Module 5 Ground Water, Drinking Water, and Standards

Introduction

The Pacific Northwest has always meant clear blue lakes, ocean beaches, the Columbia River System, and rushing streams from our vast mountainous regions. Water is perhaps our most abundant, and some would argue the most important, regional natural resource. Unfortunately, people are more aware of surface and ground water today in our region because of increasing reports of contamination. Reports of contamination raise some obvious questions. Is the water safe to drink? Today the public agencies charged with protecting drinking water and public health address these questions by establishing standards and guidelines — numbers that identify contaminant levels that do not pose a significant risk to public health.

In this module participants will examine: *Ground water, drinking water, how health risks are evaluated, how numerical drinking water standards and guidelines are set, what the numbers mean, and what they don't mean.*

Ground Water

What is Ground Water?

Ground water can be found at various depths at any location on the Earth's surface. It is the water that fills the natural open spaces (e.g., fractures or pore spaces between grains) in soil and rocks underground in much the same way as water fills a sponge. Ground water begins as precipitation and soaks into the ground where it is stored in underground geological water systems called aquifers. An aquifer is any geologic material (like sand and gravel or fractured bedrock) that is filled with water and will yield that water to a well. Ground water can move sideways as well as up or down in response to gravity, differences in elevation, and differences in pressure. The movement is usually quite slow — frequently as little as a few feet per year — although it can move as much as several feet per day in more permeable zones. Ground water does not occur as underground lakes or streams.

Who Uses Ground Water?

Of all ground water used, the majority is used for irrigation. Future population growth and land development is increasingly depending on ground water resources. Prior allocation and rising treatment costs limit future use. As an example, over 70 percent of all Oregonians (that's more than two million people) are at least partially dependent on ground water for their drinking water supplies. Approximately 95 percent of Oregonians in rural areas are dependent on ground water. In many areas, ground water is the only source of drinking water. Protecting our water supply from contamination now will help maintain a clean and safe water supply for generations to come.

Potential Sources of Contamination

- Household chemicals and cleaning products.
- Excess nitrogen fertilizers including manure and lawn fertilizers.
- New and old industrial solvents and chemicals.
- Chemical spills from highway, railroad accidents, or spills from business or manufacturing sites.
- Improperly applied pesticides or pesticide spills.
- Leaking underground storage tanks.
- Improperly installed or old domestic wells.
- Poorly maintained septic systems.
- Urban runoff.
- Waste disposal sites or dumps.

How Does Ground Water Become Contaminated?

With the increased use of chemicals in the 20th century, the contamination of ground water has become a growing concern. When rainwater comes in contact with any source of contamination at the surface or in the soil, it dissolves some of that contaminant and carries it to the aquifer. Ground water moves from areas where the water table is high to where the water table is low. Consequently, a contaminant may enter the aquifer some distance upgradient of a public or private drinking water well and move towards the well. When a well is pumping, it lowers the water table in the immediate vicinity of the well increasing the tendency for water to move towards the well.

Although it is common practice to associate contamination with highly visible features such as landfills, gas stations, industry, or agriculture, potential contaminants are widespread and often come from common everyday activities as well, such as septic systems, lawn and garden chemicals, pesticides applied to highway right-of-ways, stormwater runoff, auto repair shops, beauty shops, dry cleaners, medical institutions, photo processing labs, etc. Importantly, it takes only a very small amount of some chemicals in drinking water to raise health concerns. For example: 1 gallon of pure trichloroethylene, a common solvent, will contaminate approximately 292 million gallons of water to the health-based limit for drinking water.

How Can We Protect Water?

In Oregon for instance, the state Department of Environmental Quality (DEQ) (http://www.deq.state.or.us/pubs/water/drinkingwaterprotectionprogram.pdf) and the Oregon Health Division (OHD) are conducting "source water assessments" for most public water systems. These assessments include the identification of the source area supplying the well (commonly called the Drinking Water Protection Area), an inventory of potential contaminant sources within that area, and an identification of the areas most susceptible to contamination. Using the results of the assessment, members of the local community can form a "Drinking Water Protection Team" and develop a plan to reduce the risks of contamination from those sources. Technical assistance in Drinking Water Protection Plan development and implementation is available from DEQ. The management options implemented as part of the Drinking Water Protection Plan are highly individualized, and should be developed by the community to meet their specific needs. Cooperative decision making by public officials, water systems, public interest groups, business, agriculture, and individual citizens can create a powerful long-lasting partnership that will facilitate implementation and public acceptance of the drinking water protection plan.

Prevention Is The Key To Protection

Once ground water is contaminated, it is difficult, costly, and sometimes impossible to clean up; communities are faced with the task of installing treatment facilities or locating an alternate source. Some examples of this occurring in Oregon are:

- Milwaukie spent $2,000,000 to study and treat solvents in their ground water. Annual operations and maintenance costs for the treatment system are $100,000/year.

- Over $500,000 was spent on study and treatment at Lakewood Estates. Residents used bottled water for two years.

- Lake Oswego, Woodburn, Lebanon, and Madras have all lost the use of wells due to contamination.

That is why prevention is the key to ground water quality protection. Because of their interrelationship, maintaining ground water quality also helps protect surface water quality.

Drinking Water

Lakes, rivers, streams, groundwater aquifers, and springs can all serve as the source of a community's drinking water. Ground water, surface water, or a combination of both may serve as a community's drinking water source. For a community to stay healthy and prosperous all its residents must protect the quality and quantity of their drinking water source.

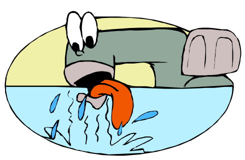
Where does drinking water come from?

A clean, constant supply of drinking water is essential to every community. People in large cities frequently drink water that comes from **surface water sources**, such as lakes, rivers, and reservoirs. Sometimes these sources are close to the community. Other times, drinking water suppliers get their water from sources many miles away. In either case, when you think about where your drinking water comes from, it is important to consider not just the part of the river or lake that you can see, but the entire watershed. The watershed is the land area over which water flows into the river, lake, or reservoir.

In rural areas, people are more likely to drink **ground water** that was pumped from a well. These wells tap into aquifers — the natural reservoirs under the earth's surface — that may be only a few miles wide, or may span the borders of many states. As with surface water, it is important to remember that activities many miles away from you may affect the quality of ground water. Your annual drinking water quality report will tell you where your water supplier gets your water. For more information . . .

- Check out: Surf Your Watershed's "Where does my drinking water come from?" feature (http://www.epa.gov/surfnewi/surf98/wimdw.html). It will connect you to maps and dozens of sources of information about your watershed.

- Check out: Water on Tap: A Consumer's Guide to the Nation's Drinking Water (http://www.epa.gov/safewater/wot/wot.html). It will answer these questions: Where does your drinking water come from? How do you know if your drinking water is safe? How can you protect it? What can you do if there's a problem with your drinking water?



What contaminants may be found in drinking water?

There is no such thing as naturally pure water. In nature, all water contains some impurities. As water flows in streams, sits in lakes, and filters through layers of soil and rock in the ground, it dissolves or absorbs the substances that it touches. Some of these substances are harmless. In fact, some people prefer mineral water precisely because minerals give it an appealing taste. However, at certain levels, minerals, just like man-made chemicals, are considered contaminants that can make water unpalatable or even unsafe.

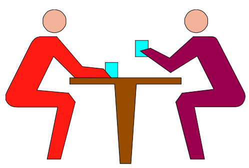
Some contaminants come from erosion of natural rock formations. Other contaminants are substances discharged from factories, applied to farmlands, or used by consumers in their homes and yards. Sources of contaminants might be in your neighborhood or might be many miles away. Your local water quality report tells which contaminants are in your drinking water, the levels at which they were found, and the actual or likely source of each contaminant. Some ground water systems have established wellhead protection programs to prevent substances from contaminating their wells. Similarly some surface water systems protect the watershed around their reservoir to prevent contamination. Right now, Pacific Northwest states and water suppliers are working systematically to assess every source of drinking water and to identify potential sources of contaminants. This process will help communities to protect their drinking water supplies from contamination, and a summary of the results will be in future water quality reports. For more information . . .

- Read a list of the drinking water contaminants that EPA regulates (http://www.epa.gov/safewater/mcl.html), including their sources in drinking water and their potential health effects.

- Read a list of your state drinking water contaminants (see Handout in Part One).

Ground Water and Drinking Water Standards

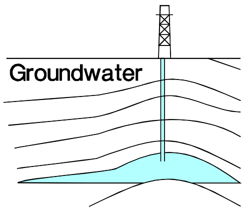
Idaho, Oregon, and Washington regulate both ground water and drinking water. The regulations differ, however, in their intentions and in the actions taken when a standard is exceeded in each state.



Drinking Water

Based on the federal Safe Drinking Water Act, the U.S. Environmental Protection Agency and the states have established drinking water standards for the 20± health-related contaminants including arsenic, nitrate, bacteria, radioactivity, heavy metals such as lead and mercury, and several pesticides. The standards do not presently include many other contaminants sometimes found in drinking water. In the absence of established standards, states use guidelines called Health Advisories. Health Advisories currently cover a number of pesticides and volatile organic chemicals.

The drinking water standards and guidelines have the same purpose — to place a ceiling on contaminant levels in the drinking water supplied by public water systems, whether the source is ground water or surface water. When a standard or guideline is exceeded in a municipal or community water system, the states require the operator of the system to take corrective steps. These steps can include treating the water through filtration or aeration, blending water from several sources to reduce contaminant levels in the system, or constructing a new well.



Ground water

In Idaho, Oregon, and Washington statewide ground water protection legislation has been enacted. Ground water standards have been adopted for a wide range of contaminants. Standards cover contaminants of health concern (such as volatile organic chemicals, pesticides, and heavy metals) and other contaminants (such as iron and hydrogen sulfide) that can give water an undesirable taste or odor without making it unhealthy. Ground water standards are generally based on drinking water standards and Health Advisories, although the states can use different numbers where warranted by new scientific research.

The ground water law is designed to protect the ground water resource by regulating the contamination *sources* such as landfills, underground gasoline storage tanks, stockpiles of road salt, mines, chemicals applied to farm fields, and so on. When a ground water standard is exceeded, state agencies can take a range of actions including closing a facility, requiring the responsible party to change procedures, or requiring other actions to eliminate the source of the contamination.

Standards

What Are the Health Concerns?

Contaminants in drinking water are always cause for concern. However, it is important to distinguish between acute and chronic effects of harmful substances.

Acute effects are usually seen within a short time after exposure to a toxic substance. An example is a farmer who accidentally spills a pesticide, and shortly thereafter suffers from nausea, dizziness, and vomiting. Nationally and in the Pacific Northwest the most commonly detected drinking water problem is bacterial contamination caused by improper well construction and maintenance. Bacterial contamination is a common cause of acute toxicity, causing symptoms as mild as stomach upsets to diseases as serious as dysentery, typhoid fever, and hepatitis.

Chronic effects result from exposure to a substance over a period of weeks or years. An example is an asbestos miner who breathes in traces of asbestos dust for many years and later develops serious respiratory problems. With contaminants such as pesticides and volatile organic chemicals in drinking water, health officials are almost always concerned about chronic effects such as cancer or damage to the central nervous system.

How Do Experts Estimate Human Health Effects?

People will continue to use chemicals and to discharge effluent into water bodies. Some chemicals will invariably end up in some drinking water. Therefore, we need standards and guidelines for various contaminants.

The process for establishing a **drinking water standard** or **guideline** begins with a scientific assessment of the risk to public health posed by the contaminant. Scientists usually assess risk based on toxicity studies researchers conduct on laboratory animals and on studies of humans exposed to chemicals in the work place. Testing for acute toxicity is done on mice, rats, rabbits, hamsters, guinea pigs, cats, dogs, fish, and fowl. Occasionally, scientists test human volunteers with acute but sublethal exposure to a chemical.

Direct study of long-term chemical exposure and chronic effects in humans is extremely difficult and costly. So, to check for chronic effects such as cancer or birth defects, scientists test animals with small amounts of chemicals over long periods of time. To see if a chemical causes genetic changes, researchers conduct tests on bacteria and on animal or human cells grown in the laboratory.

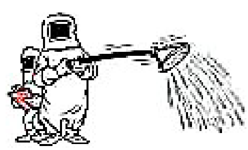
Based on the toxicity studies, researchers determine contaminant concentrations in drinking water that are not expected to cause public health problems. There are two general approaches for estimating safe levels of contaminants in drinking water. The two approaches start from different assumptions and produce different results.

Acceptable Daily Intake Method

This method defines an "Acceptable Daily Intake" (ADI) for humans. Scientists using this method analyze existing toxicological test data and determine the highest dose at which they observe no adverse health effects in laboratory animals. That level is then divided by a "safety" or "uncertainty" factor to find a concentration at which the experts expect no adverse health effects in humans.

The size of the safety factor depends on the thoroughness and conclusiveness of the toxicity testing. Safety factors commonly range from 10 to 1,000. Generally, more conclusive test results are reflected in a smaller safety factor.

For example, the highest dose of the pesticide aldicarb that caused no observable health effects in animals was 0.1 milligrams of aldicarb per kilogram of body weight per day. That level was then divided by a safety factor of 100 to determine an acceptable daily intake for humans, 0.001 milligrams per kilogram of body weight per day. Finally, scientists estimated the amount of water an average person consumes on an average day, and calculated the concentration of aldicarb in water that would result in a person consuming the acceptable daily intake. For aldicarb, this worked out to 0.01 milligrams per liter of water or, stated another way, 10 parts per billion.



Risk Estimate Method

A risk estimate is always used when setting a standard for cancer-causing substances, because scientists agree that there may be no zero-risk or absolutely safe level of exposure to these substances.

Scientists develop a risk estimate by looking at the health effects that high doses produce when administered to laboratory animals; then they estimate the risk of human health effects from the much lower concentrations found in drinking water. Rather than producing an acceptable daily intake, this method produces estimates of different levels of risk at different levels of contamination.

For example, the risk estimate for the widely used chemcial benzene state that 6.8 parts per billion of benzene in drinking water could produce one additional case of cancer in a population of 100,000 people who consume the contaminated water over a 70-year lifetime. A smaller concentration of the chemical, 0.68 parts per billion, represents a smaller theoretical risk — one additional cancer per million people drinking the water.

The important difference between a risk estimate and the ADI method is that the ADI method assumes that there is a threshold or "safe" dose below which there will be no adverse health effects. The risk estimate assumes that at *any* dose, no matter how small, some adverse health effect is theoretically possible. Drinking water standards or advisories based on this approach are set at a level at which the risk, while present, is judged to be acceptably low.

Do the Standards Guarantee Safety?

All human activities, even those considered perfectly safe, involve some degree of risk. Ultimately, most people are probably less interested in guarantees of absolute safety than in reasonable assurances. Drinking water standards provide a reasonable assurance that water that comes from the tap will not cause any health problems, now or in the future.

Like other laws designed to protect public health, drinking water standards cannot always guarantee that there is absolutely zero risk from water containing a contaminant. Drinking water standards do, however, guarantee that scientists and public officials have looked at all available information on the health effects of a substance and have made a careful, conservative judgement of the level of contamination that will not endanger public health.

(Information contained in the **Standards** section was adapted from the following publication. How Drinking Water Standards Are Established. Gary Jackson and Bruce Webendorfer. University of Wisconsin-Extension publication number G3338. (http://cf.uwex.edu/ces/pubs/pdf/G3338.pdf)

What Do the Numbers Mean?

How much confidence should we place in numerical standards and guidelines for drinking water? For example, a health advisory might suggest that levels of a particular chemical in drinking water should not exceed 10 parts per billion. If water contains more than that, say 12 parts per billion, is it completely unsafe to drink? If the water contains only 8 parts per billion, is it completely safe? Unfortunately, there is no simple answer.

One area of uncertainty stems from the difficulty of applying the results from tests on genetically similar laboratory animals in a controlled environment to a diverse human population living in a complex environment.

A second area of uncertainty stems from incomplete toxicity data on some chemicals. Even if good toxicity studies are available for individual chemicals, scientists have rarely studied the combined toxicity of various chemicals that frequently occur together in the environment.

A third area of uncertainty exists because the objective scientific analysis involves numerous assumptions and judgements. These include how large a safety or uncertainty factor to apply to the animal toxicity data, the average amount of water consumed, and to what extent the public is exposed to a contaminant from other sources such as food and air.

To compensate for some of these uncertainties, scientists typically make a series of “safe” or conservative decisions when assessing health risks. For example, if there is doubt about whether to use a safety factor of 10 or 100, the larger number is used. Similarly, acceptable daily intakes are usually calculated to protect a small child, which results in a greater degree of protection for larger adults. Also, scientists use mathematical models to estimate human health effects based on high-dose animal studies. To be on the safe side, they generally select a model that gives a comparatively high estimate of the risk associated with the chemical.

Before scientific findings become public policy, they are debated in the public arena, where political, economic, and social considerations come into play. Do the benefits of a chemical outweigh its risks? Are the people exposed to the chemical the same individuals who benefit from its use? Are there alternatives to the use of the chemical? What risks do the alternatives present? These questions and others are weighed against the scientific evaluation of the health effects of the contaminant.

This complex process of science, judgement, and public policy results in generally conservative or “safe” standards. However, because the numbers are not strictly the results of objective science, they are not absolute and unchangeable. The case of the pesticide aldicarb is a good example. Using the same data, state and federal officials decided on 10 parts per billion as the maximum concentration to allow in water, while the National Academy of Sciences suggest 7 parts per billion as a standard, and the manufacturers of the pesticide argue that the standard should be 35 parts per billion. The maximum concentration allowable in water may change if additional information about aldicarb’s health effects becomes available.

Discussion Points

- Identify at least three areas in your county or community where surface or ground water is collected for drinking. Who is responsible for maintaining the quality of the water so you know it is safe to drink? Do you think this water is safer than bottled water, why or why not?
- What is a well water testing program and why might it be important for members of your community?
- Where could you find evidence of good drinking water quality in your community? How long should these records be kept and why is it important?
- Contamination can lead to many water quality problems. If there is a decrease in water quality upstream of the location where a community takes their water, how could the community find out? Why would this be important?
- List the 10 most important standards you believe need to be set in your community for drinking water quality. Explain why!

Major Points to Remember

- Ground water is the underground water found in cracks of bedrock and in the spaces between sand and gravel. Ground water is not an underground lake. Ground water can occur just a few feet below the surface or may be buried several hundred feet down.
- People in large cities frequently drink water that comes from **surface water sources**, such as lakes, rivers, and reservoirs.
- Today the public agencies charged with protecting drinking water and public health address these issues by establishing standards and guidelines — numbers that identify contaminant levels that do not pose a significant risk to public health.

Journal and Evaluation

In your journal write in your own words the important points your mother should know about ground water, surface water, and drinking water.

Additional Activities

- Obtain a ground water flow model and demonstrate how this might be used to explain issues or concerns in the local aquifer.

Short-course Presenters

Two activities are helpful in reinforcing the concepts presented in this module. The first activity is to compare and contrast at least three municipal water system reports from their county or community. It should be completed after the drinking water section is presented in the guide (page 98). The second activity is to have each learner test water samples that they bring in using test strips. This should be done at the conclusion of the guide materials before or after the discussion depending on organizer preference. Both activities reinforce content presented in the chapter and increase awareness of why it is important to monitor water and water quality for a variety of purposes including drinking. Designers found it helpful to have participants complete their journals after the activities and discussion . . . the letters to Mom or some other important person can then take on new meaning.

Activity one: To compare municipal water systems obtain copies of the most recent reports that are required by law. In pairs or groups of three have participants compare and contrast three different reports for 10-15 minutes and answer your own or the provided questions. In addition, individuals might bring recent water tests of their private wells to supplement this information. If possible, choose reports for different types of systems in use (well, surface water, springs) in your area. This difference can show the variety of types of minerals, solids, and contaminants that may show up. By comparing the different systems participants can gain an appreciation for the standards that will be discussed later in the module. Ask the participants the following questions:

- What is the most surprising thing you found in the report?
- What type of water system is this (well, surface, spring, mixed)?

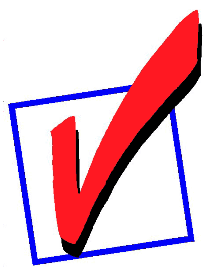
- What are the primary contaminants of concern in the systems you reviewed? Why?
- Which of the systems would you choose to drink?

In Oregon reports can be pulled from the Department of Health's drinking water program web site (http://www.ohd.hr.state.or.us/dwp/welcome.html). In Idaho and Washington organizers need only contact city, community, and water districts and ask for their annual consumer confidence report. Besides the list of federal drinking water contaminants listed by EPA at their web site (page 100) the WSU Extension Bulletin 1721, *Defining Water Quality,* can also be used to supplement this discussion (http://cru.cahe.wsu.edu/CEPublications/eb1721/eb1721.html).

Activity two: In the second activity it is helpful to have the water samples from the three municipal water systems studied during the first activity, samples of bottled water that can be purchased at a local store, and at least one water sample brought by each of the participants. Pour 2-4 oz. from each of the water samples into paper cups, using test strips (HACH Aquacheck Water Quality Test Strips for 5-in1; Cat # 27552; chlorine, total hardness, total alkalinity, and pH) follow the directions and record the results on index cards. If time permits use an electronic TDS meter to compare and contrast the TDS levels across the assembled sample group. Other strips are available to test for copper, iron, and other potential contaminants. Participants will really enjoy this and the outcomes lay the groundwork for the monitoring that they will discuss and do in Parts Three and Four. The second activity requires the following materials: water samples, index cards, deionized (demineralized) water for rinsing equipment, test strips, paper cups, pencils or pens to record results, and TDS meter.

WATER SAMPLE RESULTS

Type of water:	Spring
Location:	Selle Road
Chlorine:	0
Hardness:	17 ppm
Alkalinity	20
pH	< 6.2
TDS	43 ppm
Copper	none
Iron	none



Tips for Short-course Presenters

- **Ground Water, Drinking Water, and Standards:** Some short-course participants may not be connected to a public water system, but rather supplied with water from a private well on their property. Water from private wells are not monitored, tested, or regulated by any public entity. Dependence on private well water means that the well owner needs to take responsibility for knowing about the quality of the water and safeguarding it from contamination. Farm*A*Syst and Home*A*Syst are excellent and appropriate tools to assist private well owners with this process (see section for more information) .

  Drinking water sources, such as lakes, rivers, streams, groundwater aquifers, and springs, may also be known as source waters. The terms "drinking water source" and "source water" may be used interchangeably, especially by state agencies that develop the state assessment programs. For example, a state's drinking water source assessment program may be called a source water assessment program.