PugetSoundPartnership

our sound, our community, our chance

INITIAL DISCUSSION DRAFT

FRESHWATER RESOURCES TOPIC FORUM

APRIL 14, 2008

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Puget Sound Partnership

Introduction to the Topic Forum Discussion Draft

The attached topic forum discussion draft is one of five papers designed to provoke and inspire a long-term, community conversation and critical thinking about the specific problems facing Puget Sound, and the strategies and actions needed to address the threats we face. These papers and your comments will be used to help create the 2020 Action Agenda. Background on the topic forum process and how this information will be used can be found on our website at www.psp.wa.gov in the Action Agenda Center.

These initial draft papers are the first effort in our region to synthesize and document what we know about the problems, solutions that work, our current approach to solving problems, and what approaches we need to continue, add, or change. This is hard work that has not been done before. It means 1) looking at Puget Sound ecosystem from the crest of the Cascades to the Strait of Juan de Fuca, 2) providing sources to back up our statements and conclusions, and 3) establishing links between science and policy.

The discussion papers are DRAFT. They do not yet represent an opinion or position of the Partnership. We very much appreciate your interest and expertise in reviewing this initial work. The Partnership asked a small group of science and policy experts to prepare these draft discussion papers as a starting place for the discussion. As you read this paper and prepare to participate in one of the five upcoming workshops, participate in an online discussion, or submit specific comments, the Partnership requests that reviewers keep this context in mind.

- The Partnership will be identifying priority actions that are based on science. There is currently a wide range of opinion about the problems and literally hundreds ideas for solutions. Our hope is that if we can agree on the documented threats to Puget Sound in terms of magnitude and impact, we will have a better chance of creating priority and durable solutions.

- The papers mainly focus on the Sound as a whole. We know that there are variations in problems and solutions in different parts of our region. The action area profiles that we are also preparing will highlight local issues.

- The papers are organized to logically step through three initial questions (two are science and one is policy) that build to a rational conclusion (the fourth question) about the strategies and actions that we will need continue, add, or change as a region. The design is intentional so that 1) our policies are based on science and 2) scientists and policy experts talk to one another.

- These initial papers will contribute to a synthesis paper that will describe links between each of the topic areas. Reviewers may want to read more than one paper to begin to see the links across our individual interests and concerns. The papers reach different types of conclusions for where to focus efforts, and in some cases the suggested solutions are far-reaching. Before we get to a synthesis paper (and workshop), we want the initial papers to be as accurate as we can in the time that we have available.

- The intent of papers is to focus on WHAT the problem is and WHAT solutions are needed, rather than HOW to implement specific solutions. For example, we know that we will need to do more to protect habitat and concentrate growth into urban areas. There are many ways to accomplish this task and different methods will be needed around Puget Sound. We will create the "how" with those who have to implement the solutions.

- The papers intentionally do not focus on the need for more education/outreach, new funding strategies including creative incentives, and a coordinated monitoring and adaptive management program. The Partnership knows that these three aspects are critical to long-term success and is using other processes to

address them. That work is linked to the development of the action agenda. By addressing the system-wide needs, we will be able to more effectively focus the education/outreach and funding.

- The Quality of Life "topic", or Partnership goal, is not yet represented in these papers, but will be part of our subsequent work to synthesize across the topics.

You may comment on the draft papers by attending in the topic forum workshop, participating in the online discussion at www.psp.wa.gov, or submitting a comment via email or in writing. When reviewing the papers, please consider the following questions:

- Current knowledge: Have we accurately described what we know and don't know about the status of and threats to this topic in the Puget Sound region and the certainty of our knowledge? Have we missed any major documented findings?

- Effectiveness of tools: Have we accurately characterized what is certain and uncertain about the effectiveness of the tools available to address threats to this topic? Have we missed any major documented findings?

- Current strategies: From a topic perspective, have we accurately characterized what we are now doing to address threats? Have we missed any major programs or projects?

- Strategies to continue, add, or change: Given the status of and threats to the topic, effectiveness of the tools available, and current strategies to address threats, have we accurately captured the strategies we should continue, add or change? Have we missed any strategies and actions we should continue, add or change to address the threats (not just good ideas)? What sources have informed your thinking?

- Establishing criteria: Are the proposed criteria for prioritizing topic-specific actions appropriate and sufficient? Are there other criteria to consider?

- Measuring progress: Have we identified appropriate measures to assess progress toward goals for this topic? Have we missed any key measures of progress?

INITIAL DISCUSSION DRAFT PAPER

FRESHWATER RESOURCES

APRIL 14, 2008

Science Question 1 (S1): Status of Freshwater Quantity in the Puget Sound Region

A. Where in the Puget Sound region are the amount, timing, and distribution of freshwater flows adequate? Where are they impaired?

Freshwater Inflows to Puget Sound

From an ecosystem viewpoint, we know that the flow regime of a river is a major factor in determining long-term aquatic ecosystem health and sustainability both in upland areas, and in estuarine, nearshore, and marine environments. The central role of naturally varying water flows, including day-to-day and seasonal variations, in maintaining the health of rivers, floodplains, and estuaries has been firmly established (Arthington *et al*. 1992, Walker *et al*., 1995, Sparks, 1995, Poff *et al*., 1997, Bunn and Arthington, 2002). The full range of natural flow variation (ranging from base flows to high-flow pulses and floods) and the timing and duration of those flows play important ecological roles in a river ecosystem (Postel and Richter, 2003).

Flows of fresh water into estuaries have an important effect on aquatic food webs and the habitats found in estuarine and nearshore areas (Olsen *et al*., 2006). Freshwater inflows deliver nutrients and sediments to estuaries and affect the levels of salinity and the circulation of water. In addition to surface flows, groundwater flows can also influence the flow of fresh water into estuaries and marine environments in areas where groundwater is hydrologically connected to these habitats. Together, these natural hydrologic regimes sustain native species and ecosystems that benefit human populations (Postel and Richter, 2003, Olsen, *et al*., 2006).

While the effect of freshwater flows on Puget Sound is complex and a detailed discussion is beyond the scope of this paper, major factors include:

- There are two major periods of freshwater runoff into Puget Sound: Peak flows occur in December and June (U.S. Department of Commerce, 2007).

- The major sources of fresh water from Puget Sound river systems are the Skagit and Snohomish River watersheds. The Fraser River in Canada provides much more fresh water that enters the Strait of Georgia (Gustafson, *et al*., 2000).

- The amount of fresh water entering Puget Sound in June through September has decreased by 18 percent between 1948 and 2003. This likely represents changes due to warming, land use, and regulation of flows (Snover, *et al*., 2005).

- Annual freshwater inflows from Puget Sound rivers help to drive the marine circulation patterns in Puget Sound. The subtidal circulation of Puget Sound is largely driven by the difference in salinity between fresher waters within the Sound and the saltier ocean waters in the Strait of Juan de Fuca. This means that circulation in the Sound is sensitive to the timing and amount of freshwater inflow, the mixing within the Sound, and the salinity of ocean waters in the Strait.

- Circulation data for Puget Sound have shown that different subbasins within the Sound have varying sensitivities to freshwater inflow (U.S. Department of Commerce, 2007).

Changes in Watershed Hydrology

Generally, the healthiest and most biologically productive streams are found in undisturbed watersheds (Booth, *et al*., 2006). However, most watersheds in the Puget Sound region have been altered by urban or suburban land uses, agriculture, or forest practices, and many contain facilities that store water or generate power. The hydrology of these watersheds has been altered to varying degrees.

The greatest human population densities in Puget Sound occur in King, Kitsap, Pierce, Snohomish, Island, and Thurston Counties (WSCC, 2005). Many studies have been done on the effects of increasing human population and associated land use on hydrology. Some of the major effects include:

- Flow regimes, species viability, and habitat are linked to land use changes such as loss of forest canopy and riparian vegetation, increase in impervious surface, ditching, draining, diking of floodplains and wetlands, and armoring of streambanks.

- As a general rule, the health of aquatic systems declines when the level of impervious surface in the watershed exceeds around 10 percent (Booth, *et al*., 2002, Cassin, *et al*., 2005, Morley, 2000).

- Increasing human population density and associated land use changes lead to greater differences between low and peak flows. This results in channel conditions that are less favorable to native flora and fauna most of the year, and that require higher flows (than typical) to make them favorable during low-flow periods.

- Full ecosystem function must be considered to determine whether flow is adequate to protect habitat function. Naturally varying high flows as well as minimum low flows are important. Over the evolutionary history of Puget Sound's native aquatic species, naturally varying flow conditions have played an important role in the adaptation of those species to local river and stream systems and habitats. When flow conditions fall outside of the range of historic natural variation, the viability of native species adapted to that local variation in flow can be affected (Spence, *et al.*, 1996; Naiman, *et al.,* 1992, 2008).

- Water withdrawals for human use also lead to flow impairment (Ecology, 1998; Poff *et al.*, 1997; Postel and Richter 2003; Richter *et al*. 2003).

In contrast, lower levels of hydrologic alteration are found in rivers located in large undeveloped areas where there are no mainstem dams (including Olympic National Park). This includes the following rivers: North and South Forks Nooksack, Sauk-Suiattle Rivers and Cascade River, Skykomish and Snoqualmie Rivers and Snohomish River, Deschutes River above Deschutes Falls, Kennedy Creek, South Fork Skokomish River above confluence with North Fork, Liliwaup Creek, Hamma Hamma River, Duckabush River, Dosewallips River, other east Olympic Hood Canal tributaries south of the Dosewallips, Lyre River, East Twin River, West Twin River, and Hoko River (Beecher, 2008).

Data Gaps and Uncertainties

To date, no regional summary exists of the adequacy of freshwater resources in the Puget Sound basin. Much of what we know about the adequacy of water resources in Puget Sound has been assessed at a watershed scale by WRIA (water resource inventory area) or more locally. There are 19 WRIAs within the Puget Sound basin (Figure S1-1).

Appendix A presents a summary of our knowledge about the adequacy of freshwater resources for both instream needs and out-of-stream benefits by WRIA and provides references for local studies[1].

However, even with local information, a regional summary of ecological and human water needs is difficult due to:

- The disparity in water quantity data and its varying geographic distribution,
- Regional variation in climate and geology,
- The temporal and geographic variability in the needs of different species, and
- Institutional and political sensitivities associated with water use and instream flows.

For example, the adequacy of groundwater to meet human needs can vary at a local level within a watershed, or even within an aquifer. Some wells may provide adequate supply while others within the same subwatershed may provide inadequate or saline water.

Similarly, streamflows may be limiting for human water supply or aquatic species in some tributaries and not in others within a single watershed. Our understanding of whether low flows are adequate for individual aquatic species is further limited by incomplete knowledge of the complex relationship between flow and channel structure and function, off-channel wetland storage, and riparian condition. Full ecosystem function needs to be considered to determine whether flow is "adequate" for species' needs.

B. Where do we know that freshwater supply is not adequate to protect habitat function?

Current Adequacy of Freshwater Supply

We do not know where flow regimes are "adequate" to protect habitat function in Puget Sound, but we do know where they are altered from their natural condition (see A., above).

A limiting factors analysis (WSCC, 2005) indicates that 11 out of 19 watersheds in the Puget Sound region are known to have low flows that may be limiting to fish survival. In addition, 12 out of 19 watersheds are known to have "poor" high-flow ranges for fish. The limiting factors ranking of flows is included in Table S1-1 by WRIA. Individual watershed chapters of the Puget Sound Salmon Recovery Plan (Shared Strategy, 2007) provide additional assessment of factors that limit salmon in the region. Appendix A provides local examples where low flows appear inadequate for fish and wildlife and habitat type based on numerous local data sources.

The 2004 State of Salmon Watersheds Report lists the Nooksack, Snohomish, Lake Washington, Green, White, Puyallup, Dungeness and Elwha as "water-critical basins" that are over-appropriated. The Stillaguamish and lower Skagit watersheds are listed as "low flow," and are noted to be experiencing signficiant pressure for increased water use and declining flows. However, data are not presented to document the impact of these flows on aquatic species. Of all the Puget Sound Chinook natal watersheds, the mid-Hood Canal and the upper Skagit were not listed as having potential flow problems for salmon. (State of Washington Governor's Salmon Recovery Office, 2004; NMFS, 2006).

Data Gaps and Uncertainties

Major gaps in our understanding include:

- Low-flow requirements for aquatic species are not well understood, and they are intricately linked to other elements of the ecosystem. For example, relationships between flow and the four Viable Salmon Population (VSP) parameters (abundance, productivity, spatial structure, and diversity) that are used to determine the relative health of salmonids have not been determined in the Puget Sound region (Shared Strategy, 2007).

[1] Material for this appendix was supplied primarily by the Department of Ecology and WDFW with input from other participants in watershed planning under RCW 90.82.

- There is no regional assessment of the adequacy of flow variations for optimum habitat function, although some newer operational permits for FERC licenses and HCPs are considering high- and low-flow release prescriptions (Cushman Hydroelectric Project, Seattle Public Utilities Cedar River HCP).

- Local data about the effects of flow alterations on native species are available. For example, local empirical data indicate the adverse effects of scouring floods and low spawning flows on smolt production (e.g., Seiler *et al.*, 2005). However, such information has not been quantified or extrapolated more regionally.

- There are no known studies that address the potential adequacy of flows for aquatic habitat in the future. Threats such as increased groundwater and surface water withdrawals due to growth, associated land use impacts, and climate change may impair flows in watersheds where this is not currently an issue.

C. Where do we know that freshwater supply is not adequate to meet current and future human demands (e.g., municipal, domestic, agricultural, industrial)?

Current Demand for Fresh Water

Almost every watershed in Puget Sound has local areas where freshwater supplies are not adequate to meet current human demands. The adequacy of water supply is different in every watershed and varies around the Puget Sound region. Appendix A indicates WRIAs where local issues have occurred, but it is by no means comprehensive.

Exempt Wells

Exempt wells represent an unquantified, growing, and potentially significant component of the regional freshwater supply. The full effects of current domestic use by permit-exempt wells are unknown. The exempt wells are individually minor in volume, but comprise a component of freshwater use that is unaccounted for, unregulated, and continuing to increase with population growth in the region.

The well exemption conflicts with the state's ability to manage this portion of Puget Sound's water supply. Over 58,000 well logs from the Puget Sound region have been received by Ecology since 1990 (over 3,200 wells per year) (Ecology, 2008a). This represents reported drilling of permit-exempt and larger wells that require water rights. It is estimated that approximately 95 percent of these wells are permit-exempt, and that approximately 20 percent of permit-exempt wells go unreported, statewide (Ecology, 2008b). By county, self-supplied water use (Group B systems and permit-exempt wells) comprised between 5 and 54 percent of total domestic water use in 2000 for counties located within the Puget Sound basin (Lane, 2004). Typically, more rural counties have a greater percentage of exempt well use.

Future Demand for Fresh Water

Puget Sound's growing human population poses significant threats to freshwater supply in the region. The current population of the Puget Sound region of 3.8 million is expected to increase by another 1.4 million people by 2020 (PSP, 2006). With a current average per capita water use of approximately 97 gallons per day (gpdc) (Lane, 2004), this amounts to a need for an additional 136 million gallons of water each day for domestic and municipal uses on an average annual basis in 2020. Peak flow demands during dry, warm summer months will be greater.

Many watershed plans[2] and water system plans address uncertainty in meeting future needs either due to water supply shortfalls or seawater intrusion (San Juan County WRMC, 2005; Island County WRMC, 2005; Nisqually Indian Tribe, 2003; WRIA 1 Watershed Planning Unit, 2005; Cascadia Consulting Group, 2007; HDR Engineering, 2007). These evaluations generally indicate that there are a number of water systems that do not have adequate physical water or water rights to provide for future growth.

[2] Where watershed planning is occurring under RCW 90.82.

Water can be physically available, but limited by legal availability. This occurs in areas where regulatory instream flows are not met throughout the year and/or where basins have been closed to new appropriations. Ecology cannot make a finding of water availability if streamflows are not meeting regulated flow levels on a regular basis. Areas where instream flows have been set and basin closures have occurred are indicated in Table S1-1.

Instream flow rules have been set by Ecology in 12 watersheds in the Puget Sound region. In most of these 12 watersheds, streamflows were met less than 50 percent of the time during low-flow periods, and in some watersheds, less than 80 percent of the time. In these cases, Ecology has difficulty in making a finding of water availability and cannot appropriate additional water without full mitigation. In closed basins, junior water rights for uninterruptible supplies cannot be obtained without fully mitigating for the impact to impaired streams. This situation makes obtaining new water rights for future water uses uncertain and more difficult. Watersheds without instream flow rules include the San Juan, Island, Skokomish – Dosewallips, Quilcene-Snow, Elwha-Dungenes, and Lyre-Hoko (WRIAs 2, 6, 16, 17, 18 and 19). Lack of an instream flow rule in a watershed does not imply that Ecology could make a finding of water availability in the watershed. Ecology is attempting to set flow rules in every Puget Sound watershed in the next several years.

Data Gaps and Uncertainties

Major gaps in our understanding include:

- There is no statewide program that compiles and reports water use information (Lane, 2004). Where watershed planning has occurred (under RCW 90.82), local communities have attempted to identify local problem areas for water supply and develop demand solutions. However, watershed planning under RCW 90.82 is not occurring in all watersheds in the Puget Sound region, nor are the data consistent between watersheds planning under the act, and so data on potential water supply shortfalls are not available consistently throughout the Sound.

- Water system plans are numerous and not regionally compiled. Water supply management is typically addressed at the scale of a retail or wholesale service area of a water system through a water system plan. The plan addresses population projections, demand forecasts, supply sources, and infrastructure requirements. There are over 2,300 Group A water systems (water systems with 15 or greater connections) that have prepared water system plans in the Puget Sound region (WDOH, 2008). The Washington State Department of Health is responsible for approving water system plan updates once every six years. However, they do not compile water system information at a regional scale. Comprehensive Irrigation District Management Plans address the adequacy of water supply for agriculture in the Dungeness and Skagit River watersheds.

- Water rights provide an accounting of permitted water withdrawals. However, actual water withdrawals may differ from the water right, and illegal water use occurs.

- Regional water supply planning is not occurring everywhere. In some areas such as central Puget Sound, regional water supply planning is comparing regional water demand with regional water availability (CPSWSF, in process). This has not occurred in other areas in Puget Sound.

- Permit-exempt water use is not well accounted for. More current instream flow rules call for tracking future installation and use of permit-exempt wells. Reservations for new domestic and municipal supply have been established in those basins, and new uses are tracked through a reservation as a condition of the instream flow rule. Other watersheds that do not have instream flow rules, or have older flow rules, have no method of accounting for current or future permit-exempt water use.

D. Watershed scale assessments and other data sources

Watershed Scale Assessments

Numerous studies and planning processes have addressed aspects of freshwater supply needs, some focusing on species' needs and others including human water uses. Table S1-1 describes these assessments and indicates where these studies and planning processes have been conducted in the Puget Sound region and general outcomes by WRIA. Each has a different geographic coverage and uses different methodologies for identifying flow needs and inadequacies. Lack of inclusion of a watershed in a study or a planning process does not necessarily indicate that there are water availability issues in that geographic area.

Water Quantity Data

The collection and analysis of data on freshwater quantity, and the use of this information in planning, occurs on geographic scales ranging from individual point locations to coordinated regional monitoring. Surface water data are monitored through stream gages maintained by federal, provincial, state, and local agencies. These gages provide point data that are often used to infer flow conditions in some portion of the upstream area. Where data do not exist, it is possible to use models to create streamflow records based on rainfall, stream gage data, and runoff characteristics from a similar watershed.

There is no statewide ambient groundwater monitoring program and generally, there is a lack of ambient groundwater monitoring data for Puget Sound. Where groundwater is monitored within Puget Sound, it is not monitored uniformly. Monitoring is primarily performed by local or state agencies. It typically is driven by site-specific needs and limited in scope to particular management objectives (e.g., nitrates, chlorides for seawater intrusion, or other contaminants of concern).

Climate Change Data

For the Puget Sound region, climate change models indicate that reduced snowpack and earlier runoff will likely affect water resources. In many Puget Sound watersheds that are dominated by snowmelt, warming will result in increased winter flows, earlier and reduced peak flows in the spring, and reduced summer flows with higher instream temperatures (PAWG, 2008). These trends will likely increase the number of days when utilities must rely on water stored behind dams as the natural storage in the form of snowpack continues to decrease. In basins that are not dominated by snowmelt, groundwater recharge patterns may shift. This will make it more difficult to maintain streamflows for native aquatic species and their habitat, and to provide water for municipal uses. (U.S. Department of Commerce, 2007).

The University of Washington Climate Impacts Group (CIG) has modeled predicted climate change impacts on regional hydrology, regional demand forecasts, and water supply alternatives in Pierce, King, and Snohomish Counties. The work included modeling of the major water supply drainage basins used for water supply in the study area (the Sultan, Tolt, Cedar, Green, and White Rivers). By 2075, the ensemble average discharge across basins compared to historic flows is predicted to decrease by 37 percent during the summer and increase by 48 percent in the winter (Palmer, 2007).

The shift in the hydrograph due to climate change has many implications for water resource management, streamflow augmentation, and ecosystem function (PAWG, 2008). These include:

- Changes in the seasonality of water supply (e.g., reductions in summer);
- Changes in water demand (e.g., potentially increasing evaporation);
- Changes in drought stress;
- Increasing conflicts between water supply and other uses and users of water;
- Changes in low-flow risks;
- Changes in the need for releases from storage to reproduce existing streamflow regime;
- Impacts to ecosystem function as a result of changes in the timing and volume of freshwater inflows (e.g., increased winter peak flows, reduced summer low flows);

- Changes in water resources management related to water quality (e.g., to provide dilution flow or to control temperature);
- Impacts to fish and aquatic ecosystems related to changes in the seasonality and intensity of flows (e.g., increased winter peak flows, reduced summer low flows); and
- Changes in watershed function due to large-scale changes in vegetation (e.g., fire, insect damage).

E. What are the major threats to freshwater supply and availability?

Major threats to freshwater supply and availability include:

- Over commitment of the resource through water withdrawals and diversions;
- Projected increases in domestic, municipal, commercial, and industrial water demand associated with population growth;
- Land use practices that increase impervious surfaces and cause higher peak flows, lower low flows, and reduced groundwater recharge;
- Altered hydrology, including loss of wetlands;
- Loss of coastal groundwater supplies due to seawater intrusion;
- Modified stream channels; and
- Altered weather regimes associated with climate change.

All of these threats will continue to impact streamflows and compromise the ability to support freshwater and terrestrial species, as well as the increasing uses of water for human activities and other out-of-stream beneficial uses. Reduced freshwater inflows also impact estuarine, nearshore, and marine food webs and the habitat upon which they depend (U.S. Department of Commerce, 2007).

F. What is the certainty of our understanding?

As described in earlier sections of this report, there is little certainty regarding freshwater supply, or its adequacy for instream needs and out-of-stream beneficial uses at a regional level. In the Puget Sound region, most ecological assessments and studies have been broadly focused on habitat conditions and impacts to salmon species listed under the Endangered Species Act, and have not addressed water quantity and streamflow issues. As a result, the information regarding the extent and nature of streamflow issues is in most cases general in nature (Lombard and Sommers, 2004). The salmon limiting factors analysis (WSCC, 2005), which provides the most detailed statewide assessment, is a snapshot in time of habitat conditions.

In those places where quantitative models and empirical data confirm conclusions, it is reasonable to hold them with confidence. However, given the disparity of data across the Puget Sound region, whether it is gage measurements of freshwater supplies or studies conducted to establish flow-biota relationships, it may not currently be possible to apply site-specific analysis to other areas in the region.

G. What are the main known gaps in our understanding?

Specific topics were detailed earlier in this report. In summary, the main gaps include:

- Data that indicate groundwater levels, trends, and depletion on a regional scale;
- Localized hydraulic continuity between surface water and groundwater;
- A quantitative correlation between streamflow and fish productivity;
- A quantitative understanding of geomorphology and fish needs during high flows;
- Identification of flow impairments (both low and high flow problems) within the Puget Sound watershed (similar to the inventory of low flow impairments conducted by the King County Tributary Flow Committee (2006) in WRIAs 8 and 9);

- Regional understanding (survey) of water system plans and watershed plans: Where is current water supply inadequate to meet projected demand between now and 2020;
- Evaluation of freshwater requirements for estuary health; and
- The quantity of water used to meet consumptive needs.

Table S1-1: Watershed Scale Assessments, Closures and Instream Flows

Puget Sound Partnership Action Area	WRIA	WRIA Name	2514 Watershed Planning	Instream Flow Rule	Basin Closures	TNC Assessment	King County Regional Water Planning	Basin Assessment	Fish Critical Basins	Salmon Recovery Planning	Limiting Factors Analysis		Central Puget Sound Low Flow Study
											High Flow	Low Flow	
San Juan/Whatcom	1	Nooksack	Phase 4; water quality, habitat instream flow	1986	Partially Closed. Basin closed except for lower mainstem Nooksack River	Tier 1			X	Low summer/fall flows	POOR	POOR	
San Juan/Whatcom	2	San Juan	Phase 4; water quality, habitat instream flow	N/A	No rule. Only one stream not dry in summer						N/A	POOR	
Whidbey	3	Lower Skagit - Samish	Phase 3;Draft plan completed in12/03, not finalized or voted on. Limited to Samish Sub-basin. instream flow							Low flows	POOR	N/A	
Whidbey	3&4	Lower Skagit/ Upper Skagit	Phase 3; instream flow	• Original flow rule, 2001 • Revision adopted 5/15/2006	Not closed now, but will be by existing rule.Unique rule with automatic closure of streams after remaining small allocations (reservation) is used	Tier 1				Hydroelectric dam operations, low flows	POOR	N/A	
Whidbey	5	Stilliguamish	No	• Adopted in 2005	Closed.	Tier 2				Increased magnitude of high flows, low flows	POOR	POOR	summer/fall baseflows
Whidbey	6	Island	Phase 4; no optional elements	N/A	No Rule. Camano and Whidby Islands			X			N/A	N/A	

Puget Sound Partnership Action Area	WRIA	WRIA Name	2514 Watershed Planning	Instream Flow Rule	Basin Closures	TNC Assessment	King County Regional Water Planning	Basin Assessment	Fish Critical Basins	Salmon Recovery Planning	Limiting Factors Analysis		Central Puget Sound Low Flow Study
											High Flow	Low Flow	
Whidbey	7	Snohomish	No	• Adopted in 1979	Partially Closed. 5 mainstem rivers and their tributaries open but 7 streams closed .			X	X	Increased magnitude of high flows due to loss of connectivity with floodplain	FAIR	POOR	summer/fall baseflows in all AND spring flows and fall freshets in Tolt, Sultan and Wallace Rivers, Riley Slough, Haskel Slough, summer flows in Wallace River
South-Central Puget Sound	8	Cedar-Sammamish	No	• Adopted in 1979	Closed		X	X	X	Low base flows, higher peak flows following storms, increased flashiness	POOR	POOR	summer/falll baseflows in all AND spring flows and fall freshets in Cedar River
South-Central Puget Sound	9	Duwamish-Green	No	• Adopted in 1980	Partially Closed. Mainstem Green River open but tributaries closed, Tribal agreement with Tacoma has higher instream flows than in rule		X	X	X	Changes in flow due to diversion of rivers and streams	POOR	POOR	summer/fall baseflows in all AND spring flows, fall freshets in Middle and Lower Green River
South-Central Puget Sound	10	Puyallup-White	No	• Adopted in 1980	Partially Closed by rule in 1980 (WAC 173-510). Mainstem Puyallup and Carbon Rivers open but tributaries including White River closed			X	X	Diversion of flows and hydroelectric dam operations	POOR	GOOD/ POOR	summer/ fall baseflows AND spring flows, fall freshets in Puyallup and White Rivers
South Puget Sound	11	Nisqually	Phase 4; water quality, habitat instream flow	• Adopted in 1981. PU found existing flows and closures adequate,	Partially Closed. Upper and lower Nisqually open but mid-river and tributaries closed	Tier 2				Reliability of tributary flows	GOOD	GOOD	

Puget Sound Partnership Action Area	WRIA	WRIA Name	2514 Watershed Planning	Instream Flow Rule	Basin Closures	TNC Assessment	King County Regional Water Planning	Basin Assessment	Fish Critical Basins	Salmon Recovery Planning	Limiting Factors Analysis		Central Puget Sound Low Flow Study
											High Flow	Low Flow	
				except for Mashel River --IFIM conducted in 2004									
South Puget Sound	12	Chambers-Clover	Plan not Adopted. Phase 3; water quality, habitat	• Adopted in 1979. Most streams and lakes closed	Closed			X	X		POOR	POOR	summer/fall baseflows AND spring flows in Clover Creek
South Puget Sound	13	Deschutes	Plan not Adopted. Phase 3; water quality,habitat, instream flow	• Adopted in 1980	Closures in 1980 (WAC 173-513). Closed exept for two tiny unnamed streams			X			POOR	N/A	
South Puget Sound	14	Kennedy-Goldsborough	Phase 3; water quality, habitat, instream flow.	• Adopted in 1984	Partially Closed. Over 20 streams closed only 7 streams open						N/A	N/A	
South Puget Sound and Hood Canal and South Central Sound	15	Kitsap	Plan not Adopted. Phase 3; water quality, habitat, instream flow	• Adopted in 1981	Partially Closed. Most streams closed only 4 streams open			X		Low summer flows, increased peak flows during rainy season	POOR	N/A	
Hood Canal	16	Skokomish - Dosewallips	Phase 4; water quality, habitat instream flow	No Rule - HIghPriority Basin.	No Rule	Tier 1 and Tier 2				High winter flows, low summer flows	GOOD	N/A	
Hood Canal and Straight of Juan De Fuca	17	Quilcene-Snow	Plan Adopted without instream flows. Phase 4; water quality, habitat instream flow	New Rule in process. Estimated Dec 2008. Chapter 173–518 WAC					X	Surface and groundwater withdrawals mid-April - Sept.	POOR	POOR	
Straight of Juan De Fuca	18	Elwha-Dungeness	Phase 4; water quality, habitat instream flow, storage	New Rule in process. Estimated Dec 2008. Chapter 173–518 WAC					X		GOOD	POOR	

Puget Sound Partnership Action Area	WRIA	WRIA Name	2514 Watershed Planning	Instream Flow Rule	Basin Closures	TNC Assessment	King County Regional Water Planning	Basin Assessment	Fish Critical Basins	Salmon Recovery Planning	Limiting Factors Analysis		Central Puget Sound Low Flow Study
											High Flow	Low Flow	
Straight of Juan De Fuca	19	Lyre-Hoko	Watershed Assessment; water quality, habitat, instream flow	N/A	No Rule					Surface and groundwater withdrawals mid-April - Sept.	POOR	N/A	

Table S1-1 References

- 2514 Watershed Planning (RCW 90.82)

Planning units must address water quantity issues in their plans and may also include supplemental assessments of instream flows, water quality, storage and fish habitat needs. All plans must describe strategies and recommend actions that will provide reliable water supplies to meet future instream and out-of-stream needs (Washington State Department of Ecology, 2008).

- Instream Flow Rules

Instream flow rules were first executed in the 1970s and 1980s; more recent rulemaking began in 2003. Newer rules are much more complex and comprehensive than earlier rules due to the advancement of science and technical tools. The hydrologic connectivity of groundwater to surface water and freshwater inflows to estuaries has been included in recent rules (Washington State Department of Ecology, 2008).

- Basin Closures

Full or partial basin closures have resulted based on inadequate flows and/or overappropriation. In these cases, new water rights will only be appropriated if their impacts are fully mitigated (eg., drop for drop mitigation).

- TNC Freshwater Assessment

The Nature Conservancy conducted an assessment that addresses 1) the current distribution and status of freshwater ecological systems and native freshwater species at risk, 2) the dominant future threats to freshwater biodiversity in the state, and which watersheds are most susceptible to these threats, and 3) which watersheds and strategies represent the best opportunities for effective freshwater biodiversity conservation in Washington (Skidmore, 2006).

- King County Regional Water Supply Planning – Tributary Streamflow Committee conducted **prioritization of flow impaired tributaries in WRIAs 8 and 9** (http://www.govlink.org/regional-water-planning/).

- Basin Assessments

Basin assessments were conducted in the 1990s to compile available information relating to water use, water availability, quantity of water already allocated to existing rights and claims, instream flows, and the hydrology of a basin (Department of Ecology).

- Fish Critical Basins

The Departments of Ecology and Fish and Wildlife categorized several basins as fish critical basins based upon the Conservation Commission's Limiting Factors Analysis (http://www.ecy.wa.gov/programs/wr/instream-flows/wacq.html).

- Salmon Recovery Planning

The recovery plan proposes a three-part strategy to ensure adequate water for listed Chinook salmon, bull trout and summer chum in the rivers and streams of the Puget Sound Chinook Evolutionarily Significant Unit (Shared Strategy, 2007).

- Limiting Factors Analysis

The limiting factors analysis identified habitat factors, including flow, limiting production of salmon in the state (Washington State Conservation Commission, 2005).

- Central Puget Sound Low Flow Survey

This report identified streams where low flows limited salmon production (Lombard and Sommers, 2004).

References

Arthington A.H., J.M. King, J.H. O'Keefe, S.E. Bunn, J.A. Day, B.J. Pusey,D.R. Bluhdorn and R.E. Tharme, 1992. Development of an Holistic Approach for Assessing Environmental Flow Requirements of Riverine Ecosystems. *In:* Proceedings of an International Seminar and Workshop on Water Allocation for the Environment. John J. Pigram and Bruce P. Hooper (Editors). The Centre for Water Policy Research, Armidale, Australia. pp. 69-76.

Beecher, Hal. March 19, 2008. Personal Communication.

Booth, D.B., Hartley and R. Jackson, 2002. Forest Cover, Impervious-surface Area, and the Mitigation of Stormwater Impacts, Journal of the American Water Resources Association, Vol 33, No. 3, P. 835-845.

Booth, D., D. Beyerlein, S. Bolton, T.W. Holz, T.Hooper, R. R. Horner, J. R. Karr, D. Kirkpatrick, J. Lombard, and C.W. May, 2006. Open letter to Puget Sound Partnership with recommendations to: Improve Water Quality and Habitat by Managing Stormwater Runoff, Protect Ecosystem Biodiversity and Recover Imperiled Species, Provide Water for People, Fish and Wildlife, and the Environment. October 26, 2006.

Bunn, S.E. and A.H. Arthington, 2002. Basic Principles and Ecological Consequences of Altered Flow Regimes for Aquatic Biodiversity. Environmental Management 30: 492-507.

Cascadia Consulting Group, 2007. Detailed Implementation Plan for the Quilcene-Snow Water Resource Inventory Area (WRIA 17) prepared for the WRIA 17 Planning Unit, October 9, 2007. 119 p.

Cassin, J., R. Fuerstenberg, L. Tear, K. Whiting, D. St. John, B. Murray, J. Burkey, 2005. Development of Hydrological and Biological Indicators of Flow Alteration in Puget Sound Lowland Streams. King County Water and Land Resources Division. Seattle, Washington.

Central Puget Sound Water Suppliers' Forum (CPSWSF), In Progress. Update to the Central Puget Sound Outlook. *Available at:* http://www.cpswatersuppliersforum.org/Home/default.asp?ID=22

Gustafson R.G., W.H. Lenarz, B.B. McCain, C.C. Schmitt, W.S. Grant, T.L. Builder, and R.D. Methot, 2000. Status review of Pacific Hake, Pacific Cod, and Walleye Pollock from Puget Sound, Washington. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC- 44, 275 p. *Available at:* http://www.nwfsc.noaa.gov/publications/techmemos/tm44/environment.htm

HDR Engineering, Inc., 2007. City of Everett 2007 Comprehensive Water Plan.

Island County Water Resources Advisory Committee, 2005. Island County Water Resource Management Plan. June 20, 2005.

King County Tributary Flow Committee, 2006. Final Report – Tributary Streamflow Technical Committee. October 2, 2006. *Available at:* http://www.govlink.org/regional-water-planning/tech-committees/trib-streamflow/TribStrmflwFinalReport10-2006.pdf

Lane, R. C., 2004. Estimated Domestic, Irrigation and Industrial Water Use in Washington, 2000. U.S. Geological Survey Scientific Investigations Report 2004-5015. *Available at:* http://pubs.usgs.gov/sir/2004/5015/

Lombard J., and D. Somers, 2004. Central Puget Sound Low Flow Summary. Prepared for Washington Department of Fish and Wildlife.

Morley, S. A., 2000. Effects of Urbanization on the Biological Integrity of Puget Sound Lowland Streams: Restoration with a Biological Focus. M.S. Thesis, University of Washington, Seattle, Washington.

Naiman, R.J., T.J. Beechie, L.E. Benda, D.R. Berg, P.A. Bisson, L.H. MacDonald, M.D. O'Conner, P.L. Olson, and E.A. Steele, 1992. Fundamental elements of ecologically healthy watersheds in the Pacific Northwest Coastal Ecoregion, p. 127-189 in R.J. Naiman (ed.) Watershed Management--Balancing Sustainability and Environmental Change. Springer-Verlag, New York.

Naiman RJ., J.J. Latterell, N.E. Pettit and J.D. Olden, 2008. Flow variability and the biophysical vitality of river systems. Comptes Rendus Geosciences.

National Marine Fisheries Service, Northwest Region, 2006. Final Supplement to the Shared Strategy's Puget Sound Salmon Recovery Plan. November 17, 2006. *Available at*: http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Puget-Sound/upload/PS-Supplement.pdf

Nisqually Indian Tribe, 2003. Nisqually Watershed Management Plan. Prepared by the Nisqually Watershed Planning Unit. October 2003, 165 pp.

Olsen, S. B., T. V. Padma and B. D. Richter, 2006. Managing Freshwater Inflows to Estuaries: A Methods Guide. *Available at* http://www.nature.org/initiatives/freshwater/conservationtools/methods.html . Supported by USAID, The Nature Conservancy, and the Coastal Research Center at University of Rhode Island.

Palmer, R.N., 2007. Final Report of the Climate Change Technical Committee. A report prepared by the Climate Change Technical Subcommittee of the Regional Water Supply Planning Process, Seattle, WA. *Available at:* http://www.govlink.org/regional-water-planning/tech-committees/climate-change/index.htm

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks and J.C. Stromberg, 1997. The Natural Flow Regime: A Paradigm for River Conservation and Restoration. BioScience 47:769-784. *Available at:* http://www.nature.org/initiatives/freshwater/conservationtools/art16896.html

Postel S. and B. Richter, 2003. Rivers for Life: Managing Water for People and Nature. Island Press, Washington, D.C.

Preparation and Adaptation Working Groups (PAWG), 2008. Preparing for the Impacts of Climate Change in Washington. Recommendations from the PAWG. Overseen by the State Departments of Ecology and Community Trade and Economic Development. *Available at:* http://www.ecy.wa.gov/climatechange/cat_pawg_wr.htm

Puget Sound Partnership, 2006. Sound Health, Sound Future: Protecting and Restoring Puget Sound. *Available at:* http://www.nwfsc.noaa.gov/research/shared/sound_science/documents

Richter B.D., Mathews R., Harrison D.L., Wigington, R., 2003. Ecologically sustainable water management: Managing river flows for ecological integrity. Ecological Applications 13:206-224. *Available at:* http://www.nature.org/initiatives/freshwater/conservationtools/art16896.html

San Juan County Water Resource Management Committee, 2005. San Juan County Water Resource Management Plan. October 2005.

Seiler D., G. Volkhardt, S. Neuhauser, P.Hanratty, L.Kishimoto, P.Topping, M. Ackley, L. Peterson, and L. Fleischer, 2005. 2005 Wild Coho Forecasts for Puget Sound and Washington Coastal Systems. Washington Department of Fish and Wildlife Science Division.

Shared Strategy, 2007. Puget Sound Salmon Recovery Plan. Plan adopted by the National Marine Fisheries Service (NMFS) January 19, 2007. *Available at:* http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Puget-Sound/PS-Chinook-Plan.cfm

Snover, A. K., P. W. Mote, L. Whitely Binder, A.F. Hamlet, and N. J. Mantua, 2005. Uncertain Future: Climate Change and its Effects on Puget Sound. A report for the Puget Sound Action Team by the Climate Impacts Group (Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Oceans, University of Washington, Seattle).

Sparks, R.E., 1995. Need for Ecosystem Management of Large Rivers and Their Floodplains. BioScience 45: 169-182.

Spence, B.C., G.A. Lomnicky, R.M. Hughes, and R.P. Novitzki, 1996. An Ecosystem Approach to Salmonid Conservation. TR-4501-96-6057. ManTech Environmental Research Services Corp. Corvallis, OR.

State of Washington Governor's Salmon Recovery Office, 2004. State of Salmon Watersheds Report. *Available at:* http://www.governor.wa.gov/gsro/publications/sosreport/default.asp

U.S. Department of Commerce, 2007. Sound Science: Synthesizing ecological and socioeconomic information about the Puget Sound ecosystem. Mary H. Ruckelshaus and Michelle M. McClure, coordinators; prepared in cooperation with the Sound Science collaborative team. National Oceanic & Atmospheric Administration (NMFS), Northwest Fisheries Science Center. Seattle, Washington. 93 p. *Available at:* http://www.nwfsc.noaa.gov/research/shared/sound_science/documents

Walker K.F., F. Sheldon, and J.T. Puckridge, 1995. A Perspective on Dryland River Ecosystems. Regulated Rivers 11: 85-104.

Washington State Conservation Commission, 2005. Salmon Habitat Limiting Factors in Washington. *Available at:* http://salmon.scc.wa.gov/reports

Washington State Department of Ecology, 2008a. Well log database. *Available at:* http://apps.ecy.wa.gove/welllog/

Washington State Department of Ecology, 2008b. Personal Communication, Dave Nazy, March 26, 2008.

Washington State Department of Ecology, 2007. Report to Legislature: Progress on Watershed Planning and Setting Instream Flows.

Washington State Department of Ecology, 1998. Report of the Technical Advisory Committee on the Capture of Surface Water by Wells: Recommended Technical Methods for Evaluating the Effects of the Capture of Surface Water by Wells. August 1998. Ecology Publication Number WR -98-154.

Washington State Department of Health (WDOH), 2008. Water System Database (Sentry database). *Available at:* http://www.doh.wa.gov/ehp/dw/sentry.htm

WRIA 1 Watershed Planning Unit, 2005. Final Draft WRIA 1 Watershed Management Plan. February 2005.

Science Question 2 (S2): Effectiveness and Certainty of Management Approaches to Address Threats to Freshwater Resources

Key Findings from Previous Efforts

A. What are the main scientific findings relating to management approaches and their documented effectiveness?

As described in the response to question S1, primary threats to water quantity in the Puget Sound region include: consumptive use of surface and groundwater; increases in consumptive use due to growth; land use practices that increase impervious surfaces, disconnect surface and ground water, and reduce wetland storage; loss of coastal freshwater supply due to seawater intrusion; and modified stream channels. Climate change will likely compound these effects.

The Land Use/ Habitat and Water Quality Topic Forums are addressing the effectiveness of management approaches aimed at reducing threats associated with land use and stormwater practices, including increased impervious surfaces, reduced groundwater recharge, and loss of wetlands. This discussion draft focuses on the effectiveness of approaches addressing overcommitment of the resource, projected increases in demand, future instream and out-of-stream needs, and the potential effects of climate change.

Management approaches for achieving ecologically sustainable water management can be divided into three categories: (1) flow-setting strategies, (2) demand strategies, and (3) supply strategies.

Flow-Setting Strategies

Flow-setting strategies are aimed at identifying instream flow needs, protecting instream values from future allocation, and making informed water management decisions. The central role of naturally varying water flows (ranging from base flows to high-flow pulses and floods) in maintaining river, floodplain, and estuarine health has been discussed in the response to question S1.

Existing regulatory instream flows codified by state rule in Washington typically address only low flows. However, advancements in river science suggest that allocations of water to sustain native species and functioning ecosystems, commonly called "environmental flows," need to address the five components of flow: extreme low flows, monthly low flows, high-flow pulses, small floods, and large floods.

A number of methods have been developed for setting environmental flows (Tharme, 2003). Recent water policy advancements in South Africa and Australia have sparked the development of innovative approaches to setting environmental flows that address the whole ecosystem and the interrelationships between its component parts. The building block, DRIFT, and benchmarking approaches that have been developed in South Africa and Australia have been effective in setting flows that address different components of the ecosystem instead of a single species or life history trait (King, *et al.*, 2003, Postel and Richter, 2003, Brizga, *et al.*, 2002).

Key components of these holistic approaches have been applied in the U.S., for example, in determining a flow prescription for the Savannah River. The resulting flow regime for the Savannah is being implemented by the U.S. Army Corps of Engineers (Richter, *et al.*, 2006). These approaches could be used in the Puget Sound region to determine streamflow regimes that consider "environmental flows."

Legal and regulatory approaches are necessary to implement these environmental flow regimes once they are quantified. Some of these new methodologies are considered a top-down approach because they begin with a natural flow regime and delineate alteration from that. Upside-down water rights, a system of identifying blocks of water that can be removed from a river system, could be used to legally implement a top-down approach. In this case, the water allocated for out-of-stream use is delineated and the rest of the water with its natural variation remains instream (Silk *et al.*, 2000). Given Washington's prior appropriation doctrine ("first in time is first in right"), setting instream flows as a state water right with a priority serves to protect the values provided by the instream flow from future allocation, but does not restore flow under state law. In the context of prior appropriation, upside-down water rights (Silk, *et al.* 2000) could currently be implemented in Washington to protect natural hydrological variability and its functions; other approaches would likely require legislative changes in Washington's water law.

Instream Flow Rule Setting in Washington

Washington is one of the few states in the country with the legal ability to secure water rights for aquatic habitat function and in quantities large enough to prevent further degradation of existing aquatic habitat. Instream flows set by rule in Washington do not affect existing water rights, so they cannot restore flow to the stream. But a new instream flow rule for a river basin can prevent new diversions that could further reduce flows and impact instream habitat. Newer instream flow rules typically address low flows (rather than the full range of flows), with associated management tools that limit future water withdrawals through basin closures or other means. These newer rules also provide tracking for new exempt wells. These rules provide effective tools for managing and tracking water allocation and use. The effectiveness of these approaches in terms of broader ecosystem health will be evaluated with time.

Demand Strategies

Demand strategies focus on reducing or maintaining consumptive uses of water. Reducing the amount of consumptive use in a watershed, or holding it constant as population increases, is an effective way to help reduce threats of population growth on freshwater resources. This can be done through regulatory, incentive, or education programs that promote water conservation, reclamation, and reuse. Improved efficiencies can be gained through water use compliance programs, water efficiency programs, infrastructure improvements, low impact development, and changed behaviors. The Water Quality Topic Forum is addressing reuse alternatives and documented effectiveness of this demand strategy.

Strategies have been applied elsewhere that successfully combine water allocation strategies (similar to Washington's basin closures but on a region-wide scale) with additional return flow and water efficiency requirements. For example, the Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement (2005) not only provided protection to the existing inflows to the Great Lakes, but is intended to also enable restoration. The Great Lakes Charter Annex agreements are intended to implement the 2001 Great Lakes Charter Annex, in which Ontario, Quebec, and the eight Great Lakes U.S. states committed to protect and manage the waters of the Great Lakes-St. Lawrence River Basin through agreements that set a common standard for decisions about proposed water uses. These agreements are currently being implemented.

Another example of strategies that have been shown to conserve water supplies (or limit consumption) is the implementation of an integrated water conservation, reuse, augmentation, and recharge project by the Upper San Pedro Partnership. The project includes wastewater recharge, conservation projects, land use restrictions, landscaping regulations, and rate incentives (or penalties). It is part of a large-scale restoration effort by the City of Sierra Vista and the Upper San Pedro Partnership to return 3.0 to 3.7 million cubic meters of water into the San Pedro River annually and attain an overall goal of a sustainable yield of groundwater by 2011 (Silk and Ciruna, 2004). During its first five years, the Upper San Pedro Partnership focused on assembling the building blocks of a science-based adaptive management program: establishing

a regional hydrologic monitoring network and conducting background research to prioritize various water conservation, reuse, augmentation, and recharge strategies. The Upper San Pedro Partnership is now implementing conservation projects and recharge, and using monitoring data to assess project effectiveness in an adaptive management context. Deficit-reducing yields as measured in 2005 exceeded goals for that year (U.S. Department of Interior and USGS, 2007).

Seattle Public Utilities (SPU) employs a conservation program that has been effective in reducing per capita water use by 1 percent per person per year. SPU has reported that their "1 percent per person per year by 2010" conservation goal has resulted in an average summer use per typical three-person family of 240 gallons of water per day (80 GPCD) (SPU, 2005). Seattle's summer usage of 80 GPCD is significantly less than the statewide annual average usage of 97 GPCD reported by Lane (2004).

Supply Strategies

Supply strategies focus on physically putting water back into the stream to meet instream needs, and identifying alternative sources for out-of-stream beneficial use that have less impact to instream resources. Water supply strategies have been used to restore hydrologic function while providing water supplies for human uses.

There are a limited number of ways to physically put water back into streams. These flow restoration strategies can involve dam operation, off-channel storage, groundwater storage (including aquifer storage and recovery), source exchange, and water marketing (including leases, water trusts, water purchase).

There are many examples of flow restoration strategies that have been implemented, but monitoring of results and effectiveness does not always occur. A recent compilation of over 37,000 river restoration efforts across the U.S. (Bernhardt, *et al.*, 2005) found that many projects had no listed goals, and only 10 percent of the projects reported any type of assessment or followup monitoring. It is relatively simple to document that flows have changed, but it is more difficult to demonstrate that the improved flows have achieved the desired ecological outcome. Examples of supply strategies with documented effectiveness monitoring are provided below. Other potential strategies where no documented effectiveness monitoring was available are explored in the response to question P1.

Dam Operation Strategies

In controlled systems, hydropower operations can provide an option to enhance low flows, address stranding of fish and drying of redds, and provide channel flushing flows. Strategies include changing the flow regime from dam releases to more closely mimic the natural flow regime; removing dams; changing diversion structures; or improving fish passage. Bednarek and Hart (2005) documented physical and biological improvements resulting from dam mitigation in the Tennessee River watershed. Other examples in Washington include:

Hydropower FERC Relicensing Opportunities

Significant restoration of flows for fish and aquatic habitat in Washington has occurred through relicensing of hydroelectric projects and negotiations associated with 401 Water Quality Certification under the Clean Water Act. Examples include the North Fork Skokomish River, the Chelan River, the Lewis River (Swift hydro project), the Skagit River, the Condit hydropower dam on the White Salmon, and the LaGrande hydropower project on the Nisqually River. Two of the flow improvements listed will occur in 2009 (Chelan and Lewis) and one is too recent (North Fork Skokomish, new flows started in March 2008) to observe their effectiveness in restoring fish runs. However, increased flows and reduced flow fluctuations associated with Seattle City Light operations on three dams in the Skagit (relicensing between 1980s and 1996) have achieved measurable increases in chum and Chinook salmon runs (Rob Masonis, Congressional Testimony, 2003; Seattle City Light, 2003). Changes in flow

on the White River due to operations at Mud Mountain Dam by the U.S. Army Corps of Engineers and reduced withdrawals from the river by Puget Sound Energy were a primary factor in significant increases in spring Chinook (U.S. Army Corps of Engineers, 2008).

Tribal Negotiations

Tribes have negotiated changes in flow regimes from dams used by cities and utilities for water supply, flood control, navigation, and other uses. One example is the Cedar River, where the Muckleshoot Tribe negotiated with the Corps of Engineers, City of Seattle, and the state and federal agencies to increase flows during summer and fall for sockeye and Chinook, prevent stranding of fish and drying up of redds, and provide fish passage into the upper watershed while still providing for multiple uses.

The Puyallup Tribe reached agreement with Puget Sound Energy to secure increased flows and passage for salmon in the Puyallup River through the Electron Hydro project. The Muckleshoot Tribe secured higher instream flows and less flow fluctuation in the Green River for salmon and steelhead in the spring, summer, and fall through negotiation with the City of Tacoma. The Jamestown S'Klallam and Elwha Tribes negotiated with the Dungeness Irrigation District to significantly increase instream flows in the Dungeness River during the low-flow time in the summer/fall for listed salmon species. Most of these operational changes involve monitoring of fish survival from spawning to emergence and adult returns.

Adaptive Management

Operational permits and agreements, such as Habitat Conservation Plans (HCPs) and FERC licenses, are now integrating adaptive management components into their operations. Seattle Public Utilities' Cedar River HCP includes consideration of low- and high-flow releases and the function of high flows on an adaptive management basis (City of Seattle, 2008). Adaptive management committees comprised of agency and tribal and utility biologists assist dam operators in determining appropriate releases. Such committees are now part of the Cedar River and Green River dam operations, and the hydroelectric operations on the Cowlitz, Lewis, Chelan, and other rivers.

Other Strategies

A number of other supply side management strategies show promise in addressing impaired streamflows. However, there has been little documentation of the effectiveness of these strategies in improving both hydrologic and ecosystem function. These strategies, listed below, are addressed in the response to question P1:

- Water Marketing/Allocation
- Streamflow Augmentation
- Aquifer Storage and Recovery
- Desalinization

Reclaimed water is addressed in the Water Quality Topic Forum discussion draft paper.

B. How is effectiveness measured and documented?

While a number of agencies monitor streamflow, groundwater, species abundance, or health in Puget Sound, there are no known monitoring programs that include a comprehensive integration of all these elements. Due to climate variability, the lack of knowledge about flow-biota relationships, changing human demands for water, and limited historical monitoring, there is a high degree of uncertainty about the effectiveness of water management approaches and flow protection, and about whether restoration actions meet their intended outcomes.

Performance-based evaluations that assess actual changes in the ecosystem rather than just progress in performing program activities are often lacking in restoration and protection activities. For example, the effectiveness monitoring of a streamflow augmentation program needs to not only include measurements of increases in flow, but also longer term measurements of ecosystem improvements due to the flow increases. In other cases, restoration programs have not been implemented long enough to assess results at an ecosystem scale.

Washington's Forum on Monitoring has recently begun a statistically designed, multi-agency evaluation of the effectiveness of habitat restoration activities conducted under Salmon Recovery Planning through a program of intensely monitored watersheds (IMWs) (Currens, *et al.*, 2006). Flow is one of the variables being monitored. Three of the IMWs being established in Washington are located in Puget Sound: in the Strait of Juan de Fuca, Hood Canal, and the Skagit basin. The results of this work are expected to be transferable to other comparable watersheds.

C. How should effectiveness be measured and documented?

Evaluating the effectiveness of management techniques requires clear goals and specific indicators. Specific hydrologic parameters can be selected for analysis in response to particular flow-biota relationships or known hydrologic changes (Konrad and Booth, 2002). The "Indicators of Hydrologic Alteration" provides a comprehensive view of streamflows and can be used for comparison between pre- and post- impact flow records or trend analysis (e.g., land use changes) (Richter *et al*., 1996, Richter *et al*., 1997, Mathews and Richter, 2007).

It may be necessary to change management approaches to better meet intended goals. The science community has long advocated adaptive approaches in water management (Stanford *et al.*, 1996; Poff *et al.*, 1997, 2003; Richter *et al.*, 1997, 2003). Adaptive management begins with defining mutually acceptable goals related to ecosystem health, economic benefits, and other societal needs and preferences (Rogers and Bestbier, 1997).

D. From a scientific standpoint, which approaches are known to have the most effective results for managing water resources for habitat? For municipal, domestic, agricultural, and industrial uses?

In summary, management approaches that have some level of documented effectiveness in protecting and/or restoring freshwater supply for both instream and out-of-stream purposes include:

- Coordinated demand management,
- Dam operation strategies that provide more optimal flow conditions,
- Instream flow rules that include provisions for future water reservations and basin closures, and
- Adequate effectiveness monitoring and adaptive management.

References

Bednarek, A. and D.D. Hart, 2005. Modifying Dam Operations to Restore Rivers: Ecological Responses to Tennessee River Dam Mitigation. Ecological Applications 15(3), 2005, pp. 997–1008.

Bernhardt, E.S., M.A. Palmer, J.D. Allan, G. Alexander, K. Barnas, S. Brooks, J. Carr, S. Clayton, C. Dahm, J. Follstad-Shah, D. Galat, S. Gloss, P. Goodwin, D. Hart, B. Hassett, R. Jenkinson, S. Katz, G.M. Kondolf, P.S. Lake, R. Lave, J.L. Meyer, T.K. O'Donnell, L. Pagano, B. Powell, E. Sudduth, 2005. Synthesizing U.S. River Restoration Efforts. Science 308, April 29, 2005, pp. 636-637.

Brizga S.O., A.H. Arthington, B.J. Pusey, M.J. Kennard, S.J. Mackay, G.L. Werren, N.M. Craigie and S.J. Choy, 2002. Benchmarking, a 'Top-Down' Methodology for Assessing Environmental Flows in Australian Rivers. *In:* Proceedings of International Conference on Environmental Flows for Rivers. Southern Waters Consulting, Cape Town, South Africa.

Currens, K. P., H. W. Li, J. D. McIntyre, W. F. Megahan, and D. W. Reiser, 2006. Review of study plan for the intensively monitored watershed program. Washington Independent Science Panel Report 2006-1. Governors' Salmon Recovery Office, Olympia, WA. *Available at:* http://www.governor.wa.gov/gsro/science/pdf/IMW_Final_Rept_2006-1_w_cover.pdf

Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement, December 13, 2005. *Available at:* http://www.mnr.gov.on.ca/mnr/water/greatlakes/Agreement.pdf

King, J. M., C. Brown and H. Sabet, 2003. A Scenario-Based Holistic Approach to Environmental Flow Assessments for Rivers. Rivers Research and Applications 19:619-639.

Konrad, C.P. and D. Booth, 2002. Hydrologic Trends Associated with Urban Development for Selected Streams in the Puget Sound Basin, Western Washington, Water-Resources Investigations Report 02-4040. U.S. Geological Survey, Tacoma, WA and University of Washington, Seattle, WA.

Masonis, Rob, 2003. American Rivers Testimony to the Subcommittee on Energy and Air Quality: Comprehensive National Energy Policy. March 12, 2003.

Mathews R. and B. D. Richter, 2007. Application of the Indicators of Hydrologic Alteration Software in Environmental Flow Setting. Journal of American Water Resources Association Vol. 43. No. 6.

Postel, S. and B. Richter, 2003. Rivers for Life: Managing Water for People and Nature. Island Press, Washington, D.C.

Richter, B.D., A. T. Warner, J.L. Meyer and K. Lutz, 2006. A Collaborative and Adaptive Process for Developing Environmental Flow Recommendations. River Research and Applications 22:297-318. *Available at:* http://www.nature.org/initiatives/freshwater/conservationtools/art16896.html

Richter, B.D., J.V. Baumgartner, J. Powell, D.P. Braun. 1996. A method for assessing hydrologic alteration within ecosystems. Conservation Biology 10: 1163-1174. *Available at:* http://www.nature.org/initiatives/freshwater/conservationtools/art16896.html

Richter, B.D., J.V. Baumgartner, R. Wigington, D.P. Braun, 1997. How much water does a river need? Freshwater Biology 37: 231-249.

Richter B.D., Mathews, R., Harrison, D.L., Wigington, R., 2003. Ecologically sustainable water management: managing river flows for ecological integrity. Ecological Applications 13:206-224. *Available at:* http://www.nature.org/initiatives/freshwater/conservationtools/art16896.html

Rogers, K. and R. Bestbier, 1997. Development of a Protocol for the Definition of the Desired State of Riverine Systems in South Africa. Pretoria (S.Africa): South African Wetlands Conservation Programme, Dept. of Environmental Affairs and Tourism.

Seattle, City of, 2008. Habitat Conservation Plan, Instream Flow Management. *Available at:* http://www.seattle.gov/util/About_SPU/Water_System/Habitat_Conservation_Plan--HCP/Instream_Flow_Commission/index.asp

Seattle City Light, 2003. Press Release: Seattle City Light Honored for Outstanding River Stewardship. April 8, 2003.

Seattle Public Utilities. 2005. Conservation Brochure.

Silk, N., J. McDonald and R. Wigington, 2000. Turning instream flow water rights upside down. Rivers 7:298-313. *Available at:* http://www.nature.org/initiatives/freshwater/conservationtools/art16896.html

Silk, N. and K. Ciruna, eds. 2004. A Practitioner's Guide to Freshwater Biodiversity Conservation. The Nature Conservancy, Boulder, CO.

Stanford, J. A., J. V. Ward, W.J. Liss, C.A. Frissell, R. N. Williams, J. A. Lichatowich and C. C. Coutant, 1996. A general protocol for restoration of regulated rivers. Regulated Rivers 12: 391-413.

Tharme, R.E. 2003. A global perspective on environmental flow assessment: emerging trends in the development and application of environmental flow methodologies for rivers. Rivers Research and Application 19:397-441.

U.S. Army Corps of Engineers, 2008. Historical fish count data at Mud Mountain Dam. *Available at:* http://www.nws.usace.army.mil/PublicMenu/Doc_list.cfm?sitename=MM&pagename=FISHCOUNTS

U.S. Department of the Interior and U.S. Geological Survey, 2007. Water Management of the Regional Aquifer in the Sierra Vista Subwatershed, Arizona—2006 Report to Congress. Prepared in consultation with the Secretaries of Agriculture and Defense and in cooperation with the Upper San Pedro Partnership in response to Public Law 108-136, Section 321.

Vigmostad, K.E., N. Mays, A. Hance and A. Cangelosi, 2005. Large-scale Ecosystem Restoration: Lessons for Existing and Emerging Initiatives, Northeast Midwest Institute, Washington, DC. *Available at:* http://www.nemw.org/restoration_products.htm

Policy Question 1 (P1): What Are We Doing (or Not Doing) Now to Address Freshwater Resources in the Puget Sound Region?

Policy approaches being used to manage freshwater resources (surface and groundwater) in the Puget Sound region, for habitat, species, and human uses

A. Threats being addressed by existing policy

Puget Sound's growing human population along with current climate trends will impact the future supply of fresh water in the region. Low streamflows and peak stormwater events already impact many rivers and streams in the region (Currens *et al.*, 2002; Shared Strategy, 2007; NMFS, 2006). As described in the response to question S1, primary threats to water quantity in the Puget Sound region include:

- Consumptive use of surface and groundwater;
- Increases in consumptive use due to human population growth;
- Land use practices that increase impervious surfaces, disconnect surface and groundwater, and reduce water storage in wetlands;
- Loss of coastal water supply due to seawater intrusion; and
- Modified stream channels.

Climate change will likely compound these effects. Agencies and organizations apply many policy approaches to manage or reduce these threats in Puget Sound, including regulations, plans, programs, incentives, education, and voluntary stewardship. A summary of the most relevant of these programs is presented in Table P1-1 and addressed in this portion of the discussion draft paper.

The goals of the Puget Sound Partnership's 2020 Action Agenda are to protect and restore the *Puget Sound ecosystem*.[3] A healthy Puget Sound region can be defined as having quantities of fresh water that are sufficient to support:

1. Freshwater and terrestrial food webs and human uses and enjoyment within all watersheds draining into the Sound; and
2. Estuarine, nearshore, and marine food webs and the habitats upon which they depend.

The Land Use/ Habitat and Water Quality Topic Forums are addressing policy approaches aimed at reducing threats to freshwater quantity associated with land use and stormwater practices, including increased impervious surfaces, reduced groundwater recharge, and loss of wetlands. This discussion draft focuses on strategies that address overcommitment of the freshwater resource, projected increases in demand, and the implications of these threats for instream and out-of-stream needs now and in the future.

B. Strategies for managing freshwater resources for habitat protection, fish and wildlife, and municipal, industrial, agricultural, and domestic supply

Washington State water law significantly affects how we manage our water. This section first provides a brief description of laws and regulations that control the use of water in Puget Sound, in light of the threats

[3] RCW 90.71.300

described above. Also included is a brief description of various programs and tools that can be used to influence the ways in which we use and manage the freshwater resource.

Washington State Water Law

Management of water supplies in Washington State is based upon the State Water Code.[4] Our water code, and western water law generally, is based on the "prior appropriation doctrine." This doctrine, also known as "first in time, first in right," means that the most senior right in the basin is entitled to its entire quantity of water before the second most senior right receives any water. Those who first put water to beneficial use have seniority in access to water over others when shortages occur. This strict seniority system continues down to the most junior right in the basin and, in times of drought, junior water right holders may not get their allotment of water. [5]

A water right must continue to be used or it will be considered lost through abandonment or relinquishment (commonly referred to as the "use-it-or-lose-it" provision). A water right is subject to relinquishment when all or a portion of the right is not used for five successive years.[6] In 2003, the Municipal Water Supply-Efficiency Requirements Act (Municipal Water Law) changed the relinquishment provision for municipal water rights for public water systems, whereby water rights that have not been used (e.g., unperfected or inchoate rights) may be changed or transferred for municipal supply purposes. [7]

"Permit-exempt" wells are exempted by statute[8] from having to obtain a water right permit, but they are not exempt from substantive requirements of the Water Code. They are generally limited to 5,000 gallons/day for primarily domestic, lawn and garden irrigation, stock water, and industrial uses. Approximately 3,250 permit-exempt wells have been drilled annually in the Puget Sound area since 1990. Such wells are sometimes used in lieu of supplies that require actual water rights in basins that are closed to further appropriation.

Historical overallocation of fresh water, combined with the prior appropriation doctrine, affects our ability to maintain water in streams to protect fish and other instream resources. It also limits mechanisms that might be employed to address threats to the freshwater resource of Puget Sound. In 1987, Ecology was authorized[9] to establish minimum water flows as a water right; however, these instream flow rights are junior rights that are subordinate to existing rights. Therefore, regulatory instream flow setting can protect instream resources from future allocation, but because they are junior rights (relatively newer rights), they cannot be depended upon to keep a minimum amount of flow in a stream when a senior user is withdrawing water.

Federal Tribal Reserved Water Rights

Tribal reserved water rights in Washington remain unquantified and likely represent the most senior rights in the state. Federal tribal reserved water rights are primarily based on the Winters doctrine established by the U.S. Supreme Court.[10] These reserved rights are based on an amount of water necessary to fulfill the purpose of the reservation. Tribal reservations include water for long-established uses such as fishing and hunting with a priority date of time immemorial. Courts have generally held that agriculture was also a

[4] 1917 Surface Water Code and 1945 Groundwater Code (RCW 90.14.031(2)).
[5] Prior to the enactment of the 1917 and 1945 water codes, water rights could be acquired by putting water to beneficial use or posting a notice near the point of diversion. These pre-code water rights could be preserved by filing a water right claim under the Claims Registration Act (RCW 90.14.068).
[6] RCW 90.14. 140-180.
[7] RCW 90.03.570.
[8] RCW 90.44.050.
[9] Chapter 90.22.010 RCW.
[10] *Winters v. United States*, 207 U.S. 564 (1908).

purpose of tribal reservations created in the 19th century. Federal tribal reserved water rights are not subject to relinquishment or abandonment for non-use. (Ecology, 2007b).

Plans and Programs Applicable to Puget Sound Watersheds

Many plans and programs in the state have some relation to management of either instream needs or out-of-stream water use. The programs tend to have a narrow mandate or focus and, individually, may be successful in achieving their goals. While many tools can be used to protect and restore streamflows, a coordinated strategy or program at a regional level is currently lacking (see further discussion in the response to question P2).

It is not within the scope of this discussion draft to evaluate each existing program separately; some programs are also relevant to the Land Use and Stormwater Topic Forums. An abbreviated summary of existing regulations and programs that address threats to freshwater quantity in the Puget Sound region is presented below and in Table P-1.

Instream Flow Setting by Rulemaking

Current instream flow rulemaking activities in the Puget Sound region are summarized by WRIA in Table S1-1. Instream flow rule setting has been effective in protecting rivers from future water withdrawals and to guide Ecology in making informed decisions regarding future water allocation. However, the rules do not put water back into streams that are already being impacted by altered flow regimes. Instream flow water rights are set at the time of the rule; therefore, they are junior to existing senior users. While the setting of instream flows establishes a surface water right for instream values, it alone is seldom adequate in achieving goals for salmon recovery or ecosystem function (American Rivers and WEC, 2003).

Ecology is working to establish instream flow rules in all watersheds draining to Puget Sound. Rules promulgated after 2000 are more comprehensive and often include groundwater closures, water reserves for future consumptive use tracked through county building permits, determinations of seasonal and year-round closures, and other innovative management tools (Ecology, 2008).

Salmon Recovery Planning and Implementation

Salmon recovery planning is occurring in the Puget Sound region under both federal and state laws.[11] Through the work of the Shared Strategy, the Puget Sound region has developed, and the National Marine Fisheries Service (NMFS) has approved, a salmon recovery program that calls for protection and restoration measures to be implemented for habitat; however, specific measures related to flow are generally absent. The watershed chapters of the Salmon Recovery Plan do not establish target flows for fish, and target flows for fish have not been identified to date for the Puget Sound Evolutionarily Significant Unit or ESU (Shared Strategy, 2007, Chapter 6). The lack of watershed-specific actions to address flow as a limiting factor was called out by NMFS in their regional supplement to the Salmon Recovery Plan (NMFS, 2006).

The Salmon Recovery Plan sets out a three-part strategy to establish protective instream flows, advance instream flow science, and implement flow programs over the next 10 years. Currently, Ecology is continuing to pursue instream flow rule setting in several basins in Puget Sound that do not have flow rules. However, we did not find any flow restoration measures currently being implemented that are focused on achieving those flows.

[11] The Endangered Species Act (federal) and 1998 Salmon Recovery Planning under ESHB 2496 (state).

Watershed Planning and Implementation
Watershed planning is voluntarily occurring in some watersheds in Washington State under RCW 90.82 (see Table S1-1). Where watershed planning has occurred, citizens, Tribes, local governments, and state agencies have worked together in WRIAs to develop watershed management plans that address the quantity of surface and groundwater. Local groups undertaking this type of planning have addressed water quantity issues in their plans, and some have also performed supplemental assessments of instream flows, water quality, storage, and fish habitat needs (Ecology, 2007a). Most plans address data gaps with actual projects to fill these gaps. Most of these WRIA groups are just beginning to implement the watershed plans they have developed; therefore the effectiveness of the plans is currently unknown and will likely vary over the region.

Watershed plans developed under RCW 90.82 and Salmon Recovery Plans (by watershed) developed under ESHB 2496 are not always coordinated. Review of available literature indicates there are no similar analyses of needs for fresh water being conducted on a more regional basis. The local recommendations could form an important foundation for a regional approach to freshwater management.

Critical Areas Ordinances
Cities and counties have adopted critical areas ordinances to protect critical habitat, including wetlands, provide protection of aquifer recharge zones, and address geologic hazards. In some areas, these ordinances have been shown to be effective in addressing the impacts of land use on aquifer recharge and in preserving wetland functions. This strategy is discussed further by the Land Use Topic Forum.

Growth Management
Designation of Urban Growth Areas (UGAs) helps to direct and concentrate growth and infrastructure. Growth management and associated land use planning are also intended to address water supply. However, it is not always possible to "build the water" needed for growth due to regulatory and resource constraints. In some areas of Puget Sound, there is currently a general lack of coordination among local planning processes (e.g., water system plans, comprehensive land use plans, and the Growth Management Act) (Nisqually Indian Tribe, 2003). This can result in uncertainty in the ability to serve projected growth with water. Strategies associated with the Growth Management Act are also discussed by the Land Use Topic Forum.

Water System Planning
Individual water purveyors update their comprehensive water system plans once every six years. Although these plans are not integrated at a more regional level, the water system planning process enables a local understanding of supply, demand, and future water needs at the scale of a water service area. These plans have been shown to be effective in acknowledging threats of increased consumptive use due to population growth, and identifying where water supply is not physically or legally available to meet future projected demand.

Water Conservation Programs
Conservation programs vary widely within the Puget Sound region. The City of Seattle employs an effective conservation program that could be used as a model in other areas. Ambitious conservation programs have been shown to be effective in reducing per capita water use. There is little consistency in goals for water use efficiency over the Puget Sound region. Starting in 2008, provisions in the 2003 Municipal Water Law will require larger water systems to provide water use efficiency plans (WDOH, 2008). However, the goals will vary by water system, and the rule does not include specific targets for efficiencies.

Streamflow Restoration Opportunities for Puget Sound Watersheds

There are a limited number of ways to physically put water back into streams. Restoration of aquatic ecosystems can include a number of supply side strategies that involve:

- Dam operation,
- Off-channel storage,
- Groundwater storage (including aquifer storage and recovery),
- Source exchange, and
- Water marketing (including leases, water trusts, water purchase).

These strategies typically involve negotiations between numerous parties and are implemented by dam operators, municipalities, water suppliers, or counties in partnership with others.

Dam Operations
The effectiveness of altering water releases from dams to more closely mimic the natural flow regime, as well as changing diversion structures and fish passage improvements, has been discussed in the response to question S2. Instream flow management is an element of FERC relicensing agreements, Habitat Conservation Plans (HCPs), and U.S. Army Corps of Engineers water management operations (Table P1-1). It has been an effective means of improving flows for instream needs. Ecology has the opportunity to influence flow regimes through the Section 401 Water Quality Certification permit under the Clean Water Act. Tribal negotiated releases are common and often successful in improving instream conditions for fish (see the response to question S2). The Army Corps of Engineers works with a number of fisheries interests as part of the flow management team for Howard Hanson Dam.

Source Exchange
Although source exchange techniques have not been implemented widely, nor monitored for effectiveness in improving hydrologic or ecologic function, these techniques could potentially help to shift consumptive use impacts away from surface waters during low-flow periods. Options include:

- Direct streamflow augmentation from groundwater,
- Aquifer storage and recovery,
- Use of reclaimed water coupled with aquifer storage and recovery, and
- Desalinization.

These measures are typically implemented by municipalities and counties.

Direct augmentation of surface flows using groundwater has been implemented in Washington State on a limited, small scale. The purpose is typically to mitigate the impacts from new water rights, and therefore the augmentation is for municipal purposes rather than habitat restoration (Ecology, 2003). The City of Kent is currently implementing a program to draw from springs and augment flows in Rock Creek. In Great Britain, the concept of directly pumping groundwater into streams and rivers to improve aquatic habitat and downstream public water supply has been practiced since the 1930s. A number of projects are currently ongoing (Voyce, 2005). In Oregon, direct augmentation is occurring on the Klamath National Wildlife Refuge, where 23,000 acre-feet of water is targeted for pumping from deep aquifers to augment water levels in the Refuge wetlands for environmental purposes (Hainline, 2001).

Desalinization is currently used for potable water for some systems in San Juan and Skagit Counties. In the future it may be a viable option for additional supply in coastal Puget Sound where new appropriations may not meet growing demand.

A number of aquifer storage and recovery (ASR) projects are in different stages of planning and implementation in the Northwest, including:

- Lacey-Olympia, Tumwater, Thurston County Partnership (LOTT) – Inject reclaimed water to increase groundwater supplies in the three cities (PGG, 2007).

- Lakehaven Utility District, King County – Inject surface water from a reservoir system to increase groundwater supply.

- City of Salem - Treated drinking water from the Santiam River is recharged to the subsurface, and stored in a highly permeable, confined basalt aquifer in the South Salem Hills area. The stored water is used to meet peaking demands and for emergency use, thus reducing diversions from the Santiam River at critical times (Banton and Pitre, 2002).

- Nooksack Watershed, Whatcom County – Inject surface water during higher flow periods to increase recharge to surface water during low-flow months.

- City of Walla Walla – Inject surface water from a reservoir to mitigate streamflow effects of pumping from a shallow aquifer.

Water Marketing/Allocation Strategies

Water banking and leasing, such as that implemented by the Deschutes River Conservancy in Oregon, has been successful in providing water for streamflow restoration. However, water marketing strategies are most effective where adjudication has occurred. Such strategies are not likely to be as effective in Puget Sound at this time, when water rights and claims have not been confirmed through an adjudication process. Increasing the efficiency of irrigation and putting conserved water in trust is a strategy that is currently being implemented in the Dungeness watershed. The Trust Water Right Program[12] can be used to acquire a water right or a portion of a right for instream flow.

C. Where are these approaches adequate to address threats to water supply and resources?

Several existing strategies discussed above appear to be effective in meeting their goals and addressing some threats to freshwater supply:

- More current instream flow setting provides tools to address threats to instream needs resulting from future consumptive use due to growth, and to link land use to water use.

- Streamflow restoration options associated with dam operations address flow impairment and instream needs.

- Other supply side strategies including source exchange, aquifer storage and recovery, and water marketing (including leases, trusts and purchase) may be useful in putting water in streams during times when flow impairment is most limiting.

- Demand management opportunities, such as increased conservation and use of reclaimed water, have the potential to significantly decrease per capita water consumption. This can help offset increased use due to population growth and exacerbation due to climate trends.

[12] RCW 90.42.020(3).

Some of the newer programs, policies and rules, based on more current science and more integrated understanding, are thought to be more effective in their focus than previous rules. (For example, instream flow rules that integrate water management tools along with flow setting promulgated after 2000.)

D. Where are these approaches inadequate to address threats to water supply and resources?

The approaches discussed above and listed in Table P1-1, individually, may be successful in their narrower mandate or local focus. However, nowhere in the Puget Sound region do we know of a program that adequately addresses threats to the freshwater resource where large populations of people also occupy the watershed, and where broader ecosystem protection and/or restoration goals related to flow are being achieved.

Despite these current policy approaches, all of the threats to fresh water that are outlined above continue to have local impacts in Puget Sound. This is demonstrated by the anticipated shortfalls in future water supply that have been identified in watershed plans and water system plans. In addition, flow has been identified as a current limiting factor for salmon in many of the watersheds in Puget Sound (WSCC, 2005; Currens *et al.*, 2002; Shared Strategy, 2007).

As the human population of Puget Sound grows to 5.2 million by 2020, it is likely that threats associated with consumptive use of groundwater and surface water, and land use impacts associated with growth, will intensify. Climate change will likely compound these effects on the availability of fresh water. The following are specific issues that need to be addressed.

Ecosystem Considerations

Despite the large number of programs that involve some aspect of water quantity, the Puget Sound region does not have policies that address threats from an ecosystem perspective. In addition, land use planning is typically not well integrated with water supply planning. There is no one program that explicitly incorporates the linkages among ecosystem elements at any scale in the region to achieve ecosystem goals. There is no system-wide analysis or framework that integrates water management among the ecosystem elements.

For example, when we design a stormwater system, we don't consider how much water is needed in a stream at certain times of year, nor do we regularly retain stormwater for the purpose of groundwater recharge. Wastewater and water utilities, in many areas of Puget Sound, "plumb" around the natural hydrology of a watershed, in effect bypassing millions of gallons per day around the freshwater-dependent ecosystem. Limiting factors analyses by WRIA have provided a better understanding of the limiting factors for fish productivity, but we do not have integrated solutions to address these factors.

Current approaches to water, land use, and stormwater management do not address the ecosystem as a whole. There appears to be either little incentive or lack of a mechanism to integrate programs. Integration of these elements would require a fundamental realignment of policy and regulation at the state level. The basis of western water law and the regulations that are derived from it provide further regulatory and institutional barriers to full integration of ecosystem components at a policy level. Furthermore, case law continues to evolve and influence the interplay between water and land use.

Gaps in Specific Programs

Gaps we have observed in existing programs are summarized as follows:

- Current conservation programs appear inadequate to address peak season use or to initiate social change in water use patterns throughout the entire region, although there are some locally successful programs. This is evidenced by per capita water use data for some utilities and the relatively small percentage of reclaimed water use, region-wide. To address the combined threats of population growth and climate change impacts to streamflow during low-flow periods, per capita consumption of water will need to be reduced in the future. There is no current program focused on social behaviors to address the combined impacts of these threats region-wide.

- Reclaimed water programs have been slow to take hold due to public acceptance and perceptions, as well as regulatory hurdles. These barriers to reclaimed water use are addressed by the Water Quality Topic Forum.

- There are few controls on the proliferation of permit-exempt wells, and these wells have no water use reporting requirements (Lane, 2004). Current statutory provisions in the groundwater code[13] make it difficult to address the proliferation of exempt wells, which threaten groundwater supplies by enabling withdrawals to occur on an individual basis without comprehensive monitoring or management.

- The full extent and validity of water right claims, permits, and certificates is currently unknown. The adjudication process provides the legal certainty to make such determinations, but the process is complex and time-consuming. This precludes us from understanding how much water is currently allocated and used in the region, and creates uncertainty about providing water for future growth.

- Review of a number of freshwater management plans[14] indicates a lack of coordination or integration among existing plans at the regional level. None of the planning programs to date have provided a consistent summary of current water use, projected future water use, current supply, and potential shortfalls in meeting projected demands or instream flow needs for the Puget Sound region at any scale (across all WRIAs, action areas, or other jurisdictional areas). This can be attributed to both programmatic inadequacies and to disparities in the scale at which different aspects of water quantity are addressed by programs in the Puget Sound region. Instream needs[15] are typically addressed at a subwatershed scale, not a WRIA scale. However, municipal water use is addressed at the even smaller scale of a water service area. Individual water users operate at the smallest scale, their own projects. Individual water use data for water systems in Puget Sound have not been summarized at a more regional level (Lane, 2004), nor have the data been correlated with watershed-scale instream needs or streamflow.

- Enforcement programs are ineffective at bringing about compliance with the water code. Significant illegal withdrawals continue to occur.

- There is no comprehensive assessment of the adequacy of flows to support estuarine, nearshore, and marine health, as stated in the second desired water quantity outcome in the Puget Sound Partnership's definition of a healthy Puget Sound region. Currently this outcome is being addressed indirectly through the adequacy of freshwater flows for instream needs.

- Some county-wide seawater intrusion programs lack monitoring and appear inadequate to address threats to the freshwater resource from seawater intrusion.

[13] RCW 90.44.050.

[14] RCW 90.82 watershed plans, individual water system plans, 2496 salmon recovery plans.

[15] As identified in the limiting factors analysis, defined by instream flow rules and addressed in salmon recovery plans, FERC license agreements, and Habitat Conservation Plans (HCPs).

E. Is there regional variation throughout the action areas?

State policy and programs are consistent across the Puget Sound region. However, implementation of these policies and programs at the local level reflects local interests and priorities, and varies significantly. As discussed in the response to question S1, freshwater supply issues occur on a very local level, both with respect to out-of-stream demand for human use and instream needs for habitat. Regional summaries of freshwater availability do not exist and local summaries are not always comparable.

Table P1-1: Water Quantity Policies and Programs

Program/Policy	Threat Addressed	Managing Agency	Goal of Program or Policy	Location Or Scale	Effectiveness In Achieving Intended Water Quantity Goals
Instream flow rule making RCW 90.22, 90.54	Low flows	WA Department of Ecology	Protection of instream values	Developed at the WRIA scale	Regulations provide a baseline for protecting flows; earlier rules did not adequately address groundwater withdrawals
Land Use Planning /Critical Areas Ordinances RCW 36.70A	Loss of habitat, geohazards, impacts to aquifer recharge areas	Local governments	Protect critical habitat, avoid geohazards, protection of aquifer recharge zones	Developed at the county scale	Ordinance have been adopted by counties, updates underway
Shoreline program RCW 90.58	Impacts to riparian areas	Local governments	The Shoreline Management Act has three broad goals: 1) Encourage water-dependent uses; 2) protect shoreline natural resources; and 3) promote public access	Developed at the county scale	Local governments in the process of revising their Shoreline Master Programs
Salmon recovery planning RCW 77.85	Habitat, harvest, hatcheries and hydro impacts to listed salmon	Puget Sound Partnership	Healthy and harvestable populations of salmon	ESU scale	Plan has been developed, recovery will take time
Watershed planning (including storage) RCW 90.82	All plans were to address water supply issues, some watershed plans are addressing instream flows	Local Planning Units	Water quantity and optional elements of instream flows, water quality, and habitat	Planning is occurring at the WRIA scale; not all WRIA's have planning groups	Some watersheds have elected not to conduct watershed plans, some of the planning efforts have been terminated, and others have reached the implementation stage
Flood control management program RCW 86	High flows	Local governments	Protect communities at risk, restore floodplain function	Planning occurs at the local government scale	Floodplain management is designed to reduce the risks to communities, however some measures have impacted aquatic habitat
HPAs	Protects instream habitat	WA Department of Fish & Wildlife	Prevent habitat impacts from projects in the stream channel	Site specific permits for projects	See Land Use Topic Forum

Program/Policy	Threat Addressed	Managing Agency	Goal of Program or Policy	Location Or Scale	Effectiveness In Achieving Intended Water Quantity Goals
RCW 77.55				throughout the ESU	
HCPs ESA Section 10	Habitat for threatened species	NOAA Fisheries reviews and approves plans	A Habitat Conservation Plan (HCP), designed to offset any harmful effects the proposed activity might have on the species. The HCP process allows development to proceed while promoting listed species conservation. The "No Surpises" regulation provides assurances to landowners participating in HCP efforts.	An HCP is tied to a landowner or project.	
FERC – Section 401 Permit, Clean Water Act	Effects of hydroelectric projects on streamflow and water quality	FERC	Section 401 certification is required for any permit or license issued by a federal agency for any activity that may result in a discharge into waters of the state to ensure that the proposed project will not violate state water quality standards. This water quality certification is part of the 1974 Clean Water Act, which allows each state to have input into projects that may affect its waters (rivers, streams, lakes, and wetlands).	Project specific	
Water System Plans RCW 70.116	Water availability for human use	WA Department of Health	Under the Coordination Act and DOH regulations, CWSPs are created for the purpose of ensuring an adequate supply of potable water for domestic, commercial, and industrial use through coordinated water supply planning and development. To further that objective, CWSPs provide for minimum planning and design standards to ensure water systems are consistent with regional needs. CWSPs are also intended to assist state agencies in the orderly provision of financial assistance, and in helping water systems meet reasonable standards of quality, quantity and pressure.	Water System Service Area scale	
Water quality	Point source and non-point pollution	WA Department of Ecology	Attain and protect water quality standards through development of Total Maximum Daily Load allocation	Specific to a watershed	TMDL's alone do not restore water quality; this occurs through the

Program/Policy	Threat Addressed	Managing Agency	Goal of Program or Policy	Location Or Scale	Effectiveness In Achieving Intended Water Quantity Goals
RCW 90.48					implementation of specific actions
Stormwater RCW 90.48, 90.78	Urban runoff from impervious surfaces	WA Department of Ecology	Prevent stormwater from degrading water quality in rivers, lakes and streams	Local governments develop stormwater plans	Stormwater management is an ongoing challenge as urbanization increases
Water Allocation/Water Rights RCW 90.03, 90.44	Provides a right to use water for beneficial purposes	WA Department of Ecology	The purpose is to provide water for beneficial uses. A water right has a purpose of use, a point of diversion or withdrawal, a place of use, a quantity of use, and a priority date. The system is governed by a seniority system – prior appropriation. When water is not available, junior users are subject to interruption of supply in order to protect the rights of senior users.	Water rights are appurtenant to a parcel of land and they have a defined place of use.	Water rights have been issued throughout the ESU for a range of purposes including municipal, industrial, domestic, and agriculture
Water Marketing – Trust water program, etc. RCW 90.42	Restoration of low flows or water supply for people	WA Department of Ecology	Trust water rights protect a water right from relinquishment and can be used to restore stream flows or provide water for out-of-stream uses	Trust water rights occur at a river reach scale	The state has processed a number of trust water rights but the effectiveness of the program (in terms of fish productivity and abundance) has not been fully evaluated
AG Efficiencies Program	Inefficient use of irrigation water	WA Department of Ecology	Provide grants to irrigators for efficiency improvements	Occurs at the irrigation district scale	Notable flow improvements have occurred, e.g. in the Dungeness Watershed
Enforcement Programs for Water Rights RCW 90.03	Unauthorized or excessive water use that can impair stream flow or senior water rights	WA Department of Ecology	The goal of the compliance program is to manage the water resources of the public by ensuring voluntary compliance with state water law, and by taking consistent, fair, and assertive enforcement actions throughout the state. Ecology relies on technical assistance, voluntary compliance, and formal enforcement to gain compliance with water laws. Efforts are being concentrated in 16 fish-critical basins across the state where low stream flows are a limiting factor for salmon populations.	Compliance occurs at the water right scale	Lack of enforcement resources in the Ecology regional offices is limiting the program's effectiveness
Climate Change "Program"/policy	Reduced water supply for instream resources and human use	WA Department of Ecology	To prevent and adapt to changing climate conditions	Statewide scale	Too early to evaluate the effectiveness, recommendations only recently adopted

Program/Policy	Threat Addressed	Managing Agency	Goal of Program or Policy	Location Or Scale	Effectiveness In Achieving Intended Water Quantity Goals
SWSLs RCW 90.22	Low flow	WA Department of Fish & Wildlife / WA Department of Ecology	Ecology has the authority to close surface waters by rule to further consumptive appropriation based upon recommendations from WDFW	Specific streams within a WRIA	Has been effective in halting the issuance of new water rights in basins that are still needing an instream flow rule
Sea Water Intrusion Programs	Loss of coastal groundwater supply due to seawater intrusion	County		For specific counties.	
Desalinization	Lack of available freshwater source.	WA Department of Ecology (for brine discharge permit), WA Department of Health	Produce sole or supplemental water source for potable purposes. Currently being explored as a supplemental source option in WRIA 17. Operation of desalinization plant should take pressure off of surface and ground water resources, keeping more water in the aquifer to be discharged during low flow periods.	Coastal areas with sufficient current and environmental conditions.	Have typically been used by island communities on the San Juans to meet potable water demands either as sole source or supplemental source.
Water Resources & Development Act [WRDA92]	Loss of natural flow regime due to dam operation	US Army Corp of Engineers	Requirement to identify impacts and benefits of dam projects to the public. Has resulted in coordination with state, tribes and federal fisheries agencies.	White River/Puyallup River Basin, Green River, and Lk Wa Ship Canal	Effective in better mimicking natural flows on Green River by use of a flow mgmt team and coordination with tribes & fisheries agencies.

References

American Rivers and Washington Environmental Council, 2003. Instream Flow Tool Kit: Advocacy Guide to Healthy River and Stream Flows in Washington.

Banton, D. and C. Pitre, 2002. Water Storage Goes Underground. Seattle Daily Journal of Commerce. 25 July, 2002.

Booth, D., D. Beyerlein, S. Bolton, T.W. Holz, T.Hooper, R. R. Horner, J. R. Karr, D. Kirkpatrick, J. Lombard, and C.W. May, 2006. Open letter to Puget Sound Partnership with recommendations to: Improve Water Quality and Habitat by Managing Stormwater Runoff, Protect Ecosystem Biodiversity and Recover Imperiled Species, Provide Water for People, Fish and Wildlife, and the Environment. October 26, 2006.

Currens, K., D.Reiser, H. Li, J. McIntyre, and W. Megahan, 2002. Independent Science Panel for Puget Sound Salmon Recovery, Technical Memorandum 2002-1, Instream Flows for Salmon, February 15, 2002. *Available at*: http://www.digitalarchives.wa.gov/GovernorLocke/gsro/science/021502memo.pdf

Hainline, J.L., 2001. Final Environmental Assessment, Development of Water Supply Production Wells for Lower Klamath National Wildlife Refuge. Prepared for U.S. Fish and Wildlife Service.

Lane, R. C., 2004. Estimated Domestic, Irrigation and Industrial Water Use in Washington, 2000. U.S. Geological Survey Scientific Investigations Report 2004-5015. *Available at*: http://pubs.usgs.gov/sir/2004/5015/

National Marine Fisheries Service, Northwest Region, 2006. Final Supplement to the Shared Strategy's Puget Sound Salmon Recovery Plan. November 17, 2006. *Available at*: http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Puget-Sound/upload/PS-Supplement.pdf.

National Research Council (NRC), 1994. Groundwater Recharge Using Waters of Impaired Quality. Washington D.C., The National Academy Press, 279 pp.

Nisqually Indian Tribe, 2003. Nisqually Watershed Management Plan. Prepared by the Nisqually Watershed Planning Unit. October 2003, 165 pp.

Pacific Groundwater Group, 2007. Aquifer Storage and Recovery in Washington State. Prepared for the State of Montana's Water Policy Interim Committee. 13 September 2007.

Puget Sound Partnership, 2006. Sound Health, Sound Future: Protecting and Restoring Puget Sound.

Shared Strategy, 2007. Puget Sound Salmon Recovery Plan. Plan adopted by the National Marine Fisheries Service (NMFS) January 19, 2007. *Available at*: http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Puget-Sound/PS-Chinook-Plan.cfm

Voyce, K., 2005. UK Environment Agency. Personal Communication, 5 May 2005.

Washington State Conservation Commission, 2005. Salmon Habitat Limiting Factors in Washington. *Available at* http://salmon.scc.wa.gov/reports

Washington State Department of Ecology (Ecology), 2003. Mitigation Measures used in Water Right Permitting. April 2003. Accessed online 20 October 2006. *Available at*: http://ecystage.ecy.wa.gov/programs/wr/instream-flows/Images/pdfs/mitmeas.pdf.

Washington State Department of Ecology, 2007a. Report to Legislature: Progress on Watershed Planning and Setting Instream Flows.

Washington State Department of Ecology, 2007b. Final Programmatic Environmental Impact Statement for the Columbia River Water Management Program. February 15, 2007. Ecology Water Resource Publication # 07-11-009. *Available at*: http://www.ecy.wa.gov/PROGRAMS/wr/cwp/eis.html

Washington State Department of Health, 2008. Water Use Efficiency Rule. *Available at:* http://www.doh.wa.gov/ehp/dw/Programs/wue.htm

Policy Question 2 (P2): What *Needs to be Done* to Address Threats to Freshwater Resources in the Puget Sound Region?

Potential policy approaches to address documented threats to freshwater resources (surface and groundwater) in the Puget Sound region, for habitat, species, and human water supply.

This discussion builds on the information presented in the responses to questions S1 and S2, and P1, to provide recommendations and conclusions that are supported by science and data.

A. Problem statement

Surface water flows and groundwater levels in the Puget Sound region have been modified through:

- Water withdrawals from rivers, streams, and aquifers for municipal, domestic, commercial, industrial, and agriculture water supplies;
- Increased impervious surfaces and reduced groundwater infiltration due to urbanization and forestry practices;
- Seawater intrusion of coastal aquifers;
- Channel modifications; and
- Altered hydrology including the loss of wetlands.

Low streamflows and peak stormwater events impact many rivers and streams in the Puget Sound region (Shared Strategy, 2007; PSP, 2006, Currens *et al*., 2002). Collectively, these changes have contributed to:

- Reductions in the abundance, viability, and diversity of native species (Annear, *et al.*, 2004; Beecher, 1990; IFC, 2008);
- Degradation of aquatic habitat; and
- Uncertainty in providing water supply for human uses and growing populations (San Juan County WRMC, 2005; Island County WRMC, 2005; Nisqually Indian Tribe, 2003; WRIA 1 Watershed Planning Unit, 2005; Cascadia Consulting Group, 2007; HDR Engineering, 2007).

With a projected human population of 5.2 million people by 2020, along with concurrent land use changes, it will be difficult to provide enough water to support native aquatic species while accommodating community growth in the Puget Sound region. Climate change will likely compound these effects.

B. What strategies are and are not working?

Several existing strategies discussed above appear to be effective in meeting their goals and addressing some threats to freshwater supply:

- More current instream flow setting provides tools to address threats to instream needs resulting from future consumptive use due to growth, and to link land use to water use.
- Streamflow restoration options associated with dam operations address some flow impairment and instream needs.

- Other supply side strategies including source exchange, aquifer storage and recovery, and water marketing (including leases, trusts and purchase) may be useful in putting water in streams during times when flow impairment is most limiting.
- Demand management opportunities, such as increased conservation and use of reclaimed water, have the potential to significantly decrease per capita water consumption. This can help offset increased use due to population growth and exacerbation due to climate trends.

Some strategies discussed in the response to question P1 are either absent or ineffective at addressing:

- Conservation at a regional level (although there are some locally successful programs);
- Permit-exempt wells;
- Extent and validity of water right claims, permits, and certificates;
- Coordination or integration among water quantity plans at the regional level;
- Enforcement of the water code;
- The adequacy of flows to support estuarine, nearshore, and marine health; and
- Monitoring of seawater intrusion.

C. Preliminary strategies and associated actions between 2008 and 2020

The Puget Sound Partnership is developing initial strategies for addressing water quantity issues in the Puget Sound region. Strategies addressing overcommitment of freshwater resources, projected increases in water demand, future instream and out-of-stream needs, and the potential effects of climate change are presented below. The Land Use Topic Forum is addressing strategies related to threats associated with land use practices, including increased impervious surfaces, reduced groundwater recharge, and loss of wetlands, and the Water Quality Topic Forum is addressing strategies for stormwater runoff.

Each of the numbered strategies listed below is followed by proposed actions that are intended to lead to a healthy Puget Sound by 2020 (Puget Sound Partnership, 2008). These actions represent preliminary recommendations for the working group to consider. To be successful in meeting their intended outcomes, these actions involve commitments by resource agencies, local governments, and water suppliers, as well as a general change in public expectations and behaviors related to water use. The actions have been denoted as "immediate," "short-term," or "long-term." Timing issues are discussed in the next section.

Strategy 1: Identify water needs or goals for the environment by watershed (WRIA).

Proposed Actions:

1a. Establish instream flows in Puget Sound basins without flow rules. (Immediate)
These include the Samish (WRIA 3), Skokomish-Dosewallips (WRIA 16), Quilcene-Snow (WRIA 17), Elwha-Dungeness (WRIA 18), and Lyre-Hoko (WRIA 19). Consider maintenance of groundwater levels, basin closures, limitations on the cumulative impact of exempt wells, and adequacy of flows to support estuarine function where applicable.

1b. Update instream flow rules that were adopted prior to 1985. (Long-term)
The science for assessing instream flow needs and our understanding of aquatic habitat and flow relationships has improved substantially since adoption of these earlier rules. Older rules did not include provisions for permit-exempt groundwater management, water reserves for future consumptive use, and determination of seasonal and year-round closures. It is these management tools that make instream flow rule-making effective at managing impacts of human water use and allocation.

1c. Identify flow limitations and targets for fish as part of Salmon Recovery Plan implementation. (Immediate)

- Develop WRIA-based inventories to determine where low- and high-flow problems occur.
- Establish the relationship between flows and viable salmonid populations.
- Identify salmonid recovery flow targets.

This work should be coordinated with the state effort to set instream flows, salmon recovery planning, and the 2020 Action Agenda as a whole.

1d. Assess adequacy of flows for estuarine and nearshore marine habitat including channel morphology and flows, salinity levels, and circulation. (Long-term)
Determine the range of freshwater inputs necessary to maintain healthy estuarine and marine nearshore habitats in Puget Sound. Assess total freshwater inputs to Puget Sound and trends in low- and high-flow inputs over time.

1f. Identify benchmarks for flow improvements and evaluate them. (Short-term)
Analyze streamflow trends for all of the major tributaries to Puget Sound and compare to instream flows set by rule. Identify metrics that indicate the benefits of flow improvements. Quantify those benefits for individual species. Collect the data that will quantify the benefits of flow improvements for individual species.

1g. Complete the task within the Puget Sound Salmon Recovery Plan for the development and implementation of comprehensive basin flow protection and enhancement programs (PEPS). (Short-term)

- Define the basic elements of a PEP and develop an initial checklist.
- Provide technical assistance and incentives for the development of PEPs in each WRIA.
- Develop benchmarks and performance measures.

Strategy 2: Identify water needs or goals for people by watershed (WRIA) and promote demand management.

Proposed Actions:

2a. Conduct a regionally consistent assessment of water use and future water needs, and availability. (Long-term)

- Estimate the quantity of ground and surface water use and future water availability by watershed (WRIA) or regional management area (action area) in the Puget Sound region. Integrate findings about water needs with reclaimed-water planning and stormwater planning.
- Develop an integrated and regionally accessible groundwater monitoring program (including some targeted streamflow monitoring) and associated database.

2b. Promote sustainable water use practices through regulations and incentives addressing water use efficiency, use of reclaimed water, and storage. (Immediate)

- Recognize and support businesses with sustainable water use practices.
- Create and implement water use efficiency rules for all sectors of use.
- Develop rules for water reclamation that promote potable water conservation.
- Implement innovative water storage projects such as aquifer storage and recovery.
- Expand financial support and incentives for capital investments in water reclamation projects, particularly where there are willing partners and demonstrable environmental benefits.

2c. Perform outreach and education to address human expectations about water use. (Immediate)
Conduct a rigorous, regional conservation program that is specifically designed to address human expectations with respect to water availability and use. Increase the public understanding of how decisions about daily water use affect streams and aquatic ecosystems. A significant shift in social behaviors is needed to reduce current per capita water use.

Strategy 3: Assess the effects of climate change on water availability.

Proposed Actions:

3a. Model climate impacts uniformly in the ESU. (Long-term)
Project the effects of a changing climate on streamflow over time by applying the model created by The Climate Impacts Group (CIG) at the University of Washington (Palmer, 2007) to all major watersheds in the Puget Sound region. Maintain a database of the information developed from the model that is available (through web access) to resource agencies and water suppliers. Update the assessments every 5 or 10 years to reflect new data and knowledge.

3b. Use the assessments of climate change (from 3a.) to estimate regional and local impacts on water supply, water demand, floods, groundwater, and the ability to meet instream flow requirements and fish targets. (Long-term)

3c. Develop strategies that address the impacts identified in 3b. (Long-term)
As part of strategy development, the Department of Ecology will coordinate with the U.S. Mayors Climate Protection Agreement to seek ways to mitigate impacts and increase public awareness.

Strategy 4: Protect instream flows (compliance and enforcement).

Proposed Actions:

4a. Develop water use compliance and enforcement plans in each Puget Sound watershed. (Immediate)
Compliance and enforcement plans need to be coordinated with local watershed planning efforts (where planning is occurring). Compliance and enforcement plans should include a prioritized list of actions, associated budget estimates, and an implementation schedule.

4b. Establish water masters for each basin to ensure compliance with water code. (Short-term)
Water masters control the use of water within a specific district to which they are assigned, and can help to address the illegal use of water.

4c. Require metering and reporting for 80 percent of water use (by volume) in all watersheds. (Immediate)
Begin with "fish critical" Puget Sound watersheds (Nooksack, Snohomish, Cedar/Sammamish, Duwamish/Green, Puyallup/White, Chambers/Clover, Quilcene/Snow, and Elwha/Dungeness). Create a web-enabled database for metering data.

Strategy 5: Affirm the social, legal and policy framework for water management.

Proposed Actions:

5a. Develop a process to recognize federally reserved instream flow water rights that is acceptable to federal, Tribal, state and other water interests. (Long-term)

5b. Consider regulation of exempt wells by general permit, either statewide, by WRIA, or by region (e.g., Puget Sound region). (Immediate)

5c. Amend the current water code to streamline the water rights adjudication process. (Long-term).
Develop a water right adjudication plan and schedule for each basin and allocate the necessary funding. Consider the funding and testing of pilot water courts.

5d. Develop water supply management plans. (Short-term)
Supply management plans should coordinate area infrastructure and development, water demand and supply projections, storage, reclaimed water, source exchange, strategies to meet water demands and instream flow needs associated with population growth, and drought preparedness plans tailored to each watershed. The scale of these plans is dependent on the area of Puget Sound being addressed. For central Puget Sound, the regional water supply management plan will encompass the three-county region (and most of five WRIAs). For other areas in the Puget Sound ESU, the "regional water supply plans" would take the form of a basin assessment, by WRIA. Water supply management planning will include reexamining and updating existing water availability determinations and closures to support improved streamflows and shape strategies to provide water for future needs of people. Use watershed planning information where possible.

Strategy 6: Address policy linkages.

There is a need to further evaluate and identify ecosystem-wide, integrated management programs. The recommendations below begin to address this need.

Proposed Actions:

6a. Develop a process to integrate land use planning, watershed planning, water quality planning, utility planning and ESA recovery planning. (Immediate)
Specifically include the linkage between land use planning and water use planning.

6b. Consider instream flow needs during planning and permitting for stormwater and reclaimed water infrastructure. (Long-term)

D. Timeline for implementing actions

Sequencing considerations and time to implementation were primary factors in determining the timeline for implementation of the actions described above. Population forecasts indicate that growth presents a greater near-term (2020) threat to water resources and supply, while climate change impacts are perceived as longer term and will be different in different parts of the Puget Sound region. Therefore, actions related to climate change were considered to be a less immediate priority.

Some actions are considered beneficial, but they will take a very long time to implement. As such, they are listed as long-term actions, but their importance should not be understated. Examples include streamlining the water right adjudication process, developing a process to recognize federally reserved water rights, and updating older instream flow rules that lack more sophisticated flow analysis and needed water management tools.

Criteria for prioritizing actions to address instream and out-of-stream freshwater supply needs

The following criteria are considered important in determining and prioritizing actions that will address the threats to freshwater supply as discussed above. Priority should be given to actions that:

- Link water use to other ecosystem elements (to land use, utility, watershed, water quality and ESA planning and implementation).
- Protect streamflows in basins without instream flow rules.
- Provide water management tools as part of instream flow rules to help protect streamflows in basins where newer rules do not currently exist.
- Identify flow limitations and targets for fish and other aquatic species.
- Address human behavioral changes regarding water use.
- Address policies for exempt wells.
- Require metering and reporting of water use at both local and regional scales.

How will we know we are making progress? Scientific and Policy Based Outcomes and Associated Benchmarks

A. What specific objectives might be used to demonstrate progress toward the goals for water quantity?

By major strategy area, suggested specific objectives are as follows:

1. Identify water needs or goals for the environment by watershed (WRIA).
   - Codify new or revised instream flow rules for all mainstem rivers and major tributaries in Puget Sound for use in water supply management by a determined target date of 20xx.
   - Assess and prioritize flow impairments in a target number of WRIAs by a determined target date of 20xx.
   - Establish and codify salmon recovery flow targets.

2. Identify water needs or goals for people by watershed (WRIA) and promote demand management.
   - Compile a regional summary (Puget Sound basin wide) of current water use (all sectors), projected water use, and water supply (consider climate change impacts).
   - Develop goals for percent of non-potable water demand provided by reclaimed water.

- Establish conservation targets – e.g., Puget Sound per capita water use factor.
- Establish purveyor conservation targets.
- Identify a target number of ASR and desalinization projects and equivalent streamflow savings.
- Determine the percent of water system plans that have adequate water supply to meet the 2020 threshold (projecting adequate supply through 2020).

3. Assess the effects of climate change on water availability.

- Summarize the number of watersheds with flow modeling that accounts for climate change impacts.
- Determine the number of large water systems that have used surface water data from modeling to predict impacts on firm yield.

4. Protect instream flows (compliance and enforcement).

- Number of illegal water users identified and water use curtailed.
- Percent of water use currently metered.

5. Affirm the social, legal and policy framework for water management.

- Determine the number of water supply management plans developed (summarizing WRIA information consistently).
- Improve the ability to manage exempt wells by general permit.

6. Address policy linkages.

- Identify and develop ecosystem-wide, integrated management programs. This will require strong regional leadership and political will.

B. What aspects of program implementation and expected ecosystem and programmatic outcomes would be important to evaluate and track progress on this topic?

1. Status and trend of ecosystem condition.

- River/stream discharge
- Groundwater elevation
- Water temperature
- Connectivity to floodplain
- Pool/riffle/run habitat composition and distribution
- Species (define species and specific metrics)

2. Status and trend of threats.

- Track water use (per capita use, water system use, WRIA use – including exempt wells, metered water use)
- Percent of impervious surface

3. Project, program, and/or strategy effectiveness (in achieving direct outcomes).

- Per capita water use reduced/increased
- Total water use reduced/increased
- Percent impervious surface reduced/increased
- Increase/decrease in distribution of flow dependent keystone species, species of concern
- Increase/decrease in species population statistics

C. What aspects of progress evaluation are most important to start immediately?

- Baseline monitoring:
    1. Hydrology (address gaps in stream gage network, groundwater levels, connectivity to surface water/ effects from pumping)
    2. Biology (fish surveys)
- Flow/biota relationships
- Survey of people's perceptions of freshwater, water use, etc., and what would change their behaviors
- A refined description of actions and metrics that could be used to evaluate behavior change

References

Annear, T., I. Chisholm, H. Beecher, A. Locke, P. Aarrestad, C. Coomer, C. Estes, J. Hunt, R. Jacobson, G. Jobsis, J. Kauffman, J. Marshall, K. Mayes, G. Smith, R. Wentworth, and C. Stalnaker, 2004. Instream Flows for Riverine Resource Stewardship - Revised Edition. Instream Flow Council, Cheyenne, WY. *Available at:* http://www.atlasbooks.com/marktplc/00710.htm

Beecher, H.A., 1990. Standards for instream flow. Rivers 1 (2): 97-109.

Cascadia Consulting Group, 2007. Detailed Implementation Plan for the Quilcene-Snow Water Resource Inventory Area (WRIA 17) prepared for the WRIA 17 Planning Unit, October 9, 2007. 119 p.

Currens, K., D.Reiser, H. Li, J. McIntyre, and W. Megahan, 2002. Independent Science Panel for Puget Sound Salmon Recovery, Technical Memorandum 2002-1, Instream Flows For Salmon, February 15, 2002. *Available at:* http://www.digitalarchives.wa.gov/GovernorLocke/gsro/science/021502memo.pdf

HDR Engineering, Inc., 2007. City of Everett 2007 Comprehensive Water Plan.

Instream Flow Council, (IFC), 2008. Bibliography. *Available at:* http://www.instreamflowcouncil.org/images/hb_if_reference_list-9-06.pdf

Island County Water Resources Advisory Committee, 2005. Island County Water Resource Management Plan. June 20, 2005.

King County Regional Water Supply Planning - Tributary Streamflow Committee, 2006. Final report of the tributary streamflow technical committee. October, 2006. *Available at:* http:// www.govlink.org/regional-water-planning/tech-committees/trib-streamflow.index.htm/

Lombard and Somers, 2004. Central Puget Sound Low Flow Survey. Prepared for the Washington State Department of Fish and Wildlife, November 30, 2004.

Miller, J., 2007. Presentation on impact of climate change on water supplies of Everett, Seattle, and Tacoma. Jim Miller, City of Everett. December 4, 2007.

Nisqually Indian Tribe, 2003. Nisqually Watershed Management Plan. Prepared by the Nisqually Watershed Planning Unit. October 2003, 165 pp.

Palmer, R.N., 2007a. Technical Memorandum #6: Framework for Incorporating Climate Change into Water Resources Planning. A report prepared by the Climate Change Technical Subcommittee of the Regional Water Supply Planning Process, Seattle, WA.

Palmer, R.N., 2007b. Final Report of the Climate Change Technical Committee. A report prepared by the Climate Change Technical Subcommittee of the Regional Water Supply Planning Process, Seattle, WA.

Puget Sound Partnership, 2006. Sound Health, Sound Future: Protecting and Restoring Puget Sound. *Available at:* http://www.nwfsc.noaa.gov/research/shared/sound_science/documents

Puget Sound Partnership, 2008. What is a Healthy Puget Sound?

San Juan County Water Resource Management Committee, 2005. San Juan County Water Resource Management Plan. October 2005.

Shared Strategy, 2007. Puget Sound Salmon Recovery Plan. Plan adopted by the National Marine Fisheries Service (NMFS) January 19, 2007. *Available at:* http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Puget-Sound/PS-Chinook-Plan.cfm

Washington Department of Fish and Wildlife, 2006. Draft Guidance: Ranking Puget Sound Streams for Low Flow Enhancement, A Proposed Watershed Based Methodology. October 4, 2006. *Available at:* http://wdfw.wa.gov/hab/science/papers/ps_ranking_method.pdf/

WRIA 1 Watershed Planning Unit, 2005. Final Draft WRIA 1 Watershed Management Plan. February 2005.

Appendix A

Summary of Freshwater Resource Adequacy

Appendix S1: Summary of Freshwater Resource Adequacy

Puget Sound Partnership Action Area	WRIA	WRIA Name	Are Streamflow and Aquifer Levels Sufficient for:				Are Streamflow and Aquifer Levels Sufficient for: (Identify water use type e.g., municipal, industrial, agricultural, residential. Are these quantified?)				Threats to Streamflows and Aquifer Levels (e.g., water withdrawal, dam operations, etc.)	Data and/or Research	
			Fish and Wildlife (list species if applicable)	Confidence Level (H, M, L)	Habitat (list habitat types)	Confidence Level (H, M, L)	Current Human Demands	Confidence Level (H, M, L)	Future Human Demands	Confidence Level (H, M, L)	Current and Future Threats:	Existing Data or Available Studies and References	Data Gaps and Research Needs
San Juan/Whatcom	1	Nooksack	With few exceptions flows are not sufficent during the low flow period to provided maximum instream habitat for salmonids, including Chinook, Coho, Chum, Pink and Sockeye salmon, steelhead, cutthroat trout and bull trout/Dolly Varden. Lowland streams such as Bertrand subject to low flows through diversion and groundwater pumping, in combination with solar heating (lack of riparian shade) are sensitive to additional flow depletion and may benefit from flow restoration. Lower mainstem of the Nooksack River in late summer/early fall gets low enough that there has been suggestion of impairment of upstream migration near mouth due to combination of sediment deposition (shallow) and warming. Recommended salmon and steelhead rearing flows at the three reaches were 200, 560, and 570 cfs and he studied flows as low as 185, 342, and 585 cfs, respectively. In two out of three reaches more flow produced more rearing habitat in low flow season.Whatcom Creek may be an anomaly because water has been diverted into the lake and then some is removed, so not sure whether the creek has more or less flow than historically it had.		Diverse freshwater, estuary, wetlands, riparian. Instream Flow, wetted channel - Negotiations regarding degree to which flows meet habitat needs in process, as an implementation action under the WRIA 1 Watershed Plan		Because most drainages in WRIA 1 are closed to further surface water appropriation (and connected groundwaters) per WAC 173-501, or are limited by season or low flows, new water rights are not generally being issued in these basins at the current time. Further assessment is needed to make more detailed determinations of water availability for additional out-of-stream (or aquifer) uses. (M) Municipal demands are high, agricultural demands are high, shallow aquifers are replenished annually. Agricultural use depletes summer flows in lower basin tributaries, municipal use impacts Middle Fork Nooksack River. (H)	M-H	The degree to which human water demands can be met in the future is uncertain pending additional investigations into instream flow needs, growth projections and implementation of water management strategies, which must preceed determinations of water availability for human needs.	M	Current Threats: Illegal water diversions; conversion of agricultural and forest land to residential or commercial development; cumulative impact of exempt wells; climate change. Future Threats: Growing demand for domestic and municipal water supply; conversion of forest and agricultural lands to subdivisions, commercial areas and industry; climate change	Utah State Univ. Decision Support Systrm Model and supporting data; USGS and Ecology Flow and Water Quality Data, TMDLs. Much of documentation for flow limitation in Nooksack basin comes from instream flow studies using IFIM conducted by Brad Caldwell (Ecology mid-1980s) and Thom Hardy (Utah State University recently). These studies generally show that rearing habitat increases with increasing flow throughout the range of summer low flows, suggesting that the amount of flow limits the amount of rearing habitat. An exception may be rearing habitat for coho salmon. The North Fork of the Nooksack River was one of the streams where Swift (1976, 1979) developed the toe-width method; in this study he determined suitable spawning and rearing flows for salmon by measurement of habitat at different flows. By comparing the flows that maximize habitat to gage data, it would be possible to ascertain that habitat is limited by low flows. • Salmon and Steelhead Habitat Limiting Factors in WRIA 1, The Nooksack Basin, Wash. State Conservation Comm. July 2002 • Nooksack Instream Resources Protection Program (WRIA 1), Chapter 173-501, Dept. of Ecology, November 1985 • Bertrand Watershed Coordinated Irrigation District Managment Plan, July 2004 • WRIA 1 Watershed Management Plan, Phase 1, Feb. 2005	Fish habitat needs in many reaches of WRIA 1 streams, hydrologic data in tributaries
San Juan/Whatcom	2	San Juan	Streamflow in Cascade Creek (Orcas) is listed as having low flow in the Salmon Habitat Limiting Factors Analysis produced by WA State Conservation Commission. Lower Cascade Creek - known to be inhabitated by coho and chum, sea-run cutthroat trout, juvenile chinook salmon. Cascade Creek on the southeast corner of Orcas Island has a limited anadromous fish zone where some salmon spawn. It is heavily diverted and the subject of current discussions about trust water rights and flow restoration. A stream that flows into False Bay on San Juan Island may support salmon (Beecher has found none but there are reports in the old WDF stream catalog). It is part of the water supply for Friday Harbor and its flow is thus somewhat depleted. One other stream near Roche Harbor was reported by a now-retired WDFW		Very small lowland streams. Chinook known to use estuarine areas of other creek mouths on San Juans. Some local concern about reduction in flow of small streams that feed estuaries (but are not spawning/rearing areas).		Dependent on area of consideration - seawater intrustion has occurred mainly on San Juan and Lopez Islands. Some communities have turned to desalinization plants. Areas where bedrock geology is prominent have less stable water supplies - may run dry in summer. Water may be boated or trucked in. Rainwater collection is permitted by San Juan County building codes. .	M-L	Urban growth areas are Eastsound, Friday Harbor, Lopez Island. Eastsound Area water suppliers looking for additional sources to supplement water supply for predicted population growth.	M-L	Current Threats: Cumulative impact of exempt wells, potential contamination of aquifers, drought conditions, seawater intrusion. Future Threats: Growing demand for domestic and muni water supply	see documentation and references. • Seawater Intrusion Report • Estimates of Ground-water Recharge from Precipitation to Glacial-Deposit and Bedrock Aquifers on Lopez, San Juan, Orcas, and Shaw Islands, San Juan County Washington (2002) • San Juan County Water Resource Mgmt Plan (Oct 2004) • WRIA 2 Phase II Basin Assessment (Aug 2002) • Multi-Purpose Water Storage Assessment (2004) • Salmon and Steelhead Habitat Limiting Factors Report for WRIA 2 (2002) • WDFW Report - Cascade Creek Fisheries (2007)	Aquifer flow model for the Eastsound Area, general groundwater monitoring (network being put in place in 2007), monitoring of seawater intrusion, effects of desalinization plants

Puget Sound Partnership Action Area	WRIA	WRIA Name	Are Streamflow and Aquifer Levels Sufficient for:				Are Streamflow and Aquifer Levels Sufficient for: (Identify water use type e.g., municipal, industrial, agricultural, residential. Are these quantified?)				Threats to Streamflows and Aquifer Levels (e.g., water withdrawal, dam operations, etc.)	Data and/or Research	
			Fish and Wildlife (list species if applicable)	Confidence Level (H, M, L)	Habitat (list habitat types)	Confidence Level (H, M, L)	Current Human Demands	Confidence Level (H, M, L)	Future Human Demands	Confidence Level (H, M, L)	Current and Future Threats:	Existing Data or Available Studies and References	Data Gaps and Research Needs
			habitat biologist (Art Stendal, Mount Vernon) to have a trout population, but when Brad Caldwell and Hal Beecher tried to verify this the stream was dry at its mouth. One stream on Lopez Island draining Hummel Lake to Port Stanley was a candidate for restoration of habitat for cutthroat trout, but it is unlikely any other salmonid might have used it. There are no instream flows in the Washington Administration Code (WAC) for this WRIA.										
Whidbey	3	Lower Skagit - Samish	Samish instream flow studies were performed for 5 targeted species- Chinook, Coho, Chum, Steelhead and cutthroat. The Samish River & Thomas Creek are on the SWSL list for flow impairments. Other flow impairments in the basin exist. Ecology is scheduled to develop and set an IRPP for the Samish basin. Other species present: Pink, Bulltrout, Sockeye. IFIM studies by John Blum and Pete Rittmueller (now with EES Consulting in Bellingham) in the Samish River suggest that low flows limit salmonid habitat. Samish River was one of the streams where Swift (1979) developed the toe-width method; in this study he determined suitable spawning and rearing flows for salmon by measurement of habitat at different flows. By comparing the flows that maximize habitat to gage data, it would be possible to ascertain that habitat is limited by low flows. Recommended salmon rearing flows at the three reaches were 25, 50, and 30 cfs and Swift studied flows as low as 12.6, 19.4, and 25.2 cfs, respectively. Thus low flows limited rearing habitat.		Diverse freshwater, wetlands, riparian, major estuary		Current muni/commerical/domestic uses are being met through exempt wells & existing water rights. Ecology is not processing new water rights. Current irrigation needs may or may not be met by existing water rights, depending on the validity of water rights.	M-L	Irrigation needs may need additional water rights & supplies. Residential and Commerical generally will be met, except for some tributary areas not served by public water.	M-L	Current Threats: Water withdrawals, landscape changes. Future Threats: Climate change, growth, water withdrawals, landscape changes.	Draft Samish Watershed Plan, Skagit CIDMP, Chinook Recovery Plan. Samish Watershed Plan & Associated reports (instream flows, water use report), Skagit Chinook Recovery Plan, LFA, SWSL list. • Swift, 1979	Groundwater/ surface water interactions, Agricultural water needs (initial work done in CIDMP and watershed plan), divide between Skagit & Samish basins.

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Whidbey	3&4	Lower Skagit/ Upper Skagit	The Skagit River is the only basin that still supports all six species of salmon. Also cutthroat and bulltrout. Yet, there are areas in the basin that are categorized as flow-limited by the Chinook recovery plan, the LFA & SWSL list.		Diverse freshwater, wetlands, riparian, major estuary. Flows have been modified in areas of the basin, including the Skagit Delta and estuary. 303(d) listings for temperature occur in the Lower Skagit tributaries.		Muni-Domestic-Commerical-existing water rights, the water reservation and stream flows are generally adequate to meet water demands for 25-50 years in the future. However, in some tributary basins where public water doesn't exist could face water shortages in the near term. Ag uses- It is unknown to the degree exising water rights cover current irrigation needs.The Skagit CIDMP did a lot of work looking at current & future irrigation water use in WRIA 3.	M-L	Projections done under the instream flow estimate the water reservation & water rights generally meets water needs basin-wide for at least 25-50 years. The CIDMP identifies future water needs that will need new water rights that exceed the agricultural irrigation reservation.	M-L	**Current Threats:** Water withdrawals are limited under the instream flow rule but can still affect flows. Dam operations have been modified under FERC licenses to be more fish-friendly, but still impact flows. Landscape modifications- impervious surfaces, diking and draining, forest conversion threaten streams & aquifers. **Future Threats:** Growth, climate change, water withdrawals	LFA, Chinook Recovery Plan, Temperature TMDL for Lower Skagit, SWSL list, Skagit CIDMP. Mainstem instream flow studies for Anacortes and Skagit PUD by Michael Barclay (now with DTA in Bellingham) and John Blum and Pete Rittmueller (now with EES Consulting in Bellingham) in the Skagit River addressed estuarine flow-habitat relationships. The work was done in cooperation with Eric Beamer and others at the Skagit River Cooperative. It suggests that high flows contribute to rearing salmon (especially Chinook) access to estuarine flats and reduction in those high flows would reduce their access to those feeding areas. They also studied a number of different tributaries to the lower Skagit in the Cultus Mountain area for the PUD; these studies suggested that habitat was limited by low flow. In their lower mainstem work and in other mainstem work farther upstream below the Baker River confluence by Phil Hilgert (R2 Resources Consultants, Redmond) habitat was not very sensitive to flow in this big river, except that connections to lateral habitats (side channels, sloughs), which can be very important for juvenile salmon production, varied with flows. An important factor for fish production is flow fluctuation and ramping rate in a regulated river such as the mainstem Skagit. Connor and Pflug (2004) documented improved production of several salmon in the upper mainstem Skagit below Seattle City Light's project in response to SCL's management of flow fluctuation to stabilize incubation and rearing flows and minimize stranding of redds and fry. Their results suggest that the regulated upper Skagit is not only more favorable for salmonid production now than it was, but more favorable than other nearby rivers.	Groundwater/ surface water interactions (current study being done by USGS), Basin-wide Water Supply Planning.
Whidbey	5	Stilliguamish	Chinook, coho, pink, chum, steelhead, cutthroat, bulltrout. LFA lists WRIA 5 as impaired by flows WRIA-wide. Ecology adopted IRPP in 2005 for the Stillaguamish basin. Recommended salmon and steelhead rearing flows at the three reaches were 110, 150, and 200 cfs and he studied flows as low as 15, 14, and 203 cfs, respectively. Clearly, low flows strongly limit rearing habitat at these reaches.		Diverse freshwater, wetlands, riparian, major estuary		Current human demands met through existing water rights and exempt wells in rural areas. No watershed planning was done to determine adequacy of existing supplies to meet current demand.		No watershed planning was done in WRIA 5-uncertain if public water suppliers face future shortfalls. IRPP reservation covers domestic exempt wells & stockwater uses up to 5 cfs. Agricultural irrigation appears to be declining in the basin.		**Current Threats:** Water withdrawals, landscape changes. **Future Threats:** Growth, climate change, water withdrawals	State of Stillaguamish report, LFA, WAC 173-505, Stillaguamish Chinook Recovery Plan. Sandra Embrey (USGS, Tacoma) conducted a series of IFIM studies for the Stillaguamish Tribe in the 1980s. In general, her results also suggested that flow limits habitat because more flow resulted in higher habitat index (WUA) within the range of low flows normally encountered. The North Fork of the Stillaguamish River was one of the streams where Swift (1976, 1979) developed the toe-width method; in this study he determined suitable spawning and rearing flows for salmon by measurement of habitat at different flows. By comparing the flows that maximize habitat to gage data, it would be possible to ascertain that habitat is limited by low flows. State of Stillaguamish report, LFA, WAC 173-505, Stillaguamish Chinook Recovery Plan.	Ground-surface water interaction, current & future water use and demands
Whidbey	6	Island	Chum, coho, cutthroat. Unknown-no studies done under watershed planning & many stock status are unknown. Limited information available in LFA. Salmon streams are few and small on Whidbey Island. Steve Boessow (WDFW Habitat Program, Water Rights Biologist) evaluated at least one salmon-bearing stream and concluded that flow was probably a limiting factor and additional water withdrawal would be detrimental to fish habitat. There are no instream flows in the Washington Administration Code (WAC) for this WRIA.	L	Very small lowland streams. Unknown how & if salmon use freshwater resources or just marine habitats.	L	Parts of WRIA 6 experience seawater intrusion. Other areas appear to have adequate freshwater supplies. Almost all human water use is from groundwater. Ecology is currently processing new water rights in WRIA 6.	M	Some parts of WRIA 6 may not have enough water supply for future growth. Other parts of WRIA 6 appear to have adequate water supplies.	M	**Current Threats:** Water withdrawals, seawater intrusion, loss of native landscape lowering recharge. **Future Threats:** Growth/water withdrawals, climate change, loss of native landscape and recharge capacity of the land.	Island County Water Resource Management Plan, USGS Island County Study, Salmon Recovery Plan.	Freshwater use by fish. Freshwater needs of near-shore areas. Recharge areas.

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Whidbey	7	Snohomish	Chinook, coho, pink chum, steelhead, cutthroat, bulltrout. Salmon Plan & LFA lists flows as a limiting factor in parts of WRIA 7. Instream flow frequently not met. Recommended salmon rearing flows at the three reaches were 1200, 860, and 2800 cfs and he studied flows as low as 624, 934, and 2200 cfs, respectively. At these relatively large, mainstem river site, low flow limits rearing habitat.	M	diverse freshwater, wetlands, riparian, major estuary		Everett & KC communities participate in regional water supply planning. Unknown if current human demands are being met elsewhere.	?	Everett & KC communities participate in regional water supply planning. Demands met until 2060. No watershed planning has been done to determine if future demands will be met. IRPP limits development of new water rights.	?	Current Threats: Water withdrawals, loss of native landscape, climate change. Future Threats: Growth, water withdrawals, climate change, land cover loss & impervious surfaces		Enhance documentation of flow problems, modeling flows/salmon survival & productivity, SHIRAZ/EDT model changes related to flow, evaluate land use/land cover & runoff impacts, address socio-economic concerns
South-Central Puget Sound	8	Cedar-Sammamm ish	No- for Sammamish River(chinook, steellhead, coho ,sockeye), Cedar River (chinook, steelhead, sockeye), Issaquah Cr (chinook, coho, sockeye, steelhead), Bear Cr(chinook, coho, sockeye, steelhead),Rock Cr (chinook, steellhead, sockeye). Also bulltrout, cutthroat, pink. Instream flows frequently not met. Recommended steelhead and salmon rearing flows at the three reaches were 5, 7, and 8 cfs and he studied flows as low as 4.8, 5.4, and 7.4 cfs, respectively, in Bear Creek; they were 25, 35, and 40 cfs and he studied flows as low as 27, 37, and 57 cfs, respectively, in Issaquah Creek; they were 75, 90, and 80 (revised to 150, Swift 1976) cfs and he studied flows as low as 76, 89, and 200 cfs, respectively, in the Cedar River. In Bear Creek low flows limit rearing habitat, in Issaquah Creek and the Cedar River low flows showed no clear evidence of limiting rearing habitat.	M	Lake, low to mid elevation streams of small to medium size, wetlands and riparian						Current Threats: Sammamish River- domestic development (closed by rule), Cedar River-municipal and domestic development(minimum instream flows set by rule), Issaquah Cr-domestic development (closed by rule), Bear Cr (closed by rule) Rock Cr- development (closed by rule)		
South-Central Puget Sound	9	Duwamish-Green	Chinook, coho, steelhead, cutthroat. No-Green River, Newaukum Creek, Soos Cr. Instream flow frequently not met. Recommended steelhead and salmon rearing flows at the three reaches were 200, 250, and 250 cfs and he studied flows as low as 188, 232, and 225 cfs, respectively. Low flow limited rearing habitat.	M	Lake, low to mid elevation streams of small to medium size, wetlands and riparian						Current Threats: Green River- municipal diversion(minimum instream flows set by rule),Newaukum Creek -Dairy diversions(closed by rule) , Soos Cr-domestic development(closed by rule)	Bear Creek, Issaquah Creek, and the Cedar River were streams where Swift (1976, 1979) developed the toe-width method; in this study he determined suitable spawning and rearing flows for salmon and steelhead by measurement of habitat at different flows. By comparing the flows that maximize habitat to gage data, it would be possible to ascertain that habitat is limited by low flows. Brad Caldwell (1989) conducted IFIM studies on the Green River and his results suggested that low flows limit fish habitat. His results were similar to Swift's. April 2, 1999 Ecology response to Legislature on Flow Impaired Streams with Significant Diversions	

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South-Central Puget Sound	10	Puyallup-White	Chinook, coho, pink, chum, steelhead, cutthroat, bulltrout. Maybe-Puyallup River, White River. Recommended steelhead and salmon rearing flows at the three reaches were 80, 100, and 100 cfs and he studied flows as low as 35, 39, and 55 cfs, respectively. Low flow limited rearing habitat.	M	Diverse freshwater, wetlands, riparian						**Current Threats:** Puyallup River - hydroelectric project but large recent improvement (minimum instream flows set), White River-hydroelectric project now gone and flows restored for last 4 years and last 2 years spring chinook run restored to thousands(closed by rule)	South Prairie Creek was a stream where Swift (1976, 1979) developed the toe-width method; in this study he determined suitable spawning and rearing flows for salmon and steelhead by measurement of habitat at different flows. By comparing the flows that maximize habitat to gage data, it would be possible to ascertain that habitat is limited by low flows. Instream flow studies using IFIM were conducted in the 1980s by Phil Hilgert for Puget Sound Energy in the White River bypass reach for the hydroelectric project. Subsequent restoration of much of the flow to the bypass reach has led to significant increases in salmon use of the 23-mile bypass reach. April 2, 1999 Ecology response to Legislature on Flow Impaired Streams with Significant Diversions	
South Puget Sound	11	Nisqually	Summer flows are "of concern" to meet the needs of Nisqually River (NR) Fall Chinook (threatened); NR Winter Chum; NRr Coho; (candidate); NR Pink; NR Winter Steelhead; NR Sockeye; NR Bull Trout (threatened); NR Coastal Cutthroat.		Diverse freshwater, wetlands, riparian, major estuary		Municipal supply problem exist now, and allocations generally exceed both summer and winter supply, with July-Sept "points of concern". McAllister Creek is closed to further withdrawals. Aquifers appear to be depleting throughout the WS, with rates ranging from high (McAllister) to low (most others).				**Current Threats:** Growth, including increased water demands and water quality degradation; there are 18 dams in the WS. **Future Threats**: Growth, including increased water demands and water quality degradation;	Level 1 WS Assessment; Nisqually Chinook Recovery Plan 2001; Nisqually River Basin Plan Characterization Report 2006; Assessment of Surface Water and Groundwater Interchange within the Muck Creek WS Pierce County 2001; Flow Investigation of the Nisqually River Lower Reach Thurston County, WA 2001. Instream flow studies in 1979-80 by John Easterbrooks (Washington Department of Fisheries, now at WDFW, Yakima office) were used to regulate instream flow releases at the Yelm hydroelectric project and subsequent studies were used to determine flow release requirements at LaGrande Dam. The watershed planning unit commissioned an IFIM study by Golder on the Mashel River, but study is not complete.	Evaluation of various hydrologic impacts of development; estimation of natural stream flows; extent of actual irrigation; additional groundwater modeling; additional gaging; verification of WR claims; evaluate WR usage; correct WRATS;
South Puget Sound	12	Chambers-Clover	Chinook, coho, chum, steelhead, cutthroat. No-Sequalitchew Cr	M	Low elevation streams, lakes, riparian and wetlands						**Current Threats:** Sequalitchew Cr-municipal, floodway relief (closed by rule)	No instream flow studies have been conducted, but upper reaches of the watershed were found to be intermittent during review of water right applications in the 1990s by Hal Beecher (WDFW). It is one of the original 16 critical water limited basins (as determined by professional opinion of Department of Ecology staff).	
South Puget Sound	13	Deschutes	Chinook, coho, chum, steelhead, cutthroat. Recommended steelhead and salmon rearing flows at the three reaches were 40, 60, and 70 cfs and he studied flows as low as 22, 26, and 68 cfs, respectively. Low flows limit rearing habitat. Woodland Creek is dry in the vicinity of the Department of Ecology headquarters below Lake Lois in most summers. There is a lot of growth pressure and groundwater withdrawal in this area.		Lake, low to mid elevation streams of small to medium size, wetlands and riparian						**Current Threats:** Growth pressure and groundwater withdrawal	The Deschutes River was a stream where Swift (1976, 1979) developed the toe-width method; in this study he determined suitable spawning and rearing flows for salmon and steelhead by measurement of habitat at different flows. By comparing the flows that maximize habitat to gage data, it would be possible to ascertain that habitat is limited by low flows.	

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South Puget Sound	14	Kennedy-Goldsborough	Chinook, coho, chum, steelhead, cutthroat. Limited by low flow.		l\Lake, small low elevation streams, wetlands and riparian, estuary							Ken Slattery (Ecology) conducted an IFIM study of Goldsborough Creek in the 1980s and results suggested rearing habitat is limited by low flow. Kennedy Creek has been the subject of considerable study, but instream flow studies have not been part of the studies.	
South Puget Sound and Hood Canal and South Central Sound	15	Kitsap	Chinook, coho, chum, steelhead, cutthroat. Many basins closed to further allocation - instream flow rules under WAC 173-515-040. See also: Salmonid Habitat Limiting Factors WRIA 15 (Kitsap). A number of streams seasonally or fully closed to water allocation. Recommended salmon rearing flows at three reaches on the Dewatto River were 20, 20, and 40 cfs. Low flows limit rearing habitat on the Dewatto River. Low flow limits habitat in Barker Creek.		Lake, small low elevation streams, wetlands and riparian, estuary. Numerous low-elevation, low-gradient streams. 125 separate streams supportin salmonids. Highly productive for chum, coho, cutthroat. Many streams do not have year round surface flow.		Kitsap County relies heavily on groundwater supplies. Concern about recharge rates and sustainabiliy of aquifers throughout basin. Many closed streams from instream flow rules set in the 1980s. See WAC 173-515-040. Much effort being put towards study of reclaimed water opportunities.		Concern about recharge rates of aquifers. Reclaimed water being considered to help provide for future secondary uses.		Current Threats: Cumulative impact of exempt wells, stormwater runoff, flashy streamflows, drought conditions. Future Threats: Population growth, development; Retention of natural stream hydrology imperative. Drawdown of aquifers that support streamflow through hydraulic continuity	see documentation and references. The Dewatto River was a stream where Swift (1979) developed the toe-width method; in this study he determined suitable spawning and rearing flows for salmon by measurement of habitat at different flows. By comparing the flows that maximize habitat to gage data, it would be possible to ascertain that habitat is limited by low flows. The WDFW Water Team conducted instream flow study using IFIM (http://wdfw.wa.gov/hab/science/papers/barkercrk_instreamflow.pdf) in Barker Creek near Silverdale. This study indicated that low flow limits habitat in Barker Creek. Big Beef Creek is one of the more intensively studied streams, but instream flow studies have not been a direct focus of the studies. Big Beef Creek is one of several streams in the area being studied as part of the Intensively Monitored Watersheds by WDFW and Ecology, in which flows and fish production are being monitored. • Kitsap Instream Resources Protection Program (WRIA 15), Chapter 173-515, Dept. of Ecology • WRIA 15 - Instream Flow Assessment Step C Report • Barker Creek Rainwater Study • Site Screening/Selection Report - Kitsap Stormwater Infiltration Project • Karcher Creek - Reclaimed Water Production and Distribution Report • Kitsap County WISER Water Summary Report • Kitsap County - Reclaimed Water Quality - Regulatory and Permitting Considerations • Kingston Reclaimed Water Report • Salmonid Habitat Limiting Factors WRIA 15 (Kitsap) and WRIA 14 (Kennedy Goldsborough Basin) • WRIA 15 Watershed Plan (not approved)	Economic viability of reclaimed water use, aquifer modeling, impact of wells on instream flows, viability of aquifer storage, infiltration galleries

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Hood Canal	16	Skokomish - Dosewallips	Chinook, coho, chum, pink, steelhead, cutthroat, bulltrout. Low summer flows impact the Hood Canal Summer Chum runs, currently a listed species. Aspect 2005 Instream flow study focused on fish passage flows in drought year. Recommended salmon rearing flows at the three reaches were 180, 300, and 220 cfs and he studied flows as low as 131, 128, and 129 cfs, respectively. Low flows limit rearing habitat.	M	Diverse freshwater, wetlands, riparian, major estuary. Passage for summer chum, fall chum, coho, pink, steelhead, chinook	M	Stream flows are generally adequate for most water uses, although there is currently not a great demand. Low summer flows are exacerbated by agriculture in the Skokomish valley. Municipal, residential, hydro (Skokomish), limited agriculture.	M	Population growth along the shoreline of Hood Canal will present significant potential stress on available supplies through existing municipal water suppliers. Future exempt well usage may have a significant impact on summer stream flows. Municipal, residential.	M	Current Threats: Cushman dam diversion. No limitations on permit exempt wells. Forest practices, land use, dam operation (Skokomish), gw withdrawals. Future Threats: Limited new water rights will be issued. Climate change, land use, seawater intrusion	Level 1 Technical Assessment. Brinnon area groundwater study. Yes, for water use estimates, very limited flow data, limited gw/sw interaction data, limited gw characterization studies. The Dosewallips River was a stream where Swift (1976, 1979) developed the toe-width method; in this study he determined suitable spawning and rearing flows for steelhead and salmon by measurement of habitat at different flows. By comparing the flows that maximize habitat to gage data, it would be possible to ascertain that habitat is limited by low flows. Brad Caldwell (Ecology) has conducted IFIM instream flow studies on several of the rivers in this watershed: Jorsted, Fulton, Dosewallips, Hamma Hamma, John, Duckabush, NF and SF Skokomish. In addition, Hal Beecher (Game) proposed instream flows by letter of March 22, 1985 for these as well as other streams where toe width had been done. Several IFIM studies were conducted for proposed hydroelectric projects in the 1980s: Hamma Hamma by Forrest Olson (CH2M Hill, Bellevue), Dosewallips by Phil Hilgert (now with R2 Resources, Redmond). These studies all indicated that low flows limit fish habitat. The Dosewallips study was a key piece of evidence in the Pollution Control Hearings Board appeal of the Water Quality Certification instream flow conditions; this case went the State Supreme Court and the U.S. Supreme Court, affirming Ecology authority to set instream flows under the Clean Water Act. There are no instream flows in the Washington Administration Code (WAC) for any streams in this WRIA. This makes the basin more susceptible to withdrawals that could exacerbate low flows. Hydrogeologic study of lower Dosewallips/Brinnon Area, Aspect Consulting, 2005; WRIA 16 Instream Flow Studies, Jefferson and Mason Counties, WA Aspect Consulting, 2005; WRIA 16 Technical Assessment, USGS Estimates of nitrogen loading and ground water discharge to Hood Cana, pending 2009	Verification of hundreds of water right claims. Tracking existing water right usage. Unknown illegal water use. Limited groundwater level monitoring. Only partial stream flow gauging. Long term trends, Varification of initial findings in Aspect instream flow study requires more time/flow data
Hood Canal and Straight of Juan De Fuca	17	Quilcene-Snow	Chinook, coho, chum, pink, steelhead, cutthroat. Low summer flows impact the Hood Canal Summer Chum runs, currently a listed species, in particular in Big Quilcene, Chimacum Creek	M	Diverse freshwater, wetlands, riparian, major estuary	M	Stream flows are generally to the point that, while adequate for most existing water uses, futute appropriations of water are problemmatic. Low summer flows are exacerbated by agriculture in the Chimacum valley. Industrial (paper mill), municipal, agriculture (Chimacum Valley), residential	H	Population growth along the shorelines will present significant stress on available supplies through existing municipal water suppliers. Future exempt well usage may have a significant impact on summer stream flows. Municipal, residential,agriculture and industrial uncertain	M	Current Threats: No limits on permit exempt wells. Population growth, forest practices, land use, gw withdrawal impacts to streams, sea water intrusion. Future Threats: Very limited new water rights will be issued. Restrictions may be imposed on all future groundwater withdawals (including exempt wells). Climate charge, forest practices, land use, gw withdrawals, sea water intrusion	Level 1 Technical Assessment. WRIA 17 Detailed Implementation Plan. USGS Chimacum Groundwater Study. Limited ground water characterization, some gw/sw interaction studies, unpublished instream flow work (WDFW). Brad Caldwell (1999) conducted an IFIM study in the Quilcene River in the 1980s and Hal Beecher (WDFW) evaluated summer chum salmon spawning and incubation habitat as a function of flow using a wetted width approach in the lower Quilcene. These results indicated that low flow limits fish habitat in the Quilcene. The Quilcene River is the water supply for Port Townsend and the mill. Beginning in 1979, Hal Beecher (WDFW) conducted an IFIM study in Snow Creek but the study was not completed until 2004. Terra Hegy (2005; http://wdfw.wa.gov/hab/science/papers/quill_snow_watershed.pdf) completed a wetted width study that showed habitat is limited by flow in many streams in the watershed. There are no instream flows in the Washington Administration Code (WAC) for this WRIA although a rule is in progress. Ground-Water System in the Chimacum Creek Basin and Surface Water/Ground Water Interaction in Chimacum and Tarboo Creeks and the Big and Little Quilcene Rivers, Eastern Jefferson County, Washington, USGS, 2004; WRIA 17 Technical Assessment, Parametrix, 2000; USGS Groundwater Model Chimacum Valley, pending 2009	Verification of hundreds of water right claims. Unknown illegal water use. Limited groundwater level monitoring. Only partial stream flow gauging. Long term trends for sw/gw; hydrogelogic characterization of Quilcene-Dabob Bay area; precipitation coverage.

Puget Sound Partnership Action Area	WRIA	WRIA Name	Are Streamflow and Aquifer Levels Sufficient for:				Are Streamflow and Aquifer Levels Sufficient for: (Identify water use type e.g., municipal, industrial, agricultural, residential. Are these quantified?)				Threats to Streamflows and Aquifer Levels (e.g., water withdrawal, dam operations, etc.)	Data and/or Research	
			Fish and Wildlife (list species if applicable)	Confidence Level (H, M, L)	Habitat (list habitat types)	Confidence Level (H, M, L)	Current Human Demands	Confidence Level (H, M, L)	Future Human Demands	Confidence Level (H, M, L)	Current and Future Threats:	Existing Data or Available Studies and References	Data Gaps and Research Needs
Straight of Juan De Fuca	18	Elwha-Dungeness	Chinook, coho, chum, pink, steelhead, cutthroat, bulltrout. No-Dungeness River, Little Quilcene River, Chimacum Cr. Flows limit fish habitat.	M	diverse freshwater, wetlands, riparian, major estuary						Current Threats: Dungeness- Irrigation, municipal, domestic development diversions (no instream flows set by rule),Little Quilcene River- Irrigation, municipal, domestic development diversions (no instream flows set by rule), Chimacum Cr-Irrigation, municipal, domestic development diversions (no instream flows set by rule).	An instream flow study of the Dungeness River using IFIM was conducted by Phil Wampler and Joe Hiss (1999). This study indicated that rearing habitat is limited by low flows. Jonathan Kohr (WDFW, Yakima) is evaluating flow restoration and is documenting low flows limiting upstream migration of spawning salmon in the late summer and early fall in the Dungeness River. The Dungeness flow protection and restoration efforts are discussed in a chapter in Locke et al. (2008, in press), including discussions of negotiations as well as technical details. Morse Creek has been the subject of an instream flow study using IFIM by Ken Slattery (Ecology) in the 1980s and validation of some of the assumptions in IFIM by Beecher et al. (1993, 1995, 1997). Slattery's studies indicated that flow limits fish habitat. There are no instream flows in the Washington Administration Code (WAC) for this WRIA although a rule is in progress. Dungeness- Irrigation, municipal, domestic development diversions (no instream flows set by rule), WRIA 18 Technical Assessment	
Straight of Juan De Fuca	19	Lyre-Hoko	Chinook, coho, chum, pink, steelhead, cutthroat, bulltrout. No- but these rain fed naturally go very low - there are few diversions		lake, mid to low elevation streams, riparian and wetlands							Flows get so low early in the summer and late in the spring that downstream migrants are sometimes trapped behind the beach, based on observations of residents who corresponded with Terra Hegy (WDFW). John Blum (EES Consulting, Bellingham) conducted a modified IFIM study in some of these streams and his results also suggest that flow limits habitat. Toe width data were collected by Terra Hegy (WDFW) and Jim Pacheco (Ecology) and then developed into instream flow recommendations which show streams flow limited when comparing ideal habitat flows and actual flows. There are no instream flows in the Washington Administration Code (WAC) for this WRIA although a rule is in progress.	

Table S-1 Matrix References

Ames, J., and H. Beecher. 1995. Recommended spawning flows for Cedar River sockeye salmon: with a review of spawning distribution and flood risk studies. Washington Department of Fish and Wildlife, Olympia. 108 pp.

Ames, J., and H. Beecher. 2001. Incorporating flood risk into controlled flow regimes for Pacific salmon: An example using Cedar River sockeye salmon. Report #FPT 01-13. Washington Department of Fish and Wildlife, Olympia. 123 pp.

Beecher, H.A. 1981. Instream flows for steelhead production in western Washington. Proceedings of the Western Association of Fish and Wildlife Agencies: 395-410. Kalispell, Montana.

Beecher, H.A., B.A. Caldwell, and S.B. DeMond. 2002. Evaluation of depth and velocity preferences of juvenile coho salmon in Washington streams. North American Journal of Fisheries Management 22: 785-795.

Beecher, H.A., J.P. Carleton, and T.H. Johnson. 1995. Utility of depth and velocity preferences for predicting steelhead parr distribution at different flows. Transactions of the American Fisheries Society 124: 935-938.

Beecher, H.A., J.P. Carleton, and T.H. Johnson. 1997. Testing the independence of microhabitat preferences and flow: response to comments. Transactions of the American Fisheries Society 126 (3): 541-542.

Beecher, H.A., T.H. Johnson, and J.P. Carleton. 1993. Predicting microdistributions of steelhead parr from depth and velocity criteria: Test of an assumption of the Instream Flow Incremental Methodology. Canadian Journal of Fisheries and Aquatic Sciences 50 (11): 2380-2387.

Caldwell, B. 1989. Green River Fish Habitat Report Using the Instream Flow Incremental Methodology. Washington Department of Ecology, IFIM Technical Bulletin OFTR 89-35. http://www.ecy.wa.gov/pubs/89035.pdf

Caldwell, B. 1999. Big Quilcene Fish Habitat Report Using the Instream Flow Incremental Methodology. Washington Department of Ecology, Open File Technical Report OFTR 99-05. http://www.ecy.wa.gov/pubs/oftr9905.pdf

CES (Cascades Environmental Services, Inc.). 1991. Final report – Cedar River Instream Flow and Salmon Habitat Utilization Study. Seattle Water Department.

City of Seattle. 2000. Final Cedar River Watershed Habitat Conservation Plan for the Issuance of a Permit for the Incidental Take of Threatened and Endangered Species. (http://www.cityofseattle.net/util/stellent/groups/public/@spu/@ssw/documents/webcontent/habitatco_200401201705386.pdf)

Connor, E.J., and D.E. Pflug. 2004. Changes in the distribution and density of pink, chum, and Chinook salmon spawning in the upper Skagit River in response to flow management measures. North American Journal of Fisheries Management 24 (3): 835-852.

Locke, A., and others. 2008 (in press). Instream flows for riverine resources: case histories. Instream Flow Council, Bozeman, MT. (citation uncertain)

Miller, J.W. 1976. The effects of minimum and peak Cedar River streamflows on fish production and water supply. M.S. thesis, Civil Engineering, University of Washington, Seattle.

Seiler, D., G. Volkhardt, S. Neuhauser, P. Hanratty, L. Kishimoto, P. Topping, and M. Ackley. 2003. 2003 wild coho forecasts for Puget Sound & Washington coastal systems. Washington Department of Fish and Wildlife, Olympia. 23 pp.

Smoker, W.A. 1953. Stream flow and silver salmon production in western Washington. Washington Department of Fisheries, Fisheries Research Papers 1 (1): 5-12.

Smoker, W.A. 1955. Effects of streamflow on silver salmon production in western Washington. Doctoral dissertation. University of Washington, Department of Fisheries, Seattle.

Swift, C.H., III. 1976. Estimation of stream discharges preferred by steelhead trout for spawning and rearing in western Washington. U.S. Geological Survey Open-File Report 75-155, Tacoma.

Swift, C.H., III. 1979. Preferred stream discharges for salmon spawning and rearing in Washington. U.S. Geological Survey Open File Report 77-422, Tacoma.

Wampler, P.L., and J.M. Hiss. 1991. Fish habitat analysis for the Dungeness River using the Instream Flow Incremental Methodology. U.S. Fish and Wildlife Service, Olympia, Washington. 133 pp.

Zillges, G. 1977. Methodology for determining Puget Sound coho escapement goals, escapement estimates, 1977 preseason run size prediction and in-season run assessment. Washington Department of Fisheries Technical Report 28. Olympia.