CRITICAL AQUIFER RECHARGE AREA

SKAGIT COUNTY

DISCUSSION AND BEST AVAILABLE SCIENCE REVIEW

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Discussion

The Growth Management Act identifies "critical aquifer recharge areas" (CARAs) as one of several types of critical areas that local jurisdictions must protect under their critical area regulations. The goal of establishing Critical Aquifer Recharge Areas is to "*protect the **functions and values** of a community's drinking water by preventing pollution and maintaining supply"* (Morgan, 2005). In addition, "*the GMA also requires that local jurisdictions give special consideration to conservation or protection measures necessary to preserve or enhance anadromous fisheries* (Morgan, 2005)*".*

Protection of the drinking water resource, both quality and quantity, can be achieved via a joint effort by local Health and Planning jurisdictions. Skagit County Health Department is charged with the task of protecting the health of the County's citizens and visitors by protecting drinking water sources. Skagit County's drinking water code (12.48.010 SCC) states:

> "Purpose and intent**.** These rules and regulations are established by the Skagit County Board of Health pursuant to its authority under Revised Code of Washington (R.C.W.) 70.05.060 and W.A.C. 246-290-030 permitting local boards of health to enact local rules and regulations as are necessary in order to preserve, promote and improve the public health and provide for the enforcement thereof. The purpose of these rules are to: . . .
>
> "Direct the public to the best source of drinking water and the best location for that source of water;"

Skagit County Planning and Development Services is charged with long-term and short-term planning for both the built and natural environments.

Department of Ecology's (DOE) recent adoption of a revised Skagit River Basin instream resource protection rule (WAC 173-503) and a Stillaguamish River Basin in-stream resource protection rule (WAC 173-505) speaks to the concern of assuring water availability for environmental resources as well as human needs now and into the future.

To achieve good stewardship of Critical Aquifer Recharge Areas, there are eight steps outlined in DOE's Guidance Document for Critical Aquifer Recharge Areas:

Step 1: Identify where groundwater resources are located.
Step 2: Analyze the susceptibility of the natural setting where groundwater occurs.
Step 3: Inventory existing potential sources of groundwater contamination.
Step 4: Classify the relative vulnerability of ground water to contamination events.
Step 5: Designate areas that are most at risk to contamination events.
Step 6: Protect by minimizing activities and conditions that pose contamination risks.
Step 7: Ensure that contamination prevention plans and best management practices are followed.
Step 8: Manage groundwater withdrawals and recharge. (Morgan, 2005)

It is a challenge in the best of times to allocate time and resources to expand this effort beyond the current level. Many of the recommendations found at the end of this report would be difficult to achieve without additional money and staff time to do so. However, setting goals can provide

a road map by which we can determine achievable steps to reach these goals. Indeed, lofty goals are imperative for both short and long-term planning. One of the first efforts should be directed to prioritizing critical aquifer recharge areas most at risk.

For this document, the County relied heavily on BAS reviews developed by other counties and jurisdictions.

Hydrogeology

The Skagit River is the main water course in Skagit County. The third-largest river on the West Coast of the contiguous United States, the Skagit travels 125 miles from the high Cascades of British Columbia to the salt water of Puget Sound. Its 3,100-square mile watershed is easily the largest in Puget Sound (Pacific Coast Watershed Partnership 2003-2004). The Skagit Basin is mostly mountainous except for the downstream reaches of the lower basin and adjacent river terraces. The eastern boundary of the Skagit Basin follows the crest of the Cascade Mountain range, where most of the peaks range in elevation from about 7,000 to 9,000 feet above sea level. The peak elevations decrease to the east, although the highest point in the basin, Mount Baker at an elevation of 10,773 feet, is located on the northwest margin of the basin. Geologically, the upper basin consists of bedrock ridges and glacially-carved valleys. Bedrock consists predominantly of metamorphic and granitic rocks, although sedimentary and volcanic rocks are also present (Drost and Lombard 1978). Most of the rock formations have been intricately folded and faulted. The lower slopes and valley bottoms became the sites of deposition of great thicknesses of sediment carried by glaciers from several alpine and continental Pleistocene glacial advances and retreats and subsequent alluvial deposition (Jones 1999). These deposits are thickest in the lower valley and delta region.

Groundwater in the basin occurs mostly in sand and gravel deposits within the unconsolidated alluvial and glacial material. These deposits are found in significant thicknesses only in the bottoms of the major river valleys and in the western lowland area (Drost and Lombard 1978). The multiple glacial and alluvial events have created a complex groundwater flow system within the unconsolidated deposits. Most of the bedrock in the basin acts as a groundwater flow barrier, although where fractures and joints provide sufficient secondary porosity, these formations can yield sufficient water for single and small group domestic water supplies. Little is known about the flow in bedrock formations. Although the majority of domestic supply wells withdraw water from the more-productive coarse-grained unconsolidated deposits, many domestic wells extract water from relatively fine-grained unconsolidated deposits and in bedrock formations.

Groundwater in the Upper Skagit Basin is suspected to generally flow toward valley bottoms and discharge to streams and/or eventually to the Skagit River (Vaccaro et al. 1997). Groundwater in the Lower Skagit Basin is suspected to flow generally to the west and discharge to the Lower Skagit River, smaller salt water drainages, or directly to salt water (GeoEngineers, Inc. 1996). However, no comprehensive groundwater studies have been conducted to date and only a few limited local studies are known to exist (Drost and Lomard 1978; Embrey and Jones 1998; GeoEngineers, Inc. 1996; Jones 1999; Thomas and Cox 1998, and Vaccaro et al. 1998). Furthermore, there are limited studies that address groundwater-surface water interactions in the basin. To help address this lack of data, Skagit County has contracted the U.S. Geological Survey to conduct a groundwater-surface water interaction study in four Lower Skagit Basin tributaries and also a groundwater flow study in the Skagit River mainstem delta area. Existing studies should be relied upon, whenever possible, to determine CARA parameters.

Aquifer Susceptibility and Vulnerability to Contamination

Aquifer susceptibility is determined by many factors including depth to groundwater, infiltration rate, permeability, etc. (Morgan, 2005). Vulnerability of an aquifer is more difficult to address because of the significant amount of time required to gather and organize information regarding the distribution of contaminants overlying an aquifer. There are potential sources of contamination that are in place permanently, such as on-site sewage disposal (septic) systems as well as point sources of contamination such as chemical spills. Pressures on water resources are dynamic: increased density, changes in land use, and new water sources can create a moving target for aquifer protection.

Time and resources (GIS and hydrogeologist) would need to be dedicated to create a map to determine a vulnerability component to CARA designation (Focazio et al. 2002). Regular upgrades to this map would be necessary in light of land use changes. In the absence of data regarding potential contaminants, it is prudent to consider an aquifer's vulnerability based on susceptibility.

CARA Designations

Drinking Water Resources Over half the population of Skagit County is provided drinking water by either Public Utility District #1 of Skagit County (PUD) or the City of Anacortes. Historically, PUD's primary source of water is from the diversion of multiple tributaries to the Skagit River, which is stored in Judy Reservoir located near Clear Lake, and then treated and distributed throughout much of the western portion of Skagit County. In the near future, PUD plans to supplement their water supply by withdrawing water directly form the Skagit River and discharging it to Judy Reservoir. Aside from this main system, PUD also owns seven smaller public water systems that each rely on separate groundwater sources. The City of Anacortes collects water directly from the Skagit River near Mount Vernon and distributes this water throughout the City of Anacortes, Fidalgo Island, the town of La Conner and other locations in Skagit and Island Counties. A rough estimate of the Skagit County population served by these two large, Group A water systems is 66,000 of the Skagit County population (Environmental Health, Skagit County Health Department 2001). The remainder of Skagit County residents are served by smaller Group A systems (Attachment A), Group B systems (Attachment B) or individual wells.

Water System Classification Group A systems serve 15 or more service connections, regardless of the number of people; or they serve an average of 25 or more people per day for at least 60 days within a calendar year, regardless of the number of service connections. Group B systems generally serve 2 to 14 connections and fewer than 25 people.

The Washington State Department of Health (DOH) has jurisdiction over Group A water systems (WAC 246-290). Skagit County Health Department (SCHD) contracts with DOH to administer the Group B public water system program in Skagit County (WAC 246-291)

Sole Source Aquifers. Residents of Guemes Island rely almost entirely on groundwater as their water source (Kahle and Olsen 1995). Based on this and other criteria, the U.S. Environmental Protection Agency (EPA) has designated Guemes Island as a sole source aquifer system (USEPA 2006). Proposed development projects on Guemes Island will be reviewed and an assessment of the project's potential to adversely impact the quality or quantity of groundwater

in the aquifer system will be conducted and, if necessary, mitigation measures will be required of the project proponent. (Attachment C)

Flow Sensitive Basins. Flow sensitive basins are so designated to balance development pressure with the need to protect instream flows in salmon-producing streams. Groundwater withdrawals in flow sensitive basins have the potential to adversely affect stream flows if the groundwater source is in hydraulic continuity with the salmon-producing streams. Consequently, maximum groundwater withdrawal limits have been established at levels that would not significantly impact salmon populations in the stream if these withdrawals result in a corresponding depletion in stream flow (Morgan and Jones 1999 and Washington Department of Ecology 2006). Additional future studies are expected to expand the understanding of groundwater-surface water interactions in flow-sensitive basins with high development pressure. It is anticipated that these future studies will provide the basis for subsequent modifications of this portion of the CARA. Maximum groundwater withdrawal limits and an associated tracking system will be utilized to track water use in flow-sensitive basins. Furthermore, limits on the amount of impervious surfaces that can be created in these basins will be established and/or recharge mitigation measures will be required to preserve the amount of groundwater recharge occurring and consequently, to reduce the potential for significant depletion of stream flows (Booth et al. 2002; Brandes et al. 2005; Konrad and Burgess 2001; and, Konrad and Booth 2005). In addition to these regulations, the Washington Department of Ecology has established a revised Skagit in-stream resource protection rule (WAC 173-503) which sets the framework for management of water resources in the basin. The affected sub-basins are found in Maps 1 and 2.

Seawater Intrusion Seawater intrusion areas require special protection to prevent degradation of the aquifer from salt water. At this writing, seawater intrusion areas are designated only on Guemes Island (Map 3). Other potential seawater intrusion areas may be present along the marine shorelines of Skagit County, but data are not available at this time to designate other seawater intrusion areas. Skagit County is in the process of compiling historical sampling data collected from wells situated in possible seawater intrusion areas to determine if additional areas should be designated as seawater intrusion areas. Until the necessary data become available, Skagit County will assess development projects that rely on a groundwater withdrawal located within one-half mile of a salt water body for its potential risk to induce seawater intrusion and, where appropriate, will require mitigation measures to reduce this risk.

In addition to the CARA section of the CAO, Skagit County's Interim Seawater Intrusion Policy (Attachment D) has been in place since 1995. This policy focuses on education of well drillers and water users as to pumping rates and monitoring parameters. Skagit County Health Department will be revising the local water code (Skagit County Code 12.48) and will be considering revision and inclusion of the seawater intrusion area policy to incorporate the results of more-recent studies (Island County Health Department 2005).

Wellhead Protection Areas (WHPAs) are areas delineated as providing recharge to a drinking water well. In Washington, WHPAs are mapped for all large (Group A) water systems. In addition, Group B water systems have the option of delineating a WHPA. Amendments to the federal Safe Drinking Water Act in 1996 require States to implement the Source Water Assessment Program. DOH utilizes the Wellhead Protection program under WAC 246-290 to implement the source water assessment requirements (Washington State Department of Health 2005).

There are a variety of means by which public water system purveyors establish a wellhead protection area (Forster, et al. 1997 and Miller 2005). Community Group A public water system purveyors designate wellhead protection areas usually by a susceptibility assessment (Attachment E) or occasionally through professional hydrogeology reports. For some Group A public water systems such as transient, non-community systems like restaurants or campgrounds, a WHPA is used with guidance from Appendix E of the Susceptibility Assessment. Appendix E provides a method for determining a calculated fixed radius (CFR) wellhead protection area based upon how much water is being drawn for those water systems using less than 5 million gallons per year. Group B public water systems in Skagit County may also use either of these means to establish a WHPA.

(Map 4)

On-site Sewage Systems and Nitrate Loading On-site sewage systems (OSS) are used to treat and dispose of sanitary waste in areas that do not have access to a public sanitary sewer system. In Skagit County, these systems are used in most areas outside of cities and urban growth areas. On-site sewage systems are primarily regulated by WAC 246-272A and SCC 12.05. When sited, installed, operated, and maintained properly, they are able to treat and remove contaminants from the waste stream prior to entering drinking water aquifers. However, if they are not sited properly or several systems are concentrated in a small area, contaminants from the waste stream can reach drinking water aquifers and potentially reach drinking water wells. Of the typical contaminants in the domestic systems, nitrate is the most common contaminant to reach the aquifer and be transported with the groundwater. Because of this risk, projects that propose to treat a large volume of sanitary waste in on-site sewage systems or otherwise propose to install systems in a manner that could adversely impact groundwater quality will be required to assess potential impacts to groundwater by nitrate (such as that developed by Hantzsche and Finnemore 1992) and, if necessary, implement mitigation measures that reduce the potential concentration of nitrate in groundwater to an acceptable level. The same measures will be required of other development projects that have the potential to release unacceptable amounts of nitrate into susceptible aquifers.

Development Standards

Many land-use activities can potentially affect the quality and quantity of groundwater. Applicants who propose activities subject to CARA review will be required to determine their impact on aquifers with professional hydrogeological reports or studies that characterize the aquifer and the potential project impacts. Recommendations are provided which are to be followed by the applicant and subsequent owners to protect the aquifer.

Prohibited Activities. Aquifer protection regulations typically include lists of activities that are prohibited in highly susceptible CARAs or WHPAs. Such activities are usually associated with hazardous materials or wastes and can include landfills, injection wells, and commercial and industrial facilities that use highly toxic and mobile chemicals.

Exempt Activities. Certain activities present low potential impacts to ground water quality and quantity and may not be practical to regulate.

Other

Data Gaps

When hydrogeological studies are not available for public drinking water sources, a calculated fixed radius (CFR) may be utilized for wellhead protection. Using a CFR for administration of a wellhead protection program may capture properties not affecting the groundwater and conversely, may miss properties that have an impact on the water source to the well (Miller 2005). The calculated fixed radius model of establishing a wellhead protection area is best applied to situations of slow aquifer movement and flat terrain.

Water quality data for individual wells is not being captured in a database at this time, making it difficult to determine if there are water quality trends occurring. Collection and coordination of these data for wellhead protection, seawater intrusion, as well as water quantity administration over time is needed.

Future Trends

Development of individual wells in areas not served by public water systems and where water is difficult to locate can be problematic. As development pressures increase, "well fields" may start to develop to utilize a local water resource. Individual wells, or even small public water system wells, which are in close proximity, may create pressures on each other and the groundwater source from which they draw. A careful evaluation of the interconnectivity of these wells and their draw-down impact on aquifers is necessary to assure that adequate clean water will be available now and into the future.

Findings and code recommendations

Finding	Recommendation
Step 1: Identify where Groundwater Resources are Located	
Finding #1: Existing data, maps, and reports, combined with the GIS capabilities of the County, provide an information base to support development of CARA designations and aquifer protection measures by Skagit County. The data are in several different formats and departments, thus requiring an evaluation of time and resources to compile.	Use available water quality, water quantity, and land use data to support creation of the CARA component of the County Code.
	Evaluate existing data to support mapping of aquifers in Skagit County. Identify data gaps.
	Compile mapping data from County GIS and technical reports to map aquifers. Distinguish between unconfined and confined aquifers, to the extent feasible.

Step 2: Analyze the susceptibility of the natural setting where groundwater occurs	
Finding #2: Existing data are not sufficient to determine aquifer susceptibility and to support vulnerability assessment.	Identify means of support to determine susceptibility of specific aquifers. Utilize recent field data if available. Plot on the CARA map.
	Compile all available wellhead protection area (WHPA)

	designations from public supply wells, using information from water purveyors, the Skagit County Health Department, and the state Department of Health as resources. Update WHPAs on the CARA map.
	Research and develop model by which to determine if or when to add a vulnerability analysis to the susceptibility determination. Consider the resources and costs required to accomplish this step.
	Identify areas of groundwater level declines and potential overdraft, in coordination with the Department of Ecology. Plot on the CARA map.

Step 3: Inventory existing potential sources of groundwater contamination.	
Finding #3: Resources are available to map point and some non-point contamination sources, including Ecology web site mapping tools and technical reports of past contamination incidents.	Determine the desired scale and scope of contamination source mapping, including staff and GIS availability
	Separate documented chemical release from potential releases and superimpose on CARA map.

Step 4: Classify the relative vulnerability of groundwater to contamination events.	
Finding #4: Hydrogeological reports, together with potential contamination source information, may be available to achieve this vulnerability evaluation.	Identify resources needed to compile existing information and identify gaps.
	Prioritize aquifer recharge protection requirements based on this vulnerability assessment.

Step 5: Designate areas that are most at risk to contamination events.	
Finding #5: Potential contamination assessment, including population base and land use, can help identify high risk areas.	Map risk-assessed areas on CARA map with different color designations as to level of risk.
	Evaluate mitigation plans, wellhead protection plans or other actions to assure adequate protection in high-risk areas. Conversely, low-risk areas may require fewer land-use restrictions.

Step 6: Protect by minimizing activities and conditions that pose contamination risks.	
Finding #6: Clearly identified areas of aquifer vulnerability will allow better direction for limiting activities or conditions that pose contamination risks.	Educational materials for new and existing activities in critical aquifer recharge area should be provided. Based on "social marketing" techniques to convince residents in these zones to be good stewards of the water resource, long-term results may be achieved. Identify resources to do so.
	Evaluation of the social marketing campaign to evaluate effectiveness.
	Review and develop enforcement protocols for high risk aquifer recharge areas.

Step 7: Ensure the contamination prevention plans and best management practices are followed.	
Finding #7: Resources are currently not available to follow-up on mitigation plans over time. Agricultural best management practices are dealt with on a complaint basis.	Identify resources to conduct periodic survey of residents within critical aquifer recharge areas to determine new activities, and remind residents of mitigation requirements.
	Develop water quality database.
	Periodic review of water quality data from wells to determine contamination trends.

Step 8: Manage groundwater withdrawals and recharge.	
Finding #8: Establishment of water reservations in the Skagit River Basin will induce data collection process to better manage groundwater withdrawals.	CARA section works in tandem with revised Skagit in-stream flow rule (WAC 173-503) to manage groundwater withdrawals and recharge for the protection of instream flows.

Develop Sections for Update of Skagit County Code, Chapter 14.24 Critical Aquifer Recharge Areas
Sections 14.24.300 through 14.24.360
Findings
Finding #9: The model code outline for CARAs in Washington State (Washington Office of Community Development (2002); attached as Appendix A) provides an appropriate basis for updating SCC 14.24.300 – 14.24.370
Finding #10: The revised Skagit in stream flow rule (WAC 173-503) provides the basis for critical area aquifer recharge and protection within flow-sensitive basins.

Recommendations	
14.24.300 – Intent *General*	Addition of reference to Skagit instream flow rule (WAC 173-503), Stillaguamish instream flow rule (WAC 173-505) and Skagit County water code 12.48 and intent to be consistent with DOH wellhead protection guidance.

14.24.310 - Designations *General*	Addition of susceptibility to designation. Note that there are currently no susceptible groundwater management areas, or special protections areas designated in Skagit County.
Section (1) – Closed, Low Flow Streams identified as "Flow Sensitive Basins" and moved to new Section (2)	Changed closed or low-flow streams to designation as Flow Sensitive Basins and created a unique category for Flow Sensitive Basins that is distinct from Category 1 and 2 designations. Flow Sensitive Basins have specific designation and mitigation sections (Sections 14.24.350 through 14.24.370).
Section (1)(a)(iii)	Redefine wellhead protection areas to include Health Officer or Administrative Official determination, thereby allowing flexibility to address potential 'well-field' scenarios requiring Category I CARA review. The purpose of this change is to replace the language that addresses plats with 5 or more individual wells where lot size is less than or equal to two acres, which was found to not be indicative of potential threats to aquifers.

	Redefine public water system wellhead protection definitions to capture all Group A water system 10-year time-of-travel zones and Group B water system one-year time of travel zones.

SECTON 14.24.320 LISTED EXEMPTIONS AND PROHIBITED ACTIVITIES. EXEMPTIONS ARE NOW LISTED AS SUCH UNDER SITE ASSESSMENT REQUIREMENTS (SECTION 14.24.330). PROHIBITED ACTIVITIES ARE NOW LISTED EXCLUSIVELY IN SECTION 14.24.320.

14.24.320 – Prohibited Activities	
Section (1)	This definition has been updated to reflect current solid waste codes.
Section (2) through (6)	Better define and expand activities that are prohibited in Category I areas.

SECTION 14.24.330 (INITIAL PROJECT REVIEW) WAS REMOVED AS THIS IS NOW COVERED UNDER SCC 14.24.080 (CRITICAL AREA REVIEW PROCEDURES GENERALLY). THE SCOPING SECTION (14.24.330(2)) WAS MOVED TO SECTION 1 UNDER SITE ASSESSMENT REQUIREMENTS (SECTION 14.24.330).

14.24.320 – Site Assessment Requirements *General*	Exempt activities now included in this section. Portions of Section .330 (Initial Project Review) included in this section.
Section(3)(k) – Site Assessment Elements	Change 'closed or low-flow' basins to Flow-Sensitive Basins.
Section (3)(l) – Site Assessment Elements	Assess seawater intrusion potential. The Skagit County Health Department needs to update Interim Seawater Intrusion Policy and consider placing it in SCC 12.48 (water code).
Section (3)(m) – Site Assessment Elements	Evaluate nitrate loading at full project build-out. (This is not a change from current procedures).
Section (4)(b) - Exemptions	Addition of accessory dwelling units outside Category I areas to exemption list. ADU's were not termed as such in the previous CAO.
Section (4)(e) - Exemptions	Link with 14.24.100 – activities allowed without critical area review.

14.24.330 - Mitigation *General*	Addition of language "or otherwise required per SCC 14.24.310 to determine mitigations necessary as determined by Health Officer or Administrative Official." Reference to mitigation for groundwater withdrawal section (Flow Sensitive Basins) for clarity.
Section (1) and (2)	General mitigation plan and recording sections moved from .350 (6) and (7) to Section .330(1) and (2).
Section (1)(f)	Removal of language '5 or more lots of two acres or less in size and is proposed to be served by individual wells" for reasons described in 14.24.310(1)(a)(iii) above.
Section (1)(i)(ii) – Nitrate Loading Mitigation	Nitrate loading mitigation revised to specify that a mitigation plan for a land division is required at 5 mg/L calculated nitrate loading, and that a contingency plan is required at 10 mg/L at the point of compliance. Also, plat notes required referring to these plans (current practice).
Closed – Low flow Stream Mitigation	Moved to Sections .350 through .380
	Removed public water hook-up requirement as this is more appropriately addressed in SCC 12.48.
	Removed interim well section to be consistent with WAC 173-503 and 173-505.
	Impervious surface section moved to Section .360 for organizational clarity.

	Removed lawn watering restriction to be consistent with WAC 173-503 and 173-505..
	Removed requirement to record mitigation plan summaries.

OLD SECTION SCC 14.24.360 (AQUIFER RECHARGE AREA PUBLIC NOTICE AND REVIEW) ELIMINATED AS THIS IS COVERED UNDER SCC 14.24.070 WHICH REQUIRES PUBLIC NOTIFICATION UNDER 14.06 (PERMIT PROCEDURES).

14.24.350 – Flow-Sensitive Basins *General*	New designation replacing closed and low-flow streams for basins with instream flow rules to be consistent with WAC 173-503 and 173-505.
Section 1(a) – Flow-Sensitive Basin reservations	Commensurate with WAC 173-503, Skagit in-stream flow rule.
Section 1(b) – Samish Basin	This language reflects the current code. When a Samish instream flow rule is adopted by Department of Ecology, this section will be amended.
Section 1(c)	Commensurate with WAC 173-505, Stillaguamish in-stream flow rule.
Section 2	Reporting requirement. Provision for mitigation measures that will allow water use not to be debited against the groundwater withdrawal limits.
Section 2(a) and (b)	Mitigation measures for groundwater withdrawals are to be approved by the Department of Ecology or Skagit County, in cooperation with Department of Ecology, for Flow Sensitive Basins.
Section 2(c)	If an applicant proposes a project based on an interruptible water supply, measures to utilize such a water source need to be approved by the Health Officer.
Section 2(d)	Parameters for determining when to debit a proposed water use against a Flow-Sensitive Basin groundwater withdrawal limit.

14.24.360 – Flow Sensitive Basin Mitigation Measures *General*	Mitigation measures in addition to SCC 14.24.330 Impervious surfaces from old 'in-stream' flow section increased from 5% to 20% based on best available science, and now applicable to projects within Flow Sensitive Basins (to be consistent with WAC 173-503 and 173-505). Current code addresses projects within ½ mile of streams identified as 'closed' or 'low flow.'
Section 1	This section is similar to what is in current code: SCC 14.24.350(5)(a)(iii) addressing impervious surfaces. There is an addition of language, "Health Officer or Administration Official determination that storm water infiltration will not be deleterious to health or the environment." This is to allow flexibility to address areas where storm water infiltration is not an acceptable mitigation measure.
Section 2	For projects utilizing septic systems and are served by a water supply from outside the project's basin, return flows from septic systems can be used to mitigate for recharge impacts from emplacement of impervious surfaces exceeding the limitations established in section .360.(current code per SCC 14.24.350(5)(a)(iii).
Section 3	Hydrogeological characterization that placement of

	impervious surfaces will not adversely impact stream flows allows for increase of impervious surface area.
Section 4	Addition of areas subject to tidal influence exempt from impervious surface mitigation requirements.

14.24.370 - Mapping	Maps for flow-sensitive basins to be produced.

Best Available Science – Scientific Literature

Booth, D.B., D. Hartley, and R. Jackson. 2002. Forest Cover, Impervious-Surface Area, and the Mitigation of Stormwater Impacts. Journal of the American Water Resources Association 38: 835-845.

Brandes, D., G.J. Cavallo, and M.L. Nilson. 2005. Base Flow Trends in Urbanizing Watersheds of the Delaware River Basin. Journal of the American Water Resources Association 41: 1377-1391. December 2005.

Drost, B.W. and R.E. Lombard. 1978. Water in The Skagit River Basin, Washington. Washington Department of Ecology Water-Supply Bulletin 47.

Embrey, S.S. and J.L. Jones. 1998. Reconnaissance Hydrogeology and Water Quality of the Swinomish Indian Reservation, Skagit County, Washington. U.S. Geological Survey Water-Resources Investigations Report 96-4031.

Focazio, M.J., T. E. Riley, M.G. Rupert, and D.R. Helsel. 2002. Assessing Ground-Water Vulnerability to Contamination: Providing Scientifically Defensible Information for Decision Makers. U.S. Geological Survey Circular 1224.

Forster, C.B., T.E. Lachmar, and D.S. Oliver. 1997. Comparison of Models for Delineating Wellhead Protection Areas in Confined to Semiconfined Aquifers in Alluvial Basins. Groundwater 35(4): 689-697. July-August 1997.

GeoEngineers, Inc. 1996. Report, Geologic/Hydrogeologic Services, Water Resources Plan, Skagit County, Washington. Prepared for Skagit County Public Utility District No. 1. December 11, 1996.

Hantzsche, N.M. and E. J. Finnemore. 1992. Predicting Ground-Water Nitrate-Nitrogen Impacts. Groundwater 30(4): 490-499. July-August 1992.

Island County Health Department. 2005. Seawater Intrusion Topic Paper (Final). Edited by D. Kelly. Approved by Island County Board of County Commissioners on March 16, 2005.

Jones, M.A. 1999. Geologic Framework for the Puget Sound Aquifer System, Washington and British Columbia. Regional Aquifer-System Analysis – Puget-Willamette Lowland. U.S. Geological Survey Professional Paper 1424-C.

Kahle, S.C. and T.D. Olsen. 1995. Hydrogeology and Quality of Ground Water on Guemes Island, Skagit County, Washington. U.S. Geological Survey Water-Resources Investigations Report 94-4236.

Konrad, C.P. and S.J. Burges. 2001. Hydrologic Mitigation using On-site Residential Storm-Water Detention. Journal of Water Resources Planning and Management 127(2): 99-107.

Konrad, C.P. and D.B. Booth. 2005. Hydrologic Changes in Urban Streams and Their Ecological Significance. American Fisheries Society Symposium 47:157-177.

Miller, C. 2005. The Use of a GIS to Compare the Land Areas Captured by Very Basic and Complex Wellhead Protection Area Models. Journal of Environmental Health. November 2005. pp. 21-26.

Morgan, D.S. and J.L. Jones. 1999. Numerical Model Analysis of the Effects of Ground-Water Withdrawals on Discharge to Streams and Springs in Small Basins Typical of the Puget Sound Lowland, Washington. U.S. Geological Survey Water-Supply Paper 2492.

Morgan, L. 2005. Critical Aquifer Recharge Areas Guidance Document, Washington Department of Ecology Publication #05-10-028, January 2005

Tesoriero, A.J. and F.D. Voss. 1997. Predicting the Probability of Elevated Nitrate Concentrations in the Puget Sound Basin: Implications for Aquifer Susceptibility and Vulnerability. Groundwater 35 (6): 1029-1039. November-December 1997.

Pacific Coast Watershed Partnership. 2003, 2004. http://www.pacificwatersheds.net/ontheground/skagit.htm.

Skagit County Health Department. 2001. Environmental Health Skagit County Report. December 2001

Thomas, B.E. and S.E. Cox. 1998. Ground-Water Age, Flow, and Quality Near a Landfill, and Changes in Ground-Water Conditions From 1976 to 1996 in the Swinomish Indian Reservation, Northwestern Washington. U.S. Geological Survey Water-Resources Investigations Report 98-4014.

U.S. Environmental Protection Agency web-site: http://www.epa.gov/safewater/swp/ssa/reg10.html .

Vaccaro, J.J., A.J. Hansen, Jr., and M.A. Jones. 1998. Hydrogeological Framework of the Puget Sound Aquifer System, Washington and British Columbia, Regional Aquifer-System Analysis – Puget-Willamette Lowland. U.S. Geological Survey Professional Paper 1424-D.

Washington State Department of Community, Trade and Economic Development Growth Management Services. Critical Areas and Best Available Science Information Page. *Page includes Critical Areas Assistance Handbook, Appendices, Findings of Fact and Local Examples*. (Need to include access date.)

Washington State Department of Community, Trade and Economic Development, Growth Management Services. 2002. Citations of Recommended Sources of Best Available Science for Designating and Protecting Critical Areas
569 KB, March 2002.

Washington Department of Ecology. 2006. Skagit Rule Amendment Rule Making Criteria: Background on the Reservations, Closures, and Hydraulic Continuity. Prepared in support of the amendment to: Chapter 173-503 WAC, Instream Resource Protection Program – Lower and Upper Skagit Water Resource Inventory Area (WRIA 3 and 4). May 2006.

Washington State Department of Health. 2005. Washington State's Source Water Assessment Program (SWAP). Department of Health Publication No. 331-148. June 2005.

Local Government Documents

- Local Government Documents
    - Issaquah Best Available Science Report Draft (235 KB), Planning Department 2004
    - Bellevue Best Available Science Paper, 2005 and Best Available Science Papers, 2003
    - Edmonds 2004 Best Available Science Report, Draft (261.8 KB)
    - Jefferson County Review of Best Available Science for 2004 Comprehensive Plan and Development Regulations Update (172 KB)
    - King County Best Available Science
    - Kitsap County Critical Areas Ordinance Revision and Best Available Science Review
    - Redmond Best Available Science Review and Summary Papers
    - Thurston County Critical Areas Update, Best Available Science
    - Whatcom County Critical Areas Ordinance, Best Available Science Review and Recommendations for Code Update, Draft, (2.74MB) Parametrix et al., 2005

Other Web Sites:

- Washington State Department of Health, Source Water Assessment Program.
- Washington State Department of Health Drinking Water
- Department of Ecology Critical Aquifer Recharge Area Ordinance Page