WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Critical Aquifer Recharge Areas

Guidance Document

January 2005
Publication Number 05-10-028

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Guidance Document

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Water Quality Program

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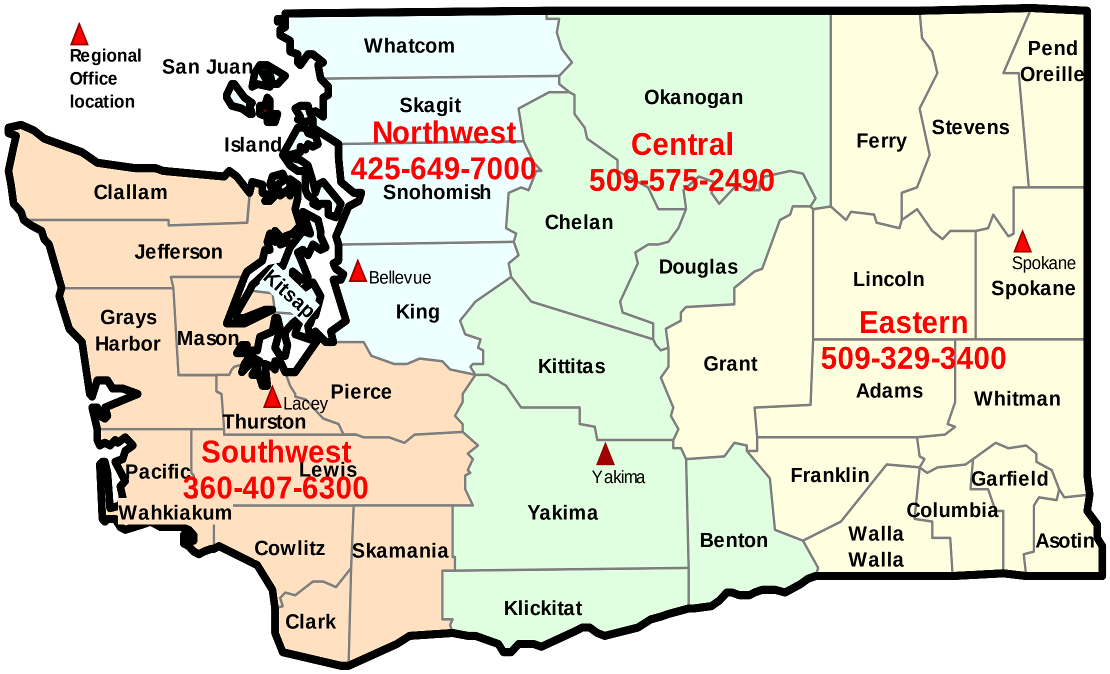

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Acknowledgements

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I would also like to express deep appreciation for all of the counties and cities that are working on their Critical Aquifer Recharge Area ordinances and planning. I would particularly like to mention eastern Washington jurisdictions working on groundwater protection from which I have gained knowledge and perspective including Ferry County, Spokane County, the Columbia Basin Ground Water Management Area, and others.

Section 1
Introduction

This guidance document helps local jurisdictions and the public understand what is required for the protection of local groundwater resources under the Growth Management Act. It includes guidance for planning, ordinances, and for including the Best Available Science (BAS) as these relate to Critical Aquifer Recharge Areas.

This guidance will also explain how the laws and rules of the state of Washington for water quality, pollution prevention, and water resources relate to Critical Aquifer Recharge Area protection.

We are revising the guidance to improve usability and clarity, and to provide additional explanation.

When the public drinking water supply is compromised, the community faces risk and great expense. Contaminated water can cause illness and ingestion of toxic chemicals or other harmful substances. Remediation of contaminated ground water is overwhelmingly expensive. A contamination event can cause city wells to be shut down, result in expenses for new wells, and incur costs for cleaning up contaminated soil and ground water.

Prevention of groundwater contamination is far less expensive than cleanup. EPA studies have shown that investing funds for groundwater protection is cost-effective compared to groundwater cleanup at a ratio that runs anywhere from 1:5 to 1:200 (U.S. EPA, 1995).

The Growth Management Act requires protection of public groundwater drinking supplies so that tragic contamination events and their associated costs can be prevented. In addition, public drinking water supply depends on groundwater availability. Without replenishment, the amount of water in aquifers can be diminished or even depleted.

A good groundwater protection program involves:

- Identifying groundwater resources at risk,
- Identifying threats to ground water, and
- Monitoring to make sure a condition that could cause an unacceptable risk is not occurring and taking action when necessary.

The Growth Management Act and Critical Areas

The Growth Management Act (Chapter 36.70A Revised Code of Washington) (GMA) requires comprehensive land use planning by counties and cities. The act, commonly known as the GMA, specifies 13 overall planning goals. These goals include urban growth, transportation, economic development, natural resource industries, public facilities, open space and recreation, historic preservation, environmental planning, and others.

The environmental planning goal is to "protect the environment and enhance the state's high quality of life, including air and water quality, and the availability of water" (RCW 36.70A.020**)**.

The GMA requires the designation and protection of "Critical Areas" to prevent harm to the community from natural hazards and to protect natural resources.

- **Natural hazards** are frequently flooded areas and geologically hazardous areas.
- **Natural resources** are wetlands, fish and wildlife habitat conservation areas, and "areas with a critical recharging effect on aquifers used for potable water," which are called **Critical Aquifer Recharge Areas**.

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.

Critical Aquifer Recharge Areas

A Critical Aquifer Recharge Area (CARA) is defined by the GMA as "areas with a critical recharging effect on aquifers used for potable water."

The Washington Administrative Code (WAC) Chapter 365-190 uses the following definition:

> *"Areas with a critical recharging effect on aquifers used for potable water are areas where an aquifer that is a source of drinking water is vulnerable to contamination that would affect the potability of the water."*

Identifying "areas with a critical recharging effect on aquifers used for potable water," depends on understanding aquifer recharge and what is meant by "a critical recharging effect."

Aquifer recharge occurs where rainfall, snowmelt, infiltration from lakes, wetlands and streams, or irrigation water infiltrates into the ground and adds to the water underground that can supply a well. On the other hand, **discharge areas** are where ground water is headed toward the ground surface and ultimately flows out from a spring, wetland, stream, lake, estuary, or ocean shore. Wells can also serve as discharge areas, especially larger volume wells, such as those used by municipalities.

Most of a watershed is typically a recharge area, with discharge areas occurring to a more limited extent in topographically lower areas. Recharge areas and discharge areas can be mapped using hydrogeologic techniques to determine where ground water is and where it is flowing.

Aquifers used for potable water are identified by looking at existing and future planned uses. Existing wells and their protection areas, sole source aquifers, and aquifers otherwise identified as important supplies, are examples of "aquifers used for potable water."

Setting priorities for the most critical supplies helps jurisdictions make decisions about where to focus their efforts. Areas may be categorized to reflect these priorities. An example would be to apply more strict regulations and monitoring within the one-year time of travel of a city well, as opposed to more sparsely developed areas of the county. More strict regulation may be applied in an area where the aquifer is shallow and vulnerable to contamination more than an aquifer that is deep and protected.

Ground Water and Other Critical Areas

Ground water is inextricably linked with all of the critical areas including wetlands, fish and wildlife habitat, critical aquifer recharge areas, frequently flooded areas, and geologically hazardous areas.

- Ground water is a source of water to streams, lakes, estuaries, wetlands, and springs; and therefore serves a critical function for wildlife and fish habitat. Some plants that provide habitat, like willows, depend on shallow ground water.
- Ground water is often a key factor in flooding and geologic hazards.

The GMA also requires that local jurisdictions give special consideration to conservation or protection measures necessary to preserve or enhance anadromous fisheries. Since ground water is an important component of stream flow, it is necessary to maintain the groundwater supply to streams where needed to protect salmon and other anadromous species.

Qualified Professional Assistance

Professional hydrogeologic work for the establishment of Critical Aquifer Recharge Areas should be performed by a hydrogeologist licensed in the state of Washington (RCW 18.220 and WAC 308-15). In particular, the delineation and characterization of aquifers and the analysis of environmental fate and transport of potential contaminants through the ground should be performed by a qualified licensed professional.

Many activities associated with Critical Aquifer Recharge Areas may be done by others (who are not licensed professional hydrogeologists) such as planning, pollution prevention, education and outreach, ordinance enforcement, and other activities associated with city and county programs.

Section 2
Basic Concepts

This section lists basic concepts that help with understanding the occurrence and movement of ground water.

Where Ground Water Comes From

Recharge is water that is added to ground water, whether it is from rainfall that infiltrates through the ground, snowmelt, or some other source. Recharge can come from quite a distance through the ground over a long period, or it can come from relatively local and more recent sources.

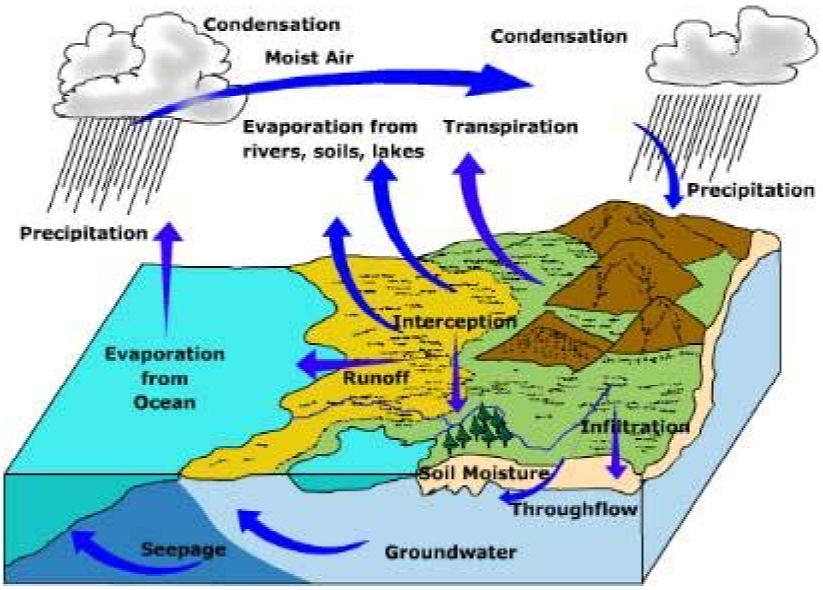


Figure 1: The Hydrologic Cycle

The Hydrologic Cycle

The hydrologic cycle is how water evaporates from the oceans, gathers in clouds, and rains or snows onto the land. After it rains or the snow melts, the water then either evaporates, is used up by plants, runs off to streams, lakes, or the ocean; or infiltrates into the soil. Some of this infiltration will reach the underground water table and will **recharge** the aquifer.

Recharge can also carry contaminants into ground water from the land surface. Therefore, recharge is at the center of preventing pollution and maintaining supply both for drinking water and for freshwater habitats.

Where Ground Water Goes

Ground water flows through the ground from where it is recharged to where it is discharged. **Discharge** is where water moves from underground to the land surface. Springs are a familiar example. Ground water also discharges to lakes and streams. In fact, in Washington, ground water can make up a majority of stream flow, especially in late summer and early fall (Pitz, Sinclair, 1999). This is why groundwater discharge is such an important aspect of maintaining or restoring freshwater habitat.

The Water Table

The water table occurs where the underground is saturated with water. Discharge of ground water, whether by pumping or by seeping into streams and springs, can lower the water table if the recharge does not keep up. The effect can be to pull the water down below a well or to dry up a stream. Sometimes the water table rises above the land surface. This can fill lakes and streams, or even cause flooding when the water has nowhere to drain.

People can cause the water table level to lower both by removing ground water from wells and by reducing the quantity of recharge, as happens where there is too much paved or impervious surface and ground water cannot infiltrate where it formerly did. Figure 2 shows the effects of a declining water table (modified from USGS illustration at http://ga.water.usgs.gov/edu/earthgwaquifer.html).

The Importance of Recharge…

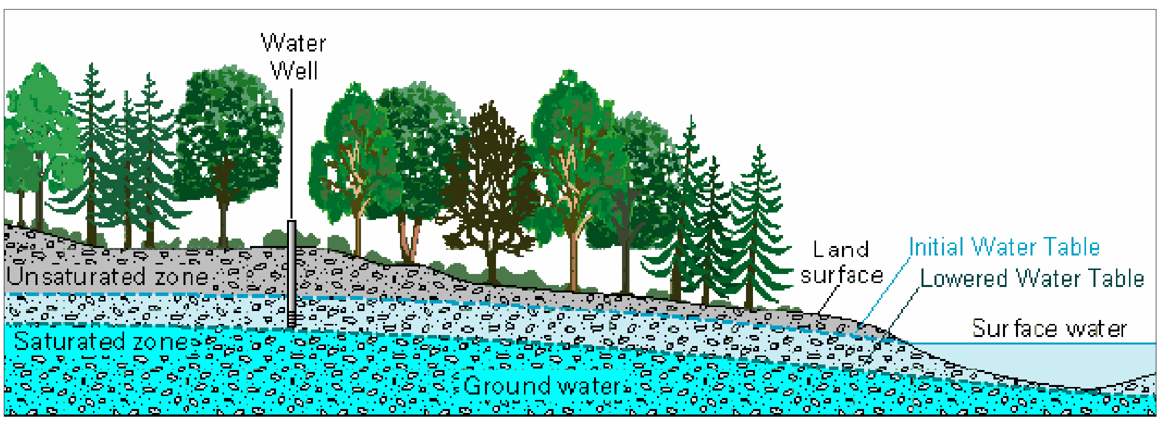


Figure 2: If the groundwater table drops to the lower dashed line, both the stream and the well go dry. The water table lowers when discharge (water out) is greater than recharge (water in).

Hydrogeologists can map recharge and discharge zones by measuring many water levels.

The hydrogeologic setting is the framework that controls groundwater occurrence and movement. Where ground water flows, the rate at which it flows, where it recharges or discharges, and how deep it occurs are all functions of what the land is like – the soil, sediments, and rocks that ground water moves through. The hydrogeologic setting also includes the topography and the weather patterns that control recharge.

Knowledge of hydrogeologic settings is useful for establishing critical aquifer recharge areas. Prioritization of critical aquifer recharge areas can be based on the susceptibility of those settings to contamination or water quantity impacts.

Susceptibility refers to what the ground is like. When water can move readily through the ground, it can carry contaminants to ground water more quickly. Sandy, shallow aquifers are more susceptible than deep aquifers that are overlain by clay.

Vulnerability refers to the risk of contamination from chemical use combined with the risk from the susceptibility of aquifers.

Note: Sometimes, the terms vulnerability and susceptibility are used interchangeably, so you should be sure of the author's meaning when you encounter these terms.

Susceptibility factors:

- **The vadose zone** consists of the unsaturated earth materials above an aquifer. Depth to water is the distance through the vadose zone a contaminant would travel to reach the water table. The deeper the water table, the longer the travel time.

- **Permeability** is a scientific measurement of the rate of infiltration in inches of water per hour. Infiltration rate is a measure of how fast water and pollutants can move downwards through the earth materials of the vadose zone. The more permeable the ground is, the faster water moves down through it, the more the underlying ground water is susceptible to contamination. Coarse sands and gravels allow water to pass through much more quickly than fine silts and clays.

- **Chemical retardation** is a measurement of how clays and organic matter react with some chemicals to slow their passage or change them chemically.

- **Adsorption** is a measurement of the tendency of ions dissolved in water to stick to particles of silt or clay. The particle size and the amount of organic matter affect the adsorption. A sand with no organic matter may not adsorb at all, while an organic silt or clay may adsorb well. In short, a contaminant can be captured or slowed down by sticking to clay.

- **Low permeability layers**, such as clay or glacial till, may occur between the land surface and an aquifer, either within the vadose zone or within an aquifer system. These layers would restrict downward migration of contaminants and would provide a measure of protection to the aquifer.

  Note: Care should be taken with presuming a confining layer is protective, because layers may not be laterally extensive and may have some feature that allows leakage.

- **Hydraulic conductivity** is a measure of how fast a quantity of water can move through an aquifer (for a given gradient through a unit area). The higher the hydraulic conductivity, the faster the flow.

- **Gradient** is the result of differences in elevation between two locations of the water table or the differences in pressure between locations in a confined aquifer. The higher the gradient, the faster the flow.

  Just as a ball rolls downhill, water flows downhill – from higher water table elevations to lower water table elevations. Water also flows in the direction that pressure is moving it. Just as you can push a ball uphill, high-pressure conditions can push water upwards. Both pressure differences and elevation differences create gradients.

- **Groundwater flow direction** is determined by gradients, which in turn are influenced by pumping, discharge to surface water, topography, and geologic setting.

- **Groundwater flow rate** depends on the nature of the geologic materials water flows through along with the pressure on the water. Coarser materials allow faster flow, and higher pressures induce faster flow.

Preventing pollution depends on controlling land use activities to prevent contaminant spills and leaks. Critical aquifer recharge areas are designated so that greater control can occur where land use activities are a high-risk for polluting sensitive aquifers.

Prioritization of Critical Aquifer Recharge Areas can be accomplished by identifying where high-value water resources are located in highly susceptible areas (King County, 2004).

Critical aquifer recharge area maps are delineations of where a community's groundwater supply meets criteria such as susceptibility, potential for contamination, and priority.

Wellhead protection zones are areas around wells where contamination would result in polluting the water supply well within a specific time period. Time periods used by the Department of Health Drinking Water Program are six months, one year, five years, and ten years.

Aquifers are created when water saturates, or fills, the underground where the ground is permeable enough to yield useable quantities of water to a well. Layers that are not permeable enough to yield useable quantities of water to a well are called *aquitards*. Common types of aquifers are sand and gravel, fractured bedrock, and *kars*t (limestone).

In the Puget Sound region, the landscape that defines aquifers is made up mainly of glacial deposits. In eastern Washington, there are several types of geologic settings that contain aquifers. One major type of aquifer in eastern Washington is the Columbia Flood basalts. In the Columbia Basin, irrigation has created aquifers by filling the sands and gravels over the Columbia Flood basalts.

There may be a whole system of multiple confined aquifers and a water-table aquifer in an area. Sometimes the water table aquifer and confined aquifers beneath are connected and water from one aquifer flows into another.

A **confined aquifer** is an aquifer that lies beneath a confining layer, such as a silt or clay layer. This condition can cause the water to be under pressure, resulting in an artesian well. Sometimes this pressure is great enough to cause the well to flow out at the surface. Ground water in confined aquifers flows from the direction of the highest pressure to the lowest pressure.

A **water-table aquifer** is water under normal atmospheric pressure. This aquifer is not capped by a layer of clay or fine silt. Water-table aquifers flow generally in accordance with the topography towards rivers, streams, lakes, and springs.

Safe yield (Fetter, 1980) is the amount of naturally occurring ground water that can be economically and legally withdrawn from an aquifer on a sustained basis without impairing the native groundwater quality or creating an undesirable effect such as environmental damage. It cannot exceed the increase in recharge or leakage from adjacent strata plus the reduction in discharge caused by pumping.

Section 3
Protecting the Functions and Values of Critical Aquifer Recharge Areas

The functions and values of Critical Aquifer Recharge Areas are to provide the public with clean, safe, and available drinking water. In order to accomplish this goal, information is needed about the location and extent of aquifers that supply public drinking water, the susceptibility of these supplies to contamination, and potential contamination risks. In addition, planning, programs, and ordinances are needed to prevent contamination from occurring.

The following steps characterize where groundwater resources are important to the community and how to protect them.

- **Identify** where groundwater resources are located.
- **Analyze** the susceptibility of the natural setting where ground water occurs.
- **Inventory** existing potential sources of groundwater contamination.
- **Classify** the relative vulnerability of ground water to contamination events.
- **Designate** areas that are most at risk to contamination events.
- **Protect** by minimizing activities and conditions that pose contamination risks.

- **Ensure** that contamination prevention plans and best management practices are followed.
- **Manage** groundwater withdrawals and recharge impacts to:
    - **Maintain availability** for drinking water sources.
    - **Maintain stream base flow** from ground water to support in-stream flows, especially for salmon-bearing streams.

The following section provides more details about each one of these steps

Step 1: Identify where groundwater resources are located

The GMA discusses the use of both mapping and performance standards to identify critical areas.

Maps are highly useful for Critical Aquifer Recharge Areas because they can show the location of public water supply wells, private wells, and aquifer boundaries. They can also be used to show the location of areas that have been rated for susceptibility. Maps can be used to see where pollution prevention is most needed and to help plan development. Known Critical Aquifer Recharge Areas should be mapped.

Performance standards are the *criteria* for designation of a critical area. A performance standard is applied when reviewing development projects to determine what category of Critical Aquifer Recharge Area the proposal is in and what the applicable site conditions are. Policies, planning, ordinances, and programs are applied based on the outcome of the evaluation of the proposal using performance standards.

The use of performance standards is recommended for … circumstances where critical areas cannot be specifically identified [WAC 365-190-040(1)]. The purpose of a performance standard is to have an objective standard for comparison (WWGMHB, 1997).

To use performance standards, local jurisdictions need sufficient information to:

- Make an informed determination as to whether or not critical areas are present on the site.
- Determine whether or not the proposed activity will impact those critical areas.

The *Critical Areas Handbook* (Washington Dept. of Community Trade and Economic Development, 2003) states that:

> *"Critical areas may be designated by adopting specific performance standards, delineating specific geographic areas, or both. Generally, performance standards are preferred, as any attempt to comprehensively map wetlands, for example, throughout a jurisdiction would likely be too inexact for regulatory purposes. Even so, mapping critical areas for information purposes is advisable. All areas meeting the definition of one or more critical area type, regardless of any formal identification, are required to be designated critical areas."*

Identifying the Location and Extent of Drinking Water Supply Aquifers

Mapping drinking water supply aquifers makes use of well location and well log information as well as the location and characteristics of aquifers.

Well locations are important to identify to help prioritize risk and guide local ordinances and planning near active public wells.

Aquifer locations are important to identify to give the jurisdiction information about where groundwater resources are. When new wells are needed, knowledge of where aquifers may supply water is critical. This knowledge is used in water system planning and is a vital consideration for long-term planning.

The following illustration shows:

- Public water supply wells (Group A) and their protection zones
- Smaller public water supply wells (Group B)
- Wells that serve one or two households
- The location and the extent of a local aquifer - - - - - - - - - -

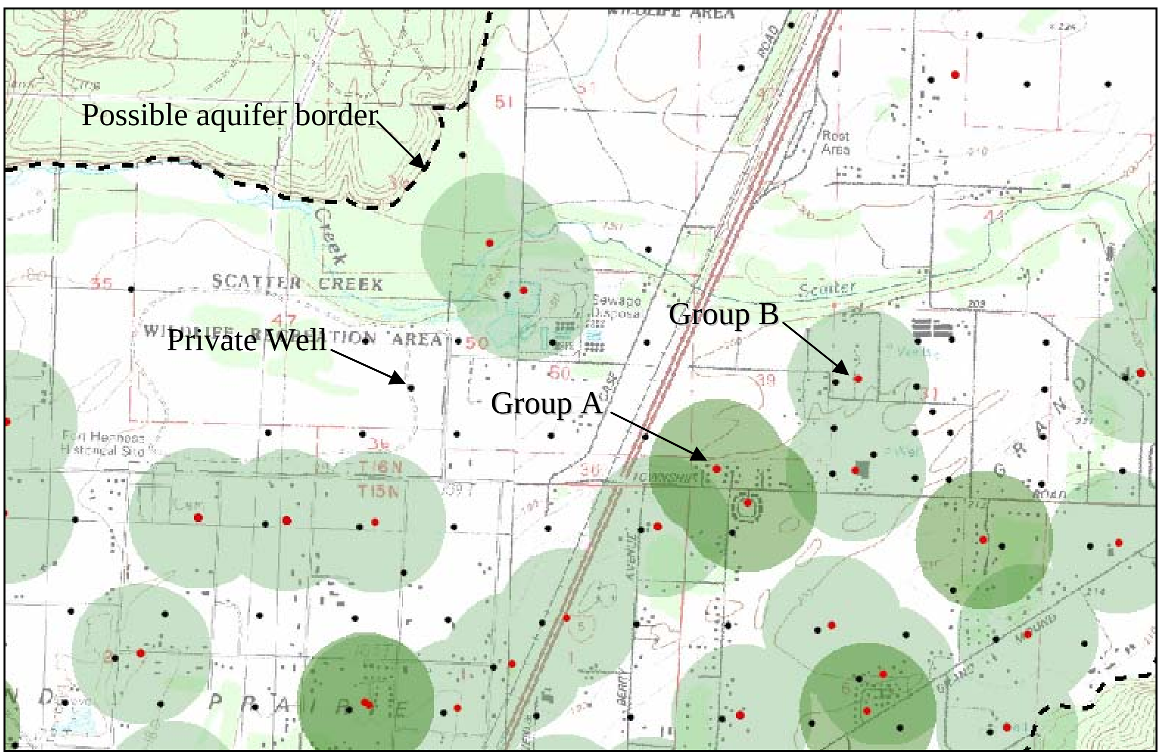


Figure 3: Location, extent, and uses of a drinking water supply aquifer.

Note: The private wells on this map appear at the nearest quarter-quarter section, NOT where they are actually located on the ground. This is because well logs report locations *this way, and that is what we have to use for mapping. Private wells are included in this illustration to give an idea of the use of the aquifer.*

Public Water Supply Wells

Public drinking water supply systems are regulated by the Department of Health under the Safe Drinking Water Act (SDWA). The state regulates systems with 15 or more connections, and the local health jurisdiction regulates systems with 3 to 14 connections.

The SDWA also includes the Source Water Protection Program. Under this program, wellhead protection zones are defined and the susceptibility of the well to contamination is rated. Potential contamination sources within the protection zones are also inventoried.

The wellhead protection zones are defined by the areas where a spill incident could result in contamination of the well within a specified time period. The time periods are six months, one year, five years, and ten years. Zones based on these time periods are known as time-of-travel zones. Methods of delineating wellhead protection zones vary from modeling to drawing a circle around the well at a fixed radius (least accurate method). These mapped wellhead protection zones may be designated as a category of Critical Aquifer Recharge Area. A jurisdiction may have stricter requirements closer to the well. For example, some uses may be prohibited within the one-year time-of-travel zone that is allowed with mitigation in the ten-year time-of-travel zone.

Maps of public water supply wells and their protection zones are available on the internet.

- Washington State Department of Health Source Water Protection: http://www.doh.wa.gov/ehp/dw/our_main_pages/swap.htm
- Washington State Department of Ecology Facility/Site on the web: http://www.ecy.wa.gov/services/as/iss/fsweb/fshome.html

Note: It should be kept in mind that any information system may have missing or inaccurate information.

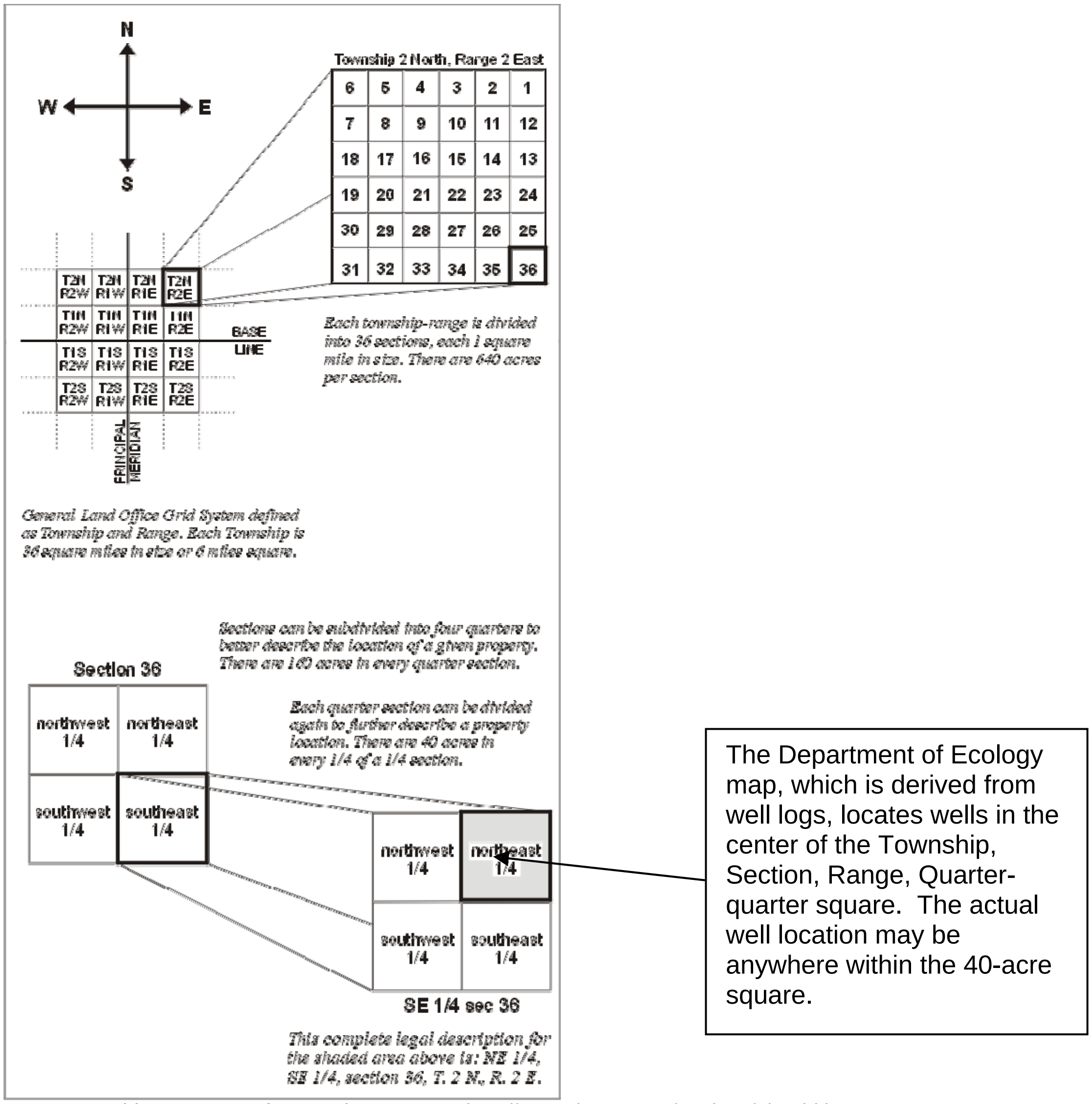
Domestic Wells

Residences that are located too far from a public water supply system must rely on individual wells, springs, or surface water. Individual domestic wells are an important and widespread source of drinking water supply in Washington.

Maps of domestic well locations together with well logs help with identifying the location, extent and use of drinking water supply aquifers.

To find information about domestic wells, contact the Department of Ecology Water Resources Program.

State law requires that a well log be filed with the Department of Ecology when a well is constructed. Well log information includes location by address and township/range/section/quarter-quarter.



Source: Washington Dept. of Natural Resources, http://www.dnr.wa.gov/geology/glogrid.htm#trs

Figure 4: Township, range, section, quarter-quarter, and well location

Well logs are available at the Department of Ecology Regional Offices in Lacey, Yakima, Spokane, and Bellevue. Many counties also maintain copies. The Department of Ecology Well Log Viewer internet site has downloadable well logs, well records, and maps of well locations at http://apps.ecy.wa.gov/welllog/.

The well locations were created by placing a point at the center of the township/range/section/quarter/quarter-quarter square. The following should be kept in mind when using these well locations.

- There are many wells for which well logs have not been submitted, and therefore do not appear on this map.
- Sometimes the location information written on the well log is incorrect, and so the location shown for the well on the map is inaccurate.

  It is up to the well driller to provide accurate information on the well log. The well owner should make sure the location information is correct.
- The point that represents the well is placed in the center of the township, range, section, quarter-quarter square. The actual location of the well is anywhere within the 40-acre square.

  For example, if the center of the square is in a lake, and the actual well location is on shore, the map will plot the well in the lake. The well IS NOT in the lake. There are thousands of well logs, and the locations have not been adjusted individually.

Well Identification Using Parcel Maps

Another way of identifying private wells is to look at a map of parcels with existing residences that are outside of public water supply service areas. This will give an indication of areas within the jurisdiction that rely on private wells.

Aquifers

This section looks at what tools are used to identify and characterize aquifers. Well logs, maps, testing, and field reconnaissance are some of the tools used to identify aquifers.

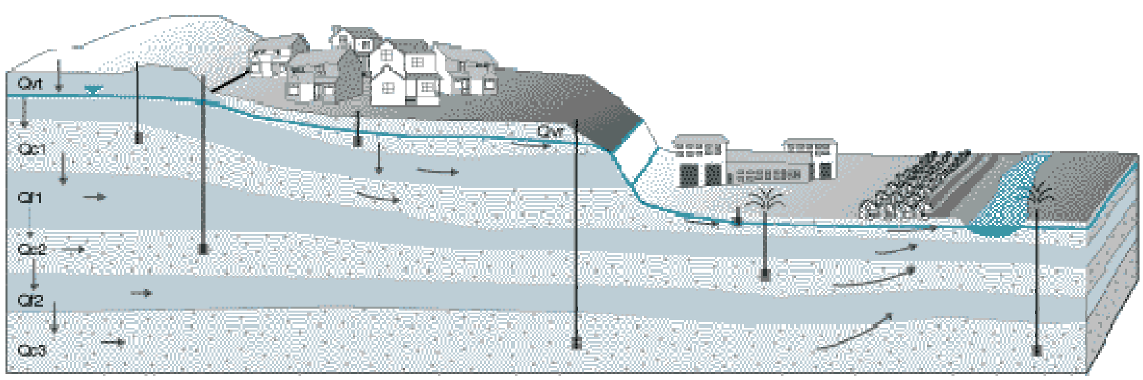


Figure 5: Representation of an aquifer system (Jones, 1999)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W11448
UNIQUE WELL I.D. # ACR 769
Water Right Permit No. Appl.→ 62-29165 - Prelim Permit

(1) OWNER: Name CITY OF LACEY Address P.O.Box 3400, 420 College St. Lacey, WA 98509-3400

(2) LOCATION OF WELL: County Thurston - NW 1/4 NW 1/4 Sec 24 T. 18 N., R 1W W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) MADRONA PARK SUBDIVISION

(3) PROPOSED USE: ☐ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal X Other ☐

(4) TYPE OF WORK: Owner's number of well (If more than one) "C"
Abandoned ☐ New well XX Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable XX Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 334 feet. Depth of completed well 333 ft.

(6) CONSTRUCTION DETAILS:
Casing Installed: 16" Diam. from +2 ft. to 265 ft.
Welded X
Liner installed ☐ " Diam. from ft. to ft.
Threaded ☐ " Diam. from ft. to ft.

Perforations: Yes ☐ No X
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes X No ☐
Manufacturer's Name Westco
Type Stainless steel Model No.
Diam. 14" Slot size 150/120 from 265 ft. to 282 ft.
Diam. 14" Slot size 150 from 294 ft. to 306 ft.
14" 150/100 313 326
Gravel packed: Yes ☐ No X Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes X No ☐ To what depth? 130 ft.
Material used in seal Quick Grout
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 219.53 ft. below top of well Date 6/4/97
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes X No ☐ If yes, by whom? Hokkaido
Yield: 1025 gal./min. with 2.01 ft. drawdown after 1 hrs.
" 1025 " 2.00 " 2
" 1025 " 2.21 " 4.23

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
0	221.75	10m	219.77	120m	219.7
1 min.	219.69	30m	219.76		
5 min.	219.81	60m	219.70		

Date of test 6/4/97
Bailer test gal./min. with ft. drawdown after hrs.
Airtest gal./min. with stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes X No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Brown gray sandy till, hard	0'	10'
Gray brown sandy till w/cobbles	10'	69'
Dirty sand and gravel, moist	69'	76'
Brown gray till	76'	79'
Brown clay with gravel	79'	87'
Brown waterbearing sand & gravel	87'	121'
Brown silty sand with gravel	121'	123'
Blue gray clay	123'	133'
Brown silty sand, H_2O	133'	153'
Brown silty sand with clay and gravel, H_2O	153'	163'
Brown sandy silt with gravel, H_2O	163'	195'
Yellowish Sand & Gravel with binder, waterbearing	195'	306'
Brown Sand and gravel with clay lenses	306'	328'
Brown, fine to medium sand with gravel	328'	331'
Brown silty sand with binder	331'	334'
Bottom hole	334'	

RECEIVED '97 JUN 25 AM 10:18

Work Started March 21, 1997 Completed June 11, 1997

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME HOKKAIDO DRILLING & DEVELOPING CORP. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address P.O. BOX 100, GRAHAM, WA 98338-0100
(Signed) [signature] (WELL DRILLER) License No. 1146
Contractor's Registration No. HOKKADD178D3 Date JUNE 24, 1997

(USE ADDITIONAL SHEETS IF NECESSARY)

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Figure 6: Well logs include observations about aquifers and the earth materials that overlie the aquifers.

Well logs contain information about aquifers:

- Location of the well
- The kinds and depths of underground materials (sand, gravel, silt, clay, bedrock, etc.)
- Water level at the time of drilling
- Where the aquifers are and how far they extend. Many well logs are needed for this analysis.
- An estimate of the amount of water that can be pumped from a well.

Maps are used to help define the boundaries of aquifers.

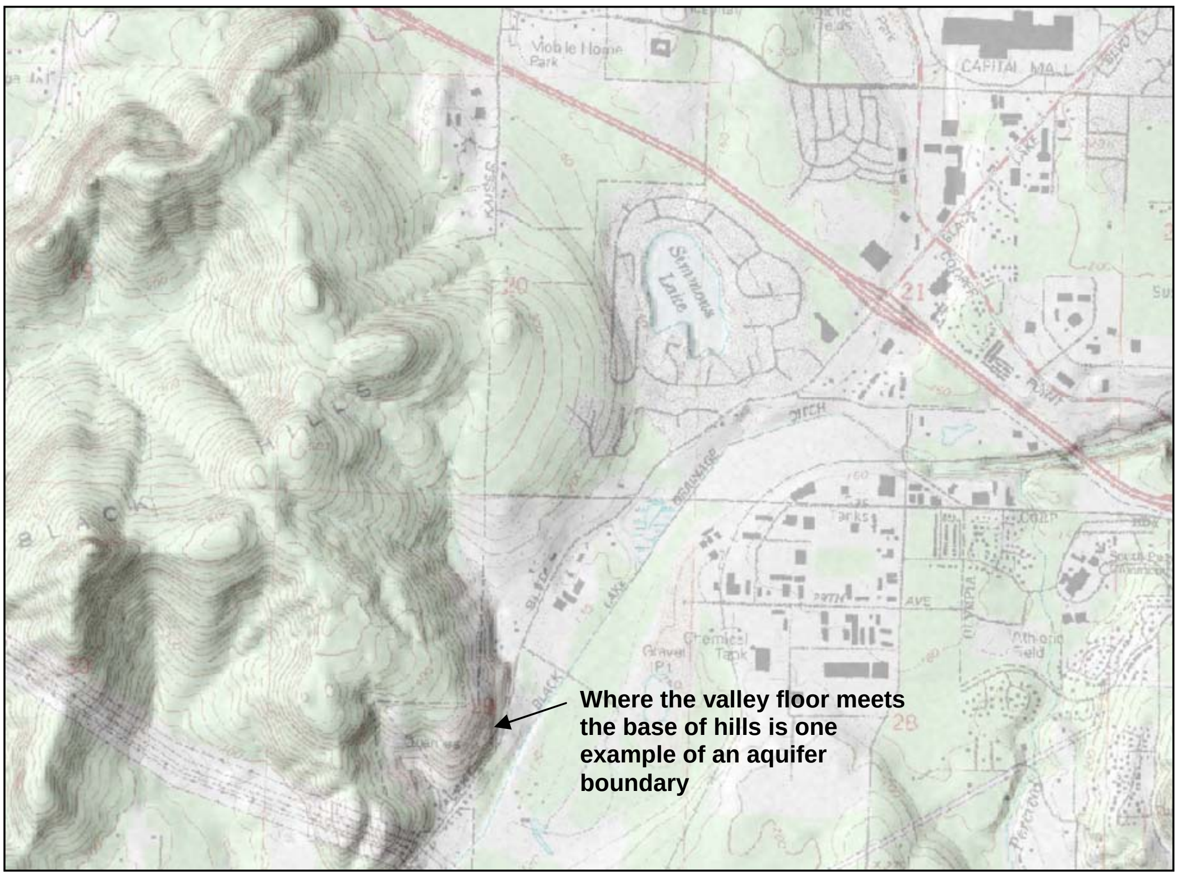

Figure 7: This topographic map shows hilly bedrock next to a flatter river valley. The boundary of the aquifer is likely to be where the hills slope up from the valley.

Topographic maps show landscape changes that are often associated with aquifer boundaries. (For example, the boundary for a river valley aquifer may be where the bedrock slopes up from the valley floor.)

Surficial geology maps show where geologic materials are located that are likely to contain aquifers, such as alluvial deposits.

Testing methods help hydrogeologists to identify and characterize aquifers. For example, aquifer tests involve pumping water out of a well at a known rate and measuring the effect in other wells over time. These tests show how much water can be pumped from a well, how far away other wells can be affected. They may also show to what extent water from one aquifer may leak into another.

Geophysical methods are used to determine characteristics such as the nature and geometry of geologic materials, the extent of aquifers, depth to water, and water quality.

Modeling takes all of the available information and observations that a hydrogeologist has and uses the computer to account for known conditions. It allows a hydrogeologist to model different (what-if) scenarios and to find out what may happen when various choices are made. Example questions that modeling can address are:

- What would the effect of pumping from a well field be on stream flow?
- If a spill occurred here, how long would it be before the contaminants reach the well?
- How would a drought affect water table levels and stream flows?

Hydrogeology studies look at all the available resources to map and describe aquifers. Consultants, the state, academic studies, the U.S. Geological Survey (USGS) and other agencies are sources of this type of information. These studies can be used to support the identification and characterization of Critical Aquifer Recharge Areas. Figures 8 and 9 show a hydrogeologic map and cross-section from a USGS study in Jefferson County (Simonds, 2004).

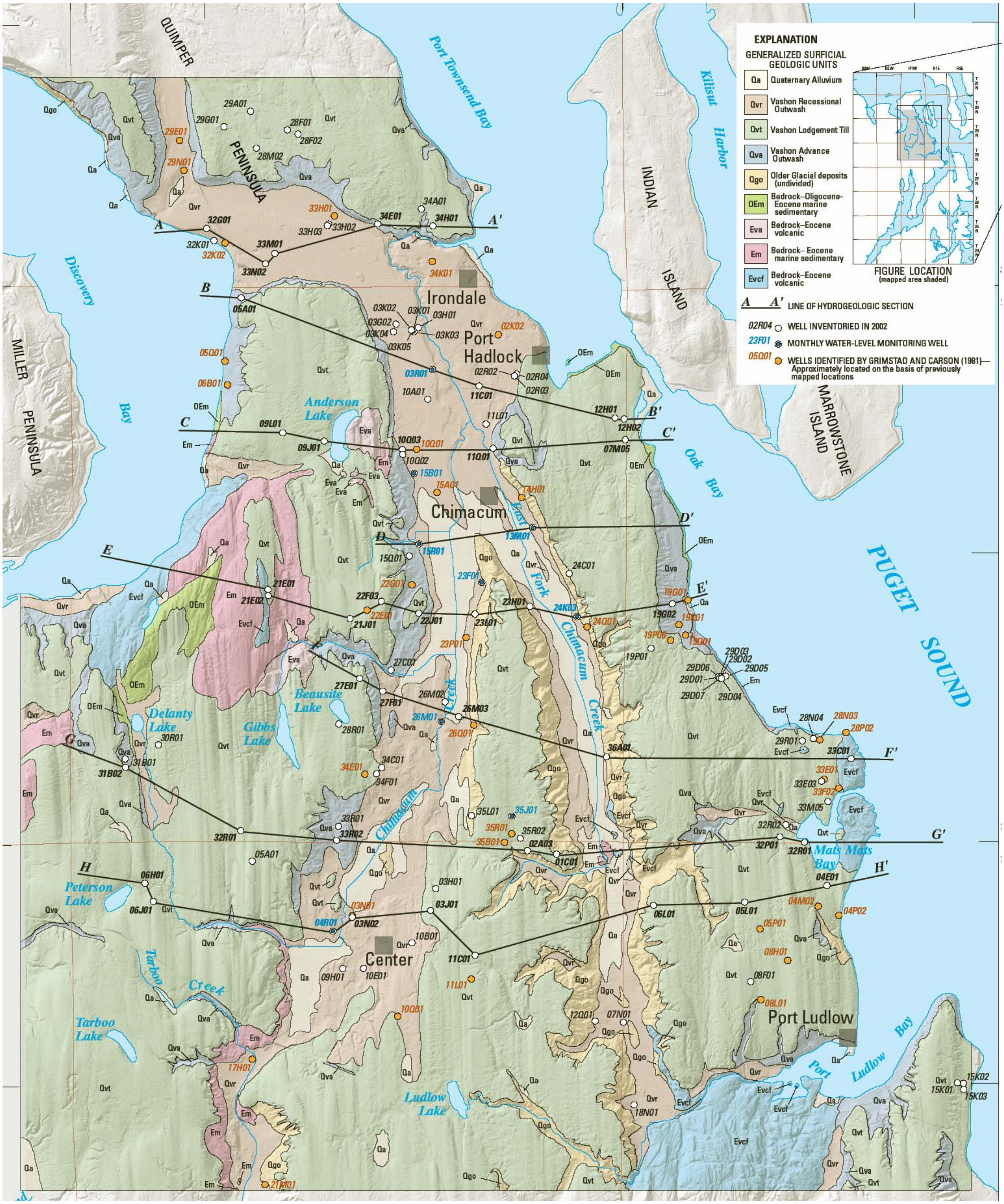

Figure 8: Hydrogeologic map of the Chimacum Basin (Simonds, 2004)

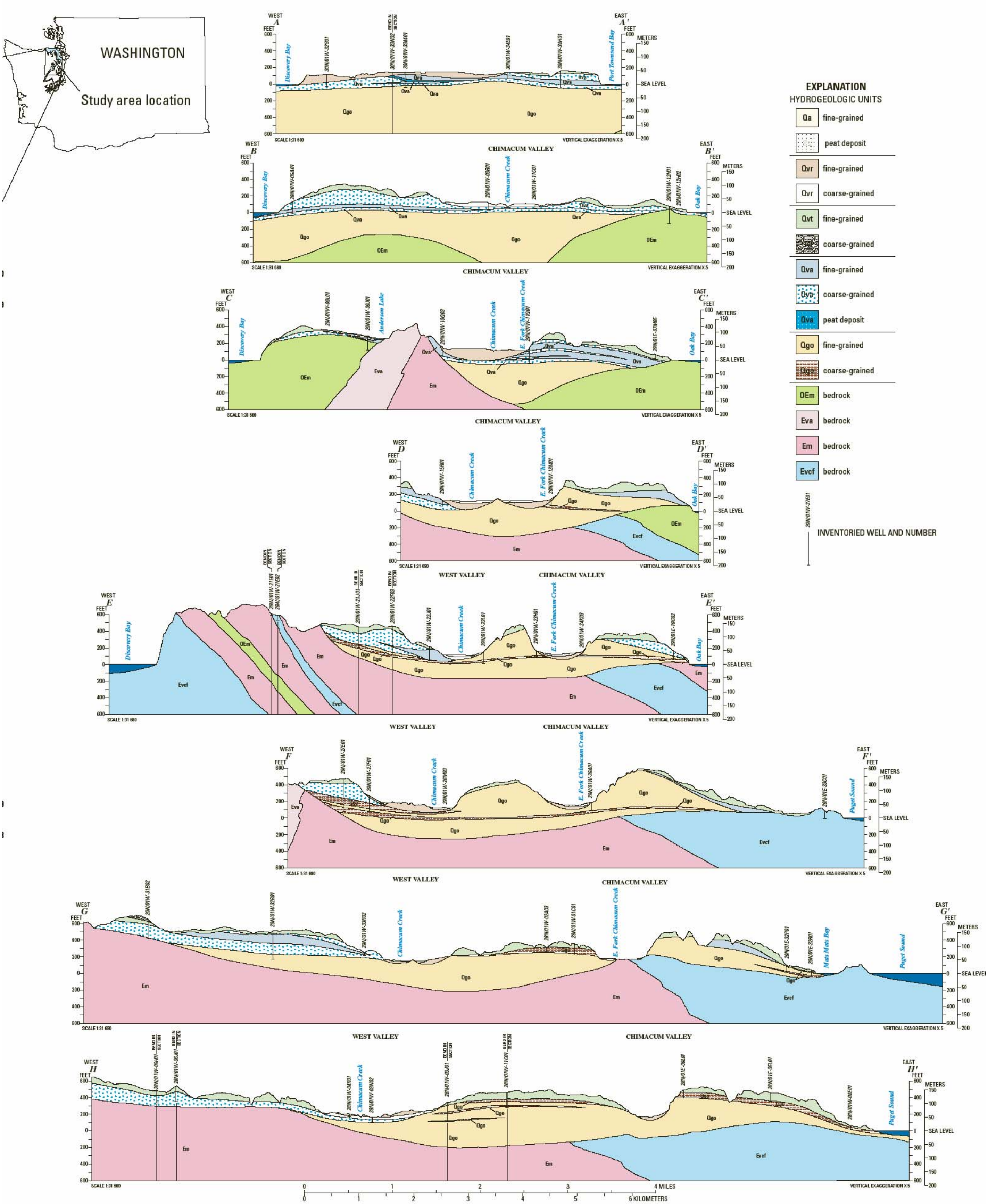

Figure 9: Hydrogeologic cross-sections of the Chimacum Basin (Simonds, 2004)

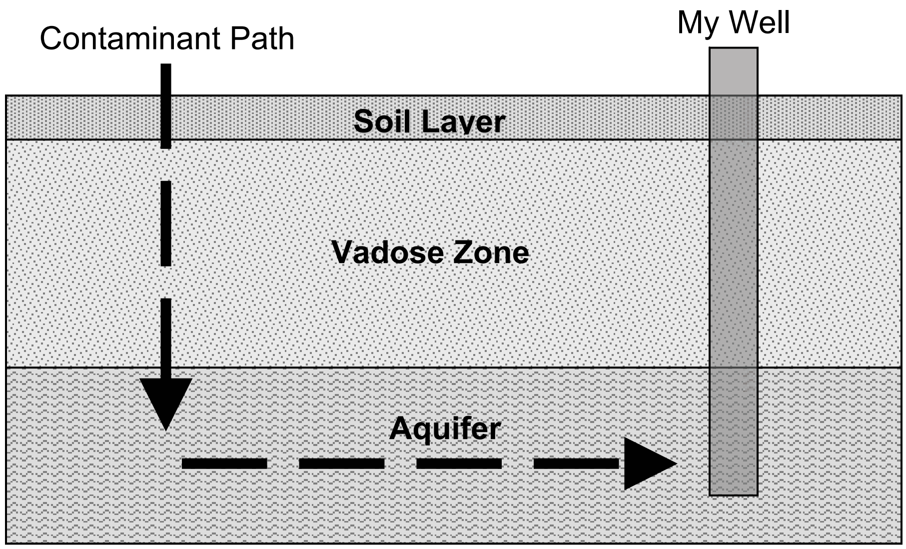

Figure 10: Contaminant path, vadose zone, and aquifer schematic drawing.

Step 2: Analyze the susceptibility of the natural setting where ground water occurs.

How do contaminants get to a well? Contaminants be spilled onto the ground or may leak from an underground tank and travel downward to the aquifer. After reaching the aquifer, contaminants may be carried along with the ground water flow to a well.

How fast and how far a contaminant travels depends on both the natural setting and the chemical and physical characteristics of the contaminant. There are many different chemicals with varied characteristics and this makes assessing all of the possible environmental fate scenarios difficult.

It is much more feasible to start with characterizing susceptibility. This involves determining the physical characteristics of the ground above the aquifer, called the vadose zone, and the characteristics of the aquifer. With susceptibility assessed, the nature of the contaminants can be taken into account by limiting or prohibiting the use of chemicals that are high-risk contaminants within high priority susceptible areas.

Susceptibility of the ground (vadose zone)

Along with the characteristics of the contaminant, the characteristics of the **vadose zone** determines how easily a spill of a contaminant could get down to the water table. Characteristics important for susceptibility assessment typically may include depth to water, infiltration rate, permeability, chemical retardation factors, adsorption, and the presence or absence of a impermeable layer.

Susceptibility of the aquifer

The characteristics of the aquifer control how fast a contaminant reaches a well once it has entered the aquifer. Factors typically considered in assessing the susceptibility of aquifers include hydraulic conductivity, vertical and horizontal gradients, and ground water flow direction and rate.

Hydrogeologic studies contain information about aquifers useful for understanding aquifer characteristics and relative susceptibility. Where aquifer studies have not yet been undertaken, well logs and maps of surficial geology and soils will begin to provide an idea of relative susceptibility to contamination. A qualified professional knows how to use this information along with other methods to describe the overall hydrogeologic setting and its relative susceptibility.

Hydrogeologists use this information along with contaminant characteristics such as solubility, sorption, concentration, and other chemical and physical properties to answer questions such as:

- How likely is it that a contaminant spilled in a certain location would reach a well?
- How fast would a contaminant spill get to a water well?
- How concentrated would the contaminant still be when it got there?

Source water protection susceptibility rating

The Department of Health evaluates and assigns a susceptibility rating for each public water supply well, based on a number of factors, including whether or not there is a protective confining layer above the aquifer. This rating and information is useful in support of a susceptibility assessment, along with wellhead protection plans, which include information about how fast a contaminant could move toward the well based on time-of-travel estimates.

Step 3: Inventory existing potential sources of groundwater contamination.

Anywhere that a potential pollutant is used, handled, transferred, or stored is a potential source of groundwater contamination. Examples are facilities for transferring chemicals from trucks to tanks, drycleaners, machinery manufacturers, and many more. The U.S. EPA Potential Sources of Drinking Water Contamination Index is in Appendix A.

Many of these facilities may be constructed, maintained, and operated in a way that prevents spills from getting to the ground as much as is feasible. Some operations, however, are inherently more risky for pollution than others. These would include facilities that handle a large quantity of toxic materials, especially where these toxic materials are transferred or handled, increasing the possibility of an incident leading to a spill.

Source water protection contaminant inventories

Public water supply systems with 15 or more connections are regulated under the federal Safe Drinking Water Act. They must inventory potential contamination sources around the wells. The Department of Health works with the Department of Ecology to provide web-based maps of potential contamination sources along with locations of wellhead protection zones. The Facility-Site atlas can be accessed from the Department of Ecology geographic information system (GIS) applications website: http://www.ecy.wa.gov/services/gis/apps/apps.htm

The GIS cover of facilities and sites regulated by the Department of Ecology can be accessed from the GIS Data website (click on Facility Site): http://www.ecy.wa.gov/services/gis/data/data.htm

Step 4: Classify the relative vulnerability of ground water to contamination events.

All ground water is vulnerable; some areas where strategic public groundwater resources are located are more vulnerable than other areas. The concept of using criteria to create classifications or categories of vulnerability helps local jurisdictions apply the appropriate measures for the risks involved.

Susceptibility refers to natural conditions, and **vulnerability** refers to the total contamination risk from both the natural conditions and potential contaminant sources. The base classification of Critical Aquifer Recharge Areas can be based on susceptibility, and an overlay of existing contamination sources used to give the community an idea of where its strategic groundwater supplies may be most at risk under current land use conditions.

For new development, classification based on natural conditions allows a jurisdiction to make decisions about the type of land uses that should or should not be allowed, or which may be allowed with conditions.

There is more than one way to classify Critical Aquifer Recharge Areas. Here are three methods and some illustrations:

- Categories based on susceptibility
  - Water table sand and gravel aquifers
  - Deeper less susceptible aquifers
  - Confined aquifers

- Categories based on set priorities and risk
  - Large public water supply systems one-year time of travel protection zone
  - Densely populated areas that rely on ground water

  - Medium public water supply systems protection zones
  - Rural areas with a high dependence on ground water
  - Discontinuous local drinking water aquifers of limited extent
  - Sole Source Aquifers

- Categories based on areas that have the same policies, plans, ordinances, and programs that will be applied.

The examples are not meant to be exhaustive. The categories depend on local hydrogeologic settings, use of the drinking water aquifers, and the actions that a local jurisdiction needs to set in place to protect the public potable groundwater resource.

Step 5: Designate areas that are most at risk to contamination events.

The next step in establishing Critical Aquifer Recharge Areas is to designate areas where the public drinking water supply has been determined to be at risk for contamination.

So that local planning and regulation can be guided appropriately, designation makes it clear.

- Where these areas are located (map) and what the performance standards are (criteria).
- Why they are at risk (susceptibility and potential contaminant sources).
- What the importance of this area is to the public drinking water supply (prioritization).

Step 6: Protect by minimizing activities and conditions that pose contamination risks.

Anywhere chemicals are stored, handled, transferred, or used is a potential spill or leak risk.

There are all too many examples of groundwater contamination here in Washington. Municipal water supplies have been contaminated by industrial or commercial use of chemicals. The city of Tumwater, the city of Vancouver, and the city of Lakewood all have had contaminated wells. In Eastern Washington, well water turned yellow from dinoseb, a pesticide spilled at Alexander Farms. These events have been expensive and distressing.

Local jurisdictions need authority to require pollution prevention and to obtain compliance before a situation contaminates the local drinking water supply. Ordinances can be specific to the jurisdiction, or a jurisdiction may choose to adopt state or federal laws or rules by reference. Often, county or city hazardous waste pollution prevention programs with associated regulations are operated to prevent local land use activities from creating major cleanup sites.

Step 7: Ensure that contamination prevention plans and best management practices are followed.

The best plans and practices cannot prevent contamination if they are not used. The ability to inspect, obtain compliance and enforce is needed to make sure that the county or city can stop a threat to ground water when the land user is negligent or uncooperative.

Step 8: Manage groundwater withdrawals and recharge.

- Maintain availability for drinking water sources.
- Maintain stream-base flow from ground water to support instream flows, especially for salmon-bearing streams.

Recharge

Development has a profound effect on the hydrology of an area. The increase in impervious surfaces and disturbance of natural vegetation result in increasing runoff and decreasing recharge. Local jurisdictions can improve recharge by encouraging methods that increase recharge, such as low impact development and rain gardens.

The Puget Sound Action Team is a helpful resource for information and assistance with low impact development at http://www.psat.wa.gov/Programs/LID.htm.

Water supply planning

The Watershed Planning Act (Chapter 90.82 RCW) provides for water supply planning by local entities within a Water Resources Inventory Area (WRIA), including at least the counties, the largest city or town within the WRIA, and the water utility that uses the most water. Many of the WRIAs are engaged in watershed planning. For the current status of watershed planning, see the website at http://www.ecy.wa.gov/watershed/index.html

Ground Water Management Areas (GMA) may be established by either the state or local government under RCW 90.44.400. Criteria for identifying potential Ground Water Management Areas include (among others): Aquifer systems that are declining due to restricted recharge or over-utilization and aquifers identified as the primary source of supply for public water supply systems.

Large water systems regulated by the Department of Health are required to have a water system plan. This plan includes analyses of future water demand and supply. Smaller water systems are required to have a small water system management program (see http://www.doh.wa.gov/ehp/dw/Programs/water_sys_plan.htm.)

The Water System Planning Handbook (Washington State Dept. of Health, 1997) is available on the web at http://www.doh.wa.gov/ehp/dw/Publications/newes2.pdf.

Local governments also include water planning in their comprehensive plans and must meet water supply planning requirements under the Growth Management Act. The Washington Department of Community, Trade, and Economic Development has written a fact sheet called Watershed Planning that explains the link between growth management, and watershed planning at http://www.cted.wa.gov/DesktopModules/CTEDPublications/CTEDPublicationsView.aspx?tabID=0&alias=CTED&lang=en&ItemID=897&MId=944&wversion=Staging.

Section 4
Best Available Science

Best available science is required by the Growth Management Act and is defined by the Washington Administrative Code. Best available science guidance has been published by the Department of Community, Trade, and Economic Development. These sources should be consulted to obtain a good knowledge of how the concept of best available science functions within the Growth Management Act.

The main sources of information for requirements of the Growth Management Act and related rules for best available science and critical areas are:

- **Chapter 36.70A.172 RCW**
  Critical areas, designation and protection, best available science to be used.

  In designating and protecting critical areas under this chapter, counties and cities shall include the best available science in developing policies and development regulations to protect the functions and values of critical areas. In addition, counties and cities shall give special consideration to conservation or protection measures necessary to preserve or enhance anadromous fisheries.

- **Chapter 365-195-905 through 925 WAC**

  Chapter 365-195-905 WAC discusses the characteristics of a valid scientific process.

  In the context of critical areas protection, a valid scientific process is one that produces reliable information useful in understanding the consequences of a local government's regulatory decisions and in developing critical areas policies and development regulations that will be effective in protecting the functions and values of critical areas.

  The objective of including science is "to protect the functions and values of critical areas." Science plays a central role in delineating critical areas, identifying functions and values, and recommending strategies to protect their functions and values (OCD, 2003).

The rule goes on to list the characteristics of a valid scientific process, including peer review, methods, logical conclusions and reasonable inferences, quantitative analysis, context, and references. It then lists sources, including research, monitoring, inventory, survey, modeling, assessment, synthesis, and expert opinion. This section of the WAC is particularly applicable to Critical Aquifer Recharge Areas.

- **The *Critical Areas Handbook*** (Washington Dept. of Community Trade and Economic Development, 2003). This Handbook is available on the internet at http://qa.cted.wa.gov/portal/alias__CTED/lang__en/tabID__418/DesktopDefault.aspx

See Appendix B – Resources for more information about how to obtain or access these sources.

How best available science applies to Critical Aquifer Recharge Areas

Science for **Critical Aquifer Recharge Areas** involves knowledge about the occurrence and movement of ground water.

- Identifying where "areas with a critical recharging effect on potable aquifers" are located.
- Analyzing their physical characteristics.
- Assessing the risk for contamination.
- Evaluating effective best management practices for preventing contamination.
- Assessing the potential impacts on drinking water sources and stream flow from groundwater withdrawals and changes in recharge.

*The GMA requires best available science to be used for **special consideration of anadromous fish species**. Science is used to establish where ground water affects streams and other surface water habitats, and what the effects are.*

Best available science and the functions and values of Critical Aquifer Recharge Areas. The Growth Management Act requires protection of **water quality and quantity**:

- Planning goals include water quality and availability.

  RCW 36.70A.020 – Planning goals

  Protect the environment and enhance the state's high quality of life, including air and water quality, and the availability of water.

- Comprehensive plans should address groundwater quality and quantity protection in the land use element.

  RCW 36.70A.070 Comprehensive plans – Mandatory Elements

The land use element shall provide for protection of the quality and quantity of ground water used for public water supplies.

Best available science for Critical Aquifer Recharge Areas, therefore, should address both quality and quantity.

When Should Best Available Science Be Applied?

1. Upfront, during the planning process.

   Two main benefits of applying best available science **upfront** in the planning process (Washington Department of Community Trade and Economic Development, 2003) are:

   - It enables understanding of where critical areas are located and how they naturally function. This guides how best to regulate land uses that may impact critical areas.
   - Upfront planning and adoption of scientifically defensible development standards enables decisions to be made with information that is on-hand instead of needing to be developed for each project. This should lessen the expense and time needed to make decisions.

2. At the time of application.

   Project review may entail that the applicant provide the county or city with information that is supported by best available science. An example would be a hydrogeologic report. This information is especially important to evaluate projects against performance-based standards.

Sources for Best Available Science for Critical Aquifer Recharge Areas

Groundwater scientists rely on a number of standard methods for characterizing the occurrence and movement of ground water. These methods involve everything from topographic maps, aerial photos, on-the-ground mapping, use of existing maps for soils and geology, well log analysis, aquifer tests, geophysics, water quality testing, water level measurements, monitoring well installations, testing for seepage of ground water into streams (or from streams into ground water), and modeling.
There are also dozens of approaches to assessing groundwater vulnerability or susceptibility to contamination in the professional literature. Pollution prevention and best management practices for preventing contamination are widely published.

These methods have **standards of practice**. Some examples, just to name a few, are:

- Quality assurance standards for water quality sampling
- Standard methods for measuring water levels
- Aquifer test methods and standards
- Field methods

Existing Sources of Information

Local government can use information that local, state or federal natural resource agencies have determined represents the best available science. They can also use information provided by a qualified scientific expert or team of qualified scientific experts.

Sources that provide scientifically valid information useful for Critical Aquifer Recharge Areas include:

Public water supply data and source water protection information

- Well head protection zone plans
- Contaminant inventories
- Aquifer characterization/susceptibility rating
- Well information
- Water quality sampling data
- System size and location
- Water system plans
- Studies completed for public water supply systems

State, federal, local, academic, and consultant studies

- USGS studies
- Water supply papers
- State studies
- Consultant studies for local government
- Consultant studies for a state-regulated facility
- Academic studies

Smaller jurisdictions can rely on the information generated by public water supply systems, state, and federal required studies for facilities located within their jurisdiction, and other studies as listed above. A literature review helps to document best available science for the record. Asking for volunteers in the community, technical assistance from the state, and applying for grants are ways to augment local resources. (See WAC 365-195-910 (2)).

What are the potential consequences if best available science is not applied?

Failure to apply best available science for critical areas under the Growth Management Act may be appealed to the Growth Management Hearings Board. When the board finds a county or city in noncompliance with the Growth Management Act, the board issues a Compliance Order. Failure to comply with a board order can result in state sanctions and loss of funding. See Appendix B for where to find more information about the Growth Management Hearings Board.

Section 5
Working with State and Federal Laws and Rules

The Washington State Growth Management Act and rules refer to how local authorities should coordinate with other government authorities in several places. Three of the concepts contained in the GMA rules follow.

- Local government should consider and coordinate with state, federal, and other authority's laws, rules, and permits (WAC 365-195-735 – State and Regional Authorities).
- Local plans and policies may in some respects be adequately implemented by adopting the provisions of such other programs as part of the local regulations (WAC 365-195-825 – Regulations specifically required by the act).
- Projects may be approved based on compliance with other local, state or federal rules or laws, providing environmental concerns are mitigated (RCW 43.21C.240 – Project review under the growth management act).

The GMA allows jurisdictions to avoid duplication of effort by making use of what is already being done by others. The functions and values of Critical Aquifer Recharge Areas should still be protected. Success, then, depends on identifying potential contamination sources, identifying other laws, rules, and planning efforts that are relevant to Critical Aquifer Recharge Areas and identifying where local action is needed to ensure protection.

Potential Contamination Sources

EPA has listed common potential sources of contamination along with likely contaminants. The U.S. EPA Potential Sources of Drinking Water Contamination Index Listed in Appendix A is the table copied from their web page, which also may be accessed at http://www.epa.gov/safewater/swp/sources1.html

This chart lists some potential facilities and activities where one might find the contaminants referred to as *primary and secondary drinking water standards.* The listing of a contaminant does not mean that it will always occur at the associated source, nor does it encompass all contaminants that may be present. Sources are divided into four major categories.

- Commercial/industrial
- Residential municipal
- Agricultural/rural
- Miscellaneous (underground injection control/naturally occurring)

This list is intended as a resource guide for creating an inventory list. A state or local community may have different sources of concern from the list in Appendix A based on local variability such as existing industrial activity, and known contaminant occurrence information.

Existing Regulation of Potential Contamination Sources

The GMA lists laws, rules, permits, and planning processes to consider in WAC 365-195-710 – Identification of other laws.

The following table (after Cook, 2000) lists many of the activities relevant to groundwater protection along with the citation.

Table 1: Laws, rules, and guidance for groundwater protection

Activity	Statute - Regulation - Guidance
Above Ground Storage Tanks	Chapter 173-303-640 WAC
Animal Feedlots	Chapter 173-216 WAC, Chapter 173-220 WAC
Automobile Washers	Chapter 173-216 WAC, Best Management Practices for Vehicle and Equipment Discharges (WDOE WQ-R-95-56)
Below Ground Storage Tanks	Chapter 173-360 WAC
Dangerous Waste Regulations - Siting of Chemical Treatment Storage and Disposal Facilities; - Hazardous Waste Generators (*Boat Repair Shops, Biological Research Facility, Dry Cleaners, Furniture Stripping, Motor Vehicle Service Garages, Photographic Processing, Printing and Publishing Shops, etc.)* - Spills and discharges into the environment	Chapter 173-303 WAC - Chapter 173-303-282 WAC - Chapter 173-303-170 WAC - Chapter WAC 173-303-145
Injection Wells (Dry Wells)	Federal 40 CFR Part 144—Underground Injection Control Program and Part 146—Underground Injection Control Program: Criteria And Standards; Chapter 173-218 WAC
Junk Yards and Salvage Yards	Chapter 173-304 WAC, Best Management Practices to Prevent Stormwater Pollution at Vehicles Recycler Facilities (WDOE 94-146)
Oil and Gas Drilling	Chapter 332-12-450 WAC, Chapter 173-218 WAC
On-Site Sewage Systems (Large Scale)	Chapter 173-240 WAC
On-Site Sewage Systems < 14,500 gal/day	Chapter 246-272 WAC, Local Health Ordinances
Pesticide Storage and Use	Chapter 15.54 RCW, Chapter 17.21 RCW
Sawmills	Chapter 173-303 WAC, 173-304 WAC, Best Management Practices to Prevent Stormwater Pollution at Log Yards (WDOE 95-53)
Solid Waste Handling and Recycling Facilities	Chapter 173-304 WAC
Surface Mining	Chapter 332-18 WAC
Waste Water Application to Land Surface	Chapter 173-216 WAC, Chapter 173-200 WAC, Guidance on Land Treatment of Nutrients in Wastewater, with Emphasis on Nitrogen, Best Management Practices for Irrigated Agriculture

Identifying Gaps in Protection

Federal and state laws and rules do not replace local planning, ordinances, and programs. Local jurisdictions should maintain the ability to protect ground water under their own authority. Local government can focus on local conditions in a way that the state cannot.

The Department of Ecology through RCWs, WACs, and permits, sets minimum operating standards for many types of potentially polluting facilities. If a permitted facility is poorly managed or experiences some sort of engineering failure (which may happen even with good management), contamination may be released into the environment.

Local government planning can influence the types of future developments that occur in various areas and may be able to encourage potentially contaminating facilities to locate in areas where the aquifer has a lower susceptibility if contaminants are released. In this way, the potential for aquifer pollution is lowered and the public is protected. Land use planning at the local level is the most effective way to influence where facilities choose to locate.

- **Counties and cities.**
  - Regulate land use through comprehensive planning, zoning, and ordinances.
  - Have authority to ensure a landowner does not pollute the public drinking water supply.
  - Are more able to track conditions and adapt to local concerns much more readily than the state.
- **Federal and state laws, rules, and programs are often targeted toward larger facilities**. For example, pollution prevention plans are required by the state if a facility generates 2,640 pounds of hazardous waste a year. A much smaller quantity of hazardous chemicals can cause contamination, especially if improper disposal into a septic system or a dry well occurs. The local jurisdiction should consider requiring pollution prevention plans where needed and not already required.
- **Compliance depends on state resources to enforce**. The state covers a large area and a large number of facilities, and therefore illegal activities may occur that are not detected by the state until contamination has occurred. Local attention can prevent the creation of new cleanup sites.

Prohibited and conditioned uses

Some land use activities, such as landfills, have been found to be a high-risk for groundwater contamination. Although a high-risk use may be regulated by other authorities, local jurisdictions should consider prohibiting these uses from being located within high-risk high-priority Critical Aquifer Recharge Areas. Where these uses are already sited, they should be closely monitored and strict pollution prevention requirements followed.
Examples of uses that should be considered for prohibition in Critical Aquifer Recharge Areas are landfills, wood treatment facilities, chrome platers, tank farms, and facilities that treat, store, or dispose of hazardous waste. Chemical facilities that transfer or use large amounts of chemicals should also be considered to be a risk for ground water contamination.

Some uses that have a moderate to low risk for contamination can be allowed within Critical Aquifer Recharge Areas conditionally on meeting certain requirements for approval. These are typically pollution prevention measures such as secondary containment for chemical storage areas, spill prevention measures, and contingency plans for emergencies.

Here are some questions the local jurisdiction should consider when coordinating their planning and ordinances with federal and state laws, rules, and programs.

- Does the jurisdiction know where potentially polluting activities are located?
- Are effective protective requirements for potentially polluting activities in place?
- Is there provision for compliance monitoring?
- Is there a means to obtain compliance if there is a violation?
- Does the jurisdiction have a plan for ensuring that existing land uses are protective of ground water?

Section 6
Adapting to Local Conditions and Settings

The Growth Management Act allows for differences in regional or local conditions.

See WAC 365-195-060 Regional and Local Variations

Washington has varied landscapes and populations, from sparsely populated rural areas to large cities, from dry desert to rain forest.

Ferry County has a population of 7300 (in 2003). Republic, the county seat, has a population of 975 people. Ferry County is located in the mountainous Okanogan region where ponderosa pines flourish in the dry climate.

King County has both populous and rural areas and has varied landscapes, from the Puget Sound to the high plateau in the shadow of Mount Rainier. The total population of King County was 1,779,300 in 2003.

The settings in which ground water occurs, the resources for programs, and the resources at risk vary in different parts of the state. This means that a program that protects the functions and values of Critical Aquifer Recharge Areas in one part of the state will not necessarily look like a program in another.

The Western Washington GMA Hearings Board (WWGMHB) states:

> The GMA does not require a "one size fits all" approach. A GMHB is to be guided by a common sense appreciation of the size and resources of a local jurisdiction and the magnitude of the problems to be addressed. *MCCDC v. Shelton* 96-2-0014 (FDO 11-14-96)

The fundamental requirement of the Growth Management Act is that the functions and values of the critical area should be protected. For Critical Aquifer Recharge Areas, that means that public drinking water quality and quantity should be addressed in planning and ordinances.

A good groundwater program:

- Identifies threats to ground water.
- Identifies groundwater resources at risk.
- Monitors to make sure a condition that could cause an unacceptable risk is not occurring.
- Educates and informs people so that they can do their best to protect ground water
- Takes action when necessary!

Section 7
Adaptive Management – Change Happens

The GMA requires periodic review and update of plans and ordinances for critical areas. In addition, when the scientific information for addressing critical areas is inadequate, it requires that adaptive management be used in order to determine the impacts on the critical areas from development regulations, and to reduce those impacts to protect the functions and values of the critical areas. (WAC 365-195-920 <http://www.leg.wa.gov/WAC/index.cfm?section=365-195-920&fuseaction=section>)

Adaptive management involves strategic testing of hypotheses and related monitoring to see how well plans, ordinances, and programs are protecting Critical Aquifer Recharge Areas. Changes are then made as more is known or as early hypotheses are proven incorrect, as conditions change, or to improve or correct a method of protection as needed. Monitoring data results can also lead to changes in how monitoring is done and what is monitored. The comprehensive plan and development regulations should include an iterative process for amendments as new information becomes available.

Examples of new information are hydrogeologic studies that provide more information about the boundaries and characteristics of aquifers, significant land use changes and the associated groundwater contamination risks associated with population increases, and the results of the evaluation of voluntary and regulatory programs. A fundamental component of adaptive management is the commitment to change based upon the outcome of testing hypotheses through strategic monitoring.

Section 8
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Appendix A
U.S. EPA Potential Sources of Drinking Water Contamination Index

POTENTIAL SOURCE	CONTAMINANT
Commercial / Industrial	
Above-ground storage tanks	Arsenic, Barium, Benzene, Cadmium, 1,4-Dichlorobenzene or P-Dichlorobenzene, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Lead, Trichloroethylene (TCE), Tetrachloroethylene or Perchlorethylene (Perc)
Automobile, body shops/repair shops	Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, Copper, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, 1,4-Dichlorobenzene or P-Dichlorobenzene, Lead, Fluoride, 1,1,1-Trichloroethane or Methyl Chloroform, Dichloromethane or Methylene Chloride, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE), Xylene (Mixed Isomers)
Boat repair/refinishing/marinas	Benzene, Cadmium, cis 1,2-Dichloroethylene, Coliform, Cryptosporidium, Dichloromethane or Methylene Chloride, *Giardia Lambia*, Lead, Mercury, Nitrate, Nitrite, trans 1,2-Dichloroethylene, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE), Vinyl Chloride, Viruses
Cement/concrete plants	Barium, Benzene, Dichloromethane or Methylene Chloride, Ethylbenzene, Lead, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, Xylene (Mixed Isomers)
Chemical/petroleum processing	Acrylamide, Arsenic, Atrazine, Alachlor, Aluminum (Fume or Dust), Barium, Benzene, Cadmium, Carbofuran, Carbon Tetrachloride, Chlorobenzene, Copper, Cyanide, 2,4-D, 1,2-Dibromoethane or Ethylene Dibromide (EDB), 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,4-Dichlorobenzene or P-Dichlorobenzene, 1,1-Dichloroethylene or Vinylidene Chloride, cis 1,2 Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) adipate, Di(2-ethylhexyl) phthlate, 1,2-Dichloroethane or Ethylene Dichloride, Dioxin, Endrin, Epichlorohydrin, Ethylbenzene, Hexachlorobenzene, Hexachlorocyclopentadiene, Lead, Mercury, Methoxychlor, Polychlorinated Biphenyls, Selenium, Styrene, Sulfate, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,2,4-Trichlorobenzene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)
Construction/demolition	Arsenic, Asbestos, Benzene, Cadmium, Chloride, Copper,Cyanide, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Fluorides, Lead, Selenium, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Turbidity, Xylene (Mixed Isomers), Zinc (Fume or Dust)
Dry cleaners/dry cleaning	Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, 1,1,2-Trichloroethane
Dry goods manufacturing	Barium, Benzene, Cadmium, Copper, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthlate, Lead, 1,1,1-Trichloroethane or Methyl Chloroform, Polychlorinated Biphenyls, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, Trichloroethylene (TCE), Xylene (Mixed Isomers)
Electrical/electronic manufacturing	Aluminum (Fume or Dust), Antimony, Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, Copper, Cyanide, Carbon Tetrachloride, 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthlate, Ethylbenzene, Lead, Mercury, Polychlorinated Biphenyls, Selenium, Styrene, Sulfate, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, 1,1,2-Trichloroethane, Trichloroethylene (TCE), Thallium, Toluene, Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)

POTENTIAL SOURCE	CONTAMINANT
Commercial / Industrial continued	
Fleet/trucking/ bus terminals	Arsenic, Acrylamide, Barium, Benzene, Benzo(a)pyrene, Cadmium, Chlorobenzene, Cyanide, Carbon Tetrachloride, 2,4-D, 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,4-Dichlorobenzene or P-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthlate, Epichlorohydrin, Heptachlor (and Epoxide), Lead, Mercury, Methoxychlor, Pentachlorophenol, Propylene Dichloride or 1,2-Dichloropropane, Selenium, Styrene, Toxaphene, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers)
Food processing	Arsenic, Benzene, Cadmium, Copper, Carbon Tetrachloride, Dichloromethane or Methylene Chloride, Lead, Mercury, Picloram, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Xylene (Mixed Isomers)
Funeral services/taxidermy	Glyphosate, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Total Coliforms, Viruses
Furniture repair/manufacturing	Barium, 1,2-Dichloroethane or Ethylene Dichloride, Dichloromethane or Methylene Chloride, Ethylbenzene, Lead, Mercury, Selenium, Trichloroethylene (TCE)
Gas stations (see also above ground/underground storage tanks, motor-vehicle drainage wells)	cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE)
Graveyards/cemeteries	Dalapon, Lindane, Nitrate, Nitrite, Total Coliforms, Viruses.
Hardware/lumber/parts stores	Aluminum (Fume or Dust), Barium, Benzene, Cadmium, Chlorobenzene, Copper, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl)adipate, Di(2-ethylhexyl) phthlate, 1,4-Dichlorobenzene or P-Dichlorobenzene, Ethylbenzene, Lead, Mercury, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Toluene, Xylene (Mixed Isomers)
Historic waste dumps/landfills	Atrazine, Alachlor, Carbofuran, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Diquat, Dalapon, Glyphosate, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Oxamyl (Vydate), Sulfate, Simazine, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene(TCE)
Home manufacturing	Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, Copper, Carbon Tetrachloride, 1,2-Dichlorobenzene or O-Dichlorobenzene, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthlate, Ethylbenzene, Lead, Mercury, Selenium, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Toluene, Turbidity, Xylene (Mixed Isomers)
Industrial waste disposal wells (see UIC for more information on concerns, and locations)	Acrylamide, Arsenic, Atrazine, Alachlor, Aluminum (Fume or Dust), Ammonia, Barium, Benzene, Cadmium, Carbofuran, Carbon Tetrachloride, Chlorobenzene, Copper, Cyanide, 2,4-D, 1,2-Dibromoethane or Ethylene Dibromide (EDB), 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,4-Dichlorobenzene or p-Dichlorobenzene, 1,1-Dichloroethylene or Vinylidene Chloride, cis 1,2 Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) adipate, Di(2-ethylhexyl) phthlate, 1,2-Dichloroethane or Ethylene Dichloride, Dioxin, Endrin, Epichlorohydrin, Hexachlorobenzene, Hexachlorocyclopentadiene, Lead, Mercury, Methoxychlor, Oxamyl (Vydate), Polychlorinated Biphenyls, Selenium, Styrene, Sulfate, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,2,4-Trichlorobenzene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)
Junk/scrap/salvage yards	Barium, Benzene, Copper, Dalapon, cis 1,2-Dichloroethylene, Diquat, Glyphosate, Lead, Polychlorinated Biphenyls, Sulfate, Simazine, Trichloroethylene (TCE), Tetrachloroethylene or Perchlorethylene (Perc)

POTENTIAL SOURCE	CONTAMINANT
Commercial / Industrial continued	
Machine shops	Arsenic, Aluminum (Fume or Dust), Barium, Benzene, Boric Acid, Cadmium, Chlorobenzene, Copper, Cyanide, Carbon Tetrachloride 2,4-D, 1,4-Dichlorobenzene or P-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, 1,1-Dichloroethylene or Vinylidene Chloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthlate, Ethylbenzene, Fluoride, Hexachlorobenzene, Lead, Mercury, Polychlorinated Biphenyls, Pentachlorophenol, Selenium, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, 1,1,2-Trichloroethane, Trichloroethylene (TCE), Xylene (Mixed Isomers), Zinc (Fume or Dust)
Medical/vet offices	Arsenic, Acrylamide, Barium, Benzene, Cadmium, Copper, Cyanide, Carbon Tetrachloride, Dichloromethane or Methylene Chloride, 1,2-Dichloroethane or Ethylene Dichloride, Lead, Mercury, Methoxychlor, 1,1,1-Trichloroethane or Methyl Chloroform, Radionuclides, Selenium, Silver, Tetrachloroethylene or Perchlorethylene (Perc), 2,4,5-TP (Silvex), Thallium, Xylene (Mixed Isomers)
Metal plating/finishing/fabricating	Antimony, Aluminum (Fume or Dust), Arsenic, Barium, Benzene, Cadmium, Carbon Tetrachloride, Chlorobenzene, Chromium, Copper, Cyanide, 1,4-Dichlorobenzene or P-Dichlorobenzene, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) adipate, Ethylbenzene,Lead, Mercury, Polychlorinated Biphenyls, Pentachlorophenol, Selenium, Styrene, Sulfate, Tetrachloroethylene or Perchlorethylene (Perc), , Thallium, Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, 1,1,2-Trichloroethane, Trichloroethylene(TCE), Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)
Military Installations	Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Hexachlorobenzene, Lead, Mercury, Methoxychlor, 1,1,1-Trichloroethane or Methyl Chloroform, Radionuclides, Selenium, Tetrachloroethylene or Perchlorethylene (Perc), , Toluene, Trichloroethylene (TCE)
Mines/gravel pits	Lead, Selenium, Sulfate, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Turbidity
Motor pools	cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride,
Motor vehicle waste disposal wells (gas stations, repair shops) See UIC for more on concerns for these sources http://www.epa.gov/safewater/uic/cv-fs.html	Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, Copper, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, 1,4-Dichlorobenzene or P-Dichlorobenzene, Lead, Fluoride, 1,1,1-Trichloroethane or Methyl Chloroform, Dichloromethane or Methylene Chloride, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE), Xylene (Mixed Isomers)
Office building/complex	Barium, Benzene, Cadmium, Copper, 2,4-D, Diazinon, 1,2-Dichlorobenzene or O-Dichlorobenzene, Dichloromethane or Methylene Chloride, Diquat, 1,2-Dichloroethane or Ethylene Dichloride, Ethylbenzene, Glyphosate, Lead, Mercury, Selenium, Simazine, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers**)**
Photo processing/printing	Acrylamide, Aluminum (Fume or Dust), Arsenic, Barium, Benzene, Cadmium, Carbon Tetrachloride, Chlorobenzene, Copper, Cyanide, 1,1-Dichloroethylene or Vinylidene Chloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthlate, 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,4-Dichlorobenzene or P-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, 1,2-Dibromoethane or Ethylene Dibromide (EDB), Heptachlor epoxide, Hexachlorobenzene, Lead, Lindane, Mercury, Methoxychlor, Propylene Dichloride or 1,2-Dichloropropane, Selenium, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Toluene, 1,1,2-Trichloroethane, Trichloroethylene(TCE), Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)

POTENTIAL SOURCE	CONTAMINANT
Commercial / Industrial continued	
Synthetic / plastics production	Antimony, Arsenic, Barium, Benzene, Cadmium, Carbon Tetrachloride, Chlorobenzene, Copper, Cyanide, 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,4-Dichlorobenzene or P-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) adipate, Di(2-ethylhexyl) phthlate, Ethylbenzene, Hexachlorobenzene, Lead, Mercury, Methyl Chloroform or 1,1,1-Trichloroethane, Pentachlorophenol, Selenium, Styrene, Tetrachloroethylene or Perchlorethylene (Perk), Toluene,, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)
RV/mini storage	Arsenic, Barium, Cyanide, 2,4-D, Endrin, Lead, Methoxychlor
Railroad yards/maintenance/fueling areas	Atrazine, Barium, Benzene, Cadmium, Dalapon, 1,4-Dichlorobenzene or P-Dichlorobenzene, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Lead, Mercury, Tetrachloroethylene or Perchlorethylene (Perc)**,** Trichloroethylene (TCE).
Research laboratories	Arsenic, Barium, Benzene, Beryllium Powder, Cadmium, Carbon Tetrachloride, Chlorobenzene, Cyanide, 1,2-Dichloroethane or Ethylene Dichloride, 1,1-Dichloroethylene or Vinylidene Chloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Endrin, Lead, Mercury, Polychlorinated Biphenyls, Selenium, Tetrachloroethylene or Perchlorethylene (Perc), Thallium, Thiosulfates, Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers)
Retail operations	Arsenic, Barium, Benzene, Cadmium, 2,4-D, 1,2-Dichloroethane or Ethylene Dichloride, Lead, Mercury, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,1,1-Trichloroethane, Vinyl Chloride
Underground storage tanks	Arsenic, Barium, Benzene, Cadmium, 1,4-Dichlorobenzene or P-Dichlorobenzene, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Lead, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE).
Wood preserving/treating	cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Lead, Sulfate
Wood/pulp/paper processing	Arsenic, Barium, Benzene, Cadmium, Carbon Tetrachloride, Copper, Dichloromethane or Methylene Chloride, Dioxin, 1,2-Dichloroethane or Ethylene Dichloride, Ethylbenzene, Lead, Mercury, Polychlorinated Biphenyls, Selenium, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE), Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, Xylene (Mixed Isomers)
Residential / Municipal	
Airports (maintenance/fueling areas)	Arsenic, Barium, Benzene, Cadmium, Carbon Tetrachloride, cis 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Ethylbenzene, Lead, Mercury, Selenium, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Xylene (Mixed Isomers)
Apartments and condominiums	Atrazine, Alachlor, Coliform, Cryptosporidium, Dalapon, Diquat, *Giardia Lambia*, Glyphosate, Nitrate, Nitrite, Picloram, Sulfate, Simazine, Vinyl Chloride, Viruses
Camp grounds/RV parks	Benomyl, Coliform, Cryptosporidium, Diquat, Dalapon, *Giardia Lambia*, Glyphosate, Isopropanol, Nitrate, Nitrite, Picloram, Sulfate, Simazine, Turbidity, Vinyl Chloride, Viruses
Cesspools - large capacity (see UIC for more information)	Atrazine, Alachlor, Carbofuran, Coliform, Cryptosporidium, Diquat, Dalapon, *Giardia Lambia*, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram, Sulfate, Simazine, Vinyl Chloride, Viruses
Drinking water treatment facilities	Atrazine, Benzene, Cadmium, Cyanide, Fluoride, Lead, Polychlorinated Biphenyls, Toluene, Total Trihalomethanes, 1,1,1-Trichloroethane or Methyl Chloroform
Gas pipelines	cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene or TCE
Golf courses and urban parks	Arsenic, Atrazine, Benzene, Chlorobenzene, Carbofuran, 2,4-D, Diquat, Dalapon, Glyphosate, Lead, Methoxychlor, Nitrate, Nitrite, Picloram, Simazine, Turbidity

POTENTIAL SOURCE	CONTAMINANT
Residential / Municipal continued	
Housing developments	Atrazine, Alachlor, Coliform, Cryptosporidium, Carbofuran, Diquat, Dalapon, *Giardia Lambia*, Glyphosate, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Picloram, Simazine, Trichloroethylene (TCE), Turbidity, Vinyl Chloride, Viruses
Landfills/dumps	Arsenic, Atrazine, Alachlor, Barium, Benzene, Cadmium, Carbofuran, cis 1,2 Dichloroethylene, Diquat, Glyphosate, Lead, Lindane, Mercury, 1,1,1-Trichloroethane or Methyl Chloroform, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Picloram, Selenium, Simazine, Trichloroethylene (TCE)
Public buildings (e.g., schools, town halls, fire stations, police stations) and Civic Organizations	Arsenic, Acrylamide, Barium, Benzene, Beryllium Powder, Cadmium, Carbon Tetrachloride, Chlorobenzene, Cyanide, 2,4-D, 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,4-Dichlorobenzene or P-Dichlorobenzene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthlate, 1,2-Dichloroethane or Ethylene Dichloride, Endothall, Endrin, 1,2-Dibromoethane or Ethylene Dibromide (EDB), Lead, Lindane, Mercury, Methoxychlor, Selenium, Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers)
Septic systems	Atrazine, Alachlor, Carbofuran, Coliform, Cryptosporidium, Diquat, Dalapon, *Giardia Lambia*, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram, Sulfate, Simazine, Vinyl Chloride, Viruses
Sewer lines	Coliform, Cryptosporidium, Diquat, Dalapon, *Giardia Lambia*, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram, Sulfate, Simazine, Vinyl Chloride, Viruses
Stormwater infiltration basins/injection into wells (UIC Class V), runoff zones	Atrazine, Alachlor, Coliform, Cryptosporidium, Carbofuran, Chlorine, Diquat, Dalapon, *Giardia Lambia*, Glyphosate, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Nitrosamine, Oxamyl (Vydate), Phosphates, Picloram, Simazine, Trichloroethylene(TCE), Turbidity, Vinyl Chloride, Viruses
Transportation corridors (*e.g.*, roads, railroads)	Dalapon, Picloram, Simazine, Sodium, Sodium Chloride, Turbidity
Utility stations	Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, Cyanide, 2,4-D, 1,4-Dichlorobenzene or P-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Lead, Mercury, Picloram, Toluene, 1,1,2,2- Tetrachloroethane, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE), Xylene (Mixed Isomers)
Waste transfer /recycling	Coliform, Cryptosporidium, *Giardia Lambia*, Nitrate, Nitrite, Vinyl Chloride, Viruses
Wastewater treatment facilities/discharge locations (incl. land disposal and underground injection of sludge)	Cadmium, Coliform, Cryptosporidium, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Fluoride, *Giardia Lambia*, Lead, Mercury, Nitrate, Nitrite, Tetrachloroethylene or Perchlorethylene (Perc) Selenium, sulfate, Trichloroethylene (TCE), Vinyl Chloride, Viruses
Agricultural / Rural	
Auction lots/boarding stables	Coliform, Cryptosporidium, *Giardia Lambia*, Nitrate, Nitrite, Sulfate, Viruses
Animal feeding operations/ confined animal feeding operations	Coliform, Cryptosporidium, *Giardia Lambia*, Nitrate, Nitrite, Sulfate, Turbidity, Viruses
Bird rookeries/wildlife feeding /migration zones	Coliform, Cryptosporidium, *Giardia Lambia*, Nitrate , Nitrite , Sulfate, Turbidity, Viruses
Crops - irrigated + non-irrigated EXIT disclaimer	Benzene, 2,4-D, Dalapon, Dinoseb, Diquat, Glyphosate, Lindane, Lead, Nitrate, Nitrite , Picloram, Simazine, Turbidity
Dairy operations	Coliform, Cryptosporidium, *Giardia Lambia*, Nitrate , Nitrite, Sulfate, Turbidity, Viruses
Drainage wells, lagoons and Liquid waste disposal -agricultural EXIT disclaimer	Atrazine, Alachlor, Coliform, Cryptosporidium, Carbofuran, Diquat, Dalapon, *Giardia Lambia*, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram, Sulfate, Simazine, Vinyl Chloride, Viruses
Managed forests/grass lands	Atrazine, Diquat, Glyphosate, Picloram, Simazine, Turbidity
Pesticide/fertilizer storage facilities	Atrazine, Alachlor, Carbofuran, Chlordane, 2,4-D, Diquat, Dalapon, 1,2-Dibromo-3-Chloropropane or DBCP, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram, Simazine, 2,4,5-TP (Silvex)

POTENTIAL SOURCE	CONTAMINANT
Agricultural / Rural continued	
Rangeland/grazing lands EXIT disclaimer	Coliform, Cryptosporidium, *Giardia Lambia*, Nitrate, Nitrite, Sulfate, Turbidity, Viruses
Residential wastewater lagoons	Atrazine, Alachlor, Carbofuran, Coliform, Cryptosporidium, Diquat, Dalapon, *Giardia Lambia*, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram, Sulfate, Simazine, Vinyl Chloride, Viruses
Rural homesteads	Atrazine, Alachlor, Carbofuran, Coliform, Cryptosporidium, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Diquat, Dalapon, *Giardia Lambia*, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram, Sulfate, Simazine, Vinyl Chloride, Viruses
MISCELLANEOUS SOURCES	
Abandoned drinking water wells (conduits for contamination)	Atrazine, Alachlor, Coliform, Cryptosporidium, Carbofuran, Diquat, Dalapon, *Giardia Lambia*, Glyphosate, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Oxamyl (Vydate), Picloram, Simazine, Trichloroethylene (TCE), Turbidity, Vinyl Chloride, Viruses
Naturally occurring	Arsenic, Asbestos, Barium, Cadmium, Chromium, Coliform, Copper, Cryptosporidium, Fluoride, *Giardia Lambia,* Iron, Lead, Manganese, Mercury, Nitrate, Nitrite, Radionuclides, Selenium, Silver, Sulfate, Viruses, Zinc (Fume or Dust)
Underground injection control (UIC) wells CLASS I - deep injection of hazardous and non-hazardous wastes into aquifers separated from underground sources of drinking water	see UIC at http://www.epa.gov/safewater/uic/index.html
UIC wells CLASS II deep injection wells of fluids associated with oil/gas production (for more detailed list of sites click here)	see UIC at http://www.epa.gov/safewater/uic/index.html
UIC wells CLASS III re-injection of water/steam into mineral formations for mineral extraction	see UIC at http://www.epa.gov/safewater/uic/index.html
UIC wells CLASS IV - officially banned. Inject hazardous or radioactive waste into or above underground sources of drinking water	see UIC at http://www.epa.gov/safewater/uic/index.html
UIC wells Class V (SHALLOW INJECTION WELLS). Click here for more information on sources of UIC Class V wells	http://www.epa.gov/safewater/uic/cv-fs.html

Appendix B
Where to Get More Information

GMA Hearings Boards

GMA Hearings Boards were created by the legislature to hear cases related to the Growth Management Act. The three GMA Hearings boards are for Eastern Washington, Western Washington, and Central Puget Sound. Critical Areas planning and ordinance decisions are subject to review by the board. The board hears cases when a "Petition for Review" is filed.

The GMA Hearings Board website, http://www.gmhb.wa.gov/, contains a wealth of information about the boards and how they work. Each of the boards has a decision digest where decisions that effect critical aquifer recharge areas (CARAs) and other growth management issues can be viewed on-line.

You may also contact the Hearings Board as follows:

Central Puget Sound	**Western Washington**	**Eastern Washington**
King, Snohomish, Pierce and Kitsap counties 900 4th Avenue Suite 2470 Seattle, WA. 98164 Tel: (206) 389-2625 Fax: (206) 389-2588 E-mail to: central@cps.gmhb.wa.gov	Western Washington counties not in the central Puget Sound 905 24th Way SW, Suite B-2 Olympia, WA 98502 P.O. Box 40953 (MS: 40953) Olympia, WA. 98504-0953 Tel: (360) 664-8966 Fax: (360) 664-8975 E-mail to: western@ww.gmhb.wa.gov	Counties and cities east of the crest of the Cascade Mountains 15 West Yakima, Suite 102 Yakima, WA 98902 Tel: (509) 574-6960 Fax: (509) 574-6964 E-mail to: AAndreas476@EW.GMHB.WA.GOV

Ten counties and their included cities in Washington are not required to plan fully under the GMA. These jurisdictions must still plan for Critical Areas and Natural Resources Lands. These ten counties are Adams, Asotin, Cowlitz, Grays Harbor, Klickitat, Lincoln, Okanogan, Skamania, Whitman, and Wahkiakum.

GMA Laws and Regulations

The Office of the Code Reviser website is at http://slc.leg.wa.gov/.

The Revised Code of Washington and the Washington Administrative Code are also available at public libraries.

Planning Resources

Washington State Department of Community, Trade, and Economic Development is responsible for administering the Growth Management Act and has many helpful documents on-line: http://www.cted.wa.gov/portal/alias__CTED/lang__en/tabID__375/DesktopDefault.aspx

The Municipal Research & Services Center of Washington has vast amounts of helpful on-line information for counties and cities, including Growth Management Act information: http://www.mrsc.org/

Recognition and technical assistance programs

Envirostars: http://www.envirostars.org/

Best available science for critical aquifer recharge areas

King County Dept. of Natural Resources, 2004. Chapter 6: Critical Aquifer Recharge Areas *in* Best Available Science, Volume I – A Review of Science Literature, King County Executive Report, Critical Areas, Stormwater, and Clearing and Grading Proposed Ordinances, February 2004, http://www.metrokc.gov/DDES/cao/

Local Pollution Prevention Information

King County Hazardous Waste: http://www.govlink.org/hazwaste/

Thurston County Hazardous Waste:
http://www.co.thurston.wa.us/health/ehrp/hwaste.html

Spokane Joint Aquifer Board: http://www.spokaneaquifer.org/Factsheet3_aquifer.pdf

Geologist/Hydrogeologist Licensing Laws and Regulations

Department of Licensing Geology License Website:
http://www.wa.gov/dol/bpd/geofront.htm

Washington State Code Reviser Website, with links to RCWs and WACs:
http://slc.leg.wa.gov/

Both of the above websites have links to the Geologist Licensing laws and regulations: RCW 18.220 and WAC 308-15.

State Ground Water Protection Programs

Washington State Department of Health Drinking Water Program

The Department of Health is responsible for administering the Safe Drinking Water Act program for the state. This includes regulating public water supplies and administering the Source Water Protection program.

The federal Safe Drinking Water Act includes provisions for preventing contamination of drinking water for Group A public water supply systems (15 or more connections).

Drinking Water Program website: http://www.doh.wa.gov/ehp/dw/default.htm

Source Water Protection website:
http://www.doh.wa.gov/ehp/dw/Our_Main_Pages/swap.htm.

Here is a quote from this website:

> *The SWAP program will result in an evaluation of the source water that provides drinking water to Group A public water systems in Washington state. This evaluation will estimate the degree to which a given public water source is at risk from contamination. Once completed, the assessment results will be used to assist local communities in targeting and implementing protection measures such as Best Management Practices (BMPs), zoning overlays, critical area ordinances and public education. The information can also be used to help focus technical assistance outreach efforts and compliance inspections.*

Chapter 173-200 WAC, Ground Water Quality Standards,
http://www.ecy.wa.gov/biblio/wac173200.html

Implementation Guidance for the Ground Water Quality Standards,
http://www.ecy.wa.gov/biblio/96002.html

Washington State Department of Ecology, 1992. *Assessing The Impacts Of Community Onsite Sewage Systems On Ground Water Quality, Part 2 Chapter Permit Writer's Manual*, Washington State Department of Ecology, Publication Number 92-109, revised 2001, http://www.ecy.wa.gov/biblio/92109.html, pages VIII-2 through VIII-8.

Chapter 173-303 WAC, Dangerous Waste Regulations,
http://www.ecy.wa.gov/biblio/wac173303.html

Washington State Department of Ecology Sand and Gravel General Permit:
http://www.ecy.wa.gov/programs/wq/sand/index.html

Washington State Underground Injection Control Program

- Website: http://www.ecy.wa.gov/programs/wq/grndwtr/uic/index.html
- Rule: http://www.ecy.wa.gov/biblio/wac173218.html

Federal Ground Water Programs

U.S. Environmental Protection Agency - Drinking Water Program

EPA Safe Drinking Water Act Maximum Contaminant Levels (MCLs), http://www.epa.gov/safewater/mcl.html

Delineation and Vulnerability Methods

Focazio, M.J., T.E. Reilly, M.G. Rupert, D.R. Helsel, 2003. *Assessing Ground-Water Vulnerability to Contamination: Providing Scientifically Defensible Information for Decision Makers*, U.S. Geological Survey Circular 1224, 33 pp., http://water.usgs.gov/pubs/circ/2002/circ1224/

Erwin, M.L., and Tesoriero, A.J., Predicting ground-water vulnerability to nitrate in the Puget Sound Basin: U.S. Geological Survey Fact Sheet FS-061-97, on-line at URL http://wa.water.usgs.gov/fs.061-97/index.html, accessed Nov. 10, 1997, HTML format.

Garrigues, R.S., K. Sinclair, J. Tooley, 1998. *Chehalis River Watershed Surficial Aquifer Characterization*, Washington State Department of Ecology Environmental Assessment Program Watershed Ecology Section, Publication Number 98-335, 22 pp. http://www.ecy.wa.gov/biblio/98335.html

US EPA, 2000. Technical Assistance Document (TAD) for Delineating “Other Sensitive Ground Water Areas”, EPA Office of Water Publication Number 816-R-00-016, 22 p. http://www.epa.gov/safewater/uic/tad_sensitive_gw.pdf

US EPA, 1993. *A Review of Methods for Assessing Aquifer Sensitivity and Ground Water Vulnerability to Pesticide Contamination*, US EPA Office of Water, Publication No. 813-R-93-002, September 1993, 147 pp. + appendices.

FUGRO Airborne Surveys Groundwater Recharge Mapping http://www.fugroairborne.com.au/CaseStudies/recharge.shtml

> *This is a private company who uses airborne geophysics for ground water and geology mapping. The method is used for TDS mapping, saltwater intrusion, water depth, and recharge area mapping. This is included here as an example of an airborne geophysical method for mapping recharge areas, and does not imply an endorsement.*

Eastern Washington Studies

Whiteman, K.J., J.J. Vaccaro, J.B. Gonthier, H.H. Bauer, 1994. *The Hydrogeologic Framework and Geochemistry of the Columbia Plateau Aquifer System, Washington, Oregon, and Idaho*: U.S. Geological Survey Professional Paper 1413-B, 73 p.

Drost, B.W., S.E. Cox, and K.M. Schurr, 1997. *Changes in Ground-Water Levels and Ground-Water Budgets, from Predevelopment to 1986, in Parts of the Pasco Basin, Washington*: U.S. Geological Survey Water-Resources Investigations Report 96-4086, 172 p.

On-line USGS publication index, Columbia Basin NAWQA: http://wa.water.usgs.gov/ccpt/pubs/

On-line USGS publication index, Yakima Basin NAWQA: http://oregon.usgs.gov/projs_dir/yakima/pubs.html

Western Washington Studies

Vaccaro, J.J., A.J. Hansen, Jr., and M.A. Jones, 1998. *Hydrogeologic Framework of the Puget Sound Aquifer System, Washington and British Columbia*, *Regional Aquifer System Analysis*, U.S. Geological Survey Professional Paper 1424-D, 77 pp.

Garrigues, R.S., K. Sinclair, J. Tooley, 1998. *Chehalis River Watershed Surficial Aquifer Characterization*, Washington State Department of Ecology Environmental Assessment Program Watershed Ecology Section, Publication Number 98-335, 22 pp.

Cox, S.E. and Kahle, S.C., 1999. *Hydrogeology, Ground-Water Quality, and Sources of Nitrate in Lowland Glacial Aquifers of Whatcom County, Washington, and British Columbia, Canada*: U.S. Geological Survey Water-Resources Investigations Report 98-4195, 251p.

On-line USGS publication index, Puget Sound NAWQA: http://wa.water.usgs.gov/ps.publication.index.html

Ground Water Quality Studies

Erickson, D. and D. Norton, 1990. *Washington State Agricultural Chemicals Pilot Study, Final Report*, Washington State Department of Ecology, 76 pp. + appendices.

Saltwater Intrusion

Washington State Dept. of Ecology Water Resources Program, 2002. Brochure: Seawater Intrusion in Washington, http://www.ecy.wa.gov/pubs/0211018.pdf

Impervious Surfaces

Booth, D.B., September 2000. *Forest Cover, Impervious-Surface Area, and the Mitigation of Urbanization Impacts in King County, Washington.* Center for Urban Water Resources, University of Washington, http://depts.washington.edu/cuwrm/

Database Sources

Washington State Department of Ecology on-line:

- Facility/Site: http://www.ecy.wa.gov/services/as/iss/fsweb/fshome.html

  Facilities and sites that are regulated by the Department of Ecology.
- Toxic cleanup sites: http://www.ecy.wa.gov/programs/tcp/cscs/CSCSpage.HTM
- Leaking underground storage tank sites: http://www.ecy.wa.gov/programs/tcp/ust-lust/tanks.html
- EIM: http://www.ecy.wa.gov/services/as/iip/eim/index.html

  Environmental Information Management System; sampling, measurements, and monitoring results. The link to query EIM on-line and download data is on this page.
- Environmental Assessment Program groundwater studies: http://www.ecy.wa.gov/programs/eap/groundwater/underwaystudies.html.
- GIS home page: http://www.ecy.wa.gov/services/gis/index.html

Washington State Department of Health on-line:

The Department of Health is launching a new website for water system data. The website is not yet available as of publication of this document. For currently available information on-line, and to check for new developments, see the Drinking Water Program website at http://www.doh.wa.gov/ehp/dw/default.htm.

U.S. Geological Survey on-line:

- Washington State bibliography: http://wa.water.usgs.gov/biblio.html

  This bibliography contains references to published reports, maps, journal articles, and proceedings related to the water resources of Washington State as published by the U.S. Geological Survey, or in cooperation with other Federal or State agencies.
- Washington State water at: http://waterdata.usgs.gov/wa/nwis/nwis

  NWIS, or National Water Information System, is the USGS on-line database for water resources data. This site contains data collected in the state of Washington, including groundwater and surface water data and the associated water-quality data, meteorological data, and site information.

U.S. Department of Agriculture Natural Resource Conservation Service on-line:

- NRCS soils website: http://soils.usda.gov/
- NRCS Washington website: http://www.wa.nrcs.usda.gov/
- Washington State on-line soil surveys (SSURGO): http://www.or.nrcs.usda.gov/pnw_soil/wa_reports.html
- NRCS snow survey and water resources information: http://www.wa.nrcs.usda.gov/snow/index.html

The NRCS Snow Survey Program provides mountain snowpack data and stream flow forecasts for the western United States.

Common applications of snow survey products include water supply management, flood control, climate modeling, recreation, and conservation planning.

LaSpina, J., Palmquist, R. 1992. Catalog of Contaminant Databases; *A Listing of Databases of Actual or Potential Contaminant Sources*. Washington State Department of Ecology. 92-52.

Appendix C
Selected GMA Hearings Board Decisions

Examples of GMA Hearings Board Decisions from the Digests

Each GMA Hearings Board publishes a digest of decisions that makes it easier to find decisions related to various topics. Here are some examples of decisions from the digests from the Central Puget Sound, Western Washington, and Eastern Washington Growth Management Hearings Boards:

Mapping and performance standards:

Central Puget Sound:

> “The use of performance standards is recommended in the Minimum Guidelines for … circumstances where critical areas (*e.g.*, aquifer recharge areas, wetlands, significant wildlife habitat, etc.) cannot be specifically identified." WAC 365-190-040(1). However, where critical areas are known, cities and counties cannot rely solely upon performance standards to designate these areas. [*Pilchuck II*, *5347c*, FDO, at 41-42.]

Local government discretion and the GMA framework:

Western Washington:

> The GMA provides that ultimate planning decisions rest with the local government. Such decisions are not unfettered but must be within the range of discretion allowed by the GMA. A GMHB does not substitute its judgment as to the best alternative available, but reviews the local government action to determine if it complies with the goals and requirements of the GMA. CCNRC v. Clark County 92-2-0001 (FDO 11-10-92)

Eastern Washington:

> The Act requires protection of critical areas, and the county is given the opportunity to select the manner of that protection. Their choice is given great deference. Easy, et al. v. Spokane County, EWGMHB 96-1-0016, Order on Compliance (Sep. 23, 1997).

What protecting Critical Areas (CA) means:

Central Puget Sound:

> The Act’s directive that local governments are to “protect” critical areas means that they are to preserve the structure, value and functions of wetlands, aquifer recharge areas used for potable water, fish, and wildlife habitat conservation

areas, frequently flooded areas and geologically hazardous areas. [derived from WAC 365-195-825(2)(b)] [*Pilchuck II, 5347c,* FDO, at 20.]

Western Washington:

The GMA requirement to protect CAs directs a local government to adopt appropriate and specific criteria and/or standards. Willapa v. Pacific County 99-2-0019 (FDO 10-28-99)

Compliance monitoring and enforcement:

Western Washington:

If BMPs are relied upon for protection of CAs some form of monitoring and enforcement must be included to ensure that the plans are actually implemented and followed. ARD v. Shelton 98-2-0005 (FDO 8-10-98)

Eastern Washington:

Further, laws can be so vague that they simply are unenforceable. That is the case here. Such an ordinance cannot satisfy GMA's duty to adopt enforceable "development regulations" to "protect" critical areas. A person should be able to determine what the law is by reading the published code. Ordinance no. 109-2003 (ICAO) relies on language too vague to create an enforceable standard and therefore cannot not operate to "control" land use activities and does not satisfy the county's GMA obligation to adopt "development regulations" to protect critical areas. The enforcement measures adopted by the county provide only for ad hoc enforcement. This does not constitute a reasoned adaptive management program, particularly where, as here, there is no provision for the monitoring of compliance. Larson Beach Neighbors and Jeanie Wagenman v. Stevens County, EWGMHB 00-1-0016, EWGMHB, Order on Compliance, November 13, 2003.

Critical Aquifer Recharge Areas:

Eastern Washington:

The GMA directs counties to designate, classify and protect areas with a "critical recharging effect on aquifers used for potable water." It is necessary to determine the location of recharge areas as a first step in designating and protecting them. The county must provide criteria necessary to indicate when an area needs specific scientific analysis to determine whether it is a critical aquifer recharge area. Save Our Butte Save Our Basin Society, et al. v. Chelan County, EWGMHB 94-1-0015, Compliance Hearing Order (Apr. 8, 1999).

Critical Areas and pre-existing land uses:

Western Washington:

A local government must regulate preexisting uses in order to fulfill its duty to protect critical areas. GMA requires any exemption for preexisting use to be limited and carefully crafted. PPF v. Clallam County 00-2-0008 (FDO 12-19-00).

Critical Areas and best available science:

Central Puget Sound:

When any local government in the Central Puget Sound region adopts amendments to policies and regulations that purport to protect critical areas pursuant to RCW 36.70A.060(2), those enactments will be subject to meeting the best available science requirements of RCW 36.70A.172 and the potential of appeal to this Board pursuant to RCW 36.70A.280. [Tulalip II, 9313, 1/28/00 Order, at 4.]

Appendix D
Example Costs and Consequences of Ground Water Contamination

Former Pacific wood treating site (at the Port of Ridgefield)

A former Port tenant using wood treating chemicals contaminated ground water beneath the Port of Ridgefield and the National Wildlife Refuge. Sediments of Lake River have also been contaminated. The cost of this clean up has been estimated at $40 to $50 million dollars.

Source: Department of Ecology Budget and Program Overview 2003-05
http://www.ecy.wa.gov/pubs/0301023.pdf

City of Tumwater, Palermo Well Field

In 1993, the city of Tumwater, Palermo well field was contaminated with trichloroethylene (TCE) and was threatened by perchloroethylene (PCE). Three of the city's six wells were removed from service and replaced with two new wells at another location. The total cost for dealing with solvent contamination was $3.9 million dollars, the cleanup took more than six years, and three of six city wells were closed for five years.

Sources:
http://www.crcwater.org/issues5/0#0, from an article by Joel Coffidis in the Daily Olympian, July 1, 1998: WATER SAFETY: EPA tests pinpoint the origin of the toxic chemicals that have closed three wells.

http://www.epa.gov/superfund/sites/npl/nar1484.htm, NPL Site Narrative at Listing, U.S. EPA web site, latest update information 1997. Source: Superfund NPL Assessment Program (SNAP) Database.

Alexander Farms

In 1998, yellow water was found coming out of two domestic wells in the vicinity of the Alexander Farms site. The source was from a spill of dinoseb, a pesticide. More than 12,000 tons of Dinoseb-contaminated soils were excavated. The costs to owners for cleanup were said to top $1 million (Tri-city Herald, 4/26/2002).

Boomsnub electroplating facility

The Boomsnub Corporation is an electroplating facility located in Vancouver, Washington. Repeatedly and illegally, it has disposed of spent hexavalent chrome into the environment. As a result, the entire water supply for the city of Vancouver and the Clark County area was threatened.

The groundwater remediation project cost more than $3 million to the Washington State taxpayers. At least six thousand tons of highly contaminated soils have been removed. In 1995, it was estimated that $10 million would be spent in an attempt to save the city of Vancouver water supply.

Sources:
Excerpt from US EPA Office of Enforcement FY 1995 Enforcement and Compliance Assurance Accomplishments Report – United States v. Boomsnub Corporation (W.D. WA) http://www.epa.gov/compliance/resources/reports/accomplishments/oeca/fy95accomplishment.pdf

Walkerton, Ontario, Canada

The town of Walkerton, Ontario, Canada, endured a horrible contamination event that killed seven people and sickened hundreds in May 2000. The cause was the application of manure to fertilize a field near a town well. The town well was supposed to be monitored, but the person who was supposed to sample and make sure the well was chlorinated had fallen into improper practices.

The following excerpt is from the *Report of The Walkerton Inquiry: The Events of May 2000 And Related Issues*, http://www.walkertoninquiry.com/report1/index.html#summary):

> *[Improper practices] included mislabeling sample bottles for microbiological testing, failing to adequately chlorinate the water, failing to measure chlorine residuals daily, making false entries on daily operating sheets, submitting false annual reports to the Ministry of the Environment (MOE), and operating wells without chlorination.*

A groundwater protection program would have identified the well location and its importance, and would have identified the risk inherent in allowing manure to be spread on adjacent land. Only compliance monitoring would have caught the inadequate practices of the water system operator. Compliance monitoring is important for operators of facilities that are contamination risks for the same reasons.

A cost estimate of the remediation alone was set at $9,222,215. A fuller explanation of the costs is available at http://www.newswire.ca/releases/November2001/26/c0319.html.

The Walkerton Inquiry homepage is located at http://www.walkertoninquiry.com/index.html.

Appendix E
Example County Fact Sheets for Pollution Prevention


Photos courtesy of U.S. EPA Region 10

The following fact sheet is copied from the Thurston County Business Pollution Prevention Program Fact Sheet - Floor Drains (February 2004), http://www.co.thurston.wa.us/health/ehrp/hwaste.html

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Floor Drains

"Convenient disposal to floor drains today can lead to expensive clean-up costs later when you try to sell or refinance your property."

The Problem

Many types of businesses use floor drains as an easy way to dispose of floor cleaning or other wastes. What many business owners do not realize is that putting wastes down floor drains may violate the Thurston County Nonpoint Source Pollution Ordinance and several other federal and state laws.

Many floor drains send untreated wastes directly to storm drains, septic systems, dry wells, pits, or ditches. When wastes enter these types of drains, they pass through soil and may enter groundwater, or may enter streams or lakes directly -- *they do not necessarily go to a sewage treatment plant.* Moreover, even a treatment plant cannot effectively handle many types of wastes.

When commercial property is sold or refinanced, finance companies often require an environmental site assessment that evaluates whether property is contaminated. Convenient disposal to floor drains today can lead to expensive clean up costs later when you try to sell or refinance your property. Irresponsible disposal can also lead to contaminated drinking water that may affect your community and your family.

What You Can Do

Find out where your floor drains go. Consider each drain separately. Call your city or county public works department or local sewer utility and ask for help in identifying where your drains lead. If your business was built before 1970, or is located in a rural area, your floor drains most likely do not lead to a sanitary sewer.

If your floor drain is already connected to a sanitary sewer. You still need to meet local sewer discharge limits. All discharges to a sewer system are authorized by the LOTT Wastewater Alliance. LOTT may be reached at 753-8428.

*If your floor drain is not connected to a sanitary sewer. C*ontact the Thurston County Business Pollution Prevention Program for help in determining if you have a pollution problem from this floor drain. Two options to consider for non-connected floor drains.

1. Connect the floor drain to a sanitary sewer and meet sewer discharge limits; or
2. Seal the floor drain and change your current disposal practices.

Practical tips to eliminate the use of and, therefore, the need for a floor drain:

3. Sweep and spot-mop floors frequently to minimize the need for complete floor cleaning. Improve general housekeeping practices.
4. Build a "dead-end" sump where occasional wastewater can collect and either evaporate or be pumped into a dedicated and labeled container. Sludge that may build up in the sump will need to be removed and possibly managed as hazardous waste.
5. If you must keep a floor drain, consider installing a recirculating floor scrubber or "closed-loop" wastewater recycling system, or investigate treatment-by-generator options.

Keep a Record of Your Actions

If you seal off a floor drain, create a record of past uses for the drain, the date when the drain was sealed, and describe the physical location of the drain before it was sealed. Keep records of flow into any drains that are connected to a sanitary sewer to demonstrate that you have met discharge permit requirements. This information may be important if the property is offered for sale, and it could be useful in reducing liability in the case of an investigation of contaminated soil or ground water.

Additional Information

Staff from the Thurston County Business Pollution Prevention Program is available to answer questions about floor drains, best management practices for wastewater, and other hazardous waste related issues. We also offer free, non-regulatory on-site technical assistance. Please contact the Business Pollution Prevention Program at (360) 786-5457, Monday through Friday, from 8 a.m. to 5 p.m., or at TDD (360) 754-2933 or see our website at http://www.co.thurston.wa.us/health/ehrp/hwaste.html.

Other Hazardous Waste Management and Disposal Fact Sheets

- *Antifreeze, Used Oil, and Oil Filters*
- *Compliance with Nonpoint Source Pollution Ordinance*
- *Disposal of Petroleum-Contaminated Absorbent Materials*
- *Doing Business in a Wellhead Protection Area*
- *Hazardous Waste Management in Printing and Photography*
- *Secondary Containment*
- *Solvents and Parts Cleaners*
- *Spill Plans*
- *Storing and Labeling Hazardous Waste*
- *Used Shop Towels*

February 2004

The following fact sheet is copied from the Thurston County Business Pollution Prevention Program Fact Sheet - Secondary Containment (February 2004), http://www.co.thurston.wa.us/health/ehrp/hwaste.html

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Secondary Containment

"Liquid hazardous materials such as petroleum products, antifreeze, and solvents can present a threat to soil, ground water, and surface water."

The Problem

Liquid hazardous materials such as petroleum products, antifreeze, and solvents can present a threat to soil, ground water, and surface water if accidentally spilled or leaked. These substances must be stored so that if a spill or leak does occur, the material remains contained and does not contaminate the environment. A solution to the problem is to use secondary containment when storing hazardous liquids.

The Regulatory Requirements

The Thurston County Nonpoint Source Pollution Ordinance (Article VI of the Sanitary Code) requires that hazardous waste, including petroleum products, be stored so that if a container leaks or ruptures the contents will not contaminate ground or surface water. The best way to ensure this is to provide secondary containment for all containers of liquid hazardous products and wastes.

The Thurston County Critical Areas Ordinance Chapter 17.15.520 C(2) also requires businesses that are located in aquifer recharge areas to provide secondary containment for hazardous materials that are stored on-site.

The Thurston County Mineral Extraction Code requires that fuel and hazardous materials are stored according to the requirements of the Nonpoint Source Pollution Ordinance. The Department of Ecology requires coverage and containment of hazardous materials through the "National Pollutant Discharge Elimination System and State Waste Discharge General Permit for Process Water and Stormwater Associated with Sand and Gravel Operations and Asphalt Batch Operations" RCW Chapter 90.48.

What is Secondary Containment?

Secondary containment is a liquid-tight barrier that will adequately contain hazardous materials that are released from a storage container. A simple example of secondary containment is placement of a 5-gallon drum (primary containment) inside a 55-gallon drum (secondary containment). Another example is placement of 55-gallon drums or a large fuel tank (primary containment) inside a liquid-tight concrete bunker (secondary containment). The outer wall of a double-walled fuel storage tank is also an example of secondary containment.

The size and design of a secondary containment unit or device depends on the type and amount of material that it holds.

The Options

Four secondary containment method options will satisfy Thurston County regulatory requirements. Liquid hazardous materials, including petroleum products, can be:

1. Stored indoors on a liquid-tight concrete floor without secondary containment if the storage area is able to contain 100 percent of the largest container in the event of a spill and prevent it from flowing or leaking out of the building. Also, spilled or leaked materials must be prevented from entering floor drains that are not part of a liquid-tight containment system designed to capture and hold hazardous materials.
2. Stored in outdoor or indoor covered secondary containment that can hold 110 percent of the volume of the largest storage container or 10 percent of the total volume stored, whichever is greatest, plus the displacement volume of any items inside the containment.
3. Stored in **outdoor uncovered** secondary containment that can hold 120 percent of the volume of the largest storage container *or* 10 percent of the total volume stored, whichever is greatest, plus the displacement volume of any items inside the containment.
4. Stored in UL-certified double-walled storage tanks. The volume requirements that are listed in options 1, 2 and 3 do not apply to these storage tanks, because they do not require additional containment provisions.

Secondary Containment Criteria

Chemical Compatibility and Structural Integrity

- The structural materials used in secondary containment units, including expansion joints and seals (if applicable) must be chemically compatible with the substance(s) that will be contained.
- Secondary containment must be maintained liquid-tight at all times, except when draining storm water under direct supervision (see below).
- Secondary containment must be physically adequate to hold a release and remain liquid-tight.
- Discharge valves must be closed and locked when not in use. The key or combination for the lock must be kept on-site and available during all work shifts.

Stormwater Accumulation and Discharge

- Stormwater must be managed in accordance with the Thurston County Drainage Design and Erosion Control Manual.
- Outdoor uncovered containments must be maintained free of stormwater accumulation.
- An operator must be present during stormwater discharge from secondary containment.
- All discharge valves must be closed and locked after a supervised discharge is completed.
- Stormwater discharged from petroleum product secondary containment must be treated through an oil/water separator. (See the Thurston County fact sheet “Oil/Water Separators.”)

Spills

Keep secondary containment areas free of small spills and drips. Drip pans that can be conveniently cleaned are helpful in preventing contamination of the secondary containment area. Hazardous materials, liquid hazardous waste and petroleum product spills must be cleaned up immediately.

Remember that even a small spill, drip, or leak must be cleaned up and disposed of as a hazardous waste. Absorbents and other cleanup materials that are contaminated must also be managed as a hazardous waste. Up to 55 gallons of petroleum-contaminated absorbents may be deposited at the Thurston County Waste and Recovery Center annually, as explained in the Thurston County fact sheet “Disposal of Petroleum Contaminated Absorbent Materials.”

Additional Information
Please call the Thurston County Business Pollution Prevention Program at (360) 786-5457 or TDD 754-2933 or see our website at http://www.co.thurston.wa.us/health/ehrp/hwaste.html.
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