station are located on Jimmycomelately Creek, which are not included in this study. Although Jimmycomelately Creek is in WRIA 17, it is managed as part of the Elwha-Dungeness watershed planning area and was analyzed in a previous study of that area (Pickett, 2012).

The United States Geological Survey (USGS) has gaged streamflow in WRIA 17 and in neighboring basins at a variety of sites historically and currently (USGS, 2009):

- One active USGS stations in WRIA 17 and two active gages in neighboring basins are listed in Table 2. One station is “real time” (same telemetry), while the other two are “non-real time” (non-telemetry continuous – data usually lags by several months from collection to posting).
- Five historical USGS stations in WRIA 17 with continuous flow have no data after 1994 and will not be used for this analysis.

Table 1. Ecology flow monitoring stations in the Quilcene-Snow watershed planning area (WRIA 17).

ID	Station Name	Code	Status	Type[1]	Proposed Control Station?	Start	End	No. days	Comment
17A060	Big Quilcene R. near Mouth	BigQ-ECY	Active	T	Yes	10/26/1999	11/13/2012	3646	MSH only 10/26/1999 - 9/25/2001
17D060	Little Quilcene near Mouth	LilQ	Active	T	Yes	8/21/2002	11/17/2012	3665	
17G060	Tarboo Creek near Mouth	Tarboo	Active	T	Yes	4/10/2003	11/17/2012	3208	
17B050	Chimacum Creek near Mouth	Chim	Active	T	Yes	4/10/2003	11/17/2012	3276	
17E060	Snow Creek at WDFW	Snow	Active	T	Yes	8/21/2002	11/17/2012	3388	
17F060	Salmon Ck. at West Uncas Rd.	Salmon	Historical	C	Yes	10/31/2002	9/29/2012	3508	Former telemetry station
17H060	Thorndyke Creek near Mouth	Thorn	Historical	C	Yes	10/1/2003	9/30/2010	2277	Former telemetry station
17J050	Pheasant Creek at Mouth	Pheas	Historical	MSH	-	4/29/2003	4/22/2008	205	

[1] T = Telemetry; C = Continuous; MSH = Manual Stage Height

Table 2. USGS flow monitoring stations in and adjacent to the Quilcene-Snow watershed planning area (WRIA 17).

ID	Station Name	Code	Status	Type[1]	Proposed Control Station?	Start	End	No. days
12048000	Dungeness River near Sequim	Dung	Active	RT	-	10/1/1999	11/17/2012	3596
12054000	Duckabush River near Brinnon	Ducka	Active	NRT	-	10/1/1999	9/30/2011	3596
12052210	Big Quilcene River below Diversion near Quilcene	BigQ-GS	Active	NRT	-	10/1/1999	10/16/2012	3596

[1]RT = Real time (Telemetry); NRT = Non-real time (Continuous)

Streamflow Patterns

To compare flows at gages in the watershed, Figures 2 through 7 show the characteristics of flow at the 11 Ecology and USGS stations that will be used in this study.
Figures 2, 4, and 6 show the distributions of flows at flow monitoring stations during ten complete years: November 2002 through October 2012. Figures 3, 5, and 7 show time series of flows for the entire period of record for Ecology gages and from December 1, 1999 to November 17, 2012 for the USGS gages. Note that for the time series, the Y-axis scale is logarithmic; this deemphasizes the difference between high and low flows.

- Flows for the largest rivers – the Dungeness, Duckabush, and Big Quilcene Rivers – are shown in Figures 2 and 3.
  - Peak flows can exceed 1,000 cfs while low flows can drop below 100 cfs.
  - The range of flows, as measured by the ratio of the 95th percentile to the 5th percentile flows, is almost twice as wide for the Duckabush and Big Quilcene Rivers as for the Dungeness River.
  - Flows in the Duckabush and Dungeness Rivers appear to have a stronger spring snowmelt signal than the Big Quilcene. This may be because the Big Quilcene has the smallest watershed. But also, as compared to the Big Quilcene watershed, the watershed above the Dungeness gage has a higher average elevation, while the Duckabush watershed receives higher average precipitation.
- Flows for the Little Quilcene River and for Chimacum, Salmon, and Snow Creeks are shown in Figures 4 and 5.
  - Peak flows in these streams rarely exceed 100 cfs, while low flows may drop below 10 cfs. Low flows in Salmon Creek are particularly low.
  - Flows vary more widely between high and low flows in Salmon and Snow Creeks than in Chimacum Creek or the Little Quilcene River.
  - A moderate spring snowmelt peak can be seen for some years in the Little Quilcene time series, and a weaker snowmelt signal in Snow Creek, suggesting a mixed rain-snow regime. Little snowmelt is evident in Chimacum and Salmon Creeks, which are likely rain-dominated.
- Flows for Pheasant, Tarboo, and Thorndyke Creeks are shown in Figures 6 and 7.
  - Flows in Tarboo and Thorndyke Creeks rarely exceed 30 cfs. Pheasant Creek is generally below 10 cfs, although because this is a staff gage the data are less representative of the true distribution.
  - Thorndyke Creek has a much more stable flow regime, suggesting significant groundwater sources during low flow conditions.
  - These three streams are rain-dominated, as evidenced by the absence of a snowmelt signal.

Instream Flow Rule

The WRIA 17 Quilcene-Snow Watershed Plan made recommendations for the management of future water supplies and stream flow for many of the rivers and streams in the planning area. In November 2009, Ecology adopted Chapter 173-517 WAC, the instream flow rule for the Jefferson County portion of the Quilcene Snow, WRIA 17.

Regulatory instream flows were set at specific *control stations* throughout the basin, with seniority set by the date of rule adoption. When water flow at a control station decreases to the rule's flow levels, water users with more junior (newer) appropriations cannot diminish or negatively affect the regulated flow and may have to stop diverting or provide mitigation. The gages addressed by this study designated as regulatory control stations are identified in Table 1.

Implementation of the instream flow rule is now proceeding. Details about the rule and its implementation can be found in Ecology reports from 2009 and 2012 (listed in References) and at http://www.ecy.wa.gov/programs/wr/instream-flows/quilsnowbasin.html.

Project Description

Goals and Objectives

The goals of this project are to:

1. Develop computer modeling tools that can estimate streamflows in the Quilcene-Snow watershed planning area for each Ecology flow monitoring station.
2. Assess the ability of computer modeling tools to support Ecology and other agencies as well as members of the East Jefferson Watershed Council and other local stakeholders in their water management activities in the basin.
3. Support Ecology in making decisions about use of its flow gaging resources statewide.

To meet these goals, this project has the following objectives:

1. Develop statistical and simple hydrologic models that can predict streamflows at Ecology flow monitoring stations in the study area based on relationships with active long-term USGS flow stations or other Ecology flow stations.
2. Assess the quality of the results of the modeling tools developed for objective 1.
3. Provide support in determining a long-term approach to flow discharge assessment that combines direct monitoring of stage height with modeling approaches, thus allowing the total number of flow monitoring stations using continuous stream gage measurements to be reduced.
4. Identify any data gaps found in the modeling analysis and, if warranted, recommend more complex modeling approaches that might reasonably improve the use of models for flow discharge assessment.
5. Provide training and technology transfer of project products to Ecology staff and local partners.

Model Development

The first study objective will be met by an analysis of (1) the streamflow records for the gages in the study area and (2) other relevant information such as geographical, geological, or meteorological data. The planned approach is to first select *reference stations*, such as active long-term USGS flow stations and to then predict flow data at Ecology stations (*study stations)* from one or more of the reference stations. Based on the results of the analysis, one or more Ecology flow stations may also be selected as a reference station.

Several methods will be explored for this analysis, including:

- Simple linear regression or correlation with data transformations such as log-transformation.
- Areal flows (discharge per watershed area) and drainage area ratios.
- Time-lagging of data.
- Hydrograph separation by baseflow and by season.
- Inclusion of meteorological, geographical, and other non-hydrologic data to adjust predictive equations.

This list is provided roughly in order from the simplest to the most complex approach. The analysis will begin with the simplest approach and will only progress to more complex approaches depending on:

- The quality of the results from the simpler approach.
- Whether the available data support a more complex approach.
- The time available in the project schedule to pursue a more complex approach.
- The potential use of the modeling tools.
- The priority of the station to local stakeholders and Ecology.

Simple correlations will be used as the starting point to choose reference stations. Correlations were developed[1] between continuous flow time series from the Ecology and USGS stations (Table 3). This initial analysis shows how some gages appear to correlate well, while others will have much poorer relationships.

Reference stations for this analysis will be selected from stations with the closest statistical relationship to each study station. Typically four reference stations will be selected from the stations with the strongest correlations, also taking into account geographic and topographic similarities. Fewer reference stations may be selected if the first two or three produce high quality regression-based models.

In most cases the following modeling approaches will be used:

- A simple linear regression or power regression (equivalent to linear regression of log-transformed data) of the study gage time series to the reference gage time series.
- Separation of the two time series by a baseflow threshold, and linear or power regressions for the baseflow and non-baseflow data.
- Separation of the baseflow and non-baseflow data sets into summer (warm season) and winter seasons, and linear or power regressions for the four data sets.
- Linear or power regressions for three data sets: summer baseflow, summer non-baseflow, and winter flows.
- Linear or power regressions for three data sets: summer baseflow, winter baseflow, and non-baseflows for the entire year.

The quality of each modeling approach will be evaluated and the approach with the best quality metrics will be selected.

[1]The Correlation analysis tool was used from the Excel® Analysis ToolPak.

Table 3. Correlations between flows from gages in the Quilcene-Snow watershed planning area.

*Coefficient colors and font size emphasize strongest correlations (**blue** = greater than or equal to 0.9, **green** = between 0.80 and 0.89, **red** = between 0.70 and 0.79).*

Station colors and footnotes are explained in the legend (upper right). Station ID defined in Tables 1 and 2.

	BigQ-ECY	*Chim*	*LilQ*	*Snow*	*Tarboo*	*Salmon**	*Thorn**	*Pheas**	*Dung*	*Ducka+*
Chim	0.66									
LilQ	**0.88**	**0.77**								
Snow	**0.82**	**0.82**	**0.93**							
Tarboo	**0.77**	**0.80**	**0.85**	**0.81**						
Salmon*	0.69	**0.79**	**0.80**	**0.88**	**0.73**					
Thorn*	**0.71**	0.54	**0.76**	**0.76**	**0.85**	0.59				
Pheas*	0.41	0.44	0.52	0.49	0.50	0.41	0.04			
Dung	**0.75**	0.28	0.53	0.46	0.32	0.38	0.43	0.26		
Ducka+	**0.87**	0.37	0.63	0.54	0.53	0.44	0.52	0.34	**0.85**	
BigQ-GS+	**0.97**	0.54	**0.81**	**0.73**	0.64	0.60	0.64	0.38	**0.84**	**0.91**

ECY-Telemetry

ECY-Continuous

ECY-Manual Staff

USGS

Potential Control Station

* **Historical gage**

\+ **Not real time**

Model Quality Assessment

Best practices of computer modeling should be applied to help determine when a model, despite its *uncertainty*, can be appropriately used to inform a decision (Pascual et al., 2003).

Specifically, model developers and users should:

1. Subject their model to credible, objective peer review.
2. Assess the quality of the data they use.
3. Corroborate their model by evaluating how well it corresponds to the natural system.
4. Perform sensitivity and uncertainty analyses.

The study will follow this approach to meet the fourth study objective of assessing the quality of model results.

Study results will undergo a technical peer review by a designated Ecology employee with appropriate qualifications. Review of the study by Ecology staff, local stakeholders, and the public will also ensure quality.

Practices 2 through 4 above are addressed through *Model Evaluation.* This is the process for generating information over the life cycle of the project that helps to determine whether a model and its analytical results are of a quality sufficient to serve as the basis for a decision. Model quality is an attribute that is meaningful only within the context of a specific model application. Evaluating the uncertainty of data from models is conducted by considering the models' accuracy and reliability.

Accuracy Analysis

Accuracy refers to the closeness of a measured or computed value to its *true* value, where the *true* value is obtained with perfect information. Due to the natural heterogeneity and random variability of many environmental systems, this *true* value exists as a distribution rather than a discrete value.

In this project, accuracy is determined from measures of the *bias* and *precision* of the predicted value from model results, as compared to the observed value from flow measurements on the assumption that measured flows are closer to the *true* value. The known precision and bias of flow measurement values will also be taken into account in interpreting results.

Bias describes any systematic deviation between a measured (i.e., observed) or computed value and its *true* value. Bias in this context could result from uncertainty in modeling or from the choice of parameters used in calibration.

Bias will be inferred by the precision statistic of relative percent difference (RPD)[2]. This statistic provides a relative estimate of whether a protocol produces values consistently higher or lower than a different protocol. Bias will be evaluated using RPD values for predicted and observed pairs individually and using the median of RPD values for all pairs of results.

RPD =

$$\frac{(P_i - O_i) * 2}{(P_i + O_i)}$$

where:

P_i = i^{th} prediction
O_i = i^{th} observation

The RPD was chosen over other measures of bias because of the wide range in flows found in hydrologic records. Using residuals or mean error would tend to underemphasize predictive error during critical low-flow periods and overemphasize error during the highest flows. On the other hand, percent error tends to overemphasize error for low flows. RPD provides the most balanced estimate of error over a wide range of flows.

Precision of modeled results will be expressed with percent relative standard deviation (%RSD). Precision will be evaluated using this statistic for predicted and observed pairs individually and using the mean of values for all pairs of results.

The %RSD presents variation in terms of the standard deviation divided by the mean of predicted and observed values.

%RSD = (SD_i * 200) / (P_i + O_i), where
SD_i = standard deviation of the i^{th} predicted (P_i) and observed (O_i) pair.

Percent error measures have been selected for assessment of accuracy because of the wide range of values expected in the flow record. Uncertainty in flow measurements is usually reported as a percentage; the same approach is being adopted for flow modeling.

[2] RPD commonly uses the absolute value of the error, but a formulation without an absolute value is used in this report to retain the sign, which indicates the bias of the predicted value relative to the observed value.

Reliability Analysis

Reliability is the confidence that potential users have in a model and its outputs, such that the users are willing to use the model and accept its results (Sargent, 2000). Specifically, reliability is a function of the performance record of a model and its conformance to best available, practicable science. Reliability can be assessed by determining the robustness and sensitivity.

Robustness is the capacity of a model to perform equally well across the full range of environmental conditions for which it was designed and which are of interest. Model calibration is achieved by adjusting model input parameters until model accuracy measures are minimized. Robustness will then be evaluated by examining the quality of calibration for different seasons and flow regimes. The variation between accuracy measures for model results from different seasons and flow regimes provides a measure of robustness of model performance.
Sensitivity analysis is the study of how the response of a model can be apportioned to changes in a model's inputs (Saltelli et al., 2000). A model's sensitivity describes the degree to which the model result is affected by changes in a selected input parameter. Sensitivity analysis is recommended as the principal evaluation tool for characterizing the most- and least-important sources of uncertainty in environmental models. Uncertainty analysis investigates the lack of knowledge about a certain population or the real value of model parameters.

Quality Characterization

The uncertainty and applicability of model results will be assessed by evaluating model *quality* results for all flows and for summer baseflow conditions. The median %RSD value will be used for comparison for each model at each station within the season or range of flow measurements being considered. Terminology similar to the following will be used to describe model results:

Median %RSD for annual streamflow and summer baseflow	Characterization
Less than 5%	Excellent
Greater than 5% and less than 10%	Good
Greater than 10% and less than 20%	Fair
Greater than 20%	Poor

Flow Gaging Assessment

Project objectives 3 and 4 will be accomplished by evaluating the results of the model assessments described above. Each flow monitoring study station will have a preferred modeling approach identified and an evaluation of the quality of the model. That evaluation will include a recommendation for the gage at each station, based on the quality of the model and redundancy of flow information with other gages.

This information will be provided to Ecology staff and local stakeholders to support decisions about allocation of resources for flow gaging. The overall process of assessing both Ecology's and local stakeholders' needs for gaging information will occur as a separate process on a parallel track.

Possible recommendations for use of the Ecology flow monitoring stations resulting from this project could include:

- Continuing operation of the gage as a telemetry gage with full Ecology support.
- Decommissioning the station and using modeling to assess flows at the site, combined with spot-flow measurements for confirmation of modeled flows.
- Transferring the station to another party.
- Continuing operation of the gage as a telemetry gage with cooperative funding from stakeholders.

As a result of the analysis, data gaps may be identified that limit the ability to use modeling tools to estimate streamflows. Recommendations for potential changes in data acquisition to fill these gaps will be made where warranted.

In addition, if the analysis in this study points towards other, more complex, models that could improve the quality of flow estimation, recommendations will be made for using those models in possible future work.

Project Report and Public Involvement

During the course of the project, internal review, input, and guidance will be provided by Ecology's Gaging Strategy Workgroup and other Ecology staff identified in the Organization and Schedule section below. Input from local partners and the public during the project will be through members of the East Jefferson Watershed Council and the Hood Canal Coordinating Council. The form and timing of input during the project will be determined by the project and client leads.

A project report will present the results of the study. Review of the draft report will be the primary mechanism for providing input to the final conclusions and recommendations.

Training and Technology Transfer

Project objective 5 will be achieved by providing (1) modeling tools to interested parties through the internet or other means and (2) presentations and training to Ecology staff and local partners. The timing and content of presentations and training during this project will be determined through consultation with project clients and responsible staff and groups.

Organization and Schedule

Table 4 lists the people involved in this project. All are employees of the Washington State Department of Ecology. Table 5 presents the proposed schedule for this project.

Table 4. Organization of project staff and responsibilities.

Staff	Title	Responsibilities
Cynthia Nelson SEA Program, SWRO Phone: (360) 407-0276	Regional Client	Provides internal review of the QAPP, approves the final QAPP, and reviews the project report. Serves as regional program point of contact.
Bill Zachmann SEA Program Phone: (360) 407-6548	Client, Statewide Watershed Coordinator	Clarifies scopes of the project. Reviews and approves the QAPP. Reviews the project report.
Brad Hopkins Freshwater Monitoring Unit, EAP Phone: (360) 407-6686	Client, Manager of Ecology's Flow Monitoring Network	Clarifies scopes of the project. Provides internal review of the QAPP and approves the final QAPP. Reviews the project report.
Robert F. Cusimano Western Operations Section, EAP Phone: (360) 407-6698	Section Manager for EAP Client and Study Area	Reviews the draft QAPP and approves the final QAPP. Reviews the project report.
Paul J. Pickett MISU, SCS, EAP Phone: (360) 407-6882	Project Manager/ Principal Investigator	Writes the QAPP and report. Organizes, analyzes, and interprets data. Develops model and analyzes quality of data and model.
Karol Erickson MISU, SCS, EAP Phone: (360) 407-6694	Unit Supervisor for the Project Manager	Reviews and approves the QAPP. Reviews and approves the project report. Approves the budget and tracks progress.
Will Kendra SCS, EAP Phone: (360) 407-6698	Section Manager for the Project Manager	Reviews the project scope and budget. Reviews and approves the QAPP. Reviews the project report.
William R. Kammin Phone: 360-407-6964	Ecology Quality Assurance Officer	Reviews and approves the draft QAPP and the final QAPP.

QAPP: Quality Assurance Project Plan
SEA: Shorelands and Environmental Assistance
EAP: Environmental Assessment Program
SWRO: Southwest Regional Office
MISU: Modeling and Information Support Unit
SCS: Statewide Coordination Section

Table 5. Proposed schedule for completing field and laboratory work, data entry into EIM, and reports.

Final report	
Author lead	Paul Pickett
Schedule	
Draft due to supervisor	April 2013
Draft due to client/peer reviewer	April 2013
Draft due to external reviewer(s)	May 2013
Final due to Publications Coordinator	June 2013
Final report due on web	July 2013

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Figures

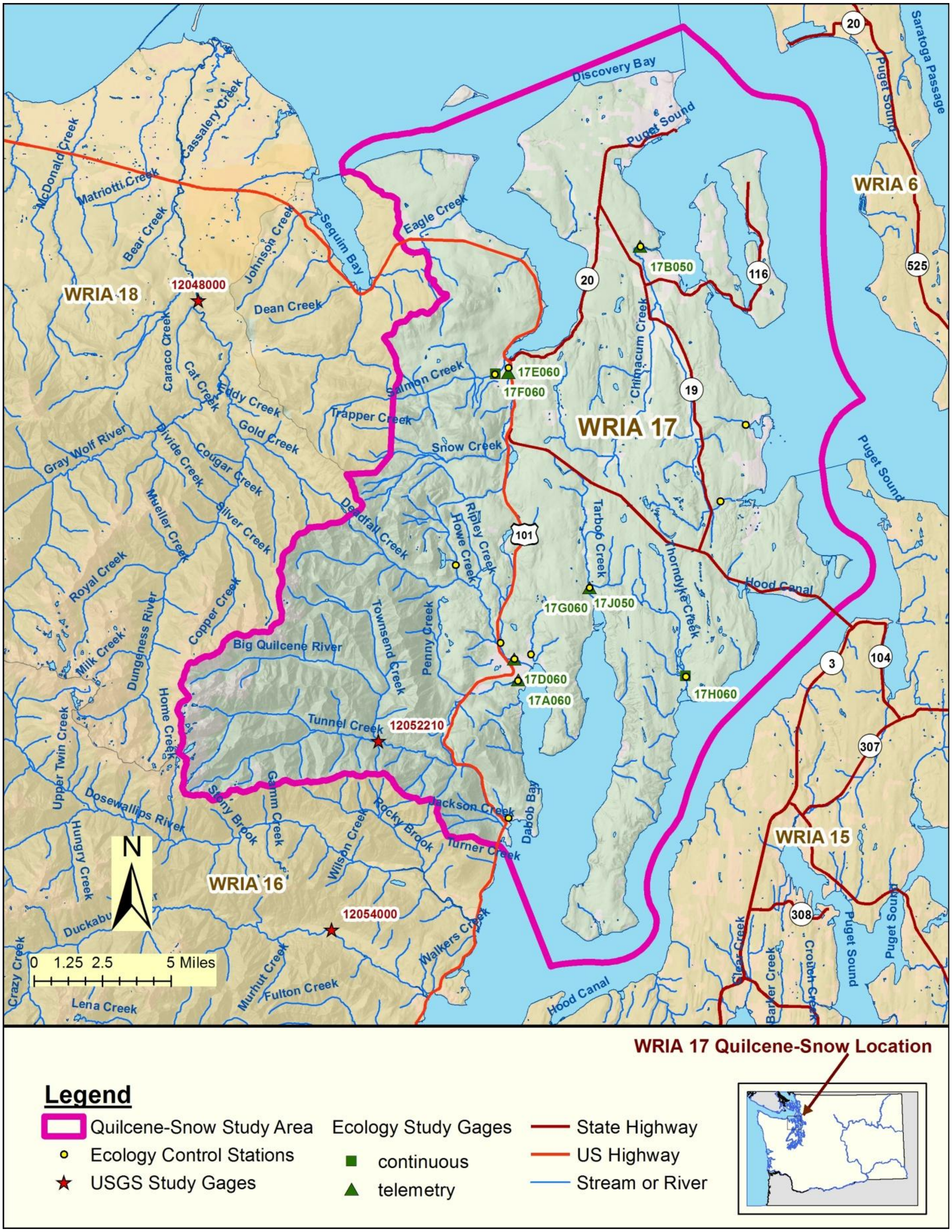

Figure 1. Quilcene-Snow watershed study area.

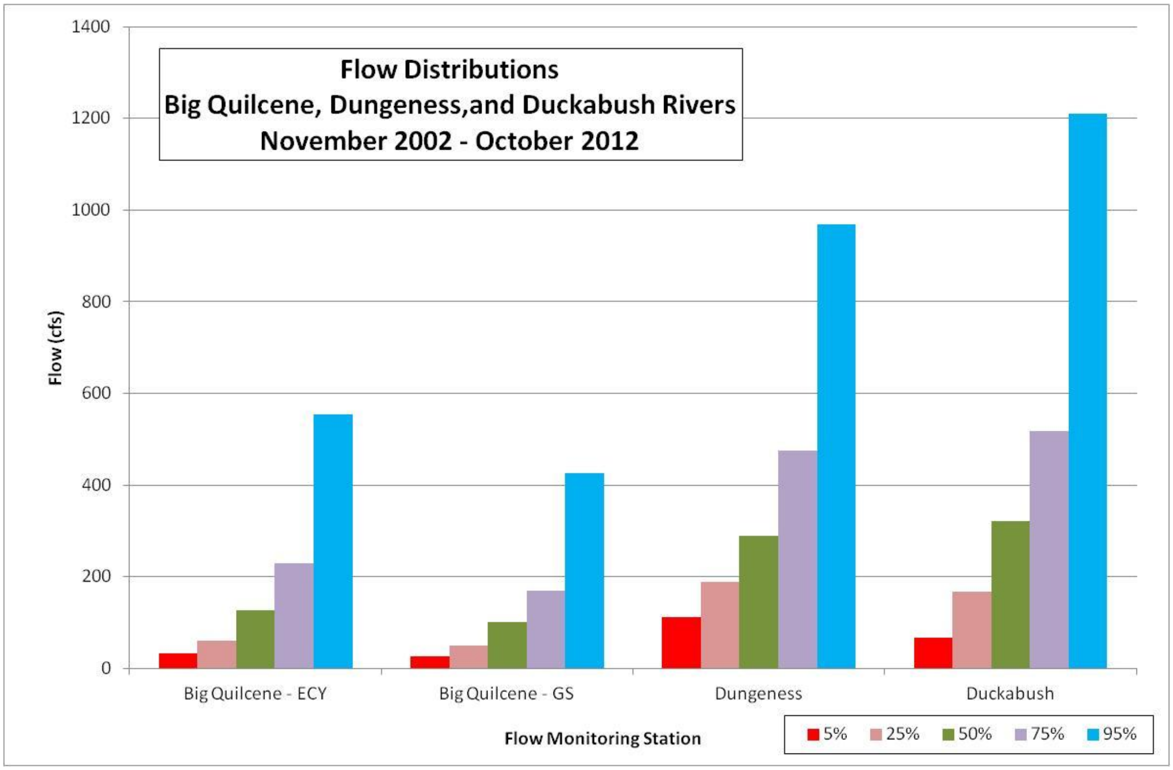

Figure 2. Flow distributions for Big Quilcene, Dungeness, and Duckabush River gaging stations.

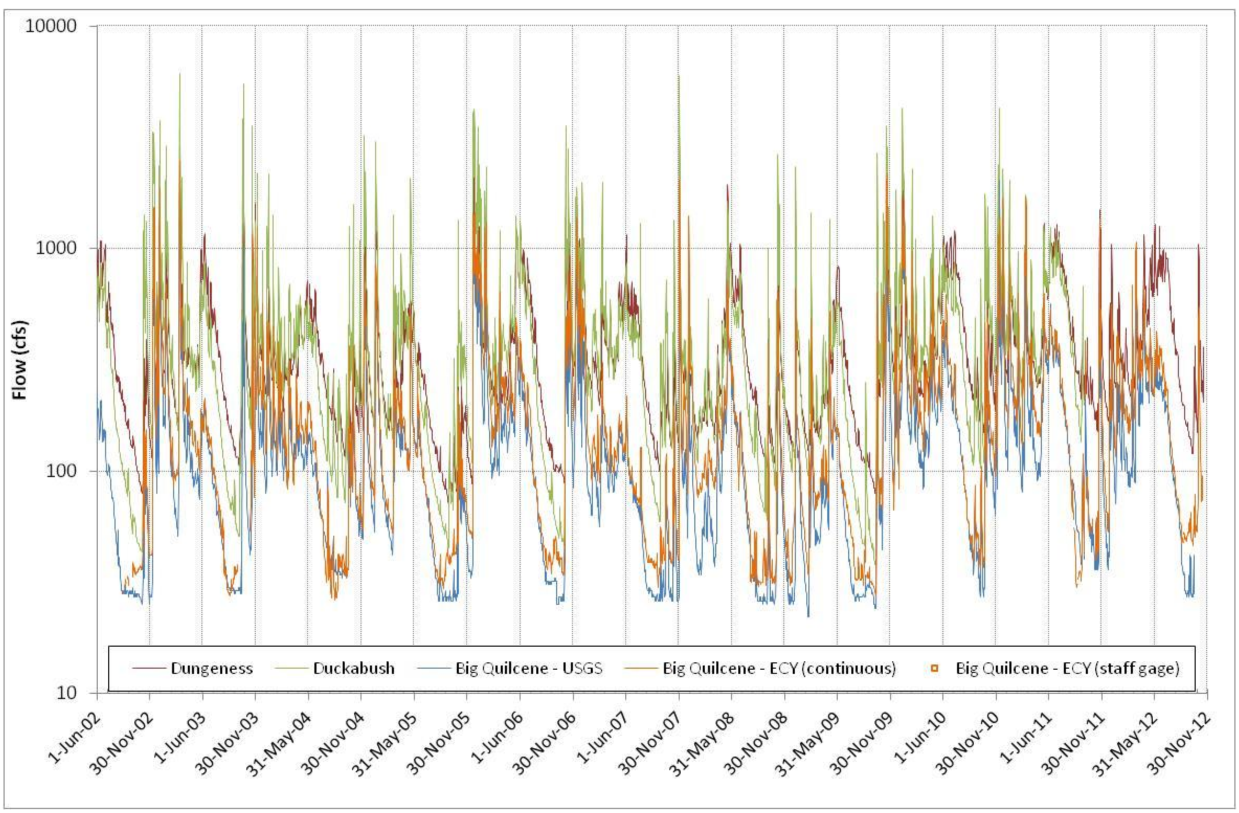

Figure 3. Flow at Big Quilcene, Dungeness, and Duckabush River gaging stations.

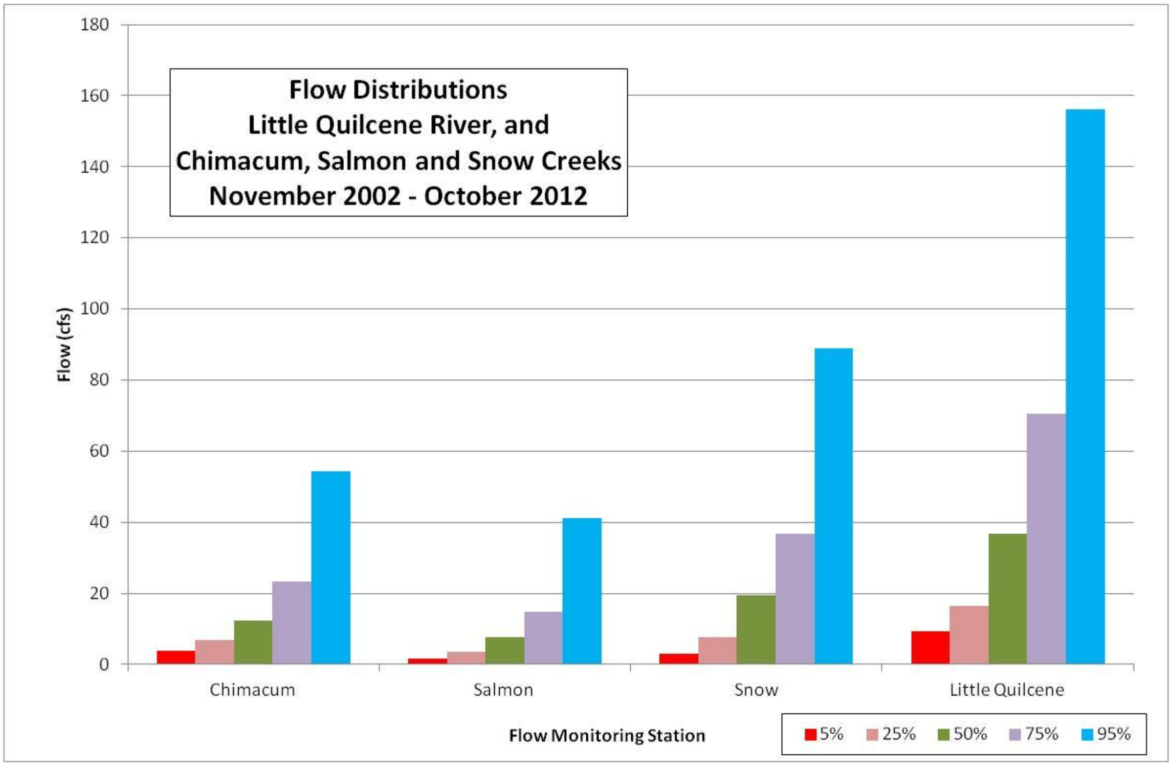

Figure 4. Flow distributions for Little Quilcene River, and Chimacum, Salmon, and Snow Creek gaging stations.

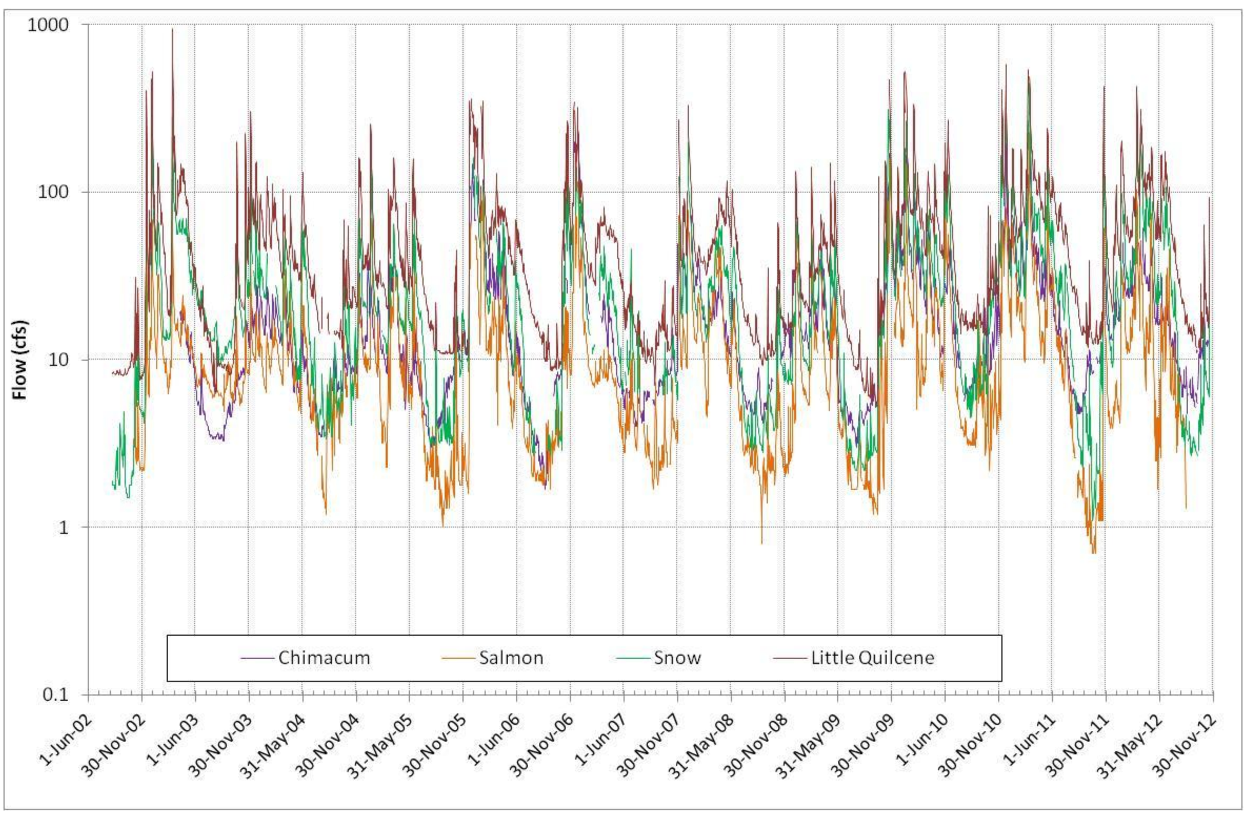

Figure 5. Flow at Little Quilcene River, and Chimacum, Salmon, and Snow Creek gaging stations.

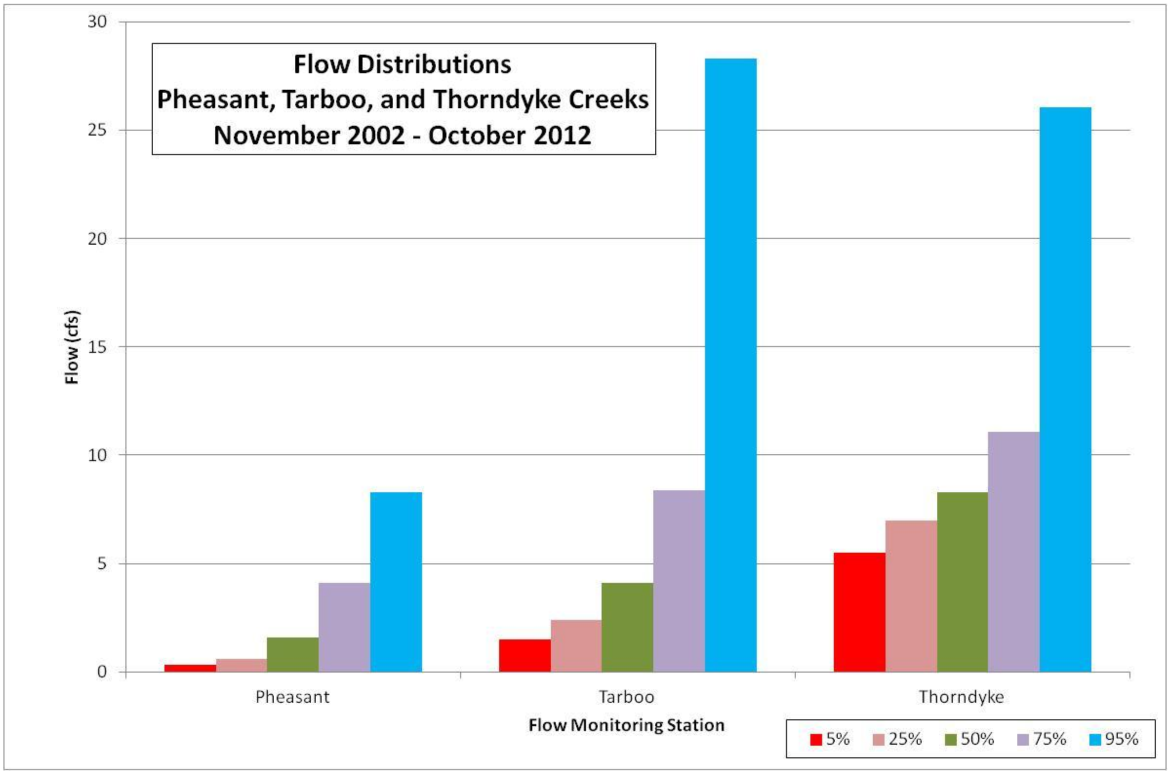

Figure 6. Flow distributions for Pheasant, Tarboo, and Thorndyke Creek gaging stations.

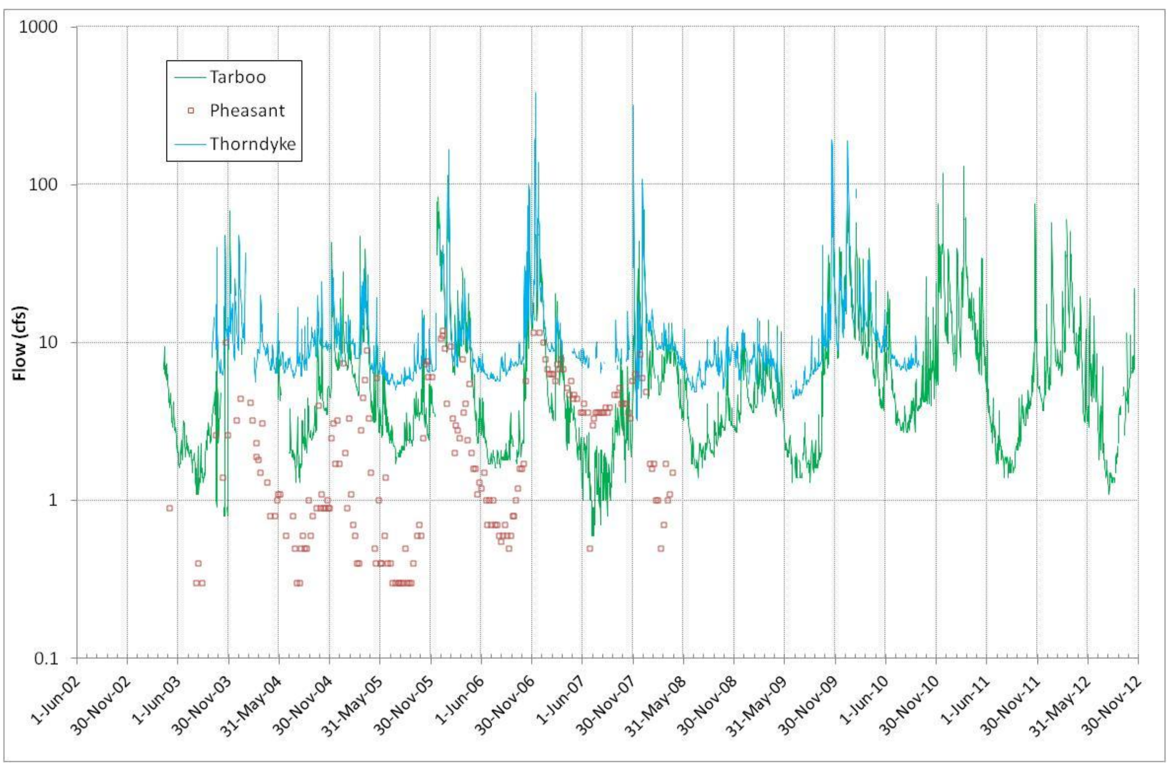

Figure 7. Flow at Pheasant, Tarboo, and Thorndyke Creek gaging stations.

Appendix. Glossary, Acronyms, and Abbreviations

Glossary

Acre-feet: A volume of water equivalent to one acre of surface area multiplied by one foot of depth.

Areal flow: Surface water discharge per unit of watershed area, in units of length per time (for example, inches per day).

Baseflow: The component of total streamflow that originates from direct groundwater discharges to a stream.

Control Station: A location on a stream or river where regulatory instream flows are set by rule in a watershed, with a seniority date set by the date of rule adoption.

Hydrologic: Relating to the scientific study of the waters of the earth, especially with relation to the effects of precipitation and evaporation upon the occurrence and character of water in streams, lakes, and on or below the land surface.

Parameter: A physical chemical or biological property whose values determine environmental characteristics or behavior.

Reach: A specific portion or segment of a stream.

Stage height: Water surface elevation from a local datum.

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snowmelt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Streamflow: Discharge of water in a surface stream (river or creek).

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and water courses within the jurisdiction of Washington State.

Telemetry: The automatic transmission of data by wire, radio, or other means from remote sources.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Water year (WY): An annual period defined by hydrologic characteristics. The water year used in this study is October 1 through September 30, and the number of the year represents the calendar year at the end of the water year. For example, WY 2010 describes the water year beginning October 1, 2009 and ending September 30, 2010.

90th percentile: A statistical number obtained from a distribution of a data set, above which 10% of the data exists and below which 90% of the data exists.

Acronyms and Abbreviations

Following are acronyms and abbreviations used frequently in this report.

%RSD	Percent relative standard deviation
Ecology	Washington State Department of Ecology
EJWC	East Jefferson Watershed Council
GIS	Geographic Information System software
HCCC	Hood Canal Coordinating Council
No.	Number
RCW	Revised Code of Washington
RM	River mile
RPD	Relative percent difference
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WRIA	Water Resource Inventory Area
WY	Water Year

Units of Measurement

^oC	degrees Centigrade or Celsius
cfs	cubic feet per second, a unit of flow discharge
ft	feet
in/d	inches per day
mm	millimeters