A Department of Ecology Report

Procedures for Evaluating the Department of Ecology's Statewide Flow Gaging Network

Abstract

The Washington State Department of Ecology's Gaging Strategy Workgroup was established in 2008. One of its goals is to develop a statewide strategy for the agency's streamflow measurement network.

This report describes some of the challenges in reaching that goal, and documents the procedures that have been developed to make decisions about the flow gaging network. These decisions can include establishing new stations, decommissioning or transferring existing stations to third parties, changing flow assessment methods for stations, establishing partnerships for cooperative funding or operation of gages, or prioritizing grant funding to support stations.

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Background

Over the last several decades, the Washington State Department of Ecology's (Ecology's) Environmental Assessment (EA) Program has been building the capacity to do high quality streamflow monitoring. Staff gages and continuous monitoring with pressure transducers and data-loggers have been used in water quality studies for many years. Beginning in 2002, the legislature funded the EA Program to develop and implement a statewide flow monitoring network to support watershed planning under Chapter 90.82 RCW and other water management initiatives.

As a result, over 200 flow gaging stations have been installed around the state over the years. These have included staff gages, continuous measurement with data-loggers, and near-real-time continuous monitoring with telemetry. Many of these stations were concentrated in watersheds with active watershed management programs. There are currently 113 active stations statewide (https://fortress.wa.gov/ecy/wrx/wrx/flows/regions/state.asp).

Early on, EA management recognized that flow gaging resources would need to be reallocated as statewide priorities changed. In the last few years, financial pressures have resulted in a greater emphasis on setting priorities for a reduced flow gaging network in a climate of declining resources. In either case a rational process is needed to evaluate gages, set priorities, and allocate resources to the statewide gaging network.

A long-term goal for Ecology is to have an agency strategy for statewide flow gaging and assessment. Such a strategy would logically be part of a greater water management strategy. However, for a variety of reasons Washington has no "State Water Plan". Water policy in Washington is controversial and dynamic. Every year sees legislative debate and action that at times adds new legislative direction and authority, but more often fails to find consensus and clarify policy. In this complex context, a comprehensive water management strategy remains elusive.

For example, here are some of the questions regarding water management that would need clear resolution in order to determine a statewide gaging strategy:

- What are Ecology's statewide priorities for managing water?
- What does 'managing water' really mean to the agency?
- What are the agency's priorities and schedule for developing new or amending old instream flow rules, and for implementing existing and future instream flow rules?
- Within any given basin, who ultimately make the final decisions on which kinds of water management needs will be addressed?
- How do we assess flow for managing instream flows at control points established by rule, or at other specific places to protect instream resources and protect senior (surface) water rights? Where would we want gages for direct real-time flow measurement, and where could models or other assessment tools suffice?

In addition, it is becoming clear, after conducting detailed gage network evaluations in several basins, that most watershed plan implementation goals or water management activities are very watershed specific. Gaging 'needs' are often influenced by or dependant on the desires of individual interest groups involved in watershed plan development and implementation. At times there is also disagreement between Ecology staff in both headquarters and regional offices regarding local stream gaging strategies, gage density in basins, and gage decommissioning. These circumstances have made the development of a statewide stream gaging strategy a challenging task.

Even though a statewide water strategy has yet to be clearly described, Ecology has established strategic goals and policy objectives for water management, which are implemented through commitments and investments made in specific projects and programs. These established agency goals and objectives can be linked to scientific information and identified state and local needs to make rational and practical decisions about how resources are used for flow monitoring.

By developing analytical tools and working through specific challenges, progress has been made on creating a process for making decisions on the state's flow monitoring network. This process allows for the collection of information and setting of priorities on a case-by-case basis by accessing the science and policy knowledge of the agency.

Roles and Responsibilities

Water Advisory Group

Ultimate decision-making resides with the Water Advisory Group (WAG), which consists of Ecology's Program Managers for the EA, Water Resources (WR), Water Quality (WQ), and Shorelands and Environmental Assistance (SEA) Programs. Other WAG members include all four Ecology Regional Directors, the Special Assistant for Water, the Director of Governmental Affairs, and the Chief Financial Officer. The WAG establishes all agency policy and overarching statewide strategies regarding water management.

Gaging Strategy Workgroup

In August 2007 WAG directed the EA Program to form a cross-program agency workgroup to develop a statewide stream gaging strategy to answer the questions or address the needs noted below:

1. Why we are supporting gages at current locations and do we need to continue?
2. Where can we move existing lower priority gaging resources to address higher priority needs?
3. Where do we need to install and manage new gages (not to replace a gage at a current site, but to install a gage at a new location)?
4. Update language in watershed plan implementation grant applications involving stream gaging.
5. Develop/implement guidance on how to evaluate requests for gage installation and operation through the 90.82 watershed grant application process.

In the spring of 2008, the Gaging Strategy Workgroup (GSW) was formed. The GSW is led by the EA Program and includes technical staff from the EA, WR, WQ, and SEA Programs. GSW also includes staff from the State Department of Fish and Wildlife, who seek to ensure that the priorities set will be protective of fish. The GSW meets several times a year to review staff analyses, discuss policy and prioritization issues, and develop recommendations to WAG for decision. GSW meetings, discussions, and interim products often include regional staff, and tools developed by the GSW include the involvement of local watershed groups. The GSW is currently chaired by the EA Western Operations Section manager, Bob Cusimano.

One purpose of the GSW is to establish a process for evaluating and setting priorities for existing gages. This includes identification of gage locations that are a lower priority for agency funding. In these cases the gages can often be decommissioned and moved to other sites, or left in place and turned over to local partners who can assume operation and maintenance needs. Other options include conversion of the gage to seasonal use, or establishing partnerships with cooperators who can assume part of the funding or labor to support the gage.

The GSW has also developed updated grant application language for watershed plan implementation whenever stream gaging activity was proposed. This new content was included in the last several biennial rounds of grant requests. This enabled a better process for evaluating stream gaging grant requests.

Statewide Flow Monitoring Network

The direct management of flow gaging stations is conducted by EA Program staff across the state. This work is coordinated through the Stream Hydrology Technical Coordination Team (SH-TCT), which consists of staff engaged in this work. The SH-TCT management representative is currently the EA Freshwater Monitoring Unit supervisor, Brad Hopkins. Tasks include installing equipment, directly measuring flow, developing rating curves, surveying and calibrating equipment, quality assurance procedures, processing data, maintaining software for data analysis, and posting streamflow information to the worldwide web.

Regional Staff and Management

The management of water “on the ground” typically occurs in the regional offices by staff from the WR, WQ, and SEA Programs. These employees have the experience and knowledge necessary to understand how flow gaging data are used and what Ecology’s day-to-day needs are for flow information. They are also the primary contacts for discussions with local stakeholders.

Each region also has a Water Resource Management Team (WRMT), which includes the Regional Director and the managers of the WR, WQ, and SEA regional sections. The Regional WRMT plays a critical role in coordinating water management in the region and advising WAG on regional positions and needs.

Other Agency Staff and Management

The WR Program's Program Development and Operations Support Section plays a lead role in statewide water resources management. Two staff from this section are members of the GSW, and the section manager Brian Walsh is a key program contact for policy.

The WR Program also manages a recurring item in the Capital Budget called the *Watershed Plan Implementation and Flow Achievement* proviso. This proviso funds efficiency improvements to public water supply and delivery systems such as irrigation districts and municipal infrastructure, and funds the development of water banks and exchanges. The fund can also be used to purchase and install streamflow gages or groundwater monitoring equipment.

Bill Zachmann is the SEA Program's statewide coordinator for watershed plan implementation. He is staff to the WAG, is a member of the GSW, and has oversight on watershed grants based on the Operating Budget, including those that support local governments to manage streamflow gaging projects.

Paul Pickett is an environmental engineer in the EA Modeling and Information Services Unit. He is also a member of the GSW and is the lead for modeling assessments of flow gages by watershed.

Flow Gaging Station Review Procedures

There are two tracks by which flow gaging stations are reviewed: a statewide review, and a modeling assessment study.

Statewide Review Process

A statewide review is conducted as part of annual budgeting and planning cycles. This review is triggered by three events:

- New gages proposed as part of the annual EA Program planning process in the winter and spring of each year.
- Direct funding of the statewide gaging network as identified in Ecology's budget for the fiscal year, usually available annually in the late summer to early fall.
- Funding of flow gaging stations through watershed grant funding, also identified in the fiscal year budget available each summer.

Gages are usually managed according to a 'water year', which starts October 1 and ends the following September 30. However, other factors can influence the timing of gage management decisions, such as the need to deploy, maintain, or retire gages due to specific on-site needs and conditions or to budgetary and fiscal constraints.

The statewide review process relies on questions developed by Ken Dzinbal, Bill Zachmann, and Brad Hopkins (see Appendix B). The goal of the questions is to identify site-specific gaging needs and synthesize those needs into a statewide priority list for gaging stations.

The development of this priority list begins with the answers to 14 questions:

1. Has this river or stream been gaged before?
2. Have instream flows on the river and stream been established in a state regulation?
3. Do formal agreements exist that require the continued Operations and Maintenance (O&M) of this gage (water sharing)?
4. If instream flows are not established, how far off is the planned date for setting them?
5. Is this gage needed to implement an adopted Watershed Plan under RCW 90.82?
6. Are there Total Maximum Daily Load (TMDL) activities on this river or stream?
7. Should water quality be added to this gage?
8. Are there Endangered Species Act (ESA) listed fish in this river or stream?
9. Is this gage needed to monitor climate-related trends?
10. Would this gage help provide flood warning?
11. A flow model exists or could be developed to manage water in place of this gage?
12. What are the current funding sources for on-going gage O&M?
13. Would the local planning group be willing to provide support for the O&M of the gage?
14. What are the impacts if this gage is discontinued?

These questions are linked to a priority policy or strategic goal for the agency, or to practical considerations that increase or lower the importance of Ecology's commitment of resources to the gage. Each potential answer is assigned a point score, which can be totaled for a combined score for the station.

The following steps (also summarized in Table 1) are used to evaluate gaging needs statewide using the questions above:

1. SH-TCT[1] management representative: Develops a list of gages for review. (This would usually be a statewide list of existing gages. However the list could also include gages proposed by the annual planning process, or could be a subset of only grant-funded gages.)
2. SH-TCT management representative: Distributes questions to designated regional staff most knowledgeable about existing gages or gage needs in a given watershed. (This will usually be either a designated Watershed Lead or staff from the WR Program. The Regional WRMT can help identify the appropriate person.)
3. Regional lead: Answers questions from the agency's perspective.
4. Regional lead: Distributes the questions and coordinates answers with local stakeholder groups and other individual input.
5. SH-TCT management representative: Collects the answers and tabulates the scores. (Follow-up discussions will occur to evaluate scores that are unusually high or low. Also, the GSW or other knowledgeable staff may review the answers to help ensure that they are accurate and comparable.)

[1] Stream Hydrology-Technical Coordination Team

6. SH-TCT management representative: Lists the gages under consideration in order of the scores by region. (Available resources will be compared to the list to determine a cut-off line for gages to keep or discontinue.)
7. GSW: Reviews the list. A meeting may be scheduled for discussion, and key staff from the regions may be included in the discussion for gages where controversy exists.
8. SH-TCT management representative: Distributes the draft prioritized list to the Regional WRMT for comment. (Further discussion may occur to fine-tune the priorities.)
9. Regional lead: Coordinates public comment on the list, once internal review of the prioritized list is completed. (The most effective approach is for the regional leads to distribute the list to their stakeholder contacts for their review and comment.)
10. SH-TCT management representative: Finalize the list after public comments are evaluated.
11. GSW: Reviews final list and approves as recommendations to WAG.
12. SH-TCT management representative: Send list to WAG for their endorsement.

Table 1. Stepwise summary of gage review responsibilities.

Step No.	SH-TCT management representative	Regional staff	Gaging Strategy Workgroup (GSW)
1	Develops gage review list		
2	Sends questions to Regional Lead		
3		Answers questions from regional perspective	
4		Coordinates answers to questions from stakeholder groups	
5	Collects and tabulates answers		
6	Ranks gages by scoring order		
7			Reviews prioritized list
8	Sends list of priority gage sites to WRMTs		
9		Coordinates public review	
10	Finalize list		
11			Approve prioritized list as recommendation to WAG
12	Send list to WAG for approval		

Modeling Assessment Study

Watersheds with a large number of gages may be identified for a special modeling assessment study. A project plan for this activity was developed and is attached in Appendix C. Since May 2008, modeling assessment studies have been completed for the following Water Resource Inventory Areas (WRIAs):

- Entiat River Basin (WRIA 46)
- Nooksack River Basin (WRIA 1)
- Walla Walla River Basin (WRIA 32)
- Wenatchee River Basin (WRIA 45)

A study is currently underway for the Elwha-Dungeness Planning Area (WRIA 18 and Sequim Bay watershed in WRIA 17).

The following watersheds have studies planned for 2011-2012:

- Middle Snake Planning Area (WRIA 35)
- Quilcene-Snow Planning Area (the rest of WRIA 17)

These studies evaluate flow gaging stations in a basin by developing regression-based models for each Ecology gage, and in some cases for U.S. Geological Survey flow gaging stations funded by Ecology. The models are based on other reference gages in the basin using power or linear relationships and a hydrograph separation method. The quality of these regressions was assessed using statistical tools.

Recommendations are made regarding the discontinuation or retention of the gages based on study results. Other options include shared funding of a gage or transfer of the gage to another party. Using the questionnaires described earlier, the needs of the state and of local partners for this flow information are evaluated and compared to the quality of the models to determine whether direct flow measurements or models are adequate to meet those needs.

The schedule of modeling assessment studies for each year is determined during the annual planning process.

Conclusions and Recommendations

A comprehensive strategy for flow gaging is difficult to articulate when Ecology's statewide vision and mission for water management is subject to political debate and is affected by unprecedented funding challenges. Many legitimate stream gaging questions are posed in circumstances that indicate a variety of answers, some of which are aligned with current strategies and some of which are unanswered by existing policy.

However, it is possible to link a decision-making process for a statewide flow monitoring network to existing agency strategic goals and policy objectives. A procedure has evolved over time that ensures those linkages occur in a practical way.

Two pathways are available for decision-making on flow gaging stations.

1. Questions were developed and used to allow a broad assessment of gaging needs, both within the agency and among stakeholders. A process has been described for collecting information internally and externally to set gage station location and duration priorities.

2. The second pathway is an intensive study of a watershed with a high concentration of flow gaging stations. Regression-based models can be developed for gages in a watershed and the quality of those models assessed. The results of this analysis then triggers further evaluation with the questionnaire and a decision-making process similar to the first pathway.

These procedures will continue to be assessed and adapted as they are applied. Although not a strategy per se, these procedures are a practical method to make decisions consistent with agency policy objectives and needs for water management.

Appendix A: Glossary, Acronyms, and Abbreviations

cfs	Cubic feet per second
EA	Environmental Assessment
Ecology	Washington State Department of Ecology
ESA	Endangered Species Act
GSW	Gaging Strategy Workgroup
O&M	Operations and Maintenance
RCW	Revised Code of Washington (state laws)
SEA	Shorelands and Environmental Assistance
SH-TCT	Stream Hydrology Technical Coordination Team
TMDL	Total Maximum Daily Load
U.S.	United States (of America)
WAG	Water Advancement Group
WQ	Water Quality
WR	Water Resources
WRIA	Water Resource Inventory Area
WRMT	Water Resource Management Team

Appendix B: Example of Flow Gaging Station Questionnaire

Stream Gaging Questionnaire

WRIA	Station Name
00	*Test station*

Question 1 — Have instream flows on the river and stream been set in rule?

- ***Yes*** • ***No***

a) Will this gage help facilitate water management schemes (e.g., writing permits, interruptible water rights)?

- ***Yes*** • ***No***

b) What is the regional priority for managing water within this river or stream at this gage?

- ***High*** • ***Medium*** • ***Low*** • ***No Action Planned***

c) Number of interruptible water rights within this river or stream than are associated with this gage?

- ***0-10*** • ***11-20*** • ***21-50*** • ***>50***

d) What is the quantity of water within this river or stream that has interruptible water rights that are tied to this gage?

0-10 cfs • ***11-20 cfs*** • ***21-50 cfs*** • ***>50 cfs***

Question 2 — Do formal agreements exist that require the continued O&M of this gage (e.g., water sharing, trust water rights, purchases, reserve)?

- ***Yes*** • ***No***

a) Amount of water involved?

- ***< 1%*** • ***2-5%*** • ***6-10 %*** • ***>10 % of total flow***

Question 3 — If instream flows are not established, how far off is the planned date for setting them on this river system?

1-2 years • ***2-4 years*** • ***> 4 years***

a) Is a temporary gage needed to determine flows for rule setting?

- ***Yes*** • ***No***

b) The hydrograph for this gage needs to cover which flow ranges?

- ***Low flow only*** • ***Full range***

c) How long will you need flow information from this gaging station?

- ***1 season (3-6 months)*** • ***1 year*** • ***1-3 years*** • ***3-5 years***

Question 4 Is this gage needed to implement an adopted Watershed Plan under RCW 90.82?

- ***Yes • No***

a) Stream gaging information will be used for the following

- ***Yes • No*** Set/achieve instream flow rules.
- ***Yes • No*** Permit writing
- ***Yes • No*** Comparing existing flows to historical values
- ***Yes • No*** To better understand baseflow conditions
- ***Yes • No*** Total Maximum Daily Load (TMDL) development and implementation
- ***Yes • No*** Flow adjusting water quality information for trend detection
- ***Yes • No*** Flood warning
- ***Yes • No*** Climate change

Question 5 Are there TMDL activities on this river or stream?

- ***Yes, TMDL Complete & Approved • Yes, but TMDL pending approval • No***

a) Is stream flow at this location identified in the plan as a key parameter for this TMDL?

- ***Yes • No***

b) What is the regional priority for this TMDL on this river and stream?

- ***High • Medium • Low***

Question 6 Should water quality be added to this gage?

- ***Yes • No***

a) Which parameters should be added?

- ***Yes • No*** Dissolved oxygen
- ***Yes • No*** Temperature
- ***Yes • No*** Turbidity
- ***Yes • No*** Conductivity
- ***Yes • No*** Threshold sequential water quality samples
- ***Yes • No*** Other

b) What is the funding source for this activity?

- ***Local Commitment • Ecology Commitment • Active grant proposal from Ecology or local funding. • No funding commitments***

Question 7 Are there ESA-listed fish in this river or stream?

- ***Yes • No***

a) If yes, how many ESA populations?

- ***Only 1 • 2-4 • >4***

b) If yes, how many fall with the listed ESA population status categories?

Depressed • ***None • Only 1 • 2-4 • >4***
Threatened • ***None • Only 1 • 2-4 • >4***
Endangered • ***None • Only 1 • 2-4 • >4***

c) Is flow a limiting factor in the ESA recovery plan?

- ***Yes • No***

Question 8 Is this gage needed to monitor climate-related trends?

- ***Yes*** • ***No***

a) How long will gaging be required?

- ***1-5 years*** • ***6-10 years*** • ***>10 years***

b) This gage measures flow on a system that falls into which of the following hydrologic classifications?

- ***Rain Dominant*** • ***Transient Snow*** • ***Snow Dominant***

Question 9 Would this gage help provide flood warning?

- ***Yes*** • ***No***

If yes, which of the following applies? (Only a or b can be answered "Yes", not both.)

- ***Yes*** • ***No*** a) Stage only values would be acceptable.
- ***Yes*** • ***No*** b) Stage information needs to be converted to CFS.
- ***Yes*** • ***No*** c) Station would only be active seasonally (Nov-Apr).

Question 10 Based on current and historic gages and the hydrology of the river or stream, can modeled flows be used to manage water in place of this gage?

- ***Yes*** • ***No***

a) What degree of model uncertainty is acceptable?

- ***<5%*** • ***5-10%*** • ***10-20%*** • ***20-25%*** • ***>25%***

b) What level of model verification would be acceptable?

- ***Only after major flood events*** • ***Only as flows drop below a certain preset low flow point*** • ***At least 1-2 times annually*** • ***More than twice per year***

Question 11 What are the current funding sources for on-going gage O&M?

- ***Local commitment*** • ***Ecology commitment*** • ***Active grant proposal from Ecology or local funding*** • ***No funding commitments***

Question 12 Would the local planning group be willing to provide support for the O&M of the gage if Ecology were no longer able to do so?

- ***Yes*** • ***No***

a) This local O&M support would come in what form?

- ***Locals would look for someone other than Ecology to operate the gage***
- ***Locals would provide funding to Ecology to cover the O&M costs***
- ***Locals would share duties with Ecology (locals conduct fieldwork, Ecology everything else)***
- ***Locals would take over all O&M for this gage***

Question 13 What are the impacts if this gage is discontinued?

- ***Yes*** • ***No*** Local watershed plan not fully implemented
- ***Yes*** • ***No*** Water management activities tied to the gage within this system reduced or stopped altogether.
- ***Yes*** • ***No*** Reduced ability to detect trends in quality and quantity within the system
- ***Yes*** • ***No*** Lose flood warning capabilities of the gage
- ***Yes*** • ***No*** TMDL development or post-TMDL effectiveness monitoring adversely impacted

Appendix C: Workplan for Water Resource Modeling Activities

Project Plan
Used to Define Scope of Work for Projects with No Data Collection

October 24, 2008

TO: Brad Hopkins, Supervisor, EA Program Freshwater Monitoring Unit
Kurt Unger, WR Program Policy and Planning Section
Bill Zachmann, SEA Program

THROUGH: Will Kendra, Manager, EA Program Statewide Coordination Section
Karol Erickson, Supervisor, EA Program Modeling and Information Support Unit

FROM: Paul Pickett, EA Program Modeling and Information Support Unit

SUBJECT: Workplan for Water Resource Modeling Activities
EA Program Project Tracker Code: 08-107

Organizational Background

The Washington State Department of Ecology's (Ecology) Environmental Assessment (EA) Program maintains a statewide network of flow monitoring stations. There are currently 190 active stations where flow information is collected (Figure 1). There are three types of stations used:

- *Telemetry stations* collect stage height readings remotely and then transmit the information by satellite to Ecology where it is automatically imported into a database (101 active stations).
- *Stand-alone stations* collect stage height data remotely and store the data until downloaded by staff (27 active stations).
- *Manual-stage-height stations* are locations where gage height is collected manually using a staff gage, wire weight gage, or reference point.

At all stations, direct flow measurements are used to develop a rating curve that predicts flow from stage height. Rating curves are evaluated after each site visit and corrected if drift or channel change is detected. Stage and flow data and rating curves are managed with the Hydstra database program. All data are posted on Ecology's website as provisional data as soon as they are available (https://fortress.wa.gov/ecy/wrx/wrx/flows/regions/state.asp), updated after site visits, and finalized once a year after the end of a water year. All flow data are subject to quality assurance procedures

as described in the Quality Assurance Monitoring Plan (Ecology, 2007) for the flow monitoring network.

Ecology's Water Resources (WR) Program has primary responsible for the regulation of water rights. Data from the EA flow monitoring network is used by WR for management of instream flows, including compliance with minimum instream flows set in state regulations. Information is also used for other WR policy and regulatory needs, such as water rights permitting.

Ecology's Shorelands and Environmental Assistance (SEA) Program is responsible for planning under the state's Watershed Planning Act (Chapter 90.82 RCW). Watershed planning has been pursued in 40 basins representing either one, two, or three Water Resource Inventory Areas each (WRIAs, outlined in green in Figure 1). Many of the flow monitoring network stations have been located to support the watershed planning process.

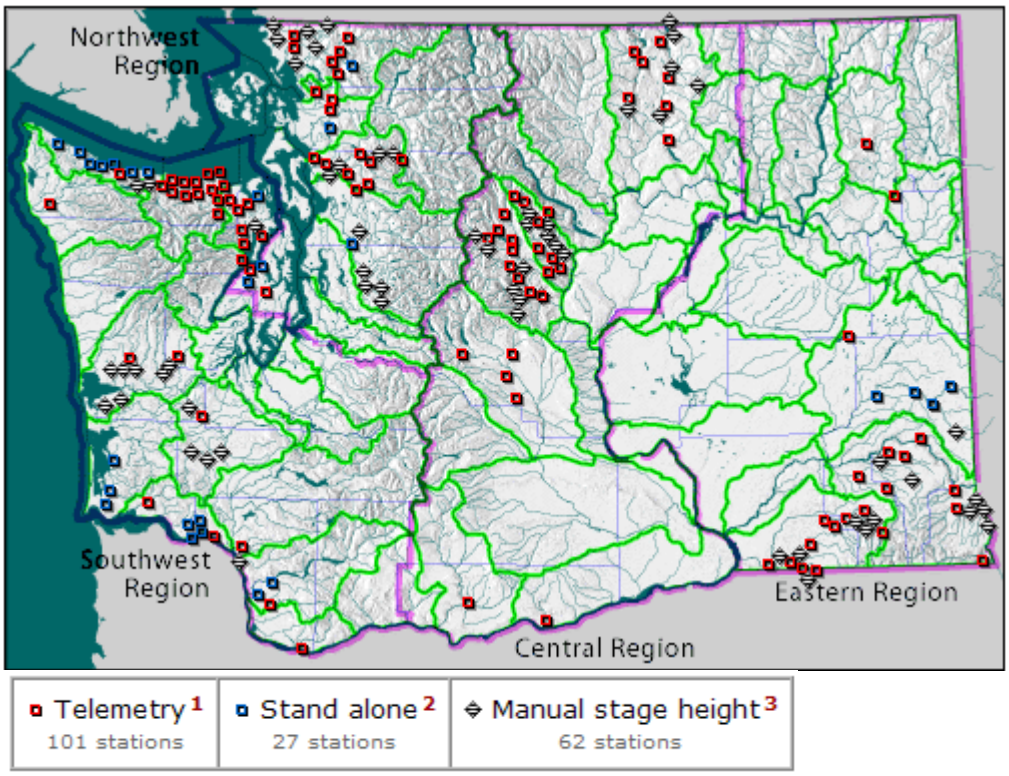

Figure 1. Department of Ecology Monitoring Stations in Washington State

As can be seen from Figure 1, Ecology has made a significant investment in flow monitoring. However, it can also be seen that the effort has been concentrated in certain basins while Ecology has directed minimal or no resources to flow monitoring in other basins. Ecology would like to explore ways to use mathematical water resource models to expand the availability of flow information and optimize the use of stage and flow measurement resources.

Objectives of Activities

Water resource models will be developed for flow to meet the following objectives:

- Provide alternative tools to estimate instream flows.
- Expand the number of locations where flows can be determined on a real-time basis.
- Provide recommendations for efficiently expending funds for flow gaging.
- Provide additional tools for:
  - Implementation of water resources laws, regulations, and policies.
  - Analysis of water resources policies under development.
  - Water management by local governments, planning units, and other partners.

Scope-of-Work

Water resource models, in this context, are mathematical tools that allow flows to be estimated using physical and statistical principles. Models, when used in combination with stage measurements and direct flow measurements, are powerful tools to estimate flows in ungaged locations and expand the available information about instream flows.

There are several categories of flow modeling methods:

- *Empirical models* use statistical relationships to estimate unknown stage or flow values from known values. These tend to be the simplest models available, but they are most reliable when interpolating among the observed values used for calibration. Extrapolation of empirical models is uncertain and can produce values of unknown validity.
- *Physical models* predict flow using the physical characteristics of the stream channel, watershed, and weather. These are more robust models since they are based on physical principles, but they are more resource- and data-intensive to develop.
- *Stochastic models* predict unknown flow values by reproducing both the physical and statistical characteristics of flow regimes. These are powerful models, but complex and require the large amounts of data.

There are many different methods available for modeling stream stage and flow, including the following (roughly in order of complexity):

- Simple linear regression to another gaging station.
- Non-linear regression or regression after data transformation, such as log-transformation.
- Time lagging of data.
- Hydrograph separation.
- Simple hydrologic routing models.
- Inclusion of other non-hydrologic data to adjust predictive equations.
- Runoff models, such as the Antecedent Precipitation Index, the Rational Equation, or the SCS (Soil Conservation Service) Method.
- Physical stream routing models, such as HEC-RAS.
- Watershed runoff models such as SWMM or HSPF.
- Integrated watershed mass balance models that include groundwater, runoff processes, instream routing, and human water use.

The approach employed for projects developed under this workplan will be to begin with the simplest method available and assess the quality of the results. Complexity will be added depending on the availability of data, the time available, and the likelihood of obtaining results that better meet project objectives. For a specific basin, the availability of an existing model or a richness of data might suggest beginning with a more complex model. However, in all cases, the choice of model will depend on project objectives and the long-term availability of information for future applications of the model.

The following potential projects—proposed, or begun previously, but not completed—represent examples of what might be completed under this workplan:

- Evaluation of Entiat basin flow data and the use of models to replace existing gages (Butkus, 2005a).
- A comprehensive evaluation of the statewide flow gaging network (Butkus, 2005b).
- Development of synthetic hydrographs for selected streams with minimum instream flow requirements.
- Evaluation of the effect of regional climate change on data from critical flow gage stations.

Organization and Process

Paul Pickett is the EA lead for the water resource modeling activities. Kurt Unger is currently designated as the contact person for WR and Bill Zachmann is the contact person for SEA. Brad Hopkins is the contact person for the EA Program Statewide Flow Monitoring Network. These staff will be responsible for providing day-to-day, cross-program coordination of activities, including identification and coordination with key regional staff for particular projects.

The Gaging Strategy Workgroup (GSW) is a cross-program team that makes policy recommendations regarding the Statewide Flow Monitoring Network. The GSW will be the overall client for WR Modeling Activities. The Committee's responsibilities include: providing input to project scoping, reviewing project plans and project reports, determining project public outreach strategies, and resolving policy issues that arise during the project. The staff members listed above are all members of the GSW, Bob Cusimano is the coordinator of the GSW, and Bill Zachmann will serve as the primary point of contact for coordinating the planning and outcomes of WR modeling activities within the GSW.

The agency Watershed Action Group (WAG), program managers from EA, SEA, WR, and WQ programs, will be kept informed of WR modeling activities and projects. Bill Zachmann will be the contact to WAG. WAG will usually only get directly involved in these activities if a cross-program issue cannot be resolved first by the GSW, or then by consultation among EA, WR, and SEA section managers. Of course the WAG may choose to elevate issues at their discretion.

Under this workplan, specific projects can be proposed by EA, WR, or SEA. EA will keep a prioritized list of proposed projects to use for planning. The EA lead will conduct preliminary scoping of a proposed project to determine objectives and estimated workload and duration.

The GSW will then provide their prioritization of projects. Based on these recommendations, the EA Program management will set the priority of projects, make the final selection of approved projects to begin work on, and make final decisions about EA lead's time and project deliverables.

Projects can be proposed at any time. The EA Program will solicit project ideas during annual project planning, including projects that represent on-going advisory or technical assistance duties. In the future, EA may limit project proposals to the annual planning period, if necessary, for the orderly management of WR modeling activities.

The EA lead will develop a Project Plan for each individual project, including quality management and specific completion dates. The WR and SEA contacts may identify an appropriate regional lead or leads, either solely from SEA or WR or from both, depending on the project's objectives. The draft Project Plans will go through a three-step review:

1. Review by the supervisor for the EA lead.
2. After revision, internal review (at the same time) by the GSW, the regional lead and the Regional Water Resource Management Team (WRMT), and any other Ecology staff identified by EA management and by the WR and SEA contacts. If appropriate, the WAG may be consulted to ensure project success and provide guidance or decisions on statewide strategies.
3. After revision, the GSW will coordinate with the appropriate WRMT to jointly decide when external review by stakeholders and other agencies outside Ecology is needed. When external review is needed, WRMT and the GSW will decide who the external audience is and which appropriate entities should participate.

Based on the Project Plan, the project will be carried out and a draft Project Report developed, which will go through the same three step review as the Project Plan. Based on input from stakeholders and the WRMT, and if the GSW determines that it is appropriate for the particular project, a fourth review step may be included where the Project Report is sent out for a general public review.

The Project Report may include recommendations for action by EA, WR, or SEA programs. The GSW will consider the Project Report recommendations along with other information from the programs, regions, and local stakeholders. The GSW will develop overall recommendations and transmit them to WAG for a final decision.

The EA lead will be responsible for technology transfer from projects, presentations and training on project results, and will be available for consultation during decision-making regarding implementation of recommendations. The EA lead will coordinate with the GSW, WRMT, and other EA, SEA, and WR program staff for the publication of results, implementation of the model in the Hydstra database, and presentation of model results on the agency website.

An outline of the process and roles for these activities is summarized in Table 1.

References and Bibliography

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Gaging Strategy Workgroup

Table 1. Water resource modeling process

A = Always **N = If needed**

Activity	Paul	GSW	EAP	Region	WAG
Projects proposed		A			
Proposal scoped	A				
Proposals prioritized		A			
Final proposal priorities set			A		N
QAPP drafted for top priority	A				
Regional roles identified		A		N	
Internal Review of draft QAPP		A		N	
Policy issues resolved		N			N
QAPP revision	A				
External Review of draft QAPP		A		N	
QAPP finalized	A		A		
Project analysis	A				
Status reports on project		A		N	
Internal Review of draft report		A		N	
Policy issues resolved		N			N
Report revision	A				
External Review of draft report		A		N	
Report finalized and published	A		A		
Technology Transfer from report	N			N	
Report recommendations reviewed		A		N	
Final decisions made from report and other information		A			A

QAPP: Quality Assurance Project Plan.